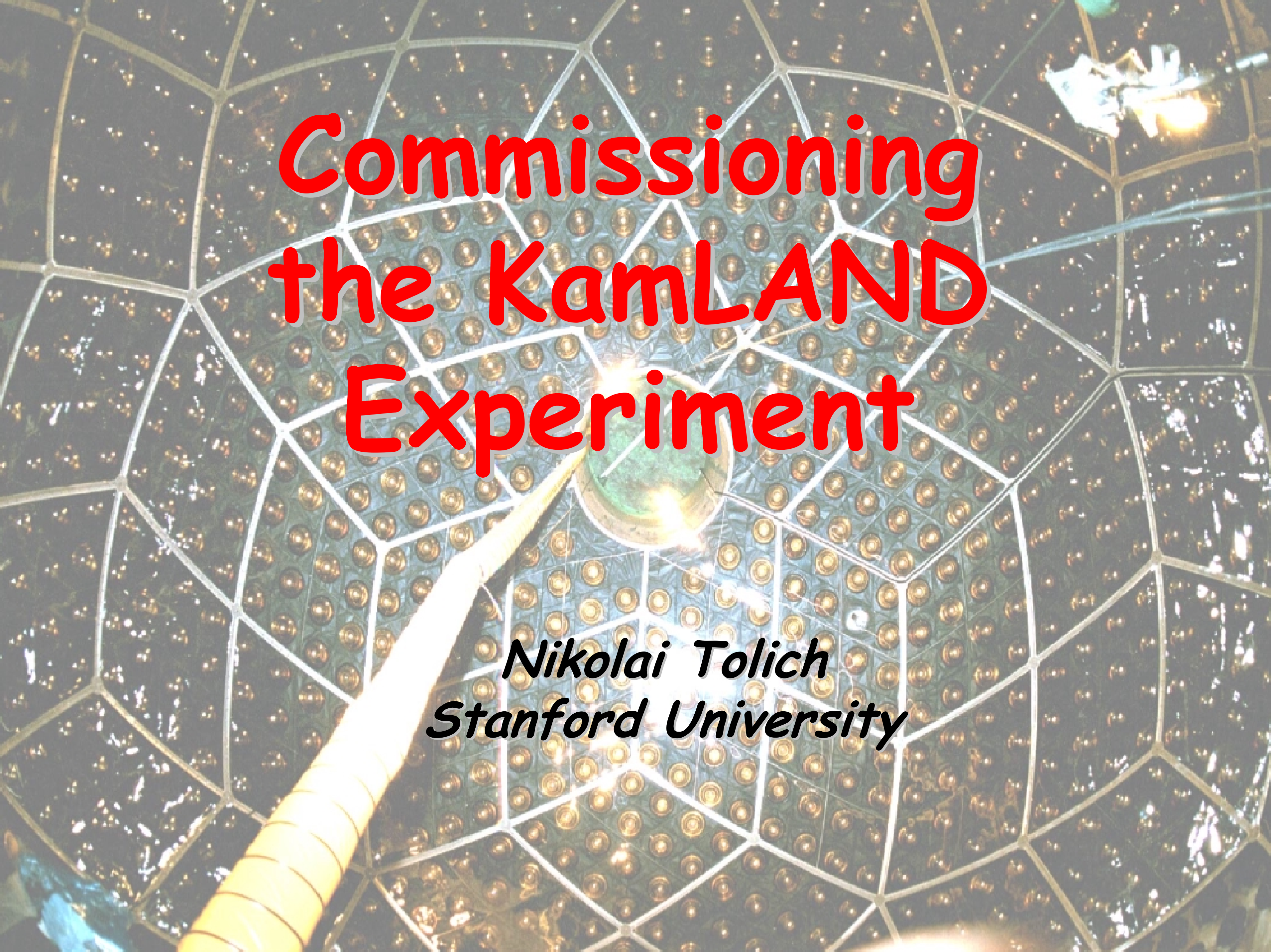

Commissioning the KamLAND Experiment

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The KamLAND Collaboration

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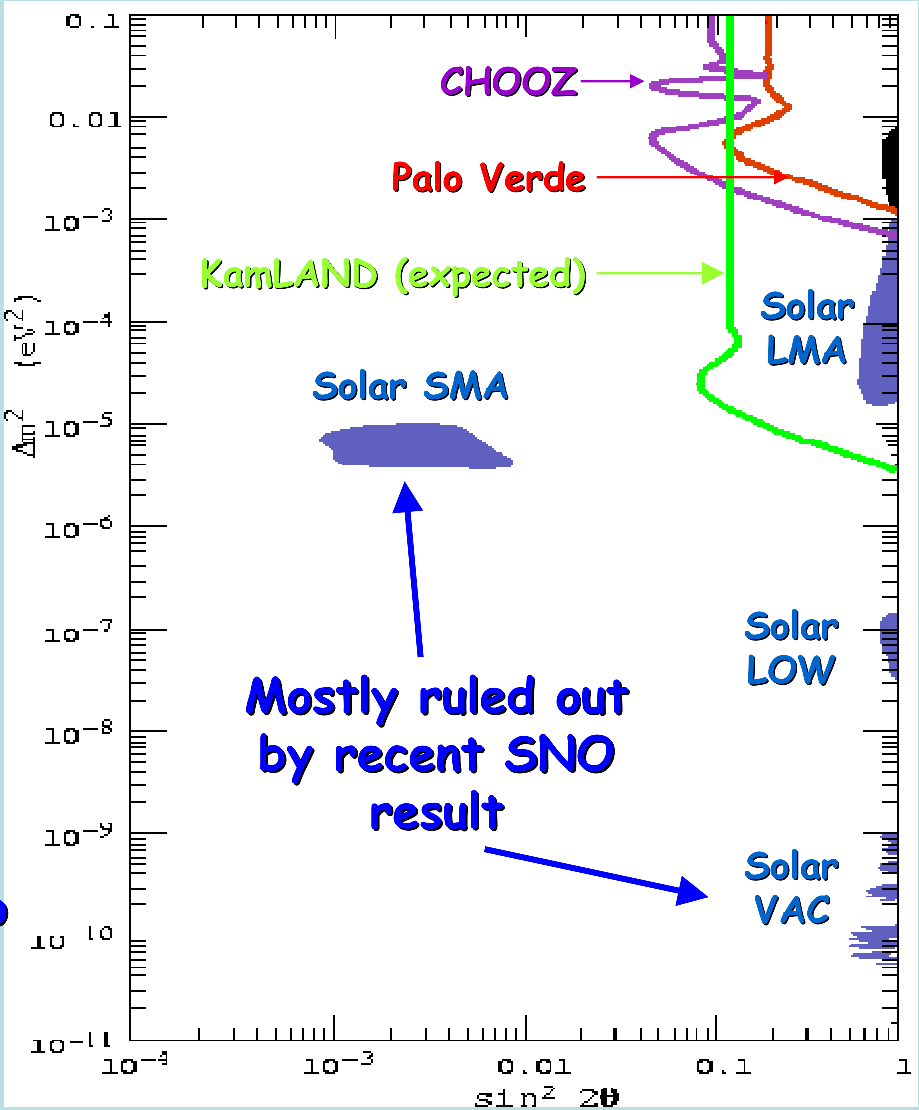
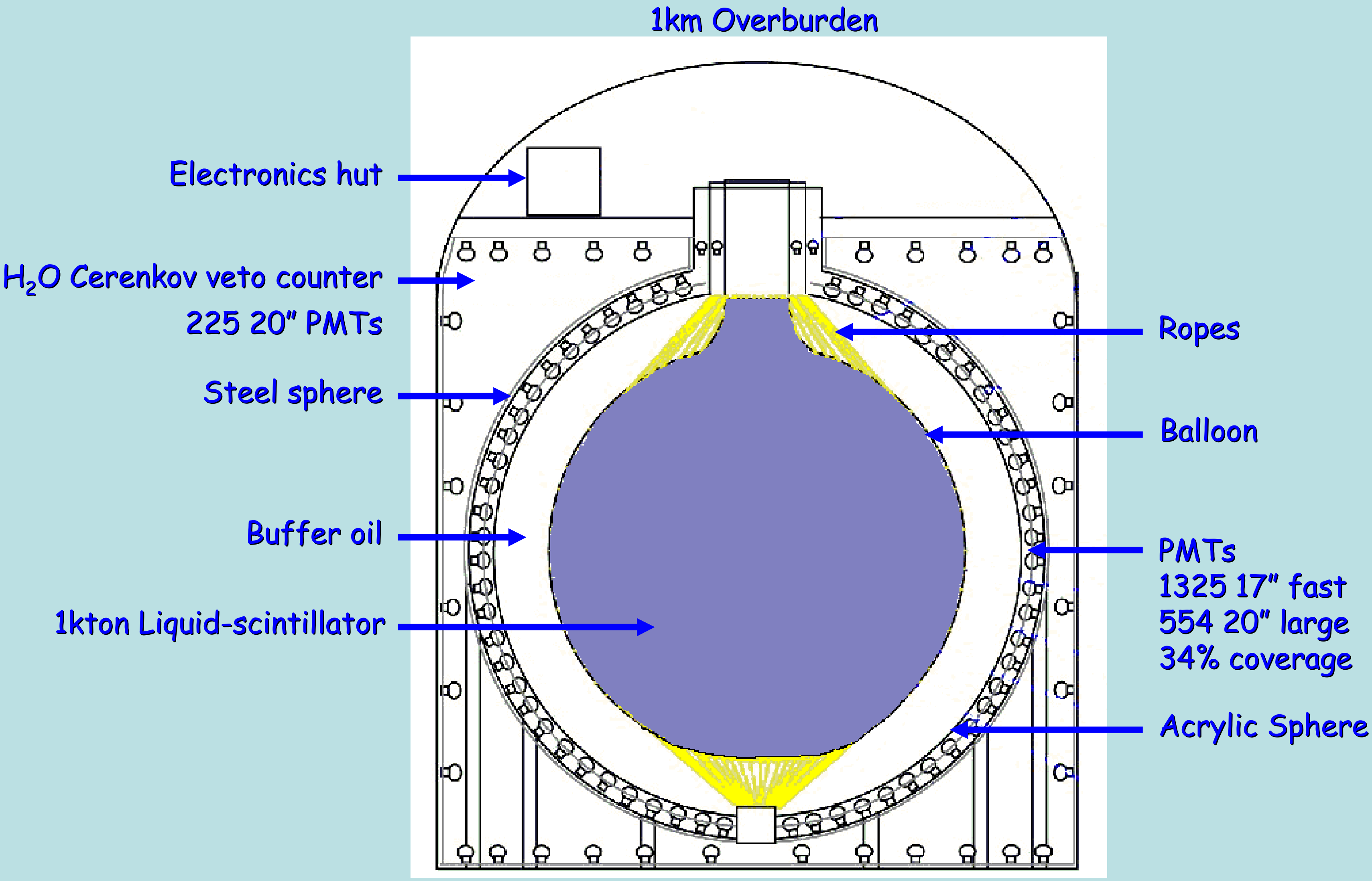
Solar LMA solution within reach

- KamLAND (Kamioka Liquid-scintillator AntiNeutrino Detector)
- Liquid-scintillator allows us to probe lower neutrino energies than water Cherenkov detectors
- KamLAND is studying the disappearance of electron anitneutrinos produced in nuclear reactors
- The reactor baseline is limited with 85.3% of the signal coming from reactors with a baseline of 140 km to 344 km Giving an expected Δm^2 sensitivity of $7{*}10^{-6}$ eV^2

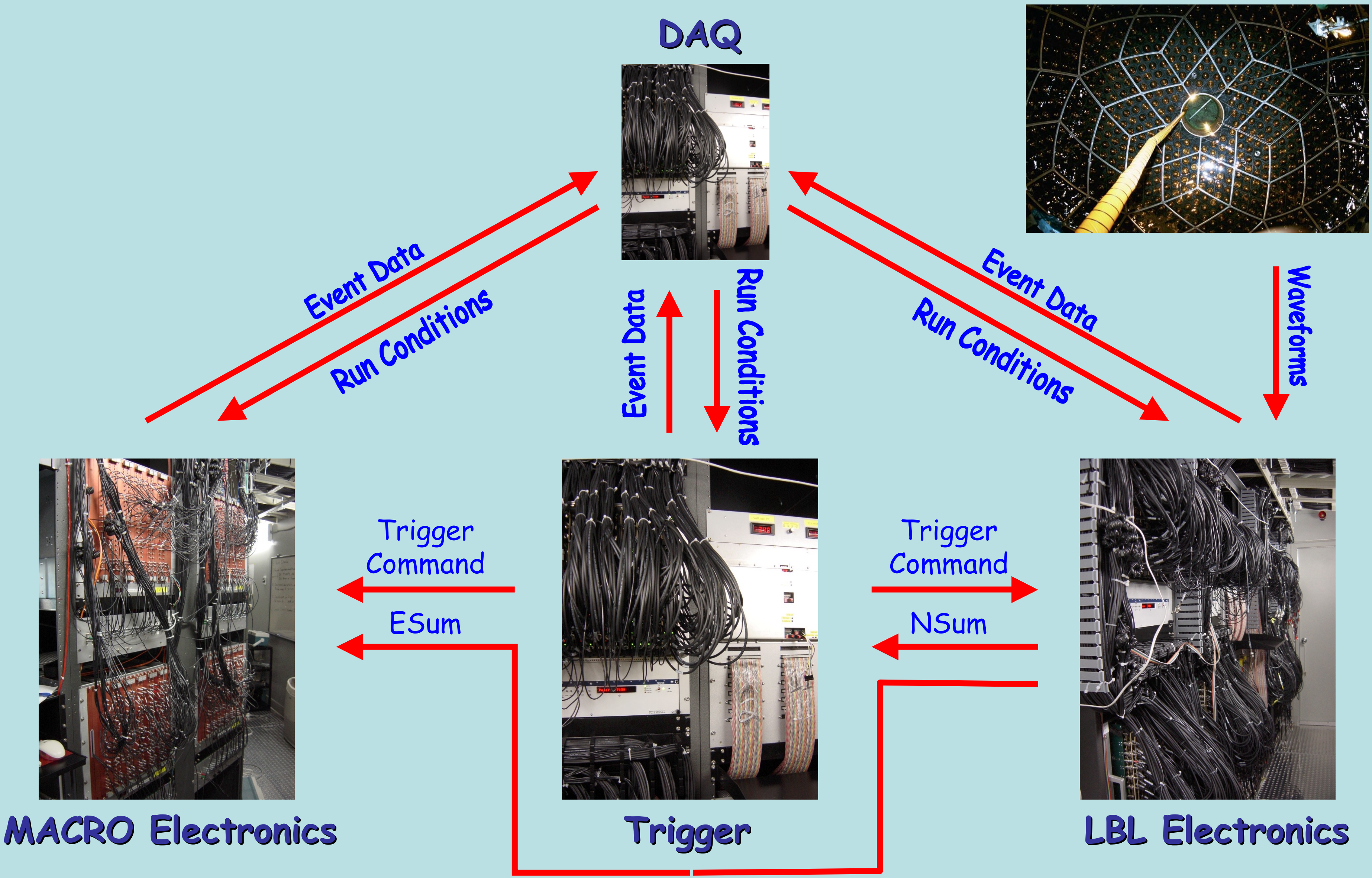


The Detector

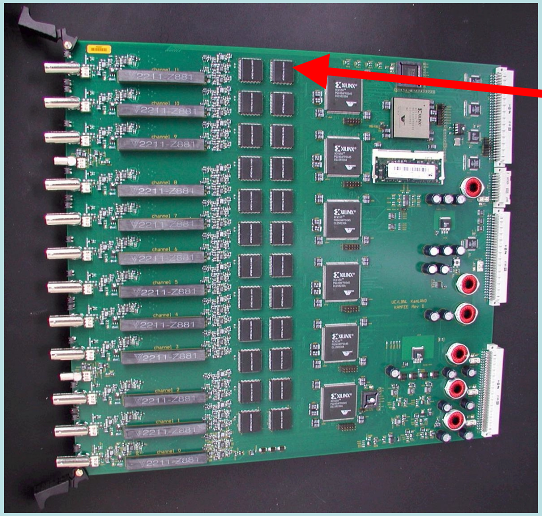


The Electronics

PMTs

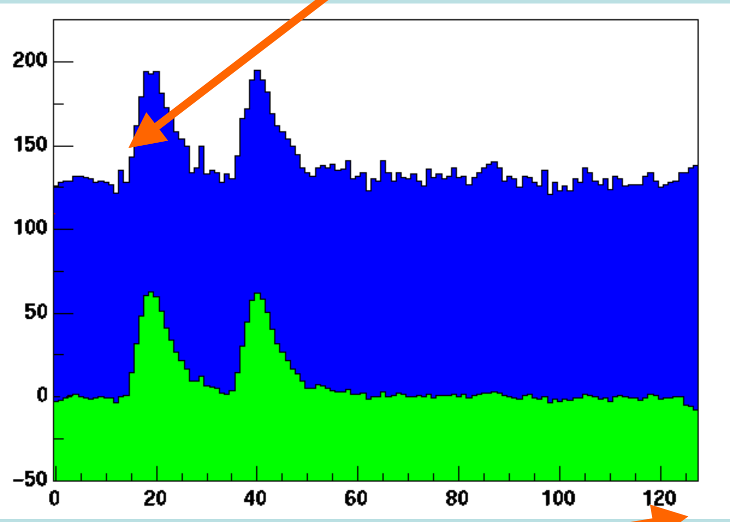


The LBL Electronics



- Waveforms for each PMT are recorded using Analogue Transient Waveform Digitizers (ATWDs) Allowing multi p.e. resolution

- The ATWDs are self launching with a threshold ~1/3 p.e.



- Each PMT is connected to 2 ATWDs Reducing deadtime

- Each ATWD has 3 gains (20, 4, 0.5) Allowing a dynamic range of ~1mV to ~1V

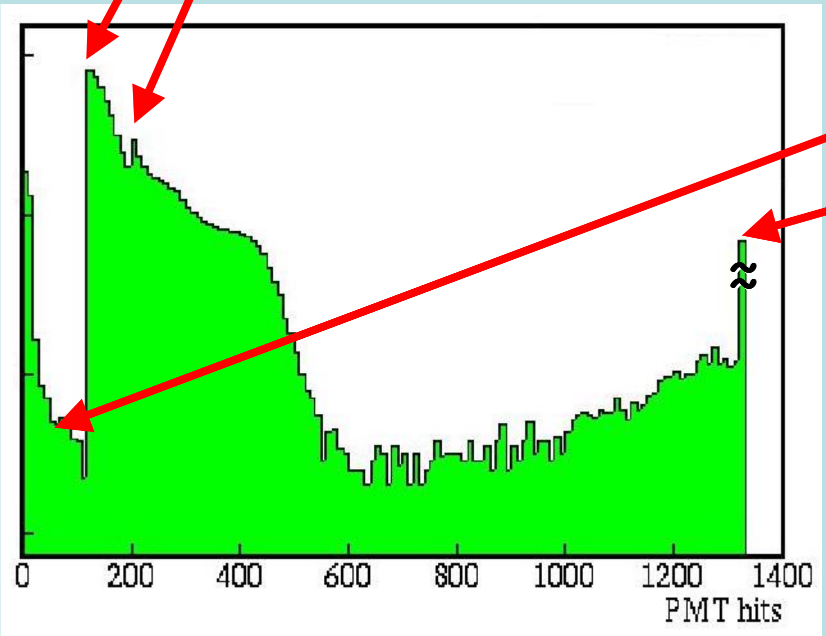
- There are 128 samples per waveform with a sample time of 1.5ns

The Trigger

- The trigger receives the number of PMTs above threshold on each FEE board every 25ns ~4 Gbytes/s

- Based on the PMT hit pattern a capture command is sent to the LBL and MACRO electronics within 200 ns

  - Delayed trigger > ~0.5MeV less than 1ms after Prompt
  - Pre-scaled trigger > ~0.5MeV for 0.1ms every second
  - Prompt trigger > ~0.8MeV

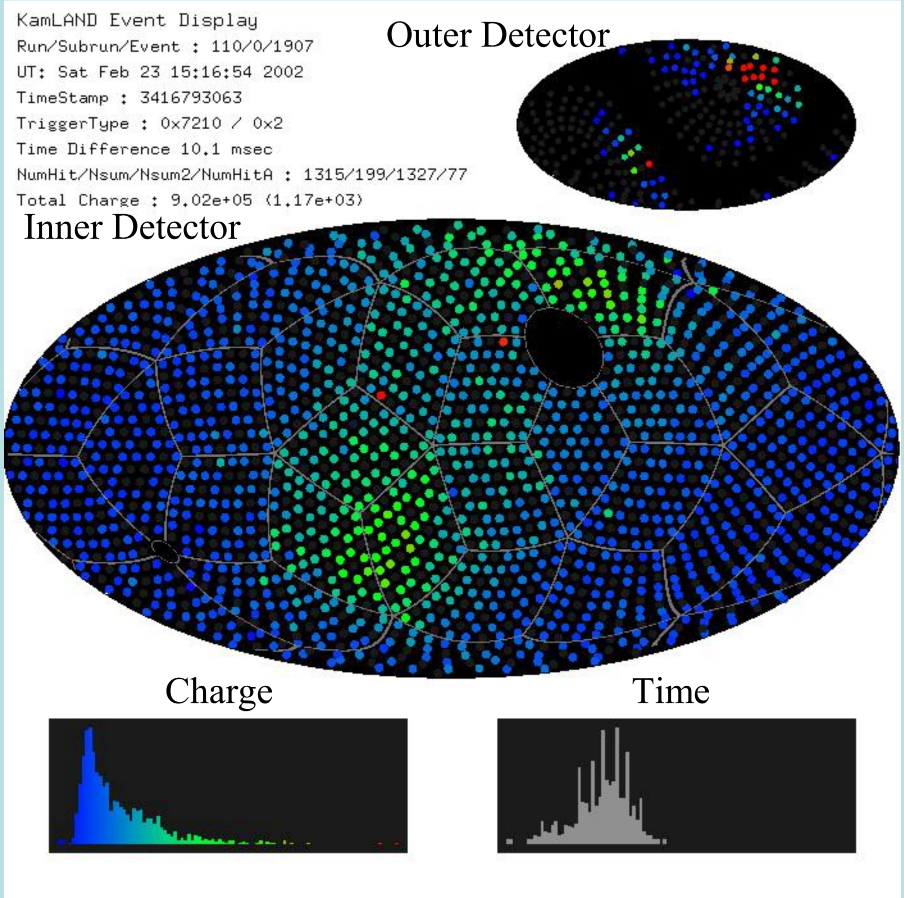


- Non physics triggers
- Muon events all PMTs fire

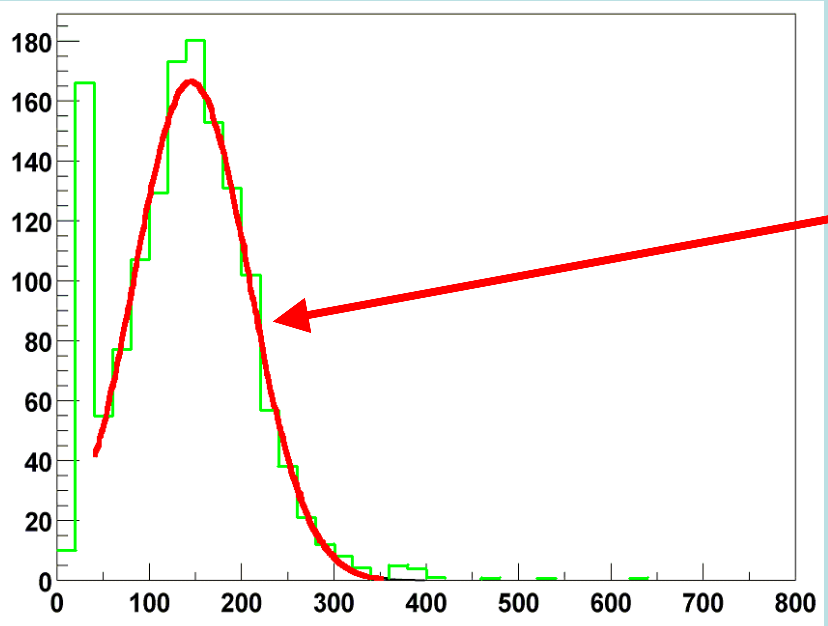
- Supernova "burst trigger"
48 events > 4MeV in 1s

DAQ

- KamLAND uses KINOKO for DAQ
- KINOKO is a linux based DAQ system developed for KamLAND
- Each VME crate is connected to a separate front end PC running a KINOKO process
- The data from each front end PC is sent to a control PC
- The control PC is responsible for setting the run conditions, recording, and displaying the data

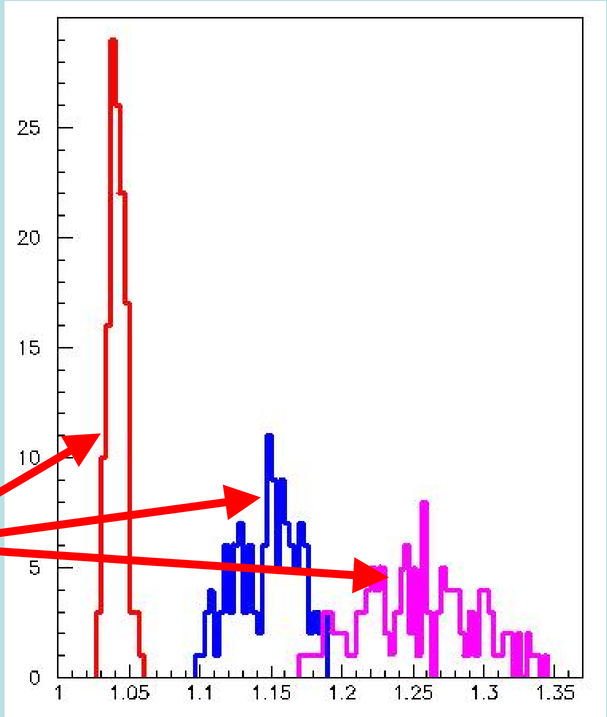


Gain Calibration



Charge

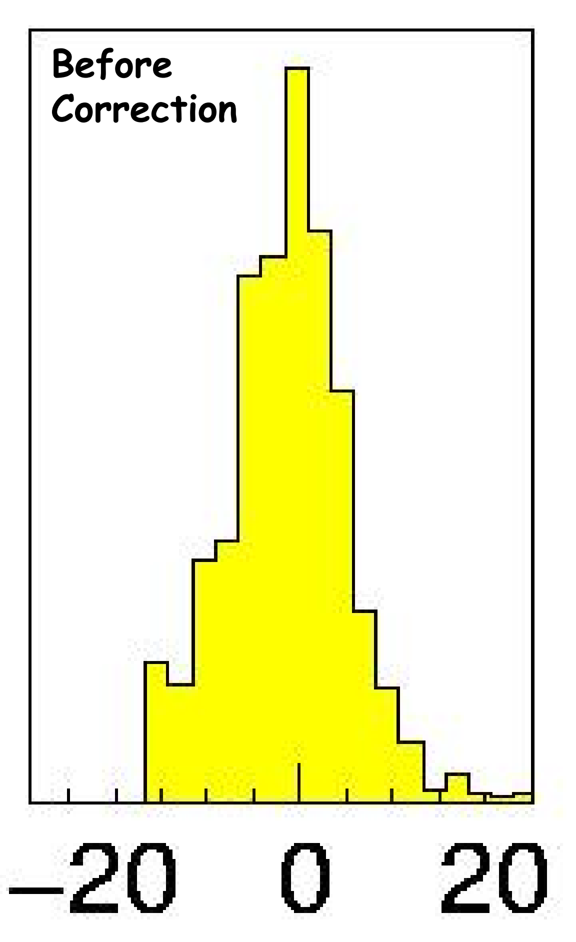
- Gain calibration has been done at 1p.e. level with peripheral LEDs
- Very good quality single p.e. peak
- For gain calibration at higher p.e.'s we used a nitrogen laser
- The laser intensity was controlled within 15% using different filters



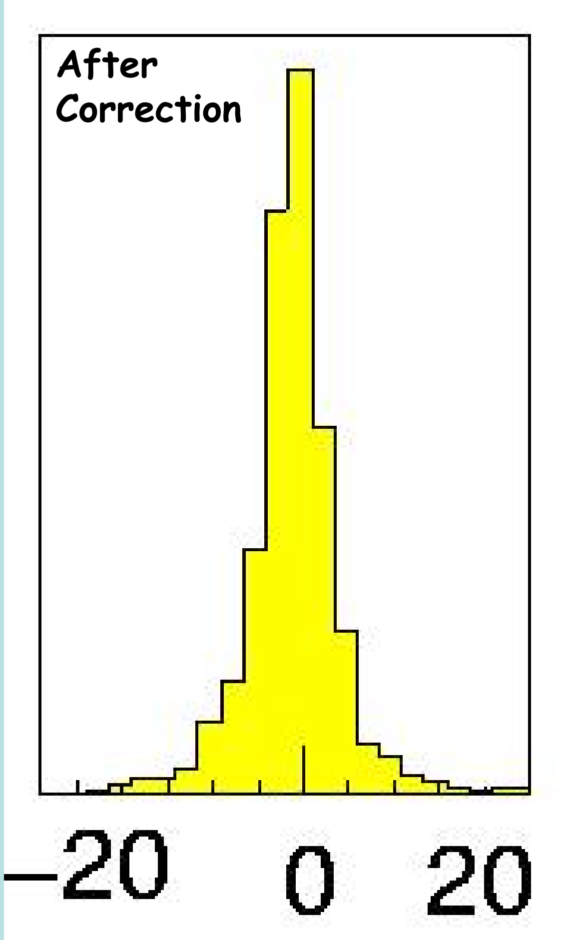
p.e.'s

Timing Calibration

Event Time All Tubes



ns

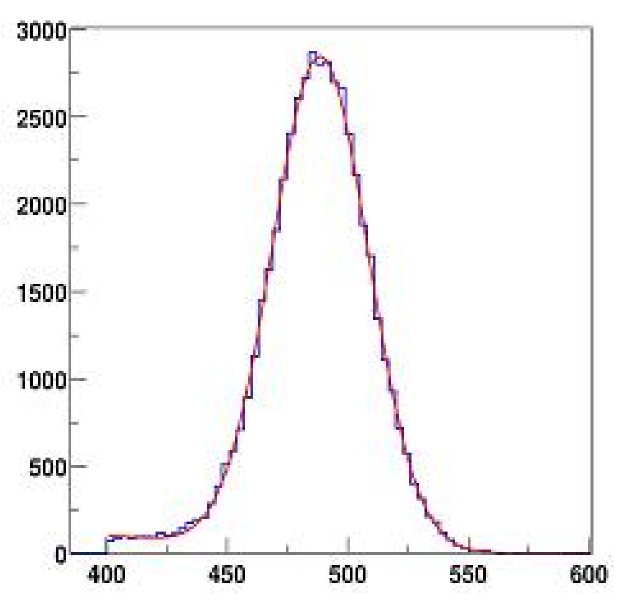


ns

- Timing calibration was done using a dye laser λ=500nm
- The liquid scintillator is transparent at 500nm
- This correction is waveform analysis dependent, we may be able to do better

Energy Calibration

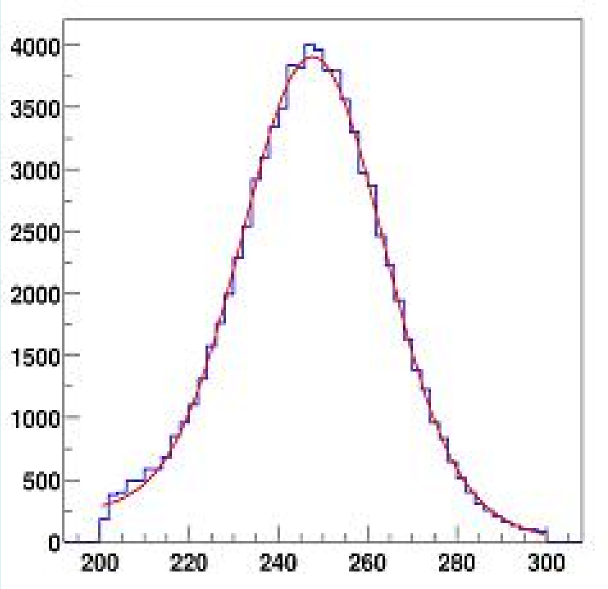
^{60}Co 2.505 MeV γ+γ source



NSum

- So far two sources have been placed in the detector, ^{60}Co & ^{65}Zn
- The light yield is very high 241 p.e./MeV

^{65}Zn 1.115 MeV γ source

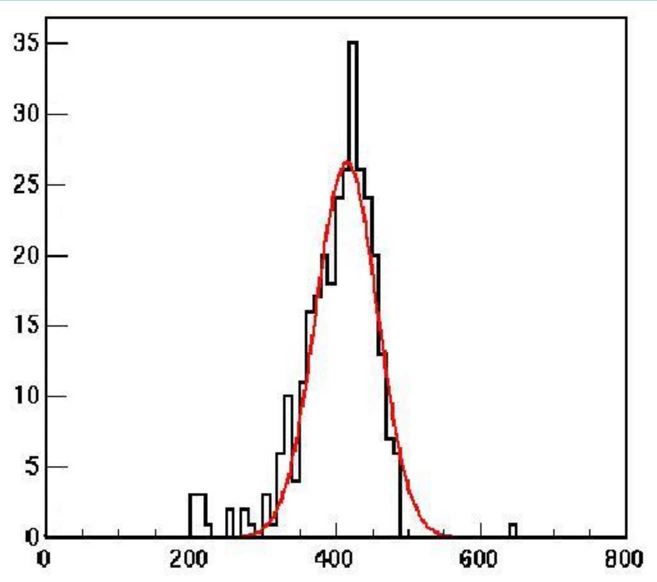


NSum

- Soon we will deploy a ^{137}Cs 0.662 MeV γ source and a AmBe 4.4 MeV neutron source

Energy Calibration 2

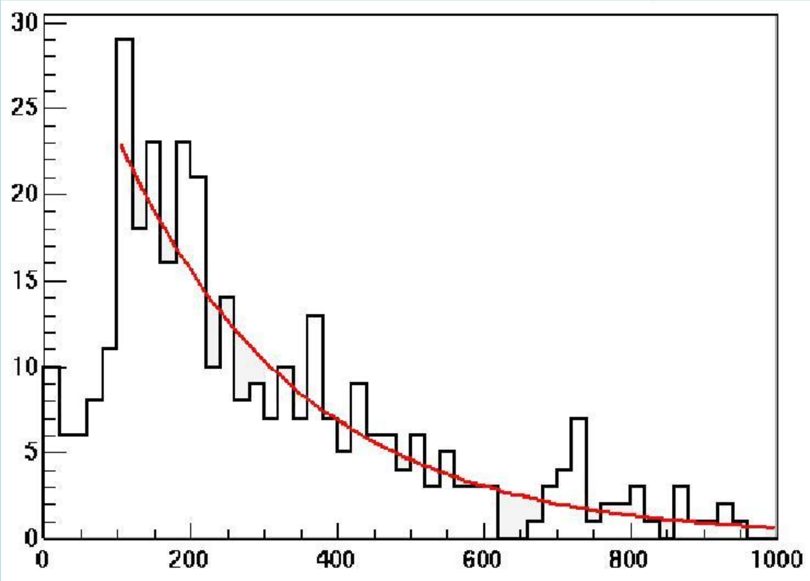
Neutrons following muons



NSum

- Following muons we get neutron events, these allow us to calibrate the energy for neutrons
- The energy of this peak is consistent with a 2.2 MeV n-capture

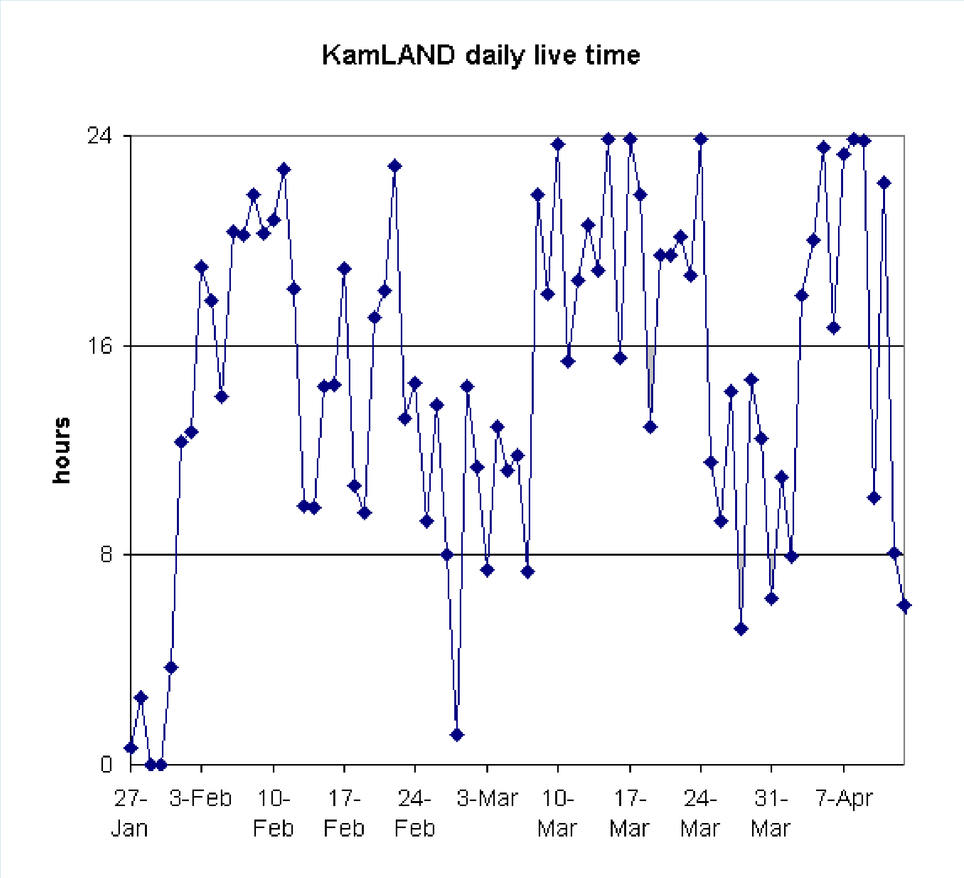
Time since muon



μs

- The capture time of 189±19μs is consistent with the expected value of 180 μs

Data is now coming in smoothly…



stay tuned for results…