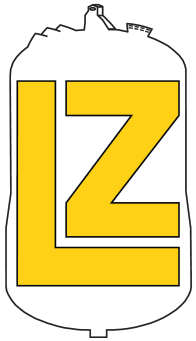
UNIVERSITY OF LIVERPOOL

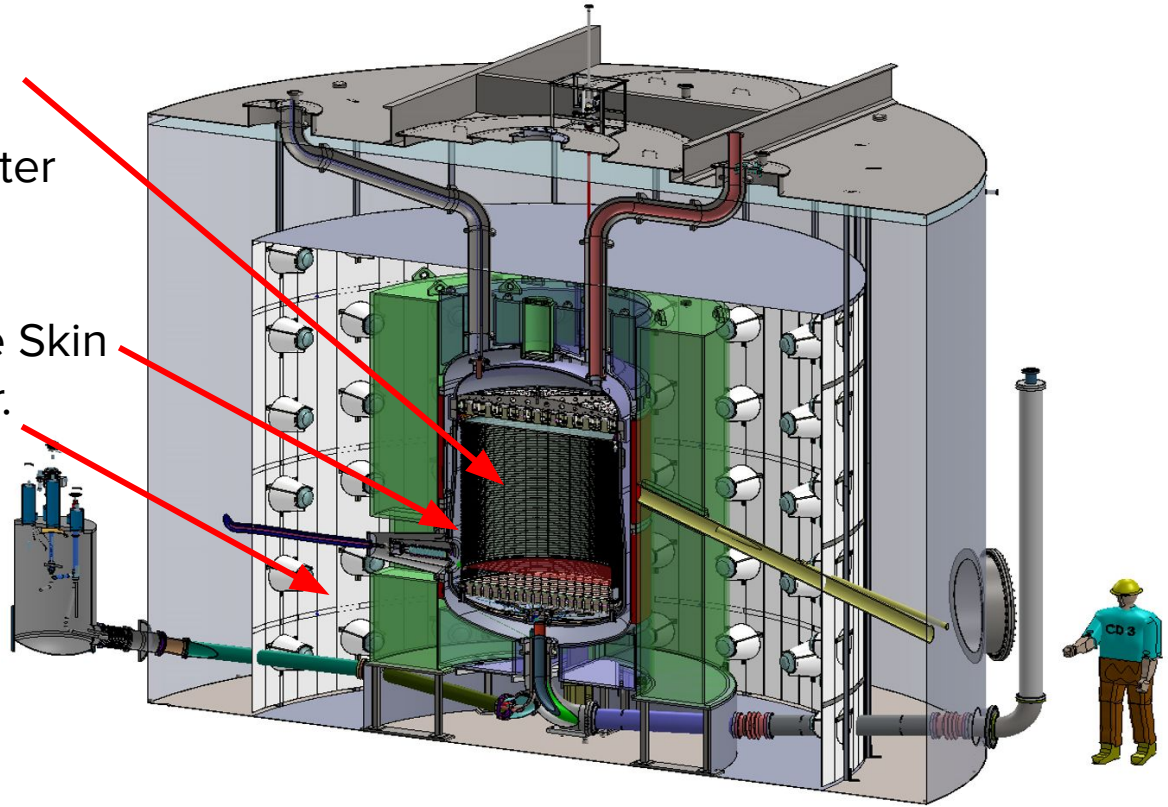


LZ Veto + Offline Data Quality

Ewan Fraser

LUX-ZEPLIN!

- Dual Phase LXe TPC.
- Looking for WIMPs. Dark Matter Candidate.
- Surrounded by 2 vetoes. LXe Skin and an Gd-LS Outer Detector.



Offline Data Quality - PREM - **P**hysics **Re**adiness **M**onitor

Motivation:

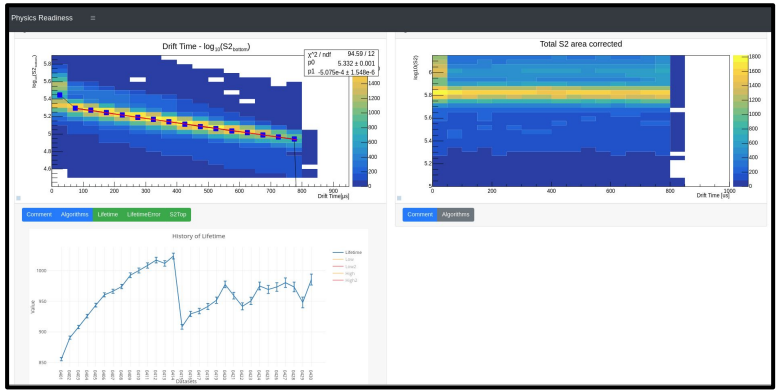
- ❏ Validate that LZ's data Runs are ready for their respective physics analysis.
- ❏ Verify the stability of the LZ detectors.
- ❏ Identity and catalogue any defects in the data.

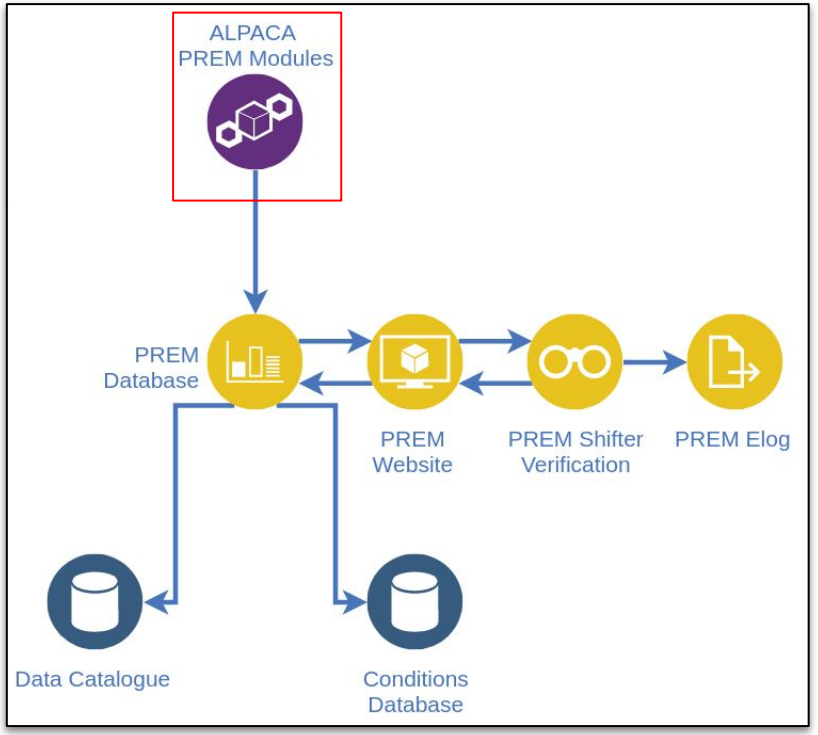
Components:

- ❏ Automatically run, data analysis modules (ALPACA).
- ❏ Data Quality Leads - write and coordinate these analysis. Outer Detector - Me.
- ❏ Shifters - monitoring of PREM.
- ❏ Website to display the results of these analysis.
- ❏ Database - store associated metadata.

ALPACA - LZ's Analysis Package

- ❑ Modify ALPACA to output JSON metadata files.
- ❑ Analyse time varying parameters.
  - ❑ Across multiple Runs.
  - ❑ Within a Run.
- ❑ Flag significant changes in time varying parameters.





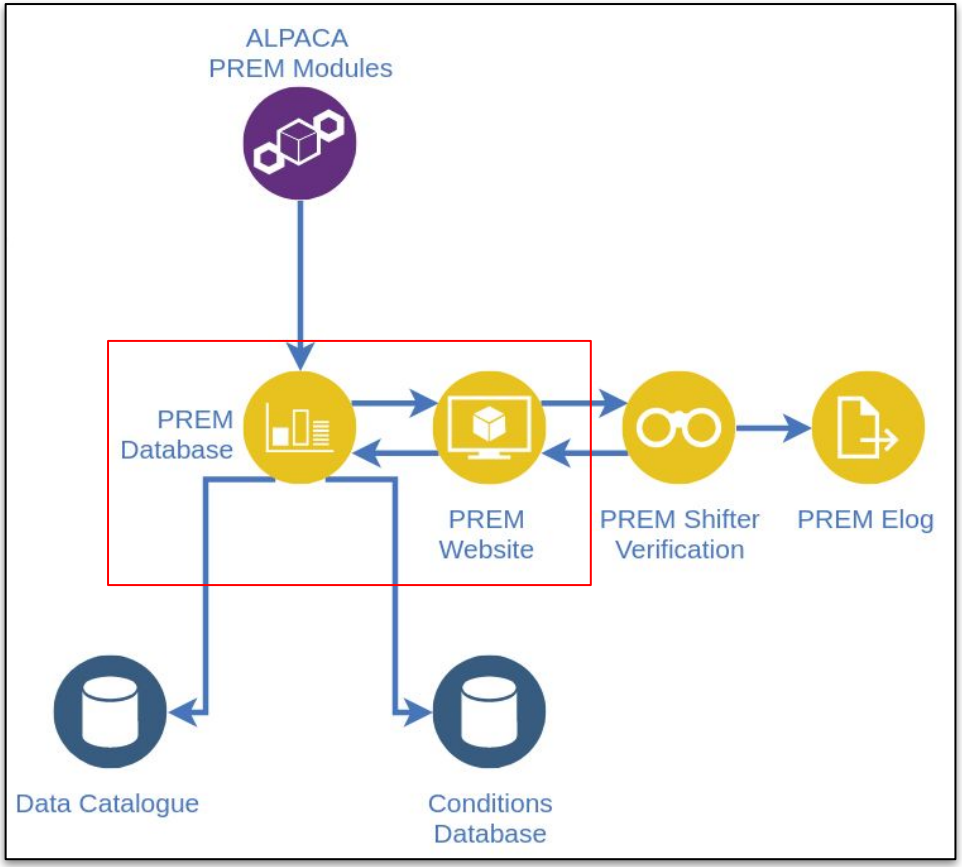
PREMweb

PREM Database:

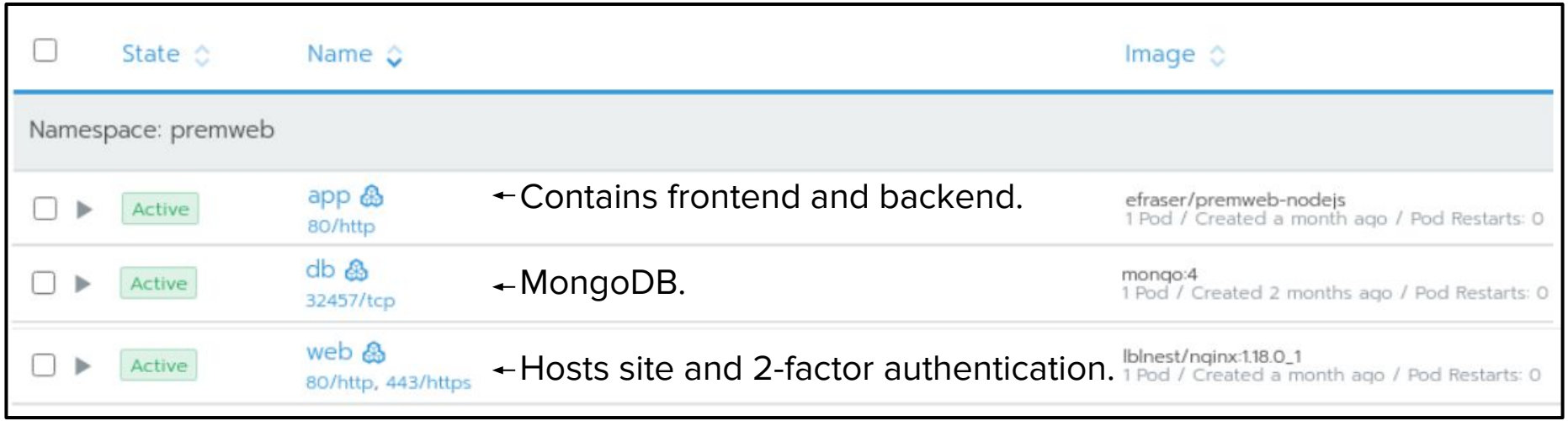
- ❏ Store JSON Metadata files for each run.
- ❏ Semi-structured, MongoDB

PREM Website:

- ❏ Frontend: Bootstrap CSS and Javascript.
- ❏ Backend: NodeJS App.
- ❏ Express + Mongoose to interact with DB.



PREM Stack deployed at NERSC



PREM Stack deployed on SPIN2, viewed in Rancher2.

SPIN2:

- ❏ NERSC's container-based platform for science gateways.
- ❏ Deploy each project using a Docker image.
- ❏ Creates a Kubernetes cluster.

Photos! Outer Detector installation

Alice installing the OCS fibres to monitor scintillator and acrylic degradation.

Harvey working on OCS and OD PMT installation.

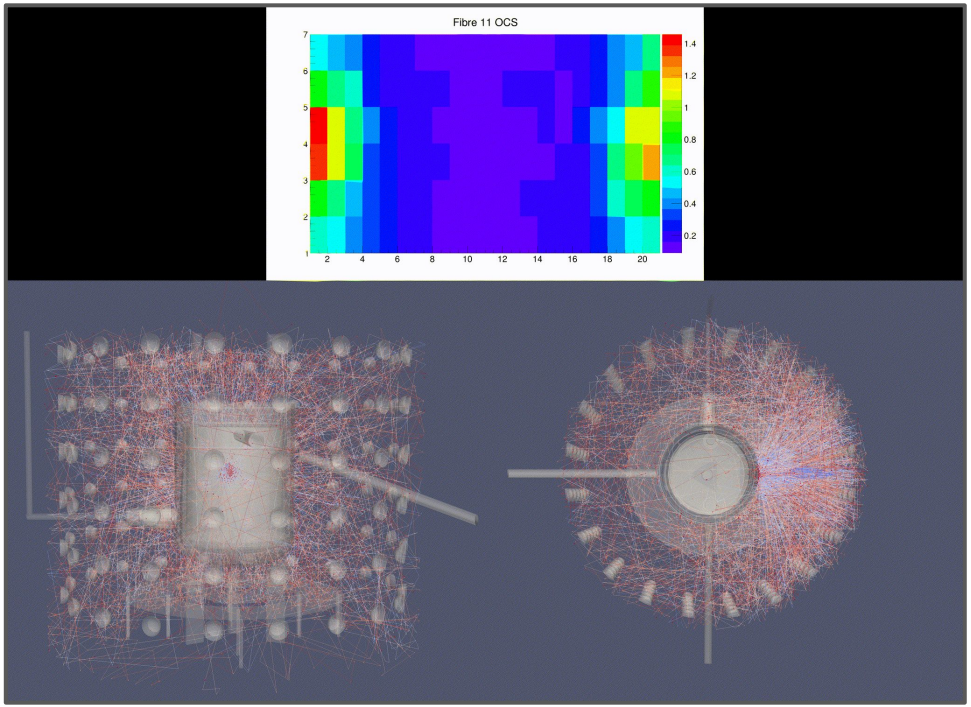
OD PMT QA: Analysis

Motivation:

- ❏ Provide QA for the OD PMTs.
- ❏ Calibrate ⟶ Improve our model of the OD.

Simulations:

- ❏ SPE: 1k photons, 100k events.
- ❏ Afterpulsing: 10k photons, 500k events.

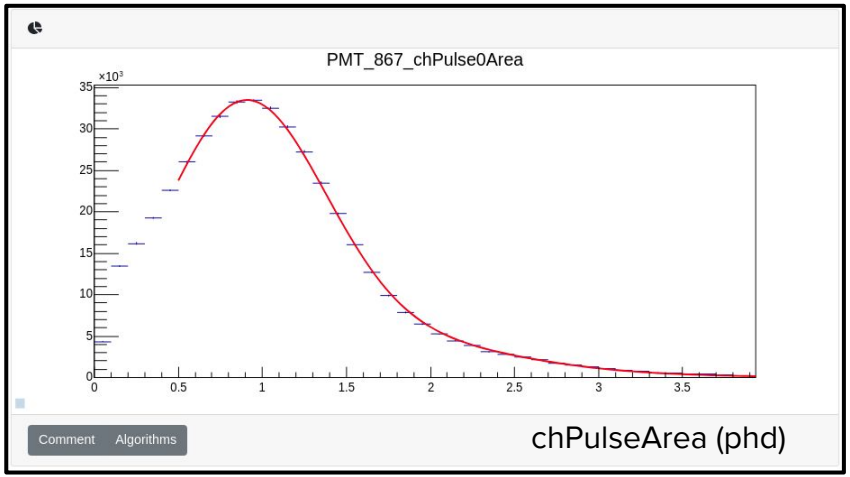


OD PMT QA: SPE

- Measure the response of the OD PMTs to a single photoelectron (SPE).
- Spectra in LZ are measured in photons detected (phd).
- Calibrating this response is the first step towards energy calibration.

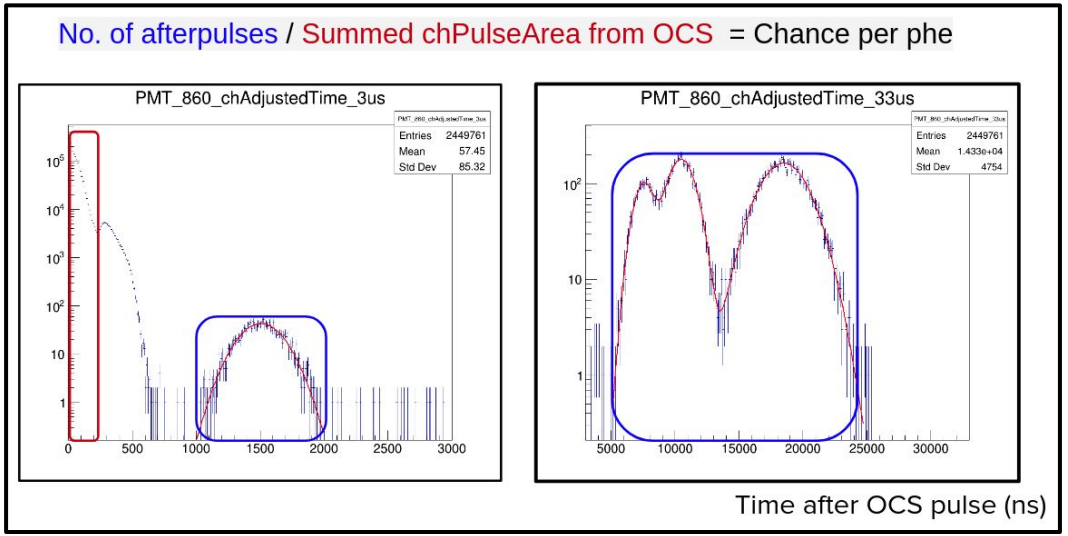
Analysis Note - Qing He, Daya Bay

$$
\begin{aligned}
S_{ideal}(x) &= P(n;\mu) \otimes G_n(x) \\
&= \sum_{n=0}^{\infty} \frac{\mu^n e^{-\mu}}{n!} \frac{1}{\sigma_1 \sqrt{2n\pi}} \exp\left(-\frac{(x-nQ_1)^2}{2n\sigma_1^2}\right).
\end{aligned}
$$



OD PMT QA: Afterpulsing

- Photoelectron ionizes a molecule when travelling between photocathode and first dynode.
- The more molecules the more afterpulsing.
- Measure of the quality of the vacuum in a PMT.
- Has it degraded since production in Korea?



Neutron Selection in the LZ Veto

- Begun to look at extending the Neutron Selection analysis for the LZ Veto.
- Improve our understanding of the dominant background in the Veto, gammas from cavern rock.
- Simulating the U238, Th232 and K40 decay chains in the cavern Rock. CPU intensive, not many make it through the water shield.
- Use event biasing to improve the efficiency of the simulation.

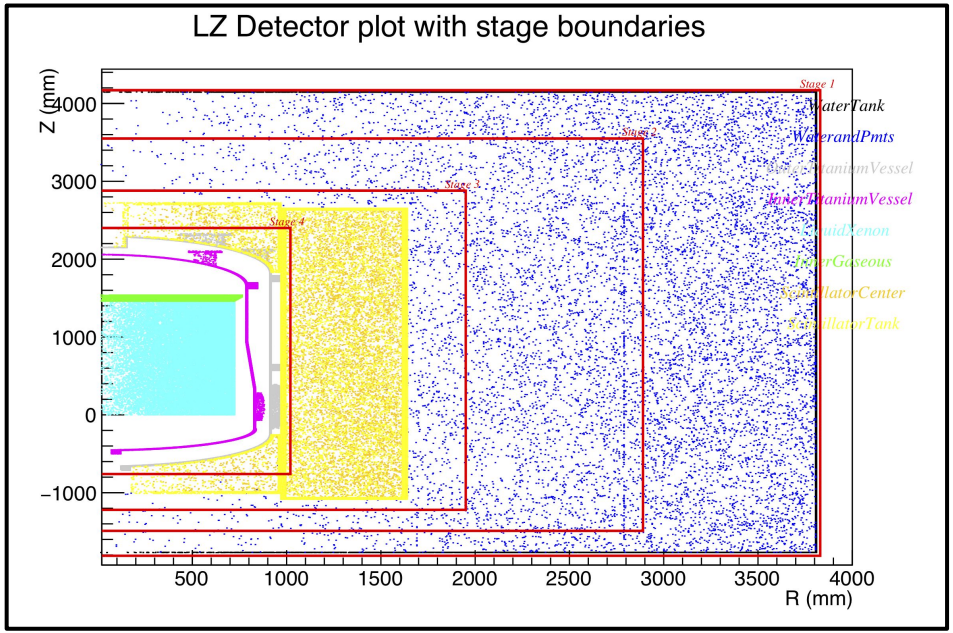


Diagram of surfaces in LZ used for event biasing, Andrew N - Sheffield.

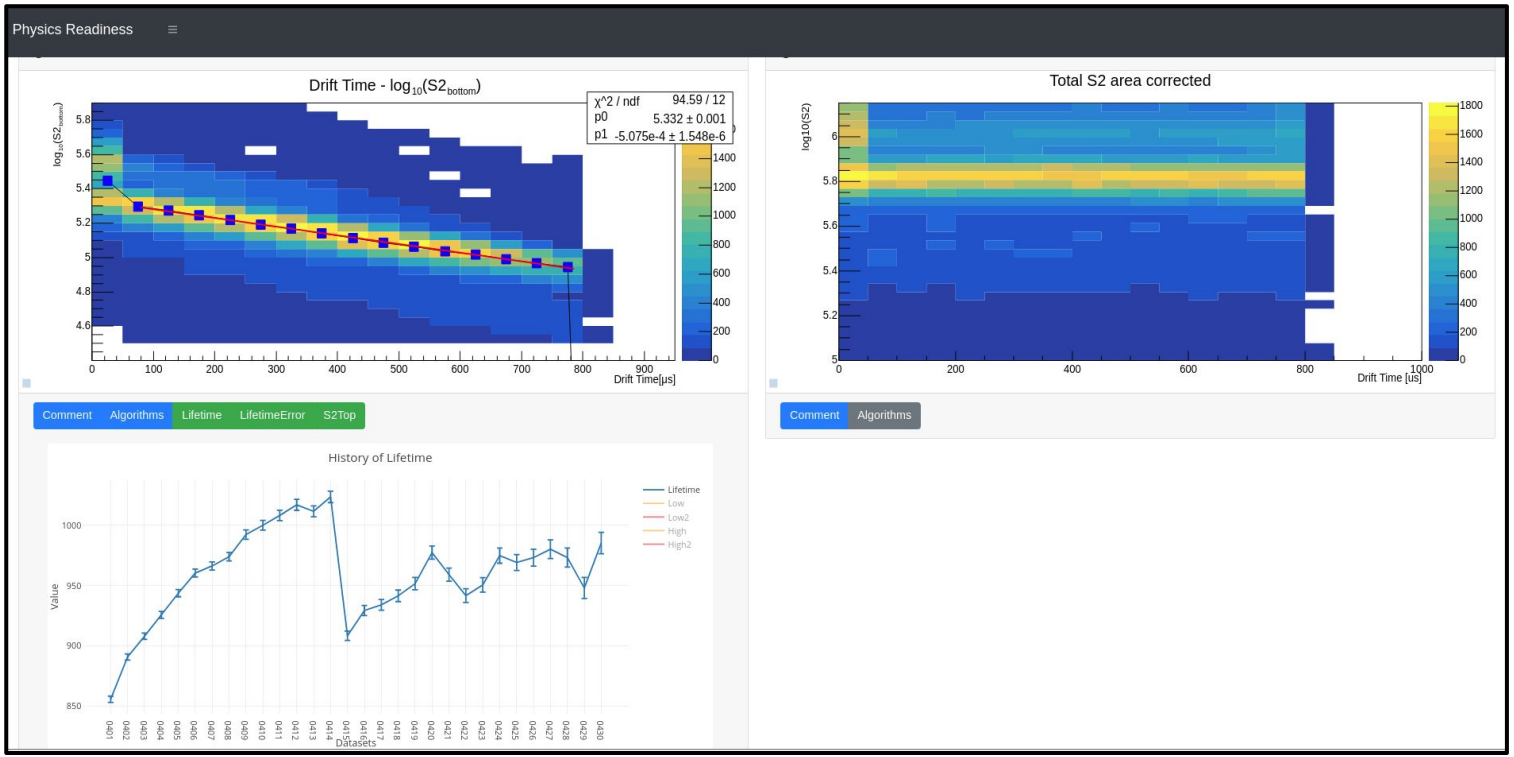
Summary

- ❏ Developed LZ's Offline Data Quality tool PREM.
- ❏ Helped coordinate Data Quality analysis group and the various analysis modules produced.
- ❏ Responsible for the Data Quality analysis in the Outer Detector.

- ❏ OD PMT QA is about to begin!
- ❏ Developed an SPE analysis and Afterpulsing analysis for this effort.

- ❏ Begun work on looking at the neutron selection in the LZ Veto.
- ❏ Simulating the main veto backgrounds using an Event Biasing technique.

- Analysis: Andrew S - Oxford - LZ
- Electron Lifetime: Measure of LXe purity - Important correction for analysis



Current Development for PREM

Sam Woodford - Liverpool:

- ❏ Automation of analysis.
- ❏ Database Queries!

Anna D - UCL:

- ❏ Creating a data structure.
- ❏ Handle calibration values for all PMTs.