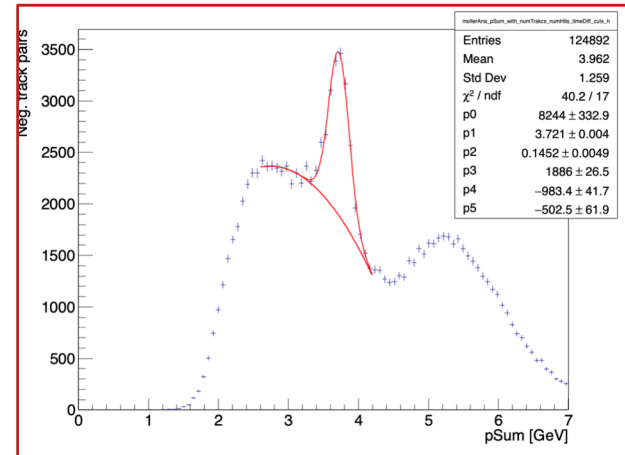


## 2021 HPS Trigger

Valery Kubarovsky  
Jefferson Lab

November 15, 2021



# HPS 2021 Triggers

3.7 GeV and 1.9 GeV

Two beam energies suggest MonteCarlo simulation for all HPS processes under study

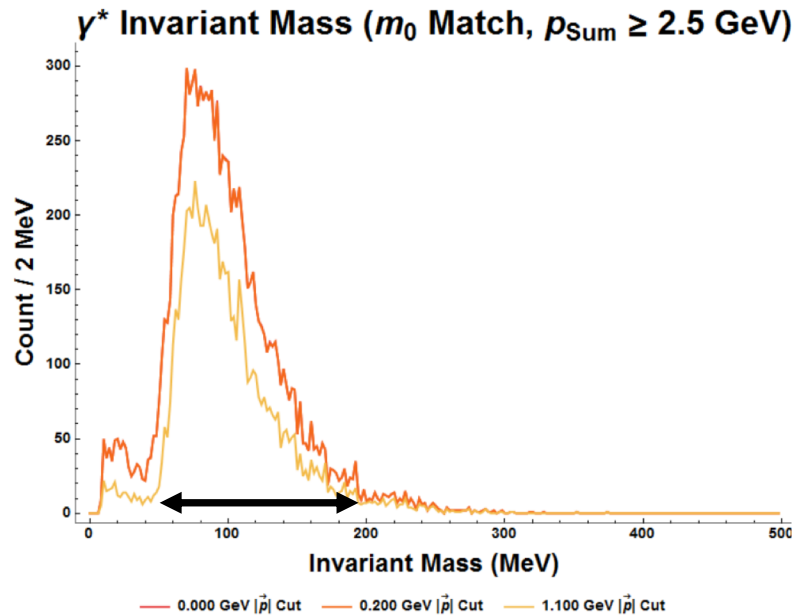
- Positron Trigger (with/without Hodoscope) for  $A'$  search, used in 2019
- Pair trigger for  $A'$  search, used in 2015 and 2016
- Elastic electron scattering, so called Full Energy Electron trigger, to study the energy calibration
- Moller Trigger for the invariant mass resolution study
- Muon Trigger

# What was done

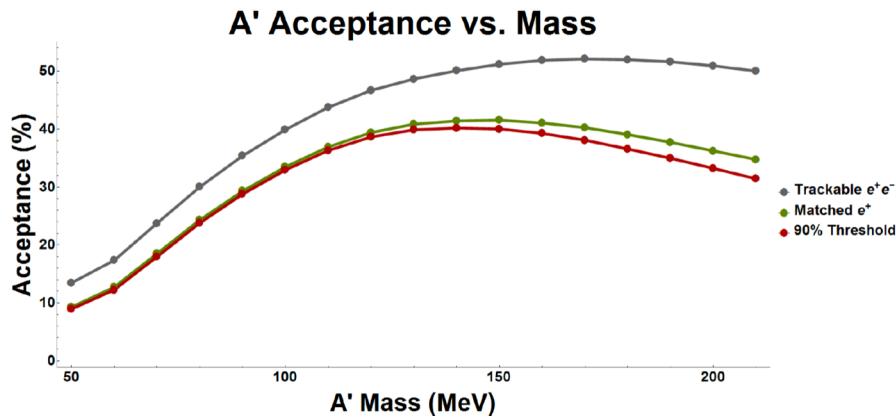
---

- Tongtong produced MC for 3.7 and 1.92 GeV
  - Pure radiative tridents
  - $A'$  with different masses in the range 50-210 MeV
  - Pure Moller sample
  - Tritrig-WAB-beam
  - Moller-WAB-beam
- Tongtong developed a complete set of codes in HPS analysis platform to tune various triggers for HPS 2021 run, including  $A'$  pair triggers, FEE and Moller. This code was used to extract trigger conditions for 3.7 GeV and 1.92 GeV beam energy
- Sam is tuning trigger conditions using his own code
- Comparison shows that the results of two independent analysis generally consistent with each other.

# $e^+e^-$ Invariant mass and acceptance

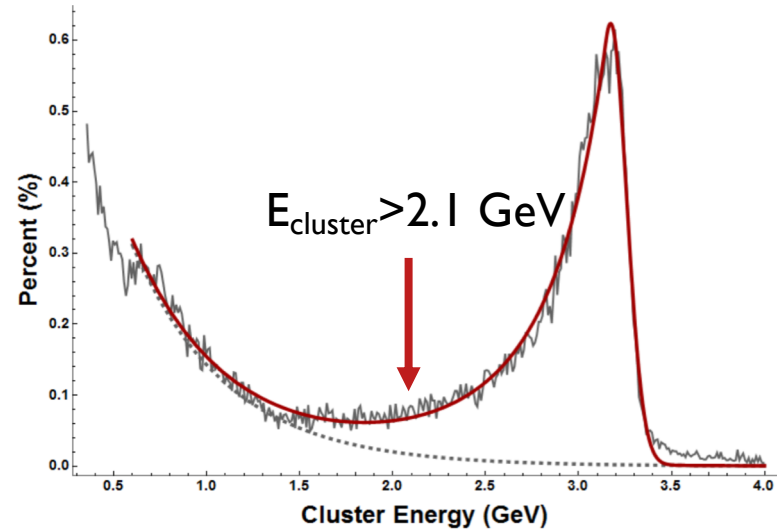


- The  $A'$  cross section is proportional to the radiative trident production
- 2021 HPS run will be sensitive to the mass range 50-200 MeV
- This interval determines the study of the HPS trigger for upcoming run
- The HPS acceptance is pretty flat for the  $A'$  mass  $> 100$  MeV

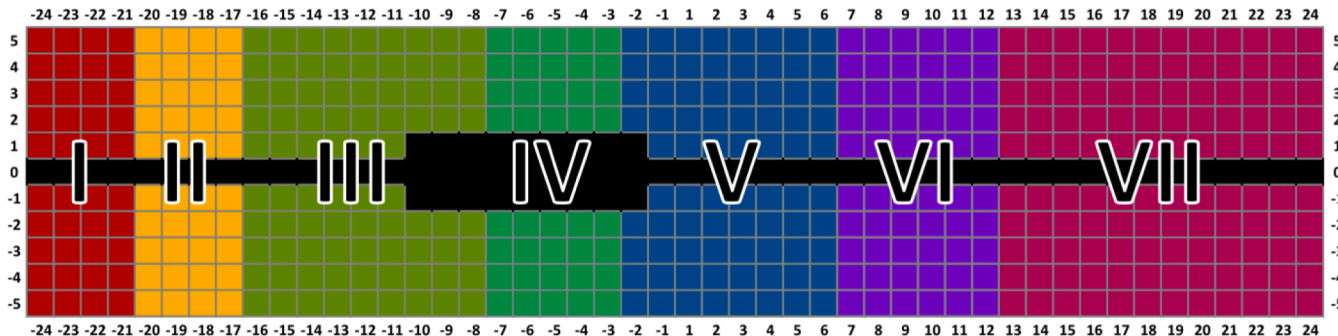


# Elastic electron scattering: FEE trigger

- Elastic scattering cuts
  - $E_{\text{cluster}} > 2.1$  GeV
  - $N_{\text{hits per cluster}} > 2$
  - New prescale regions suggested



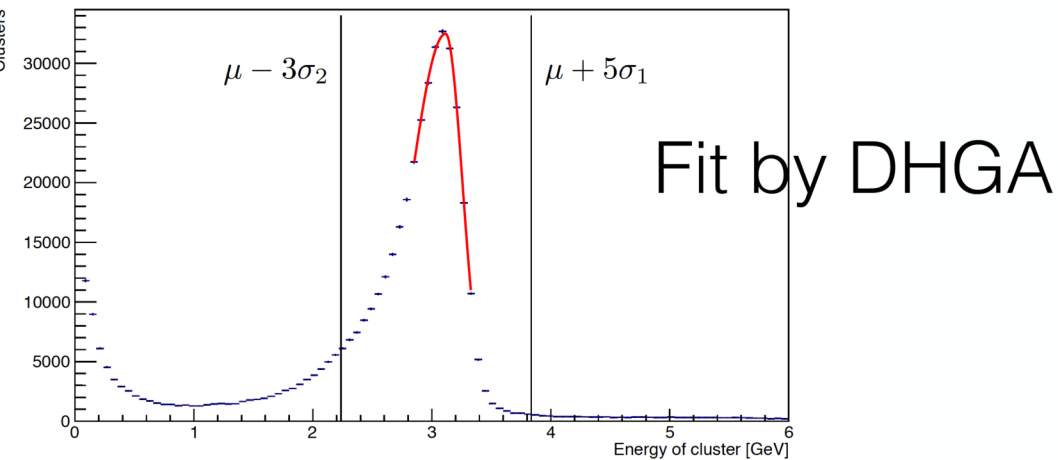
Prescale regions  
2021 version



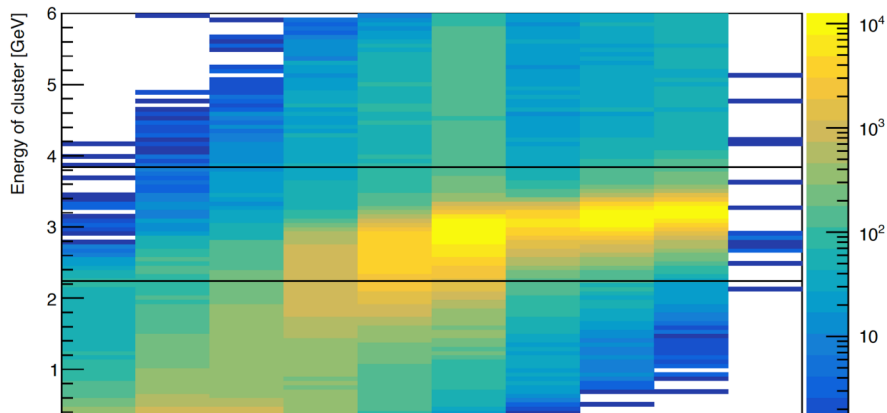
Region	Prescale
I	I
II	9
II	129
IV	1025
V	513
VI	13
VII	I

# FEE Cuts for FEE (Tongtong)

triggerParameterExtractionAna\_energy\_cluster\_analyzable\_h



triggerParameterExtractionAna\_energy\_vs\_n\_hits\_cluster\_analyzable\_hh

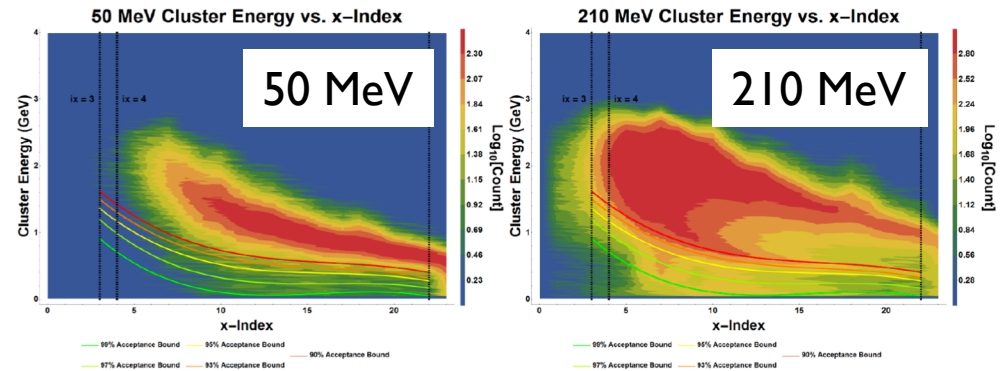


Suggested Cuts for FEE Triggers with Requirement of Track Association

- Cluster energy: [2.24, 3.84] GeV
- NHits:  $\geq 4$

# A' Position Dependent Energy Cut (DPEc)

- 4 different versions to choose from
  - 99% acceptance
  - 97% acceptance
  - 95% acceptance
  - 93% acceptance
- Trident events and A' events with masses 50-210 MeV were used for the tuning PDEC
- Beam energy dependent



Parameter	90%	93%	95%	97%	99%
$p_0$	2.394022	2.264997	2.137665	2.025302	1.738096
$p_1$	-0.309924	-0.306223	-0.311977	-0.336346	-0.339251
$p_2$	0.018050	0.018015	0.018942	0.020893	0.022323
$p_3$	-0.000367	-0.000369	-0.000392	-0.000429	-0.000472

$$E_{cluster} > C_0 + C_1x + C_2x^2 + C_3x^3$$

$$x_{cluster} > x_{min}$$

$C_i, x_{min}$  are trigger parameters

# A' Positron Trigger parameters

Cluster Energy: [0.3,2.7]

Nhits  $\geq 2$

Xmin=5

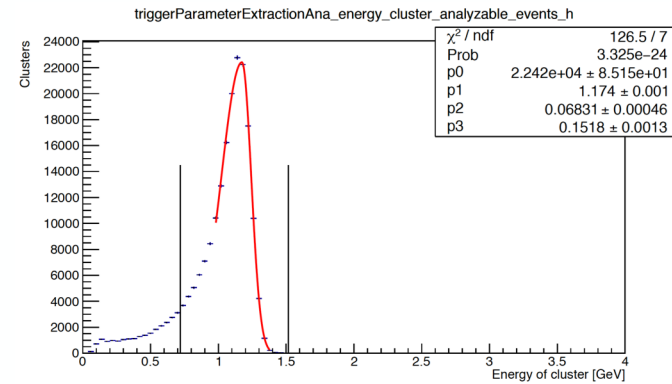
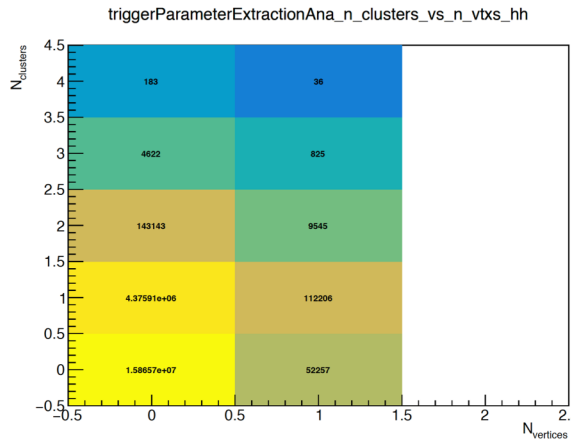
PDE from rad

- PDE from rad

3rd pol.	C0 [GeV]	C1 [GeV]	C2 [GeV]	C3 [GeV]
93%	1.91675	-0.146853	0.00477729	-5.086E-05
95%	1.80138	-0.14849	0.00524208	-6.20168E-05
97%	1.42235	-0.107099	0.00311637	-2.22483E-05
99%	0.805655	-0.0701922	0.00263551	-3.46273E-05



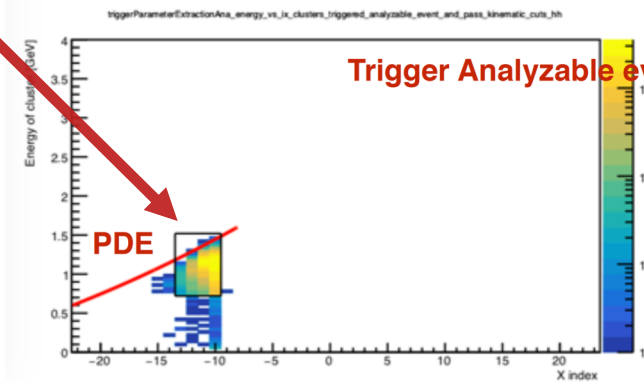
# Moller Trigger



Moller

Moller

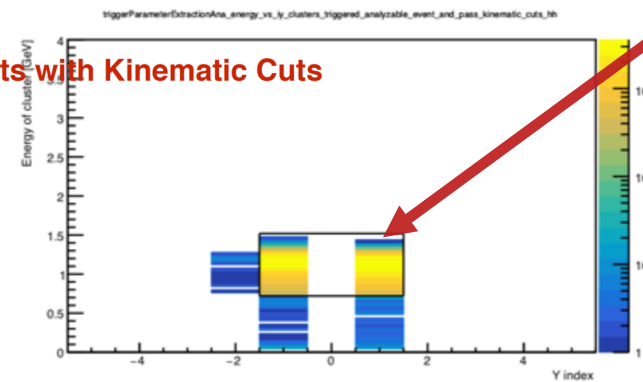
ECAL Energy



Trigger Analyzable events with Kinematic Cuts

PDE

X index



Y index

# Moller: study of the PDE cut

## Moller trigger study

Lognumber 3901607. Submitted by vpk on Mon, 09/06/2021 - 11:25.

Logbooks: HBLOG

Entry Makers: vpk

Moller trigger study

<https://logbooks.jlab.org/entry/3901580>

Rates at 155 nA beam current and 8um target.

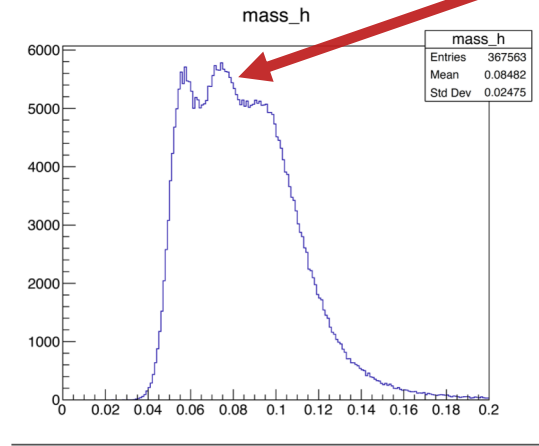
Cluster energy 660-1410:_____	361310 Hz.
Add iX=(-13,-10)_____	110925 Hz..... 1.000
Add 4 sigma PDE cut_____	109041 Hz..... 0.983
Add 3 sigma PDE cut_____	106285 Hz..... 0.958

X=(-13,-10) gives a good suppression factor =3.25 in comparison with only cluster energy cut.  
The PDE (position dependent energy cut) even with 3 sigma decreases rate only by 4%.  
I suggest to take this cut out.

# Moller 3.7 GeV

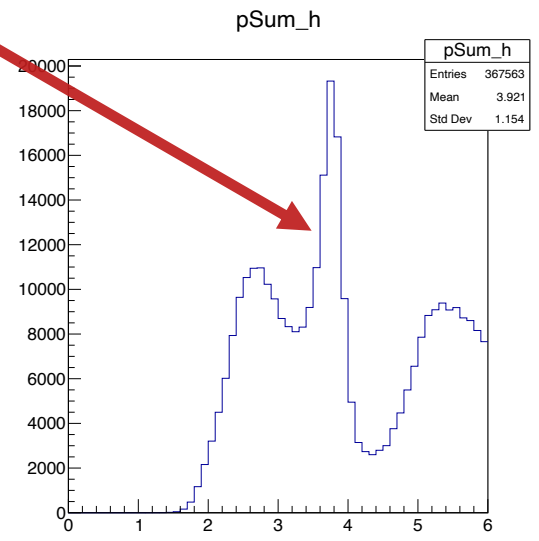
## e-e- Invariant mass

Moller



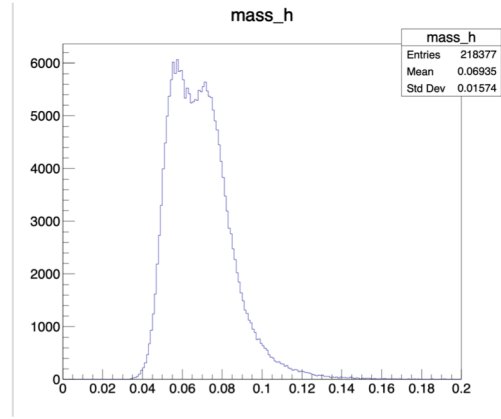
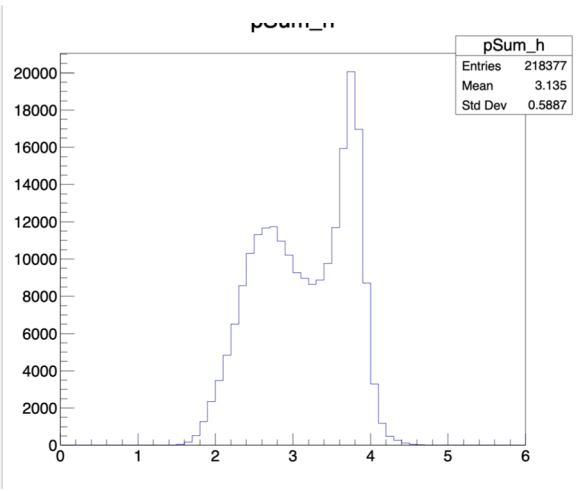
## Momentum Sum

Moller



No cuts

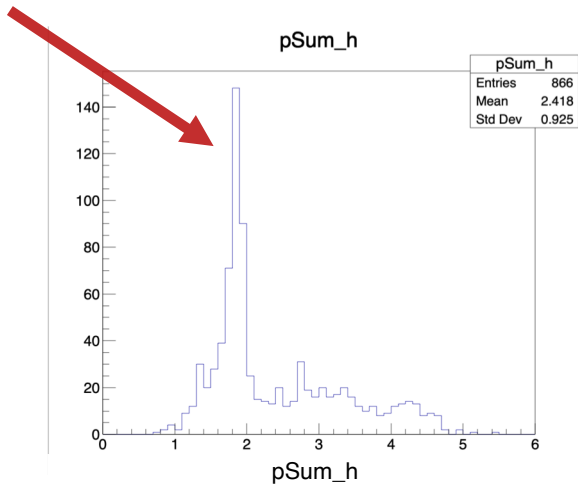
With FEE cut



# Moller 1.9 GeV

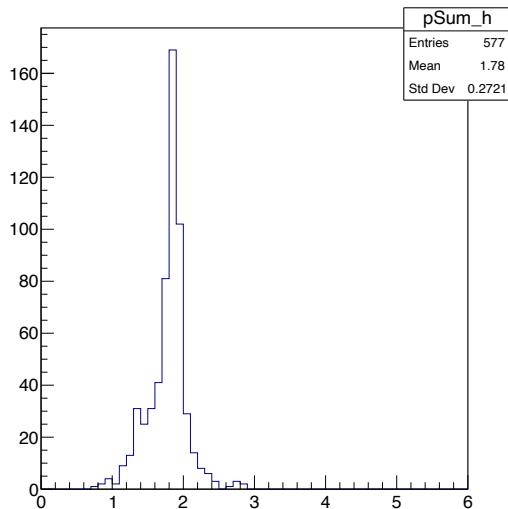
## Momentum Sum

Moller



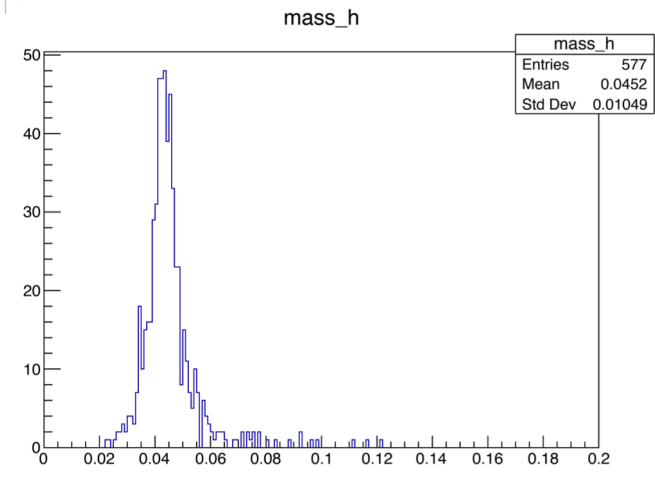
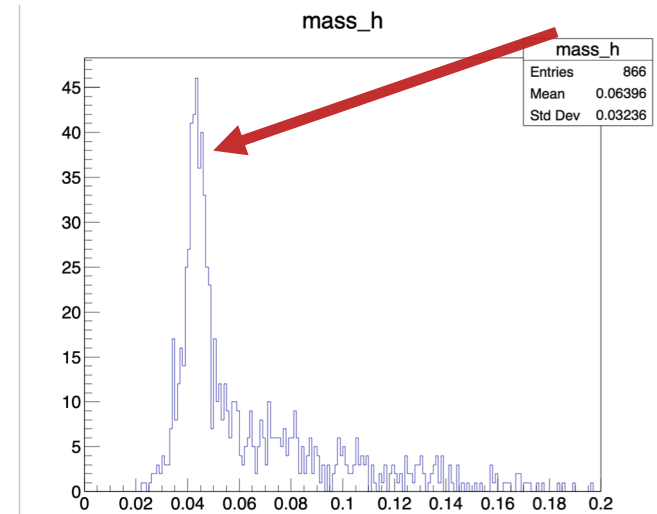
No cuts

With FEE cut

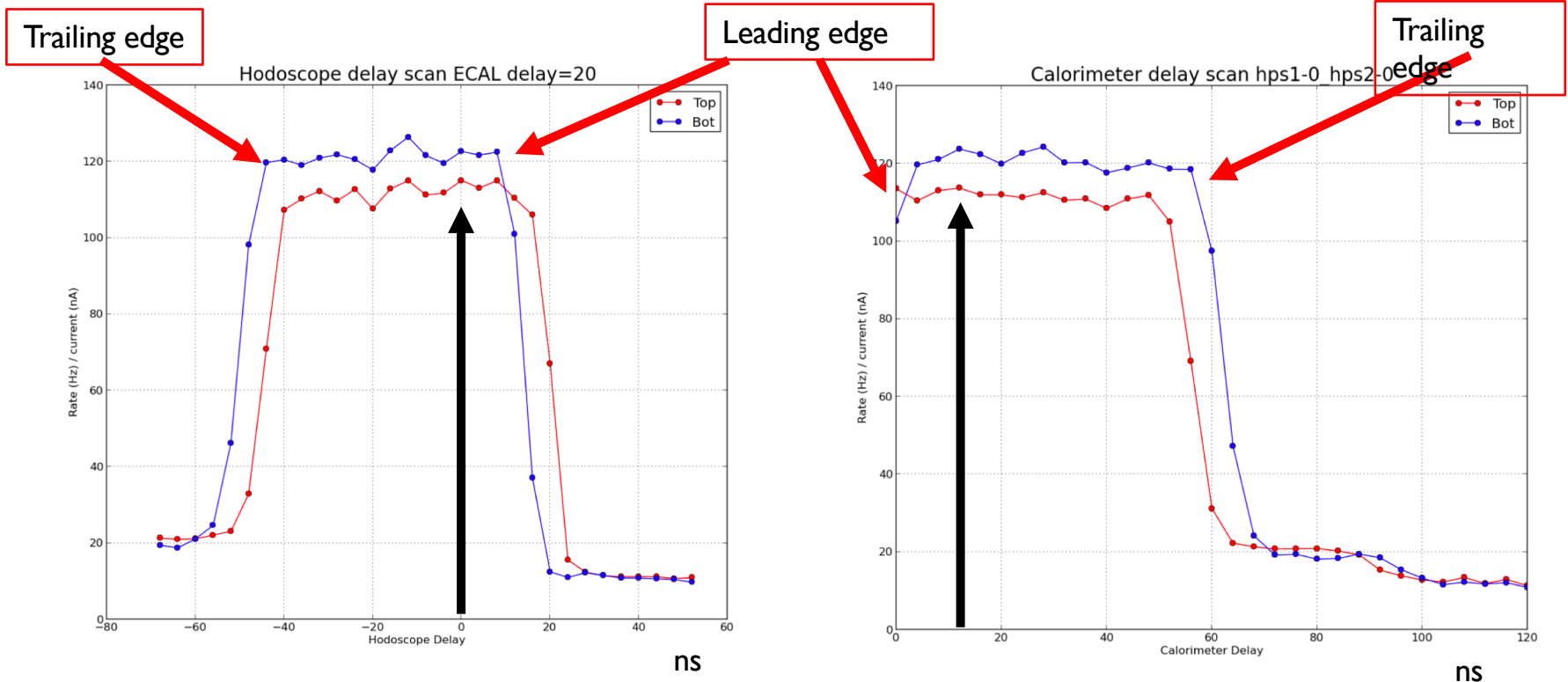


## e+e- Invariant mass

Moller



# Hodoscope and Calorimeter Trigger delays



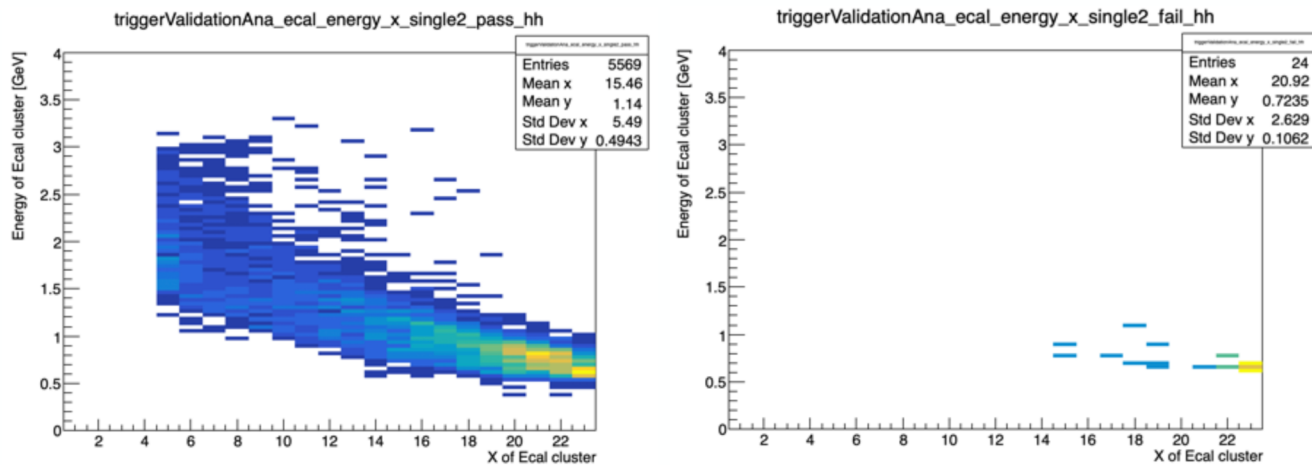
Arrows indicate position of the calorimeter delay in respect with the hodoscope signal in production runs

# Trigger Commissioning Plan

1. Test the Moller trigger
  - Test the trigger cuts of the Moller trigger
  - DAQ: PROD77\_NOSVT
  - Trigger file: [moller\\_test.trg](#)
  - Target 8 um
  - Beam current 300 nA
  - 5 minutes with beam. Record the trigger GUI!
2. Hodoscope only trigger
  - Test the single calorimeter trigger from positron side
  - DAQ: PROD77\_NOSVT
  - Trigger file: [hps2021\\_ValidatePDE\\_V0.trg](#)
  - Target 8 um
  - Beam current 300 nA
  - Number of events 100M (around one our beam time)
  - Record the trigger GUI
3. Calorimeter only trigger
  - Test the production trigger logics: ECAL and Hodo
  - DAQ: PROD77\_NOSVT
  - Trigger file: [hps2021\\_Validate\\_Prod.trg](#)
  - Target 8 um
  - Beam current 300 nA
  - Number of events 100M (around one our beam time)
  - Record the trigger GUI
4. Random trigger @ max current
  - Determine the absolute trigger efficiency
  - DAQ: PROD77
  - Trigger file: [hps2021\\_v2\\_1\\_30kHz\\_random.](#)
  - Production current
  - Production target
  - Take data when the SVT will be completely ready
  - 4 hours of **BEAM TIME**
  - Record the trigger GUI

# Trigger Validation

## Efficiency for Single2

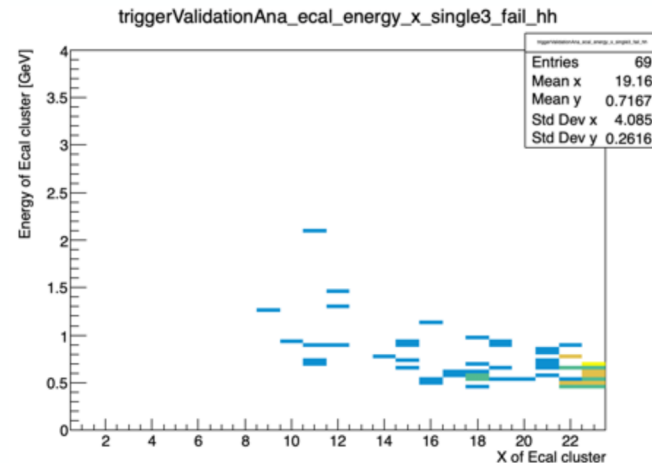
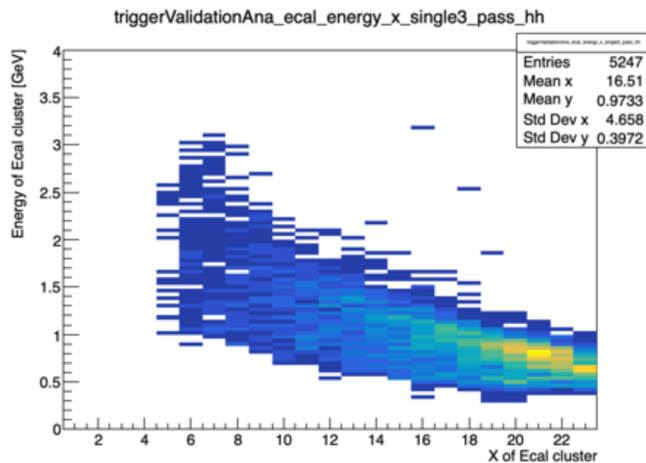


Efficiency = 99.6%

Most of failed cases are located at the edge of Ecal.

# Trigger Validation

## Efficiency for Single3



Efficiency = 98.7%

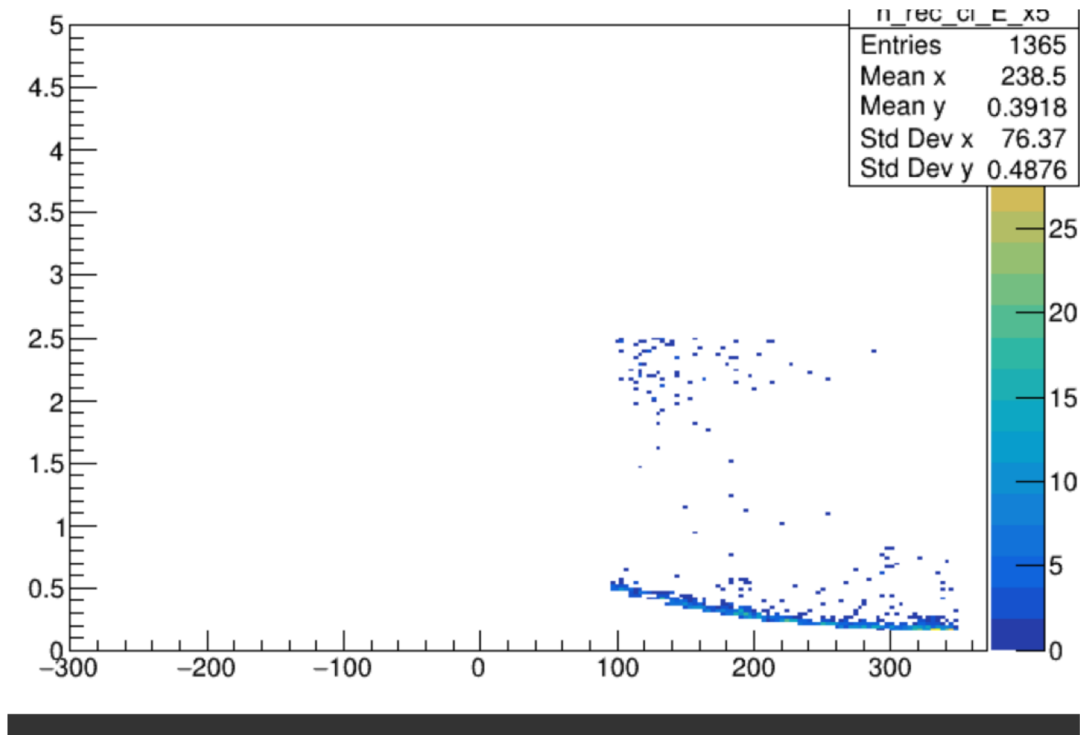
Most of failed cases are located at the edge of Ecal.



# Trigger Validation: Single 2

Hodoscope only trigger.

Efficiency(single2, positron without hodoscope) >98.5%



Rafo

# 2021 HPS Trigger Zoo

- Moller 1 cluster trigger (top, bottom)
- Positron trigger
  - 2 tops
  - 2 bottoms
- Pairs (top+bottom)
  - old 2016 trigger
  - Moller
  - 2 gamma
  - Muon trigger
- 2 gammas (anywhere in the calorimeter)
- 3 gammas (anywhere in the calorimeter)
- FEE
  - Top
  - Bottom
- Special triggers
  - Pulser
  - Hodoscope
  - Cosmic
  - LED
  - Faraday Cup

Removed

Run#4486 Target:20 um W HPS Triggers  10/06/2021 09:37:01

Beam Currents (nA) 2C21 125.32 FCup 119.59

Trigger:hps2021\_v2\_3.cnf Event Rate 3.09e+04 Data Rate (MB/s) 1.03e+02 Lifetime (%) 84.10

Total Events 5.55e+07 Total Data (MB) 7.26e+05

#	Description	Raw Rate (Hz)	Prescaled Rate (Hz)	%	Prescale
00	Single-0 Top	2525191.0	109.0	0.2	20000
01	Moller Top	228608.0	455.0	0.8	500
02	Single-2 Top (e+)	13377.0	13457.0	23.2	1
03	Single-3 Top (e+/Hodo)	13967.0	13989.0	24.1	1
04	Single-0 Bottom	2941446.0	125.0	0.2	20000
05	Moller Bottom	262416.0	521.0	0.9	500
06	Single-2 Bottom (e+)	14110.0	13997.0	24.1	1
07	Single-3 Bottom (e+/Hodo)	13706.0	13657.0	23.5	1
08	Pair-0 (Old e+e-)	27265.0	261.0	0.4	100
09		134963.0	0.0	0.0	0
10		121854.0	0.0	0.0	0
11	Pair-3 (mu+mu-)	780.0	718.0	1.2	1
12	LED	0.0	0.0	0.0	0
13	Cosmic	0.0	0.0	0.0	0
14	Hodoscope	4036045.0	0.0	0.0	0
15	Pulser	100.0	101.0	0.2	1
16		250225.0	0.0	0.0	0
17		13413.0	0.0	0.0	0
18	FEE Top	344.0	361.0	0.6	1
19	FEE Bottom	360.0	348.0	0.6	1
Sum:			58099.00		

Front Panel (Hz): Faraday Cup 4446.0 N/A 0.0

FADC Data Rate (MB/s): hps1 59.87 hps2 70.70

- I=125 nA
- DAQ rate 31 kHz
- Lifetime 84%
- Trigger version hps2021\_2.3

# Positron trigger

I=125 nA

Cut's values  
are beam  
energy  
dependent

			$E_{\min}$	$E_{\max}$	PDEC	Hodo	Rate	Pre scale
#00	Single-0	Top	150	8191			2.5M	20000
#01	Moller	Top	200	2700			228K	500
#02	Single-2	Top	400	2500	93%		13K	1
#03	Single-3	Top	300	3000	97%	Geom	14K	1
#04	Single-0	Bot	150	8191			2.9M	20000
#05	Single-1	Bot	200	3000			262K	500
#06	Single-2	Bot	400	3000	93%		13K	1
#07	Single-3	Bot	200	3000	99%	Geom	14K	1

Main

HPS

Trigger

- Trigger version hps2021\_v2\_3
- Current 125 nA
- Total trigger rate 30kHz,
- Lifetime 84%

# Pair Triggers, FEE and others

Muons  
No prescale  
FEE

			$E_{\min}$	$E_{\max}$	Rate	Pre scale
#08	Pair-0	Old $e^+e^-$	300	2500	15K	100
#11	Pair-3	Muons	80	300	780	1
#18	FEE	Top	2600	5200	170	1
#19	FEE	Bot	2600	5200	161	1

# Special Triggers

			Rate	Prescale	Rates
#12	LED	Calorimeter	15K	0	
#13	Cosmic	Calorimeter	120K	0	
#14	Hodoscope		4.0M	0	
#15	Pulser		100	<b>1</b>	<b>100</b>
#16 Front Panel	Faraday Cup		4446	5(17)	250

# Conclusion

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- The 2021 triggers were simulated for 2 beam energies 1.9 and 3.7 GeV.
- All main triggers were analyzed and trigger conditions established
  - Positron Trigger (with/without Hodoscope) for A' search
  - Pair A' trigger
  - Full Energy Electron trigger
  - Moller Trigger
  - Muon trigger (stays the same)
- Trigger validation was done for all major production triggers
- Trigger efficiency was determined not less than ~99%
- The one cluster Moller trigger shows good results
- Many thanks to the team that supported this job that demands very high expert qualification: Ben, Nathan, Sergey, Sam, Tongtong and Rafo
- Special thanks to Norman and Cameron for providing us useful off-line analysis information

## mollerAna\_pSum\_with\_numTrakcs\_numHits\_timeDiff\_cuts\_h

