# Neutron Veto Instrumentation for LEGEND-1000 at LNGS

LEGEND
Large Enriched Germanium Experiment for Neutrinoless ββ Decay

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*Gran Sasso Science Institute, INFN LNGS*



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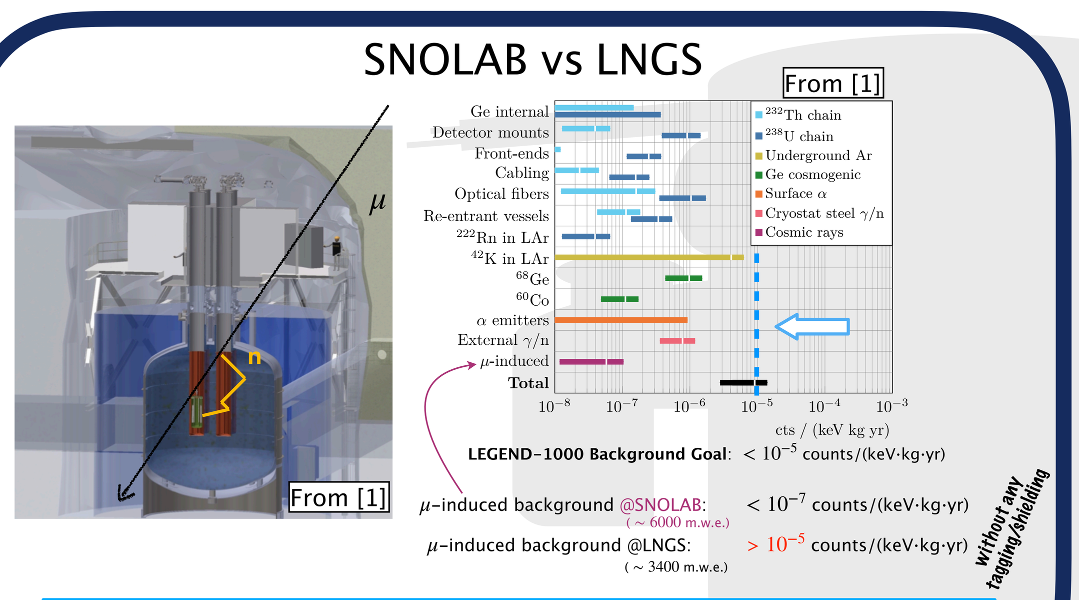
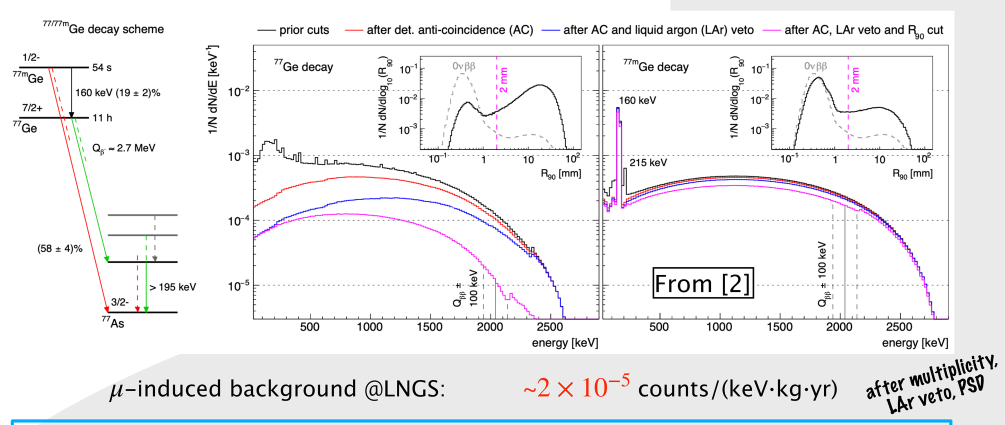
## SNOLAB vs LNGS




**Different depths imply different $\mu$-induced background!**

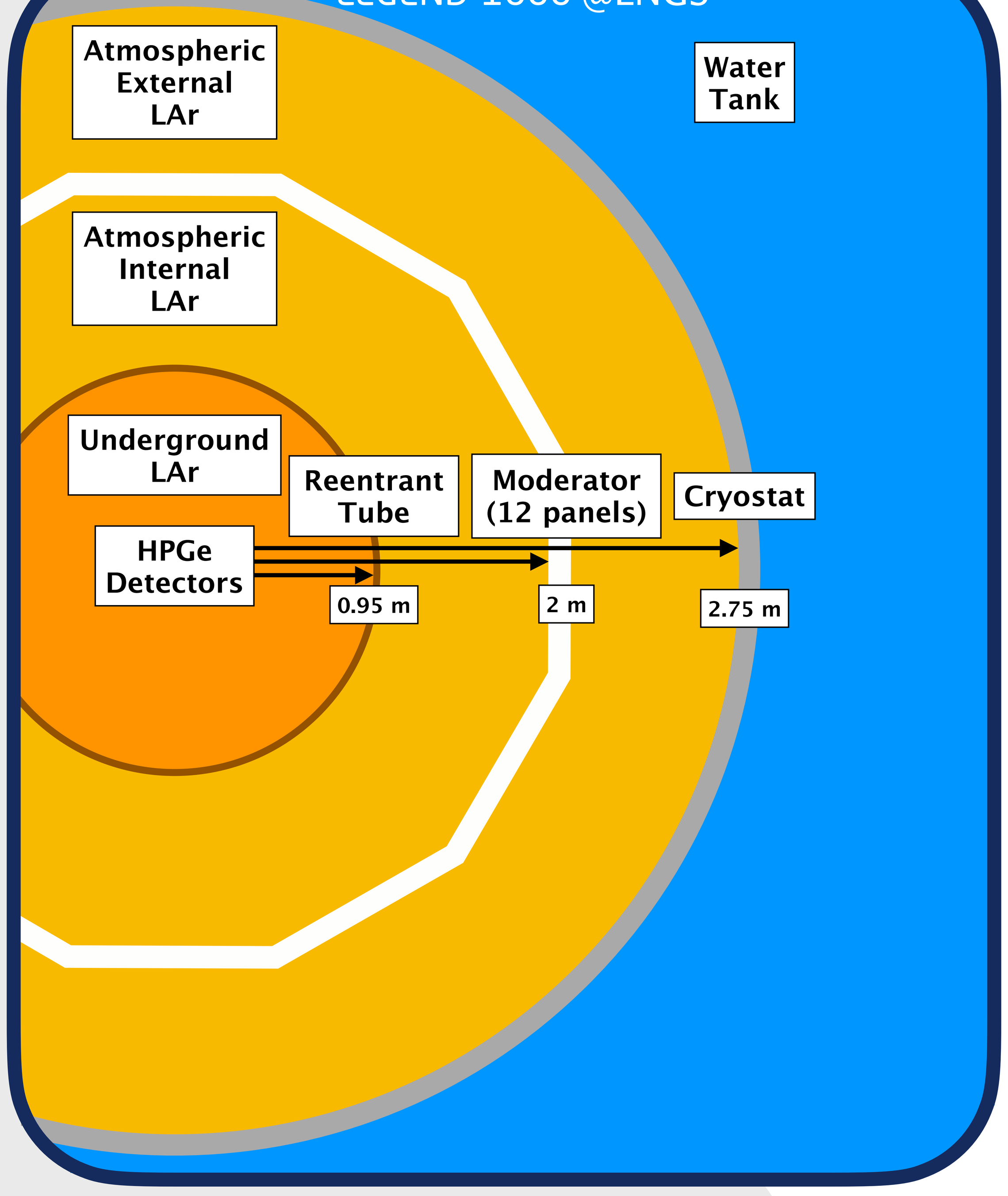
## $\mu$-induced background

$^{77}$Ge and $^{77m}$Ge are produced by neutron capture on $^{76}$Ge




**Standard cuts very efficient for $^{77}$Ge, but not for $^{77m}$Ge!**

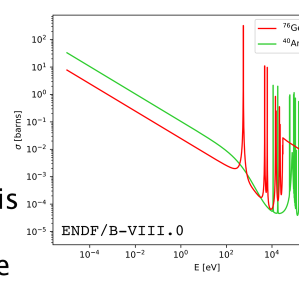
## LEGEND-1000 @LNGS



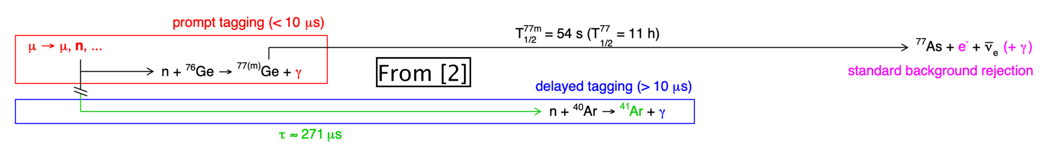

## How to *virtually* increase LNGS depth and reduce cosmogenic background?

**Offline tagging of bkg events** ⇒ $4.0^{+3.0}_{-2.9} \times 10^{-7}$ counts/(keV·kg·yr) ⇐ **Passive shielding**

- $^{77}$Ge and $^{77m}$Ge produced by n capture in muon events with high neutron multiplicity
- identify conditions to tag whether a detector is likely to have a neutron capture occurring inside

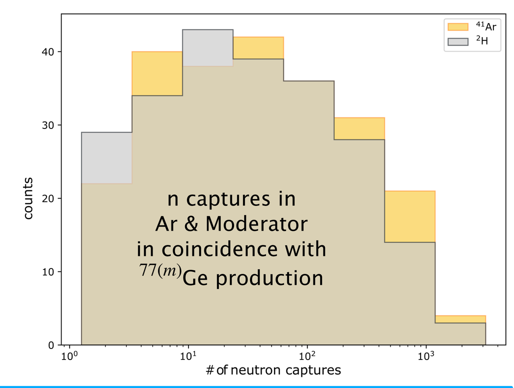


- H-rich material to reduce neutron energy produced by $\mu$
- increase probability of n capture on $^{40}$Ar preventing production of $^{77}$Ge and $^{77m}$Ge



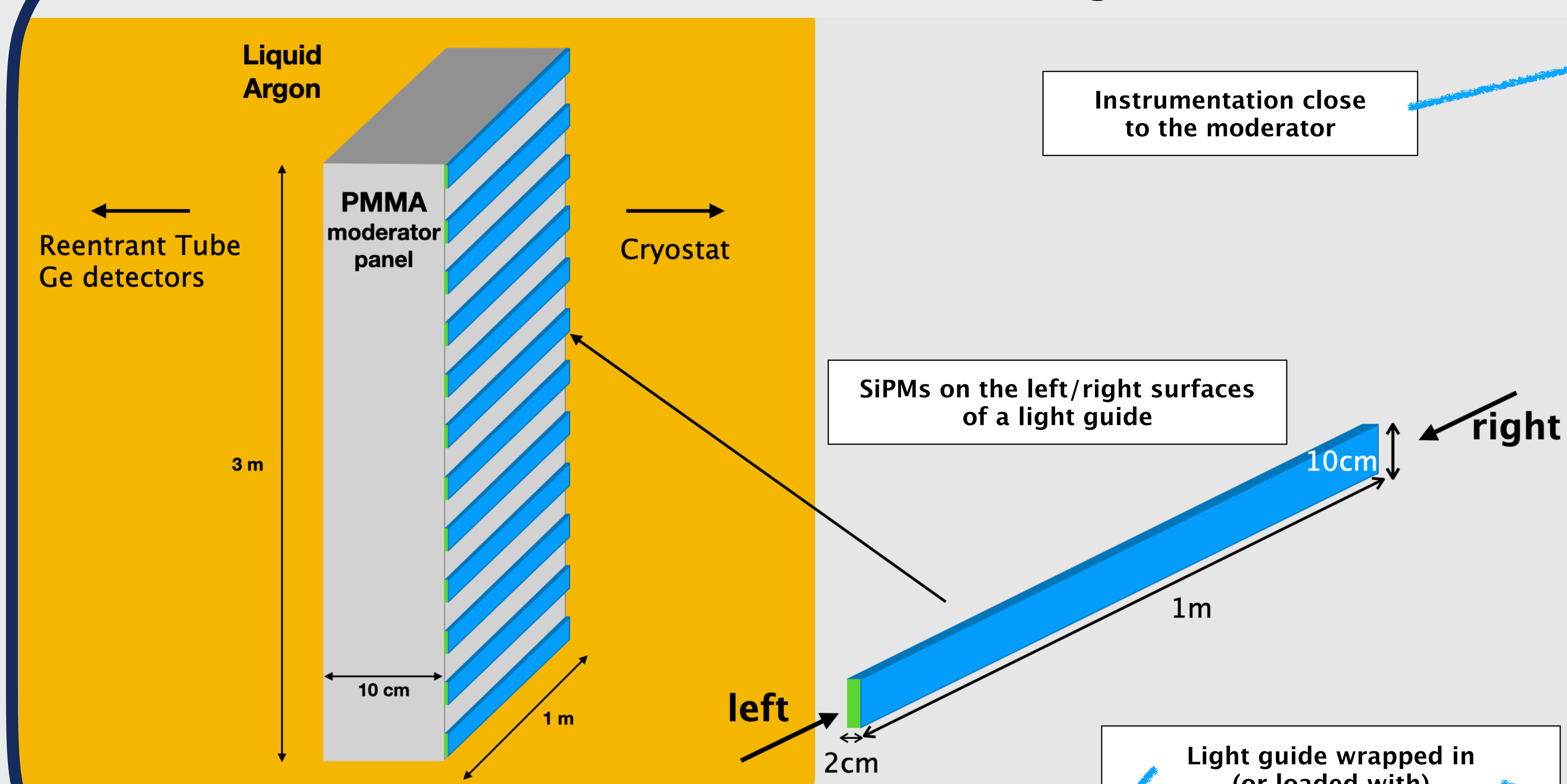

Goal of new instrumentation: detection of scint. $\gamma$s from neutron capture on

- $^{40}$Ar (~6 MeV)
- H (~2 MeV)



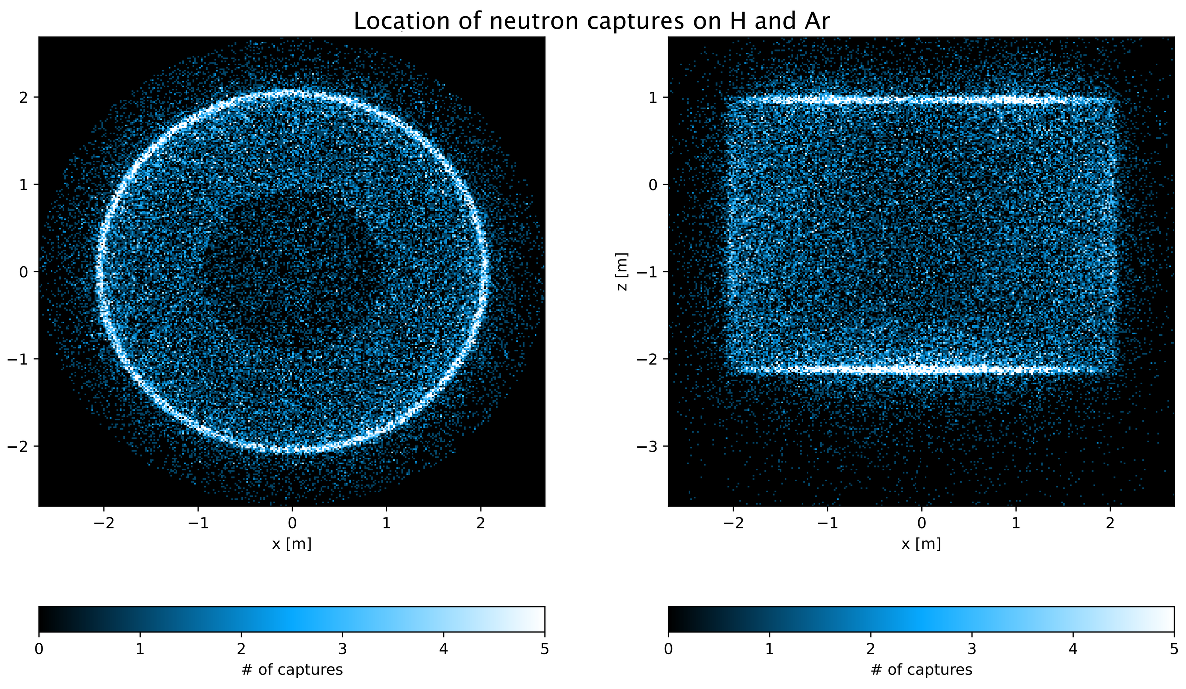

**New instrumentation to improve bkg tagging**

## Instrumentation Design




## Simulating $\mu$ in L1000

after the passage of a $\mu$, where are neutrons captured in the Ar volume?

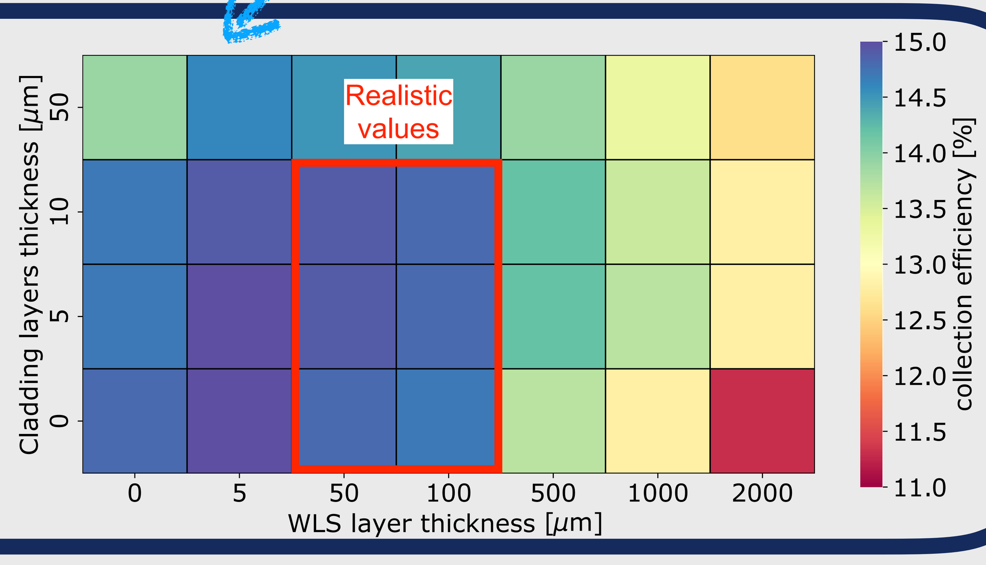



**90% of neutron captures on Ar within 47 cm of moderator**

## Simulating $\gamma$ in a light guide

- does adding layers of cladding material help collect optical photons at the left/right surfaces in a guide?

**No big difference for realistic thickness values**




## R&D

15kg sample from CLAX/EUROPROD

PMMA for moderator properties:
- transparent to optical light [3]
- stringent radio purity in Th/U (< 1 ppt)

⇒ also good candidate for making light guides!

⇒ possibility of loading PMMA with WLS

Alternatives: fiber sheets, SiPM directly on moderator's panels...

**R&D for moderator PMMA and light guide materials + readout**

## Next Steps:

- add optical simulation and finalize readout geometry through MC
- characterization of SiPM & guides/fibers and benchmark simulations


References:
[1] arXiv:2107.11462 [physics.ins-det]
[2] Eur. Phys. J. C **78**, 597 (2018)
[3] M Bodmer et al 2014 JINST 9 P02002