CLAS12 Trigger

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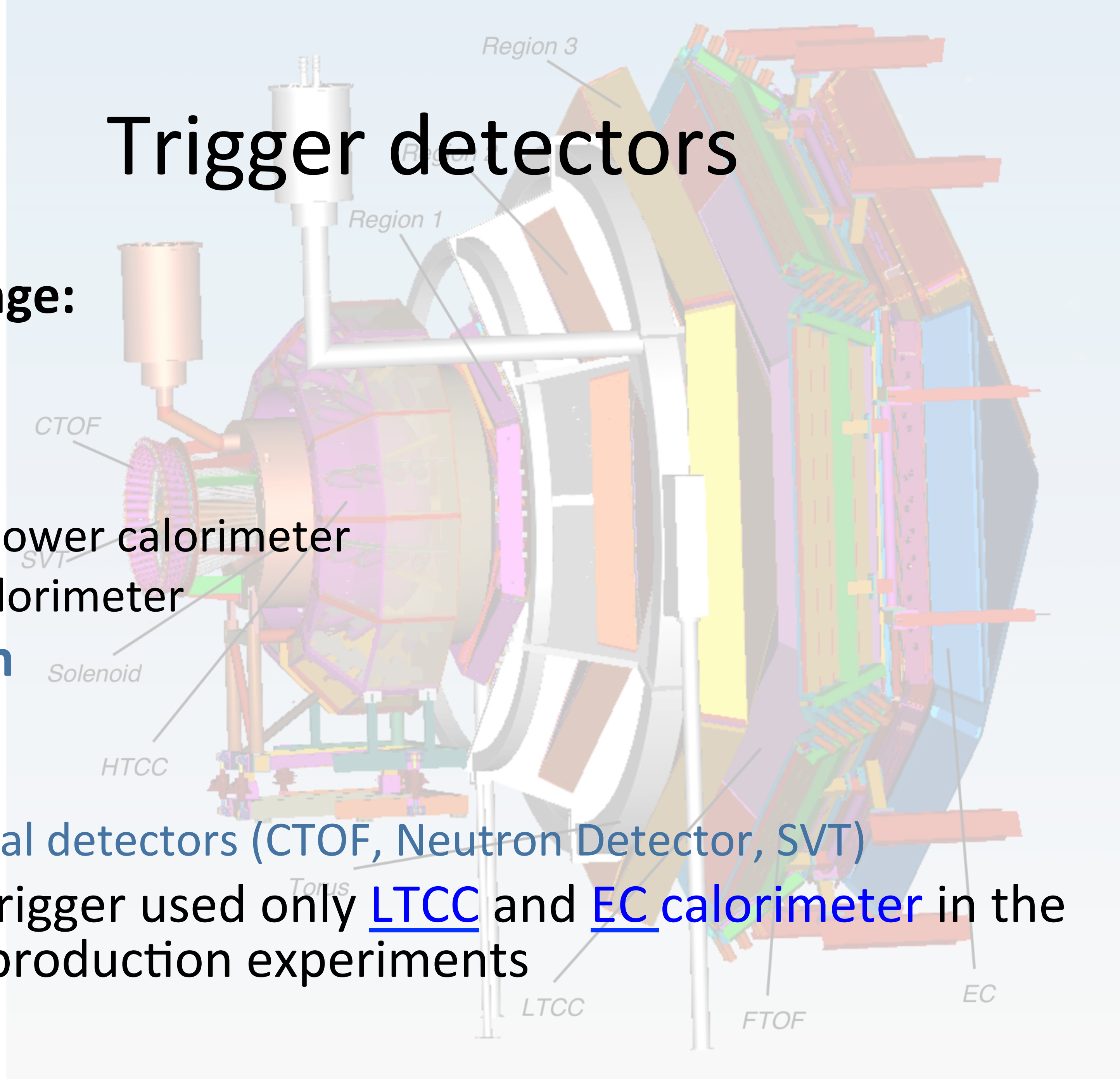
Plan

- Trigger detectors
- MC simulation
- Trigger analysis algorithms development
- Commissioning of the trigger firmware
- Slow control

CLAS12 Trigger System

- Electroproduction data
  - $ep \rightarrow e'$(in CLAS)+X
    - Trigger only on the scattered electron
- Photoproduction data
  - $ep \rightarrow e'$(in Forward tagger)+X (CLAS)
    - Trigger on coincidence between forward tagger and particles in CLAS
    - Trigger on particles in CLAS only
    - More complicated than electron trigger

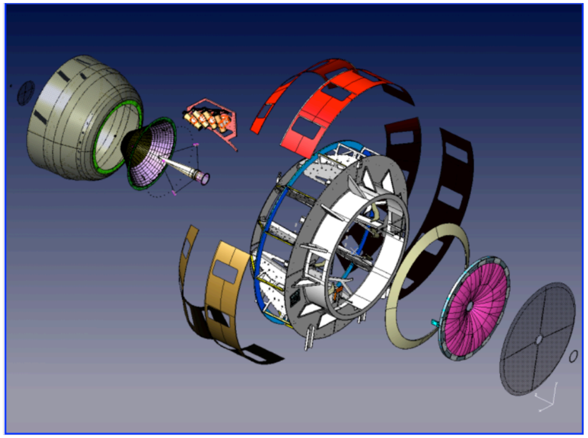
Trigger detectors



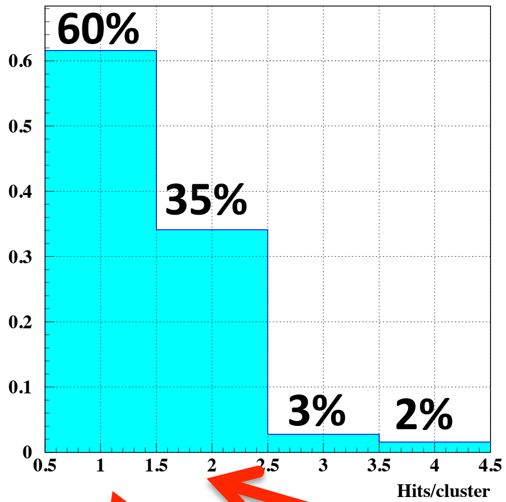
- **First stage:**
  - HTCC
  - LTCC
  - TOF
  - Preshower calorimeter
  - EC calorimeter
- **Later on**
  - DC
  - SVT
  - Central detectors (CTOF, Neutron Detector, SVT)
- CLAS6 trigger used only LTCC and EC calorimeter in the electroproduction experiments

HTCC

- 8 PMTs per sector, in total 48 PMTs
- Must be calibrated
- Trigger: number of photoelecrons
- Possible binning for matching with other detectors
  - Sector (6 bins)
  - Theta (4 bins)
  - Phi (2 bins)



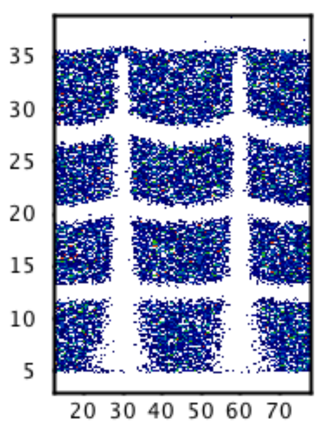
Cherenkov clusters



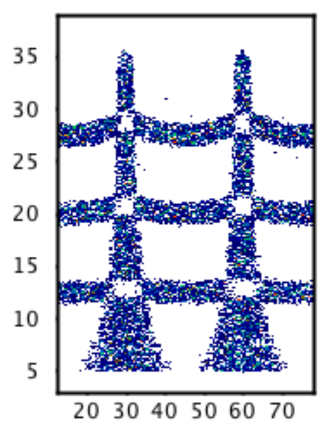
- 40% of events have nhits/cluster >=2

Nhits	1	2	3	4
ΔΘ degrees	7.5	7 2	2	2
Δϕ degrees	30	5-20 30	2-5	2

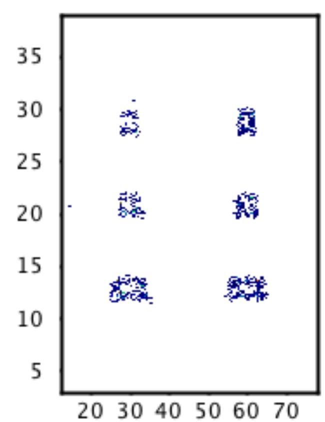
1 Hit



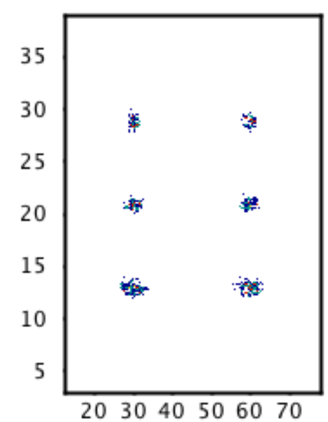
2 Hits



3 Hits



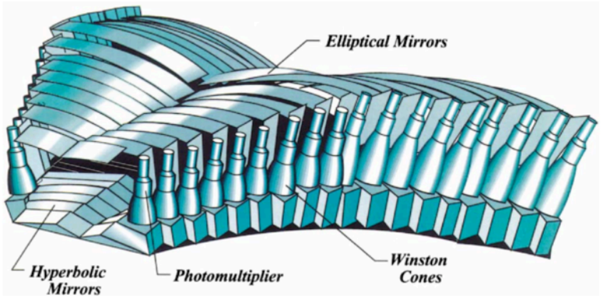
4 Hits



Nick Markov

LTCC

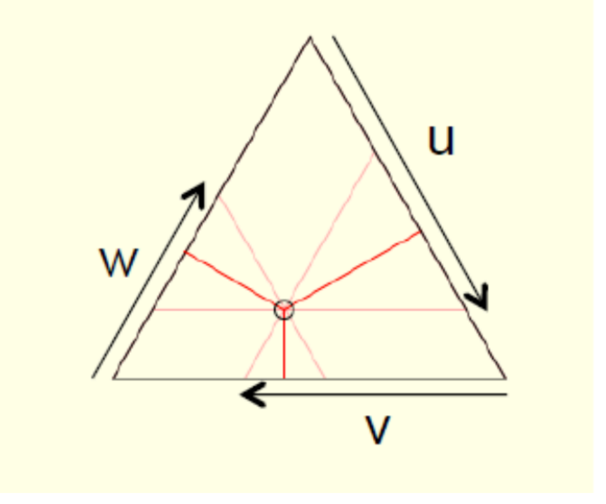
- 36 PMTs per sector, in total 216 PMTs
- Must be calibrated
- Trigger: number of photoelecrons
- Possible binning
  - Sector (6 bins)
  - Theta (18 bins)
  - Phi (2 bins)



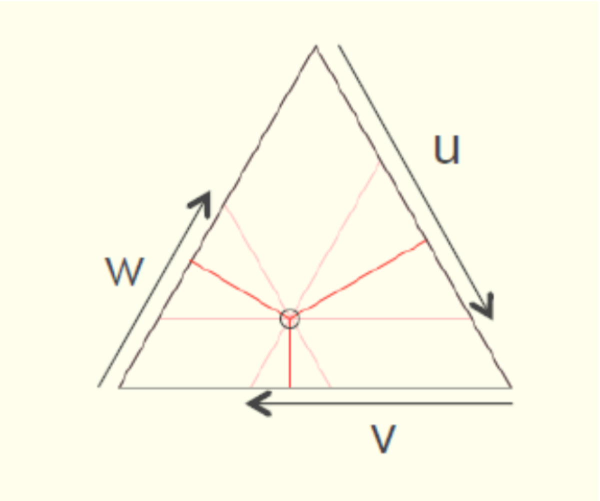
- CLAS6 trigger used one signal with low threshold (~0.2 phe) per sector

Preshower Calorimeter PCAL

- 196 channels in one sector
- Must be calibrated
- Search for clusters in (U,V,W) planes
- Calculate the cluster position and energy
- Match with EC clusters



EC Calorimeter

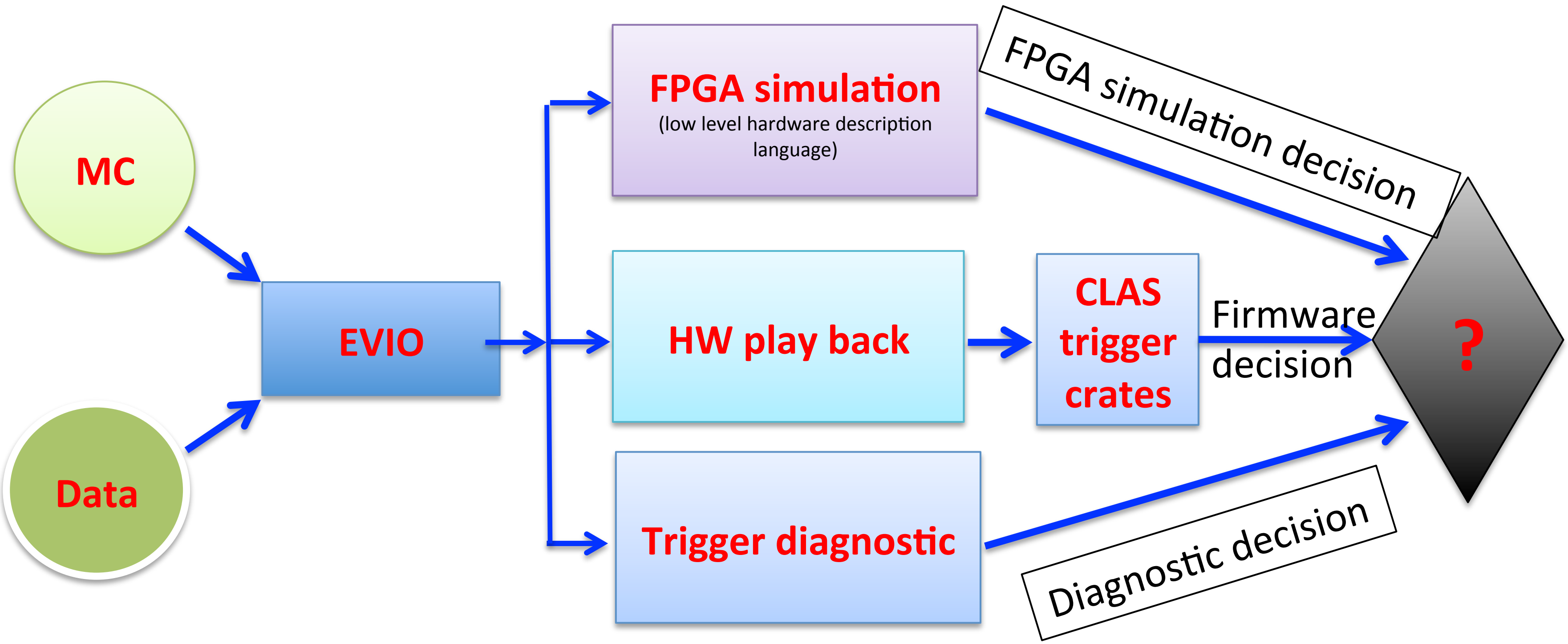


- 216 readout channels per sector
- Must be calibrated
- Search for clusters in (U,V,W) planes
- Calculate the cluster position and energy
- Match with PCAL clusters
- Calculate the energy sum PCAL+EC
- Could be matched with DC tracker in position and energy

What do we need?

1. MC simulation and analysis of the physics processes
2. Trigger Firmware
3. Trigger diagnostics
4. Slow control

Trigger Diagnostics Scheme



The firmware trigger decision will be verified against the decisions from FPGA simulation software and trigger simulation software

MC Simulation Requirements

- Simulate reaction ep→e'X (or dvcs or …)
- Provide the analysis algorithms for all trigger detectors HTCC, LTCC, TOF, PCAL and EC calorimeter
- Determine the trigger cuts for all detectors
- Develop matching algorithms for final trigger decision
- Generate background as close to the future real data as possible. These data will be used for the firmware commissioning.
- Estimate the trigger rates for the nominal luminosity based on the background simulation

Trigger Diagnostics Software

- Has to simulate the trigger firmware performance
- Must analyze raw data from all trigger detectors in accordance with the trigger algorithms provided by detector, DAQ and trigger experts
- Must include the detector calibration and geometry data base
- Has to work with MC generated data and real data
- Has to generate different trigger decisions with completely independent cuts, including electroproduction, photoproduction, random triggers, prescales etc.

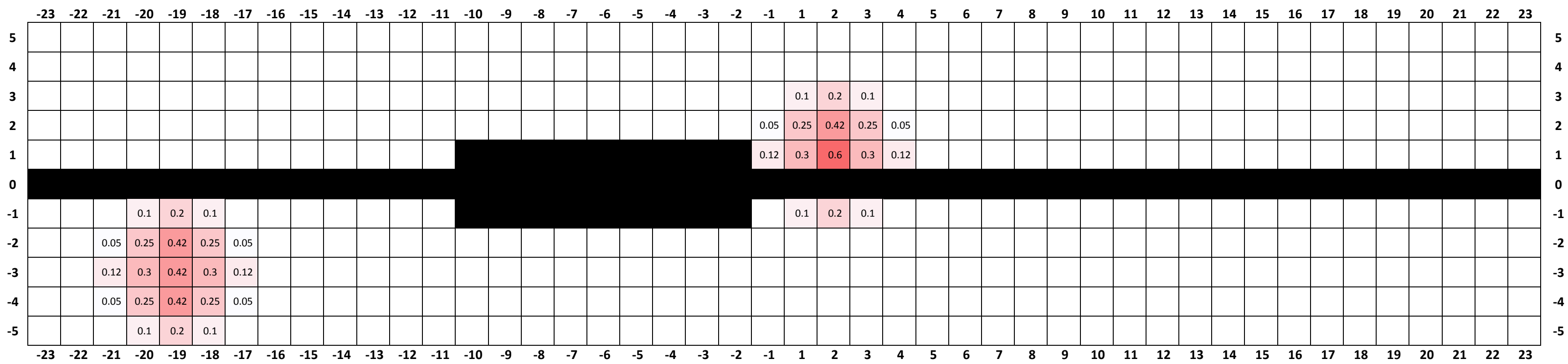
Play back

- Take EVIO as input and upload the event to the trigger crates with FADC boards
- The trigger firmware will report the trigger decision based on the preloaded values of FADCs
- The firmware trigger decision will be verified against the decisions from FPGA simulation software and trigger simulation software

Trigger Slow Control

- Provide online trigger rates for all trigger decisions
- Watch for the trigger rates during the experiments and provide alarms in case of problems
- Provide the time strip charts

Example: HPS Trigger



- Seed energy (E_{seed}>Eseed_min)
- Cluster energy (Emin<E_1,E_2<Emax)
- Number of hits in the cluster
- Energy Sum (min<E_1+E_2<max)
- Energy difference ($|E_2-E_1|$<max)
- Complanarity
- Energy slope (5.5*R+E_{min}>min)
- Cluster timing ($|T_{seed}$-Ti$|$<max)
- Cluster coincidence ($|T_{top}-T_{bottom}|$<max)

Single 0	Loose single cluster trigger
Single 1	Elastic events
Pair 0	Loose pair trigger
Pair 1	A’ trigger

Test of the trigger performance

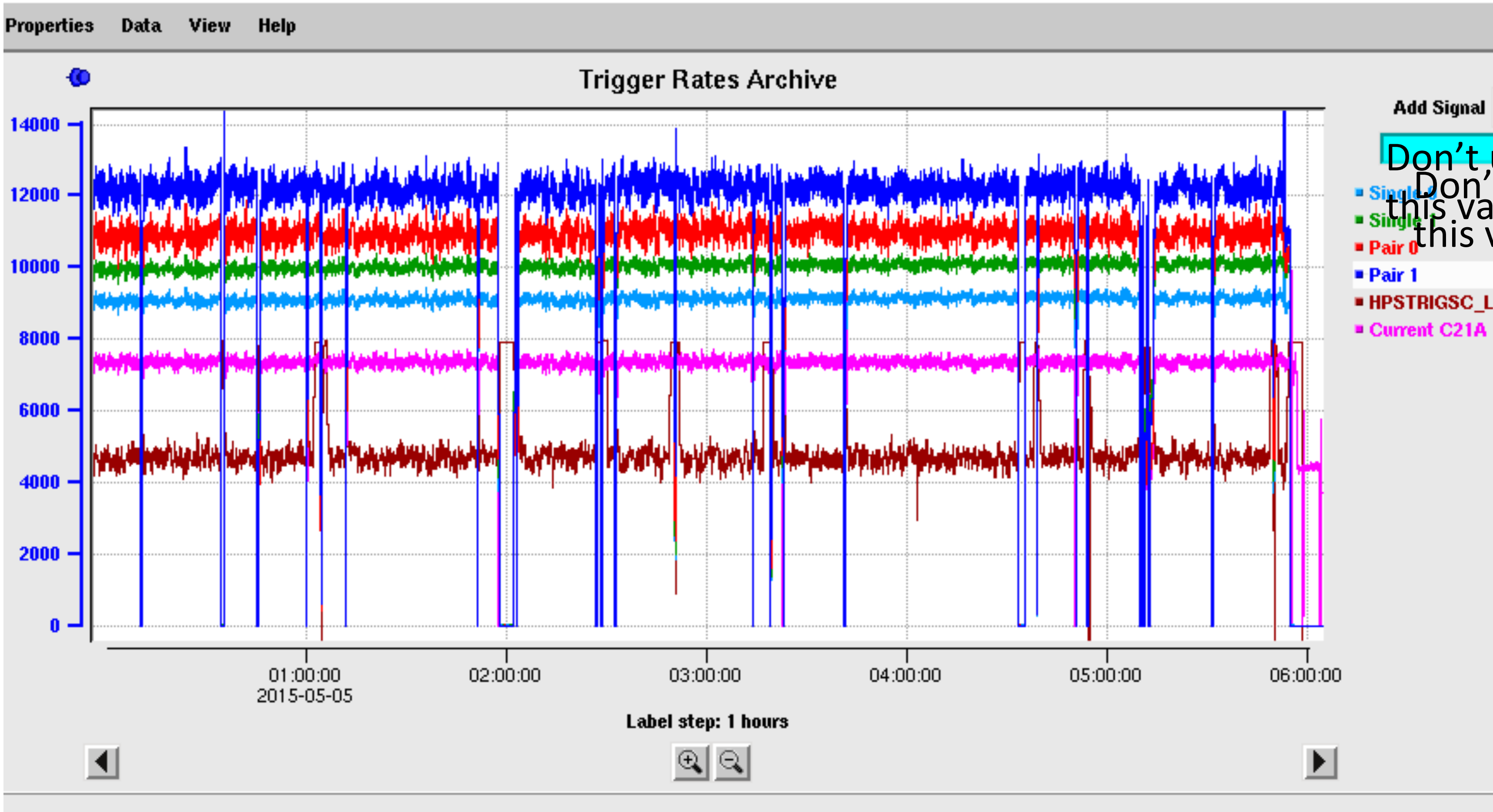
- Comparison between trigger firmware decision (SSP) and simulated trigger based on the FADC information for all types of triggers (s0,s1,p0,p1)
- Cluster verification
  - Energy of the cluster
  - Number of hits in the cluster
  - Hit's timing
- Trigger verification
  - Number of the events passed the trigger conditions
  - Test of each cut in the trigger
  - Cluster timing

Verification results

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

Trigger Rates

Night shift 2015-05-05



VK

HPS trigger slow control

16 kHz Ungated Pair trigger Rate @ 60 nA

Nathan Baltzell

Trigger Tasks

- MC simulation and physics analysis
- Trigger detector algorithms – DAQ, trigger and detector experts
- Trigger firmware
- Trigger diagnostics program
- Play back
- Slow control
- Spokespersons of the first CLAS12 experiments are encouraged to contact trigger group to collaborate in the trigger development.

God helps those who help themselves