Updated Low Energy Calibration of PandaX-II

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On behalf of PandaX collaboration
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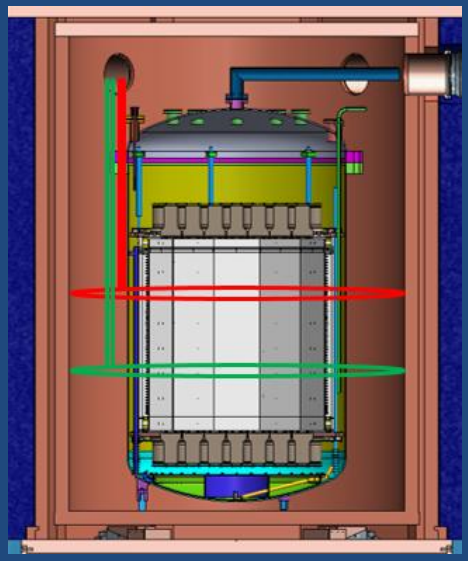
Outline

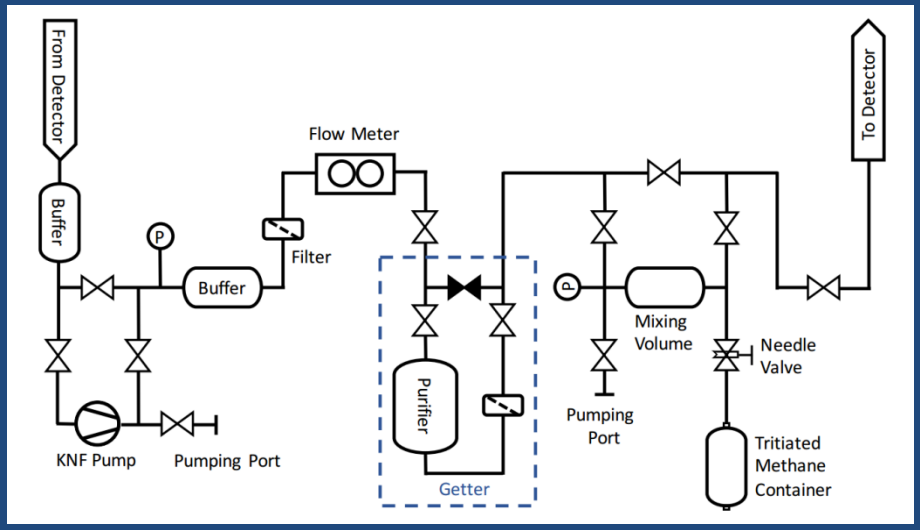
1. Low energy calibration introduction
2. Improved uniformity correction
3. Updated ZLE efficiency study
4. Energy reconstruction and resolution
5. Band and spectrum comparison
6. DM detection efficiency

PANDA X

Low energy calibration introduction

- Nuclear recoil(NR): for WIMP calibration
  - External AmBe source
  - Uniform 8 points around the loop





- Electron recoil(ER): for background calibration
  - Low energy gamma is hard to go through the inner vessel
  - Injected tritium methane
  - Injected ^{220}Rn

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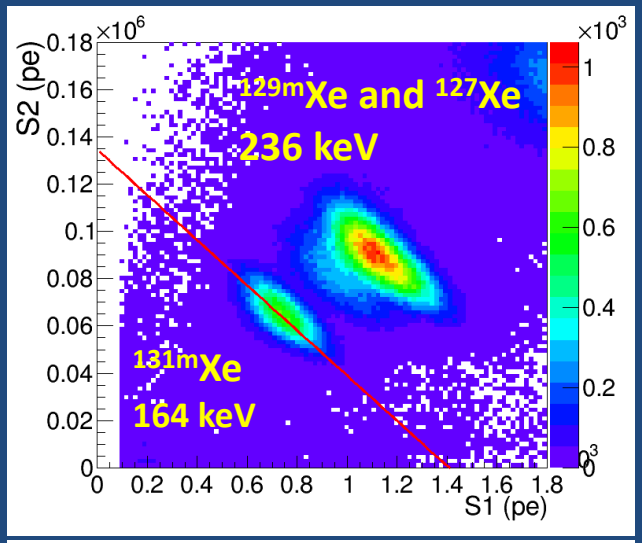
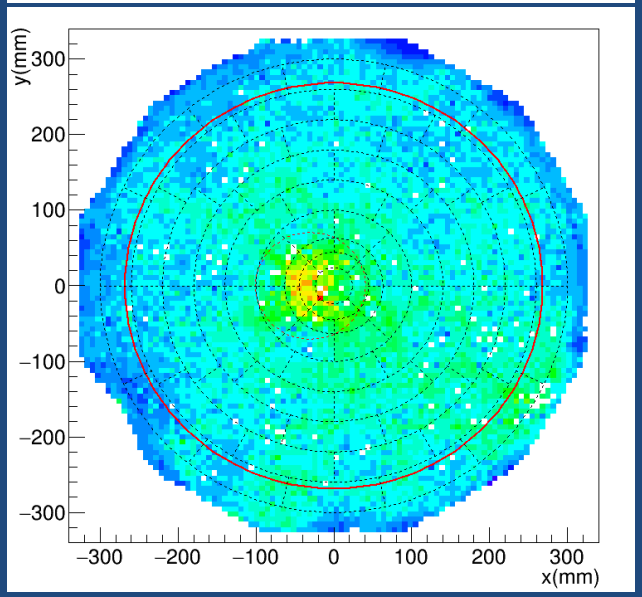
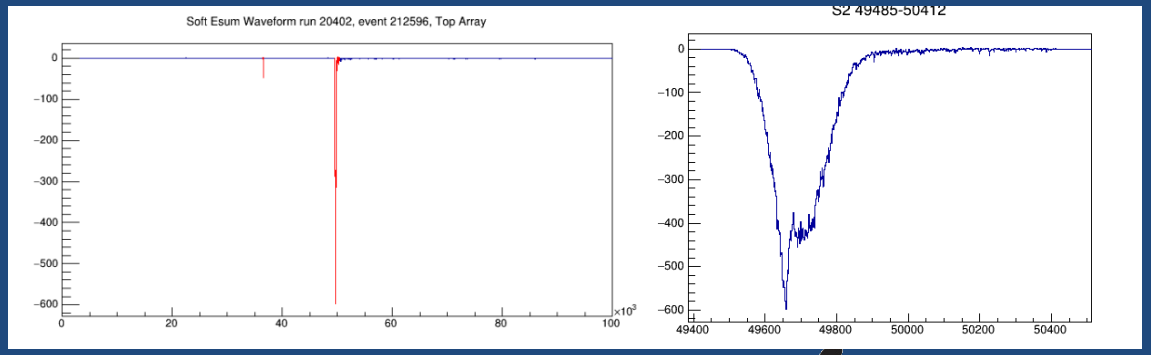
Improved uniformity correction

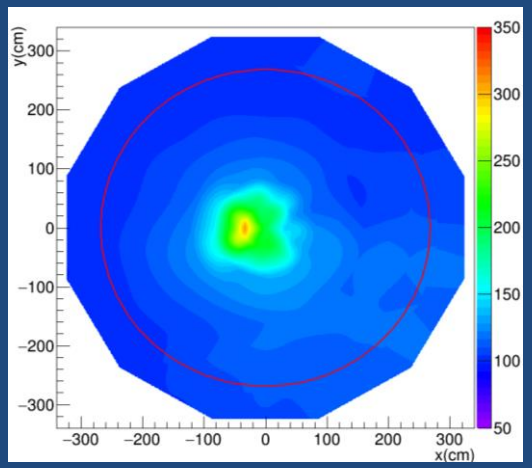




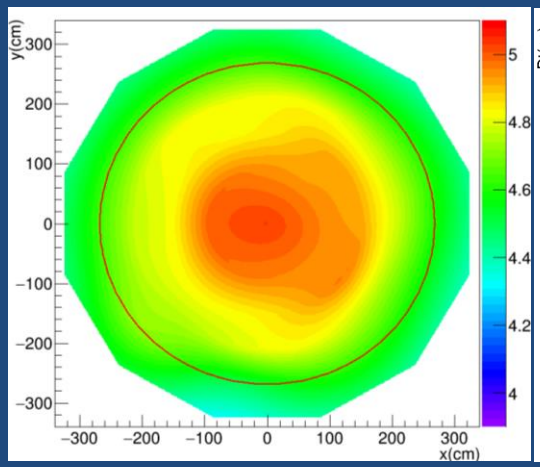
- Select uniform ^{131m}Xe 164keV gamma peak
- The uncorrected S2s in the center region are much bigger
- The biggest S2 of this region is ~15000PE in the top PMT and ~800PE in the bottom PMT
- As our PMT bases are designed for low energy signals, now we use S2 bottom only to do the analysis

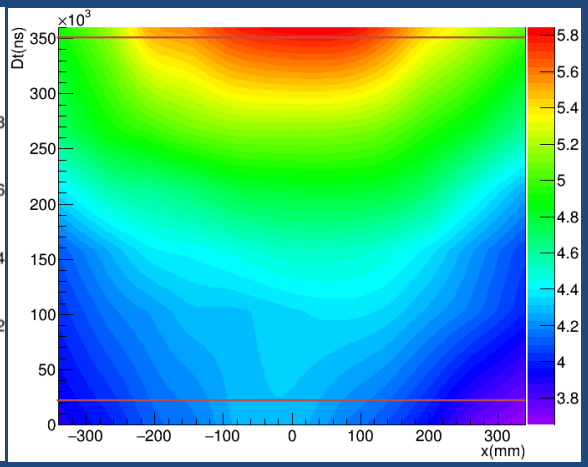


164keV Correction Mapping



- S2 bottom only in y-x plane
- The color bar is charge yeild/keV
- Z-direction is corrected by electron life-time
- Standard deviation of Cy 2D in FV 20.3%

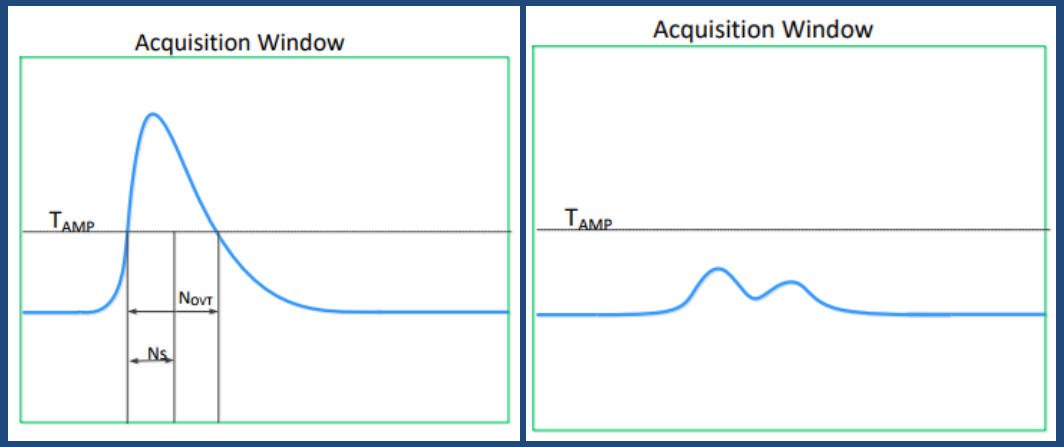




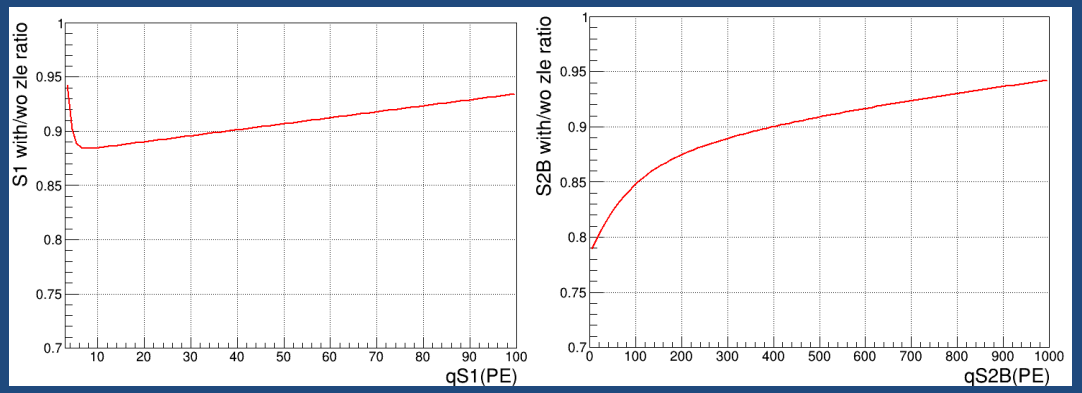
- S1 3D mapping
- The color bar is Light yeild/keV
- Standard deviation of LY 3D in FV 13.0%

ZLE efficiency

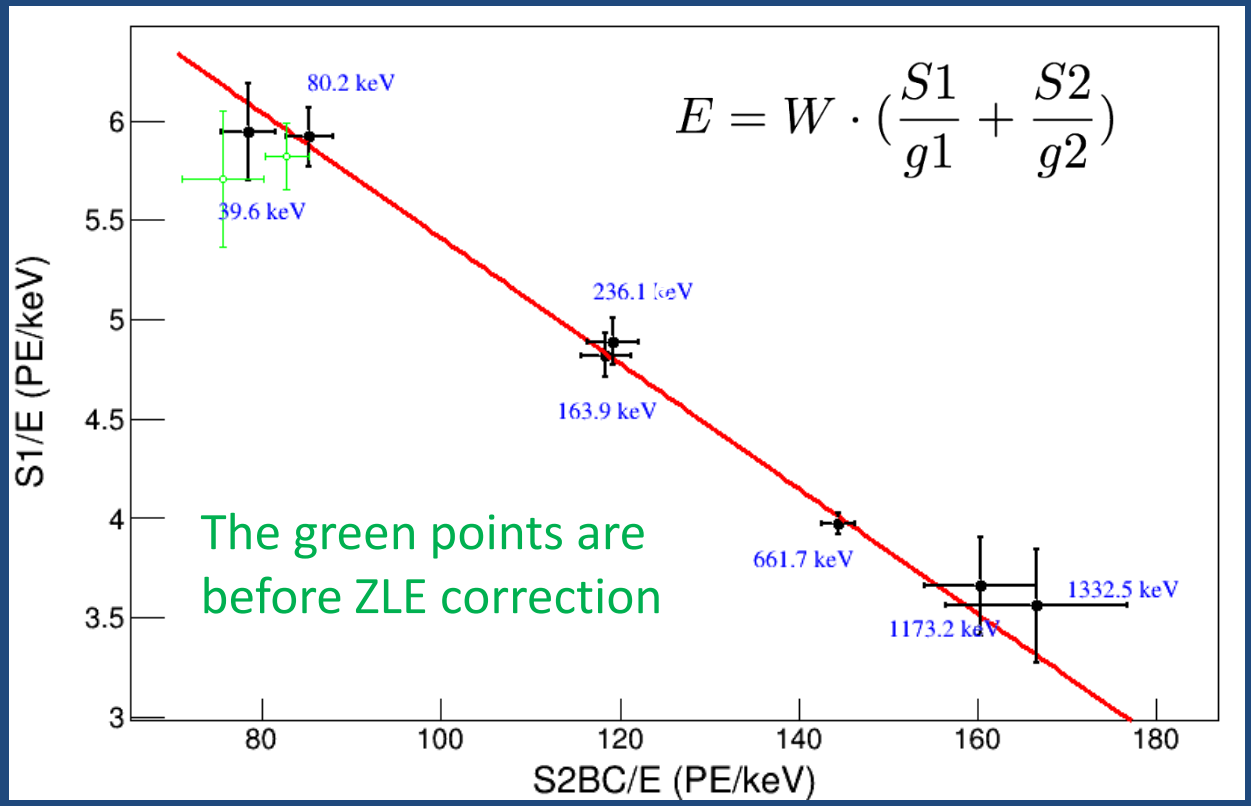
- Baseline suppression firmware (Zero Length Encoding, ZLE) in the digitizer affected SPE detection



- Data driven analysis without ZLE data and then apply software ZLE algorithm channel by channel to measure efficiency



Doke Plot



- g1 is photon detection efficiency
- g2 is electron extraction efficiency times single electron gain
- g1 = 11.79%±0.2%
- g2 = 3.70±0.055

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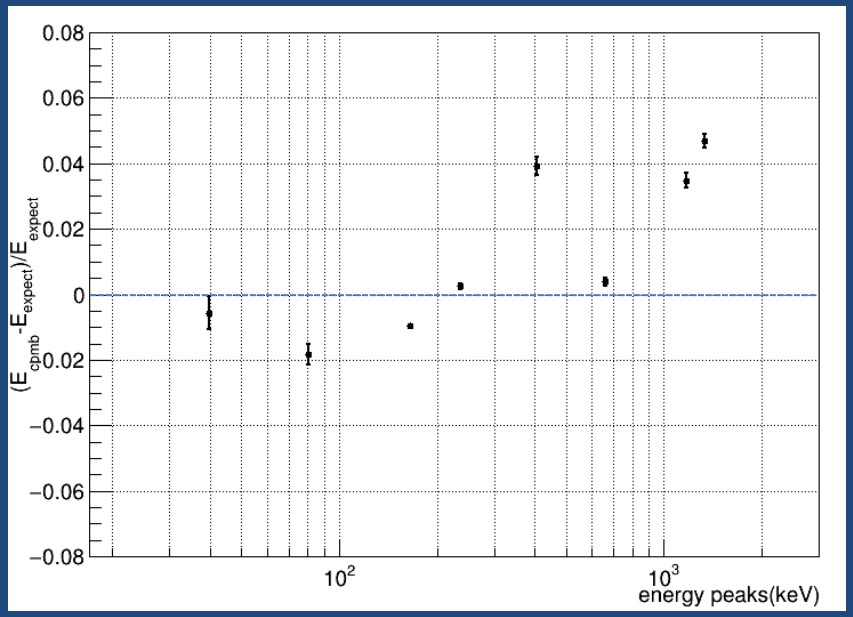
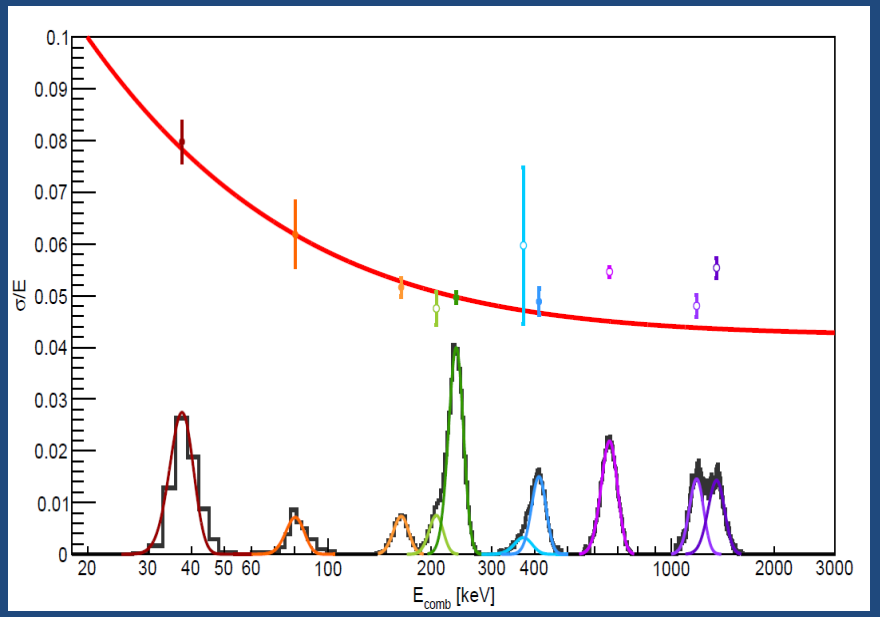
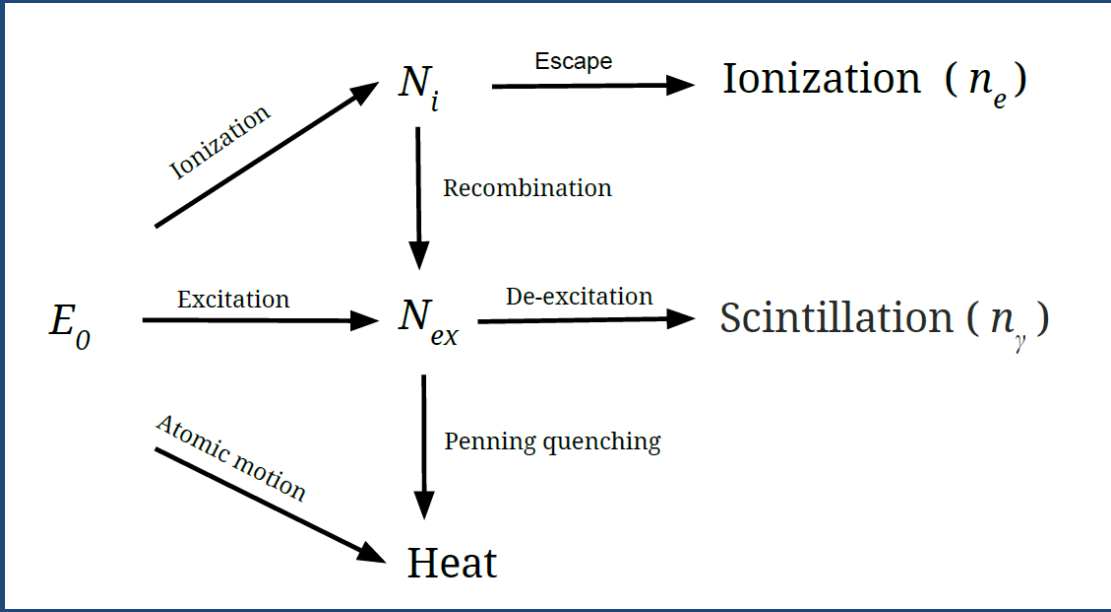
Energy reconstruction and resolution





- The difference between combine energy and expected energy is within 4%
- The energy resolution is ~8% at 40keV and ~5% at high energy region

NEST model



- The simulation based on the Noble Element Simulation Technique (NEST) framework
- Frist the detector field configuration, and then proceeded to the photon or electron productions and fluctuations
- Double PE emissions, PMT resolution, ZLE effect
- We tuned the parameters of N_{ex}/N_i ratio (alpha) and recombination rate(gamma), as well as recombination fluctuation

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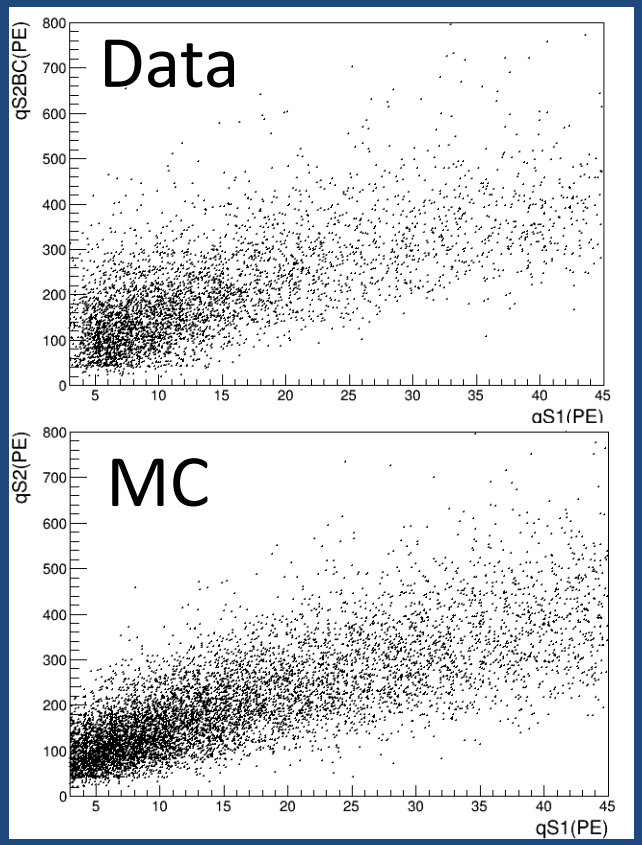
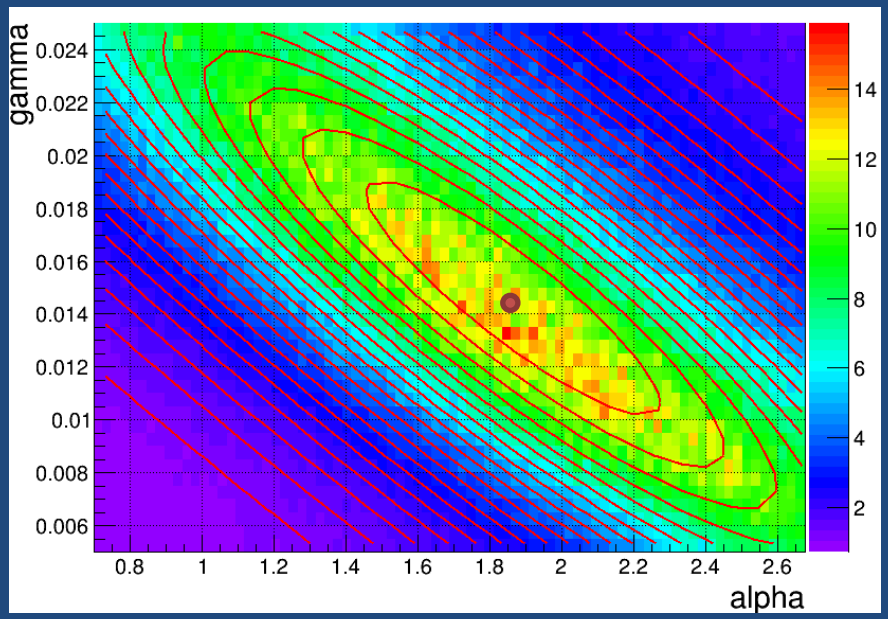
Tuned NR NEST Model





- Input neutron kinetic energy spectrum to Gent4
- Cluster algorithm to select out single scatter event
- Tuned NEST by calculating the KL divergence of data and MC 2D(qS2:qS1) distribution

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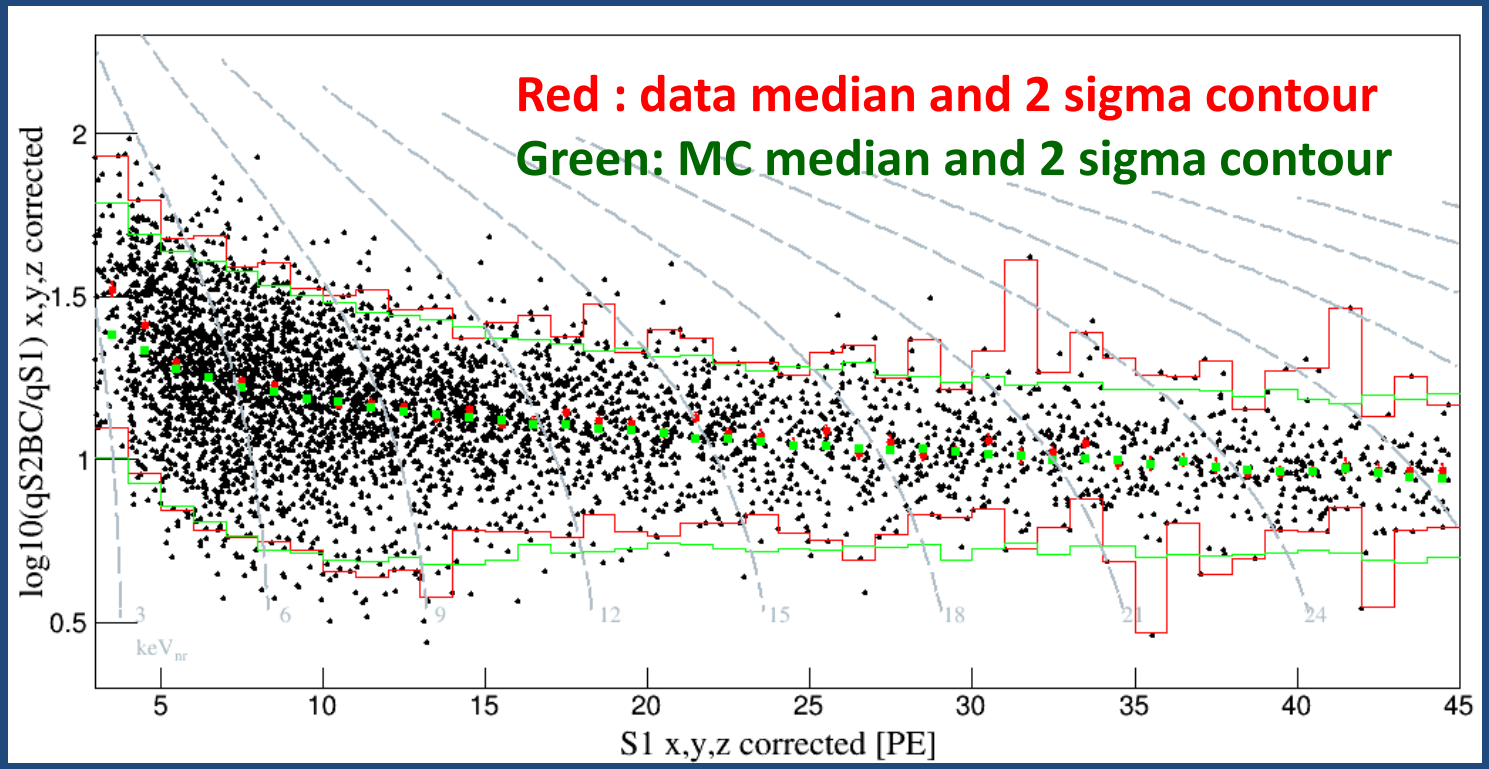
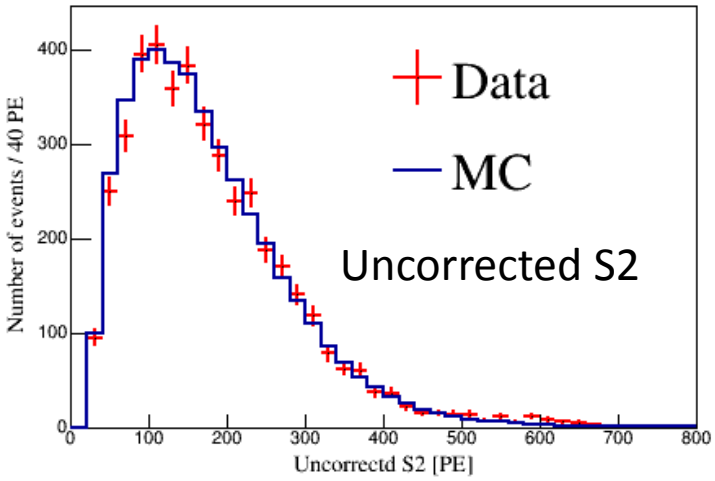
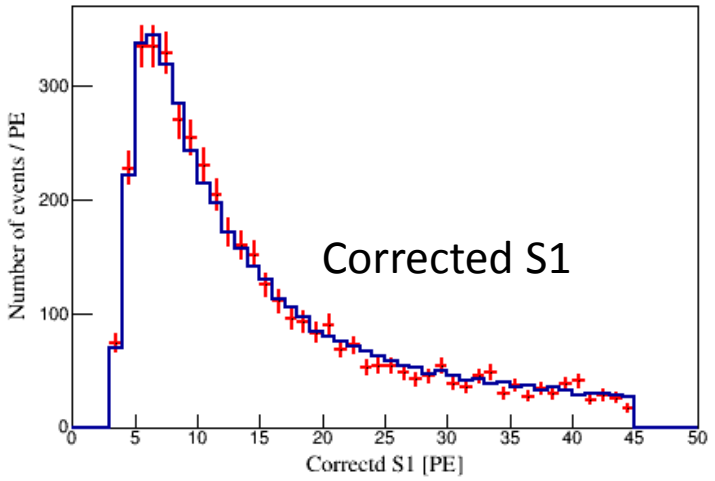
AmBe NR calibration

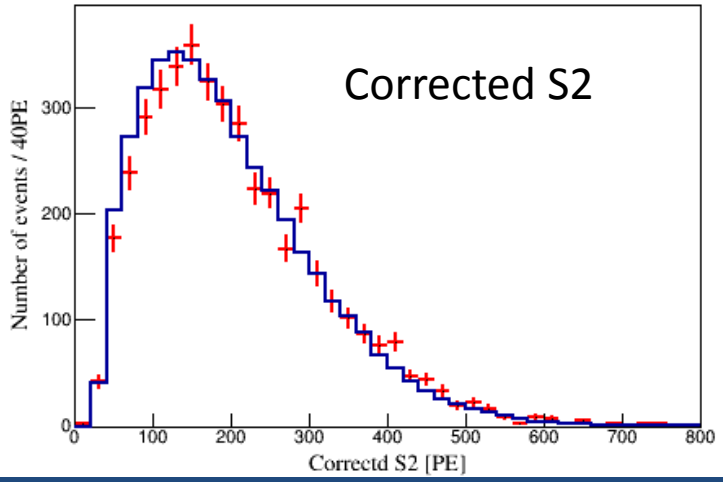


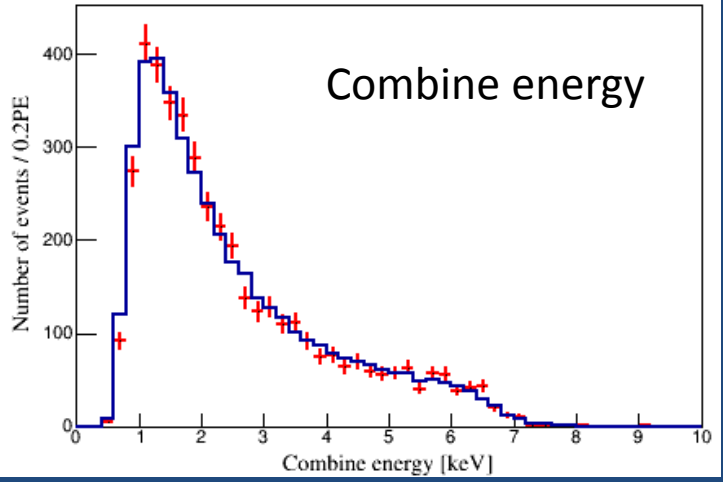
- Aug 2017
- Average electron lifetime ~710 μs, ~2500 low energy NR events

AmBe NR calibration









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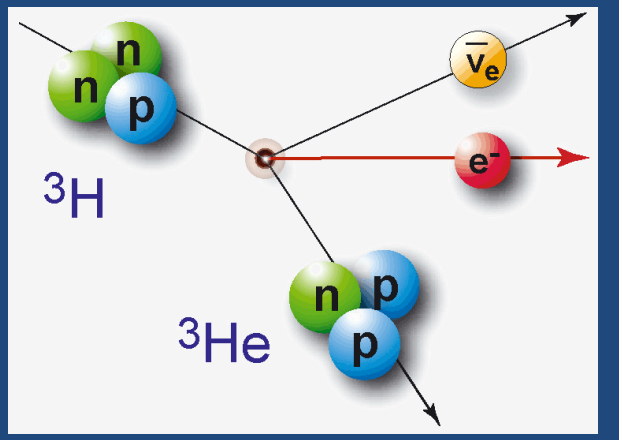
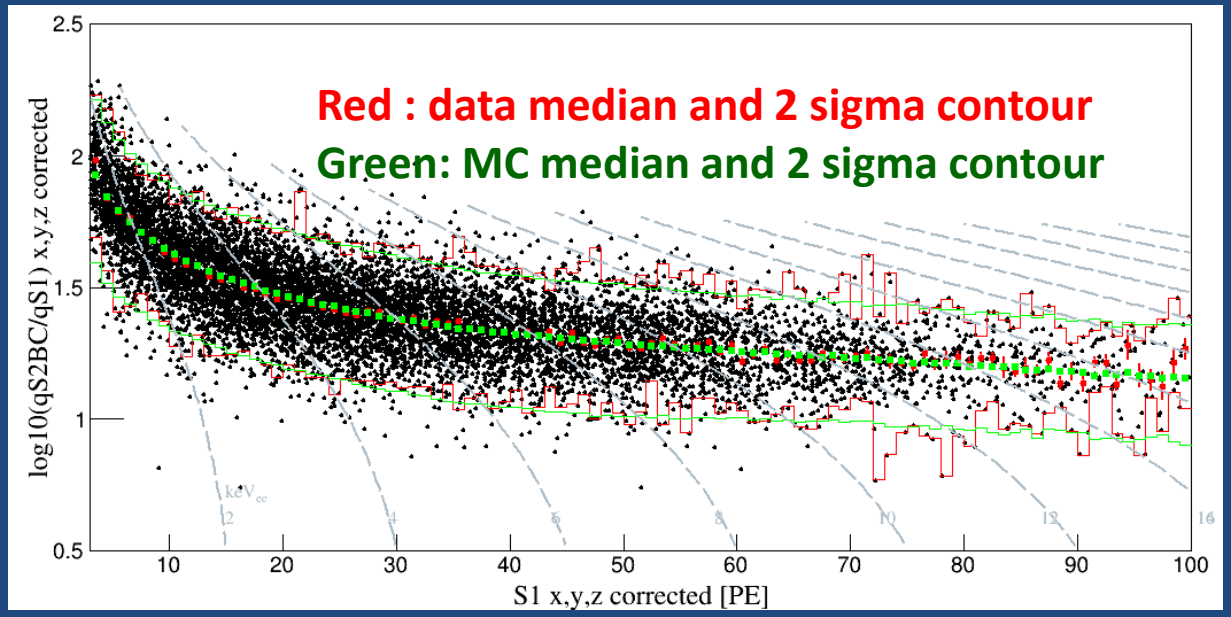
Tritium methane ER calibration(preliminary)





- July – Oct 2016, performed ER calibration using tritiated methane (a technique pioneered by LUX collaboration)
- Selected data with electron lifetime ~700 μs, ~8000 low energy ER events

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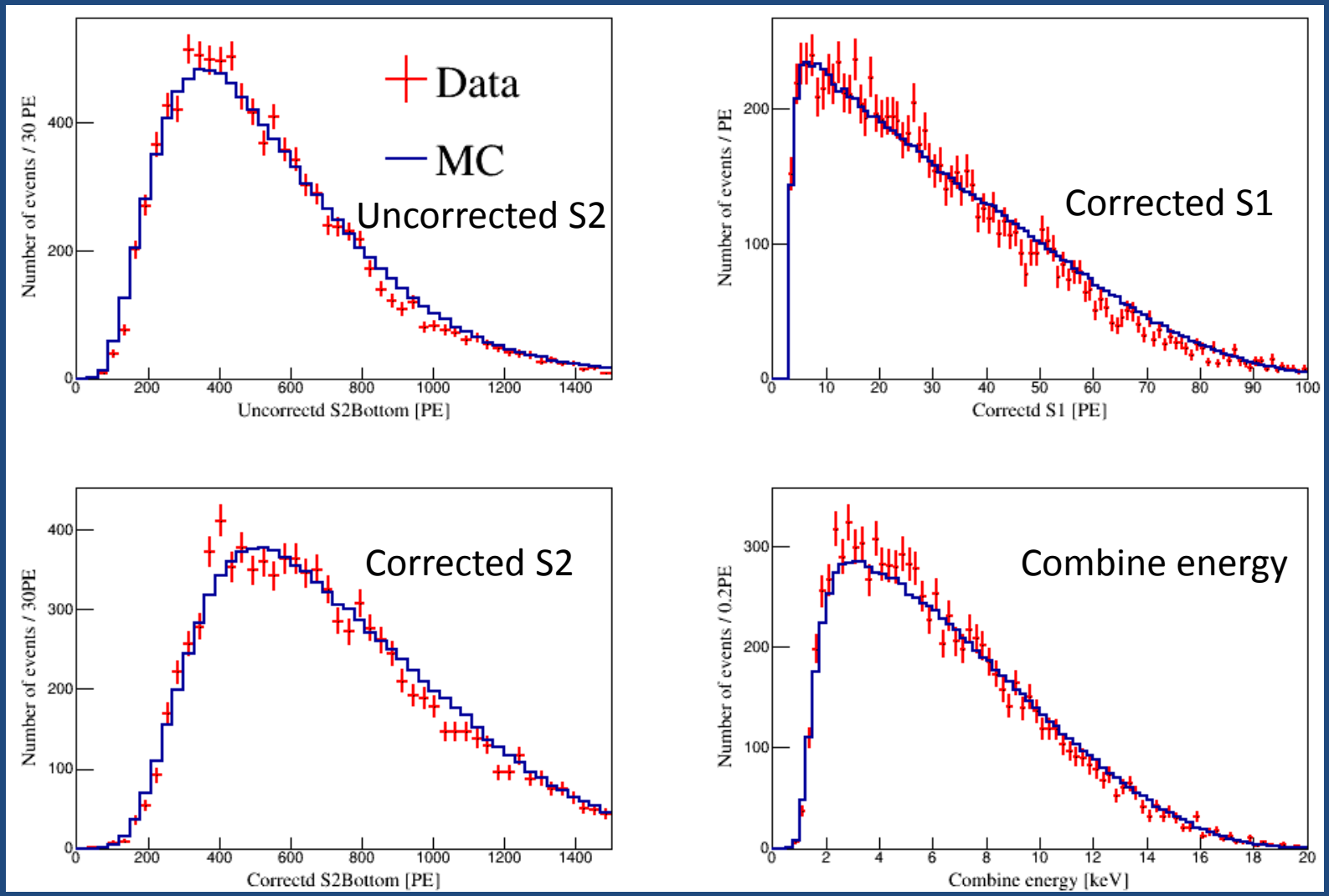
Tritium methane ER calibration(preliminary)



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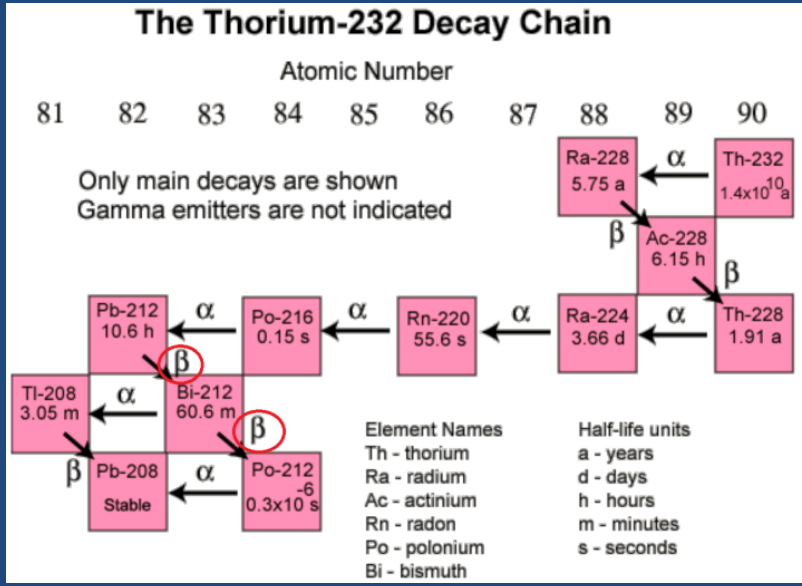
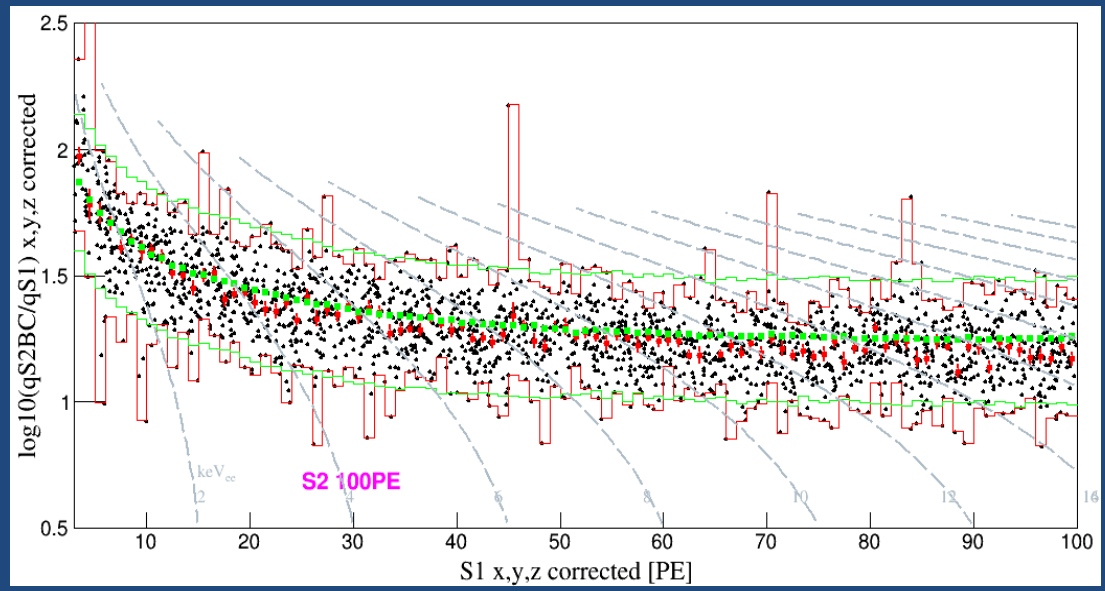
^{220}Rn ER calibration(preliminary)





- Nov – Dec 2017, took ER calibration using ^{220}Rn
- Selected data with electron lifetime >300 μs, ~2000 low energy ER events

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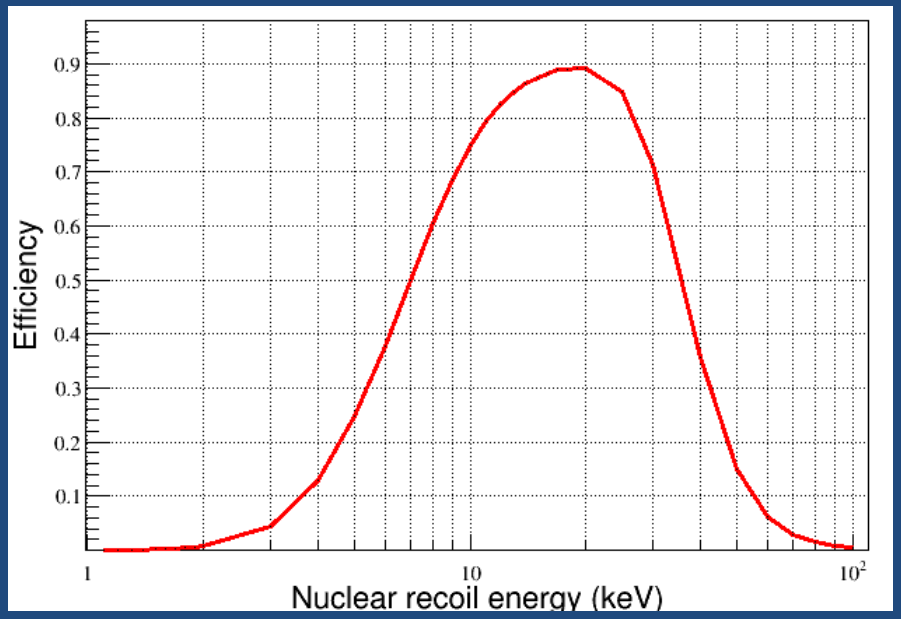
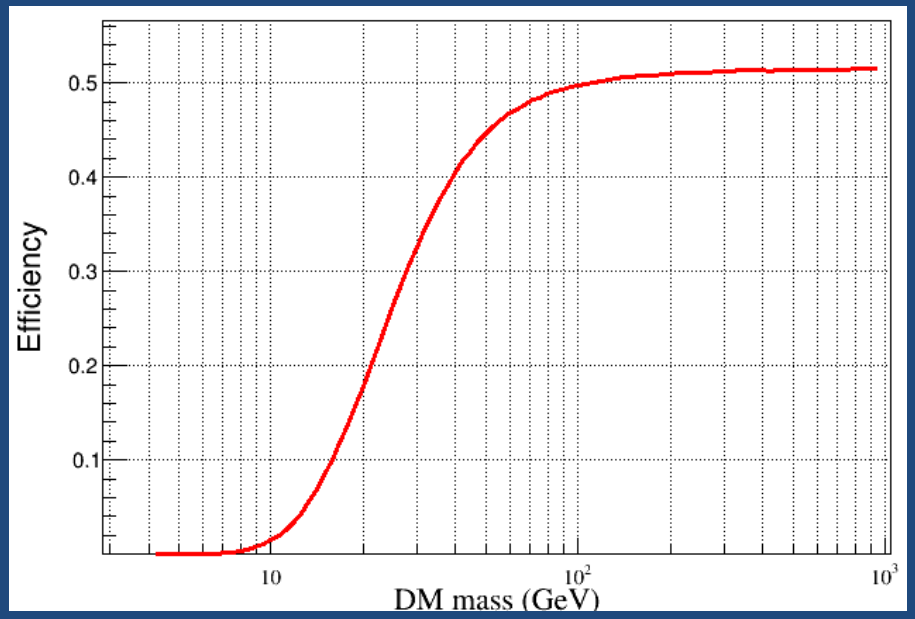
DM detection efficiency





Left: detection efficiency versus nuclear recoil energy
Right: detection efficiency per interaction versus DM mass

PANDA X

Thank you for your attention!

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