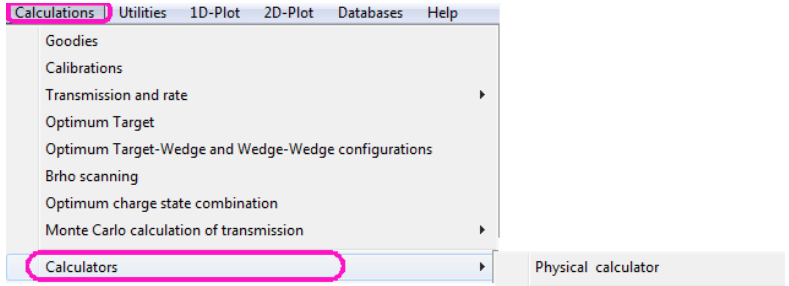
Plotting and passing two fission fragments in the Fission Kinematic Calculator

v.11.0.64 04/16/19

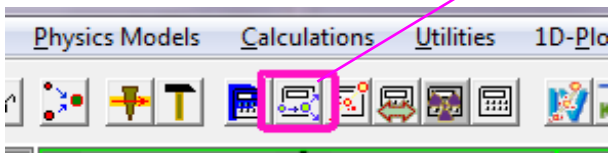
LISE++ example file:
fission2.lpp
http://lise.nscl.msu.edu/10_1/fission2.lpp

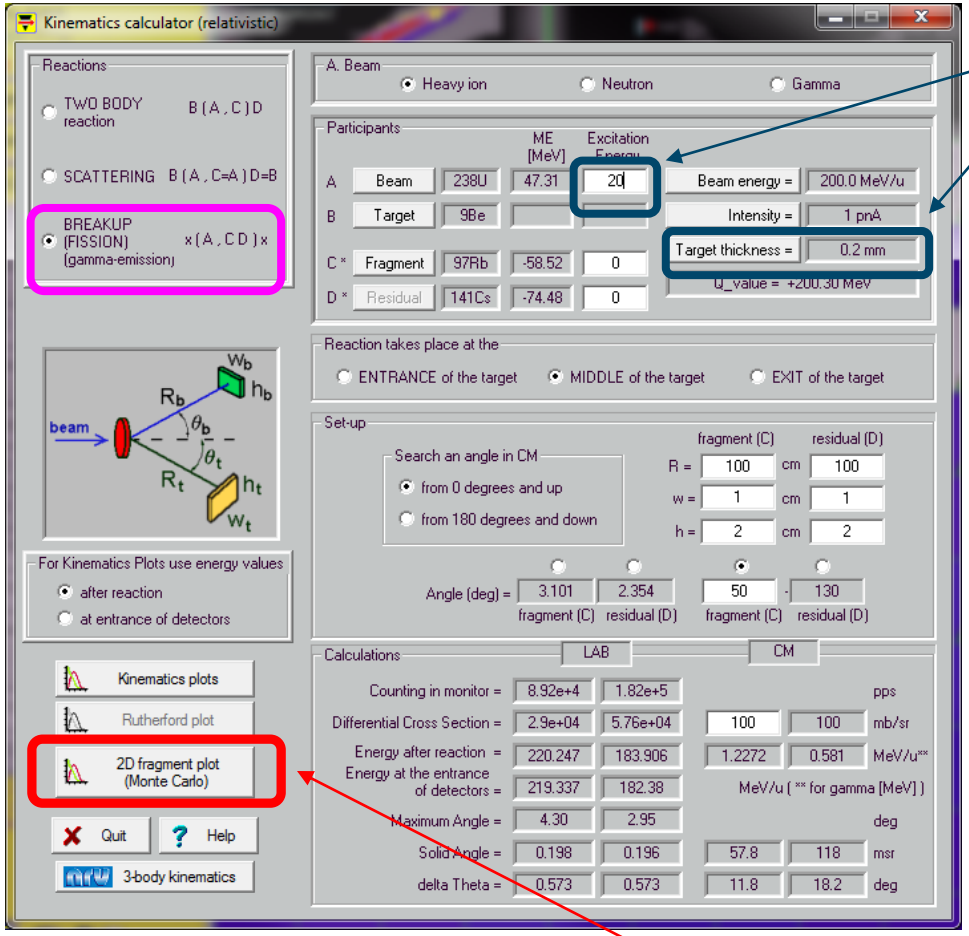
- Access to the Fission Kinematic MC Calculator
- New features of the Fission Kinematic MC Calculator
- Plotting two fission fragments simultaneously
- Passing two fission fragments simultaneously
    - Angular Acceptance
    - Momentum Acceptance
    - Angular Acceptance & Momentum Acceptance
- Using non-zero target thickness
- Acceptances and non-zero target thickness
- Some other plots…..

Access to the Fission Kinematic MC Calculator



OR

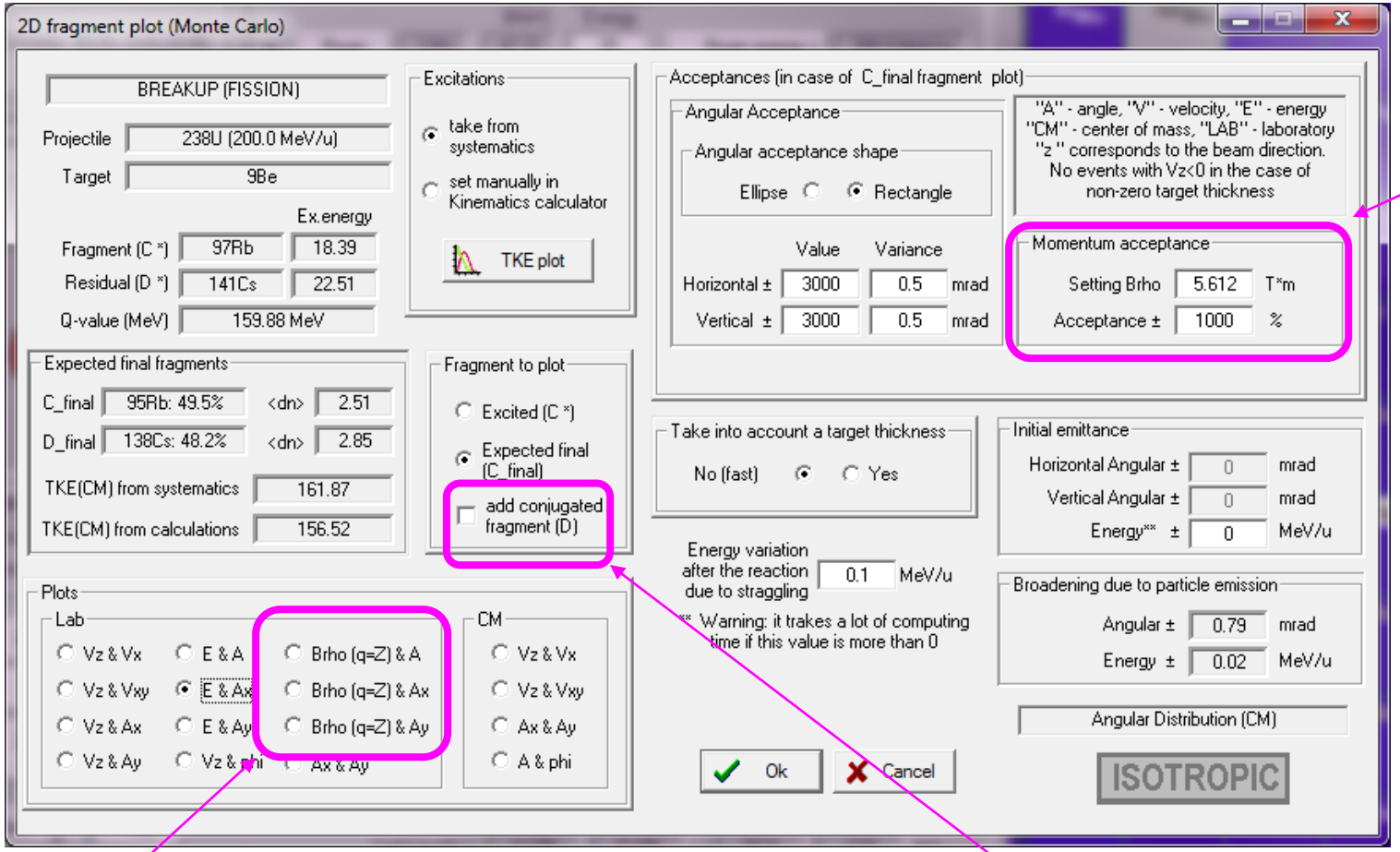




Set fissile nucleus excitation energy and target thickness in this dialog

Access to the Fission Kinematic MC Calculator

New features of the Fission Kinematic MC Calculator



Momentum acceptance instead the previous pseudo-energy acceptance

"Brho" plots

Main new feature to start plotting and passing two fission fragments simultaneously

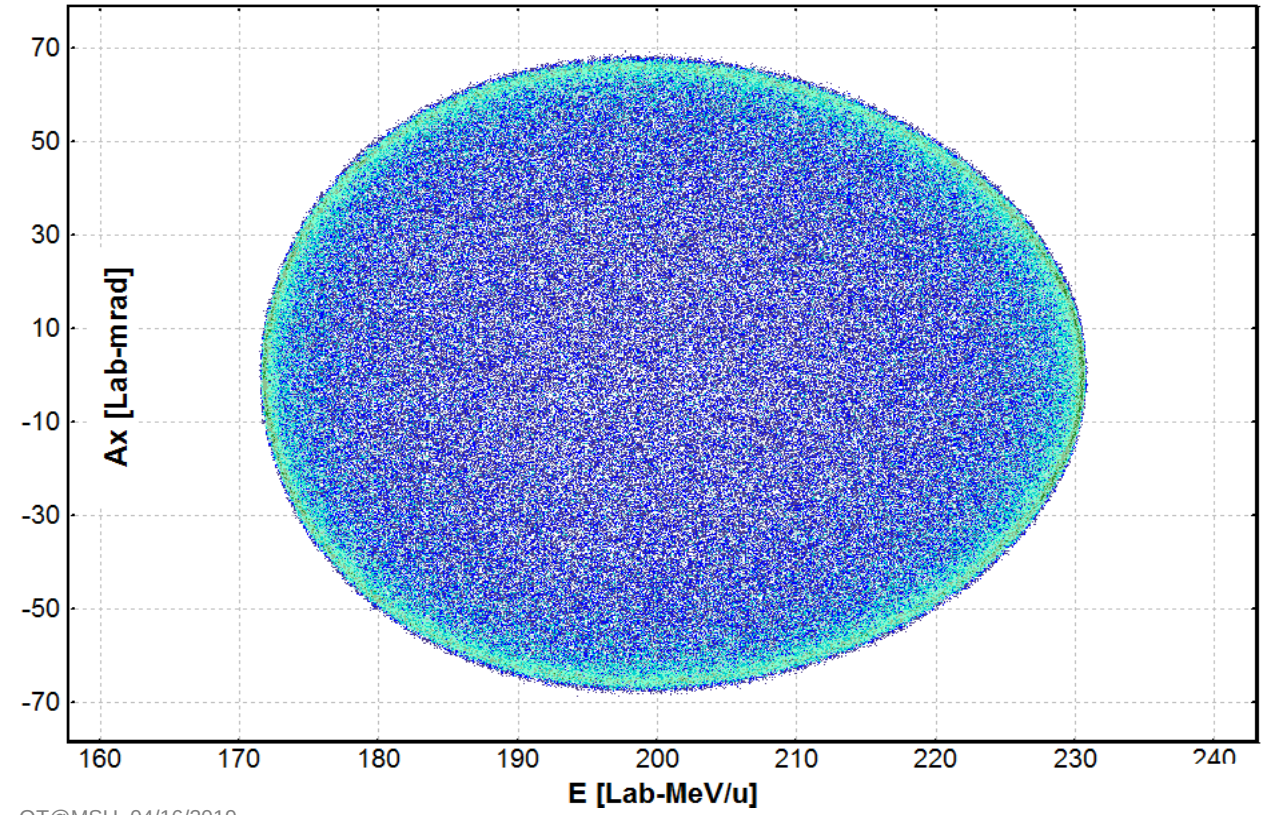
Plotting two fission fragments simultaneously (A_X vs. Energy)

☐ add conjugated fragment (D)

☑ add conjugated fragment (D)

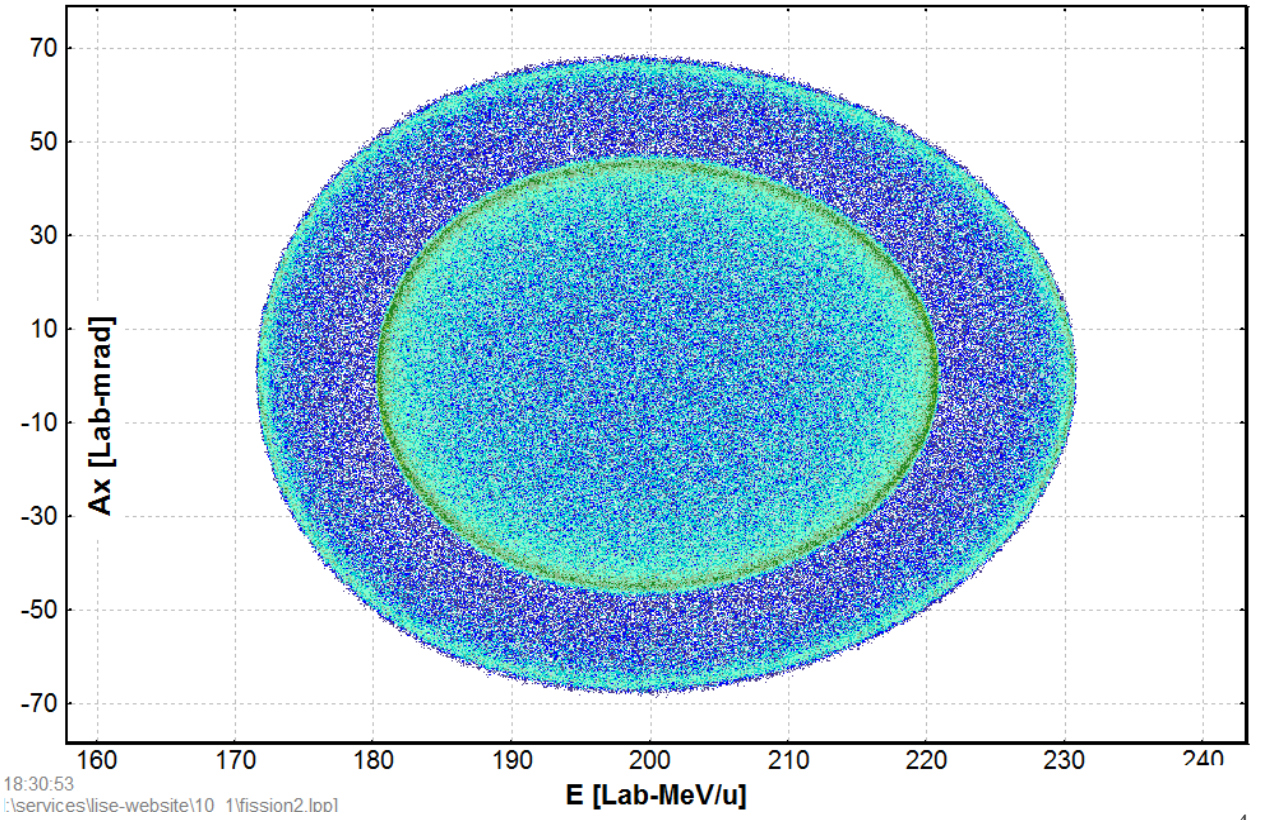
^{95}Rb fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Iso
Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5)



^{95}Rb & ^{138}Cs fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotrc
Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5)



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Plotting two fission fragments simultaneously (A_X & A vs. Brho)

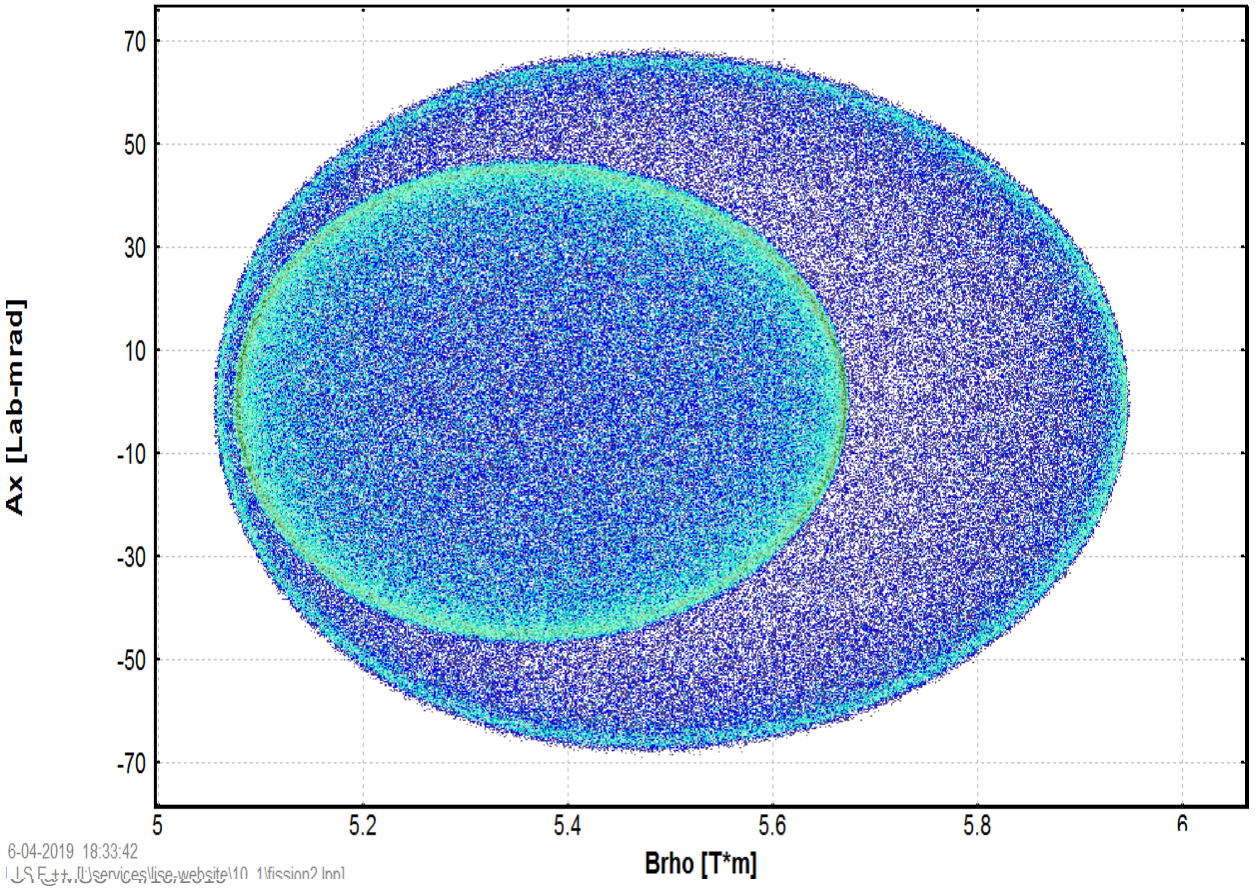
MICHIGAN STATE UNIVERSITY

☑ add conjugated fragment (D)

◉ Brho (q=Z) & A
○ Brho (q=Z) & Ax

^{95}Rb & ^{138}Cs fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic
Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5)



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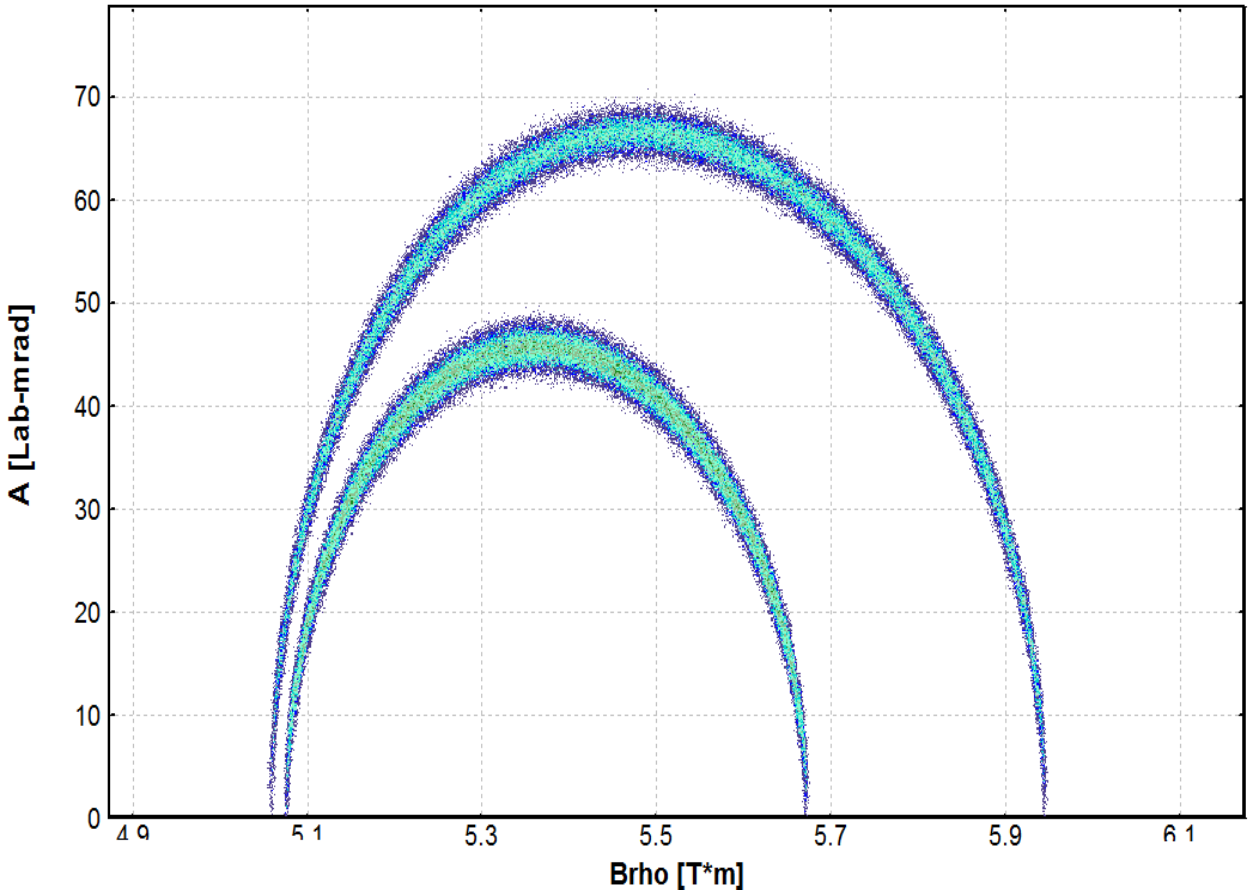
LISE++ [Users\lise_website\10_1\fission2.lpp]

^{95}Rb & ^{138}Cs fragment kinematics (expected final)

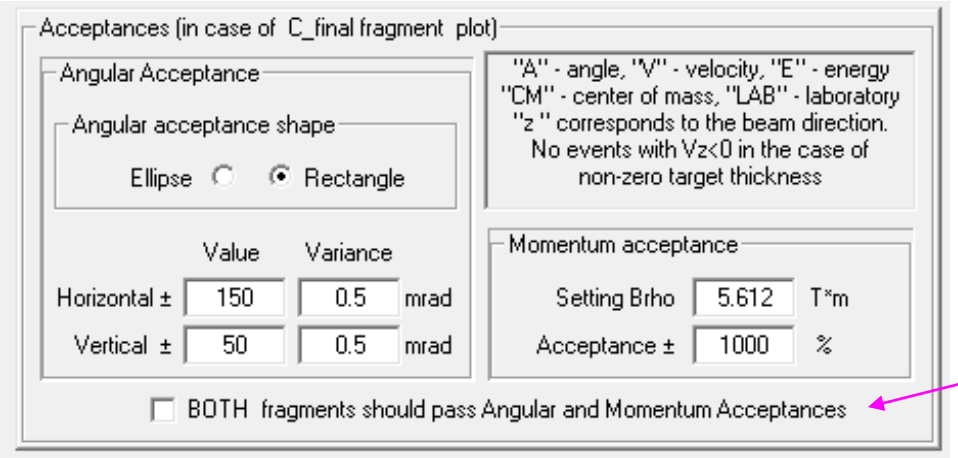
^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotro
Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5)



Passing two fission fragments simultaneously

Two-fission registration setups (SOFIA, SAMURAI) use a wide aperture magnet : large A_X angular acceptance, moderate A_Y (vertical gap), and large Brho-acceptance

Lets start with angular acceptances:



Unchecked : at least one fragment
Checked : **BOTH** fragments

should pass to register this fission event

E. PELLEREAU *et al.* PHYSICAL REVIEW C **95**, 054603 (2017)

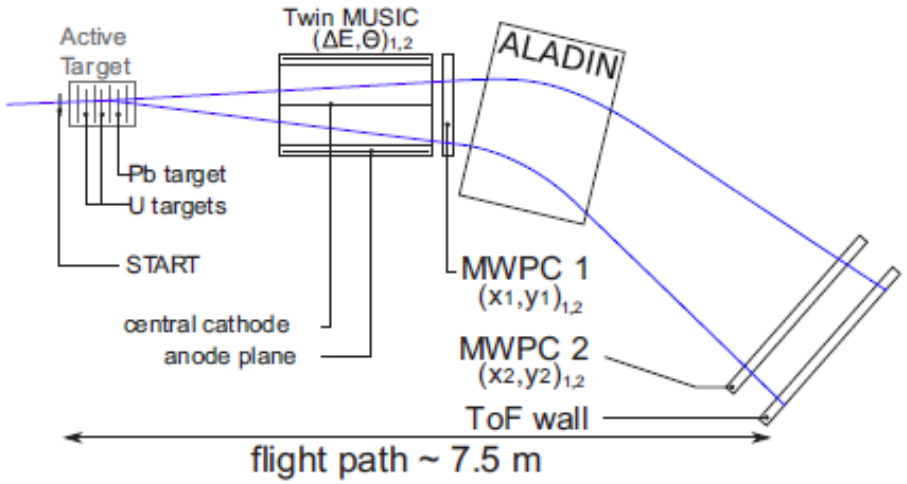
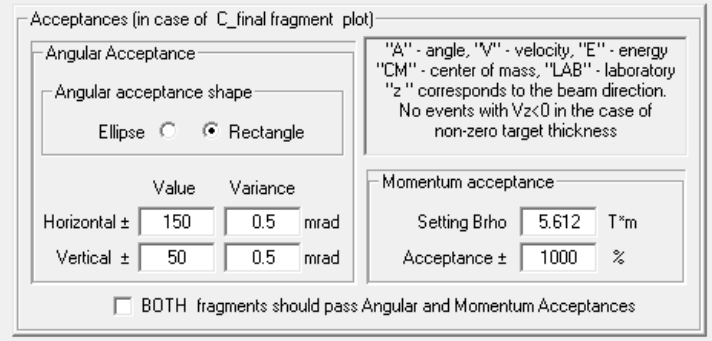
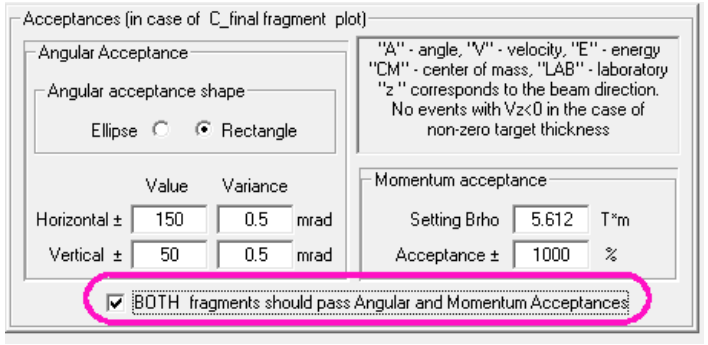


FIG. 4. Schematic view of the SOFIA setup to identify the nuclear mass and charge of both fission fragments in coincidence (top view, not on scale).

Passing two fission fragments simultaneously (Angular acceptance)



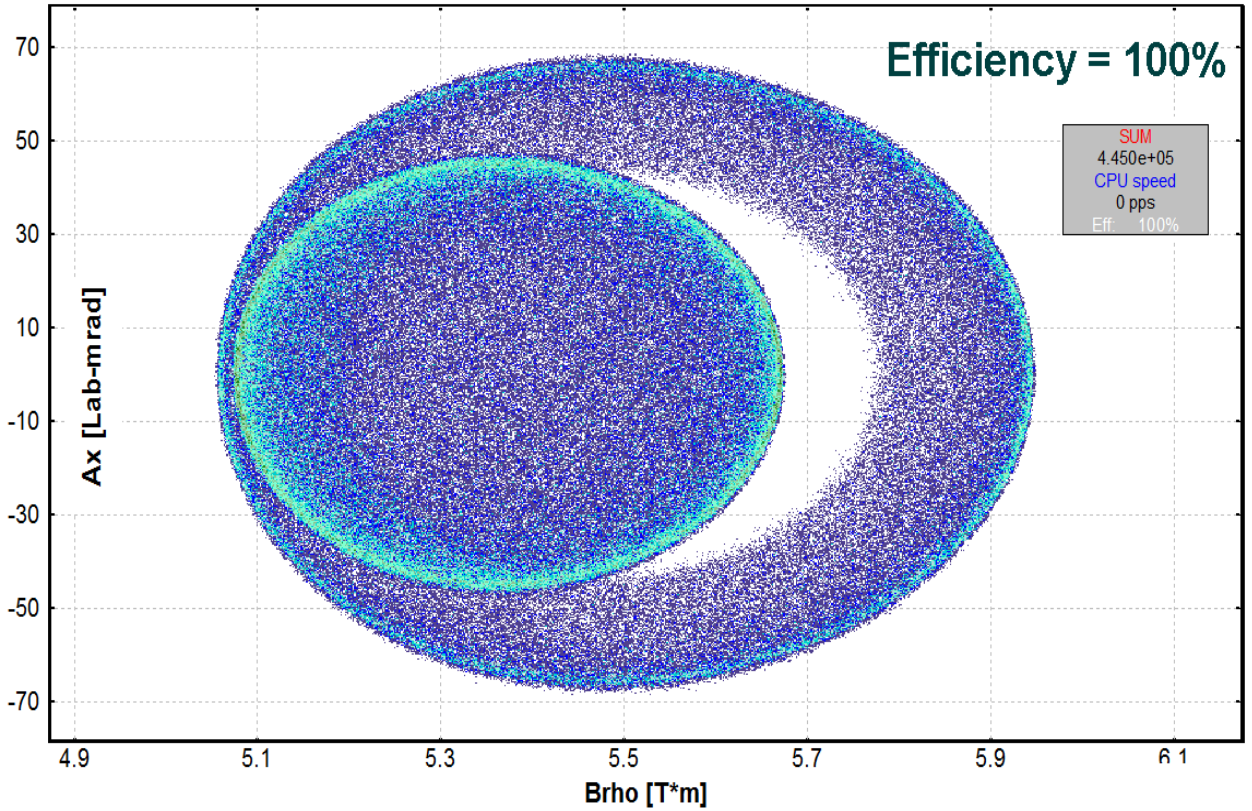


^{95}Rb & ^{138}Cs fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic

Rectangle Ang.Acceptance (mrad): H = 150.0(0.5); V = 50.0(0.5)

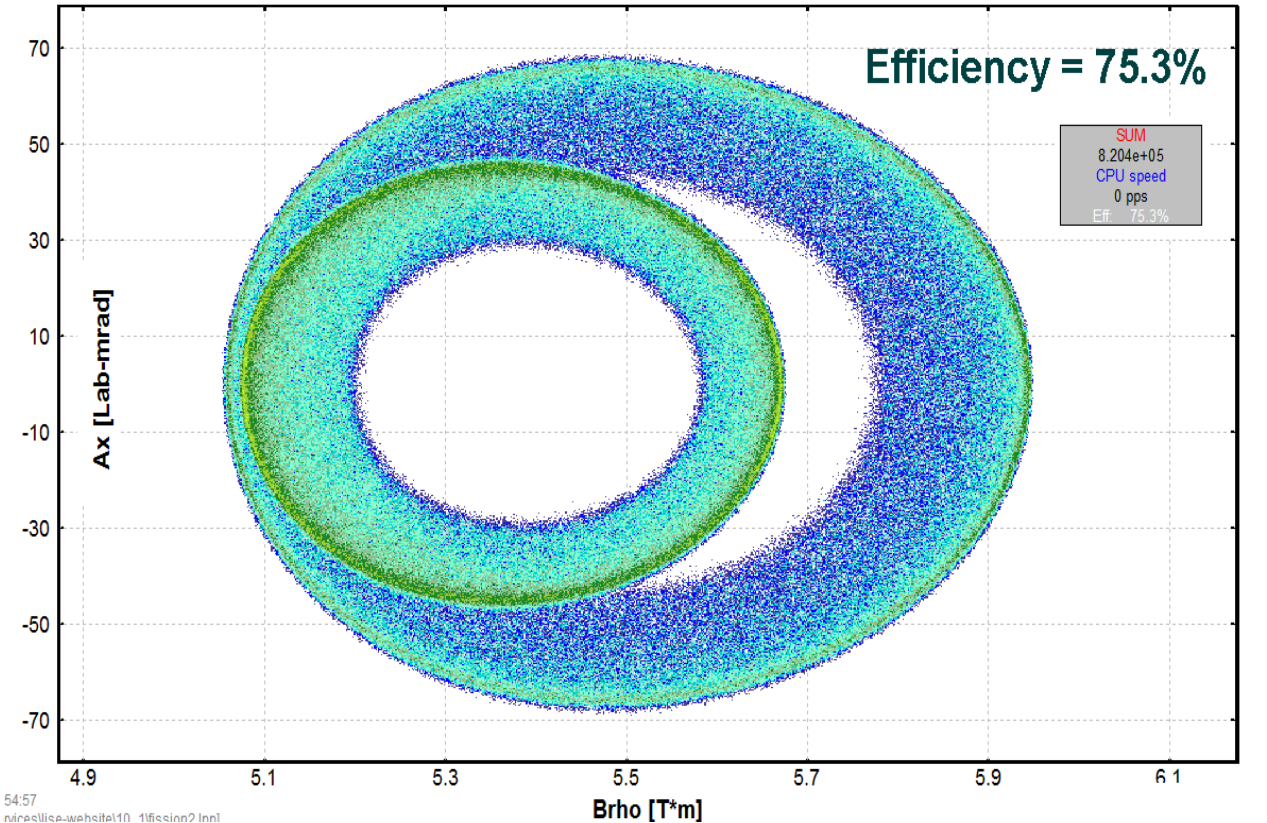


^{95}Rb & ^{138}Cs fragment kinematics (expected final) BOTH fragments should

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

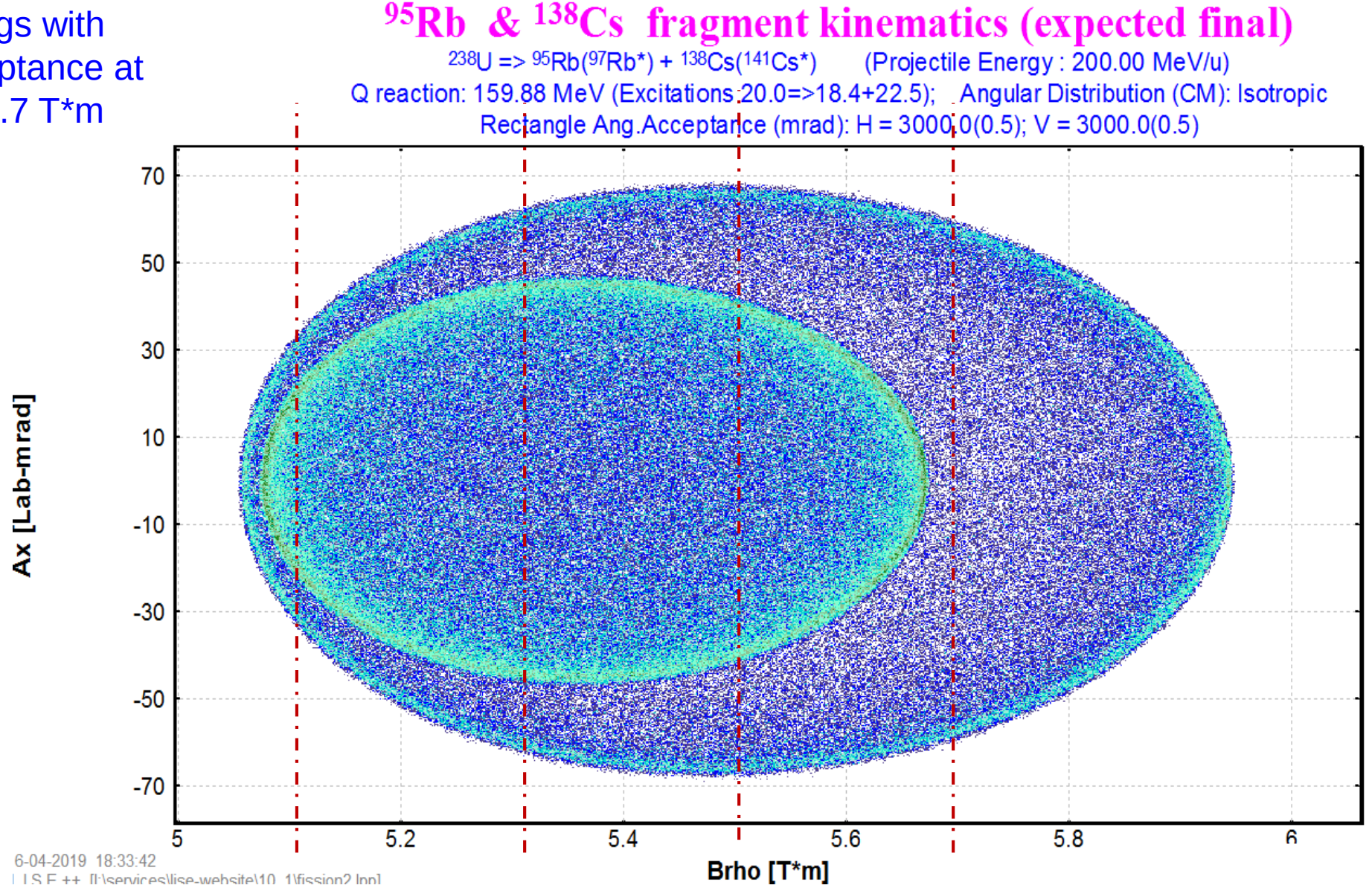
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic

Rectangle Ang.Acceptance (mrad): H = 150.0(0.5); V = 50.0(0.5)



Passing two fission fragments simultaneously (Momentum Acceptance)

Let's use 4 Brho settings with ±5% momentum acceptance at $Brho_0$ = 5.1, 5.3, 5.5, 5.7 T*m



Passing two fission fragments simultaneously : Brho = 5.1 Tm

Acceptances (in case of C_final fragment plot)

Angular Acceptance

Angular acceptance shape: Ellipse ○ Rectangle ●

	Value	Variance	
Horizontal ±	3000	0.5	mrad
Vertical ±	3000	0.5	mrad

"A" - angle, "V" - velocity, "E" - energy
"CM" - center of mass, "LAB" - laboratory
"z" corresponds to the beam direction.
No events with Vz<0 in the case of non-zero target thickness

Momentum acceptance

Setting Brho 5.1 T*m

Acceptance ± 5 %

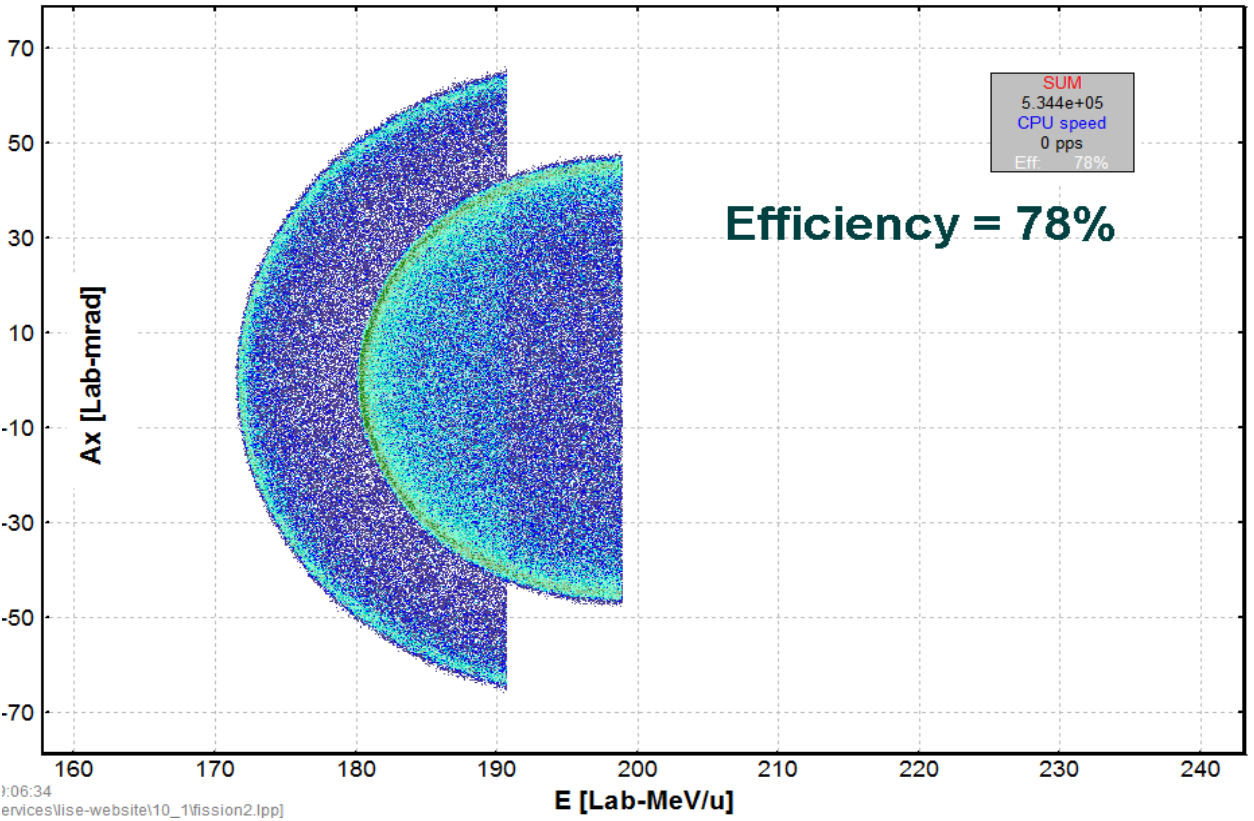
☐ BOTH fragments should pass Angular and Momentum Acceptances

^{95}Rb & ^{138}Cs fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotro

ctangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5); Momentum Acceptance : 5.00 % @



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Acceptances (in case of C_final fragment plot)

Angular Acceptance

Angular acceptance shape: Ellipse ○ Rectangle ●

	Value	Variance	
Horizontal ±	3000	0.5	mrad
Vertical ±	3000	0.5	mrad

"A" - angle, "V" - velocity, "E" - energy
"CM" - center of mass, "LAB" - laboratory
"z" corresponds to the beam direction.
No events with Vz<0 in the case of non-zero target thickness

Momentum acceptance

Setting Brho 5.1 T*m

Acceptance ± 5 %

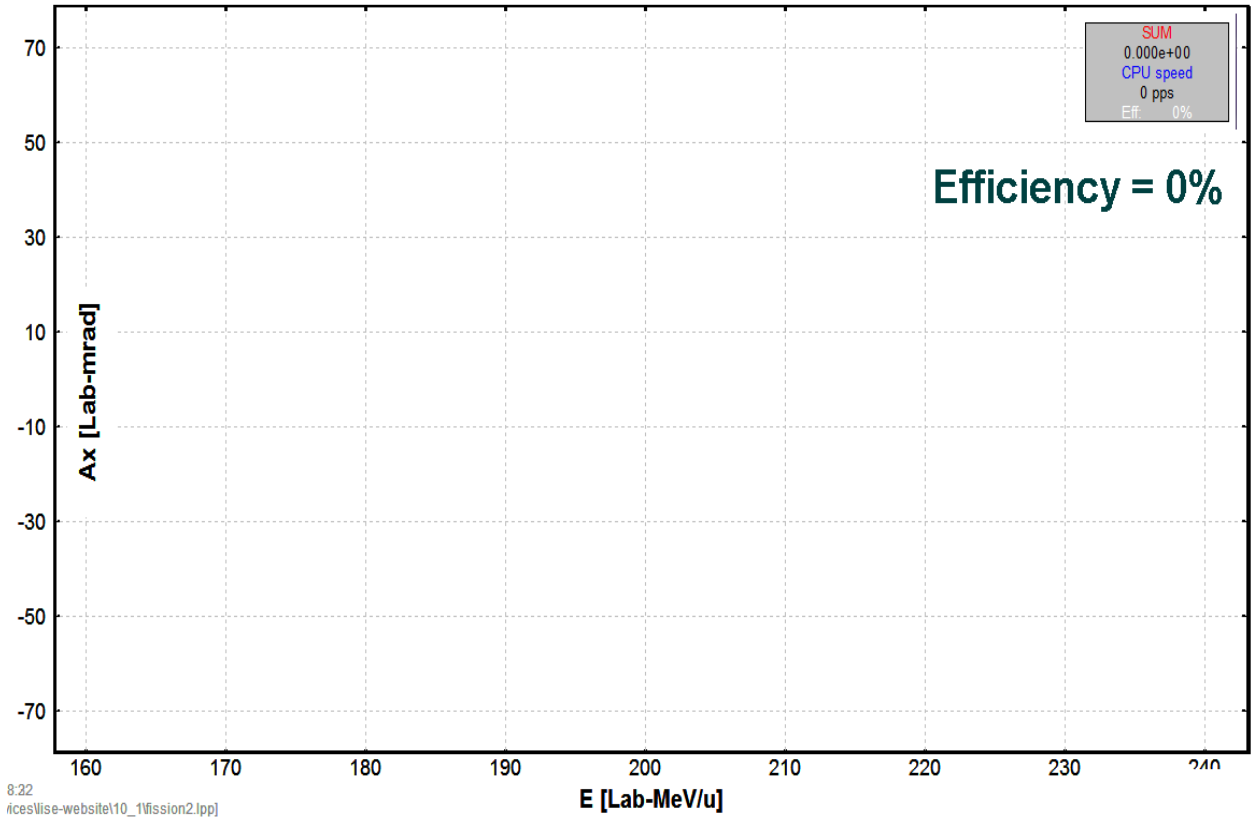
☑ BOTH fragments should pass Angular and Momentum Acceptances

^{95}Rb & ^{138}Cs fragment kinematics (expected final) BOTH fragments should

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic

Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.10



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Passing two fission fragments simultaneously : Brho = 5.3 Tm

Acceptances (in case of C_final fragment plot)

Angular Acceptance

Angular acceptance shape: Ellipse ○ Rectangle ●

	Value	Variance	
Horizontal ±	3000	0.5	mrad
Vertical ±	3000	0.5	mrad

"A" - angle, "V" - velocity, "E" - energy
"CM" - center of mass, "LAB" - laboratory
"z" corresponds to the beam direction.
No events with Vz<0 in the case of non-zero target thickness

Momentum acceptance

Setting Brho	5.3	T*m
Acceptance ±	5	%

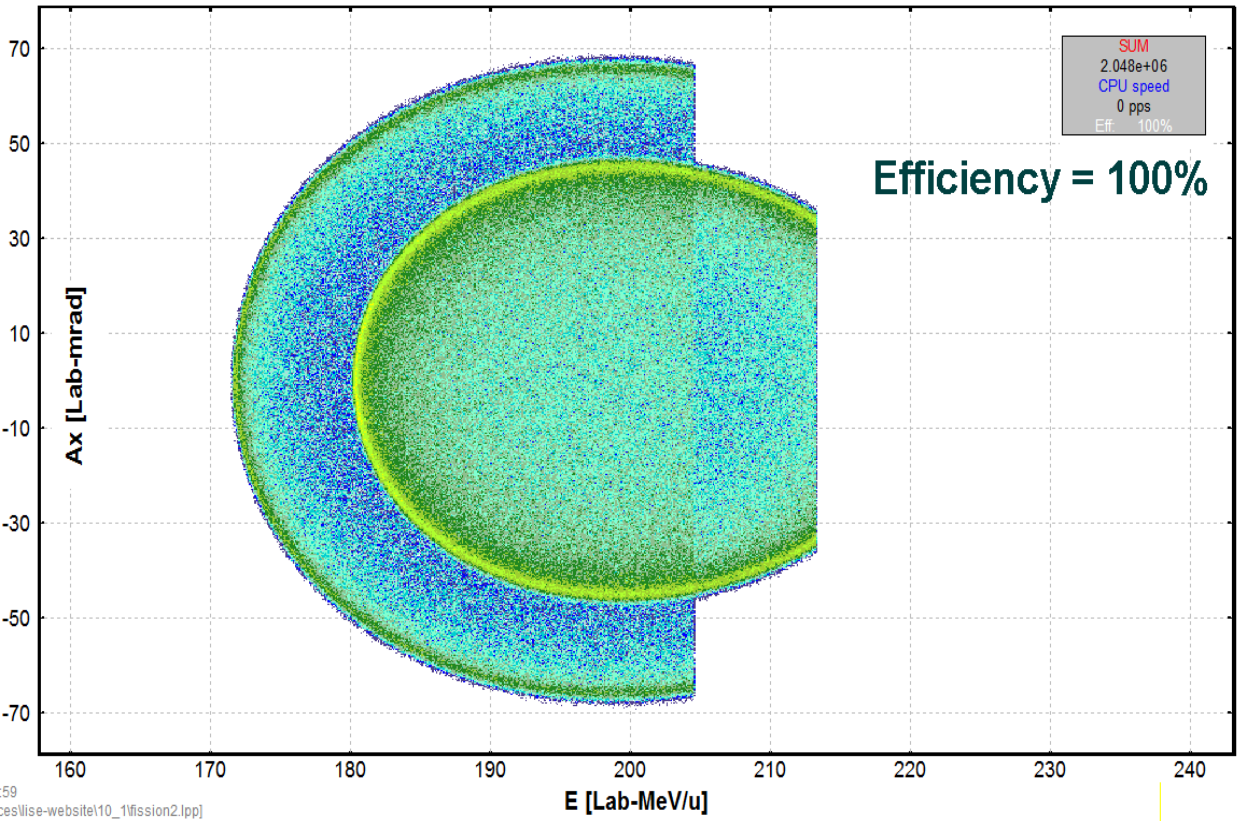
☐ BOTH fragments should pass Angular and Momentum Acceptances

^{95}Rb & ^{138}Cs fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic

Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.30(



Acceptances (in case of C_final fragment plot)

Angular Acceptance

Angular acceptance shape: Ellipse ○ Rectangle ●

	Value	Variance	
Horizontal ±	3000	0.5	mrad
Vertical ±	3000	0.5	mrad

"A" - angle, "V" - velocity, "E" - energy
"CM" - center of mass, "LAB" - laboratory
"z" corresponds to the beam direction.
No events with Vz<0 in the case of non-zero target thickness

Momentum acceptance

Setting Brho	5.3	T*m
Acceptance ±	5	%

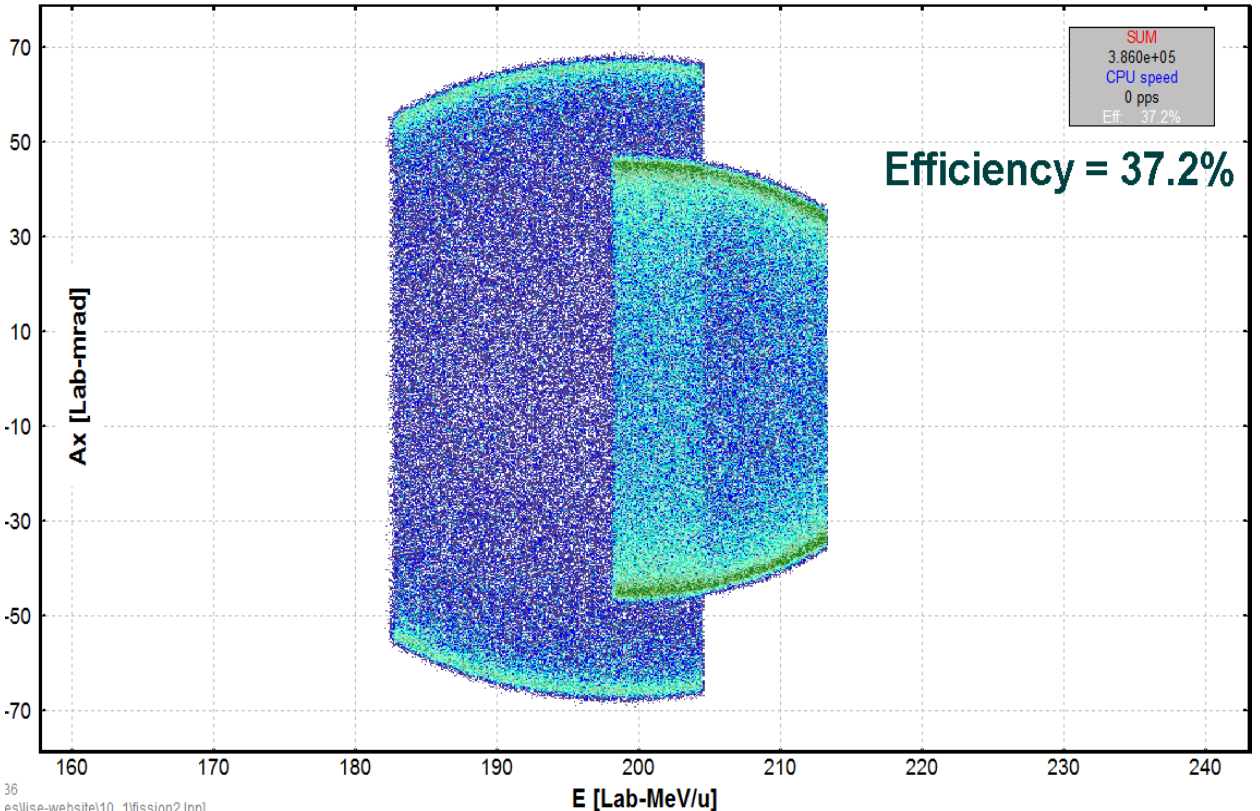
☑ BOTH fragments should pass Angular and Momentum Acceptances

^{95}Rb & ^{138}Cs fragment kinematics (expected final) BOTH fragments should

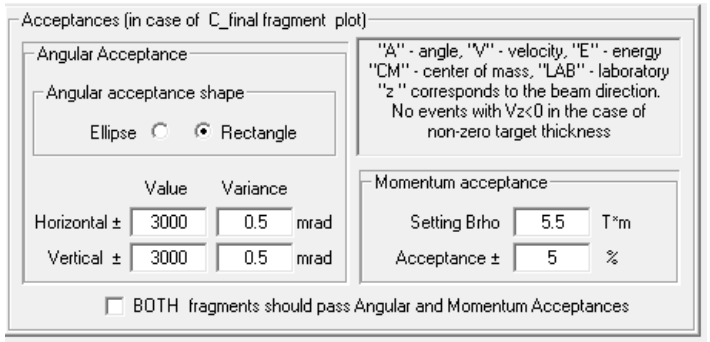
^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

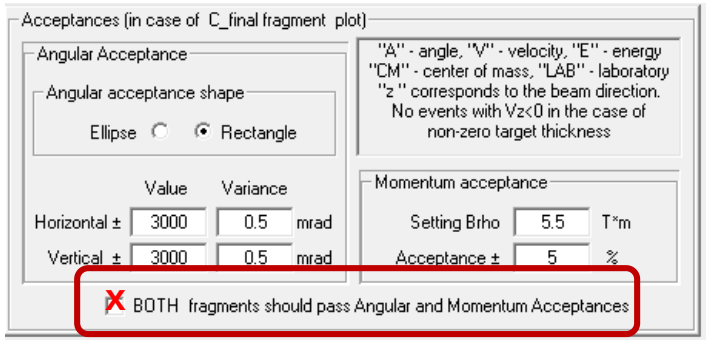
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic

Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.30



Passing two fission fragments simultaneously : Brho = 5.5 Tm



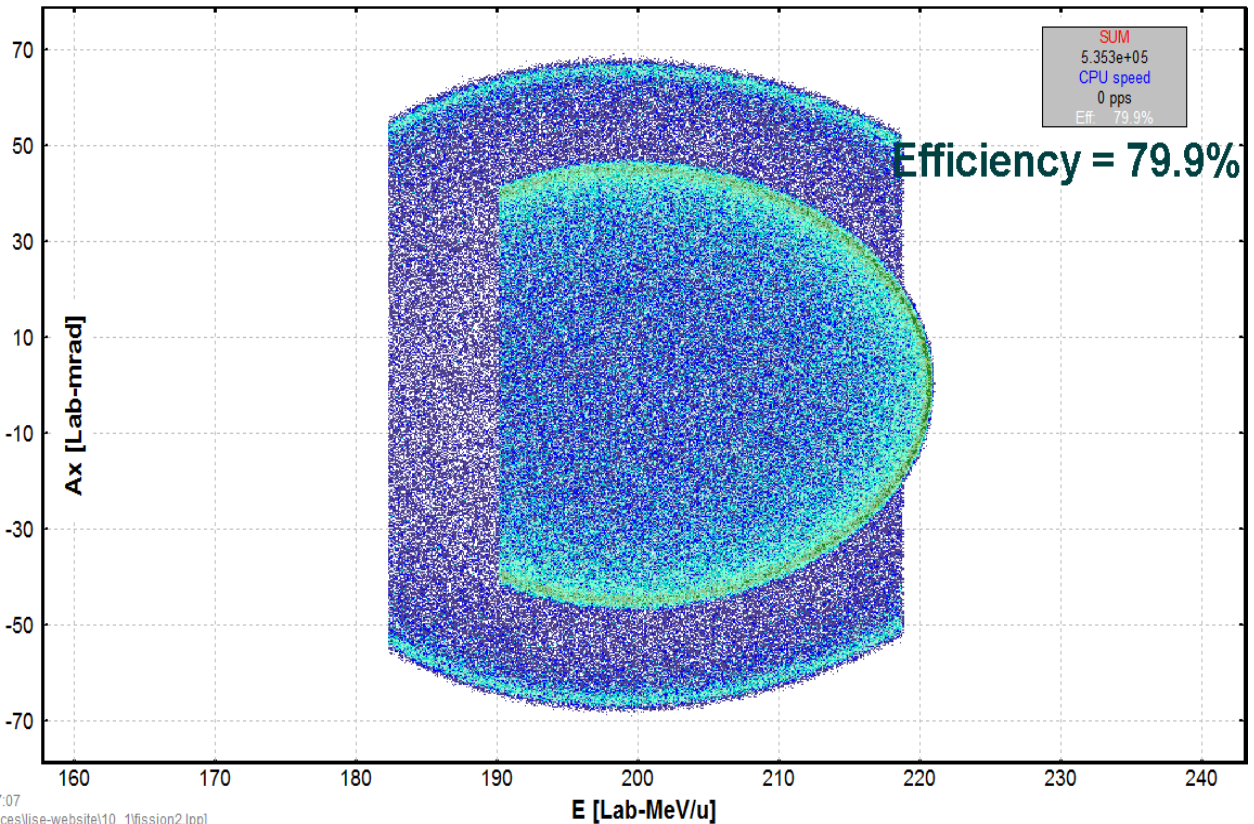


^{95}Rb & ^{138}Cs fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic

Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.5(



^{95}Rb & ^{138}Cs fragment kinematics (expected final) BOTH fragments should

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

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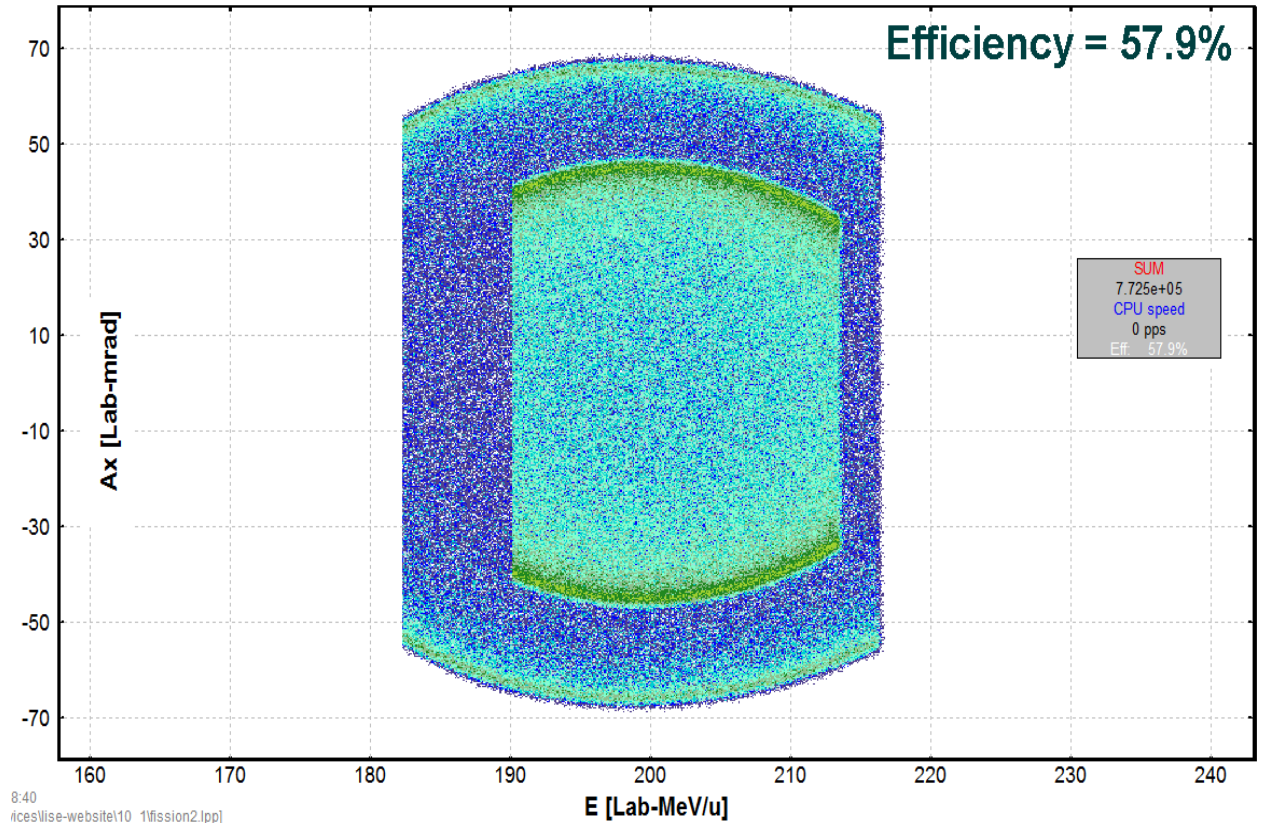
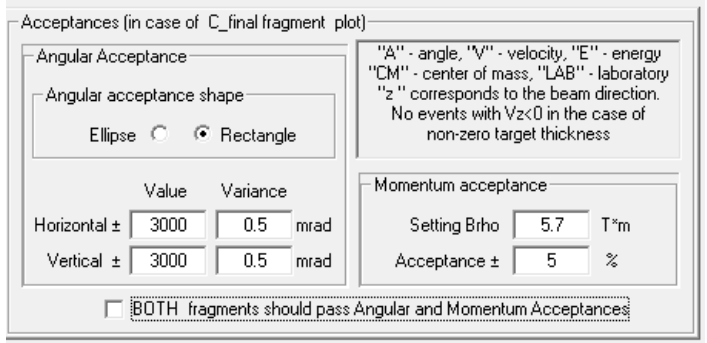
Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.5(



Passing two fission fragments simultaneously : Brho = 5.7 Tm

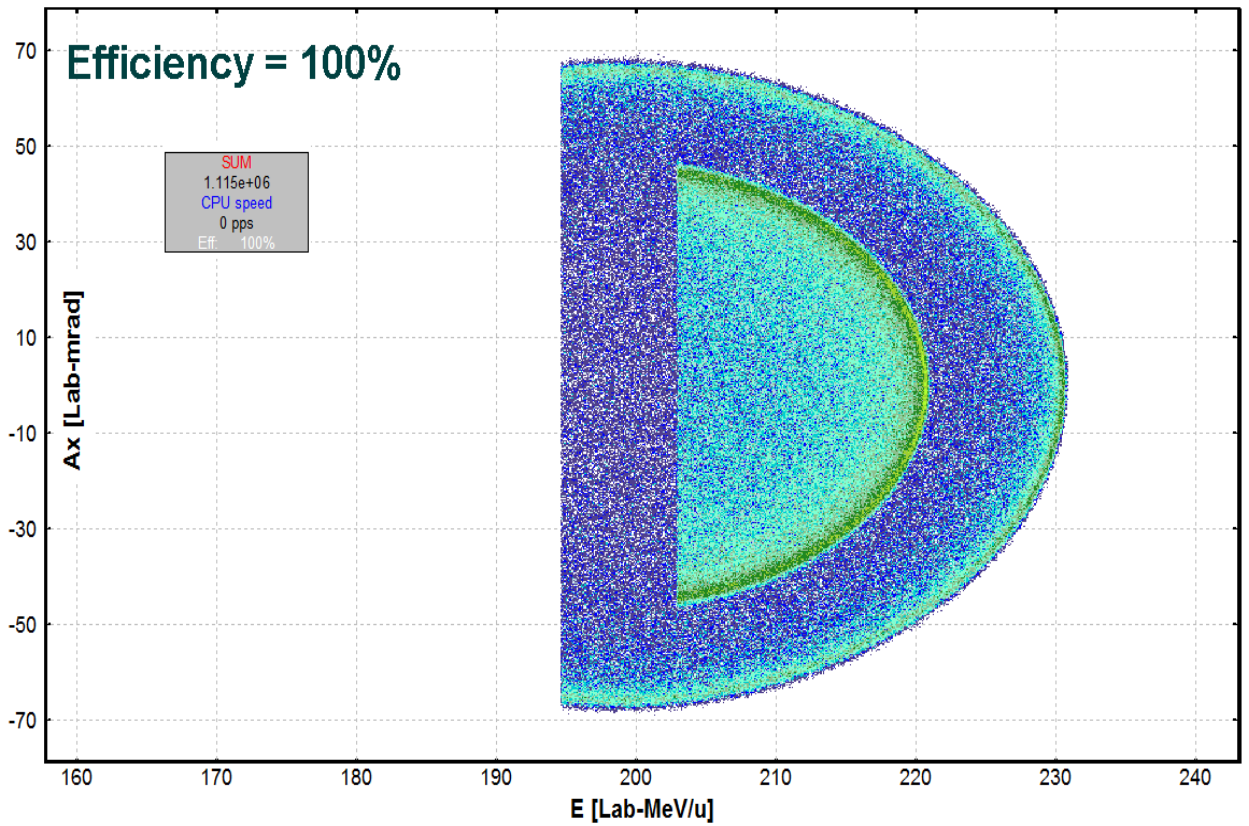


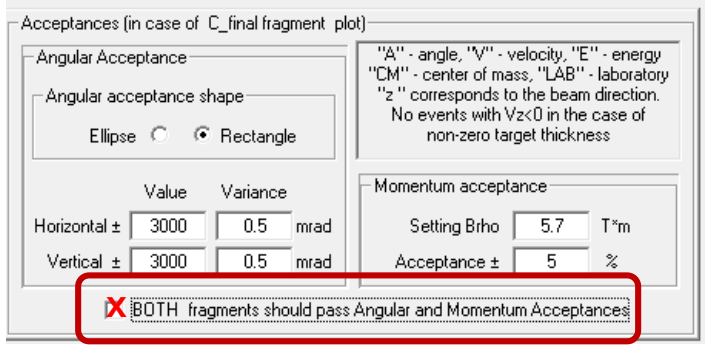
^{95}Rb & ^{138}Cs fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic

Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.70



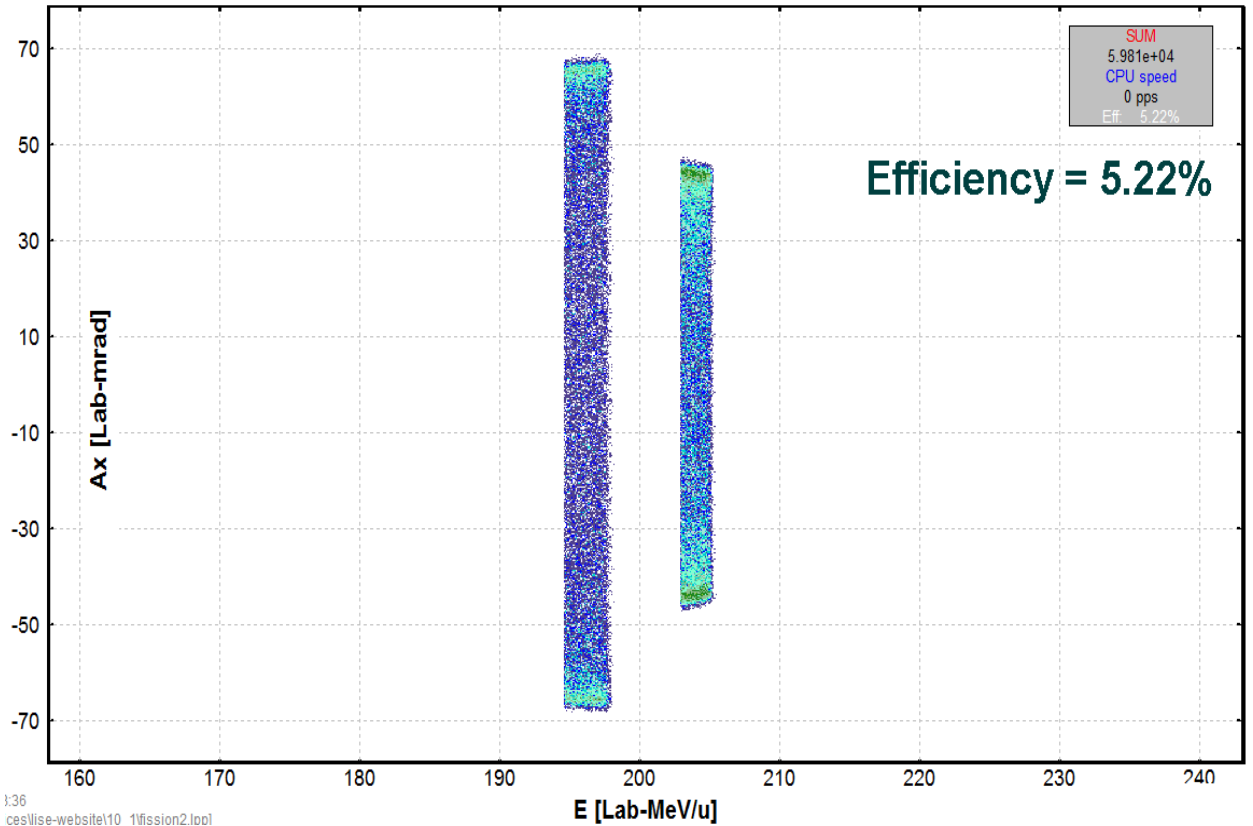


^{95}Rb & ^{138}Cs fragment kinematics (expected final) BOTH fragments should

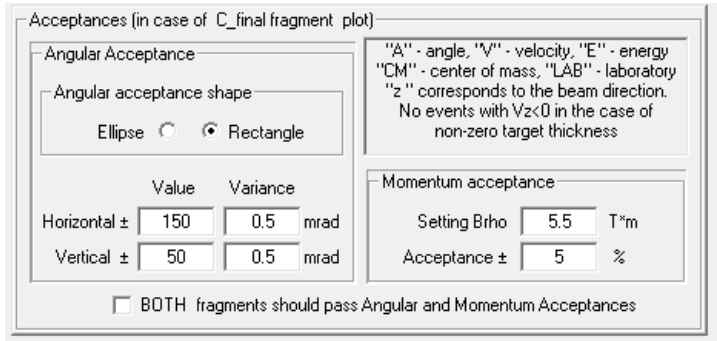
^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

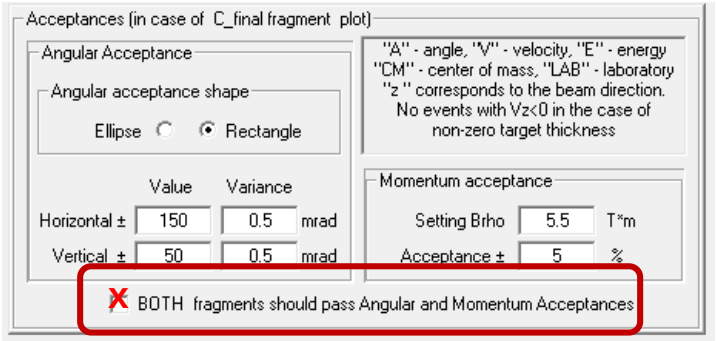
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic

Rectangle Ang.Acceptance (mrad): H = 3000.0(0.5); V = 3000.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.70



Angular acceptance & Momentum acceptance @ Brho = 5.5 Tm





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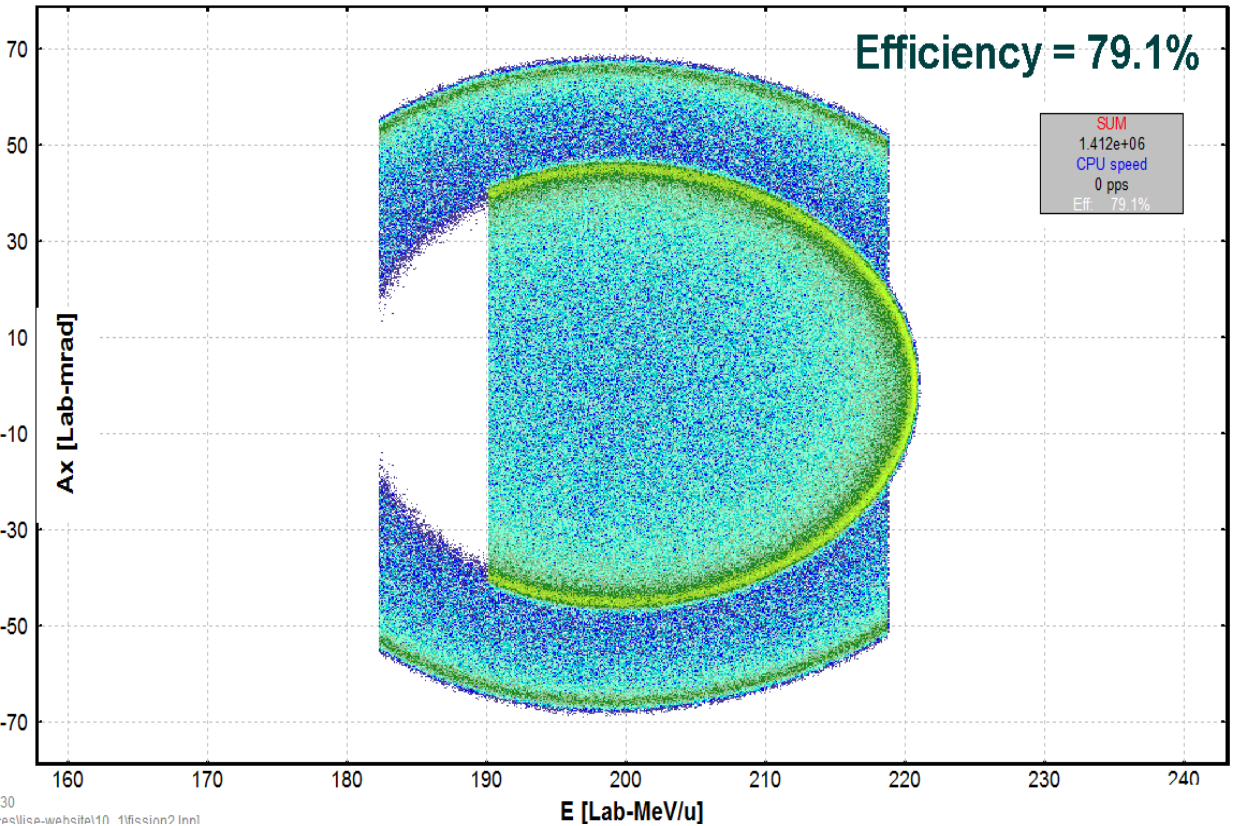
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic
Rectangle Ang.Acceptance (mrad): H = 150.0(0.5); V = 50.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.5000



^{95}Rb & ^{138}Cs fragment kinematics (expected final) BOTH fragments should

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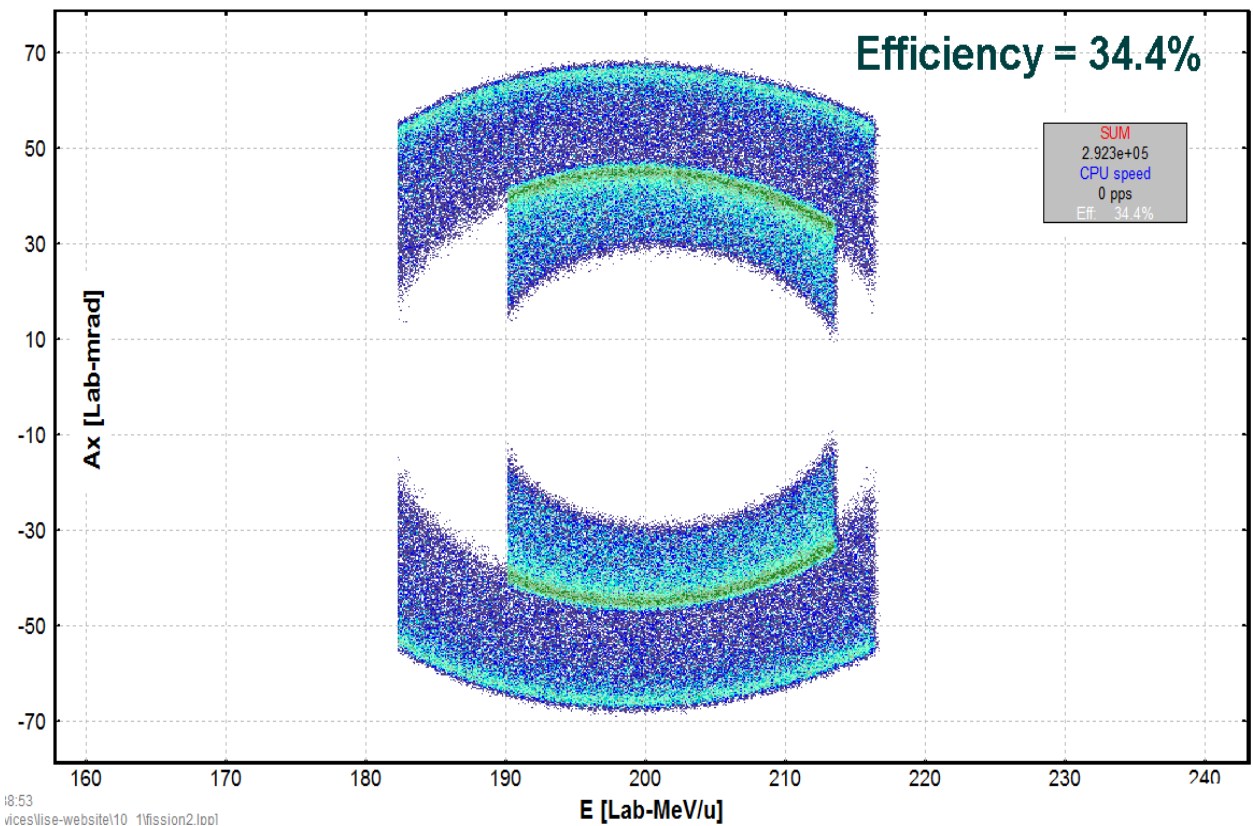
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic
Rectangle Ang.Acceptance (mrad): H = 150.0(0.5); V = 50.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.5000



Angular acceptance & Momentum acceptance @ Brho = 5.5 Tm

Acceptances (in case of C_final fragment plot)

Angular Acceptance

Angular acceptance shape: Ellipse ○ Rectangle ◉

	Value	Variance	
Horizontal ±	150	0.5	mrad
Vertical ±	50	0.5	mrad

"A" - angle, "V" - velocity, "E" - energy
"CM" - center of mass, "LAB" - laboratory
"z" corresponds to the beam direction.
No events with Vz<0 in the case of non-zero target thickness

Momentum acceptance

Setting Brho 5.5 T*m

Acceptance ± 5 %

☐ BOTH fragments should pass Angular and Momentum Acceptances

The same like the previous page but another representation : Energy vs A_Y

Acceptances (in case of C_final fragment plot)

Angular Acceptance

Angular acceptance shape: Ellipse ○ Rectangle ◉

	Value	Variance	
Horizontal ±	150	0.5	mrad
Vertical ±	50	0.5	mrad

"A" - angle, "V" - velocity, "E" - energy
"CM" - center of mass, "LAB" - laboratory
"z" corresponds to the beam direction.
No events with Vz<0 in the case of non-zero target thickness

Momentum acceptance

Setting Brho 5.5 T*m

Acceptance ± 5 %

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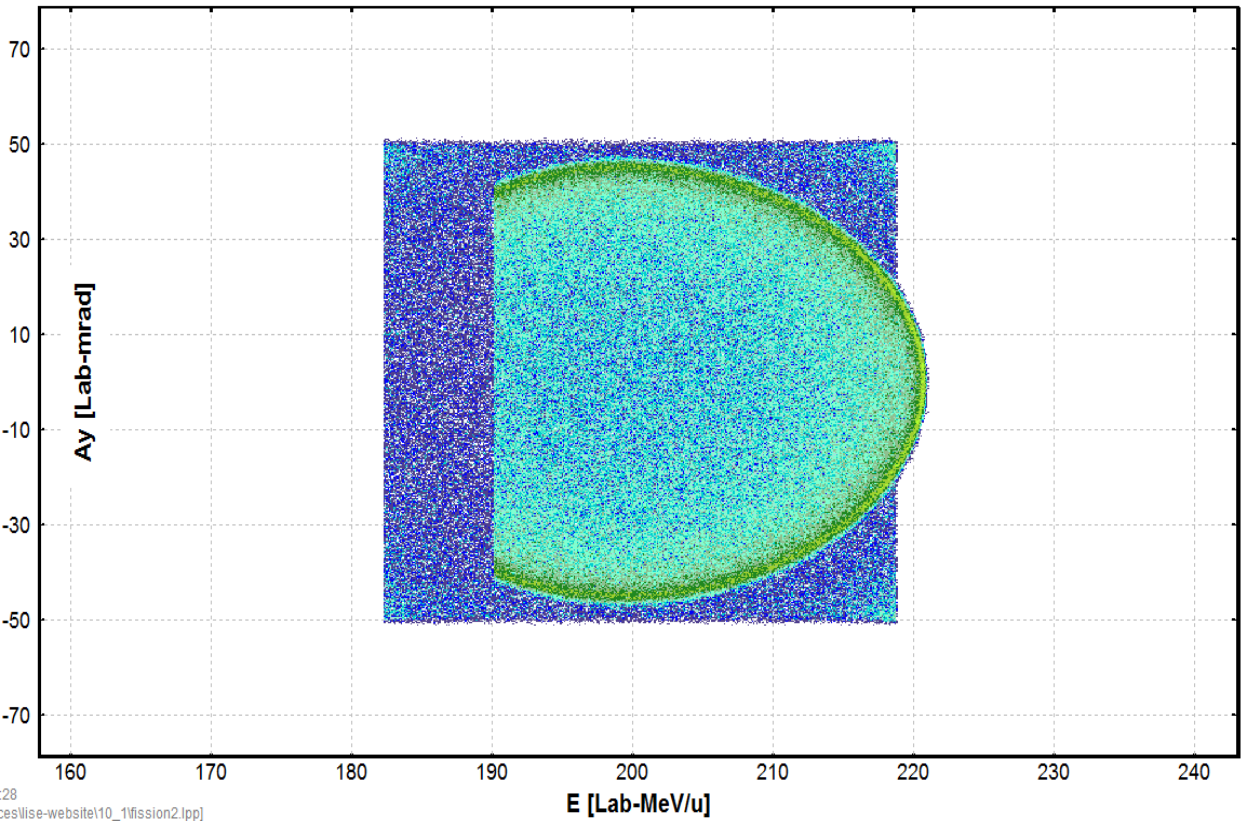
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic
Rectangle Ang.Acceptance (mrad): H = 150.0(0.5); V = 50.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.500(



^{95}Rb & ^{138}Cs fragment kinematics (expected final) BOTH fragments should

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)
Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotropic
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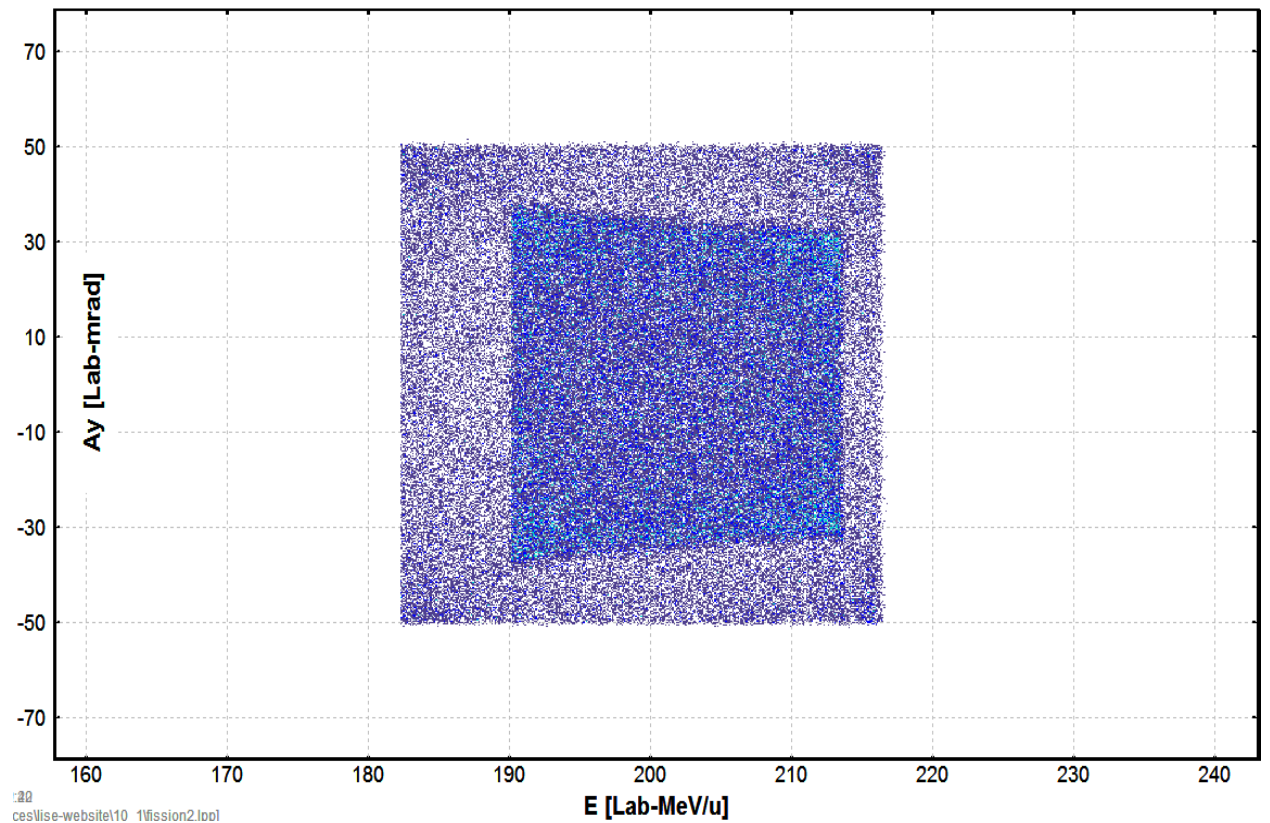
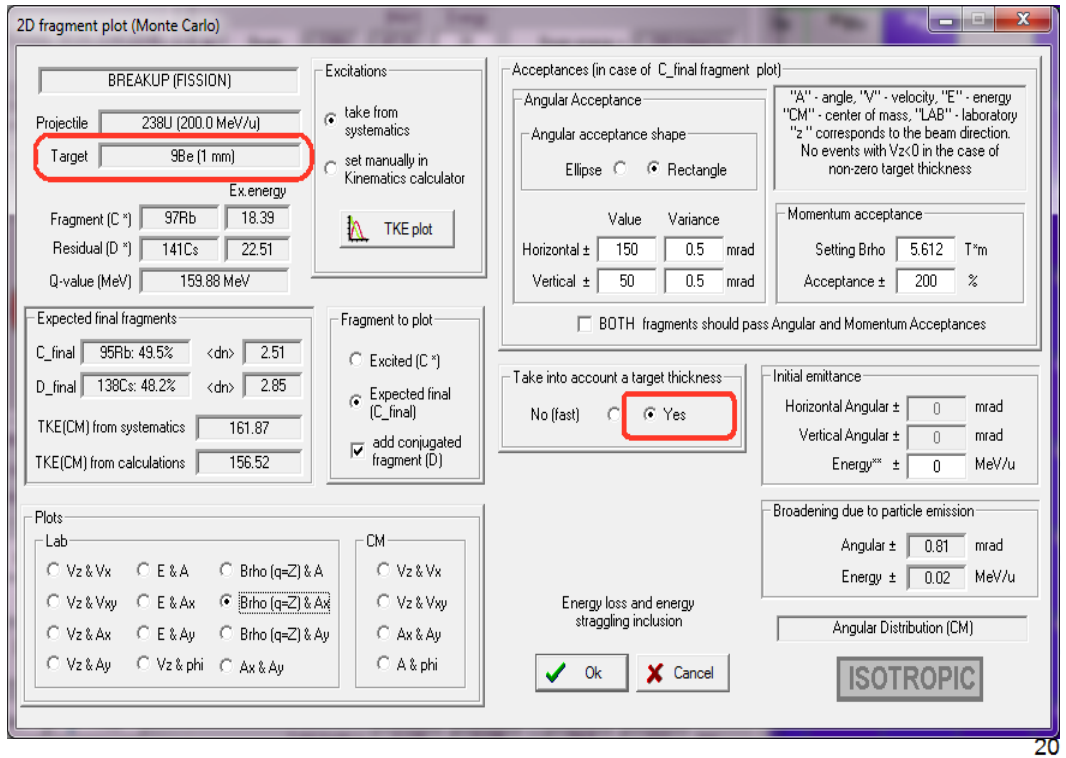


Using non-zero target thickness

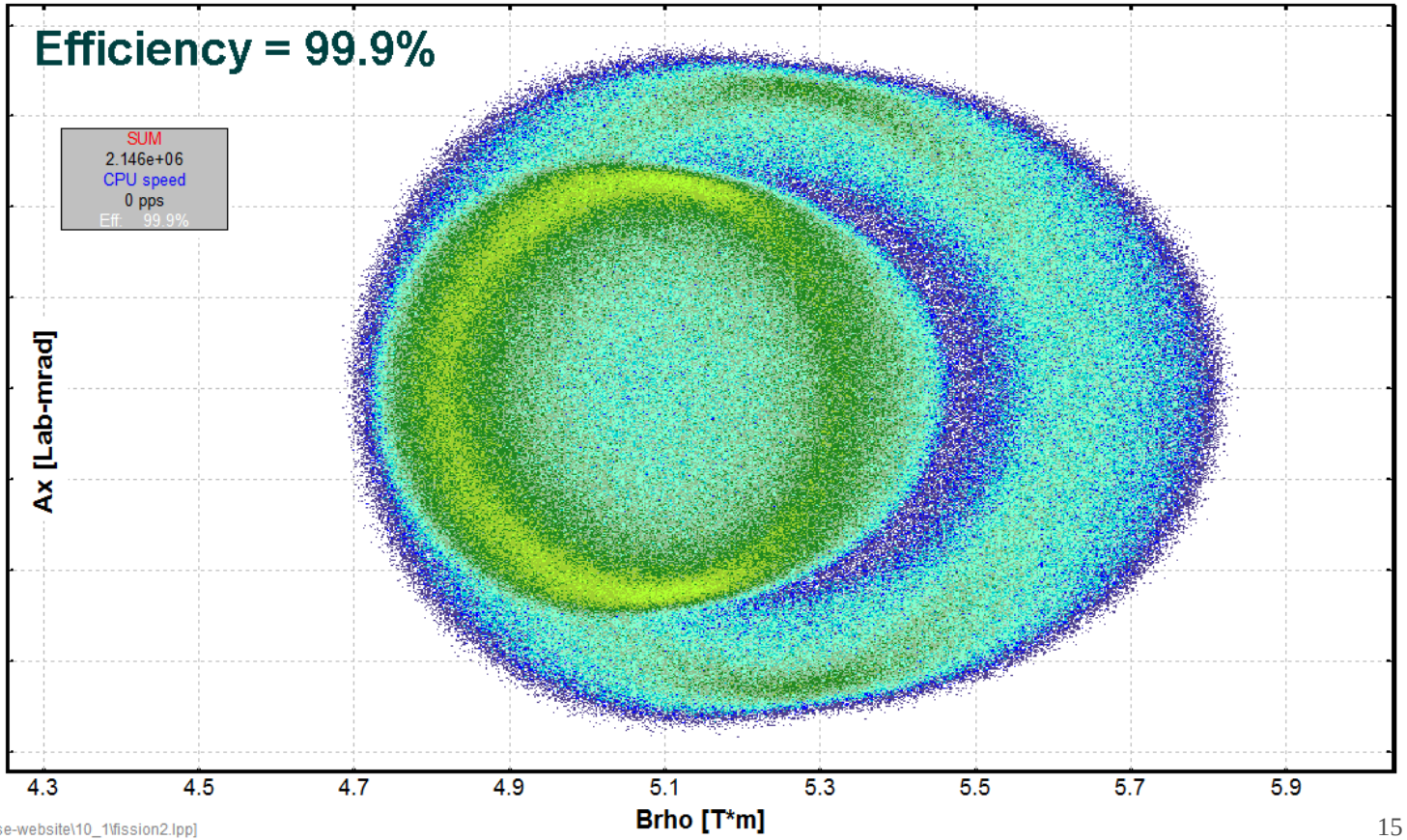


^{95}Rb & ^{138}Cs fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

Target: Be (1 mm); Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotrop

Rectangle Ang.Acceptance (mrad): H = 150.0(0.5); V = 50.0(0.5)



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Acceptances and non-zero target thickness

Acceptances (in case of C_final fragment plot)

Angular Acceptance

Angular acceptance shape

Ellipse ○ ◉ Rectangle

	Value	Variance	
Horizontal ±	150	0.5	mrad
Vertical ±	50	0.5	mrad

"A" - angle, "V" - velocity, "E" - energy
"CM" - center of mass, "LAB" - laboratory
"z" corresponds to the beam direction.
No events with Vz<0 in the case of non-zero target thickness

Momentum acceptance

Setting Brho 5.3 T*m

Acceptance ± 5 %

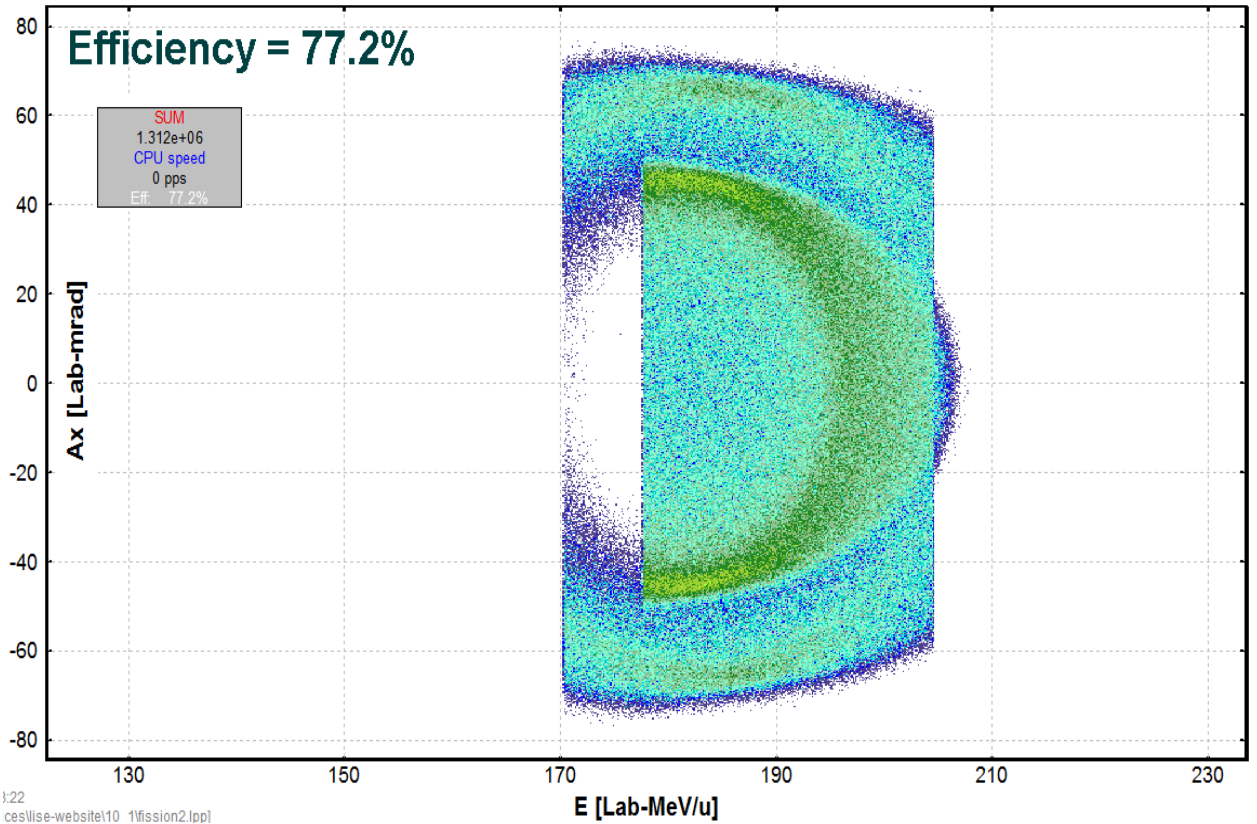
☐ BOTH fragments should pass Angular and Momentum Acceptances

^{95}Rb & ^{138}Cs fragment kinematics (expected final)

^{238}U => ^{95}Rb(^{97}Rb*) + ^{138}Cs(^{141}Cs*) (Projectile Energy : 200.00 MeV/u)

Target: Be (1 mm); Q reaction: 159.88 MeV (Excitations 20.0=>18.4+22.5); Angular Distribution (CM): Isotrop

Rectangle Ang.Acceptance (mrad): H = 150.0(0.5); V = 50.0(0.5); Momentum Acceptance : 5.00 % @ Brho = 5.300



Acceptances (in case of C_final fragment plot)

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Momentum acceptance

Setting Brho 5.3 T*m

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X BOTH fragments should pass Angular and Momentum Acceptances

^{95}Rb & ^{138}Cs fragment kinematics (expected final) BOTH fragments should

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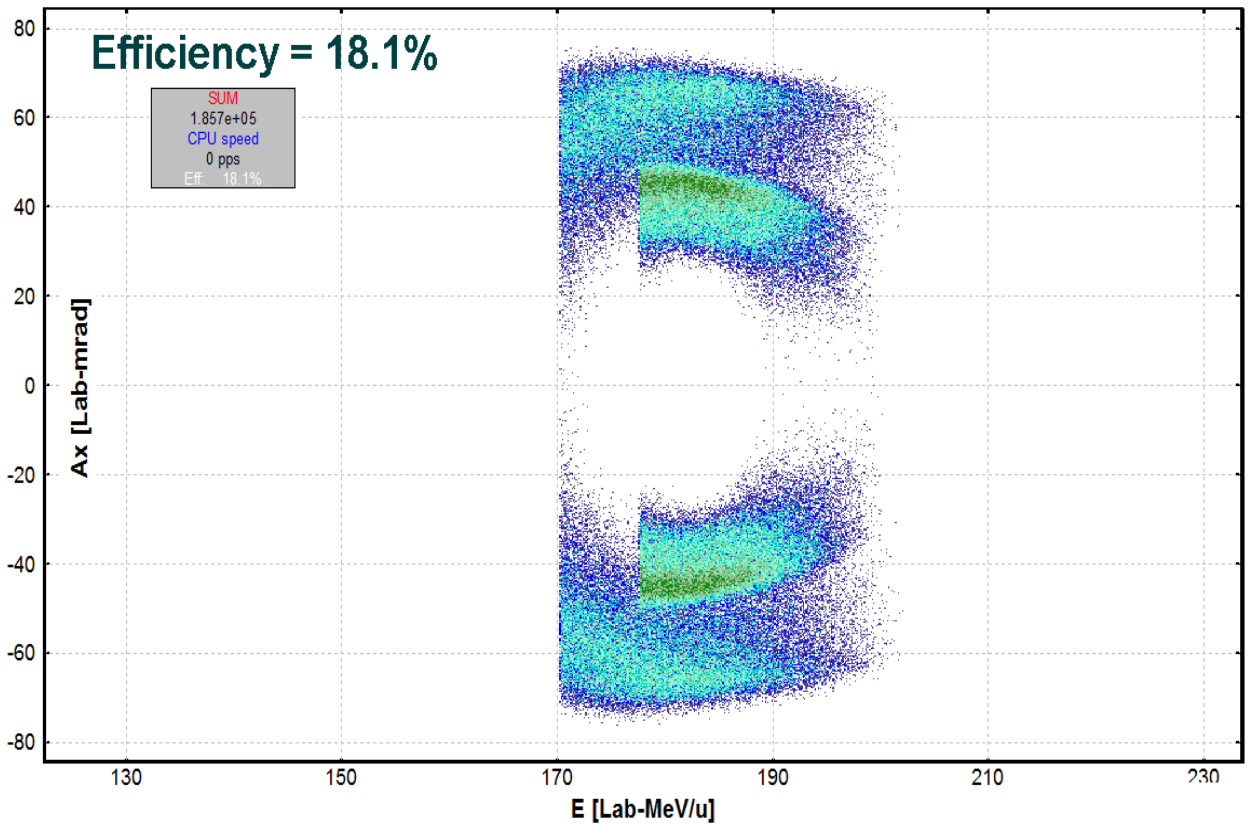

Some other plots…..