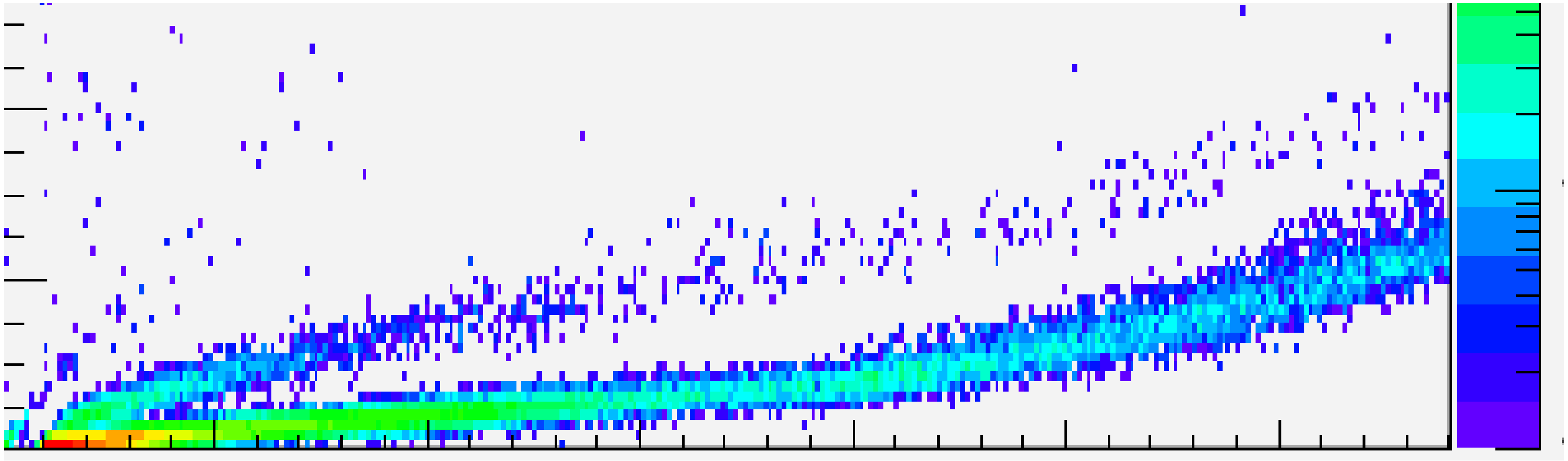
# Neutron Data Analysis

- Calibration of detectors
- Neutron/gamma discrimination



# Energy Calibration of neutron counters

- Sources used - 60Co and 137Cs
- Emission spectra of 60Co – two photo peaks at 1.17 and 1.33 MeV giving an average of 1.25 MeV
- Compton Scattering gives a Compton edge (max. KE of electron) at 1.03 MeV using the formula

$$E_{\text{Compton}} = E_T(\max) = \frac{2E^2}{m_e c^2 + 2E}$$

- Photo peak of 0.667 MeV gives Compton Edge of 0.48 MeV for 137Cs

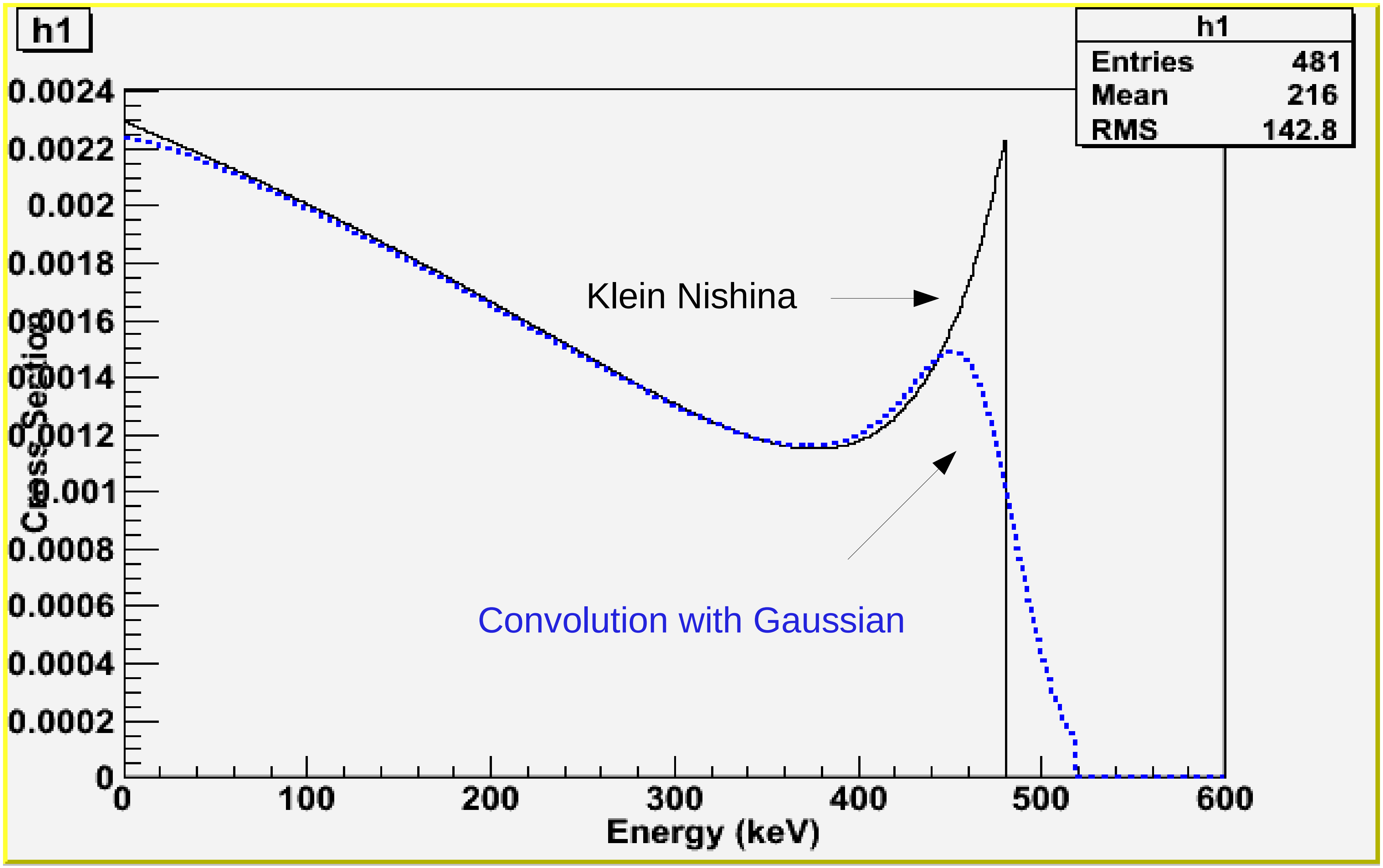
# Energy Calibration of neutron counters

Compton scattering cross section obeys Klein Nishina formula falling sharply at the Compton edge. Owing to detector resolution there is a Gaussian smearing at the edge.

So a convolution of Klein-Nishina differential scattering cross-section and Gaussian is used to fit data

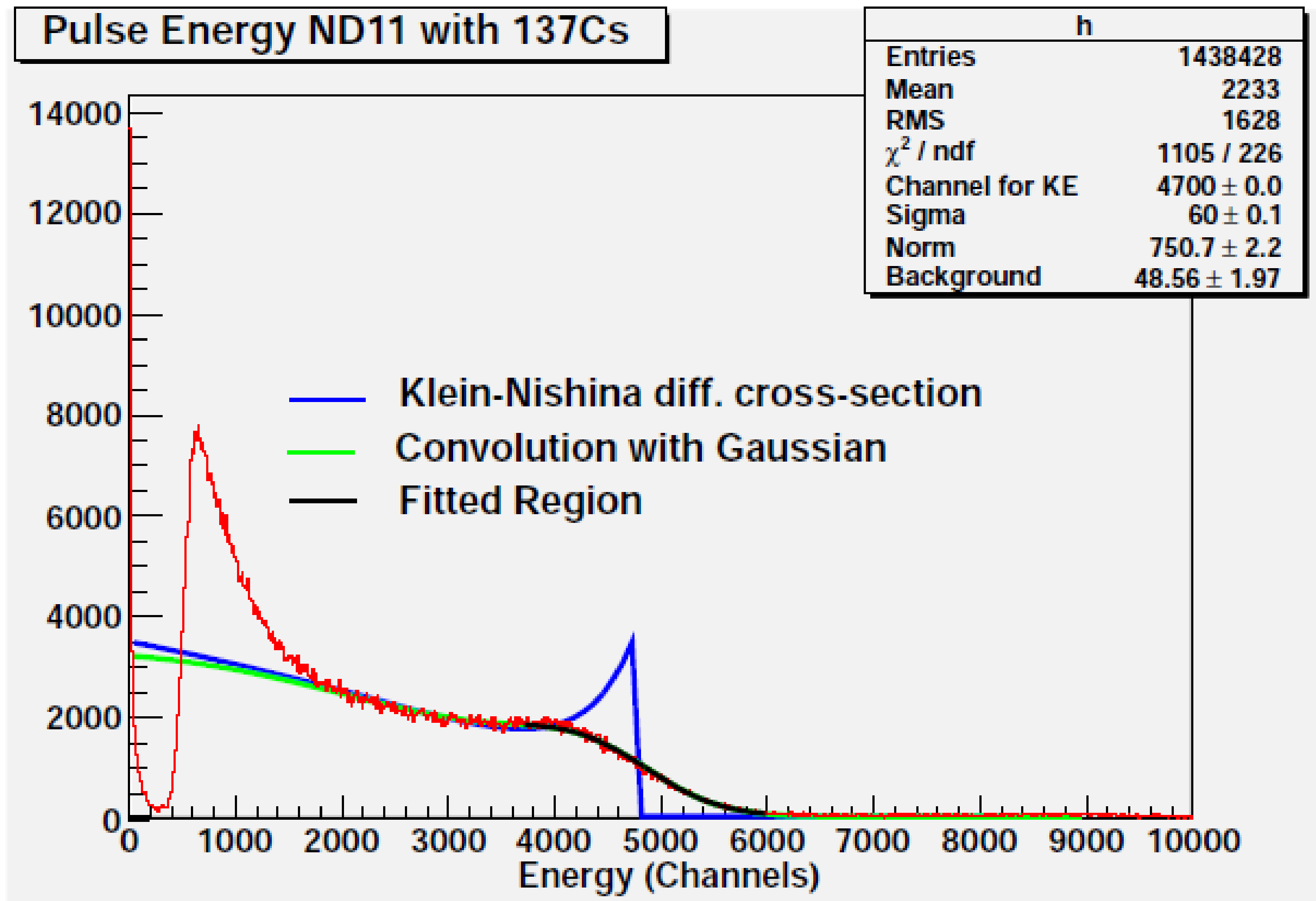
(Should I put the formula used here or not required)

# Energy Calibration of neutron counters



# Energy Calibration of neutron counters

## Example - detector ND11 with 137Cs



# Energy Calibration of neutron counters

Data taken -

- In the beginning – Ref elog:103
- After shielding from muSR magnet with mu metal – Ref elog:104
- At the end of run - Ref elog:86

# Energy Calibration of neutron counters

**Detector background -**

Caused bad fit. E.g. NU6 / ND6 end of run data. Exponential term added for this. Got worse. Ref - elog:100. Final Calibration without background.

**Reasons for background:**

- A source in the vicinity interfering with the detector
- Detector specific issue
- Not a perfect model - due to multiple scattering the distribution is distorted from Klein-Nishina scattering crosssection for a single electron undergoing Compton scattering

Interested only in the tail region and these backgrounds do not distort our region of interest

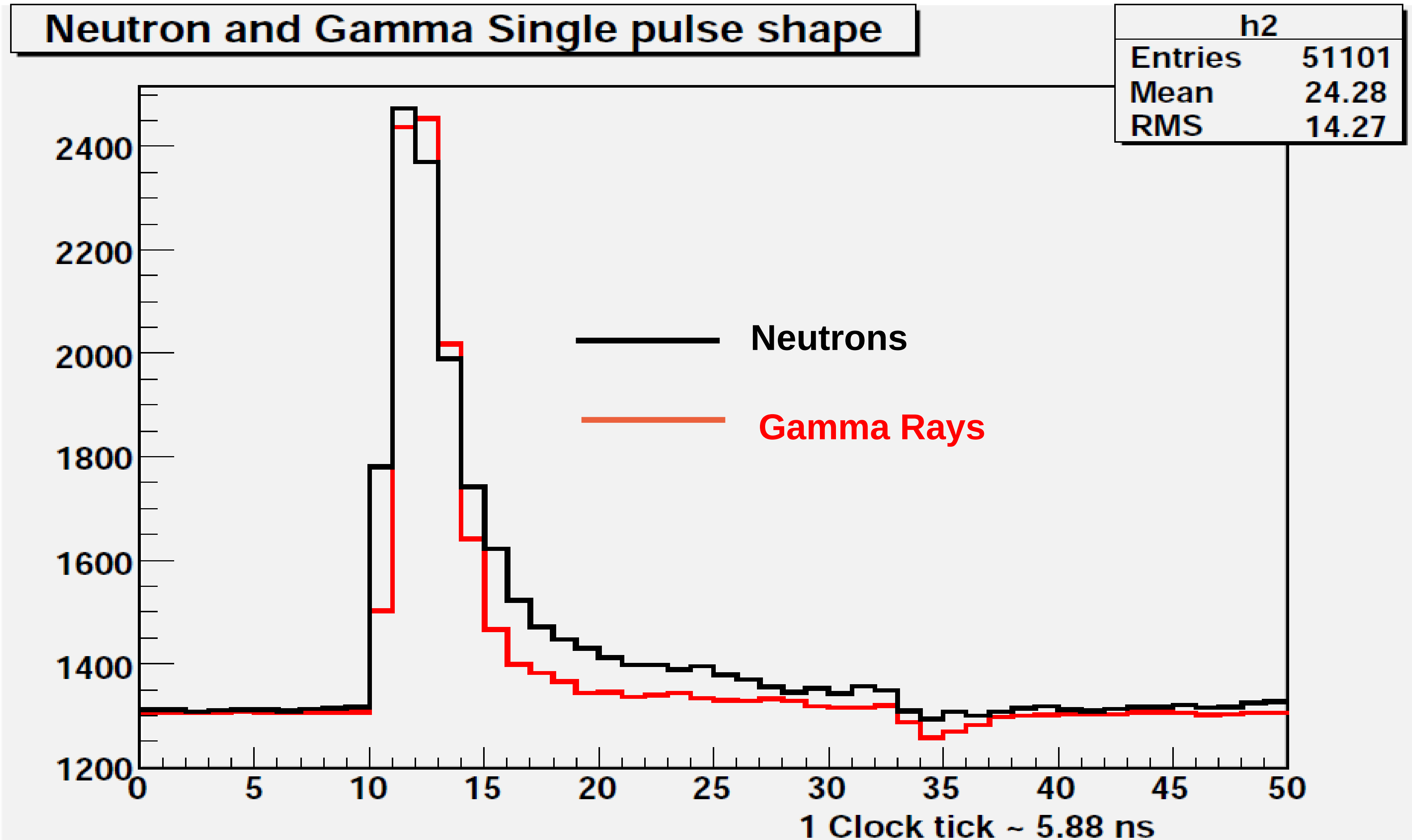
# Energy Calibration of neutron counters

Table summarizes the calibration data during different stages

| Counters | HV (V) | Gain (ch/keV_ee) After shielding | Gain (ch/keV_ee) End of run | Gain (ch/keV_ee) Initial |
|---|---|---|---|---|
| NU3 | 1140 | 6.12 | 7.32 | ~7.2 |
| ND3 | 1480 | 6.21 | 6.41 | ~5.9 |
| NU6 | 1470 | 6.21 | 6.7 | ~6.6 |
| ND6 | 1600 | 6.18 | 6.38 | ~7.31 |
| NU11 | 1660 | 6.61 | 7.75 | ~9.1 |
| ND11 | 1800 | 7.47 | 8.58 | ~9.12 |
| NU14 | 1400 | 4.32 | 4.22 | ~4.69 |
| ND14 | 1350 | 4.23 | 5.25 | ~7.59 |

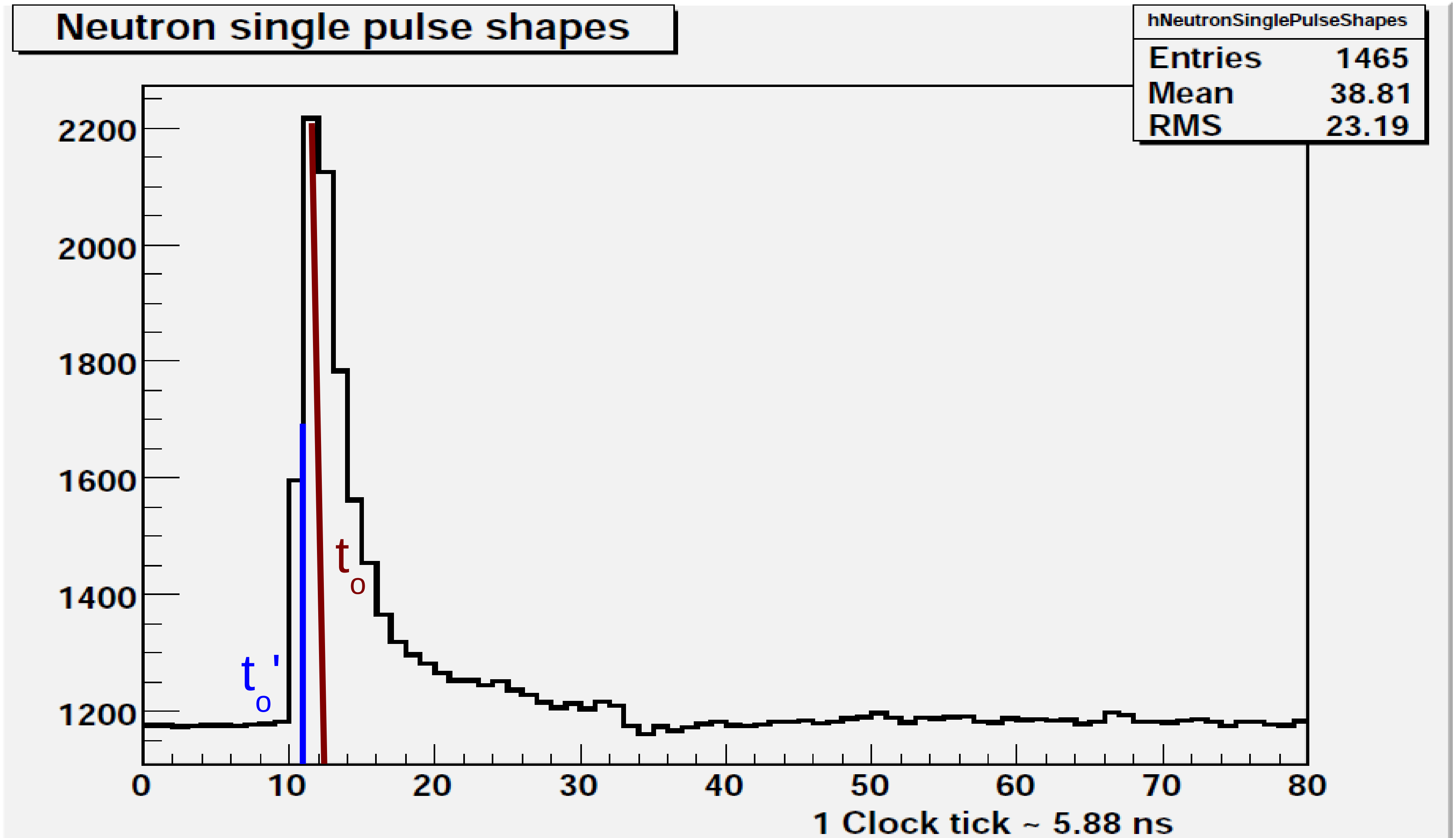
# Neutron / Gamma discrimination

Neutron pulses have a longer tails compared to gamma rays.
Used for discrimination



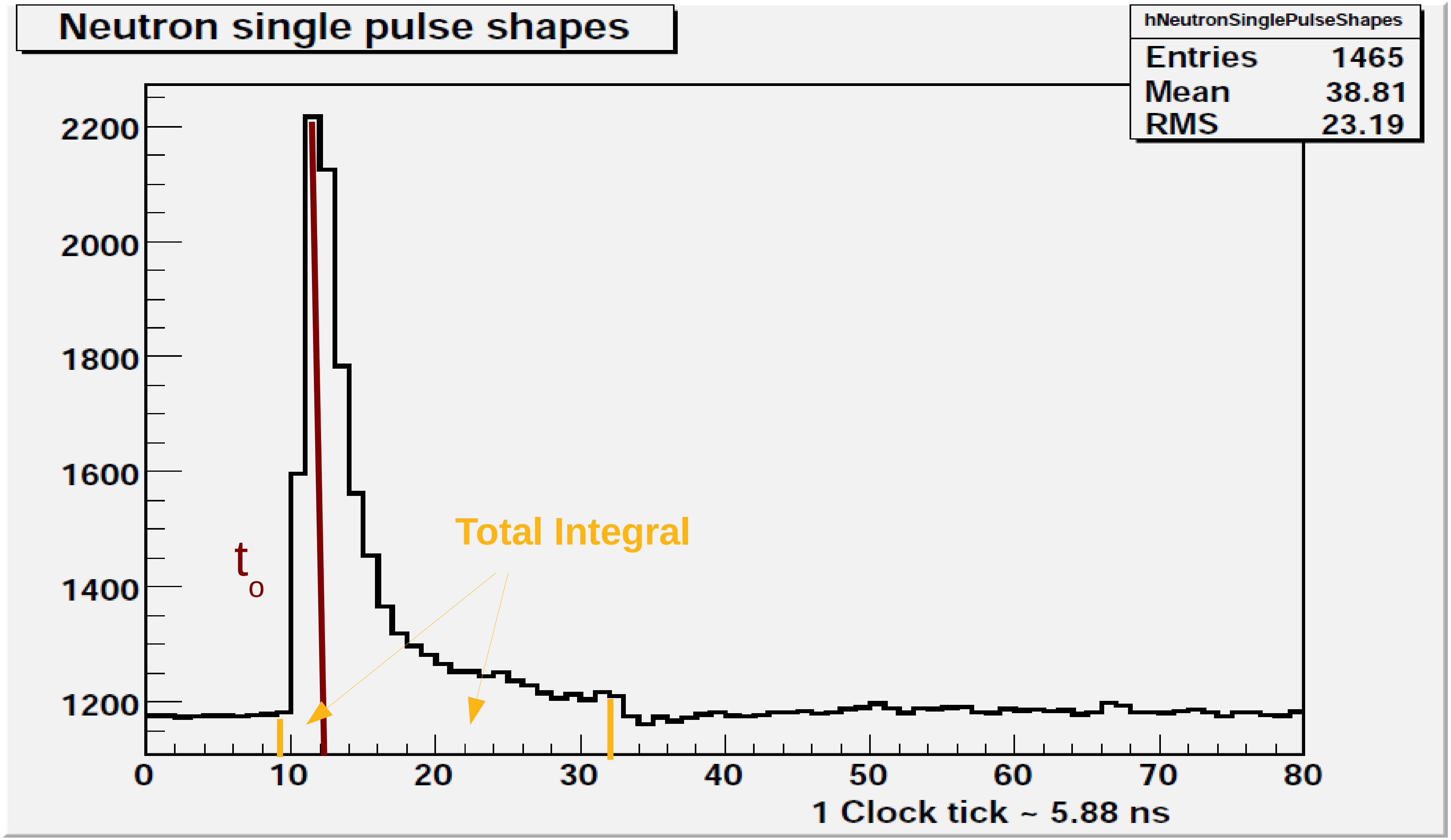
# Neutron / Gamma discrimination

Previously, all tail and total integral were defined wrt to the bin corresponding to the peak value of a neutron/gamma pulse ($t_o$), which was changed to the bin corresponding to 50% of the peak value($t_o'$).



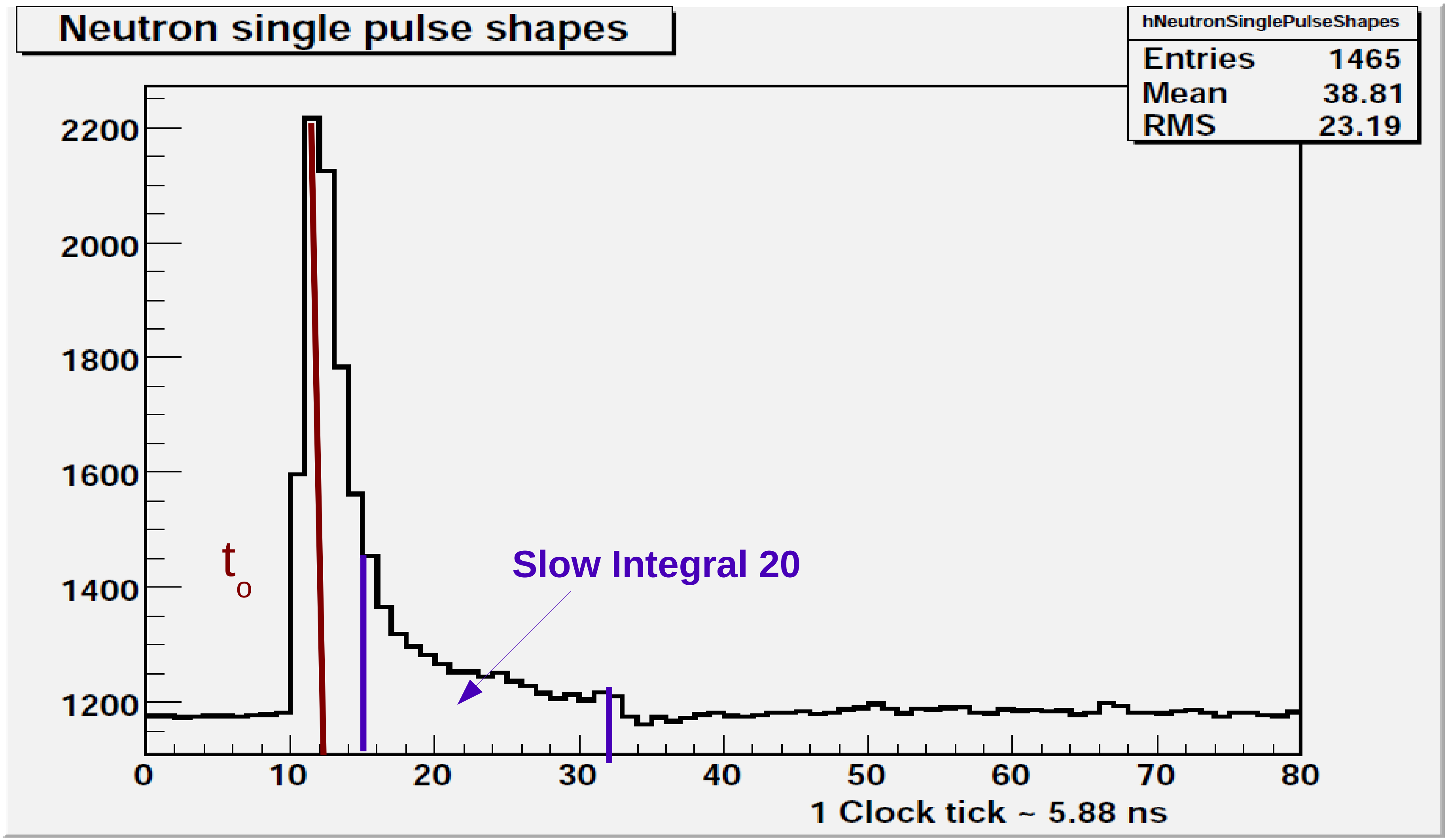
# Neutron / Gamma discrimination

**Total integral** - integral from 3 bins to the left of peak bin to 20 bins to the right of peak bin



# Neutron / Gamma discrimination

**Slow integral 20**- integral from 3 bins to the right of peak bin to 20 bins to the right of peak bin



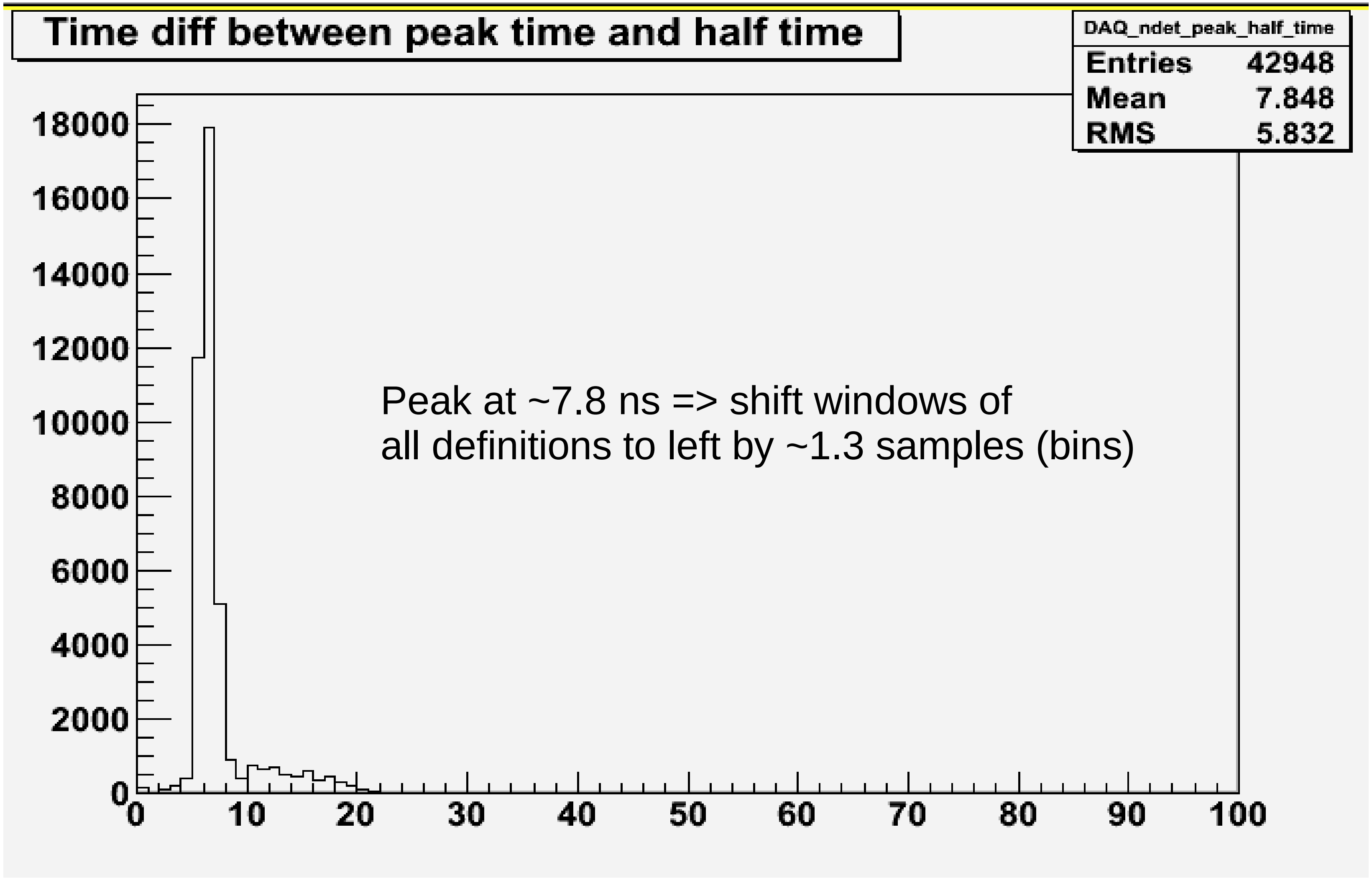
# Neutron / Gamma discrimination

Similarly other definitions are as follows -

- **Slow integral 25** - integral from 4 bins to the right of peak bin to 20 bins to the right of peak bin
- **Slow integral 30** - integral from 5 bins to the right of peak bin to 20 bins to the right of peak bin
- **Slow integral 35** - integral from 6 bins to the right of peak bin to 20 bins to the right of peak bin
- **Slow integral 40** - integral from 7 bins to the right of peak bin to 20 bins to the right of peak bin

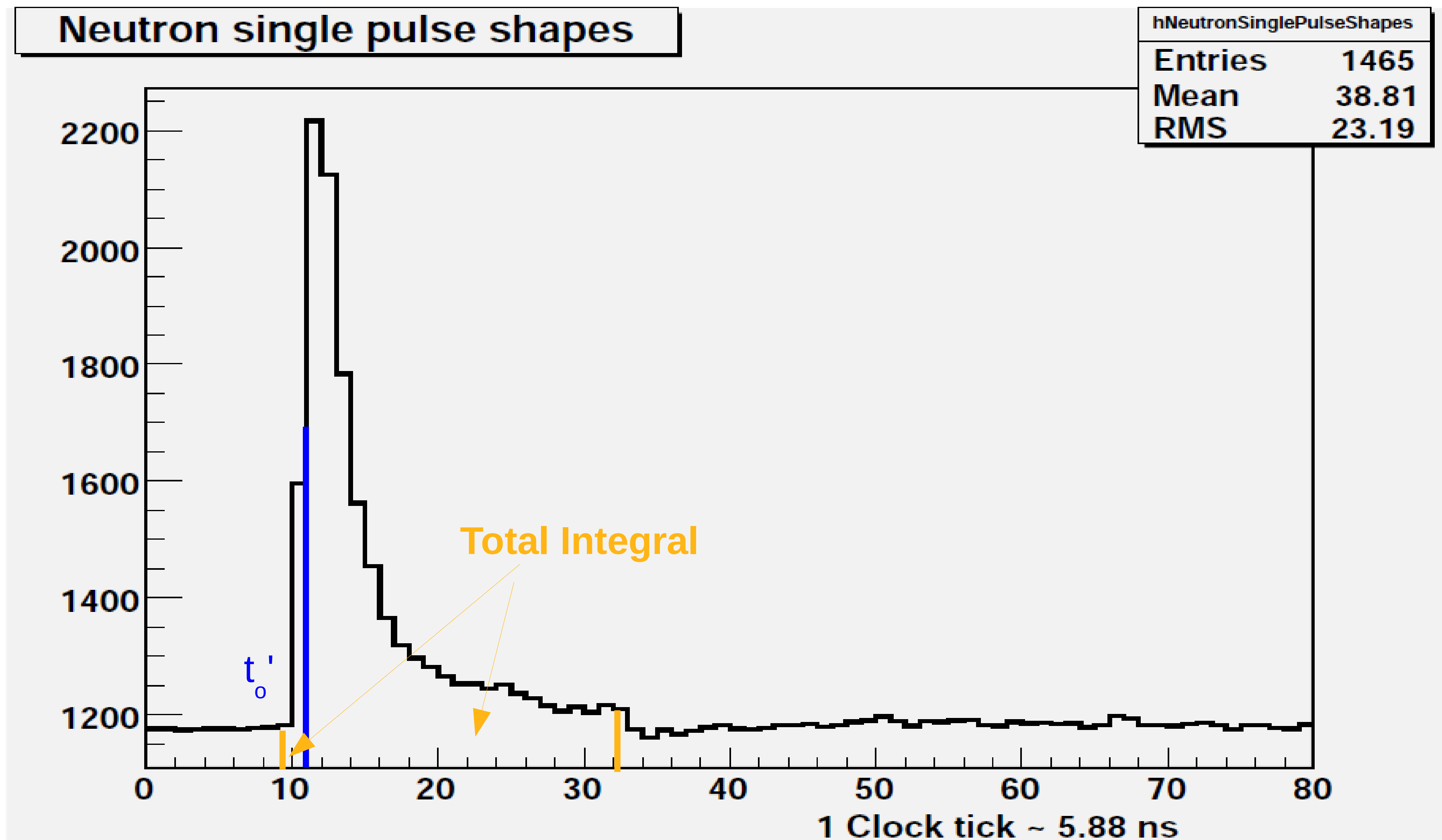
# Neutron / Gamma discrimination

Time spectrum of peak bin time ($t_o$) wrt to half of peak bin ($t_o'$)



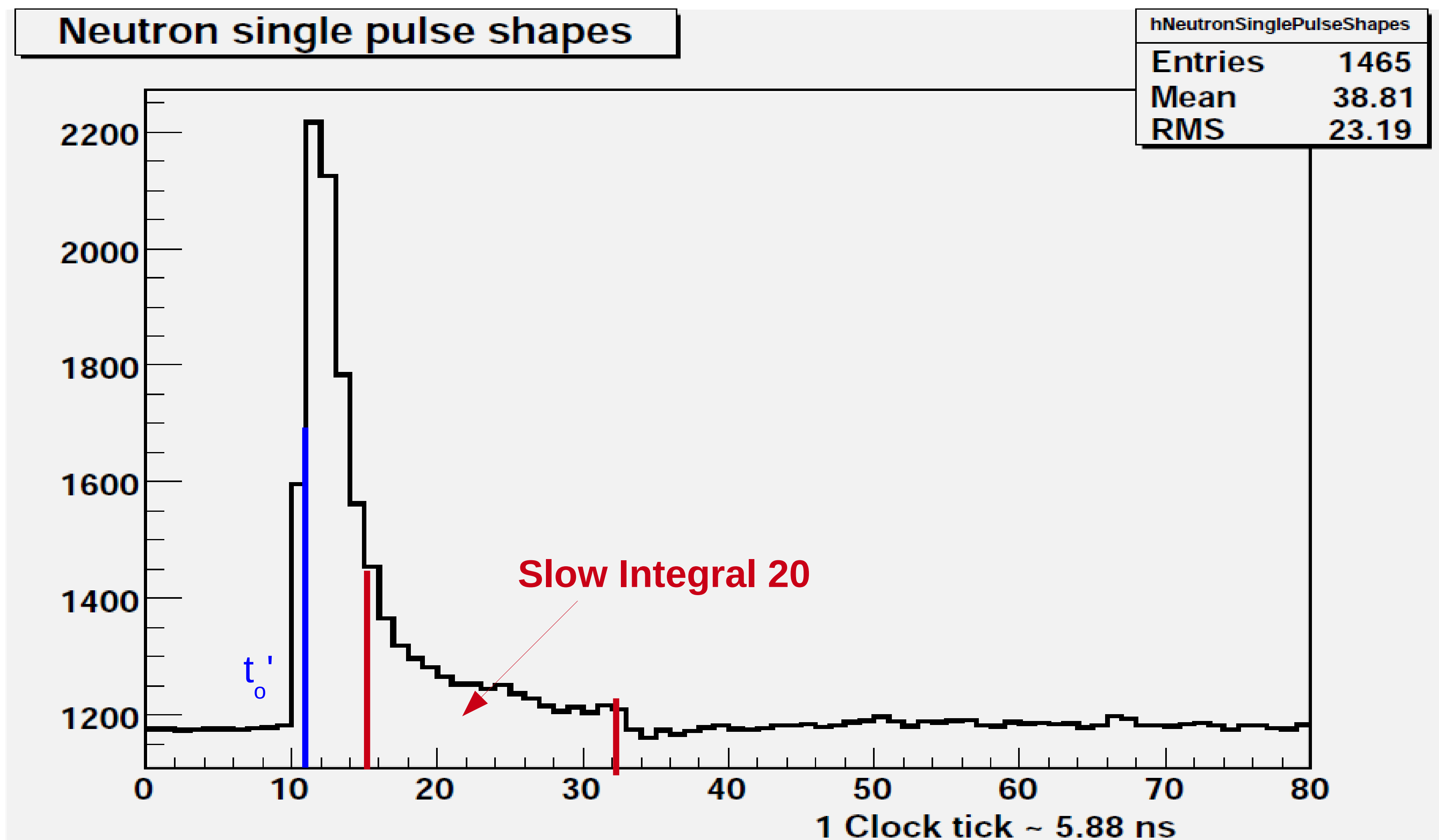
# Neutron / Gamma discrimination

**New definition - Total integral -** integral from ~2 bins to the left of peak bin to ~21 bins to the right of peak bin



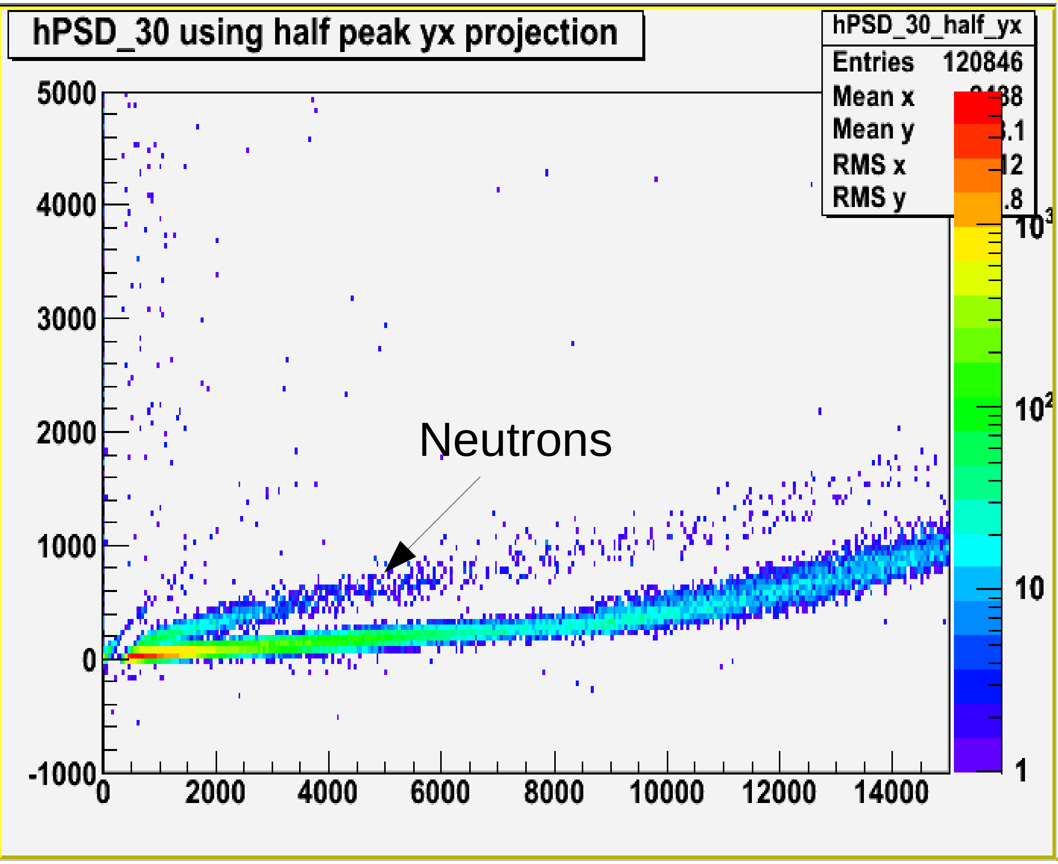
# Neutron / Gamma discrimination

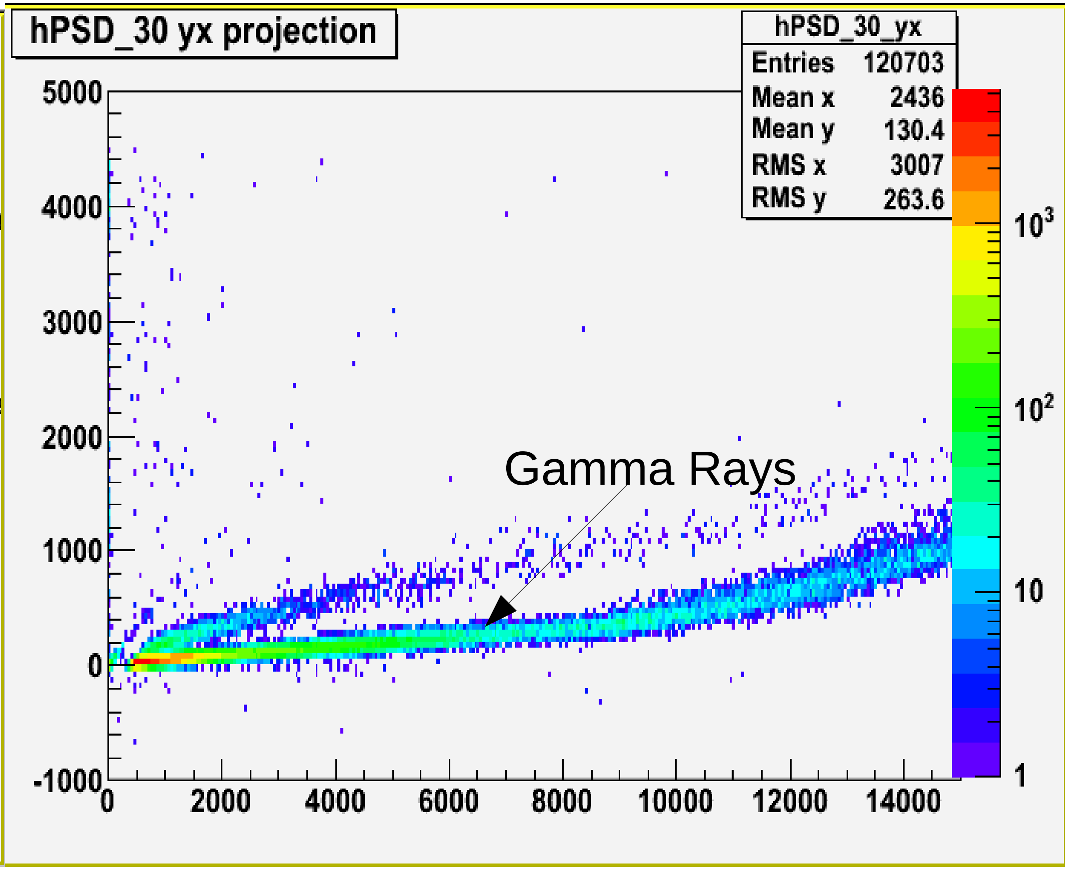
**New Slow integral 20-** integral from > 4 bins to the right of peak bin to > 21 bins to the right of peak bin



# Neutron / Gamma discrimination

Similarly other new definitions were changed accordingly. Peak and half total vs. slow30 for ND14 for a beam data - details see elog:70



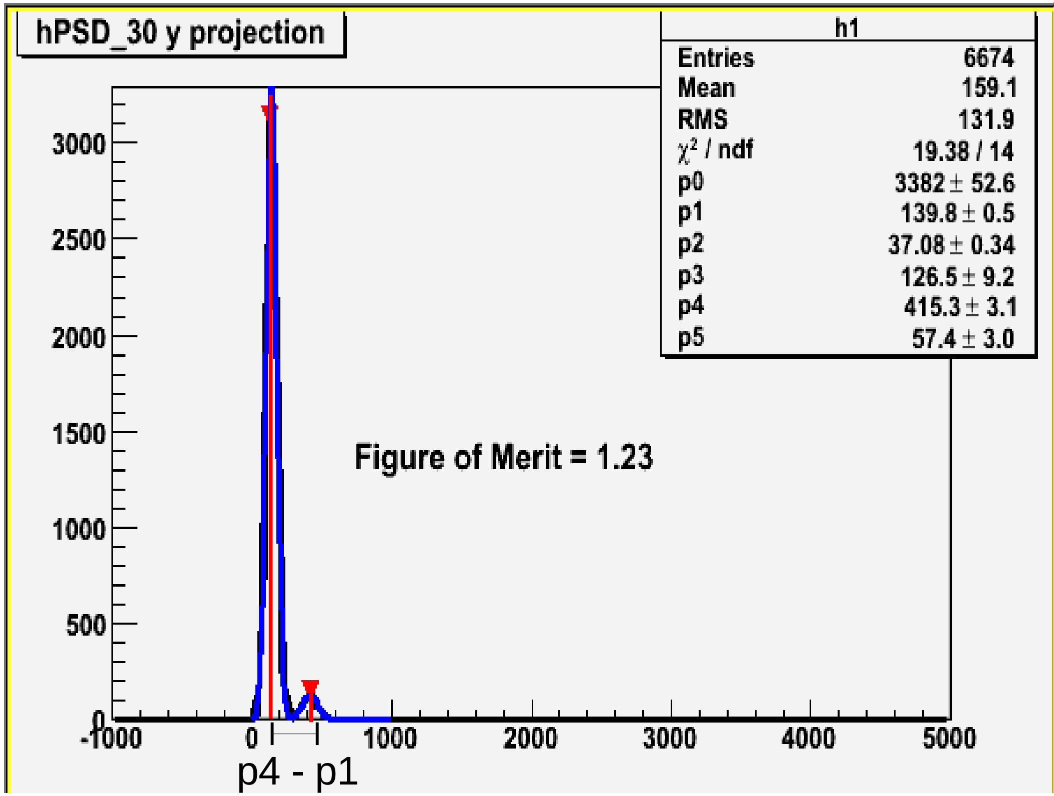



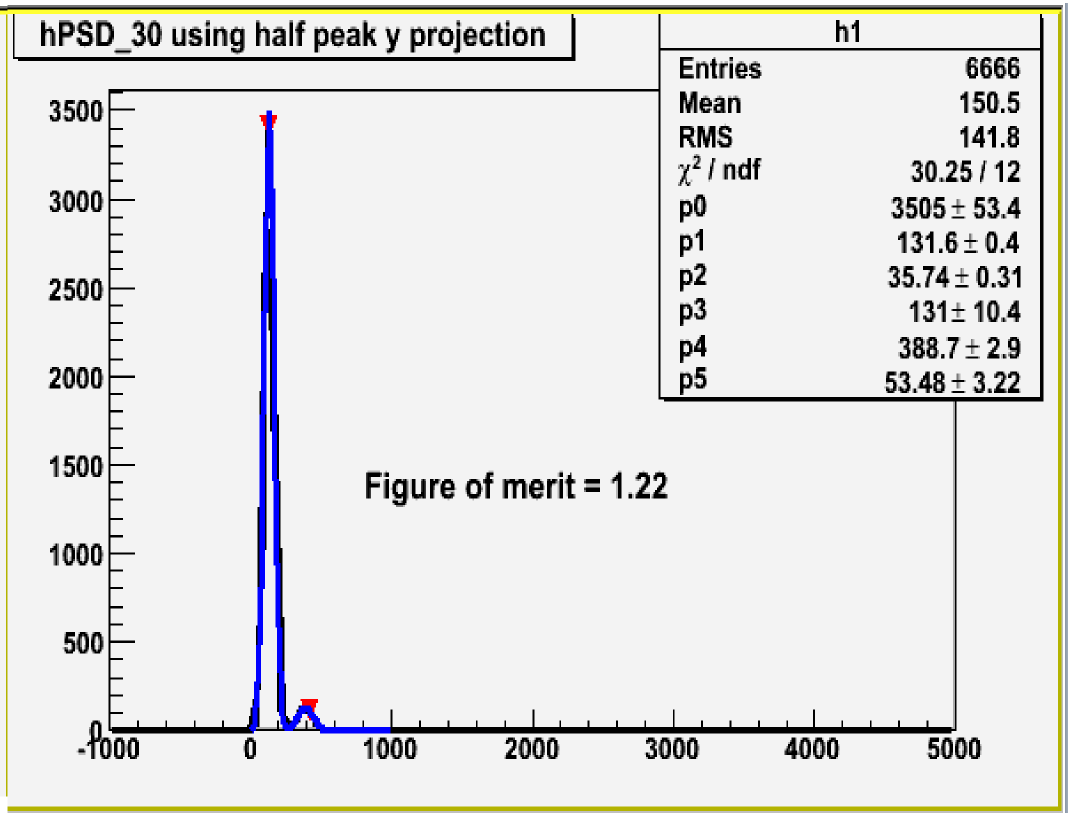
# Neutron / Gamma discrimination

**Testing performance of both definitions** -

Figure of merit in both cases (peak and half bin algorithms) for window **slowIntegral30.** Took slices of energy of above plots, found peaks and fitted with a double gaussian – shown below

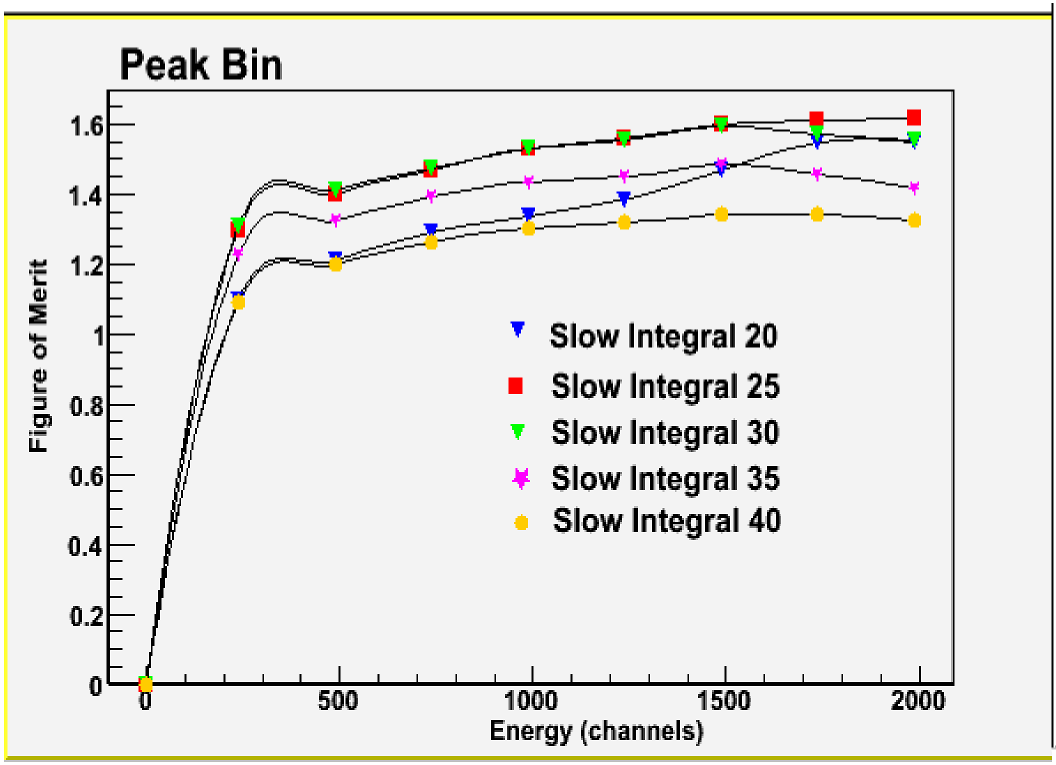
FOM = (p4-p1)/2.35(p2+p5)

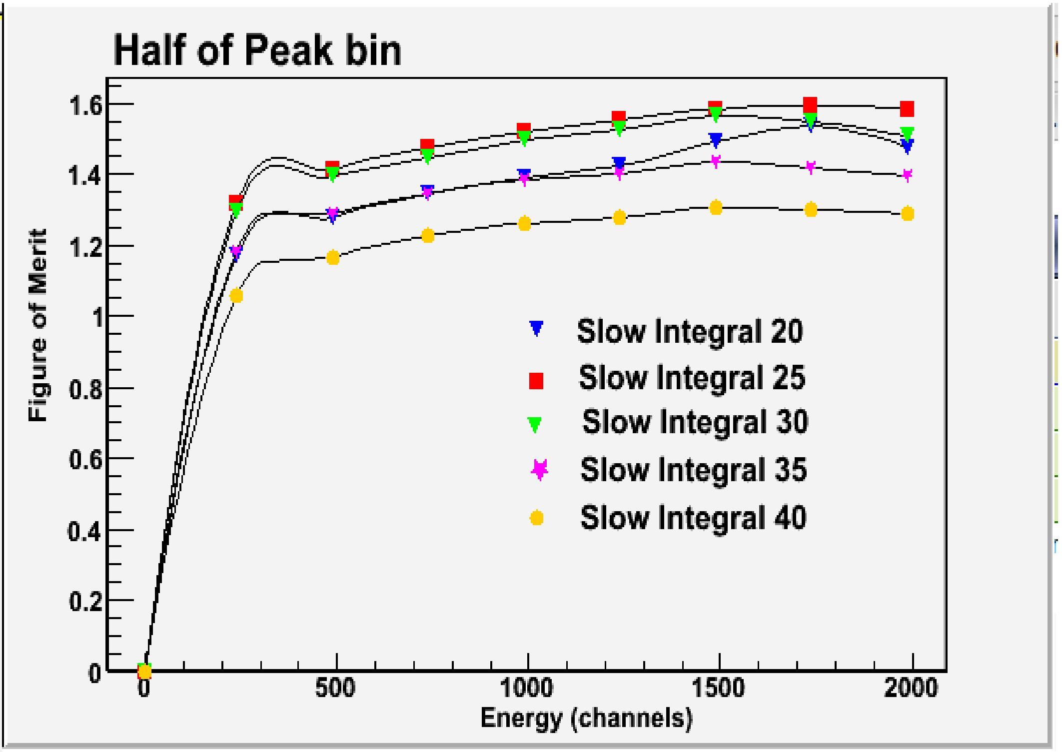


# Neutron / Gamma discrimination

Took a run with neutron source and tested FOM for ND14

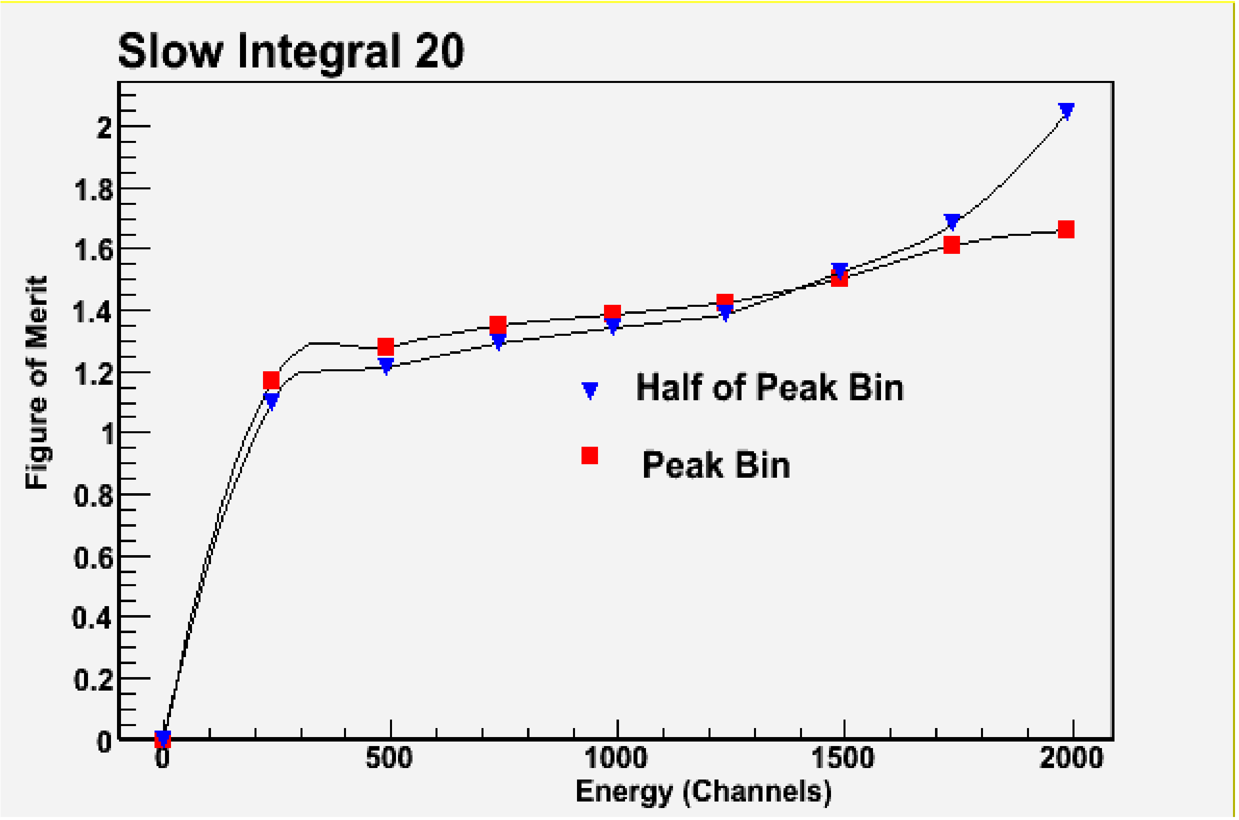


# Neutron / Gamma discrimination

Comparing figure of merits of each definition individually.

Same run & same detector (ND14)



Other definitions and comparisons continued …..