CALIBRATION AND RECONSTRUCTION IN PANDAX-II

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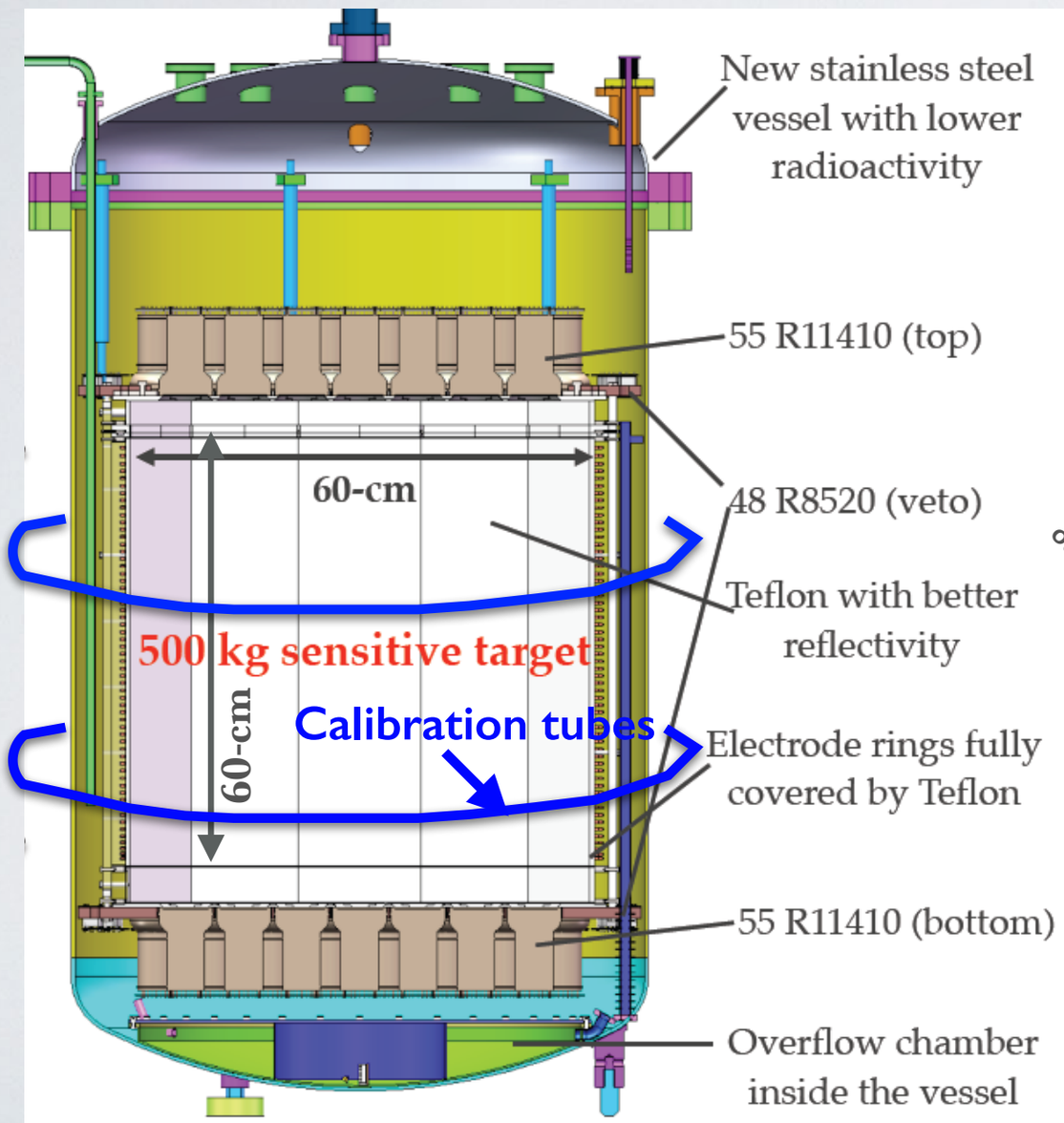
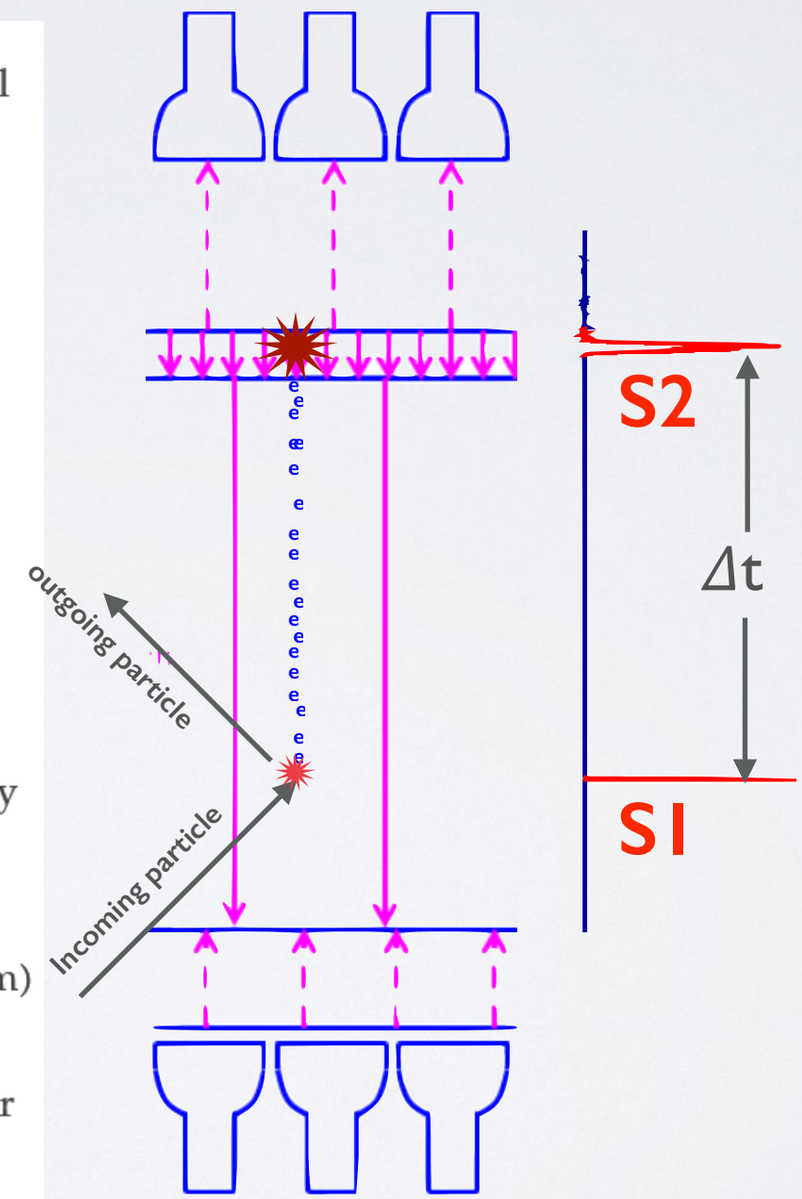
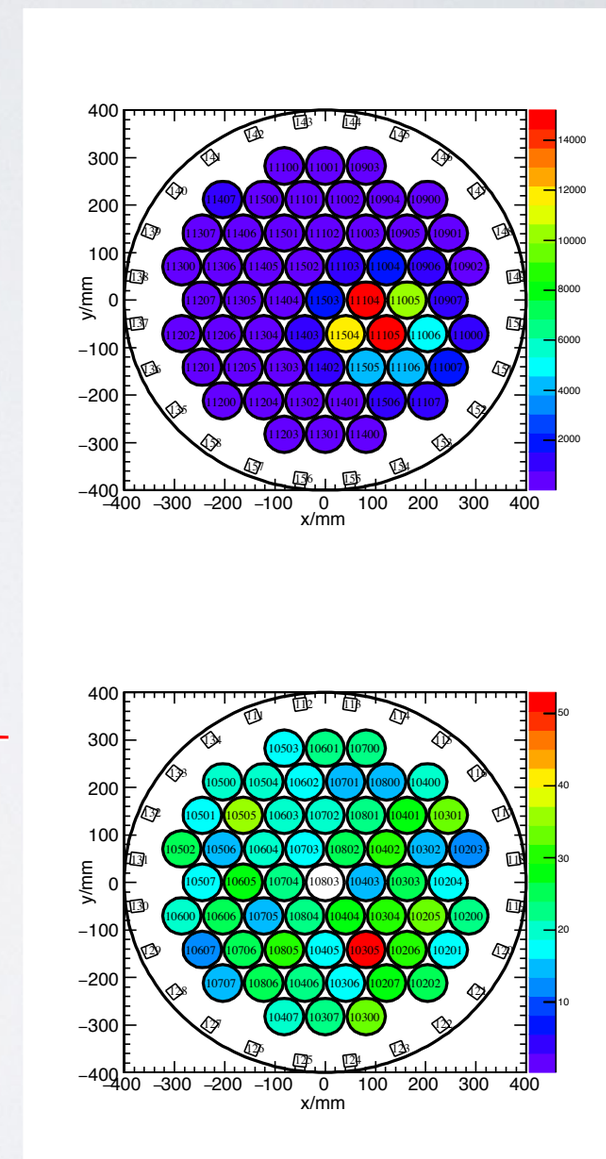
On Behalf of PandaX Collaboration

PandaX-II detector







Calibration and Reconstruction

Reconstruction

- Vertex reconstruction
  - TM (template matching method)
  - PAF (photon acceptance function)
- Energy reconstruction

$$E = W * \left(\frac{S1}{g_1} + \frac{S2}{g_2} \right)$$

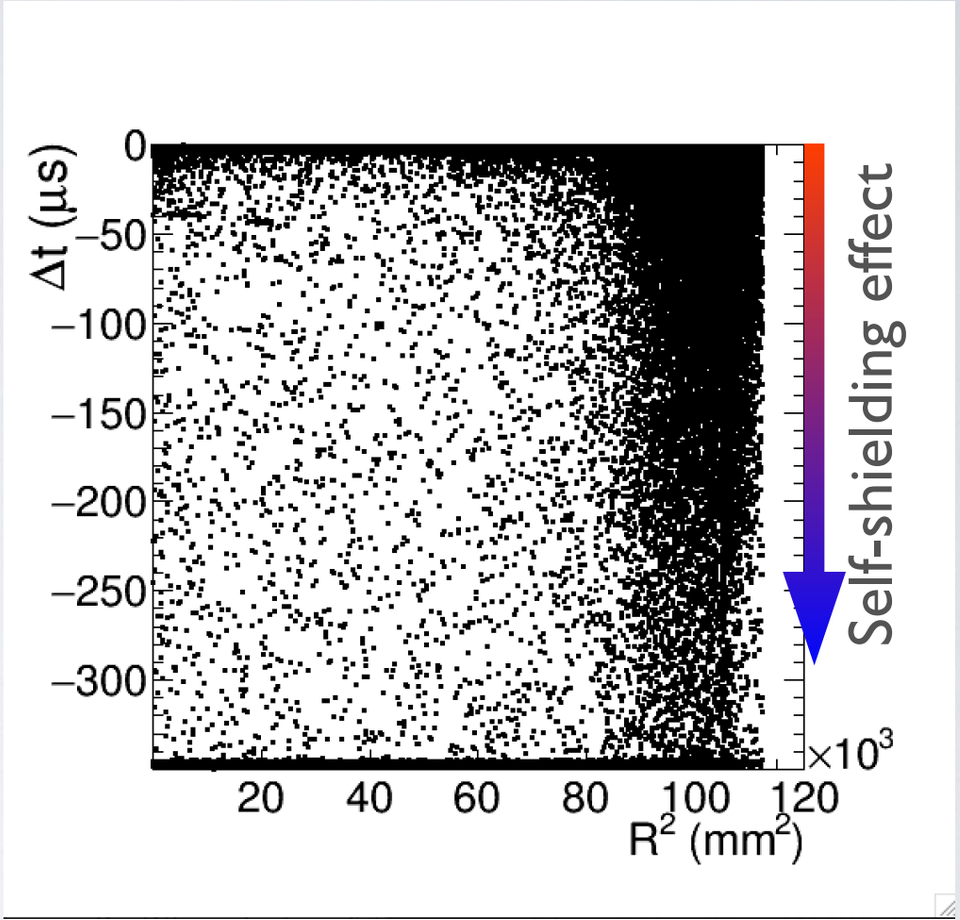
Calibration

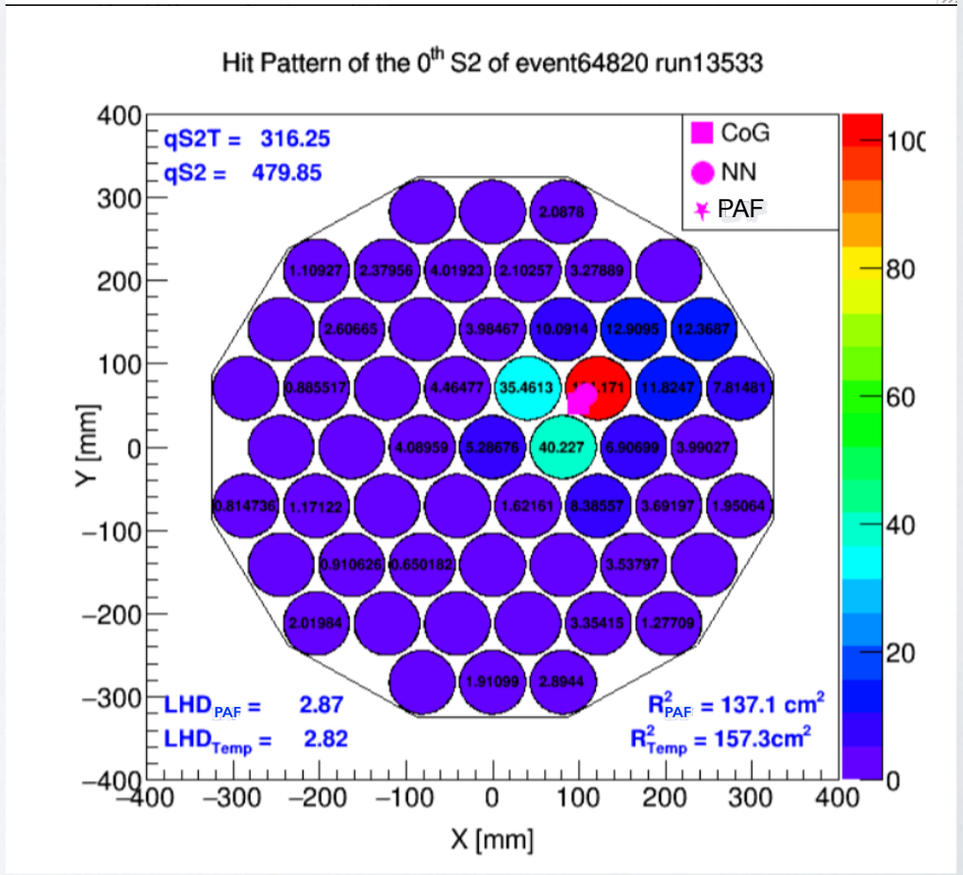
PMT gain		LED
$S1$	$S2$	164 keV γ
g_1	g_2	different γ-rays
tritiated methane		
^{241}Am-Be		

- External source: AmBe, Cs, Co from calibration tubes
- Internal source: CH_3T, ^{127}Xe, ^{129m}Xe, ^{131m}Xe, $^{129}Xe(n,\gamma)$, $^{131}Xe(n,\gamma)$.

Vertex reconstruction

- Δt between S1 and S2 → ‘Z’
- two methods developed, one based on MC (TM), and one based on data (PAF) → ‘XY’





PAF reconstruction

$$\eta(r) = A \cdot \exp\left(-\frac{a \cdot \rho}{1+\rho^{1-\alpha}} - \frac{b}{1+\rho^{-\alpha}} \right), \rho = \frac{r}{r_0}$$

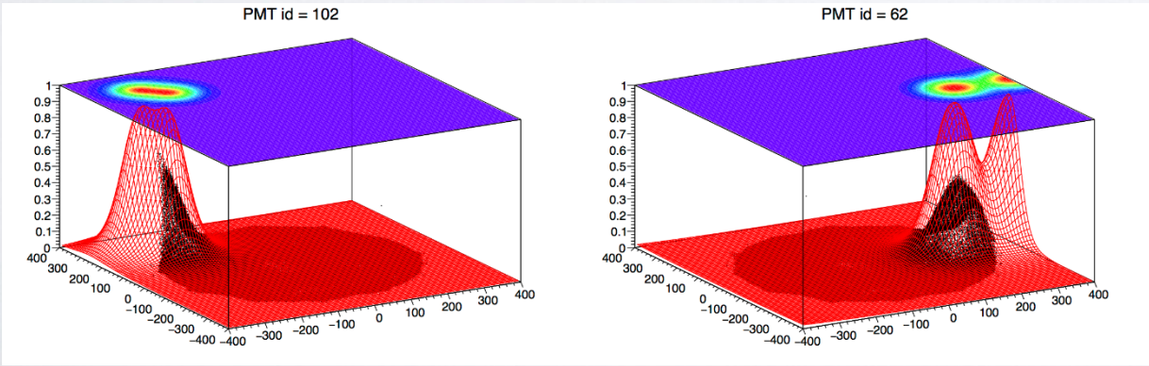
$$\vec{r}^{(0)} = \vec{r}_{\mathrm{CoG}}$$

$$\eta_i^{(1)} \longrightarrow \vec{r}^{(1)}$$

$$\eta_i^{(2)} \longrightarrow \vec{r}^{(2)}$$

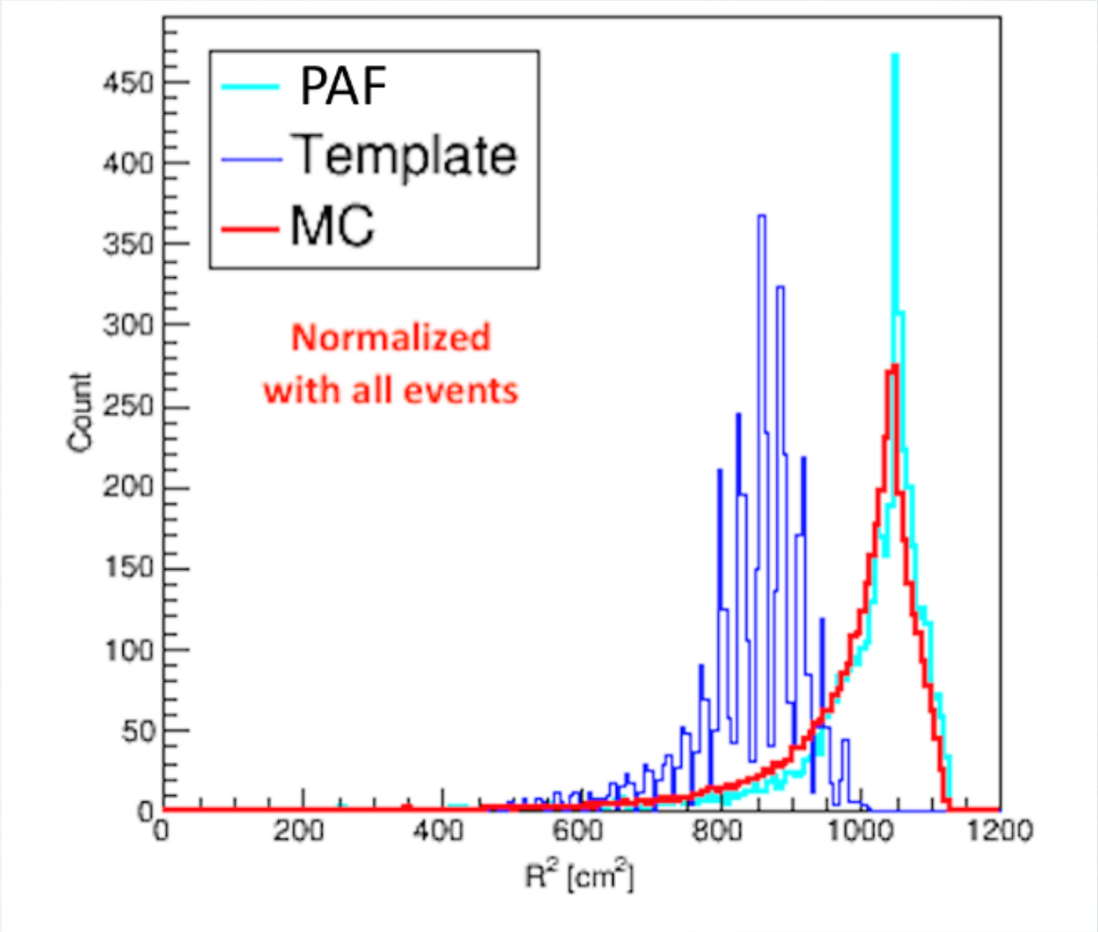
$$\vdots$$

Converge



V. N. Solovov *et al*, *IEEE* doi: 10.1109/TNS.2012.2221742

- position-dependent PAF for each PMT
- leading to a better FV definition

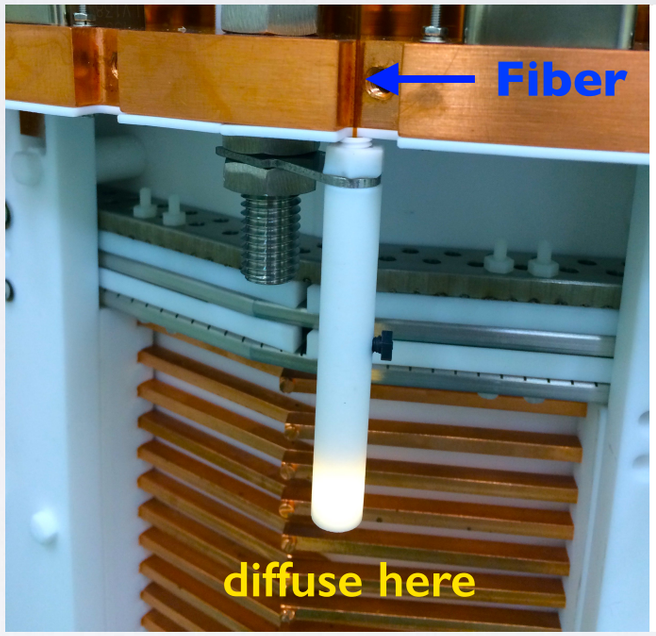


33 keV events distribution

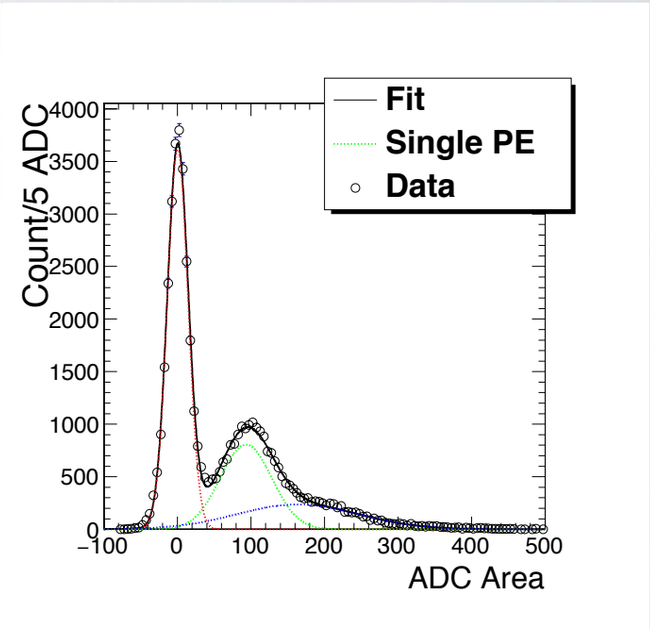
LED calibration

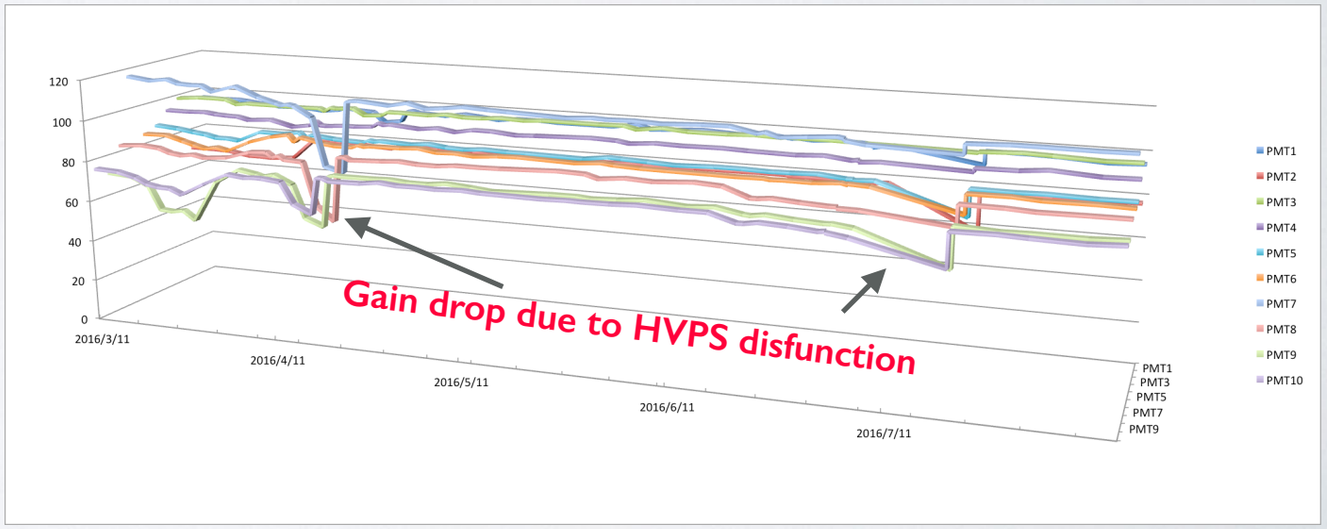
- 3 LEDs mounted for gain calibration.
- twice a week calibration carried out

Light diffuser



Single PE Spec

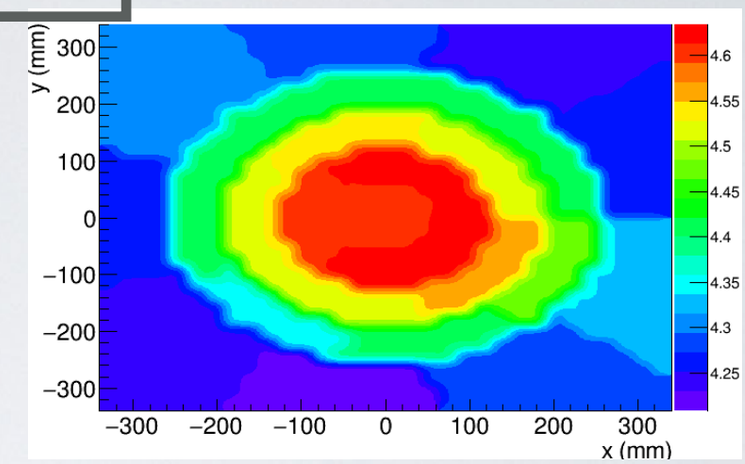




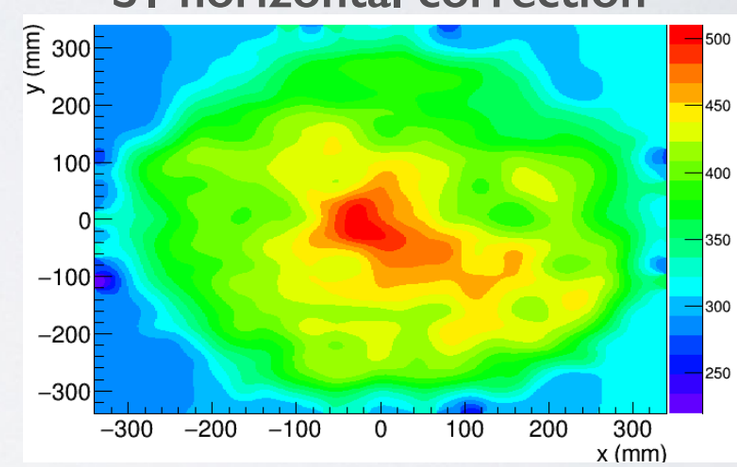
PMT gain evolution

3D uniformity correction on S1 and S2

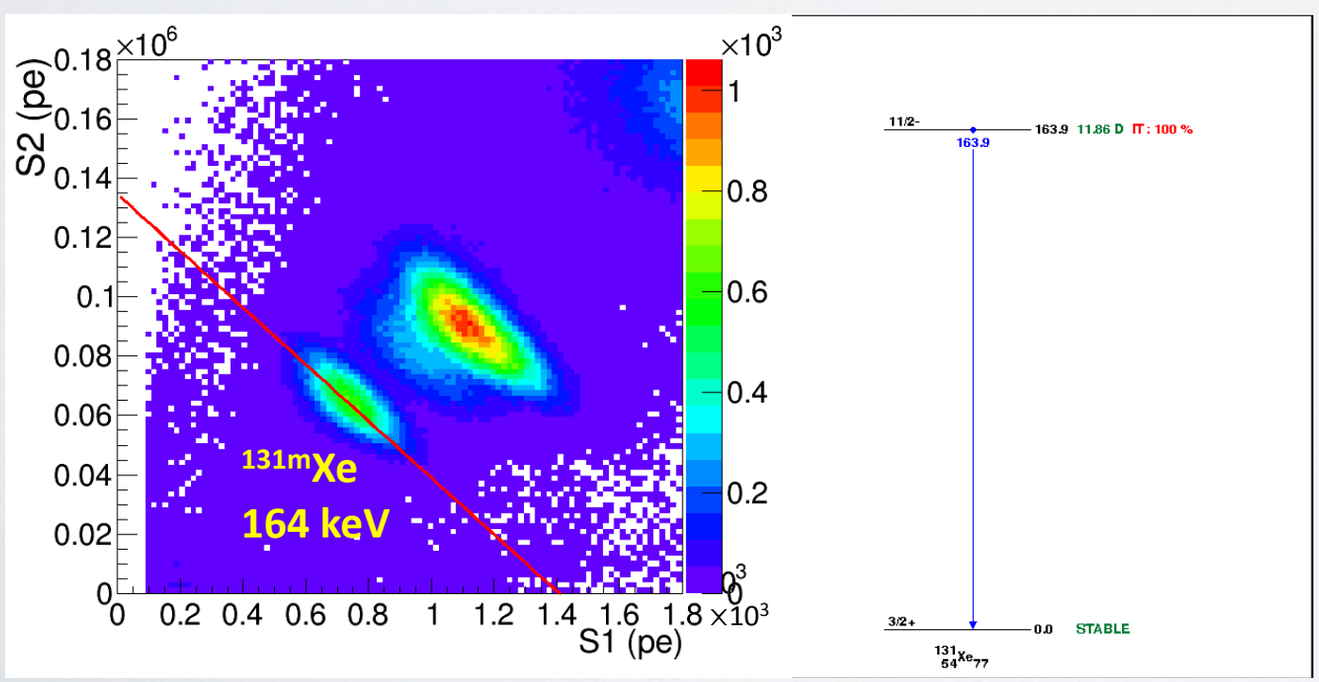
- position dependency
- Light Yield (LY) and ChargeYield (CY) @ 164 keV for vertical and horizontal correction

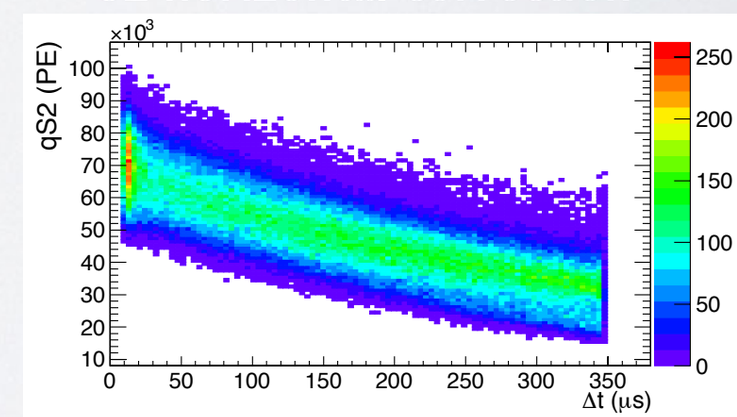


S1 horizontal correction



S2 horizontal correction

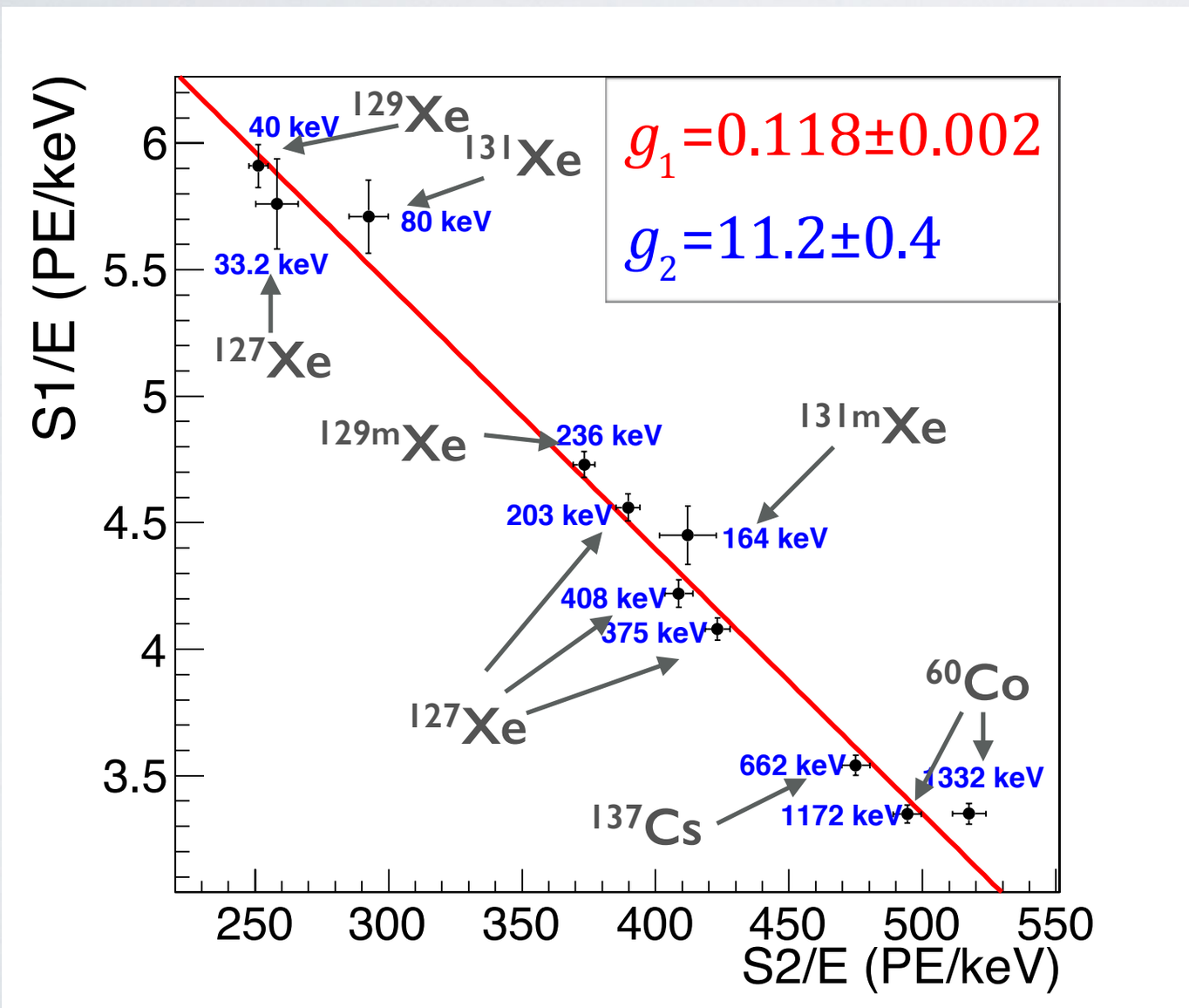




S2 vertical correction

Detector parameters g_1 g_2

S1 detected efficiency electron extract efficiency × electron gain



Doke Plot

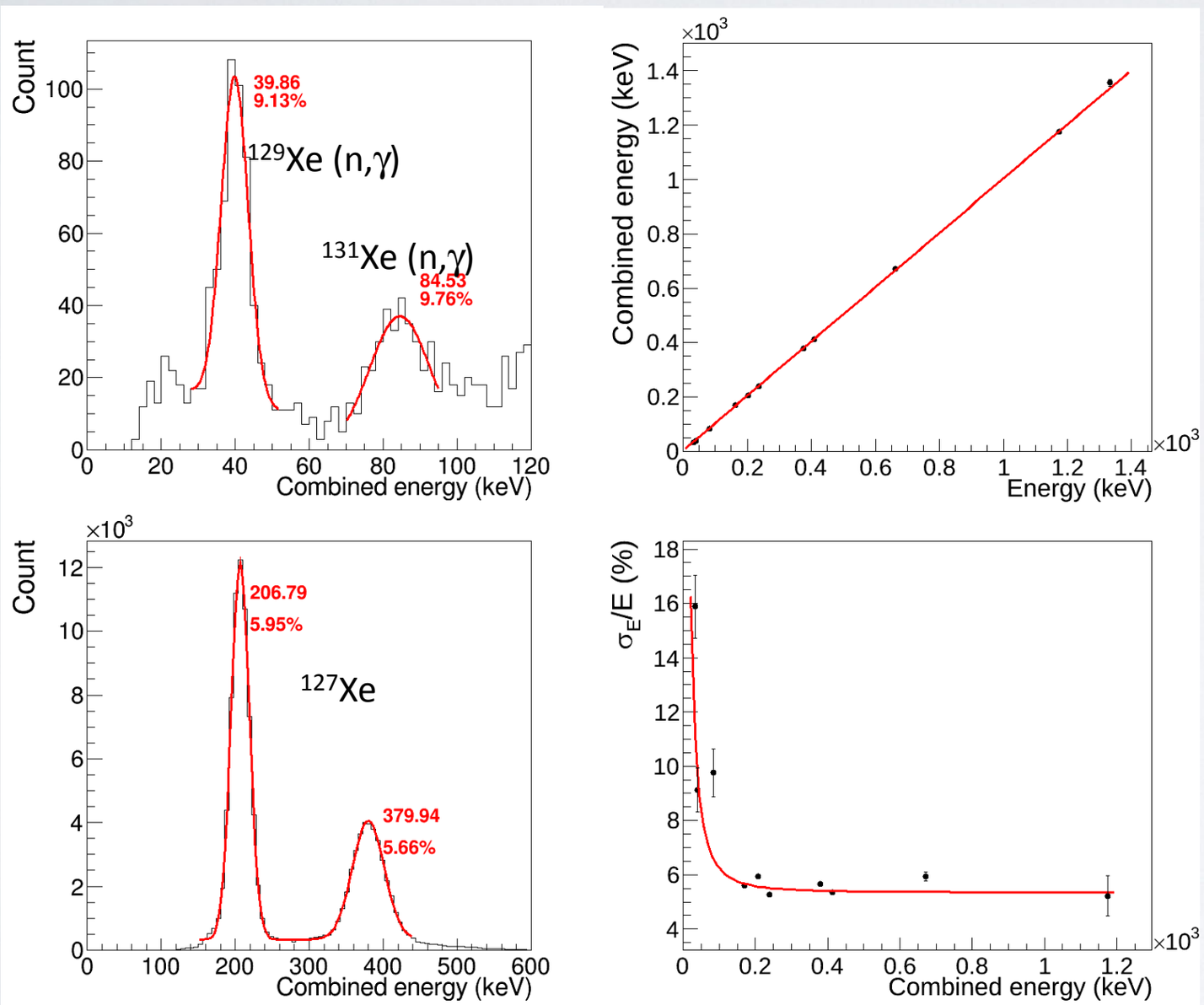
$$E = W*\left(n_{ph} + n_i\right) \quad [W = 13.7eV]$$

$$= W*\left(\frac{S1}{g_1} + \frac{S2}{g_2}\right)$$

$$1/W = \left(\frac{S1/E}{g_1} + \frac{S2/E}{g_2}\right) \longrightarrow \text{Doke Plot}$$

- Gaussian fits to all ER peaks in data
- Uncertainty estimated using energy nonlinearity
- Liner fit to extract g_1 g_2

Energy nonlinearity and resolution

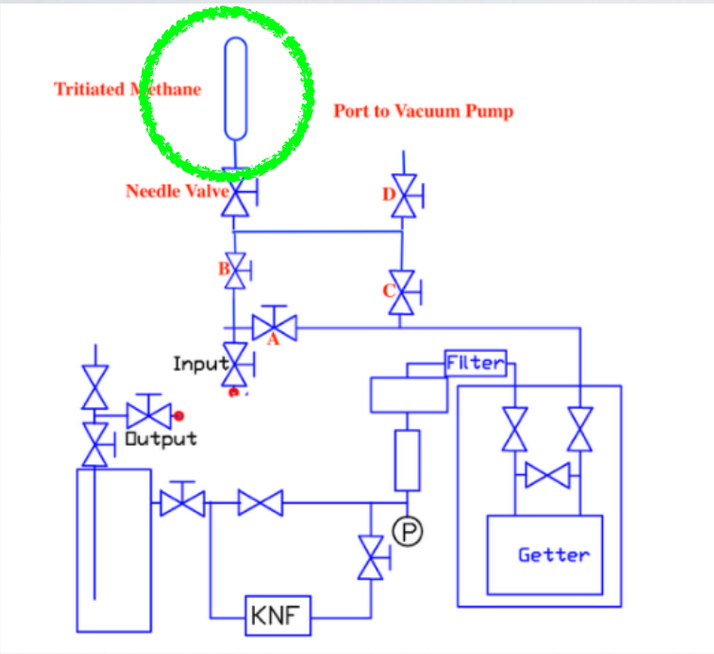


- <2% nonlinearity achieved for [33,1332]keV
- Resolution approaching 5% @ high energy

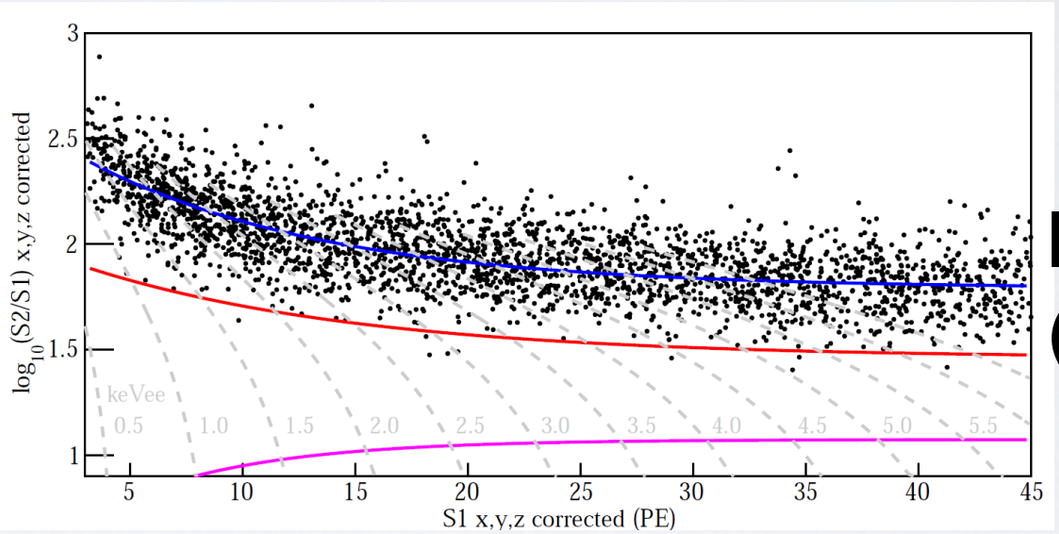
Phys.Rev. D93 (2016) no.7, 072009

Tritium calibration

- Aver. E @ 5.7keV
- spatially-uniform → FV(Fiducial Volume)
- removed by normal purification
- Single scatter (β decay)

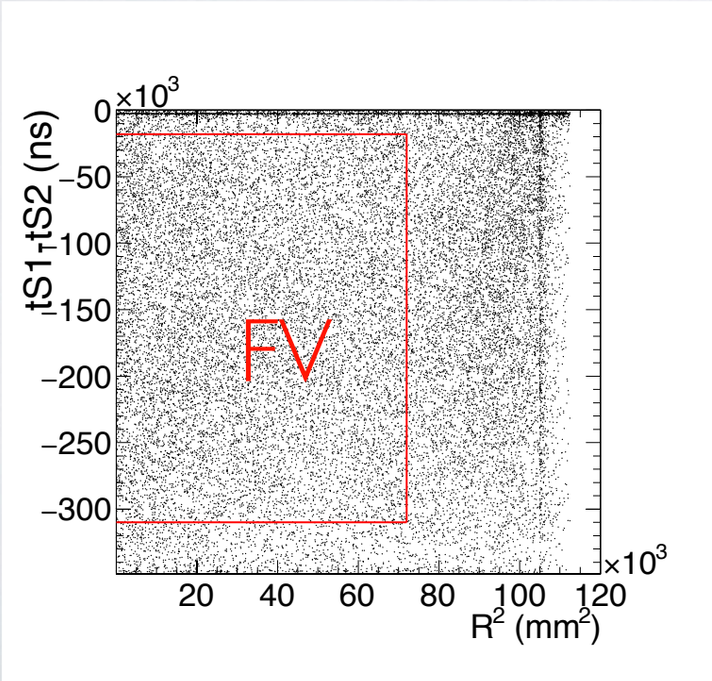


CH_3T insert system

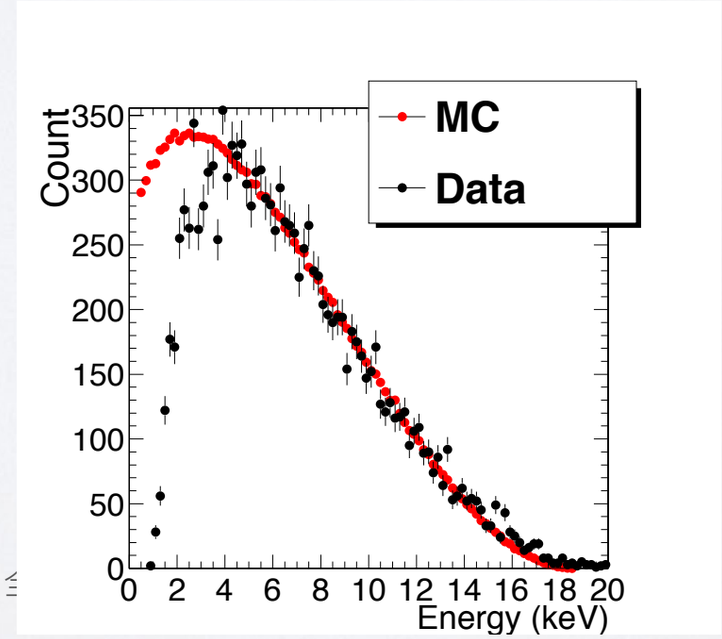


leakage fraction (0.32±0.11)%

ER band from CH3T calibration



CH_3T vertex distribution

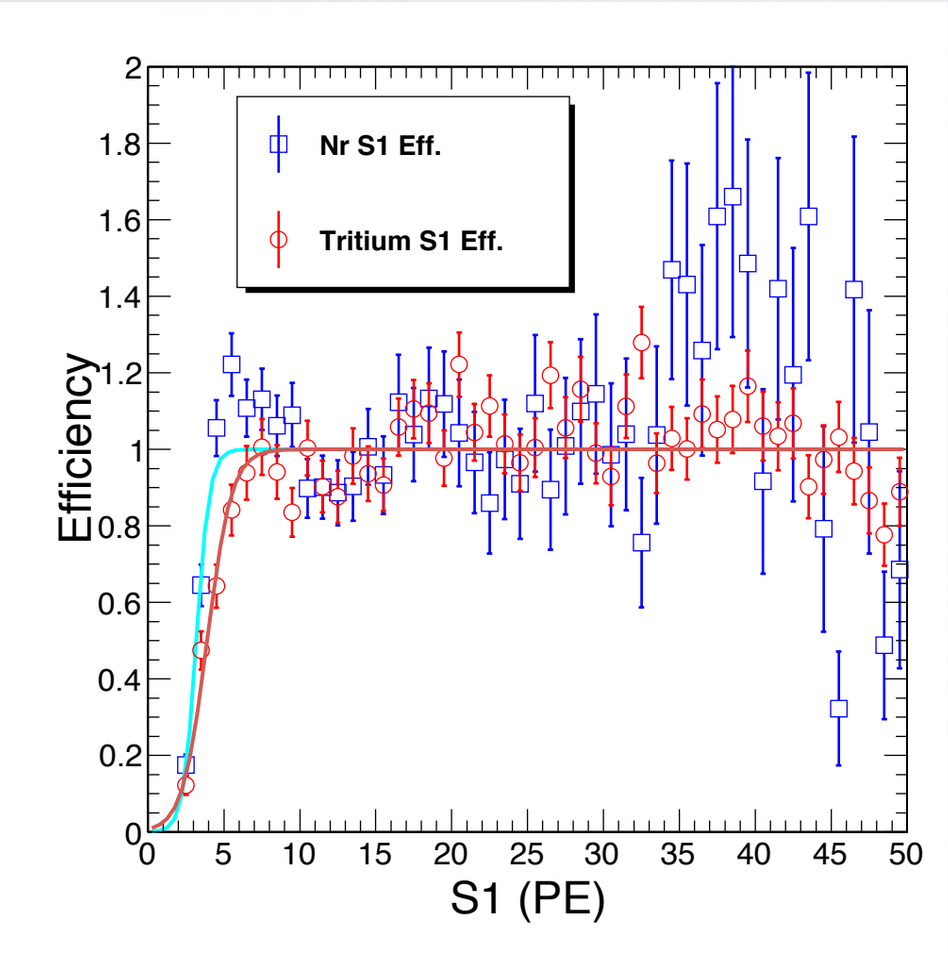


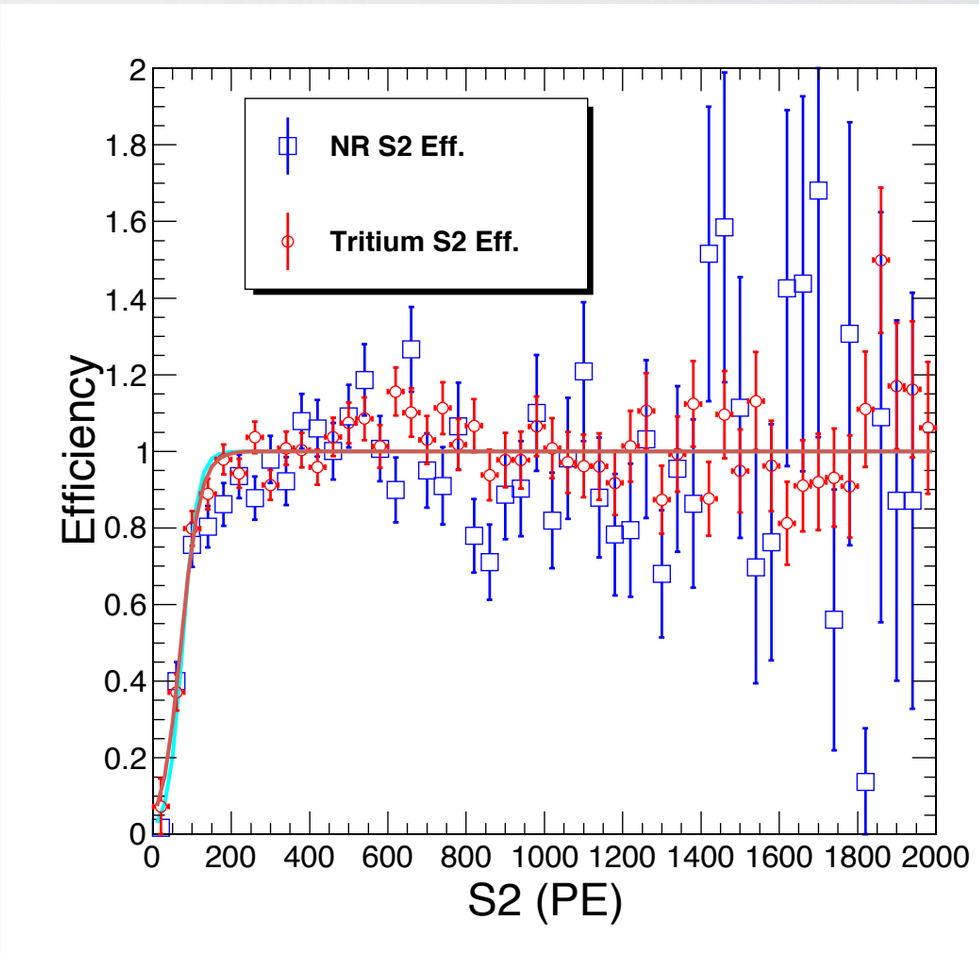
Fitting spectrum can gives g_1 g_2 also, agree well with Doke plot.

Spec. from T β decay

AmBe calibration

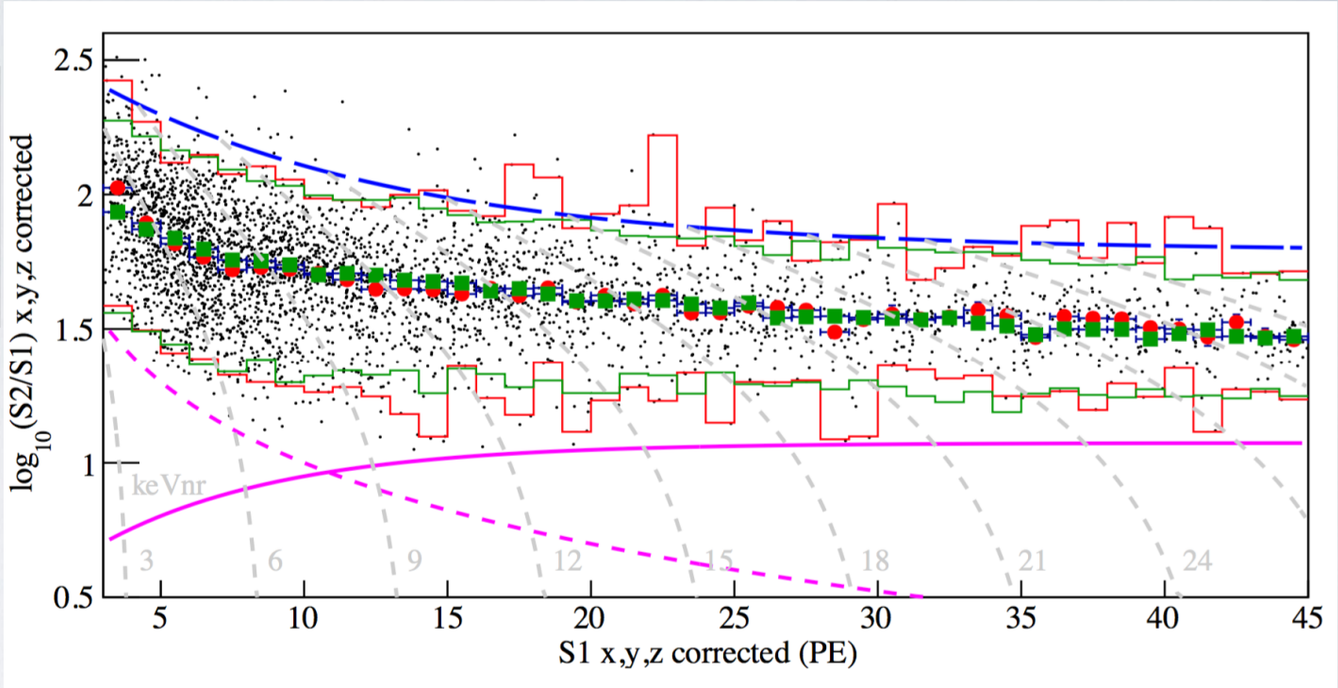
low-intensity (approximately 2 Hz) ^{241}Am-Be (AmBe) neutron source with improved statistics



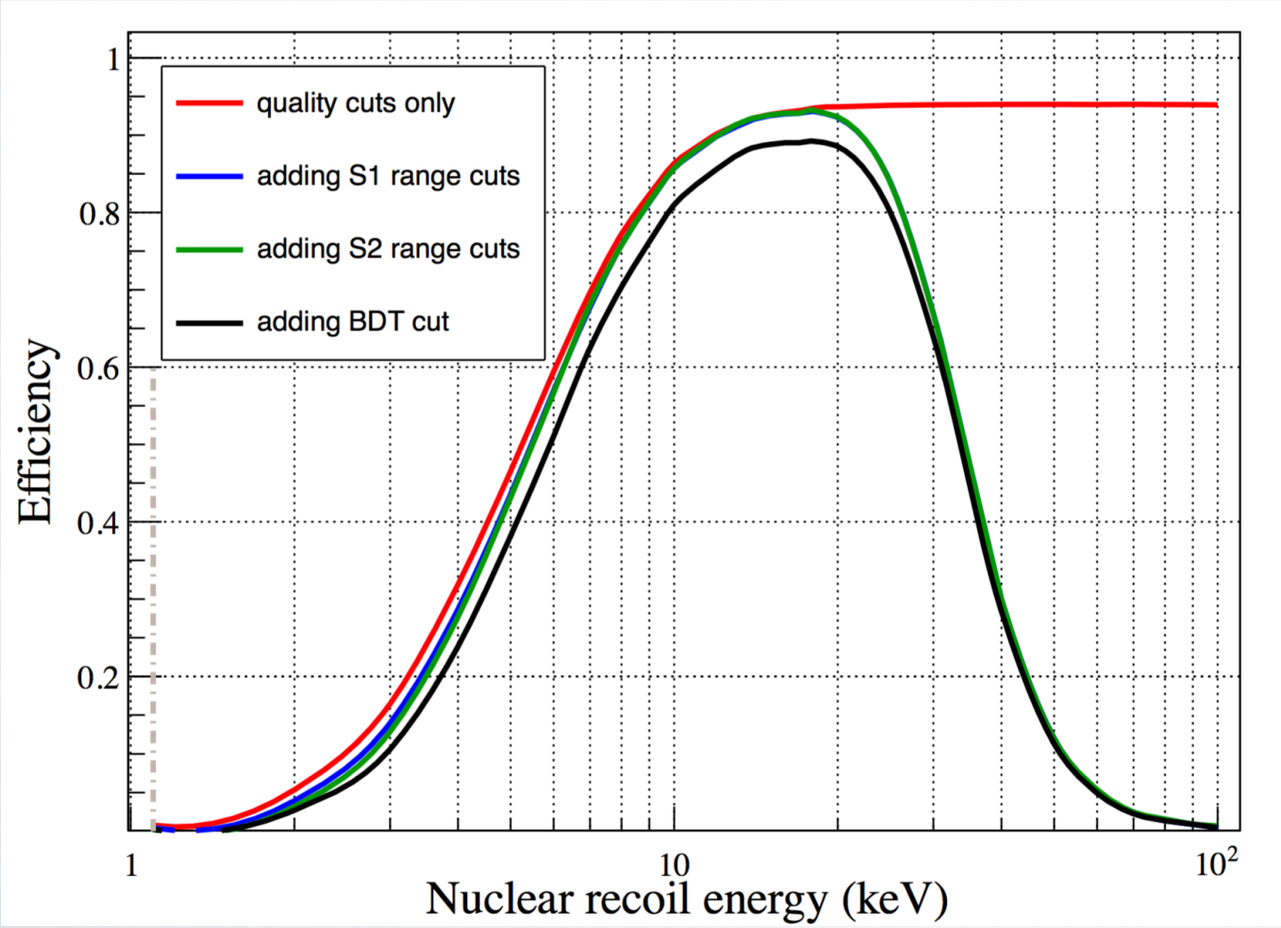


S1 and S2 efficiency from AmBe calibration, Tritium printed for comparison.

AmBe calibration



NR band from AmBe calibration



NR efficiency from AmBe calibration

MC & Data show good agreement

Applied to calculate the **dark matter** detection probability.

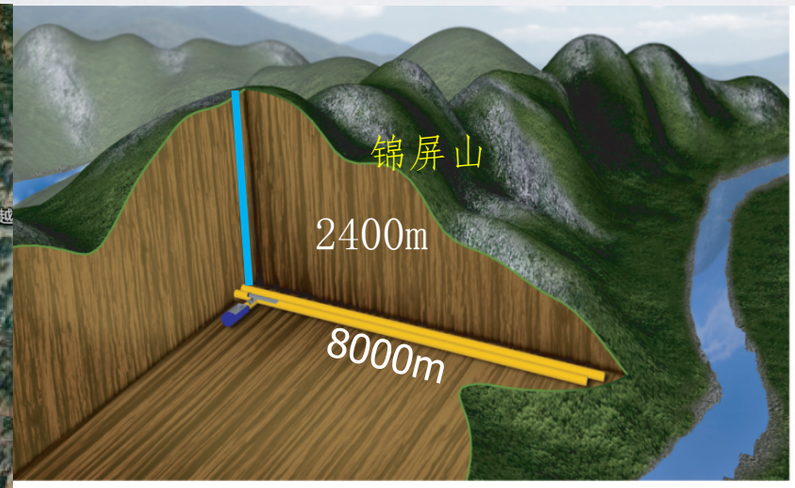
Conclusion

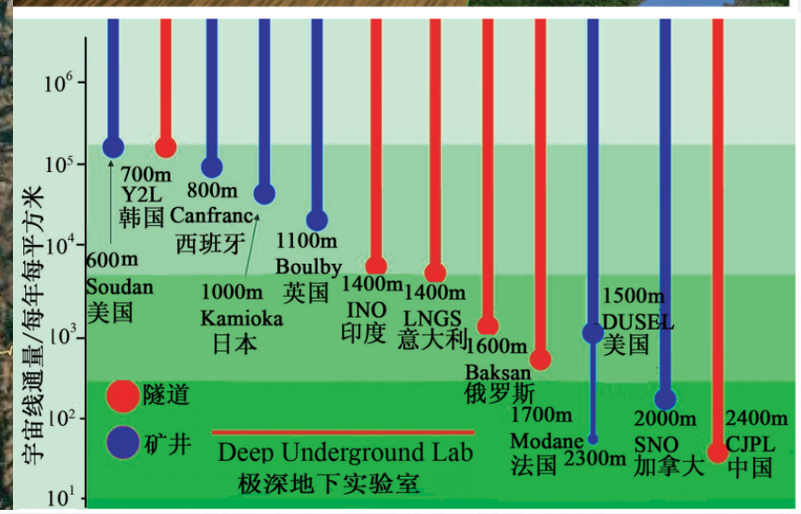
- Better reconstruction in vertex and energy
- Achieved a better understanding of Xe NR and ER from AmBe and tritium calibration
- PandaX-II results coming with these calibration is so exciting !!!

THANKS

Back-up

PandaX collaboration & CJPL





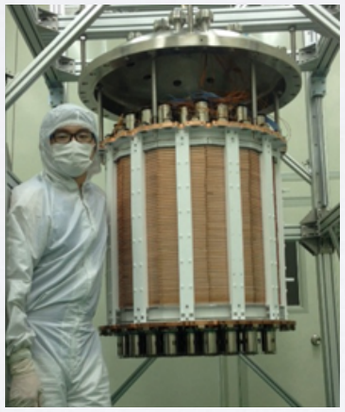
Started in 2009

- Shanghai Jiao Tong University (2009-)
- Peking University (2009-)
- Shandong University (2009-)
- Shanghai Institute of Applied Physics, CAS (2009-)
- University of Science & Technology (2015-)
- China Institute of Atomic Energy (2015-)
- Sun Yat-Sen University (2015-）
- Yalong Hydropower (2009-)
- University of Maryland (2009-)
- University of Michigan (2011-2015)
- Alternative Energies & Atomic Energy Commission(2015-)
- University of Zaragoza(2015-)
- Suranaree University of Technology(2016-)

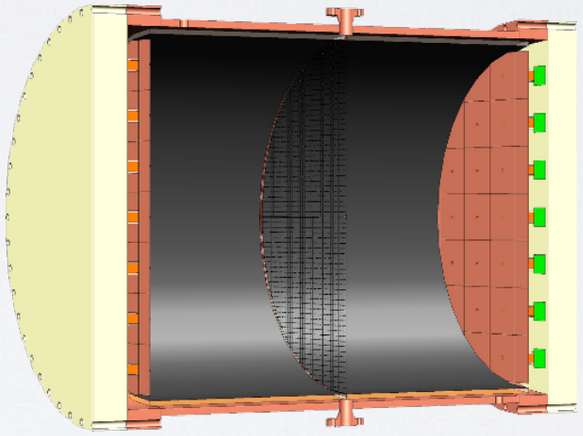
PandaX experiment

PandaX＝Particle and Astrophysical Xenon Experiments

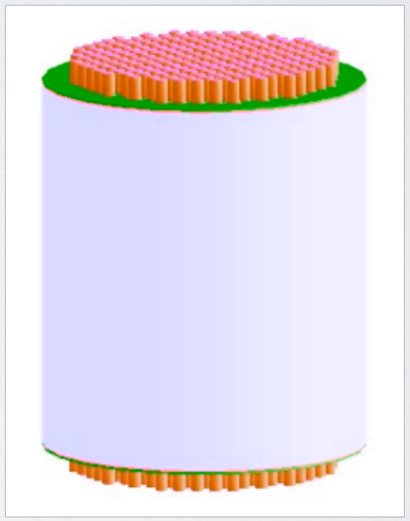
PandaX-I: 120 kg DM experiment
2009-2014



PandaX-II: 500 kg DM experiment
2014-2017



PandaX-III: 200 kg to 1 ton ^{136}Xe 0vDBD experiment
2016-



PandaX-xT: multi-ton DM experiment
2016-

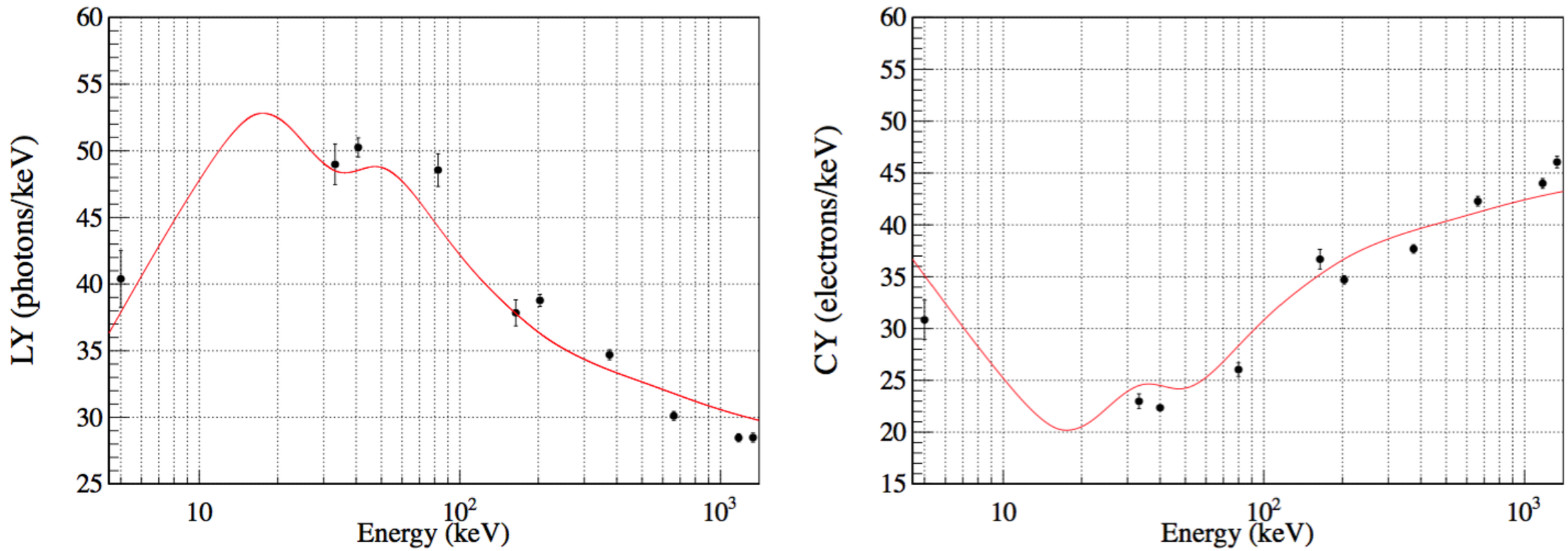
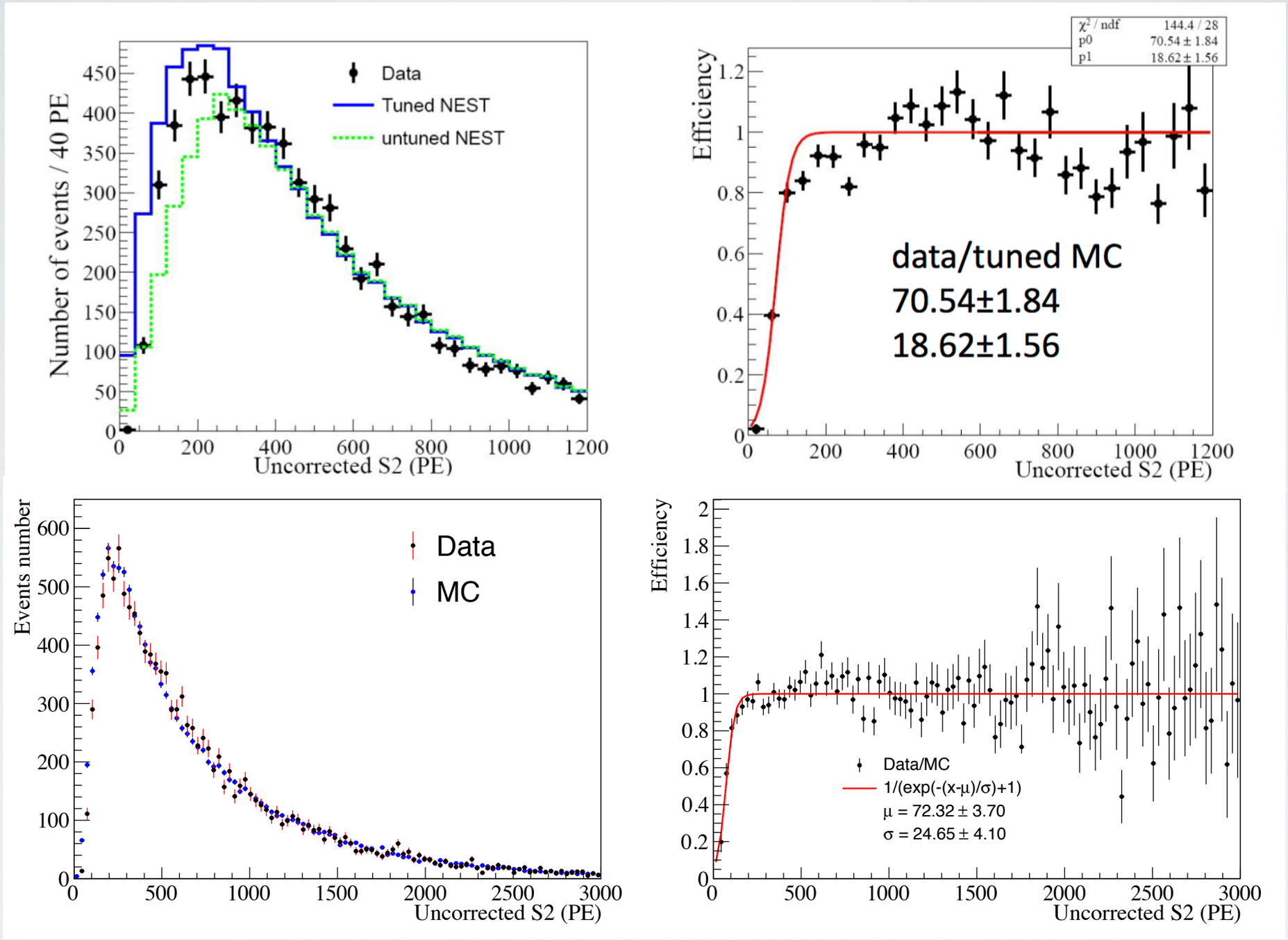
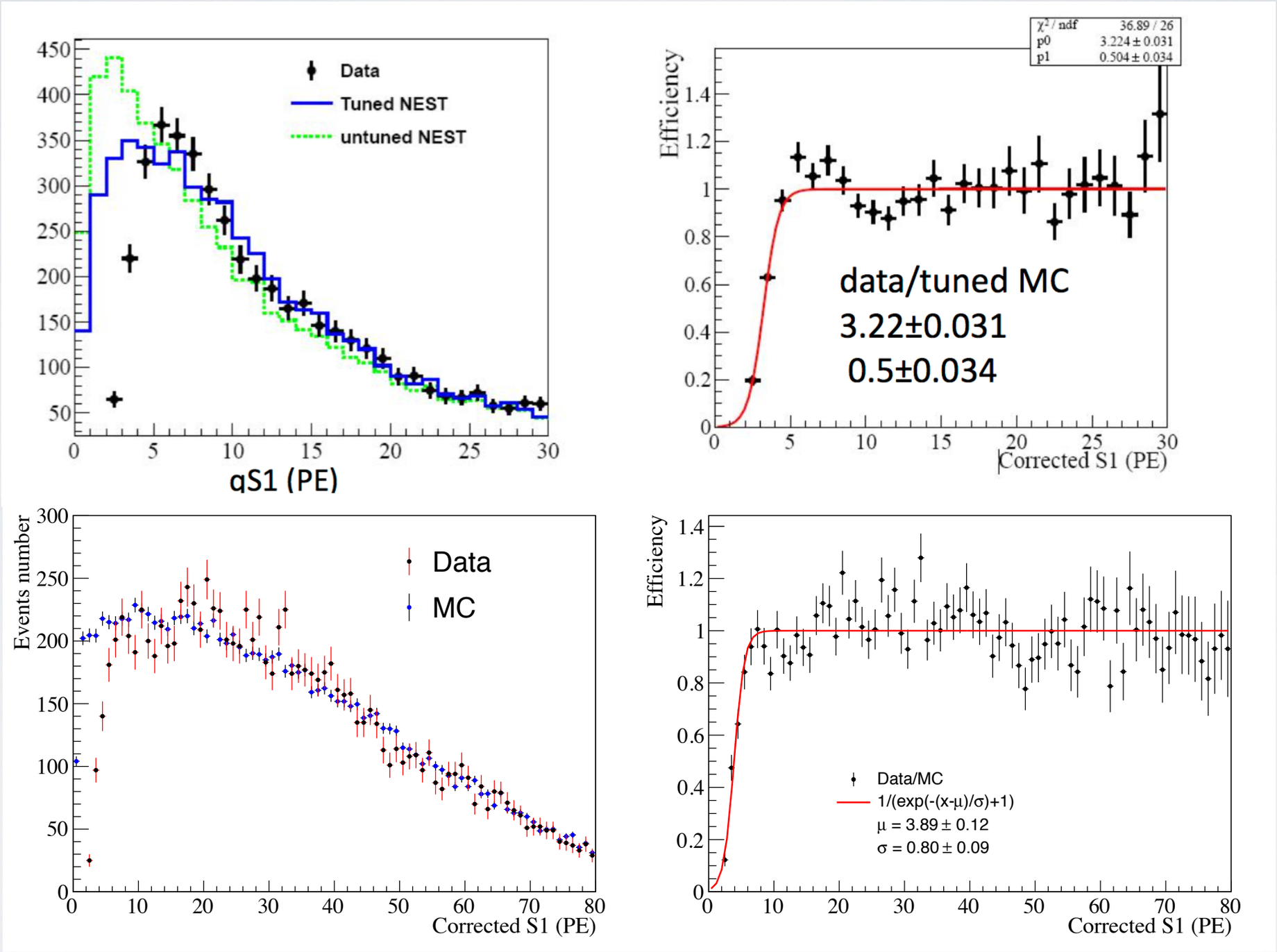
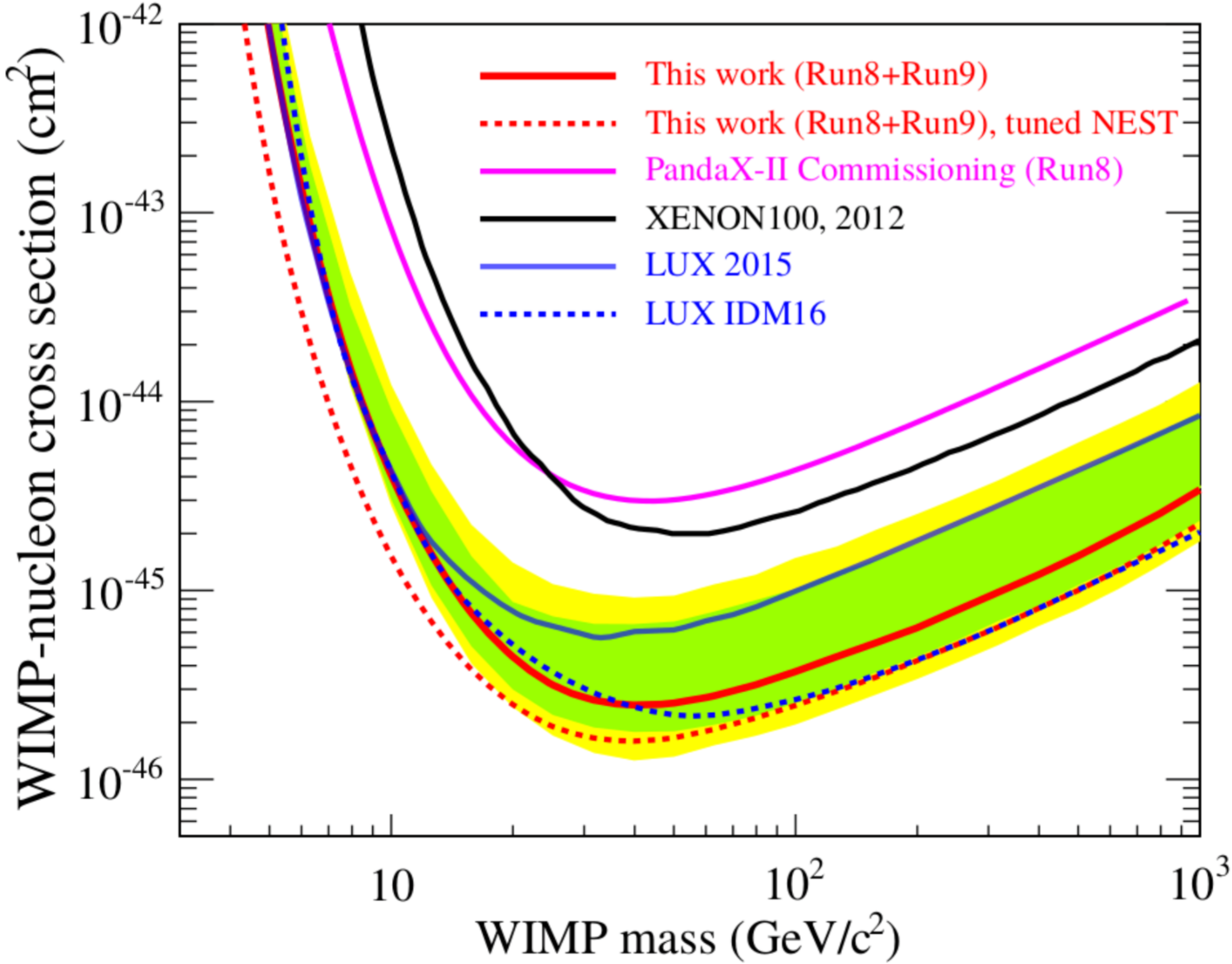


FIG. 8: Comparison of measured ER light yield (left) and charge yield (right) with NEST predictions. Only statistical uncertainties are shown. The systematic uncertainties of PDE and EEE are estimated by the difference between the data and NEST predictions.


Data
Tuned NEST
untuned NEST
Number of events / 40 PE
Uncorrected S2 (PE)
χ² / ndf 144.4 / 28
p0 70.54 ± 1.84
p1 18.62 ± 1.56
Efficiency
data/tuned MC
70.54±1.84
18.62±1.56
Uncorrected S2 (PE)
Data
MC
Events number
Uncorrected S2 (PE)
Efficiency
Data/MC
1/(exp(-(x-μ)/σ)+1)
μ = 72.32 ± 3.70
σ = 24.65 ± 4.10
Uncorrected S2 (PE)


Data
Tuned NEST
untuned NEST
qS1 (PE)
χ² / ndf 36.89 / 26
p0 3.224 ± 0.031
p1 0.504 ± 0.034
Efficiency
data/tuned MC
3.22±0.031
0.5±0.034
Corrected S1 (PE)
Events number
Data
MC
Corrected S1 (PE)
Efficiency
Data/MC
1/(exp(-(x-μ)/σ)+1)
μ = 3.89 ± 0.12
σ = 0.80 ± 0.09
Corrected S1 (PE)


This work (Run8+Run9)
This work (Run8+Run9), tuned NEST
PandaX-II Commissioning (Run8)
XENON100, 2012
LUX 2015
LUX IDM16
WIMP-nucleon cross section (cm^2)
10^{-42}
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10
10^2
10^3
WIMP mass (GeV/c^2)