November 5, 2018 Update: MAPMT ADC fitting

Andrew Hurley

The College of William and Mary

adhurley@email.wm.edu

November 5, 2018

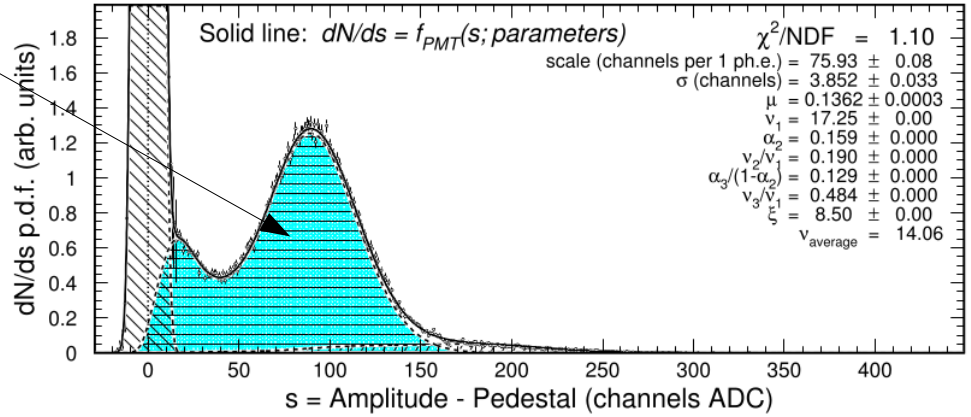
Overview

- The ADC spectra of the Hamamatsu 12700 MAPMTs are fitted using a model derived by Pavel Degtyarenko
- The form of the model we chose to use has 9 free parameters (= long computation time)
- Found that at least 3 parameters can be fixed without sacrificing fit quality to greatly improve computation time
- Ensured that the fit algorithm works across various settings and modules independently

Adc Model

Characteristic fit of the ADC spectrum from CLAS12

Single photoelectron contribution in blue



(c) Hamamatsu H12700 MAPMT GA0133, HV = 1050 V.

$$f(a;\mathbf{d}) = \sum_{n=0}^{\infty} \left\{ G(a,n;\sigma_{\text{eff}}) \left[e^{-\mu} q_0(n) + \sum_{m=1}^{\infty} P(m;\mu) T(n,m;\mathbf{t}) \right] \right\}.$$

Sum over the number of photoelectrons produced at the first stage of the PMT

Sum over the number of photoelectrons produced at the later stages of the PMT

Nuclear Inst. and Methods in Physics Research, A 872 (2017) 1–15

Adc Model cont.

$$\nu_{cL} = \sum_{u=1}^{L} \nu_u i_u$$

$$P(n;\nu) \equiv \frac{\nu^n e^{-\nu}}{n!}$$

$$\sum_{u=1}^{L} \alpha_u = 1,$$

$$T(n,m;\mathbf{t}) = \sum_{\substack{i_1+i_2+i_3=m \\ i_1,i_2,i_3\geq 0}} \frac{m!}{i_1!\, i_2!\, i_3!} \alpha_1^{i_1} \alpha_2^{i_2} \alpha_3^{i_3} P(n;\nu_c),$$

$$f(a;\mathbf{d}) = \sum_{n=0}^{\infty} \left\{ G(a,n;\sigma_{\mathrm{eff}}) \left[e^{-\mu} q_0(n) + \sum_{m=1}^{\infty} P(m;\mu) T(n,m;\mathbf{t}) \right] \right\}.$$

Sum over the number of photoelectrons produced at the first stage of the PMT

Sum over the number of photoelectrons produced at the later stages of the PMT

Nuclear Inst. and Methods in Physics Research, A 872 (2017) 1–15

"...wherein the corresponding partial gains, or average multiplicities of the Poissonian components are ν_1, ..., ν_L, their relative contributions to the SPE function are α_1, ..., α_L..."

Adc Model cont.

List of PMT model fit parameters.

Name	Limits		Brief description
scale	>0	–	Average amplitude of SPE signals (channels ADC)
σ	>0	–	Standard deviation of the pedestal fit (channels ADC)
μ	>0	–	Average multiplicity of photoelectrons
ν_1	>0	–	Average multiplicity of the first gain component in (26)
α_2	[0, 1]	–	Portion of second gain component in (26)
ν_2/ν_1	[0, 1]	–	Relative multiplicity of the second gain component in (26)
$\alpha_3/(1-\alpha_2)$	[0, 1]	–	Relative portion of third gain component in (26)
ν_3/ν_1	[0, 1]	–	Relative multiplicity of the third gain component in (26)
ξ	>1	–	Average multiplicity at the second dynode

- 9 free parameters
- 20-30 hours to fit a single run (192 channels)
- by fixing 3 of the parameters (ξ, ν_2, ν_3) $\rightarrow$ 3.5-4.5 hours (192 channels)

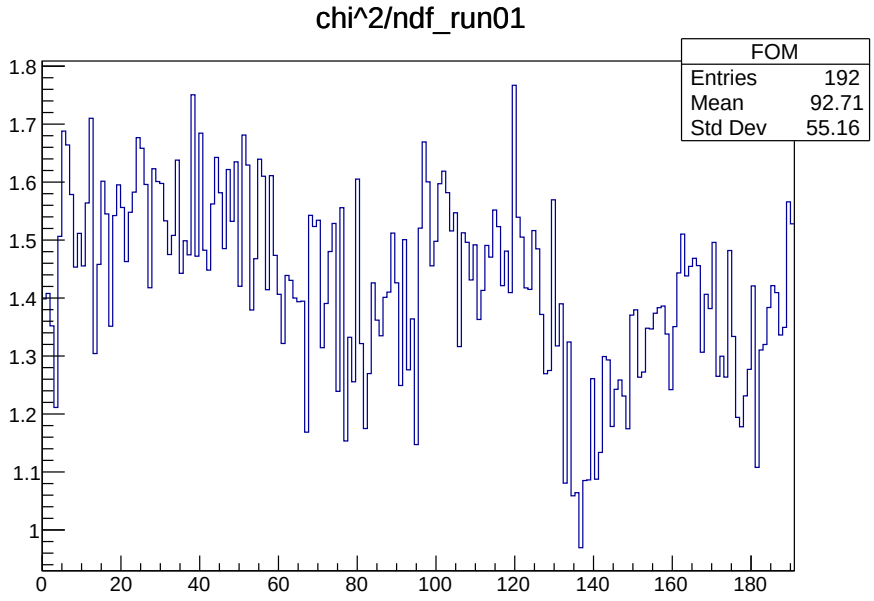
MAPMT ADC fitting with fixed parameters

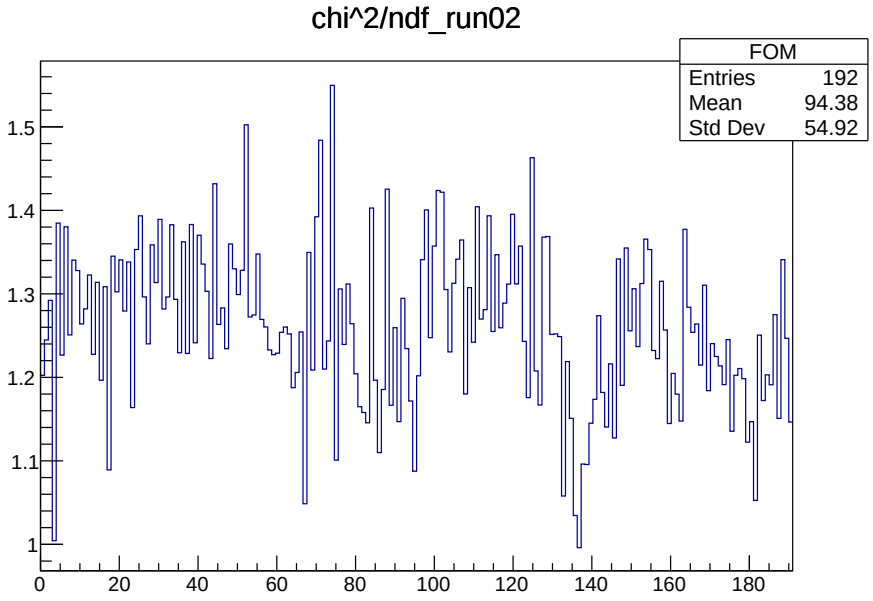
- Are these fixed parameters global to all MAPMTS and run conditions?
- Findings:
  - Fixing ξ, ν_2, and ν_3 yielded a $\chi^2/NDF \approx 1-2$ for 9 run conditions (with a different module than the one used to determine the fixed values).
  - $\chi^2/NDF \approx 1-2$ is around the same for the examples provided in Pavel's NIM paper.
  - σ may be able to be fixed for each combination of gain and HV
- runs shown, using a randomly selected module (module 075) run(hv,gain); 1(1100,32), 2(1100,64), 3(1100,128), 13(1075,32), 14(1075,64), 15(1075,128), 25(1000,32), 26(1000,64), and 27(1000,128)

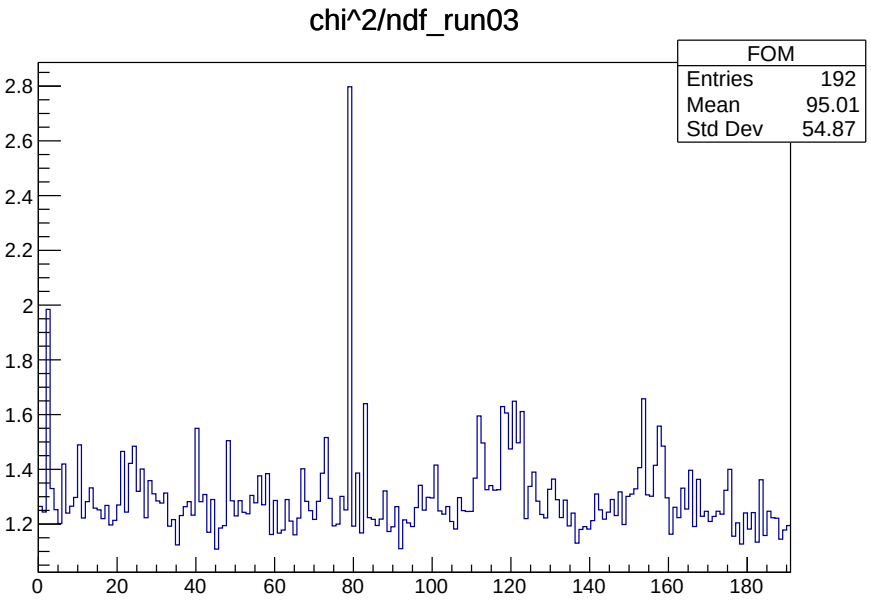
Reference Slide: Run settings for each module (presented runs highlighted)

1 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 32 THR 25 run
2 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 64 THR 25 run
3 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 128 THR 25 run
4 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 32 THR 50 run
5 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 64 THR 50 run
6 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 128 THR 50 run
7 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 32 THR 100 run
8 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 64 THR 100 run
9 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 128 THR 100 run
10 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 32 THR 200 run
11 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 64 THR 200 run
12 W 6 X 200 Y 25 HV 1100 GMODE 0 GAIN 128 THR 200 run
13 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 32 THR 25 run
14 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 64 THR 25 run
15 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 128 THR 25 run
16 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 32 THR 50 run
17 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 64 THR 50 run
18 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 128 THR 50 run
19 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 32 THR 100 run
20 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 64 THR 100 run
21 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 128 THR 100 run
22 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 32 THR 200 run
23 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 64 THR 200 run
24 W 6 X 200 Y 25 HV 1075 GMODE 0 GAIN 128 THR 200 run
25 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 32 THR 25 run
26 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 64 THR 25 run
27 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 128 THR 25 run
28 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 32 THR 50 run
29 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 64 THR 50 run
30 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 128 THR 50 run
31 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 32 THR 100 run
32 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 64 THR 100 run
33 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 128 THR 100 run
34 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 32 THR 200 run
35 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 64 THR 200 run
36 W 6 X 200 Y 25 HV 1000 GMODE 0 GAIN 128 THR 200 run
37 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 32 THR 25 run
38 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 64 THR 25 run
39 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 128 THR 25 run
40 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 32 THR 50 run
41 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 64 THR 50 run
42 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 128 THR 50 run
43 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 32 THR 100 run
44 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 64 THR 100 run
45 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 128 THR 100 run
46 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 32 THR 200 run
47 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 64 THR 200 run
48 W 4 X 200 Y 25 HV 1100 GMODE 0 GAIN 128 THR 200 run
49 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 32 THR 25 run
50 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 64 THR 25 run
51 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 128 THR 25 run
52 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 32 THR 50 run
53 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 64 THR 50 run
54 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 128 THR 50 run
55 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 32 THR 100 run
56 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 64 THR 100 run
57 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 128 THR 100 run
58 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 32 THR 200 run
59 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 64 THR 200 run
60 W 4 X 200 Y 25 HV 1075 GMODE 0 GAIN 128 THR 200 run
61 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 32 THR 25 run
62 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 64 THR 25 run
63 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 128 THR 25 run
64 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 32 THR 50 run
65 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 64 THR 50 run
66 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 128 THR 50 run
67 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 32 THR 100 run
68 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 64 THR 100 run
69 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 128 THR 100 run
70 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 32 THR 200 run
71 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 64 THR 200 run
72 W 4 X 200 Y 25 HV 1000 GMODE 0 GAIN 128 THR 200 run

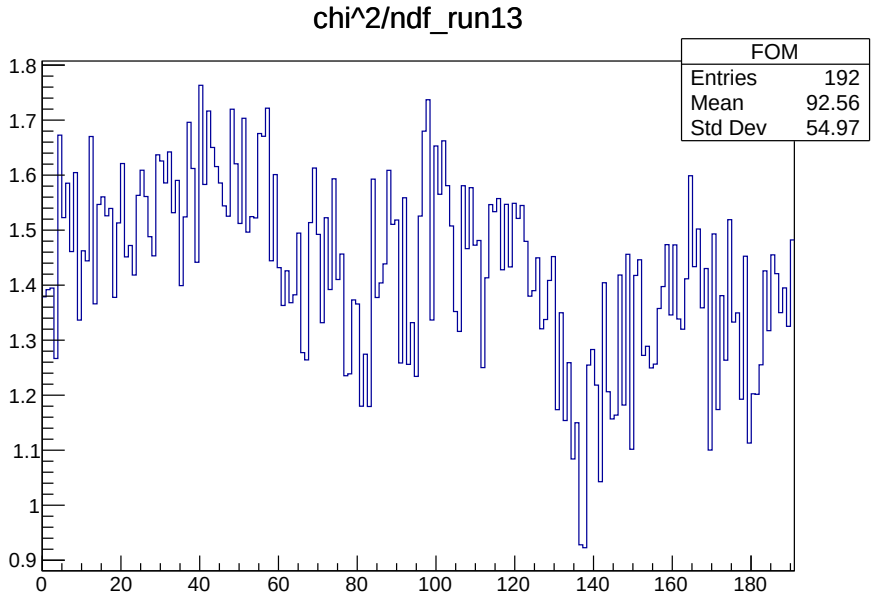
χ^2/NDF for runs 01, 02, and 03 (HV=1100)

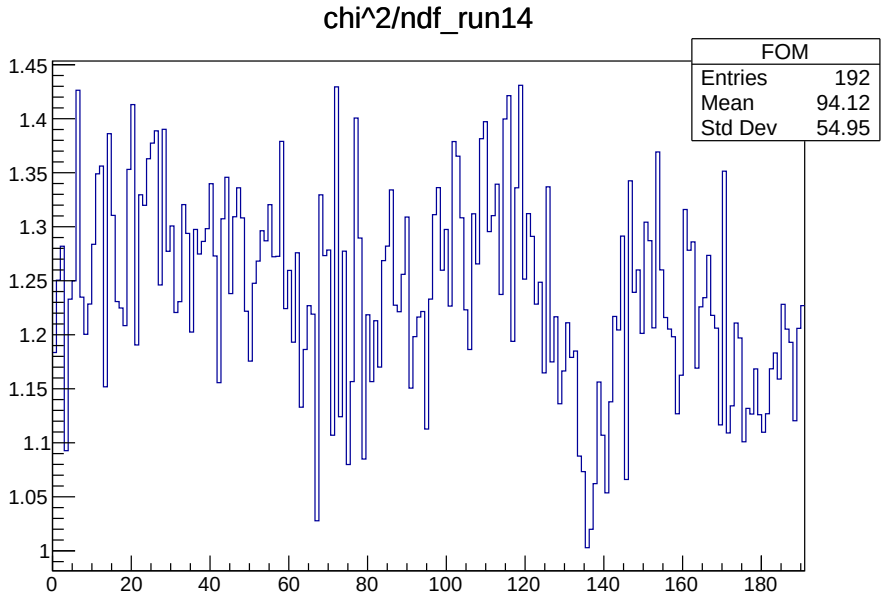


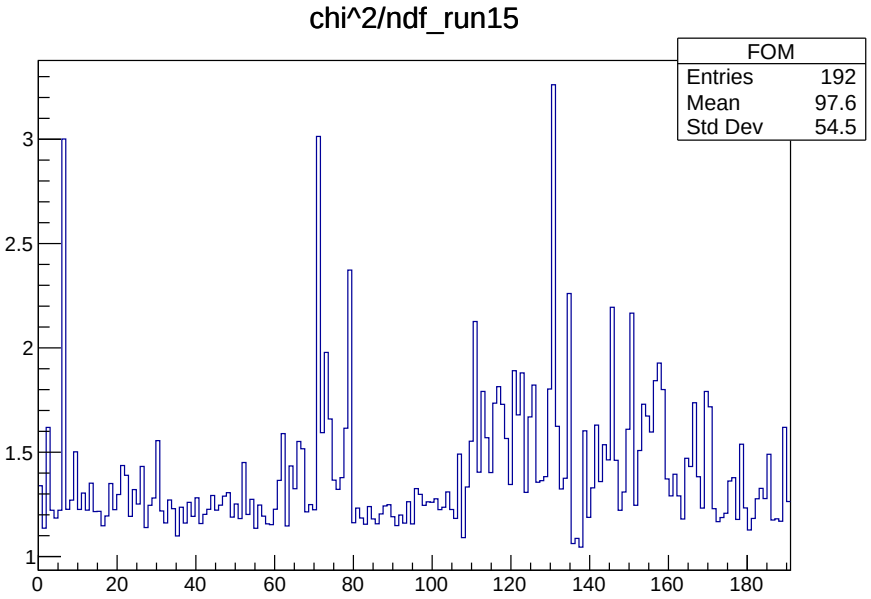




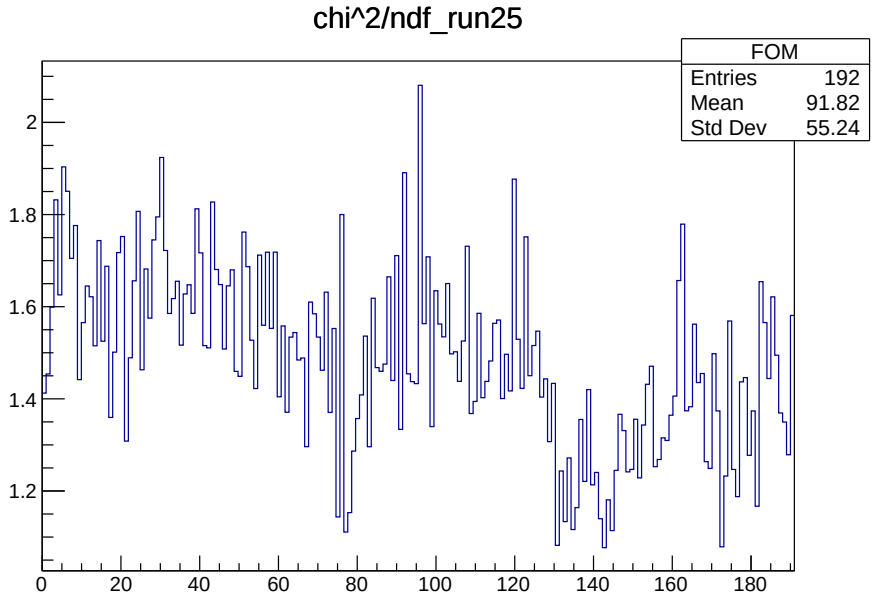
χ^2/NDF for runs 13, 14, and 15 (HV = 1075)

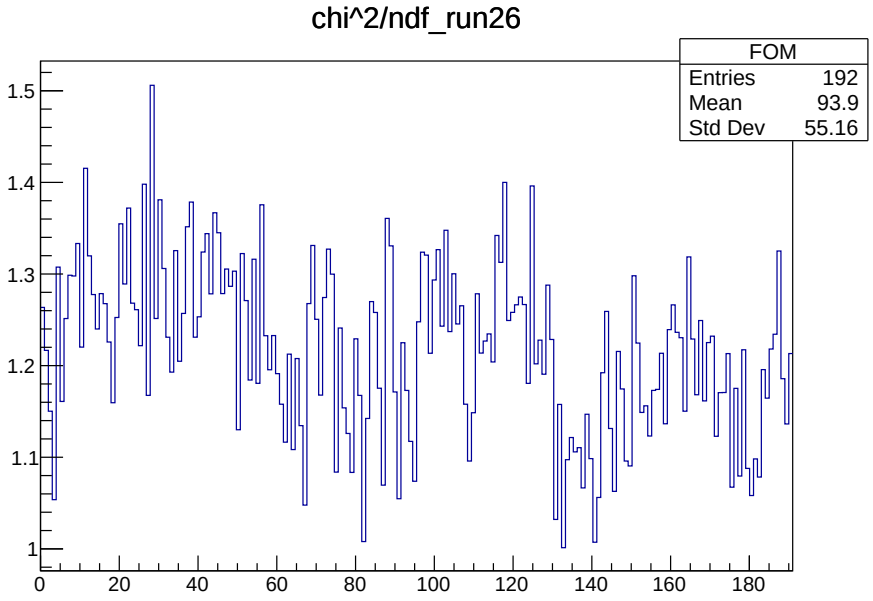


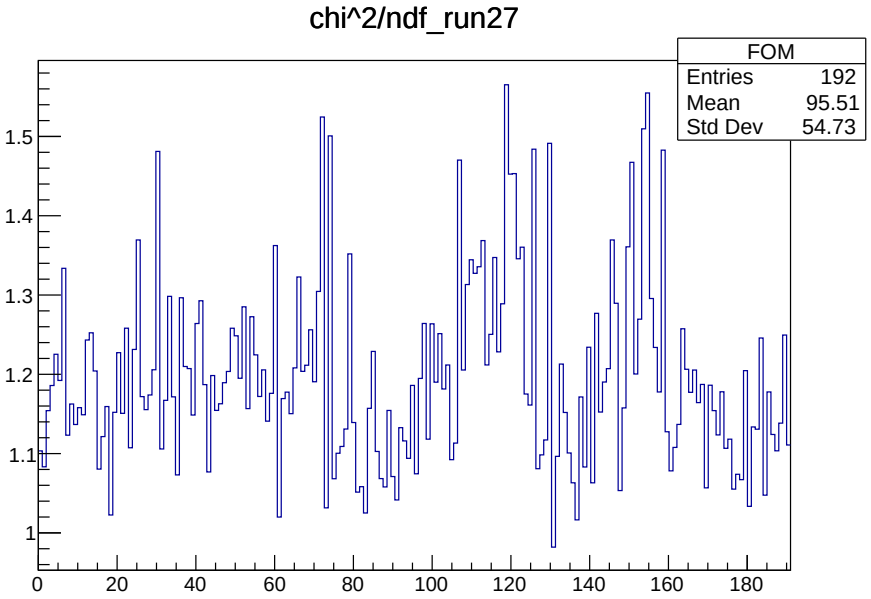




χ^2/NDF for run 25, 26, and 27 (HV = 1000)



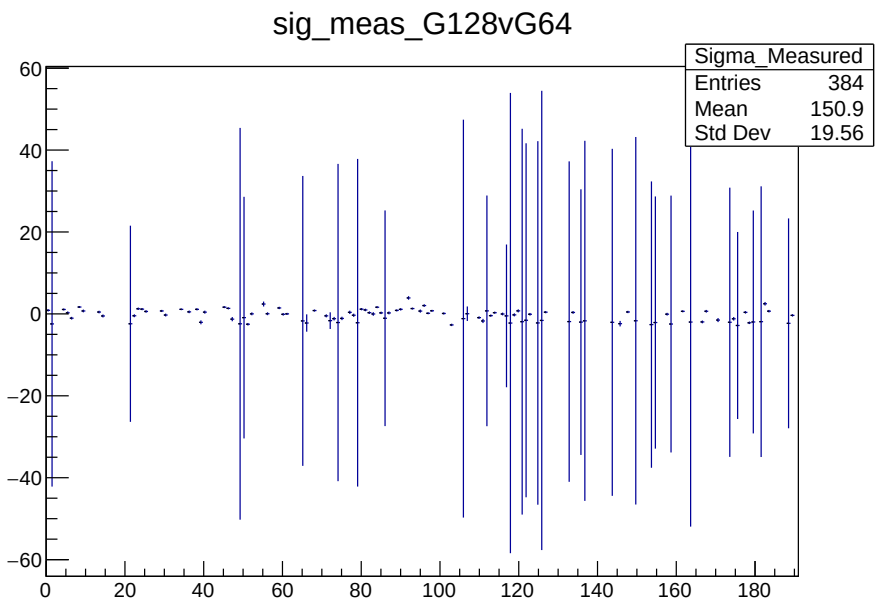


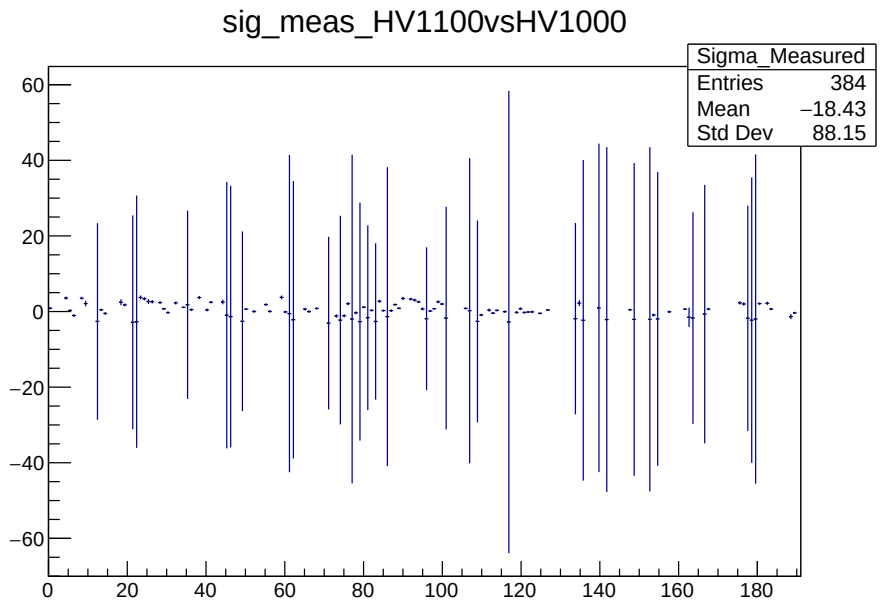


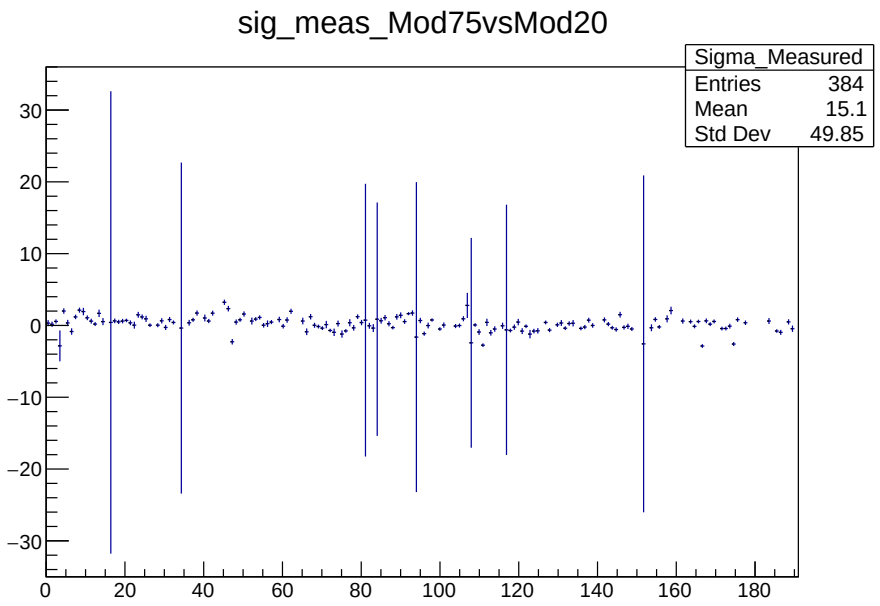
Summary

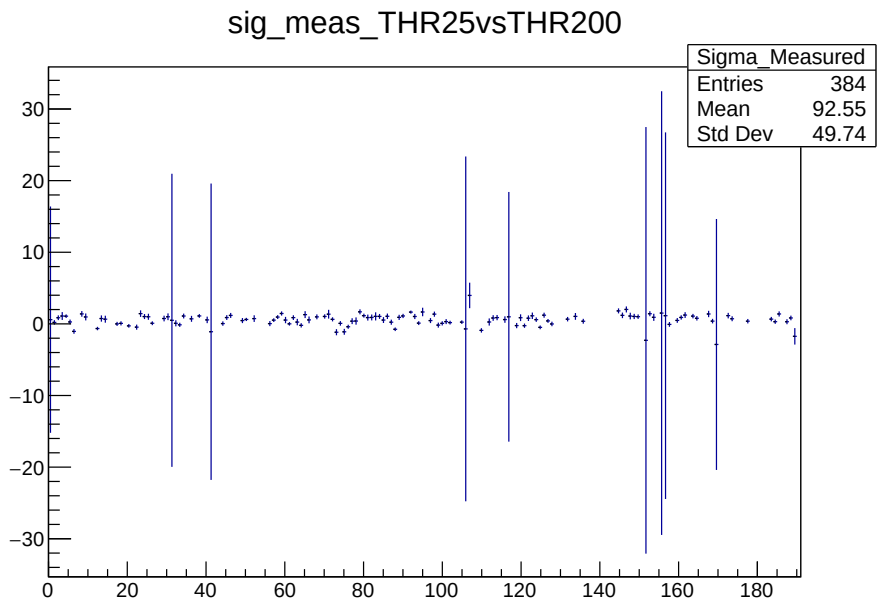
- Fits are stable with fixed parameters across various high voltage and gain settings, as well as different modules
- The fitter will be ready to run over all of the tested modules this week
- Determination of pixel efficiency for each setting will then follow

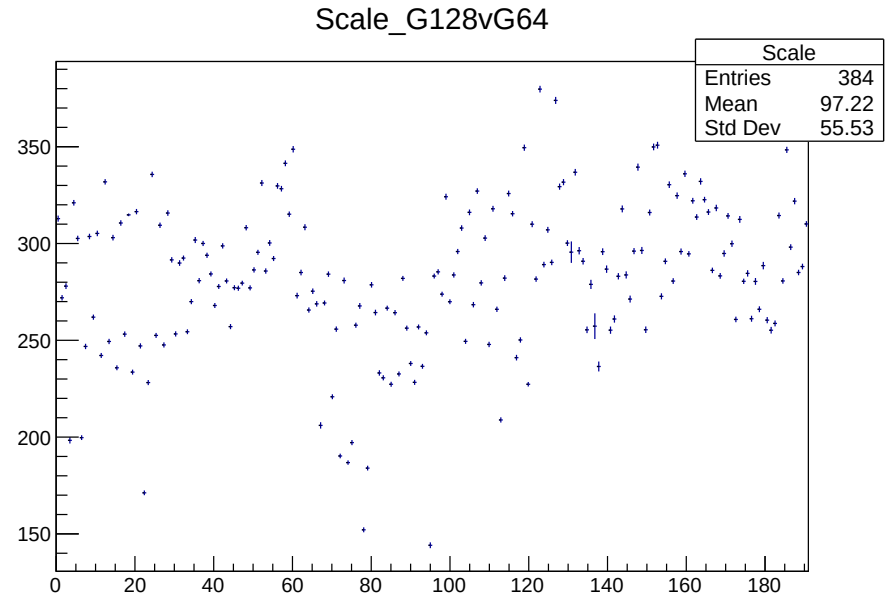
Backup slides

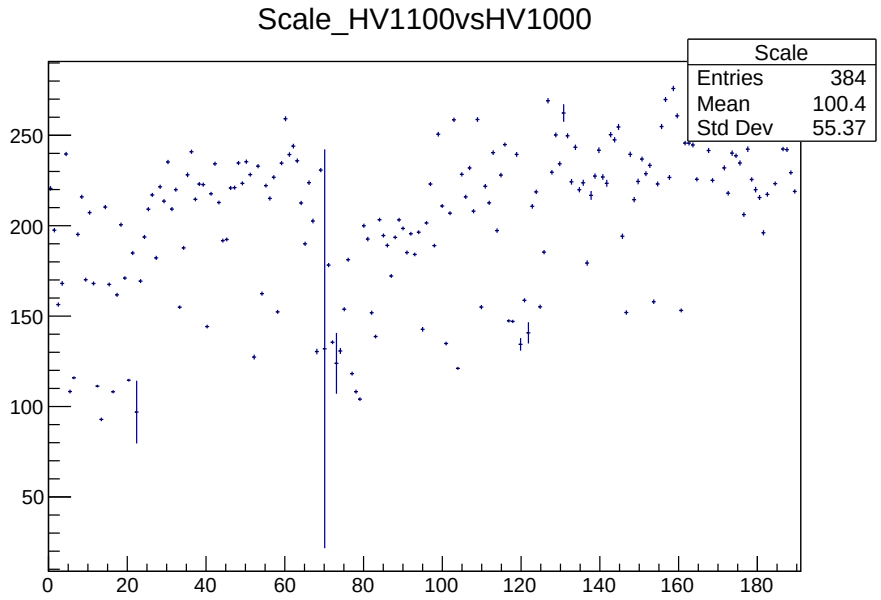

sig_meas_G128vG64
Sigma_Measured
Entries 384
Mean 150.9
Std Dev 19.56

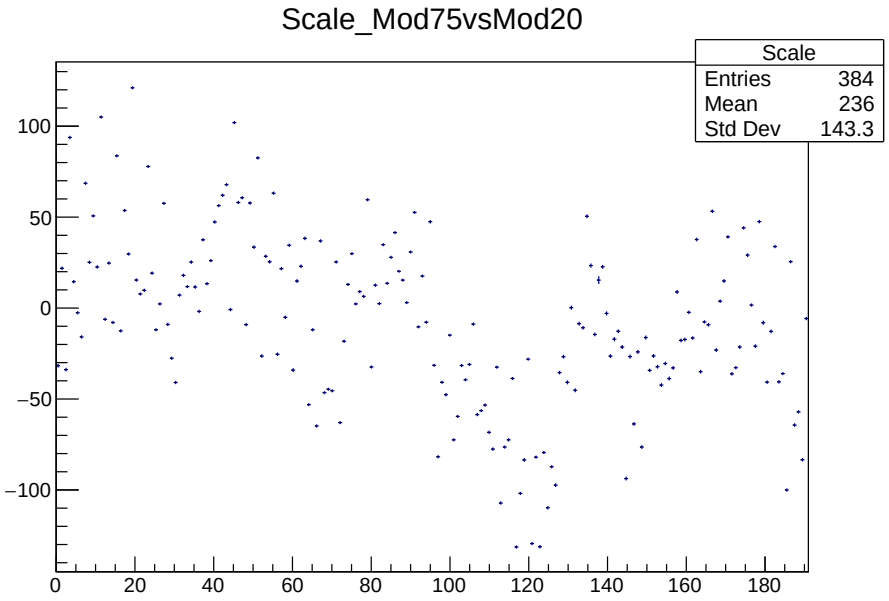

sig_meas_HV1100vsHV1000
Sigma_Measured
Entries 384
Mean −18.43
Std Dev 88.15

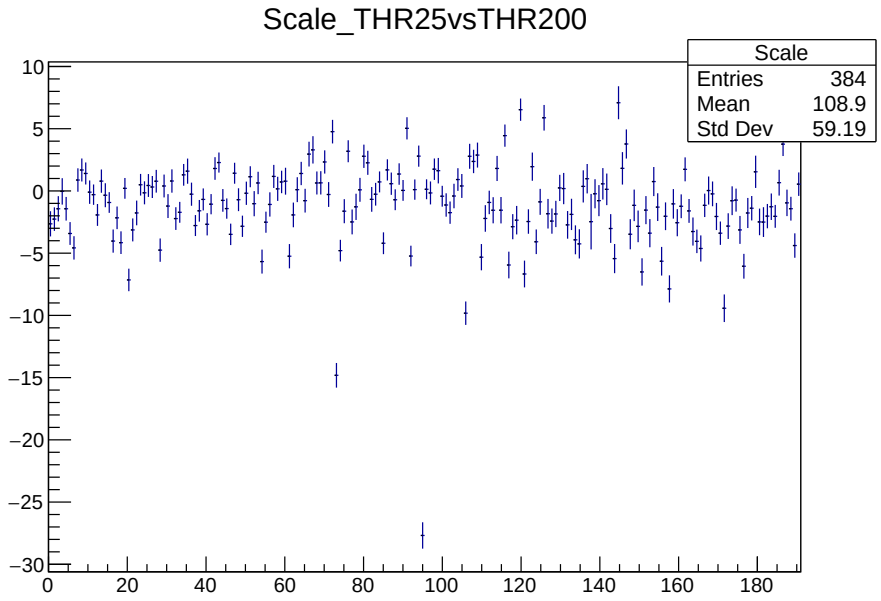

sig_meas_Mod75vsMod20
Sigma_Measured
Entries 384
Mean 15.1
Std Dev 49.85

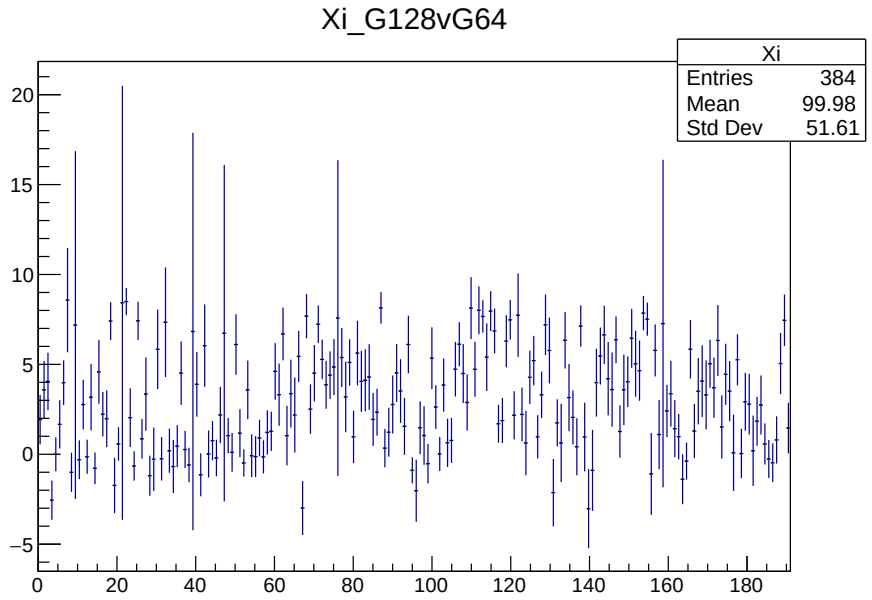

sig_meas_THR25vsTHR200
Sigma_Measured
Entries 384
Mean 92.55
Std Dev 49.74

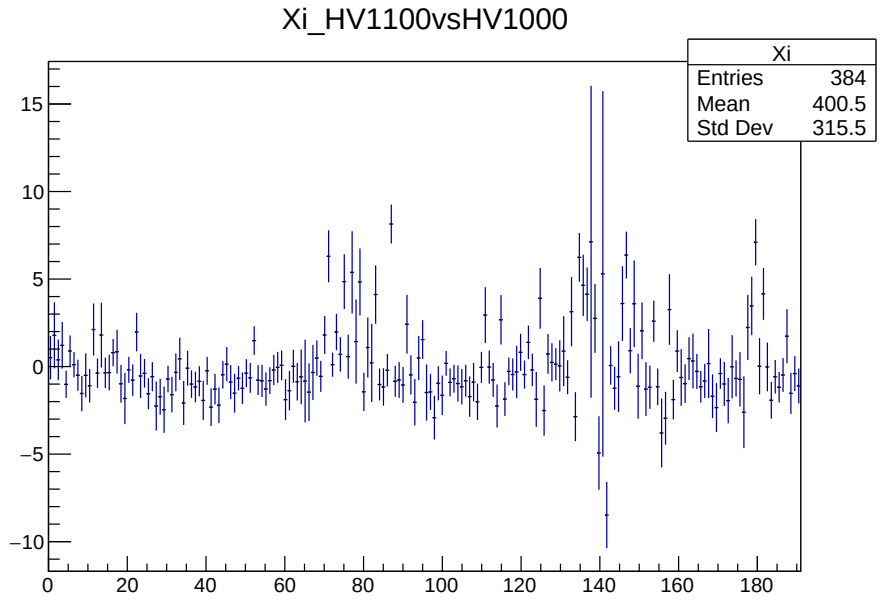

Scale_G128vG64
Scale
Entries 384
Mean 97.22
Std Dev 55.53

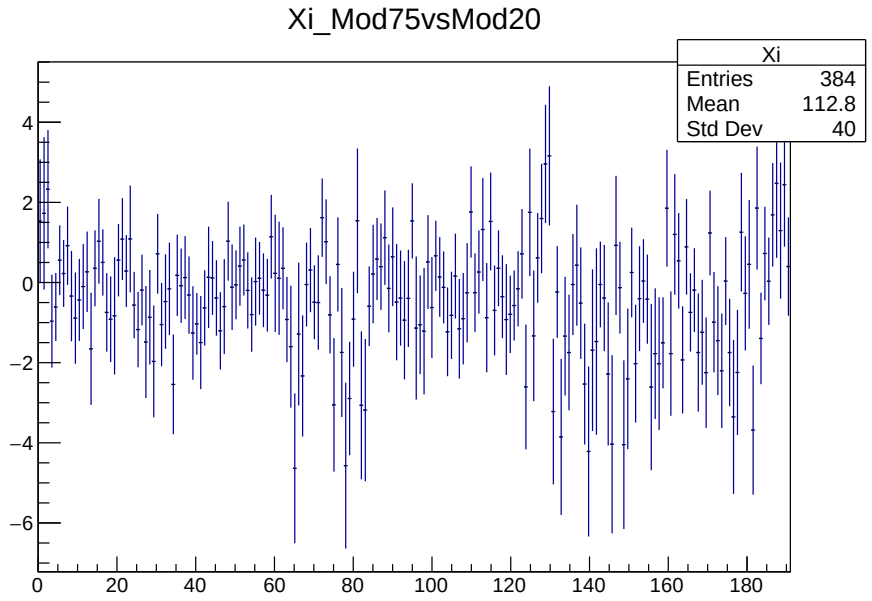

Scale_HV1100vsHV1000
Scale
Entries 384
Mean 100.4
Std Dev 55.37

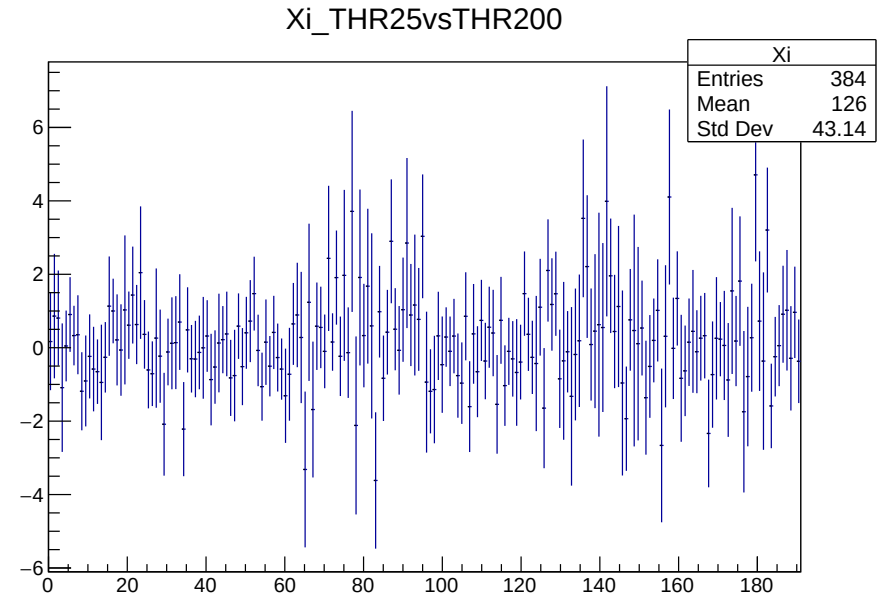

Scale_Mod75vsMod20
Scale
Entries 384
Mean 236
Std Dev 143.3

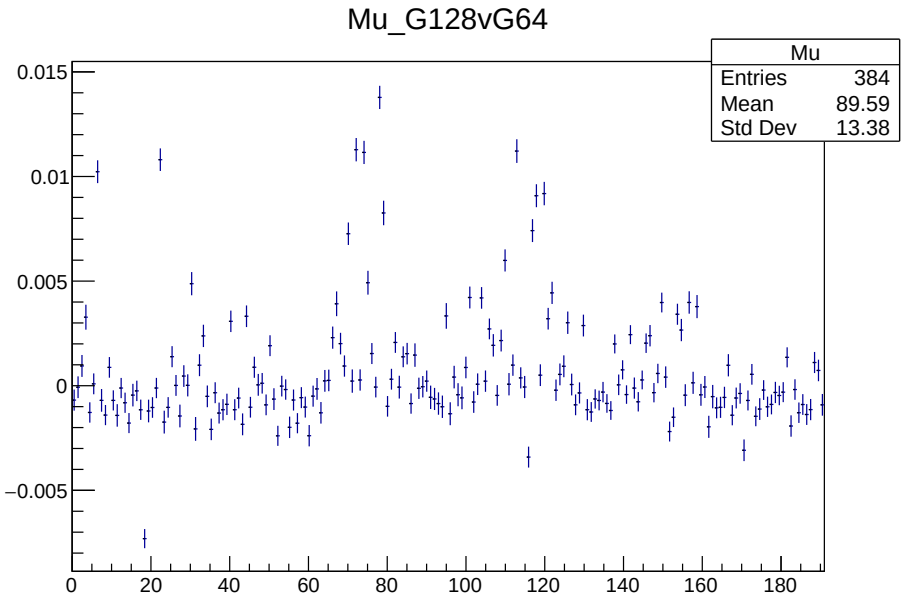

Scale_THR25vsTHR200
Scale
Entries 384
Mean 108.9
Std Dev 59.19

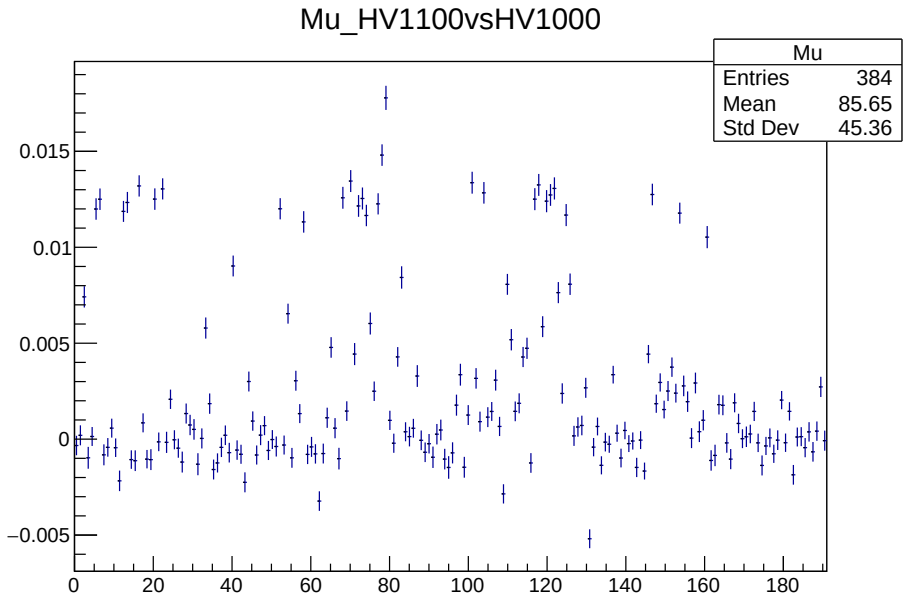

Xi_G128vG64
Xi
Entries 384
Mean 99.98
Std Dev 51.61

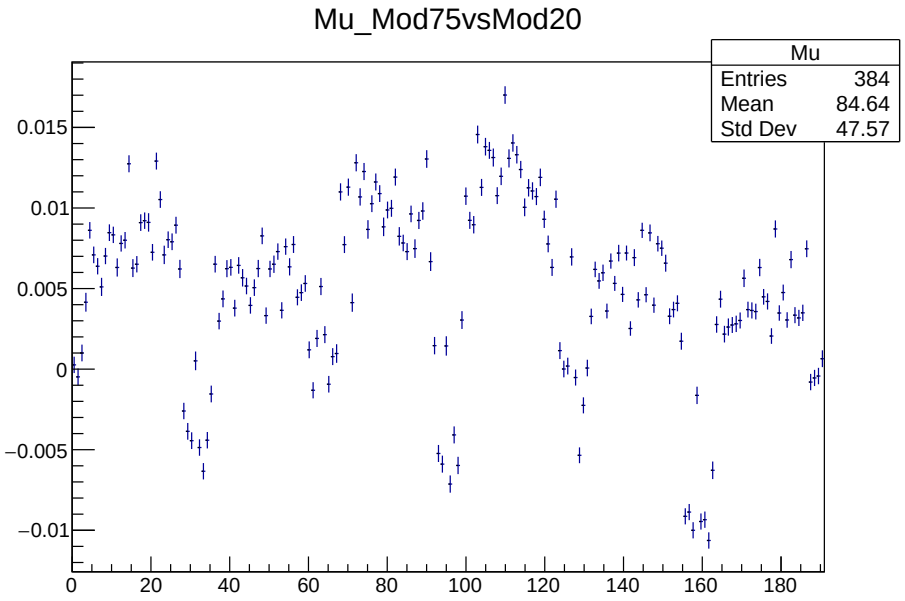

Xi_HV1100vsHV1000
Xi
Entries 384
Mean 400.5
Std Dev 315.5

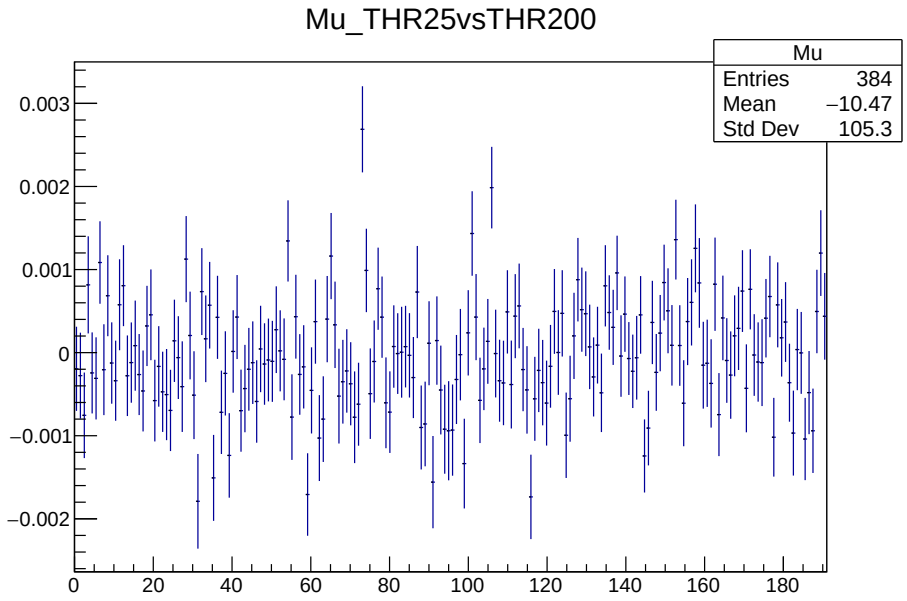

Xi_Mod75vsMod20
Xi
Entries 384
Mean 112.8
Std Dev 40

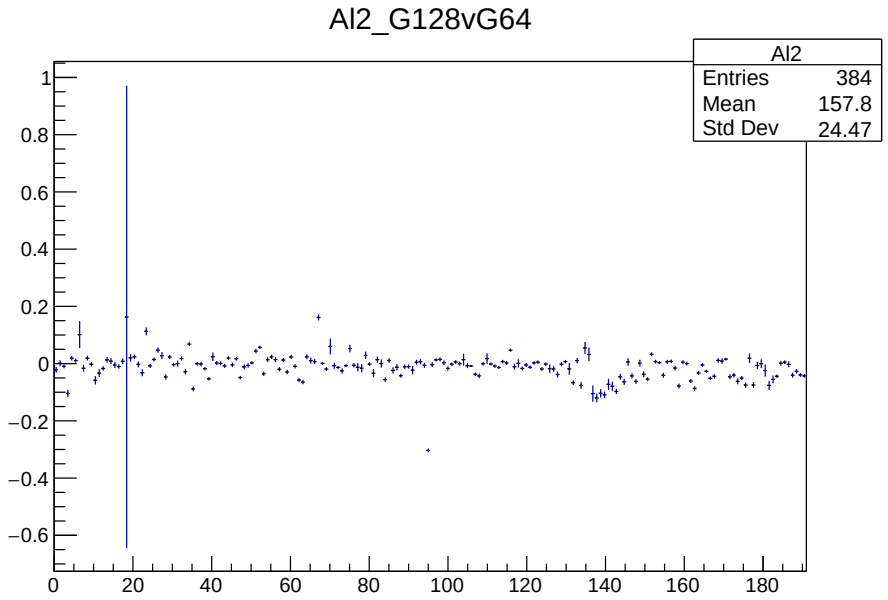

Xi_THR25vsTHR200
Xi
Entries 384
Mean 126
Std Dev 43.14

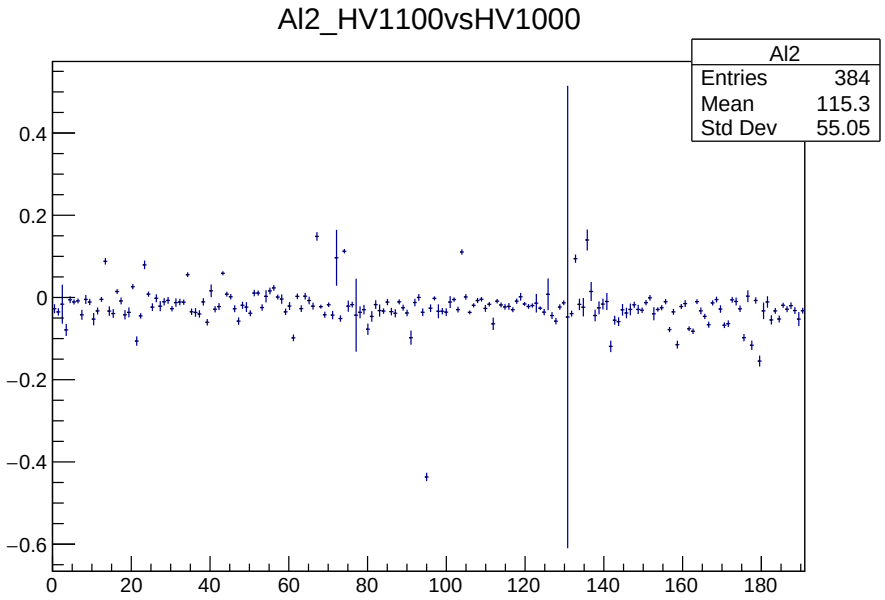

Mu_G128vG64
Mu
Entries 384
Mean 89.59
Std Dev 13.38

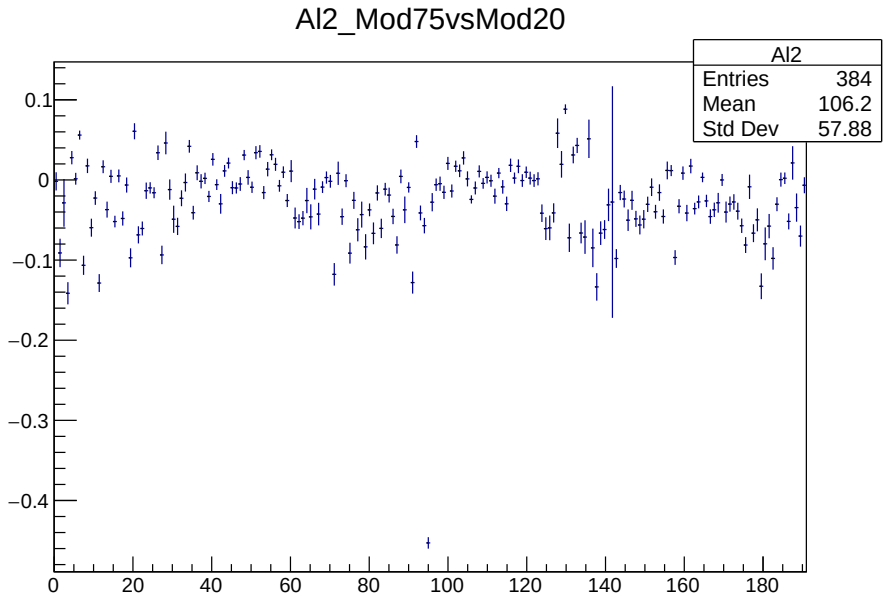

Mu_HV1100vsHV1000
Mu
Entries 384
Mean 85.65
Std Dev 45.36

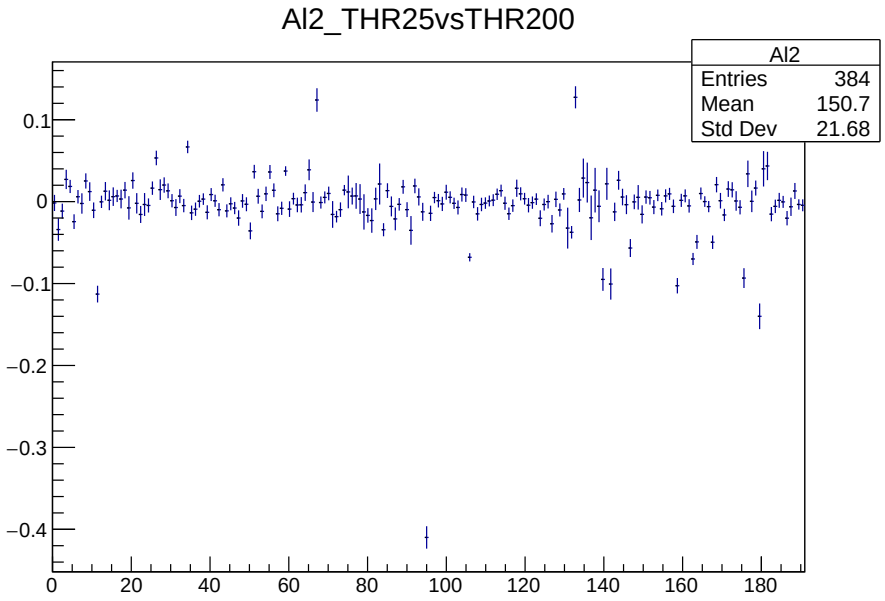

Mu_Mod75vsMod20
Mu
Entries 384
Mean 84.64
Std Dev 47.57

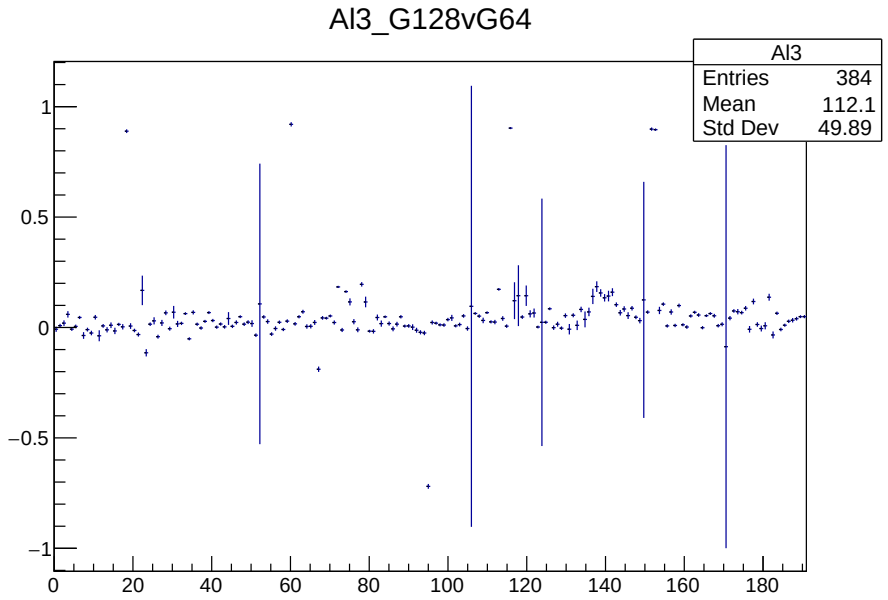

Mu_THR25vsTHR200
Mu
Entries 384
Mean −10.47
Std Dev 105.3

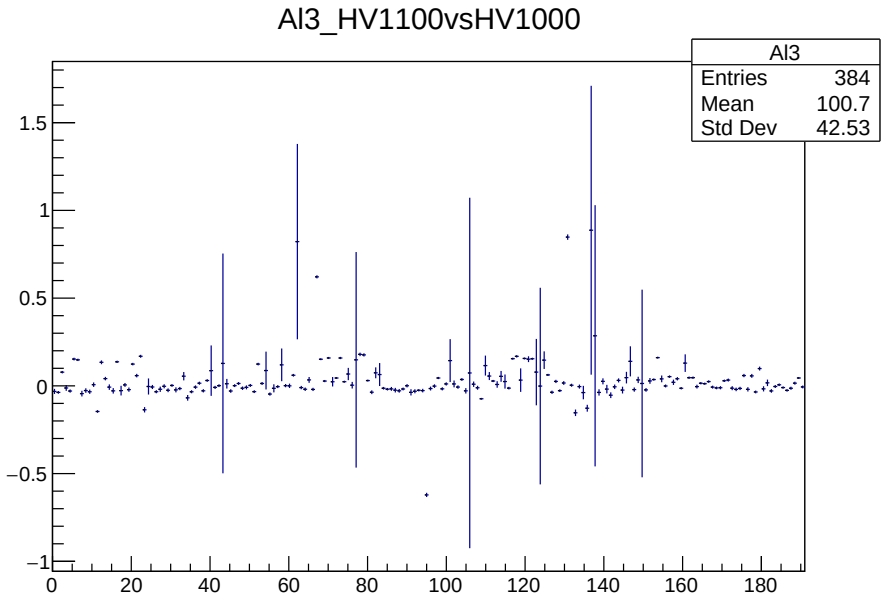

Al2_G128vG64
Al2
Entries 384
Mean 157.8
Std Dev 24.47

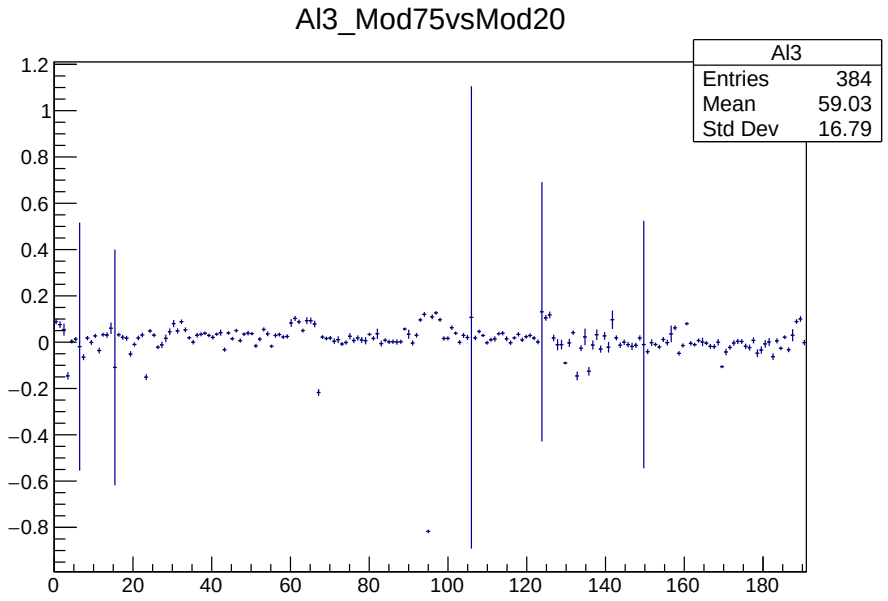

Al2_HV1100vsHV1000
Al2
Entries 384
Mean 115.3
Std Dev 55.05

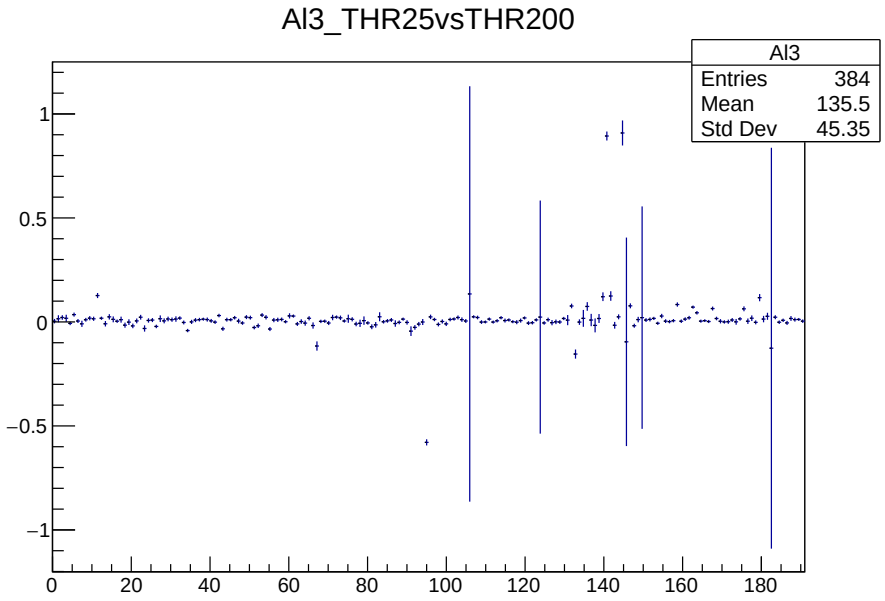

Al2_Mod75vsMod20
Al2
Entries 384
Mean 106.2
Std Dev 57.88

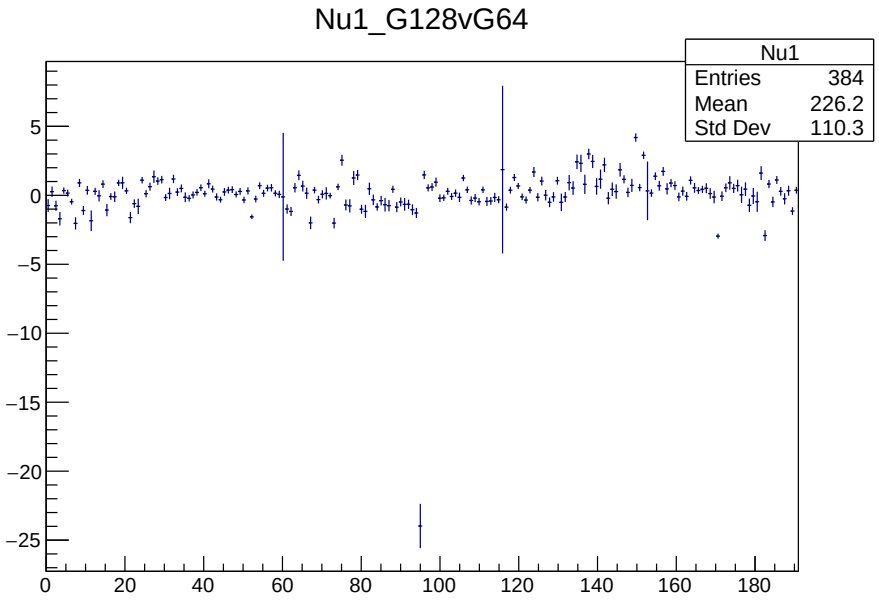

Al2_THR25vsTHR200
Al2
Entries 384
Mean 150.7
Std Dev 21.68

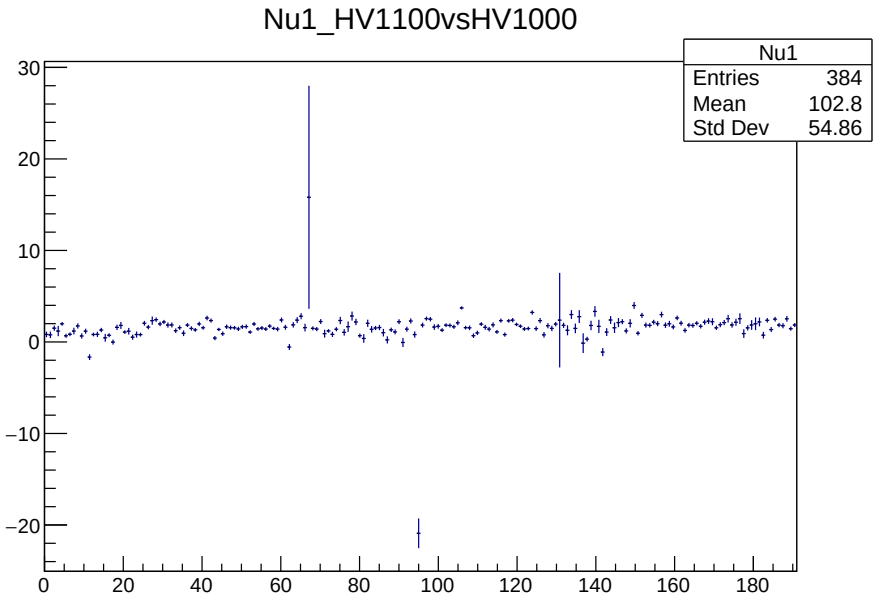

Al3_G128vG64
Al3
Entries 384
Mean 112.1
Std Dev 49.89

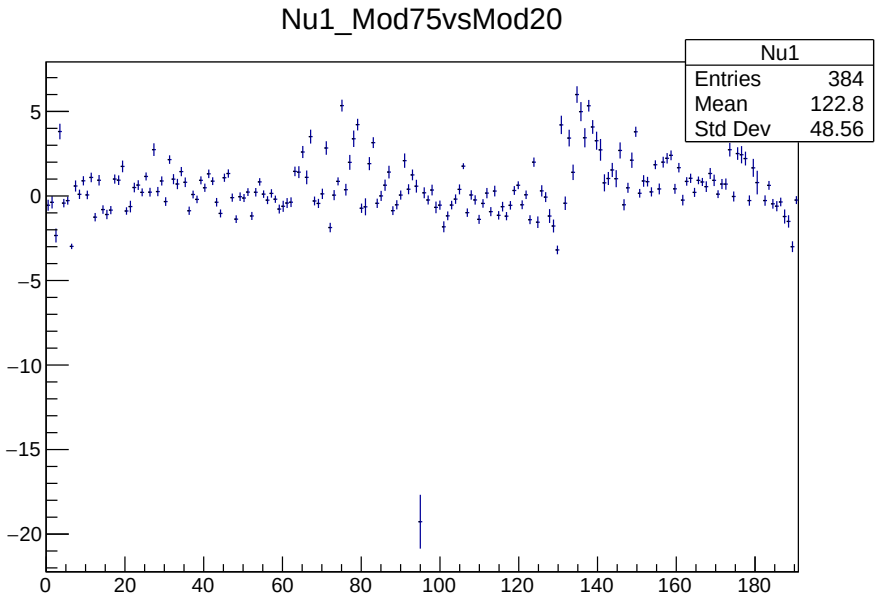

Al3_HV1100vsHV1000
Al3
Entries 384
Mean 100.7
Std Dev 42.53

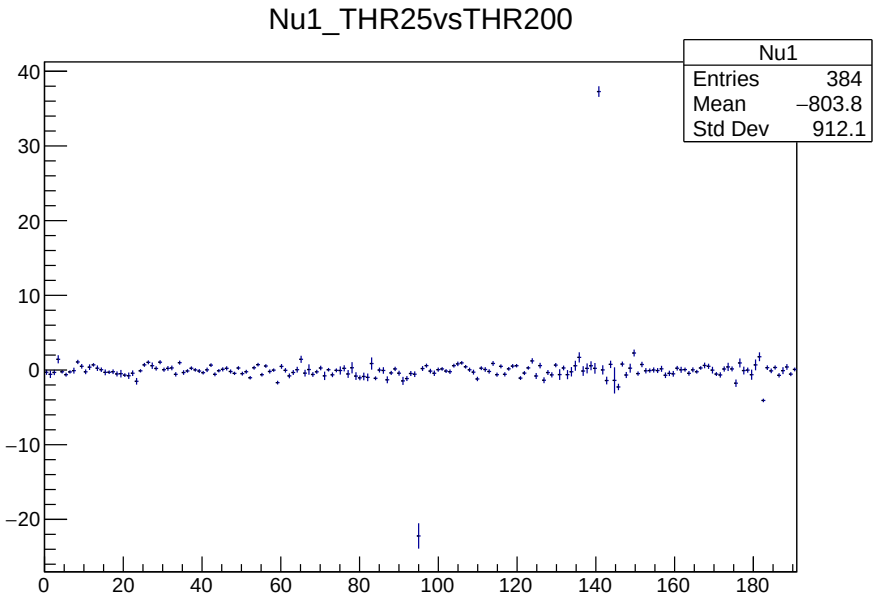

Al3_Mod75vsMod20
Al3
Entries 384
Mean 59.03
Std Dev 16.79

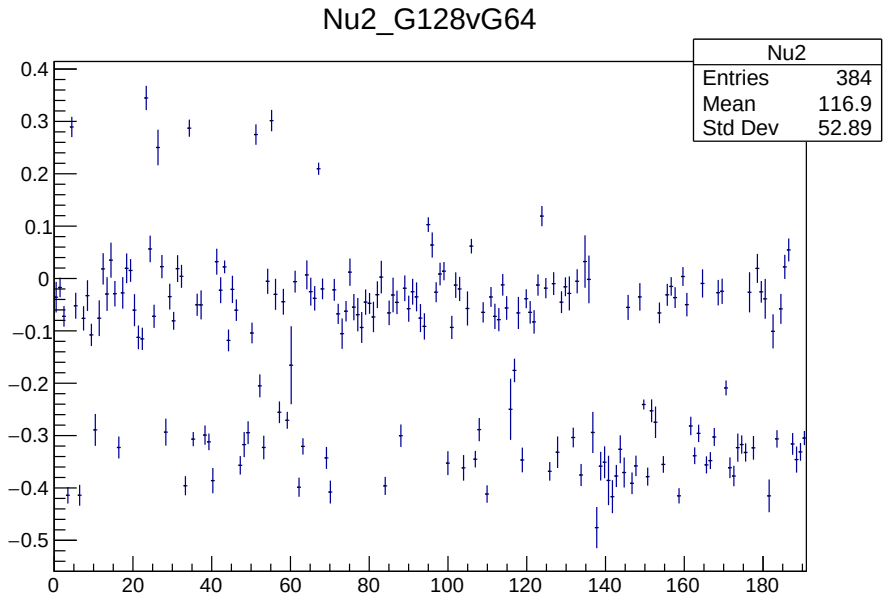

Al3_THR25vsTHR200
Al3
Entries 384
Mean 135.5
Std Dev 45.35

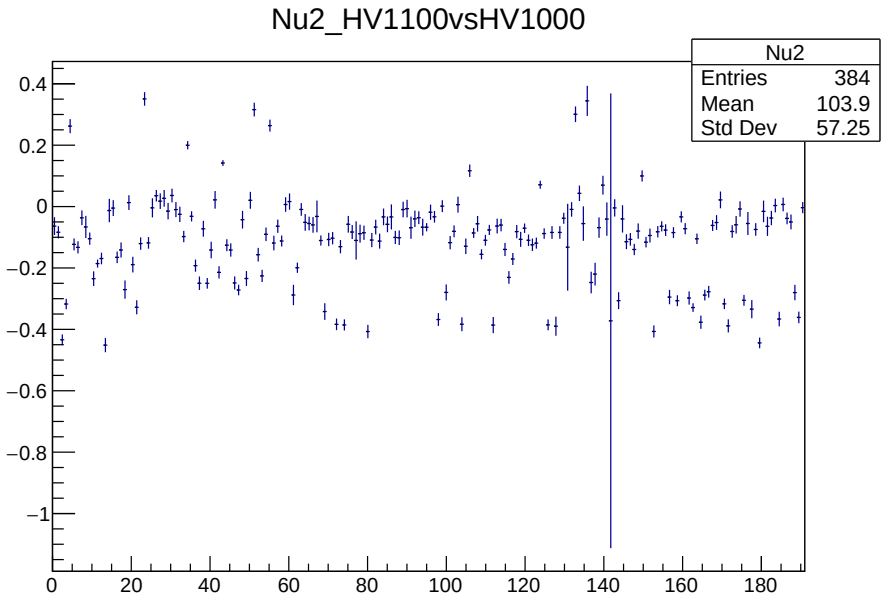

Nu1_G128vG64
Nu1
Entries 384
Mean 226.2
Std Dev 110.3

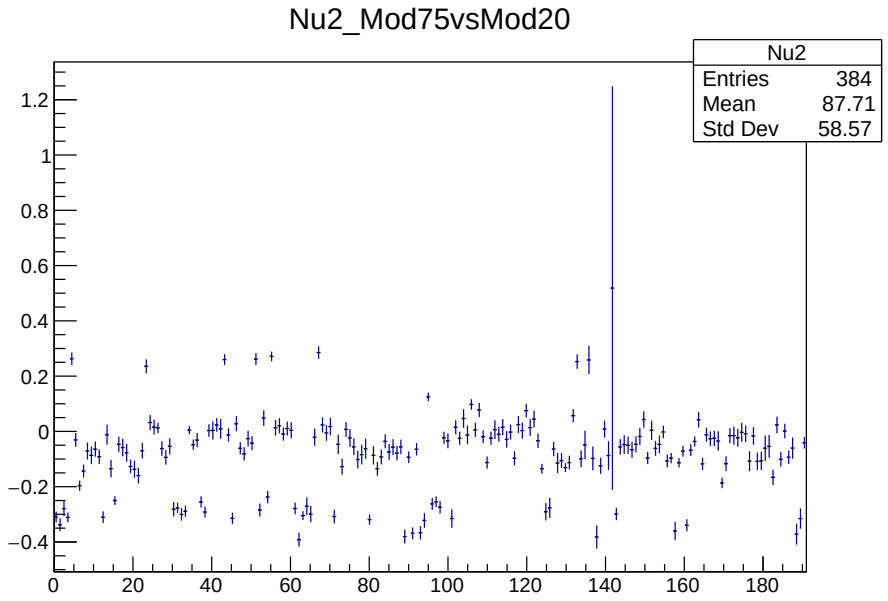

Nu1_HV1100vsHV1000
Nu1
Entries 384
Mean 102.8
Std Dev 54.86

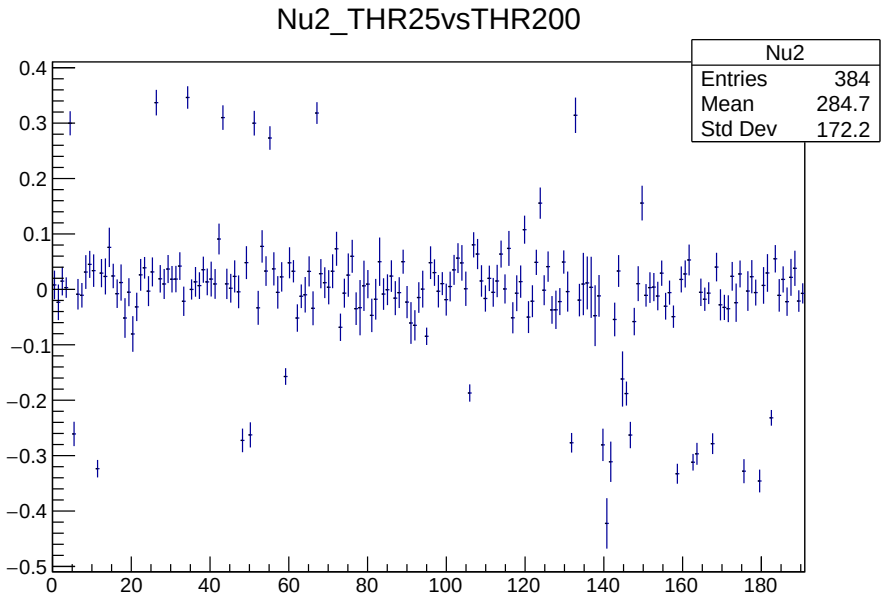

Nu1_Mod75vsMod20
Nu1
Entries 384
Mean 122.8
Std Dev 48.56

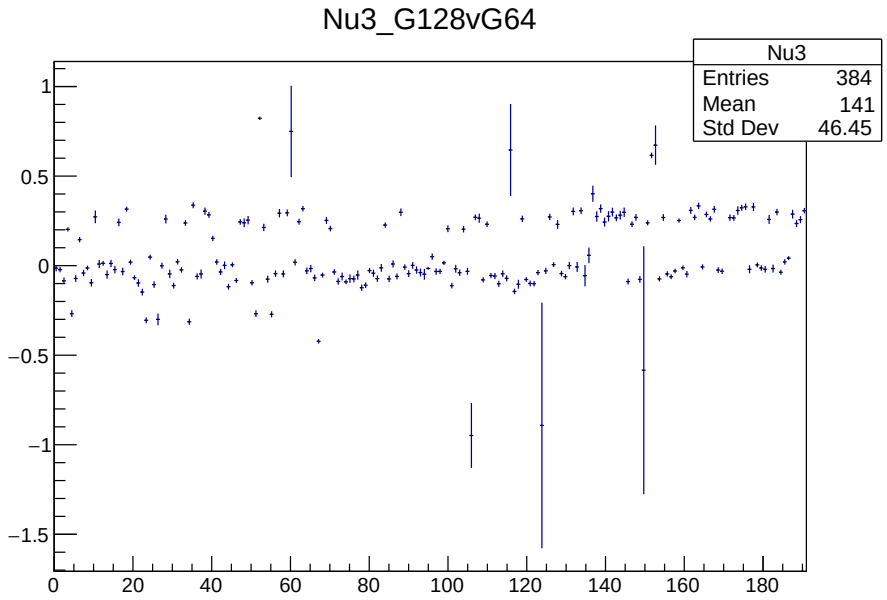

Nu1_THR25vsTHR200
Nu1
Entries 384
Mean −803.8
Std Dev 912.1

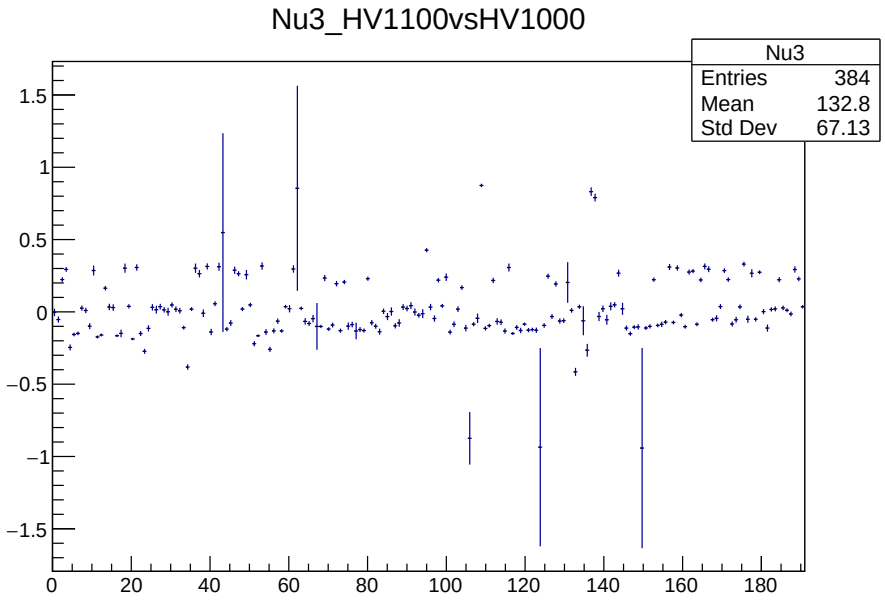

Nu2_G128vG64
Nu2
Entries 384
Mean 116.9
Std Dev 52.89

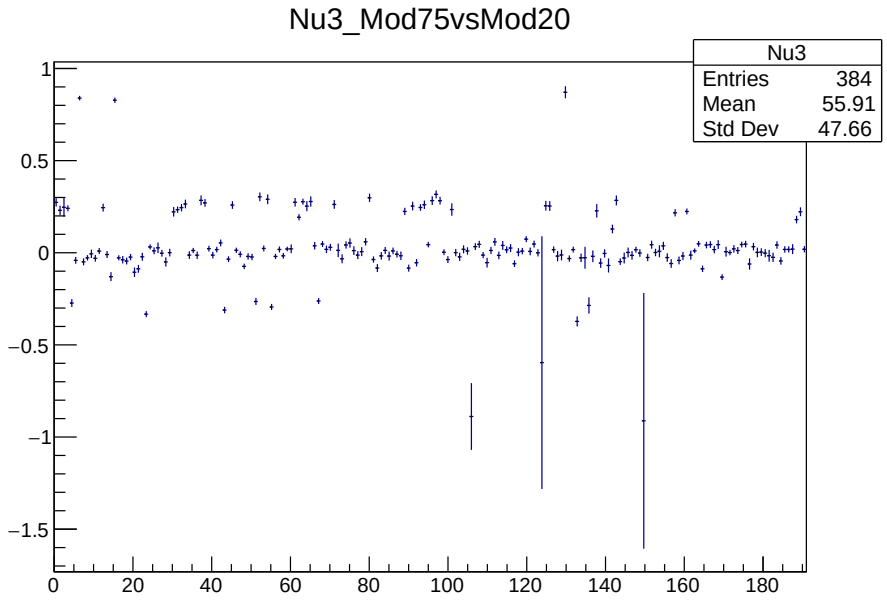

Nu2_HV1100vsHV1000
Nu2
Entries 384
Mean 103.9
Std Dev 57.25

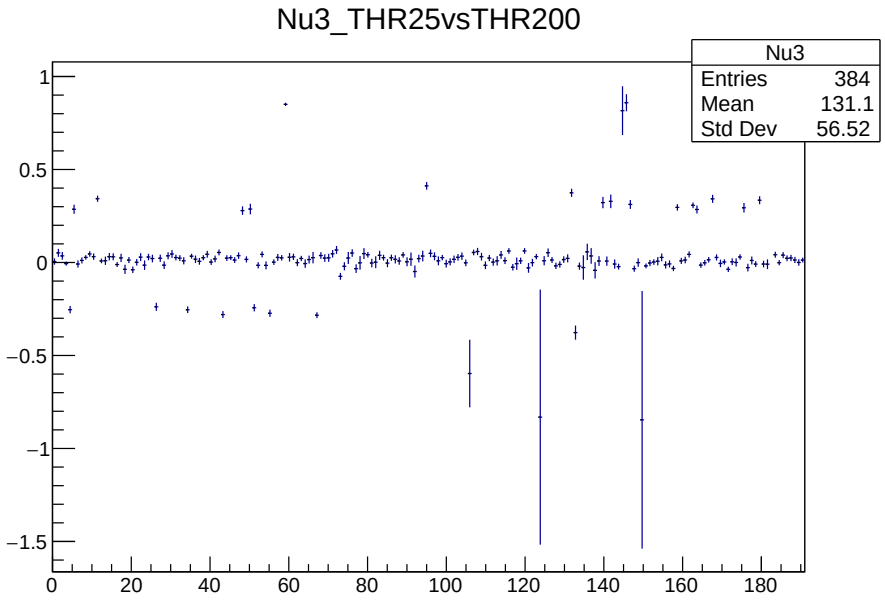

Nu2_Mod75vsMod20
Nu2
Entries 384
Mean 87.71
Std Dev 58.57


Nu2_THR25vsTHR200
Nu2
Entries 384
Mean 284.7
Std Dev 172.2


Nu3_G128vG64
Nu3
Entries 384
Mean 141
Std Dev 46.45


Nu3_HV1100vsHV1000
Nu3
Entries 384
Mean 132.8
Std Dev 67.13


Nu3_Mod75vsMod20
Nu3
Entries 384
Mean 55.91
Std Dev 47.66


Nu3_THR25vsTHR200
Nu3
Entries 384
Mean 131.1
Std Dev 56.52