The Latest from the XENON Dark Matter Project

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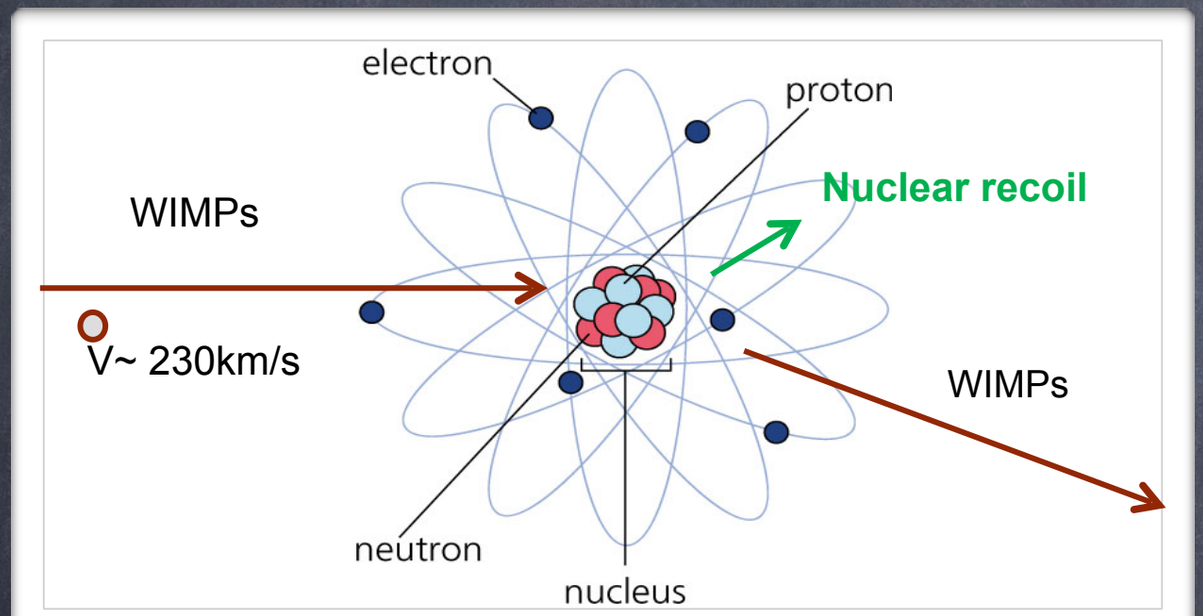
For the XENON Collaboration
ALPS 2018

Direct Detection

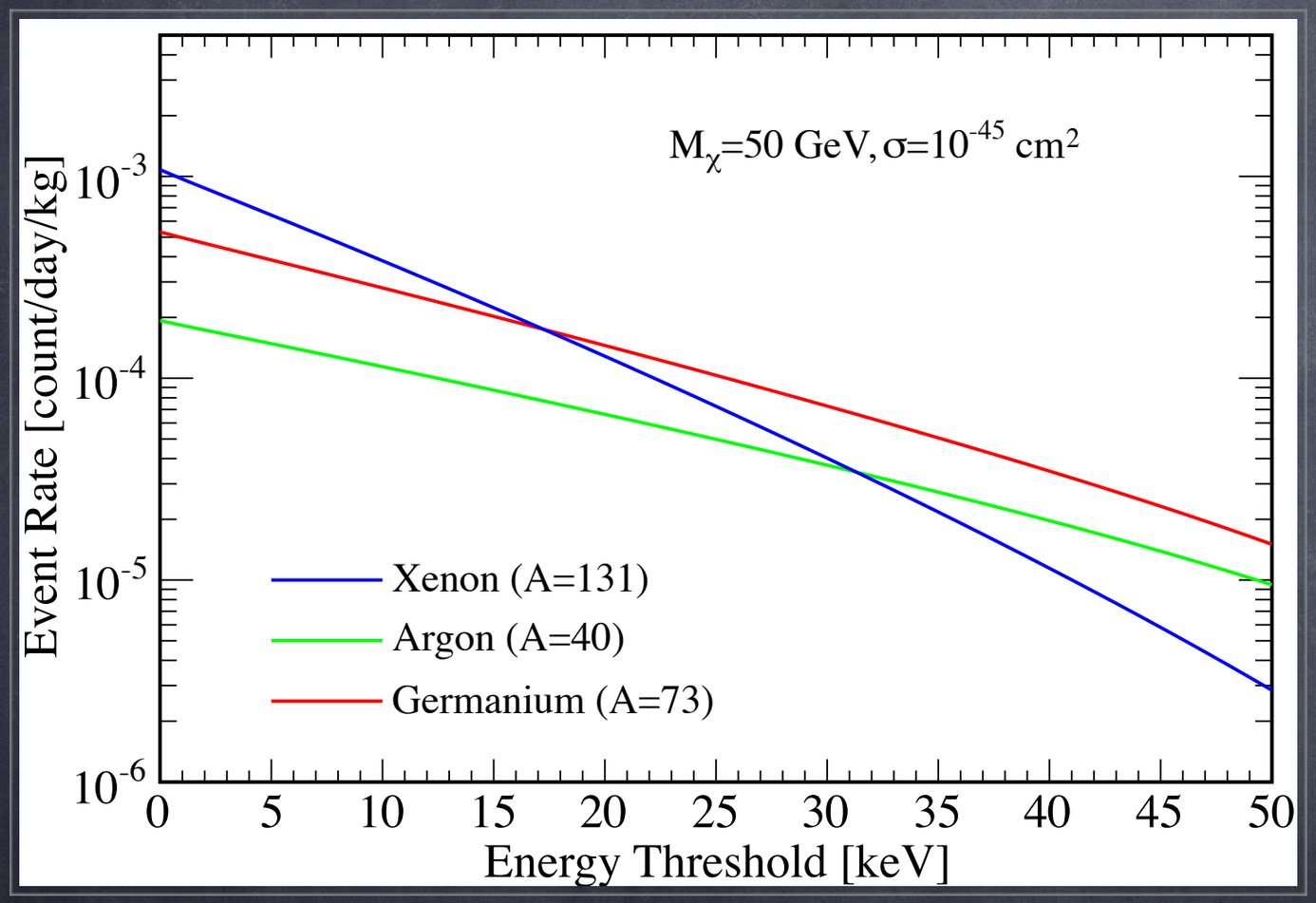
Elastic scattering off nucleus



Recoils ~10 keV

- Requirements
- Large target mass
- Low energy threshold
- Ultra-low background

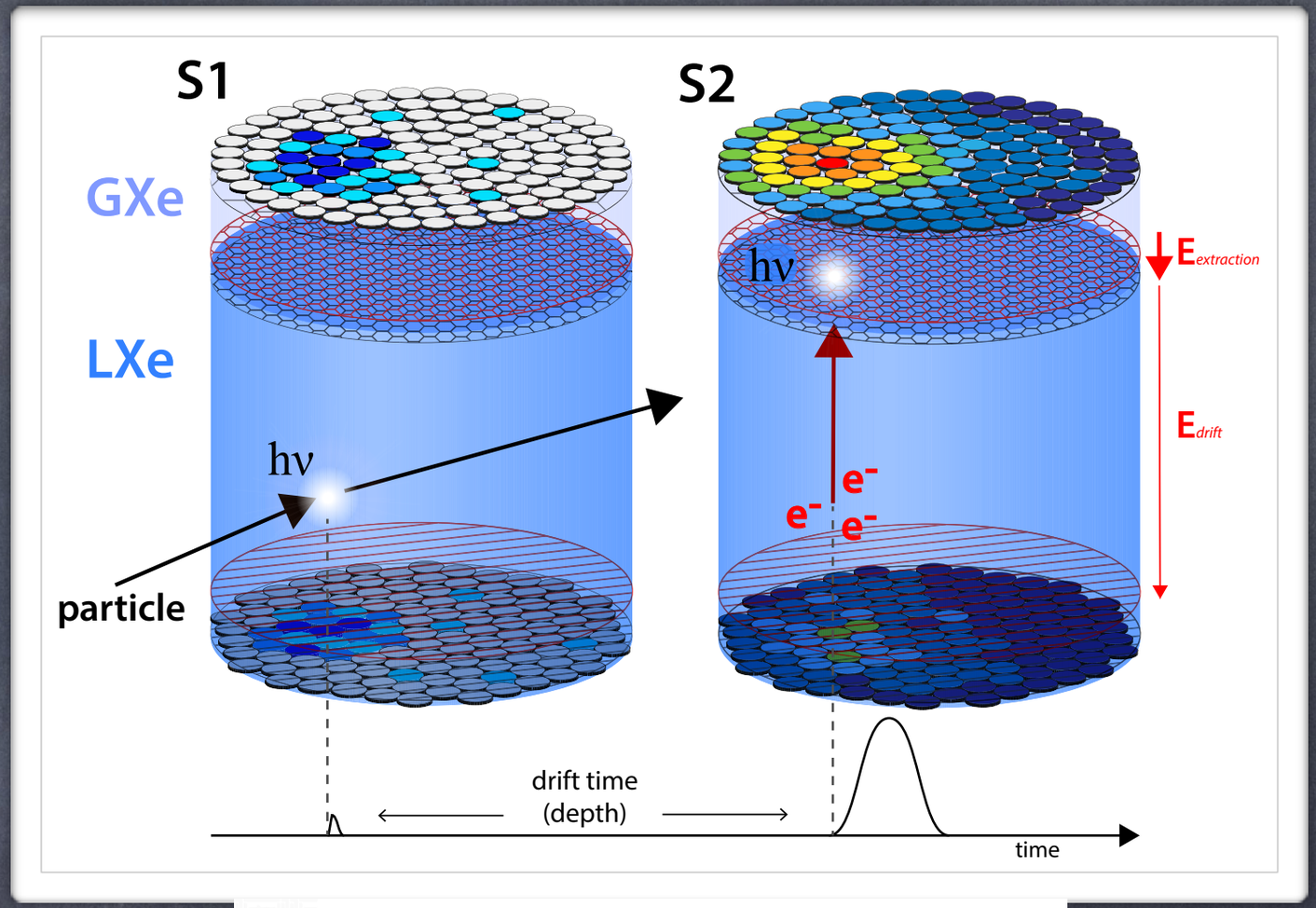
A Xenon Target

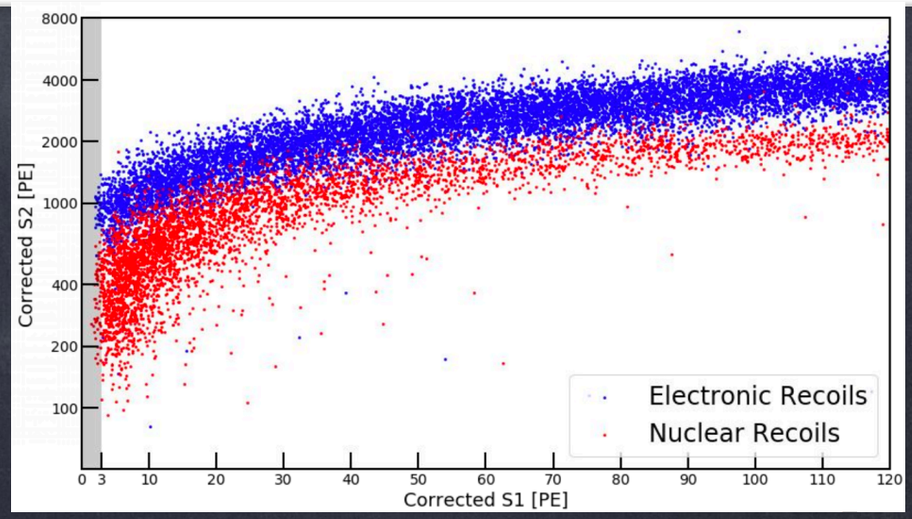


- Rate ∝ A^2
- High purity
- "Easy" cryogenics at -95°C
- Large density
  - Self-shielding
  - Compact/scalable

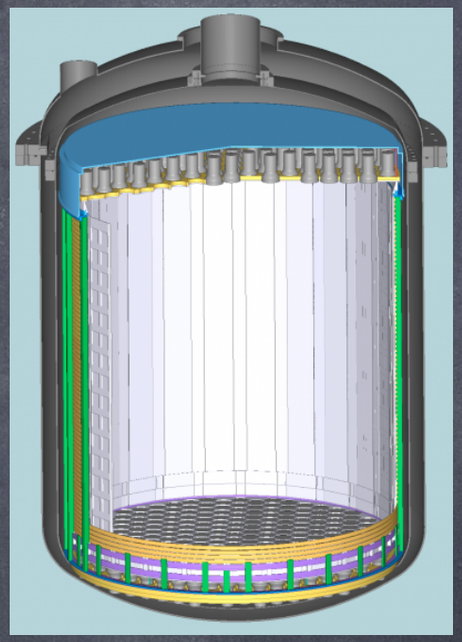
Time Projection Chamber

- Energy
  - Light signal (S1)
  - Charge signal (S2)
- Position
  - X,Y from top array
  - Z from drift time
- Discrimination
  - Charge-to-light ratio
  - Higher for ER than NR





Phases of XENON



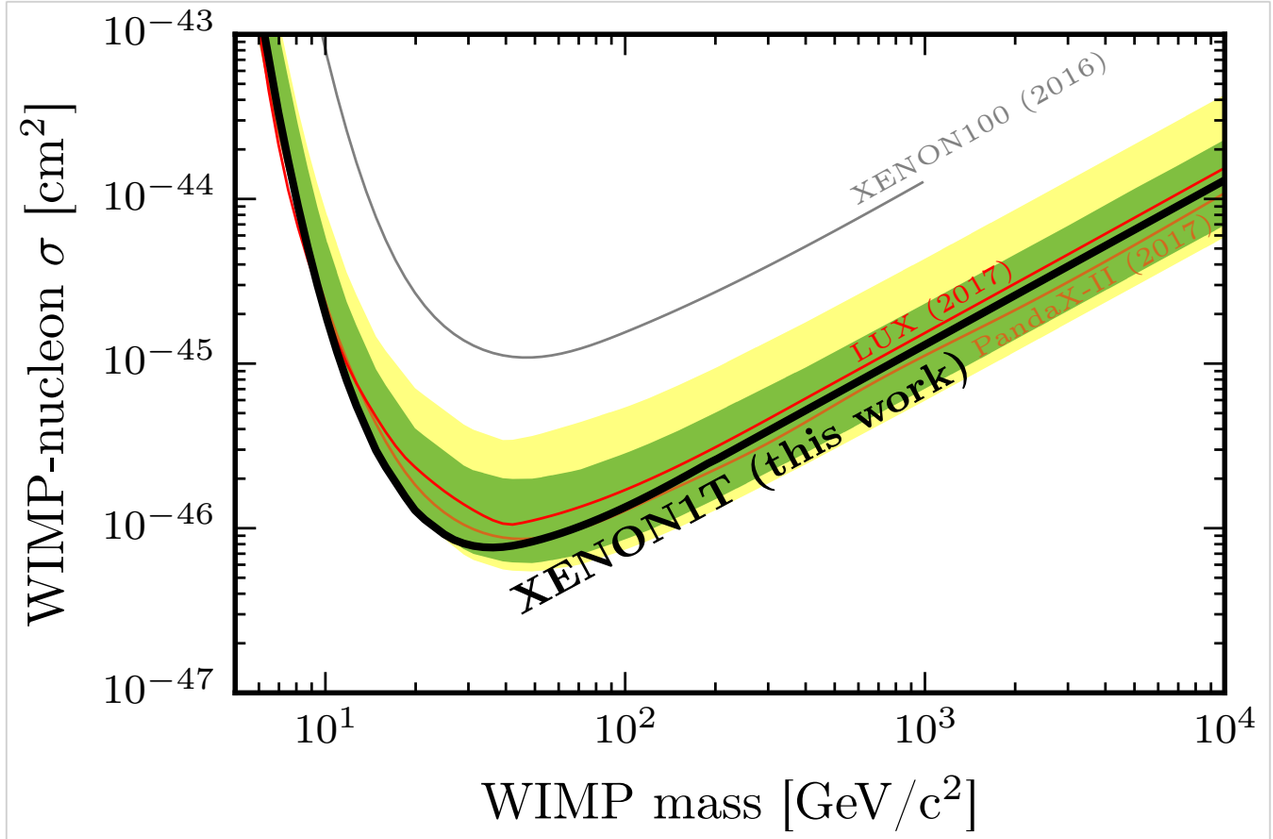
	XENON10	XENON100	XENON1T	XENONnT
Era	2005-2007	2008-2016	2012-2018	2019-2023
Mass	25 kg	161 kg	3200 kg	~8000 kg
Limit (Sensitivity)	8.8×10^{-44} cm^2	1.1×10^{-45} cm^2	7.7×10^{-47} cm^2 (1.6×10^{-47} cm^2)	(~10^{-48} cm^2)

The XENON Collaboration

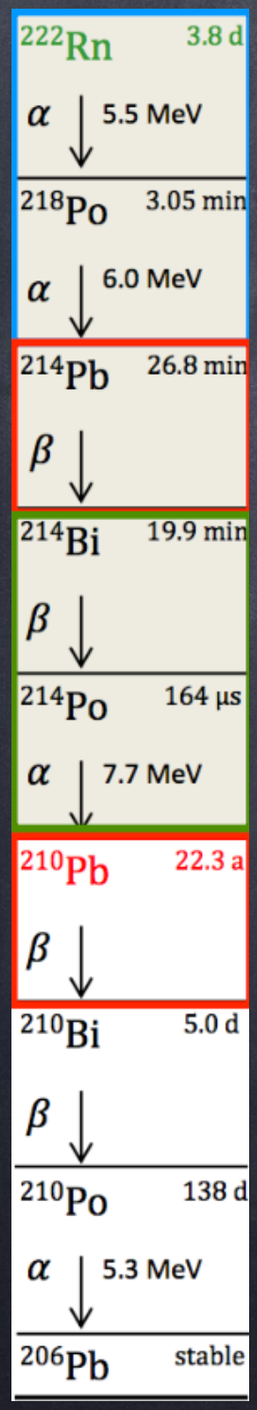
XENON1T: First Results

- 34 live days of data
- October 2016 - January 2017
- No evidence of dark matter
- Set upper limit
- 247 more live days since then

PRL 119, 181301 (2017)



ER Backgrounds



JCAP04(2016)027

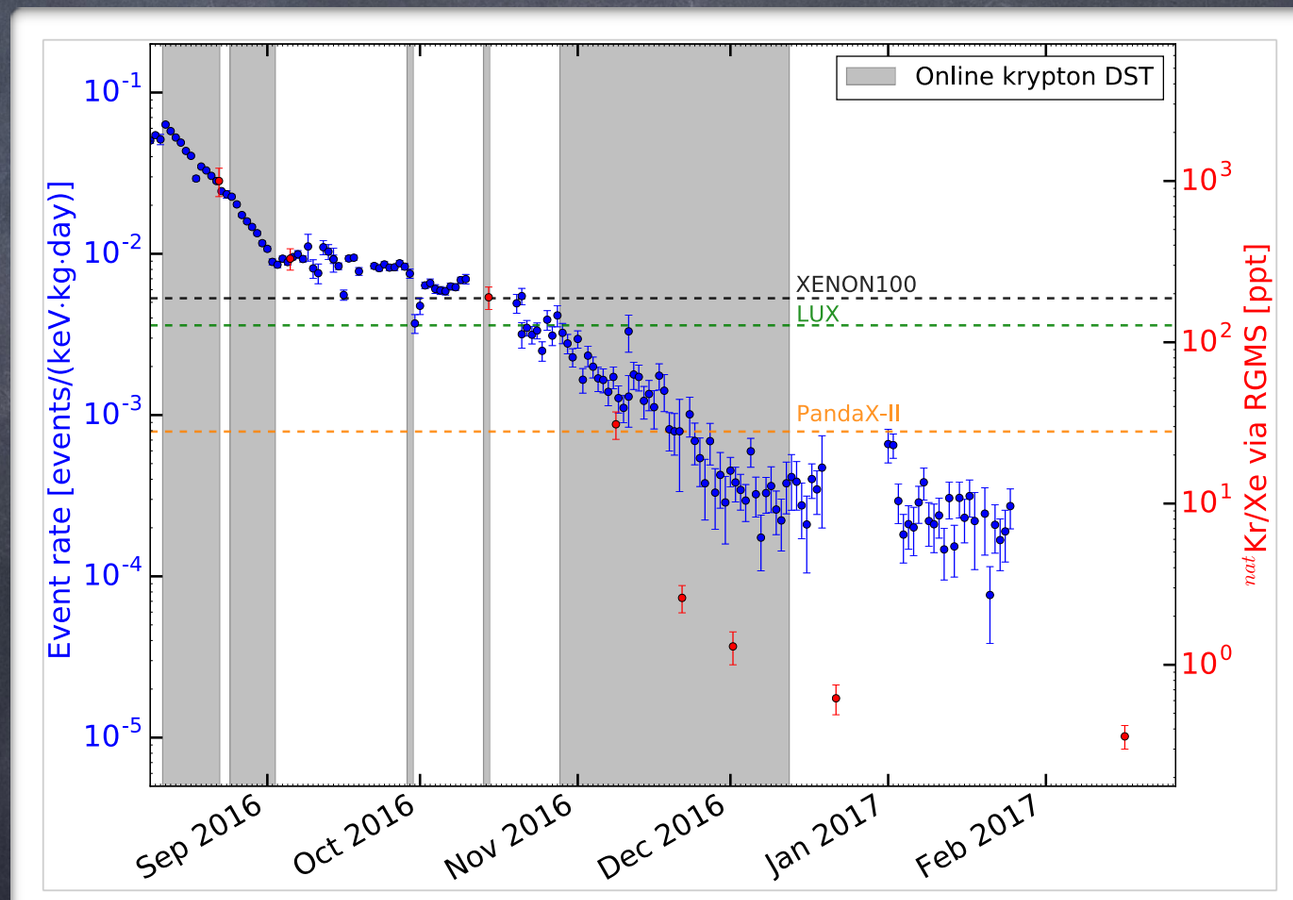
Source	Background $[(\mathrm{kg}\cdot\mathrm{day}\cdot\mathrm{keV})^{-1}]$	Background $[\mathrm{y}^{-1}]$	Fraction [%]
Materials	$(7.3 \pm 0.7)\cdot 10^{-6}$	29 ± 3	4.1
^{222}Rn	$(1.54 \pm 0.15)\cdot 10^{-4}$	620 ± 60	85.4
^{85}Kr	$(7.7 \pm 1.5)\cdot 10^{-6}$	31 ± 6	4.3
^{136}Xe	$(2.3 \pm 1.1)\cdot 10^{-6}$	9 ± 4	1.4
Solar neutrinos	$(8.9 \pm 0.2)\cdot 10^{-6}$	36 ± 1	4.9
Total	$\mathbf{(1.80 \pm 0.15)\cdot 10^{-4}}$	$\mathbf{720 \pm 60}$	**100**

expectations in 2-12 keV, 1T fiducial volume, before ER/NR discrimination

- Detector materials screened for radio-purity with HPGe detectors
- Krypton now subdominant
- Lowest background level achieved: (62±11) events/ (tonne·year·keV)

- ^{85}Kr/^{nat}Kr ~ 2x10^{-11}
- Online distillation: ^{nat}Kr/Xe ~ 0.62 ppt

EPJC (2017) 77: 275



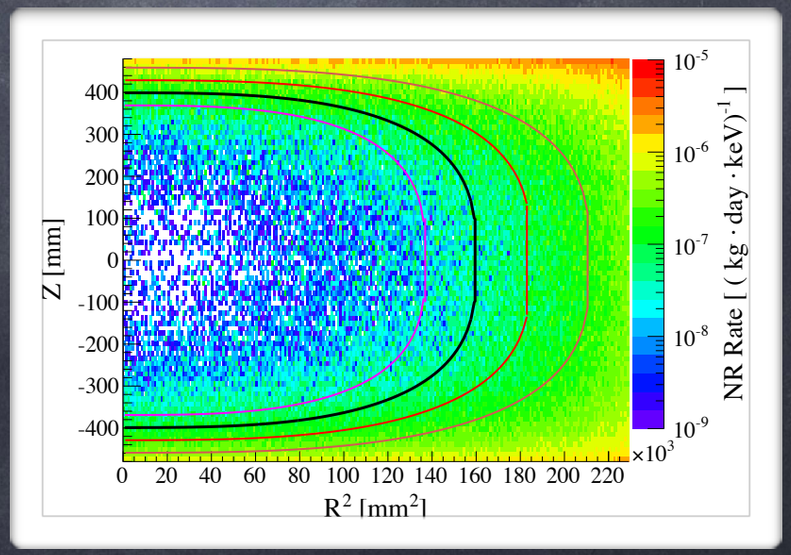
NR Backgrounds

Muon-induced Neutrons

- 3600 m.w.e. overburden
- 700 m³ demineralized water
- Water Cherenkov Muon Veto
- 0.012 events/(tonne·year)

Radiogenic

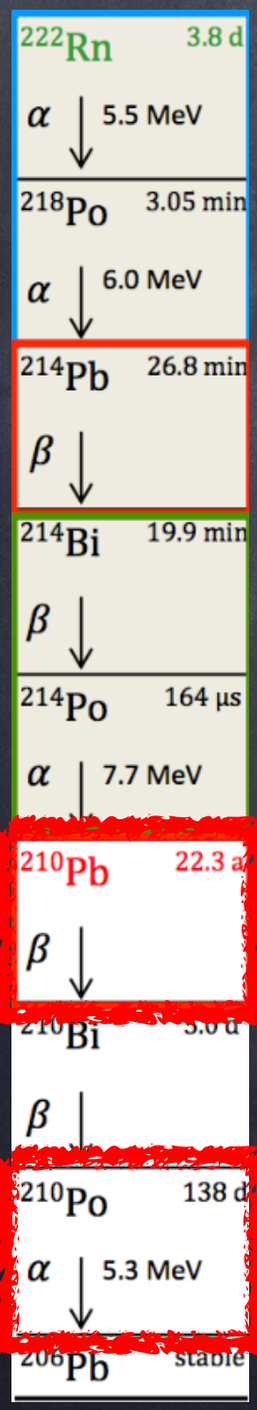
- Spontaneous fission and (α,n) reactions from U and Th chains
- Reduced with material selection
- O(1) event/(tonne·year)

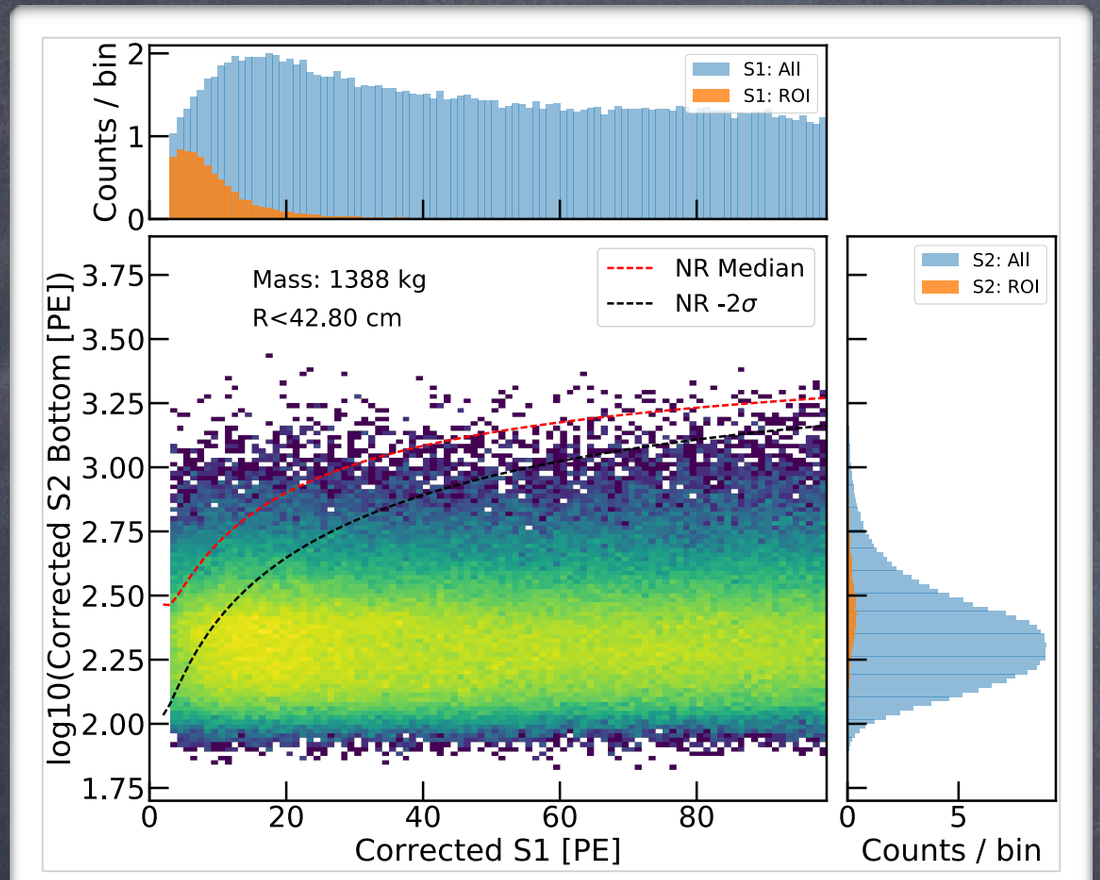


CEvNS

- Irreducible
- Almost no contribution above 5 keV

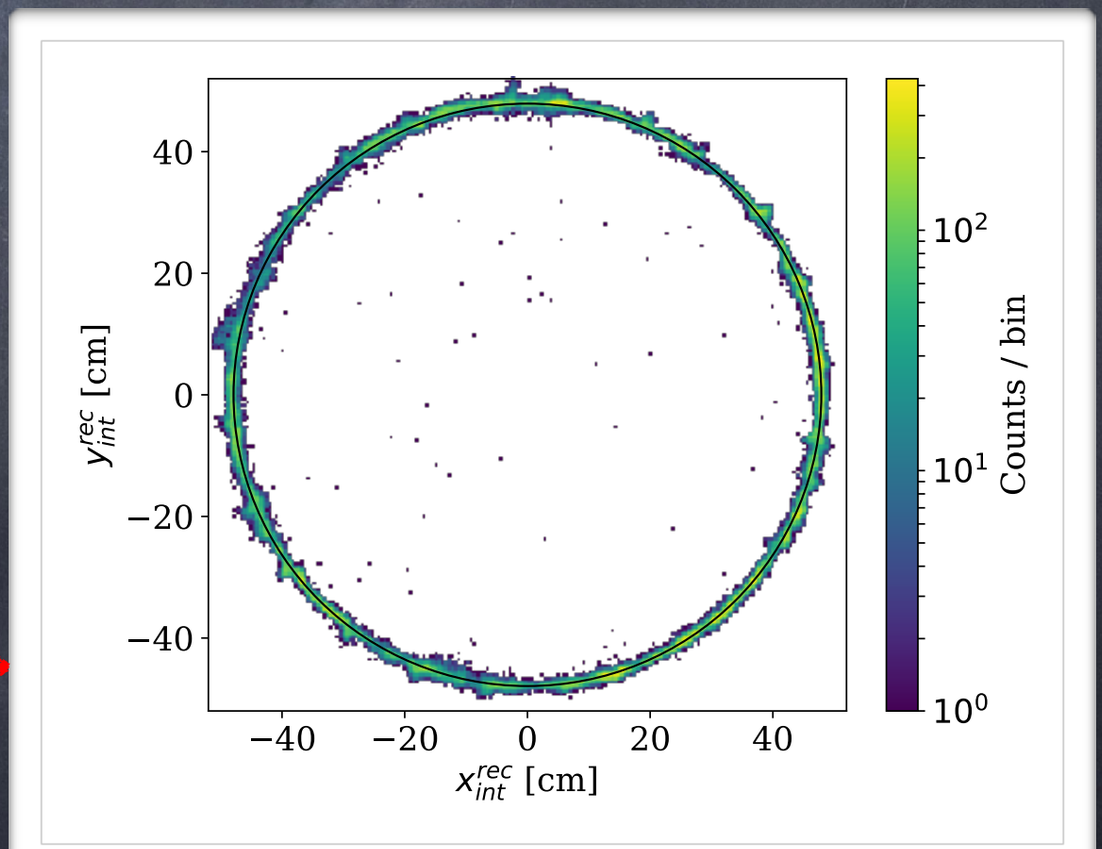
Surface Events



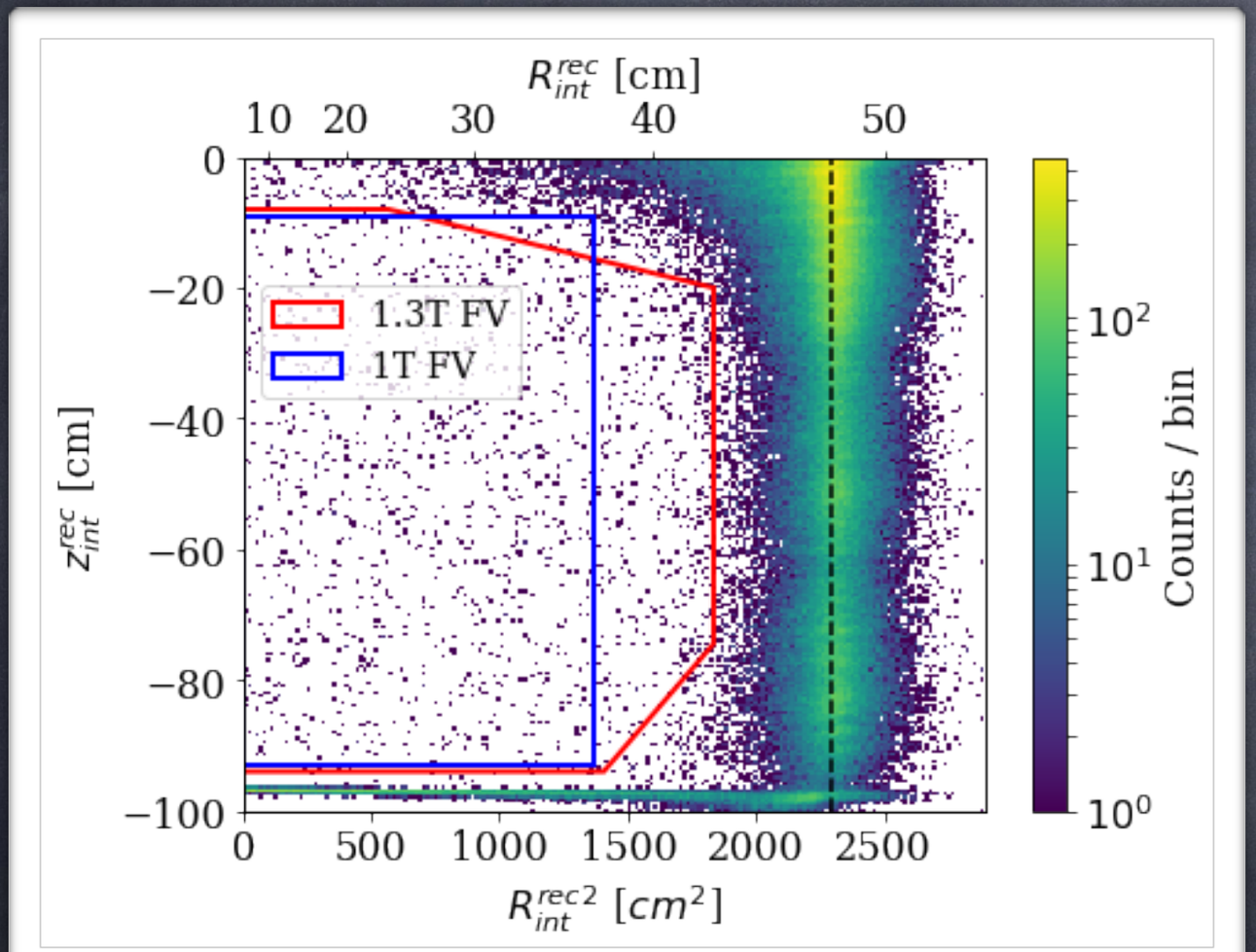


- Charge loss on PTFE wall surface
- Events incorrectly reconstructed in signal region

- Suppress with fiducial volume
- Data-driven model



Fiducial Volume



- Exploit self-shielding
- First Result: 1 tonne
- This time: +300 kg
  - Better position reconstruction
  - Improved corrections for field distortion and wall charge-up
  - Spatial dimension in statistical interpretation

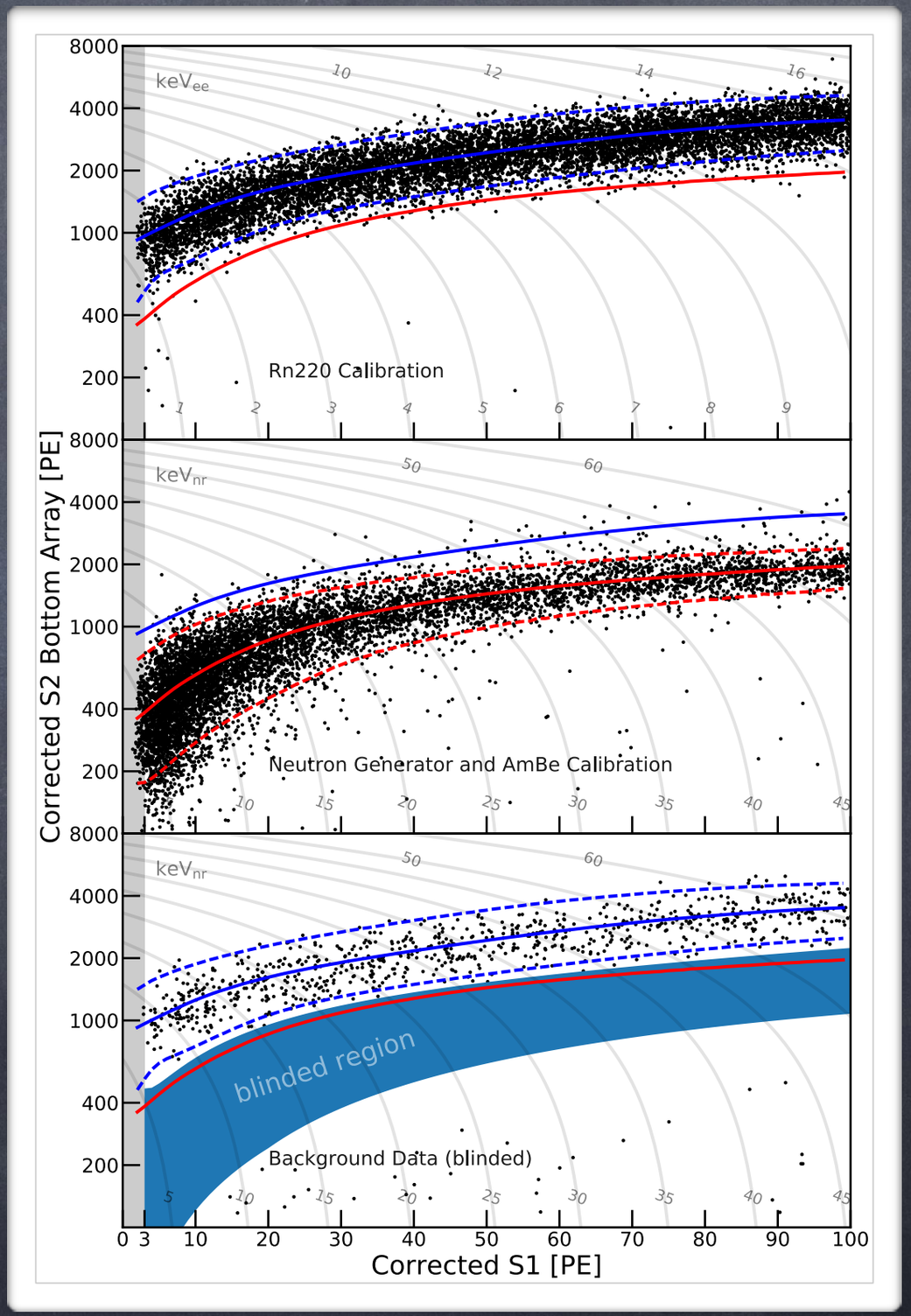
Calibration

ER

- Inject ^{220}Rn
- Daughter ^{212}Pb mimics ^{214}Pb background
- Spreads uniformly

NR

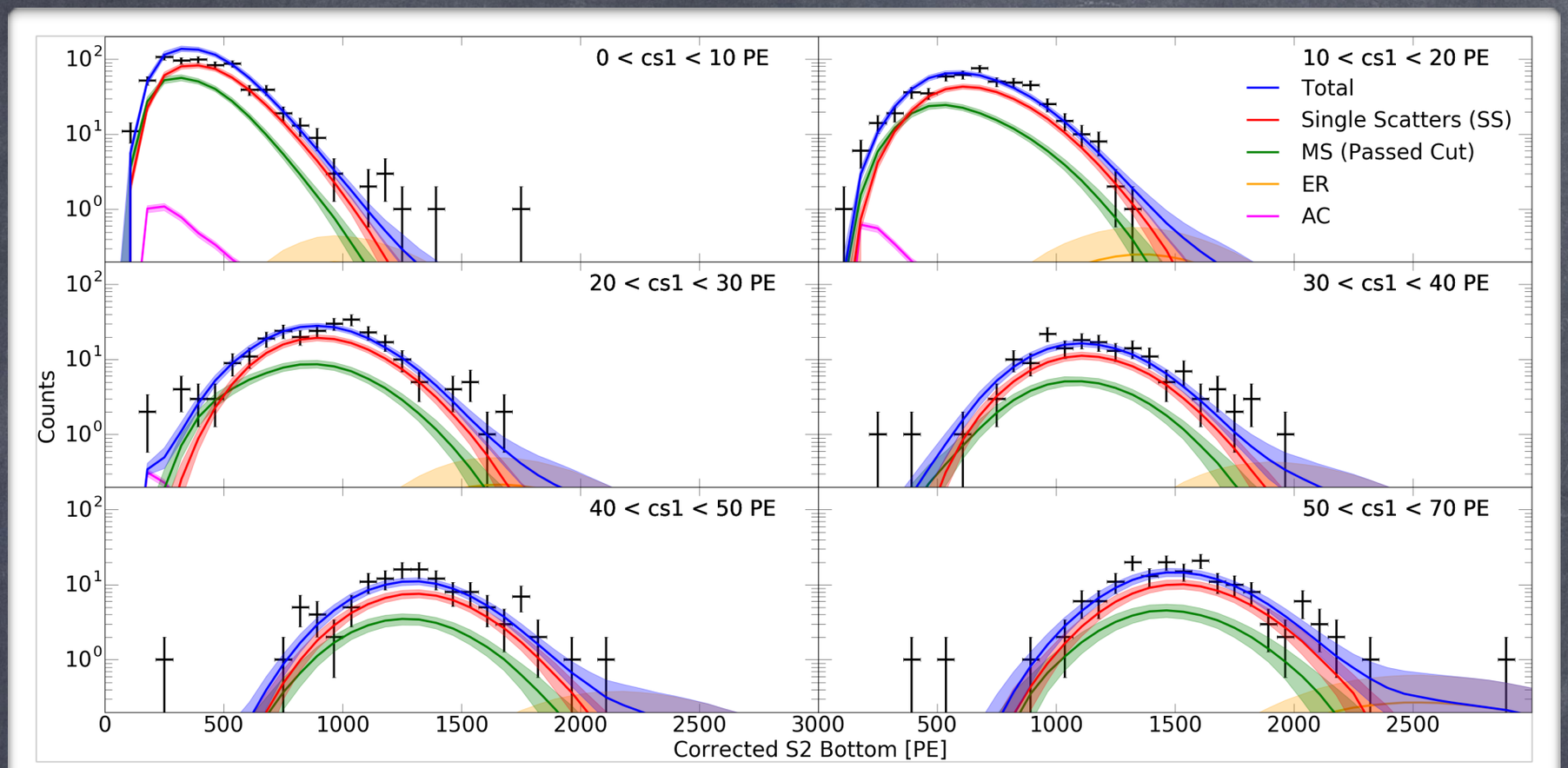
- External DD Neutron Generator and AmBe source



PRD 95, 072008 (2017)

PRD 97, 092007 (2018)

Parametrizing Signal and Background



- WIMP signal, ER/NR background models derived through agreement between calibration and Monte Carlo
- Surface background and accidental coincidence described with empirical models

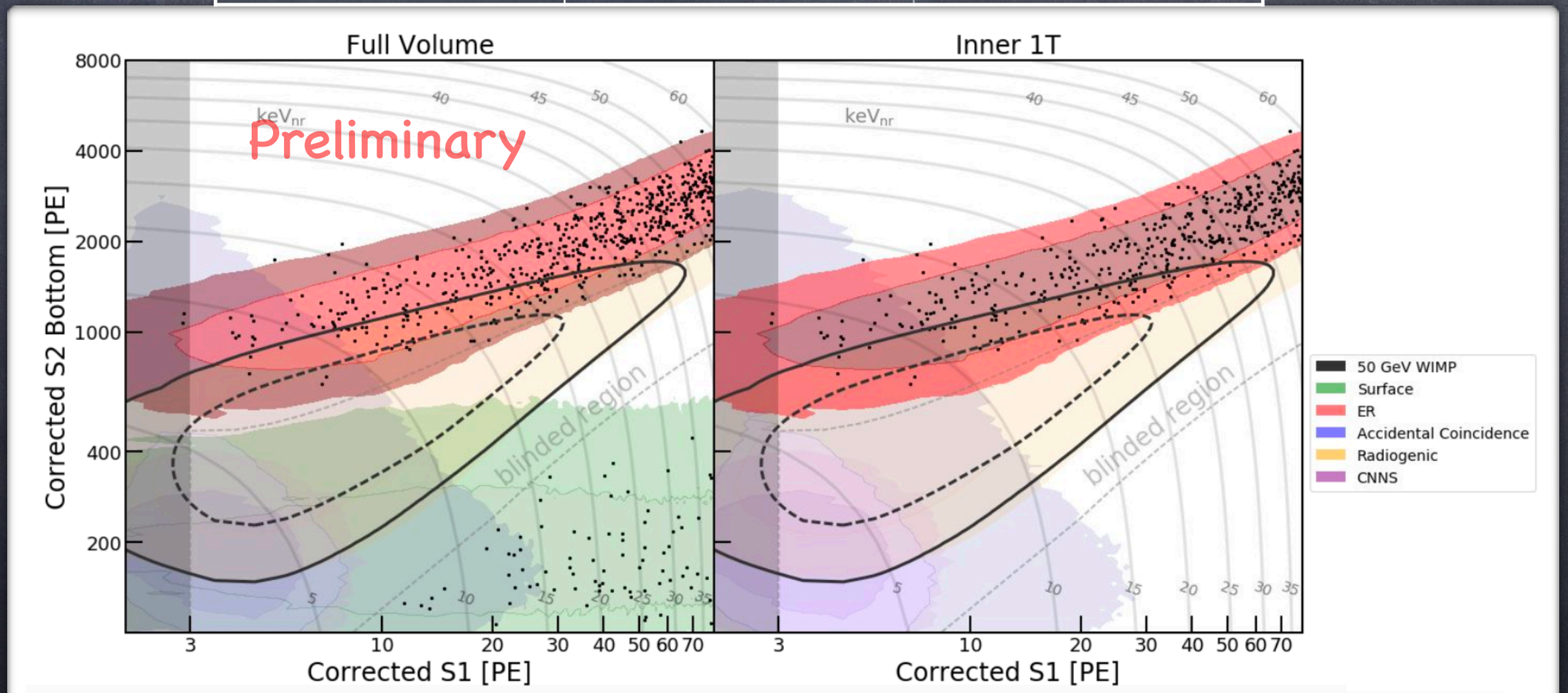
A Complete Background Model

Counts between NR median and -2σ quantile

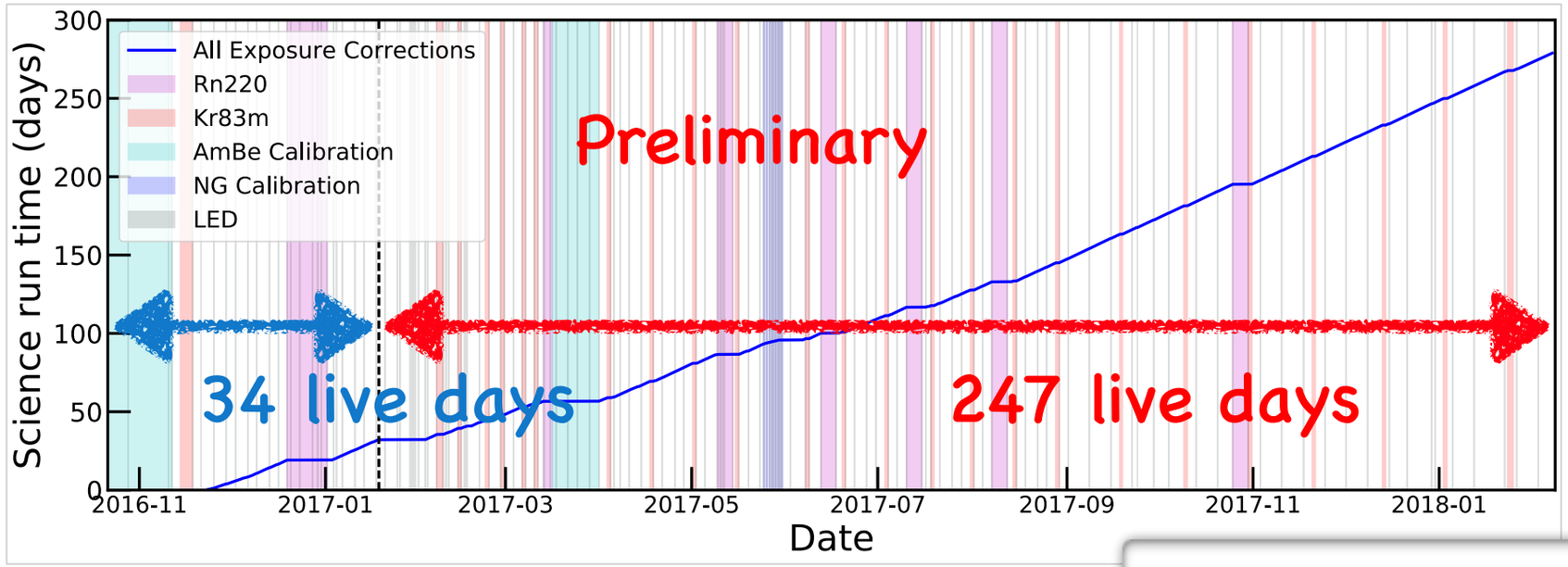
Source	1.3T FV	Inner 1T
ER	1.8 ± 0.2	1.4 ± 0.2
Radiogenic	0.6 ± 0.3	0.4 ± 0.2
CEvNS	0.04 ± 0.01	0.03 ± 0.01
Accidental	0.2 ± 0.1	0.1
Surface	6.1 ± 0.3	0.1
Total	8.7 ± 0.5	2.0 ± 0.3
WIMP (50 GeV, 10^{-47} cm^2)	0.8 ± 0.1	0.6 ± 0.1

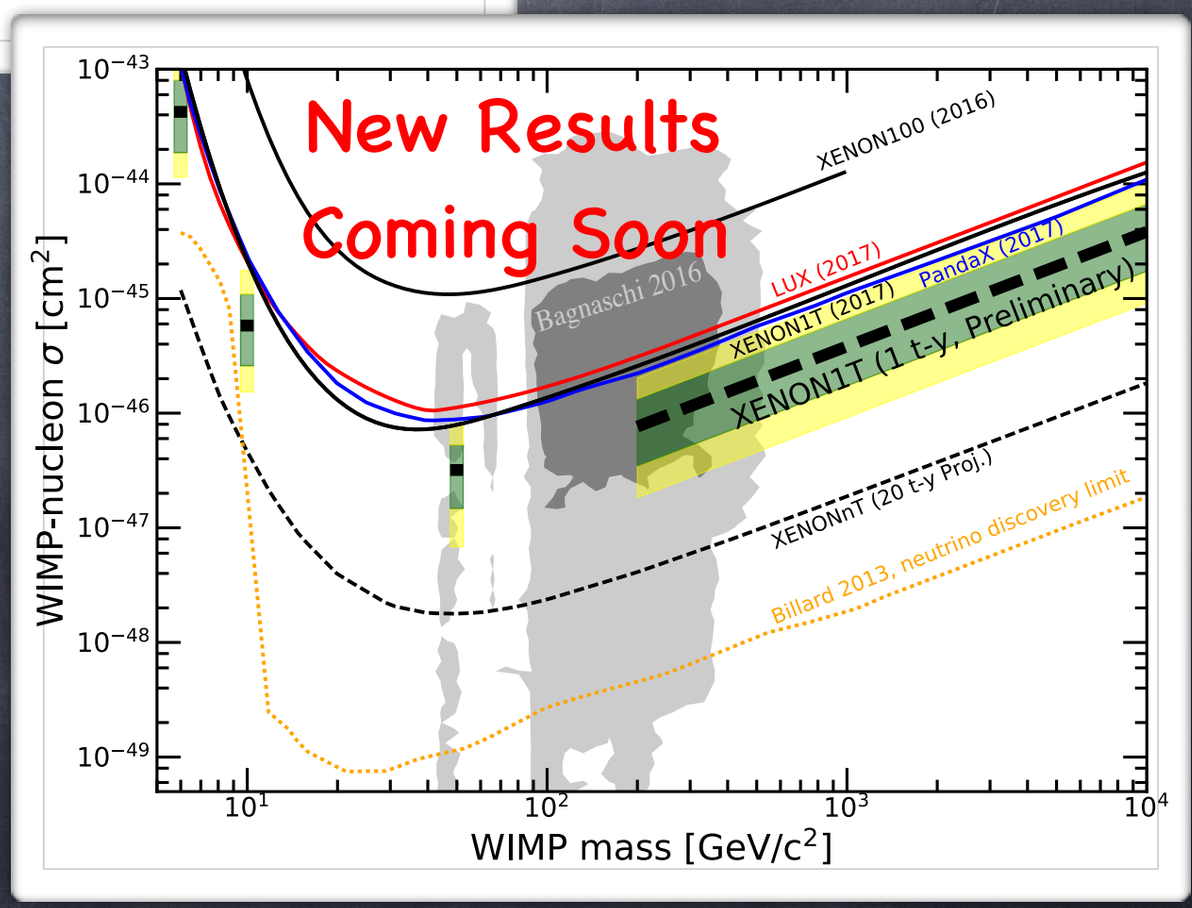
Preliminary

Expectations in 3-70 PE, 247 days



Upcoming Results





- >1 year of stable data taking
- Factor ~3 improvement in sensitivity

Data blinded and salted

Take-Home Message

- Sensitivity ~3 times better:
  - Livetime ~8 times longer
  - Larger fiducial volume (deeper understanding of detector)
- Unprecedented low background
  - More rare event searches
    - Low-mass WIMPs (S2-only)
    - ER (axions, SuperWIMPs, …)
    - Annual Modulation
- XENONnT in 2019