SBS RICH
PMT TESTING STATUS

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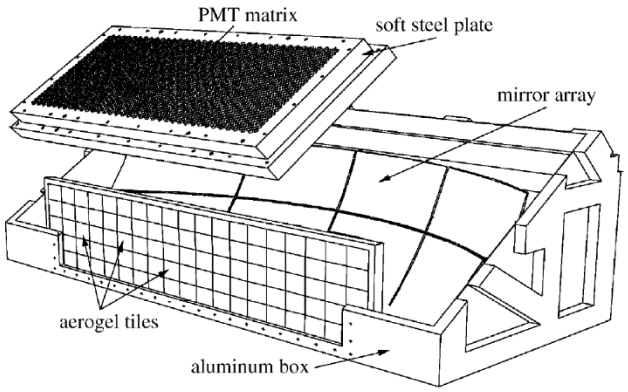
2016 SBS Collaboration Meeting

Outline:

- Brief review of the HERMES RICH detector and PMT
- Hardware implemented in testing
- Testing procedure
- Data plots from testing
- Summary for the tested PMTs
- Status and plans

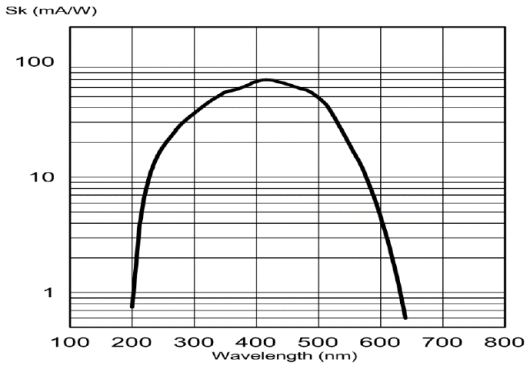
HERMES RICH detector:

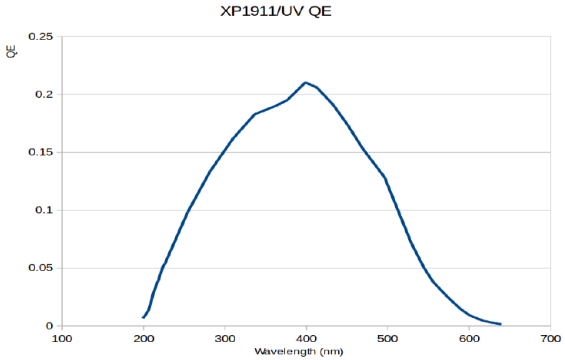
- Aerogel wall: tiles 11.4 x 11.4 x 1.13 cm^3, stacked in 5 rows , 17 columns, 5 tiles deep.
- UVT-lucite window behind aerogel, dual purpose:
  1. Protect Aerogel from C_4F_{10}
  2. Absorb UV photons $\lambda < 300$ nm, reduce Rayleigh scattering and background noise.

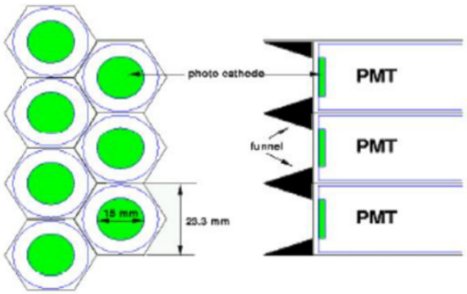


- Mirrors constructed from two rows of Carbon-fiber composite (R=2.2 m), aluminized surface provide reflectivity greater than 85% for 300-600 nm
- PMT matrix: 1934 Philips XP1911 UV PMTs with a diameter of 0.75” (15 mm active diameter).

Philips XP1911/UV PMT Specs:



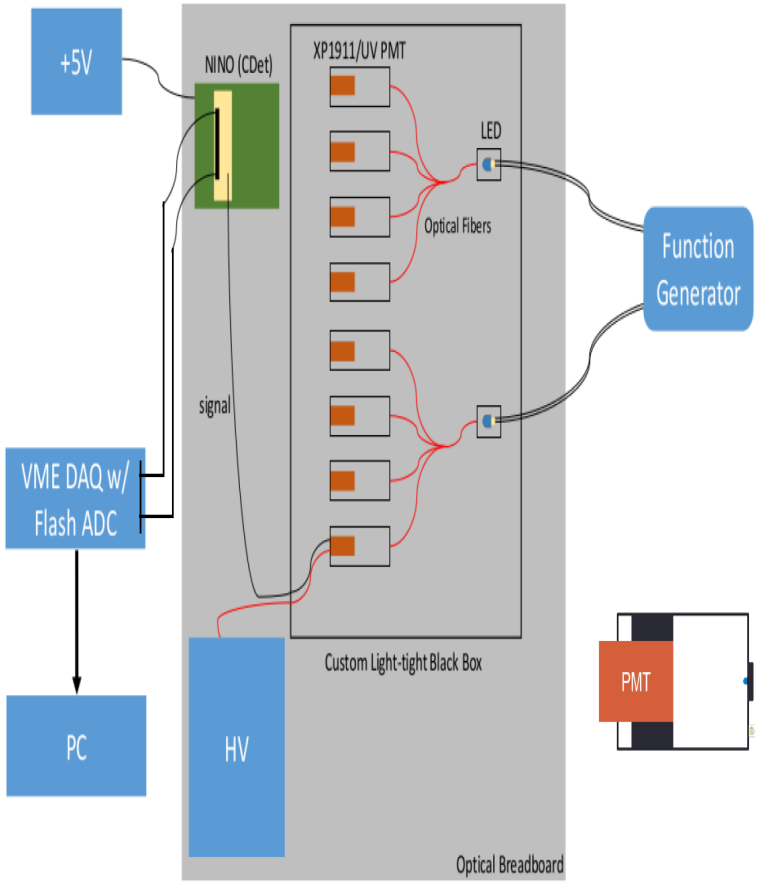




- Radiant sensitivity & converted QE plot, max. sensitivity ≈ 420 nm
- Hexagonally packed into a focal plane of dimensions 147.4 x 62.8 cm^2, pixel size 23.3 mm
- Photocathodes alone cover ~38% of focal plane, and aluminized funnels increase coverage to ~91%

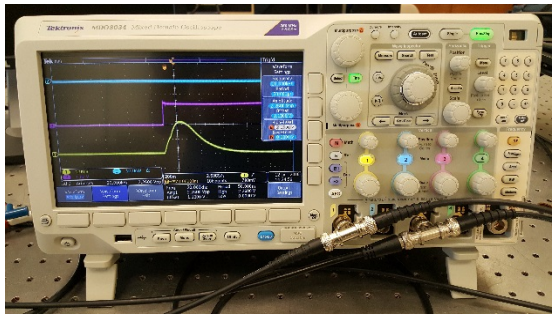
Hardware implemented for PMT testing:

- Function generator driving blue LEDs 465 nm
- Light-tight black box
- HV supply
- NINO card for amplification of signals with +5V power supply
- VME DAQ with Flash ADC
- PC

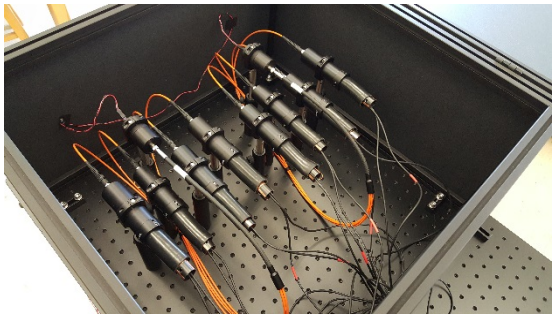


Hardware implemented for PMT testing:

Function generator:

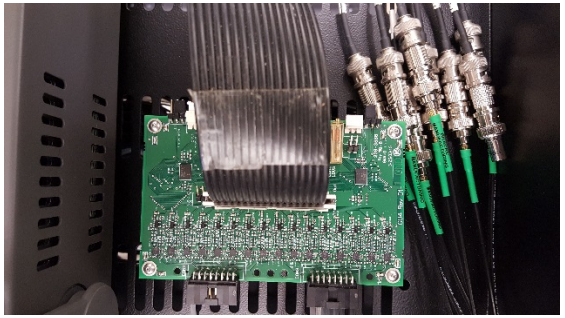


Black box:

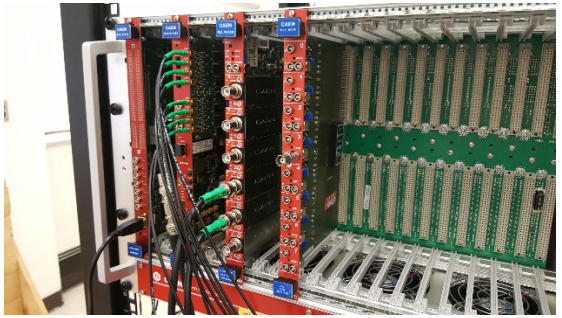


HV supply and distribution:

NINO card:



VME DAQ with Flash ADC:



Testing Procedure:

- The testing comprises of 3 main stages:

  1. Single Photoelectron

  2. Dark Counting Rate

  3. “Big Light” Scan:

     i) HV scan at constant light intensity

     ii) LED light level scan at constant HV

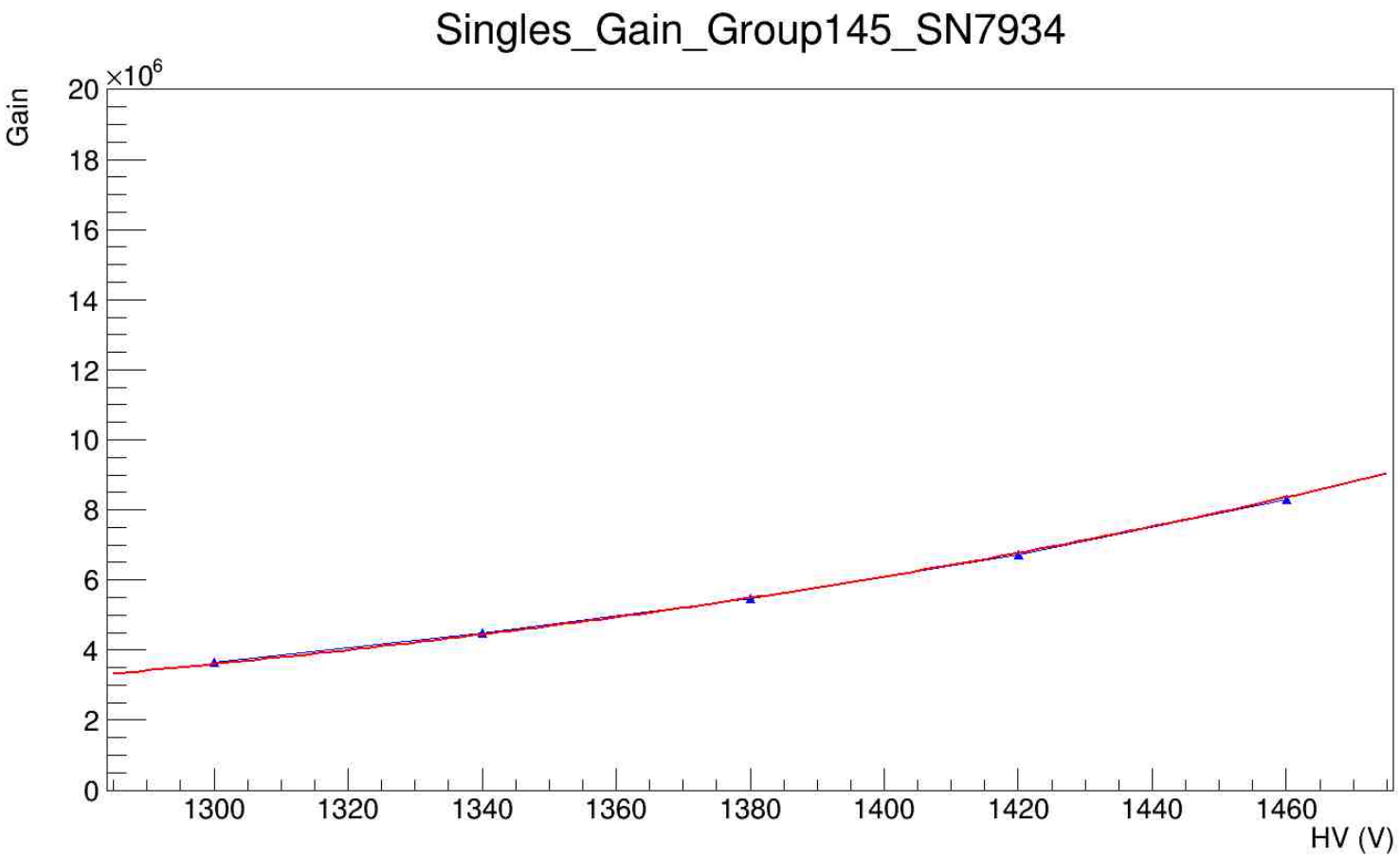
Testing Procedure:

1. **Single Photoelectron detection:**

- After loading the relevant DAQ configuration file for Single Phes., the gain of each individual PMT was measured at a fixed light level for voltages ranging between and including 1300 V-1460 V in steps of 40 V.
- LEDs are pulsed at a rate of 20 kHz, with driving voltage adjusted to give as high as possible rate (~few kHz above dark counting rate) of single photon detections while keeping probability of multi-photon detection small
- Histograms of integrated charge used to determine absolute gain.

Data plot:

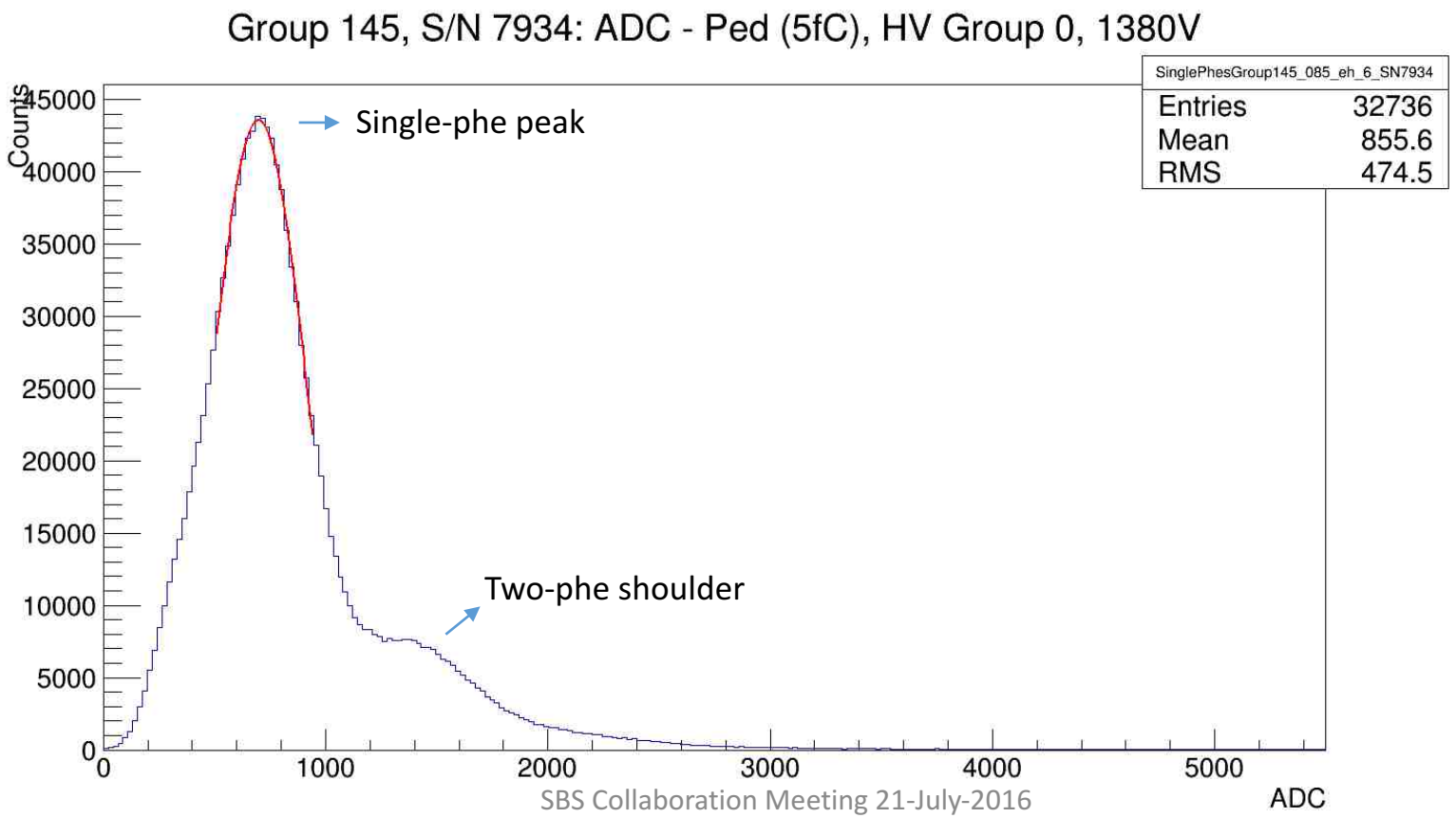
1. **Single Photoelectron detection:** Gain as a function of High Voltage



Data plot:

1. **Single Photoelectron detection:** Energy Histogram

- Gaussian fit to the single photo-electron peak was used to determine the gain
- Pedestal is subtracted from this ADC spectrum



Testing Procedure:

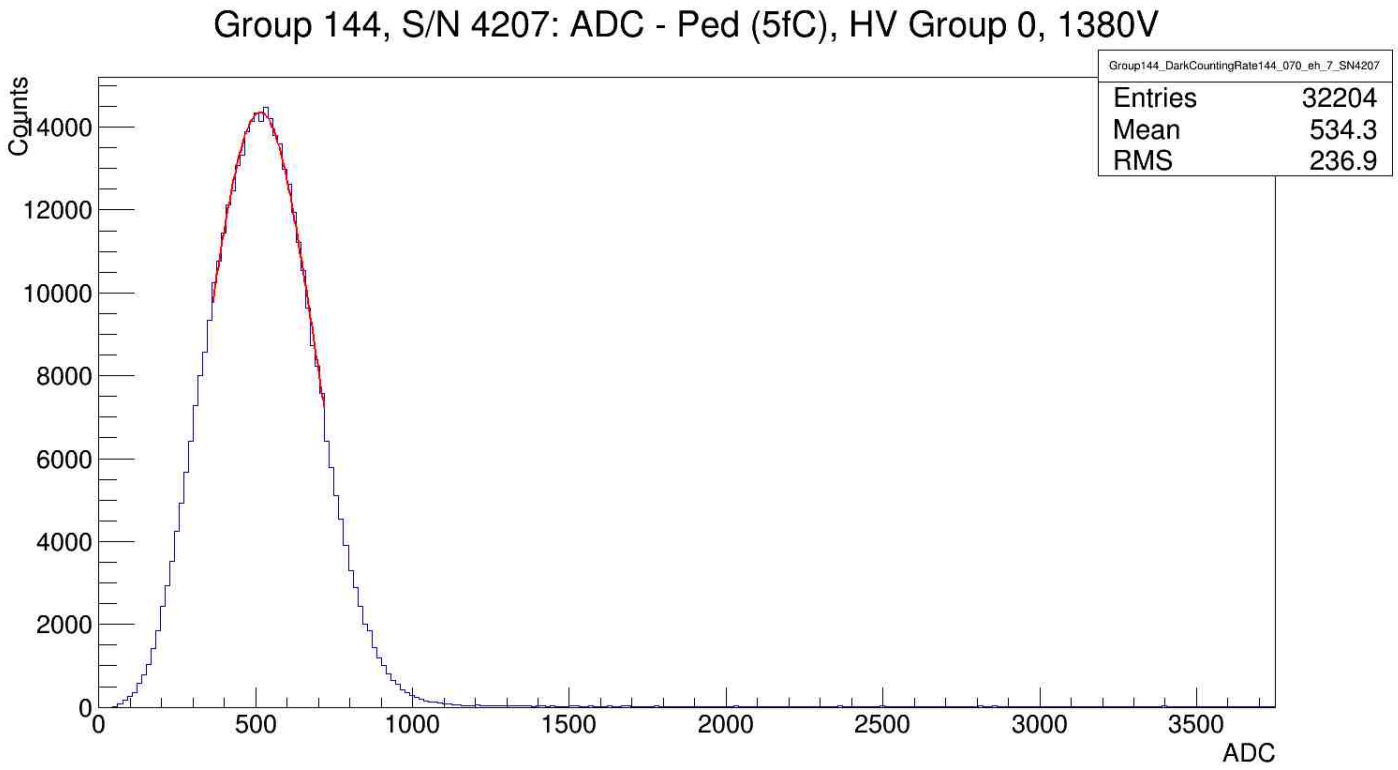
2. Dark Counting Rate:

- The signal generator which drove the LEDs was turned OFF cutting down the light level to zero.
- Dark counting rates were measured at a High Level voltage of 1380 V without disturbing other settings.
- Energy histograms depicting the count as a function of the ADC channels were obtained from this single run.

Data plot:

2. **Dark Counting Rate:** Energy Histogram

- The dark counting rate is computed by dividing the total number of events above threshold by the duration of the run (120 s).
- Thresholds for dark counting rate measurement are roughly estimated to be 0.1-0.2 ph.e., depending on the PMT gain, DAQ threshold setting.



Testing Procedure:

3. **"Big Light" scan:** i) HV scan

- After loading the relevant DAQ configuration file for Big Light pulses, the light level was increased up to the extent that the ADC count did not go into saturation.
- Keeping the light level fixed at that point, the HV was again varied in between and including 1300 V-1460 V in steps of 40 V.
- Gain curves, Energy histograms and Mean number of photo-electrons for each individual PMT for all the HV levels were obtained from this setup.

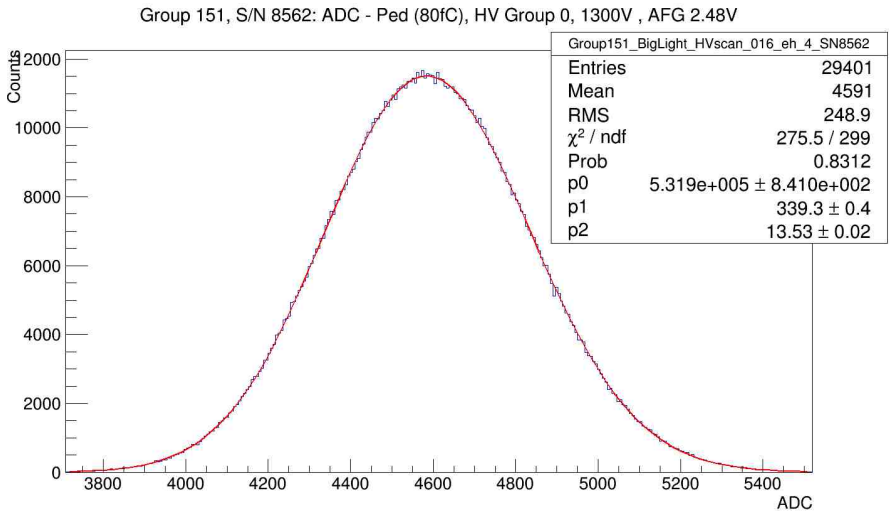
Data plot:

3. **Big Light scan:** i) HV scan (Energy histogram)

- The energy histogram which is a Poisson fit was pictured

  with the help of this density function:

$$P_{ADC} = \frac{P_0 * (P_1)^{\frac{ADC}{P_2}} * e^{-P_1}}{(\frac{ADC}{P_2})!}$$



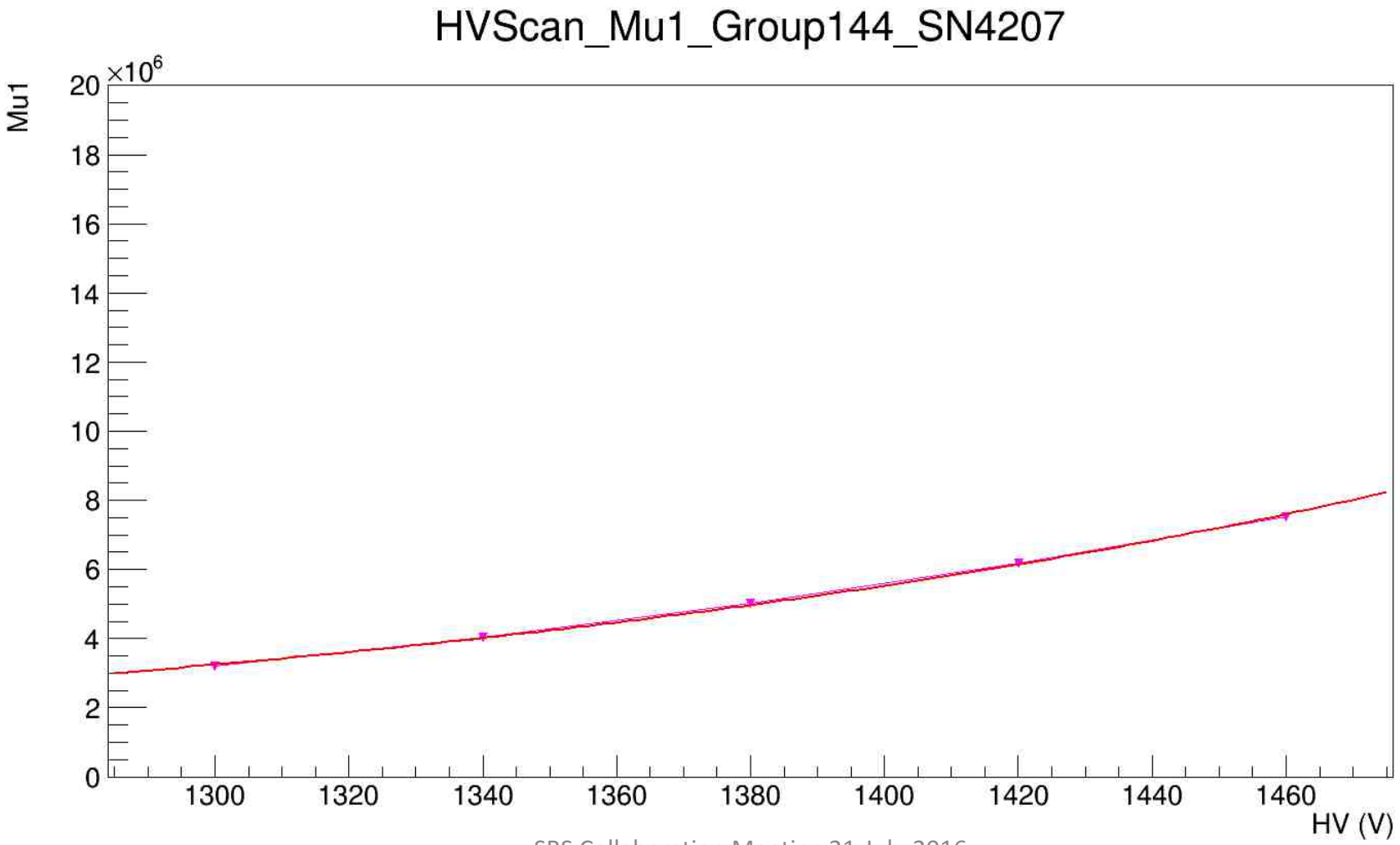
where, P_1= Mean number of photo-electrons

P_2= Gain

P_0= Constant

Data plot:

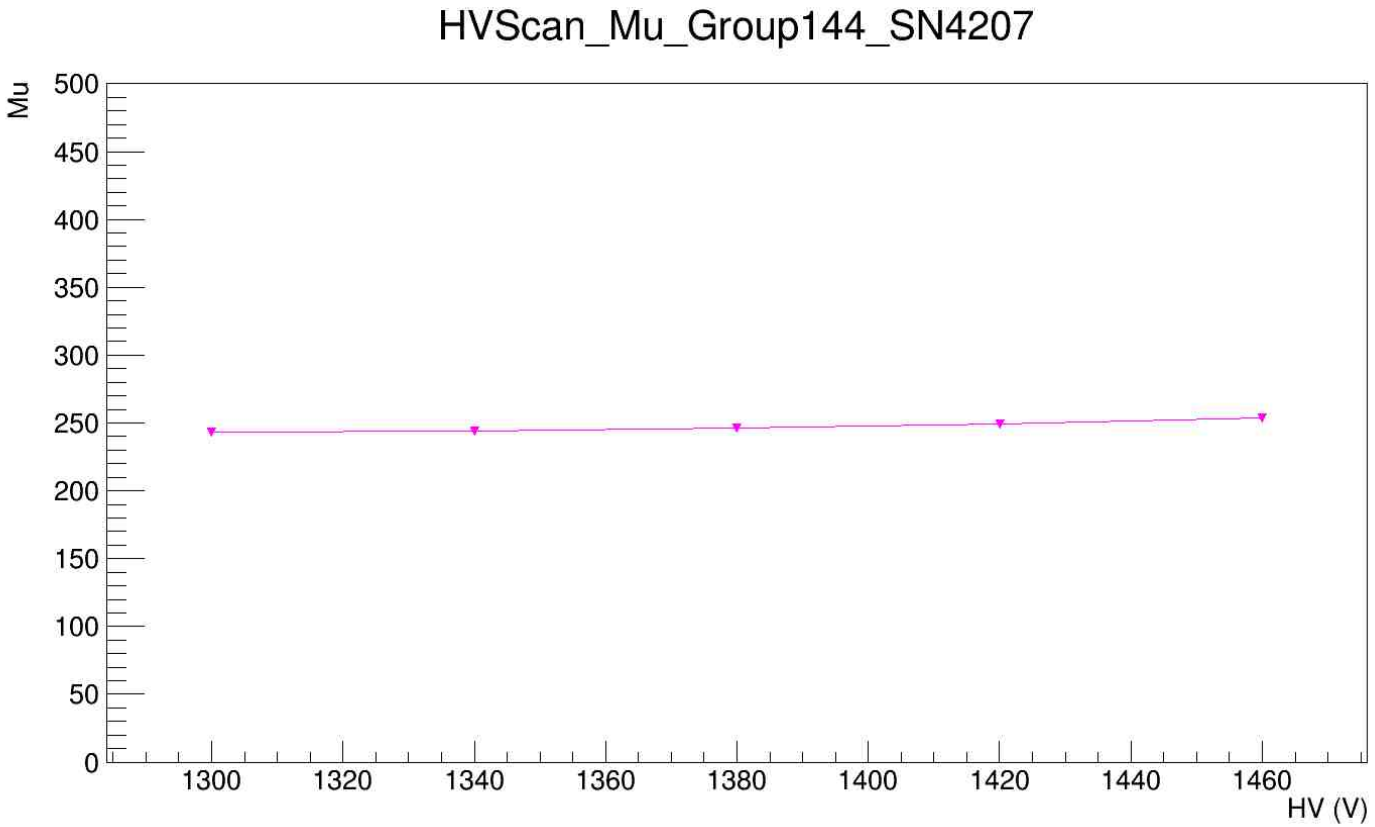
3. **Big Light scan:** i) HV scan (Gain as a function of HV)



Data plot:

3. **Big Light scan:** i) HV scan (Mean number of phes. as a function of high voltage at fixed light level)

- The mean number of phes. here is expected to be constant for all the HV levels.



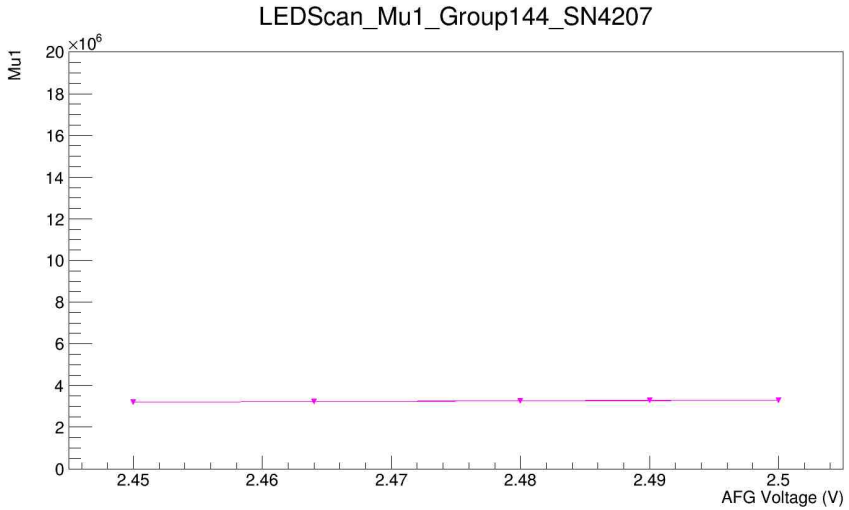
Testing Procedure:

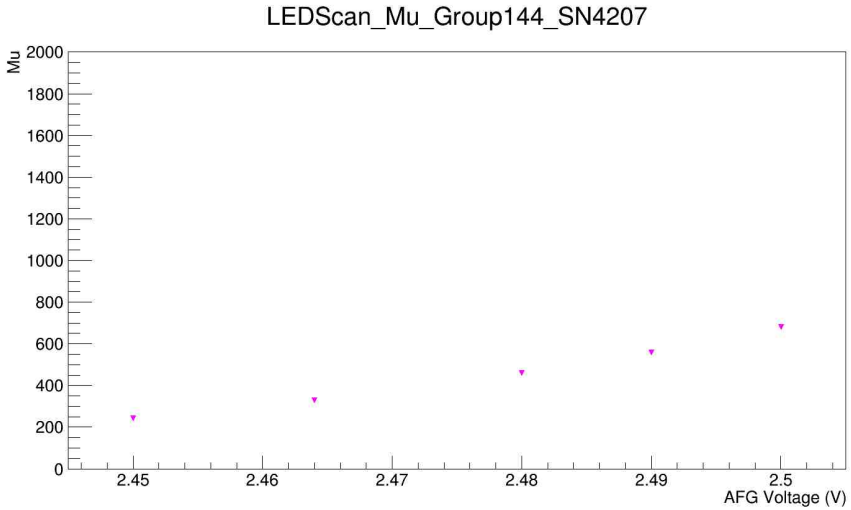
3. **Big Light scan:** ii) LED scan

- Keeping the HV level fixed at 1300 V and without disturbing any other settings, the light level was again increased up to an extent where the ADC count did not go into saturation.
- Gain curves, Energy histograms and Mean number of photo-electrons for each individual PMT this time were obtained by decreasing the light level in equal steps but not going below the one for HV scan.

Data plot:

3. **Big Light scan:** ii) LED scan (Gain and mean number of phes as a function of LED voltage level)



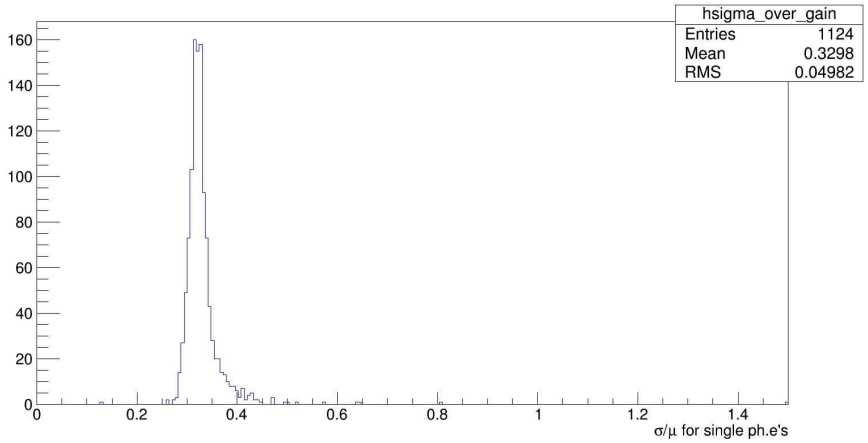


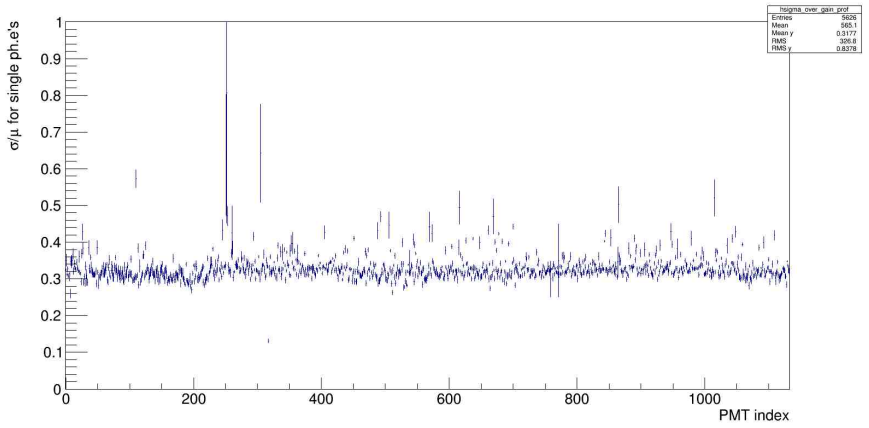
Summary for the tested PMTs:

- With a total of 143 groups of PMTs (each group with 8 PMTs) including the spare and those from the RICH detector tested by the time this presentation was made, the following slides contain the summary plots for the tested PMTs altogether.

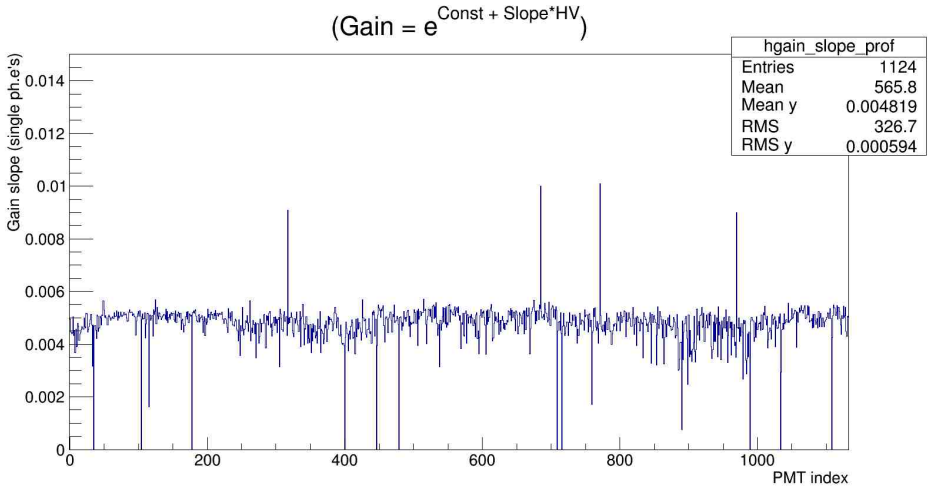
Summary plots (Single Phes.)

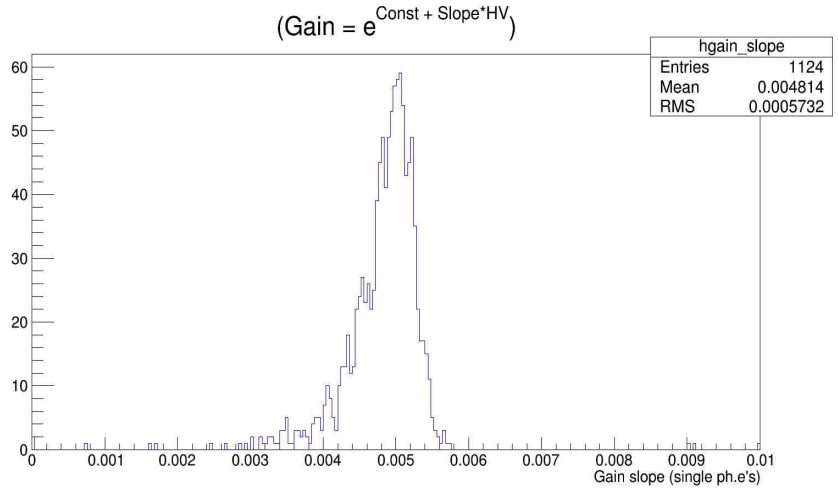
- σ/μ signifies the ratio of width of the photoelectron peak to the mean averaged over all the HV settings.

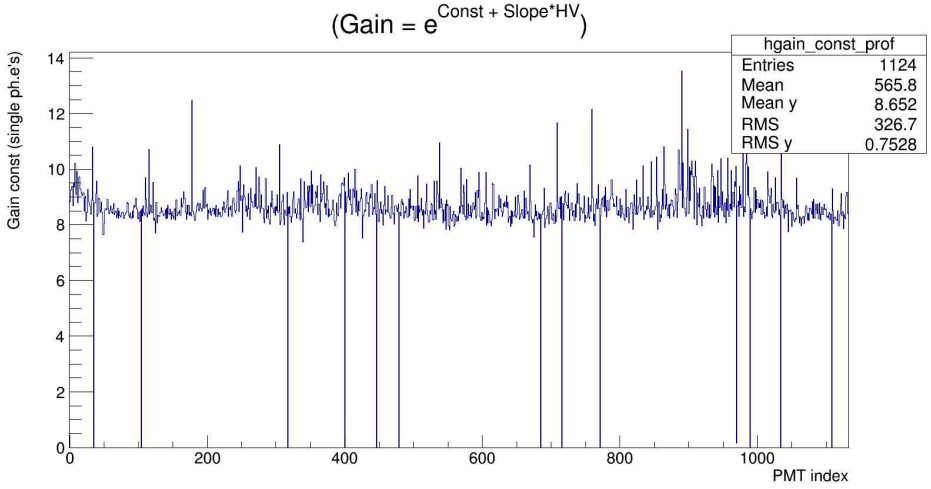


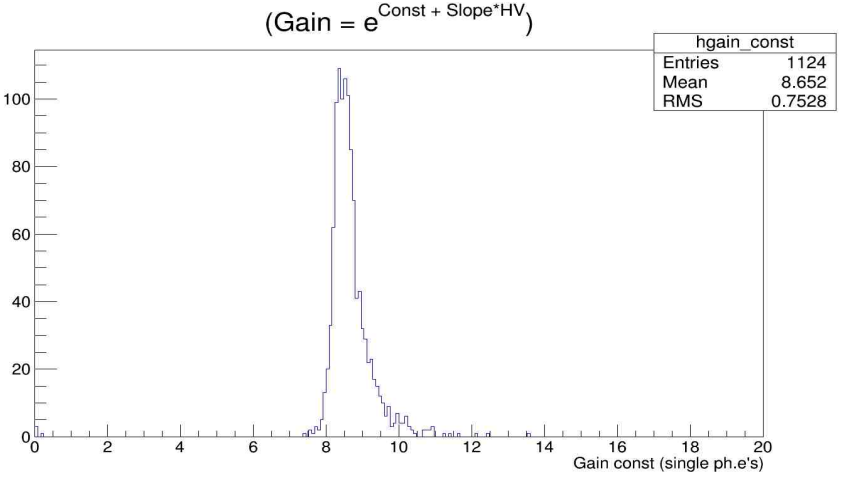


Summary plots (Single Phes.)

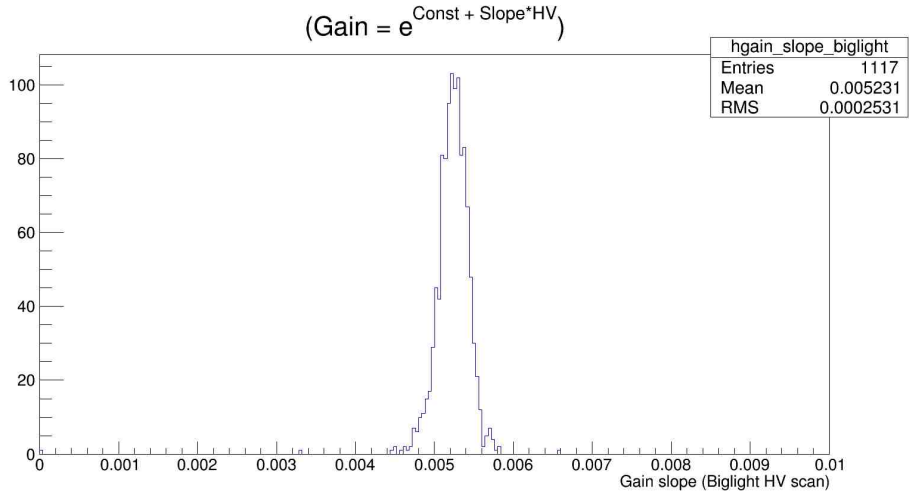


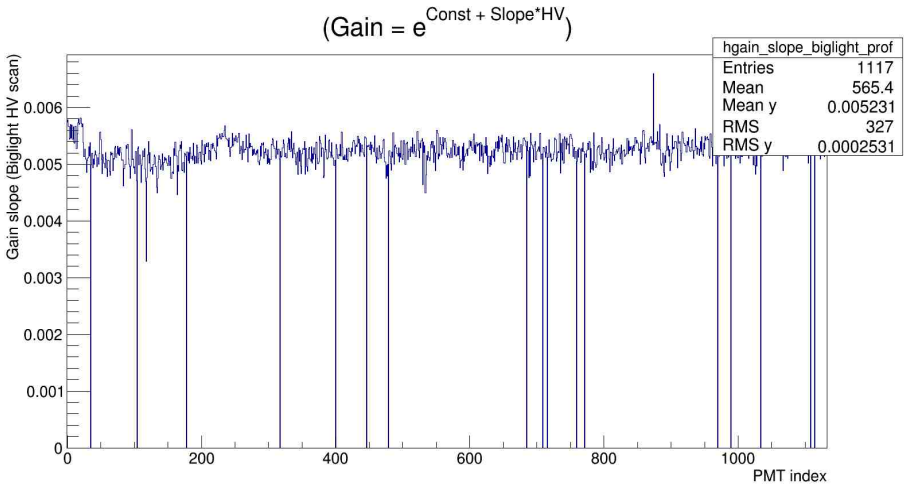


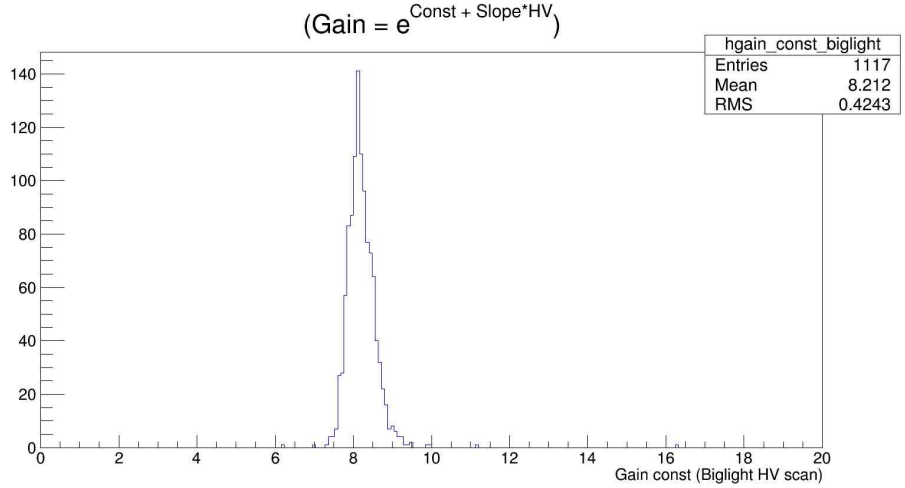


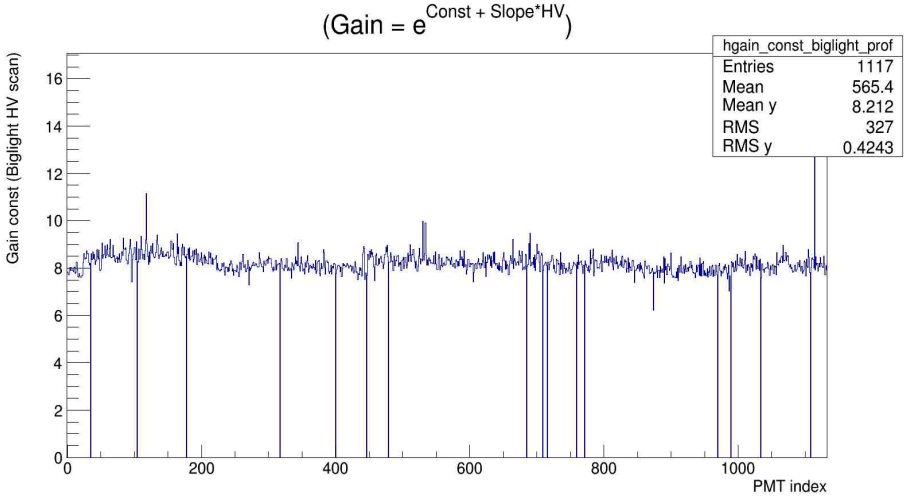


Summary plots (Big Light)



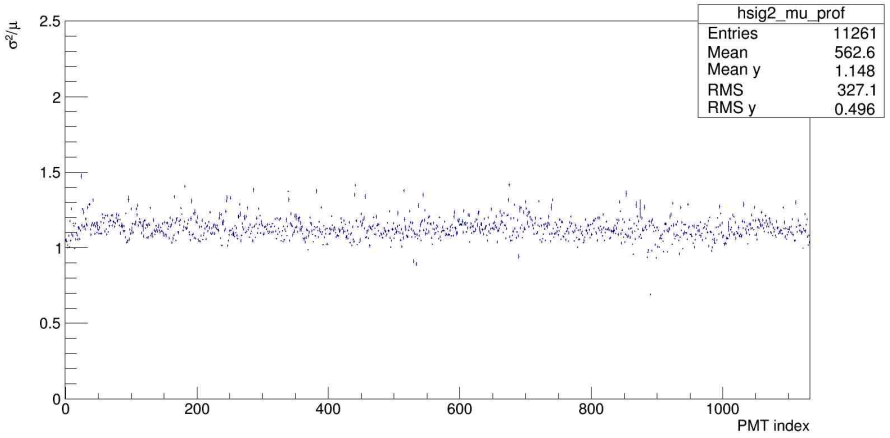


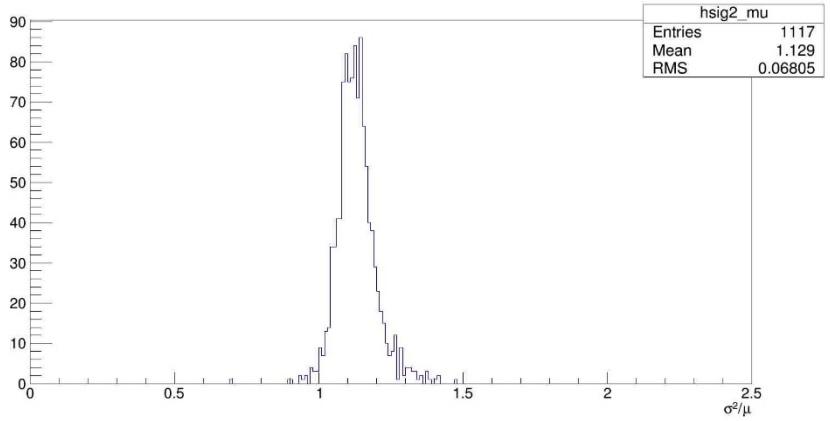




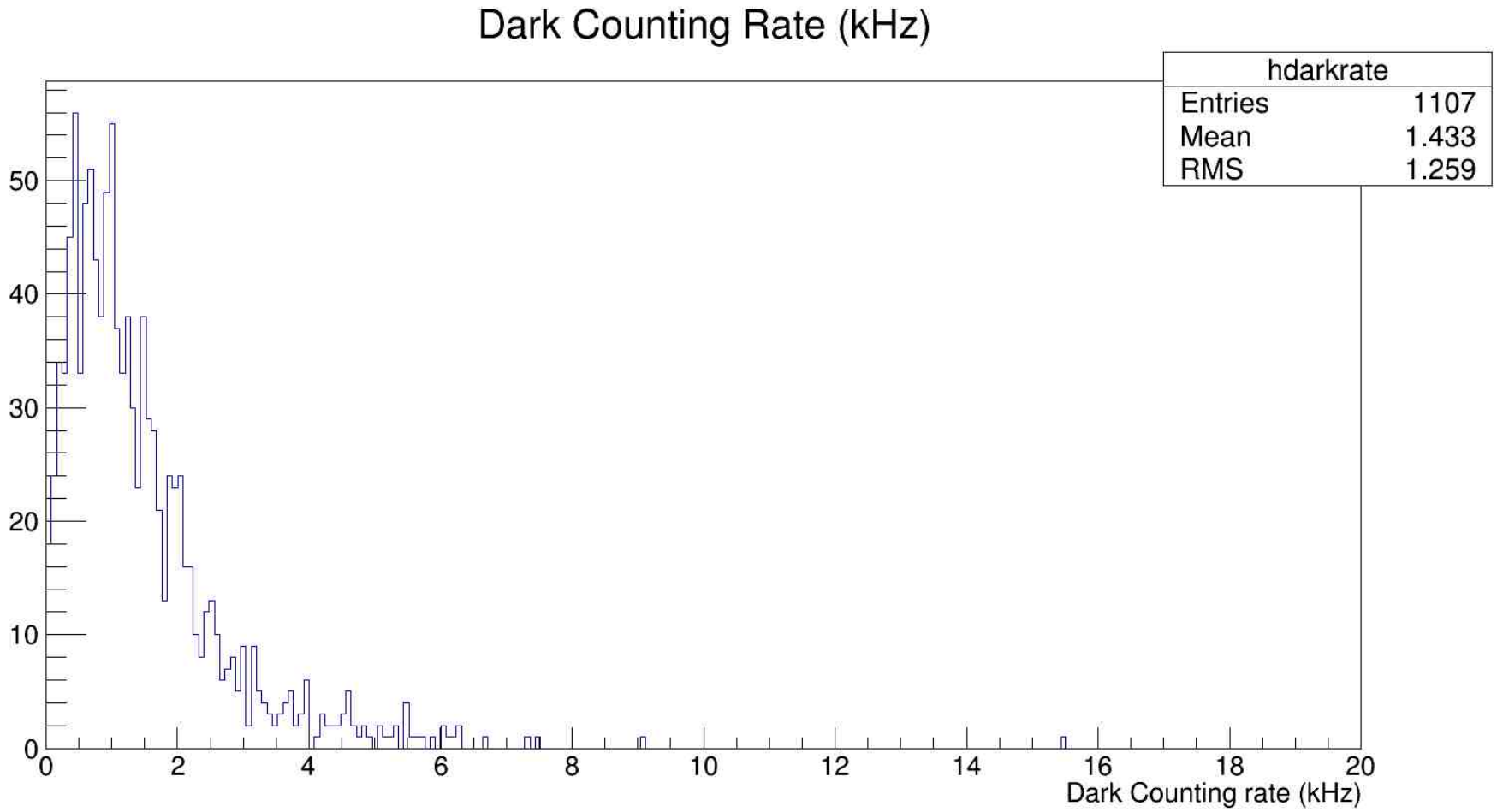
Summary plots (Big Light)

- σ^2/μ is the ratio of variance to mean of the number of phes. per "big light" pulse (averaged over all HV scan and LED scan data for each PMT), with the gain fixed at the value obtained from single photoelectron runs.
- σ^2/μ is basically a relative measure of "quantum efficiency" and is inversely proportional to it.
- For a Poisson distribution ("big light" ADC spectra), this ratio should ideally be equal to one.





Summary plots (Dark Counting Rate)



Status and plans:

- Number of spare PMTs tested: 224
- Total number of RICH PMTs: 1934
- Number of RICH PMTs tested: 1136 (approx.)
- Number of PMTs rejected as BAD: 22
- With the current rate of PMT testing, we desire to finish testing all the PMTs by the end of Summer or early into Fall semester.