Capture reactions in H and He stellar burnings with the RMS ERNA

A. Di Leva - L. Gialanella

ECT* KRINA2025 Workshop

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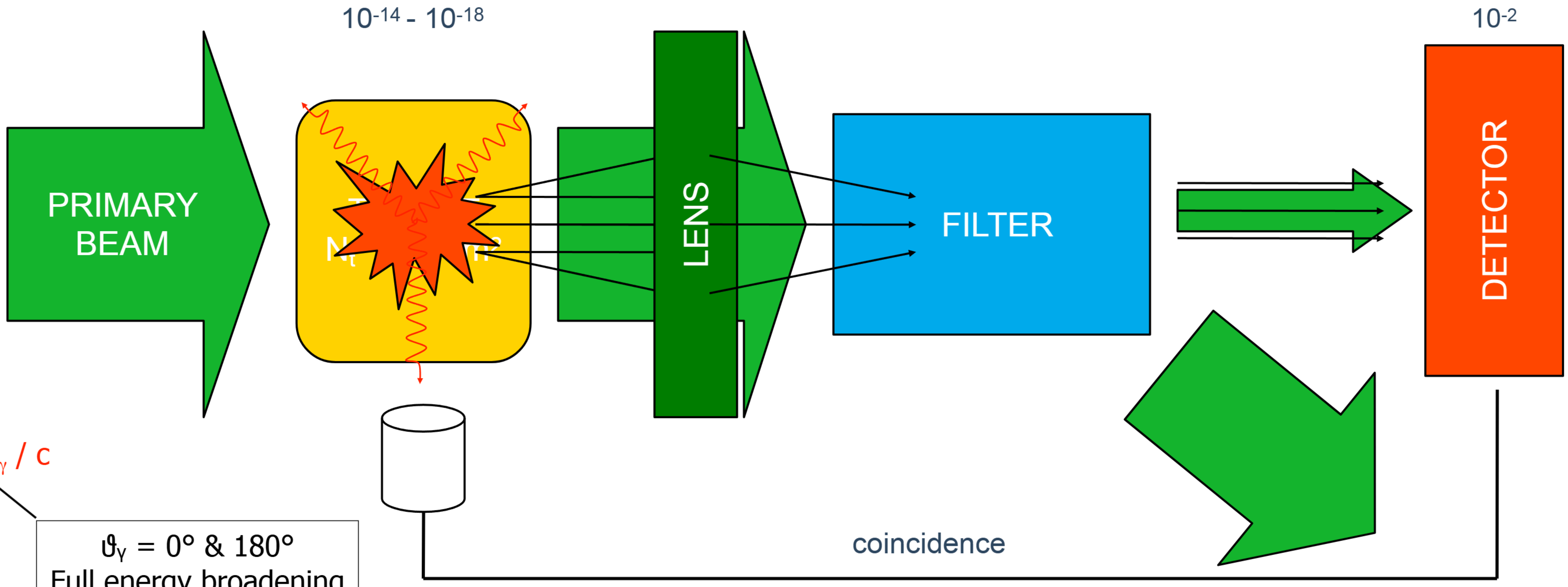
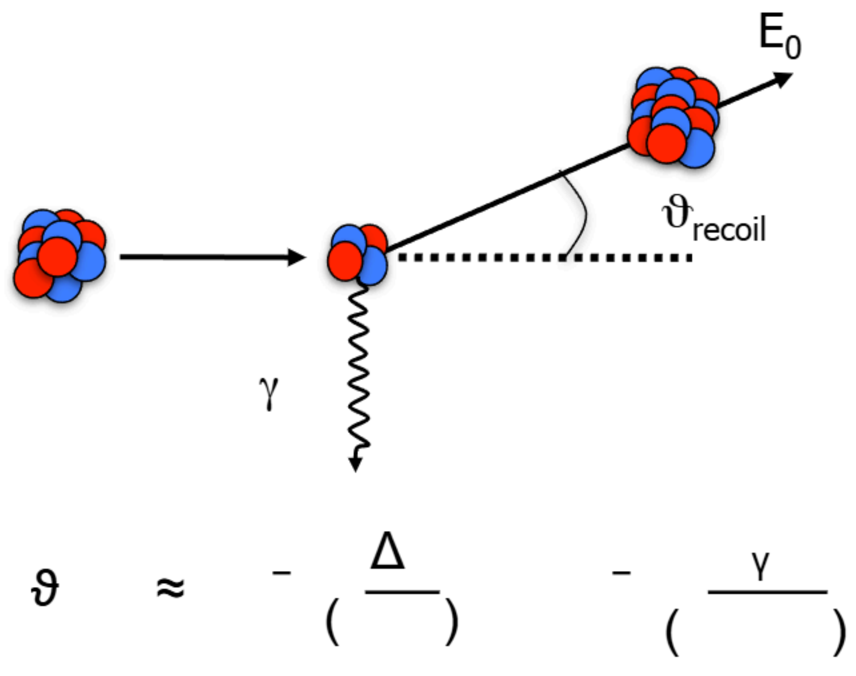
Recoil Mass Separator ERNA

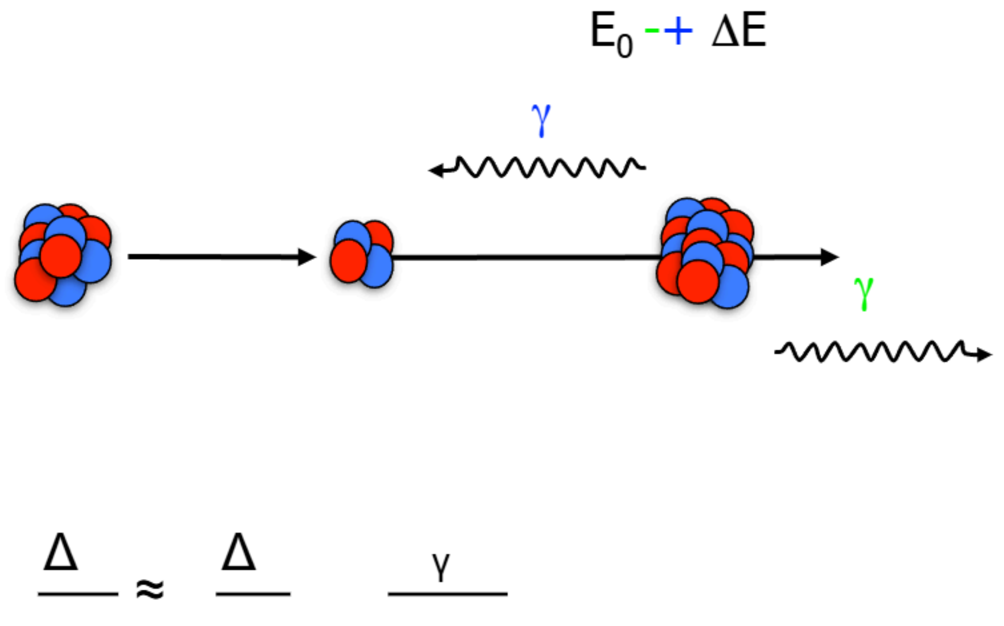


Example $^{12}C(\alpha,\gamma)^{16}O$
E_{cm}=1.2 MeV
E_{γ} = 8.4 MeV

$p_{\gamma} = E_{\gamma} / c$

ϑ_{γ} = 90° Full angular broadening	ϑ_{γ} = 0° & 180° Full energy broadening





ϑ_{Rmax} = 26 mrad
⇓
⌀52 mm after 1 m!
ΔE ~ ±185 keV

E_0 = 3.6 MeV

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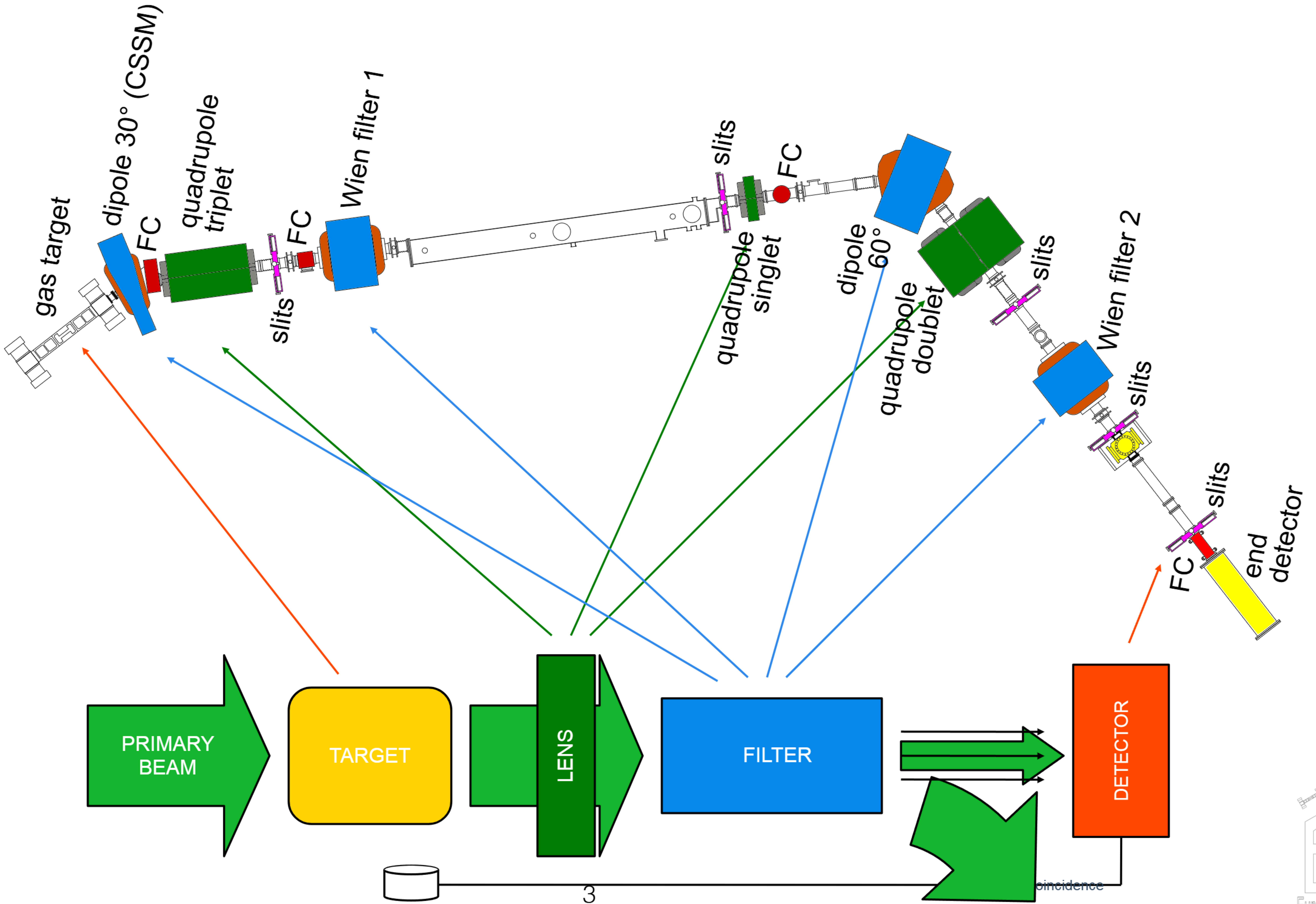
Recoil Mass Separator ERNA



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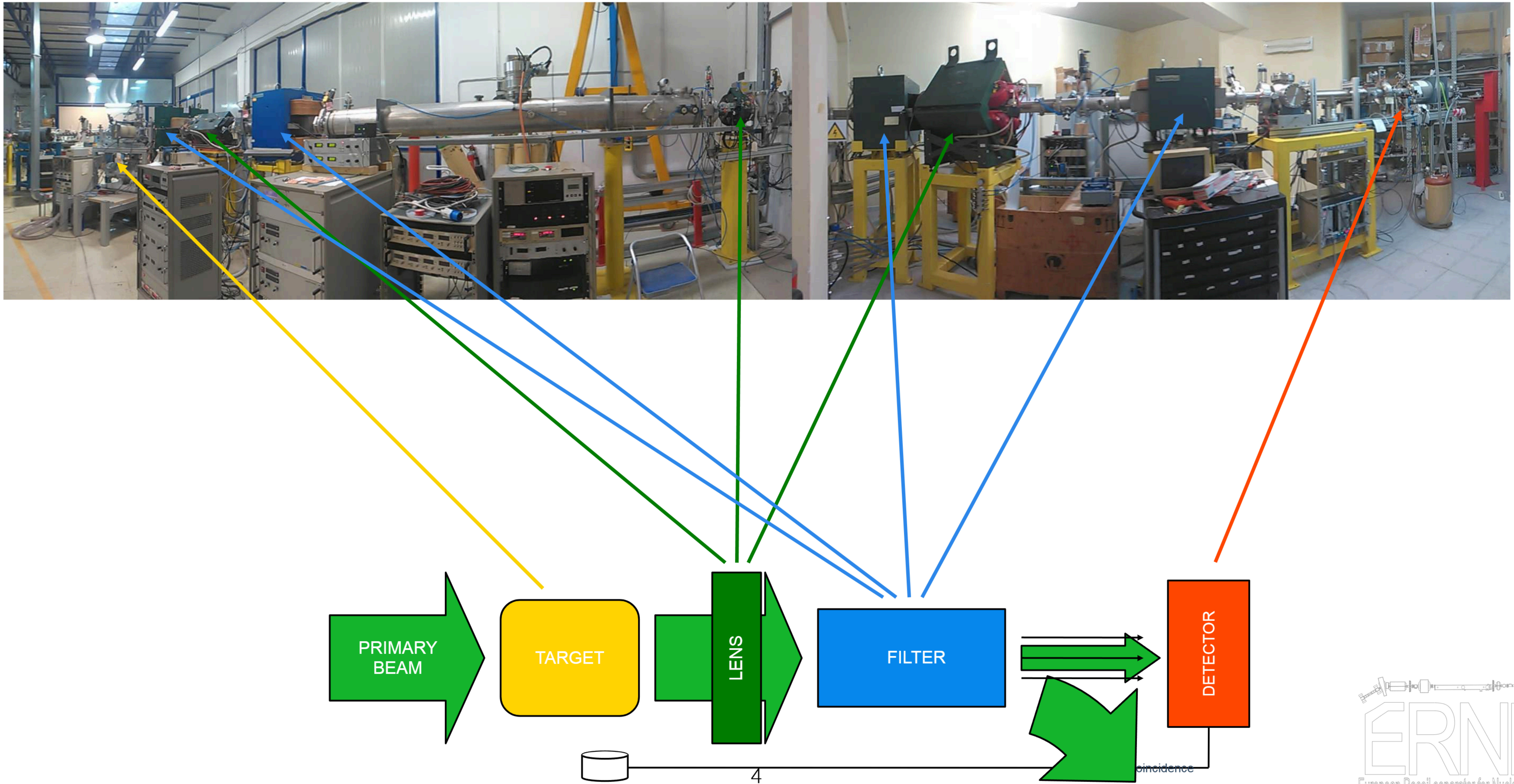
Recoil Mass Separator ERNA



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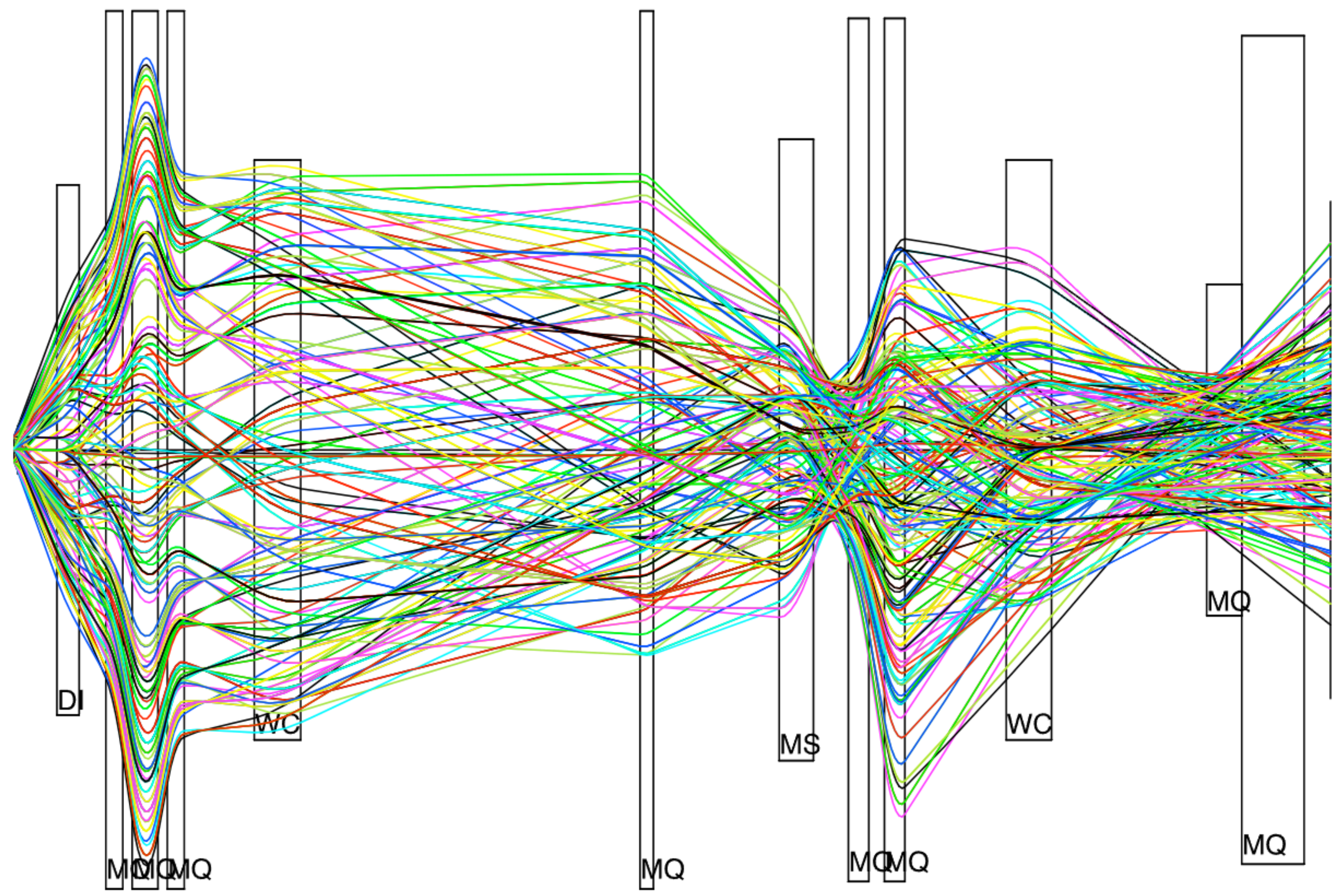
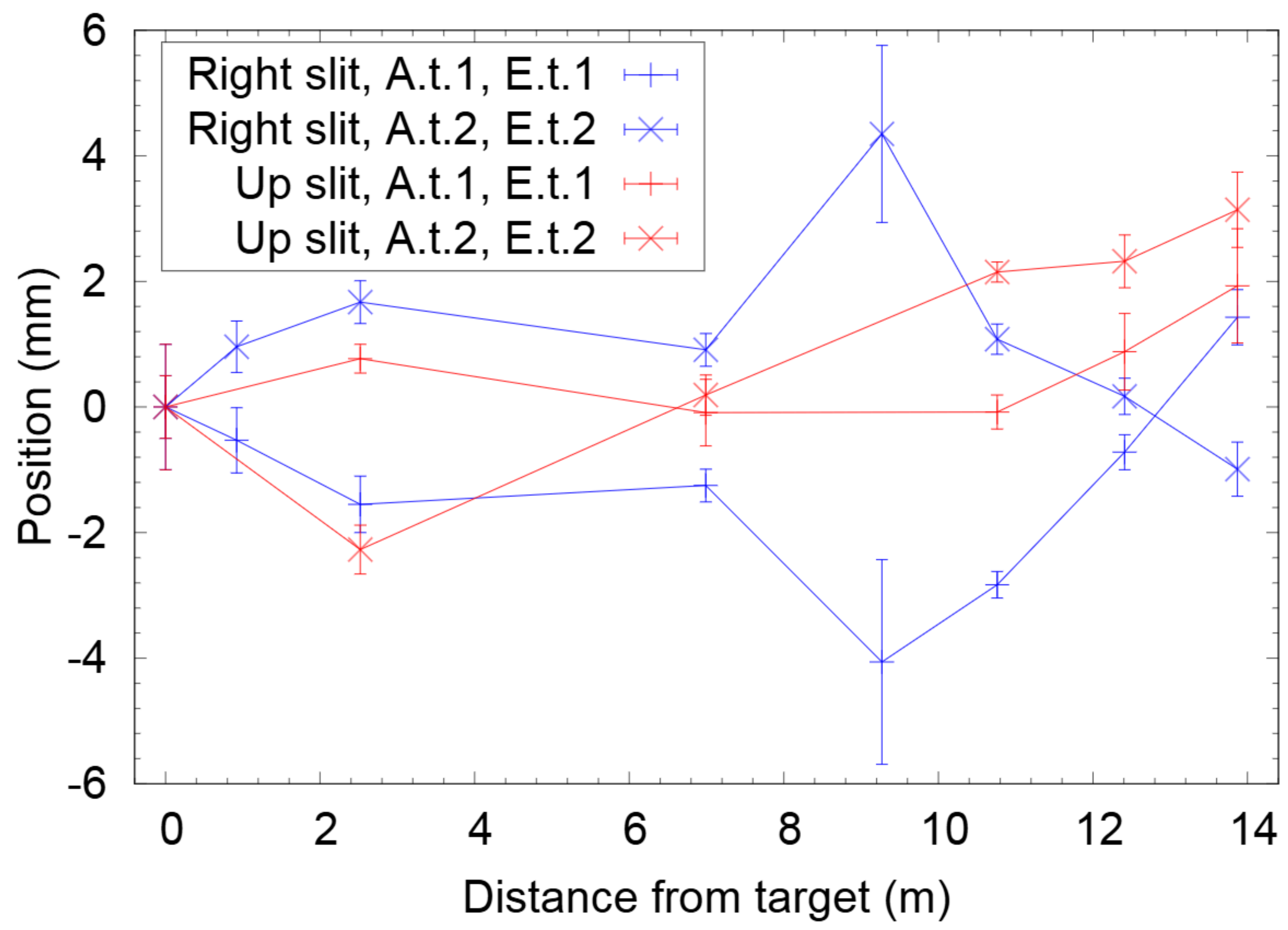
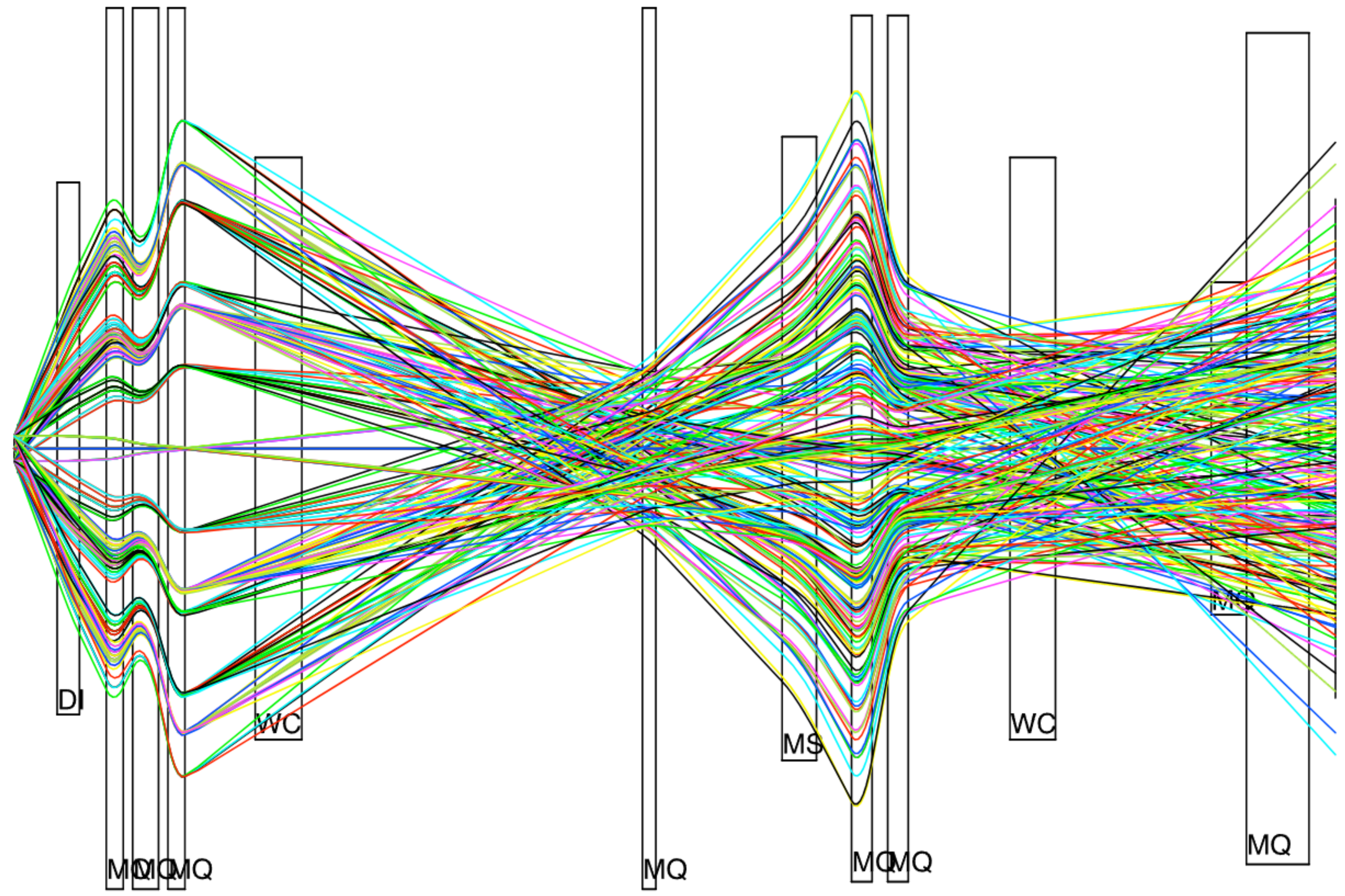
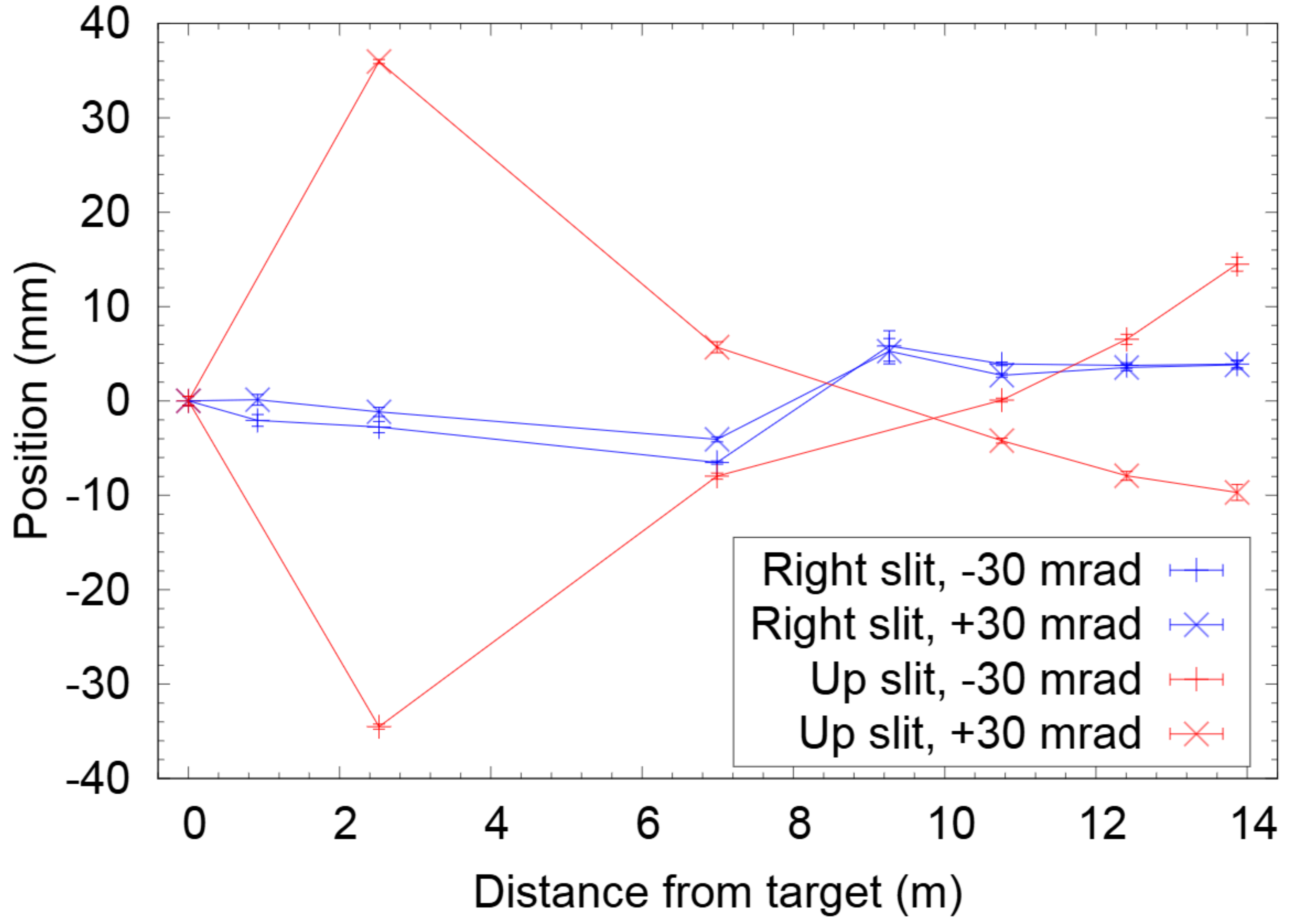
Recoils transport









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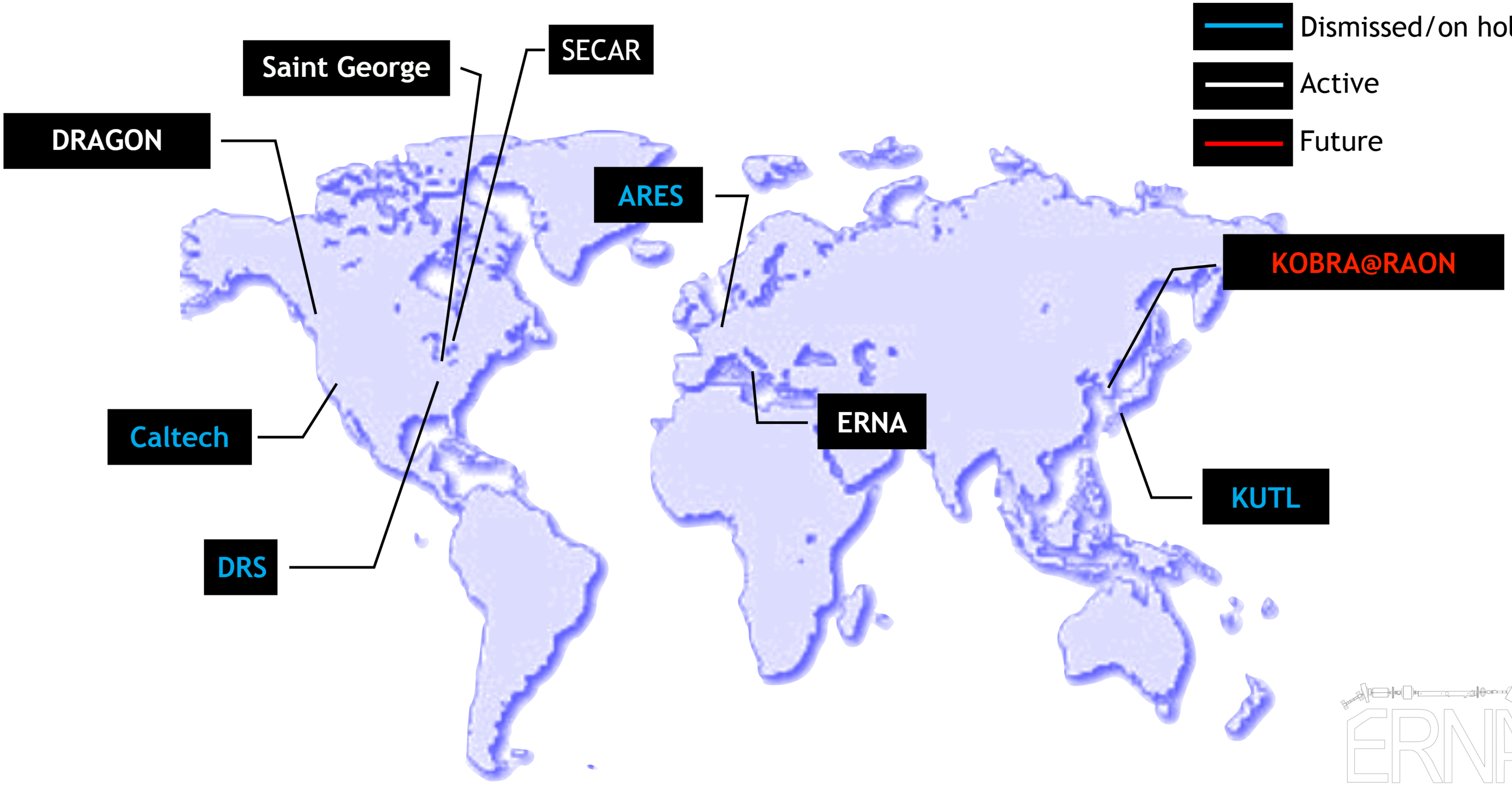
Recoil separators for Nuclear Astrophysics



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Total cross section

$$\sigma \qquad \frac{\qquad}{\phi \qquad} \quad (\qquad)$$

		typical uncertainty
	number of target atoms	**5%**
	transmission (acceptance)	1%
ϕ	charge state probability	3%
ε	detection efficiency	0.5-2%
	number of projectiles	1%
( )	number of detected recoils	2%

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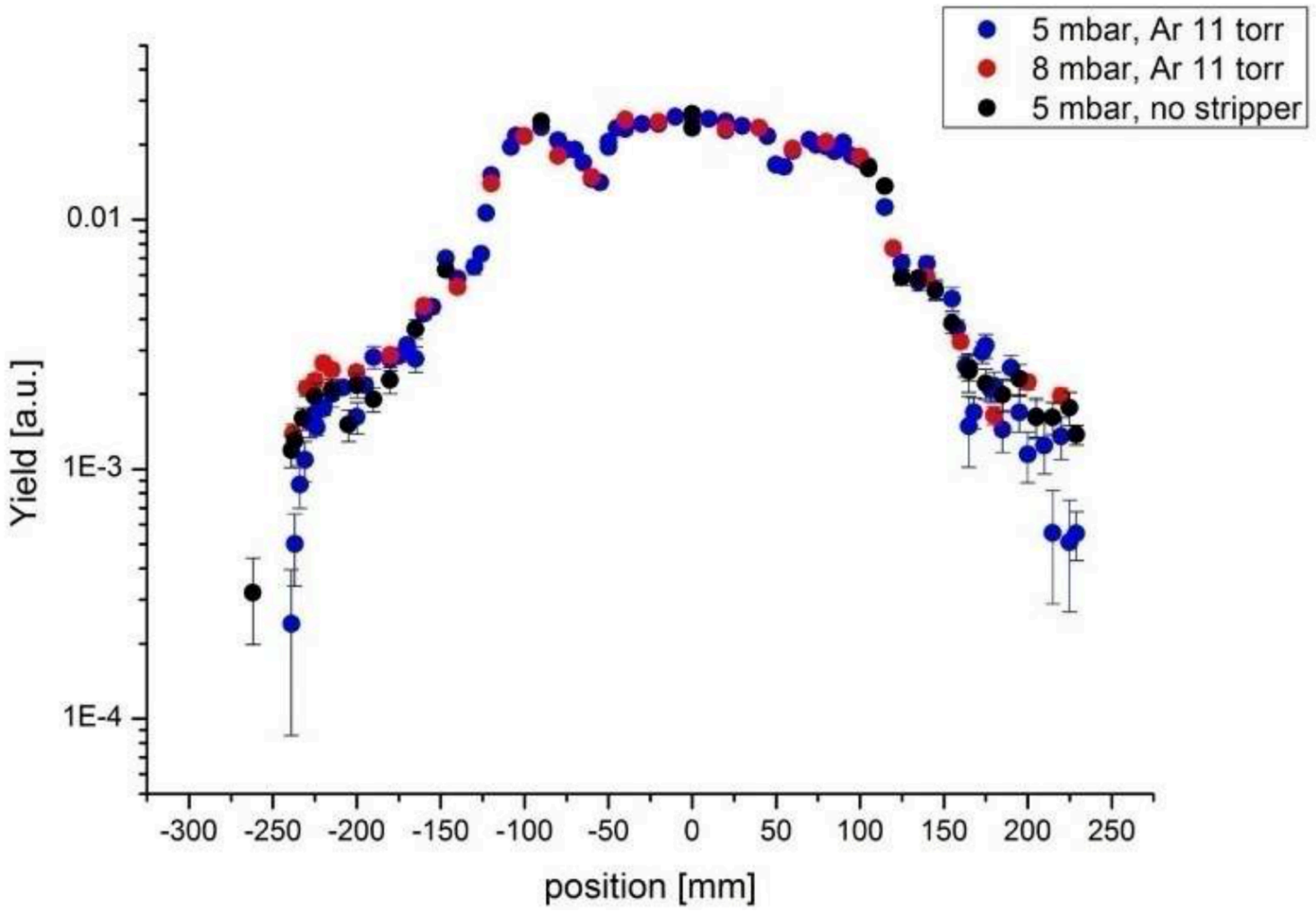
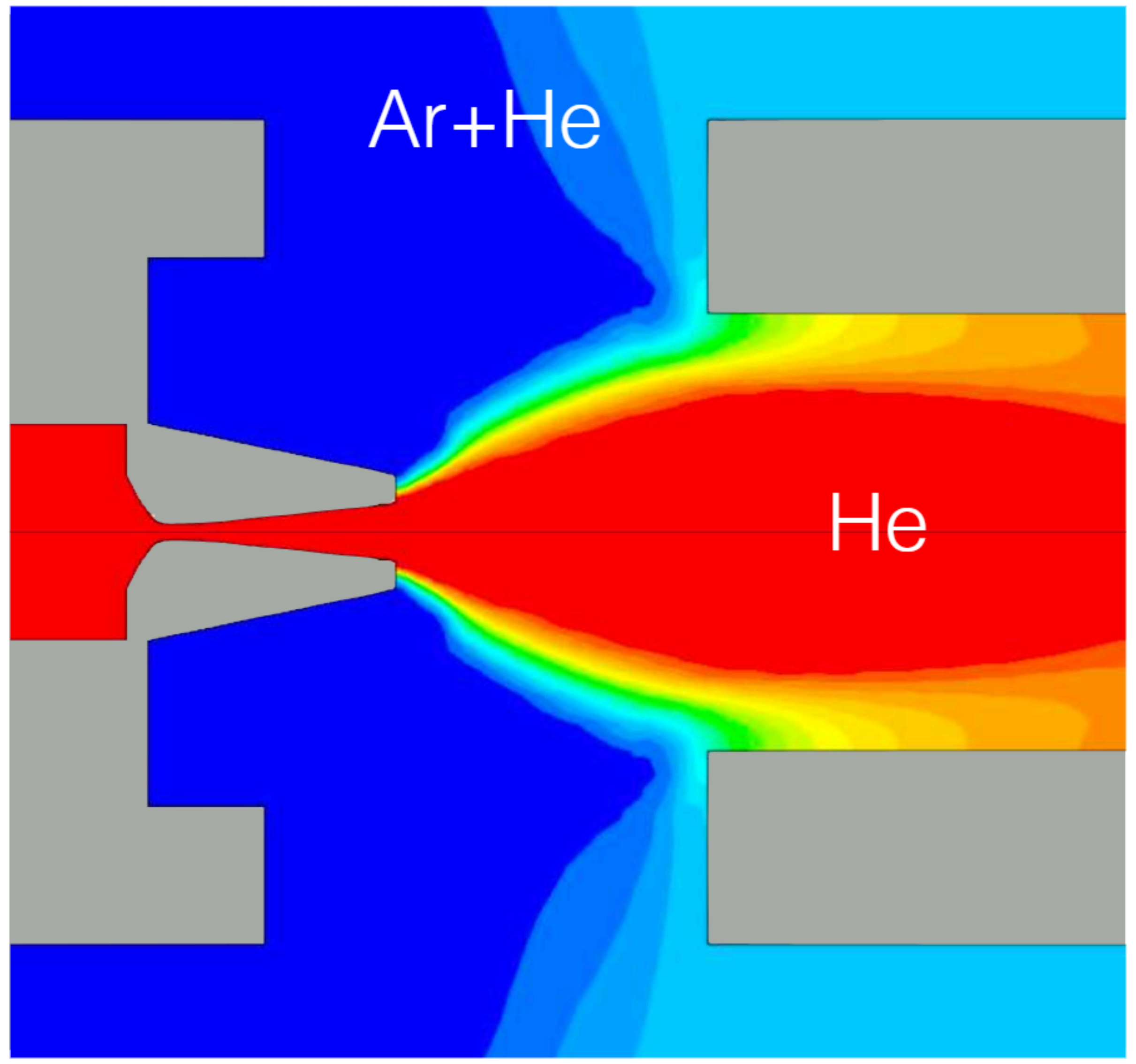
Target(s)

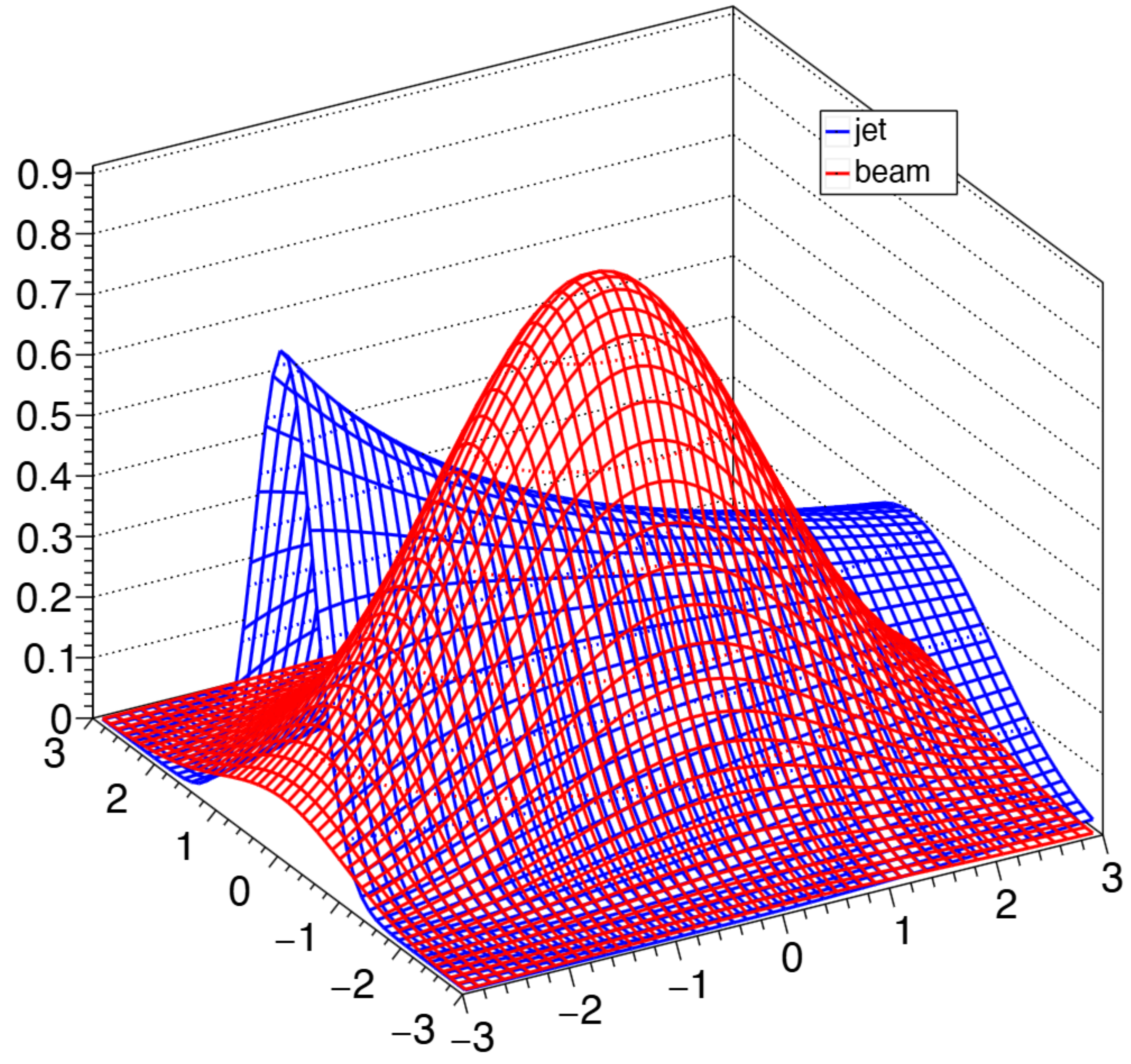
- Windowless, extended (H and He) or supersonic jet (He)
- Thickness 10^{17}-10^{18} atoms/cm^2

extended H



supersonic jet He





Total cross section

σ ——— ( )
ϕ

typical uncertainty

number of target atoms 5%

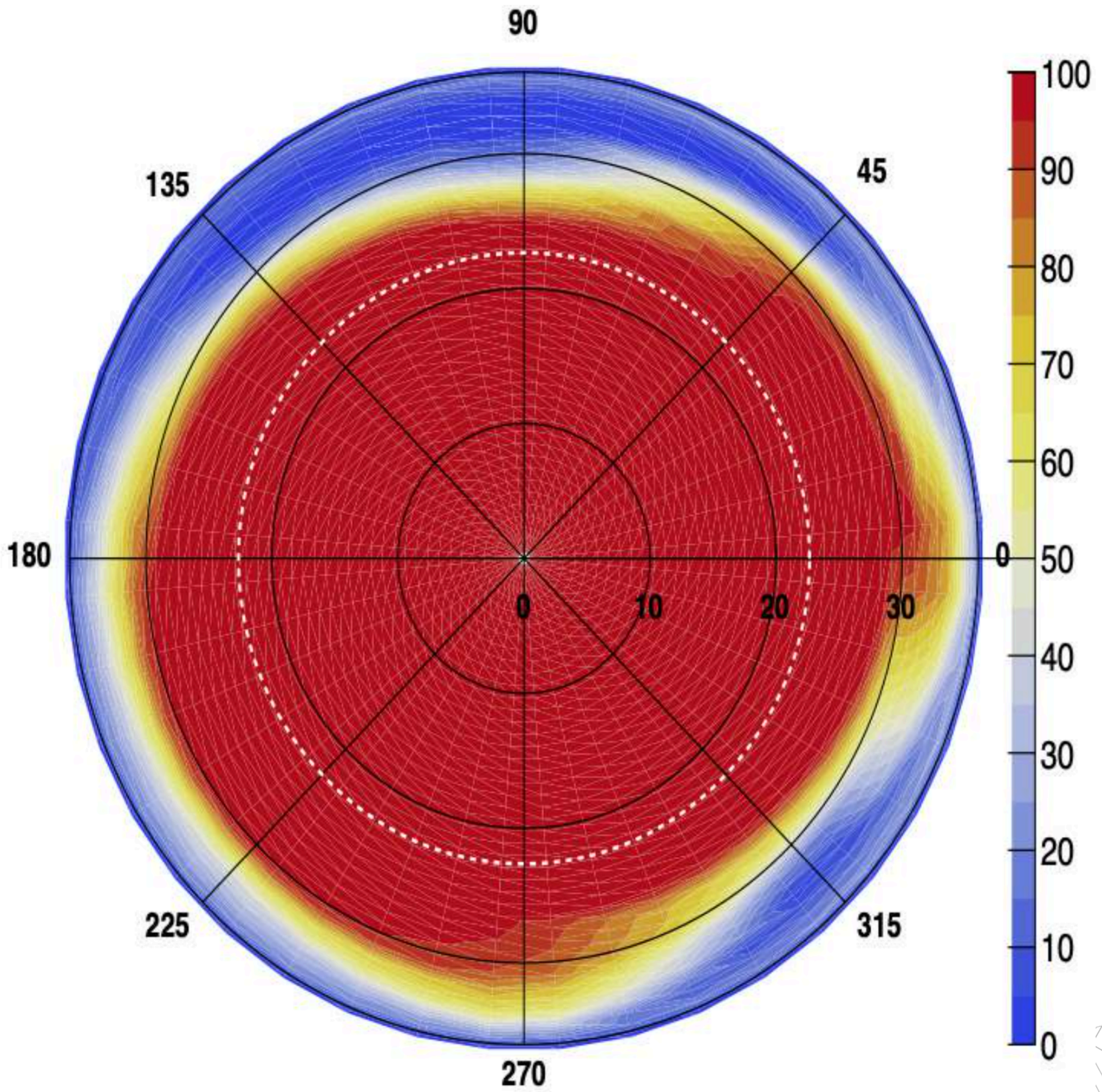
transmission (acceptance) 1%

ϕ charge state probability 3%

ε detection efficiency 0.5-2%

number of projectiles 1%

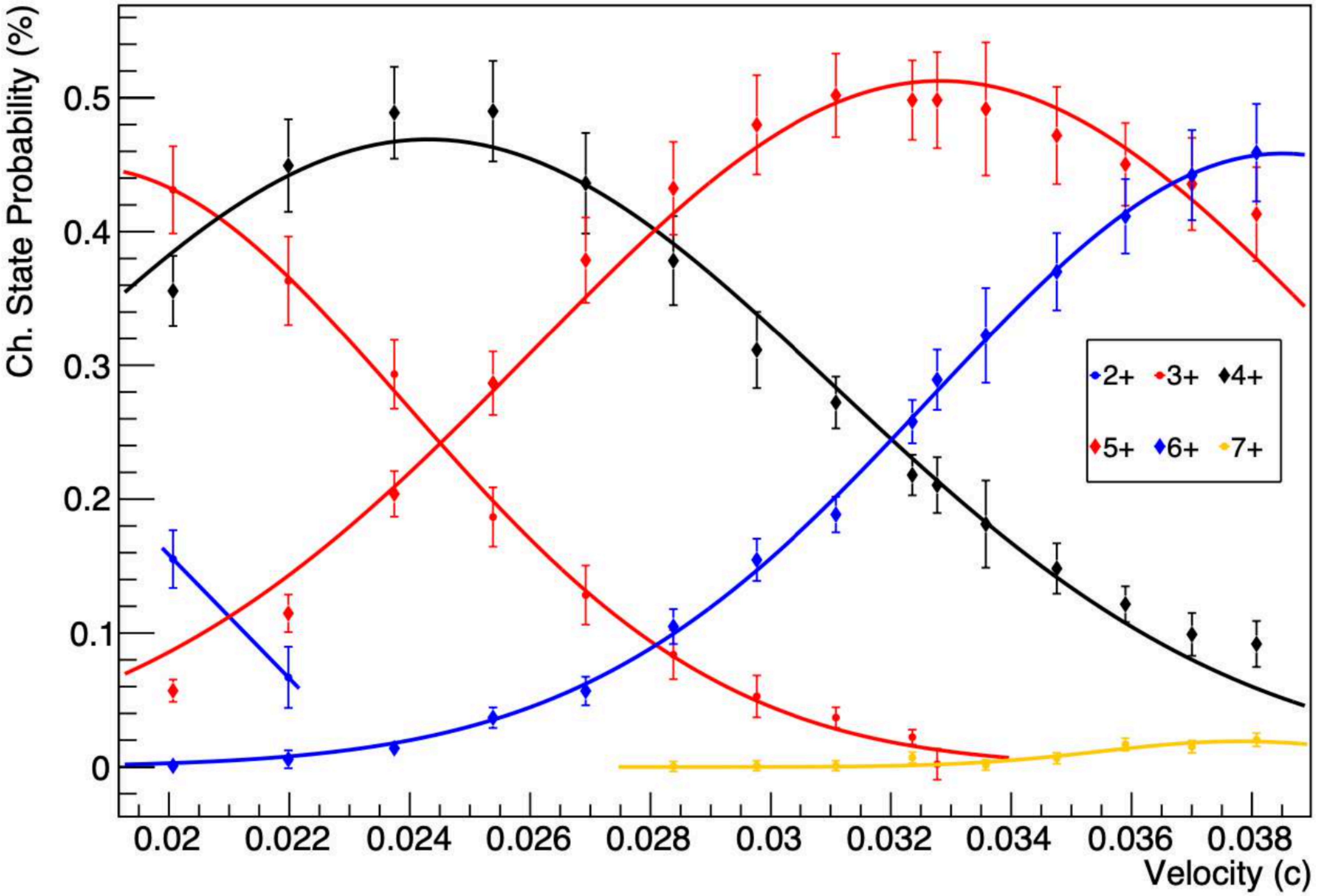
( ) number of detected recoils 2%



Total cross section

σ $\overline{\quad\quad}$ ( )
ϕ

		typical uncertainty
	number of target atoms	5%
	transmission (acceptance)	1%
ϕ	**charge state probability**	**3%**
ε	detection efficiency	0.5-2%
	number of projectiles	1%
( )	number of detected recoils	2%



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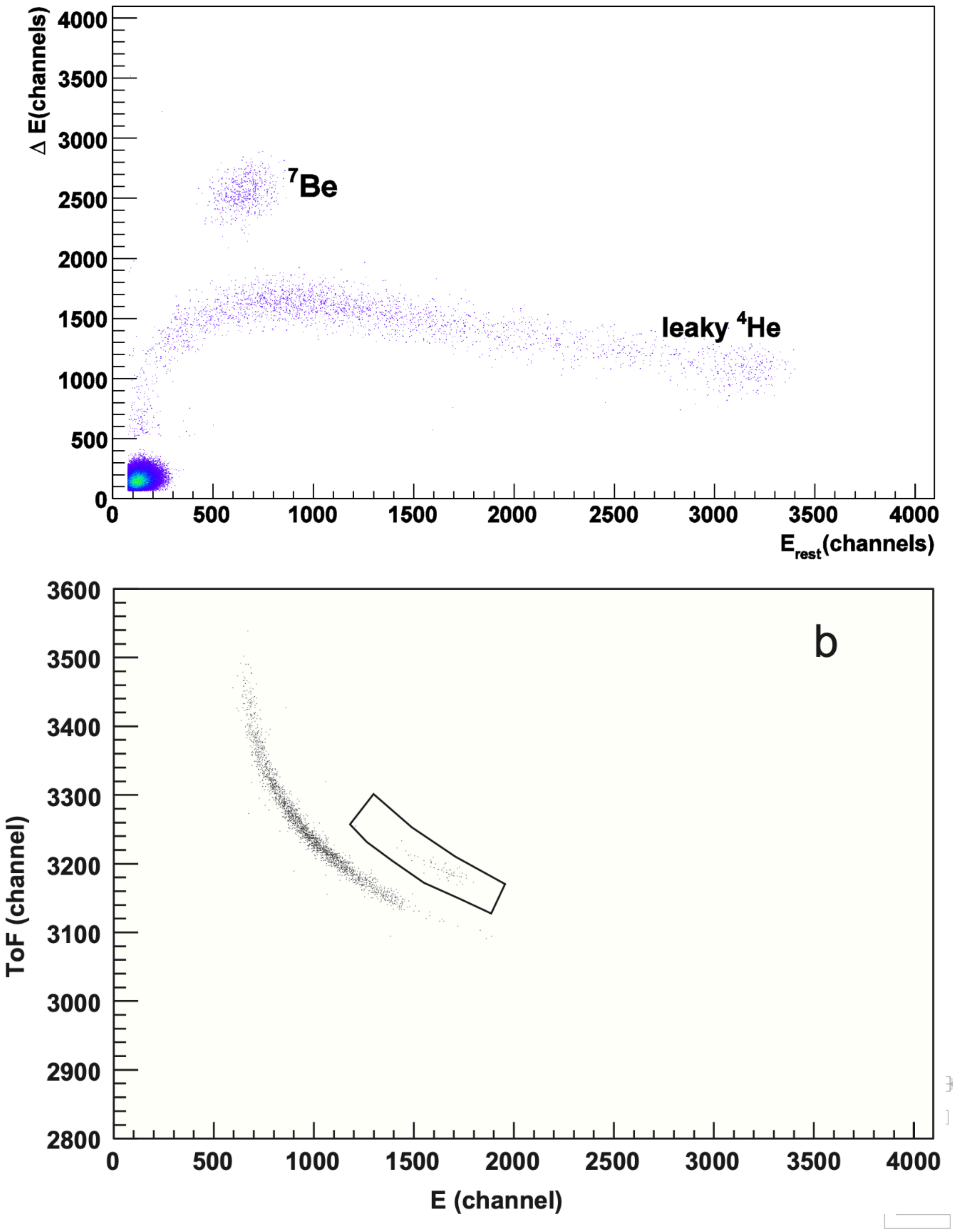
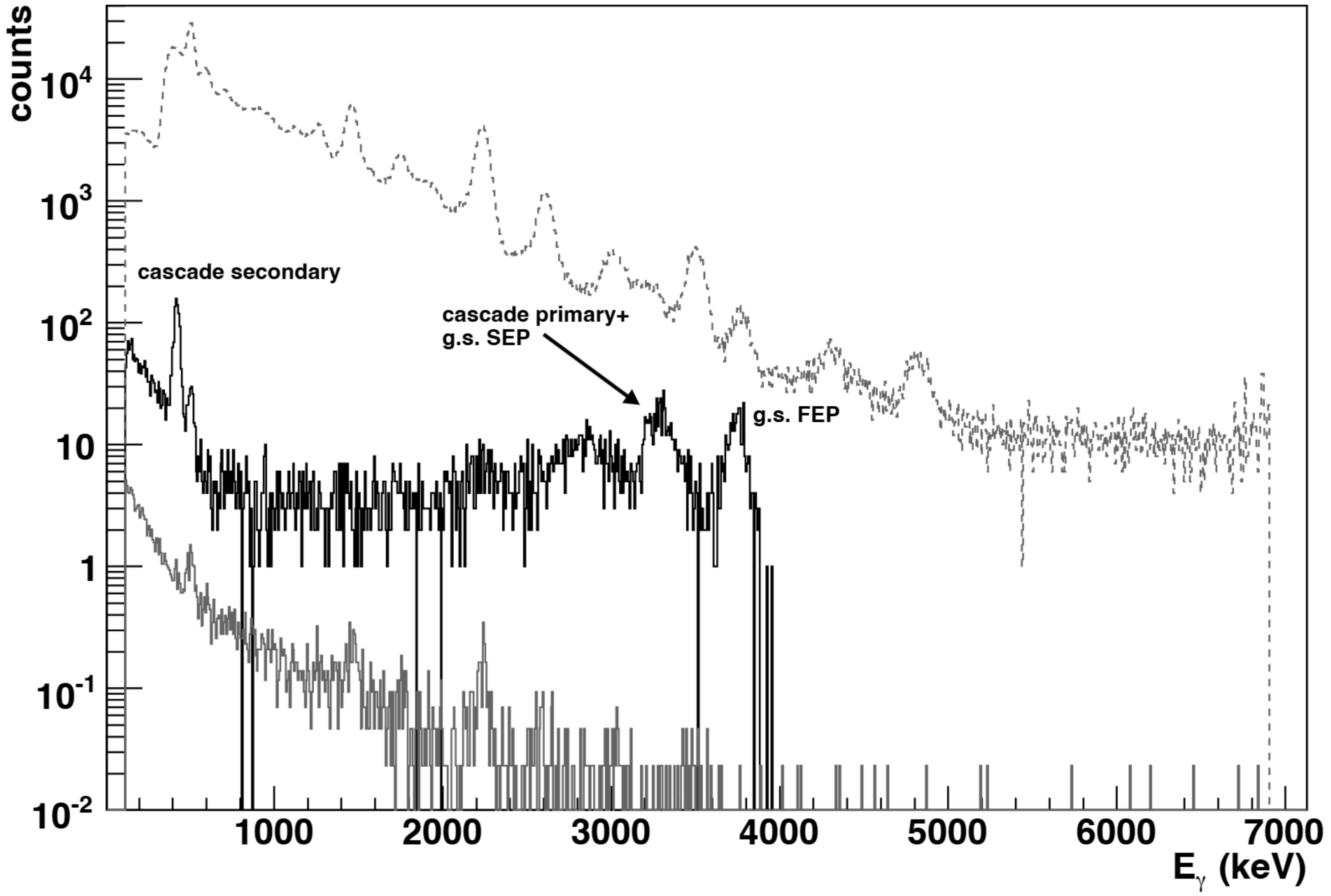
Total cross section

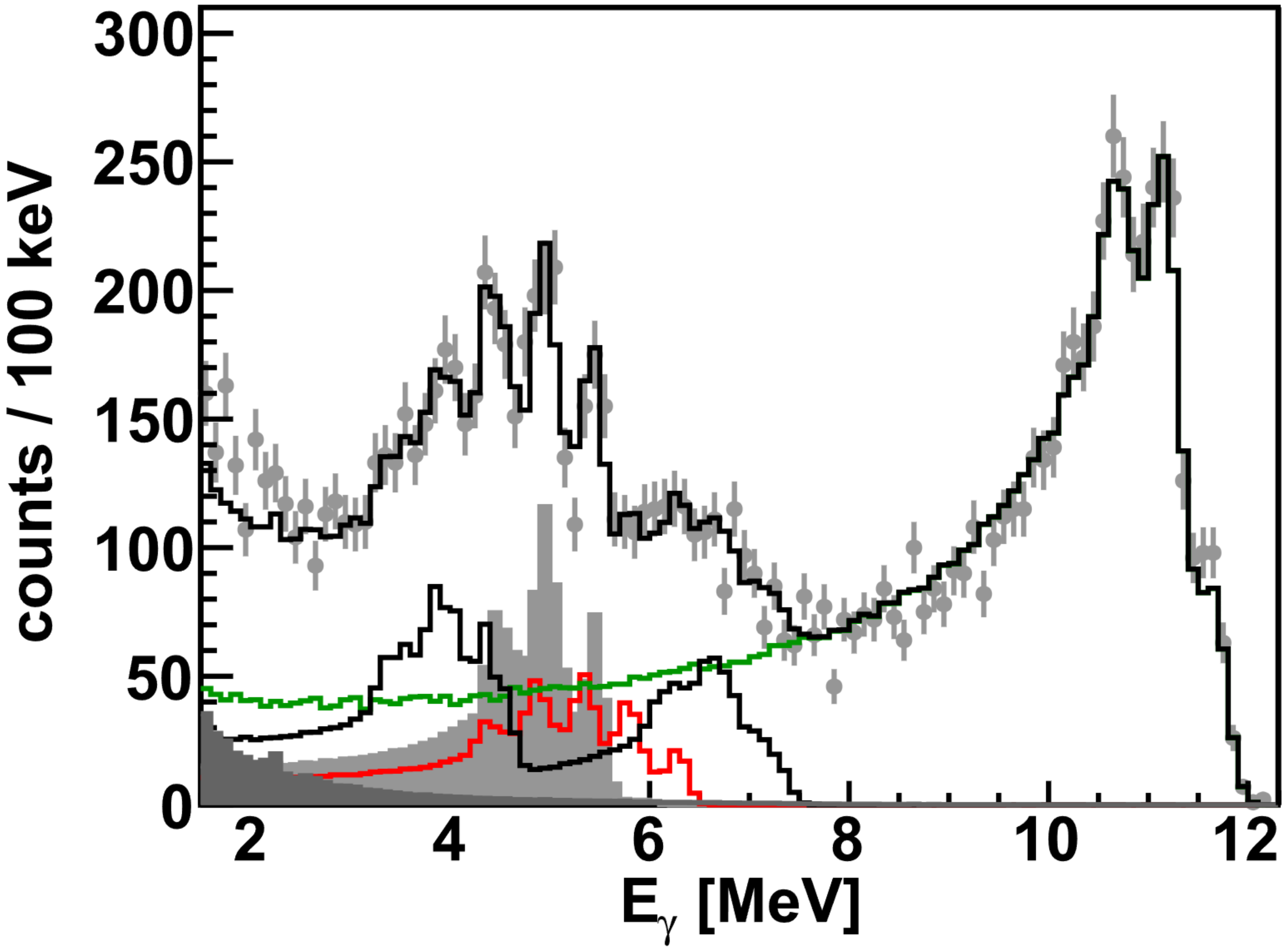
σ — ϕ ( )

		typical uncertainty
	number of target atoms	5%
	transmission (acceptance)	1%
ϕ	charge state probability	3%
ε	**detection efficiency**	**0.5-2%**
	number of projectiles	1%
( )	number of detected recoils	2%



γ-ray measurements





Di Leva et al., NIM A 595 (2008) and Schürmann et al., PLB 703 (2011)

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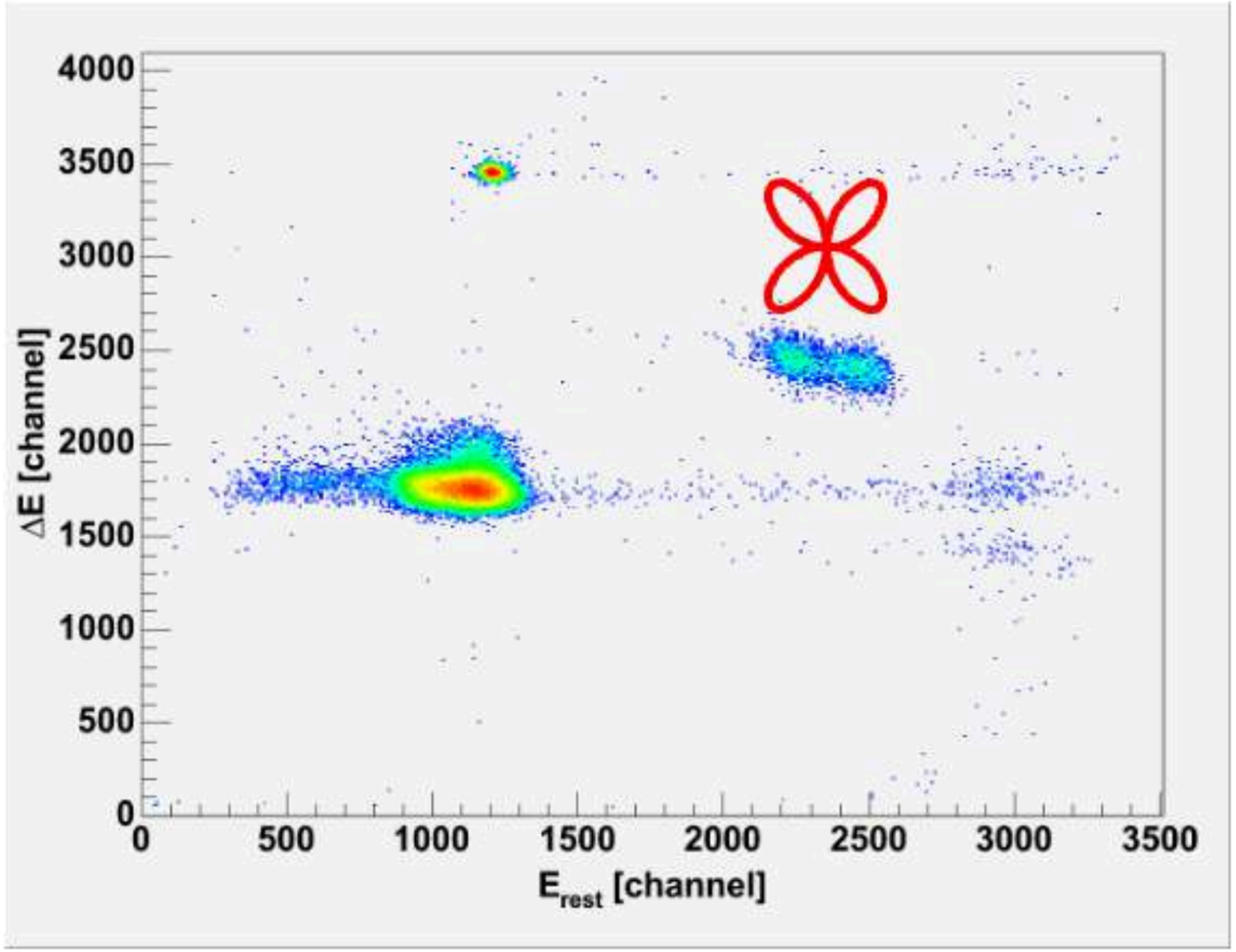
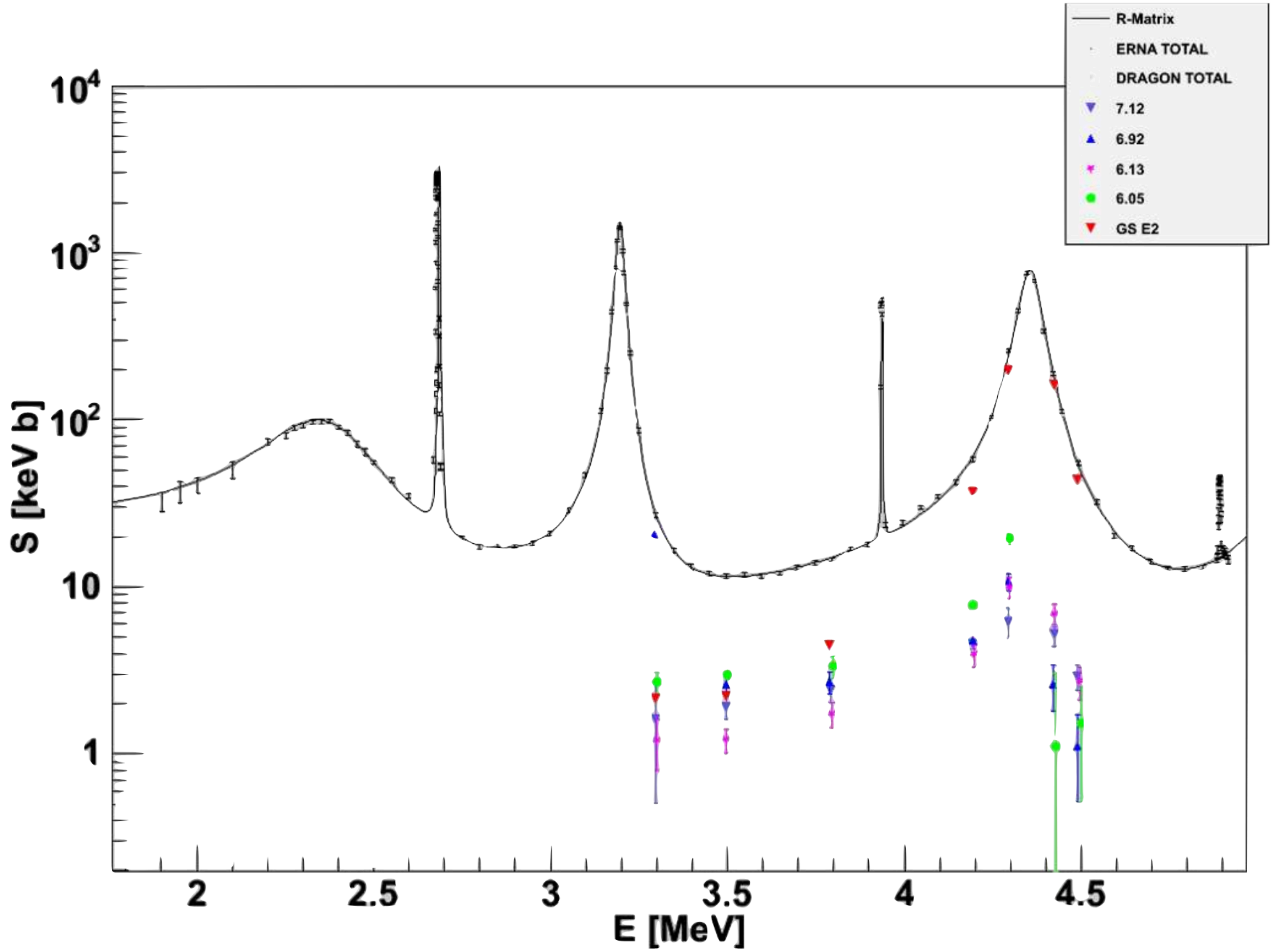
PAST

α γ





Schürmann et al., Eur. Phys. J. A 26(2005)
Schürmann et al., Phys.Lett. B 703(2011)

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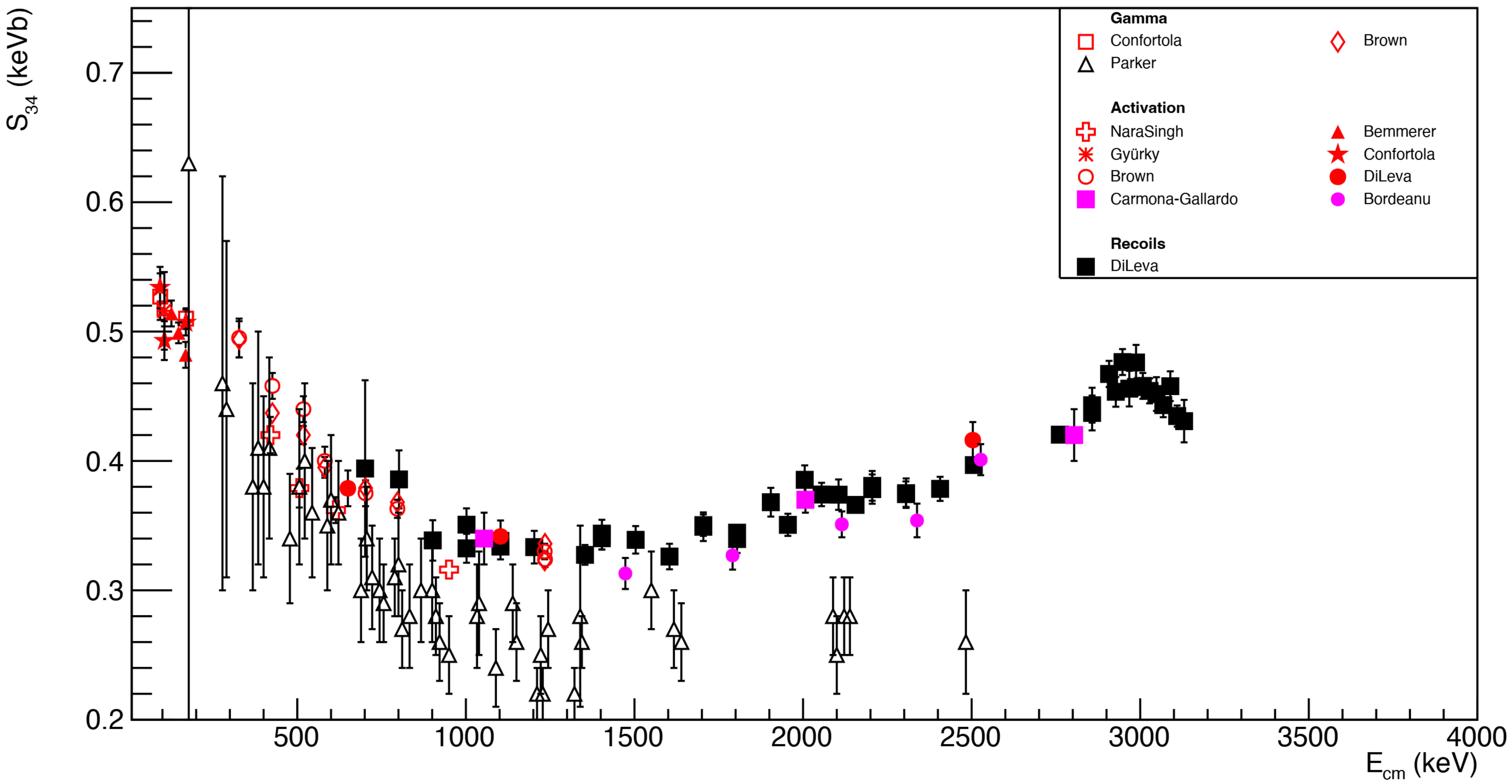
α γ



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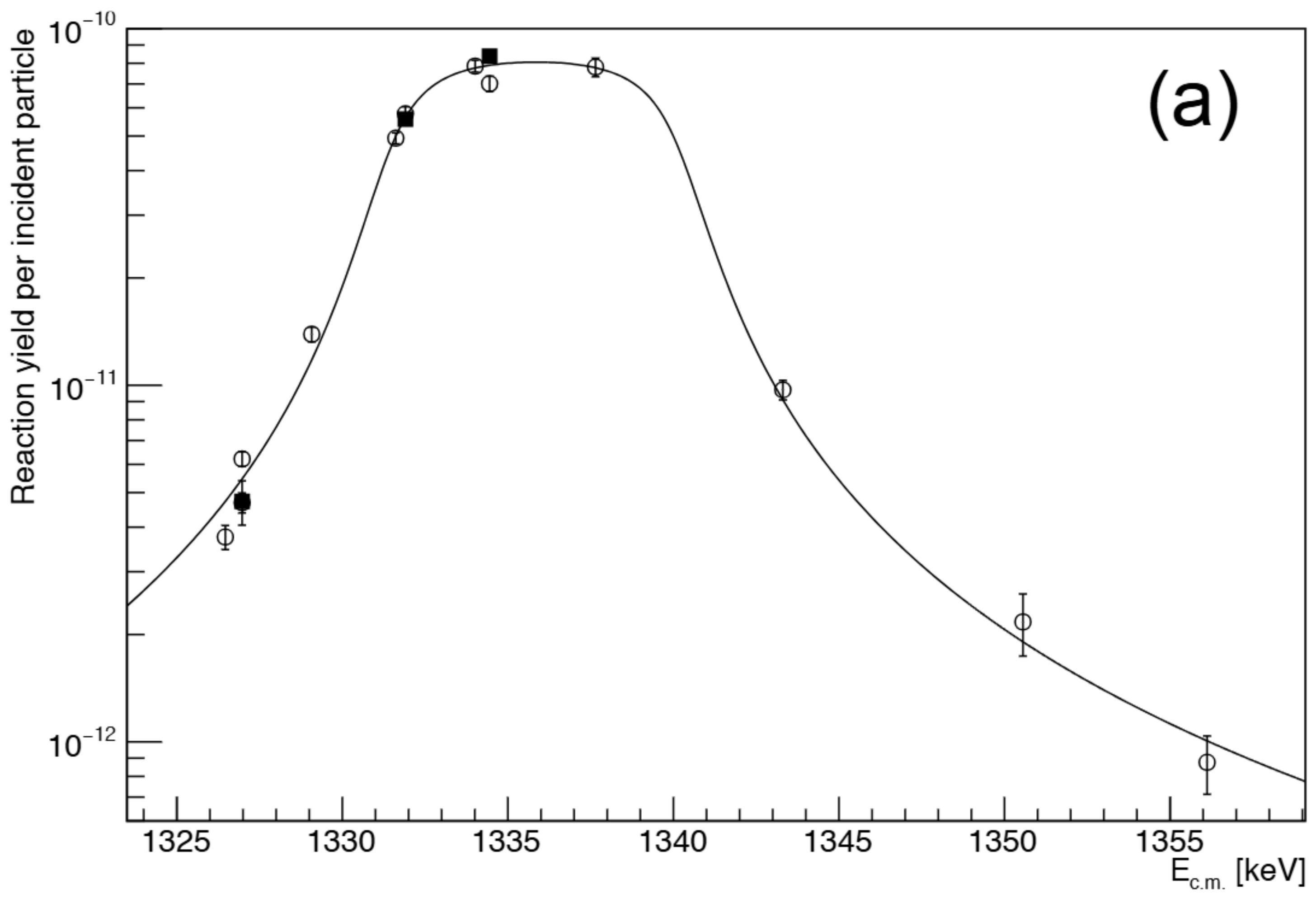
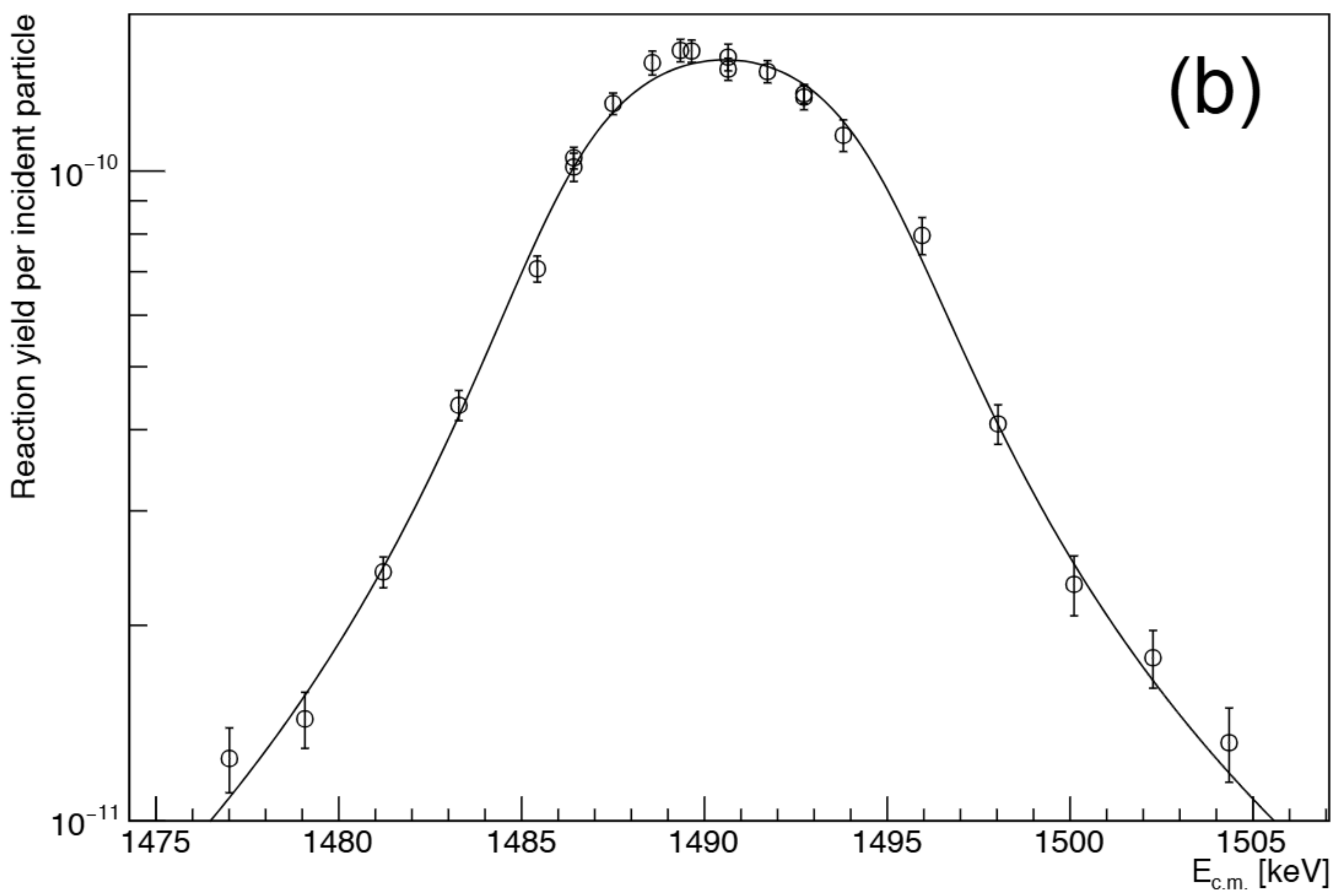
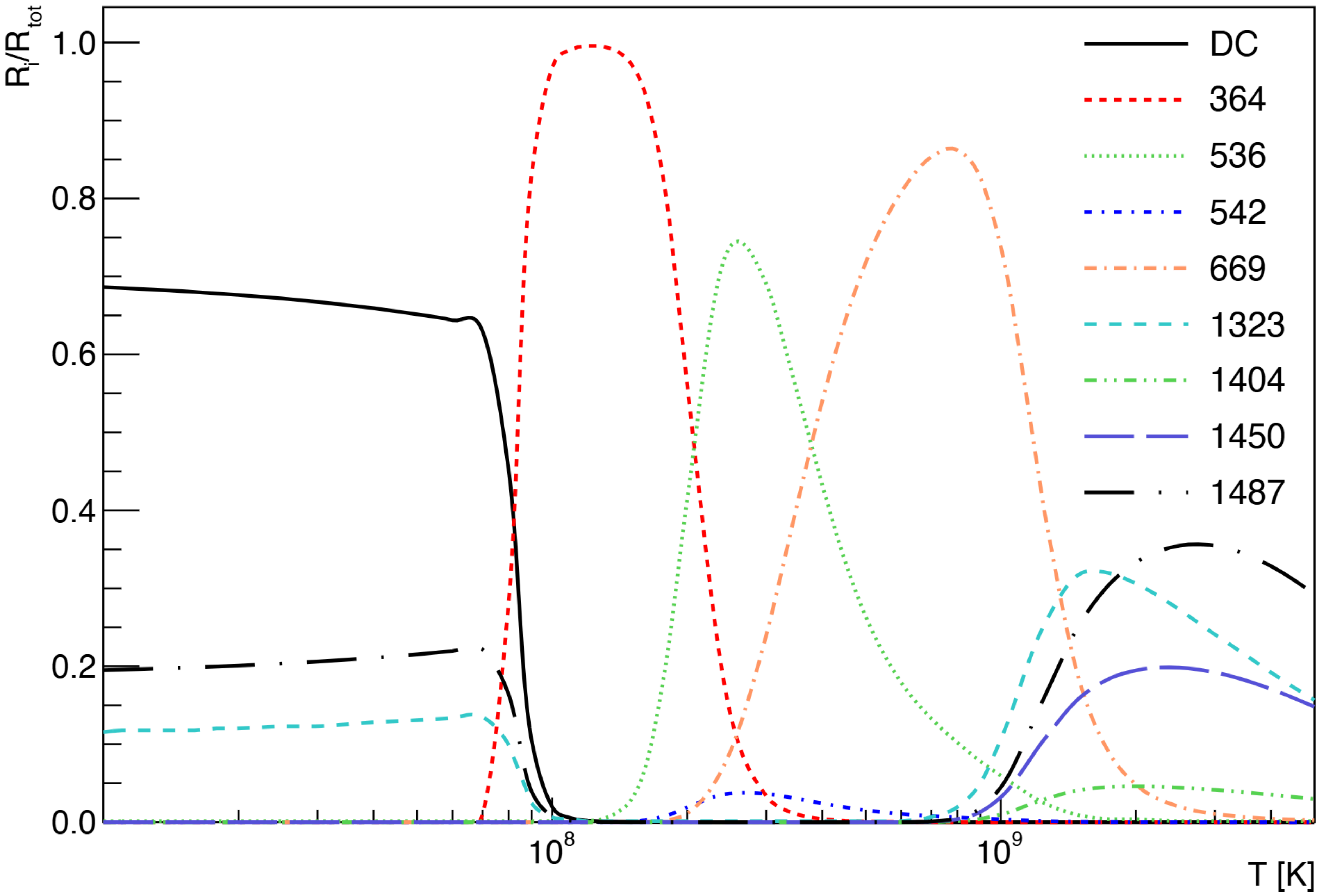
α γ



$\Gamma_\gamma = (1.62\pm0.09)$eV
$\Gamma_\alpha = (2.51\pm0.10)$keV



$\Gamma_\gamma = (2.2\pm0.2)$eV
$\Gamma_\alpha = (6.0\pm0.3)$keV



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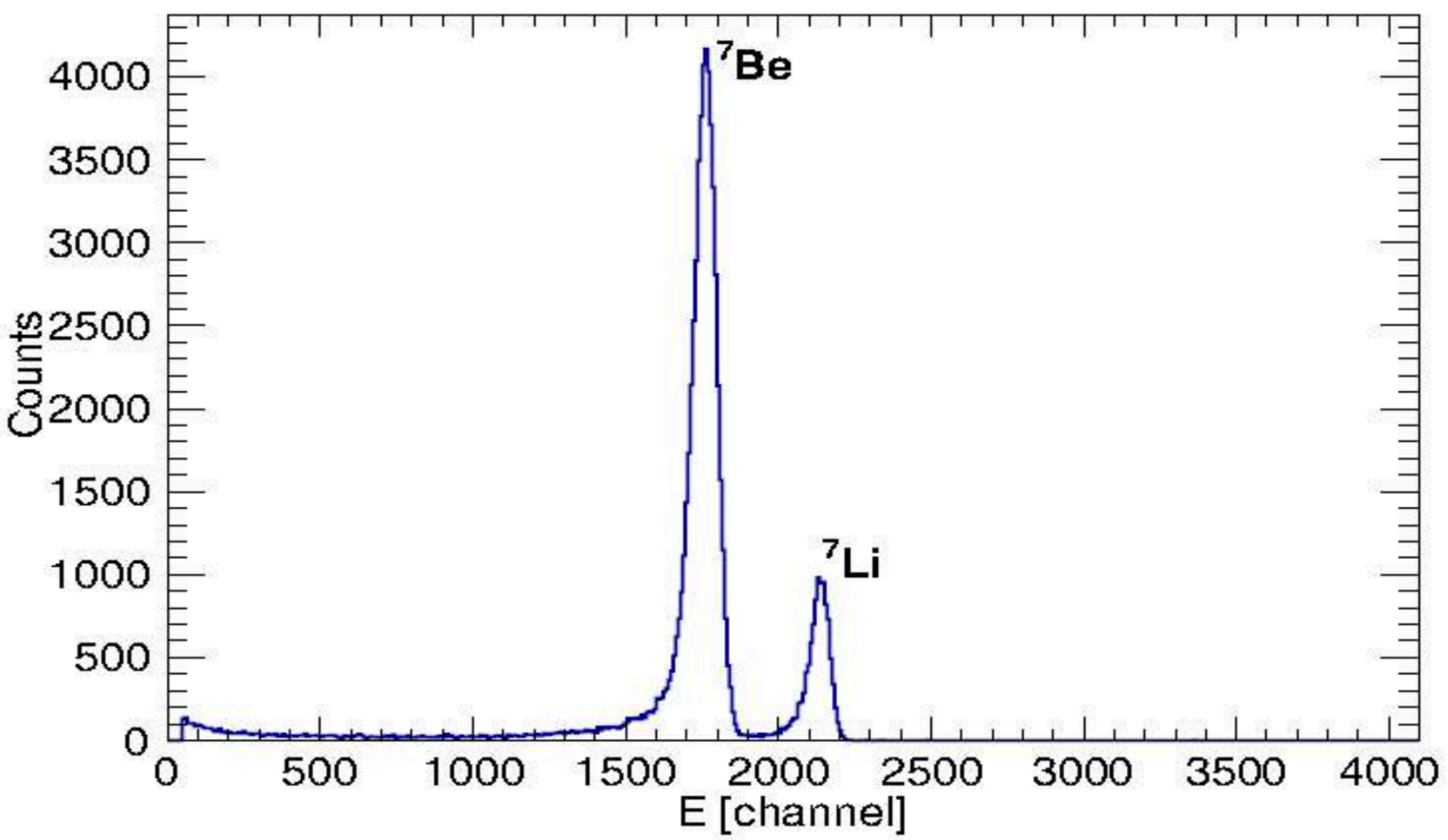
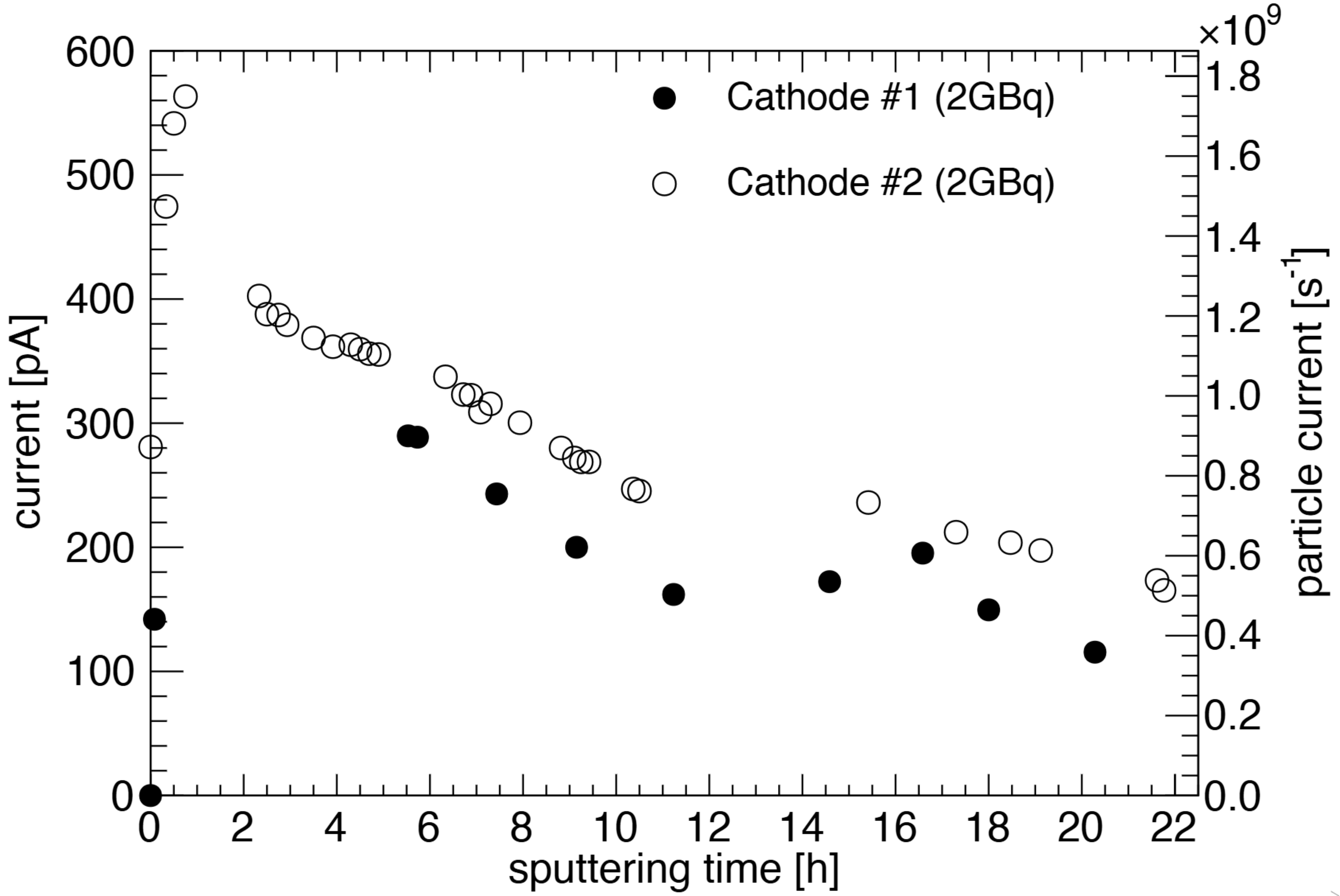
γ

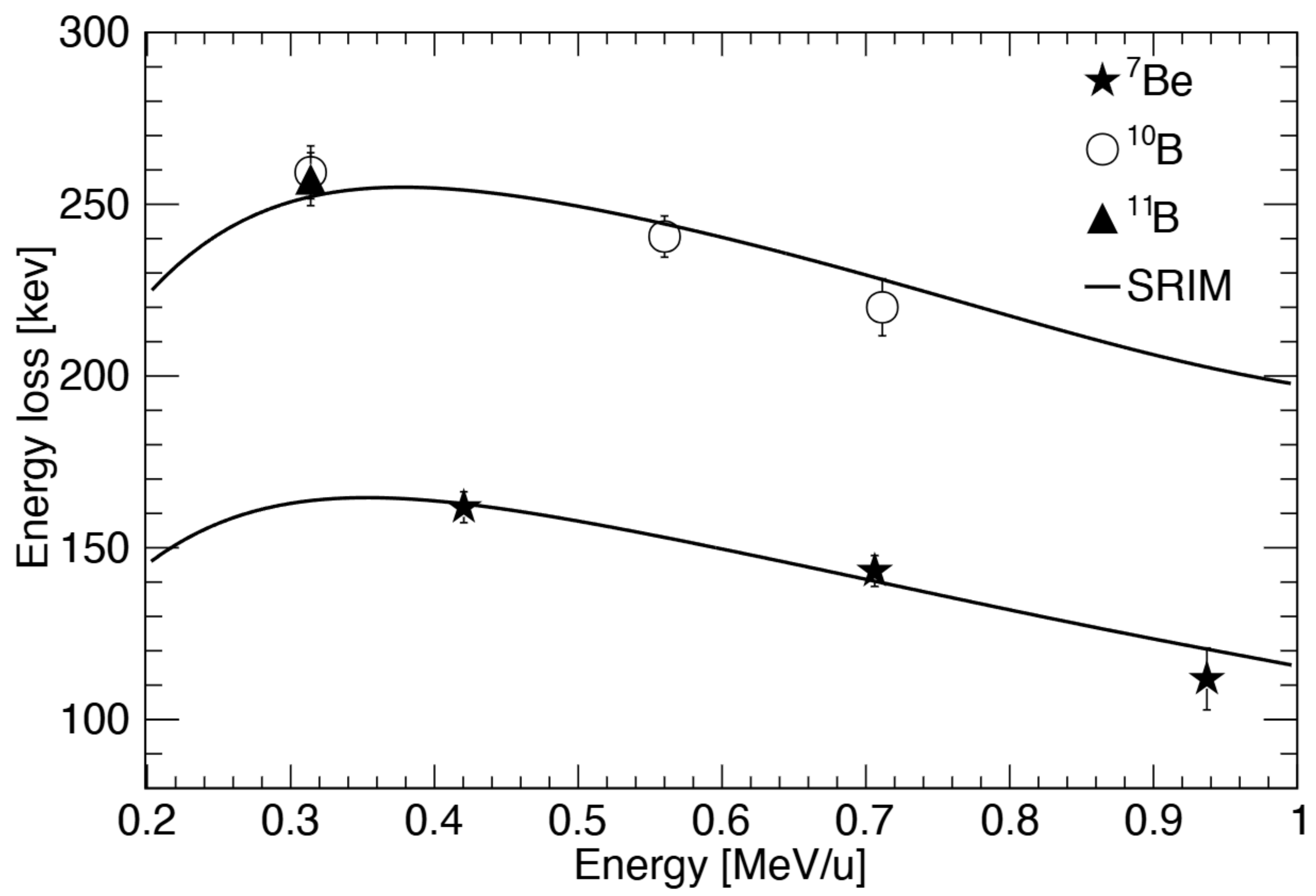
A RI beam, with a limited contamination, is routinely produced at CIRCE, intensities up to 10^9 are reached

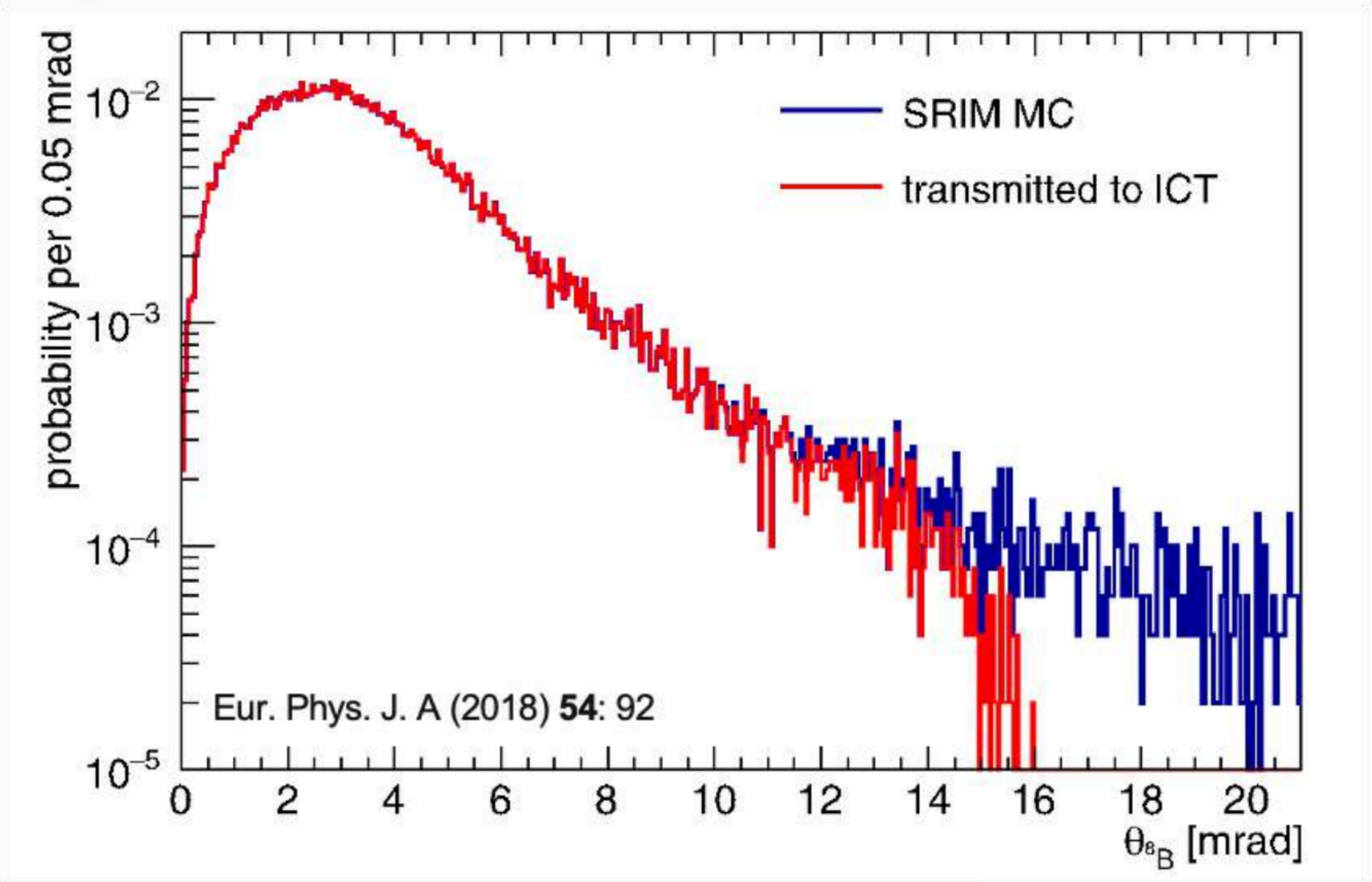


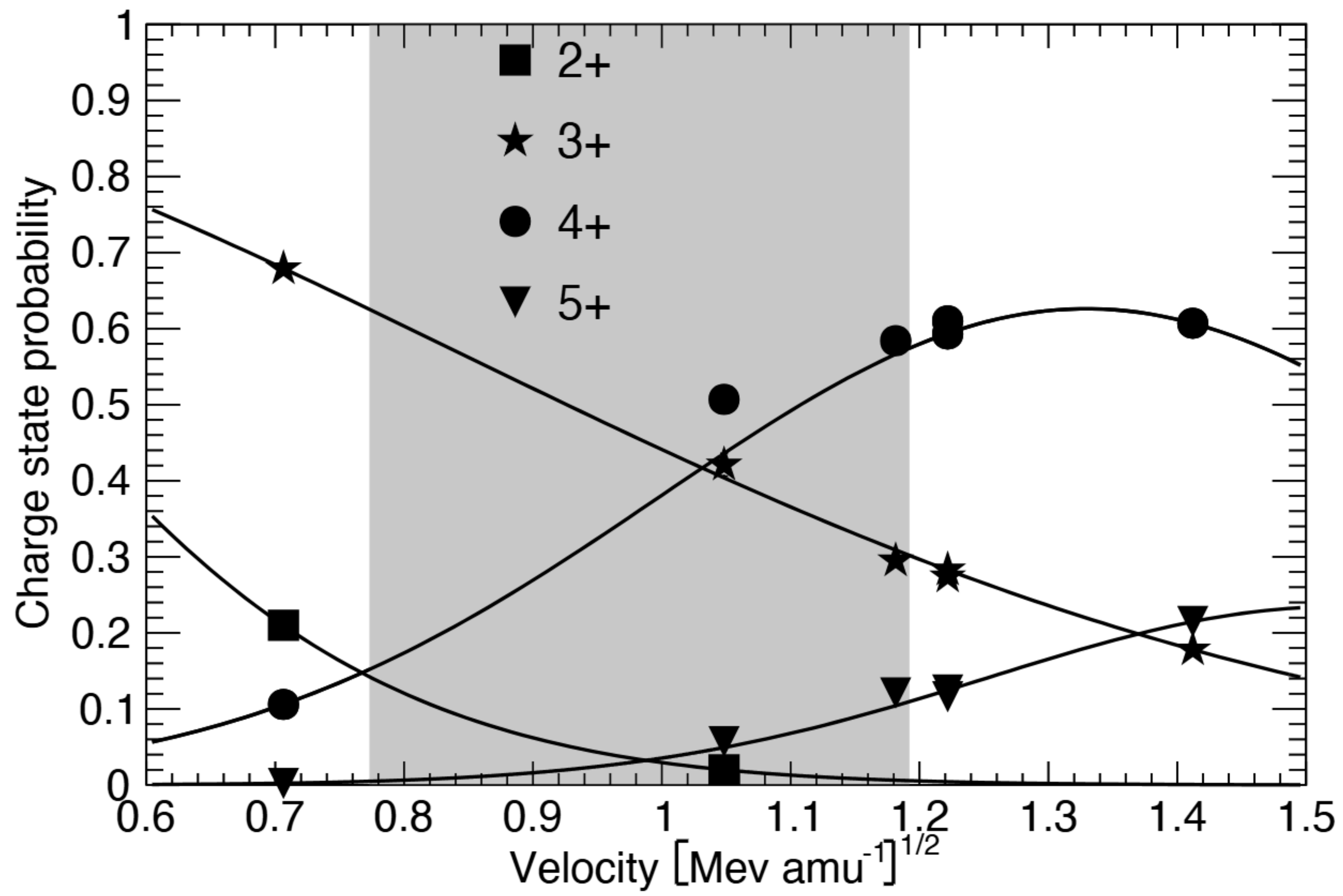


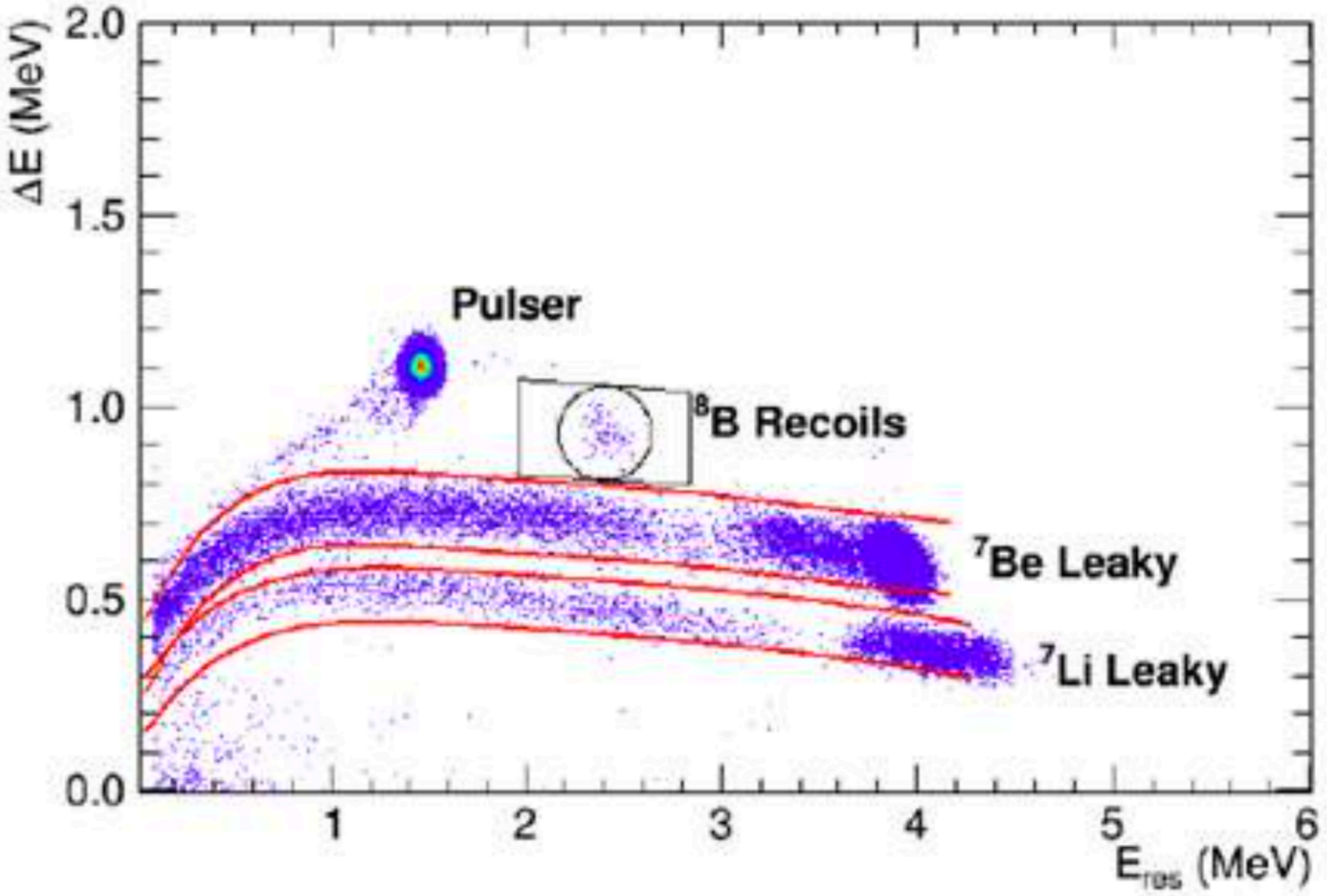
Buompane et al. Eur. Phys. J. A 54(2018) and Buompane et al., Phys.Lett. B 824(2022)

ERNA European Recoil separator for Nuclear Astrophysics γ









Buompane et al. Eur. Phys. J. A 54(2018) and Buompane et al., Phys.Lett. B 824(2022)

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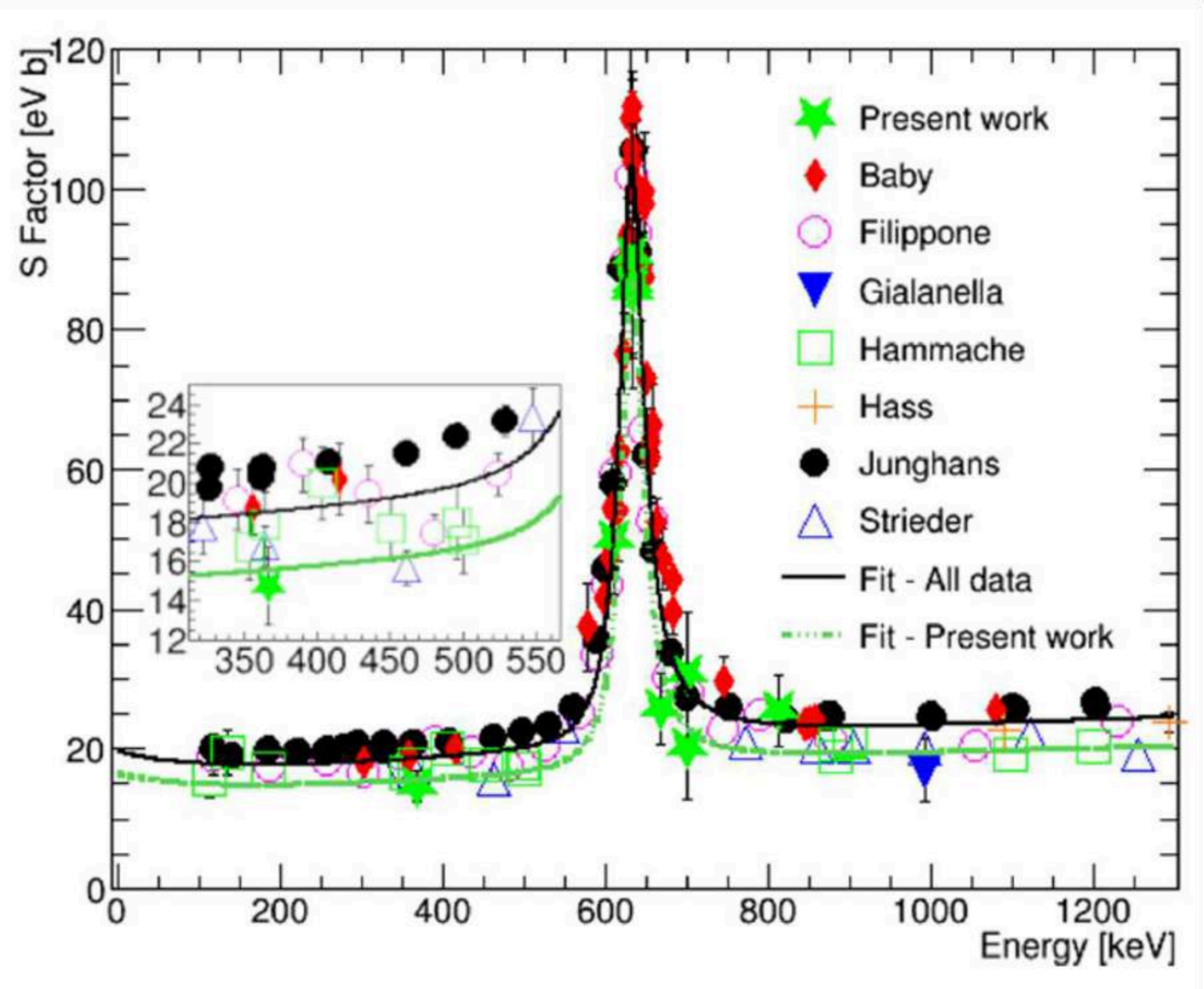
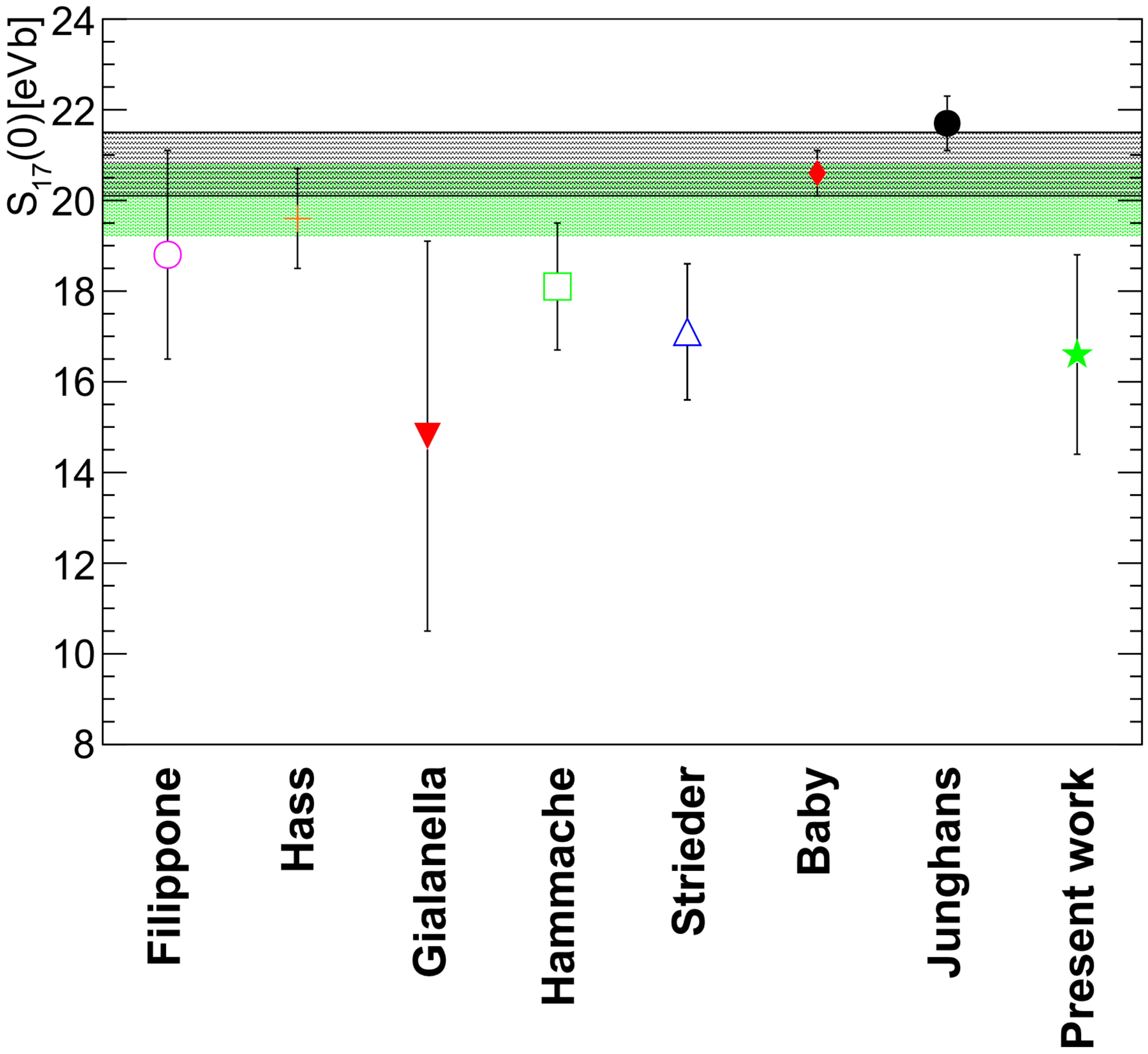
γ

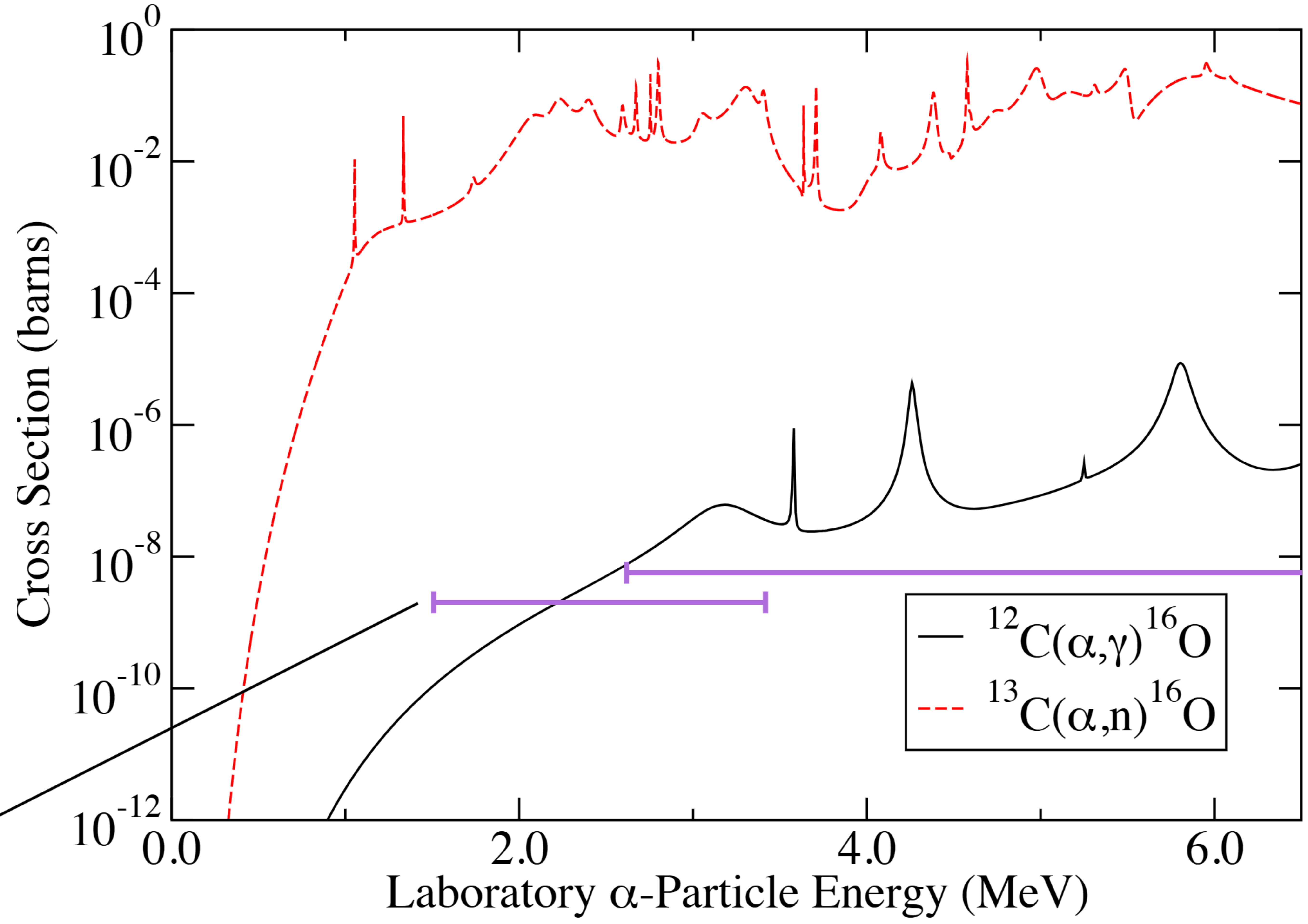




Buompane et al., Phys.Lett. B 824(2022)

PRESENT

α γ



ERNA past campaign measurement range

ERNA present campaign measurement range, **γ**-ray angular distributions at selected energies

deBoer et al., Rev. Mod. Phys. 89 (2017)

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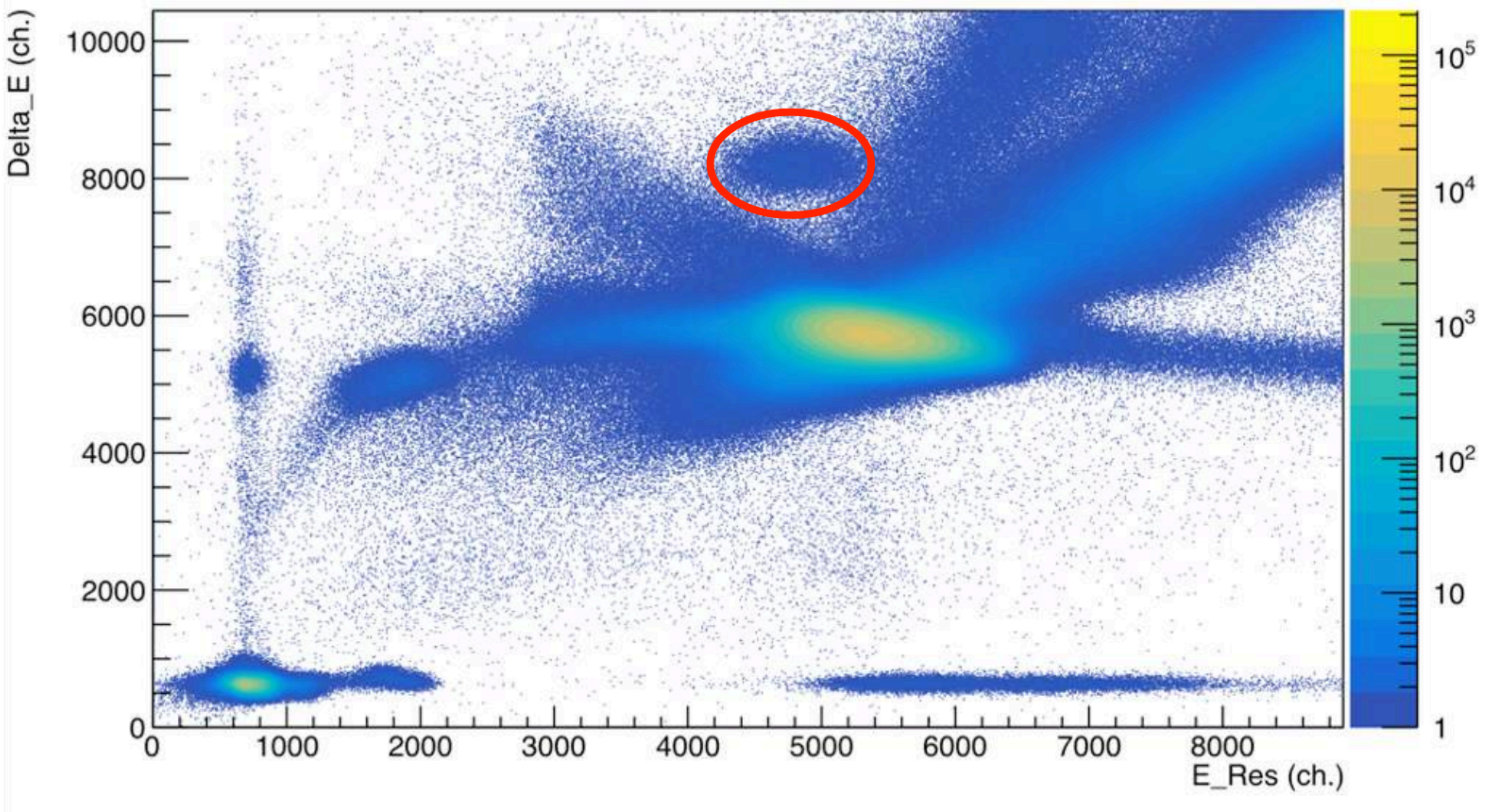
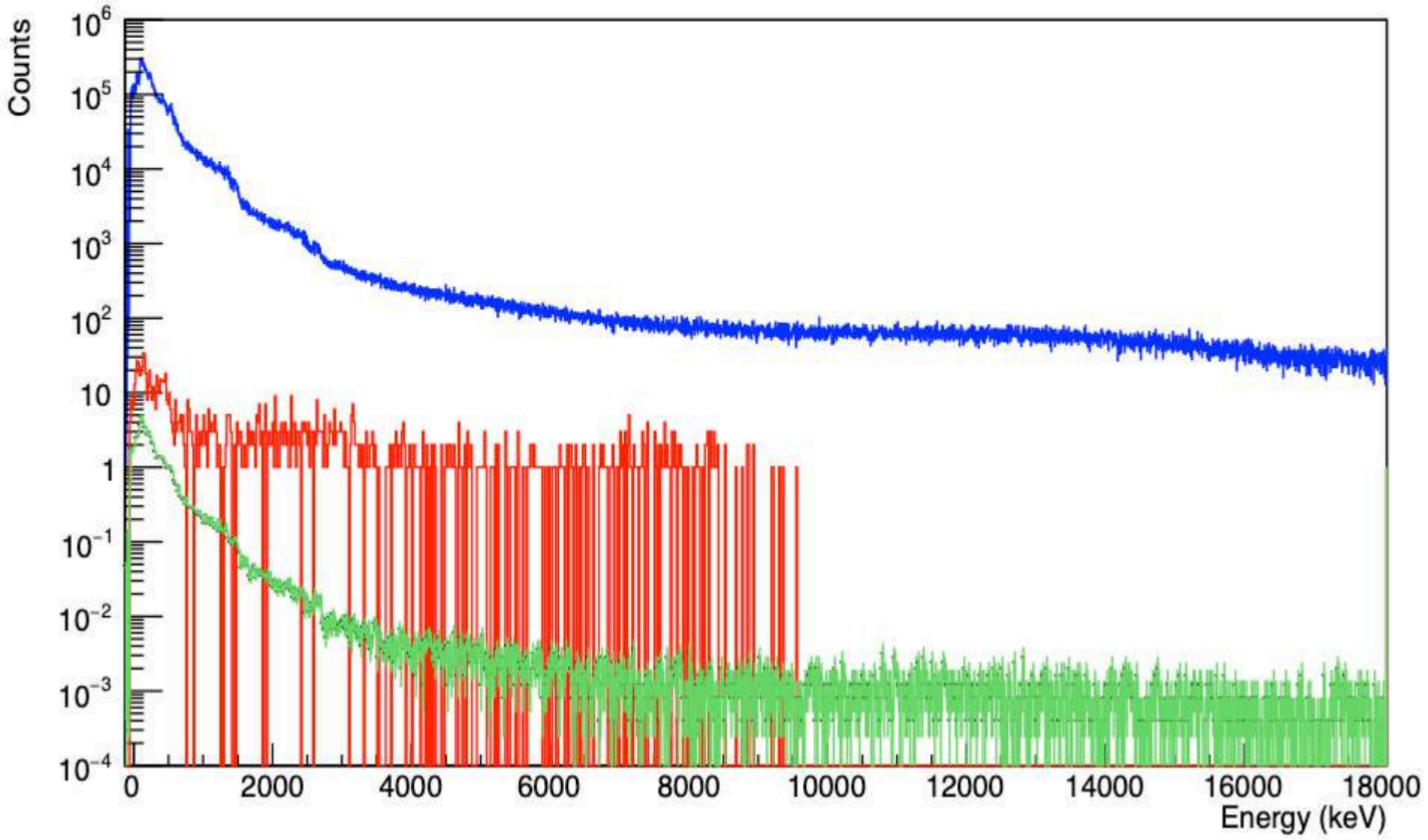
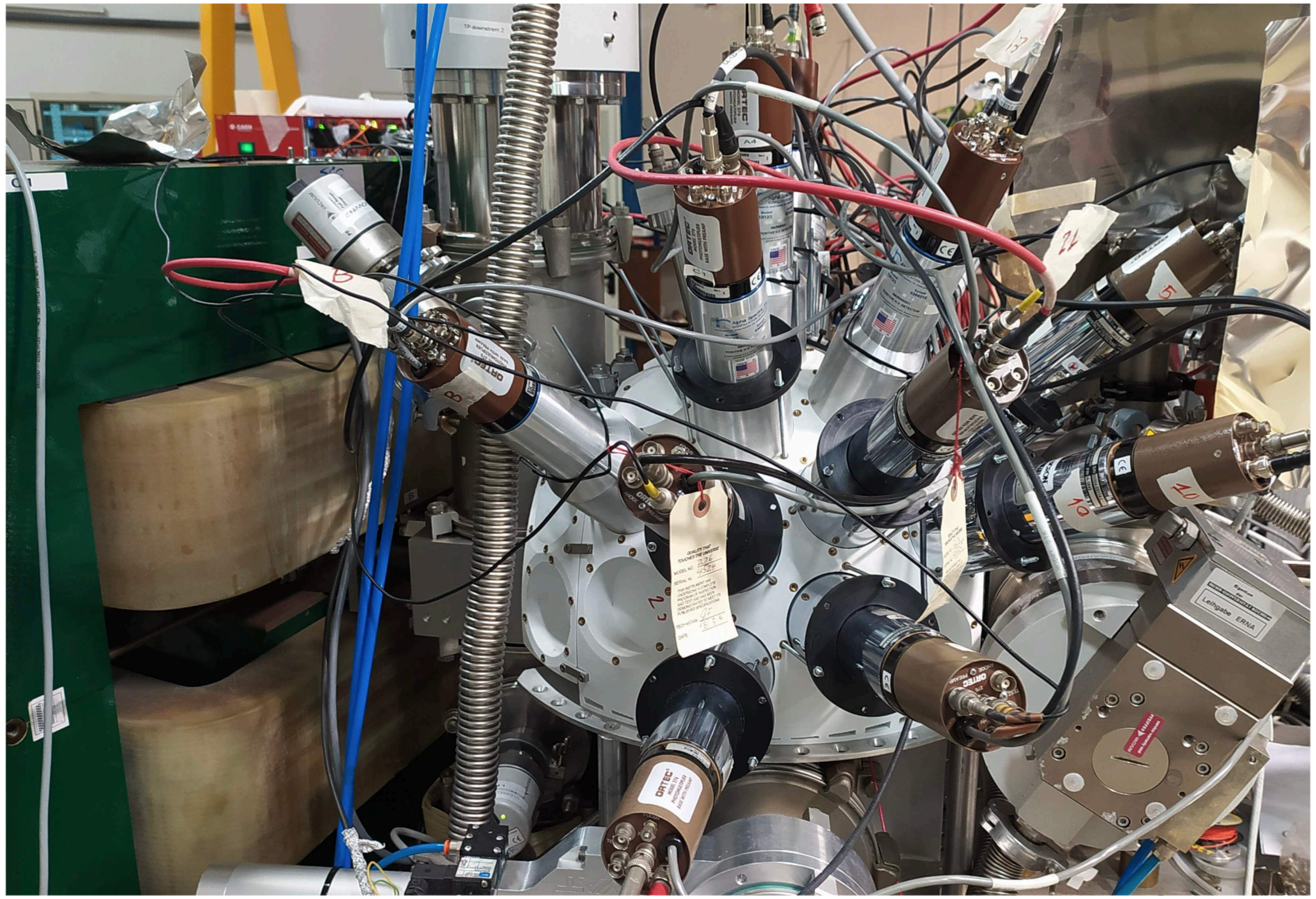
α γ







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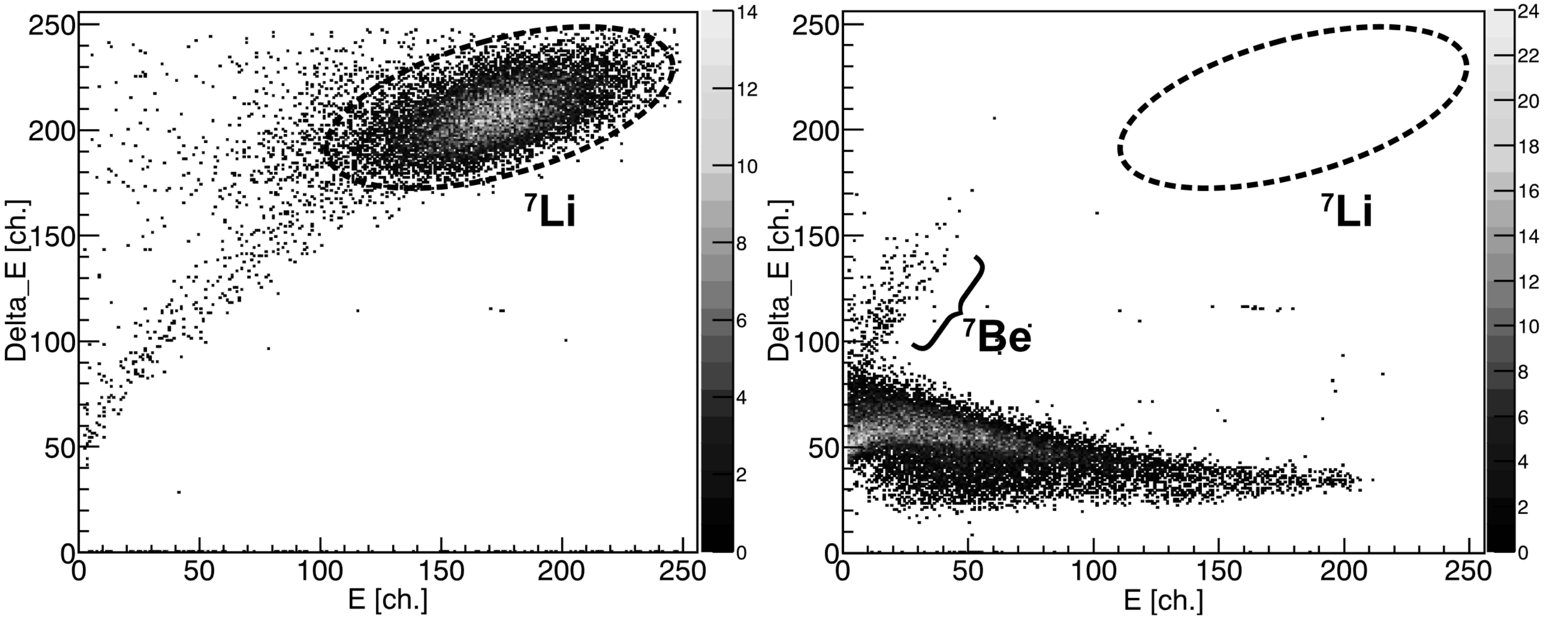
half-life

Detection of in-flight decay of thanks to the very intense beam produced at CIRCE. Part of the PRIN project ASBeST.



Santonastaso et al., Il Nuovo Cimento 44 C (2021)

NEAR FUTURE

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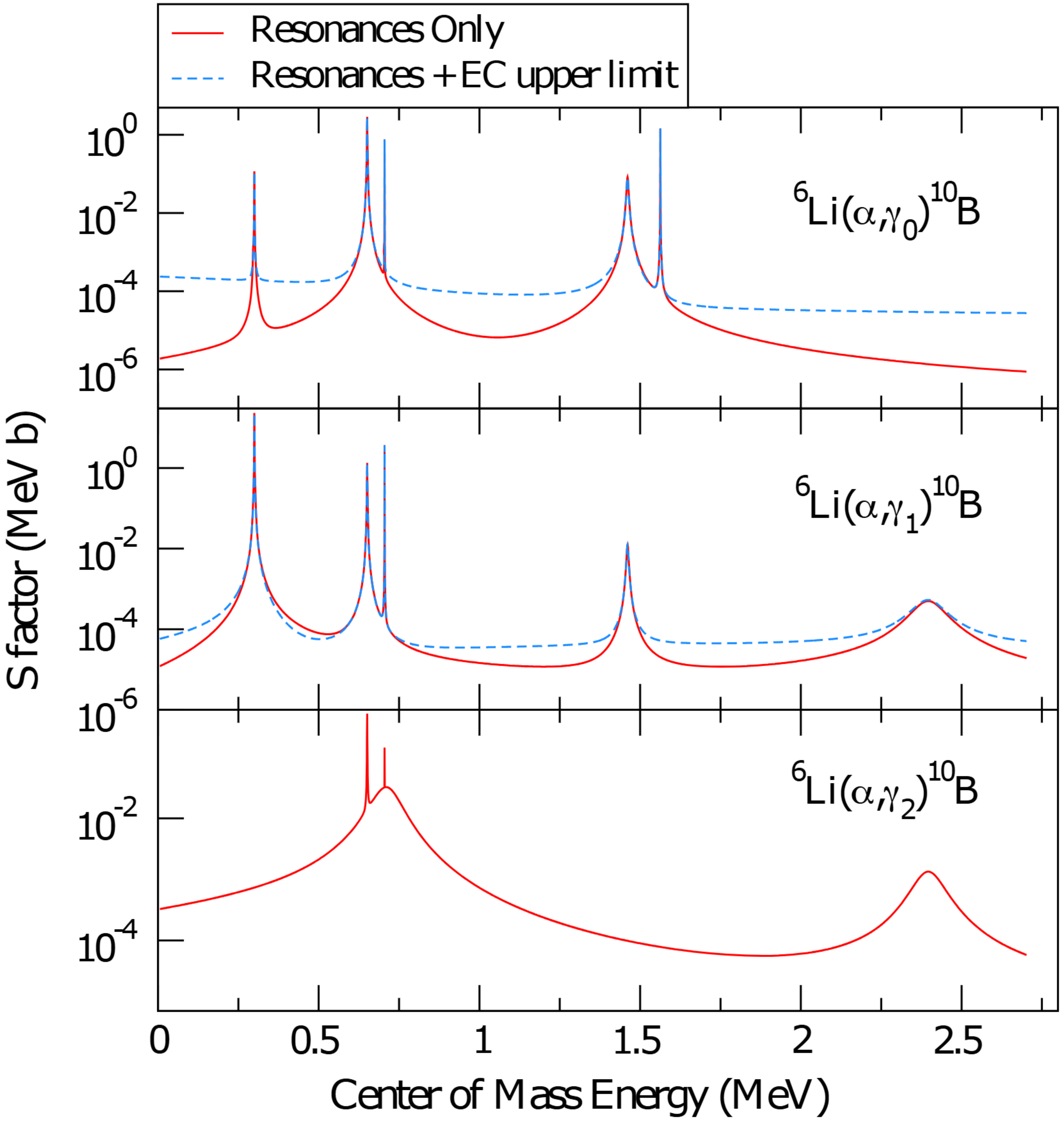
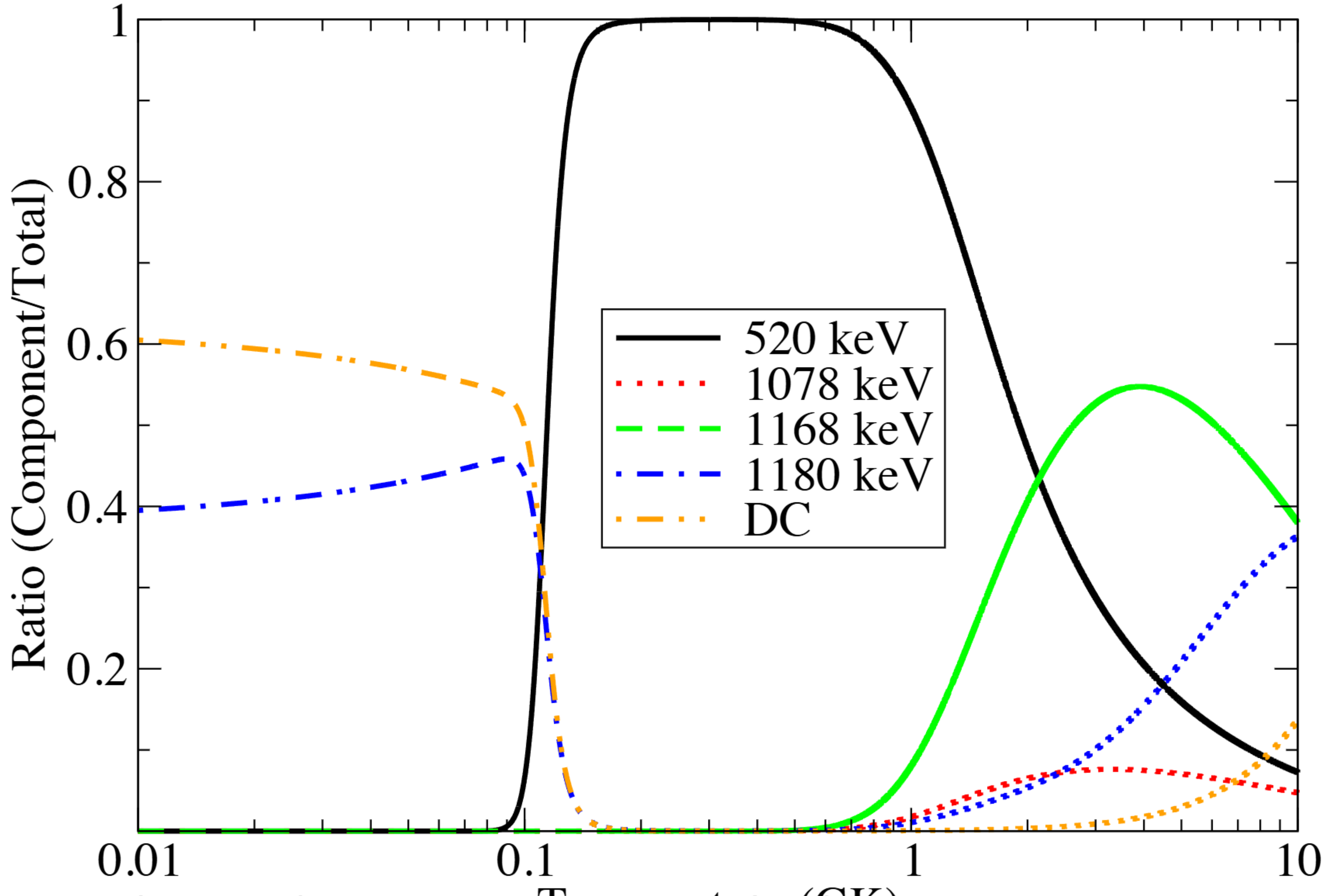
α γ

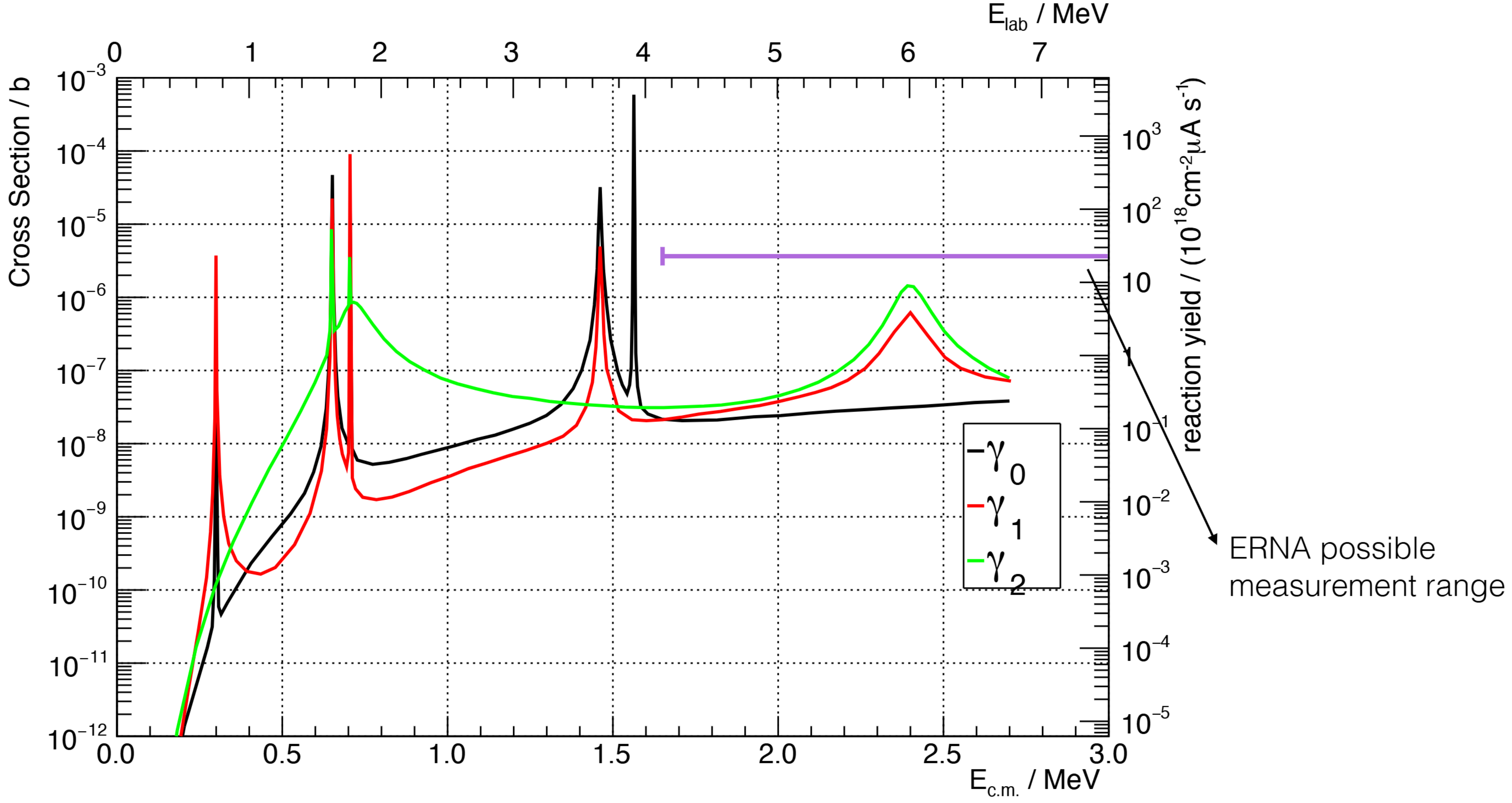




Legend reports resonances' α beam energy

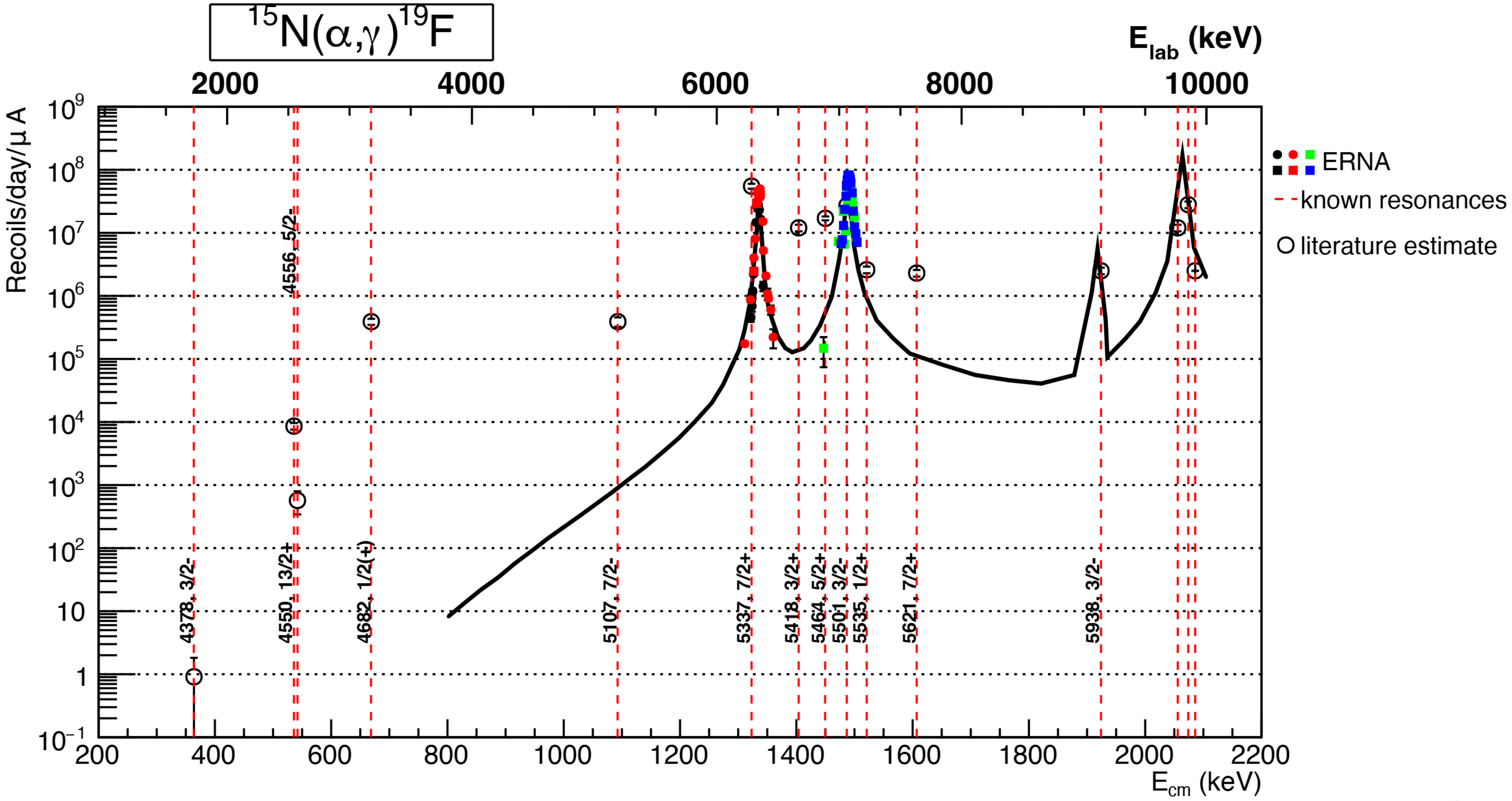
Wiescher et al., Eur. Phys. J. A 57(2021)24 and Gula et al., Phys. Rev. C 106(2022)065801

α γ



Calculated from S-factor of Wiescher et al., Eur. Phys. J. A 57(2021)24

α γ



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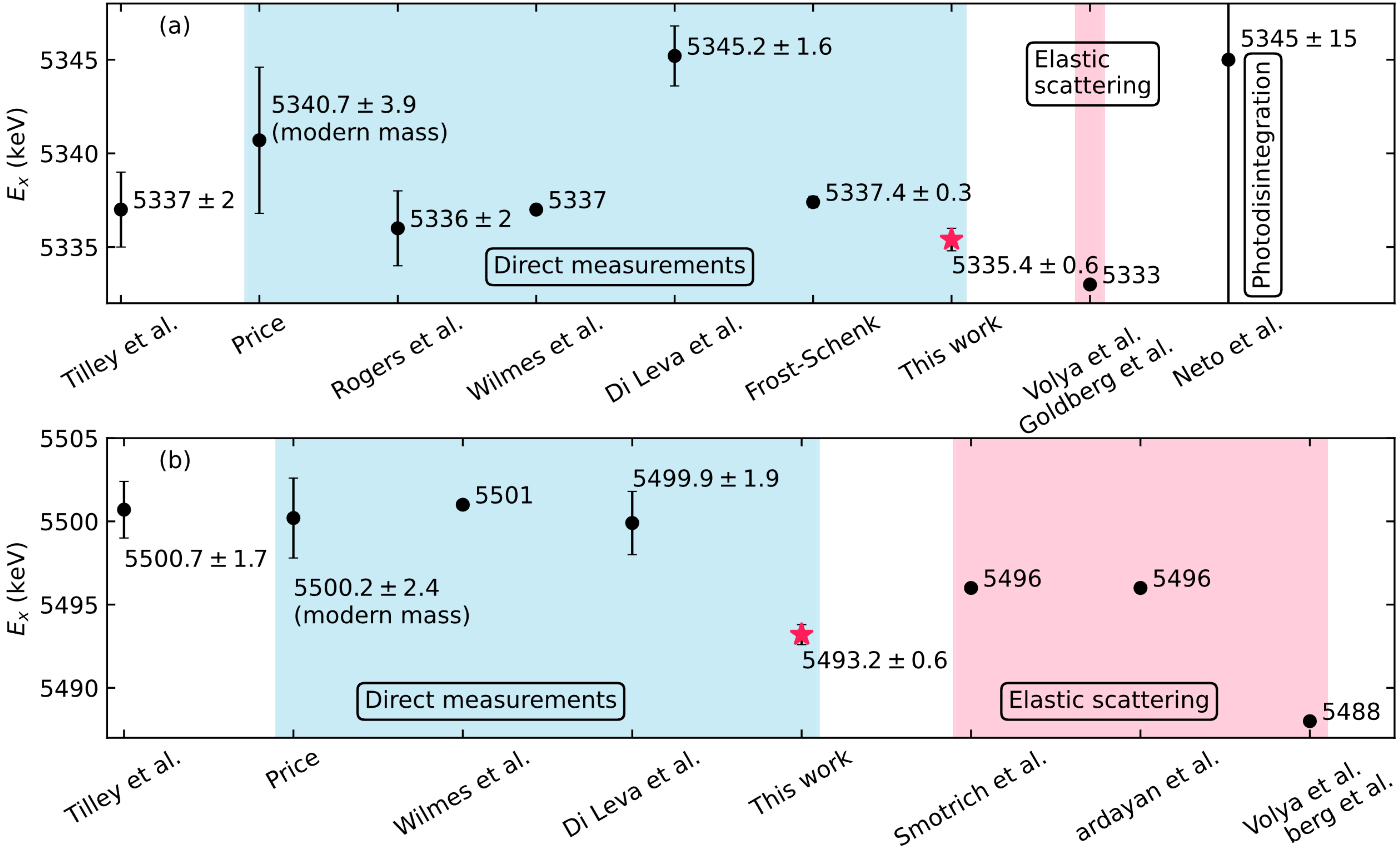
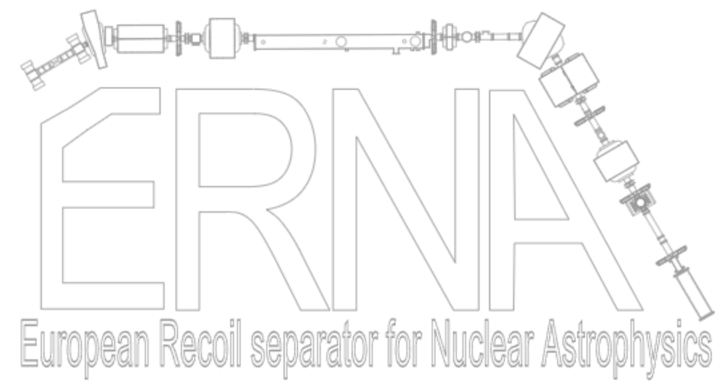
α γ



Fang et al., Phys. Rev. C 110 (2024) 025806



Thank you for your attention

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