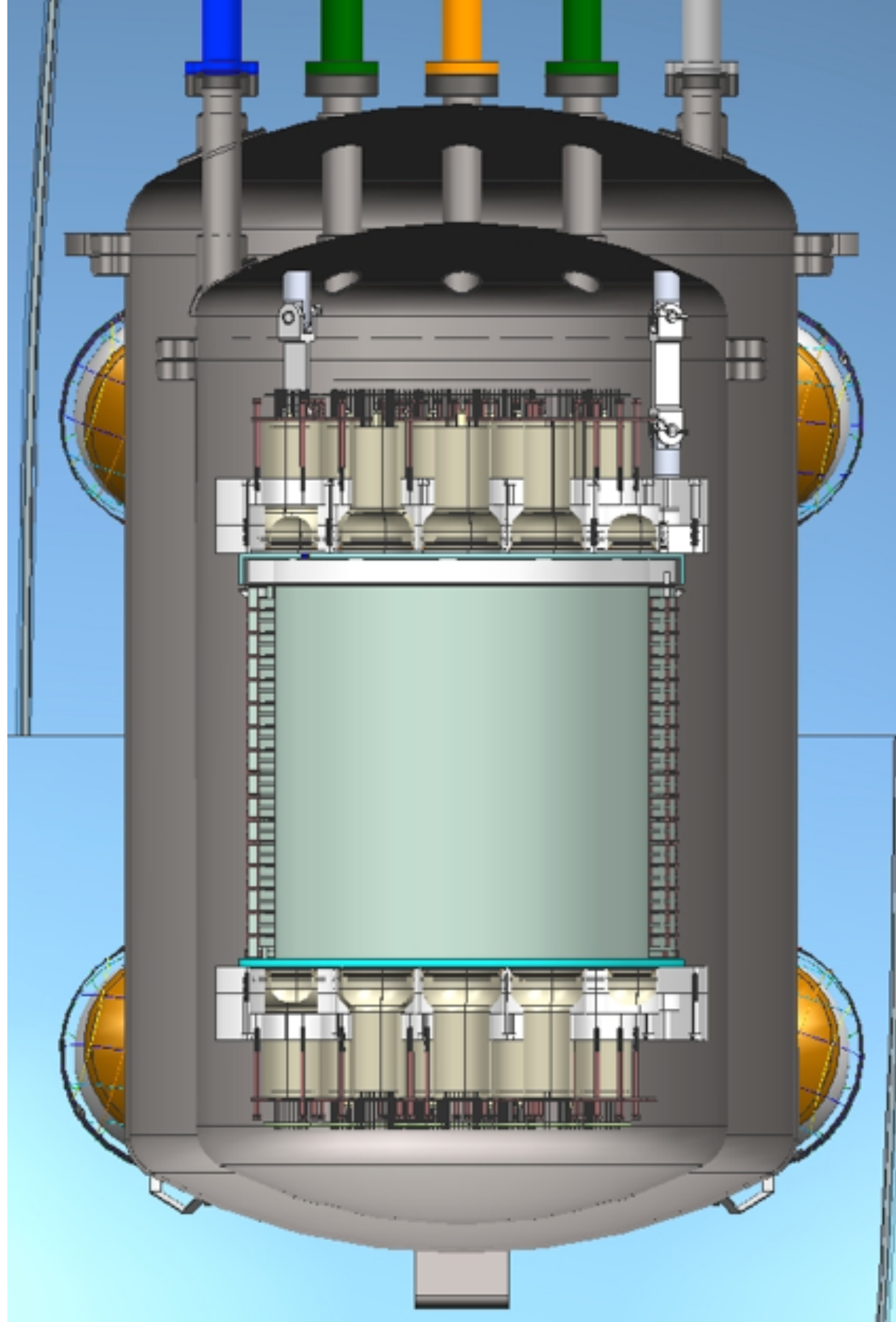


# The DarkSide Program of Direct Dark Matter Searches

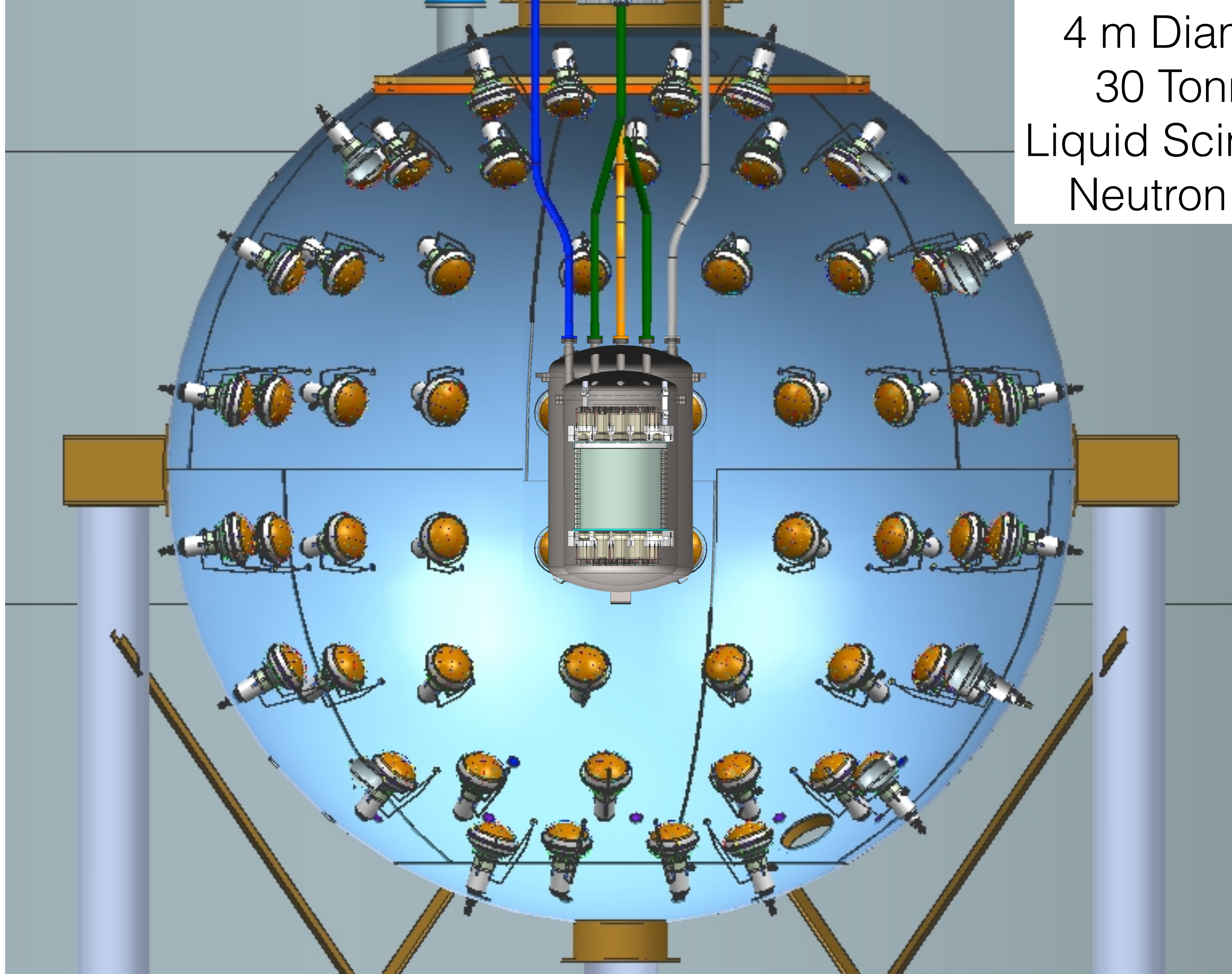
Cristiano Galbiati  
Princeton University  
LNGS Scientific Committee Meeting  
LNGS  
November 12, 2015

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



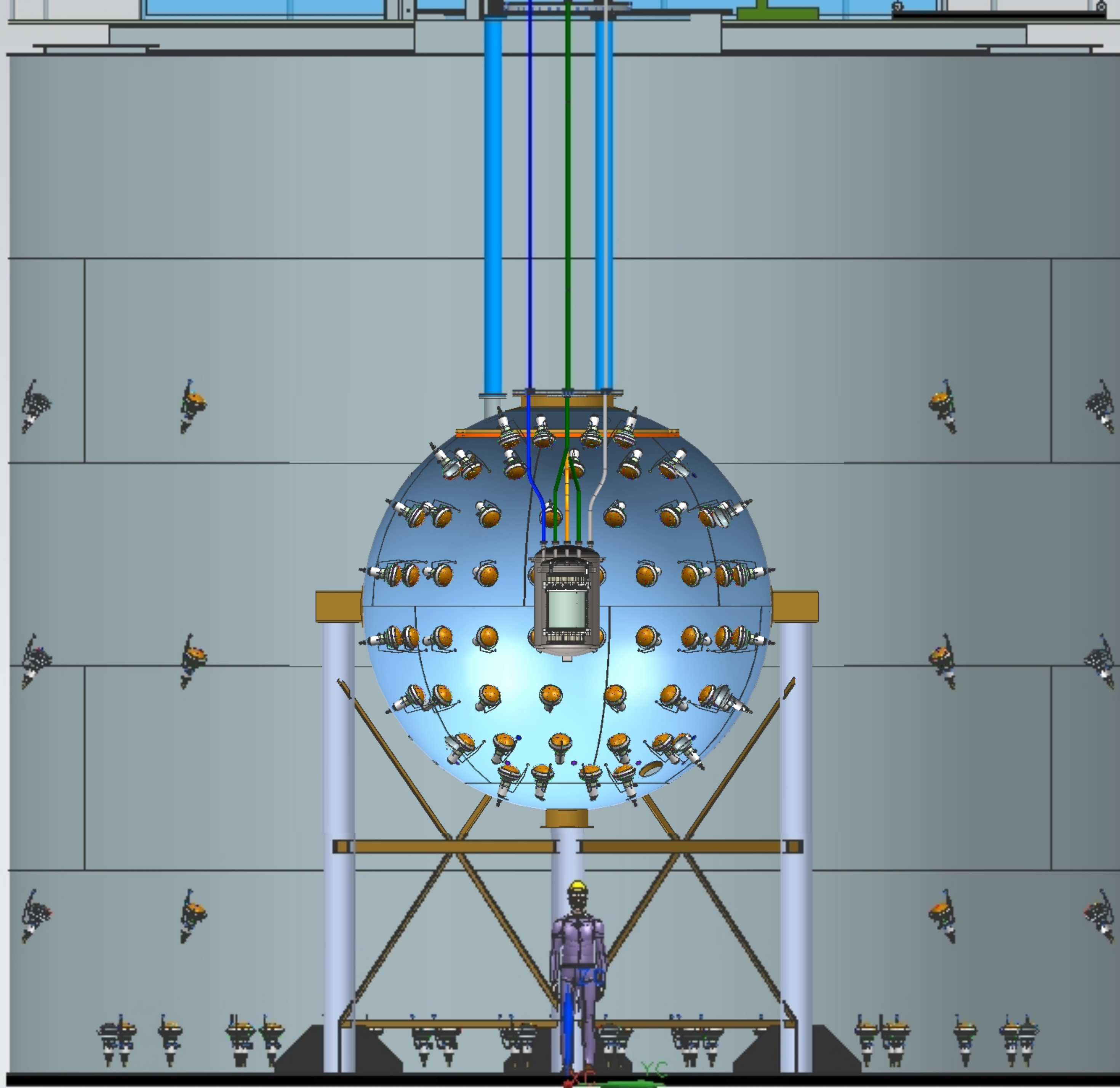


4 m Diameter  
30 Tonnes  
Liquid Scintillator  
Neutron Veto





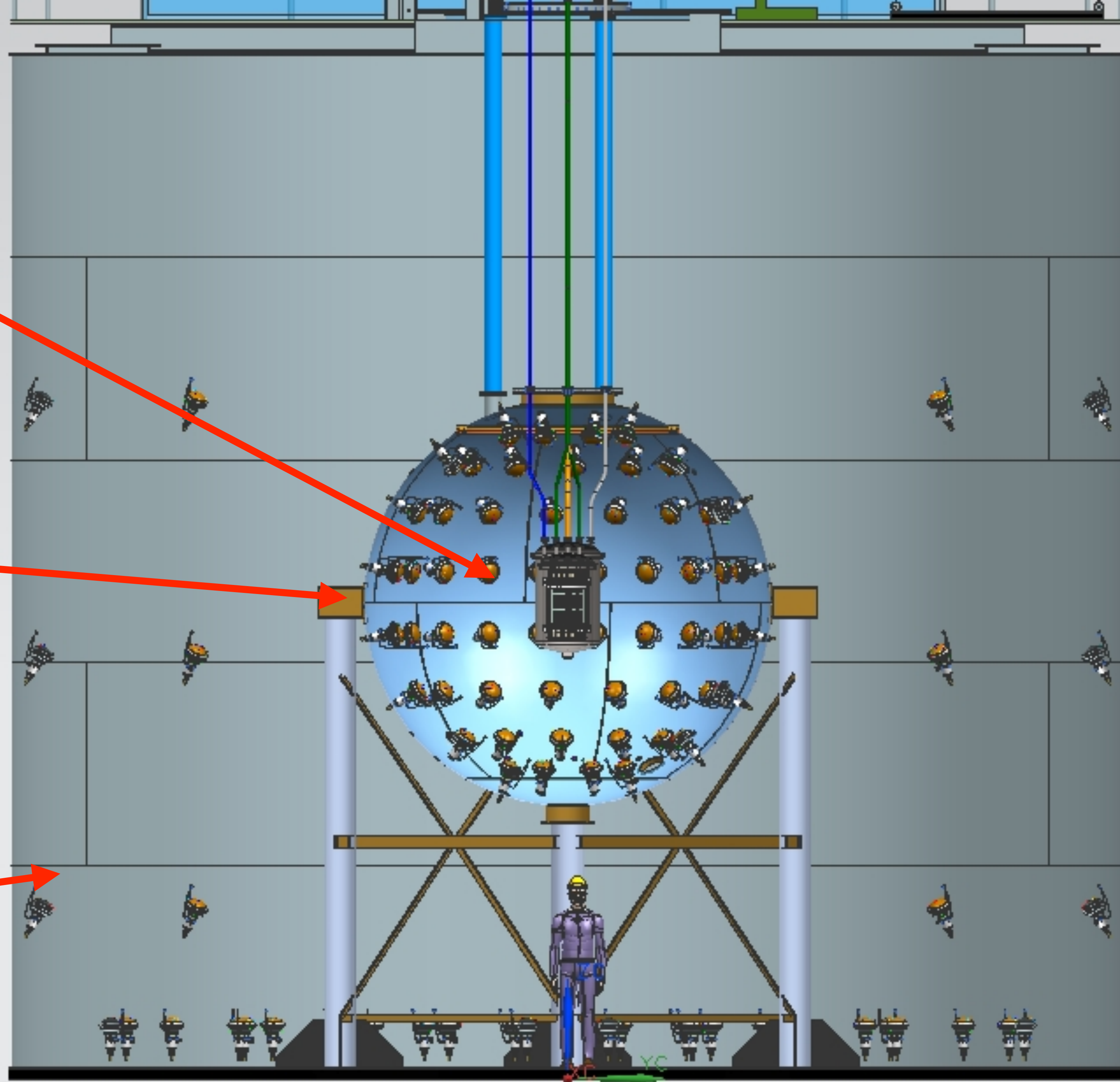
10 m Height  
11 m Diameter  
1,000 Tonnes  
Water Cherenkov  
Muon Veto



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



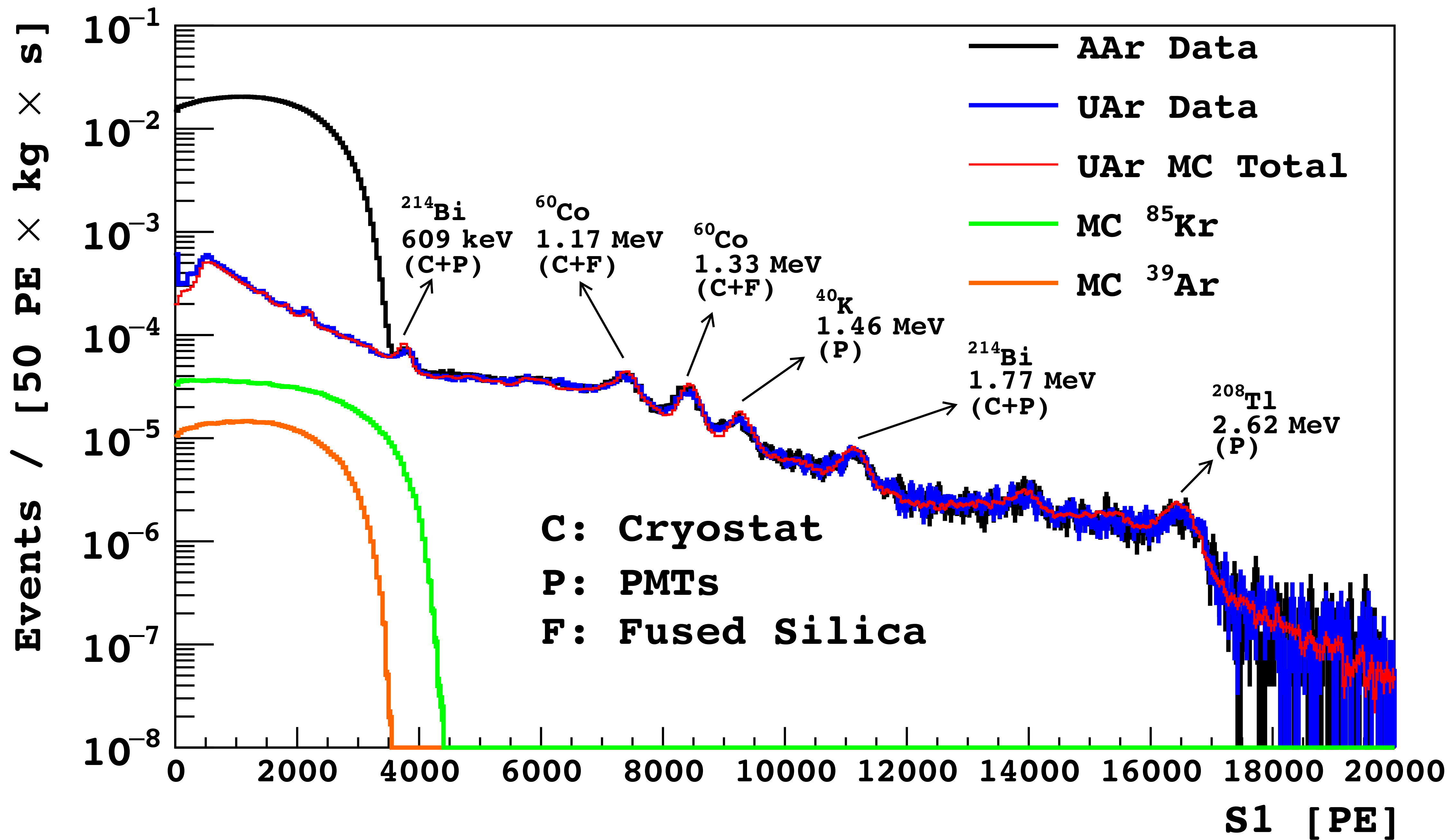




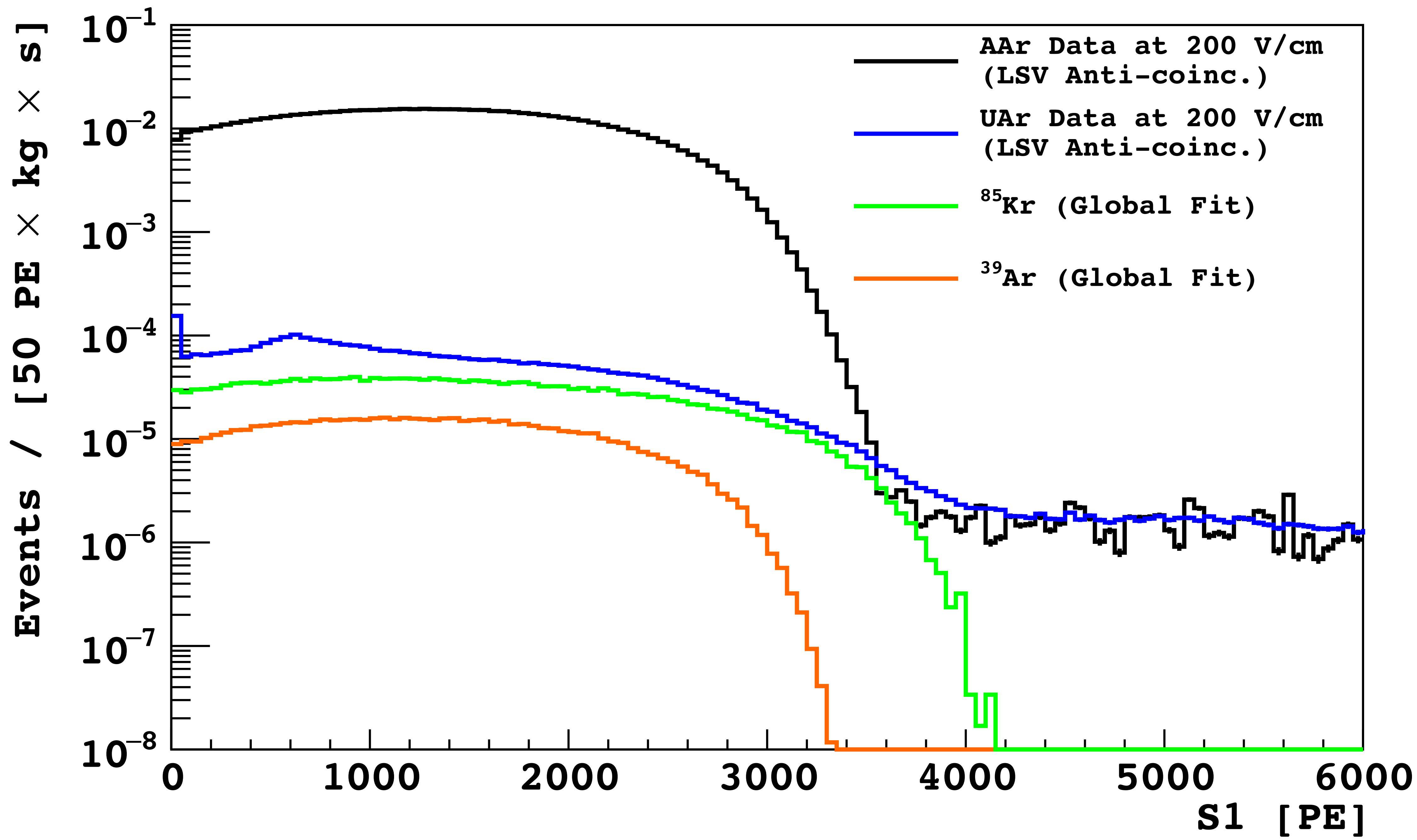


# DarkSide-50 Milestones

- Oct 2013: three detectors commissioned, cryostat filled with AAr
- Oct 2014: WIMP search results with 1422 kg d AAr exposure
- Fall 2014: Calibration campaign
- Winter 2014: Refurbishment of LSV,  $^{14}\text{C}$  rate from 150 kHz to 0.3 kHz
- Apr 2015: cryostat drained and filled with 153 kg of UAr
- Oct 2015: WIMP search results with 2616 kg d UAr exposure

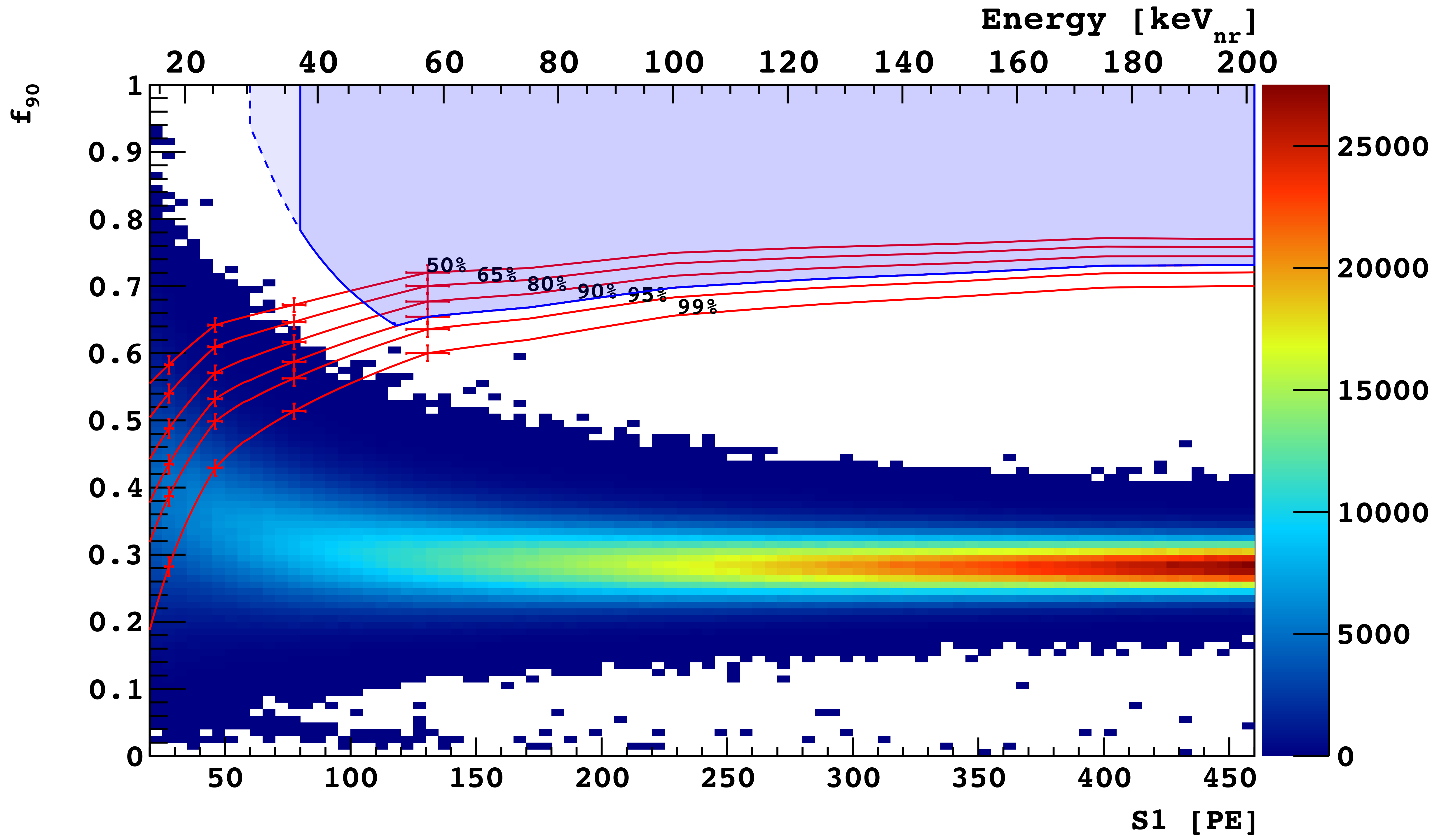




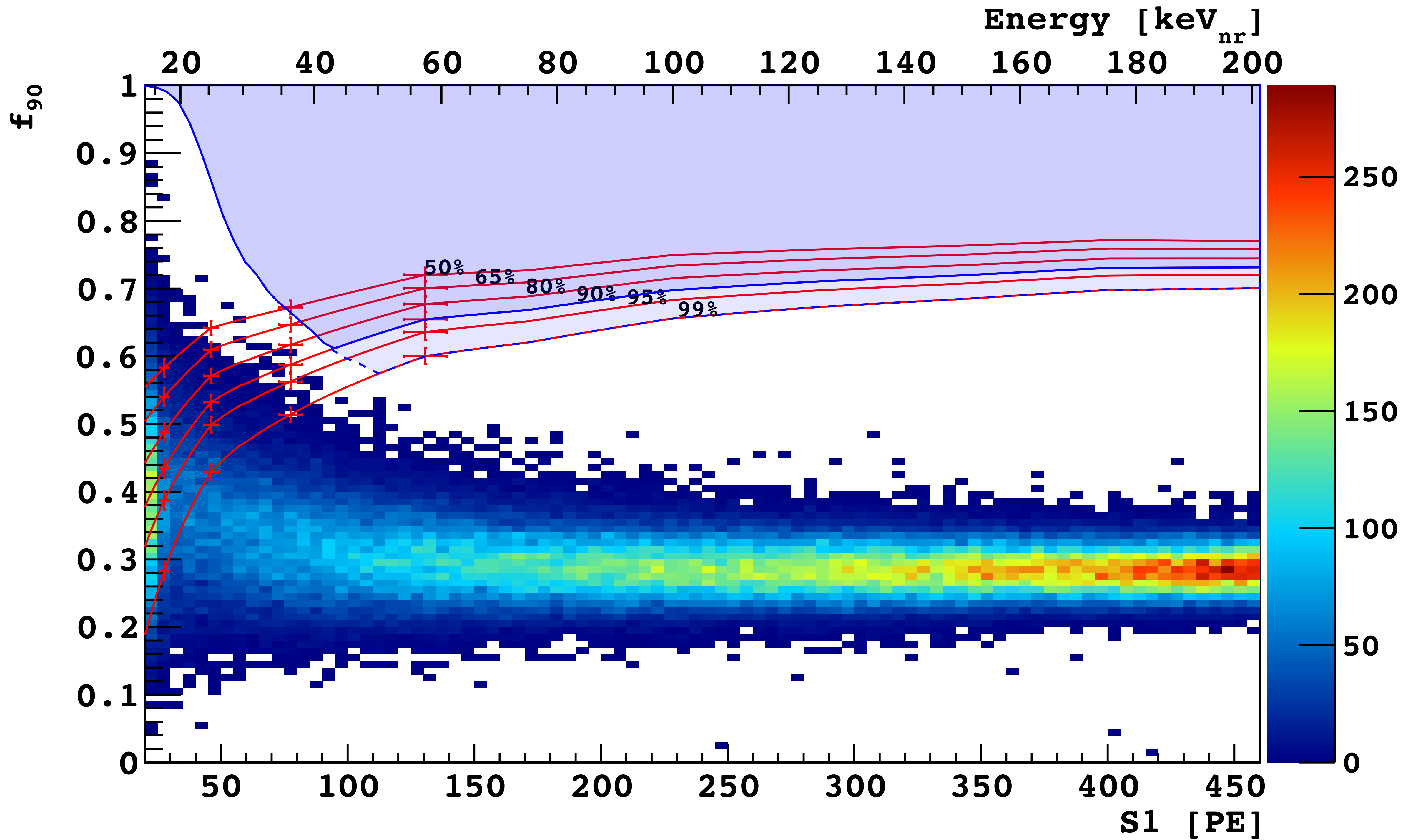




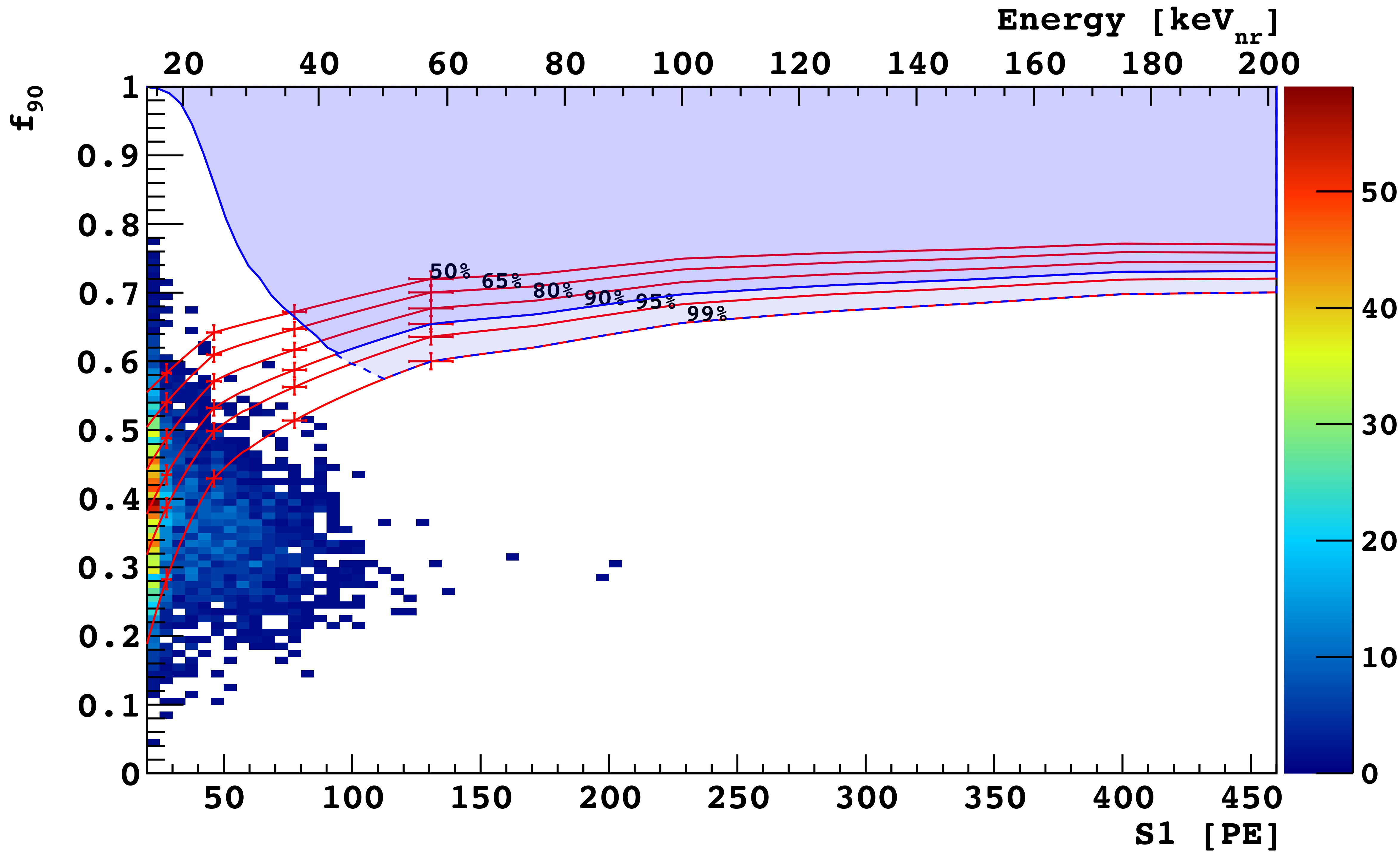
1,422 kg d AAr - PLB 743, 456 (2015)



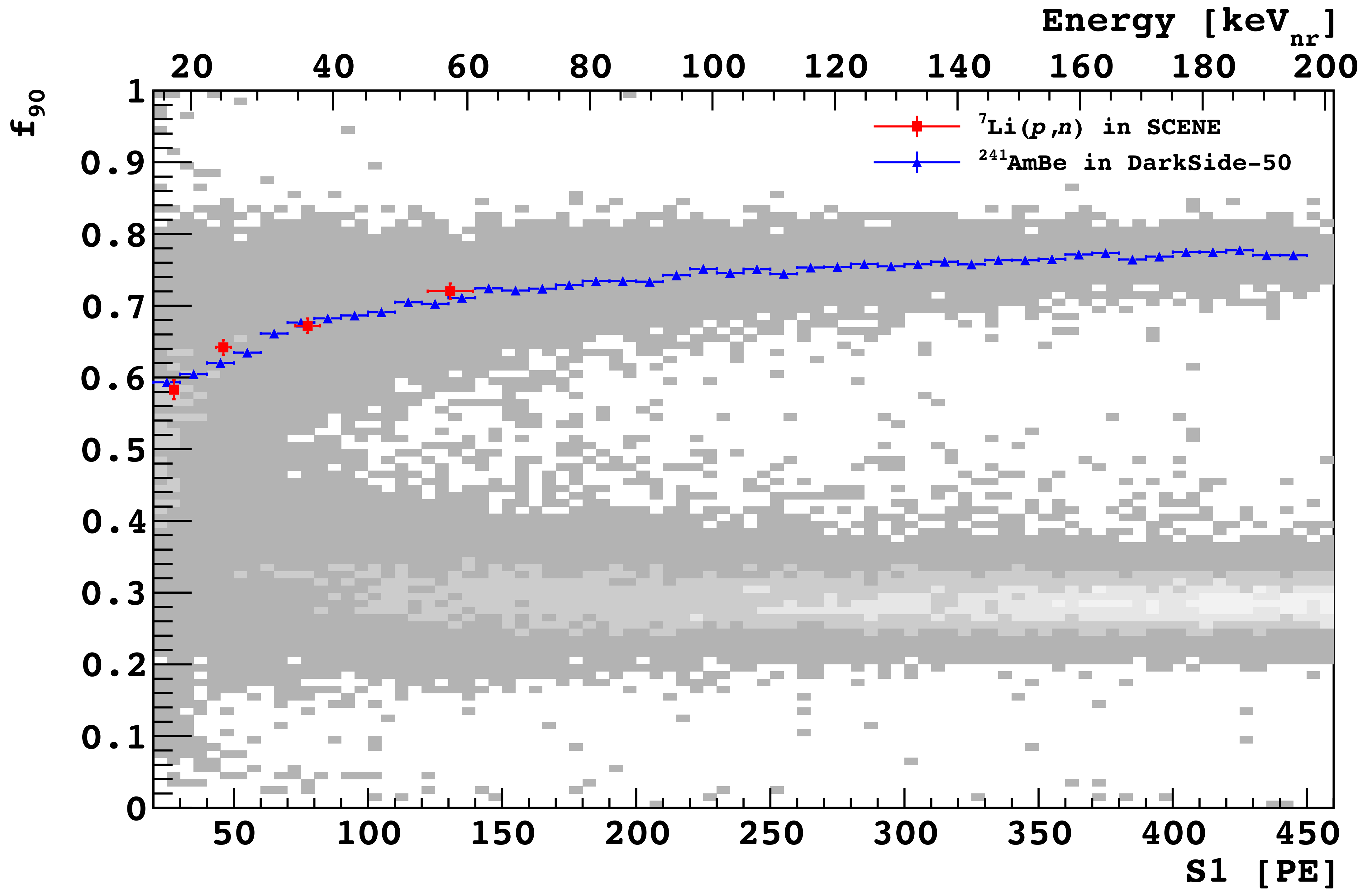


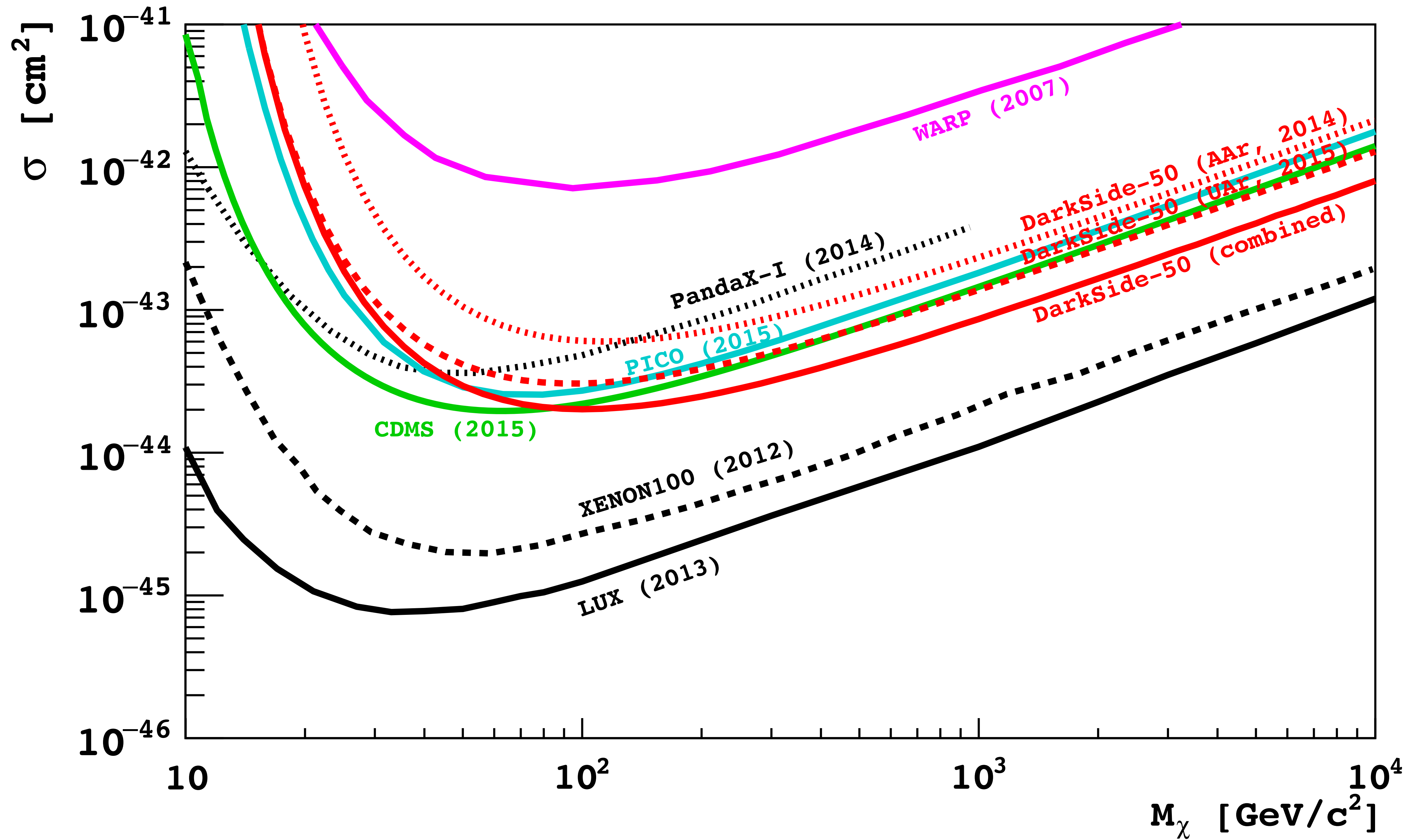




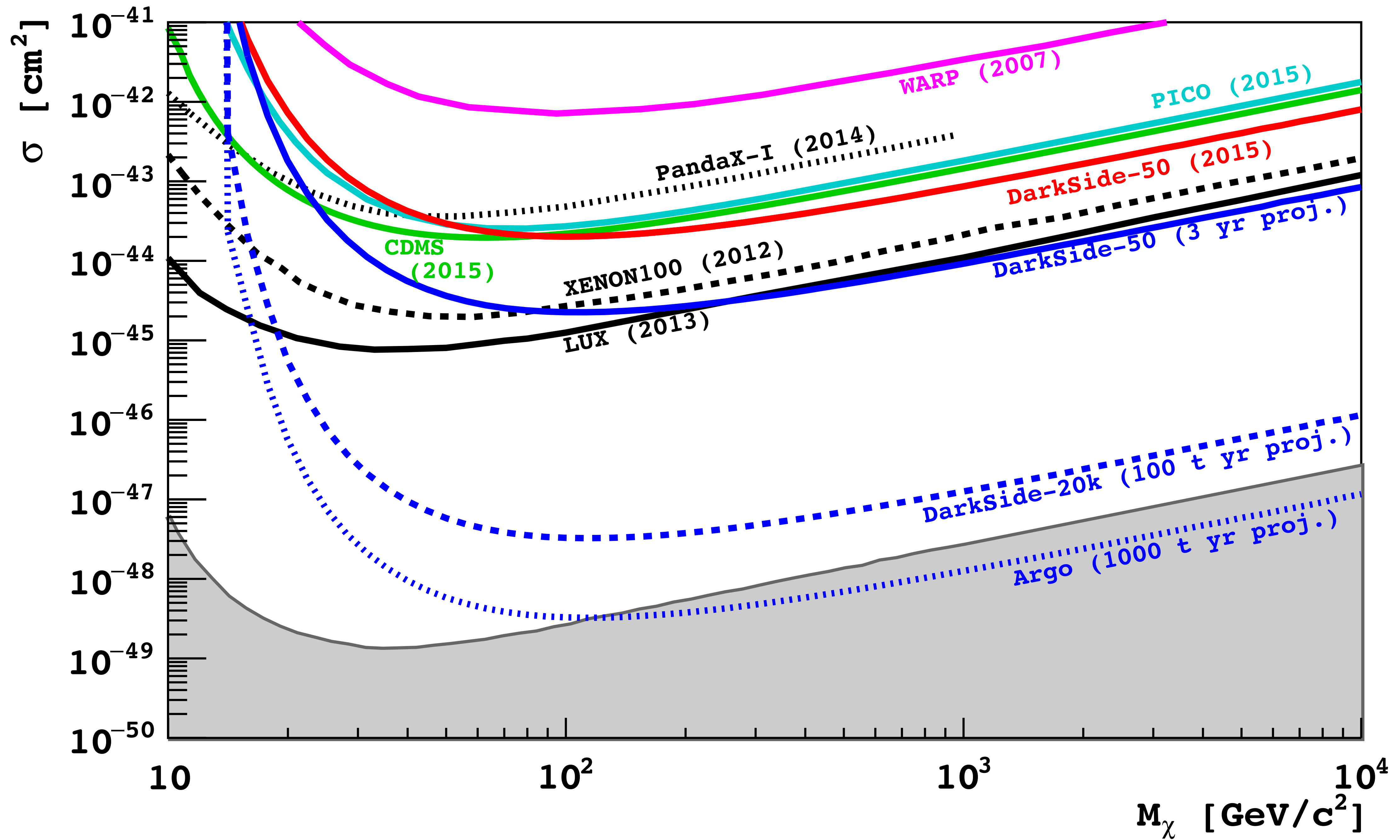












What are the backgrounds for  
large scale, high mass dark  
matter searches at the scale of  
1,000 tonnes $\times$ year?



Elastic scatters of  $pp$  solar neutrinos

Radioactive noble gases ( $^{39}\text{Ar}$ )

# Elastic Scatters of $pp$ Solar Neutrinos on Electrons

- 200 events/tonne $\times$ yr in 30-200 keV<sub>nr</sub> ROI for argon means 200,000 background events @neutrino floor
- Zero background left after  $\beta/\gamma$  rejection better than  $1 \div 1.6 \times 10^7$



# $^{39}\text{Ar}$ Rejection

1,422 kg×day (@AAr)

÷1400  
( $^{39}\text{Ar}$  AAr/ $^{39}\text{Ar}$  UAr)

already achieved

5 ton×yr (UAr) background free

Aria active  
isotopic depletion

statistically stronger  
PSD and S2/S1

1,000 ton×yr background free









## Size Comparison

The proposal is to construct a 350 meter tall distillation column at a mine called Suruci in Sardina Italy to separate Argon 39 from Argon 40.

325 meters Eiffel Tower

Seruci Distilation Column 350 mete

Man



Based on what we know today, can a depleted argon experiment be background free at the scale of 1,000 tonnes $\times$ yr?



# Yes

- $pp$  neutrino-electron scattering  
Not a concern thanks to pulse shape discrimination
- $^{214}\text{Pb}$  from  $^{222}\text{Rn}$  and  $^{85}\text{Kr}$   
Not a concern thanks to pulse shape discrimination
- $^{39}\text{Ar}$   
Discrimination proven so far on exposure of 5 tonne $\times$ yr UAr equivalent  
No deviations from statistical behavior of discrimination  
Current  $1 \div 1.6 \times 10^7$  rejection limited by statistics  
SiPM should allow to increase light yield by  $\times 1.5$ , which projects to more than 3 additional orders of magnitude in discrimination at the same threshold  
Further isotopic depletion of  $^{39}\text{Ar}$  available if required

# DarkSide-20k

**20-tonnes fiducial dark matter detector  
start of operations at LNGS within 2020  
100 tonnextyear background-free search for dark matter**



# Argo

**300-tonnes depleted argon detector  
start of operations at LNGS within 2025  
1,000 tonnextyear background-free search for dark matter  
precision measurement of solar neutrinos**





## Collaborative Research: DarkSide-20k

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The End



