Status of the LUNA experiment and LUNA-MV project

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Outline:

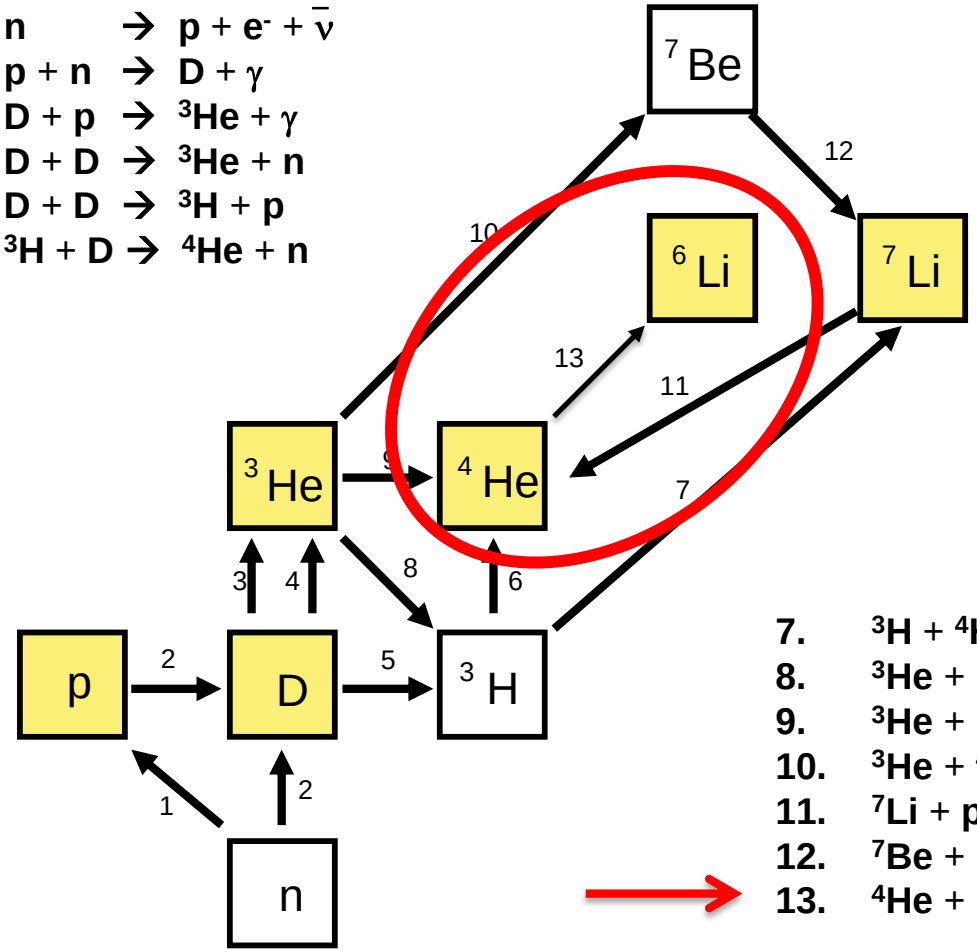
- Most recently obtained results

-On-going measurements and future of the LUNA experiment

-The LUNA MV project: present status

BBN reaction network

1. $n \rightarrow p + e^- + \bar{\nu}$
2. $p + n \rightarrow D + \gamma$
3. $D + p \rightarrow {}^3He + \gamma$
4. $D + D \rightarrow {}^3He + n$
5. $D + D \rightarrow {}^3H + p$
6. ${}^3H + D \rightarrow {}^4He + n$

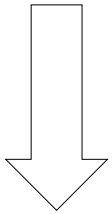


7. ${}^3H + {}^4H \rightarrow {}^7Li + \gamma$
8. ${}^3He + n \rightarrow {}^3H + p$
9. ${}^3He + D \rightarrow {}^4He + p$
10. ${}^3He + {}^4He \rightarrow {}^7Be + \gamma$
11. ${}^7Li + p \rightarrow {}^4He + {}^4He$
12. ${}^7Be + n \rightarrow {}^7Li + p$
13. ${}^4He + D \rightarrow {}^6Li + \gamma$

The two Lithium problems

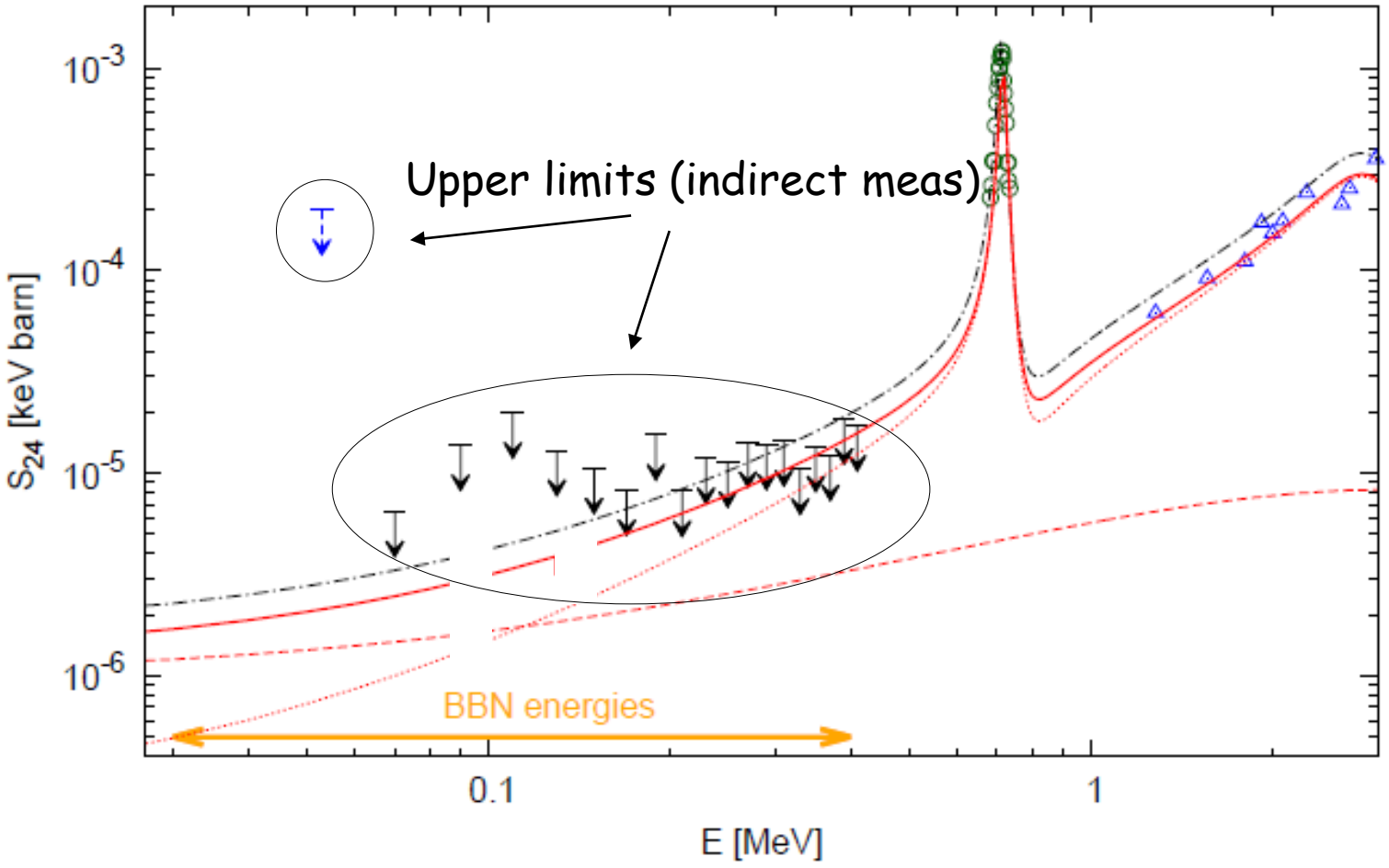
1) The BBN ^{7}Li predictions are a factor 2-4 higher than observations: a nuclear physics solution is highly improbable
(e.g $^{3}He(^{4}He,\gamma)^{7}Be$ measurement at LUNA)

2) The amount of ^{6}Li predicted by the BBN is about 3 oom lower than the observed one in metal poor stars (debated but still «true» for a few metal poor stars)



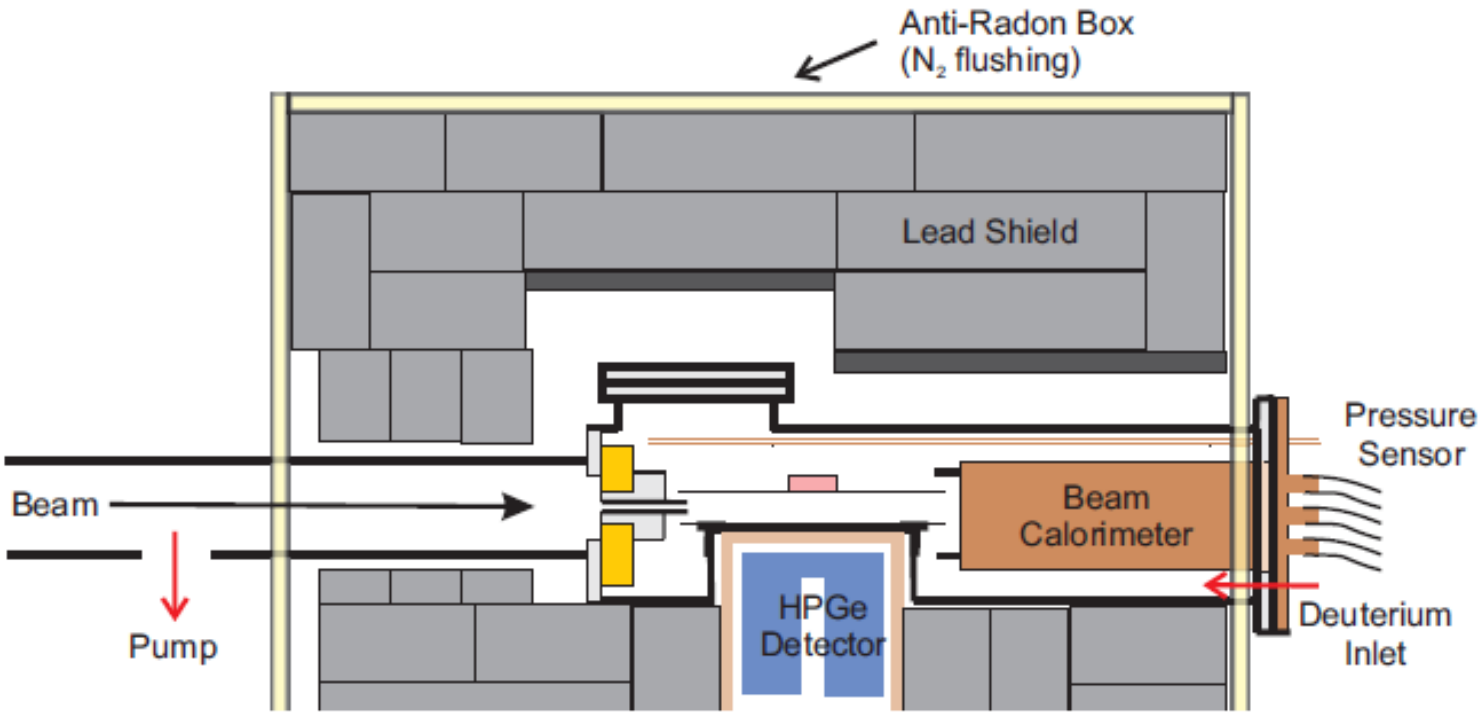
BBN predicts $^{6}Li/^{7}Li = 2 * 10^{-5}$ much below the detected levels of about $^{6}Li/^{7}Li = 5 * 10^{-2}$
Necessary to constrain nuclear physics input: $^{2}H(\alpha,\gamma)^{6}Li$

Available data



No data in the BBN energy range!

Experimental setup



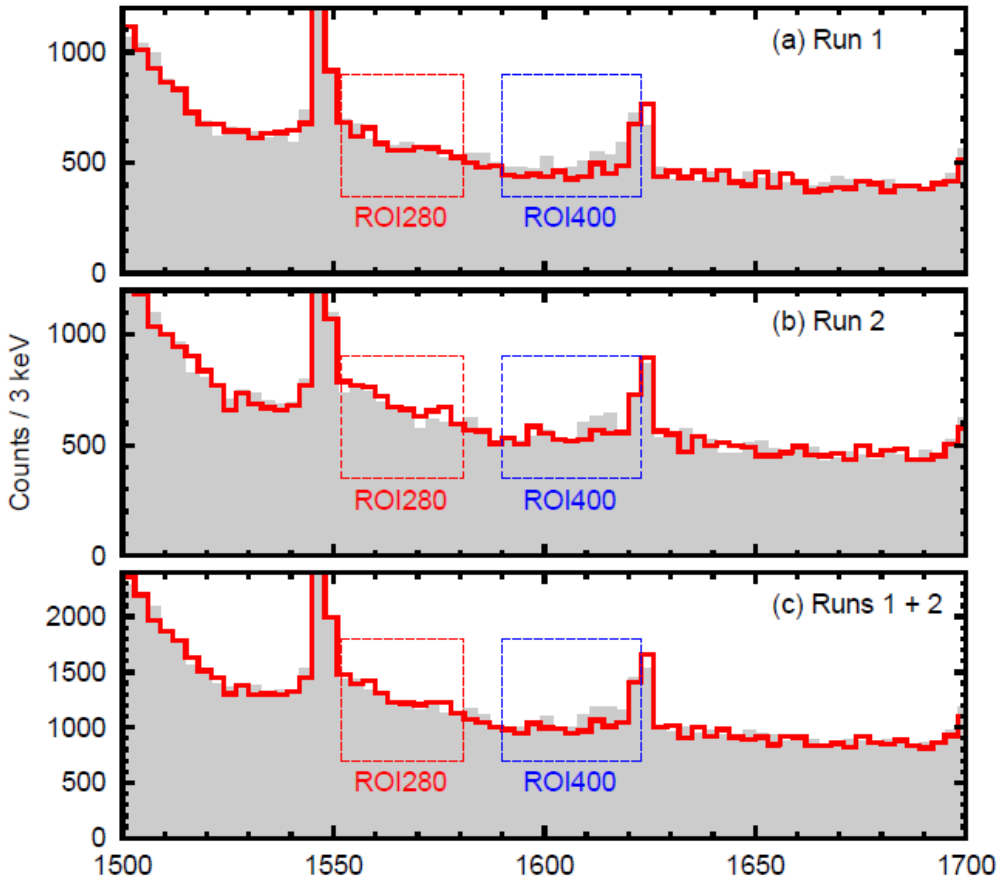
Strong beam induced background due to:

1) Rutherford scattering of ^{4}He beam on ^{2}H target
2) ^{2}H(d,n)^{3}He reaction
3) Inelastic neutron scattering on different materials (Cu, Pb, Ge,…)→ γ background in the ^{2}H(α,γ)^{6}Li RoI

The beam induced background weakly depends on the beam energy

Gamma spectra

An irradiation at one given beam energy can be used as a background monitor for an irradiation at a different beam energy, if the two ROIs do not overlap

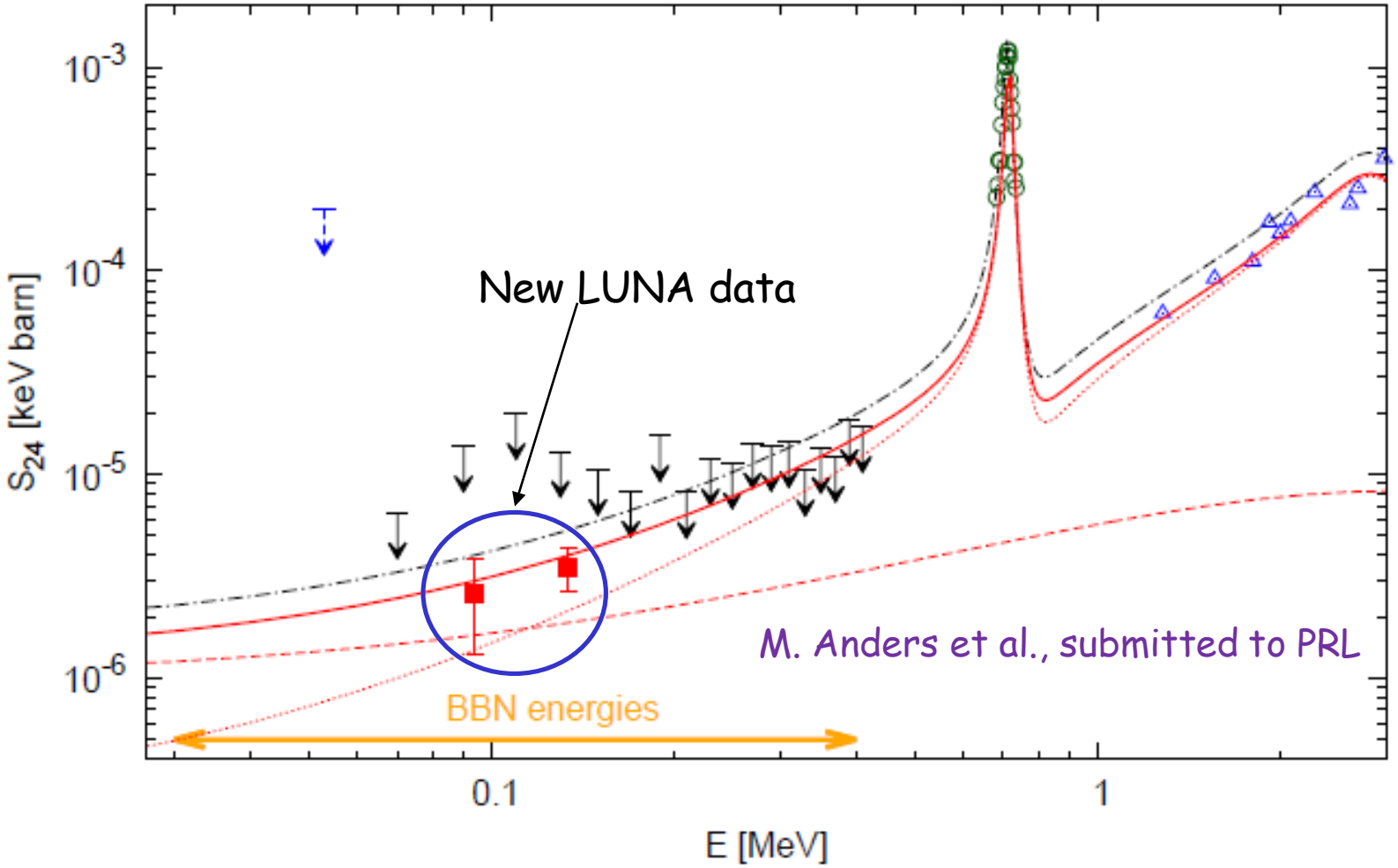


Natural background subtracted

400 keV data (grey filled)

280 keV data (red empty) rescaled to take into account the weak energy dependence of the beam induced background

Results

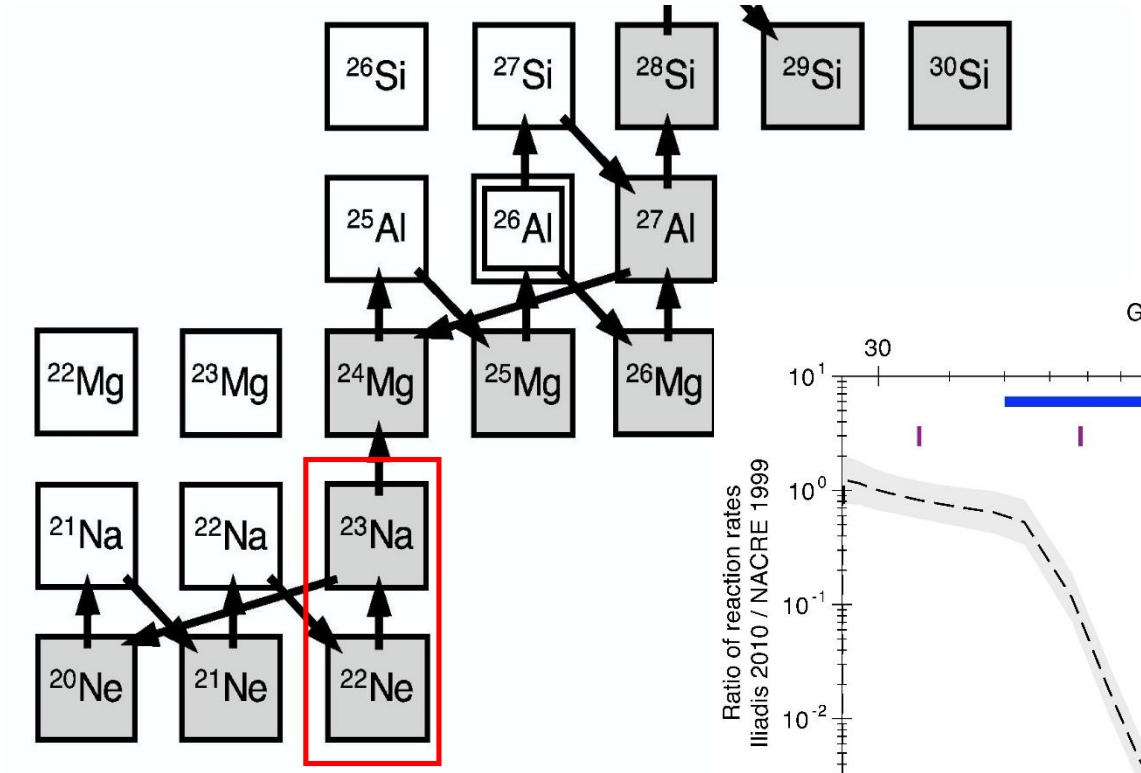


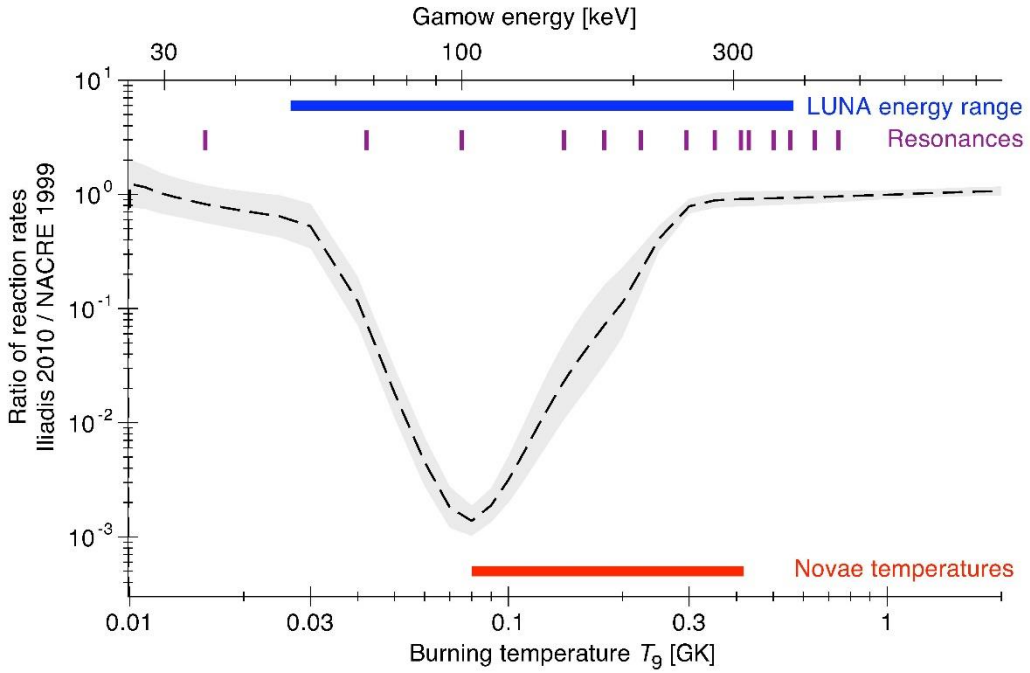
From the new data on the $^{2}H(\alpha,\gamma)^{6}Li$ reaction: $^{6}Li/^{7}Li = (1.5 \pm 0.3) * 10^{-5}$

Standard BBN production as a possible explanation for the reported ^{6}Li detections is ruled out. "Non standard" physics solutions?

On going measurements (1)

$^{22}Ne(p,\gamma)^{23}Na$: NeNa cycle of H burning. Active in astrophysical novae

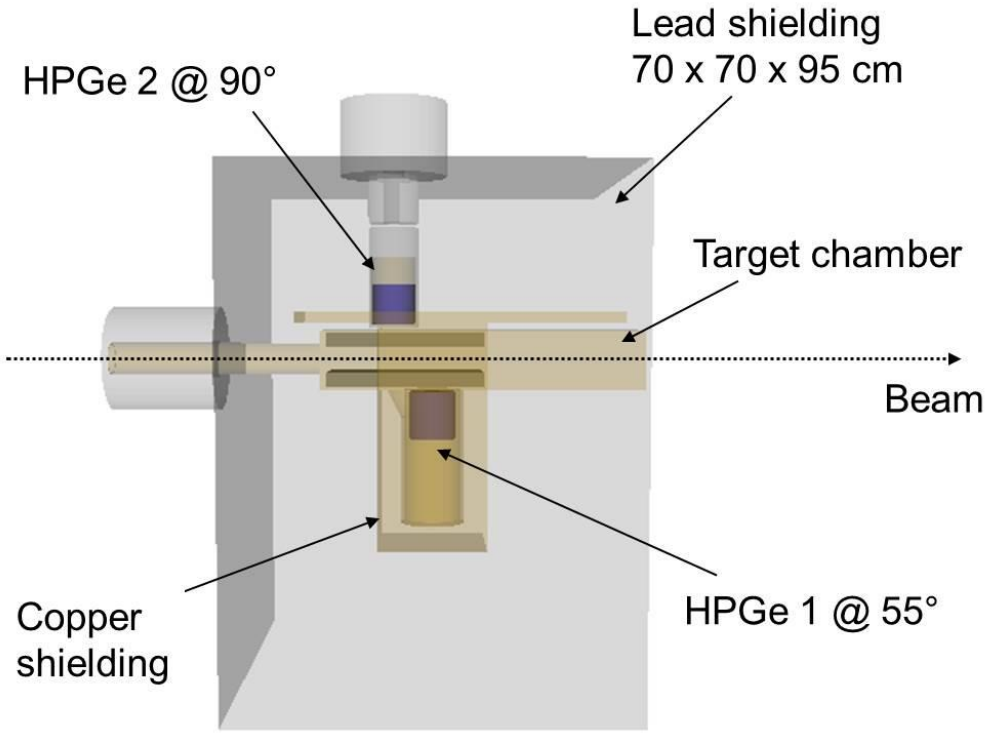


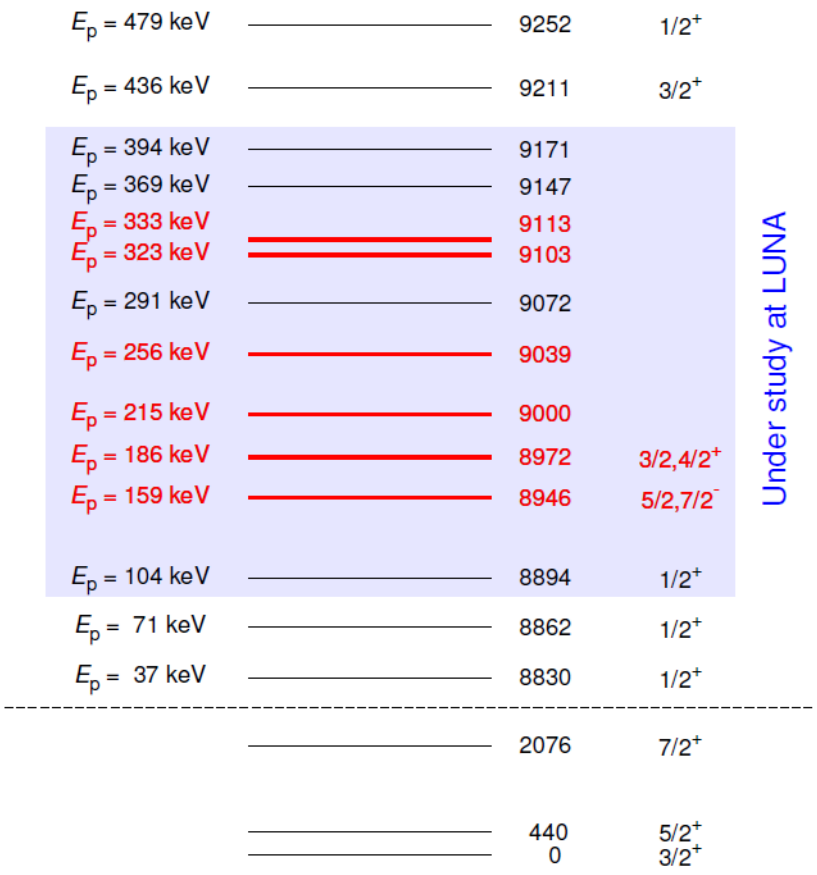


Impact on the abundances of

- ^{22}Ne (factor 100)
- ^{23}Na (factor 7)
- ^{24}Mg (factor 70)

Experimental setup and results



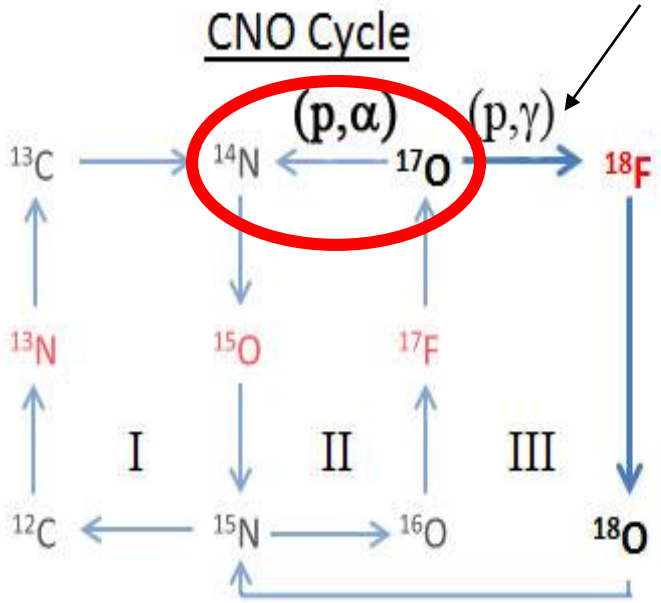


In red newly discovered resonances
Preliminary!

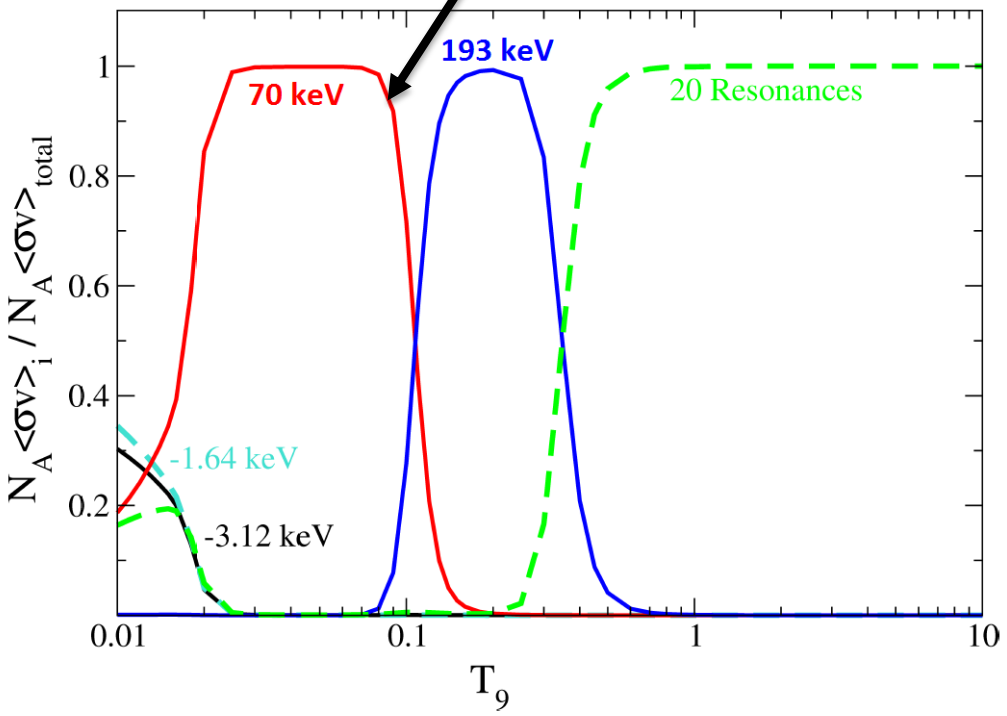
On going measurements (2)

$^{17}O(p,\alpha)^{14}N$: CNO cycle of Hydrogen burning

A. Di Leva et al., PRC 2014



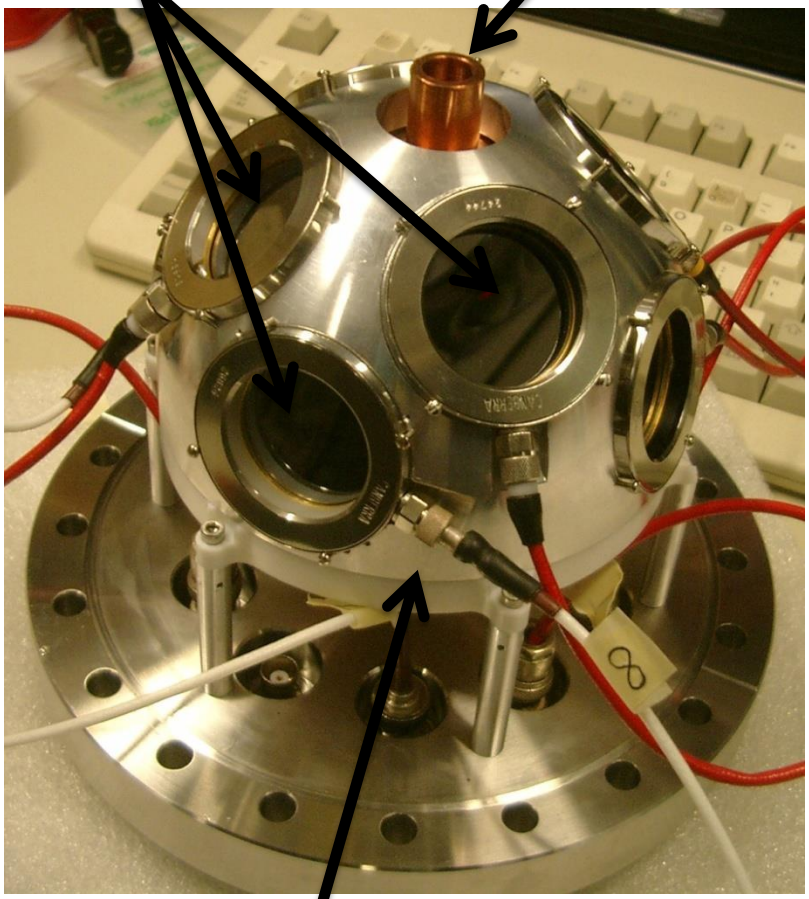
Never measured



AGB stars (T=0.03-0.1 GK)

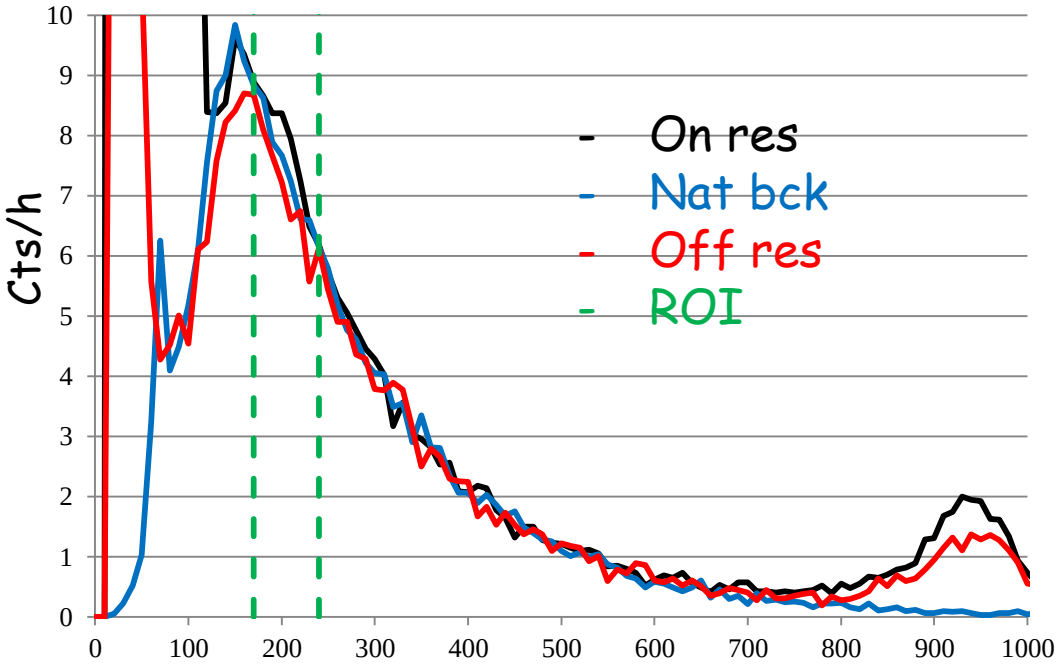
Rare isotopes production

Experimental setup and results



193 keV resonance measured and in agreement with literature

An evidence of the 70 keV resonance is present



Preliminary!

LUNA 400 kV present program

	reaction	Q-value (MeV)
Measured	$^{17}O(p,\gamma)^{18}F$	5.6
Almost completed	$^{17}O(p,\alpha)^{14}N$	1.2
From Oct 2014	$^{18}O(p,\gamma)^{19}F$	8.0
June - Sept 2014	$^{18}O(p,\alpha)^{15}N$	4.0
From Jan 2015	$^{23}Na(p,\gamma)^{24}Mg$	11.7
On the way	$^{22}Ne(p,\gamma)^{23}Na$	8.8
Measured	$D(\alpha,\gamma)^{6}Li$	1.47

The whole program will be completed by late autumn 2015

LUNA 400 kV new program 2015-2018: a bridge toward LUNA MV

Experimental program:

$^{13}C(\alpha,n)^{16}O$ – neutron source (LUNA MV)

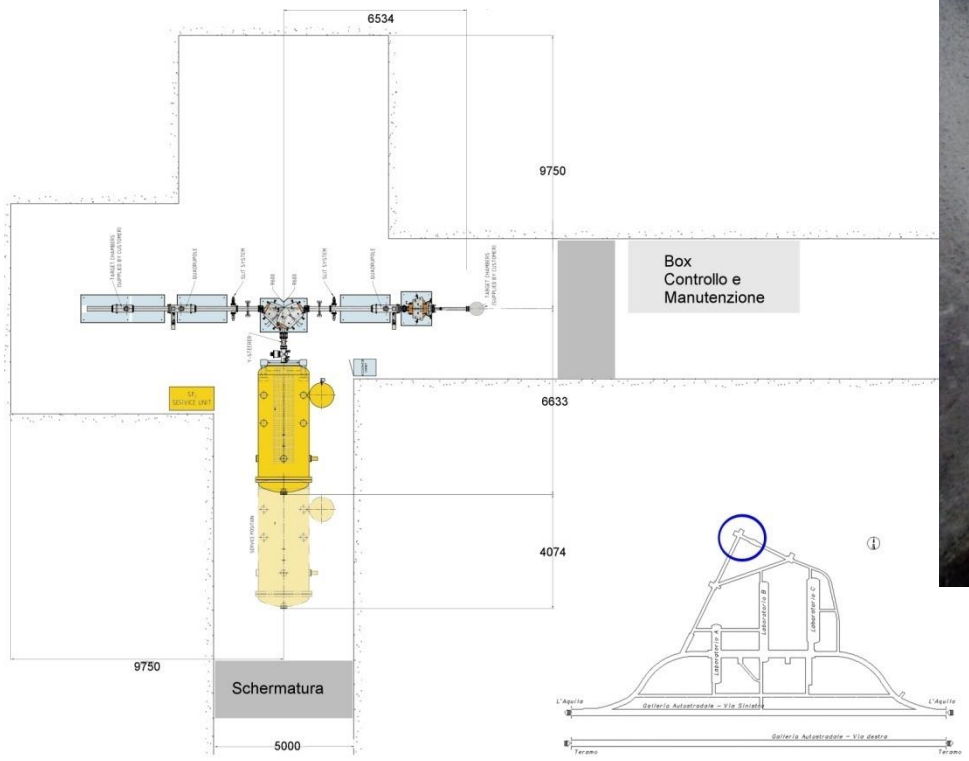
$^{12}C(p,\gamma)^{13}N$ and $^{13}C(p,\gamma)^{14}N$ – relative abundance of ^{12}C-^{13}C in the deepest layers of H-rich envelopes of any star

$^{2}H(p,\gamma)^{3}He$ – ^{2}H production in BBN

$^{22}Ne(\alpha,\gamma)^{26}Mg$ – competes with $^{22}Ne(\alpha,n)^{25}Mg$ neutron source (LUNA MV)

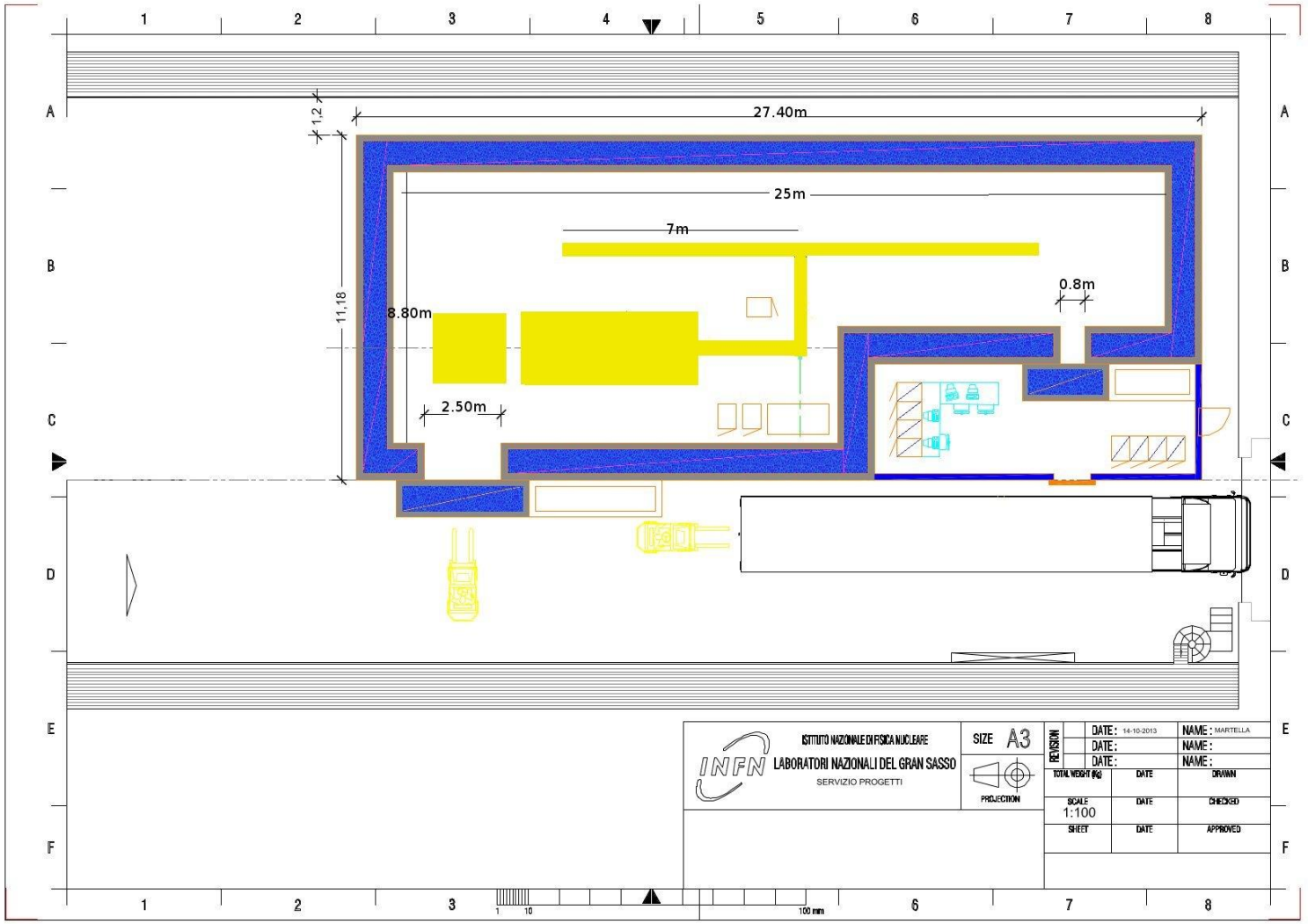
$^{6}Li(p,\gamma)^{7}Be$ – improves the knowledge of $^{3}He(\alpha,\gamma)^{7}Be$ key reaction of p-p chain (LUNA MV)

LUNA-MV Project



B node hypothesis : definitely ruled out in September 2013

LUNA-MV Project



South side of Hall C: definitely assessed in early 2014

LUNA-MV Project

Second year (call 2012) of "Progetti Premiali" money: 2.5 Meuro
To be added to the 2011 money (2.8 Meuro)

LNGS Technical division is working on the infrastructure project (site preparation, shielding, plants, …)

Different shielding hypothesis are being evaluated with respect to neutron flux suppression and technical feasibility

LUNA collaboration is ready to start tendering the accelerator!!!

THE LUNA COLLABORATION

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