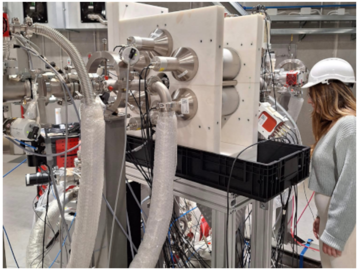
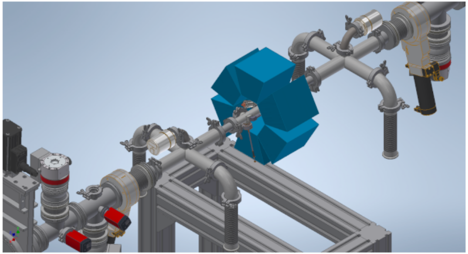
New measurements of the ^{22}Ne+α reactions
Key reactions in nuclear astrophysics
ECT*, Trento, IT





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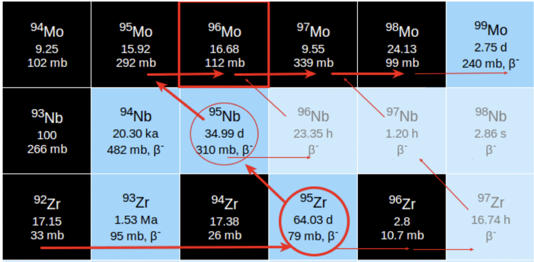
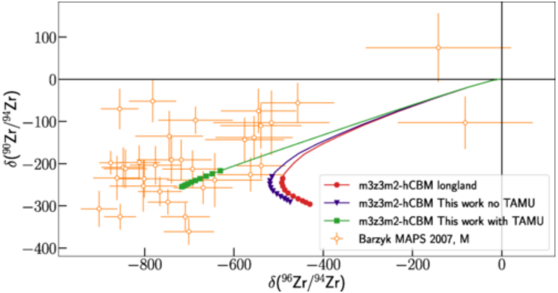
European Research Council

Established by the European Commission

$^{22}\mathrm{Ne}(\alpha,[n,\gamma])^{25,26}\mathrm{Mg}$

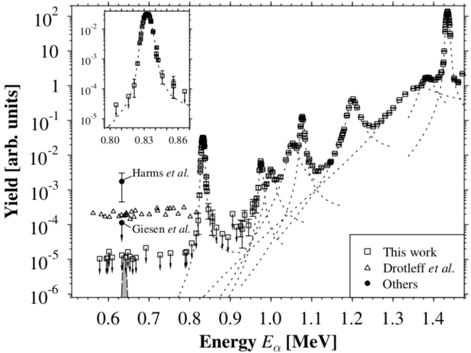


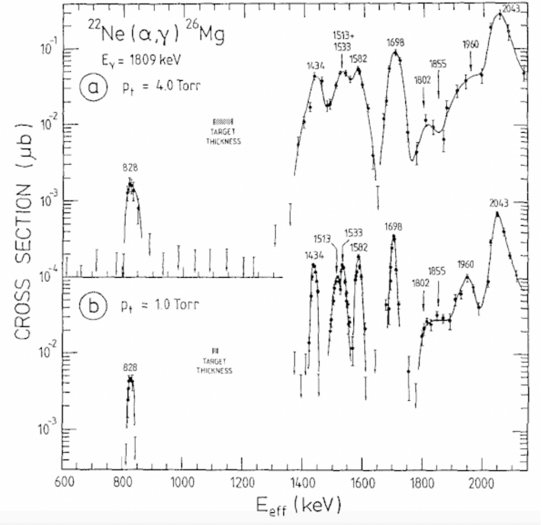


Adsley et al. PRC 103, 015805

- $^{22}\mathrm{Ne}(\alpha,n)^{25}\mathrm{Mg}$ contributes during late stages of main s process
- Determines branch point population
- Main source for weak s process
- Mg isotope observations in stellar atmospheres: γ vs. n channel
- Both channels important, both channels highly uncertain

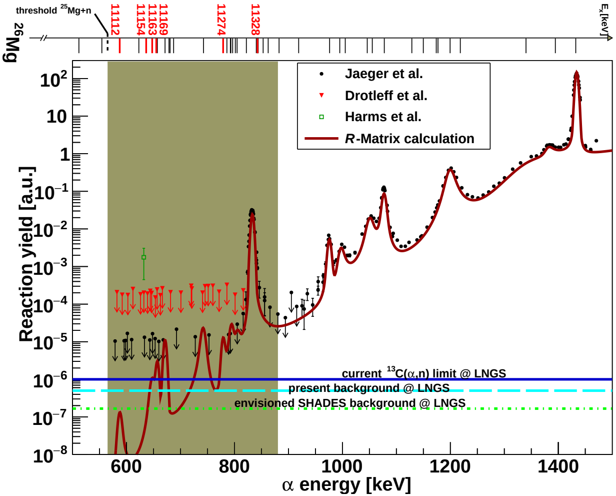
State of the Art





- (α, n): Jaeger et al. 2001
- (α, γ): Wolke et al. 1989
- Some remeasurements at $E_\alpha = 832$ keV since then
- External background limiting factor

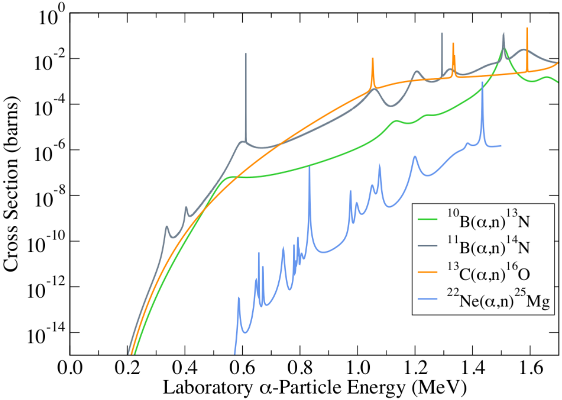
$^{22}Ne(\alpha, n)^{25}Mg$



R matrix courtesy of R. J. deBoer, University of Notre Dame/JINA

- Capabilities on surface exhausted (20+ years since last data)
- Current lowest data 2 reactions/minute
- Covered one resonance close to Gamow
- Many states that can contribute
- **300 keV of upper limits. . .**
- **We can measure < 10 reactions/hour**

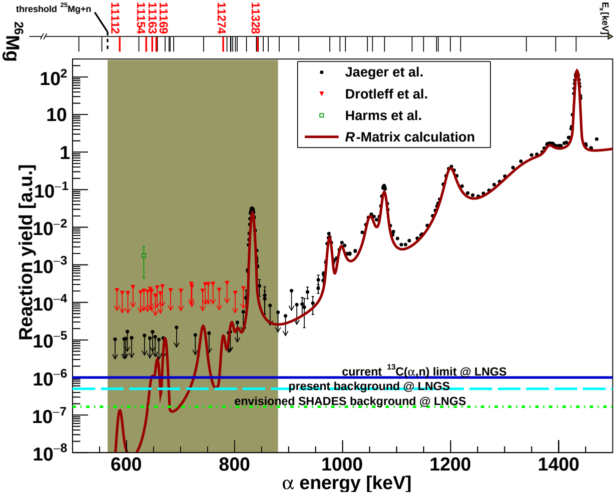
Beam-induced backgrounds



- Q-values:
  - ^{22}Ne = - 478 keV
  - ^{10}B = 1059 keV
  - ^{11}B = 158 keV
  - ^{13}C = 2216 keV

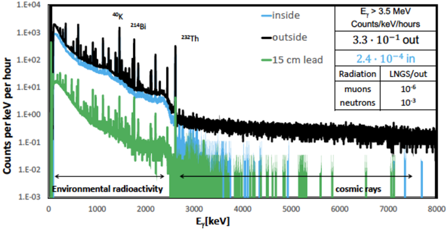
At least 600 keV gap - any kind of energy ID helps

What to do?

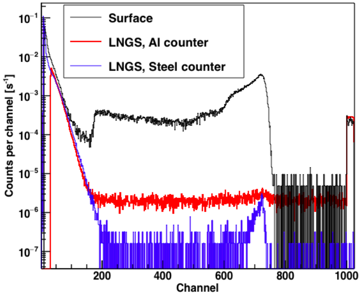


- Suppression/identification of beam-induced background
- Drastic background reduction
- Large beam current increase
- → measure underground @ Bellotti IBF MV with new detector array

Why go underground? (it's cold, dark, wet. . .)



J. Phys. G: Nucl. Part. Phys. **45** (2018) 025203



- Muons major high-energy (> 3 MeV) background in γ-detection
- Cosmic muons absorbed by rock
- "Automatic" suppression by 3 o.o.m
- Below 3 MeV bg comes from rocks etc, but can build very massive shield
- 3 o.o.m. reduction achieved with lead, copper, radon box

- Atmospheric neutrons removed
- Remainder (10^{-3}): decays in environment
- Material choice now makes a difference
- Add PSD and passive shielding
- Example: $^{13}C(\alpha,n)^{16}O$ 2 bg count/hour with 18 ^{3}He counters

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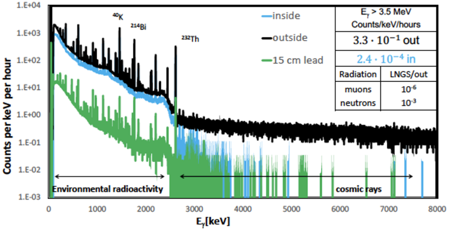

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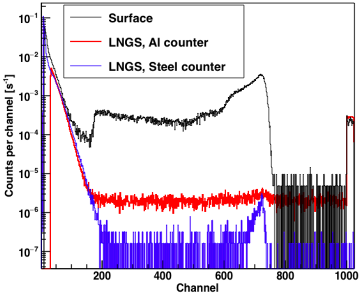

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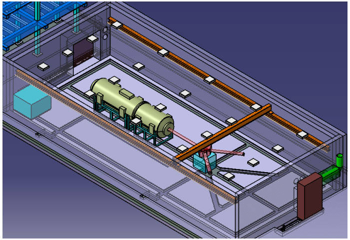
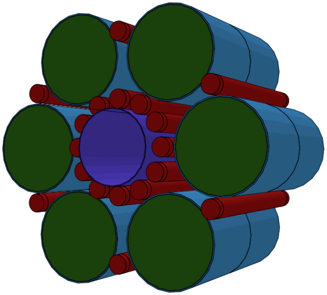
New MV accelerator of the INFN Bellotti Ion Beam Facility



- Specifically designed to fit nuclear astrophysics needs
- Reaction rates of $< 1/\text{hour}$:
  - Beam current ($\approx 5\times$ Jaeger et al.): push signal-noise ratio
  - Current stability: measurements of the order of weeks
  - Energy stability: must not drift over long periods
- 300 - 3500 kV: cover entire astrophysical energy range
- Sen et al. NIM B 450 (2019), 390
- Taken into operation with $^{14}\text{N}(p,\gamma)$

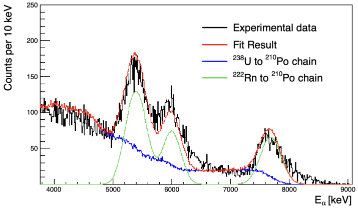
SHADES project

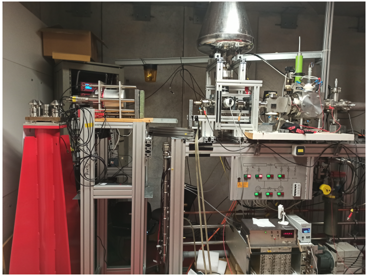


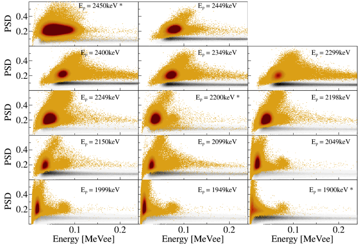
- Hybrid detector array: ^{3}He counters & liquid scintillator
- Provides good efficiency with certain energy sensitivity
- Clean apertures against BIB
- Gas target (recirculating) for long, uninterrupted runs

European Research Council
Established by the European Commission

Preparation

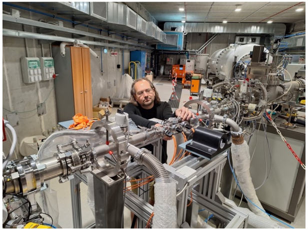


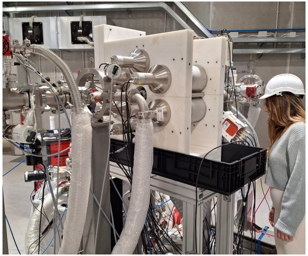


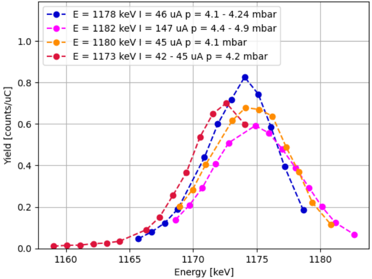


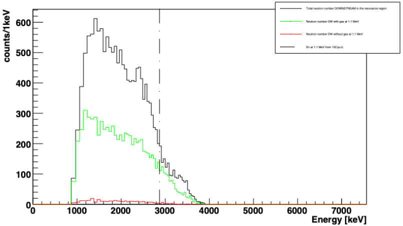
- 1st target setup and characterisation at CIRCE
- Scintillator background (Ananna et al. NIM A 1060 (2024) 169036
- Detector characterisation at FRANZ
- Paper including ML PSD - Chillery et al. in preparation
- Assembled at LNGS in 2023

Underground status



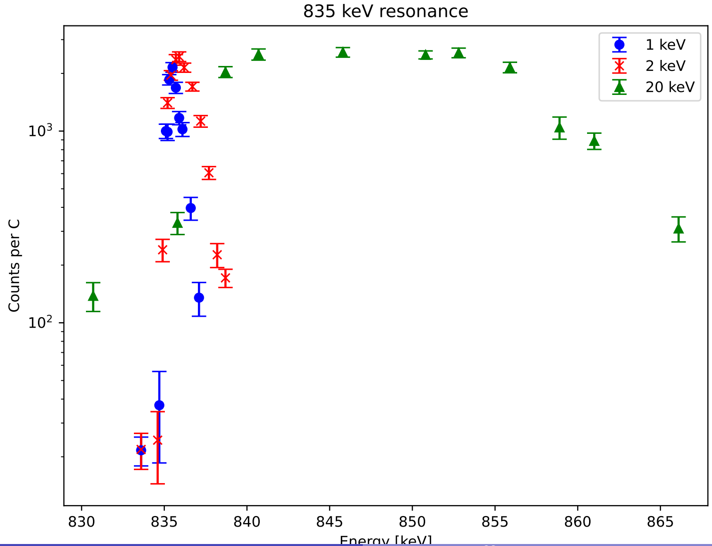






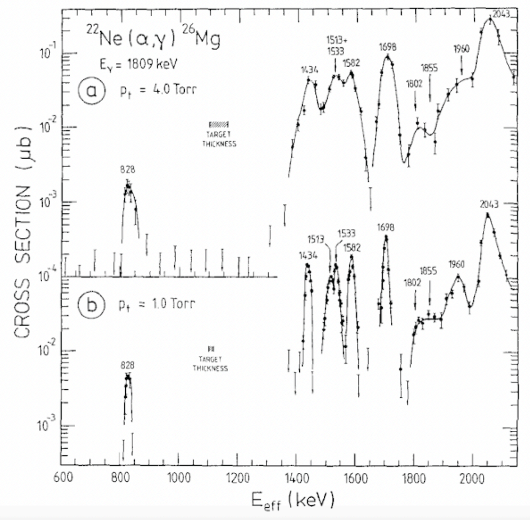
- Everything installed at a brand new beamline
- First beam into target and array summer 2024
- October-December 24 first runs with ^{22}Ne - some BIB

Results from November/December 2024



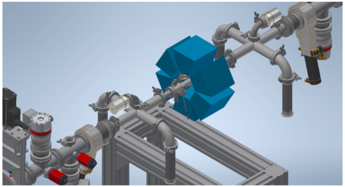
- 835 resonance easy to measure
- So far between 1 keV - ca. 35 keV scans
- High E and low E to be done
- Array efficiency to be measured at ATOMKI April 25

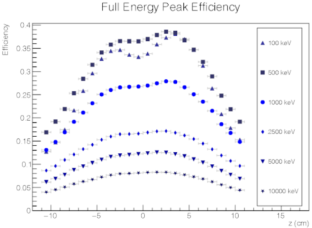
$^{22}Ne(\alpha,\gamma)^{26}Mg$

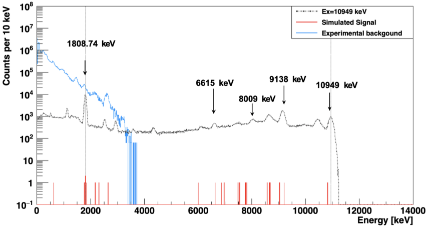


- Direct data Wolke et al. 1989 (!)
- Some remeaseurements of 830 keV res (TUNL)
- CASPAR + LUNA few new upper limits
- Vast terra incognita to explore
- Q = 10.615 MeV, use calorimeter + underground

EASγ
Experimental and Astrophysical Study of $^{22}Ne(\alpha,\gamma)^{26}Mg$



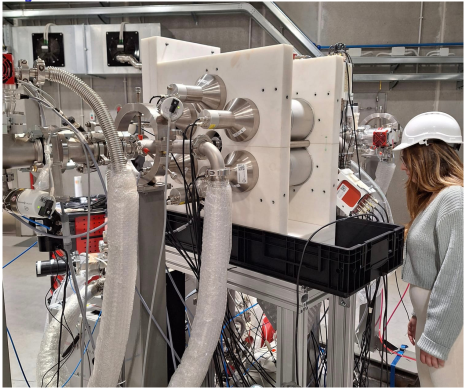




- MUR project started 1. December 2022 - 4 years
- Synergize with ERC setup
- High-efficiency γ-detection array
- Map out cross section of (α,γ) channel
- Submitted to IBF PAC for first test run in 2025 (after SHADES)
- 6 NaI crystals purchased, grad student @ CIRCE/Caserta

MUR
Ministero dell'Università e della Ricerca

Summary



- Steady influx of indirect data, need some direct input
- Push direct cross section into Gamow energy with SHADES/EASγ
- Neutron channel ongoing, to be concluded in 2025
- Beam time without BIB (?) next week
- Switch to gamma channel end of year