The LUNA MV experiment at the Gran Sasso National Laboratories

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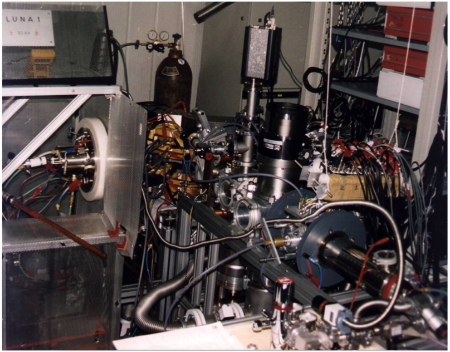
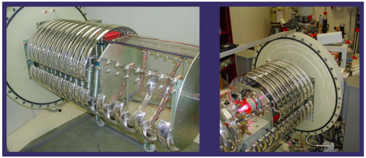
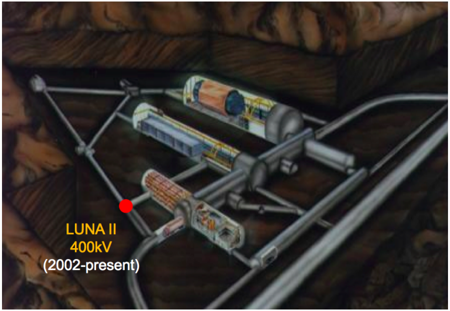
LUNA 1

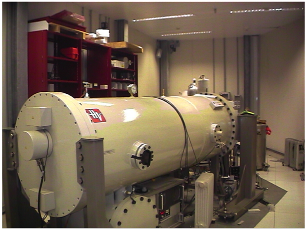


- Setup to measure p-p chain reactions
- 50 kV platform built by students
- $^{3}He(^{3}He, 2p)^{4}He$ - solar neutrino problem

LUNA 2

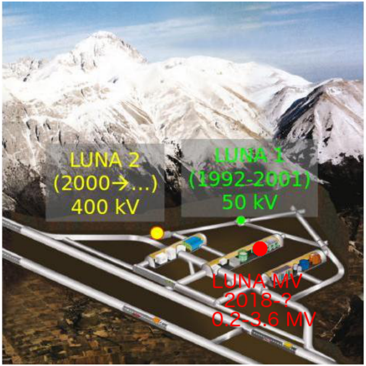






- Moved down the corridor a few meters
- In operation since 2002
- 50 - 400 kV accelerator
- 500 μA protons, alphas on target
- $^{14}N(p,\gamma)^{15}O$ - CNO neutrinos / age of the Universe

LUNA MV



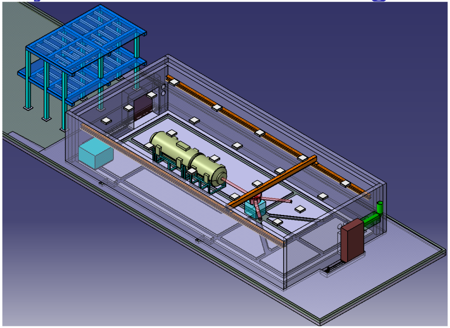
H
- $^{1}H^{+}$ (TV: 0.3 – 0.5 MV): 500 μA
- $^{1}H^{+}$ (TV: 0.5 – 3.5 MV): 1000 μA

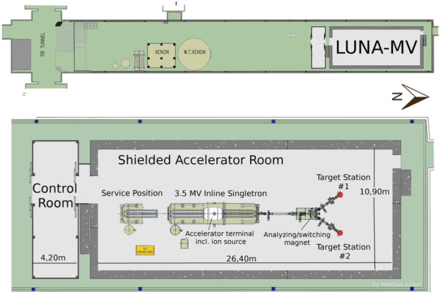
He
- $^{4}He^{+}$ (TV: 0.3 – 0.5 MV): 300 μA
- $^{4}He^{+}$ (TV: 0.5 – 3.5 MV): 500 μA

C
- $^{12}C^{+}$ (TV: 0.3 – 0.5 MV): 100 μA
- $^{12}C^{+}$ (TV: 0.5 – 3.5 MV): 150 μA
- $^{12}C^{++}$ (TV: 0.5 – 3.5 MV): 100 μA

- Progetto Premiale MIUR - 2 grants total 5.3 MEuro
- 0.2 - 3.5 MV single-ended Cockcroft-Walton
- High-intensity H, He, C beams
- Carbon burning, neutron sources

Layout, neutron shielding





- High-intensity, high-energy beams
- Lots of neutrons ("dark matter")
- 80 cm conrete walls to reduce any produced neutron flux below bg level outside

MCNP: $\Phi_n = 1.38\ 10^{-7}$ n/(cm^2 s)
GEANT4: $\Phi_n = 3.40\ 10^{-7}$ n/(cm^2 s)

Φ_n(LNGS) = $3\ 10^{-6}$ n/(cm^2 s)

LUNA-MV : schedule

Action	Date
Approval of the first HVEE technical design	October 2016
Opening of the tendering procedure for LUNA-MV plants	November 2016
Submission of the Authorization request to «Prefettura dell'Aquila»	December 2016
Beginning of the clearing works in Hall B	February 2017
End of the tendering procedure for the new LUNA-MV building	June 2017
Beginning of the construction works in Hall B	December 2017
End of the tendering procedure for LUNA-MV plants	October 2017
Beginning of the construction of the plants in the LUNA-MV building	March 2018
In-house acceptance test for the new LUNA-MV accelerator	February 2018
Completion of the new LUNA-MV building and plants	September 2018
LUNA-MV accelerator delivering at LNGS	December 2018
Conclusion of the commissioning phase	May 2019
Beginning First Experiment	June 2019

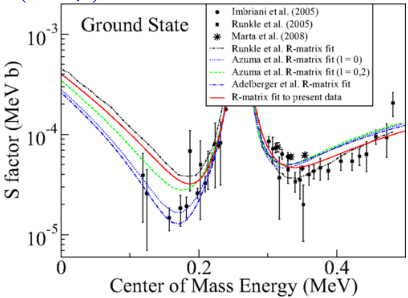
SORRY FOR THE DELAY

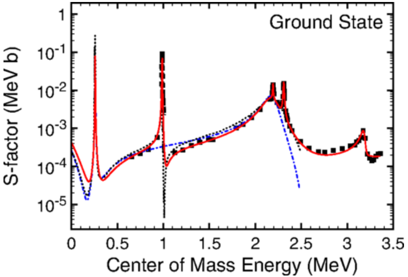
ON TIME

NIC 2018


We look forward to welcome you at the
Laboratori Nazionali del Gran Sasso

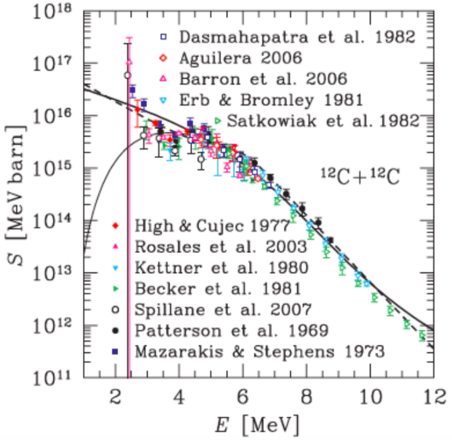
$^{14}N(p,\gamma)^{15}O$





- Good warm-up experiment
- Connect high-energy to low-E region covered by LUNA 400
- Li et al. 2016: "The inconsistencies between the low-energy data and the extrapolation from higher-energy data result in a large systematic uncertainty in S(0). Additional measurements of the low-energy ground-state transition and the γ_0 width of the $E_x = 6.79$ MeV state are critically needed to further reduce the uncertainty of the total cross section at stellar energies."

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

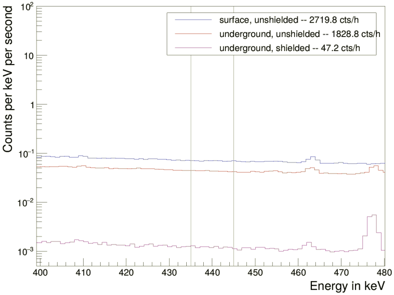


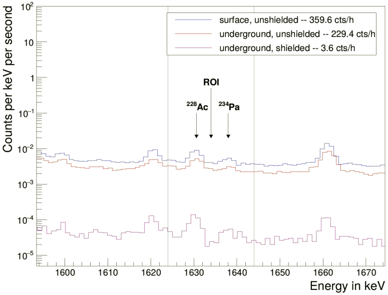
Gasquez et al. 2007

- Main focus of first 5 years
- $^{12}C(^{12}C, p, \alpha)^{23,20}\{Na, Ne\}$
- proton, alpha (and neutron) channels
- Spillane et al. 2007: "The C+C fusion reactions are an excellent case for experimental studies with a future underground facility, such as a 3 MV high-current, single-stage accelerator with an electron-cyclotron-resonance ion source."

^{12}C+^{12}C – HPGe Detector

- $^{12}C(^{12}C,p)^{23}Na$, Q = 2241 keV
  → 440 keV first excited state in ^{23}Na
- $^{12}C(^{12}C,\alpha)^{20}Ne$, Q = 4617 keV
  → 1634 keV first excited state in ^{20}Ne



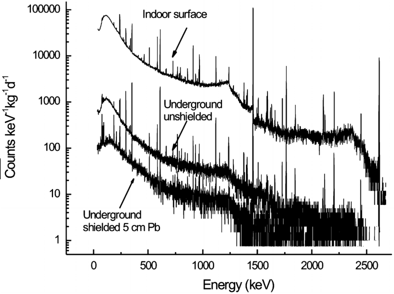


$^{12}C+^{12}C$ – HPGe Detector

- Background levels in Bochum (Spillane et al., 2007)?

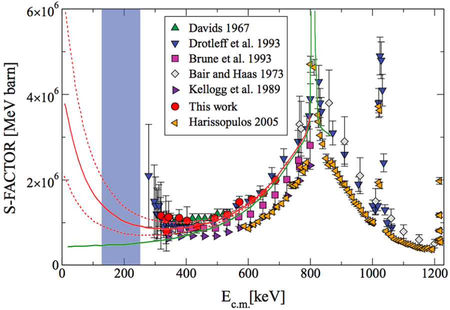
  […] an excellent case for experimental studies with a future underground facility [...]. **Measurements in the salt mine Slanic Prahova (Romania, depth 208 m) showed that the unshielded natural background near the 1634 keV ray is reduced by a factor of 50 compared to our present shielded setup in Bochum.**

- GeBochum has ~2.7kg Ge
  → Shielded BG level at LUNA is ~0.8 cts/keV/kg/d
  (average over 1634 keV ROI)



Background in Slanic-Prahova mine
https://dx.doi.org/10.1016/j.apradiso.2008.04.002

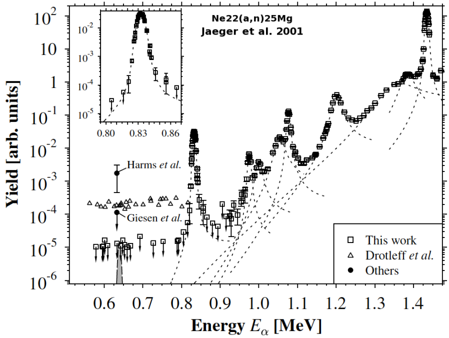
$^{13}C(\alpha, n)^{16}O$



- Main s process neutrons
- Threshold state recently measured mutiple times, but does it contribute?
- Low energy cross section measurement requires bg reduction $\rightarrow$ LUNA
- Large offsets between higher E datasets
- Connect low with high E using LUNA MV
- LUNA 400 campaign starting in 1 month

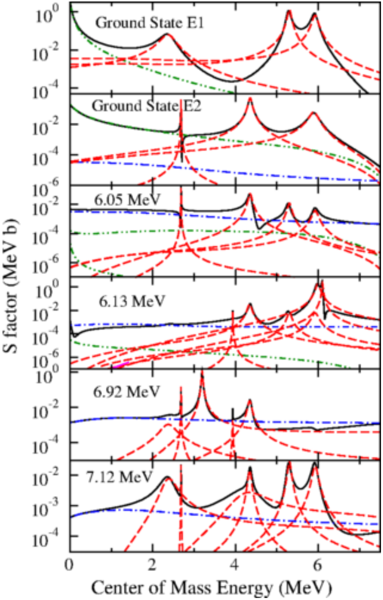
Christmas came early this year

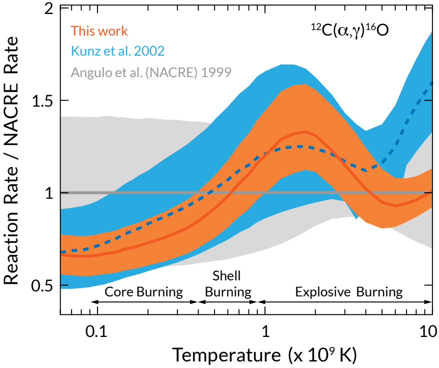
$^{22}Ne(a,n)^{26}Mg$



- Weak s process neutrons
- Threshold 565 keV: perfect for LUNA MV
- Jaeger et al. only stopped by neutron bg flux
- LNGS automatic reduction by 3-4 o.o.m.

$^{12}C(\alpha,\gamma)^{16}O$





deBoer et al. 2017

- The grail

The LUNA collaboration

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