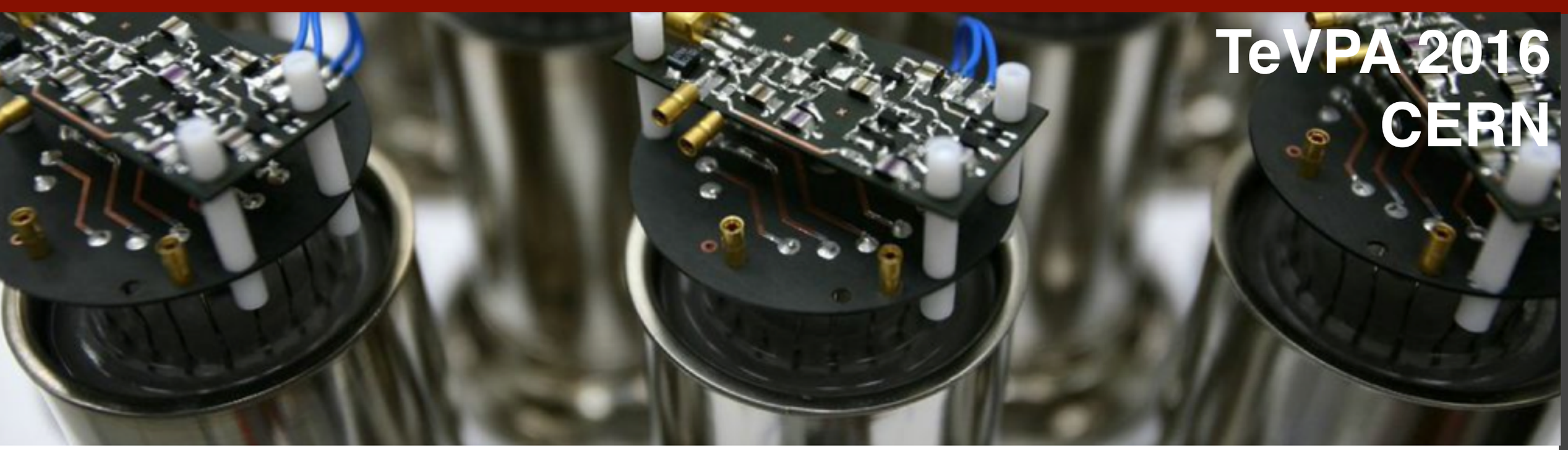
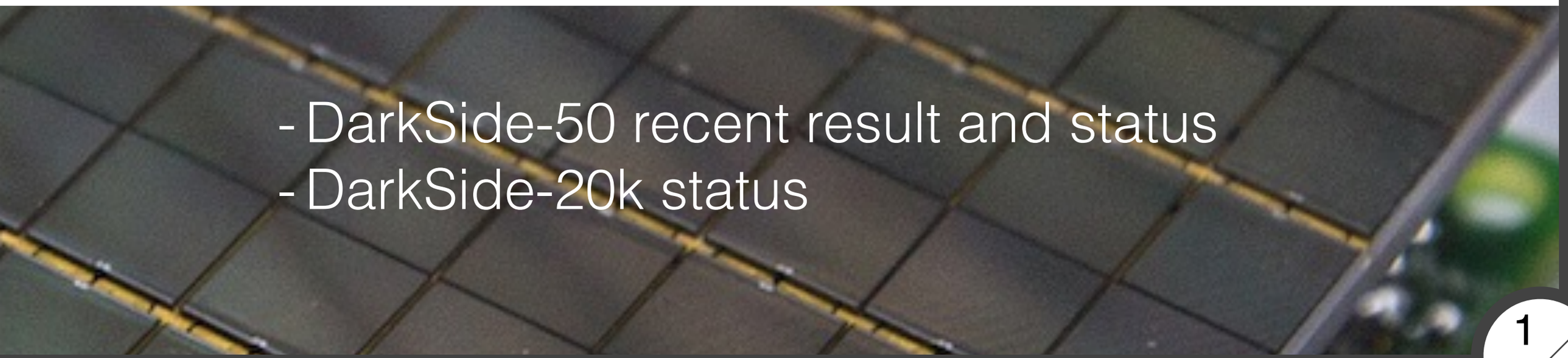


TeVPA 2016
CERN

THE DARKSIDE OF DIRECT DARK MATTER SEARCHES

Emilija Pantic
for the DarkSide collaboration

UC DAVIS
UNIVERSITY OF CALIFORNIA



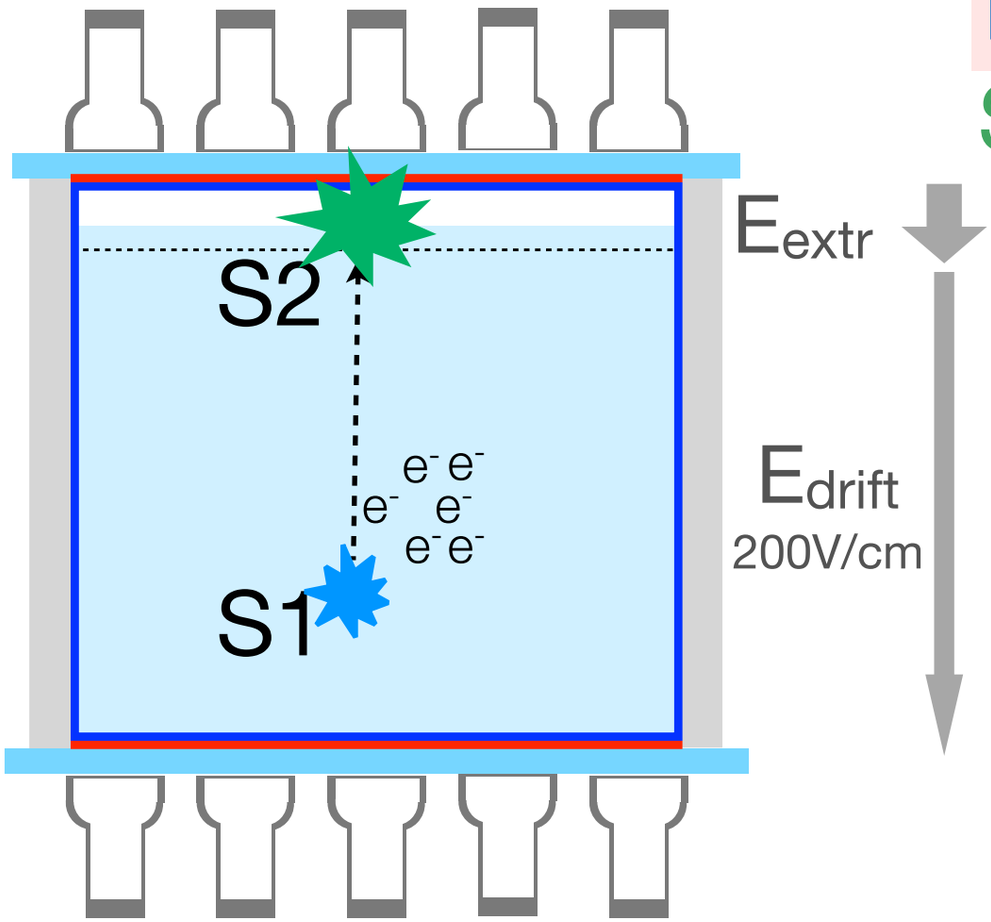
- DarkSide-50 recent result and status
- DarkSide-20k status

pantic@ucdavis.edu

http://darkside.lngs.infn.it/collaboration

DarkSide-50 LAr dual phase TPC

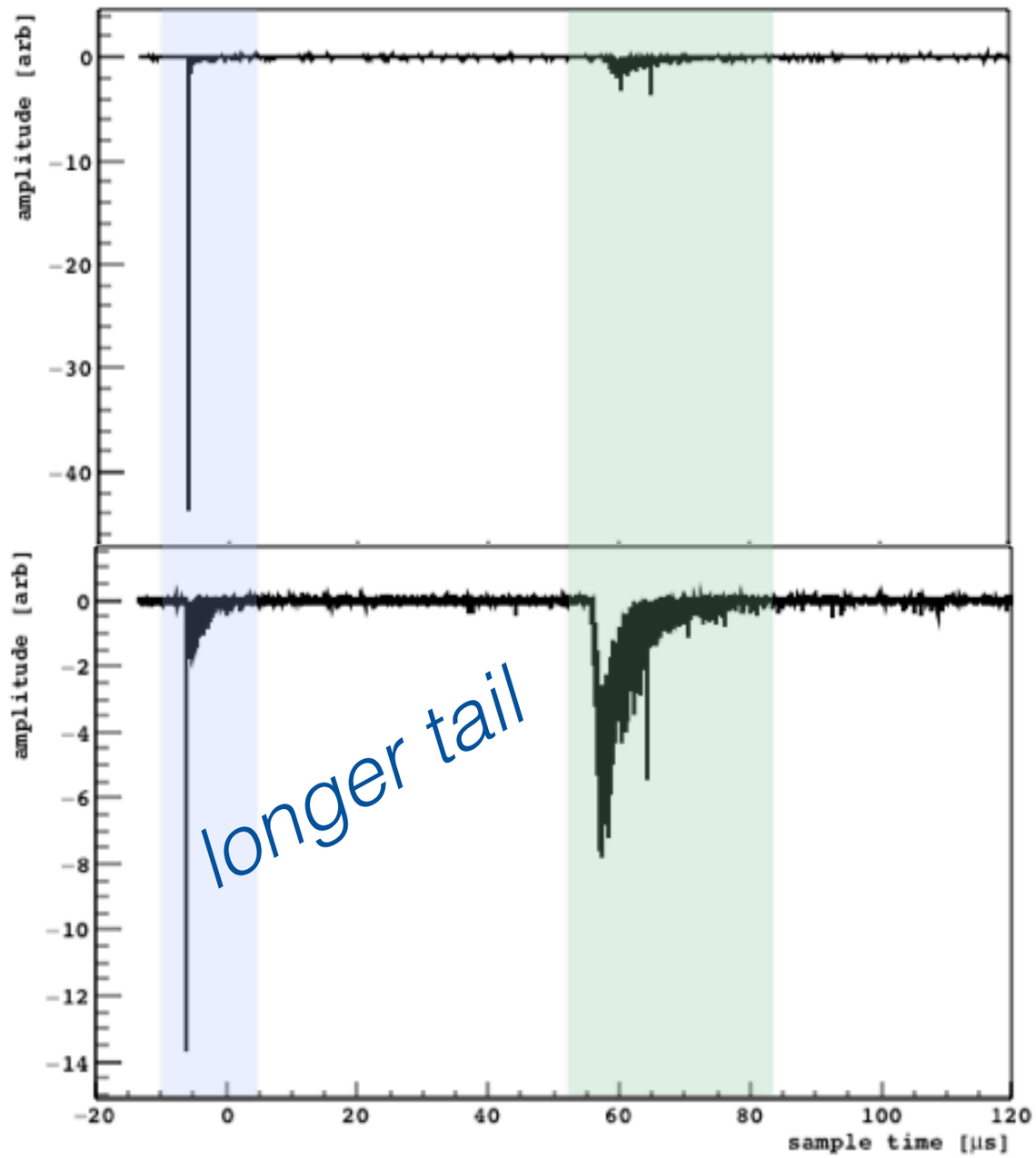
Light + **Charge**



3D positioning ◎ (few mm)

Pulse shape discrimination of ERs

S2/S1 discrimination of ERs



46kg of LAr
38 3” PMTs
TPB as wavelength shifter
cathode/anode = **ITO** on **fused silica**
Teflon as reflector
extraction grid

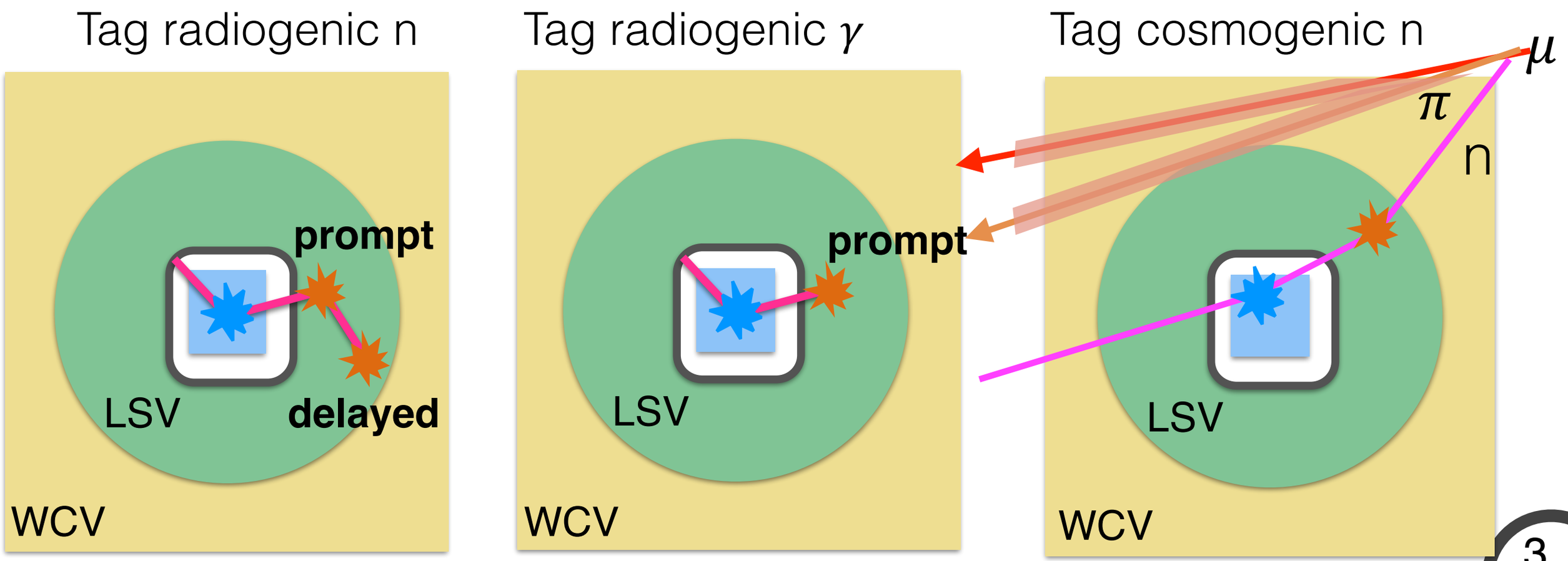
DarkSide-50 Veto Detectors:

Liquid Scintillator Veto (LSV) = 30 t of TM**B** + PPO + PC

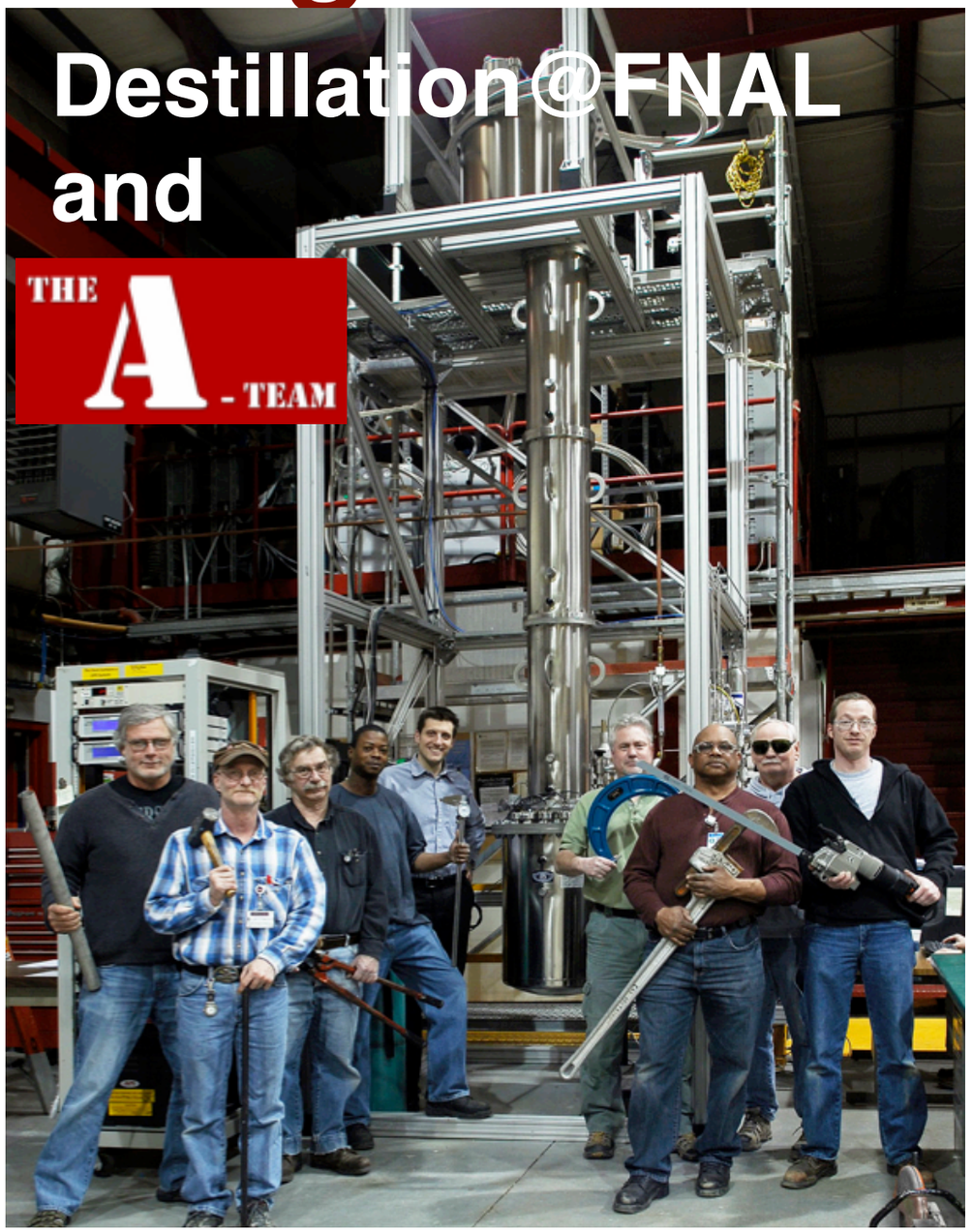
Neutrons that scatter in the TPC can be detected via capture signal on ^{10}**B** or thermalization signal in LSV.

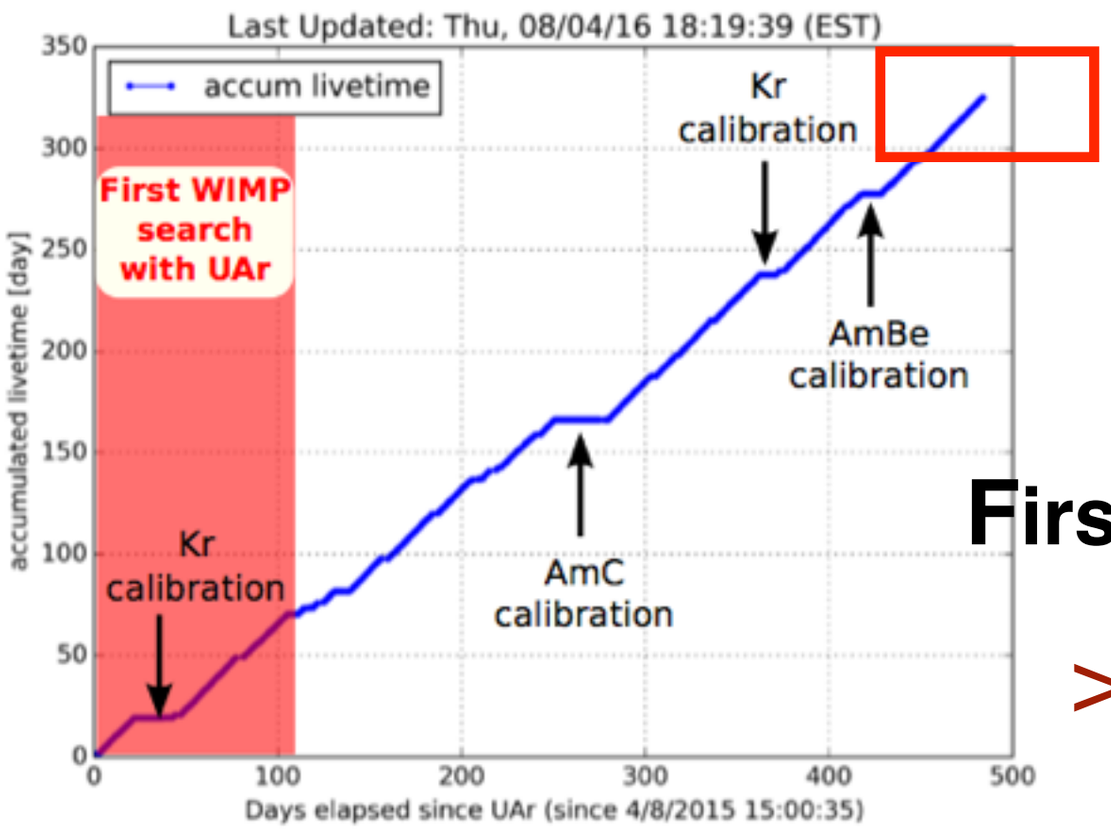
1000t Water Cherenkov Veto (WCV) to tag cosmogenic neutrons via muons.

radiopure



Low radioactivity underground Ar





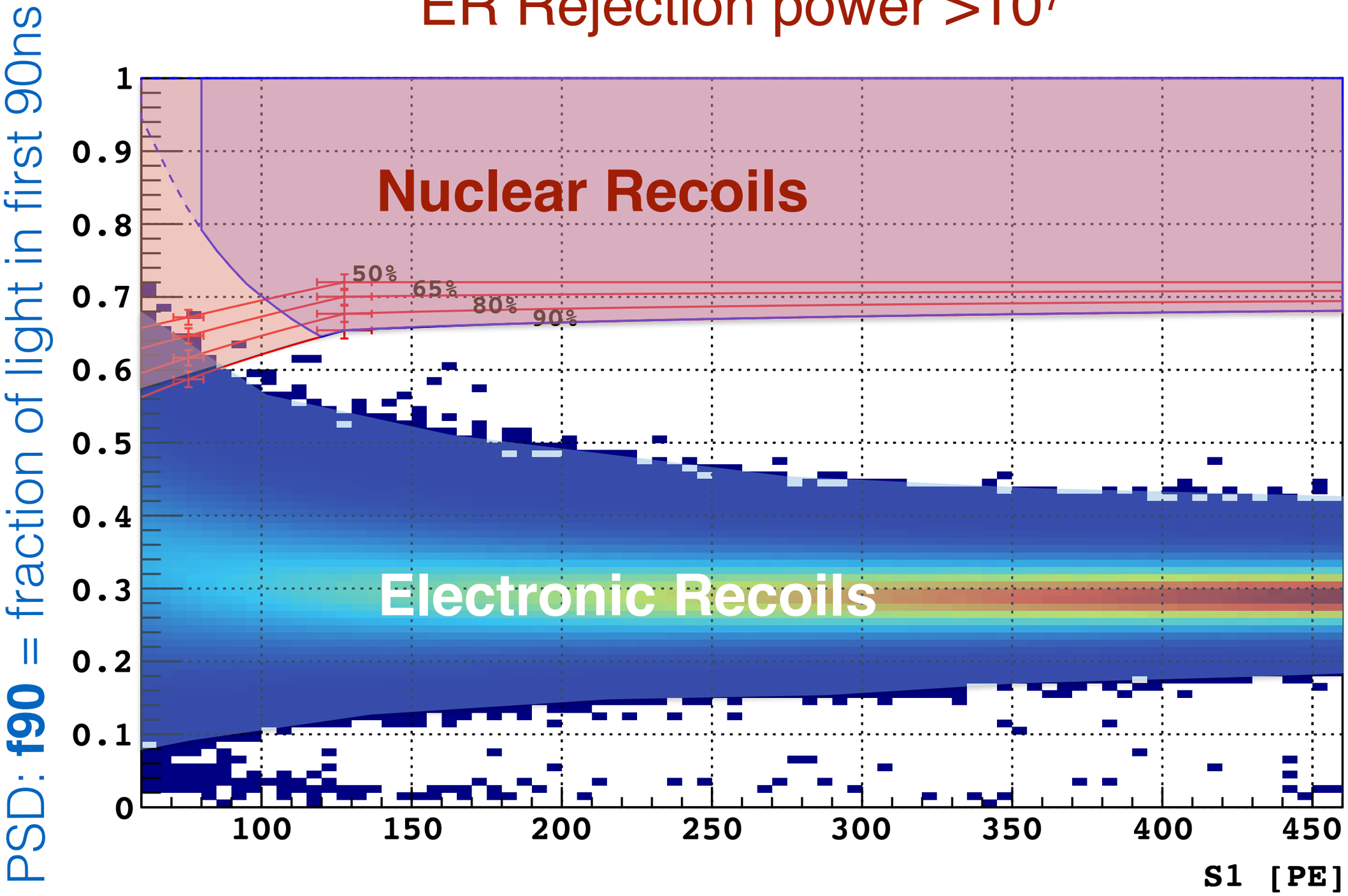
First run (70days) with 150kg of UAr

> 260 additional days recorded

A Study of the Residual 39Ar39Ar Content in Argon from Underground Sources Astropart.Phys. 66 (2015)
First Large Scale Production of Low Radioactivity Argon From Underground Sources arXiv:1204.6024

In-situ internal calibrations: TPC

50 days of Atmosph. Ar run is calibration: 1.5 x10^7 ER events
ER Rejection power >10^7

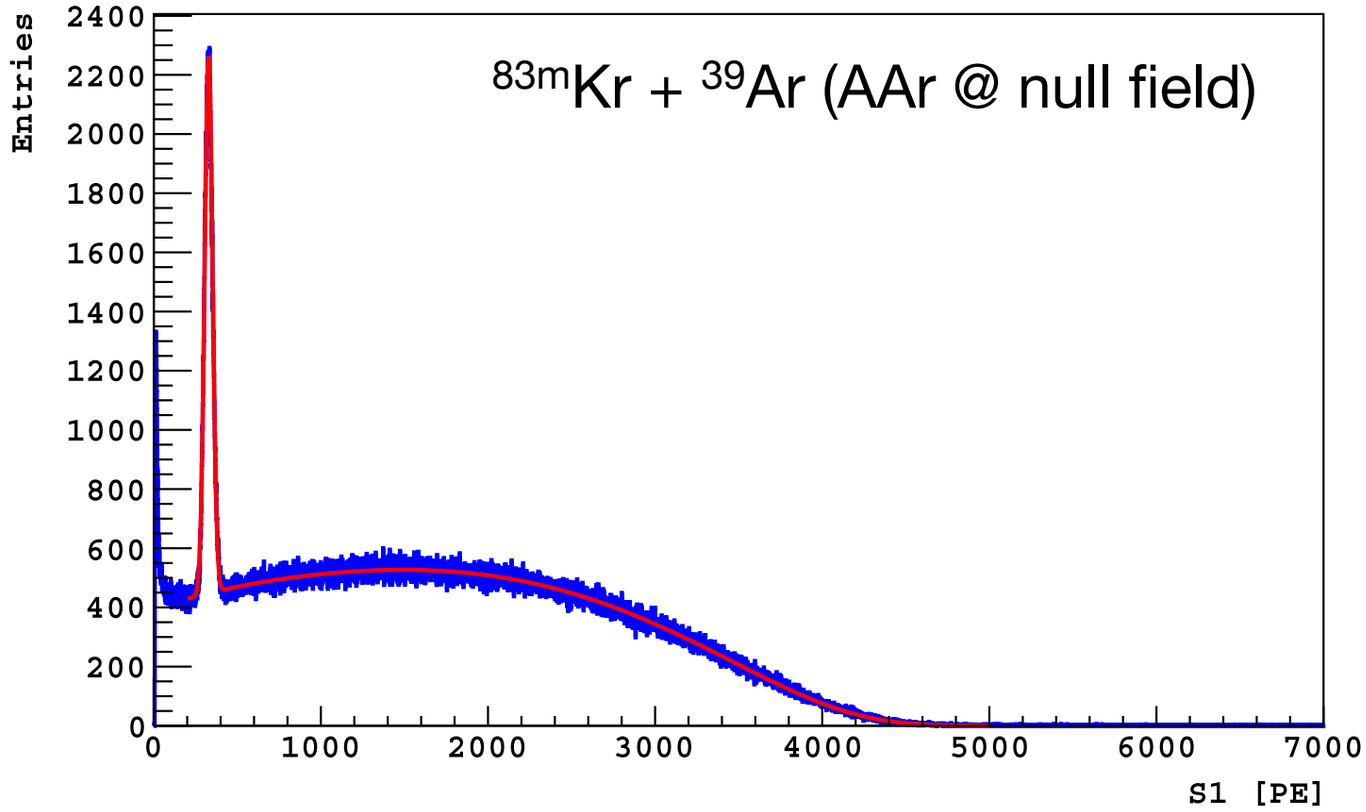


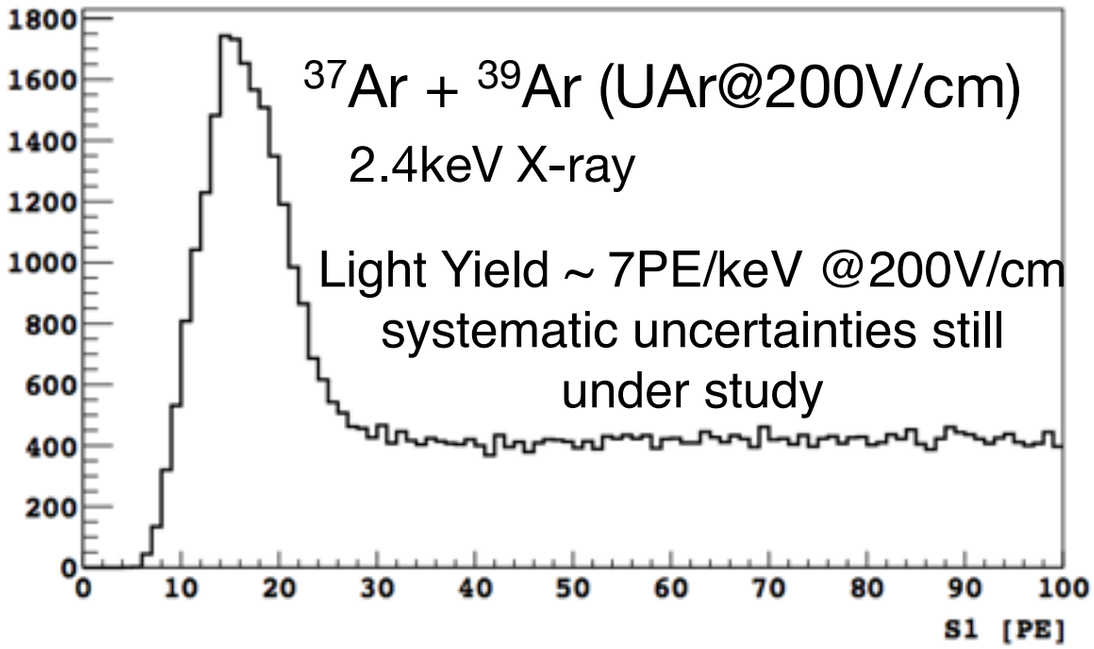
In-situ internal calibrations: TPC

^{83m}Kr Light Yield:
7.9 ± 0.4 PE/keV @ null field
7.0 ± 0.3 PE/keV @ 200 V/cm

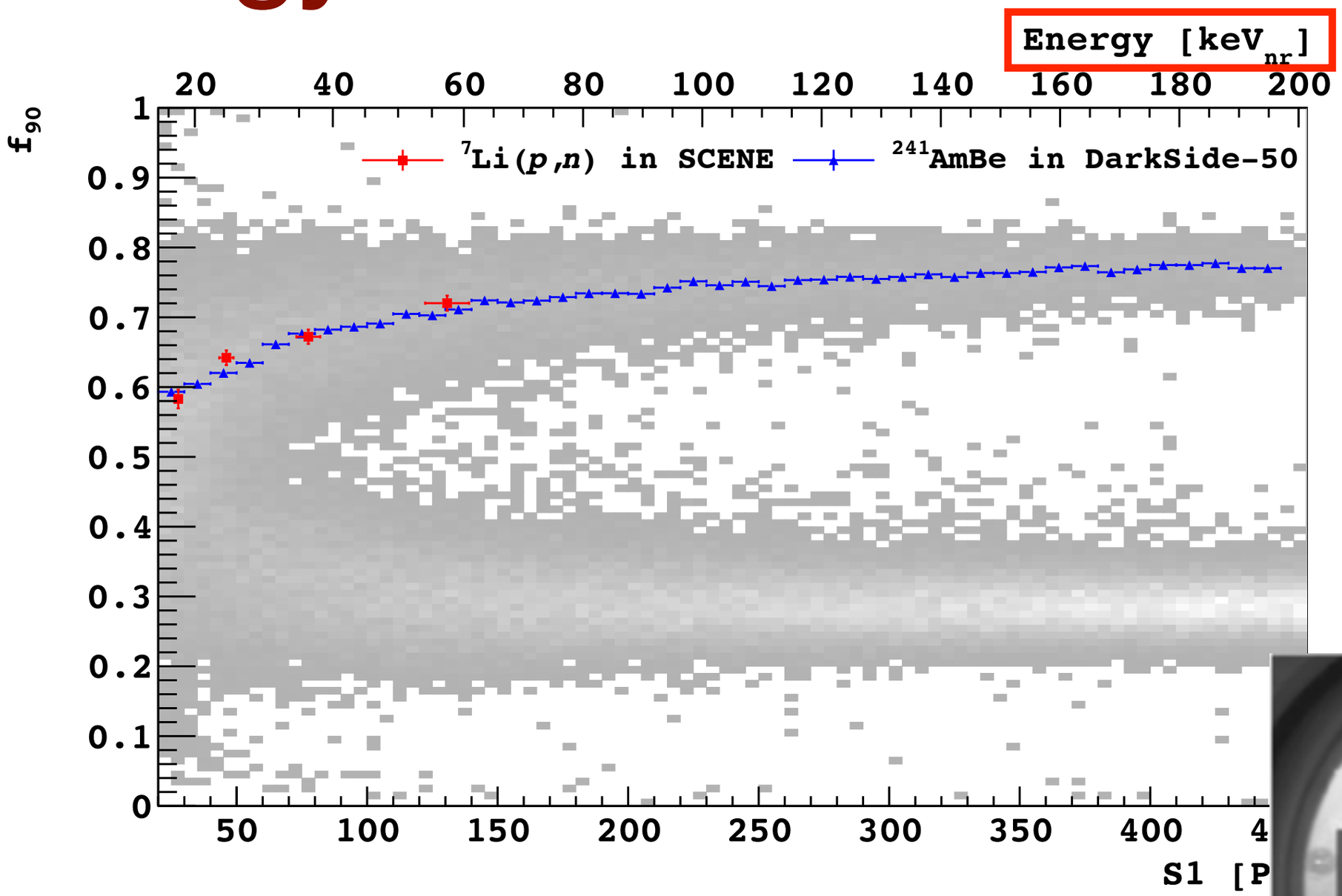
^{83m}Kr used for **light yield map correction** and electron lifetime estimates.

electron lifetime > 5000 μS
(max drift time 375 μs)
No S2 signal correction.





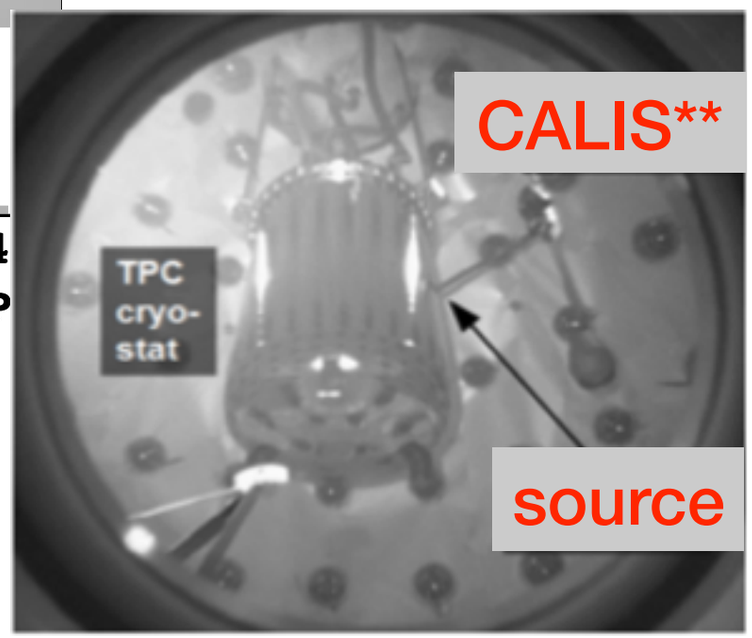
Energy scale calibration



in-situ AmBe calibration to validate extrapolation of SCENE values to DarkSide-50

SCENE= pure sample of single nuclear recoils

Extrapolate NR energy scale and F90 response from SCENE* to DS50



**Measurement of scintillation and ionization yield and scintillation pulse shape from nuclear recoils in liquid argon Phys. Rev. D 91, 092007 (2015)*

***CALIS - a CALibration Insertion System for the DarkSide-50 dark matter search experiment - Paper in Prep.*

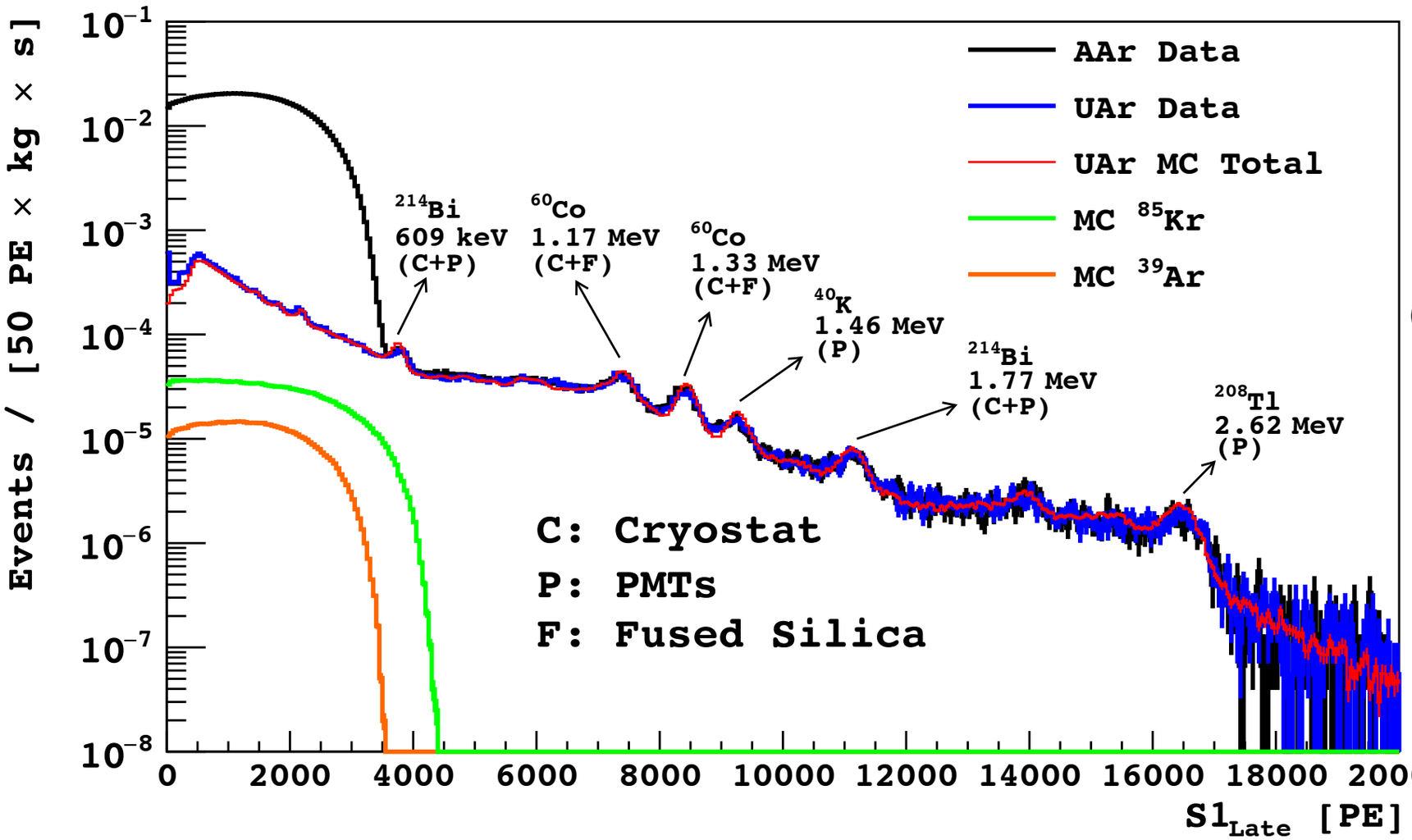
ER backgrounds

Multidimensional spectral fit of MC (g4ds*) on AAr data

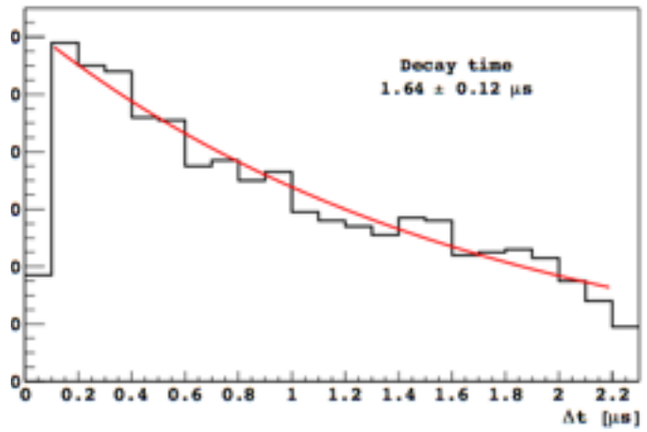
S1 spectrum with field on + S1 spectrum with field off + spatial distribution (z)

Repeat the fit on the UAr data

after subtracting background from radioisotopes in detector material from AAr fit



^{85}Kr contamination found and confirmed via delayed coincidence analysis.



*See P.Agnes talk "g4ds the DarkSide simulation tool" at UCLA DM 2016

^{39}Ar and ^{85}Kr background

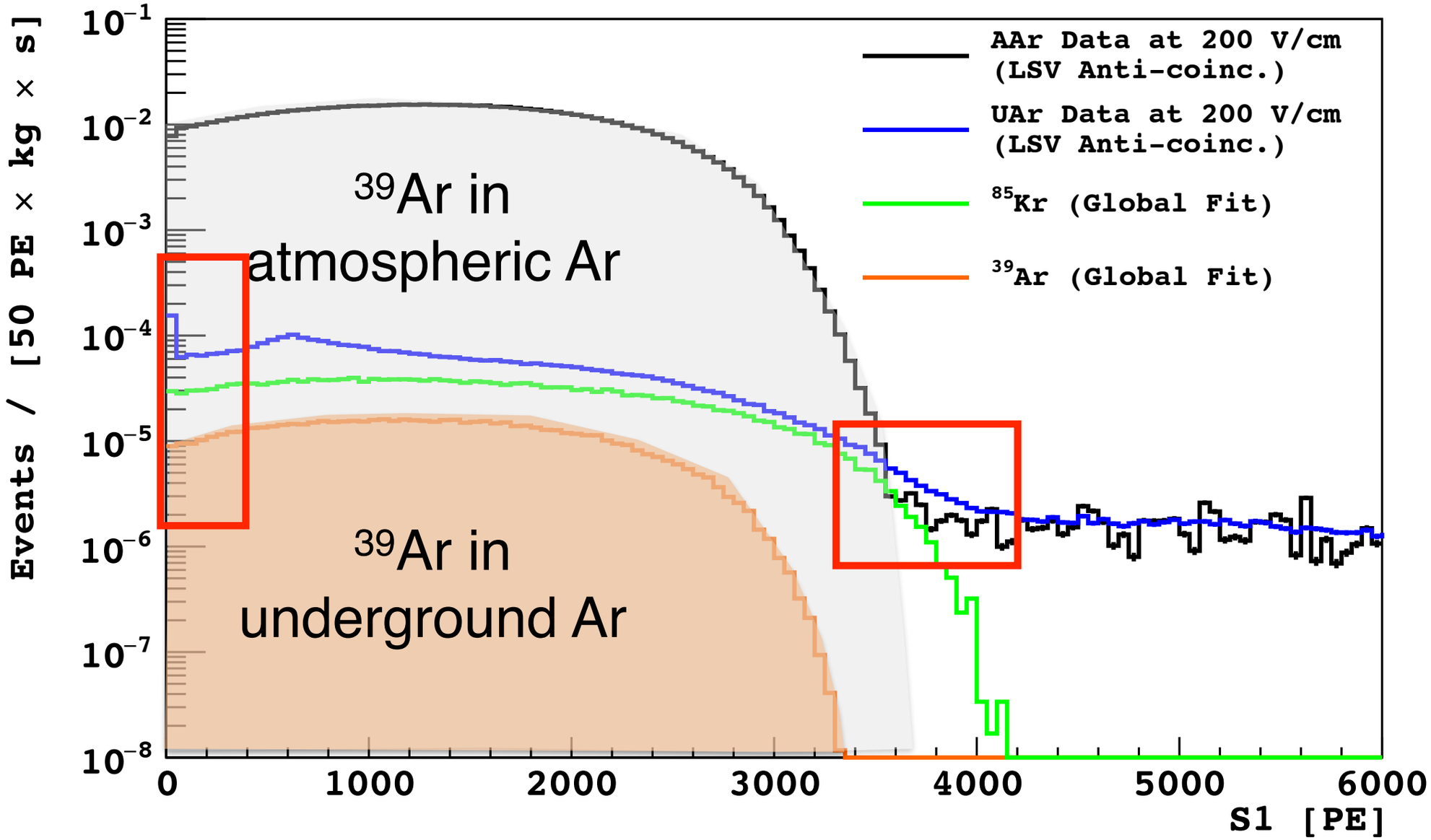
With respect to AAr:

> factor of **300** reduction of intrinsic radioactivity in UAr

~ factor of **1400** reduction of ^{39}Ar activity

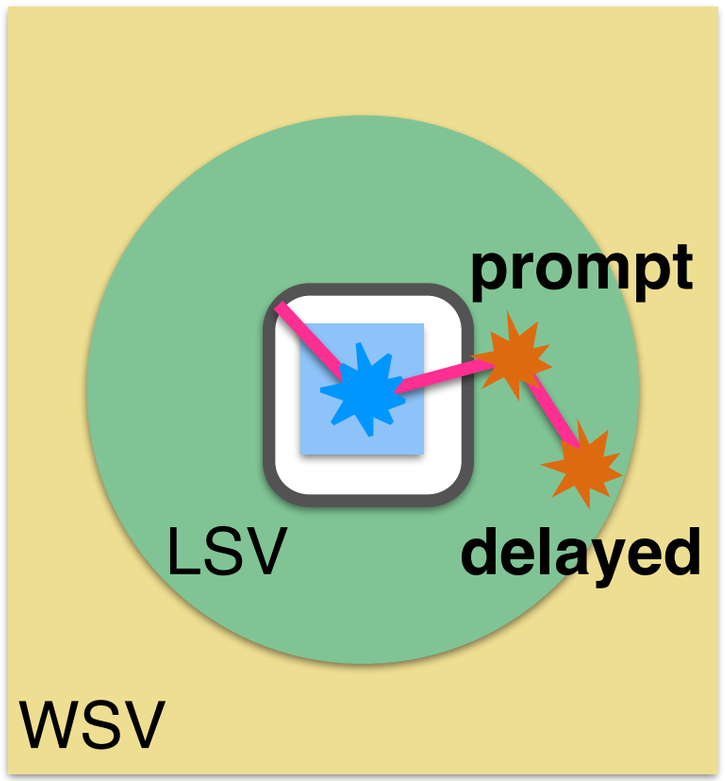
1000 mBq/kg

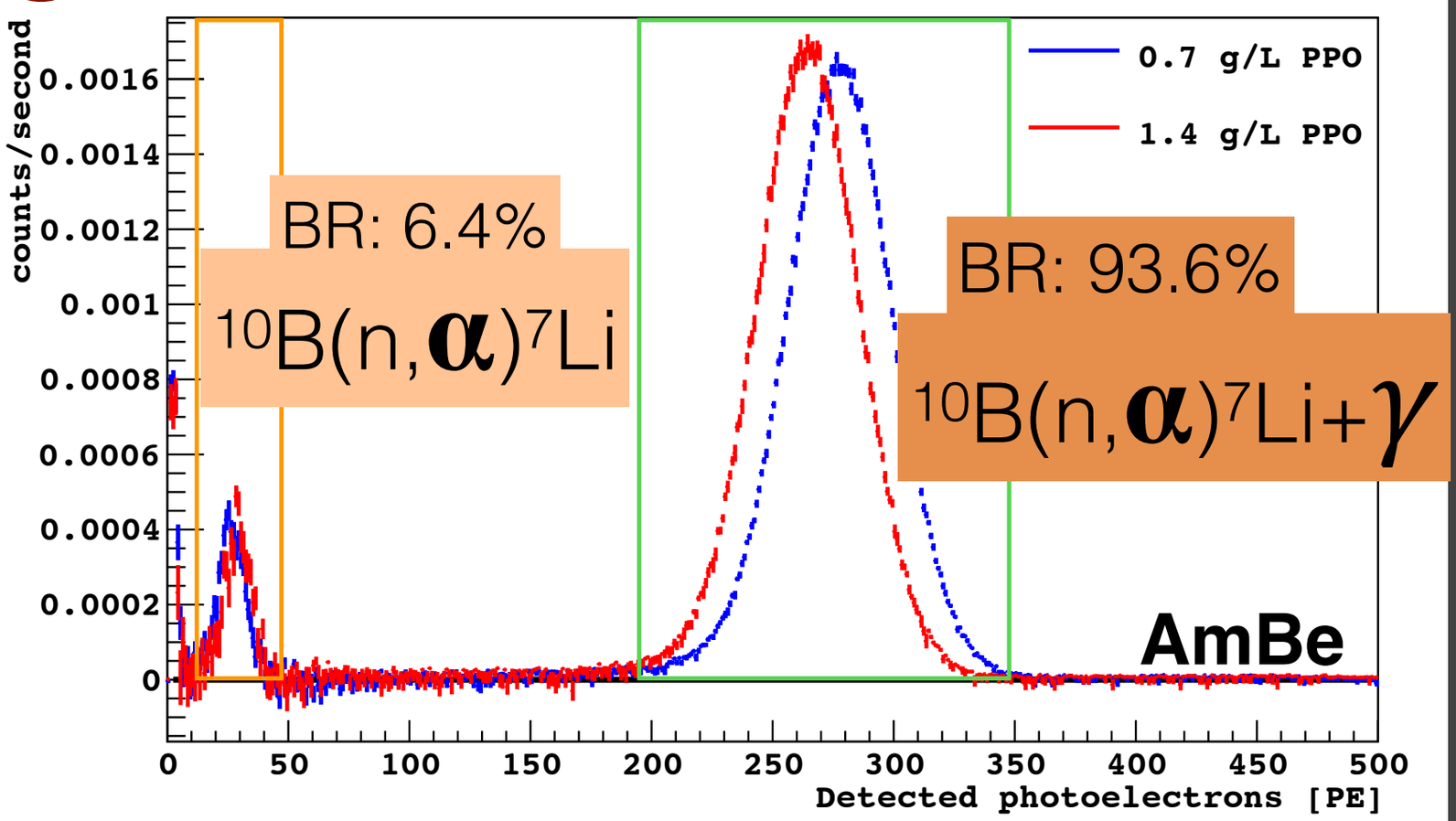
0.73± 0.11 mBq/kg



Background in ROI = ~50% β-events + ~50% of γ-events

Neutron background in 70d of UAr





>99.1% efficiency to veto radiogenic neutrons via delayed capture on ^{10}B and ^{1}H (AmBe + MC)

Tagged 1 neutron events in combined AAr + UAr data

(in agreement with MC prediction of 2±2)

Predicted <0.02 neutrons after veto cuts

Ongoing study: LSV Efficiency to tag neutron thermalization signal in prompt region using AmC calibration (custom made)

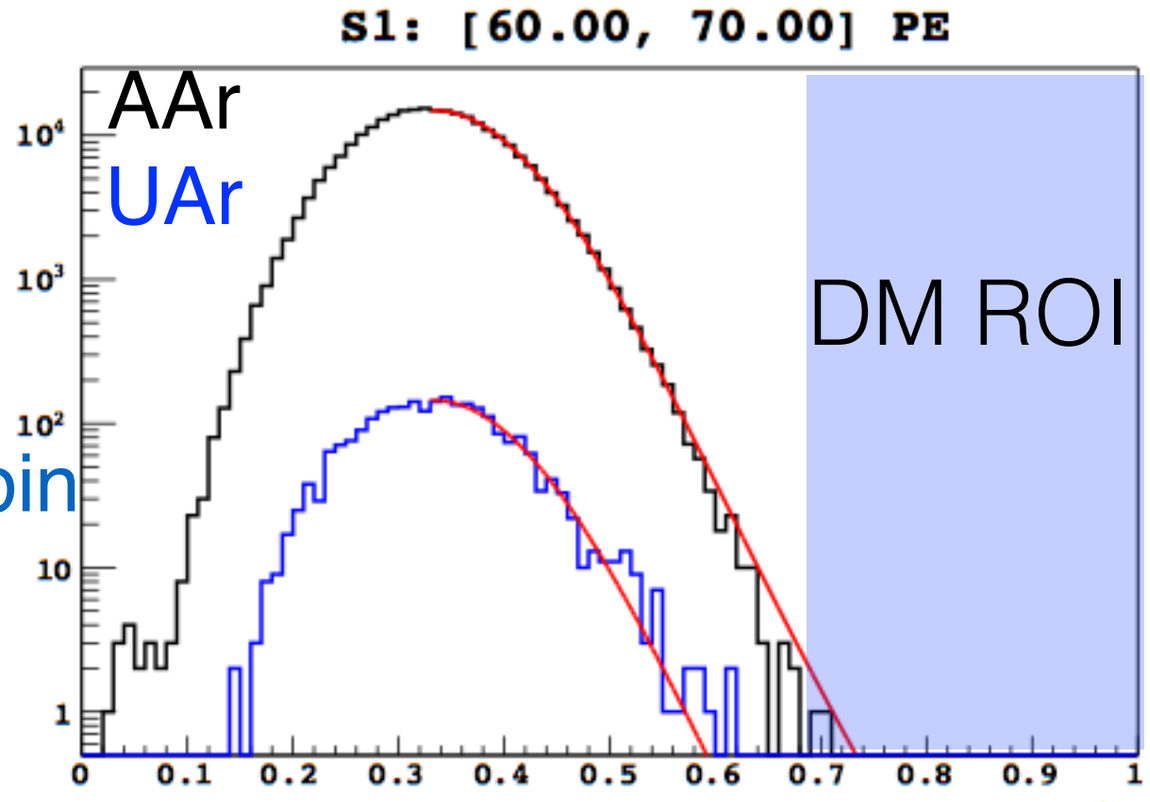
Pulse shape discrimination (f90) model

Use Hinkley analytic model for single scatters ERs

Fit to high statistics AAr data

Scale to UAr data

Derive 0.01 ER leakage events / S1 bin



For 70days of UAr:

- Dominant background are single scatters
- Unresolved multiple scatters have no visible impact (via MC)
- Hints of other spurious backgrounds but so low in statistics (they do not leak into ROI)
- Hinkley model as implemented overestimates the tails

Ongoing work: implement analytic models with improved treatment of statistics treatment; develop f90 models for other rare backgrounds

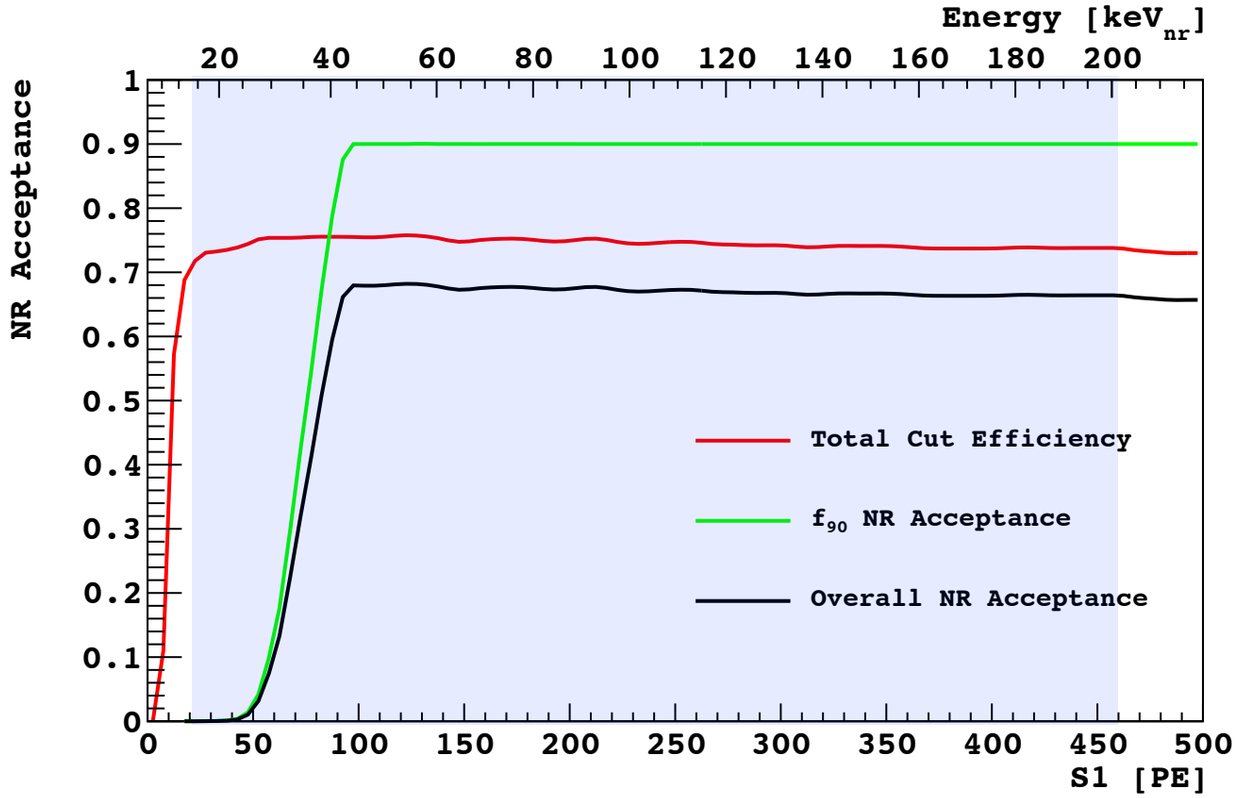
See talk of G.Koh at APS 2016;

Unblind analysis for 70d UAr

Select single scatters in 36.9 kg fiducial mass with:

- no abnormal clustering of S1 signal
- no prompt/delayed signal in LSV *major loss*
- no preceding μ-like event in LSV/WCV

Cut efficiencies evaluated via UAr data + AmBe data + MC

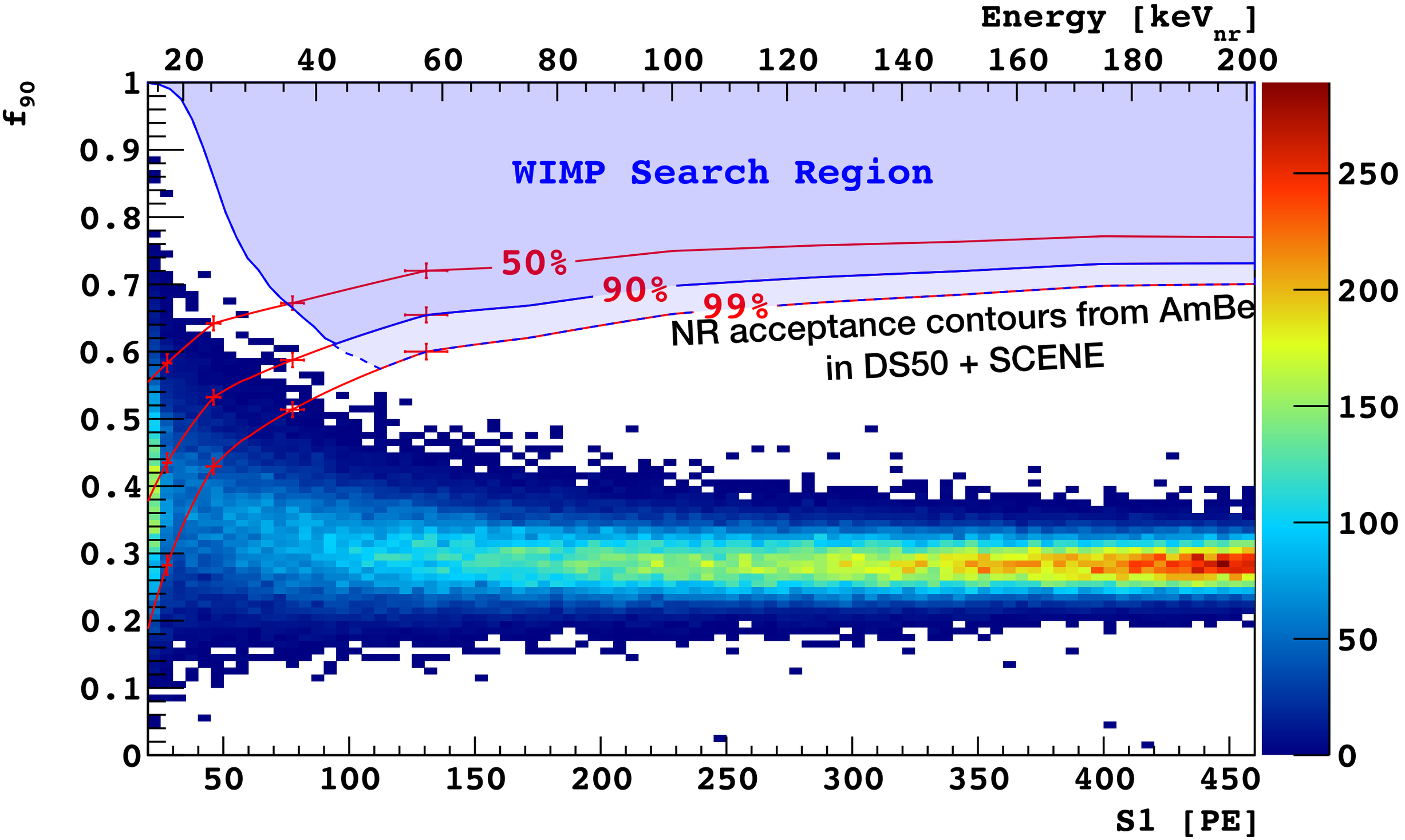


Fiducial volume cut only in z

no evidence of side surface backgrounds in or near ROI after all cuts in 70d exposure; ongoing analysis

Ongoing work: implement blind analysis but in multiple steps, use xy and S2/S1; optimize FV based on background

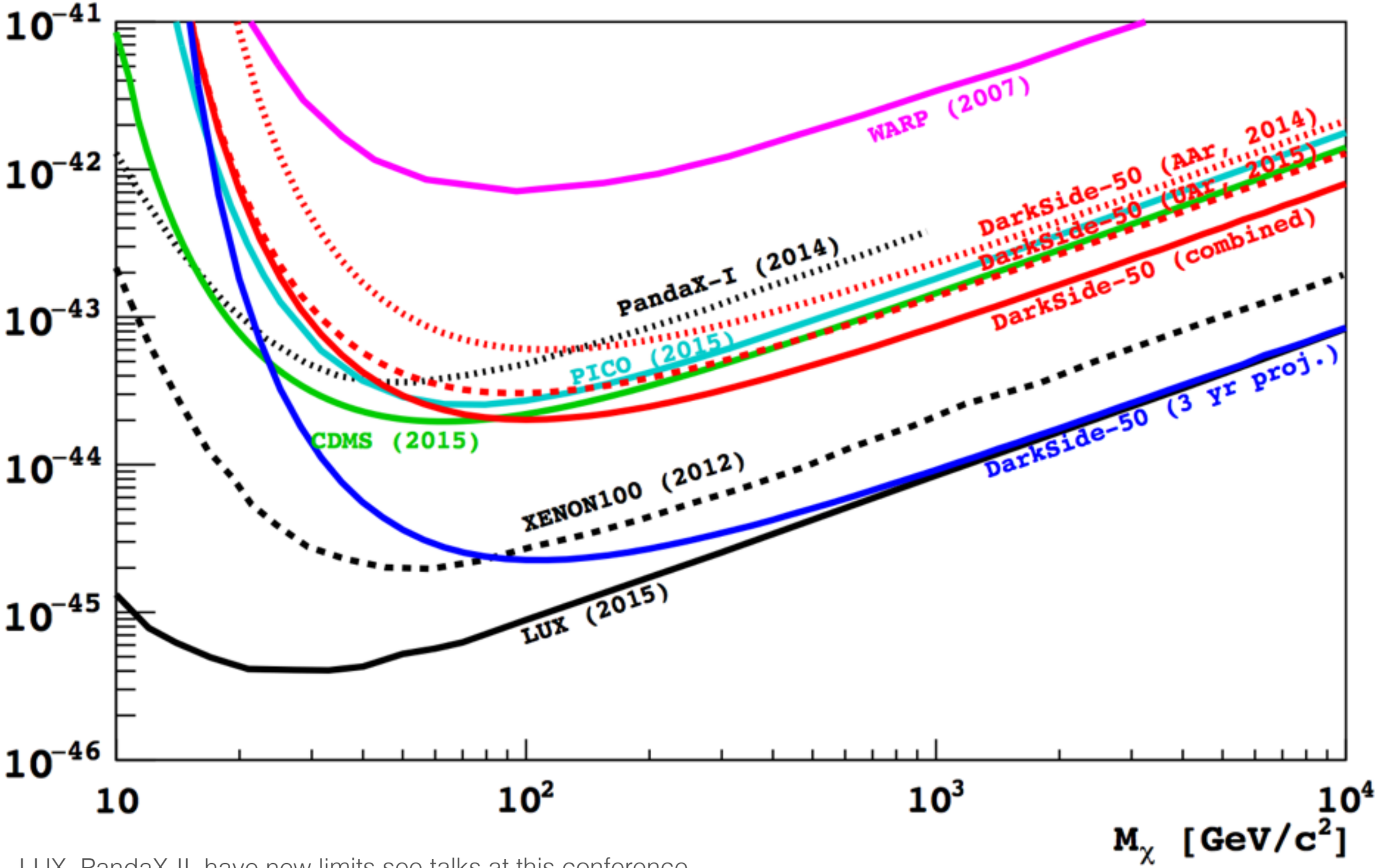
Dark Matter search data for 70d UAr



No events in the WIMP search region.

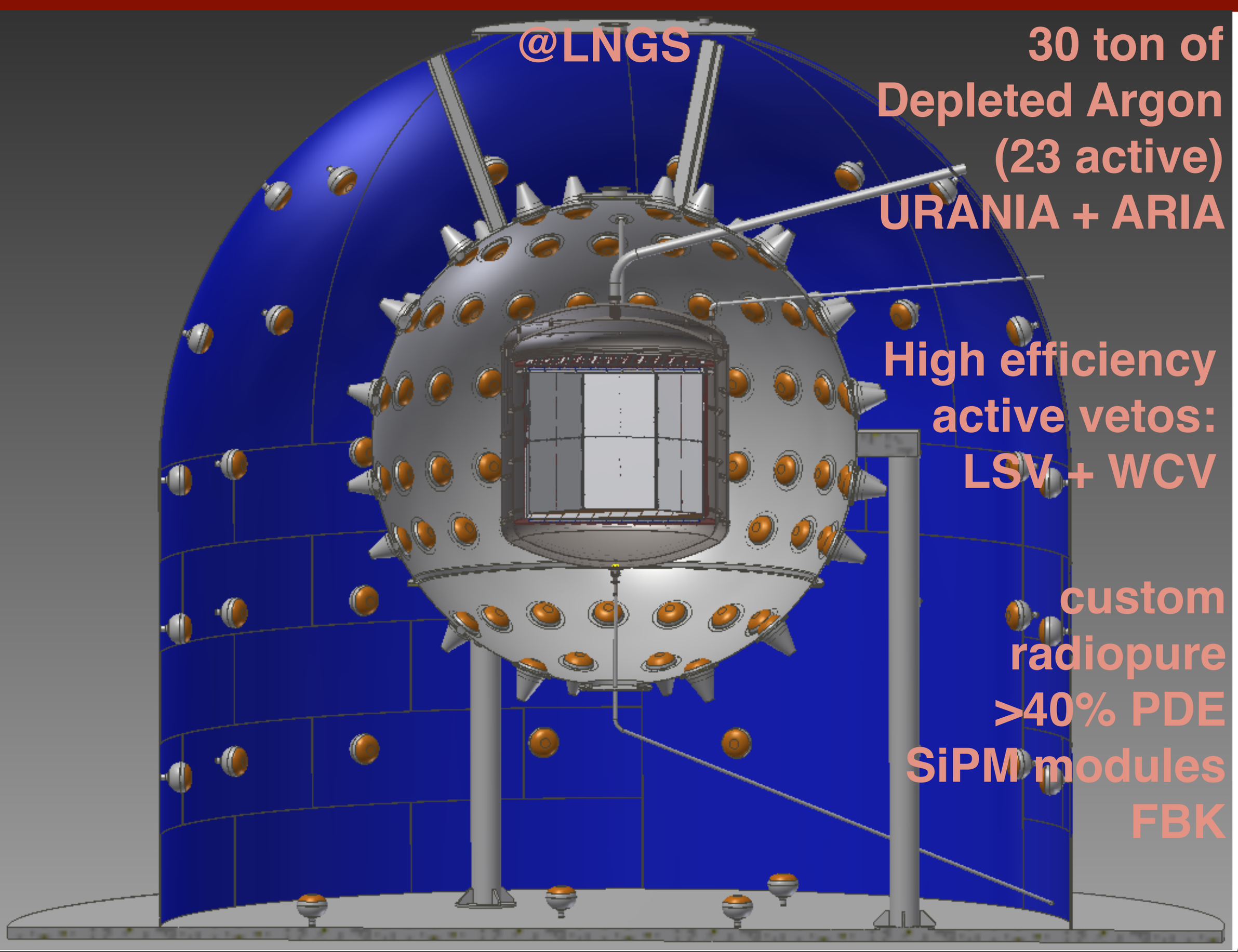
Results from the first use of low radioactivity argon in a dark matter search, Phys.Rev. D93, no.8, 08110 (2016)

Dark Matter search result and projection



LUX, PandaX-II have new limits see talks at this conference

Results from the first use of low radioactivity argon in a dark matter search, Phys.Rev. D93, no.8, 08110 (2016)



@LNGS

30 ton of
Depleted Argon
(23 active)
URANIA + ARIA

High efficiency
active vetos:
LSV + WCV

custom
radiopure
>40% PDE
SiPM modules
FBK

DarkSide-20k key points

Emilija Pantic (UC Davis) on DarkSide status at TeVPA 2016

see G.Fiorillo talk at IDM2016

see extra slides

Expected performance for 100t yr

use full g4ds simulation package

S1 light yield = 9PE/keV @200V/cm

PSD: f200 = fraction of light in the first 200ns

ER Background assumption:

internal β/γ: ^{39}Ar as in DS-50, ^{85}Kr is negligible

ν induced ER: @200 t yr

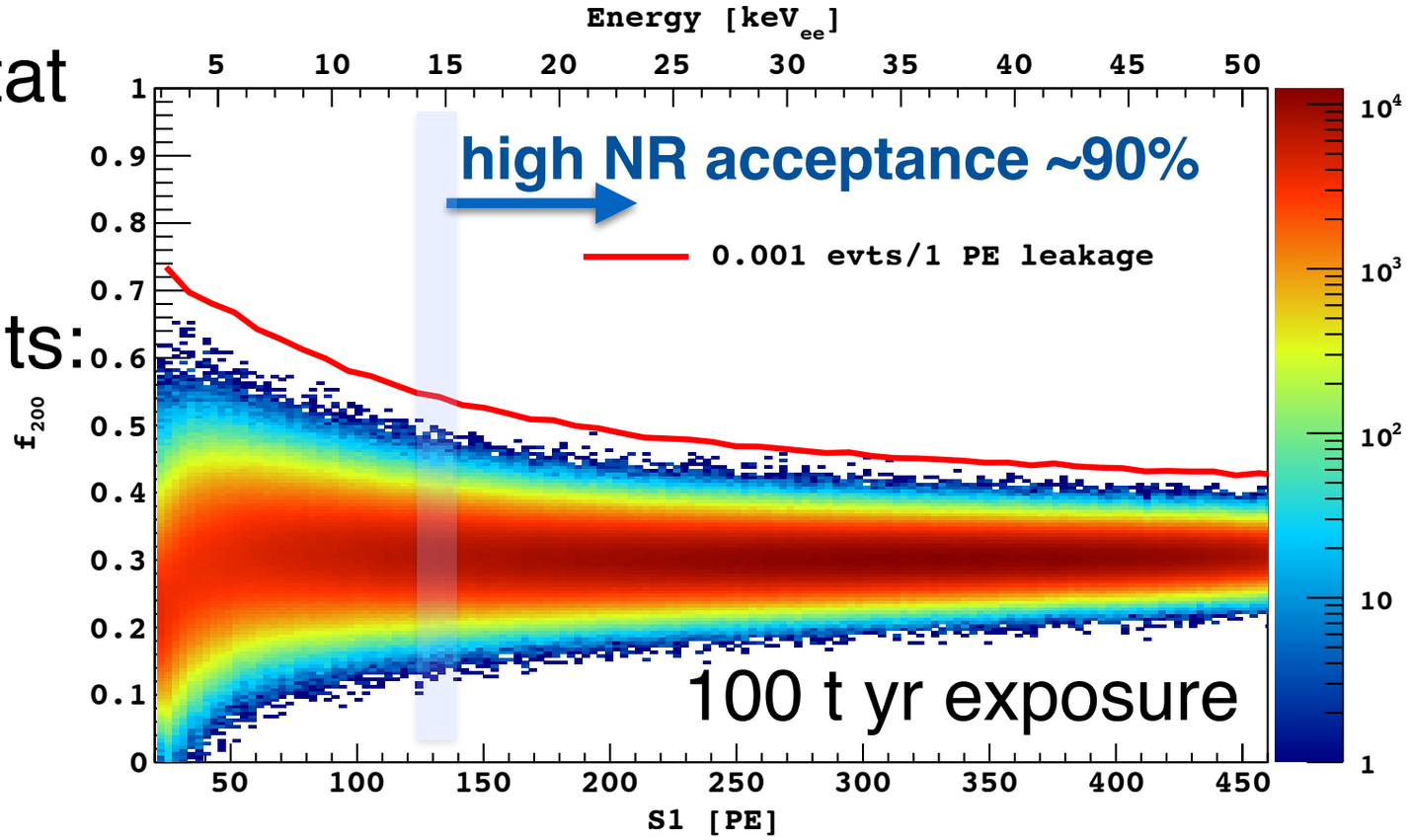
external β/γ from TPC/cryostat

NR Background after veto cuts:

radiogenic neutron <0.12 *

cosmogenic NR <0.1

ν induced NR <<

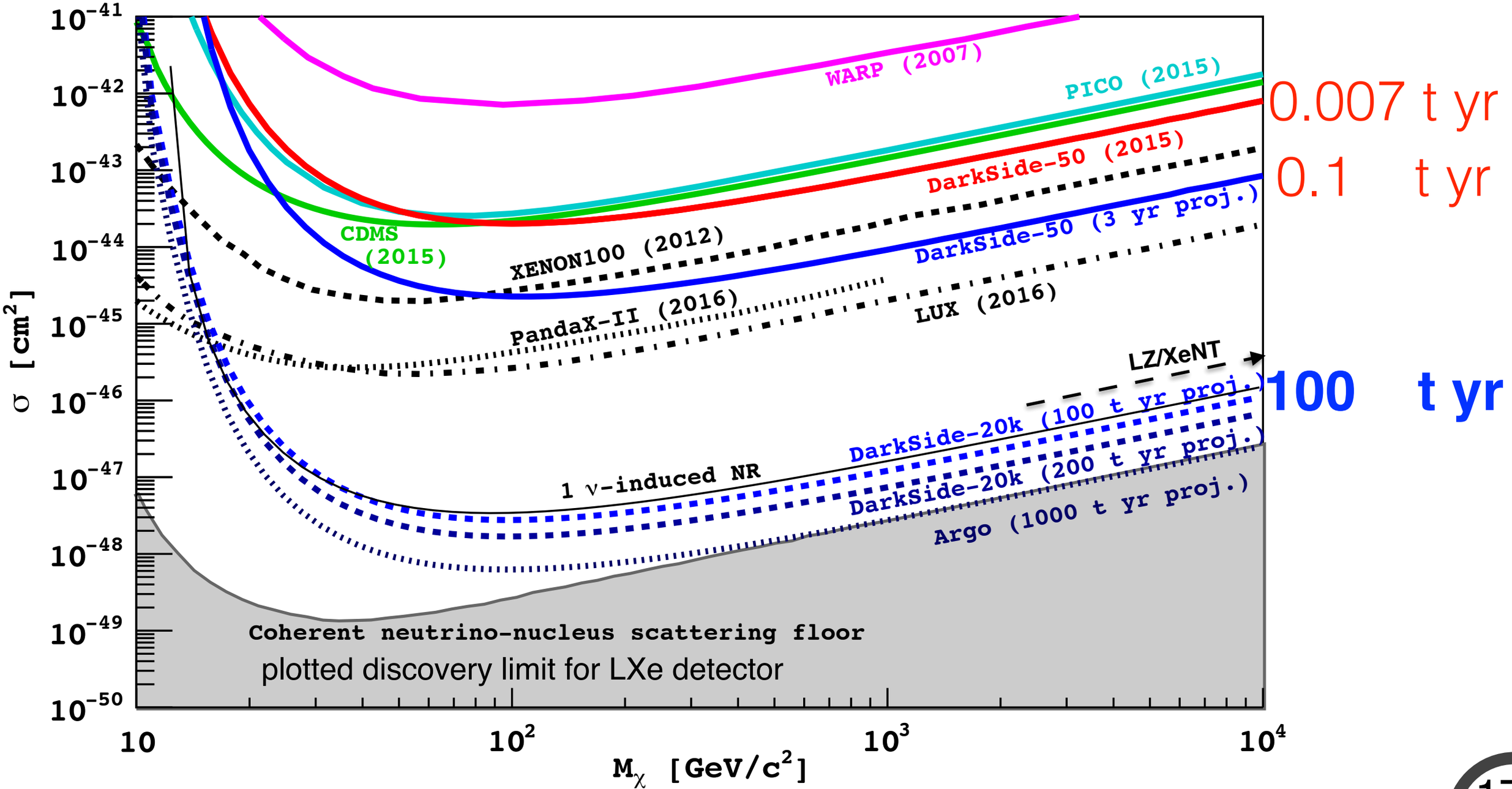


** dominant component from PTFE when using achieved upper limits -> more sensitive screening is underway*

Sensitivity of DarkSide-20k

Background-free exposure of 100 t yr
reaching 1.2 x10-47cm^2 at DM mass of 1TeV/c^2

(with ^{39}Ar level as in DS-50)



0.007 t yr

0.1 t yr

100 t yr

Summary

DARKSIDE collaboration:

Measured ^{39}Ar level in UAr to be factor 1400 smaller than in AAr.

Efficiency of the Neutron Veto via delayed capture is >99.1%.

More data for new DM search and investigation of rare backgrounds.
(Cherenkov events in coincidence with ER event)

DarkSide-50

Critical R&D facilities: URANIA, ARIS and SiPM modules, photo-electronics and prototype development are already underway.

Feasible to explore DM up to neutrino floor for M_{DM}>100GeV in background-free mode thanks to PSD against ν induced ERs and intrinsic/dissolved radioactive nuclei inducing ERs.

ARGO DarkSide-20k

300 t LAr TPC* conceived to reach 1000 t yr exposure for precision measurement of cosmic neutrinos and expanded reach of DM search

Solar neutrino detection in a large volume double-phase liquid argon experiment, JCAP 08 (2016)