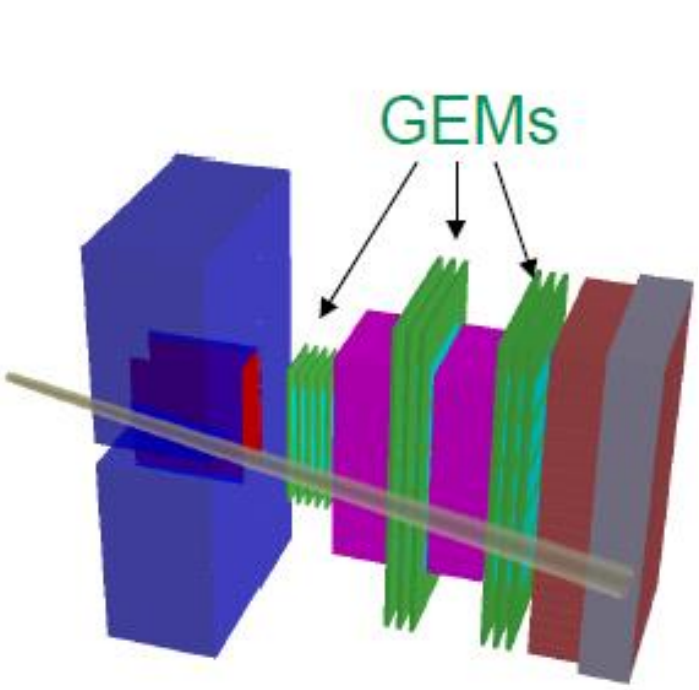
SBS DAQ lessons/status

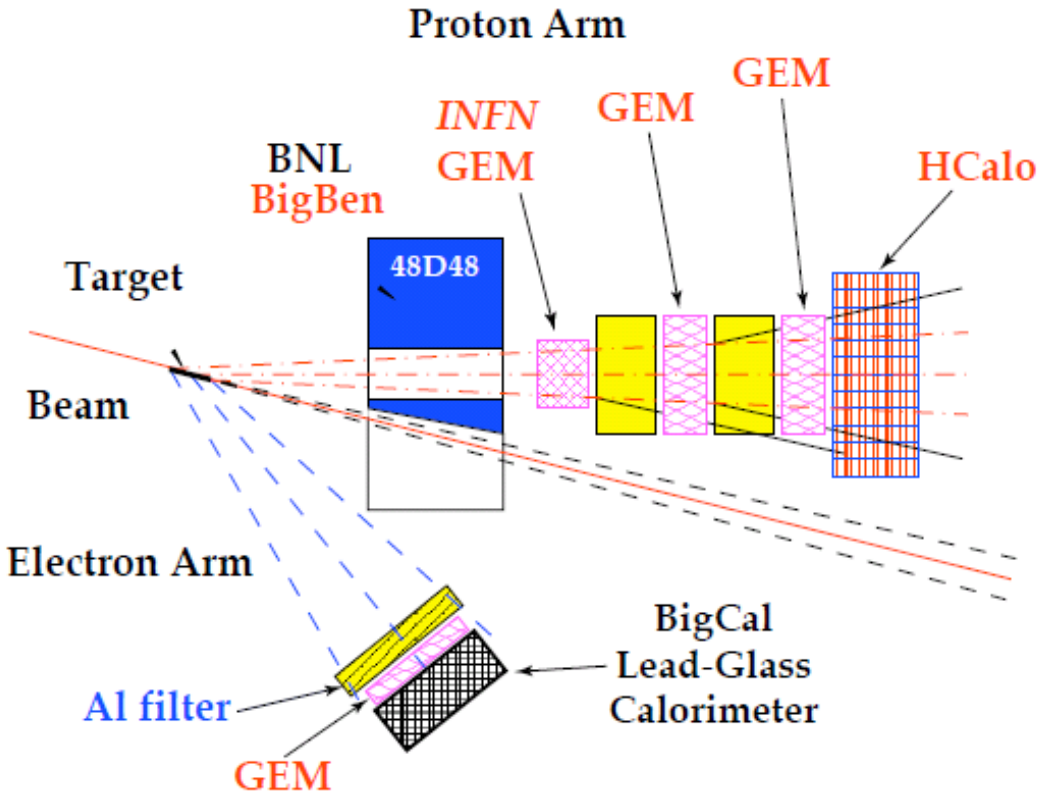
September 12th 2024

SBS collaboration meeting

Alexandre Camsonne

SuperBigbite Spectrometer
Focal Plane Polarimeter setup





Lessons learned from previous experiments

- GMn
  - 1 st experiment
  - Lots of debugging at beginning with new system
  - Inefficiency of HCAL F1 TDC (suggest full replay on farm while experiment running) – Thresholds were too low on discriminators
  - GEM worked but many DAQ crashes : implemented many diagnostics in end of run to locate APV errors
  - Up to 700 MB/s with one event recorder
- GEnII
  - Power balancing issue between phases in bunker
  - 2nd experiment : BB GEMs pretty stable
  - Implementation DAQ with 3 streams give 2 GB/s capability all software adapted to use the future
  - Tried implementation of SBS GEMs in parasitic
    - 1st INFN chamber had issues with electronics, not clear why (maybe magnetic field)
    - SBS GEMs fairly unstable so where often taken out from readout – Most likely not as much time for debugging as BigBite and large number
    - GUI for rebooting GEMs
- Gen RP
  - Issue with GEMs at beginning : tried to run DAQ with lower threshold
  - Trigger inefficiencies mainly because of HCAL HV too low (some block noisy at higher)
  - Trgger rate maxed out at 4 KHz : bottle neck VTP first layer (spread out layers across VTP crates)
  - DAQ unstable above 4 KHz and with radiator
    - Suspect single event upsets in MPD : will reload firmware of MPDs at each run
    - Additionnal shielding might be helpful (might be more stable with hydrogen than deuterium target)
    - Some MPD optical transceiver might have suffered from radiation damage
  - SBS arm more stable during Gen RP more time for cabling and debugging
  - 2 or 3 down time for LV connector melting

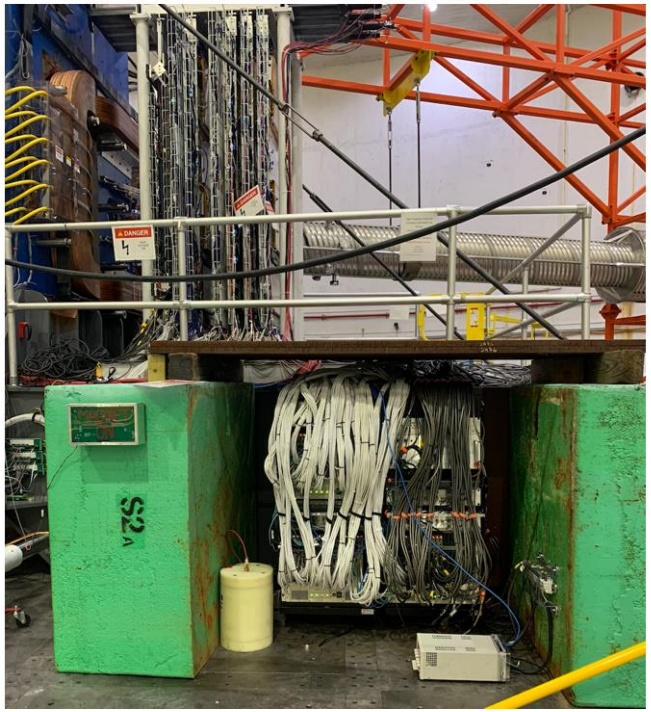
Conclusion : DAQ working – Gen RP with large number of channels

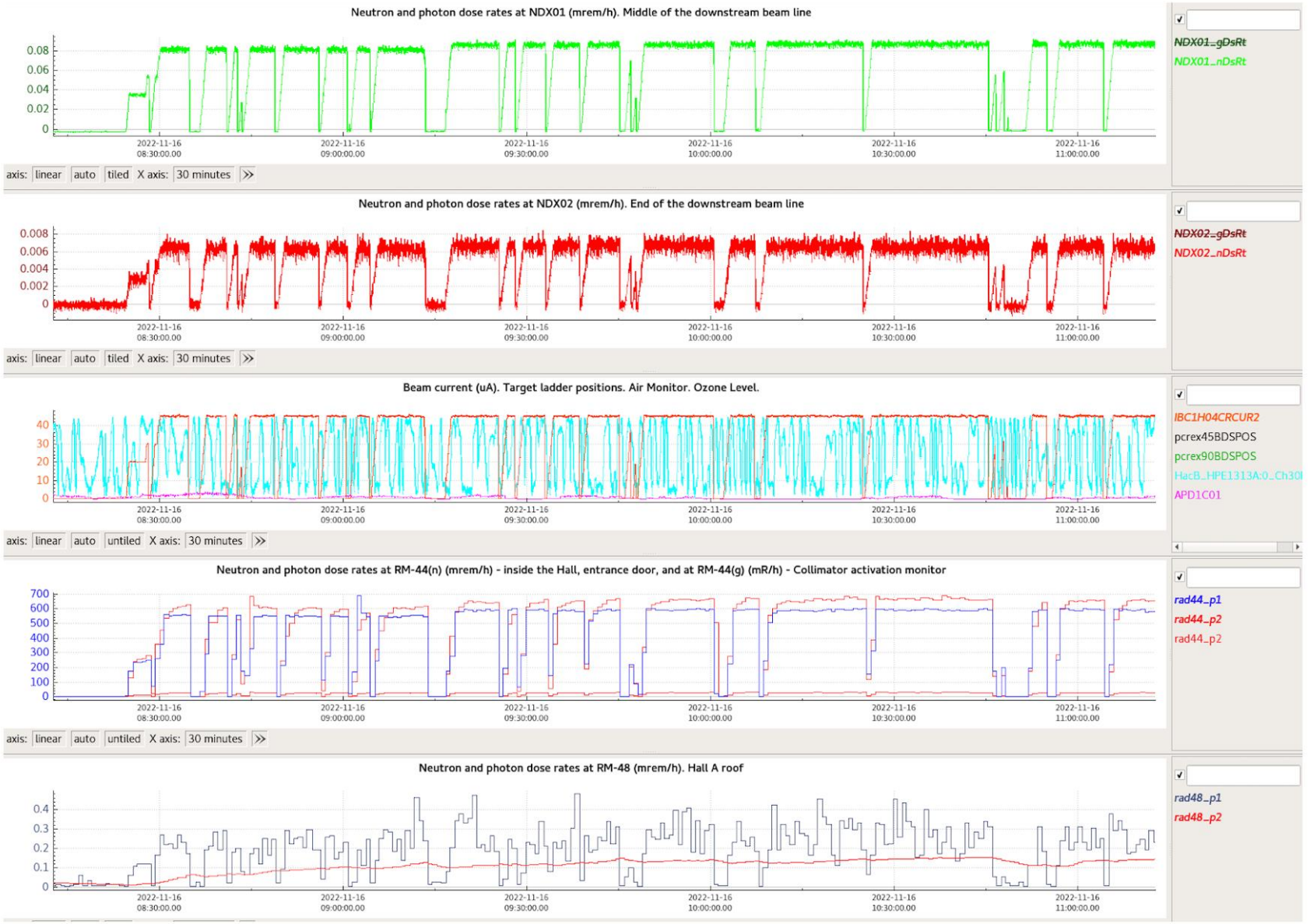
Radiation at the SBS bunker

80 mrem/hr at 40 uA beam
(100 mrem/hr at same current in BB bunker)

Maximum in GMn, sbs-14, 180 mrem/hr at 10 uA

250 mg/cm^2 material in beamline
-> x9 in GEp





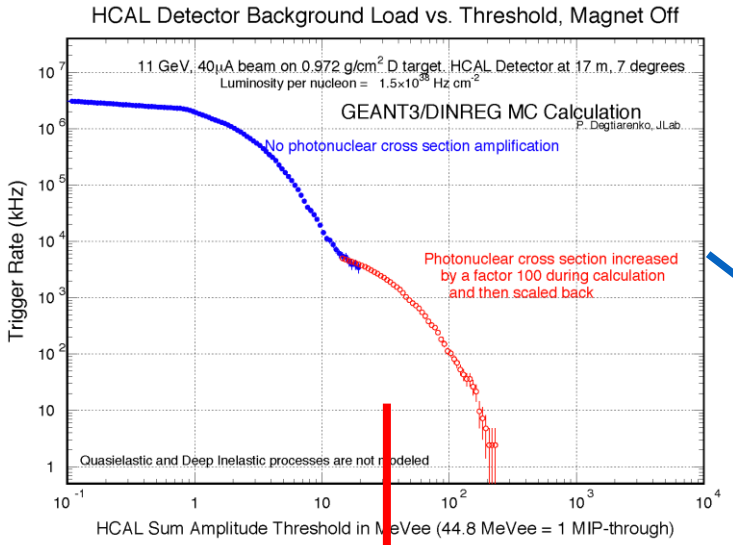
Jefferson Lab

Calorimeter Rates

(CDR section 5.1.7) Most demanding

HCAL

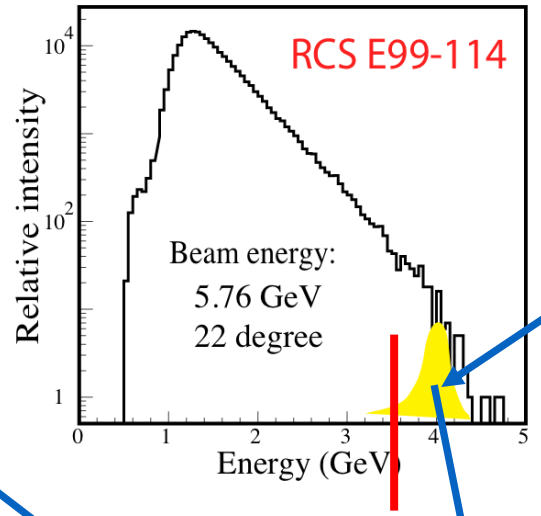
Hadron rate estimate using SLAC & DESY data, Wiser code:
w/4.5 GeV threshold: ≈ 1.5 MHz



Background rate vs. cut on deposited energy (MC studies in progress)

ECAL

From Hall A Real Compton Scattering experiment



NB: Good resolution ≈ 16%/√E

Electron rate estimate w/2.5 GeV threshold (73% of E_{elas}): ≈ 200 kHz

≈ 9 kHz coincidence rate w/ 30 ns window

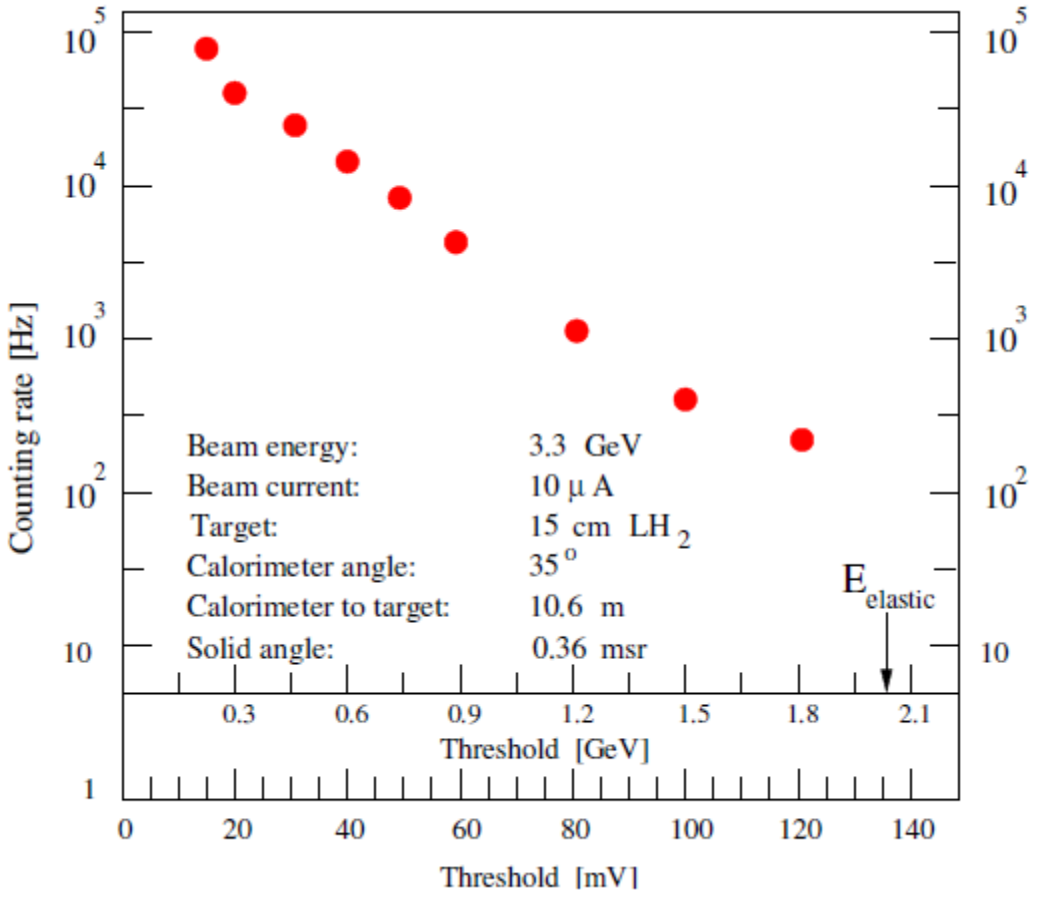
DAQ concept

- Hybrid Fastbus and pipelined electronics
- Level 1
  - ≈100 ns latency by analog summing and discrimination
  - Generated by electron arm (≈200 kHz rate)
  - Use module flipping scheme to reduce front end deadtime
  - Gate for Fastbus & non-pipelined VME for BigCal
- Level 2 : coincidence proton in HCAL (1.5 MHz) and electron in ECAL
  - Assume up to ≈1.8 µs latency (L2 800 ns max + Fast Clear 1 µs)
  - 9 KHz with 30 ns coincidence windows
  - FPGA-based coincidence logic using geometrical constraints reduction by factor 5

    ≈ 2 kHz physics DAQ rate

  - Fast Clear FB & VME after L2 timeout ⇒ ~ 13% Electronics Dead Time

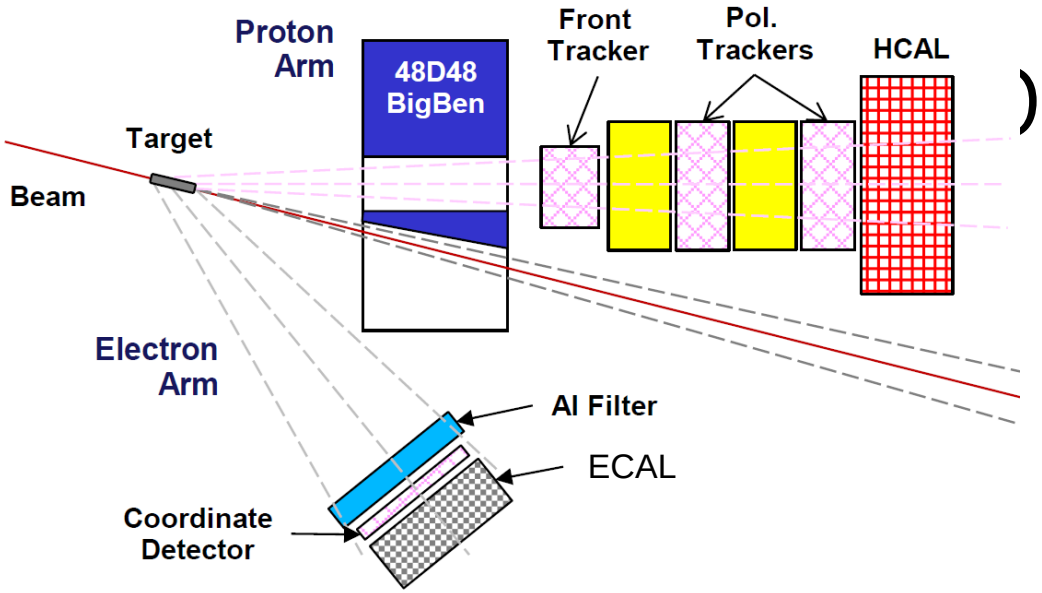
Electromagnetic calorimeter BigCal readout



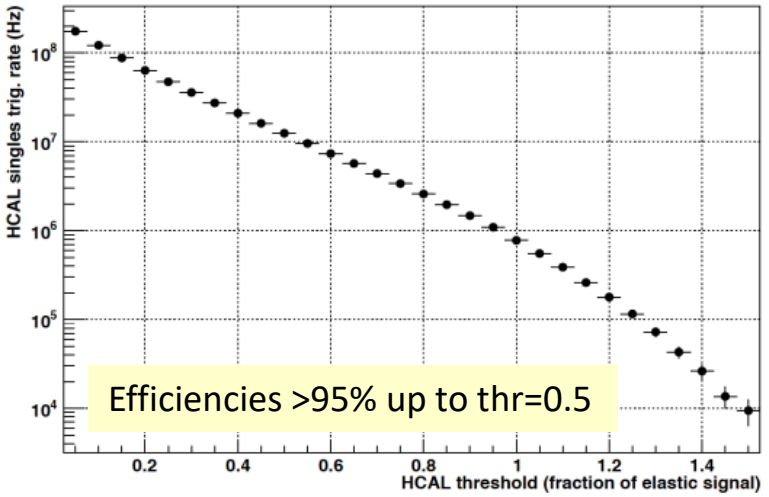
E_{thr}/E_{max} %	50	73	85	90
Rate, kHz	1400	203	60	38

2.5 sigma cut
Calorimeter BigCal resolution
16 %/sqrt E

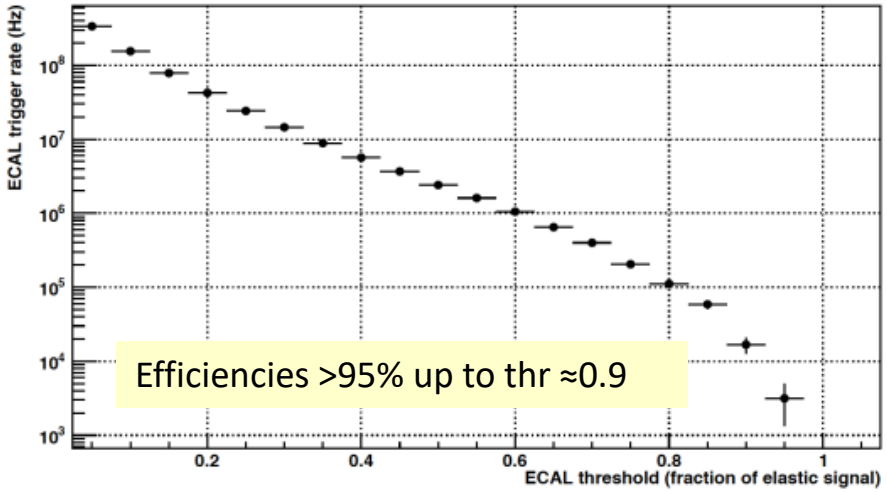
GE



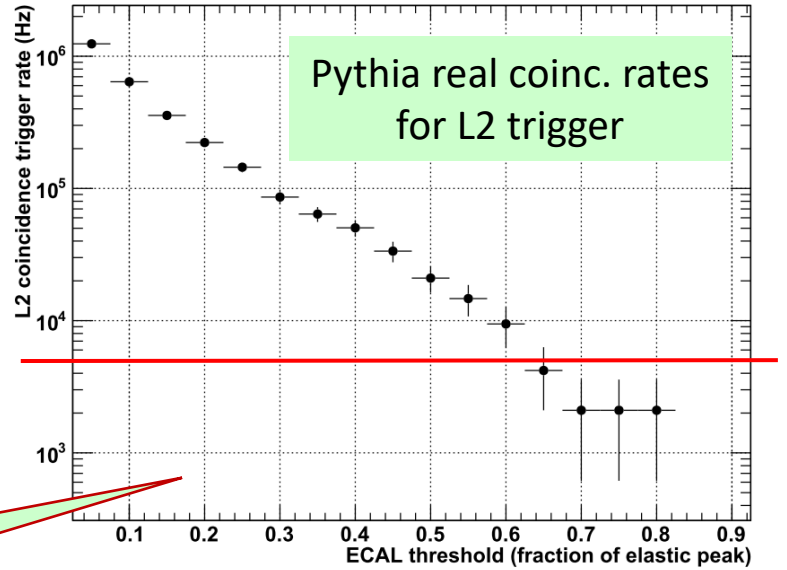
HCAL Singles: SLAC+DESY data in Wiser Code



ECAL Singles: from tuned GEANT4



HCAL threshold = 50% of elastic peak



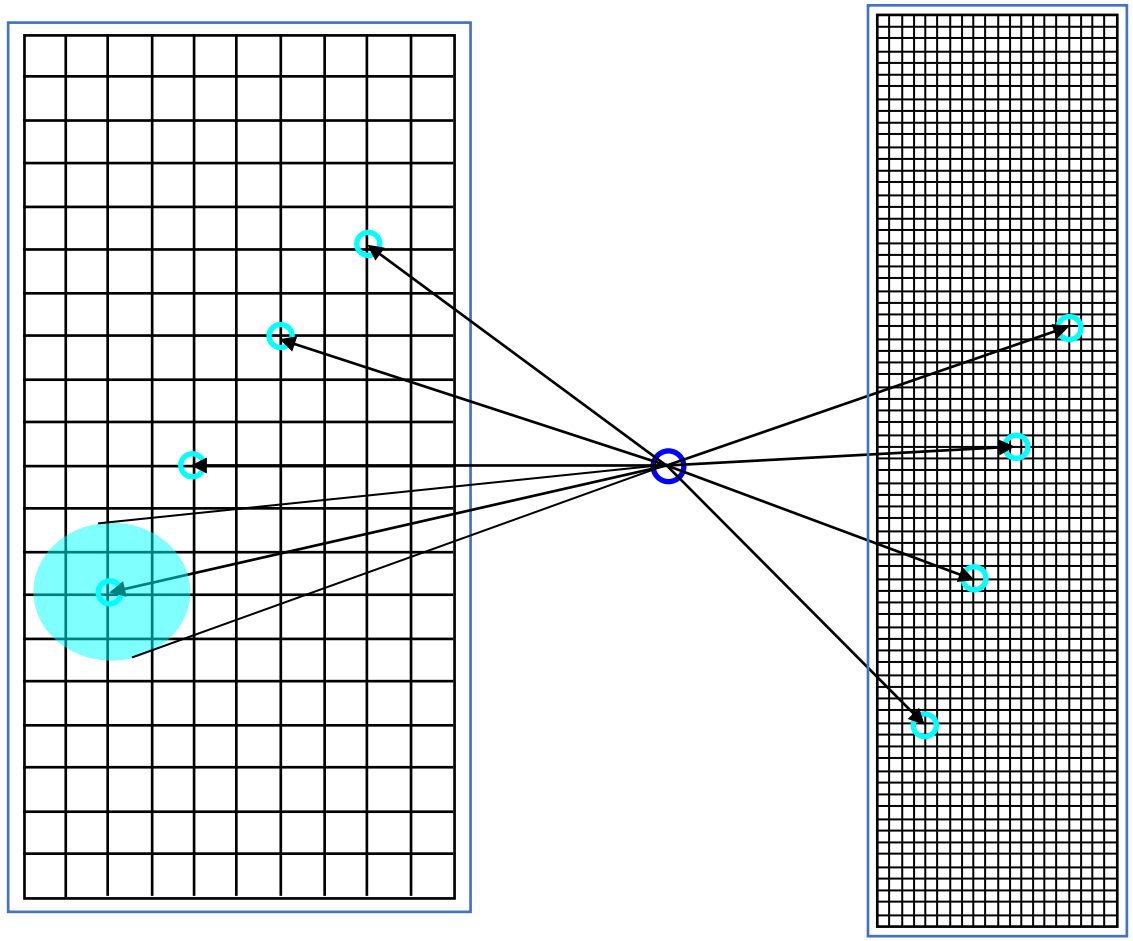
Expected Coincidence Rate (L2) up to **5 kHz** (including accidentals)

(CDR section F.3)

e’-p Kinematic Correlation

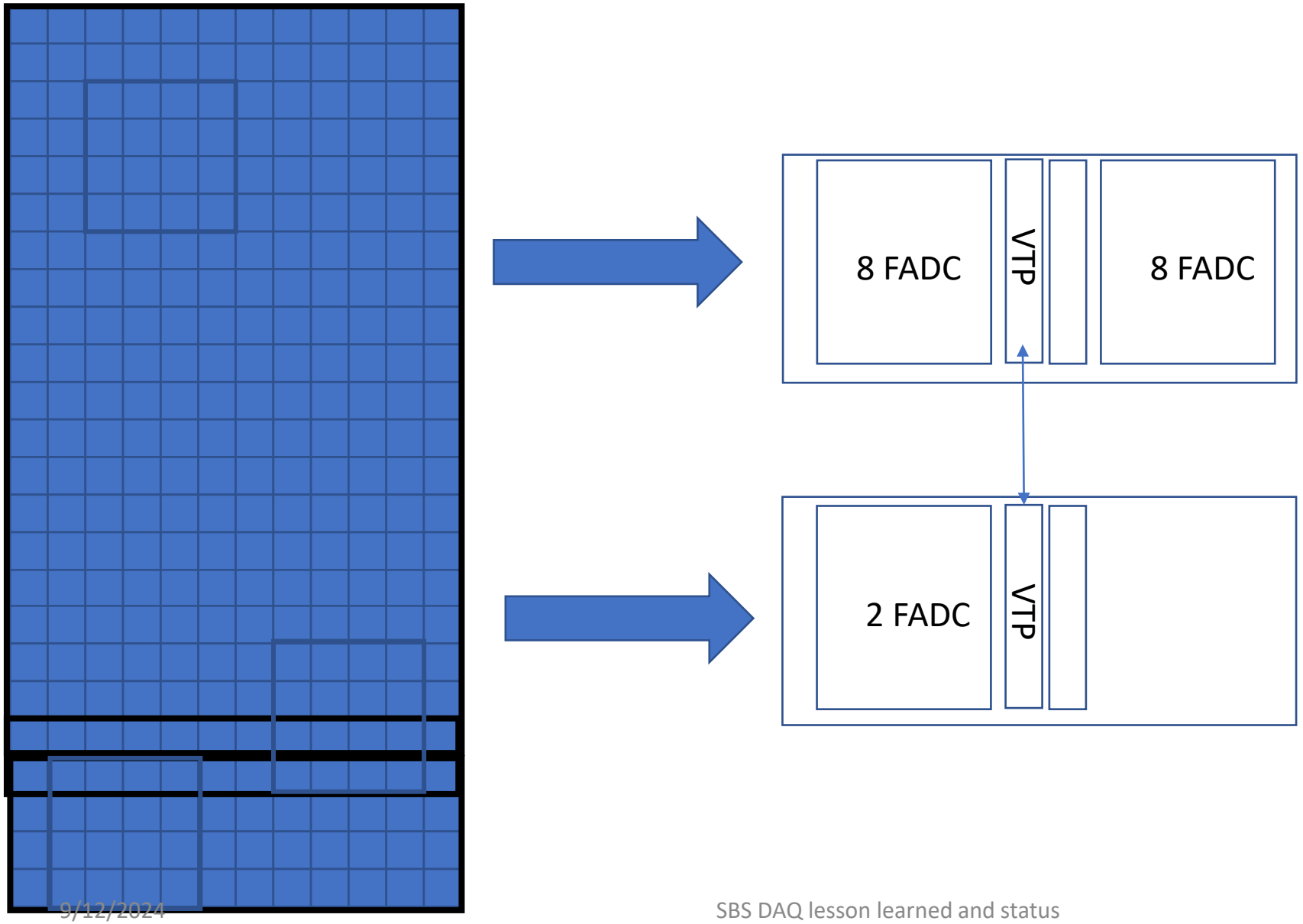
11 x 22 HCAL blocks

20 x 76 ECAL blocks



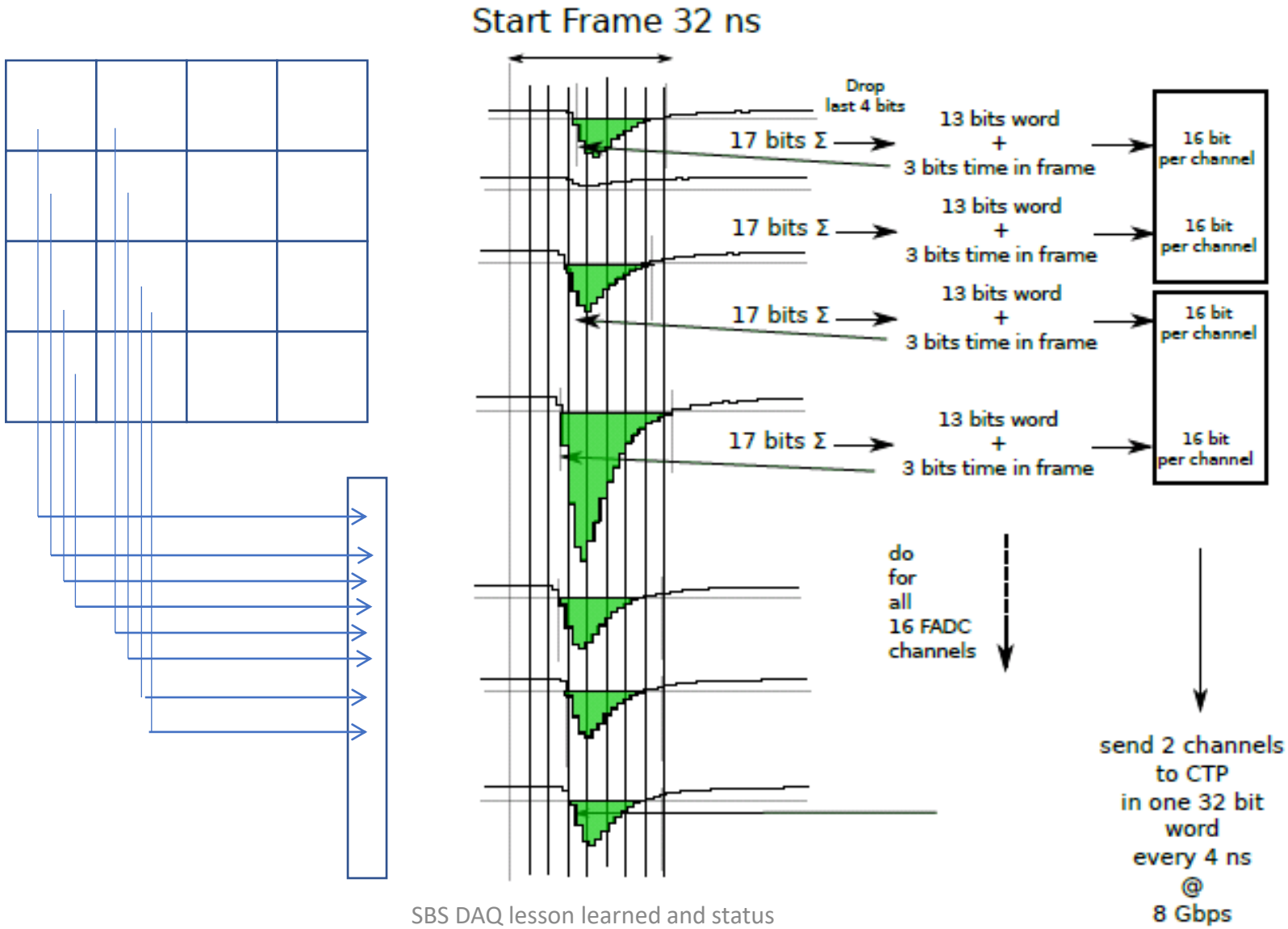
Using geometric correlations from elastic kinematic one can reduce final rate by a factor of 5 and tracker data by at least a factor of 3

SBS HCAL



- 12 x 24 = 288 blocks
- 2 VXS crates
- 18 FADCs
- 2 VTP
- Transfer blocks at crate interface through 10 Gbps optical link

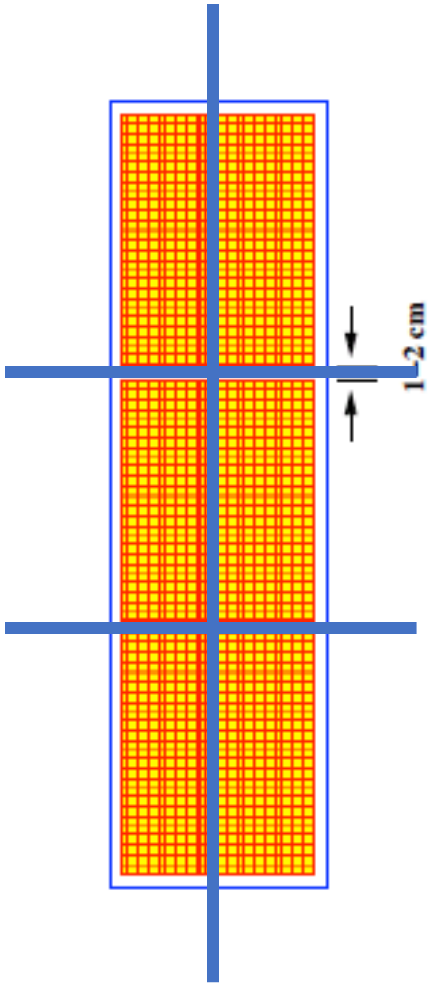
Clustering HPS like

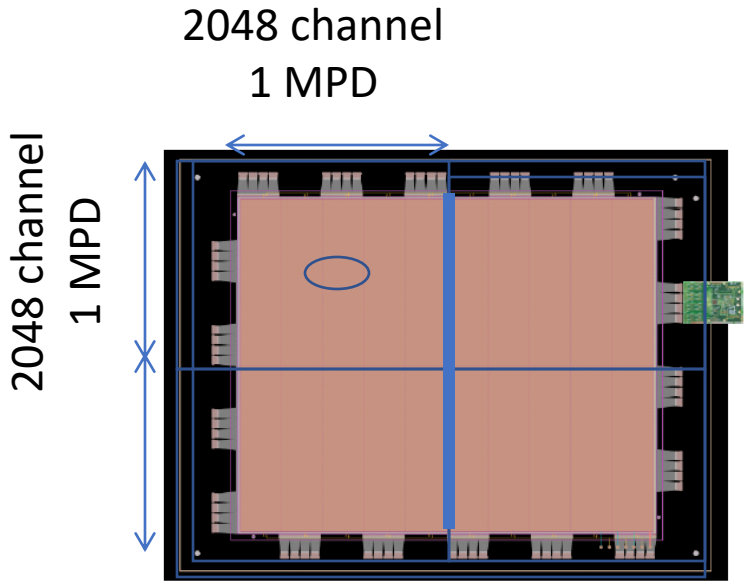


SBS HCAL trigger status

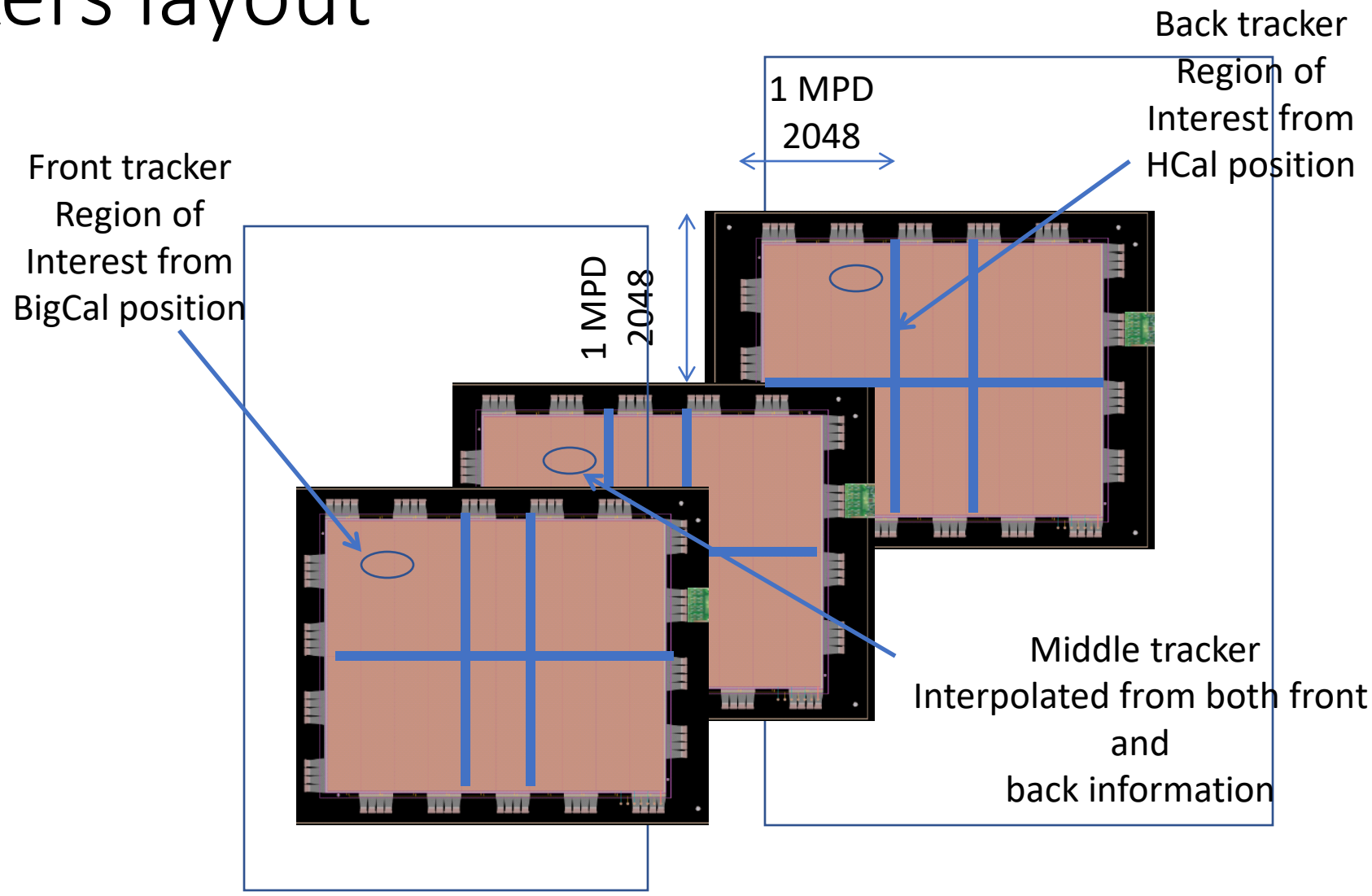
- Single crate 4 x 4 blocks cluster trigger implemented
- Clustering on two crates to be implemented
- Same algorithm for ECAL with 3x3 or 5x5 sums trigger

Front Tracker layout

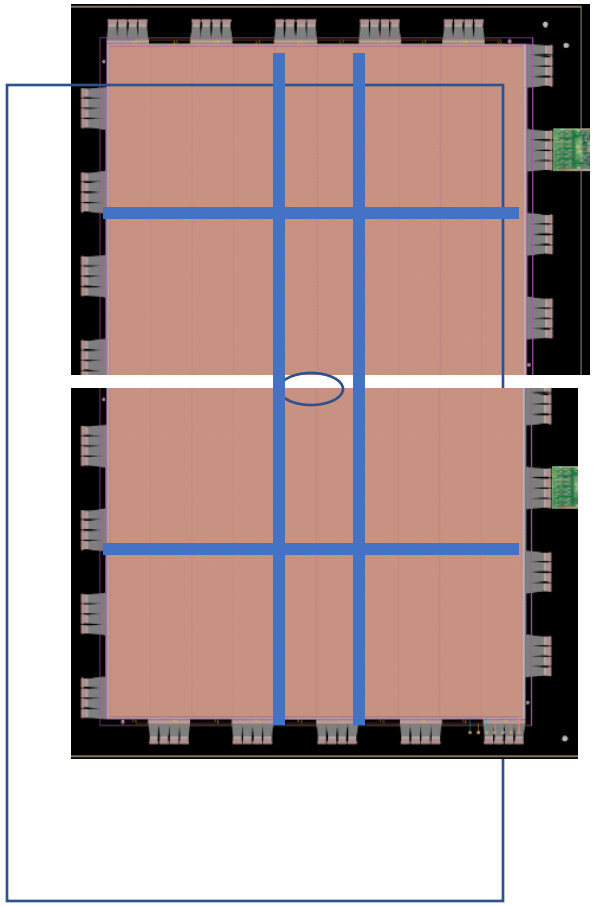




Trackers layout

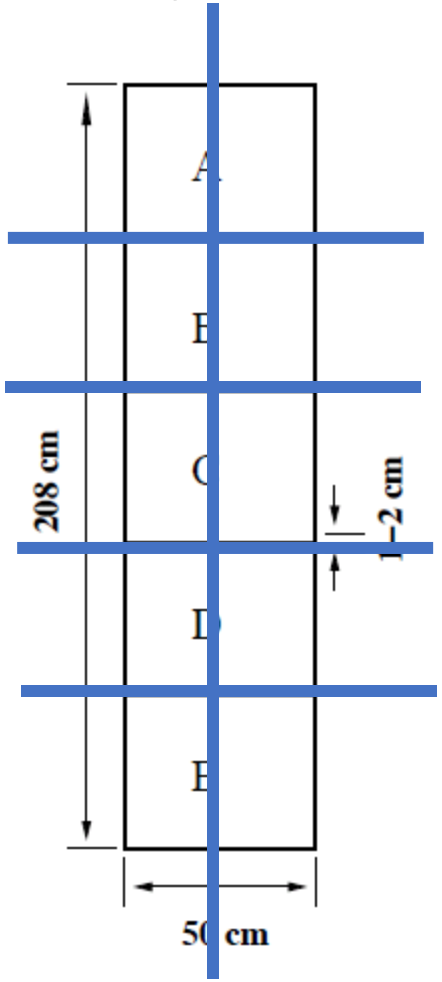


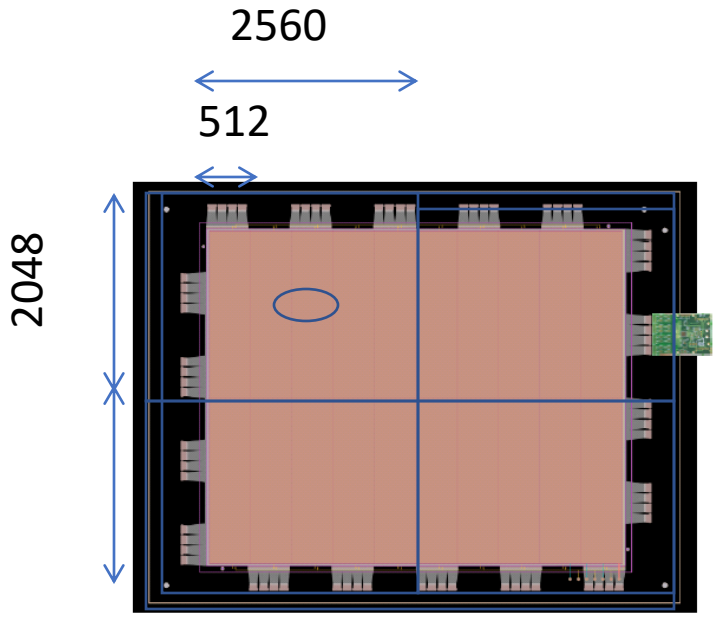
Trackers layout



Worst
case
configuration

FPP Tracker layout





GEMs Gep5 to do list

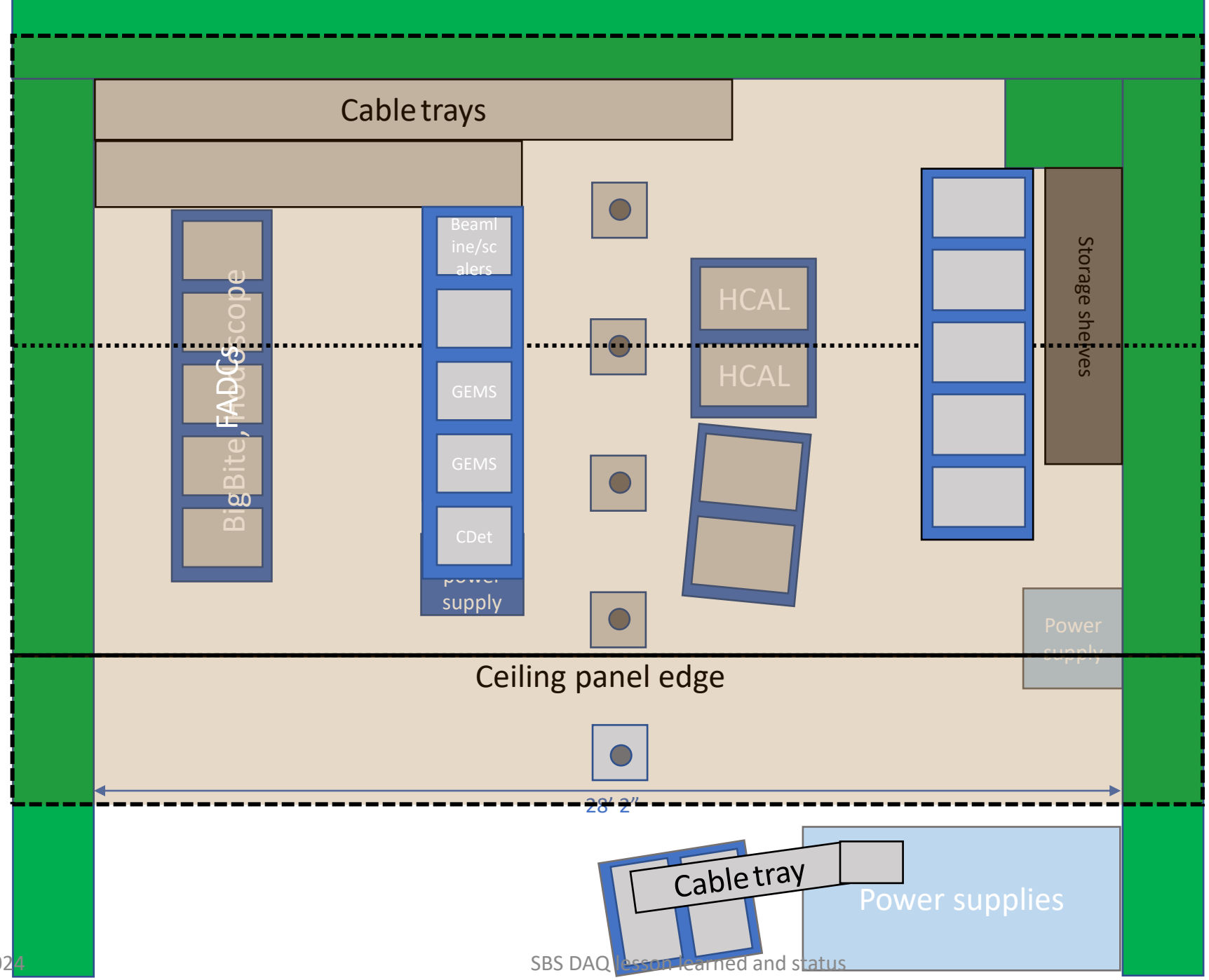
- Implement firmware with region of interested based on calorimeter information
- Histogramming method common mode suppression

- Should be ready for cosmics in a few weeks

Ecal readout

- 1656 calorimeter channels
  - Bigbite : 256 channels
  - 1400 channels
    - FADC250 : 1400 /16 = 88 modules = 6 VXS crates
  - Order for physics electronics :
    - 104 FADCs
    - 32 VTPs
    - 32 VXS crates
  - Should cover Gep5 Ecal even with NPS running

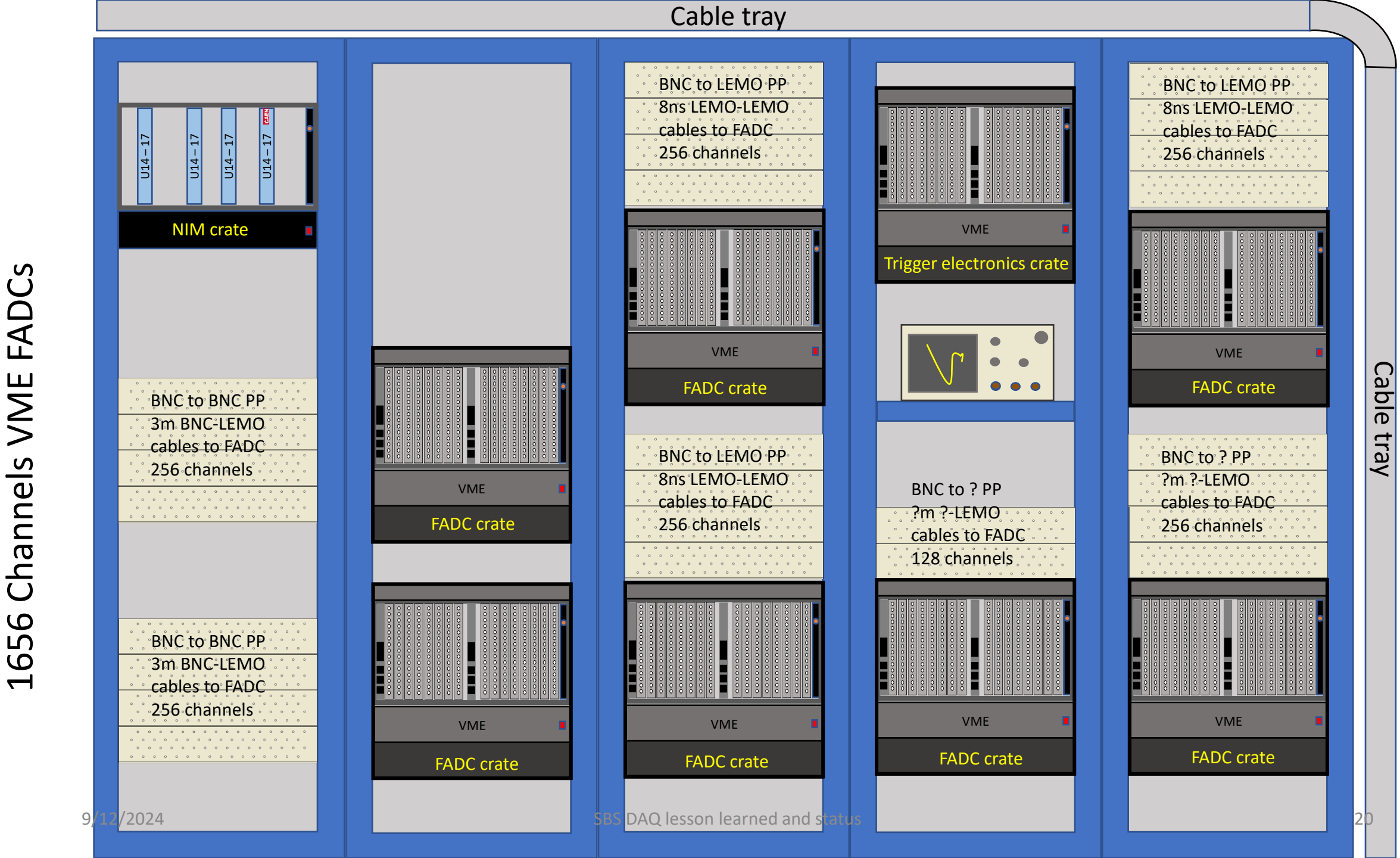
DAQ Bunker in Hall



Current layout

Reconfiguration steps

1. Move storage shelves and install 5 racks for HV in their place. Install HV crates and modules in racks (Summer 2023)
2. Move HCal racks slightly to give more room.
3. De-install BigBite and Hodoscope electronics, HV and cabling (April 2024)
4. Consolidate GEM electronics in two racks (April 2024)
5. Move central racks and power supply outward to allow 3 racks for CDET
6. Install Patch Panels, VME crates for FADCs and Trigger supervisor and install scaler crate.
7. Run cables and connect everything up.
8. Add ceiling panels?


Cable tray
1656 Channels VME FADCs
U14 – 17
U14 – 17
U14 – 17
U14 – 17
NIM crate
BNC to BNC PP
3m BNC-LEMO
cables to FADC
256 channels
BNC to BNC PP
3m BNC-LEMO
cables to FADC
256 channels
VME
FADC crate
VME
FADC crate
BNC to LEMO PP
8ns LEMO-LEMO
cables to FADC
256 channels
VME
FADC crate
BNC to LEMO PP
8ns LEMO-LEMO
cables to FADC
256 channels
VME
FADC crate
VME
Trigger electronics crate
BNC to ? PP
?m ?-LEMO
cables to FADC
128 channels
VME
FADC crate
BNC to LEMO PP
8ns LEMO-LEMO
cables to FADC
256 channels
VME
FADC crate
BNC to ? PP
?m ?-LEMO
cables to FADC
256 channels
VME
FADC crate
Cable tray

CDet

2352 channels of scintillating fiber

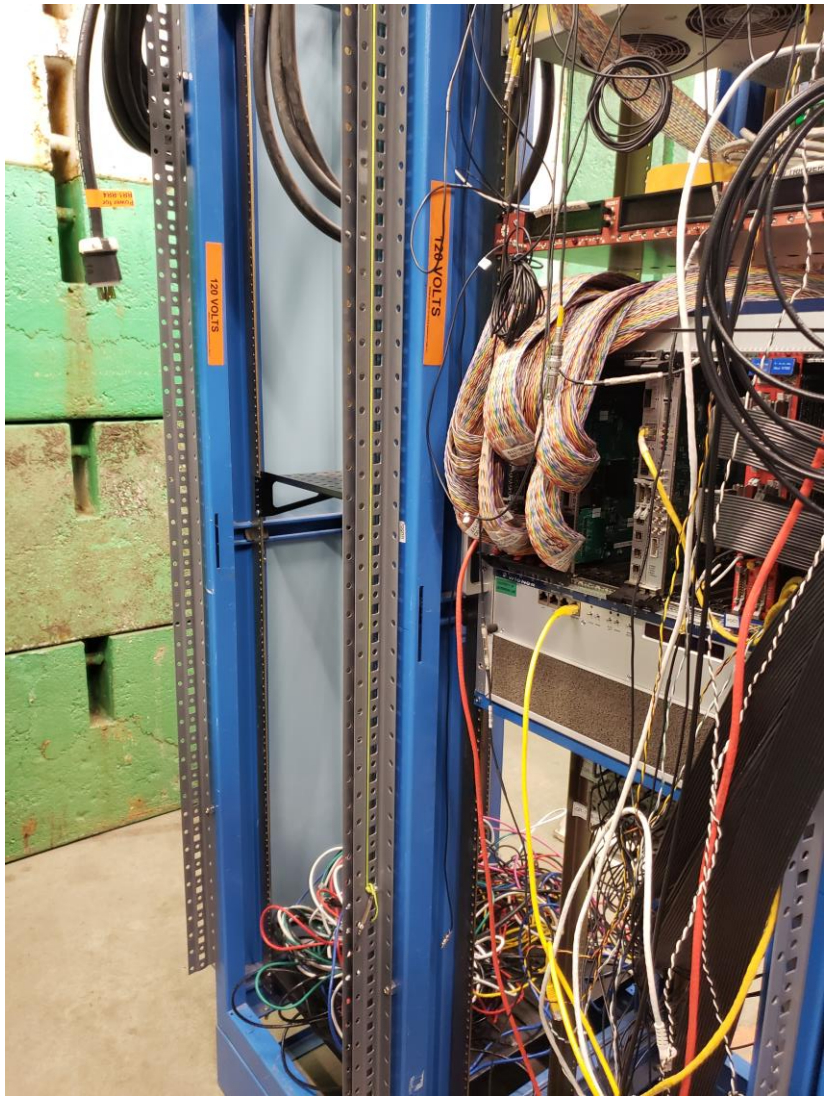
Readout with VETROC in one VXS crate

192 channels per VETROC, 128 in front and 64 in back

Use 13 VETROCs modules

VETROC already used for GRINCH during GMn and GeN

Crate setup in LHRS



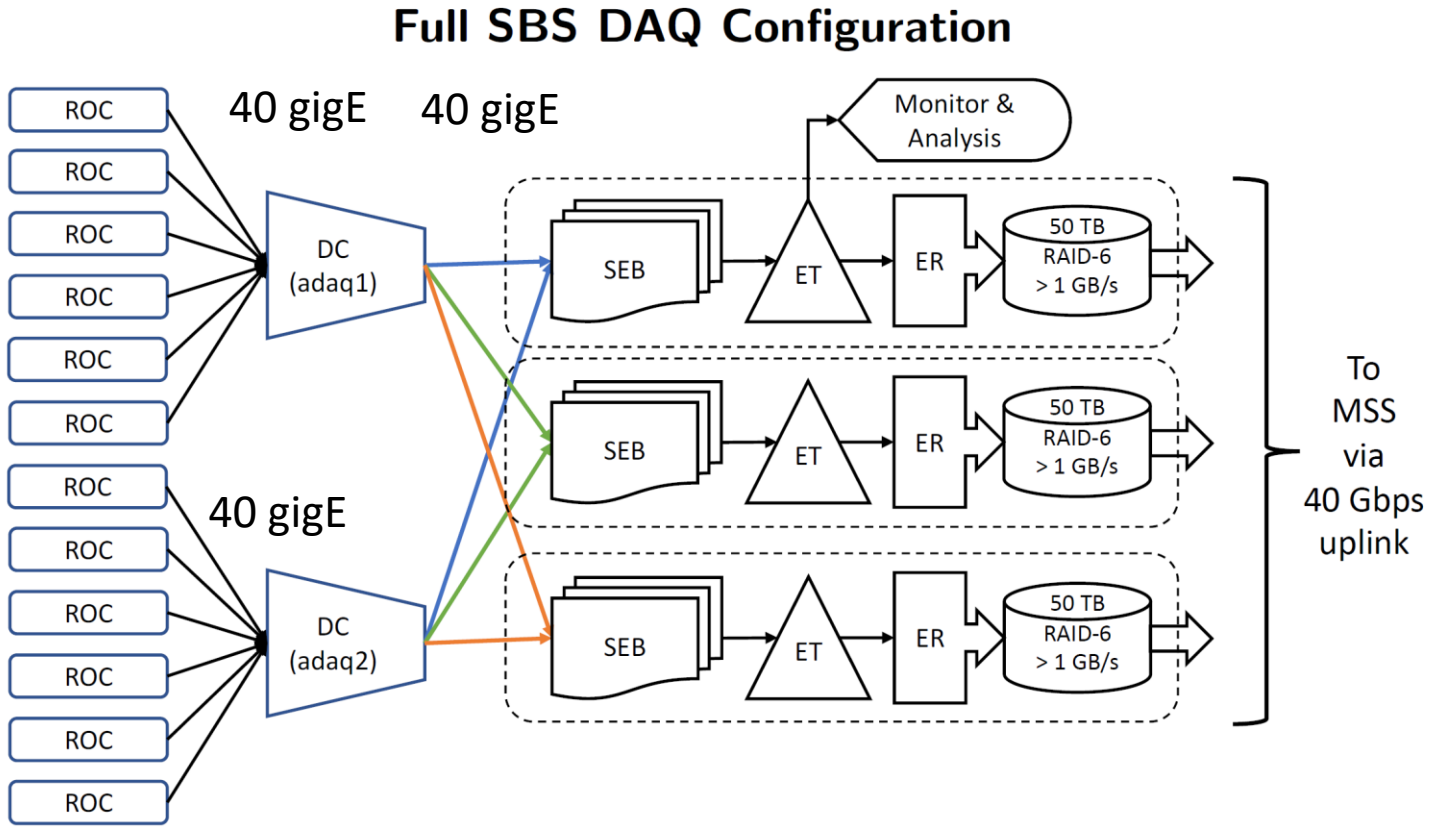
GEM data rates with latest occupancies

	Rate per cm2	Rate per plane	hits in 325 ns	occupancy	strip hits	XY	6 samples	bytes	Rate MB/s
1	170	1020	331.5	17%	1160.25	2320.5	13923	55696	278.48
2	230	1380	448.5	23%	1569.75	3139.5	18837	75348	376.74
3	260	1560	507	26%	1774.5	3549	21294	85176	425.88
4	275	1650	536.25	28%	1876.875	3753.75	22522.5	90090	450.45
5	280	1680	546	28%	1911	3822	22932	91728	458.64
6	285	1710	555.75	29%	1945.125	3890.25	23341.5	93370	466.85
7	225	1350	438.75	23%	1535.625	3071.25	18427.5	73710	368.55
8	240	1440	468	24%	1638	3276	19656	78624	393.12

	Rate per cm2	Rate per plane	hits in 325 ns	occupancy	strip hits	XY	6 samples	bytes	Rate MB/s
1	80	480	156	8%	546	1092	6552	26212	131.06
2	72	432	140.4	7%	491.4	982.8	5896.8	23587	117.94
3	66	396	128.7	7%	450.45	900.9	5405.4	21622	108.11
4	64	384	124.8	6%	436.8	873.6	5241.6	20966	104.83
5	62	372	120.9	6%	423.15	846.3	5077.8	20311	101.56
6	58	348	113.1	6%	395.85	791.7	4750.2	19005	95.03
7	55	330	107.25	6%	375.375	750.75	4504.5	18018	90.09
8	54	324	105.3	5%	368.55	737.1	4422.6	17690	88.45
								811155	
								Total	4055.78
				at 5 KHz	1		Total		4056MB/s
							Geometrical Factor		1352MB/s

CODA3

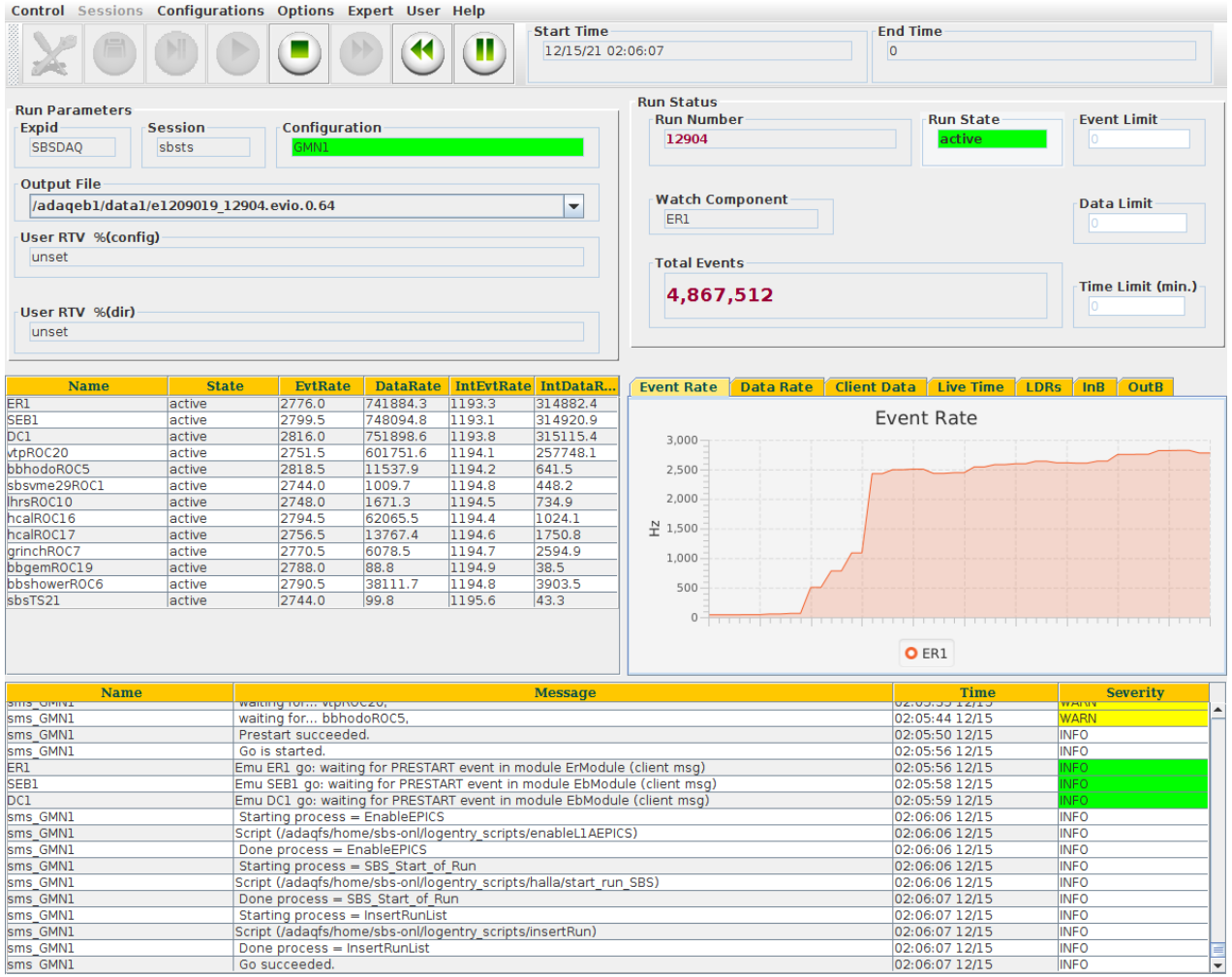
- TS/TI Fiber based
- Support for VTP
- Support for multiple stream



Production data during GMn

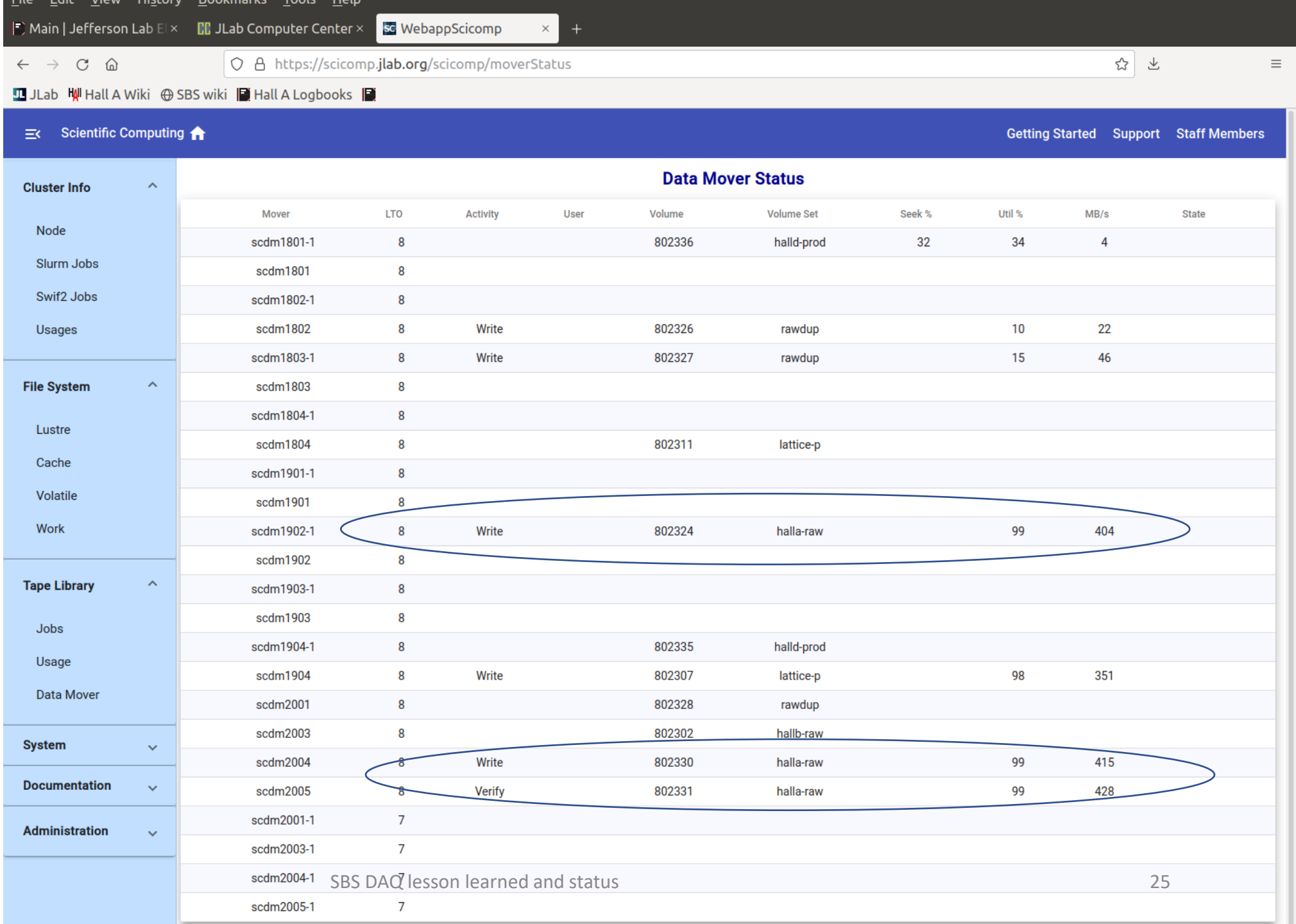
- Typical rate around 3 kHz
- 90% livetime with one event builder
- 600 MB/s from BigBite GEM
- 240 MB/s HCAL, shower FADCs
- 800 MB/s to disk

- Up to 2.4 GB/s using 3 event builder



Silo performance

- Achieved 800 MB/s



Tape cost

		Days	Weeks	Data rate	Seconds	Total data TB	Double	LTO7 in k$	LTO8 in k$
E12-12-09-019	GMN	25	3.57	100	2160000	216	432	5	3
E12-17-004	GEn RP	9	1.29	300	777600	233.28	466.56	6	3
E12-09-016	GEN	50	7.14	500	4320000	2160	4320	54	27
E12-07-109	GEP/GMP	45	6.43	3400	3888000	13219.2	26438.4	330	165
E12-09-018	SIDIS	64	9.14	1000	5529600	5529.6	11059.2	138	69
E12-15-006	TDIS	27	3.86	6000	2332800	13996.8	27993.6	350	175

To do list Gep5

- HCAL (Ben, Hanjie, Jiwan, Jihyi)
- ECAL FADC trigger and readout (Ben, Hanjie, Jiwan, Jihyi)
- Trigger with geometrical matching HCAL-ECAL (Ben, Hanjie, Jiwan, Jihyi)
- Cdet VME readout (Alexandre, Peter, Ralph + student)
- GEM ROI readout (Ben, Jacob ?)
- Simulation (Uconn : Kip ?)
  - Trigger rate
  - Occupancies
  - Look up tables for trigger and GEMs
- Beamline and scaler crate recabling (Ching, Ciprian, Alexandre)

Conclusion

- DAQ operating reasonably well at 3 KHz
- Advise trying full replay of data during experiment to catch subtle effects
- Major down time from GEMs
  - Try to improve stability by reloading firmware at each run
- Firmware developments on going for ECAL, HCAL trigger and readout and GEM ROI on going
- Getting ready for cosmics for different subsystems