

Version 11.0.79

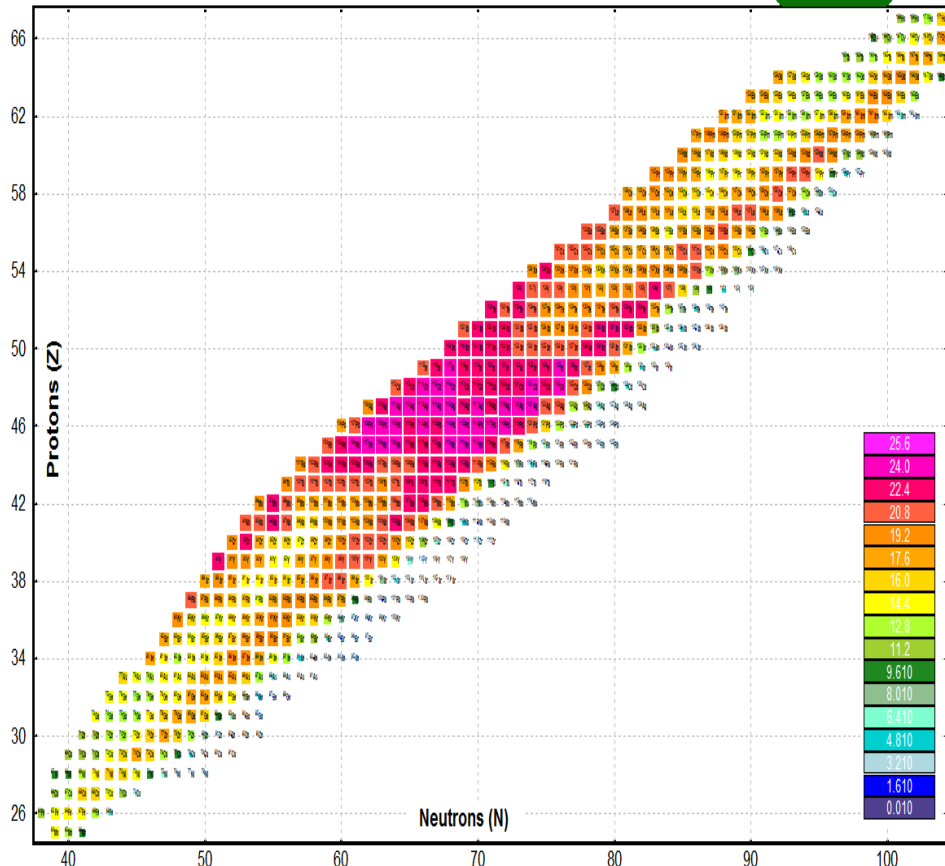
05/29/19

Fission fragment registration efficiency

Input ZN batch file: C:\user\lic\ise_pp_11\CrossSections\238U_Ex20.zn; Target: Be (300 mg/cm²)

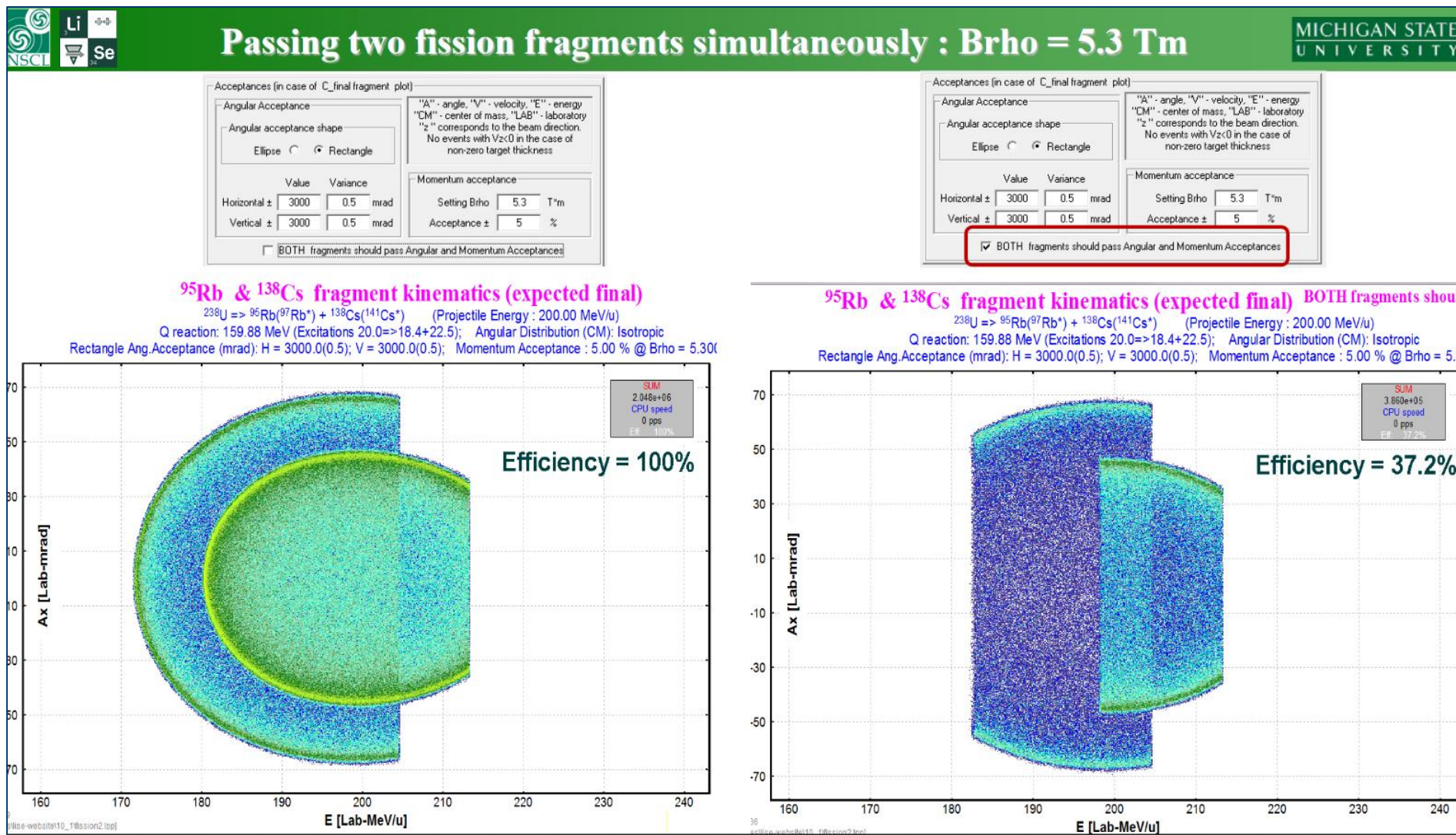
Projectile ²³⁸U (E=200.00 MeV/u; E^{*}=20.00); kinematics of two fragment(s)(final) BOTH fragments should pass

Rectangle Ang.Acc. (mrad): H = +60.0(0.5); V = +80.0(0.5); Momentum Acc.: +3.00 % @ Brho = 5.000 T*m



- Plotting and passing two fission fragments v.11.0.64
- Creation of input ZN-file for the FisFrag Batch Mode
- Initialization of the Kinematics Calculator before launch the FisFrag Batch Mode
- The Fission Fragment Batch Mode dialogue
- First element of the list: initialization of 2D Monte Carlo calculation settings
- Calculation settings discussion
- Results :
 - **no** energy loss in a target, **6%** momentum acceptance
 - **no** energy loss in a target, **100%** momentum acceptance
 - **with** energy loss in a target , **6%** momentum acceptance
- Final fragment iterations

http://lise.nsci.msu.edu/10_1/11_0_64_FissionKinematics.pdf



1st step : Creation of input ZN file (a)

1

Projectile 238U92+ AF 719
 200 MeV/u 1 pA
 LowEx: 20 MeV 238U^{*}
Fragment 120Sn50+
Target 9Be 300 mg/cm2
Stripper
MFP_PIN Si 504 mg/cm

2

Abrasion-Fission
 238U (200.0 MeV/u) + Be

Energy region definitions

Excitation energy region	LOW	MIDDLE	HIGH
Choose a primary reaction	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Perform transmission calculations for this energy region	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Choose FISSILE nucleus	238U	232Th	226Ra
Excitation energy (MeV)	20	100	250
Cross section (mb)	1000		

3

Calculate ALL
 Take primary beam yield from the list

4

1D-Plot 2D-Plot Databases Help

- Block selection distributions >
- Angular distributions >
- Horizontal (X) space distributions >
- Vertical (Y) space distributions >
- Momentum distributions >
- Energy distribution >
- Total Kinetic Energy distributions >
- Electrostatic rigidity distributions >
- Beam and Setting fragment charge state distributions >
- Debug distributions >
- Debug information
- Brho selection plot
- Wedge selection plot
- Isomeric Gamma spectrum >
- Transmission characteristics**
- Range distributions
- Charge distributions
- Average Ionic charge plot
- Cross Section distributions
- Systematic distributions (Q-g, Q-gg, dBE, dBEsn) >
- Fission TKE & Emitted nucleons

5

Choose a Plot Type

Dimension of the plot
 ONE-dimensional TWO-dimensional NZ chart

transmission characteristic to draw a plot
 03 Total: All reactions (pps)

Plot type

- Isotopes, Z=const
- Isobars, A=const
- Isotones, N=const
- Isospin, N-Z =const
- N-ZZ=const
- <N>/Z
- sum(value); Z=const
- sum(value); A=const
- sum(value); N=const

Zmin = 1
 Zmax = 90

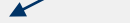
Vertical Axis

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

All
 Odd
 Even

OK Quit

Next page

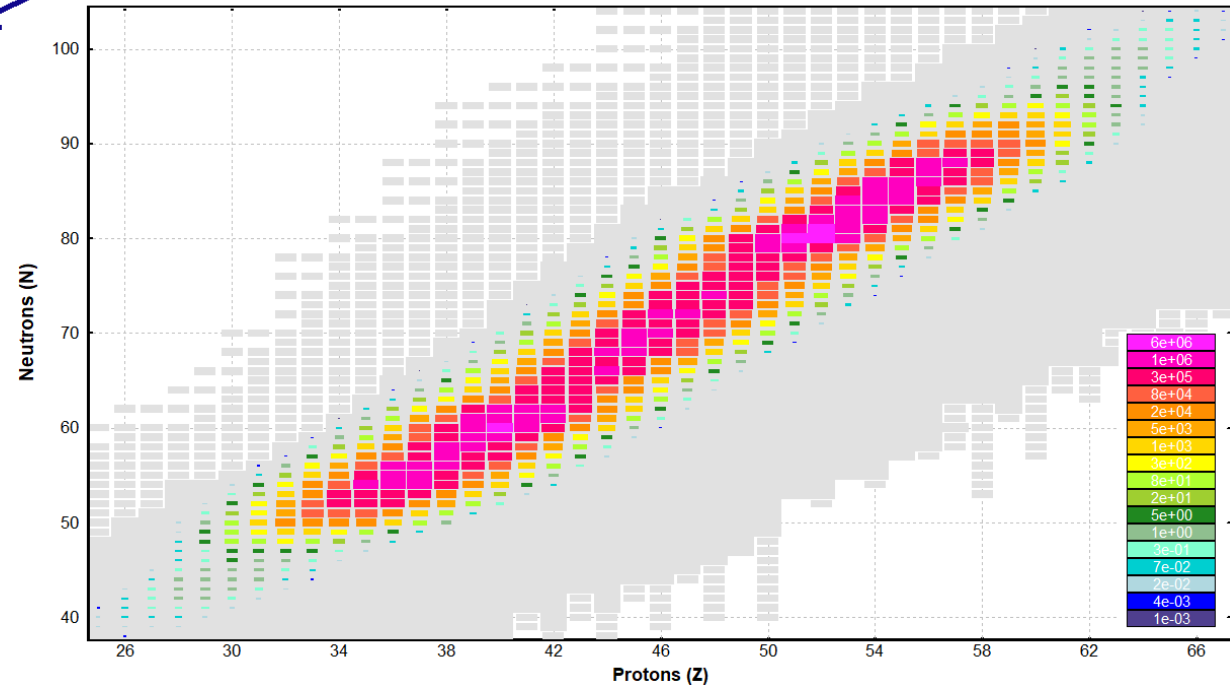


1st step : Creation of input ZN file (a)

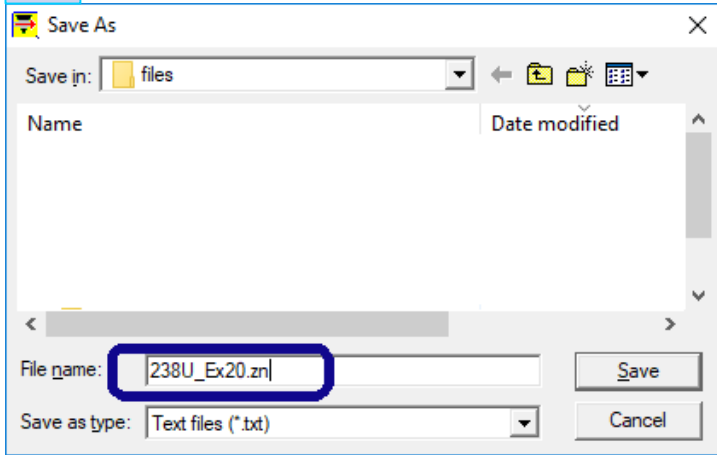
Previous page

6

[3] Total: All reactions (pps)
 ^{238}U (200 MeV/u) + Be (300 mg/cm²); Settings on ^{120}Sn ; Config: M
 dp/p=100.00%
 Z=1-90



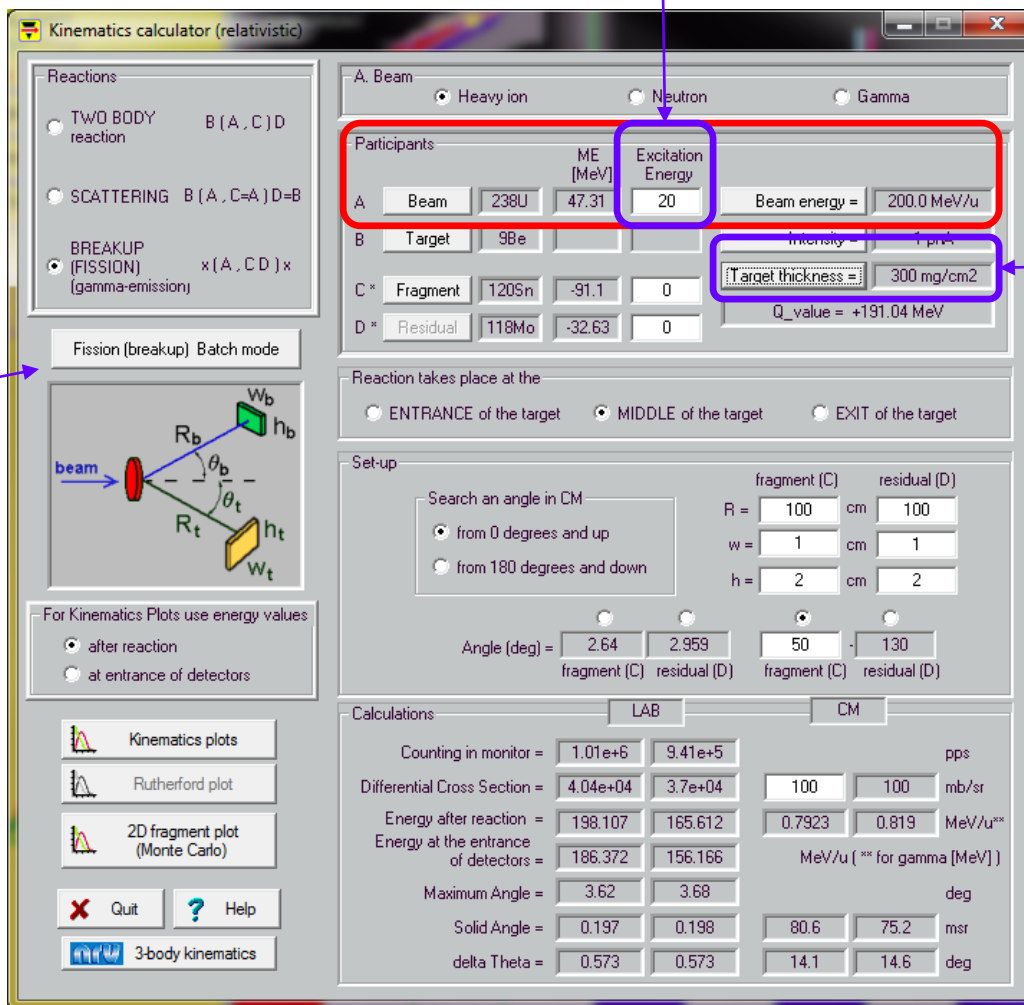
7



```

Enter - [c:/user/c/ise_pp_11/files/238U_Ex20.zn]
File Edit Options Help
| [3] Total: All reactions (pps)
| $238$U (200 Mev/u) + Be (300 mg/cm$25$); Settings on $120$Sn; Config: M
| dp/p=100.00%
| Z=1-200
|
| Protons (Z) Neutrons (N) Value [pps]
25 39 0.023754
25 40 0.037445
25 41 0.012915
26 38 0.016682
26 39 0.06087
26 40 0.21994
26 41 0.089836
26 42 0.14432
26 43 0.024054
    
```

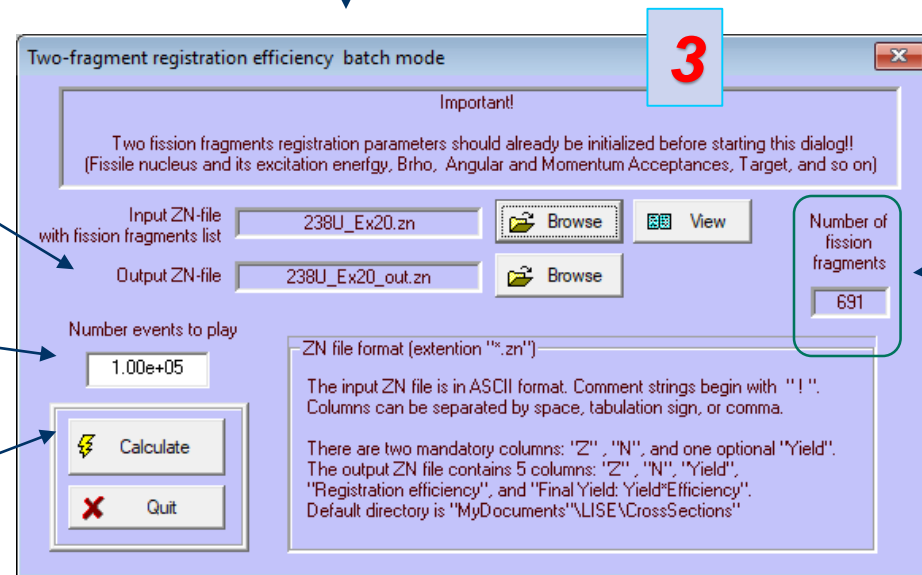
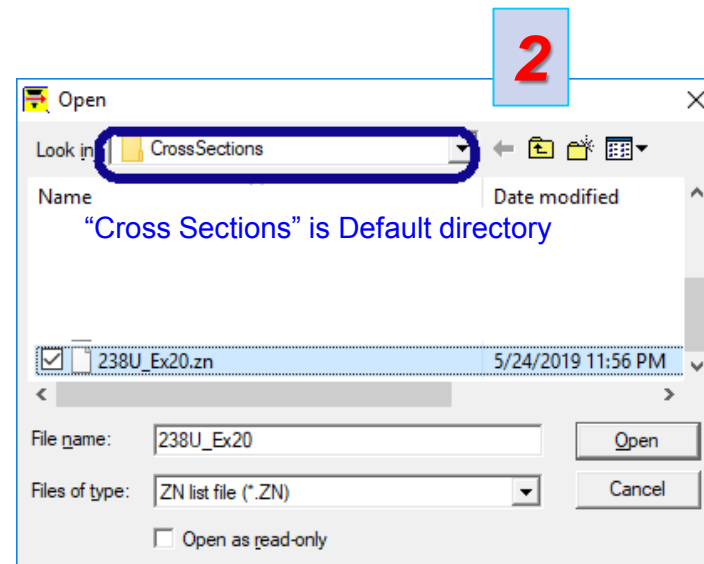
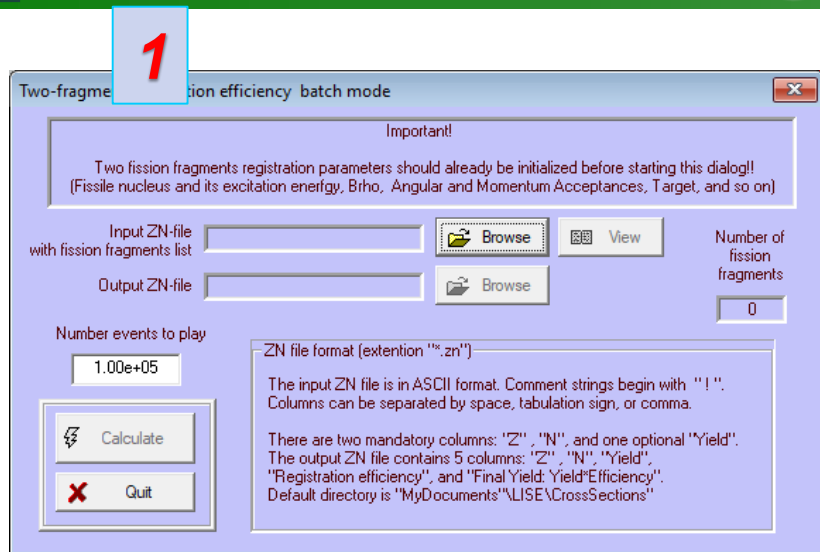
1. LISE++ fills out the Beam parameters (A,Z,energy), the user should provide manually an excitation value corresponding to an input ZN-file



2. Input target thickness, if you are interested to take energy loss into account

3. After Beam and Target initialization steps Press the “Fission batch mode” button to download the corresponding dialog.

This button is shown if the “Break-up (Fission)” radiobutton is selected in the Reactions group, and reaction Q-value is positive



LISE++ automatically proposes output file name. The user can rename it.

Calculations will be stop reaching this set number of events.
 Default value is equal to 1e5, that correspond of 1 event registration to 0.001% efficiency

Run Calculations

Pay attention for the number of lines corresponding to number of fission fragments (Z, N, Yield after target)

The user has an opportunity to modify 2D fission fragments Monte Carlo plot settings once at the beginning of batch calculations

2D fragment plot (Monte Carlo)

BREAKUP (FISSION)
 Projectile: 238U (200.0 MeV/u)
 Target: 9Be
 Ex. energy
 Fragment (C *): 65Mn 9.79
 Residual (D *): 173Ho 22.34
 Q-value (MeV): 125.87 MeV

Excitations
 take from systematics
 set manually in Kinematics calculator
 TKE plot

Expected final fragments
 C_final: 64Mn: 63.4% <dn> 1.13
 D_final: 170Ho: 49.6% <dn> 2.72
 TKE(CM) from systematics: 135.91
 TKE(CM) from calculations: 120.67

Fragment to plot
 Excited (C *)
 Expected final (C_final)
 add conjugated fragment (D) **5**

Plots
 Lab: Vz & Vx E & A E & Ax E & Ay Vz & phi Ax & Ay
7 - optional
 Brho (q=Z) & Ax
 Brho (q=Z) & Ay
 CM: Vz & Vx Vz & Vxy Ax & Ay A & phi

Acceptances (in case of C_final fragment plot)
 Angular Acceptance
 Angular acceptance shape: Ellipse Rectangle

	Value	Variance
Horizontal ±	60	0.5 mrad
Vertical ±	80	0.5 mrad

1-2
3,4
 Momentum acceptance: Setting Brho 5.5 T*m, Acceptance ± 3 %
 BOTH fragments should pass Angular and Momentum Acceptances **6**

Take into account a target thickness
 No (fast) Yes
8 - use a target
 Energy variation after the reaction due to straggling: 0.1 MeV/u
 *** Warning: it takes a lot of computing time if this value is more than 0

Initial emittance
 Horizontal Angular ± 0 mrad
 Vertical Angular ± 0 mrad
 Energy** ± 0 MeV/u

Broadening due to particle emission
 Angular ± 0.77 mrad
 Energy ± 0.01 MeV/u

Angular Distribution (CM)
ISOTROPIC

Ok Cancel

Continue calculations

Results : no energy loss in a target

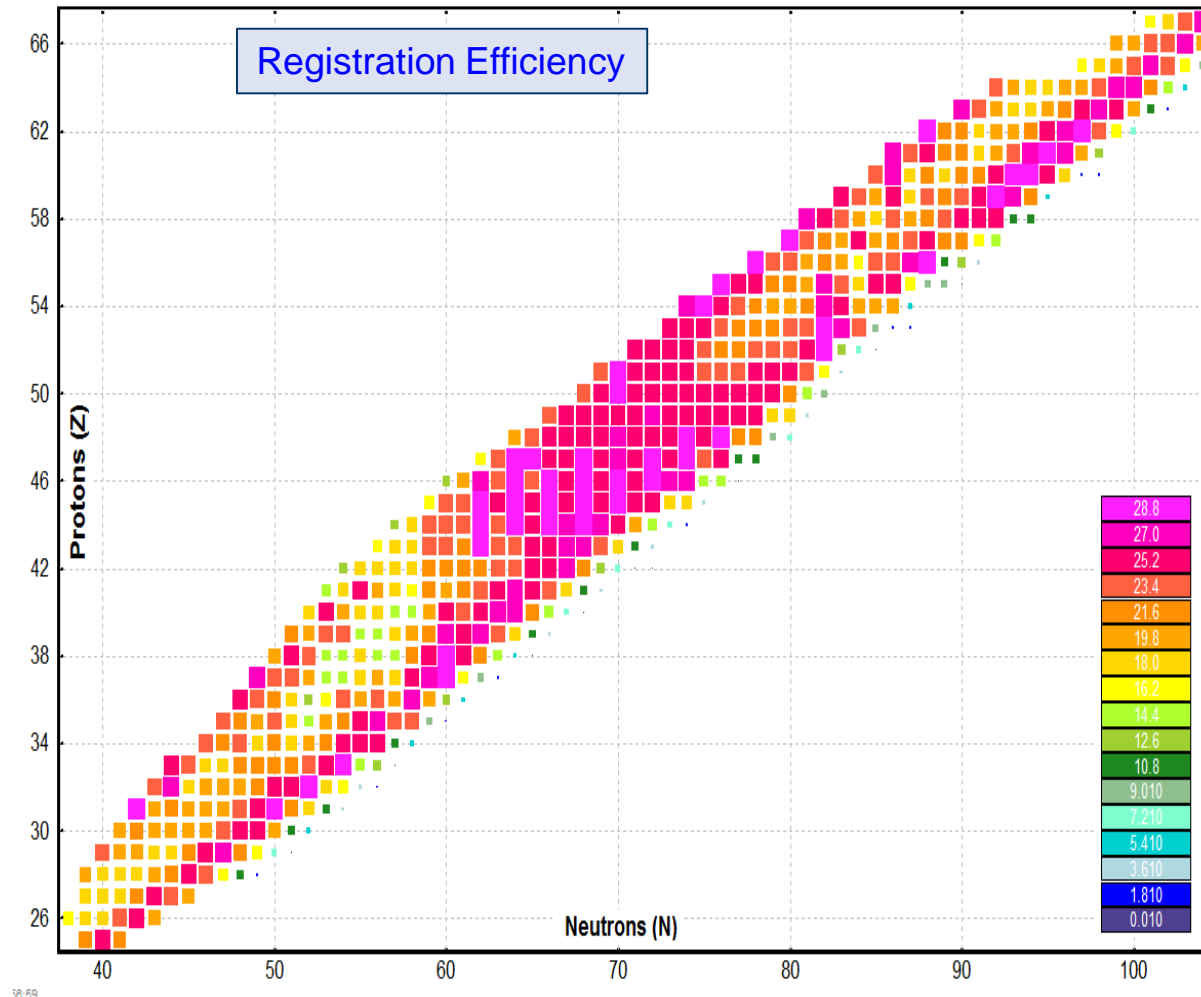
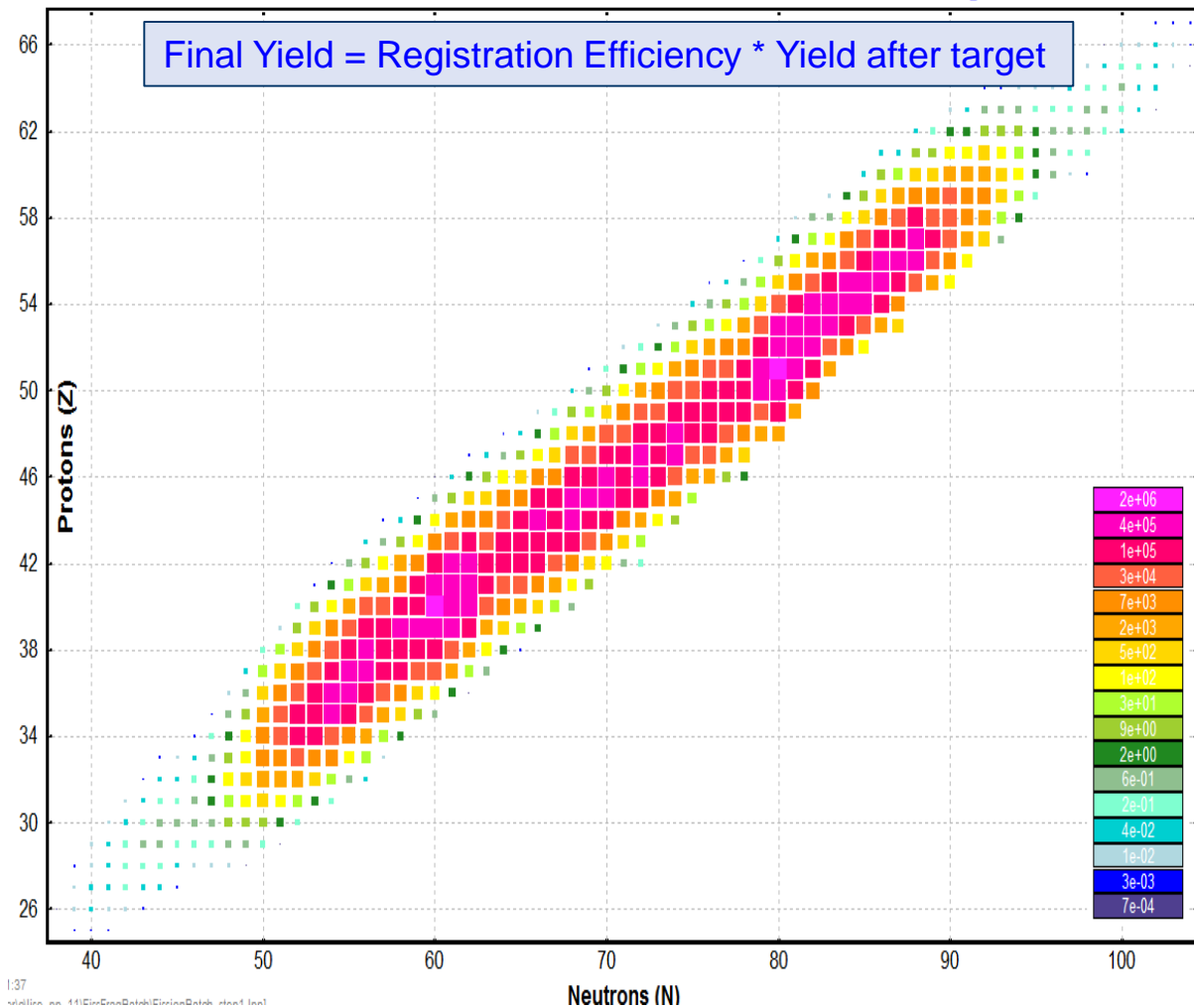
Two 2D (N vs Z) will appear immediately after the batch calculations end

Final Fission Fragment Yields

Input ZN batch file: C:\user\clise_pp_11\CrossSections\238U_Ex20.zn
 Projectile ^{238}U ($E=200.00$ MeV/u; $E^*=20.00$); kinematics of two fragment(s)(final) BOTH fragments should pass
 Rectangle Ang.Acc. (mrad): H = +60.0(0.5); V = +80.0(0.5); Momentum Acc.: +3.00 % @ Brho = 5.500 T*m

Fission fragment registration efficiency

Input ZN batch file: C:\user\clise_pp_11\CrossSections\238U_Ex20.zn
 Projectile ^{238}U ($E=200.00$ MeV/u; $E^*=20.00$); kinematics of two fragment(s)(final) BOTH fragments should pass
 Rectangle Ang.Acc. (mrad): H = +60.0(0.5); V = +80.0(0.5); Momentum Acc.: +3.00 % @ Brho = 5.500 T*m



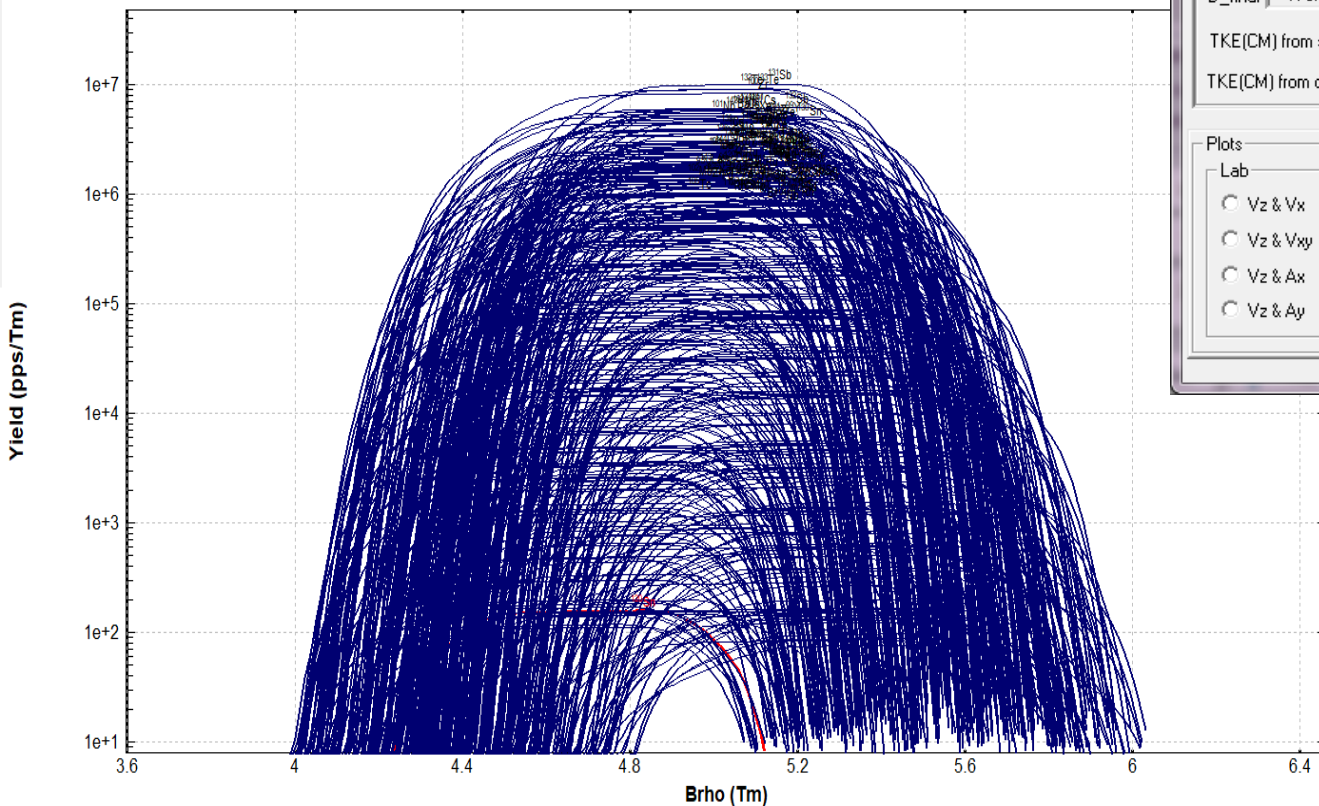
ZN Output File

Lister - [C:\user\c\lise_pp_11\CrossSections\238U_Ex20_out.zn]

Input ZN batch file: C:\user\c\lise_pp_11\CrossSections\238U_Ex20.zn
 Projectile \$238\$U (E=200.00 MeV/u; E*=20.00); kinematics of two fragment(s)(final) \$BOTH fragments should pass\$
 Rectangle Ang.Acc.(mrad): H = +-60.0(0.5); V = +-80.0(0.5); Momentum Acc.: +-3.00 % @ Brho = 5.500 T*m
 ?-----

#Z	N	YieldAfterTarget	Eff,%	FinalYield
25	39	2.38e-02	2.20e+01	5.24e-03
25	40	3.74e-02	2.58e+01	9.65e-03
25	41	1.29e-02	2.28e+01	2.95e-03
26	38	1.67e-02	1.63e+01	2.72e-03
26	39	6.09e-02	1.88e+01	1.14e-02
26	40	2.20e-01	1.95e+01	4.29e-02
26	41	8.98e-02	2.42e+01	2.17e-02
26	42	1.44e-01	2.65e+01	3.83e-02
26	43	2.41e-02	2.15e+01	5.17e-03
27	39	6.28e-02	1.84e+01	1.16e-02
27	40	2.45e-01	1.84e+01	4.52e-02
27	41	5.61e-01	1.90e+01	1.07e-01
27	42	7.38e-01	2.19e+01	1.62e-01
27	43	4.97e-01	2.53e+01	1.26e-01
27	44	2.06e-01	2.45e+01	5.04e-02
27	45	2.38e-02	2.05e+01	4.88e-03
28	39	2.49e-02	2.07e+01	5.15e-03
28	40	1.73e-01	1.86e+01	3.22e-02
28	41	7.04e-01	1.94e+01	1.36e-01
28	42	1.64e+00	1.91e+01	3.14e-01
28	43	1.87e+00	2.04e+01	3.82e-01
28	44	1.50e+00	2.33e+01	3.48e-01
28	45	2.91e-01	2.66e+01	7.73e-02
28	46	1.30e-01	2.37e+01	3.09e-02
28	47	8.62e-02	1.72e+01	1.48e-02
28	48	1.82e-01	1.18e+01	2.16e-02
28	49	6.45e-02	2.86e+00	1.85e-03
28	50	2.47e-02	0.00e+00	0.00e+00

Stripper: Momentum OC
 ^{238}U (200 MeV/u) + Be (300 mg/cm²); Settings on ^{120}Sn ; Config: M
 dp/p=100.00%



2D fragment plot (Monte Carlo)

BREAKUP (FISSION)

Projectile: ^{238}U (200.0 MeV/u)

Target: ^{9}Be (300 mg/cm²)

Ex. energy

Fragment (C *)	^{65}Mn	9.79
Residual (D *)	^{173}Ho	22.34
Q-value (MeV)	125.87 MeV	

Excitations

take from systematics

set manually in Kinematics calculator

Acceptances (in case of C_final fragment plot)

Angular Acceptance

Angular acceptance shape

Ellipse Rectangle

	Value	Variance	Unit
Horizontal ±	60	0.5	mrاد
Vertical ±	80	0.5	mrاد

BOTH fragments should pass Angular and Momentum Acceptances

Momentum acceptance

Setting Brho: 5.1 Tm

Acceptance ±: %

Initial emittance

Horizontal Angular ±	0	mrاد
Vertical Angular ±	0	mrاد
Energy** ±	0	MeV/u

Broadening due to particle emission

Angular ±	0.8	mrاد
Energy ±	0.01	MeV/u

Angular Distribution (CM)

ISOTROPIC

Energy loss and energy straggling inclusion

Ok Cancel

Fragment to plot

Excited (C *)

Expected final (C_final)

add conjugated fragment (D)

Take into account a target thickness

No (fast) Yes

Expected final fragments

C_final	^{64}Mn : 63.4%	<dn>	1.13
D_final	^{170}Ho : 49.6%	<dn>	2.72
TKE(CM) from systematics	135.91		
TKE(CM) from calculations	120.67		

Plots

Lab

Vz & Vx E & A Brho (q=Z) & A

Vz & Vxy E & Ax Brho (q=Z) & Ax

Vz & Ax E & Ay Brho (q=Z) & Ay

Vz & Ay Vz & phi Ax & Ay

CM

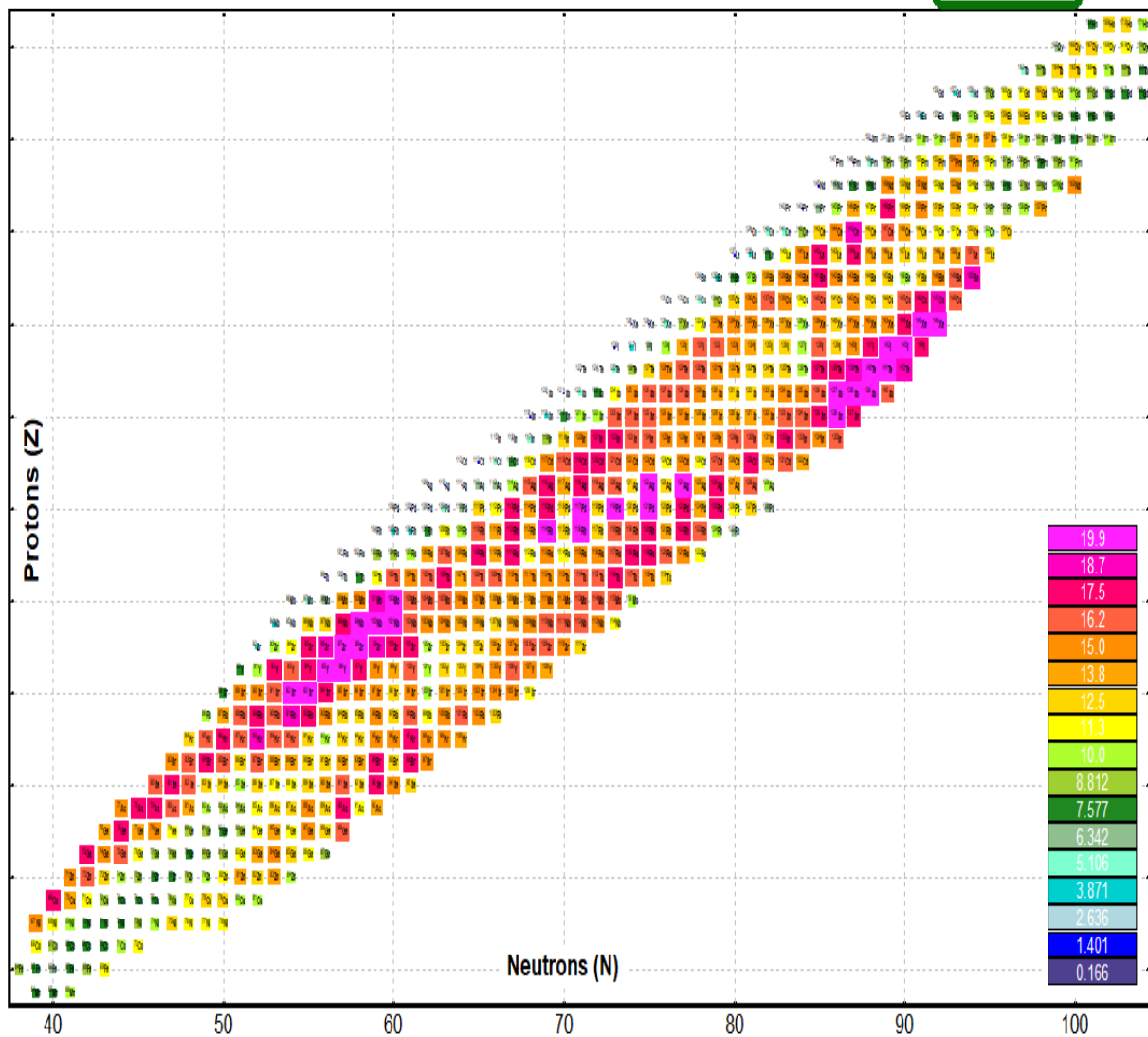
Vz & Vx Vz & Vxy Ax & Ay A & phi

Fission fragment registration efficiency

Input ZN batch file: C:\user\c\lise_pp_11\CrossSections\238U_Ex20.zn

Projectile ^{238}U (E=200.00 MeV/u; E*=20.00); kinematics of two fragment(s)(expected final) BOTH fragments should pass

Rectangle Ang.Acc. (mrad): H = +60.0(0.5); V = +80.0(0.5); Momentum Acc.: +3.00 % @ Brho = 4.900 Tm

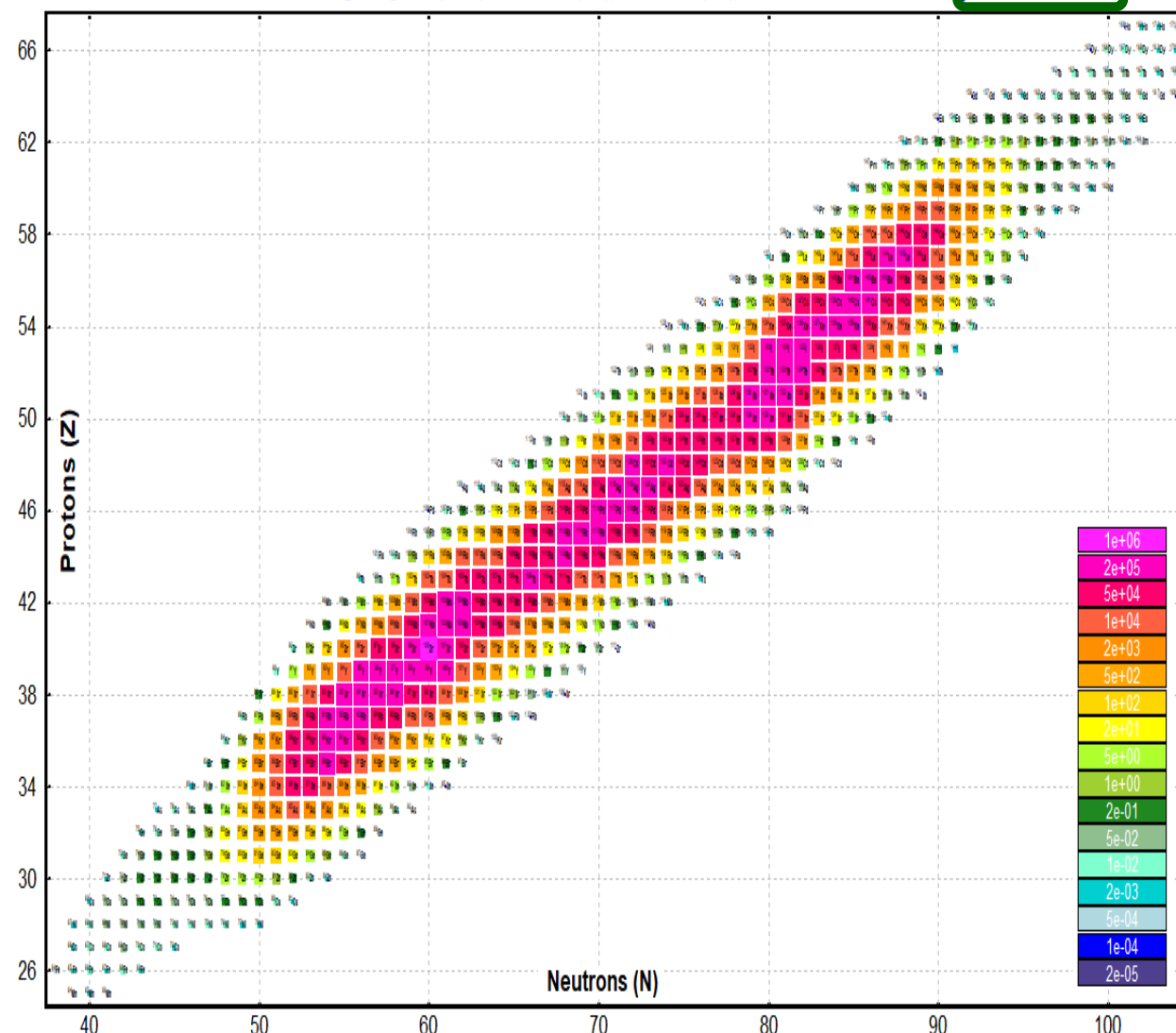


Final Fission Fragment Yields

Input ZN batch file: C:\user\c\lise_pp_11\CrossSections\238U_Ex20.zn; Target: Be (300 mg/cm²)

Projectile ^{238}U (E=200.00 MeV/u; E*=20.00); kinematics of two fragment(s)(final) BOTH fragments should pass

Rectangle Ang.Acc. (mrad): H = +60.0(0.5); V = +80.0(0.5); Momentum Acc.: +3.00 % @ Brho = 4.900 Tm

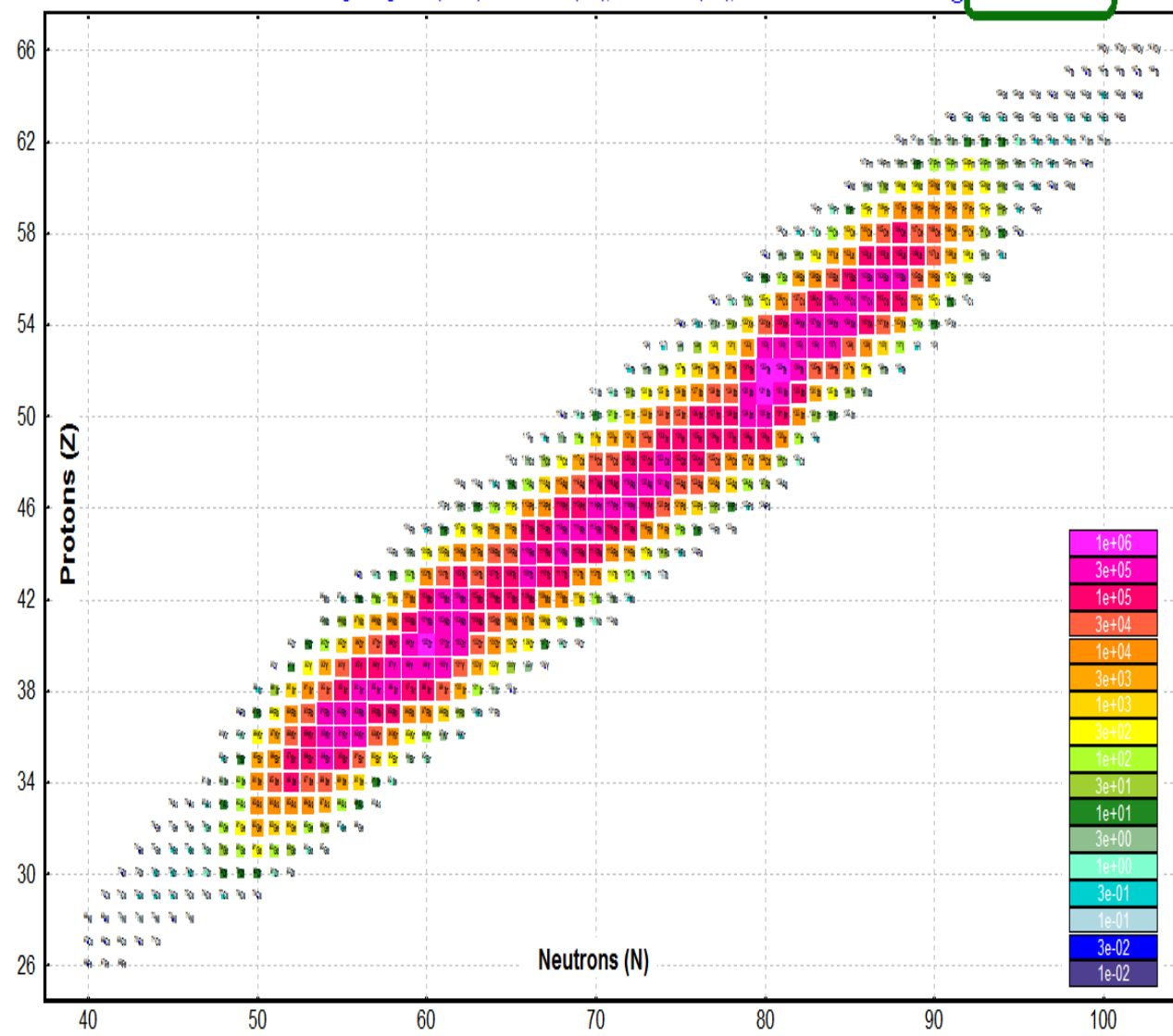
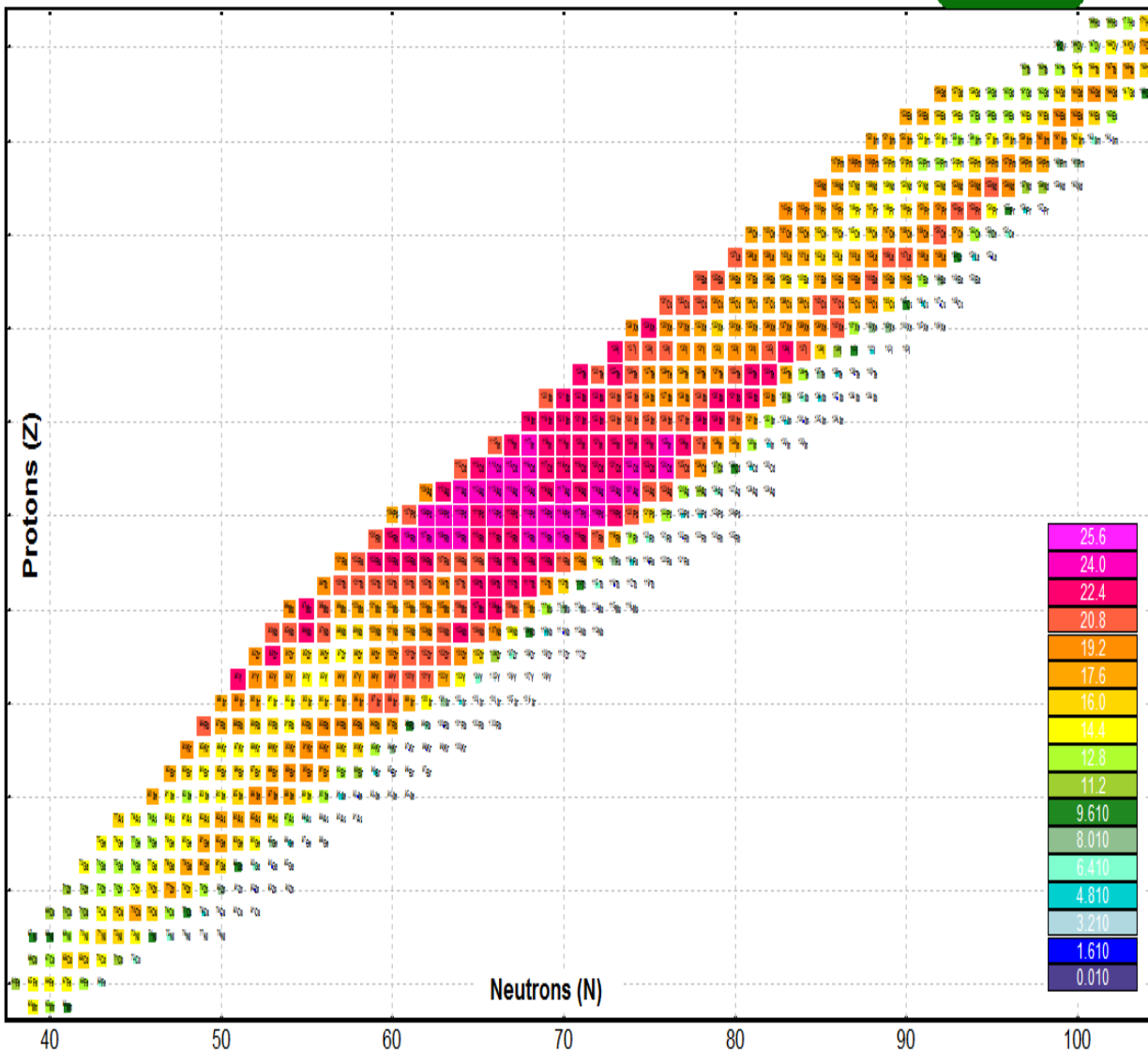


Fission fragment registration efficiency

Input ZN batch file: C:\user\c\lise_pp_11\CrossSections\238U_Ex20.zn; Target: Be (300 mg/cm²)
 Projectile ²³⁸U (E=200.00 MeV/u; E*=-20.00); kinematics of two fragment(s)(final) BOTH fragments should pass
 Rectangle Ang.Acc.(mrad): H = +60.0(0.5); V = +80.0(0.5); Momentum Acc.: +3.00 % @ Brho = 5.000 Tm

Final Fission Fragment Yields

Input ZN batch file: C:\user\c\lise_pp_11\CrossSections\238U_Ex20.zn; Target: Be (300 mg/cm²)
 Projectile ²³⁸U (E=200.00 MeV/u; E*=-20.00); kinematics of two fragment(s)(final) BOTH fragments should pass
 Rectangle Ang.Acc.(mrad): H = +60.0(0.5); V = +80.0(0.5); Momentum Acc.: +3.00 % @ Brho = 5.000 Tm

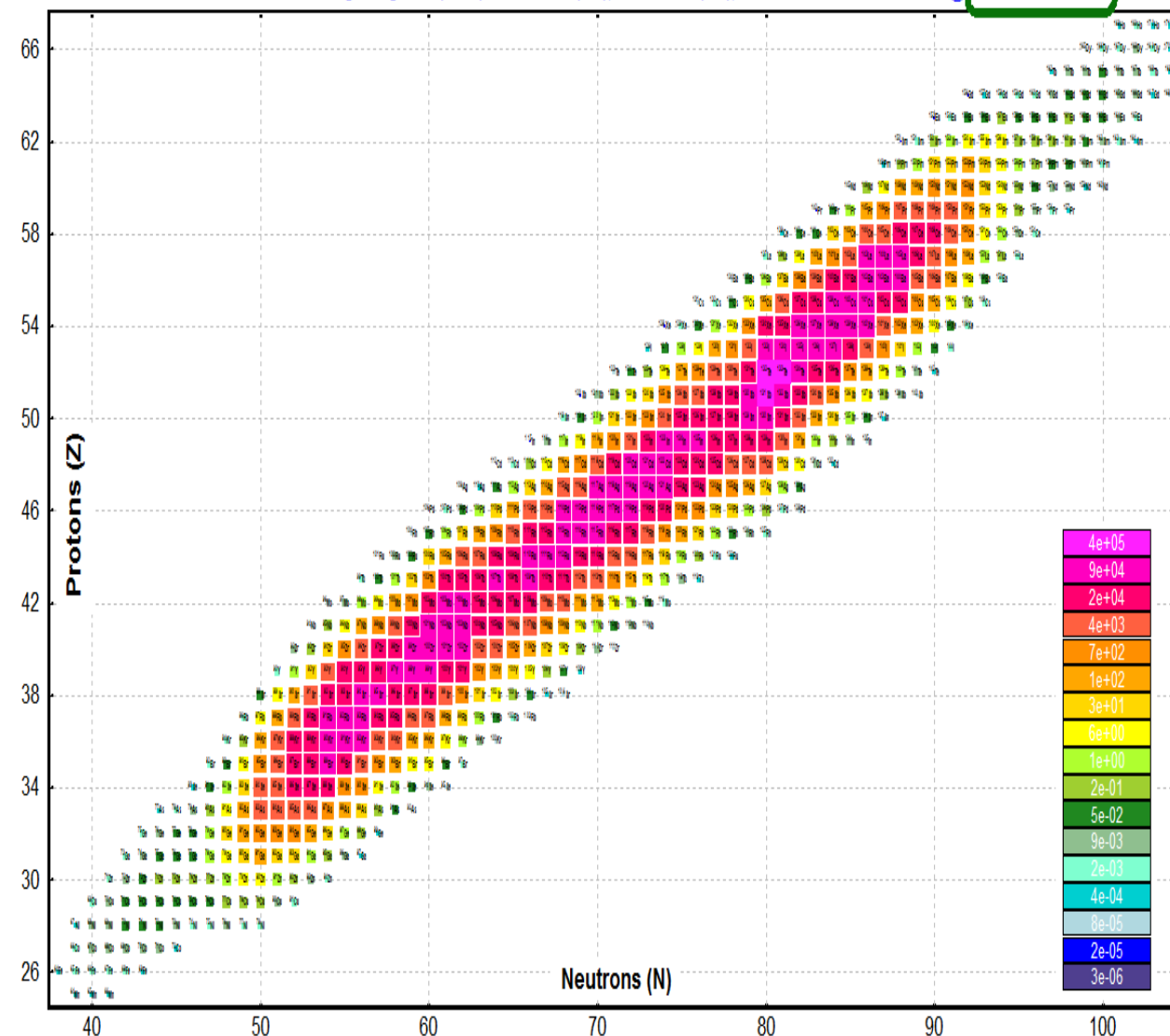
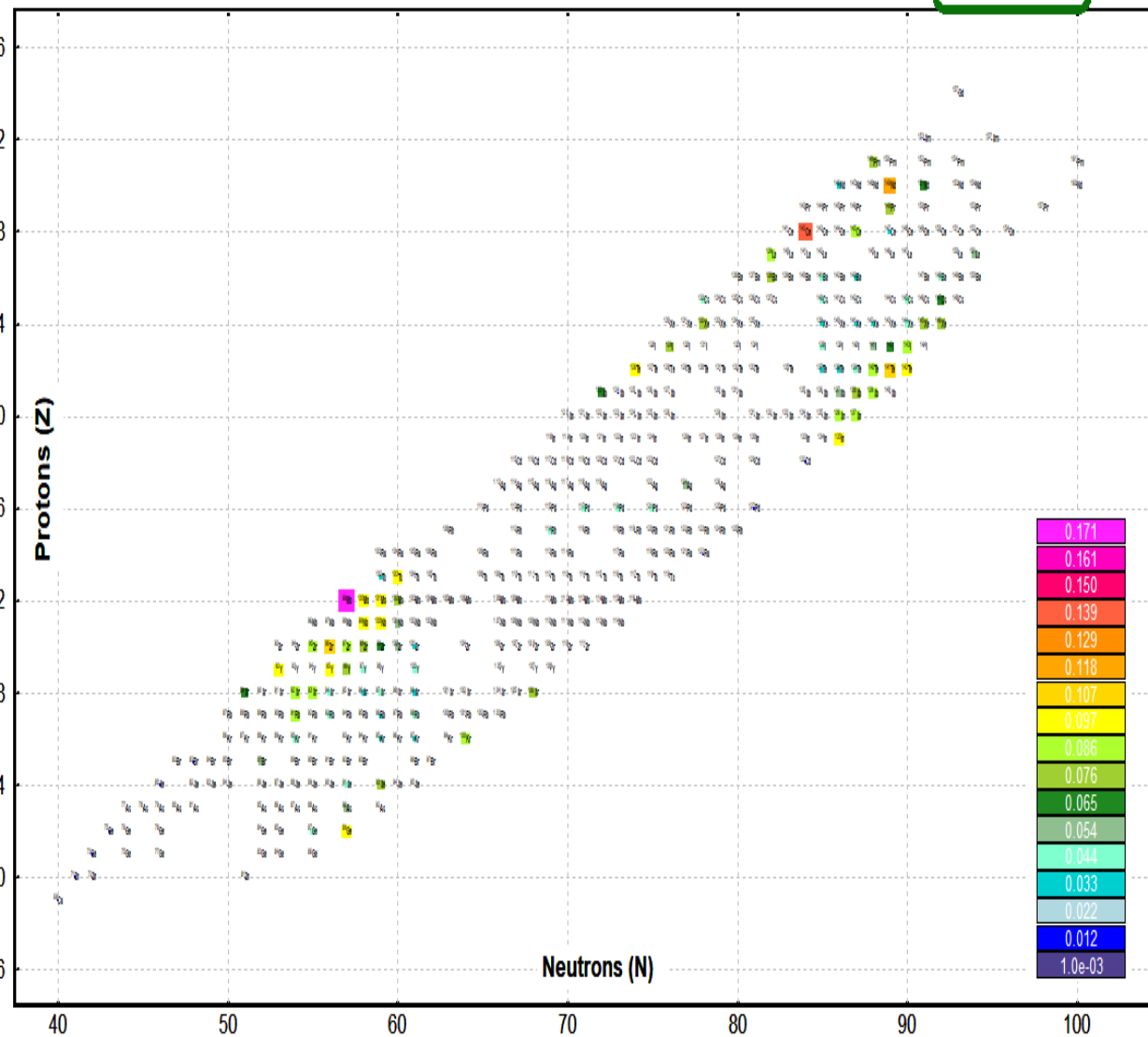


Fission fragment registration efficiency

Input ZN batch file: C:\user\c\lise_pp_11\CrossSections\238U_Ex20.zn; Target: Be (300 mg/cm²)
 Projectile ²³⁸U (E=200.00 MeV/u; E*=20.00); kinematics of two fragment(s)(final) ^{BOTH}fragments should pass
 Rectangle Ang.Acc.(mrad): H = +60.0(0.5); V = +80.0(0.5); Momentum Acc.: +3.00 % @ Brho = 4.700 T*m

Final Fission Fragment Yields

Input ZN batch file: C:\user\c\lise_pp_11\CrossSections\238U_Ex20.zn; Target: Be (300 mg/cm²)
 Projectile ²³⁸U (E=200.00 MeV/u; E*=20.00); kinematics of two fragment(s)(final) ^{BOTH}fragments should pass
 Rectangle Ang.Acc.(mrad): H = +60.0(0.5); V = +80.0(0.5); Momentum Acc.: +3.00 % @ Brho = 5.100 T*m

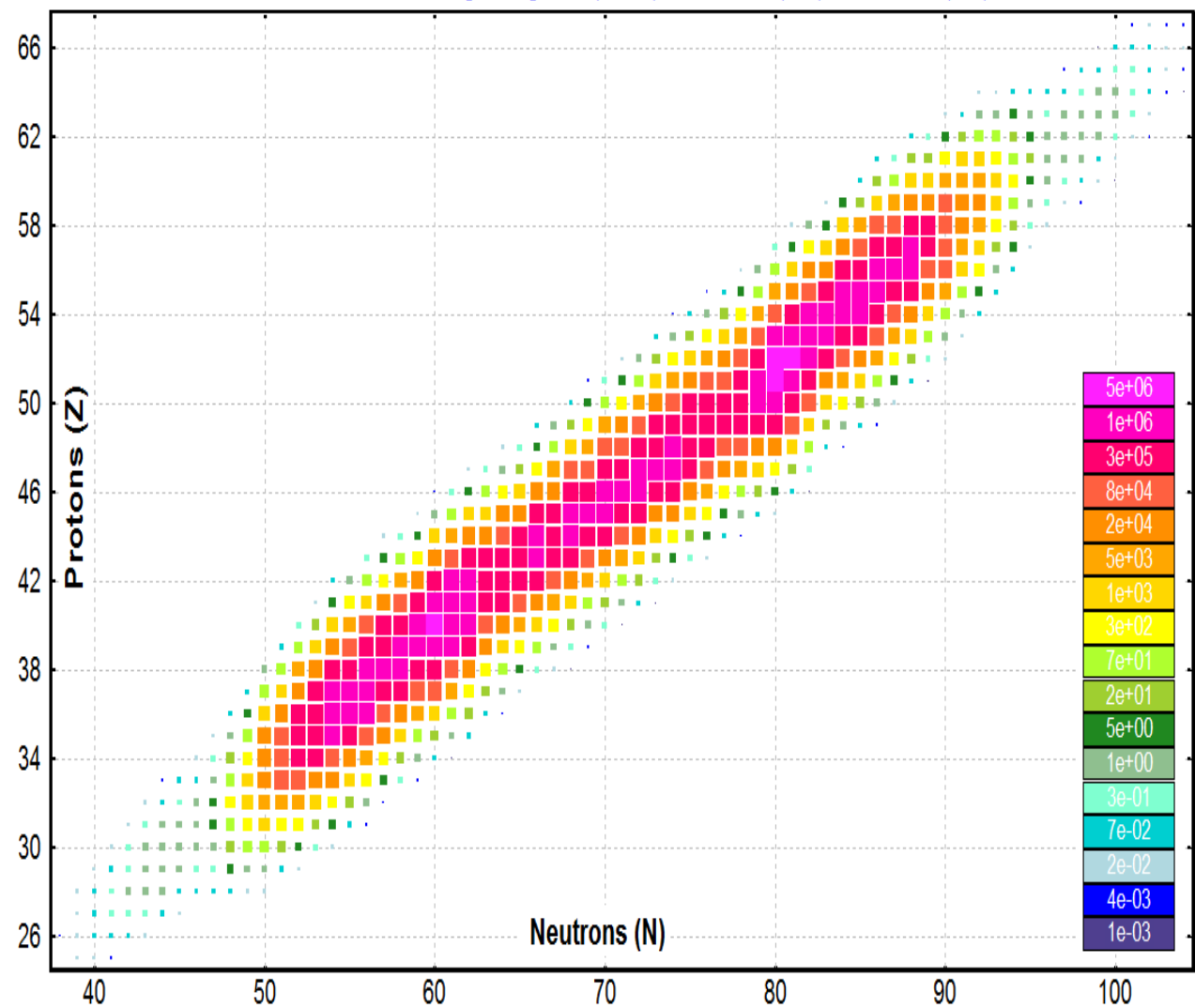
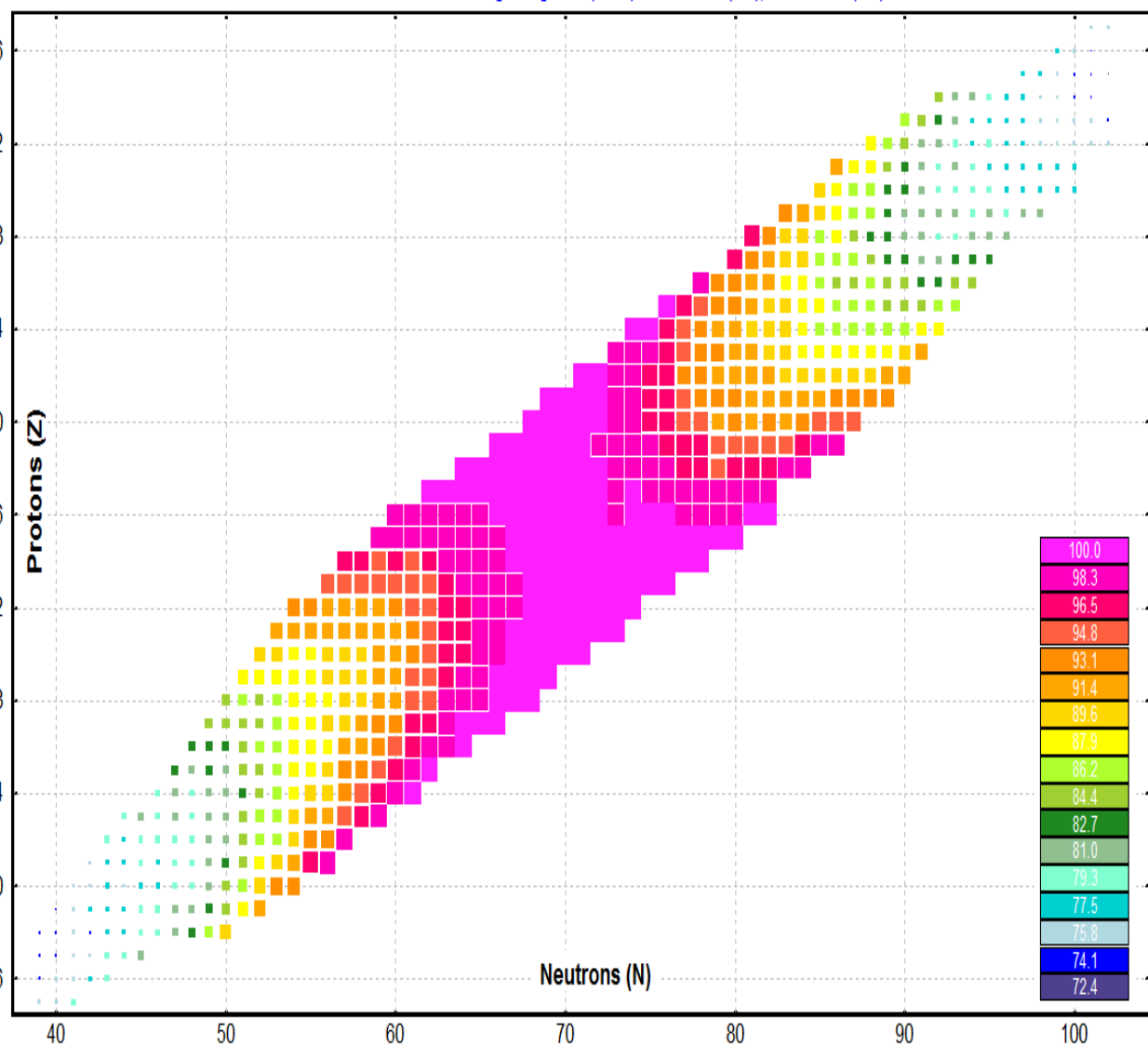


Fission fragment registration efficiency

Input ZN batch file: C:\user\c\lise_pp_11\CrossSections\238U_Ex20.zn
 Projectile ^{238}U ($E=200.00$ MeV/u; $E^*=20.00$); kinematics of two fragment(s)(final) BOTH fragments should pass
 Rectangle Ang.Acc.(mrad): H = +60.0(0.0); V = +-80.0(0.5)

Final Fission Fragment Yields

Input ZN batch file: C:\user\c\lise_pp_11\CrossSections\238U_Ex20.zn
 Projectile ^{238}U ($E=200.00$ MeV/u; $E^*=20.00$); kinematics of two fragment(s)(final) BOTH fragments should pass
 Rectangle Ang.Acc.(mrad): H = +60.0(0.0); V = +-80.0(0.5)



Final fission fragments are used in an input ZN-file.
 But initially in the Kinematics Calculator excited C* and D* fragments are used.
 For example we need to calculate a ^{115}Pd fragment transmission:

Regular mode

Participants			ME [MeV]
A	Beam	238U	47.31
B	Target	9Be	
C *	Fragment	115Pd	-80.43
D *	Residual	123Pd	-60.43

2D fragment plot (Monte Carlo)			
BREAKUP (FISSION)			
Projectile	238U (200.0 MeV/u)		
Target	9Be		
		Ex.energy	
Fragment (C *)	115Pd	21.99	
Residual (D *)	123Pd	20.78	
Q-value (MeV)	165.88 MeV		
Expected final fragments			
C_final	113Pd: 48.1%	<dn>	2.36
D_final	120Pd: 59.7%	<dn>	2.68
TKE(CM) from systematics	167.75		
TKE(CM) from calculations	162.42		

Batch mode

^{115}Pd
 ↓
 LISE++ is looking for more probable excited fission fragment (here $^{118}\text{Pd}^*$ for ^{115}Pd) by iterations for the initial final fragment

BREAKUP (FISSION)			
Projectile	238U (200.0 MeV/u)		
Target	9Be		
		Ex.energy	
Fragment (C *)	118Pd	22.11	
Residual (D *)	120Pd	21.84	
Q-value (MeV)	169.52 MeV		
Expected final fragments			
C_final	115Pd: 19.9%	<dn>	3.36
D_final	118Pd: 54.5%	<dn>	2.46
TKE(CM) from systematics	167.75		
TKE(CM) from calculations	163.15		