Calibration of XMASS 800kg detector using neutron source

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Direct dark matter (DM) particle search

- XMASS is a new particle search experiment
  - using nuclear recoil caused by weak interaction

What is the requirement 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 $3\sigma$ 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

- after pulse

- bright event (background gamma event?)

- neutron event

- multiple nuclear recoil

- dark neutron event (multiple nuclear recoil)
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: \( LY = \frac{nPE}{\text{Energy}} \sim 15 \, \text{PE/keV} \)
  - \( nPE \): 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

Before cut:
- Number of pulses: high
- Pulse start and end visible
- waveform: complex

After cut:
- Number of pulses: low
- Pulse start and end disappear
- waveform: simple

Example of pulse start/end on neutron data (real) before and after the cut.
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)

![Real neutron energy spectrum graph]

- neutron run (with BG)
- pure neutron (equivalent)
- BG
Comparison between MC & real 2

- comparison in several energy range
Comparison 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
    • source intensity 10% error, Xe crosssection 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 $\sigma \propto$ intensity
    • 15% systematic error on $\sigma$
    • error < 30%
  – mass
    • watch gradient in 3-10keV region
    • almost no obvious difference
Thank you for listening.