Validation of CLAS12 triggers

Andrea Celentano
Rafayel Paremuzyan

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RG-A production triggers

13 experiments in Run group A
- Electron trigger: 10 experiments
- MesonEx trigger: 2 experiments. Requires 2 charged tracks in different sectors of Forward Detector (FD) to be in a time coincidence with Forward Tagger (FT) charged cluster
- Muon trigger: J/ψ experiment. 2 MIP tracks in opposite sectors

This talk: Validation of MesonEx and Electron trigger

MesonEx Trigger

(FTCal⊗FTHodo)$\times$(FTOF⊗PCU)$\times$PCal$\times$DC (segm/track)

Multiplicity: 2

Electron Trigger

HTCC $\times$ PCal $\times$ EC $\times$ DC (segm/road)

The strategy:
- With special unbiased triggers, take dedicated runs, keeping all trigger decisions
- In the offline reconstruction select set of events that supposed to be triggered
- Study whether corresponding trigger bits are lit

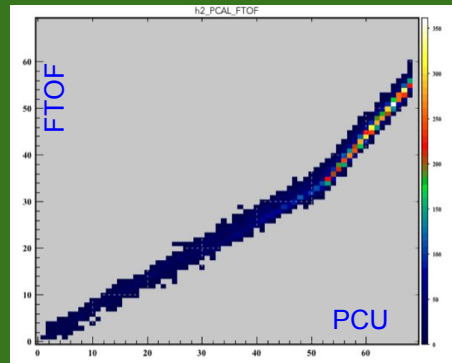# Validation of the MesonEx trigger

Runs used: 4909, 4913, 4914, 4916, 4919 (LH2 target @ 45 nA), Recon: 5c.6.8

Events with only 1 Time Based (TB) track with a matching hits in both FTOF1b and PCal
- Relay on REC::Particle, REC::Scintillator, REC::Calorimeter
- E_{PCal} > 15 MeV, E_{FTOF} > 1 MeV thresholds are used to select events with well defined hits

Check if sector based trigger bit is active
- FTOF⊗PCU
- FTOF⊗PCU $\times$ PCal > 15 MeV
- FTOF⊗PCU $\times$ PCal > 15 MeV $\times$ DC_old (segments 5 out of 6 in R2 and R3)
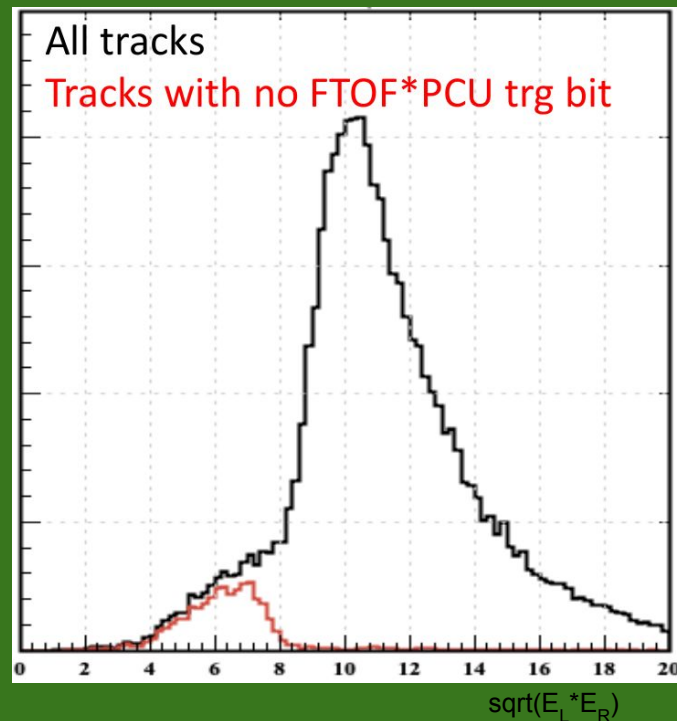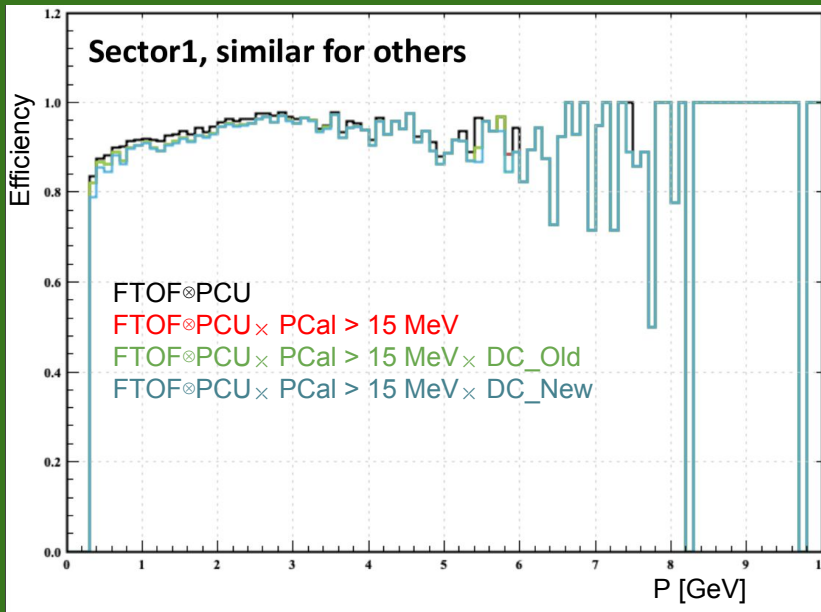- FTOF⊗PCU $\times$ PCal > 15 MeV $\times$ DC_new (Valid Roads)

For all sectors measure the trigger efficiency as a function of particle momentum, hit position in PCal/ hit position in FTOF1b

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Validation of the MesonEx trigger

Spring run trigger

Old FTOF⊗PCU map, old FTOF threshold sqrt(E_LxE_R) > <u>5 MeV</u>

Sector1, similar for others

FTOF⊗PCU
FTOF⊗PCU$_\times$ PCal > 15 MeV
FTOF⊗PCU$_\times$ PCal > 15 MeV$_\times$ DC_Old
FTOF⊗PCU$_\times$ PCal > 15 MeV$_\times$ DC_New

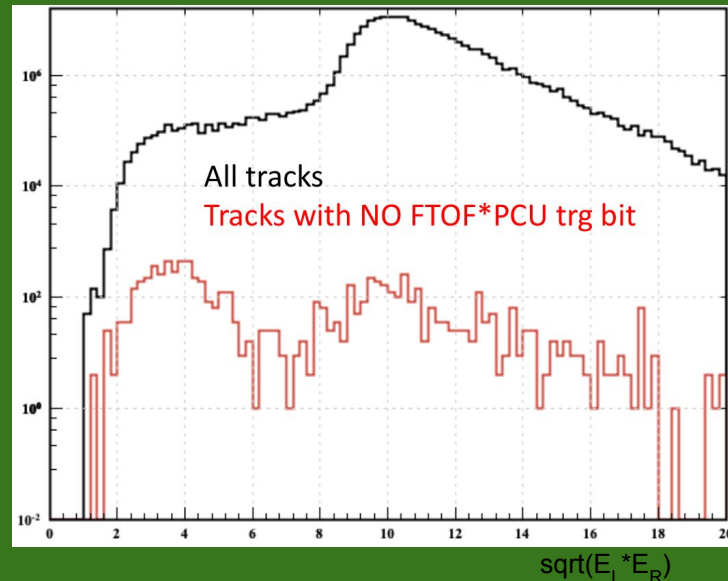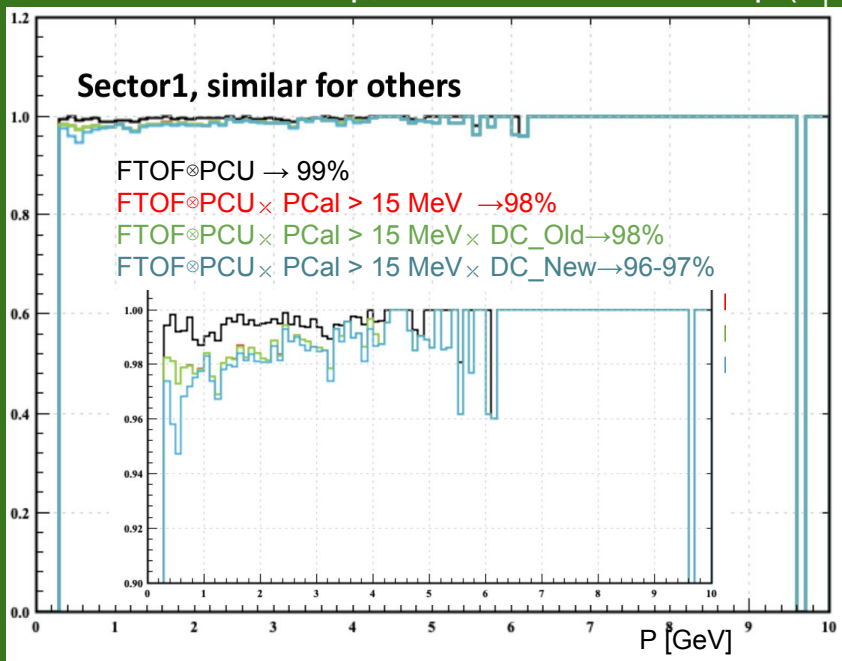
All tracks
Tracks with no FTOF*PCU trg bit

sqrt(E_L*E_R)

- The inefficiency is dominated by FTOF⊗PCU trigger
- The effect is mostly related to the FTOF threshold (PMT gain drop?)
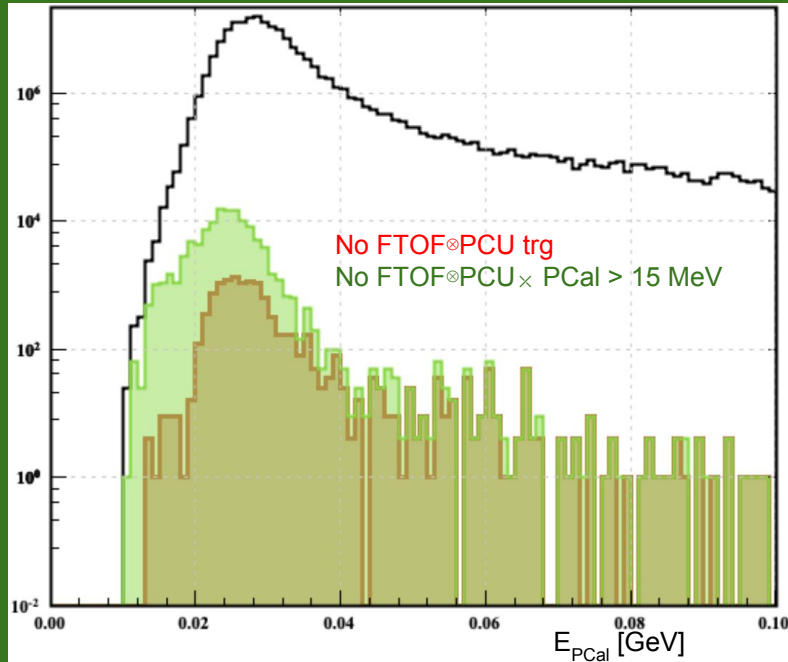
Validation of the MesonEx trigger

New FTOF threshold

Old FTOF⊗PCU map, old FTOF threshold $\sqrt{E_L \times E_R}$ > <u>2 MeV</u>

Sector1, similar for others

FTOF⊗PCU → 99%
FTOF⊗PCU × PCal > 15 MeV → 98%
FTOF⊗PCU × PCal > 15 MeV × DC_Old → 98%
FTOF⊗PCU × PCal > 15 MeV × DC_New → 96-97%

P [GeV]

All tracks
Tracks with NO FTOF*PCU trg bit

$\sqrt{E_L * E_R}$

- Threshold effect is almost vanished
- DC Segment trigger almost don't cut anything
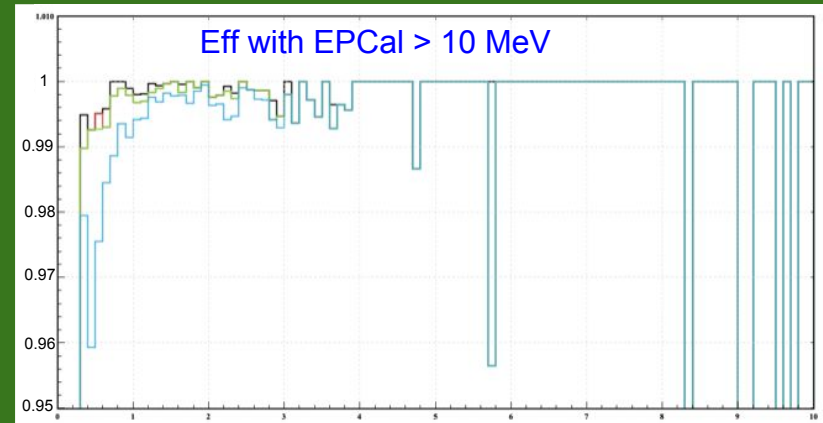- DC roads, some inefficiency at small momenta

Runs with new FTOF⊗PCU matching showed similar efficiency (slight inefficiency for low momenta), and the old trigger matching was used instead.

Validation of the MesonEx trigger

No FTOF⊗PCU trg
No FTOF⊗PCU × PCal > 15 MeV

E_{PCal} [GeV]

Low efficiency at small PCal energy is due to the difference in the offline and the VTP energies.
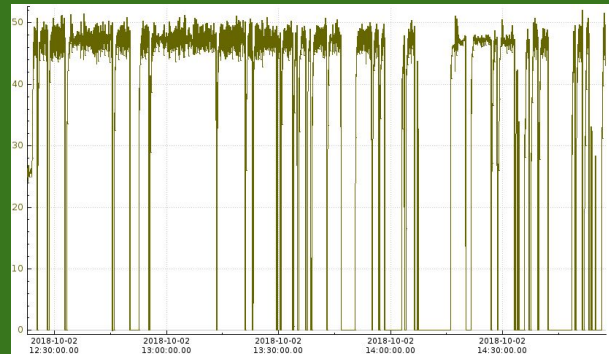
The energy threshold was changed from 15 MeV to 10 MeV

Eff with EPCal > 10 MeV

Using the new map the result didn't change the result

Electron trigger Validation

- Run: 4878: 130M events with LH2 target @45 nA, Tor: -1, Sol -1
- Events were triggered through the 15KHz random generator
- Special trg file "trigger_v20_Validation.trg"

Sector based trigger bits:
- Electron: $HTCC \times EC \otimes PCal \times DC\_segments$(5 out 6)
- HTCC
- $PCal \otimes EC$
- Electron with DC roads: $HTCC \times EC \otimes PCal \times DC\_Road\_inbending$(5 out 6)
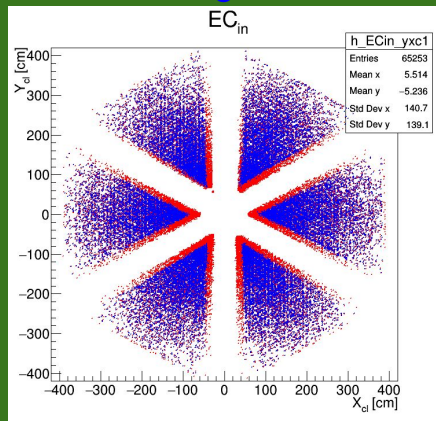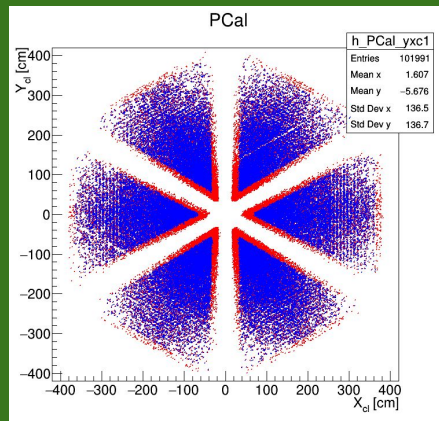- DC_Roads

The goal was to check both Electron trigger, and Electron with DC roads, however it was later found DC_inbending/DC_outbending swapped. This will not affect the electron trigger validation, however this data can not be used for validation of DC_Road.

- Run: 4999: 14M events with LH2 target @45 nA, Tor: -1, Sol -1
- Both Electron and Electron w/ DC_inbending were active
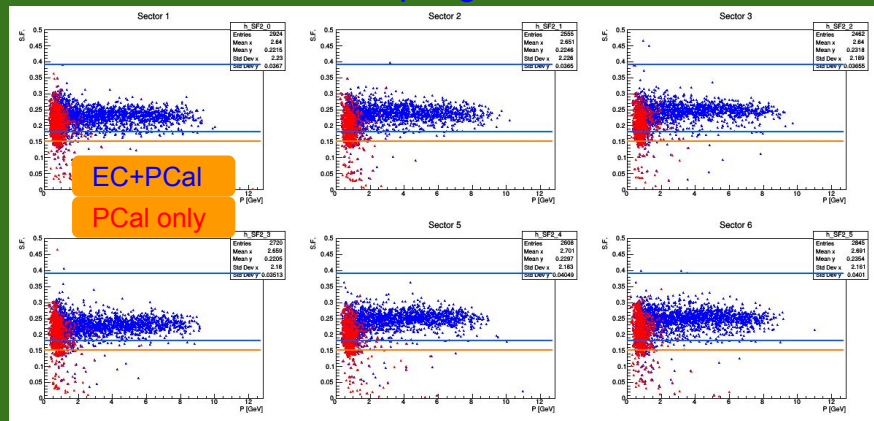- Special trg file "trigger_v20_Validation.trg"

Trusting Electron trigger, the Electron $\times$ DC_Road_inbending was checked

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Electron trigger Validation

Sampling fraction

EC+PCal

PCal only

Trigger

- E_{EC} > 10 MeV
- E_{PCal} > 60 MeV
- E_{Tot} > 300 MeV
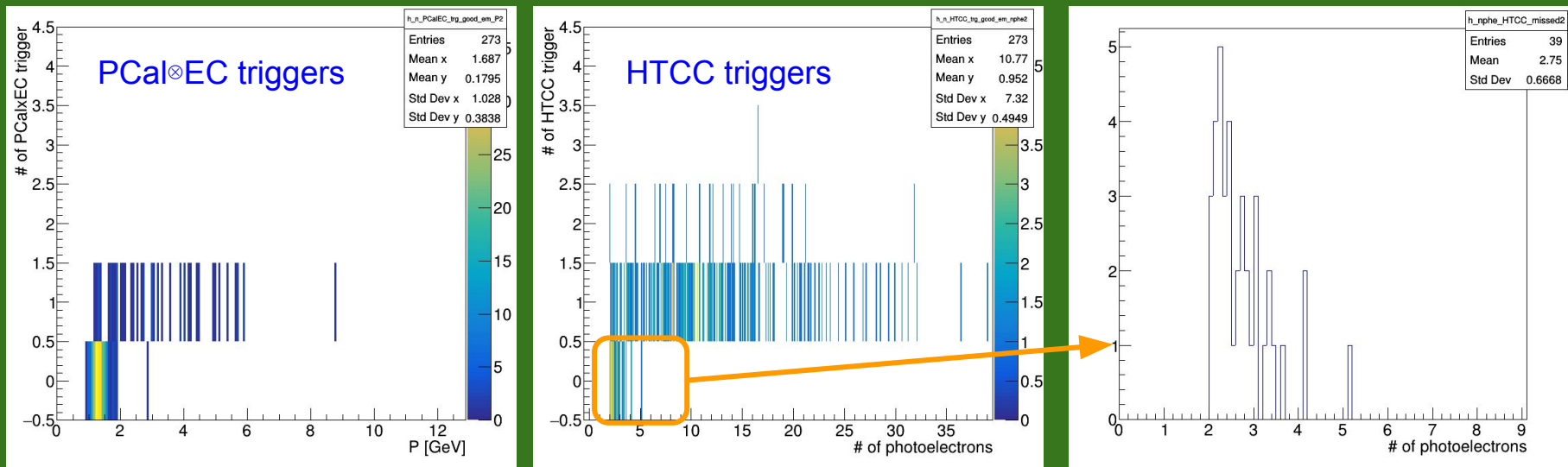- Nphe >= 2
- 5 segments out of 6

Good electros

- Electron PID cuts: SF > 0.2, <u>Nphe > 2</u>
- Fiducial cuts to avoid shower leakage effects
- Same energy and nphe cuts, that was used in the trigger

Then check how many of these events miss electron trig. bit

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Electron trigger Validation: Efficiency

Electron trigger Validation: Missed events

- Above 2 GeV PCal⊗EC trigger is almost perfect
- Failed HTCC triggers have nphe close to the threshold: consistent with threshold effects, 80% of these have nphe < 3

Electron trigger Validation: DC Roads

Run: 4999: 14M events with LH2 target @45 nA, Tor: -1, Sol -1

- Bits: 1-6, Electron trigger
- Bits 7-12, Electrons with DC roads

Select a "good electron", and check for the electron$\otimes$DC_inbending trigger bit in the corresponding sector.

25% gain in inbending e⁻ rate

Tr#		
	Current	1.00
0	e(1-6)	0.76
7	e(1-6) no DC	1.00
19	Muon 1-4	0.97
20	Muon 2-5	0.95
21	Muon 3-6	0.96
24	FTxFTOFxCTOF	0.97
25	FTx(FTOFxPCAL)^2	0.93

No event with "Good" electron has found to be missing the DC_inbending trigger

Only 2% gain in outbendings: DC_Roads are taken out from the trigger

Summary

- Both MesonEx and electron triggers are checked and validated using special unbiased trigger runs

- Lowering FTOF and PCal thresholds brought MesonEx trigger 99%+

- Inbending roads are validated too, and reduce the electron trigger rate by about 25%

- No significant gain in electron trigger rate with out-bending torus polarity, therefore DC roads are dropped from outbending runs.

- Both electron and MesonEx triggers show 99%+ efficiencies

- Inefficient events are consistent with threshold related effects

Backup slides

HTCC trigger failed

P > 2 GeV && HTCC trigger is missing