

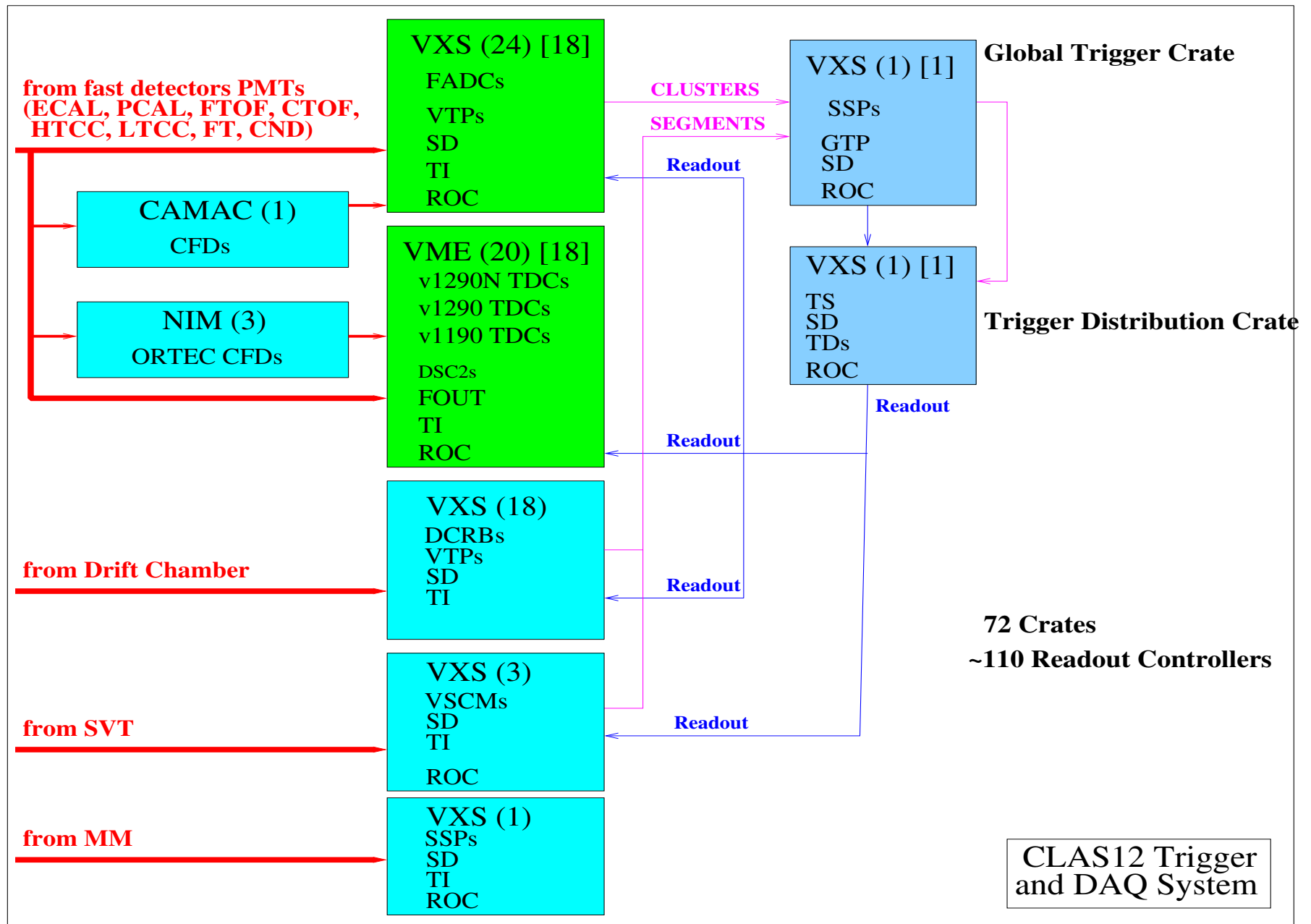
# CLAS12 DAQ & Trigger Status

1. DAQ Overview
2. Trigger Hardware Status
3. Trigger Firmware Development
4. Remaining work and schedule

Sergey Boyarinov

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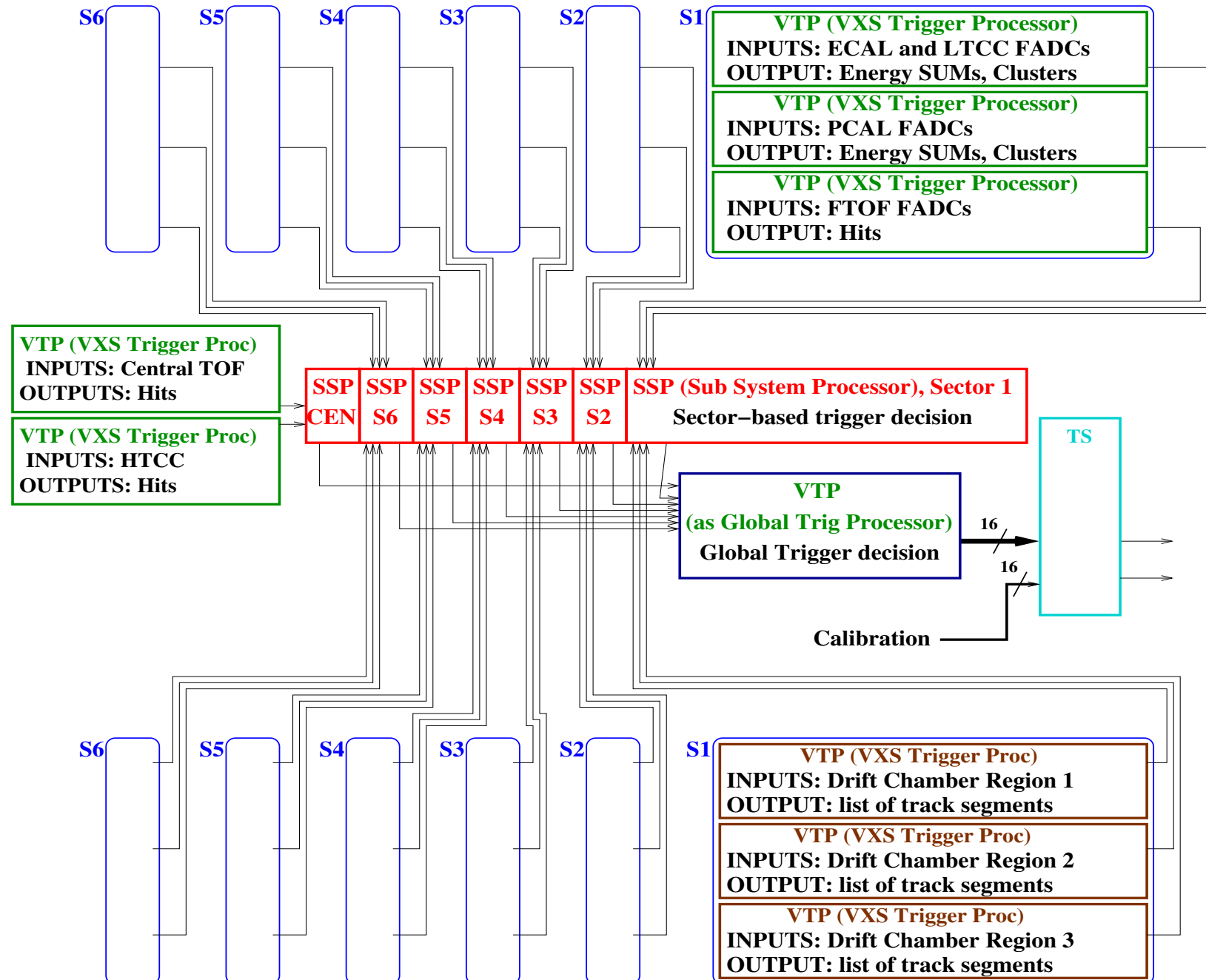
# DAQ/Trigger Hardware



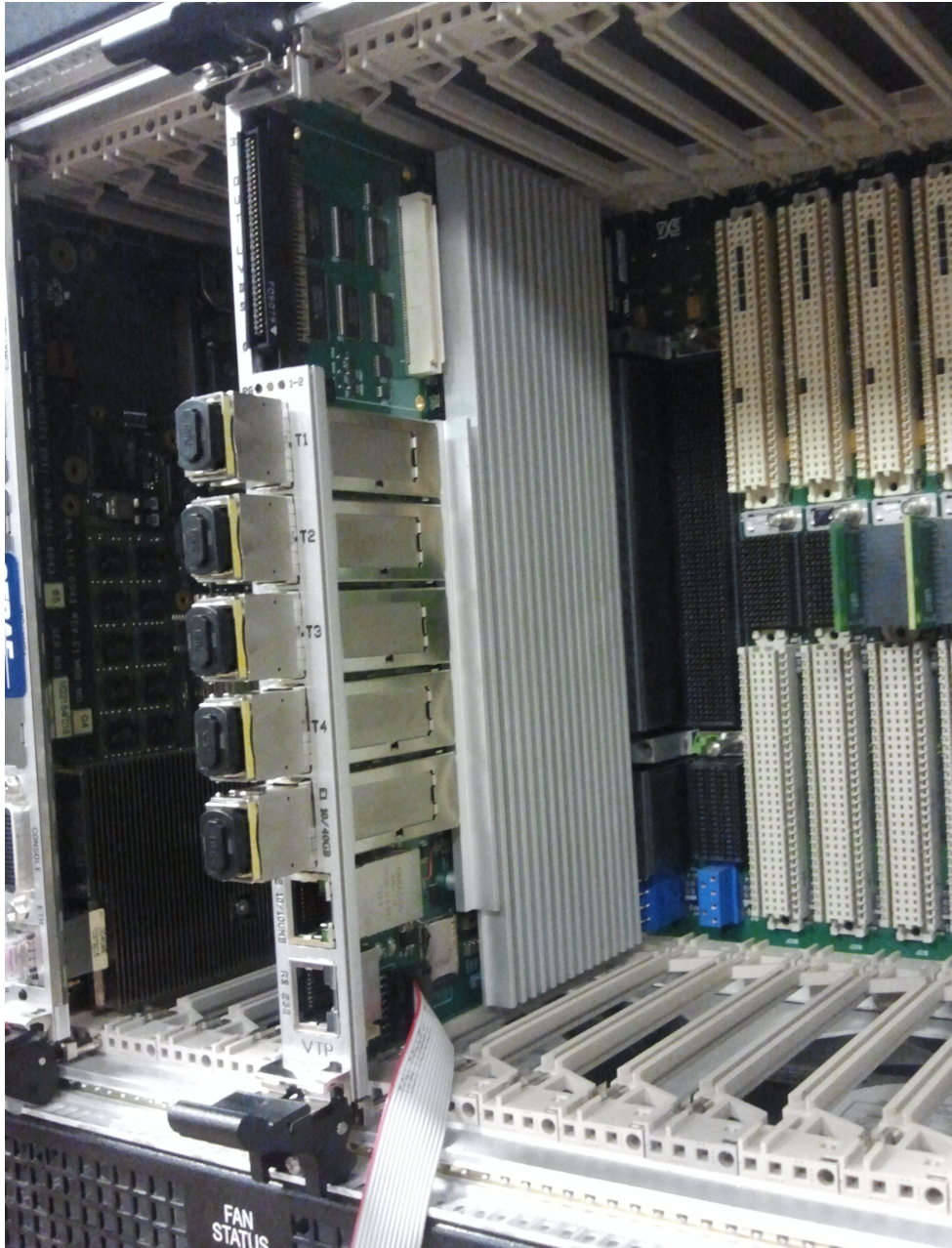
## CLAS12 DAQ Status

- Forward Carriage and Pie Tower hardware installed and operational
- Space Frame and Subway hardware is not installed, waiting for other activities to be complete; we should have enough boards, but inventory still not finished to know for sure
- DAQ software is operational, was used in HPS and being used in PRAD experiments, as well as in test setups, reliability is acceptable and performance exceeds CLAS12 requirements
- DAQ+Trigger whole system commissioning (outer detectors only) starts as soon as trigger components are installed

# CLAS12 Trigger System Logic



## VTP (VXS Trigger Processor) - stage 1 and 3

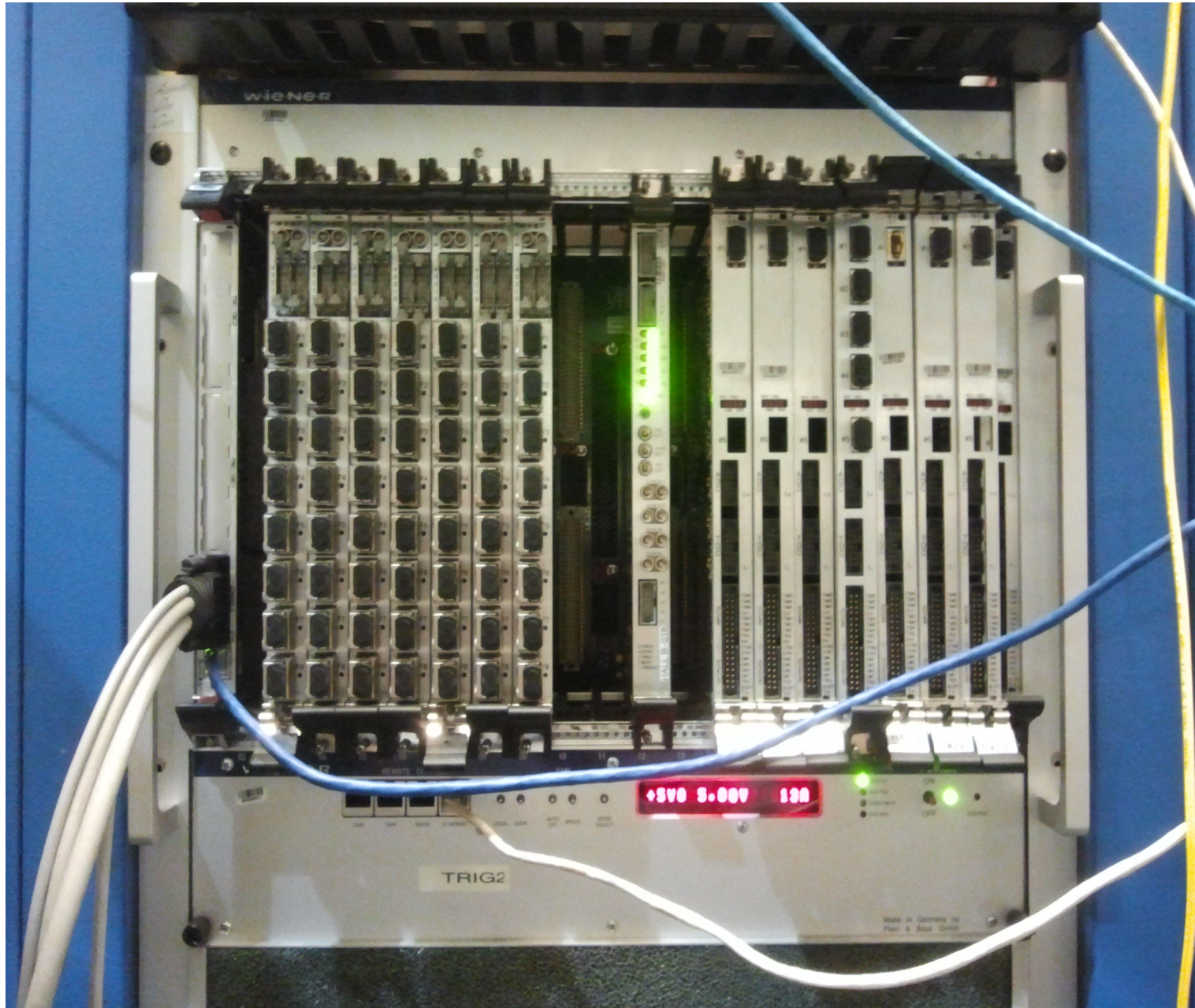


1. Four 5GBit links from each VXS slot (more bits for ADC integral, better timing resolution, possible use for readout)
2. 40GBit fiber uplinks (faster data transfer, connect several crates in parallel to form the trigger)
3. Big FPGA and 4GB memory to accommodate ECAL/PCAL clustering and Drift Chamber road finding
4. LVDS output to Trigger Supervisor, and custom IO card

W



## SSP (Sub System Processor) – stage 2





## CLAS12 Trigger Supervisor and Trigger Distribution boards



## CLAS12 Trigger Hardware Status

- All related electronics for outer detectors installed except 1 and 3 stage boards (VTPs)
- First VPT board was received two month ago, being evaluated by Ben Raydo, almost done, so far everything works as expected
- Remaining 24 VTP boards will arrive in few days
- Linux installation on VTP is in progress (Bryan Moffit), following by CODA installation (Sergey)
- Installation of all boards will start as soon as all features implemented including Linux and CODA installation, may take 2-3 more weeks



## CLAS12 Trigger Firmware

- Trigger algorithms development is in progress, primary goal is to deliver electron trigger (ECAL+PCAL+HTCC) with other detectors following
- Drift chamber road finding will be developed as well; it is not mandatory for the first run(s), but will do it now while manpower is available and to estimate possible VTP design change before buying 20 more boards for drift chamber crates

## CLAS12 Trigger Firmware: development chain

1. Existing reconstruction algorithms review – with detector group experts (Mac Mestayer for Drift Chamber, Cole Smith for ECAL/PCAL) and offline team if necessary
2. Modeling (in C using fixed point arithmetic), output comparison with offline reconstruction
3. VHDL code generation using Vivado HLS tool
4. FPGA loading and cosmic data taking (or playback if available)
5. Hardware trigger output must be identical with the one from modeling; if not, repeat steps 2-5

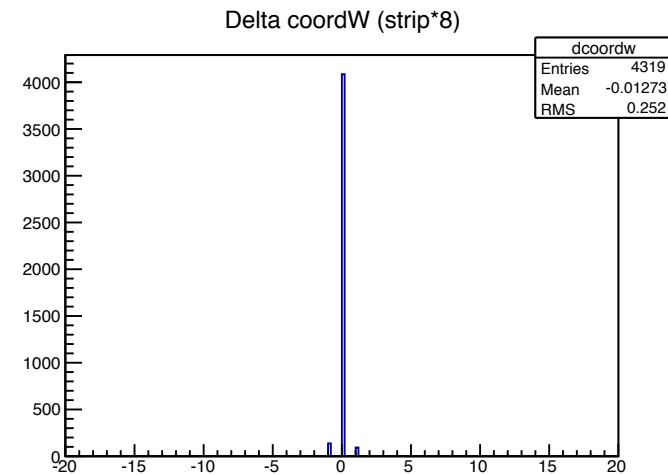
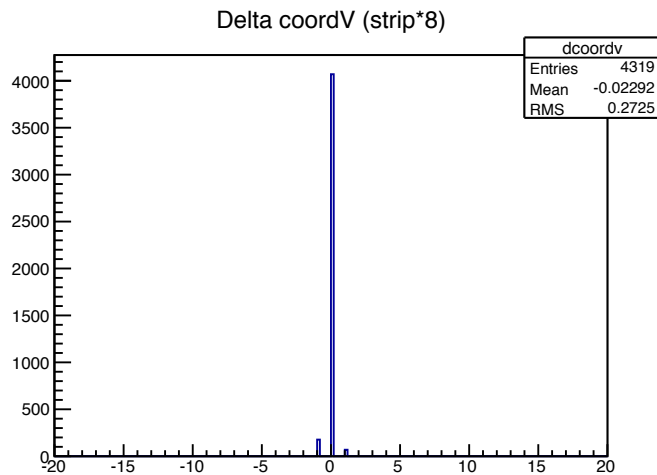
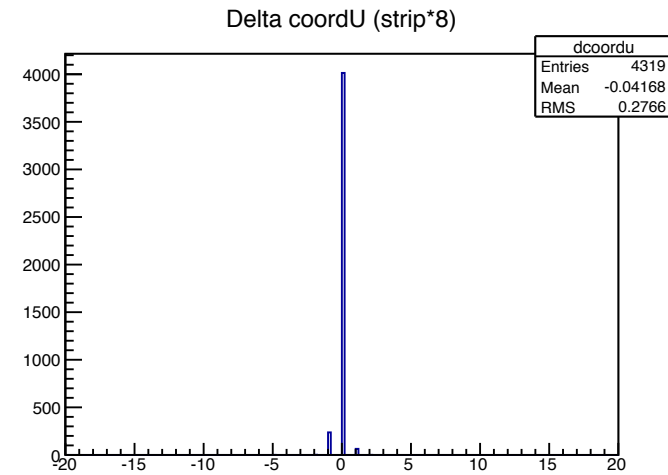
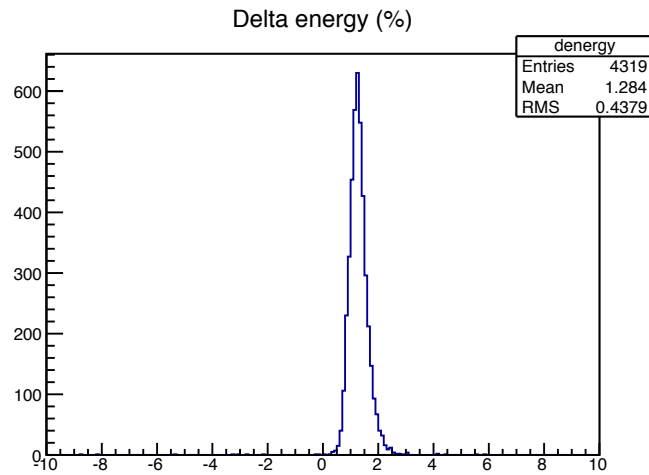
SO FAR: Items 1-3 (first pass) completed for ECAL

## CLAS12 Trigger Firmware: recent progress

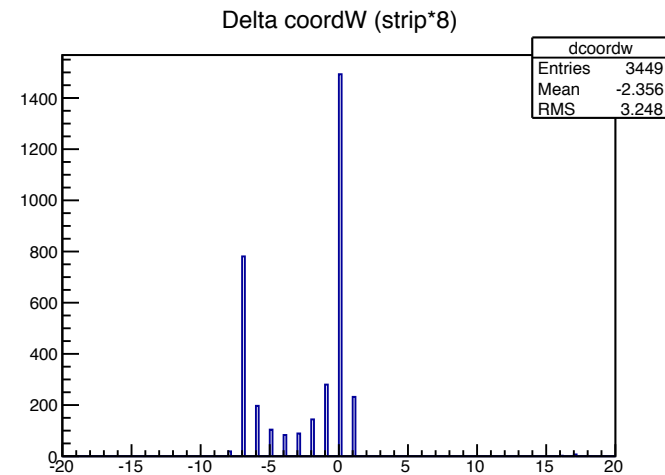
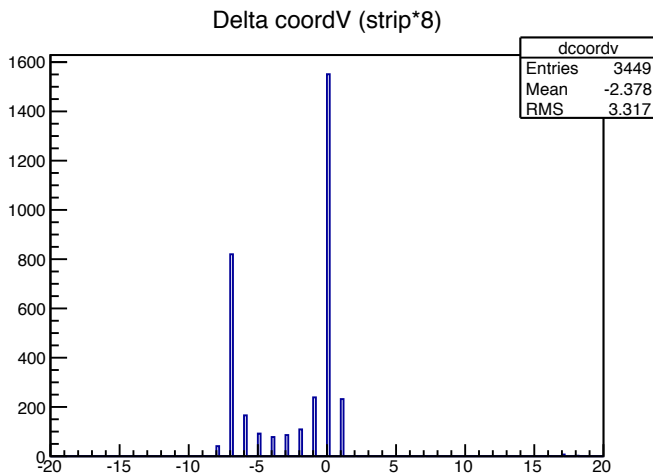
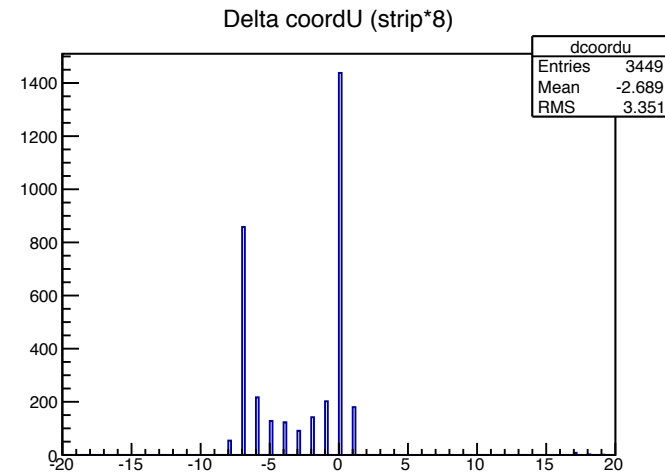
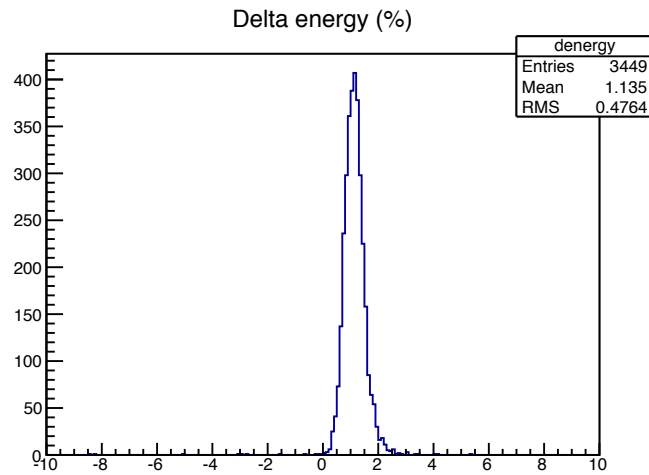
- GEANT-based data files being generated to be used for ECAL/PCAL trigger development (Cole)
- EVIO banks conversion procedures were developed to produce DAQ-like data banks from GEANT banks, and extract necessary information from ECAL/PCAL offline reconstruction for comparison purposes (Sergey)
- ECAL/PCAL offline reconstruction banks were modified by adding extra information (U-V-W coordinates) to make possible direct comparison with trigger results (Gagik)
- ECAL cluster finding and energy correction algorithm was developed, implemented in C and synthesized using Vivado HLS tool (Cole, Sergey)
- ECAL trigger output was compared with offline reconstruction (5GeV electrons, no PCAL) and shows good agreement (see following slides)
- Current version of ECAL trigger algorithm is ready for hardware implementation (Ben), several iterations will be needed
- Work started on PCAL trigger
- Work started on Drift Chamber road finding dictionary (Dave Heddle)



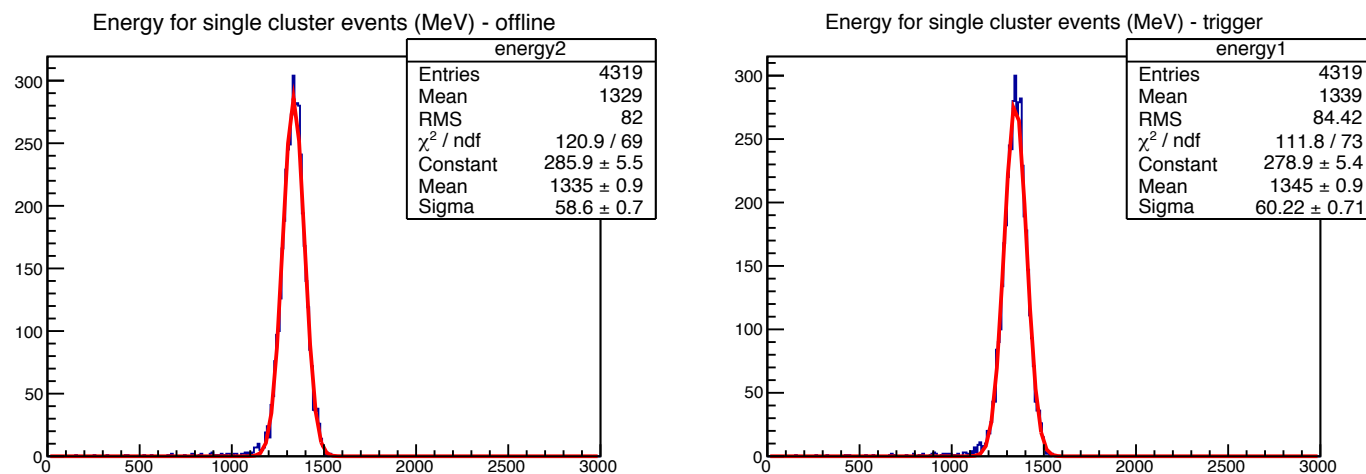
# ECAL cluster finding: difference offline-trigger model (using dividing in coordinate calculation)



# ECAL cluster finding: difference offline-trigger model (using lookup table in coordinate calculation)



# ECAL cluster finding: 5GeV electron, no PCAL, energy deposition in offline and trigger model



Sampling fraction 27%



# Vivado High-Level Synthesis (C to VHDL)

## Performance Estimates

### ▣ Timing (ns)

#### ▣ Summary

Clock	Target	Estimated	Uncertainty
ap_clk	4.00	3.48	0.50

### ▣ Latency (clock cycles)

#### ▣ Summary

Latency		Interval		Type
min	max	min	max	
298	298	18	18	function

#### ▣ Detail

##### ▣ Instance

##### ▣ Loop

## Utilization Estimates

### ▣ Summary

Name	BRAM_18K	DSP48E	FF	LUT
DSP	-	-	-	-
Expression	-	-	0	3
FIFO	-	-	-	-
Instance	381	222	196206	223399
Memory	-	-	-	-
Multiplexer	-	-	-	858
Register	-	-	4133	-
Total	381	222	200339	224260
Available	2360	2880	692800	346400
Utilization (%)	16	7	28	64

## CLAS12 Trigger: Drift Chamber hit-based segments

Segment angle (-45..+45deg)

```
7> -----
6> -----X X-----
5> -----X XX-----X-----
4> -----XX-----XX-----
3> -----XXX-----XX-----
2> -----XXX-----XXX-----
1> -----XX-----XX-----
0> -----XX-----XX-----
-1> -----X-----XX-----
-2> -----X-----X-----
-3> -----X-----XX-----
-4> -----XX-----X-----
-5> -----X-----
-6> -----XX-----
-7> -----X-----
-8> -----
```

Hardware  
Trigger

```
7> -----
6> -----
5> -----X-----
4> -----XX-----
3> -----XX-----
2> -----XXX-----
1> -----XX-----
0> -----XX-----
-1> -----XX-----
-2> -----X-----
-3> -----
-4> -----
-5> -----
-6> -----
-7> -----
-8> -----
```

Modeling

Wire number (112..1)

## Remaining Work

- VTP trigger board: first board studies, 25 boards installation and commissioning
- VTP/SSP/GTP boards trigger algorithms development: ECAL/PCAL/DC models, hardware implementation
- DAQ & Trigger electronics commissioning on Forward Carriage and Pie Tower
- Space Frame DAQ electronics installation: remaining crates, boards, cabling, configuration
- Whole DAQ & Trigger System commissioning



## Conclusion

- Main priority is trigger boards algorithms/programming: work in progress, finishing first model (ECAL) and starting testing in hardware, following by PCAL, Drift Chamber and ECAL+PCAL+HTCC decision
- Significant part of hardware (DAQ on Subway and Space Frame) still in installation stage, depends on other activities in the Hall, completion time cannot be set as that moment; good news is the all electronics is running in test setups
- Following months will be used to develop and install trigger system, and perform DAQ+Trigger commissioning for outer detectors