UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI FISICA

Nuclear Astrophysics at Gran Sasso Laboratory: present and future of the LUNA experiment

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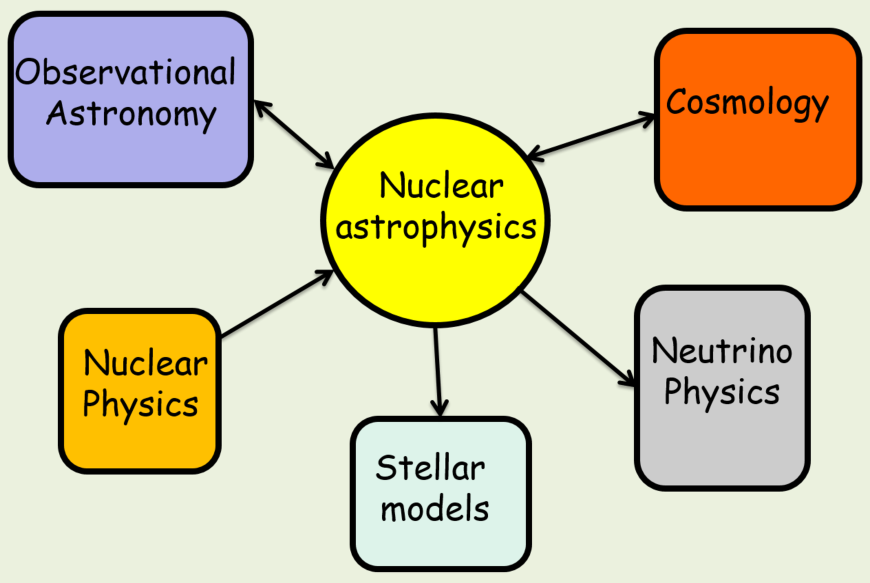
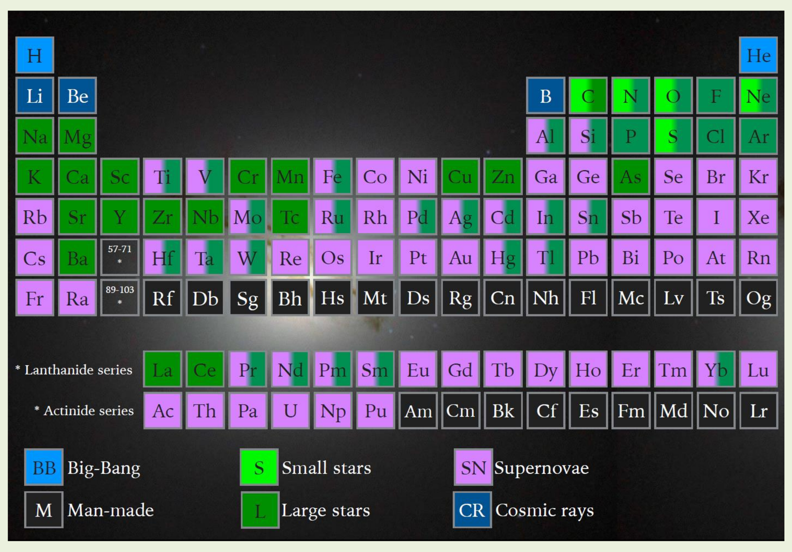
Why measuring cross sections of thermonuclear reactions?

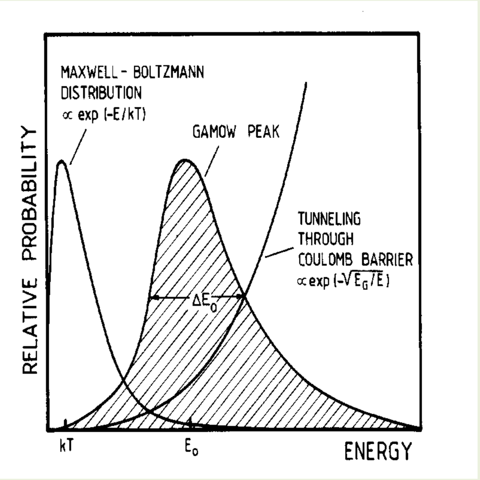
- ✓ Nucleosynthesis and stellar models
- ✓ Neutrino Physics
- ✓ Cosmology

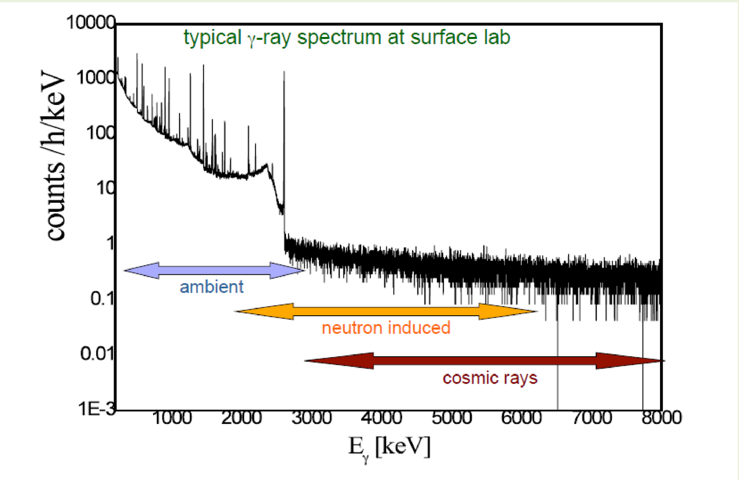


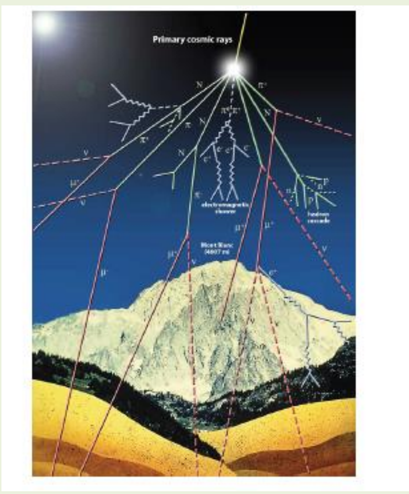


Why going underground?

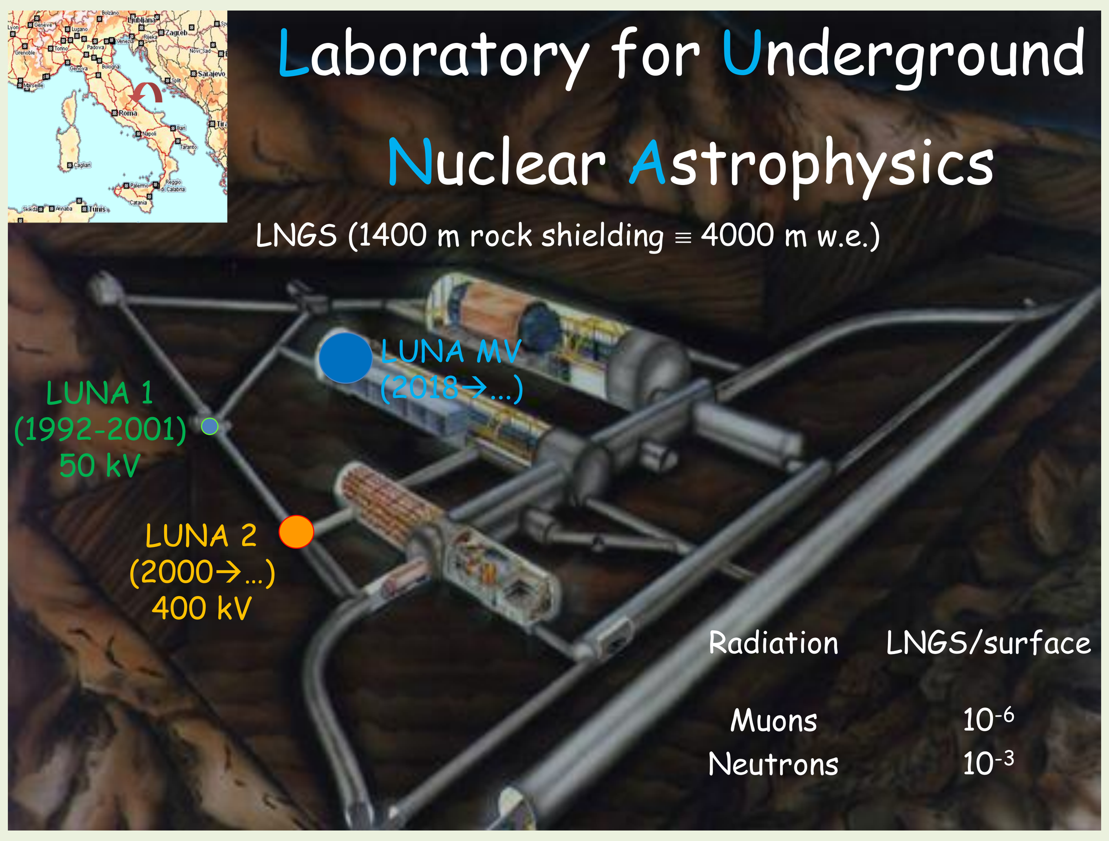
Cross sections in the range of pb-fb at stellar energies (Gamow peak)
Cross section decreasing exponentially with decreasing energy
With typical laboratory conditions reaction rate R can be as low as few events per month
R should be higher than the background→ underground





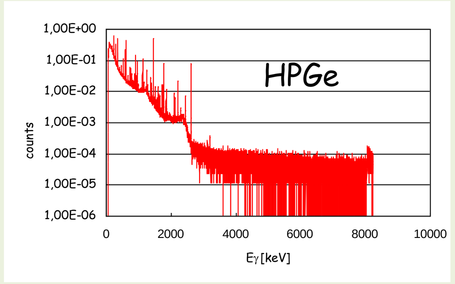


Laboratory for Underground Nuclear Astrophysics

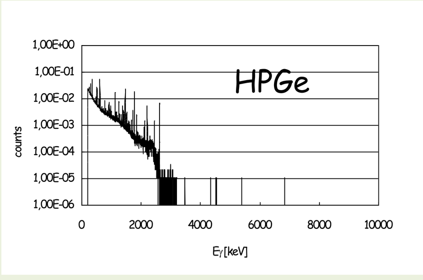


LUNA: background reduction

E_γ>3MeV: reduction of a factor 2000 simply going underground

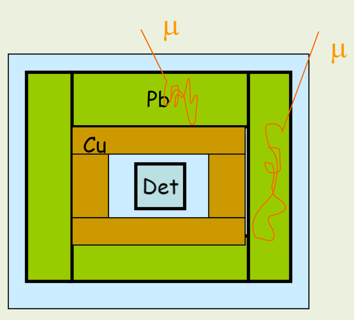


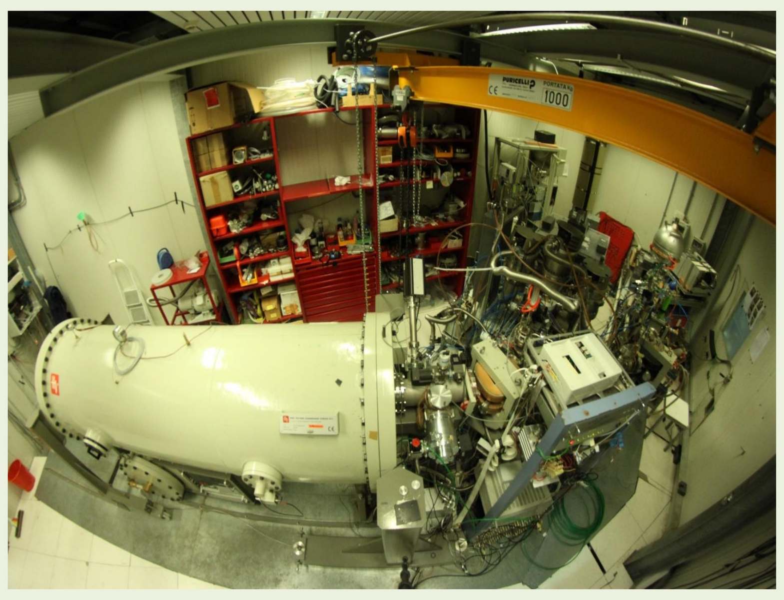
3MeV < E_γ < 8MeV:
0.5 Counts/s

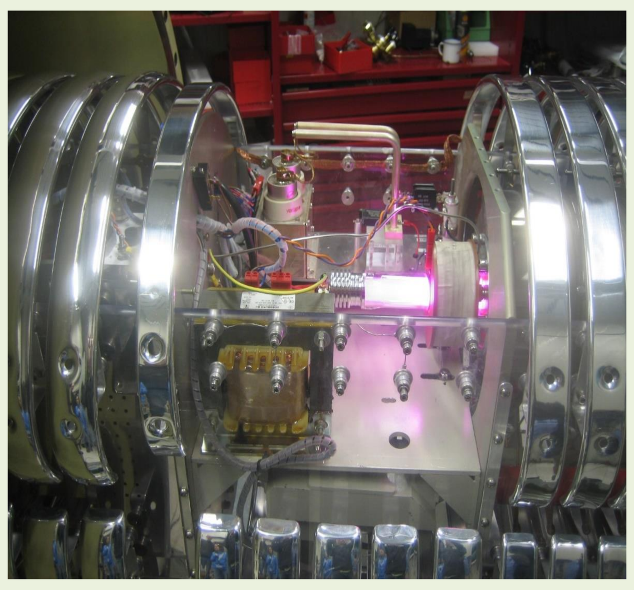


3MeV < E_γ < 8MeV:
0.0002 Counts/s

E_γ<3MeV→passive shielding
Underground passive shielding is more effective since μ flux, that create secondary γ's in the shield, is suppressed.
A reduction of 5 o.o.m. was obtained

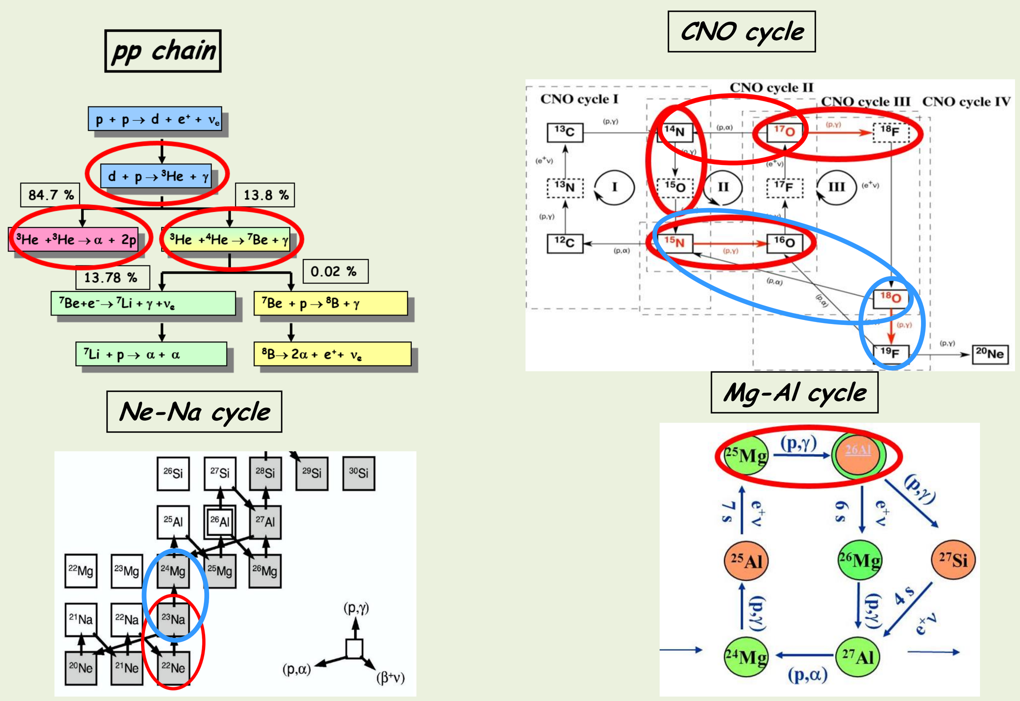




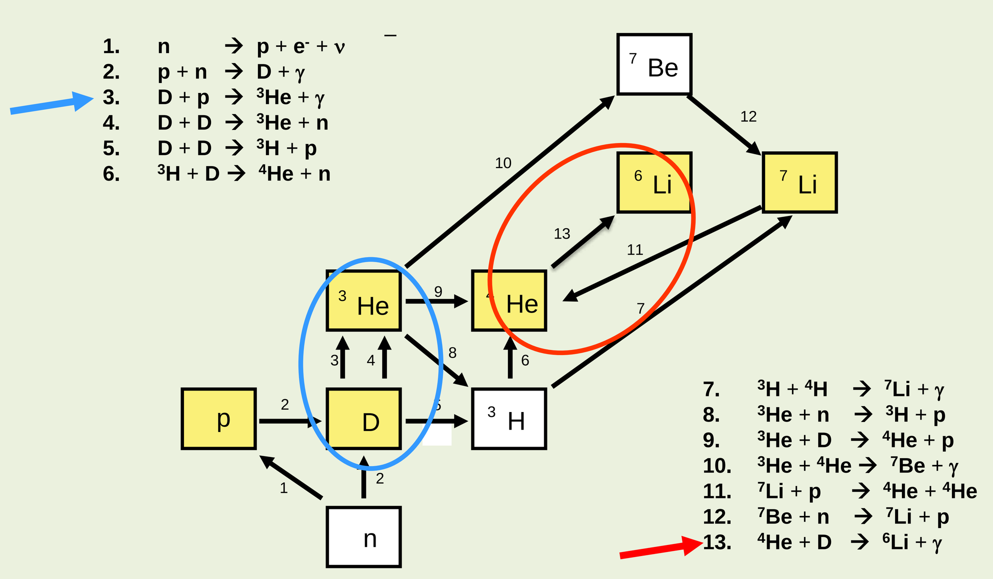


LUNA 400 kV accelerator: very intense and stable proton and alpha beams.
Very low energy spread

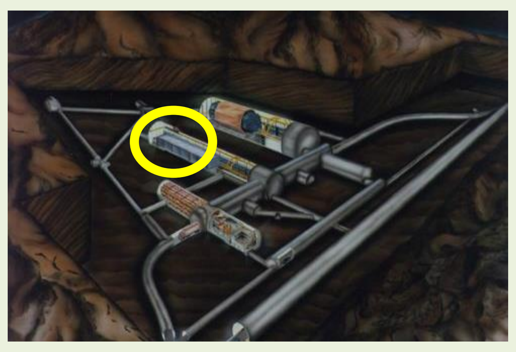
The last 25 y at LUNA: H burning



...and BBN



From Hydrogen burning to Helium and Carbon burning or... from LUNA to LUNA MV

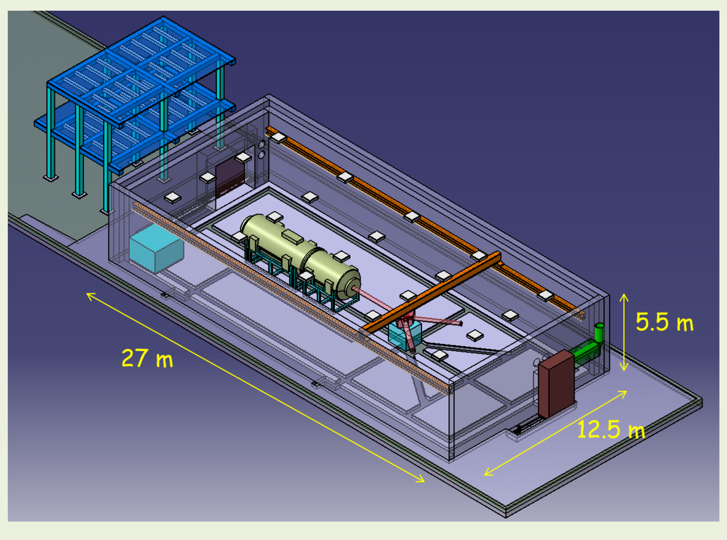


A new 3.5 MV accelerator will be installed soon in the north part of Hall B at Gran Sasso which is now being cleared

The money (5.5 Meuro) has been obtained from MIUR (Progetto Premiale LUNA MV)

The LUNA MV accelerator

In-line Cockcroft Walton accelerator



In the energy range 0.3-3.5 MeV

H^+ beam:
500-1000 eμA

He^+ beam:
300-500 eμA

C^+ beam:
100-150 eμA

C^{++} beam:
100 eμA

Beam energy reproducibility : 10^{-4} * TV or 50 V
The accelerator hall will be shielded by 80 cm thick concrete walls: no perturbation of the LNGS natural neutron flux

The scientific program of LUNA MV for the first 5 years (2019-2023)

$^{14}N(p,\gamma)^{15}O$: the bottleneck reaction of the CNO cycle in connection with the solar abundance problem. Also commissioning measurement for the LUNA MV facility

$^{12}C+^{12}C$: energy production and nucleosynthesis in Carbon burning. Global chemical evolution of the Universe

$^{13}C(\alpha,n)^{16}O$ and $^{22}Ne(\alpha,n)^{25}Mg$: neutron sources for the s-process (nucleosynthesis beyond Fe)

Later on...

$^{12}C(\alpha,\gamma)^{16}O$: key reaction of Helium burning: determines C/O ratio and stellar evolution

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The LUNA MV time schedule

Action	Date
Beginning of the clearing works in Hall B	February 2017
Beginning of the construction works in Hall B	September 2017
Beginning of the construction of the plants in the LUNA-MV building	December 2017
Completion of the new LUNA-MV building and plants	April 2018
LUNA-MV accelerator delivering at LNGS	May 2018
Conclusion of the commissioning phase	December 2018
Beginning First Experiment	January 2019

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