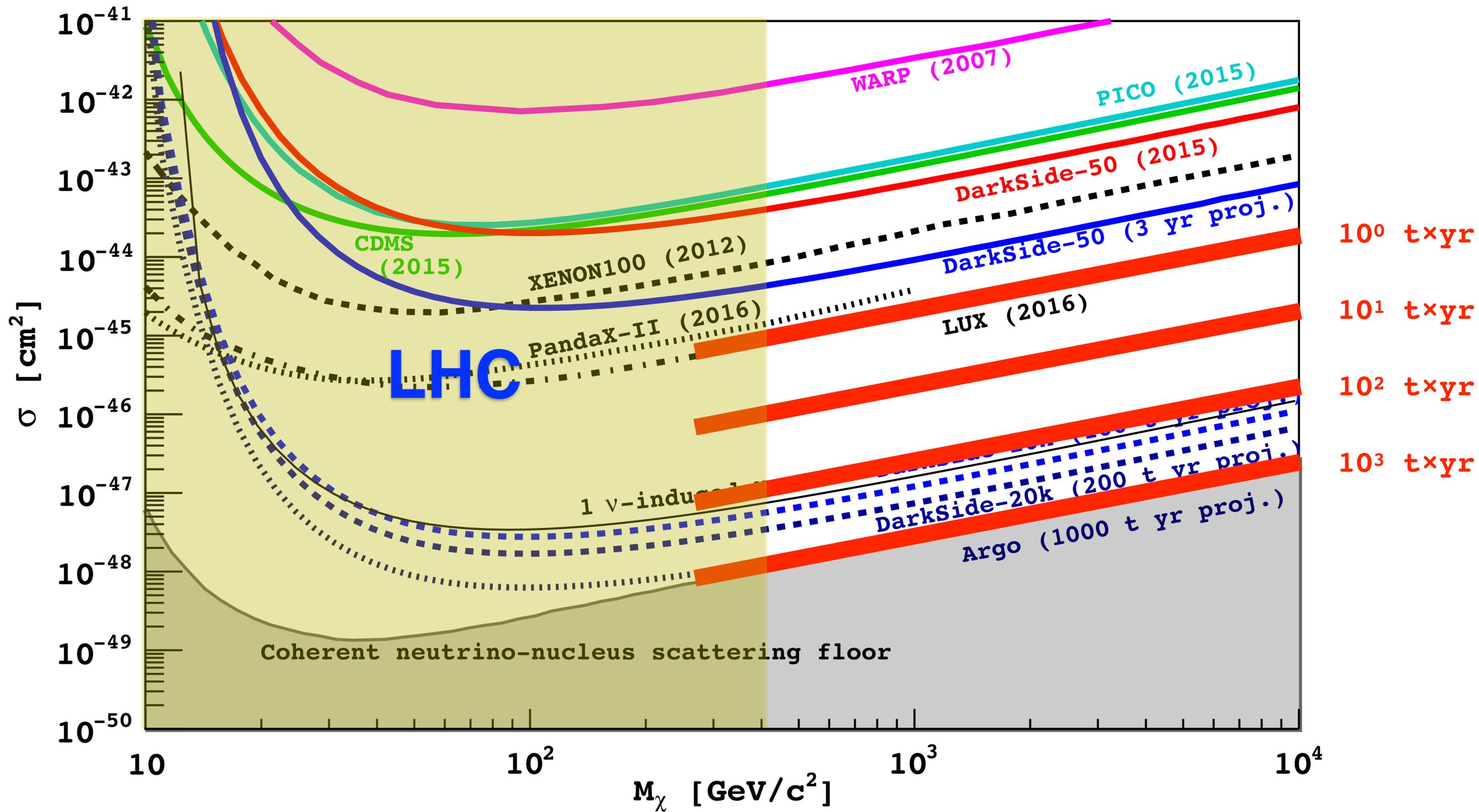
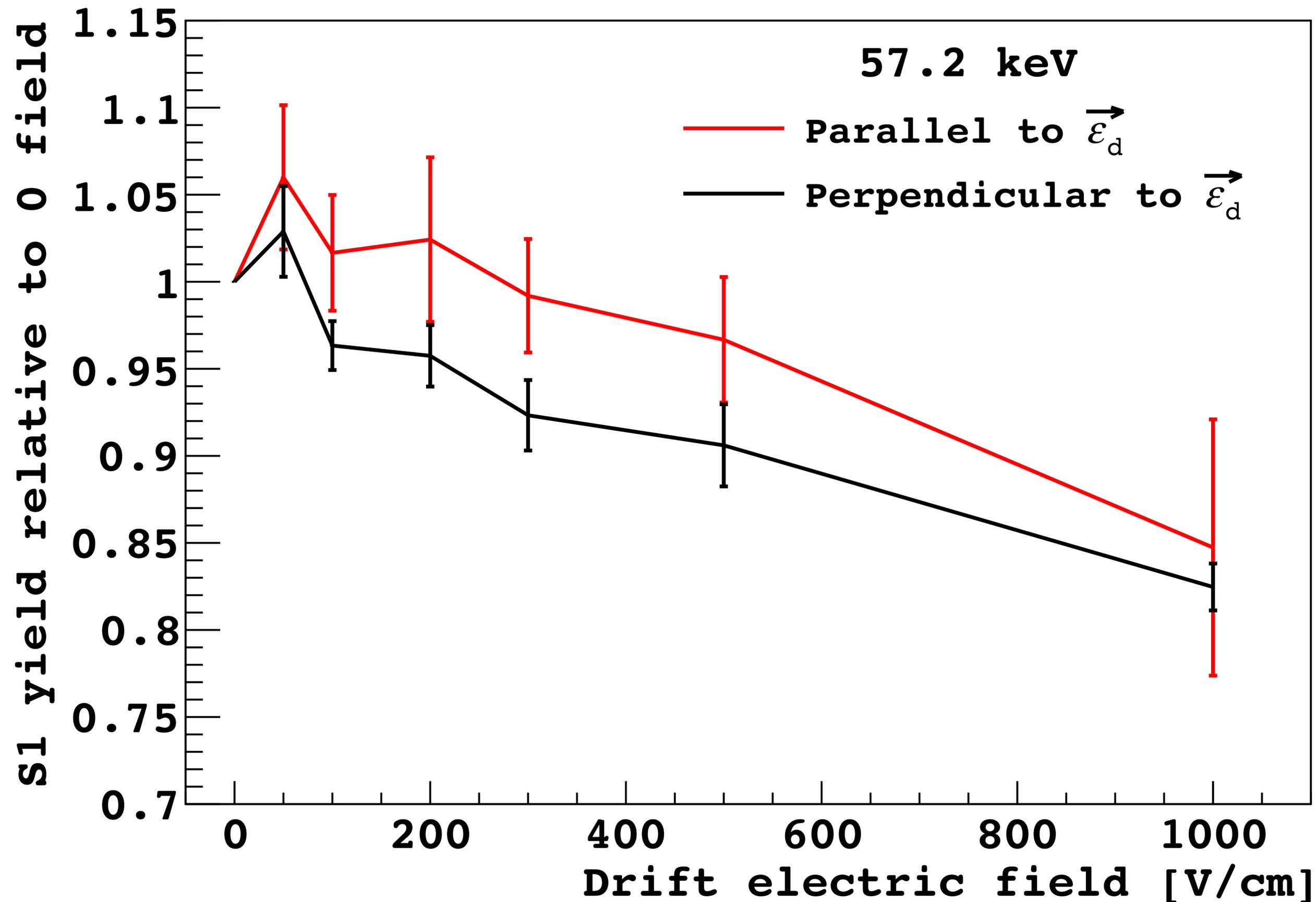
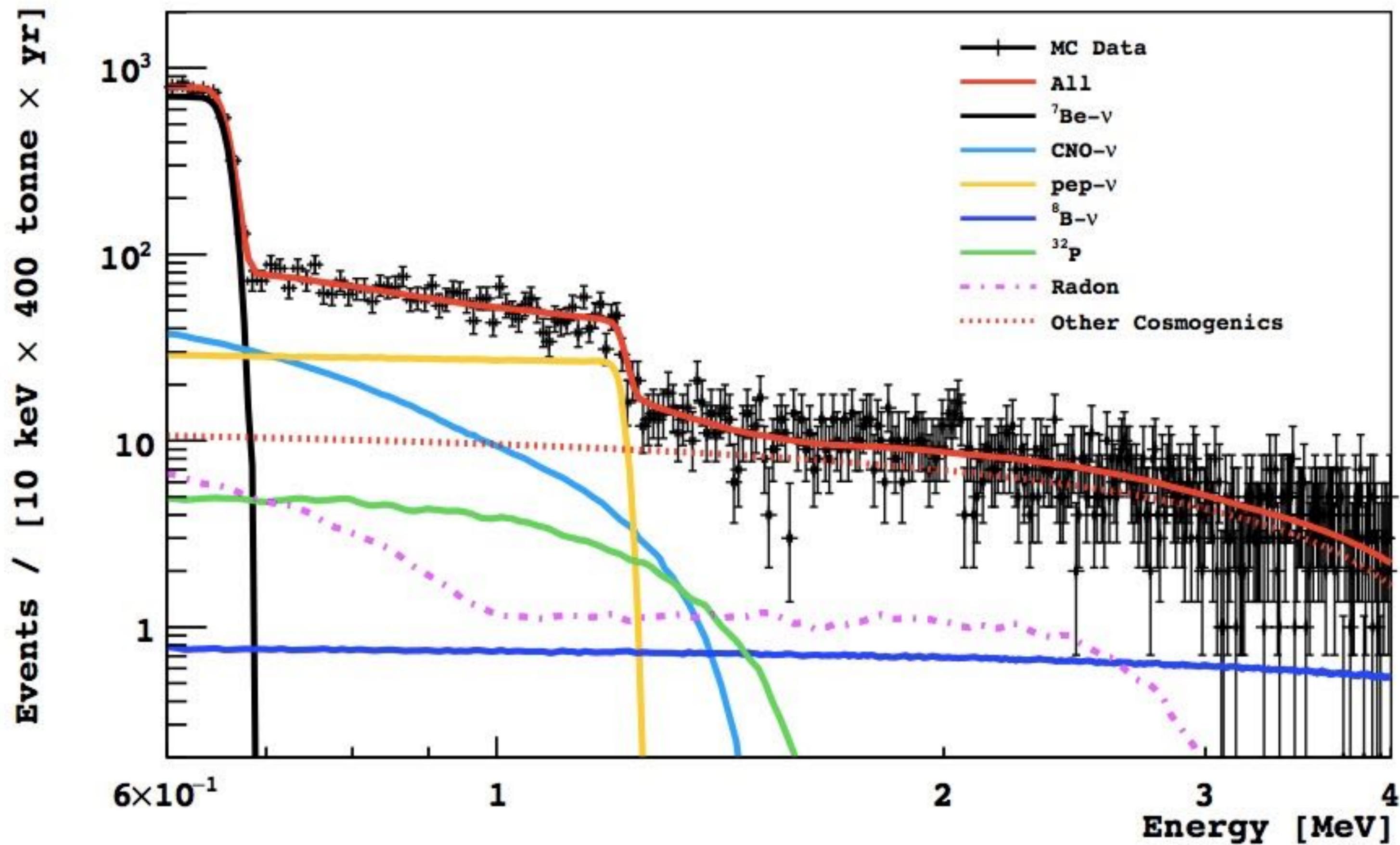


# DarkSide-20k, the Global Argon Program for Dark Matter Searches, and Its Broader Impact

Cristiano Galbiati  
Princeton University  
Kraków, Poland  
Polish Particle Astrophysics Meeting  
September 21, 2017



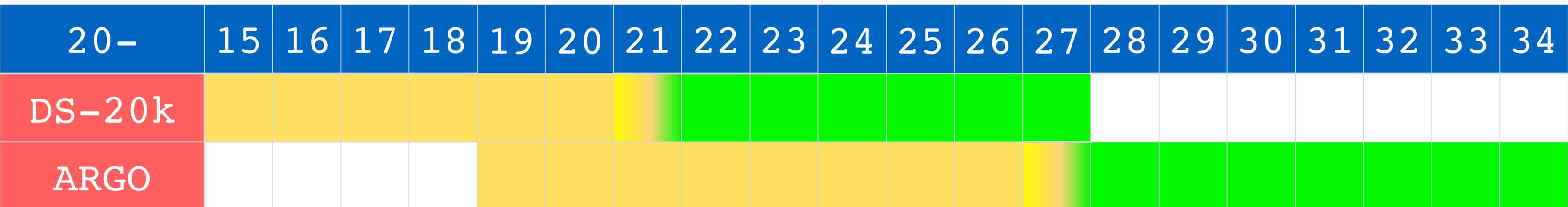




# DarkSide-20k

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

100 tonne year search for dark matter free of instrumental background



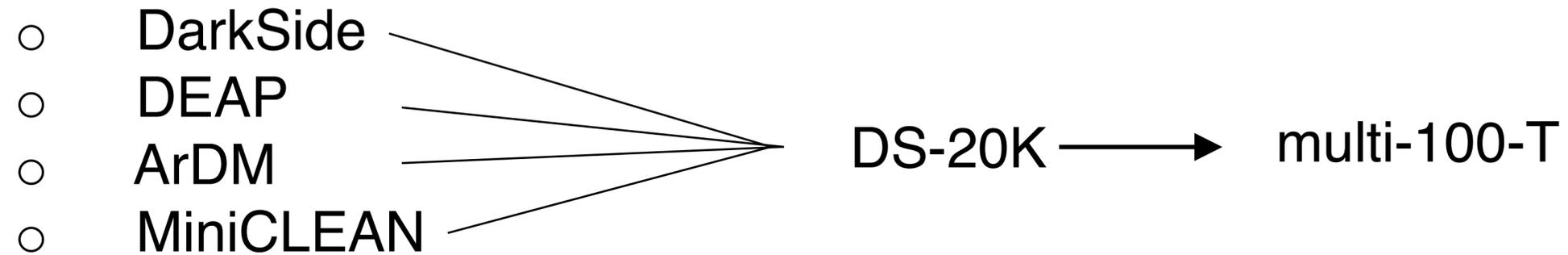
# Argo [ i.e. Exp. To Be Named Later]

300-tonnes depleted argon detector  
start of operations within 2027

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

# (New) Argon Collaboration

Researchers from



planning to collaborate on future program:

- Completion of current science and R&D programs by each collaboration (DS-50, DEAP-3600, MiniCLEAN, ArDM)
- Joint collaboration on DS-20K at LNGS, including Low Radioactivity Argon (operation starting 2021) and SiPM photodetectors
- Joint collaboration on future multi-hundred-tonne LAr detector, site TBD (mid-2020's)

Towards global argon collaboration:

DarkSide, DEAP, miniCLEAN, ArDM > 350 researchers

# Collaboration

- 68 institutes
- 350 researchers
- 12 nations:

Brasil, Canada, China, France, Greece, Italy, Poland, Romania, Spain, Switzerland, UK, USA



# Letter of Intent

September 8, 2017

*Rev B*

Scientists at LNGS, LSC, and SNOLAB are joining in an international effort to mount a phased argon dark matter program with the goal of being sensitive to the neutrino floor. This effort will include a broad collaboration of scientists and will represent the global community for dark matter searches with argon. This letter is an update of a previous communication dating June 2017, which detailed the first conception of the program; this letter was expanded to capture the intent of all institutions and scientists participating in the program.

In this document, the undersigned representatives of groups working on argon dark matter searches, including Brazilian, Canadian, Chinese, French, German, Greek, Italian, Mexican, Polish, Romanian, Russian, Spanish, Swiss, US, and UK groups among others, memorialize their intent to form a Global Argon Dark Matter Collaboration to carry out a program for direct dark matter searches, consisting of two main elements.

The first element of the program is the DarkSide-20k experiment at LNGS, whose science goal is to perform a dark matter search with an exposure of 100 tonne·yr of low-radioactivity underground argon (the low intrinsic background, free from any background other than that induced by atmospheric neutrinos, may also permit a 200 tonne·yr exposure for



**Deep underground laboratory support for global collaboration towards discovery of dark matter utilising liquid argon detectors.**

To whom it may concern;

As hosts of the existing operational liquid argon direct dark matter detectors, and as proponents and supporters of the Underground-GRI initiative, the LNGS, SNOLAB and LSC deep underground research facilities are pleased to recognize the collaborative developments within the global liquid argon dark matter community. The DarkSide project at LNGS, the DEAP project at SNOLAB and the ArDM project at LSC are all developing new technologies and capabilities to search for WIMP dark matter, and are beginning to coalesce into one collaboration to develop future, larger generations of liquid argon direct dark matter detectors. We encourage and support the development of this global community, with a focus on the development of DarkSide-20k at LNGS in the first instance, and a larger detector at a location to be determined from scientific requirements, in the future. Using available assay and research infrastructure,



CANADA FOUNDATION  
FOR INNOVATION

FONDATION CANADIENNE  
POUR L'INNOVATION

August 30, 2017

Dr. Arthur McDonald  
Department of Physics, Engineering Physics and Astronomy  
64 Bader Lane  
Queen's University  
Kingston, ON K7L 3N6

**Re: DEAP 3600**

Dear Dr. McDonald (Art),

The Canada Foundation for Innovation (CFI) has supported the DEAP project and the operations at SNOLAB through its various funding mechanisms and national research infrastructure competitions over the past several years. More recently, a CFI award provided the DEAP project with funding to acquire a significant additional quantity of liquid Argon (LAr) as it seeks to scale up its detector (DEAP 3600). As DEAP pursues its science program, discussions between international proponents and supporters of large-scale future global collaborations for dark matter detection are progressing.

As part of these discussions, the possibility to provide an extension of the sensitivity for dark matter detection beyond the present sensitivity of the DEAP 3600 project is being explored. These plans include the provision of LAr currently being produced for the DEAP project, and its

**CERN**

CH-1211 Geneva 23  
Switzerland



**Technology  
Department**

*CERN TE/Group*

**CRG**

*EDMS Document No.*

**1837551**

Date: 25 AUGUST 2017

*Management Report*

# **Assembly and Test Activities for the Cryogenic System of DarkSide-20k at CERN**

**A review of the CERN resources**

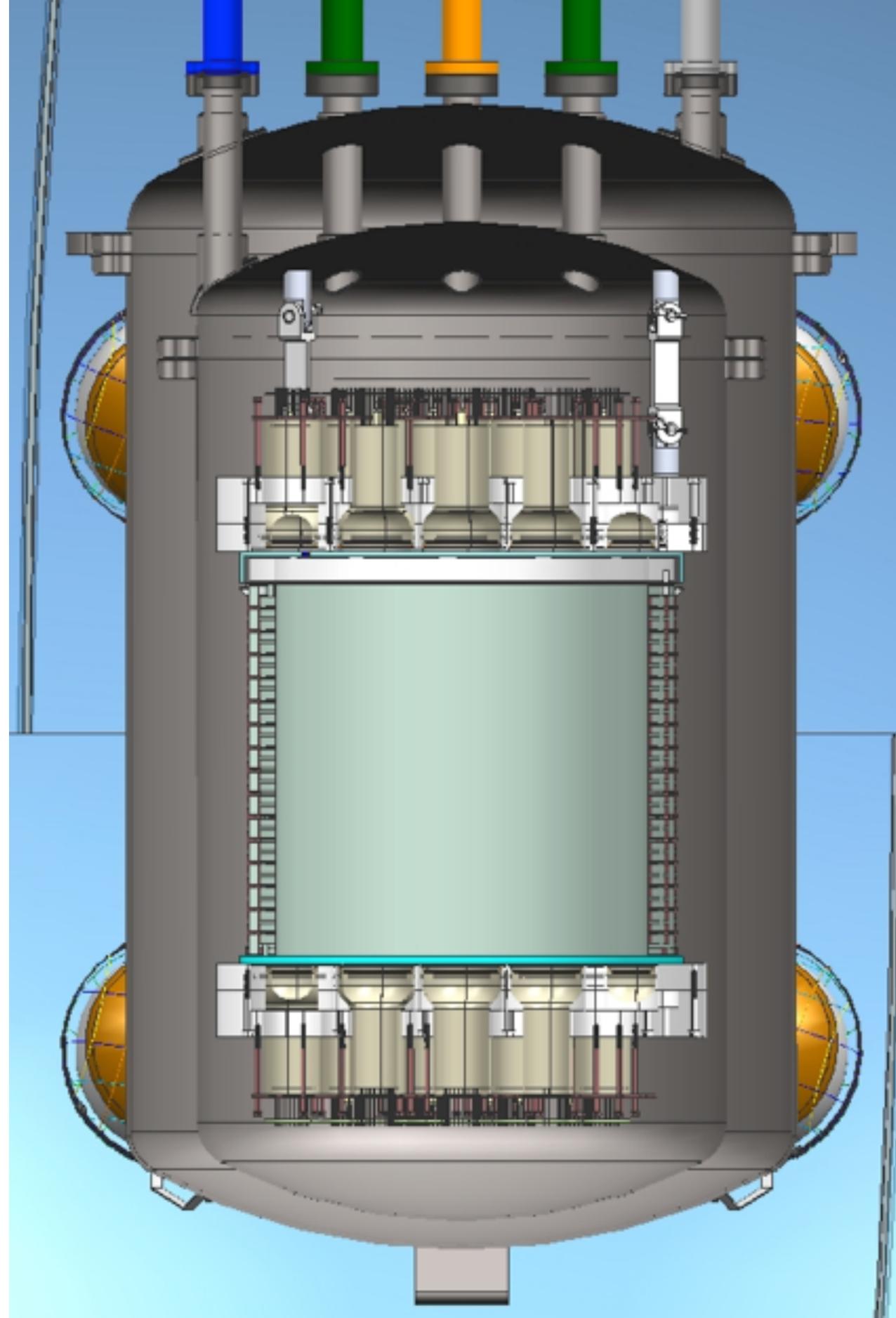
# Poland

- Jagiellonian University
  - Marcin Wojcik, Grzegorz Zuzel, Krzysztof Pelczar

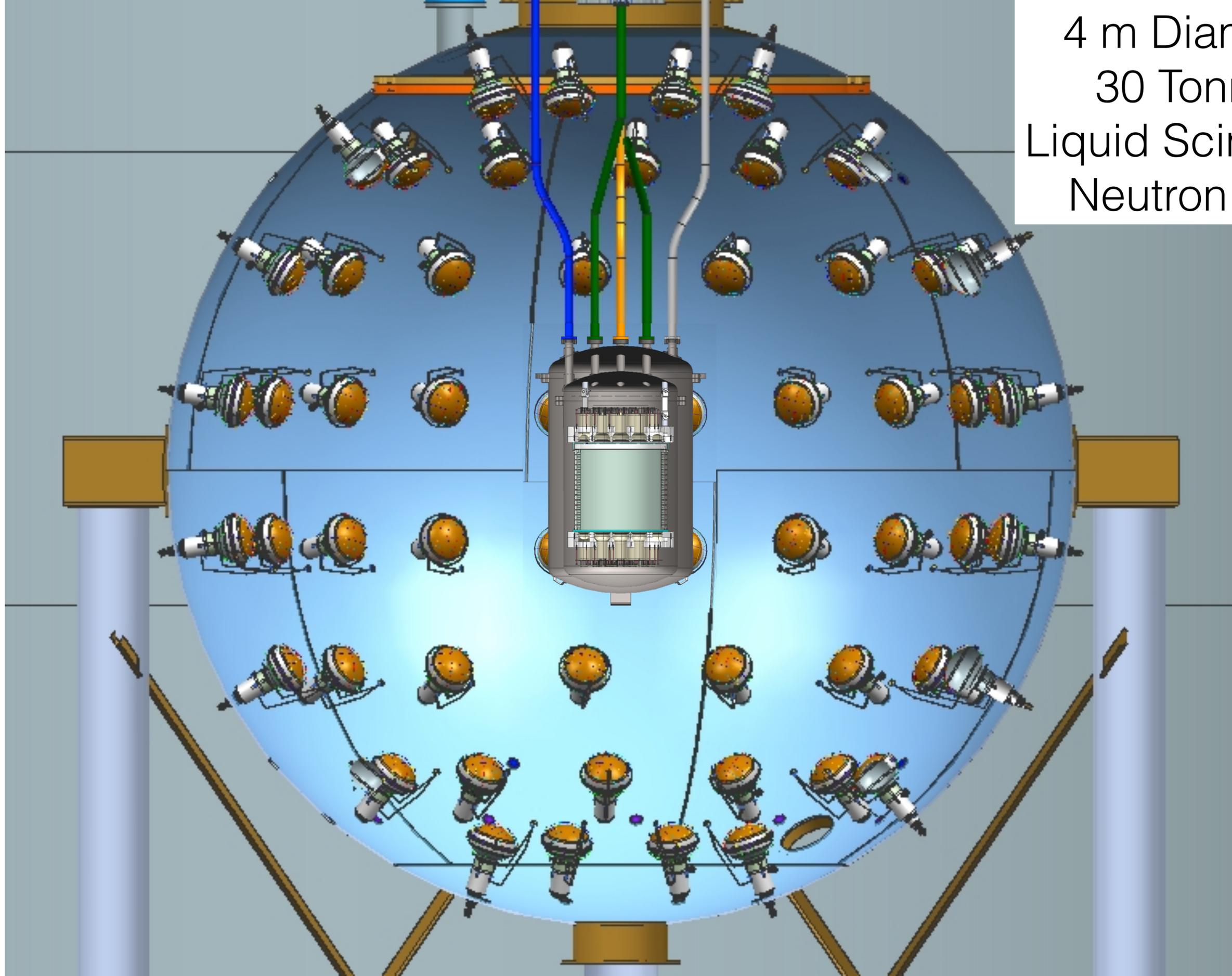
# An Ambitious Discovery Program

- 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

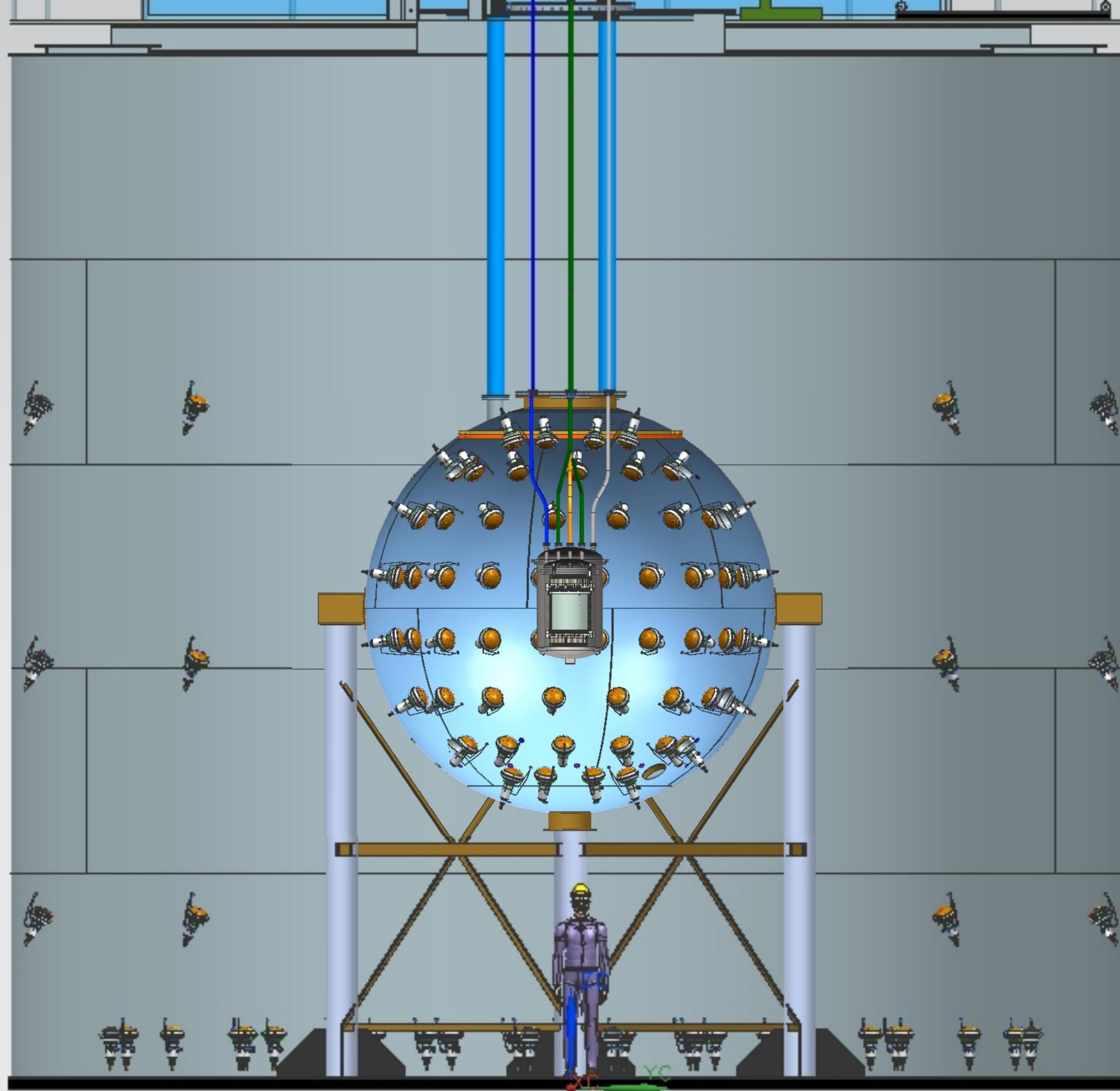
Liquid Argon TPC  
153 kg  $^{39}\text{Ar}$ -Depleted  
Underground Argon  
Target



4 m Diameter  
30 Tonnes  
Liquid Scintillator  
Neutron Veto



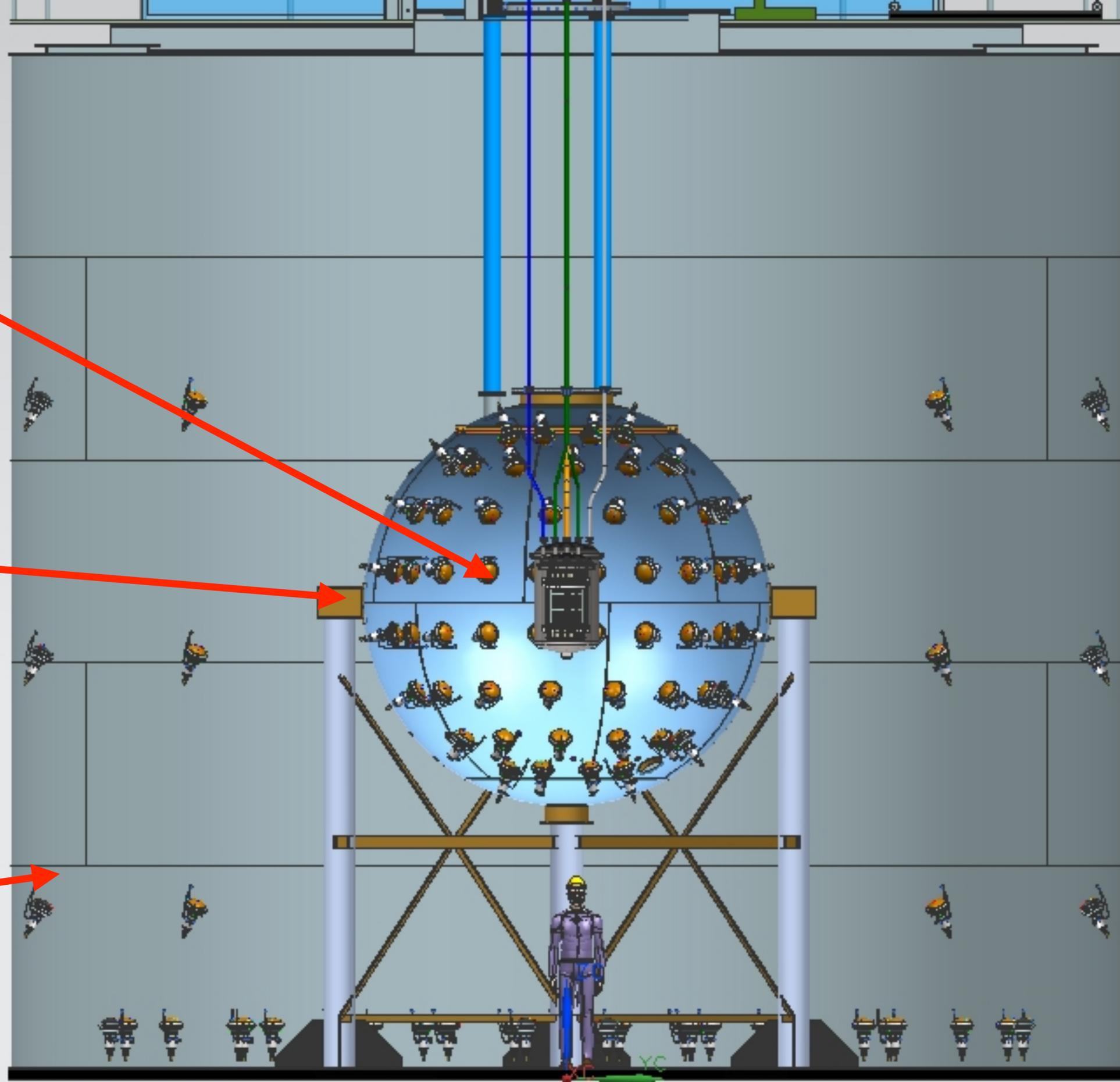
10 m Height  
11 m Diameter  
1,000 Tonnes  
Water Cherenkov  
Muon Veto



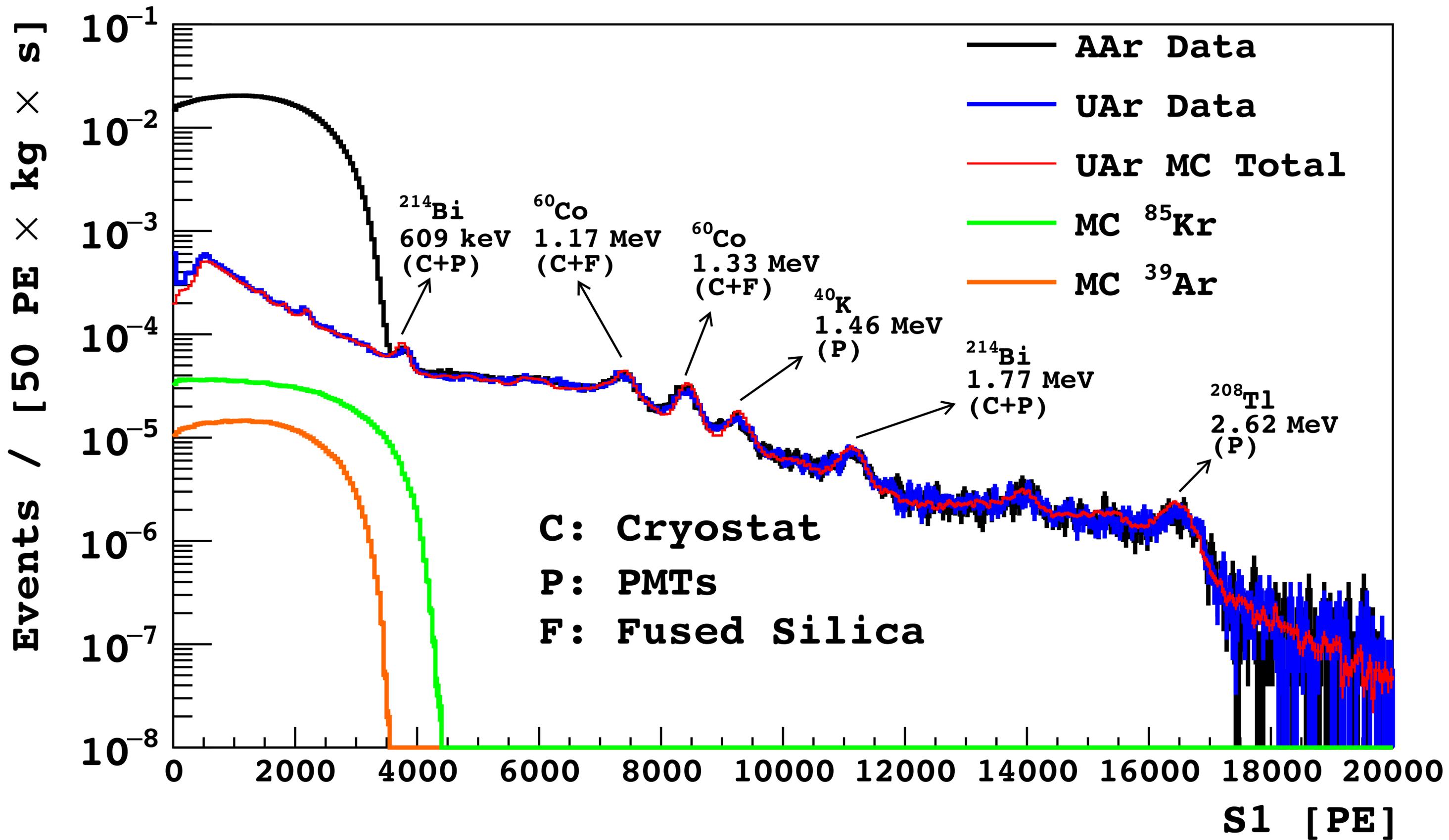
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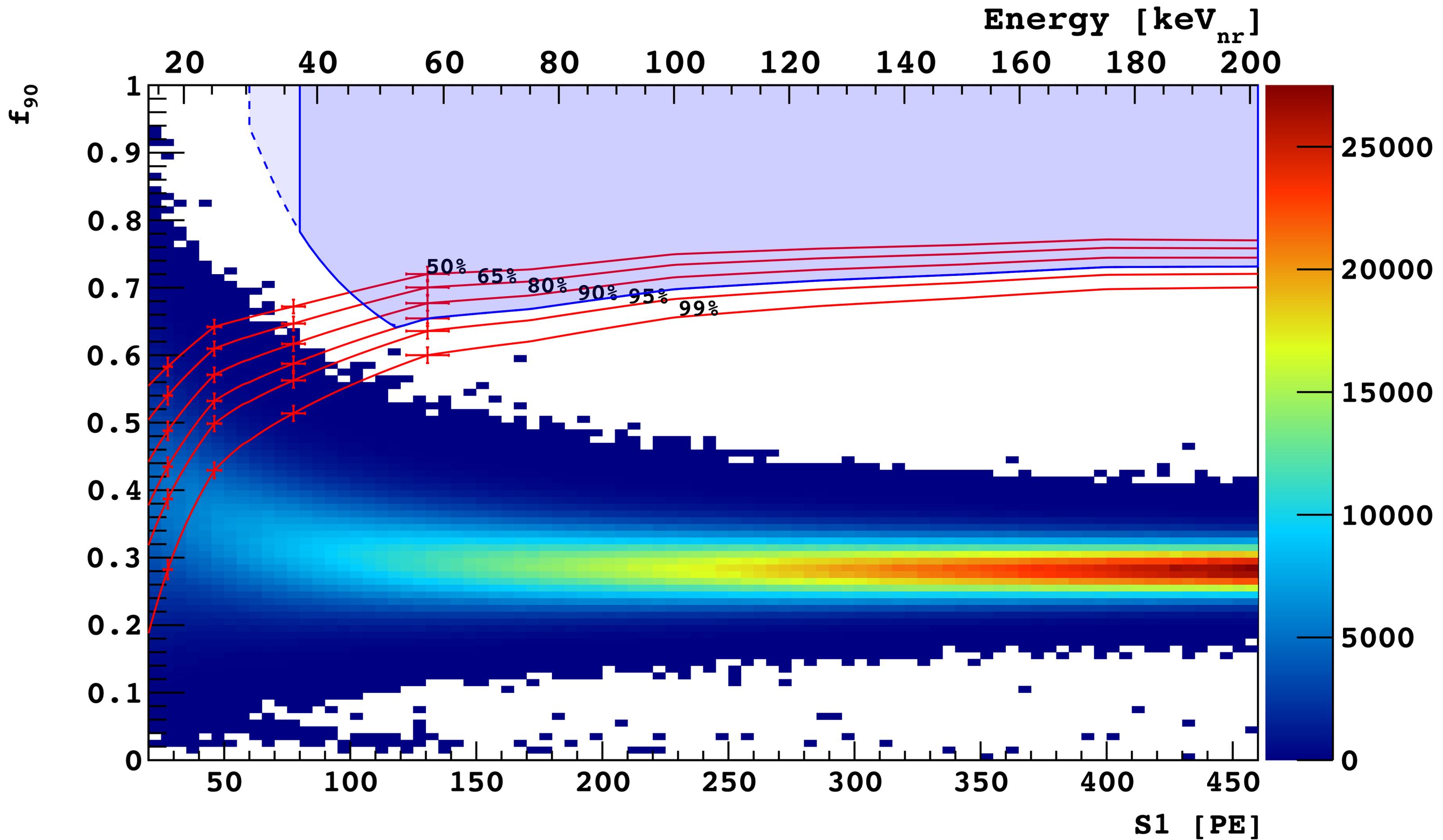
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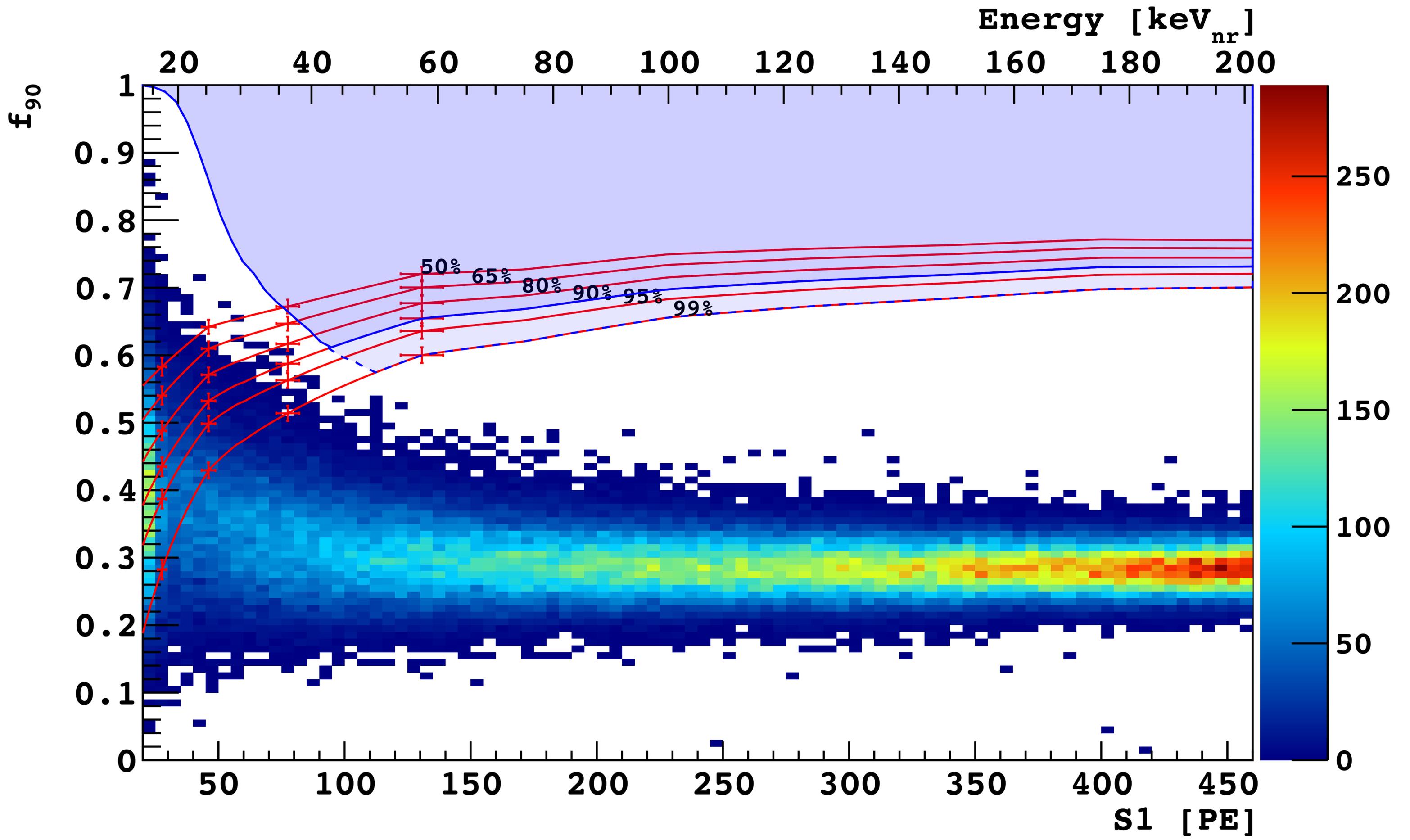


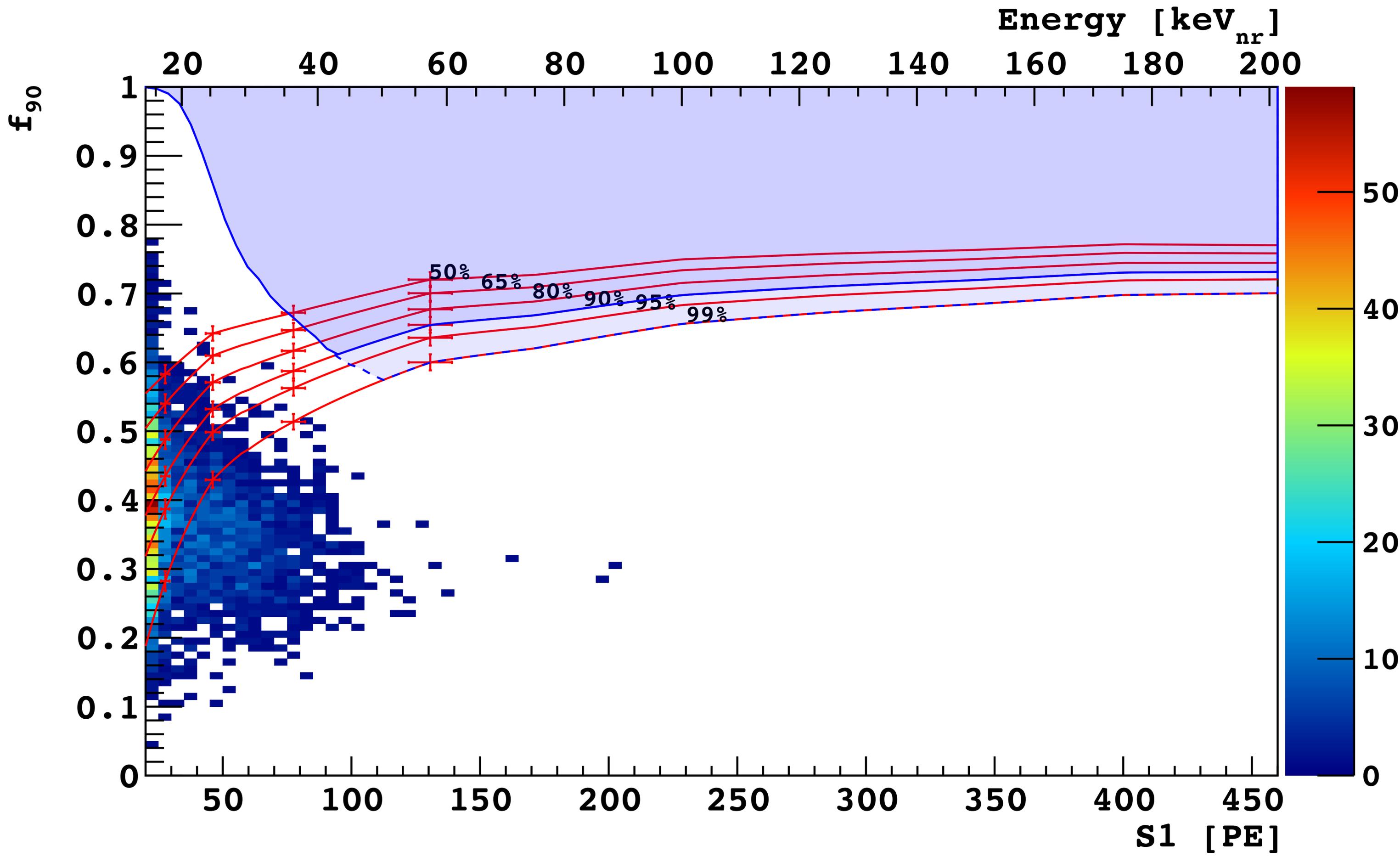




1,422 kg d AAr - PLB 743, 456 (2015)







“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 ( $^{39}\text{Ar}$ )

## 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  $1 \div 1.6 \times 10^7$

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)

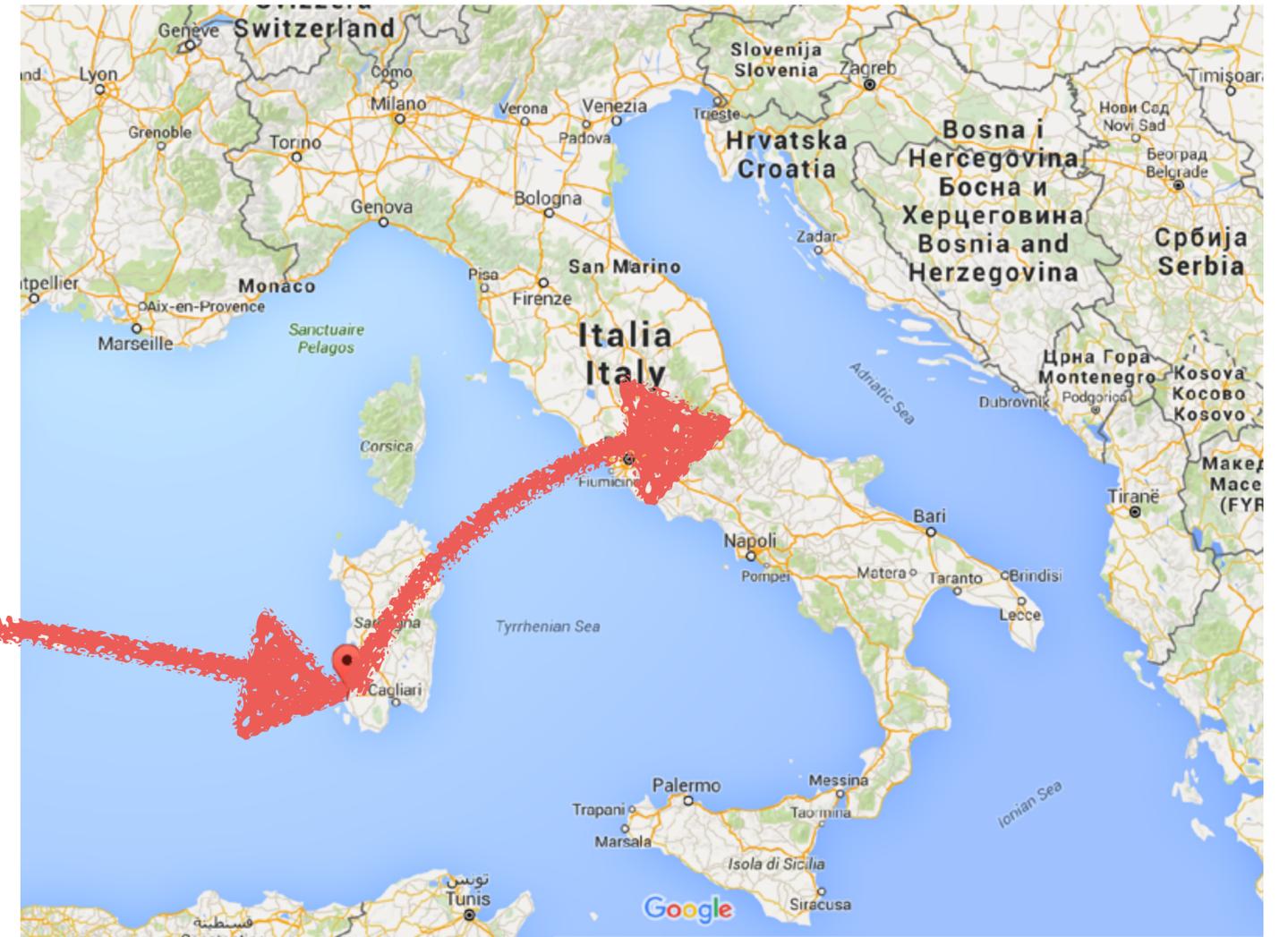
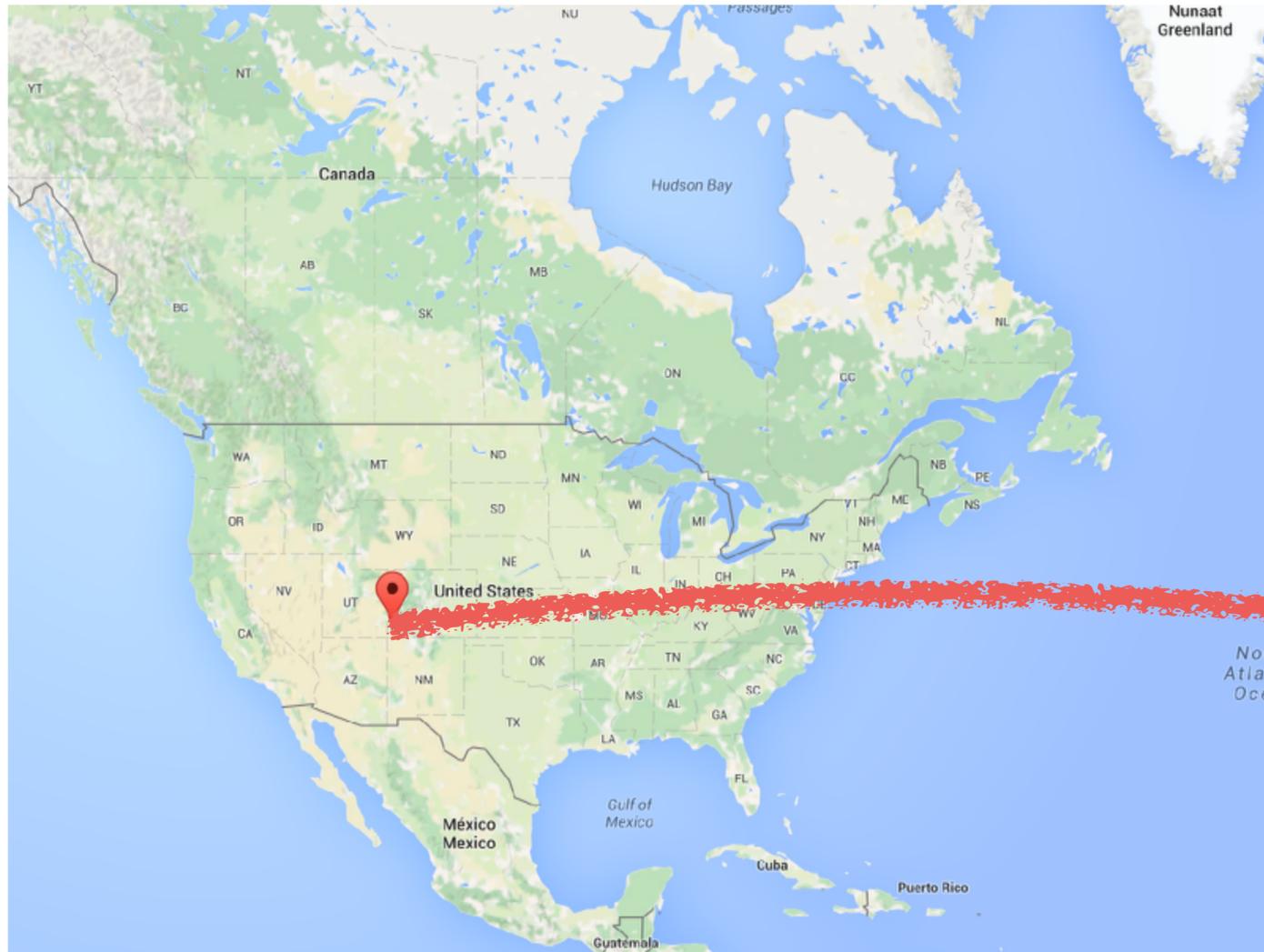
additional active  
isotopic depletion  
higher light yield

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

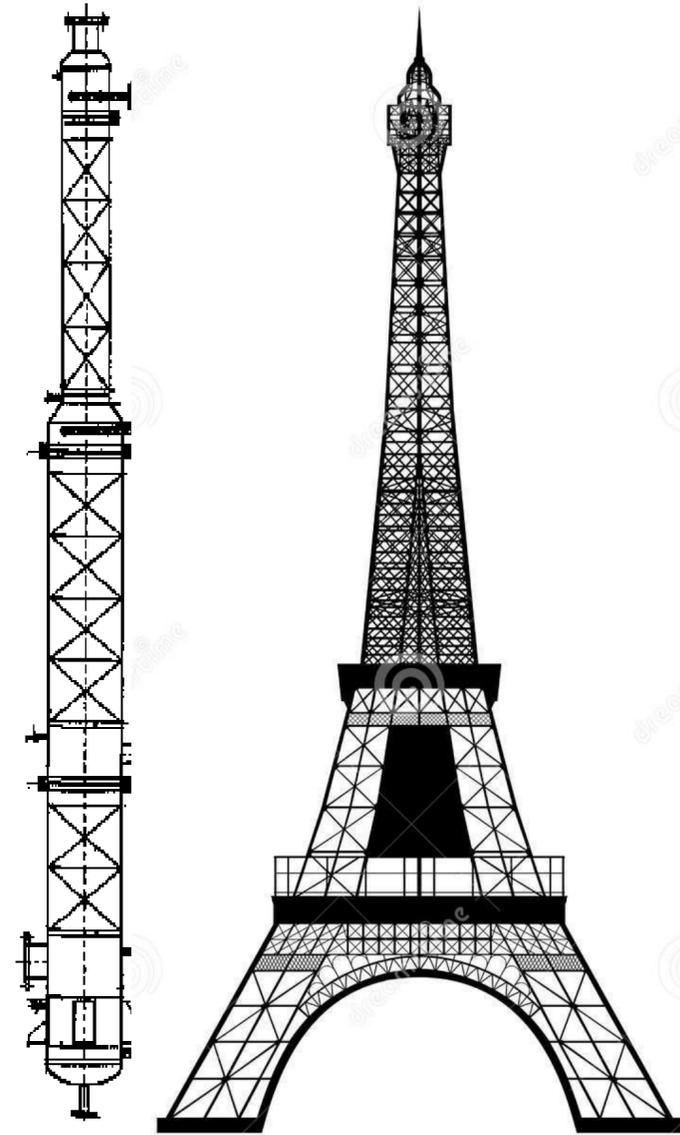
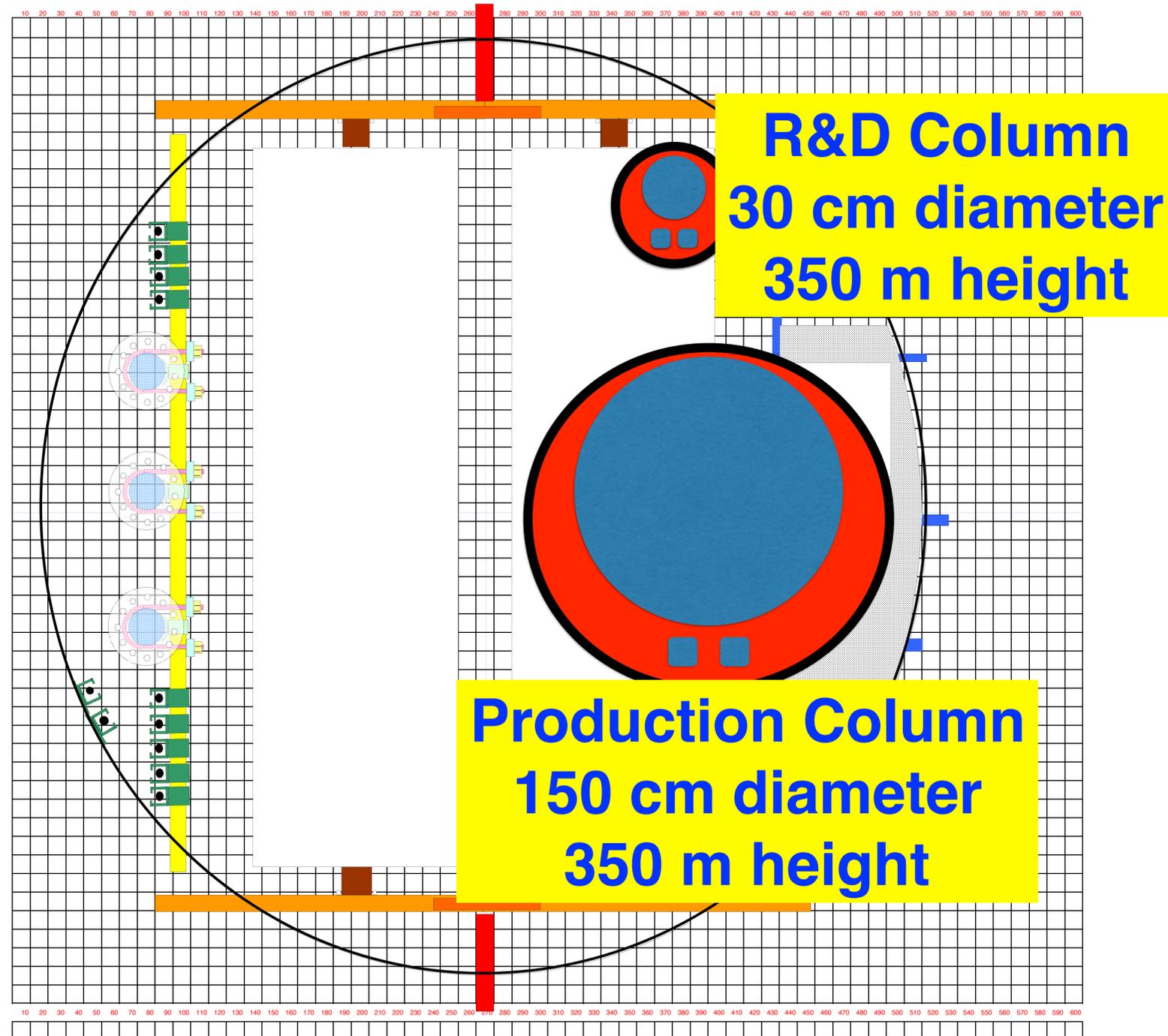
Based on what we know today, can a depleted argon experiment be free of any instrumental (other than  $\nu$ -induced recoils) background at the scale of 1000 tonnes $\times$ yr?

Yes.

# Urania to Aria to LNGs

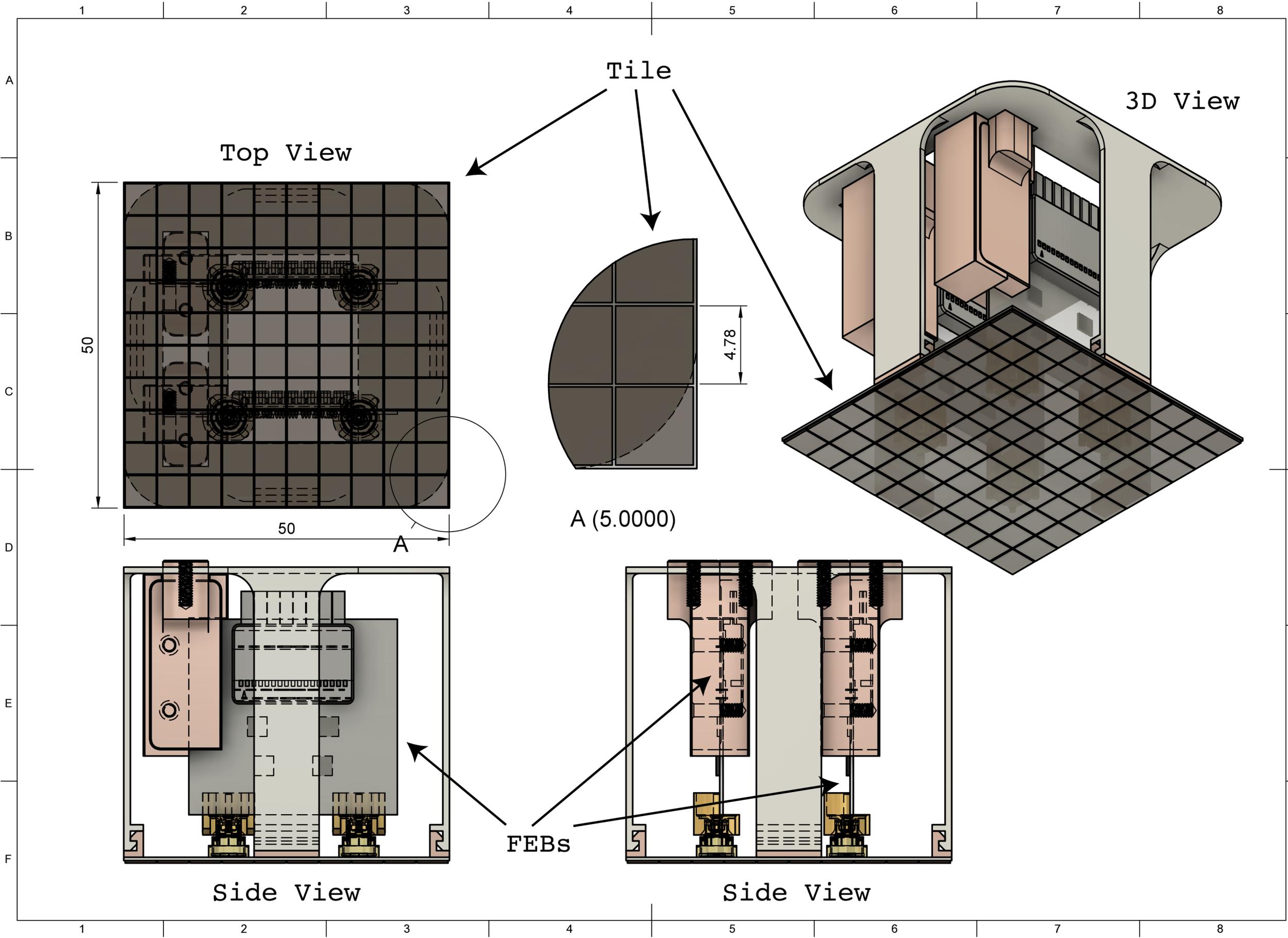


# Aria



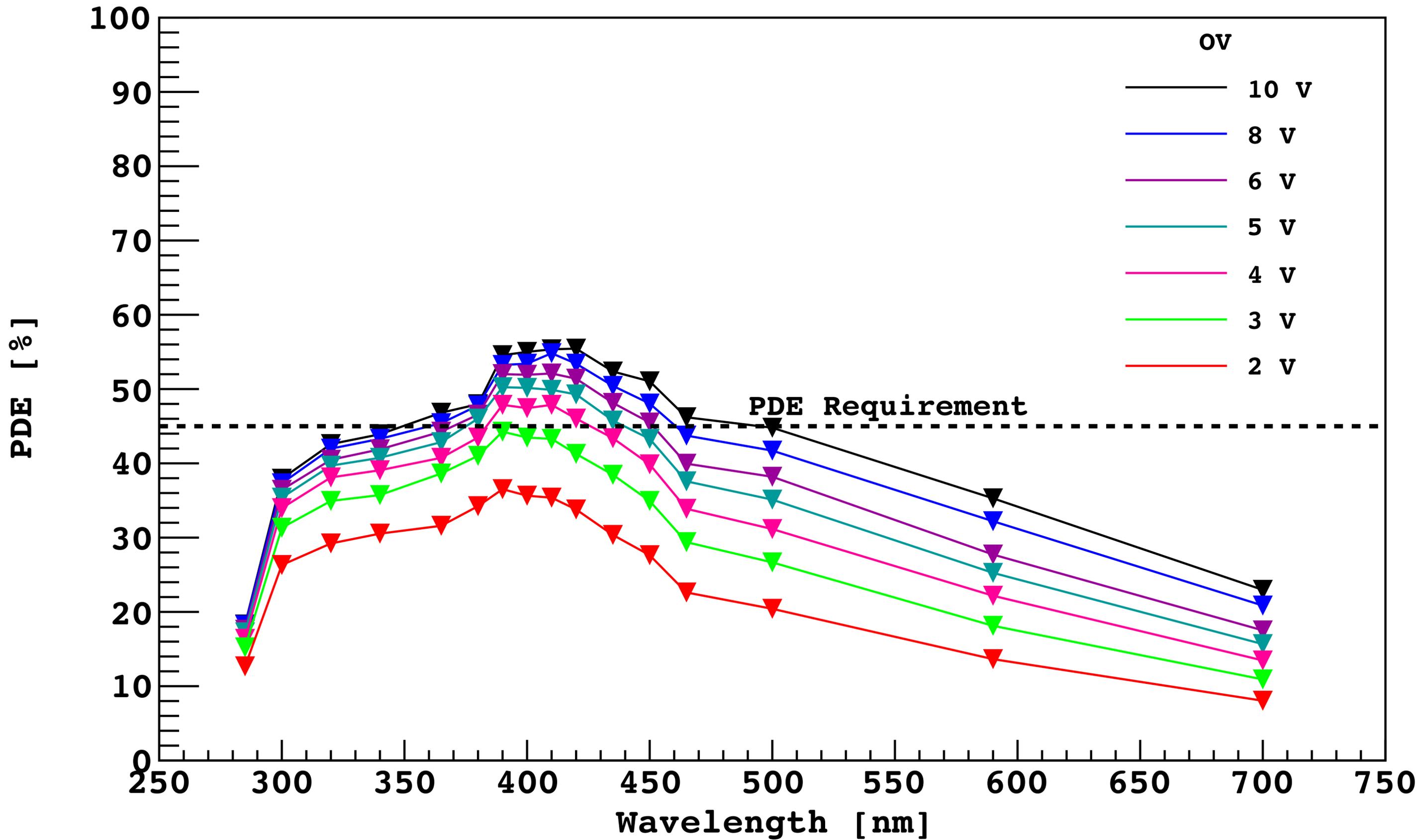


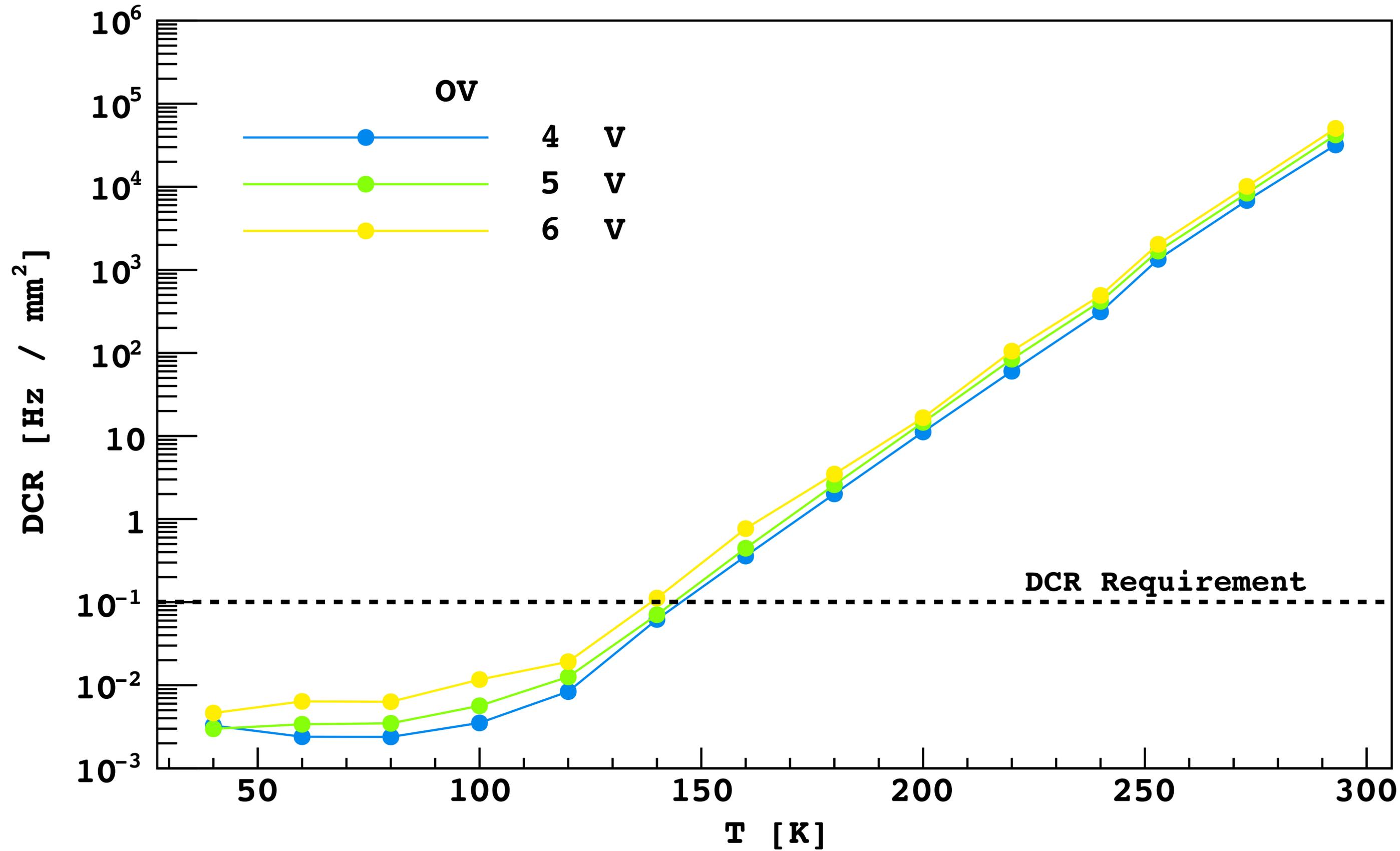


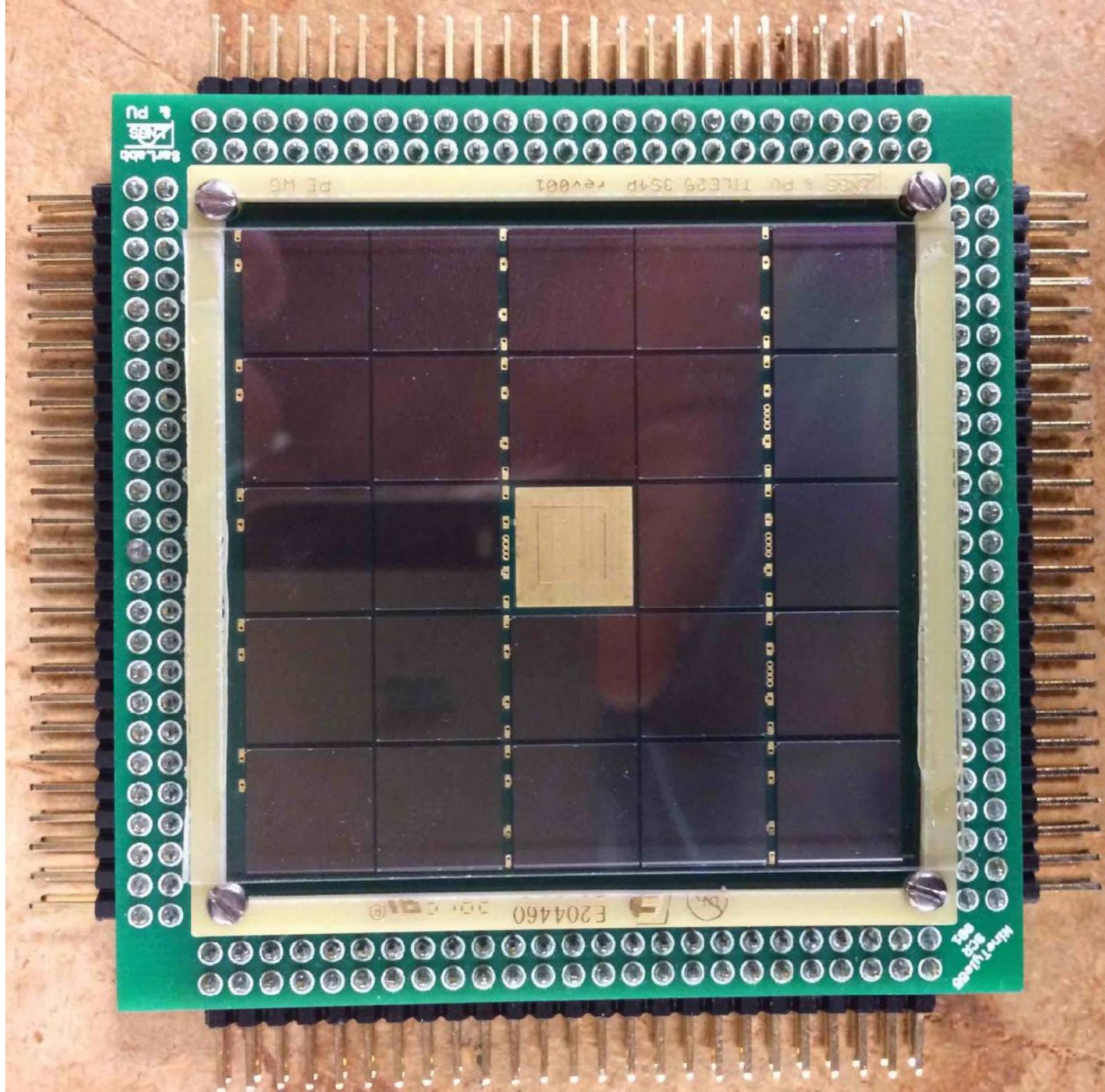


# SiPM Status

- 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: on the way, success projected on the basis of available data
  - 5×5 cm<sup>2</sup> tile: in 2017, some R&D necessary to improve SNR due to the increase in capacity





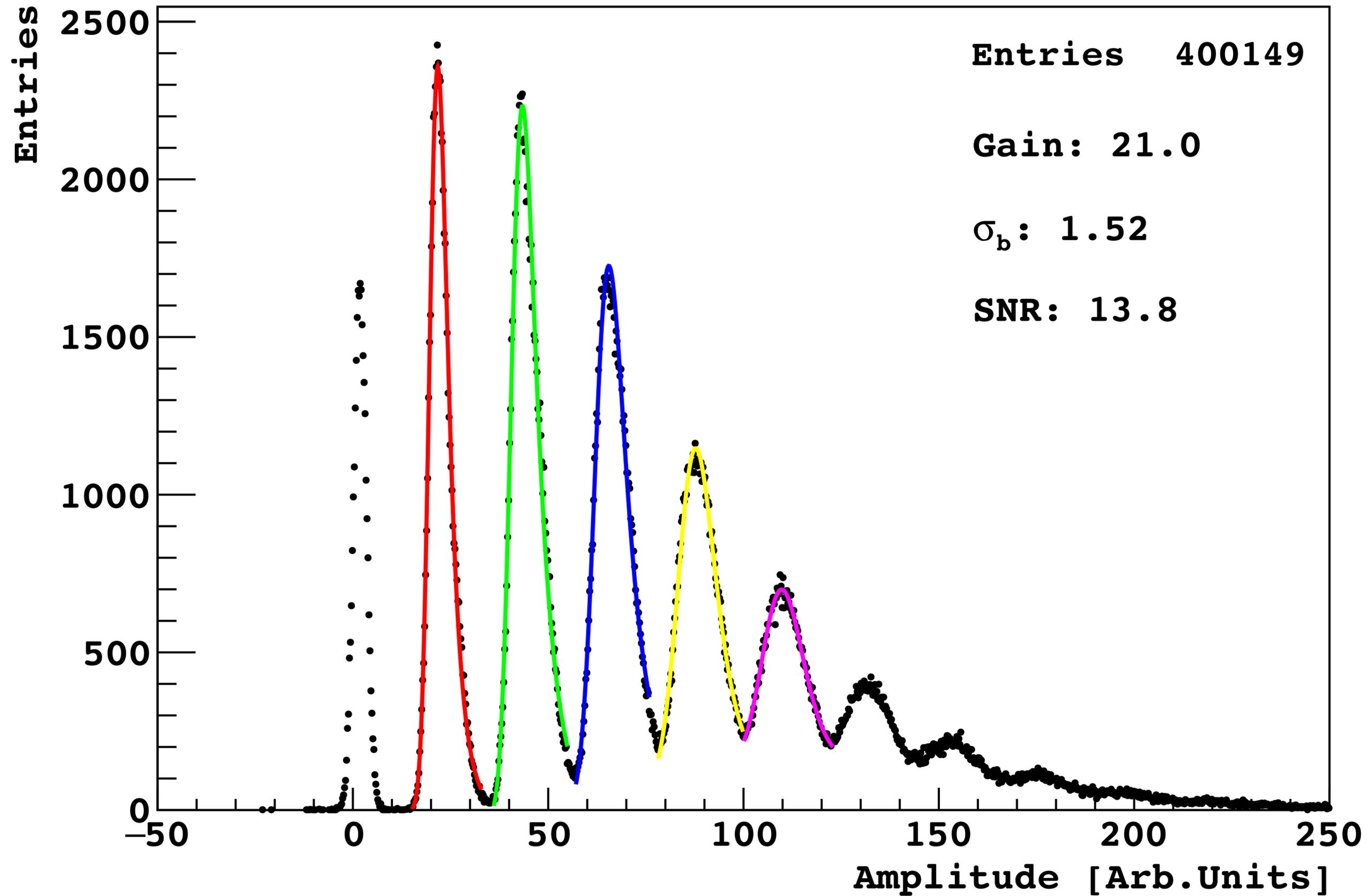


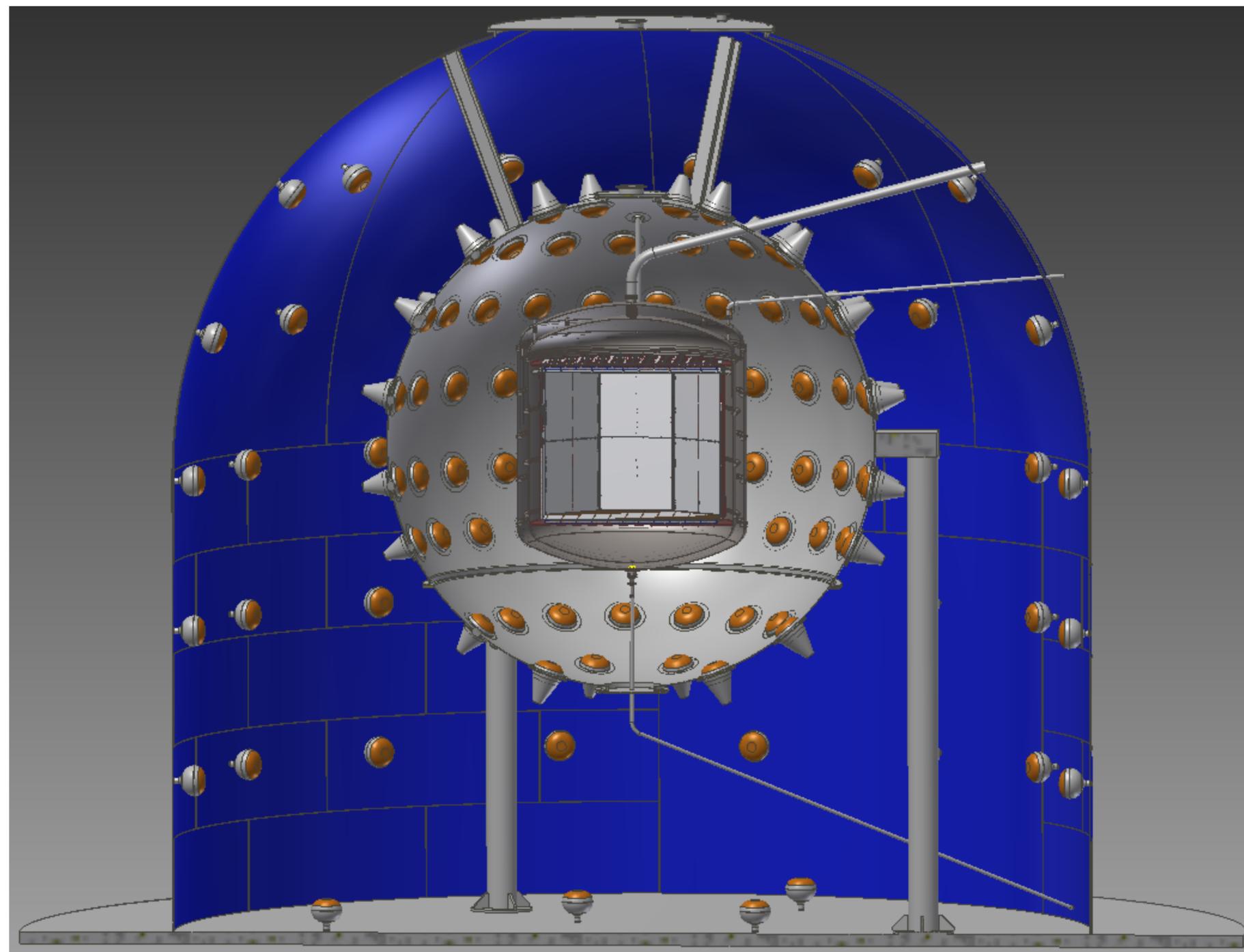
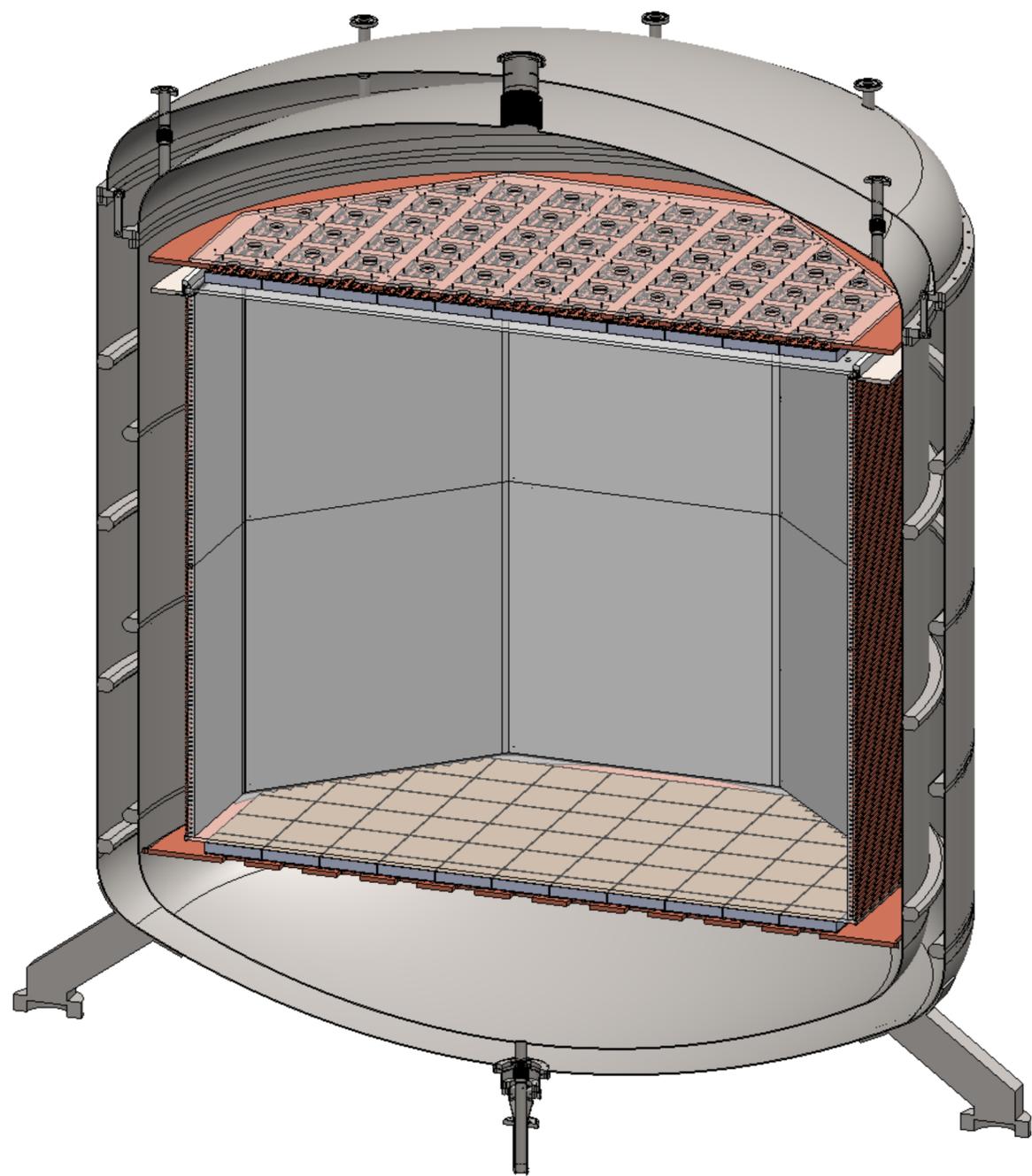
SoftLab  
Labs

PE MG ZMS & PU TILE26 354P rev001

E204460 ©

Microfluidics  
SCS





# DarkSide-20k

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

100 tonnextyear search for dark matter free of instrumental background

INFN-NSF science review: ✓

Yellow Book to LNGS: ✓

INFN-NSF budget and schedule review: ongoing

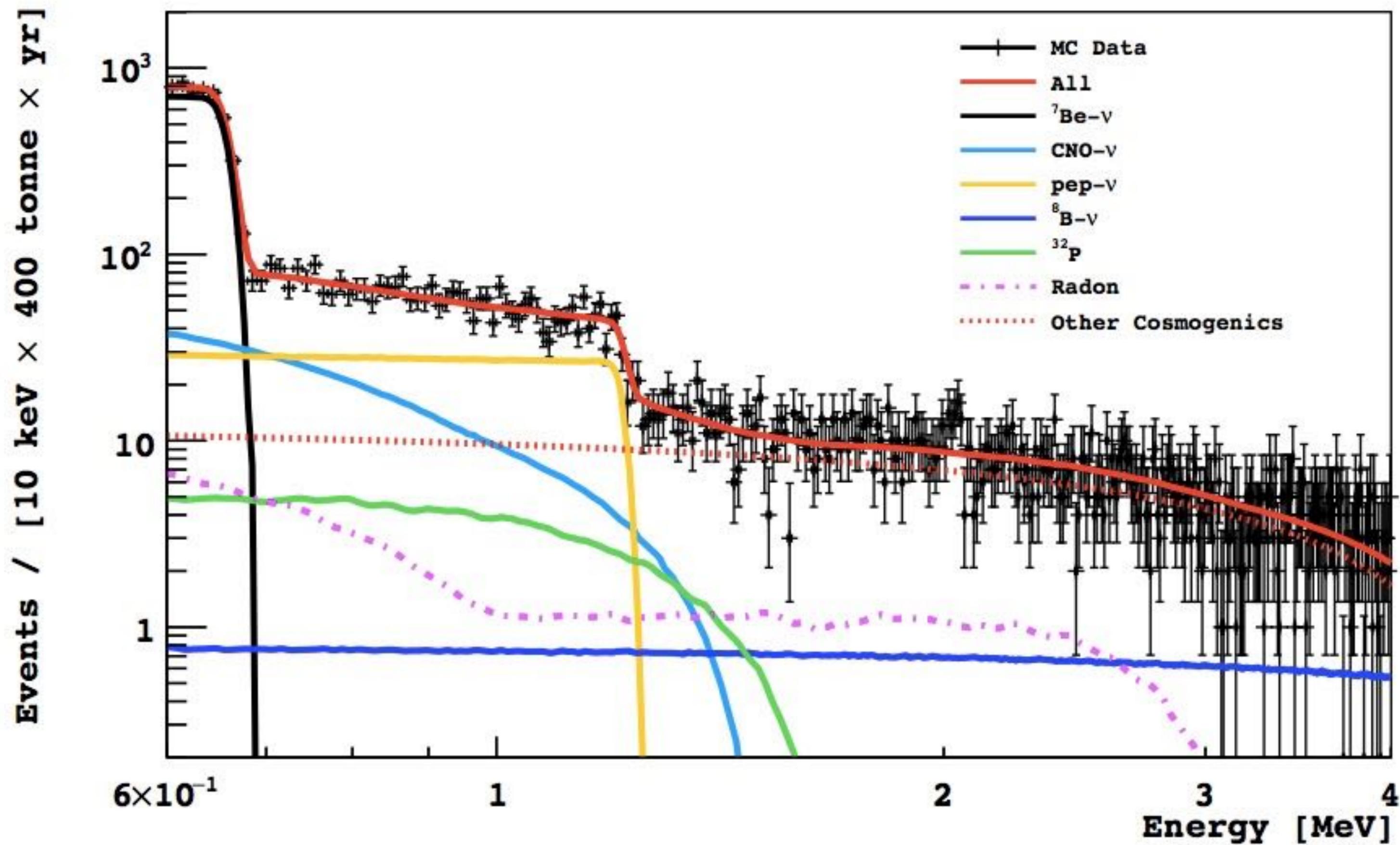


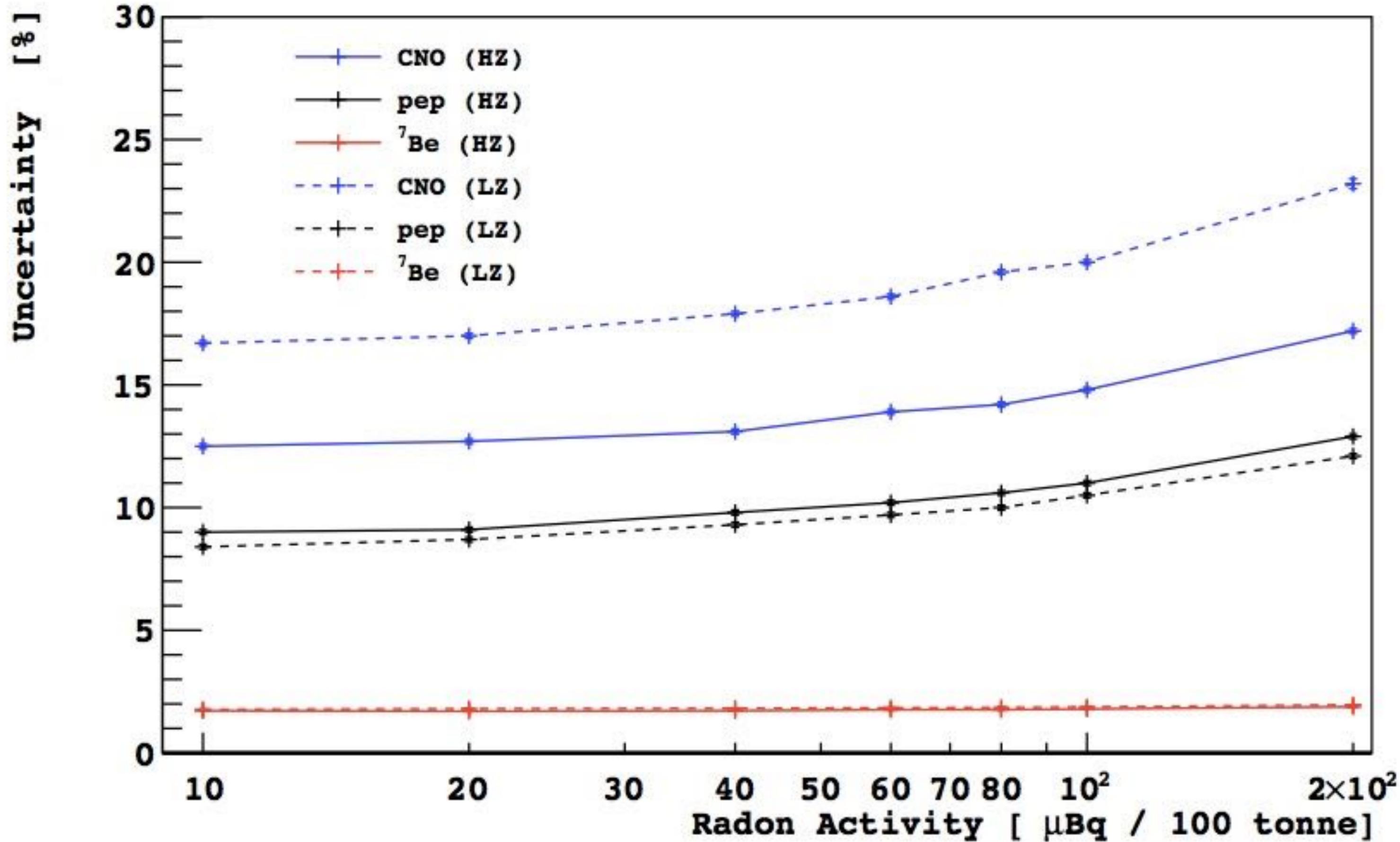
# Argo

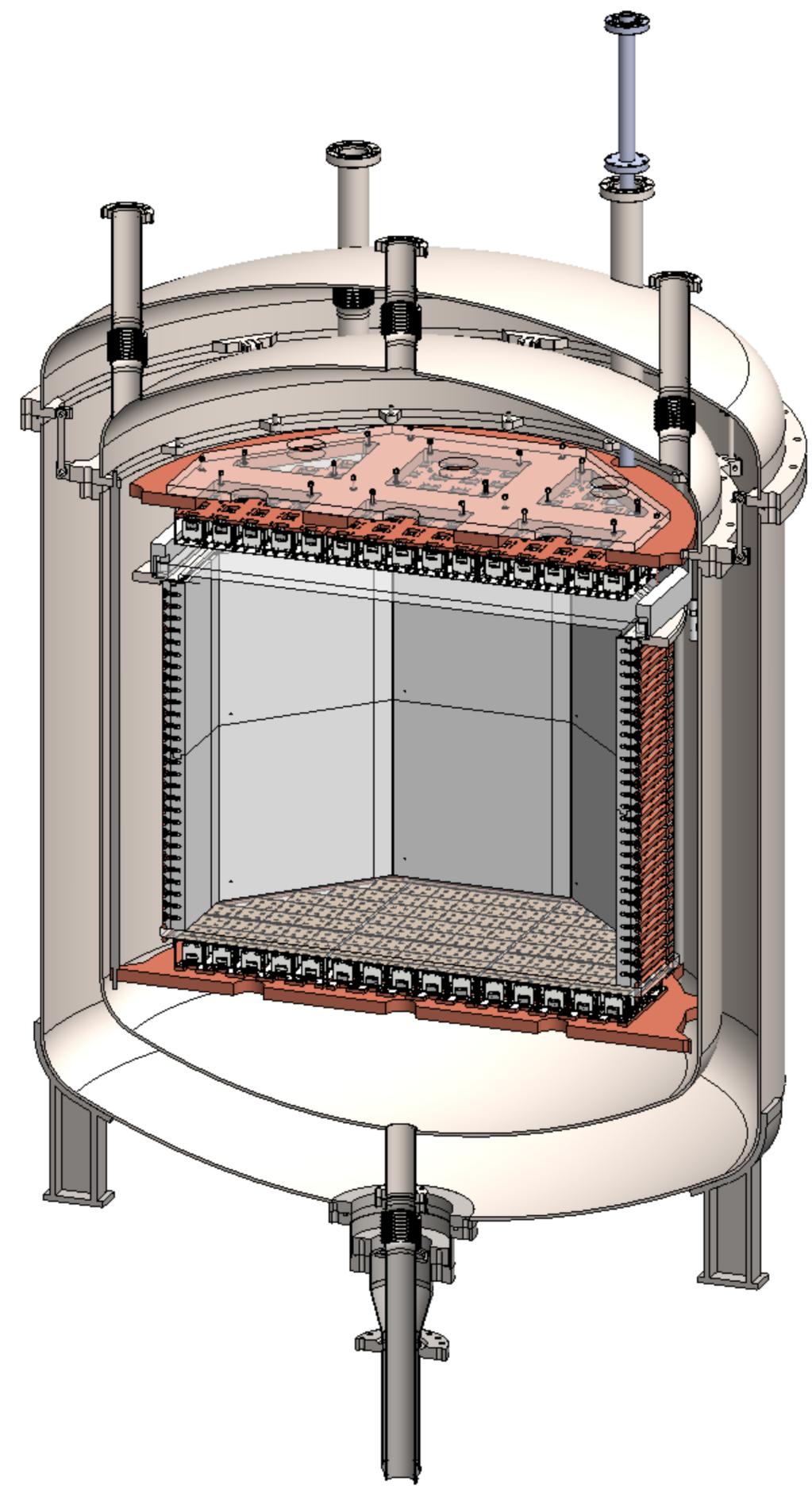
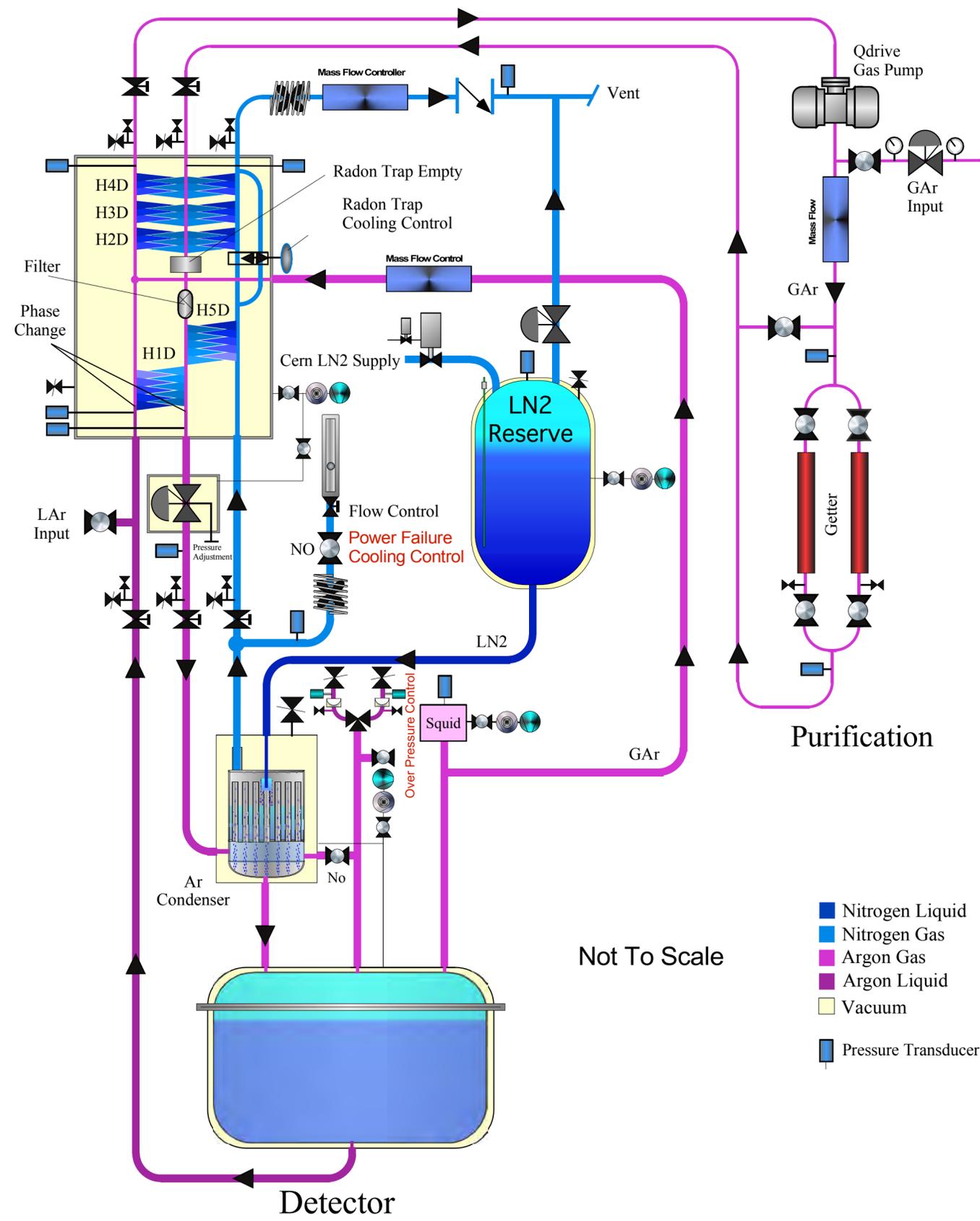
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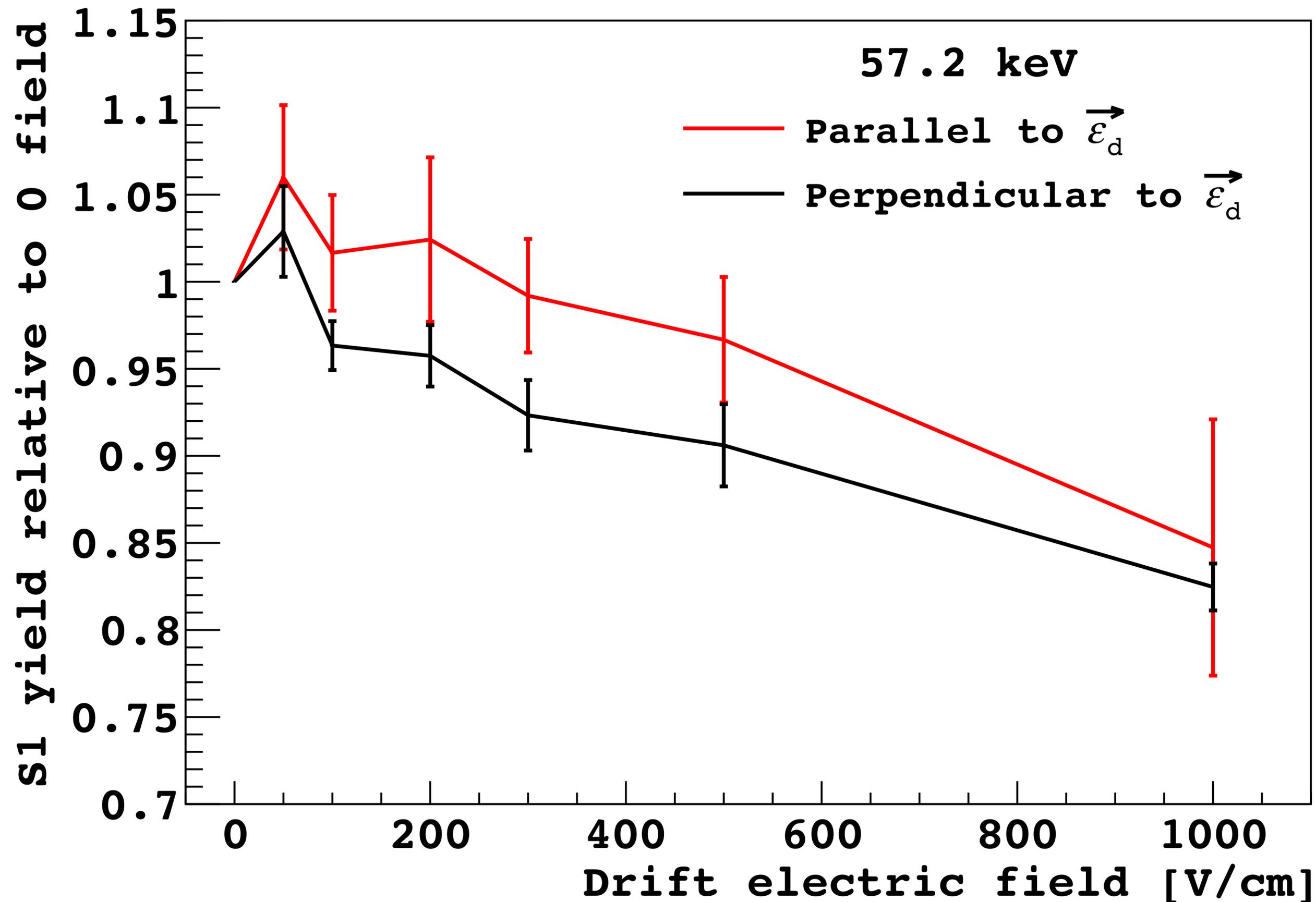
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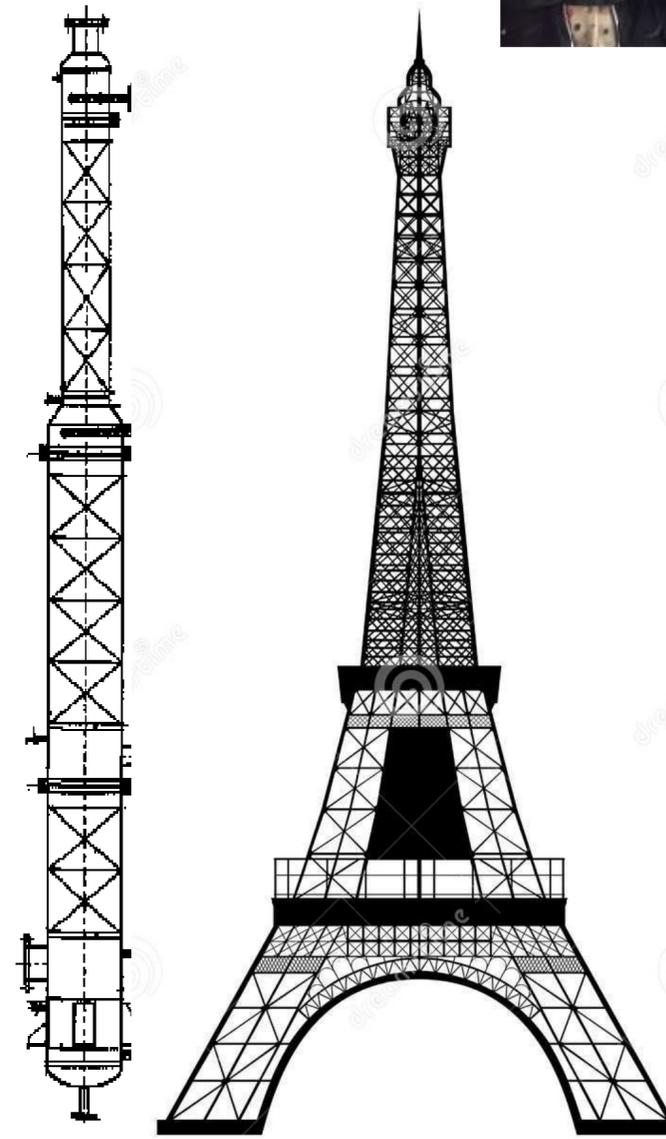
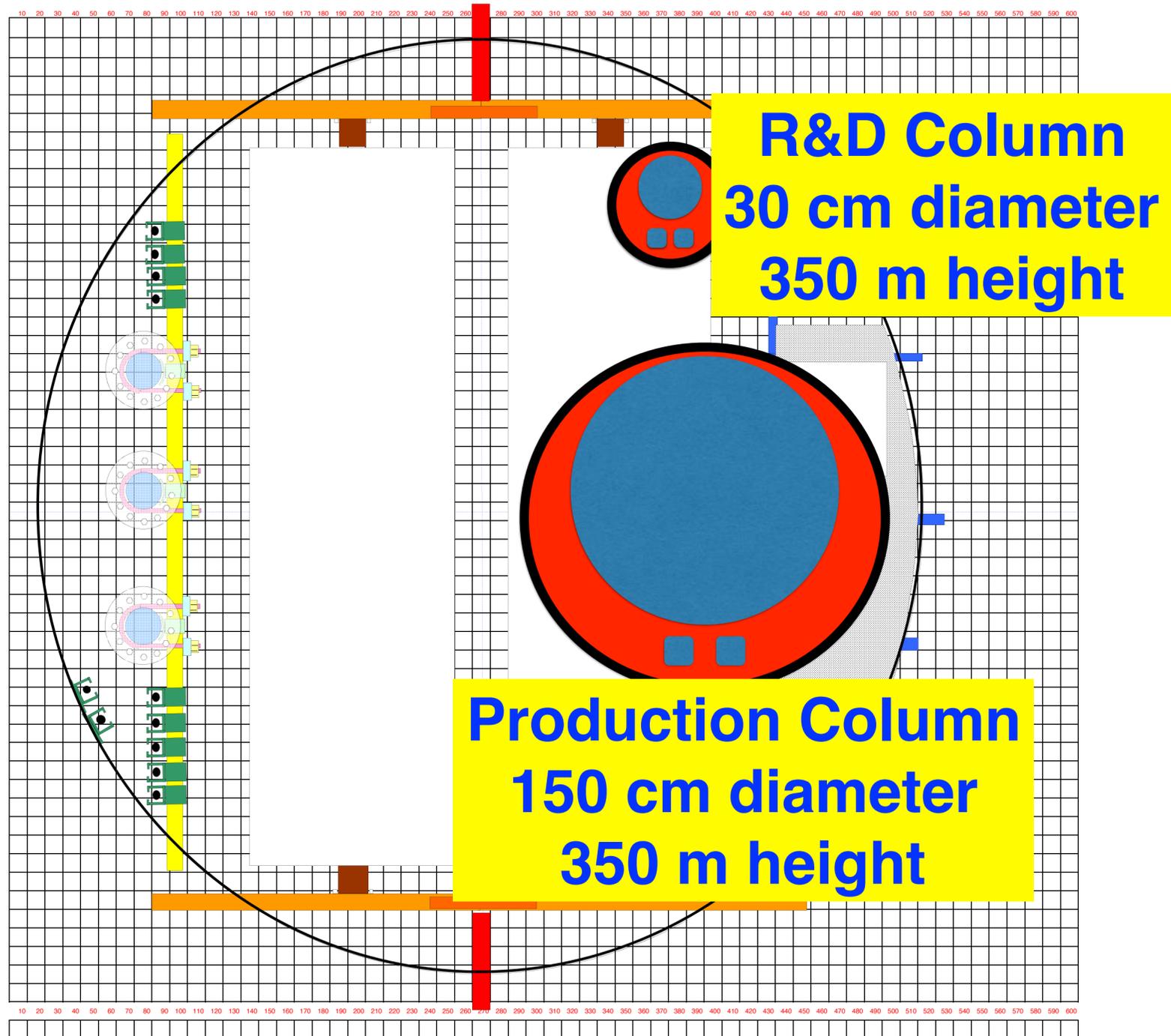


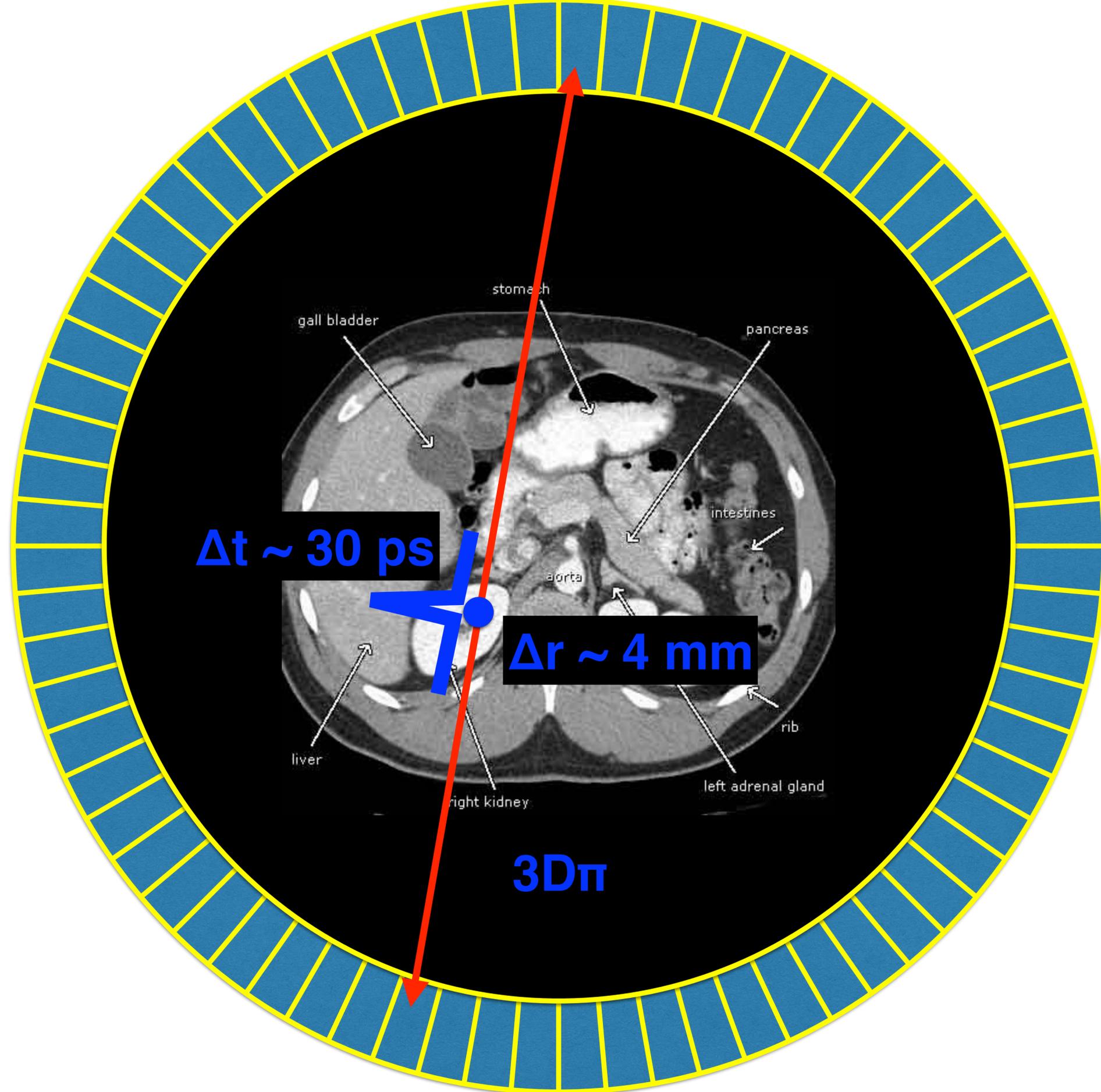


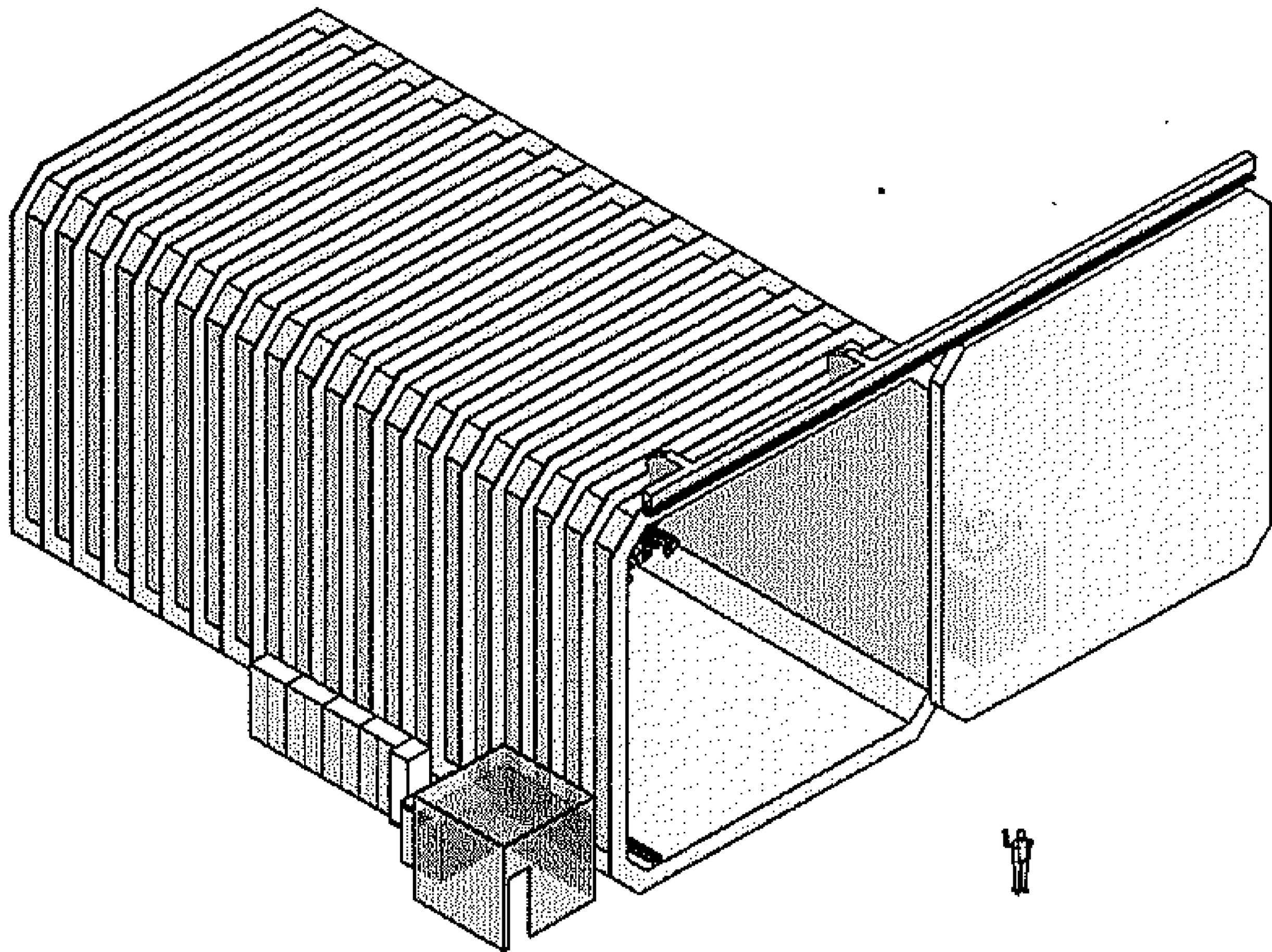




# Aria







The End