SBS DAQ GMn

February 10th 2022

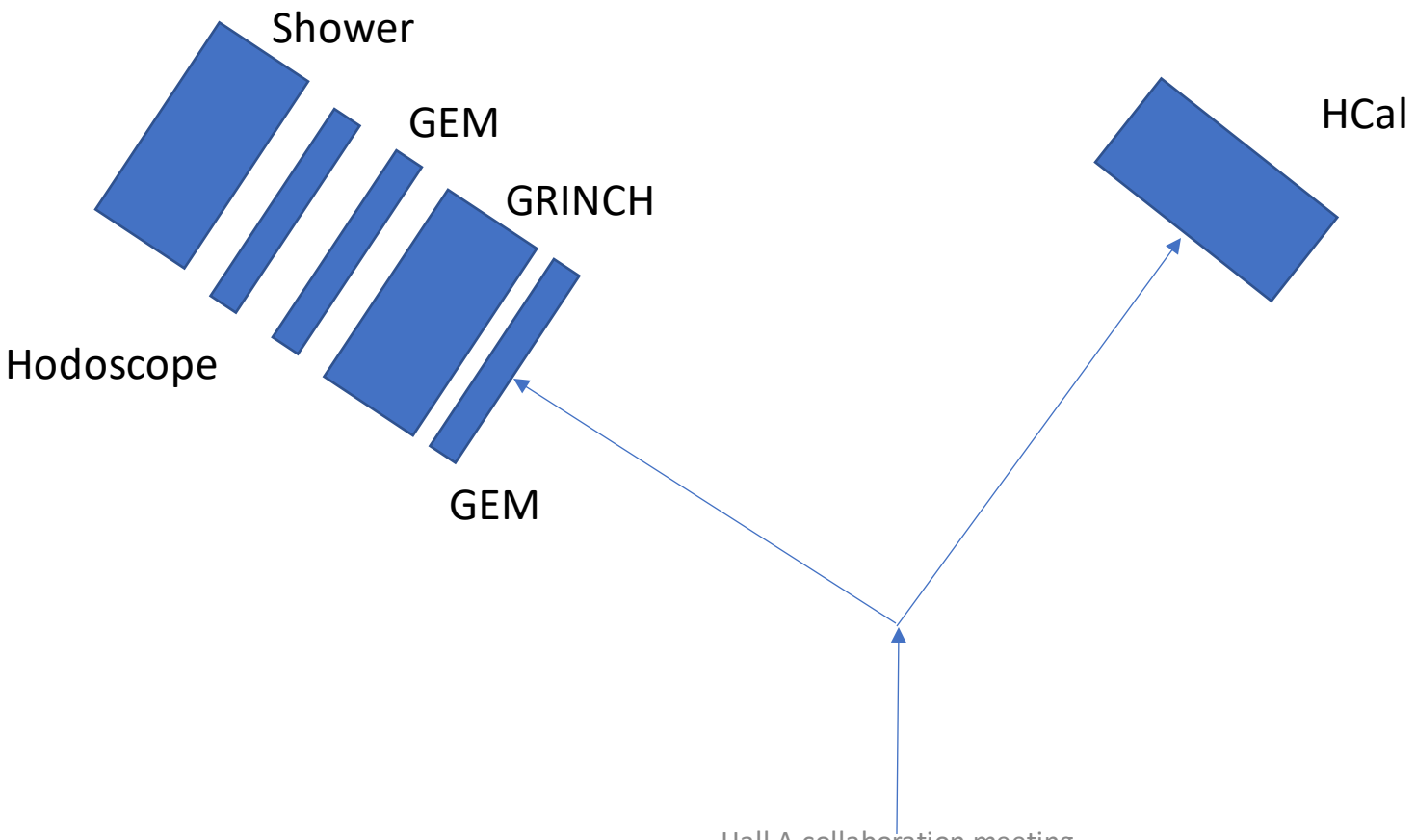
Hall A collaboration meeting

Alexandre Camsonne

GMn

- Superbigbite used as neutron detector
- Bigbite : electron detector
- Add polarimeters on SBS side
- Start in October 4th 2021

GMn



Experimental setup GMn

- BigBite
  - Shower
  - Preshower
  - Scintillator
  - GRINCH
  - GEM
- Neutron detector
  - HCAL
- LHRS

Detector	Channels	NINO	Readout
Shower	7x27 = 189 27 sums		FADC
Preshower	2x27 =54 2 sums		FADC
Scintillator	200 x 2	X	CAEN 1190
GRINCH	550	X	VETROC
GEM	5 planes		MPD

Detector	Channels	NINO	Readout
HCAL	288		FADC

SBS configuration GMn/Gen/Gen RP

		Channels	Modules	Nb modules
BigBite	Shower	189	1881	3
	Preshower	54	1881	1
	Scintillator	180	V1190	1
	Cerenkov	550	VETROC	6
	GEM INFN	14000	MPD	24
	GEM UVA	113000	MPD	77
BigBen				
	HCAL	288	FADC	18
HRS				
	S2m	32	FADC	2
	S0	2	FADC	1
	Cerenkov	10	FADC	1
	PRL	68	FADC	4
	VDC	1536	1877	16
	Raster	4	FADC	1
	BPM	8	FADC	1
RP				
	Proton Large Angle	96	FADC	6
	Active analyzer	32	FADC	2
			TDC	1

Triggers

1. Ecal
2. Hcal
3. HRS
4. Coincidence
5. Grinch LED
6. HCAL LED

Bigbite

- Shower
  - 1 VXS crate , 16 FADCs + 2 FADCs for sums + TDC
- Hodoscope
  - 1 VME 64X crate
  - 2 CAEN V1190
  - 4 FADC for calibration
- GRINCH
  - 1 VXS crate
  - 6 VETROCs
  - 4 FADC

HCal

- 288 channels
- 2 VXS crates
- 18 + 1 FADC
- 4 F1 TDC (1 spare)

LHRS

- S0, S2, Pion rejector, A1 on FADC
- Beamline and helicity
- All detectors cables
- CODA3 setup

Updated trigger rates from Andrew (Pythia)

Q^2 (GeV^2)	E_e (GeV)	θ_{BB}/d_{BB} (deg)/(m)	E'_e (GeV)	Thrsh. (GeV)	Eff. %	Trig. Rate. (kHz)					Total (kHz)
						El.	Inel.	π^+	π^0	π^-	
3.5	4.4	32.5/1.80	2.18	1.81	96.9	0.8	5.3	0.04	3.5	0.1	9.7
4.5	4.4	41.9/1.55	1.70	1.35	94.0	0.2	2.3	0.2	7.3	0.2	10.2
5.7	4.4	58.4/1.55	1.14	0.89	94.8	0.02	0.6	0.4	12.9	0.6	14.5
6.1	6.6	30.3/1.55	2.90	2.38	95.9	0.08	1.7	0.006	1.0	0.02	2.8
8.1	6.6	43.0/1.55	1.94	1.56	95.5	0.007	0.4	0.06	1.6	0.03	2.1
10.2	8.8	34.0/1.75	2.92	2.37	96.8	0.003	0.3	0.003	0.3	0.002	0.6
12	8.8	44.2/1.55	2.05	1.62	95.4	0.0008	0.1	0.005	1.2	0.02	1.3
13.5	11	33.0/1.55	3.30	2.60	94.0	0.0008	0.2	0.003	0.2	0.002	0.4

GEM readout

- 3 VXS crates with VTP readout
- Optical to VXS adapter on hand
- 3 crates : 1 BigBite 2 for SBS
- VTP firmware done
- CODA VTP readout on going
- 22 MPDs = 6 fibers

Expected trigger rates GMn

Preferably single electron trigger to avoid biased in neutron detector

Q^2 GeV^2	n+p QE xsec fb	L(per atom) 10^38/cm^2/s design	QE rate Hz	Beam time Hours	Proposal Total Hz	Updated rates Hz
3.5	6700	0.35	235	12	2100	9700
4.5	1015	0.7	70	12	1400	10200
5.7	97.9	1.4	13.5	18	140	14500
8.1	47.4	1.4	6.6	18	390	2100
10.2	31.6	0.7	1.5	24	210	600
12	5.04	1.4	0.7	36	200	1300
13.5	6.25	1.4	0.87	96	100	400

Maximum trigger rate 2.1 KHz, assume factor 2 safety margin for 4.2 KHz for low Q^2

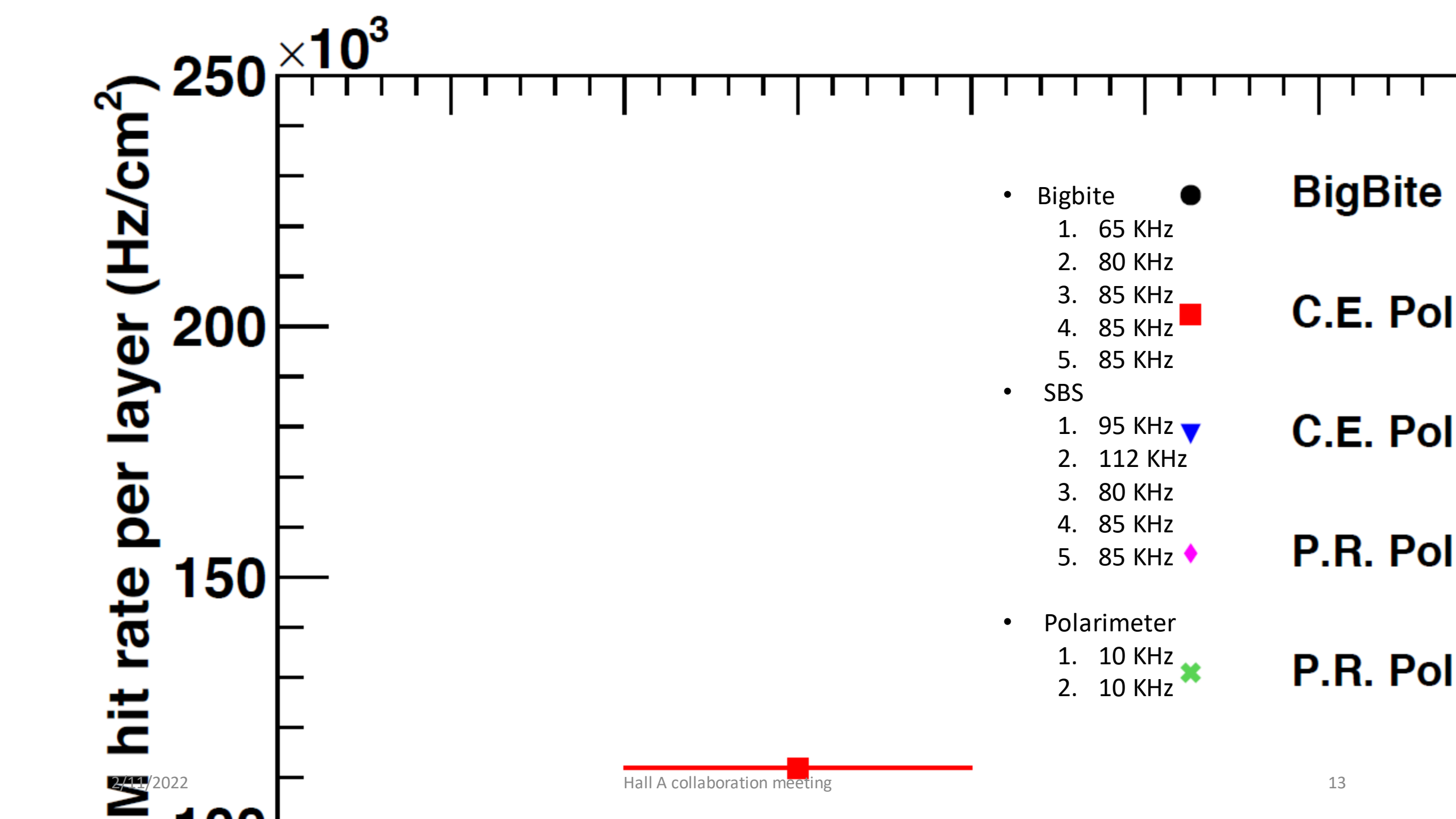
less than 500 Hz at high Q^2

Single electron trigger is a good option

(possibility to add Cerenkov in the trigger if needed)

High trigger rate capabilities : rates high for 2 low Q2 points

rates are modest for other points


×10³
250
200
150
M hit rate per layer (Hz/cm²)
• Bigbite
1. 65 KHz
2. 80 KHz
3. 85 KHz
4. 85 KHz
5. 85 KHz
• SBS
1. 95 KHz
2. 112 KHz
3. 80 KHz
4. 85 KHz
5. 85 KHz
• Polarimeter
1. 10 KHz
2. 10 KHz
BigBite
C.E. Pol
C.E. Pol
P.R. Pol
P.R. Pol

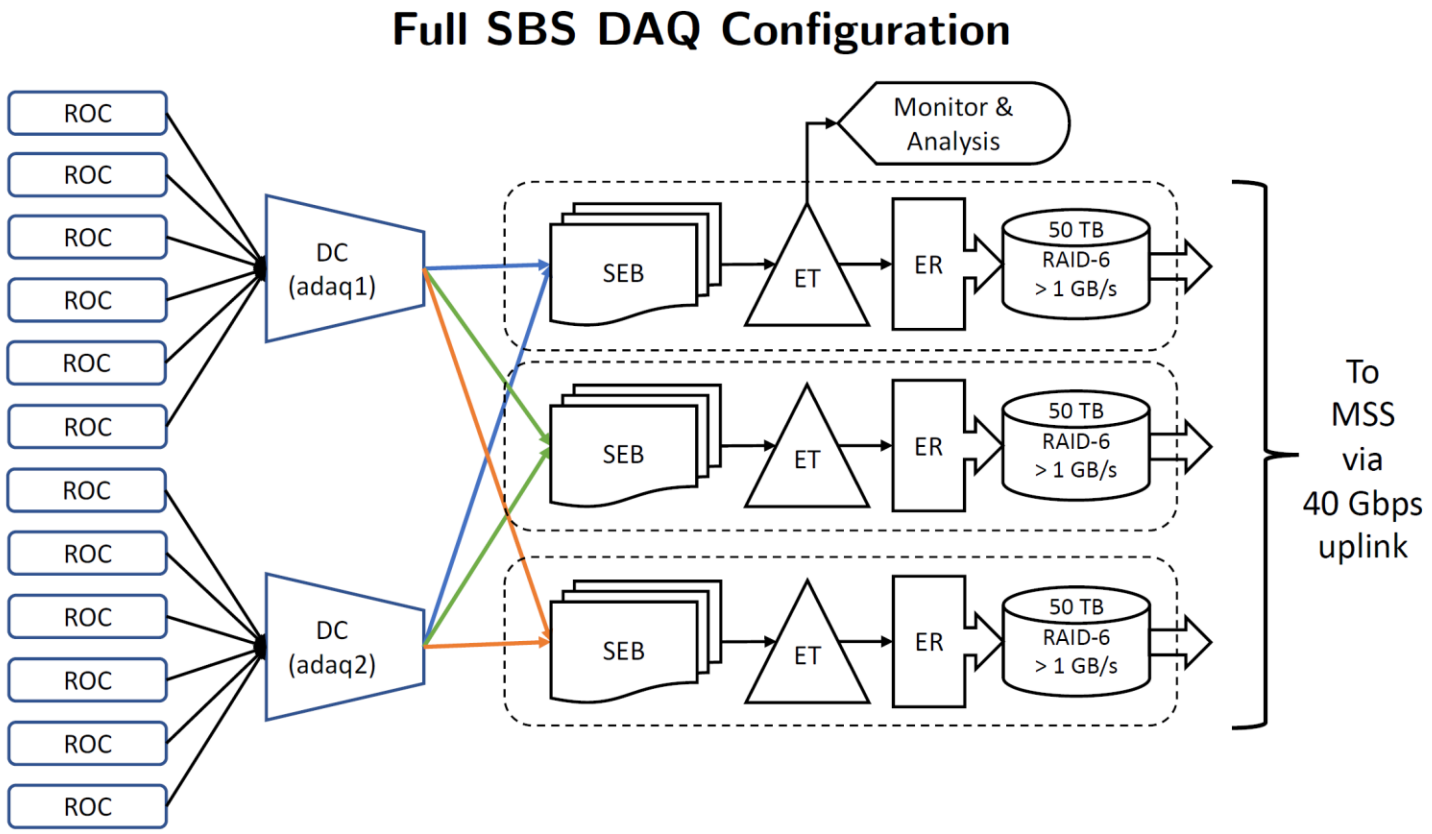
GMn data rates

				Trigger rate :	5000							
Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10	Column11	Column12	Column13
	Rate per cm2	Rate per plane	hits in 325 ns	occupancy	strip hits	XY	6 samples	bytes	Rate MB/s		Rate	Rate MB/s
1	65	390	126.75	20%	443.625	887.25	5323.5	21298	106.49		1.06E+08	106.49
2	80	480	156	24%	546	1092	6552	26208	131.04		1.31E+08	131.04
3	85	1020	331.5	34%	1160.25	2320.5	13923	55692	278.46		2.78E+08	278.46
4	85	1020	331.5	34%	1160.25	2320.5	13923	55692	278.46		2.78E+08	278.46
5	85	1020	331.5	34%	1160.25	2320.5	13923	55692	278.46		2.78E+08	278.46
												1,072.91
Samples	20											
FADC		Event size										
	288	13968	69.84									
		Total	1142.75									

5 KHz single arm gives 1.1 GB/s

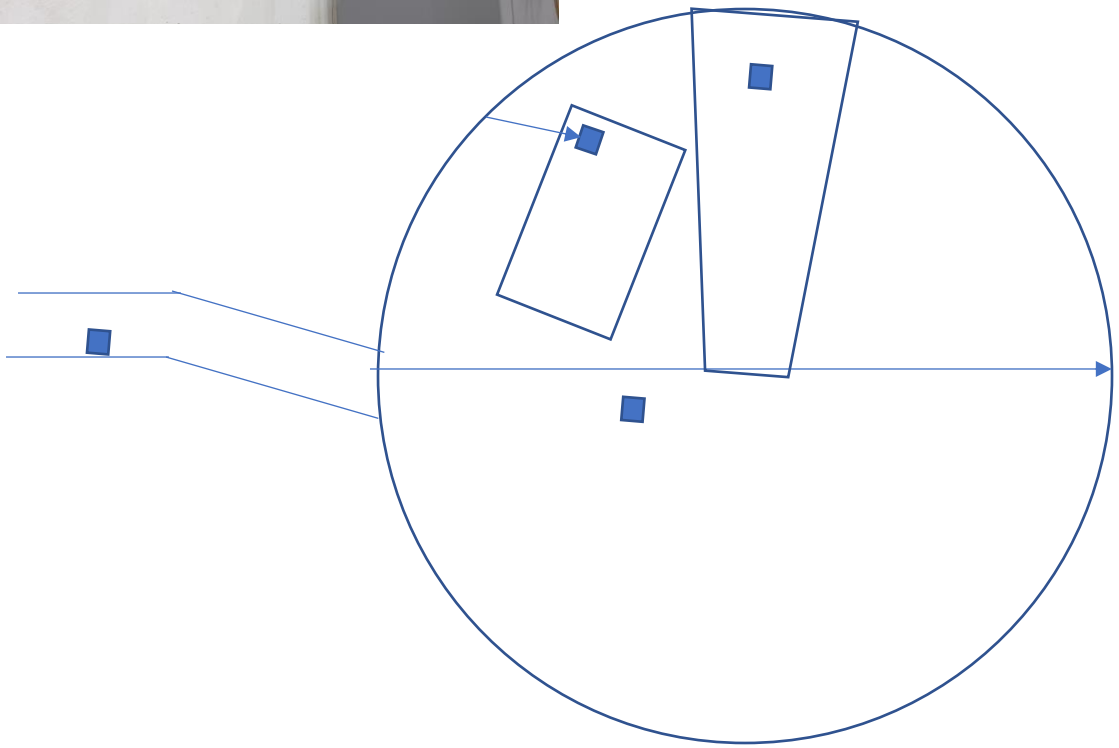
CODA3

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



Hall A

- Upgrade fibers for 10gigE to LHRS, Labyrinth, Rack , SBS weldment
- Each connection 24 fibers x10 gigE upgradable to 40 gigE
- SBS weldment
  - 3 VTPs: each use 1 fiber
  - 48 1gigE router to 4 x 10 gigE fibers



Counting house

- Router
- 4x24 10 gigE port
- 40 gigE uplink to DAQ computer and SILO

GEM – Readout Electronics

- 128 analog ch / APV25 ASIC
- 3.4 μs trigger latency (analog pipeline)
- Capable of sampling signal at 40 MHz
- Multiplexed analog output (100 kHz readout rate)

	Channels	APV25	MPDs
Front Tracker	28000	216	16
Rear Tracker	12000	100	7

MPD (INFN)

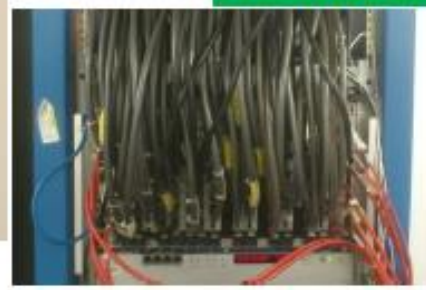
MPD Main Block

Arriga GX FPGA
128 MB DDR2-RAM
Firmware V4.0 (74% resources):
FIR Filter (16 param)
Zero Suppression
Common mode and pedestal subtraction
Remote config,
≈2 ns trigger time resolution

MPD-SSP Interface → SSP-Protocol → Aurora Protocol → Optical Fiber → SSP

MPD-VME Interface → VME-Protocols → 2eSST, 2eVME, VME32 ..., VXS → VME (64x) → VME Master (Intel SBC)

All major firmware issues fixed so far

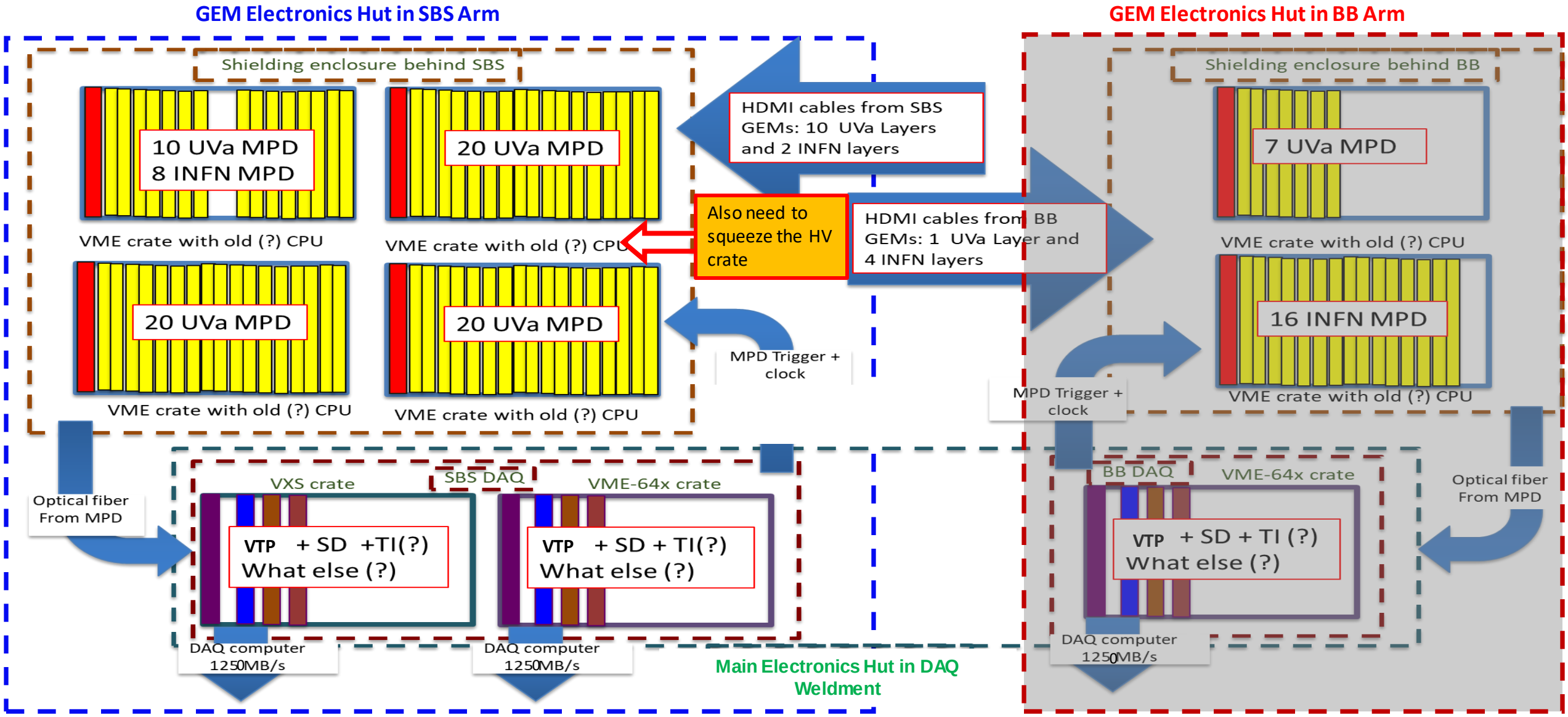


Electronics is up and running (or going to run) on:

- Front-GEM cosmic test in VME mode
- SSP mode in Rear GEM cosmic test
- PREX UVa GEM

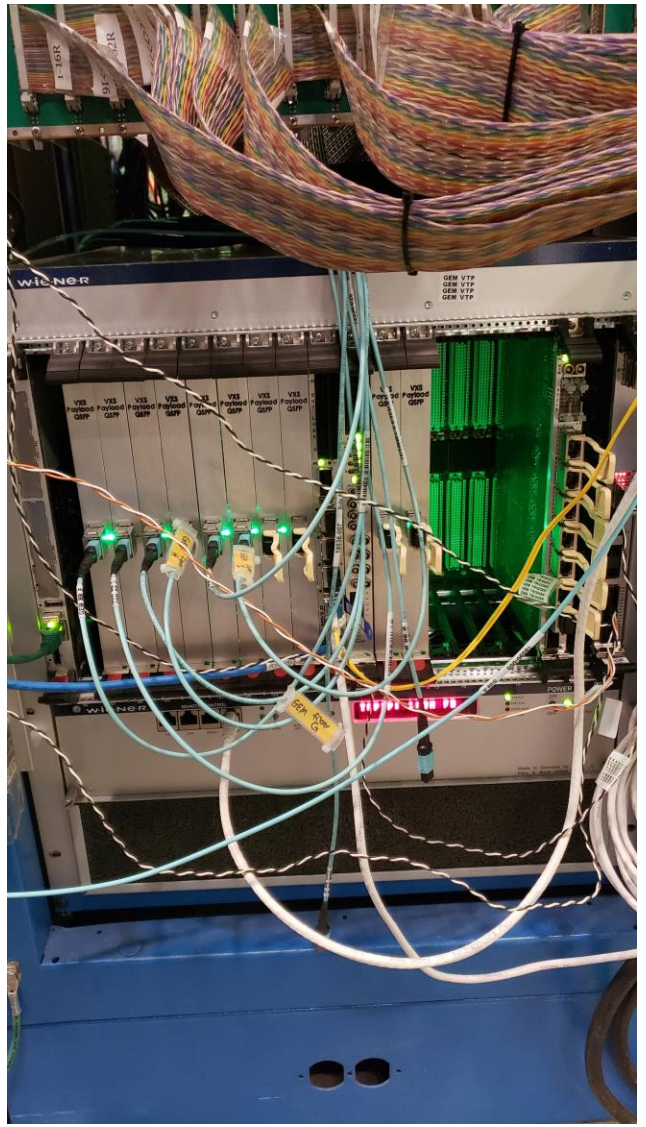
05/Aug/2019

SBS GEM Electronics for Gen-RP



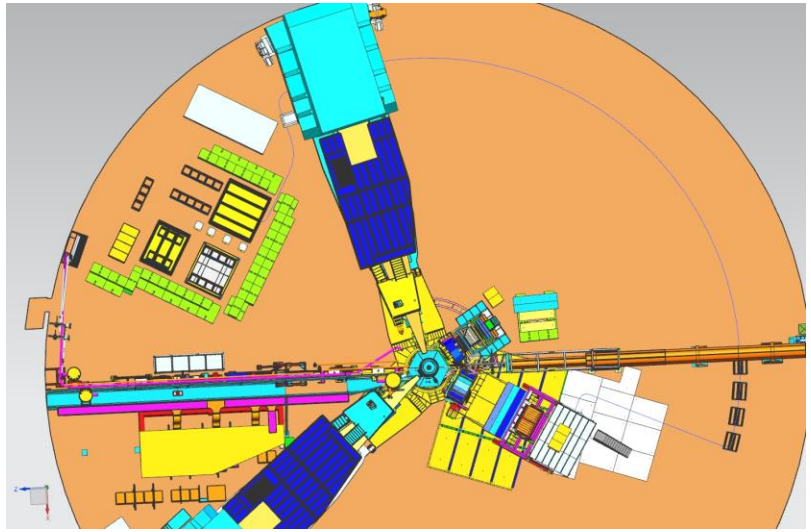
VTP MPD readout

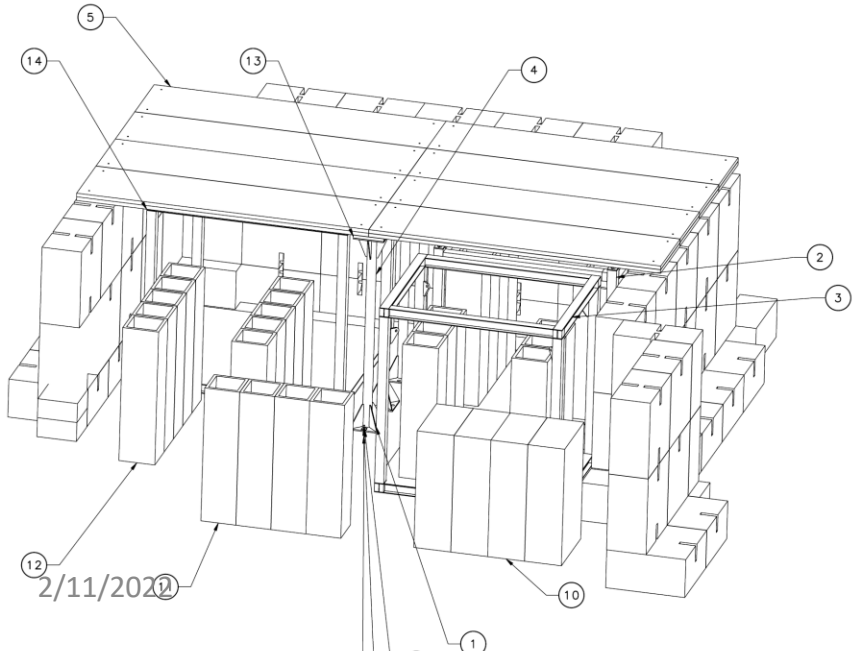
- New Optical to VXS adapter developped
- VTP readout implemented
- One fiber per board = 4 MPD
- Up to 32 MPDs per crate right now



DAQ weldment

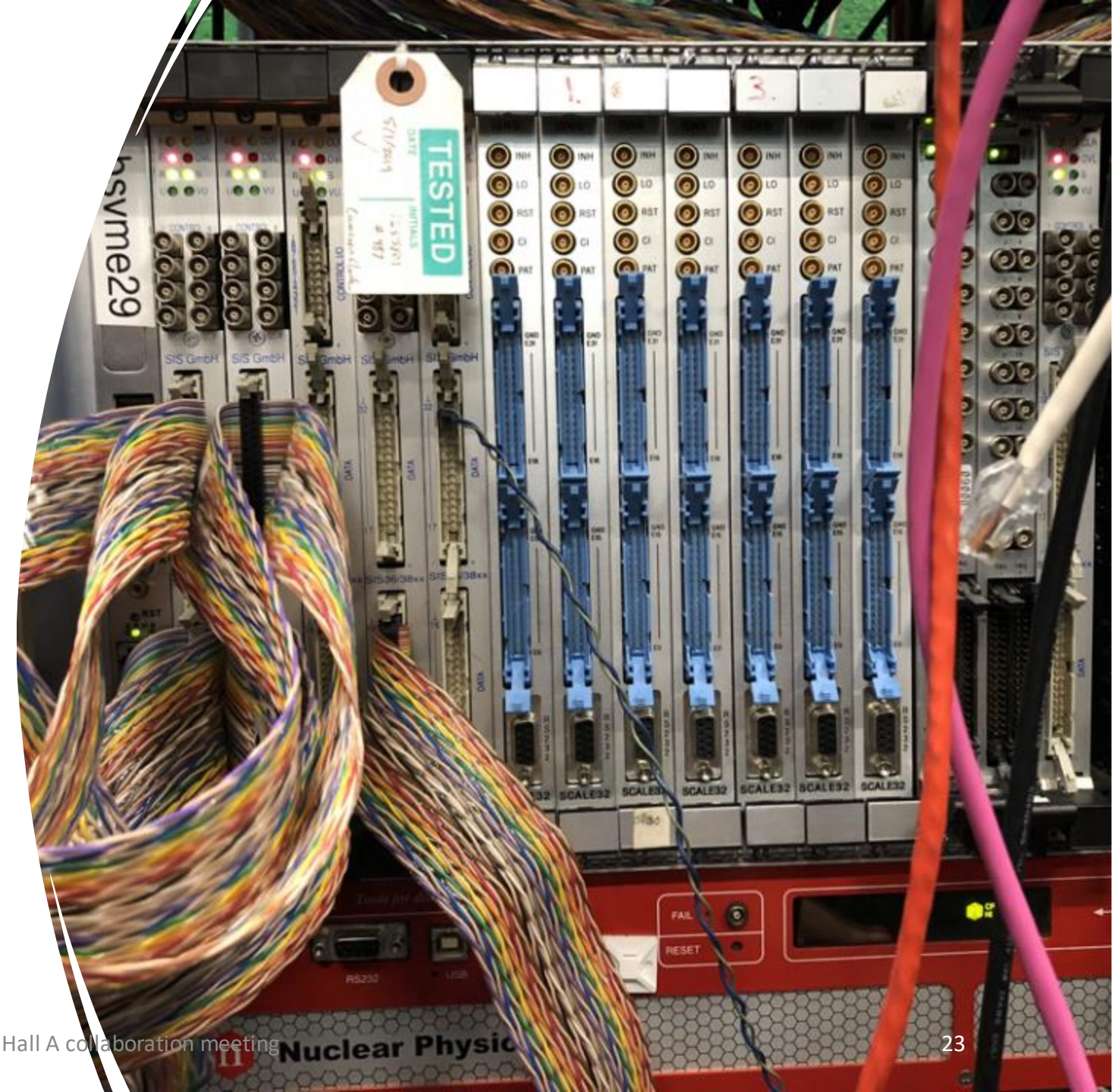
DAQ weldment





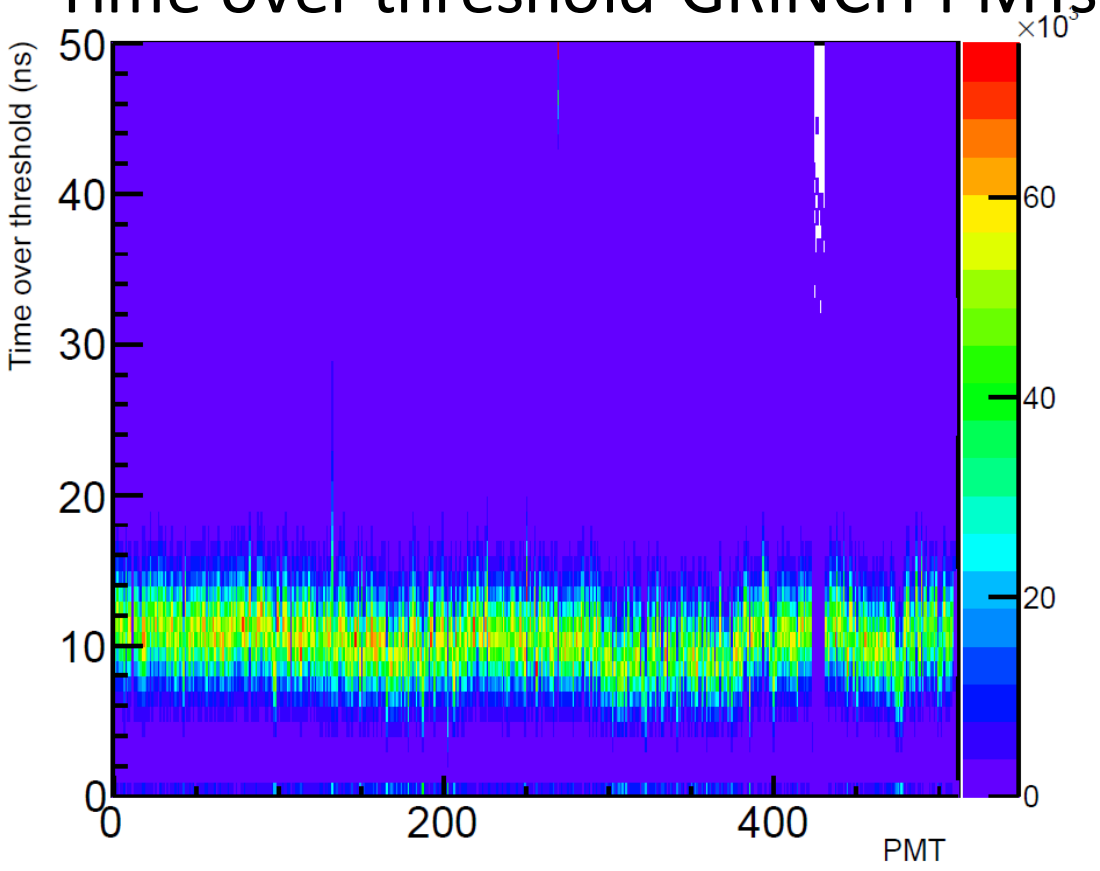
Beamline crate weldment

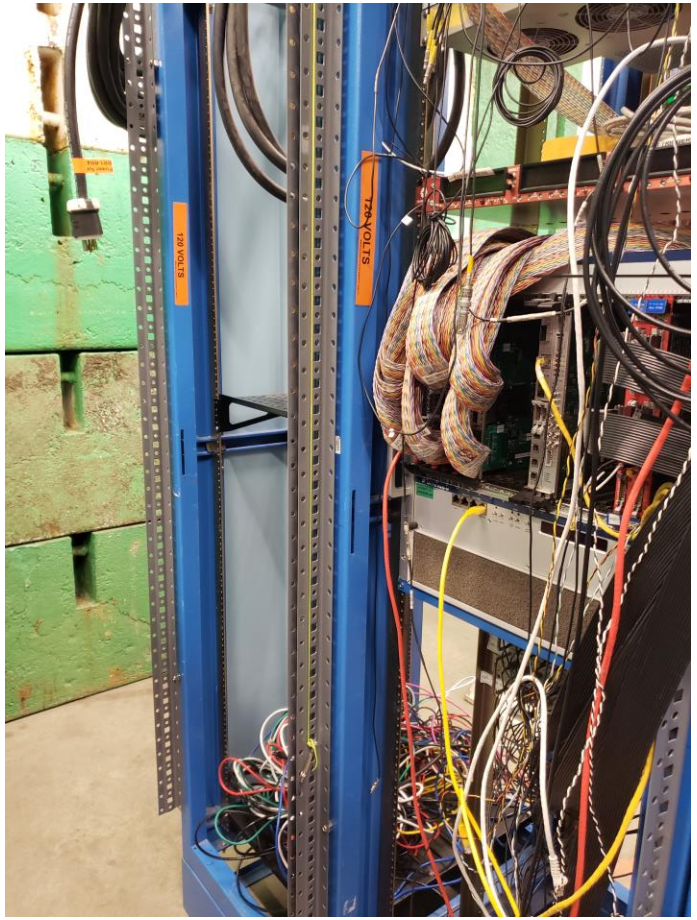
- VME 64X crate in SBS weldment + LHRS for redundancy
- 1 FADC in scaler crate for BPM/Raster



GRINCH VETROC

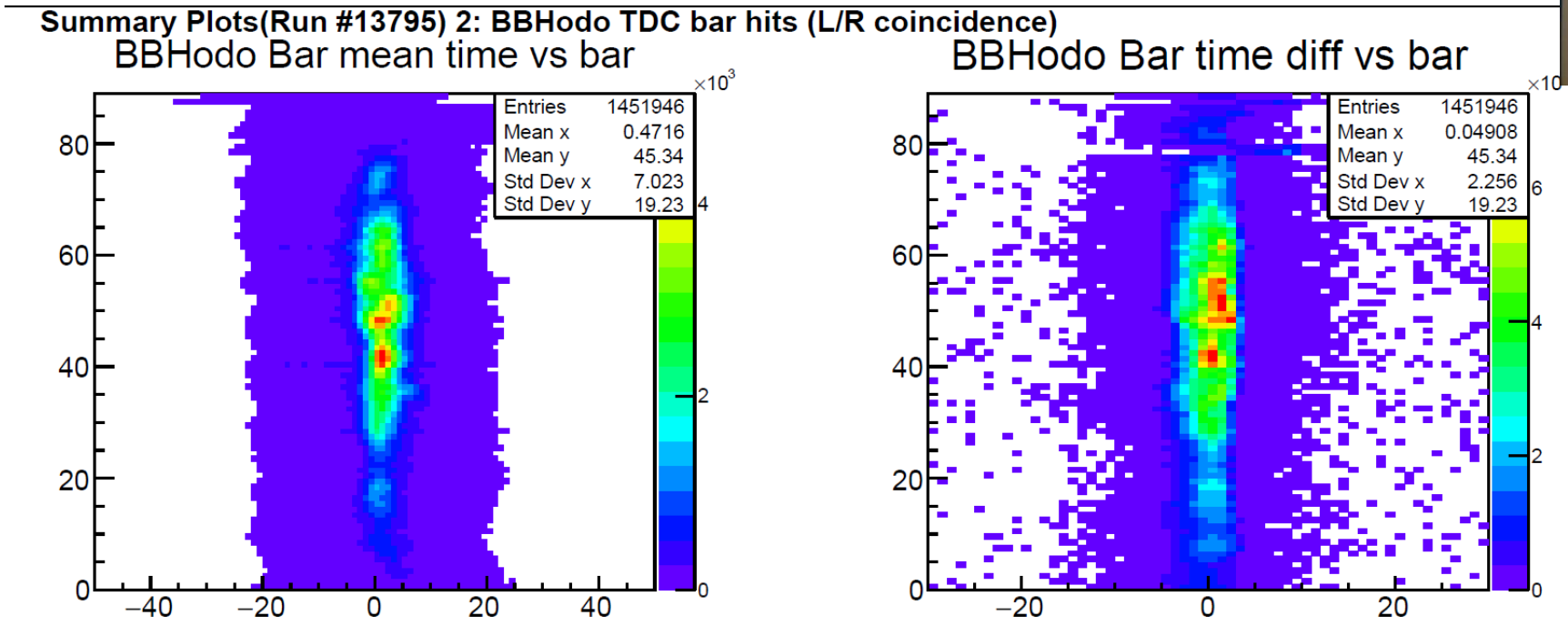
- Time over threshold GRINCH PMTs





Bigbite Hodoscope

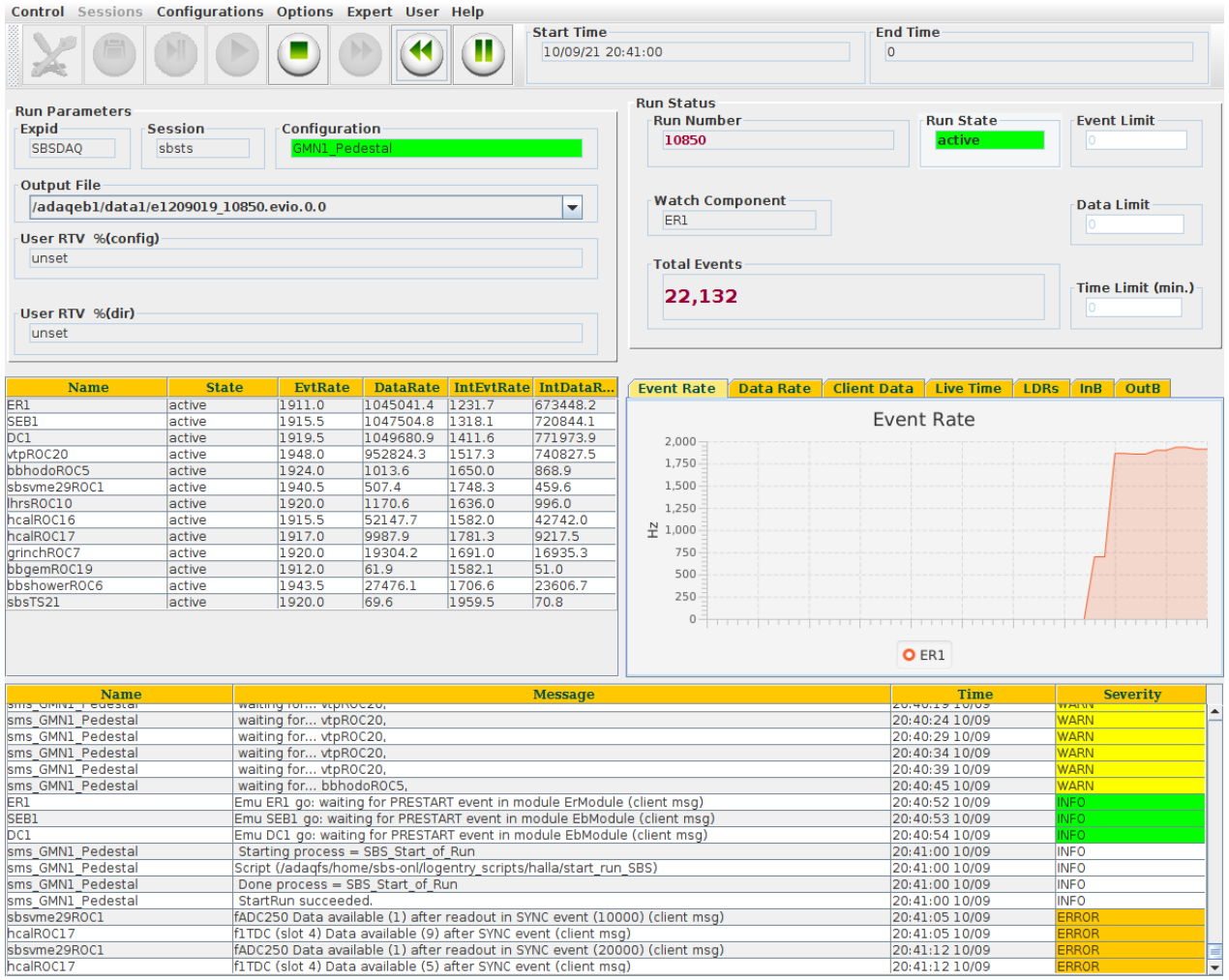
- Hodoscope



GEM VTP readout perfomance

- GEM pedestal configuration
- 1.9 KHz trigger rate
- 0% livetime
- 953 MB/s from BigBite GEM

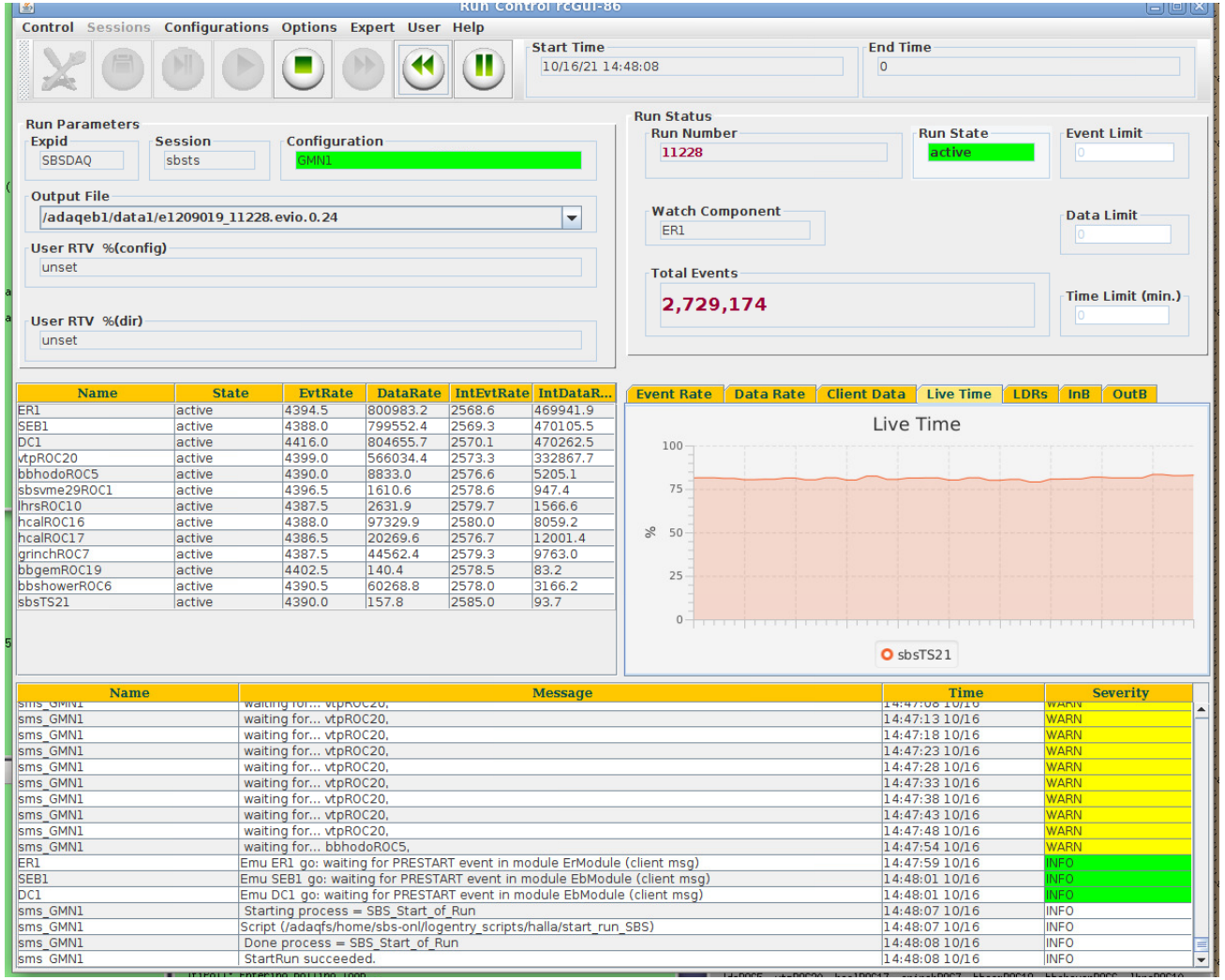
- 100 MB/s HCAL, shower FADCs
- 1045 MB/s to disk



Beam rates 5uA

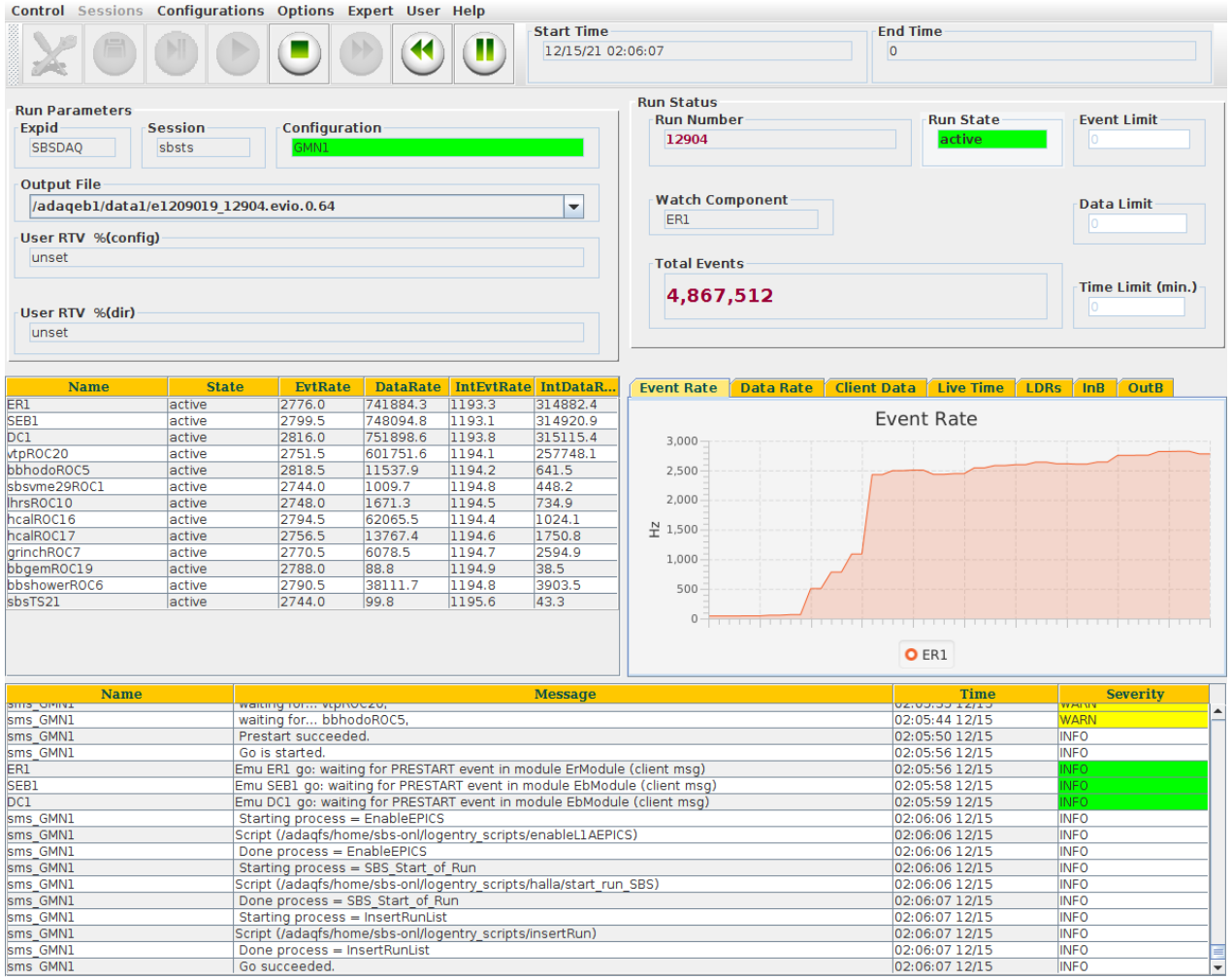
- 4.4 KHz trigger rate
- 75% livetime
- 566 MB/s from BigBite GEM

- 240 MB/s HCAL, shower FADCs
- 800 MB/s to disk



Production data

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



GMn data rates

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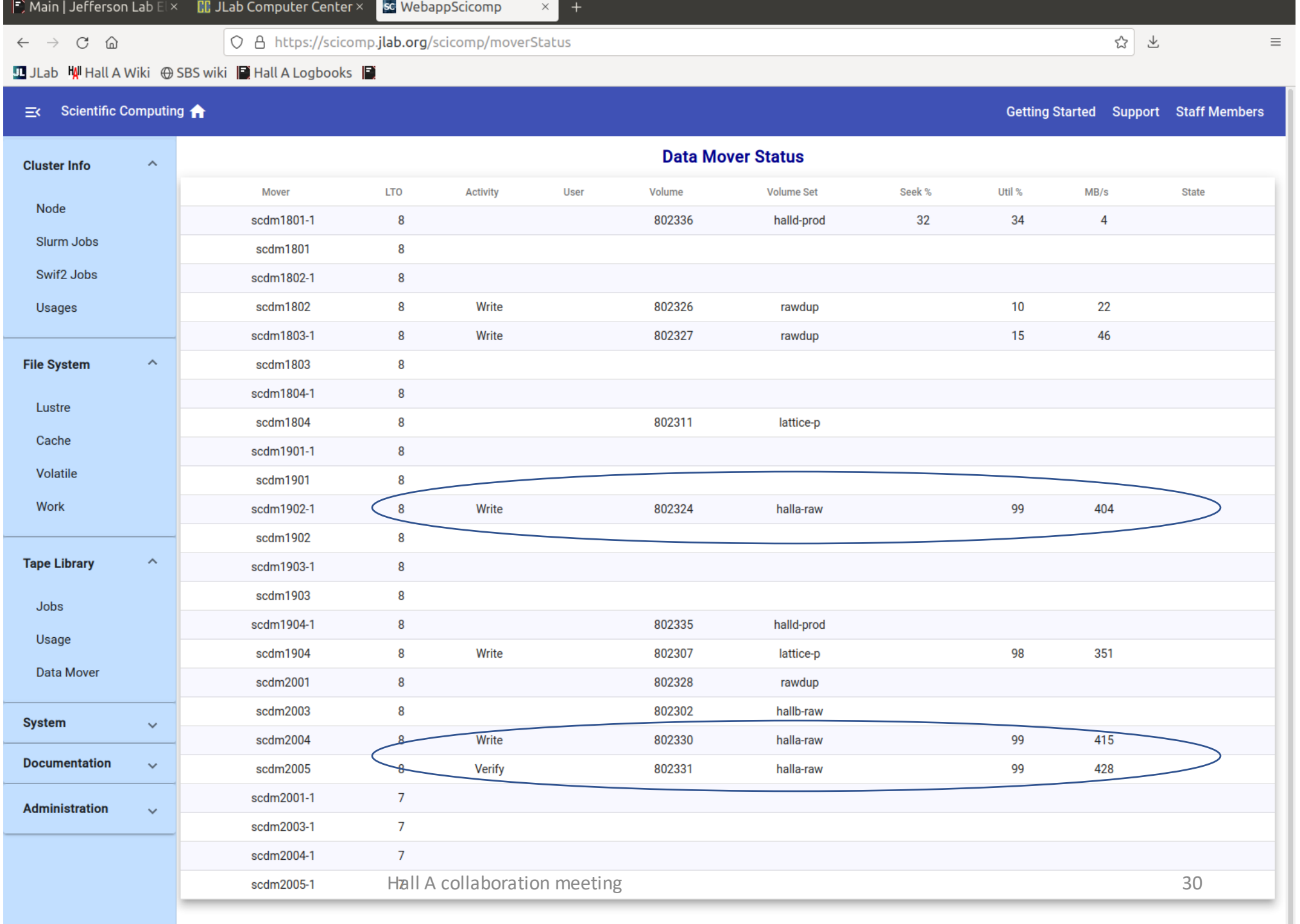
												1,072.91
Samples	20											
FADC		Event size										
	288	13968	69.84									
		Total	1142.75									

5 KHz single arm gives 1.1 GB/s

Typical rate 3 KHz and data rates from 700 MB/s to 200 MB/s

Silo performance

- Click to add text



DAQ team

- Bryan Moffit (GEM /CODA/ everything !)
- Ben Raydo (GEM /almost everything)
- William Gu (TI/TS/clock distribution)
- David Abbott(CODA support)
- Ed Jastrzemski (F1)
- Carl Timer (ET support)
- Bob Michaels (HRS, scripts, data to silom scalers)
- David Flay (Beamline,helicity)
- Paul King (Beamline,helicity)
- Steve Wood (scaler, HV)

+all detector subsystems

Future developments

- Shower digital trigger
- HCAL digital trigger
- FADC VTP fast readout for HCAL and Shower
- VETROC for HCAL TDC to complement F1
- 2 or 3 computers stream scheme

Conclusion

- Major upgrade to DAQ
  - MPD VTP readout
  - Network upgrade
  - CODA3
- DAQ performance up to 1.1 GB/s single computer expect 3 GB/s with 3 computers
- VTP GEM readout implement
- First experiment GMn successful
- Expect to be able to handle up to 3 GB/s in counting house (limited by silo cost)
- More developments for GEn/RP and GEp