

UPDATED SHMS HGC CALIBRATION CODE

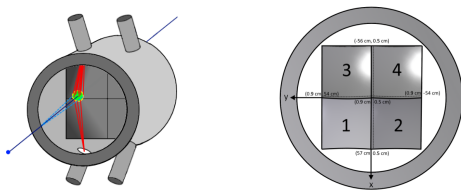
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Heavy Gas Cherenkov (HGC) Detector

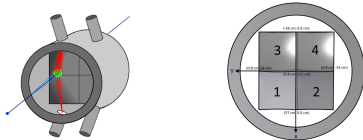
- HGC detector used for the separation of charged Pion/Kaon mesons.
- A cone of Cherenkov light reflected from the four mirror quadrants.



- Reflected Cherenkov light collects through the four PMTs.
- It is necessary to check the gain stability of all the PMTs during experiments.

HGC Calibration

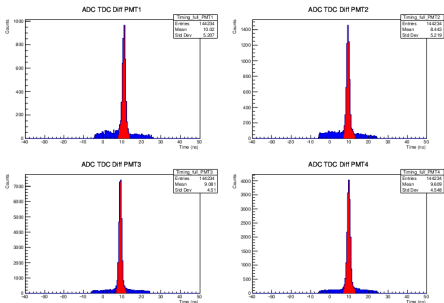
- Calibration means convert the charge (pC) into a physically acceptable number of photoelectrons (NPE).
- A reasonable calibration can be achieved by isolating the single photoelectron (SPE) peak.
- PMTs focusing on its own mirror quadrants receive too much light (difficult to isolate SPE peak).



- Placing the correct timing cuts is necessary to get reasonable calibration parameters for each PMT.

Timing Cuts

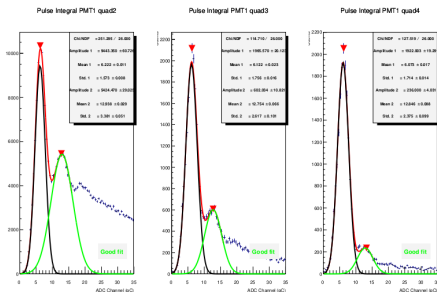
- Code has modified to handle the timing cuts on each individual PMT.



- Blue regions are the full timing information for each PMT.
- Red regions are selected out as the good timing information for each PMT.

Calibration Procedure

- All off-quadrant histograms of all the PMTs are fitted with a function, $f(x)$.
- $f(x)$ is the sum of two Gaussian functions.
- Fitting constraints are set up for each PMT.



$f(x)$	Par
p0	2000
p1	6.0
p2	2.0
p3	1000
p4	12.0
p5	3.0

- Other two functions, black & green are the individual Gaussian functions drawn from $f(x)$.

Calibration Parameter

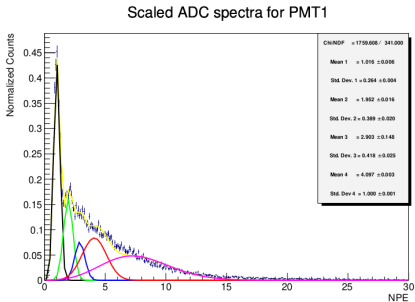
- Calibration algorithm checks the maximum events at the first photoelectron peak and χ^2 of the fit function.
 - Default value for max events > 40 , $0.5 < \chi^2 < 20$.
- If quadrants satisfy these conditions then the calibration algorithm is considered as “Good fit” and proceeds it for the calibration.
- Calibration algorithm takes the error weighted average of all “Good fit” quadrant means for each PMT.

Study for Quality Control

- A new histogram is created to store the full (summed over all 4 mirrors) calibrated spectrum for each PMT.
- The new histogram is fitted with a new function $g(x)$, which is a sum of 4 Gauss and 2 Poisson distributions.
- Initial few photoelectron peaks provide the Gaussian distributions.
- Higher order photoelectron peaks are approximated by 2 Poissons.

Full Distribution of Cherenkov light

- In $g(x)$, 2nd, 3rd and 4th photoelectron peaks are wider than 1st photoelectron peak.
- Fitting constraints are setup for each PMT.

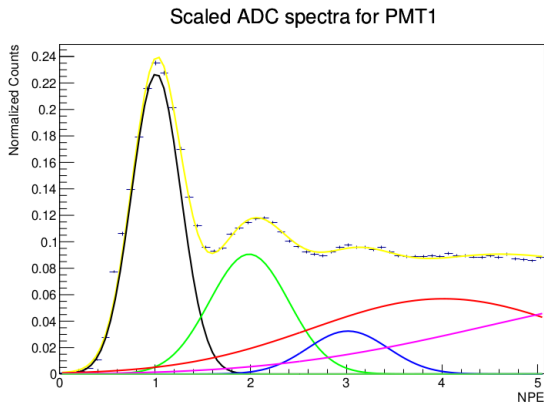


$g(x)$	Parameter Limit
p1	$1-3\sigma, 1+3\sigma$
p4	$2-3\sigma, 2+3\sigma$
p7	$3-3\sigma, 3+3\sigma$
p10	$4-3\sigma, 4+3\sigma$

- Other all plots are the individual functions drawn from $g(x)$.

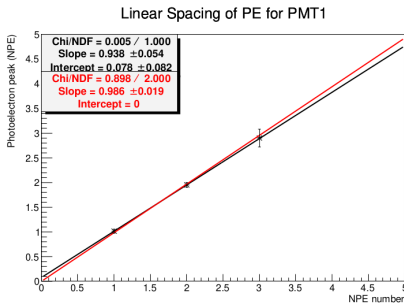
Zoom Version of Full Distribution

- The calibration algorithm produces another set of calibration parameters from the quality control work.



Linear Spacing of Photoelectron Peaks

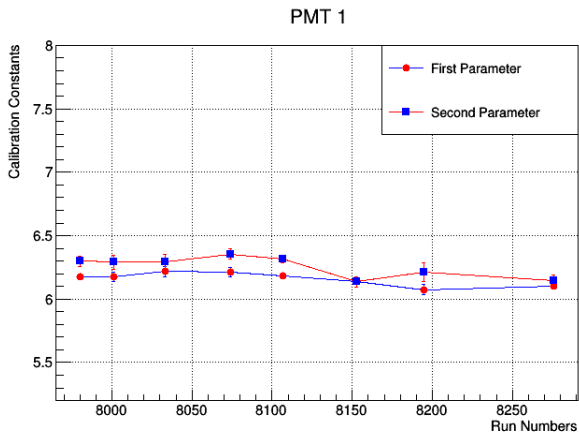
- The means of 3 photoelectron peaks in $g(x)$ are plotted on Y axis.
- X axis is fixed at 1 for 1st mean, 2 for 2nd mean and 3 for 3rd mean.



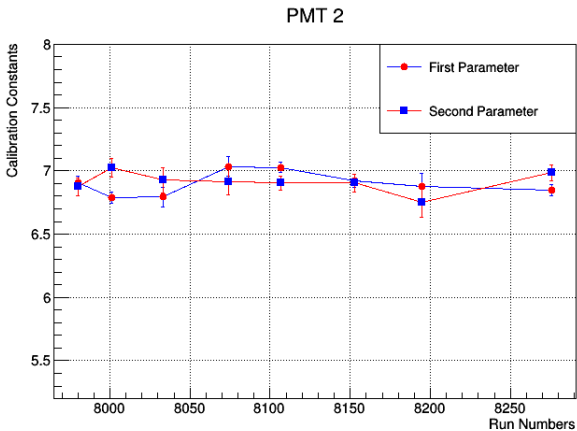
- The error bars are statistical. It is the error in means and plus the error in mean of the SPE peak.

Consistency Plot for 8.19 GeV Beam Energy

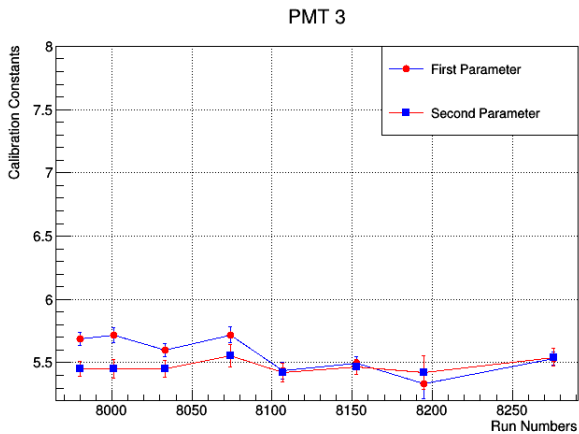
- Calibration parameters from 5.38 GeV/c, 6.05 GeV/c & 6.75 GeV/c SHMS momentum.



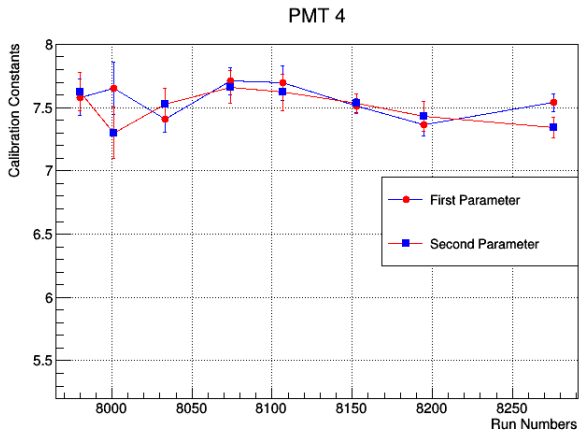
Consistency Plot for 8.19 GeV Beam Energy



Consistency Plot for 8.19 GeV Beam Energy



Consistency Plot for 8.19 GeV Beam Energy



New and Old Calibration Parameters

- Calibration parameters from a calibrated set of the three run numbers (6918, 6919 & 6920) are shown in table.
 - $E_b = 4.9 \text{ GeV}$
 - $P_{shms} = 2.5 \text{ GeV}/c$

PMT No	Cal from $f(x)$	Cal from $g(x)$	Error Weighted Ave	Old Par
1	6.17 ± 0.008	6.237 ± 0.011	6.19 ± 0.006	6.26
2	6.82 ± 0.010	6.839 ± 0.013	6.82 ± 0.007	7.30
3	5.36 ± 0.013	5.384 ± 0.015	5.37 ± 0.009	5.85
4	6.86 ± 0.039	6.893 ± 0.045	6.87 ± 0.029	6.98

- A significant change has been observed in the new and old calibration parameters.
- The errors in all calibration parameters are statistical only.

Summary

- Calibration code is available on the hallc github account.
 - https://github.com/JeffersonLab/hallc_replay/tree/master/CALIBRATION/shms_hgcer_calib
- From our consistency studies, there is no indication that one set is more consistent than the other for all PMT.
- We decided that just take the **error weighted average** from the two sets as the final calibration parameters for each PMT.
- Users can find more information of the code in the report. The report document number is **HallC-doc-1098**.

- Any questions or concerns, please contact me at vkb135@uregina.ca

Thank You