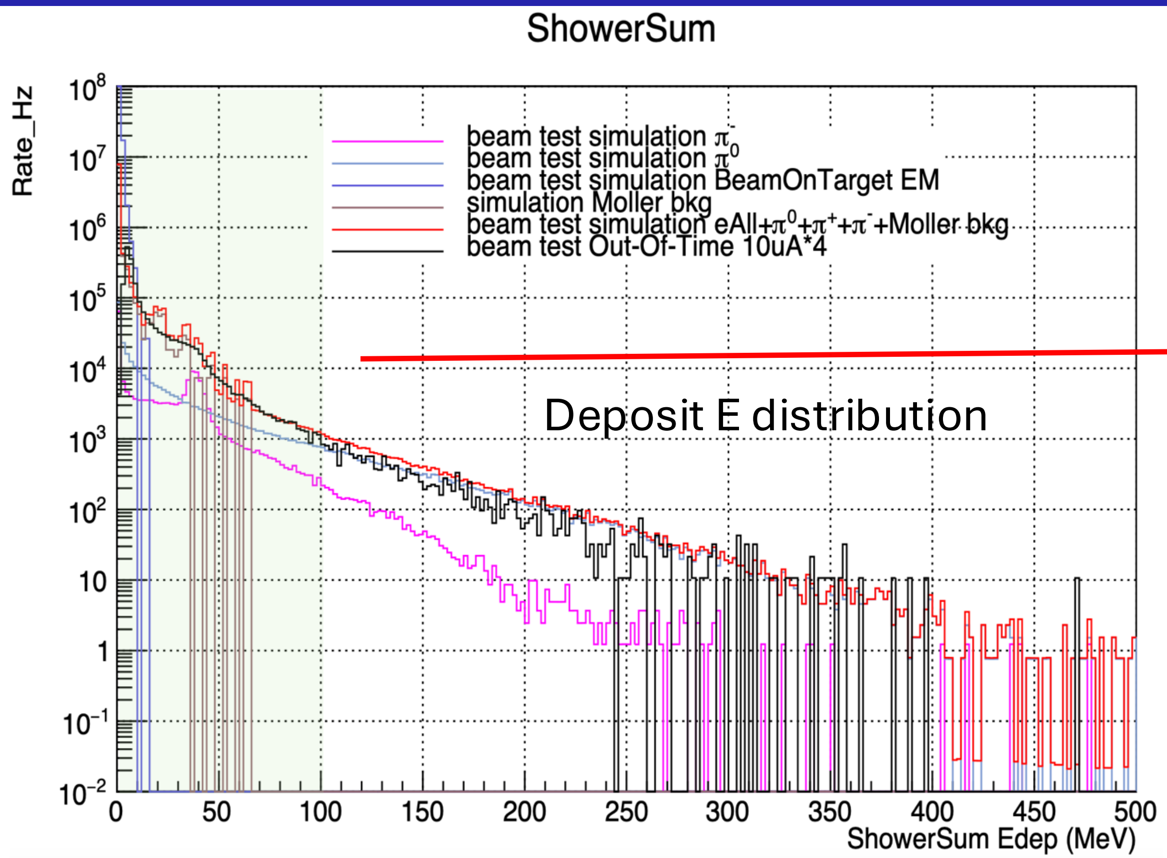
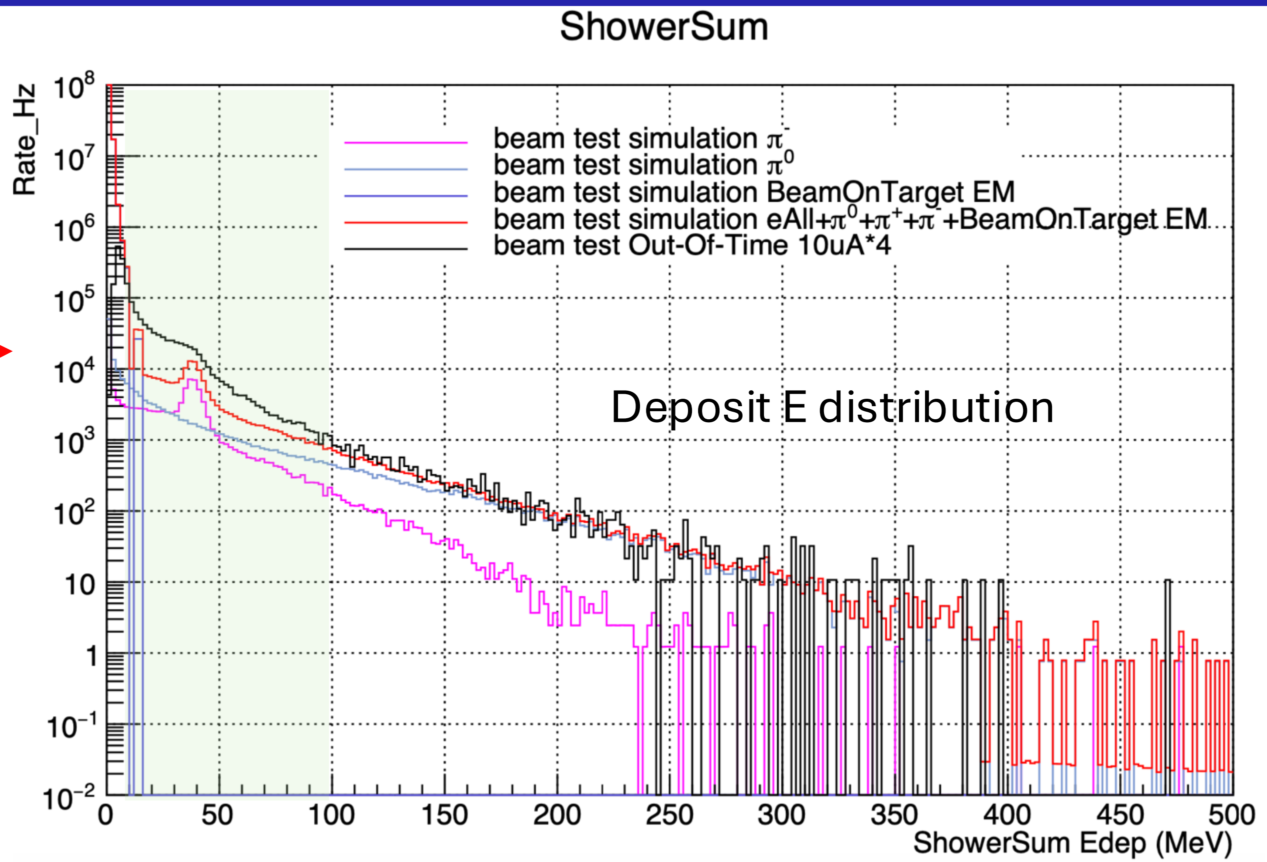
Beam Test and Comparison with Simulation

Ye Tian
Syracuse University
For ECal Beam Test Group

- Shower MIP Study
- Cherenkov Npe Study

Moller Background Simulation





Red: simulated eAll+ $\pi^0 + \pi^- + \pi^+$ + **Moller**
Black: beam test data

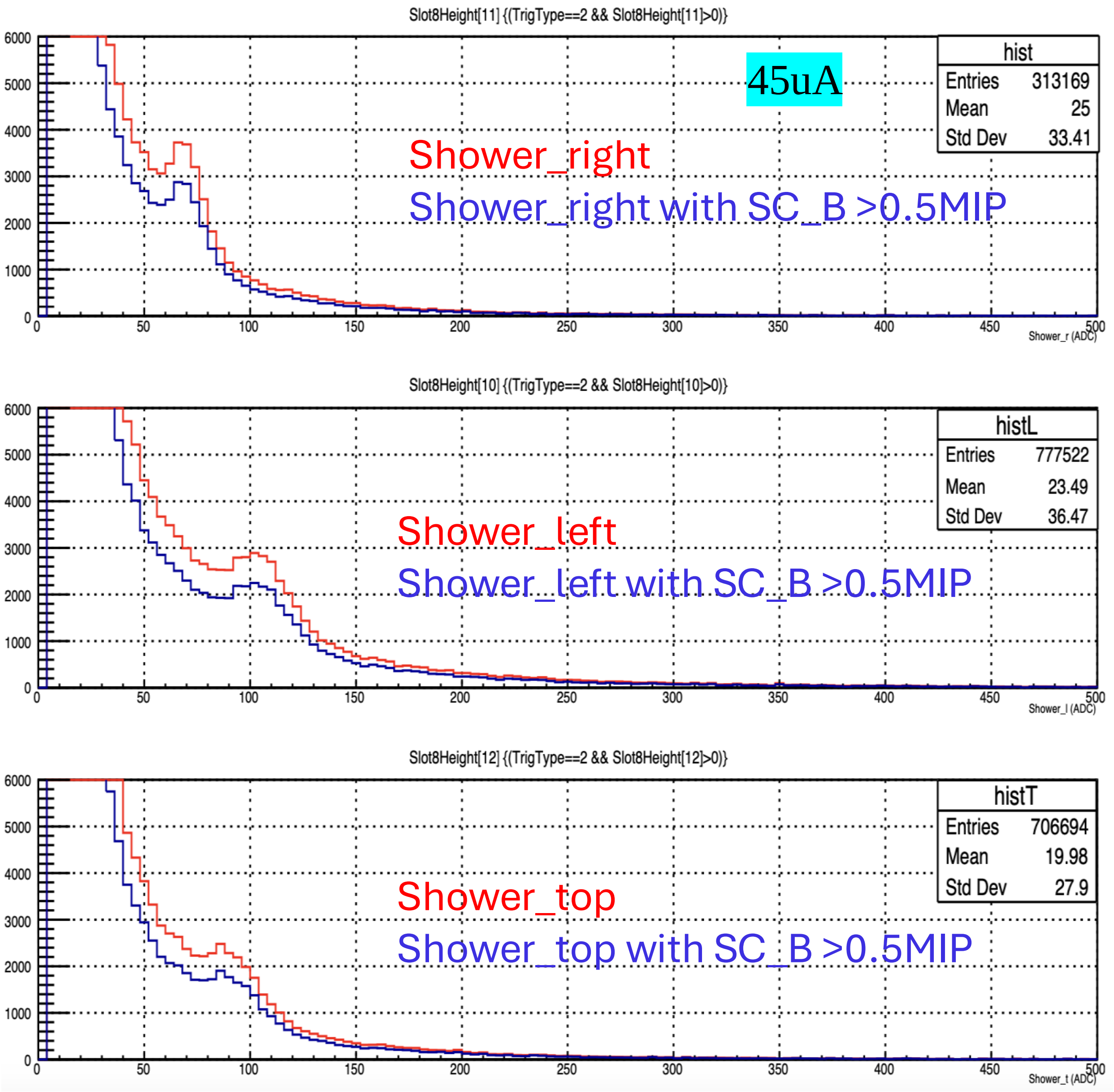
- Moller background contributes to the photon signal when it interacts with the beam pipe

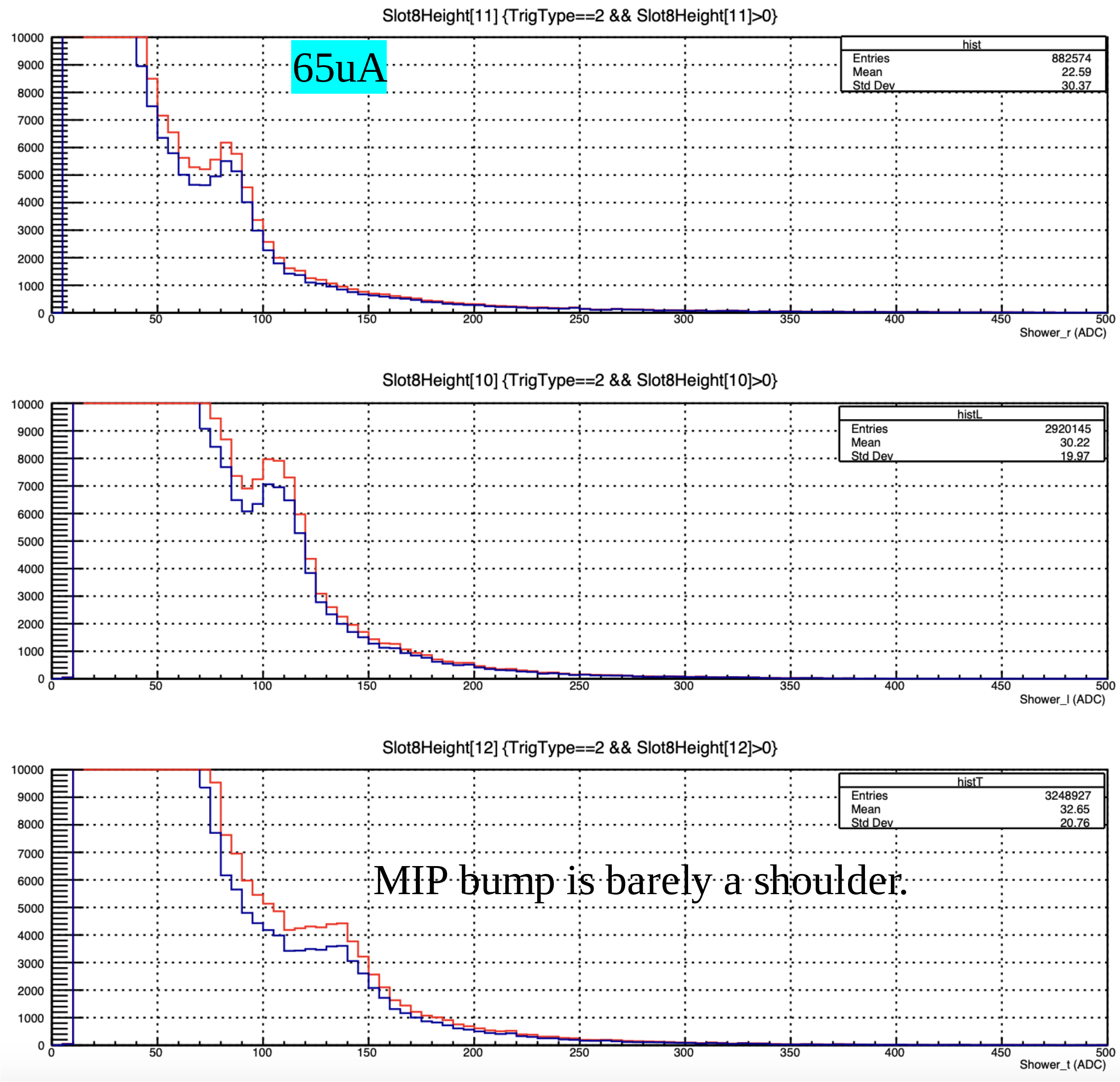
--- Test it with the Moller event generator from PRad:**PRadSim**/evgen/**norc**

Red: simulated eAll+ $\pi^0 + \pi^- + \pi^+$(**no Moller**)
Black: beam test data

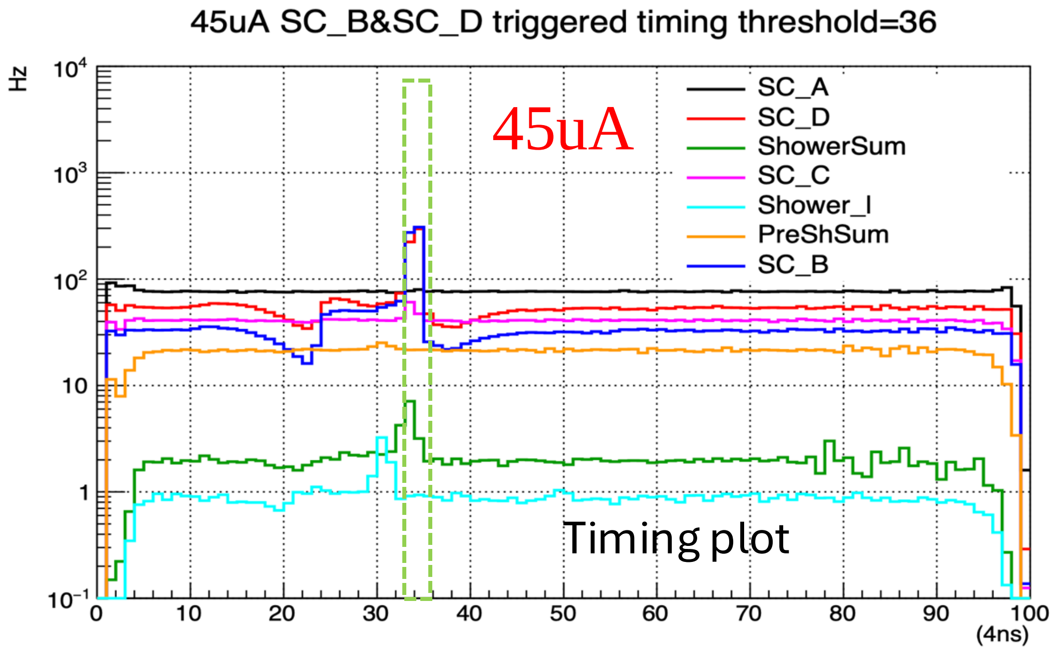
- The discrepancy between the simulation and the data is due to the absence of Moller background.

Beam Test ShowerSum MIP

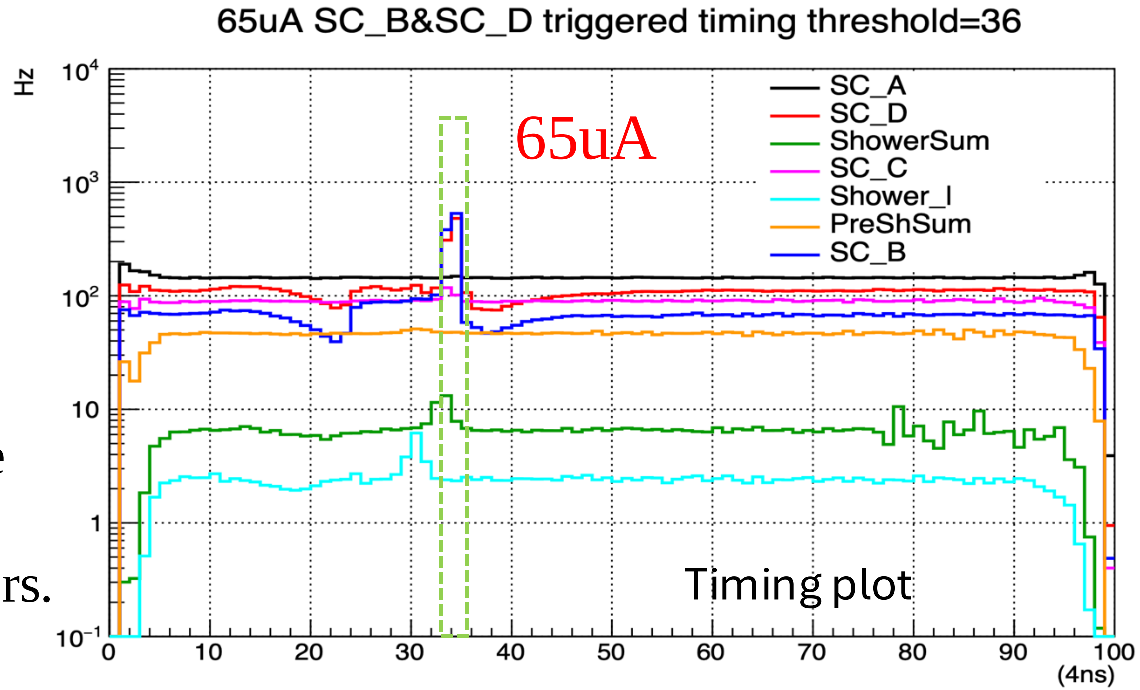




Scintillators with Coincidence Trigger



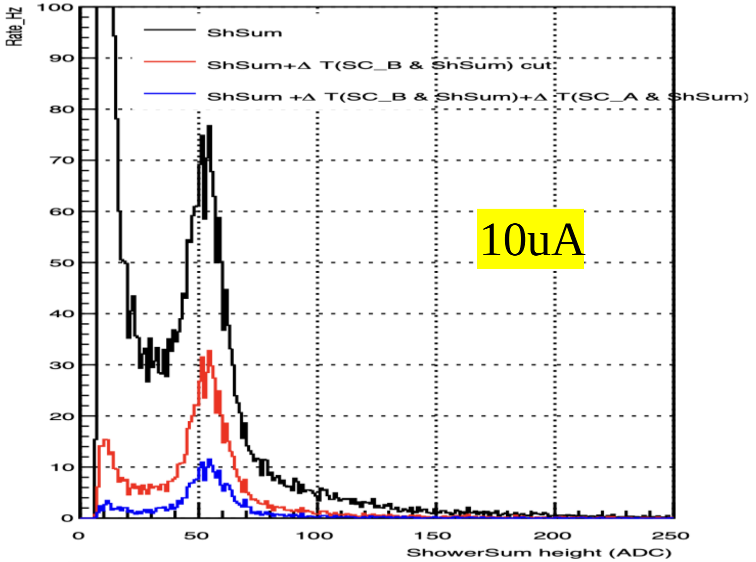
- The scintillator trigger used do find the MIP's was dominated by accidentals.
- we had to develop methods to use the signals from the waveform electronics to minimize the background, a useful task that will be useful in minimizing systematic errors in the SoLID data.



33<T_SC_D≤36

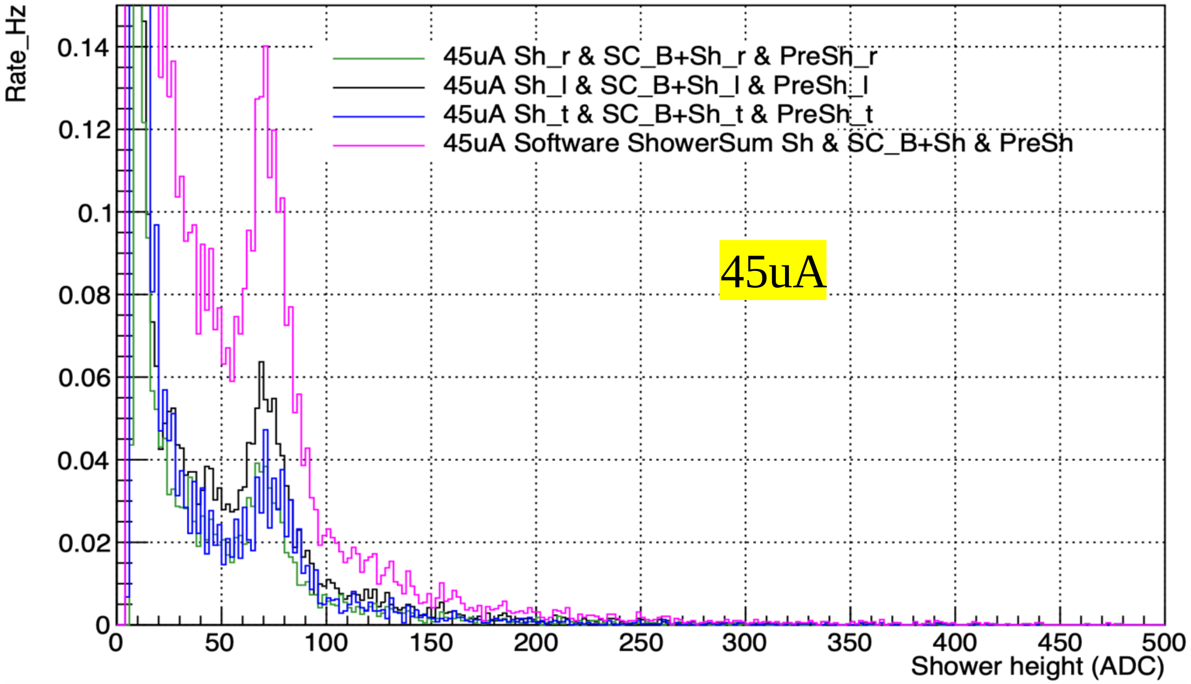
- The MIP peak should be cleanest for a tight 12 ns triple coincidence (SC_D & SC_B & ShSum), less clean for coincidences with SCD, and weakest for random triggers.

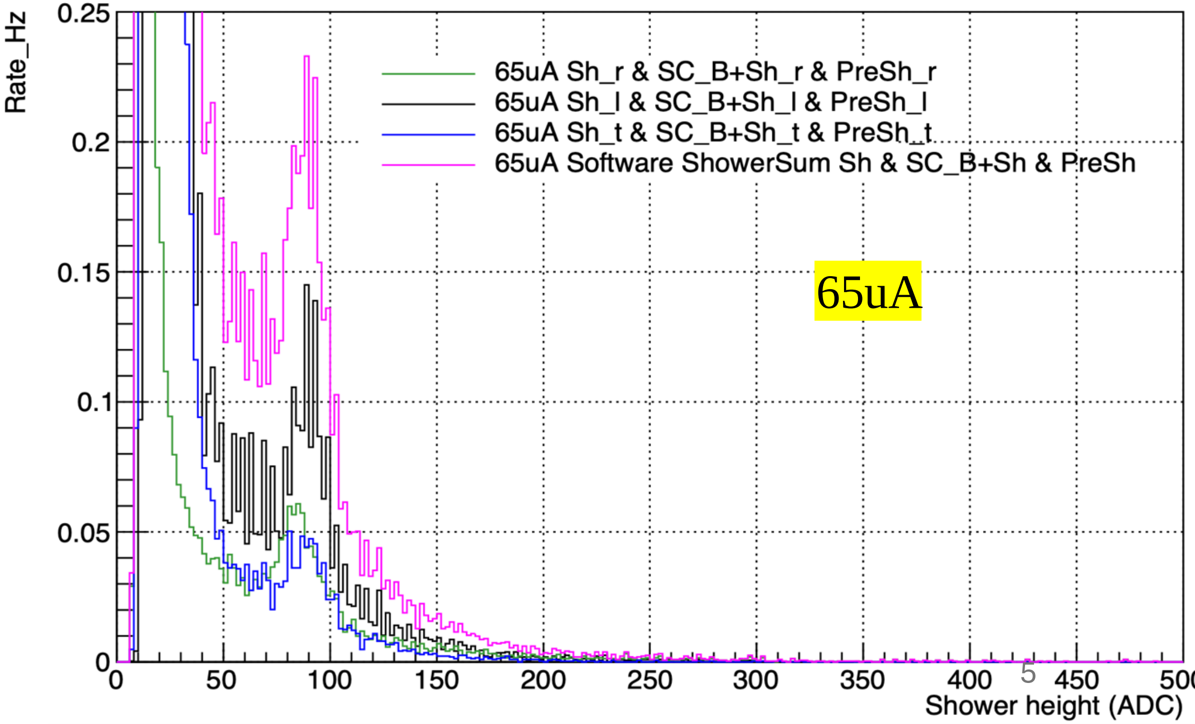
ShowerSum MIP Peaks at Various Beam Currents



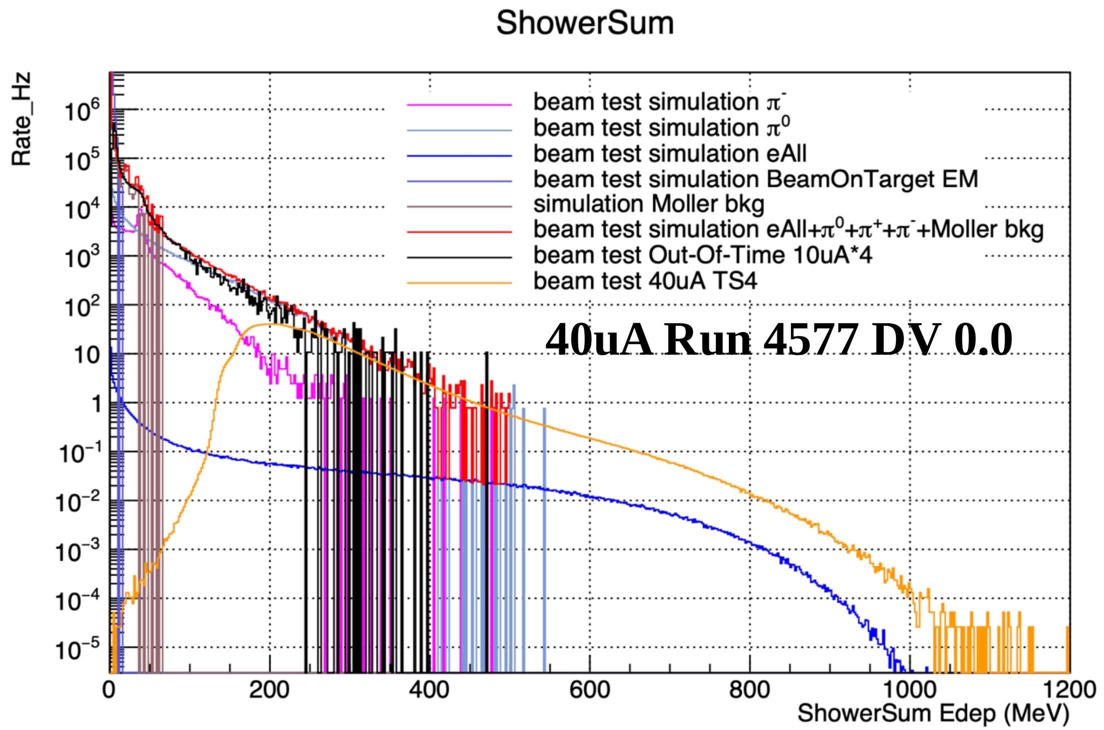
Improving the MIP Peak:

- Correcting for the rate-dependent gain changes. This is done by aligning the MIP peaks and also by matching the high energy of the Shower spectrum.
- Correcting the base-line shift due to small pulses from electromagnetic background.
- Tight timing cuts to reduce accidentals based on the timing plots.
- Optimize the thresholds of the scintillators.

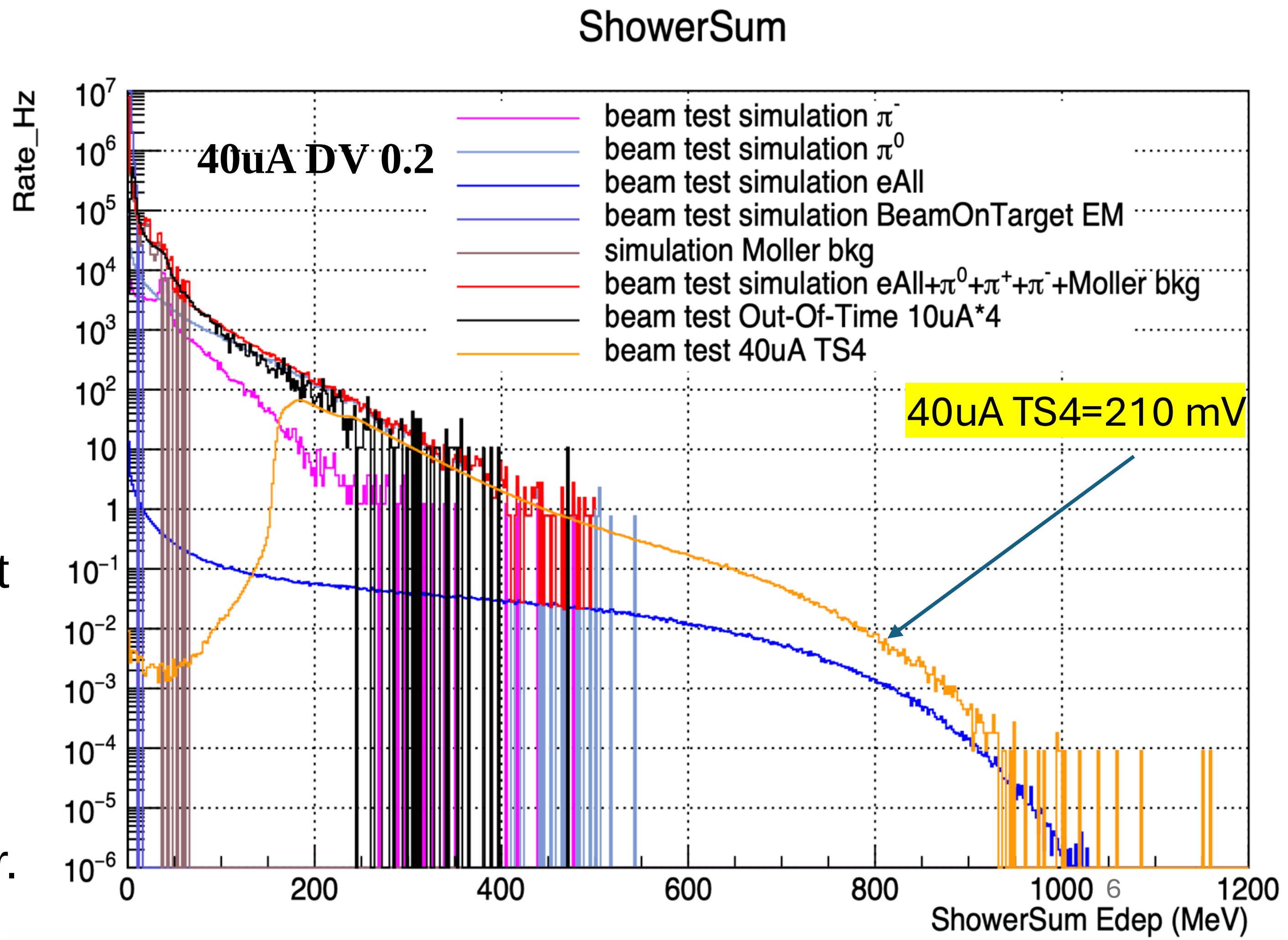




Beam Test Data and Simulation Comparison for the Shower Edep Distribution



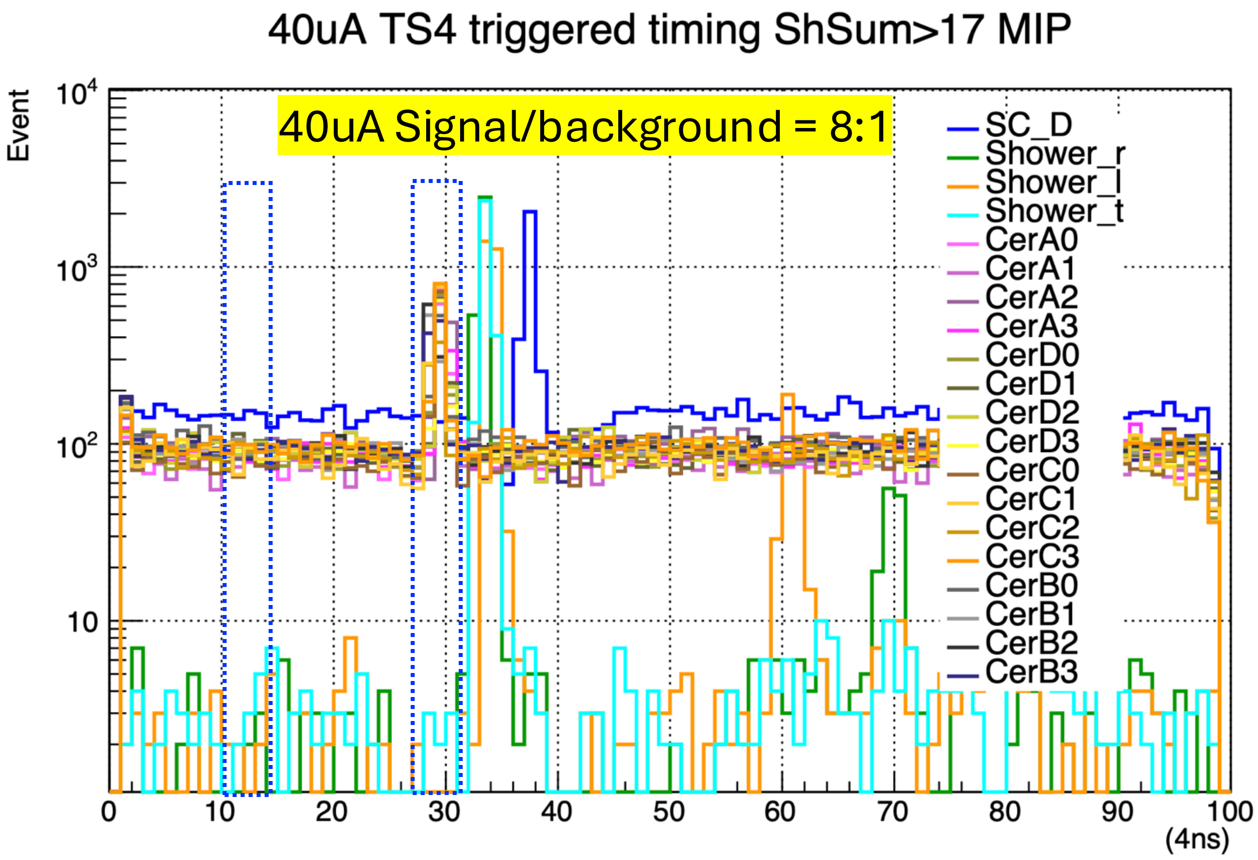
- Baseline correction applied
- The integration Time Window for the waveform is from the left half maximum of the peak(T LHMP) to T LHMP+40ns.
- Fixed integration TW as 40ns.

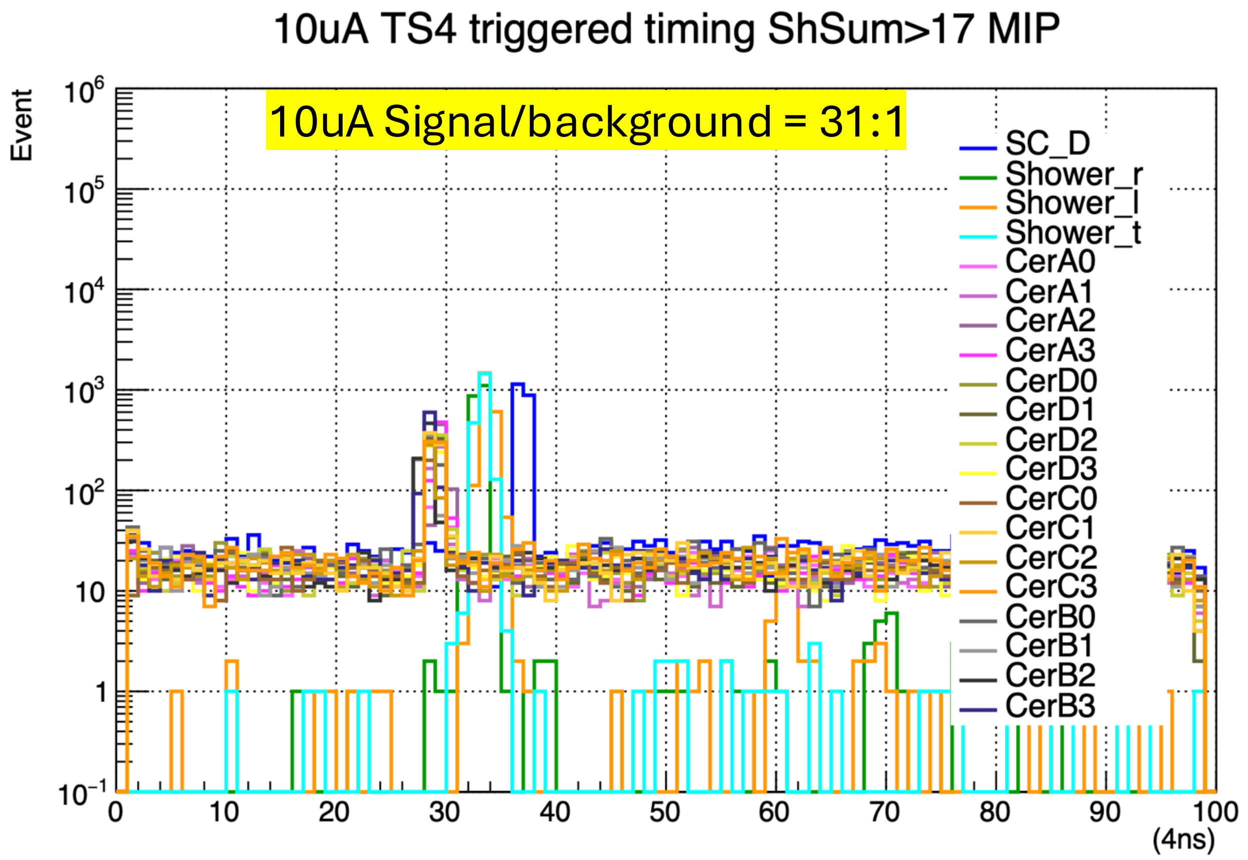


Can we see high energy electrons?

- The uncertainty in the calibration of the Shower has a big effect on the **e^-/π^0 ratio** at the highest energies. (It is >10%, which changes the rate by a factor of 10 at high energies.)
- Cherenkov is ~20X more efficient for electrons than photons detected by Shower.

Timing Plots





Accidental rate @ 40uA:

$$\frac{90*100}{\mathbf{4535}*0.4us} = 5.0 \text{ MHz}$$

Triggered Total_N=4535

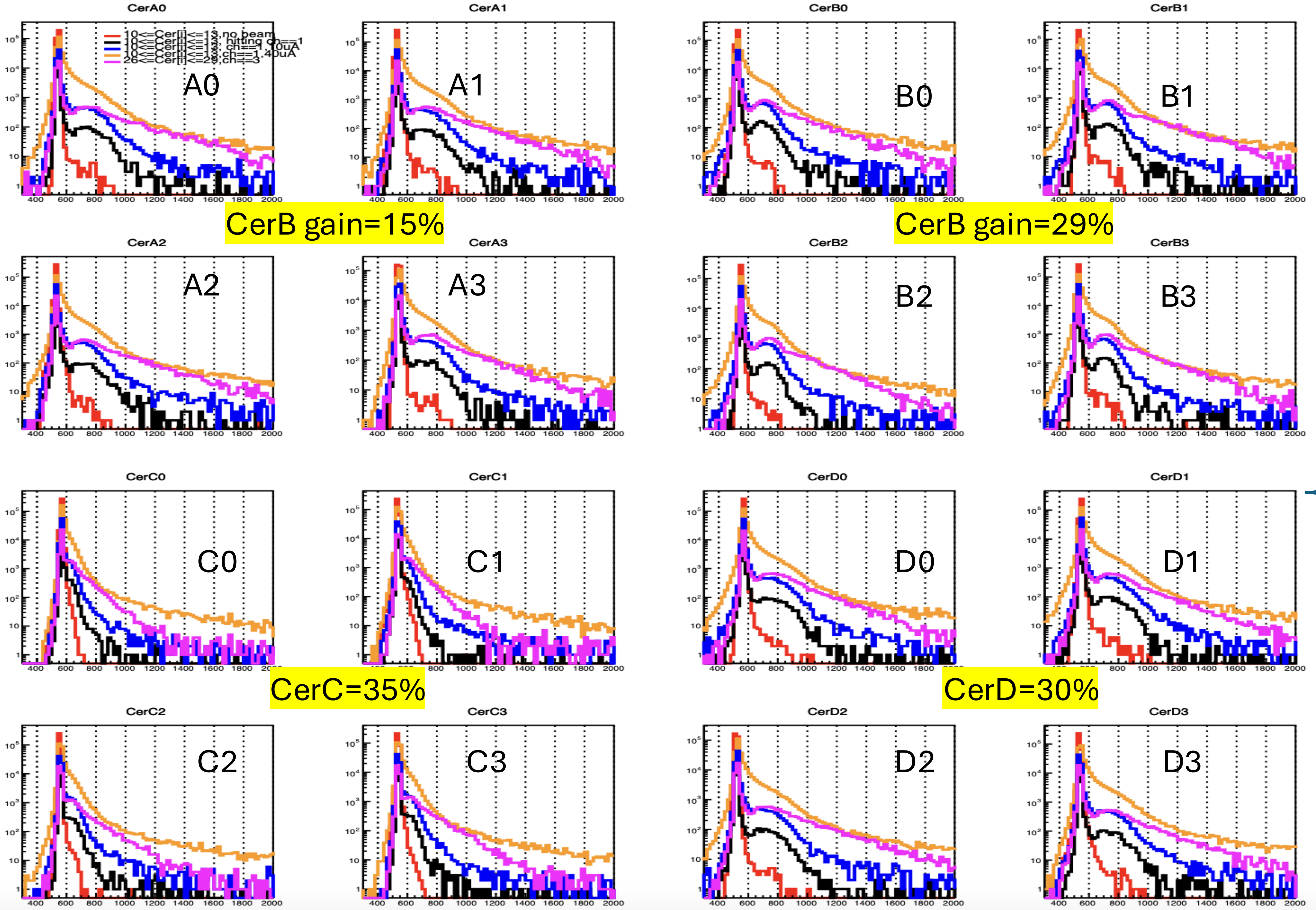
10uA and 40uA:

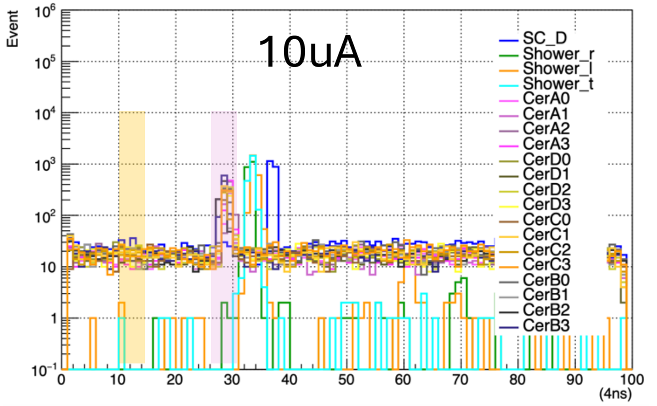
- gain shift and balance
- Narrow timing window
- (Sh_r-SC_D), (Sh_l-SC_D), and (Sh_t-SC_D) timing cuts

Accidental rate @ 10uA:

$$\frac{17*100}{\mathbf{3070}*0.4us} = 1.40 \text{ MHz}$$

Cherenkov Spectra with 10<=Cer[i]<=13





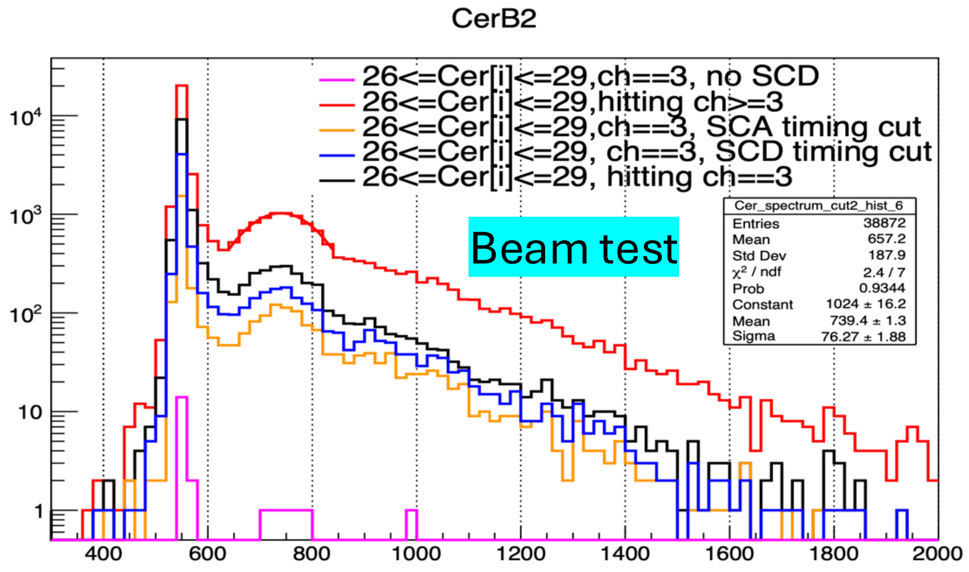
10<=Cer[i]_pos<=13

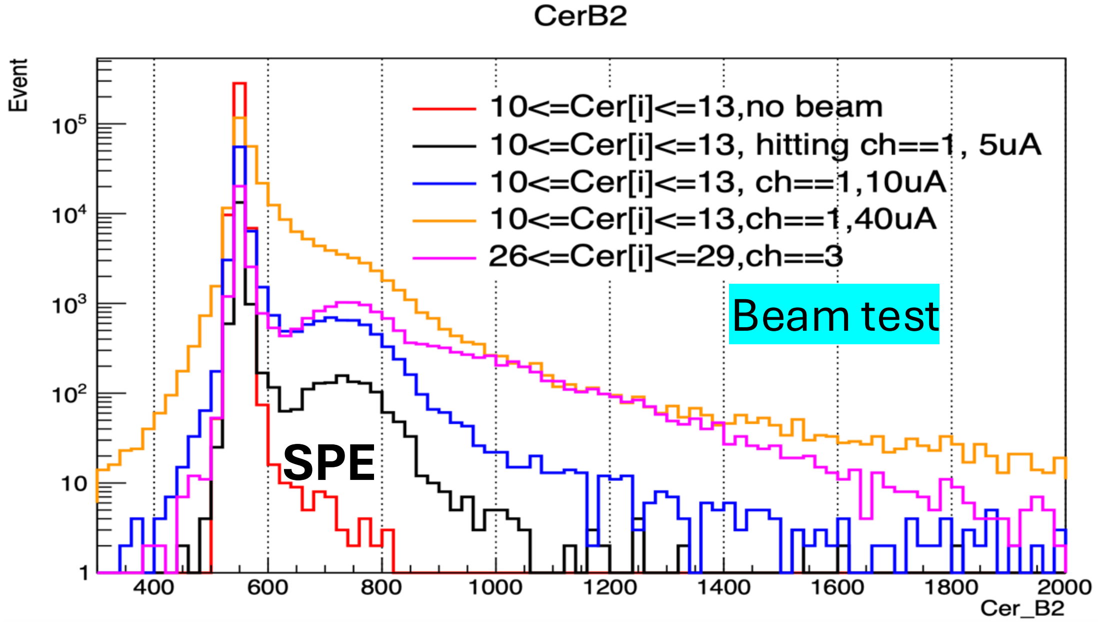
- no beam
- 5uA+ 1 channel fired
- 10uA+1 channel fired
- 40uA+ 1 channel fired

26<=Cer[i]_pos<=29

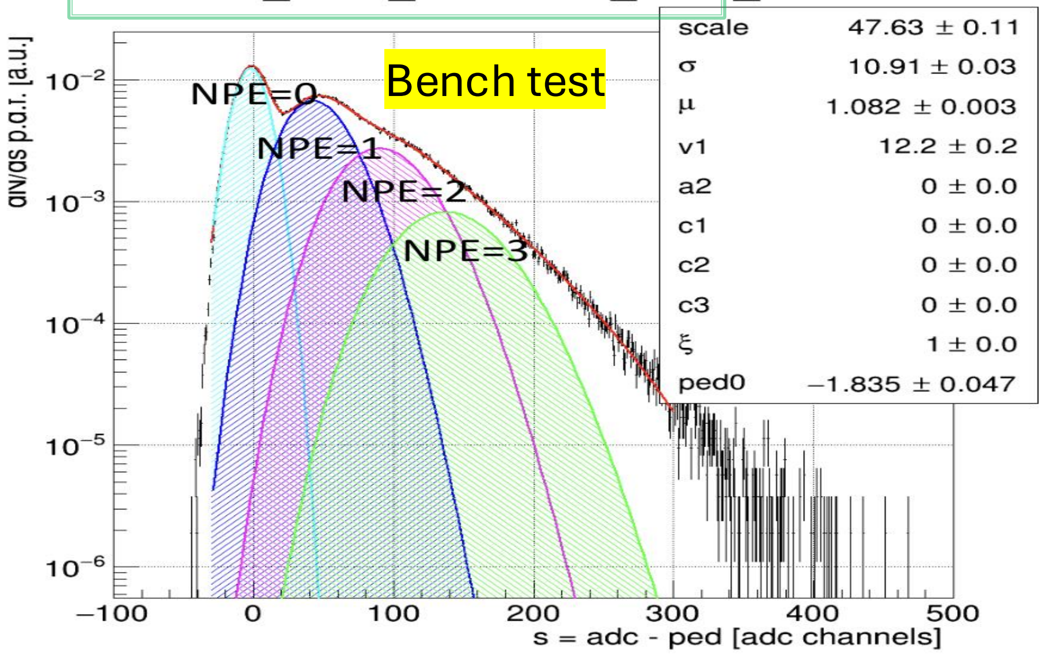
- 10uA + >3-channels fired

Cherenkov Integrated Spectra

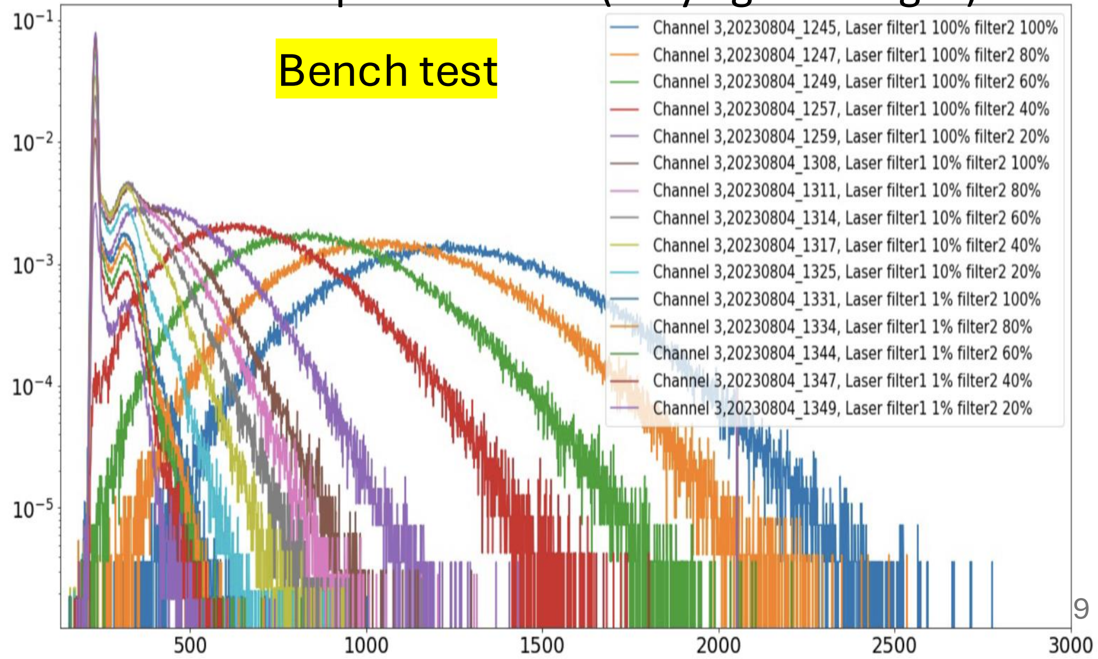




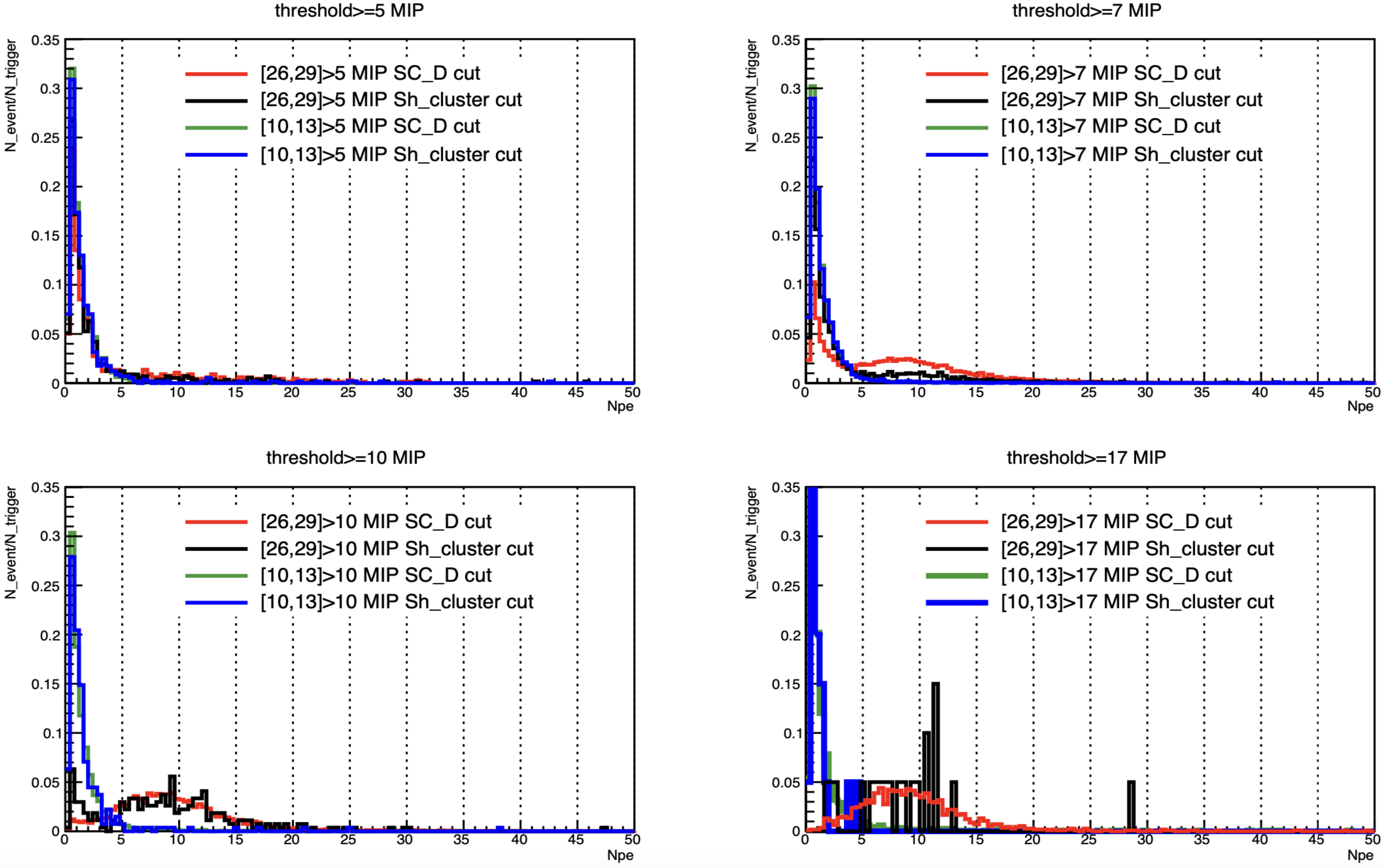
from Bo Yu and Zhiwen Zhao



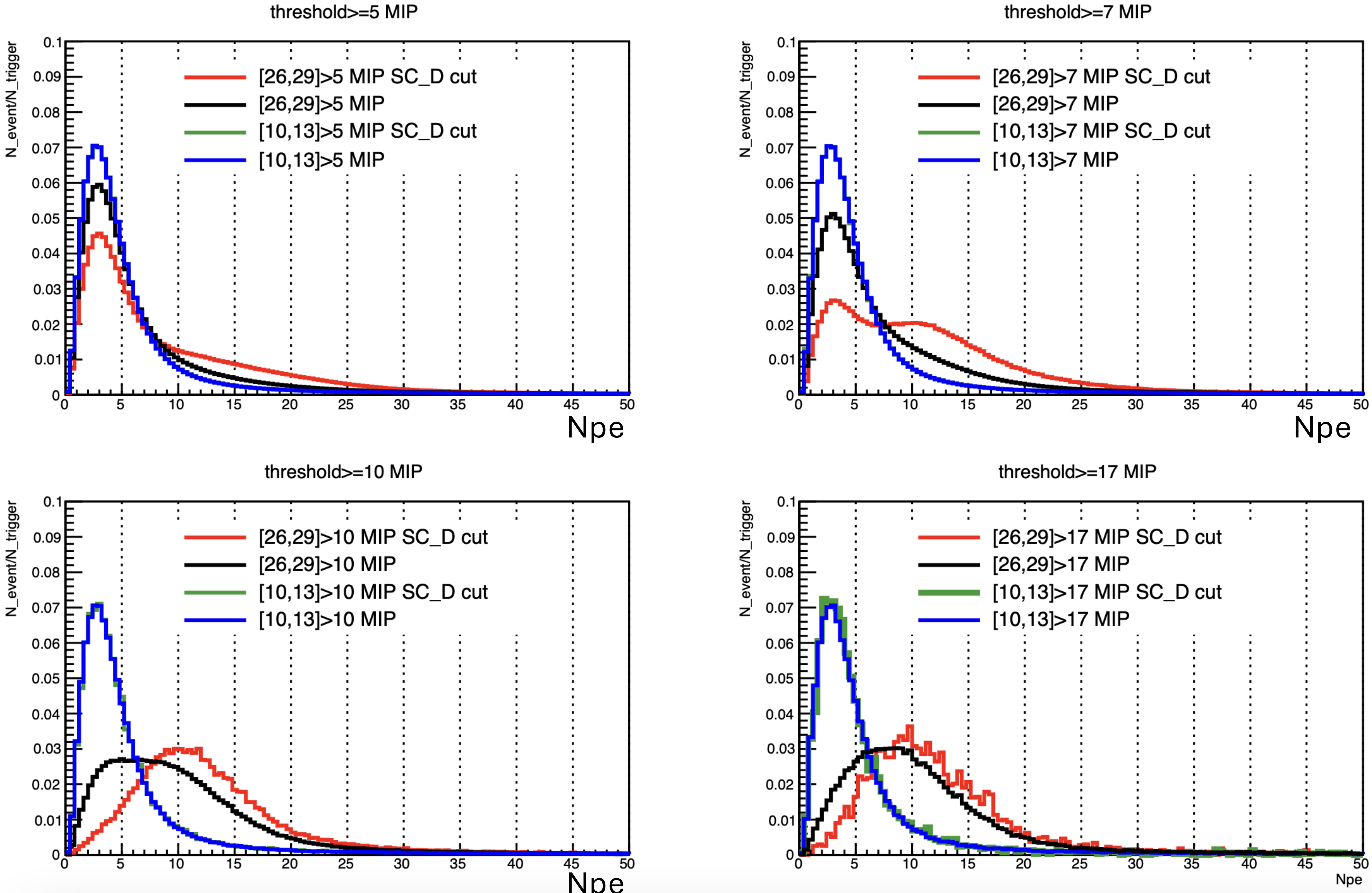
simple sum PMT (only light changes)



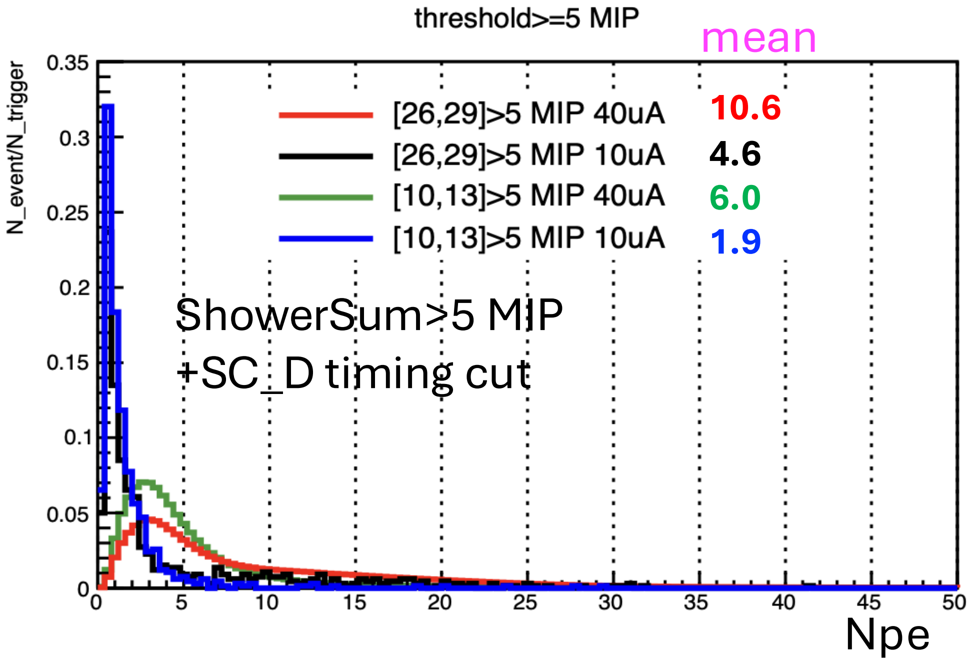
10uA Npe ShowerSum Triggered with SC_D cut vs 1.5 cm<Sh_cluster_X/Y<1.5 cm Cuts

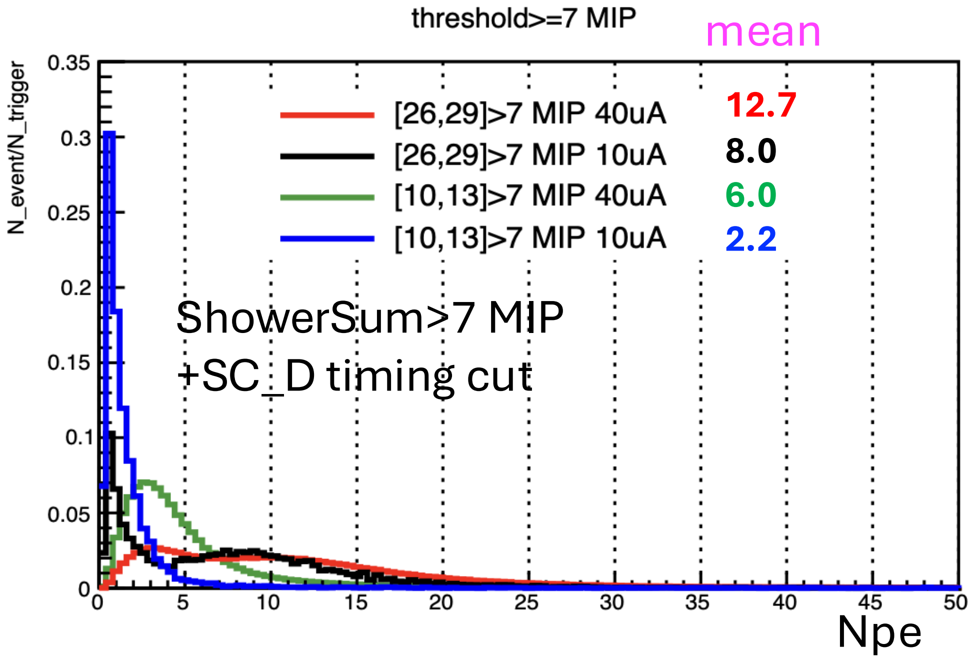


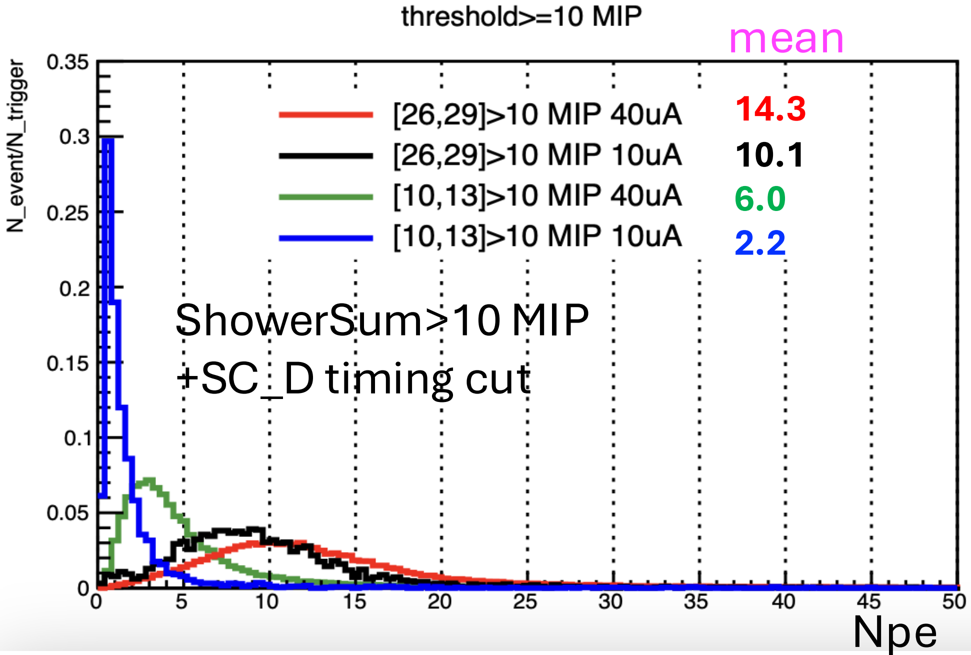
40uA Npe ShowerSum Triggered with/without SC_D Timing Cut

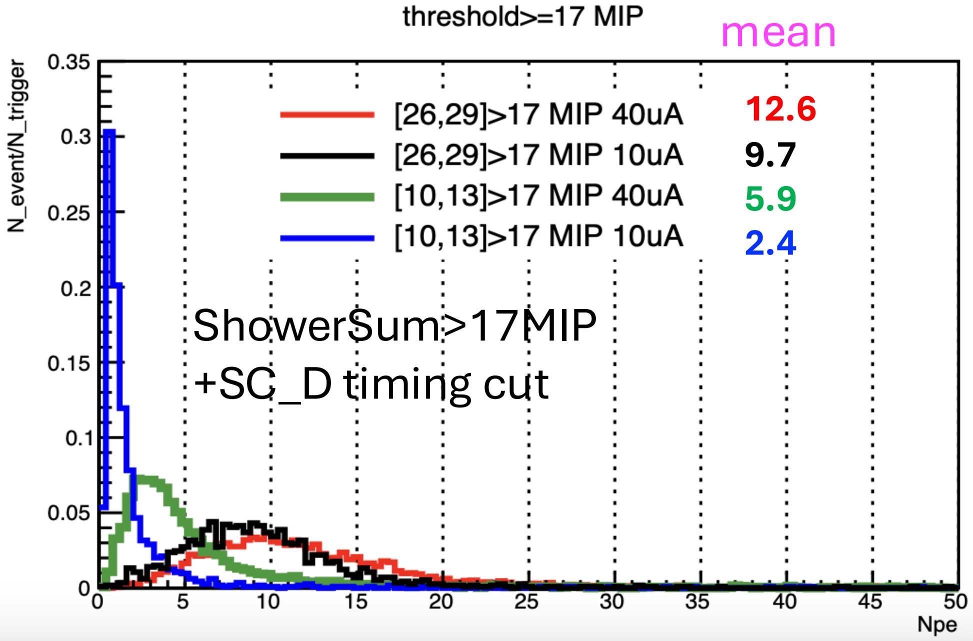


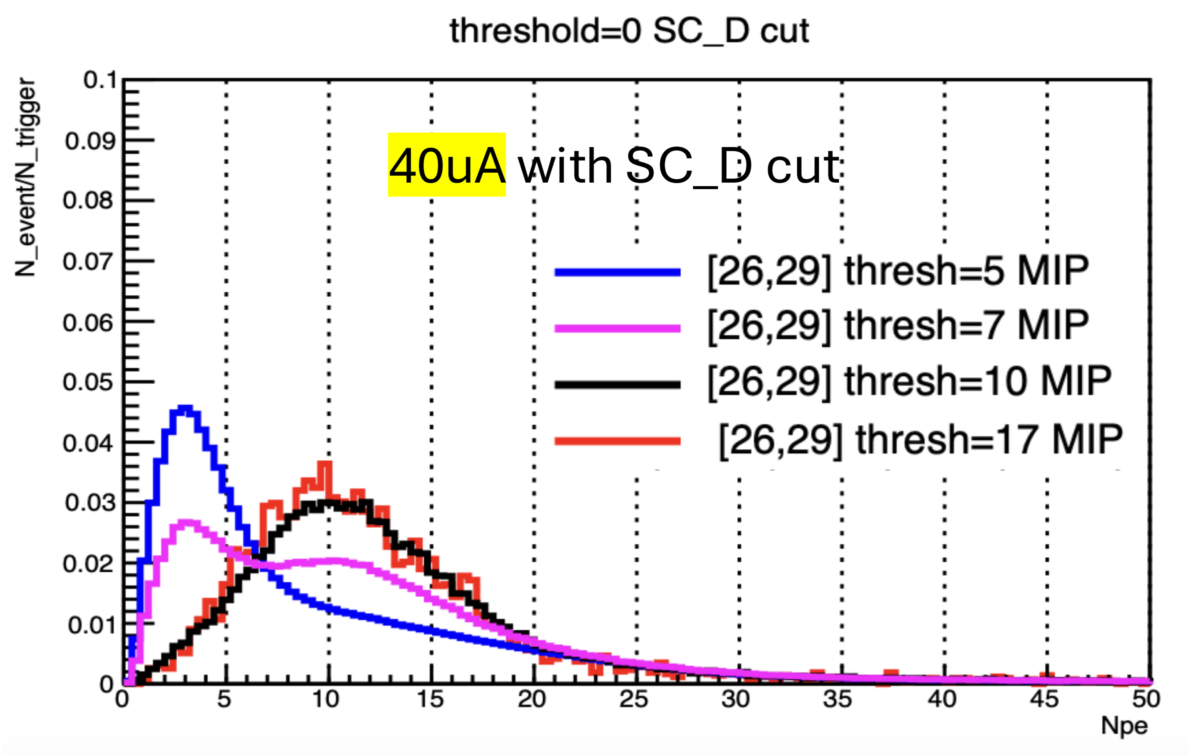
40uA and 10uA ShowerSum triggered Average Npe with SC_D cut



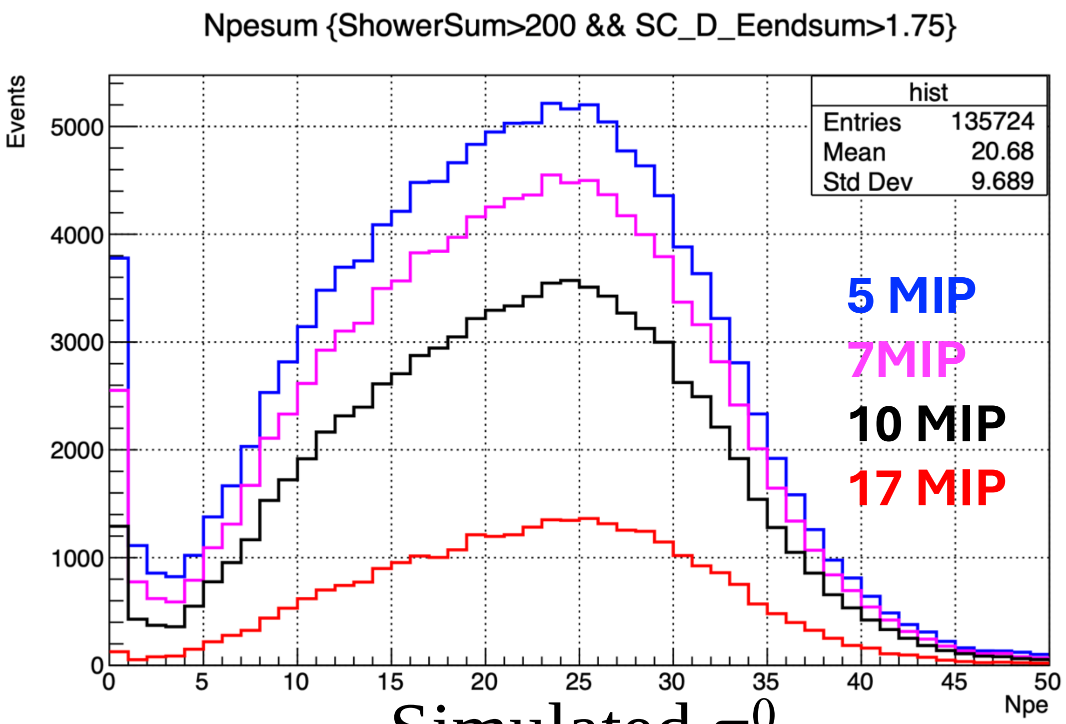




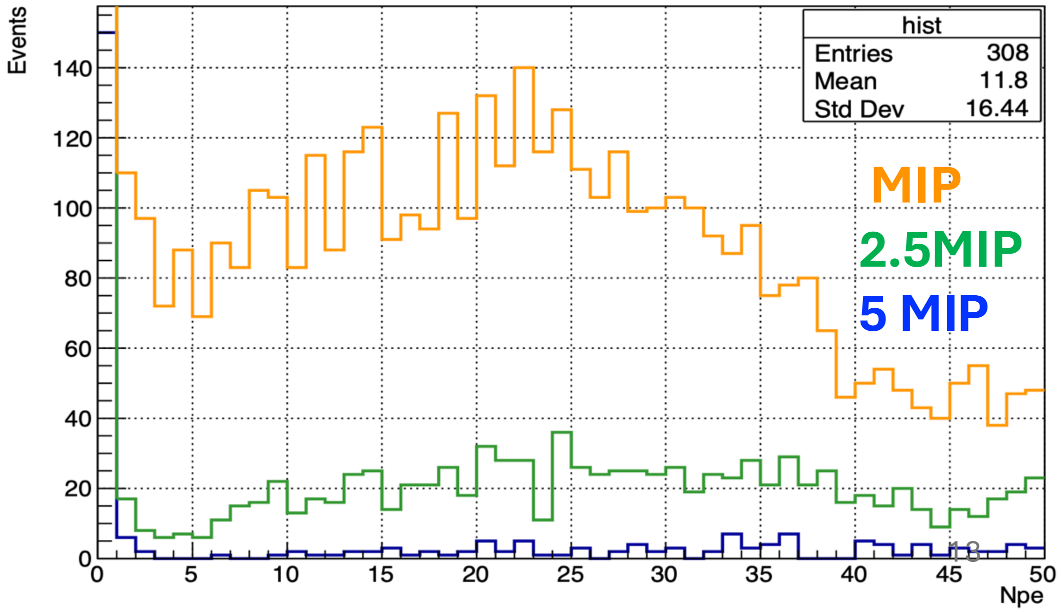




Simulated e^-

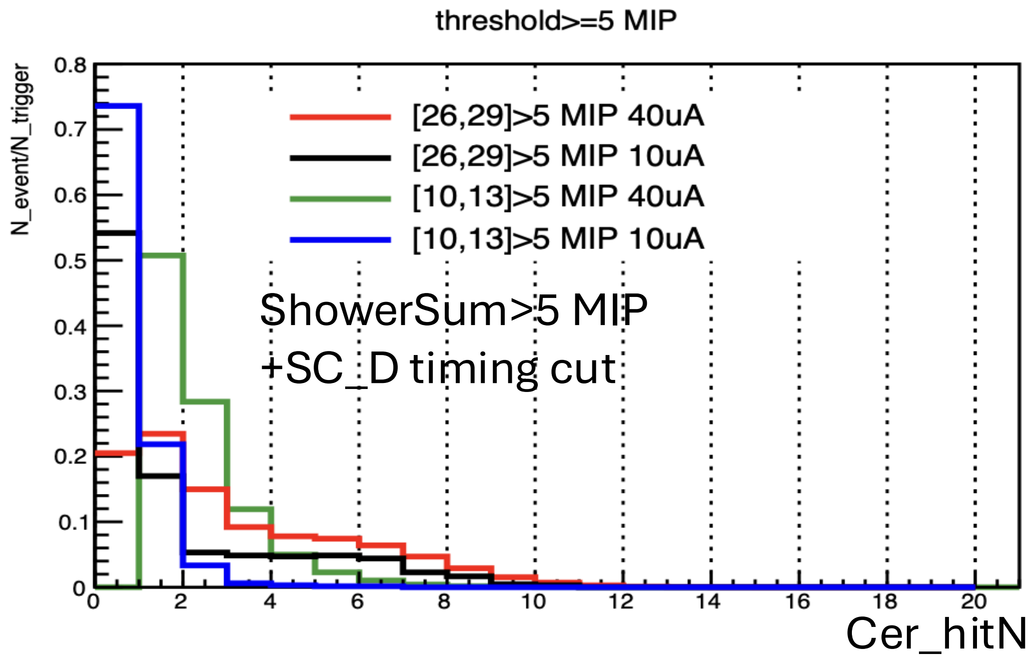


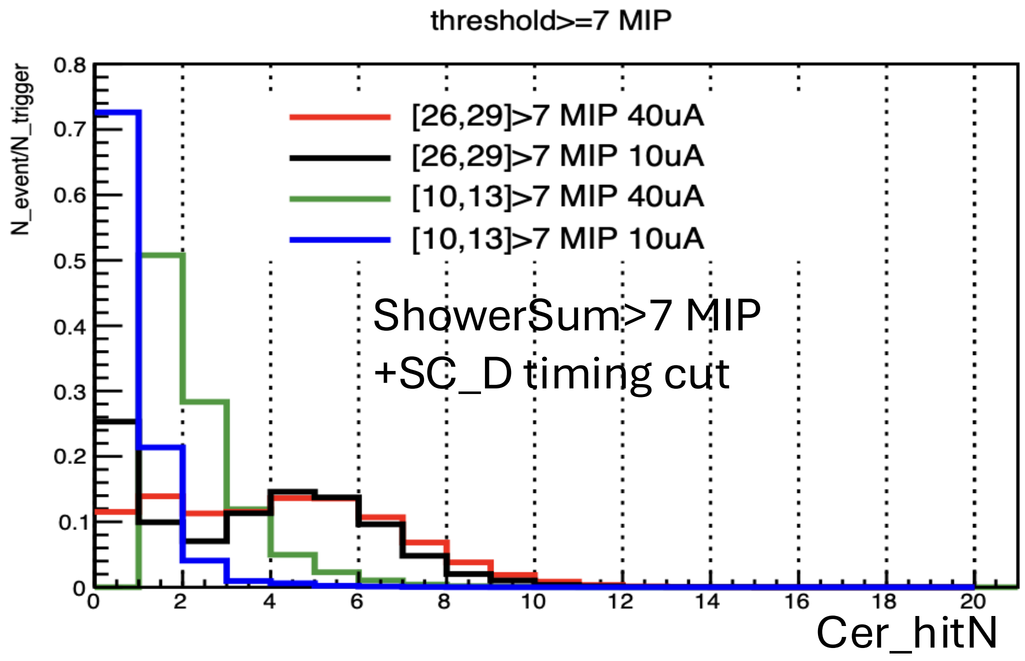
Simulated π^0

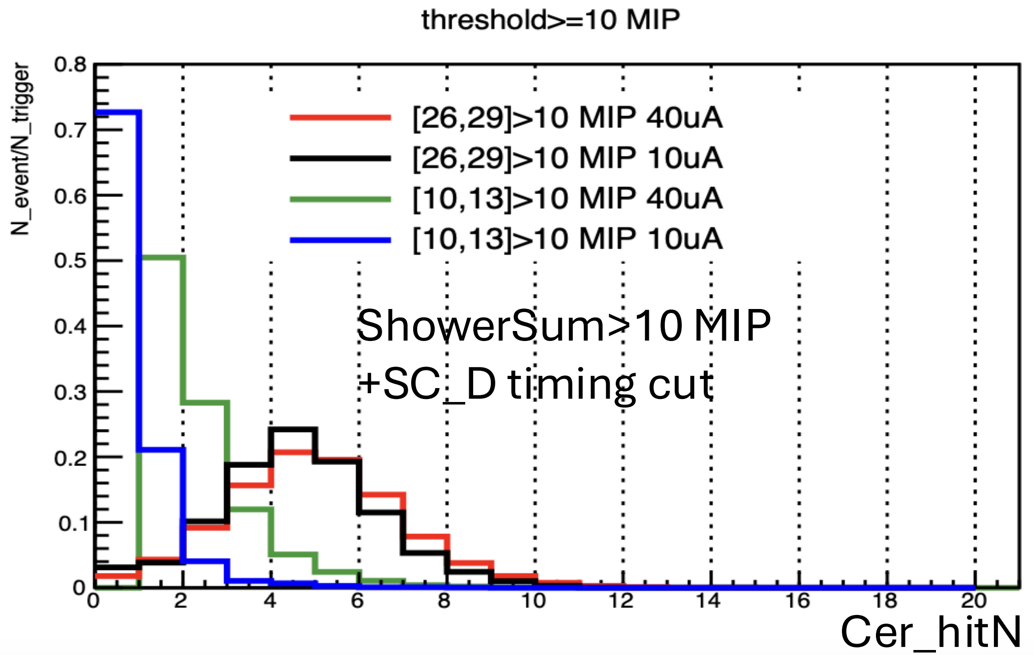


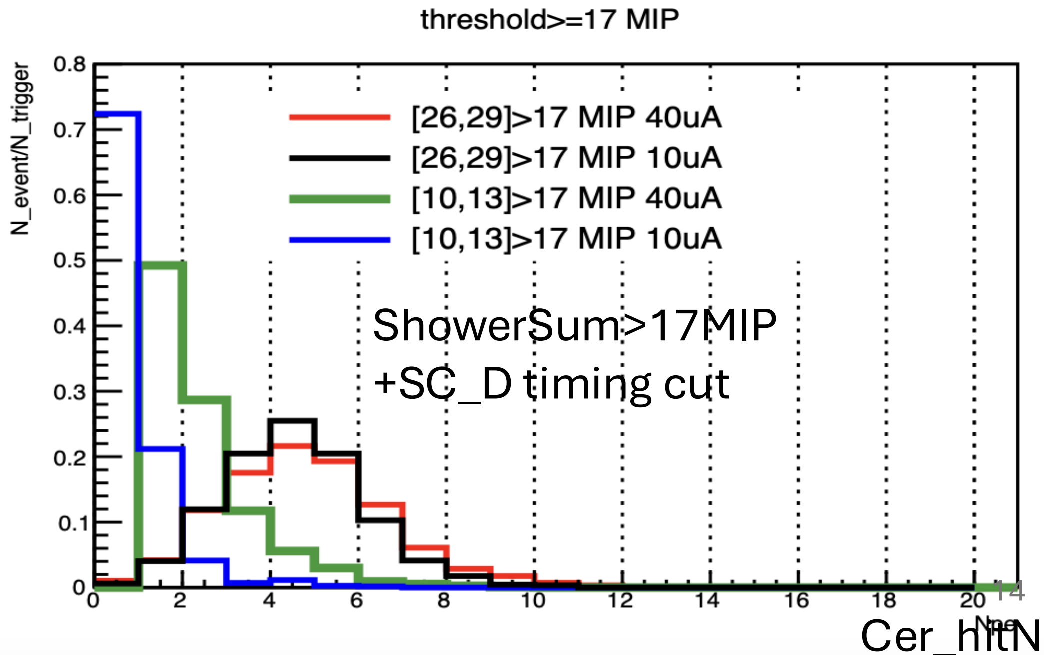
- Use software ShowerSum threshold cuts
- ΔT(Shower_r-SC_D), ΔT(Shower_l-SC_D), and ΔT(Shower_t-SC_D) cuts

40uA and 10uA ShowerSum triggered Average Cer_hitN with SC_D cut









Summary and Outlook

- Include Moller backgrounds to achieve better agreement between the simulation and data in the MIP region.

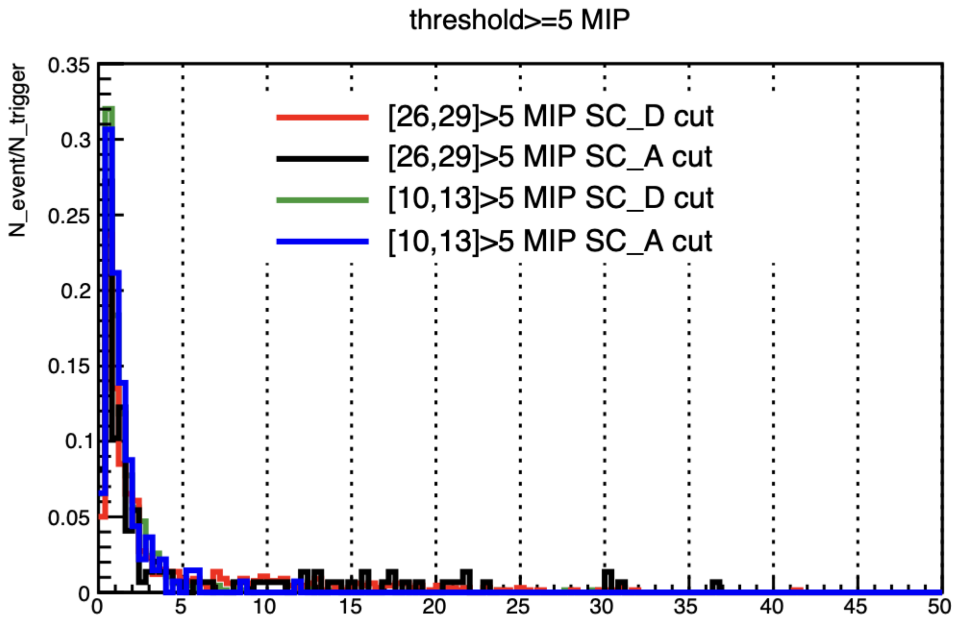
- We had to develop a method to utilize signals from waveform electronics to minimize background noise. The method helps refine MIP peaks by applying coincident timing cuts on ΔT(ShSum-SC_B) and ΔT(ShSum-PreShSum) for high-rate data at 45 μA and 65 μA.

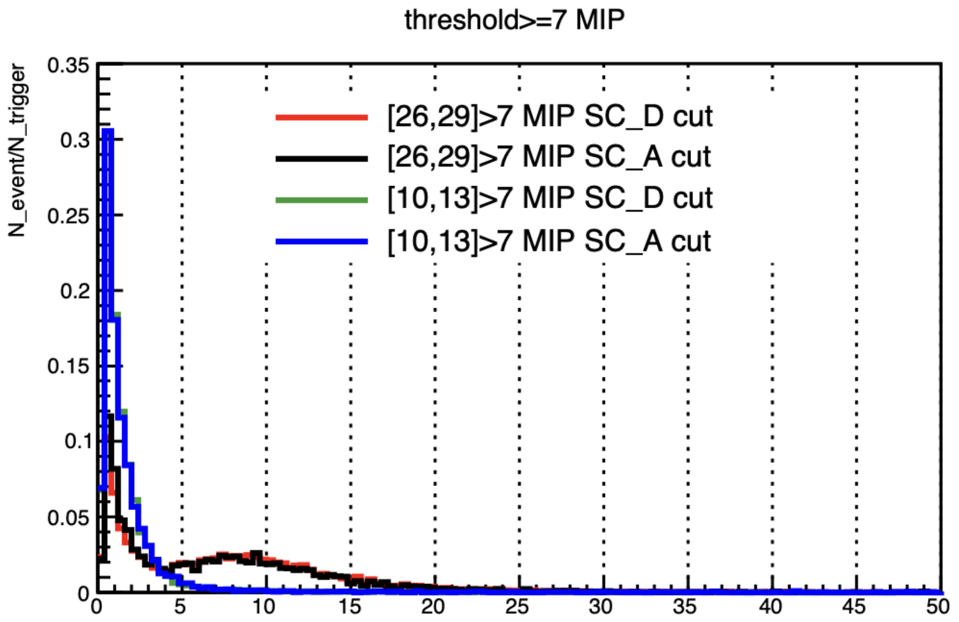
- At 18 degrees, we detect high-energy electrons using the Cherenkov detector by applying higher energy deposition thresholds on ShowerSum.

- The Cherenkov detector's number of photoelectrons (Npe) and the number of hitting channels are consistent between the 10 μA and 40 μA data. However, the observed data shows fewer photoelectrons compared to the simulation. We need to test the mirror efficiency

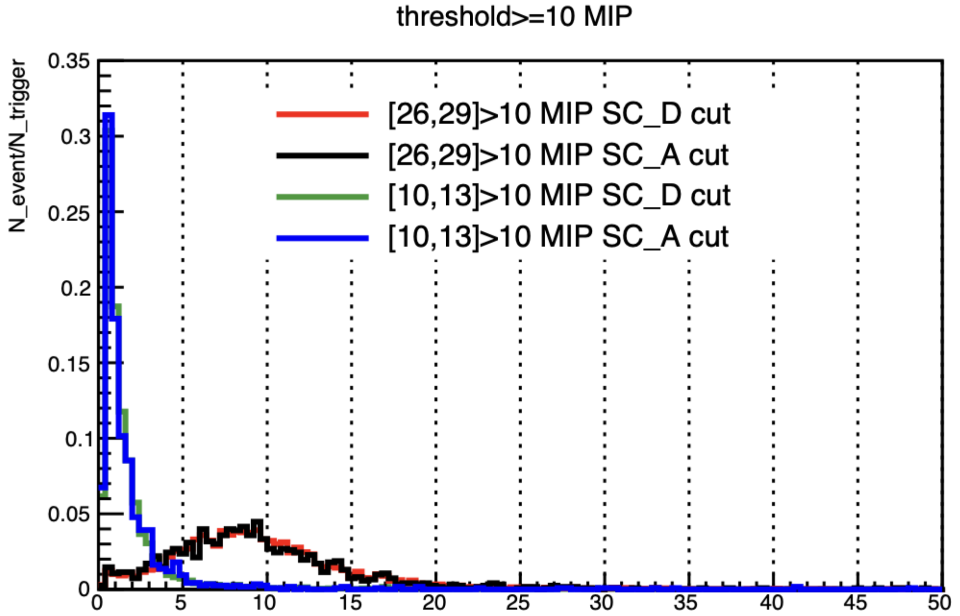
Backup

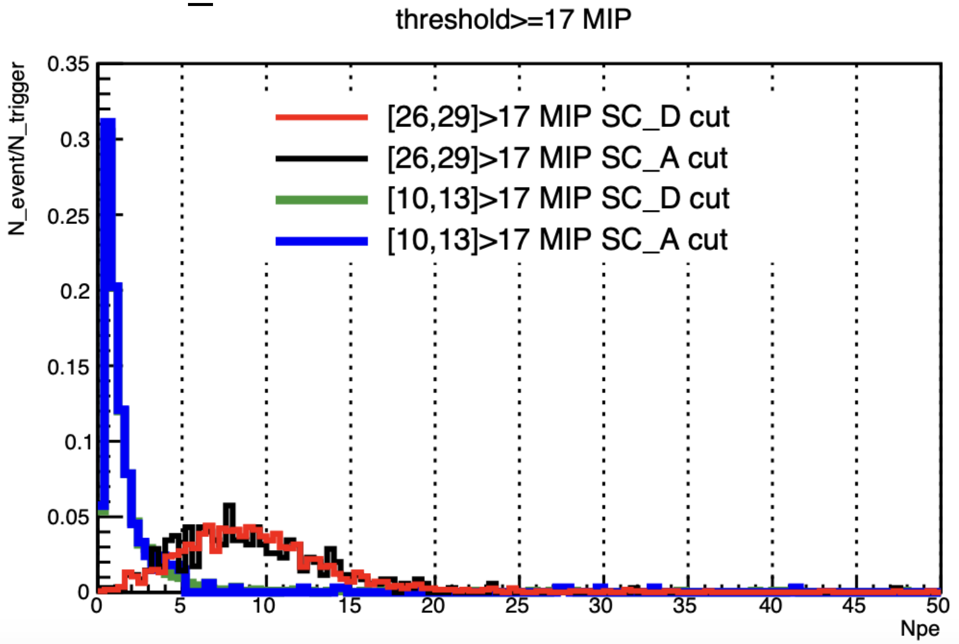
10uA Npe ShowerSum triggered with SC_D timing cut vs SC_A timing cut



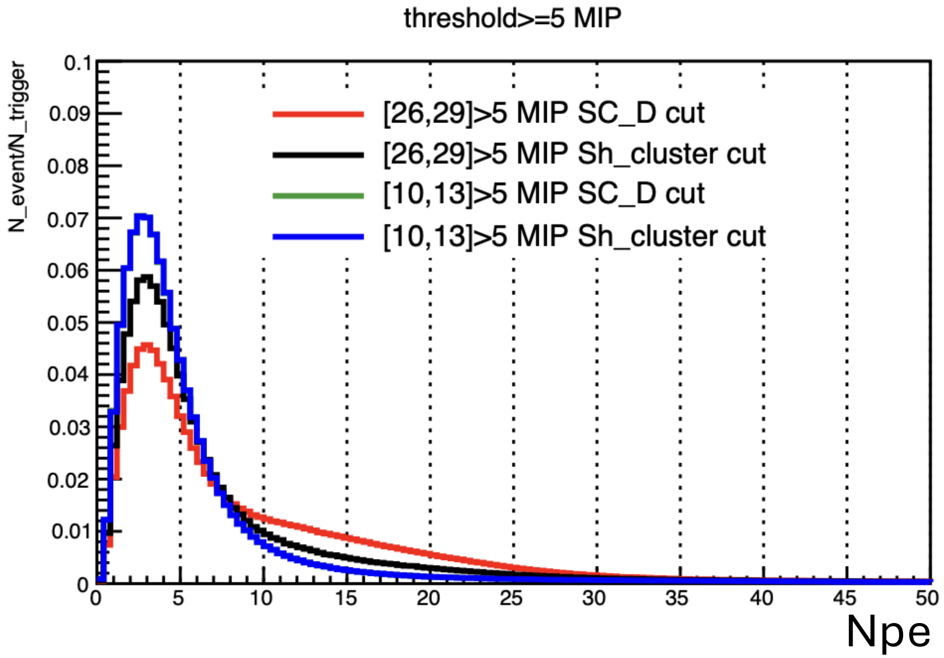


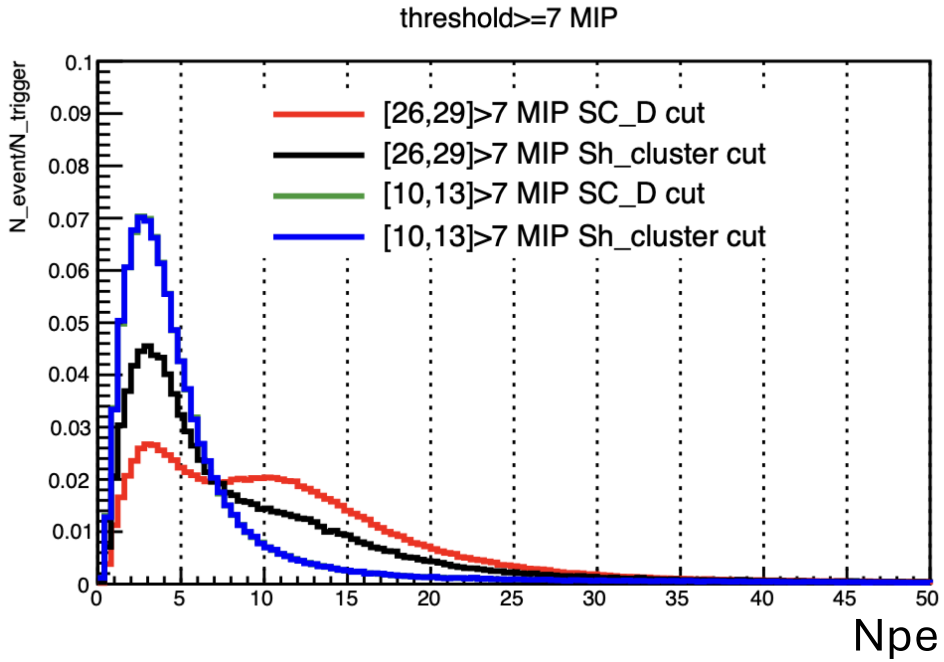
Less statistics with SC_A cut

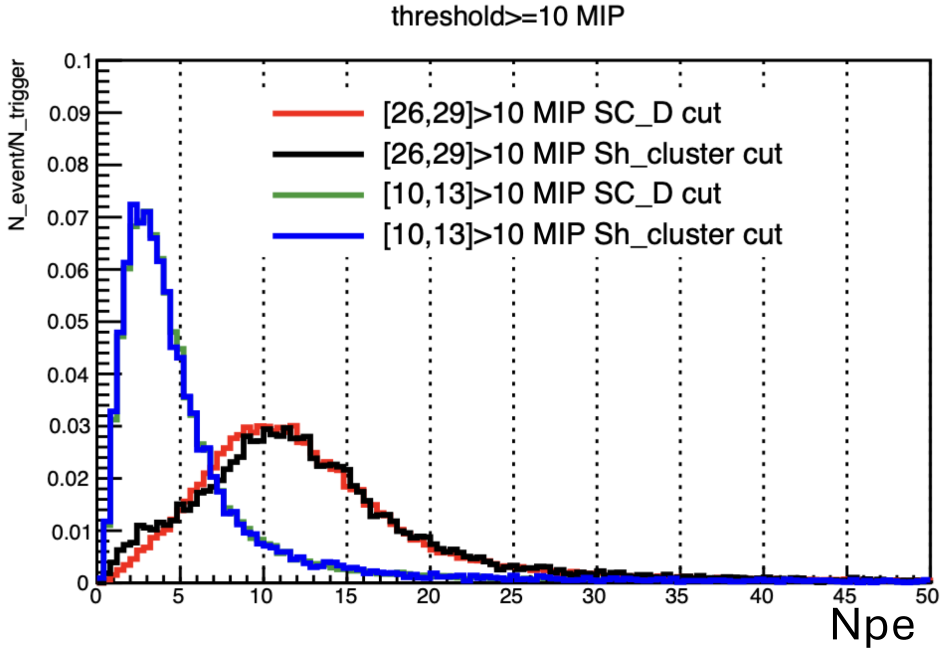


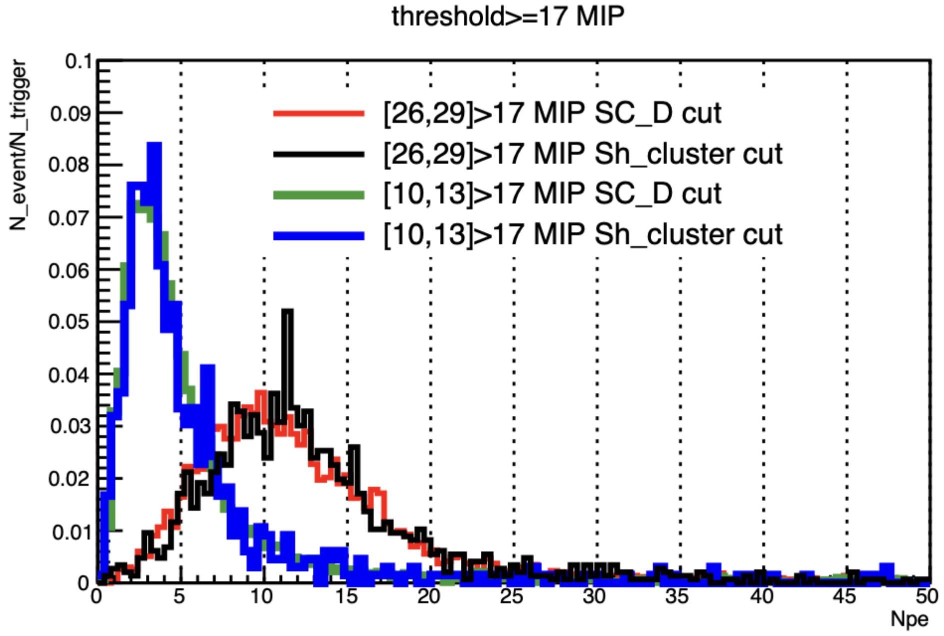


40uA Npe ShowerSum triggered with SC_D cut vs 1.5 cm<Sh_cluster_X/Y<1.5 cm cut

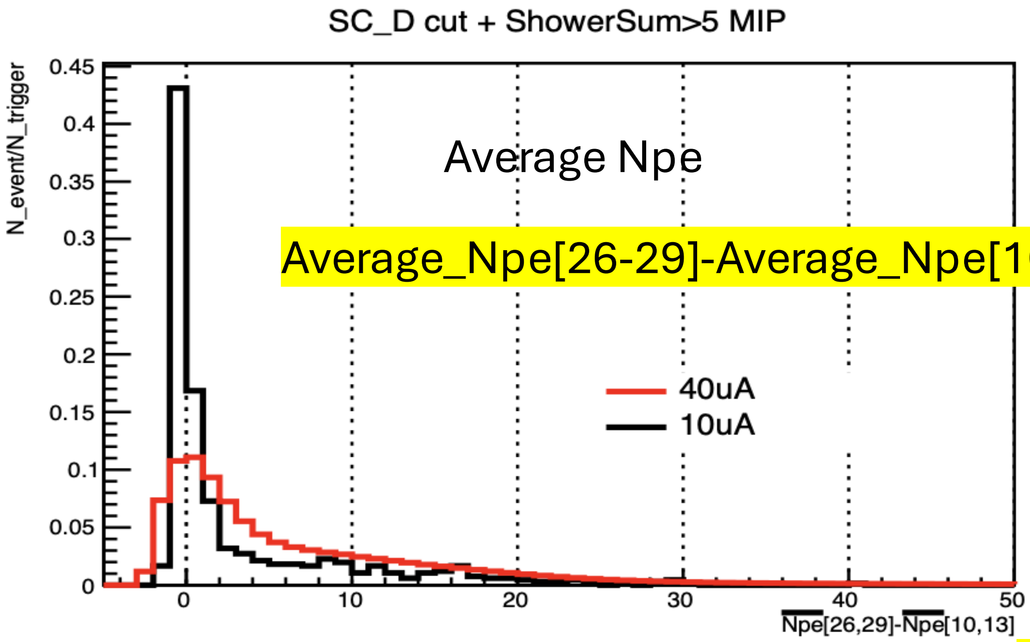




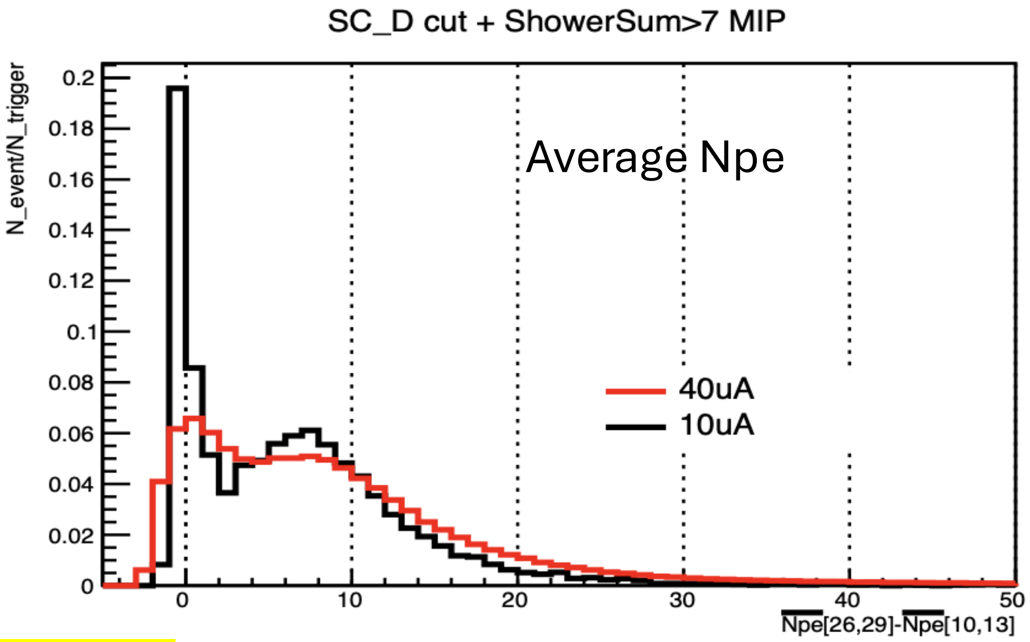




Average Npe ShowerSum triggered with SC_D Timing Cut

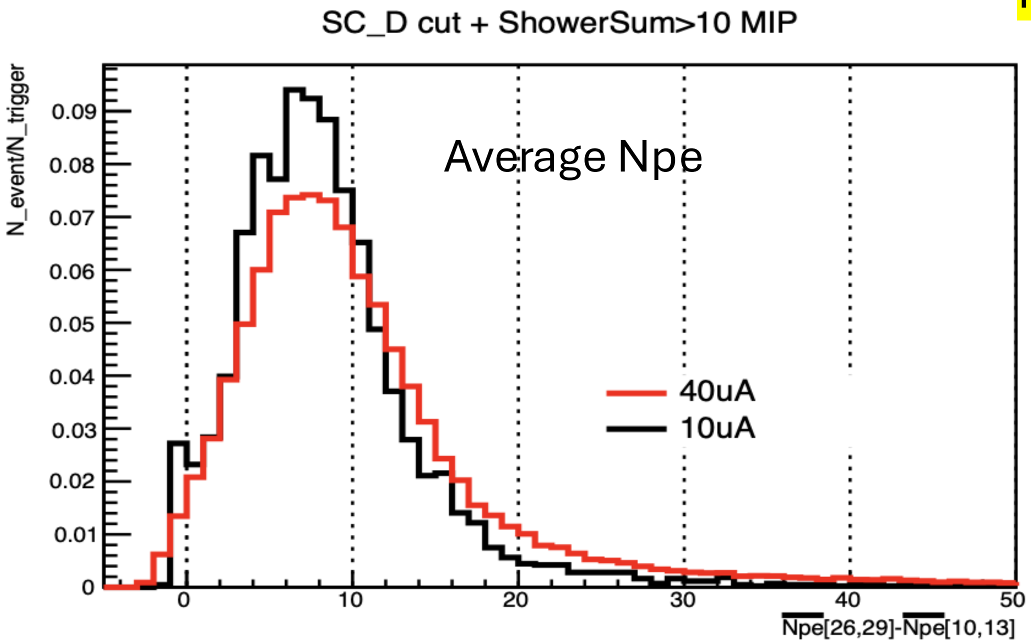


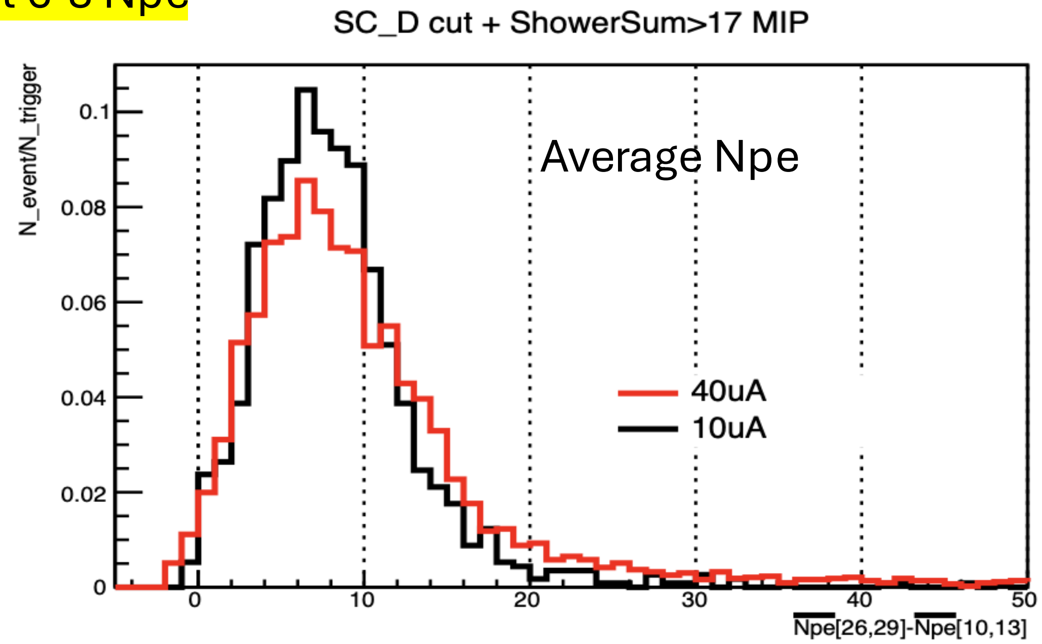
Average_Npe[26-29]-Average_Npe[10,13]



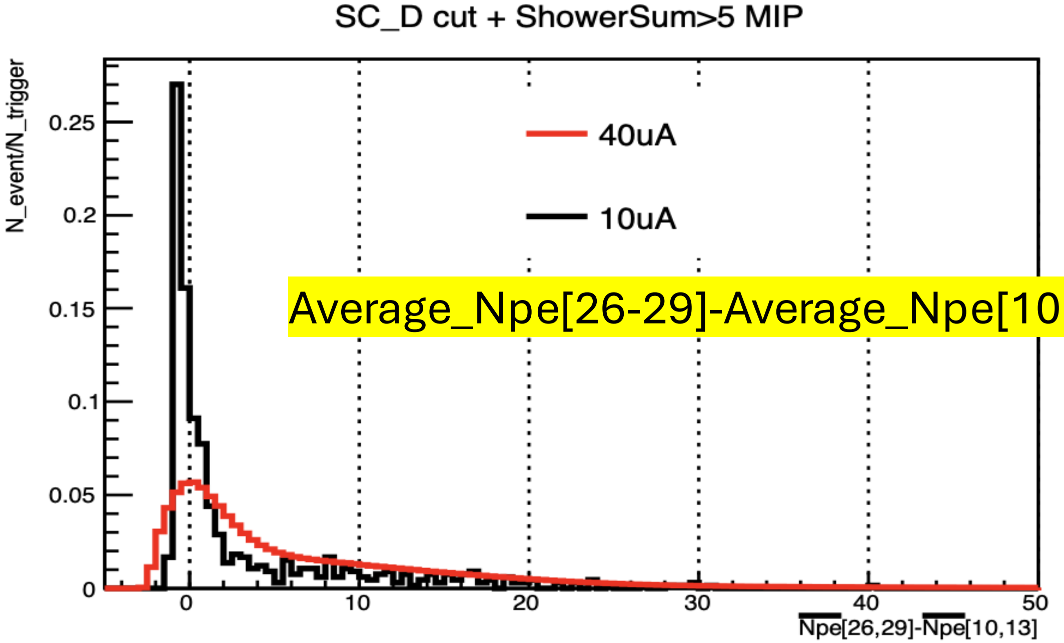
Average background subtraction

Peaks at 6-8 Npe

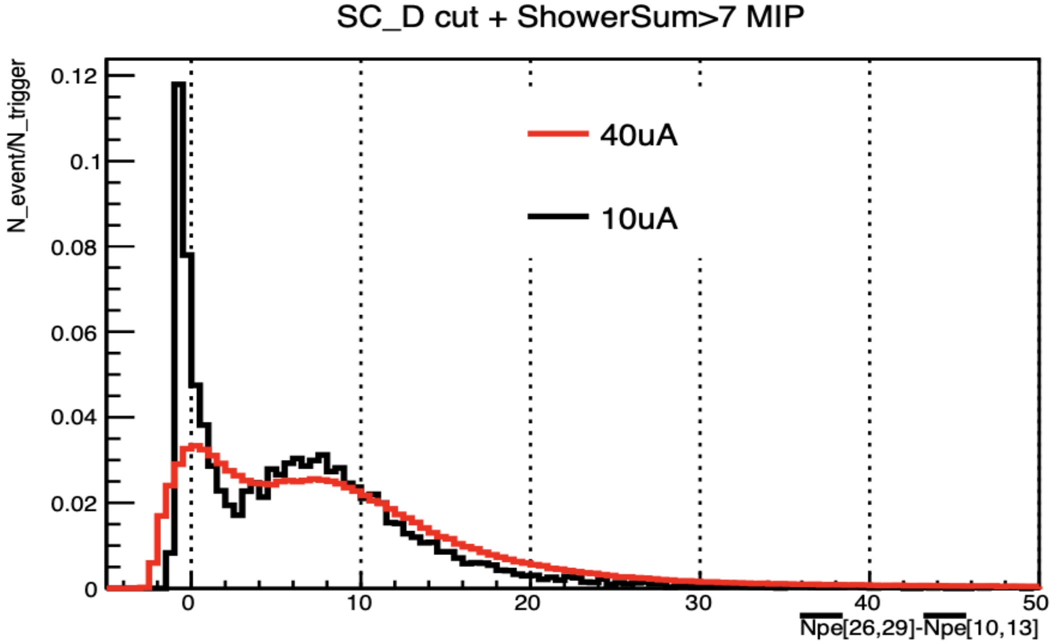




Average Npe ShowerSum triggered with SC_D Timing Cut



Average_Npe[26-29]-Average_Npe[10,13]



Average background subtraction

Peaks at 6-7 Npe with finer bin size