Calibration of XMASS 800kg detector using neutron source

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physics motivation 1

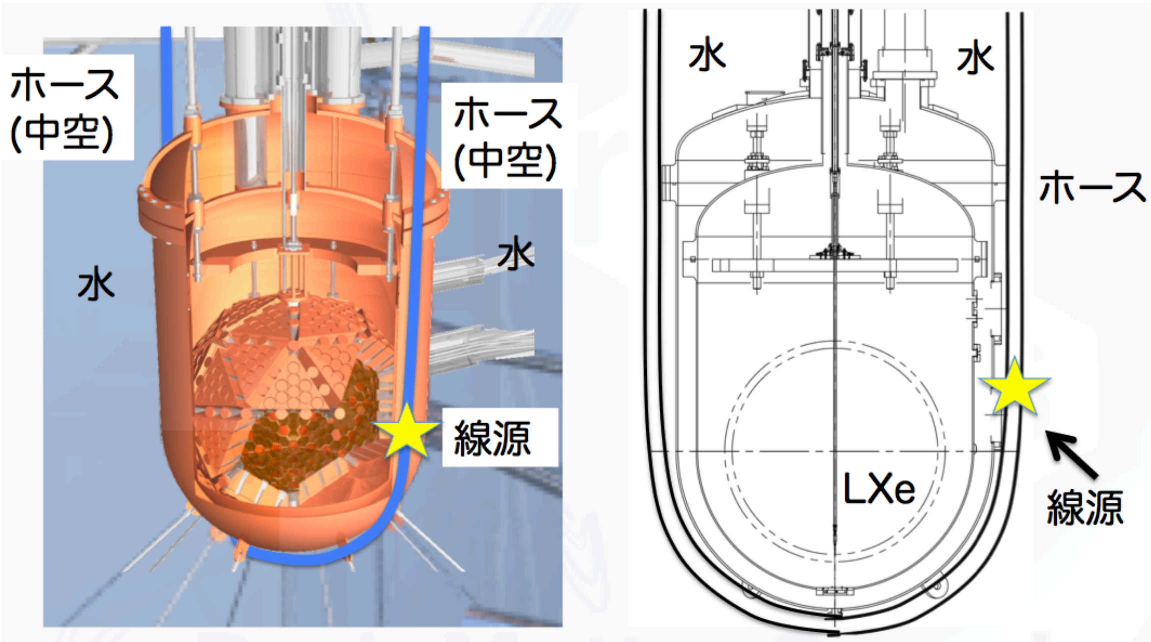
- Direct dark matter(DM) particle search
  - XMASS is a new particle search experiment
    - using nuclear recoil caused by weak interaction
- What is the requiment for “direct” detection?
  - scintillation light caused by nuclear recoil
    - how can the “light” judged that it is caused by nuclear recoil?
    - by finding same feature caused by some other nuclear recoil phenomena from signal.
    - how can nuclear recoil occurred?
    - using neutron !

physics motivation 2

- Once the signal was acquired
  - physical values of DM (crosssection, mass) must be measured
- how?
  - using MC.
  - fitting MC Energy histogram to that of real data.
  - fit parameters will give physical values
- aim in this research
  - judging MC availability
  - deviation(30%) is the aim in this research.
  - why 30% ? non zero value even in 3σ is essential

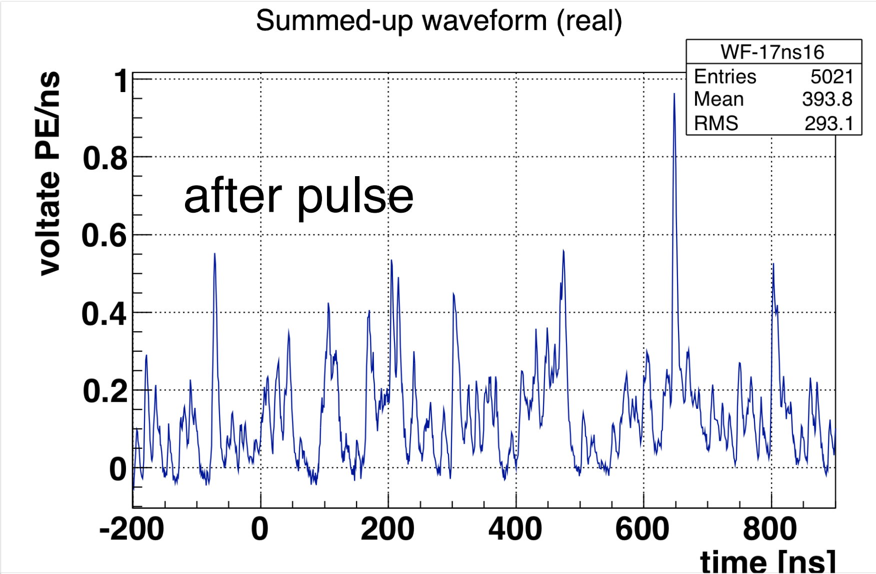
data acquisition

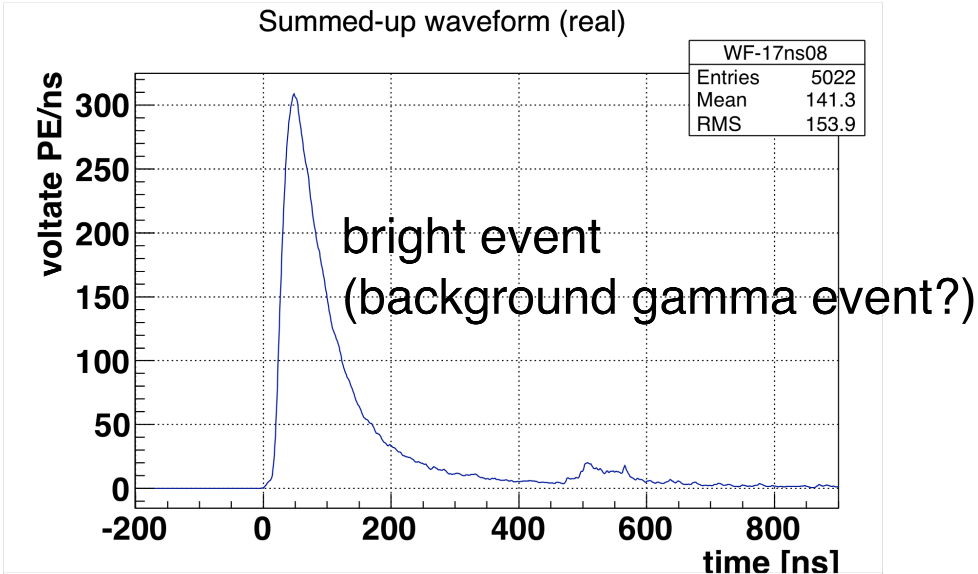
- Used 252Cf for neutron source
- Used 57Co for gamma calibration source
- Cf source intensity was specified
  - with error of ~ 10 %
- hose run
- geometry
  - installed in MC

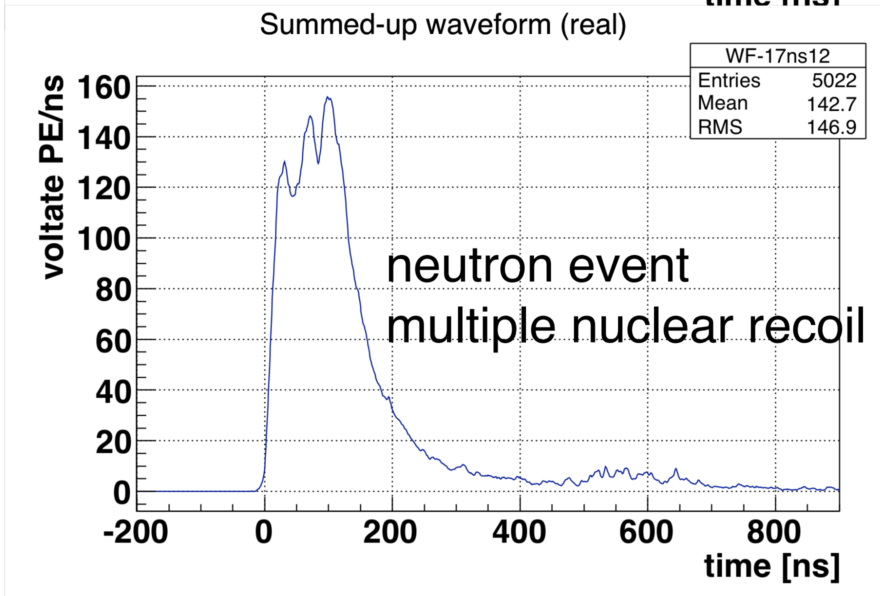


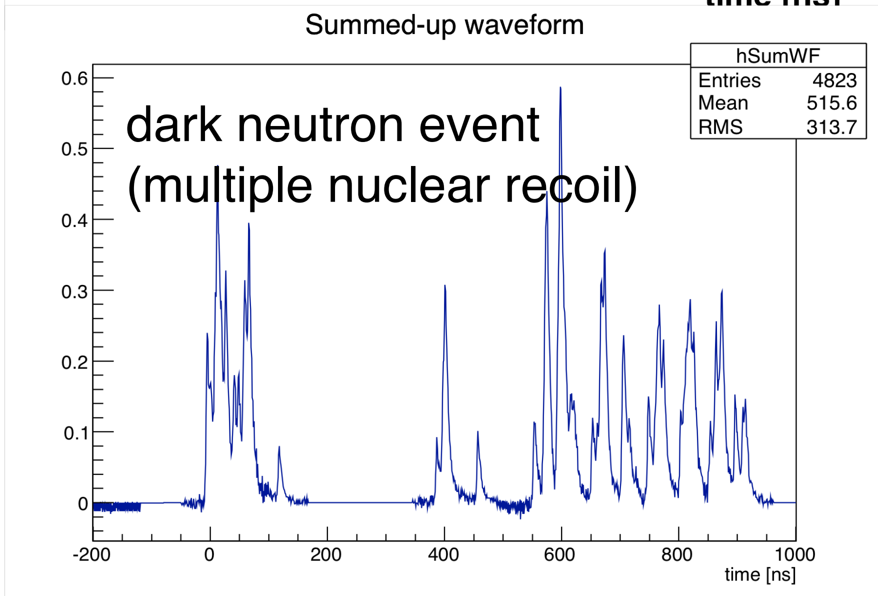
Energy and calibration 1

- examples of summed up waveforms from PMT



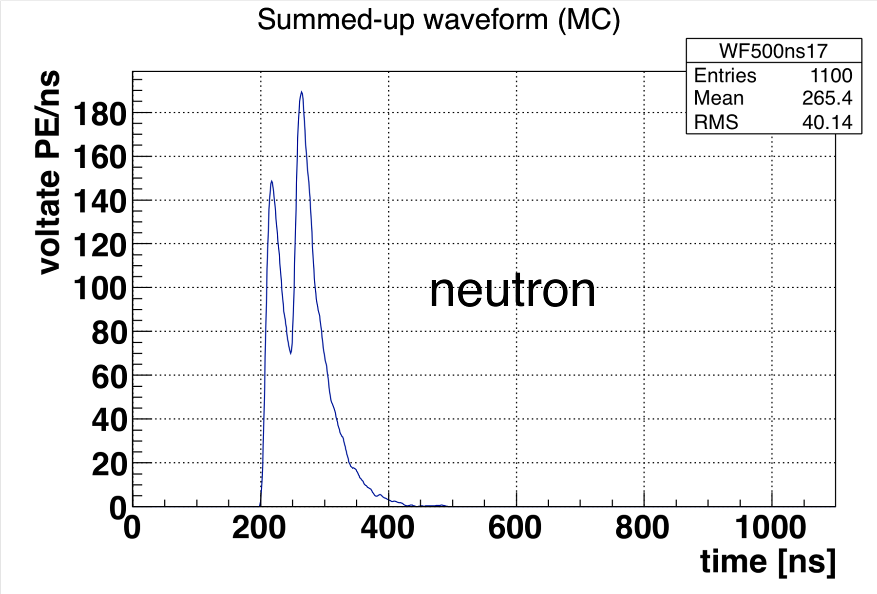


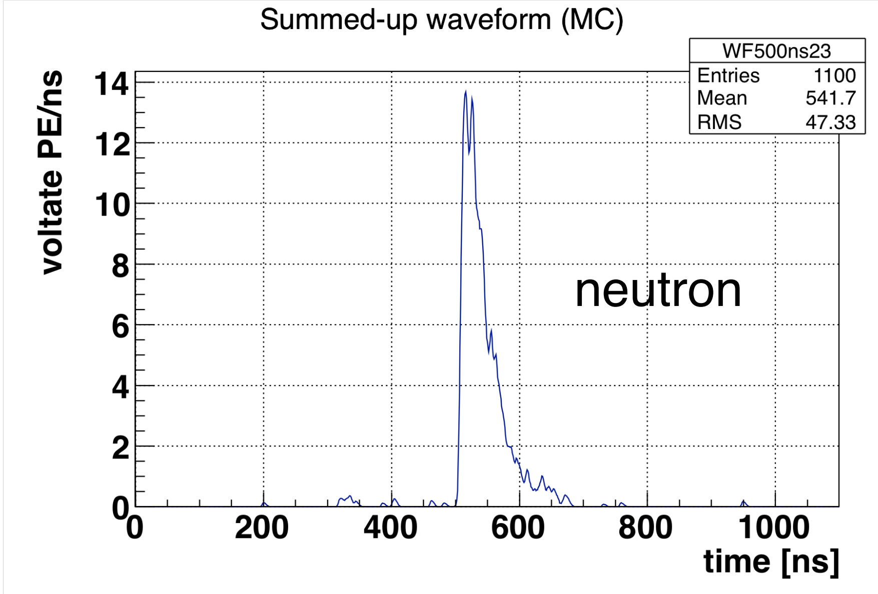


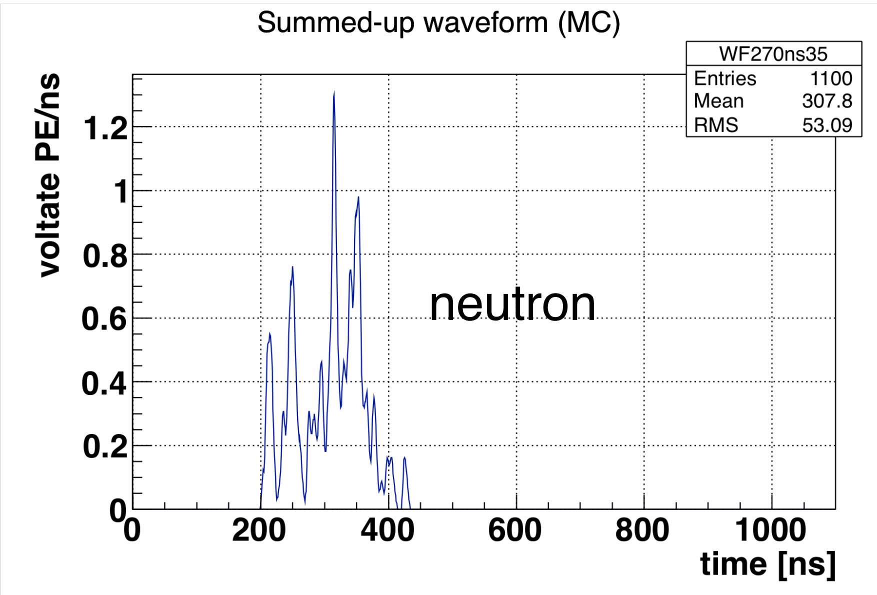


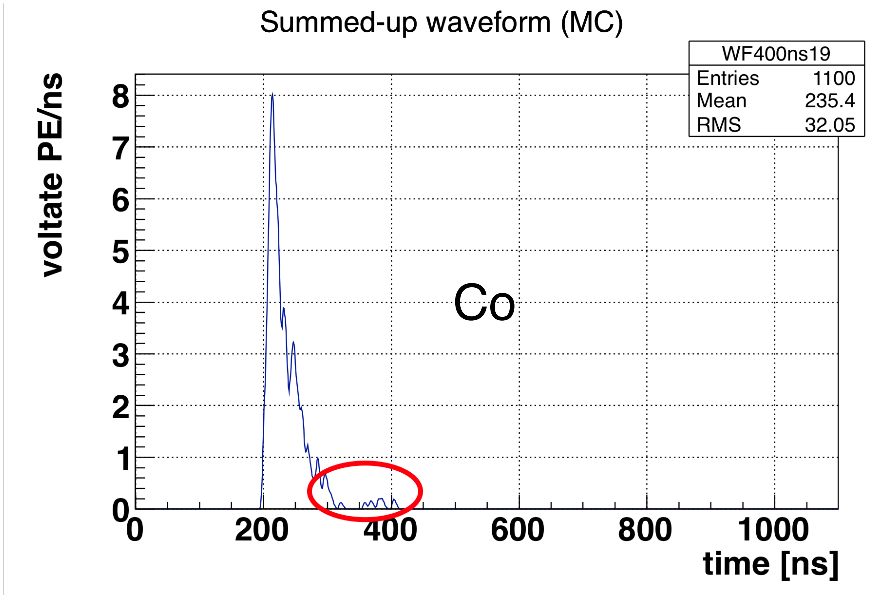
Energy and calibration 2

- examples of summed up waveforms from PMT



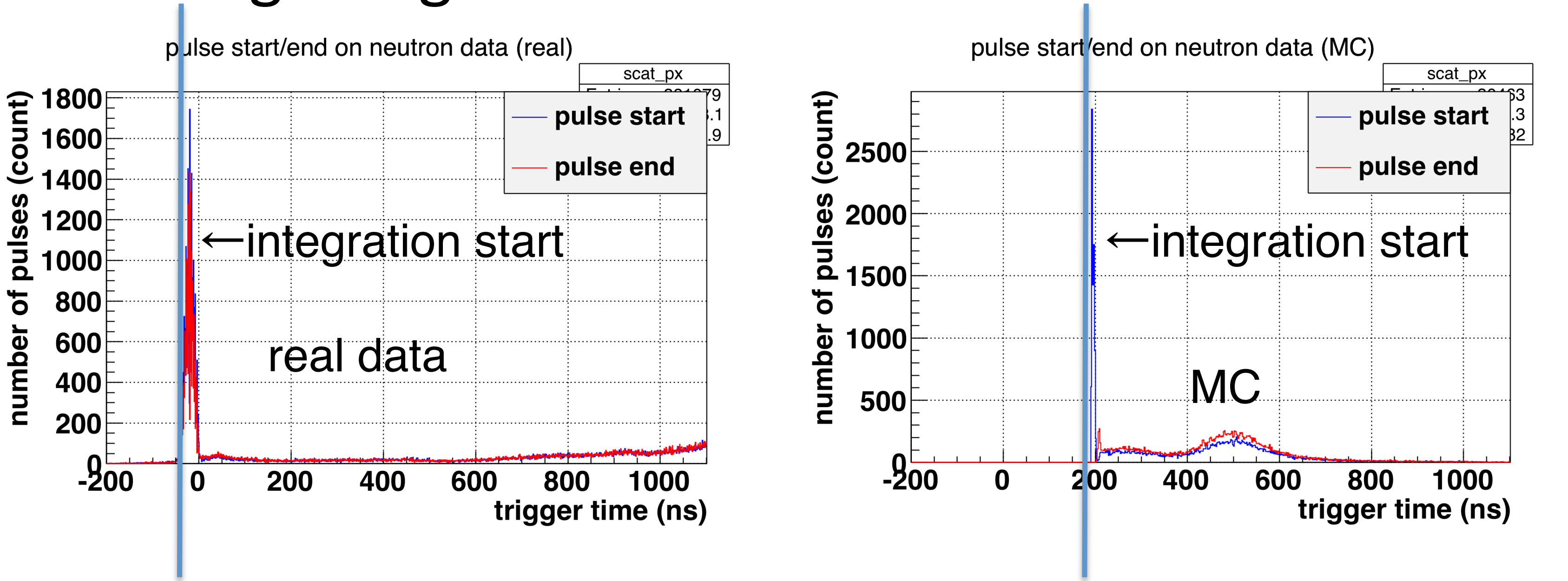






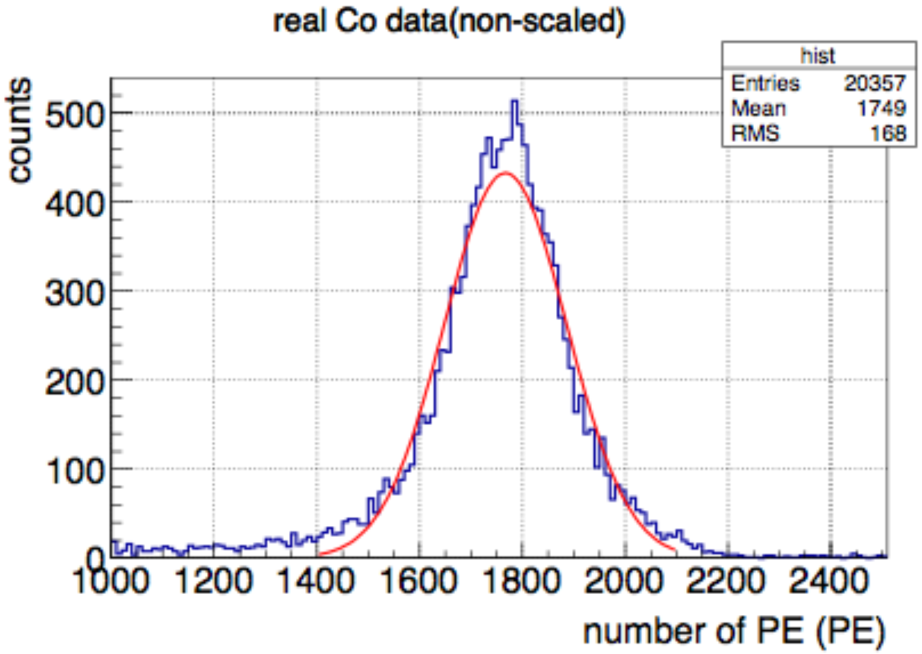
Energy and calibration 3

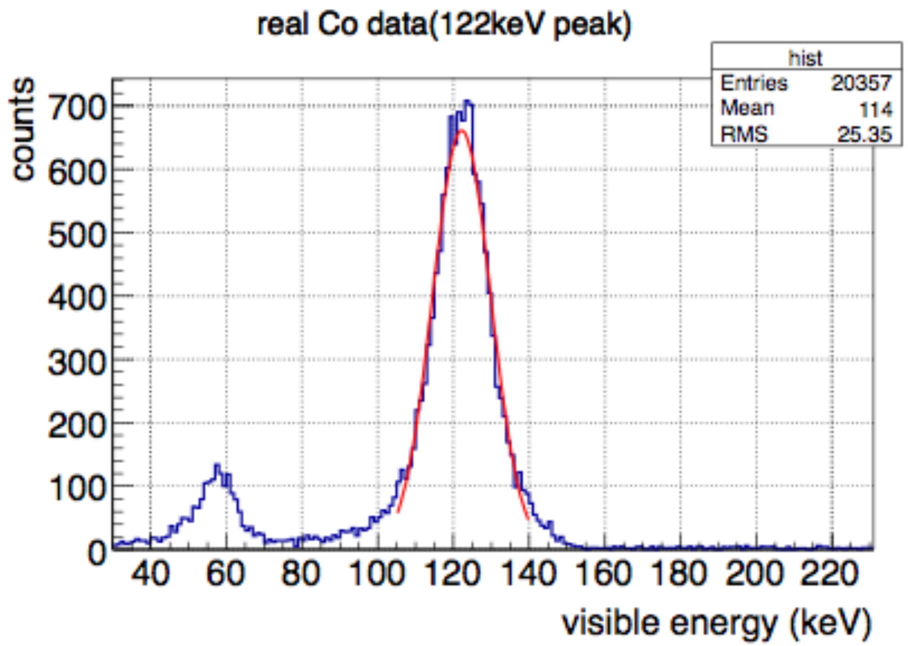
- how to solve energy
  - integrating PMT summed up waveform
- integration criteria
  - executing peak search to solve pulse start point
  - integrating for 110 ns both in MC & real



Energy and calibration 4

- light yield(LY)
  - definition: LY=nPE/Energy ~ 15 PE/keV
  - nPE: number of photoelectron (unit: PE)
- 57Co has a 122keV gamma peak calibration
  - same calibration was done on MC as well



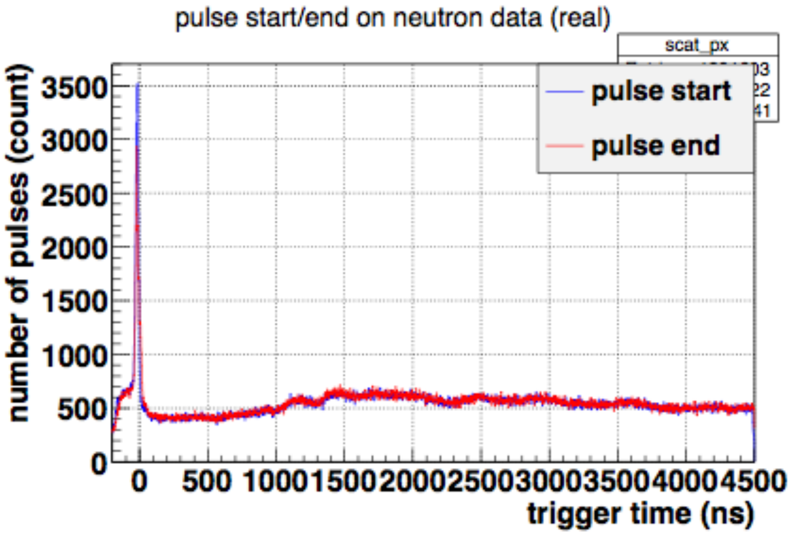


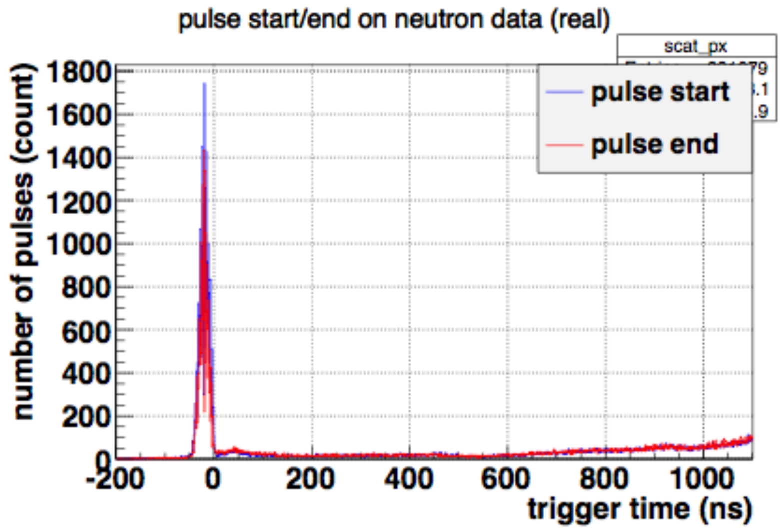
Data selection method 1 (cut criteria)

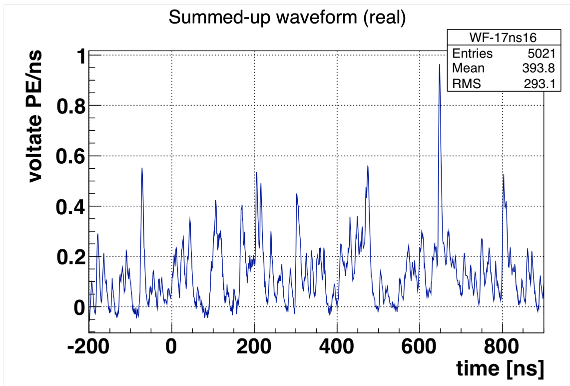
- trigger ID cut
  - muon veto (outer detector trigger event rejection)
- Nhit PMT cut
  - dark signal rejection (1,2 or 3 hit during 200ns rej.)
- dT cut
  - after pulse rejection
  - dT<400us: reject, dT>400us: alive

Data selection method 2

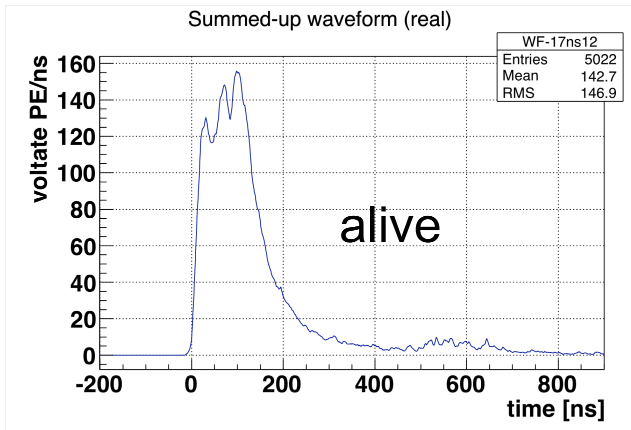
- example: effect on dT cut







disapear

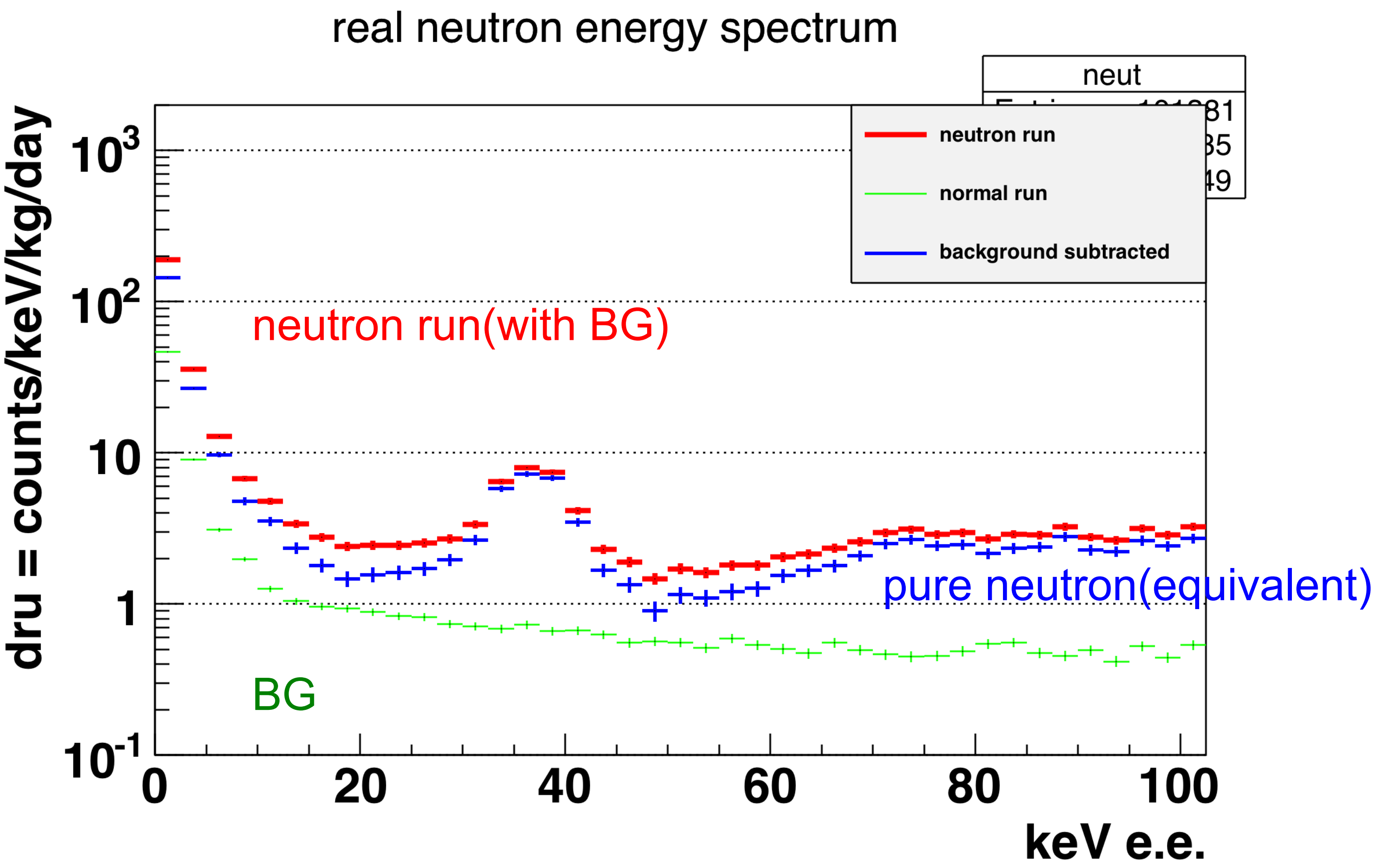


Monte Carlo simulation(MC) condition

- MC condition must be very similar to real data
  - cut condition, BG treatment, source intensity, etc.
- cut condition
  - muon, dark signal, after pulse are not simulated:
  - same cut condition as real
- gamma BG
  - subtracted normal(w/o radio source) from neutron data.
- source intensity
  - checked by experiment with error less than 10 %

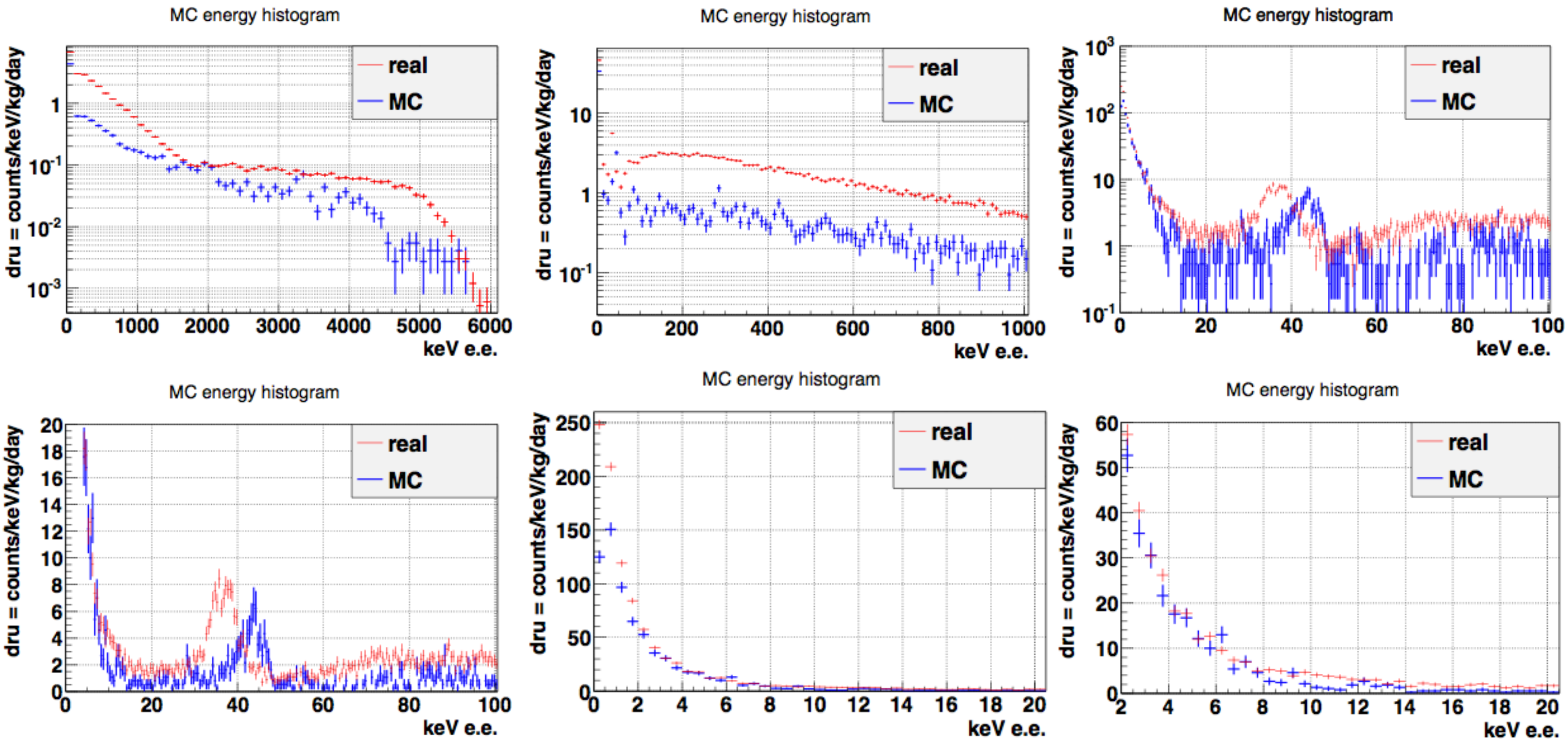
Comparison between MC & real 1

- real data (BG subtraction)



Conparison between MC & real 2

- comparison in several energy range



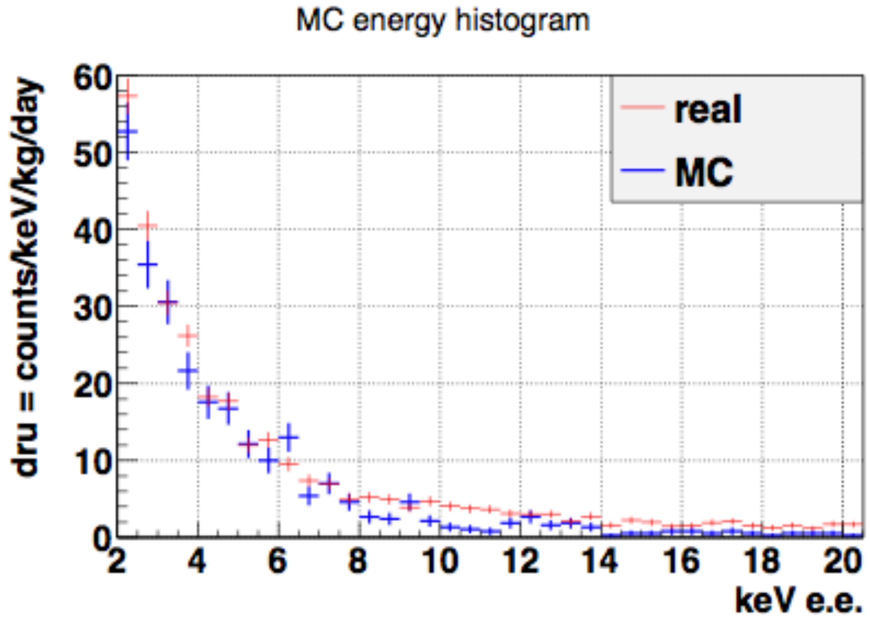
Conparison between MC & real 3

- similar tendency in energy<100keV region.
- discrepancy is seen in higher energy region
- lower energy region(2-8 keV area)
  - good agreement in intensity and resolution.
- about discrepancy
  - total event rate
    - real:25 count/sec
    - MC: 9 count/sec
  - reason is under investigation
    - souce intensity 10% error, Xe crossection 20% error, etc.

    those parameter cannot explain discrepancy of 2.5 times.

Conclusion

- assuming MC is correctly simulating real
  - cross section
    - watch 5 or 6 keV bin
    - 15% discrepancy
    - cross section σ ∝ intensity
    - 15% systematic error on σ
    - error < 30%
  - mass
    - watch gradient in 3-10keV region
    - almost no obvious difference



Thank you for listening.