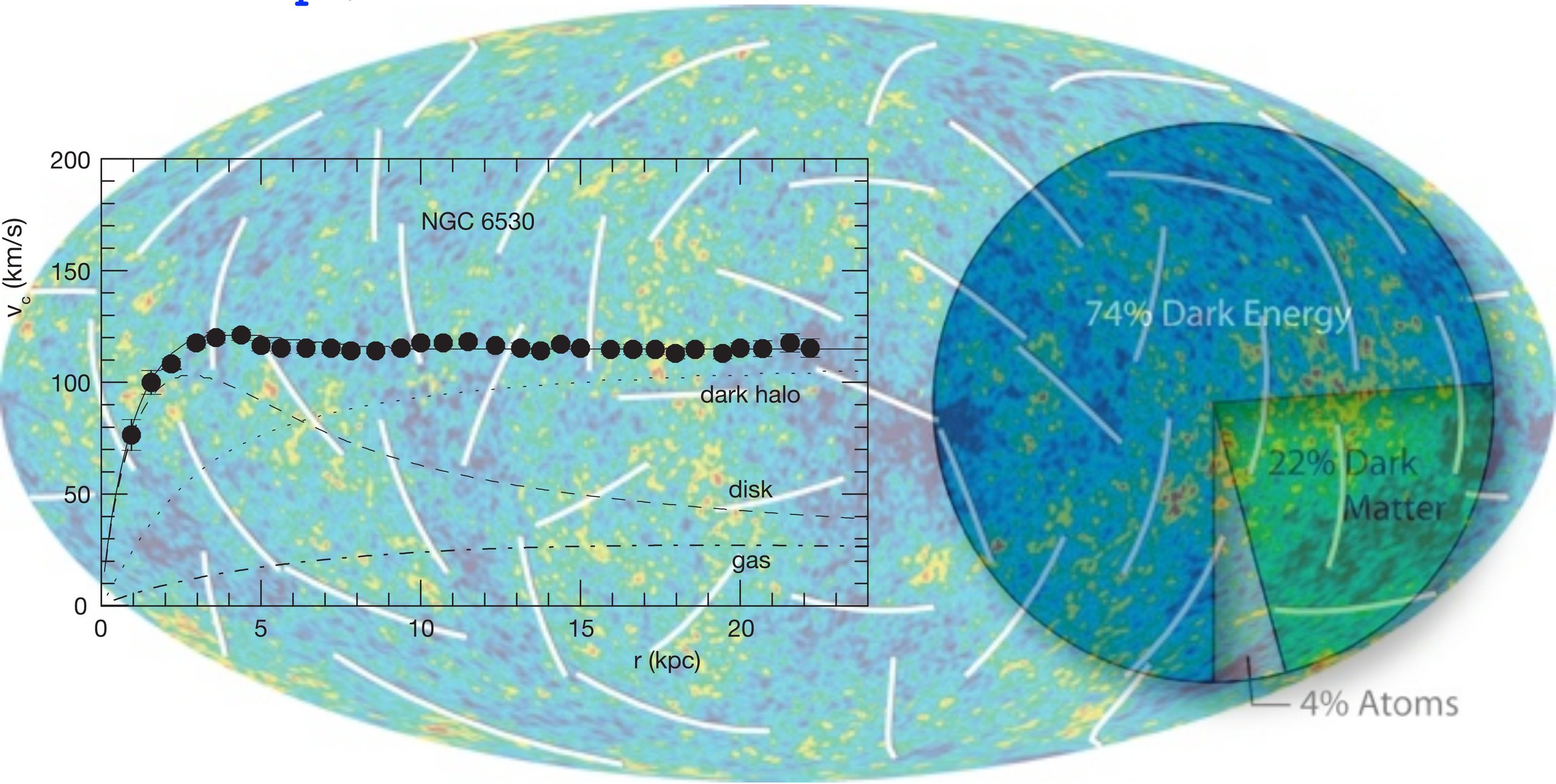
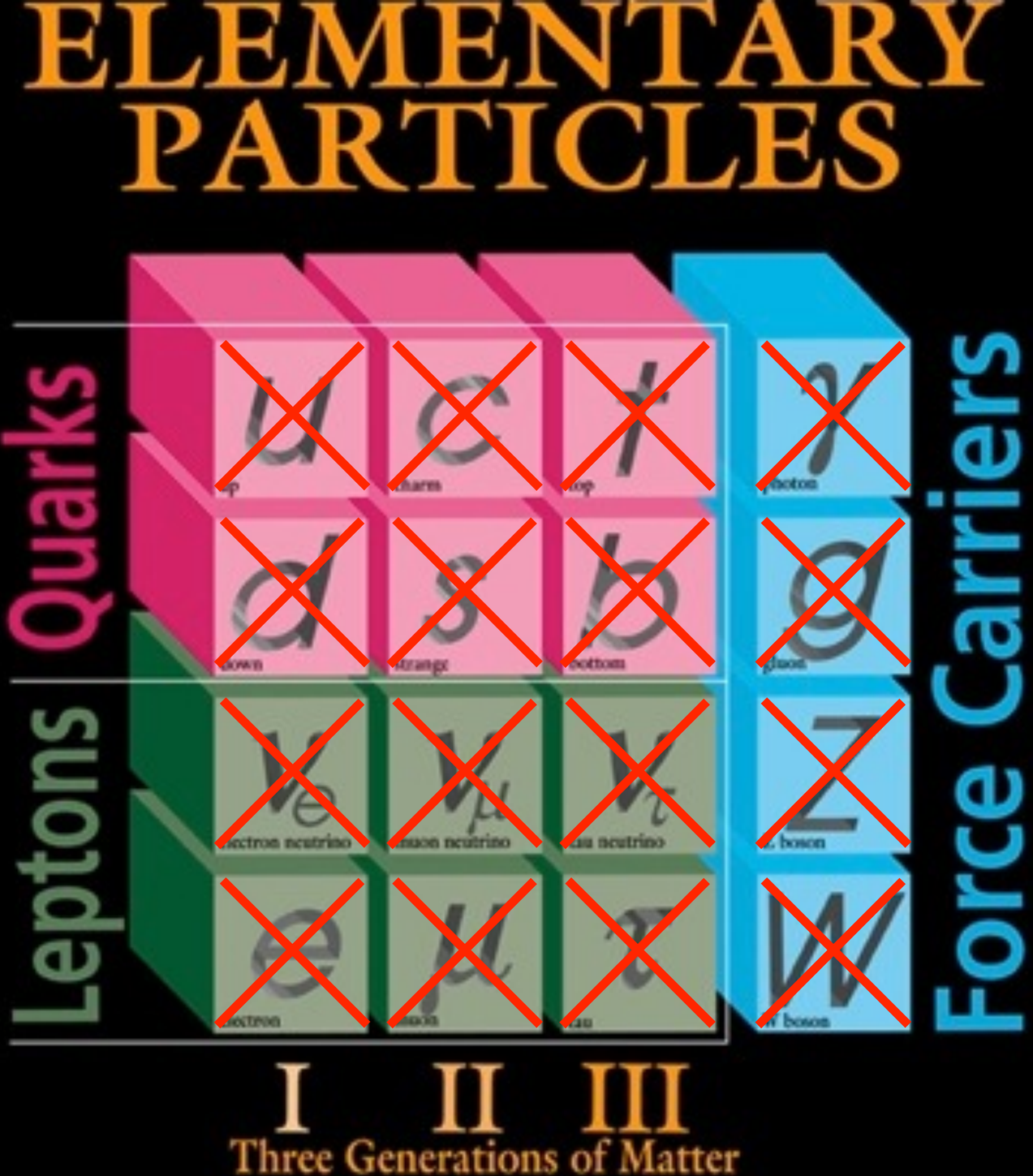
DarkSide

Cristiano Galbiati
Gran Sasso Science Institute and Princeton University
Seminar at CPPM
Marseille
September 24, 2018

Fuchs astro-ph/9812048

WMAP 2006



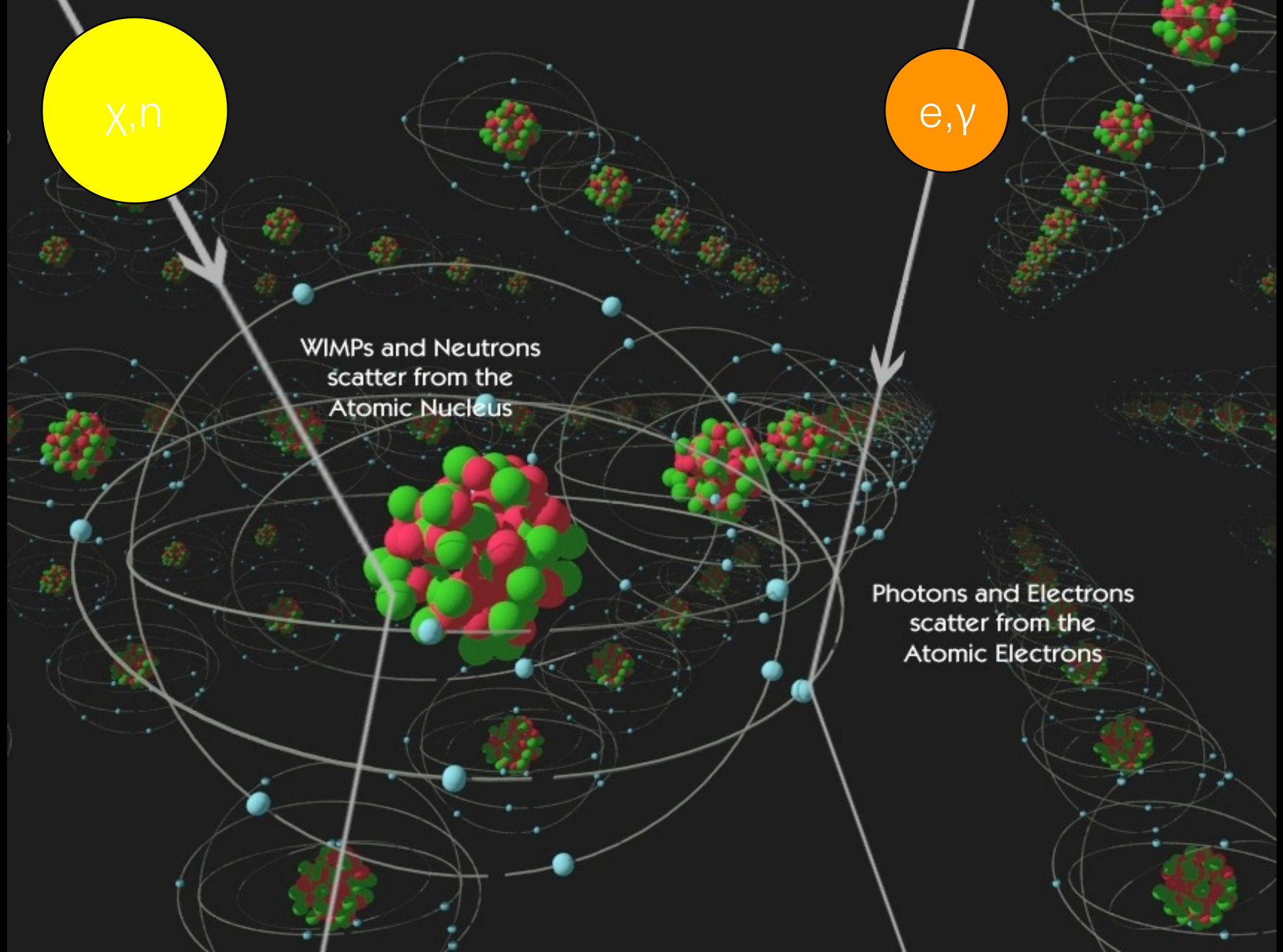


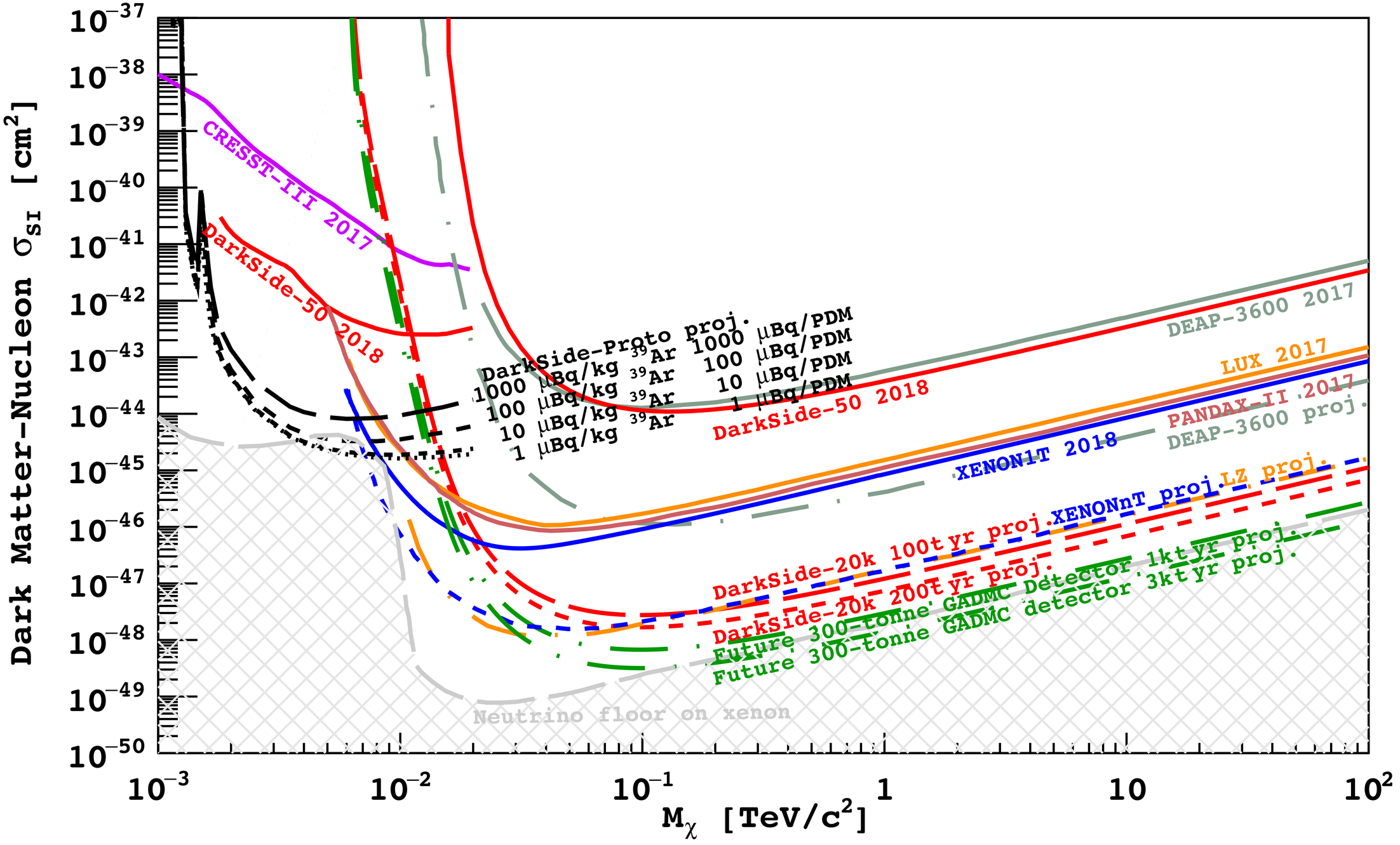
Has gravitational interactions

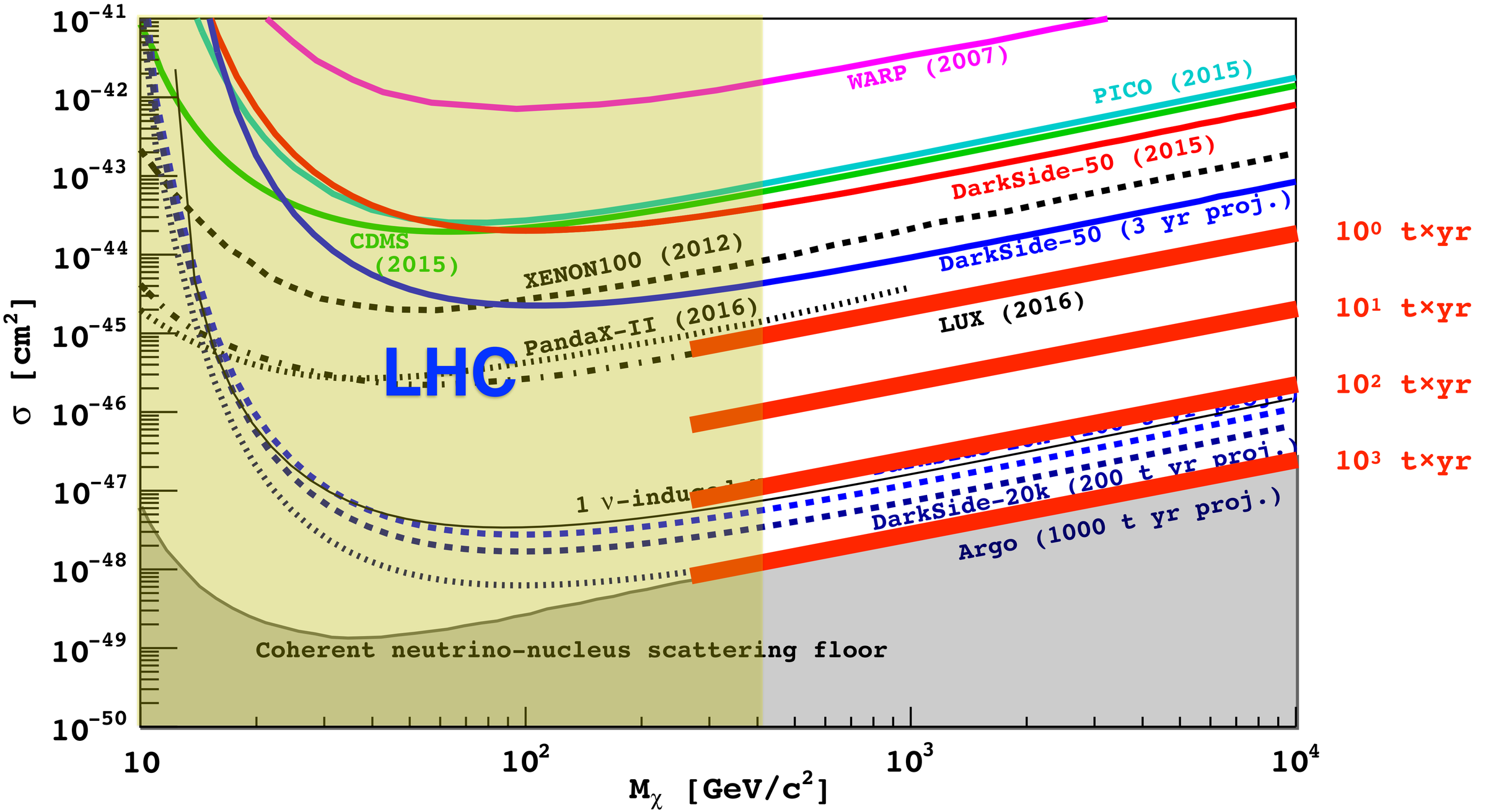
Is long lived

Is cold

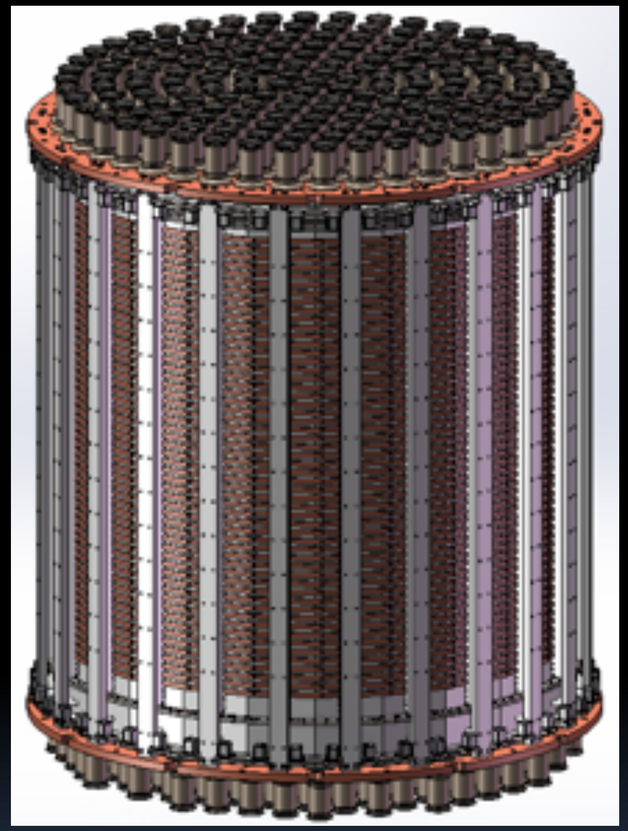
Is not baryonic

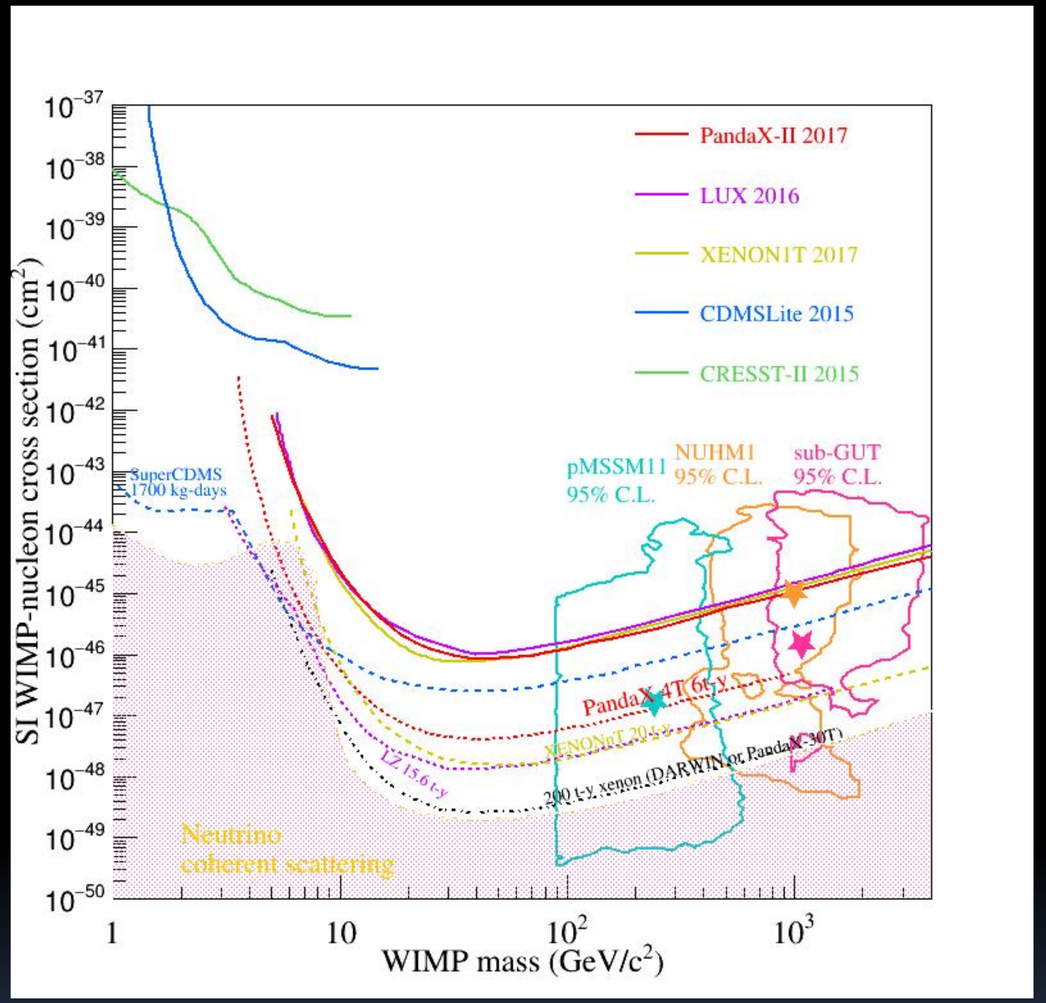

χ,n
e,γ
WIMPs and Neutrons
scatter from the
Atomic Nucleus
Photons and Electrons
scatter from the
Atomic Electrons


Dark Matter-Nucleon σ_{SI} [cm^2]
10^{-37}
10^{-38}
10^{-39}
10^{-40}
10^{-41}
10^{-42}
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10^{-47}
10^{-48}
10^{-49}
10^{-50}
10^{-3}
10^{-2}
10^{-1}
1
10
10^{2}
M_χ [TeV/c^2]
CRESST-III 2017
DarkSide-50 2018
DarkSide-Proto proj.
1000 μBq/kg ^{39}Ar 1000 μBq/PDM
100 μBq/kg ^{39}Ar 100 μBq/PDM
10 μBq/kg ^{39}Ar 10 μBq/PDM
1 μBq/kg ^{39}Ar 1 μBq/PDM
DarkSide-50 2018
DEAP-3600 2017
LUX 2017
PANDAX-II 2017
XENON1T 2018
DEAP-3600 proj.
DarkSide-20k 100t yr proj.
XENONnT proj.
LZ proj.
DarkSide-20k 200t yr proj.
Future 300-tonne GADMC Detector 1kt yr proj.
Future 300-tonne GADMC detector 3kt yr proj.
Neutrino floor on xenon


WARP (2007)
PICO (2015)
DarkSide-50 (2015)
DarkSide-50 (3 yr proj.)
CDMS (2015)
XENON100 (2012)
PandaX-II (2016)
LUX (2016)
LHC
1 ν-induced
DarkSide-20k (200 t yr proj.)
Argo (1000 t yr proj.)
Coherent neutrino-nucleus scattering floor
10^0 t×yr
10^1 t×yr
10^2 t×yr
10^3 t×yr
σ [cm^2]
M_χ [GeV/c^2]
10^-41
10^-42
10^-43
10^-44
10^-45
10^-46
10^-47
10^-48
10^-49
10^-50
10
10^2
10^3
10^4

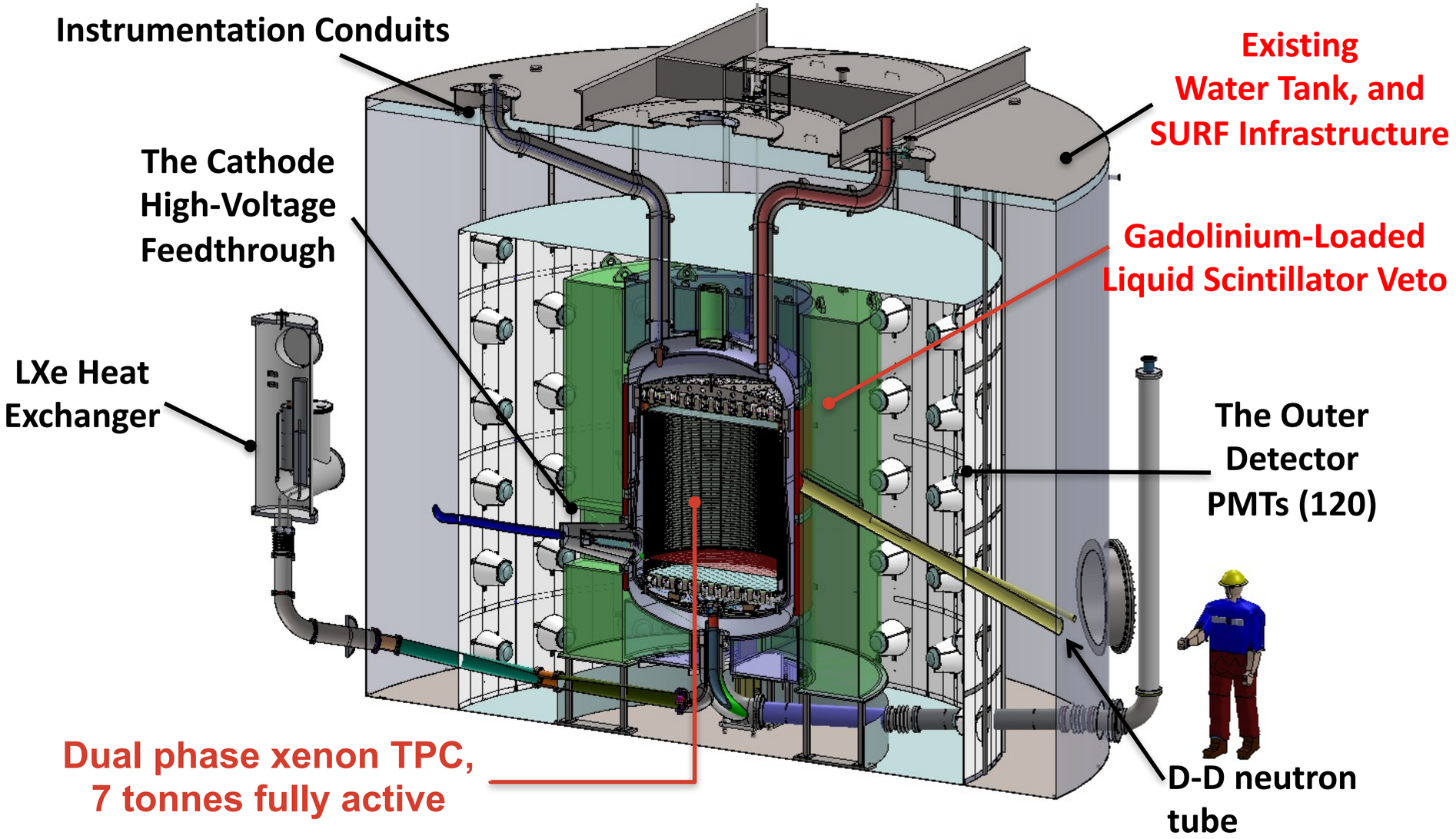
PandaX-xT





- Intermediate stage:
  - **PandaX-4T** (4-ton target) with SI sensitivity ~10^{-47} cm^2
  - On-site assembly and commissioning: 2019-2020

The LUX-ZEPLIN detector



LZ backgrounds summary

5.6 tonnes, 1000 days

Intrinsic Contamination Backgrounds	ER (cts)	NR (cts) (w/ SF rej.)
Subtotal (Detector Components)	**9**	**0.072**
222Rn (1.81 μBq/kg)	681	-
220Rn (0.09 μBq/kg)	111	-
natKr (0.015 ppt g/g)	25	-
natAr (0.45 ppb g/g)	2	-
210Bi (0.1 μBq/kg)	40	-
Laboratory and Cosmogenics	5	0.06
Fixed Surface Contamination	0	0.39
Subtotal (Non-ν counts)	**873**	**0.52**
Physics Backgrounds		
136Xe 2νββ	67	0
Astrophysical ν counts (pp+7Be+13N)	255	0
Astrophysical ν counts (8B)	0	0**
Astrophysical ν counts (Hep)	0	0.21
Astrophysical ν counts (diffuse	0	0.05
Astrophysical ν counts (atmospheric)	0	0.46
Subtotal (Physics backgrounds)	322	0.72
Total	1,190	1.24
Total (with 99.5% ER discrimination,	5.97	0.62
	6.59	

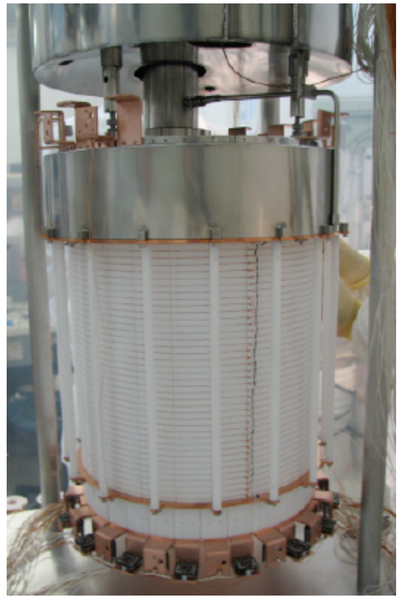
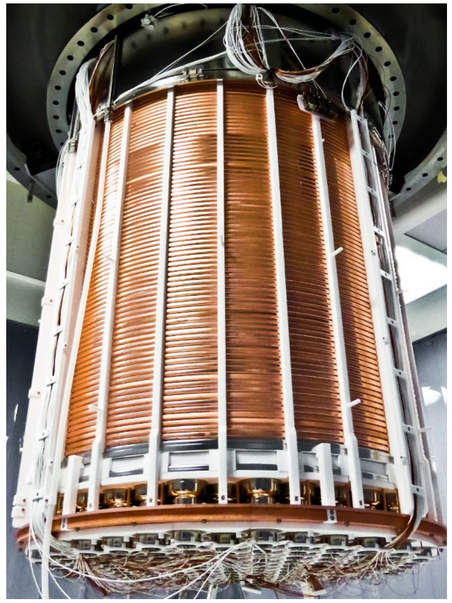
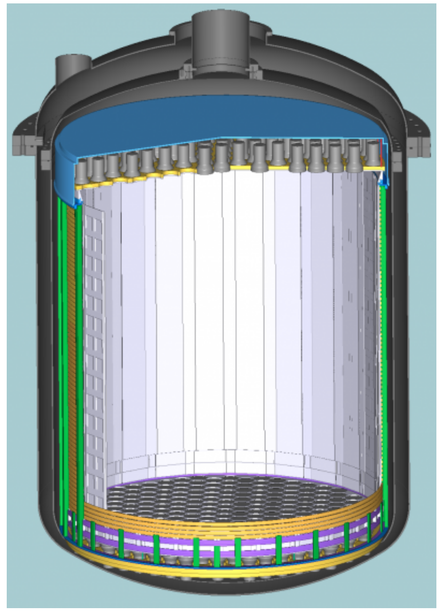
Radon dominates ER backgrounds

Gamma backgrounds (PMTs, cryostat) are negligible.

pp solar neutrinos, elastic scattering on atomic electrons

Coherent neutrino scattering on xenon nuclei

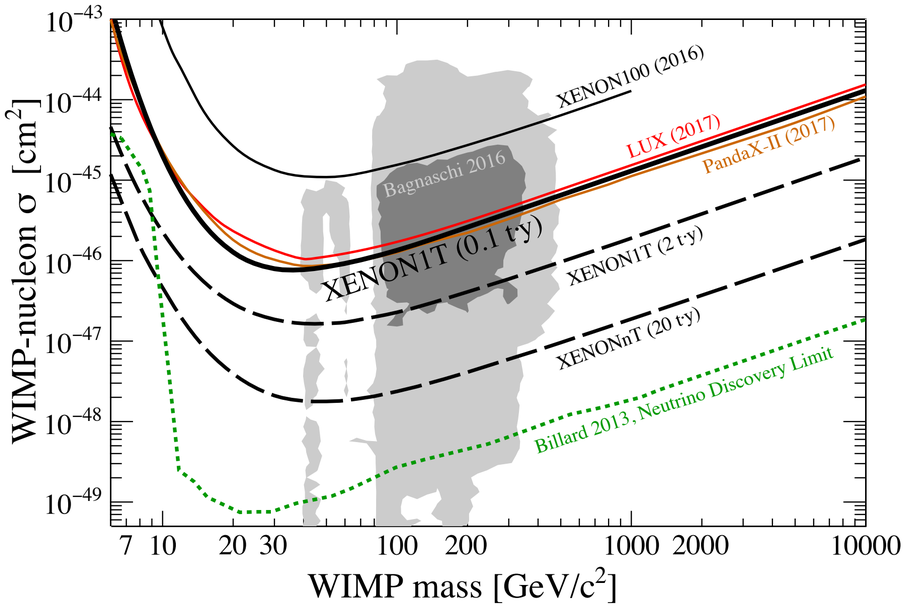
The phases of the XENON Program

XENON10	XENON100	XENON1T	XENONnT
			
2005-2007	2008-2016	2012-2018	2019-2023
25 kg- 15cm drift	161 kg- 30 cm drift	3200 kg- 100 cm drift	8000 kg-150 cm drift
~10^{-43} cm^2	~10^{-45} cm^2	~10^{-47} cm^2	~10^{-48} cm^2

XENON1T and XENONnT science reach

- XENON1T: 1.6 x 10^{-47} cm^2 with an exposure of 2 tonnes x year
- XENONnT: to start in mid 2019, aiming for 20 tonnes x year exposure

	XENON1T	XENONnT	LZ
Fiducial Volume [tons]	1	4	5.6
Livetime Fraction	80%	80%	80%
WIMP Energy Range [keV_{nr}]	4-50	4-50	6-30
NR Acceptance	40%	40%	50%
ER Rejection	99.75%	99.75%	99.5%
Bkg rate [evt/year]	2.08	1.15	2.35



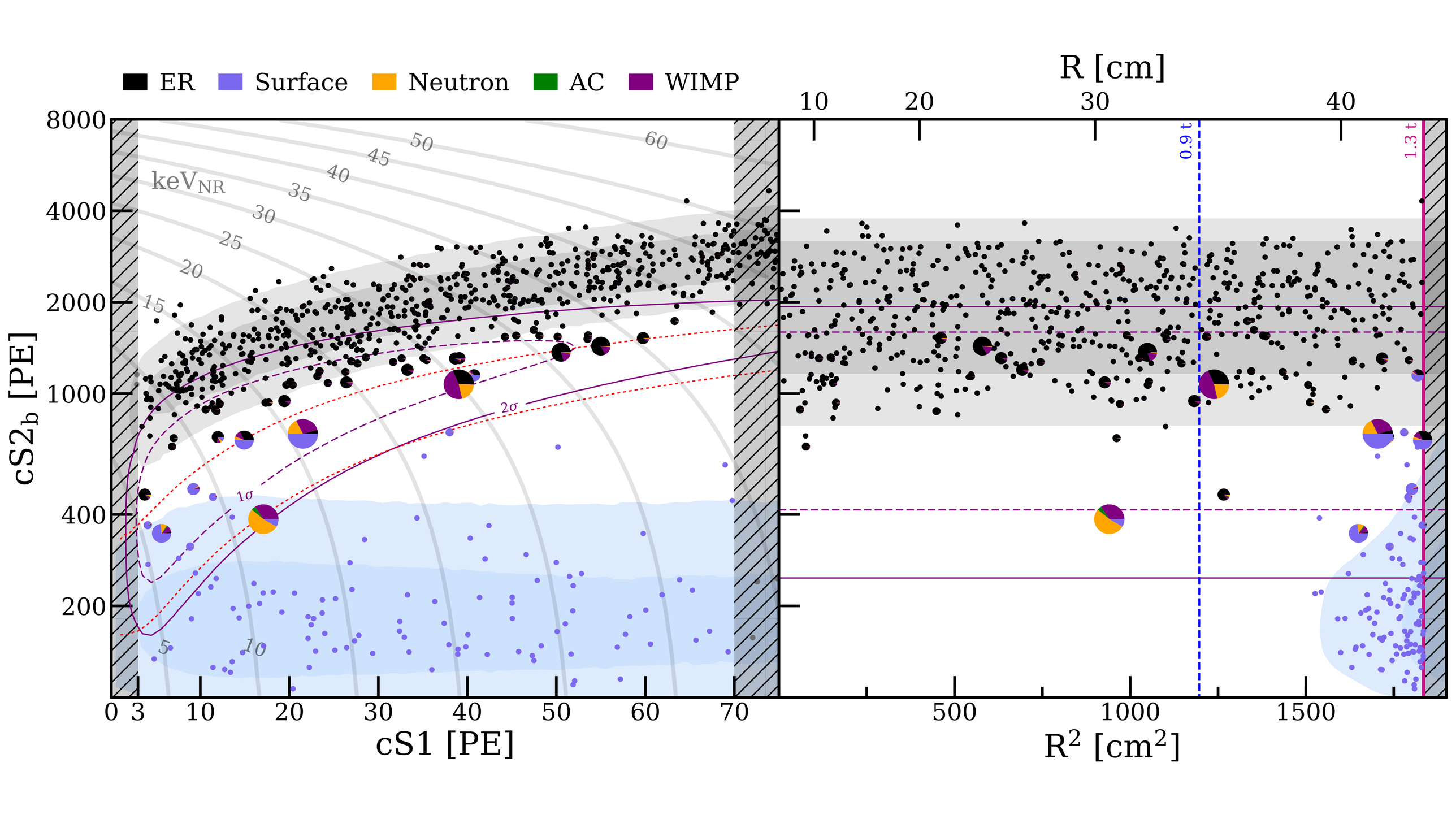
Background prediction and Unblinding

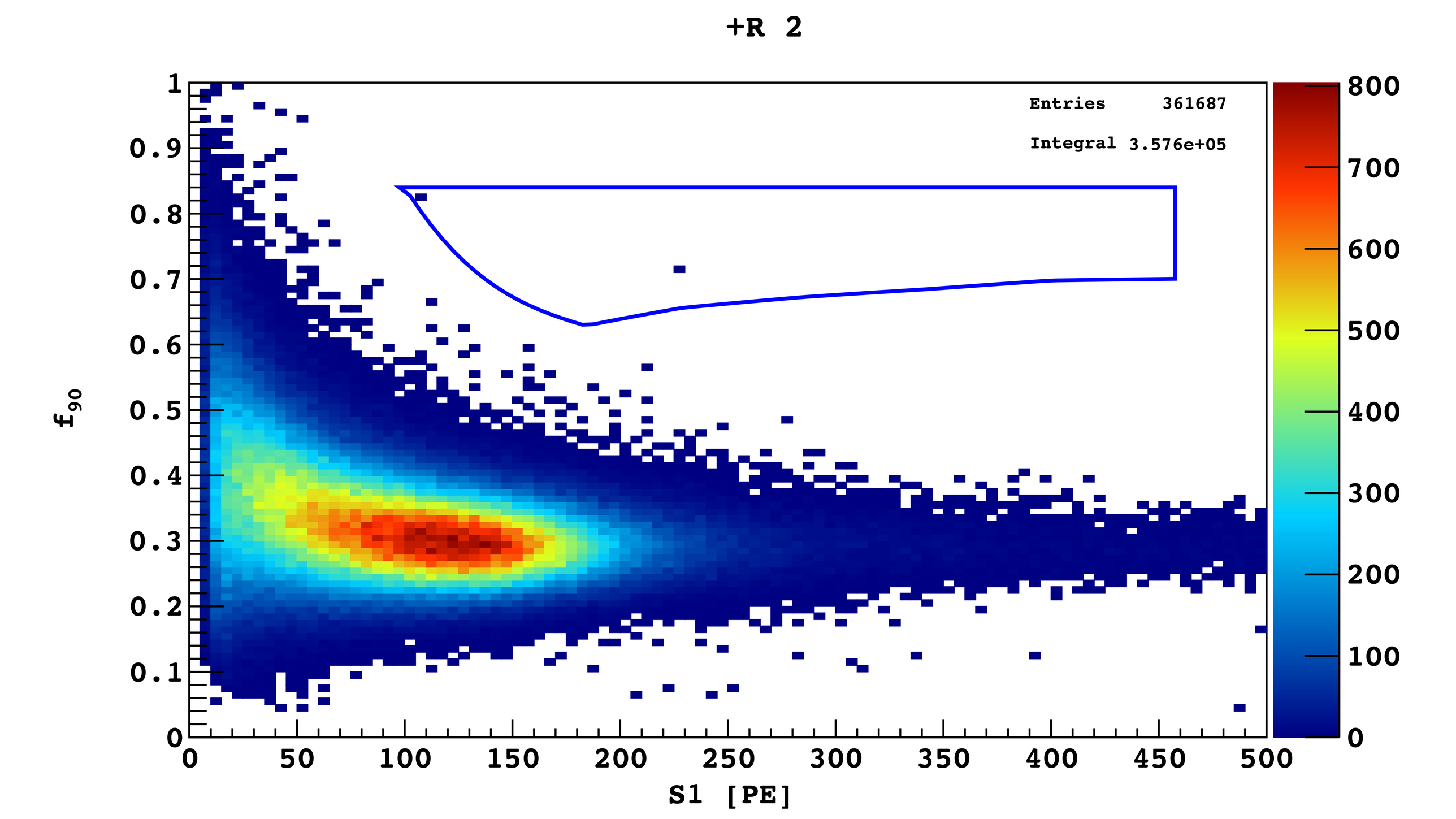
Mass	1.3t	1.3t
(S2, S1)	Full	Reference
ER	627±26	2.2±0.1
Neutron	1.4±0.6	0.8±0.3
CENNS	0.05±0.02	0.02±0.01
AC	0.47±0.15	0.10±0.03
Surface	106±11	5.4±0.5
BG	736±28	8.4±0.6
Data	**739**	**11**
WIMPs best-fit (200GeV)	3.36	1.55

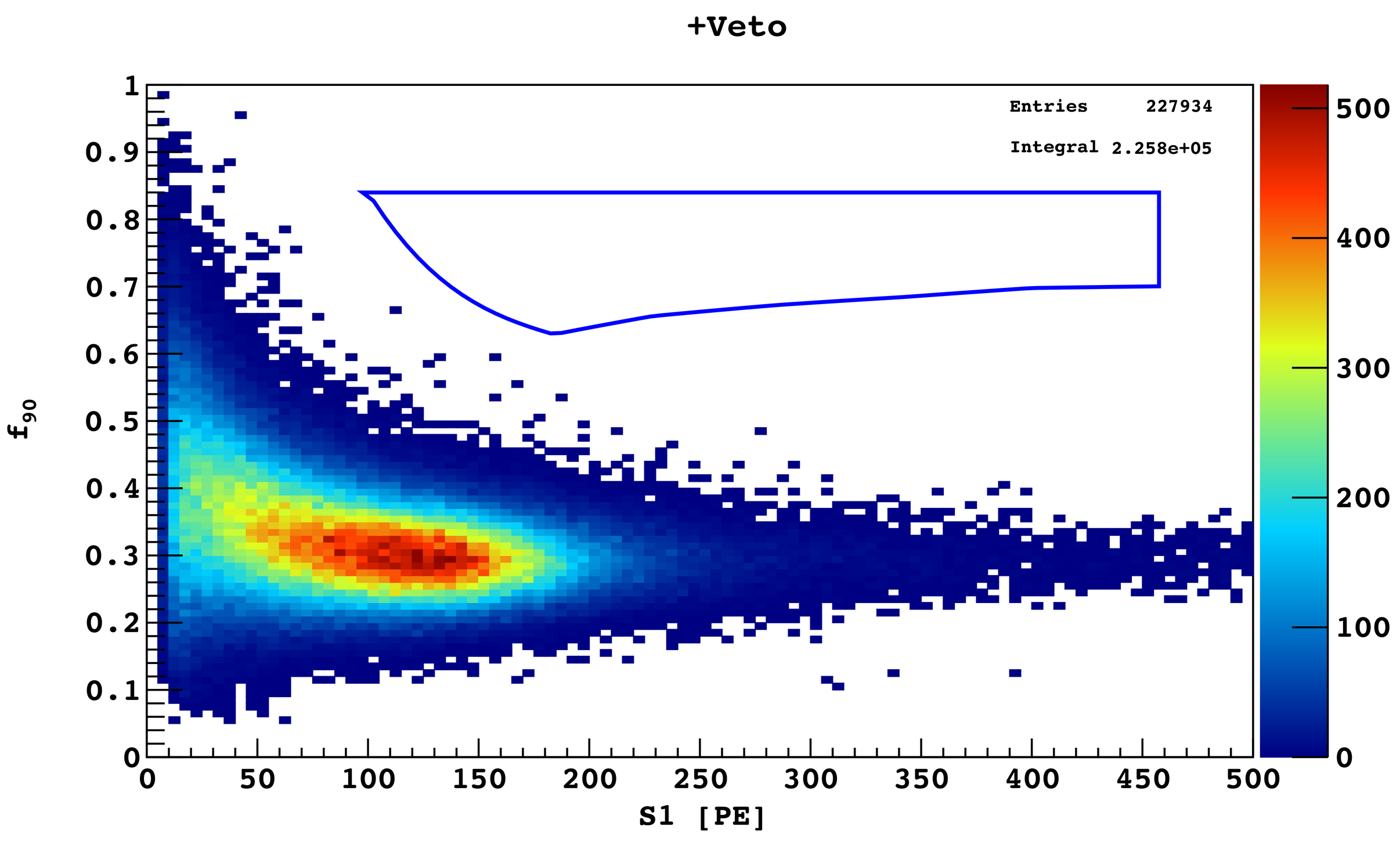
- Reference region is defined as between NR median and NR - 2sigma
- ER is the most significant background and uniformly distributed in the volume
- Surface background contributes most in reference region, but its impact is subdominant in inner R
- Neutron background is less than one event, and impact is further suppressed by position information
- Other background components are completely sub-dominant
- Numbers in the table are just for illustration, statistical interpretation is done based on profile likelihood analysis

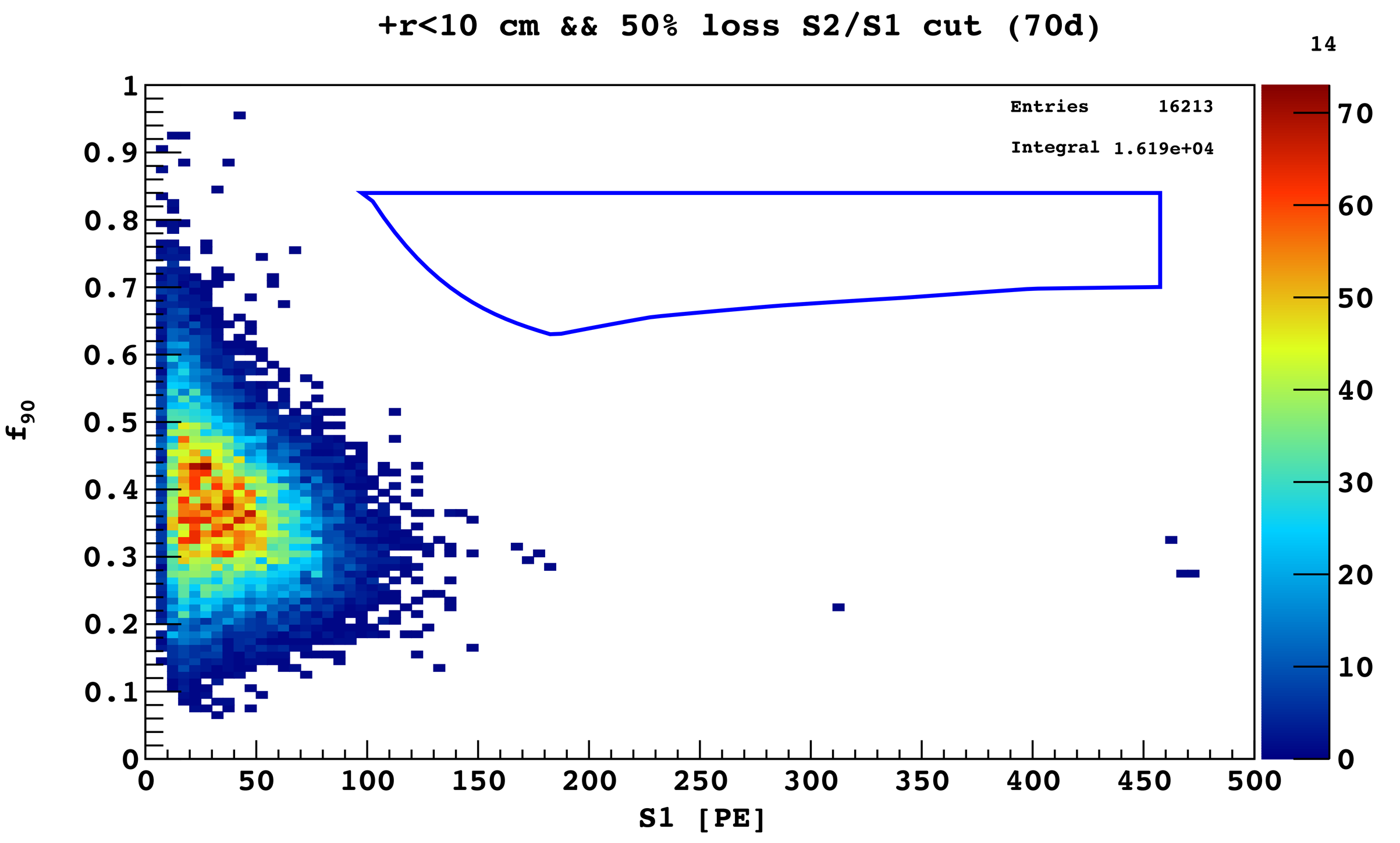
TABLE I: Best-fit expected event rates with 278.8 days live-time in the 1.3 t fiducial mass, 0.9 t reference mass, and 0.65 t core mass, for the full (cS1, $cS2_b$) ROI and, for illustration, in the NR signal reference region. The table lists each background (BG) component separately and in total, the observed data, and the expectation for a 200 GeV/c^2 WIMP prediction assuming the best-fit $\sigma_{SI} = 4.7 \times 10^{-47}$ cm^2.

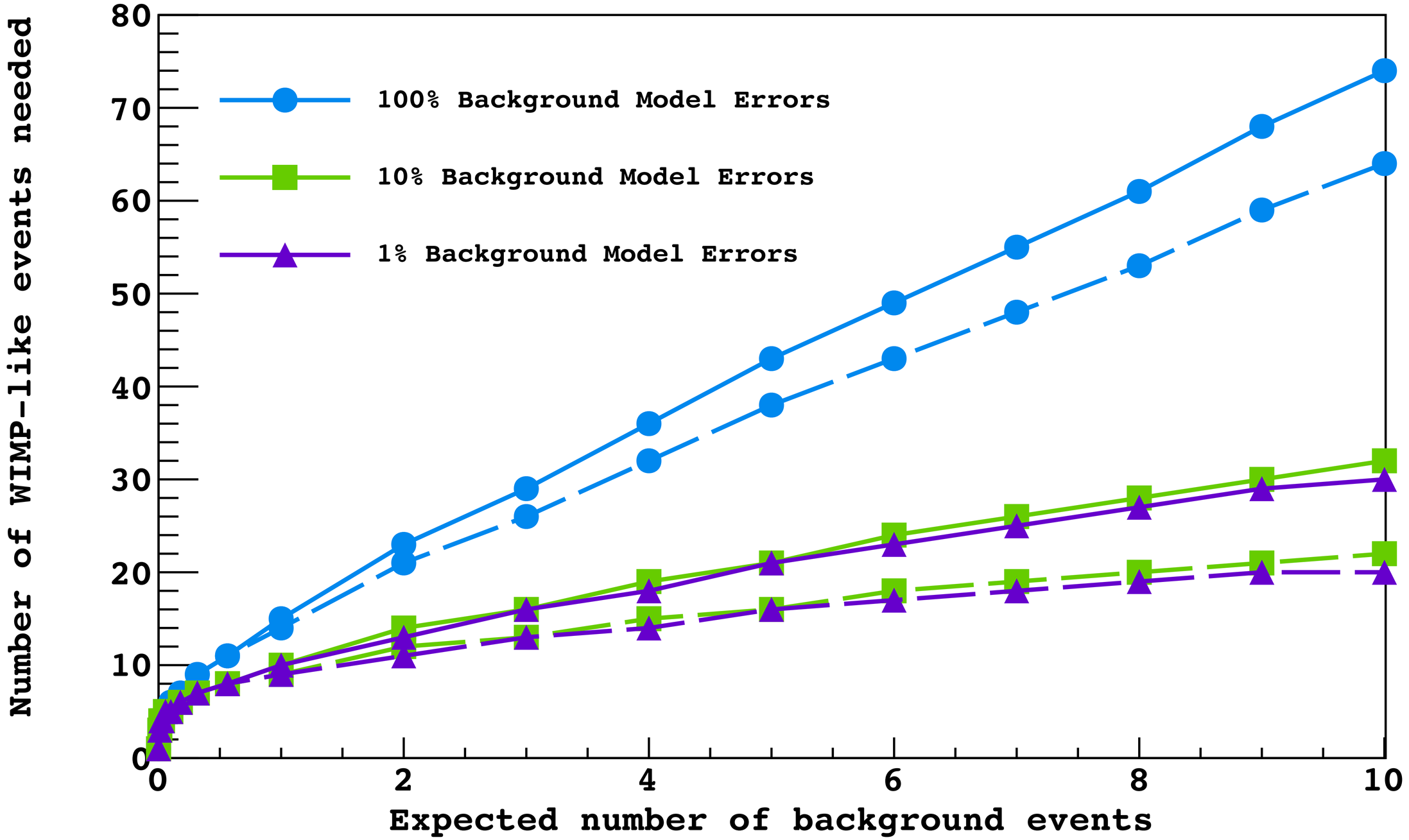
Mass	1.3 t	1.3 t	0.9 t	0.65 t
(cS1, $cS2_b$)	Full	Reference	Reference	Reference
ER	627±18	1.62±0.30	1.12±0.21	0.60±0.13
neutron	1.43±0.66	0.77±0.35	0.41±0.19	0.14±0.07
CEνNS	0.05±0.01	0.03±0.01	0.02	0.01
AC	$0.47^{+0.27}_{-0.00}$	$0.10^{+0.06}_{-0.00}$	$0.06^{+0.03}_{-0.00}$	$0.04^{+0.02}_{-0.00}$
Surface	106±8	4.84±0.40	0.02	0.01
Total BG	735±20	7.36±0.61	1.62±0.28	0.80±0.14
$WIMP_{best\text{-}fit}$	3.56	1.70	1.16	0.83
Data	739	14	2	2


ER
Surface
Neutron
AC
WIMP
R [cm]
10
20
30
40
0.9 t
1.3 t
8000
4000
2000
1000
400
200
cS2b [PE]
keVNR
60
50
45
40
35
30
25
20
15
10
5
2σ
1σ
0
3
10
20
30
40
50
60
70
cS1 [PE]
500
1000
1500
R2 [cm2]


+R 2
Entries 361687
Integral 3.576e+05
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0
100
200
300
400
500
600
700
800

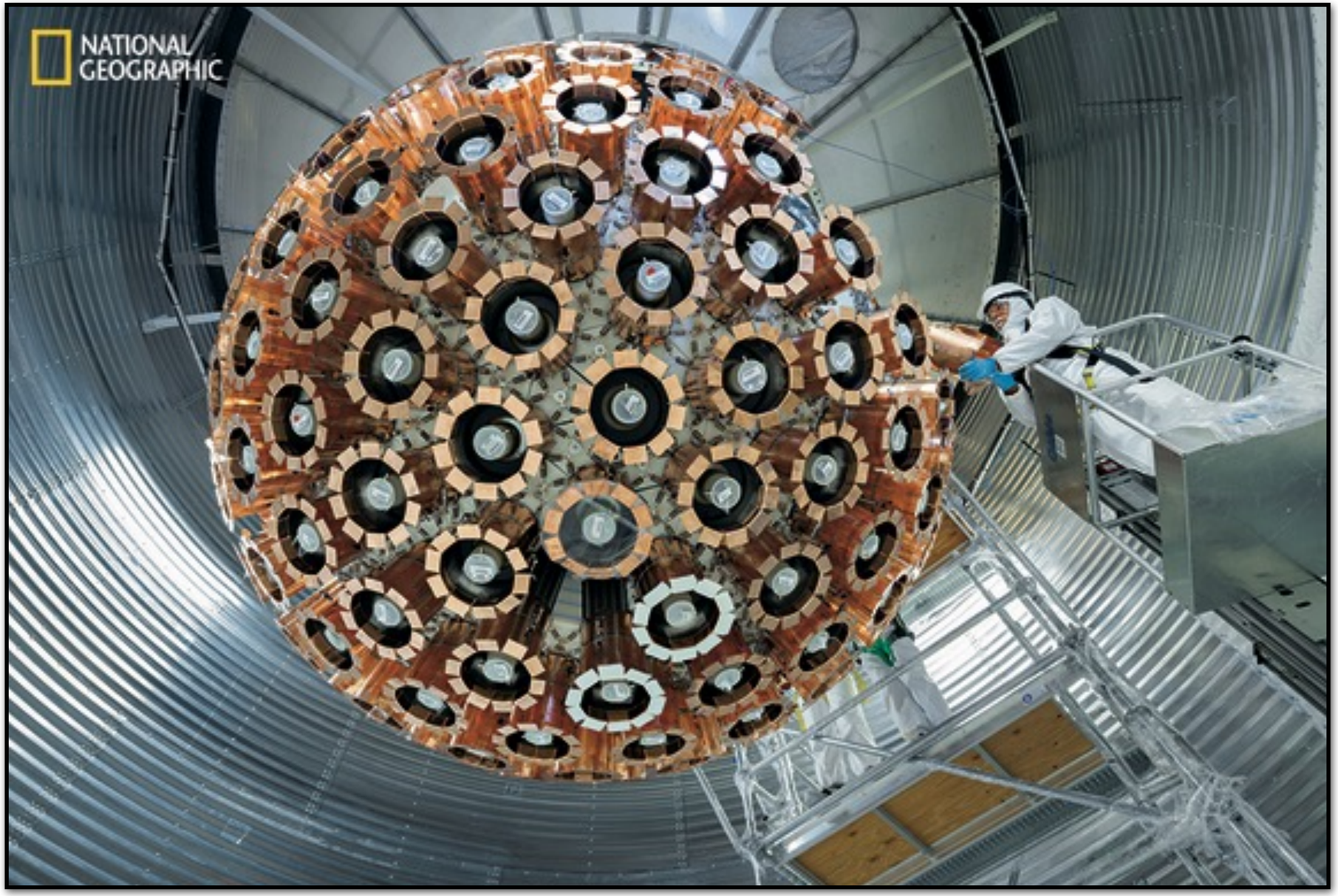

+Veto
Entries 227934
Integral 2.258e+05
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0
100
200
300
400
500


+r<10 cm && 50% loss S2/S1 cut (70d)
14
Entries 16213
Integral 1.619e+04
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0
10
20
30
40
50
60
70


Number of WIMP-like events needed
Expected number of background events
100% Background Model Errors
10% Background Model Errors
1% Background Model Errors
0
10
20
30
40
50
60
70
80
0
2
4
6
8
10

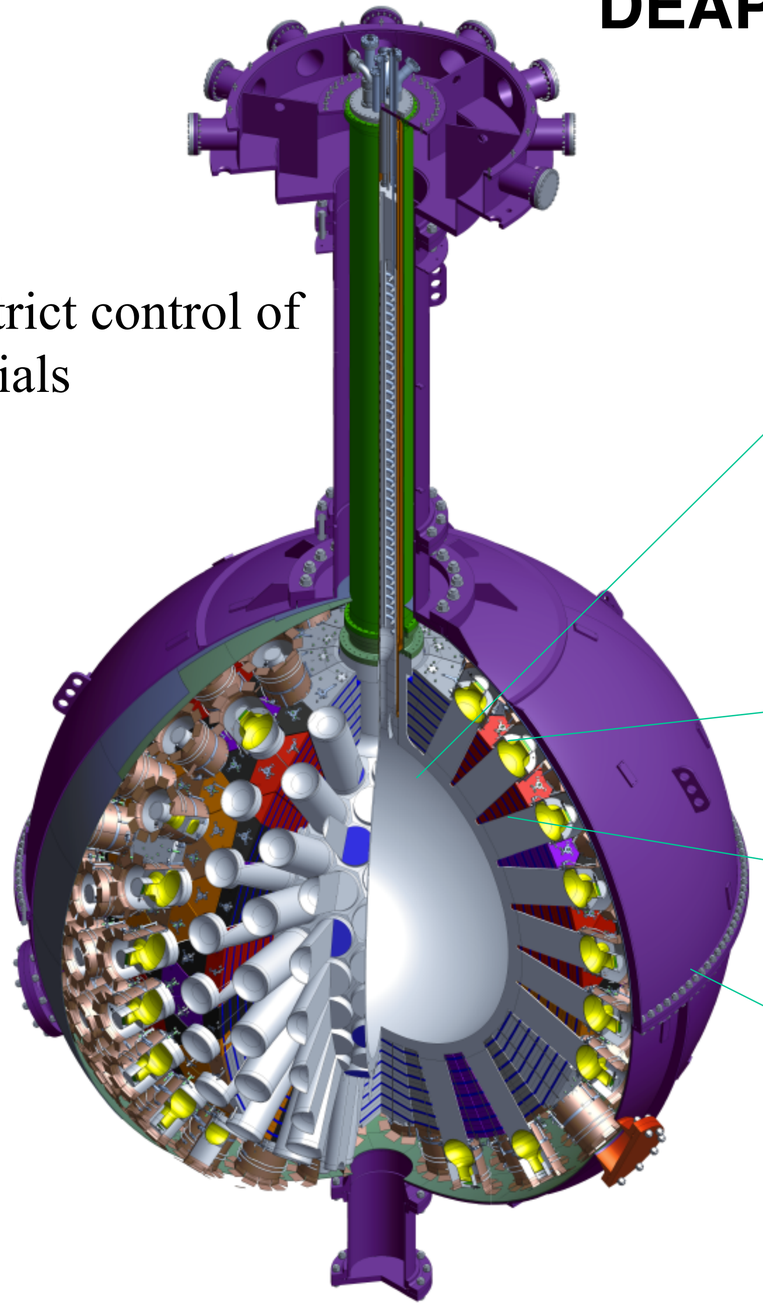
“Zero Background” condition (<0.1 background events) necessary to conduct discovery program

DEAP-3600 Status



Mark Boulay

DEAP-3600 Detector (single-phase)



very strict control of materials

3.5 meters

3600 kg argon
in sealed ultraclean
Acrylic Vessel (1.7 m ID)

Vessel is “resurfaced”
in-situ to remove
deposited Rn daughters
after construction

255 Hamamatsu
R5912 HQE PMTs 8-inch
(Light Sensors)

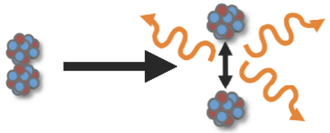
50 cm light guides +
PE shielding provide neutron
moderation

Steel Shell immersed in 8 m
water shield at SNOLAB

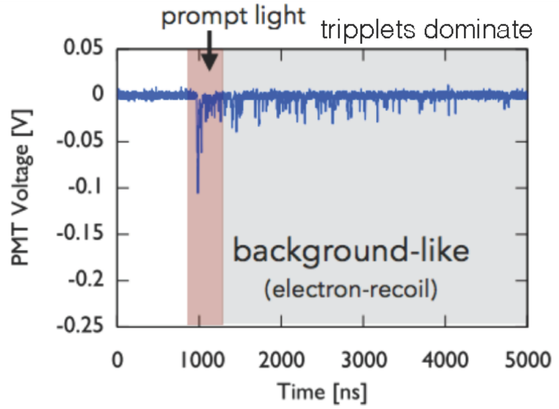
Experimental Signatures

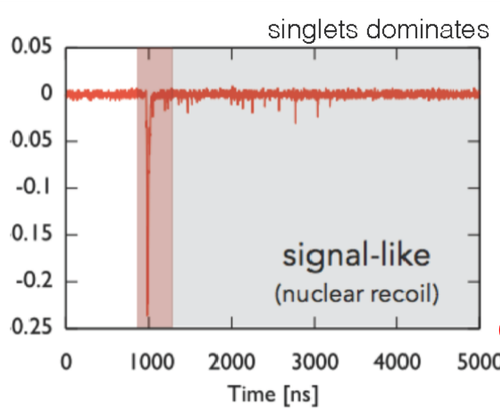
Ar scintillation:

- excimers are create



- singlet: 6 ns
- tripplet: 1500 ns
- wavelength: 128 r



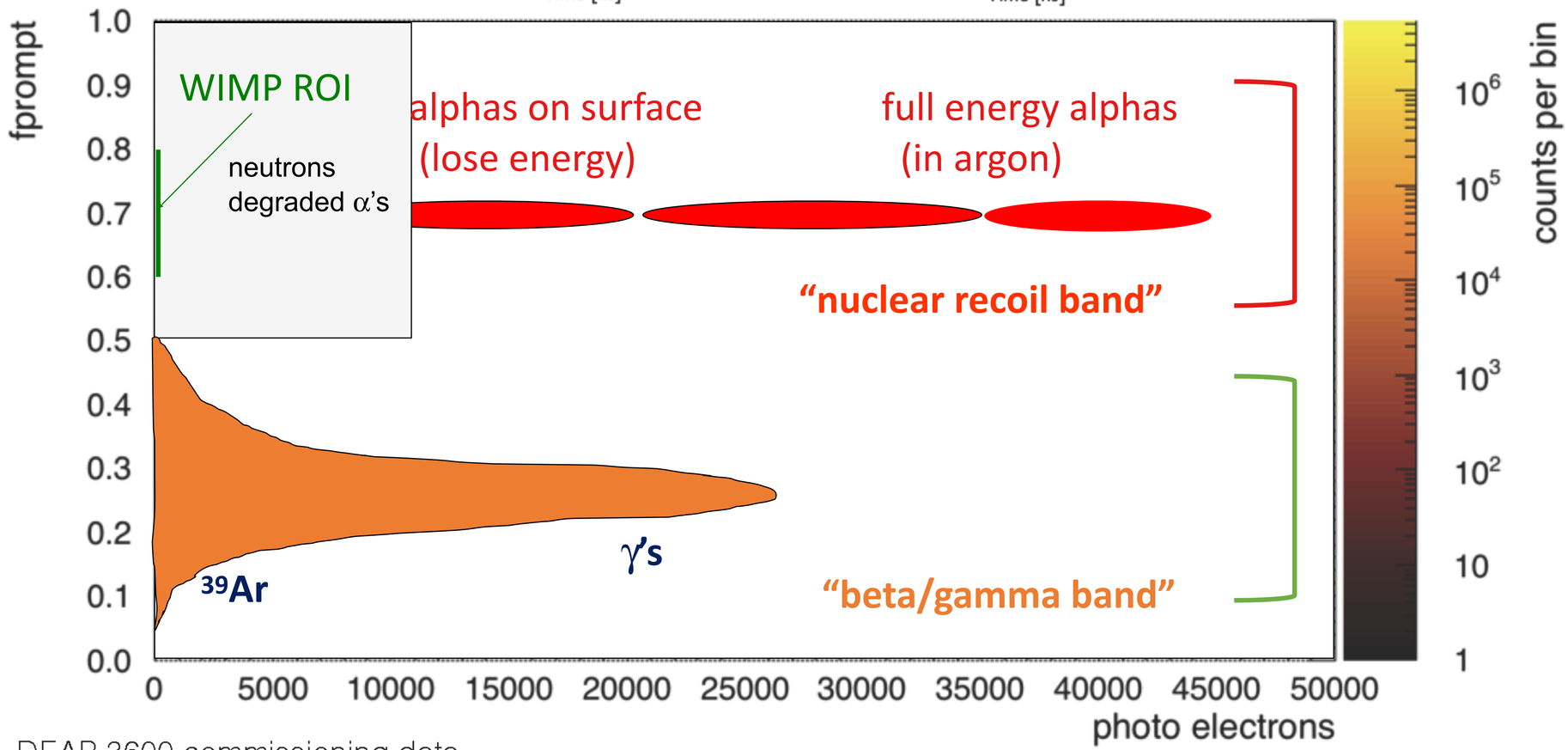


Pulse shape discrimination (PSD) parameter:

fprompt =

$$\frac{\text{prompt light (150 ns)}}{\text{total light (10000 ns)}}$$

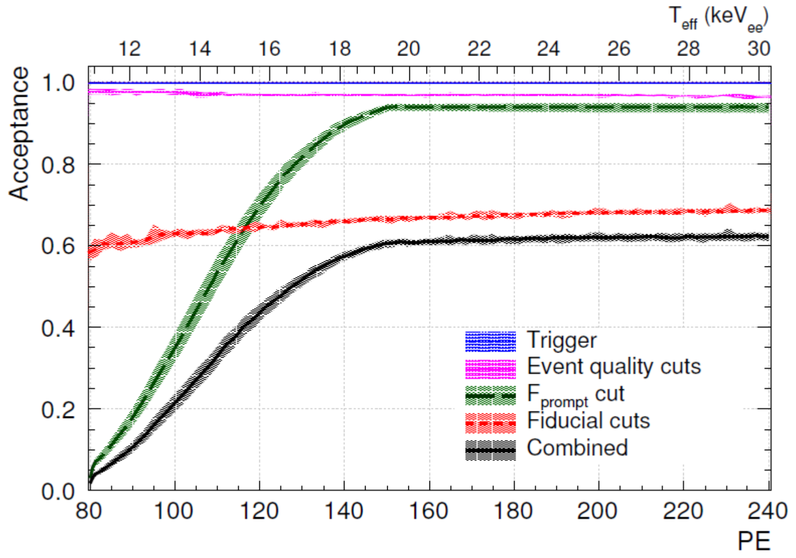
overview of backgrounds: see Bjoern Lehnert R1-5

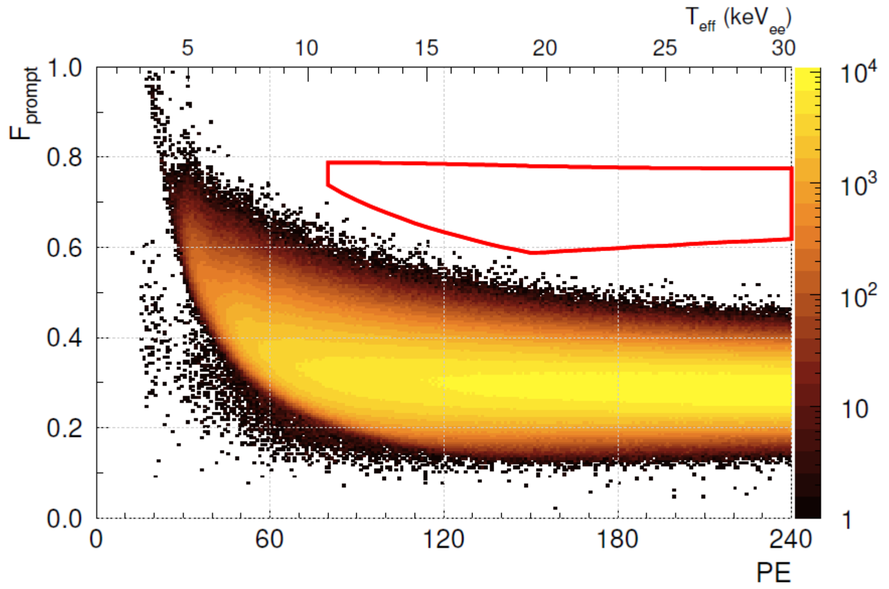


DEAP 3600 commissioning data

Slide from MG Boulay – TAUP 2017, Sudbury

First Dark Matter Search with DEAP-3600 – 9,870 kg-days July 2017 arXiv:1707.08042





	Cut	Livetime	Acceptance %		$\#^{ROI}_{evt.}$
run	Physics runs	8.55 d			
	Stable cryocooler	5.63 d			
	Stable PMT	4.72 d			
	Deadtime corrected	4.44 d			119181
low level	DAQ calibration				115782
	Pile-up				100700
	Event asymmetry				787
quality	Max charge fraction per PMT		99.58 ± 0.01		654
	Event time		99.85 ± 0.01		652
	Neck veto		$97.49^{+0.03}_{-0.05}$		23
fiducial	Max scintillation PE fraction per PMT			$75.08^{+0.09}_{-0.06}$	7
	Charge fraction in the top 2 PMT rings			$90.92^{+0.11}_{-0.10}$	0
	Total	4.44 d	96.94 ± 0.03	$66.91^{+0.20}_{-0.15}$	0

4.4 live days

Selected ROI for < 0.2 leakage from β's

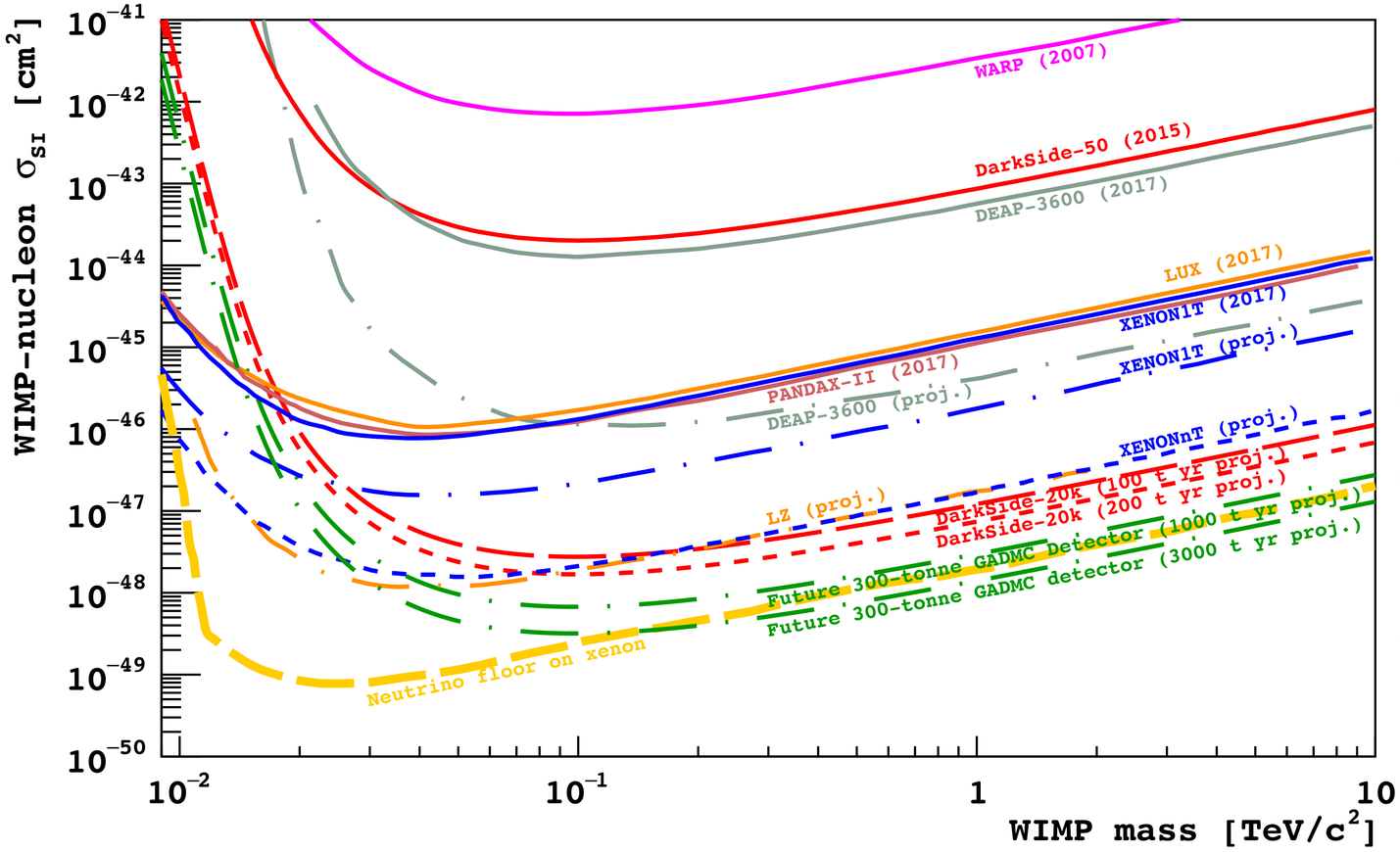
9,870 kg-day exposure

No events observed in ROI

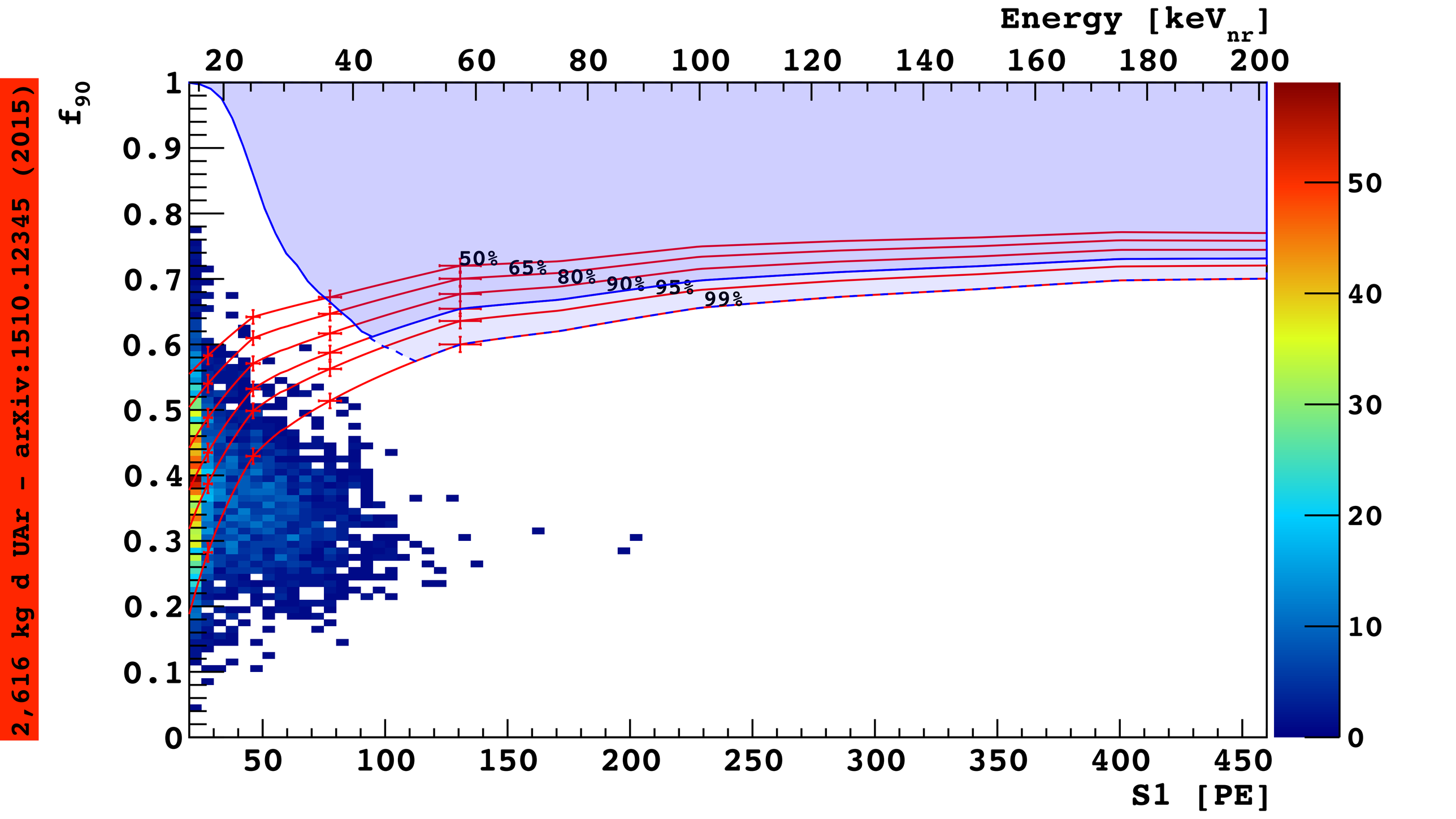
The Global Argon Dark Matter Collaboration

ArDM
DarkSide
DEAP
MiniCLEAN

} A Single Global Program for Direct Dark Matter Searches
Currently taking data: ArDM, DarkSide-50, **DEAP-3600**
Next step: DarkSide-20k at LNGS (2021-)
Last Step: **300 tonnes detector**, location t.b.d **(2027-)**



DarkSide-20k approved by INFN and LNGS in April 2017 and by NSF in Oct 2017
Officially supported by LNGS, LSC, and SNOLab
30 tonnes (20 tonnes fiducial) of low-radioactivity underground argon
14 m^2 of SiPM coverage


2,616 kg d UAr - arXiv:1510.12345 (2015)
Energy [keV$_{nr}$]
20
40
60
80
100
120
140
160
180
200
f$_{90}$
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
50%
65%
80%
90%
95%
99%
50
100
150
200
250
300
350
400
450
S1 [PE]
50
40
30
20
10
0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Black Hills State University
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Energéticas, Medioambientales
y Tecnológicas
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Founded 1927
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IPHC
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Hubert CURIEN
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JINR
FOR NUCLEAR RESEARCH
LaurentianUniversity
UniversitéLaurentienne
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di Fisica Nucleare
Laboratori Nazionali di Frascati
LPNHE
PARIS
MEPhI
MOSCOW ENGINEERING PHYSICS INSTITUTE
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POLITECNICO
MILANO
НГУ
Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965
Queen's
UNIVERSITY
ROMA
TRE
UNIVERSITÀ DEGLI STUDI
SNOLAB
UNIVERSITY
OF SUSSEX
TEMPLE UNIVERSITY
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Fundamental Physics
and Applications
POLITECNICO
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DAVIS
UCLA
UNIVERSITY OF MASSACHUSETTS
AMHERST 1863
UNIVERSIDADE DE SÃO PAULO
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

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

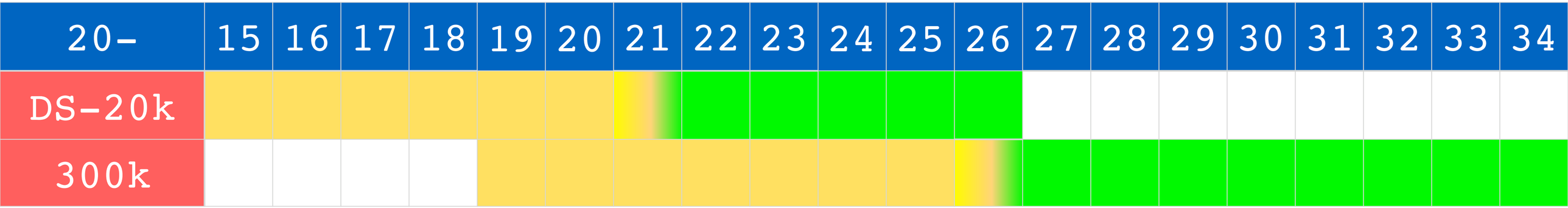
Deep underground laboratory support for global collaboration towards discovery of dark matter utilising liquid argon detectors.

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,

DarkSide-20k

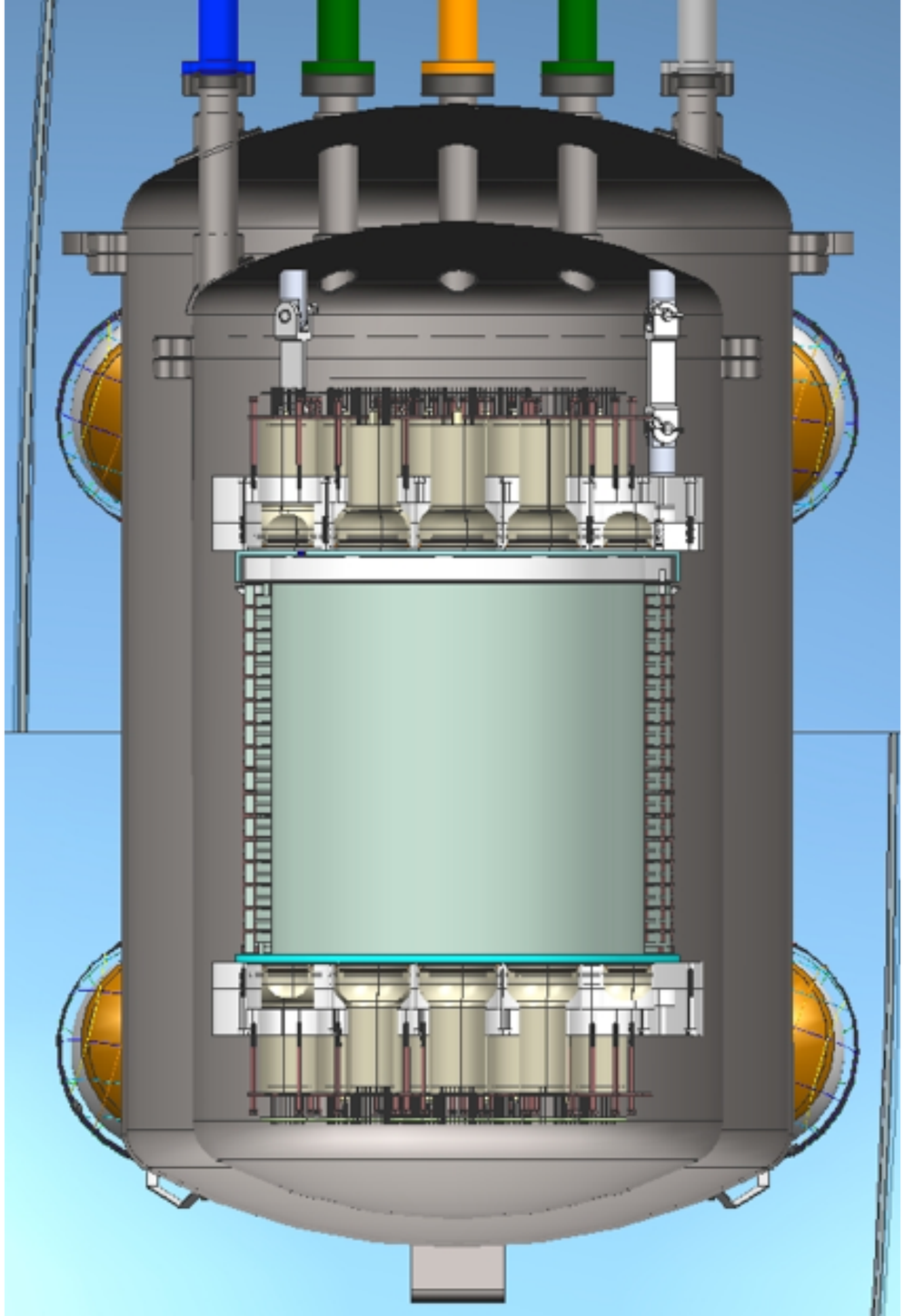
20-tonnes fiducial dark matter detector
start of operations at LNGS within 2021
100 tonne×year background-free search for dark matter

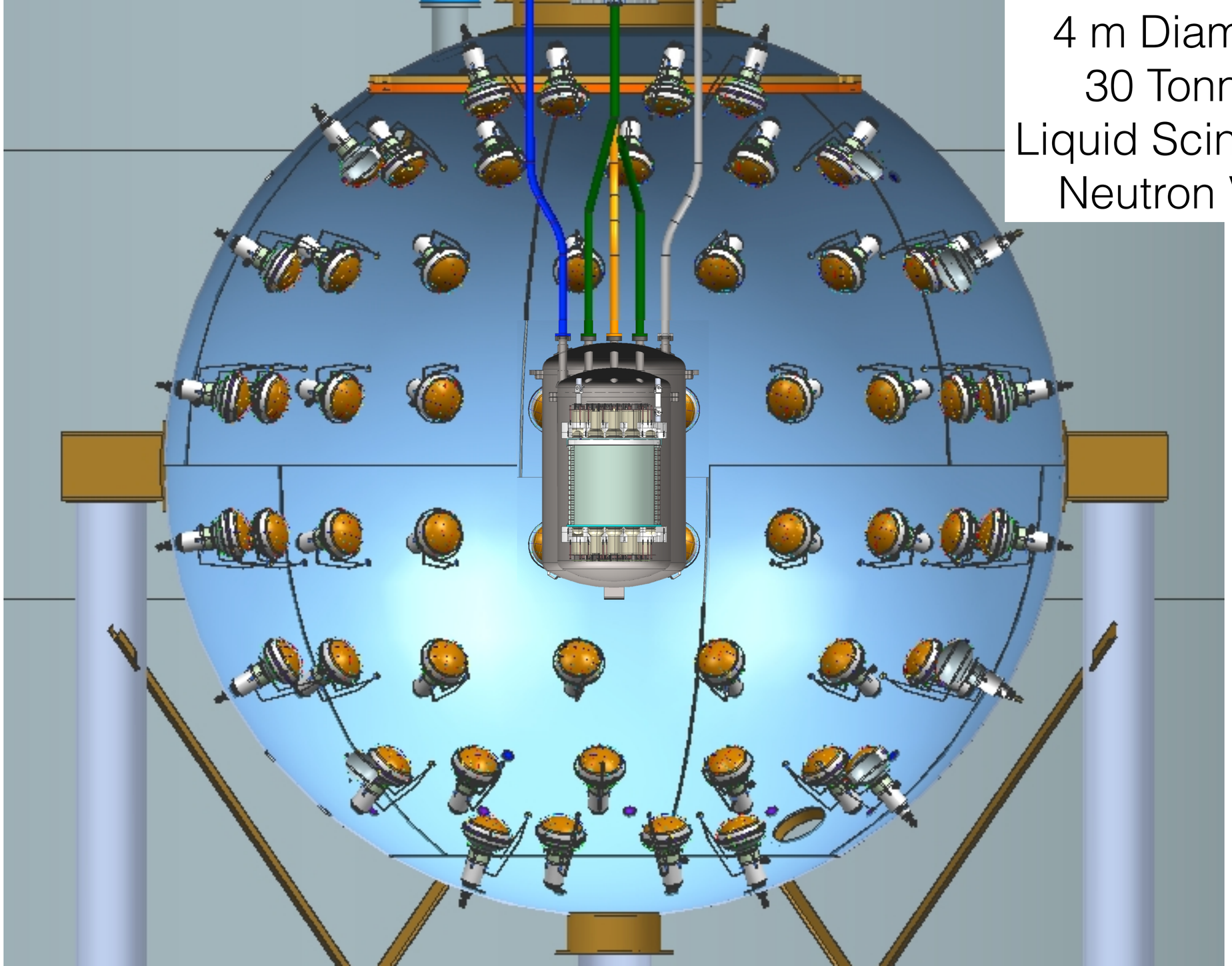


Future 300-tonne Detector

300-tonnes depleted argon detector
start of operations within 2026
1,000 tonne×year background-free search for dark matter
precision measurement of solar neutrinos

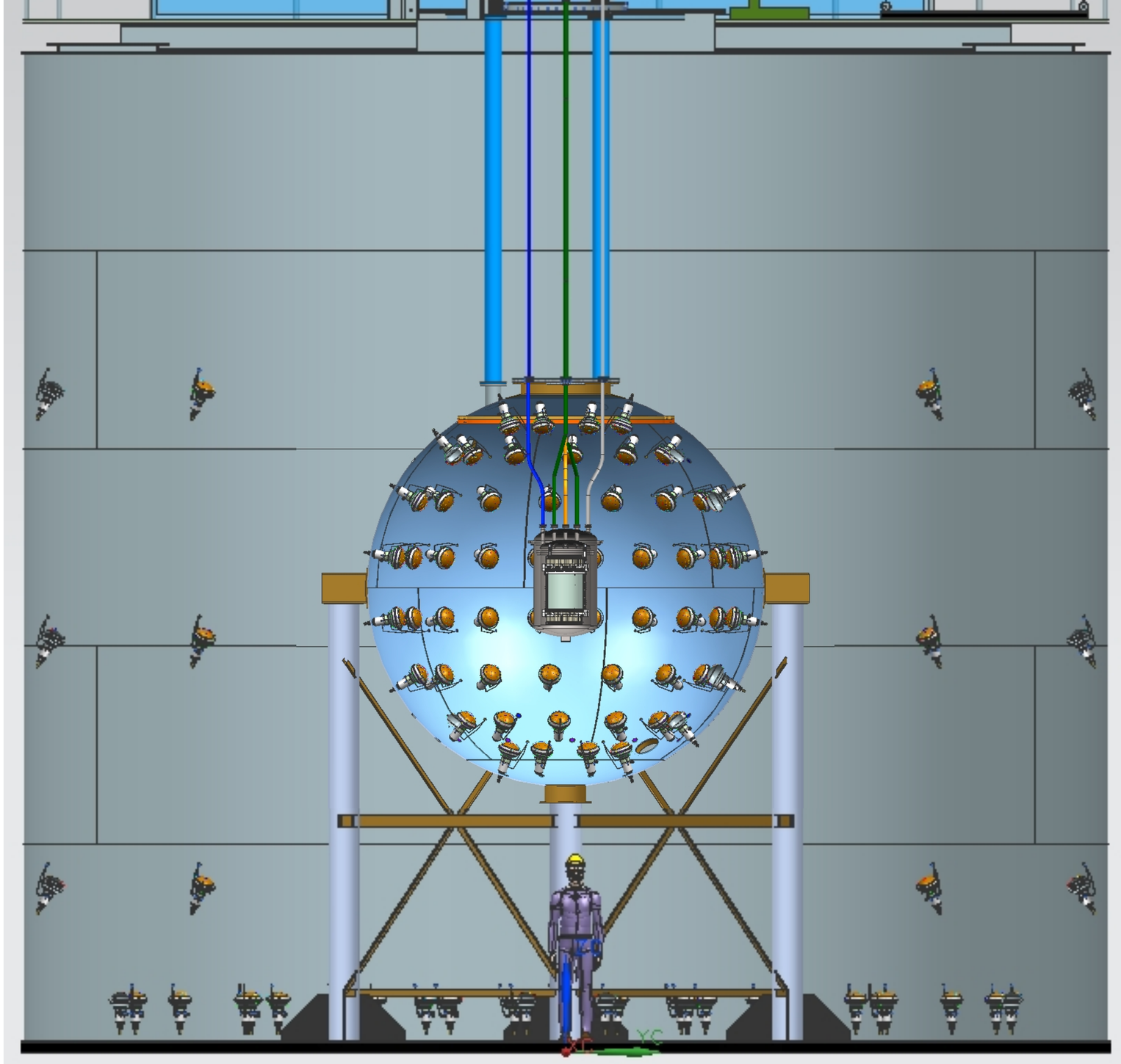
Liquid Argon TPC
153 kg ^{39}Ar-Depleted
Underground Argon
Target





4 m Diameter
30 Tonnes
Liquid Scintillator
Neutron Veto

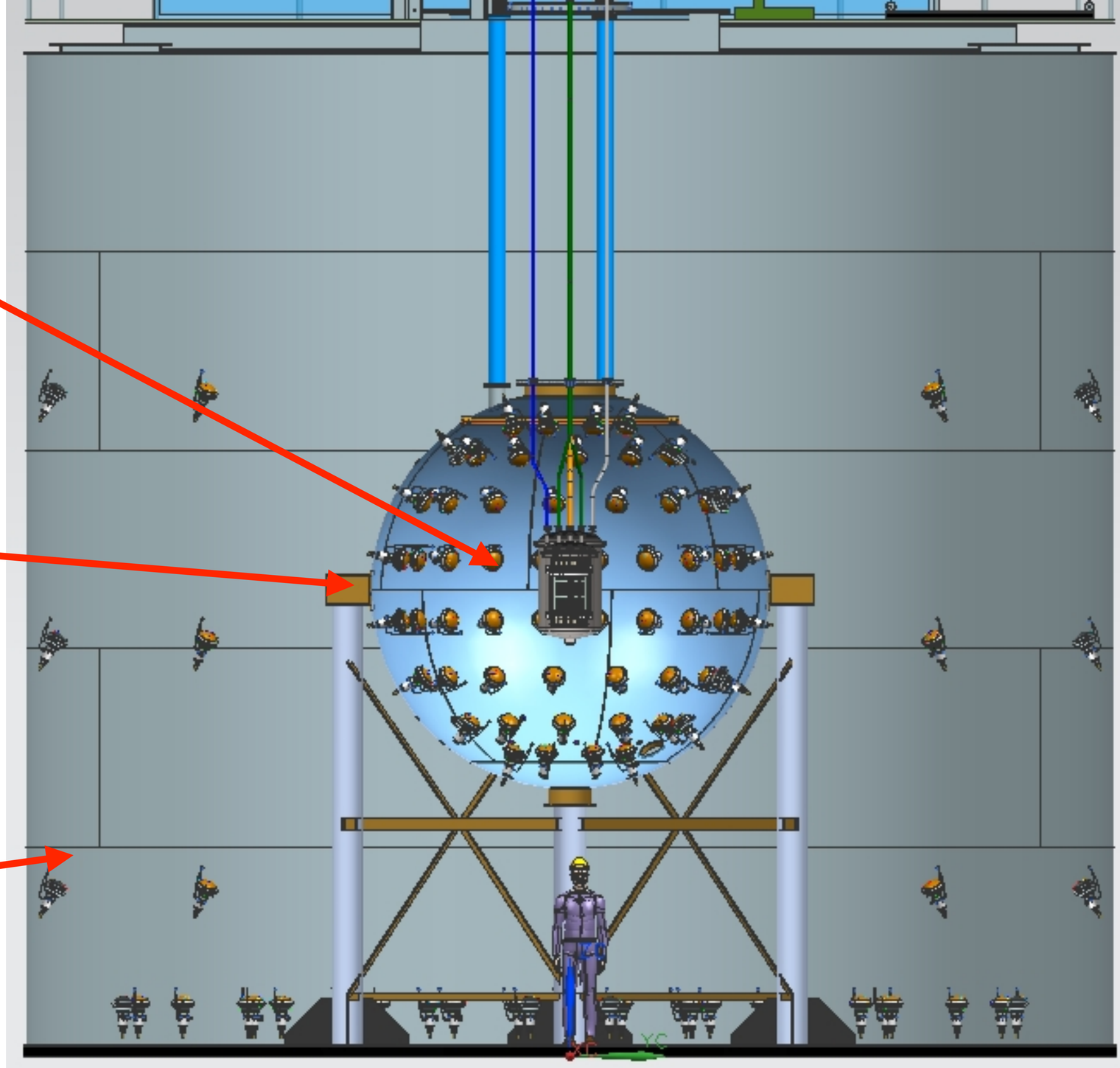
10 m Height
11 m Diameter
1,000 Tonnes
Water Cherenkov
Muon Veto



Liquid Argon TPC
153 kg ^{39}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

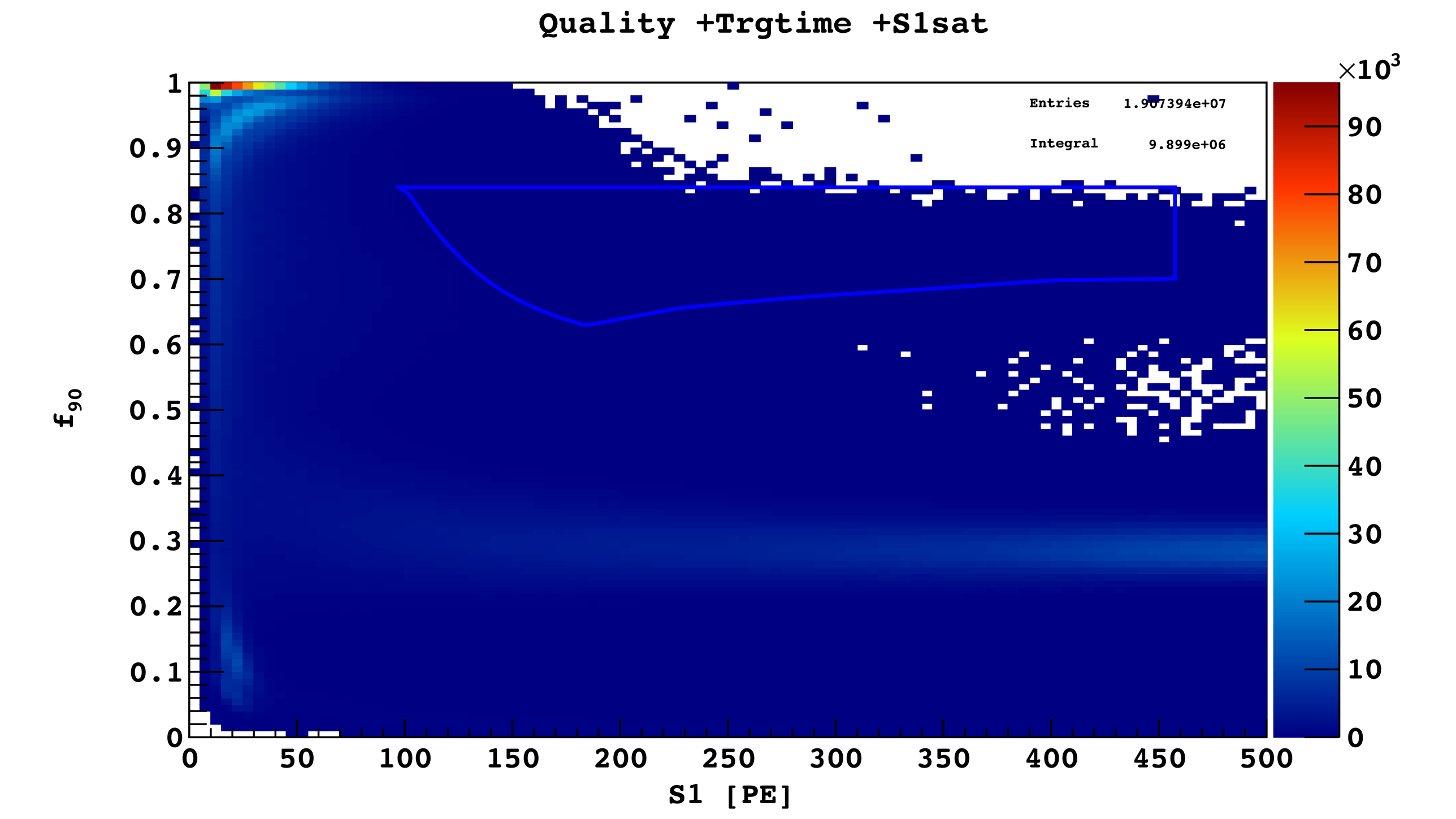


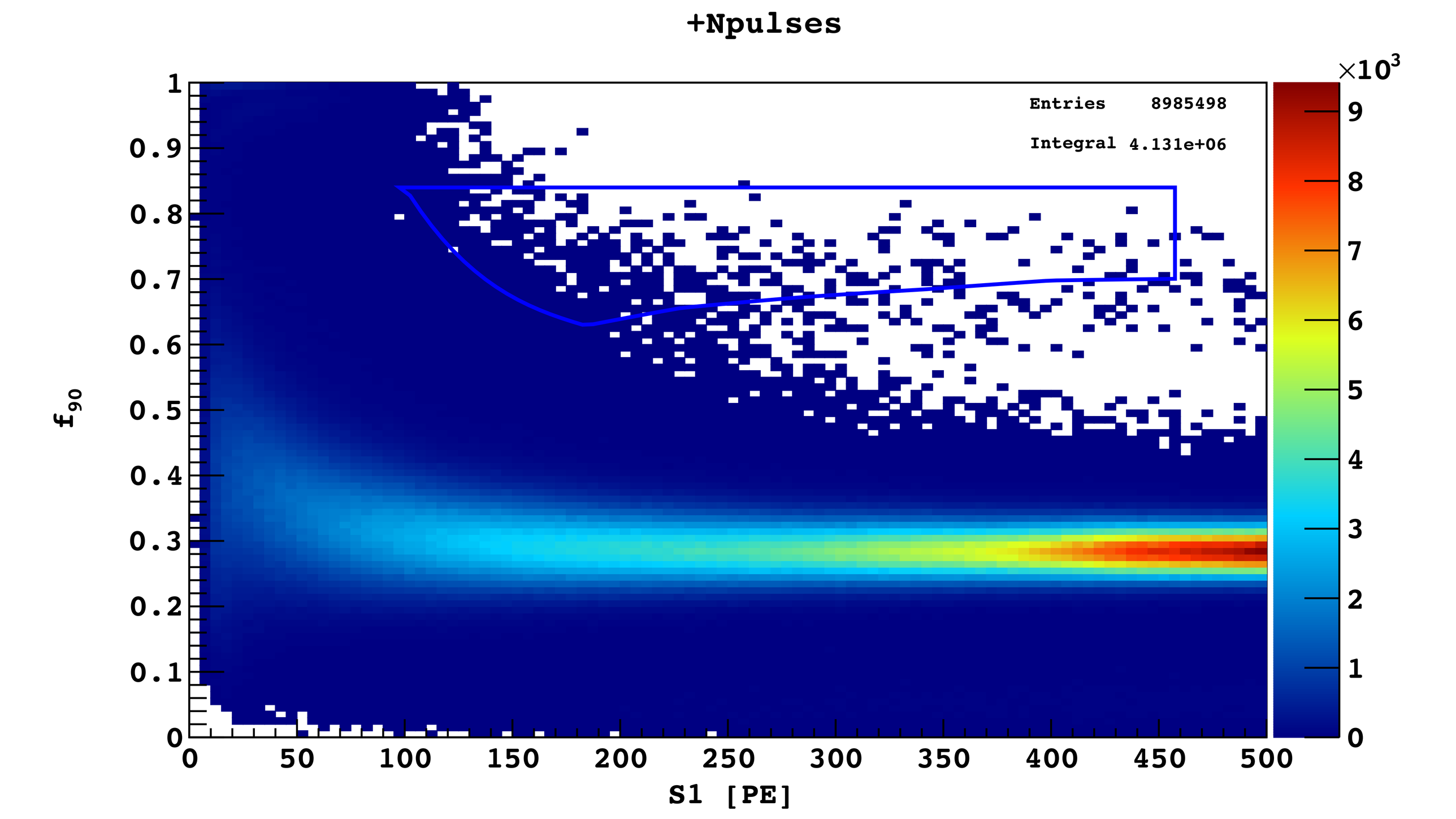
DarkSide-50

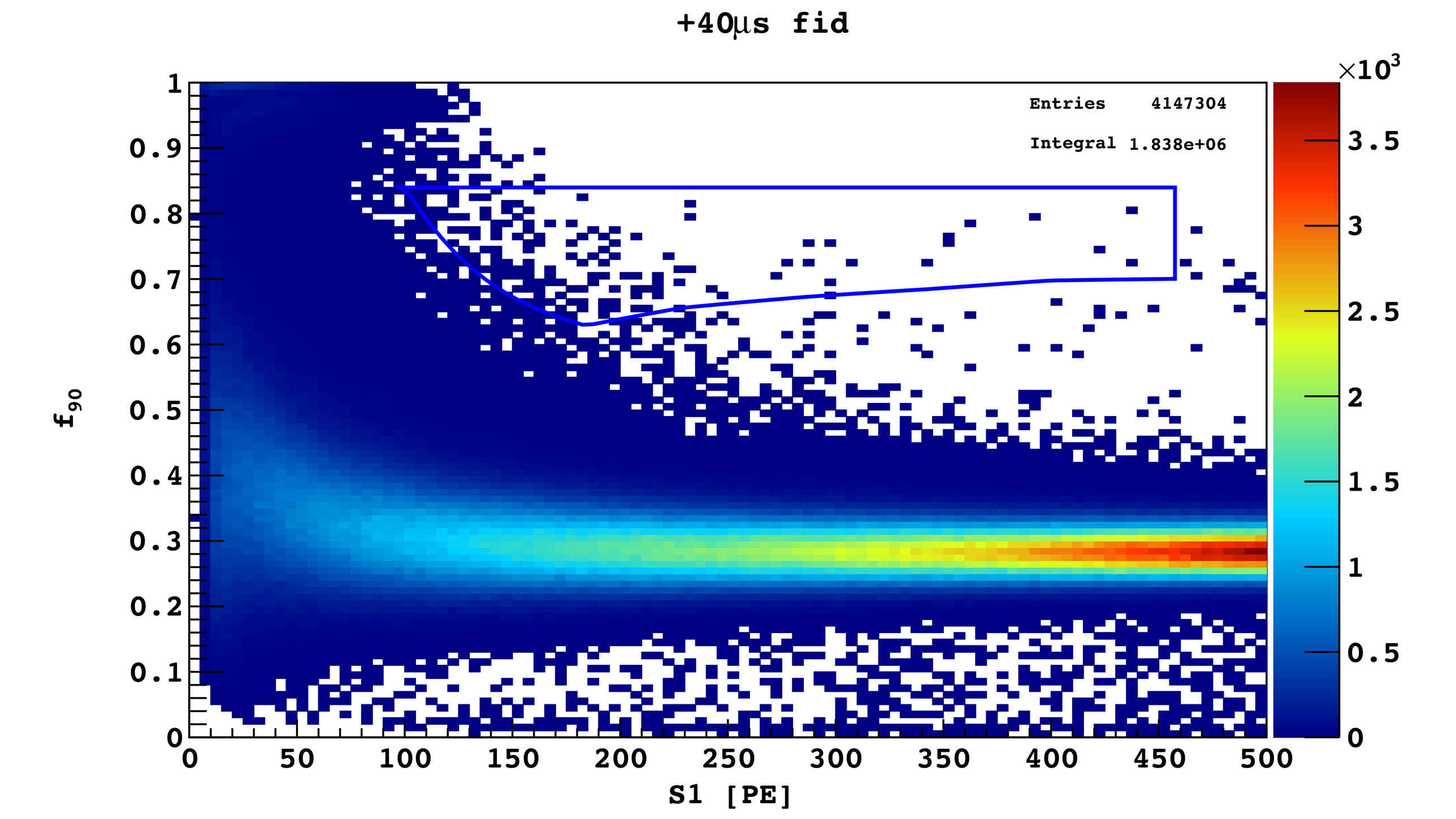
- P. Agnes et al. (The DarkSide Collaboration), “DarkSide-50 532-day Dark Matter Search with Low-Radioactivity Argon”, arxiv:1802.07198.

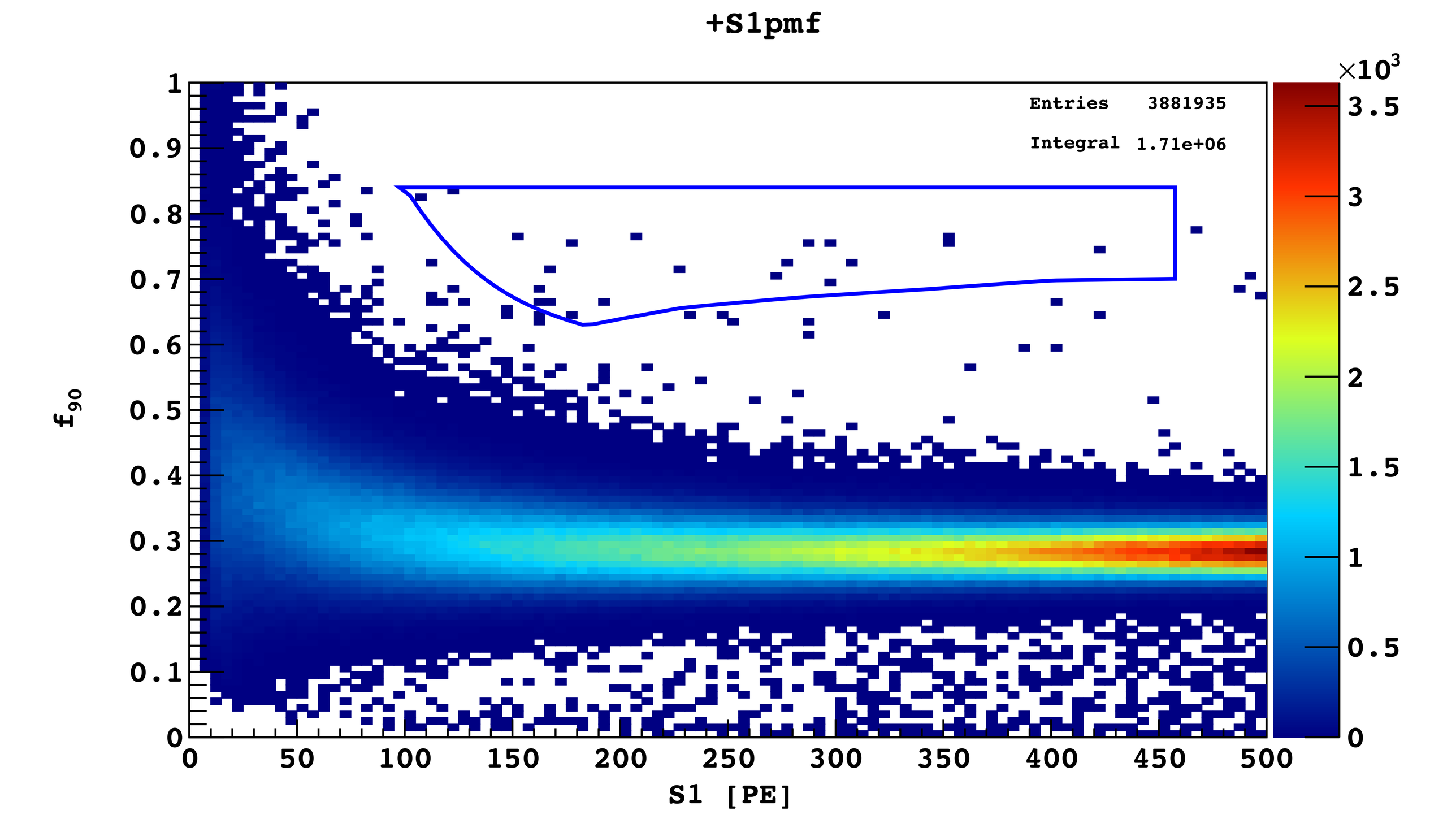
- P. Agnes et al. (The DarkSide Collaboration), “Constraints on Sub-GeV Dark Matter-Electron Scattering from the DarkSide-50 Experiment”, arxiv:1802.06998.

- P. Agnes et al. (The DarkSide Collaboration), “Low-mass Dark Matter Search with the DarkSide-50 Experiment”, arxiv:1802.06994.


Quality +Trgtime +S1sat
Entries 1.907394e+07
Integral 9.899e+06
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
$\times 10^3$
0
10
20
30
40
50
60
70
80
90


+Npulses
Entries 8985498
Integral 4.131e+06
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
×10³
0
1
2
3
4
5
6
7
8
9


+40μs fid
Entries 4147304
Integral 1.838e+06
f_{90}
S1 [PE]
×10^3
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0.5
1
1.5
2
2.5
3
3.5


+S1pmf
Entries 3881935
Integral 1.71e+06
f_{90}
S1 [PE]
$\times 10^3$
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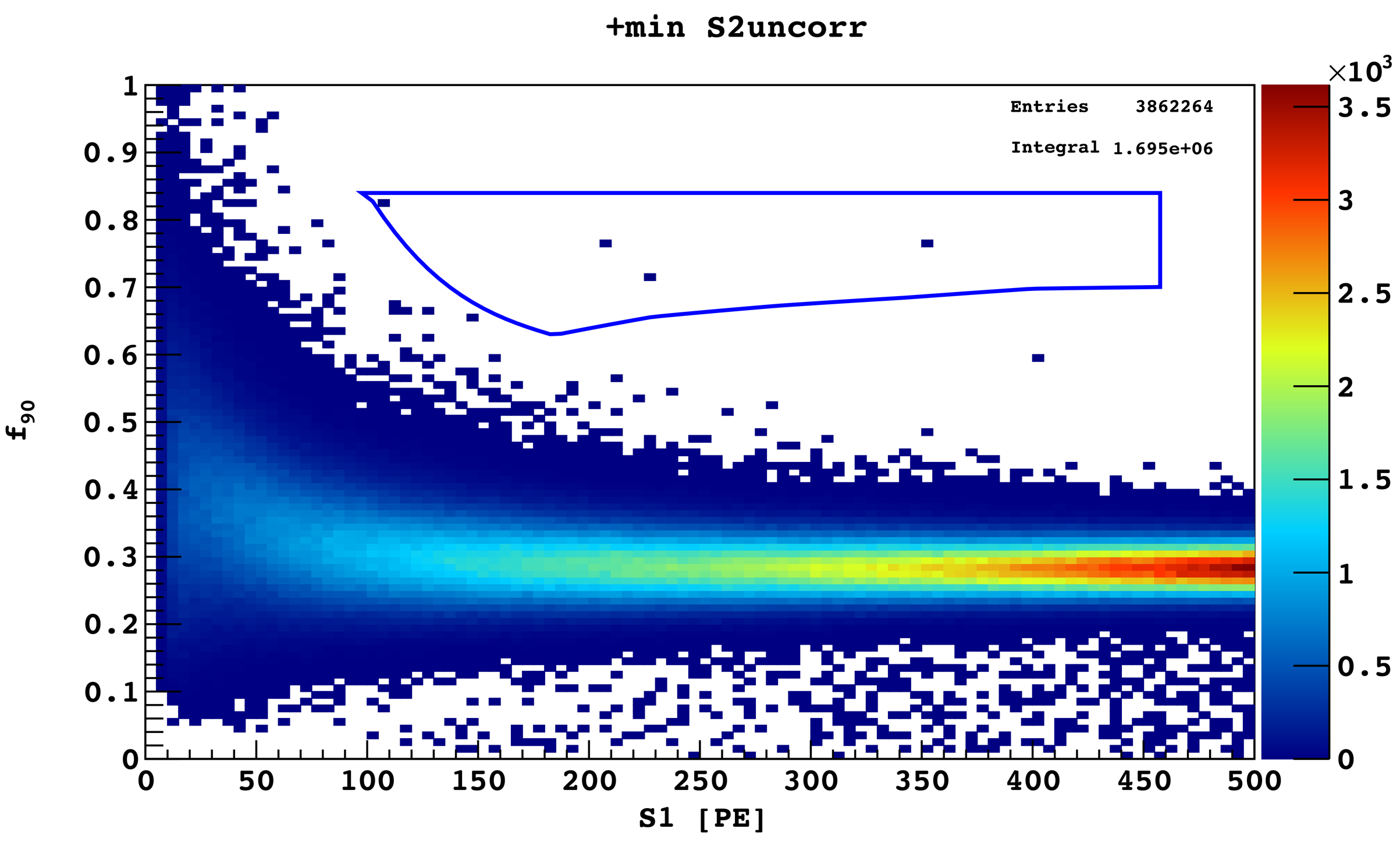
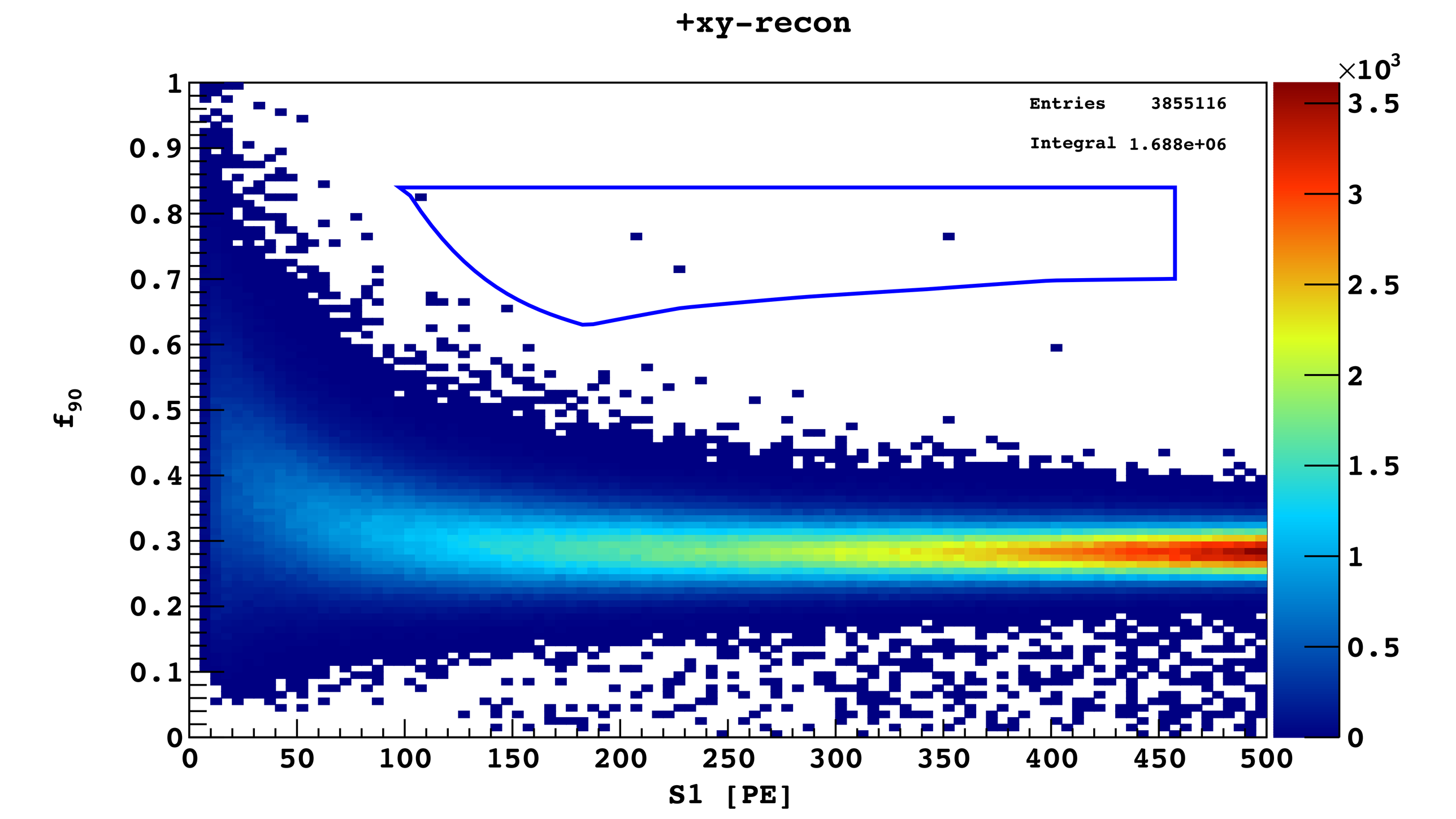
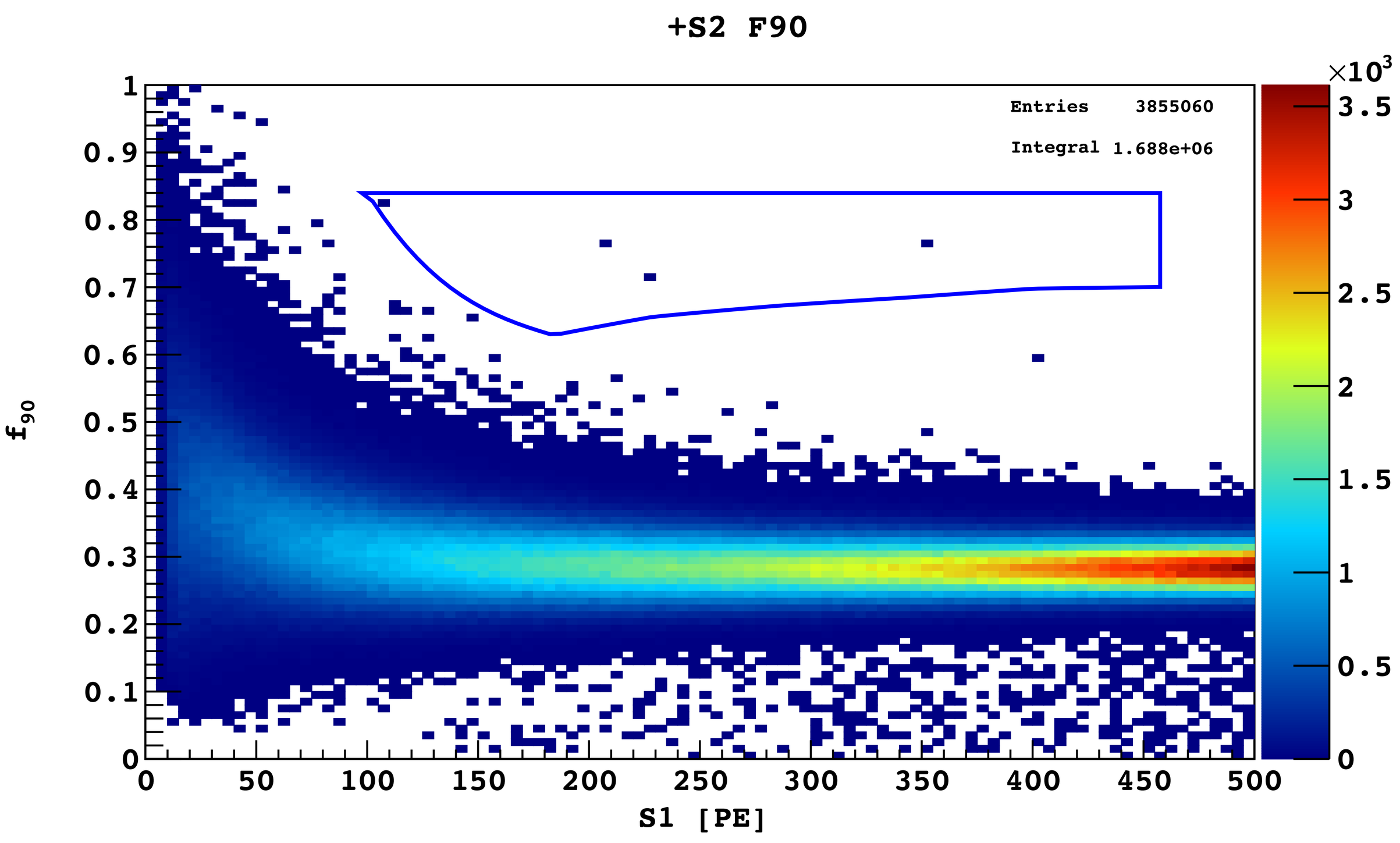
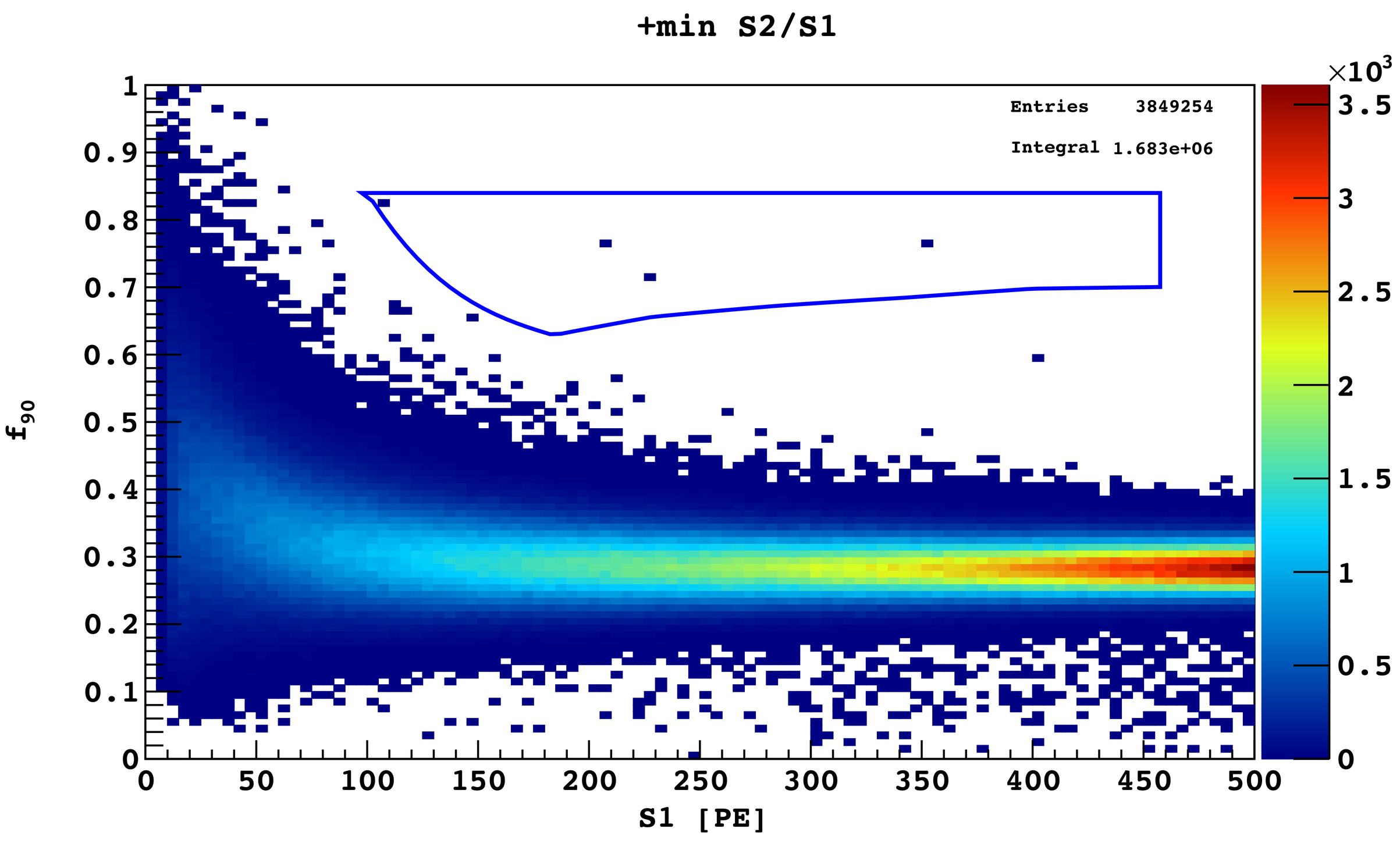
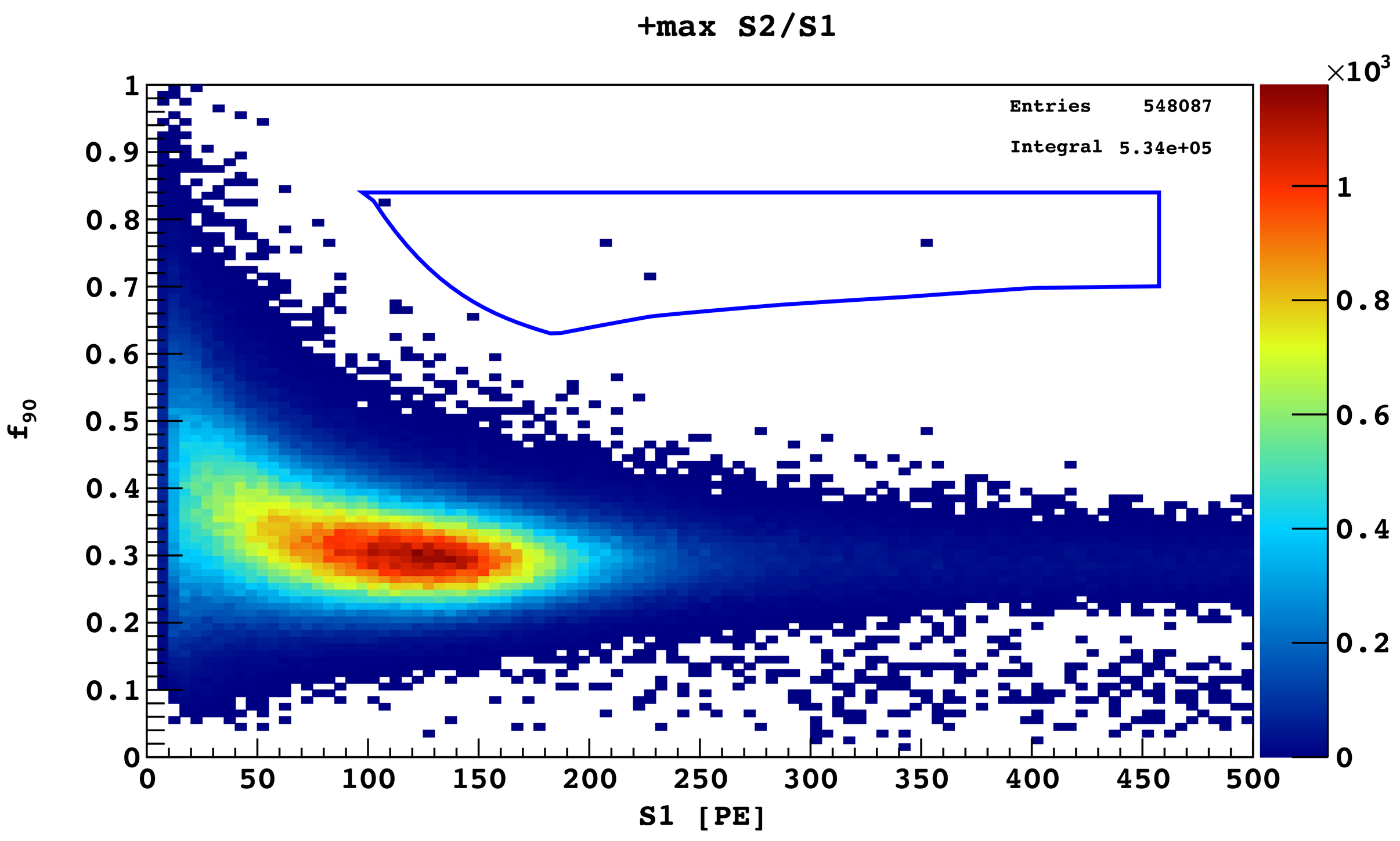
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0
0.5
1
1.5
2
2.5
3
3.5

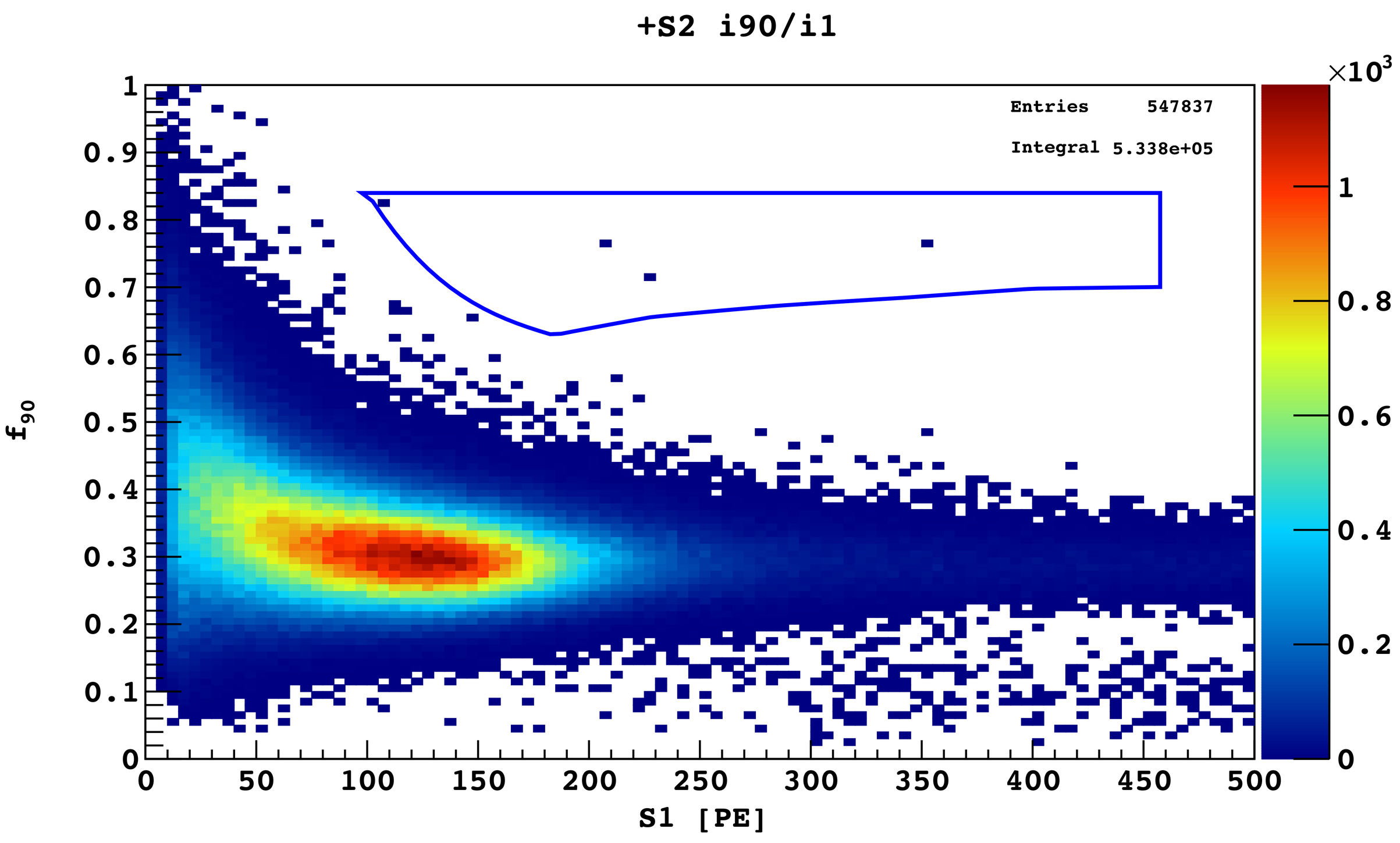

+min S2uncorr
Entries 3862264
Integral 1.695e+06
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
×10^3
3.5
3
2.5
2
1.5
1
0.5
0

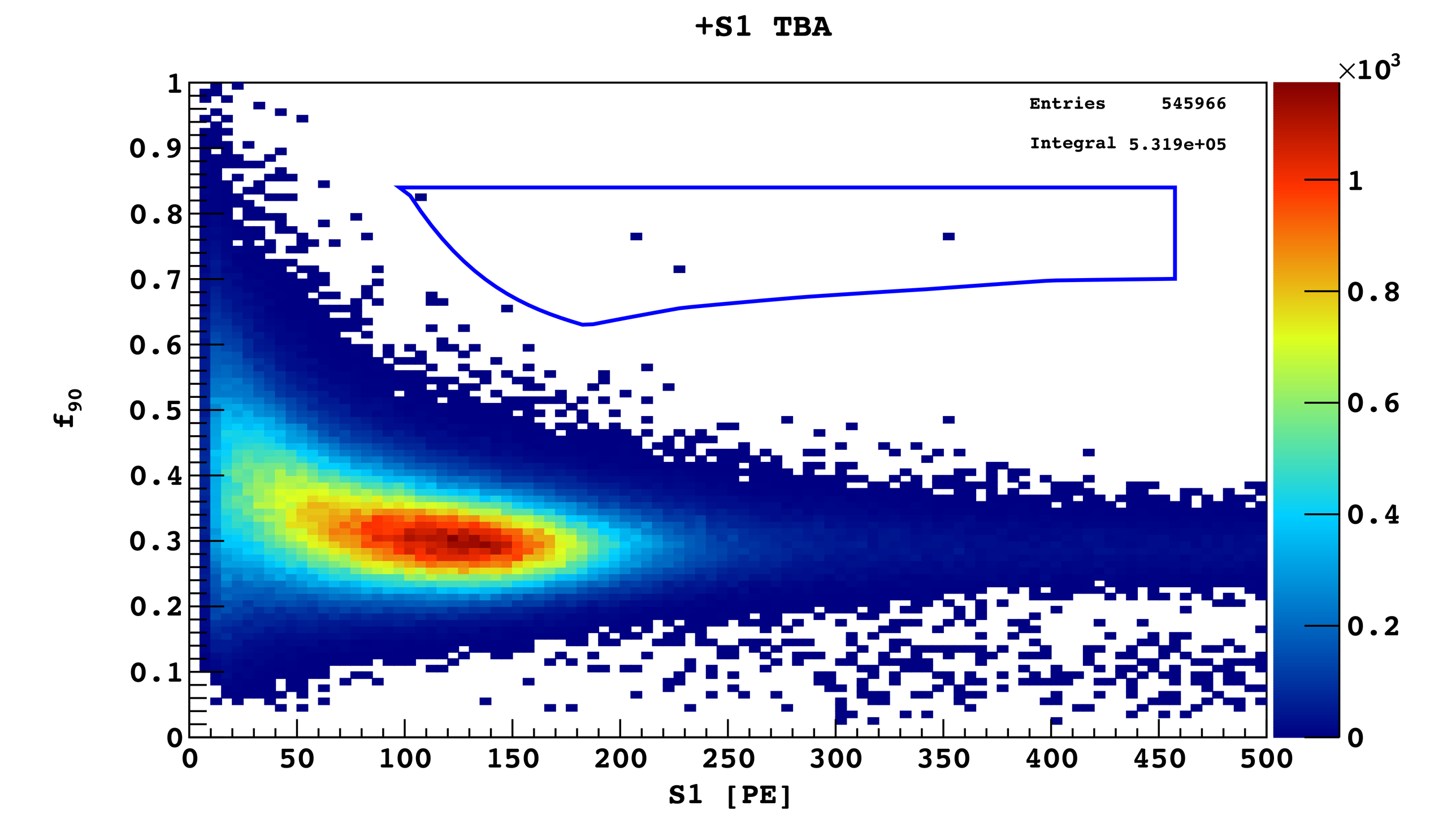

+xy-recon
Entries 3855116
Integral 1.688e+06
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
×10^3
3.5
3
2.5
2
1.5
1
0.5
0

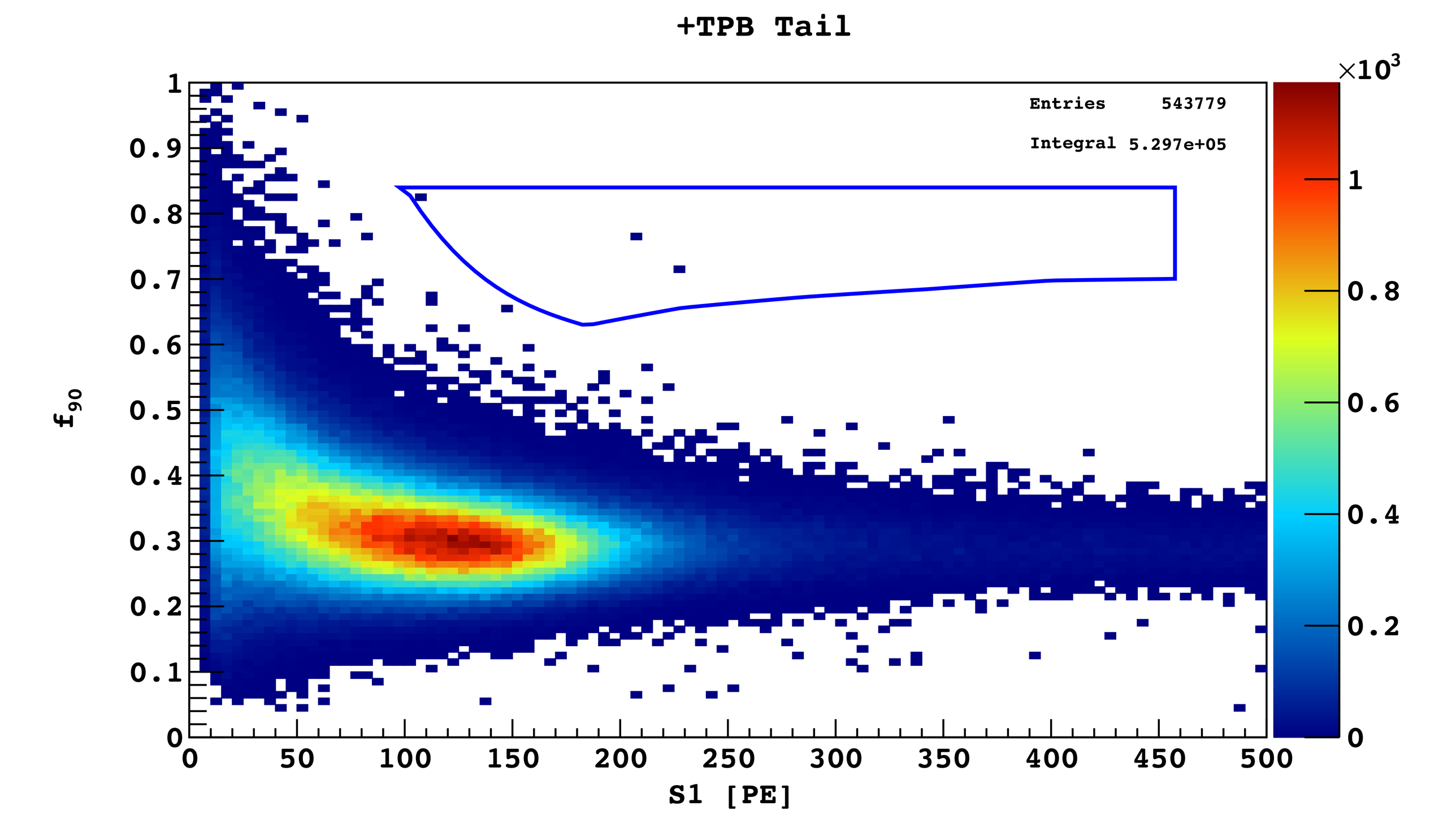

+S2 F90
Entries 3855060
Integral 1.688e+06
f_{90}
S1 [PE]
×10^3
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0.5
1
1.5
2
2.5
3
3.5

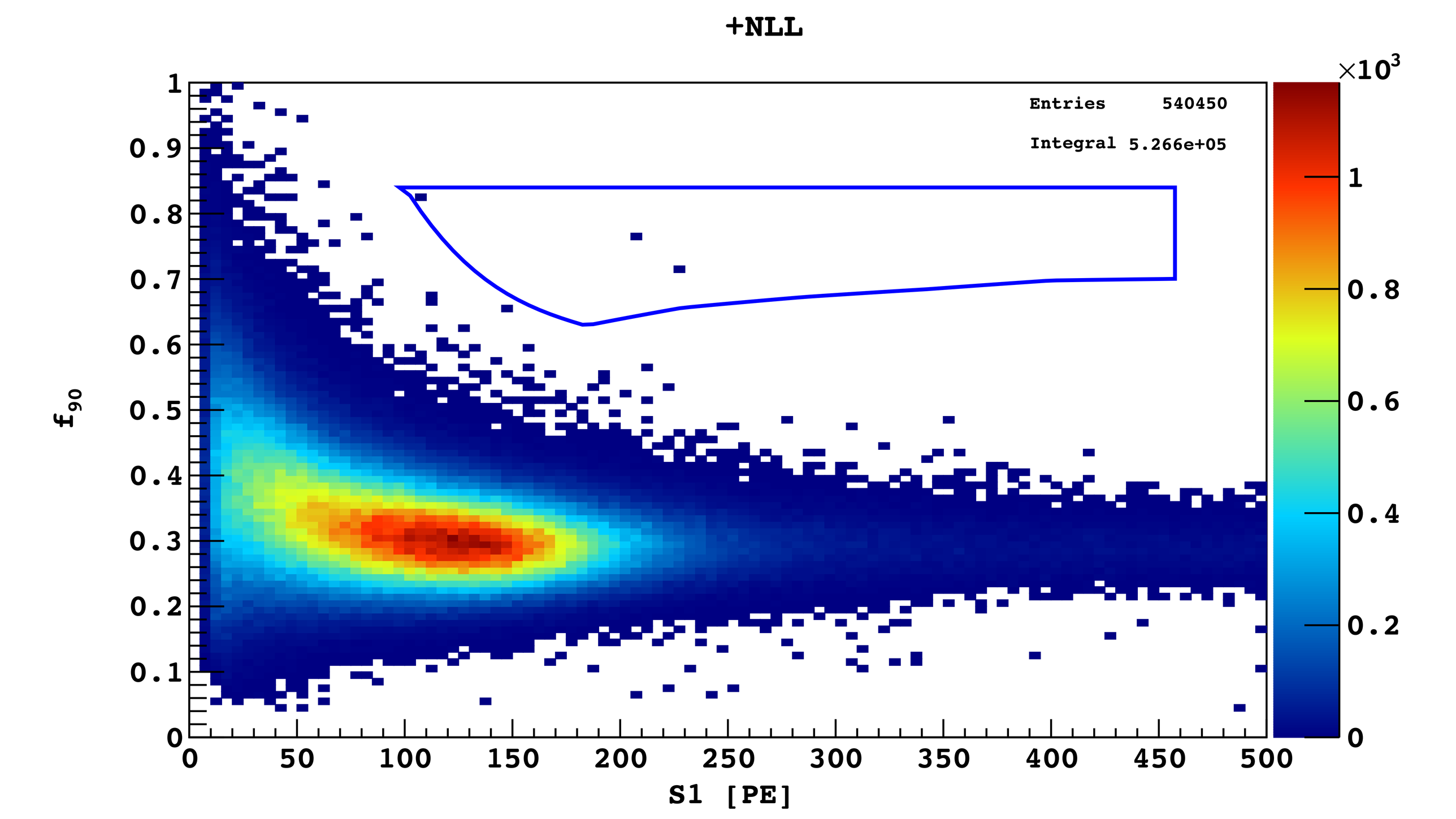

+min S2/S1
Entries 3849254
Integral 1.683e+06
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
×10^3
3.5
3
2.5
2
1.5
1
0.5
0

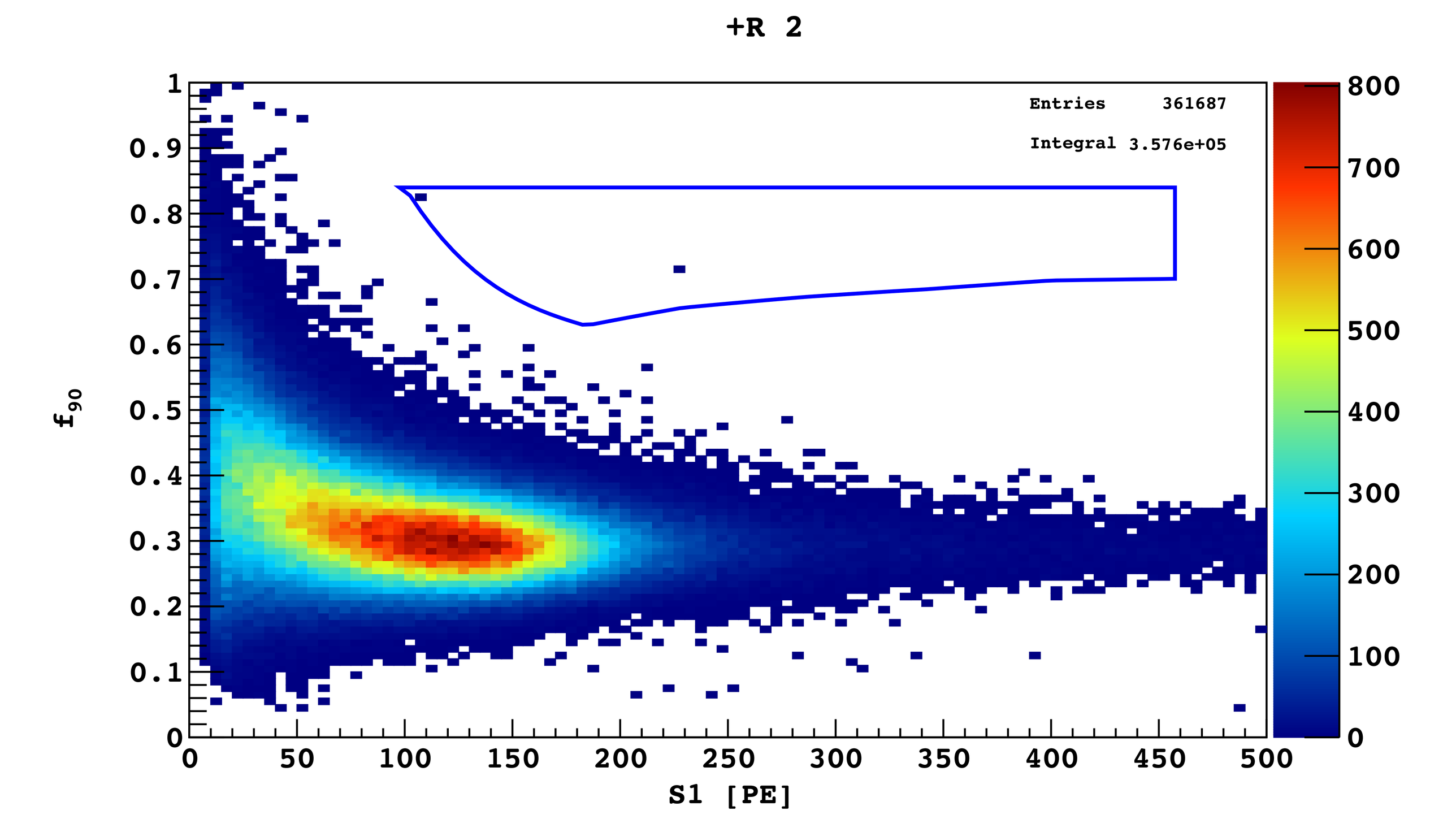

+max S2/S1
Entries 548087
Integral 5.34e+05
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
×10^3
0
0.2
0.4
0.6
0.8
1

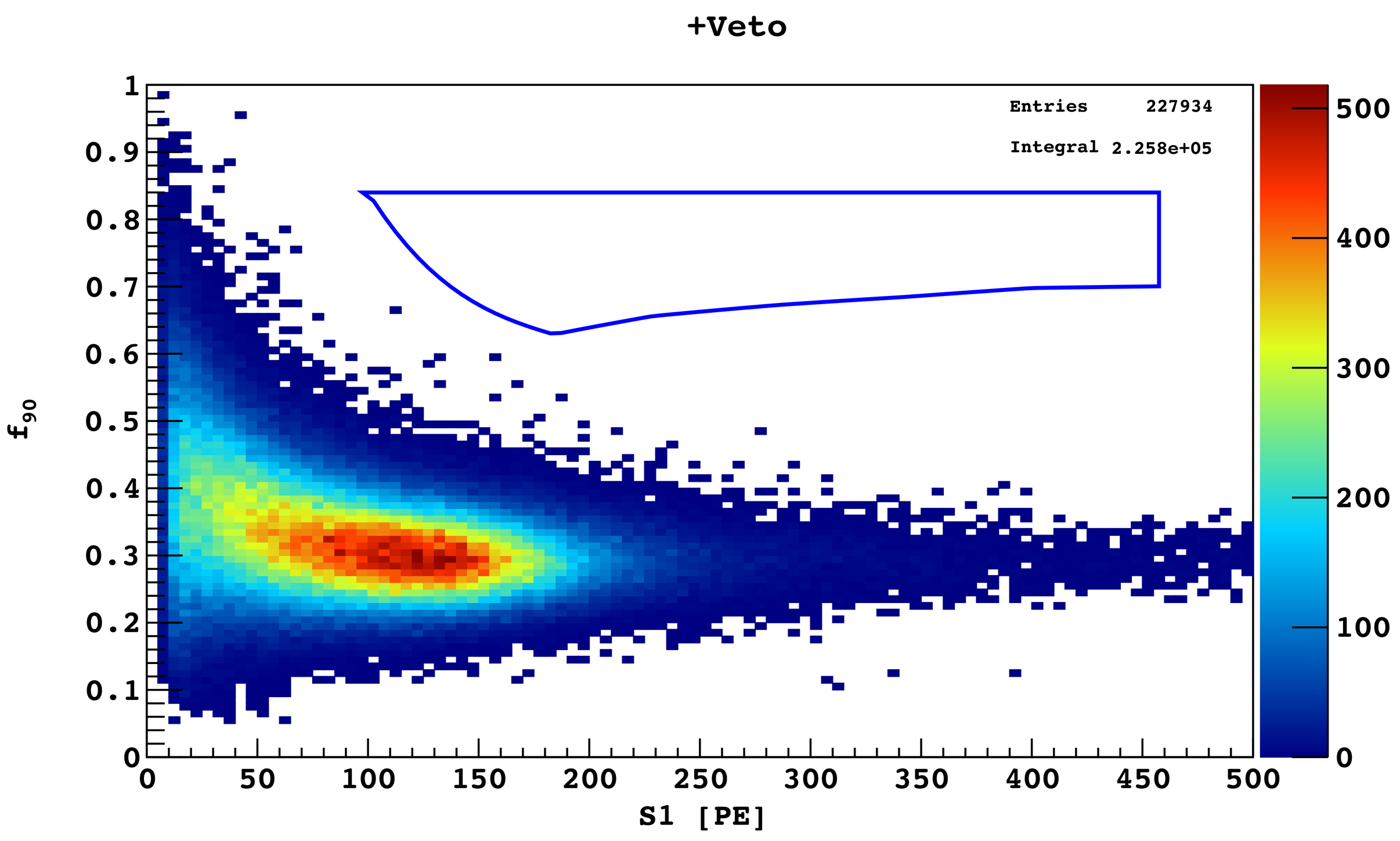

+S2 i90/i1
Entries 547837
Integral 5.338e+05
f_{90}
S1 [PE]
×10^3
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0.2
0.4
0.6
0.8
1

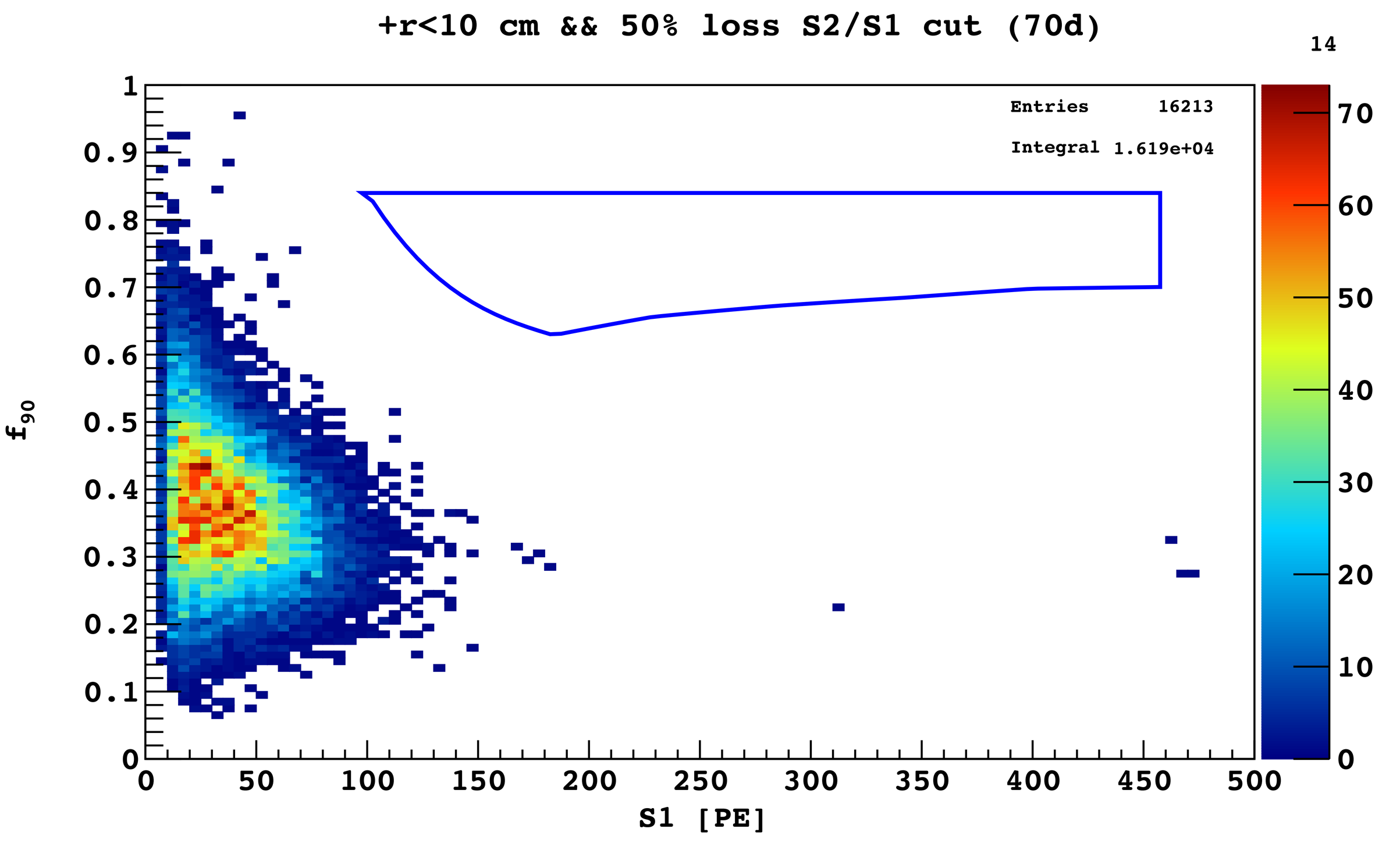

+S1 TBA
Entries 545966
Integral 5.319e+05
f_{90}
S1 [PE]
×10^3
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0
0.2
0.4
0.6
0.8
1

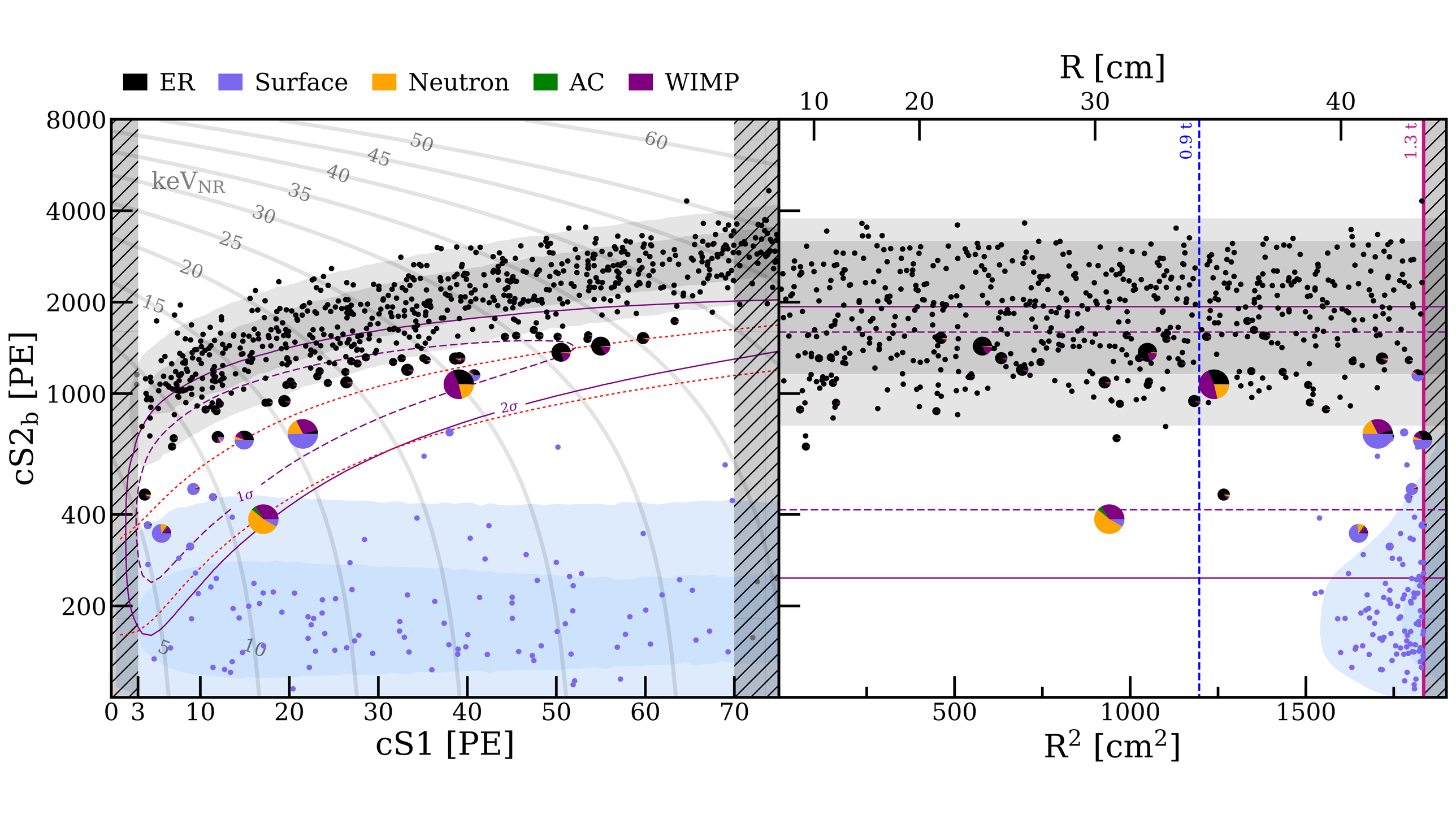

+TPB Tail
Entries 543779
Integral 5.297e+05
f_{90}
S1 [PE]
$\times 10^3$
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0.2
0.4
0.6
0.8
1


+NLL
Entries 540450
Integral 5.266e+05
f_{90}
S1 [PE]
$\times 10^3$
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0.2
0.4
0.6
0.8
1


+R 2
Entries 361687
Integral 3.576e+05
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0
100
200
300
400
500
600
700
800


+Veto
Entries 227934
Integral 2.258e+05
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0
100
200
300
400
500


+r<10 cm && 50% loss S2/S1 cut (70d)
14
Entries 16213
Integral 1.619e+04
f_{90}
S1 [PE]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250
300
350
400
450
500
0
10
20
30
40
50
60
70


ER
Surface
Neutron
AC
WIMP
R [cm]
10
20
30
40
0.9 t
1.3 t
8000
4000
2000
1000
400
200
cS2b [PE]
keVNR
60
50
45
40
35
30
25
20
15
10
5
2σ
1σ
0
3
10
20
30
40
50
60
70
cS1 [PE]
500
1000
1500
R2 [cm2]

Ionization-Only (S2-Only) Signals

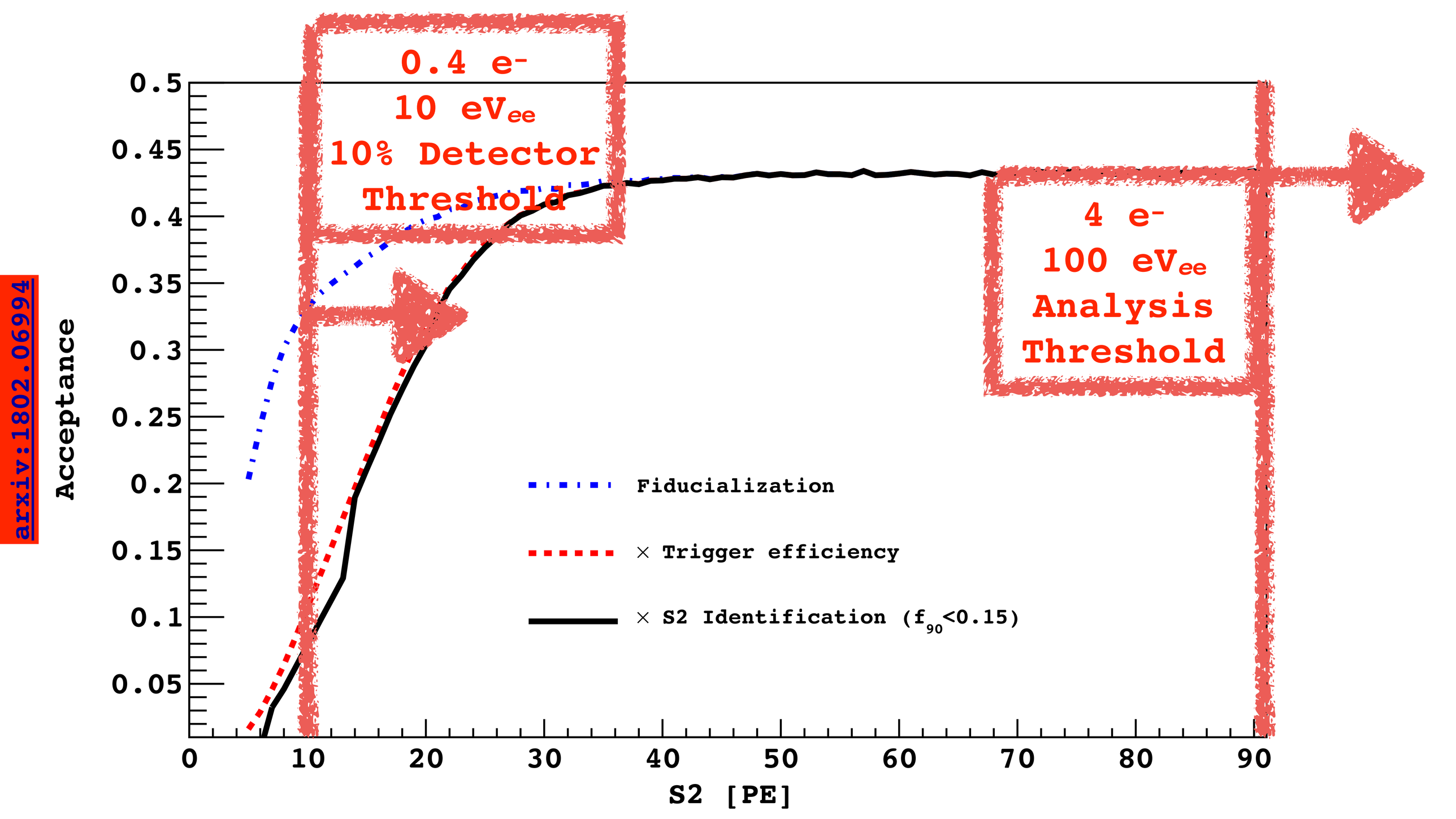
1. The PMTs have zero dark rate at 88 K so a signal is always real

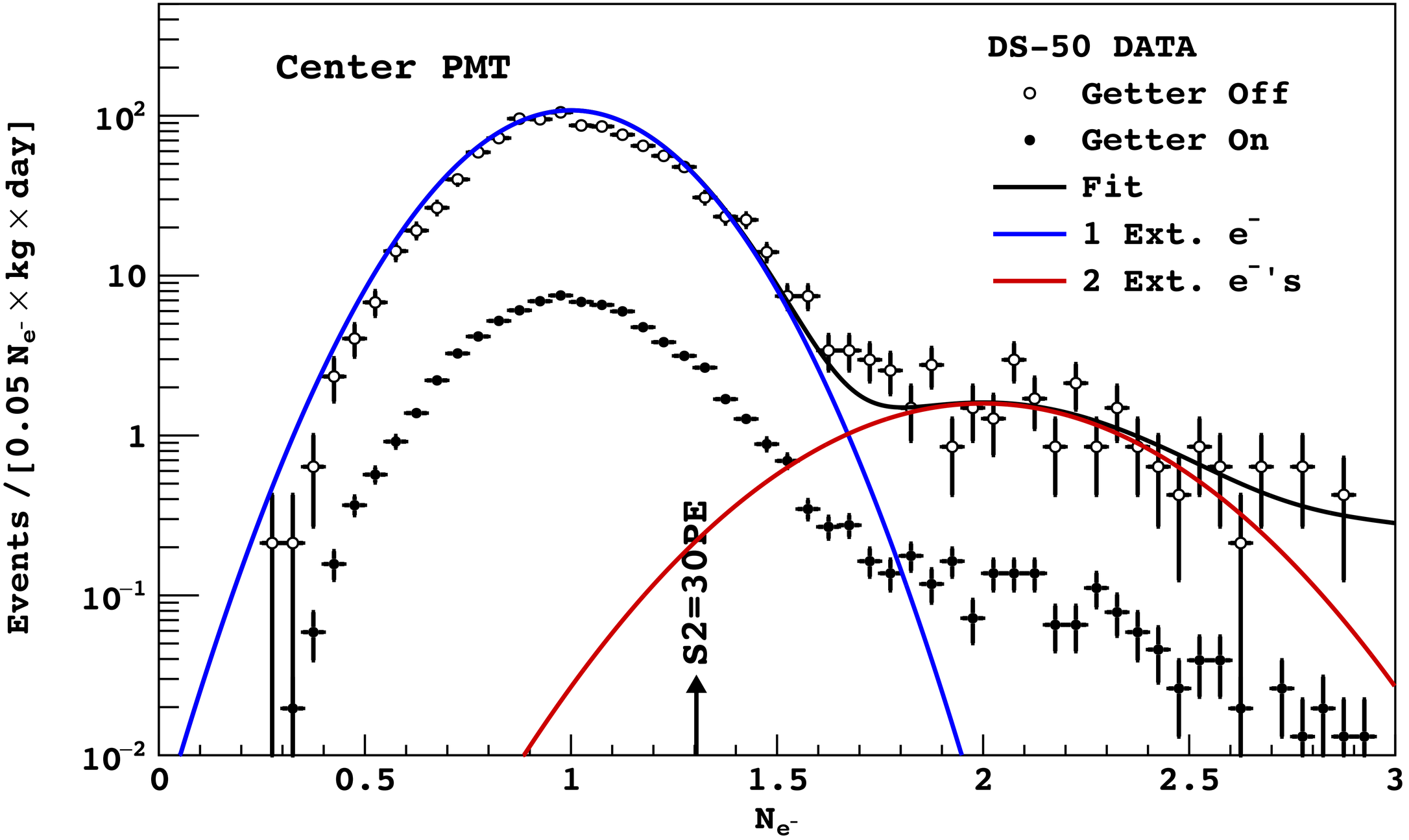
2. The gain in the gas region (~70 PE/e^-, reduced to 23 PE/e^- when accounting for the 30% QE of the PMTs) means that we are sensitive to a single extracted electron

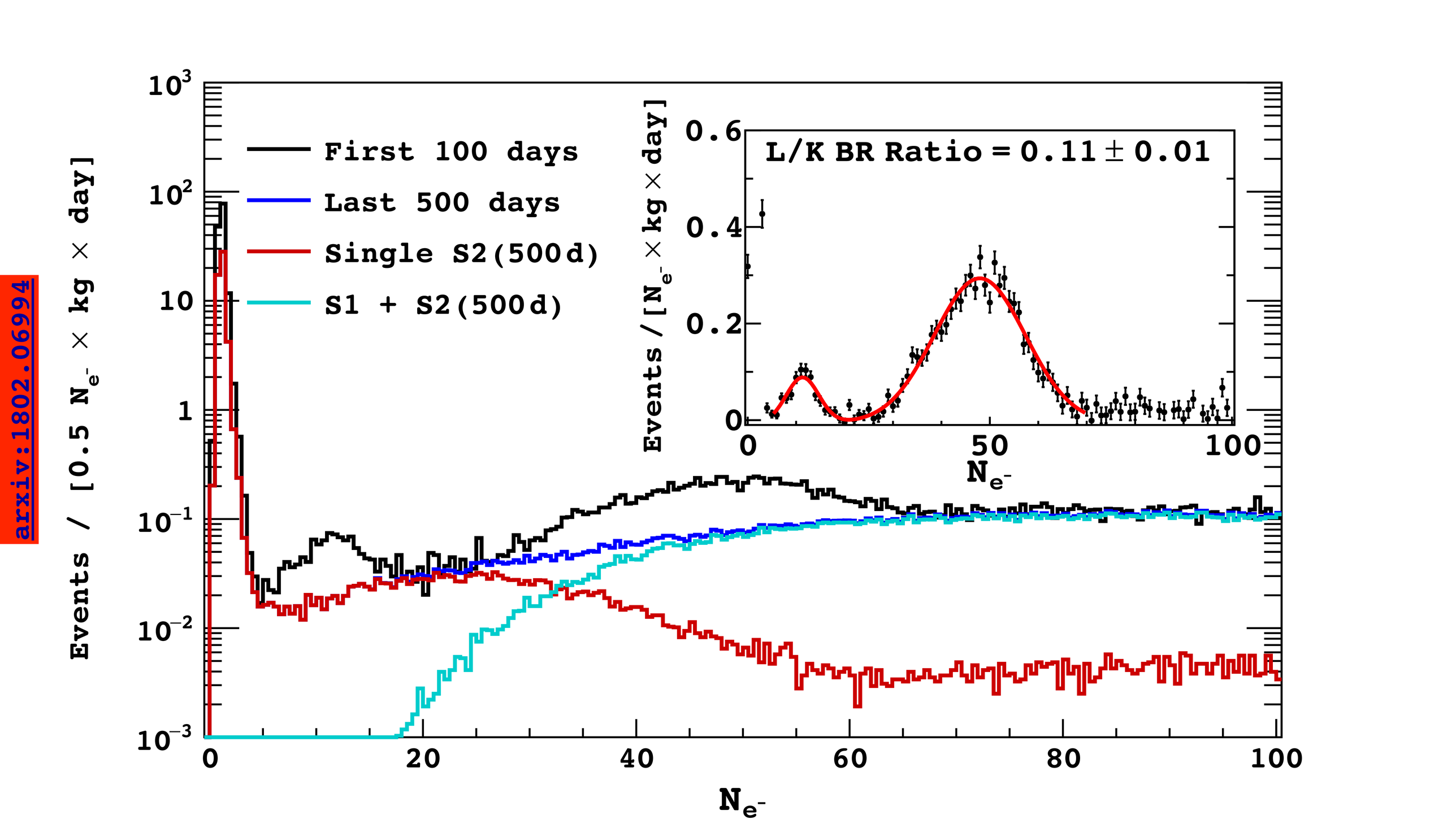
3. The radioactivity rate in the detector is remarkably low, so …

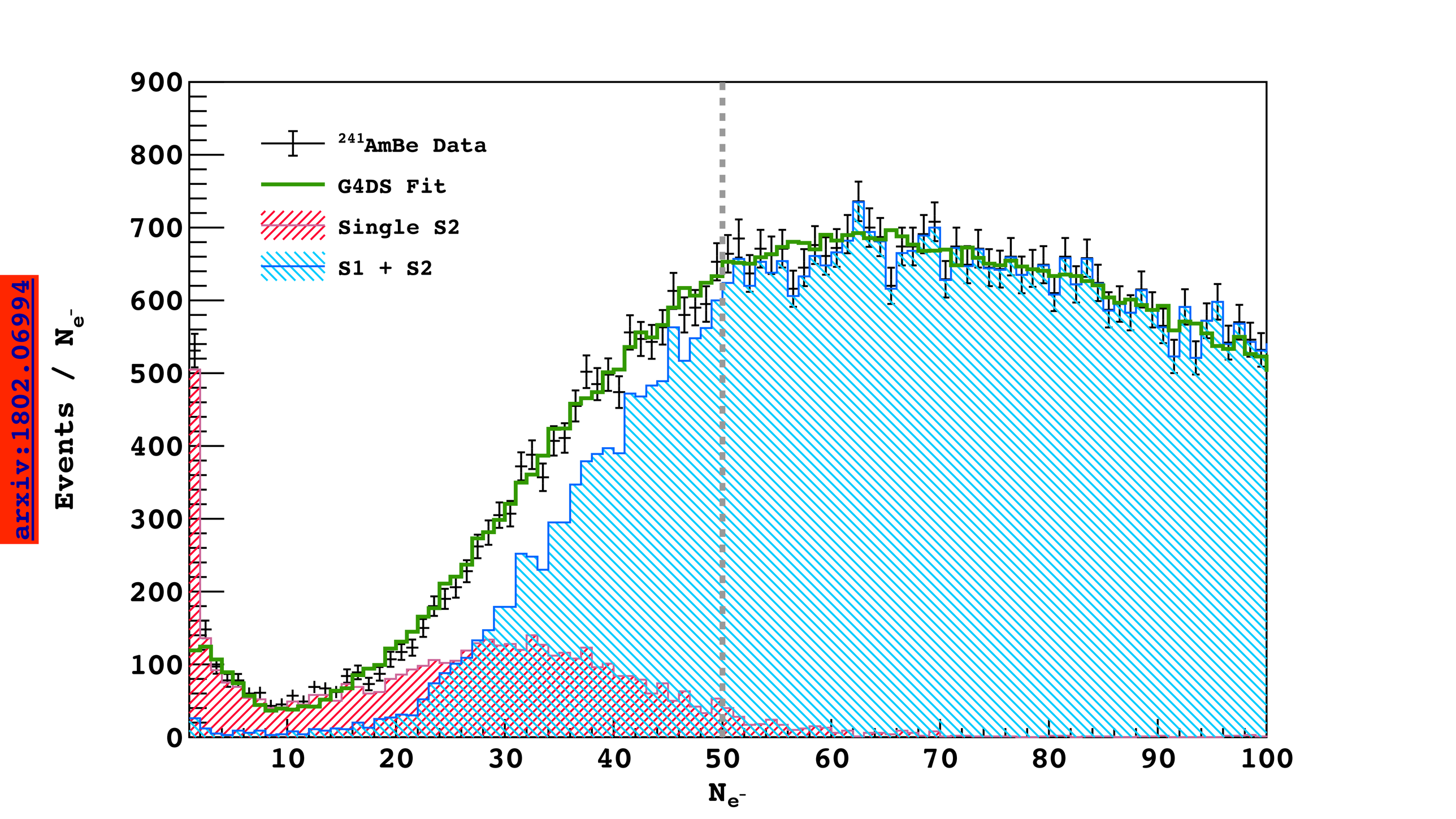
4. We don’t need PSD

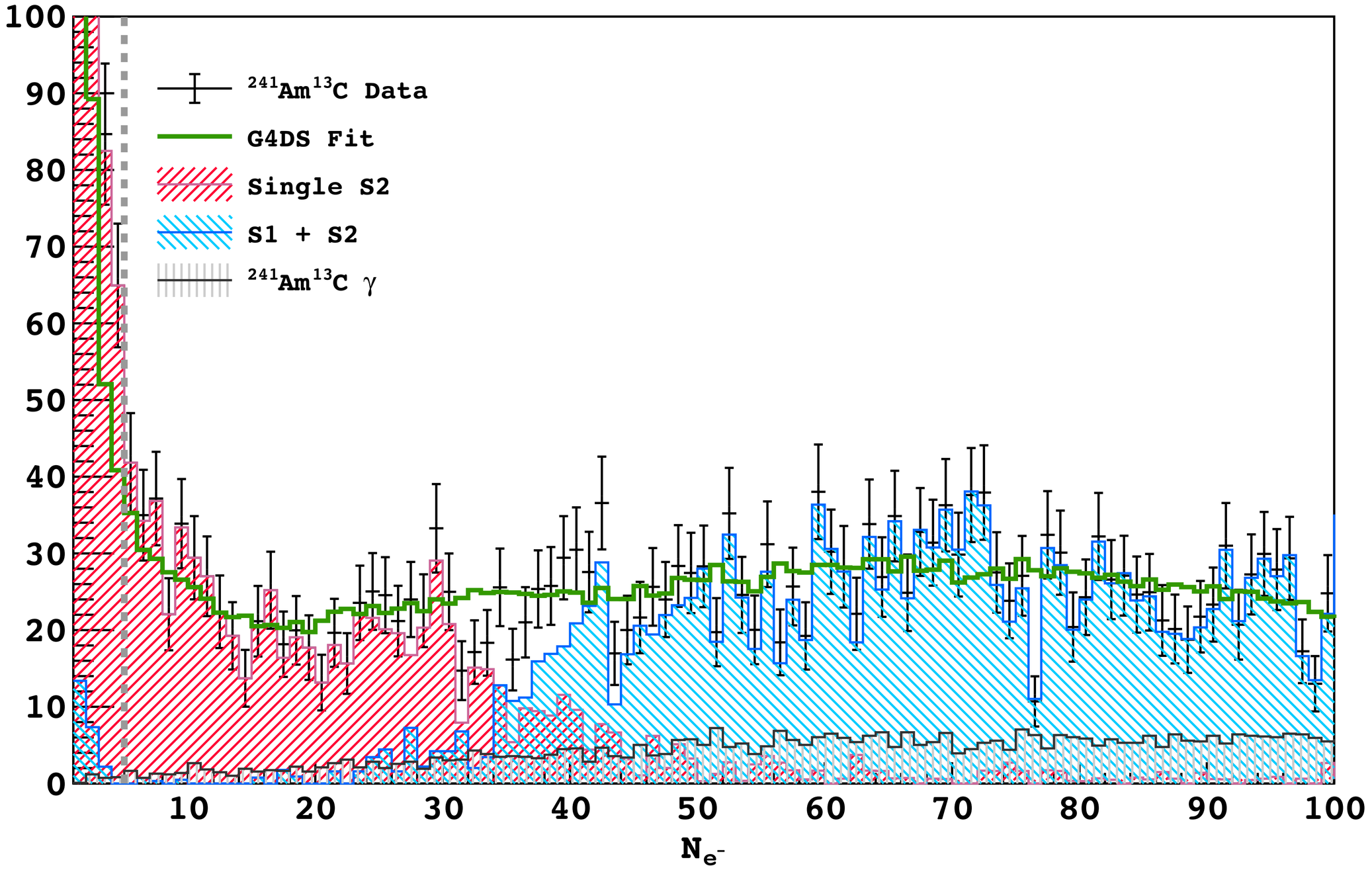
5. The electron yield for nuclear recoils rises at low energy

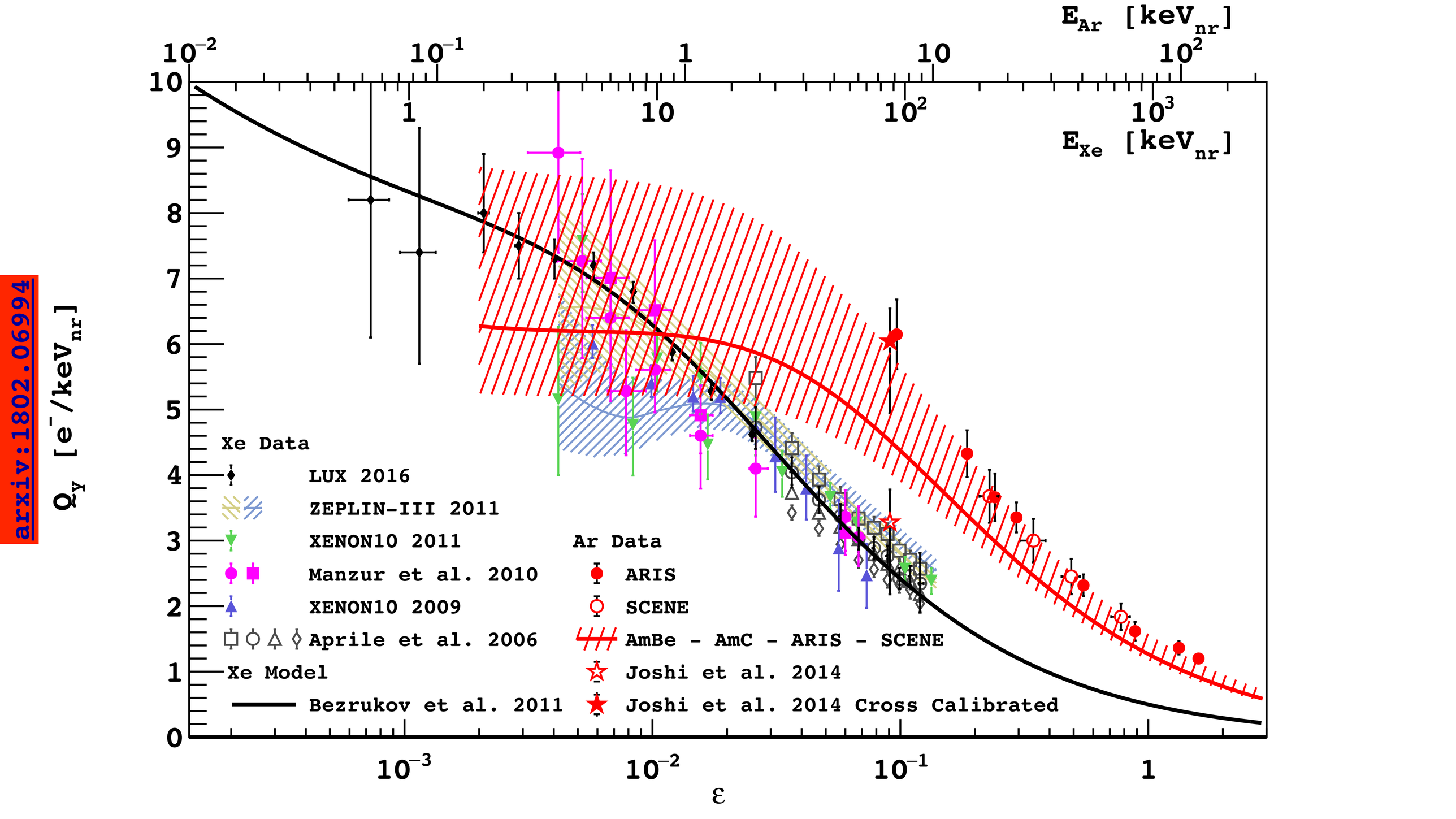

0.4 e-
10 eVee
10% Detector
Threshold
4 e-
100 eVee
Analysis
Threshold
arxiv:1802.06994
Acceptance
S2 [PE]
Fiducialization
× Trigger efficiency
× S2 Identification (f90<0.15)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10
20
30
40
50
60
70
80
90

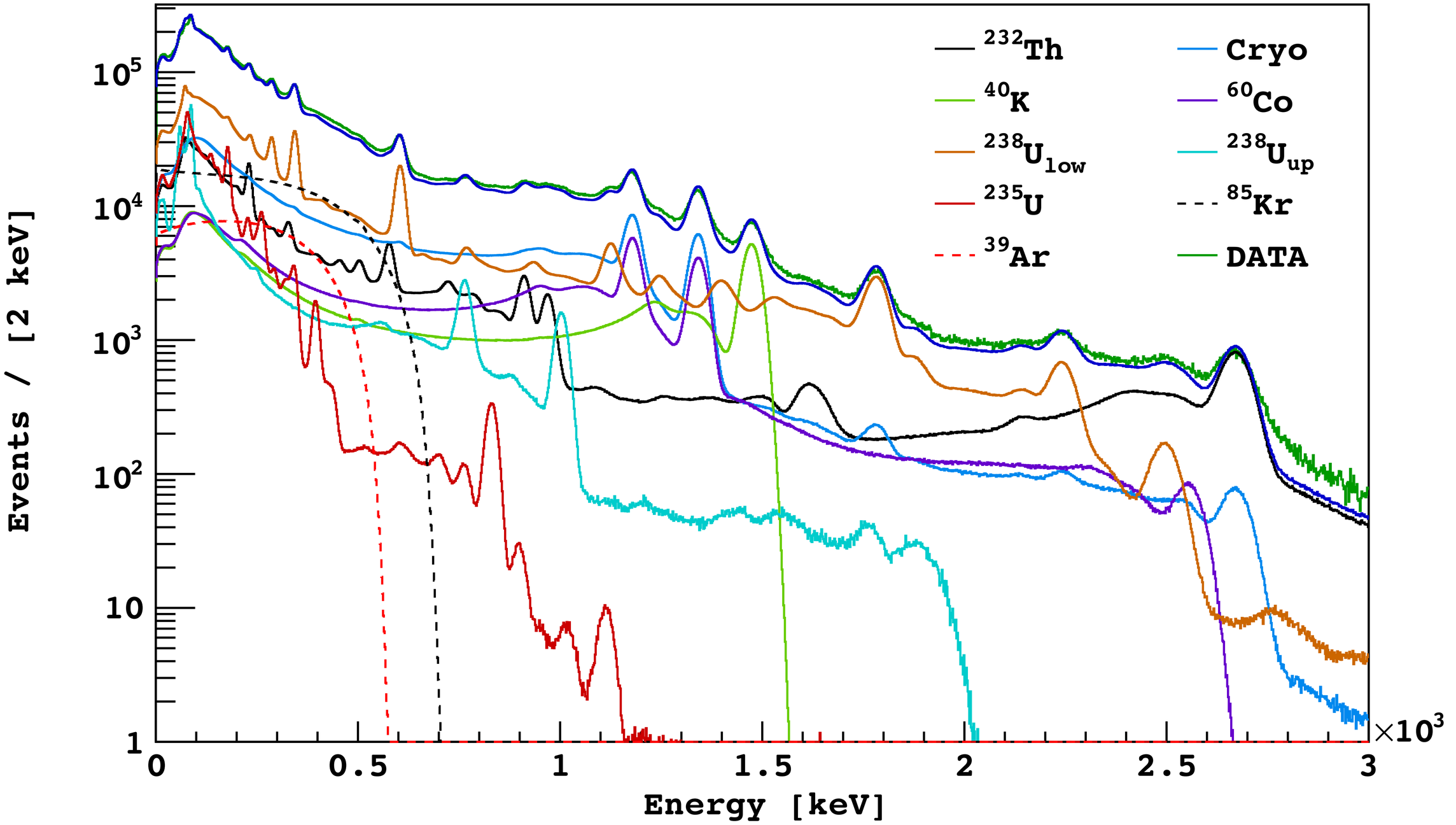


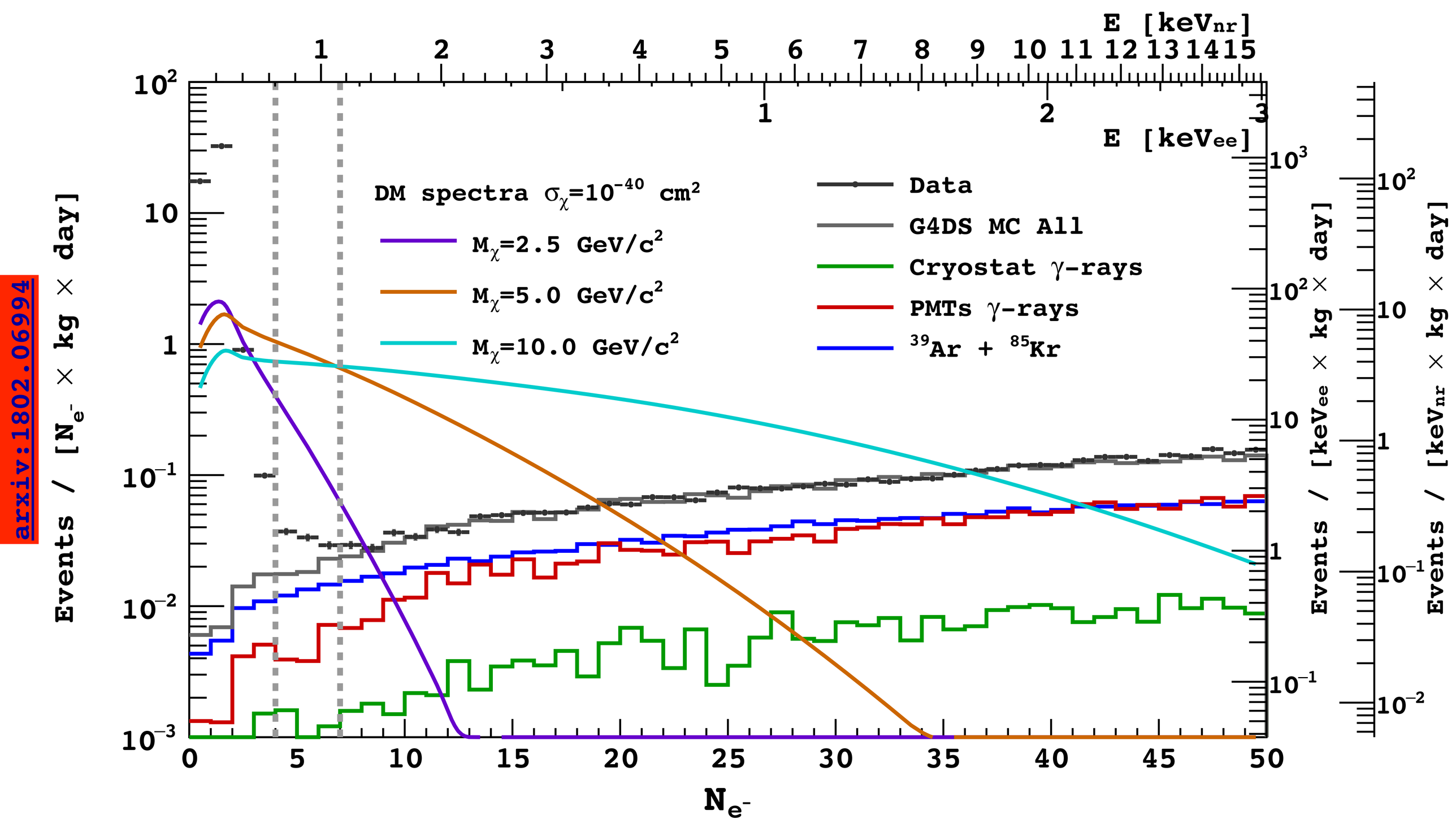

First 100 days
Last 500 days
Single S2(500d)
S1 + S2(500d)
L/K BR Ratio = 0.11 ± 0.01
Events / [0.5 N_e- × kg × day]
Events / [N_e- × kg × day]
N_e-
arxiv:1802.06994

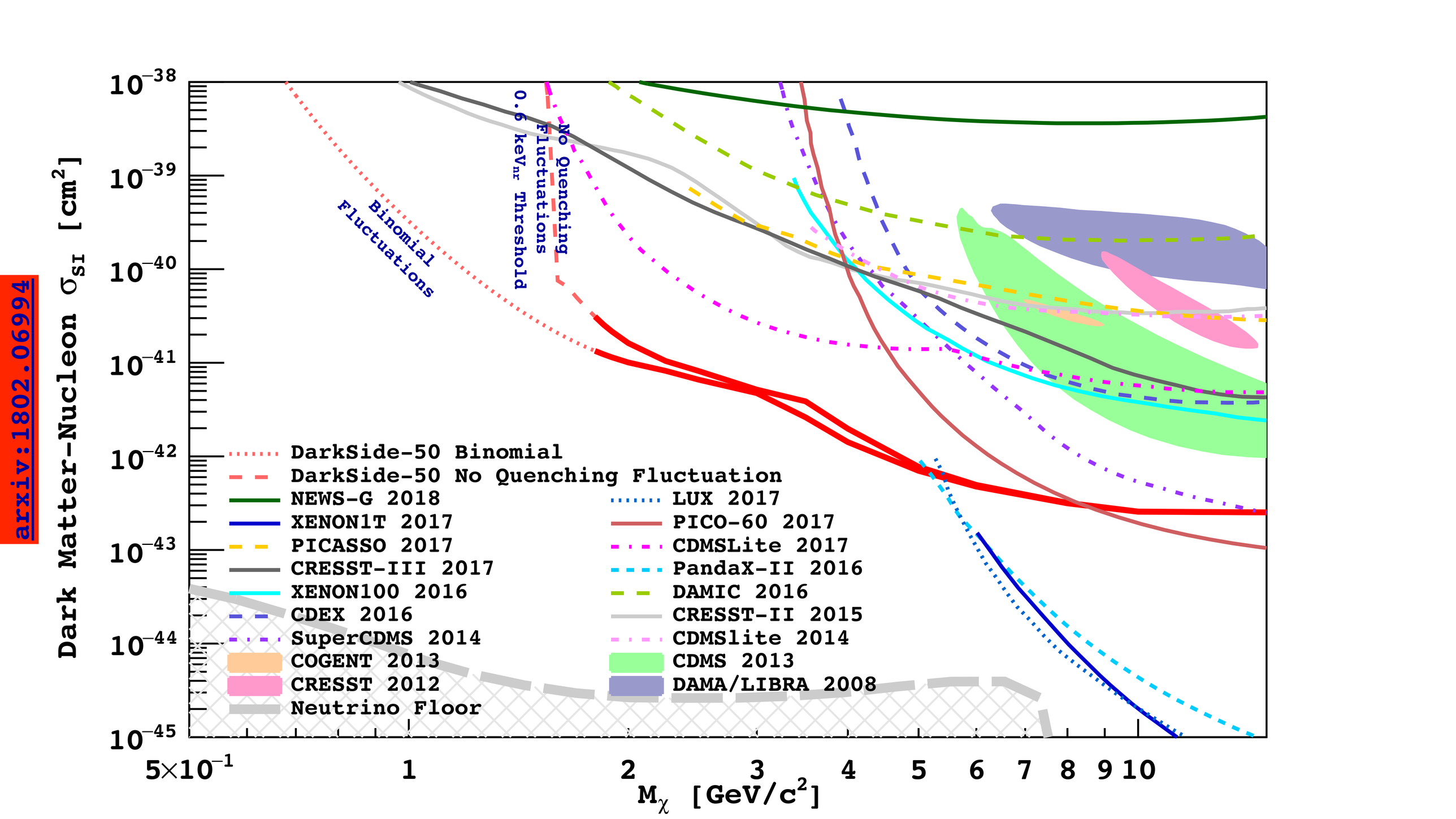


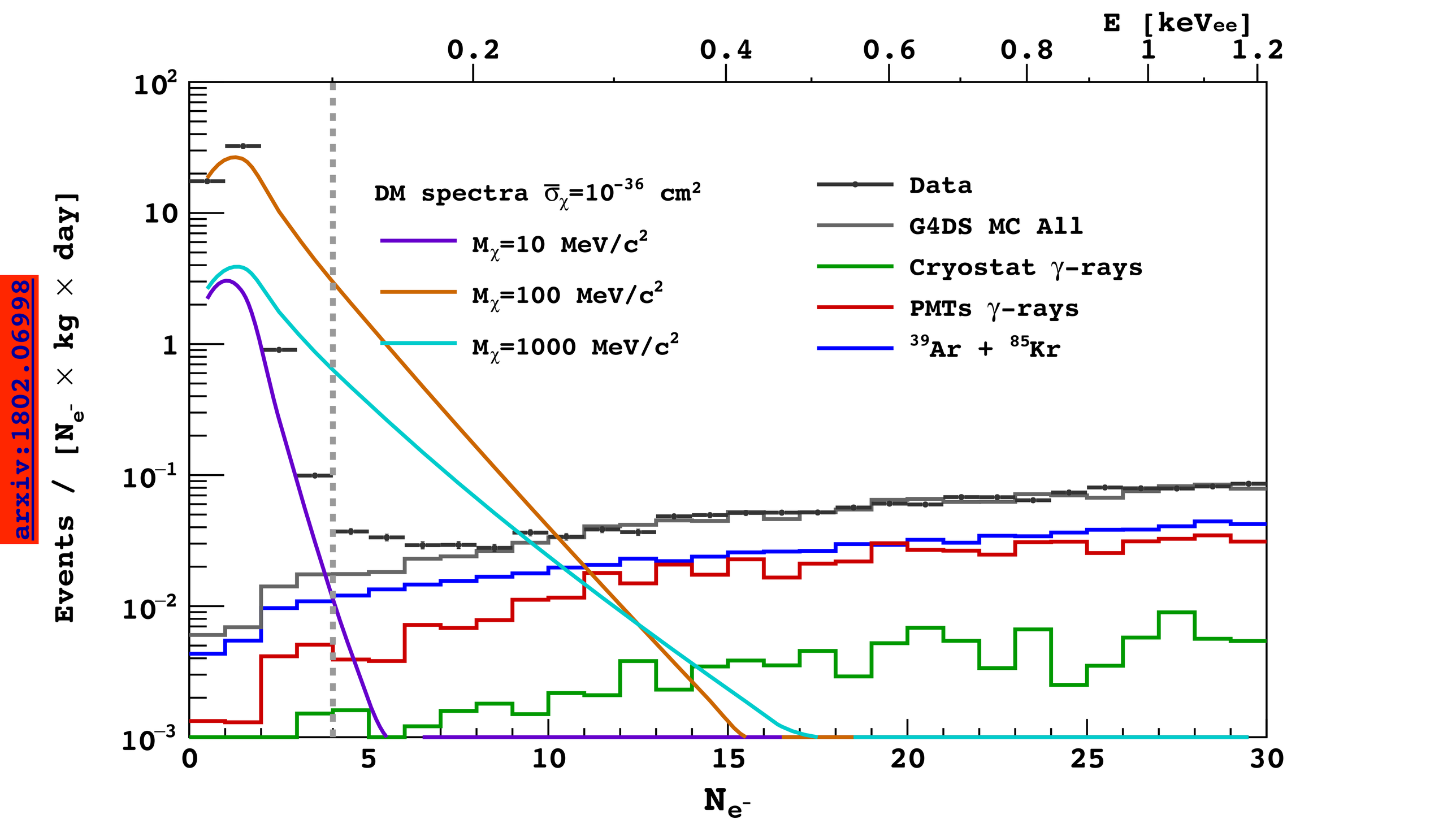


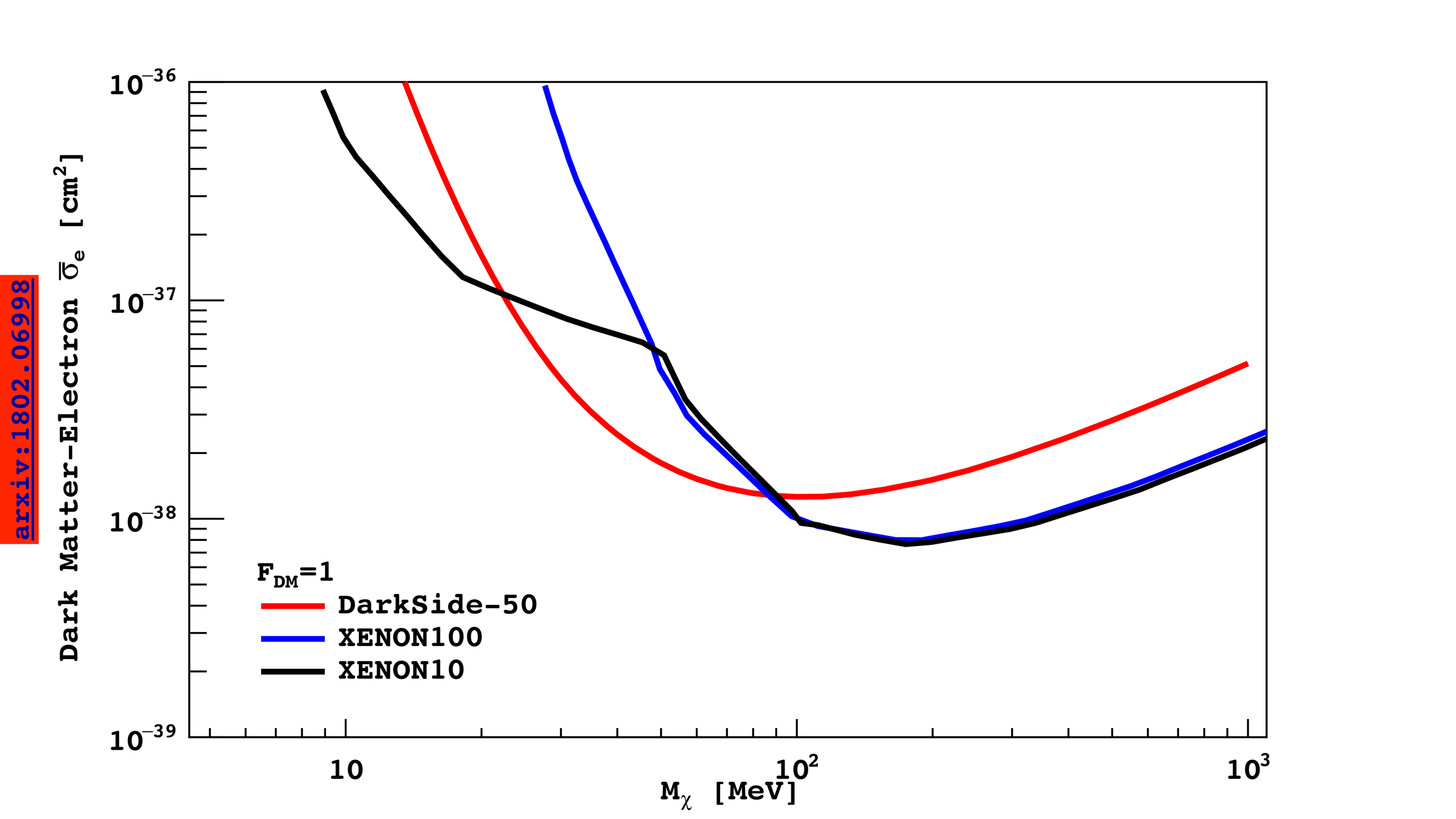


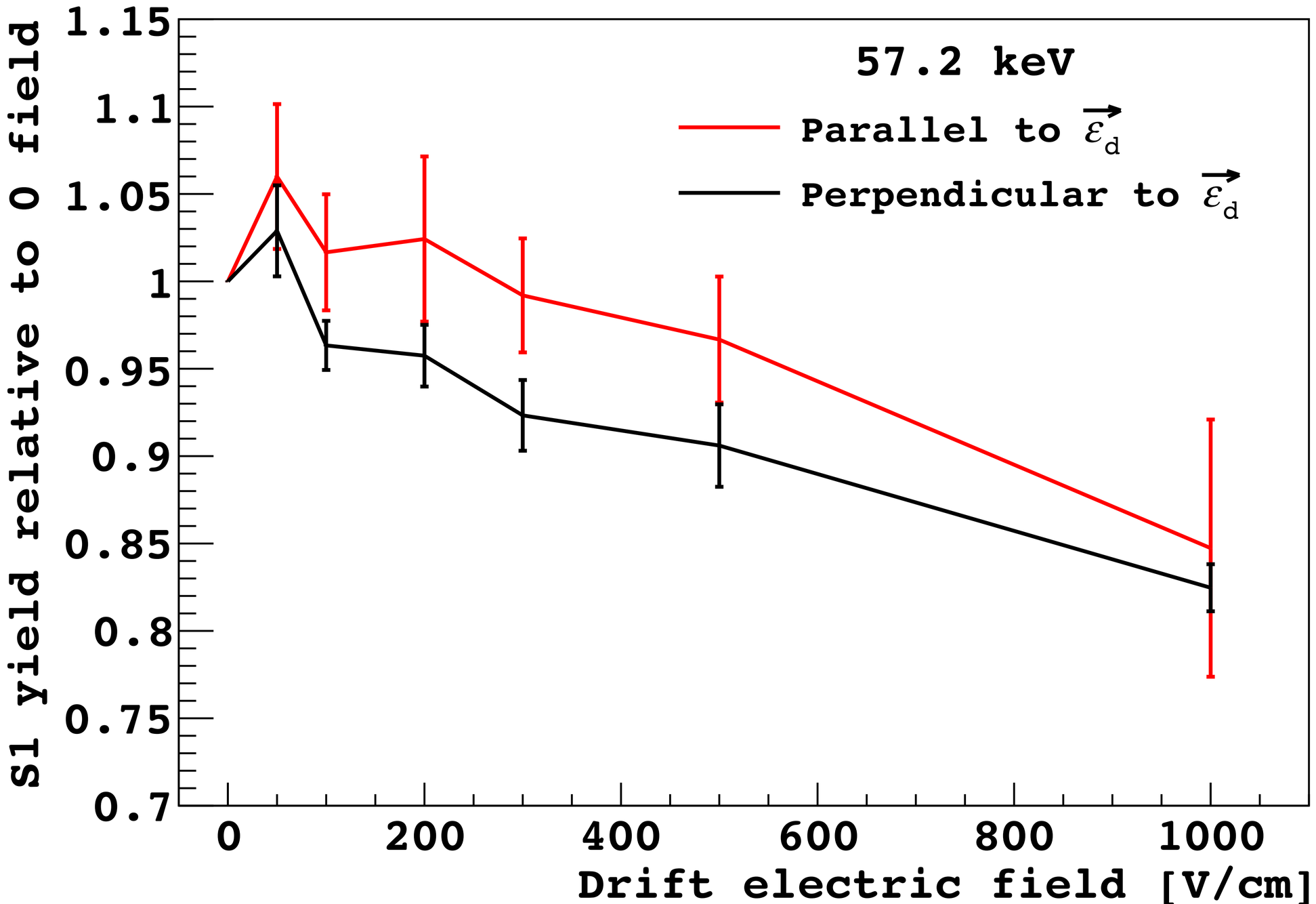



E [keVnr]
E [keVee]
DM spectra σχ=10⁻⁴⁰ cm²
Mχ=2.5 GeV/c²
Mχ=5.0 GeV/c²
Mχ=10.0 GeV/c²
Data
G4DS MC All
Cryostat γ-rays
PMTs γ-rays
³⁹Ar + ⁸⁵Kr
Events / [Ne⁻ × kg × day]
Events / [keVee × kg × day]
Events / [keVnr × kg × day]
Ne⁻
arxiv:1802.06994

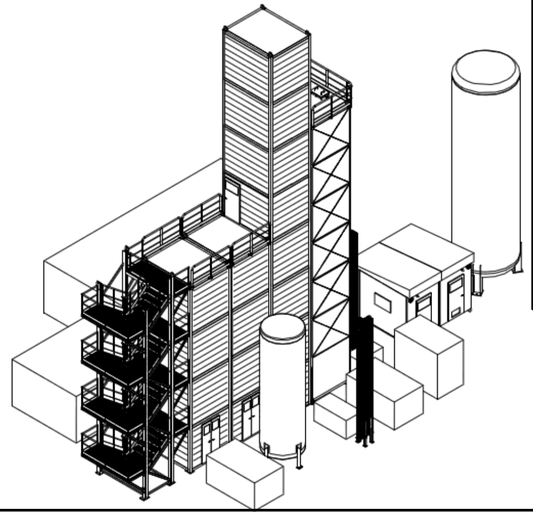

arxiv:1802.06994
Dark Matter-Nucleon σ_{SI} [cm^2]
10^{-38}
10^{-39}
10^{-40}
10^{-41}
10^{-42}
10^{-43}
10^{-44}
10^{-45}
5×10^{-1}
1
2
3
4
5
6
7
8
9
10
M_χ [GeV/c^2]
Binomial Fluctuations
0.6 keV$_{nr}$ Threshold
No Quenching Fluctuations
DarkSide-50 Binomial
DarkSide-50 No Quenching Fluctuation
NEWS-G 2018
XENON1T 2017
PICASSO 2017
CRESST-III 2017
XENON100 2016
CDEX 2016
SuperCDMS 2014
COGENT 2013
CRESST 2012
Neutrino Floor
LUX 2017
PICO-60 2017
CDMSLite 2017
PandaX-II 2016
DAMIC 2016
CRESST-II 2015
CDMSlite 2014
CDMS 2013
DAMA/LIBRA 2008

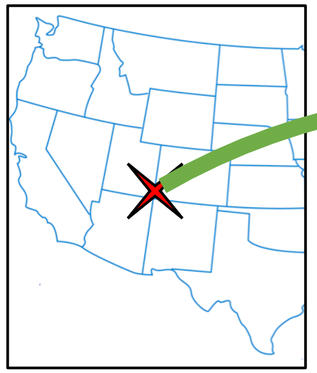

E [keVee]
0.2
0.4
0.6
0.8
1
1.2
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
Events / [N_{e^-} × kg × day]
0
5
10
15
20
25
30
N_{e^-}
DM spectra $\bar{\sigma}_\chi=10^{-36}$ cm²
M_χ=10 MeV/c²
M_χ=100 MeV/c²
M_χ=1000 MeV/c²
Data
G4DS MC All
Cryostat γ-rays
PMTs γ-rays
^{39}Ar + ^{85}Kr
arxiv:1802.06998


arxiv:1802.06998
Dark Matter-Electron $\overline{\sigma}_e$ [cm^2]
10^{-36}
10^{-37}
10^{-38}
10^{-39}
F_{DM}=1
DarkSide-50
XENON100
XENON10
10
10^2
10^3
M_χ [MeV]


57.2 keV
Parallel to $\vec{\varepsilon}_d$
Perpendicular to $\vec{\varepsilon}_d$
S1 yield relative to 0 field
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0
200
400
600
800
1000
Drift electric field [V/cm]

Production and Purification





UAr transported via boat for final purification at Aria

Production: Urania

- Commercial-scale plant to extract UAr
- Located in Southwestern Colorado
- UAr extracted from CO_2 well gas at the tonne scale

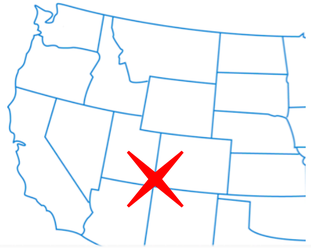
Focus of this talk

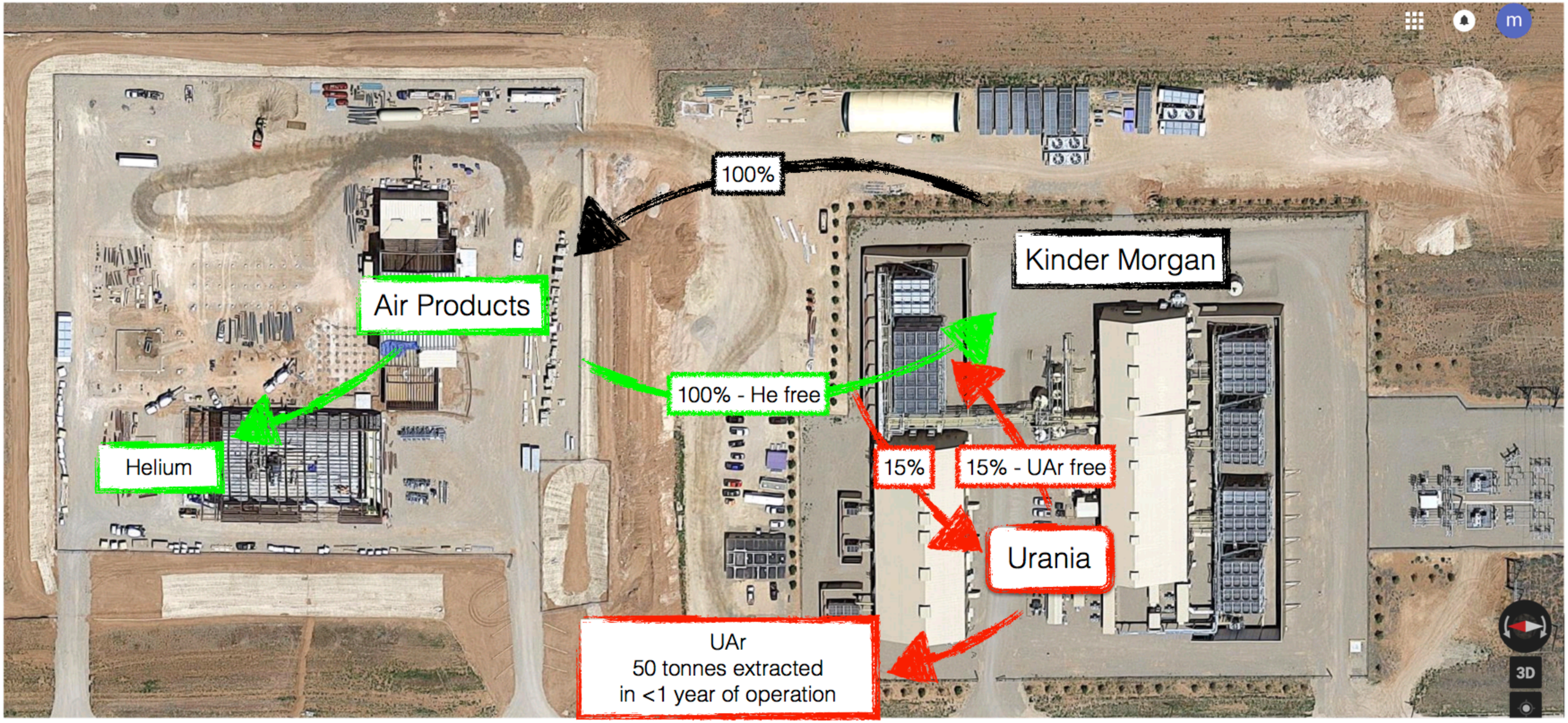
Purification: Aria

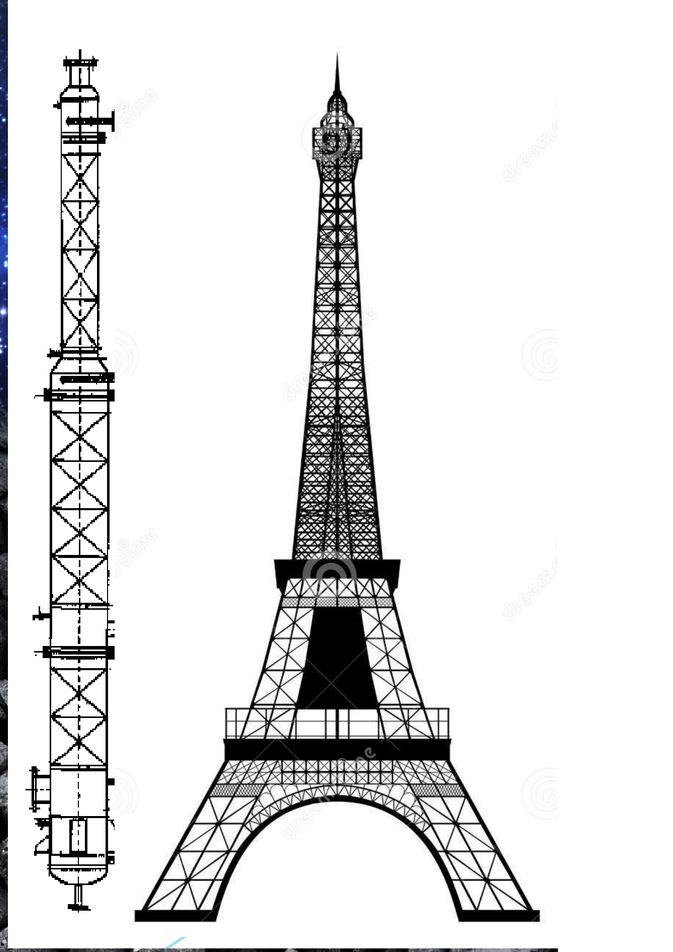
(see M. Simeone's talk for details)

- 350 m tall cryogenic distillation column to purify UAr and isotopically separate argon and other elements
- Located in refurbished carbon mine shaft in Sardinia, Italy
- Will chemically purify the UAr for DS-20k to detector grade

Enter the Age of Urania

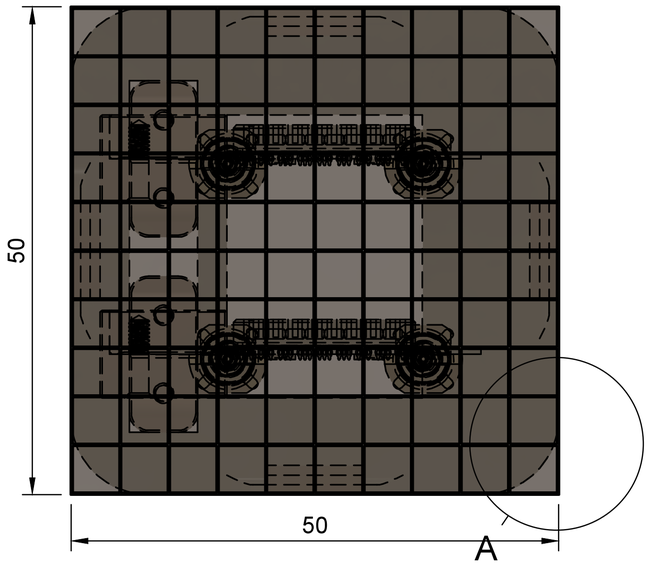


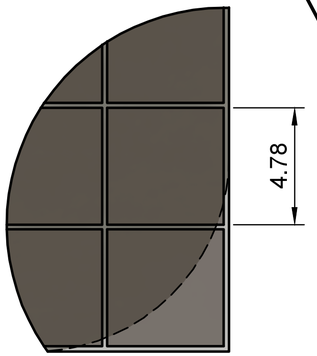




Tile

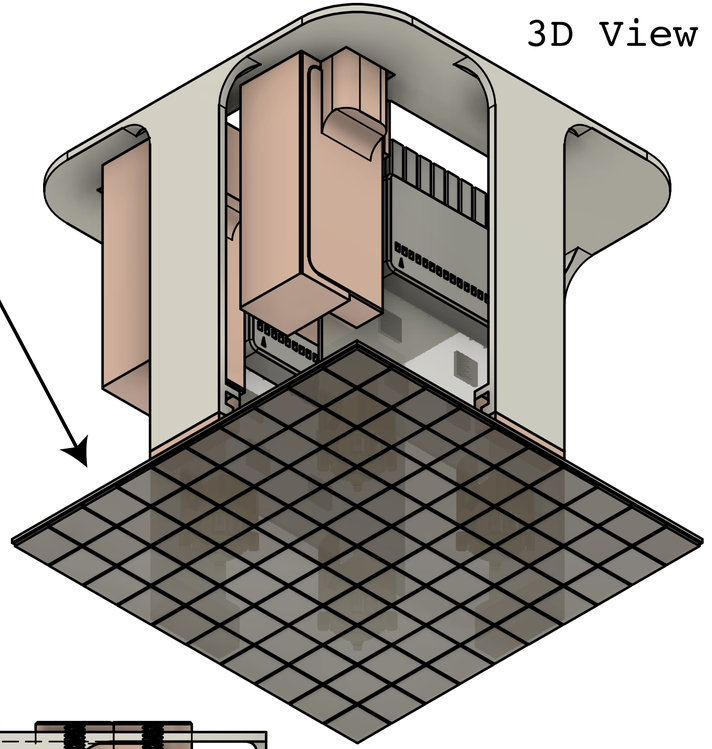
Top View

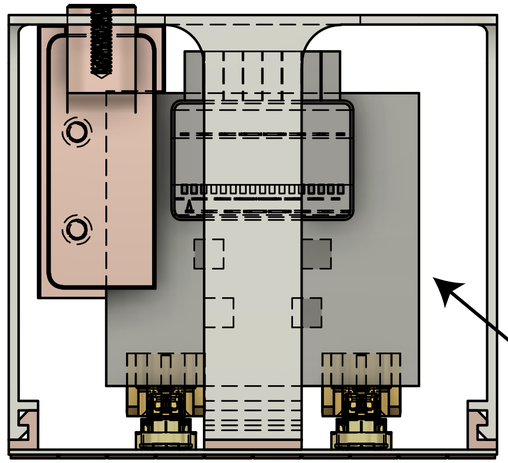




A (5.0000)

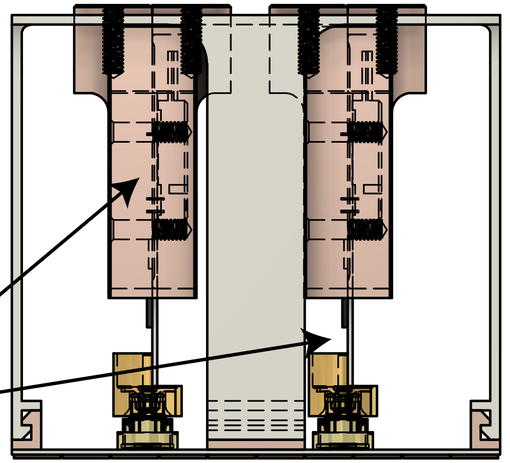
3D View



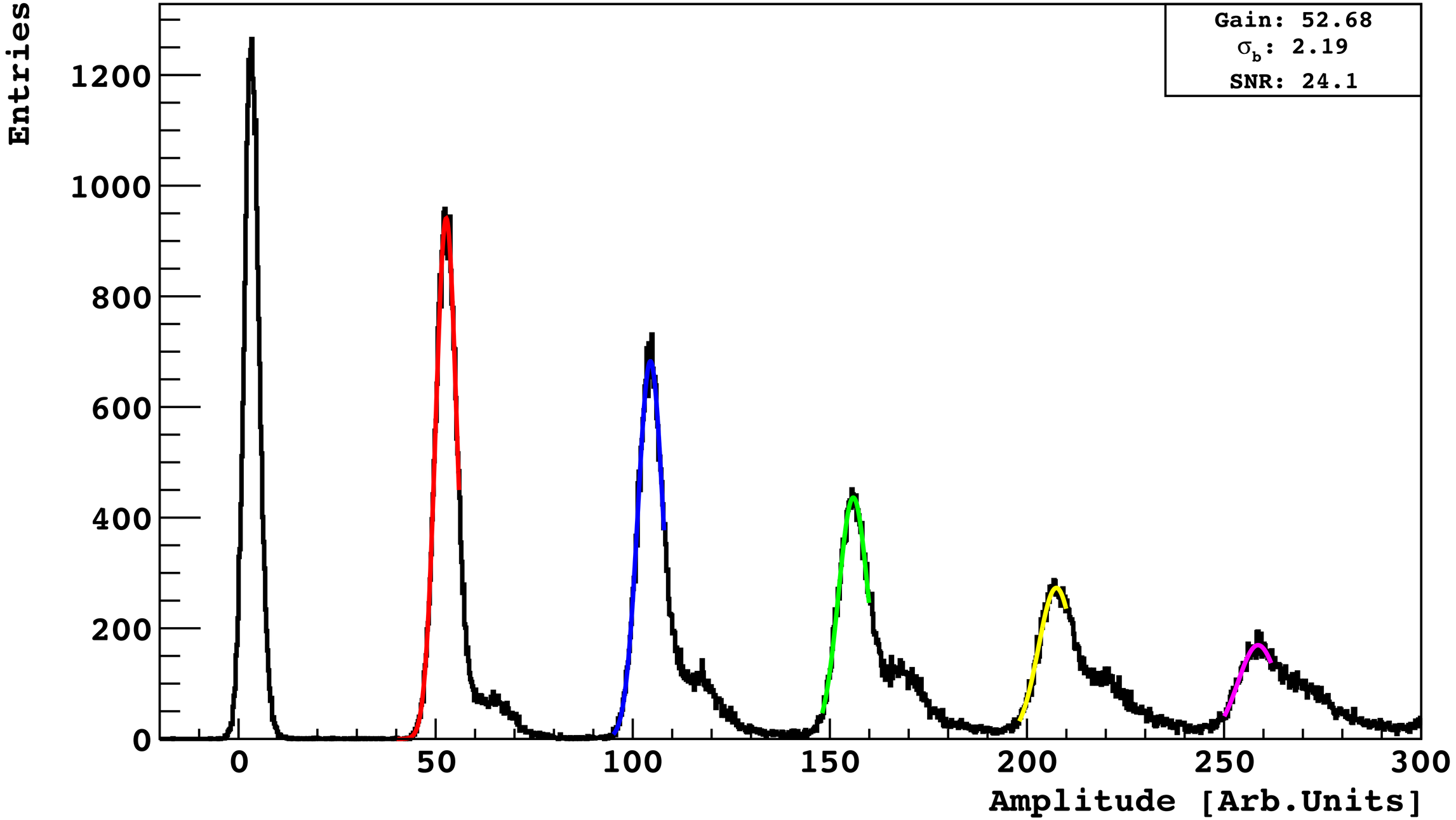


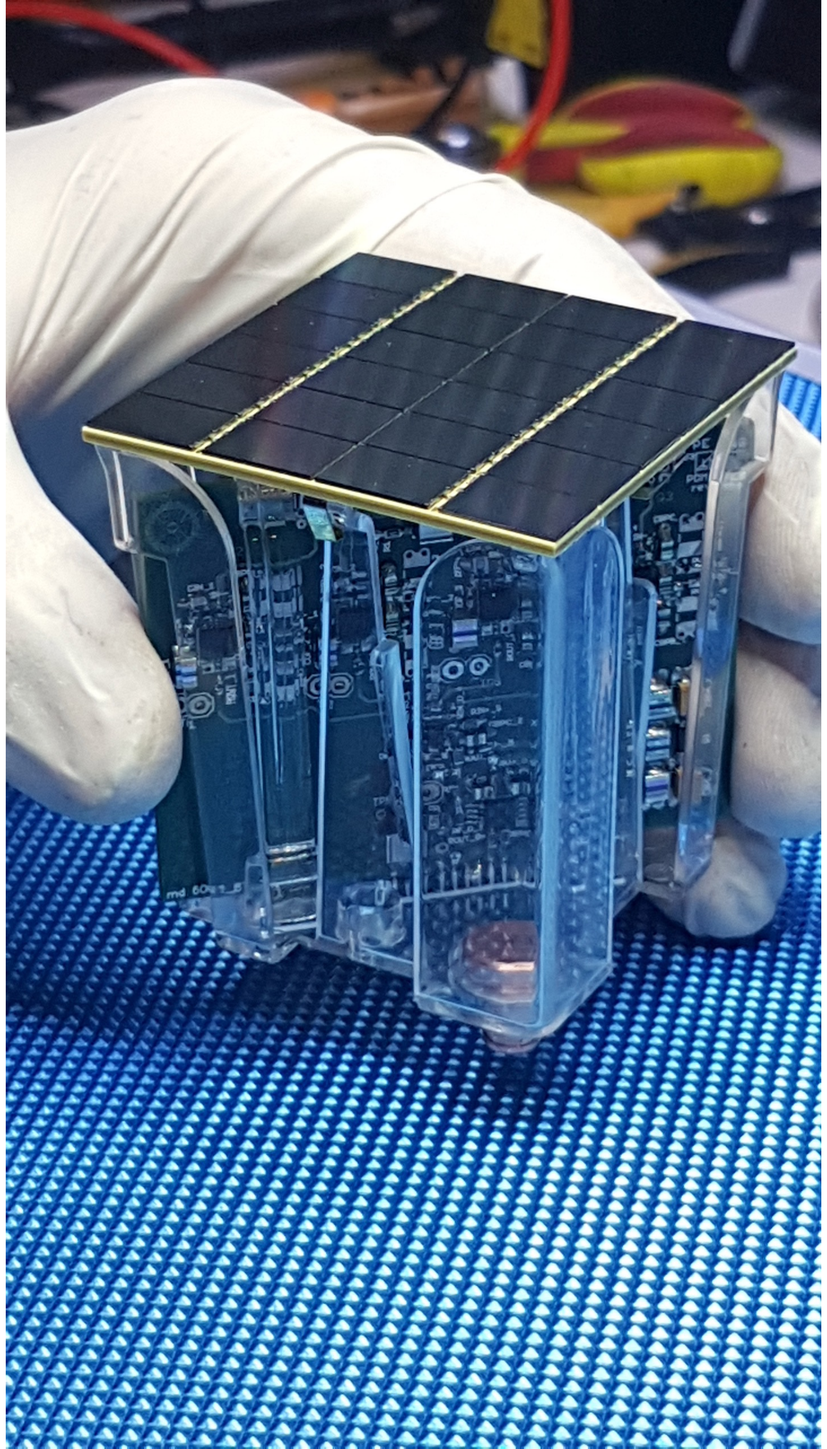
Side View

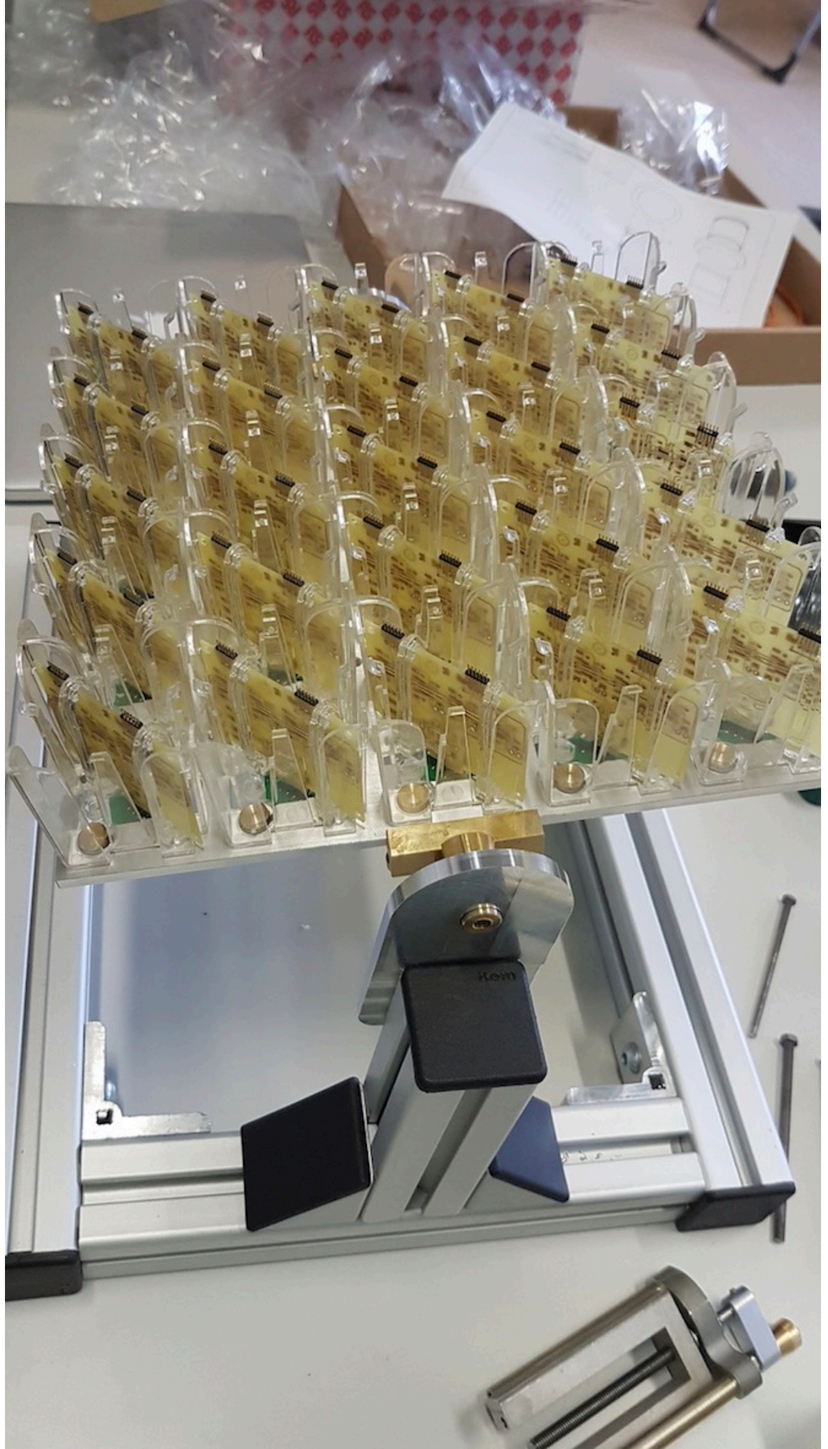
FEBs

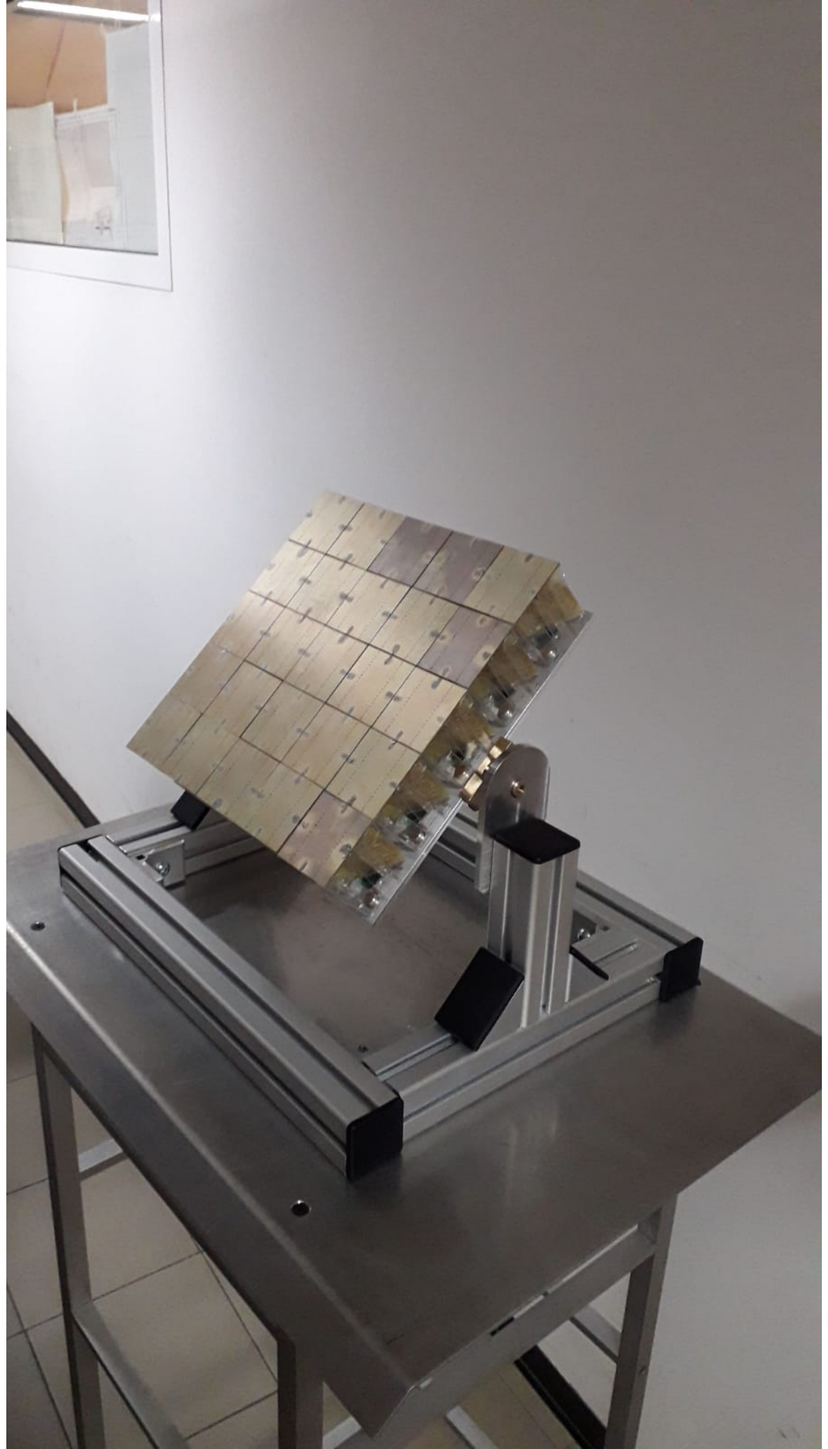


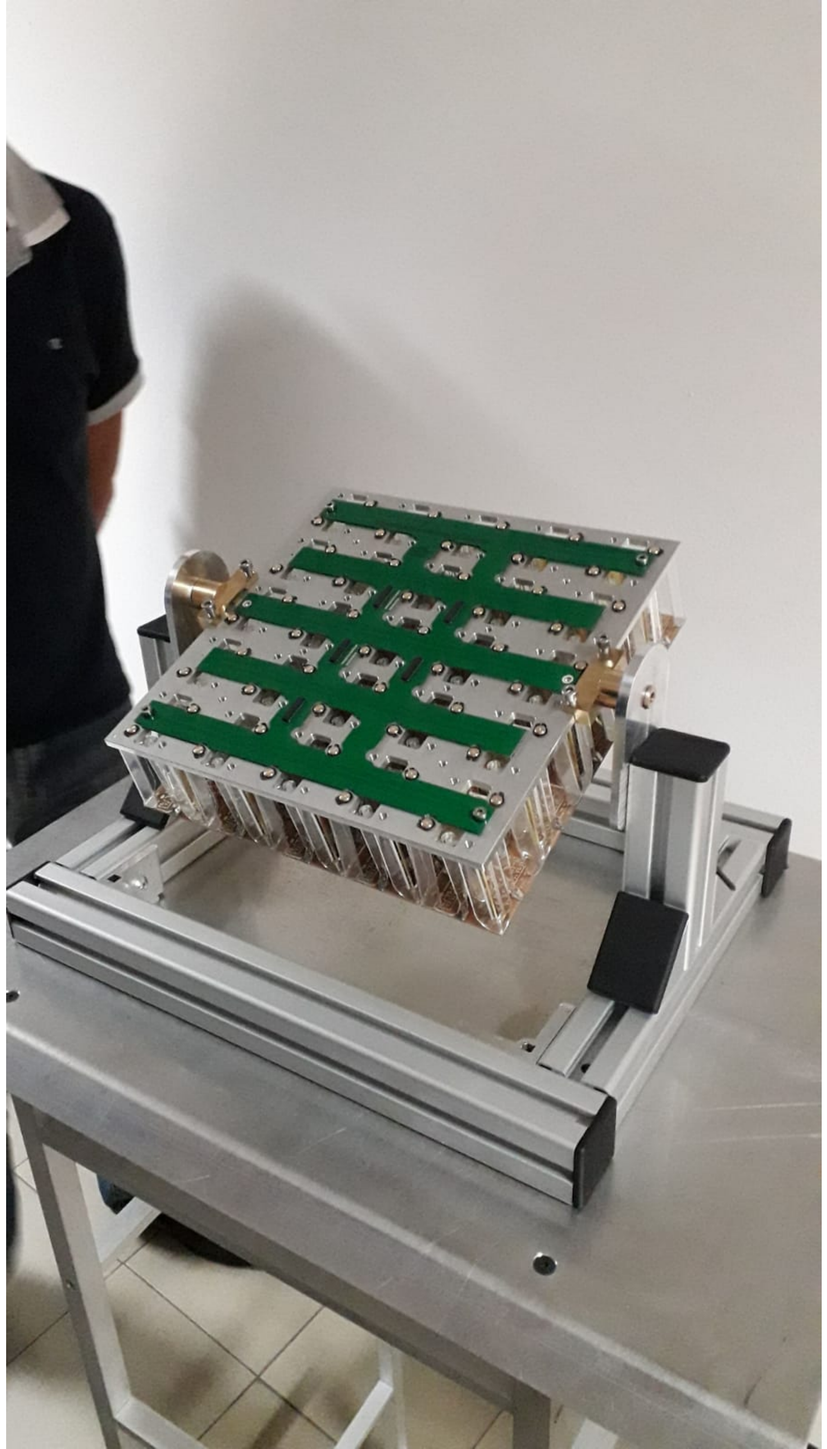
Side View

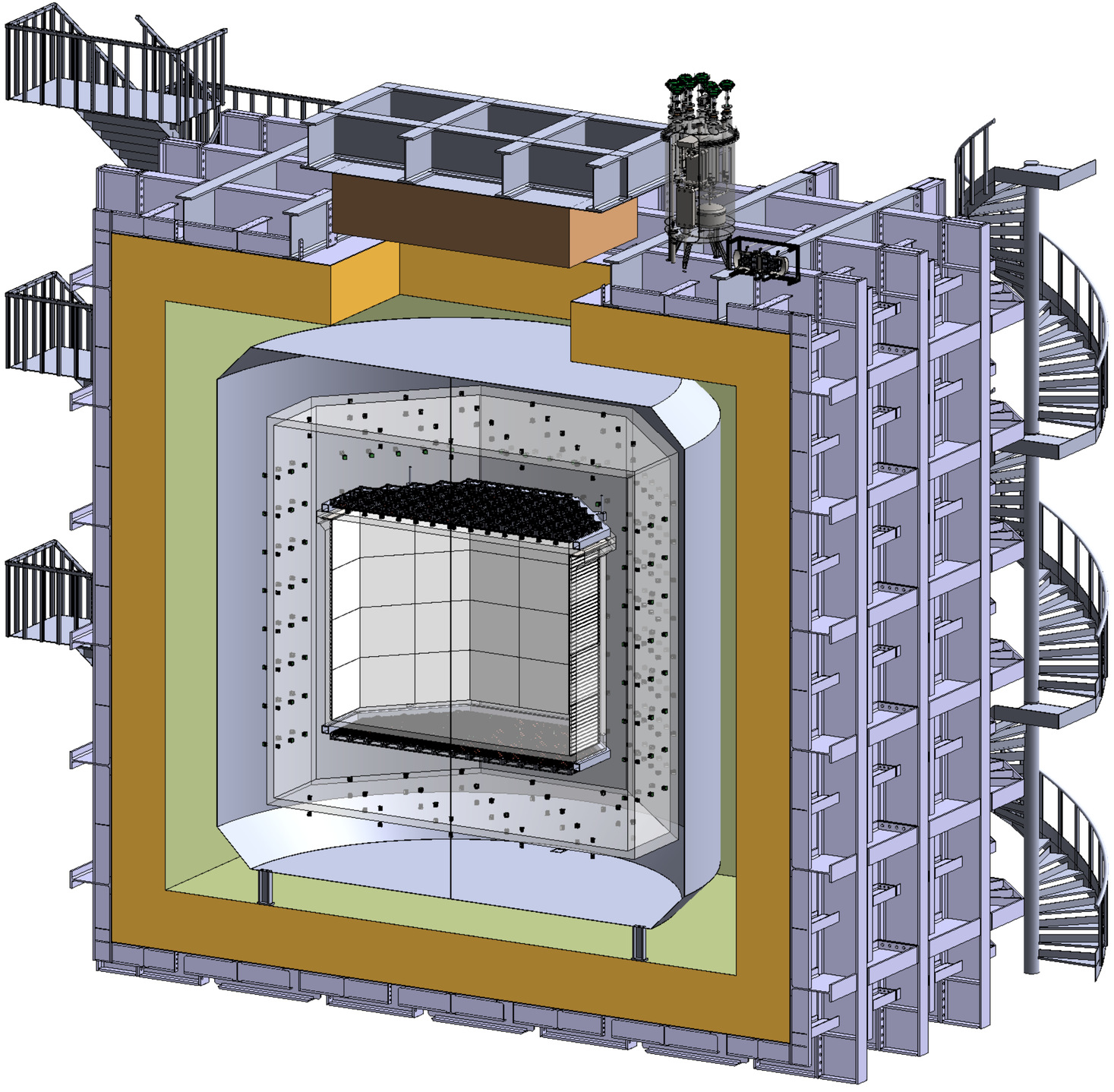

Gain: 52.68
σ_b: 2.19
SNR: 24.1
Entries
0
200
400
600
800
1000
1200
0
50
100
150
200
250
300
Amplitude [Arb.Units]












The End