First DM Search Result from the PandaX-II 500kg LXe Detector

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On Behalf of the PANDA X Collaboration

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July，21，2016

PandaX collaboration

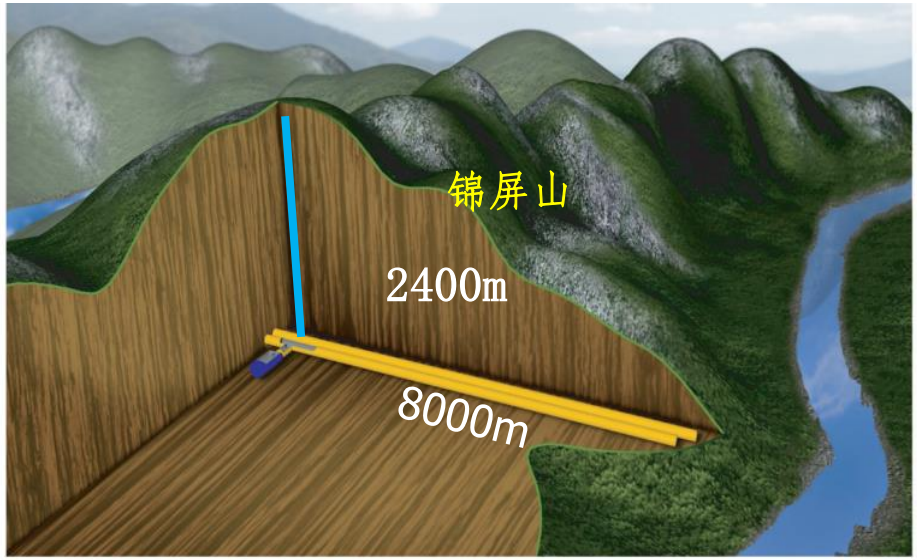
~50 people

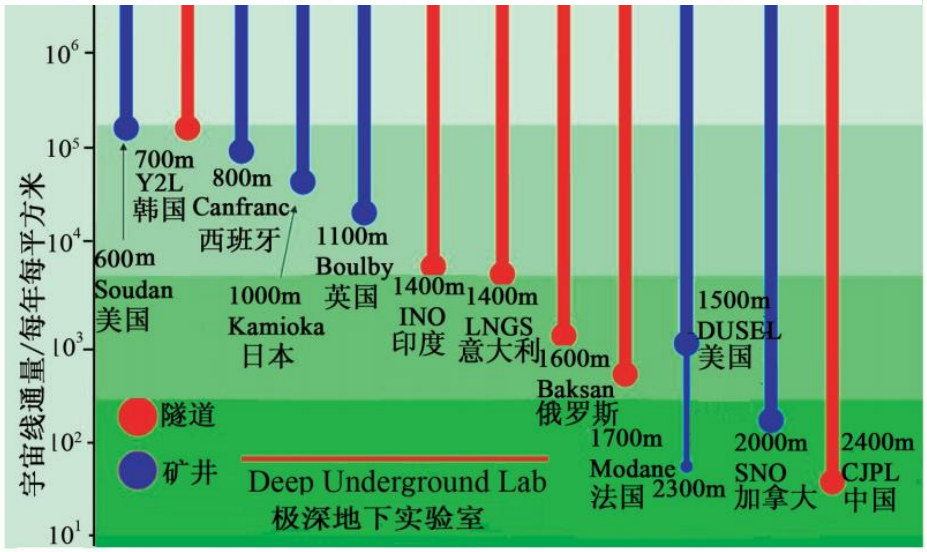
Started in 2009

- Shanghai Jiao Tong University (2009-)
- Peking University (2009-)
- Shandong University (2009-)
- Shanghai Institute of Applied Physics, CAS (2009-)
- University of Science & Technology of China (2015-)
- China Institute of Atomic Energy (2015-)
- Sun Yat-Sen University (2015-）
- Yalong Hydropower Company (2009-)
- University of Maryland (2009-)
- Alternative Energies & Atomic Energy Commission(2015-)
- University of Zaragoza(2015-)
- Suranaree University of Technology(2015-)

China Jinping Underground Laboratory

Deepest in the world (1μ/week/m^2) and Horizontal access!



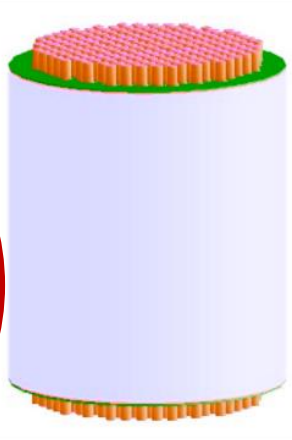


PandaX experiment

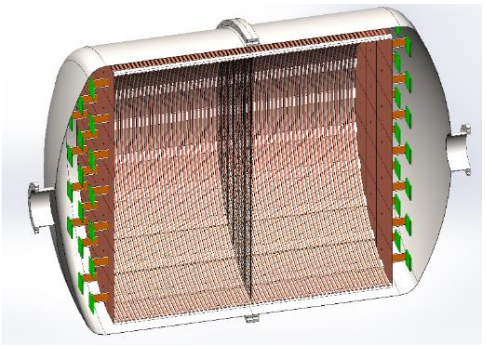
PandaX = Particle and Astrophysical Xenon Experiments

Phase I:
120 kg DM
2009-2014

Phase II:
500 kg DM
2014-2017



PandaX-xT:
multi-ton DM
future

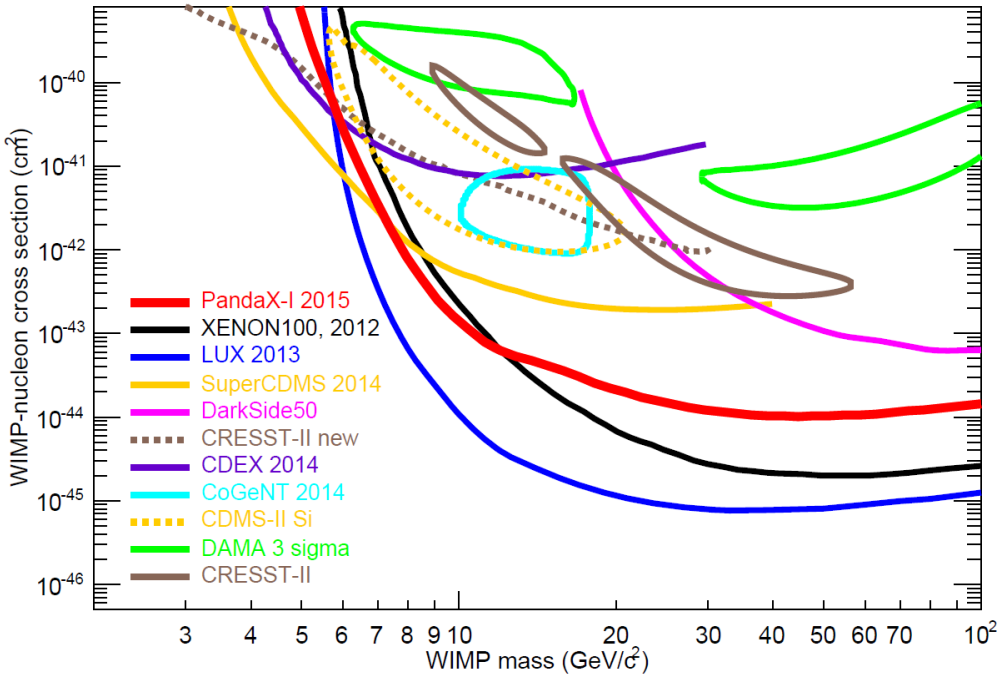


PandaX-III:
200 kg to 1 ton
^{136}Xe 0vDBD
future

First delivery of PandaX equipment to Jinping lab, Aug. 16, 2012

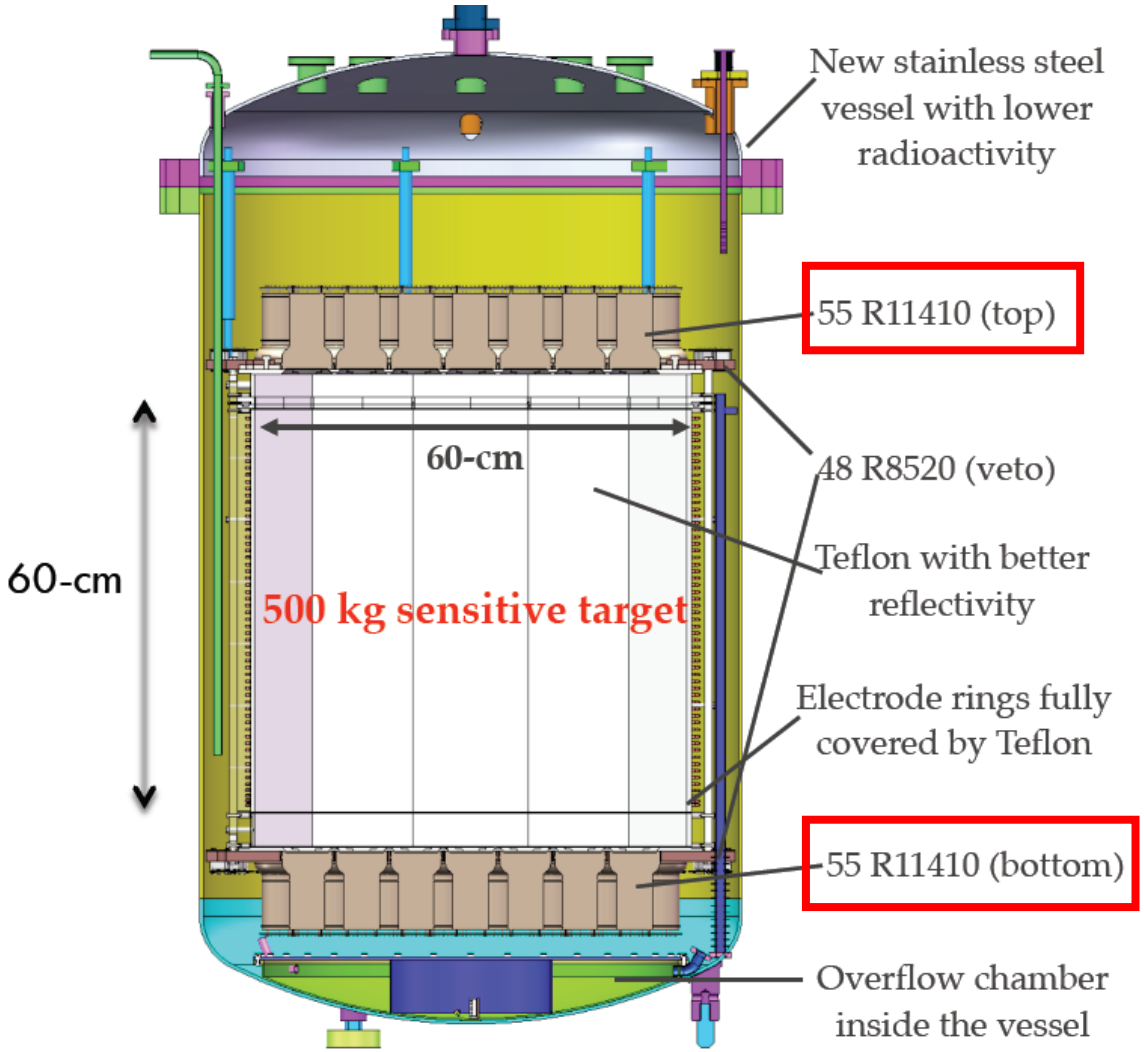
Final Results from PandaX-I

Phys. Rev. D **92**, 052004(2015)



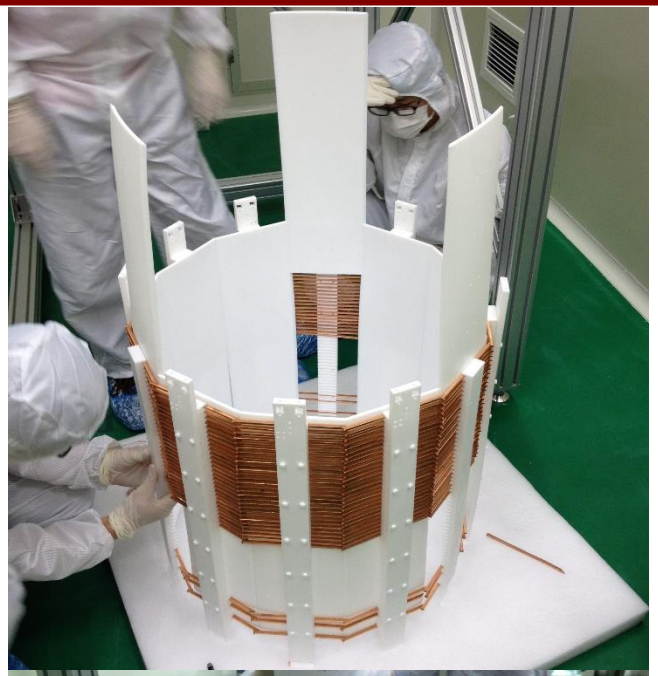
- Completed in Oct. 2014, with 54.0 x 80.1 kg-day exposure
- Data strongly disfavor all previously reported claims
- Competitive upper limits for low mass WIMP in xenon experiments

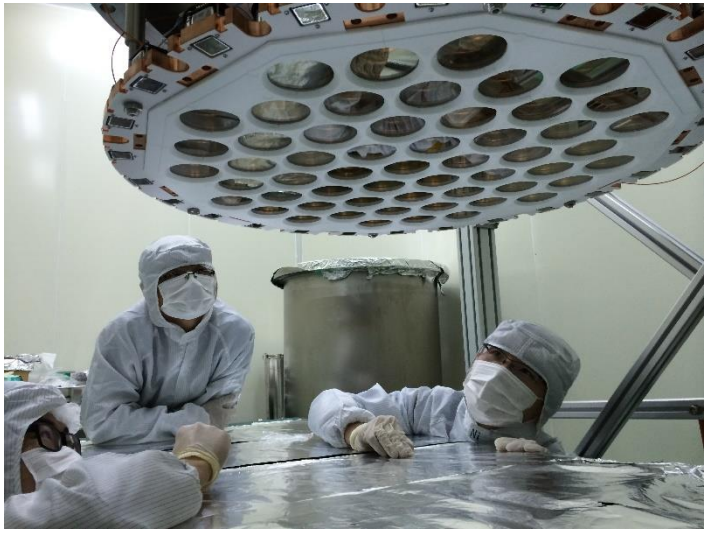
PandaX-II

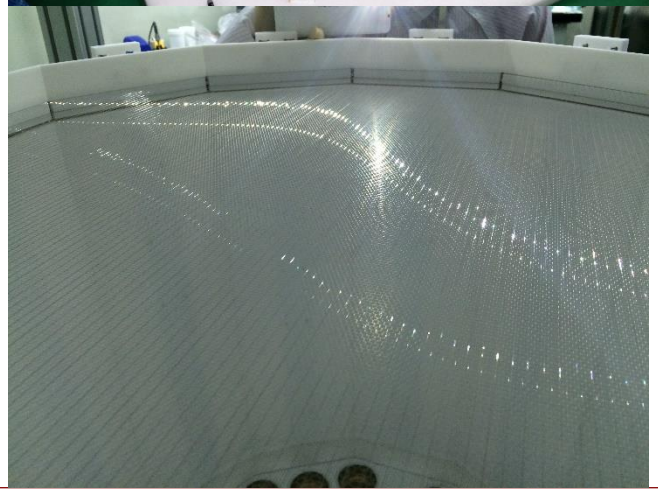


- New inner vessel with clean SS
- New and taller TPC with brand-new electrodes
- More 3” PMTs and improved base design
- New separate skin veto region

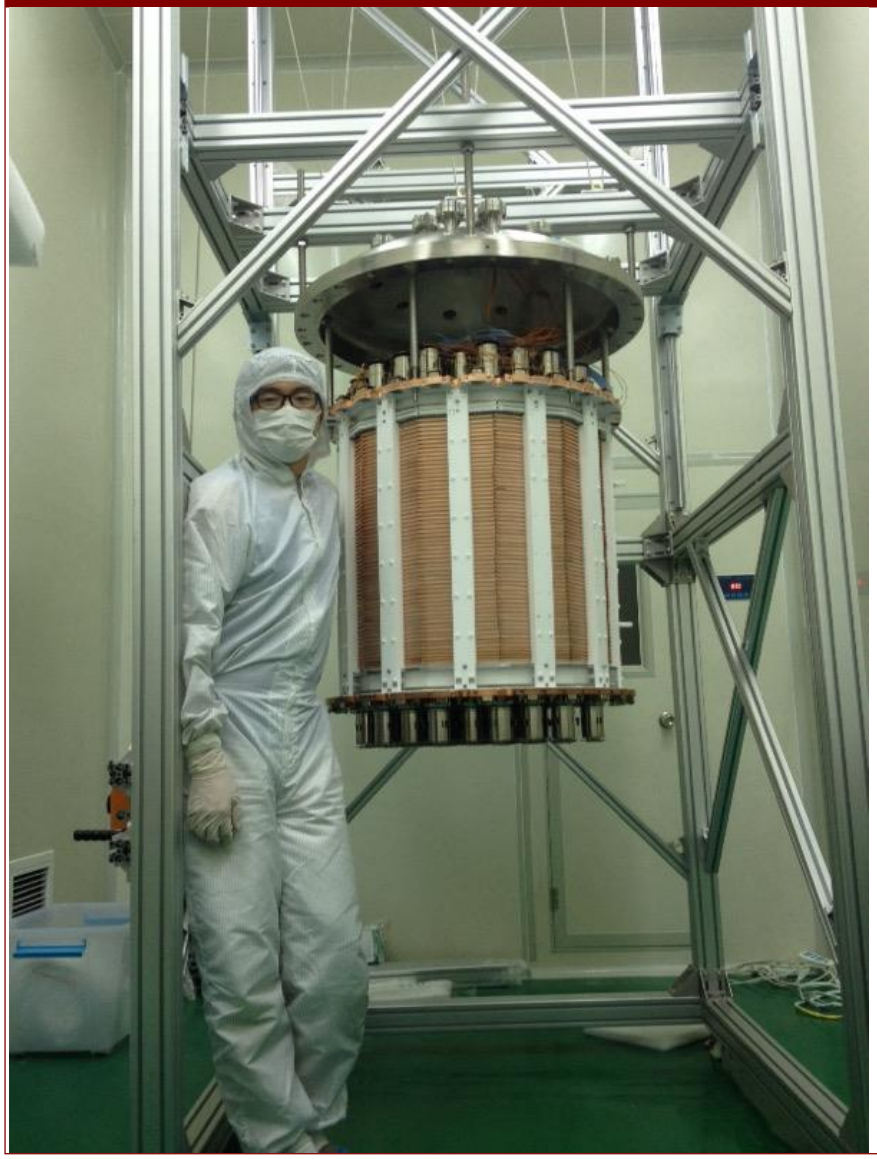
Assembling the detector

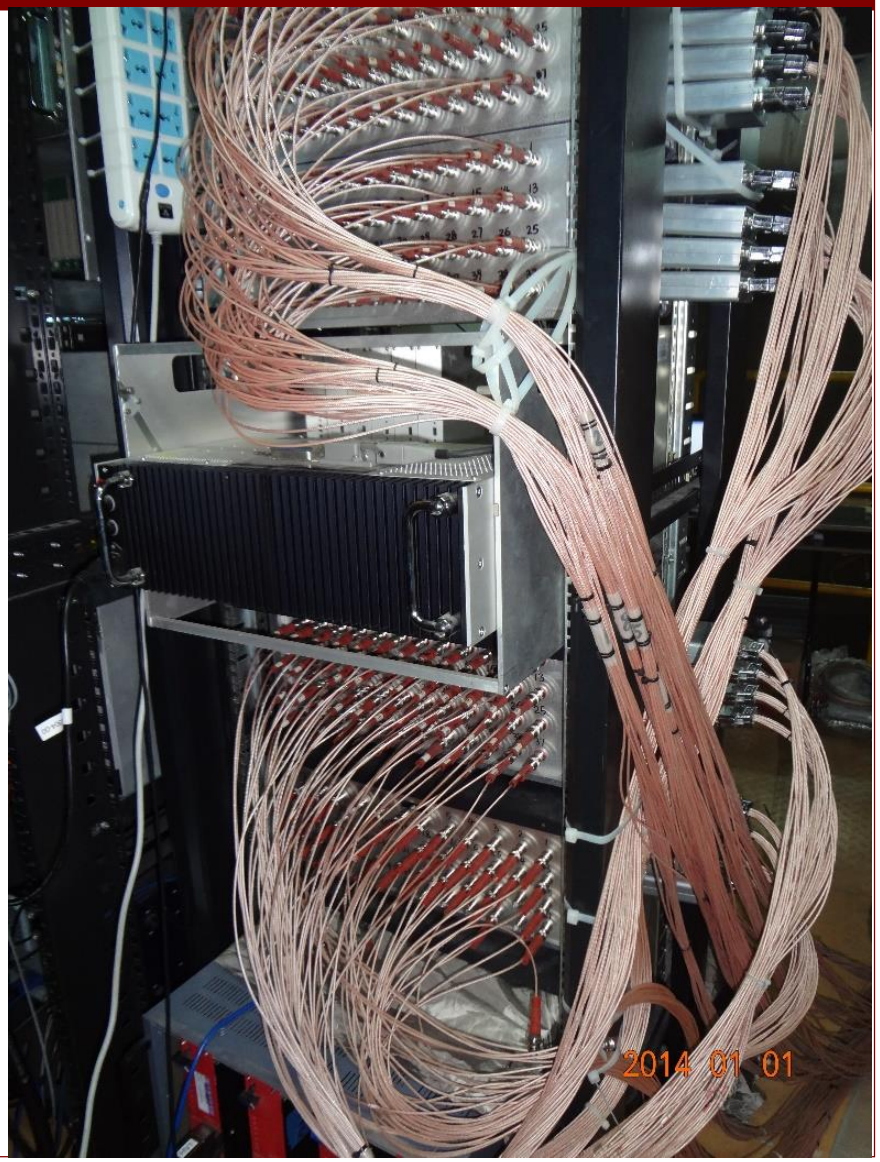






Assembling the detector



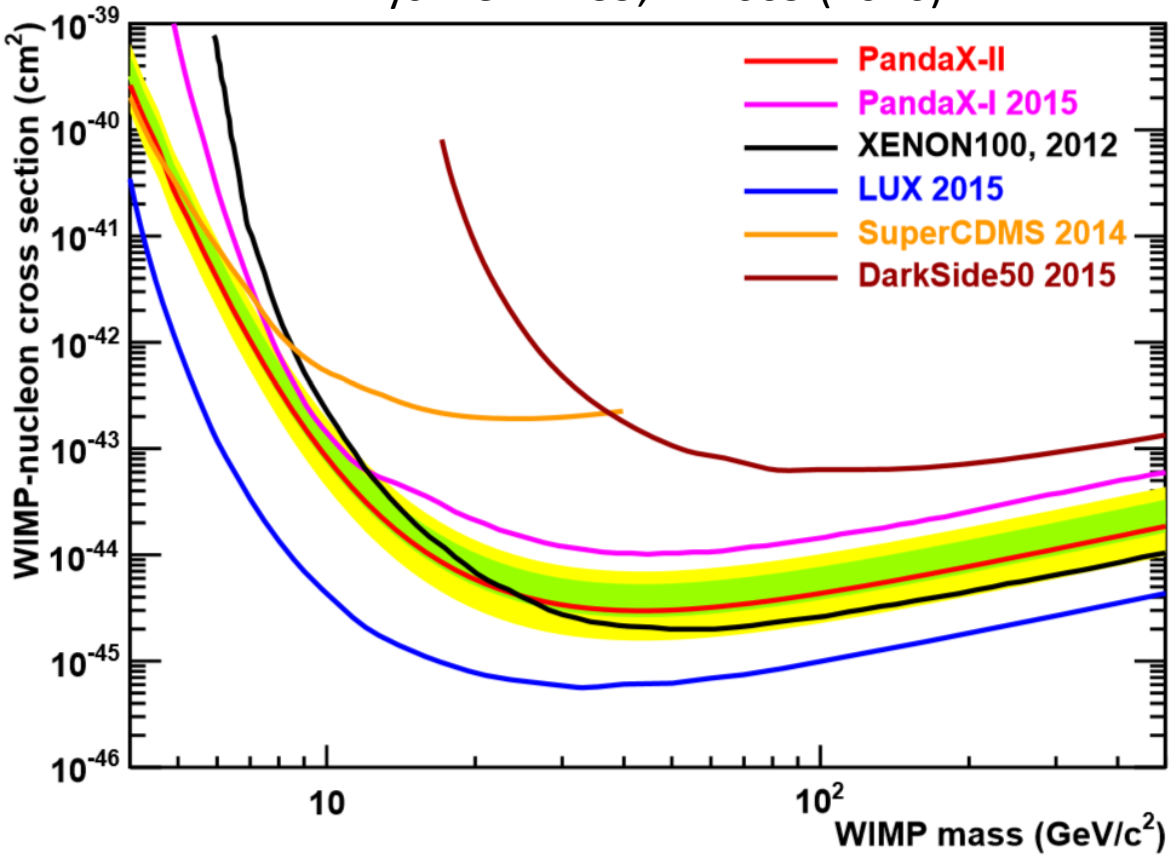


Run history

- We had a series of engineering runs in 2015, fixing various problems as we were testing all the components of the setup
- Commissioning run (Run 8): Nov. 22 – Dec. 14 (19.1 live-day x 306 kg FV) but with high Kr background (Phys. Rev. D. 39, 122009 (2016))
- After a Kr distillation campaign, the detector was refilled. Physics data taking started in Mar. 2016 (Run 9)

Results from PandaX-II Run 8

Phys. Rev. D. 39, 122009 (2016)

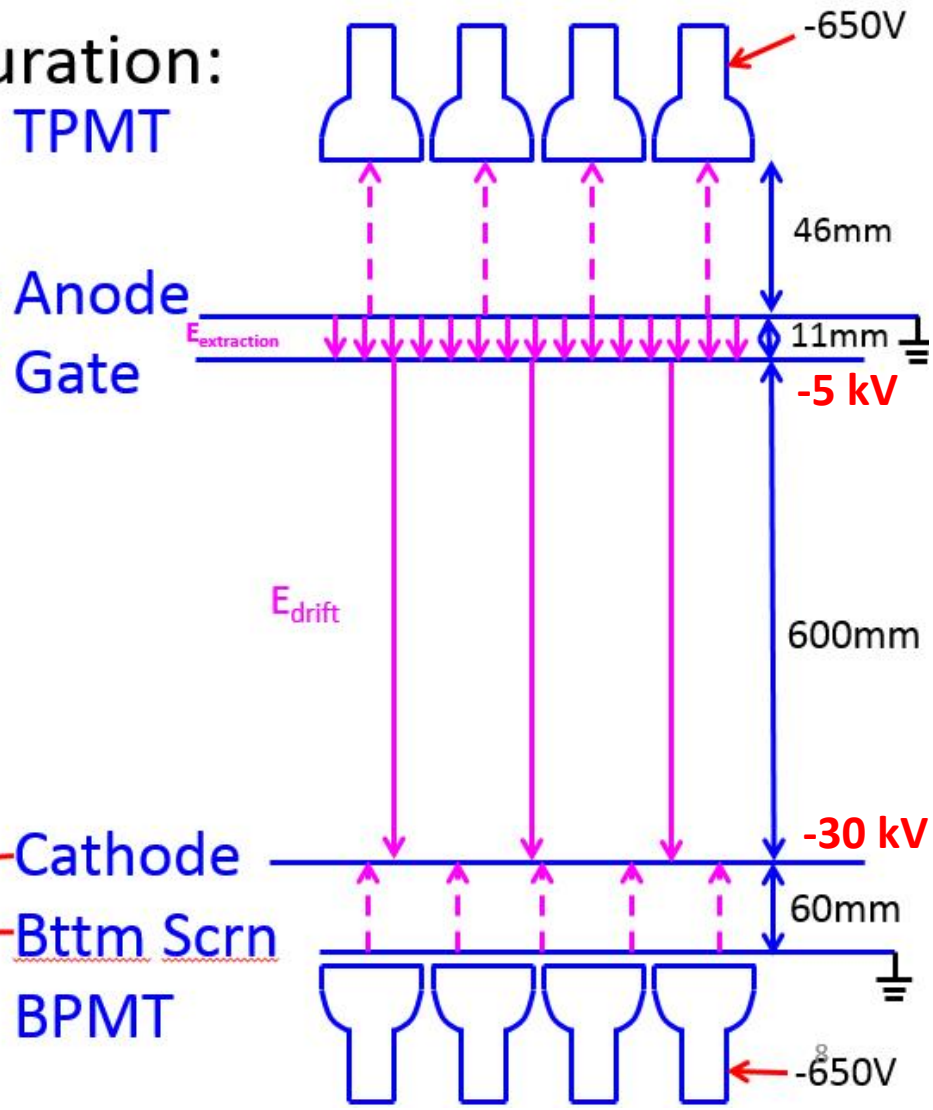


- Simple counting analysis based on an expected background of 3.2(0.7) evts and 2 observed evts
- Sizable (x2) difference of using original NEST or tuned NEST to predict DM distribution due to DM acceptance, but within 1σ band
- Low mass: competitive with SuperCDMS; high mass: similar exclusion limit as XENON100 225-day

Major upgrades in Run 9

Items	Status in Run 9
Krypton level	Reduced by x10
Exposure	Increased x4 (79.6 vs 19.1 day)
ER calibration	Now have tritium calibration
NR calibration	Statistics x6
Analysis	Improved position reconstruction
Background	Accidental background suppressed more than x2 using BDT

Configuration of fields

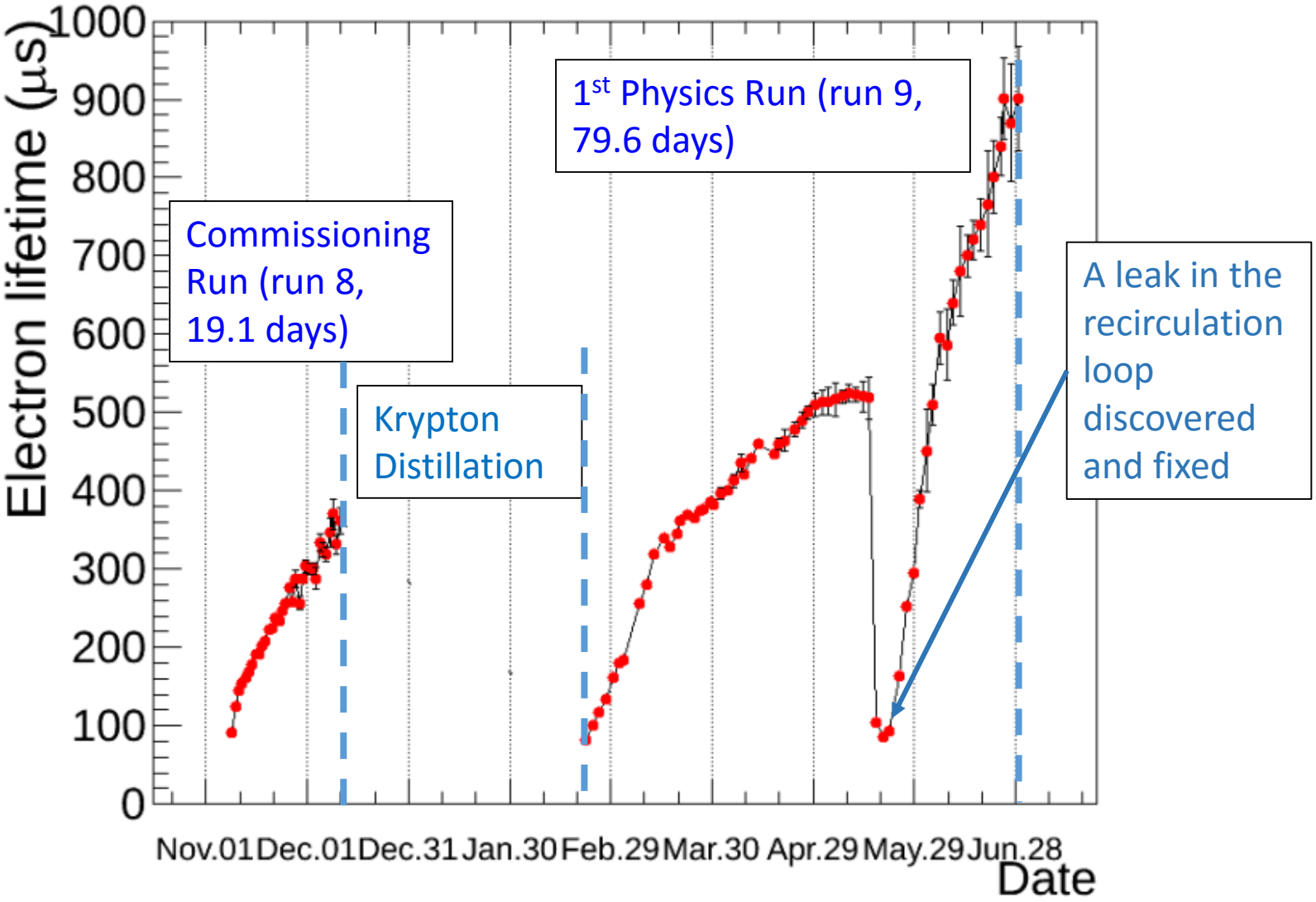


Data sets with different fields

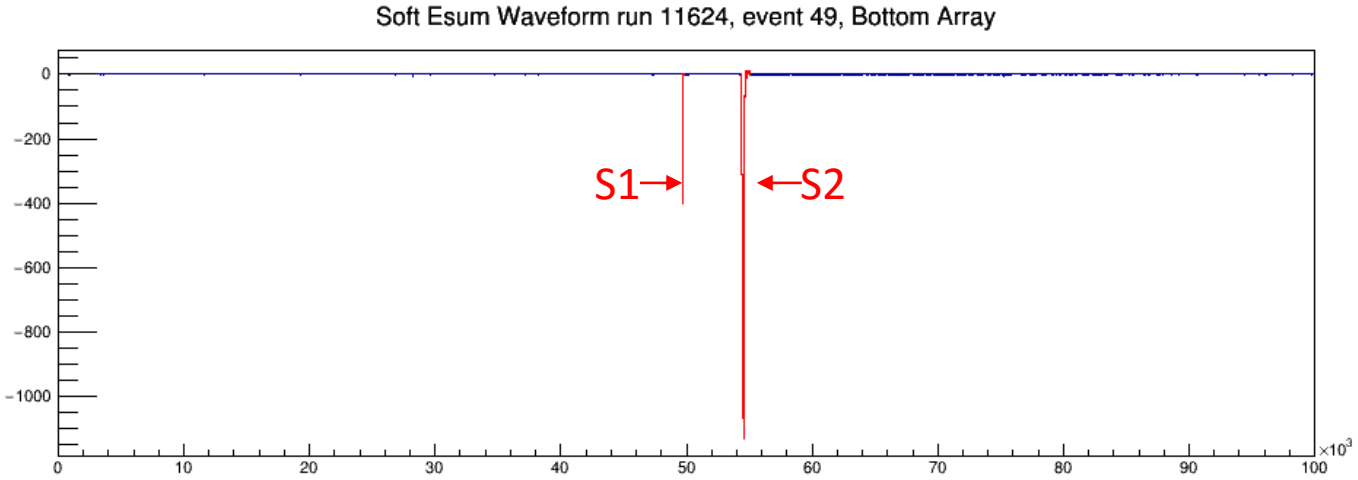
Condition	live time (day)	E_{drift} (V/cm)	E_{extract} (kV/cm)
1	7.76	397.3	4.56
2	6.82	394.3	4.86
3	1.17	391.9	5.01
4	63.85	399.3	4.56

Mar. 9-Jun 30, in total 79.6 live-day of under slightly different conditions (optimization of drift and extraction fields).

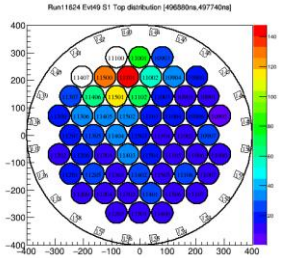
Electron lifetime evolution



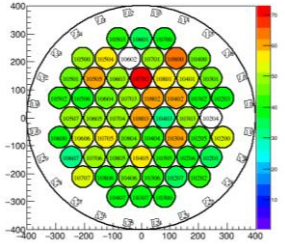
Typical single scatter waveform



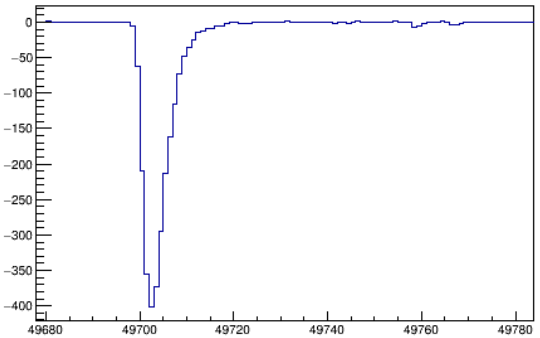
Top Array



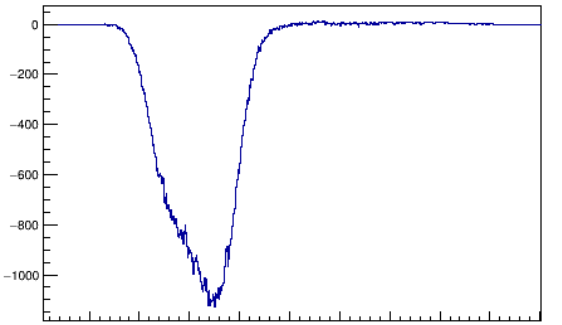
Bottom Array



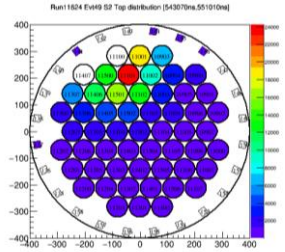
S1 waveform



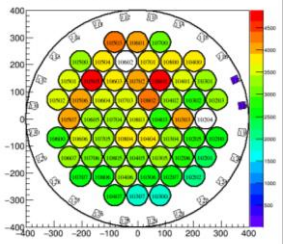
S2 waveform



Top Array

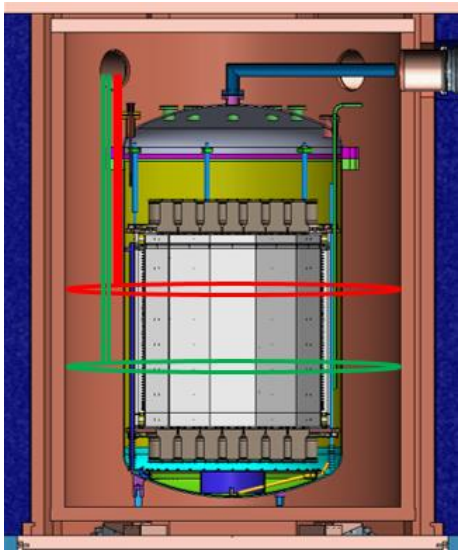


Bottom Array



Calibration program

- Internal/external ER peaks:
  - Detector uniformity corrections
  - Light/charge collection parameters



- Low rate AmBe neutron source:

$\Rightarrow$ Simulate DM NR recoil signal

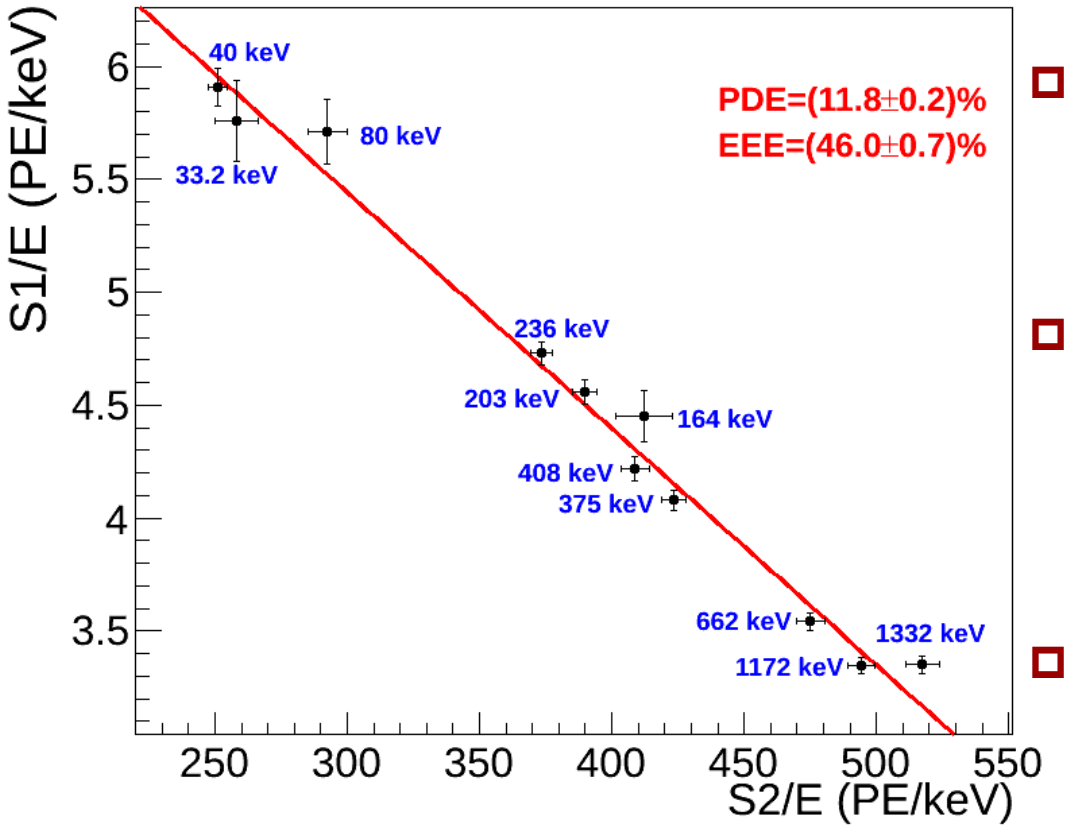
- CH_3T injection: tritium beta decays

$\Rightarrow$ Simulate gamma background

Extracting detector parameters

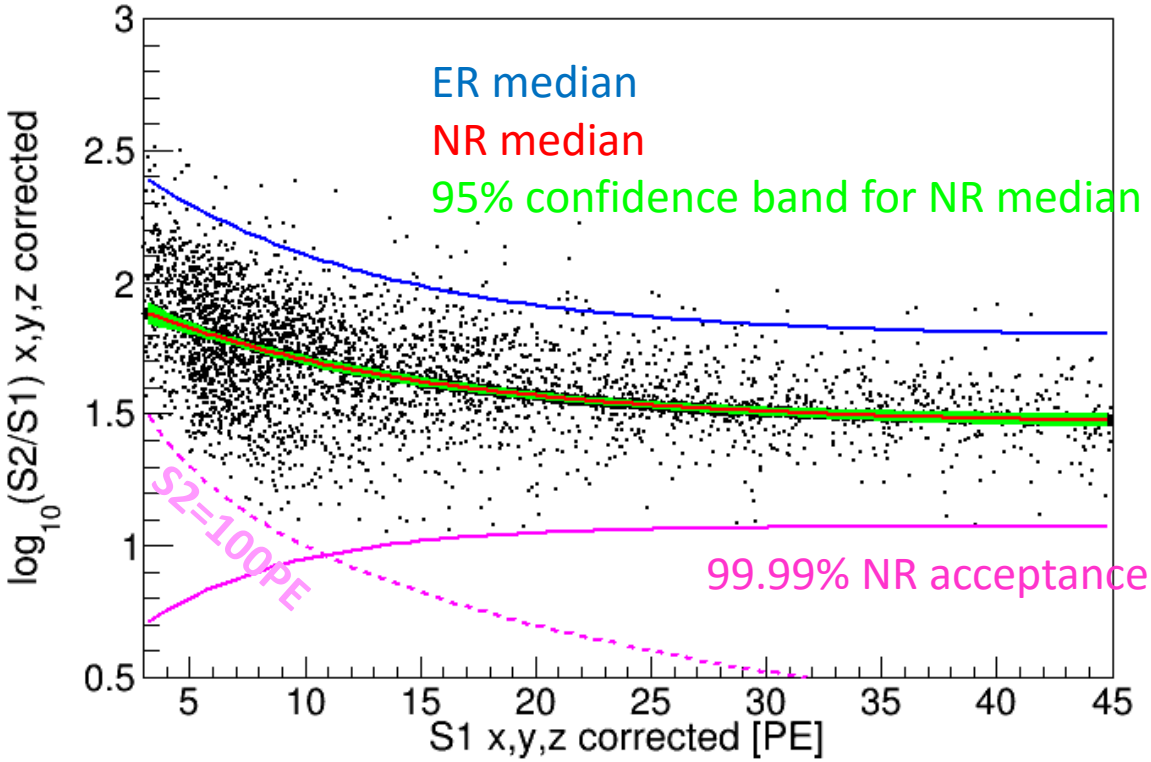
$$E_{ee} = W \times \left(\frac{\mathrm{S1}}{\mathrm{PDE}} + \frac{\mathrm{S2}}{\mathrm{EEE} \times \mathrm{SEG}}\right)$$

W = 13.7 eV

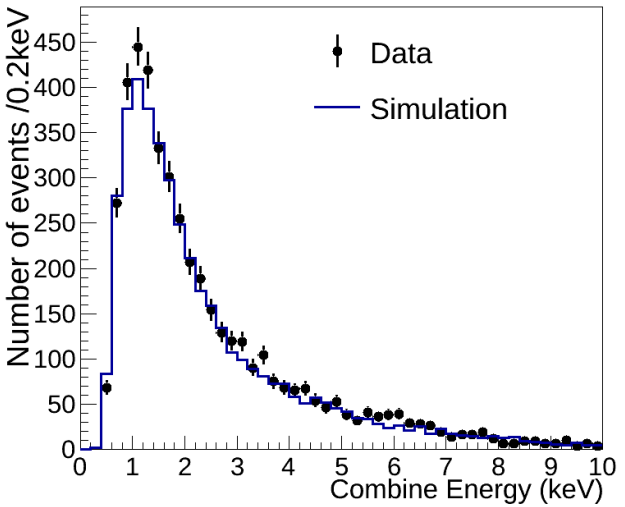


- Gaussian fits to all ER peaks in data
- Uncertainty on each data point estimated using energy nonlinearity
- Linear fit in S1/E vs S2/E to extract PDE and EEE

NR calibration

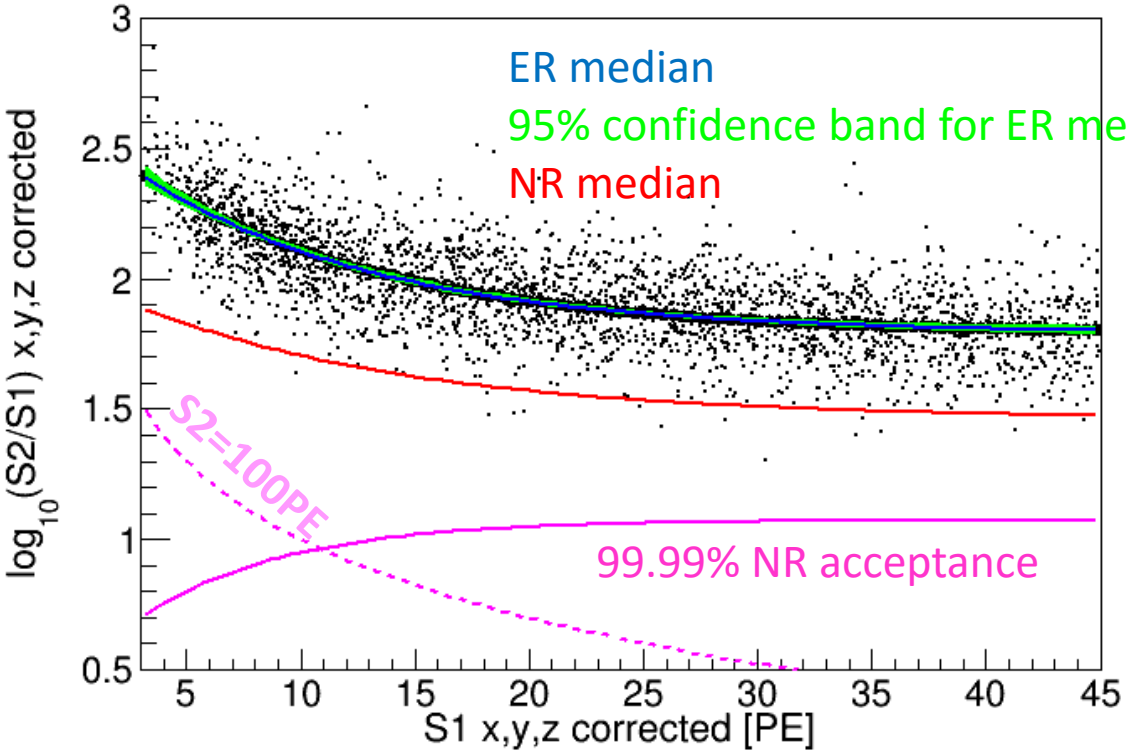


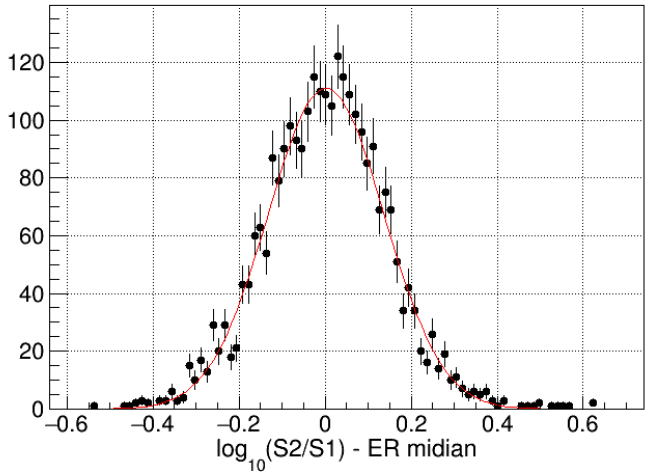
Data/MC comparison



- 162.4 hours of AmBe data taken, with ~3200 low energy single scatter NR events collected
- NR median curve and NR detection efficiency determined

ER calibration with CH_3T

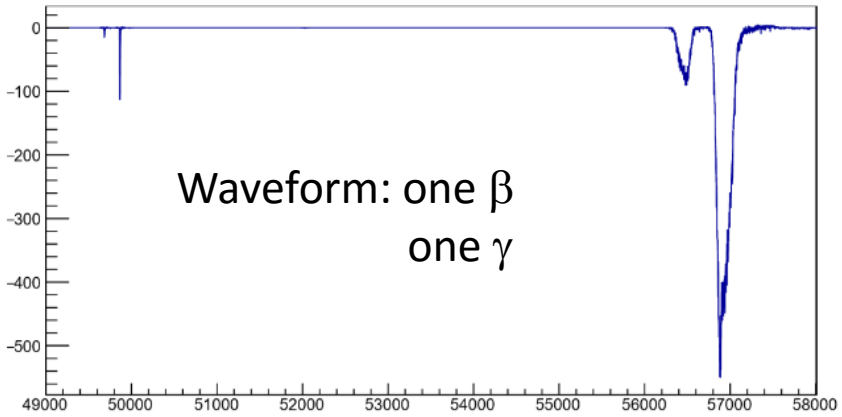


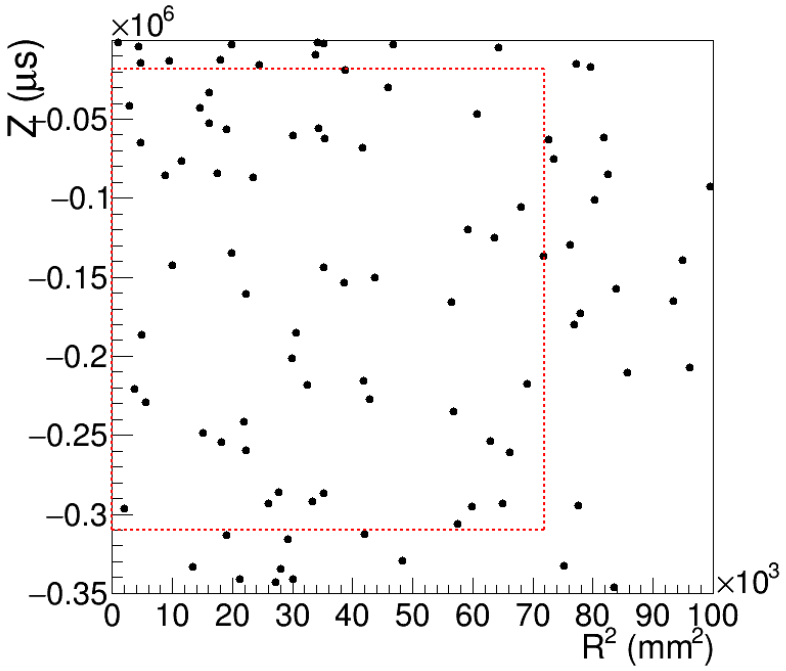


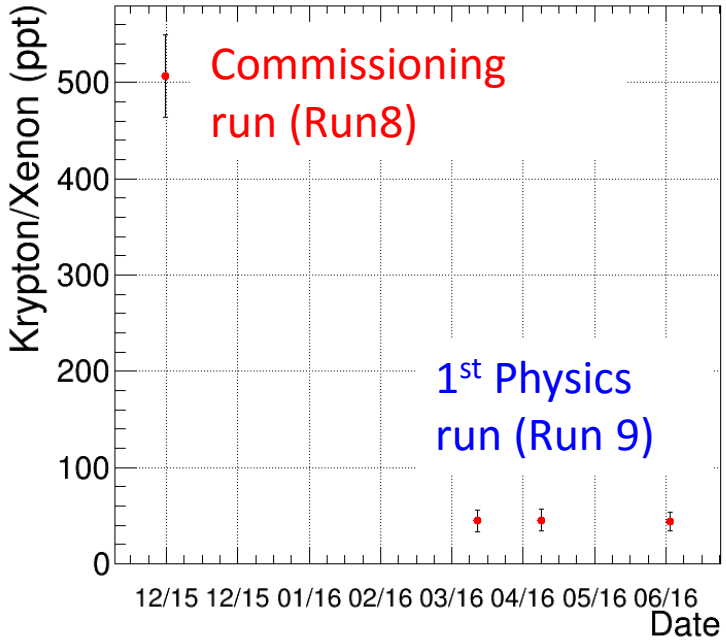
- 18.0 hours of tritium data taken, with ~2800 low energy ER events collected
- 14 events leaked below NR median, $(0.5 \pm 0.1)\%$
- Consistent with Gaussian expectation, 0.55%

^{85}Kr

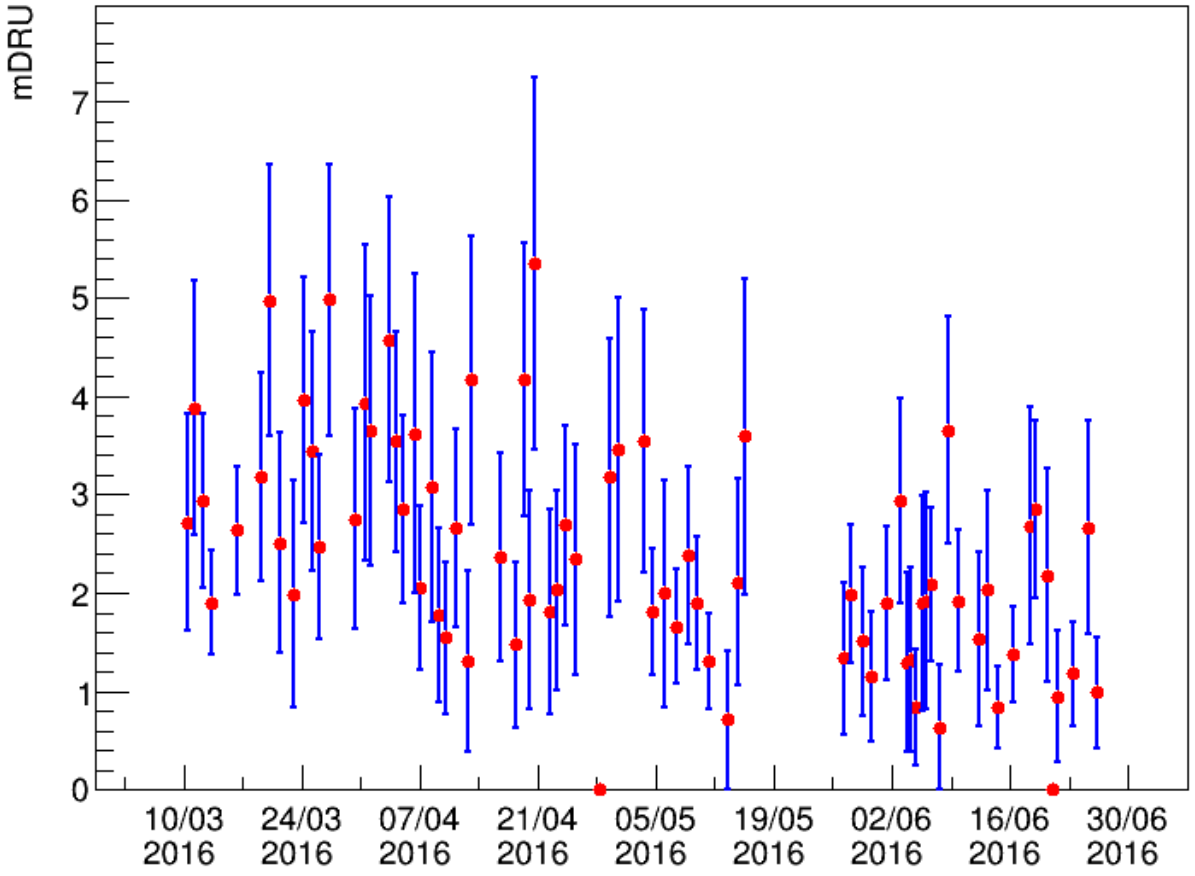
- Estimated from delayed β–γ coincidence analysis
- Uniformly distributed
- Significantly reduced after distillation







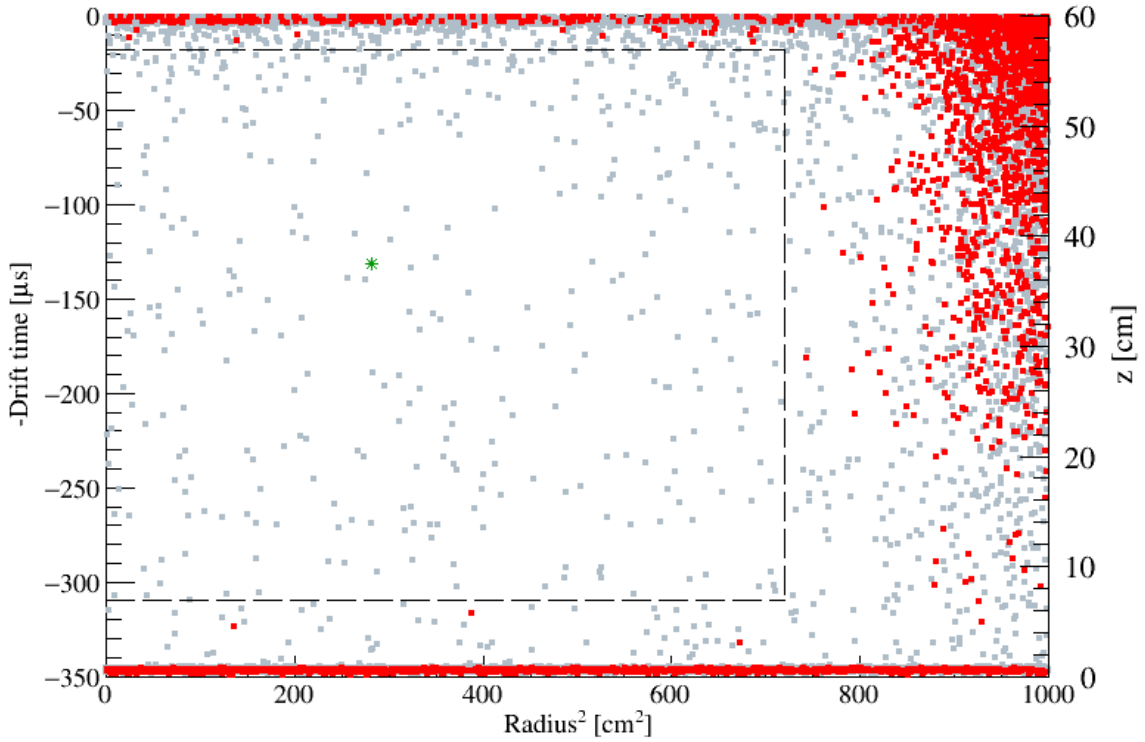
Low energy background in Run 9



- Events selected with energy <10 keV
- ~2 mDRU on average (15.3 mDRU in Run 8)
- Decrease over time due to ^{127}Xe decay

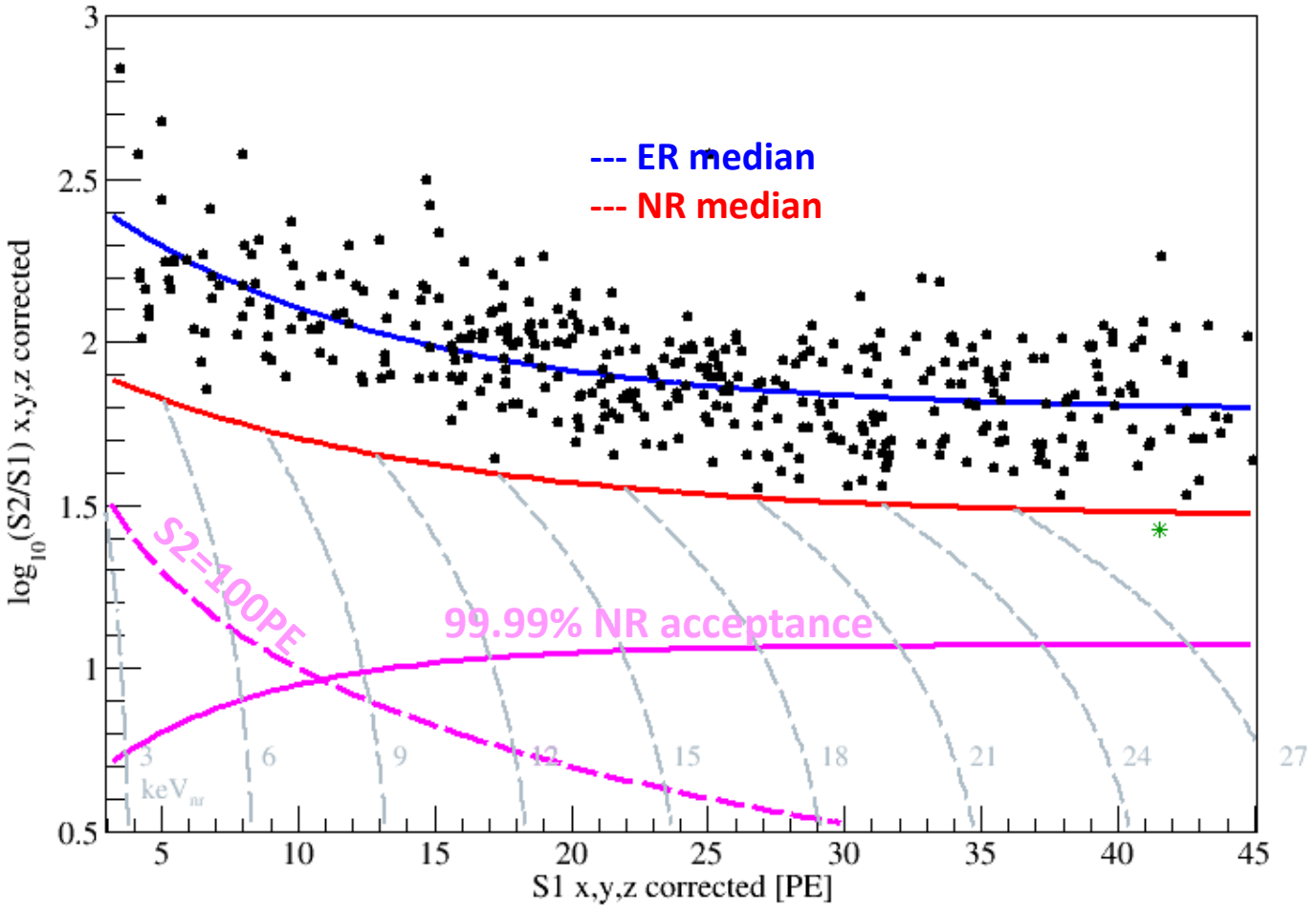
Final candidates

Gray: all
Red: below NR median
Green: below NR median and in FV

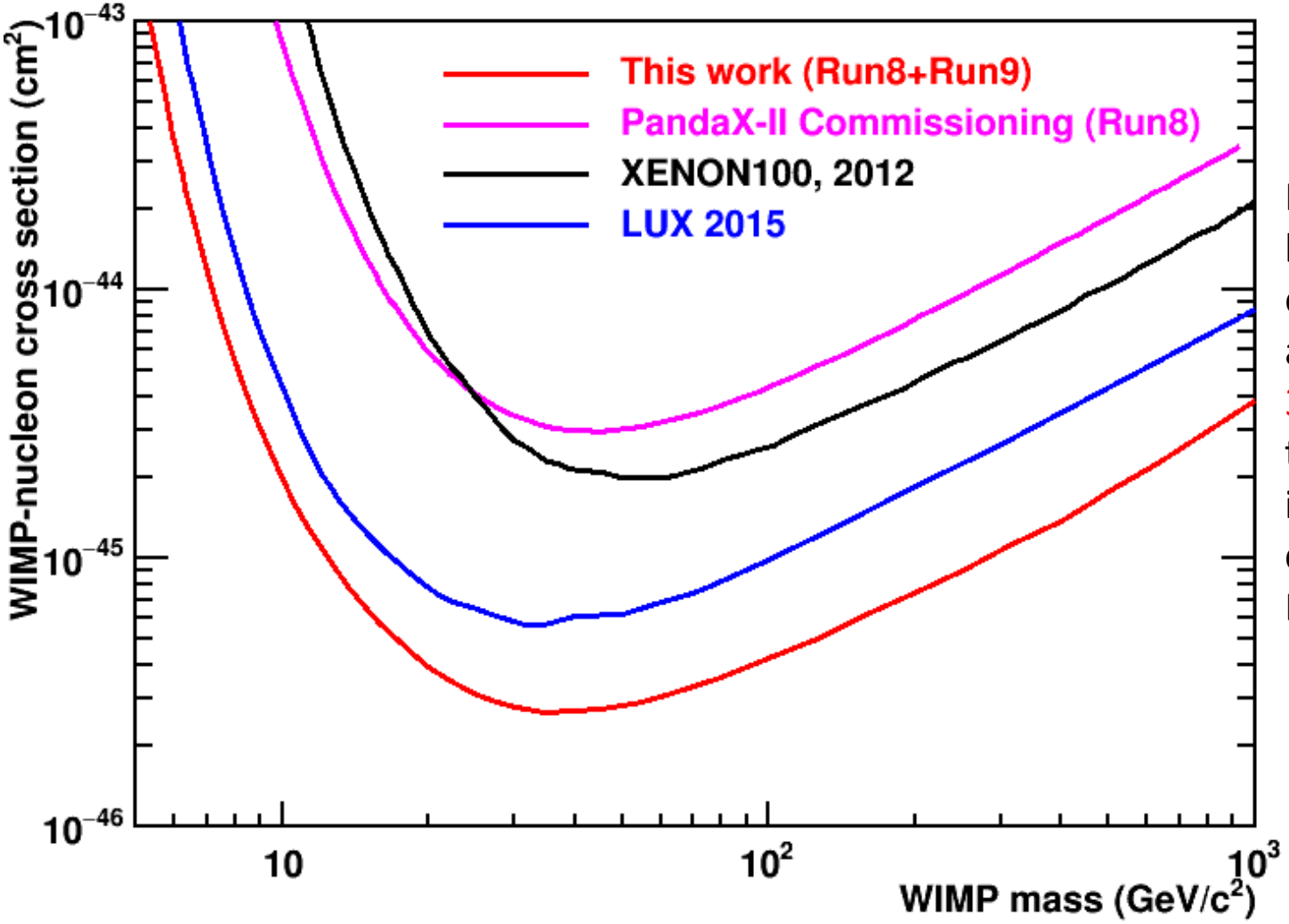


- 380 total candidates found in the FV
- **1** below NR median
- Outside FV, edge events more likely to lose electrons, leading to S2 suppression

Final candidates



Preliminary results



Minimum upper limit for isoscalar SI elastic cross section at 2.7×10^{-46} cm^2 @ 39.8 GeV/c^2, more than **a factor of 2** improvement compared to the LUX 2015 results

Summary and outlook

- 79.6 live-day of dark matter data were taken with much reduced background compared to the commissioning run (15 -> 2 mDRU)
- Extensive calibration studies with neutron and tritium
- In combination with commissioning run (19.1 day), ~3.32×10^4 kg-day exposure in total
- Analysis will be published officially soon.

Xenon experiments comparison

Experiments	FV (kg)	Total exposure (kg-day)	Background level (mDRU)
XENON100 100 day	48	4843	22
XENON100 225 day	34	7650	5
LUX 2015	147	14000	3
PandaX-I	54	4325	23.6
PandaX-II (run8)	306	5845	15.3
PandaX-II (run9)	~300	~24000	~2
PandaX-II run8+9	~300	33200	2-15