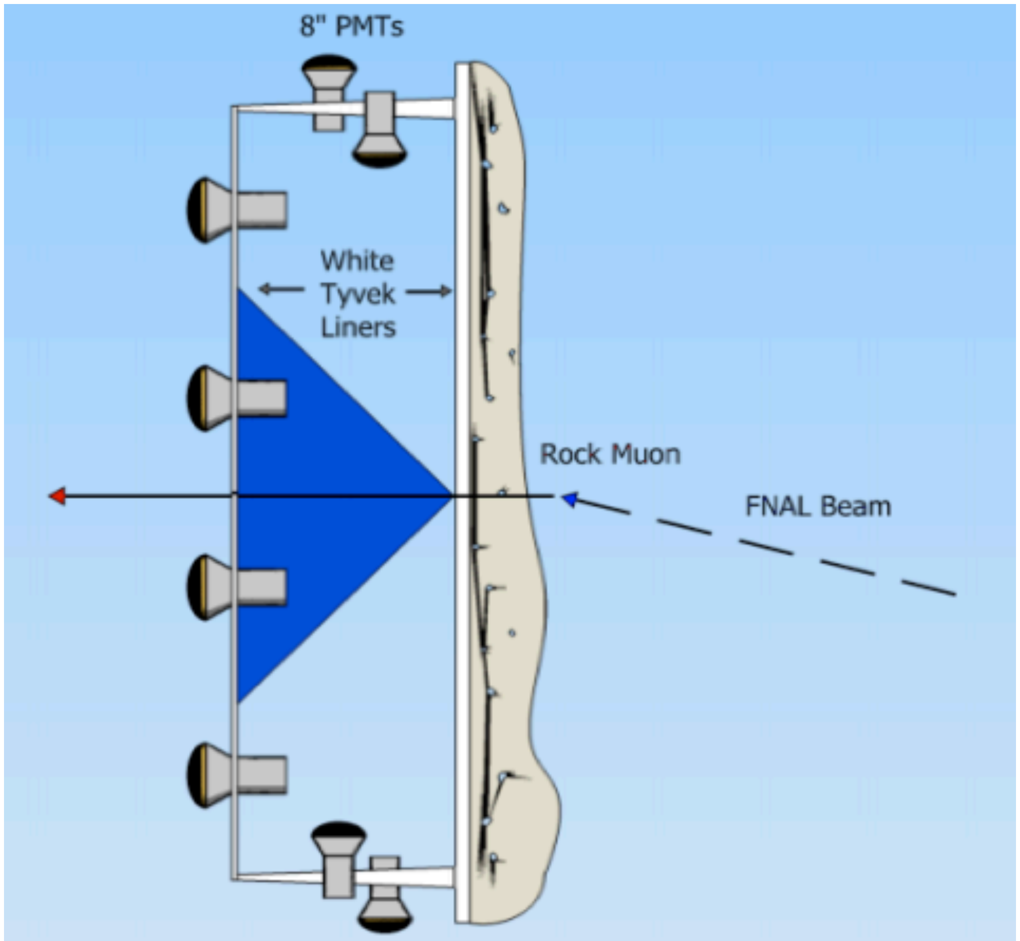
LBNE Work on a "Thin Veto"

- **Passive shield for gamma rays to allow detection of neutron capture on gadolinium**
- tagging of cosmic ray muons for atmospheric neutrino studies
- tagging of beam-associated entering muons
- How thick? How many PMT's?

Work by: R.Breedon, D.Danielson, J.Dhooghe, **J.Felde**, J.Thomson, R.Tobin

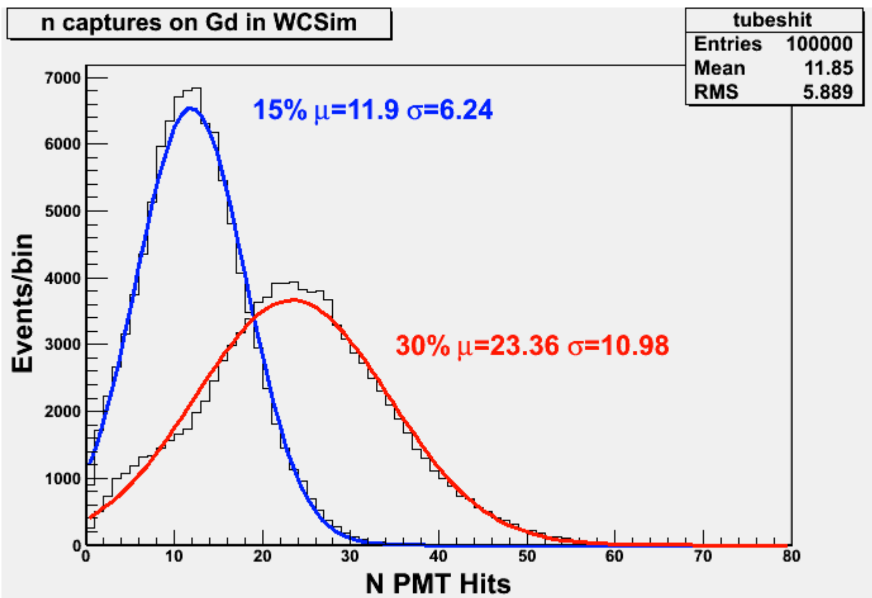
"Thin Veto"



- Space behind PMTs can be used as a veto
- PMTs looking into volume (like in KamLAND) rather than out (like Super-K)
- Less expensive, easy to make
- Is it good enough?

Recognition of n-capture

WCSim used to determine PMT hit
Levels in fiducial volume for coverage
With HQE PMTs.



- gamma rays from rock
- gammas from concrete
- gammas from PMT glass
- PMT dark noise
- radon

Parameters Used in Study

Concentrations			
Material	U	Th	K
Amphibolite	0.16 ppm	0.20 ppm	0.154%
Rhyolite	8.67 ppm	12.2 ppm	2.82%
60% - 40% Mix	3.564 ppm	5 ppm	1.22%
Concrete	2.02 ppm	1.87 ppm	0.23%
PMT Glass	67 ppb	25 ppb	16 ppm

← Identified as an average concrete, not a low radioactivity one.

See documents 729 and 101 on docdb for reference.

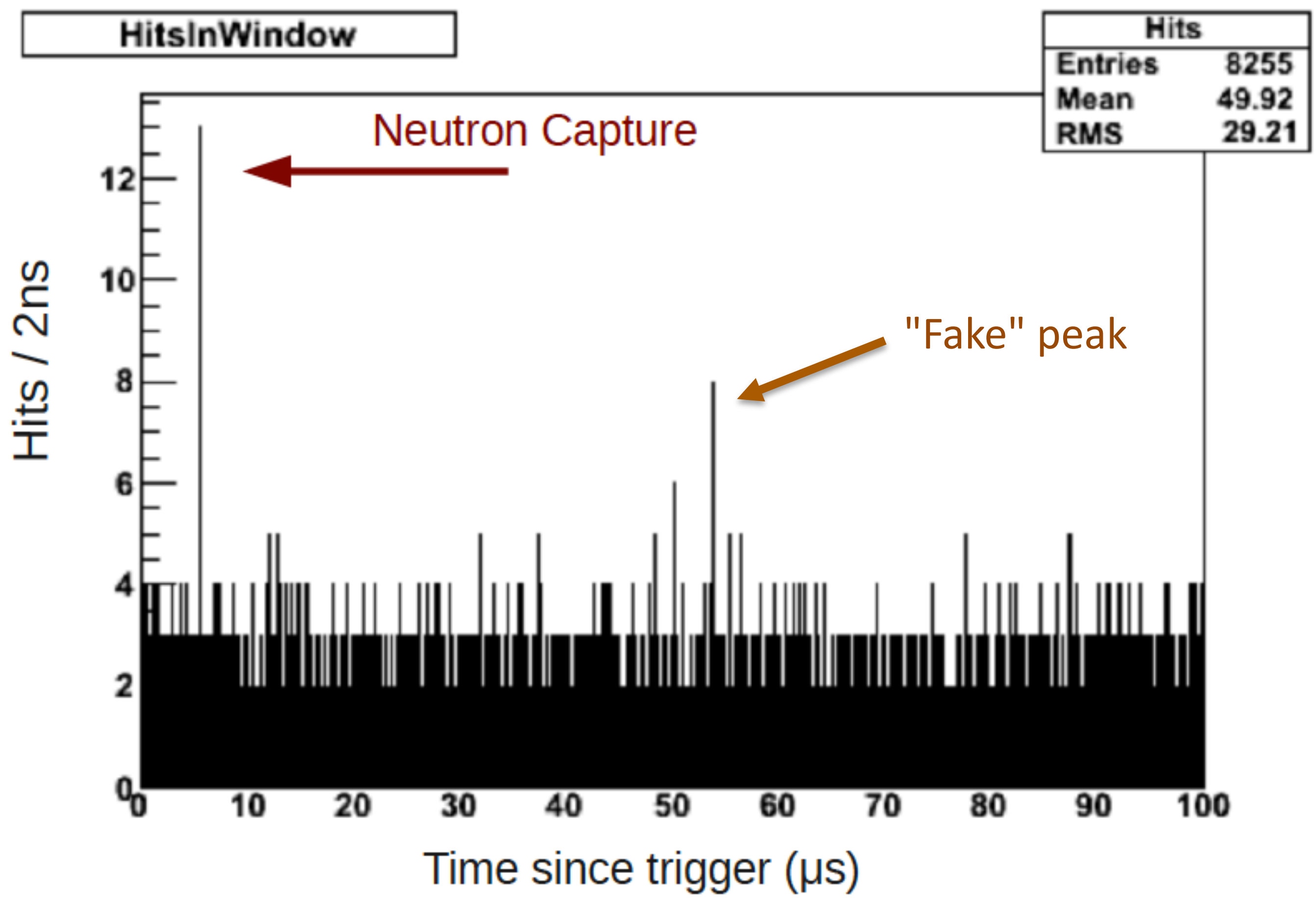
Radon rate is set to SK levels, 2 mBq/m^3 --> 280 Bq for 100kT detector

The dark noise rate is 1 kHz per pmt. Which assumes a cooled detector at 13°C

Combining Simulations

Based on the calculated activities and rates I simulate 100μs of data with PMT hits arranged in time from all processes.

The times have been corrected for photon time of flight from the smeared true vertex. I have assumed a vertex resolution of 50cm.

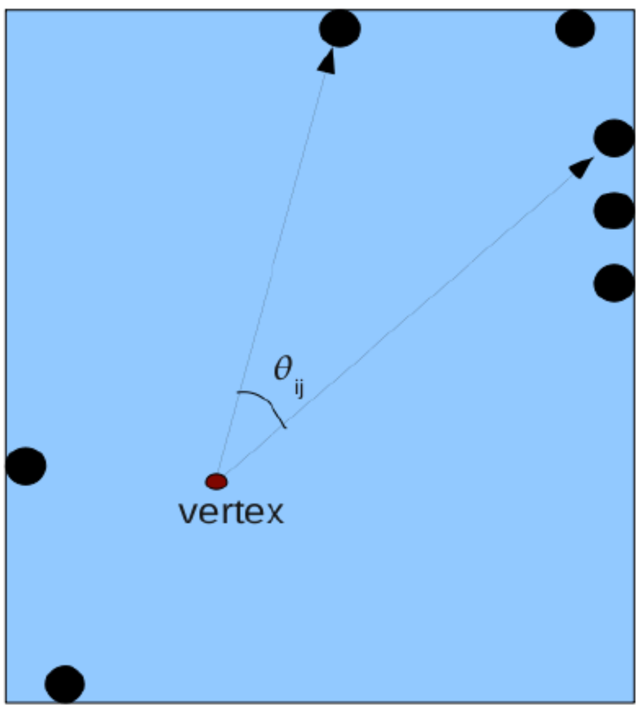


Identifying the neutron capture

For each 100μs sample I slide a 20ns window through all times and try to identify the time which corresponds to the capture time. The following likelihood ratio is maximized to determine the best 20ns window:

$$\frac{L(N,t;\mu_s,\tau)}{L(N;\mu_b,R_b)} = \frac{\frac{1}{N!}\mu_s^N e^{-\mu_s}\frac{1}{\tau}e^{\frac{-t}{\tau}}}{\frac{1}{N!}\mu_b^N e^{-\mu_b}R_b}$$

μ_s = average # hits including a n capture
μ_b = average # hits without a n capture
τ = neutron capture time
R_b = rate of background events.

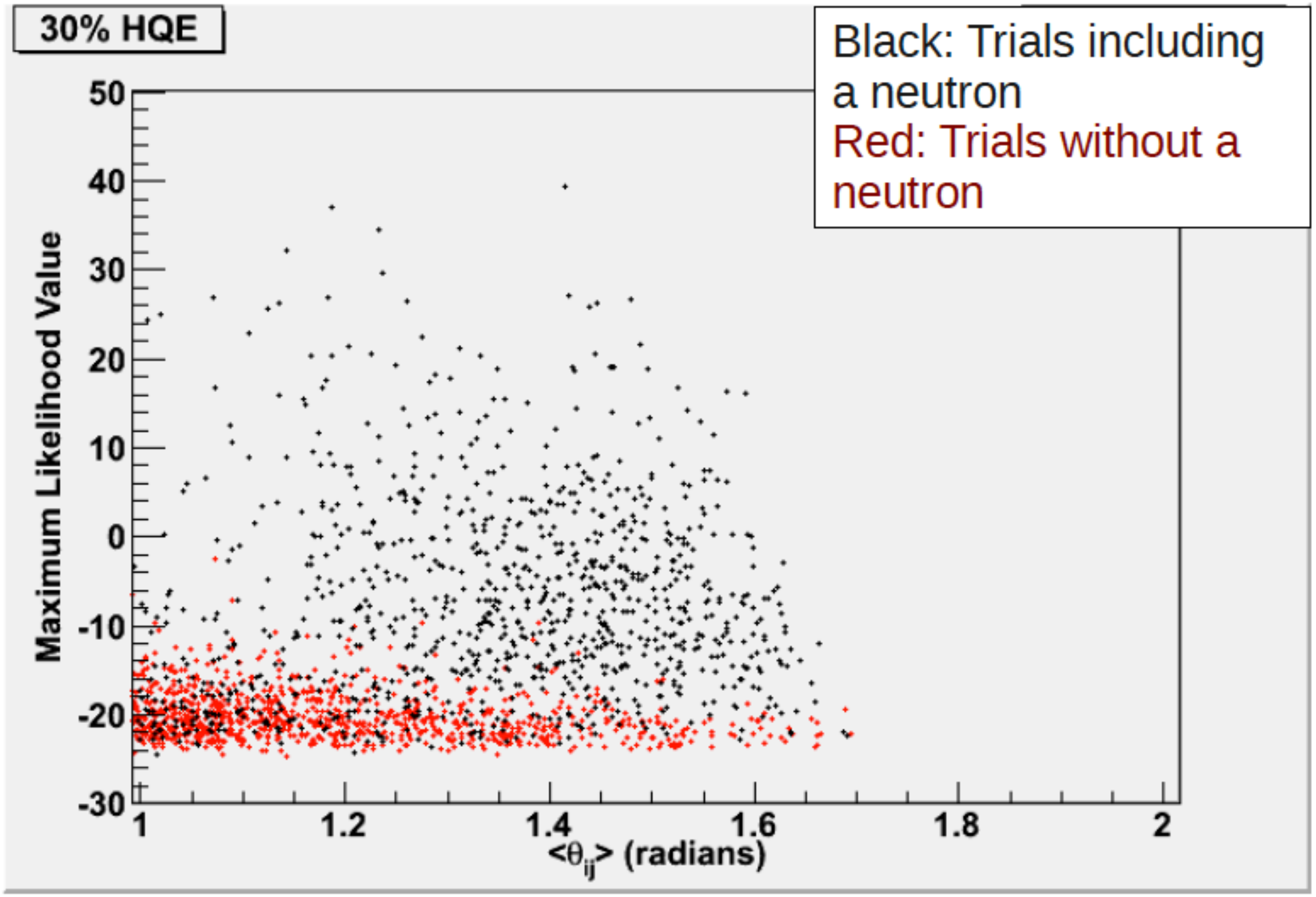


I have also made a cut on the "isotropy" of each event, requiring the hits have an average PMT pair angle greater than one radian. This is a powerful tool for removing events from external gammas.

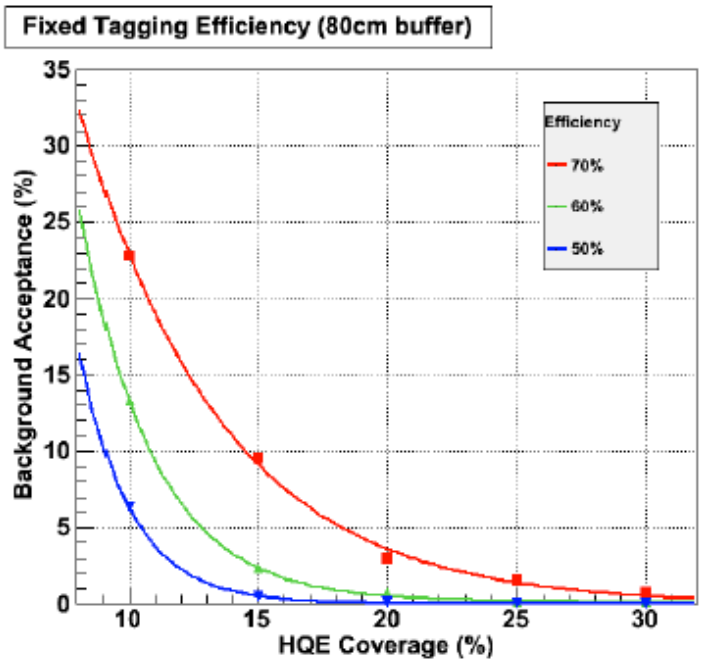
(This cut is from SNO)

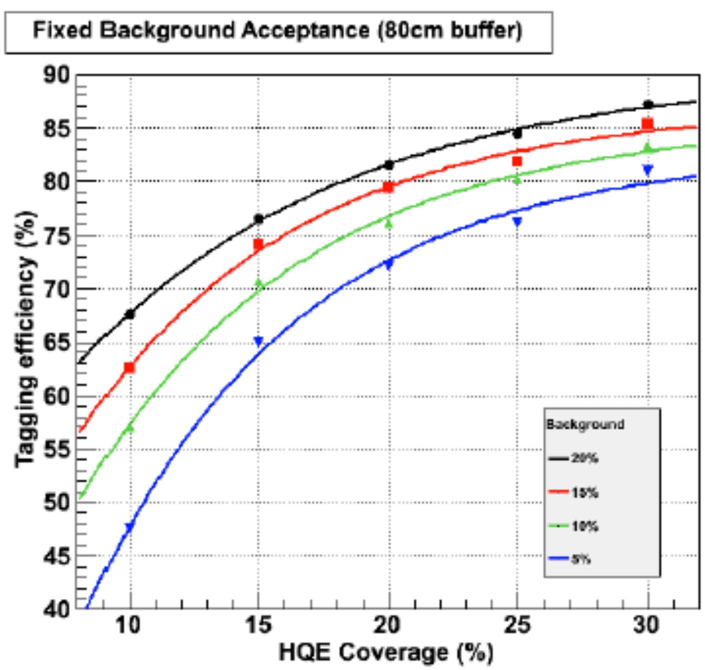
$$\langle\theta_{ij}\rangle = \frac{2}{N(N-1)}\left[\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\theta_{ij}\right] > 1 \text{ rad}$$

Distributions of Trials



For each detector configuration I generate the above distribution. I then apply simple cuts in this parameter space to select out the neutron captures. The neutron tagging efficiency and acceptance of background can then be evaluated.





The efficiency of this technique has been studied with an 80 cm thick veto. Two different scenarios: fixed efficiency and fixed background acceptance.

Most of the background comes from PMT dark noise. Need to pay special attention to this.

75.2%	from Gd
22.3%	from Dark Noise
2.3%	from gammas from Concrete
0.9%	from gammas from Rock
0.0%	from Radon
0.0%	from gammas from PMT glass

Conclusions

- Work has been to done optimize veto and other parameters for Gd-n capture detection efficiency. PMT dark noise is a major factor. Radon and gammas from rock less important.
- We also build a prototype to test muon efficiency – but that's another talk. LET'S PARTY.