Direct measurements of the $^{12}C+^{12}C$ reactions cross-sections towards astrophysical energies

Lizeth Morales-Gallegos

M. Aliotta, A. Best, C.G. Bruno, R. Buompane, T. Davinson, M. De Cesare, A. Di Leva, A. D'Onofrio, J.G. Duarte, L.R. Gasques, L. Gialanella, G. Imbriani, G. Porzio, D. Rapagnani, M. Romoli, F. Terrasi

$^{12}C+^{12}C$ Astrophysical Impact

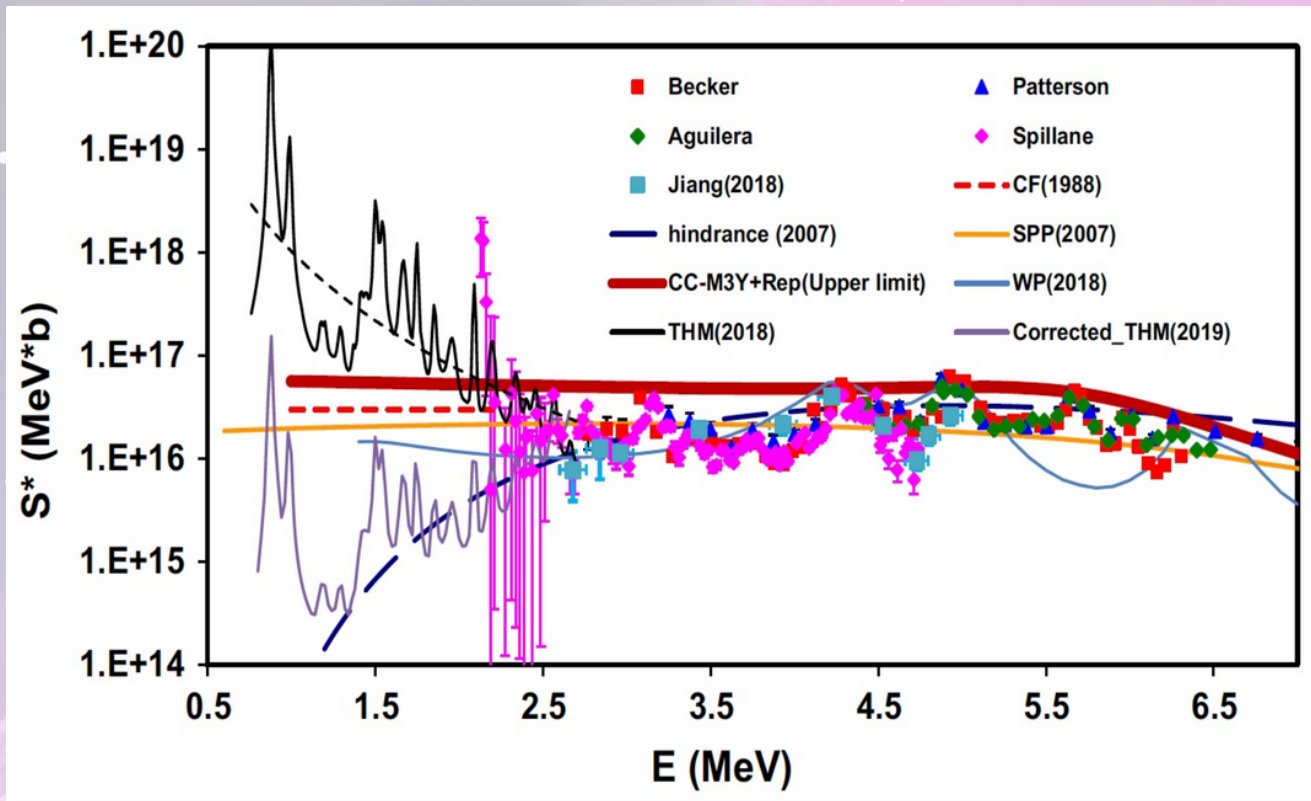
- Dominant in the core and shell C burning
- Determine MUP = mass threshold for C burning to occur:
  Mstar < MUP → White Dwarf
  Mstar > MUP → C burning
- Variation of their cross section can change the final properties of a star before supernova explosion.
- These cross sections are essential to model X-ray bursts and explosions on the surface of neutron stars.

ERNA
European Recoil separator for Nuclear Astrophysics

50 years of measurements

Still problems:

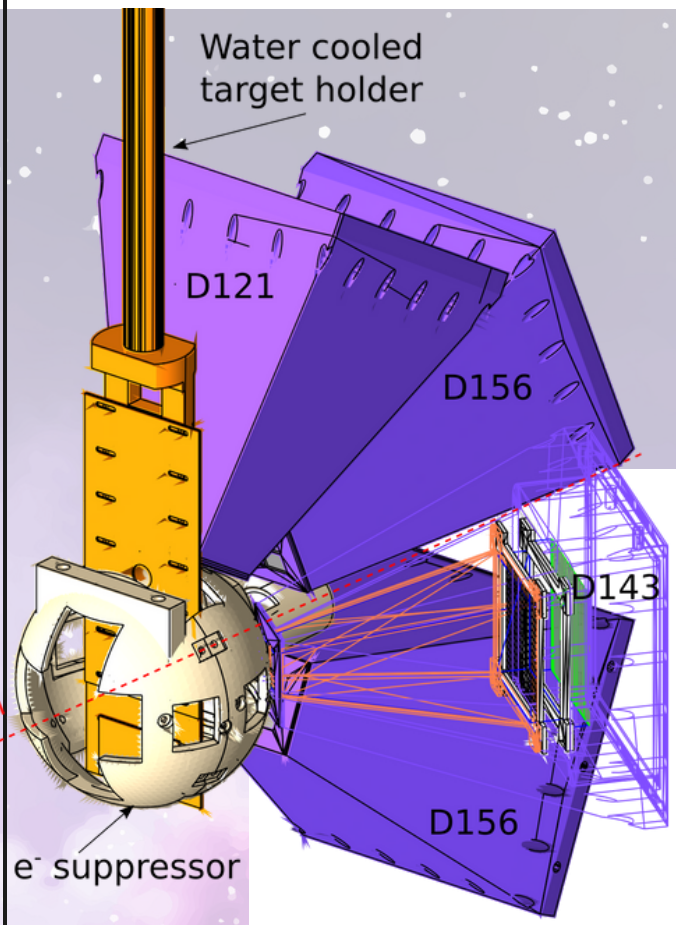
- Uncertainties
- Discrepancies
- Inaccurate extrapolations



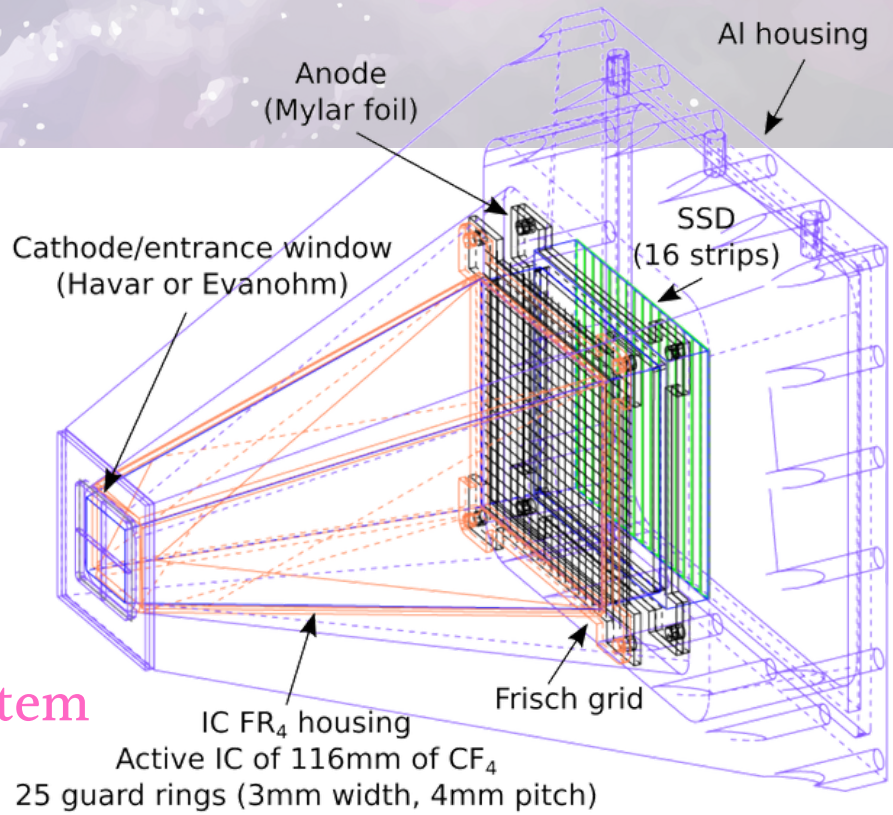
→ Direct measurements are required!

$^{12}C+^{12}C$ Previous Works

$^{12}C+^{12}C$ Measurements

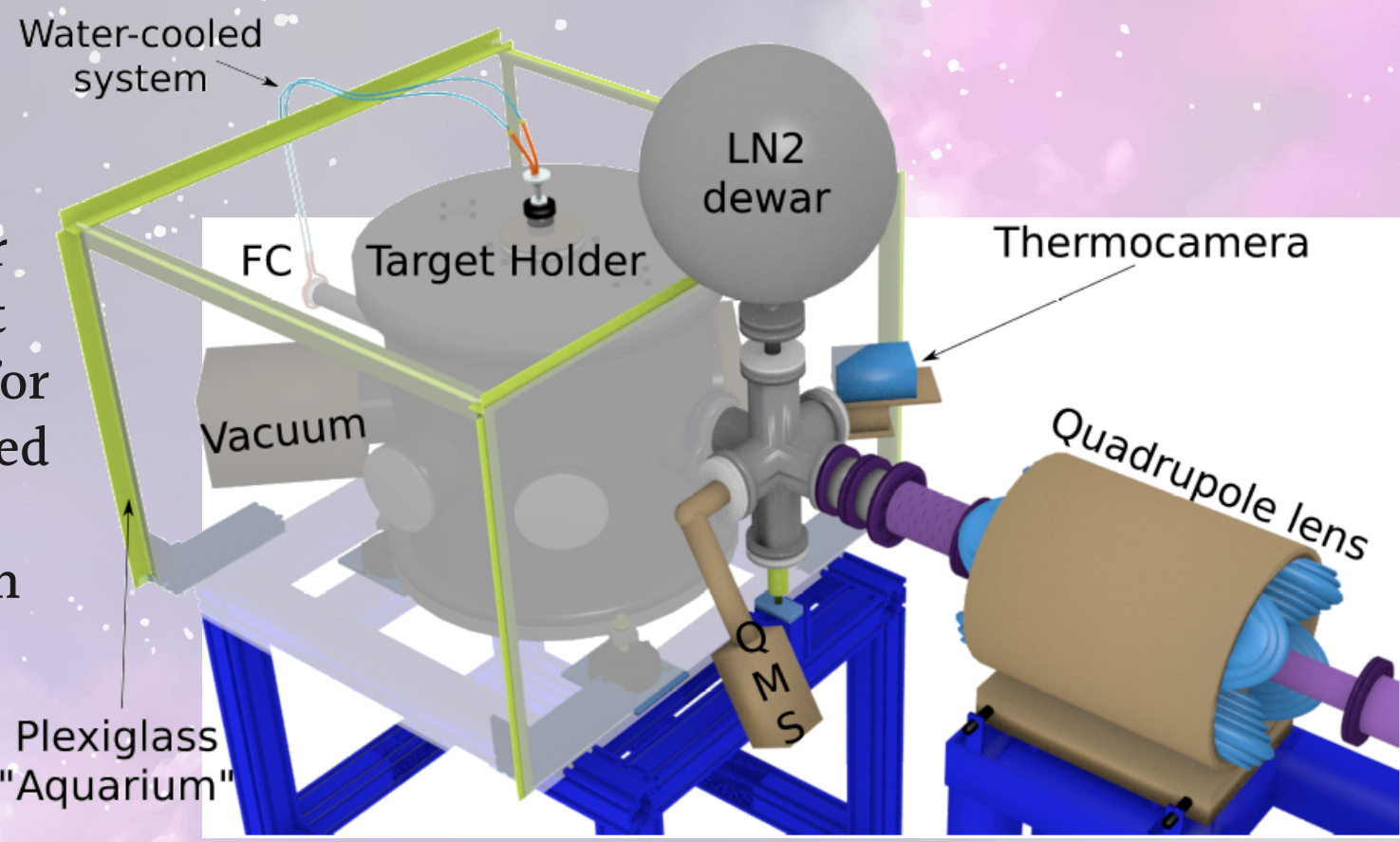


M. Romoli et al.
European Physical Journal A 54:142 (2018)



GASTLY
Gas–Silicon Two Layer sYstem

Target temperature and chamber environment monitoring for beam-induced background minimisation (up to 90%)



L. Morales-Gallegos et al.
European Physical Journal A 54:132 (2018)

$^{12}C+^{12}C$ Experimental Setup

$^{12}C+^{12}C$ Typical Matrix

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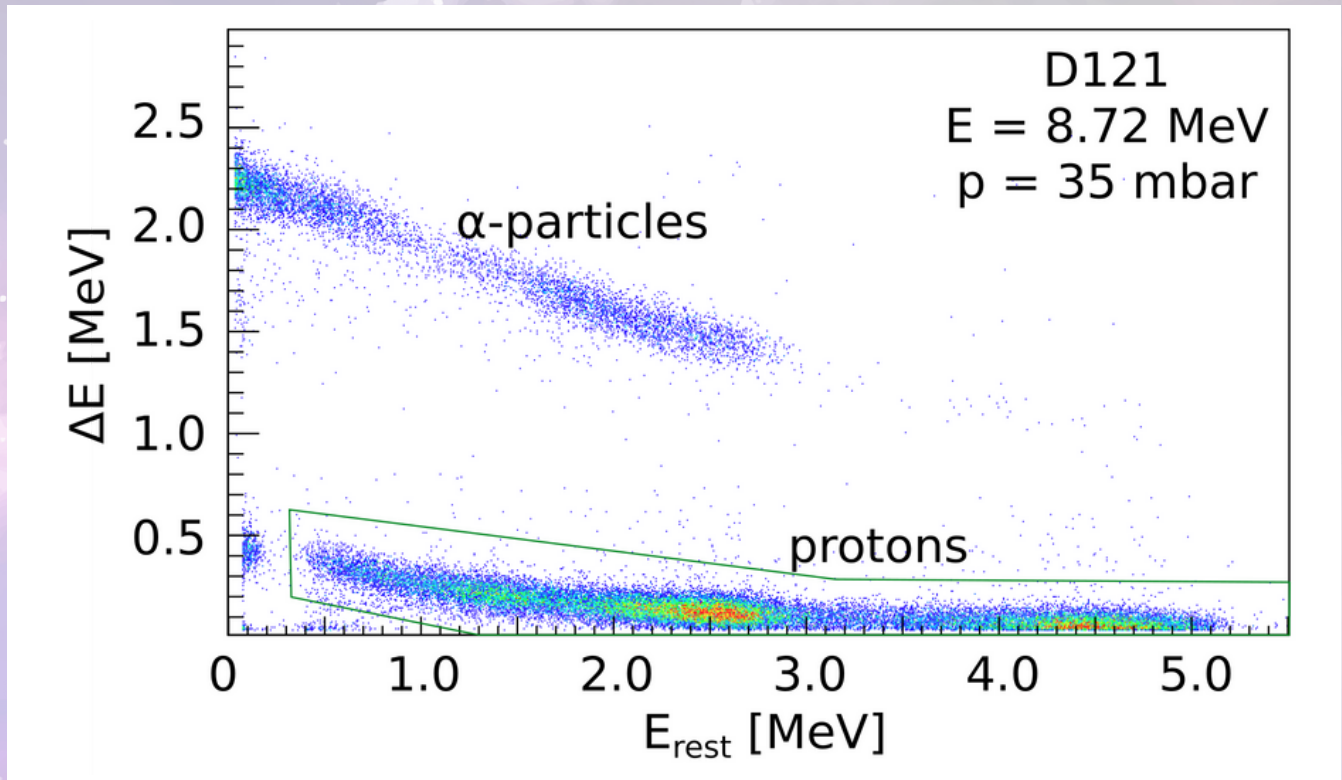

- Excellent resolution of the GASTLY detectors (identification of target contamination for discrimination)
- Non constant branching ratios
- Anisotropic angular distributions

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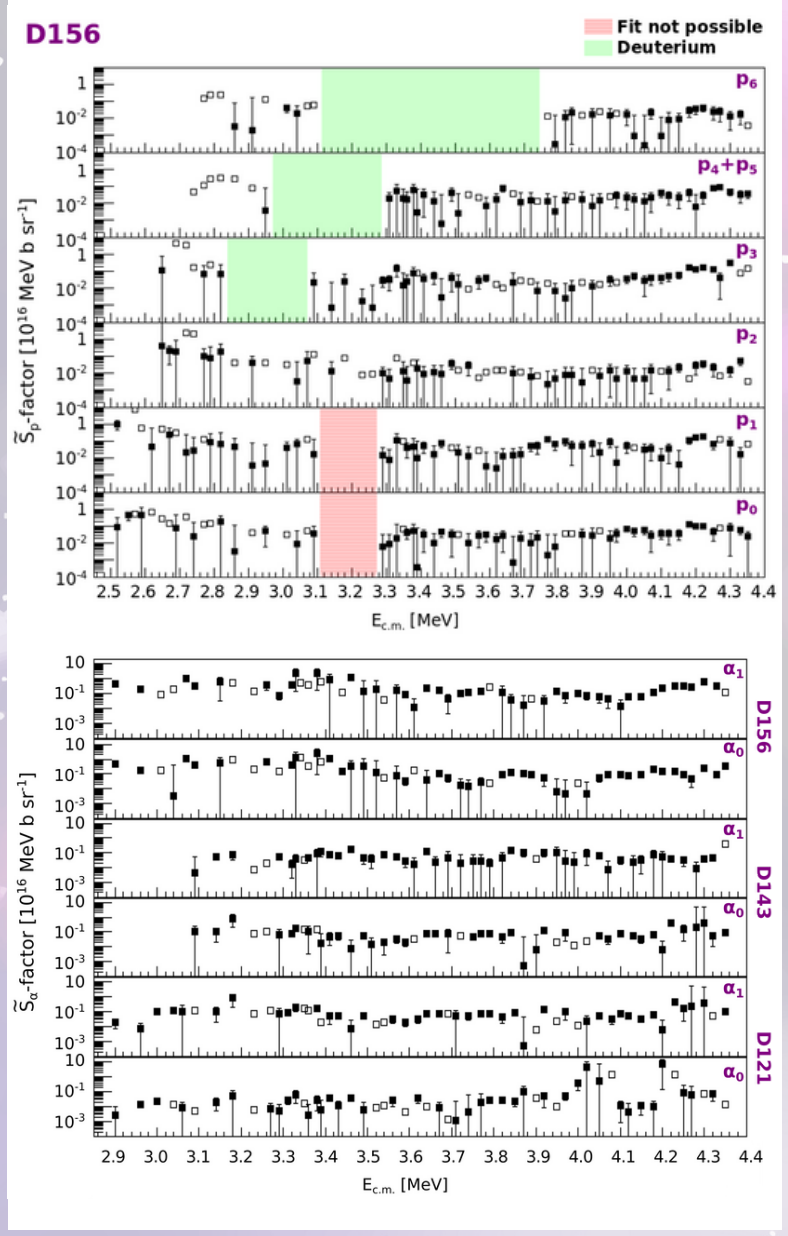

$^{12}C+^{12}C$ Results

$^{12}C+^{12}C$ Results

- Excellent resolution of the GASTLY detectors (identification of target contamination for discrimination)
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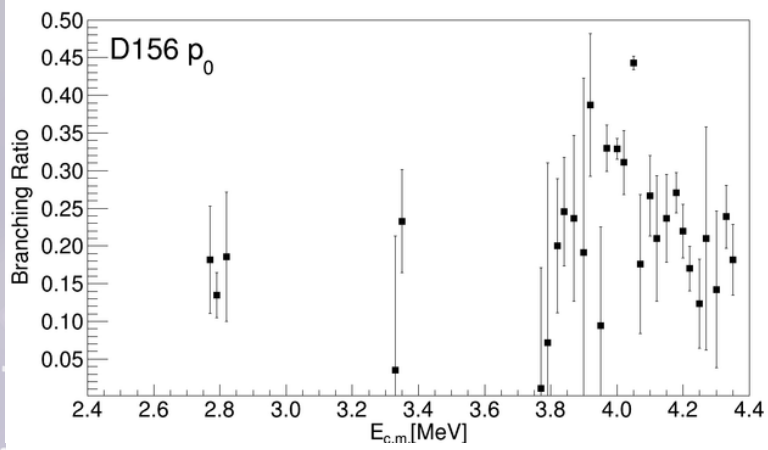
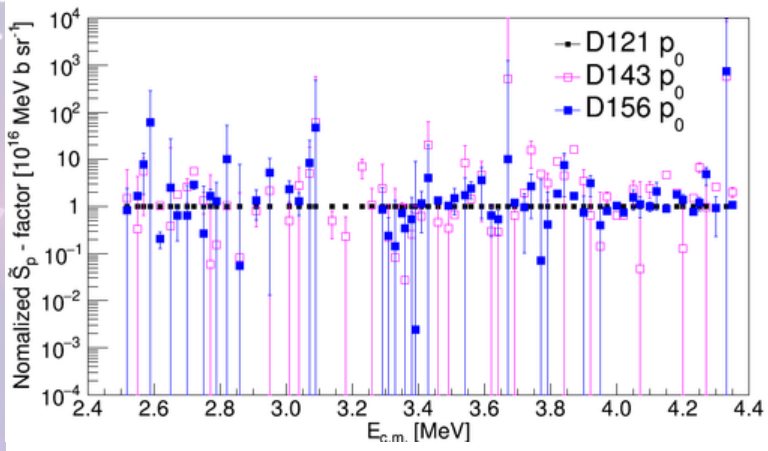
- Anisotropic angular distributions





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$^{12}C+^{12}C$ Qualitative Comparisons

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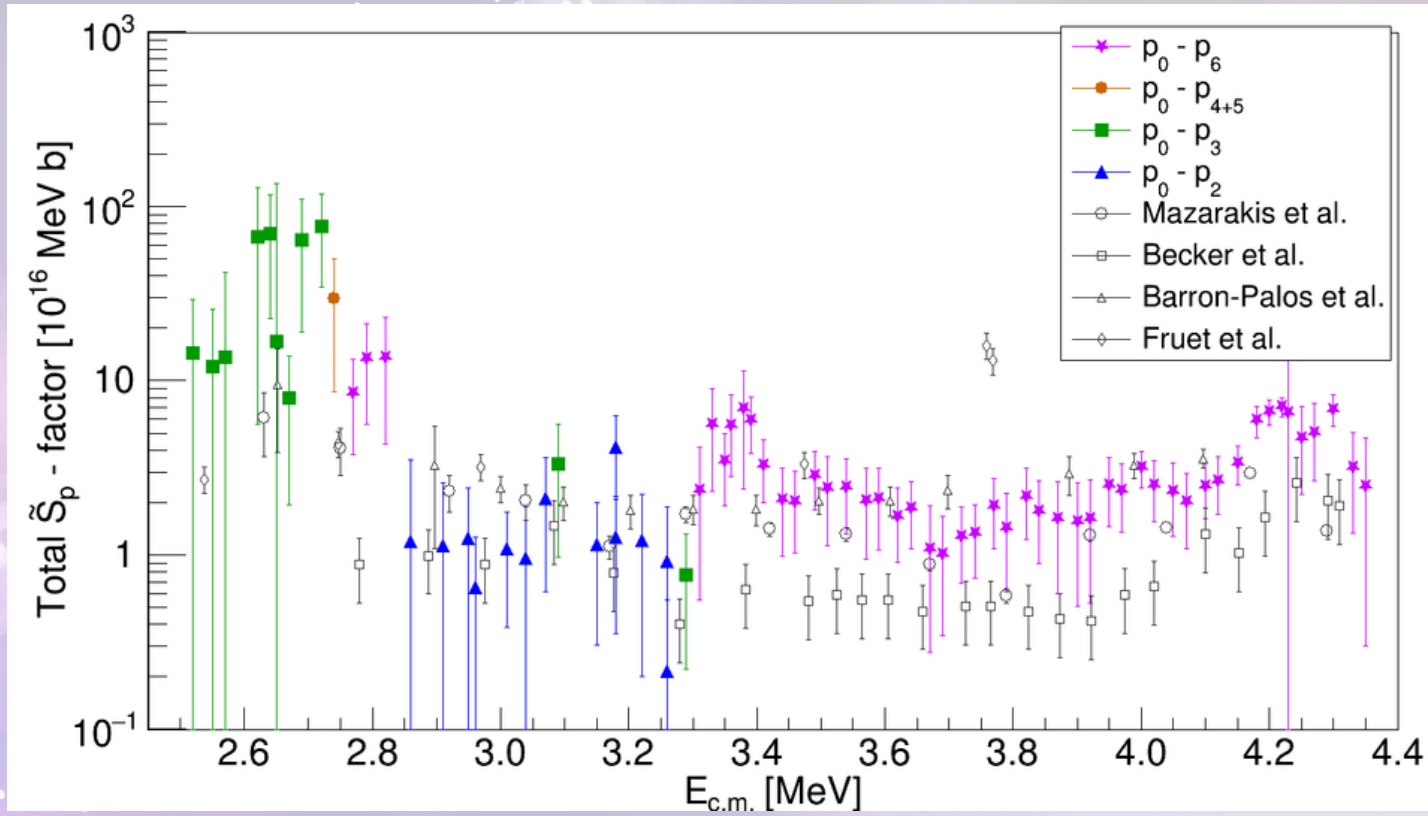

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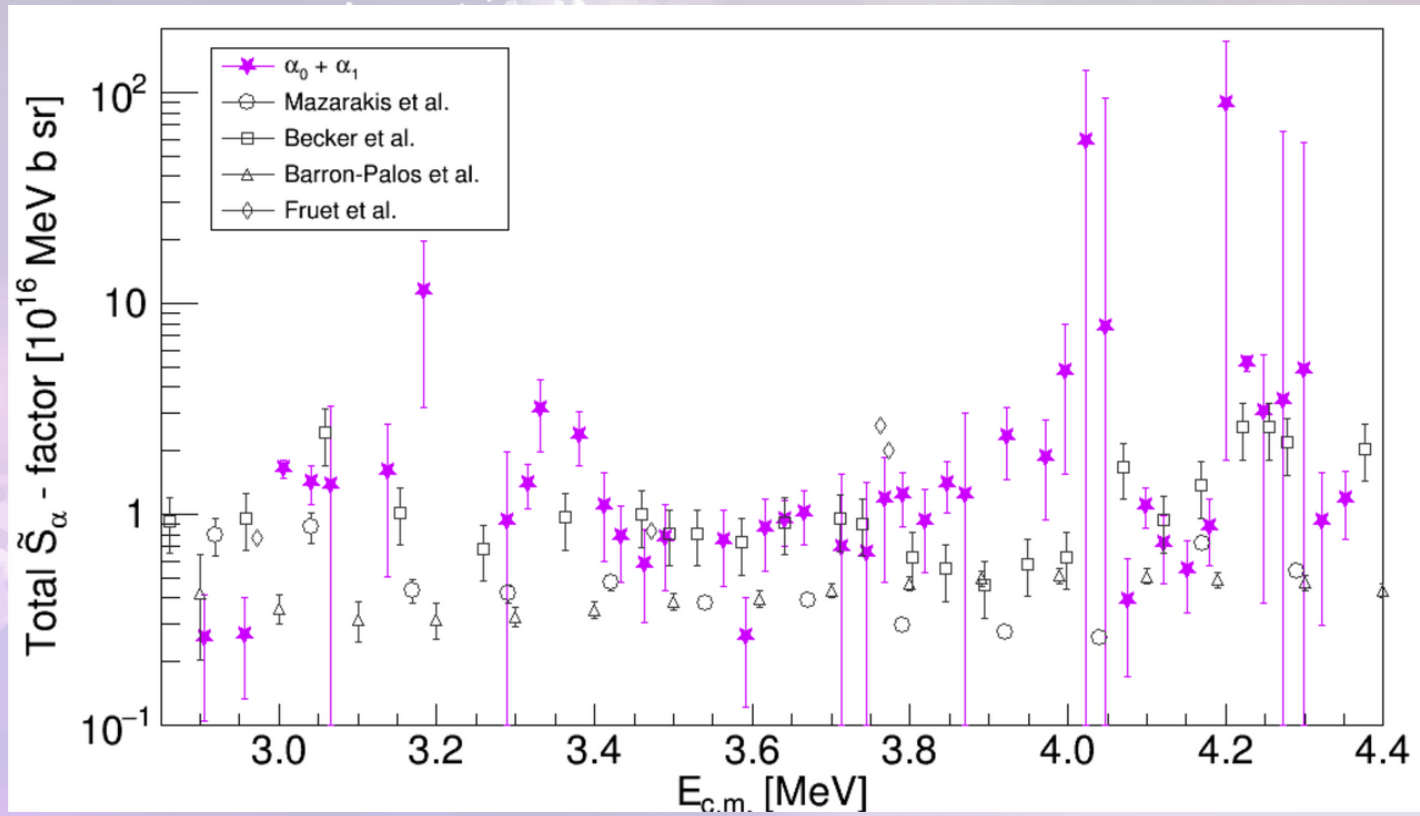


Updated GASTLY detectors

Single strip read-out

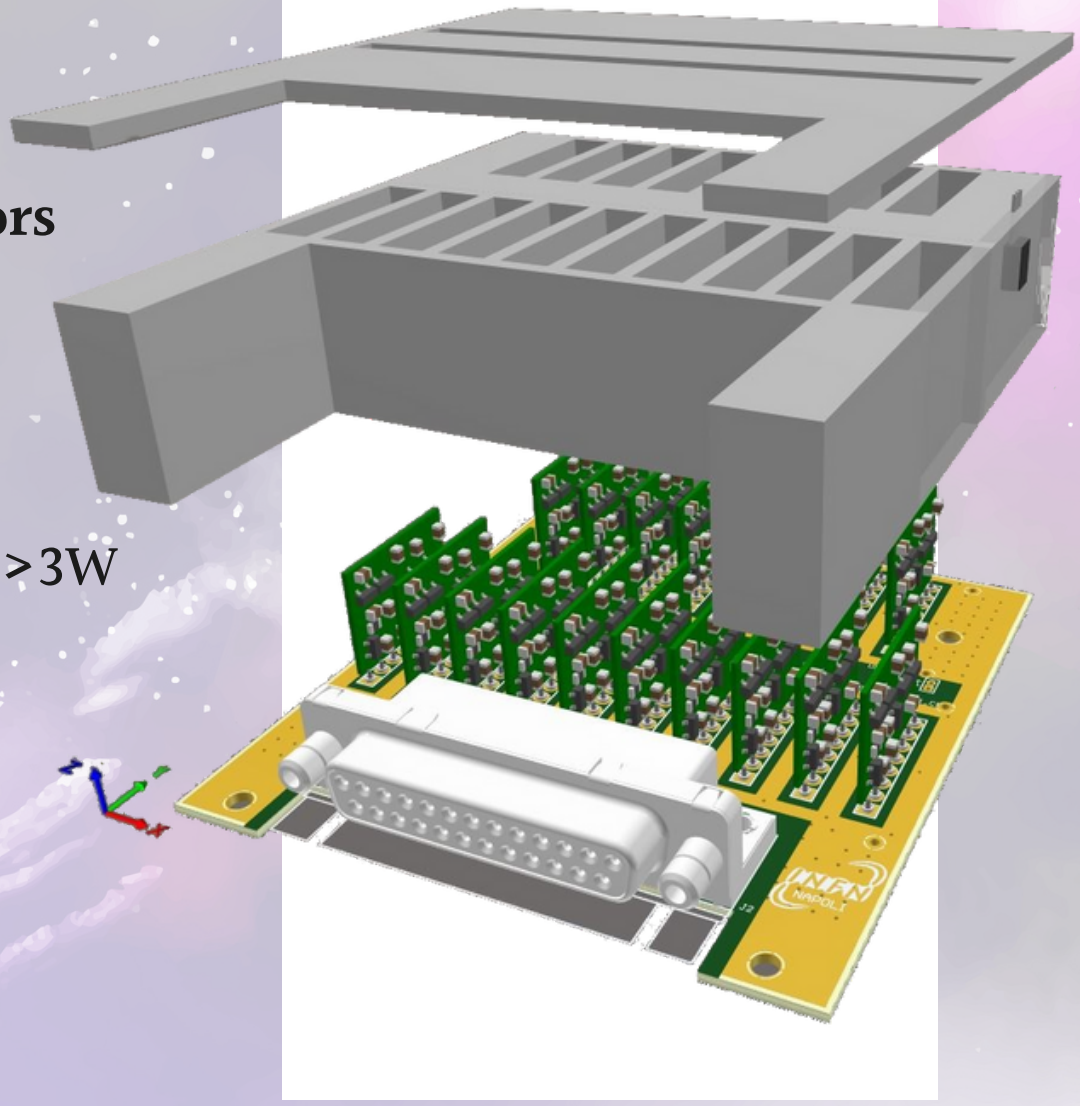
18 CHAPLIN inside each module: dissipation power >3W

Conductive dissipator

3-level noise shielding

2 temperature sensors

Pressure sensor



$^{12}C+^{12}C$ Future

ERNA
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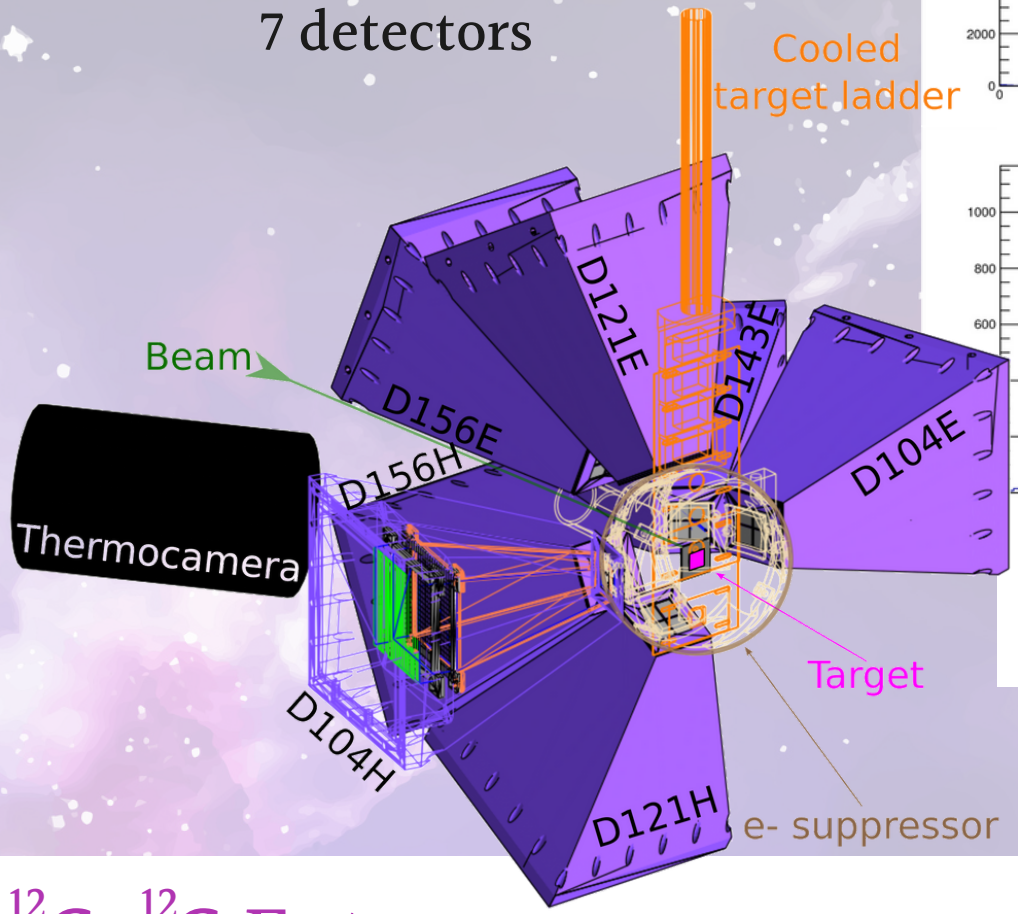
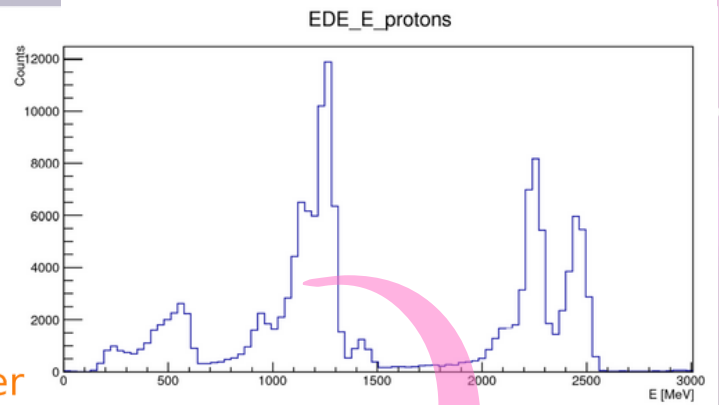
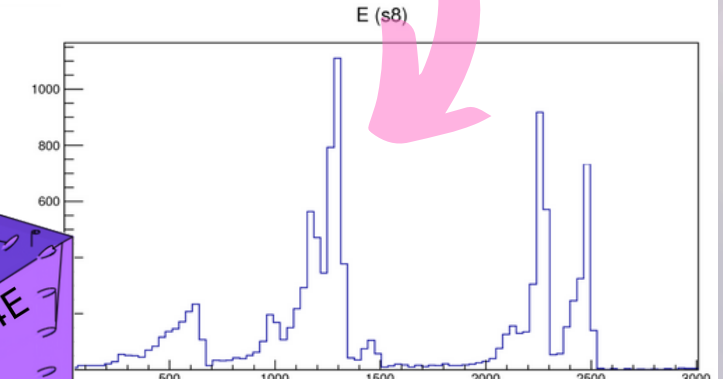
16 working strips
< 1.3° step
Range = 95°–163°

7 detectors







$^{12}C+^{12}C$ Future

ERNA
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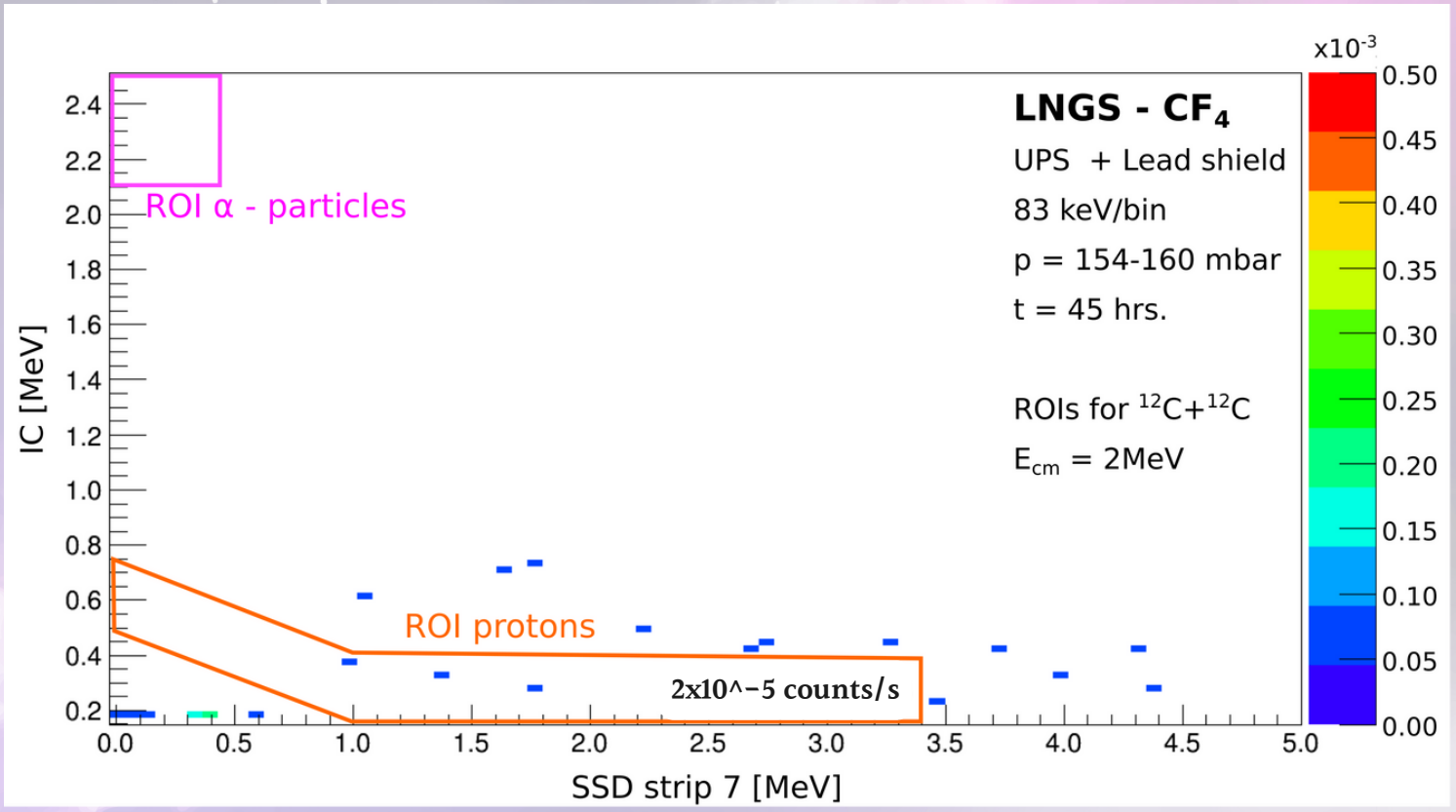
The ERNA–LUNA collaboration
GASTLY underground



$^{12}C+^{12}C$ Collaboration

The analysis of a >20 days of data taking is ongoing.

Preliminary results indicate:

- Alpha particles are not limited by intrinsic bkg
- A 12C+12C measurement underground (with 100uA of carbon beam, a ~1.2 S/N ratio and only one strip) is possible:
  - down to 1.54MeV (following the THM results)
  - down to 1.85MeV (if the reaction is not resonant)
- This can be improved using less emitting materials in the detector (study ongoing).

$^{12}C+^{12}C$ Collaboration

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THANKS!

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