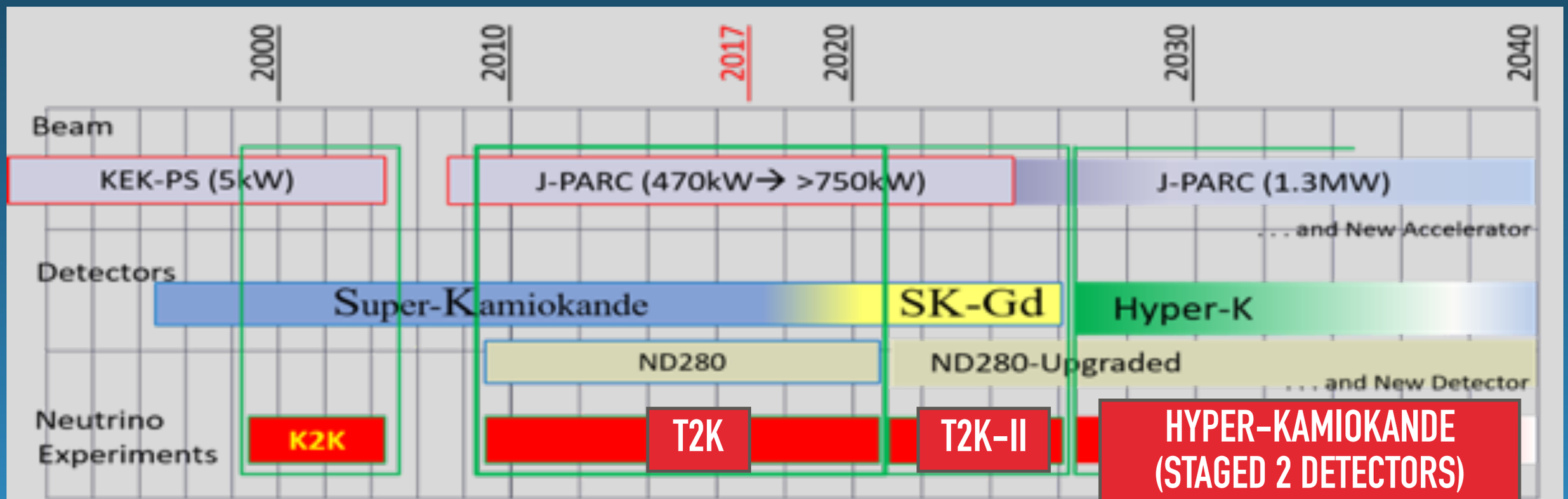
JENNIFER COLLABORATION MEETING
PARIS, OCTOBER 30-31 2018

FRANCESCA DI LODOVICO (QMUL)

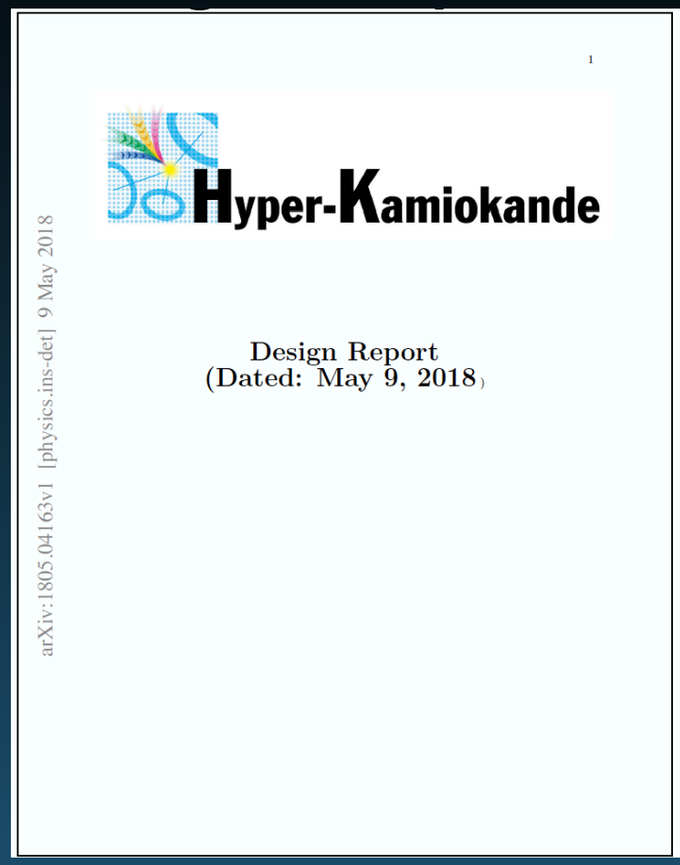
OVERVIEW OF WP4 (HYPER-KAMIOKANDE)

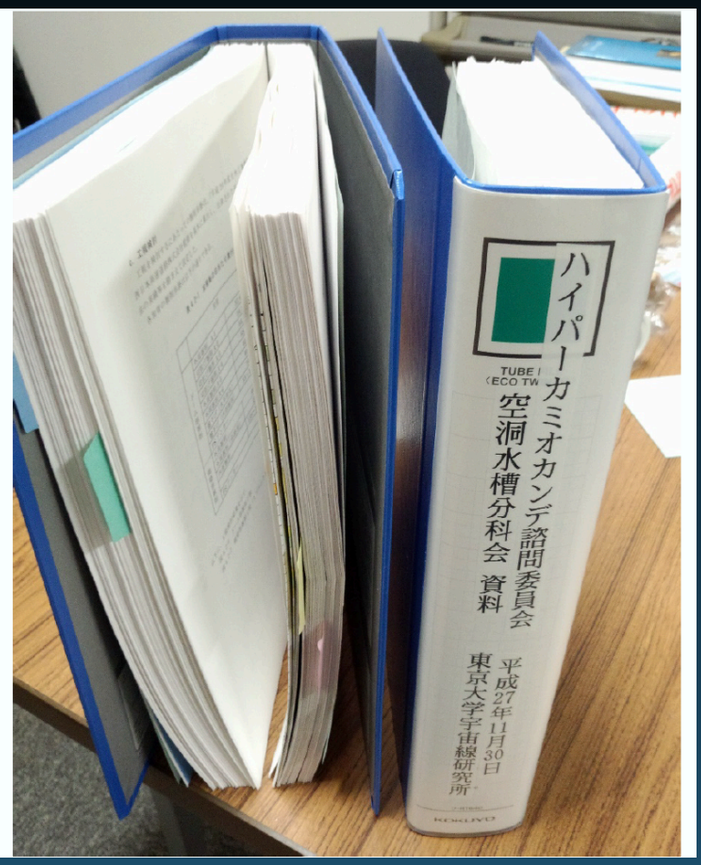
INTRODUCTION

- **W4 was overall very successful:**
  - Our design studies are accepted and moving towards construction (Hyper-K is approved to start construction in 2020).
  - Strong collaboration with Japanese and several important leadership positions in the experiment.
  - As a consequence of our work we have been invited and accepted to join Super-Kamiokande -> WC as Hyper-K, it can give experience and test ground for Hyper-K.



DESIGN REPORT HAS BEEN RELEASED





- Our work is reported in the three following documents from the collaboration:
  - **"Hyper-Kamiokande Design Report", arXiv:1805.04163** May 9, 2018. 333 pp.
  - **"Hyper-Kamiokande Technical Report" is being internally reviewed** - timescale for completion 2019
  - Other recent references:
    - **Physics potentials with the second Hyper-Kamiokande detector in Korea** PTEP 2018 (2018) no.6, 063C01

WORKING AREAS

- The areas in which we worked on are:
  - Beam (talk by Chris Densham)
  - Photosensors. Focussing on the 3" PMTs for two systems: mPMTs and Outer Detector (talk by Gianfranca de Rosa)
  - DAQ and Triggering. Developed new software (ToolDAQ, UK).
  - Calibration. A few methods, but the optical system was deployed at Super-K during the refurbishment and will be used in the future running of the experiment.
  - Analysis and software: we provided the sensitivity studies for both the Hyper-K detector and the second detector in Korea as well as being responsible of the software release and production.
  - Finally, we worked on the near detectors:
    - High Pressure TPC (talk by Federico Sanchez)
    - TITUS -> E61 (after merge with nuPRISM). All above work is being applied to E61 as well and furthermore, we are working on the Gadolinium concentration measurement and simulation.

TRIGGERING

Investigating triggering down to 3 MeV

- Combination of test vertices trigger and cone information looks promising
- Determine required stability of PMT calibration
- Rejection of wall radioactivity events is promising
- Inclusion of charge to reduce PMT radioactivity events is under investigation

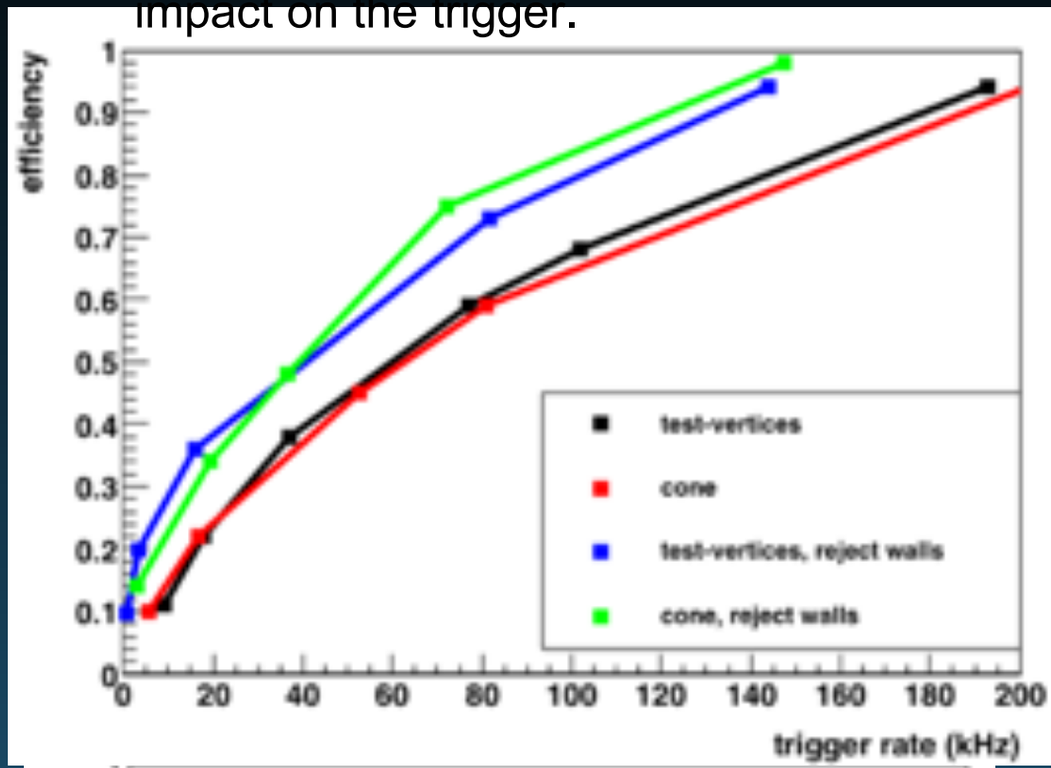
Near detector triggering

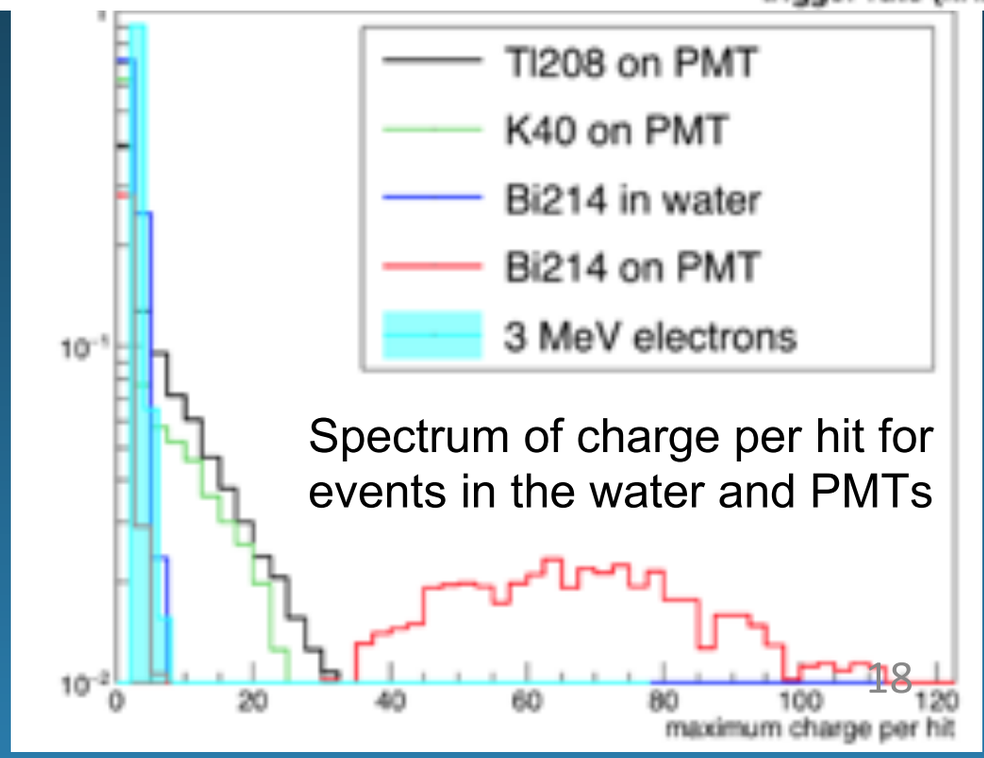
- Studies of trigger window and pile-up nearing completion.

Supernova triggering and monitoring

- Super-K type trigger being implemented/ tested

Rejection of wall radioactivity events and its impact on the trigger.



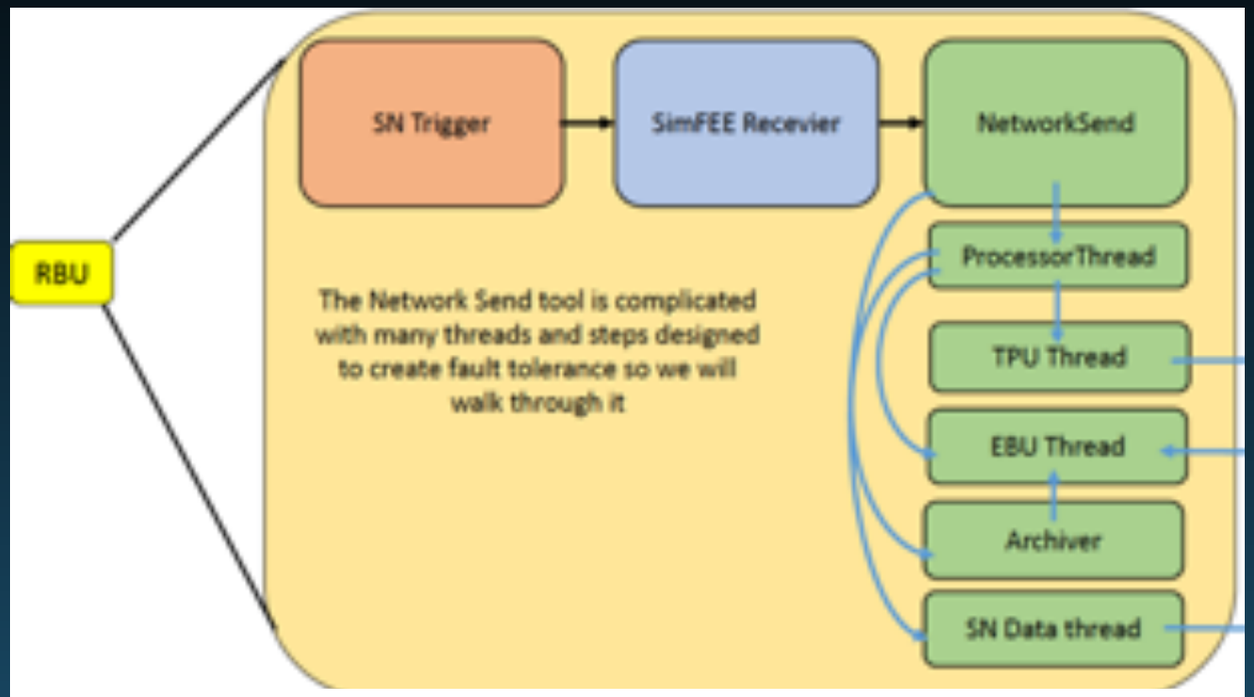


Spectrum of charge per hit for events in the water and PMTs

DAQ

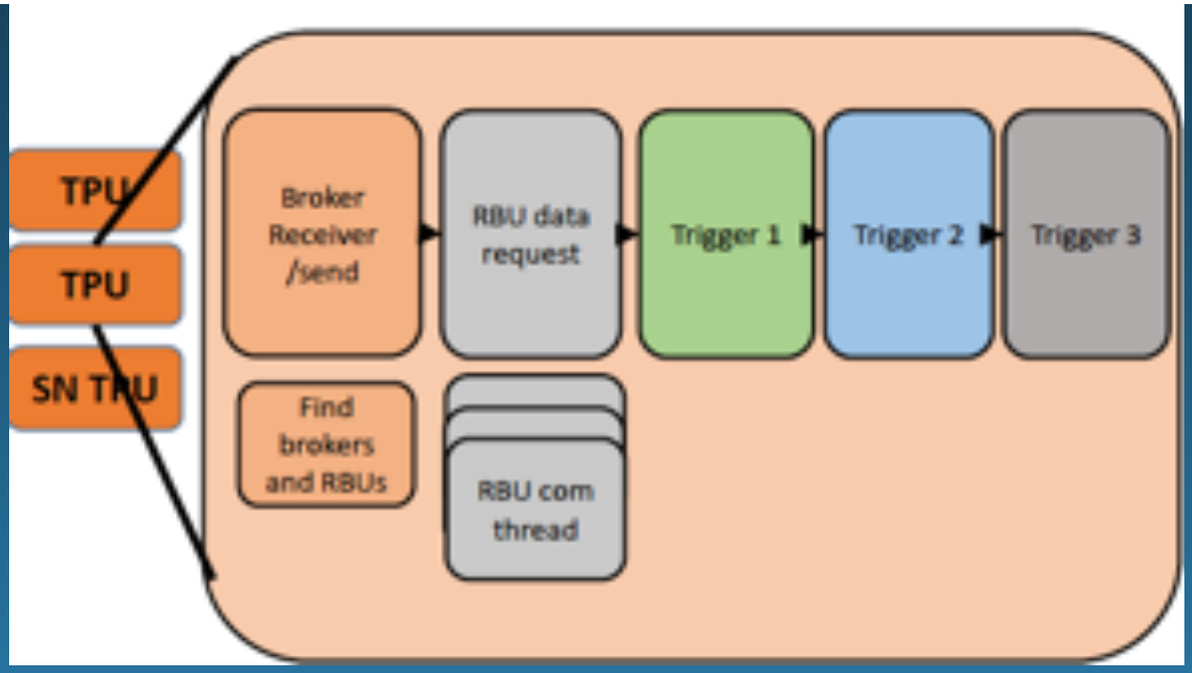
Framework Chosen

- ToolDAQ framework
- Design developing nicely
- Tests undertaken on DAQ teststand
- Built in fault tolerance - key to ensure high supernova livetime



Data format under discussion

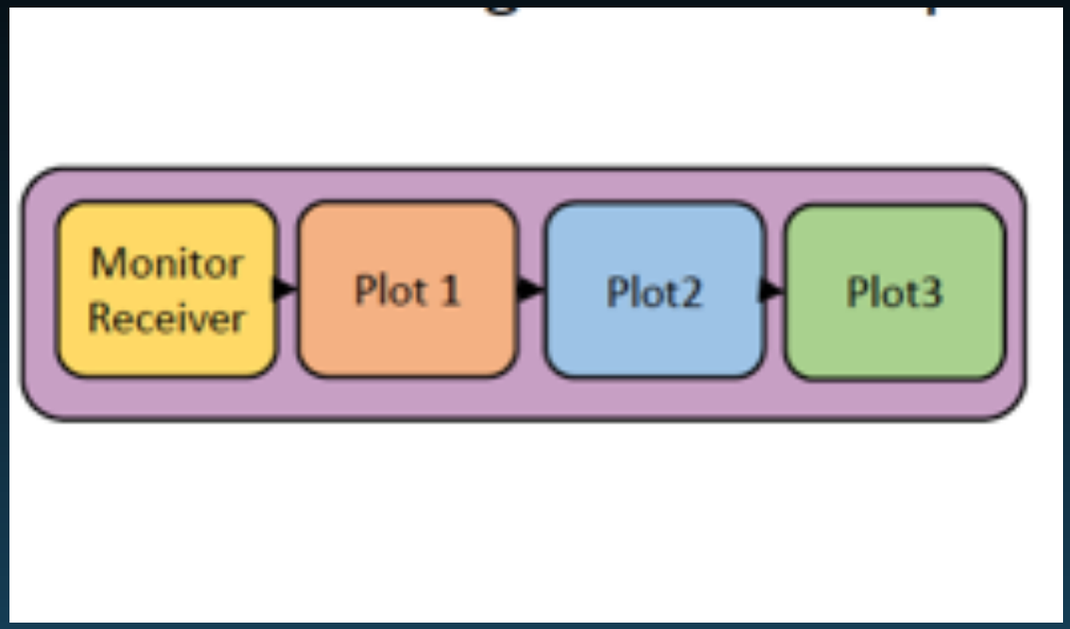
- Working on common data format/ structure for MC and “data” files
- Discussions with software/ computing group regarding interface between WCSim and ToolDAQ

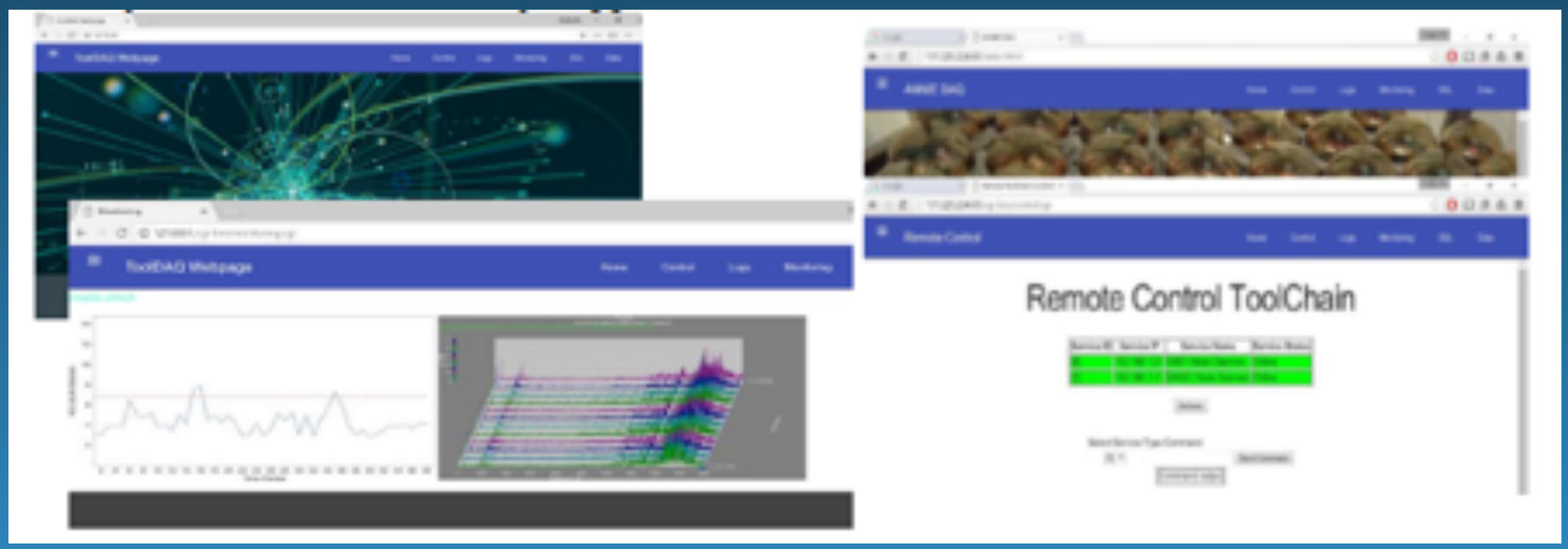


DAQ

Monitoring and control

- Under development
- Web-based, easy to use design
- Docker container simplifies development
- Interfacing event display into monitoring chain
- Creating supernova monitoring stream





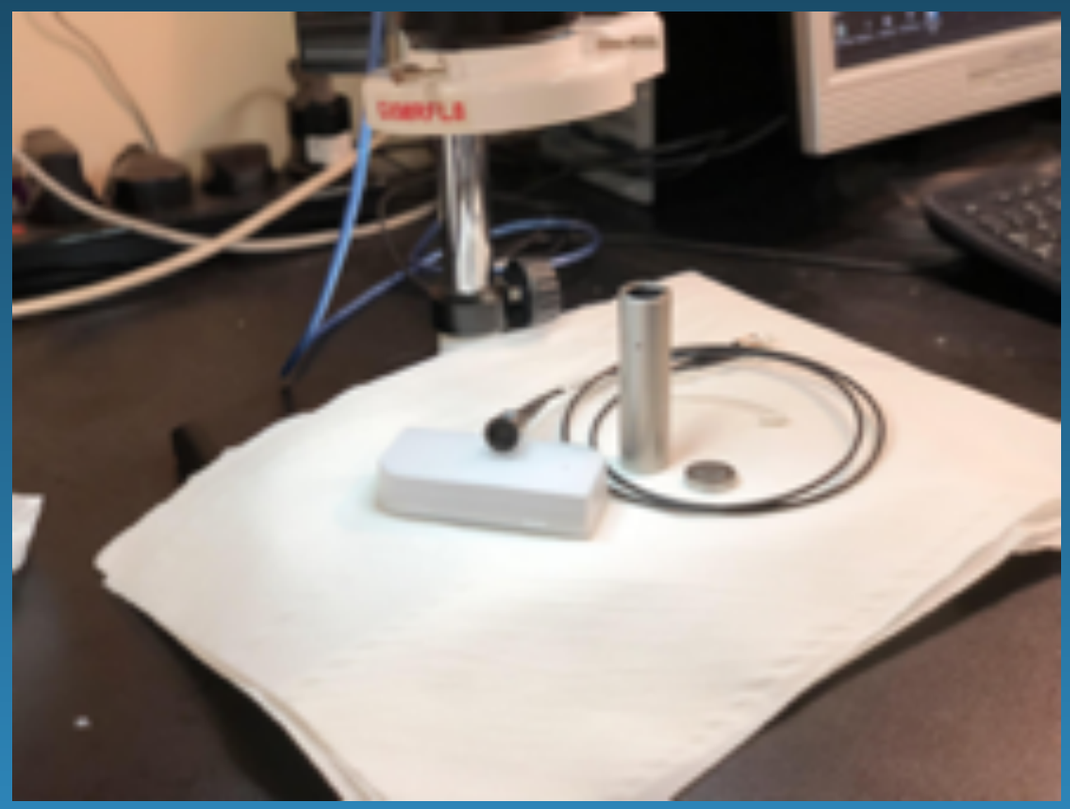
CALIBRATION

InBuilt calibration system

- Deployment of full system in SK almost completed.
- Diffusers and fibres Jun – Aug 2018
- B1 on June 29th
- Electronics Oct 2018
- Test deployment in SK occured Jan 23rd using available vertical injection point.
- Data analysis showed redesigns required for collimator, now complete and installed.

Test deployment system at SK.

Completed diffuser plate



GADOLINIUM CONCENTRATION MEASUREMENT

Optical system to measure the Gd concentration in water

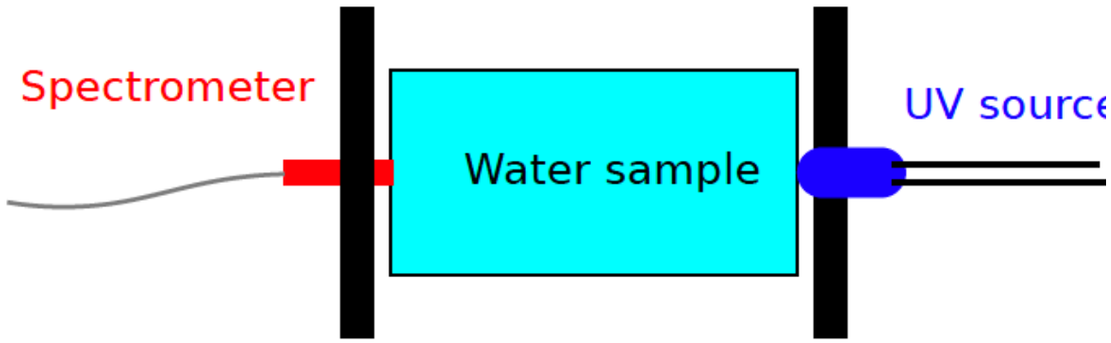
The concentration of Gd in water affects the **efficiency** and **timing** of neutron captures $\Longrightarrow$ measurements of antineutrino rate is affected.
It is fundamental to measure the concentration **regularly**: it can change in time inside the tank (**temperature** and **flow** dependency).

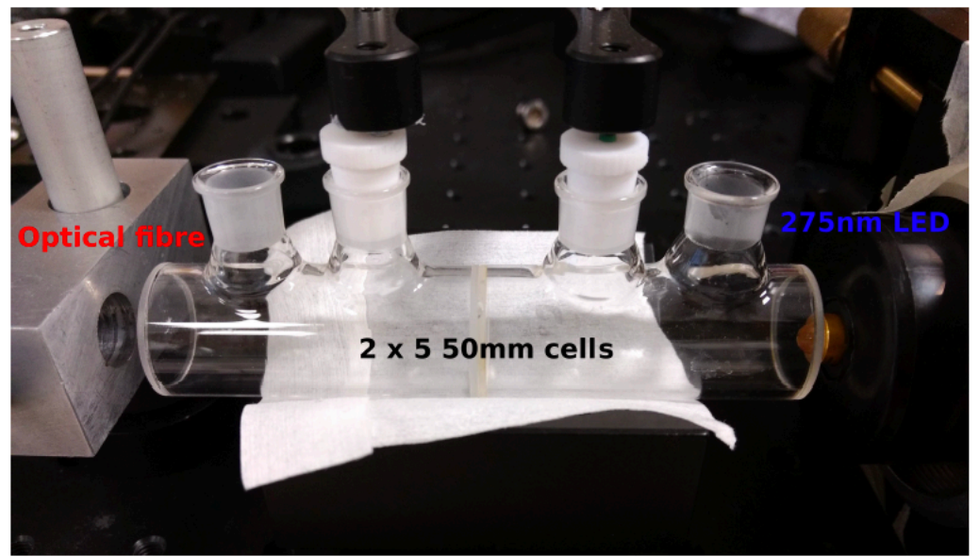
Idea

- Measure absorption lines of Gd, around 275 nm.
- Using a UV source and a spectrometer
- Extract the absorbance A
- Absorption is directly proportional to Gd%.

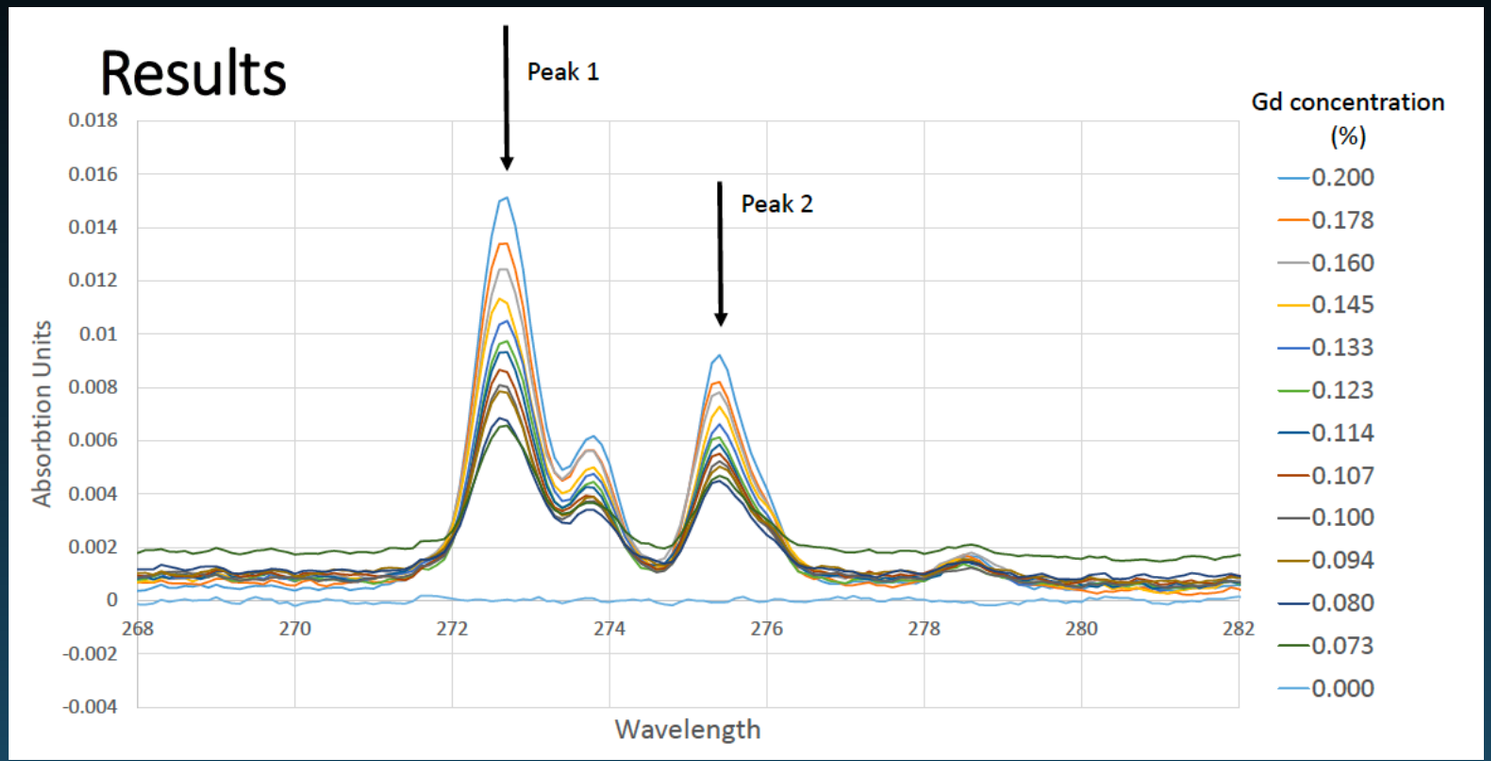
$$A = \log_{10}\left(\frac{I_0}{I_{\mathrm{Gd}}}\right)$$

I_0 is the **reference**, I_{Gd} is the Gd-loaded sample.



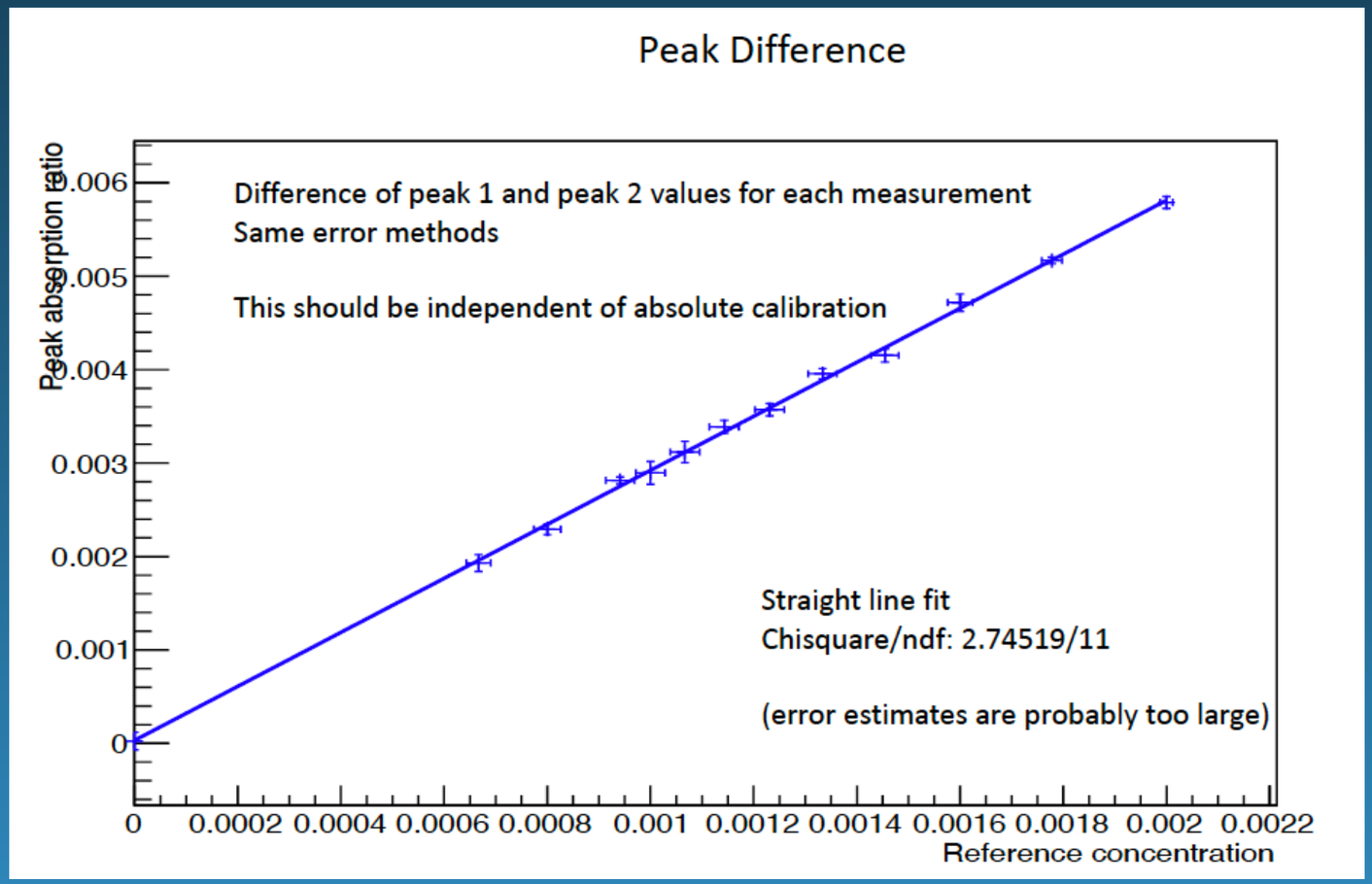


GADOLINIUM CONCENTRATION MEASUREMENT



With a commercial spectrophotometer Shimadzu UV-2600 and 10 mm quartz cuvette.

Taking the peak difference to reduce broad backgrounds of contaminants (air bubble, other impurities, etc). The difference is also linear with the concentration.



GADOLINIUM SIMULATION AND ANALYSIS

- Goal: measure the distributions of neutron capture distance, angle and multiplicity from neutrino interactions:
  - Understand capture signal at the far detector.
  - Improve cross section models
  - Improve understanding of atmospheric and nucleon decay backgrounds at the far detector.

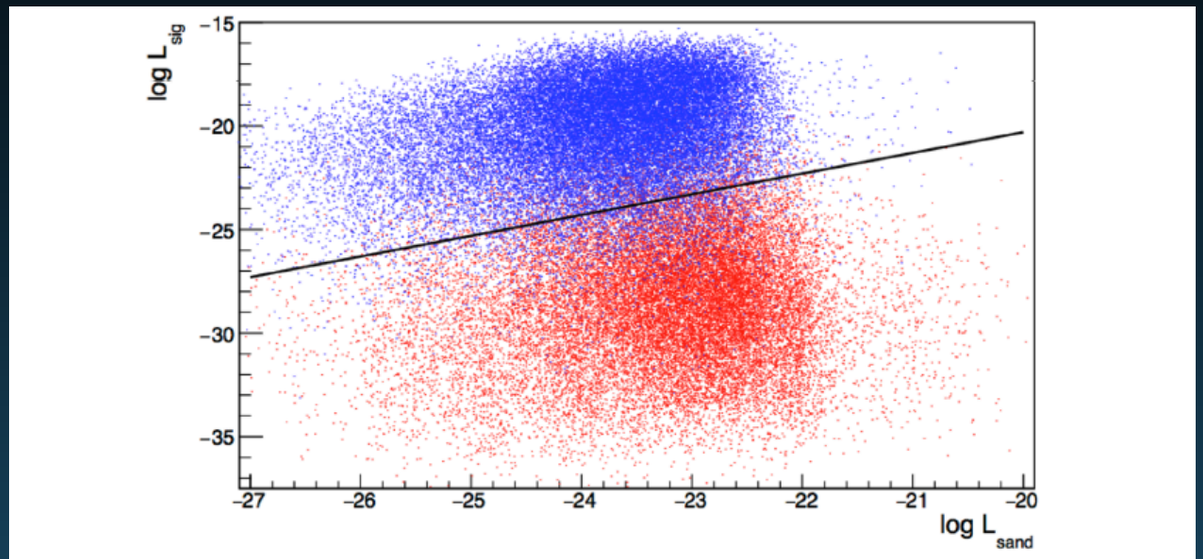
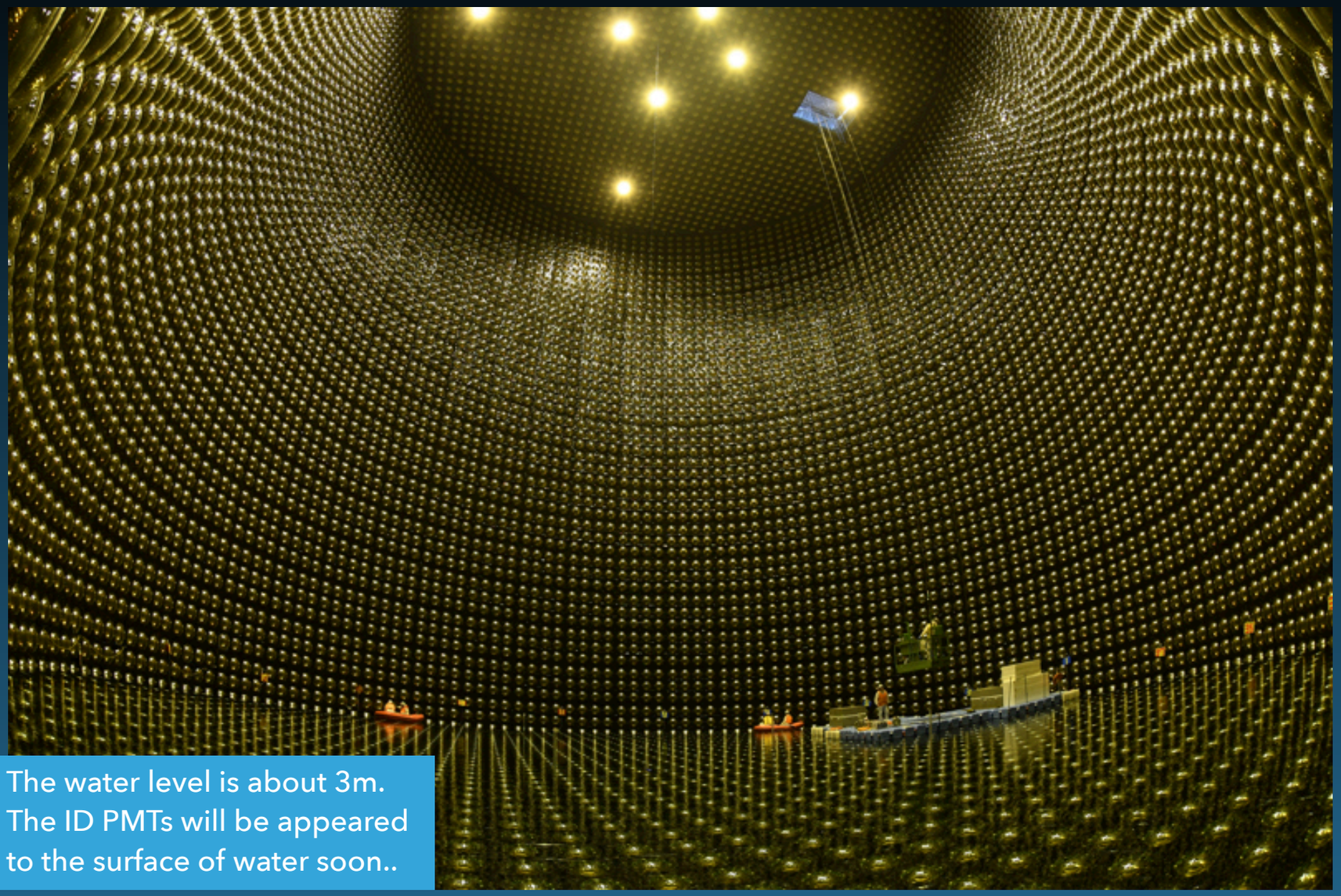


Figure 4.9: Signal neutron and sand neutron log-likelihoods for signal events (blue) and background events (red), with cut on the log-likelihood difference $\log L_{\text{sig}} - \log L_{\text{sand}}$

	Signal			Background					
	Selected	Efficiency	Purity	Sand	Cosmic	NC	Radioactivity	Other	Total
All captures in ID	138939	—	—	80806	761	9497	—	—	91064
Captures on Gd	121830	—	—	67736	658	8253	—	—	76647
Captures on H	17087	—	—	13037	102	1240	—	—	14379
All triggers	132478	95.3 %	17.7 %	340828	36598	15336	159623	64875	617259
OD veto	131862	94.9 %	23.5 %	180017	8487	15336	159623	64826	428288
10 < PMT charge < 100	125736	90.5 %	32.3 %	118131	1386	13423	86049	44574	263563
Reconstruct in ID	115225	82.9 %	40.6 %	86739	1371	10398	30223	39713	168445
200 ns < t < 100 µs	112621	81.1 %	48.6 %	78779	1368	8657	30165	0	118970
Likelihood	105032	75.6 %	92.1 %	5919	134	1106	1827	0	8986

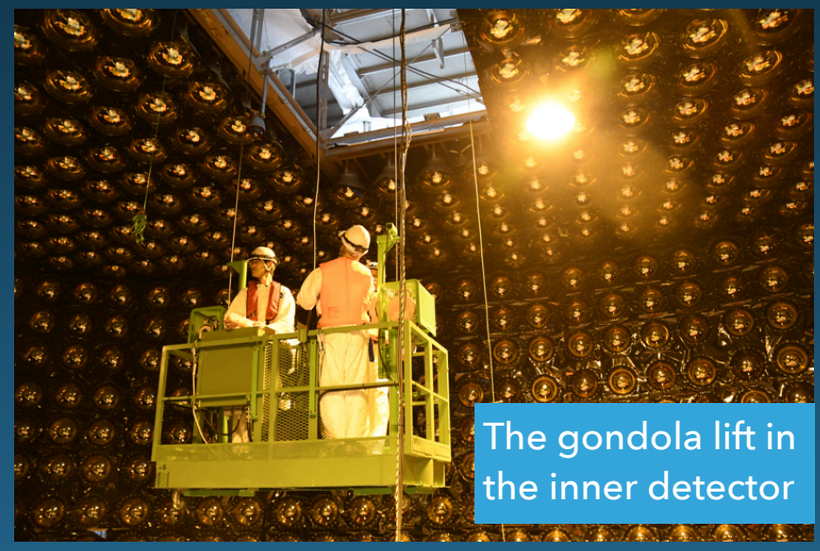
Table 4.4: Table of signal and background true and selected neutron capture candidate rates for 10^{21} POT of running E61 at the 2.5° off-axis position. This corresponds to 175 402 selected primary events. Backgrounds include triggers from neutrino interactions in surrounding material (sand), cosmic rays, neutrino interactions in the tank with no visible primary event (NC), radioactive decay of impurities in PMT glass and water, and other non-neutron capture triggers from the signal primary event.

SK-GD REFURBISHMENT

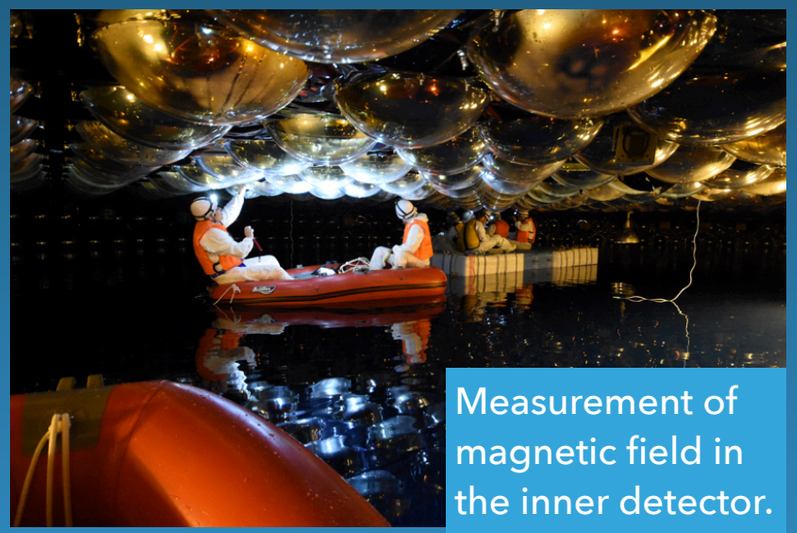


The water level is about 3m. The ID PMTs will be appeared to the surface of water soon..

Replacement work of inner detector PMTs.



The gondola lift in the inner detector



Measurement of magnetic field in the inner detector.

Works in the outer detector. The outer detector is about 2m wide..

All the water of the tank is drained

SUMMARY OF THE JENNIFER WORK AND SECONDMENTS

- **All deliverable achieved.**
- Work performed expanded the original goals.
- Members of Super-K as well now.
- Due to the natural evolution of the experiment, the numbers of secondments has been increasing gradually.
- In 2018, apart from Hyper-K, we have been spending long periods in Japan for the Super-Kamiokande refurbisment.