

# DarkSide

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XLVI LNGS Scientific Committee Meeting

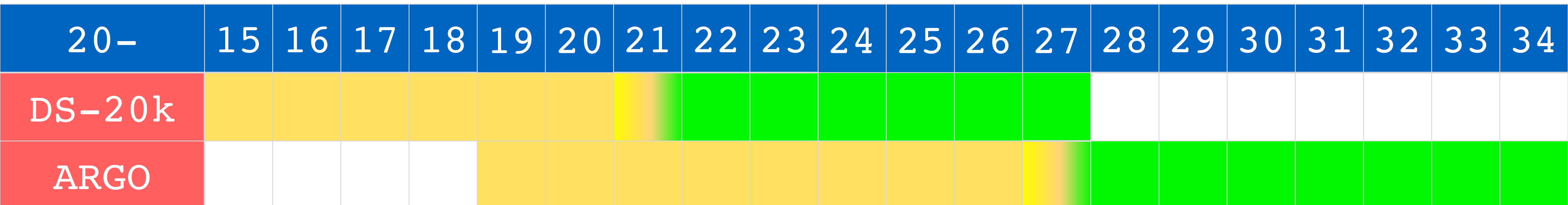
October 17, 2016

LNGS

# DarkSide-20k

20-tonnes fiducial dark matter detector  
start of operations at LNGS within 2021

100 tonne year search for dark matter free of instrumental background



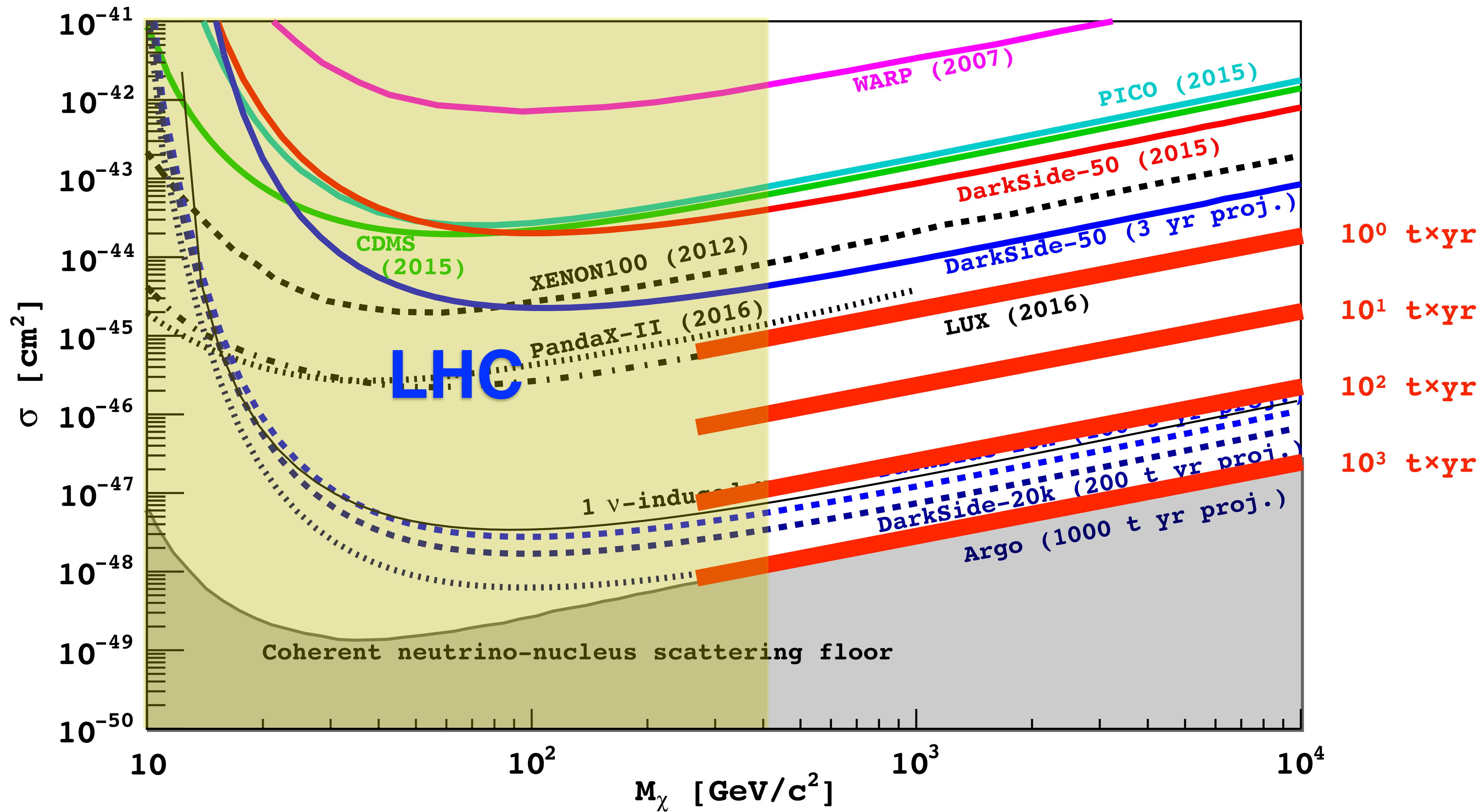
# Argo

300-tonnes depleted argon detector  
start of operations at LNGS within 2027

1,000 tonne year search for dark matter free of instrumental background  
precision measurement of solar neutrinos

1  
2  
3  
The DarkSide-20k Yellow Book  
Technical Proposal/Pre-Technical Design Report  
September 5<sup>th</sup>, 2016

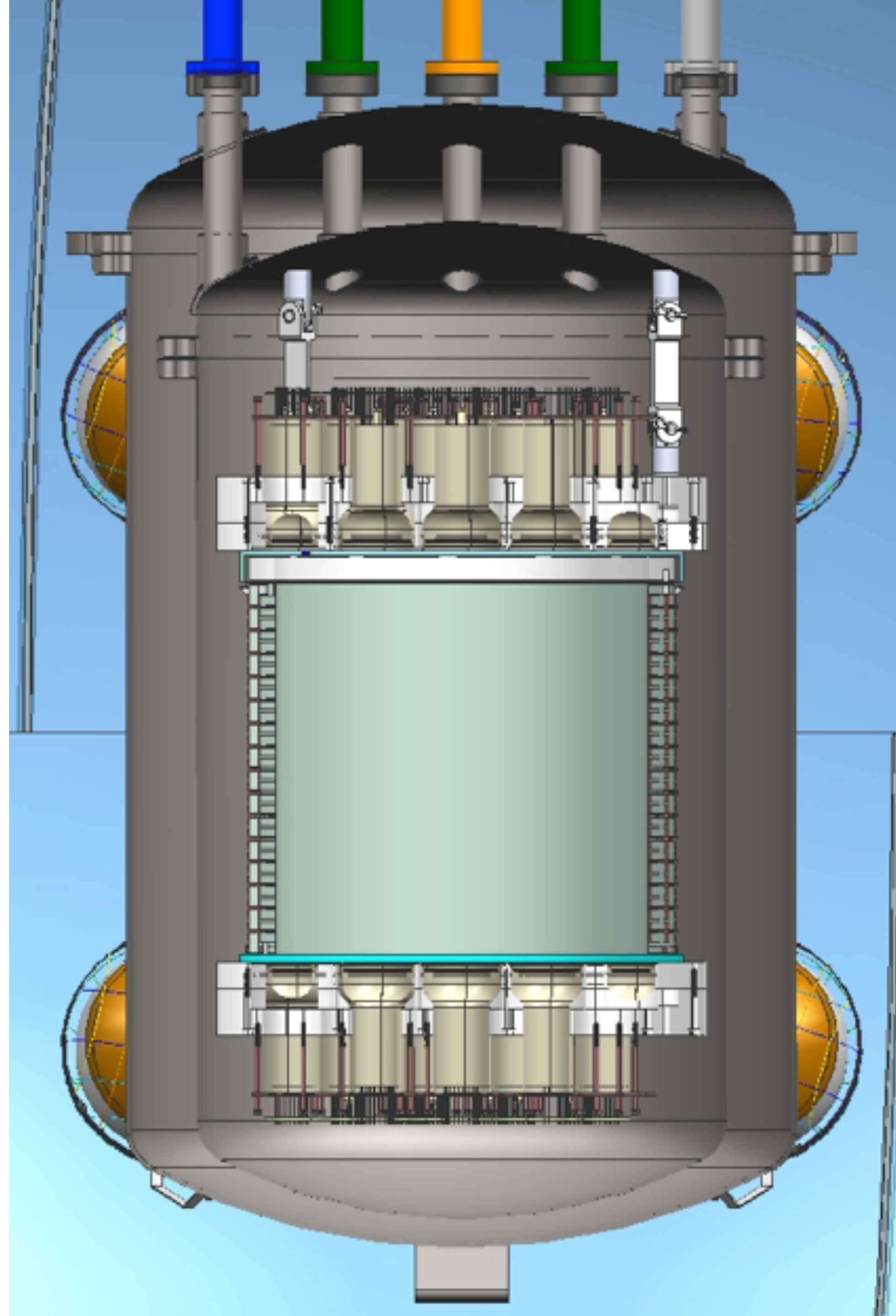




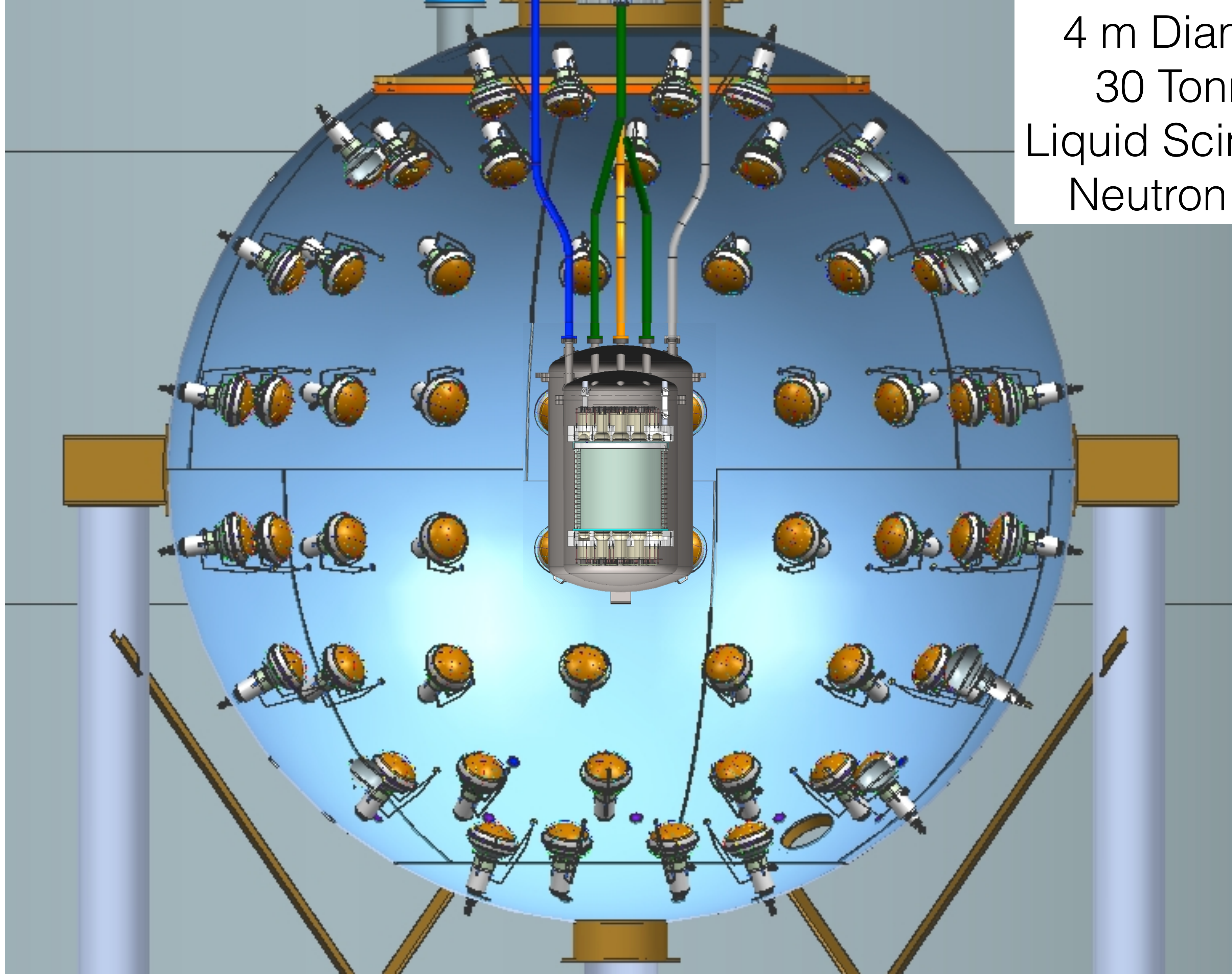
# An Ambitious Discovery Program

- Complementary to LHC
- Raising the bar: from 1 tonne  $\times$  yr  $\rightarrow$  1,000 tonne  $\times$  yr
- “Zero Background” necessary for a discovery program
- Two crucial technologies
  - Liquid argon target depleted in the radioactive  $^{39}\text{Ar}$
  - SiPMs replacing cryogenic PMTs

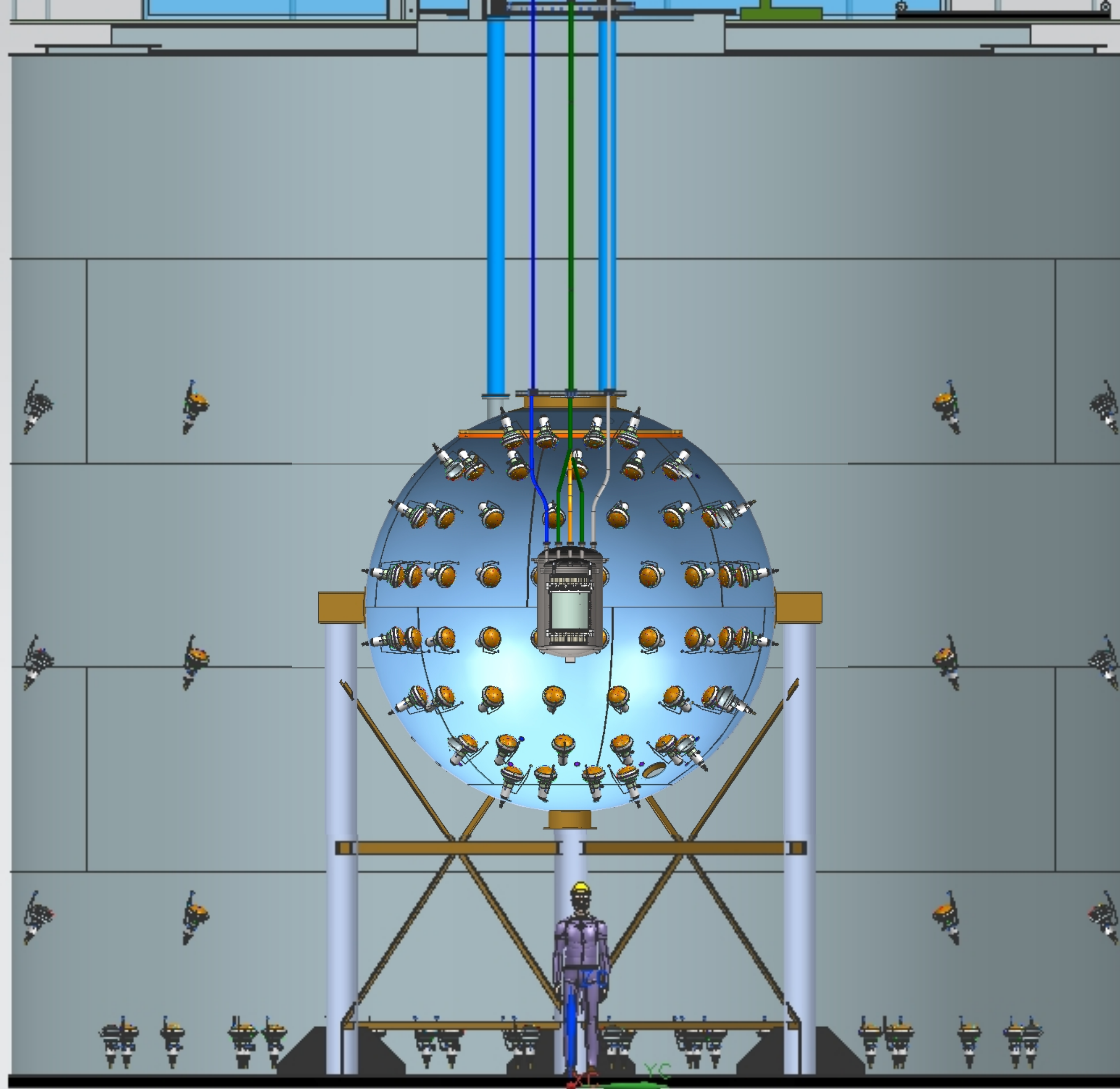
Liquid Argon TPC  
153 kg  $^{39}\text{Ar}$ -Depleted  
Underground Argon  
Target



4 m Diameter  
30 Tonnes  
Liquid Scintillator  
Neutron Veto



10 m Height  
11 m Diameter  
1,000 Tonnes  
Water Cherenkov  
Muon Veto

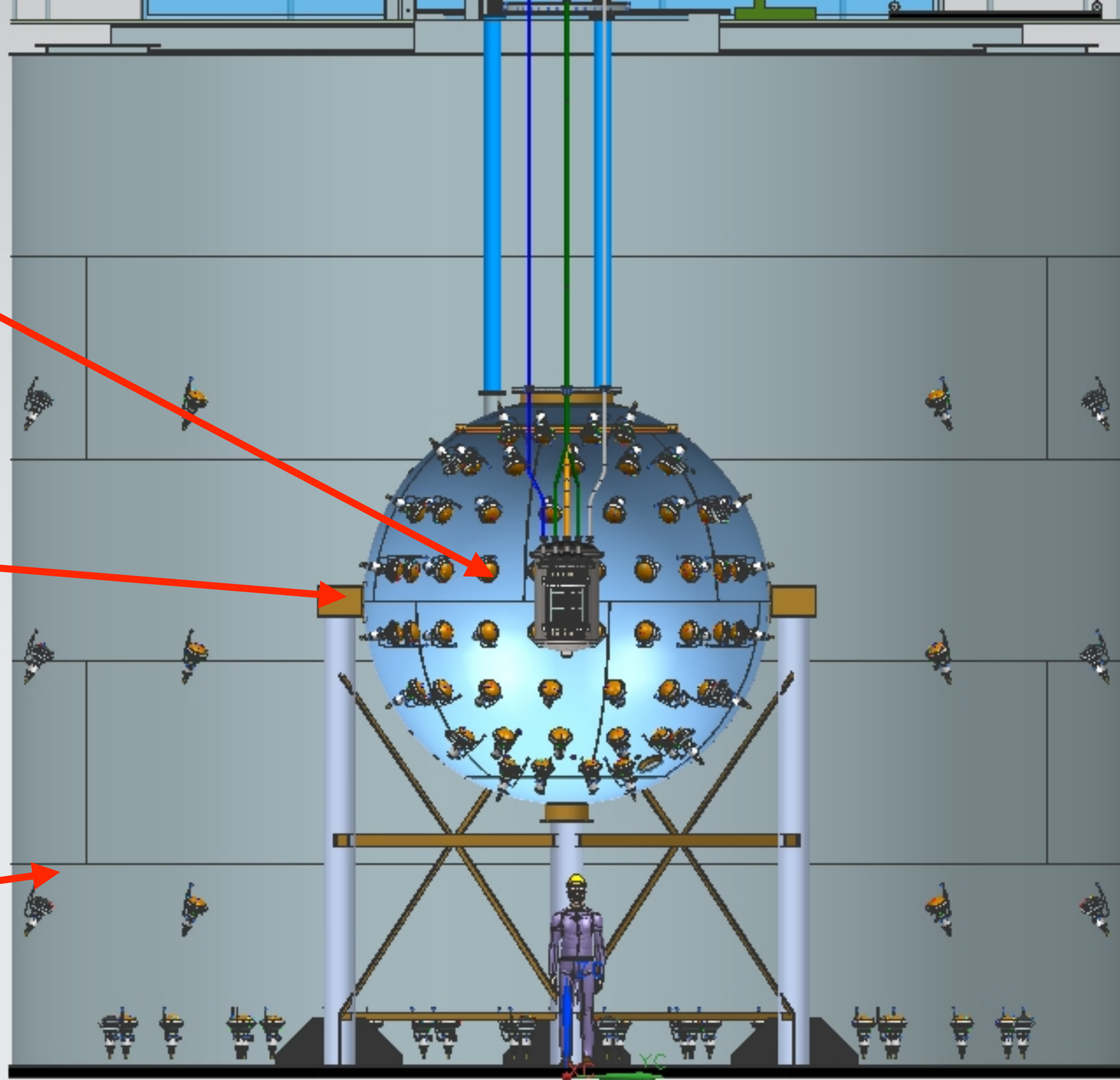




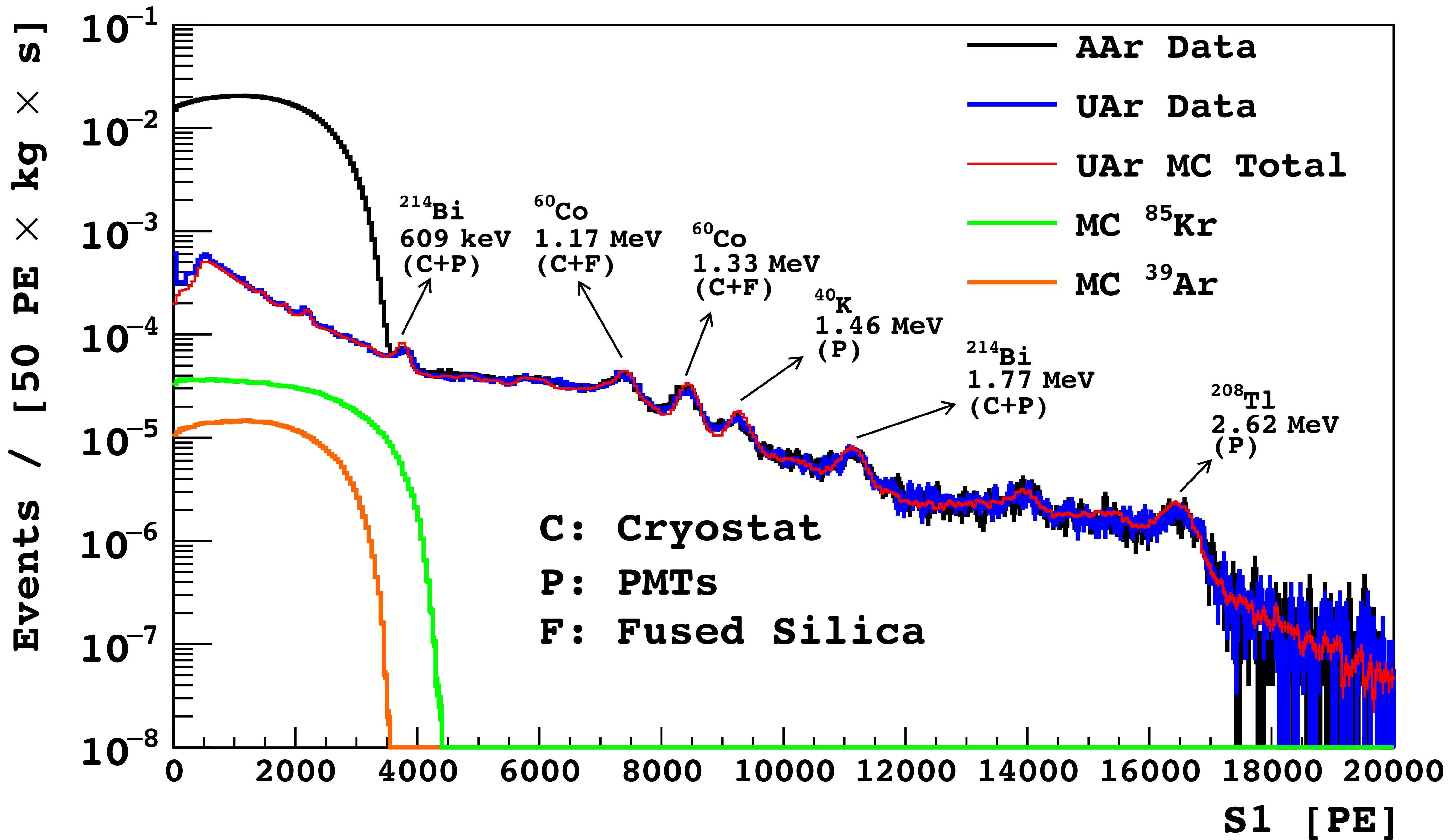
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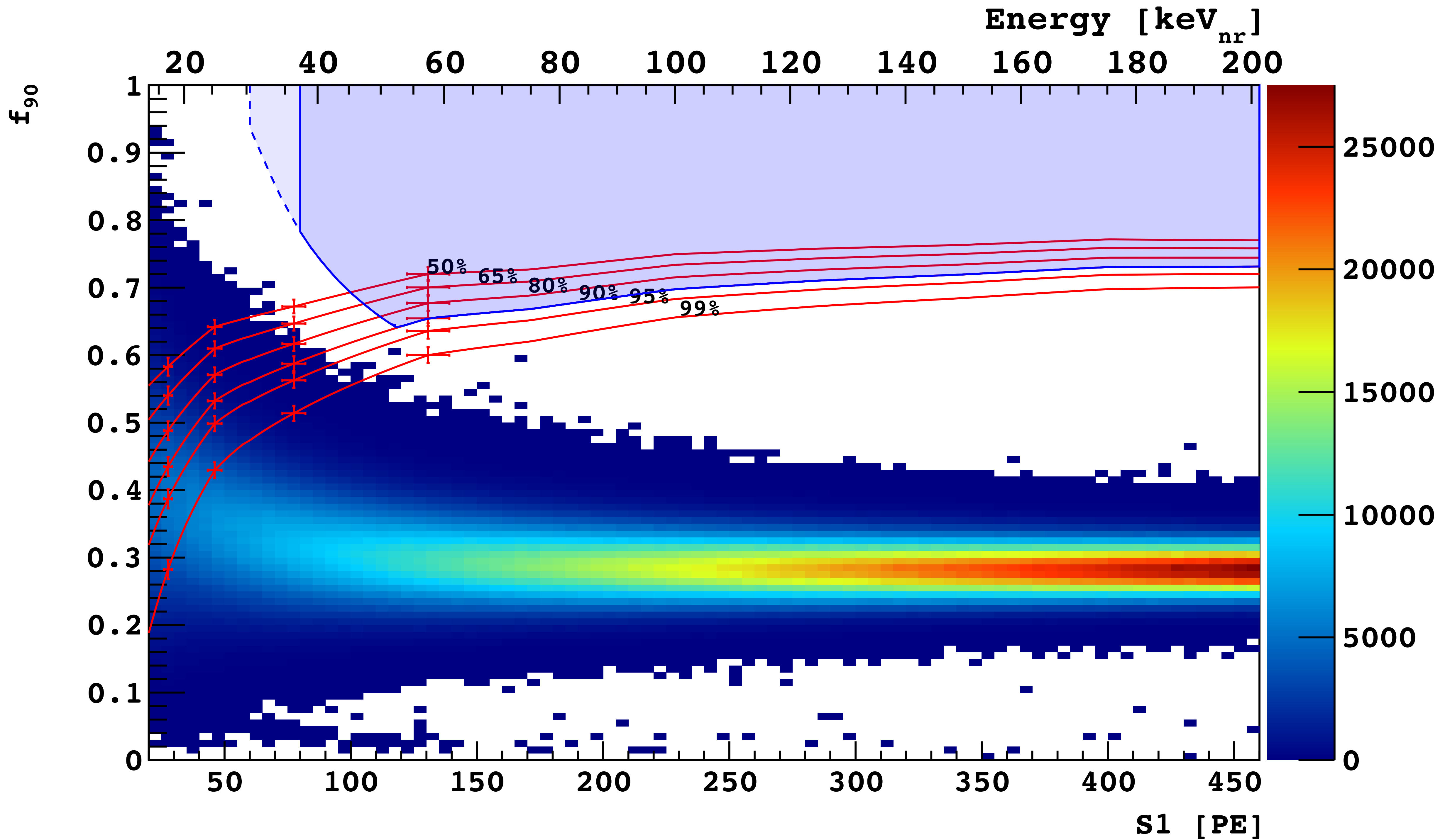
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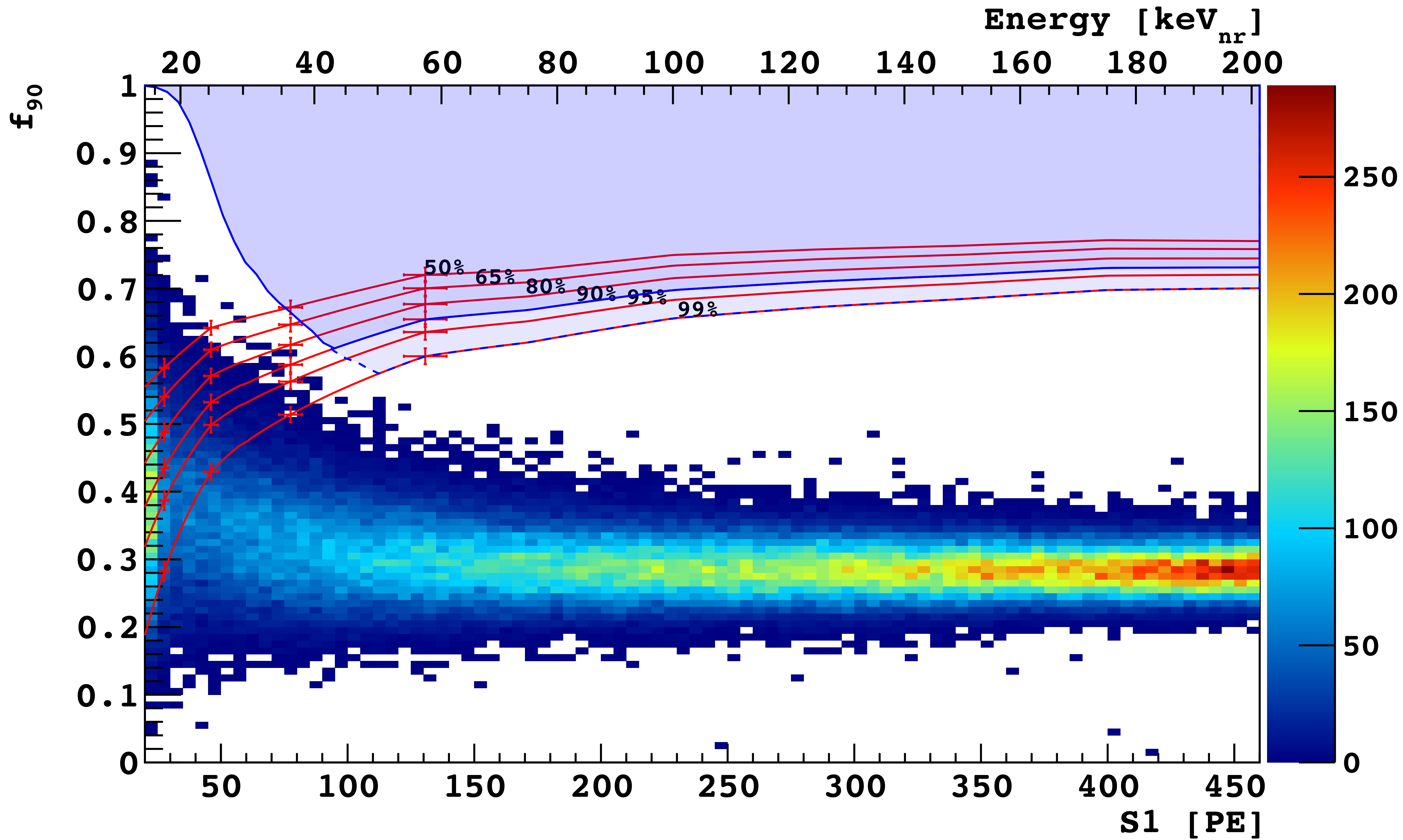


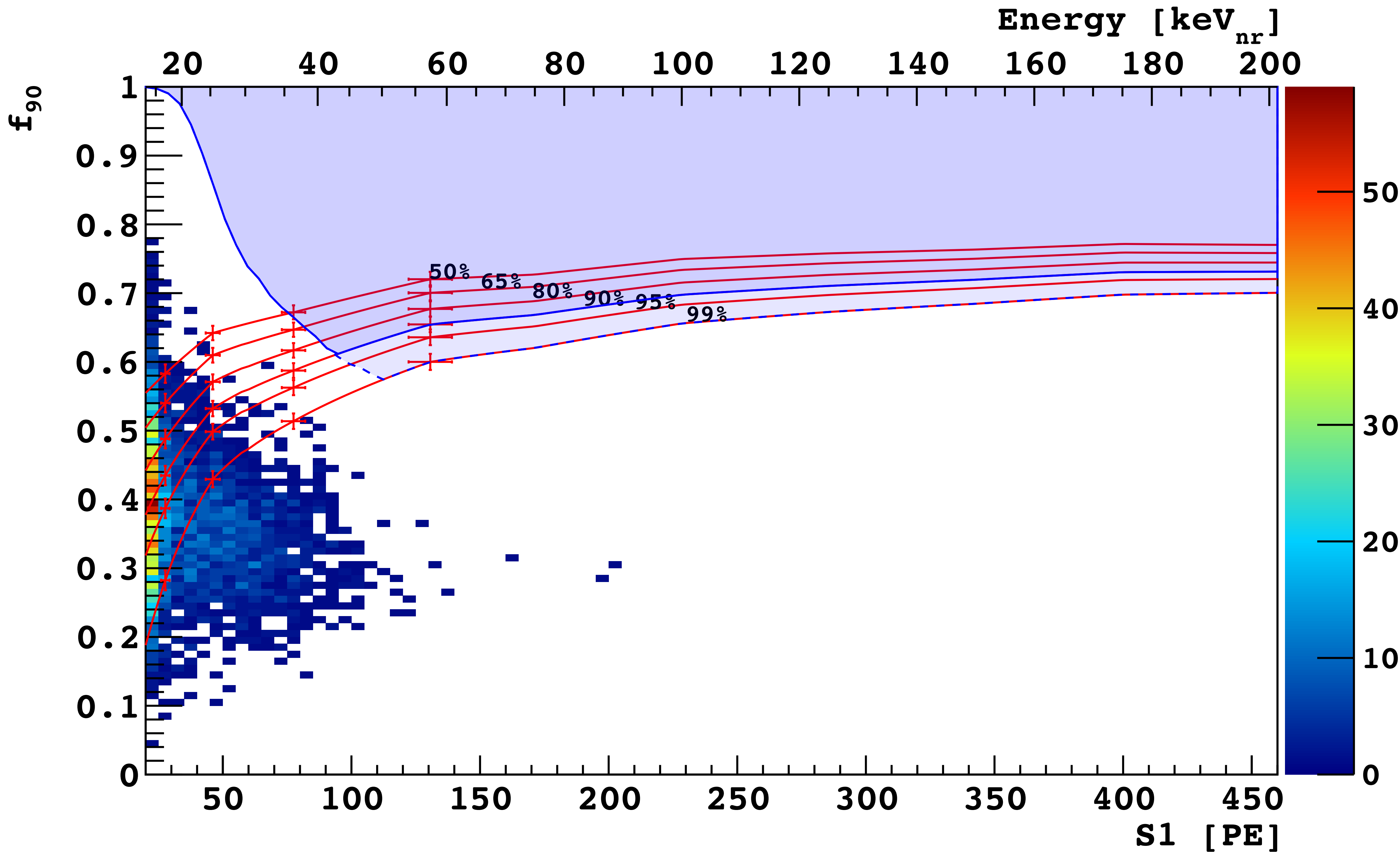




1,422 kg d AAr - PLB 743, 456 (2015)







“Zero Background” condition  
( $<0.1$  background events)  
necessary to conduct  
discovery program

What are the instrumental  
backgrounds for large scale,  
high mass dark matter  
searches?



## Minimum Ionizing Events:

- Scatters of  $pp$  solar neutrinos on electrons
- Radioactive noble gases ( $^{222}\text{Rn}$ ,  $^{39}\text{Ar}$ )

## Nuclear Recoils:

- $\nu$ -induced coherent scattering of atm neutrinos [ $\sim 1/(100 \text{ tonne} \times \text{yr})$ ]

# Elastic Scatters of $pp$ Solar Neutrinos on Electrons

- 200 events/tonne $\times$ yr in ROI
- 200,000 background events @neutrino floor
- Defeated in argon thanks to  $\beta/\gamma$  rejection better than  $1 \div 1.6 \times 10^7$

# $^{222}\text{Rn}$

- $<2 \mu\text{Bq/kg}$  demonstrated in DarkSide-50
- 100 events/tonne $\times$ yr in ROI
- 1,000,000 background events @neutrino floor
- Defeated in argon thanks to  $\beta/\gamma$  rejection better than  $1 \div 1.6 \times 10^7$

16M  $^{39}\text{Ar}$  events  
1,422 kg $\times$ day (@AAr)

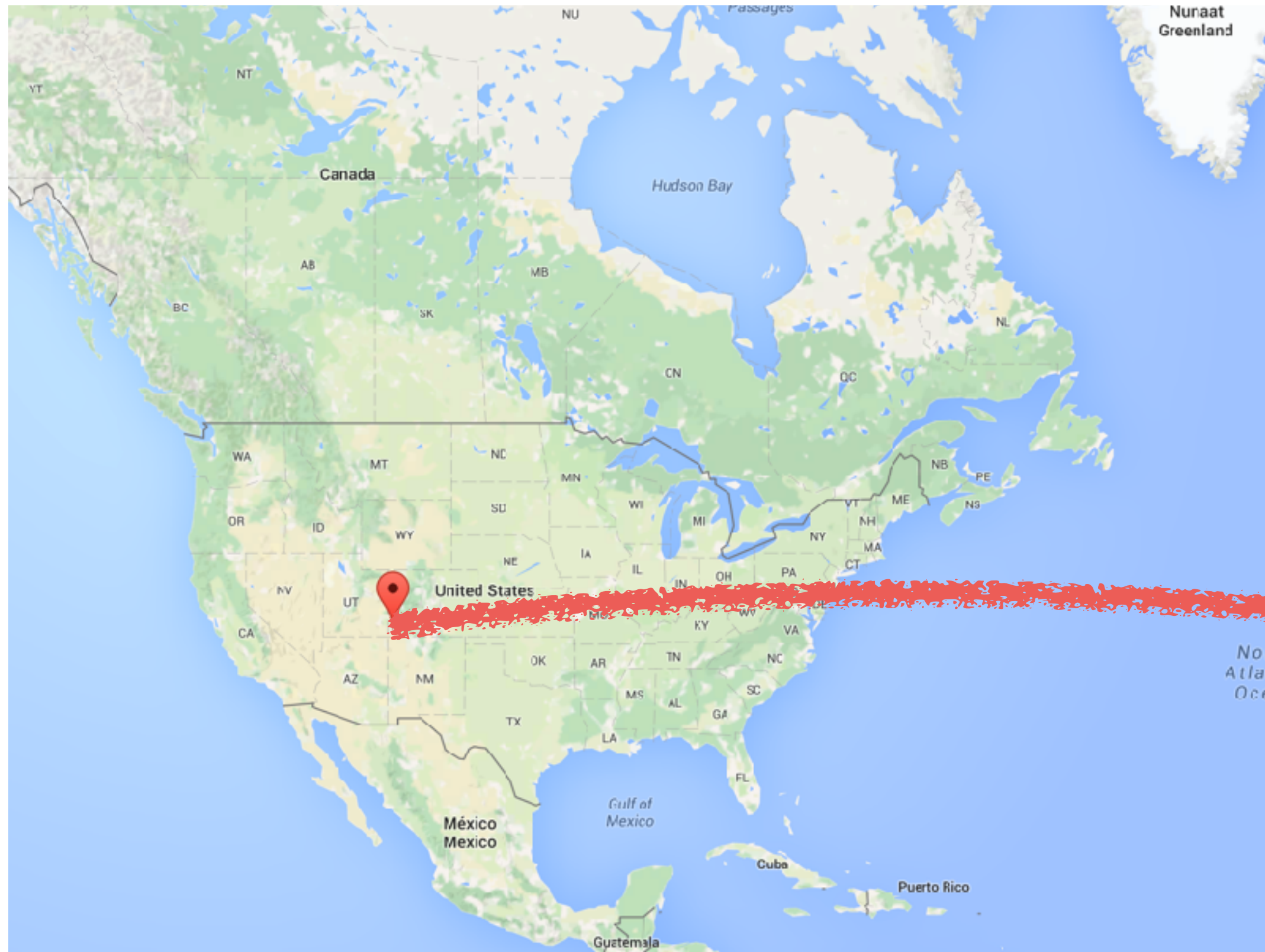
$\div$  1400  $^{39}\text{Ar}$  depletion  
AAr/UAr

16M  $^{39}\text{Ar}$  events  
5.5 tonne $\times$ yr (UAr)

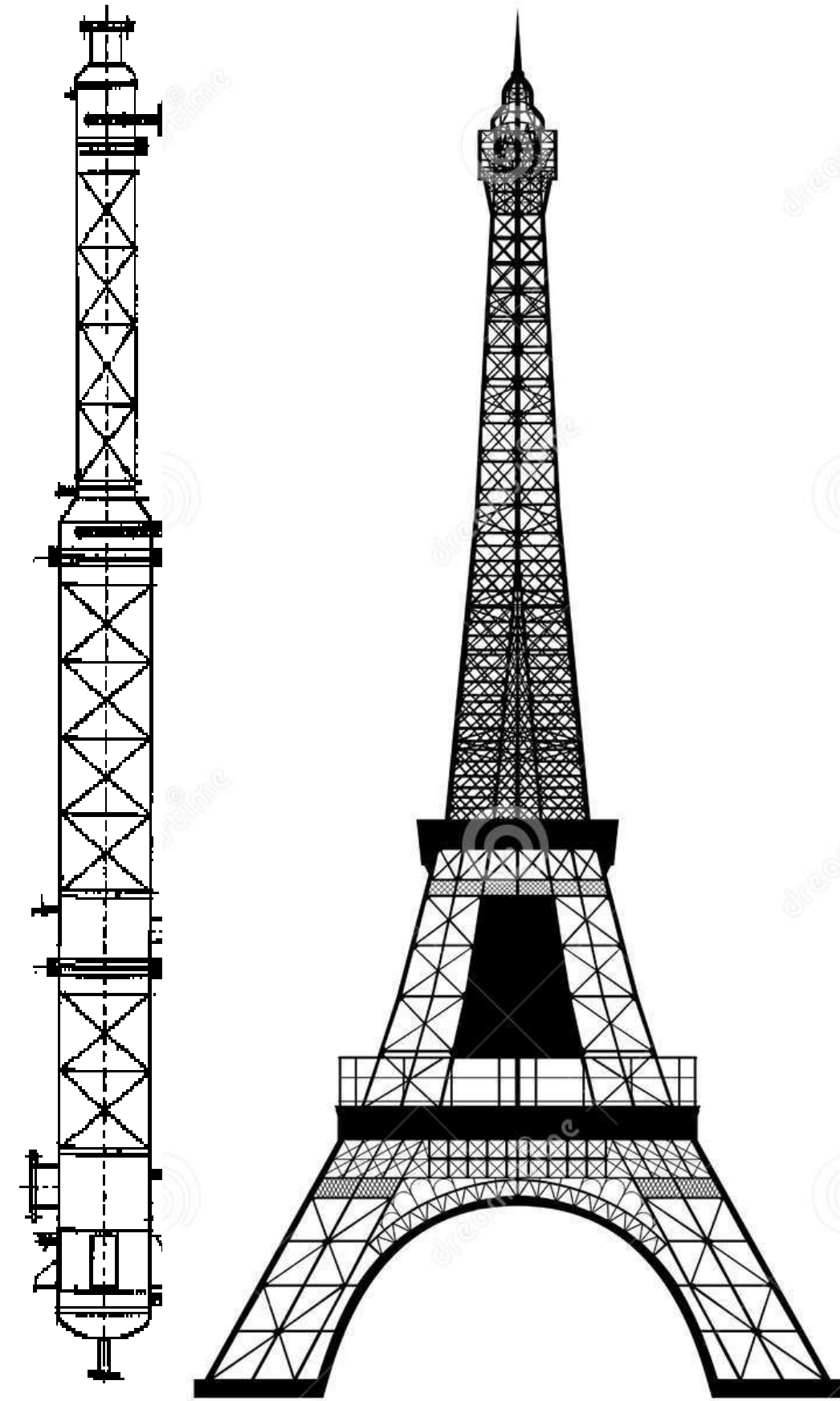
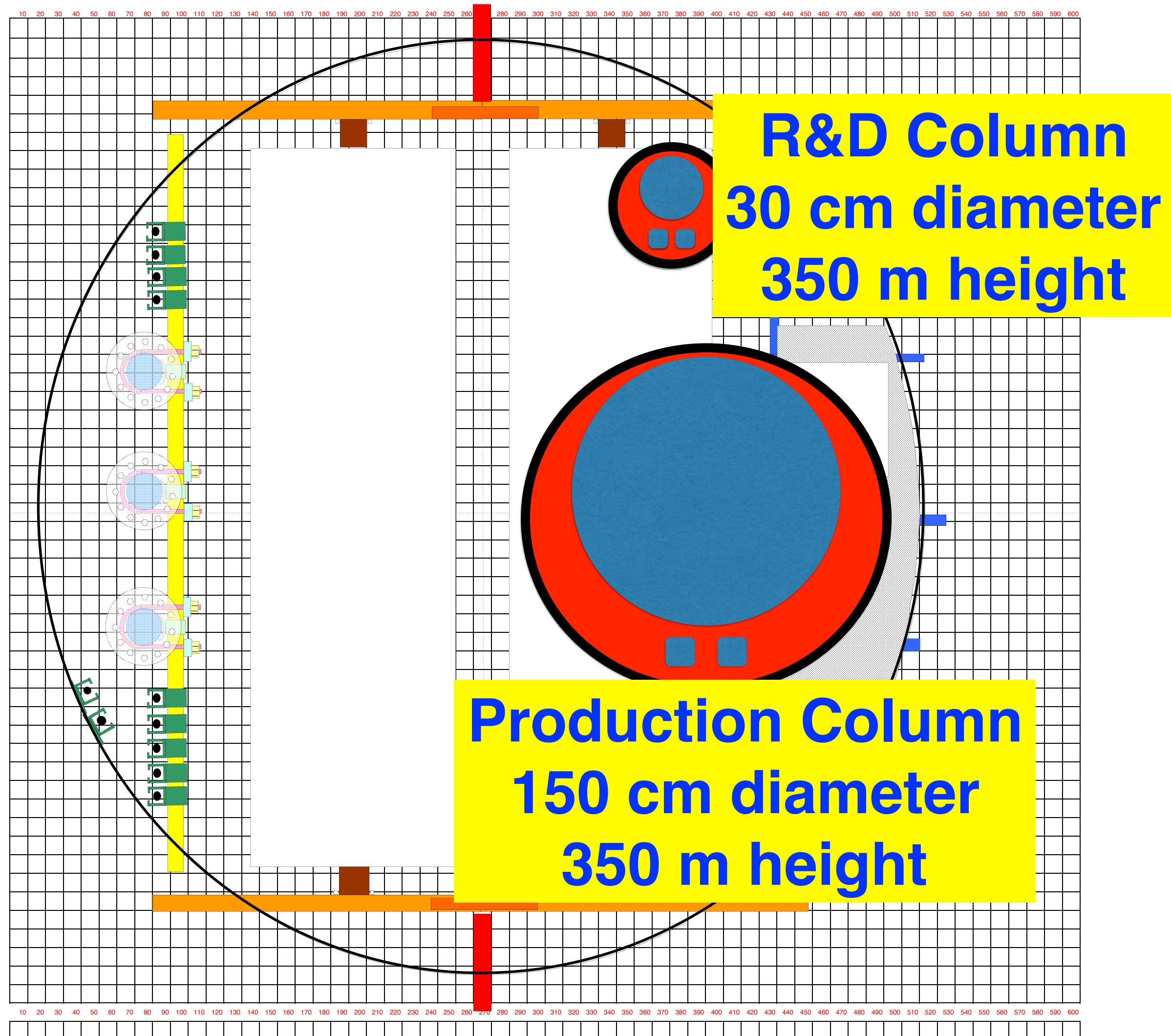
higher light yield  
additional active  
isotopic depletion

1,000 tonne $\times$ yr (DAr)

# Urania to Aria to LNGS



# Aria







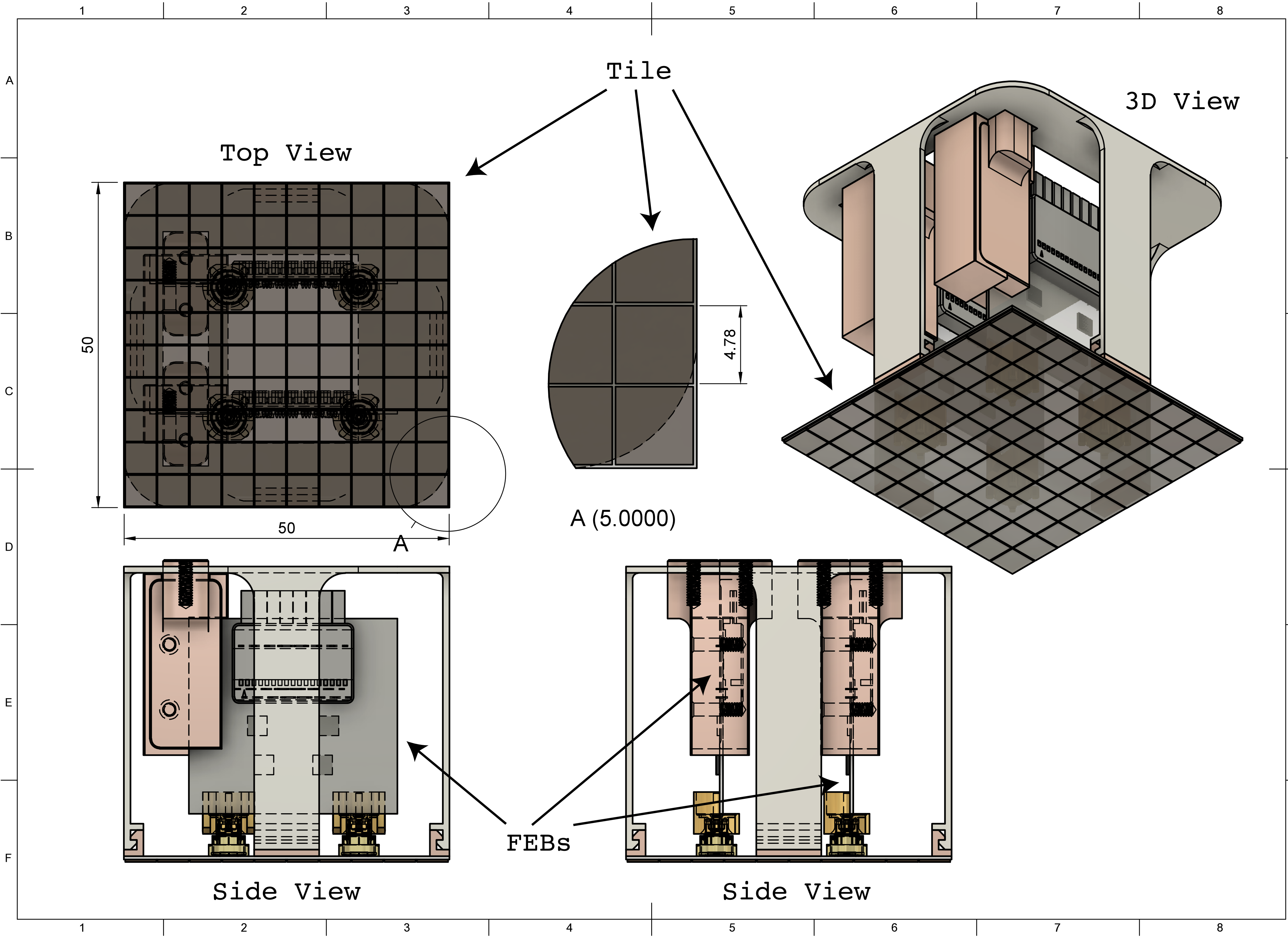


Based on what we know today, can a depleted argon experiment be free of any instrumental (other than  $\nu$ -induced recoils) background at the scale of 1000 tonnes $\times$ yr?

Yes.

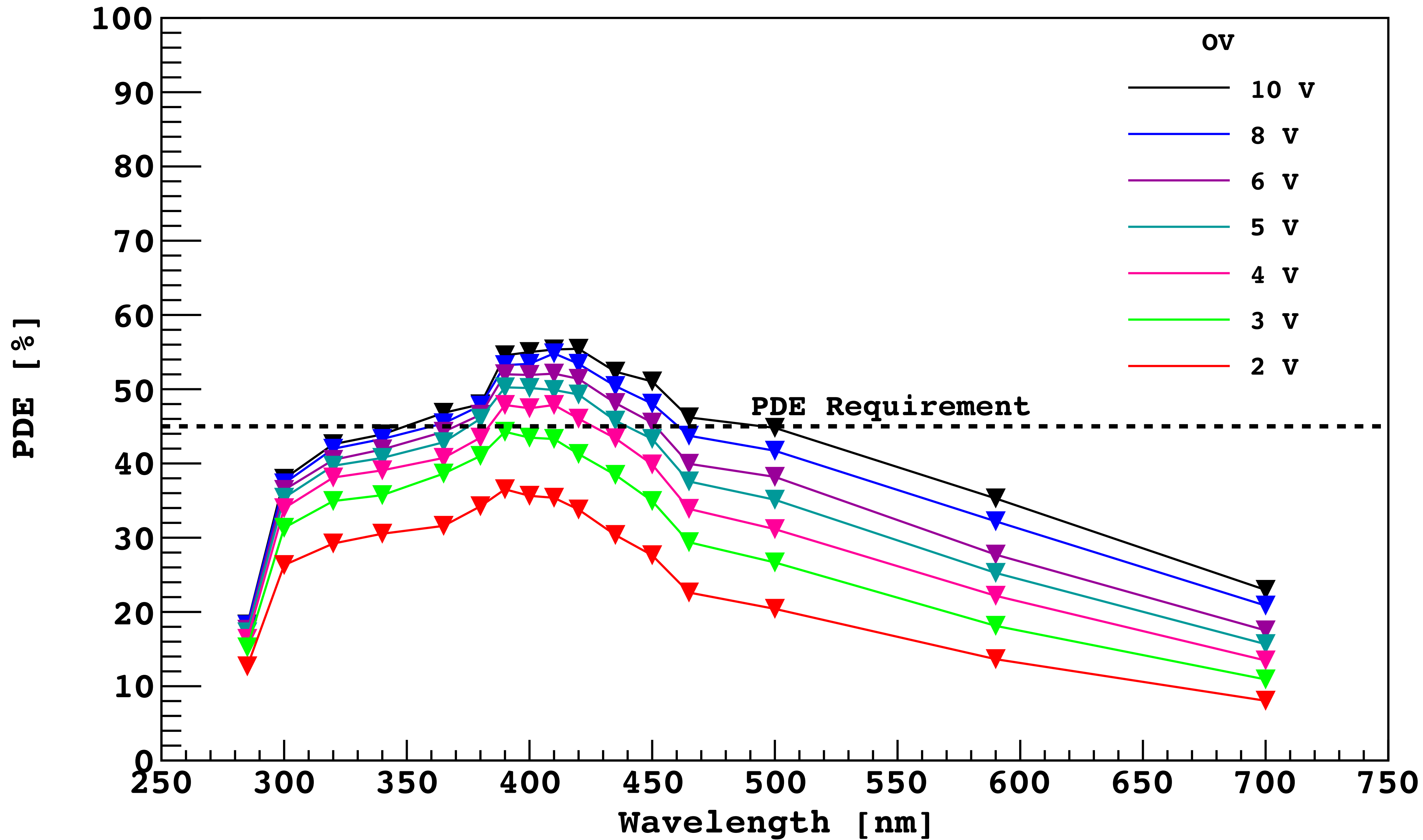
# Screening Program

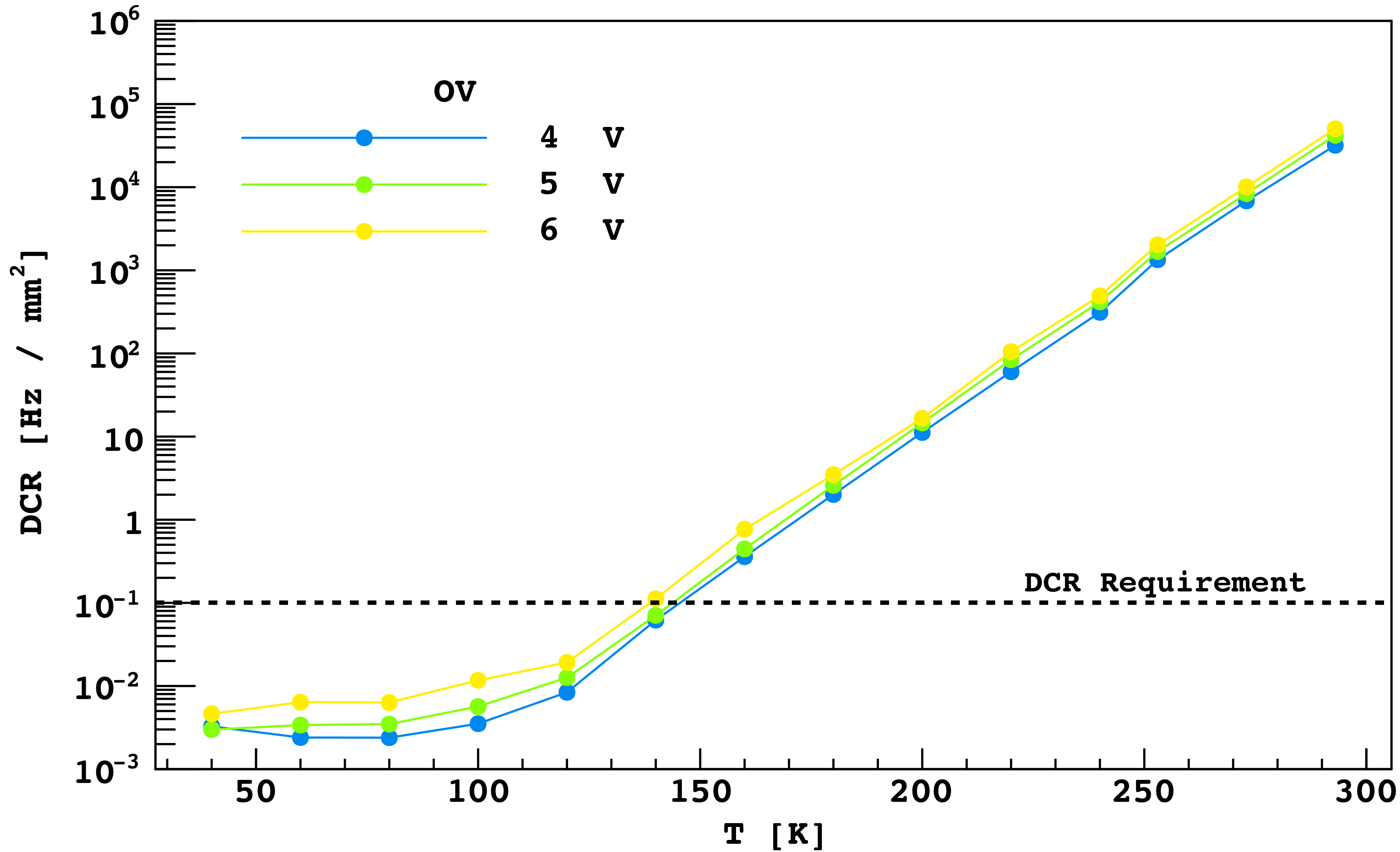
- Minimize nuclear recoils from (α,n) interactions
  - <0.1 events in signal region for full exposure
  - Screen all detector components
  - Utilizing assay capabilities across ten institutions
  - World-leading ultra-sensitive assay methods

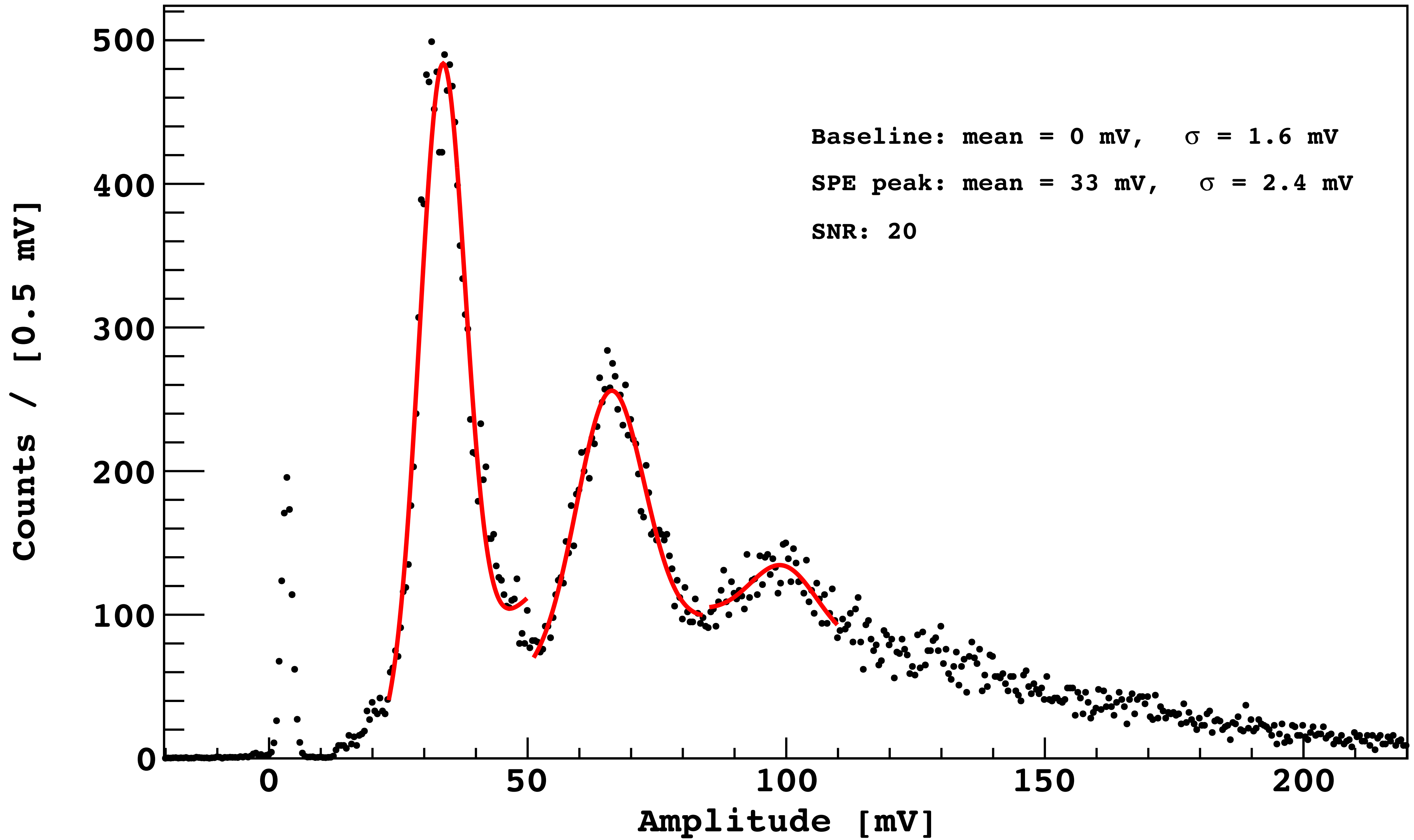


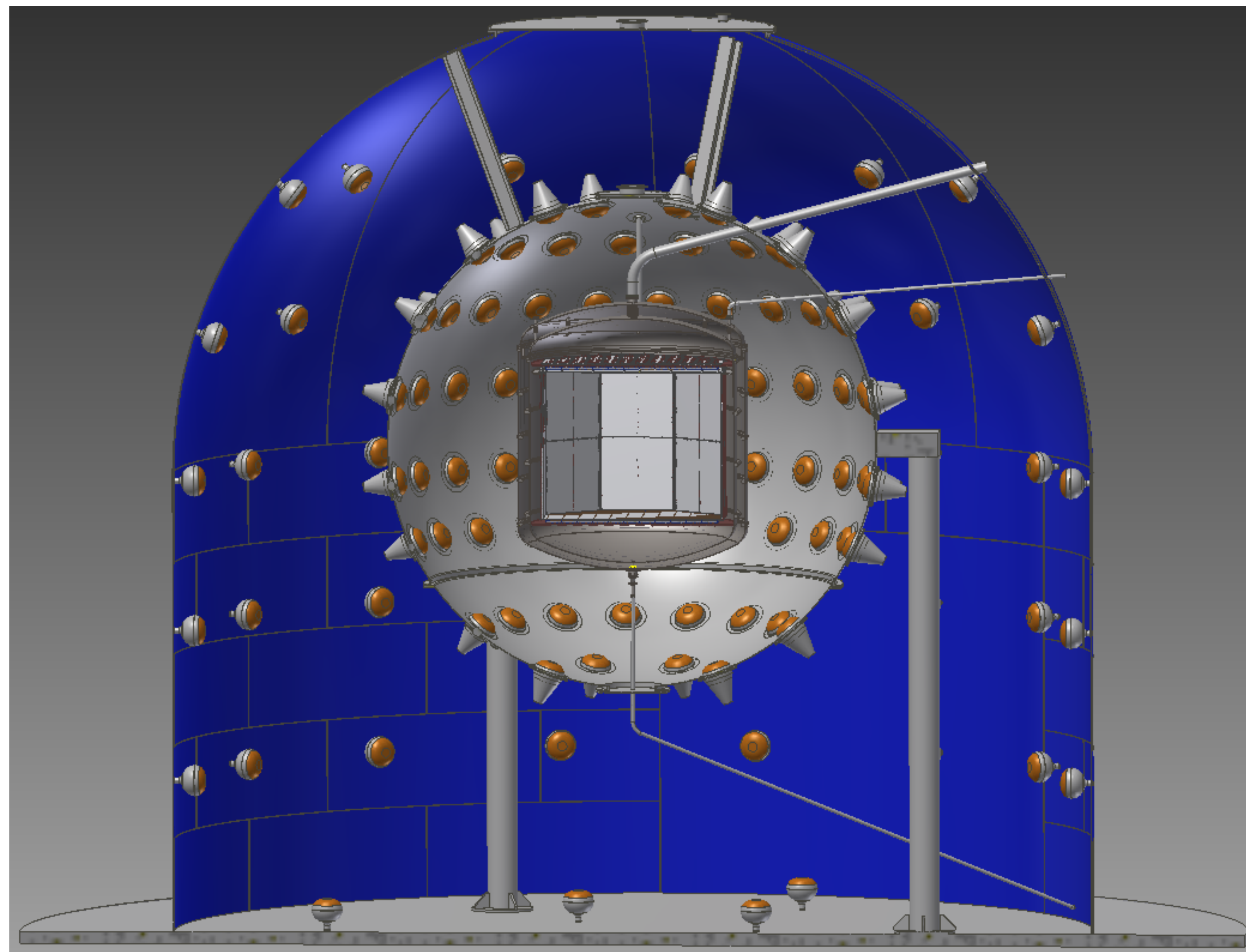
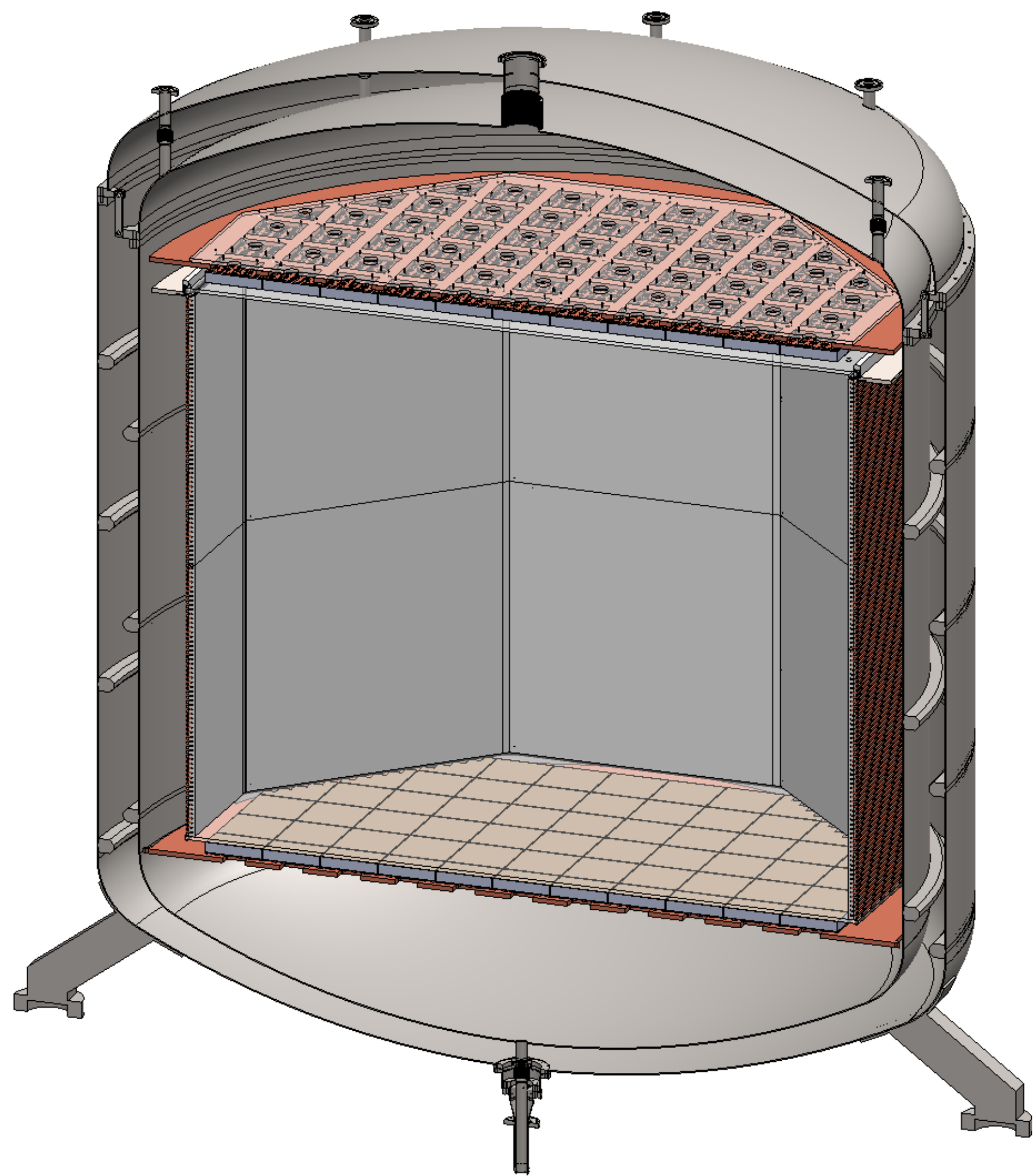
# SiPM Status

- Photon Detection Efficiency (PDE): 45% requirement met and surpassed
- Dark Count Rate (DCR): 0.1 Hz/mm<sup>2</sup> requirement met and surpassed
- Challenge in tiling due to 50 pF/mm<sup>2</sup> capacity. Signal-to-Noise Ratio (SNR) rapidly decreases with increasing surface. The steps:
  - 2×2 cm<sup>2</sup> tile: fully demonstrated
  - 3.5×3.5 cm<sup>2</sup> tile: device under test since 20 days, SPE peak well visible, full characterization and optimization under way
  - 5×5 cm<sup>2</sup> tile: in 2017, some R&D necessary to improve SNR due to the increase in capacity
- We fully demonstrated (on small volumes) SiPM-based cryogenic photosensors replacing cryogenic PMTs. The SiPM-based solution outperforms PMTs

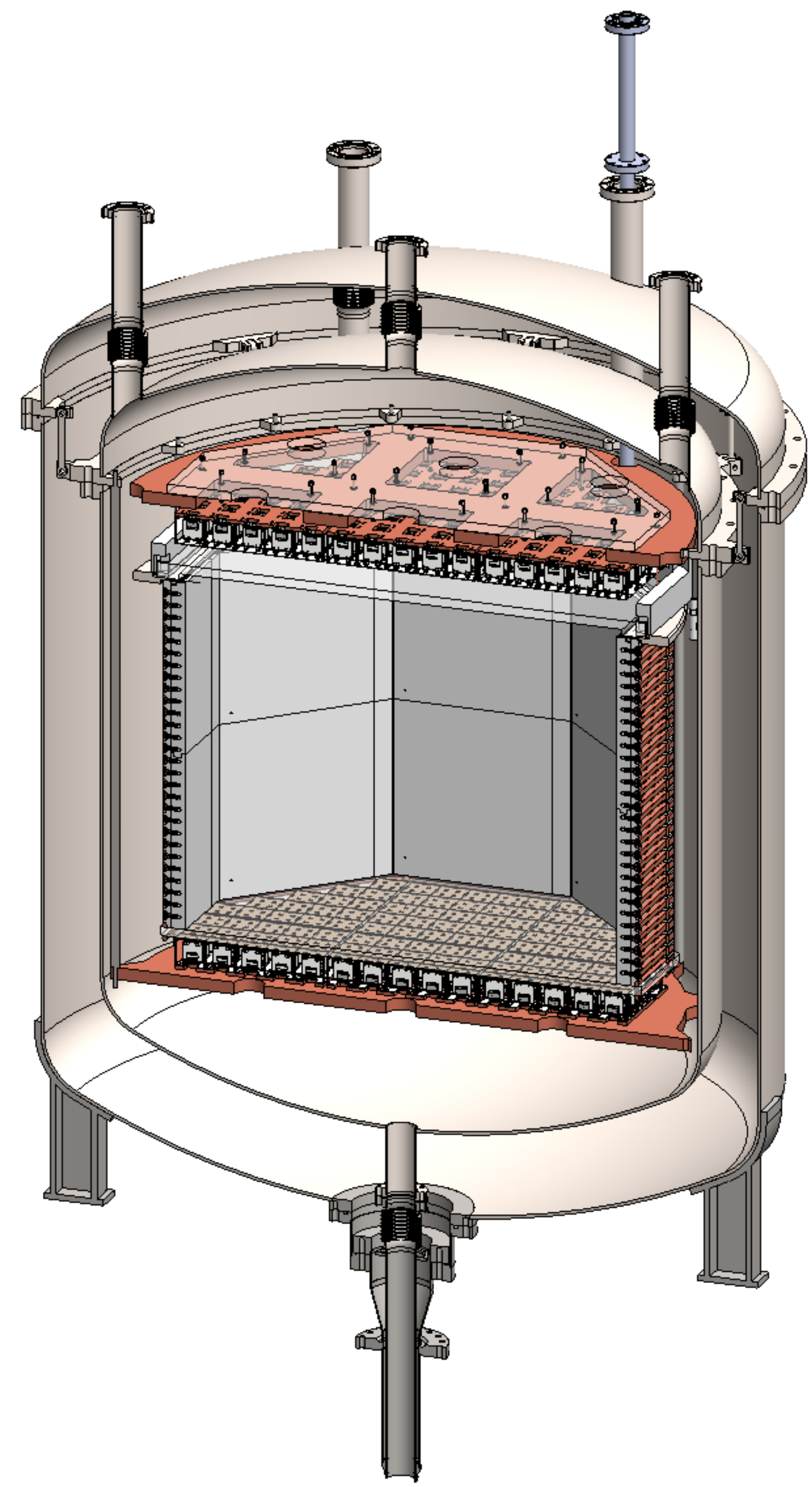
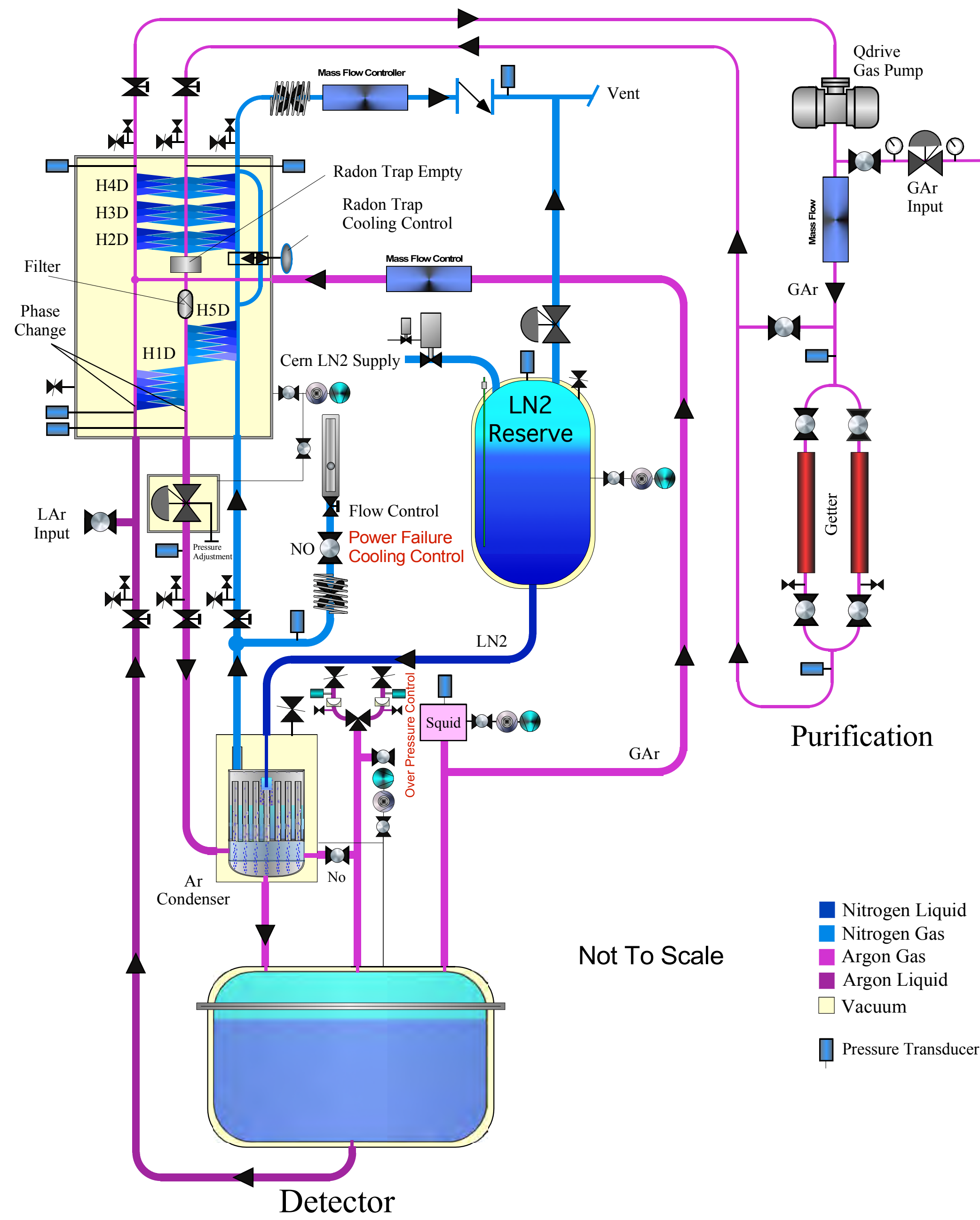












The End

Closed Session Slide

# Baseline: Clarification

- Argon target: use of underground argon from Urania chemically purified with Seruci-I to fully remove Kr and to obtain detector grade argon. Note Seruci-I capacity insufficient for isotopic depletion of 30-tonnes target. Seruci-II use for active isotopic depletion to be considered in alternate scenario only if funding for construction granted in time (or later, in case of discovery of dark matter and in need of proving persistence of signal with lower  $^{39}\text{Ar}$  rate)
- Scintillator handling: reliance on development of storage and processing plants independent from Borexino, designed to fit within area in Hall C preliminarily allotted by LNGS. Reuse of Borexino facilities to be considered in an alternate scenario in case of absence of experimental conflicts