Status of the LUNA experiment and LUNA-MV project

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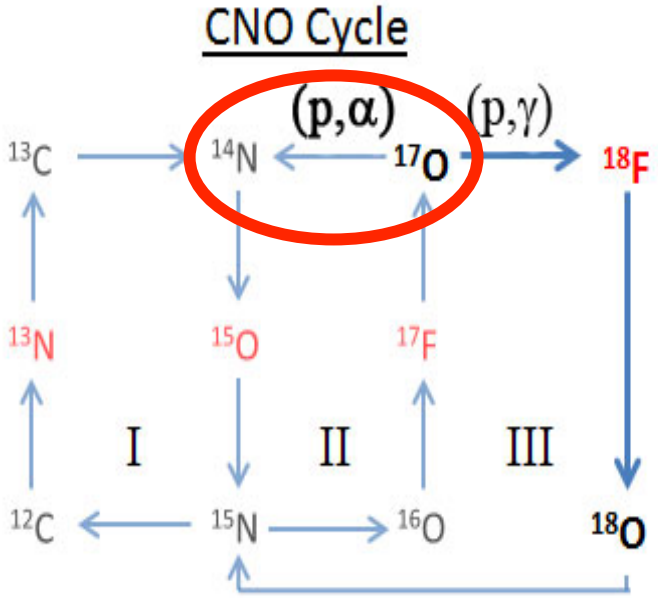
Laboratory
Underground
Nuclear
Astrophysics

Outline:

- Recent result at LUNA 400 kV accelerator: the $^{17}O(p,a)^{14}N$ reaction

-The LUNA MV project: present status and perspective

The $^{17}O(p,a)^{14}N$ reaction: astrophysical motivation



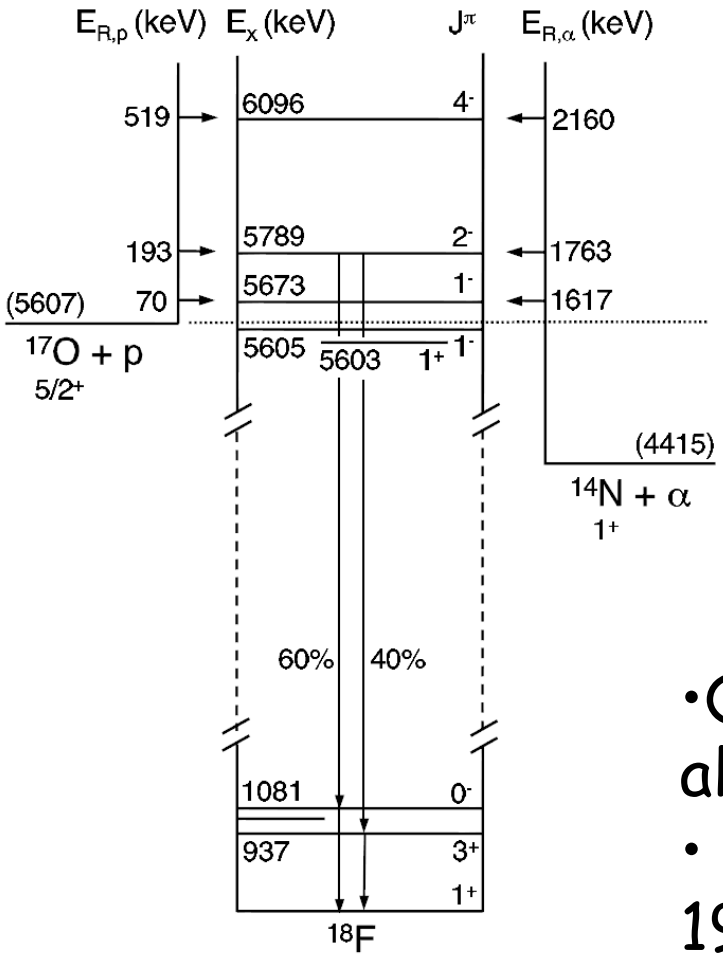
- Influence ^{17}O abundance in several stellar sites

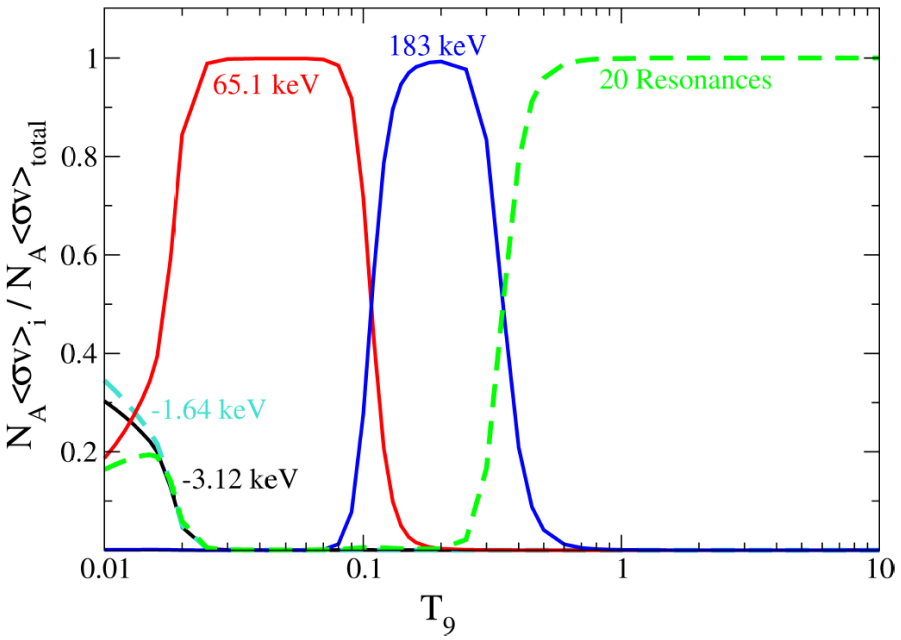
- In AGB stars (T=0.03-0.1 GK) CNO cycle takes place in core of star only

- Measured $^{17}O/^{16}O$ abundance in pre-solar grain give information on AGB surface composition: higher ^{17}O quantity with respect to predictions

- Information on mixing processes if cross section is well known

The $^{17}O(p,a)^{14}N$ reaction: nuclear physics aspects





- Q-value = 1.2 MeV→expected alpha energy 1 MeV
- Two narrow resonances at 70 and 193 keV (lab)

The $^{17}O(p,a)^{14}N$ reaction: state of the art

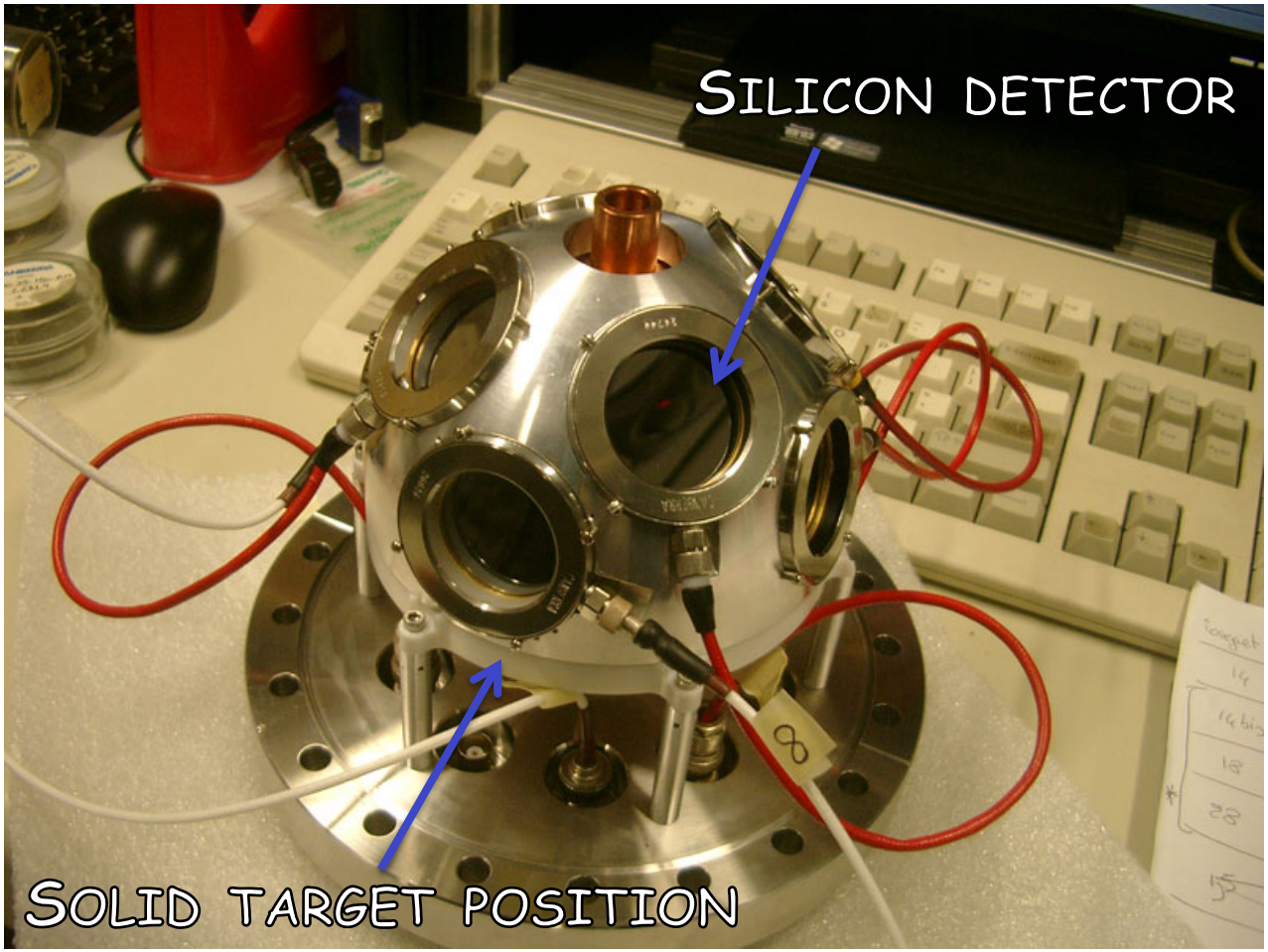
193 keV Resonance:

Authors	**Resonance strength**	**Approach**
Chafa (2005-07)	$(1.6\pm0.2)\times10^{-3}$ eV	Activation
Moazen (2007)	$(1.70\pm0.15)\times10^{-3}$ eV	Direct (inverse kinematics)
Newton (2007-10)	$(1.66\pm0.17)\times10^{-3}$ eV	Direct

70 keV Resonance: ← Our goal!

Berheide (1992)	$< 8\times10^{-10}$ eV	Direct (upper limit)
Blackmon (1995)	$5.5\ ^{+1.8}_{-1.5}\times10^{-9}$ eV	Direct
Sergi (2010)	$3.66^{+0.76}_{-0.64}\times10^{-9}$ eV	Indirect (Trojan horse)

The $^{17}O(p,a)^{14}N$ reaction: experimental setup (I)



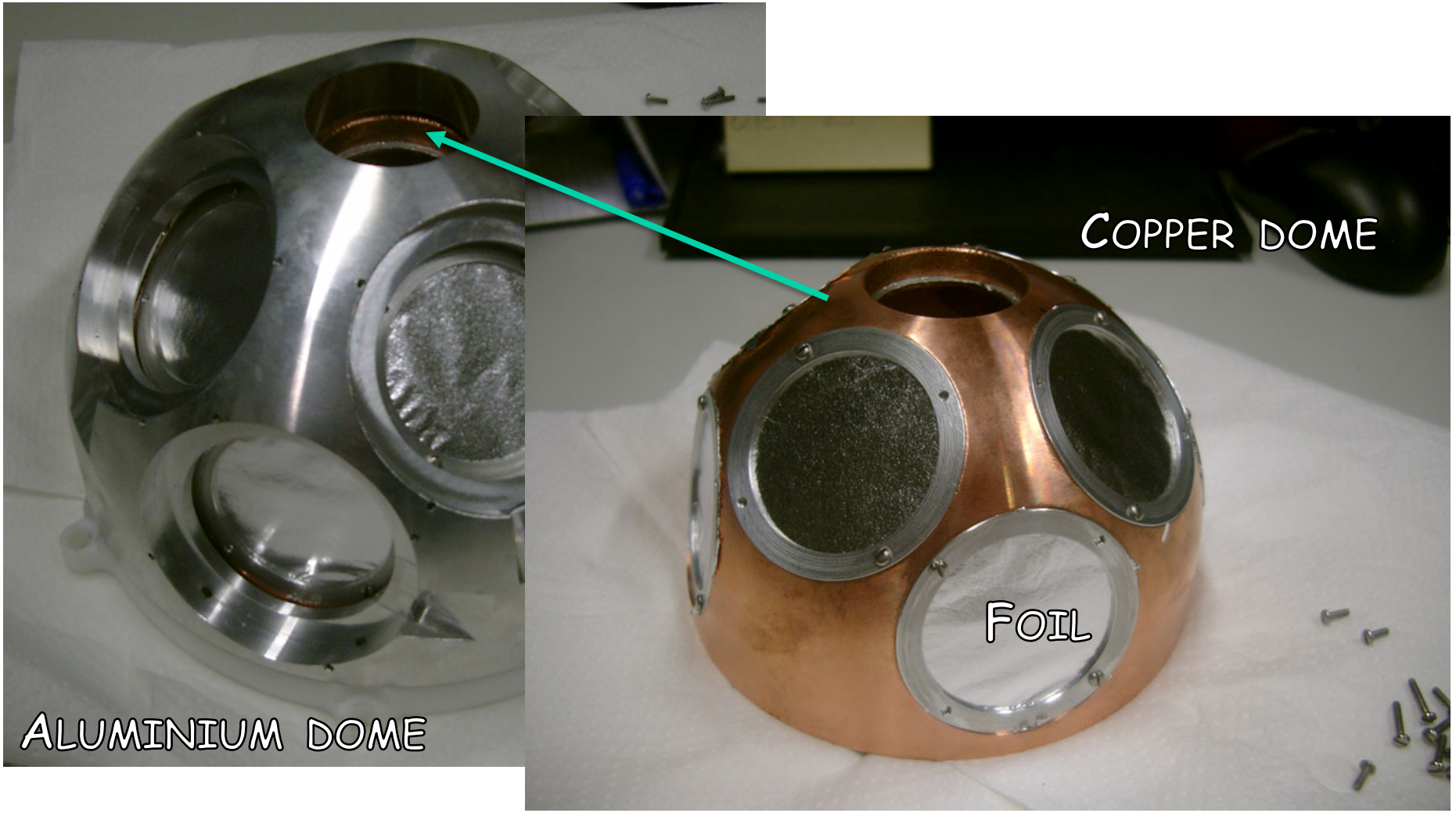
proton beam from LUNA 400 kV

enriched ^{17}O targets

8 silicon detectors

The $^{17}O(p,a)^{14}N$ reaction: experimental setup (II)

Foils of Al Mylar to stop backscattered protons



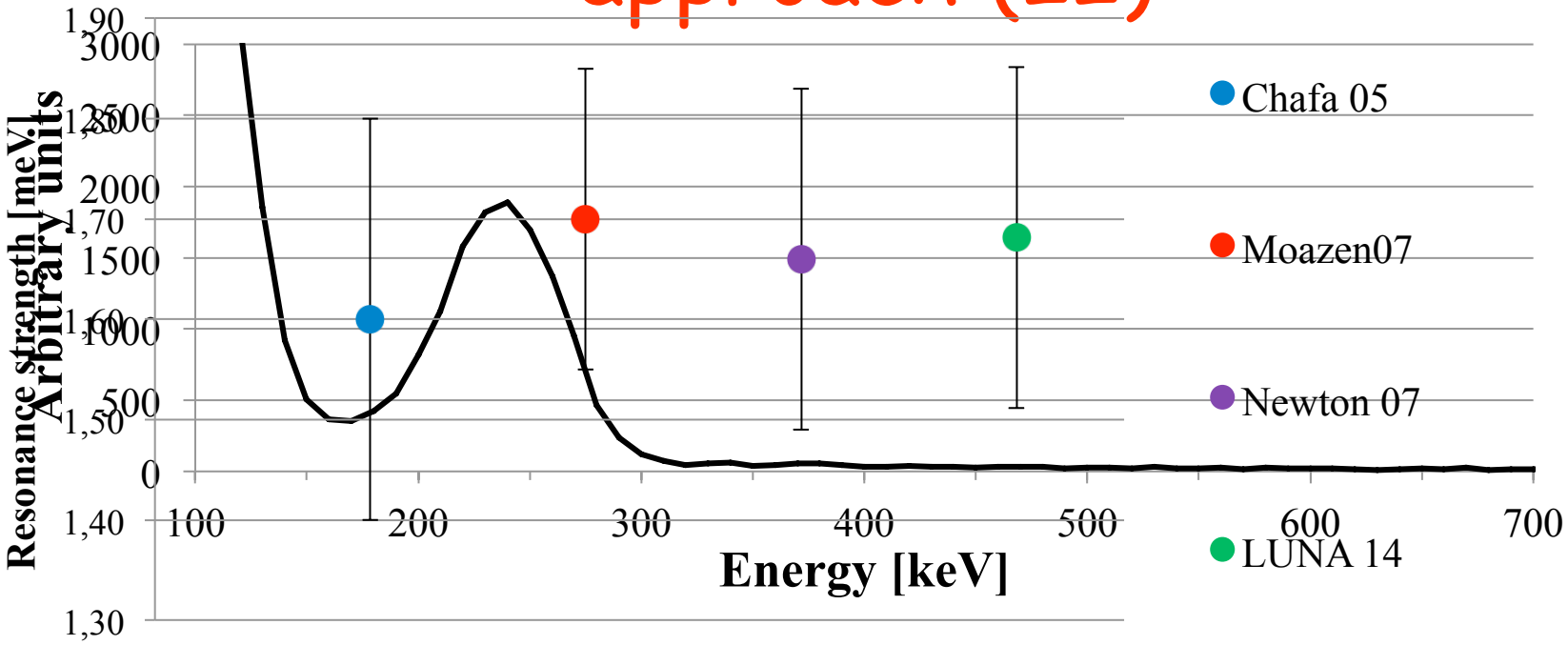
The $^{17}O(p,a)^{14}N$ reaction: experimental approach (I)

- **151 keV resonance** in $^{18}O(p,a)^{15}N$
  -well-known resonance strength (~eV)
  -very high rate (few kHz per detector)
  -high alpha energy (2.6 MeV)
  Used to commission the setup. In excellent agreement with literature

- **193 keV resonance** in $^{17}O(p,a)^{14}N$
  -relatively well-known resonance strength (~meV)
  -high rate (few Hz per detector)
  -low alpha energy (250 keV)

- **70 keV resonance** in $^{17}O(p,a)^{14}N$
  -mostly unknown resonance strength (~neV)
  -low rate (few counts per hour)
  -low alpha energy (200 keV)

The $^{17}O(p,a)^{14}N$ reaction: experimental approach (II)



- 1-2 alphas/s/detector at ~250 keV
- clear peak visible in spite of low energy and rate

In agreement with literature!

The $^{17}O(p,a)^{14}N$ reaction: 70 keV resonance (I)

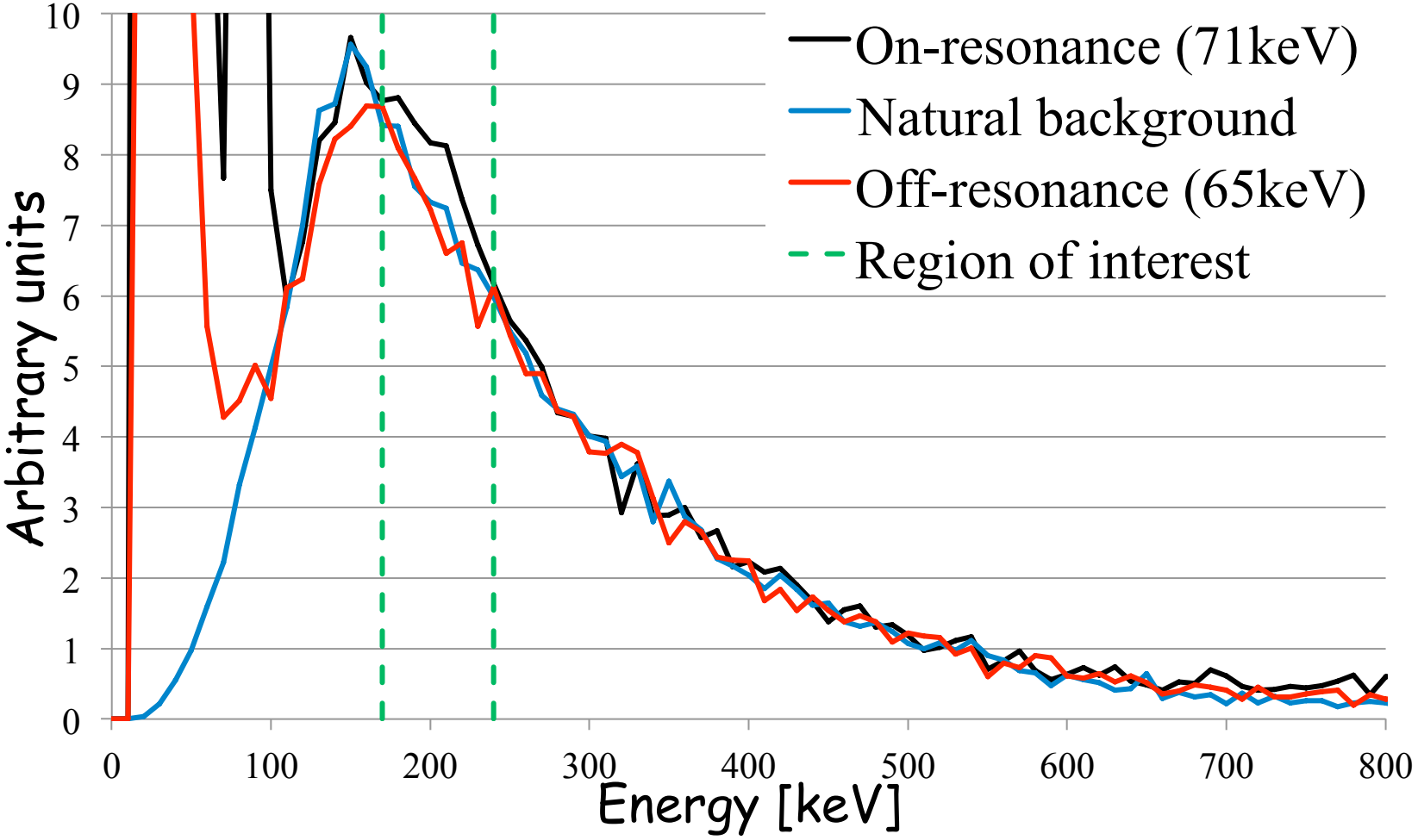
-Assuming typical experimental conditions and a conservative value for the resonance strength (1 neV) the expected rate is 0.1 counts/hour/detector

Alpha energy around 200 keV

Very low energy and rate: the background must be under control

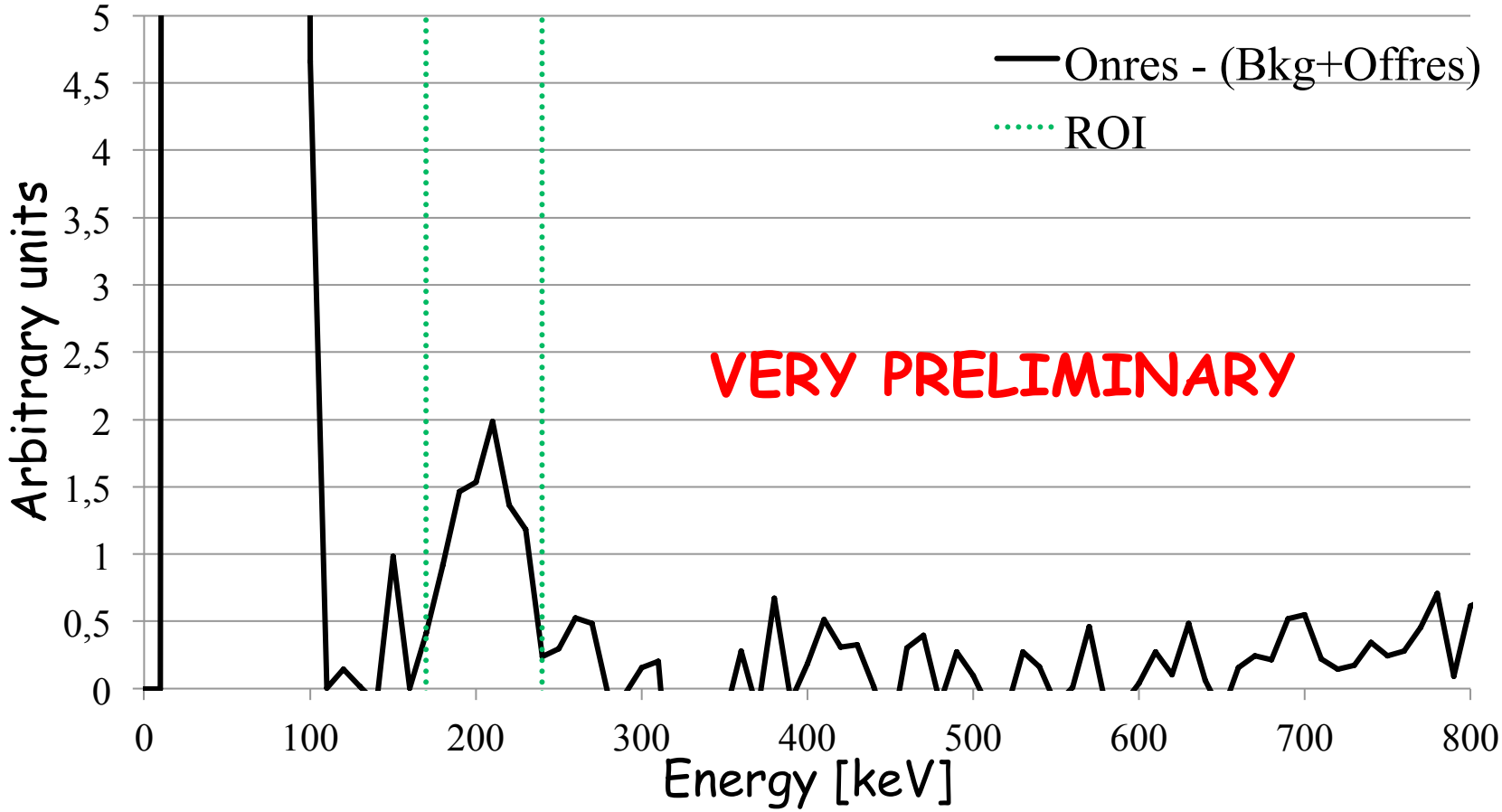
A long time (months) is necessary to see the signal

The $^{17}O(p,a)^{14}N$ reaction: 70 keV resonance (II)



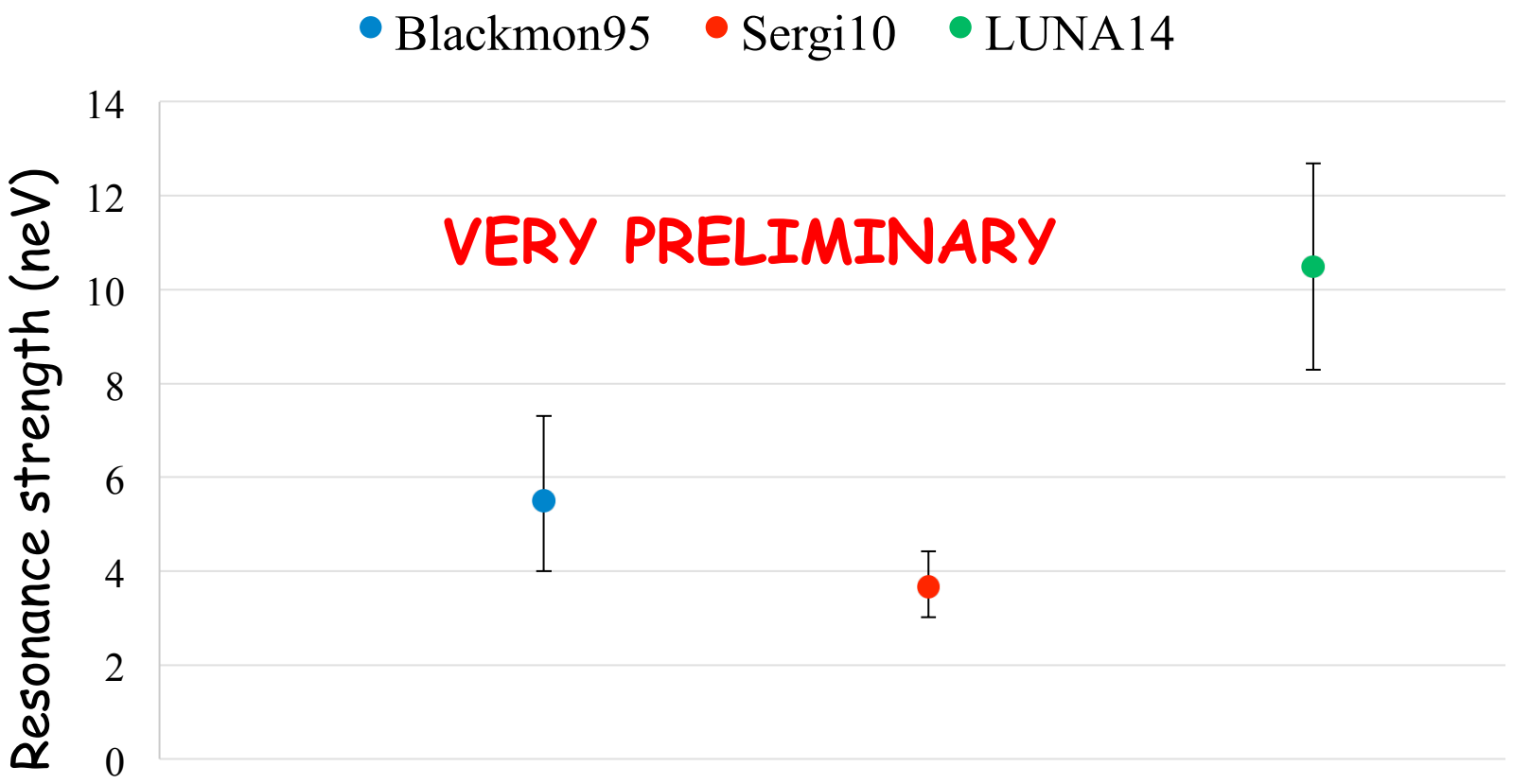
Evidence of a counting excess in the region of interest!

The $^{17}O(p,a)^{14}N$ reaction: 70 keV resonance (III)



-expected energy
-expected width
-significance >5 sigma

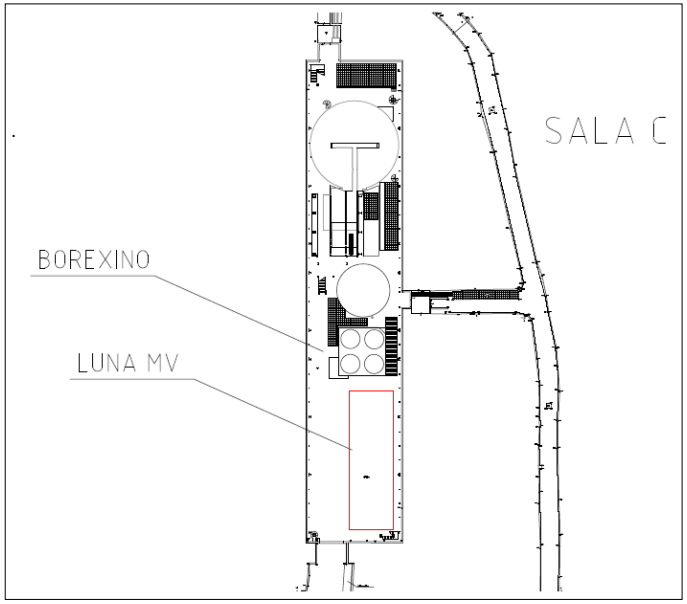
The $^{17}O(p,a)^{14}N$ reaction: 70 keV resonance (IV)



larger strength value compared with literature
If confirmed, it would have an astrophysical impact
Analysis is still ongoing…

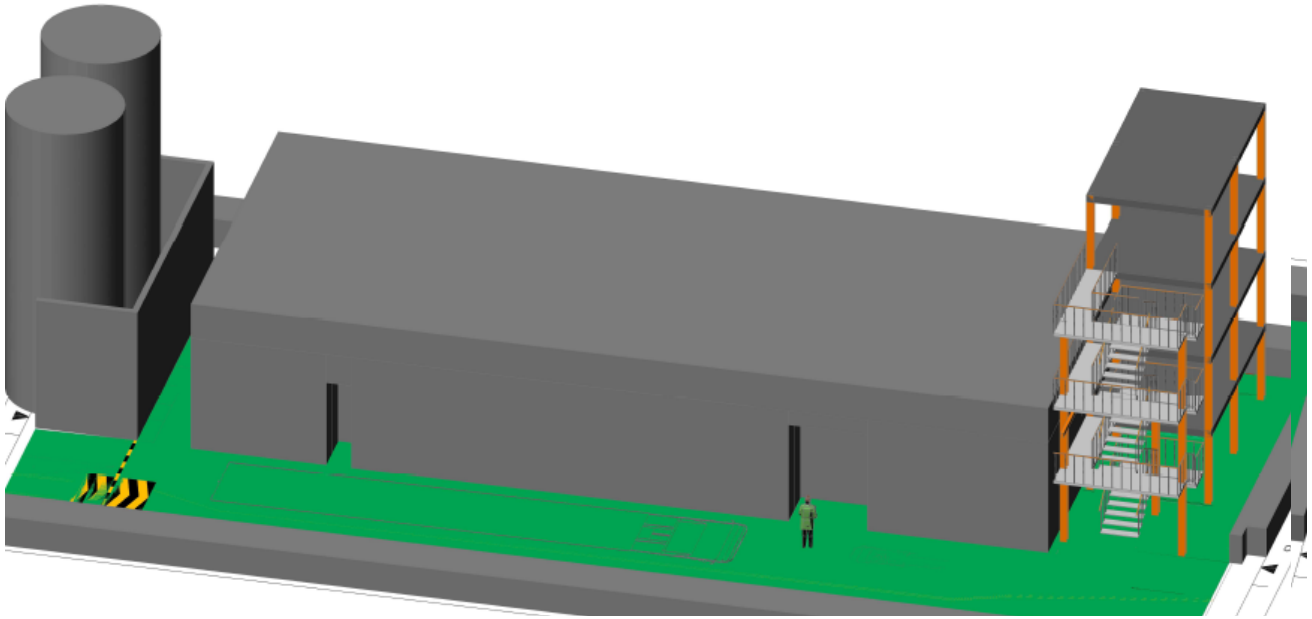
LUNA MV project

Project for installation in Hall C (South part) started



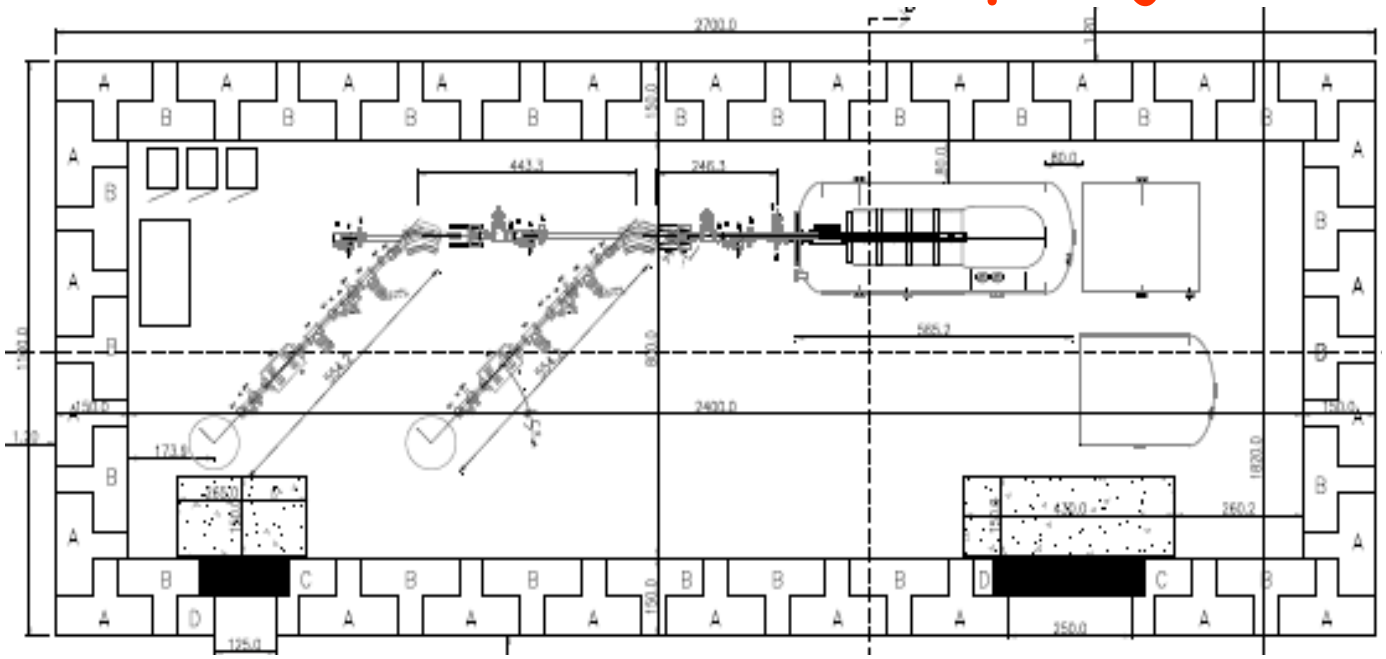
Provisionary dimensions 27x11x4.5 m^3. Definitive dimensions to be defined soon

LUNA MV project



Preliminary project of installation

LUNA MV project

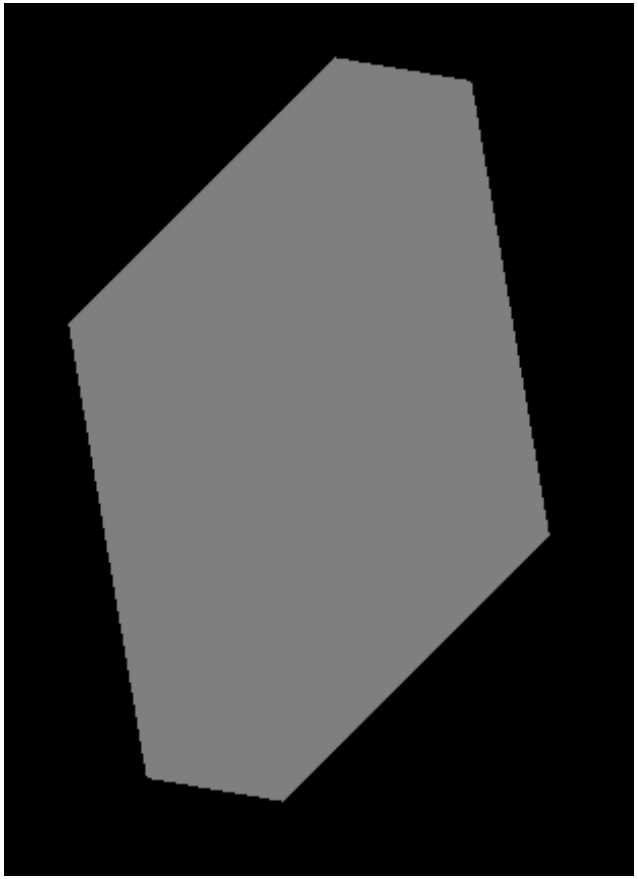


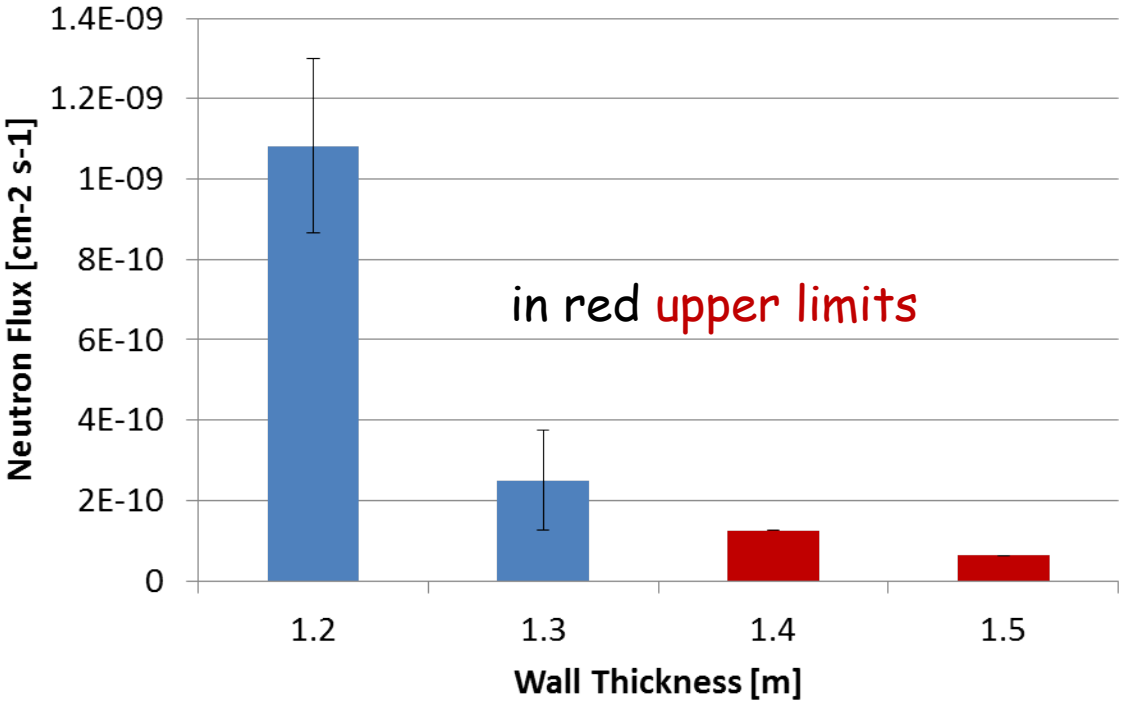
Preliminary project of installation and shielding: 1.5 m concrete for lateral walls and 1.3 m concrete for roof.

Final solution to be defined also considering definitive dimensions, cost, timeline, decommissioning, …

LUNA MV project

Neutron flux vs wall thickness for pure GEANT4 concrete





Different solutions to be defined considering also experimental needs

LUNA MV project

Accelerator: intense p, a, C beams 350 keV-3.5 MeV

3.5 Meuro arrived at LNGS at the end of October

Tendering procedure started. Accelerator installed at LNGS by June 2018

S. Gazzana technical coordinator of the project→ link to OPERA decommissioning

STAY TUNED!

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