Discussion of configurations in LISE^{++}

This document describes the options for determining the transmission through a fragment separator and includes some description of these options

1. **Introduction, definitions**
2. **Using Quadrupole and Dipole fast editing dialog**
3. **Concept of "Tuning" dipole**
4. **Definition of the cuts by the block**
   (Angular acceptances, Apertures, Slits)
5. **Slits and optical blocks**
6. **Slits and material blocks**
7. **Angular acceptance and Apertures**
8. **Using extended configurations with Monte Carlo**
9. **How to obtain an angular acceptance?**
10. **Benchmarks**

Some definitions will be used in the presentation


User


Advanced


Beam physicist

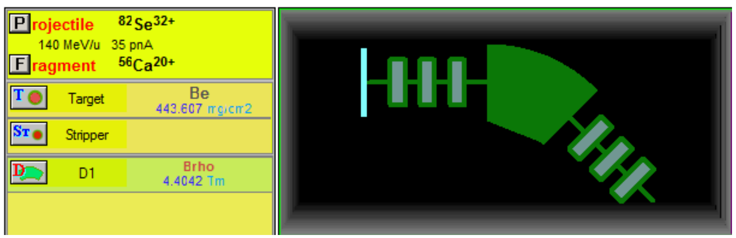
1. Introduction : LISE^{++} configuration types

- **Classical or original** (segmented) **configuration:**
  dispersive block contains quads, drifts, dipole and other optical components

- **Extended** (elemental) **configuration:**
  like in the TRANSPORT code all elements are separated, and their matrices can be calculated by the LISE^{++} code

So, let's take the first dispersive block of A1900 as an example

segmented ***Only 1 block* after stripper**



Taken from TRANSPORT

Block matrix

1. X	-2.28459	0.009	0	0	0	29.2533
2. T	1.06245	-0.44189	0	0	0	-0.00283
3. Y	0	0	0.73853	0.0022	0	0
4. F	0	0	3.74271	1.36526	0	0
5. L	3.10738	-1.2927	0	0	1	5.7769
6. D	0	0	0	0	0	1

extended ***16 blocks* after stripper**

Calculated by LISE^{++} including 2nd order (see next page)

Global matrix

-2.30361	0.00906	0	0	0	28.88518	[mm]
1.07573	-0.43836	0	0	0	-0.00018	[mrad]
0	0	0.73839	0.00259	0	0	[mm]
0	0	3.731	1.36722	0	0	[mrad]
3.10724	-1.26623	0	0	1	-2.42226	[mm]
0	0	0	0	0	1	[%]
/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]	

A comparison of the two configuration types from LISE++

Calculations
- Optics ▸
- Goodies
- Calibrations
- Transmission and rate ▸
- Optimum Target
- Optimum Target-Wedge and Wedge-Wedge configurations
- Brho scanning
- Optimum charge state combination
- Monte Carlo calculation of transmission ▸
- Calculators ▸

Optics submenu:
- Tune spectrometer for setting fragment on beam axis
- Tune spectrometer for setting fragment at middle of slit
- Update matrices linked with COSY files
- Envelope plot
- First order matrix elements : PLOT
- First order matrix elements : View & Print
- Quad & Dipole settings : EDIT
- Quad & Dipole settings : View & Print
- Brho(Erho) Analyzer
- The First- and Second-Order Matrix Elements for an Ideal Magnet

Boxes indicate the parameters generally changed by user

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

Comparison of the Classical Segmented & Extended configurations

Classical (segmented) configuration:

- Fast transmission calculations
- Optical matrices can be input by user or linked to COSY maps
- Simple and compact description of optical system
- Effective with analytical calculations for experiment planning

Extended (elemental) configuration:

- Allows detailed analysis of transmission
- Optical matrices can be input by user, linked to COSY maps or <u>calculated</u> in the LISE^{++} code,
  and used in segmented configurations
- Tools to obtain angular acceptances,
  (which can be entered into classical segmented configurations)
- Tools for displaying ion-beam optics

Very useful with Monte Carlo calculations
including fragment separator design

1. Introduction : Types of transmission calculations

“Distribution” (analytical) method

- **Fast calculations**
- **All internal optimization procedures in the code are based on this method**
- **Mostly used with segmented configurations for experiment planning**
- **Calculation of very small transmission values** (for example charge states of primary beams)

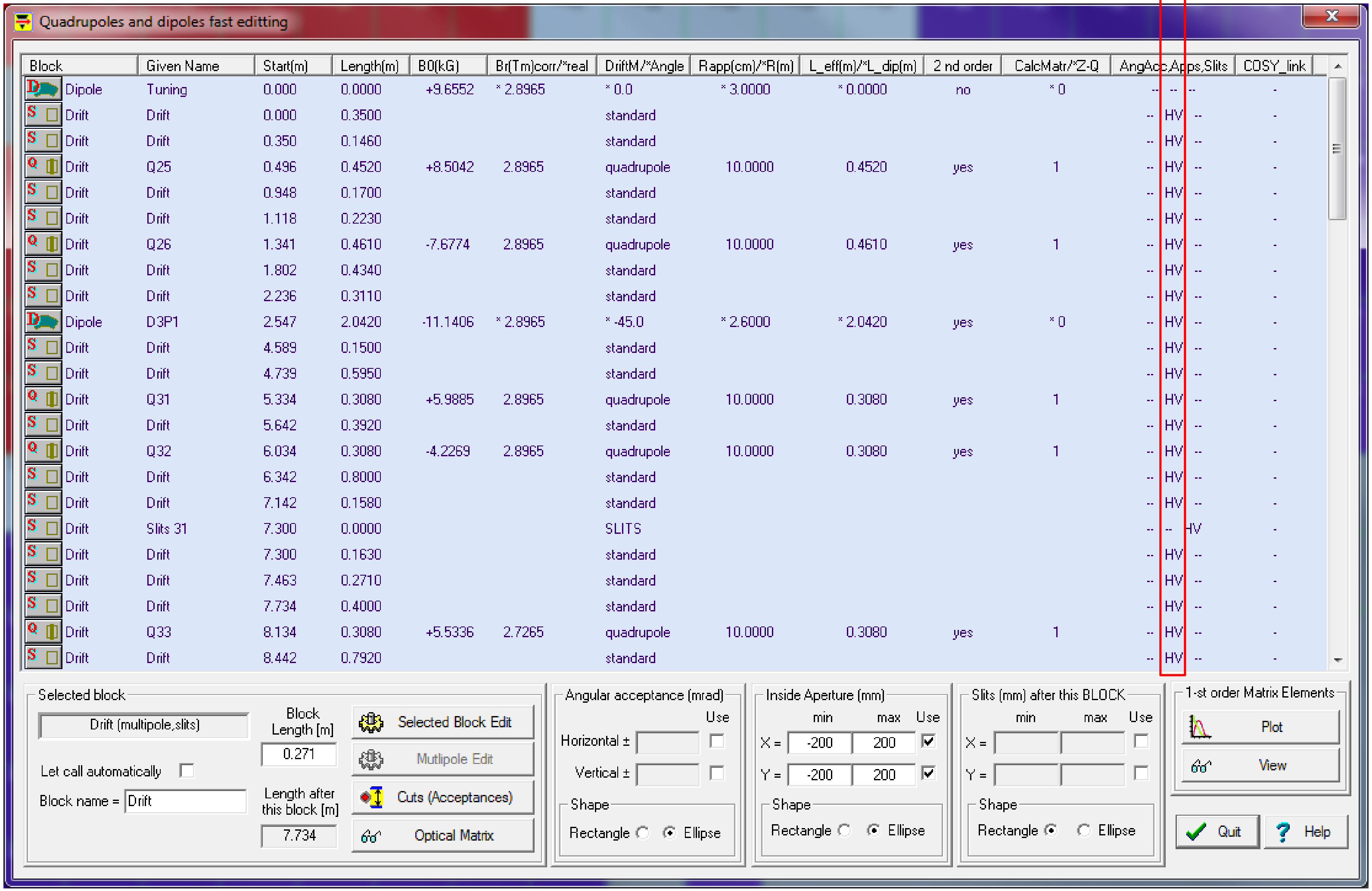
LISE ver.1	“Distribution”	: D. Bazin, B. Sherrill, Phys. Rev. E 50 (1994) 4017
LISE ver.4	“Distribution2”	: 2000
LISE++ ver.6	“Distribution4”	: 2002

Monte Carlo method: (since 2007)

- **Used to benchmark the fast “Distribution” method**
- **Allows detailed analysis of transmission with extended configurations**
- **Allows using High Order Optics (up to fifth order)**
- **Allows observation of correlations between parameters in different blocks**
- **Includes gating on all correlations in parameters (four gates)**
- **Tools for displaying ion-beam optics**
- **Useful for fragment separator design**
- **Some optical blocks (Solenoid, RF buncher) are calculated exactly only in MC mode**

2. Using Quadrupole and Dipole fast editing dialog

Useful dialog box for editing Quadrupole and Dipole settings
"Calculations → Optics → Quad & Dipole settings : EDIT"
shown all set slits, acceptances, Apertures

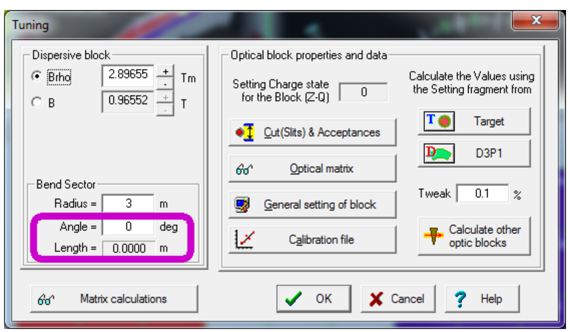


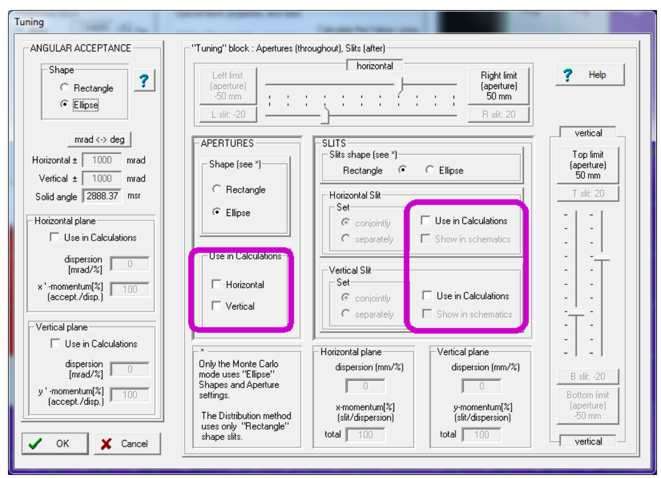
Block	Given Name	Start(m)	Length(m)	B0(kG)	Br(Tm)corr/*real	DriftM/*Angle	Rapp(cm)/*R(m)	L_eff(m)/*L_dip(m)	2 nd order	CalcMatr/*Z-Q	AngAcc	Apps	Slits	COSY_link
Dipole	Tuning	0.000	0.0000	+9.6552	* 2.8965	* 0.0	* 3.0000	* 0.0000	no	* 0	--	--	--	-
Drift	Drift	0.000	0.3500			standard					--	HV	--	-
Drift	Drift	0.350	0.1460			standard					--	HV	--	-
Drift	Q25	0.496	0.4520	+8.5042	2.8965	quadrupole	10.0000	0.4520	yes	1	--	HV	--	-
Drift	Drift	0.948	0.1700			standard					--	HV	--	-
Drift	Drift	1.118	0.2230			standard					--	HV	--	-
Drift	Q26	1.341	0.4610	-7.6774	2.8965	quadrupole	10.0000	0.4610	yes	1	--	HV	--	-
Drift	Drift	1.802	0.4340			standard					--	HV	--	-
Drift	Drift	2.236	0.3110			standard					--	HV	--	-
Dipole	D3P1	2.547	2.0420	-11.1406	* 2.8965	* -45.0	* 2.6000	* 2.0420	yes	* 0	--	HV	--	-
Drift	Drift	4.589	0.1500			standard					--	HV	--	-
Drift	Drift	4.739	0.5950			standard					--	HV	--	-
Drift	Q31	5.334	0.3080	+5.9885	2.8965	quadrupole	10.0000	0.3080	yes	1	--	HV	--	-
Drift	Drift	5.642	0.3920			standard					--	HV	--	-
Drift	Q32	6.034	0.3080	-4.2269	2.8965	quadrupole	10.0000	0.3080	yes	1	--	HV	--	-
Drift	Drift	6.342	0.8000			standard					--	HV	--	-
Drift	Drift	7.142	0.1580			standard					--	HV	--	-
Drift	Slits 31	7.300	0.0000			SLITS					--	--	HV	-
Drift	Drift	7.300	0.1630			standard					--	HV	--	-
Drift	Drift	7.463	0.2710			standard					--	HV	--	-
Drift	Drift	7.734	0.4000			standard					--	HV	--	-
Drift	Q33	8.134	0.3080	+5.5336	2.7265	quadrupole	10.0000	0.3080	yes	1	--	HV	--	-
Drift	Drift	8.442	0.7920			standard					--	HV	--	-

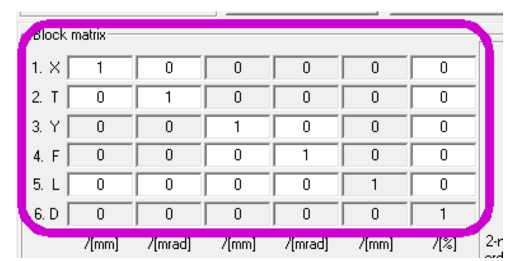
3. Concept of "Tuning" dipoles

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	-- -- --

- A tuning dipole defines magnetic rigidity for entire segment, particularly for quadrupole fields.
- A "tuning" dipole with zero length indicates an extended configuration
- It is especially important for the first segment just after target (stripper)
- Parameters for tuning dipole : 0-length, 0-angle, unitary matrix, no slits, no bounds



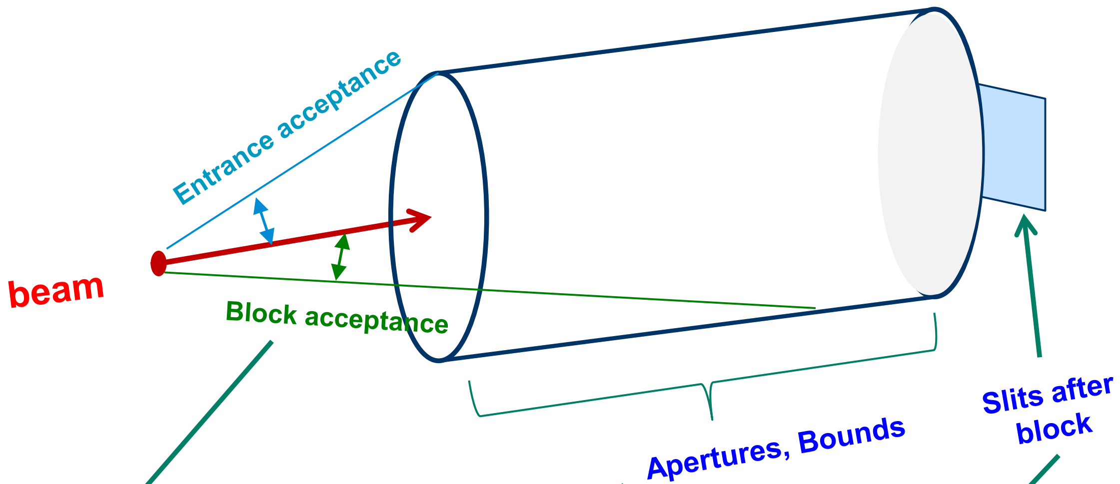


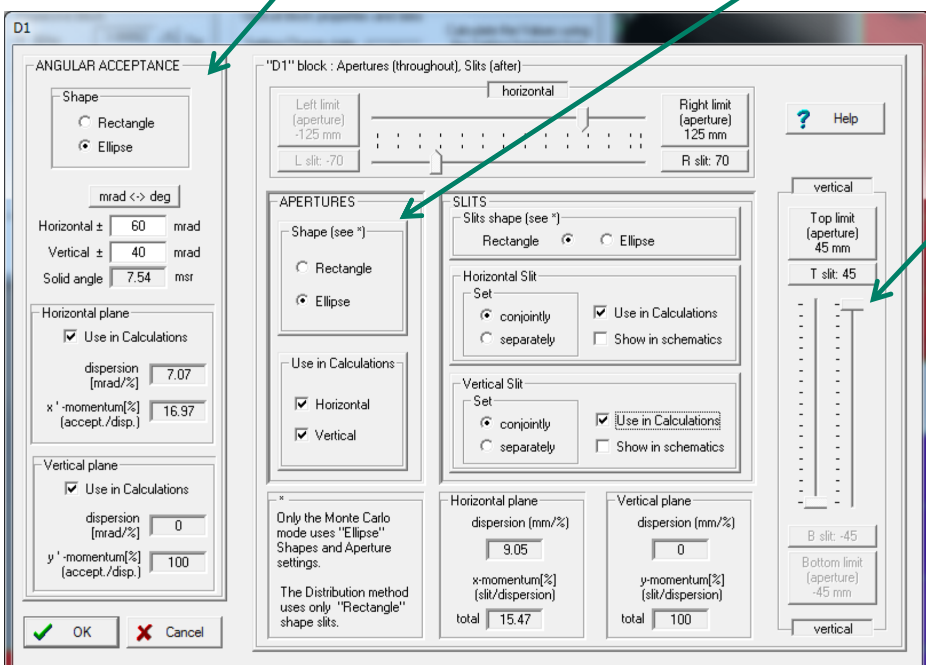


1. X	1	0	0	0	0	0
2. T	0	1	0	0	0	0
3. Y	0	0	1	0	0	0
4. F	0	0	0	1	0	0
5. L	0	0	0	0	1	0
6. D	0	0	0	0	0	1
	/[mm]	/[mrad]	/[mm]	/[mrad]	/[mm]	/[%]

4. Definition of the cuts by the block

Block angular acceptance < Entrance acceptance





Configuration type	Angular Acceptance	Aperture	Slits after block
Classical ("segment")	Yes	No	Yes
Extended ("element")	No	Yes*	please use only for "slits" element

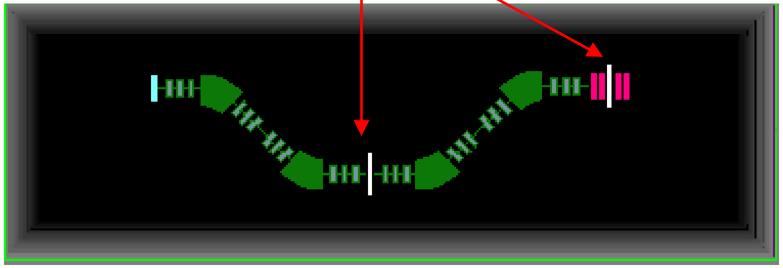
Note: the code does not distinguish segmented and extended configurations, it's up to the user.

* - *Apertures are used only in Monte Carlo calculations*

5. Slits and optical blocks

1. **It is recommended to include a "slit" block instead using the slits in the Dispersive blocks themselves.**

   Only include the minimum number of slit blocks because it slows down the calculation and causes an unphysical decrease in transmission in analytical calculations



Configuration type	Angular Acceptance	Aperture	Slits after block
Classical ("segment")	Yes	No	Yes
Extended ("element")	No	Yes*	please use only for "slits" element

2. **In the analytical solution mode avoid using slits at positions without a focus. In MC mode Apertures are used in addition to slits.**

3. **Long optical blocks should be split to obtain a better calculation of the effects of Apertures.**

6. Slits in materials

It is not recommended to use slits in any material, especially if they are located at dispersive planes.

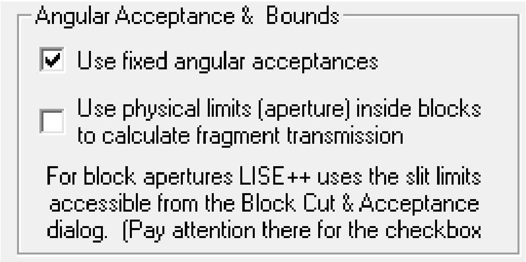
The slit should be a separate optical block!

7. Angular Acceptances & Apertures

1. **In extended configurations the user has several options for transmission calculations.**

   Recommendation do not use a fixed angular acceptance in MC mode for extended configurations if the Bound mode is turned on.

   Apertures defines angular acceptances.



2. **Apertures are not used in "Distribution" analytical case.**

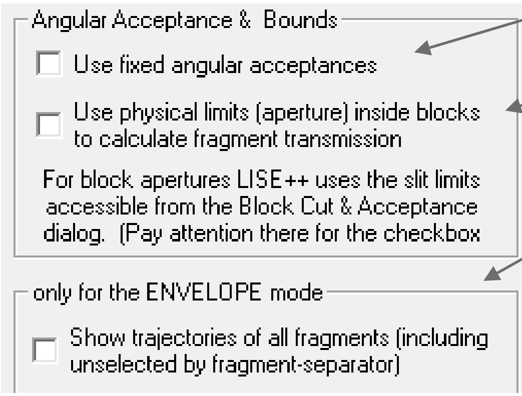
   Angular acceptances should be entered by hand in each segment for both configuration type.

Configuration type	Angular Acceptance	Aperture	Slits after block
Classical ("segment")	Yes	No	Yes
Extended ("element")	No	Yes*	please use only for "slits" element

** - Apertures are used only in Monte Carlo calculations*

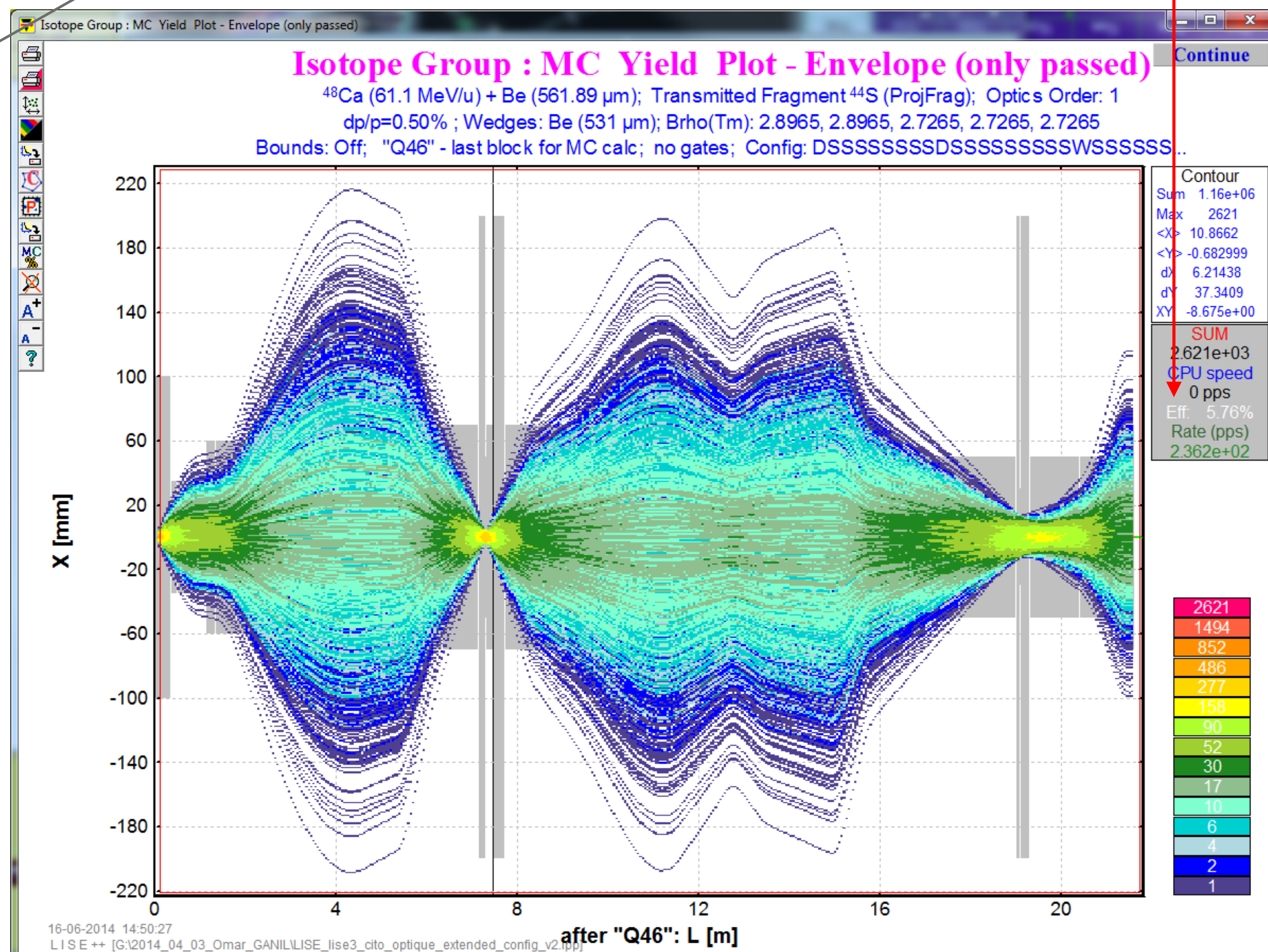
<u>Note:</u> the code does not distinguish segmented and extended configurations, it's up to the user.

MC transmission options dialog



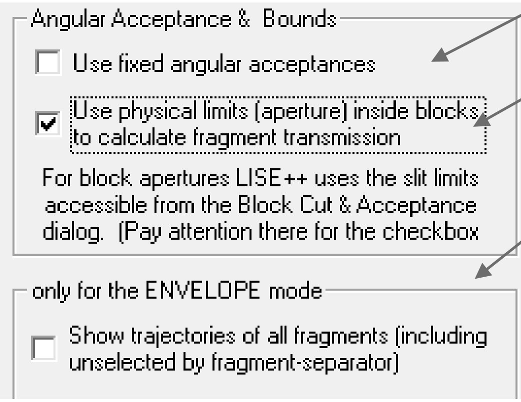
no angular acceptances,
no bounds,
no trajectories show
(example LISE3 separator)

Cut by slits



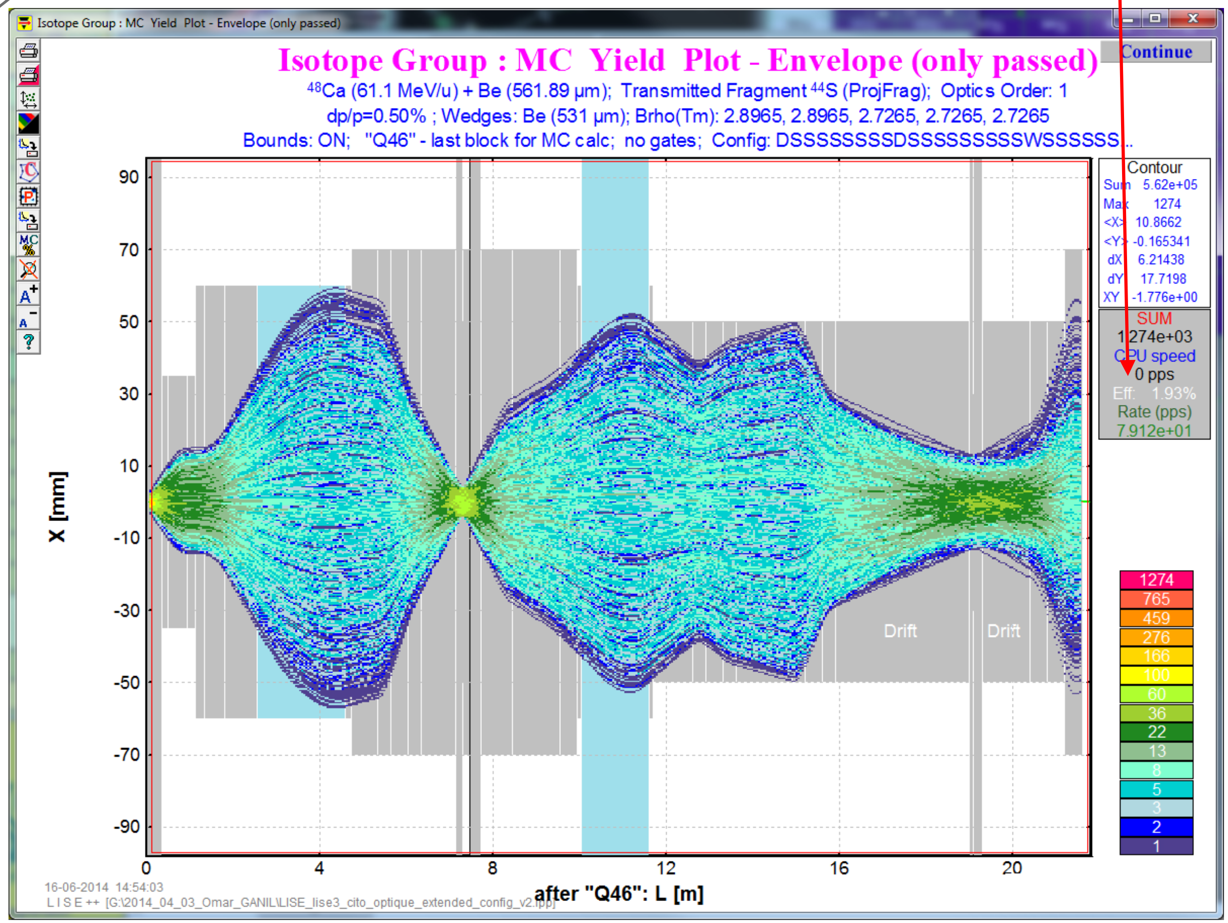
8. Using extended configurations with Monte Carlo

MC transmission options dialog

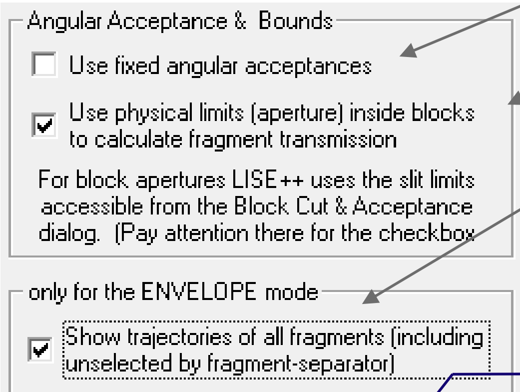


no angular acceptances,
with bounds,
no trajectories show,
(example LISE3 separator)

Cut by slits and Apertures



MC transmission options dialog



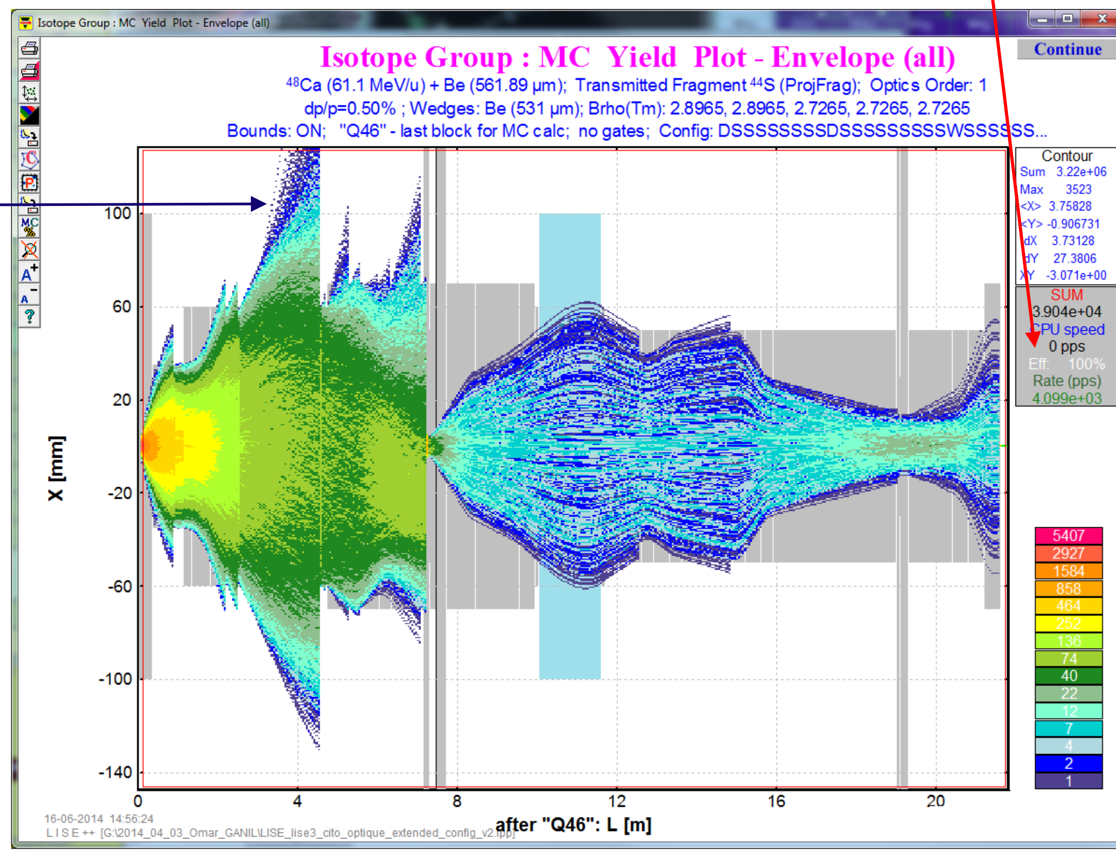
no angular acceptances,

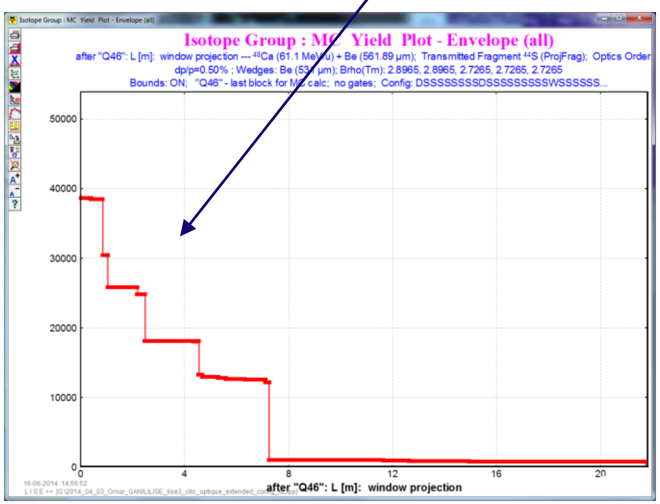
with bounds,

show trajectories

(example LISE3 separator)

No transmission cuts





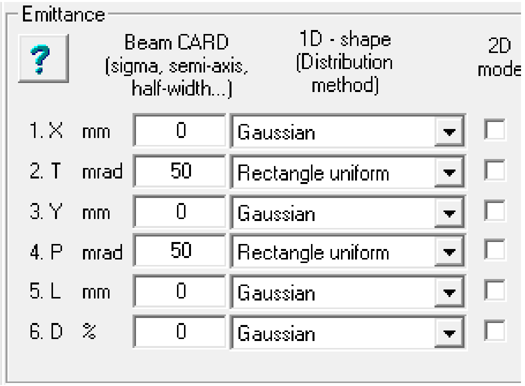
Extended Configuration Settings

1. No target

2. No wedges and materials

3. Setting fragment = Primary beam

4. **Beam Emittance sx=sy=sp=0, sx' and sy' should be large**

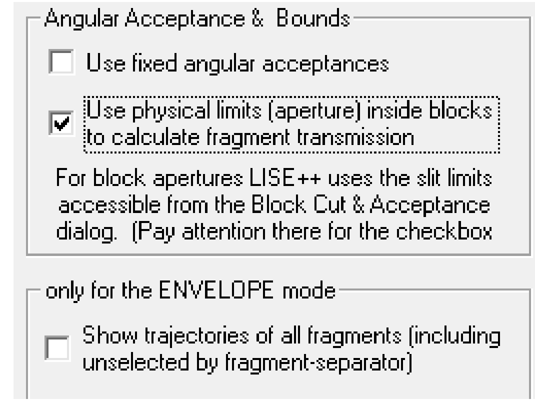


5. Open momentum slits

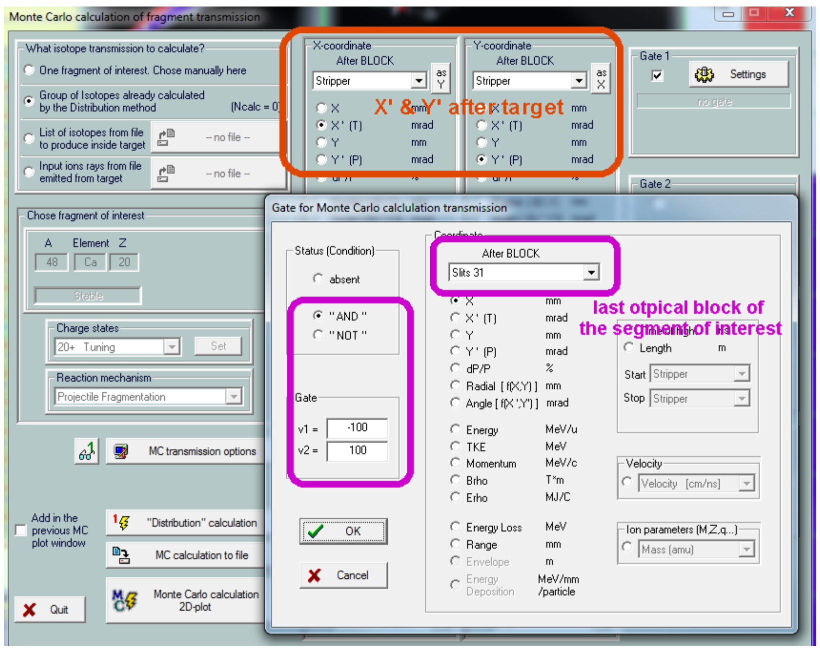
6. Enable only the segment that you want to calculate the angular acceptance in the Set-up dialog using enable-disable commands with a Faraday cup after the segment

Monte Carlo settings

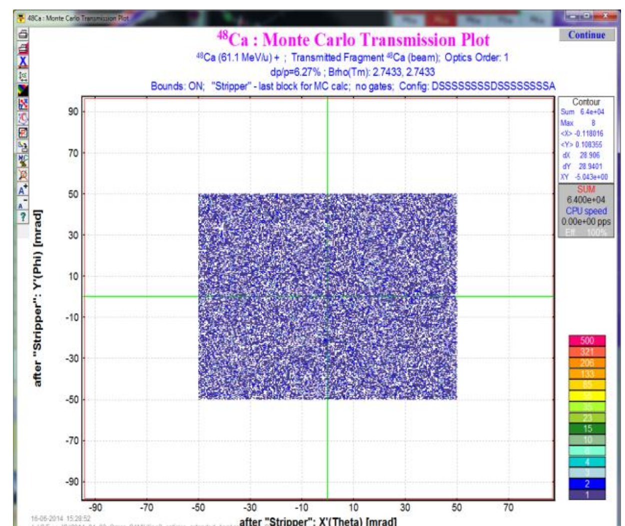
1. The Bound mode should turned on in the MC dialog



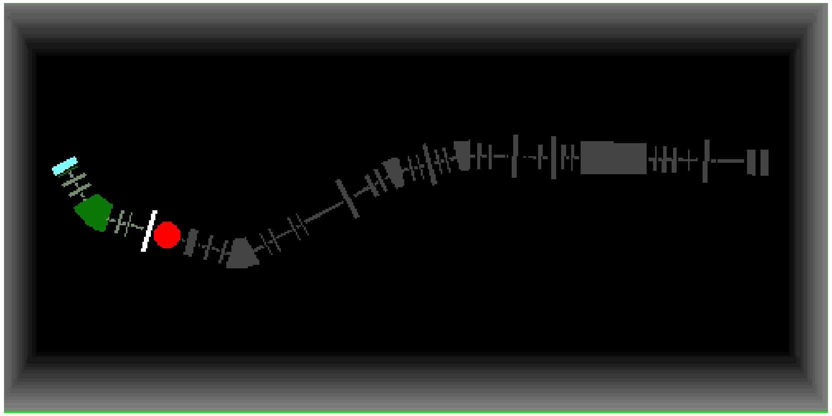
2. Set the gate and MC block parameters as indicated in figure



Example with "No gates"

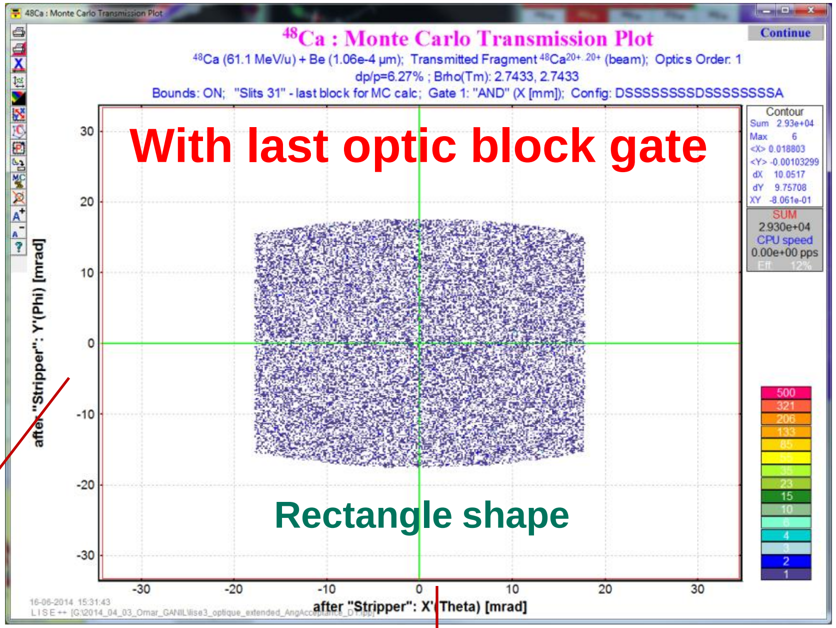


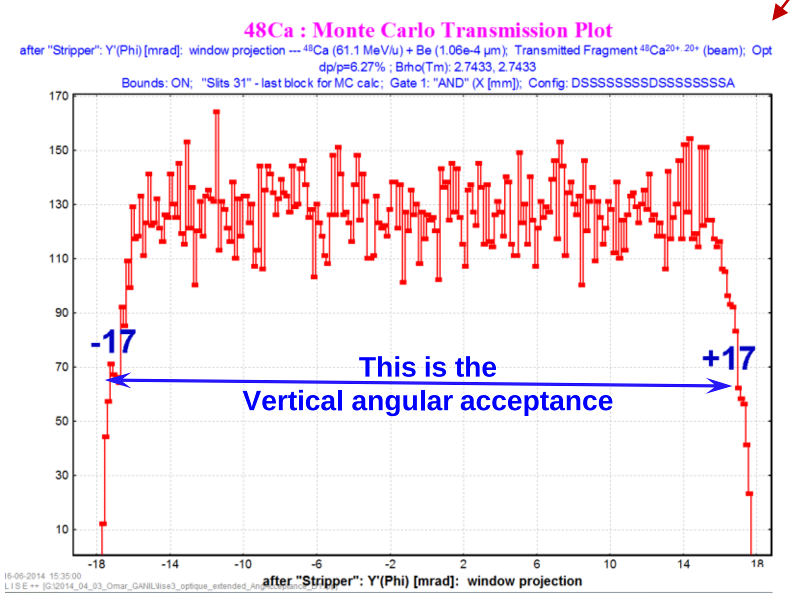
9. How to obtain an angular acceptance? (3)

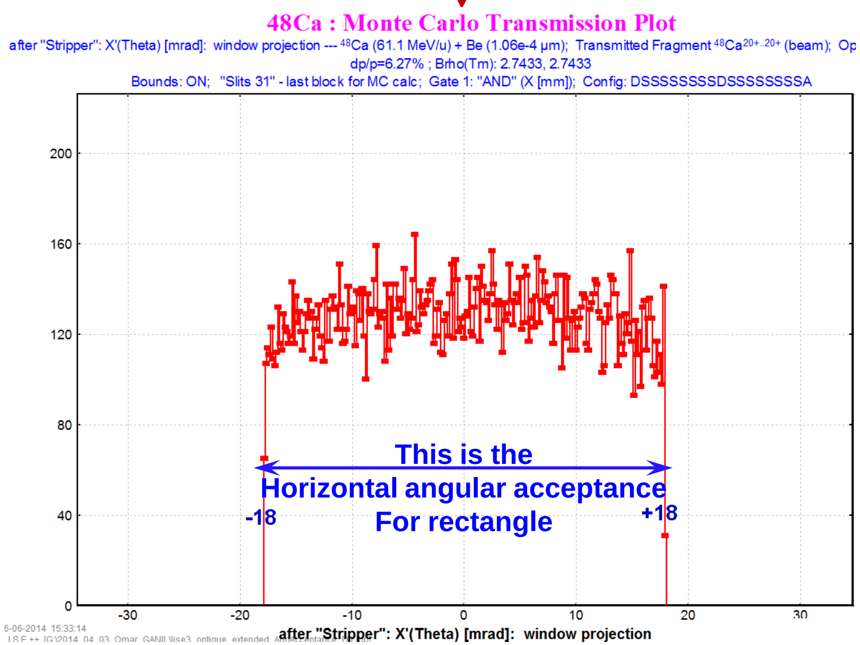


1st segment (D3P1) of LISE3 separator

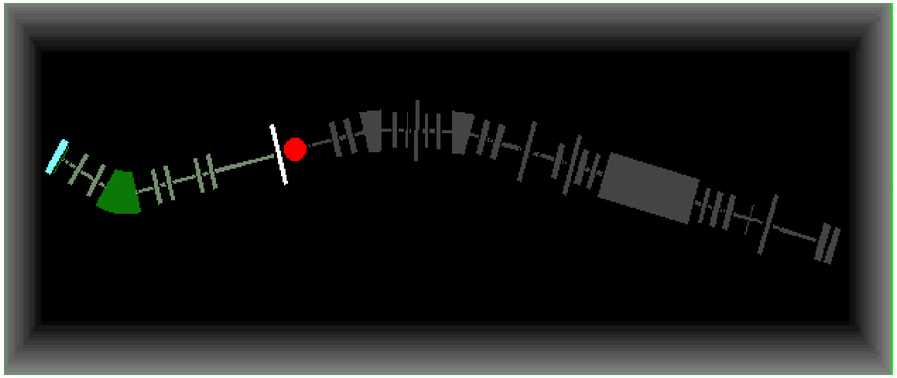
File: http://lise.nscl.msu.edu/9_8/LISE3/lise3_AngAcc_D1.lpp





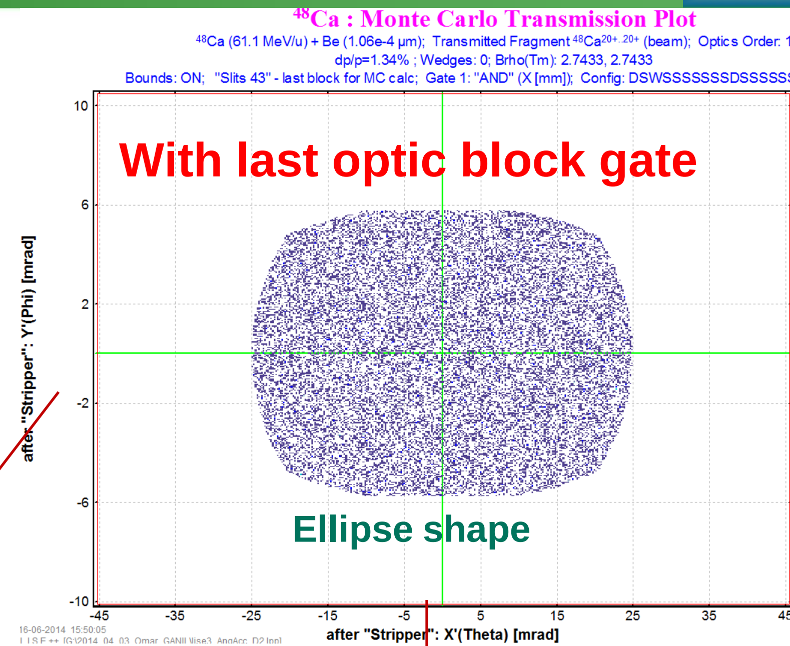


9. How to obtain an angular acceptance? (4)

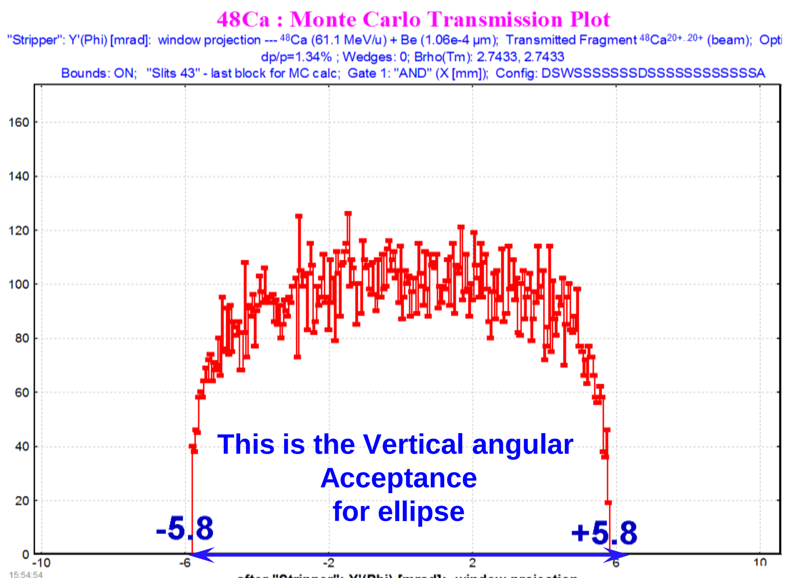


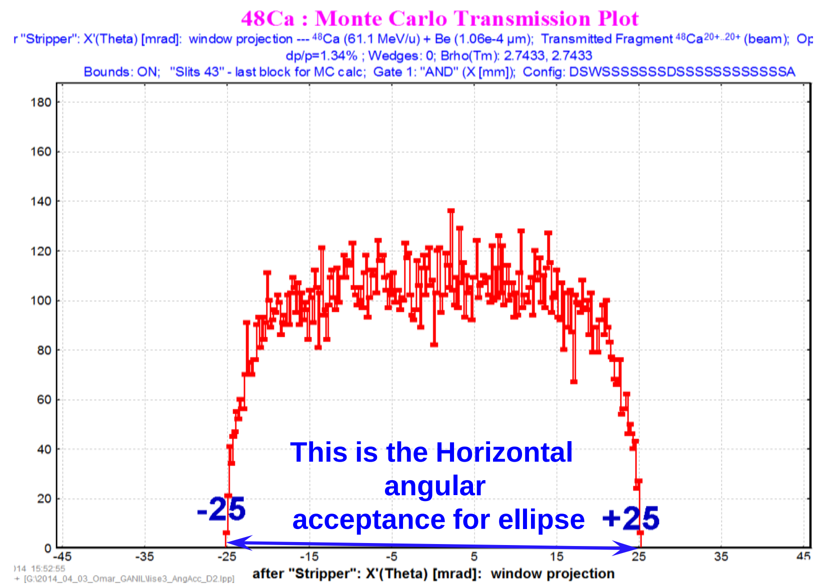
An example the
2nd segment (D3P) of LISE3 separator

File: http://lise.nscl.msu.edu/9_8/LISE3/lise3_AngAcc_D2.lpp

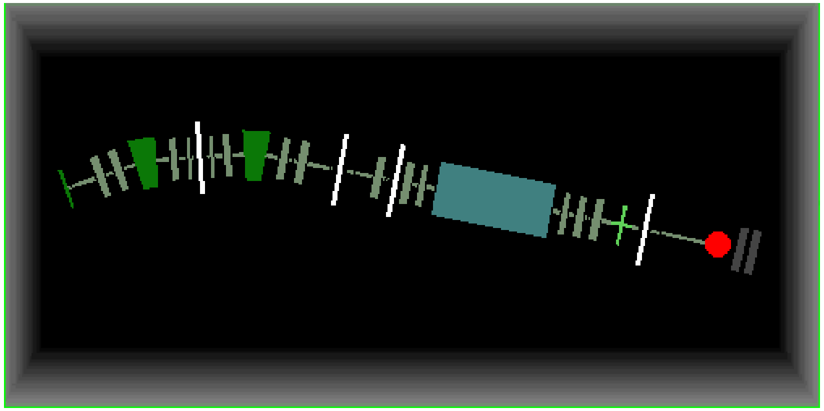


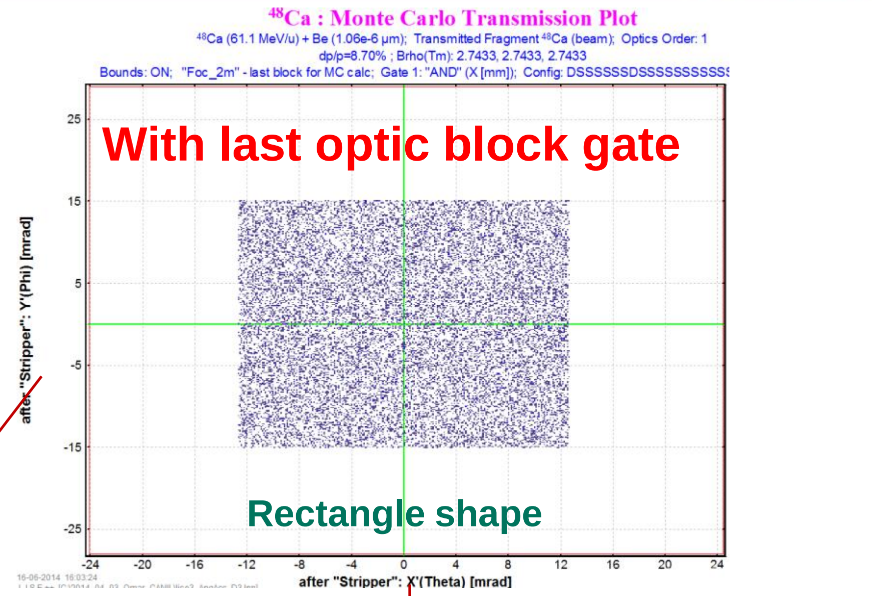
projection





8. How to obtain an angular acceptance? (5)

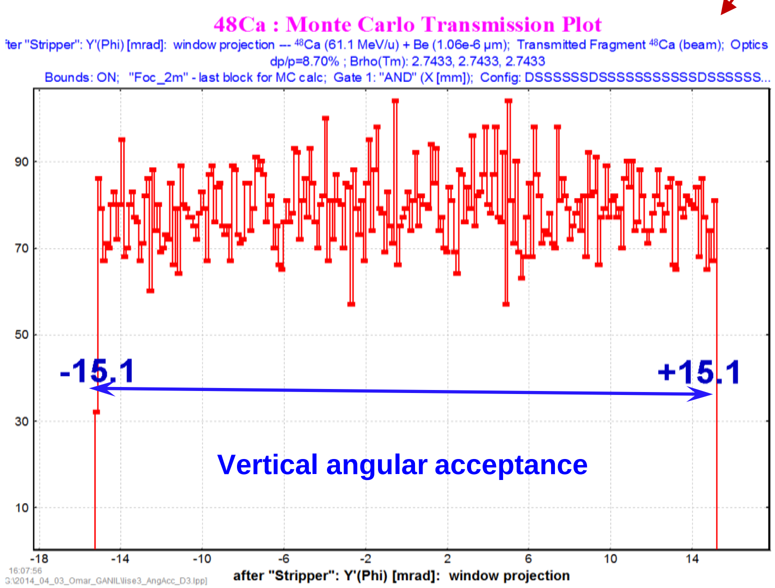


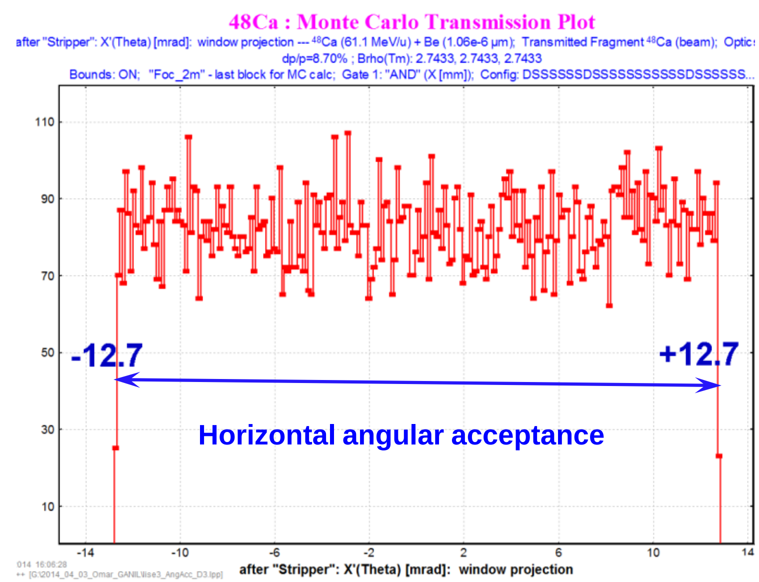


Another example the 3rd segment (D3P) of LISE3 separator

File: http://lise.nscl.msu.edu/9_8/LISE3/lise3_AngAcc_D3.lpp

projection





File: http://lise.nscl.msu.edu/9_8/LISE3/LISE3_cito_extended_v2.lpp

An example the LISE3 separator

statistics: 44S

44S		Beta- decay (Z=16, N=28)
Q1 (Tuning)		16
Q2 (D3P1)		16
Q3 (D3P)		16
Q4 (DA1)		16
Q5 (DA2)		16
Q6 (Wien 1)		16
Q7 (CompDip)		16
Reaction		ProjFrag
Ion Production Rate	(pps)	9.41e+1
Total ion transmission	(%)	2.297
Total: All reactions	(pps)	9.41e+1
X-Section in target	(mb)	1.06e-3
Target	(%)	98.78
Unreacted in material	(%)	98.78
Unstopped in material	(%)	100
Tuning	(%)	37.25
X angular transmission	(%)	62.4
Y angular transmission	(%)	59.69

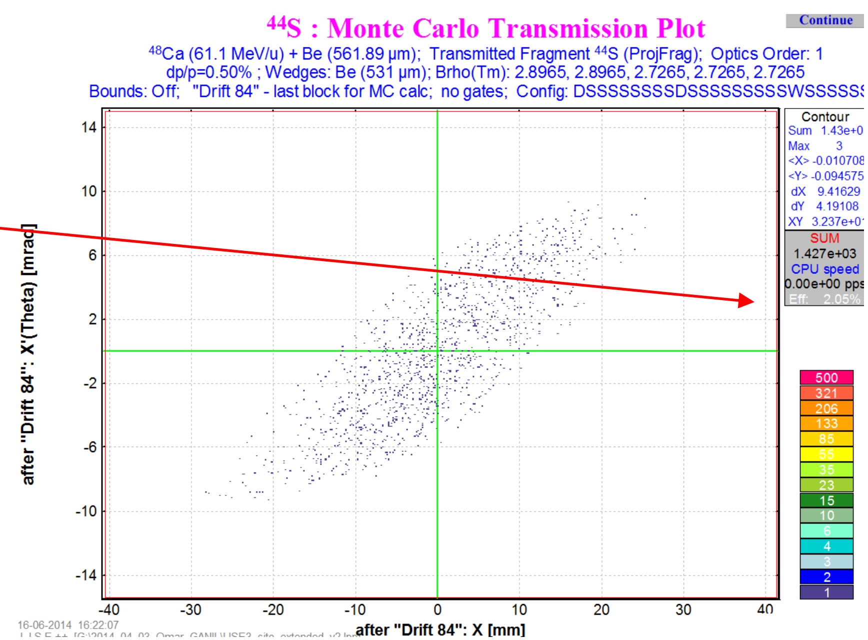
1. "Distribution" method = 2.3%

With Angular Acceptances

2. Monte Carlo method = 2.1%

With Angular Acceptances

No bounds

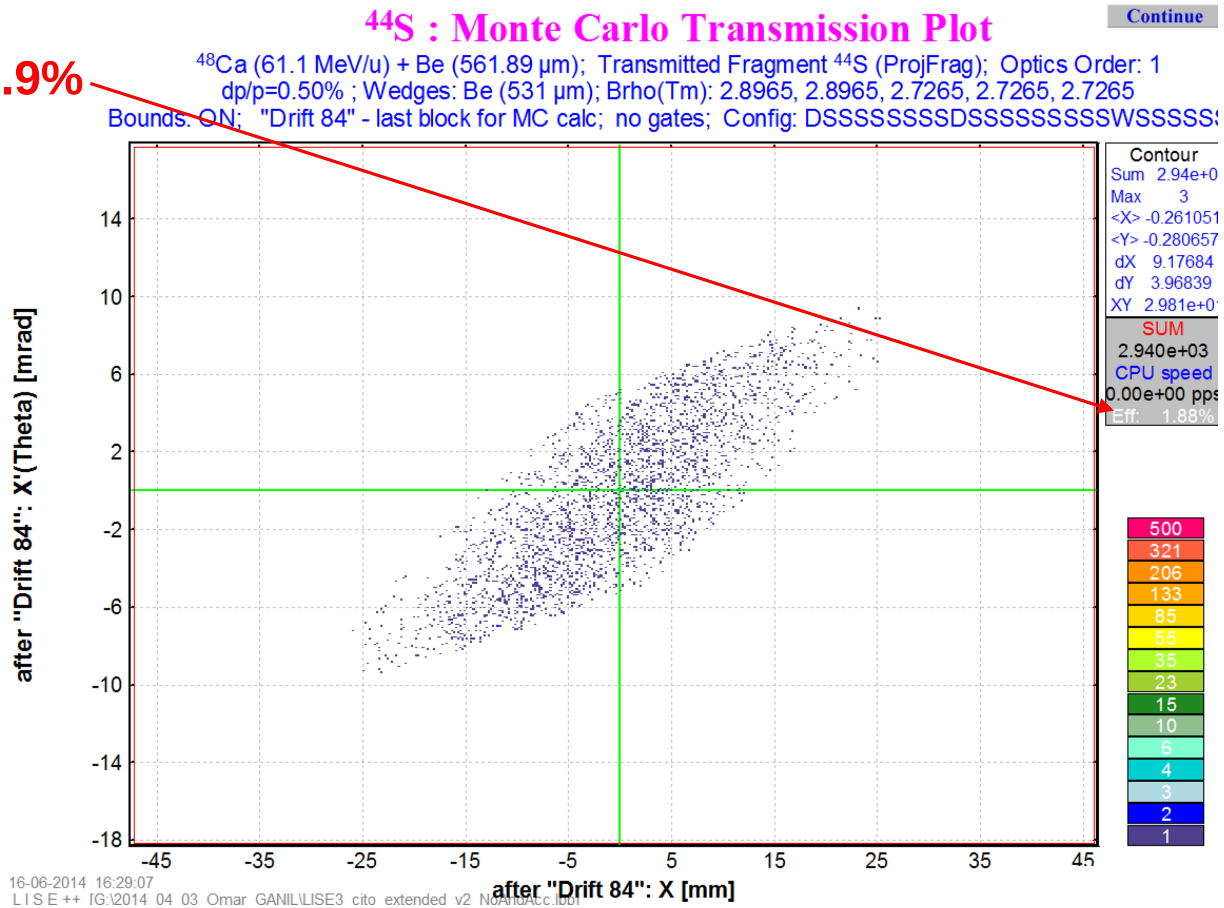


File: http://lise.nscl.msu.edu/9_8/LISE3/LISE3_cito_extended_v2_NoAngAcc.lpp

3. Monte Carlo method = 1.9%

No Angular Acceptances

With bounds



Conclusion: all three runs (Distribution, MC+bounds-AngAccept, MC-bounds+AngAccept) give almost the same transmission about 2 % (90 pps)

Acknowledgements

Thank to Dr. Omar Kamalou
for providing the
LISE3 extended configuration.

Remarks and Comments of
Prof. Dave Morrissey
are very appreciated.