Physics triggers and the trigger commissioning plan

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HPS Meeting

HPS-2019 Trigger List

- Calibration triggers
- Single cluster triggers
- Pair triggers
- ECAL cluster multiplicity trigger

HPS-2019: Calibration Triggers

- Cosmic trigger
- LED trigger
- Pulser trigger: frequency 0 to 125 MHz
- Hodoscope only trigger
  - Hodoscope hits on top, bottom or both.
  - Will be used to test singles trigger efficiency (ECAL only, positron side).

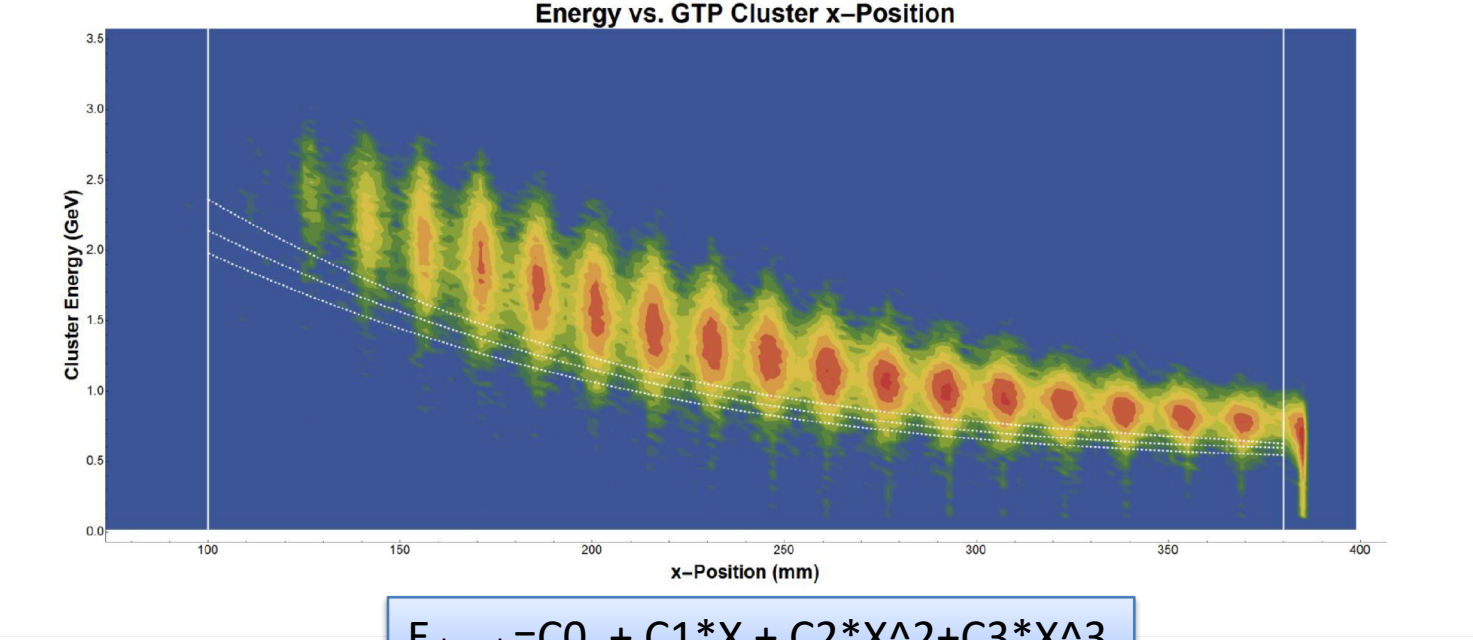
HPS-2019: Single Cluster Trigger

- 4 independent decisions for top
- 4 independent decisions for bottom
- ECAL trigger parameters
  - Min/Max cluster energy
  - Number of hits in the cluster
  - Minimum cluster X-coordinate (-31,31)
  - Cluster position dependent energy cut
    - E_{thresh}=C0 + C1*X + C2*X^2+C3*X^3
- Hodoscope
  - Hit in layer 1
  - Hit in layer 2
  - Hits in layer1 and 2 with geometry matching
  - Hits in layer1 and 2 with cluster X geometry matching

Single Cluster Trigger

- A’ positron trigger with hodoscope
- Elastic scattering trigger
- Trigger with low cluster energy (highly prescaled) to test trigger firmware

Energy vs. Cluster X-position



E_{thresh}=C0 + C1*X + C2*X^2+C3*X^3

- This is the main A' trigger cut in 2019 run
- The picture has to be redone with the A' MC simulation data

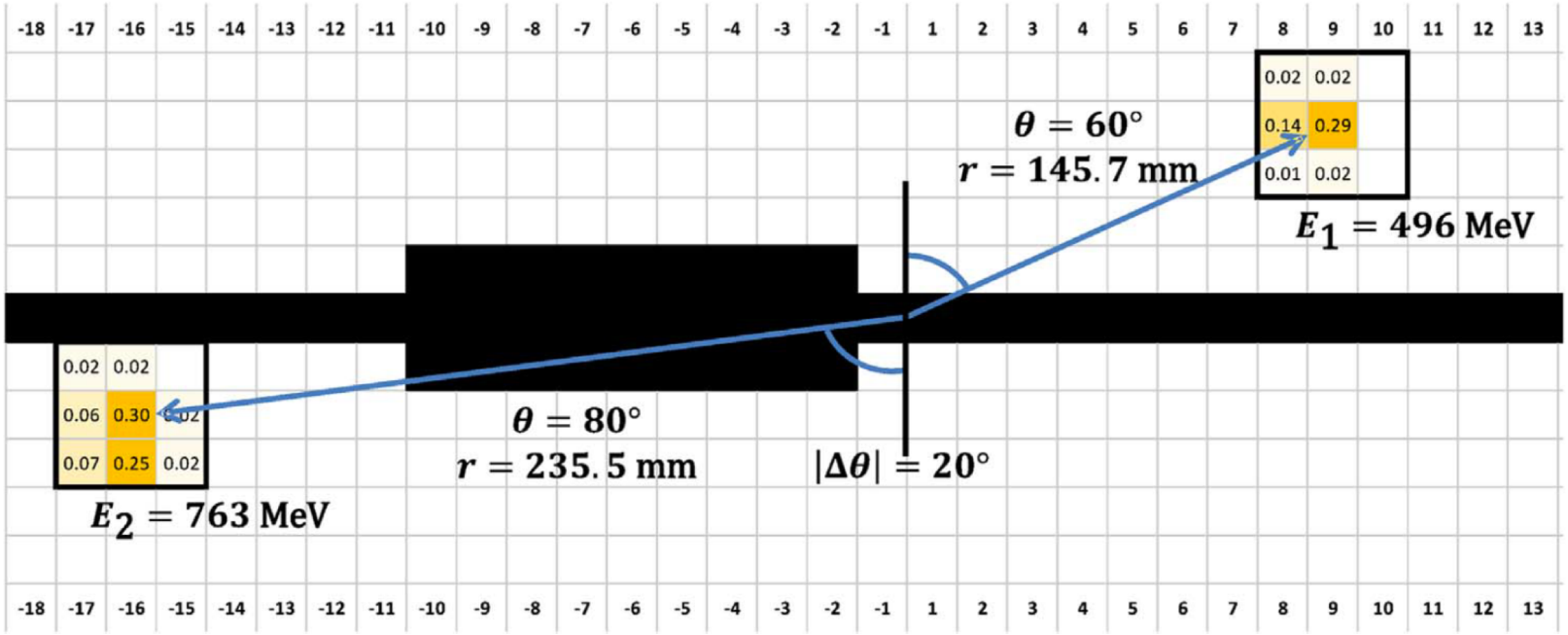
HPS-2019: Pair Trigger

- 4 independent decisions
- Very much similar to HPS-2016 trigger except the number of the possible decisions.

HPS-2016 Trigger

Single Trigger 0	One low energy cluster (>0.1 GeV)	Test trigger logic
Single Trigger 1	One Cluster 1.3-2.6 GeV	Elastic scattering
Pair Trigger 0	Two clusters 0.15-1.4 GeV	Moller scattering
Pair Trigger 1	Two clusters 0.15-1.4 GeV	A' trigger
Random trigger		
Cosmic Trigger		

Pair Trigger



2.3 GeV Trigger Settings

Parameter	Single 0 Loose Trigger	Single 1 Elastic	Pair 0 Moller	Pair 1 A’
Elow	200	1300	150	150 MeV
Ehigh	2700	2600	1400	1400 MeV
Nhits	>=3	>=3	>=2	>=2
Esum low	--	--	500	600 MeV
Esum high	--	--	1900	2000 MeV
Edifference	--	--	1100	1100 MeV
Complanarity	--	--	--	$<40^0$
Energy slope	--	--	400	600 MeV
Prescale	2^{13}	2^{11}	2^2	2^0
Rate (200 nA)	2500 kHz	810 kHz	24 kHz	14 kHz
After prescale	0.3 kHz	0.4 kHz	6 kHz	14 kHz

HPS-2019: Multiplicity Trigger

- ECAL trigger only
- Only one trigger decision for a moment
- Min/Max cluster energy
- Minimum number of hits in the cluster
- Coincidence time window Δt
- Nclusters_Top >= Ntop
- Nclusters_Bot >= Nbot
- Nclusters_Top+Nclusters_Bot >= Ntot
- May be used to select 2 or 3 clusters events

HPS Trigger Scalers

Beam Current, Live Time

Single triggers - Top

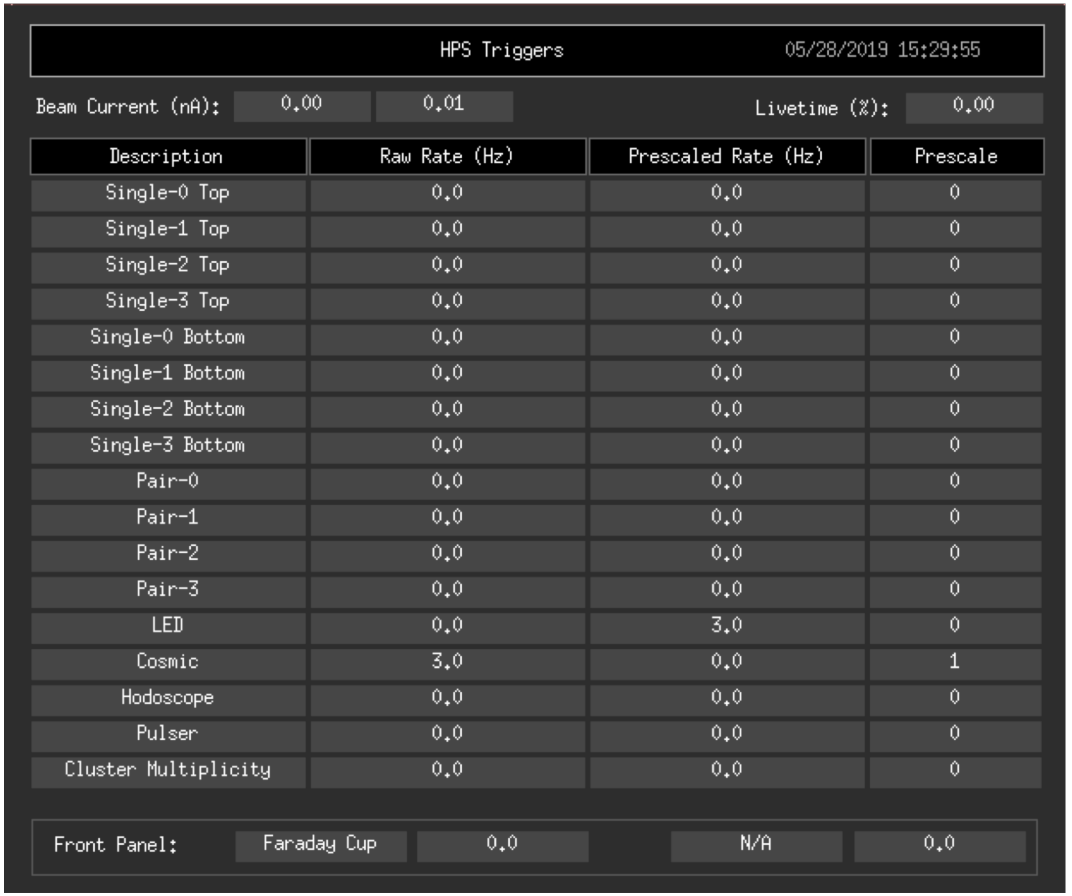
Single triggers - Bottom

Pair triggers

Calibration triggers

Multiplicity triggers

Faraday Cup, Random



HPS Triggers 05/28/2019 15:29:55

Beam Current (nA): 0.00 0.01 Livetime (%): 0.00

Description	Raw Rate (Hz)	Prescaled Rate (Hz)	Prescale
Single-0 Top	0.0	0.0	0
Single-1 Top	0.0	0.0	0
Single-2 Top	0.0	0.0	0
Single-3 Top	0.0	0.0	0
Single-0 Bottom	0.0	0.0	0
Single-1 Bottom	0.0	0.0	0
Single-2 Bottom	0.0	0.0	0
Single-3 Bottom	0.0	0.0	0
Pair-0	0.0	0.0	0
Pair-1	0.0	0.0	0
Pair-2	0.0	0.0	0
Pair-3	0.0	0.0	0
LED	0.0	3.0	0
Cosmic	3.0	0.0	1
Hodoscope	0.0	0.0	0
Pulser	0.0	0.0	0
Cluster Multiplicity	0.0	0.0	0

Front Panel: Faraday Cup 0.0 N/A 0.0

Trigger Commissioning

- Random trigger run @ max current
  - 30-40 kHz trigger rate
  - Reconstruct and select events of interest, singles and pair
  - Check the trigger decision for particular trigger
  - Estimate trigger efficiency
  - Works very well for the CLAS12 trigger study
- One cluster with low threshold trigger runs
  - Keep the trigger rate at the level of 20-30 kHz
  - Significantly improve the statistics for the trigger study
  - Help with the commissioning of our main triggers
  - 2-3 hours of data taking will be enough for the commissioning
- Hodoscope only trigger
  - Test the single calorimeter trigger from positron side
- Test all trigger decisions during data taking as we did before.

Test of the trigger performance

- Comparison between trigger firmware decision and simulated trigger based on the FADC information for all types of triggers
- Cluster verification
  - Energy of the cluster
  - Number of hits in the cluster
  - Hit’s timing
- Trigger verification
  - Test each cut in the triggers
  - Cluster timing

What do we need?

- MC for all reactions that we want to take.
- Full of-line reconstruction software. It has to be ready by day one
- We will take trigger commissioning runs as soon as detectors will be in a reasonably good shape
- Trigger commissioning software

Conclusion

- Trigger hardware is ready
- Trigger decomposition is still under discussion
  - One cluster trigger
    - A’ positron trigger for top and bottom
    - Trigger with low threshold for the trigger logics test
    - Elastic scattering
    - Moller ?
  - Pair trigger
    - A’
    - π^0
  - Three clusters trigger
- We urgently need MC for A’, elastic, Moller…

2015 Trigger Settings
E_{beam}=1.06 GeV

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

2016 Trigger Setting
E_{beam}=2.3 GeV

Table 1
All trigger settings for the Single-0, Single-1, Pair-0 and Pair-1 triggers for the run with beam energy 2.3 GeV. Note that energies are not corrected for shower leakage at the trigger stage. The purpose of the different triggers is described in the text.

Parameter	Single-0	Single-1	Pair-0	Pair-1
E_{min}	0.100 GeV	1.300 GeV	0.150 GeV	0.150 GeV
E_{max}	2.700 GeV	2.600 GeV	1.400 GeV	1.400 GeV
$N_{threshold}$	3 hits	3 hits	2 hits	2 hits
E_{summin}	—	—	0.500 GeV	0.600 GeV
E_{summax}	—	—	1.900 GeV	2.000 GeV
$E_{difference}$	—	—	1.100 GeV	1.100 GeV
E_{slope}	—	—	0.400 GeV	0.600 GeV
F	—	—	0.0055 GeV/mm	0.0055 GeV/mm
$\theta_{coplanarity}$	—	—	—	40°
$t_{coincidence}$	—	—	8 ns	12 ns
Prescale	$2^{12} + 1$	$2^{10} + 1$	$2^5 + 1$	1