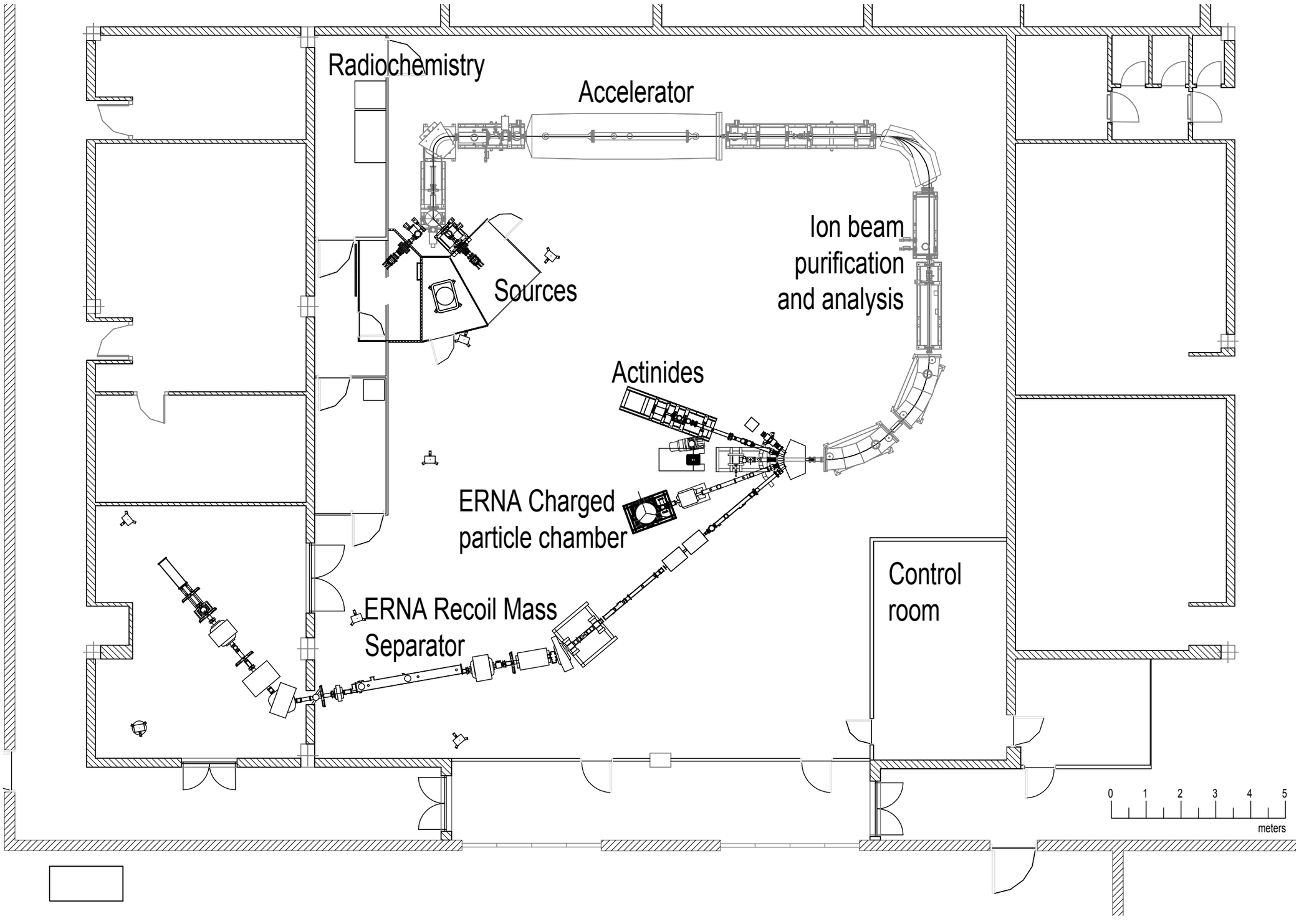
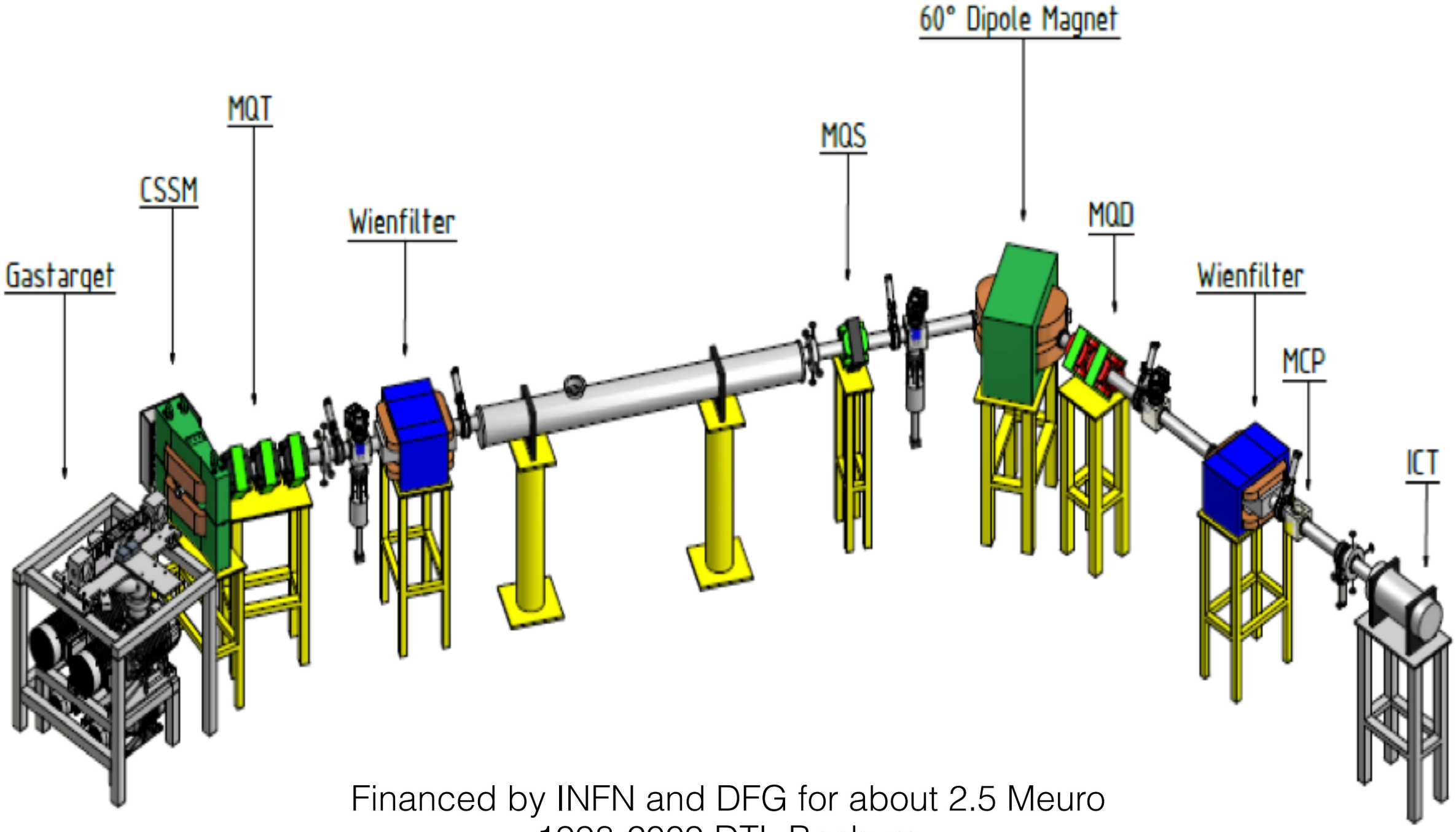
Measurement of the $^{7}Be(p,\gamma)^{8}B$ cross section

A. Di Leva - Università di Napoli Federico II and INFN
for the ERNA Collaboration

ERNA @ CIRCE

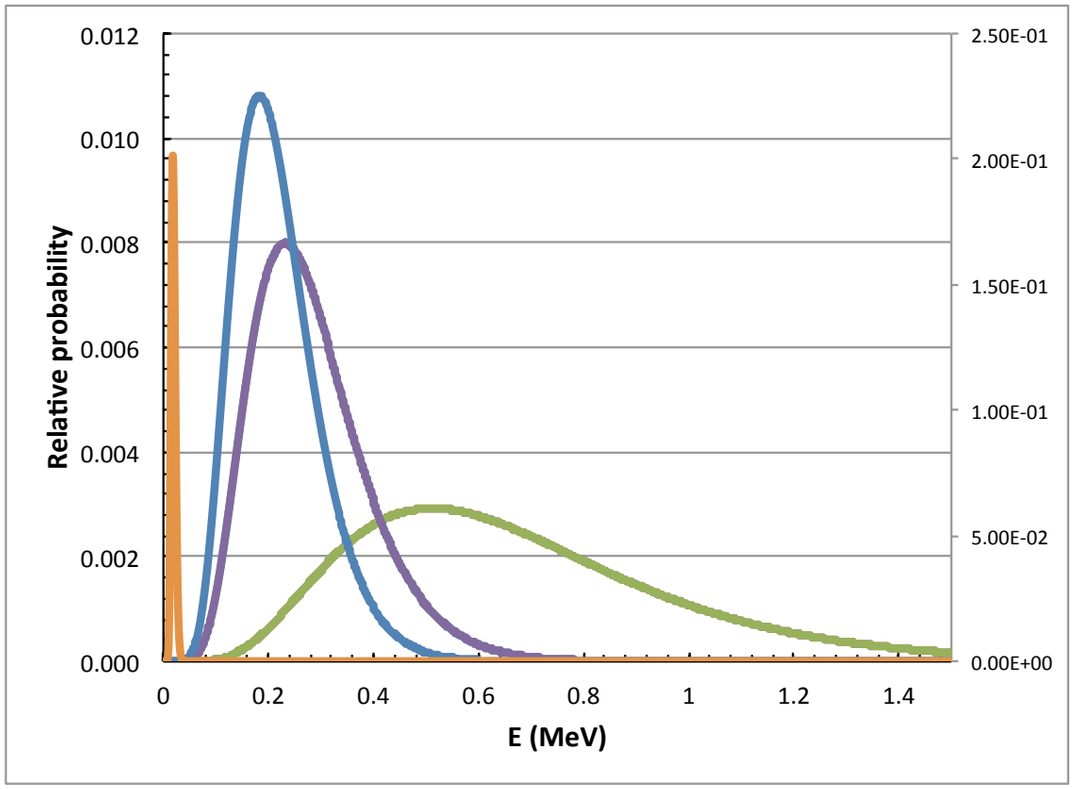

Radiochemistry
Accelerator
Sources
Ion beam
purification
and analysis
Actinides
ERNA Charged
particle chamber
Control
room
ERNA Recoil Mass
Separator
0 1 2 3 4 5
meters

European Recoil Separator for Nuclear Astrophysics

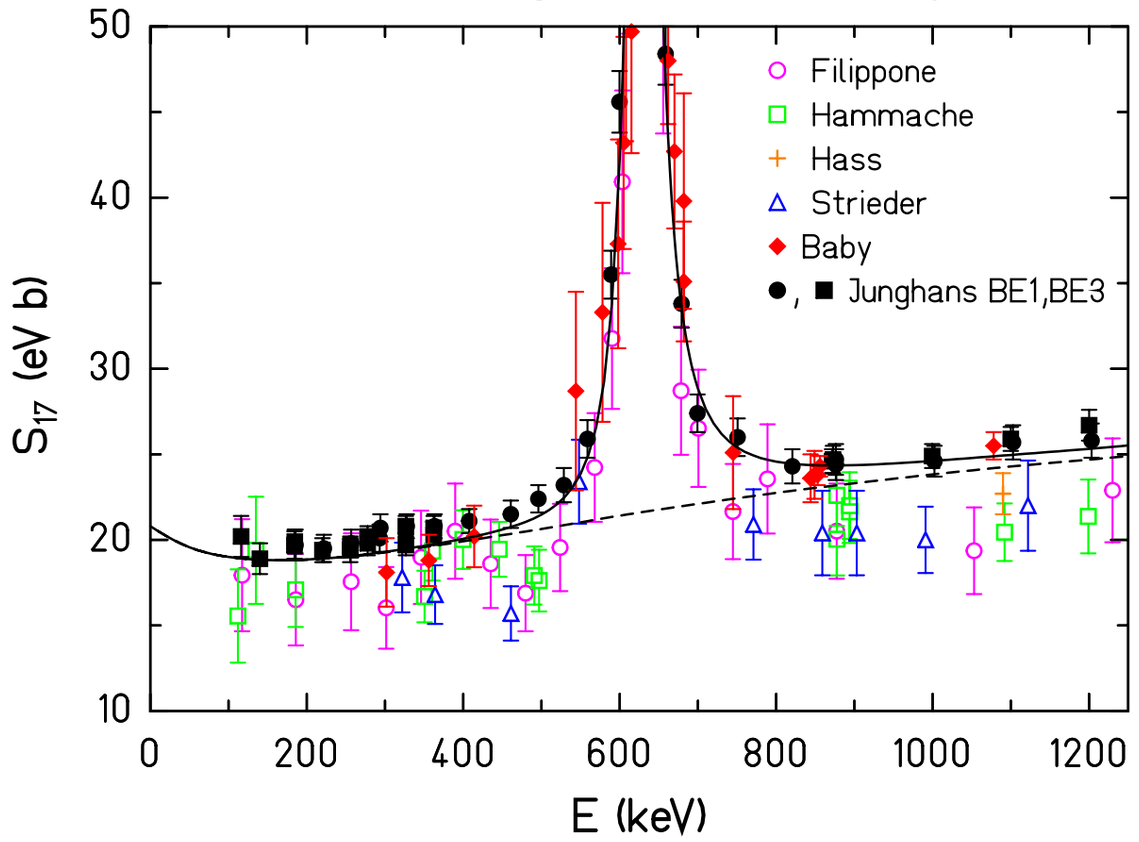


Financed by INFN and DFG for about 2.5 Meuro
1998-2009 DTL Bochum
2009 moved to CIRCE Caserta

$^{7}Be(p,\gamma)^{8}B$



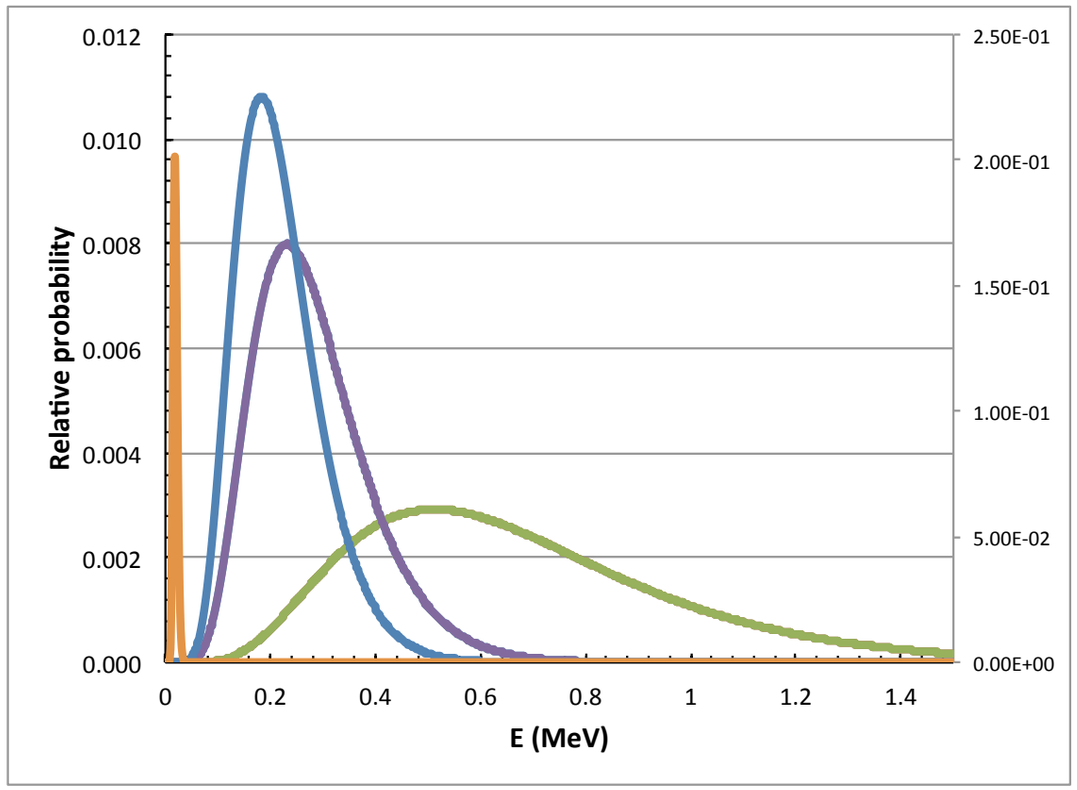
Adelberger et al. Rev.Mod.Phys.83(2011)



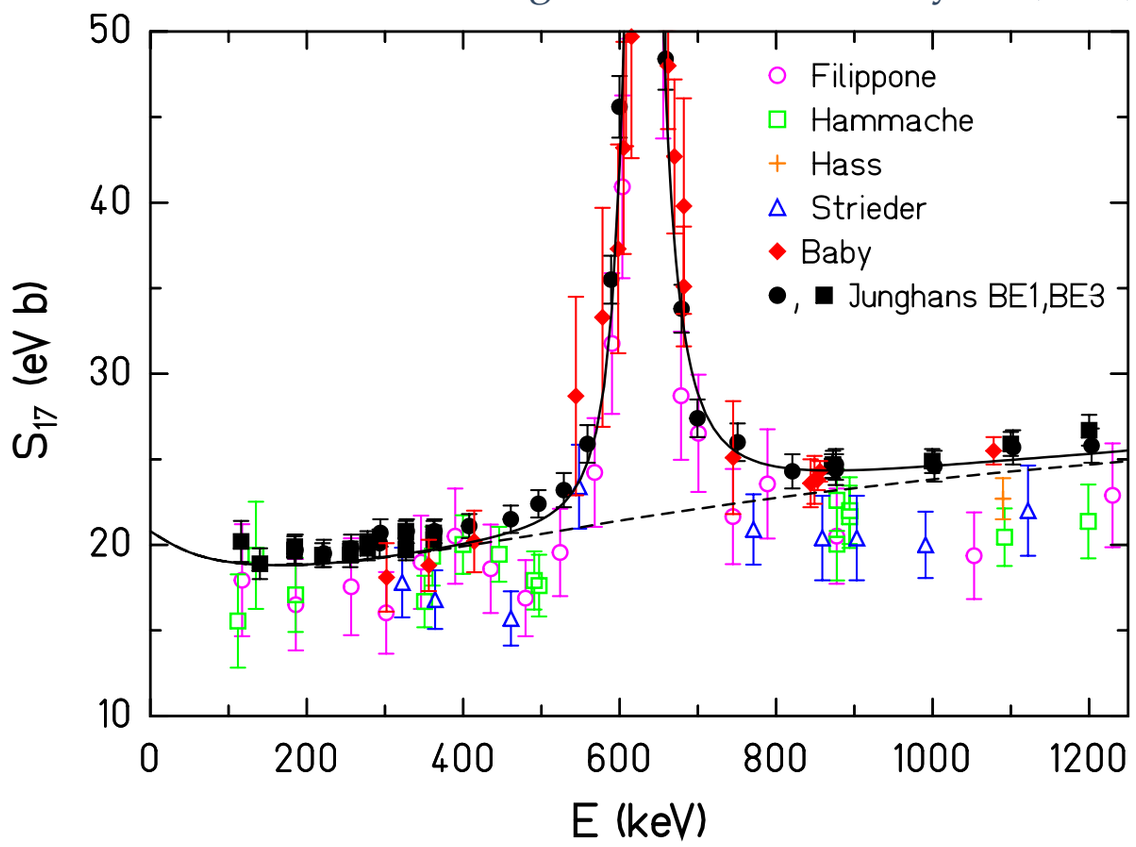
Direct measurements: p beam on ^{7}Be target

Indirect measurements: ^{8}B Coulomb break-up

$^{7}Be(p,\gamma)^{8}B$



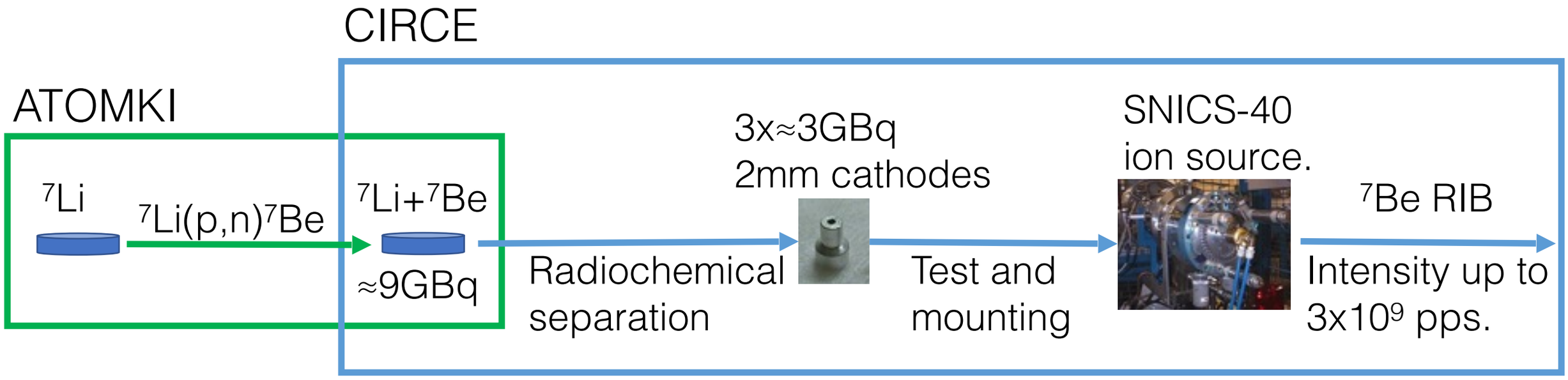
Adelberger et al. Rev.Mod.Phys.83(2011)

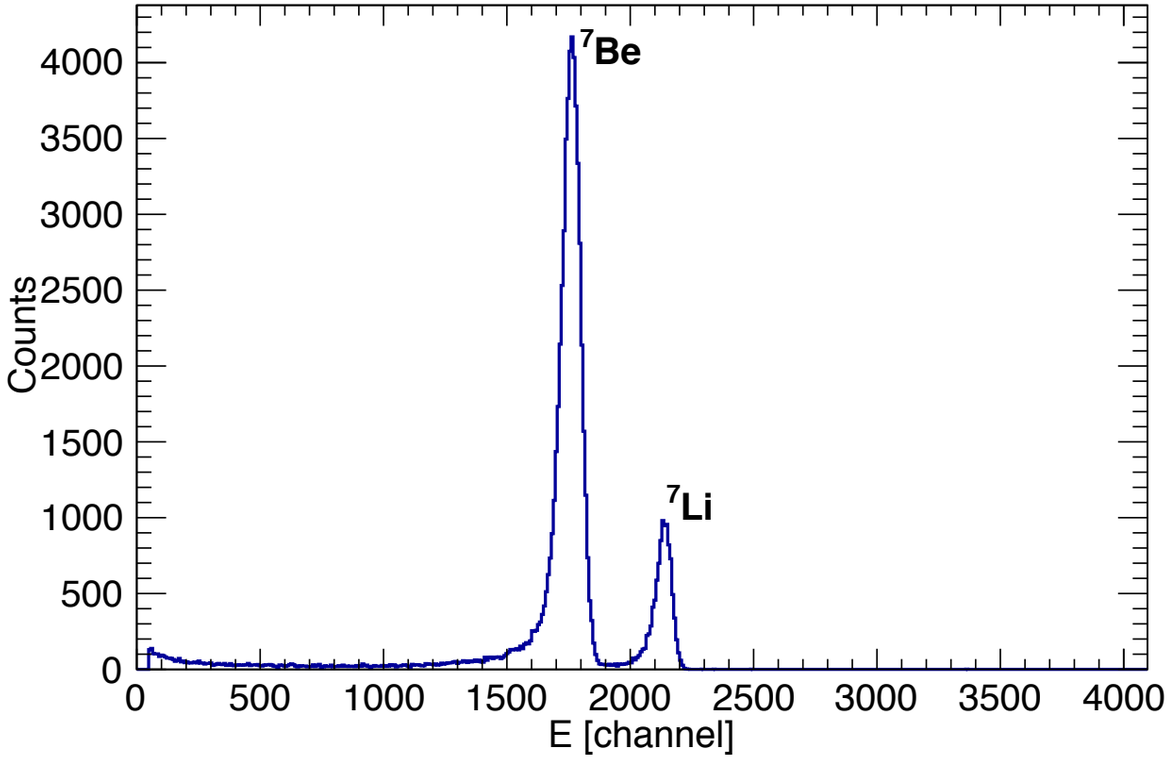


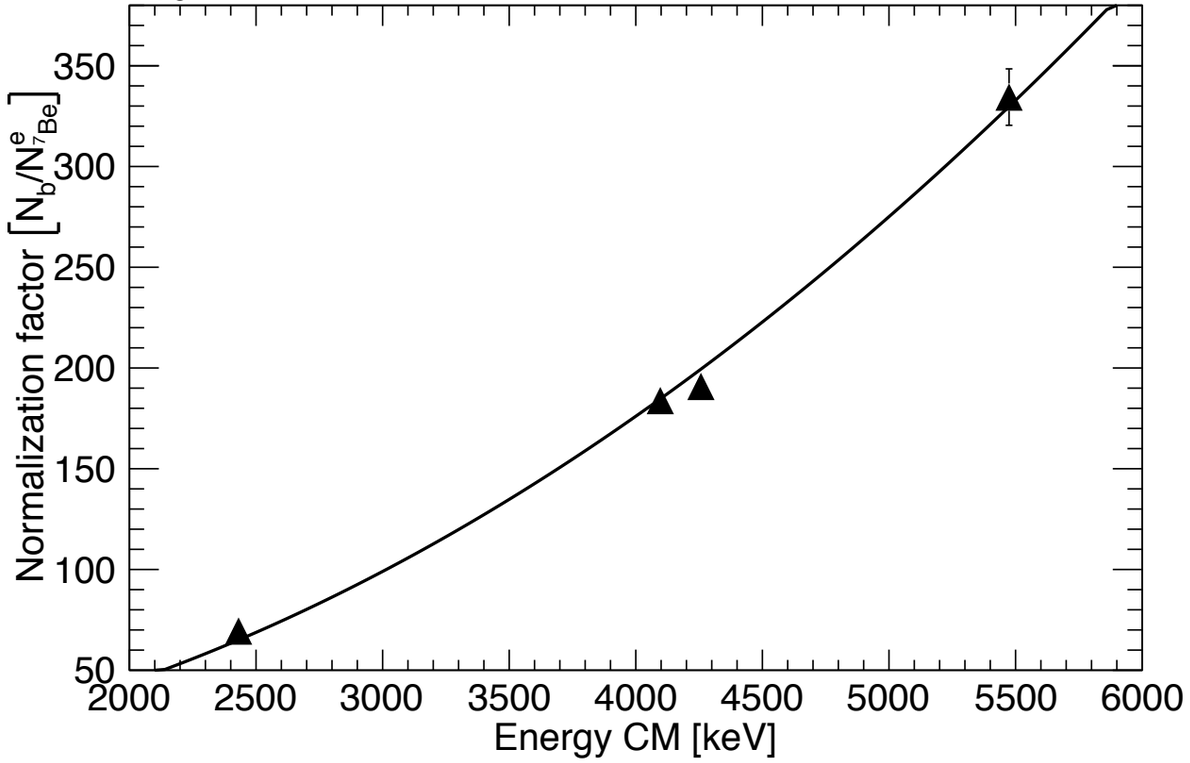
Direct measurements: p beam on ^{7}Be target
Indirect measurements: ^{8}B Coulomb break-up

Direct Measurements		Indirect Measurements	
Strieder et al. NuPhA 696(2001) – Bochum	S(0) = 18.4 ± 1.6 eVb	Azhari et al. PRL 82 (1999) - ANC	S(0) = 17.8 ± 2.8 eVb
Hammache et al. PRL 86(2001) – Orsay	S(0) = 18.8 ± 1.7 eVb	Tabacaru et al. PRC 73(2006) - ANC	S(0) = 18.0 ± 1.8 eVb
Jumgans et al. PRC 68(2003) – Seattle	S(0) = 21.4 ± 0.6 ± 0.6 eVb	Schumann et al. PRC 73(2006) - CD	S(0) = 20.6 ± 0.8 ± 1.2 eVb
Baby et al. PRC 67 (2003) – Weizmann	S(0) = 21.2 ± 0.6 eVb		

^{7}Be RIB production

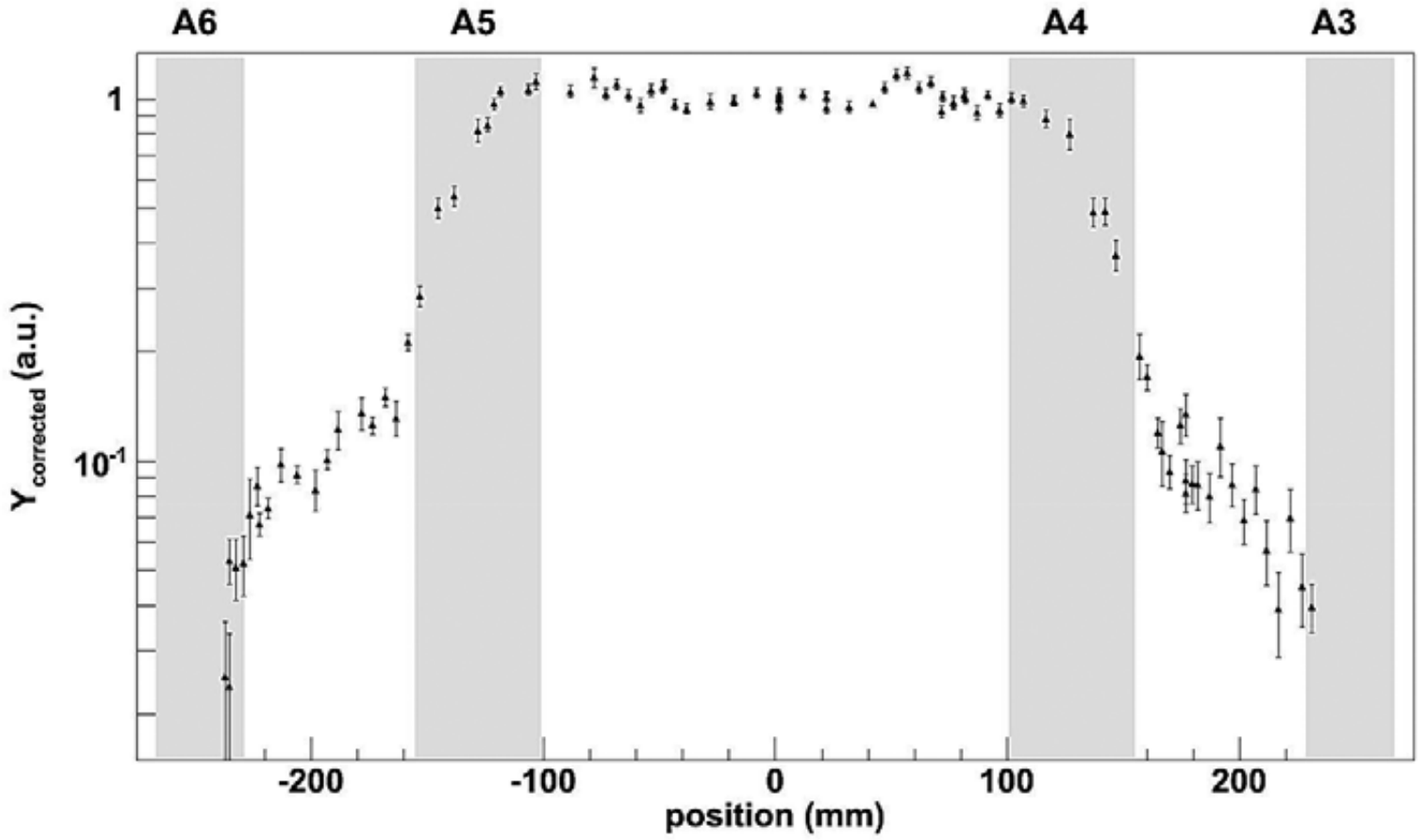


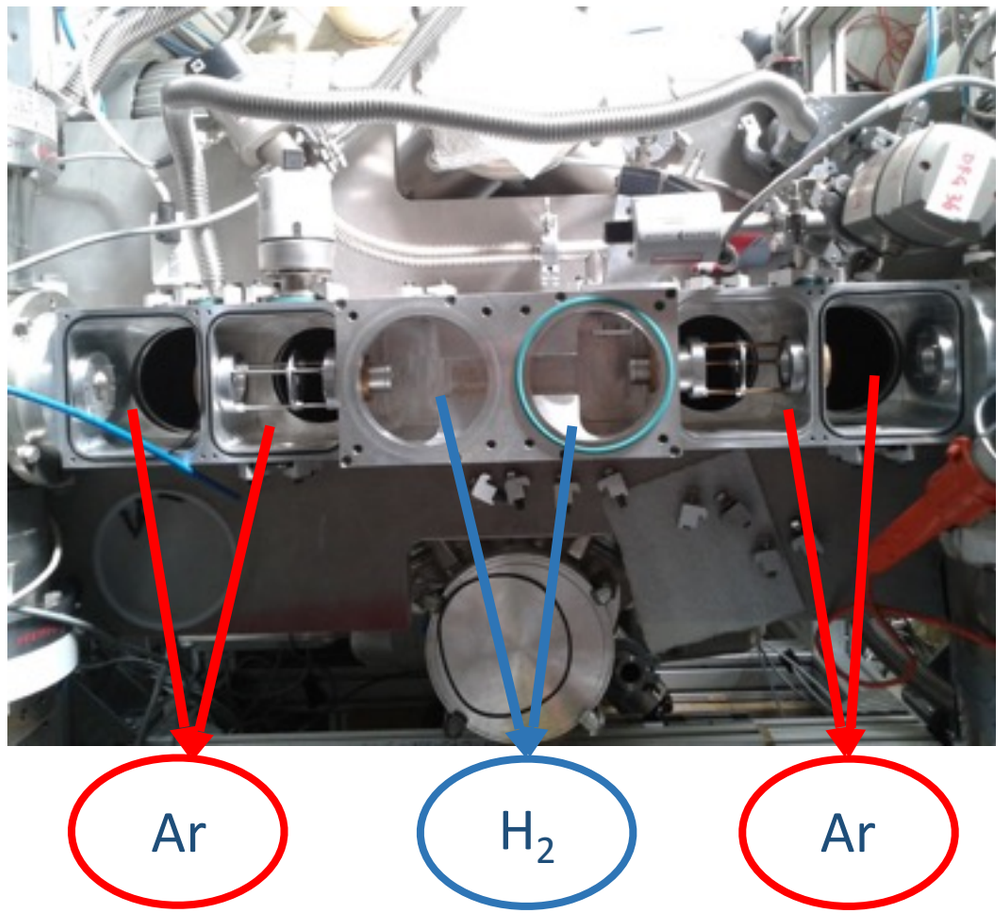




The number of incident projectiles, including lithium contamination, is monitored on line through elastic scattering.

Windowless gas target

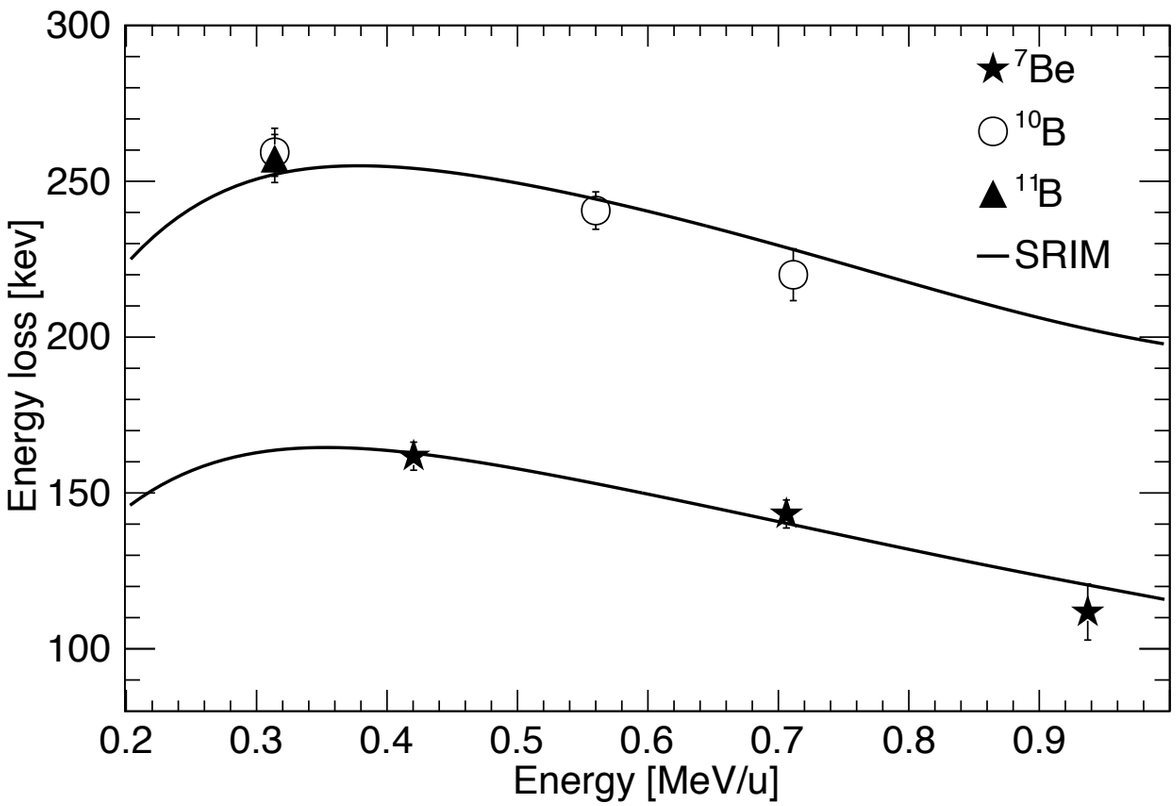




Density profile of the gas target as seen in the yield of the 478 keV γ-ray line from the $^{7}Li(p, p)^{7}Li$

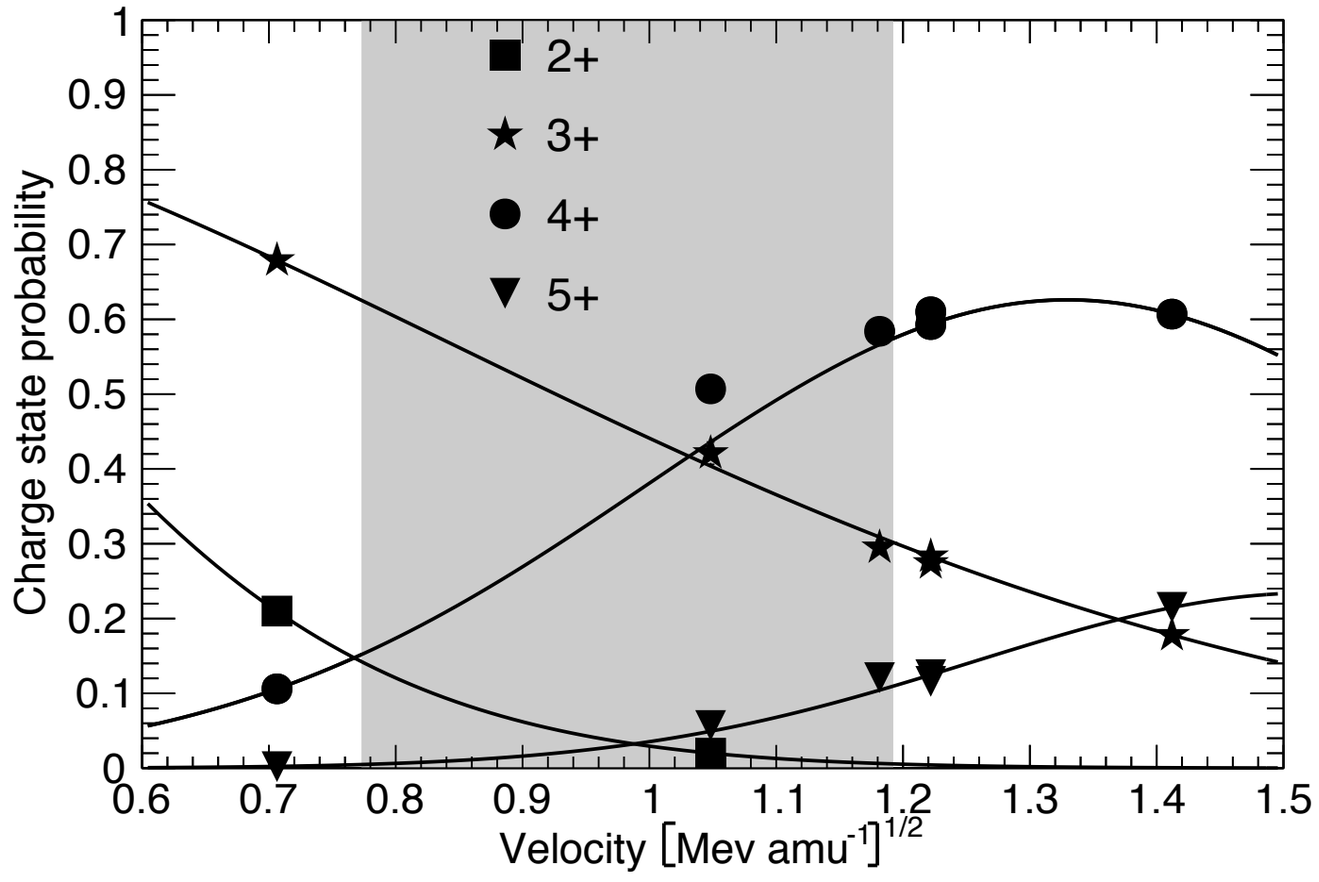
Target density $N_T = (7.22 \pm 0.15) \cdot 10^{18}$ at/cm^2
D. Schürmann et al., Eur. Phys. J. A 49 (2013) 80

Stopping power & charge states

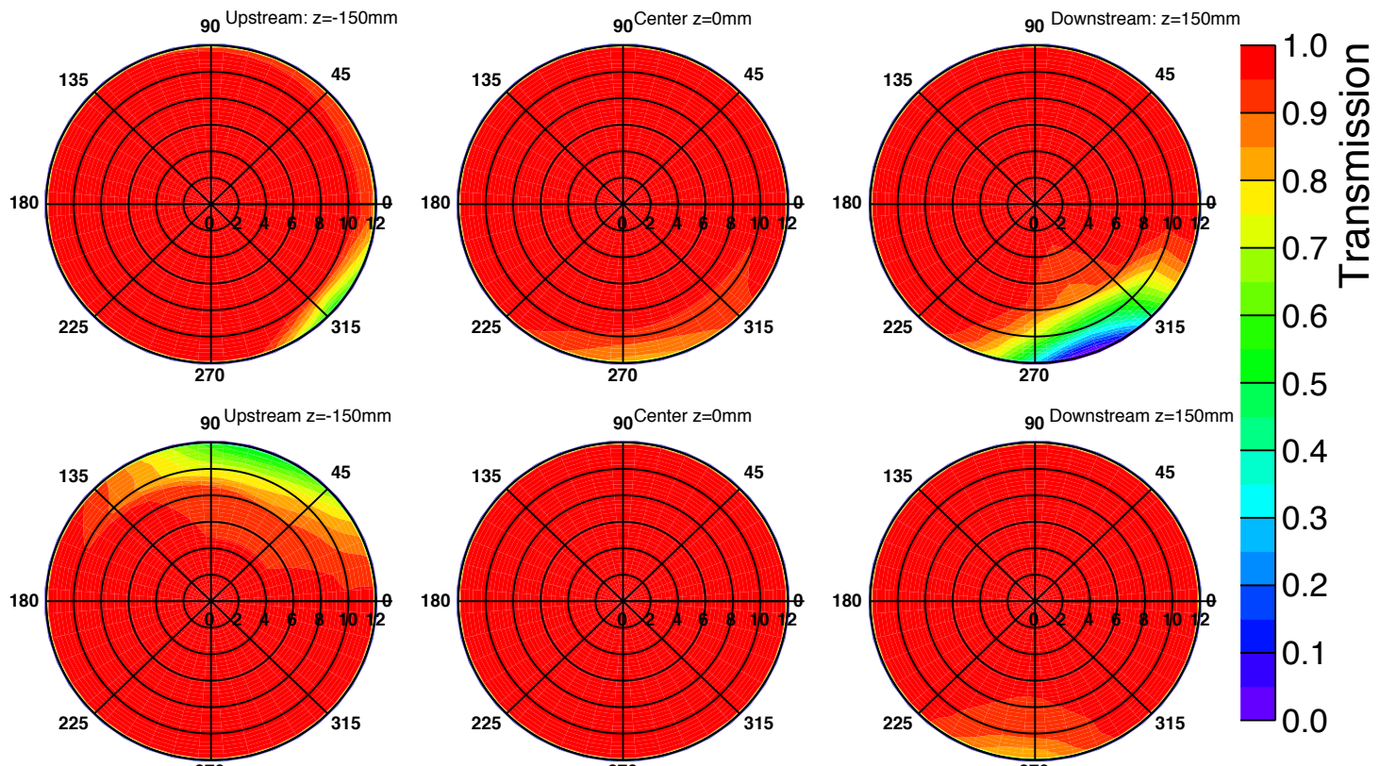


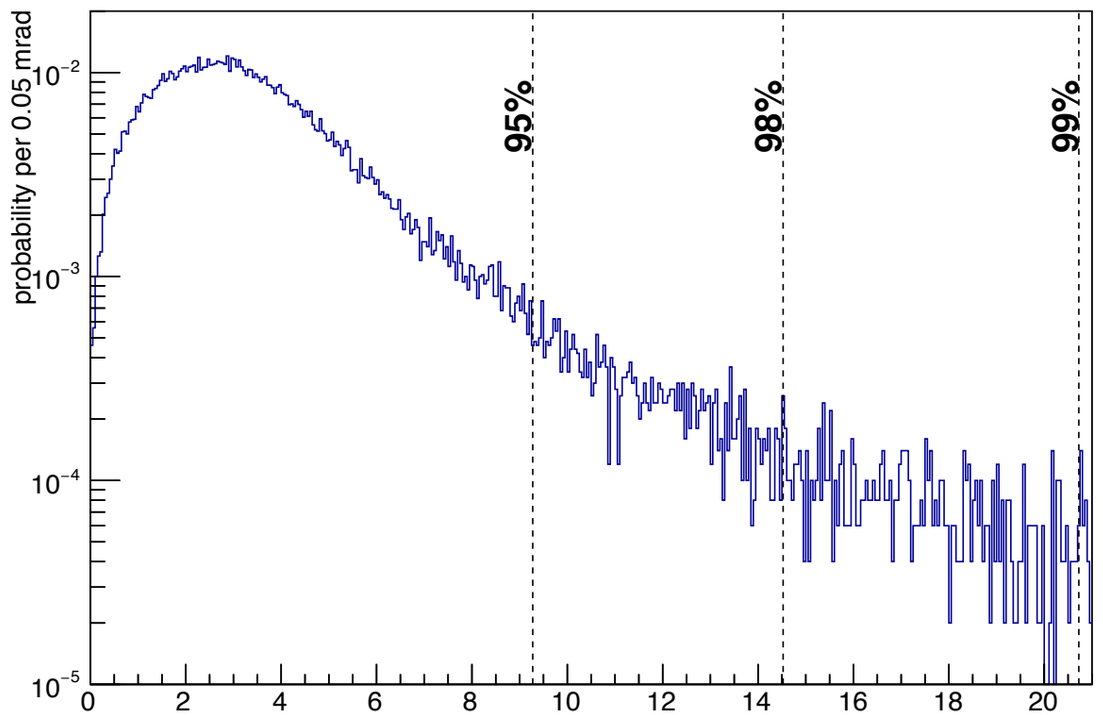
Energy loss of the projectile ^{7}Be and of the projectile ^{8}B in the target.
The curve is a renormalized SRIM table.

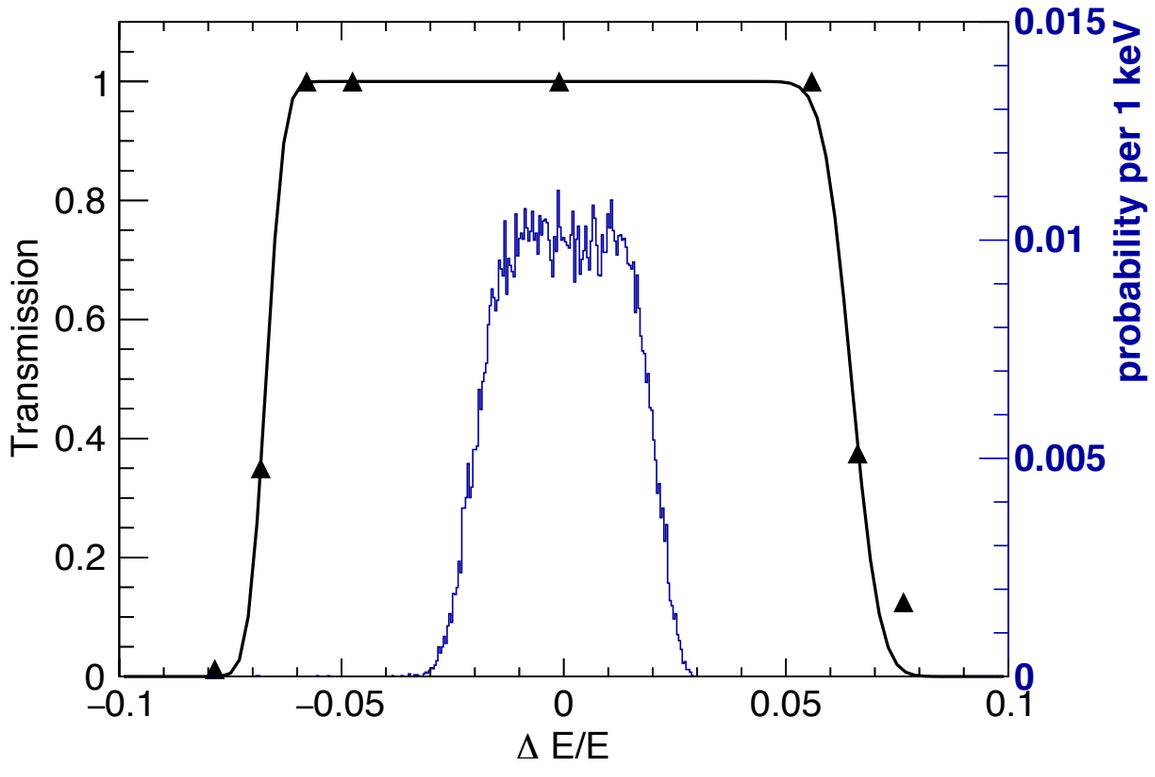
^{8}B charge state probability.
The measurements performed selecting the 3+ recoils.



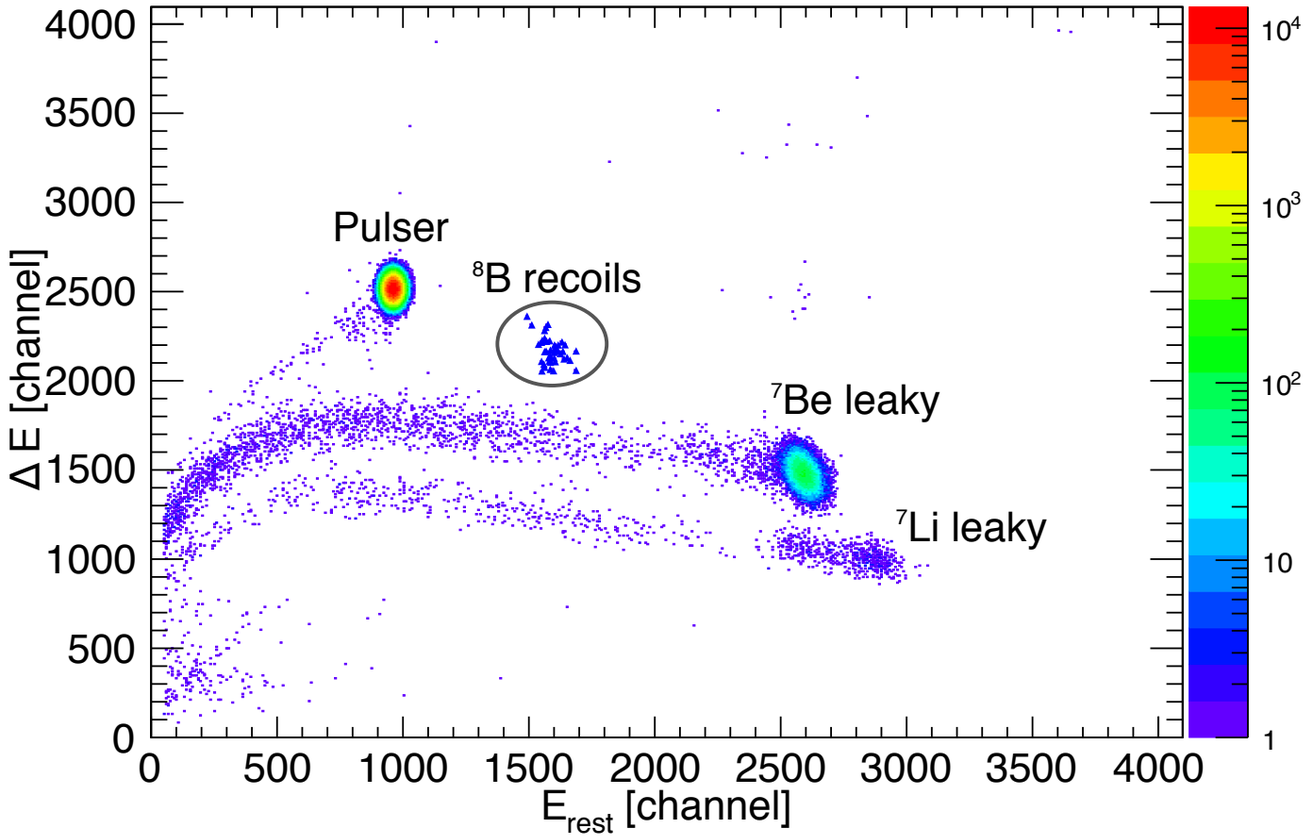
Acceptance


Upstream: z=-150mm
Center z=0mm
Downstream: z=150mm
Upstream z=-150mm
Center z=0mm
Downstream z=150mm
90
135
45
180
0
225
315
270
0 2 4 6 8 10 12
Transmission
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0


probability per 0.05 mrad
10^{-2}
10^{-3}
10^{-4}
10^{-5}
95%
98%
99%
0 2 4 6 8 10 12 14 16 18 20
θ [mrad]

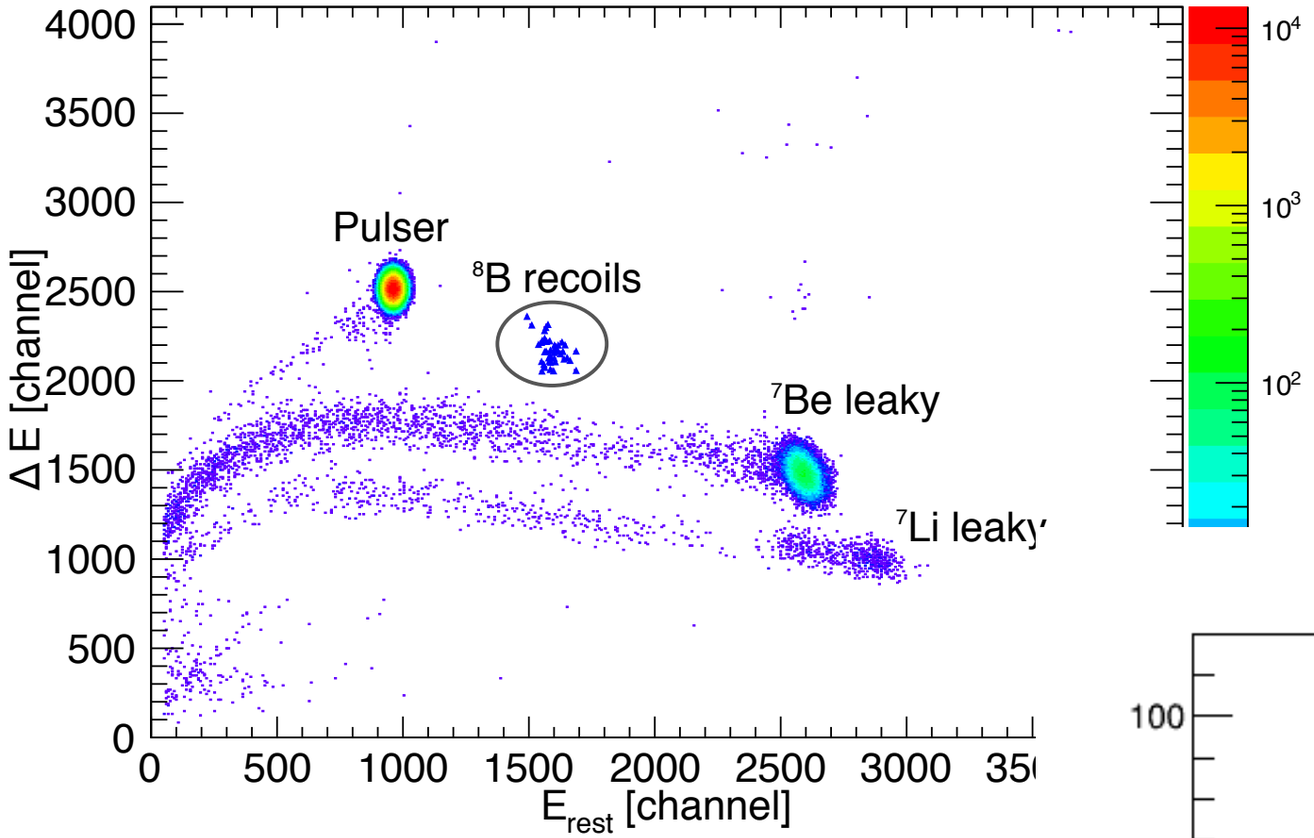

Transmission
1
0.8
0.6
0.4
0.2
0
–0.1
–0.05
0
0.05
0.1
Δ E/E
0.015
0.01
0.005
0
probability per 1 keV

$^{7}Be(p,\gamma)^{8}B$ with ERNA

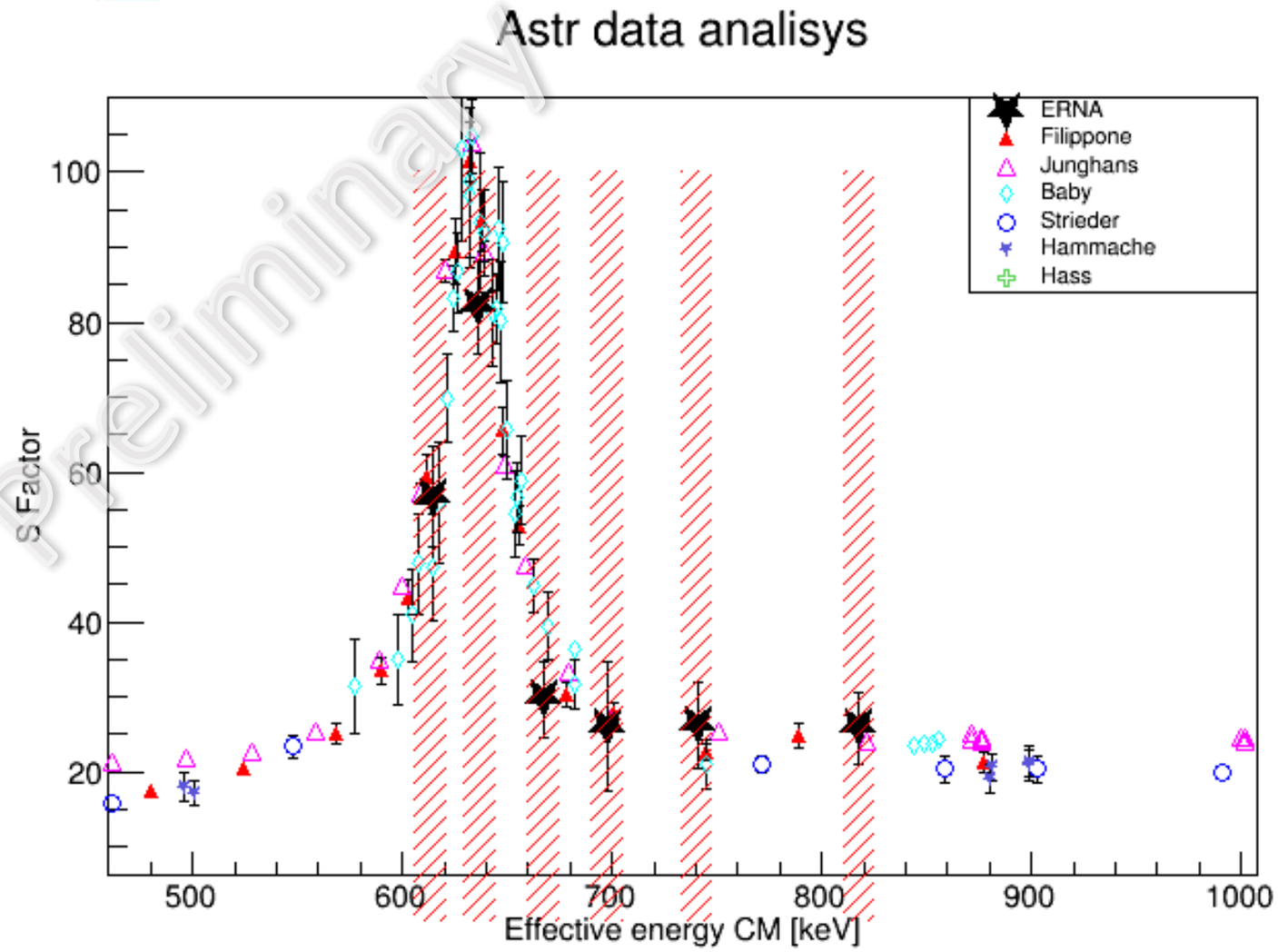


Typical ionization chamber telescope E-ΔE spectrum.
The ^{8}B recoils are well separated from the primary beam residues.

$^{7}Be(p,\gamma)^{8}B$ with ERNA



Typical ionization chamber telescope E-ΔE spectrum.
The ^{8}B recoils are well separated from the primary beam residues.



Conclusions

- A very intense ^{7}Be beam, up to 3x10^{9} pps, is routinely produced and characterized at CIRCE laboratory

- All the ancillary measurements (target characterization, tunings, charge state distributions) are completed for the measurements in the E_{cm} = 350 to 800 keV range

- The measurements of absolute cross section trough the 629 keV resonance and up to 800 keV have been performed and analysis is complete

- The measurement at 350 keV closed the measurement campaign, data analysis is ongoing

- Experimental results and their impact on the extrapolation of the cross section are expected to be submitted within this year

Perspectives

- we have recently put online the ^{4}He jet gas target chamber, more details in D. Rapagnani talk

- soon target will be equipped with an array of NaI scintillators and several $e^{+}e^{-}$ pair spectrometers for measurements in coincidence with recoils

- we plan to fit an H_2 extended target cell in the newly installed jet gas target chamber

- there is thus the possibility of measuring radiative capture reaction cross section on ^{1}H or ^{4}He

- we are interested in exploiting the possibilities of the intense ^{7}Be RIB available at CIRCE, at present:
  - ^{7}Be(p,p)^{7}Be already started in collaboration with Edinburgh group
  - ^{7}Be(α,α)^{7}Be in planning stage