Atmospheric Argon Instrumentation for LEGEND-1000 @LNGS

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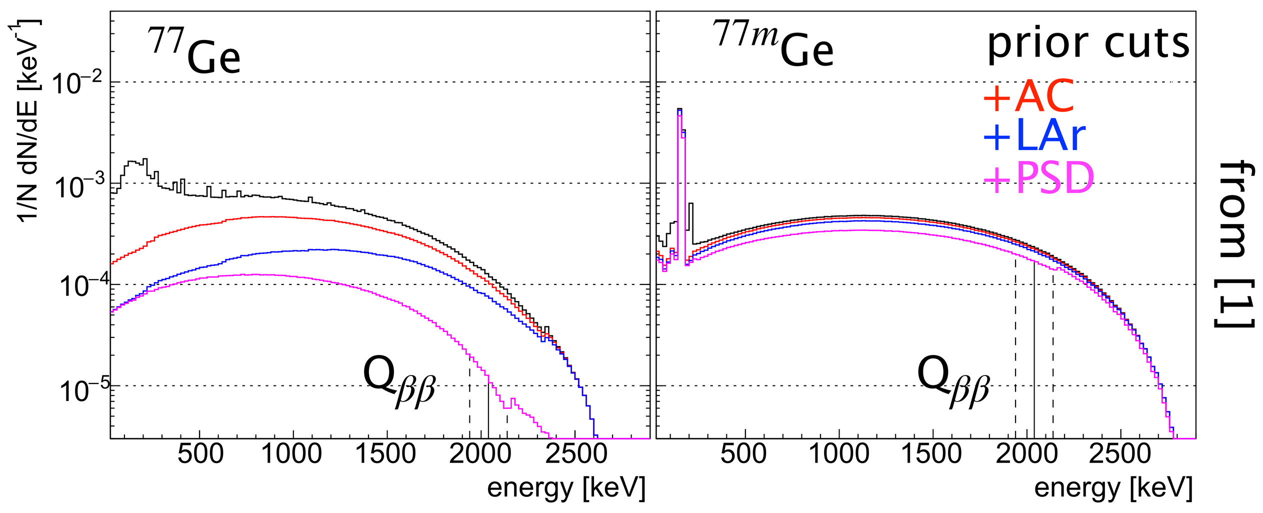
LEGEND Large Enriched Germanium Experiment for Neutrinoless ββ Decay

μ-induced background for LEGEND

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



μ-induced bkg @LNGS: ~1×10^{-5} counts/(keV·kg·yr)
same value as L1000 goal

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

How to reduce cosmogenic background?

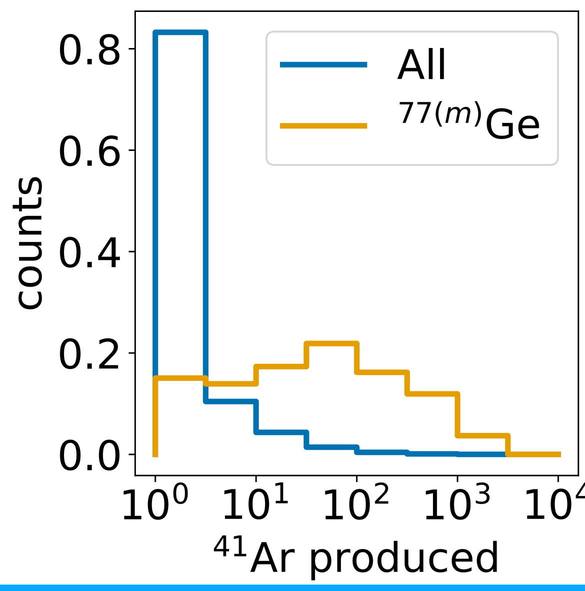
Passive shielding — H-rich material to slow down neutrons and capture them on ^{40}Ar before arriving to ^{76}Ge

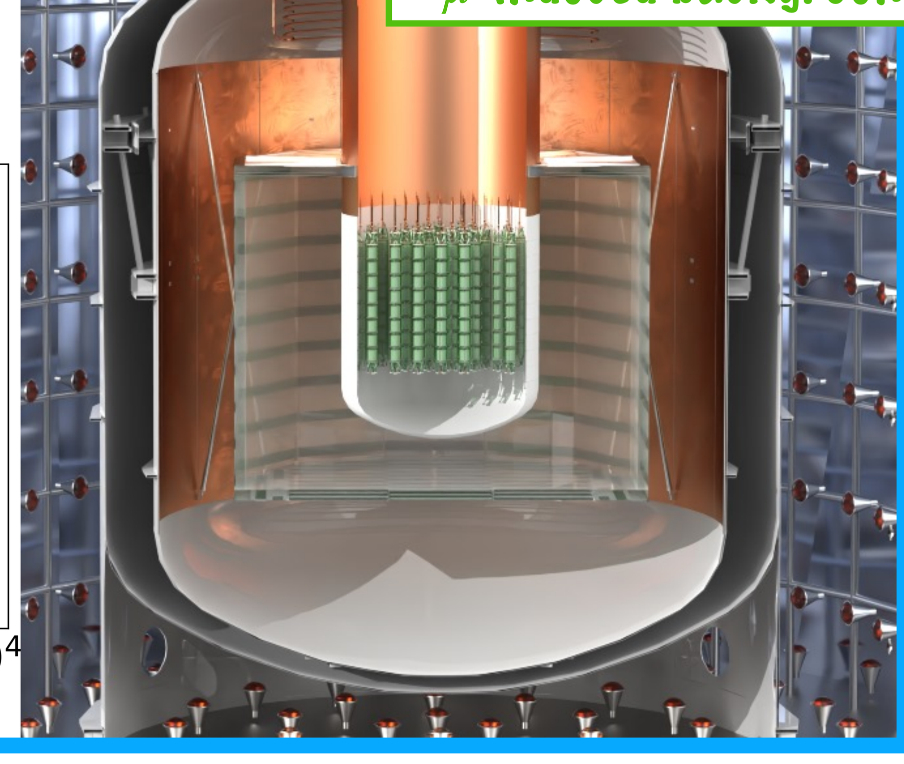
+

Offline tagging — identify conditions (^{40}Ar captures) to tag $^{77(m)}$Ge events

=

$3.8^{+2.7}_{-2.6}\times10^{-7}$ counts/(keV·kg·yr)





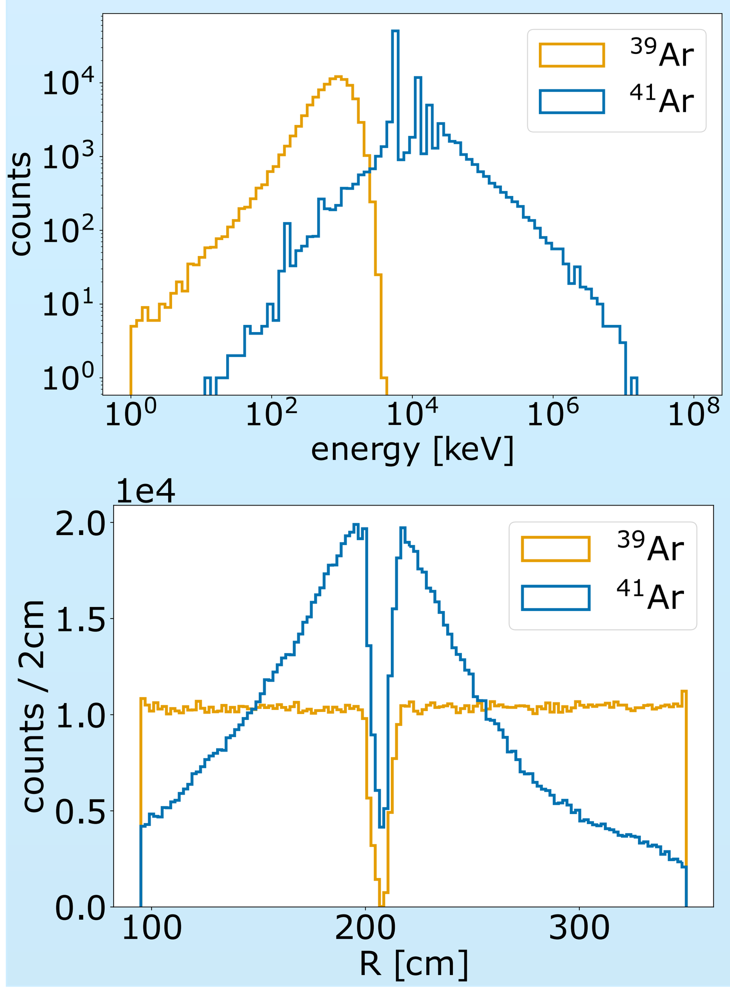
Instrument Atmospheric Argon to detect ^{40}Ar captures (i.e. ^{41}Ar production) and improve tagging of μ-induced background

How to optimize the instrumentation to detect ^{40}Ar captures?

Factorize simulation into independent steps for more flexible approach!!

physics

^{41}Ar (signal) → ~6 MeV/capture, ~0.6 mHz
^{39}Ar (bkg) → Q_β = 565 keV, 355 kHz



energy

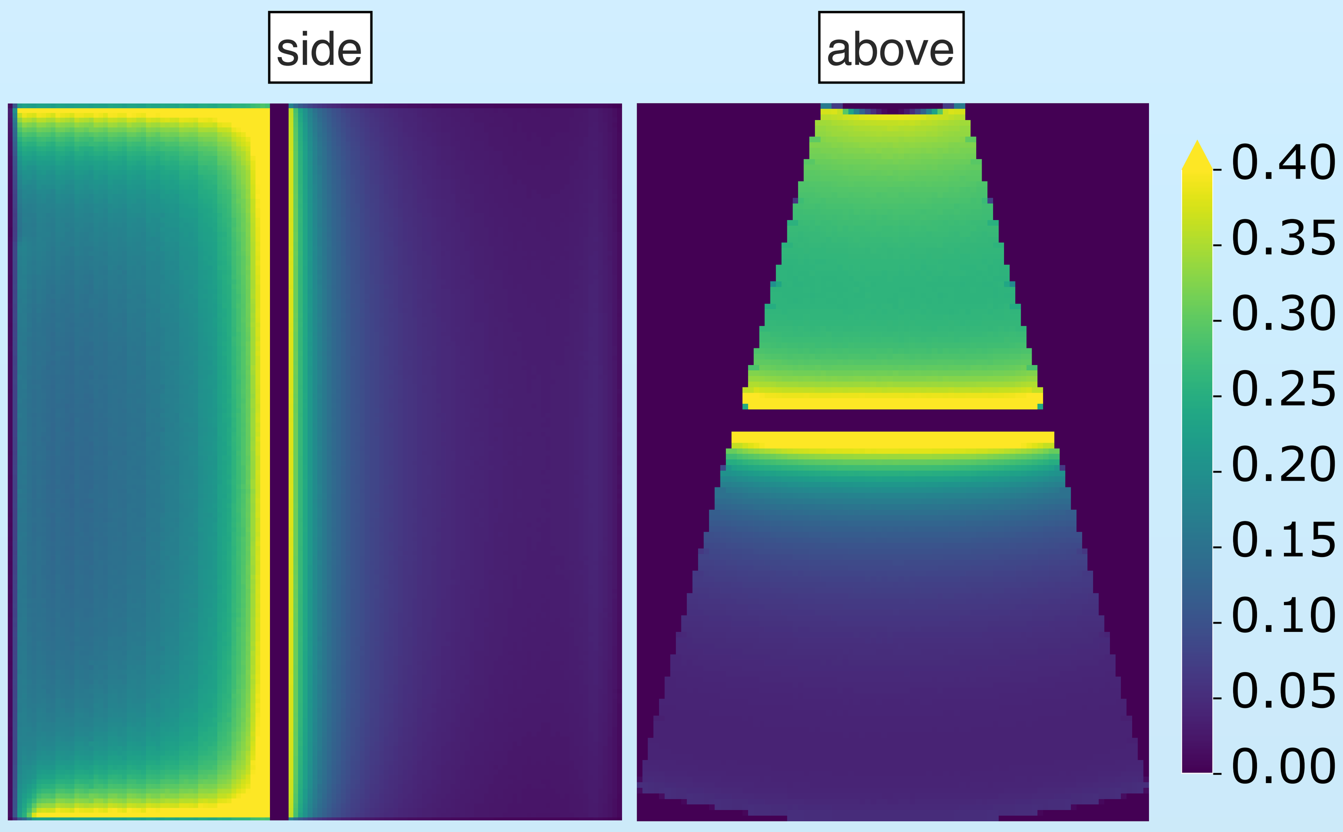
same area normaliz.

radial position

×

transport of LAr scintillation photons

probability for a scintillation γ produced in LAr at (x,y,z) to arrive on the instrumented shield surface at (x',y',z')



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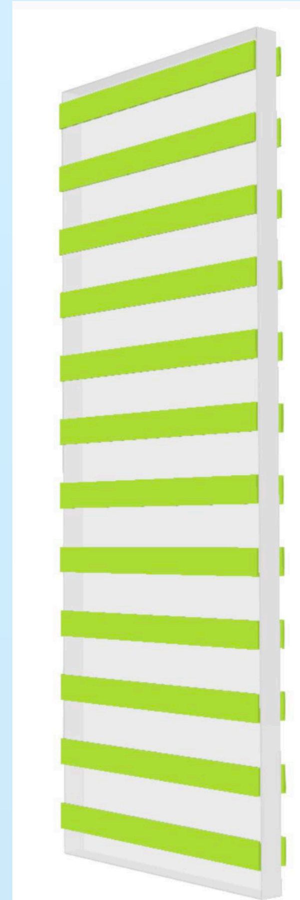
detection

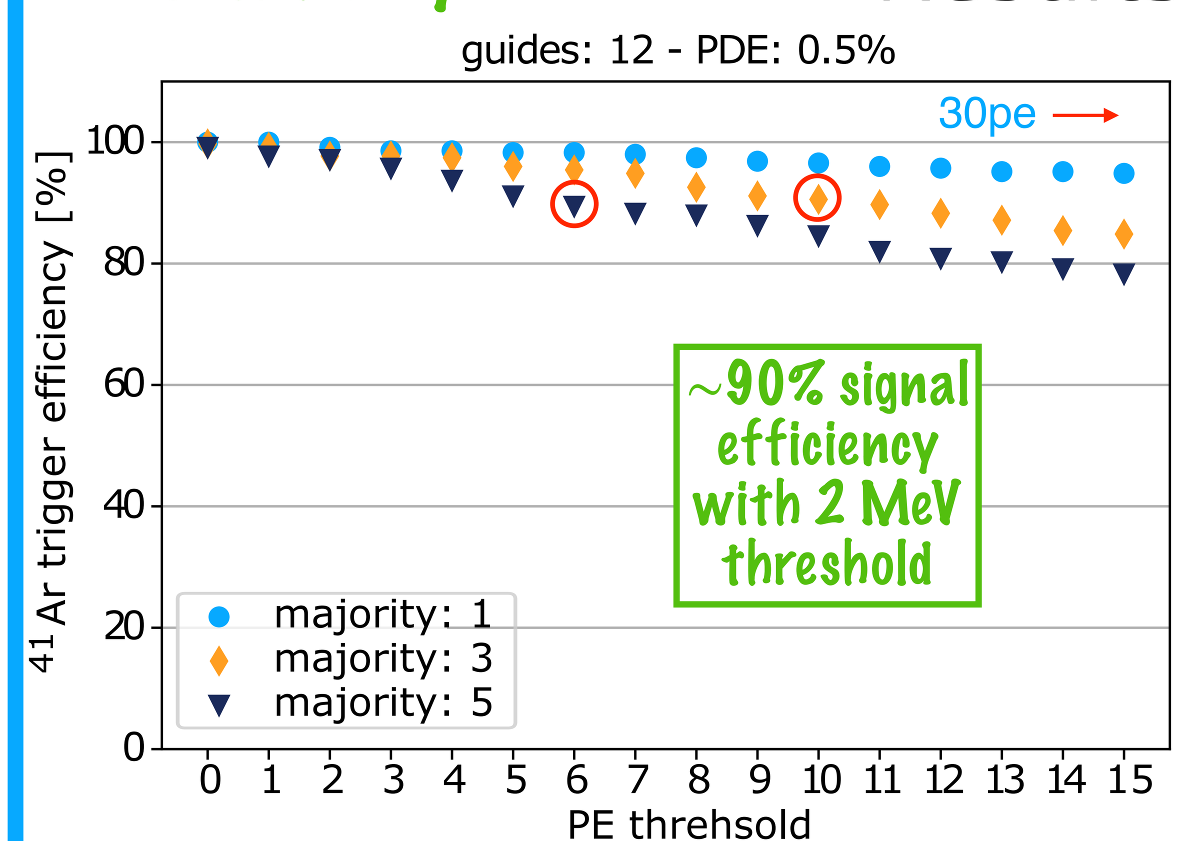
Photon Detection Efficiency (PDE) of instrumentation

- Light guides on the front and the back of the panel
- PDE extracted from simulations of light guides to be validated with R&D
- at the moment, PDE assumed in the range [0.1, 1]%



Preliminary

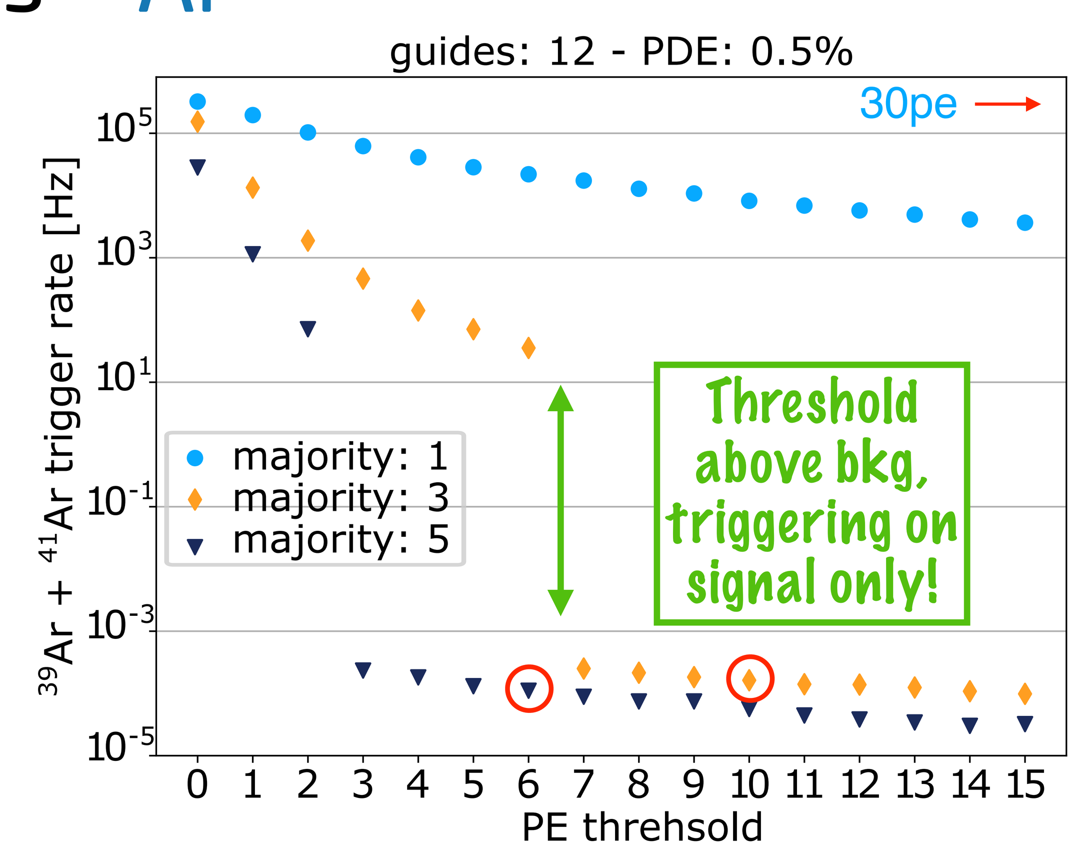
Results: ^{39}Ar vs ^{41}Ar



~90% signal efficiency with 2 MeV threshold

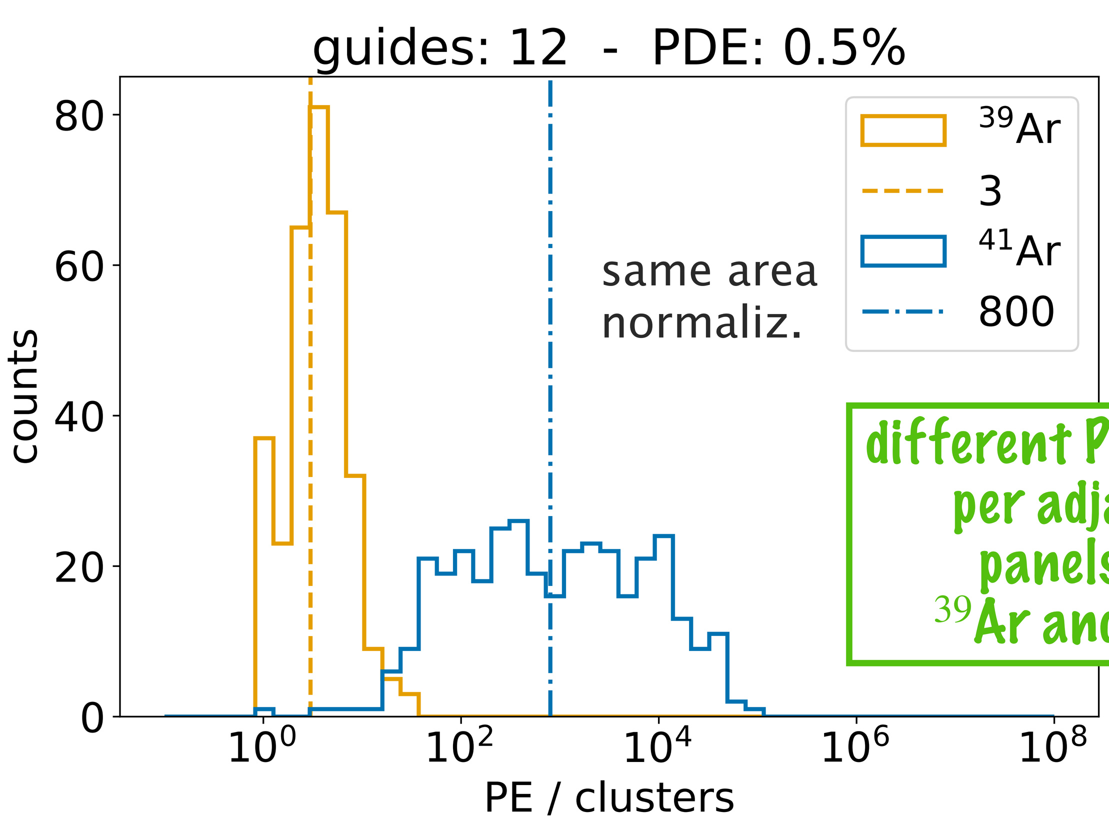
Light Yield ~15 PE/MeV

2 MeV threshold



Threshold above bkg, triggering on signal only!

Discrimination can be further improved to reduce ^{39}Ar and increase ^{41}Ar efficiency



different PE density per adjacent panels for ^{39}Ar and ^{41}Ar!

What's next?

Simulations:
- add Ar39 pile-up & U/Th
- multivariate discrimination
- more realistic inst. sim from R&D result

R&D:
- test and optimize light guides design at LNGS dedicated setup
- measure PDE

Production of final design

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References:
[1] Eur. Phys. J. C **78**, 597 (2018)

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