

Oleg B. Tarasov
NCSL / MSU, USA


LISE ++

Modeling Exotic Beam Production with Fragment Separators

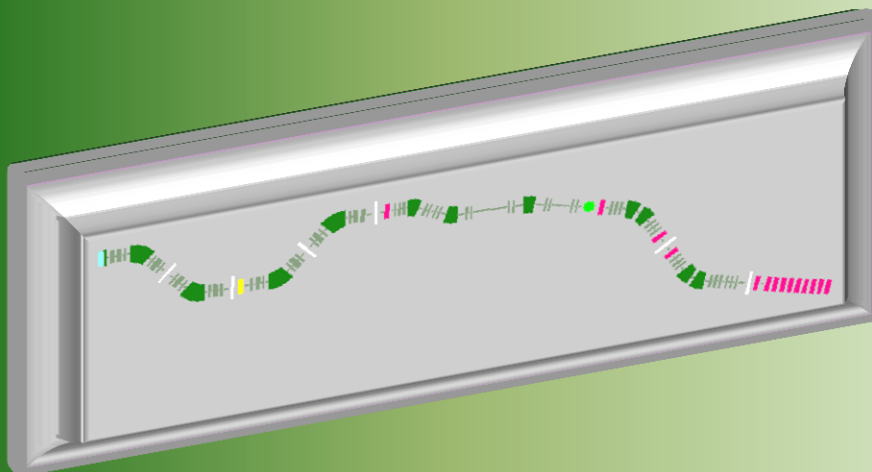
5th Fragment-Separator Experts Meeting
5th Fragment-Separator Experts Meeting

10-12 / 12 / 2013

LISE ++

- 
1. Introduction
 2. Types of transmission calculations in LISE++
 3. 2011-2013 principal modifications
 4. Some complications
 5. Perspectives, next tasks
 6. Statistics
 7. Conclusion

LISE ++



1. Introduction

4th Fragment-Separator experts meeting : v. 9.2.33 (10-DEC-2010)

5th Fragment-Separator experts meeting : v. 9.7.01 (01-NOV-2013)

v.9.3 **01/06/2012**

v.9.5 **03/06/2013**

v.9.7 **11/01/2013**

Lectures at the Euroschool on Exotic Beams 2013

August 26-31, 2013

Dubna, Russia

"Production of Fast Rare Ion Beams"
with the use of examples prepared with the LISE++ code

(available on-line through LISE++ and Euroschool sites)

4th Fragment-Separator experts meeting

LISE++ : high order optic calculations

MOCADI : make user-friendly, interface

COSY : use of materials



Introduction to transmission
calculations in LISE++

New address:

<http://lise.nslc.msu.edu>

Redirection from previous addresses

<http://www.nslc.msu.edu/lise>
<http://groups.nslc.msu.edu/lise>

New download link is

<http://lise.nslc.msu.edu/download>

No more FTP-server to download the LISE⁺⁺ package

version 9.5

LISE⁺⁺

- Home
- Introduction
- Documentation
- Last Changes
- Perspectives
- Download
- MOTER
- PACE 4
- Spectrometers
- Related topics
- Personal pages
- Registration
- Email

v. 9.5

SIMULATION OF FRAGMENT SEPARATORS

Range of application

The program **LISE⁺⁺** has been developed to calculate the transmission and yields of fragments produced and collected in a spectrometer. This code allows to simulate an experiment, beginning from the parameters of the reaction mechanism and finishing with the registration of products selected by a spectrometer. The program allows to quickly optimize the parameters of the spectrometer before or during the experiment. It also makes it possible to estimate and work in conditions of maximum output of studied reaction products and their unambiguous identification. Wedge and Wien filter selections are also included in the program.

LISE⁺⁺ is the new generation of the **LISE** code, which allows the creation of a spectrometer through the use of different "blocks". The number of blocks used to create a spectrometer in **LISE⁺⁺** is limited by operating memory of your PC and your imagination.

built-in Energy loss, Time-of-Flight, Position, Angular, Charge, Cross-Section distribution plots and dE-E, dE-TOF, Z-A/Q and dE-X two-dimensional plots allow to visualize the results of the program calculations. An application of transport integral lies in the basis of fast calculations of the program for the estimation of temporary evolution of distributions of phase space.

The **LISE** code may be applied at medium-energy and high-energy facilities (**fragment- and recoil-separators with electrostatic and/or magnetic selections**). A number of these facilities, like A1900 and S800 at NSCL, LISE3, SISSI/LISE3 and SPEG at GANIL, FRS and SuperFRS at GSI, RIPS and BigRIPS at RIKEN, based on the separation of projectile-like and fission fragments, fusion residues are included or might be easily added to the existing optical configuration files.

The Projectile Fragmentation, Fusion-Evaporation, Fusion-Fission, Coulomb Fission, and

lise.nslc.msu.edu/download/

Index of /download

Name	Last modified	Size	Description
Parent Directory	-	-	-
LISE++ 9.5.exe	09-Mar-2013 16:19	11M	-
open version/	07-Mar-2013 11:13	-	-
other/	18-Feb-2013 14:19	-	-

LISE site connect...

<http://lise.nslc.msu.edu/version>

```

lise.nslc.msu.edu-- Host Resolved
Connected
16 bytes of 16 received
Disconnected
HTTP Success = Get Success
Status: Transaction Completed
Disconnected
9.5
06-MAR-2013
    
```

Nuclear Reactions Video Low Energy Nuclear Knowledge Base

Supported by
Russian Foundation for Basic Research

Nuclear Properties	Nuclear Models	Nuclear Decays	Nuclear Reactions	
Nuclear Map	Shell Model	Alpha - decay	Elastic scattering Classical Semiclassical Optical Model Phase analysis	Experimental Data $d\sigma/d\Omega$
Check your Browser Settings Java applets blocked? Warning! NRV extensively uses Java. Your browser must support Java Virtual Machine	Liquid Drop Model	Beta - decay	Inelastic Scattering Coulomb excitation Direct process (DWBA) Channel coupling Deep inelastic collision	
	Two-Center Shell Model	Fission	Transfer reactions: Direct process (DWBA) Semiclassical approach (GRAZINC code) 3-body classical model Two-nucleon transfer Massive transfer	
		Decay of excited nuclei	Fragmentation EPAX v.3 Break-up (DWBA) Semiclassical model	LISE⁺⁺
			Fusion Empirical model Channel Coupling Langevin equations	Experimental Data $\sigma_{fus}(E)$
			Driving potentials Synthesis of SHE (movie)	
			Evaporation residues Monte-Carlo	Experimental Data $\sigma_{en}(E)$
			Radiative capture Potential model	Experimental Data NACRE NACRE-II
			Pre-equilibrium LP formation 4-body classical model Semiclassical model Moving sources	
			Kinematics: 2-body // 3-body // Q-values Detector loading	

What is it?

History and Support

NRV under Windows

Work team

Nuclear databases

Partner site

It's diffused freely



- Home
- Introduction
- Documentation
- Last Changes
- Perspectives
- Download
- MOTER
- PACE 4
- Spectrometers
- Related topics
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v. 9.4.52

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The [Projectile Fragmentation](#), [Fusion-Evaporation](#), [Fusion-Fission](#), [Coulomb Fission](#), and [Abrasion-Fission](#) assumed in this program as the production reaction mechanism allows to simulate experiments at beam energies above the Coulomb barrier.

Built-in powerful tools:

- «Physical Calculator»,
- «Relativistic Kinematics Calculator»,
- «Evaporation Calculator»,
- «Spectroscopic calculator" (of J.Kantele»,
- «Matrix calculator",
- «PACE4» (fusion-evaporation code),
- «Global» (charge-state distribution code),
- «Charge» (charge-state distribution code),
- Nuclide and Isomeric state Databases utilities,
- Units converter,
- ISOL catcher,
- Twinsol (solenoid) utility,
- Transport calculations,
- Brho analyzer,
- Stripper foil lifetime utility (new),
- Monte Carlo simulation of fragment transmission (new),
- Monte Carlo simulation of fission fragment kinematics,
- «BI» - the automatized search of two-dimensional peaks in spectra and definition of their characteristics

permit to work well below this energy limit, and this makes the program **very attractive for all users dealing with physics of heavy ions** from 10 keV up to some GeV per nucleon.

- LISE++ presentation on EBSS2011 - PDF (1.6 MB)
- LISE++ first steps - PDF (EBSS2011-tutorial)
- LISE++ status (2008) - PDF (1.8 MB)
- LISE++ presentation (2007) - PowerPoint (4.3 MB)
- LISE++ presentation (2004) - PowerPoint (4 MB)
- LISE++ Coulomb fission - PowerPoint (3 MB)
- LISE++ Abrasion-Fission - PowerPoint (3 MB)
- LISE++ site statistics (16 Nov 2011)

partner site



Low Energy Nuclear Knowledge Base



Fusion -> Residual

Evaporation settings

Transmission probability for a one-dimensional potential barrier

Classical
 Quantum-mechanical

h_{ω} - Curvature parameter of the parabolic potential describing the barrier (default value 3 MeV) MeV

Probability for compound nucleus formation $P_{\{CN\}}$

Take into account the Probability for compound nucleus formation $P_{\{CN\}}$ according to V.Zagrebaev & W.Greiner, PRC78, 034610 (2008)

OK Make default
 Cancel Help

Partner site

[Fusion](#)

[Evaporation](#)

Kinematics calculator (relativistic)

Reactions

TWO BODY reaction B (A, C) D
 SCATTERING B (A, C=A) D=B
 BREAKUP (FISSION) x (A, C D) x (gamma-emission)

Use Mott's scattering

For Kinematics Plots use energy values

after reaction
 at entrance of detectors

Kinematics plots
 Rutherford plot
 2D fragment plot (Monte Carlo)

[3-body kinematics](#)

Quit Help

Participants

		ME [MeV]	Excitation Energy	E[CM] = 1018.16 MeV
A	Beam	40Ar	-35.04	0
B	Target	9Be	11.35	0
C*	Fragment	40Ar	-35.04	0
D*	Residual	9Be	11.35	0

Beam energy = 140.0 MeV/u
 Intensity = 1 pA
 Target thickness = 1e-1 micron
 Q-value = 0.00 MeV

Reaction takes place at the

ENTRANCE of the target
 MIDDLE of the target
 EXIT of the target

Set-up

Search an angle in CM

from 0 degrees and up
 from 180 degrees and down

	fragment (C)	residual (D)
R =	100 cm	100
w =	1 cm	1
h =	2 cm	2

Angle (deg) = 8.439 62.885 50 130

	fragment (C)	residual (D)	fragment (C)	residual (D)
Counting in monitor =	1.13e-2	5.1e-4		
Differential Cross Section =	7.29	0.33	0.203	0.203
Energy after reaction =	124.55	68.51	4.864	91.41
Energy at the entrance of detectors =	124.55	68.51	MeV/u (** for gamma [MeV])	
Maximum Angle =	13.03	90.00		
Solid Angle =	0.2	0.2	7.17	0.325
delta Theta =	0.57	0.57	3.9	1.1

Calculations LAB CM
 pps
 mb/sr
 MeV/u**
 deg
 msr
 deg

Fusion -> Residual

Evaporation settings

Transmission probability for a one-dimensional potential barrier

Classical
 Quantum-mechanical

h_{ω} - Curvature parameter of the parabolic potential describing the barrier (default value 3 MeV) MeV

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Take into account the Probability for compound nucleus formation $P_{\{CN\}}$ according to V.Zagrebaev & W.Greiner, PRC78, 034610 (2008)

OK Make default
 Cancel Help

Partner site

[Fusion](#)

[Evaporation](#)

Types of transmission calculations in LISE++

➤ **“Distribution” (analytical) method**



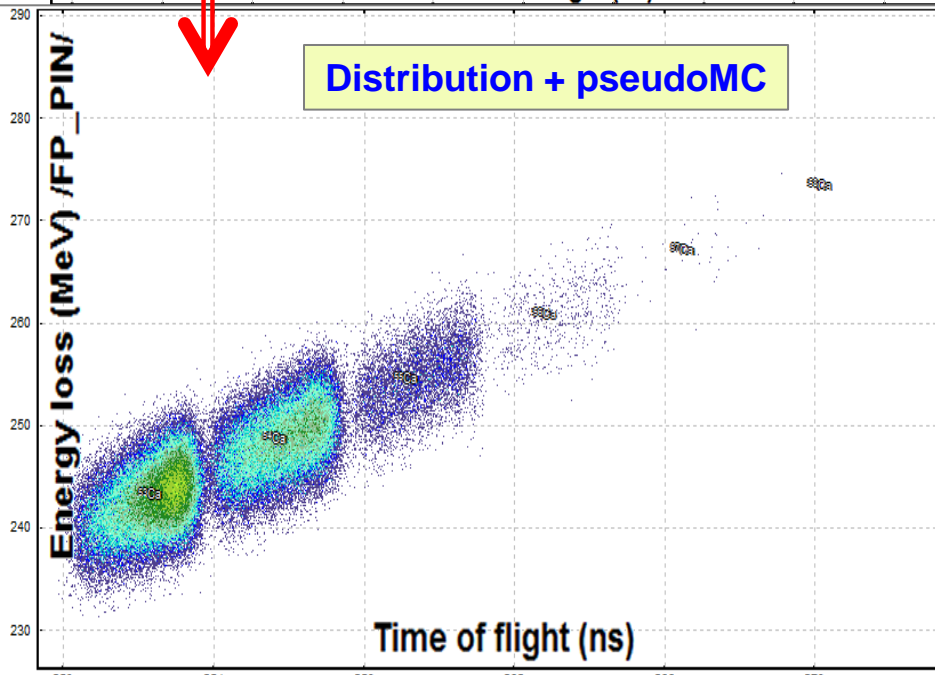
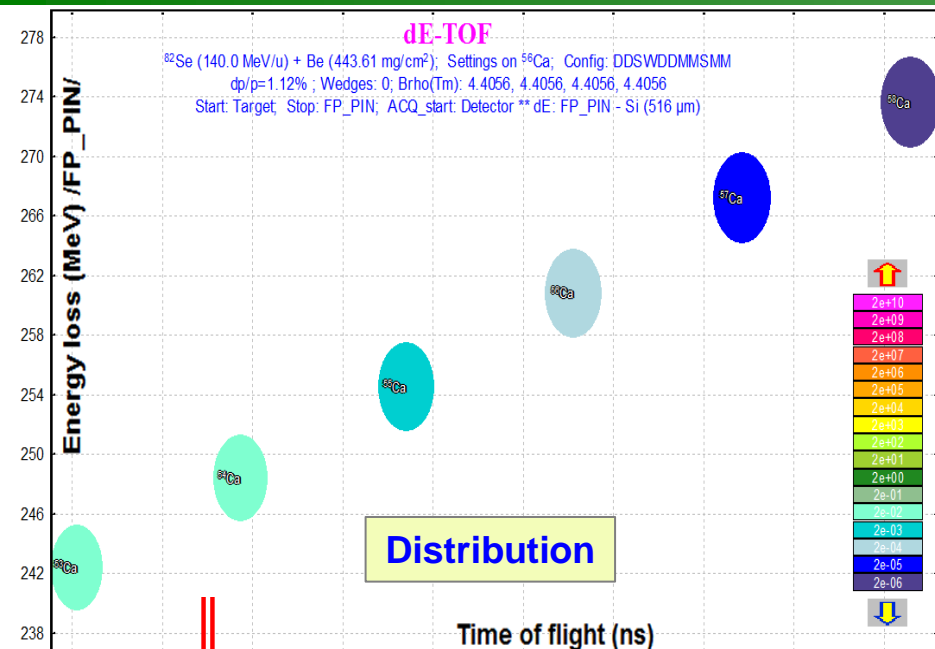
- Fast calculations
- All Optimization procedures in the code based on this method
- Effective with segmented configurations for experiment planning
- Calculation of low transmission (important for primary beams)

LISE class “Distribution” : D. Bazin, B. Sherrill, Phys. Rev. E 50 (1994) 4017
 LISE class “Distribution2” : 2000
 LISE++ class “Distribution4” : 2003

➤ **Monte Carlo method:** (from 2007)

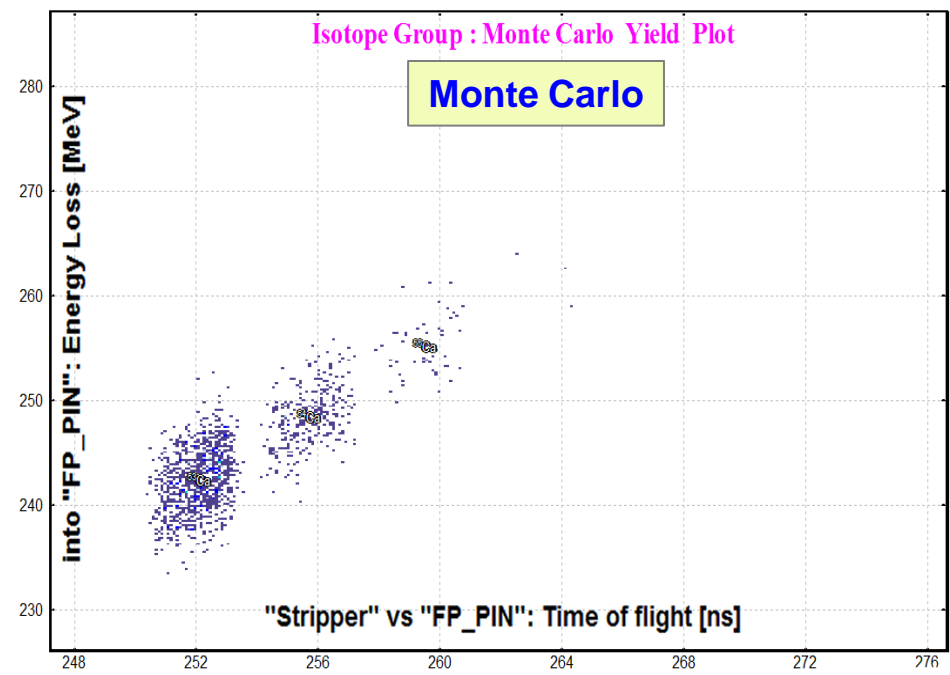


- Benchmark for the “Distribution” method
- Detailed analysis of transmission with extended configurations
- Possibility to use High Order Optics
- Observation of correlations between different parameters of different blocks
- Possible gates on different parameters
- Good tools for understanding (learning) ion-beam optics issues
- Effective for fragment separator design
- Some optical blocks (Solenoid, RF buncher) are effective only in MC mode



pseudoMC method for plots :

Monte Carlo method is applied to analytically calculated Final Distributions

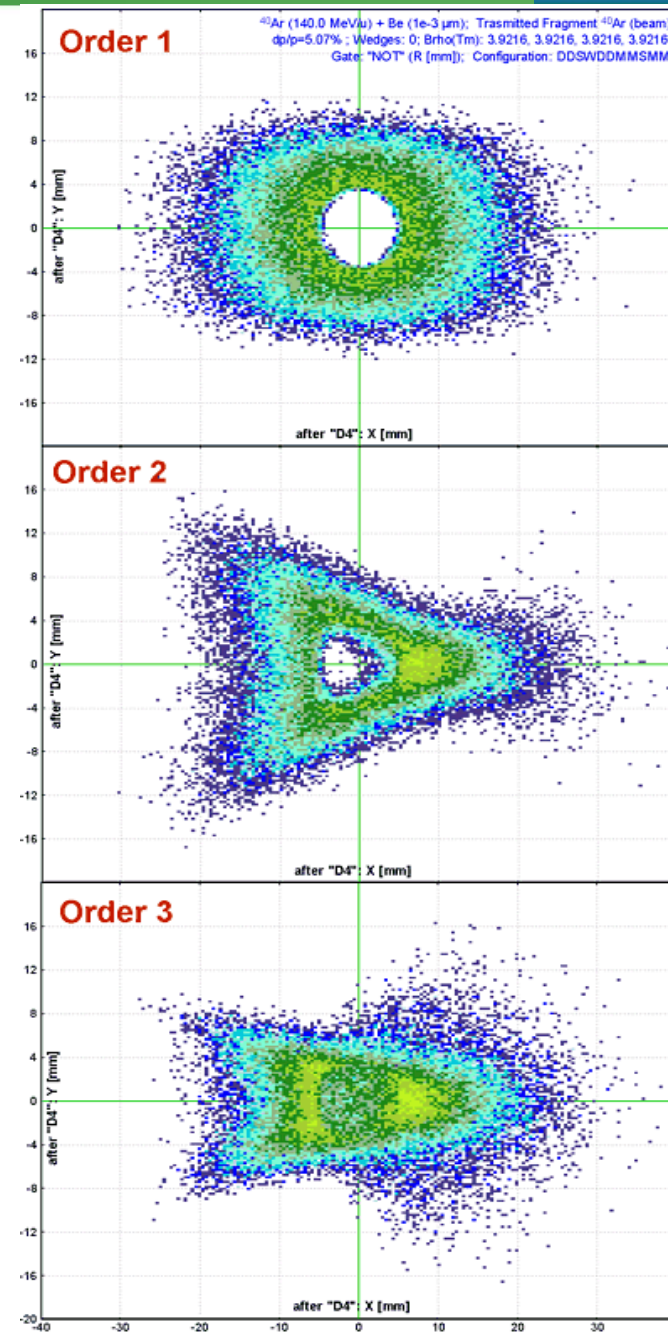
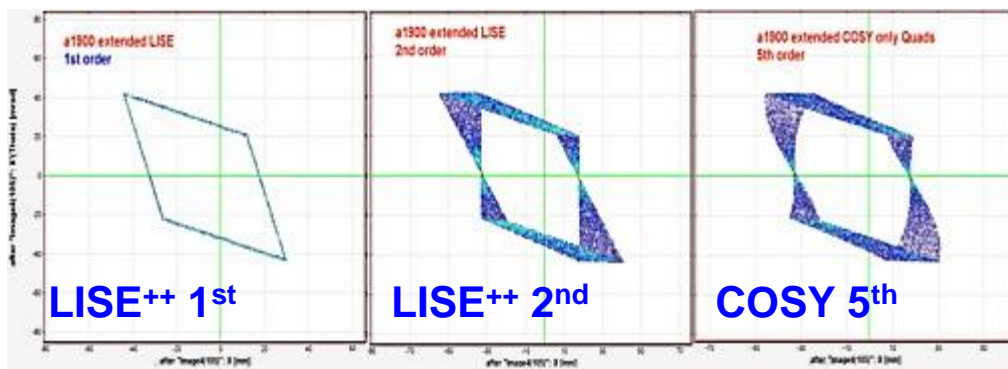


- LISE++ is able to operate with 5th order matrices
- High order optics can be used only in Monte Carlo mode

http://lise.nsl.mscl.msu.edu/8_3/HighOrder_v8_3_158.pdf

- LISE++ can calculate 1st and 2nd order matrices based on the Transport formalism
- Higher matrices can be loaded (or linked) from files prepared by the COSY code

http://lise.nsl.mscl.msu.edu/9_2/9_2_33/9_2_33.pdf





➤ **Classical (segmented) configuration:**

- Fast transmission calculations
- Simple structure
- Effective with analytical calculations for experiment planning



➤ **Extended (elemental) configuration:**

- Detailed analysis of transmission
- Optical matrices can be calculated in the code, and used in segmented configurations
- Tools to obtain angular acceptances, which can be used in segmented configurations
- Good tools for understanding (learning) ion-beam optics issues
- Effective with Monte Carlo calculations for fragment separator design

Calculations	
Optics	Tune spectrometer for setting fragment on beam axis
Goodies	Tune spectrometer for setting fragment at middle of slit
Calibrations	
Transmission and rate	Update matrices linked with COSY files
Optimum Target	Envelope plot
Optimum Target-Wedge and Wedge-Wedge configurations	First order matrix elements : PLOT
Brho scanning	First order matrix elements : View & Print
Optimum charge state combination	
Monte Carlo calculation of transmission	
Calculators	
	Brho(Erho) Analyzer
	The First- and Second-Order Matrix Elements for an Ideal Magnet

segmented

Block	Given Name	Start(m)	Length(m)	B0(kG)	Br(Tm)corr/*real	DriftM/*Angle	Rapp(cm)/*R(m)	L_eff(m)/*L_dip(m)	2 nd order	CalcMatr/*Z-Q	AngAcc.Apps.Slits
Dipole	D1	0.000	8.7190	+14.2116	* 4.4056	* 45.0	* 3.1000	* 2.4347	no	* 0	HV -- HV

Brho → ← **Slits, acceptance**

extended

Block	Given Name	Start(m)	Length(m)	B0(kG)	Br(Tm)corr/*real	DriftM/*Angle	Rapp(cm)/*R(m)	L_eff(m)/*L_dip(m)	2 nd order	CalcMatr/*Z-Q	AngAcc.Apps.Slits
Dipole	tuning	0.000	0.0001	+14.6853	* 4.4056	* 0.0	* 3.0000	* 0.0000	no	* 0	-- -- --
Drift	z015	0.000	0.3960			standard					-- HV --
Drift	Q017-1TA	0.396	0.7480	+15.4196	4.4056	quadrupole	13.3000	0.7480	yes	1	-- HV --
Drift	z018	1.144	0.1756			standard					-- HV --
Drift	Q019-1TB	1.320	0.7480	-14.3295	4.4056	quadrupole	13.3000	0.7480	yes	1	-- HV --
Drift	z020	2.068	0.1720			standard					-- HV --
Drift	Q021-1TC	2.240	0.4300	+10.3091	4.4056	quadrupole	15.0000	0.4300	yes	1	-- HV --
Drift	z022	2.670	0.5260			standard					-- HV --
Dipole	D1	3.196	2.4300	+14.2396	* 4.4056	* 45.0	* 3.0939	2.4299	yes	* 0	-- HV --
Drift	z030	5.626	0.5640			standard					-- HV --
Drift	Q031-2TA	6.190	0.4300	+12.6140	4.4056	quadrupole	15.0000	0.4300	yes	1	-- HV --
Drift	z032	6.620	0.1358			standard					-- HV --
Drift	Q033-2TB	6.755	0.8120	-15.5591	4.4056	quadrupole	15.0000	0.8120	yes	1	-- HV --
Drift	z034	7.567	0.1358			standard					-- HV --
Drift	Q035-2TC	7.703	0.4300	+13.6724	4.4056	quadrupole	15.0000	0.4300	yes	1	-- HV --
Drift	z036	8.133	0.5860			standard					-- HV --
Drift	Image1(037)	8.719	0.0000			SLITS					-- -- HV

Brho → ← **Slits, acceptance**

Configuration: A1900_S800BL_extended_LISE 2012 2nd order

Spectrometer designing

Block	Given Name	Z-Q	Length,m	Enable
T	Target			+
St	Stripper			+
D	Dipole	tuning	0	+
S	Drift	z015	0.396	+
Q	Drift	Q017-1TA	0.748	+
S	Drift	z018	0.176	+
Q	Drift	Q019-1TB	0.748	+
S	Drift	z020	0.172	+
Q	Drift	Q021-1TC	0.43	+
S	Drift	z022	0.526	+
D	Dipole	D1	2.43	+
S	Drift	z030	0.564	+
Q	Drift	Q031-2TA	0.43	+
S	Drift	z032	0.136	+
Q	Drift	Q033-2TB	0.812	+
S	Drift	z034	0.136	+
Q	Drift	Q035-2TC	0.43	+
S	Drift	z036	0.586	+
S	Drift	Imane1(037)	0	+

Insert Mode
 before
 after

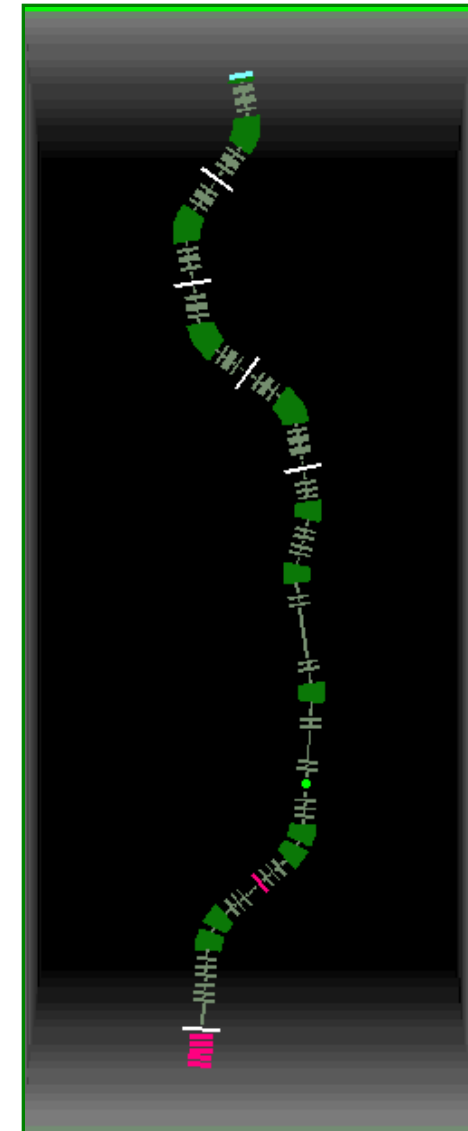
Move element

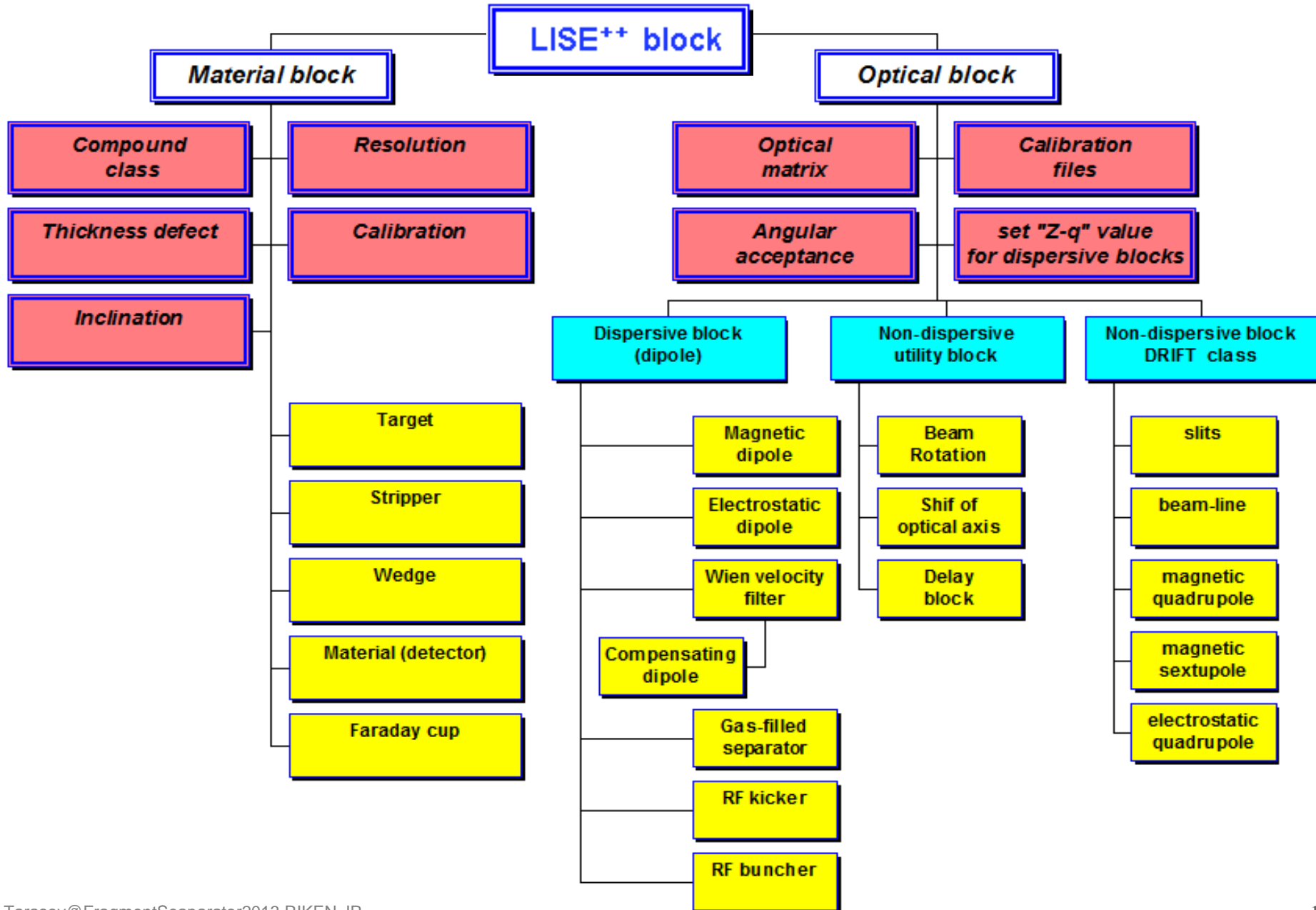
Insert block

- Target
- Stripper after Target
- Wedge
- Material(Detector)
- Faraday cup
- Dispersive (Dipole)
- Wien velocity filter
- Drift (multipole,slits)
- Beam Rotation
- Shift of Optical Axis
- Electrostatic dipole
- Gas-filled separator
- Compensating Dipole
- RF separator
- RF buncher
- Solenoid
- Delay (efficiency) block

Selected block
 Dispersive (Dipole)
 Enable
 Let call automatically
 Block name = tuning
 Charge State [Z-Q] = 0
 Block Length [m] = 0.0001
 Length after this block [m] = 0
 Sequence number = 3

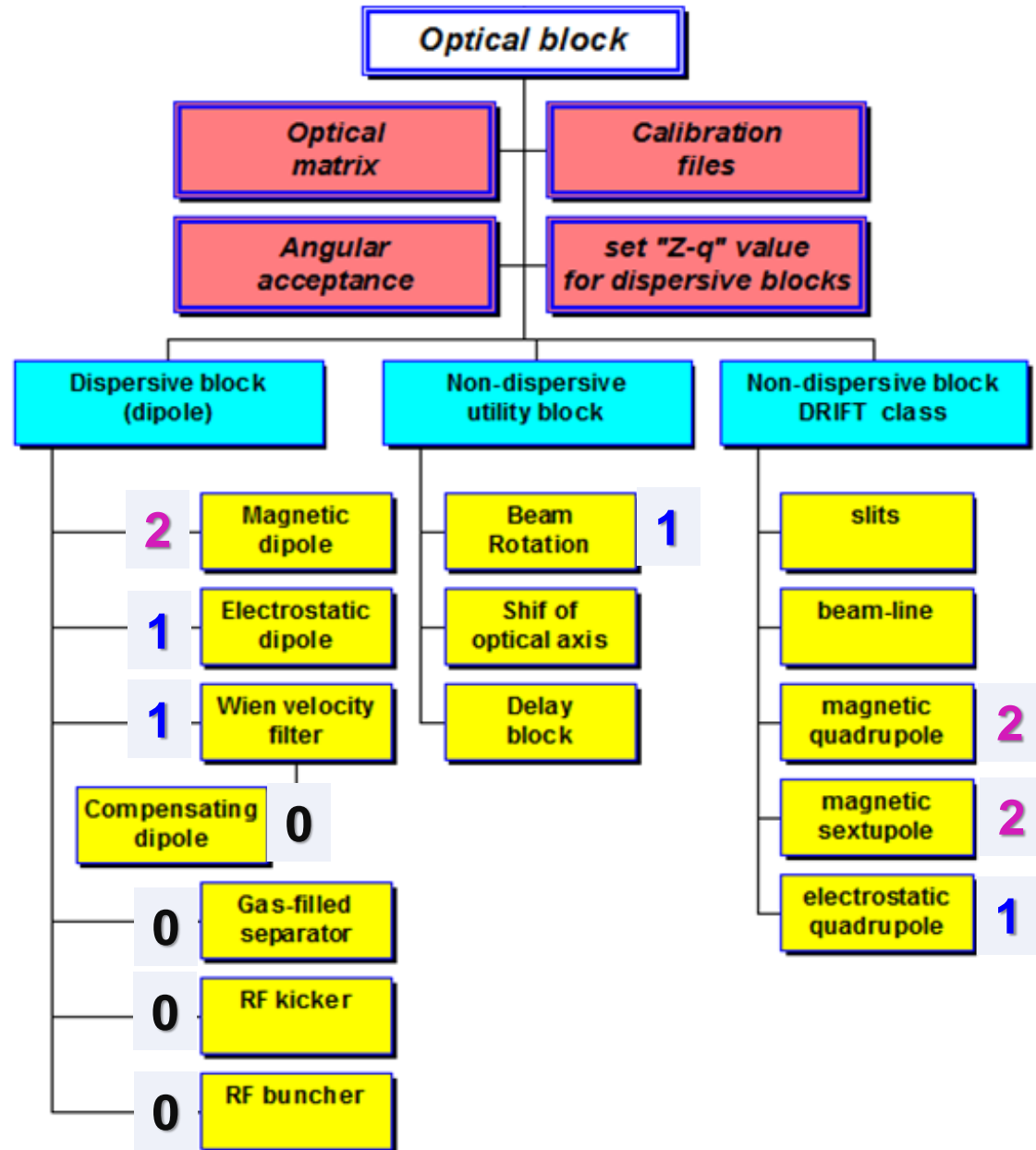
Total
 Number of Blocks: 164
 Length [m]: 82.898





High order optics
calculated by LISE⁺⁺

0 1 2



LISE++
Development
2011-2013

v.9.3 01/06/2012

v.9.5 03/06/2013

v.9.7 11/01/2013

version 9.3

Optics calculation up to second order inside LISE++

Utilities to develop and modify extended configurations

Important updates of analytical transmission calculations (v.9.2.7)

Important updates of analytical transmission calculations (v.9.2.88)

Nucleus identification in 2d-plots, Customization of the Nuclide Chart

Isotope discovery history, Decay analysis dialog, Decay mode revision

Update of the Stripper lifetime utility

PACE4 code update: batch mode, detailed analysis of omitted particles

Miscellaneous

version 9.5

EPAX 5 Implementation

Update of the internal database based on AME_S_NUBASE_2012

Probability for compound nucleus formation

Abrasion-Ablation update, Plot of initial prefragments

NBL and FRIB rate plots

New Database Plots, Database features, Plot options

New block "RF-buncher" RESOLUT separator configuration

Aooulina2 detector configuration

NRV Low Energy Nuclear Recoil Detector: LISE++'s partner site

Asymmetry of momentum distributions (projectile fragmentation)

Modifications table: sorting by application

Modification table: sorting by time

version 9.7

User Differential Cross Sections for Two body reactions

Electrostatic optical blocks: E-quadrupole, E-bender (dipole)

New optical block: E-Bender

New features of LISE++ Monte Carlo calculations

"WAR 8" spectrometer extended configuration

Neutron and Gamma induced reactions in the Kinematic Calculator

Plotting Envelopes with rotation blocks

List of Modifications: version 9.5 -> 9.6 -> 9.7

1. Development: versions v.9.6.006 - 9.6.018
2. Development: versions v.9.6.123 - 9.6.123
3. Setup and Setting fragment charge state distributions plot

New blocks

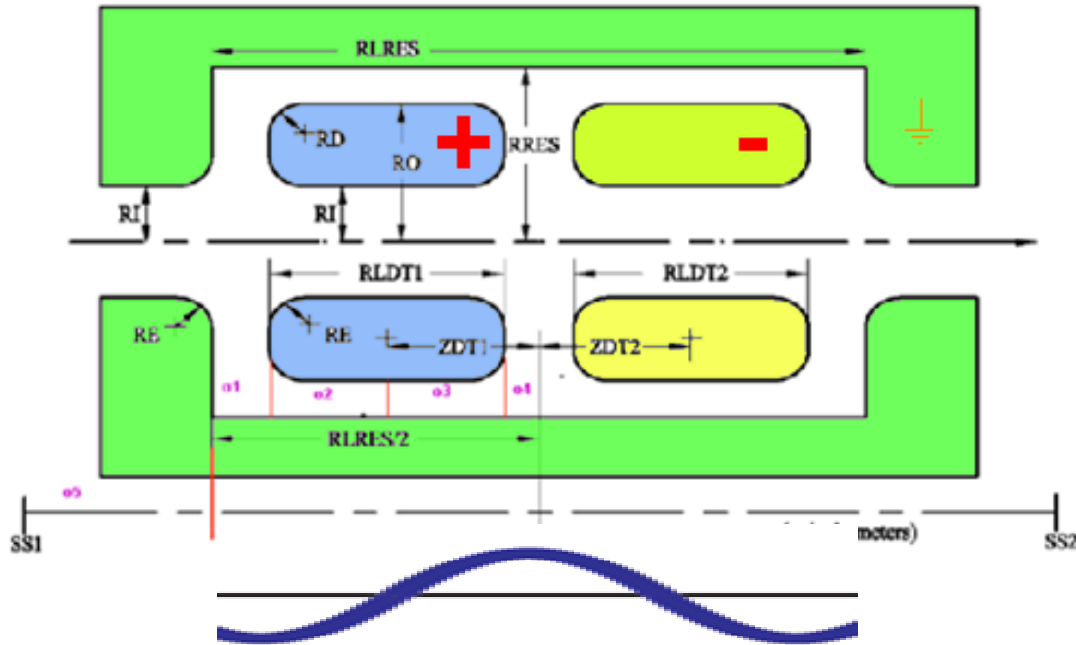
- **RF-buncher**
- **Shift of optical axis**
- **Electrostatic dipole (revision, matrix calculation)**
- **Electrostatic quadrupole**

RF-buncher

Note: RF-buncher block is more effective in MC mode

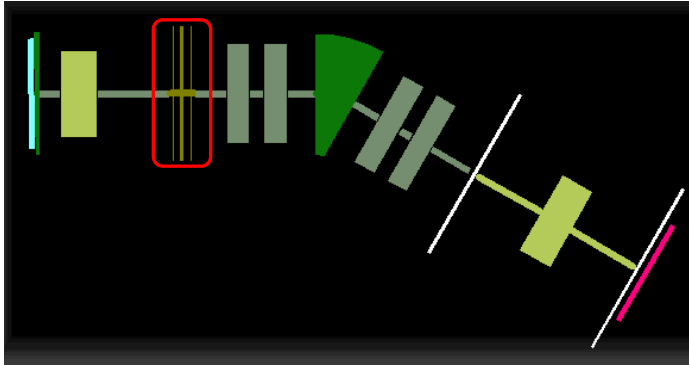
RESOLUT (FSU) configuration

http://lise.nsci.msu.edu/9_4/buncher/9_4_87_buncher.pdf



Gap	Gap Size	Bias
1	D	+V
2	2D	-2V
3	D	+V

Multi-gaps bunchers are constructed for specified speed



RESOLUT_3gap.lpp

COSY 3 gaps :

Gap	Gap Size	Bias
1	D	+V
2	2D	-2V
3	D	+V

LISE++ 3 bunchers:

Buncher	Gap Size	Bias	Phase
1	D	V	a
2	2D	2V	a+180
3	D	V	a

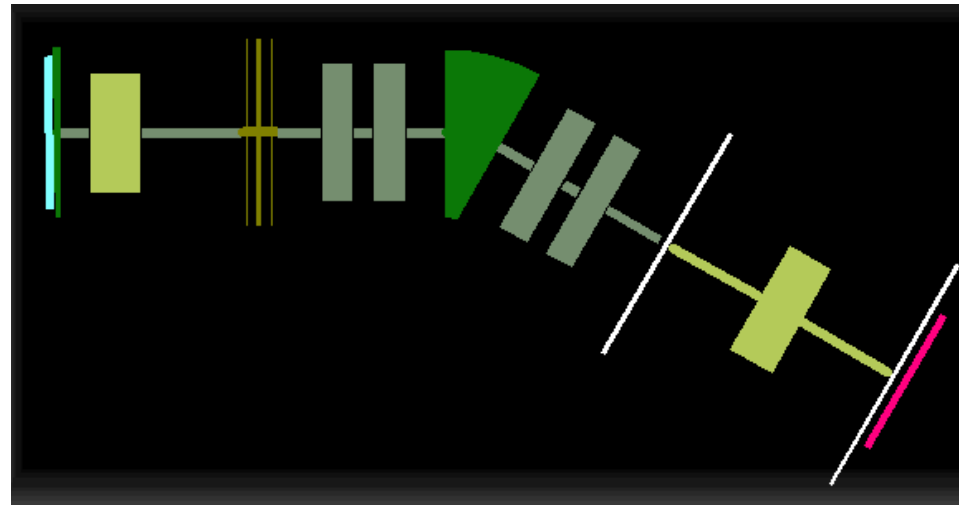
D	Tuning Dipole	Brho	0.6197 Tm
S	Drift 1	standard	0.35 m
L	Solenoid 1	B	2.6844 T
S	Drift 2	standard	1.21 m
B	RFbuncher 1	U Ph	119 kV 35 deg
B	RFbuncher 2	U Ph	238 kV 215 deg
B	RFbuncher 3	U Ph	119 kV 35 deg
S	Drift 3	standard	0.54 m
Q	MQ1	quadrupole	0.38 m
S	Drift 4	standard	0.22 m
Q	MQ2	quadrupole	0.41 m
S	Drift 5	standard	0.47 m
D	Dipole	Brho	0.6197 Tm
S	Drift 6	standard	0.48 m
Q	MQ3	quadrupole	0.41 m
S	Drift 7	standard	0.22 m
Q	MQ4	quadrupole	0.38 m
S	Drift 8	standard	0.74 m
S	slits1	s-ls	
		-200	+200
		-50	+50
L	Solenoid 2	B	2.2688 T
S	slits2	s-ls	
		-200	+200

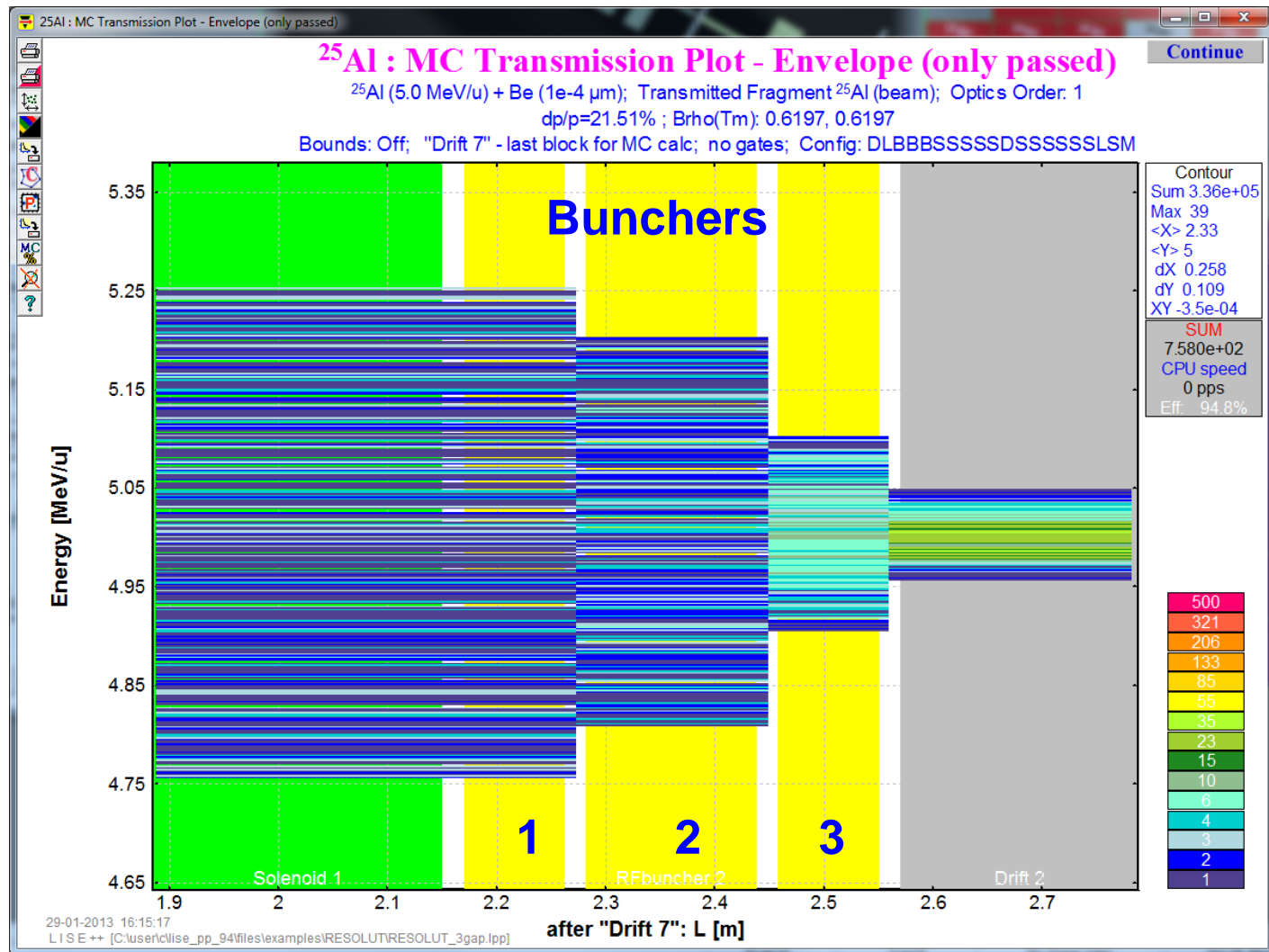
← Tuning dipole to define magnetic rigidity of the separator,
Unitary matrix, no slits, zero length

← Initial drift+solenoid+drift
configuration to define angular acceptance

← 3 gap Rf-buncher was realized as 3 RF bunchers

← QQDQQ spectrometer





File: RESOLUT_3gap.lpp

File: RESOLUT_3gap_reaction.Ipp

Beam

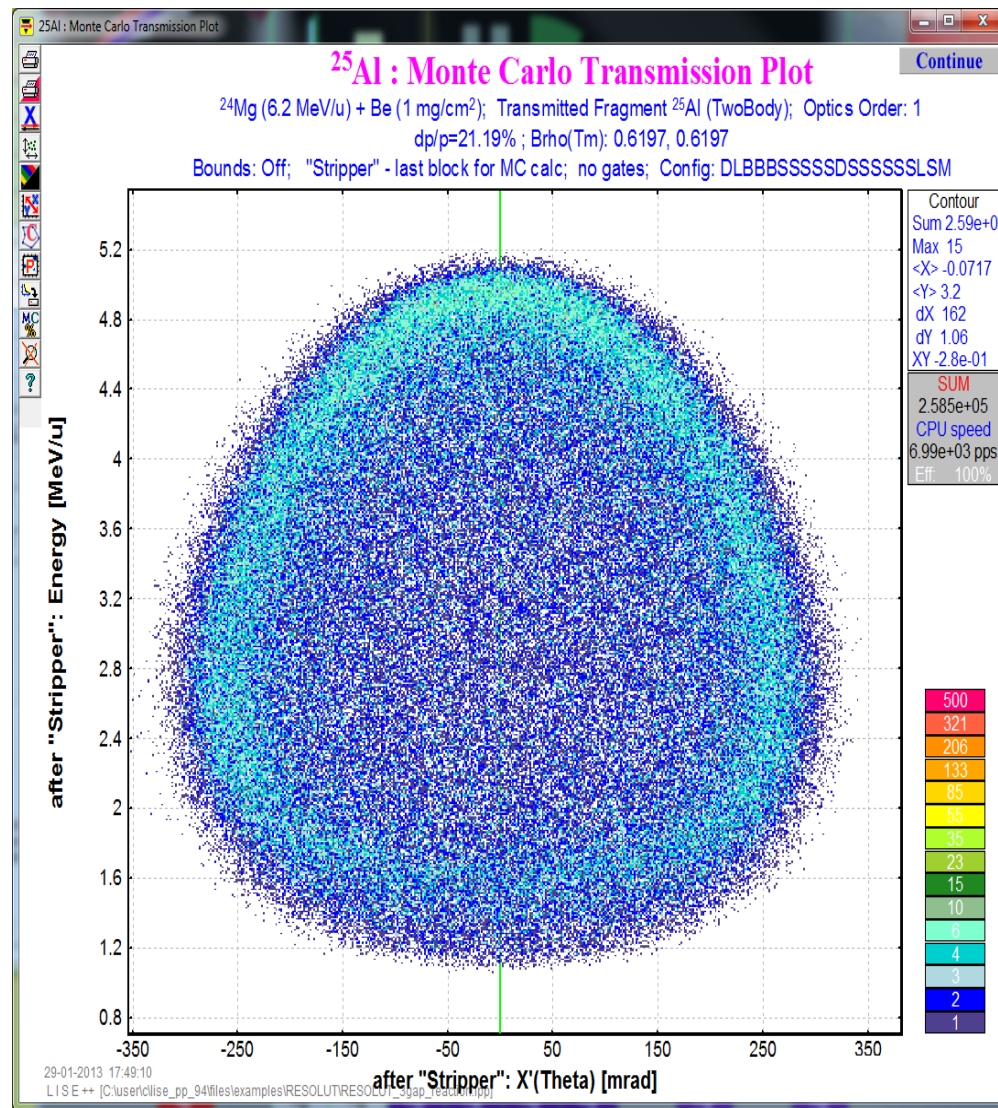
A	Element	q+	Beam energy		Emittance	
24	Mg	12	Energy	6.2 MeV/u	Beam CARD	1D - shape
12			TKE	148.71 MeV	(sigma, semi-axis, half-width...)	(Distribution method)
Z			Brho	0.7177 Tm	1. X mm	1.5 Gaussian
Stable			P	2.582 GeV/c	2. T mrad	20 Gaussian
Table of Nuclides			U	1.24e+4 KV	3. Y mm	1.5 Gaussian
Z			Beam intensity		4. P mrad	20 Gaussian
N			12 enA		5. L mm	0 Gaussian
Ok			1 p nA		6. D %	0.5 Gaussian

P Projectile	$^{24}\text{Mg}^{12+}$
	6.2 MeV/u 1 p nA
F Fragment	$^{25}\text{Al}^{13+}$
T Target	Be
	1 mg/cm ²
Two body reaction	
D Tuning Dipole	Brho
	0.6197 Tm

Primary beam is taken into account, but
Think about other reactions.

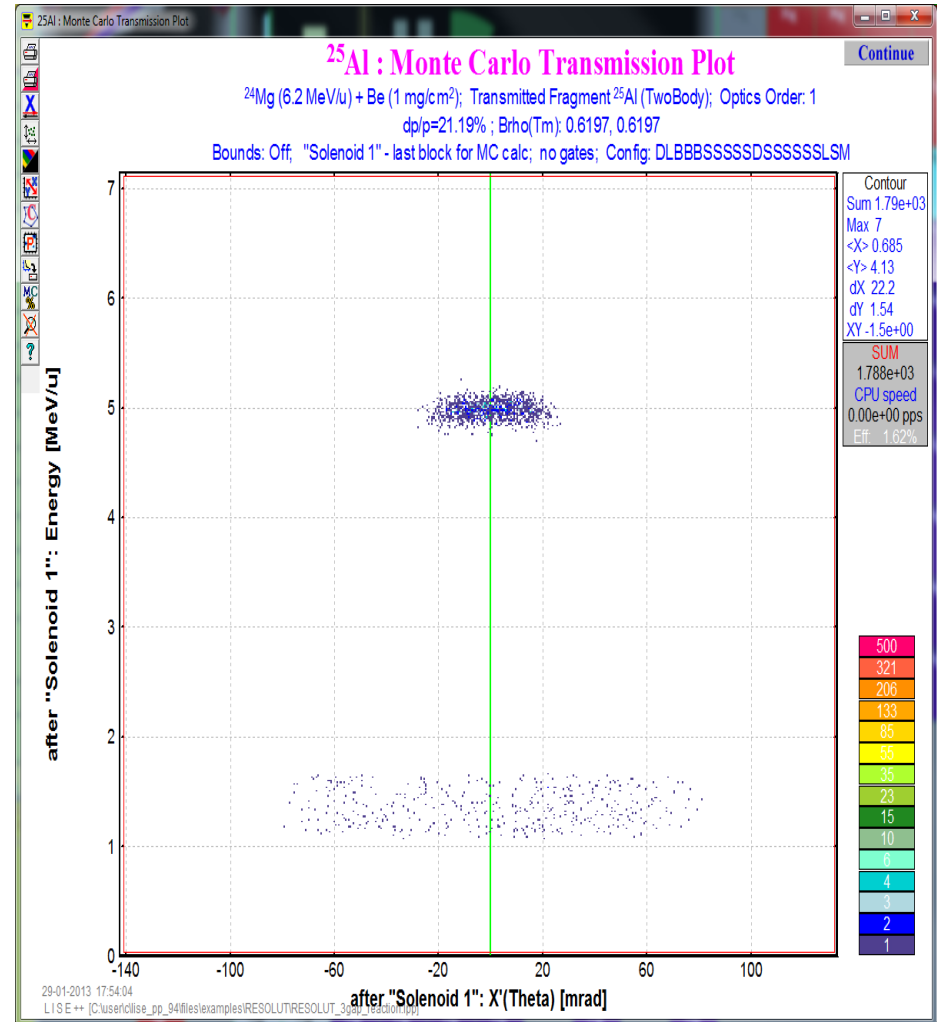
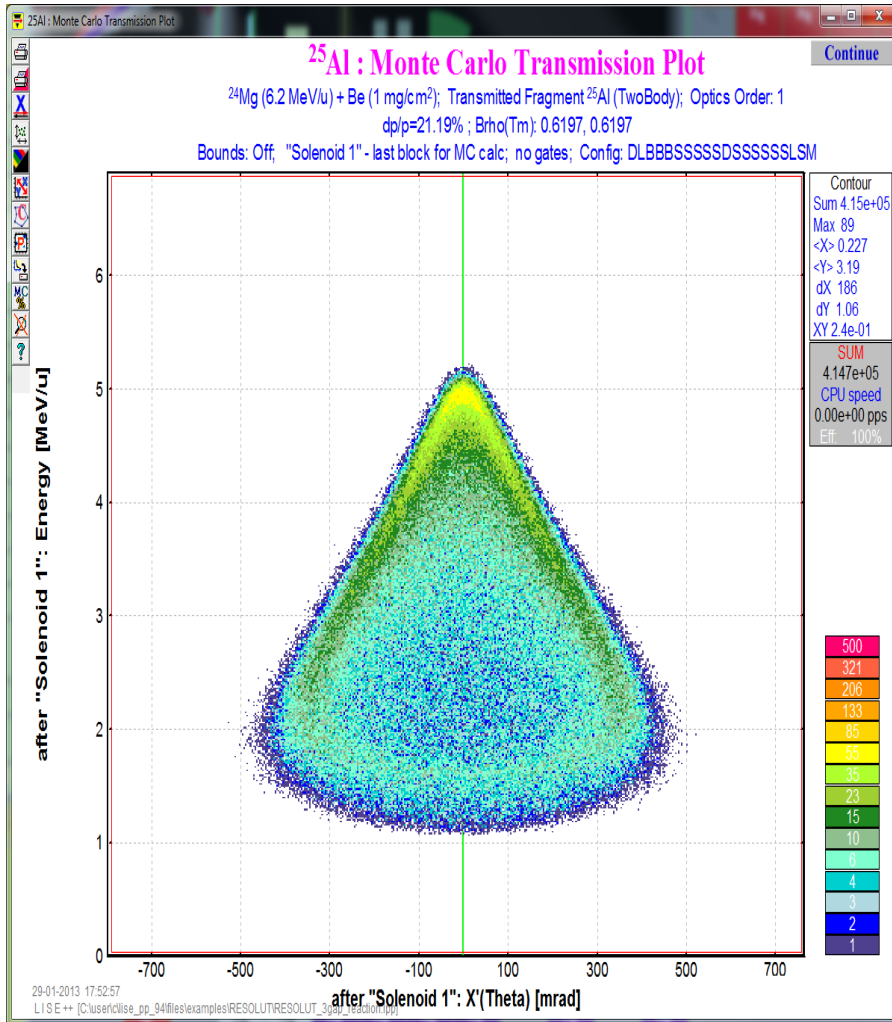
EPAX cross section have been used
for Two-body reactions

After target

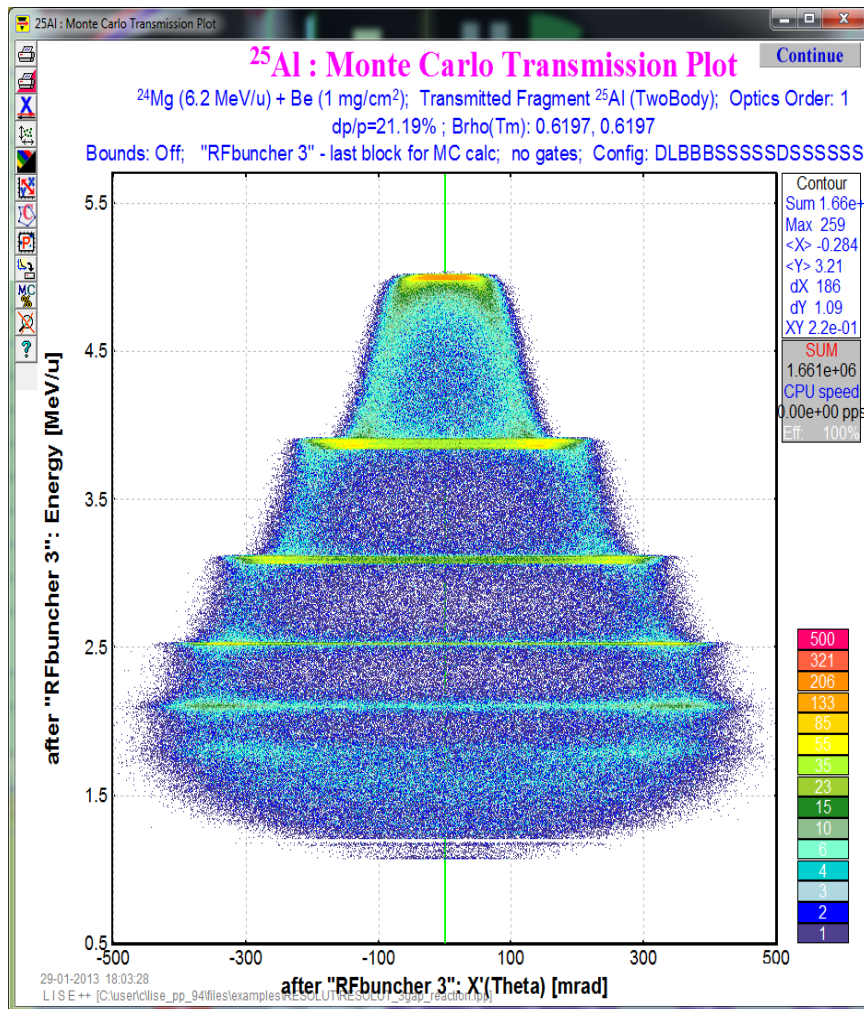


After the 1st solenoid **without** angular acceptance

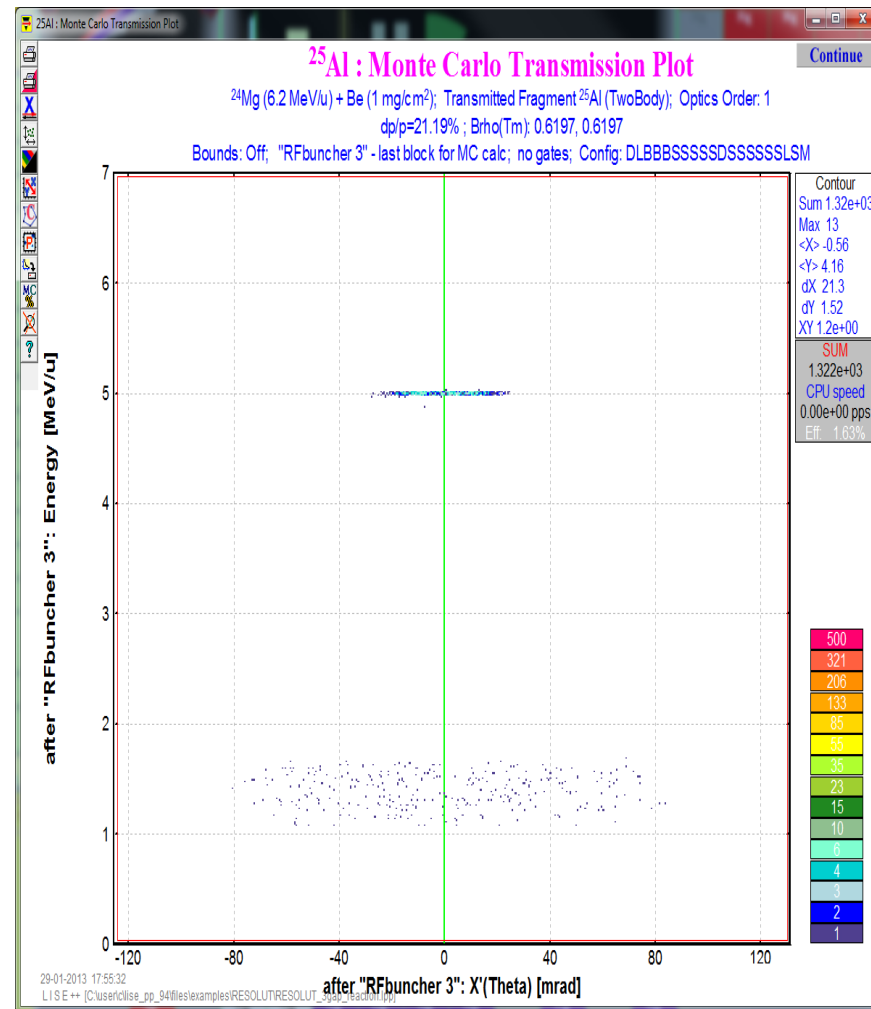
After the 1st solenoid **with** angular acceptance



After the 3 gap buncher **without** angular acceptance

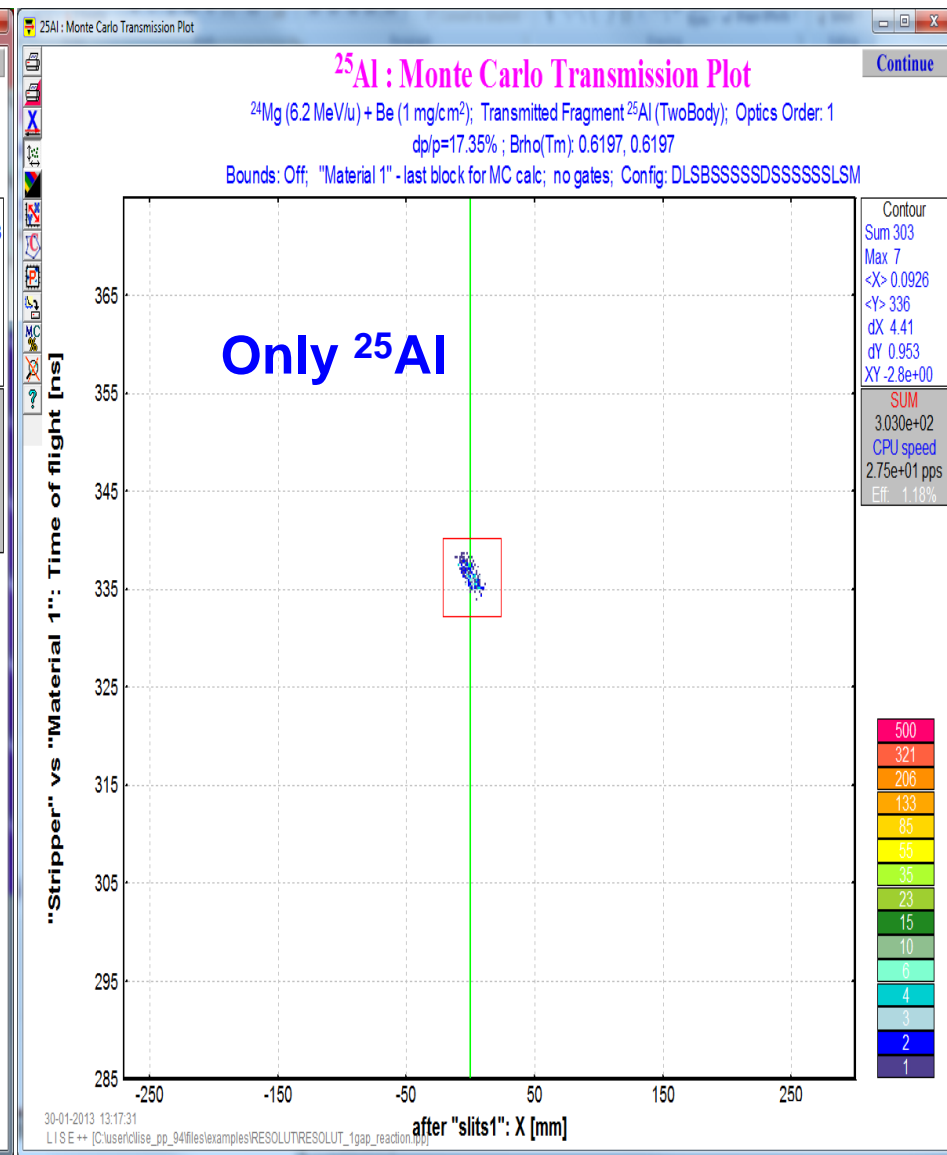
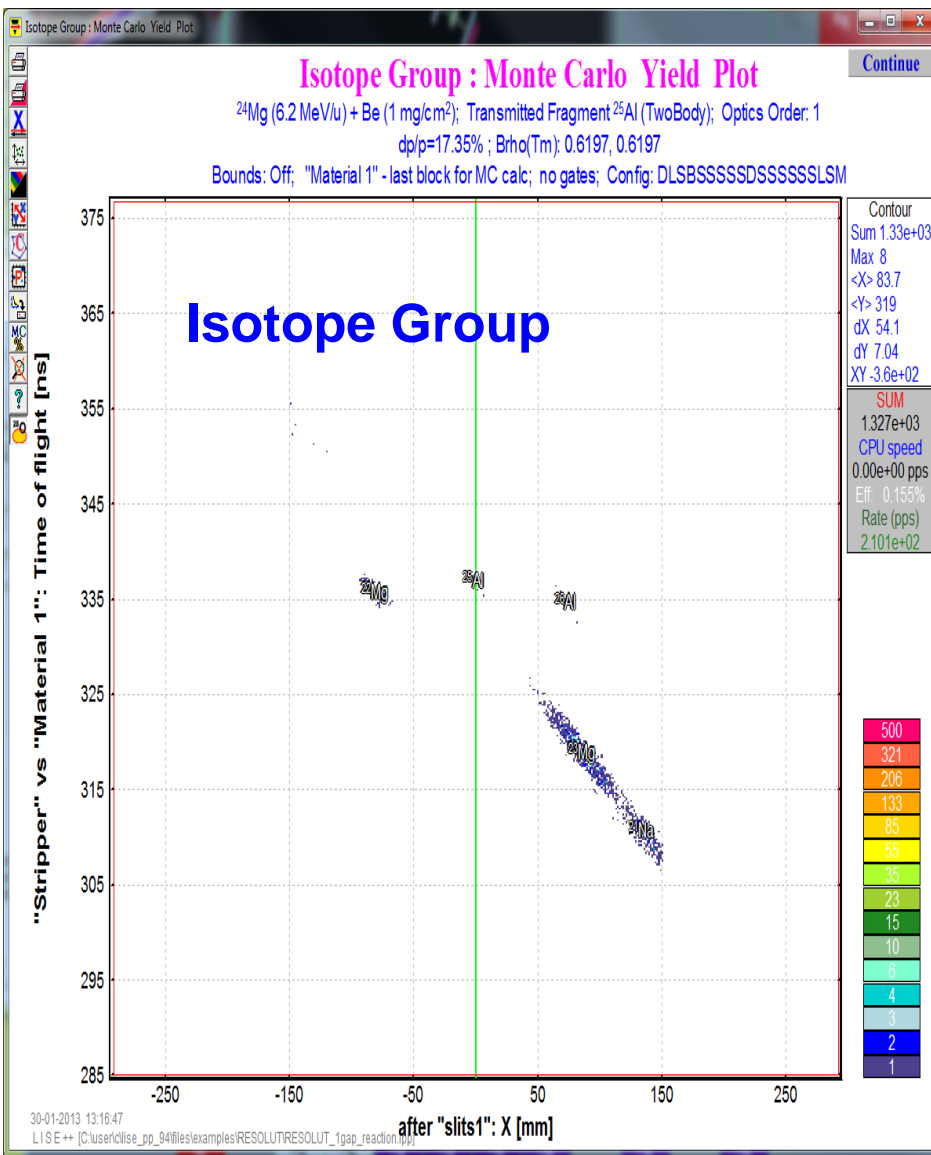


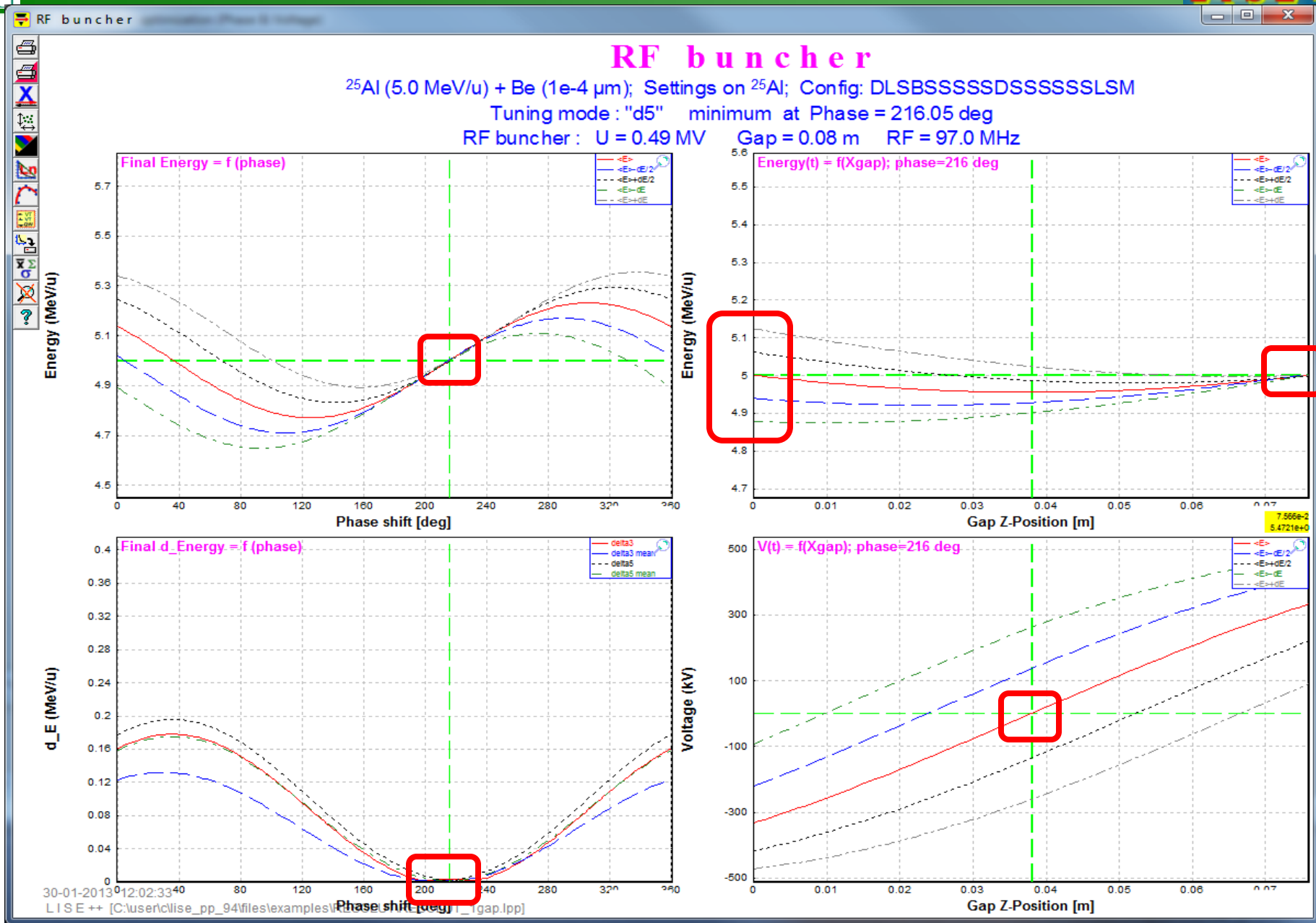
After the 3 gap buncher **with** angular acceptance

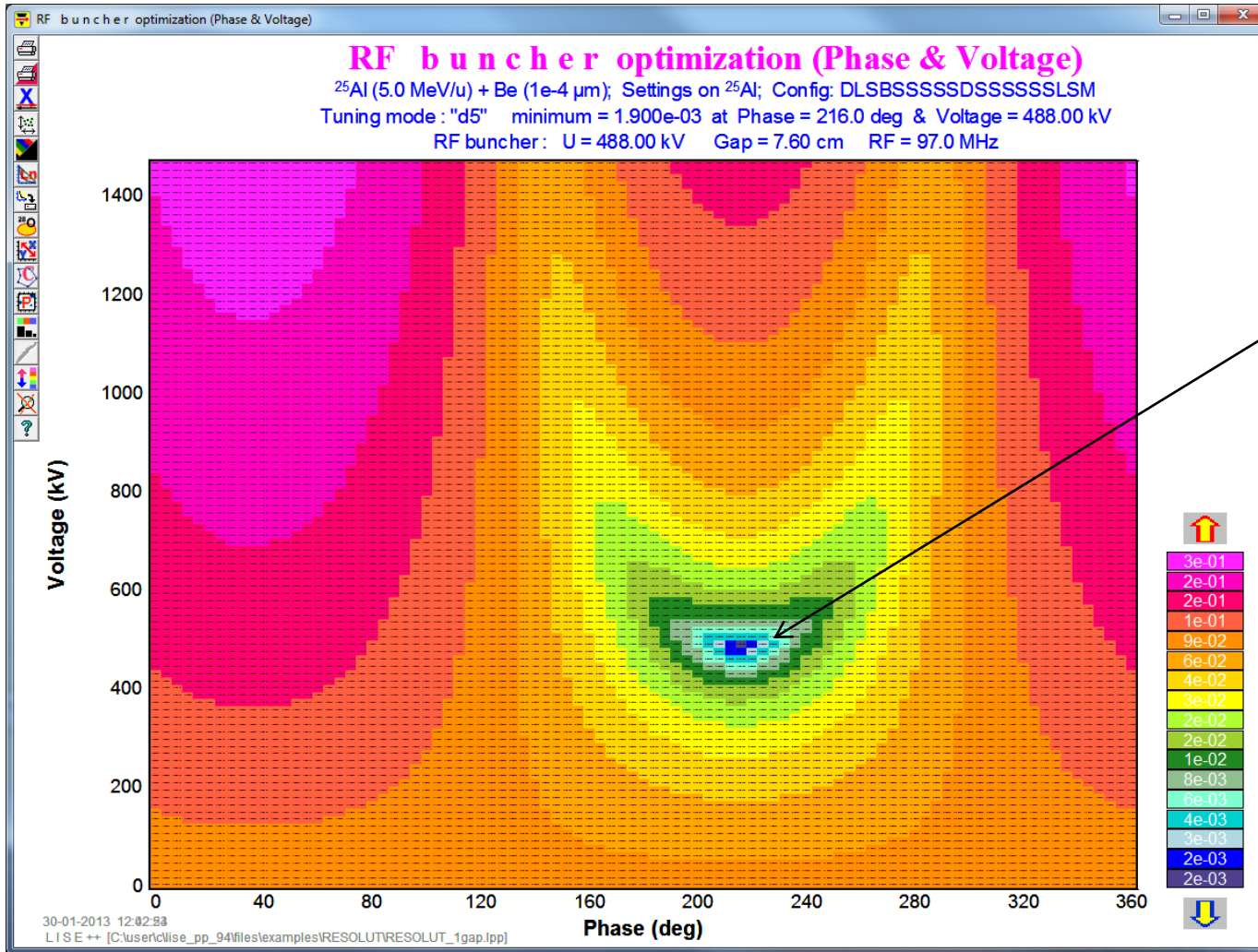


**+/- 47 mrad acceptance,
 Transmission 1.6%**

After the Slits1 with angular acceptance, Bounds OFF





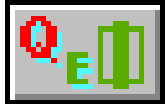


488 kV
216 degrees

488 kV in this mode
corresponds to
122 kV nominal value.

From FSU COSY file
V= 119.6 kV
(see page 7)

Optical blocks :
E-quad, E-bender



B01_D957

Kind of Drift (or Multipole) block

- BEAM-LINE block. Non-dispersive optical block. User can change the optical matrix values.
- STANDARD DRIFT block as in the Transport code. Use this mode for a long detector. The Optical matrix is determined by the code.
- QUADRUPOLE (magnetic). The matrix can be calculated as in the Transport code with using block parameters (radius, effective length, magnetic field)
- SEXTUPOLE (magnetic). The matrix can be calculated as in the Transport code with using block parameters (radius, effective length, magnetic field)
- Electrostatic QUADRUPOLE (electrostatic). The matrix can be calculated with using block parameters (r,V,g,L)**

Optical block properties and data

Length = 0.1 m
Brho = 0.3523 Tm

Buttons: Calculate Optical matrix, Settings, Cut (Slits) & Acceptances, Optical matrix, General setting of block

Show in the "Setup" window

- Block length
- Brho value

Do not forget to recalculate the Optical matrix if you changed the DRIFT MODE!

Buttons: OK, Cancel, Help

Electrostatic Quadrupole

Settings

L_eff (effective length) = 0.1 m
U (voltage) = -5.50491 kV
Radius (half-aperture) = 3 cm
Quad fixed Erho-value corresponding to the setting fragment: 0.12004 MJ/C
Fix current value

Information

Block length: 0.1 m
Current (Real) Erho-value for the setting fragment: 0.12004 MJ/C
Setting fragment: 100Ru1+

Do not forget to recalculate the Optical matrix if you changed cell contents in the Manual mode!

Buttons: Recalculate Voltage for the fragment current Erho, Calculate Optical matrix, Edit optical matrix, OK, Cancel

if Erho-value has been changed then

- no actions
- recalculate automatically U (voltage), keep the matrix [Recommended]
- recalculate automatically the matrix, keep U (voltage)

checkbox: calculate 2nd order matrix elements

Optical matrix - B01_D957

Block matrix

1. X	1.55431	0.01179	0	0	0	0	0
2. Y	1.201e+2	1.55431	0	0	0	0	0
3. Z	0	0	0.53228	0.00839	0	0	0
4. X'	0	0	-95.46067	0.53228	0	0	0
5. Y'	0	0	0	0	0	1	0
6. D	0	0	0	0	0	0	1

Global matrix

1.55431	0.07518	0	0	0	0	[cm]
1.201e+2	6.45228	0	0	0	0	[mrad]
0	0	0.53228	0.0301	0	0	[cm]
0	0	-95.46067	-2.95301	0	0	[mrad]
0	0	0	0	1	0	[cm]
0	0	0	0	0	1	[m]

Beam (sig)

3.0086
258.1916
1.2043
118.2317
0
0.01

Buttons: OK, Cancel, Help, Spectrometer matrix

Right now it is only 1-st order calculations

E-quad -- options : matrix keeping & automatic U recalculation, and U-keeping & automatic matrix recalculation



ElecDip 1

Electrostatic Dipole Settings

Separation plane
 Horizontal Vertical

E (electric field) 133.51 KV/m
 U (voltage) 13.351 KV
 Electric rigidity 0.40053 MJ/C
 Magnetic rigidity 0.09106 Tm
 (corresponds to the setting fragment)

Electrostatic Dipole Constants

Distance between plates (gap) = 0.1 m

Bend Sector

Radius (r0) = 3 m
 Angle = 45 deg
 Length = 2.3562 m

Optical block properties and data

Setting Charge state for the Block [Z-Q] 0

Calculate the Values using the Setting fragment from

Target
 D1

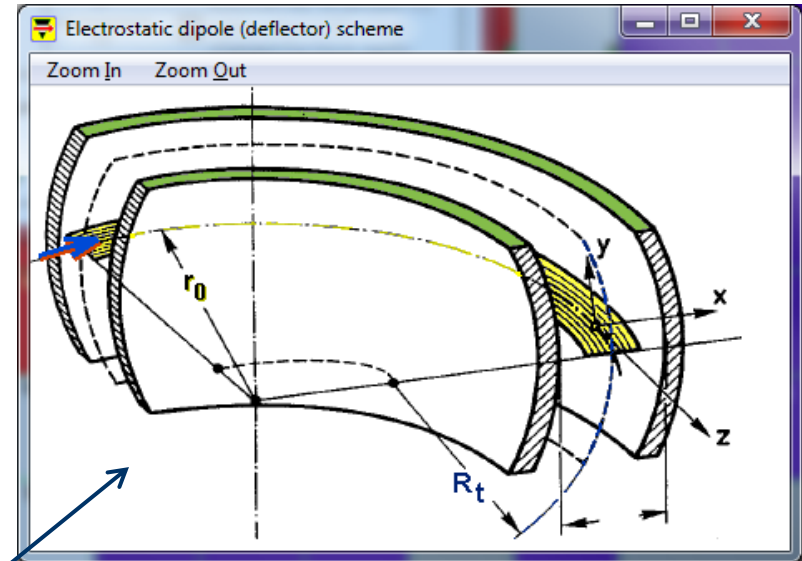
Advanced Elec.Dipole settings for extended configurations

Bend type: Rt (m)

Cylindrical INF
 Spherical 3
 Toroidal 10

Matrix calculations
Automatically recalculate the matrix, when LISE++ has changed the block rigidity.

Important: Selection [X/D] in this block by Electric rigidity, where $D = d(Erho)/(Erho)$

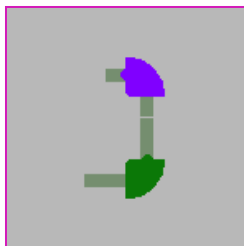


This checkbox is available after matrix calculations done

http://lise.nsci.msu.edu/9_6/Edipole/EB_case.lpp

M.Portillo's example, and COSY calculations

LISE++



Purpose

- Create an energy achromat system
 - Using double focusing
 - E-dipole
 - » Bend of 90deg at R=0.2 m spherical electrodes for equal x- and y-focus strength
 - » Drift before and after bend = R
 - B-dipole
 - » Bend of 90deg at R=0.2 m
 - » 26.56deg entranc & exit edge angles for equal x- and y-focus strength
 - » Drift before and after bend = 2R

COSY

Dimension: mm cm

Global matrix:

-1	0	0	0	0	0.8	[cm]
-50	-1	0	0	0	20	[mrad]
0	0	-1	0	0	0	[cm]
0	0	-50	-1	0	0	[mrad]
-2	-0.08	0	0	1	-0.45664	[cm]
0	0	0	0	0	1	[%]

/[cm] /[mrad] /[cm] /[mrad] /[cm] /[%]

Det = 1.00000

E bend focus

Lister - [c:\user\cosy\LISE_COSY_App\EB_focus1.TXT]

-1.0000E+01	-.55116E-07	.00000E+00	.00000E+00	.00000E+00	.80000E+00
-.50000E+02	-.10000E+01	.00000E+00	.00000E+00	.00000E+00	.20000E+02
.00000E+00	.00000E+00	-.10000E+01	.00000E+00	.00000E+00	.00000E+00
.00000E+00	.00000E+00	.00000E+02	-.10000E+01	.00000E+00	.00000E+00
-.20000E+01	-.80000E-01	.00000E+00	.00000E+00	.10000E+01	-.45664E+00
.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.10000E+01

MAP IN TRANSPORT UNITS, COSY FORMAT, PM

-.2945573E-08	-.7363969E-07	.0000000	.0000000	.1681321E-08	00000000
-.9999986	-.49.99997	.0000000	.0000000	-2.000000	10000000
-.5511577E-07	-.9999986	.0000000	.0000000	-.7999999E-01	01000000
.0000000	.0000000	-1.000000	-50.00000	.0000000	00100000
.0000000	.0000000	.0000000	-1.000000	.0000000	00010000
.0000000	.0000000	.0000000	.0000000	1.000000	00001000
.7999999	20.00000	.0000000	.0000000	-.4566366	00000100
-.39.99997	-.999.9994	.0000000	.0000000	22.83182	00000010
-40.00002	-1000.001	.0000000	.0000000	22.83184	00000001

Dimension: mm cm

Matrices: Block (local) Global

Global matrix:

1.00121	0.00002	0	0	0	-0.00066	[cm]
87.52197	1.00033	0	0	0	-35.0121	[mrad]
0	0	0.99885	-0.00002	0	0	[cm]
0	0	80.34935	0.99973	0	0	[mrad]
3.49967	0	0	0	1	-3.37062	[cm]
0	0	0	0	0	1	[%]

/[cm] /[mrad] /[cm] /[mrad] /[cm] /[%]

Det = 0.99998

E + B bend focus

Lister - [c:\user\cosy\LISE_COSY_App\EB_focus2.TXT]

.10000E+01	-.61419E-06	.00000E+00	.00000E+00	.00000E+00	-.24965E-04
.87501E+02	-.10000E+01	.00000E+00	.00000E+00	.00000E+00	-.35000E+02
.00000E+00	.00000E+00	.99996E+00	-.66931E-06	.00000E+00	.00000E+00
.00000E+00	.00000E+00	.80364E+02	.99999E+00	.00000E+00	.00000E+00
.35000E+01	-.34741E-06	.00000E+00	.00000E+00	.10000E+01	-.33708E+01
.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.10000E+01

MAP IN TRANSPORT UNITS, COSY FORMAT, PM

-.1061954E-12	-.1288709E-06	.0000000	.0000000	.1241115E-07	00000000
1.000045	87.50076	.0000000	.0000000	3.499983	10000000
-.6141881E-06	1.000009	.0000000	.0000000	-.3474118E-06	01000000
.0000000	.0000000	.9999564	80.36445	.0000000	00100000
.0000000	.0000000	-.6693090E-06	.9999898	.0000000	00010000
.0000000	.0000000	.0000000	.0000000	1.000000	00001000
-.2496493E-04	-.35.00045	.0000000	.0000000	-3.370789	00000100
40.00114	2500.019	.0000000	.0000000	162.8314	00000010
-.39.99865	1000.026	.0000000	.0000000	174.2475	00000001

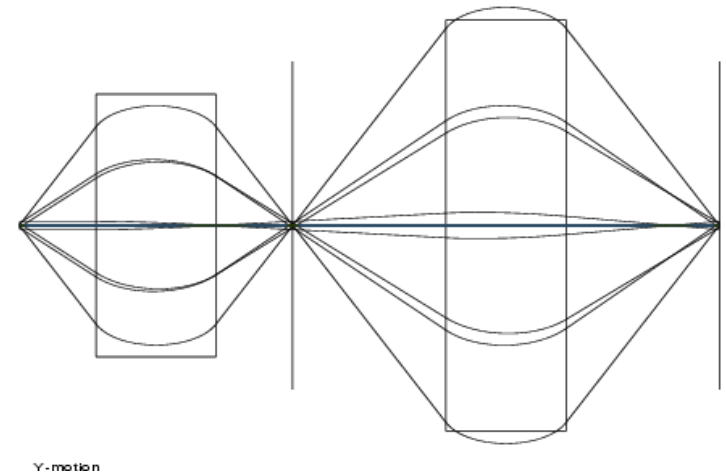
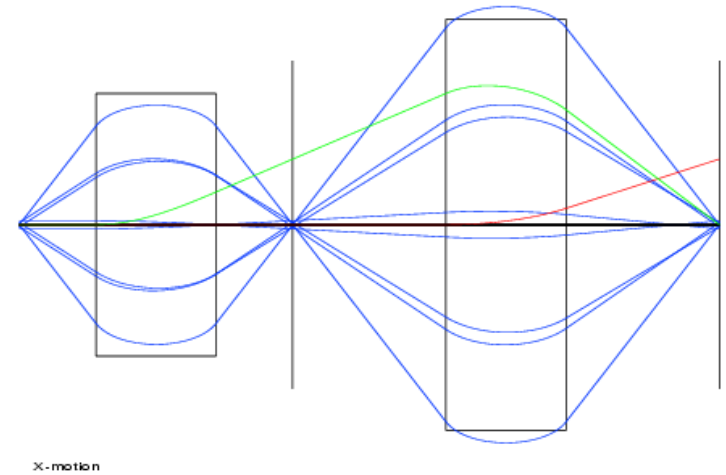
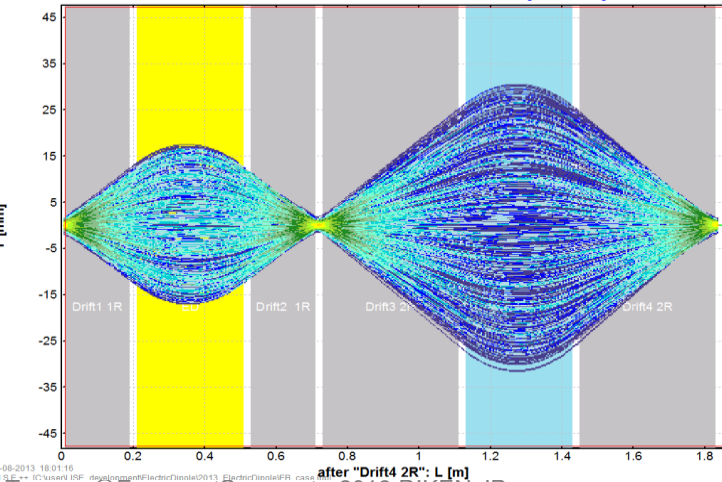
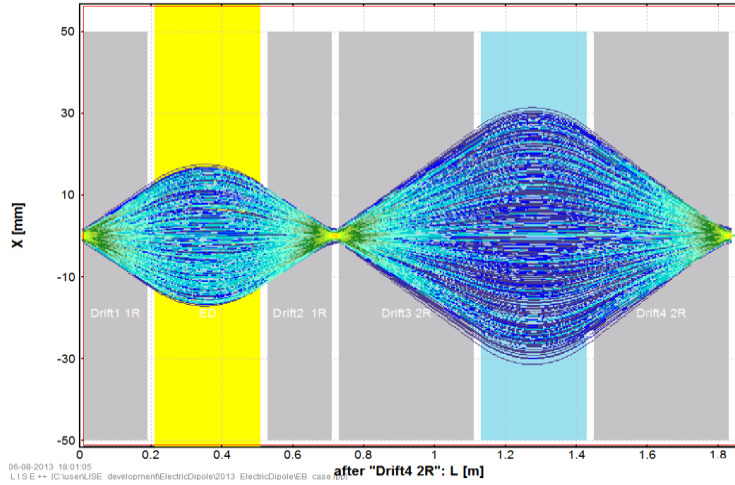
M.Portillo's example,
and COSY calculations

COSY

http://lise.nsl.msui.edu/9_6/Edipole/EB_case.lpp

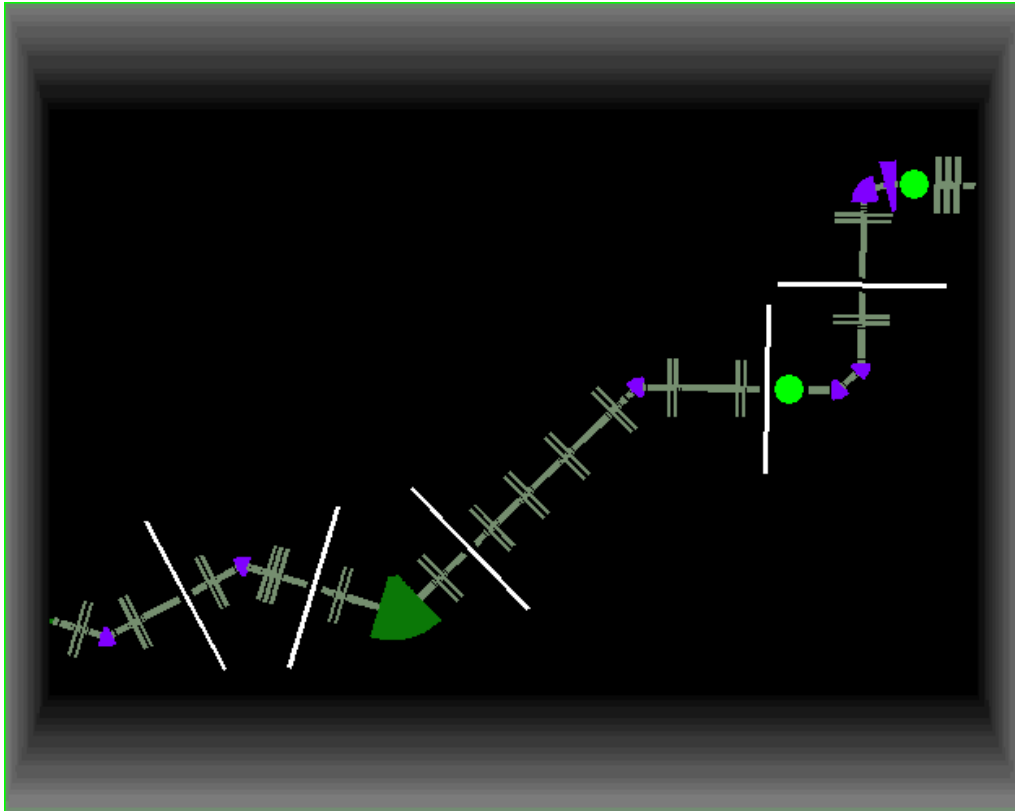
LISE++

Emittance		
	Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm 0.5	Gaussian
2. T	mrاد 60	Rectangle uniform
3. Y	mm 0.5	Gaussian
4. P	mrاد 60	Rectangle uniform
5. L	mm 0	Gaussian
6. D	% 0.01	Gaussian



LISE++ file:

http://lise.nsci.msu.edu/9_6/Edipole/D-line_BTS01-12%20with%20rotation.lpp

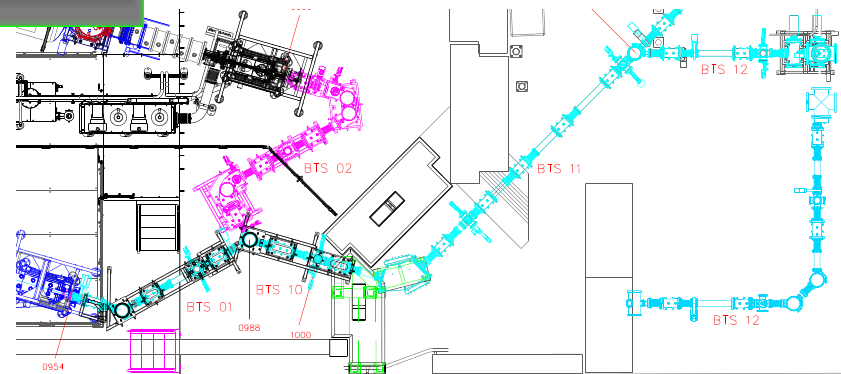


Almost 137 blocks,
where

M-dipole : 1

E-dipole : 7

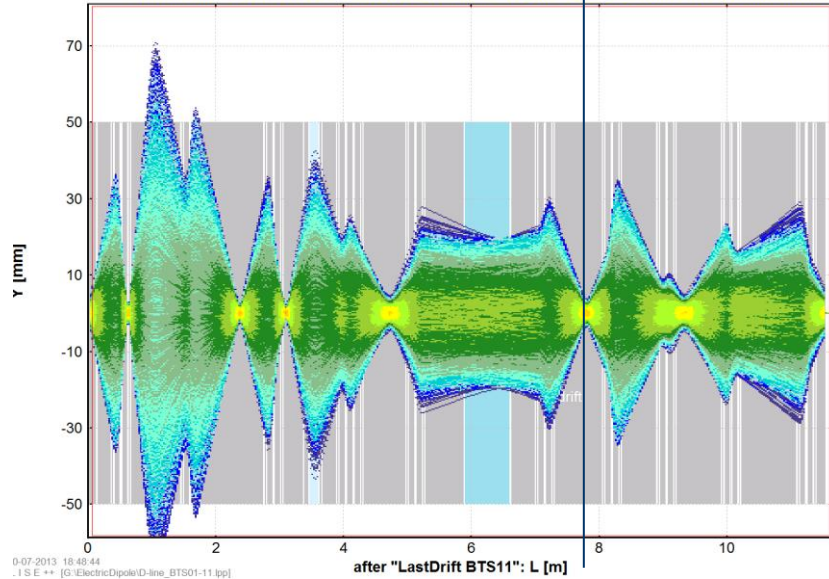
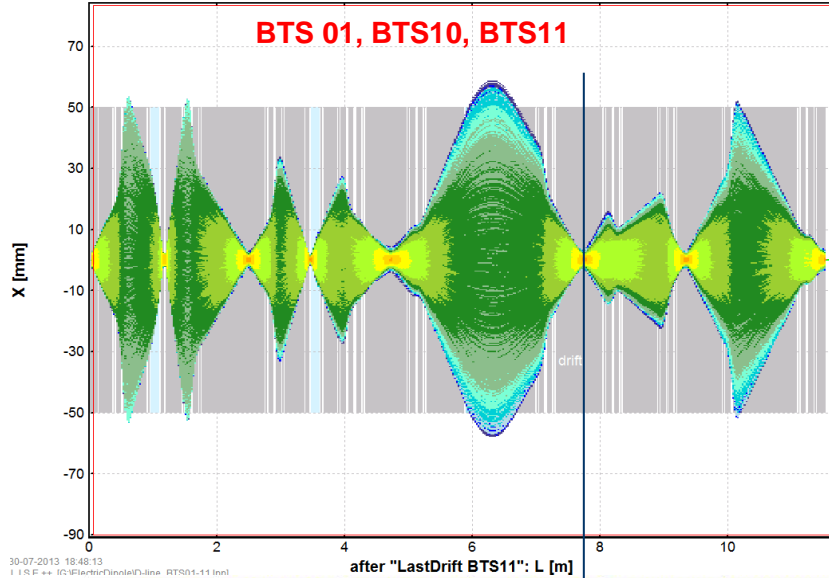
E-quad : 32



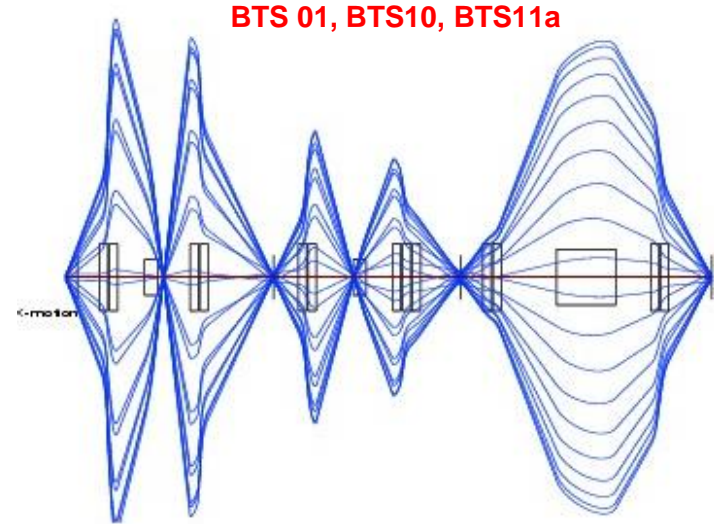
LISE++ file: http://lise.nsl.msu.edu/9_6/Edipole/D-line_BTS01-12%20with%20rotation.lpp

From "Report on recalculation of Low-E beam lines" by M.Portillo

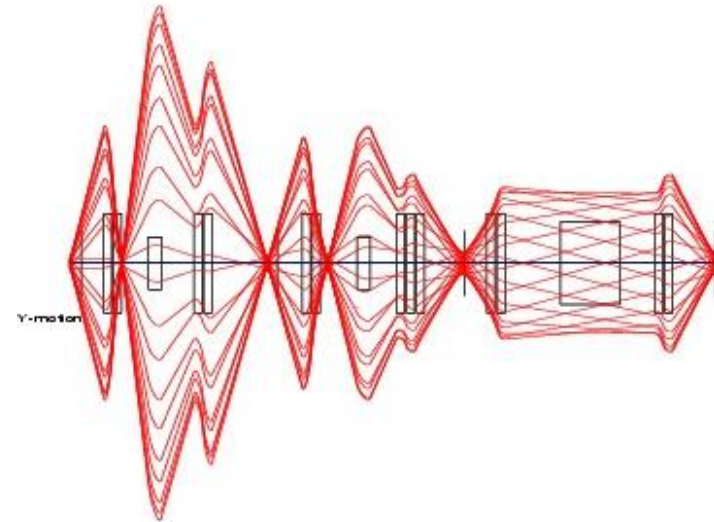
^{100}Ru (0.0 MeV/u) + ; Transmitted Fragment $^{100}\text{Ru}^{1+}$ (beam); Optics Order: 1
 $dp/p=0.76\%$; $B\rho(Tm)$: 0.3523, 0.3523
 Bounds: Off; "LastDrift BTS11" - last block for MC calc; no gates; Config: DSSSSSSSSSESSSSSSSSSS



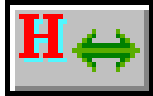
X



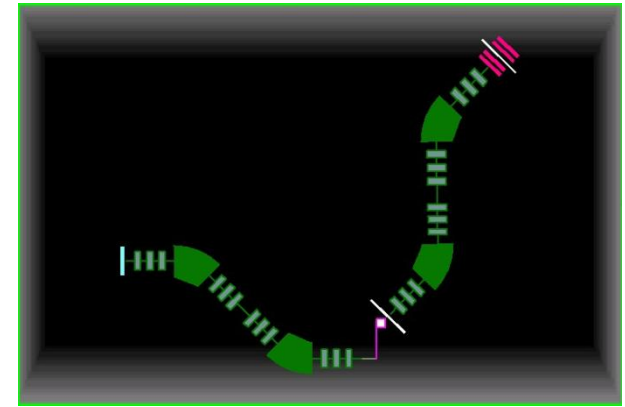
Y



Optical blocks : **Shift of optical axis**



Allows to simulate misalignment, projectile scattering and so on.



Spectrometer designing

Block	Given Name	Z-Q	Length,m	Enable
Target	Target			+
Stripper	Stripper			+
Dipole	D1	0	8.719	+
Drift	I1_slits	0		NO
Wedge	I1_wedge			NO
Dipole	D2	0	8.767	+
Material	I2_PPAC0			NO
Drift	I2_slits	0		NO
Wedge	I2_wedge			+
Material	I2_PPAC1			NO
Material	I2_SCI			NO
Dipole	D3	0	8.767	+
Drift	I3_slits	0		NO
Wedge	I3_wedge			NO
Dipole	D4	0	9.39	+
Material	FP_PPAC0			+
Material	FP_PPAC1			+
Drift	FP_slits	0		+
Material	XF_SCI			NO

Insert Mode: before / after

Move element: Up / Down

Edit / Delete

OK / Help

Total: Number of Blocks: 26, Length [m]: 35.643

Insert block:

- Target
- Stripper after Target
- Wedge
- Material(Detector)
- Faraday cup
- Dispersive (Dipole)
- Wien velocity filter
- Drift (multiple slits)
- Beam Rotation
- Shift of Optical Axis**
- Electrostatic dipole
- Gas filled separator
- Compensating Dipole
- RF separator
- RF buncher
- Solenoid
- Delay (efficiency) block

Selected block: Dispersive (Dipole)

Block Length [m]: 8.719

Block name = D1

Charge State (Z-Q) = 0

Shift

mm / cm

Optical matrix

General setting of block

Optical Axis Shifts:

dX 2000 mm

dT -800 mrad

dY 0 mm

dP 0 mrad

dT -45.84 degrees

dP 0 degrees

Ok / Help / Cancel

- Property : optical block
- Always Identity matrix
- Length block = 0

Shift d X = +2000.0 mm d T = -800.0 mrad

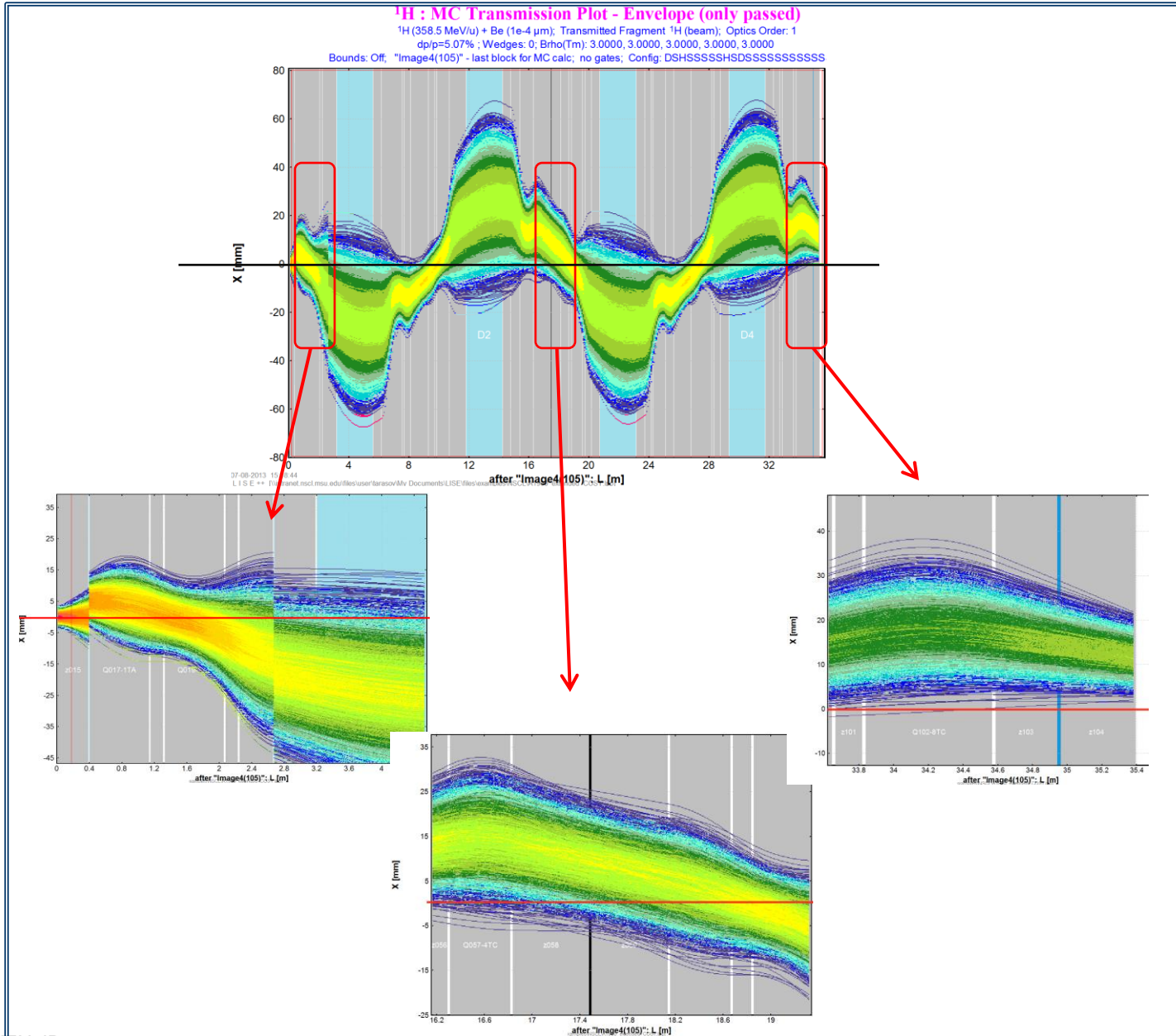
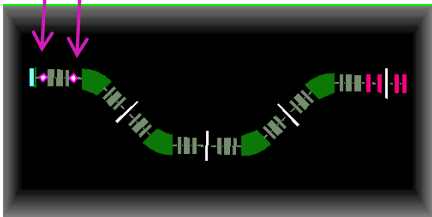
LISE++ file: http://lise.nsl.mscl.edu/9_6/Edipole/misalignemnt_A1900_extended_COSY.lpp

Example:

1st triplet 5 mm

All dipoles set to 3.0 Tm

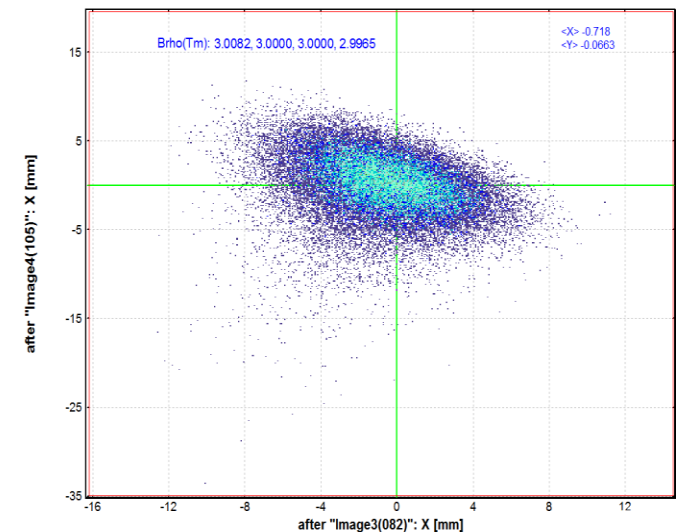
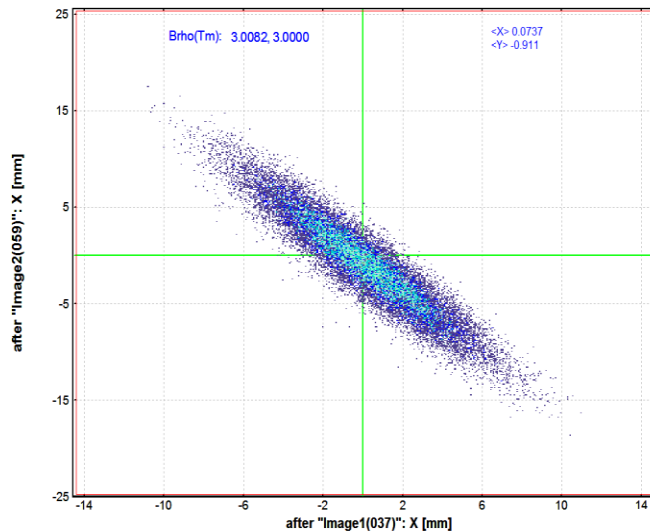
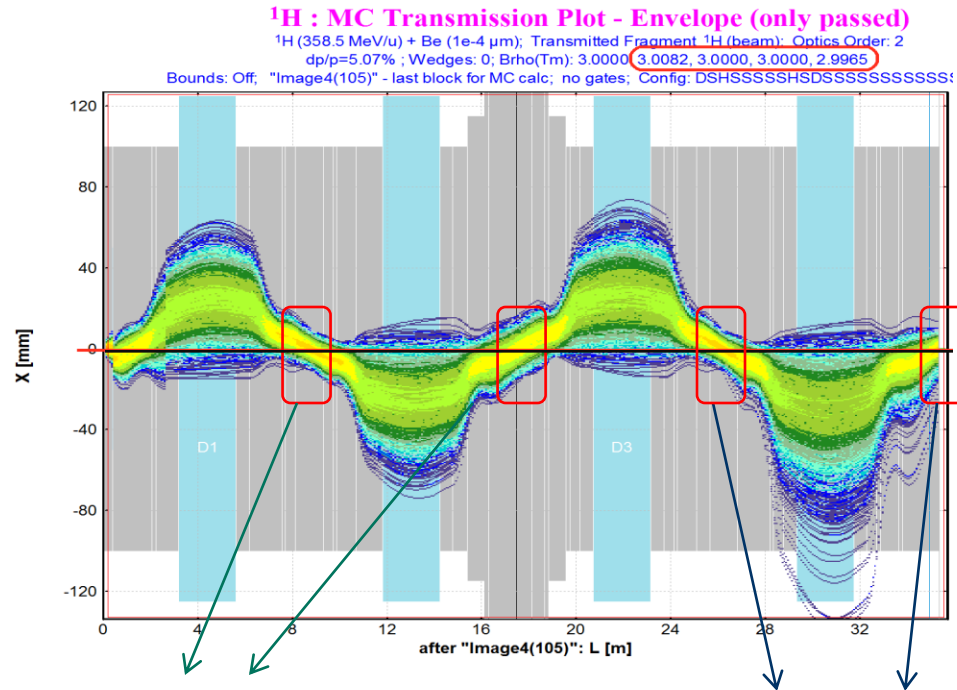
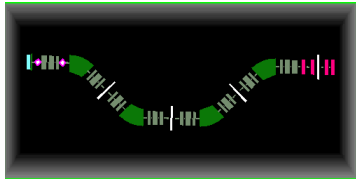
P	Projectile	¹ H ¹⁺	
		358.49 MeV/u	1 pA
F	Fragment	¹ H ¹⁺	=beam=
T	Target	Be	0.0001 π circ
Sr	Stripper		
D	tuning	Brho	3.0000 Tm
S	z015	standard	3 Tm
H	Shift 1	Δ X = +5.0 mm	
Q	Q017-1TA	quadrupole	3 Tm
S	z018	standard	3 Tm
Q	Q019-1TB	quadrupole	3 Tm
S	z020	standard	3 Tm
Q	Q021-1TC	quadrupole	3 Tm
H	Shift 2	Δ X = -5.0 mm	
S	z022	standard	3 Tm
D	D1	Brho	3.0082 Tm
S	z030	standard	56.4 cm
Q	Q031-2TA	quadrupole	43 cm



LISE++ file: http://lise.nsci.msu.edu/9_6/Edipole/misalignemnt_A1900_extended_COSY.lpp

Example:
1st triplet 5 mm

Playing with Dipoles
to be for Images
at the central axis



	Brho, Tm		
	Initial	Set	Set/Init
Beam	3	3	-
Dipole 1	3	3.0082	0.27%
Dipole 2	3	3	-
Dipole 3	3	3	-
Dipole 4	3	2.9965	-0.12%

Monte Carlo calculation of Transmission

MC dialog

MC option dialog

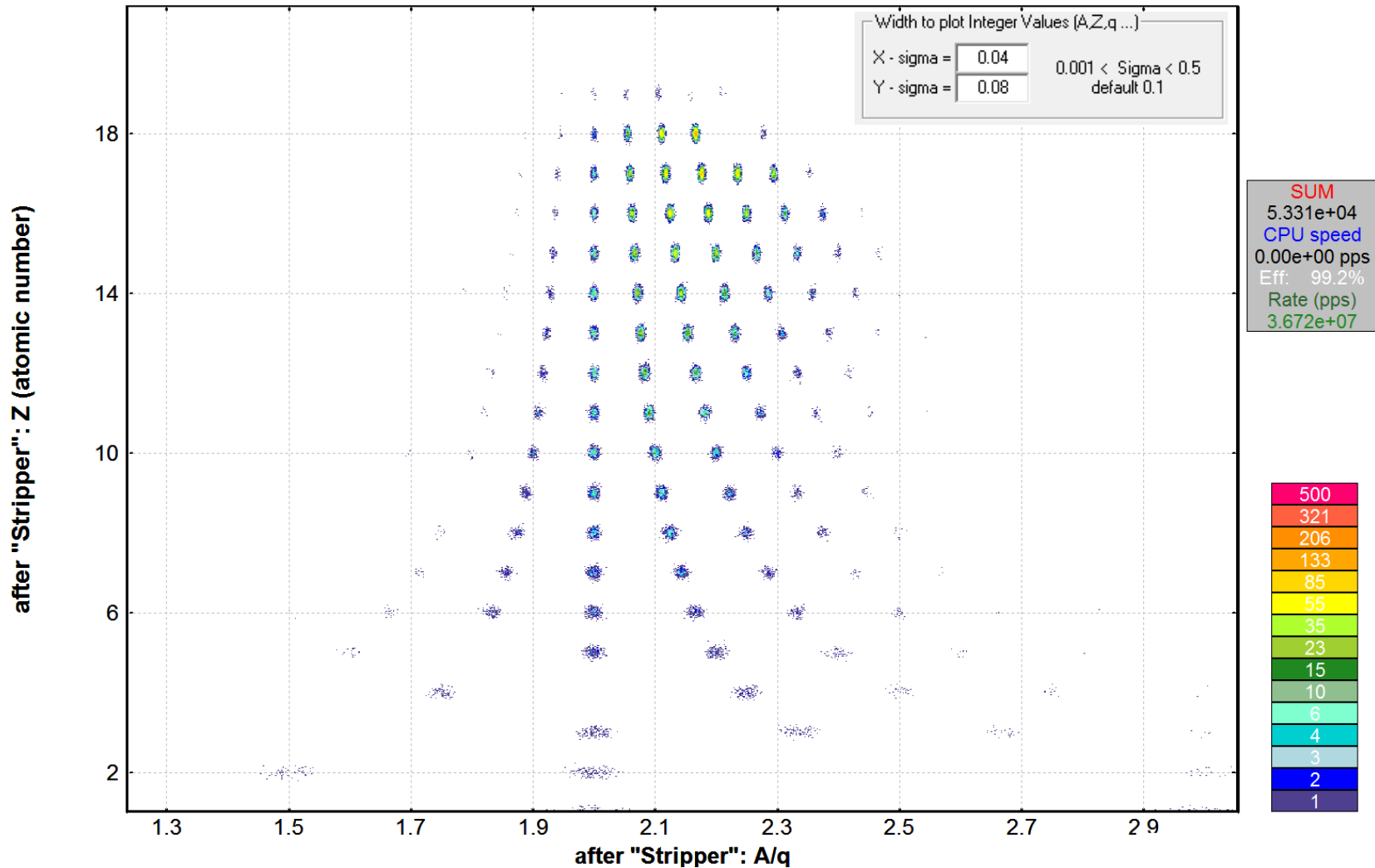
Example: After target without beam

Isotope Group : Monte Carlo Yield Plot

^{40}Ar (140.0 MeV/u) + Be (500 μm); Transmitted Fragment ^{32}S (Fragmentn); Optics Order: 1
dp/p=100.00%

Bounds: Off; "Stripper" - last block for MC calc; no gates; Config: A

Continue



$1 \leq \text{Number of locations} \leq 10$
 $1 \leq \text{Number of fields} \leq 10$

In previous version:
 Number of locations = 1

“last” block” (most downstream) is
 defined from gate locations, location
 for file, location for plot

new

Rays generator

Setting Fragment
 100Sn50+.50+ Projectile Fragmentation

Gate
 no gate

Only for plot

Fields to Plot
 X-axis: X [mm]
 Y-axis: dP/P [%]

after BLOCK: D1
 ("INTO" this Block for Range and Energy Loss)

Output Ray file
 MC_LISE.ray

Locations

Number of locations = 5
 1..10

N	Location
1	Stripper
2	I2_slits
3	D3
4	FP_slits
5	FP_PIN

Locations for file

Fields

Number of fields = 10
 1..10

N	Field
1	X [cm]
2	X'(Theta) [mrad]
3	Y [cm]
4	Y'(Phi) [mrad]
5	dP/P [%]
6	Momentum [GeV/c]
7	Length from Target [m]
8	Time from Target [ns]
9	Range (mm)
10	q [ion charge]

File format

Field separator = tab

Number of Rays = 100 1.. 1 000 000

Header (settings, field names)
 Make Default

Run Quit

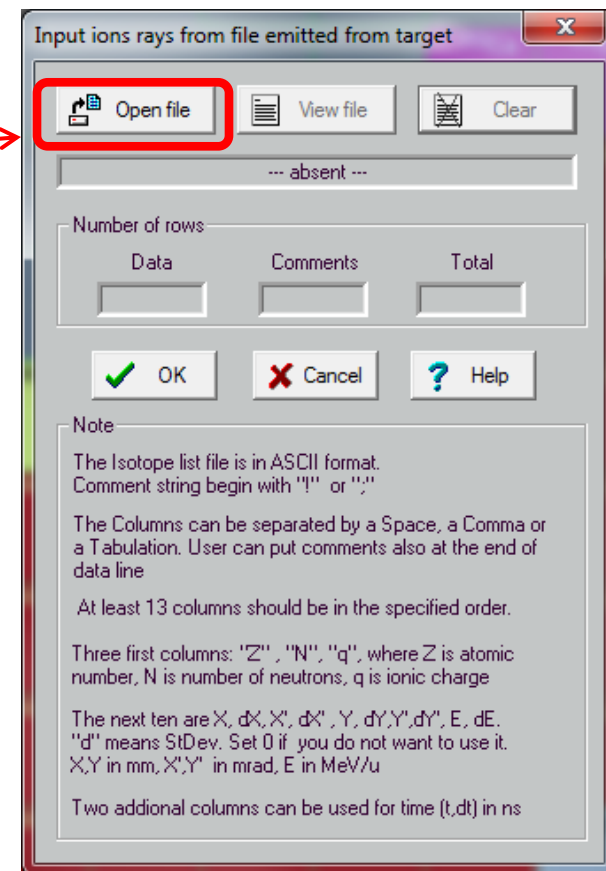
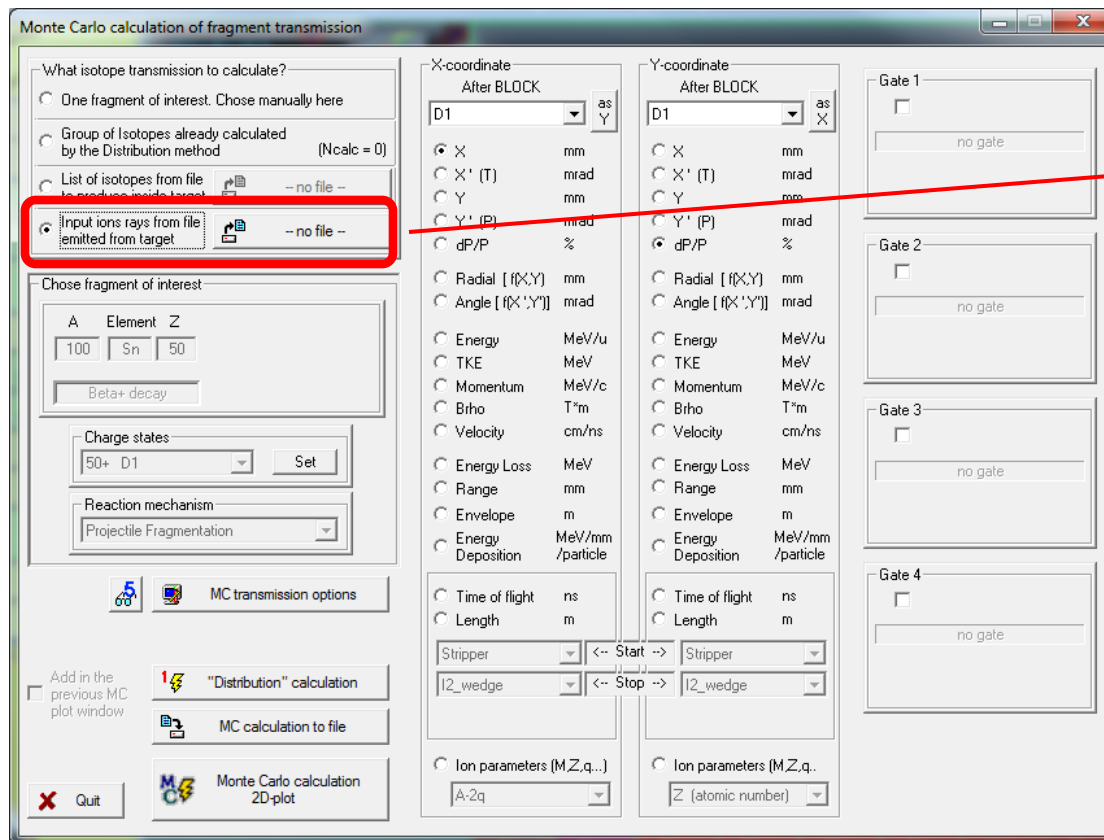
Field

- X [cm]
- X'(Theta) [mrad]
- Y [cm]
- Y'(Phi) [mrad]
- dP/P [%]
- Radial [cm]
- Angle [mrad]
- Energy [MeV/u]
- TKE [MeV]
- Momentum [GeV/c]
- Brho [T*m]
- Length from Target [m]
- Time from Target [ns]
- Energy Loss (MeV)
- Range (mm)
- Cross Section (mb)
- Mass (amu)
- A (mass number)
- Z (atomic number)
- q (ion charge)
- Z-q
- A/q
- A-2q
- A-3q
- 0 (empty)

Column name: "Location position (0,1,2..) – Field Name"

```
! Last block "FP_PIN", setting fragment: 100Sn50+..50+ (Projectile Fragmentation); N_Locations=5; N_fields=10; N_Rays=100
! location #01 : Stripper
! location #02 : I2_slits
! location #03 : D3
! location #04 : FP_slits
! location #05 : FP_PIN
```

I N	01-X [cm]	01-X'(Theta) [mrad]	01-Y [cm]	01-Y'(Phi) [mrad]	01-dP/P [%]	01-Momentum [GeV/c]	01-q (ion charge)	02-X [cm]	02-X'(Theta) [mrad]	02-Y [cm]	02-Y'(Phi) [mrad]	02-dP/P [%]	02-Momentum [GeV/c]	02-Length from Target [m]	02-Time from Target [ns]	02-Range (mm)	02-q (ion charge)	03-X [cm]	03-Y'(Theta) [mrad]
1	-0.1129	7.1959	-0.08535	15.994	0.55118	60.997	50	-3.4593	4.9788	-0.0412	15.21	0.55118	60.997	17.521	106.64	0	50	1.7004	-5.371
2	-0.1034	-11.708	-0.18591	-13.868	-0.4247	60.404	50	2.3029	-2.3776	-0.1548	-27.278	-0.4247	60.404	17.472	107.07	0	50	-1.1027	1.071
3	-0.0763	10.787	1.58E-05	2.1415	0.14412	60.75	50	-1.0236	5.5121	0.01037	3.0404	0.14412	60.75	17.521	106.94	0	50	0.51187	-5.770
4	-0.2455	16.445	-0.07911	16.538	0.01029	60.668	50	-0.5326	11.026	0.04611	20.454	0.01029	60.668	17.553	107.24	0	50	0.12823	-12.49
5	0.03839	-8.1885	0.11778	6.0167	0.36481	60.883	50	-2.0458	-3.5871	0.08634	13.784	0.36481	60.883	17.468	106.46	0	50	0.90589	3.372
6	-0.1524	4.346	-0.13551	0.96609	-0.6603	60.262	50	3.5747	3.2643	-0.1306	-7.3991	-0.6603	60.262	17.504	107.45	0	50	-1.6265	-3.407
7	-0.0803	16.51	-0.21527	5.5061	0.67223	61.07	50	-4.1487	7.9158	-0.1736	-7.1395	0.67223	61.07	17.539	106.66	0	50	1.9576	-8.359
8	0.10658	30.736	0.024456	-4.2877	-0.0938	60.605	50	0.79488	12.473	-0.0018	-4.8769	-0.0938	60.605	17.561	107.36	0	50	-0.8	-13.22
9	-0.0447	-16.965	0.08971	-4.7103	-0.3342	60.459	50	1.8671	-6.5517	0.07398	-0.1478	-0.3342	60.459	17.447	106.85	0	50	-0.9158	6.707
10	0.03292	-2.2843	0.19896	-20.981	-0.5731	60.314	50	3.557	-0.4255	0.16668	-13.721	-0.5731	60.314	17.484	107.25	0	50	-1.8213	0.4869
11	-0.0066	1.9967	-0.1925	6.2534	0.49975	60.965	50	-2.9596	0.78228	-0.1613	-4.9283	0.49975	60.965	17.495	106.52	0	50	1.4361	-0.8354
12	-0.0745	16.087	0.010426	2.5637	-0.8187	60.165	50	4.7286	7.3007	0.03743	4.8563	-0.8187	60.165	17.528	107.72	0	50	-2.3646	-7.379
13	0.01758	11.048	0.11291	2.412	-0.5771	60.312	50	3.4812	4.4142	0.1192	10.614	-0.5771	60.312	17.511	107.43	0	50	-1.7954	-4.7
14	-0.0596	-2.5842	-0.01268	-9.1291	-0.092	60.606	50	0.4208	-0.0777	-0.0308	-12.41	-0.092	60.606	17.486	106.91	0	50	-0.1648	-0.1801
15	-0.0878	-3.9601	-0.00054	-10.435	-0.1519	60.57	50	0.71231	-0.2775	-0.0265	-13.431	-0.1519	60.57	17.485	106.94	0	50	-0.2788	-0.0082
16	0.03588	-7.0353	-0.13446	-4.0601	-0.1641	60.563	50	1.0604	-3.0864	-0.1162	-12.988	-0.1641	60.563	17.468	106.85	0	50	-0.5912	2.820
17	0.07869	8.0604	-0.10436	3.5092	-0.0457	60.634	50	0.45453	2.6144	-0.0839	-2.0557	-0.0457	60.634	17.502	106.97	0	50	-0.3286	-2.732



Data line structure

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	!	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	!	Z	N	q	X	d(X)	X'	d(X')	Y	d(Y)	Y'	d(Y')	E	d(E)	t	d(t)
3	!				mm	mm	mrاد	mrاد	mm	mm	mrاد	mrاد	MeV/u	MeV/u	ns	ns
4	18	20	18	-0.549	1	-0.409	4	-1.521	0.8	-4.046	5	95.20	1	-0.891	2	
5	18	23	18	-0.509	1	6.557	4	0.120	0.8	7.029	5	102.66	1	-0.463	2	
6	16	19	16	-1.603	1	-1.041	4	-1.435	0.8	8.051	5	97.17	1	0.869	2	
7	15	19	15	-2.177	1	4.244	4	1.317	0.8	-0.575	5	104.09	1	0.683	2	
8	15	19	15	0.209	1	-2.225	4	1.561	0.8	1.710	5	98.53	1	0.004	2	
9	14	15	14	2.412	1	-4.756	4	-1.051	0.8	0.530	5	102.42	1	-0.095	2	
10	14	17	14	2.288	1	0.295	4	0.992	0.8	4.415	5	95.77	1	-0.173	2	
11	14	15	14	1.495	1	1.112	4	0.580	0.8	-0.943	5	102.13	1	0.455	2	
12	17	20	17	1.533	1	4.954	4	0.863	0.8	6.794	5	98.28	1	-0.404	2	
13	16	17	16	2.462	1	-5.620	4	1.109	0.8	-1.494	5	104.95	1	0.424	2	
14	13	15	13	1.185	1	-4.911	4	1.873	0.8	-1.027	5	99.03	1	-0.504	2	
15	18	22	18	1.373	1	7.311	4	0.105	0.8	-9.834	5	98.95	1	0.191	2	
16	16	19	16	0.710	1	5.501	4	-0.534	0.8	-6.920	5	98.37	1	-0.057	2	
17	15	19	15	1.785	1	5.563	4	1.699	0.8	8.535	5	104.78	1	-0.263	2	
18	18	20	18	0.117	1	-2.653	4	0.445	0.8	9.797	5	98.79	1	0.593	2	
19	17	19	17	0.203	1	1.481	4	0.955	0.8	-9.887	5	95.41	1	-0.557	2	
20	17	18	17	-1.885	1	-7.375	4	-0.024	0.8	-7.897	5	99.34	1	0.995	2	
21	15	16	15	-0.357	1	-0.539	4	0.392	0.8	-6.350	5	98.54	1	0.800	2	
22	18	22	18	-1.197	1	7.231	4	-1.778	0.8	-2.706	5	99.27	1	-0.911	2	
23	16	20	16	-2.477	1	1.283	4	-0.446	0.8	-5.652	5	96.69	1	-0.120	2	
24	16	19	16	0.857	1	5.091	4	0.604	0.8	5.536	5	104.44	1	-0.002	2	
25	15	17	15	0.849	1	2.037	4	-1.268	0.8	-8.649	5	98.56	1	0.614	2	
26	17	22	17	2.320	1	2.574	4	1.015	0.8	-2.753	5	95.23	1	0.680	2	
27	14	15	14	0.974	1	-6.327	4	-1.404	0.8	9.402	5	99.26	1	-0.119	2	
28	18	20	18	-0.816	1	4.964	4	-0.116	0.8	5.200	5	97.26	1	0.200	2	
29	16	17	16	-0.543	1	-6.363	4	1.384	0.8	-0.102	5	101.26	1	0.429	2	
30	14	15	14	-1.535	1	-1.722	4	0.291	0.8	-0.900	5	97.06	1	0.120	2	
31	15	19	15	-2.164	1	4.317	4	1.030	0.8	5.206	5	102.23	1	-0.493	2	
32	16	19	16	0.135	1	5.462	4	1.926	0.8	9.343	5	100.70	1	-0.119	2	
33	18	22	18	-1.250	1	6.402	4	1.069	0.8	-3.461	5	98.95	1	0.736	2	
34	14	18	14	-1.402	1	2.364	4	1.405	0.8	-7.775	5	97.24	1	0.716	2	
35	16	17	16	-0.948	1	-7.159	4	0.966	0.8	1.677	5	97.07	1	-0.595	2	
36	15	17	15	-1.916	1	-1.048	4	-1.879	0.8	1.071	5	103.65	1	-0.446	2	

The Isotope list file is in ASCII format.
Comment string begin with "!" or ";

The Columns can be separated by a Space, a Comma or a Tabulation. User can put comments also at the end of data line

At least 13 columns should be in the specified order.

Three first columns: "Z", "N", "q", where Z is atomic number, N is number of neutrons, q is ionic charge

The next ten are X, dX, X', dX', Y, dY, Y', dY', E, dE.
"d" means StDev. Set 0 if you do not want to use it.
X,Y in mm, X',Y' in mrad, E in MeV/u

Two additional columns can be used for time (t,dt) in ns

Example of Input ion rays file is located in LISE++ package:

`\Files\examples\ Input MC rays.inrays`

This Excel example with random generator values is located at

Options:

MC transmission options

High Order Optics Calculations

Use in calculations : through 3rd order Highest Order in this configuration

only 1-st order through 4th order

through 2nd order through 5th order

for the Isotope group case only

X-sections independent calculations (all cross sections equal)

Straggling in material

Angular

Energy

Lateral ***

Detector resolution

Use energy and time resolution of detectors for TOF, Energy loss, and TKE values

Use spatial resolution of detectors for X and Y values

^ No resolution will be taken into account if the selected block is optical or wedge

^ Only energy resolution of first detector after the selected block will be taken into account for TKE value

Bounds

Use physical limits (aperture) inside blocks to calculate fragment transmission

For block apertures LISE++ uses the slit limits accessible from the Block Cut & Acceptance dialog. (Pay attention there for the checkbox)

Take into account thickness defect of materials

Take into account losses due to reactions in materials

Include charge state calculations in the total transmission ***

*** time consumed options

only for ENVELOPE mode

Show trajectories of all fragments (including unselected by fragment-separator)

Assume the reaction takes place at the middle of target

for Angular distributions * these two distributions are correlated for fusion and fission reactions

for Momentum distributions

Width to plot Integer Values (A,Z,q ...)

X - sigma = 0.001 < Sigma < 0.5 default 0.1

Y - sigma =

Options for the "Input file of ion rays" mode

Recycle input reading file

Use standard deviations from the file

OK Cancel Help Make default

If this option is set, then after MC reaches the end of file, MC starts to read file from beginning

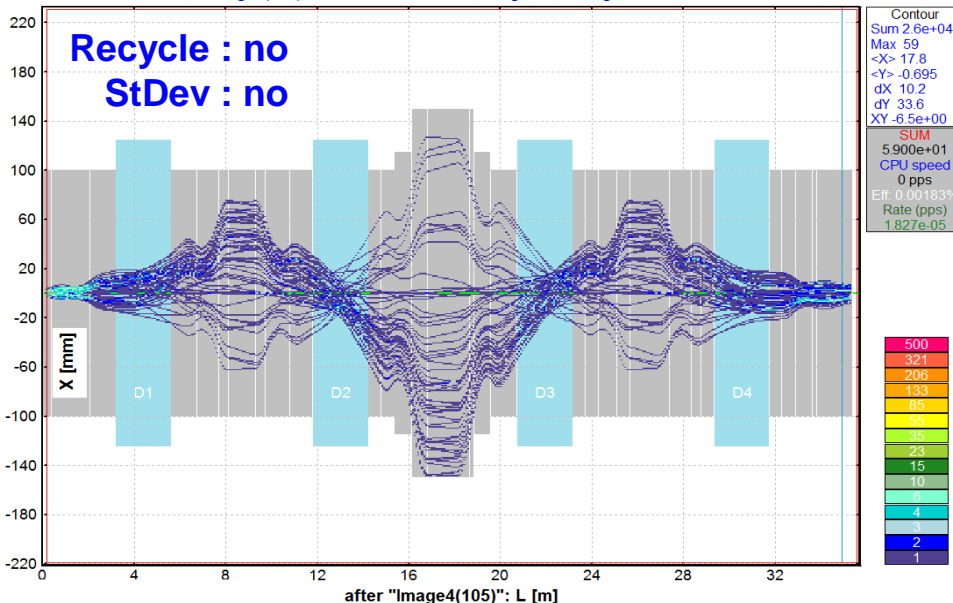
If this option is set, MC uses St.Dev. values from file to randomize output values.

If this option is not set, then it is equivalent to all of St.Dev values are zero

Ions rays after target : MC Yield Plot - Envelope (only passed) Continue

Input rays file: "Input MC rays"; Number of rays: 433; Optics Order: 1
 dp/p=5.07% ; Wedges: 0; Brho(Tm): 3.0000, 3.0000, 3.0000, 3.0000, 3.0000

Bounds: Off, "Image4(105)" - last block for MC calc; no gates; Config: DSSSSSSSDSSSSSSSSSSSSSSSDS...

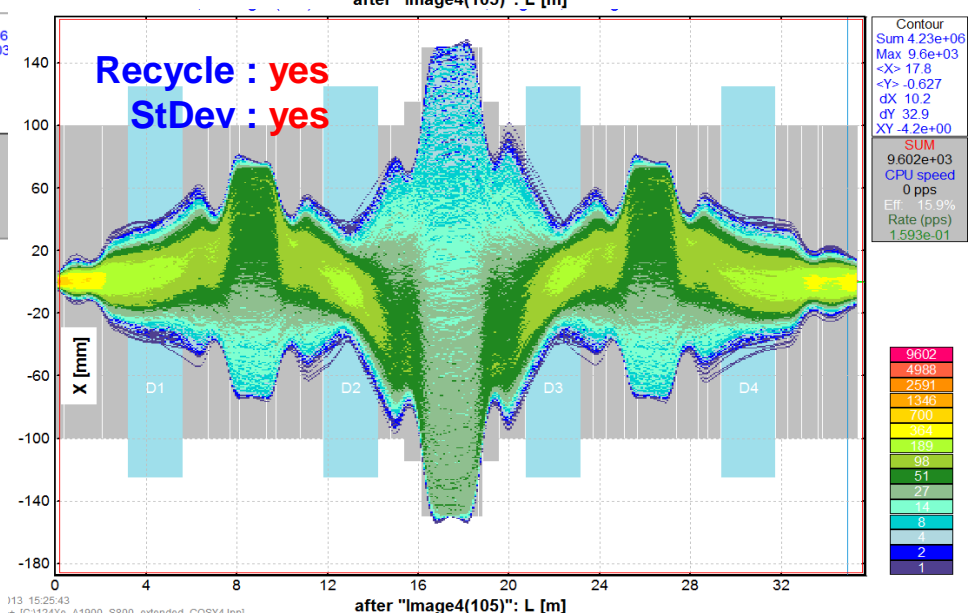
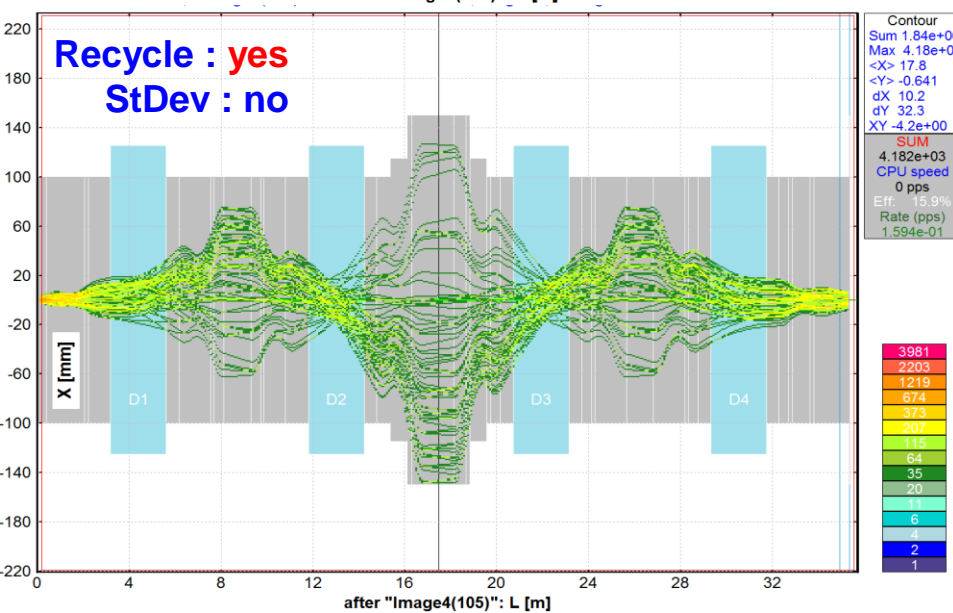
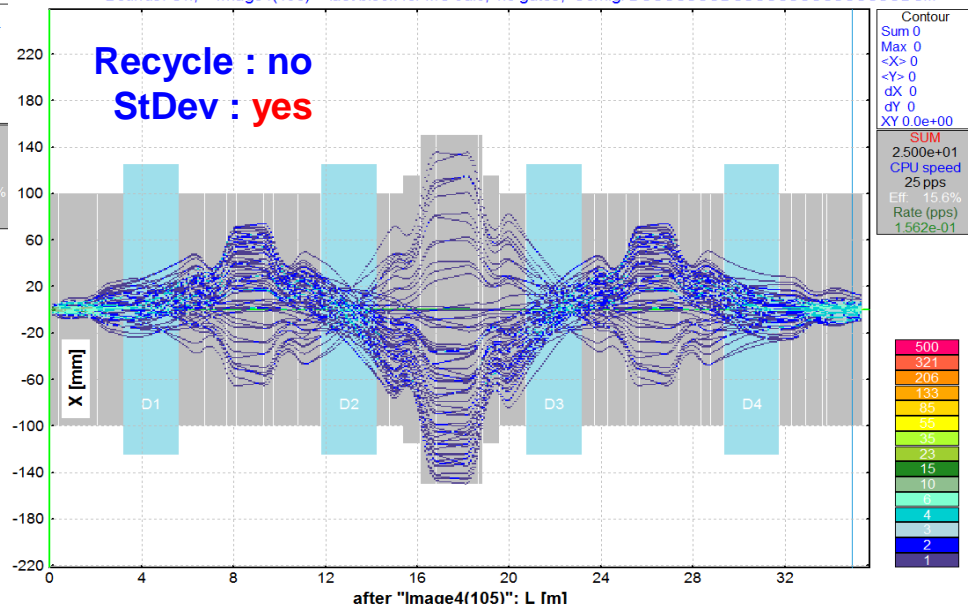


Ions rays after target : MC Yield Plot - Envelope (only passed) STOP

Input rays file: "Input MC rays"; Number of rays: 433; Optics Order: 1

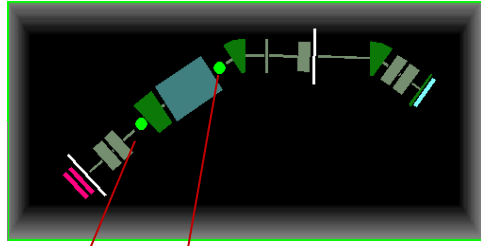
dp/p=5.07% ; Wedges: 0; Brho(Tm): 3.0000, 3.0000, 3.0000, 3.0000, 3.0000

Bounds: Off, "Image4(105)" - last block for MC calc; no gates; Config: DSSSSSSSDSSSSSSSSSSSSSSSDS...



Plotting configurations with Rotation blocks

Plotting Envelopes with rotation blocks : Monte Carlo method



Previous versions and

X-Y orientation

- "Absolute" --> Laboratory frame
- "Local" --> Follow Rotation blocks

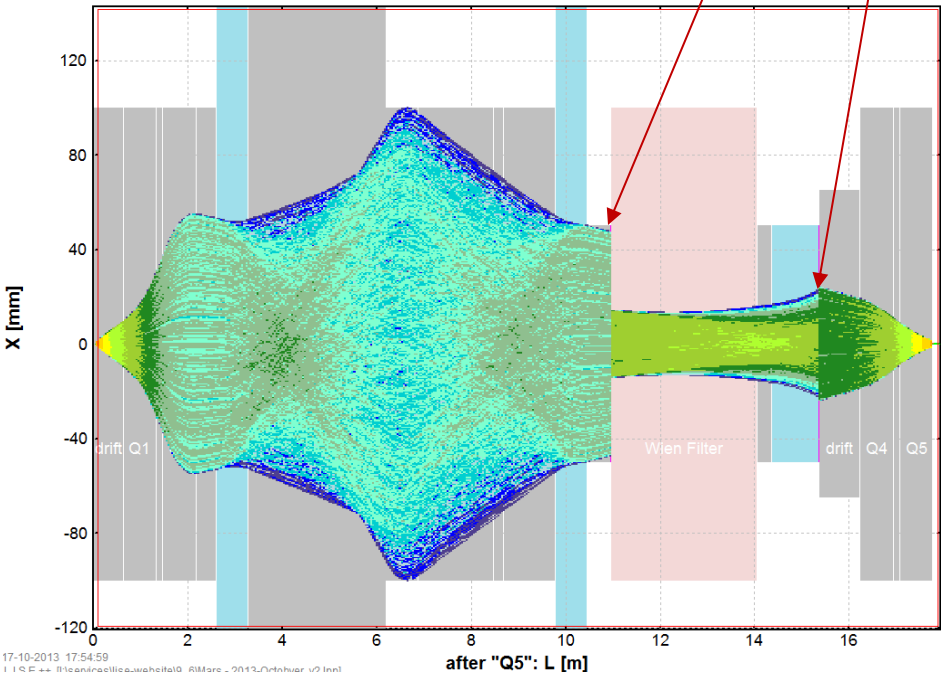
X-Y orientation

- "Absolute" --> Laboratory frame
- "Local" --> Follow Rotation blocks

⁷Li : MC Transmission Plot - Envelope (only passed)

⁷Li (16.0 MeV/u) + Al (1e-4 mm); Transmitted Fragment ⁷Li^{3+..3+} (beam); Optics Order: 1
 dp/p=20.55% ; Brho(Tm): 1.3510, 1.3510, 1.3510, 1.3510

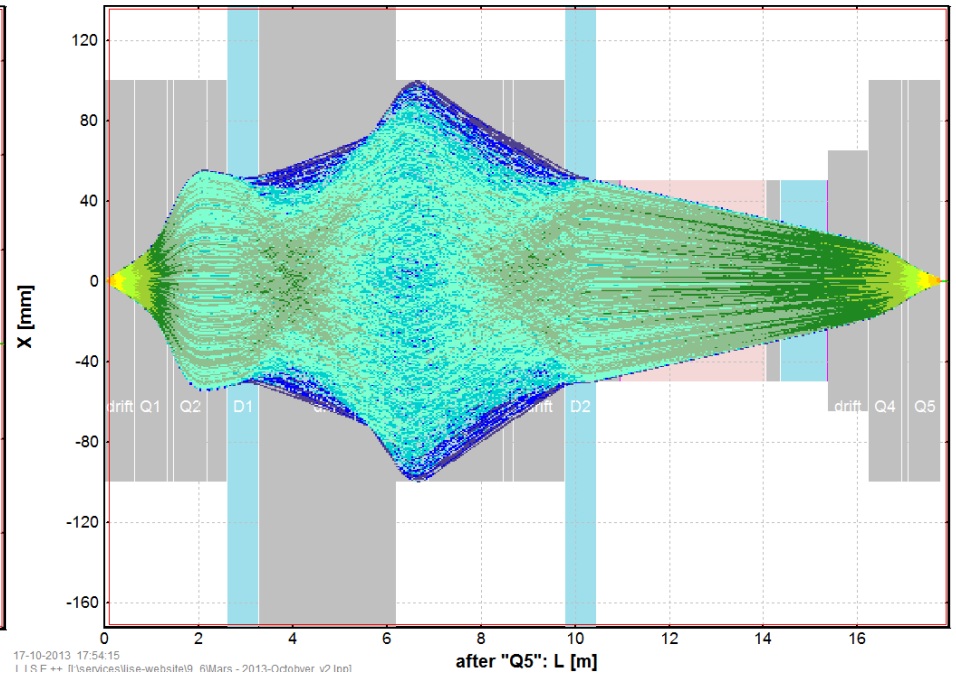
Bounds: ON; "Q5" - last block for MC calc; no gates; Config: DSSSSSDSSSSSDSONSDOSSSS



⁷Li : MC Transmission Plot - Envelope (only passed)

⁷Li (16.0 MeV/u) + Al (1e-4 mm); Transmitted Fragment ⁷Li^{3+..3+} (beam); Optics Order: 1
 dp/p=20.55% ; Brho(Tm): 1.3510, 1.3510, 1.3510, 1.3510

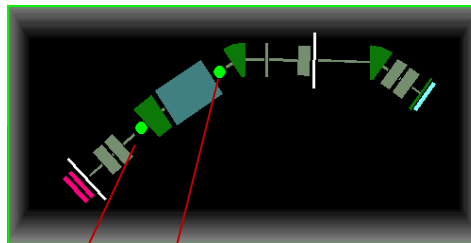
Bounds: ON; "Q5" - last block for MC calc; no gates; Config: DSSSSSDSSSSSDSONSDOSSSS



Previous versions and

X-Y orientation

- "Absolute" --> Laboratory frame
- "Local" --> Follow Rotation blocks

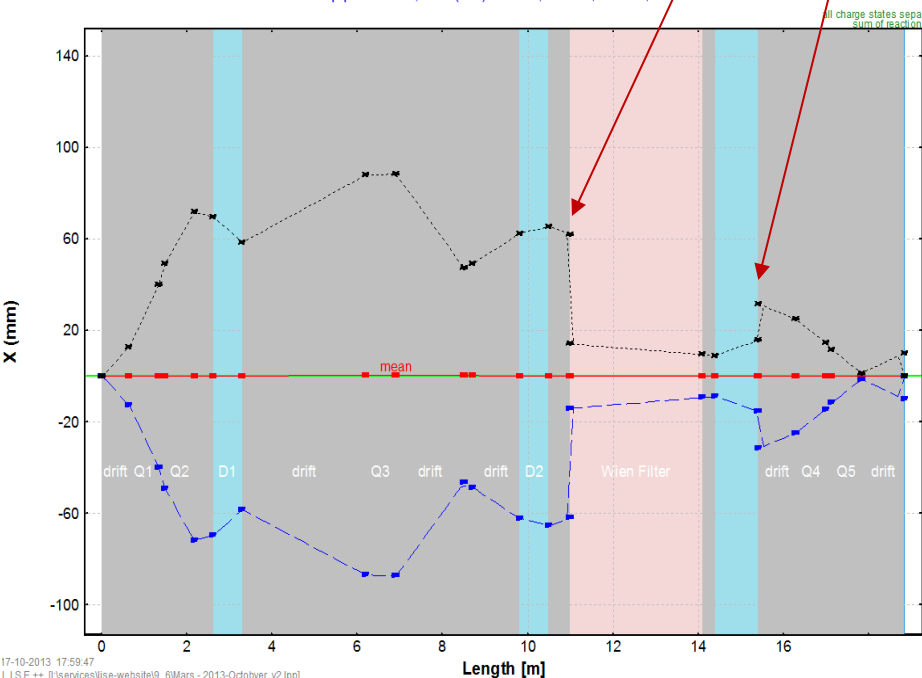


X-Y orientation

- "Absolute" --> Laboratory frame
- "Local" --> Follow Rotation blocks

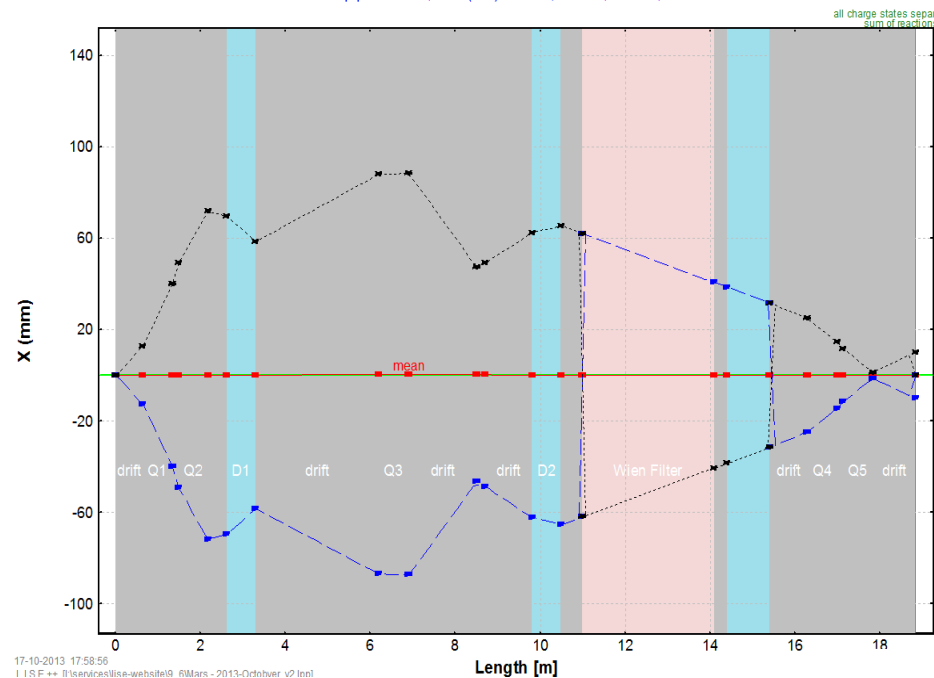
Envelope for 7Li_ProjFrag 3+ 3+ 3+ 3+ 3+: x space

7Li (16.0 MeV/u) + Al (1e-4 mm); Settings on 7Li^{3+,3+}; Config: DSSSSSDSSSSSSSDSONSDOSSSSSS...
dp/p=20.55% ; Brho(Tm): 1.3510, 1.3510, 1.3510, 1.3510

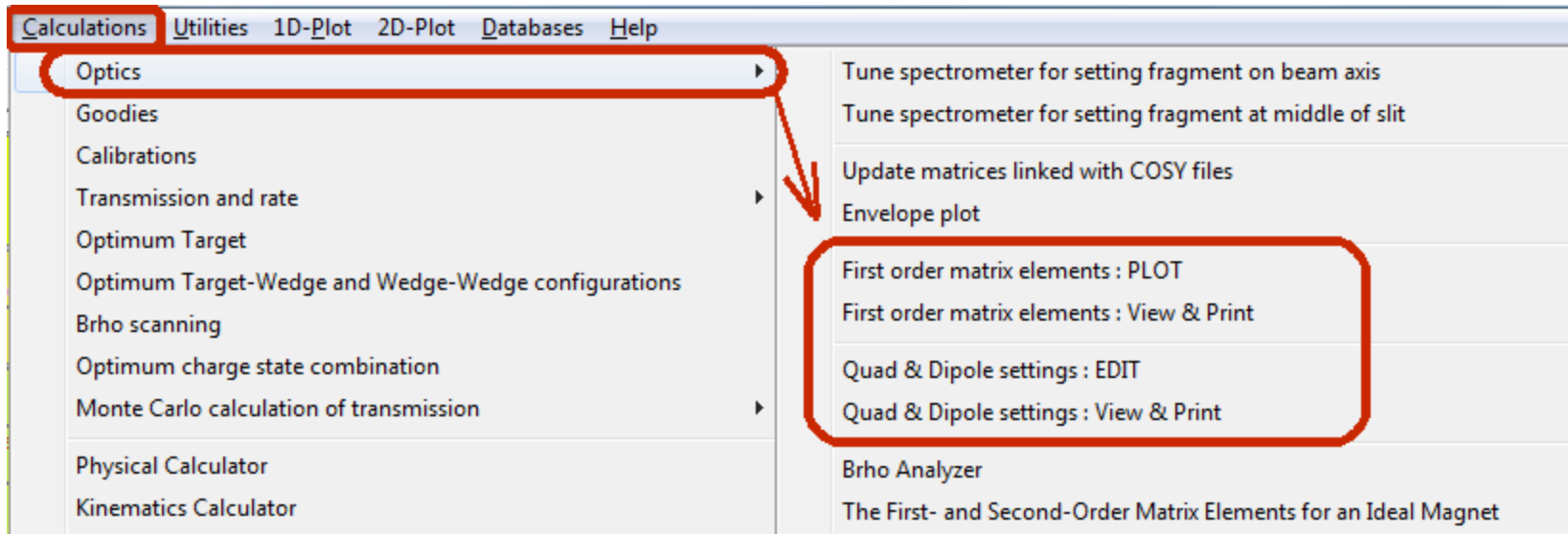


Envelope for 7Li_ProjFrag 3+ 3+ 3+ 3+ 3+: x space

7Li (16.0 MeV/u) + Al (1e-4 mm); Settings on 7Li^{3+,3+}; Config: DSSSSSDSSSSSSSDSONSDOSSSSSS...
dp/p=20.55% ; Brho(Tm): 1.3510, 1.3510, 1.3510, 1.3510

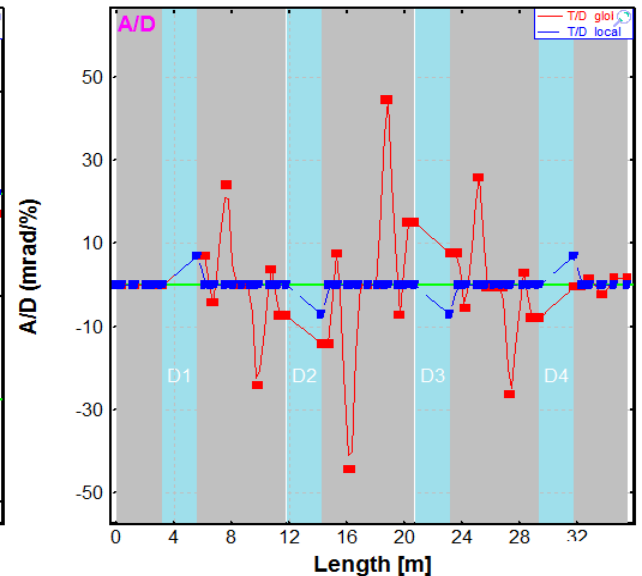
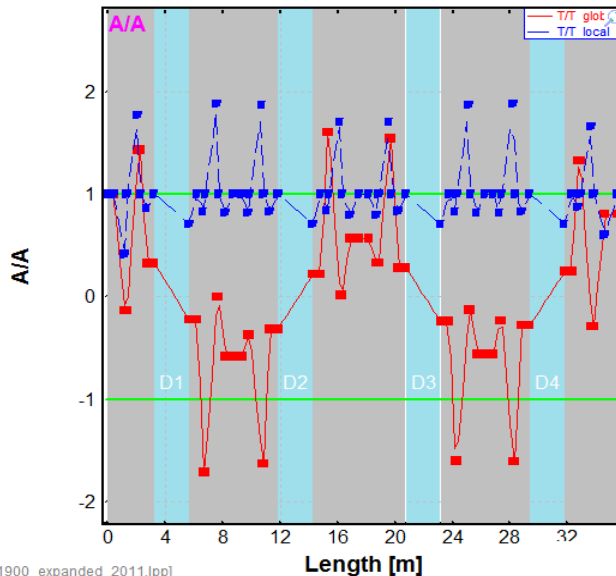
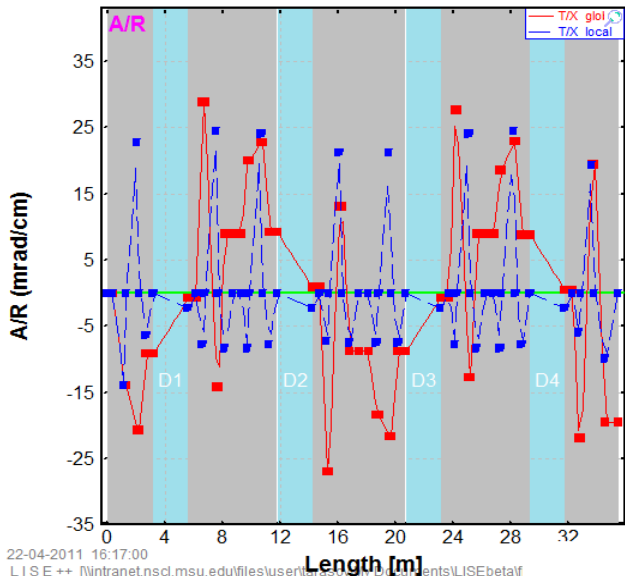
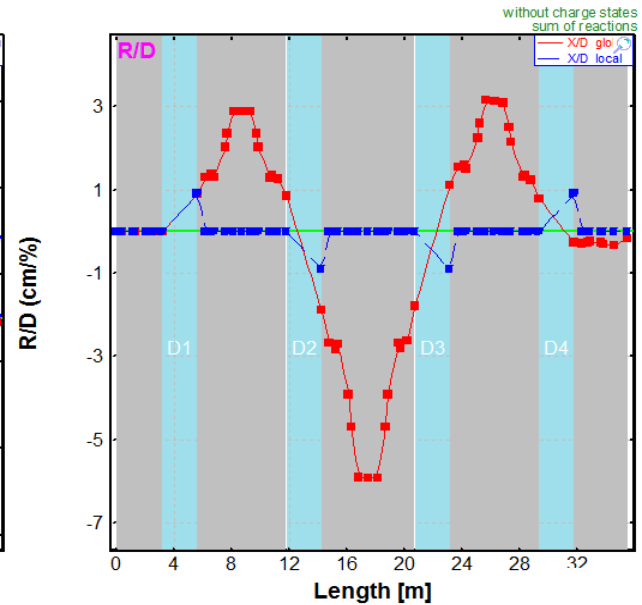
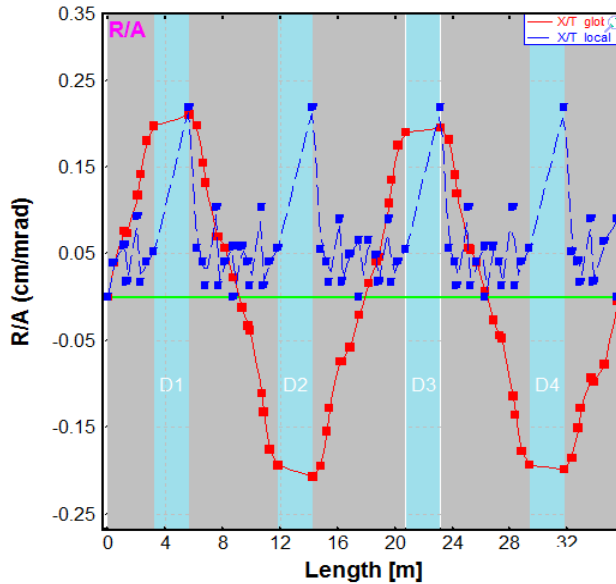
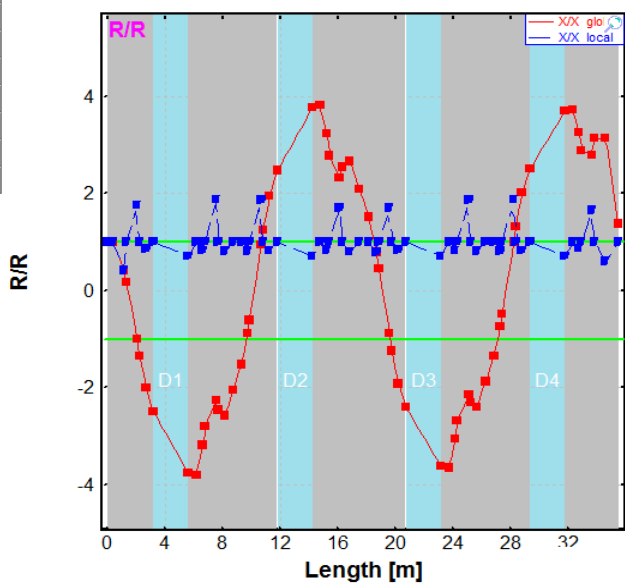


Optics: utilities



First order matrix elements

^{40}Ar (84.3 MeV/u) + Be ($1\text{e-}4\ \mu\text{m}$); Settings on ^{40}Ar ; Config: SSSSSSDSSSSSSSSSSSSSSSSSSSDSS...
dp/p=5.07% ; Brho(Tm): 3.0000, 3.0000, 3.0000, 3.0000



It's easy access to edit all kind of slits

Example of extended configuration

Quadrupoles and dipoles fast editing

Block	Given Name	Start(m)	Length(m)	B0(kG)	Br(Tm)corr./real	DriftM/*Angle	Rapp(cm)/*R(m)	L_eff(m)/*L_dip(m)	2 nd order	CalcMatr/*Z-Q	AngAcc.Apps.Slits	COSY_link	
Dipole	tuning	0.000	0.0001	+11.5317	* 3.4595	* 0.0	* 3.0000	* 0.0001	no	* 0	-- -- --	-	
S	Drift	z015	0.3960			standard					-- HV --	-	
Q	Drift	Q017-1TA	0.396	0.7480	+12.1083	3.4595	quadrupole	13.3000	0.7480	yes	1	-- HV --	yes
S	Drift	z018	1.144	0.1756		standard					-- HV --	-	
Q	Drift	Q019-1TB	1.320	0.7480	-11.2523	3.4595	quadrupole	13.3000	0.7480	yes	1	-- HV --	yes
S	Drift	z020	2.068	0.1720		standard					-- HV --	-	
Q	Drift	Q021-1TC	2.240	0.4300	+8.0953	3.4595	quadrupole	15.0000	0.4300	yes	1	-- HV --	yes
S	Drift	z022	2.670	0.5260		standard					-- HV --	-	
Dipole	D1	3.196	2.4300	+11.1817	* 3.4595	* 45.0	* 3.0939	* 2.4299	yes	* 0	-- HV --	yes	
S	Drift	z030	5.626	0.5640		standard					-- HV --	-	
Q	Drift	Q031-2TA	6.190	0.4300	+9.9052	3.4595	quadrupole	15.0000	0.4300	yes	1	-- HV --	yes
S	Drift	z032	6.620	0.1358		standard					-- HV --	-	
Q	Drift	Q033-2TB	6.755	0.8120	-12.2178	3.4595	quadrupole	15.0000	0.8120	yes	1	-- HV --	yes
S	Drift	z034	7.567	0.1358		standard					-- HV --	-	
Q	Drift	Q035-2TC	7.703	0.4300	+10.7362	3.4595	quadrupole	15.0000	0.4300	yes	1	-- HV --	yes
S	Drift	z036	8.133	0.5860		standard					-- HV --	-	
S	Drift	Image1(037)	8.719	0.0000		SLITS					-- -- --	-	
S	Drift	z038	8.719	0.5860		standard					-- HV --	-	
Q	Drift	Q039-3TA	9.305	0.4300	+10.7362	3.4595	quadrupole	15.0000	0.4300	yes	1	-- HV --	yes
S	Drift	z040	9.735	0.1358		standard					-- HV --	-	
Q	Drift	Q041-3TB	9.871	0.8120	-12.0441	3.4595	quadrupole	15.0000	0.8120	yes	1	-- HV --	yes
S	Drift	z042	10.683	0.1358		standard					-- HV --	-	
Q	Drift	Q043-3TC	10.819	0.4300	+9.9018	3.4595	quadrupole	15.0000	0.4300	yes	1	-- HV --	yes

Selected block: Block Length [m]:

Let call automatically:

Block name = Length after this block [m]:

Charge State [Z-Q] =

Angular acceptance (mrad) Use

Horizontal ±

Vertical ±

Shape: Rectangle Ellipse

Inside Aperture (mm) Use

X = min: max:

Y = min: max:

Shape: Rectangle Ellipse

Slits (mm) after this BLOCK Use

X = min: max:

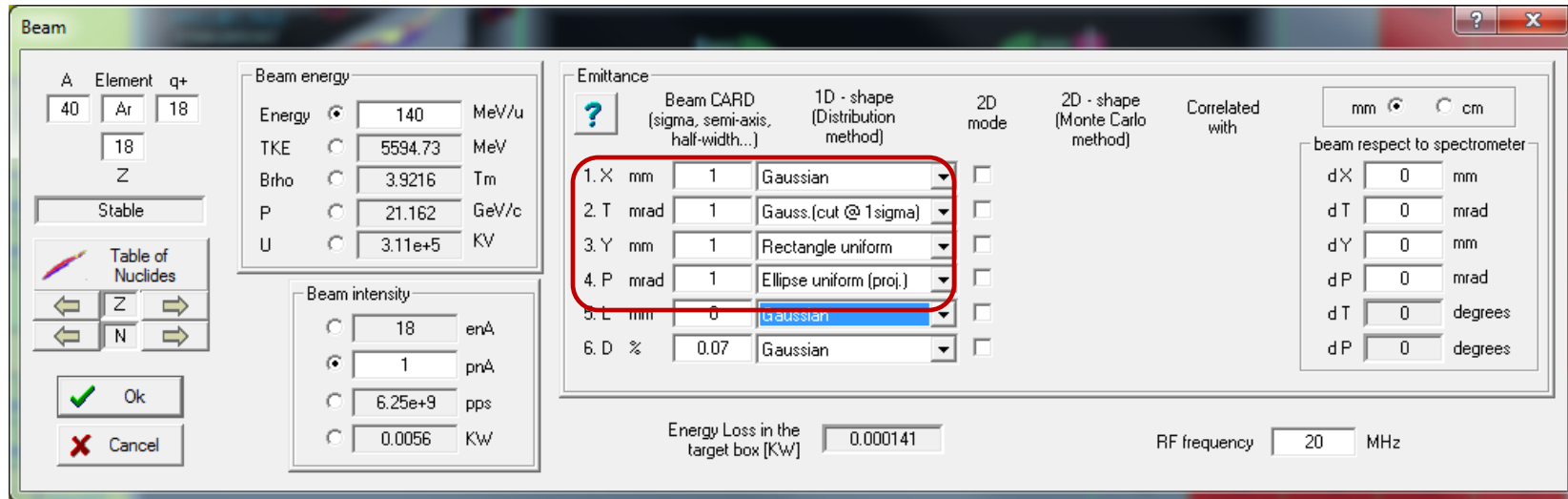
Y = min: max:

Shape: Rectangle Ellipse

1-st order Matrix Elements

H – horizontal
V – vertical

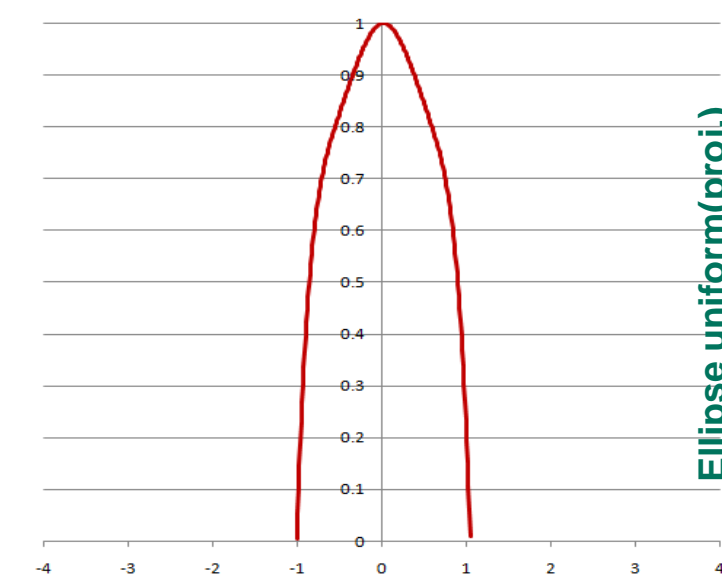
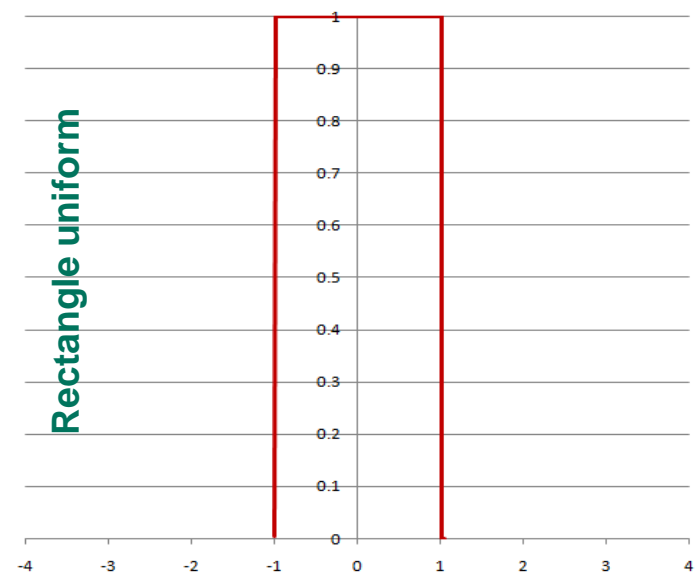
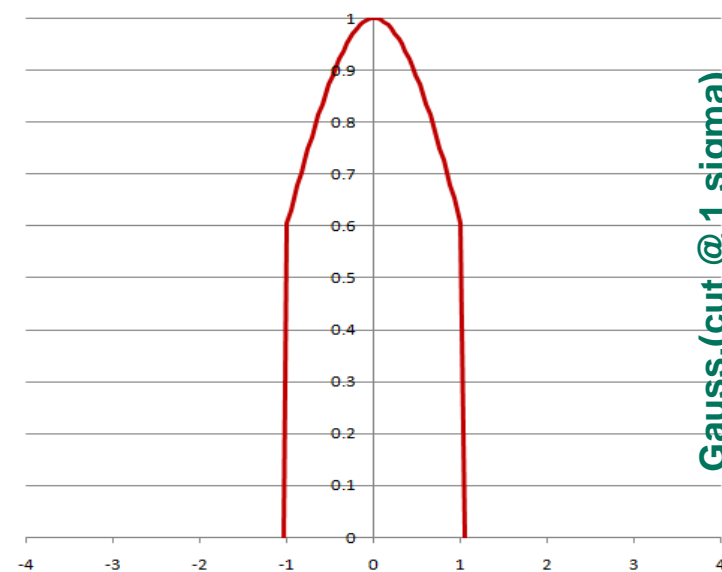
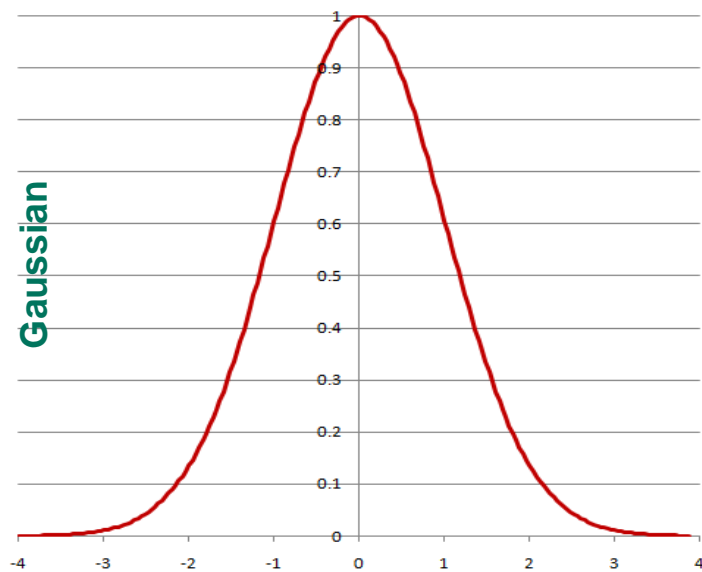
Optics: Beam shapes

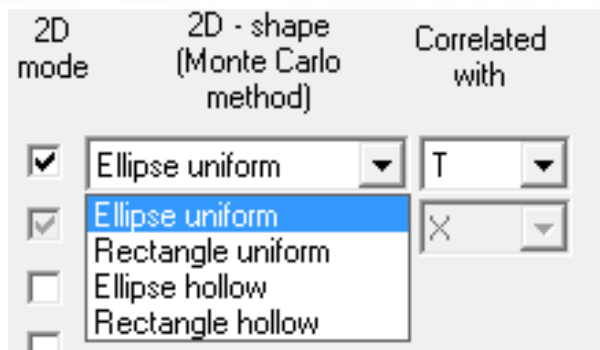


1D-shape

1. Gaussian	Sigma=1	=>	Area = 2.51	St.Dev = 1
2. Gauss.(cut @ 1 sigma)	Sigma=1	=>	Area = 1.74	St.Dev = 0.55
3. Rectangle uniform	Half-width=1	=>	Area = 2.00	St.Dev = 0.58
4. Ellipse uniform(proj.)	Semi-axis=1	=>	Area = 1.56	St.Dev = 0.51

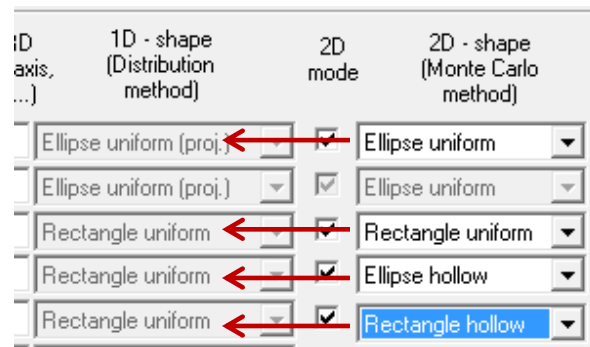
See the next slide



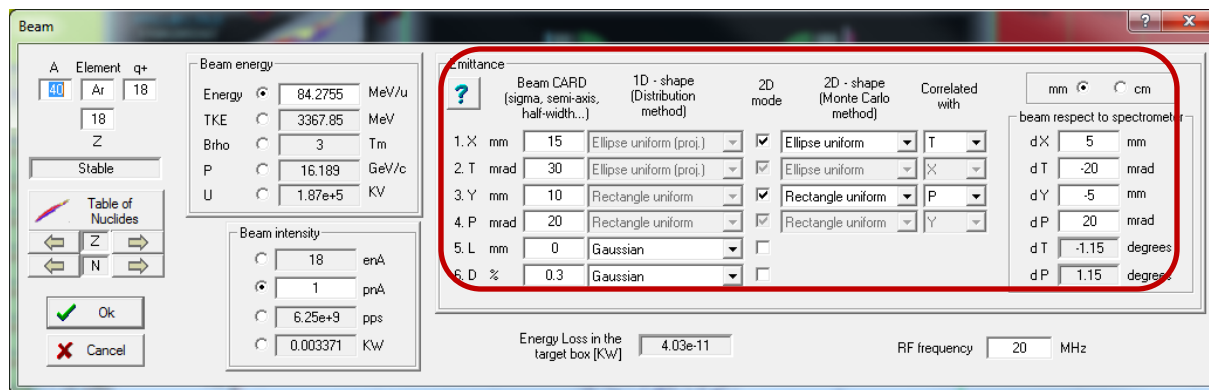


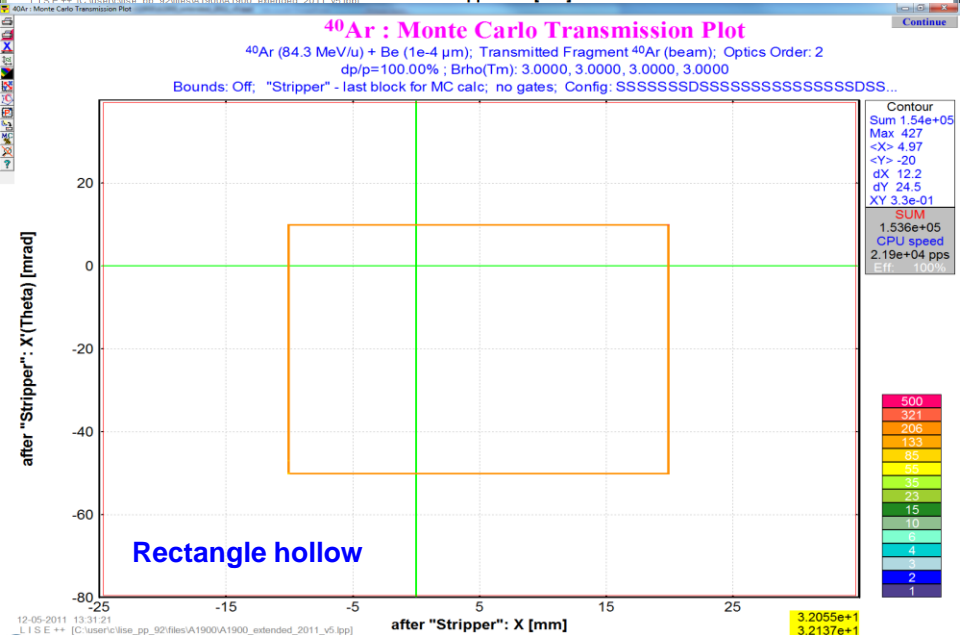
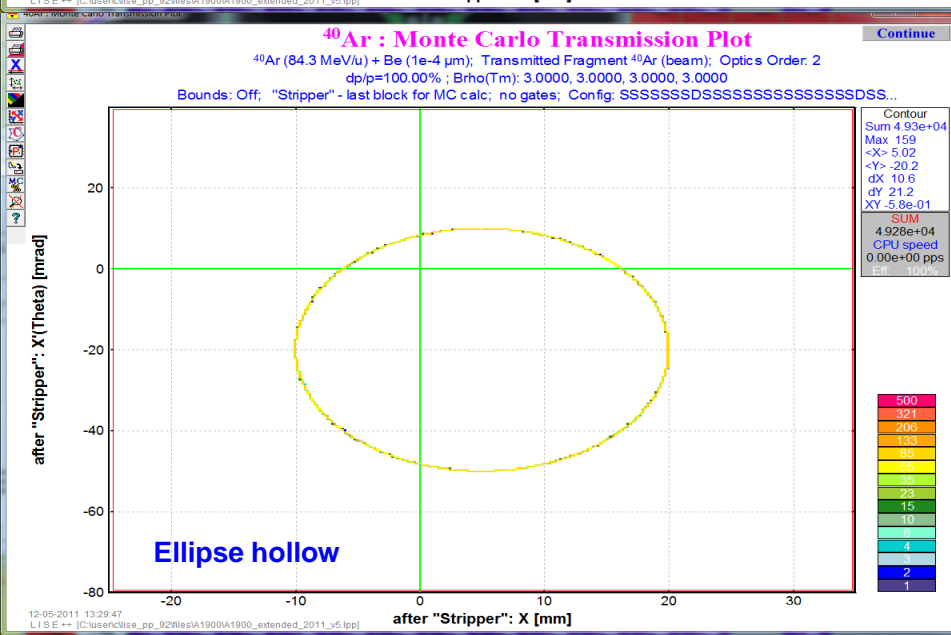
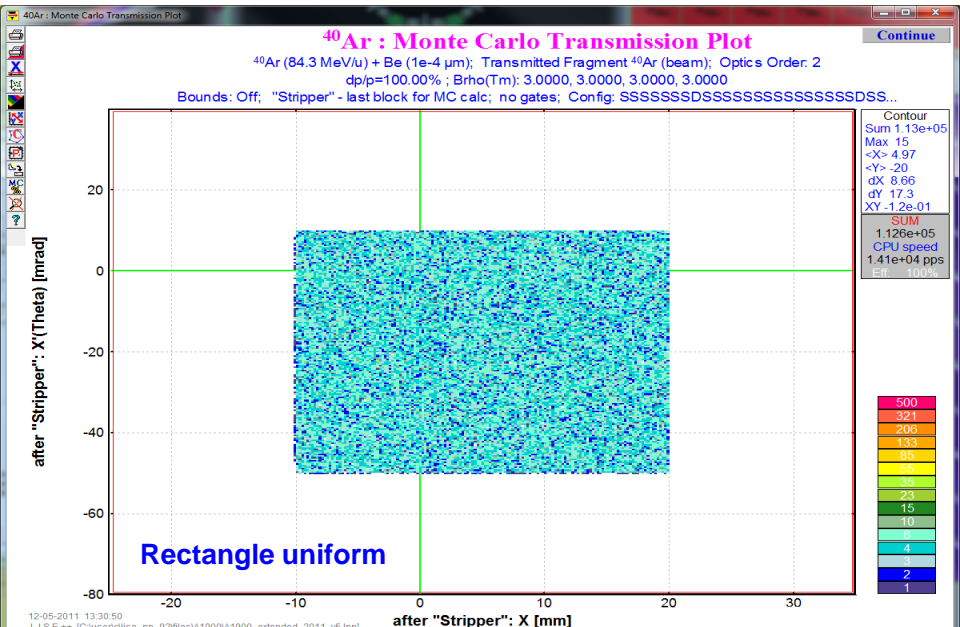
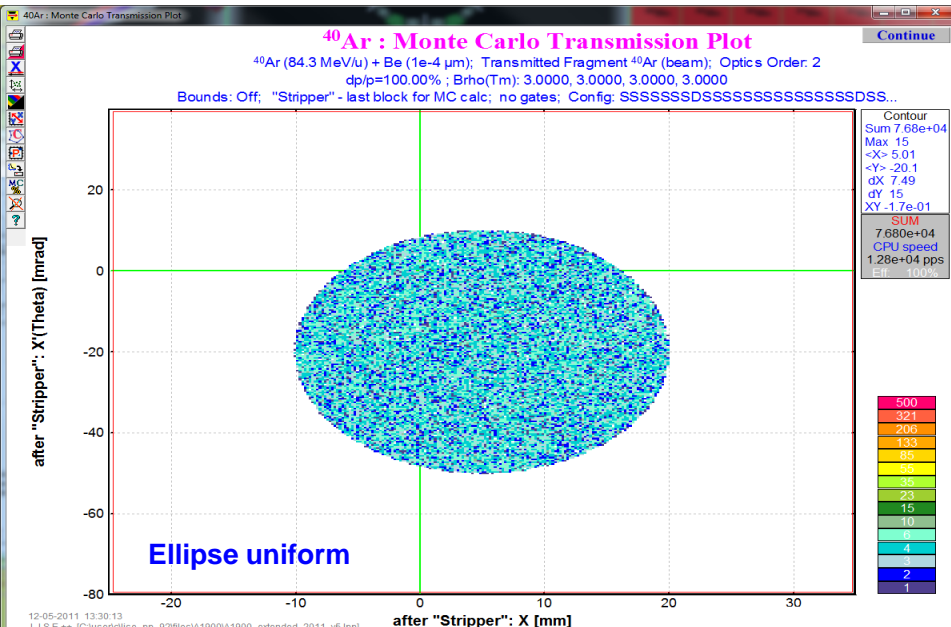
Four 2D-shapes.
Hollow configurations (which are not physical)
are designed for debug purposes

Assignment for 1D-shapes,
which are used for the
Distribution method



File used for the next slides: http://groups.nslc.msu.edu/lise//9_2/9_2_85/A1900_extended_2011_v5.lpp





Physics

PHYSICAL REVIEW C **78**, 034610 (2008)

Synthesis of superheavy nuclei: A search for new production reactions

Valery Zagrebaev¹ and Walter Greiner²

¹Flerov Laboratory of Nuclear Reactions, JINR, Dubna, Moscow Region, Russia

²Frankfurt Institute for Advanced Studies, J. W. Goethe-Universität, Frankfurt, Germany

(Received 23 May 2008; published 24 September 2008)

Nuclear reactions leading to the formation of new superheavy (SH) elements and isotopes are discussed in the paper. "Cold" and "hot" synthesis, fusion of fission fragments, transfer reactions, and reactions with radioactive ion beams are analyzed along with their abilities and limitations. If the possibility of increasing the beam intensity and the detection efficiency (by a total of one order of magnitude) is found, then several isotopes of new elements with $Z = 120$ – 124 could be synthesized in fusion reactions of titanium, chromium, and iron beams with actinide targets. The use of light- and medium-mass neutron-rich radioactive beams may help us fill the gap between the SH nuclei produced in the hot fusion reactions and the mainland. In these reactions, we may really approach the "island of stability." Such a possibility is also provided by the multinucleon transfer processes in low-energy damped collisions of heavy actinide nuclei. The production of SH elements in fusion reactions with accelerated fission fragments looks less encouraging.

$$P_{\text{CN}}(E^*, l) = \frac{P_{\text{CN}}^0}{1 + \exp\left[\frac{E_B^* - E_{\text{int}}^*(l)}{\Delta}\right]},$$

where

$$P_{\text{CN}}^0 = \frac{1}{1 + \exp\left[\frac{Z_1 Z_2 - \zeta}{\tau}\right]},$$

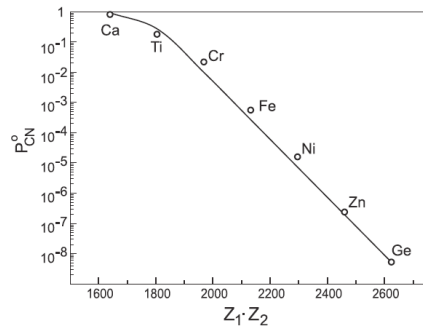


FIG. 5. Above-barrier CN formation probability in the ²⁰⁸Pb induced fusion reactions. Results of calculation are shown by the circles, whereas the fitted curve corresponds to expression (3).

✕

Evaporation settings

Transmission probability for a one-dimensional potential barrier

Classical
 Quantum-mechanical

$\hbar\omega$ - Curvature parameter of the parabolic potential describing the barrier (default value 3 MeV)

MeV

Probability for compound nucleus formation P_{CN}

Take into account the Probability for compound nucleus formation P_{CN} according to V.Zagrebaev & W.Greiner, PRC78, 034610 (2008)

OK

Cancel

Make default

Help

Partner site

Fusion

Evaporation

PHYSICAL REVIEW C **78**, 034610 (2008)

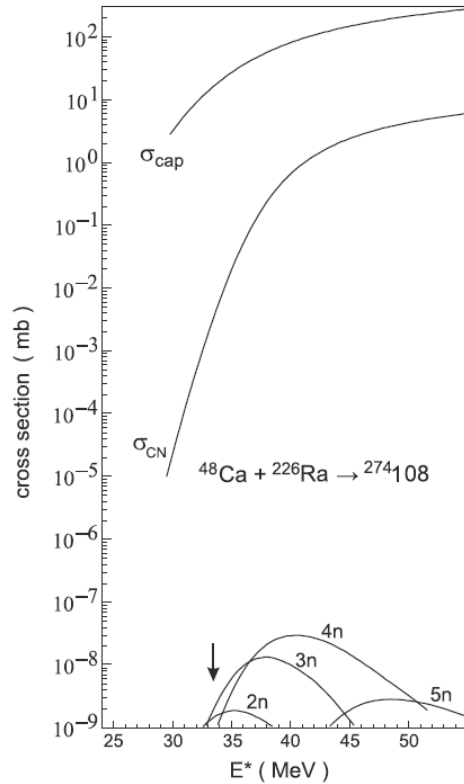


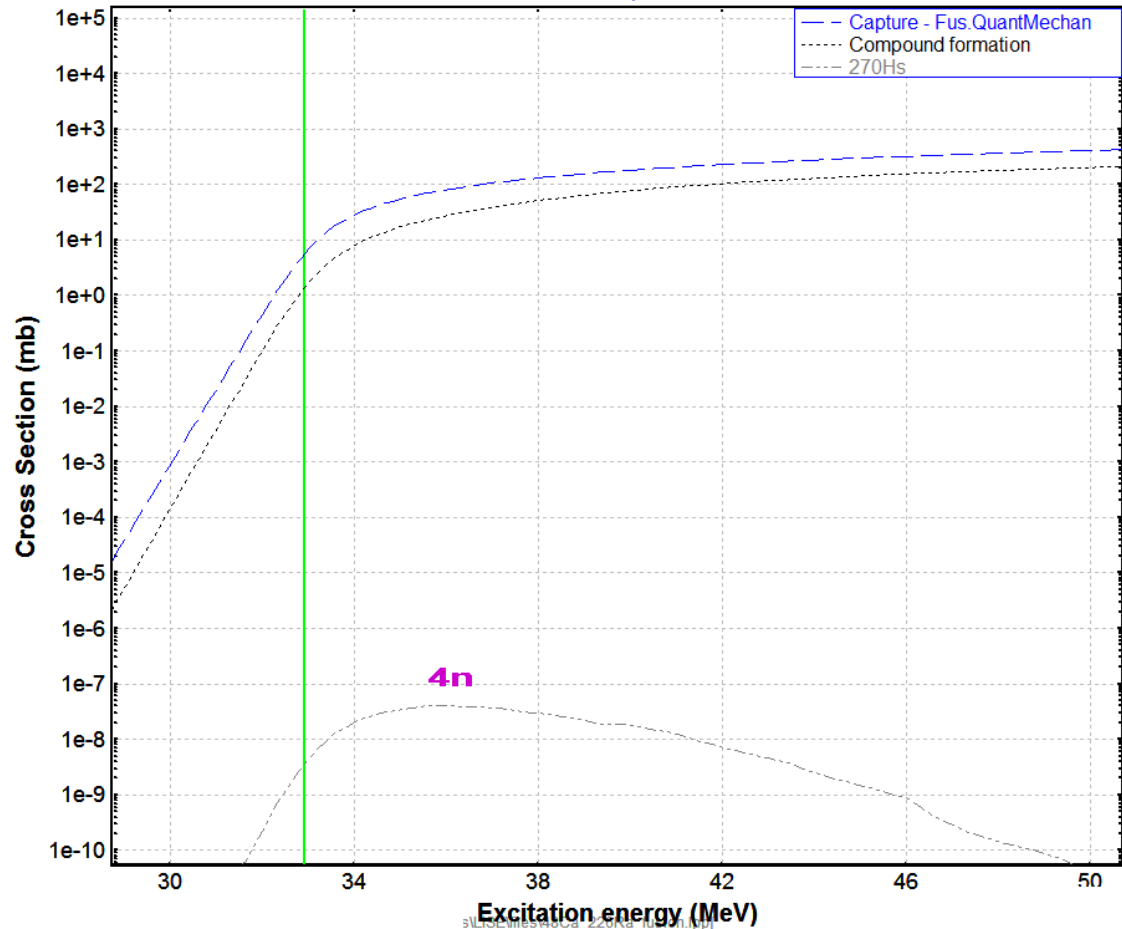
FIG. 7. Calculated capture, fusion, and evaporation residue ($2n$, $3n$, $4n$, and $5n$ channels) cross sections in the $^{48}\text{Ca} + ^{226}\text{Ra}$ fusion reaction. The arrow indicates the Bass barrier.

Cross sections (Fusion-Residual) [with P_{CN}]

$^{48}\text{Ca} + ^{226}\text{Ra} \rightarrow ^{274}\text{Hs}^*$ ($Q = -154.04$) Model: LisFus v.4.0 Fis.Bar, MeV: 3.65 FisRot* - RLDM(Cohen)

$V_{\text{Coulomb}} = 184.38$ MeV; Fusion height $^{\text{Bass}}$ $_{\text{max}}$: $B_f = 186.97$ MeV; $h_{\omega} = 2.00$ MeV

Beam energy: $E_{\text{Lab}} = 4.50$ MeV/u; $N_{\text{evap}}=32$; Vert. lines: B_f & $E_{\text{beam}}(1/2 \text{ target})$

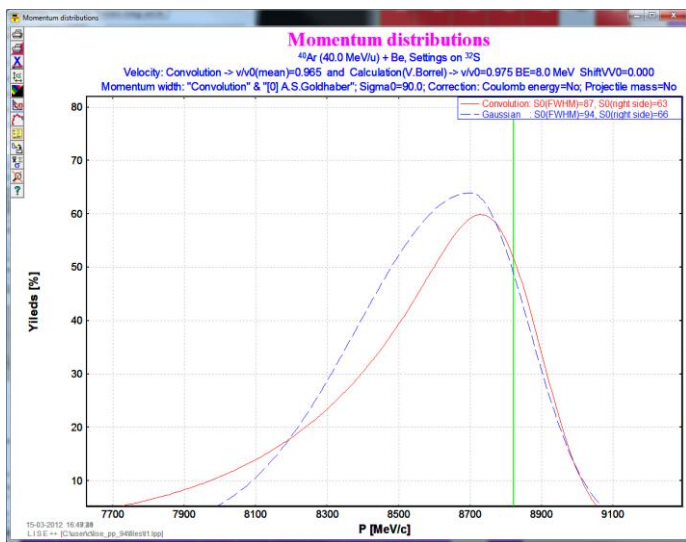


Excitation energy (MeV)

The asymmetry coefficient “alpha” is applied for models [1-3]

asymmetry coefficient “ α ” (in %) and reduced width “ σ ” are used to describe an asymmetrical Gaussian momentum distribution

asymmetry



Projectile fragmentation

Fragment velocity | Momentum distribution | Cross section, Excitation energy and etc

40Ar(140.0 MeV/u) + Be → 32S

Parallel momentum distribution been used in the program (MeV/c) = 245.9 with Gamma-factor = 282.9°

Parallel momentum distribution

- [1] A.S.Goldhaber
Phys.Lett.B 53(1974)306
 $\sigma_{||}^2 = \sigma_0^2 \frac{A_F(A_P - A_F)}{A_P - 1}$ $\sigma_0 = 90$ $\sigma_{||} = 230.6$
- [2] D.J.Morrissey
Phys.Rev.C 39(1989)460
 $\sigma_{||}^2 = \sigma_M^2 (A_P - A_F)$ $\sigma_M = 87$ $\sigma_{||} = 245.9$
- [3] W.A.Friedman
Phys.Rev.C 27(1983)569
 $\sigma_{||}^2 = \frac{\mu}{2x_0} \left[\frac{1 + 0.5y}{\sqrt{1+y}} + \frac{1}{\mu x_0} \right]$ $\sigma_{||} = 155.4$

Asymmetry coefficient for Gaussian-like distributions [1-3] alpha (%) = 11.4 $\alpha = \frac{\sigma_{low}}{\sigma_{||}} - 1 = 1 - \frac{\sigma_{high}}{\sigma_{||}}$? Help

- [4] Universal parameterization (Convolution)
O.Tarasov, NPA 734(2004)536 $\sigma_0^{conv} = 91.5$ $\sigma_{||} = 199.7$

Corrections of the momentum distribution width

- [a] Coulomb energy correction [W.A.Friedman, PRC 27(1983) 569] $\sigma_0^* = \sigma_0 (1 - E_B / E_{CM})^{1/2}$ Sigma0(M) corrected, [MeV/c]
- [b] Particle mass correction [R.K.Tripathi, L.W.Townsend, PRC 49(1994)2237] $\sigma_0^* = (\sigma_0 - 20 + 2A_P / 3)$

Perpendicular momentum distribution

$\sigma_{\perp}^2 = \sigma_{||}^2 + \sigma_D^2 \frac{A_F(A_P - 1)}{A_P(A_P - 1)}$ $\sigma_D = 200$ MeV/c

$\sigma_{\perp} = 293.1$ MeV/c

Make default

OK Cancel Help

EPAX 3 set by default in the version 9.5

PHYSICAL REVIEW C **86**, 014601 (2012)

Improved empirical parametrization of fragmentation cross sections

K. Sümmerer

GSI Helmholtzzentrum für Schwerionenforschung, Planckstr.1, D-64291 Darmstadt, Germany

(Received 25 May 2012; published 2 July 2012)

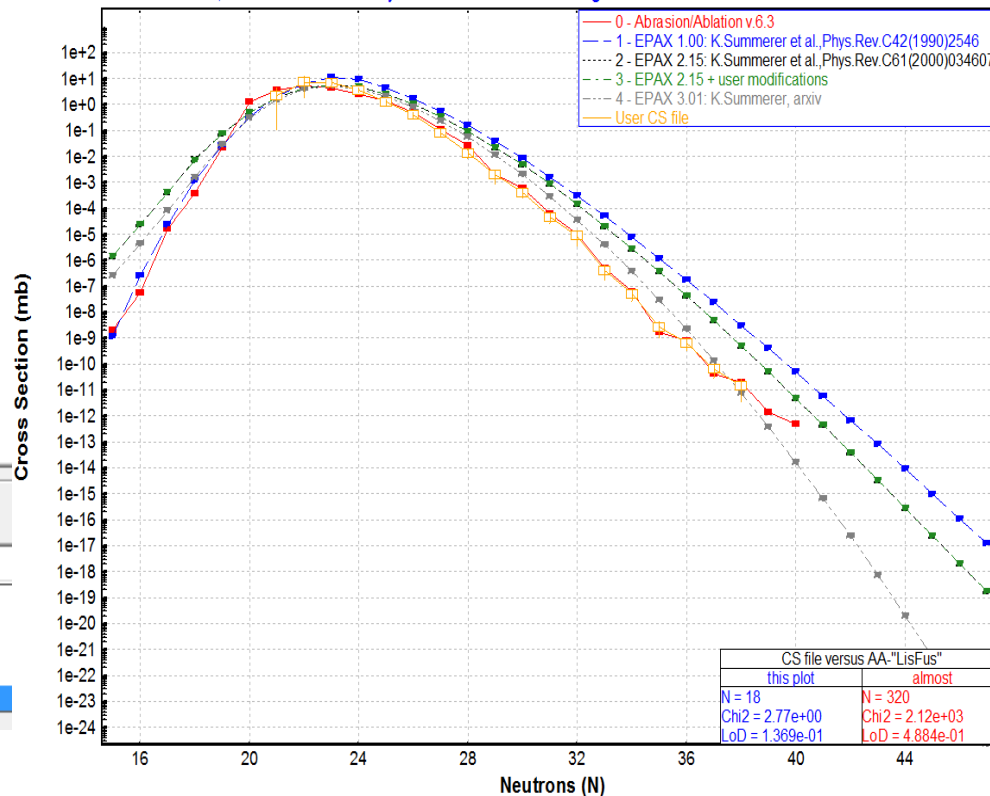
A new version is proposed for the universal empirical formula, EPAX, which describes fragmentation cross sections in high-energy heavy-ion reactions. The new version, EPAX 3, is shown to yield cross sections that are in better agreement with experimental data for the most neutron-rich fragments than the previous version. At the same time, the very good agreement of EPAX 2 with data on the neutron-deficient side has been largely maintained. Comparison with measured cross sections show that the bulk of the data is reproduced within a factor of about 2, for cross sections down to the picobarn range.

Cross Sections	
4 - EPAX 3.01: K. Sümmerer, Phys. Rev. C86(2012)014601	
0 - Abrasion/Ablation v.6.3	
1 - EPAX 1.00: K. Sümmerer et al., Phys. Rev. C42(1990)2546	
2 - EPAX 2.15: K. Sümmerer et al., Phys. Rev. C61(2000)034607	
3 - EPAX 2.15 + user modifications	
4 - EPAX 3.01: K. Sümmerer, Phys. Rev. C86(2012)014601	

Cross sections (Projectile Fragmentation)

$^{82}\text{Se} + \text{Be} \rightarrow Z=20$

Excit. Energy Method: < 2 >; < E >: 15.0 dA MeV Sigma: 9.15; Coef^{Thermalization}=5.00e-22 MeV.s DB₁="GXPF1B"
NP=64; SE:"DB1+Cal0" Density:"auto" GeomCor:"On" Tunlg:"auto" FisBar=#1 Bar^{Fac}=1.00 Modes=1010 1010 010



Selected for a [Viewpoint](#) in *Physics*

PHYSICAL REVIEW C **87**, 054612 (2013)



Production cross sections from ^{82}Se fragmentation as indications of shell effects in neutron-rich isotopes close to the drip-line

O. B. Tarasov,^{1,4} M. Portillo,² D. J. Morrissey,^{1,3} A. M. Amthor,² L. Bandura,² T. Baumann,¹ D. Bazin,¹ J. S. Berryman,¹ B. A. Brown,^{1,4} G. Chubarian,⁵ N. Fukuda,⁶ A. Gade,^{1,4} T. N. Ginter,¹ M. Hausmann,² N. Inabe,⁶ T. Kubo,⁶ J. Pereira,¹ B. M. Sherrill,^{1,4} A. Stolz,¹ C. Sumithrarachichi,¹ M. Thoennessen,^{1,4} and D. Weisshaar¹

Physics :

**User differential
cross sections**

Options Calculations Utilities 1D-Plot 2D-Plot Databases

Preferences

- Production Mechanism
- Evaporation options
- Excitation energy of prefragment
- Fission Barrier
- User Cross Sections**
- User Cross Sections from File
- Options of Fragment Production in Material (wedge)
- Secondary Reactions in target
- Isotopes

Cross sections: Two body reaction

A	Element	Z
1	H	1

Reaction: 2H + 0

Number of saved cross sections:

All CS	Int CS	Dif CS
All reactions	0	0
this reaction	0	0

Input new Int CS: absent mb

Input (View) Dif CS: [Empty]

Selected Reaction: Two body reaction

Differential cross section file

2H (6.0 MeV/u) + 180 -> 1H (+190)

Data File: Load from file, View data, Clear data

Number of rows: Data, Comments, Total

Excitation energies of products (MeV): E* of 1H = 0, E* of 190 = 0

Integrated Cross Section (mb): [Empty]

Utilities: Kinematics Plots, 2D Kinematics (MC)

OK Cancel Help

Two body reactions

User CSs are saved to LISE++ files and retrieved at reading of LISE++ files

Cross sections: Two body reaction

A	Element	Z
1	H	1

Reaction: 2H + 0

Number of saved cross sections:

All CS	Int CS	Dif CS
All reactions	1	0
this reaction	1	0

Input new Int CS: 2.21e+01 mb

Input (View) Dif CS: 190_gs.txt

Selected Reaction: Two body reaction

Differential cross section file

2H (6.0 MeV/u) + 180 -> 1H (+190)

Data File: Load from file, View data, Clear data

Number of rows: Data, Comments, Total

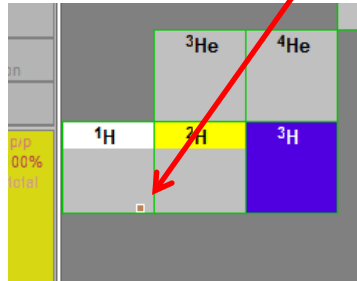
Excitation energies of products (MeV): E* of 1H = 0, E* of 190 = 0

Integrated Cross Section (mb): 22.12

Utilities: Kinematics Plots, 2D Kinematics (MC)

OK Cancel Help

User CS sign



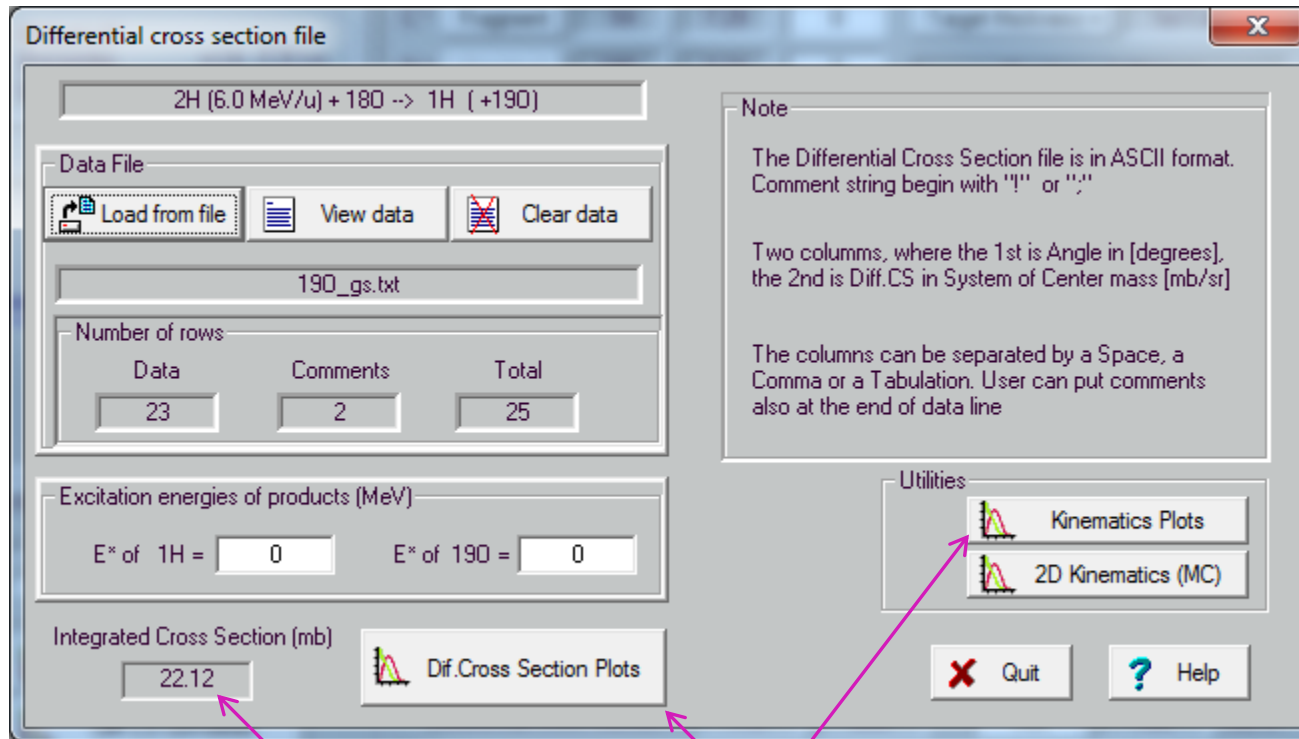
statistics: 1H

1H	Stable (Z=1, N=0)	Hydrogen
AME2012 index	1000	error
Mass excess, [MeV]	7.2890	0.0000
Binding energy	0.0000	0.0000
Beta- decay	-777.0000	-777.0000
Beta+ decay	-0.7823	-777.0000
S (2n)	*	*
S (2p)	*	*
Q (alpha)	*	*
S (n)	*	*
S (p)	0.0000	0.0000
<Stable> Abundance:	99.99%	

Reaction (b+t -> f1+f2) 1.73 MeV (error=0.0026 MeV)

N=0 user cross section : 2.21e+01(0.00e+00)mb for Two body reaction [Diff. CS]

User Diff Cs file is $d\sigma / d\Omega$ (mb/sr) in CMS



LISE++ automatically integrates the UserDiffCS ($d\sigma / d\theta$)

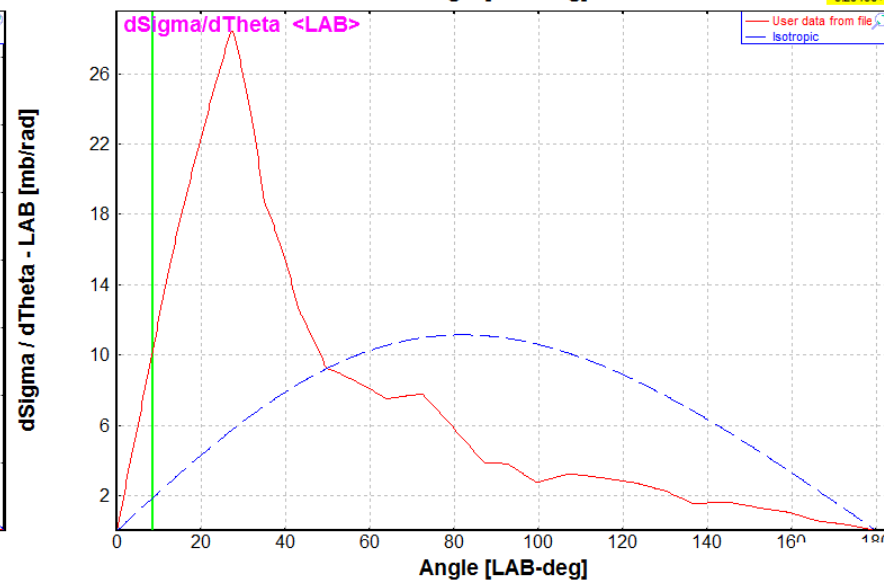
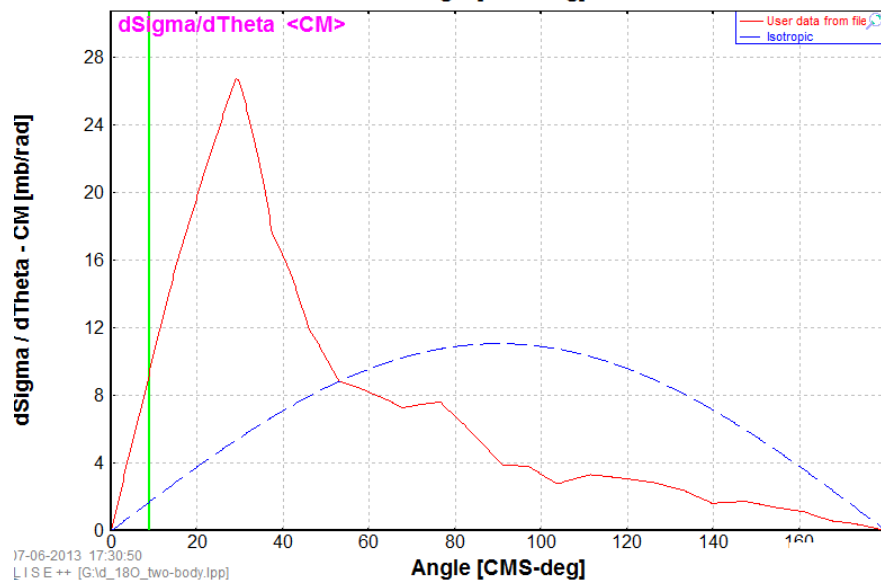
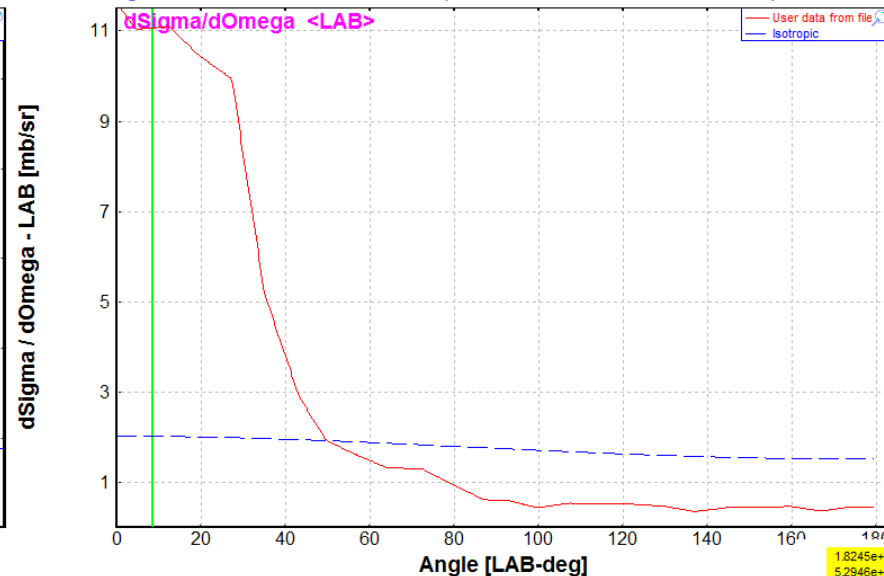
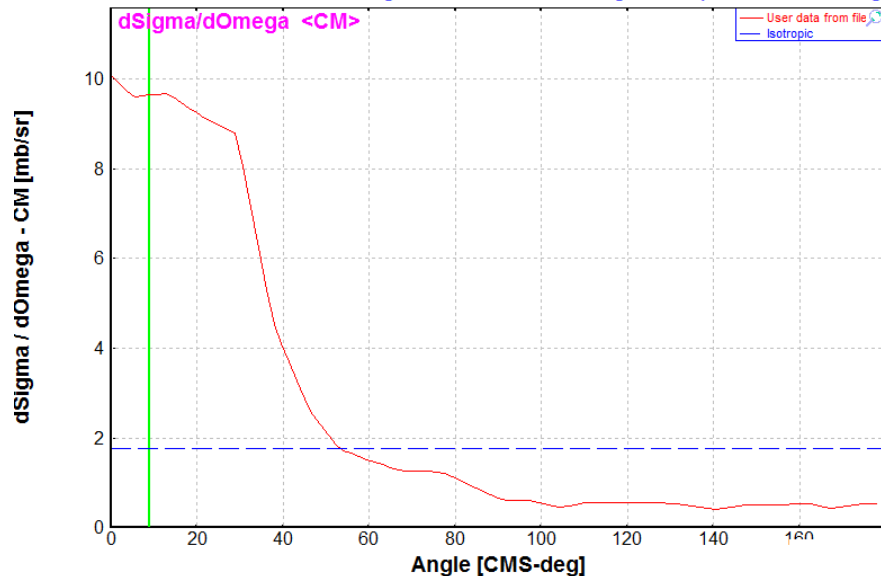
These buttons become enable after the UserDiffCS file loaded

Differential Cross Section

^2H (6.0 MeV/u) + ^{18}O \rightarrow ^1H (+ ^{18}O)

User file: "19O_gs.txt"; Integrated Cross Section: 22.12 mb; Grazing angle in CMS [$^2\text{H}+^{18}\text{O}$]: 9.00 deg

Max.Angle in Lab: 180.00 deg corresponds to CM Angle 180.0 deg; Q reaction : 1.73 MeV (Excitations 0.0+0.0=>0.0+0.0)



17-06-2013 17:30:50
LISE++ [G:\d_18O_two-body.lpp]

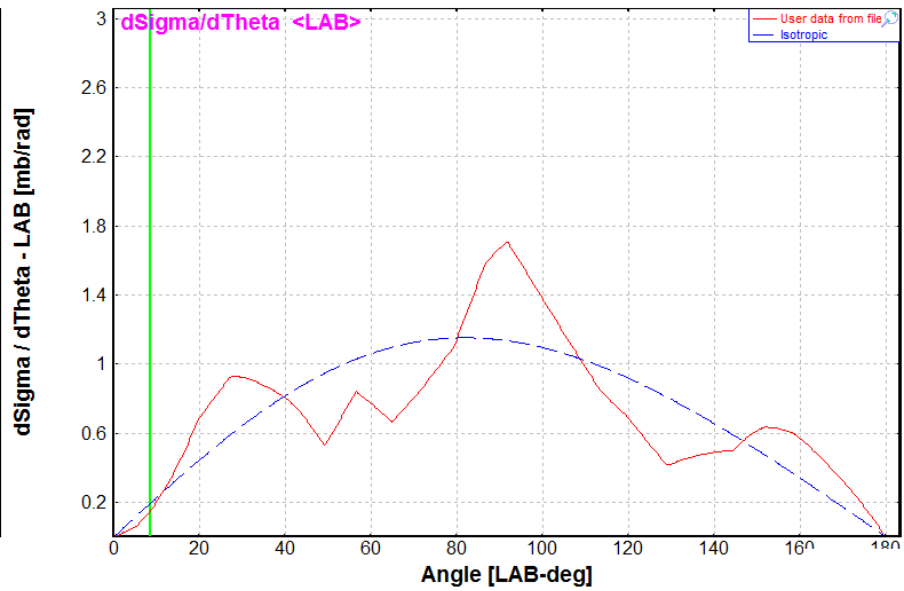
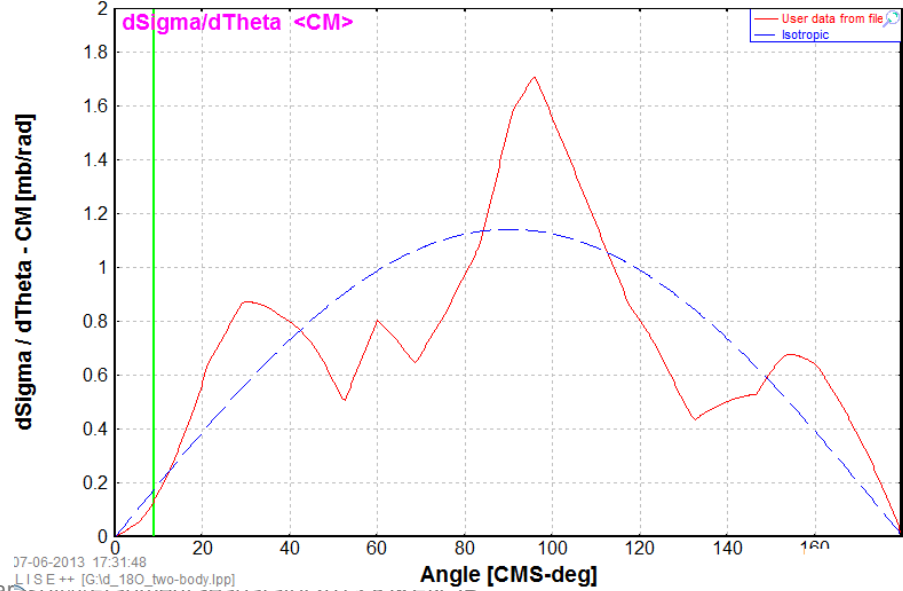
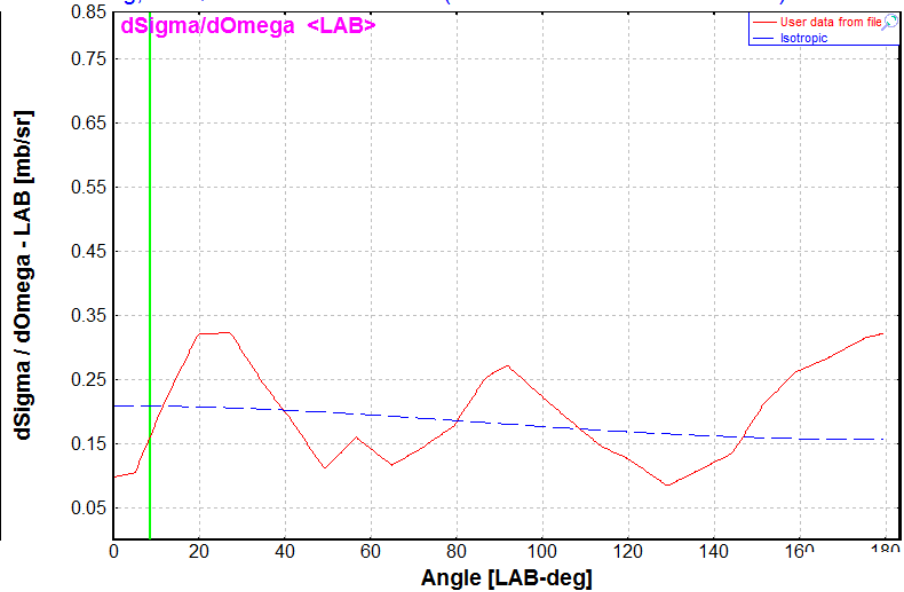
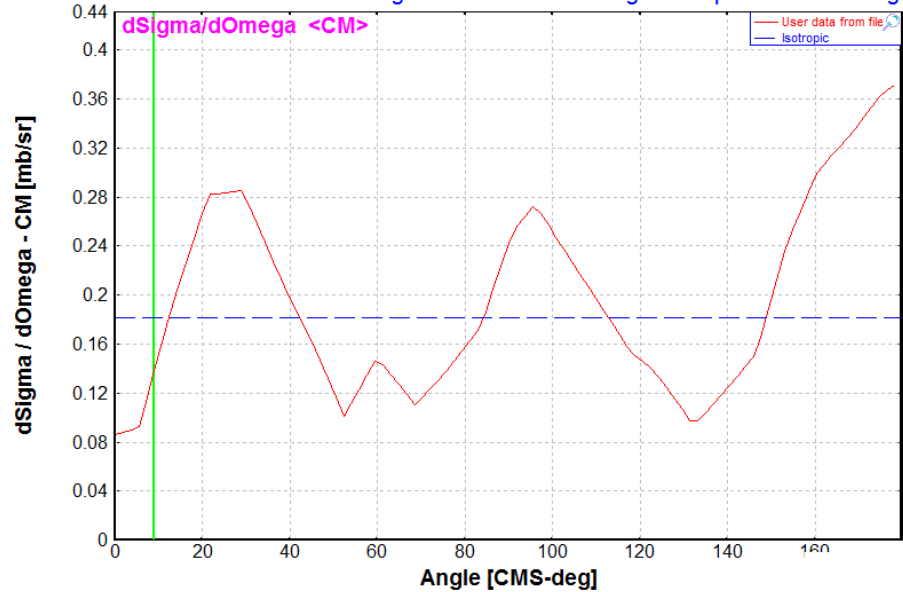
1.8245e+2
5.2946e+0

Differential Cross Section

${}^2\text{H}$ (6.0 MeV/u) + ${}^{18}\text{O}$ \rightarrow ${}^1\text{H}$ (+ ${}^{19}\text{O}$)

User file: "19O_L0.96.txt"; Integrated Cross Section: 2.286 mb; Grazing angle in CMS [${}^2\text{H}+{}^{18}\text{O}$]: 9.00 deg

Max.Angle in Lab: 180.00 deg corresponds to CM Angle 180.00 deg; Q reaction : 0.77 MeV (Excitations 0.0+0.0= \rightarrow 0.0+1.0)

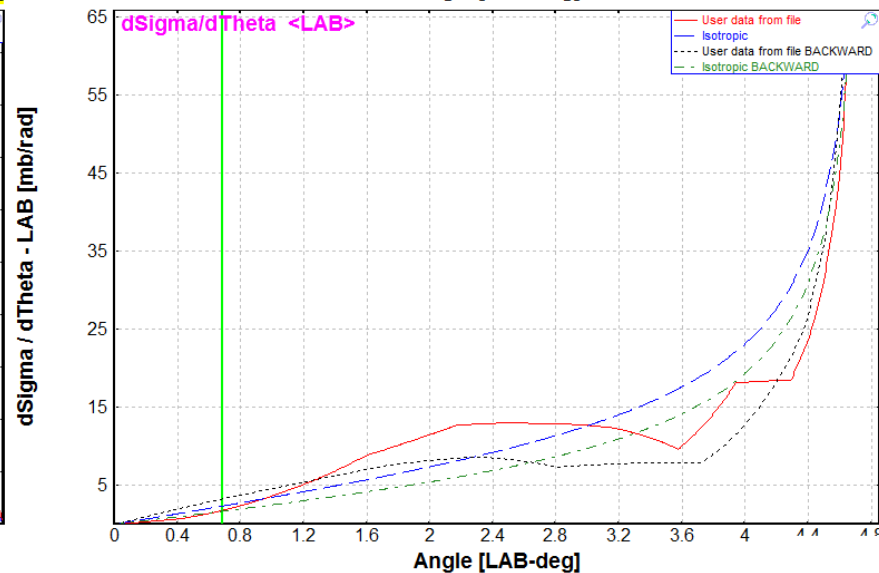
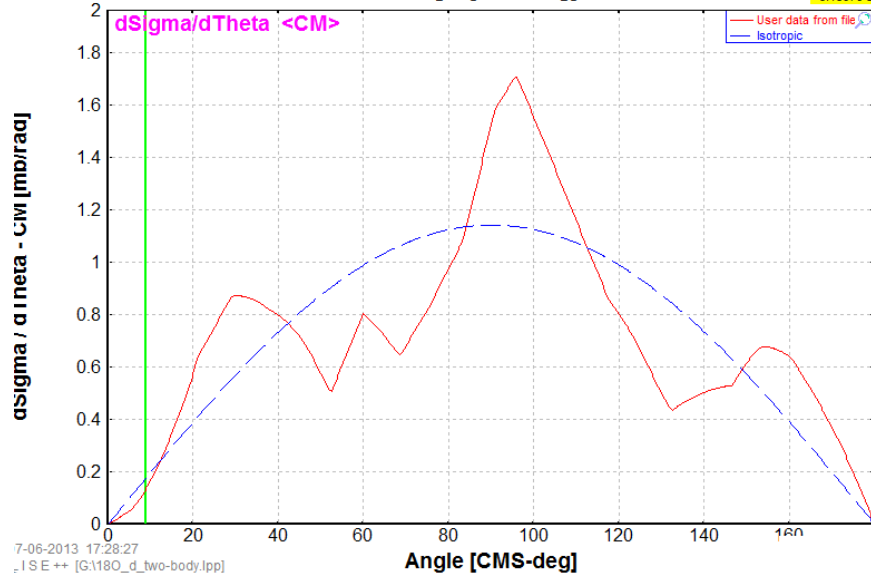
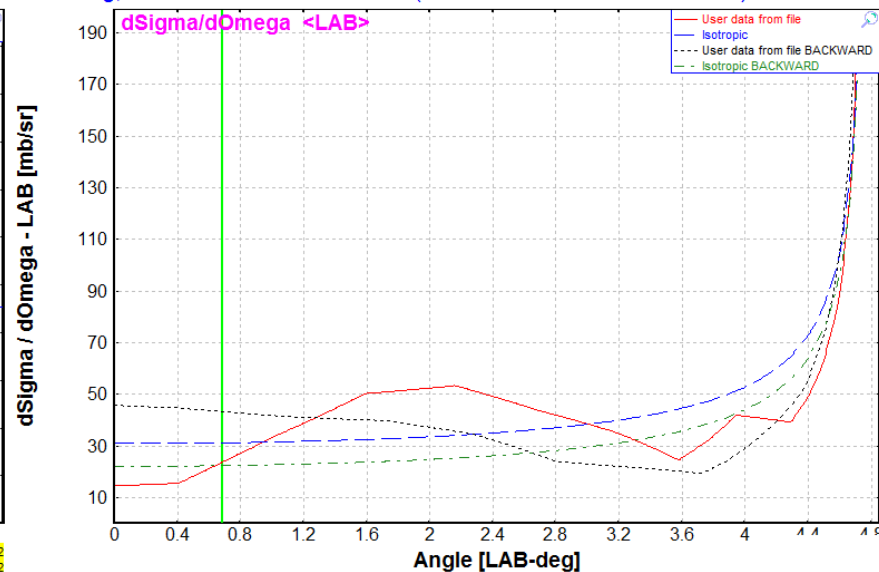
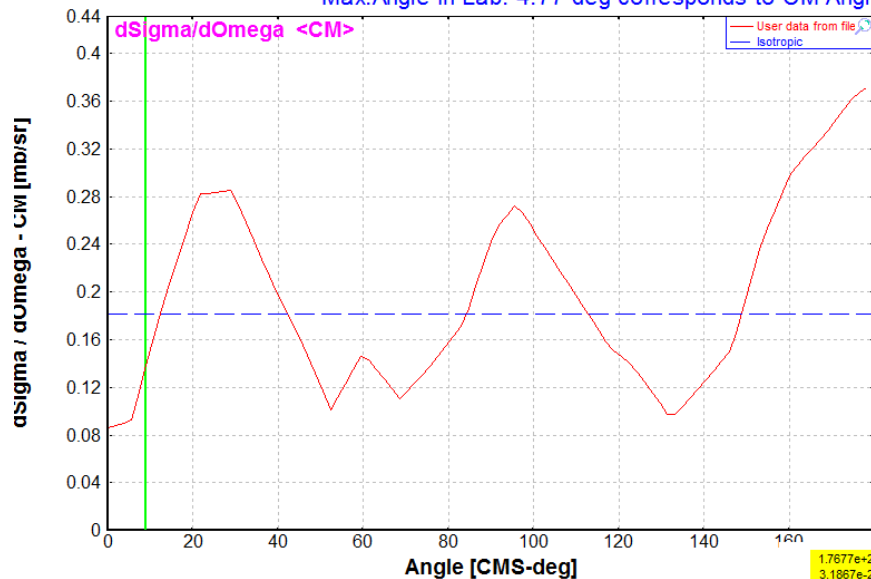


Differential Cross Section

^{18}O (6.0 MeV/u) + ^2H \rightarrow ^{19}O (+ ^1H)

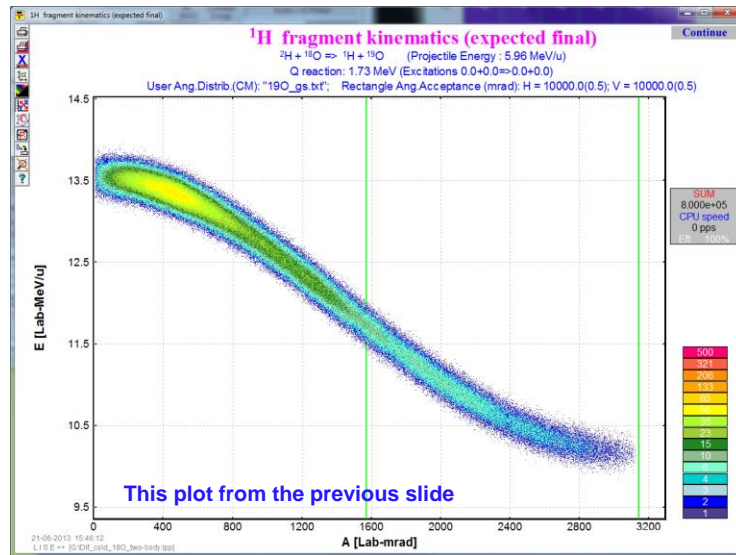
User file: "19O_L0.96.txt"; Integrated Cross Section: 2.286 mb; Grazing angle in CMS [^{18}O + ^2H]: 8.93 deg
 Max.Angle in Lab: 4.77 deg corresponds to CM Angle 94.9 deg; Q reaction : 0.77 MeV (Excitations 0.0+0.0=>1.0+0.0)

Inverse for test

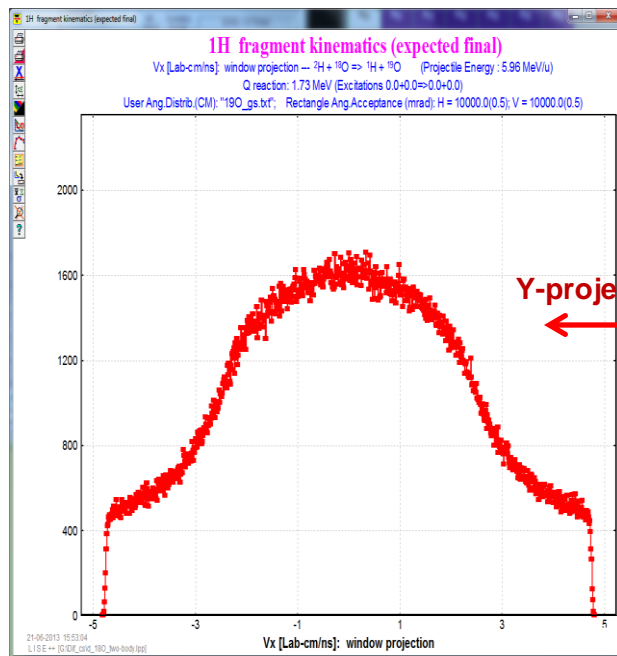
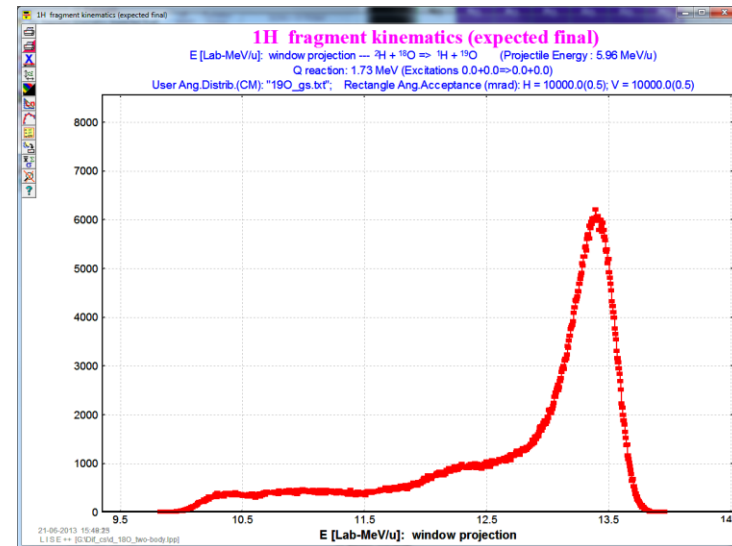


Isotropic

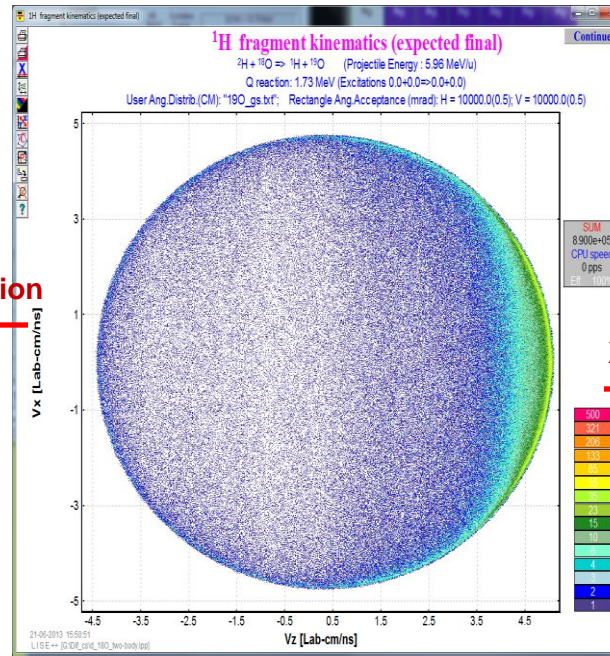
UserDiffCS



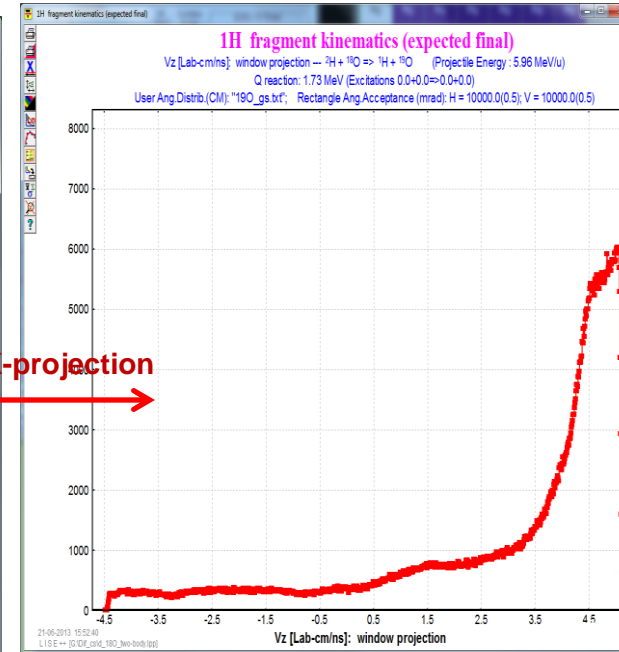
Y-projection

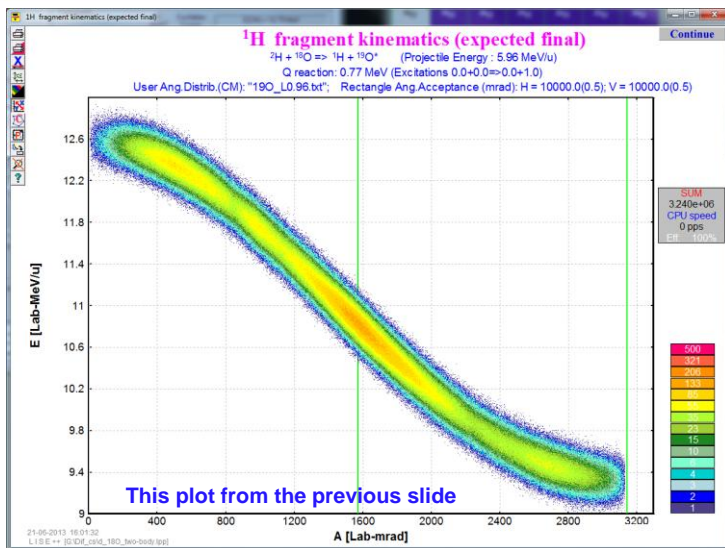


Y-projection

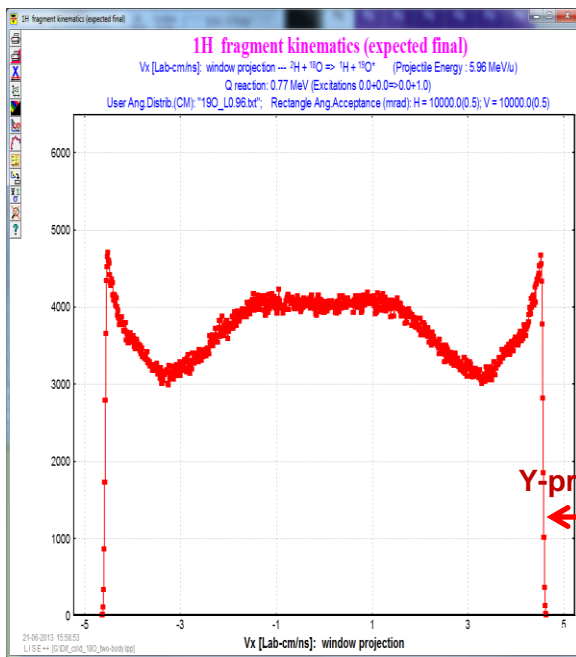
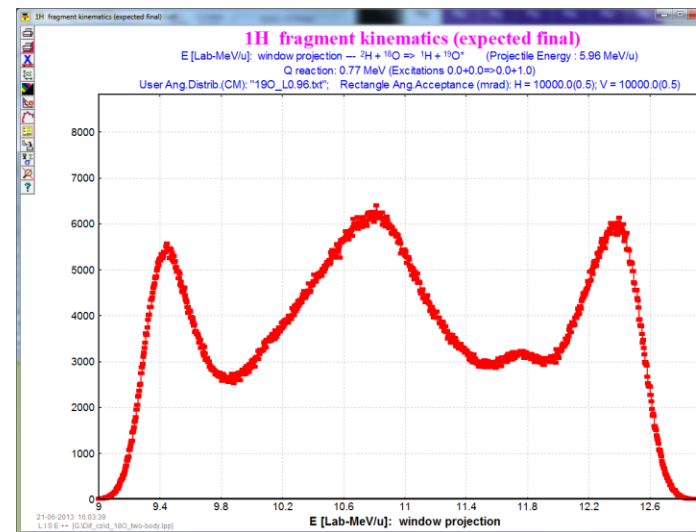


X-projection

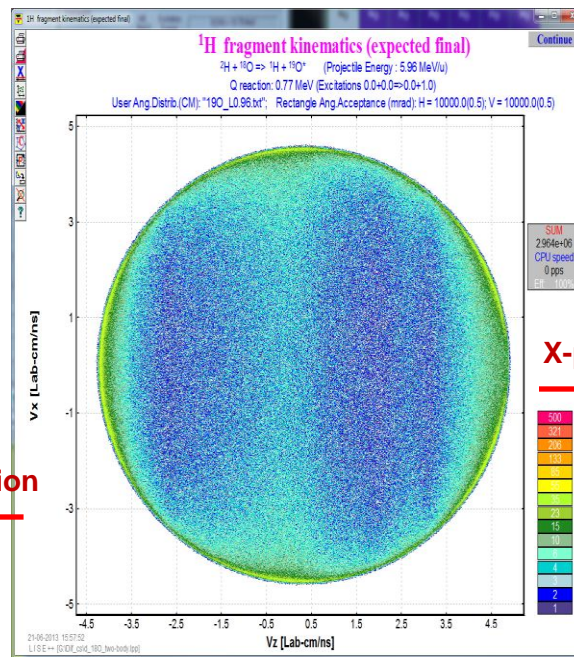




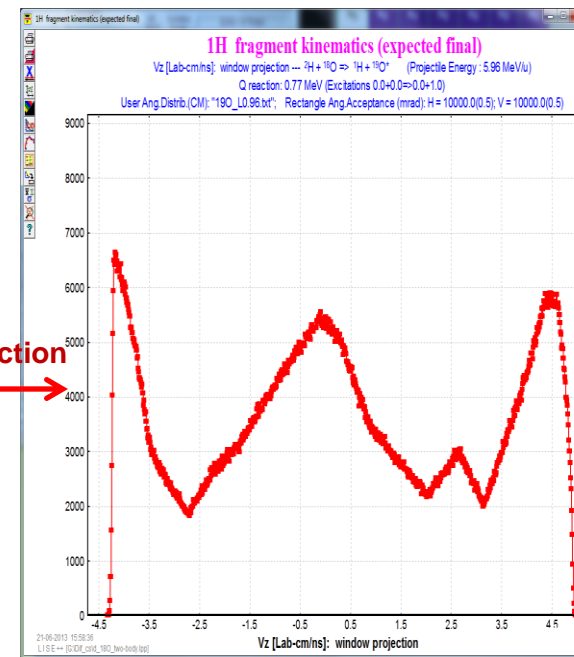
Y-projection



Y-projection



X-projection



LISE++ automatically proposes (p,n) case, if the conjugate fragment has been chosen

Cross sections: Two body reaction

A	Element	Z
19	F	9

Reaction: 18O + H

Number of saved cross sections:

All CS	Int CS	Dif CS
All reactions: 0	0	0
this reaction: 0	0	0

Input new Int CS: absent mb

Input (View) Dif CS: ..

Selected Reaction: Two body reaction

Integral cross sections from models for selected reaction:

Quit

Delete All user cross sections

Differential cross section file

18O (6.0 MeV/u) + 2H -> 19F + 1n

Data File: Load from file | View data | Clear data

190_gs.txt

Number of rows:

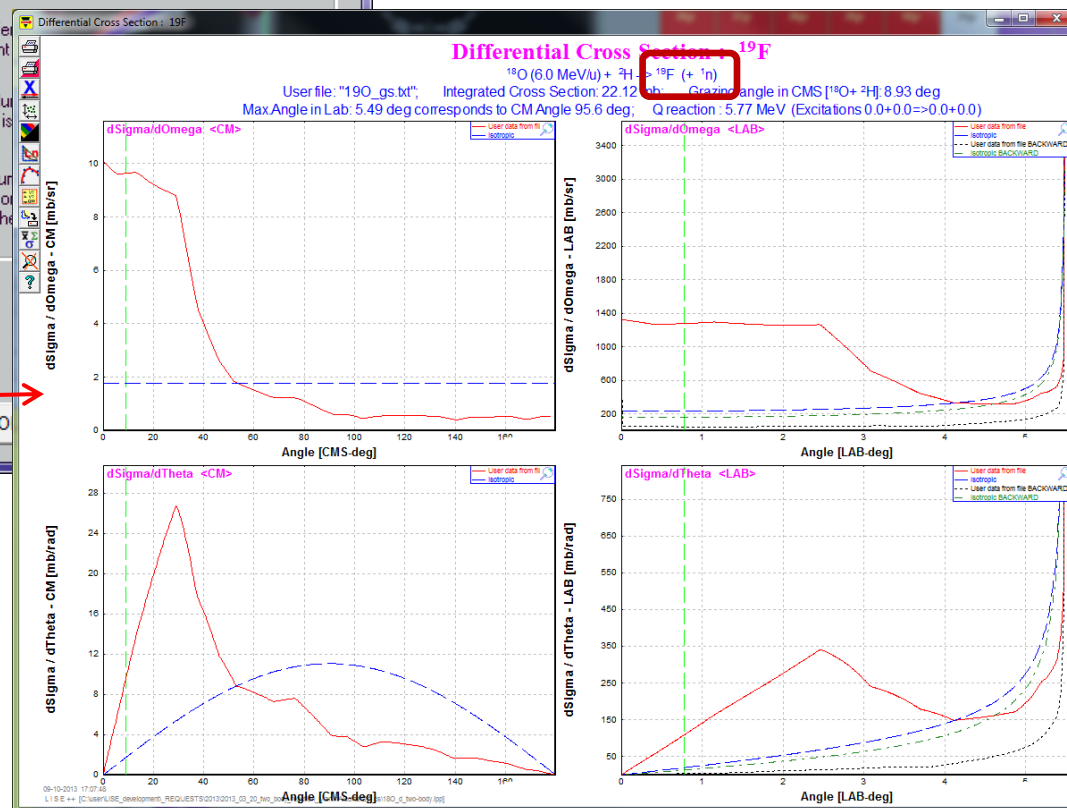
Data	Comments	Total
23	2	25

Excitation energies of products (MeV):

E* of 19F = 0 E* of 1n = 0

Integrated Cross Section (mb): 22.12

Dif. Cross Section Plots



Physics : Abrasion-Ablation

During analysis of GSI's ^{238}U , RIKEN's ^{238}U , MSU's ^{82}Se experiments there was significant modification of LISE⁺⁺ AA:

- Improving/Fixing problems (interpolation, new methods),
- new properties (excitation energy thermalization and etc),
- new utility: Initial prefragments plot, Decay Analysis utility update,
- new mass tables (AME2011, GXPF1B), unknown masses extrapolation procedure update and so on

Evaporation calculator

Initial nucleus: 82Se
 Excitation energy window: Lower = [] MeV (gaussian), Upper = [] MeV (rectangle)
 Initial nucleus production cross-section = [] mb
 make calculations down to Z = [1]

Modes:
 Fragmentation of beam (Abrasion-Ablation)
 Excited nucleus evaporation
 Load initial conditions from file

2D-plots:
 Final Evap. Residue CS
 Decay channel analysis
 Fission channel CS
 Temperature
 Break-up channel CS
 Fission Excitation Energy

Final nucleus:
 A: 54, Element: Ca, Z: 20
 stable
 Table of Nuclides
 Z: [] N: []
 Excitation energy plot

Final fragment production cross-section: 6.14e-8 mb
 Initial production CS of Final fragment (for fragmentation or file options): 1.04e+0 mb
 Cross section from EPAX 2.15: 2.79e-6 mb

Minimum separation energy (SE): 3.59 MeV
 Minimum sum of (SE + deduced effective Coulomb barrier): 3.59 MeV
 Fission barrier at L=0: 46.89 MeV

Average values:
 $\langle E_x \rangle$ = 220.69
 $\langle T \rangle$ = 5.39

PARENT	3.49e+0	4.1e-1	1.78e-1	2.01e-1			4.28e+0	55Ca
Decay modes	1n	1p	alpha	t			Break-up	sum
DAUGHTER	4.95e+0	1.64e-1	5.03e-2	1.61e-1			5.32e+0	53Ca

N° of all calculated nuclei: 1331

Sum	1.09e+4	2.34e+3	7.84e+2	1.97e+2			Initial	Residues	Fission	Break-up
							1.66e+3	1.66e+3		1.16e-2

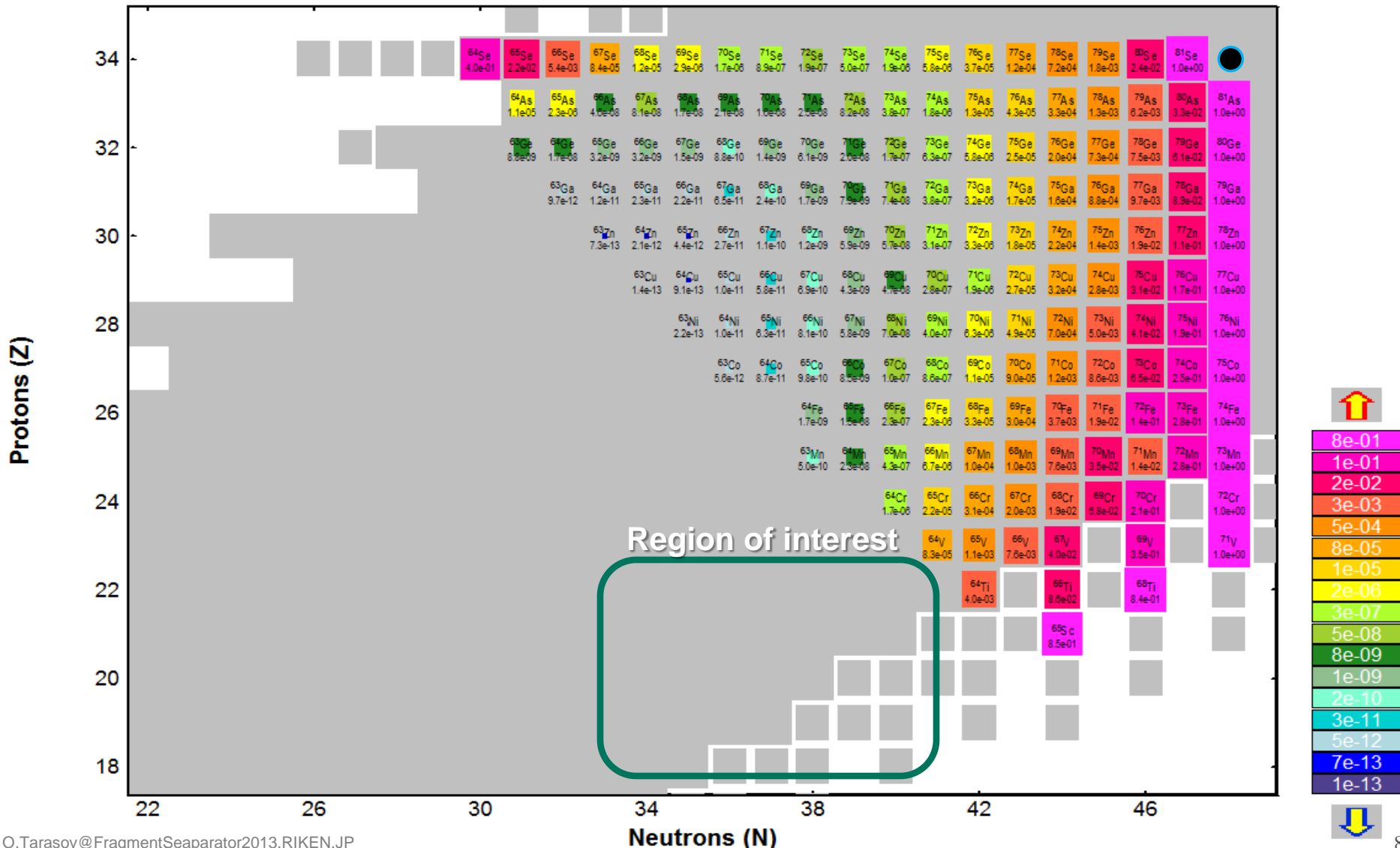
Output cross-section file: 08234_00904.lcs
 Output file of parent-daughter: 08234_00904.lpd
 Fission CS output file: 08234_00904.lcs

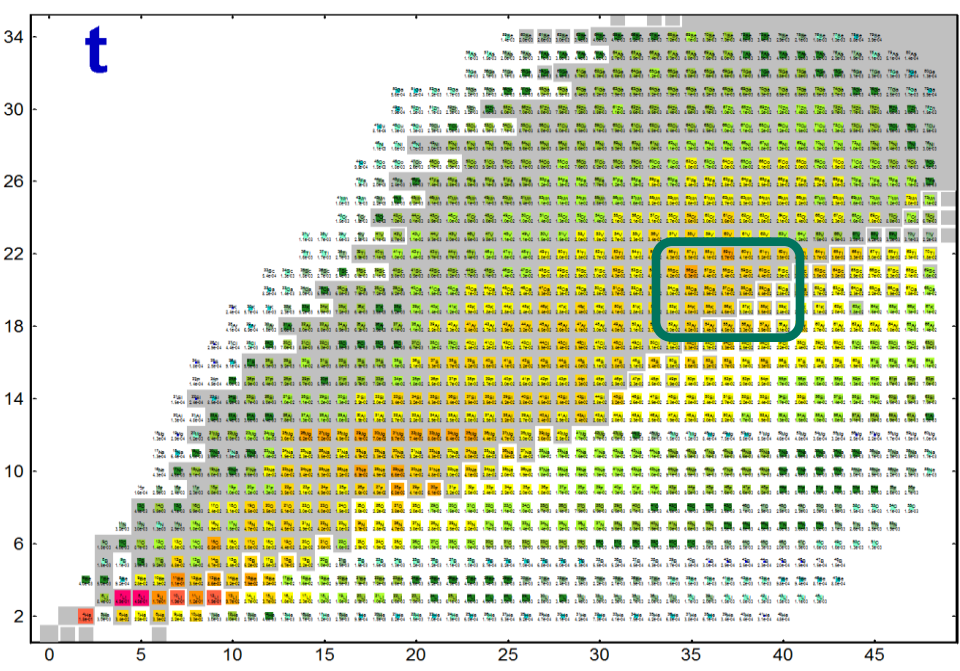
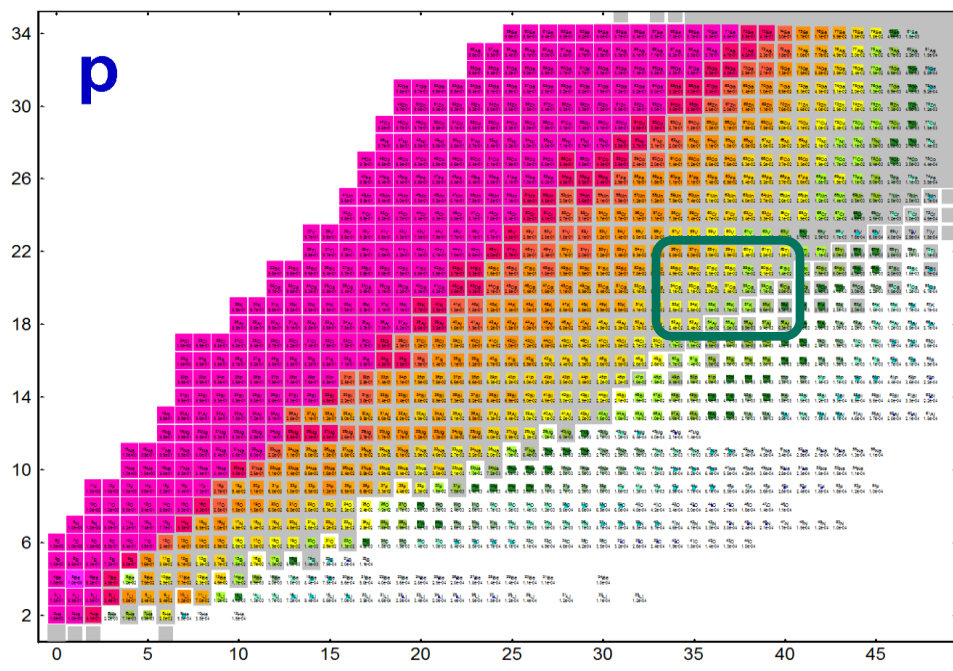
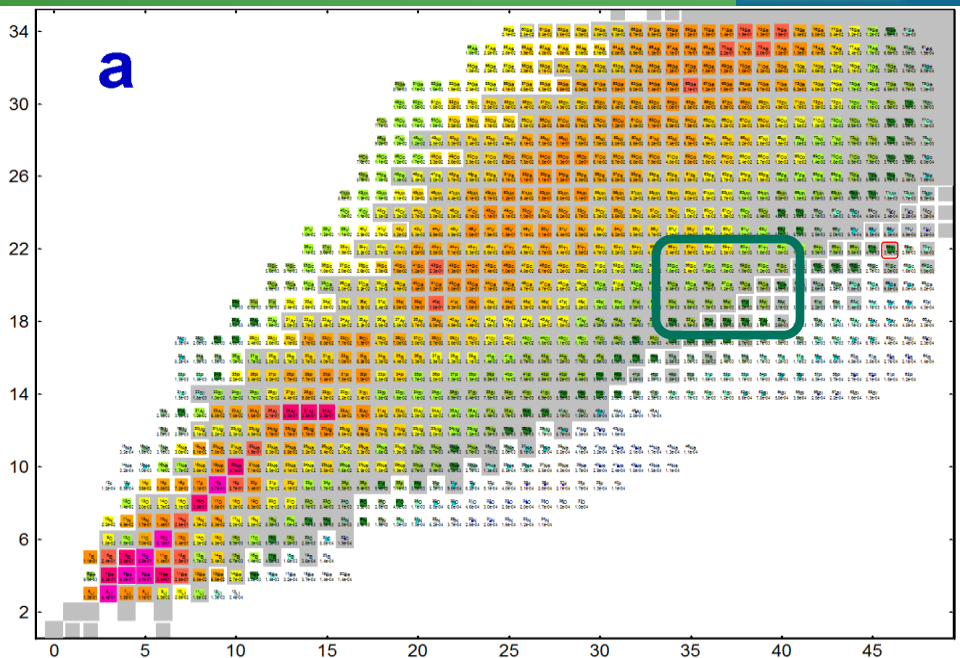
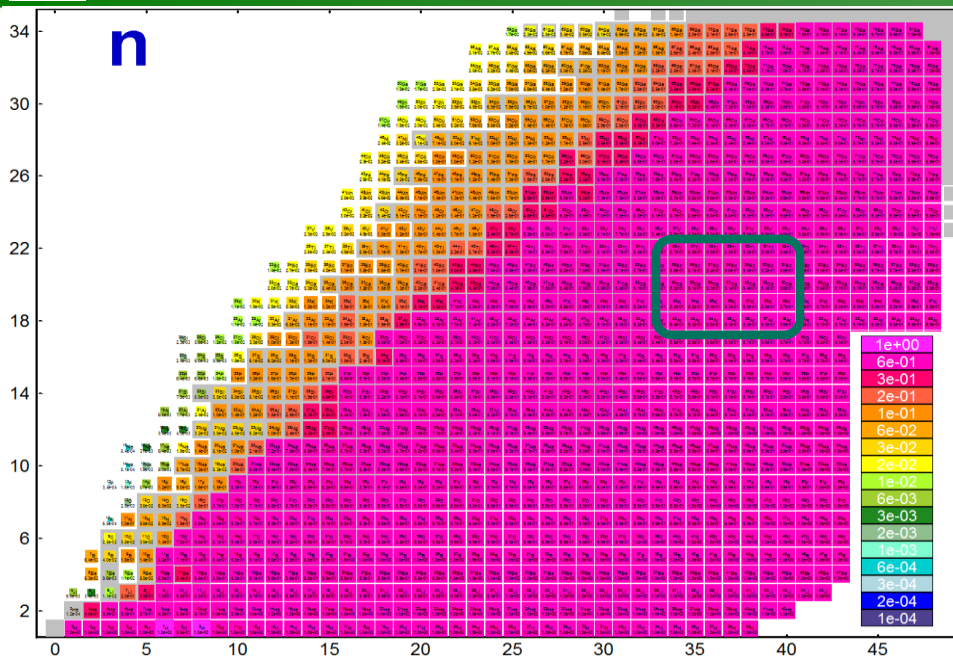
Buttons: CALCULATE, Evaporation settings, Initial Prefragments Plot for final nucleus, Help, Quit

Current mode: Initial CS -> [S residue] / [Sr total]

ABRASION-ABLATION - $^{82}\text{Se} + \text{Be}$

Excit.Energy Method:< 2 >; < E* >:15.0*dA MeV Sigma:9.15; Coef^{Thermalization}=5.00e-22 MeV.s DB₁="GXPF1B"
 NP=64; SE:"DB1+Cal0" Density:"auto" GeomCor:"On" Tunlg:"auto" FisBar=#1 Bar^{Fac}=1.00 Modes=1010 1010 010



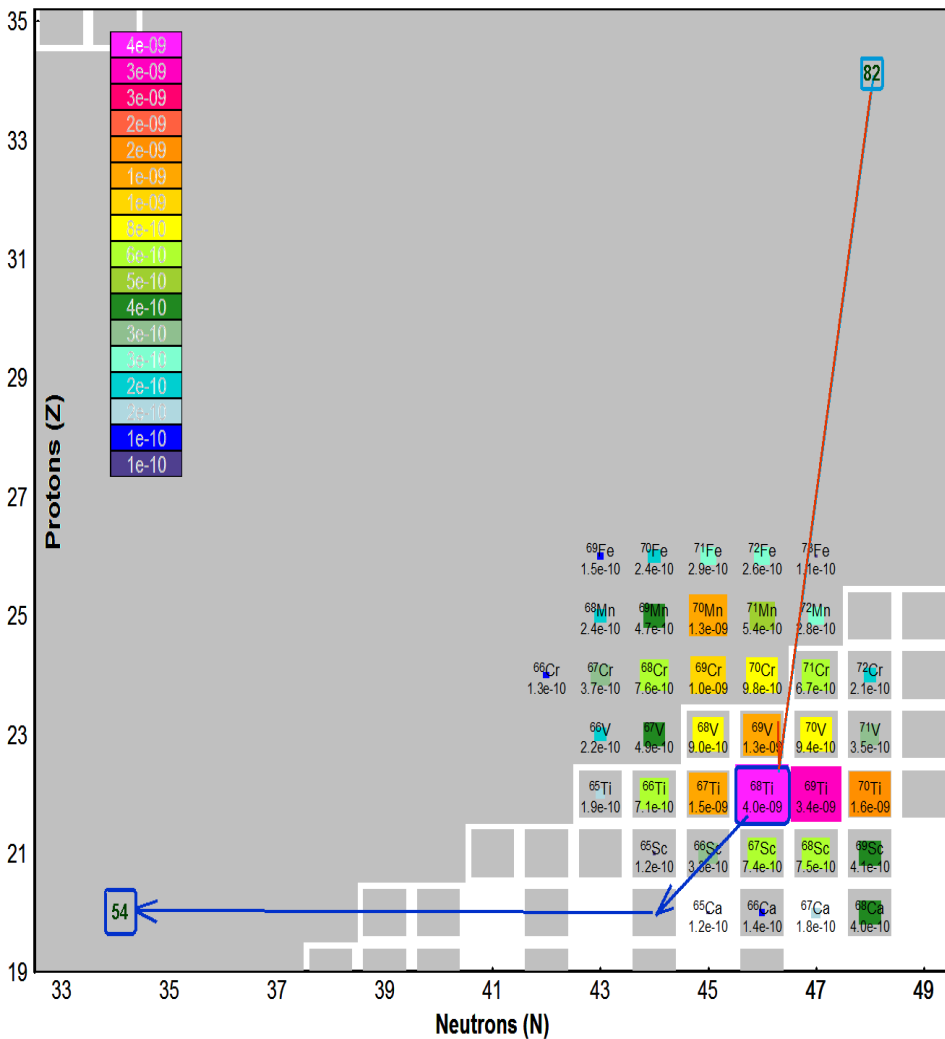


Initial Prefragments Plot for ⁵⁴Ca (2.78e-08 mb)

ABRASION-ABLATION - ⁸²Se + Be: more probable ⁶⁸Ti(4.02e-09 mb); <-dZ>=2.88 <-dN>=11.78

Excit.Energy Method:< 2 >; <E*>:15.0*dA MeV sigma:9.20; Thermal.Intr.Coef. = 5.00e-22 MeV*s

NP=64; SE:"DB1+CaI0" Density:"auto" Geom.Corr:"On" Tunlg:"auto" FisBar=#1 BarFac=1.00 Modes=1010 1010 010

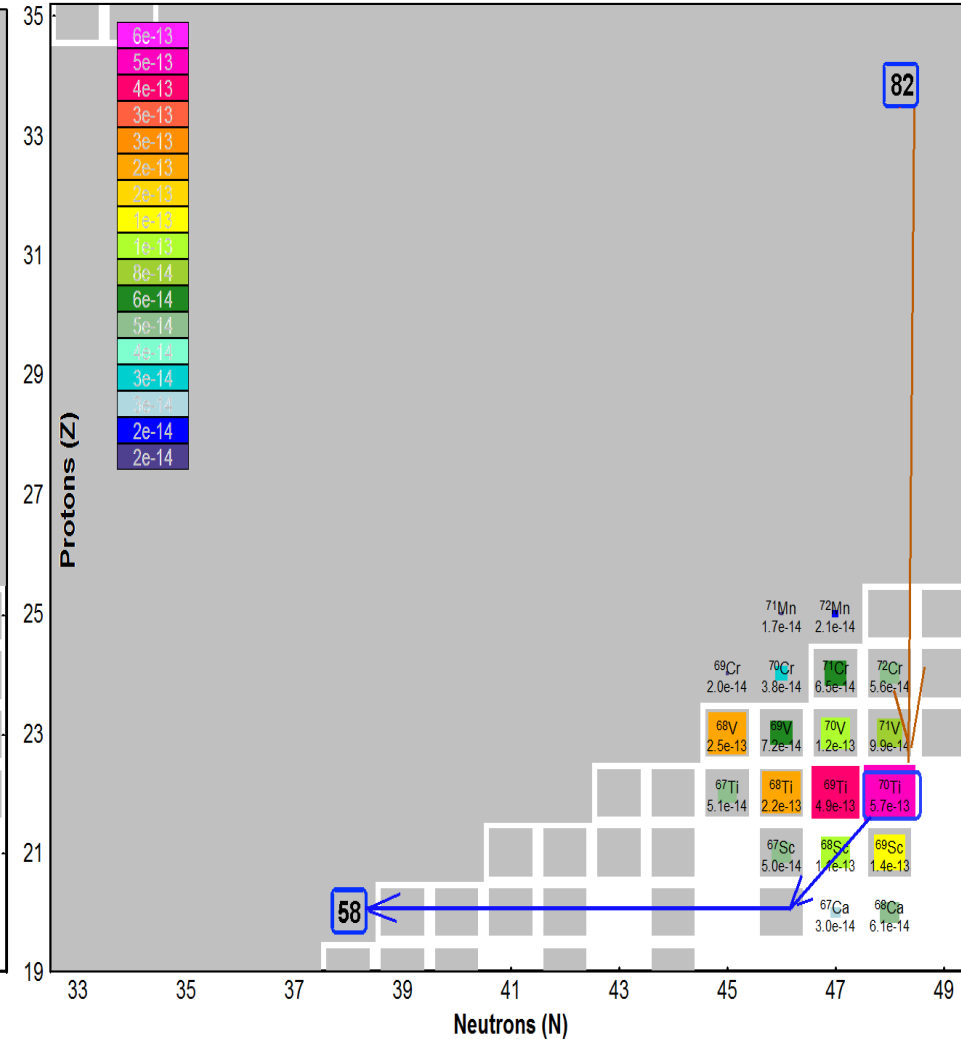


Initial Prefragments Plot for ⁵⁸Ca (2.57e-12 mb)

EVAPORATION - Compound nucleus ⁶⁸Ti: more probable ⁷⁰Ti(5.73e-13 mb); <-dZ>=2.27 <-dN>=8.89

Excit.Energy: 149.0-207.0 MeV; Fus.CS: 0.0 mb; Fus.Barrier: 10.82 fm; h_omega = 2.0 MeV

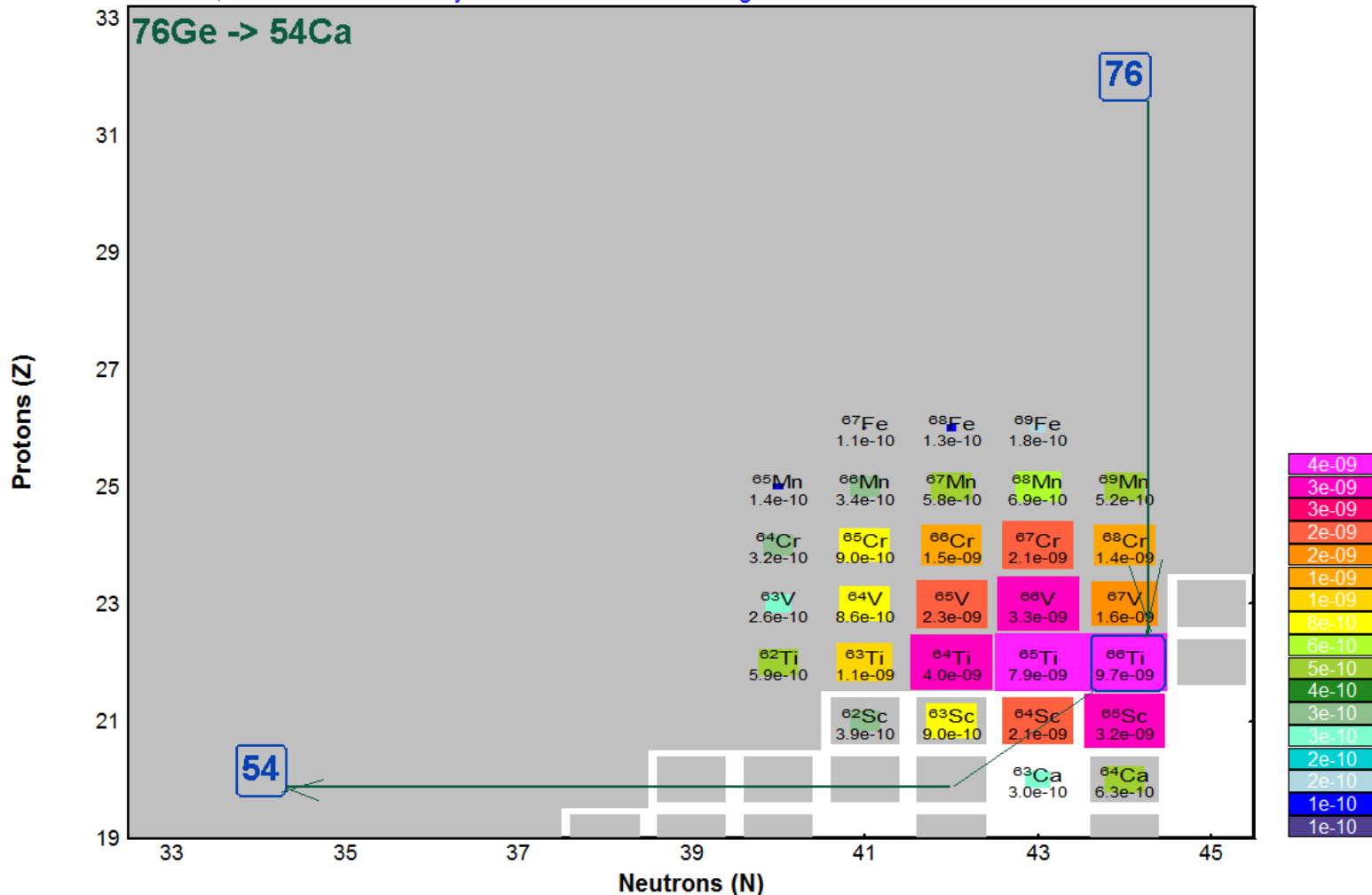
NP=64; SE:"DB1+CaI0" Density:"auto" GeomCor:"On" Tunlg:"auto" FisBar=#1 BarFac=1.00 Modes=1010 1010 010



More probable prefragments are Ti-isotopes (dZ=2)

Initial Prefragments Plot for ⁵⁴Ca (4.85e-08 mb)

ABRASION-ABLATION - ⁷⁶Ge + Be: more probable ⁶⁶Ti(9.68e-09 mb); <-dZ>=2.46 <-dN>=8.90
 Excit.Energy Method:< 2 >; <E*>:15.0*dA MeV Sigma:8.60; Coef^Thermalization=5.00e-22MeV.s DB1="GXPF1B"
 NP=64; SE:"DB1+Cal0" Density:"auto" GeomCor:"On" Tunlg:"auto" FisBar=#1 Bar^{Fac}=1.00 Modes=1010 1010 010



More probable prefragments are Ti-isotopes (dZ=2)

PACE 4

PACE4 version 4.18
LISE++ package version 9.2.75

IDIST should be > 0 to have access to the "Particle analysis" group

The screenshot shows the PACE4 software interface with the following parameters and options:

- NCASC**: 100 (number of cascades. (events in Monte Carlo calculation < 1 000 000))
- INPUT**: 1 (dropdown menu)
- FYRST**: 0 (parameter determining yrast line to be used. FYRST < 0 provides the G-C yrast line. < 0 Gilbert-Cameron spin cutoff parameter. EROT = (SPIN)**2/(2.*SIGSQ) != 0. EROT = rotating liquid drop rotational energy, multiplied by factor of FYRST. ==0 value changed to FYRST = 1. In both cases level density calculated at E = EX-EROT.
- BARFAC**: 0 (The program assumes the A.J.Sierk modified rotating liquid drop barrier if this is equal to 0. If you provide a fission barrier of your own, the Sierk barrier will be renormalized accordingly. If BarFac is positive it will be taken as the desired zero spin fission barrier. If BarFac is negative, its absolute value will be taken as a factor to multiply the Sierk barrier.)
- ARATIO**: 1 (Ratio of the Fermi gas level density parameter 'LITTLE-A' at the saddle point to the ground state value. The saddle point level density is determined by g.s. 'LITTLE-A' * ARATIO.)
- FACLA**: 10 (level density parameter = MASS/FACLA if not zero. if ==0 Gilbert and Cameron value used.)
- IDIST** (radio buttons):
 - =0 brief, schematic results of particle spectra and list of evaporated (residual) nuclei
 - =1 detailed angular and energy distribution of residual nuclei and evaporated particles.
 - =2 detailed(1) + transmission coefficients for particle emission
- MDIR** (radio buttons):
 - = 0 Compound nucleus is initially in M=0 states and the Z-axis is the recoil axis.
 - = 1 Compound nucleus is initially in M=J states, the Z axis is perpend. to recoil direction.
- ITRAC** (radio buttons):
 - = 0 produces compact traceback, summed over all residues.
 - = 1 detailed traceback leading to each individual isotope separately.
- NOSHL** (radio buttons):
 - =0 uses AME2003 values (A,W&T, NPA 729, 2003, pp.336-676)
 - =1 uses Lysekil masses with shell correction
- Particle analysis** (checkboxes):
 - Create output file
 - neutron
 - proton
 - alpha

Annotations in the image include a blue arrow pointing to the IDIST section and a red arrow pointing to the Particle analysis section.

"Particle analysis" group

The code operates under MS Windows environment and provides a highly user-friendly interface. It can be freely downloaded from the following internet addresses:

<http://www.nsci.msu.edu/lise>

Detailed analysis of Emitted particles: "Untitled.particles"

Decay Mode	N mode	N All	Chain	Z_f final	N_f final	Zc emitter	N_c emitter	J_c init	J_f final	M_Jc proj-n	Fission prob	Ex_i MeV	Ex_f MeV	Ep_Lab MeV	Ap_Lab deg
1	1	1	1	70	93	70	102	58	54	0	1.5e-03	143.1	126.5	6.5	115.0
1	2	2	2	68	90	70	102	24	21	0	4.5e-05	143.1	127.5	7.2	087.1
1	3	3	35	67	91	70	102	24	26	0	4.5e-05	143.1	131.5	1.7	136.6
1	4	4	81	66	91	70	102	24	23	0	4.5e-05	143.1	130.5	2.2	151.1
1	5	5	3	69	92	70	102	22	22	0	3.1e-05	143.1	132.5	3.5	056.4
1	6	6	23	70	91	70	102	22	21	0	3.1e-05	143.1	133.5	2.5	049.2
1	7	7	4	70	92	70	102	52	48	0	5.5e-04	143.1	129.5	6.9	059.0
1	8	8	33	70	92	70	102	52	46	0	5.5e-04	143.1	126.5	7.8	093.0
1	9	9	80	68	91	70	102	52	51	0	5.5e-04	143.1	133.5	1.9	065.5
1	10	10	100	69	93	70	102	52	47	0	5.5e-04	143.1	127.5	10.3	041.8
1	11	11	31	70	92	70	102	31	31	0	4.7e-05	143.1	132.5	3.8	051.1

Decay mode : type of particle emitted 1-n, 2-p, 3-alpha

N mode : number of emitted particle in this mode (for example "p")

N all : number of emitted particle in all modes (n,p,a)

Chain : Number of chain (cascade)

Z_f, N_f : Z and N of the final nucleus in the chain of decay

Z_c, N_c : Z and N of emitting nucleus (if Z_c is negative, it means that the nucleus fissioned)

J_c, J_f : initial and final spin indices for this particle emission indices for this particle emission

M_Jc : the projection of J_c on the Z-axis.

(Fractional spins are neglected for the projection. For J_c, J_f, the actual spin = J_c, J_f-1 in even mass nucleus, J_c, J_f-1/2 in odd mass nucleus)

Fission prob : Fission probability

Ex_i : excitation energy at emitting level (MeV)

Ex_f : excitation energy at final level (MeV)

Ep_Lab : emitted particle energy in the Lab. System (MeV)

Ap_Lab : emitted particle angle in the Lab. System (degrees)

PACE4 version 4.19.2

LISE++ package version 9.2.108

06/14/2011

PACE4 [batch.in] → filename_step00x

Previous page **CARD 2-1** Next page

Projectile	Target	Compound
A = 48 N = 28	A = 124 N = 74	A = 172 N = 102
Z = 20 Ca	Z = 50 Sn	Z = 70 Yb
Spin (gs) = 0	Spin (gs) = 0	
ME (MeV) = -44.214 DB	ME (MeV) = -88.237 DB	ME (MeV) = -59.260 DB

QCN = 0 Q value of reaction [MeV].
If == 0 it is calculated from mass tables.

Beam Energy (MeV)

ELAB_min = 300 Batch Mode

ELAB_max = 390 N of Steps = 20

Calculation

QCN = -73.191

E_CM = 216.279

Ex = 143.089

EXPSIG = 0 experimental fusion cross section if known. TL-S from optical model shifted to reproduce this value if inputted, preserving the L-diffuseness. if == 0 Bass model (PRL 1977) fusion cross section being used. (only for "classical" mode).

JCMAX = 0 Maximum J to be used during calculations. (if 0 it is taken from optical model routine)

AGRAZ = 4 To bypass input channel optical model routine (TLOM) specify L-diffuseness of fusion cross section. If == 0 diffuseness will be set to 0.5 which is essentially sharp cutoff. (only for "classical" mode)

ELOSS = 0 energy loss of beam thru full target width. (total dE) energies will be distributed between Ebeam & Ebeam-Eloss

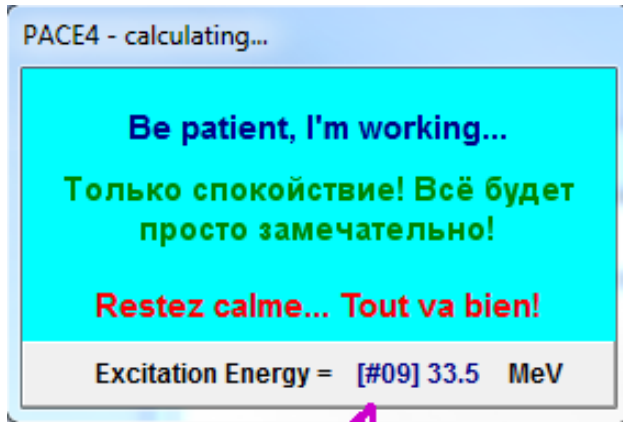
LMINN = 0 Lowest partial wave L in calculation. Partial waves from L=0 to LMINN excluded, enabling low-L non-fusion window in reaction calculation.

Transmission probability for a one-dimensional barrier (O.T.)

Classical (use it above the barrier)

Quantum-mechanical [D.Hill & J.Wheeler, PhysRev 89(1953) 1105]

Note: If you are running at high bombarding energies for which the grazing angular momentum is above 75 hbar, it is recommended to input AGRAZ > 0, and to specify an arbitrary value for EXPSIG (or 0 = Bass) which corresponds to a fusion cross section with a limiting L-value around 80. This will give you all the evaporation residue data and the fission probabilities you need. For J>80 all nuclei will fission anyway, and you will run out of dimension if you try.



shows current step in the Batch mode

The code operates under MS Windows environment and provides a highly user-friendly interface. It can be freely downloaded from the following internet addresses:

<http://www.nsci.msu.edu/lise>

- batch
- batch
- batch_step001
- batch_step001
- batch_step002
- batch_step002
- batch_step003
- batch_step003
- batch_step004
- batch_step004
- batch_step005
- batch_step005
- batch_step006
- batch_step006
- batch_step007
- batch_step007
- batch_step008
- batch_step008

```

in                170
rtf               94,208
particles         1,606,052
rtf              107,244
particles         1,754,603
rtf              112,204
particles         1,851,573
rtf              121,202
particles         1,949,429
rtf              128,027
particles         2,060,912
rtf              124,967
particles         2,192,401
rtf              134,066
particles         2,306,423
rtf              124,422
particles         2,391,162
rtf              126,073
    
```

Name	Ext	Size
[..]		<DIR>
[PublishedData]		<DIR>
batch	cs4	637
batch_step001	cs4	927
batch_step002	cs4	985
batch_step003	cs4	1,101
batch_step004	cs4	1,217
batch_step005	cs4	1,246
batch_step006	cs4	1,362
batch_step007	cs4	1,478
batch_step008	cs4	1,622
batch_step009	cs4	637
batch_step010	cs4	753
batch_step011	cs4	782
batch_step012	cs4	898
batch_step013	cs4	782
batch_step014	cs4	869
batch_step015	cs4	956
batch_step016	cs4	810
batch_step017	cs4	956
batch_step018	cs4	927
batch_step019	cs4	1,014
batch_step020	cs4	1,130

PACE4 [batch.in] filename_step00x

Projectile: A = 48, N = 28, Z = 20, Ca, Spin (gs) = 0, ME (MeV) = -44.214 DB

Target: A = 124, N = 74, Z = 50, Sn, Spin (gs) = 0, ME (MeV) = -88.237 DB

Compound: A = 172, N = 102, Z = 70, Yb, ME (MeV) = -59.260 DB

Beam Energy (MeV): ELAB_min = 300, ELAB_max = 390, N of Steps = 20, Batch Mode

QCEN = 0, QCEN = 73.191, E_CM = 216.279, Ex = 143.089

EXPSIG = 0, JCMAX = 0, AGRAZ = 4, ELOSS = 0, LMINN = 0

Transmission probability for a one-dimensional barrier (D.T.): Classical (use it above the barrier), Quantum-mechanical (D.Hill & J.Wheeler, PhysRev 89(1953) 1105)

Note: If you are running at high bombarding energies for which the grazing angular momentum is above 75 hbar, it is recommended to input AGRAZ > 0, and to specify an arbitrary value for EXPSIG (or D = Bess) which corresponds to a fusion cross section with a limiting L-value around 80. This will give you all the evaporation residue data and the fission probabilities you need. For >80 all nuclei will fission anyway, and you will run out of dimension if you try.

PACE version : 4.20

In LISE++ package v.9.6.31

from 23-May-2013

Transmission probability for a one-dimensional barrier (O.T.)

Classical (use it above the barrier)

Quantum-mechanical [D.Hill & J.Wheeler, PhysRev 89(1953) 1105]

1. R_fusion value has been used to calculate partial waves L in QM mode, in order to avoid “classical” subroutines in at energies below the barrier.

However this assumption gives some serious jumps (it will be shown later), and the code has been modified to avoid this problem, coming back above the barrier to the classical solution in QM mode.

2. Default value of AGRAZ which was equal to 4, now set to 2

LISE for Excel

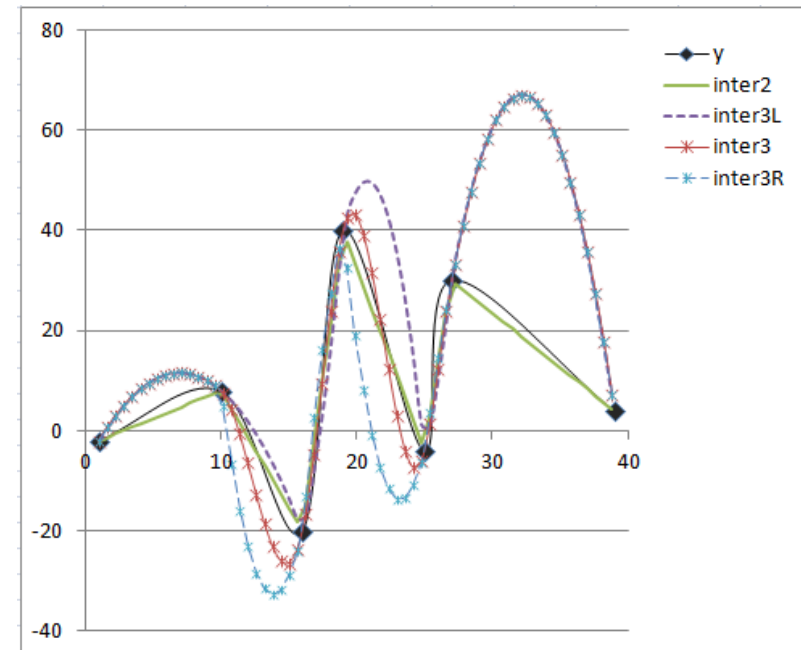
New functions:

- public **find_line** (x1,y1,x2,y2, **x**)
- public **find_parabola** (x1,y1,x2,y2,x3,y3, **x**)
- public **interpolate2** (Xarray, Yarray, **x**)
- private **interpolate3L** (Xarray, Yarray, **x**) : based on *find_parabola*. X is between 1st and 2nd parabola points
- private **interpolate3R** (Xarray, Yarray, **x**) : based on *find_parabola*. X is between 2nd and 3rd parabola points
- public **interpolate3** (Xarray, Yarray, **x**) : combination of interpolate3L and interpolate3R. **Recommended**

Xarray should be sorted!

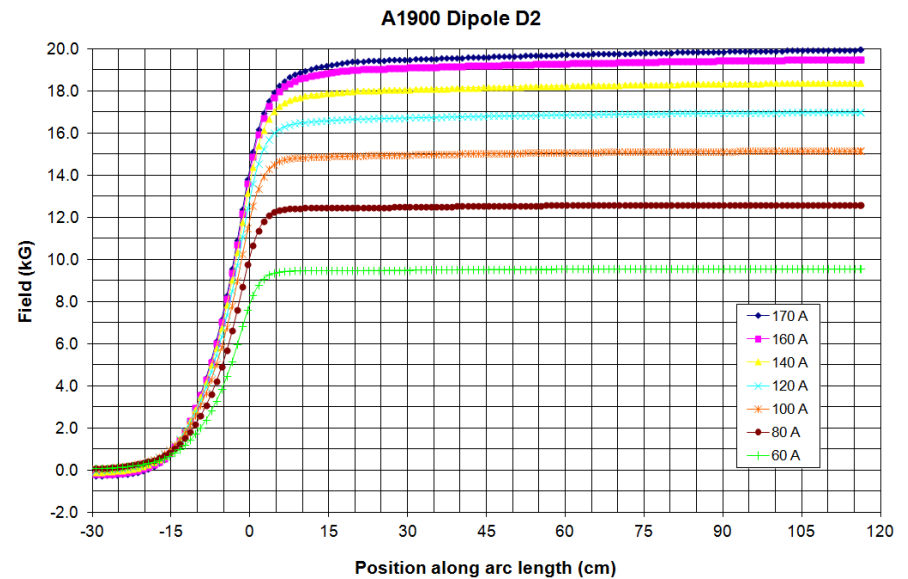
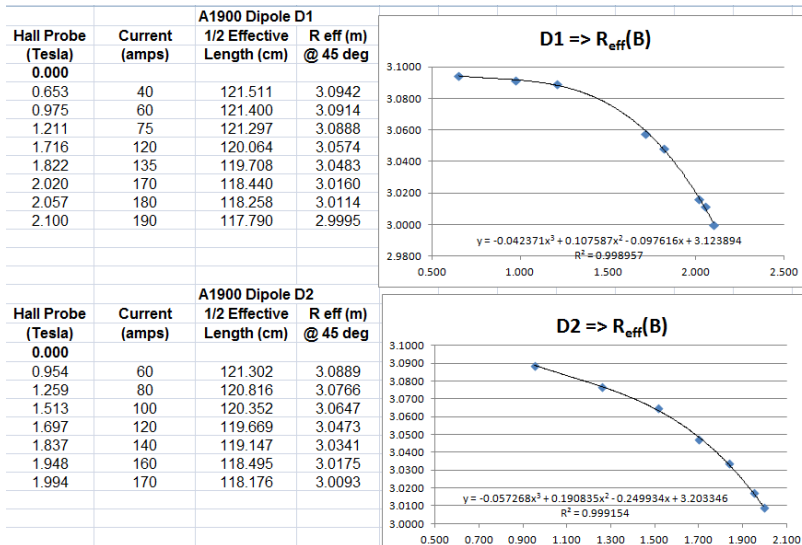
- 778 : count(Xarray) != count(Yarray)
- 777 : at least one cell in Xarray is not value
- 776 : Xarray order is wrong. Non-sorted
- 775: count(Xarray) < 3
- 774: x < min(Xarray)
- 773: x > max(Xarray)
- 771: at least one cell in Yarray is not value

See example "[test_for_lise_excel.xlsx](#)",
Sheet "interpolation"



New functions (2011):

- public **A1900_R_Dipole** (N,B), where N – dipole number, B – magnetic field (T); return R in m
- public **A1900_Br_Dipole** (N,B), where N – dipole number, B – magnetic field (T); return Brho in Tm
- private **A1900_R_DipoleX** (B), where X – dipole number, B – magnetic field (T); return R in m
- private **A1900_Br_DipoleX** (B), where X – dipole number, B – magnetic field (T); return Brho in Tm m



See example [“test_for_lise_excel.xlsx”](#)
Sheet “A1900_dipoles”

Daniel has transported some LISE++ libraries to Mac OS, and modified the LISE-Excel shell and its macros to operate under Mac OS. It is a beta-version. Please, submit your remarks to Daniel (bazin@nscl.msu.edu)

http://lise.nsl.msu.edu/download/other/LISE_for_Excel_Mac_OS/

Links to download the installer of "LISE_for_Excel" version for Mac OS from the LISE++ site

Version	Description
16-04-13	LISE for Excel – Mac OS version
9.6.23	New features of LISE++ Monte Carlo calculations
16-04-13	

Name	Last modified	Size	Description
Parent Directory	-		

LISE_forExcel_MacOS installer will be in this directory soon

Configurations

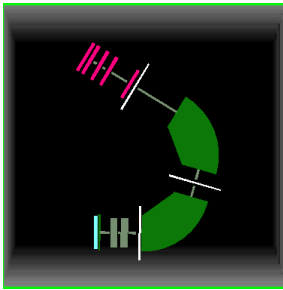
version 9.2.106

<i>Segmented configurations:</i>	<i>Number of blocks</i>	<i>Start</i>	<i>Stop</i>	<i>Optics order</i>	<i>Source maps</i>
A1900_2010.lcn	4	z15	z105	1	
A1900_segmented_COSY.lcn	4	z15	z105	5	link
 <i>Extended configurations:</i>					
A1900_extended_COSY.lcn*	73	z15	z106	5	link
A1900_extended_COSY_only_Quads.lcn	73	z15	z106	5	link
A1900_extended_LISE.lcn	73	z15	z106	2	
A1900_I190_extended_LISE.lcn	113	z15	i190	2	link
A1900_S800BL_extended_LISE.lcn	157	z15	i250	2	
 <i>Final extended configuration (version 9.2.107):</i>					
A1900_extended_COSY_S800BL_LISE.lcn*	73	z15	i250	5-2	

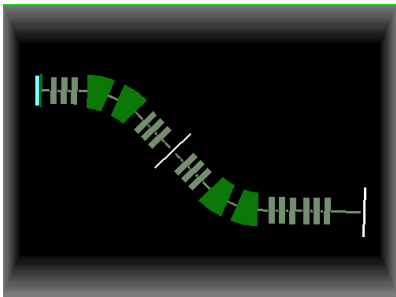
*- includes sextupoles and octupoles for A1900

- Extended_LISE versions (based on TRANSPORT calculations) have been created with use of TRANSPORT files obtained from J.Stetson, T.Ginter & D.Bazin
- Extended_ & Segmented_COSY versions (based on COSY maps) have been created with use of COSY files obtained from M.Portillo

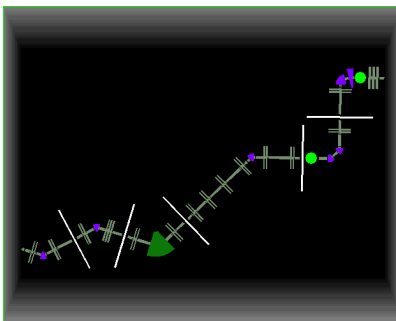
S800 - spectrograph



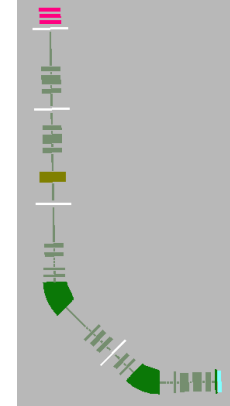
S800 beam-line



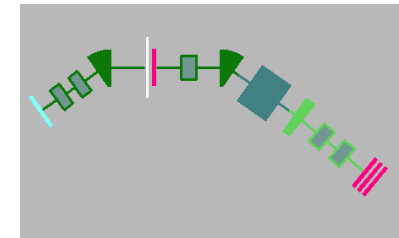
G-line



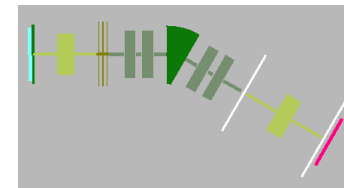
ACCULINNA2 @ FLNR



MARS @ TAMU



RESOLUT @ FSU



*After E-bender & E-quad
Development*

FMA @ ARGONNE

DRAGON @ TRIUMF

S3 @ GANIL

MARS @ TAMU
+ compensating dipole

Beam physicists:

A2400 @ FRIB

SupeFRS @ GSI

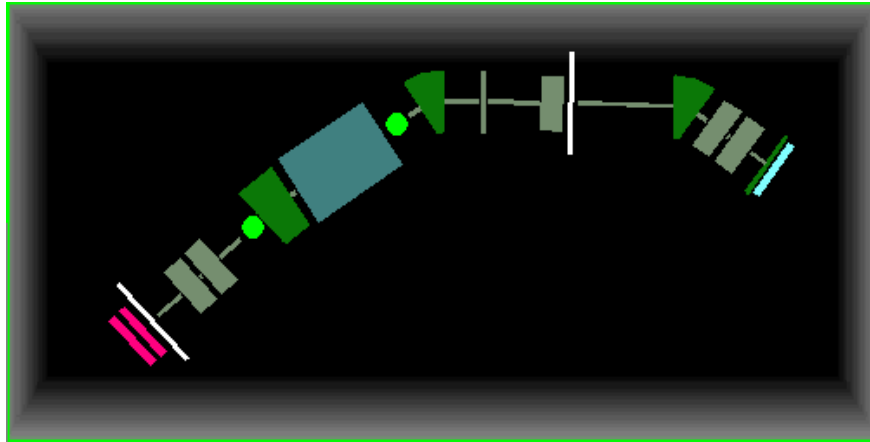
FRS @ GSI

BigRIPS @ RIKEN

LISE3 @ GANIL

- almost finished

Configurations: MARS



- Use of two rotation blocks for vertical selection performance
- Using regular the “dipole” block instead the “compensating dipole” block
- Vertical dipole parameters (angle, radius) were calculated manually
- Second order optics

Using Monte Carlo method

1st order

momentum acceptance:

sig(P) ~ 4.9%

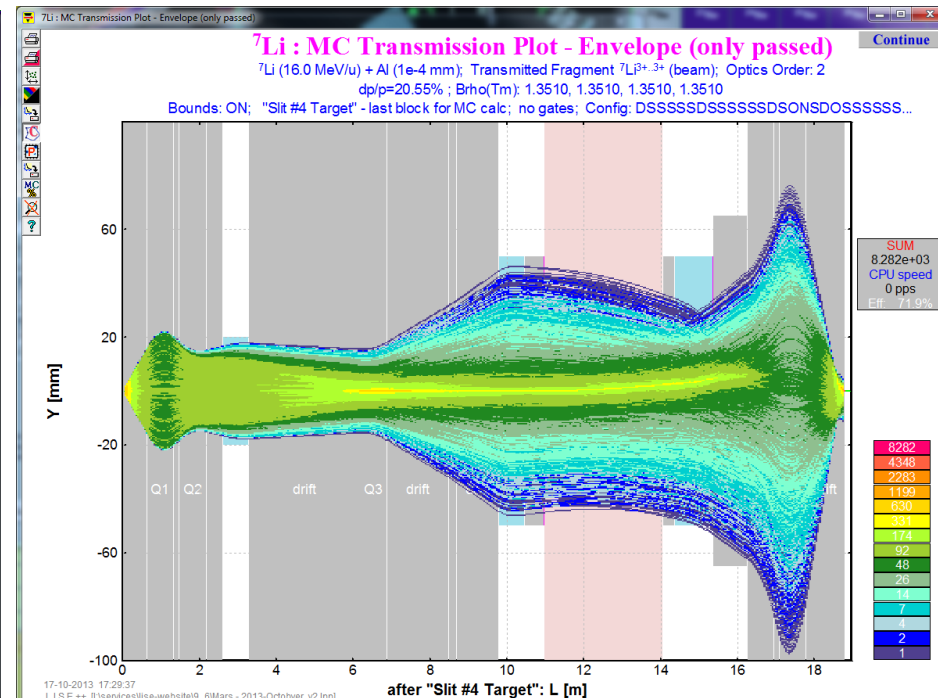
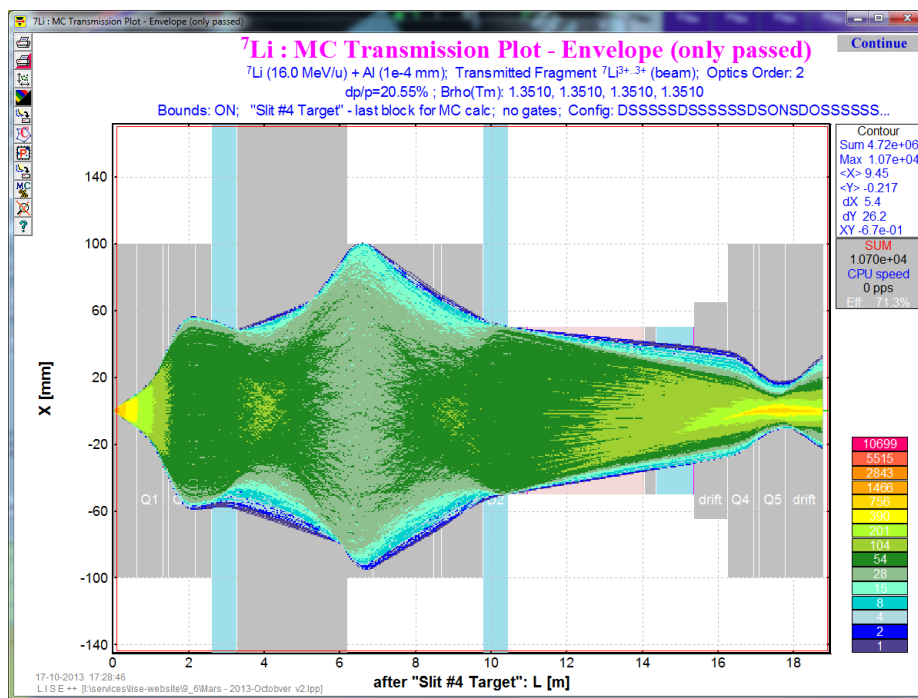
angular acceptance

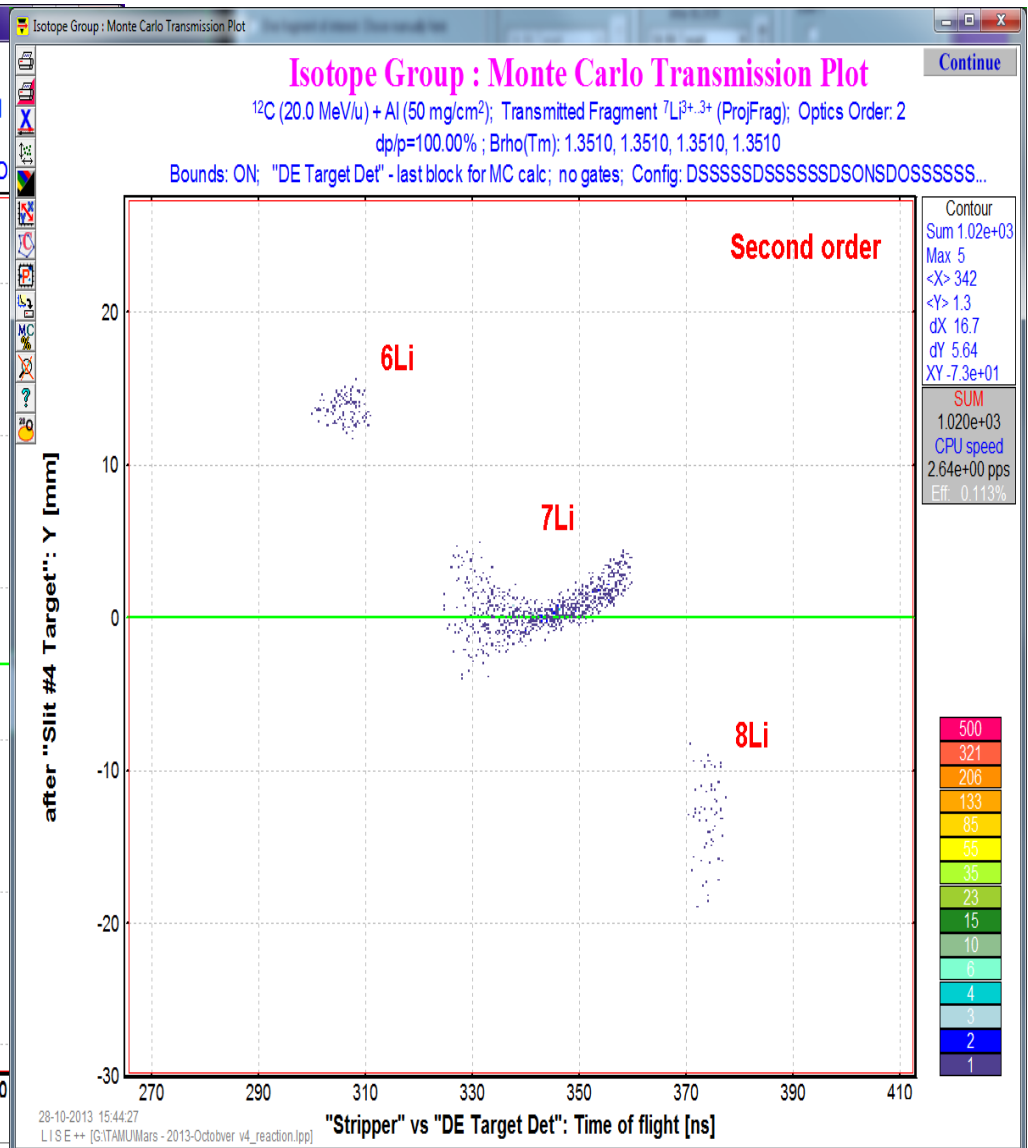
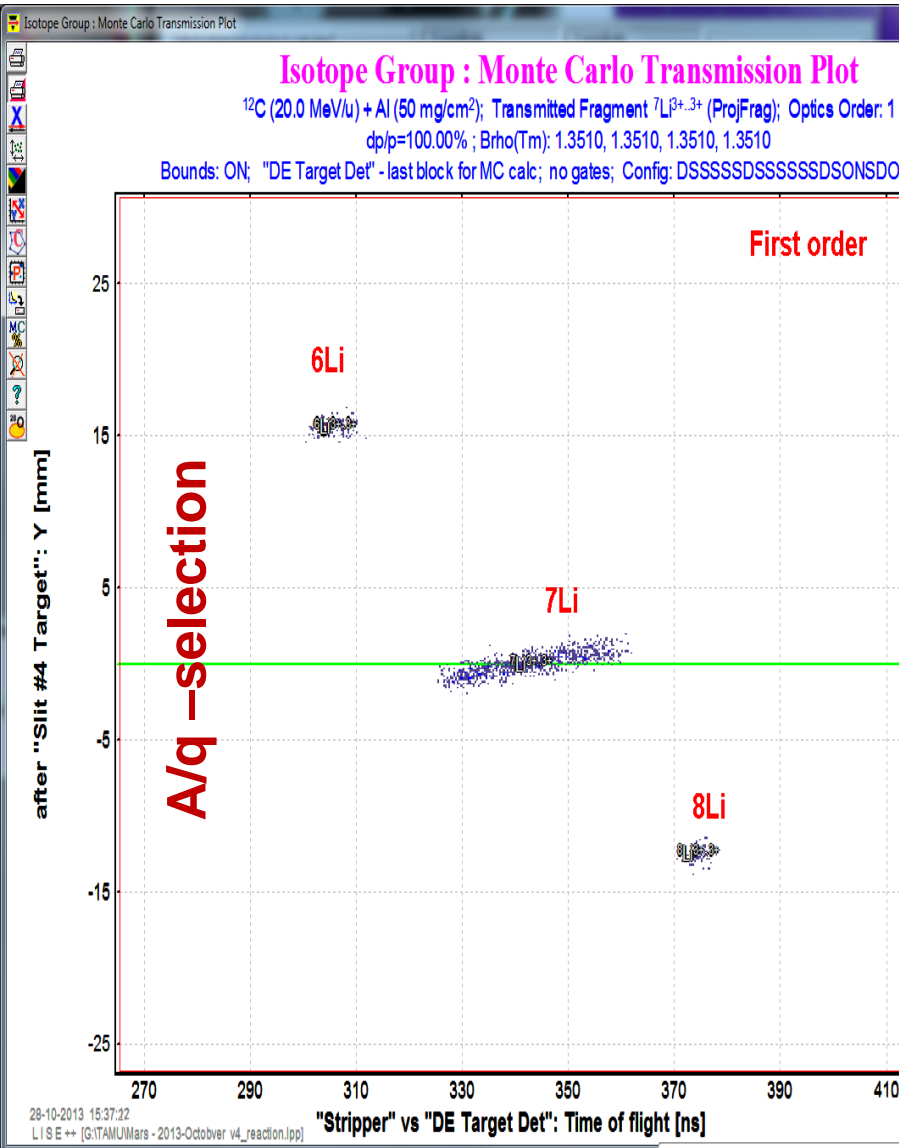
T ~ 15 mrad, P ~ 35 mrad

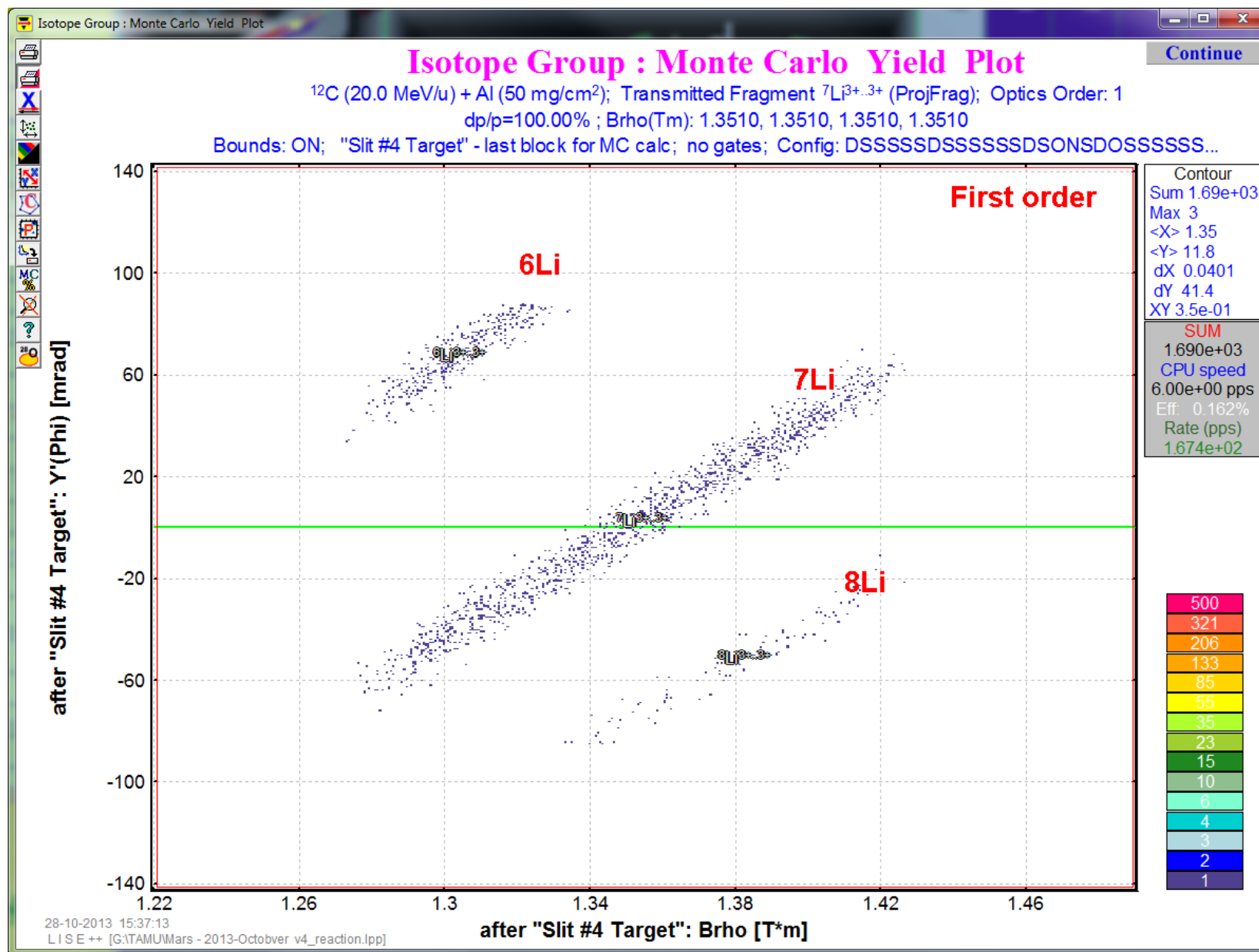
Emittance		
	Beam CARD (sigma, semi-axis, half-width...)	1D - shape (Distribution method)
1. X	mm 0.001	Gaussian
2. T	mrاد 20	Rectangle uniform
3. Y	mm 0.001	Gaussian
4. P	mrاد 25	Rectangle uniform
5. L	mm 1	Gaussian
6. D	% 4.5	Rectangle uniform

Monte Carlo method
2nd order, transmission ~75%

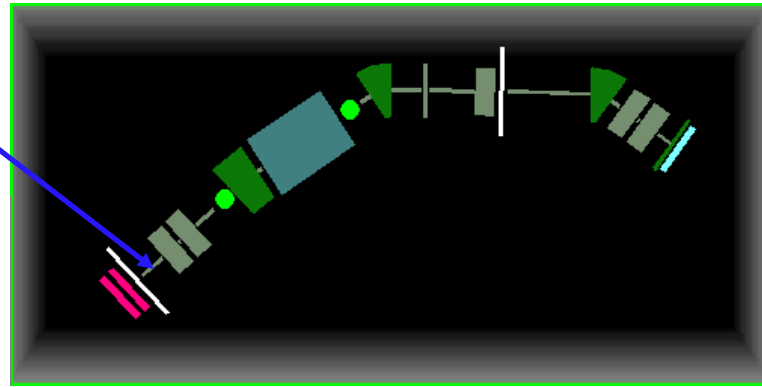
for sig(P) = 4.5%







If insert one more PPAC between the last Quad and FP

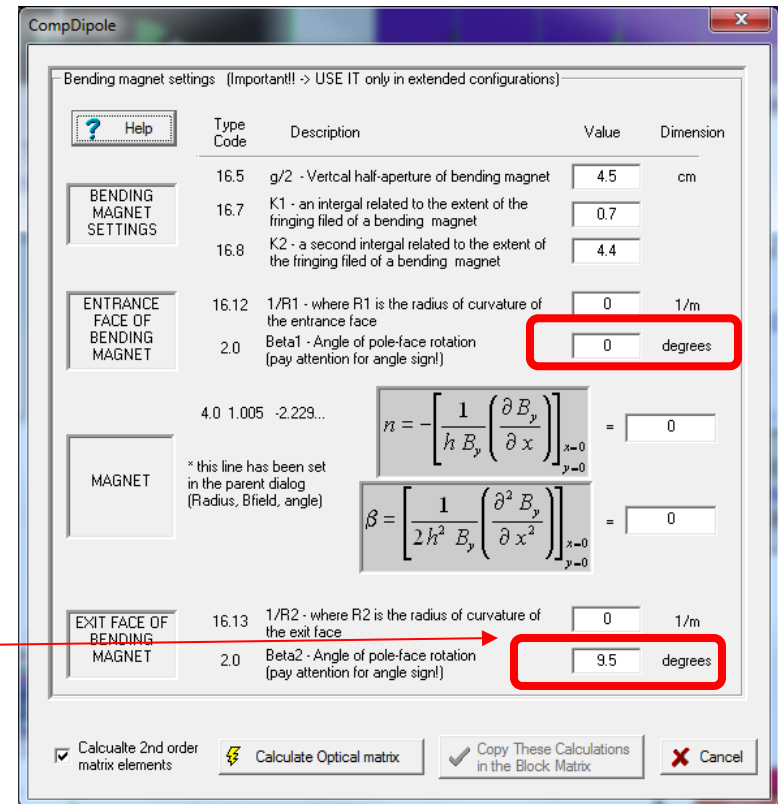
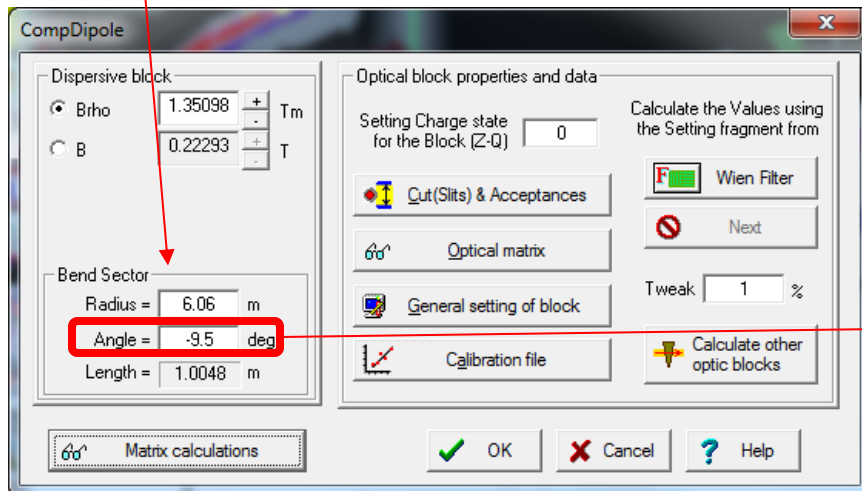


	MARS	S800 BL
x, PPAC resolution	1 mm	1 mm
x, 2 PPACs resolution	1.414 mm	1.414 mm
distance between PPACs	0.5 m	1 m
angle	2.83 mrad	1.4 mrad
angular dispersion	11.8 mrad/%	53 mrad/%
dp/p-resolution	0.24%	0.03%
dp/p-resolution from optics	0.50%	
total dp/p resolution	0.55%	

Assuming rectangle shape

NOTE: in the future LISE++ should calculate itself the angle to compensate dp/p dispersion with taking a shape into account

degrees	rad	sin	Length m	Radius m
0.001	0.000	0.000	1	
0.5	0.009	0.009	1.000013	114.364
1.0	0.017	0.017	1.000051	57.241
1.5	0.026	0.026	1.000114	38.176
2.0	0.035	0.035	1.000203	28.639
2.5	0.044	0.044	1.000318	22.916
3.0	0.052	0.052	1.000457	19.101
3.5	0.061	0.061	1.000623	16.376
4.0	0.070	0.070	1.000813	14.332
4.5	0.079	0.078	1.001029	12.743
5.0	0.087	0.087	1.001271	11.471
5.5	0.096	0.096	1.001538	10.432
6.0	0.105	0.105	1.001831	9.565
6.5	0.113	0.113	1.002149	8.832
7.0	0.122	0.122	1.002493	8.204
7.5	0.131	0.131	1.002862	7.660
8.0	0.140	0.139	1.003257	7.184
8.5	0.148	0.148	1.003678	6.765
9.0	0.157	0.156	1.004125	6.392
9.5	0.166	0.165	1.004598	6.058
10.0	0.175	0.174	1.005096	5.758
10.5	0.183	0.182	1.00562	5.487



Utilities

Inspired by the 4th F.-S. experts meeting

v. 9.2.38

- ❖ Target initial temperature
- ❖ Modification for “stationary beam” models in the case of pulsing beams
- ❖ Rotation target: modifications for a reduced beam pulse length
- ❖ New flux structure: Pulsing beam & rotating target

Calculation of the lifetimes of thin stripper targets

Set-up
 Beam: 238U Energy = 1000.0 MeV/u Intensity = 3.2e+7 pA
 Foil: 12C Thickness = 3 g/cm2

Flux structure
 Stationary beam
 Pulsing beam
 Stationary beam & rotating target
 Pulsing beam & rotating target

Pulse structure
 Beam pulse length = 5e-8 sec
 Repetition rate = 1 Hz
 Rotation target options:
 Rotation Frequency = 1 Hz
 Radial position of beam spot = 25 cm
 Final reduced structure:
 Beam pulse length = 5e-8 sec
 Repetition rate = 0.00127 Hz
 Beam on-off time ratio = 6.37e-9 %

Material properties
 Initial temperature = 293 K
 Emissivity factor = 0.8
 target's atom displacement energy = 25 eV
 $time = k_1 \cdot K_d^{-5/4} \exp(-k_2/T)$
 k1 = 0.0798 LISE reduced value
 k2 = 870 default 870 (Carbon)
 Use LISE++ k1(Z) function
 k10 = 50 default 50
 k11 = -0.07 default -0.07
 Heat Capacity [J / g / K] [3]
 Carbon capacity dependence from T
 manually (constant from T)
 c = 0.502 Table

Sublimation influence ("Pulsing beam" case [1])
 alpha (eq.22 for [1]) = 8.12e+10 g K^(1/2) / sec/cm2
 Mode to plot (dimension):
 F (N = 1e3)
 M (N = 1e4)
 S1 (N = 1e5)
 S2 (N = 1e6)
 S3 (N = 1e7)
 * - with compression pay attention for "compression" results in the case of very short pulses. Might be curious.
 Rise Time (dT= +1K) = 4.67e-10 sec [a]
 "Plateau" (dT= -1K) = 6.58e-10 sec [b]
 Fall Time (dT= -1K) = 1.03e+01 sec [c]
 Range to plot = 3.93e+03 sec
 Height & Temperature from Time
 [a] T0 = 293.0K
 [b] T0 = 448.9 K, P>0
 [c] T0 = 448.9 K, P=0

Radiation damages
 Kd (atom displacement rate) = 2.63e-11 1 / cm2
 Target warming up temperature = 448.9 K [c]
 Foil lifetime due to radiation damages = 1.93e+11 sec
 5.4e+07 hour
 Lifetime and Temperature from Beam Current

Sublimation influence ("Stationary beam" [2])
 alpha (eq.13 for [2]) = 7.83e+10 cm K^(1/2) / sec
 LISEcoef = 1.7 0.1 ... 10 (deflt 1.7)
 "Stationary beam" Foil lifetime due to sublimation = INF sec
 INF hour
 Height (time) & Lifetime (Beam Current)

Shape
 2-D Gaussian Radius from Interaction Area
 Uniform: ellipse Reduced beam spot radius(sigma) = 2.45 mm
 Uniform: rectangle Area (68.0%) = 42.71 mm2

Calculated beam characteristics (during the pulse)
 Beam power lost (W/cm2) at the center of target (t=0) = 4.73e+09
 Density of particle flux (at the center) = 8.49e+04 pA / cm2
 5.30e+17 pps / cm2

References
 [1] S.G.Lebedev & A.S.Lebedev, PhysRev ST: A&B 11 (2008) 020401
 [2] B.Gikal et al., Preprint P9-2005-110, JINR, Dubna
 [3] C.Liaw et al., Proceedings of the 1999 PAC, New York, p.3300

Pulsing beam

Flux structure

Stationary beam

Pulsing beam

Stationary beam & rotating target

Pulsing beam & rotating target

Pulse structure

Beam pulse length = 5e-8 sec

Repetition rate = 1 Hz

Rotation target options

Final reduced structure

Beam pulse length = 5e-8 sec

Repetition rate = 1 Hz

Beam on-off time ratio = 5e-6 %

Rotating target

Flux structure

Stationary beam

Pulsing beam

Stationary beam rotating target

Pulsing beam & rotating target

Pulse structure

Rotation target options

Rotation Frequency = 1 Hz

Radial position of beam spot = 25 cm

Final reduced structure

Beam pulse length = 0.00127 sec

Repetition rate = 1 Hz

Beam on-off time ratio = 0.127 %

Pulsing beam + Rotating target

Flux structure

Stationary beam

Pulsing beam

Stationary beam & rotating target

Pulsing beam & rotating target

Pulse structure

Beam pulse length = 5e-8 sec

Repetition rate = 1 Hz

Rotation target options

Rotation Frequency = 1 Hz

Radial position of beam spot = 25 cm

Final reduced structure

Beam pulse length = 5e-8 sec

Repetition rate = 0.00127 Hz

Beam on-off time ratio = 6.37e-9 %

Probability with rotating target is defined as $X\text{-spot size} / \text{Target Length} = 0.127\%$,

where the target length is $2\pi R$,

Therefore distance between reduced "pulses" is 787 seconds, with the pulse length equal to 50 ns

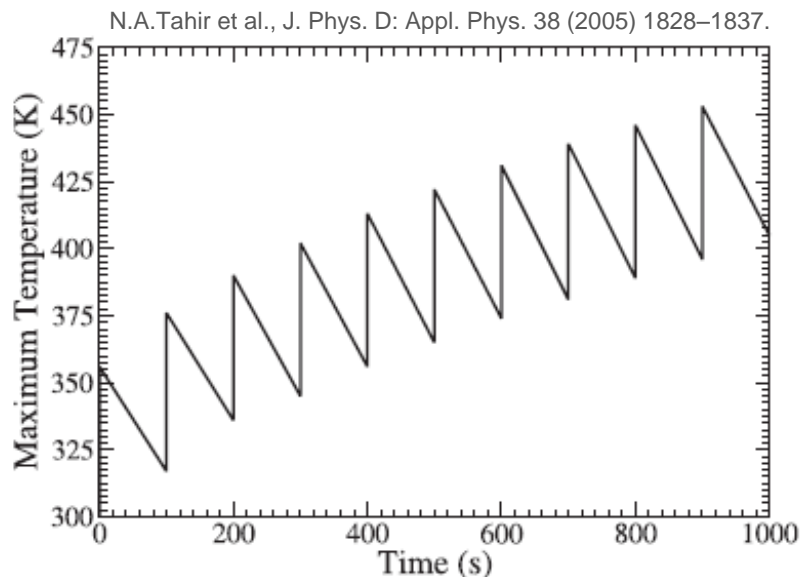
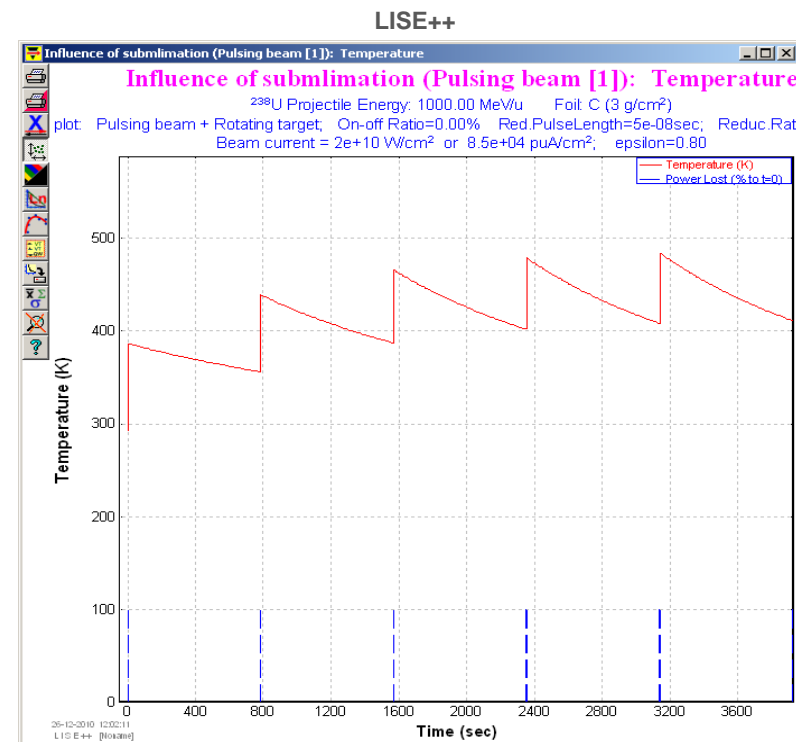


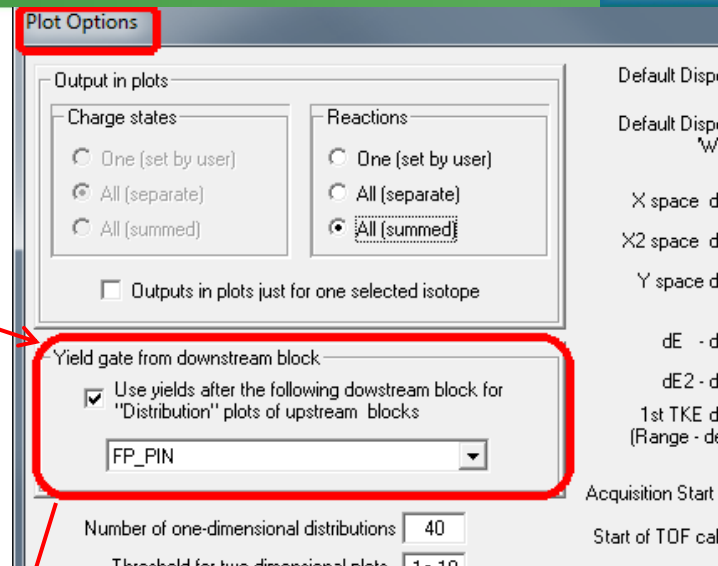
Figure 5. (a) Temperature versus time in the target during 1000 irradiations by a 1 GeV u^{-1} U bunch with $N = 10^{10}$ and $\tau = 50$ ns, $\sigma_x = 1$ mm and $\sigma_y = 6$ mm.



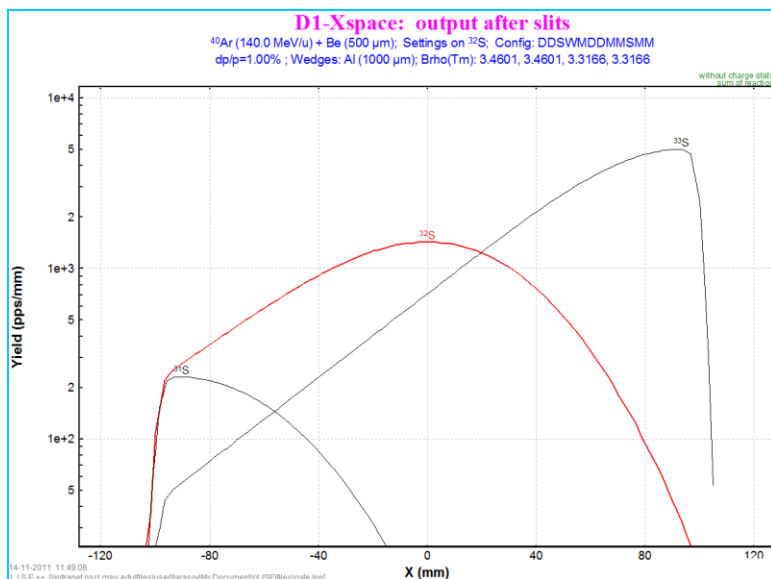
Inspired by the RIKEN experiment
 ^{238}U beam, November 2011

- Only for “Distribution” method **1-D plots & 2-D PseudoMC plots**
- For “Distribution” method just yield is gated, not a shape!
- Use the MC transmission dialog to see shape changes due to gates on downstream blocks

Example File: [gate.lpp](#)

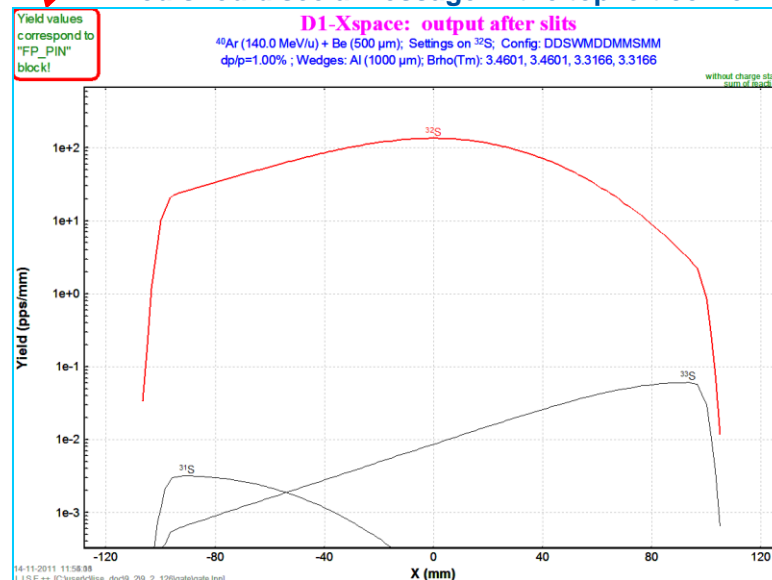


No gates



With applied gate.

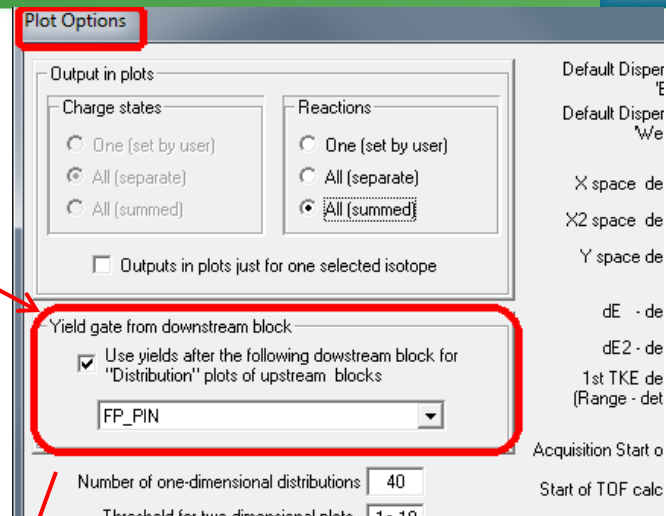
You should see a message in the top left corner



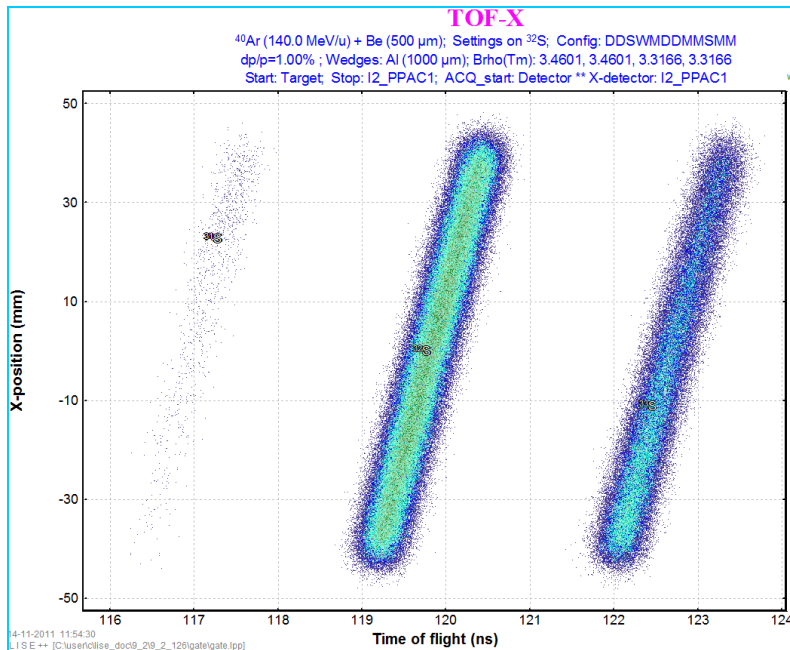
2-D PseudoMC plot

- For “Distribution” method just yield is gated, not a shape!
- Use the MC transmission dialog to see shape changes due to gates on downstream blocks

Example File: [gate.lpp](#)

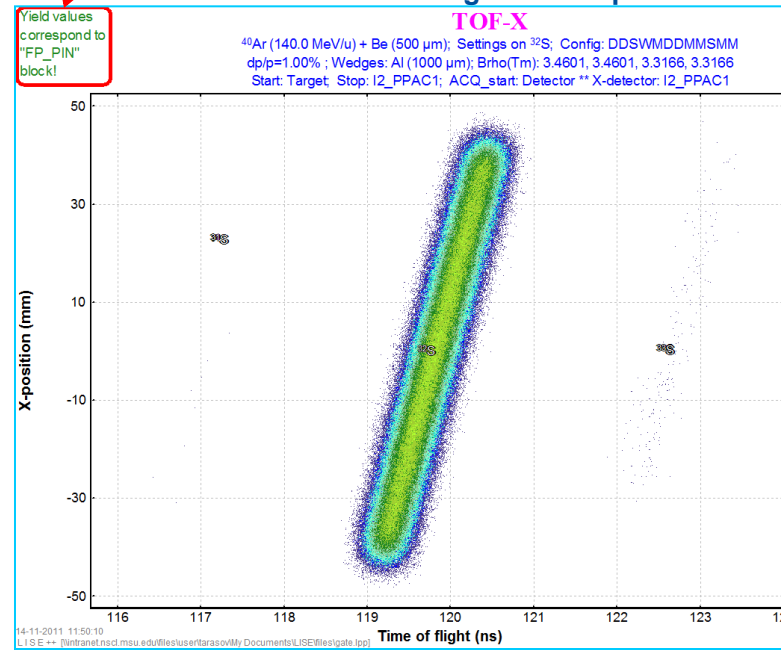


No gates



With applied gate.

You should see a message in the top left corner



www.nsci.msu.edu/~thoenness/isotopes/abstracts/20-calcium/20-Ca-39.pdf

Isotopes

Calcium

A	Element	Z
39	Ca	20

Beta+ decay

Atomic Mass: 38.9707 aem

Discovery History

Discovery History is Available for this isotope

Show Discovery History availability in the chart

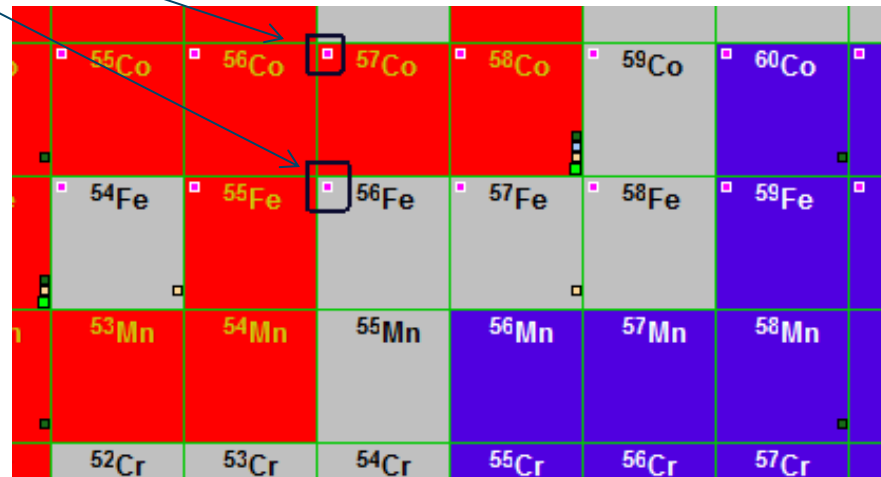
³⁹Ca

³⁹Ca was first observed in 1943 by Huber et al.: "Der Kernphotoeffekt mit der Lithium-Gammastrahlung: I. Die leichten Elemente bis zum Calcium" [?]. ³⁹Ca was populated in a radiative capture reaction with 17 MeV γ -rays. 500 keV protons bombarded lithium to produced the γ -rays from the reaction ${}^7\text{Li}(p,\gamma)$. Subsequent to the irradiations the decay curves of the emitted β -rays were measured. "Als Resultat von 600 durchgeführten Bestrahlungen erhielten wir die in Fig. 13 aufgezeichnete Zerfallskurve mit einer Halbwertszeit von $T = 1.06 \pm 0.03$ sec." (As a result of 600 irradiations we achieved the decay curve shown in Figure 13 with a half-life of $T = 1.06 \pm 0.03$ sec.).

[1] O. Huber, O. Lienhard, P. Scherrer, H. Waffler, *Helv. Phys. Acta* 16 (1943) 33.

Adapted from
 A. Amos, J.L. Gross, and M. Thoennessen
At. Data Nucl. Data Tables 97, 383 (2011)

Show discovery history availability in the chart of nuclides



from LISE++ masses [in MeV]	
Beta- decay	-19.1471 ✓
Beta+ decay	16.1441 ○
S 1p	-1.6712 □
S 2p	0.7479 ✓
S 1n	21.7313 ✓
S 2n	39.5379 ✓
Q alpha	-8.8049 ✓

2nd step

If after 1st step the mode was set as “decay” then

Accept as “unbound” if half-life of this mode smaller than “does not exist” threshold

Accept as “stable” if half-life of this mode greater than “stable” threshold

1st step

According chosen mass model or database

- ✓ Stable. No decay. $Q_\alpha, b^-, b^+ < 0$, and $S_{1n}, S_{2n}, S_{1p}, S_{2p} > 0$
- Decay. $Q_\alpha, b^-, b^+ > 0$, and $S_{1p}, S_{2p} < 0$
- Unbound. $Q_\alpha - CB > 0$, and $S_{1p} + CB, S_{2p} + CB, S_{1n}, S_{2n} < 0$, where CB – Coulomb Barrier

3rd step

- If more than 2 decay modes are present, than only two will be chosen based on short half-life
- if there are two bunches are present, then LISE++ accepts the second mode if its half-life no greater than 1st mode half-life divided on “2nd branch value” or

$$[T/2]_2 * coef < [T/2]_1$$

New decays :

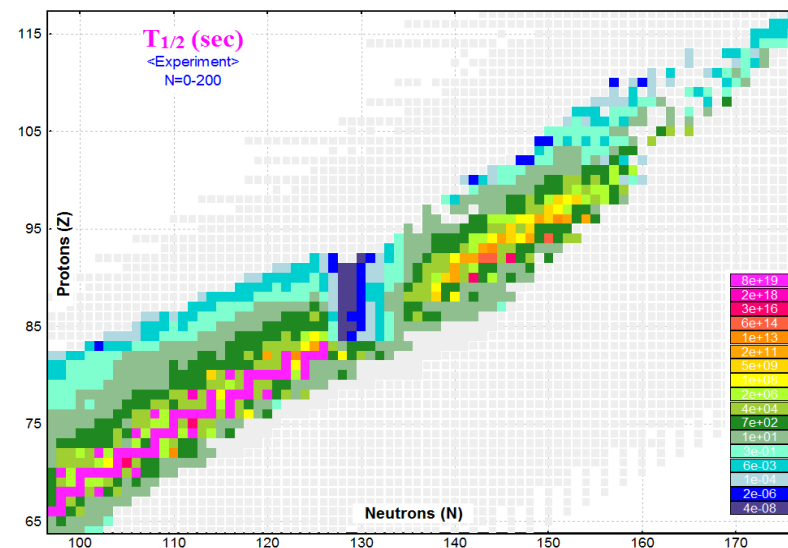
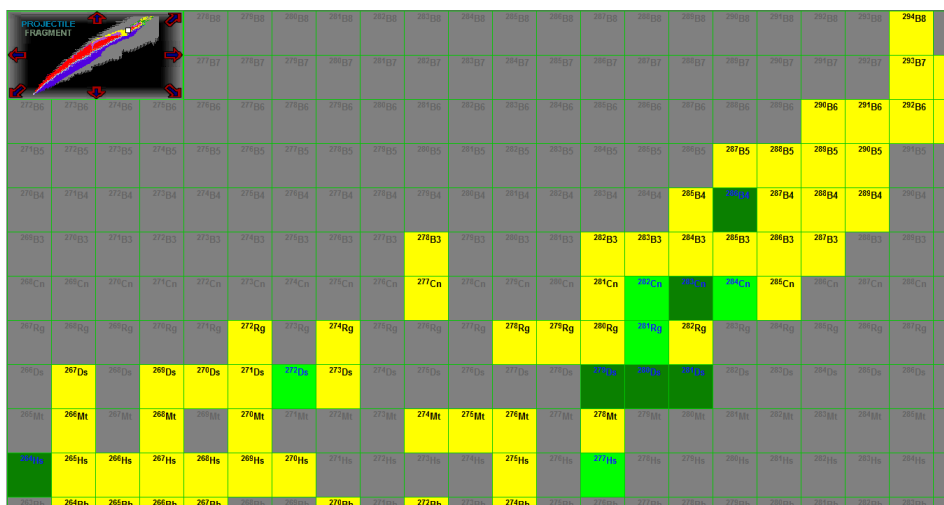
p & β^+ , p & α , β^- & α , SF & β^+ , SF & β^-

New order of decay modes

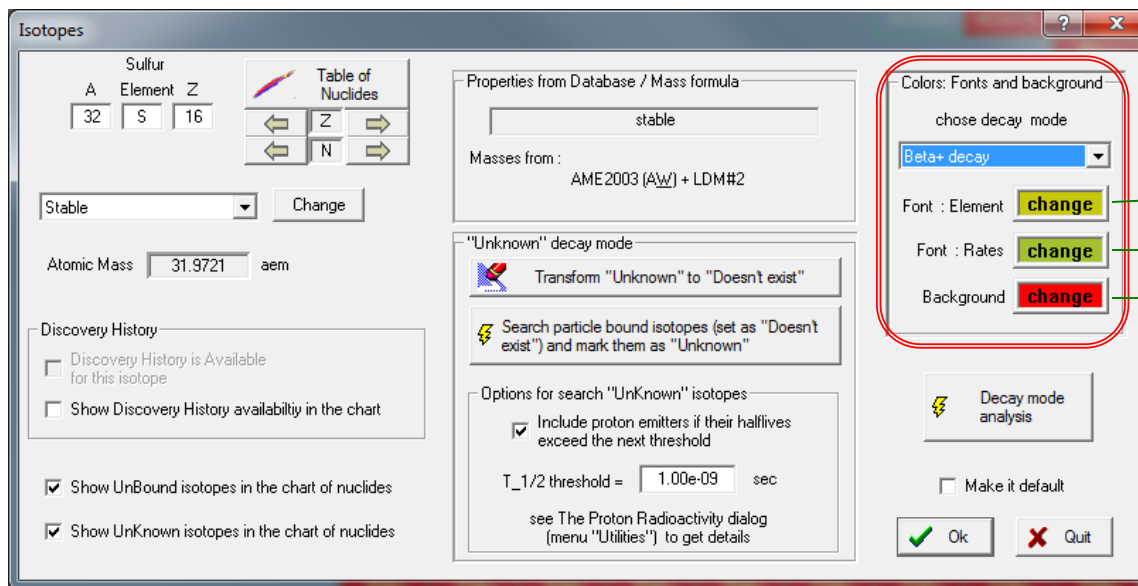
=> New iso-file : “table2012.iso” instead previous “table.iso”)

Total Revision of Decay modes in the LISE++ chart of nuclides,
and revision of half-lives of heavy elements

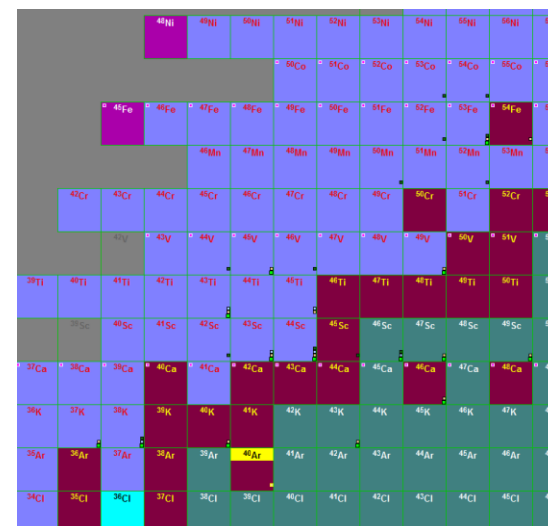
- Doesn't exist!
- Stable
 - Beta+ decay
 - Beta- decay
 - Beta+ and Beta- decay
 - Alpha decay
 - Alpha and Beta+ decay
 - Alpha and Beta- decay
 - Proton decay
 - Proton and Beta+ decay
 - Proton and Alpha decay
 - Spontaneous fission
 - SF and Beta+ decay
 - SF and Beta- decay
 - SF and Alpha decay
 - Unbound
 - Unknown



9.2.154 07/12/11 Color editing of the table of nuclides

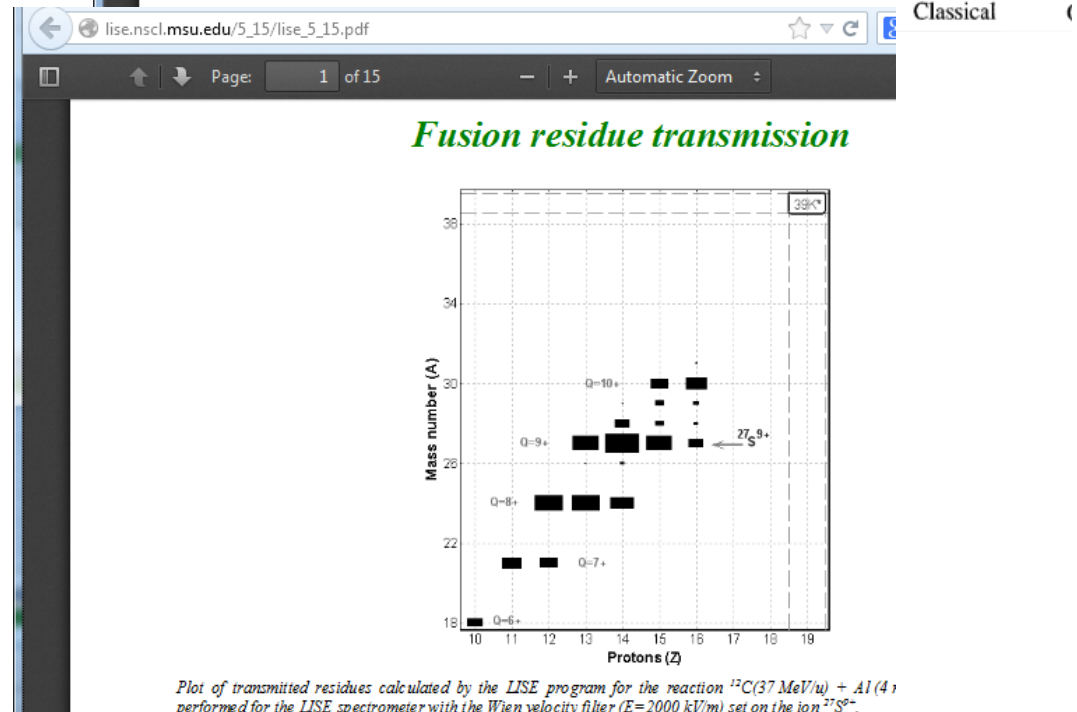
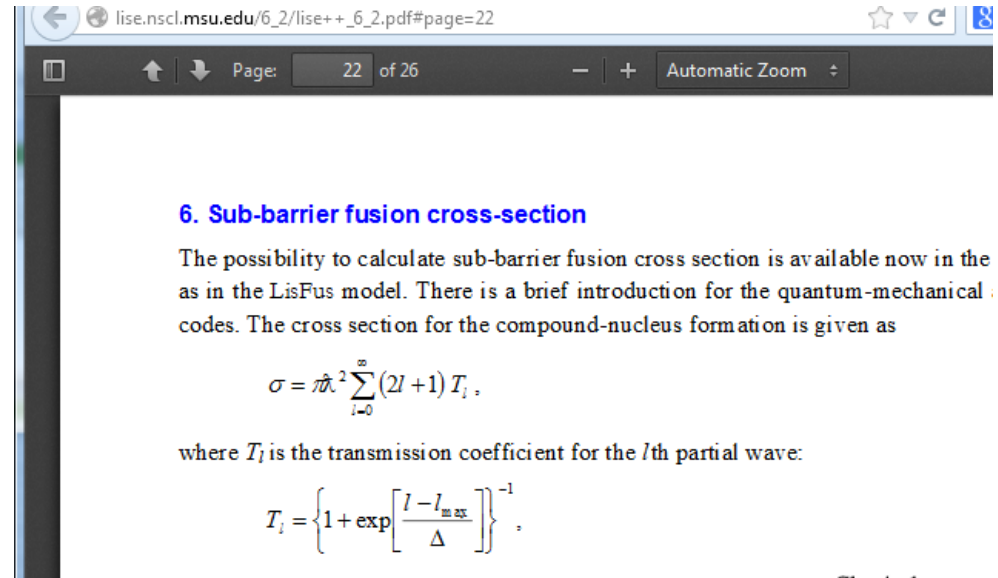
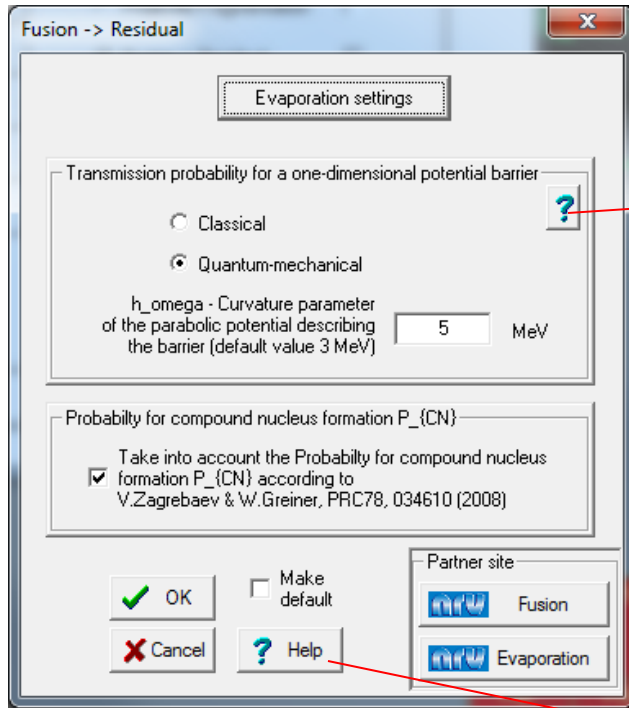


Example of user modifications

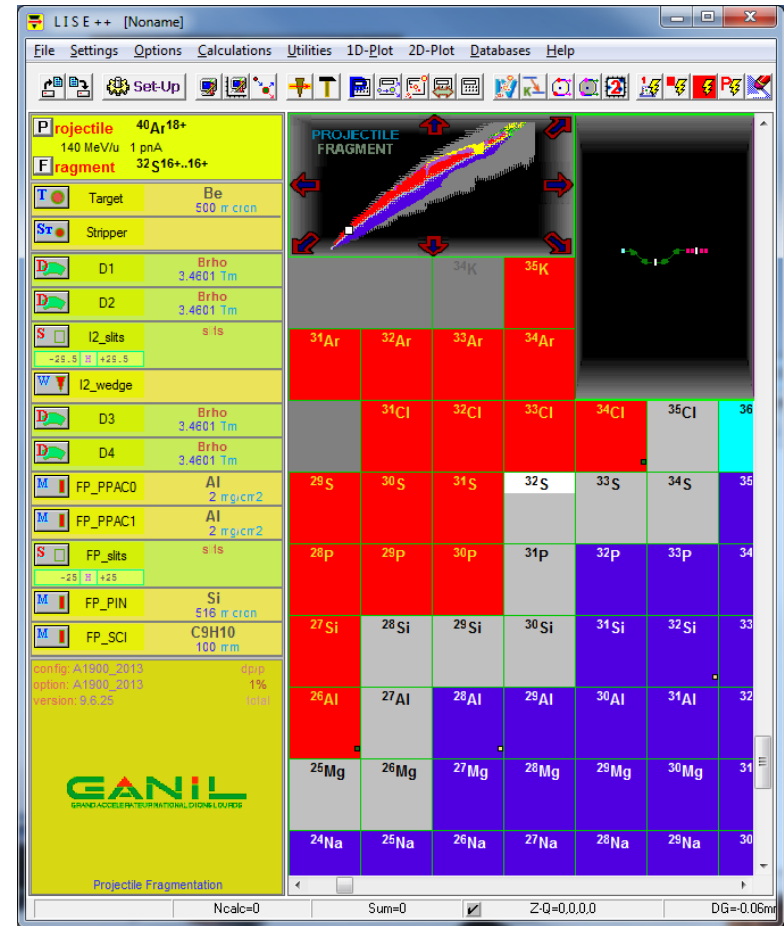
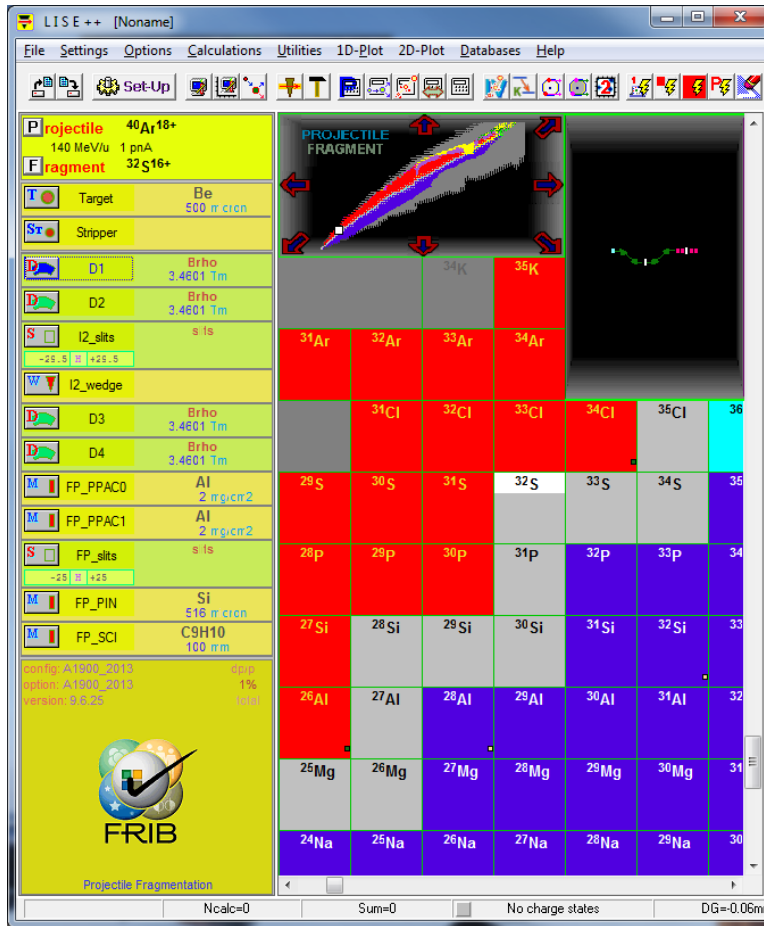


- Color modifications will be saved in the "lisepp.ini" file (if you have checked "make it default" in the "Isotopes" dialog)
- If you want to restore default LISE++ colors, then erase blocks [Decay_Font], [Decay_Background], [Decay_Label] in the "lisepp.ini" file

example



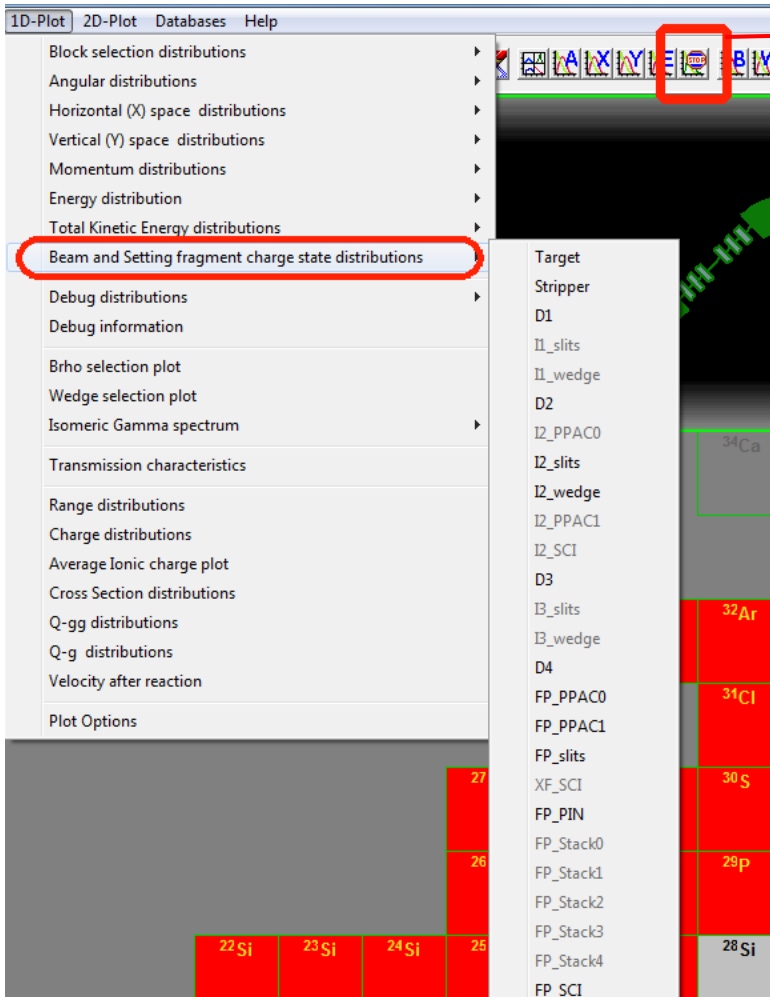
No F1-key help more



Use this CheckButton to change the charge state option

v.9.6.29
from 04/19/13

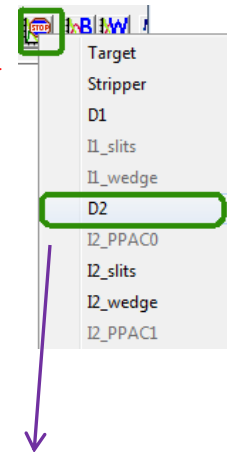
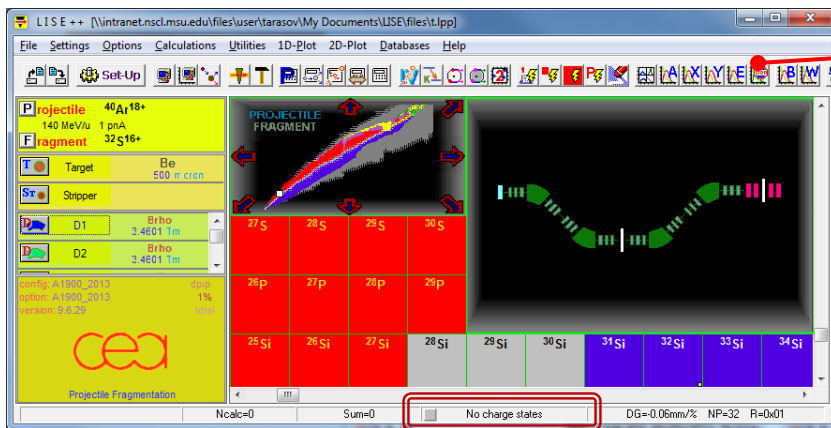
TB's request



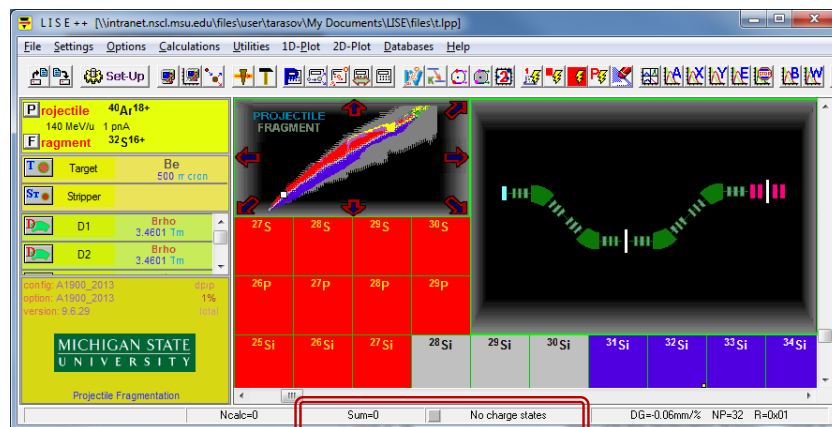
Actions:

1. Save the Charge State option
2. Set Charge State on
3. Insert the Faraday Cup after the selected block
4. Calculate beam projectile and setting fragment charge states transmission up to this Faraday cup
5. Find out a direction of the dispersive plane (X or Y)
6. Plot spatial distributions of ions in the dispersive plane
7. Delete the Faraday cup
8. Restore the Charge State Option

before

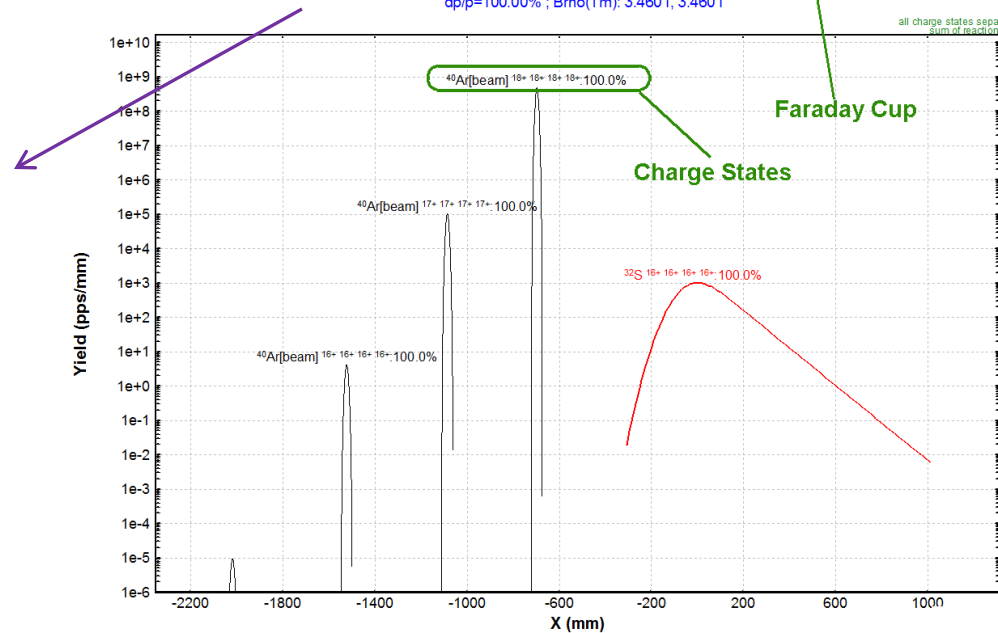


after



D2-Beam & SetFrag Charge States

^{40}Ar (140.0 MeV/u) + Be (500 μm); Settings on $^{32}\text{S}^{16+}$; Config: DDA
 dp/p=100.0%; Brho(Tm): 3.4601, 3.4601



Utilities :

Neutron and Gamma induced reactions in the Kinematic Calculator

9.6.132 10/08/13

Kinematics calculator (relativistic)

Reactions

- TWO BODY reaction B (A, C) D
- SCATTERING B (A, C=A) D=B
- BREAKUP (FISSION) x(A, CD) x (gamma-emission)

Beam: Heavy ion Neutron * Gamma * * test version

Participants

	ME (MeV)	Excitation Energy	E(CM) = 18.13 MeV
A Beam	1n	8.07	n-energy (MeV) = 20
B Target	9Be	11.35	Intensity (cps) = 1.00e+10
C* Fragment	3H	14.95	Target thickness = 1 micron
D* Residual	7Li	14.91	Q-value = -10.44 MeV

Reaction takes place at the

ENTRANCE of the target MIDDLE of the target EXIT of the target

Set-up

Search an angle in CM

- from 0 degrees and up
- from 180 degrees and down

	fragment (C)	residual (D)
R =	100 cm	100
w =	1 cm	1
h =	2 cm	2

Angle (deg) = 37.964 79.353 50 130
fragment (C) residual (D) fragment (C) residual (D)

Calculations

	LAB	CM	
Counting in monitor =	2.45e+0	1.48e+0	pps
Differential Cross Section =	159	95.8	100 100 mb/sr
Energy after reaction =	2.76	0.2	1.782 0.33 MeV/u**
Energy at the entrance of detectors =	2.76	0.0204	MeV/u [** for gamma [MeV]]
Maximum Angle =	180.00	180.00	deg
Solid Angle =	0.2	0.2	0.317 0.192 msr
delta Theta =	0.57	0.57	0.73 0.7 deg

For Kinematics Plots use energy values

- after reaction
- at entrance of detectors

Kinematics plots

Diff. CS converter

2D fragment plot (Monte Carlo)

Quit Help

3-body kinematics

Kinematics calculator (relativistic)

Reactions: TWO BODY reaction. B (A, C) D

SCATTERING B (A, C) D=B

BREAKUP REACTION x(A, C) D

Beam: Heavy ion **Neutron** Gamma * test version

Participants: MS, Excitation, E(CM) = 18.13 MeV

	Beam	Target	Excitation	Intensity (cm ²)	Q-value
A	1n	9Be	0.07	n-energy (MeV) = 20	0
B	9Be	3H	11.35	1.00e+10	0
C	Fragment	3H	14.95	0	Target thickness = 1 micron
D	Residual	7Li	14.91	0	Q-value = -10.44 MeV

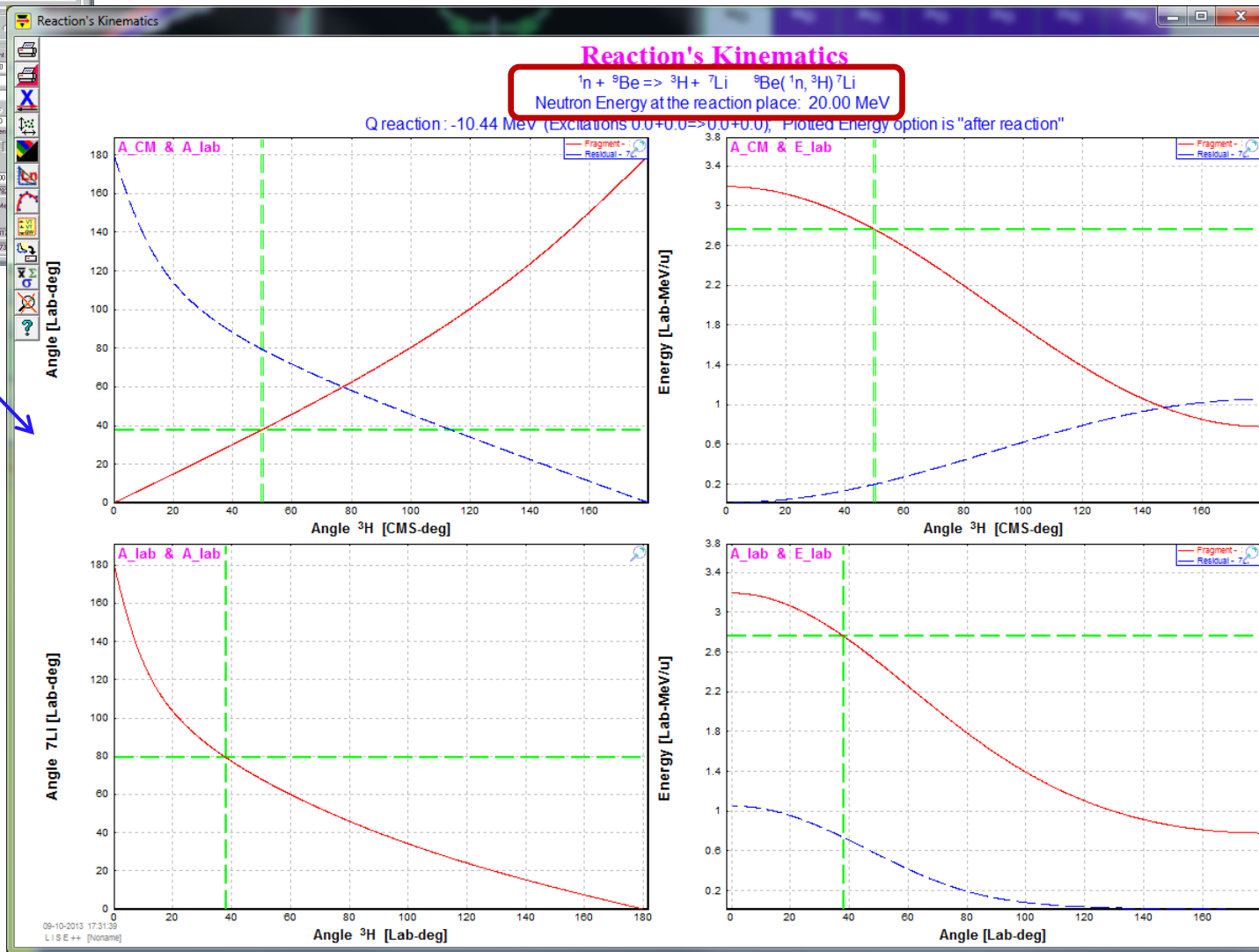
Reaction takes place at the: ENTRANCE of the target MIDDLE of the target

Setup: Search an angle in CM: R = 100, w = 1, h = 2

Angle (deg) = 37.964 fragment (C) residual (D) = 50

Calculations: LAB

Counting in monitor	Dif. CS converter	2D fragment plot (Monte Carlo)
2.45e+0	1.48e+0	
Differential Cross Section = 159 95.8	100	
Energy after reaction = 2.76 0.2	1.78	
Energy at the entrance of detectors = 2.76 0.0004	M	
Maximum Angle = 160.00 160.00		
Solid Angle = 0.2 0.2	0.31	
Delta Theta = 0.57 0.57	0.73	



09-10-2013 17:31:29
 LISE++ [None]

Kinematics calculator (relativistic)

Reactions: TWO BODY reaction. B (A, C) D

SCATTERING B (A, C) D-B
BREAKUP B (A, C) D-A
RESONANCE X (A, C) X

Beam: Heavy ion **Neutron*** Gamma* test version

Participants: MS, Excitation, E(CM) = 18.13 MeV

	Beam	Trn	E(keV)	Intensity (cps)	Intensity (u)
A	186	11.58	0	1.00e+10	1.00e+10
C	Fragment	3H	14.95	0	Target thickness = 1 micron
D	Residual	7Li	14.91	0	Q value = -10.44 MeV

Reaction takes place at the: ENTRANCE of the target MIDDLE of the target EXIT of the target

Set-up: Search an angle in CM: from 0 degrees and up from 180 degrees and down

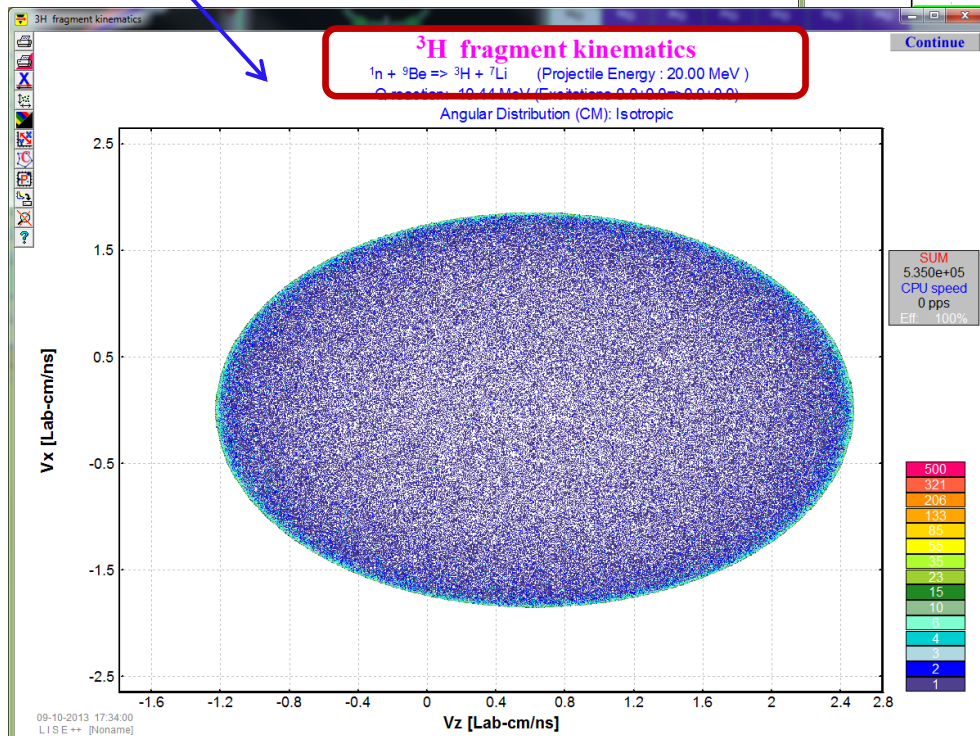
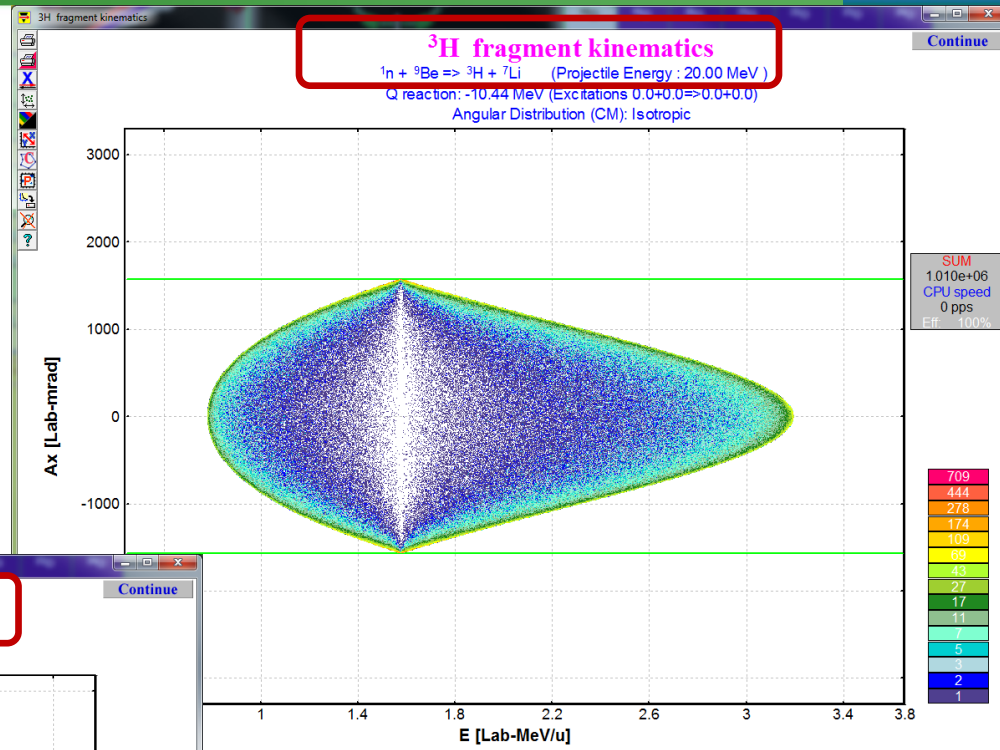
Angle (deg) = 37.984 79.353
fragment (C) residual (D) 50 130

Calculations: LAB CM

	LAB	CM	
Counting in monitor	2.45e+0	1.48e+0	pps
Differential Cross Section	159 95.8	100 100	mb/str
Energy after reaction	5.26 0.8	0.896 0.896	MeV/u
Energy at detector of detector	2.76 0.0204	MeV/u for gamma (MeV)	
Maximum Angle	100.00 100.00	deg	
Solid Angle	0.2 0.2	0.317 0.192	sr
delta Theta	0.57 0.57	0.73 0.67	deg

Fix Kinematics Plots use energy values: alter reaction at entrance of detectors

Kinematics plots: 2D fragment plot (Borke Calc)



Database

The 2012 Atomic Mass Evaluation (AME2012)

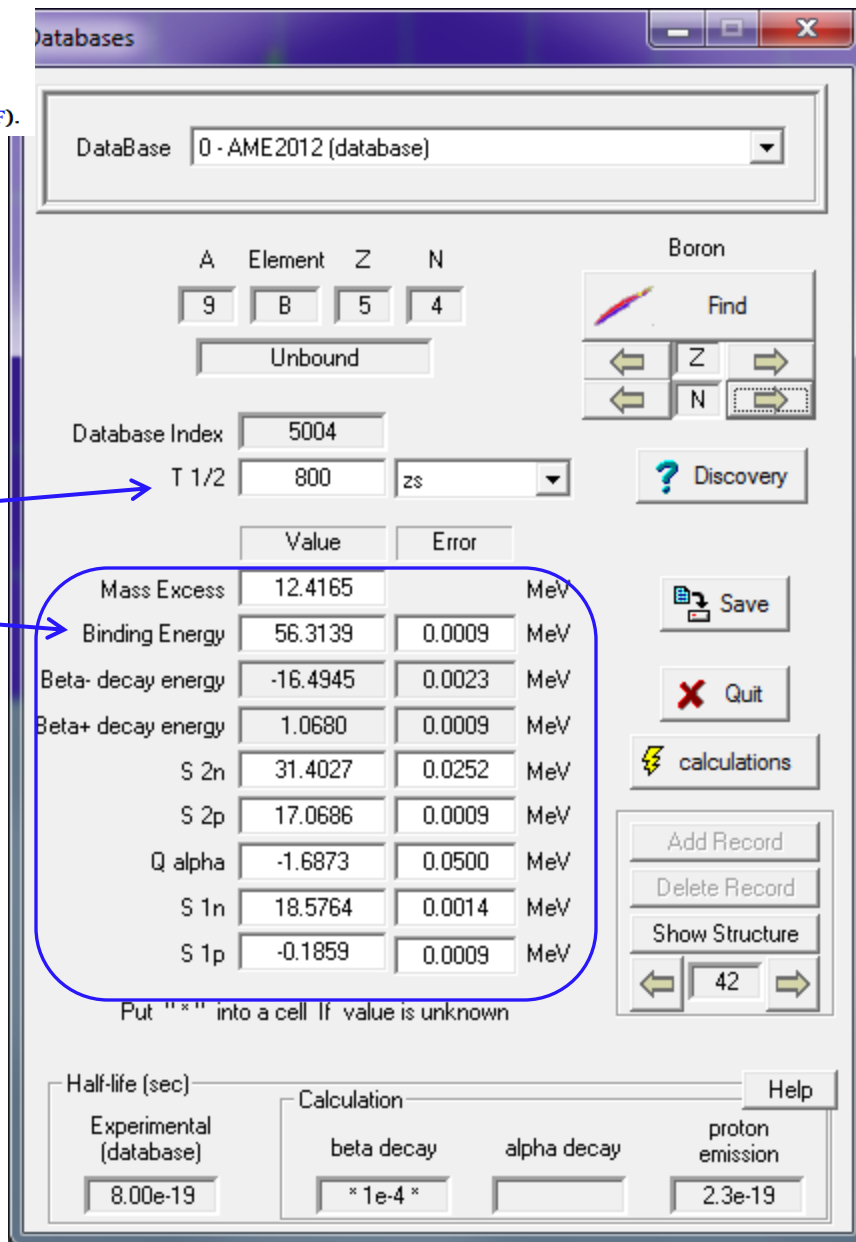
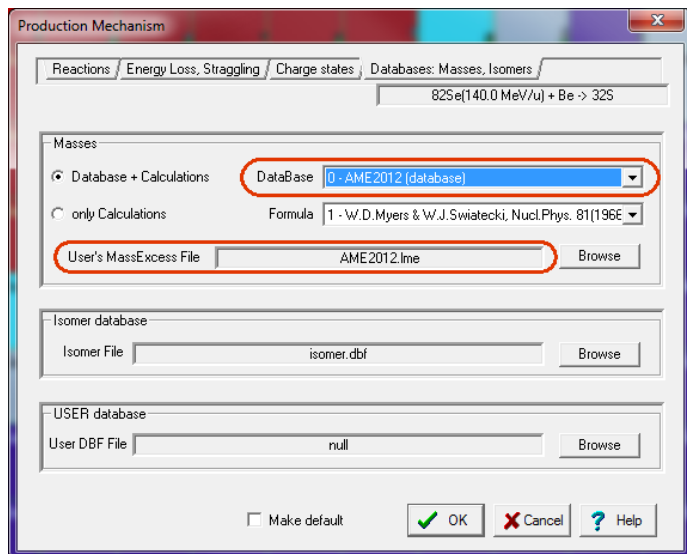
The evaluation has been published in Chinese Physics C 36 (2012) 1287-1602 (PDF), 1603-2014 (PDF).

The 2012 Nubase Evaluation (Nubase2012)

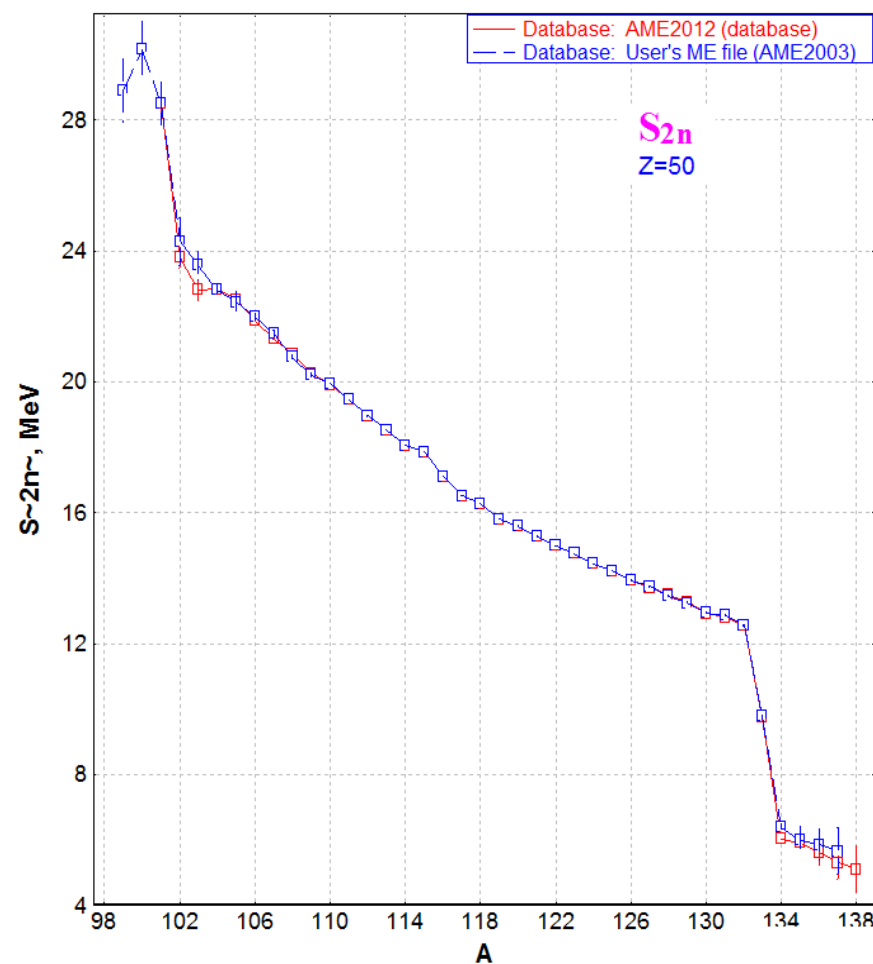
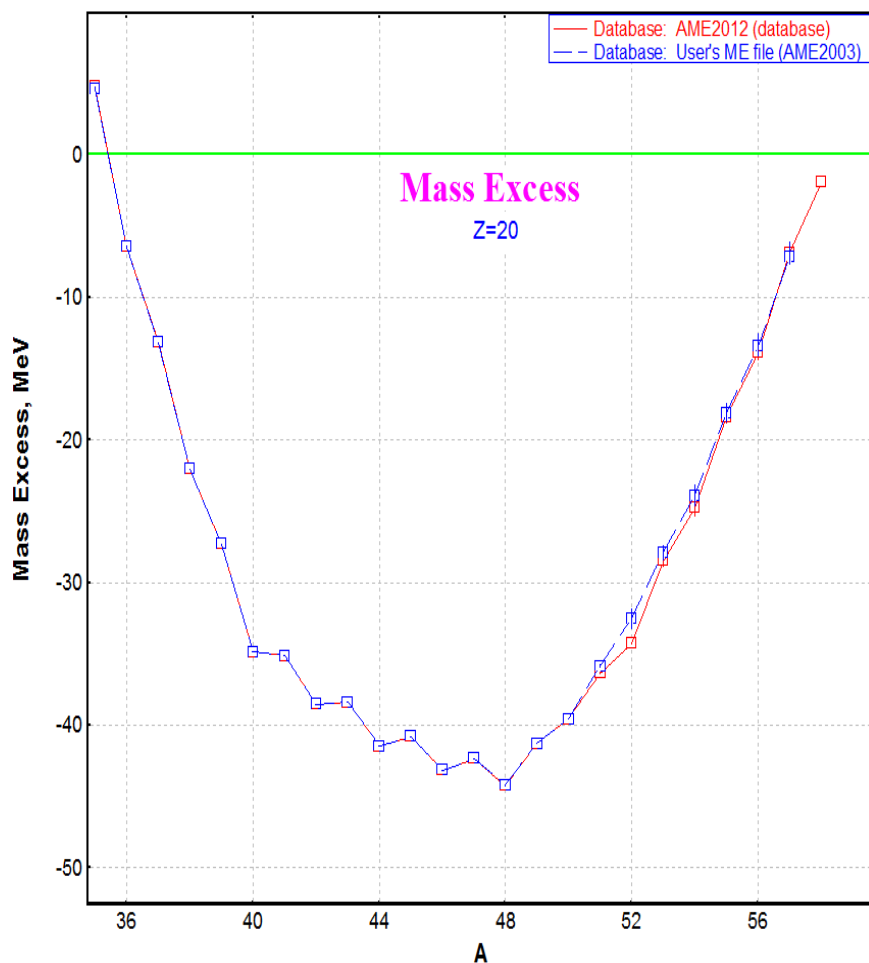
The evaluation has been published in Chinese Physics C 36 (2012) 1157-1286 (PDF).

NUBASE 2012

AME 2012



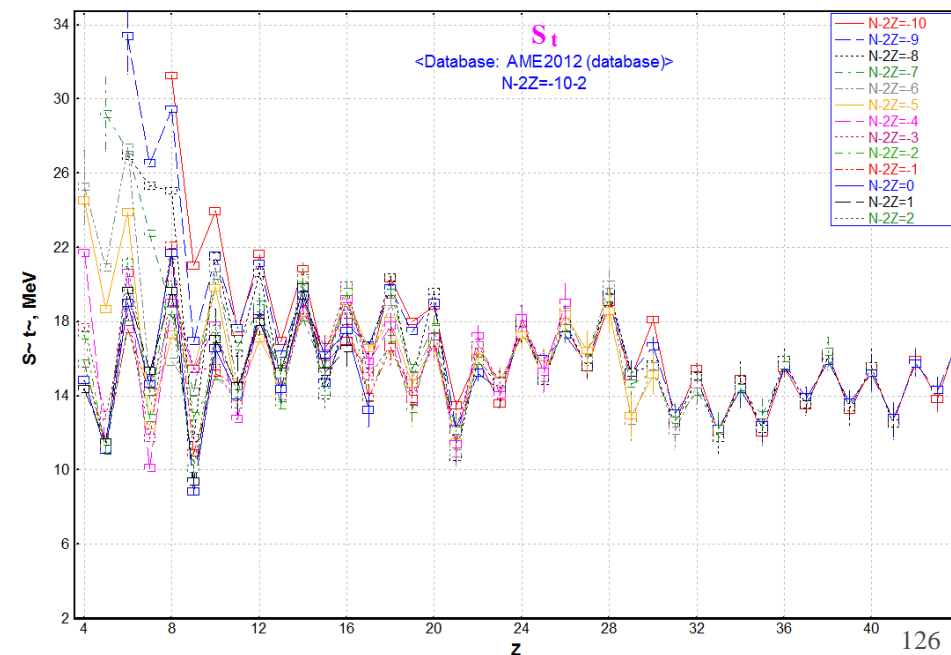
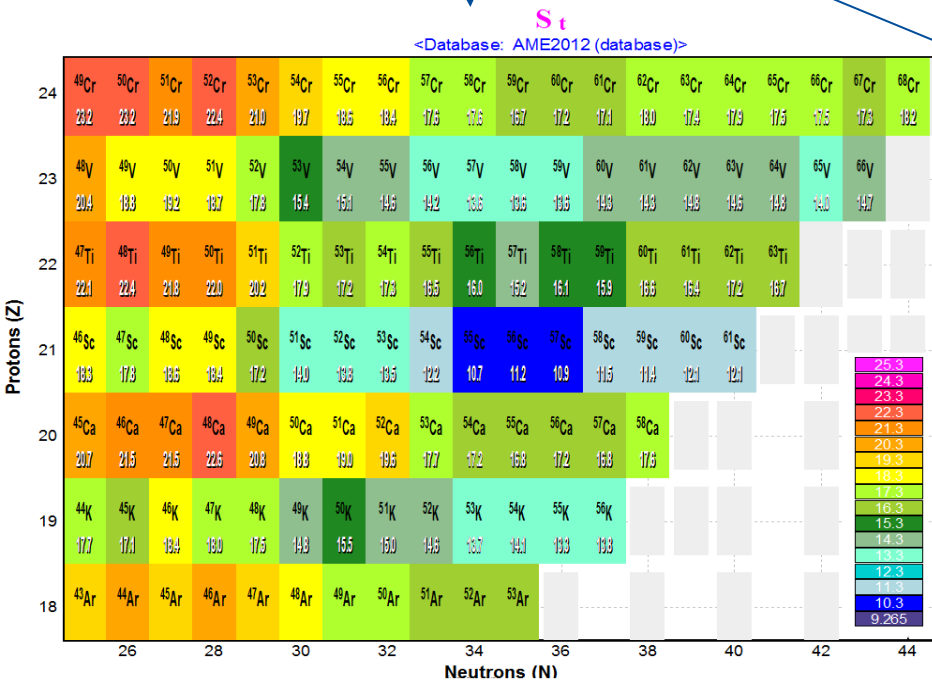
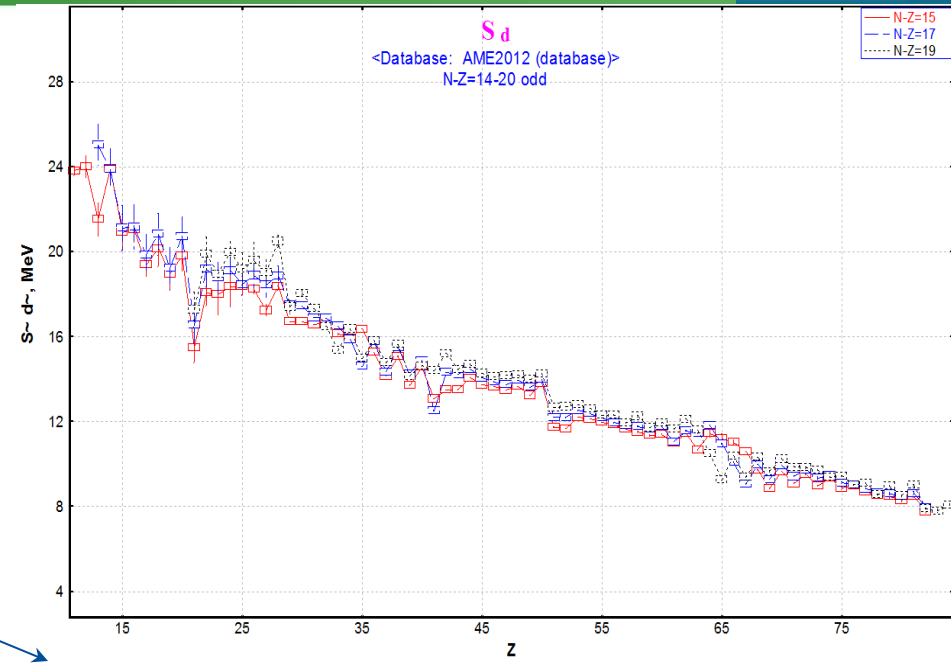
Comparison AME2003 & AME 2012 for Z=20 & 50

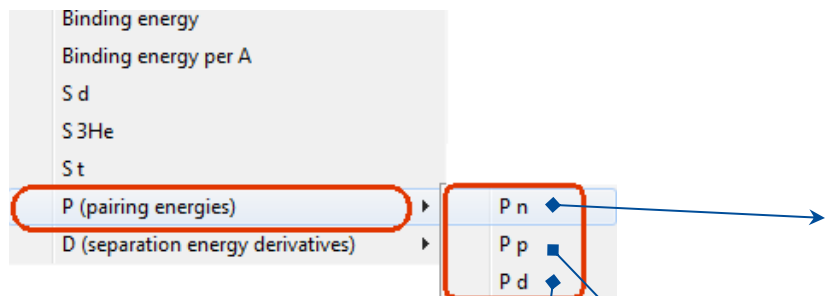


Databases Help

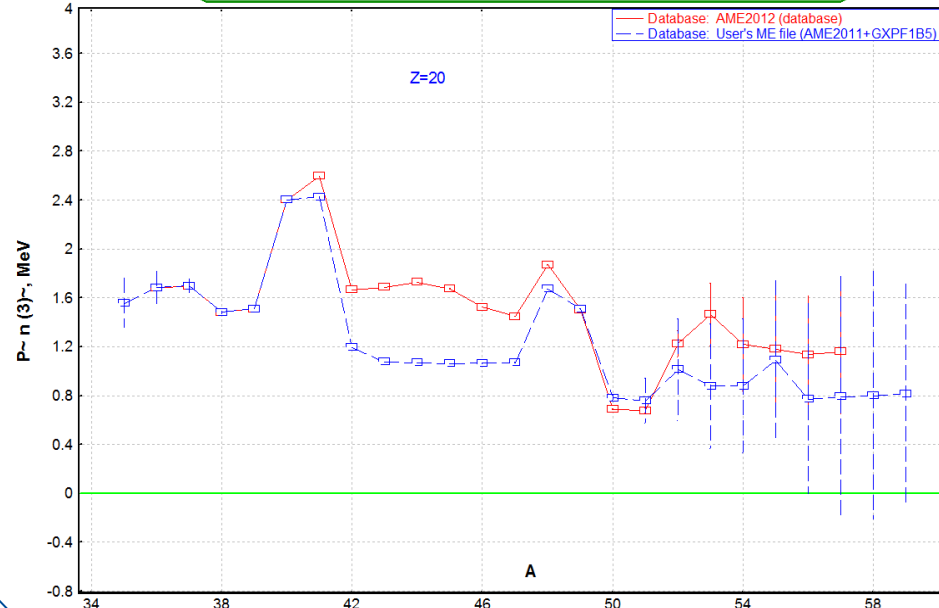
- AME & properties: View, Edit
- AME & properties: Plots
- Isomer database: View, Edit
- User database: Edit
- User database: Plots

- S1n
- S2n
- S1p
- S2p
- Q alpha
- Beta- decay
- Beta+ decay
- T 1/2**
- Mass Excess
- Binding energy
- Binding energy per A
- S d
- S3He
- S t
- P (pairing energies)
- D (separation energy derivatives)

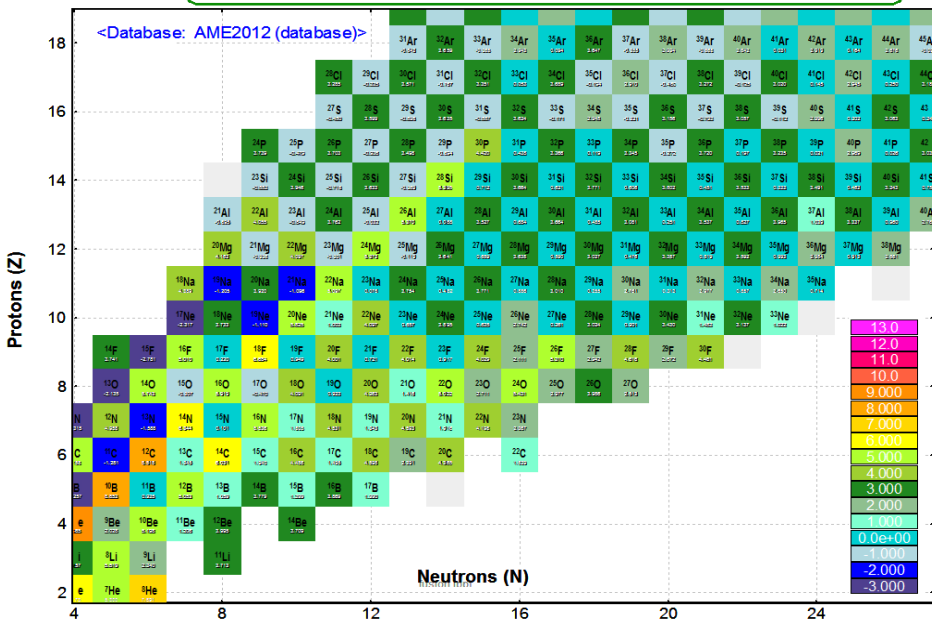




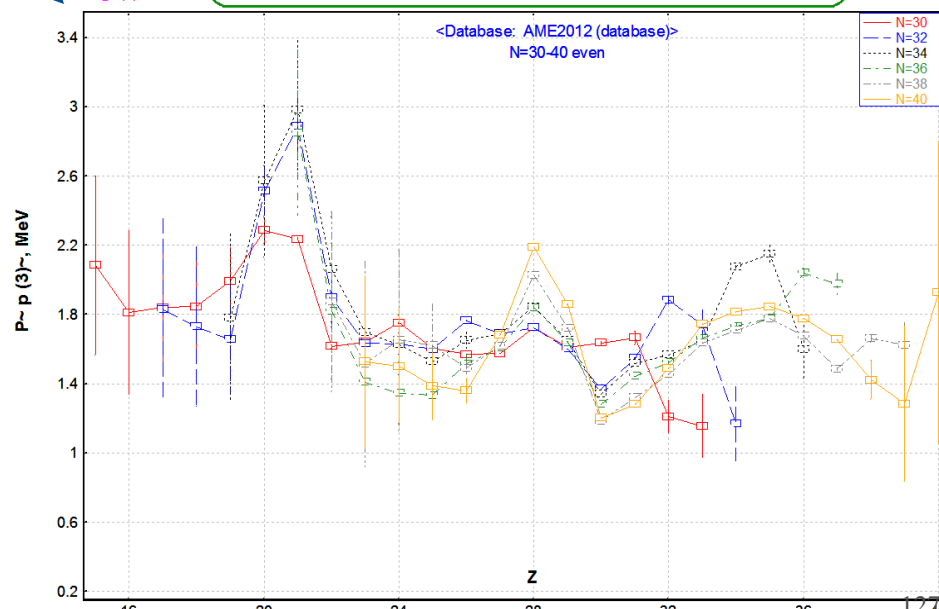
P_n(3) $P_n(\beta)(Z,N) = 0.25 \cdot (-1)^{N+1} [S_n(Z,N+1) - 2S_n(Z,N) + S_n(Z,N-1)]$; CPC 2012, 36(12): 1603



P_d(3) $P_d(\beta)(Z,N) = 0.25 \cdot (-1)^{Z+1} [S_d(Z+1,N+1) - 2S_p(Z,N) + S_p(Z-1,N-1)]$; CPC 2012, 36(12): 1603

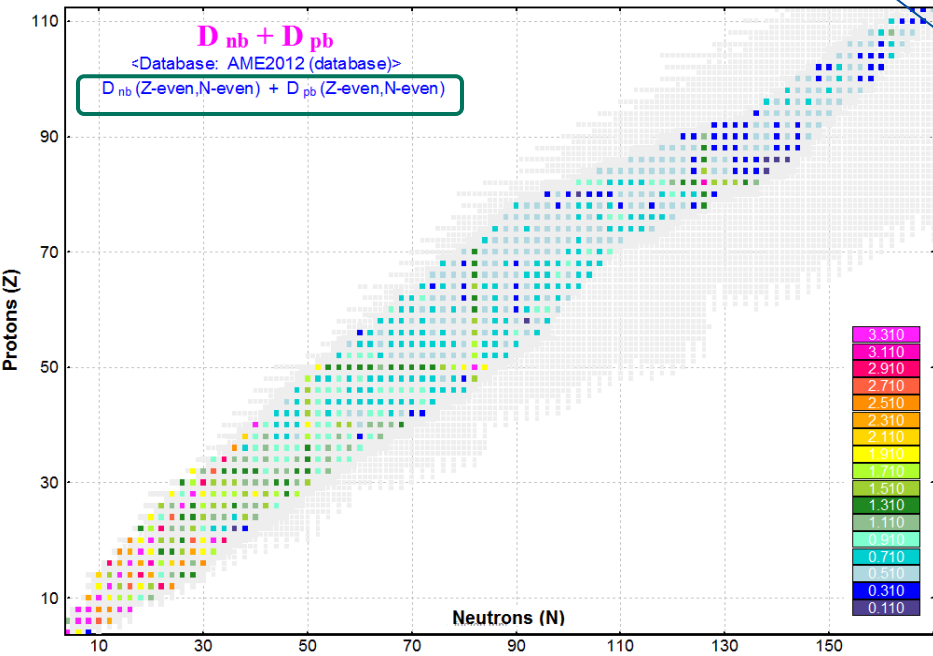
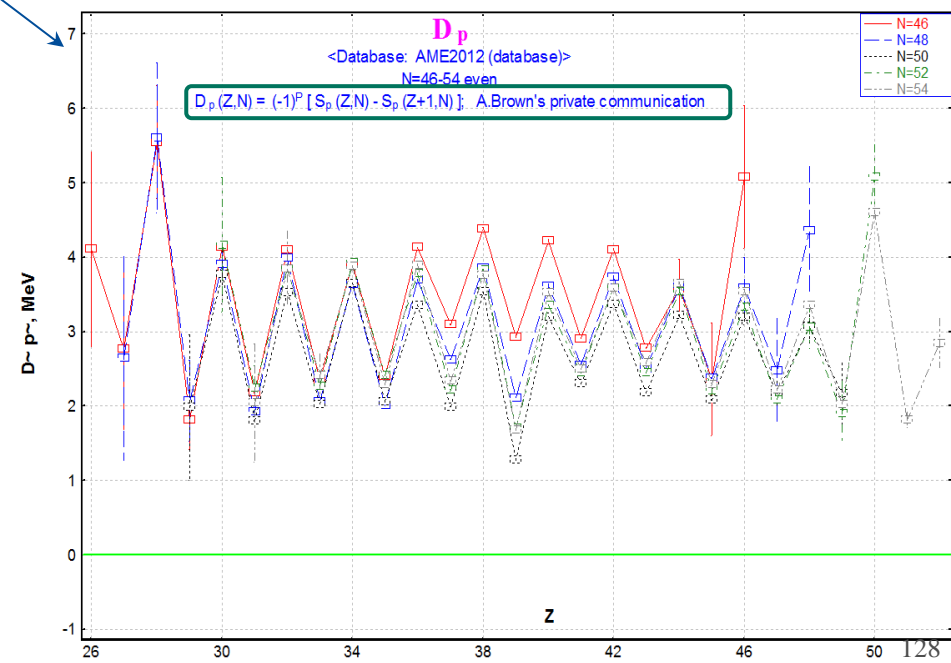
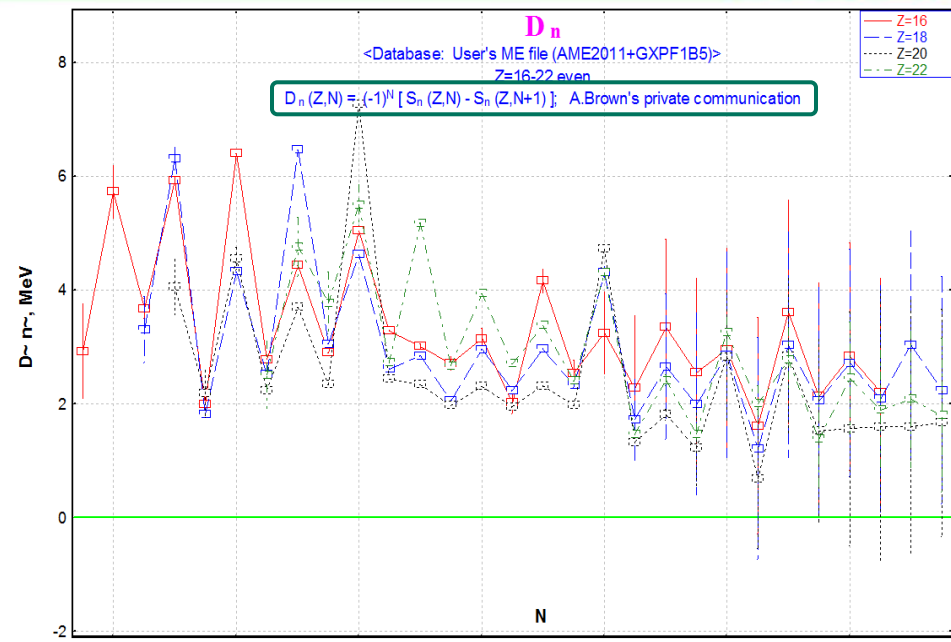


P_p(3) $P_p(\beta)(Z,N) = 0.25 \cdot (-1)^{Z+1} [S_p(Z+1,N) - 2S_p(Z,N) + S_p(Z-1,N)]$; CPC 2012, 36(12): 1603



- S3He
- St
- P (pairing energies)
- D (separation energy derivatives)**

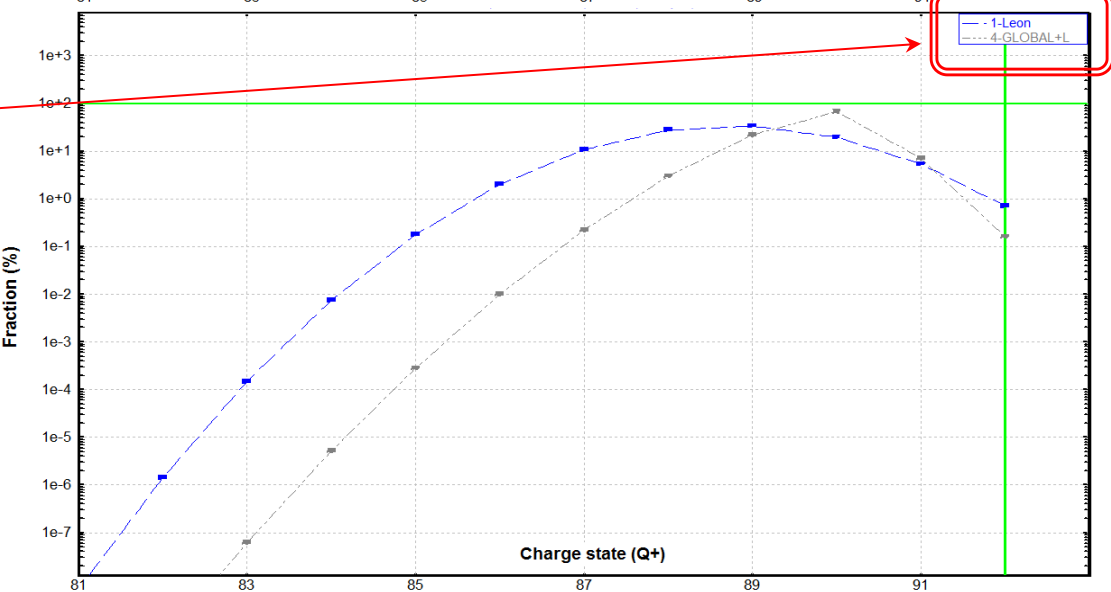
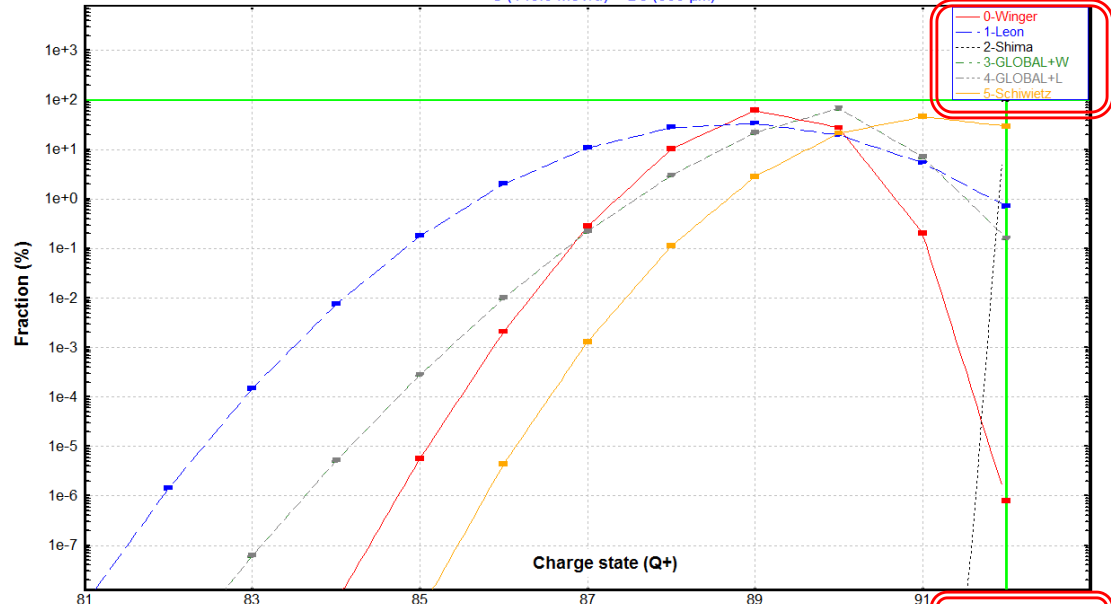
- D n
- D n (odd)
- D n (even)
- D n a
- D n b
- D p
- D p (odd)
- D p (even)
- D p a
- D p b
- Dnp + Dpb



Plots

238U equilibrium charge distribution after Target (Be): Fragment energy = 126.1 MeV/u

²³⁸U (140.0 MeV/u) + Be (500 μm)



One-dimensional Plot Drawing Methods

Simple Line
 Interpolation using 2 points
 Interpolation using 3 points
 Cubic spline
 Histogram
 NO lines

with Symbols
 Plot Errors

Draw Distribution

N! Plot:

Plot this distribution

5-Schwietz

0-Winger

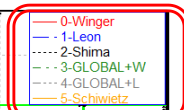
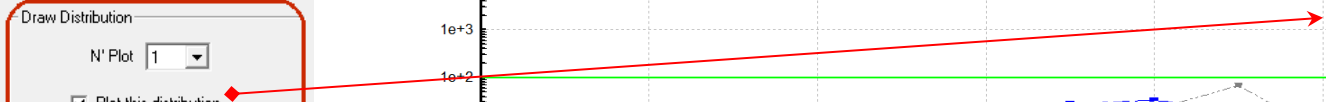
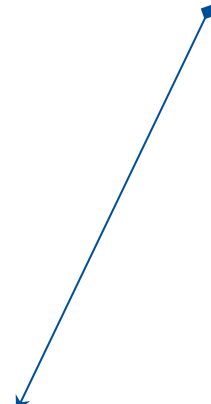
1-Leon

2-Shima

3-GLOBAL+W

4-GLOBAL+L

5-Schwietz



Plots: identification

Values (CS,T_1/2 and so on)

Show Dimension text

settings

Height : +1
Width : +2
Italic : Yes
Bold : no
ULine : no
Show : If good seen
Color : Palette

for T1/2 plots SHOW

all in seconds
 ms,sec,day,year..

^{180}Hf <i>stable</i>	^{181}Hf <i>42.39 d</i>	^{182}Hf <i>9 My</i>
^{179}Lu <i>4.59 h</i>	^{180}Lu <i>5.7 m</i>	^{181}Lu <i>3.5 m</i>
^{178}Yb <i>1.23 h</i>	^{179}Yb <i>8 m</i>	^{180}Yb <i>2.4 m</i>

Values (CS,T_1/2 and so on)

Show Dimension text

settings

Height : +0
Width : -1
Italic : no
Bold : no
ULine : no
Show : If good seen
Color : Black Color

for T1/2 plots SHOW

all in seconds
 ms,sec,day,year..

$1.0\text{e}+20$	$3.7\text{e}+06$	$2.8\text{e}+14$
$1.7\text{e}+04$	$3.4\text{e}+02$	$2.1\text{e}+02$
$4.4\text{e}+03$	$4.8\text{e}+02$	$1.4\text{e}+02$

Values (CS,T_1/2 and so on)

Show Dimension text

settings

Height : +0
Width : -1
Italic : no
Bold : no
ULine : no
Show : If good seen
Color : Black Color

for T1/2 plots SHOW

all in seconds
 ms,sec,day,year..

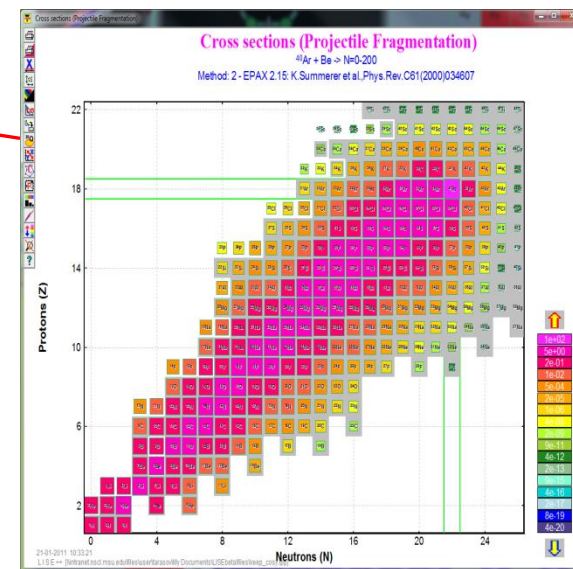
^{180}Hf $1.0\text{e}+20$ sec	^{181}Hf $3.7\text{e}+06$ sec	^{182}Hf $2.8\text{e}+14$ sec
^{179}Lu $1.7\text{e}+04$ sec	^{180}Lu $3.4\text{e}+02$ sec	^{181}Lu $2.1\text{e}+02$ sec
^{178}Yb $4.4\text{e}+03$ sec	^{179}Yb $4.8\text{e}+02$ sec	^{180}Yb $1.4\text{e}+02$ sec

Identification labels (A,Z)

settings

Height : +2
Width : +2
Italic : no
Bold : Yes
ULine : no
Show : Always
Color : White+Shading

^{180}Hf	^{181}Hf	^{182}Hf
^{179}Lu	^{180}Lu	^{181}Lu
^{178}Yb	^{179}Yb	^{180}Yb



2D-plot: Identification, values

Identification labels (A,Z)

settings

Height : +2
 Width : +1
 Italic : no
 Bold : Yes
 ULine : no
 Show : If good seen
 Color : Black+Shading

Make it default

OK Cancel

Values (CS,T_1/2 and so on)

Show Dimension text

settings

Height : -2
 Width : -3
 Italic : Yes
 Bold : no
 ULine : no
 Show : If good seen
 Color : Black Color

for T1/2 plots SHOW

all in seconds
 ms.sec.day.year..

Options

Draw grids

Draw vertical and horizontal green lines to underline the projectile

Draw cell borders

change

Option: Identification

Show mode

Show Always
 Show if good seen
 Do not show

Font Colors

Black Color
 Black Color + White Shading
 White Color + Black Shading
 Palette

Font Options

Italic
 Bold
 Underline

+2 Height
 +0 Width

OK Cancel

Color

Basic colors:

Custom colors:

Define Custom Colors >>

OK Cancel

Databases

- AME & properties: View, Edit
- AME & properties: Plots
- Isomer database: View, Edit
- User database: Edit
- User database: Plots

- S 1n
- S 2n
- S 1p
- S 2p
- Q alpha
- Beta- decay
- Beta+ decay
- T 1/2
- Mass Excess
- Binding energy
- Binding energy per A

for any plot

Choose a Plot Type

Select a data set to plot

- Exper,Beta,Alpha,Proton
- compilation set: min(Beta,Alpha,Proton)

Include "unbound" isotopes

2 - Compilation of Experiment & Min (Beta,Alpha,Proton)

Dimension of the plot

- ONE-dimensional
- TWD-dimensional

Plot type

- Isotopes, Z=const
- Isobars, A=const
- Isotones, N=const
- Isospin, N-Z =const
- Isospin, N-ZZ=const

function of

- Z (protons)
- A (nucleons)
- N (neutrons)
- N-Z (isospin)
- N-ZZ

Nmin = 0
Nmax = 200

2D: Color scale board based on

- Internal database values or calculations
- External source (iso & isolist files)

ISO file (external database): table

ISOLIST file (description of database): decay_mode

Decay mode filter: All modes

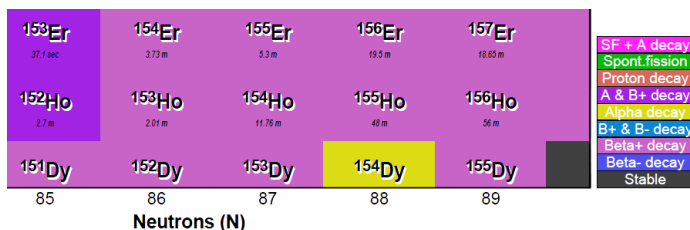
All
 Odd
 Even

OK Cancel

NZ chart

Why in database plots?

LISE++ Database (based on AME2003) values or calculations could be joined with the user color board



Default location of ISO and ISOLIST files is the "My Documents\LISE\bin" directory

ASCII file

LISE++ reads first two columns

1st column is name (should be in quotation marks)
2nd column is color (decimal base)

```

bin\decay_mode.isolist
File
"Stable"      4210752
"Beta- decay" 15224912
"Beta+ decay" 13133000
"B+ & B- decay" 13993481
"Alpha decay" 1367260
"A & B+ decay" 15016867
"Proton decay" 6121687
"Spont.fission" 767243
"SF + A decay" 16720639
    
```

```

bin\discovery_lab.isolist
File
"MSU"        2523917
"GSI"        481967
"RIKEN"      11470694
"Dubna"      598489
"GANIL"      11804186
"Argonne"    12871363
"Cern"       10593035
"Oak Ridge"  2007034
"Berkeley"   3666870
"other"      6579300
    
```

```

welcome.isolist
File
"2011"      2523917
"++"        481967
"LISE"      11470694
"to"        598489
"welcome"   11804186
    
```

SF + A decay
Spont.fission
Proton decay
A & B+ decay
Alpha decay
B+ & B- decay
Beta+ decay
Beta- decay
Stable

other
Berkeley
Oak Ridge
Cern
Argonne
GANIL
Dubna
RIKEN
GSI
MSU

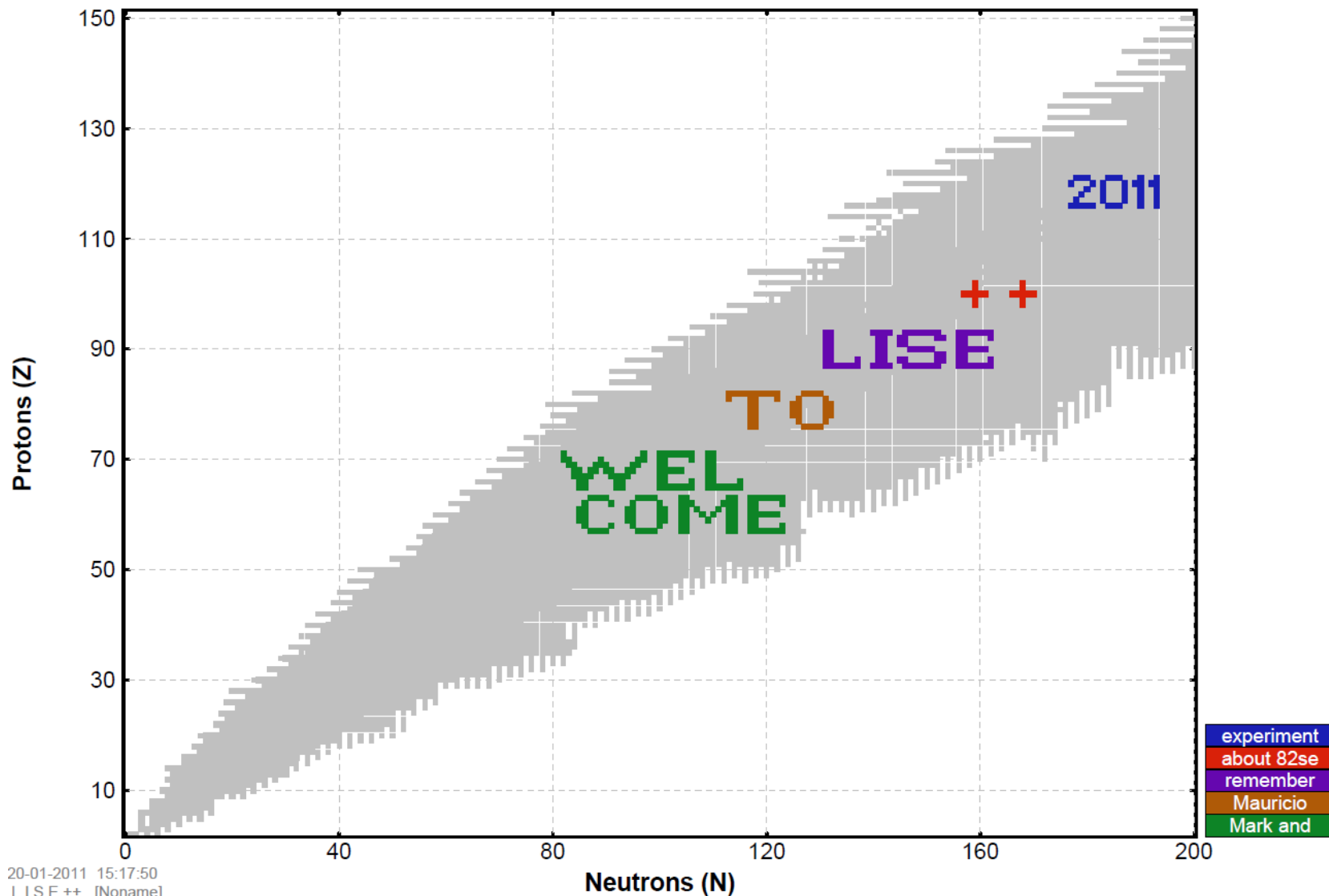
welcome
to
LISE
++
2011

S_{2p}

<Database: AME2003 (A&W) + LDM2>

N=0-200

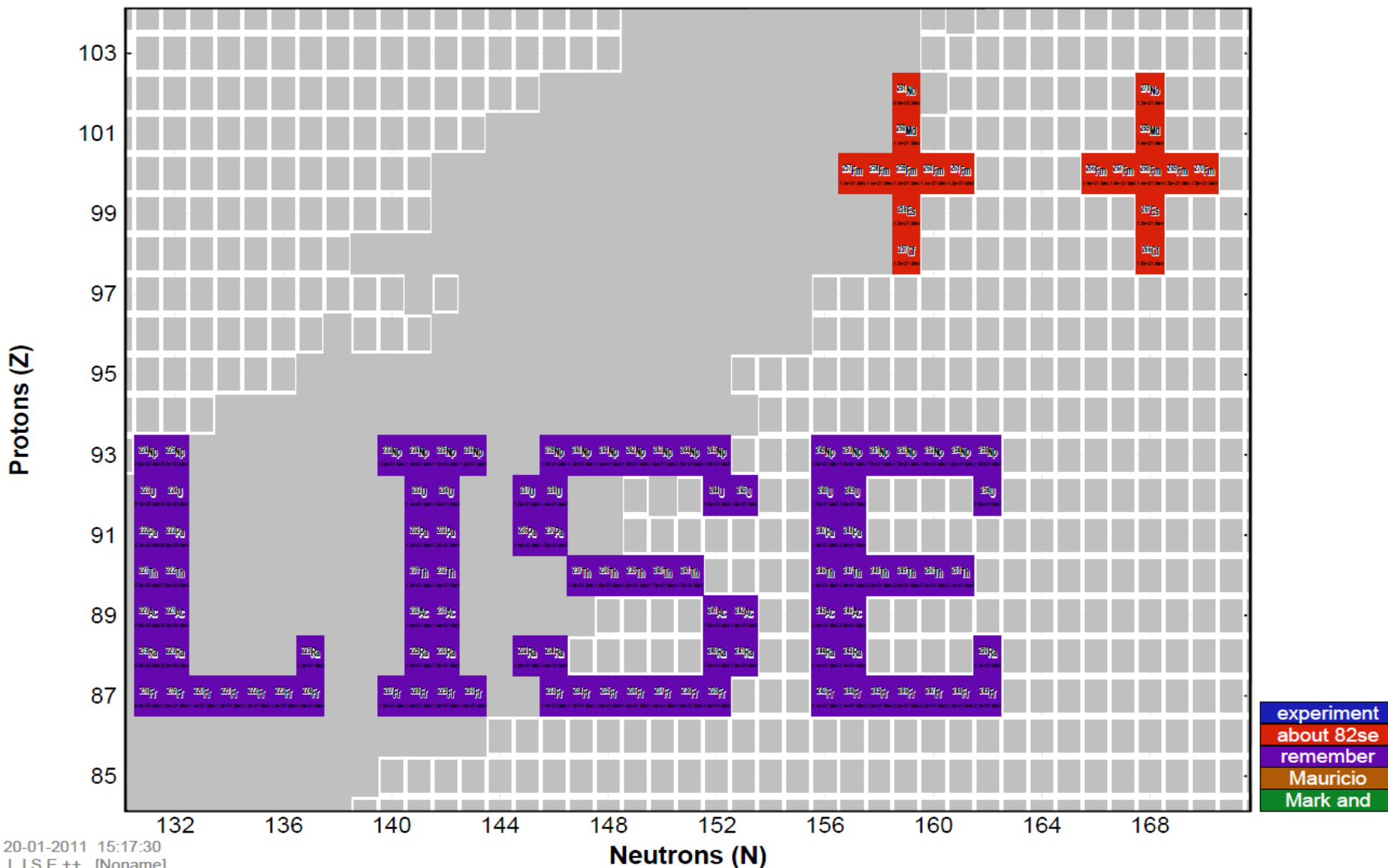
The color scale board is based on "welcome.iso" & "welcome.isolist" files



S_{2p}

<Database: AME2003 (A&W) + LDM2>
N=0-200

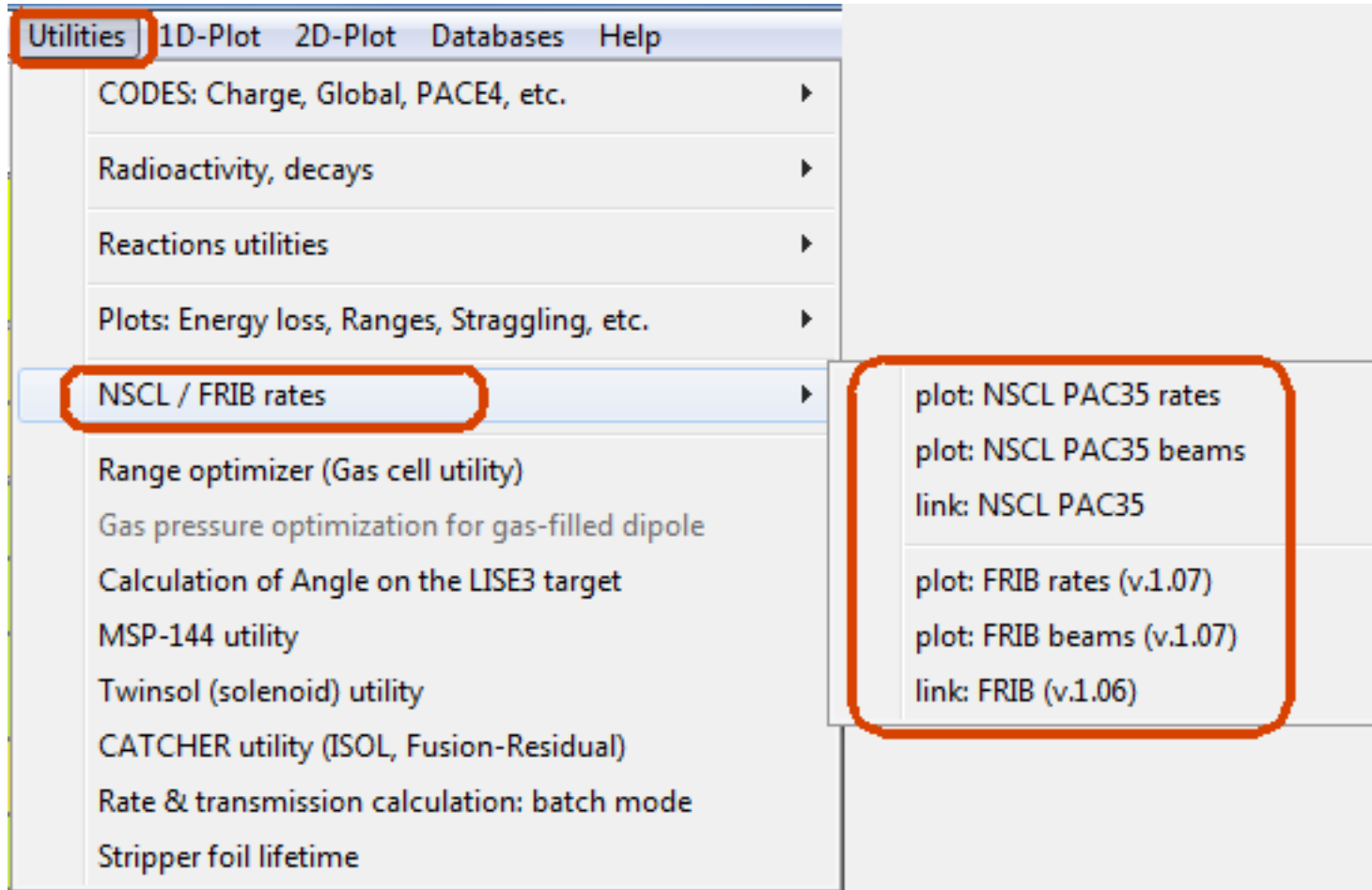
The color scale board is based on "welcome.iso" & "welcome.isolist" files



Plots :

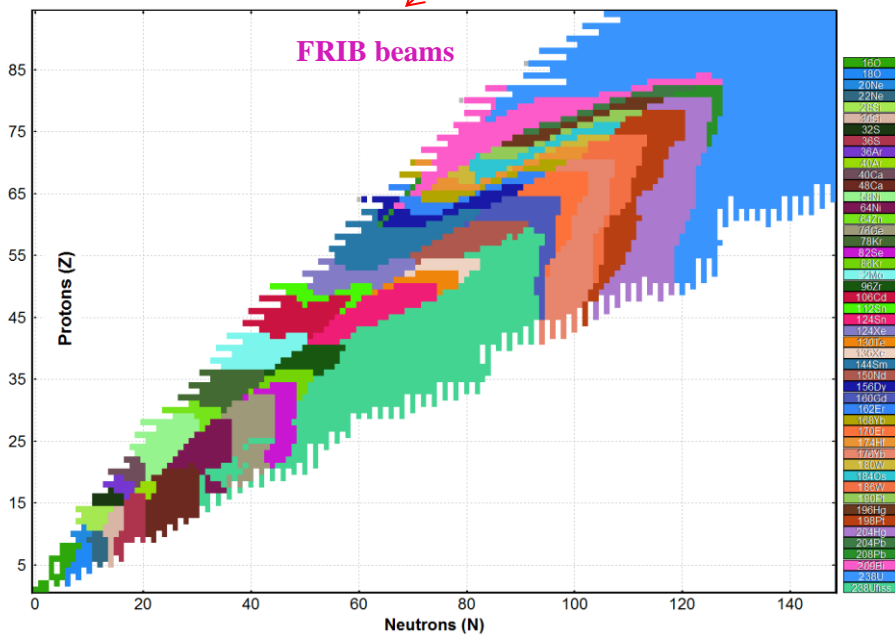
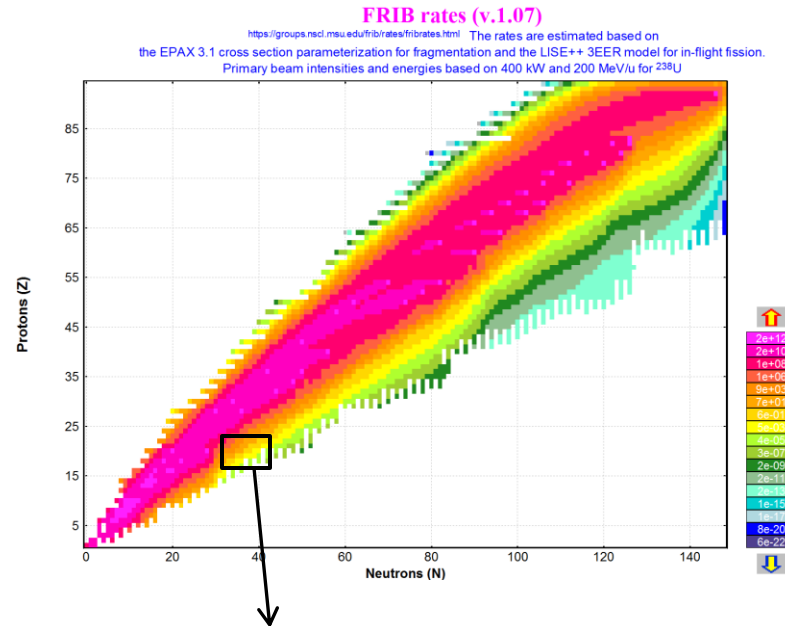
NSCL and FRIB rates

LISE⁺⁺ version 9.4.34



Utilities 1D-Plot 2D-Plot Databases Help

- LISE++ for Excel
- CODES : Charge, Global, PACE4, etc. ▶
- Radioactivity, decays ▶
- Reactions utilities ▶
- Plots : Energy loss, Ranges, Stragglng, etc. ▶
- NSCL / FRIB rates** ▶
 - plot: NSCL PAC35 rates
 - plot: NSCL PAC35 beams
 - link: NSCL PAC35
 - plot: FRIB rates (v.1.07)**
 - plot: FRIB beams (v.1.07)**
 - link: FRIB (v.1.06)
- Set-up utilities ▶
- Range optimizer (Gas cell utility)
- Gas pressure optimization for gas-filled dipole
- CATCHER utility (ISOL, Fusion-Residual)
- Rate & transmission calculation: batch mode
- Stripper foil lifetime



24	Cr	⁵⁷ Cr	⁵⁸ Cr	⁵⁹ Cr	⁶⁰ Cr	⁶¹ Cr	⁶² Cr	⁶³ Cr	⁶⁴ Cr	65
	e+10	6.3e+09	1.7e+09	3.7e+08	5.4e+07	5.9e+06	9.8e+05	1.7e+05	2.4e+04	3.8e
23	⁵⁶ V	⁵⁶ V	⁵⁷ V	⁵⁸ V	⁵⁹ V	⁶⁰ V	⁶¹ V	⁶² V	⁶³ V	64
	e+09	5.4e+08	1.2e+08	2.0e+07	2.5e+06	2.4e+05	3.2e+04	4.6e+03	6.9e+02	1.2e
22	⁴ Ti	⁵⁵ Ti	⁵⁶ Ti	⁵⁷ Ti	⁵⁸ Ti	⁵⁹ Ti	⁶⁰ Ti	⁶¹ Ti	⁶² Ti	63
	e+08	3.1e+07	5.2e+06	7.7e+05	8.3e+04	7.2e+03	9.4e+02	1.4e+02	2.6e+01	4.9e
21	Sc	⁵⁴ Sc	⁵⁵ Sc	⁵⁶ Sc	⁵⁷ Sc	⁵⁸ Sc	⁵⁹ Sc	⁶⁰ Sc	⁶¹ Sc	62
	e+06	1.2e+06	1.6e+05	4.6e+04	3.5e+03	1.2e+03	3.1e+01	7.4e+00	1.1e+00	2.0e
20	Ca	⁵³ Ca	⁵⁴ Ca	⁵⁵ Ca	⁵⁶ Ca	⁵⁷ Ca	⁵⁸ Ca	⁵⁹ Ca	⁶⁰ Ca	
	e+05	1.3e+05	1.1e+04	2.5e+03	2.0e+02	3.0e+01	4.2e+00	2.3e-01	4.3e-02	
19	¹ K	⁵² K	⁵³ K	⁵⁴ K	⁵⁵ K	⁵⁶ K	⁵⁷ K	⁵⁸ K	⁵⁹ K	
	e+03	2.1e+03	2.5e+02	3.1e+01	1.6e+00	4.1e-01	4.7e-02	8.4e-03	1.8e-03	
	32	33	34	35	36	37	38	39	40	41

Neutrons (N)

Plots : Half-lives

Databases

DataBase: 0 - AME2012 (database)

A: 270, Element: Hs, Z: 108, N: 162

Alpha decay

Database Index: 108162

T 1/2: 30# s, private

Value: ys, zs, as, fs

Mass Excess: 125.0900

Binding Energy: 1969.6500

Beta- decay energy: -5.6240

Beta+ decay energy: 0.8630

S 2n: 13.8840

S 2p: 6.2900

Q alpha: 9.0462

S 1n: 7.5710

S 1p: 3.6810

Put "*" into a cell if value is: stable, unstable, unknown

Half-life (sec): Experimental (database), Calculation: beta decay (1.74e+03), alpha decay (1.68e+02), proton emission

Help

- Private string
- New time scale
- Stable isotopes : Abundance

Databases

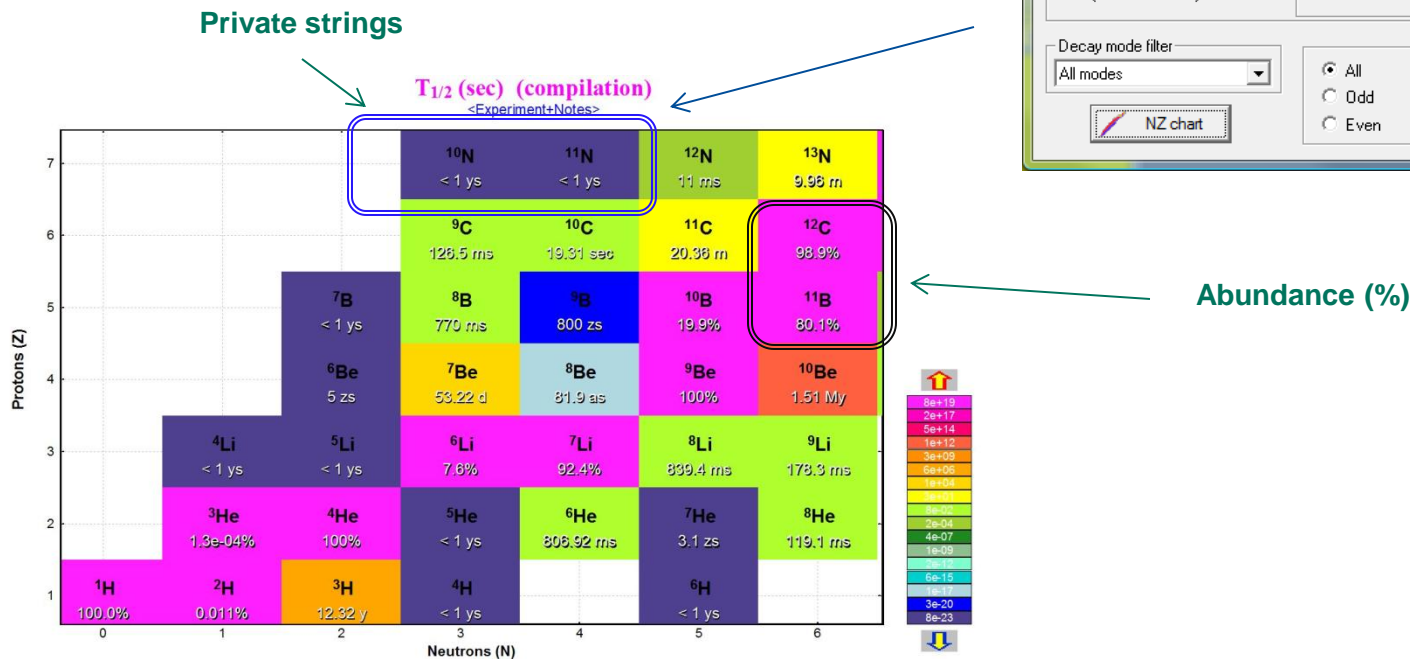
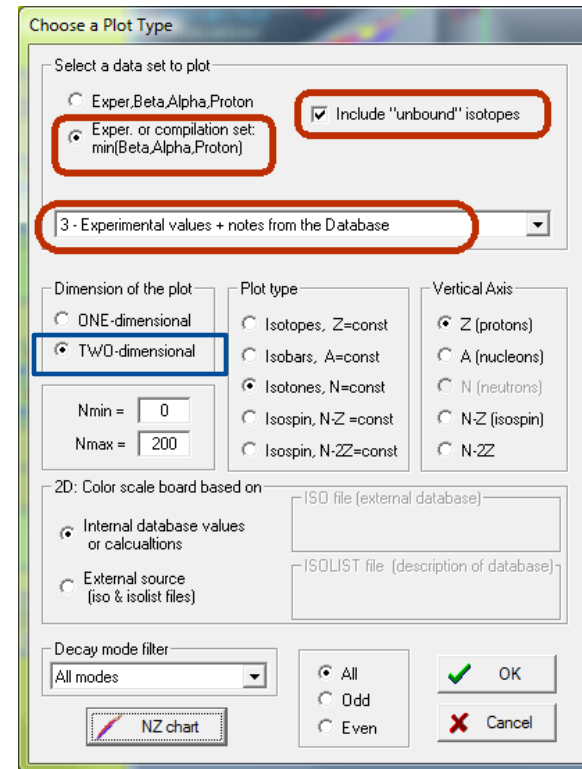
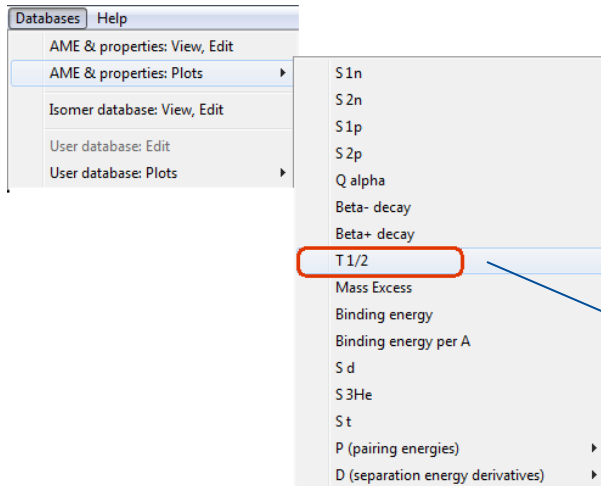
DataBase: 0 - AME2012 (database)

A: 48, Element: Ca, Z: 20, N: 28

Stable

Database Index: 20028

Abundance,%: 0.187, stable

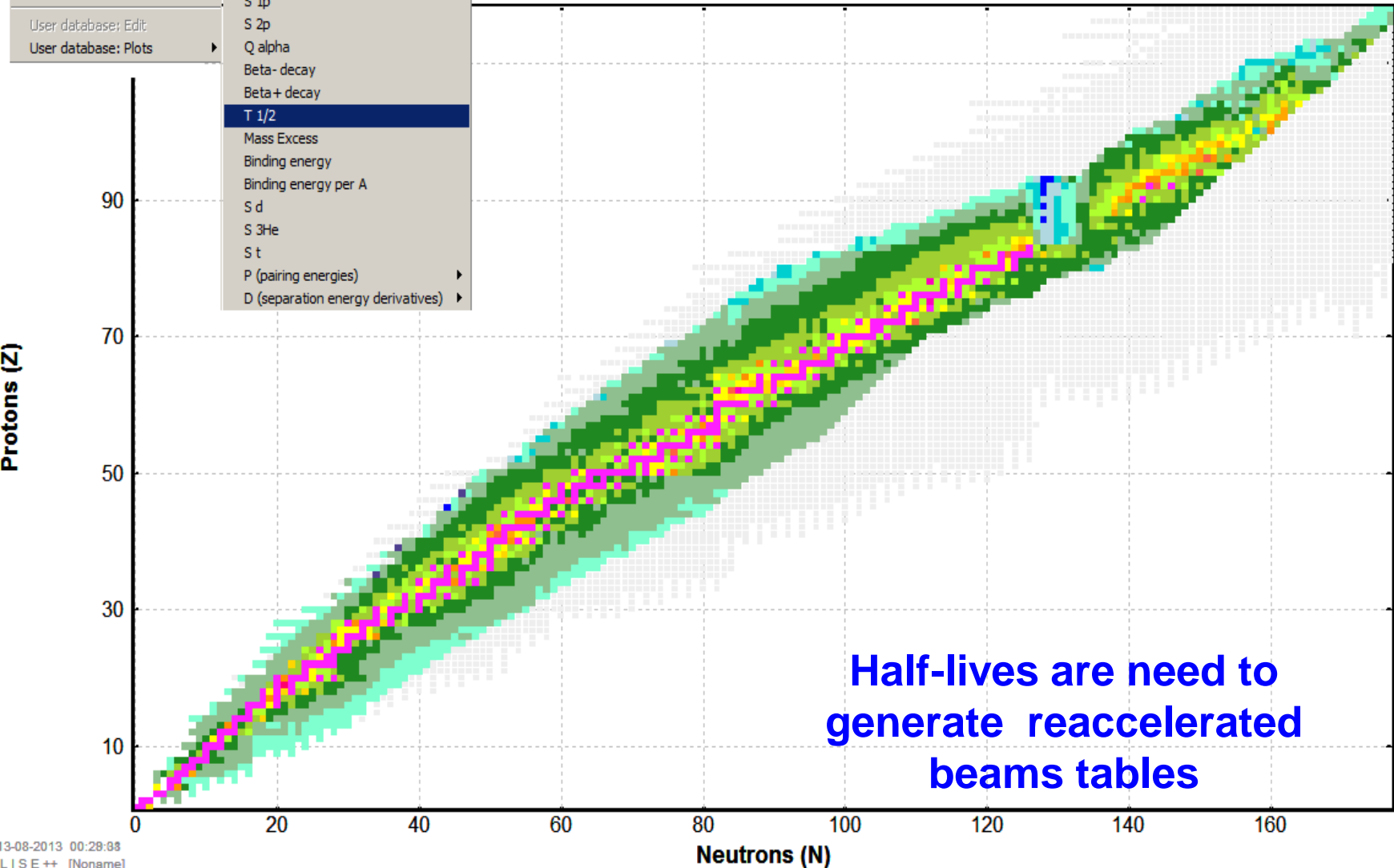


$T_{1/2}$ (sec) (compilation)
 <Experiment+Notes>
 N=0-200

Databases

- AME & properties: View, Edit
- AME & properties: Plots ▶
- Isomer database: View, Edit
- User database: Edit
- User database: Plots ▶

- S 1n
- S 2n
- S 1p
- S 2p
- Q alpha
- Beta- decay
- Beta+ decay
- T 1/2**
- Mass Excess
- Binding energy
- Binding energy per A
- S d
- S 3He
- S t
- P (pairing energies) ▶
- D (separation energy derivatives) ▶



↑

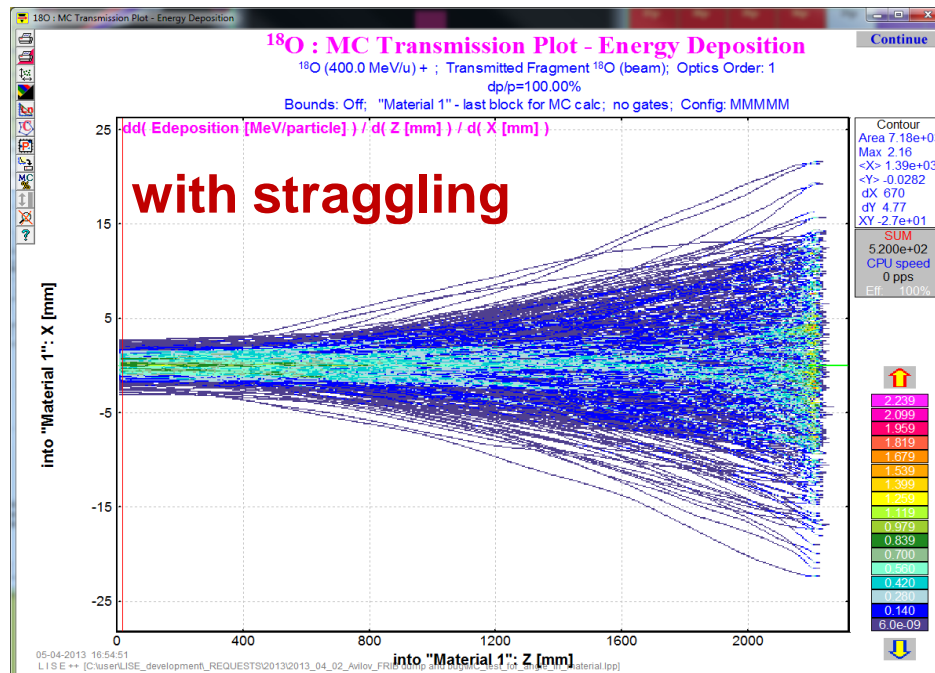
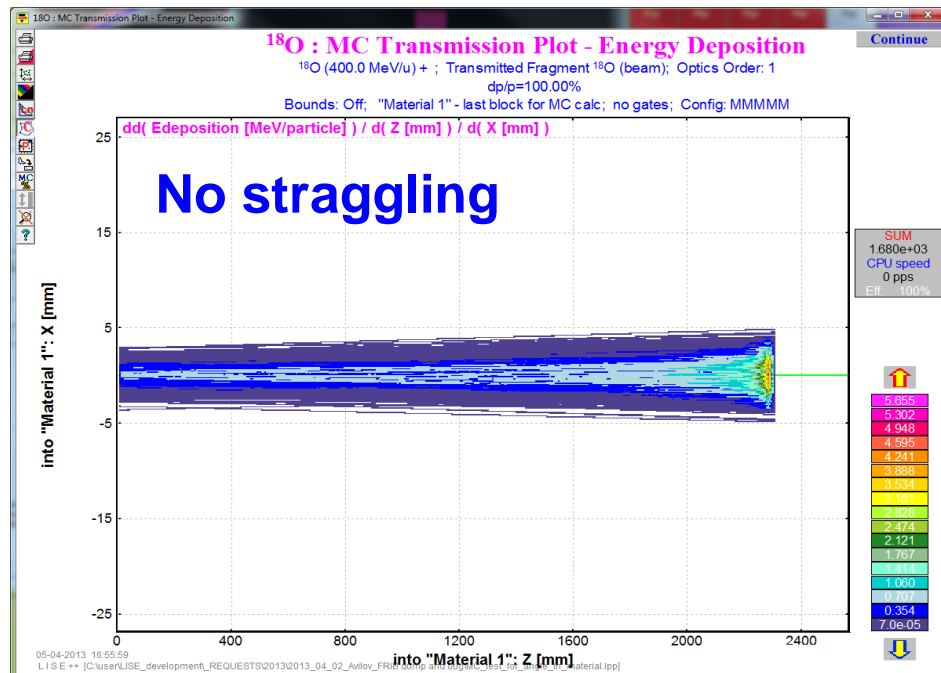
8e+19
1e+18
1e+16
1e+14
2e+12
2e+10
2e+08
3e+06
3e+04
4e+02
5e+00
5e-02
6e-04
8e-06
9e-08
1e-09
1e-11

↓

**Improvement,
Fix of bugs**

After revision

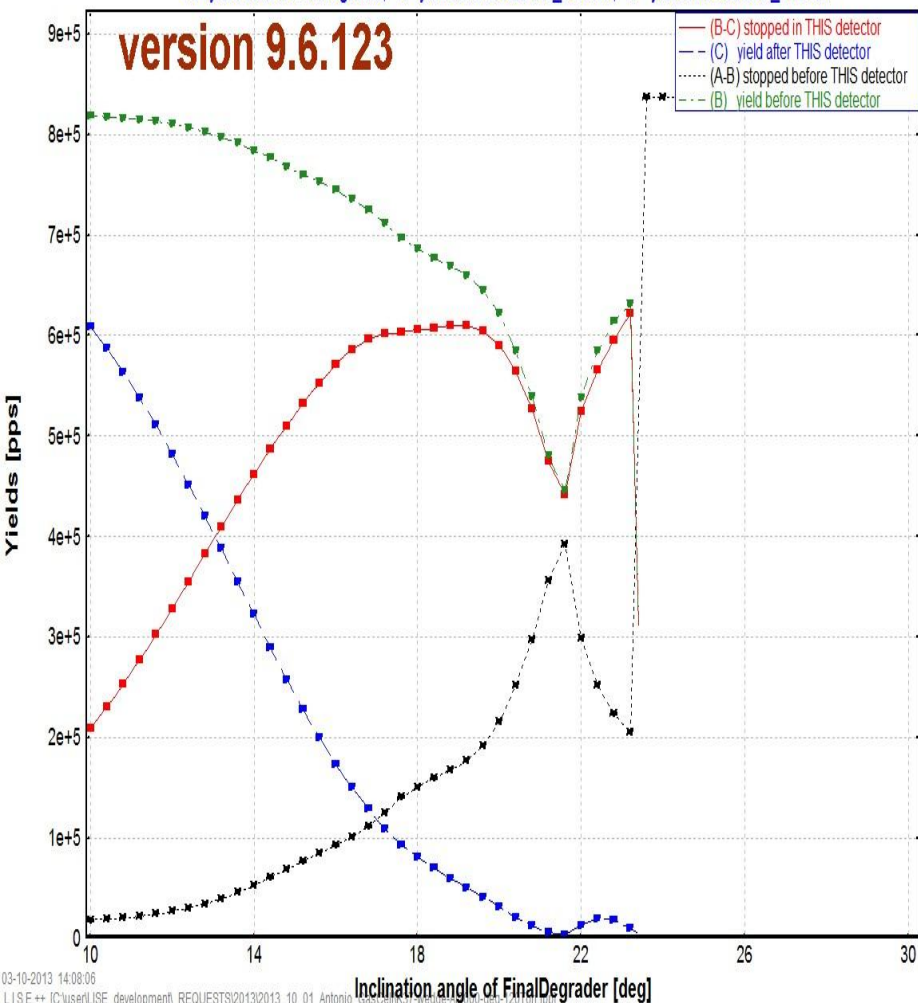
Beam CARD (sigma, semi-axis, halfwidth...)	1D - shape (Distribution method)	2D mode	2D - shape (Monte Carlo method)	Correlated with
1. X mm	1 Gaussian	<input type="checkbox"/>		
2. T mrad	1 Rectangle uniform	<input type="checkbox"/>		
3. Y mm	1 Gaussian	<input type="checkbox"/>		
4. P mrad	1 Gaussian	<input type="checkbox"/>		
5. L mm	0 Gaussian	<input type="checkbox"/>		
6. D %	0.01 Gaussian	<input type="checkbox"/>		



Gas Cell utility modification

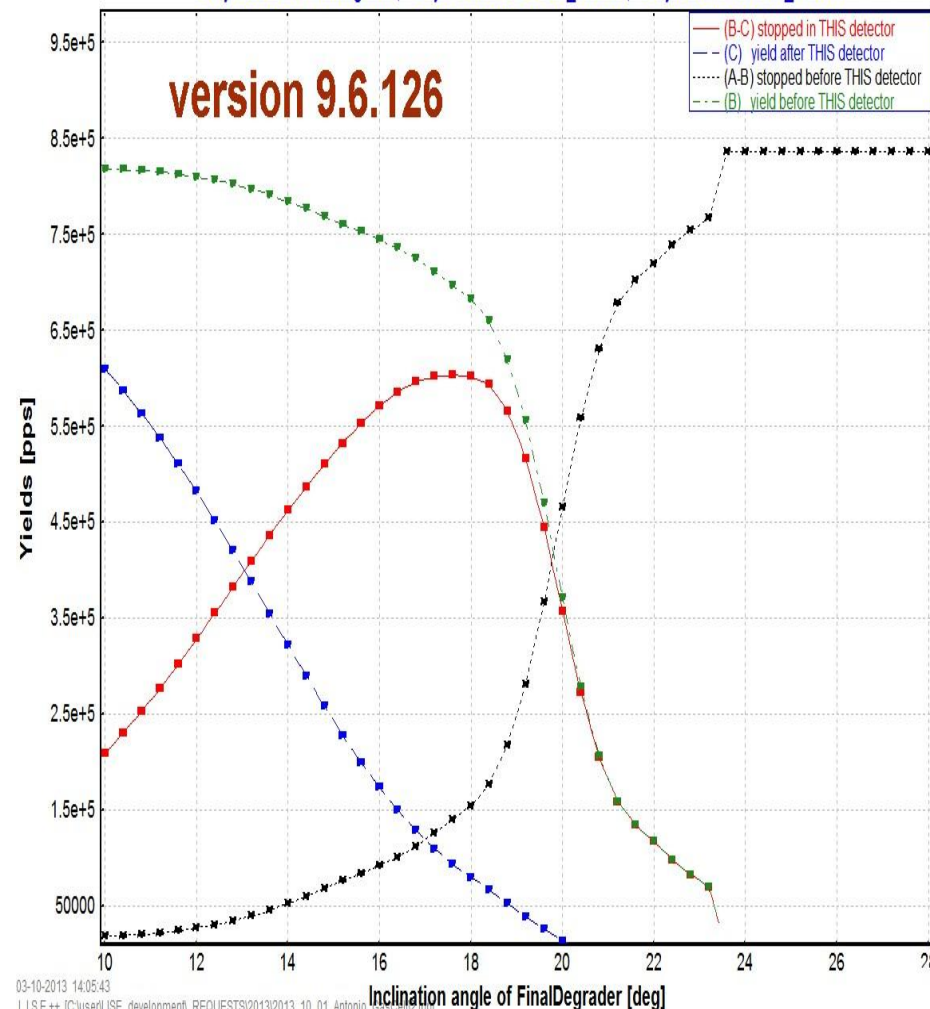
Number of particles stopped in GasCell_120Torr

^{40}Ca (140.0 MeV/u) + Be (957.24 mg/cm²); Settings on ^{37}K ; Config: DDSWDDSDDDMDMDWMSMMM
 dp/p=1.00% ; Wedges: Al (145.55 mg/cm²), Al (2000 μm); Brho(Tm): 2.6931, 2.6931, 2.5434, 2.5434, 2.5434....
 A - yield before FinalDegrader; B - yield before GasCell_120Torr; C - yield after GasCell_120Torr



Number of particles stopped in GasCell_120Torr

^{40}Ca (140.0 MeV/u) + Be (957.24 mg/cm²); Settings on ^{37}K ; Config: DDSWDDSDDDMDMDWMSMMM
 dp/p=1.00% ; Wedges: Al (145.55 mg/cm²), Al (2000 μm); Brho(Tm): 2.6931, 2.6931, 2.5434, 2.5434, 2.5434....
 A - yield before FinalDegrader; B - yield before GasCell_120Torr; C - yield after GasCell_120Torr



Monte Carlo calculation of fragment transmission

What isotope transmission to calculate?

- One fragment of interest. Chose manually here
- Group of Isotopes already calculated by the Distribution method (Ncalc = 0)
- List of isotopes from file to produce inside target
- Input ions rays from file emitted from target

Chose fragment of interest

A	Element	Z
37	K	19

Charge states: 19+ D1

Reaction mechanism: Projectile Fragmentation

MC transmission options

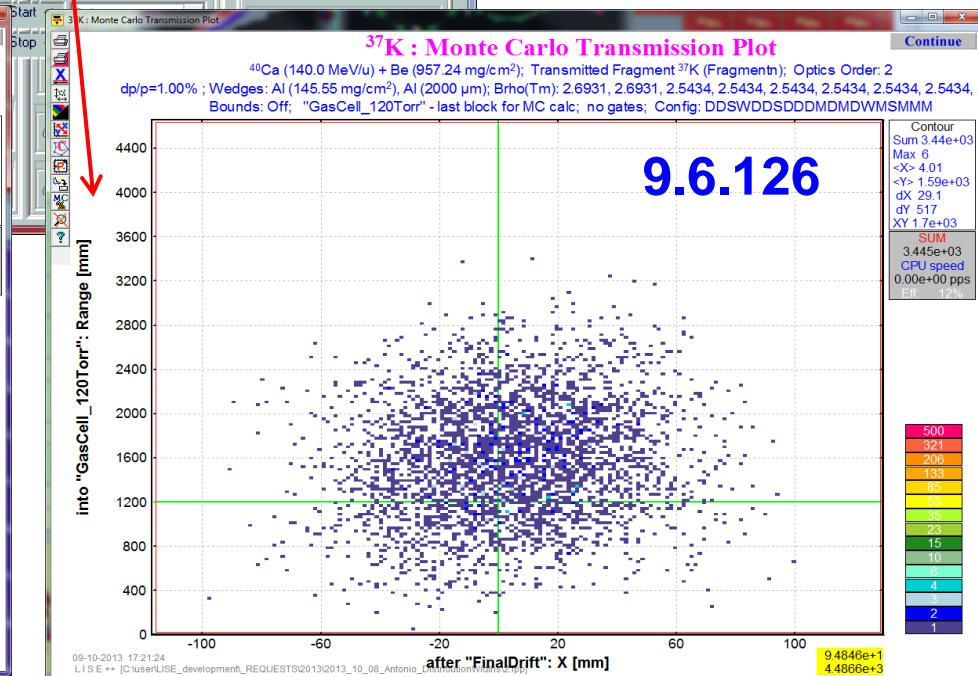
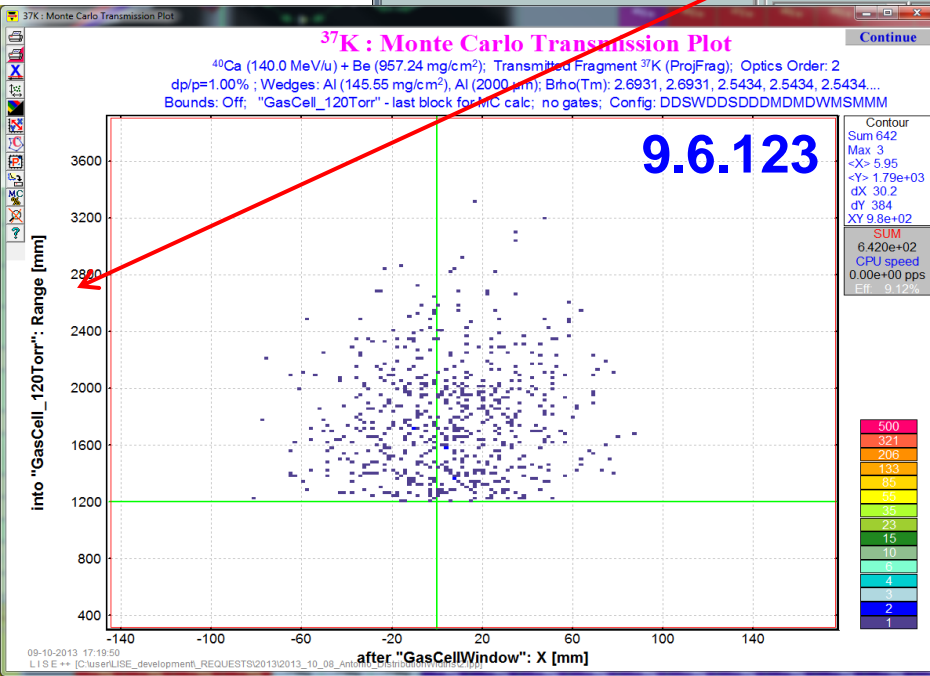
X-coordinate After BLOCK

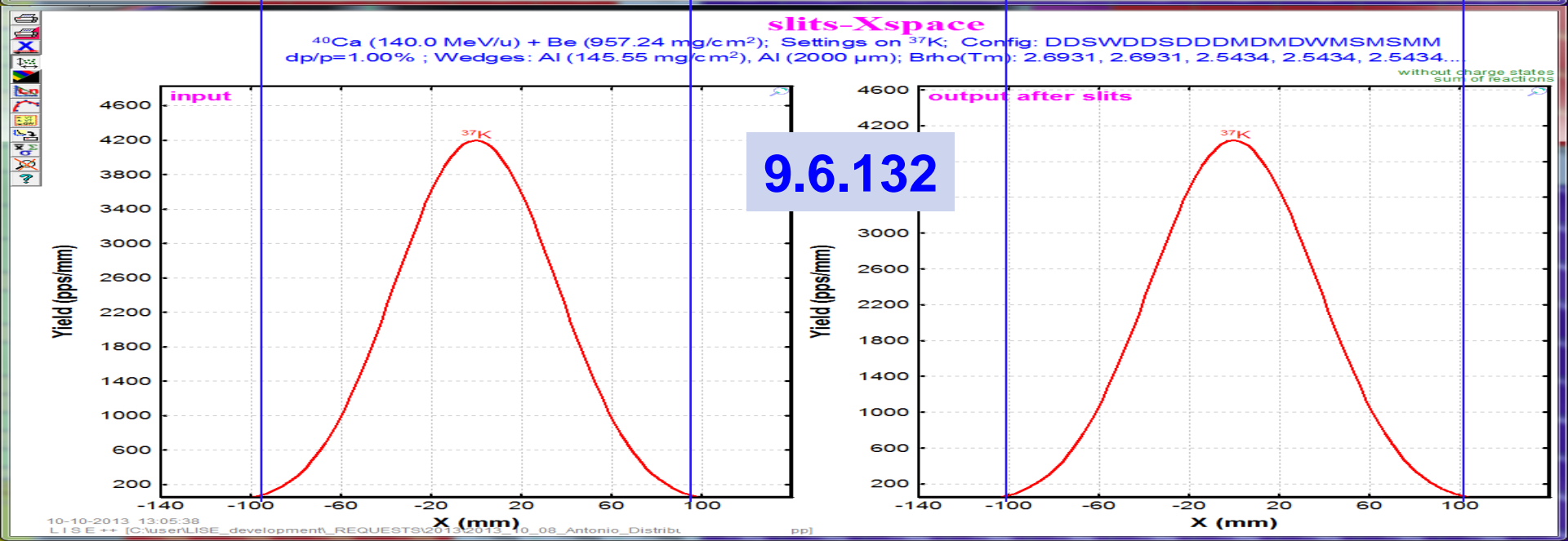
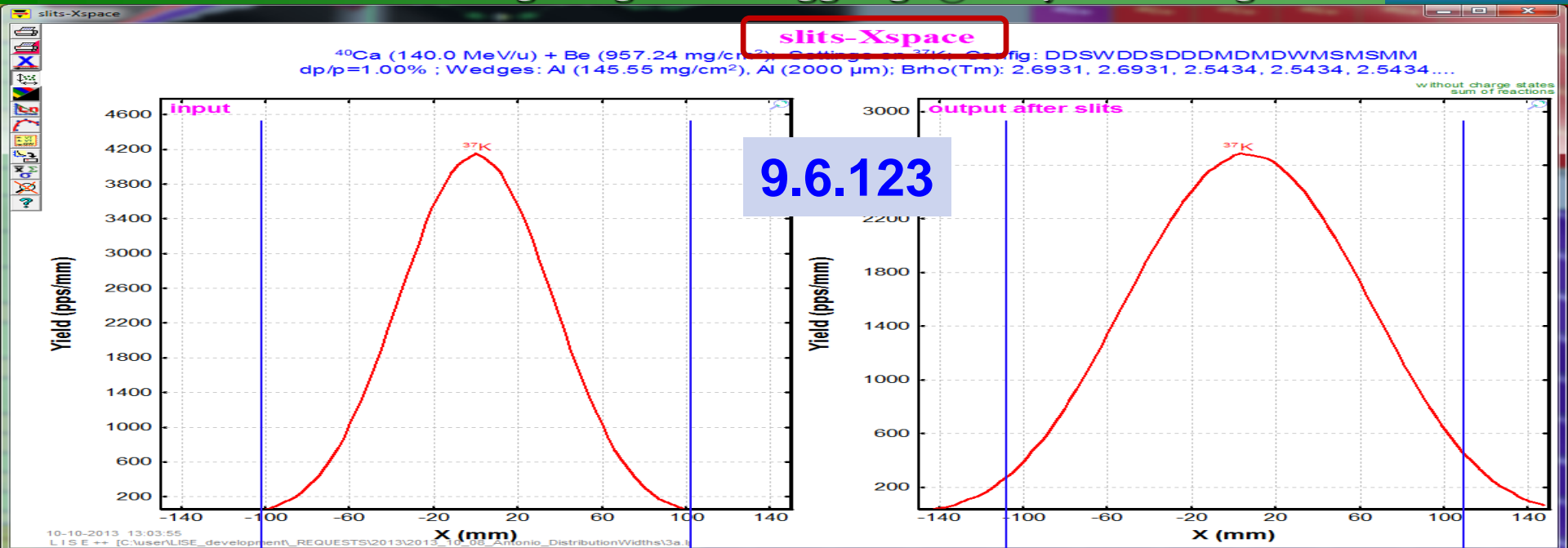
- X mm
- X' (T) mrad
- Y mm
- Y' (P) mrad
- dP/P %
- Radial [f(X;Y)] mm
- Angle [f(X';Y')] mrad
- Energy MeV/u
- TKE MeV
- Momentum MeV/c
- Brho T^m
- Erho MJ/C
- Energy Loss MeV
- Range mm
- Envelope m
- Energy MeV/mm
- Deposition /particle
- Time of flight ns
- Length m

Y-coordinate Into block

- X mm
- X' (T) mrad
- Y mm
- Y' (P) mrad
- dP/P %
- Radial [f(X;Y)] mm
- Angle [f(X';Y')] mrad
- Energy MeV/u
- TKE MeV
- Momentum MeV/c
- Brho T^m
- Erho MJ/C
- Energy Loss MeV
- Range mm
- Envelope m
- Energy MeV/mm
- Deposition /particle
- Time of flight ns
- Length m

Gate 1, Gate 2, Gate 3, Gate 4





Complications

Fusion reactions & thick targets

Abrasion-Fission (High Z)

Quad- and Sextupole fields

PF & proton drip-line

Experiment e547 @ GANIL

Fusion information window

238U(24.1 MeV/u) + Be -> 247Cm* -> 96Zr

Q-value of reaction = -6.877 MeV
 Fusion max.barrier = 42.96 MeV
 Fusion radius = 8.80 fm

Depending on a place of reaction in the target

	beginning	middle	end
Beam energy (Lab) [MeV/u]	24.10	20.65	16.87
Beam energy (Lab) [MeV]	5737.0	4915.7	4016.6
Center of mass energy [MeV]	209.26	179.31	146.51
Excitation energy [MeV]	202.39	172.43	139.63
Compound recoil energy [MeV]	5527.8	4736.4	3870.1
Capture cross section [mb]	2.2e+03	2.16e+03	2.09e+03
Probability of Compound	1.00e+00	1.00e+00	1.00e+00
Compound formation CS [mb]	2.2e+03	2.16e+03	2.09e+03
Compound-Fission CS [mb]	2.03e+3	1.99e+3	1.94e+3
Compound-Breakup CS [mb]	0	0	0

for setting residue after the stripper

Energy diapason (MeV/u) 17.926 .. 15.664
 Corresponding ion charge state 37.67 .. 37.17

Plot the excitation function

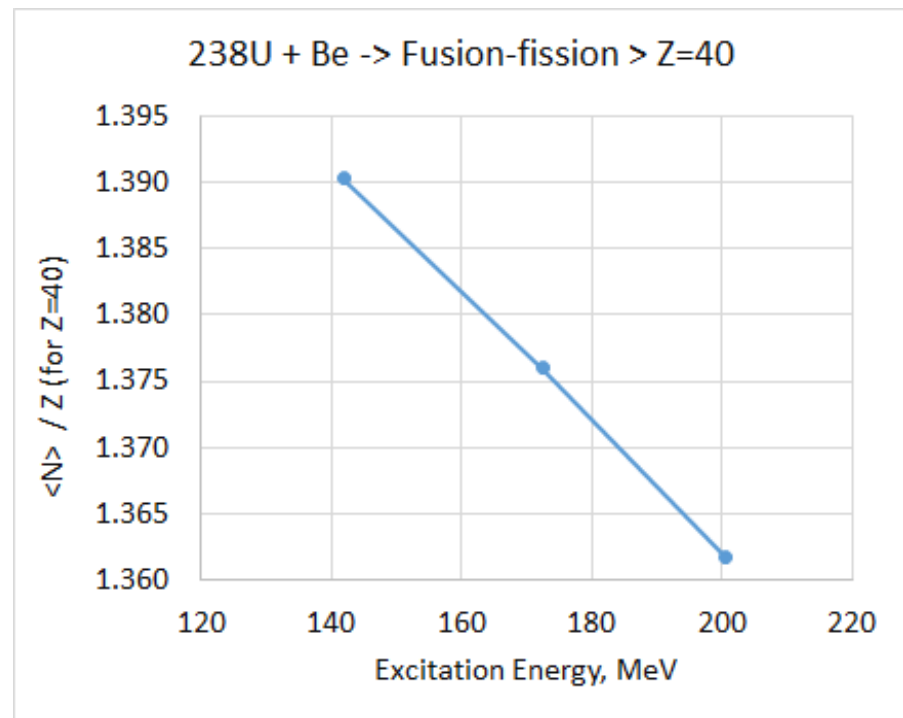
Fusion-Residue calculator

All fusion characteristics are calculated with BASS-model

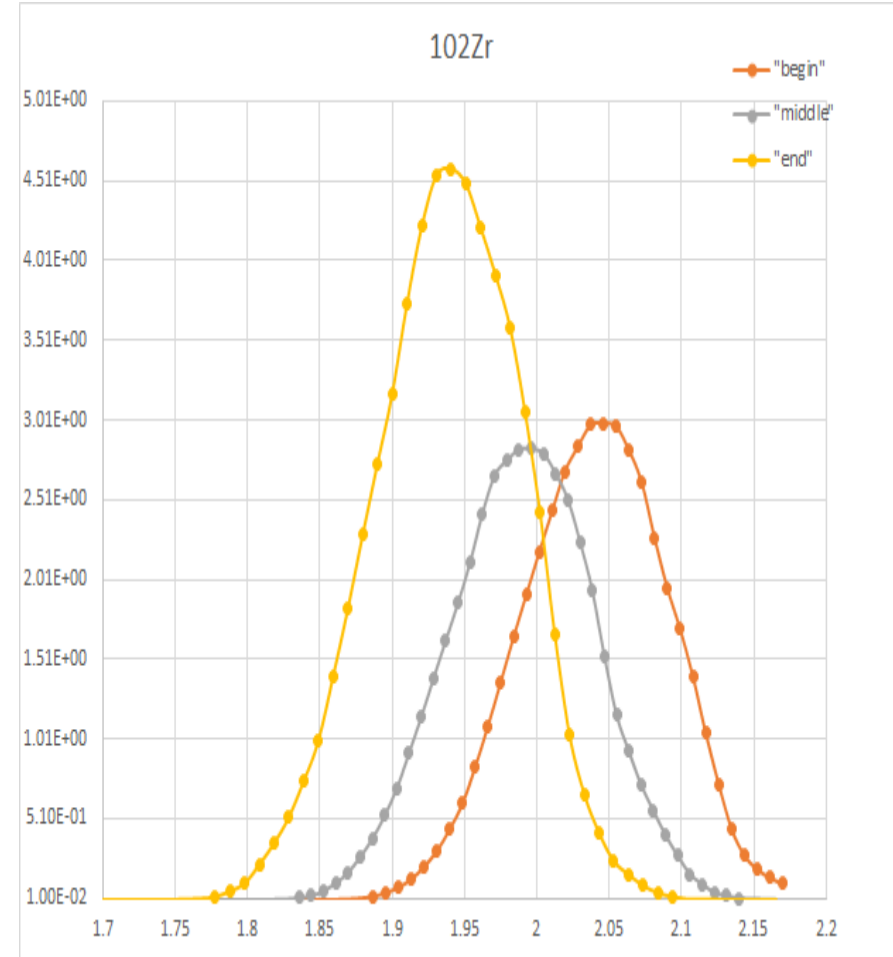
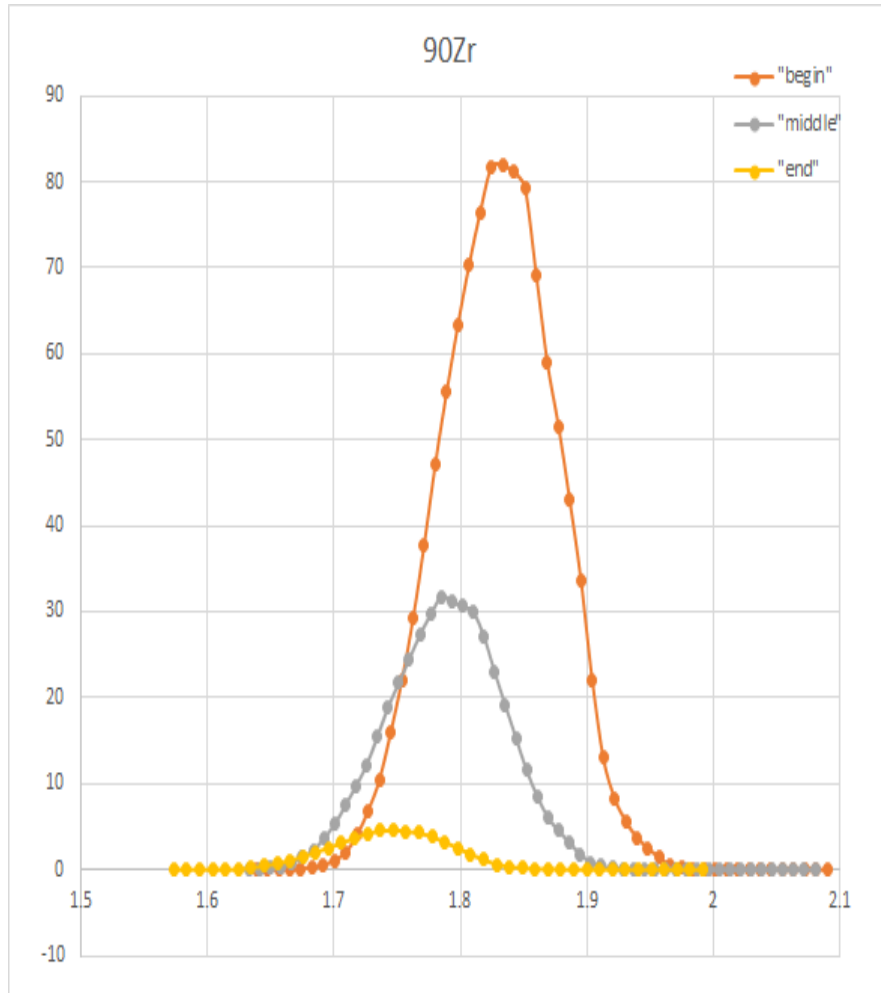
Quit

$^{238}\text{U}(24.1\text{MeV/u}) + \text{Be target } (15\text{ mg/cm}^2) \rightarrow$
Fusion-Fission

Wide excitation energy range 139.6-202.4 MeV



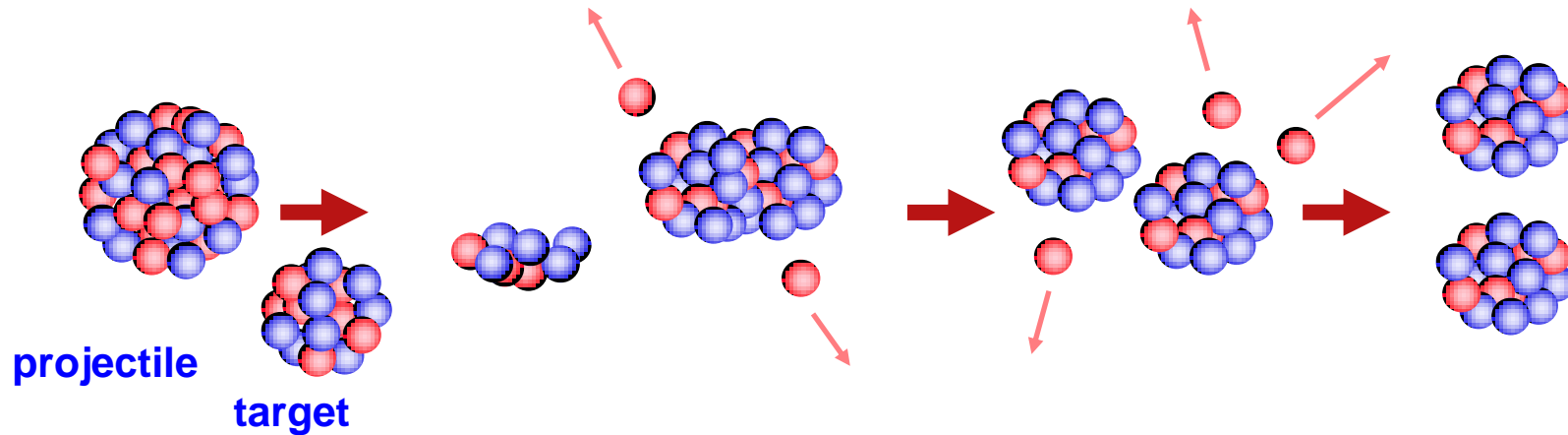
$^{238}\text{U}(24.1\text{MeV/u}) + \text{Be target (15 mg/cm}^2) \rightarrow \text{Fusion-Fission}$



Finally the "slice" technique was used to analyze these data

Abrasion-Fission cross sections

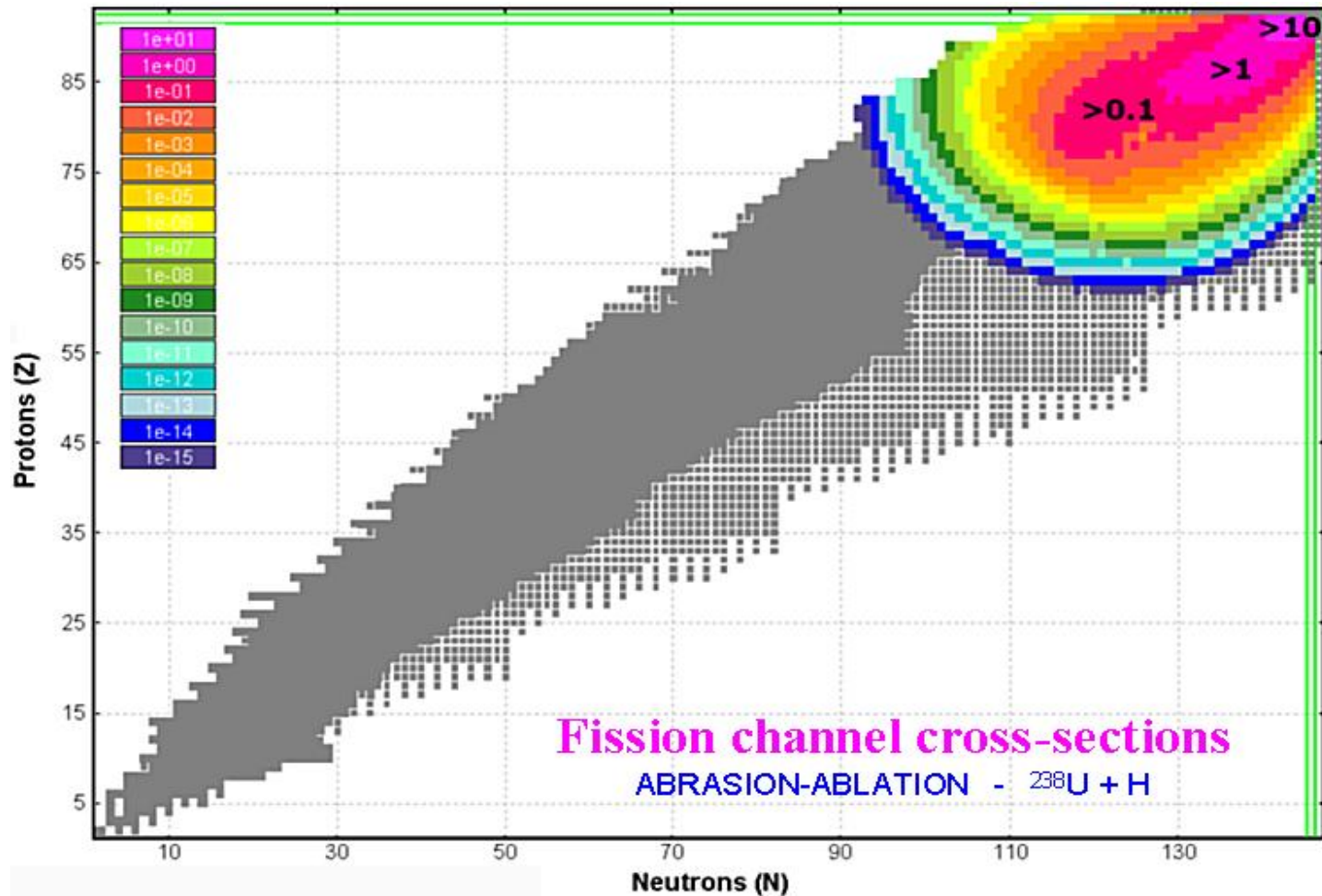
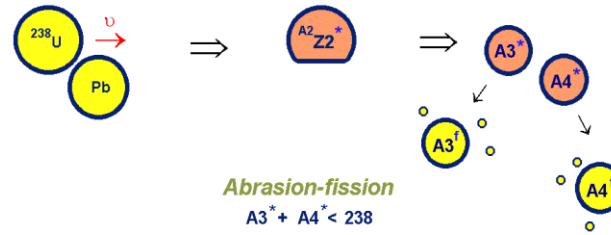
Neutron-rich & High Z

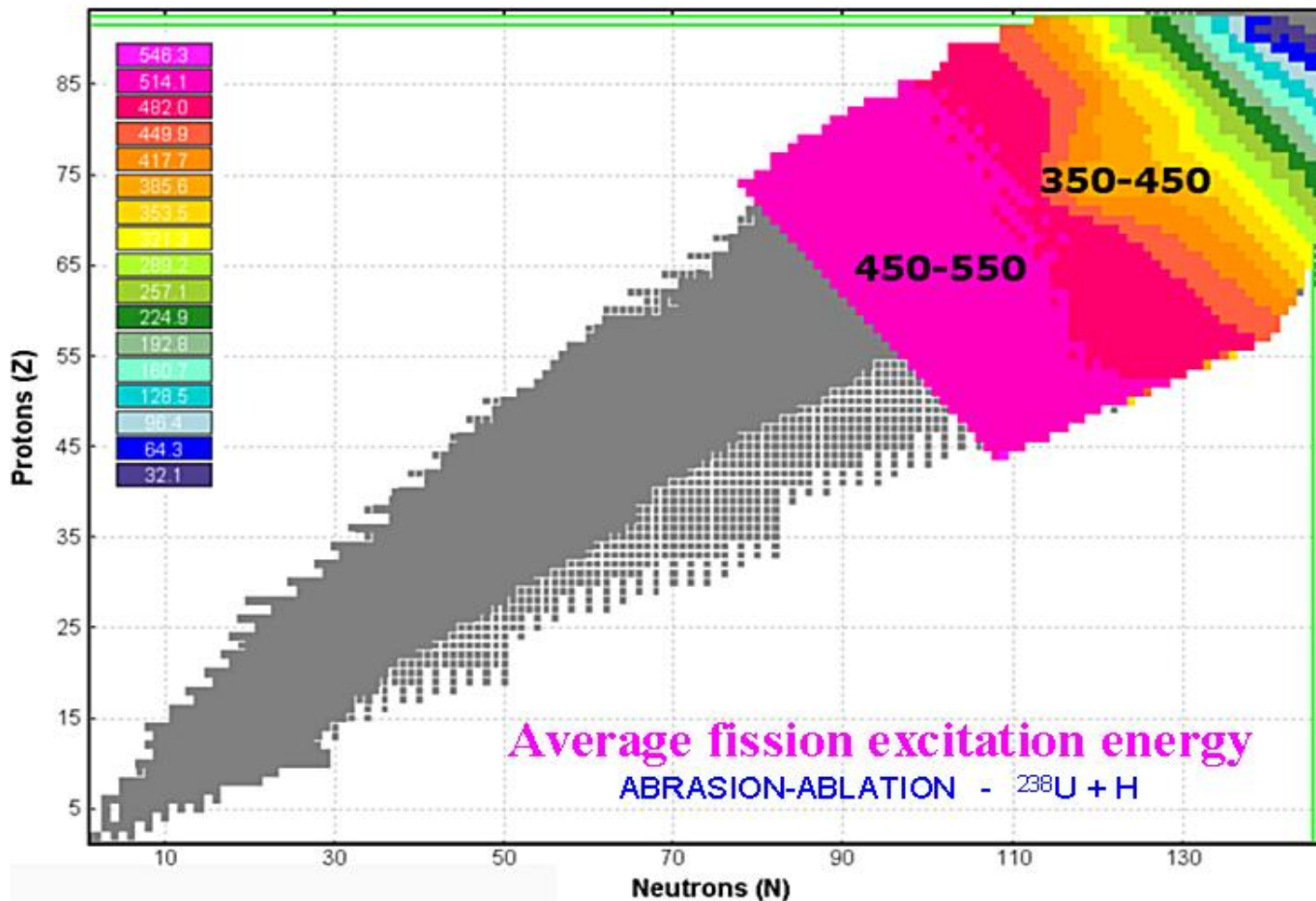
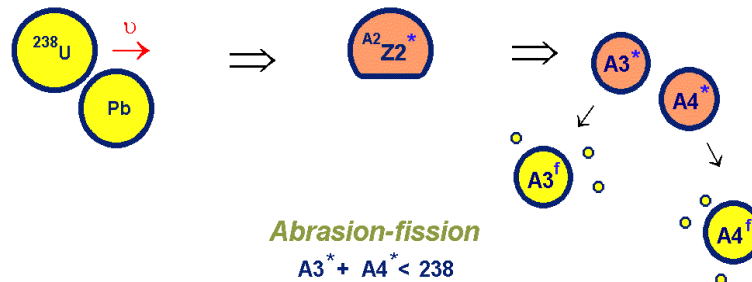


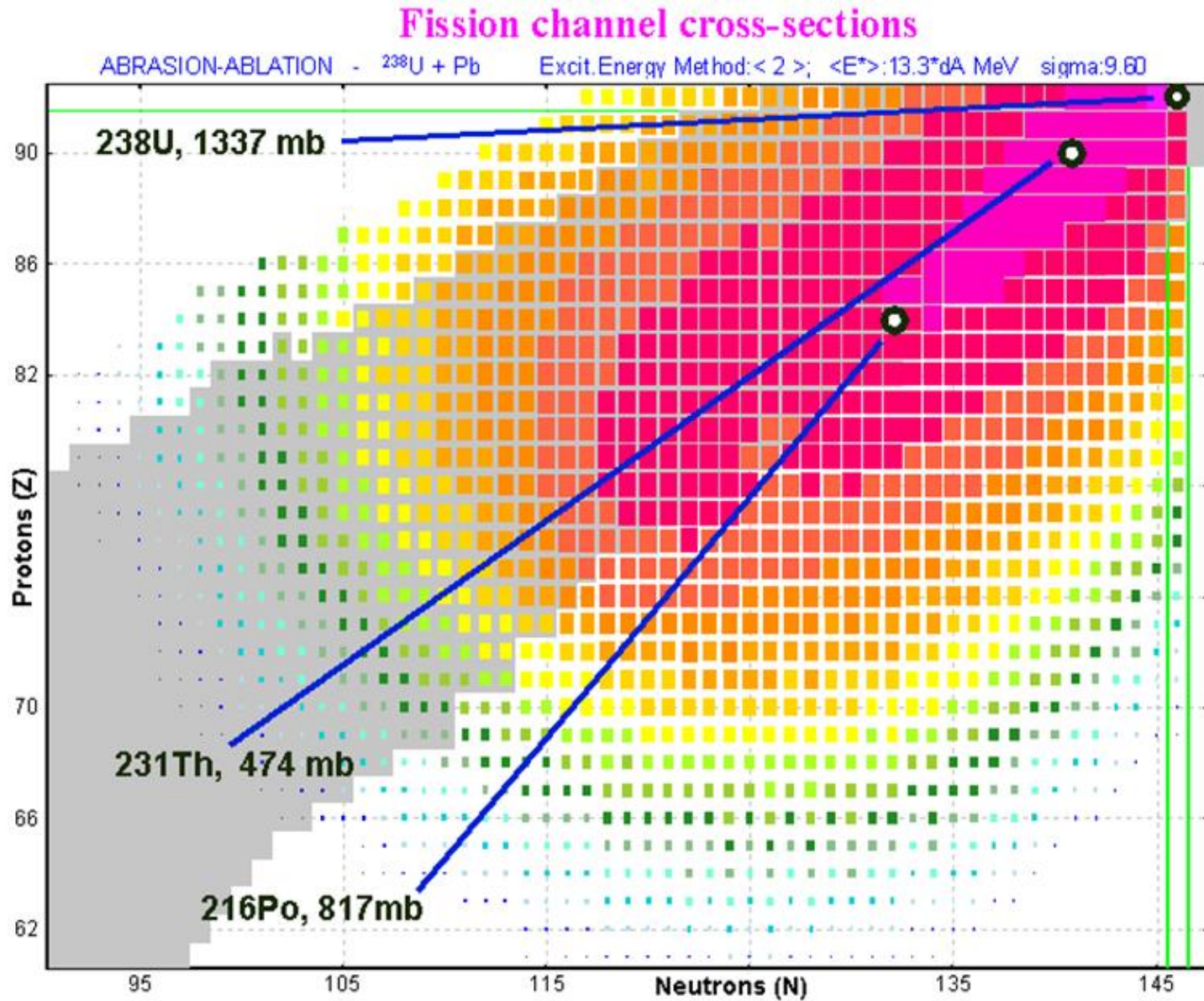
□ LISE++ 3EER Abrasion-Fission model (analytical)

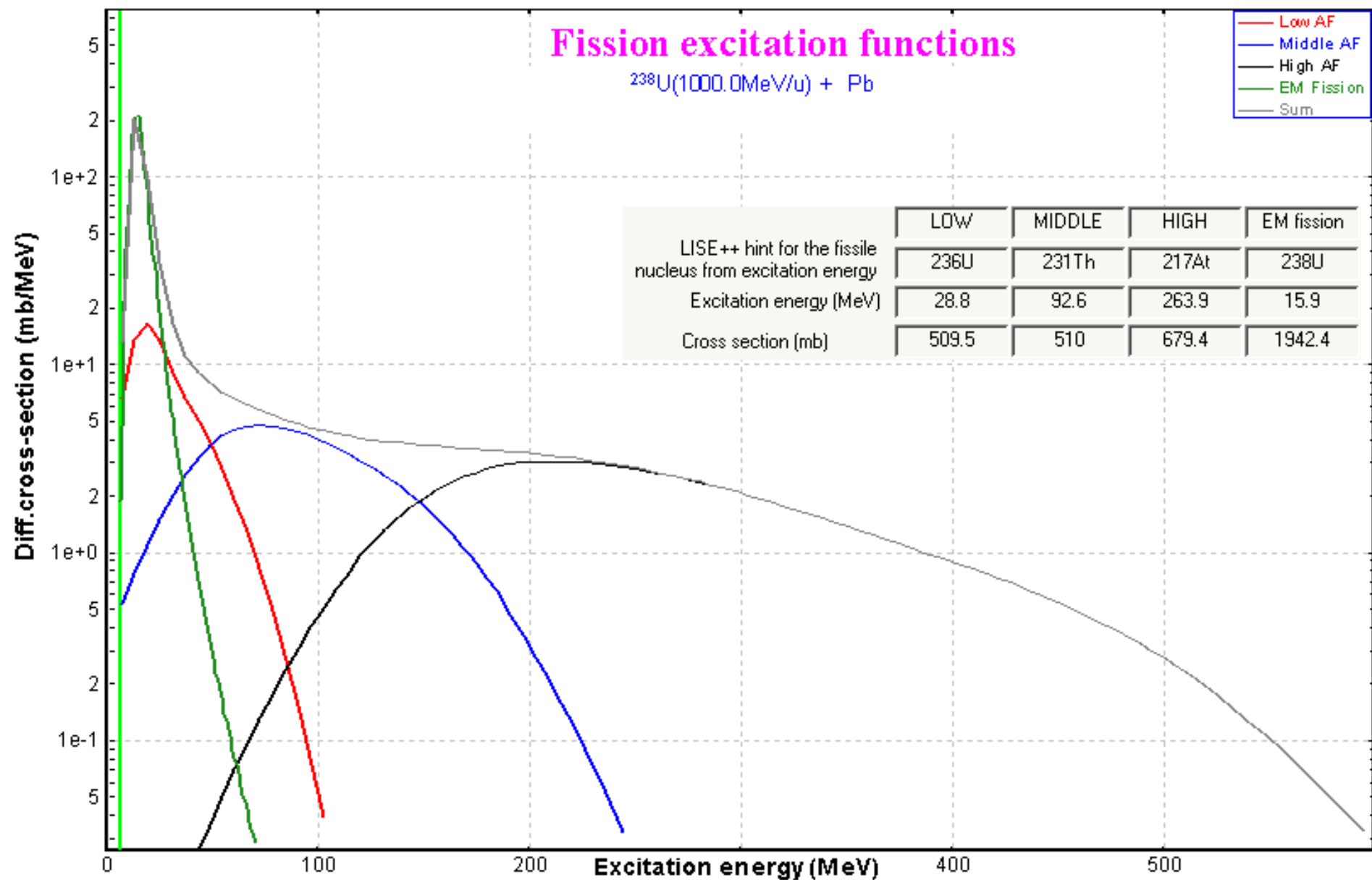
Tech. Rep. MSUCL1300, NSCL, Michigan State University, 2005

http://lise.nsl.msu.edu/7_5/lise++_7_5.pdf







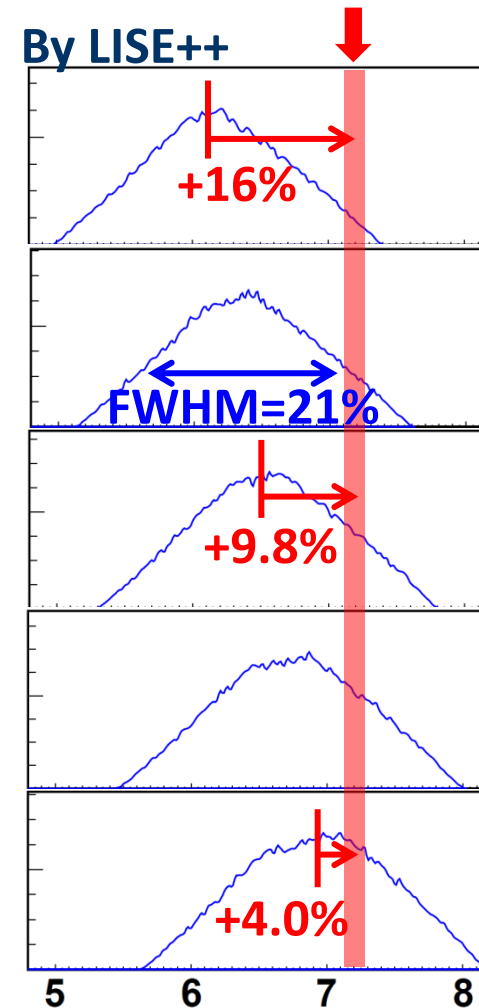
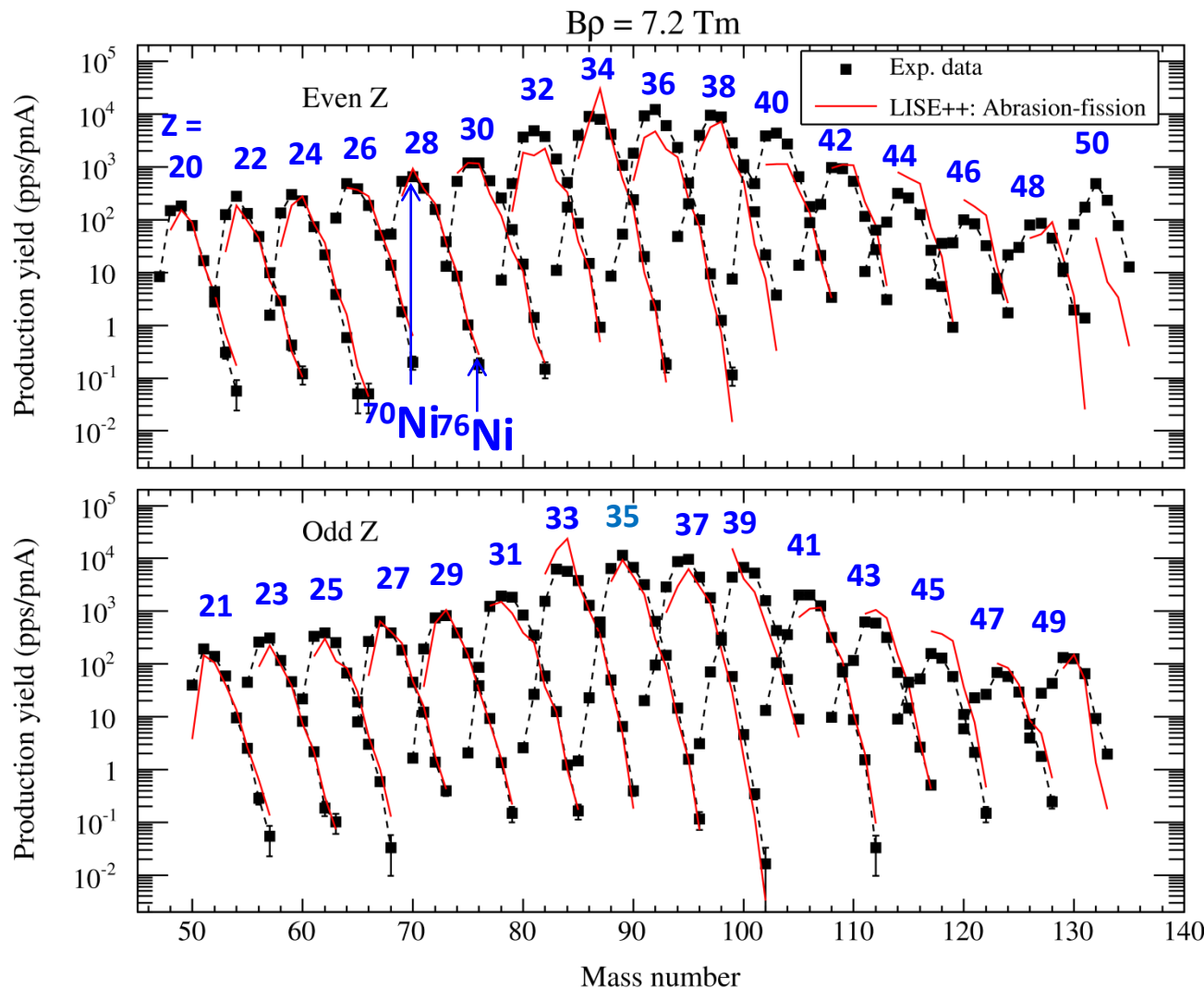


1 setting, no energy degraders used

LISE++ Abrasion-Fission

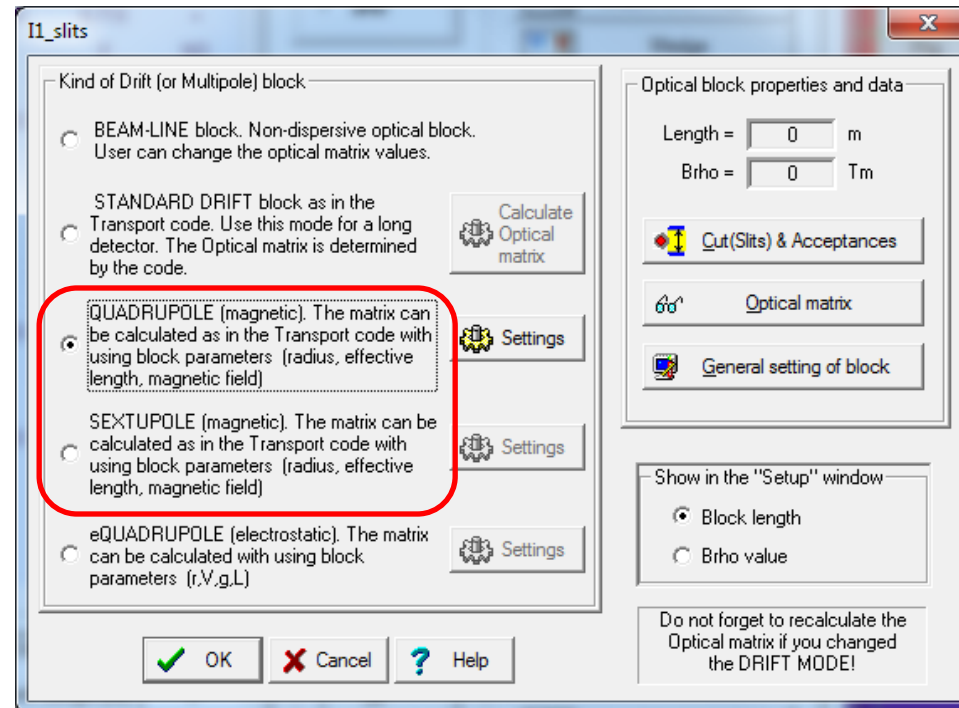
Fairly good reproduction

$B\rho = 7.2 \text{ Tm} \pm 1\%$



- ❑ **Priorities : Quality (1) & speed (2)**
- ❑ **Recent GSI & RIKEN experiments $Z=50-90$**
 - **Cross sections? Excitation energy? Kinematics-transmission?**
 - **Abrasion-Ablation (for PF)**
 - **Abrasion-Fission (define EERs)**
- ❑ **MC solution for AA**
- ❑ **Take into account angular momentum**
- ❑ **Take into account models development**
- ❑ **New analytical AF model**

Quadrupole and sextupole fields superposition



So the A1900 fragment-separator has several multipoles (Q+S)

COSY Quad

LISE++ Quad

Block: "Q021-1TC" Matrices: "LOCAL"

Block: "Q021-1TC" Matrices: "LOCAL"

trans

trans

* TRANSFORM 1 *

1 [X]:	+8.0149e-01	+4.0120e-02	0	0
2 [T]:	-8.9145e+00	+8.0149e-01	0	0
3 [Y]:	0	0	+1.2126e+00	+4.6010e-02
4 [F]:	0	0	+1.0224e+01	+1.2126e+00
5 [L]:	0	0	0	0
6 [D]:	0	0	0	0

* TRANSFORM 1 *

1 [X]:	+8.0149e-01	+4.0120e-02	0	0
2 [T]:	-8.9145e+00	+8.0149e-01	0	0
3 [Y]:	0	0	+1.2126e+00	+4.6010e-02
4 [F]:	0	0	+1.0224e+01	+1.2126e+00
5 [L]:	0	0	0	0
6 [D]:	0	0	0	0

* TRANSFORM 2 *

1 1:	0			
1 2:	0	0		
1 3:	0	0	0	
1 4:	0	0	0	0
1 5:	0	0	0	0
1 6:	+1.9166e-03	+2.8255e-05	0	0

* TRANSFORM 2 *

1 1:	0			
1 2:	0	0		
1 3:	0	0	0	
1 4:	0	0	0	0
1 5:	0	0	0	0
1 6:	+1.9166e-03	+2.8255e-05	0	0

2 1:	0			
2 2:	0	0		
2 3:	0	0	0	
2 4:	0	0	0	0
2 5:	0	0	0	0
2 6:	+8.2866e-02	+1.9166e-03	0	0

2 1:	0			
2 2:	0	0		
2 3:	0	0	0	
2 4:	0	0	0	0
2 5:	0	0	0	0
2 6:	+8.2866e-02	+1.9166e-03	0	0

3 1:	0			
3 2:	0	0		
3 3:	0	0	0	
3 4:	0	0	0	0
3 5:	0	0	0	0
3 6:	0	0	-2.1981e-03	-3.0675e-05

3 1:	0			
3 2:	0	0		
3 3:	0	0	0	
3 4:	0	0	0	0
3 5:	0	0	0	0
3 6:	0	0	-2.1981e-03	-3.0675e-05

4 1:	0			
4 2:	0	0		
4 3:	0	0	0	
4 4:	0	0	0	0
4 5:	0	0	0	0
4 6:	0	0	-1.0905e-01	-2.1981e-03

4 1:	0			
4 2:	0	0		
4 3:	0	0	0	
4 4:	0	0	0	0
4 5:	0	0	0	0
4 6:	0	0	-1.0905e-01	-2.1981e-03

5 1:	-6.0266e-04			
5 2:	+1.7880e-04	-1.8788e-05		
5 3:	0	0	-7.1031e-04	
5 4:	0	0	-2.3517e-04	-2.4696e-05
5 5:	0	0	0	0
5 6:	0	0	0	0

5 1:	0			
5 2:	0	0		
5 3:	0	0	0	
5 4:	0	0	0	0
5 5:	0	0	0	0
5 6:	0	0	0	0

COSY Sext

Block: "Q021-1TC" Matrices: "LOCAL"

trans

* TRANSFORM 1 *

1 [X]:	+1.0000e+00	+4.3000e-02	0	0
2 [T]:	0	+1.0000e+00	0	0
3 [Y]:	0	0	+1.0000e+00	+4.3000e-02
4 [F]:	0	0	0	+1.0000e+00
5 [L]:	0	0	0	0
6 [D]:	0	0	0	0

* TRANSFORM 2 *

1 1:	-1.3696e-03			
1 2:	-3.9263e-05	-4.2207e-07		
1 3:	0	0	+1.3696e-03	
1 4:	0	0	+3.9263e-05	+4.2207e-07
1 5:	0	0	0	0
1 6:	0	0	0	0

2 1:	-6.3704e-02			
2 2:	-2.7393e-03	-3.9263e-05		
2 3:	0	0	+6.3704e-02	
2 4:	0	0	+2.7393e-03	+3.9263e-05
2 5:	0	0	0	0
2 6:	0	0	0	0

3 1:	0			
3 2:	0	0		
3 3:	+2.7393e-03	+3.9263e-05	0	
3 4:	+3.9263e-05	+8.4415e-07	0	0
3 5:	0	0	0	0
3 6:	0	0	0	0

4 1:	0			
4 2:	0	0		
4 3:	+1.2741e-01	+2.7393e-03	0	
4 4:	+2.7393e-03	+7.8525e-05	0	0
4 5:	0	0	0	0
4 6:	0	0	0	0

5 1:	0			
5 2:	0	-2.1500e-05		
5 3:	0	0	0	
5 4:	0	0	0	-2.1500e-05
5 5:	0	0	0	0
5 6:	0	0	0	0

LISE++ Sext

Block: "S021-1TC" Matrices: "LOCAL"

trans

* TRANSFORM 1 *

1 [X]:	+1.0000e+00	+4.3000e-02	0	0
2 [T]:	0	+1.0000e+00	0	0
3 [Y]:	0	0	+1.0000e+00	+4.3000e-02
4 [F]:	0	0	0	+1.0000e+00
5 [L]:	0	0	0	0
6 [D]:	0	0	0	0

* TRANSFORM 2 *

1 1:	-1.3696e-03			
1 2:	-3.9263e-05	-4.2207e-07		
1 3:	0	0	+1.3696e-03	
1 4:	0	0	+3.9263e-05	+4.2207e-07
1 5:	0	0	0	0
1 6:	0	0	0	0

2 1:	-6.3704e-02			
2 2:	-2.7393e-03	-3.9263e-05		
2 3:	0	0	+6.3704e-02	
2 4:	0	0	+2.7393e-03	+3.9263e-05
2 5:	0	0	0	0
2 6:	0	0	0	0

3 1:	0			
3 2:	0	0		
3 3:	+2.7393e-03	+3.9263e-05	0	
3 4:	+3.9263e-05	+8.4415e-07	0	0
3 5:	0	0	0	0
3 6:	0	0	0	0

4 1:	0			
4 2:	0	0		
4 3:	+1.2741e-01	+2.7393e-03	0	
4 4:	+2.7393e-03	+7.8525e-05	0	0
4 5:	0	0	0	0
4 6:	0	0	0	0

5 1:	0			
5 2:	0	0		
5 3:	0	0	0	
5 4:	0	0	0	0
5 5:	0	0	0	0
5 6:	0	0	0	0

COSY Quad

COSY Quad+Sext

COSY Sext

Block: "Q021-1TC" Matrices: "LOCAL"

trans

1-1TC" Matrices: "LOCAL" tran

* TRANSFORM 1 *				
1 [X]:	+8.0149e-01	+4.0120e-02	0	0
2 [T]:	-8.9145e+00	+8.0149e-01	0	0
3 [V]:	0	0	+1.2126e+00	+4.6010e-02
4 [F]:	0	0	+1.0224e+01	+1.2126e+00
5 [L]:	0	0	0	0
6 [D]:	0	0	0	0

* TRANSFORM 2 *				
1 1:	0	0	0	0
1 2:	0	0	0	0
1 3:	0	0	0	0
1 4:	0	0	0	0
1 5:	0	0	0	0
1 6:	+1.9166e-03	+2.8255e-05	0	0

* TRANSFORM 1 *				
1 [X]:	+8.0149e-01	+4.0120e-02	0	0
2 [T]:	-8.9145e+00	+8.0149e-01	0	0
3 [V]:	0	0	+1.2126e+00	+4.6010e-02
4 [F]:	0	0	+1.0224e+01	+1.2126e+00
5 [L]:	0	0	0	0
6 [D]:	0	0	0	0

* TRANSFORM 2 *				
1 1:	0	0	0	0
1 2:	0	0	0	0
1 3:	0	0	0	0
1 4:	0	0	0	0
1 5:	0	0	0	0
1 6:	+1.9166e-03	+2.8255e-05	0	0

* TRANSFORM 1 *				
1 [X]:	+8.0149e-01	+4.0120e-02	0	0
2 [T]:	-8.9145e+00	+8.0149e-01	0	0
3 [V]:	0	0	+1.2126e+00	+4.6010e-02
4 [F]:	0	0	+1.0224e+01	+1.2126e+00
5 [L]:	0	0	0	0
6 [D]:	0	0	0	0

* TRANSFORM 2 *				
1 1:	0	0	0	0
1 2:	0	0	0	0
1 3:	0	0	0	0
1 4:	0	0	0	0
1 5:	0	0	0	0
1 6:	+1.9166e-03	+2.8255e-05	0	0

1-1TC" Matrices: "LOCAL"

tran

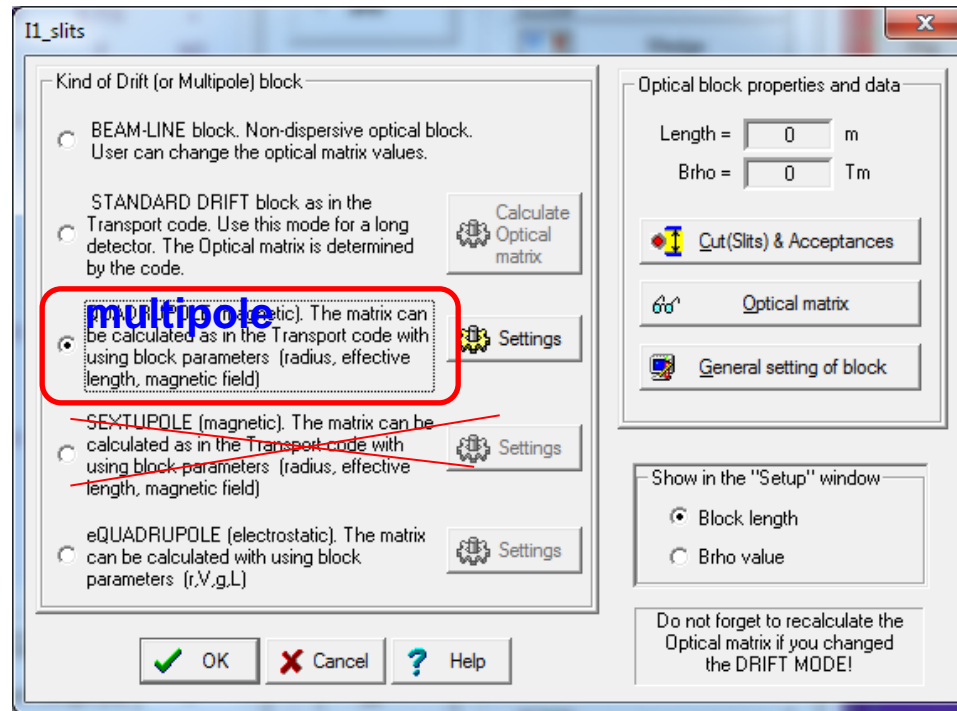
* TRANSFORM 1 *				
1 [X]:	+1.0000e+00	+4.3000e-02	0	0
2 [T]:	0	+1.0000e+00	0	0
3 [V]:	0	0	+1.0000e+00	+4.3000e-02
4 [F]:	0	0	0	+1.0000e+00
5 [L]:	0	0	0	0
6 [D]:	0	0	0	0

* TRANSFORM 2 *				
1 1:	0	0	0	0
1 2:	0	0	0	0
1 3:	0	0	0	0
1 4:	0	0	0	0
1 5:	0	0	0	0
1 6:	0	0	0	0

* TRANSFORM 1 *				
1 [X]:	+1.0000e+00	+4.3000e-02	0	0
2 [T]:	0	+1.0000e+00	0	0
3 [V]:	0	0	+1.0000e+00	+4.3000e-02
4 [F]:	0	0	0	+1.0000e+00
5 [L]:	0	0	0	0
6 [D]:	0	0	0	0

* TRANSFORM 2 *				
1 1:	0	0	0	0
1 2:	0	0	0	0
1 3:	0	0	0	0
1 4:	0	0	0	0
1 5:	0	0	0	0
1 6:	0	0	0	0

A.



B. Second order $2.5.*.*$ in LISE⁺⁺ are zeros. Is it important?

C. Check the effect between matrix (Q+S) and (matrix(Q)+matrix(S)) for the A1900 case

PF momentum Distributions

Proton drip-line

See the next presentation

Requests, Feedback

Evidently a lot of simple questions : version for MAC, why, when and so on...

Serious requests: bugs, configuration questions-analysis-requests , questions-presentations on 10 pages, then answer needs some power point presentation, LISE++ file

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[2013_03_21..]	<DIR>	03/22/2013 10:55
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[2012_12_17..]		12/17/2012 17:27	

1/19/2012

In the context of my present activity, I would be interesting in using the LISE++ for my application at **CERN**.

..... input; in particular, if the LISE++ code is applicable to simulate the **antiproton** transport through a spectrometer line.

recent

3/12/2013

I am currently looking at cancer therapy approaches such as **implanting nanospheres containing radioactive materials into specific locations within a tumor site** (e.g., the blood vessels supplying the tumor).

Set a bond as a target. I assumed Ca (3 mm). Just behind a bond we set a material "Brain" (Water 10 cm). You can input more realistic chemical formula (up to 5 components)

3/19/2013

Thank you very much. LISE++ appears to offer considerable flexibility and could be very useful in my research. The code also appears to run considerably faster than a code I wrote to investigate energy deposition from internal radiation generating devices. Attached is a recent paper to illustrate the types of items that I am investigating.

3/20/2013

It has been a while since we last communicated and I was wondering if there has been any progress with respect to including **angular distributions in the two body reaction mechanism** for LISE. Also is there a possibility of including **regular Rutherford scattering**, as you see it in the kinematics calculator? In other words, if we choose two-body for the outgoing nucleus being the same as the projectile, then instead of being isotropic distribution, we could have option of using the rutherford scattering distribution peaked at forward angles. Finally, I was wondering if there is a plan to **include excitation energy of the outgoing nucleus in two-body reaction mode**.

3/25/2013

I am beginner for using LISE. I really appreciate your work. It is amazing. Could LISE model the independent and / or cumulative photofission fragment yields of delayed gamma rays precursors?

The LISE++ code was designed to estimate yields of produced fragments passed through a fragment-separator. In your case of photofission it is possible only use LISE++ for preliminary cross section calculations.

3/26/2013 Thanks, it is also beneficial to me.

High priority

- **Bugs fix** (if they do still exist ☺)
- **Requests**
 - FRIB fragment separator group
 - A1900 fragment separator group
 - FRIB “isotope” group
- **User support**
- **Tasks from the accepted high priority list**

Low priority

- **Requests**
 - Outside
- **Tasks from the accepted low priority list**

Medium priority

- **Documentation**
- **Requests**
 - Local (MSU)
 - Collaborations
- **Tasks from the accepted medium priority list**
- **Sufficient improvement of existent utilities**

Strategy

- **Engage users in the creation and use of the extended configurations**
- **Do not create utilities based on outside requests, which wont be widely used**


Perspectives

- **Creation new block : “minimization”**
(not used for transmission calculations)
 - **Quadrupole option (checkbox) “use for minimization”**
 - **Implementation of minimization procedure**
 - **First order optics, analytical solution**
 - **First step: only quad fields**
-

additionally

Utility for storage rings?

Factor for low-energy charge state models?



EXOTIC BEAM PRODUCTION WITH FRAGMENT SEPARATORS

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Future developments of LISE⁺⁺

[Link to get the list of tasks from 6-DEC-2013](#)

[Scheduled works done out in 2013](#)

Global tasks (first priority)

- Evaporation cascade: create Monte Carlo version
- ADA (Abrasion-Dissipation-Ablation) model creation
- Implementation of Intranuclear cascade (INC) model in LISE⁺⁺ Windows
- The "MOTER" code development
- High order optics calculation: improvement, adaptation GICOSY format

Local tasks

10/10/2013 7:05 PM

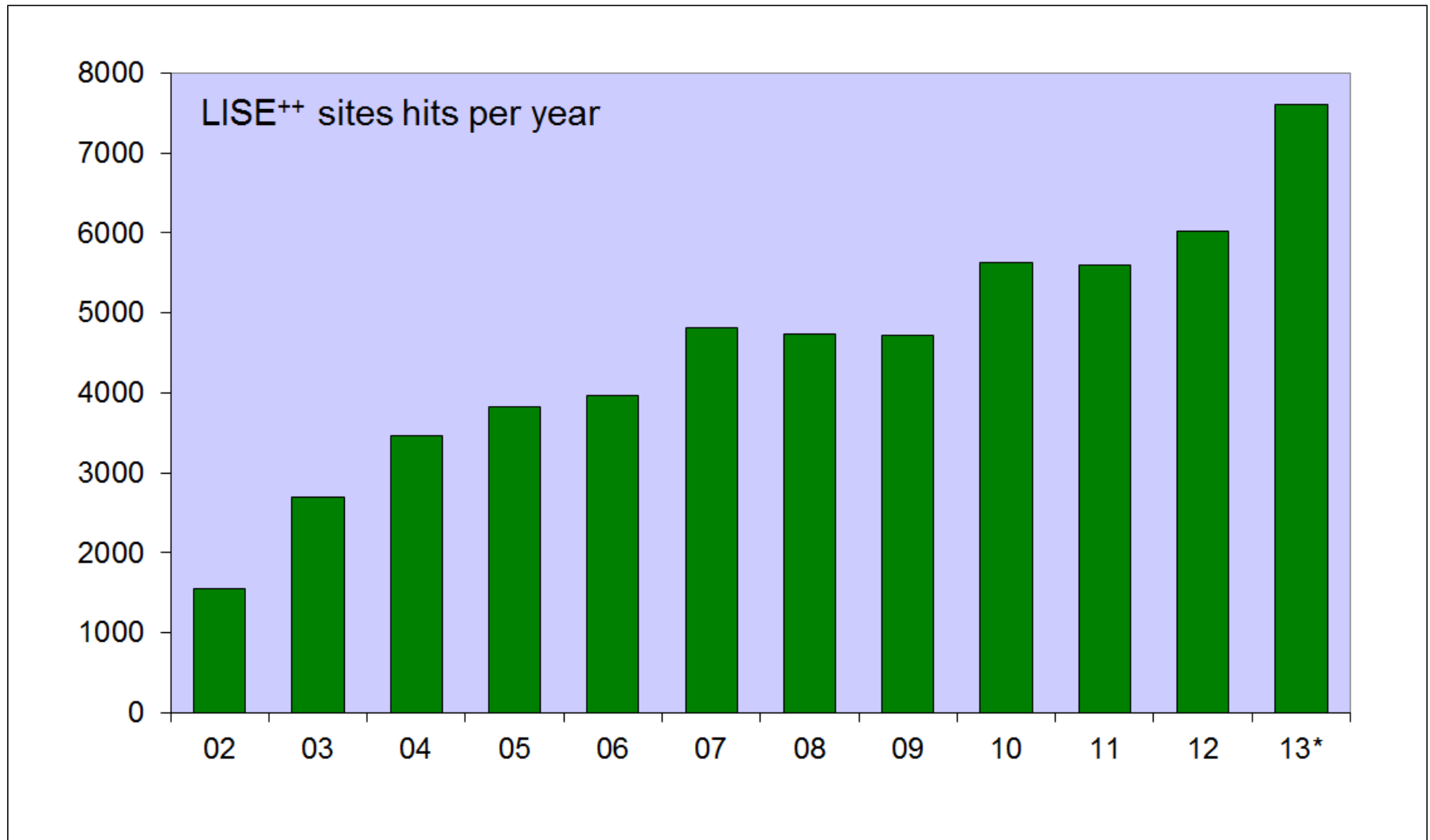
LISE++ development done

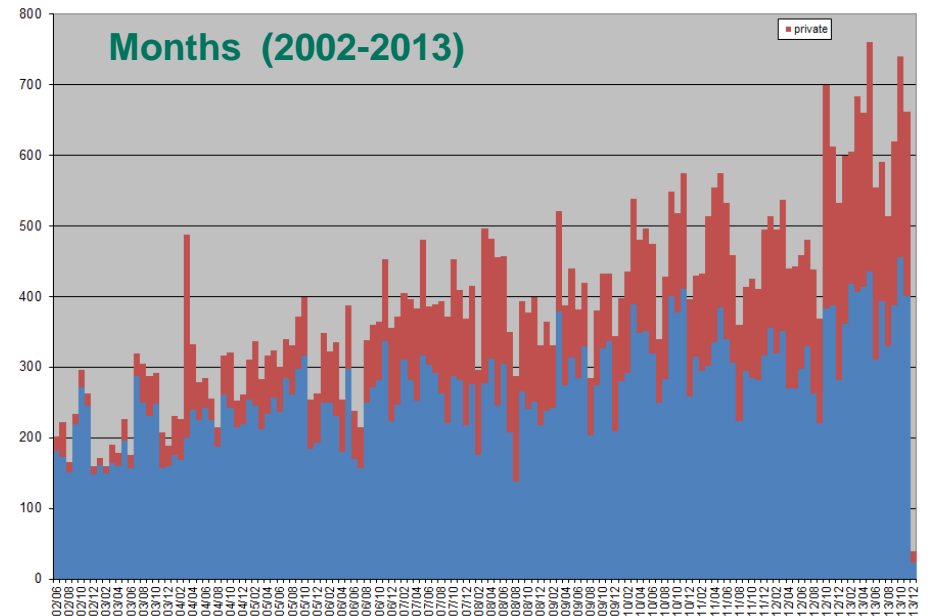
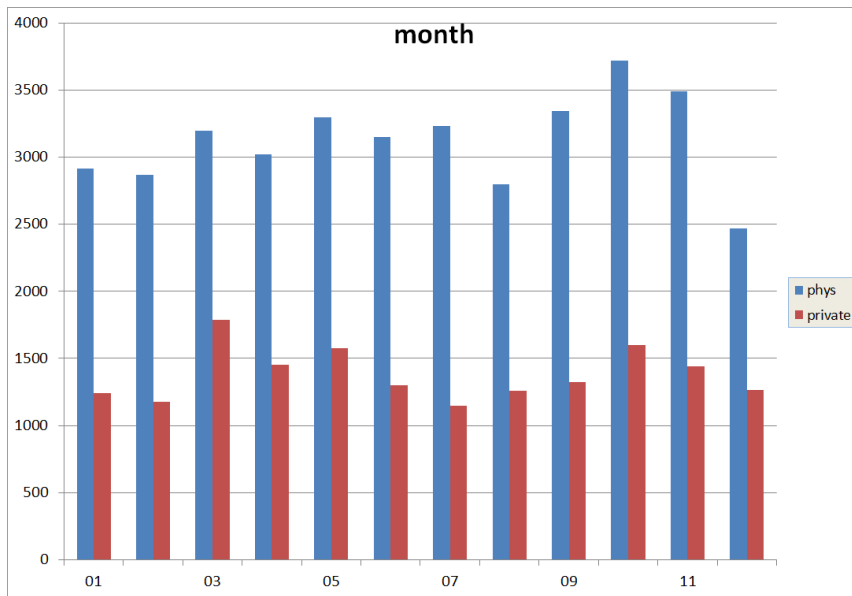
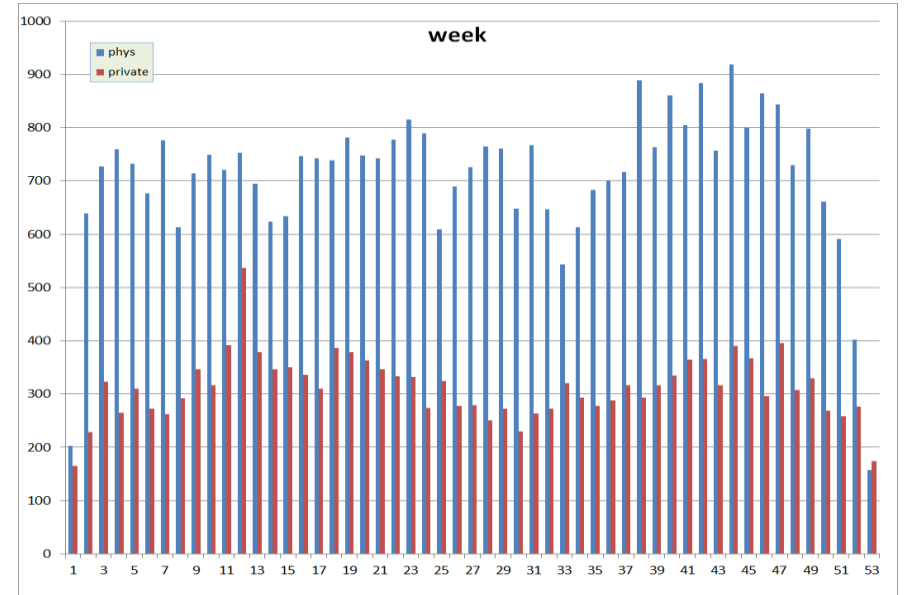
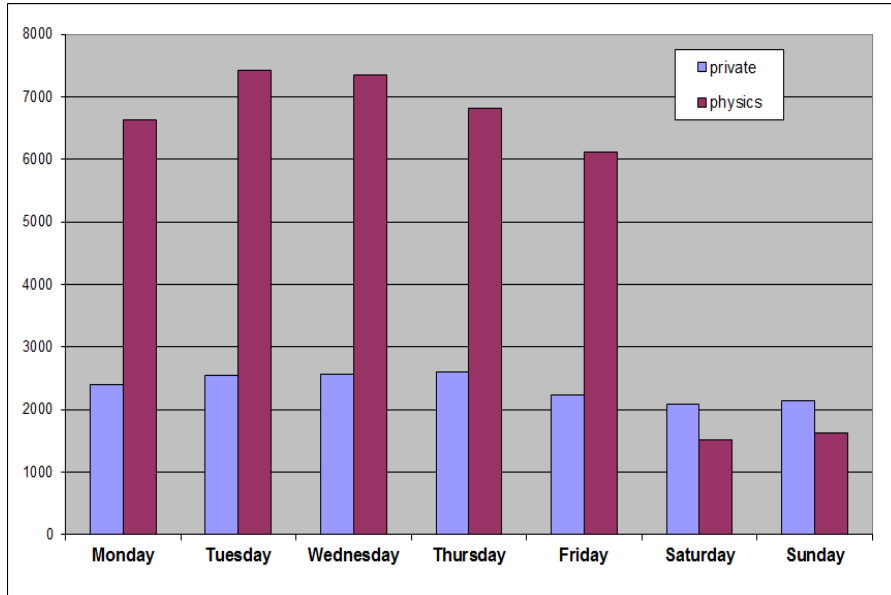
Subject	Priority	Status	new	Order	Time
LongTerm					
LISE for Mac EXCEL	high	done	X	1	1.5 weeks
Two-body reactions : user differential cross section - utilities	high	done	X	5.1	1.5 week
Two-body reactions : user differential cross section - using in transmission calculations	high	done	X	5.3	1 week
ShortTerm					
Help links from dialogs on the LISE++ site	high	done	X	2	2 days
Two or more locations for the MC output file	high	done	X	3.2	2 days
Input source of ions @ MC (A,Z,q,E*,dt,x,x',y,y')	high	done	X	3.3	2 days
Corrections in PACE4's Quantum-Mechanical mode	high	done	X	4	2 days
Two-body reactions : manually set excitation energy of fragment	high	done	X	5.2	3 days
Develop a subroutine to calculate a reduced dispersion for large values of dP/P	high	done		6.1	< 4 days
Improvement of existent blocks : Electrostaticx dipole, transport solution	high	done	X	6.2	< 5 days
Creation of Electrostatic Quad (see Drift block)	high	done	X	6.3	< 3 days
New block : SHIFT (position & direction of optical axis)	high	done	X	6.4	< 3 days
MC Gates : A,Z,Q, A/q	medium	done		3.1	< 2 days
MC gates procedure optimization for speed	medium	done	X	3.4	1 day
Easy way to change the charge state option	medium	done	X		< 1 day
Beam and setting fragment charge state distributions @ selected point	medium	done	X		1 day
neutron channel in Two-body reaction in the "User Diff.CS" case	medium	done	X	7	4 days
Kinematics calculator: g, n	low	done	X	7.1	2 days

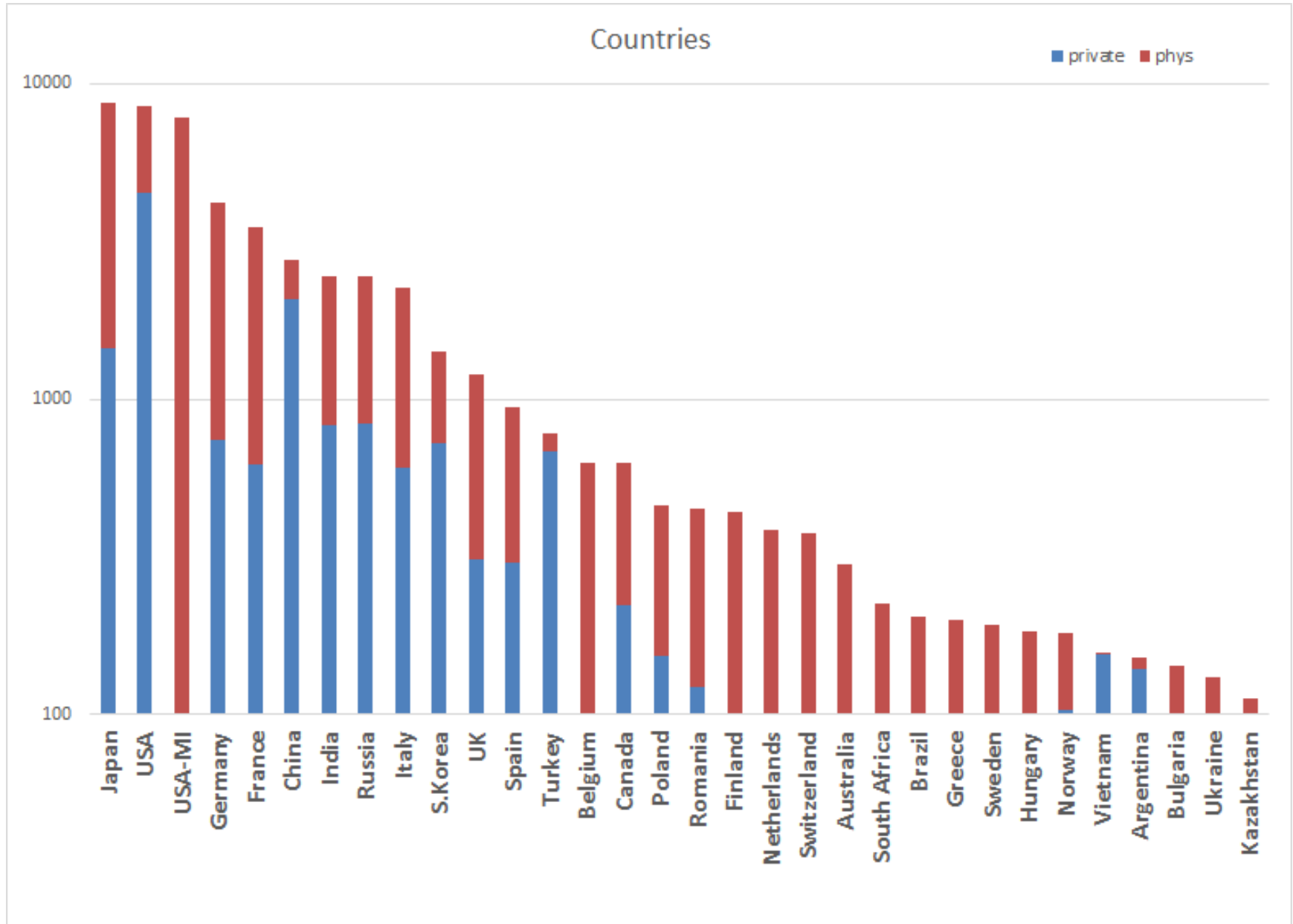
Subject	Priority	Status	new	Order	Time
LongTerm					
Evaporation cascade: improvement, create Monte Carlo version	high			1	1 month
Abrasion-Ablation: create Monte Carlo version	high			2	2 weeks
Abrasion-Fission: create Monte Carlo version	high			3	2 weeks
Abrasion-Fission: new analytical model. Calculations (CS, E*,TKE) are kept in files	high		X	4	1 month
Time in the distribution4 class (RF-buncher, RF-kicker)	medium		X		1-2 weeks
Custom shape degrader optimization in MC mode for high order optics	medium				< 2 weeks
Input angles in wedge in MC mode	medium				< 1 week
ETACHA implementation	medium				1.5 months
ADA (Abrasion-Dissipation-Ablation) model creation	medium				2 months
Implementation of Intranuclear cascade (INC) model in LISE++ Windows	medium				3 months
Minimization in LISE++ (light version -- only for quad fields)	medium				1 months
Minimization in LISE++ (TRANSPORT, MC, Ray tracing cases)	medium				2 months
Write full LISE++ documentation	medium				3 months
Ray tracing in LISE++	low				1 year
New compiler, New Shell	low				6 months
PACE4 generator of one event (creation dll-library)	low				< 1 week
PACE4 in MC LISE++ (using PACE4 dll-library)	low				< 1 week
The "MOTER" code development	low				1 year
Energy loss in PACE4	low				< 1 week
Three-body kinematics relativistic calculator	low				1 month
Water wedge procedure (wedge with one moving plane and filled by liquid)	low				< 2 weeks
Trochoidal Mass Separator	low		X		1-2 weeks
Calculation of composition from time of isotope implanted in detectors	low		X		1-2 weeks

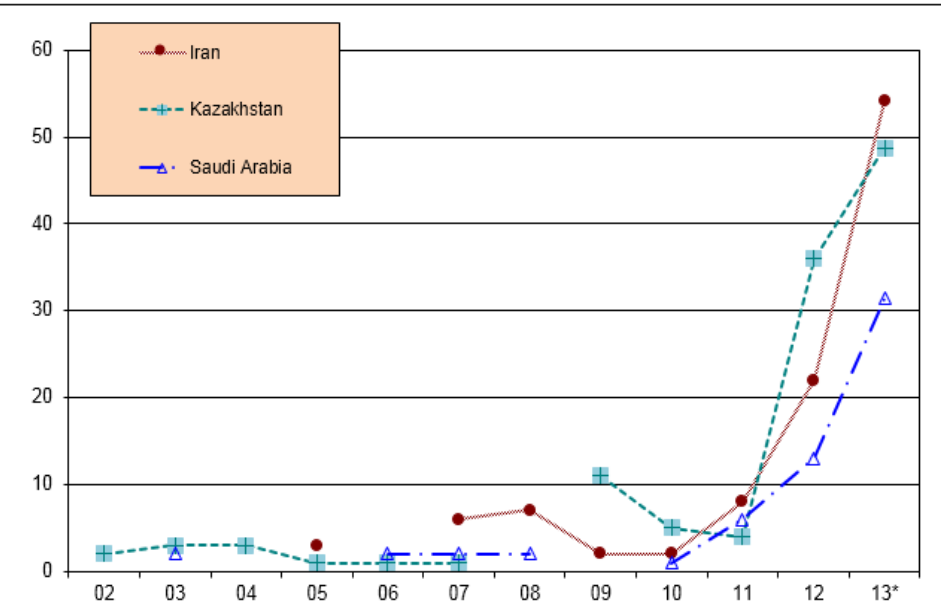
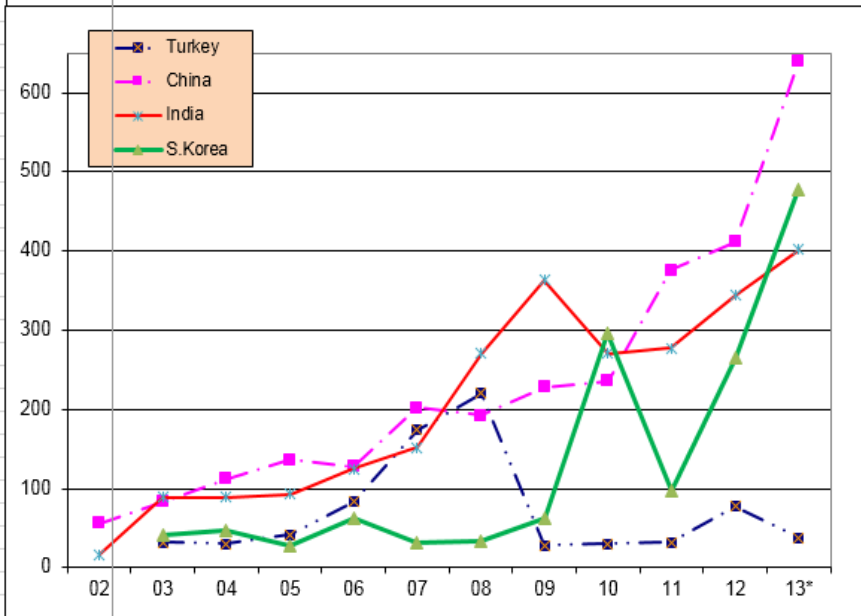
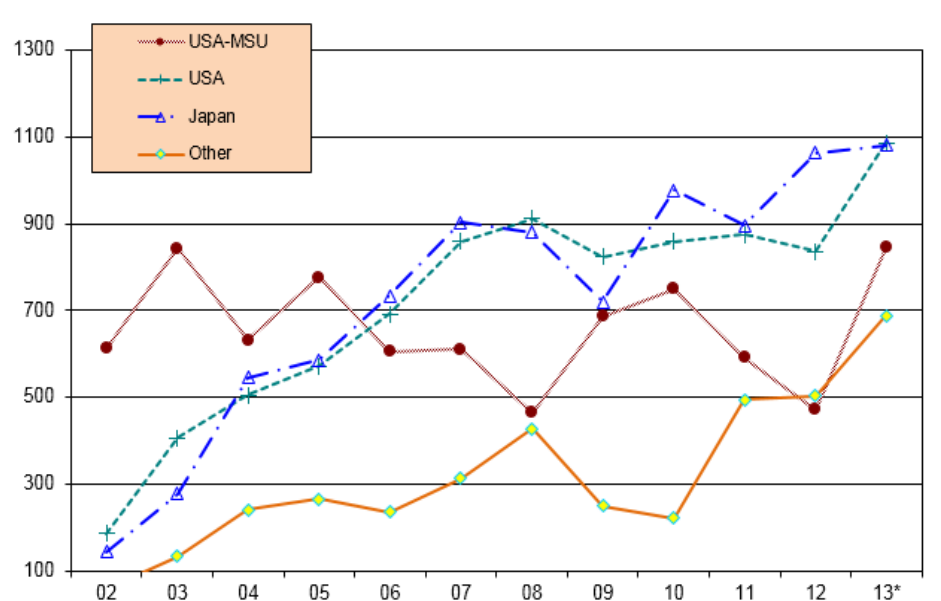
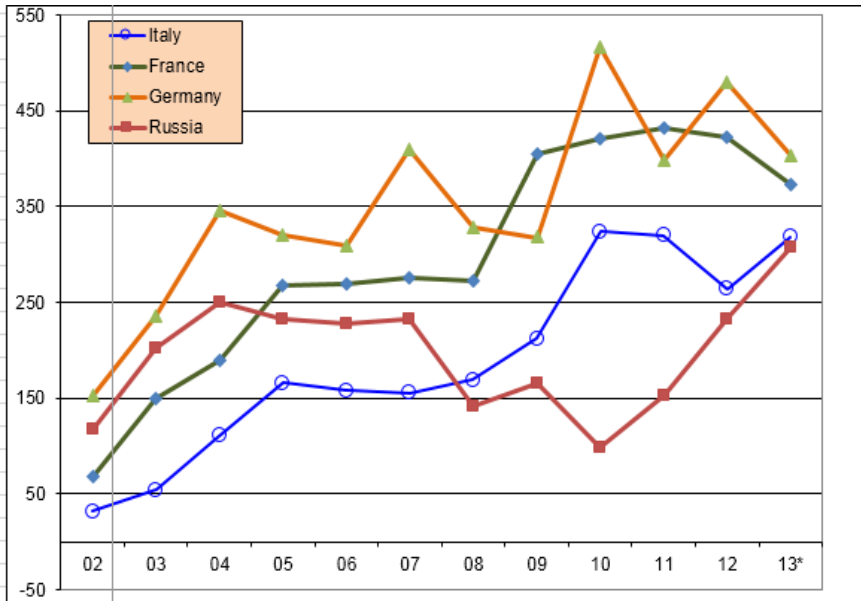
Subject	Priority	Status	new	Order	Time
ShortTerm					
Superposition Quadrupole and Sextupole fields in LISE++	high		X	1	< 2 days
Improvement of existent blocks : Compensating dipole	high		X	2	< 5 days
MARS fragment-separator & Compensating dipole	high		X	3	< 5 days
Improvement of existent blocks : gas-filled dipole	high		X	4	< 5 days
Gas-filled dipole : rays-tracing mode in MC	high		X	5	< 5 days
Gates for analytical solutions (like done for MC)	medium		X		< 2 days
Cross section for stripper	medium				< 2 days
Create possibility to Insert a material before the target	medium		X		2 days
Rutherford scattering of the primary beam (transmission)	medium		X		< 2 days
User database: import, edit, plot	low				< 5 days
Wedge (including curved profile wedge) inclination	low				< 4 days
Brho method to measure T1/2 (MC: possibility of decay in flight)	low				< 5 days
High order optics calculation: improvement, adaptation GICOSY format	low				< 3 days
MOCADI <-> LISE++ converter	low				< 4 days
Transport <-> LISE++ converter	low				< 2 days
m-rad dimensions for LISE++ optics	low				< 2 days
Problem with Projectile Fragmentation in the Catcher utility	low				< 1 day
Simulation reactions in Si-telescope in MC mode	low				< 4 days

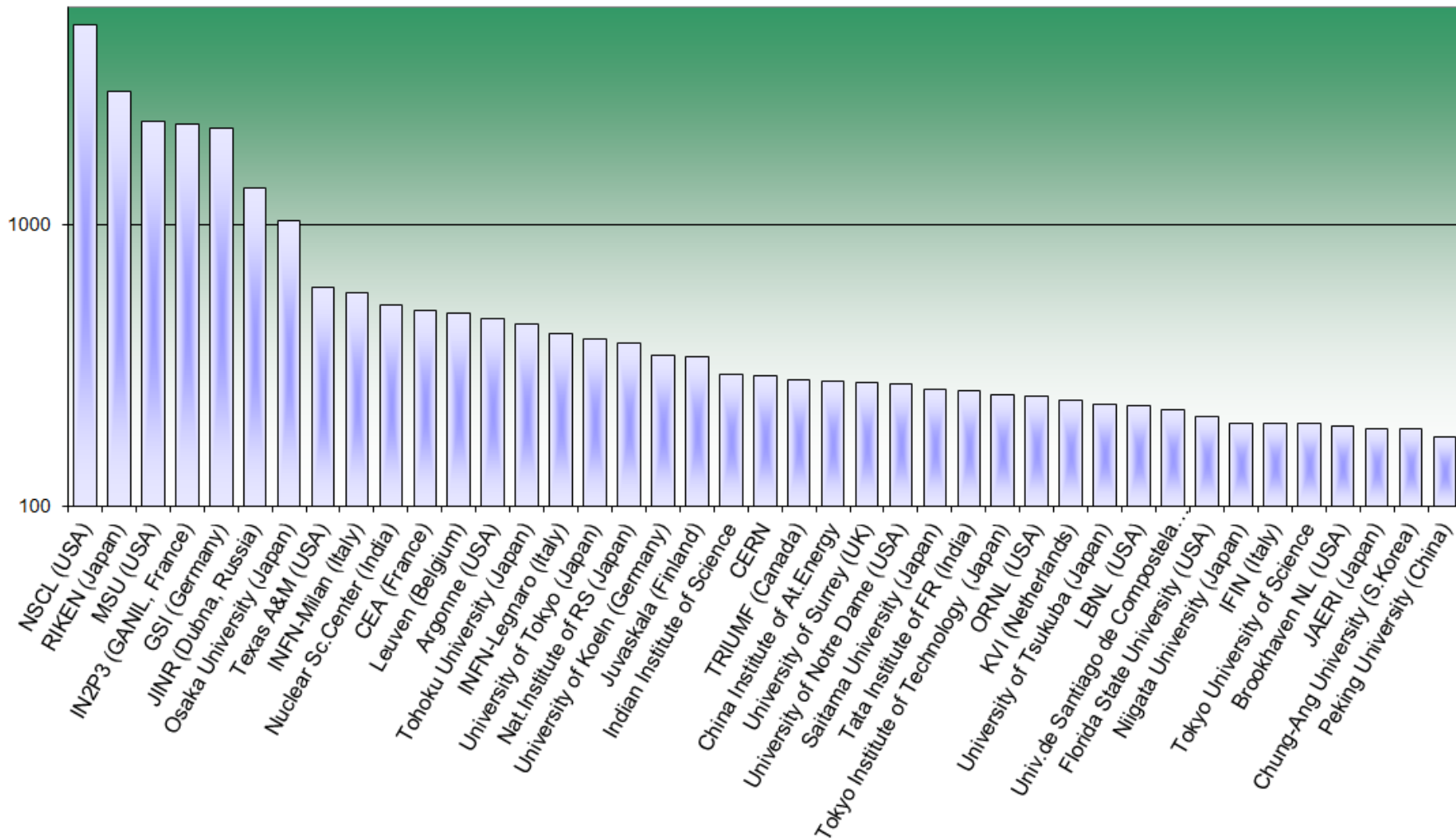
Statistics



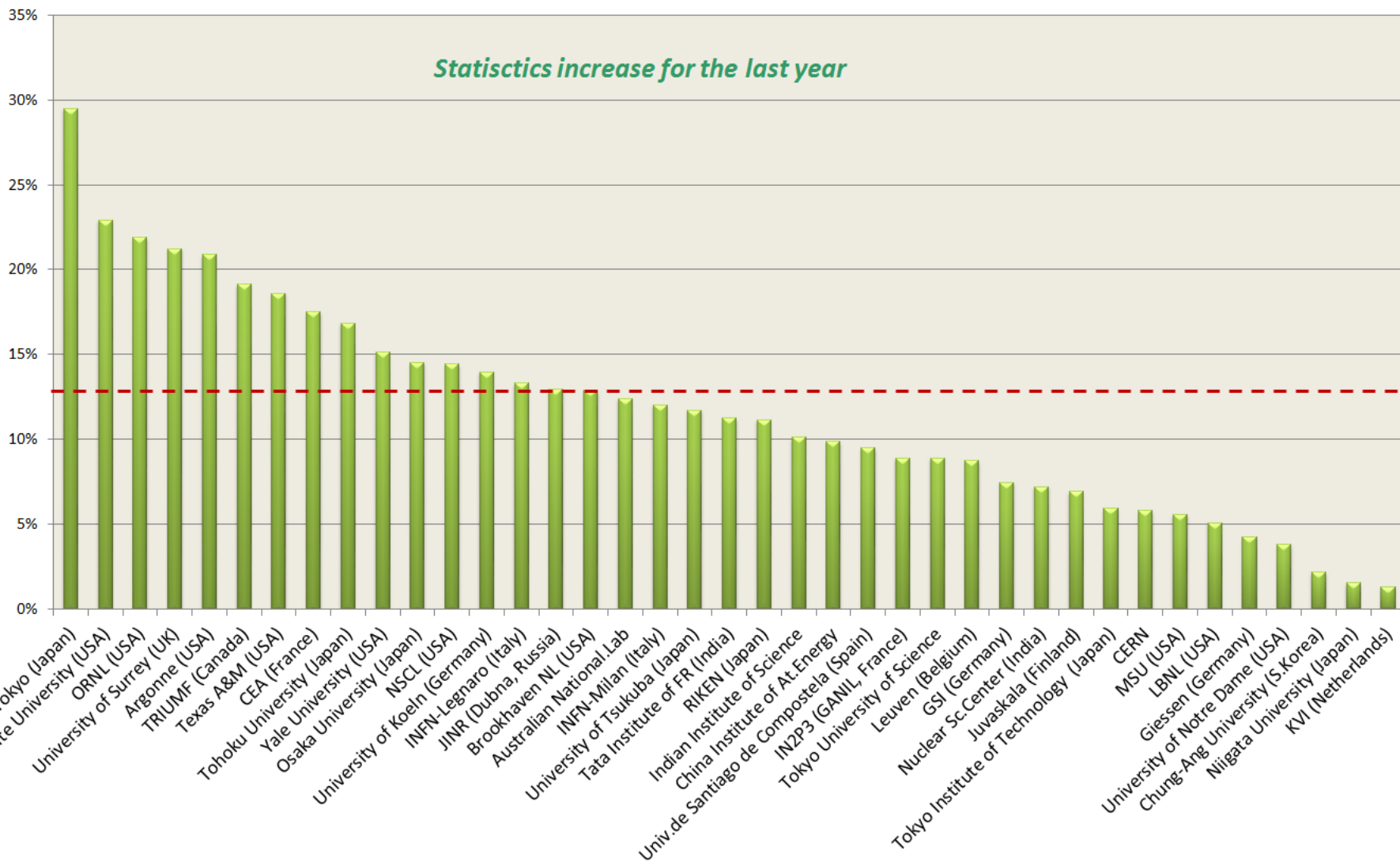






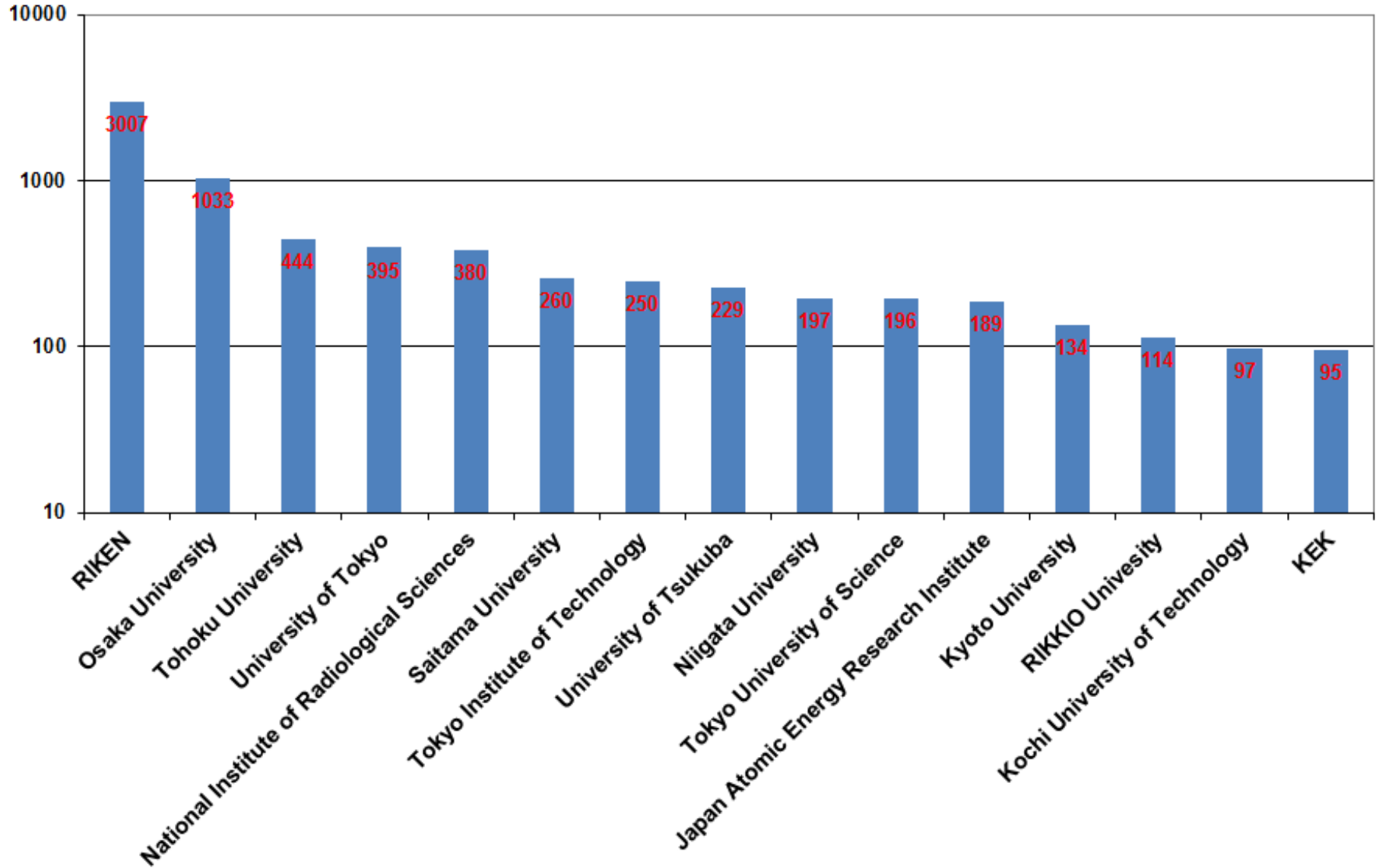


Statistics increase for the last year

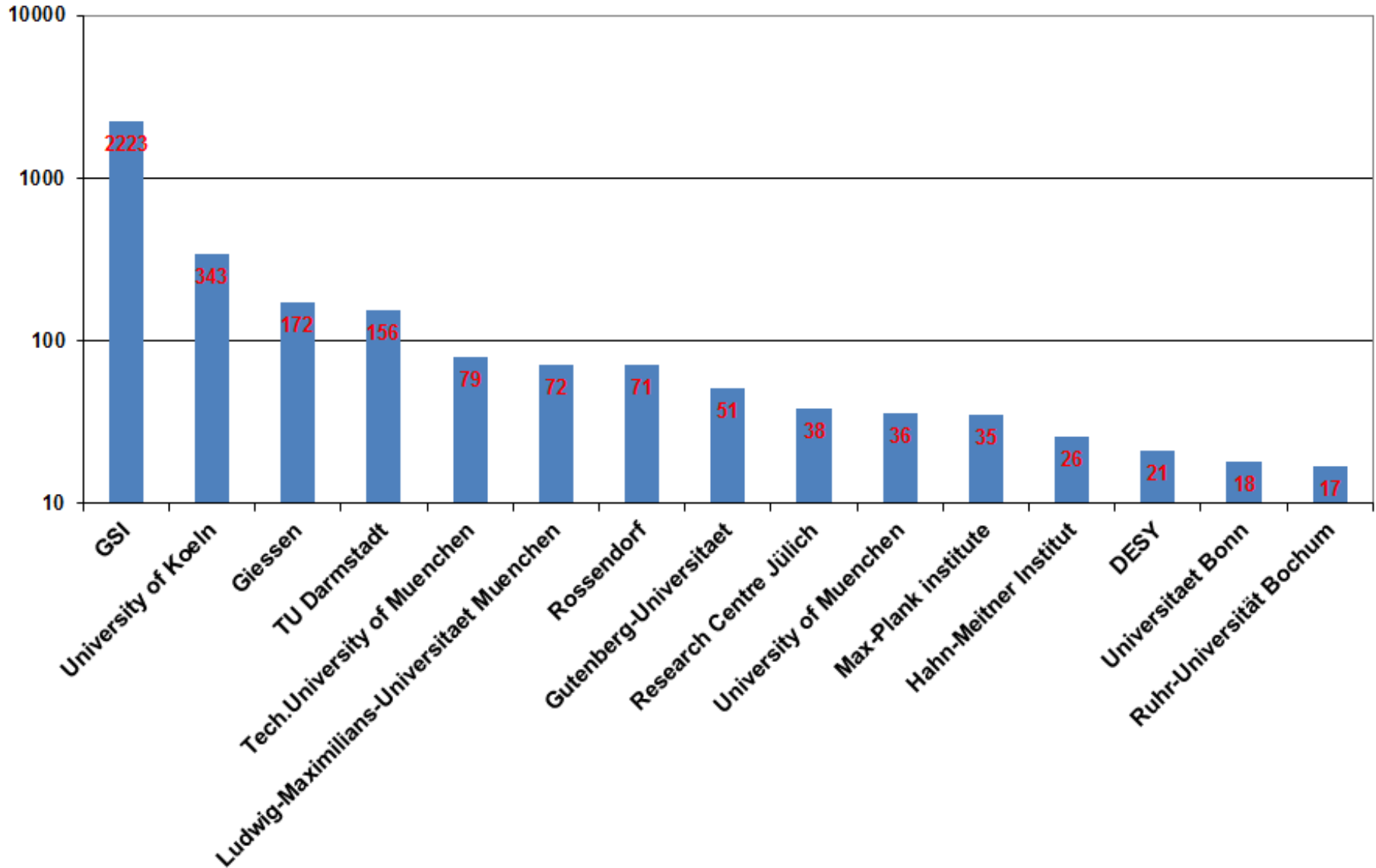


country	Total	2013*	2013* / Total	country	Total	2013*	2013* / Total
1 Uzbekistan	18	20	90%	31 Colombia	3	19	16%
2 Morocco	18	28	64%	32 Sweden	30	193	16%
3 Hong Kong	12	19	63%	33 Ukraine	20	131	15%
4 Saudi Arabia	29	57	51%	34 India	371	2462	15%
5 Iran	50	100	50%	35 UK	181	1202	15%
6 Malaysia	8	16	50%	36 Canada	92	626	15%
7 Pakistan	18	39	46%	37 South Africa	32	226	14%
8 Kazakhstan	45	112	40%	38 <u>Grand Total</u>	<u>7025</u>	<u>54047</u>	<u>13%</u>
9 Chile	6	15	40%	39 Italy	294	2264	13%
10 Egypt	18	50	36%	40 USA	1003	8532	12%
11 Philippines	5	14	36%	41 Russia	284	2453	12%
12 Iraq	11	31	35%	42 Japan	999	8726	11%
13 Thailand	11	32	34%	43 Austria	8	76	11%
14 S.Korea	441	1410	31%	44 USA-MI	781	7826	10%
15 Portugal	25	81	31%	45 France	345	3517	10%
16 Vietnam	47	158	30%	46 Croatia	8	84	10%
17 Armenia	13	47	28%	47 Denmark	8	87	9%
18 Slovakia	15	56	27%	48 Germany	372	4187	9%
19 Poland	105	462	23%	49 Belgium	53	627	8%
20 Spain	210	942	22%	50 Argentina	12	152	8%
21 China	591	2754	21%	51 Czech	6	80	8%
22 Slovenia	3	14	21%	52 Switzerland	28	375	7%
23 Indonesia	4	19	21%	53 Lithuania	1	15	7%
24 Bulgaria	28	142	20%	54 Peru	1	15	7%
25 Brazil	40	204	20%	55 Finland	29	440	7%
26 Greece	37	200	19%	56 Norway	11	182	6%
27 Serbia	12	69	17%	57 Algeria	2	35	6%
28 Romania	78	452	17%	58 Israel	3	66	5%
29 Australia	50	298	17%	59 Turkey	35	784	4%
30 Hungary	30	183	16%	60 Netherlands	7	383	2%

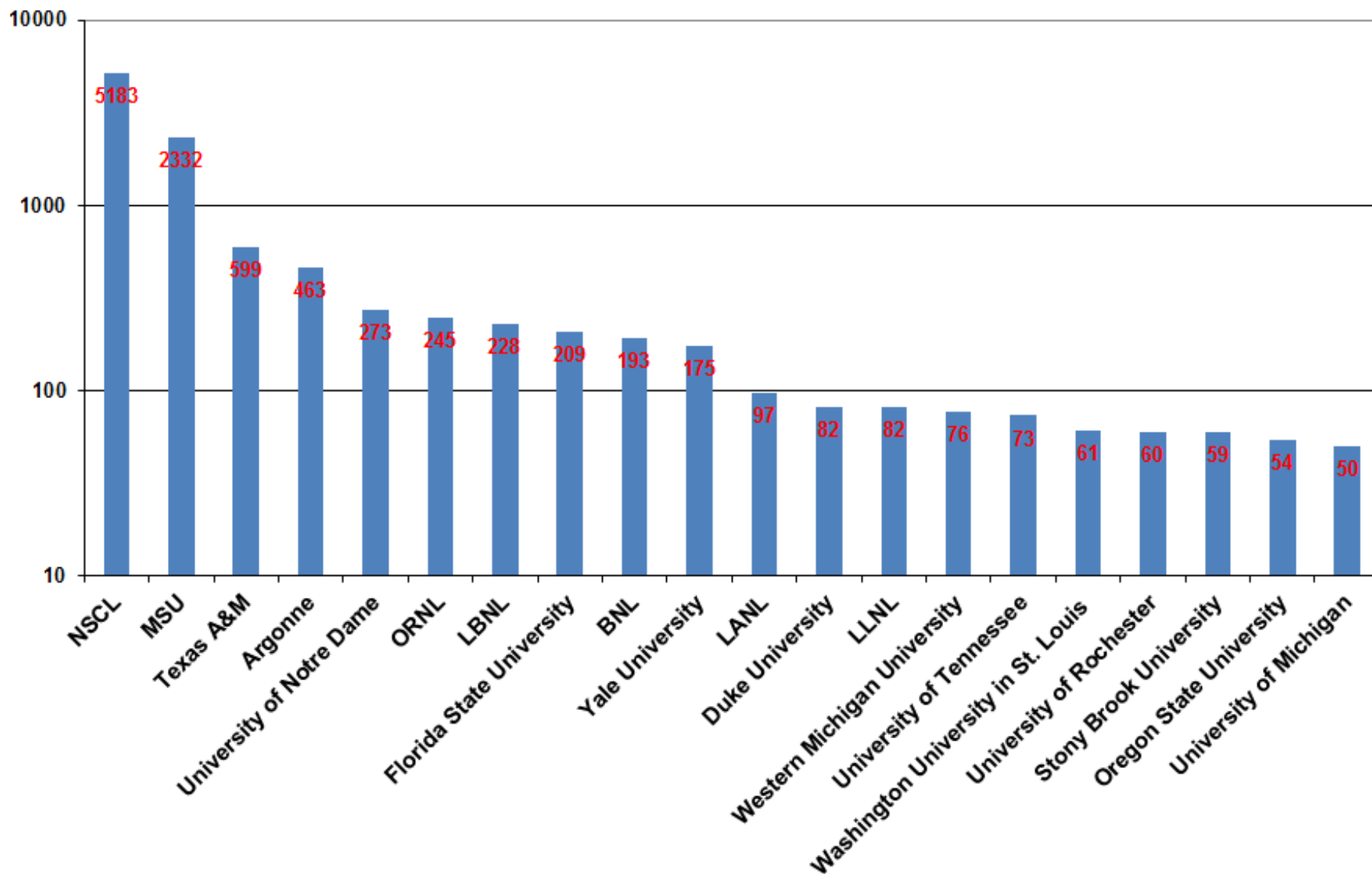
Japan



Germany



USA



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requests,
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