SRO for CLAS12

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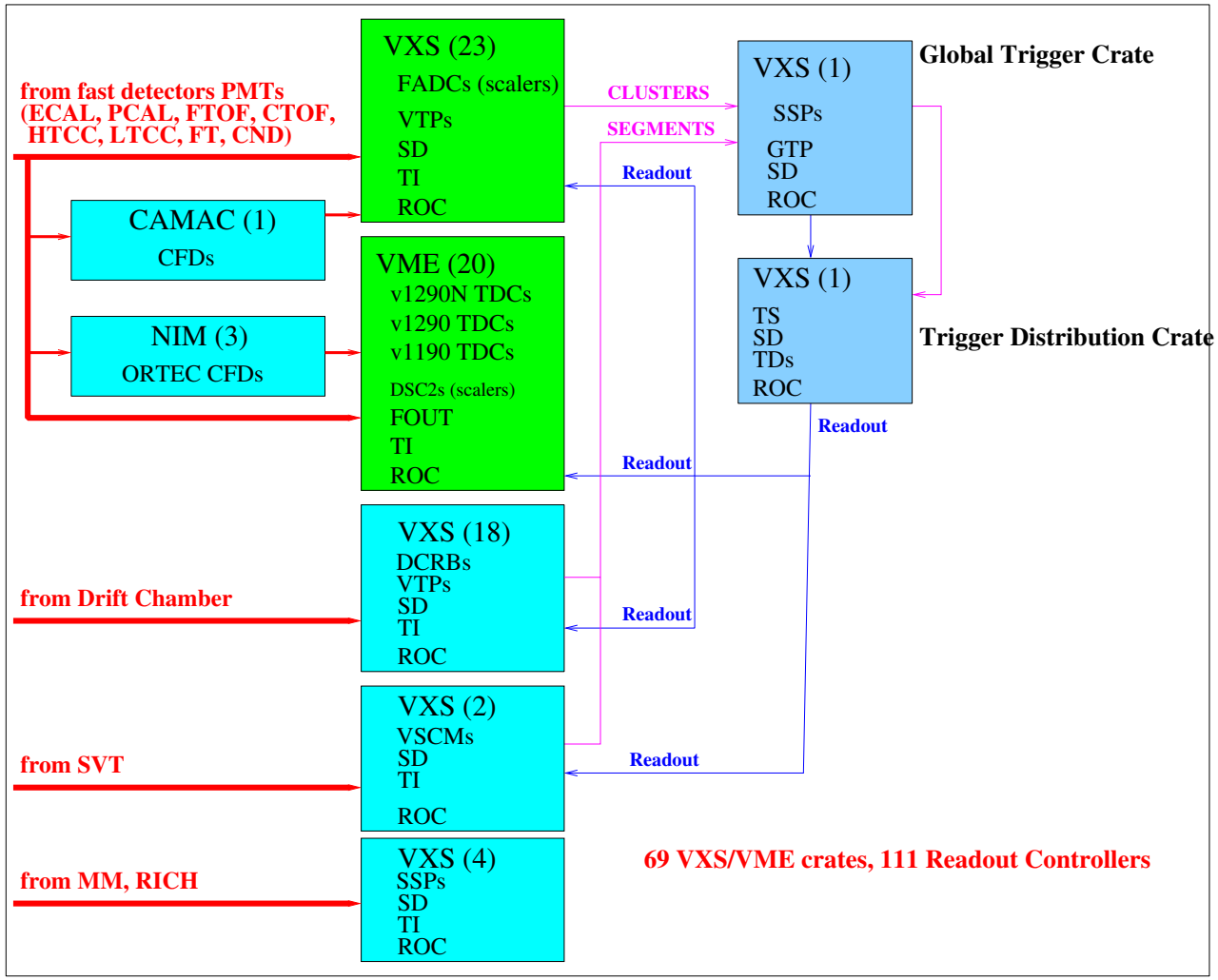
Work scope and timeline

- Implement streaming readout for Forward Tagger (Nov 2019 – Jan 2020)
- Take beam data with FT (Feb 2020)
- Continue streaming readout development in communication with other groups (current)

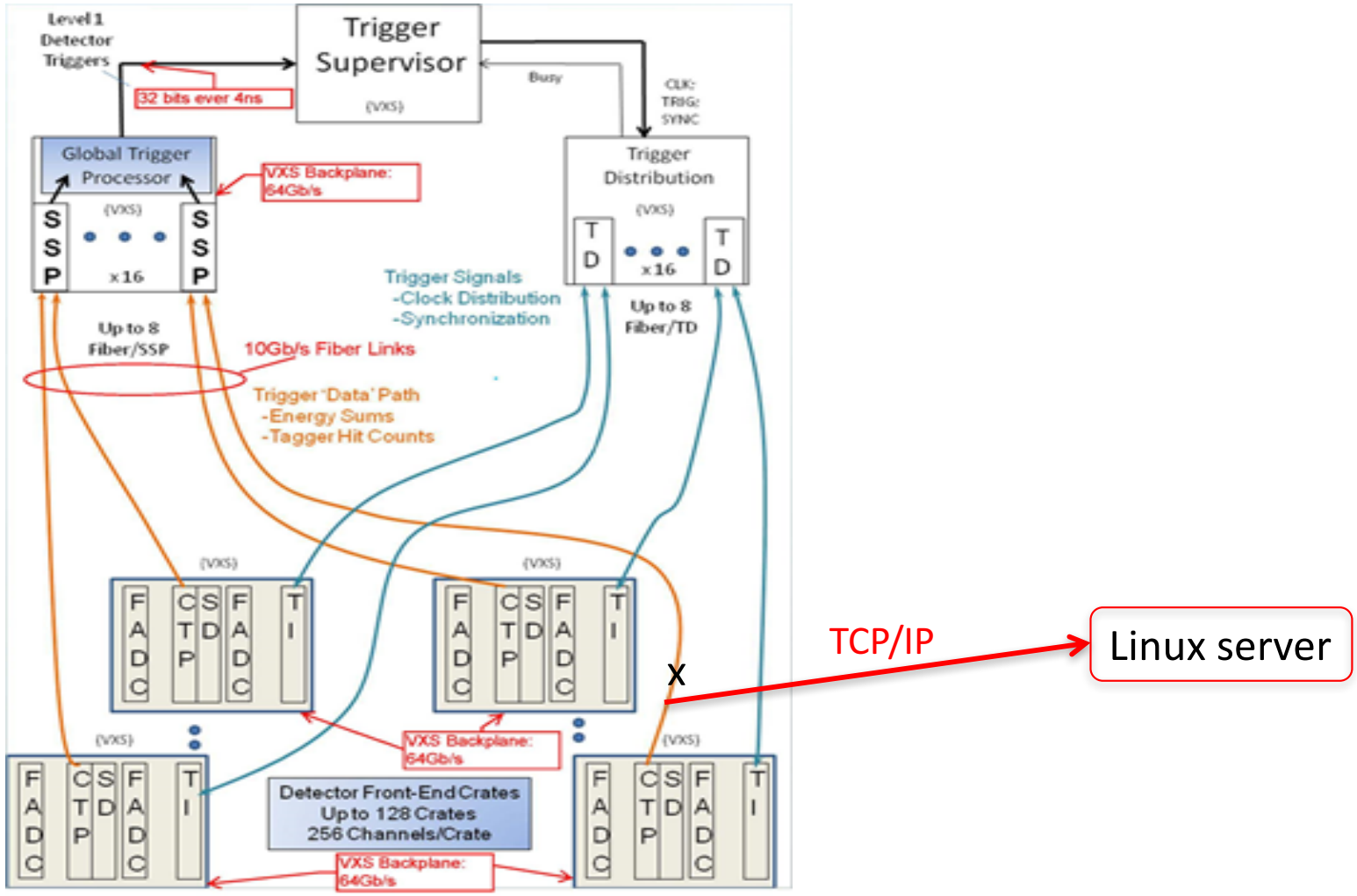
Solution

- Convert VTP (VXS Trigger Processor board) into streaming readout board
- Modify CODA software to move from Event Builder – based model to streaming one
- Make CODA to supply data to streaming back-end framework (TriDAS)
- NOTE: VTP-based streaming readout is NOT CLAS12 long term upgrade plan, it will be decided later based on the development over next few years

CLAS12 DAQ/Trigger Hardware Diagram

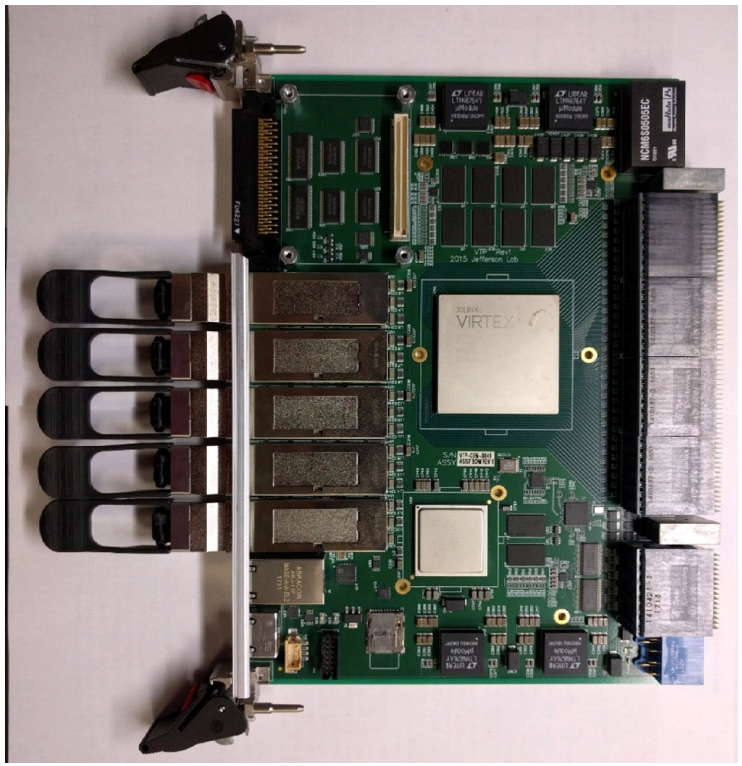


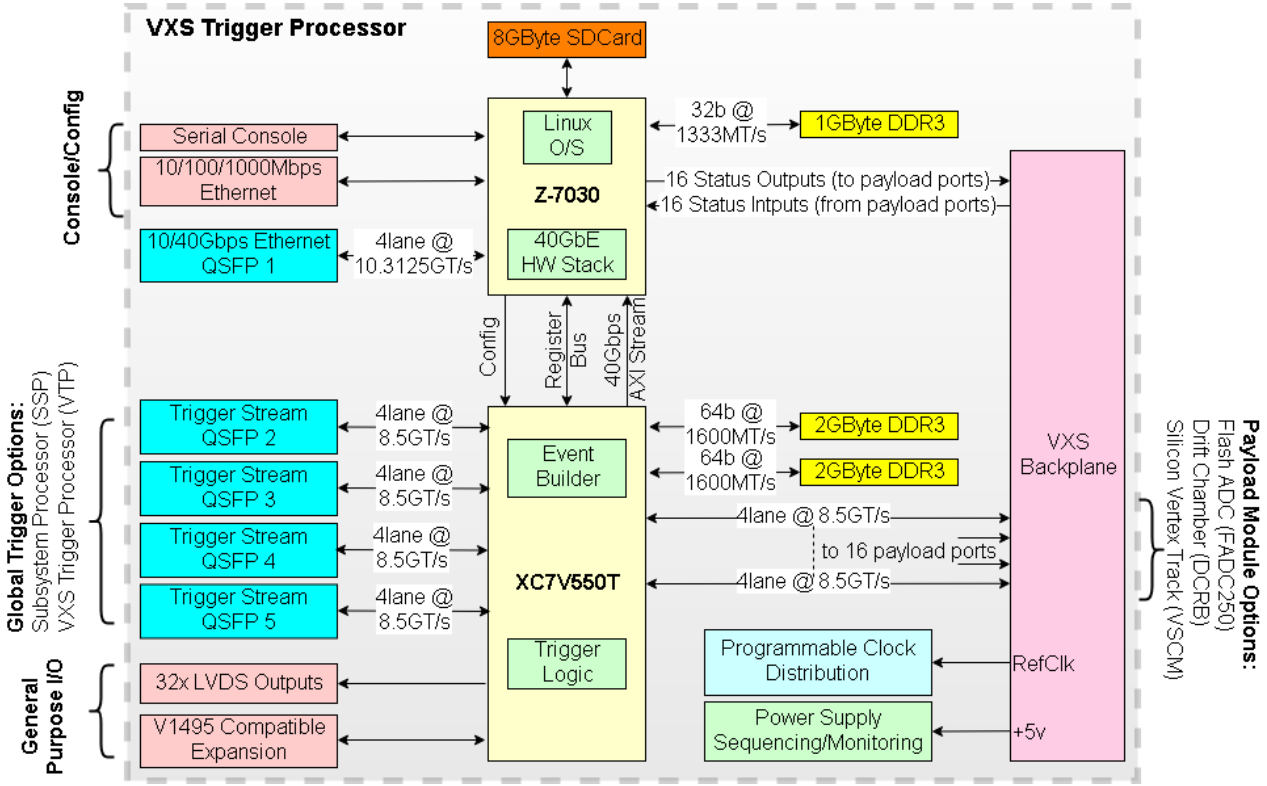
Using VXS crates with VTP boards for streaming readout



- In existing trigger-based mode, all FADCs sends trigger information to VTP, which sends it to the following trigger system stage; FADC readout is performed by VME controller over VME bus
- In streaming mode, there is no trigger information, and FADC readout is performed by VTP

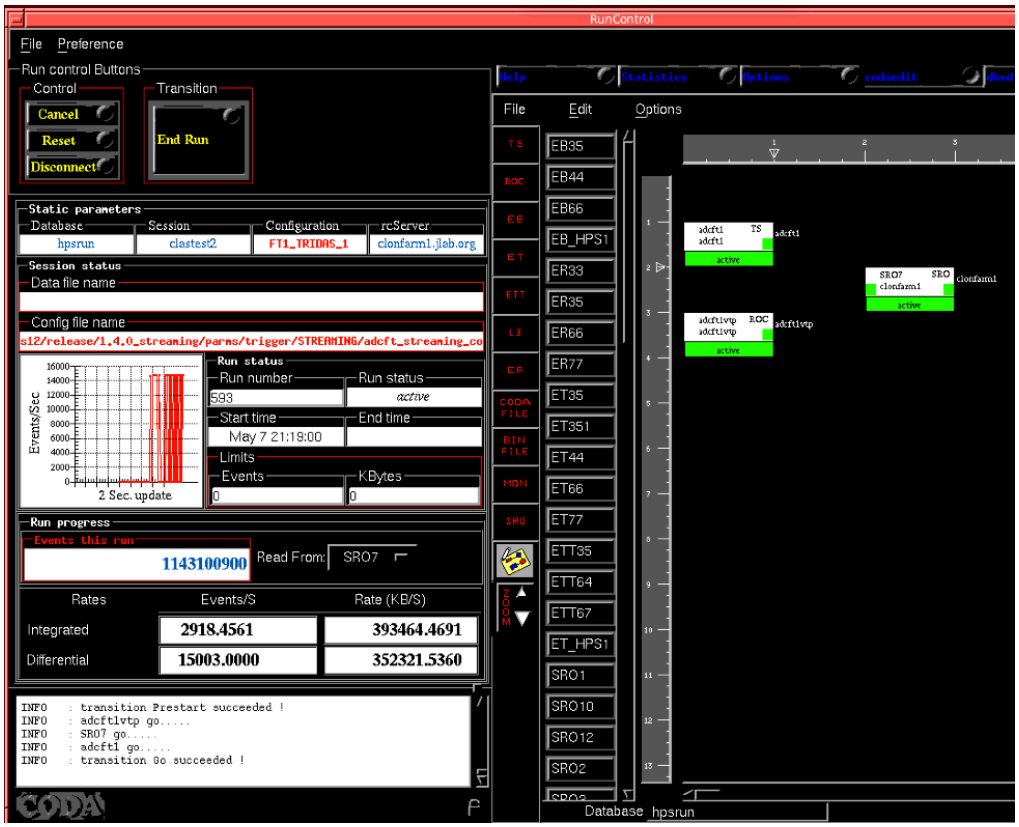
Upgrading VTP board for streaming readout

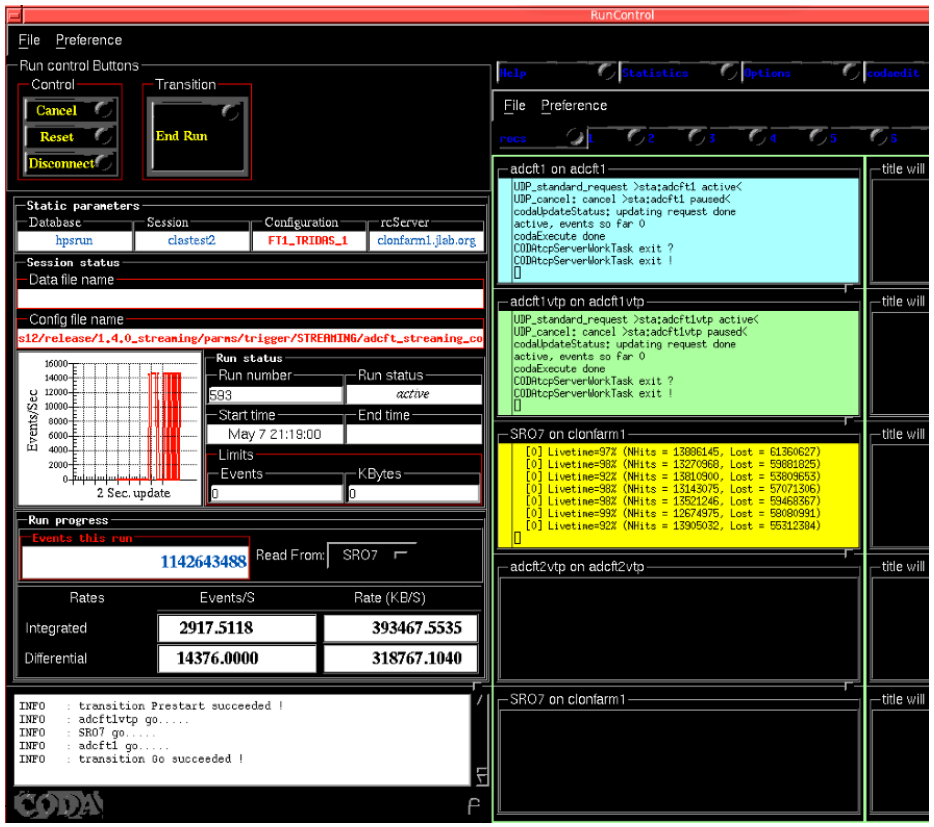




- In existing trigger-based mode, VTP sends trigger information from QSFP1 to the following trigger system stage
- In streaming mode, VTP sends stream of data from QSFP1 to Linux server with expected bandwidth 2 x 10Gbit/s link (bandwidth can be increased by using additional QSFP lanes)
- New firmware was developed
- FPGA based TCP/IP protocol is used between VTP and Linux server

Upgrading CODA software for streaming readout

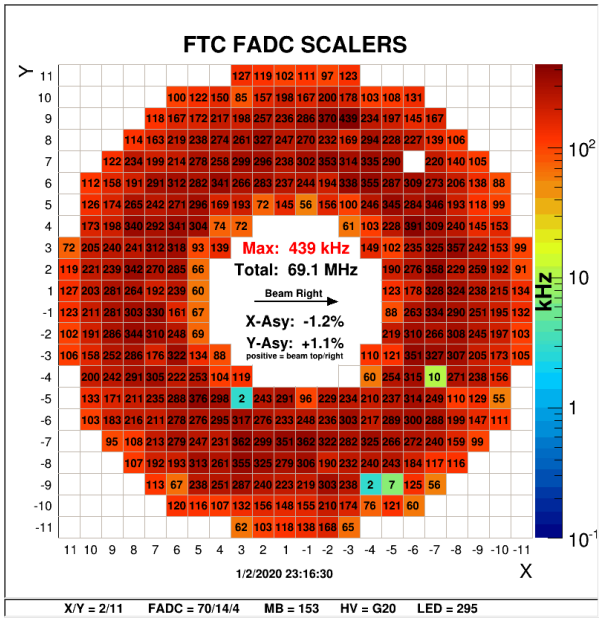




Pictures shows running streaming daq for single stream (half of VXS crate) from FTCAL

- VME ROL (readout list) was modified for streaming mode
- New VTP ROL was implemented for streaming mode
- New CODA component type SRO was implemented to replace traditional EB-ET-ER backend
- All needed information (host names and port numbers) to communicate with streaming frameworks (like TriDAS) is placed into database and json configuration file

Forward Tagger in streaming readout



FTCAL (1st half)

adcft1 | VTP

FTCAL (2st half)

adcft2 | VTP

FTHODO

adcft3 | VTP

10GBit

coda_sro component(s)
(processes on Linux server)

Input thread

Circular Buffer1

Circular Buffer10

Output Thread1

Output Thread10

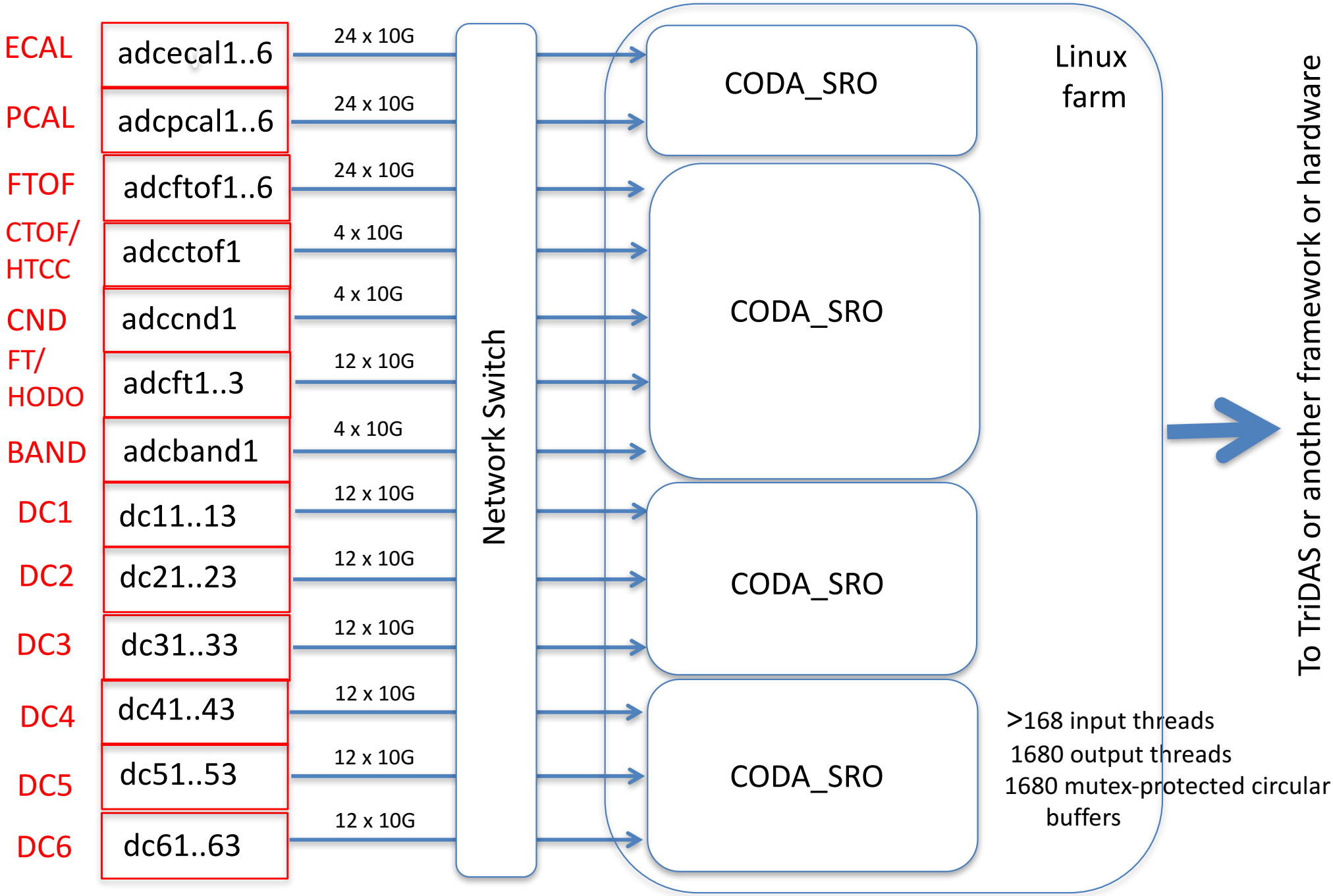
TO TriDAS

6 input threads
60 output threads
60 mutex-protected circular buffers

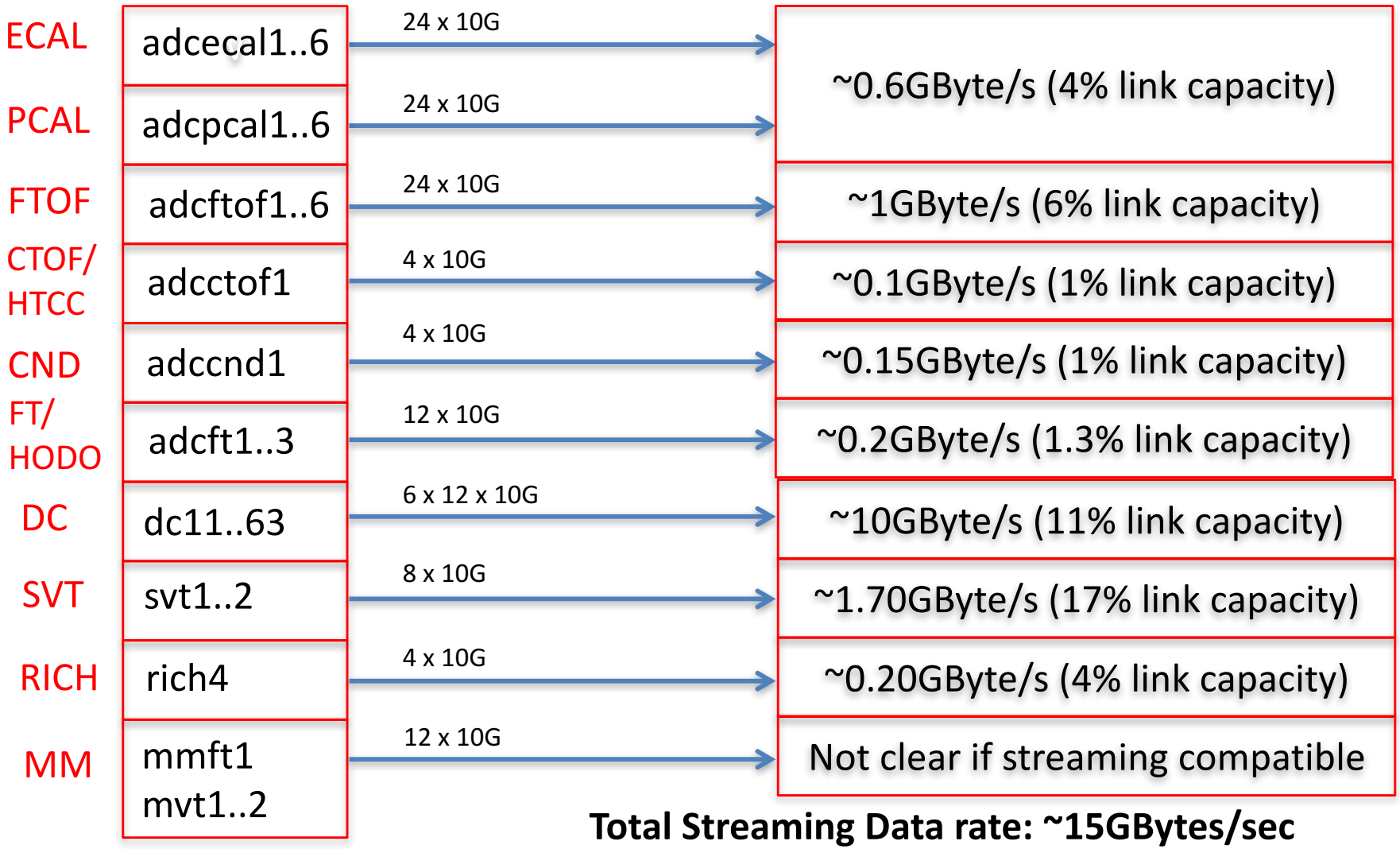
Implementation remarks

- VTP operation is controlled by software running on built-in ARM processor under Archlinux OS.
  - **In trigger-based mode**: data is moving from FPGA to ARM and then sent over 1G link using TCP/IP protocol provided by OS.
  - **It streaming mode**: data sent directly from FPGA so TCP/IP protocol has to be implemented in FPGA for full performance. Low-cost COMBLOCK 10Gbps Ethernet TCP/IP packages were used. It took some time to identify and fix all problems, as result February beam test was running with not quite stable daq. At present time, all known problems are fixed and daq is running for days without crashes. Our efforts are shifted now to performance side to make sure 10G bandwidth per link is fully utilized. Up to 4x 10Gbps per VTP can be used in parallel.
- So-called 'tridas_dummy' component was implemented (based on SRO type), it emulates streaming framework attached to the daq. It can be run as part of CODA configuration or started as standalone program. Initially it was done to check network socket handling on both sides. In future it can be developed into simple testing component to check data consistency if needed.
- We prepared two test setup which are used to develop and test streaming frameworks. One is FT-based and includes 3 VXS crates, it is used by TriDAS team. Another one is based on single VXS crates (test2) located in counting room, it is used by JLAB group (Vardan). More test setups can be prepared if needed.
- Several clon cluster Linux servers were designated for streaming daq development, in particular clonfarm1/2/3 and clondaq3 are used for that purpose. All needed software installed. CLAS12 group will continue to provide full support for streaming development.

Possible CLAS12-based full scale streaming readout test



Possible CLAS12-based full scale streaming data rates (based on CLAS12 RGA 50nA occupancies)



Total Streaming Data rate: ~15GBytes/sec
Data rate in triggered mode: ~300MByte/sec

*Triggered mode records raw FADC waveforms, streaming mode would not – this provides a significant data reduction for fadcs in streaming mode in the comparison, which would satisfy most (if not all) CLAS12 detectors. Raw waveforms could also be recorded in streaming mode, resulting streaming rate would increase significantly: If 100ns waveforms per FADC hit, then streaming total rate would be: ~38GBytes/sec – still not unreasonable

Current Status

- VTP-based front-end part of streaming DAQ is operational, two test setups are running
- Based on equipment available in CLAS12, bigger test setups can be configured with reasonable time scale and expenses (estimate: up to 6 month, $100K-$200K equipment), up to full scale setup with 42 VXS crates involved with data rate on the level of 100GByte/s
- We are working with streaming back-end developers providing testing environment