Measurement of the $^{7}Be(p,\gamma)^{8}B$ reaction cross section with the recoil mass separator ERNA

- **Raffaele Buompane**

- Università degli Studi della Campania “Luigi Vanvitelli” and INFN Naples

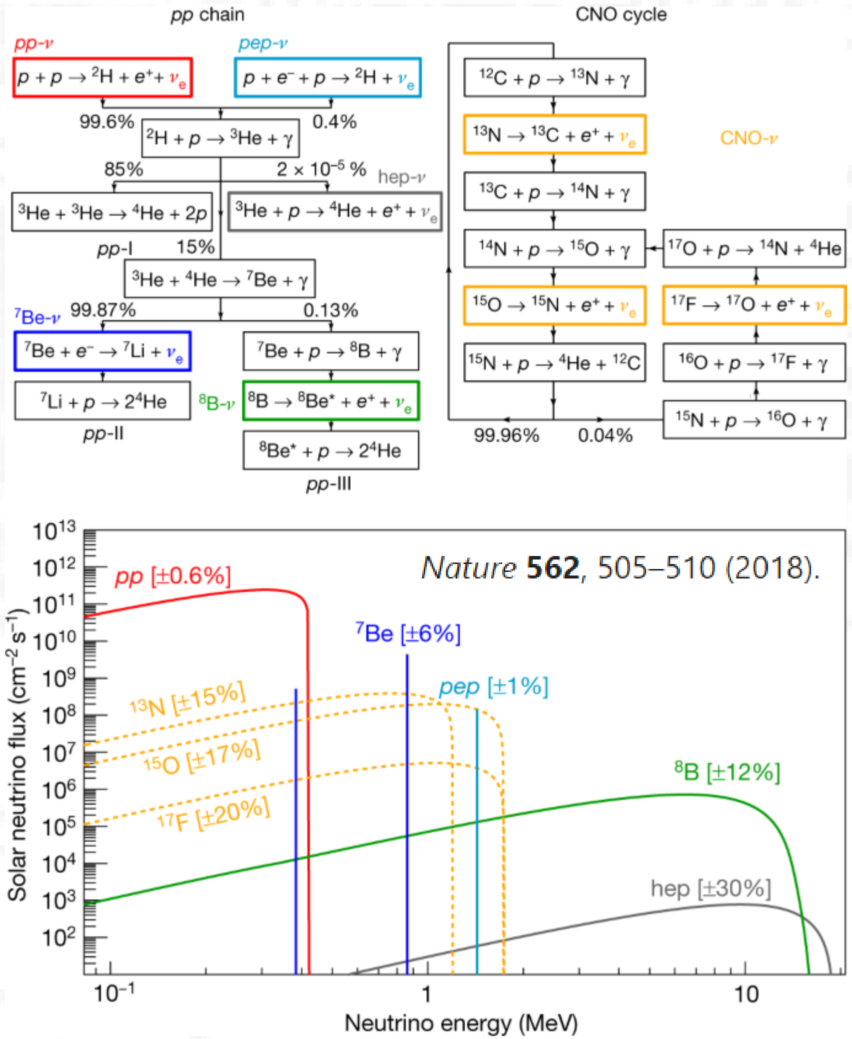
European Recoil separator for Nuclear Astrophysics

Università degli Studi della Campania Luigi Vanvitelli

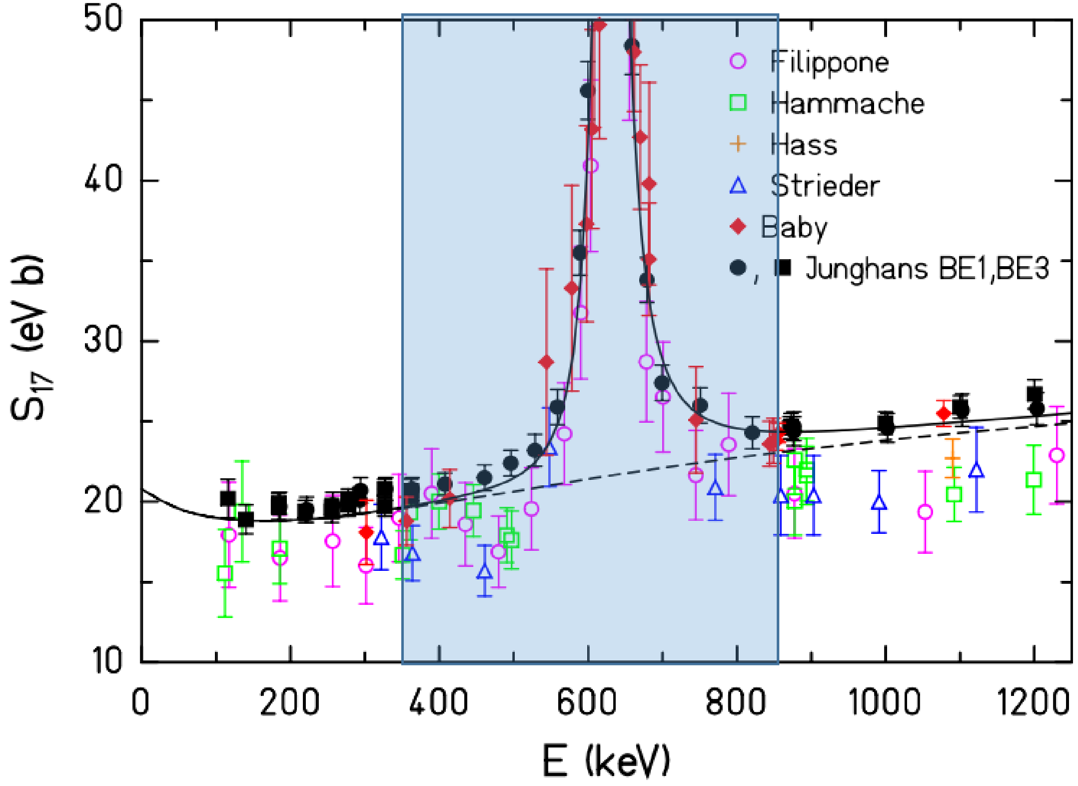
Dipartimento di Matematica e Fisica

Istituto Nazionale di Fisica Nucleare

$^{7}Be(p,\gamma)^{8}B$ - Solar Neutrino Flux



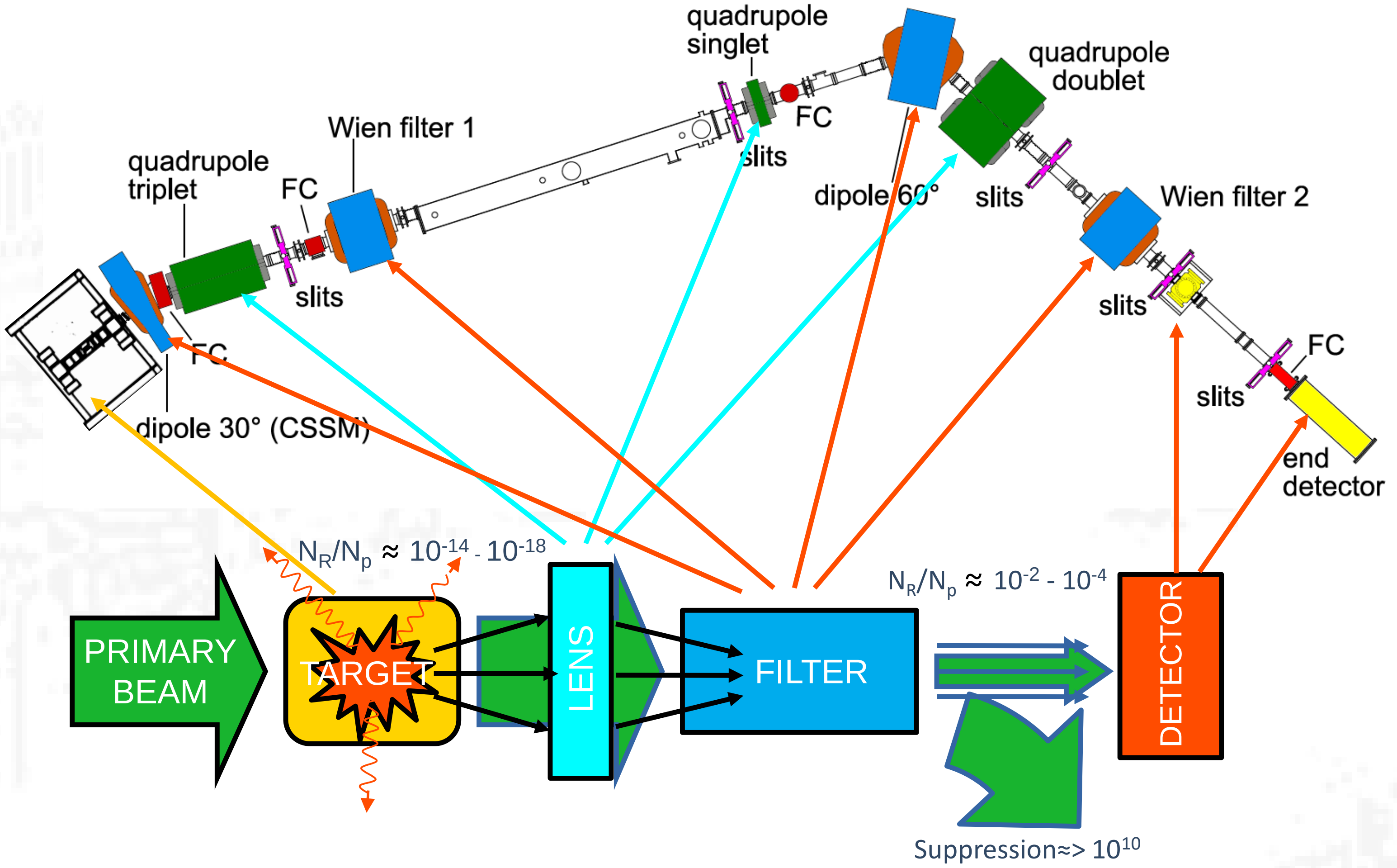
Large uncertanty on the ^{8}B component of predicted solar neutrino flux.



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

Discrepancies between existing data sets limits the precision of the extrapolation to solar energy.

European Recoil for Nuclear Astrophysics - ERNA



^{7}Be beam

ATOMKI Cyclotron Laboratory

^{7}Li pills

^{7}Li(p,n)^{7}Be

^{7}Li + ^{7}Be pills

≈10GBq

Tandem Unicampania laboratory

Radiochemical separation

Source
2mm cathodes

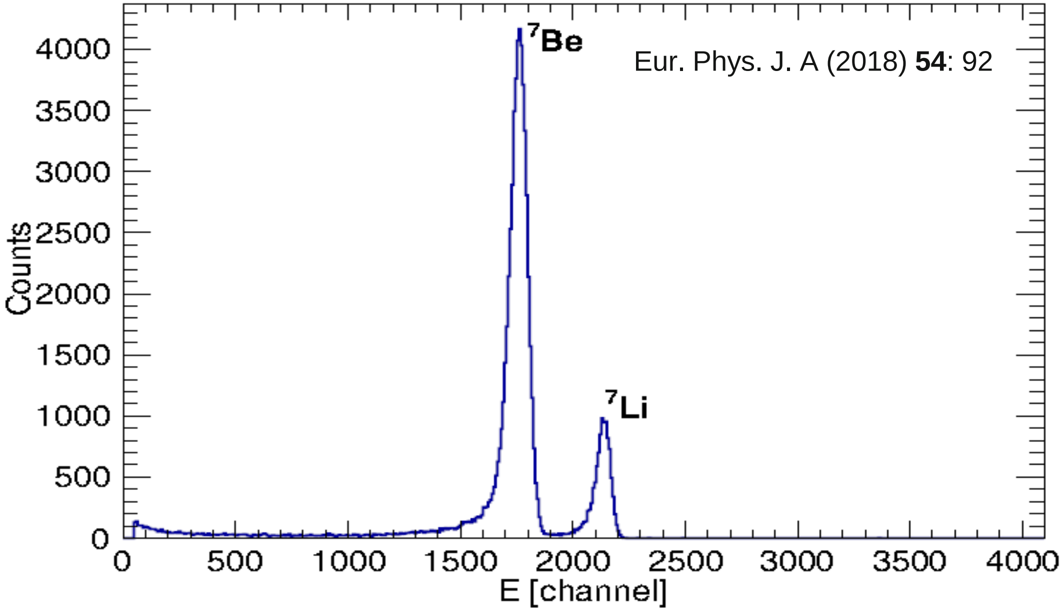
3x≈3GBq

Test and mounting

SNICS-40 ions source.

Intensity up to 10^{9} pps.

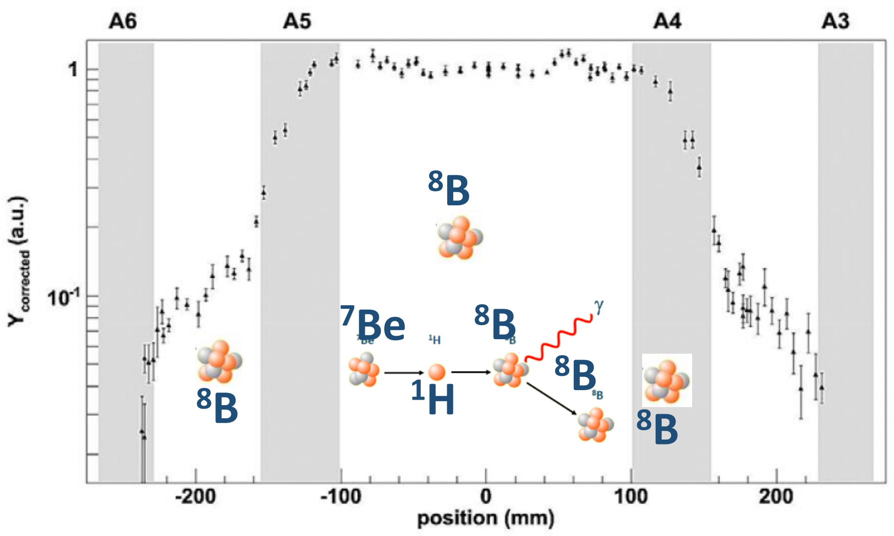
^{7}Be BEAM



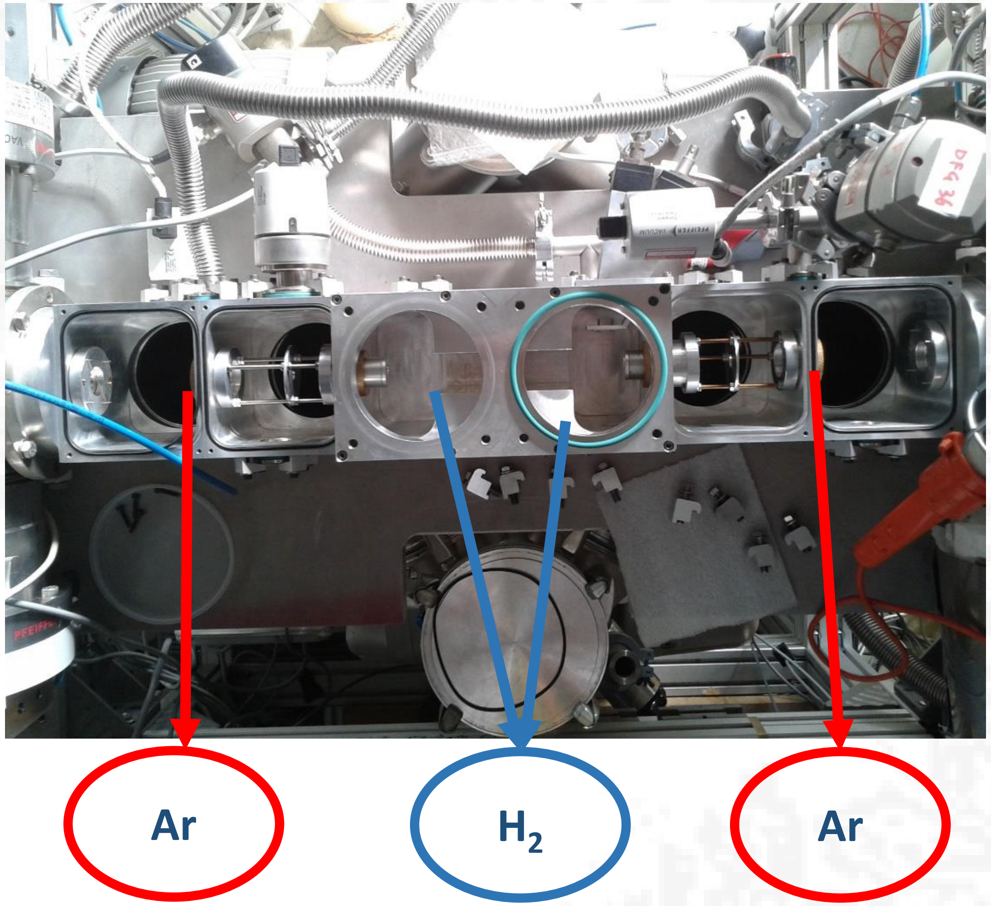
The number of incident projectiles, including lithium contamination, is monitored on line through elastic scattering.

Windowless gas target

D. Schürmann et al., Eur. Phys. J. A (2013) **49**: 80

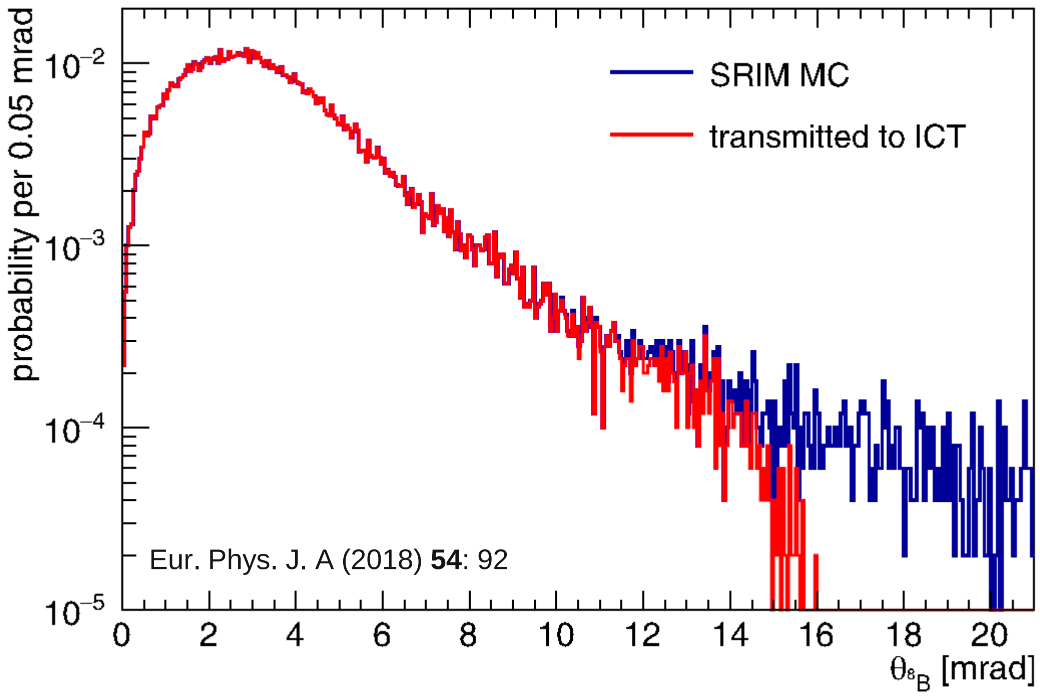


Density profile of the gas target as seen in the yield of the 478 keV γ-ray line from the ^{7}Li(p, p')^{7}Li*.
Target density n = 7.22 ± 0.15 · 10^{18} at/cm^2 at 4.9 mbar
The ^{8}B can be produced in different part along the gas target.

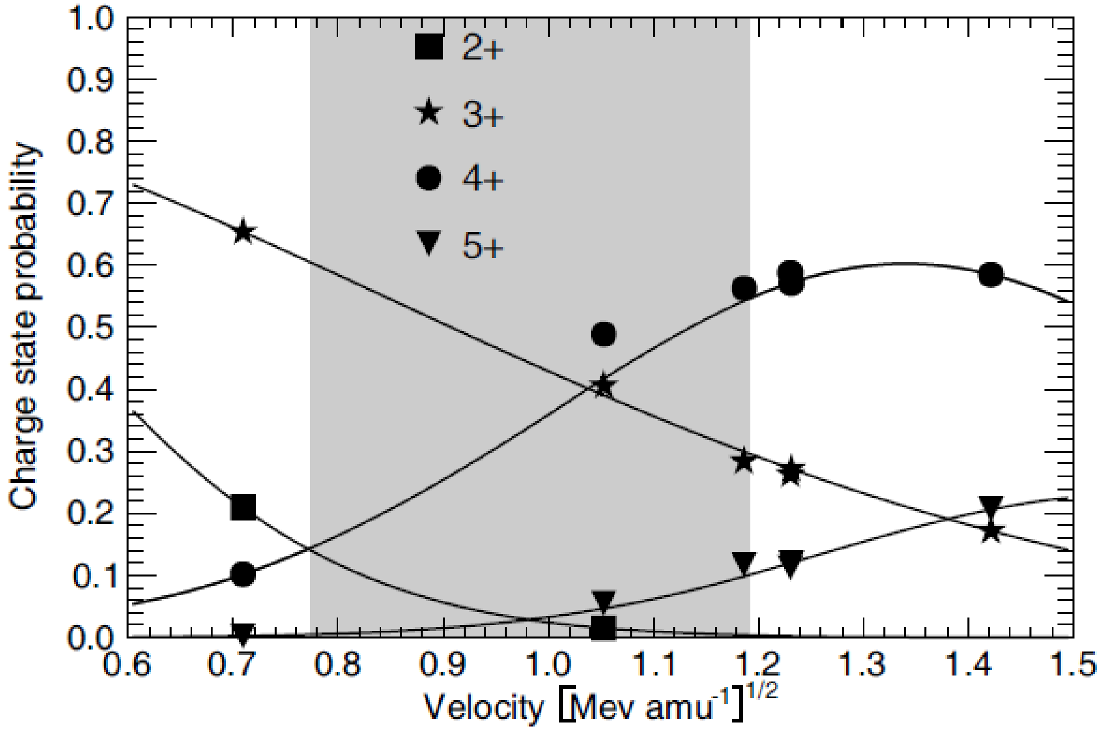


In all conditions full transmission to the end detector of the recoils in the selected charge state is mandatory.

Recoils transmission



Distribution of the ^8B recoils emerging from the target for E_{cm} = 348 keV (blue line).
The red line indicates the recoils reaching the end detector of ERNA using the **experimental acceptance curves**.

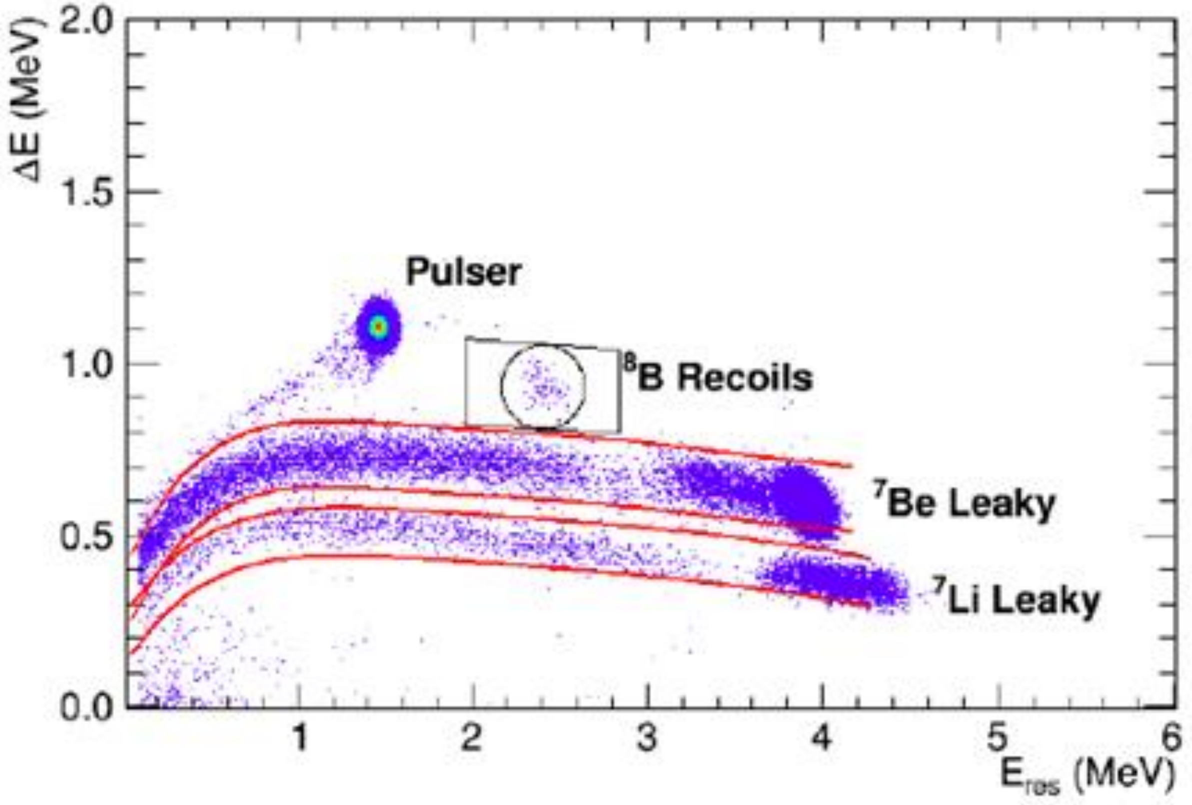


^8B ion charge state probability distribution as a function of the ion velocity.

R. Buompane et al., Eur. Phys. J. A (2018) 54: 92

Recoils detection

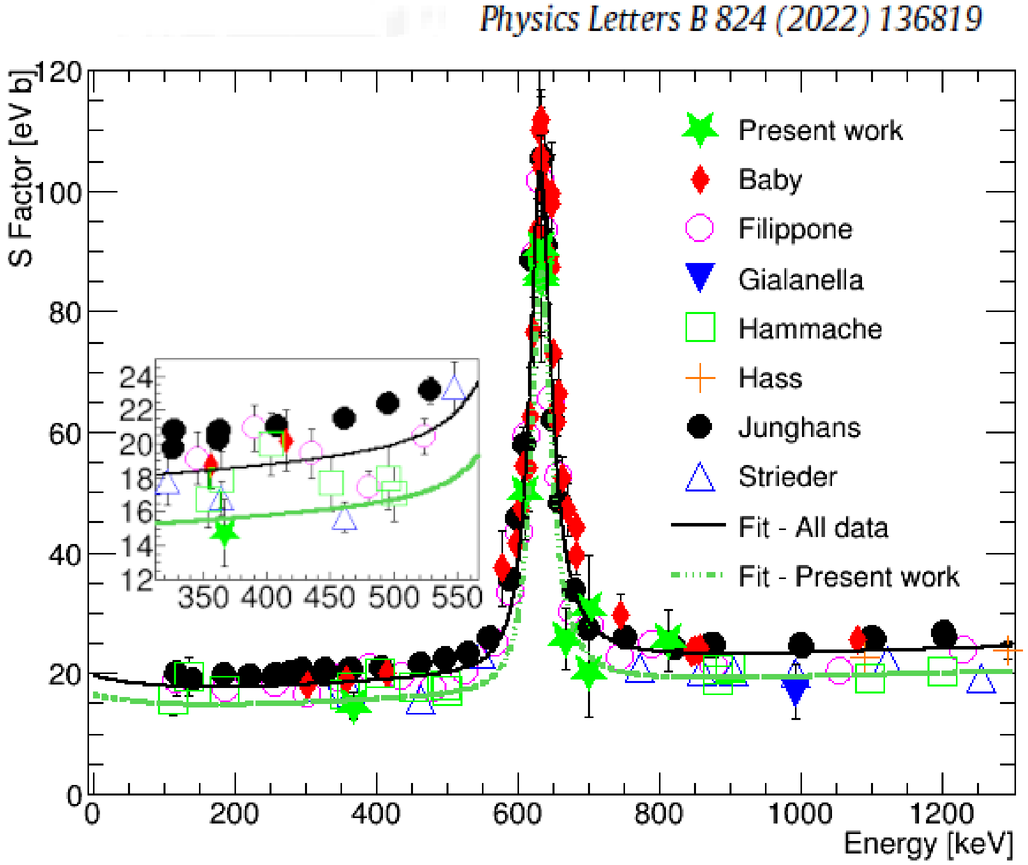
Physics Letters B 824 (2022) 136819



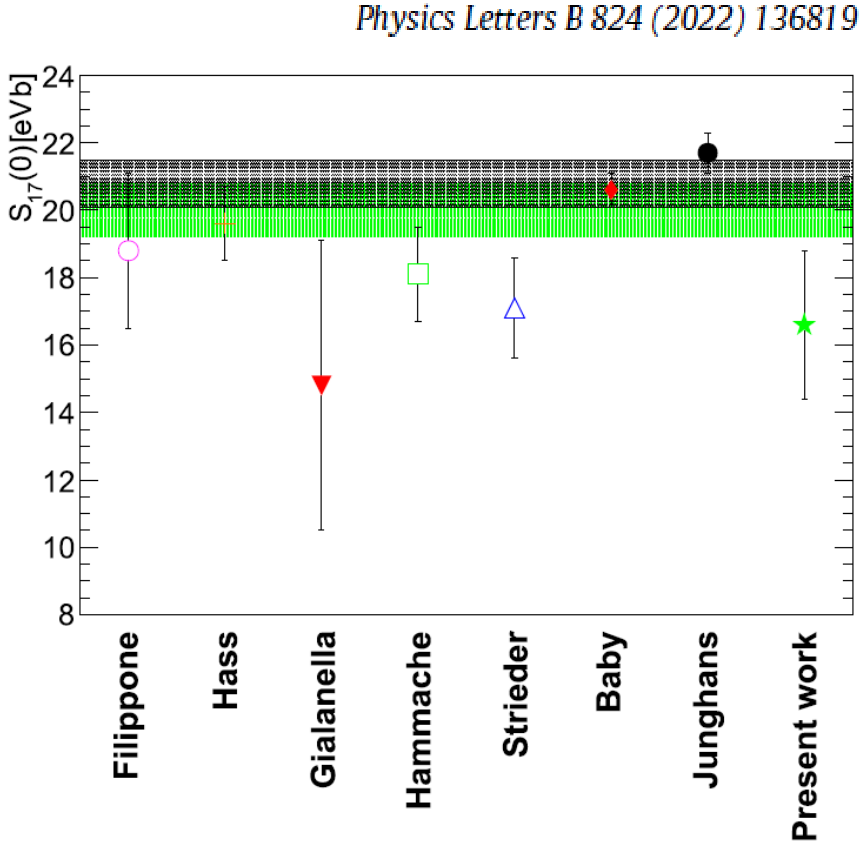
ΔE-E_{res} matrix of the end detector of ERNA for $^{7}Be(p;\gamma)^{8}B$ at 632.4 keV. Both ^{7}Li and ^{7}Be "leaky" beam ions are visible with their long low energy tails.

The contour plots represent the predictions of a Monte Carlo simulation for the different ion species. The rectangular region around the elliptical area where the ^{8}B recoils are expected is used to estimate the background.

Results



The solid green line represents the fit to the present work data alone $S_{17}(0)$ =16.6 ± 2.1 eV b.

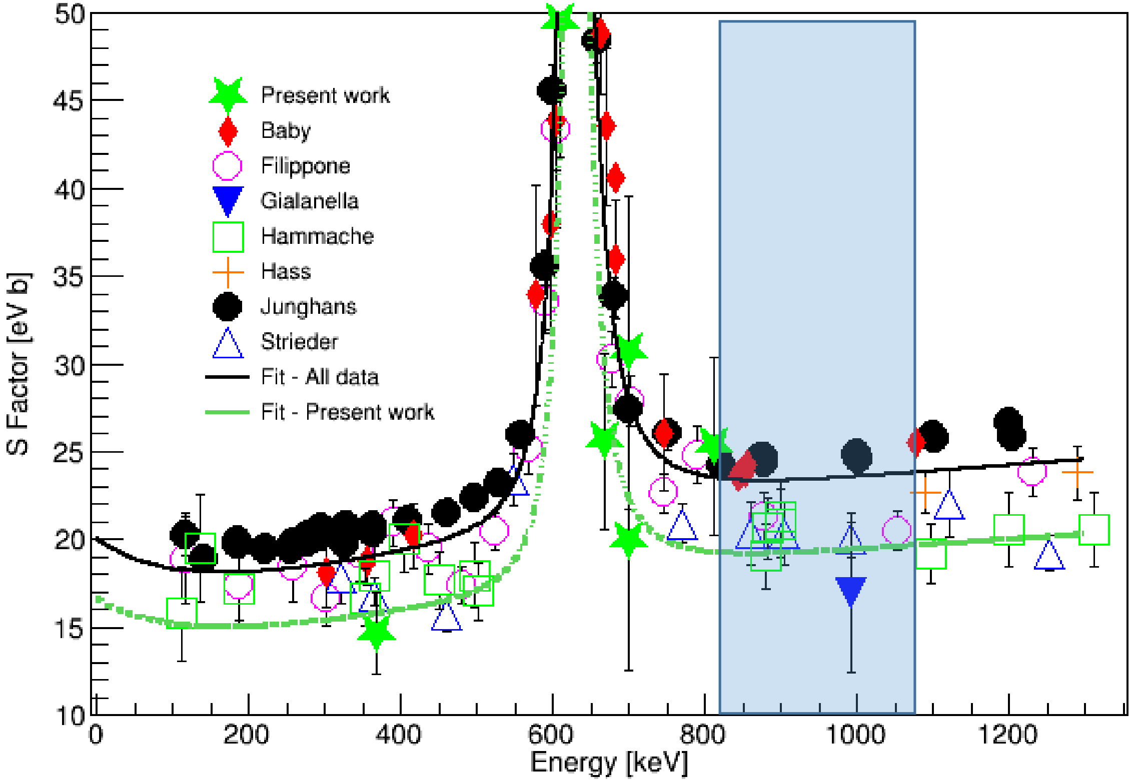


$S_{17}(0)$ values obtained fitting each data set, the error bars include systematic errors.

The solid black line (left) and the green shadowed band (right) represents the result obtained including all data sets and considering the inflation of the systematic uncertainties to obtain a statistical compatibility **$S_{17}(0)$ =20.0 ± 0.8 eV b**.

- Next -

A new solid stripper was installed at the tandem terminal.



The solid stripper increase the probability of higher charge state at terminal and than higher energy range will be explored.

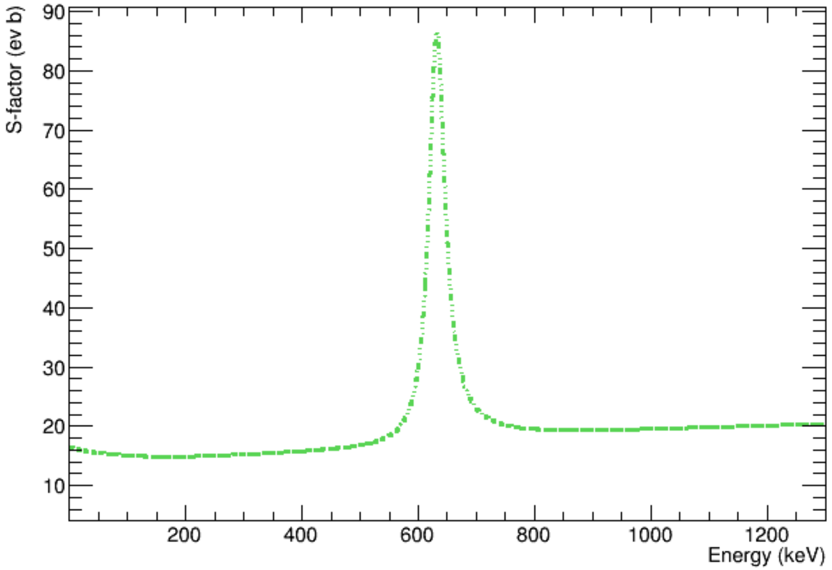
Conclusion

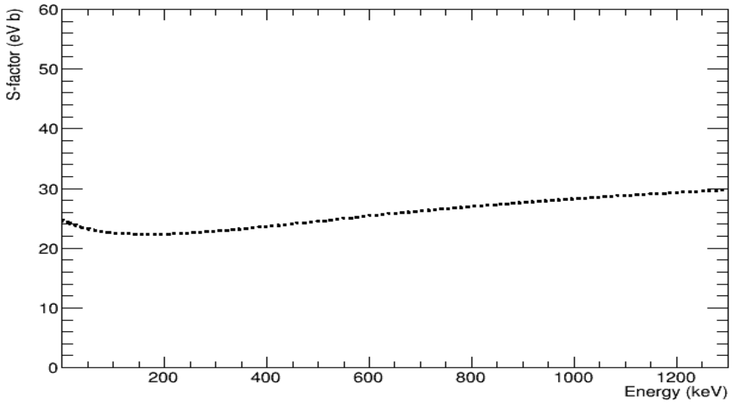
- A very intense ^{7}Be beam, up to 10^9 pps, is routinely produced and characterized at CIRCE laboratory @ Unicampania;
- The first significant total cross section measurement in inverse kinematic and using a recoil separator of the $^{7}Be(p,\gamma)^{8}B$ reaction, from E_{cm} = 366.9 keV up to the E_{cm} = 812.3 keV, has been performed;
- A fit to our data alone yields $S_{17}(0)$ =16.6 ± 2.1 eV b, this value are compatible only with a part of previous measurements, in particular those indicating a low value of the astrophysical S-factor at zero energy $S_{17}(0)$;
- A global fit including all data sets and considering the inflation of the systematic uncertainties provides an estimate $S_{17}(0)$ =20.0 ± 0.8 eV b that we suggest here.
- New measurements at energy E_{cm} > 1 MeV are planned for the next year.

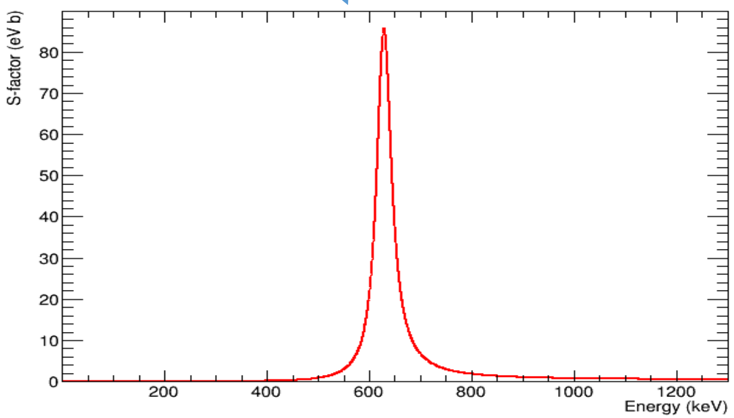
Thanks

Fit function

$$\mathrm{Sfactor(E)} = \mathrm{A} \cdot \mathrm{Sfactor(MN)(E)} + \pi\lambda^2 \cdot \frac{2\mathrm{J}+1}{(2\mathrm{J_p}+1)\cdot(2\mathrm{J_t}+1)} \cdot \frac{\Gamma_\mathrm{p}(\mathrm{E})\cdot\Gamma_\gamma(\mathrm{E})}{(\mathrm{E}-\mathrm{E_{res}})^2+(\Gamma_\mathrm{tot}(\mathrm{E})/2)^2} \cdot \mathrm{E} \cdot e^{2\pi\eta(\mathrm{E})}$$







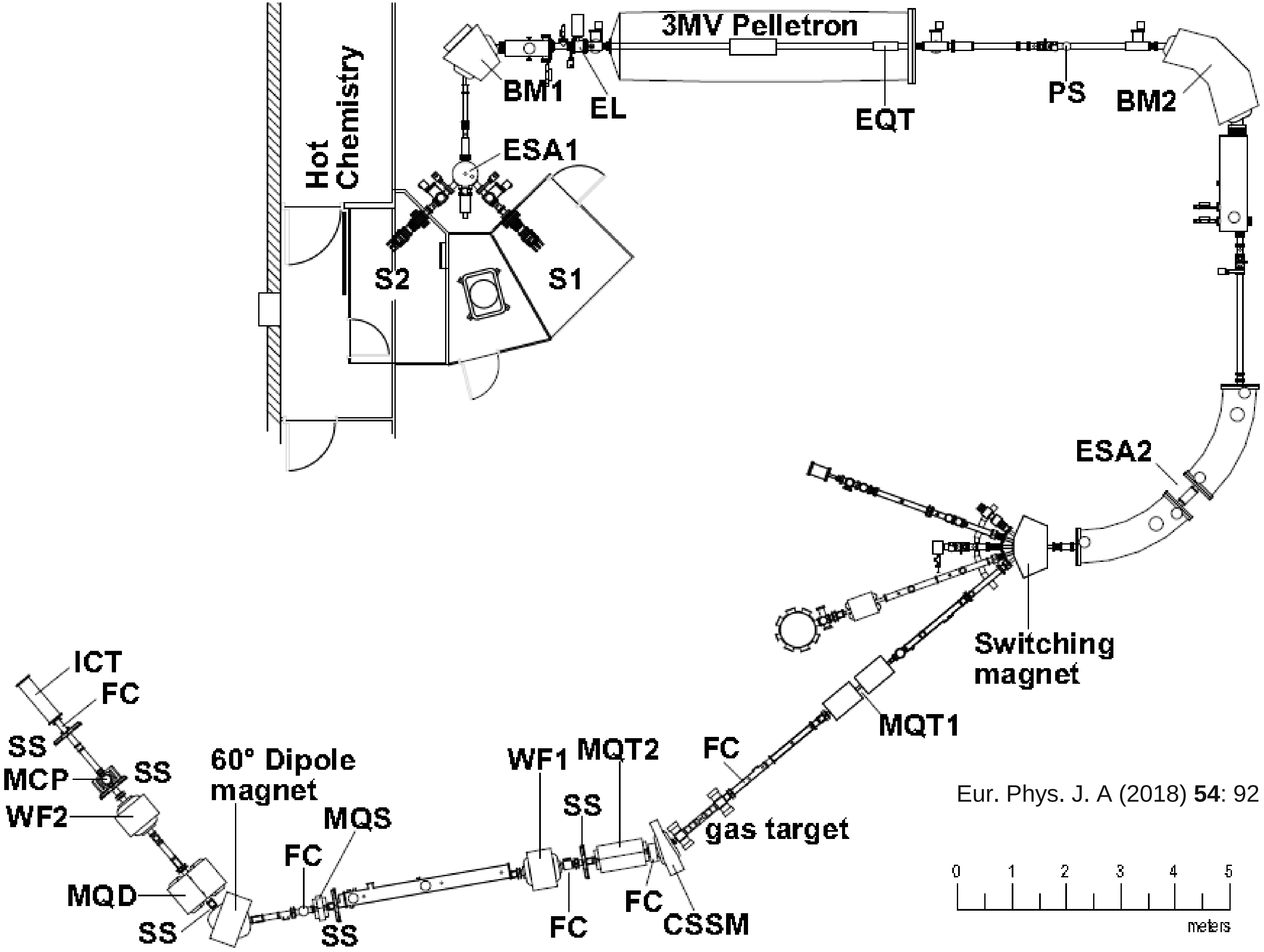
P. Descouvemont, PRC 70, 065802 (2004)

The fit function is obtained summing the non resonant component S_{MN} from Descouvemount et al. 2004 and a resonant component.

The fit function included two parameters: A for the non resonant component and Γ_p .

The E_{res} and $\Gamma\gamma$ are fixed to the literature value from Tilley et al., 2004, NPA, 745(3), respectively of 632 keV and 25.2 meV.

Tandem Laboratory @ Unicampania



Eur. Phys. J. A (2018) **54**: 92