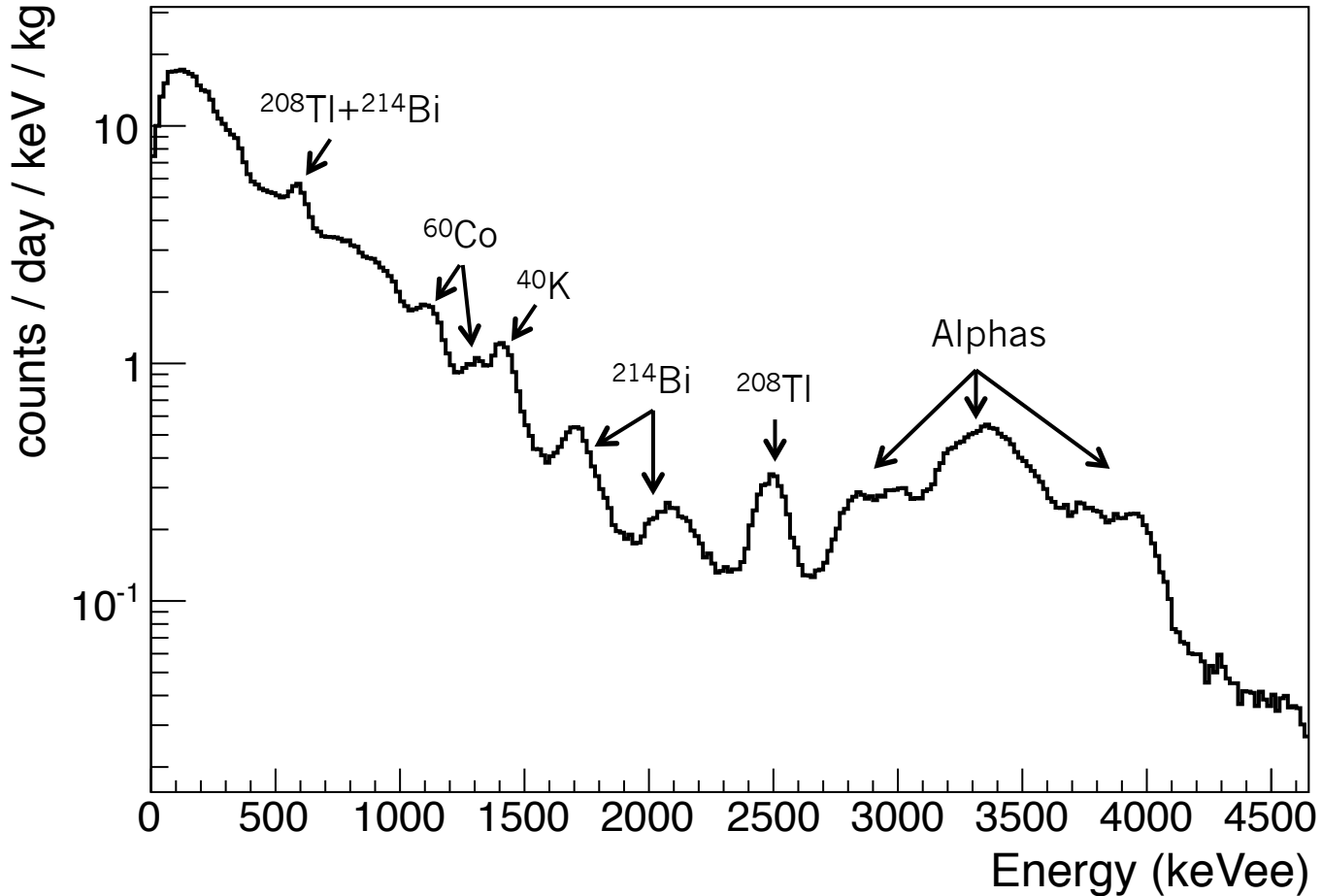


Waveform Analysis for DM-Ice17

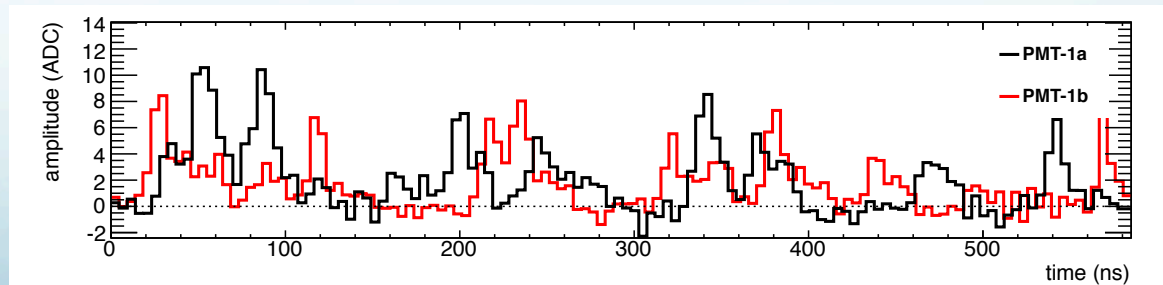
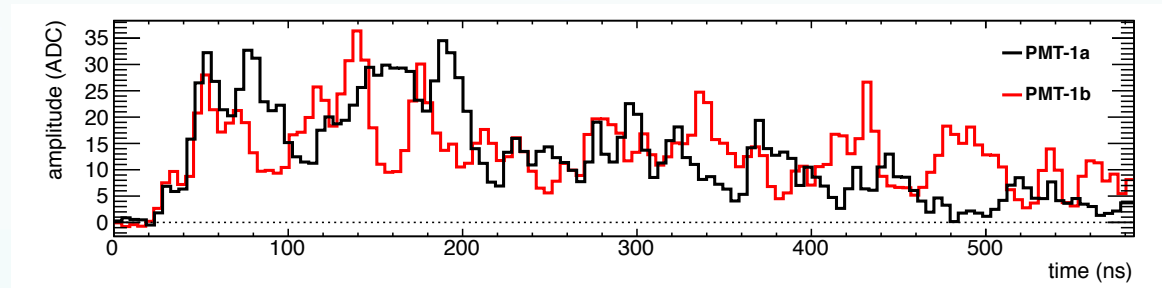
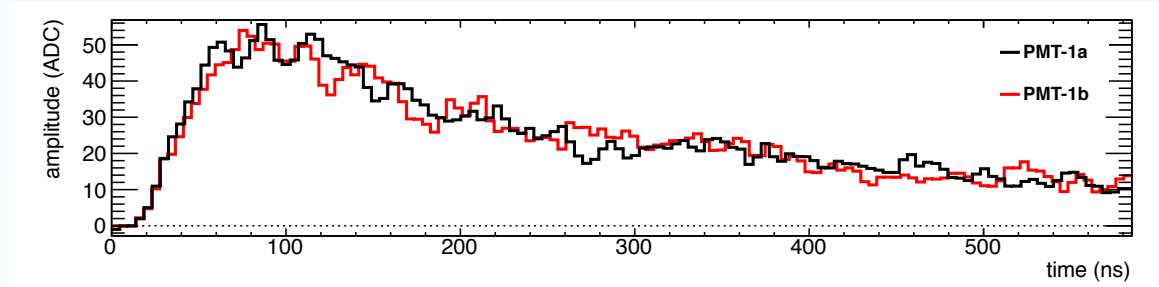
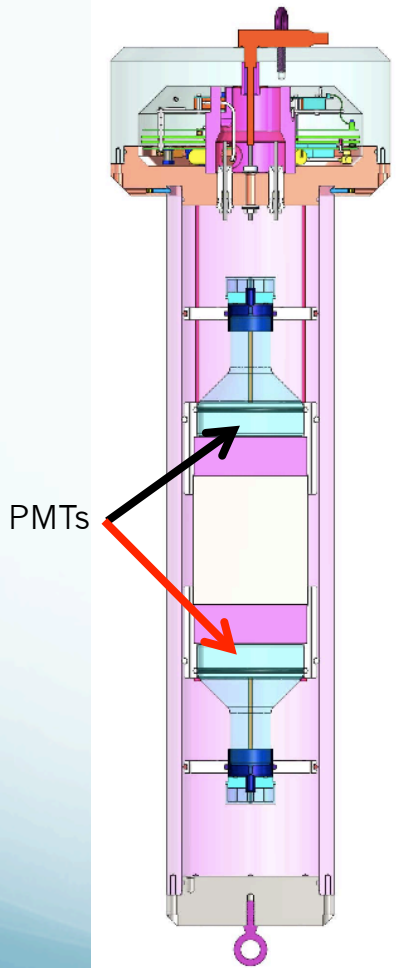
Zachary Pierpoint
University of Wisconsin - Madison
October 21, 2013
Yale Weak Interactions Discussions Group



DM-Ice17 Energy Spectrum



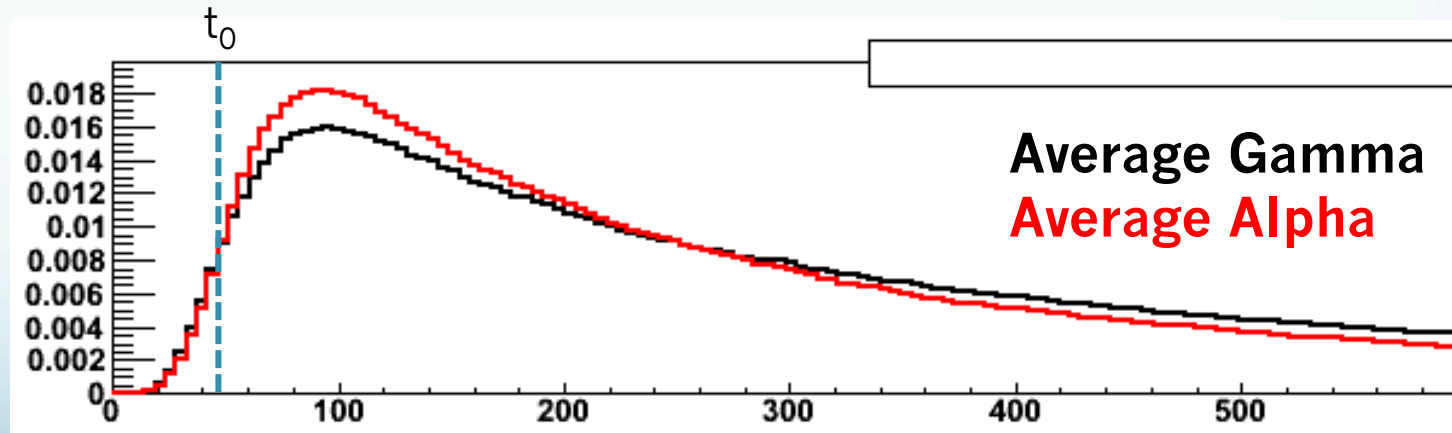
DM-Ice17 Events



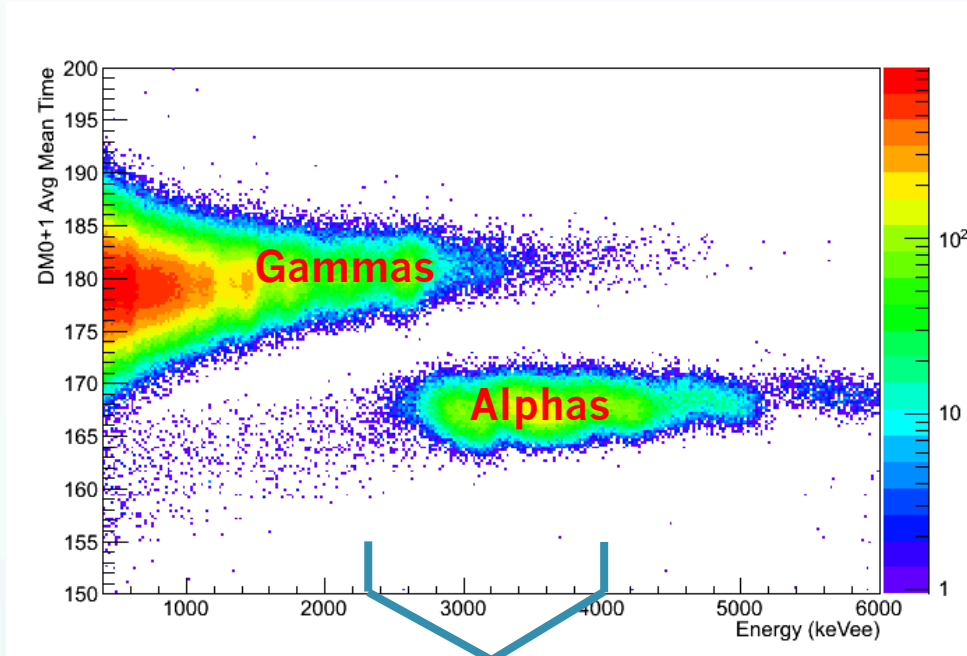
Mean Time (τ)

Studies of alpha quenching factors and alpha source concentrations are greatly improved by separating the gamma and alpha spectra. Differences in scintillation behavior for electron and nuclear recoils make such separation possible.

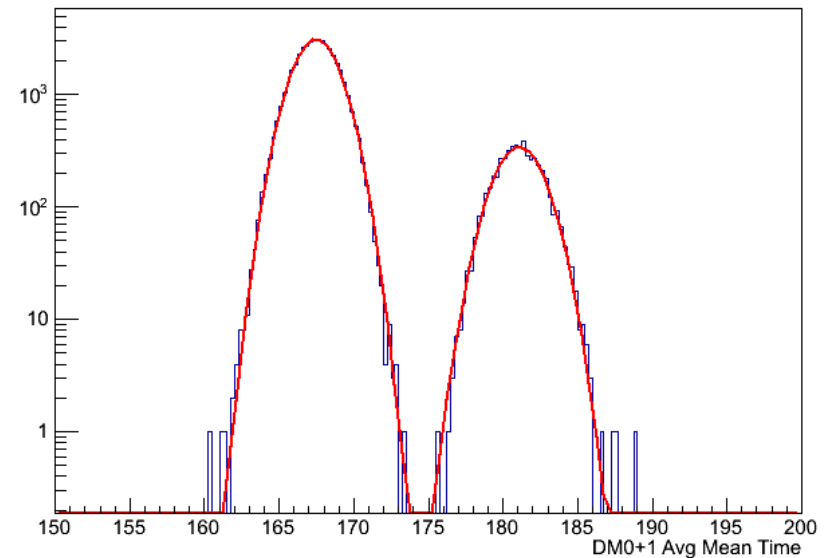
$$\frac{\sum_{t=t_0} (t - t_0) E_t}{\sum_{t=t_0} E_t}$$



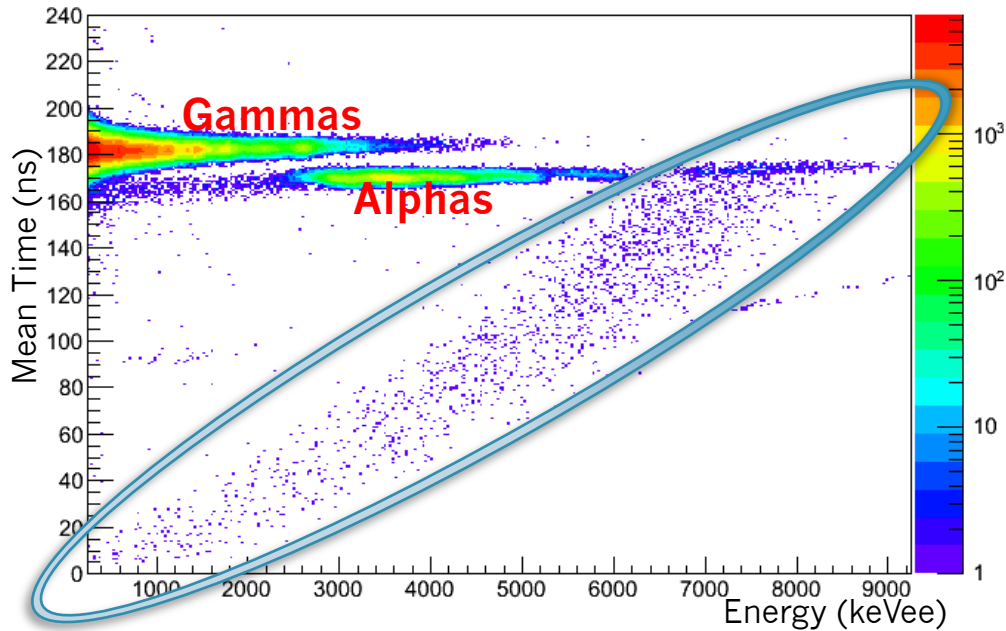
Mean Time Separation



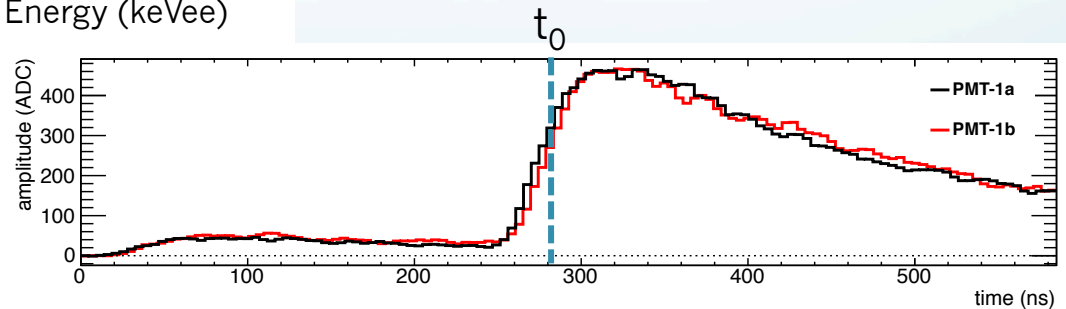
Gaussian fits separated
by 4.84 sigma



Other High Energy Events

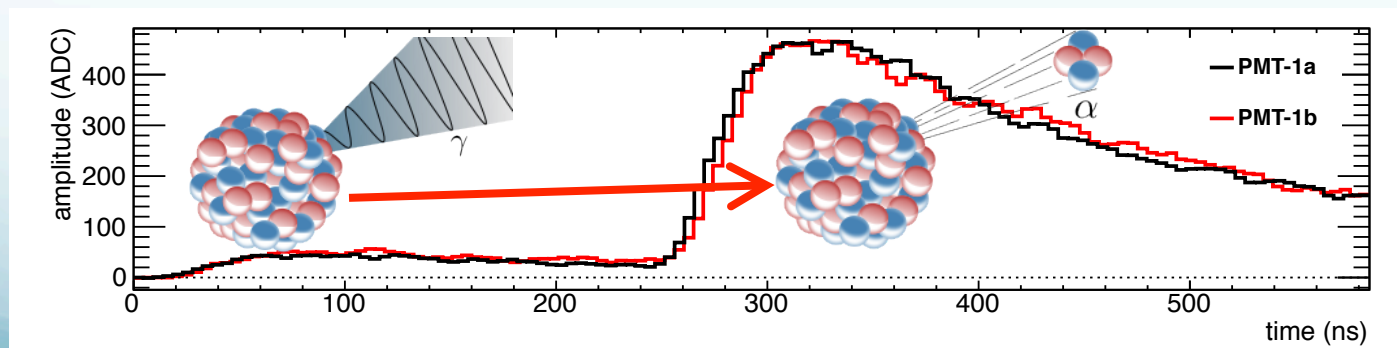


Gammas and Alphas are not the only types of high energy waveforms observed in DM-Ice17

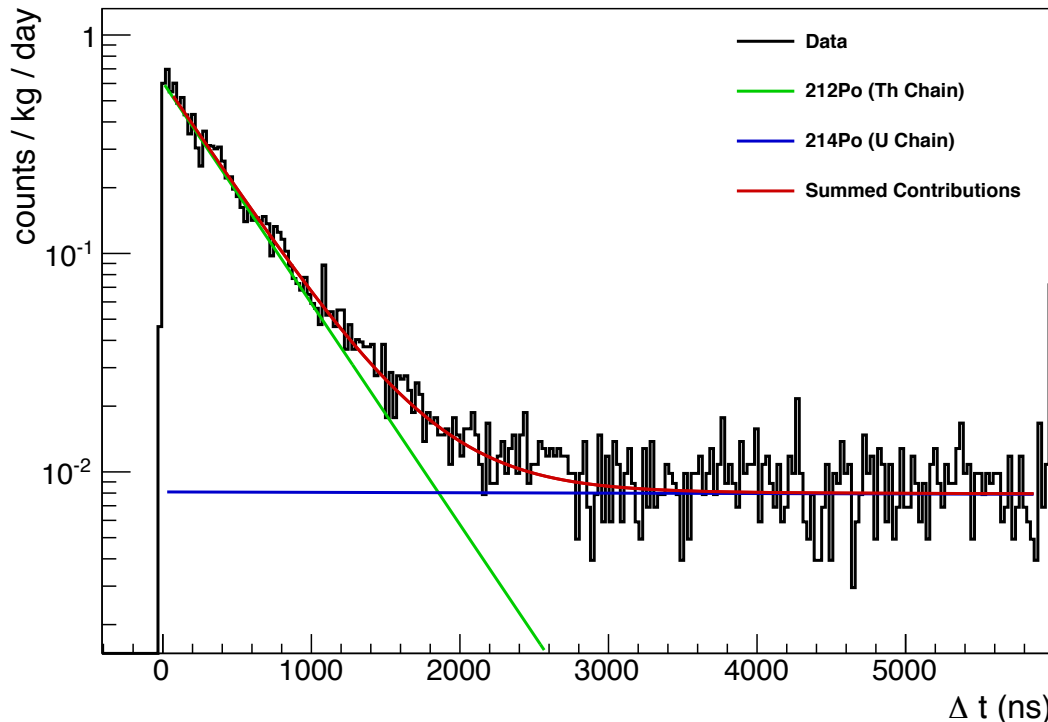
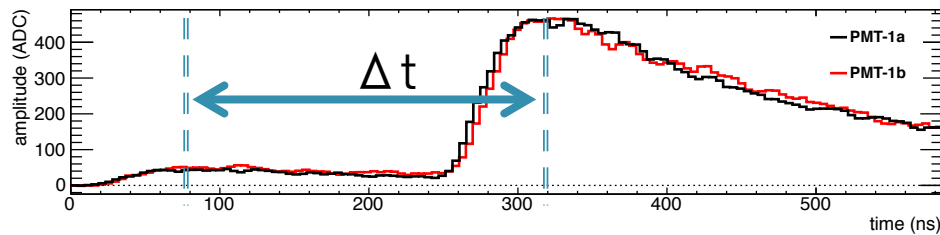


Expected “Fast” Alphas

- (Thorium Chain) ^{212}Bi gamma decays to ^{212}Po 64.05% of the time
 - ^{212}Po has a half-life of **299 ns**
 - Estimated **1164.5 uHz** rate based on previous alpha analysis
- (Uranium Chain) ^{214}Bi gamma decays to ^{214}Po 99.98% of the time
 - ^{214}Po has a half-life of **164,000 ns**
 - Estimated **198.3 uHz** rate based on previous alpha analysis.
- Accidental coincidence of gammas and alphas
 - Based on alpha event rate, expected at **1.162 uHz**, i.e. small compared to expected rate from the two BiPo contributions



BiPo Analysis

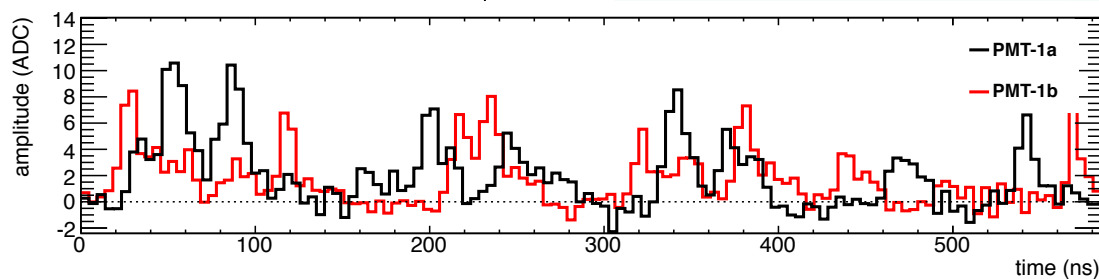
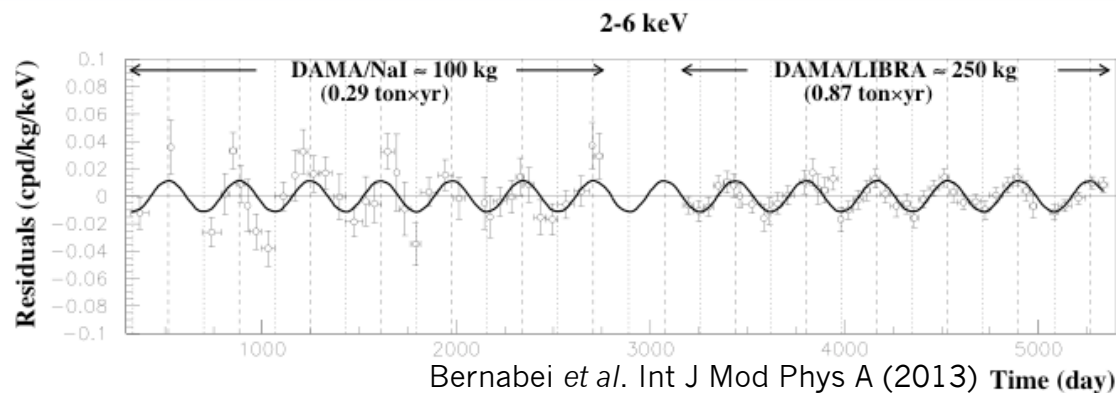
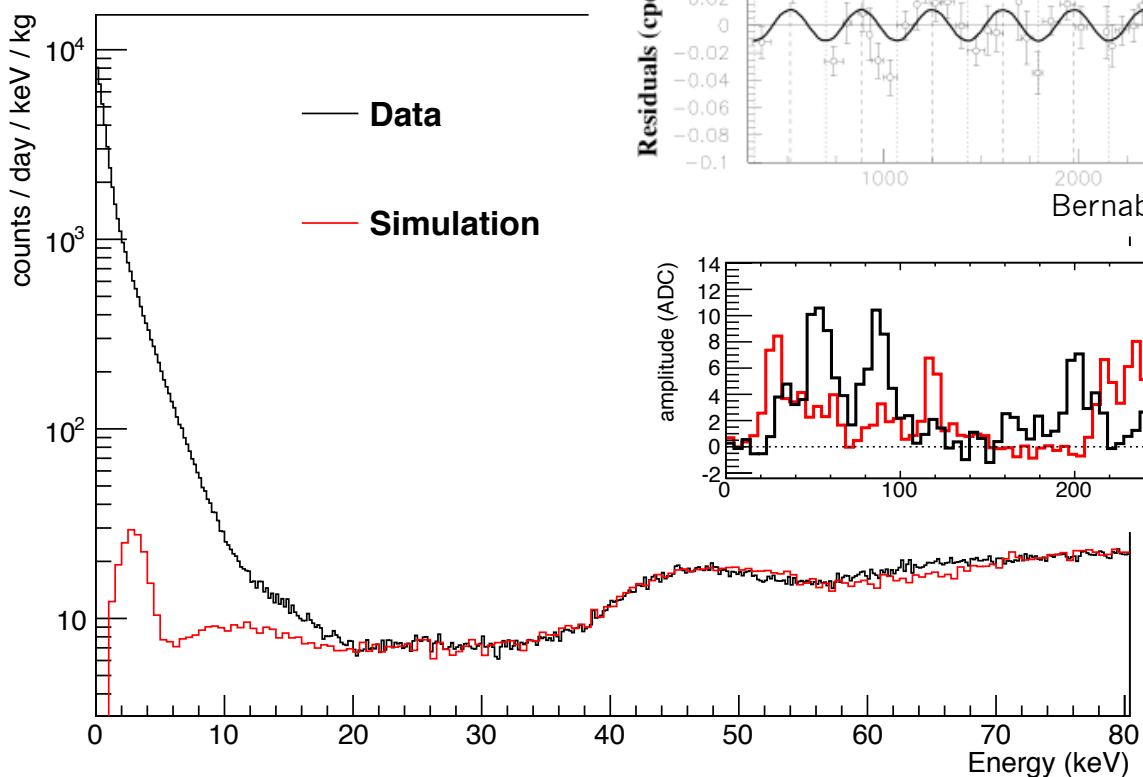


Parameter	Fit	Error	Expectation
$^{212}\text{Po } t_{1/2} \text{ (ns)}$	297.3	4.1	299
$^{212}\text{Po conc. (uHz)}$	1052.3	11.1	1164.5
$^{214}\text{Po conc. (uHz)}$	187.7	5.6	198.3

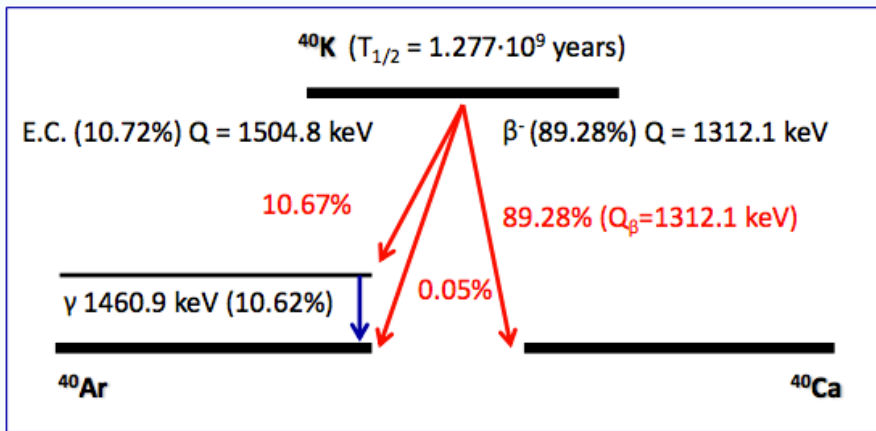
Great agreement of half-life (i.e. this *is* dominated by Thorium chain BiPo)

Good agreement of concentrations for both BiPo processes, though the alpha analysis produces values 5-10% higher.

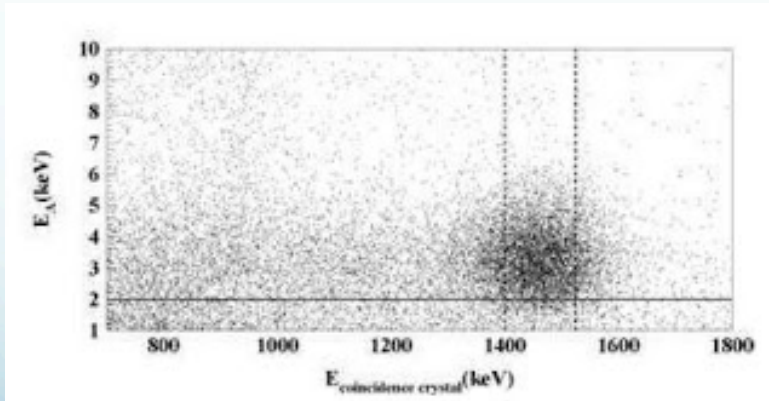
Low Energy Analysis



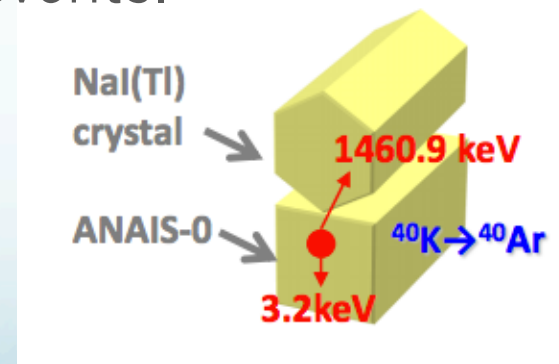
^{40}K 3 keV peak



- ^{40}K decay to ^{40}Ar results in a 3 keV peak due to x-rays and auger electrons.
- Low energy calibration point.
- “Target” line for energy threshold.
- Multi-crystal coincidence allows for tagging these events.

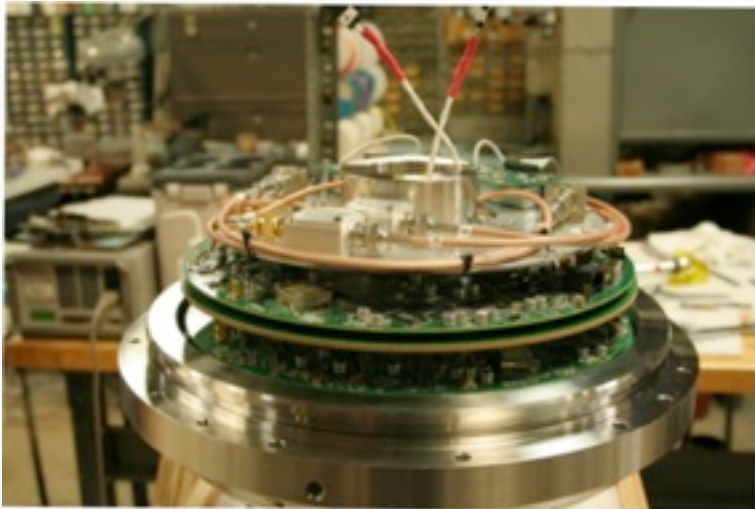


DAMA/LIBRA plot showing coincidence between 1461 keV events in one crystal with 3 keV events in a neighboring crystal.

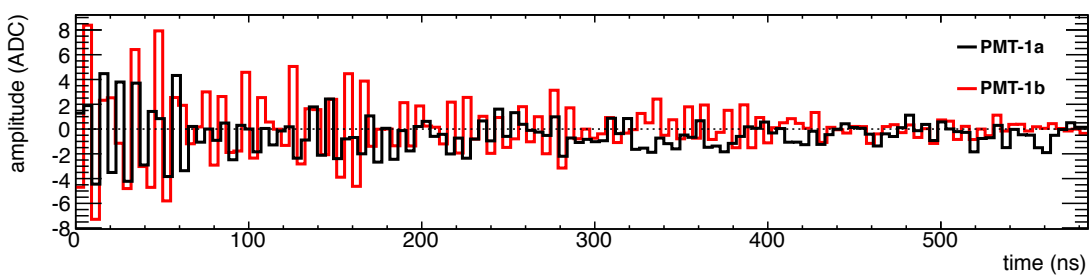


C.Cuesta, “Status of the ANAIS Experiment”
6th Multidark Consolider Meeting

Electromagnetic Interference (EMI) Events



- Hardware monitoring produces interference that triggers DM-Ice17.
- Monitoring frequency decreased in March 2012 to reduce these events.
- Pulse shape discrimination used to cut EMI events.

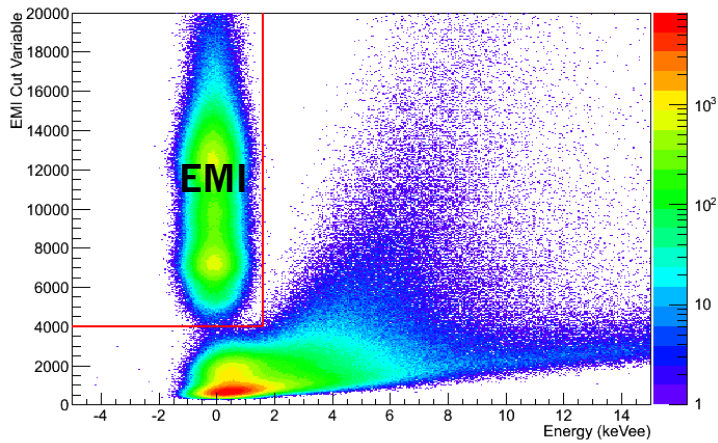


$$discriminator = \int_0^{600\text{ ns}} \left(\frac{dy}{dt}\right)^2 dt$$

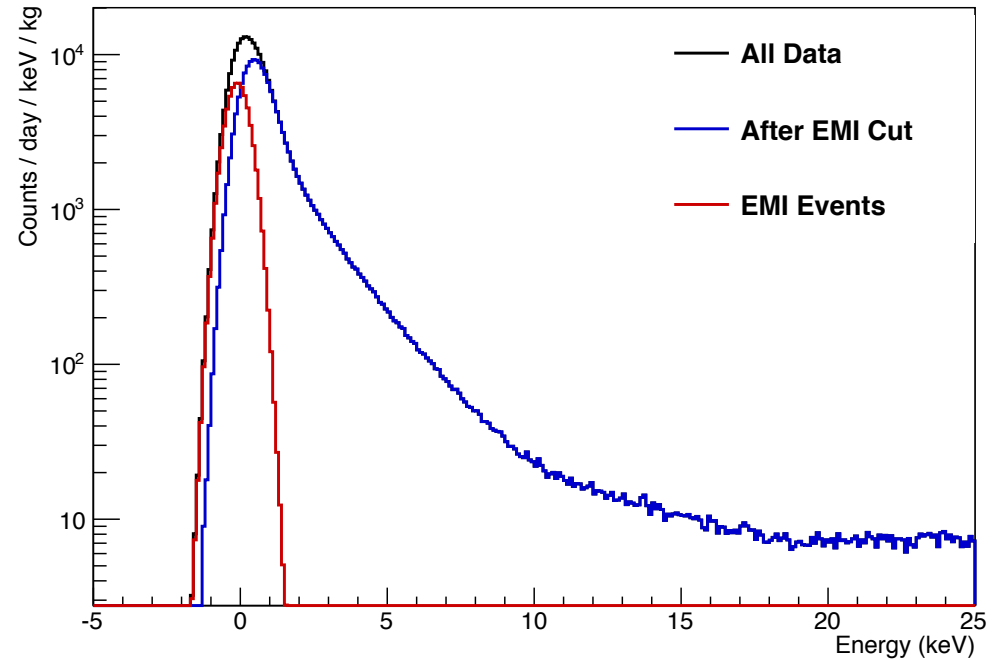
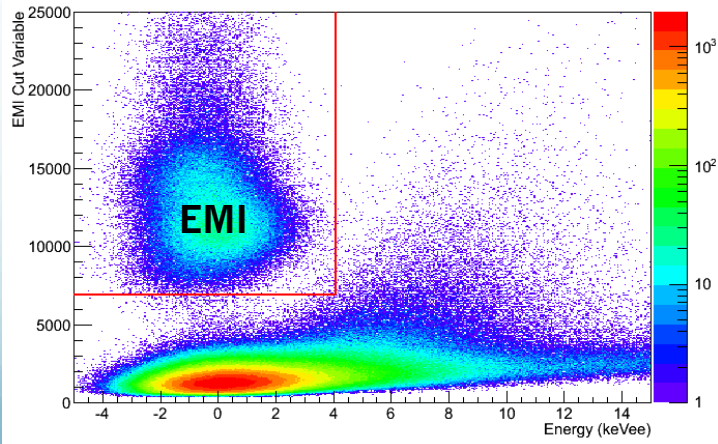
$$discriminator = \sum_{i=1}^{127} ((x_{i+1} - x_i) - (x_i - x_{i-1}))^2$$

EMI Cut

Prototype 1 EMI Cut

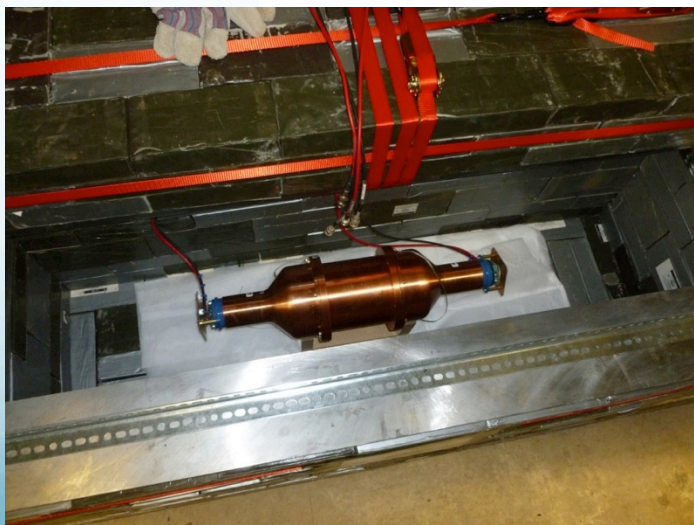
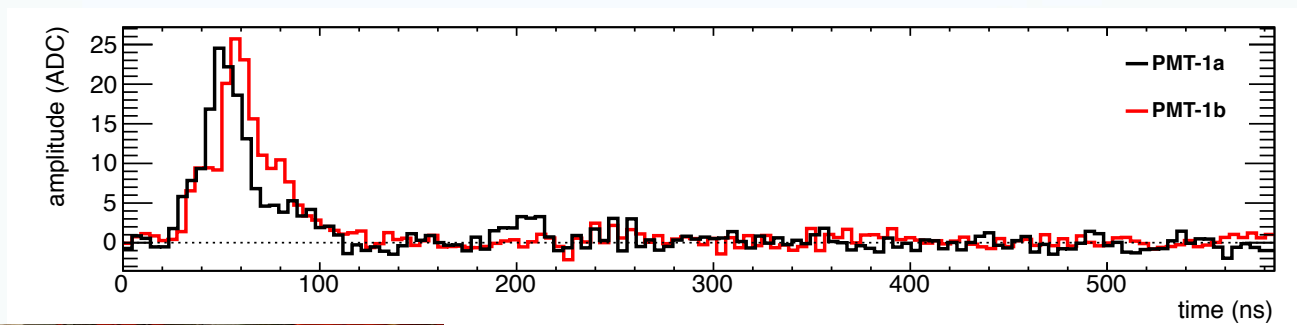


Prototype 2 EMI Cut



Thin Pulses

Interactions within the PMTs or light guides?



Plan to use Fermi test site to test origins of these events. For DM-Ice17, pulse shape discrimination required to remove this noise.

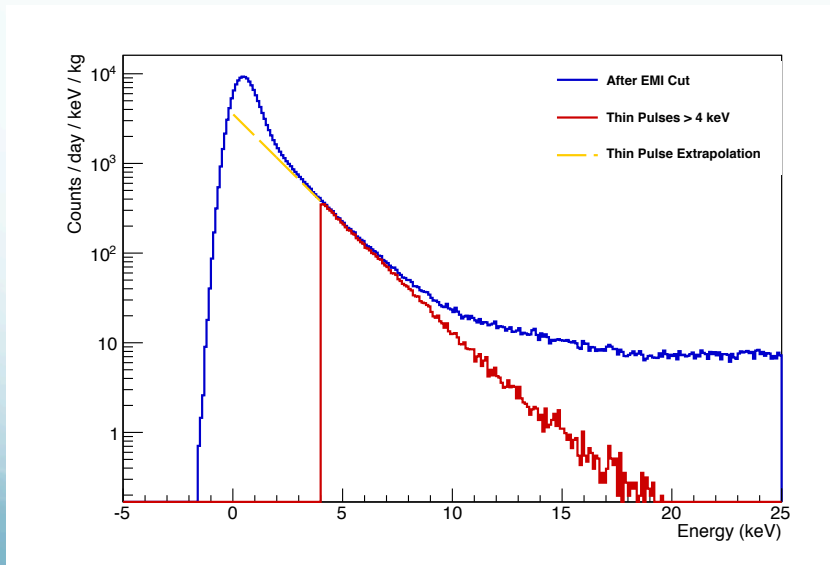
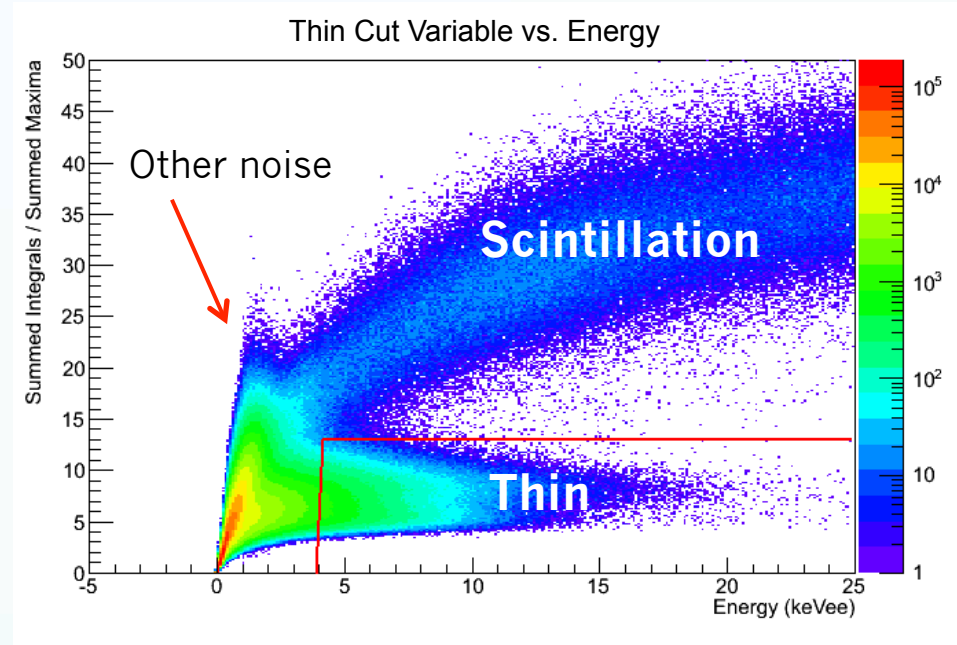
Thin Pulses

- Pulse shape discrimination:

$$\text{discriminator} = \frac{\text{DM0 Sum 128} + 0.7426 * \text{DM1 Sum 128}}{\text{DM0 Max} + 0.7426 * \text{DM1 Max}}$$

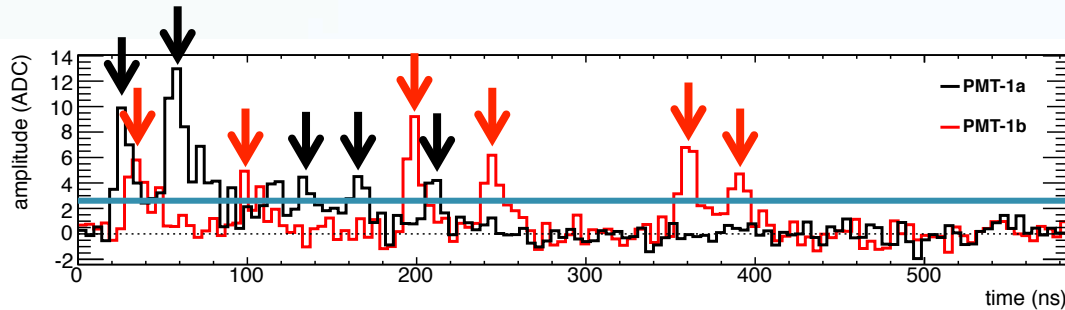
↗

Scaling factor for differences in light collection

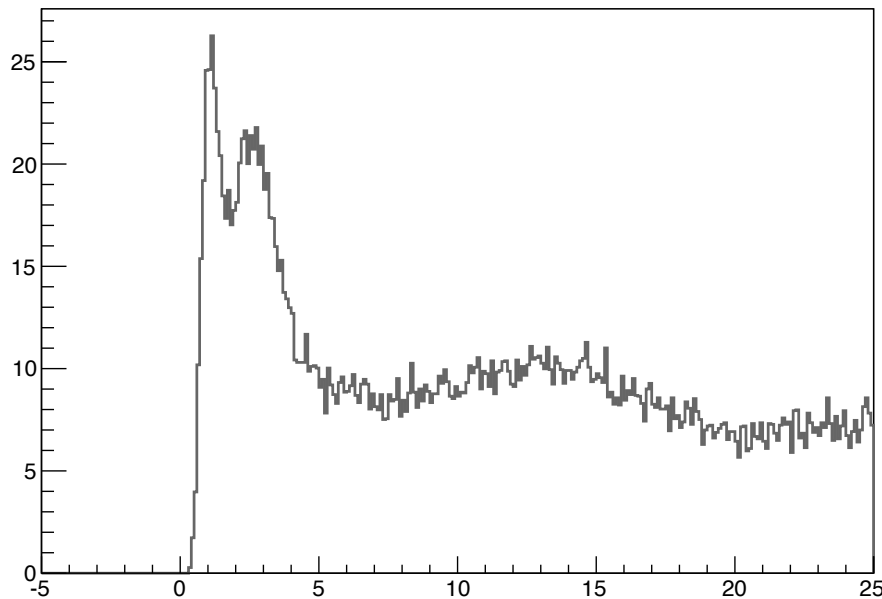


Below 4 keV, it is not enough
to just remove thin peaks!

Peak Finding Cut

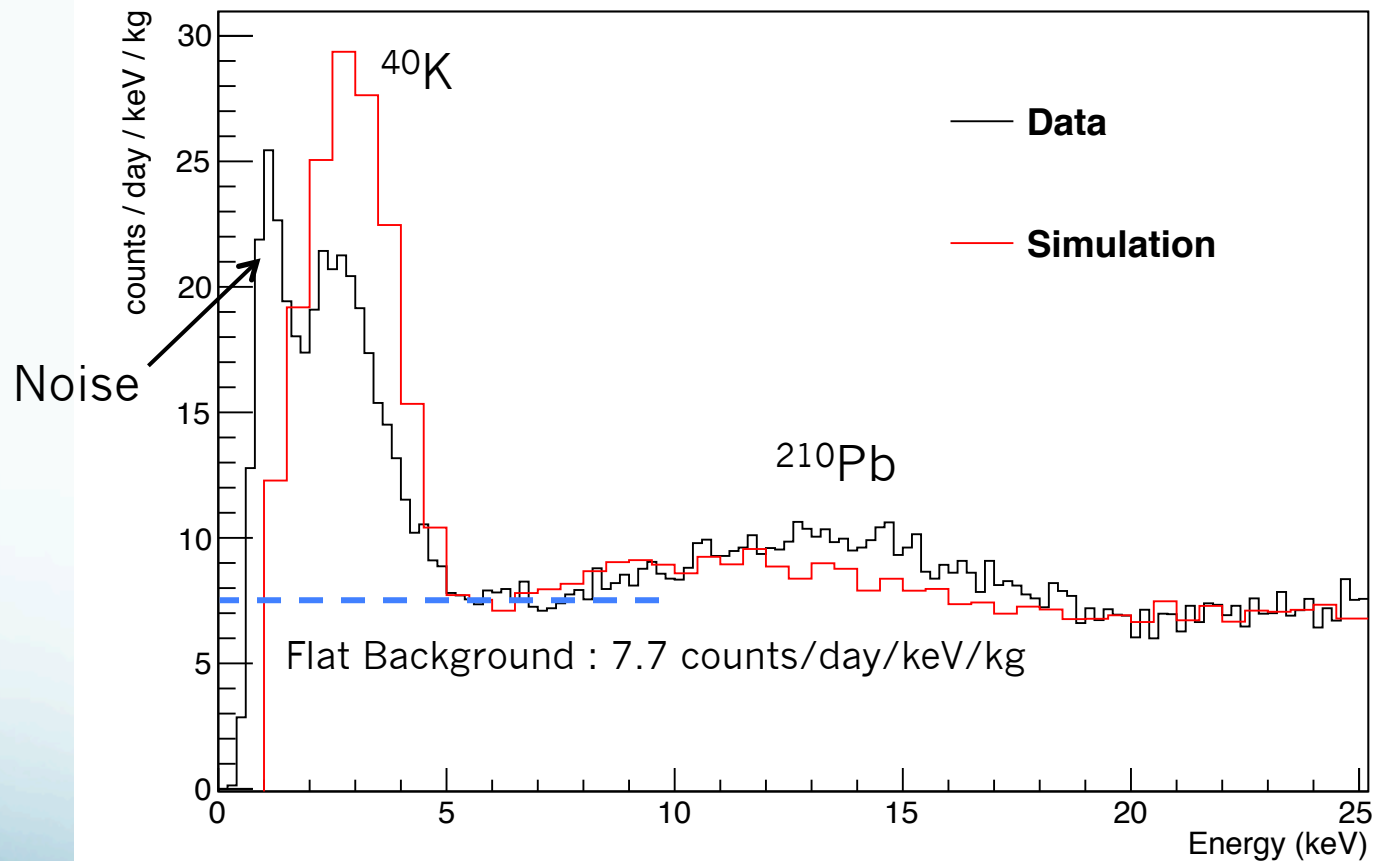


Energy Spectrum after Peak Finding Cut

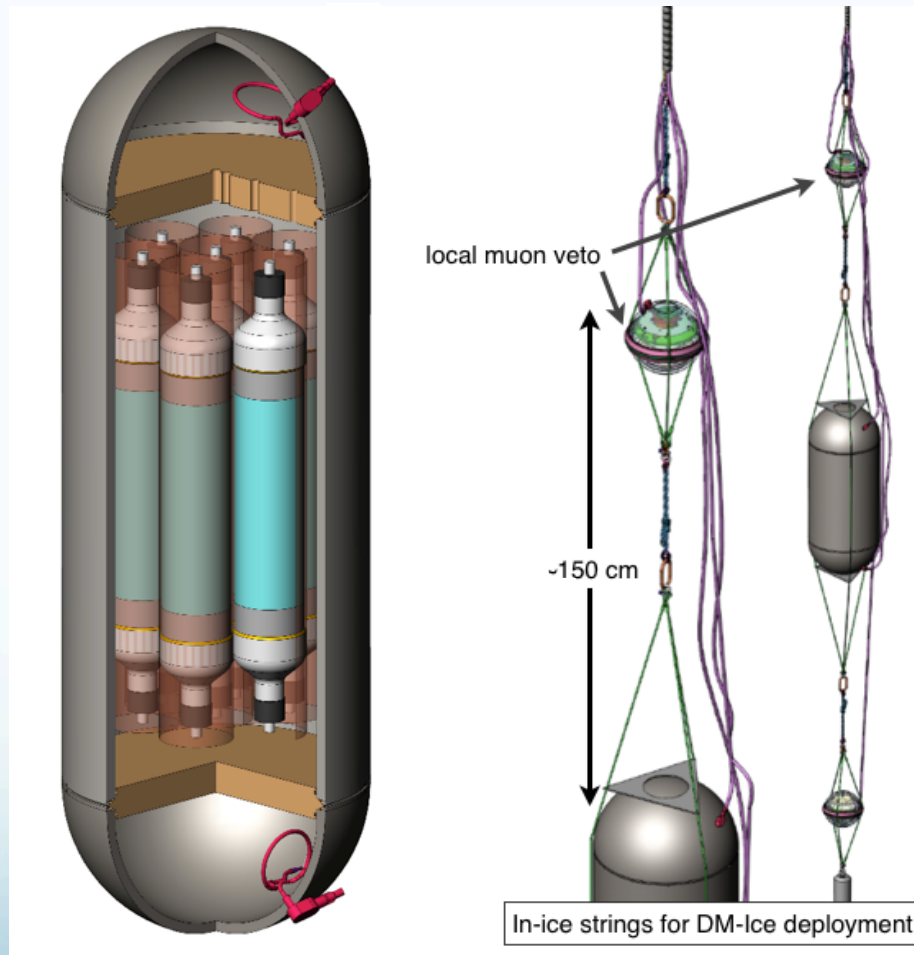


- “Peak Finding” in theory counts the number of photoelectrons in each PMT.
- In practice, a simple peak finding algorithm is used to count local maxima above a threshold.
- Cut Requirement : Each PMT sees 5+ peaks

Low Energy Region (After Cuts)



DM-Ice Full Scale



Conclusions



- Thanks to high energy analysis, we have a good understanding of the crystal contaminations and low energy backgrounds for DM-Ice17.
- From cosmogenic activation, we have a strong verification of the DM-Ice17 energy calibration.
- Studies of the stability of low energy cuts are underway for modulation analysis