Dark Matter search results from PandaX-II

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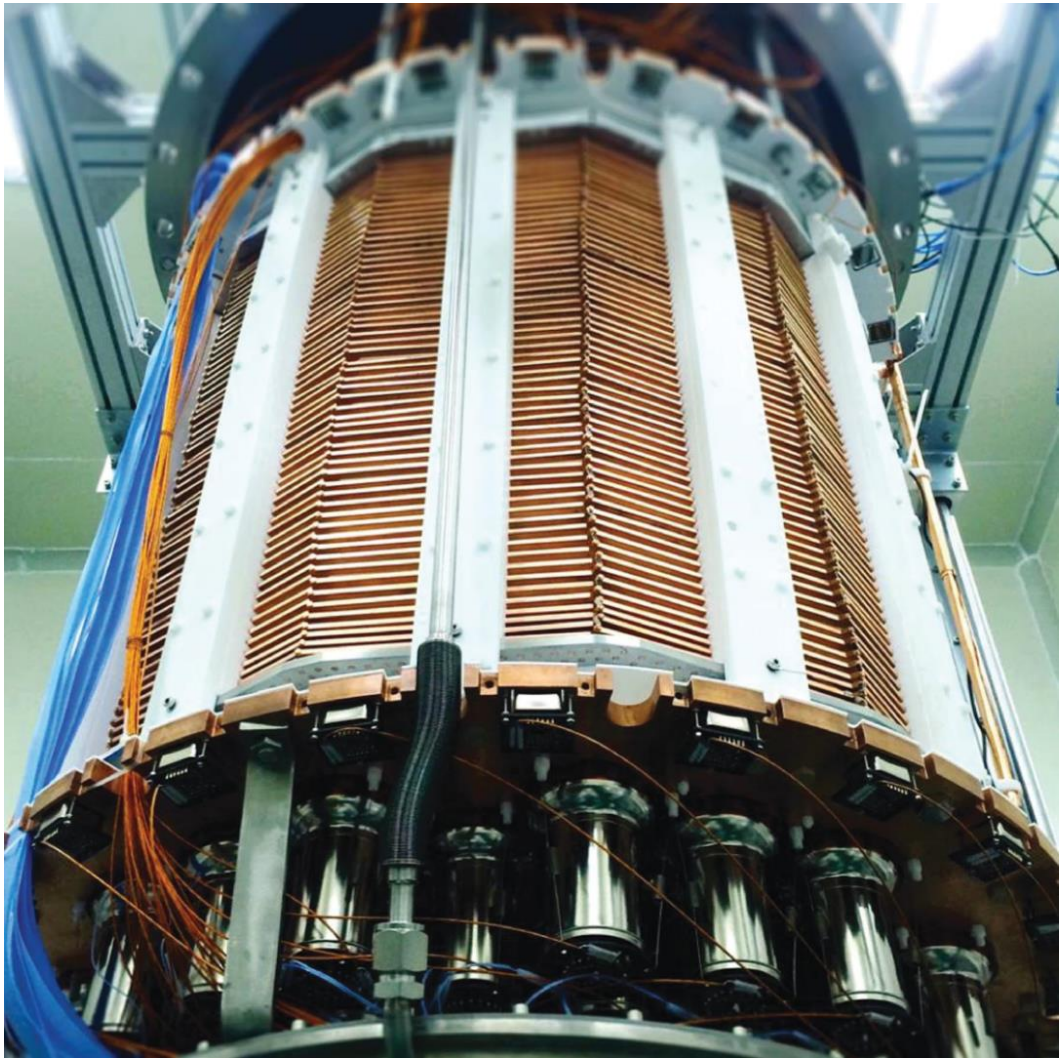
On behalf of PandaX-II Collaboration

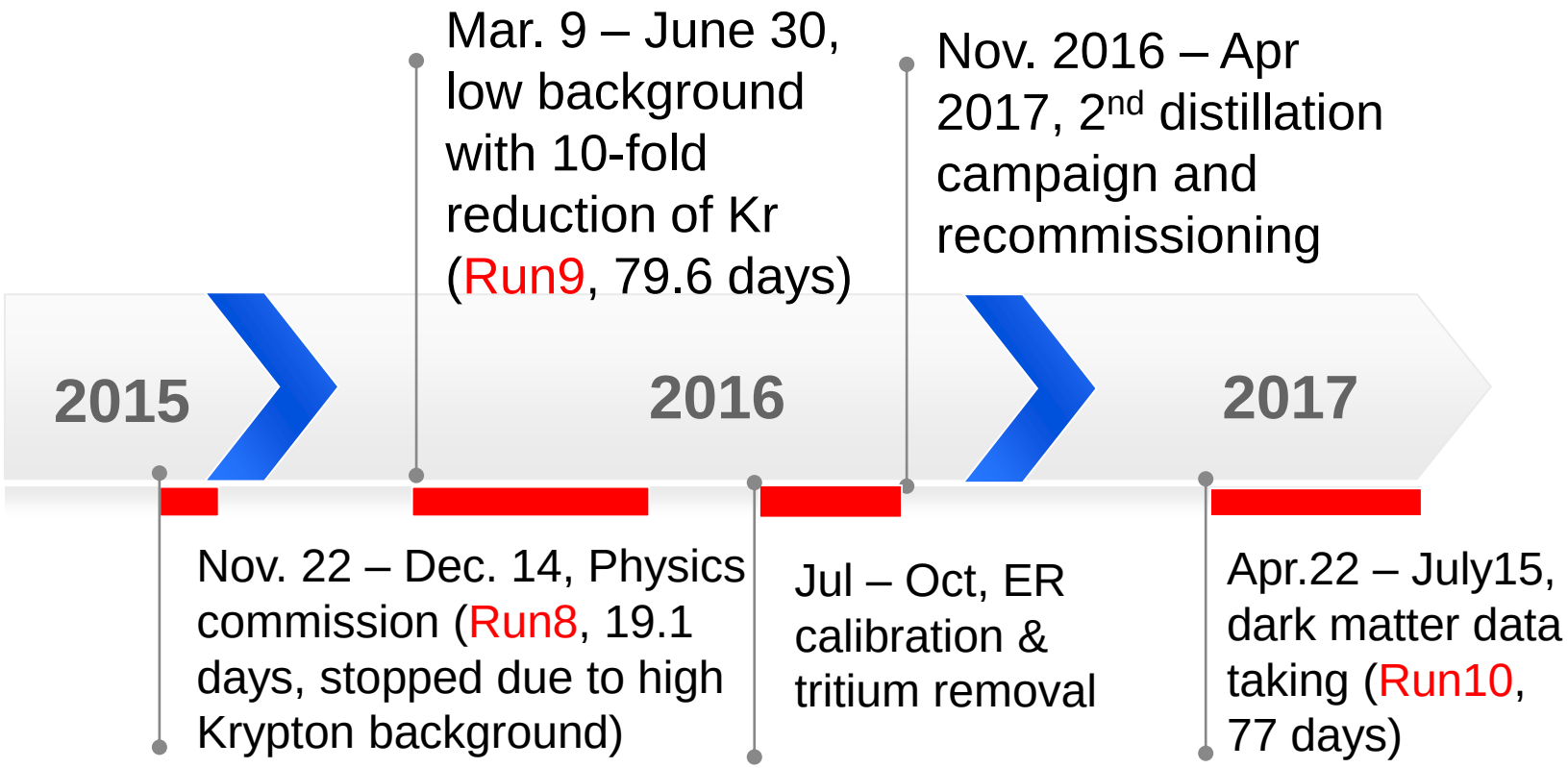
TeVPA, 2017-08-08

PandaX-II detector



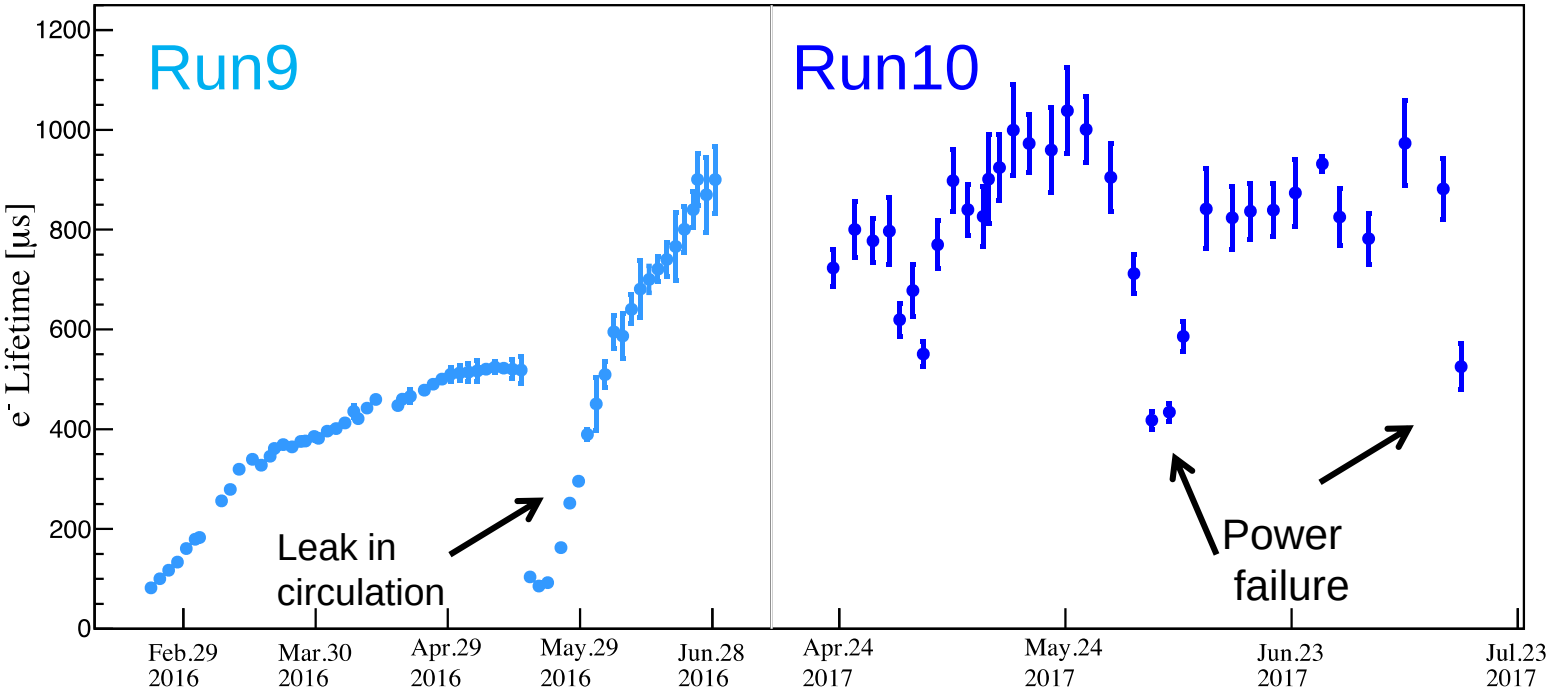
- 60 cm x 60 cm cylindrical TPC
- 580-kg of LXe in sensitive region, 1.2-ton LXe in total
- 55 top + 55 bottom R11410 3” target PMTs (split –ve and +ve HV)
- 24 top + 24 bottom R8520 1” VETO PMTs

PandaX-II run history



- Run9 =79.8 days, exposure: 26.2 ton-day
- Run10 =77.1 days, exposure: 27.9 ton-day
- Largest reported DM exposure to date

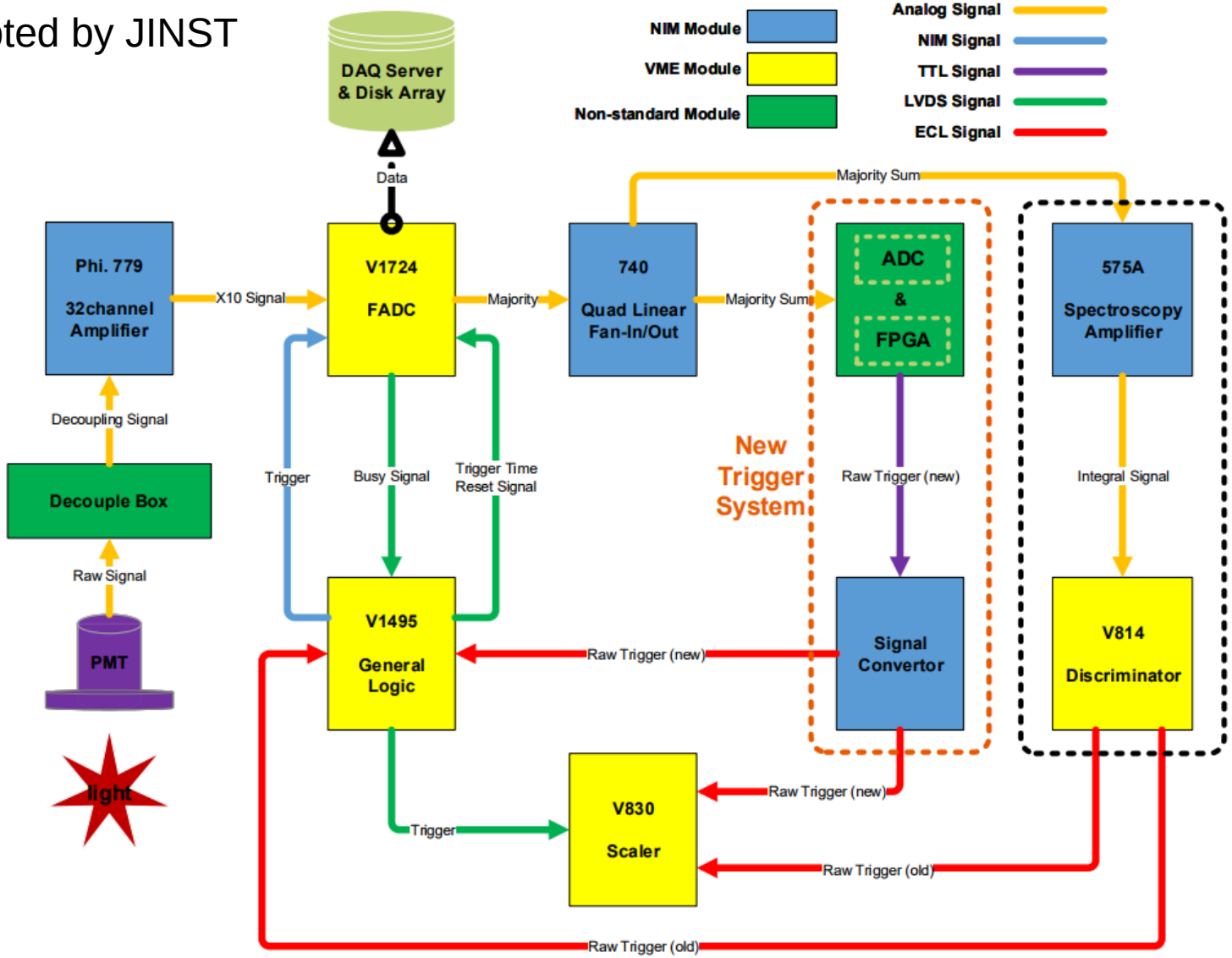
Improved electron lifetime



- Electron lifetime on average 800 μs (1.4 m drift distance) in Run 10, and generally stable
- Significantly improved from Run 9

Updates on trigger for DAQ

arXiv:1707.02134
accepted by JINST



Analog -based

Updates on trigger for DAQ

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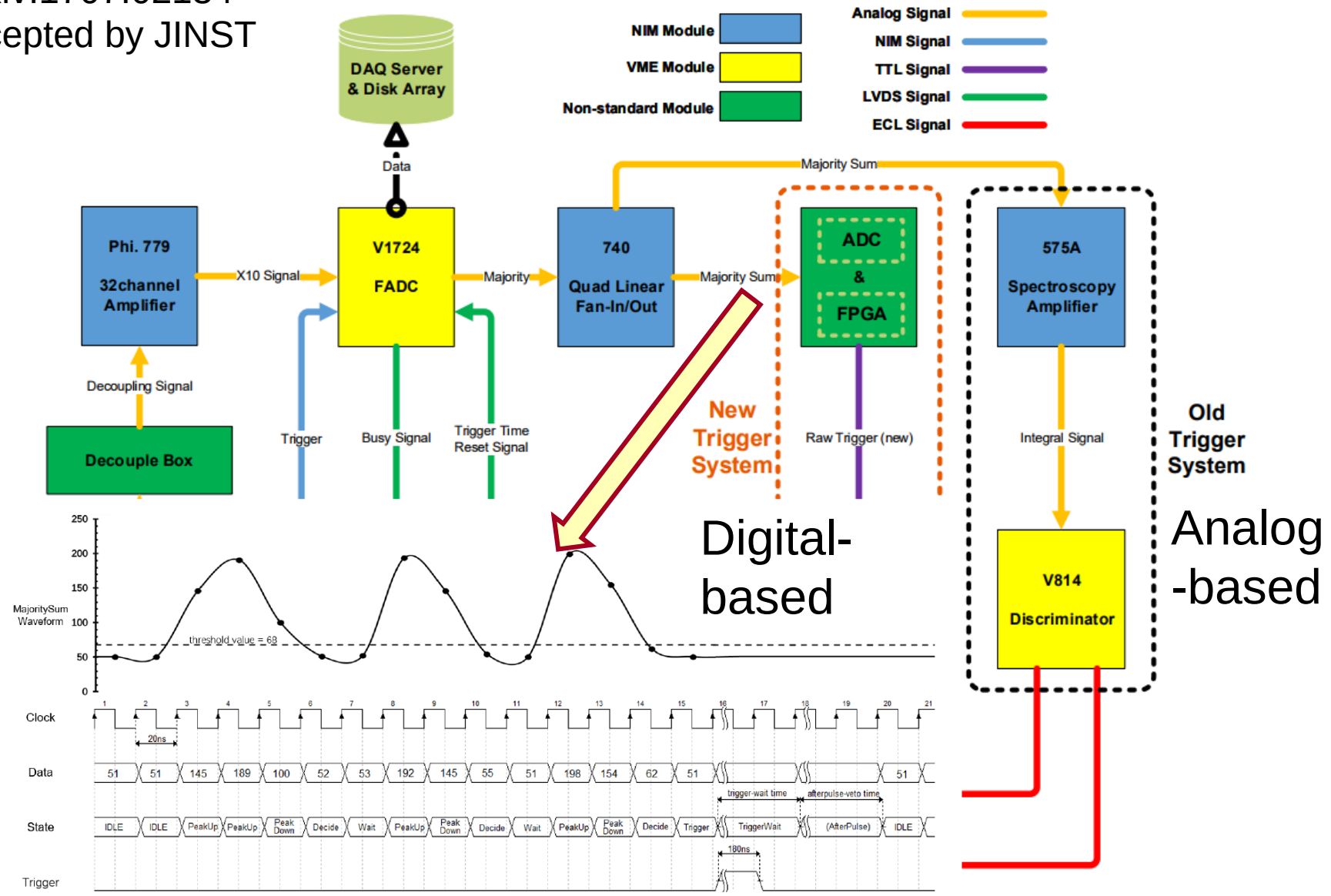
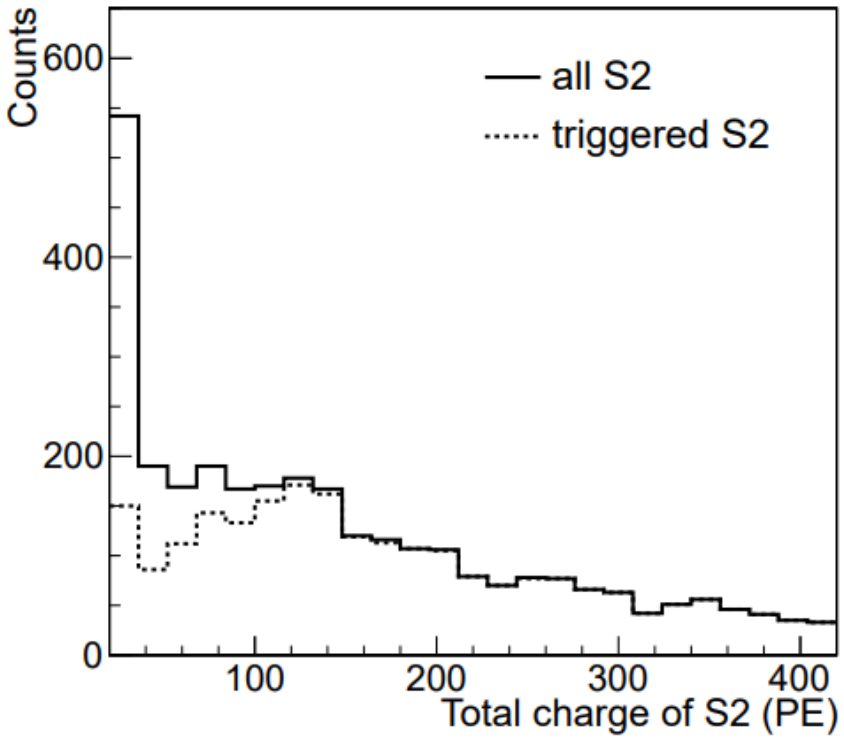
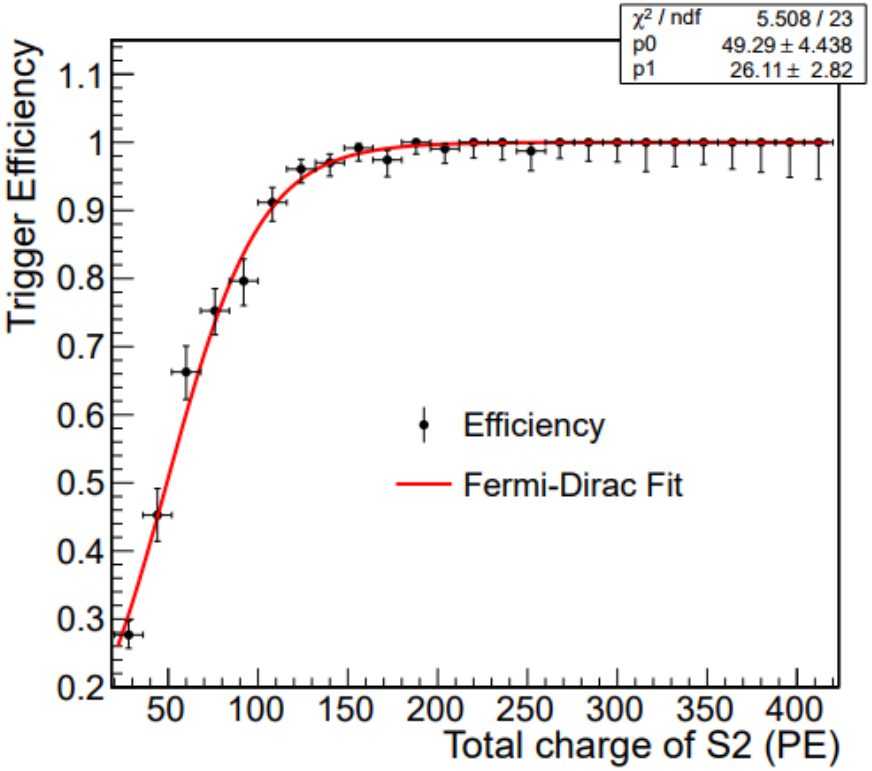


Data-driven trigger turn-on curve

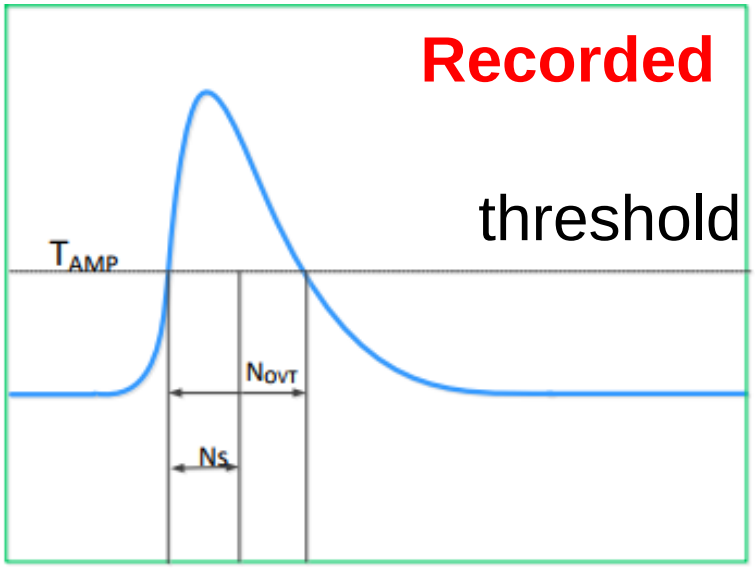


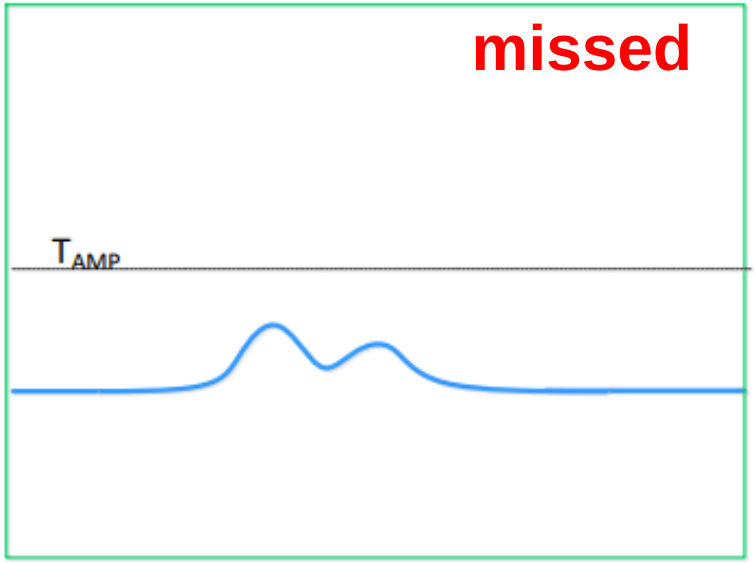


Real data-driven determination of trigger threshold using off-trigger-window S2s $\Rightarrow$ threshold 50 PE, about 2 photoelectrons. (before ~80 PE)

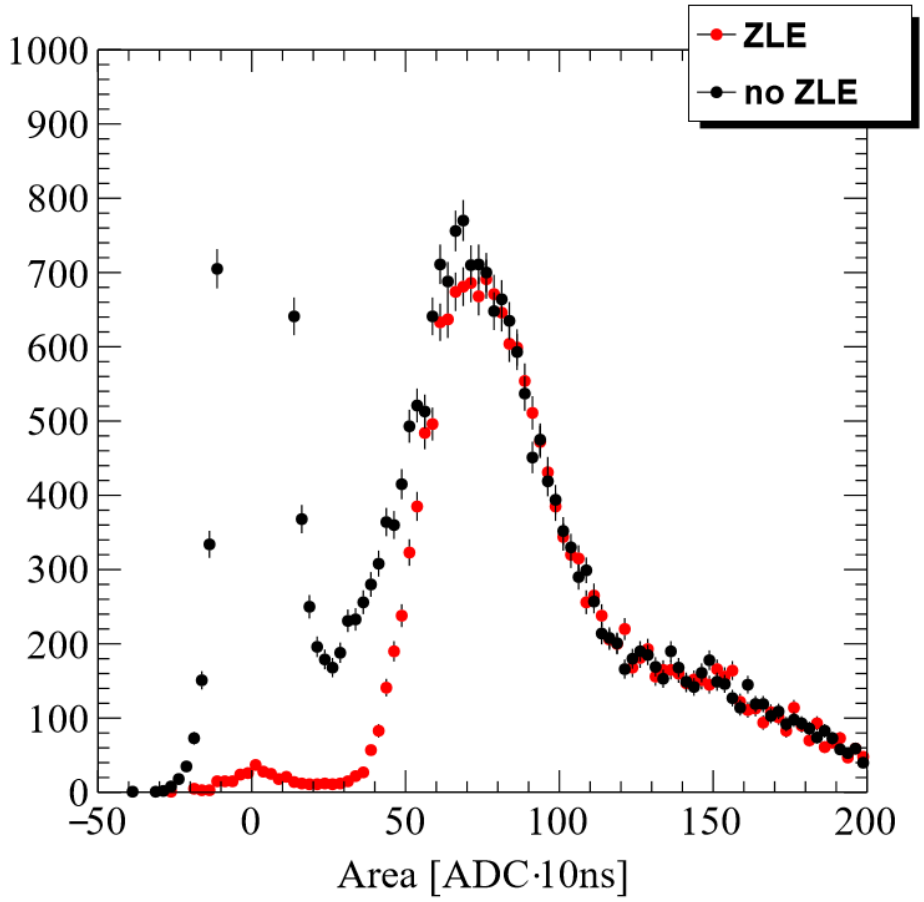
Zero-suppression

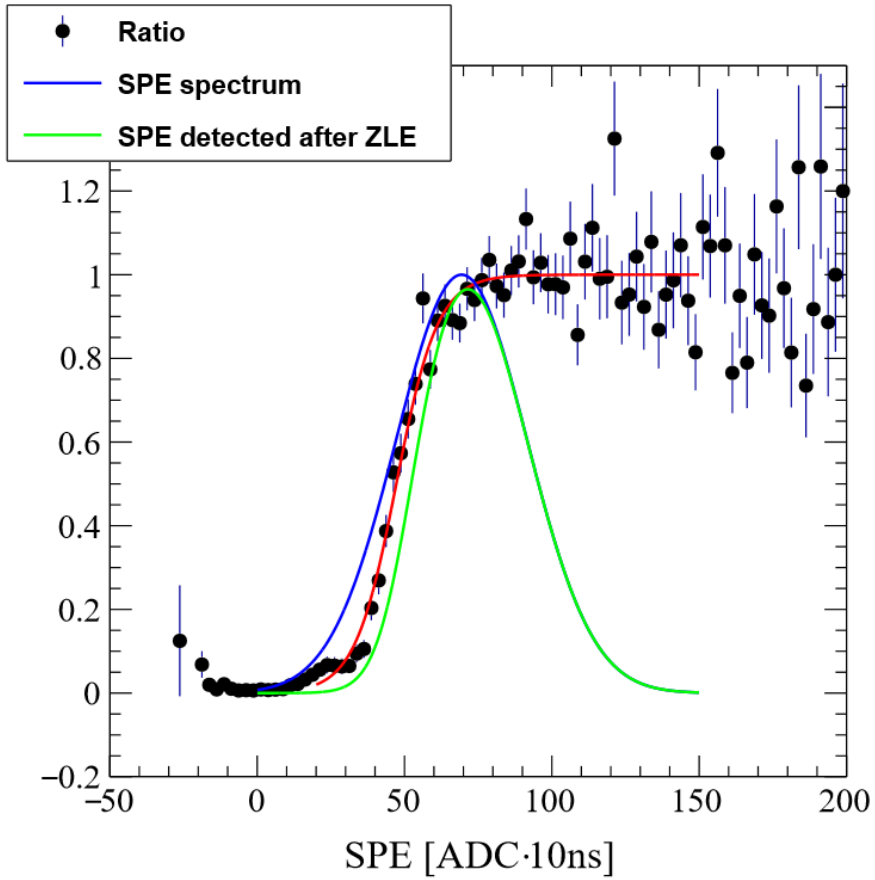
- In PandaX-II, electron maximum drift time is 60cm / (1.7mm/μs) ~ 350 μs
- The recording length of one event is 1 ms. CAEN 724 digitizer: 100MS/s ➔ 10^5 samples/event/channel, huge amount data.
- Zero Length Encoding (ZLE) applied to record data above threshold (plus a few before and after)





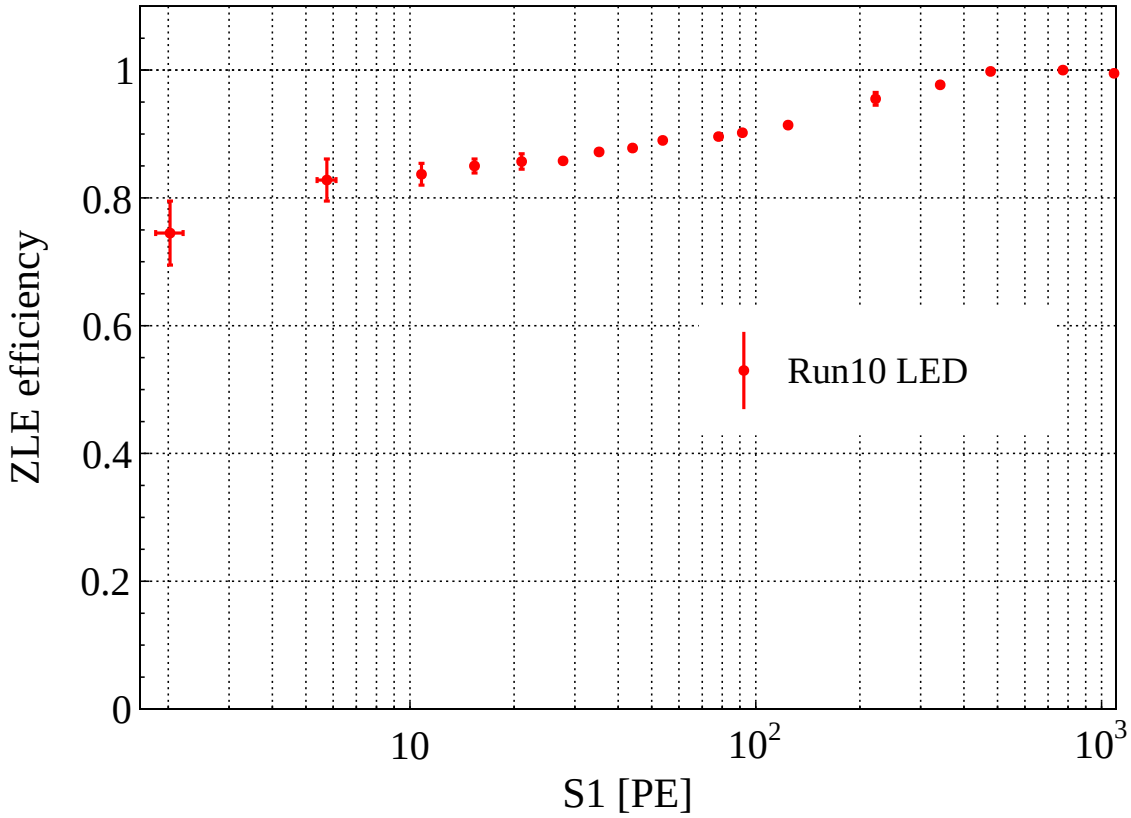
SPE efficiency due to ZLE





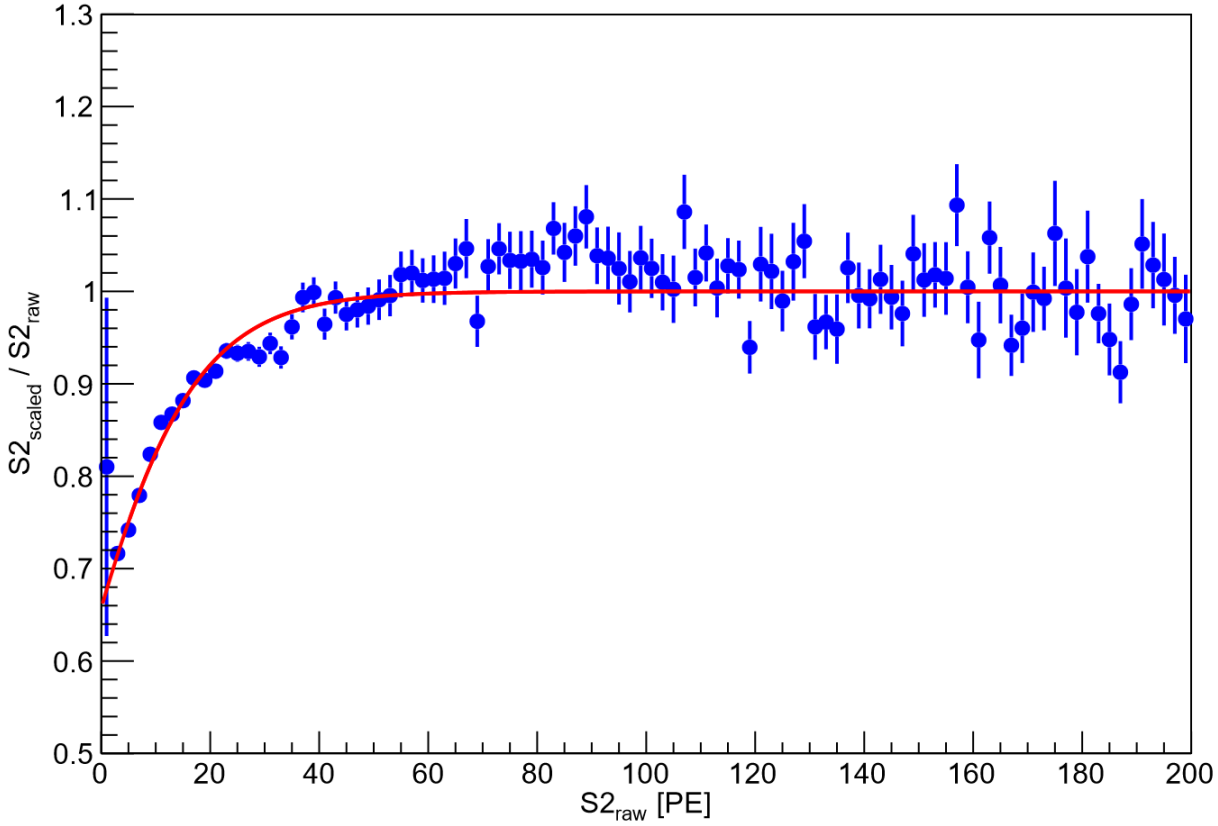
Channel-by-channel ZLE efficiency measured from low-intensity LED runs (single photon data) with/wo ZLE algorithm applied in data acquisition.

ZLE impact on S1 efficiency



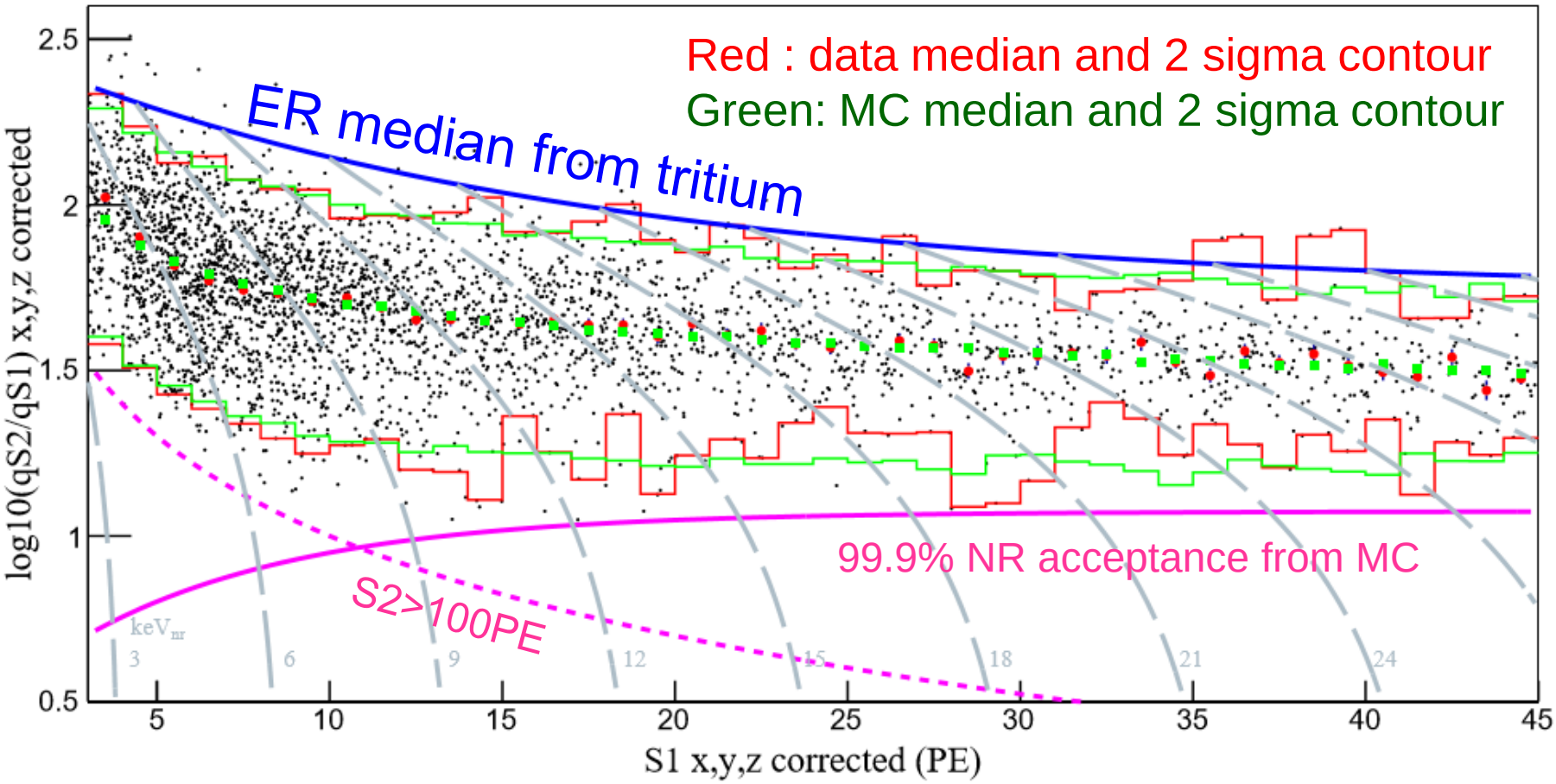
- Average efficiency for 3 PE (S1 threshold) is 80% using LED data.

ZLE impact on S2



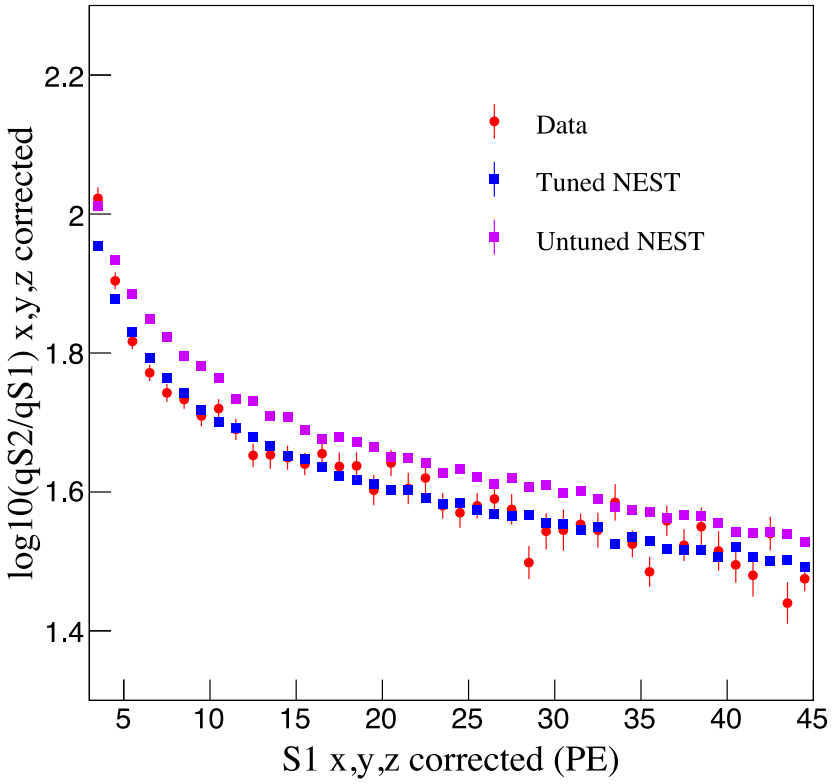
- S2 efficiency estimated by using S2 charge collected by the high gain PMTs ($\varepsilon_{ZLE} > 95\%$) as a true estimator.
- Little impact to S2, little impact to position reconstruction

NR Calibration data

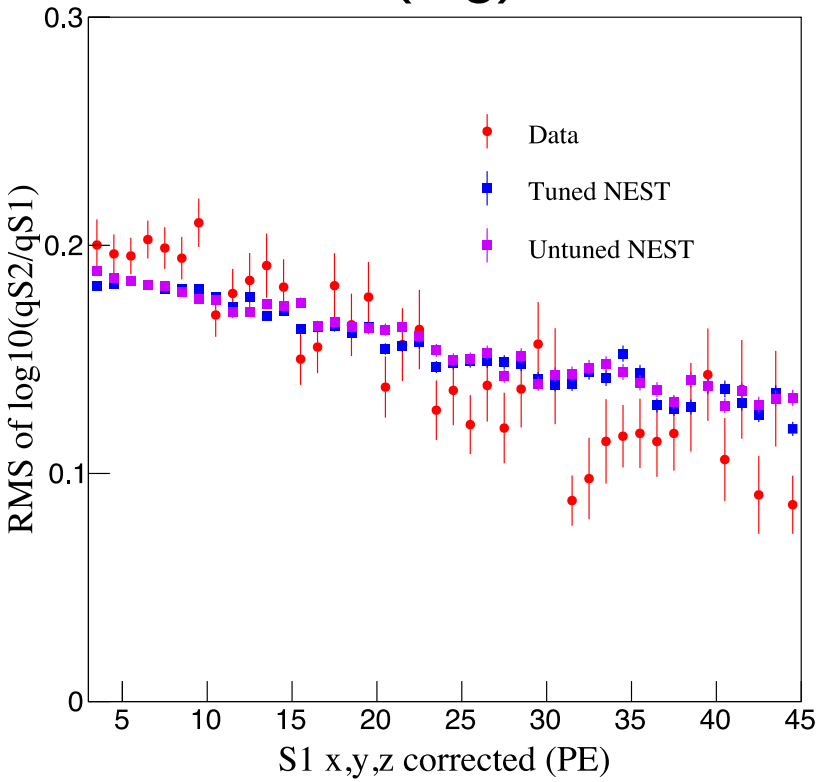


NR band: mean and RMS

Mean (log)

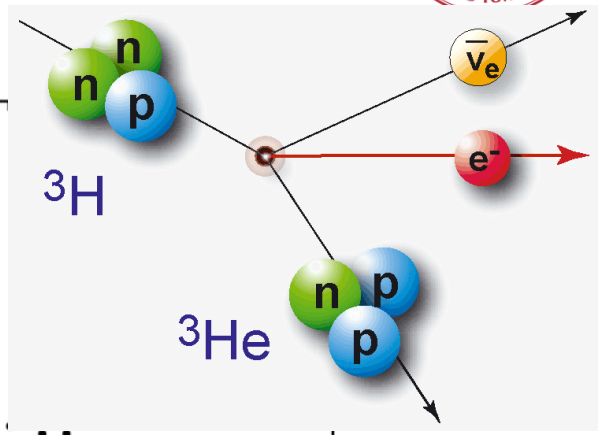


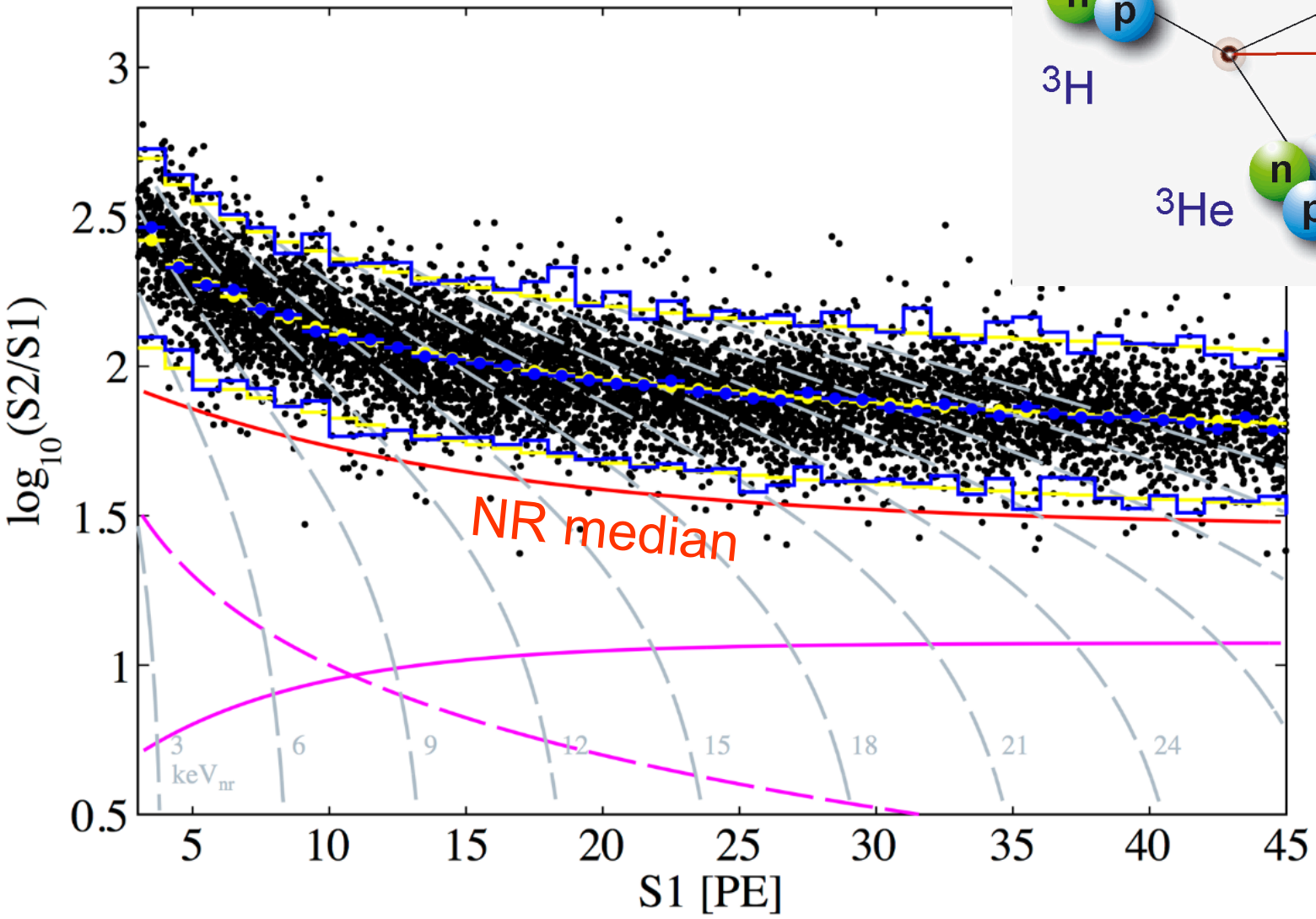
RMS (log)



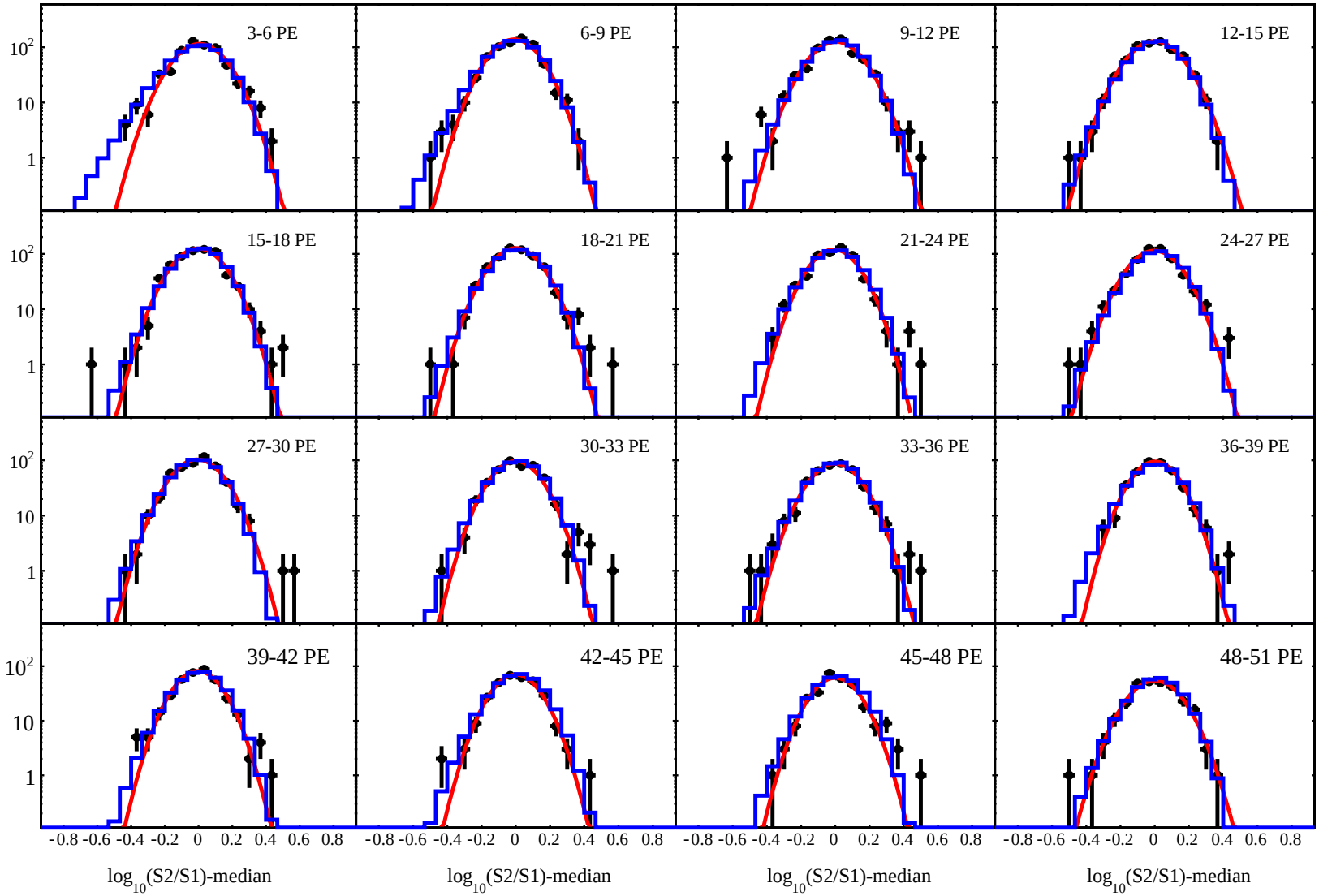
A tuning of the N_{ex}/N_i (excitation/ionization) parameter is made on the NEST model, after which the data/MC yield good agreement

ER calibration data





Comparisons in S1 slices



Background level in new data

	Run9 (mDRU)	Run10 (mDRU)
Xe127	0.42	0.033
Tritium	0	0.22
Kr85	1.19	0.20
Rn222	0.13	0.10
Rn220	0.01	0.02
Detector ER	0.20	0.21
Solar neutrino	0.01	0.01
Xe136	0.0022	0.0023
Total	1.95	0.79

1 mDRU = 10^{-3} evts/keV/kg/day

Original ^{127}Xe (cosmogenic, 36-day $\tau_{1/2}$) gone, additional introduced by a fresh "surface" bottle. Down 13 times

Based on best fit to data (later)

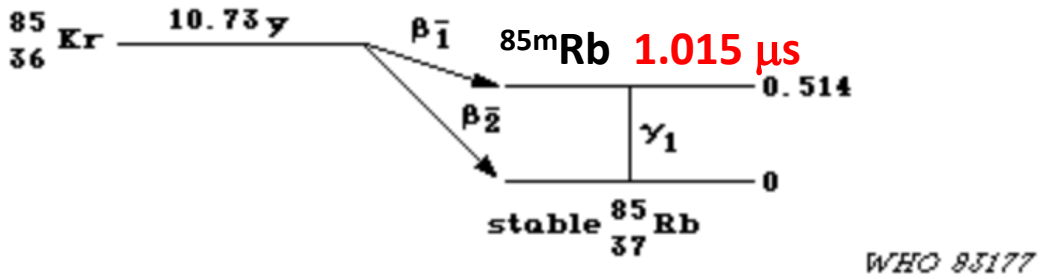
Reduced 6 times

These are consistent between Run 9 and Run 10

Reduced 2.5 times

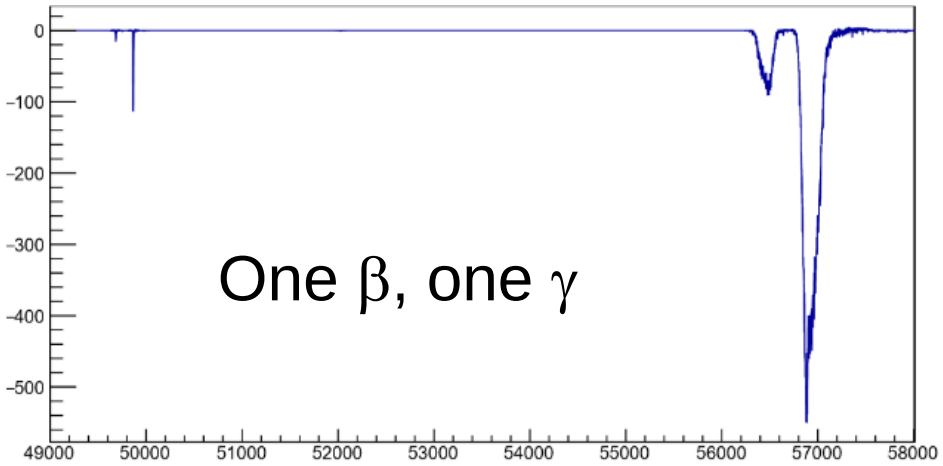
Krypton: Internal background

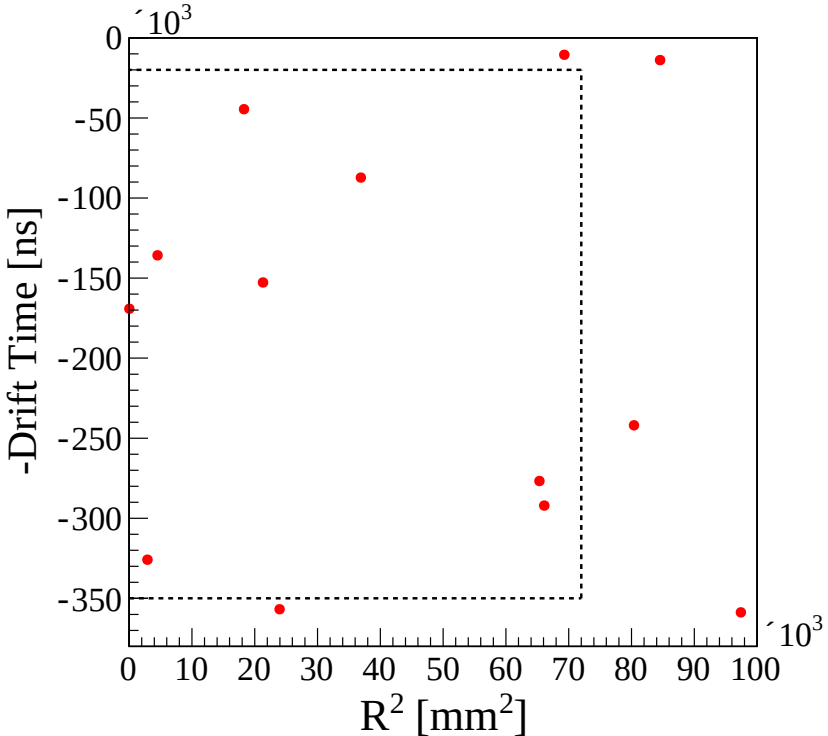
- krypton is intrinsically present on the ppb (parts per billion level=10^{-9} Kr/Xe) in commercially available xenon. (In atmosphere, ppm=10^{-6} level)
- Kr85/Kr = 2×10^{-11}



Radiation type	Energy (keV)	Intensity (%)
β_1^-	max. 173.0 avg. 47.5	0.437
$\beta_{2\,1}^-$	max. 678.0 avg. 251.4	99.563
γ_1	514.0	0.434

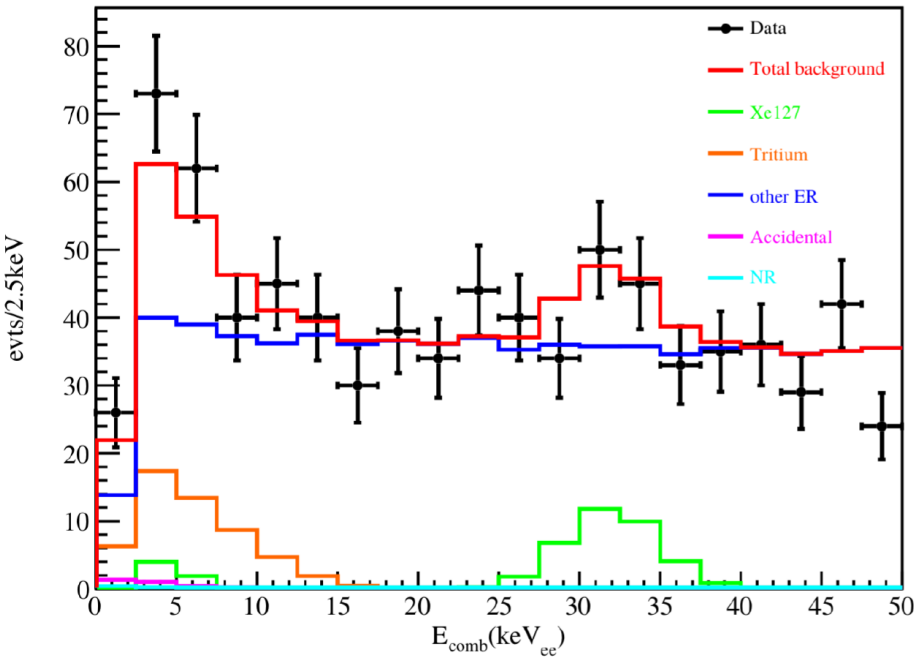
Krypton background

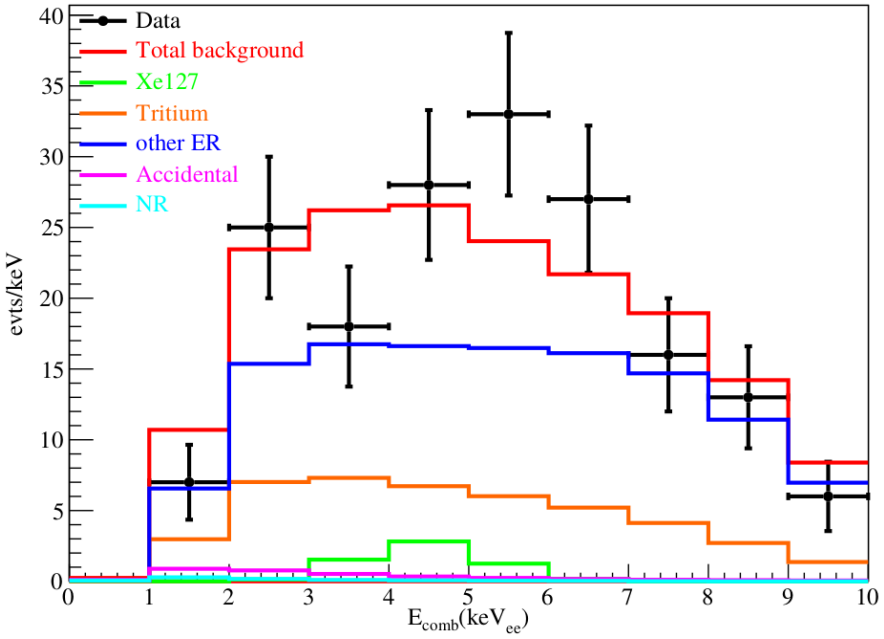




- Use (β,γ) delayed coincidence tag
- 13 events found in target
  ⇒ 6.6(1.8) ppt of Kr in Xe
- Reduced by 6 times from previous run (run 9)

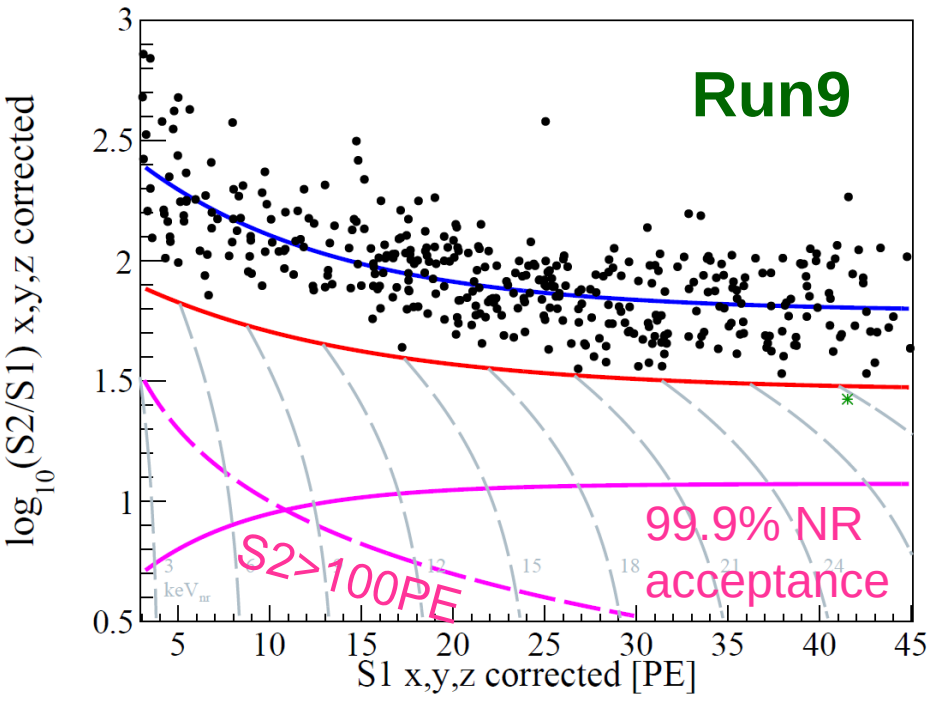
Energy spectrum

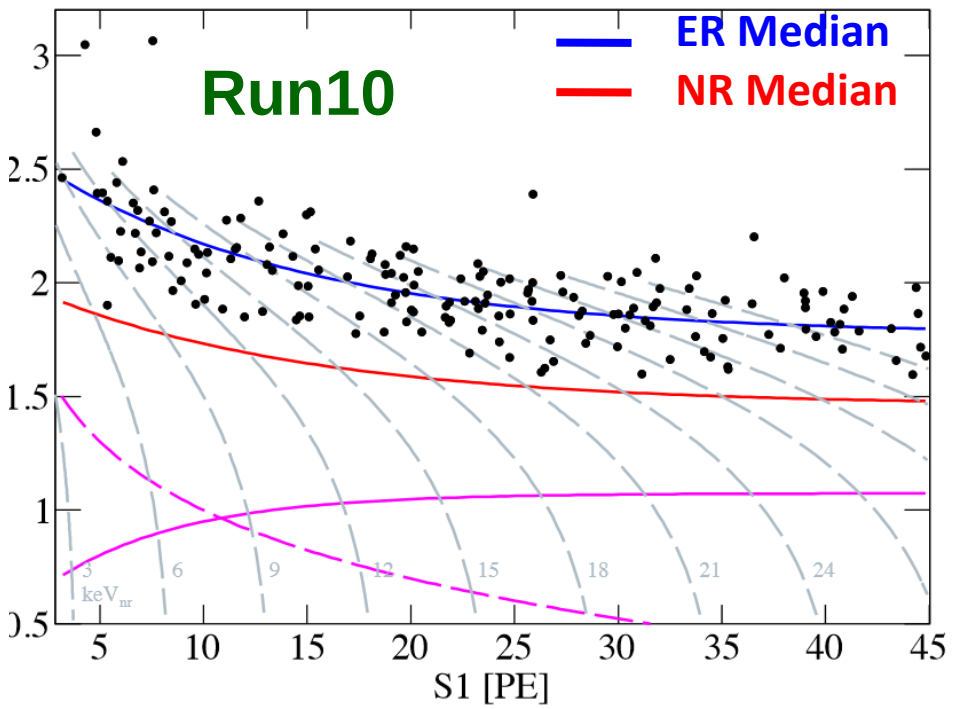




- MC: best fit to data (shape fixed).
- Tritium contribution extracted from the fit.

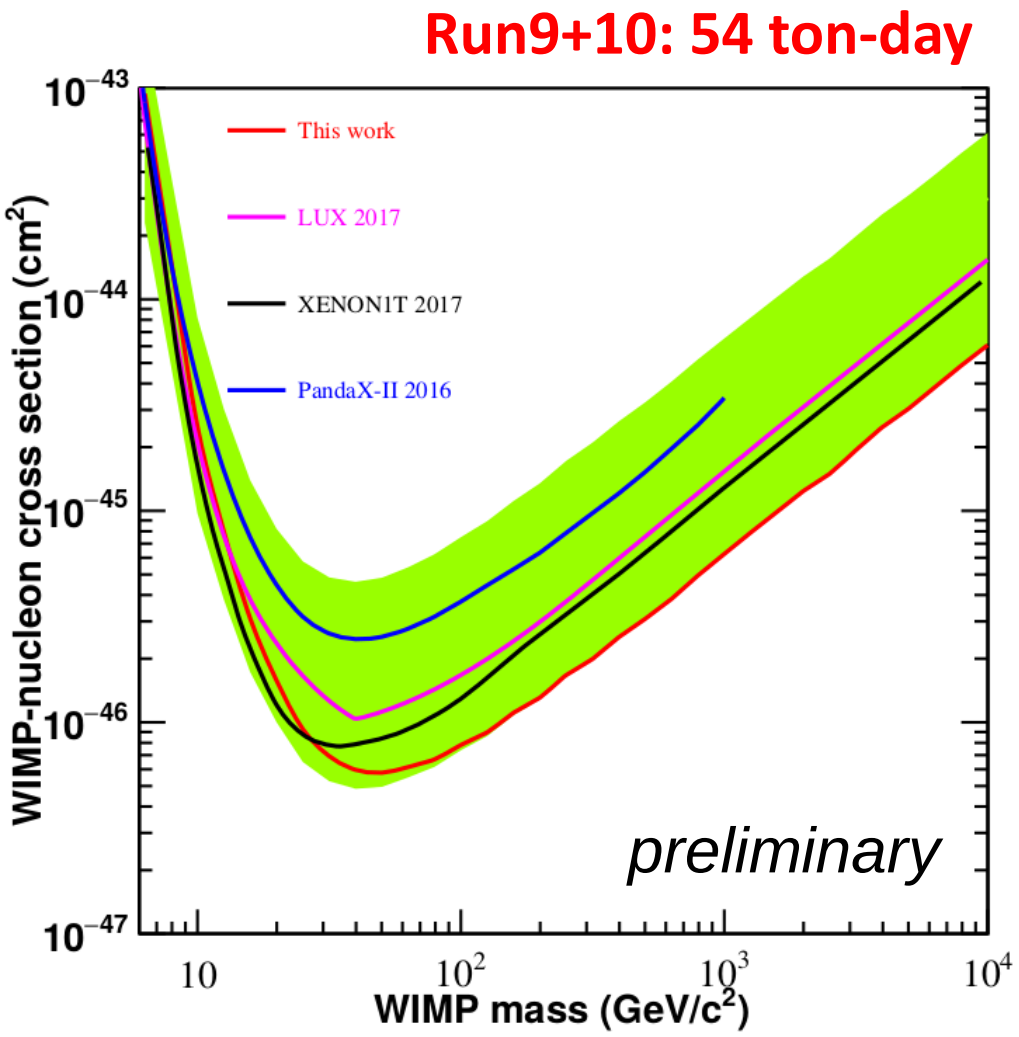
Data matter search data





	Data in FV	Below NR median	Expected Bkg below NR median
Run9	389	1	2.4
Run10	177	0	2.1

Results on SI cross sections



- Profile likelihood fits made to the data in grids of (m_χ, σ_χ).
- 90% upper limits produced comparison of test static to toy MC, and power-constrained to -1σ
- Improved from PandaX-II 2016 limit ~4 times for mass>30 GeV.
- More constraining than LUX and XENON1T 2017

Summary

- 54 ton-year exposure of PandaX-II gives no hint of WIMP signals.
- Recent improvement includes:
  - Better trigger method
  - Better understand of efficiency due to zero-suppression
  - Better NR/ER modeling
  - Lower background
- Produced strongest SI limits for high masses. Minimum 6×10^{-47} cm^2 at 50 GeV.

Thanks for your attention