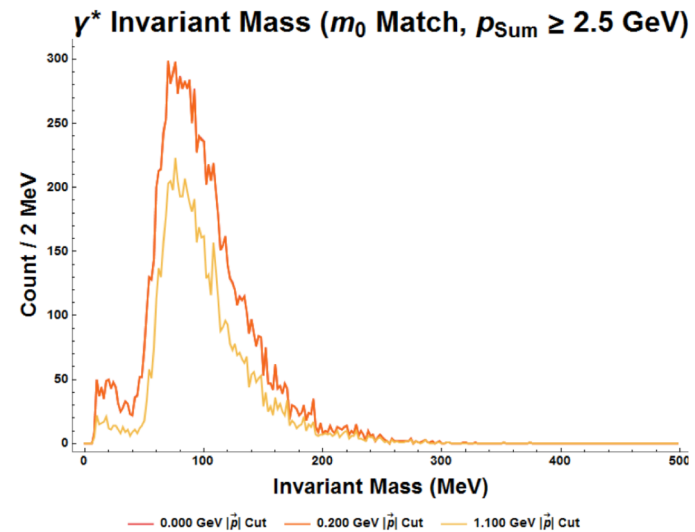


2021 HPS Trigger

Valery Kubarovsky
Jefferson Lab

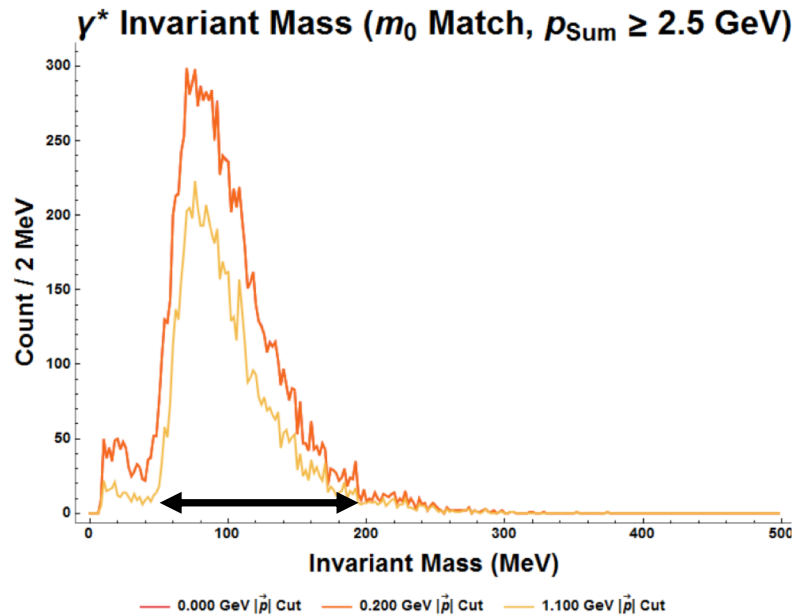
June 24, 2021



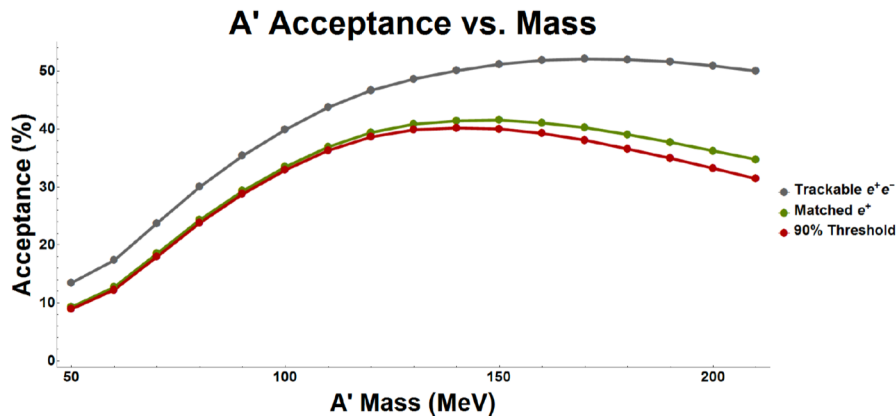
Plan

- HPS-2021 trigger overview
- Sam McCarty. Positron trigger and FEE trigger
- Tongtong Cao. Moller trigger and A' pair trigger

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



What was done so far

- 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 will be used for 1.92 GeV beam energy
- Sam is tuning trigger conditions using his own code
- Preliminary comparison shows that the results of two independent analysis generally consistent with each other.

2019 HPS Trigger Zoo

- Positron trigger
 - 4 tops
 - 4 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

hps_trigger_expert.adl

Run# 10637 Target: 20 um W HPS Triggers Latencu 09/01/2019 13:59:18

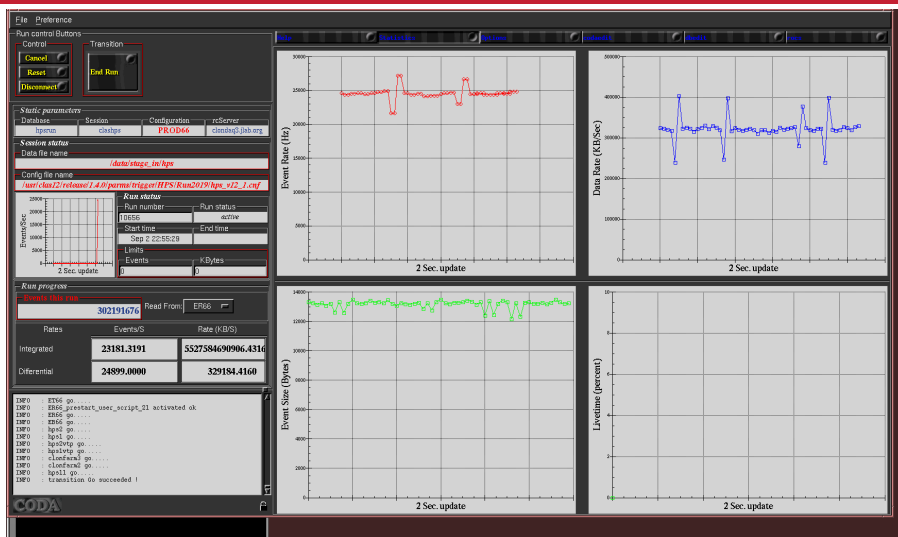
Beam Currents (nA) 2C21: 126.83 FCup: 119.26 Livetime (%): 94.90

#	Description	Raw Rate (Hz)	Prescaled Rate (Hz)	%	Prescale
00	Single-0 Top	1909370.0	86.0	0.2	20000
01	Single-1 Top	32517.0	0.0	0.0	0
02	Single-2 Top (e+)	7861.0	7872.0	20.2	1
03	Single-3 Top (e+/Hodo)	10292.0	10197.0	26.1	1
04	Single-0 Bottom	2073968.0	92.0	0.2	20000
05	Single-1 Bottom	30844.0	0.0	0.0	0
06	Single-2 Bottom (e+)	8291.0	8446.0	21.7	1
07	Single-3 Bottom (e+/Hodo)	10703.0	10602.0	27.2	1
08	Pair-0 (Old e+e-)	15431.0	149.0	0.4	100
09	Pair-1 (Moller)	120077.0	106.0	0.3	1000
10	Pair-2 (2gamma)	80940.0	147.0	0.4	500
11	Pair-3 (mu+mu-)	729.0	686.0	1.8	1
12	LED	0.0	0.0	0.0	0
13	Cosmic	0.0	0.0	0.0	0
14	Hodoscope	6197356.0	0.0	0.0	0
15	Pulser	100.0	102.0	0.3	1
16	Multiplicity-0 (2gamma)	170979.0	86.0	0.2	2000
17	Multiplicity-1 (3gamma)	8679.0	107.0	0.3	80
18	FEE Top	170.0	157.0	0.4	1
19	FEE Bottom	161.0	170.0	0.4	1
Sum:			39005.00		

Front Panel (Hz): Faraday Cup 4648.0 N/A 0.0

FADC Data Rate (MB/s): hps1 49.96 hps2 60.59

2019 DAQ and Trigger Performance



Run# 10656 Target: 20 um M HPS Triggers Latencu 09/03/2019 02:32:50

Beam Currents (nA) 2C21: 127.97 FCup: 120.48 Livetime (Z): 94.70

#	Description	Raw Rate (Hz)	Prescaled Rate (Hz)	%	Prescale
00	Single-0 Top	1950547,0	87,0	0,2	20000
01	Single-1 Top	32839,0	0,0	0,0	0
02	Single-2 Top (+)	7867,0	7970,0	20,0	1
03	Single-3 Top (+/Hodo)	10408,0	10536,0	26,4	1
04	Single-0 Bottom	2113550,0	94,0	0,2	20000
05	Single-1 Bottom	31733,0	0,0	0,0	0
06	Single-2 Bottom (+)	8627,0	8577,0	21,5	1
07	Single-3 Bottom (+/Hodo)	10922,0	10768,0	27,0	1
08	Pair-0 (Old e+e-)	15798,0	152,0	0,4	100
09	Pair-1 (Moller)	122979,0	110,0	0,3	1000
10	Pair-2 (2gamma)	83160,0	152,0	0,4	500
11	Pair-3 (nu+nu-)	766,0	722,0	1,8	1
12	LED	0,0	0,0	0,0	0
13	Cosmic	0,0	0,0	0,0	0
14	Hodoscope	6275500,0	0,0	0,0	0
15	Pulser	99,0	101,0	0,3	1
16	Multiplicity-0 (2gamma)	175732,0	88,0	0,2	2000
17	Multiplicity-1 (3gamma)	8820,0	111,0	0,3	80
18	FEE Top	206,0	190,0	0,5	1
19	FEE Bottom	195,0	194,0	0,5	1
Sum:		39852,00			
Front Panel (Hz):		Faraday Cup 4721,0	N/A	0,0	
FADC Data Rate (MB/s):		hps1 50,68	hps2 60,37		

- $I=120$ nA
- DAQ rate 25 kHz
- Data Rate 325 MB/s
- Event size 13 KB
- Lifetime 95%
- Trigger version hps_v12_1.trg

Special Triggers

			Rate	Prescale
#12	LED	Calorimeter	15K	0
#13	Cosmic	Calorimeter	120K	0
#14	Hodoscope		6.3M	0
#15	Pulser		100	1
#16 Front Panel	Faraday Cup		4648	5

Positron trigger

September, 2019 $I=120$ nA

Cut's values
are beam
energy
dependent

			E_{\min}	E_{\max}	PDEC	Hodo	Rate	Pre scale
#00	Single-0	Top	150	8191			1.9M	20000
#01	Single-1	Top	200	3000			32K	0
#02	Single-2	Top	400	3000	93%		7.7K	1
#03	Single-3	Top	200	3000	99%	Geom	10K	1
#04	Single-0	Bot	150	8191			2.0M	20000
#05	Single-1	Bot	200	3000			31K	0
#06	Single-2	Bot	400	3000	93%		8.3K	1
#07	Single-3	Bot	200	3000	99%	Geom	10K	1

Main

HPS

Trigger

- Trigger version hps_v12_1.trg
- Current 120 nA
- Total trigger rate 25kHz,
- Lifetime 95%

Positron Triggers

Top

- **#00 Singles-0.**
 - Low energy cluster (150-8191) MeV
 - Calorimeter iX index=(-23,+23). Full detector
- **#01 Singles-1 Positron.**
 - Cluster energy= (200-3000) MeV
 - Calorimeter iX index=(+4,+23)
- **#02 Singles-2 Positron.**
 - Cluster energy=(200-3000) MeV
 - Calorimeter iX index= (+4,+23)
 - Position Dependent Energy Cut
- **#03 Singles-3 Top Positron.**
 - Cluster energy=(200-3000) MeV
 - Calorimeter iX index= (+4,+23)
 - Position Dependent Energy Cut
 - Hodoscope

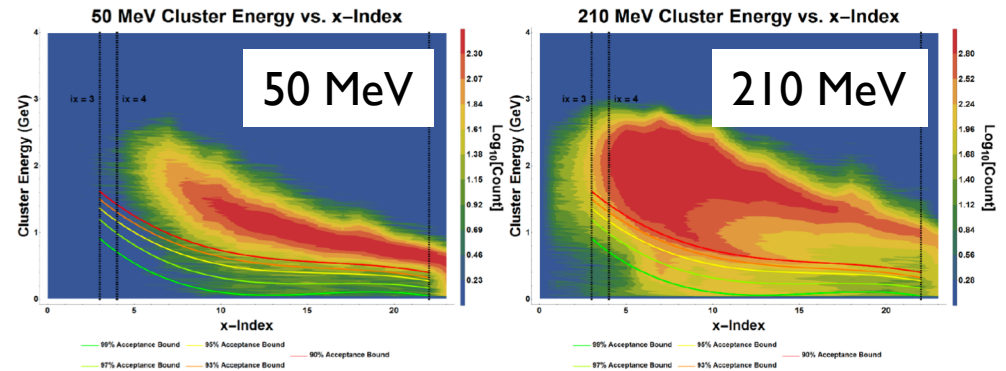
#00-01 trigger test and control
#02-03 – our main production triggers

Bottom

- Symmetric to Top

Position Dependent Energy Cut (PDEC)

- 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

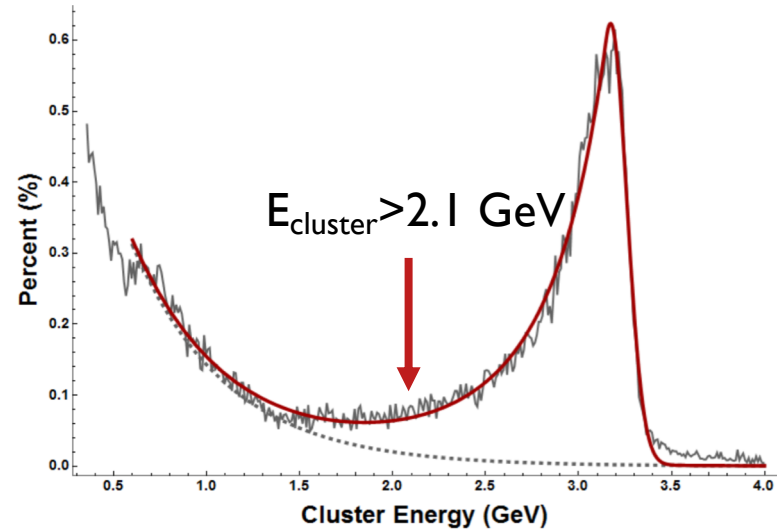
$$E_{cluster} > C_0 + C_1x + C_2x^2 + C_3x^3$$

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

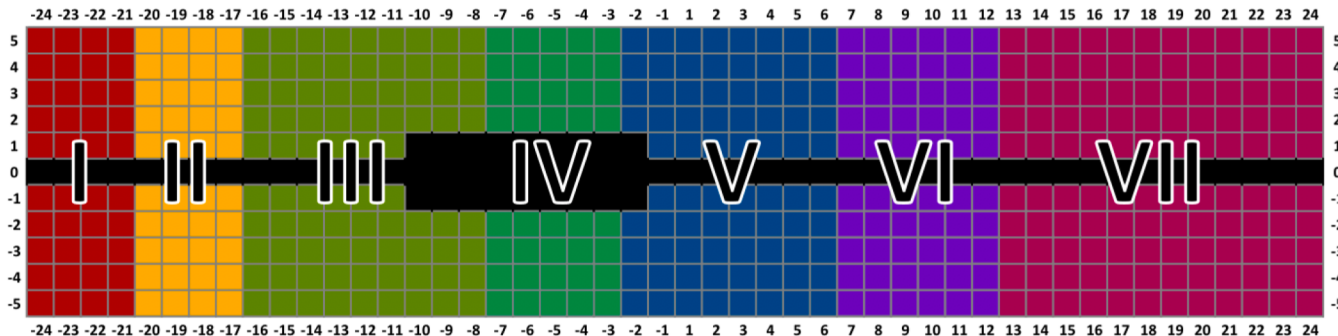
C_i, x_{min} are trigger parameters

FEE trigger

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



Prescale regions
2019 version



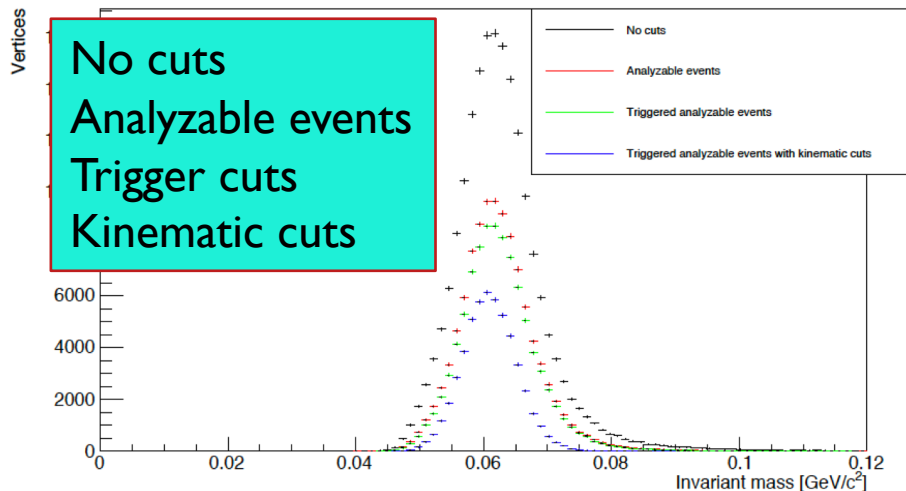
Region	Prescale
I	I
II	9
II	129
IV	1025
V	513
VI	13
VII	I

New Moller Trigger

- Two cluster trigger doesn't work for the 3.7 GeV beam energy
- Tongtong suggested to use one cluster trigger for Moller scattering process.

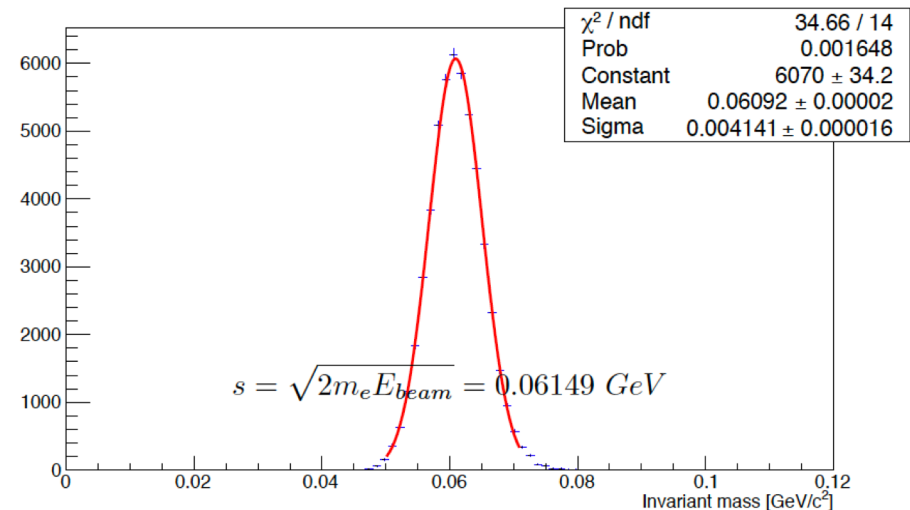
$\Delta M/M=7\%$ for $M=60$ MeV

triggerParameterExtractionAna_invariant_mass_vertex_h



Trigger analyzable events with kinematic cuts

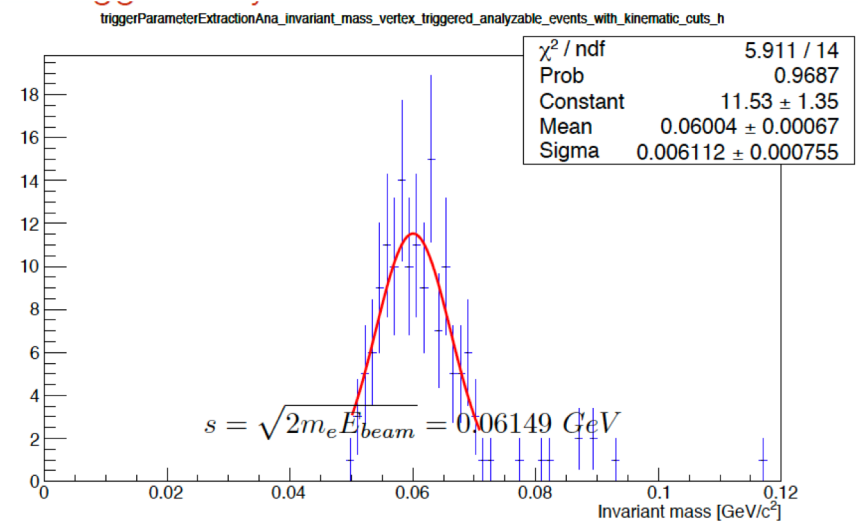
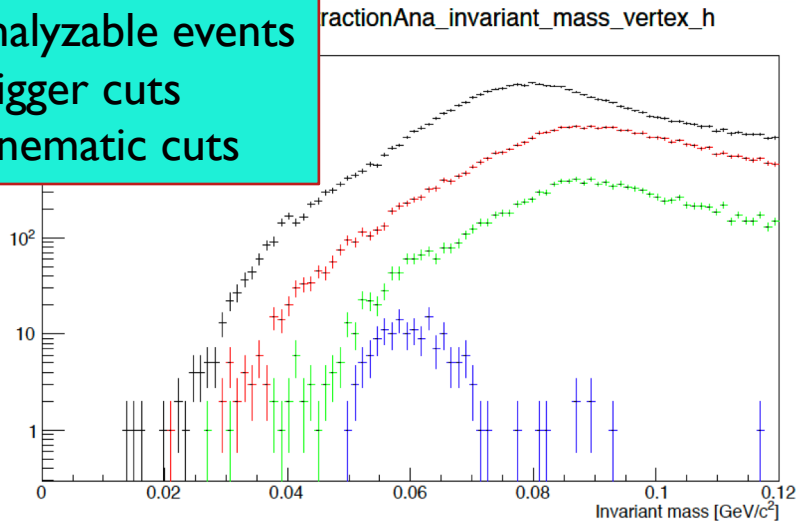
triggerParameterExtractionAna_invariant_mass_vertex_triggered_analyzable_events_with_kinematic_cuts_h



Moller cuts

- Cluster energy 0.7-1.5 GeV
- Nhits>0
- Xindex<-10
- Yindex [-2,2]
- Position dependent energy upper limit

No cuts
 Analyzable events
 Trigger cuts
 Kinematic cuts



Pair Triggers, FEE and others

			E_{\min}	E_{\max}	Rate	Pre scale
#08	Pair-0	Old e^+e^-	300	3000	15K	100
#09	Pair-1	Moller	300	3000	120K	1000
#10	Pair-2	2 gammas Top-Bot	300	3500	80K	500
#11	Pair-3	Muons	80	300	730	1
#16	2 gammas	Top or Bot	150	8191	170K	20000
#17	3 gammas	Top+Bot	200	3000	8.7K	80
#18	FEE	Top	2600	5200	170	1
#19	FEE	Bot	2600	5200	161	1

Muons

No prescale

FEE

Do we need some of 2019 triggers?

			E_{\min}	E_{\max}	Rate	Pre scale
#08	Pair-0	Old e^+e^-	300	3000	15K	100
#09	Pair-1	Moller	300	3000	120K	1000
#10	Pair-2	2 gammas Top-Bot	300	3500	80K	500
#11	Pair-3	Muons	80	300	730	1
#16	2 gammas	Top or Bot	150	8191	170K	20000
#17	3 gammas	Top+Bot	200	3000	8.7K	80
#18	FEE	Top	2600	5200	170	1
#19	FEE	Bot	2600	5200	161	1

Muons
No prescale
FEE

We suggest to take these triggers out if there are no objections from the collaboration.

Conclusion

- The 2021 trigger tuning is in a very good shape
- All main triggers were analyzed and trigger conditions established
- The one cluster Moller trigger is suggested
- Suggested to dismiss some old triggers if there are no objections from collaboration
- The offline reconstruction program must be ready on the first day for trigger validation

Discussion

- Remove triggers
 - 9 Pair-1 Two gammas
 - 10 Pair-2 Moller
 - 16 Two gammas
 - 17 Three gammas
- Keep trigger 8 Old e^+e^- Pair trigger
- Add trigger Moller 1 and 5 One clusters trigger