SHELS: ^{48}Ca(216Mev) + PbS(0.35mg/cm^2) $\longrightarrow$ ^{254}No^{19+}

MICHIGAN STATE UNIVERSITY

LISE++

LISE^{++} Version 9.10.209
from 11/19/2015

11/19/15	11/24/15
~~^{48}Ca(219Mev) + PbS(0.406mg/cm^2)~~	^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

1. Dubna's ray table
2. How to use a rays table in LISE++
3. Results
4. Disagreements
    - Beam emittance. What is the real beam emittance?
    - Energy loss ?
    - Distribution after neutron emission
    - Rutherford scattering : is it so important in this case??
5. "Today solution" – simple solution for distributions
6. Comparison of LISE MC, LISE distribution, Dubna distributions
    - Energy
    - Brho
    - Angular

Ray table

Initial

X(mm) Y(mm) X'(rad) Y'(rad) E(MeV) q(un e) B\rho(Tm)

	A	B	C	D	E	F	G	H	I
1		-2.63	-2.22	0.0597	0.0267	34.65	21	0.643	
2		2.86	-3.98	-0.1579	0.0524	30.11	17	0.741	
3		1.97	3.26	0.0003	0.0172	40.76	17	0.862	
4		-0.97	3.16	-0.0109	0.0005	38.66	19	0.751	
5		0.56	-4.79	-0.0511	0.0521	26.04	17	0.689	
6		-1.05	4.4	0.1051	-0.005	29.58	18	0.693	
7		-1.51	1.64	0.0005	-0.0475	32.11	20	0.65	
8		4.06	1.98	0.0271	0.0061	34.28	16	0.84	
9		0.54	-0.07	-0.1172	0.1031	28.71	20	0.615	
10		1.69	3.61	0.0531	-0.0024	28.26	20	0.61	
11		2.85	-1.43	0.0228	-0.0196	36.79	13	1.071	
12		-4.49	-0.68	0.0997	-0.0876	34.67	16	0.845	
13		-1.69	0.85	0.0613	0.0782	28.23	21	0.581	

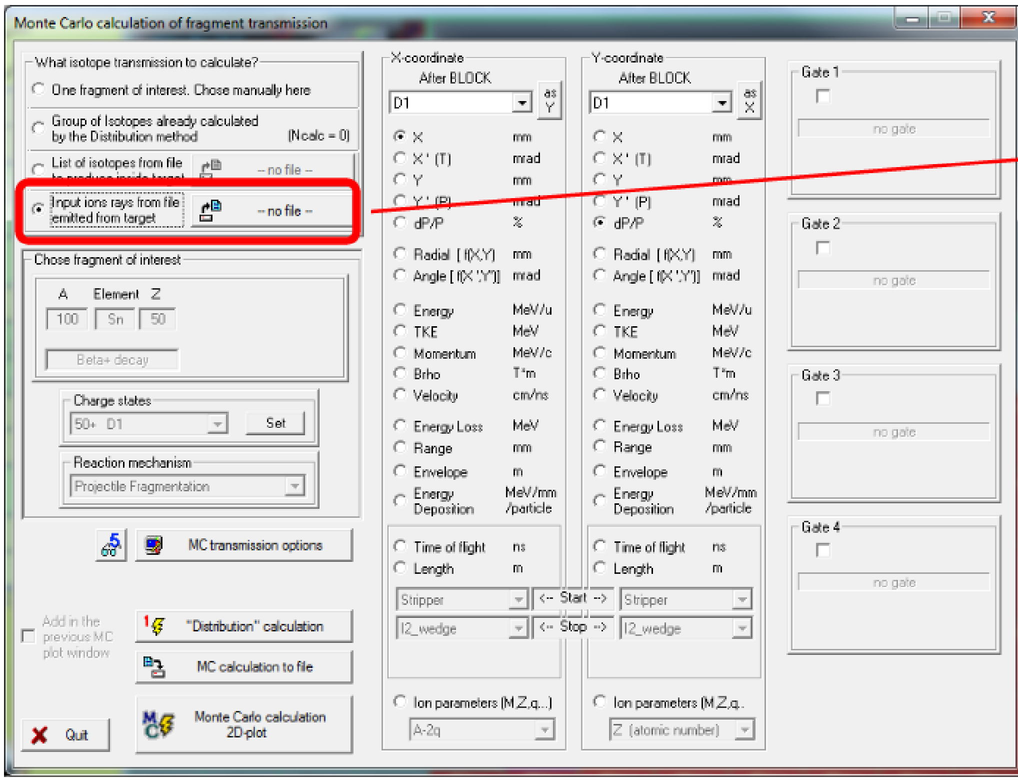
Final for LISE++

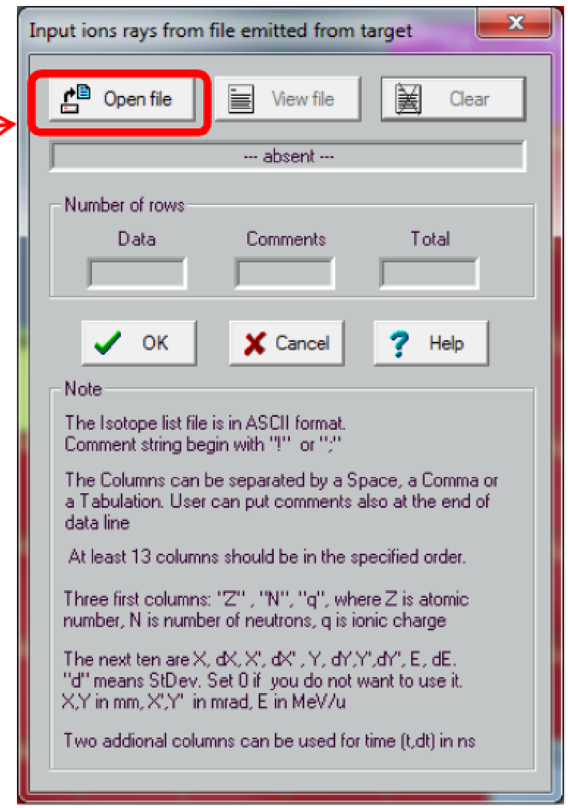
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	! Z	N	q	X,mm	dX	X'mrad	dX'	Y,mm	dY	Y'mrad	dY'	E,MeV/u	dE
2	102	152	21	-2.63	1	59.7	1	-2.22	1	26.7	1	0.136417	0.002
3	102	152	17	2.86	1	-157.9	1	-3.98	1	52.4	1	0.118543	0.002
4	102	152	17	1.97	1	0.3	1	3.26	1	17.2	1	0.160472	0.002
5	102	152	19	-0.97	1	-10.9	1	3.16	1	0.5	1	0.152205	0.002
6	102	152	17	0.56	1	-51.1	1	-4.79	1	52.1	1	0.10252	0.002
7	102	152	18	-1.05	1	105.1	1	4.4	1	-5	1	0.116457	0.002
8	102	152	20	-1.51	1	0.5	1	1.64	1	-47.5	1	0.126417	0.002
9	102	152	16	4.06	1	27.1	1	1.98	1	6.1	1	0.134961	0.002
10	102	152	20	0.54	1	-117.2	1	-0.07	1	103.1	1	0.113031	0.002
11	102	152	20	1.69	1	53.1	1	3.61	1	-2.4	1	0.11126	0.002
12	102	152	13	2.85	1	22.8	1	-1.43	1	-19.6	1	0.144843	0.002

SHELS particles v2.inrays file is attached to the e-mail

How to use an input ray table?

lise.nscl.msu.edu/9_6/9_6_23.pdf#page=10





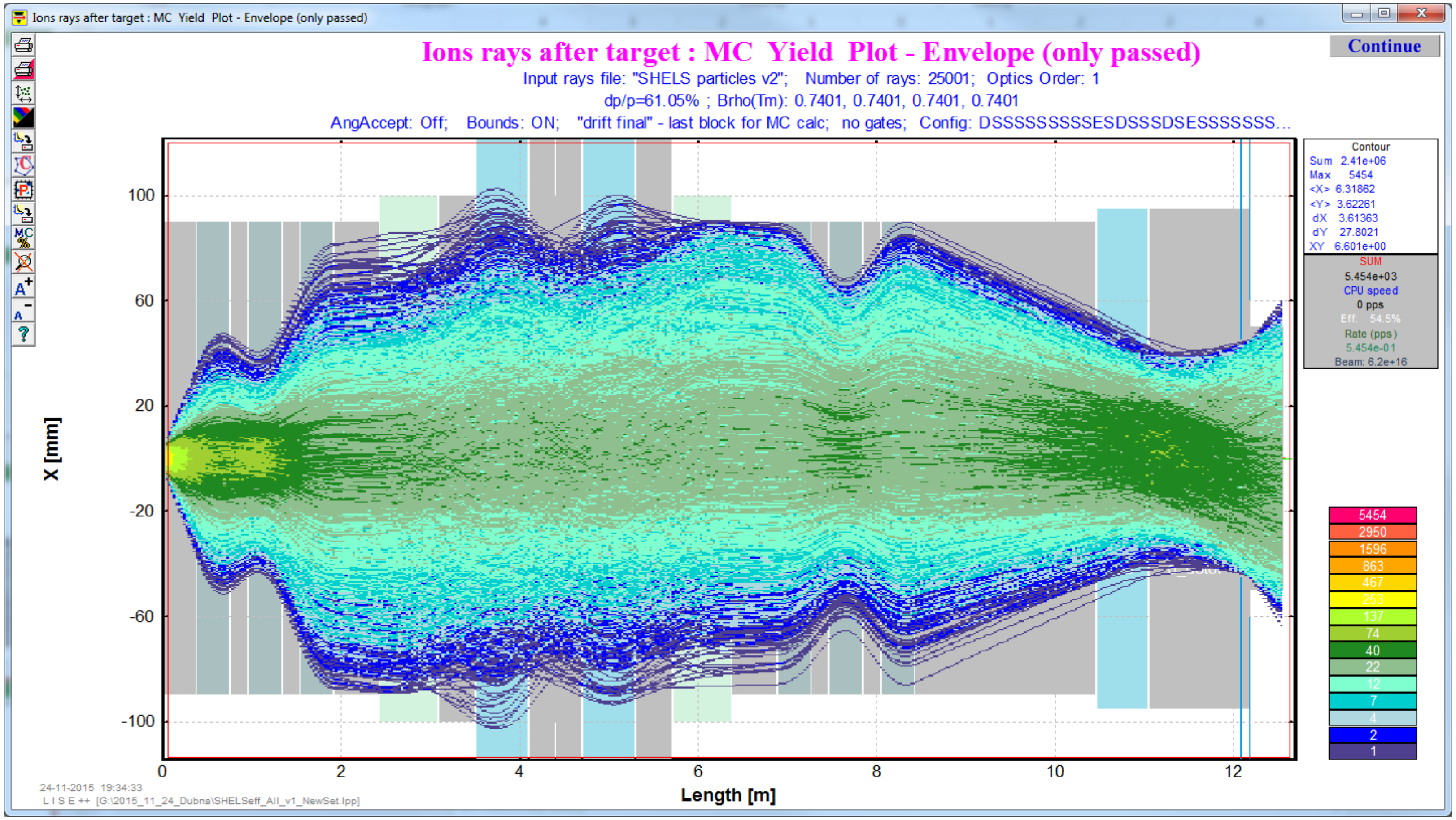
Results with the ray table

MICHIGAN STATE UNIVERSITY
LISE++

SHELSeff_All_v1_NewSet.lpp

The File is attached to the e-mail

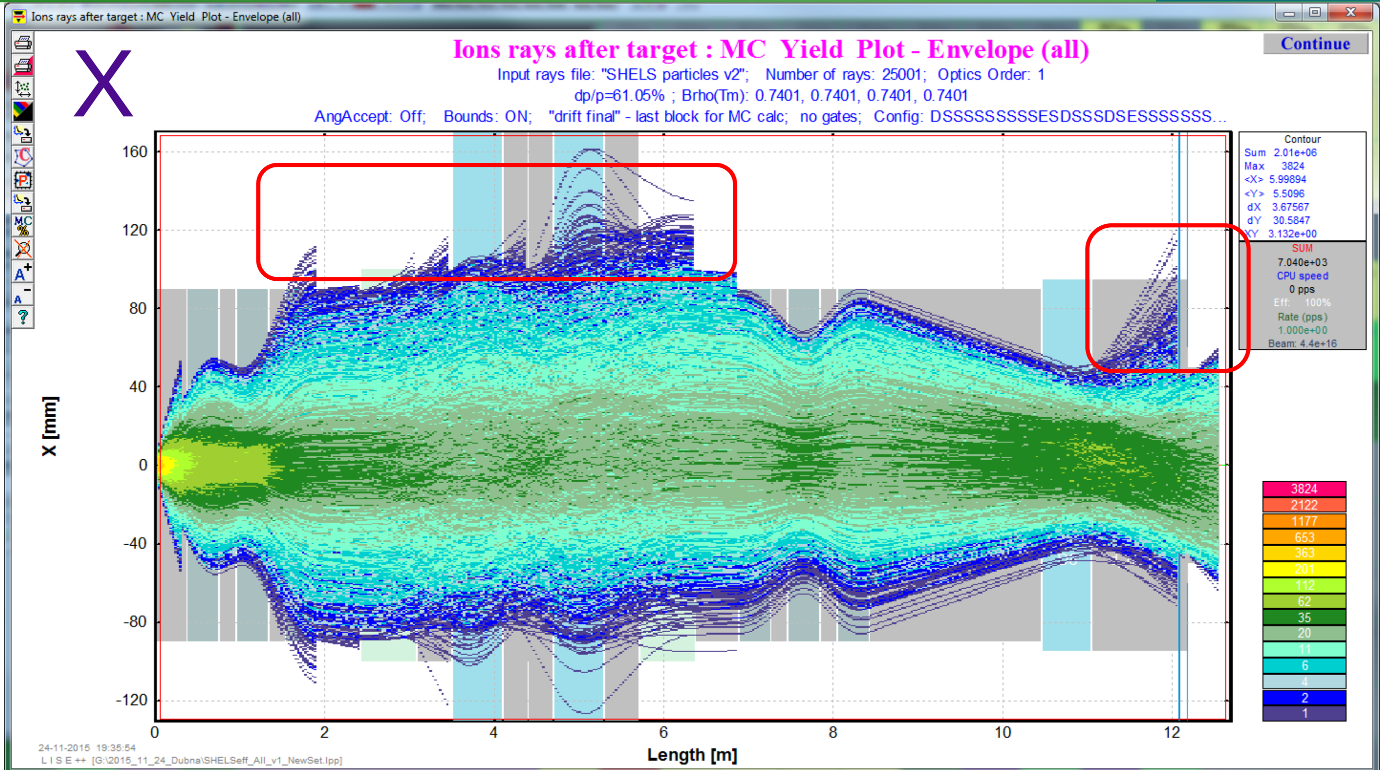
Transmission 54.5%



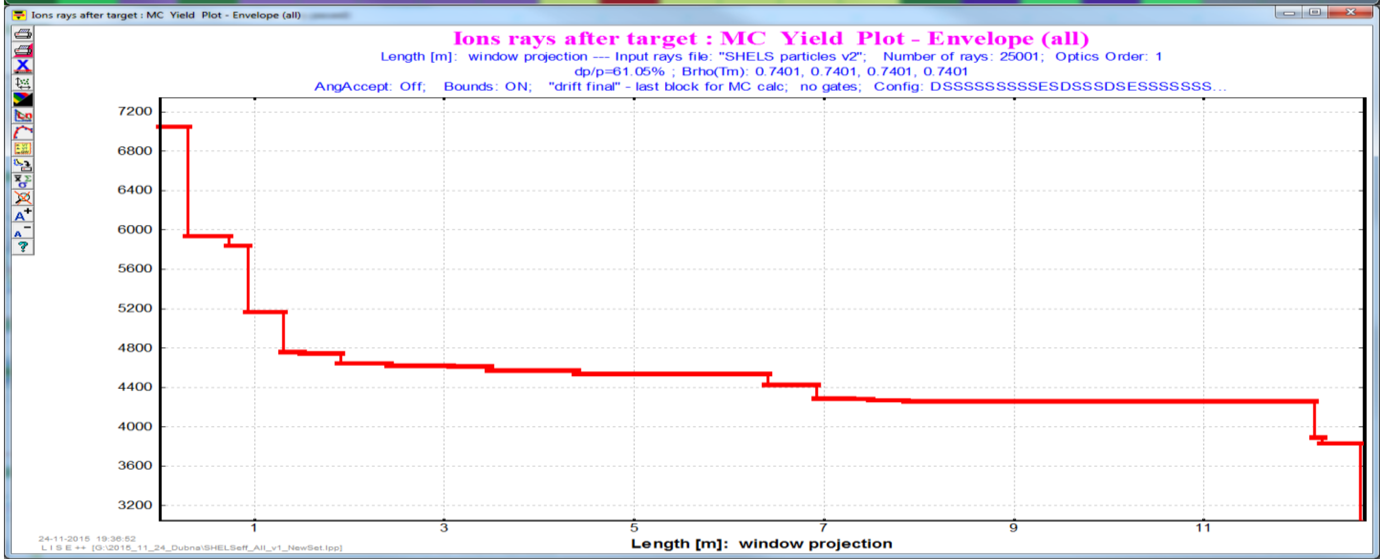
Results with the ray table

SHELSeff_All_v1_NewSet.lpp

The File is attached to the e-mail



where transmission lost?

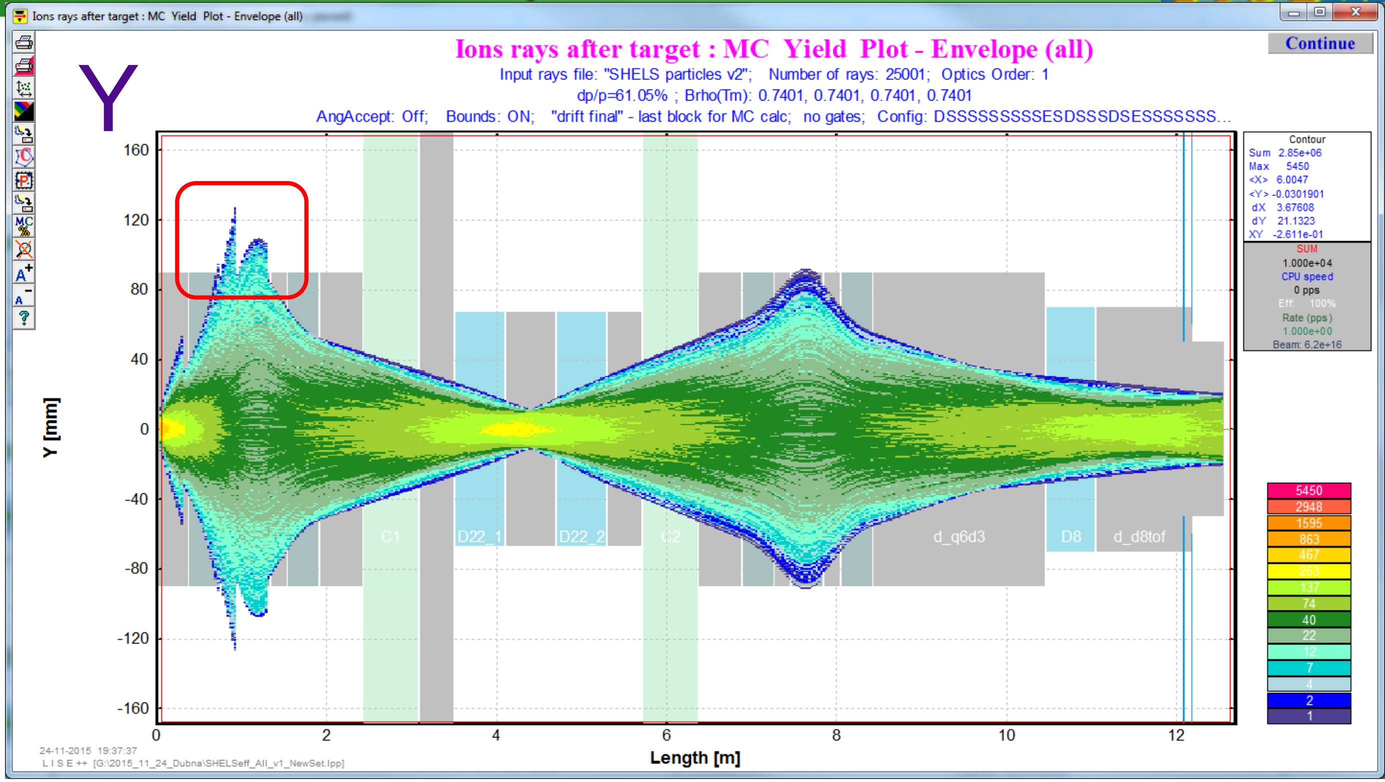


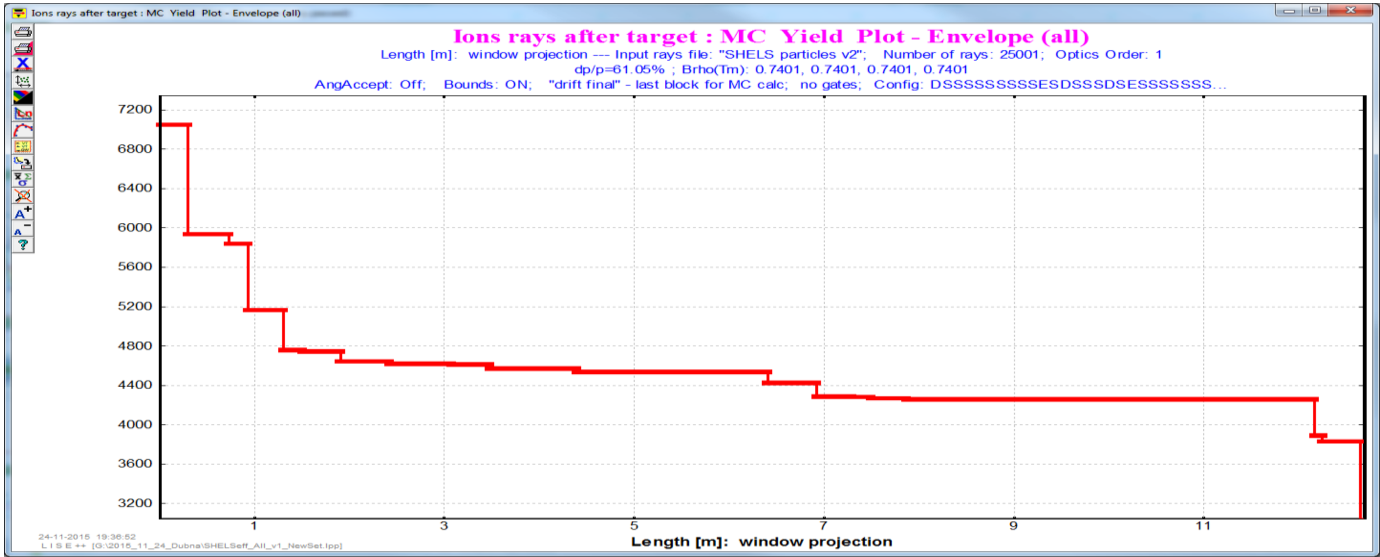
Results with the ray table

SHELSeff_All_v1_NewSet.lpp

The File is attached to the e-mail

where transmission lost?



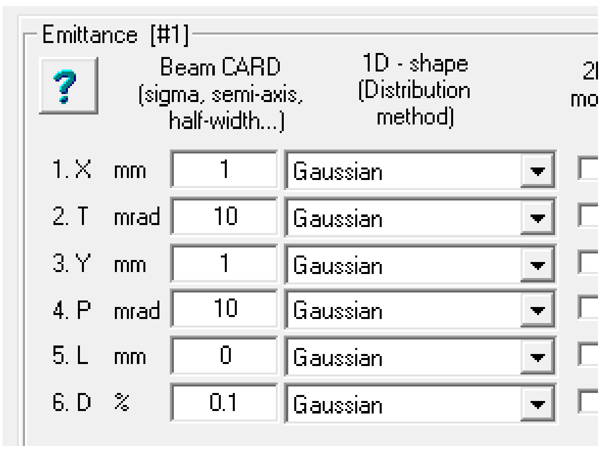


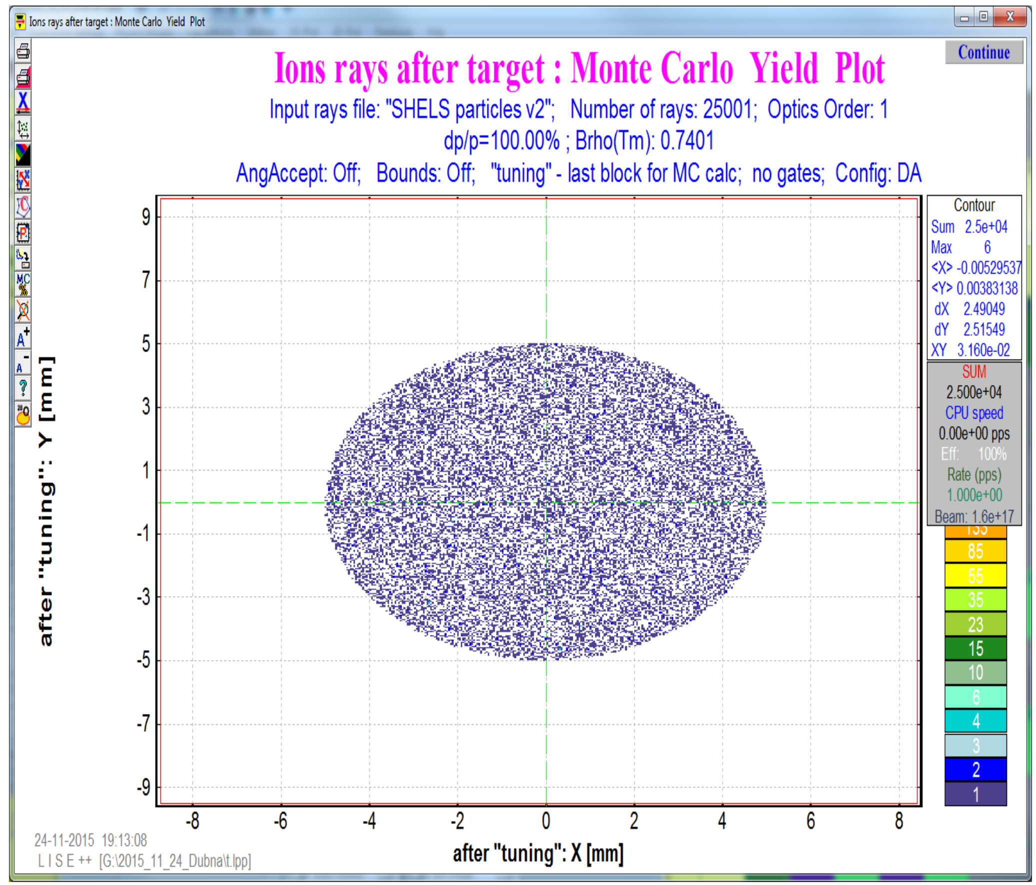
Where are disagreements?

- Beam emittance. What is the real beam emittance?
- Energy loss ? (very different <E> and FWHM)
- Distribution after neutron emission (angular distribution shape, width) ?
- Rutherford scattering : is it so important in this case??

Dubna's ray table

It has been used
in LISE^{++} files





It is the ellipse by 5x5 mm!!

Energy distribution

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

$E_{beam} = 4.505484$ MeV/u

"Today simple"

Reaction @ beginning of target

1. $^{256}No^*$ Compound energy 40.6 MeV or 0.158569 MeV/u.
   Excitation energy 21.6 MeV

2. Evaporation of two neutrons (more probable are 1.3 and 1.5 MeV)

Components		Shape
Evaporation	$\sigma(E)$ = 2.9e-3 (7.2e-3) MeV/u or 1.82%	Gaussian
	$\sigma(Ax)$ = 8.1 mrad (FWHM 21.5)	Gaussian

kinematics.xlsx is attached.

More probable consecutive emission of two neutrons with 1.3 and 0.9 MeV

3. ^{254}No passing the target

Components		Shape
Energy remain	E = 0.141755 MeV/u	
Straggling	$\sigma(E)$ = 1.6452e-4 MeV/u (0.116%)	Gaussian
	$\sigma(Ax)$ = 17.058 mrad	Gaussian

Energy distribution

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

E_{beam} = 4.505484 MeV/u

"Today simple"

Reaction @ end of target

1. ^{48}Ca passing the target

Components		Shape
Energy remain	E = 4.44186 MeV/u	
Straggling	σ(E) = 1.4e-3 MeV/u (0.03%)	Gaussian
	σ(Ax) = 3.25 mrad	Gaussian

2. ^{256}No* Compound energy 40.0 MeV or 0.156226 MeV/u.
   Excitation energy 19.15 MeV

3. Evaporation of two neutrons (assume as in the previous case)

Energy distribution

^{48}Ca(216Mev) + PbS(0.35mg/cm^2) E = 4.505484 MeV/u "Today simple"

Components	Energy	Shape
1. Beam emittance	±0.2%	Gaussian
or	σ(E) = 2.98e-4 MeV/u	(for final energy)

2. Energy rectangle due to energy loss difference
   E1 = 0.141755 MeV/u
   E2 = 0.156226 MeV/u <E>=0.1489905 MeV/u
   FWHM = 0.014471 MeV/u (rectangle)

3. Straggling $\sigma(E) = \mathrm{sqrt}(\sigma_{beam}^2 + \sigma_{resid}^2)/2 = 0.06\%$

4. Evaporation σ(E) = 1.82%

5. Target non-uniformity (3% thickness) Gaussian

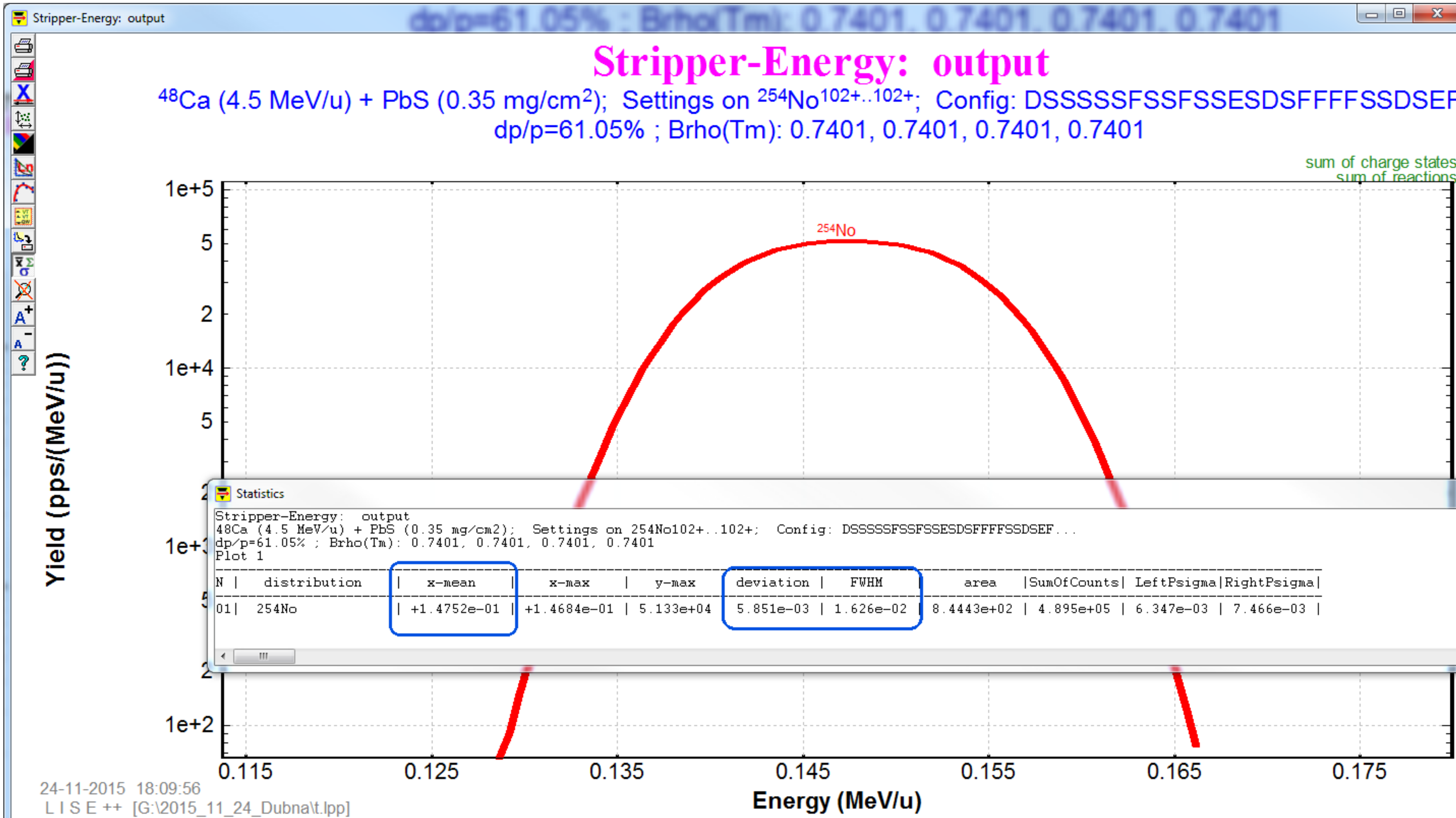
Components	Energy	
1. Gaussian	σ(E) = 1.83%	(or 2.72e-3 MeV/u)
2. Rectangle	<E>=0.1489905 MeV/u FWHM = 0.014471 MeV/u (rectangle)	

Energy distribution

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

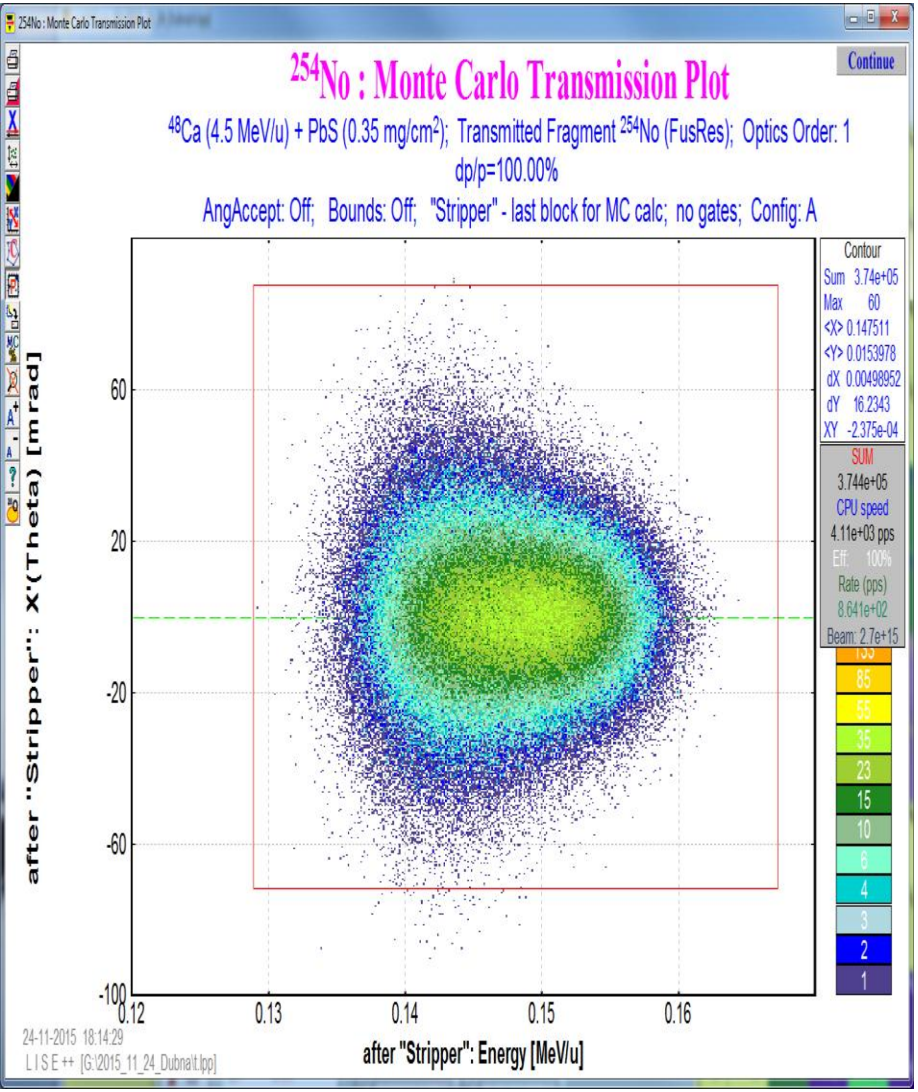
1. X	mm	1	Gaussian
2. T	mrad	0	Gaussian
3. Y	mm	1	Gaussian
4. P	mrad	0	Gaussian
5. L	mm	0	Gaussian
6. D	%	0.1	Gaussian

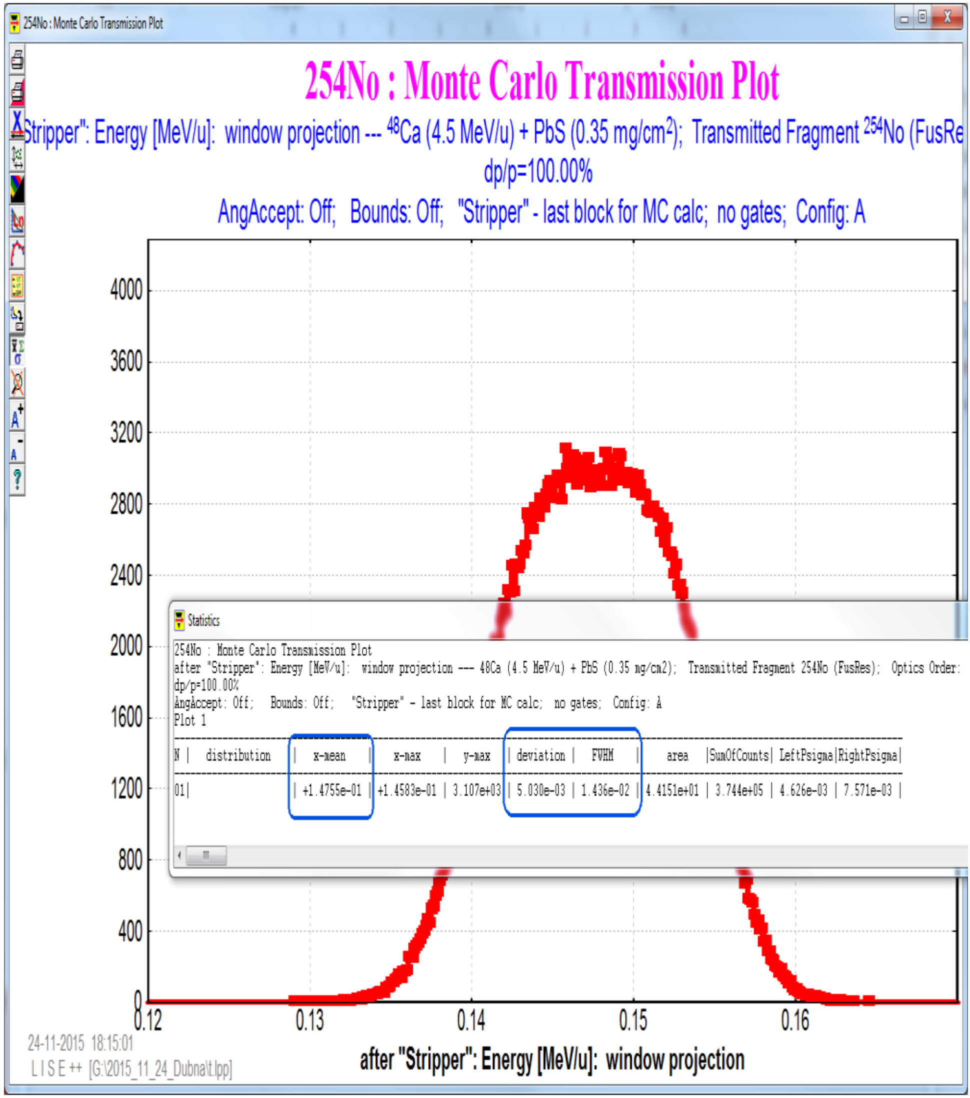
LISE^{++} analytical



^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

LISE^{++} Monte Carlo

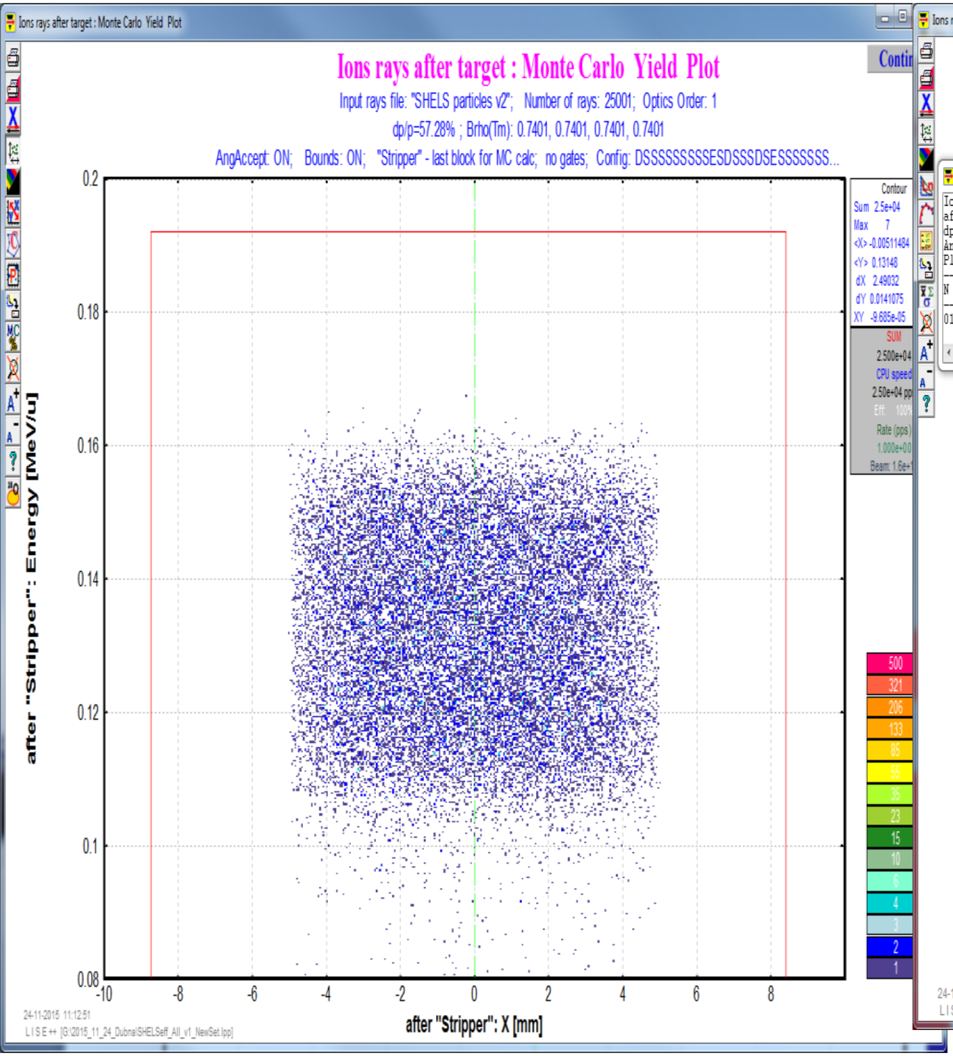


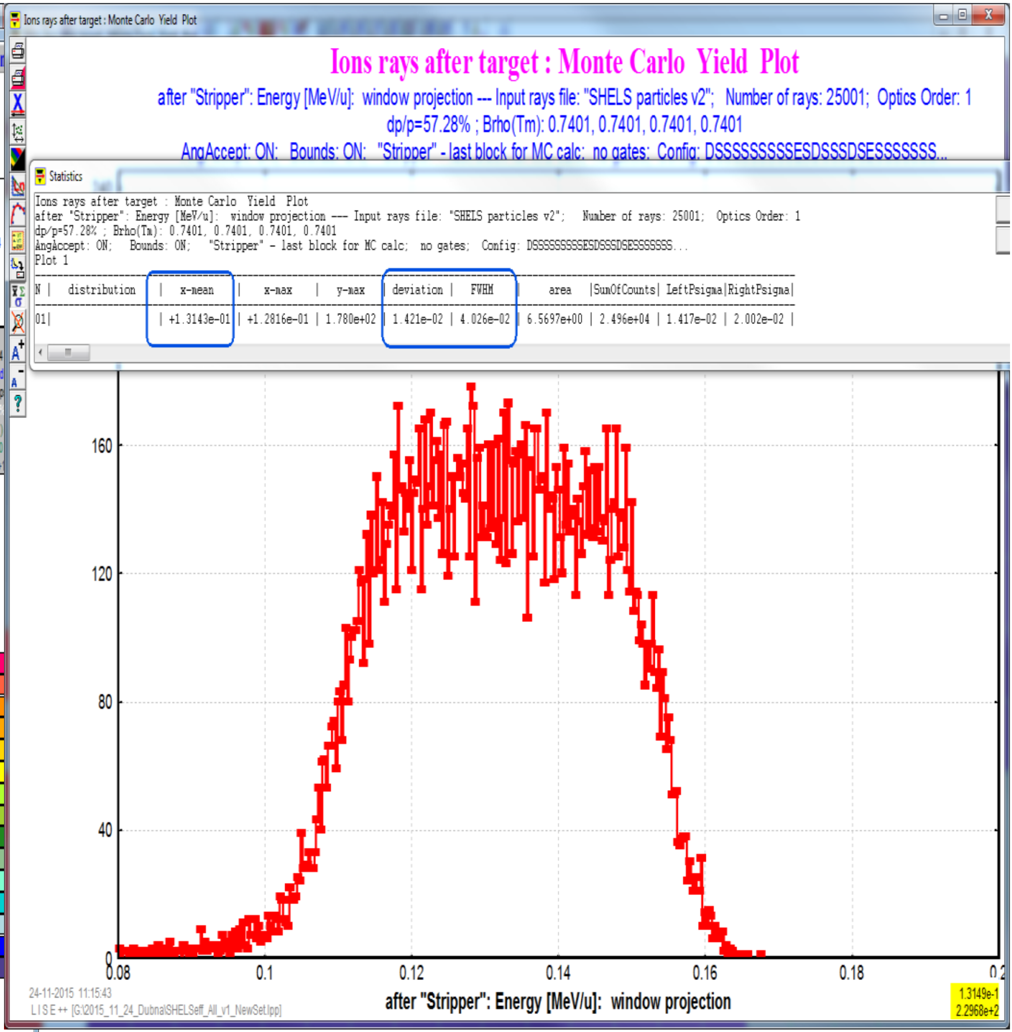


Energy distribution

Dubna

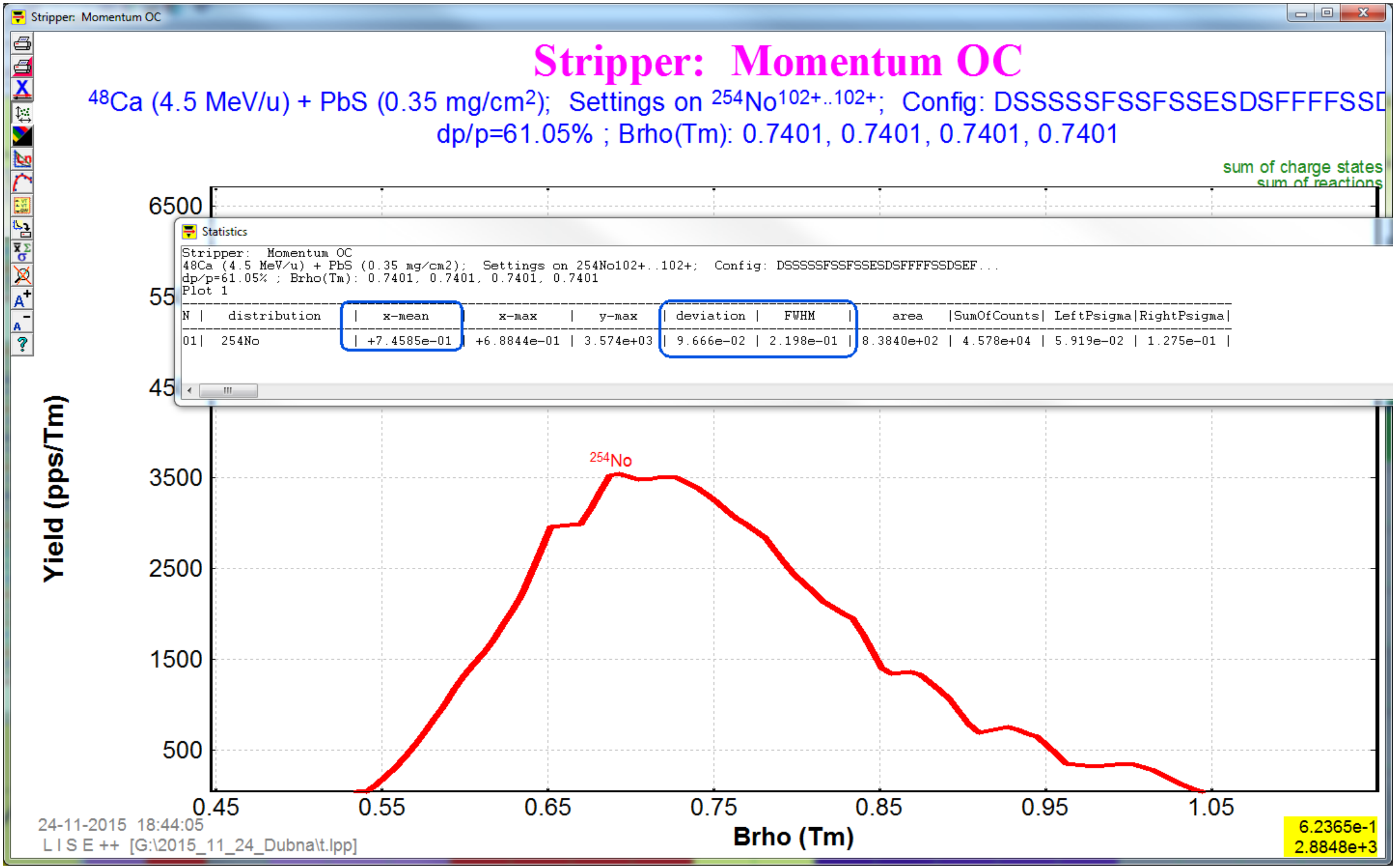
^{48}Ca(216Mev) + PbS(0.35mg/cm^2)





^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

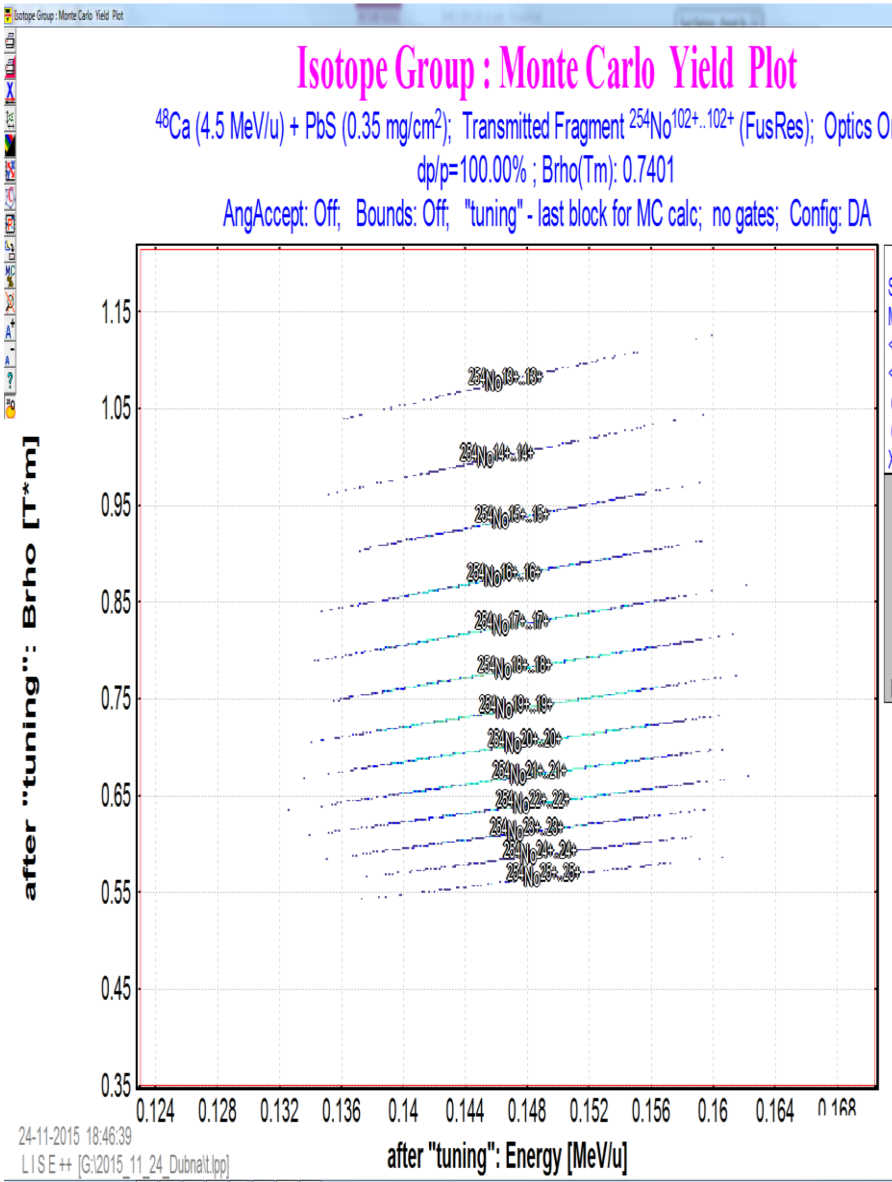
LISE^{++} analytical

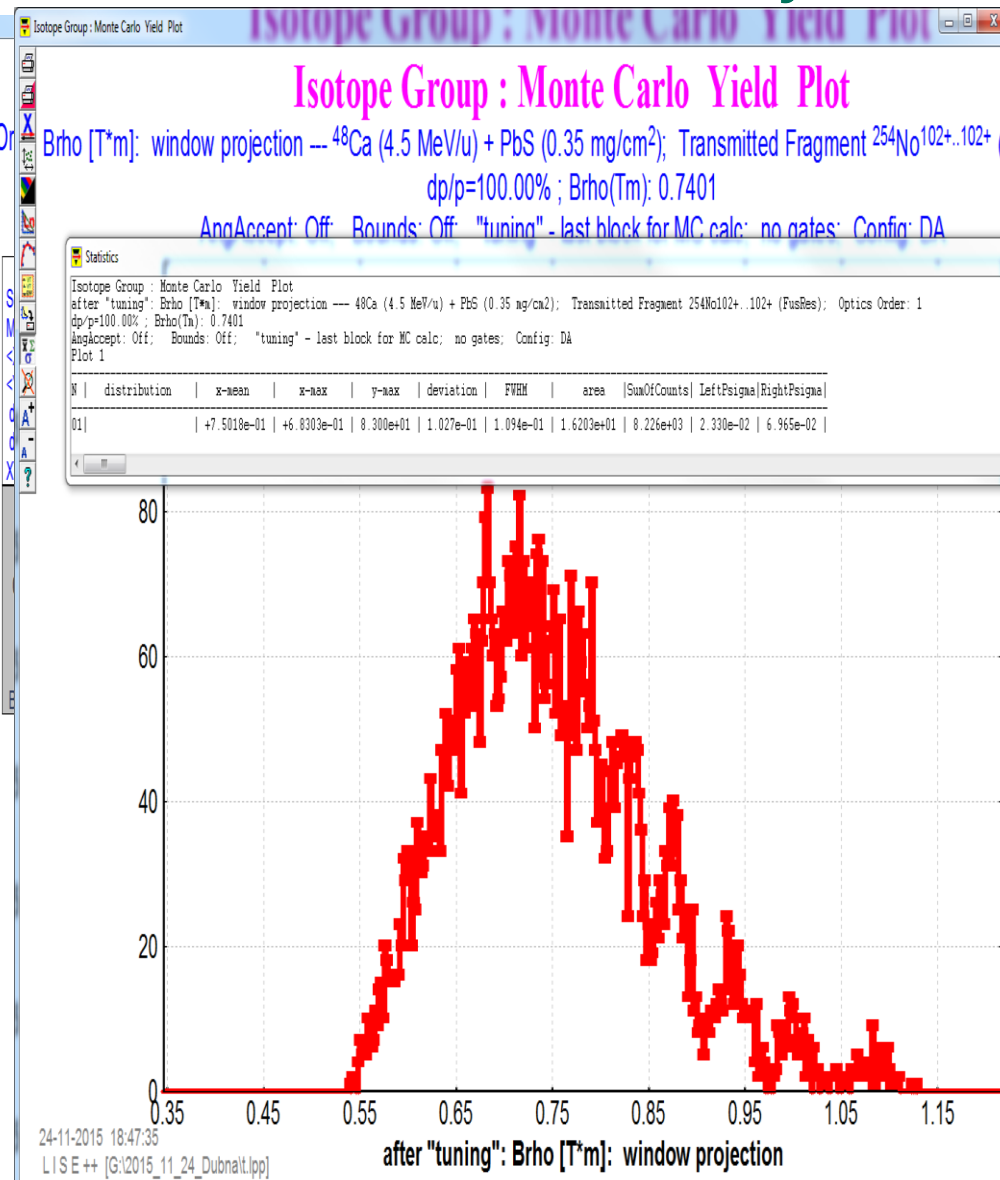


Brho distribution

LISE^{++} analytical

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

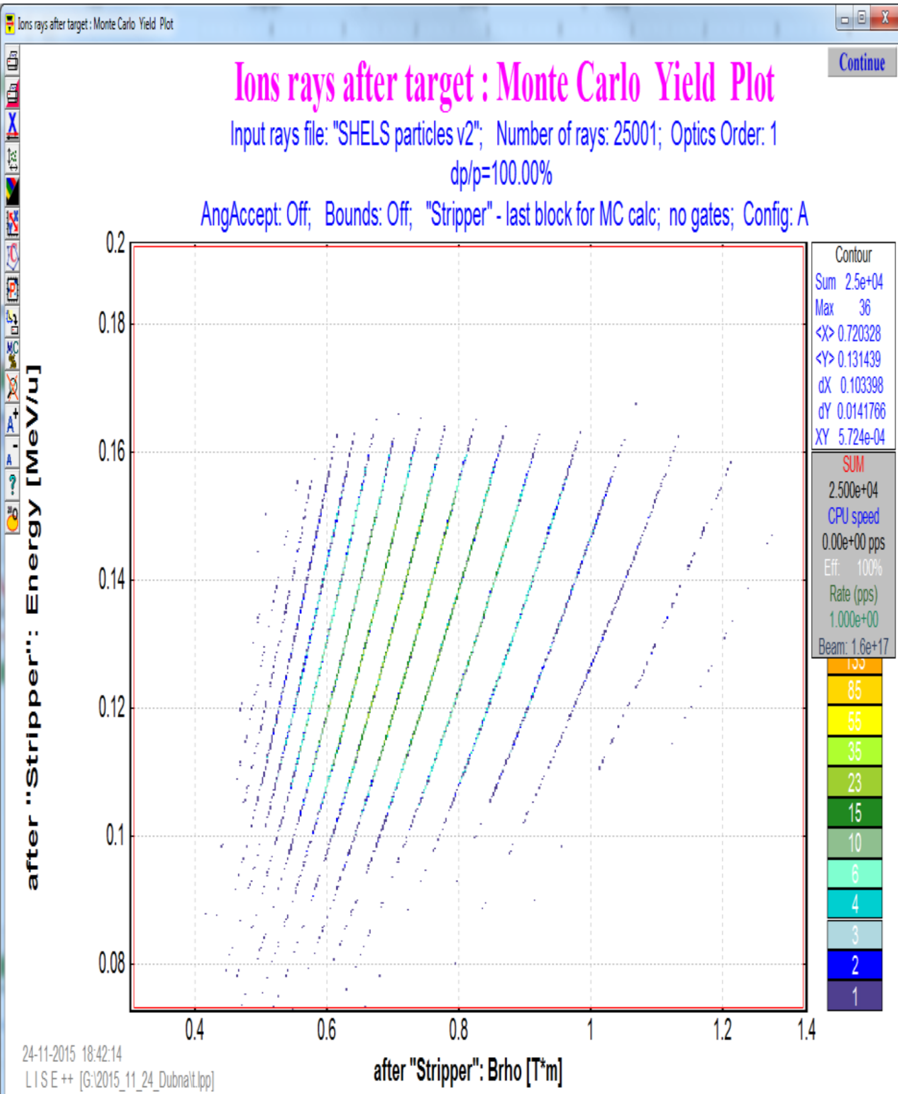


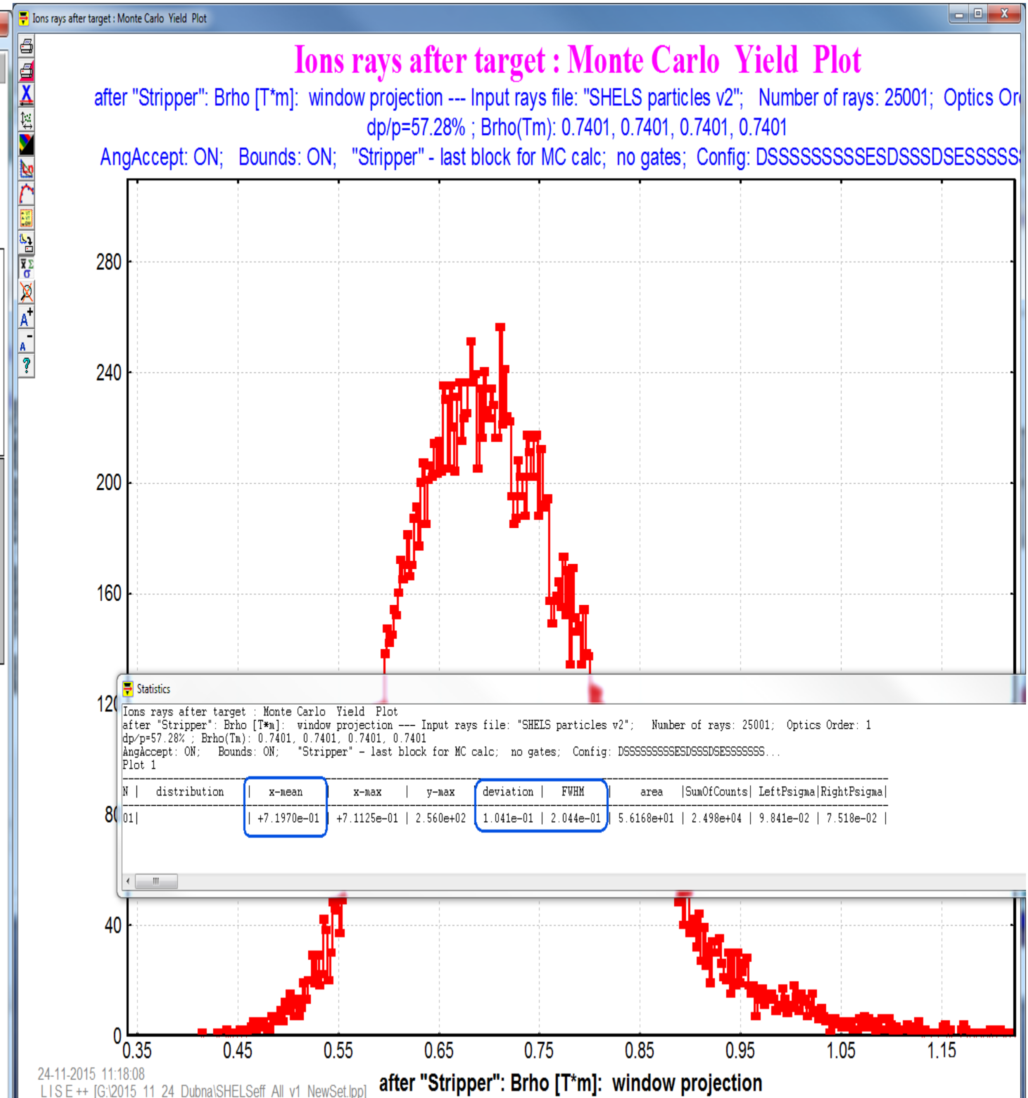


Brho distribution

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

Dubna





Energy and Brho distributions : comparison

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

	in MeV/u		
	<E>	sig.E	FWHM E
Dubna	0.1343	1.42E-02	4.03E-02
LISE MC	0.14755	5.03E-03	1.44E-02
LISE analytical	0.14752	5.85E-03	1.63E-02
"today simple"	0.14899	~ 0.006-0.007	~0.015

	in T*m		
	<Brho>	sig.Brho	FWHM Brho
Dubna	0.7197	1.04E-01	2.04E-01
LISE MC	0.7502	1.03E-01	
LISE analytical	0.7459	9.67E-01	2.20E-01

Angle distribution

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

E = 4.505484 MeV/u

"Today simple"

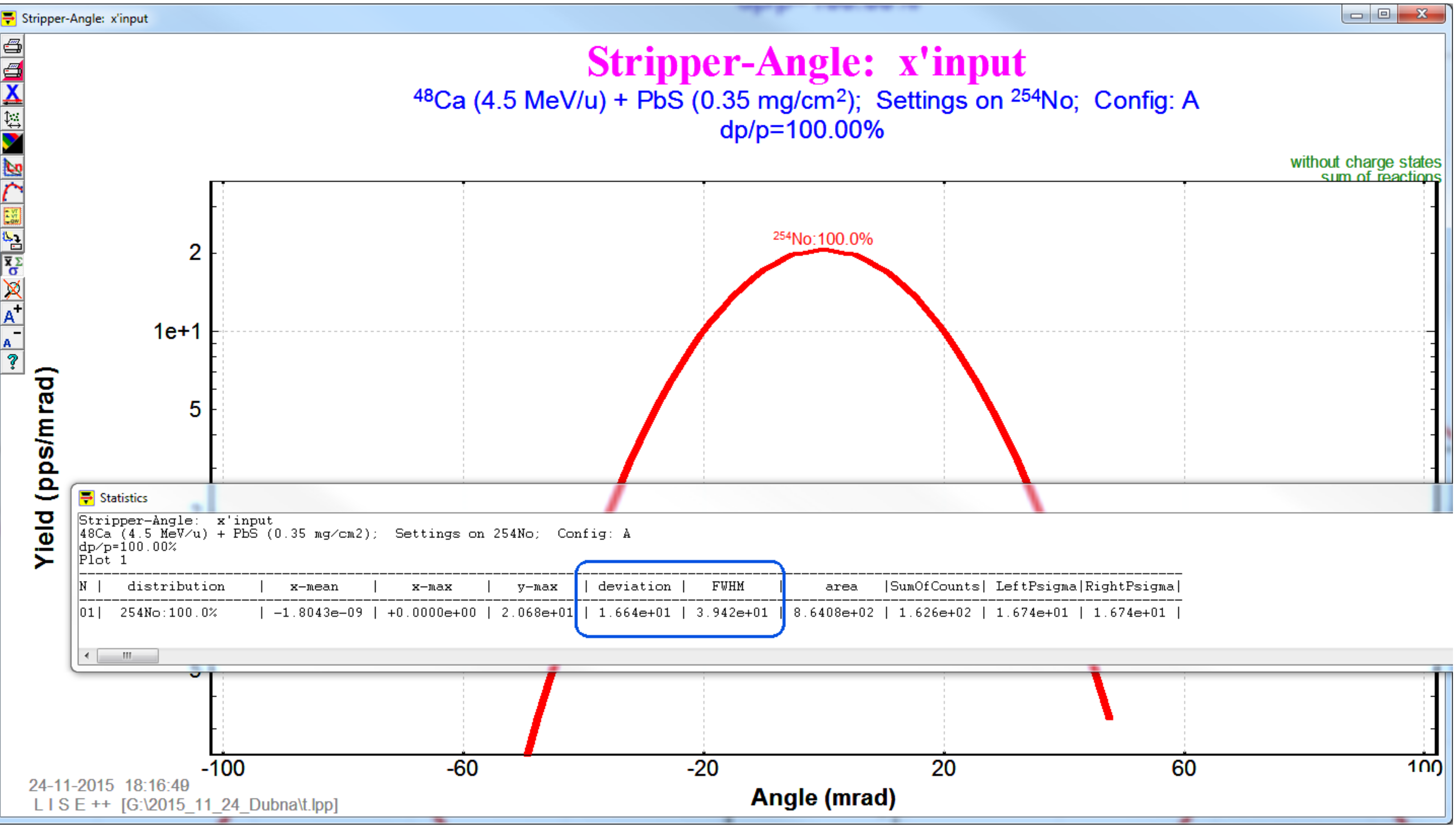
Components	Energy	Shape
1. Beam emittance	$\sigma(Ax)$ = 10 mrad	Gaussian
2. Evaporation	$\sigma(Ax)$ = 8.8 mrad	Gaussian
3. Straggling	$\sigma(A) = \mathrm{sqrt}(\sigma_{beam}^2 + \sigma_{resid}^2)$	
	= 17.3 mrad	Gaussian
Final	$\sigma(Ax)$ = 21.8 mrad	Gaussian

Energy distribution

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

LISE^{++} analytical

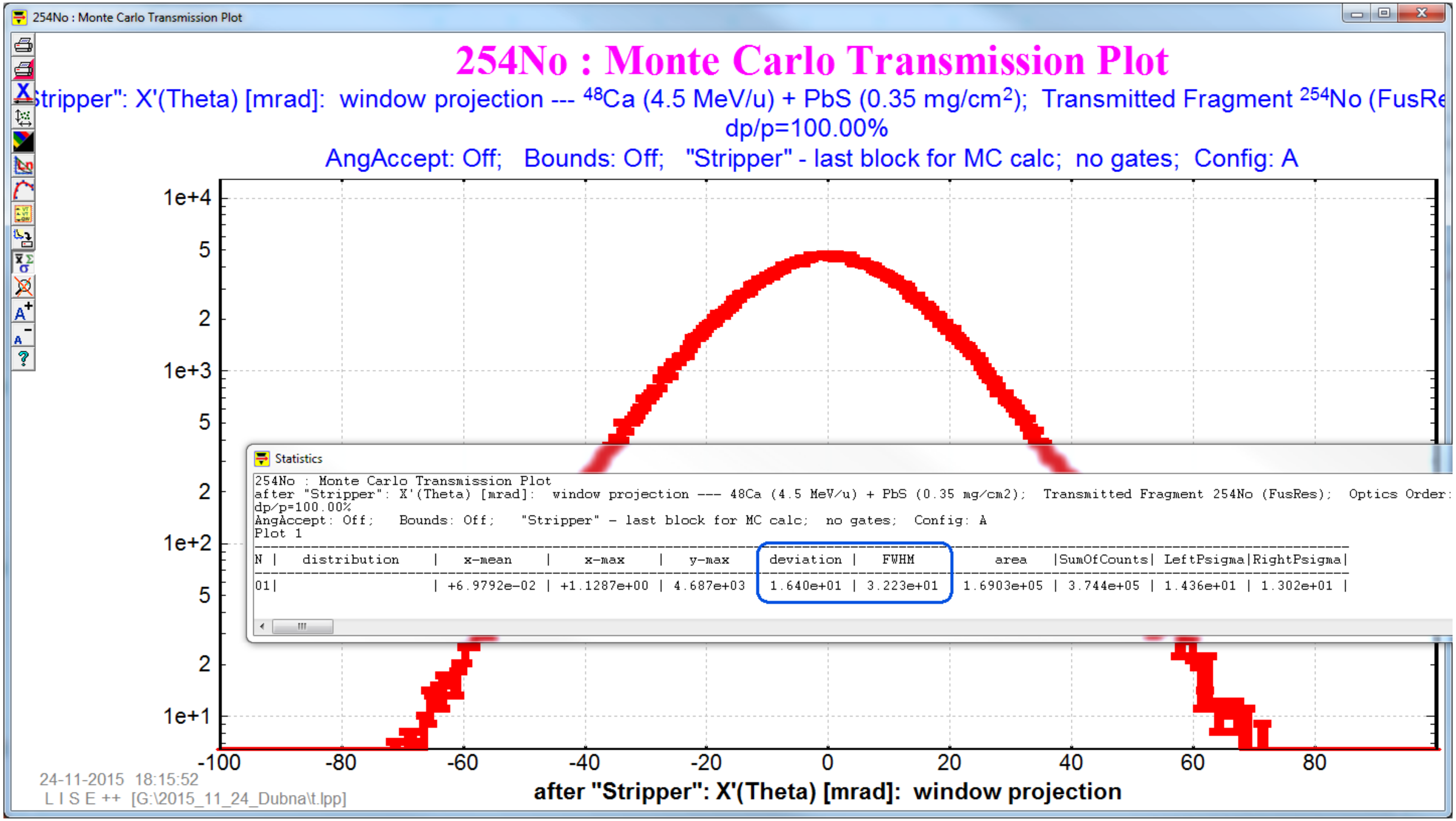
Without angular emittance



Energy distribution

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

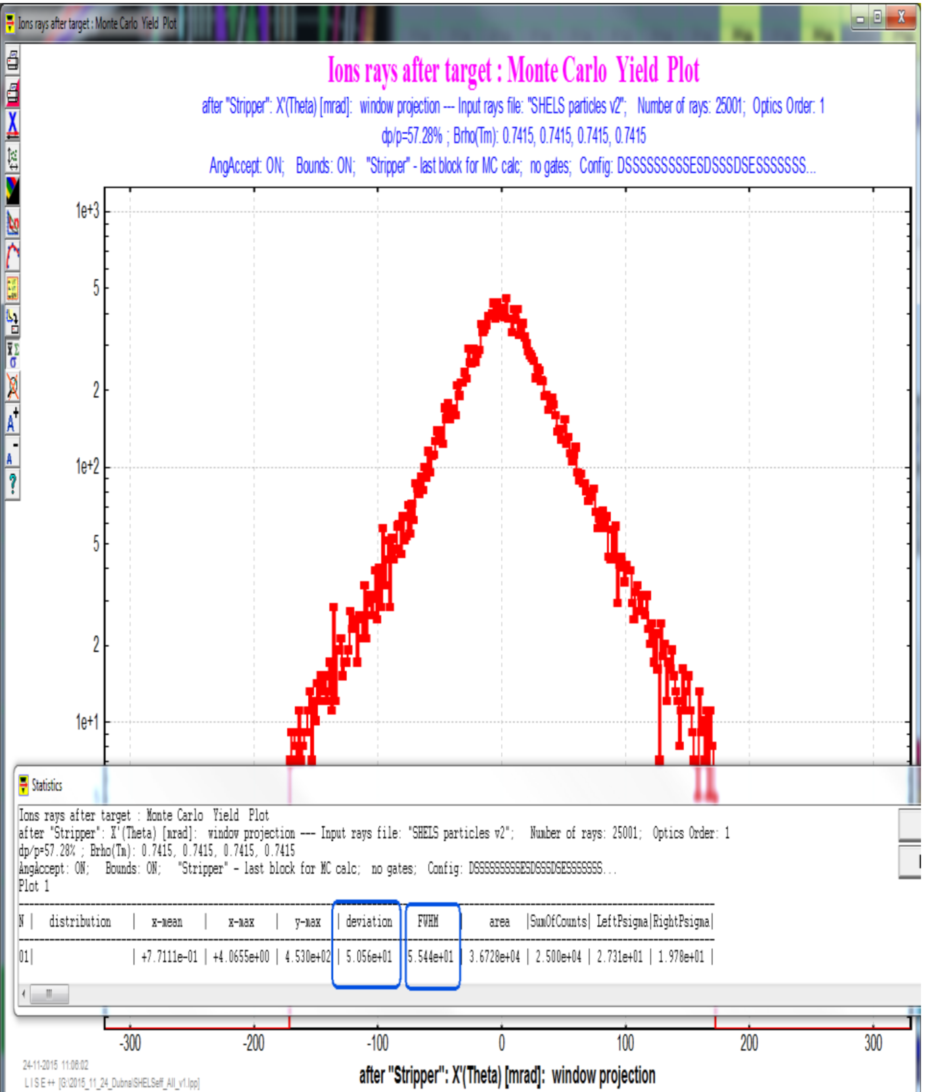
LISE^{++} Monte Carlo

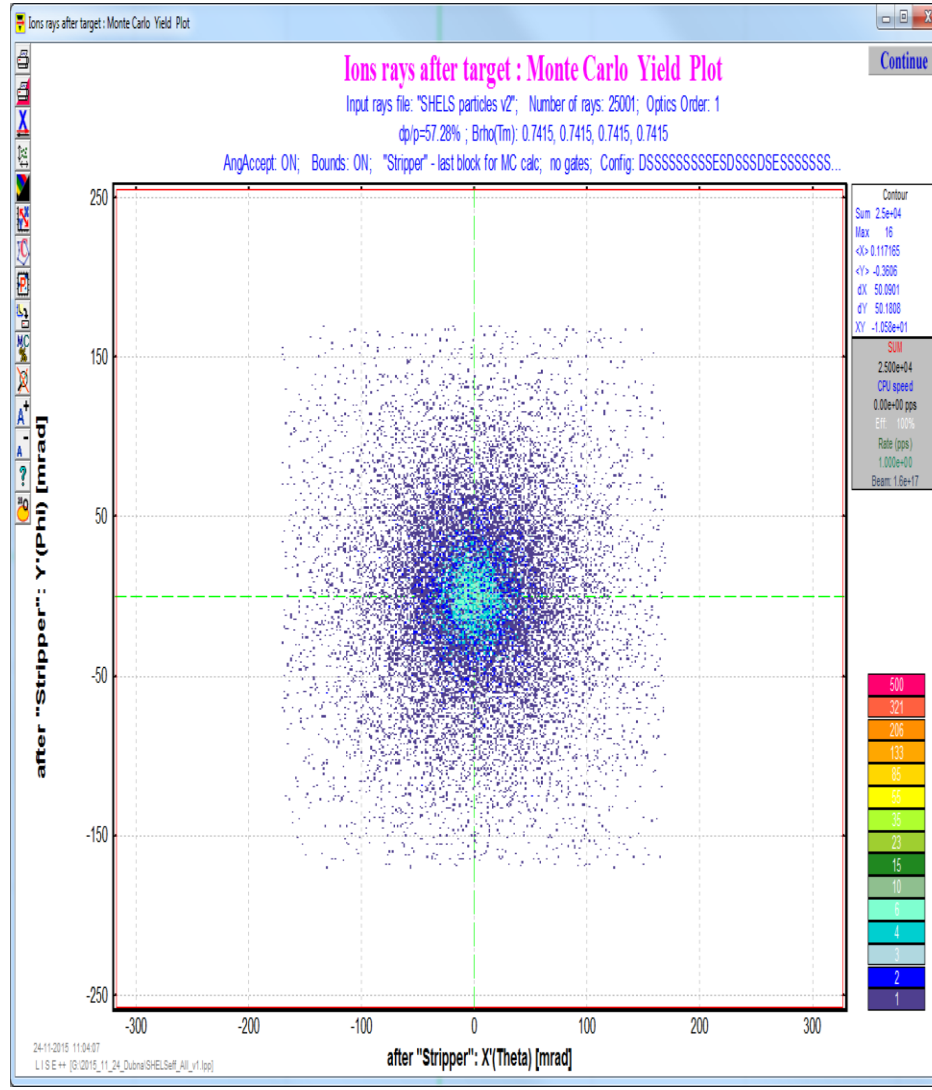


Energy distribution

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

Dubna





Angular distribution : comparison

^{48}Ca(216Mev) + PbS(0.35mg/cm^2)

	in mrad		
		sig.Ax	FWHM Ax
Dubna		**5.06E+01**	5.55E+01
LISE MC *		1.64E+01	3.22E+01
LISE analytical *		1.66E+01	3.94E+01
"today simple"	gaussian	2.18E+01	5.14E+01
* without beam angualr emittance			