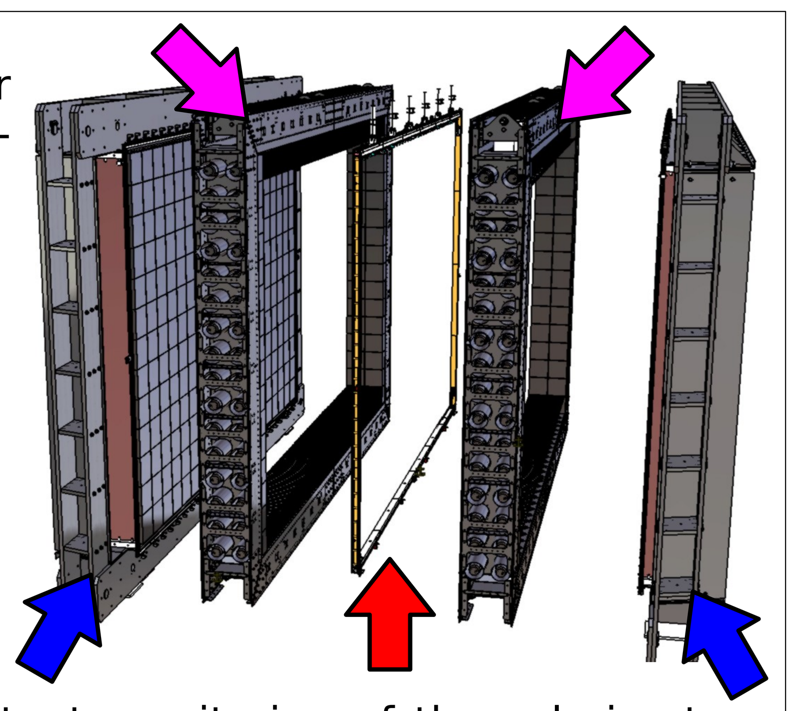
# The Radioactive Source Calibration and Light Injection Monitoring Systems for SuperNEMO

John P. Cesar (jpcesar23@physics.utexas.edu), Ramon M. Salazar (ramonmsalazar@gmail.com)
The University of Texas at Austin, Department of Physics
on behalf of the SuperNEMO collaboration

## The SuperNEMO Demonstrator

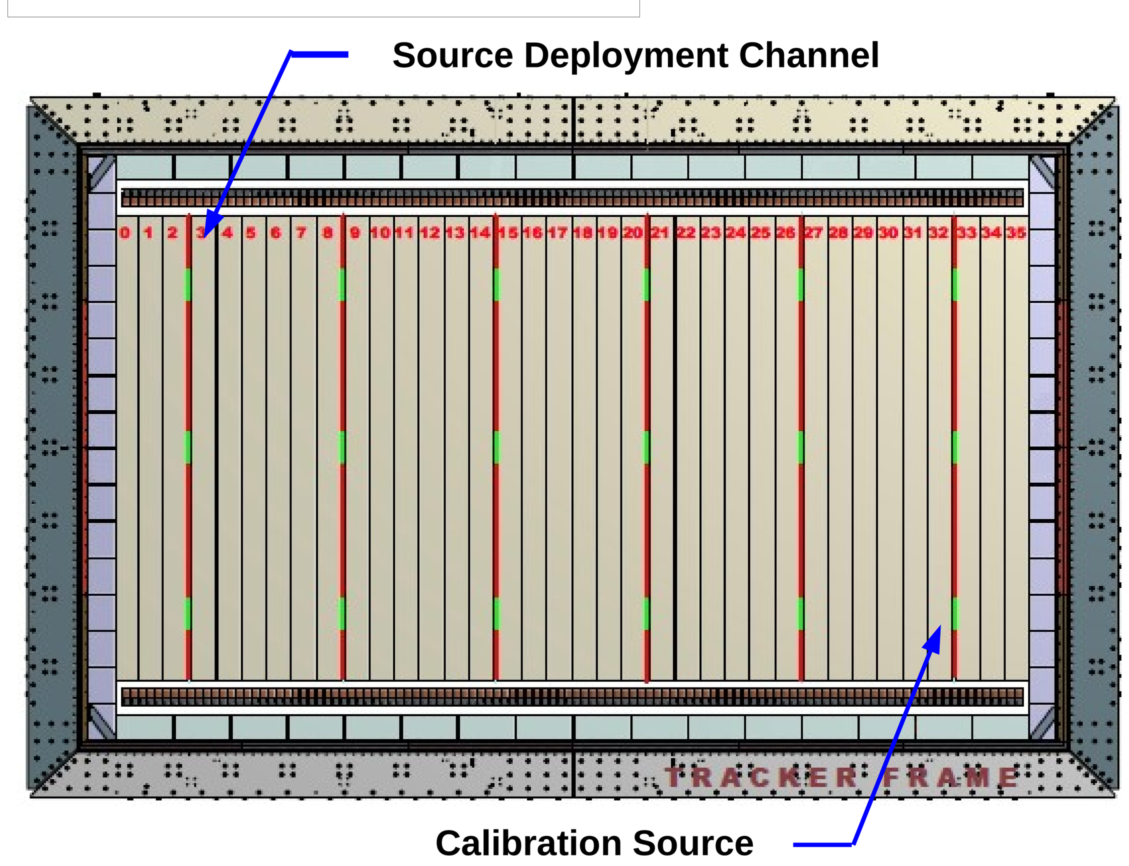
Serving as the first module of SuperNEMO, the Demonstrator consists of three primary sub-modules that exemplify the tracker-calorimeter technique of NEMO experiments

- The central **Source Frame** consists of foil strips of the ββ decay isotope, 7kg of $^{82}$Se for the Demonstrator
- The **Tracking Chamber** surrounds the source strips with 2034 drift cells operated in Geiger mode
- Finally, the **Calorimeter** encloses the above with photomultiplier tubes coupled to scintillator blocks for a total of 520+128+64 optical modules

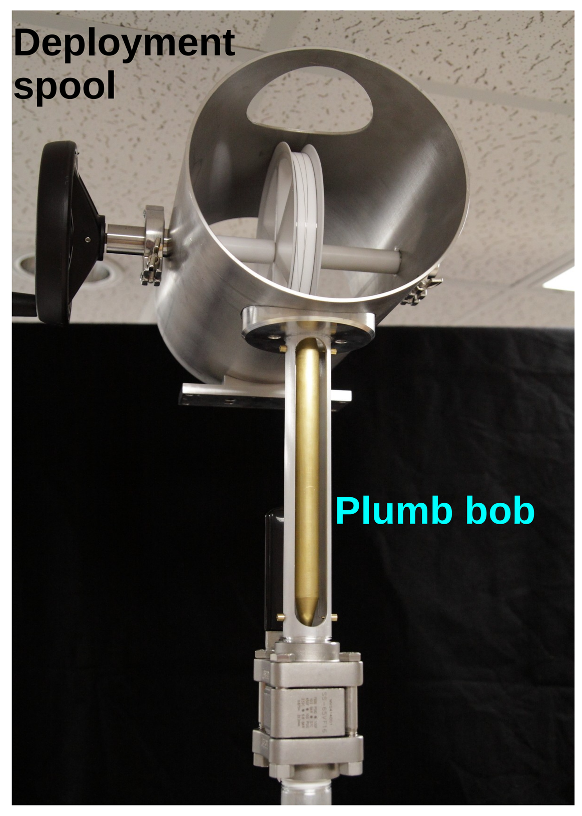


The long exposure time typical of ββ searches necessitate constant monitoring of the calorimeters stability and regular calibration checks all with an intended precision of 1%. A robust two part system has been developed to deploy various radioactive calibration isotopes and also inject LED light into all optical modules.

## Source Frame



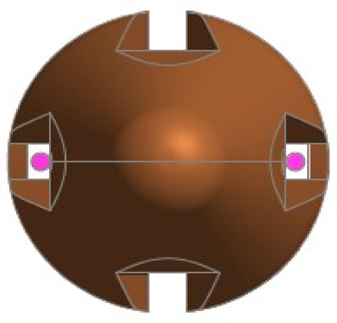

There will be six deployment channels spaced equally apart between source foil strips. Special chambers above the source frame will house the sources when not in use and also control their introduction and removal into the detector volume via plumb bob



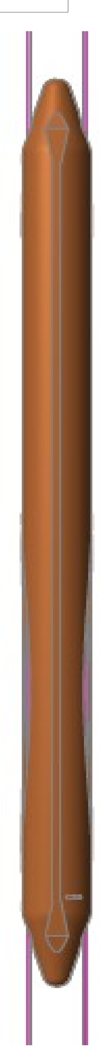

## Source Deployment

Three sources per channel will be mounted on two wires attached to a copper plumb bob that will guide them into the detector volume.
To avoid rotation and vibration as it moves, two serpentine grooves have been made in the bob to allow for guide wires to stabilize it without slipping out

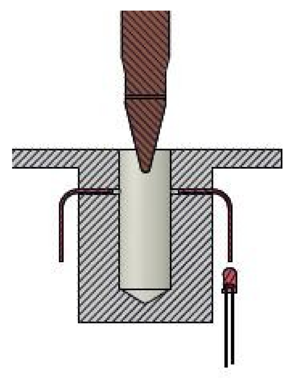
The sources in envelopes that mount them to deployment wires



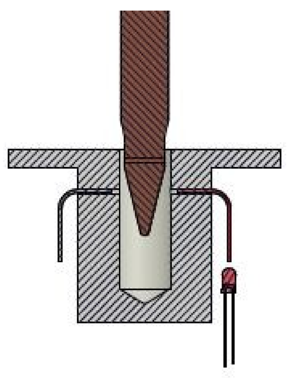
Two larger grooves also exist to pre-position the bob for the guide wires



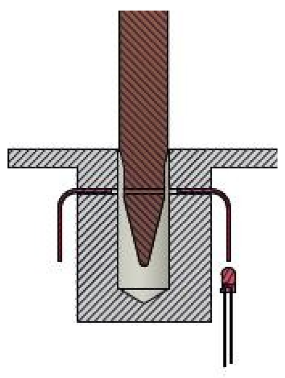
Automation of the plumb bob's ascent and descent is handled with LabVIEW controlled stepper motors. Many protocols prevent the bob from getting lost or overshooting its target.
This is achieved with a specially designed laser nest system below each channel which defines the bob's stopping point.



Bob lowering into the nest. Laser light uninterrupted



Bob reaches the nest and interrupts the laser. Descent is slowed

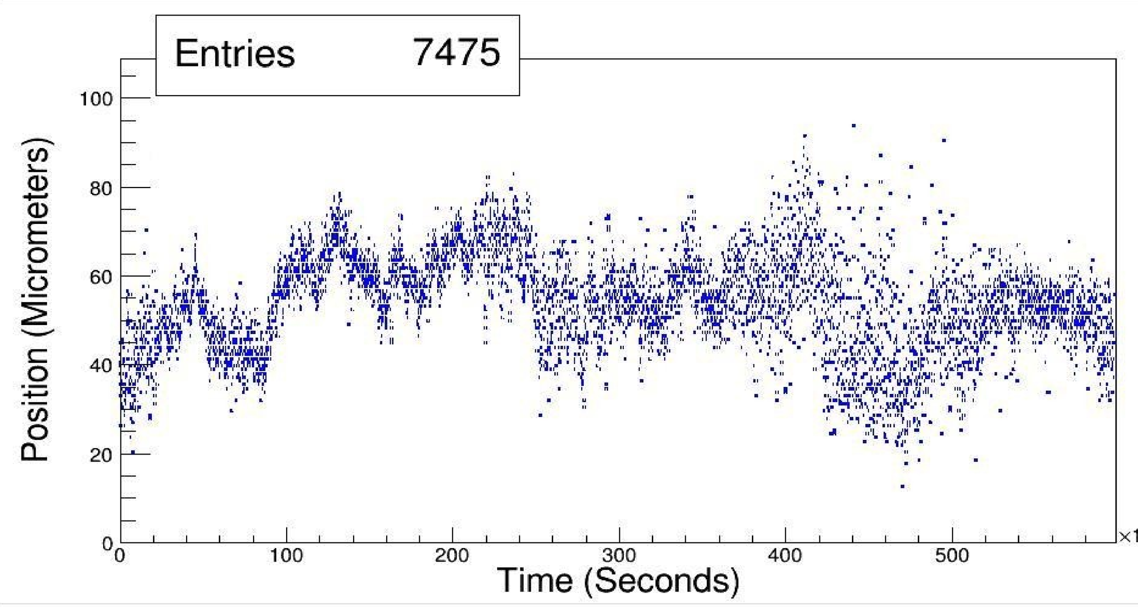


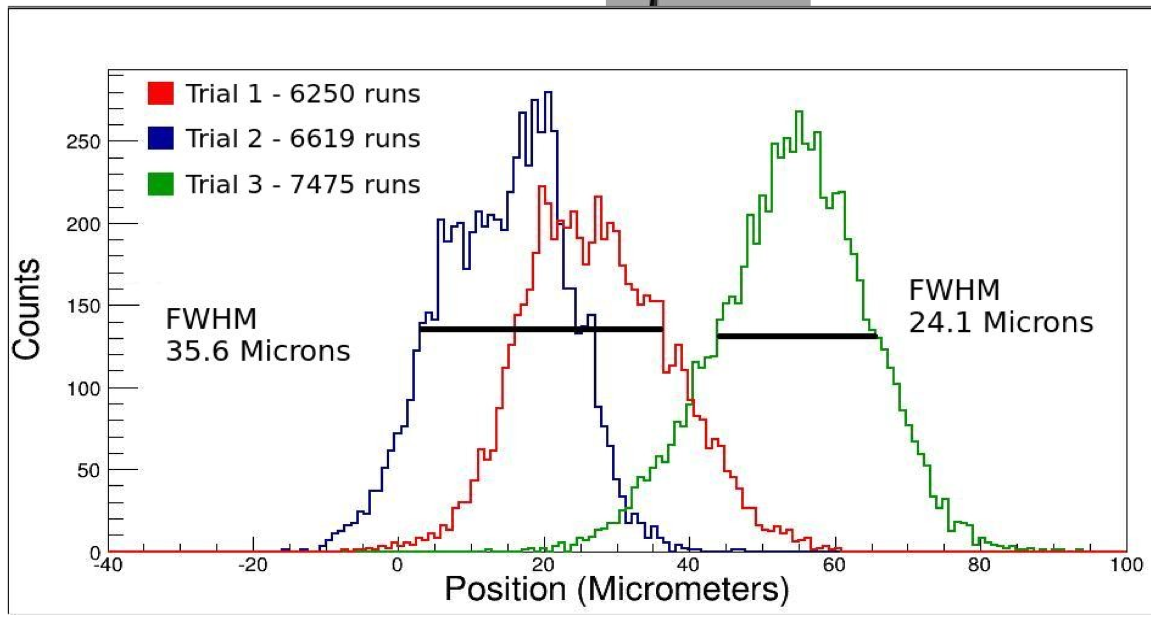
Bob is stopped when laser light once again passes through hole

## Deployment Precision

Using an independent position monitor, shown right, the precision and long term stability of the system was verified. One run consisted of deploying the bob to its target, measuring its position, and then returning it to the start position. These were executed in succession many times more than what will be expected of the system.
The Demonstrator itself requires that the sources be stopped regularly with a precision of a few millimeters. The FWHM of the histogram of stopping position over time gives a precision better than 50 microns.

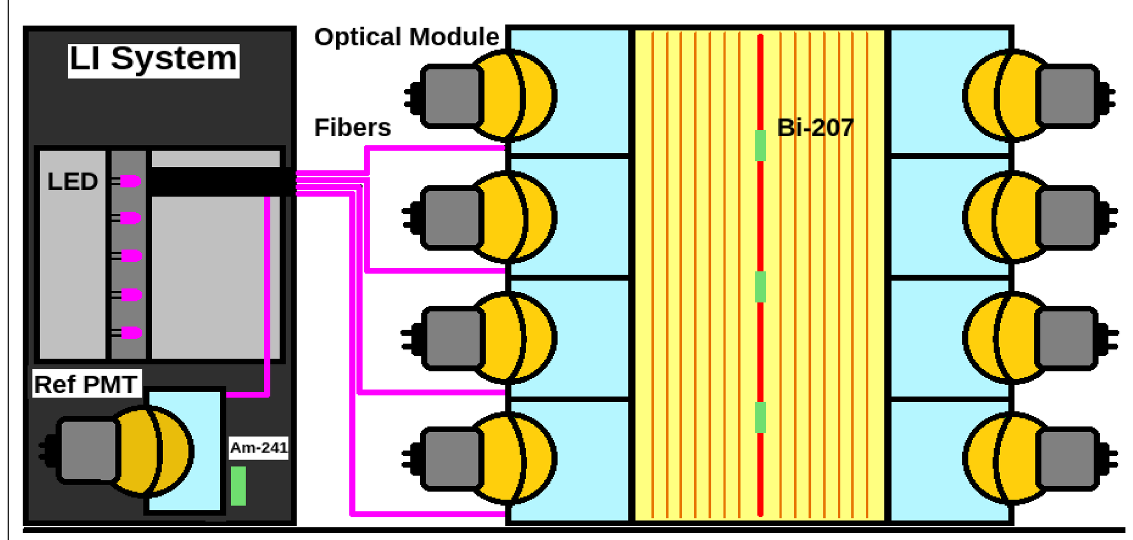
A linear variable differential transformer was used to measure the laser system's precision



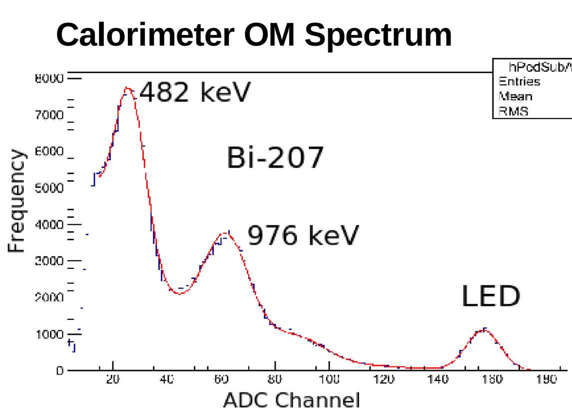

## The Light Injection System

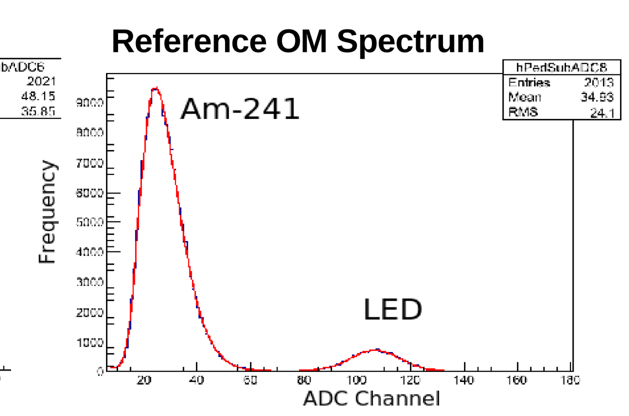
The light injection (or LI) system works in conjunction with the calibration sources to monitor and calibrate the calorimeter.
It consists of a rack that houses a reference PMT and scintillator looking at an $^{241}$Am source and a pulser box driving 10 UV LEDs which can inject light into calorimeter modules via fiber optics

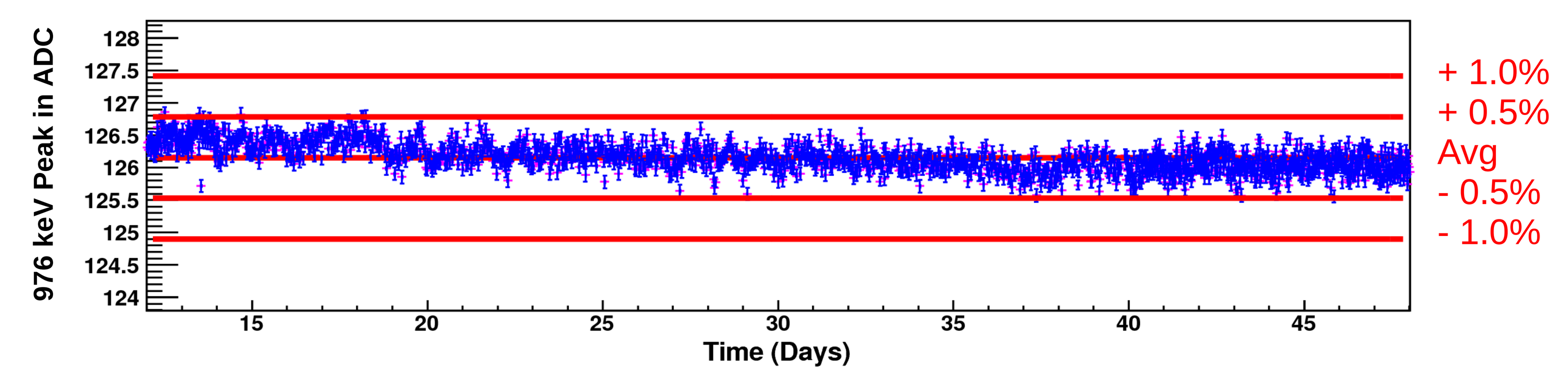



A total of 18 $^{207}$Bi sources provide calorimeter optical modules with 482 keV and 976 keV conversion electrons for absolute energy calibration.

Pulse height spectra recorded in a test optical module and reference block



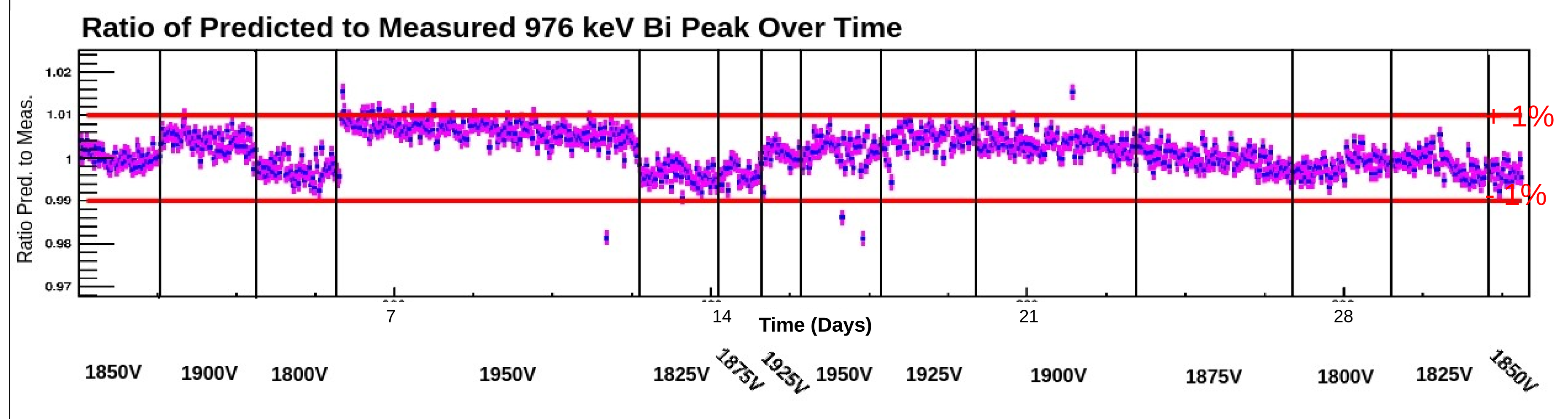




The position of the peaks (976 keV $^{207}$Bi shown above) are plotted over time to study the stability of the calorimeter optical modules.

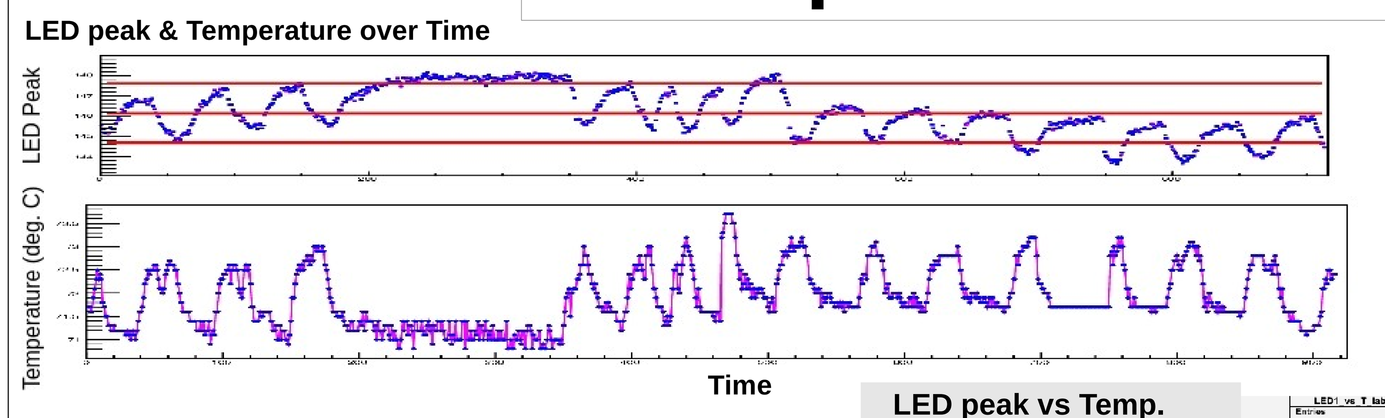
## Monitoring to within 1%

To study how well the LI system will be able to monitor and calibrate between the $^{207}$Bi runs, we used the initial position of the 976 keV $^{207}$Bi peak and tried to predict where it would shift to at a later time using only the later LED peaks as seen by each PMT and the later $^{241}$Am peaks. The plot below shows the ratio of the predicted to actual value and their consistency to within 1%




The discontinuities in the data correspond to changes in HV on the 8-inch PMT which mock possible operational jumps. Even with these perturbations the system holds up well and the overall time scale is just over one month.

## Temperature Effects




Above, LED peak positions in the reference block compared with lab temperatures over time. Shown right, relative fluctuations in same LED peaks versus relative temperature fluctuations. There is high negative correlation, denoted by the Pearson coefficient, between the individual LED peak and temperature but not between the predicted $^{207}$Bi peak values and temperature. This was proven true for any measured source peak as well.