HPS Trigger

Valery Kubarovsky
Jefferson Lab

October 27, 2015
HPS Collaboration Meeting

Plan

- HPS trigger overview
- Implementation of the trigger cuts in the data analysis

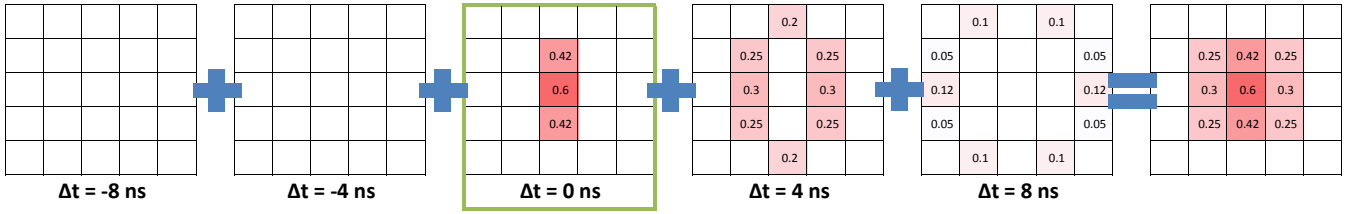
HPS Trigger

1. Pulser (random) trigger
2. Cosmic trigger
3. Single trigger 0
4. Single trigger 1
5. Pair trigger 0
6. Pair trigger 1

- Each trigger can be individually enabled or disabled
- Individual cuts can be deactivated.
- Singles and pair triggers use completely independent cuts
- Triggers can also be prescaled individually.

Cluster Definition

- $E_{seed} \geq E_{threshold}$
- $N_{hits} \geq N_{threshold}$
- $E_{low} \leq E_{cluster} \leq E_{high}$

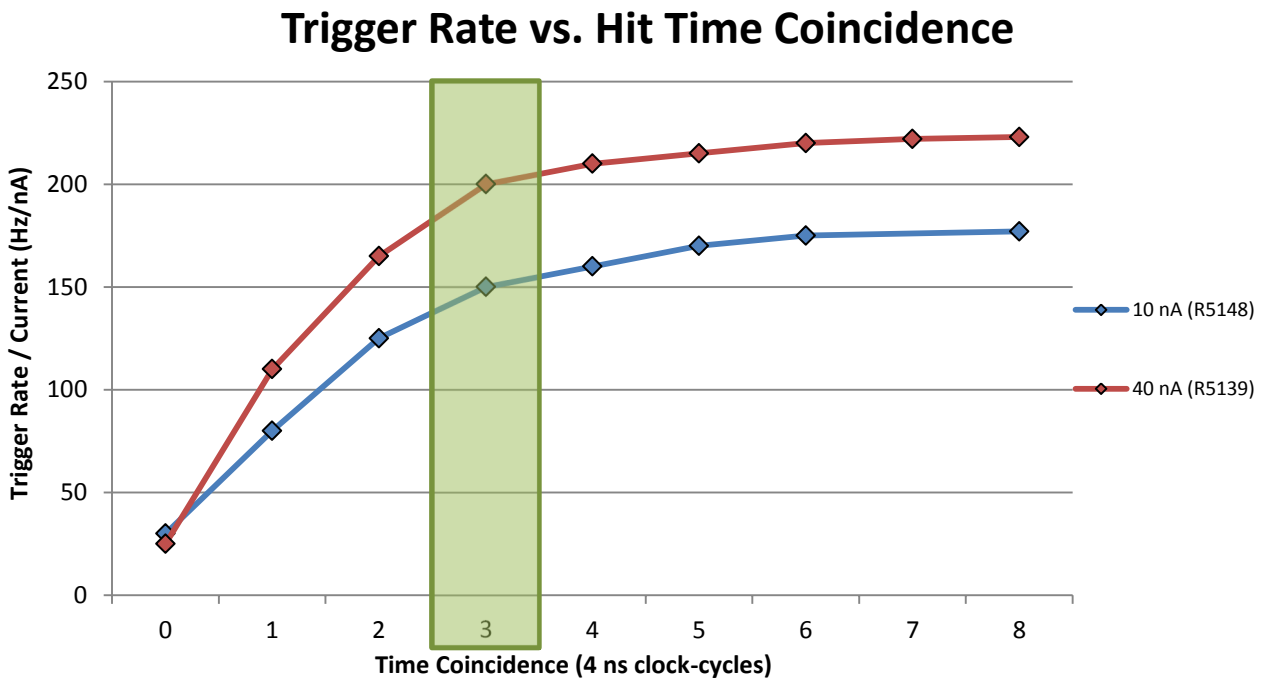


Example: the combination of all the snapshots produces a cluster with nine hits and a total energy of 3.04 GeV

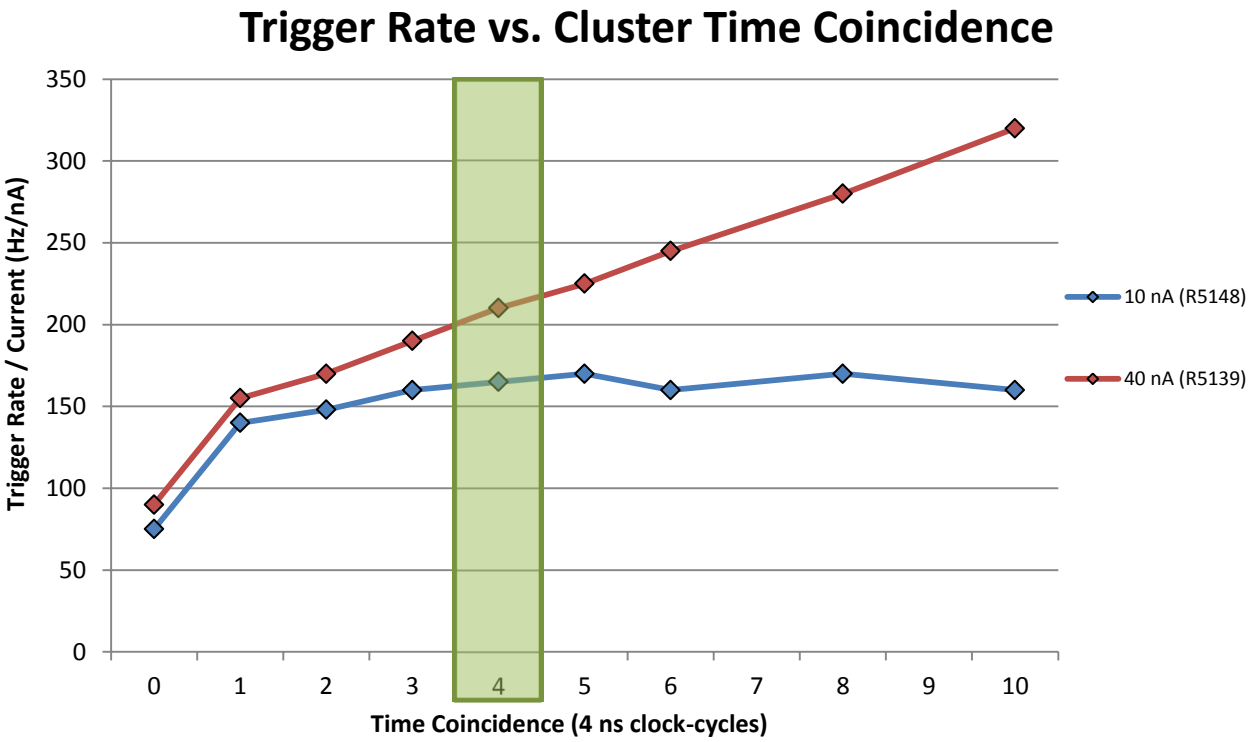
Trigger Settings and Rates

Parameter	**Singles 0**	**Singles 1**	**Pair 0**	**Pair 1**
E_{low}	0.060 GeV	0.400 GeV	0.054 GeV	0.054 GeV
E_{high}	2.500 GeV	1.100 GeV	1.100 GeV	0.630 GeV
$N_{\text{threshold}}$	3 hits	3 hits	1 hit	1 hit
$E_{\text{sum low}}$	—	—	0.120 GeV	0.180 GeV
$E_{\text{sum high}}$	—	—	2.000 GeV	0.860 GeV
$E_{\text{difference}}$	—	—	1.000 GeV	0.540 GeV
E_{slope}	—	—	—	0.600 GeV
F	—	—	—	0.0055 GeV
$\theta_{\text{coplanarity}}$	—	—	—	30°
$t_{\text{coincidence}}$	—	—	16 ns	12 ns
Prescale	2^{13}	2^{11}	2^{10}	2^{0}
Rate (50 nA)	0.4 Hz	1.3 kHz	0.7 kHz	16.6 kHz

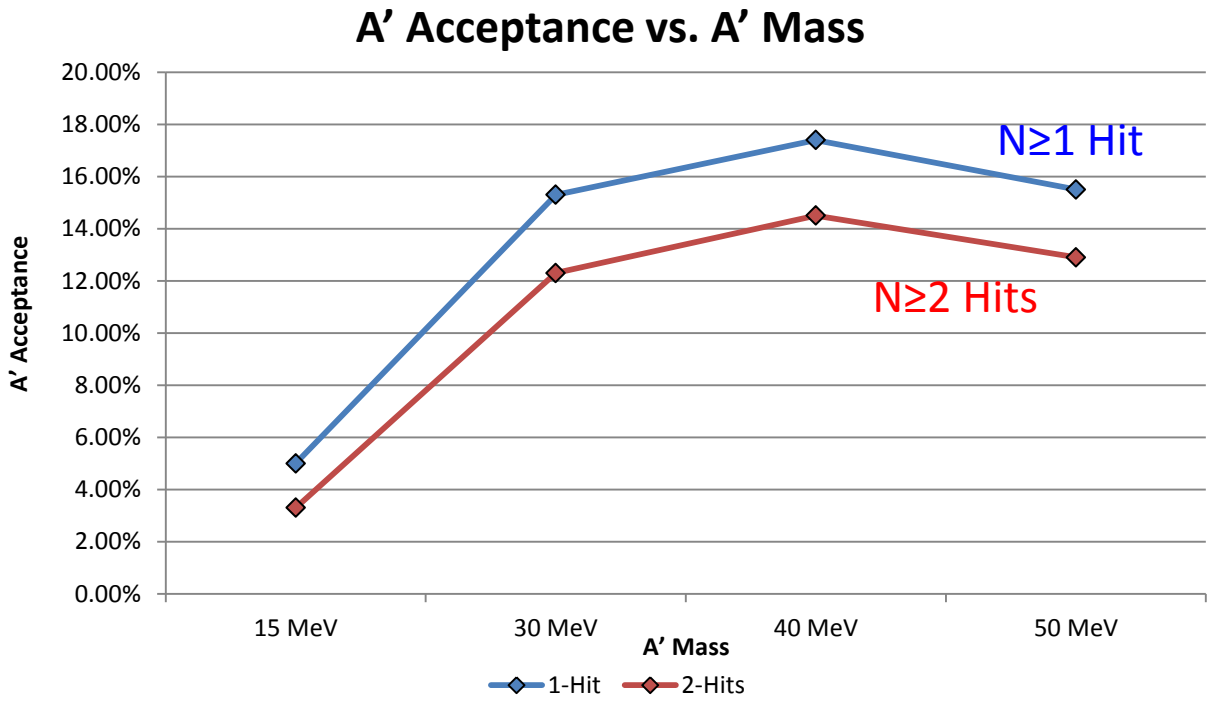
Cluster Timing



Cluster Time Coincidence



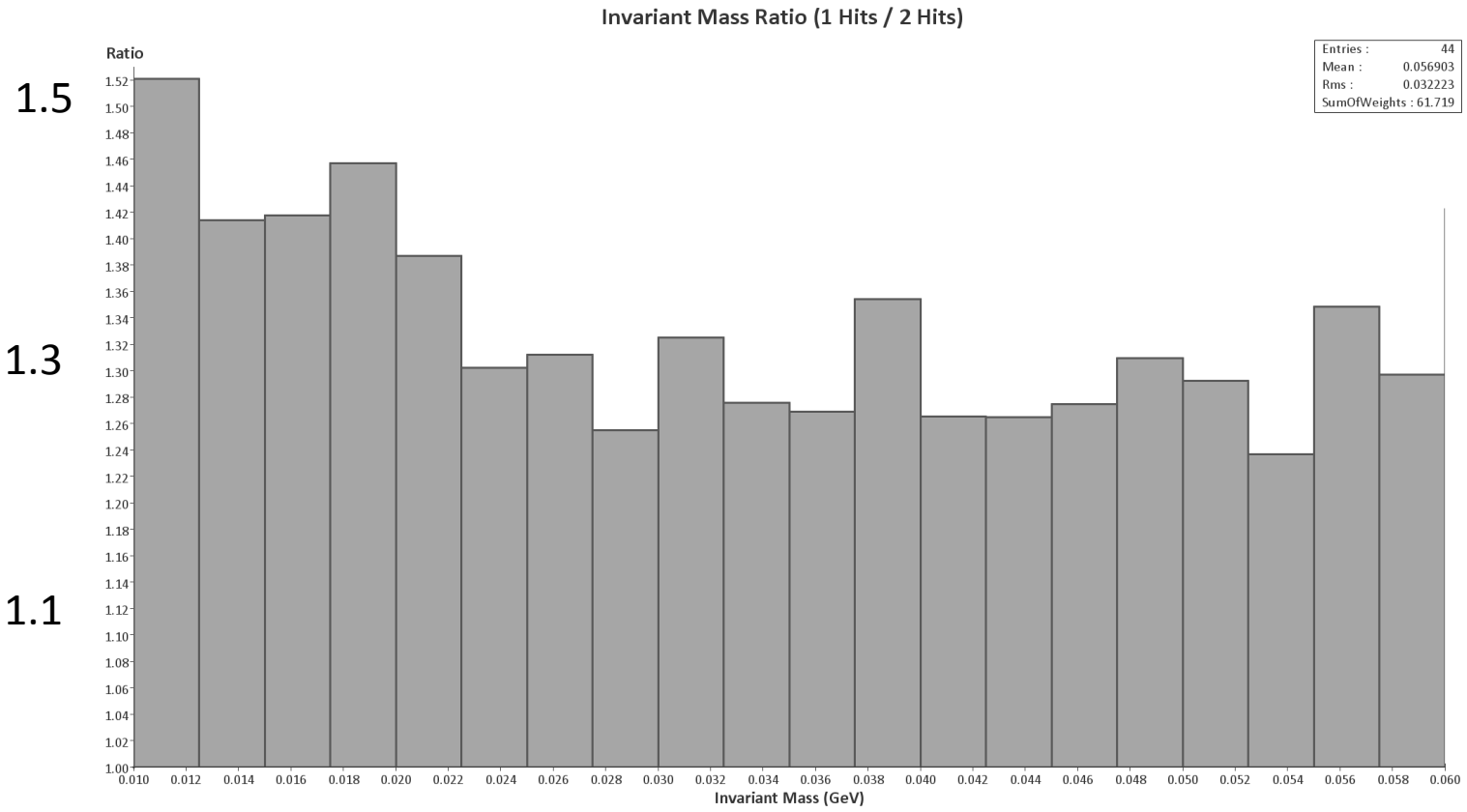
Nhits in Cluster



25-50% Acceptance increase

N≥1 / N≥2 Acceptance Ratio

Ratio



10 MeV 20 MeV 30 MeV 40 MeV 50 MeV

$M(e^+e^-)$

Trigger Diagnostics

- Simulate clusters
- Compare simulated clusters with hardware clusters stored in the SSP bank
  - Check number of hits
  - Energy
  - Time stamp
  - Calculate cluster reconstruction efficiency
- Simulate triggers
- Compare simulated with hardware triggers
  - Time stamp
  - Check every cut
  - Calculate trigger efficiency

Verification results

- Cluster finding efficiency 98.8%
- Single trigger efficiency 99.6%
- Pair trigger efficiency 99.7%

Careful investigation of the trigger demonstrated that trigger firmware performs as expected. Period.

Absolute trigger efficiency

- 6.2 M pulser events with 400 ns time window in mode 1 (full FADC information)
- It corresponds to 2.4 seconds of HPS operation
- Search for pair1 trigger
  - 3362 Hz based on FADC data
  - 3387 Hz based on SSP data
  - 3300 Hz from the trigger scalers

  Very good result. Inside the statistical accuracy.

HPS Trigger Upgrade

- ***Fix the bug in the firmware connected with the trigger latency issue***

  This bug did not affect the HPS data collection because shifters were instructed to check the trigger latency issue and restart runs manually in case of problems

  Ben promised to take a look where the issue is coming from. It will be definitely be done before the next run.

  It is the only known firmware bug for a moment.

- ***Prescale the single clusters based on the coordinates***

  This trigger will be used for the calibration.

  This firmware is already completed. Ben confirmed it works. We just need to add these options to the SSP trigger configuration files so that we are able to select this kind of configuration. This is a pretty easy change.

- ***Change the TI firmware*** to show the trigger decision independently of the prescale value (Maurik's request)
- ***Revisit "Pare 0" trigger***, adjust for Moller events.

Trigger documentation

- Nathan is working on the run trigger wiki.
- Kyle wrote 25 pages HPS note about the trigger performance during the 2015 run
- The note includes
  - Hardware Clustering Algorithm
  - HPS trigger definitions (singles, pairs etc)
  - Detailed description of the trigger parameters
  - Selecting the trigger cuts
  - Trigger rates
  - Trigger diagnostics
- This will be of use in future HPS general publications.

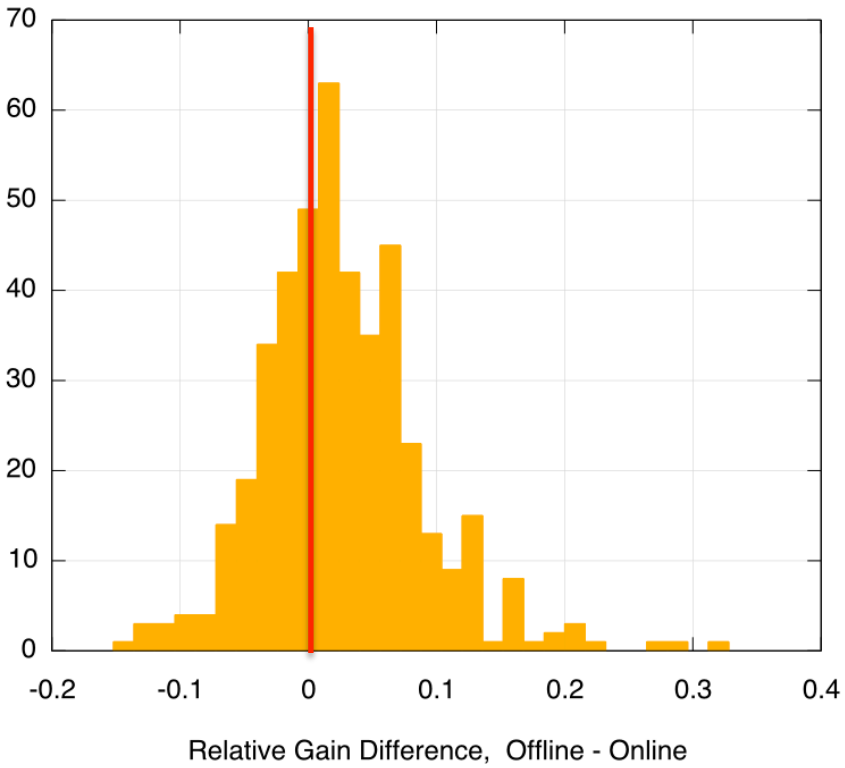
Implementation of Trigger Cuts in Data Analysis

- Calibration constants
- MC-Data discrepancy

Trigger cuts in the data analysis

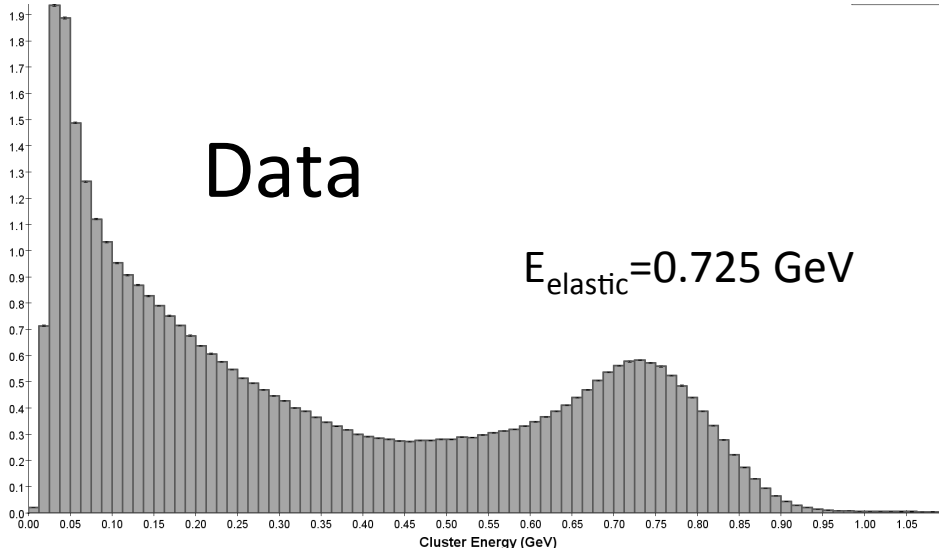
1. The EC calibration constants (gain) are changing with time. We have better calibration now than at time of data taking
2. The right way to apply the trigger cuts is to use the on-line calibration constants
3. It will account for the badly calibrated counters during data taking
4. Is it big effect? Look next slide

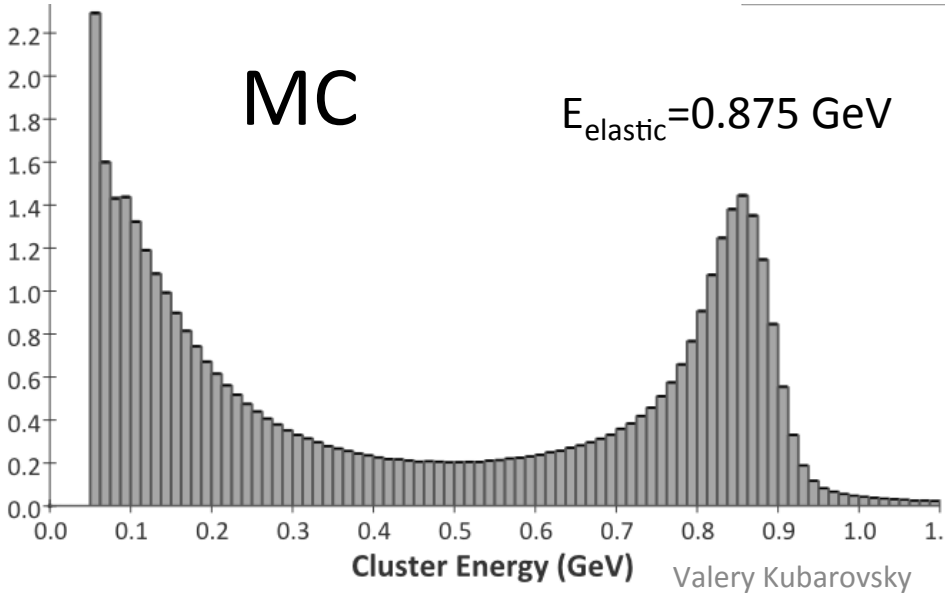
Calibration Constants Relative Difference (Now-May, 2015)



We took data with one set of Gains but simulate trigger with another set of parameters. That's not right.

MC-Data energy scale discrepancy





$$E_{Data} = 83\% E_{MC}$$

- The reason is unclear for a moment
- The trigger cuts are applied at this stage of analysis before the so called “sampling fraction ” corrections.
- Note: our calorimeter is homogeneous calorimeter and has no sampling corrections.

MC cuts adjustment

	Monte Carlo	Hardware
Hit Count	1	1
Seed Energy	$[60\ \text{MeV}, \infty)$	$[50\ \text{MeV}, \infty)$
Cluster Energy	65 MeV, 750 MeV	54 MeV, 630 MeV
Energy Sum	$[215\ \text{MeV}, 1{,}025\ \text{MeV}]$	$[180\ \text{MeV}, 860\ \text{MeV}]$
Energy Difference	$[0\ \text{MeV}, 650\ \text{MeV}]$	$[0\ \text{MeV}, 540\ \text{MeV}]$
Energy Slope	$[725\ \text{MeV}, \infty)$	$[600\ \text{MeV}, \infty)$
Coplanarity	$[30°, \infty)$	$[30°, \infty)$
Hit Coincidence	± 16 ns	± 16 ns
Pair Time Coincidence	± 12 ns	± 12 ns

Another way to account for the MC-Data discrepancy is to use different trigger cuts for data and MC.

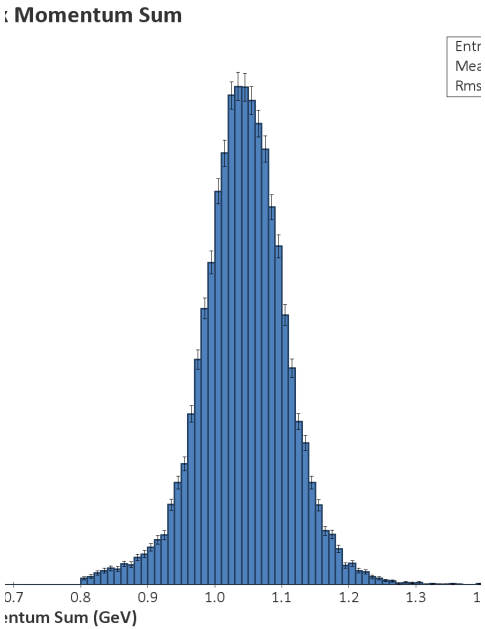
Conclusion

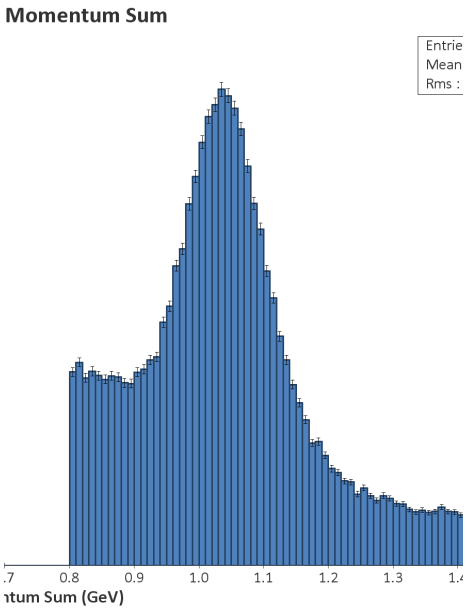
- Trigger is working as expected
- Trigger update will be done before the next run
- Trigger documentation is 95% ready
- There are some issues in the implementation of trigger cuts in data analysis. May affect the cross section evaluation. Needs to be investigated on more details.

Trigger Settings and Rates

Parameter	**Singles 0**	**Singles 1**	**Pair 0**	**Pair 1**
E_{low}	0.060 GeV	0.400 GeV	0.054 GeV	0.054 GeV
E_{high}	2.500 GeV	1.100 GeV	1.100 GeV	0.630 GeV
$N_{\text{threshold}}$	3 hits	3 hits	1 hit	1 hit
$E_{\text{sum low}}$	—	—	0.120 GeV	0.180 GeV
$E_{\text{sum high}}$	—	—	2.000 GeV	0.860 GeV
$E_{\text{difference}}$	—	—	1.000 GeV	0.540 GeV
E_{slope}	—	—	—	0.600 GeV
F	—	—	—	0.0055 GeV
$\theta_{\text{coplanarity}}$	—	—	—	30°
$t_{\text{coincidence}}$	—	—	16 ns	12 ns
Prescale	2^{13}	2^{11}	2^{10}	2^{0}
Rate (50 nA)	0.4 Hz	1.3 kHz	0.7 kHz	16.6 kHz

MC-Data elastic peak





- SVT momentum for MC(left) and Data(right).
- The position of the peak is in the right place