

SBS DAQ

February 17th 2021

Alexandre Camsonne

SBS collaboration meeting

Outline

- Overview
- Bigbite
 - Shower
 - GRINCH
 - Hodoscope
 - GEM
- Superbigbite
 - HCAL
 - Recoil polarimeter
 - CDet
- LHRS
- Floor plan
- Cabling
- Network
- Timeline

First SBS run group

- GEn-RP
 - HCAL
 - BigBite
 - RP
- nTPE
- WAPP
- GMn
 - HCAL
 - BigBite

SBS DAQ subsystems and manpower

- BigBite
 - Shower : Mark, Arun
 - Hodoscope : Rachel, Ralph
 - GEM
 - INFN : Evaristo, Ezekiel
 - UVA : Kondo, Anruda, Thir
 - BigBite : Holly, Xinzhan
- HCal : Scott, Juan Carlos
- Gen RP
 - Scintillators : Brad
 - UVA GEMs : Kondo, Anruda, Thir
- LHRS : Bob, Maria
- Helicity : Paul, Bob
- Beamline : David, Bob, Paul
- DAQ : Alexandre Camsonne, Bryan Moffit, Ben Raydo

SBS configuration GMn/Gen/Gen RP

		Channels	Modules	Nb modules	On-hand	Ordered	Installed	Needed
BigBite	Shower	189	FADC	12	1	2	0	
	Preshower	54	FADC	4	0	4	0	
	Scintillator	180	V1190	2	2		2	
		64	V792	4	2		2	
	Cerenkov	550	VETROC	6	6		6	
			V792	4	4		4	
	GEM INFN	14000	MPD	23	23		7	
	GEM UVA	113000	MPD	77	77		0	
BigBen								
	HCAL	288	FADC	19	18		18	
			F1	5	5		5	
	CDet	2520	VETROC	13		13		
HRS								
	S2m	32	FADC	2	2		2	
	S0/Cerenkov	12	FADC	1	1		1	
	PRL	68	FADC	4	4		0	
	A1	22	FADC	2	2		2	
	VDC	1536	1877	16	16		16	
	BPM/Raster	12	FADC	1	1		1	
RP								
	Proton Large Angle	96	FADC	6	4		0	
	Active analyzer	32	FADC	2	0		0	
			TDC	1			0	

New trigger rates GMn

Gen/RP

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

HCAL rates

Expt.	Q^2 (GeV ²)	BeamE (GeV)	SBS ang./dst. (deg)/(m)	SBS Bdl	HCAL dst. (m)	Thrsh. (GeV)	HCAL Trigger Rates (MHz)
GMn	3.5	4.4	31.1/2.00	1.71	7.2	0.08	3.83 ± 0.07
GMn	4.5	4.4	24.7/2.25	1.71	8.5	0.10	3.65 ± 0.04
GEN-RP	4.5	4.4	24.7/2.25	1.71	8.5	0.08	1.25 ± 0.04
GMn	5.7	4.4	17.5/2.25	1.71	11.0	0.14	5.09 ± 0.05
GMn	6.1	6.6	24.7/2.25	1.71	8.5	0.13	4.39 ± 0.07
GMn	8.1	6.6	17.5/2.25	1.65	11.0	0.20	5.31 ± 0.08
GMn	10.2	8.8	17.5/2.25	1.60	11.0	0.23	5.91 ± 0.08
GMn	12	8.8	13.3/2.25	1.50	14.0	0.28	8.08 ± 0.10
GMn	13.5	11	14.8/3.10	0.97	17.0	0.26	4.46 ± 0.01

GEN-RP coincidence : 1.25 MHz x 10 KHz x 50 ns = 625 Hz

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 if SSP give factor 3 reduction around 300 MB/s but need to be checked

Data rates Gen RP BigBite

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10
	Rate per cm2	Rate per plane	hits in 325 ns	occupancy	strip hits	XY	6 samples	bytes	Rate MB/s
1	86	516	167.7	26%	586.95	1173.9	7043.4	28178	95.81
2	94	564	183.3	28%	641.55	1283.1	7698.6	30794	104.70
3	93	558	181.35	28%	634.725	1269.45	7616.7	30467	103.59
4	92	552	179.4	28%	627.9	1255.8	7534.8	30139	102.47
5	54	324	105.3	16%	368.55	737.1	4422.6	17690	60.15
								Total	466.71
									311.14263

Coincidence trigger rate expected 625 Hz

Bigbite rate : about 311 MB/s expect factor of 3 reduction from SSP about 100 MB/s

1 VXS crate with VTP readout 1.25 GB/s

Data rates Gen RP polarimeter GEMS

	Rate per cm2	Rate per plane	hits in 325 ns	occupancy	strip hits	XY	6 samples	bytes	Rate MB/s
1	62	372	120.9	19%	423.15	846.3	5077.8	20316	69.07
2	63	378	122.85	19%	429.975	859.95	5159.7	20639	70.17
3	62	372	120.9	19%	423.15	846.3	5077.8	20311	69.06
4	11	66	21.45	3%	75.075	150.15	900.9	3604	12.25
5	11	66	21.45	3%	75.075	150.15	900.9	3604	12.25
6	14	84	27.3	4%	95.55	191.1	1146.6	4586	15.59
7	9	54	17.55	3%	70.2	140.4	421.2	1685	5.73
8	27	162	52.65	9%	210.6	421.2	1263.6	5054	17.18
9	5	30	9.75	2%	39	78	234	936	3.18
10	19	114	37.05	7%	148.2	296.4	889.2	3557	12.09
									286.59

- About 300 MB/s so 100 MB/s after online reduction
- Total GEM data rate about 200 MB/s , 2 VXS crates total bandwidth 2.5 GB/s , computer with 40gigE adapter

Requirement summary

- Max 5 KHz trigger rate for GMn
- Max 2 KHz trigger rate for Gen-RP at 30 % GEM occupancy
- 1 GB/s data rate

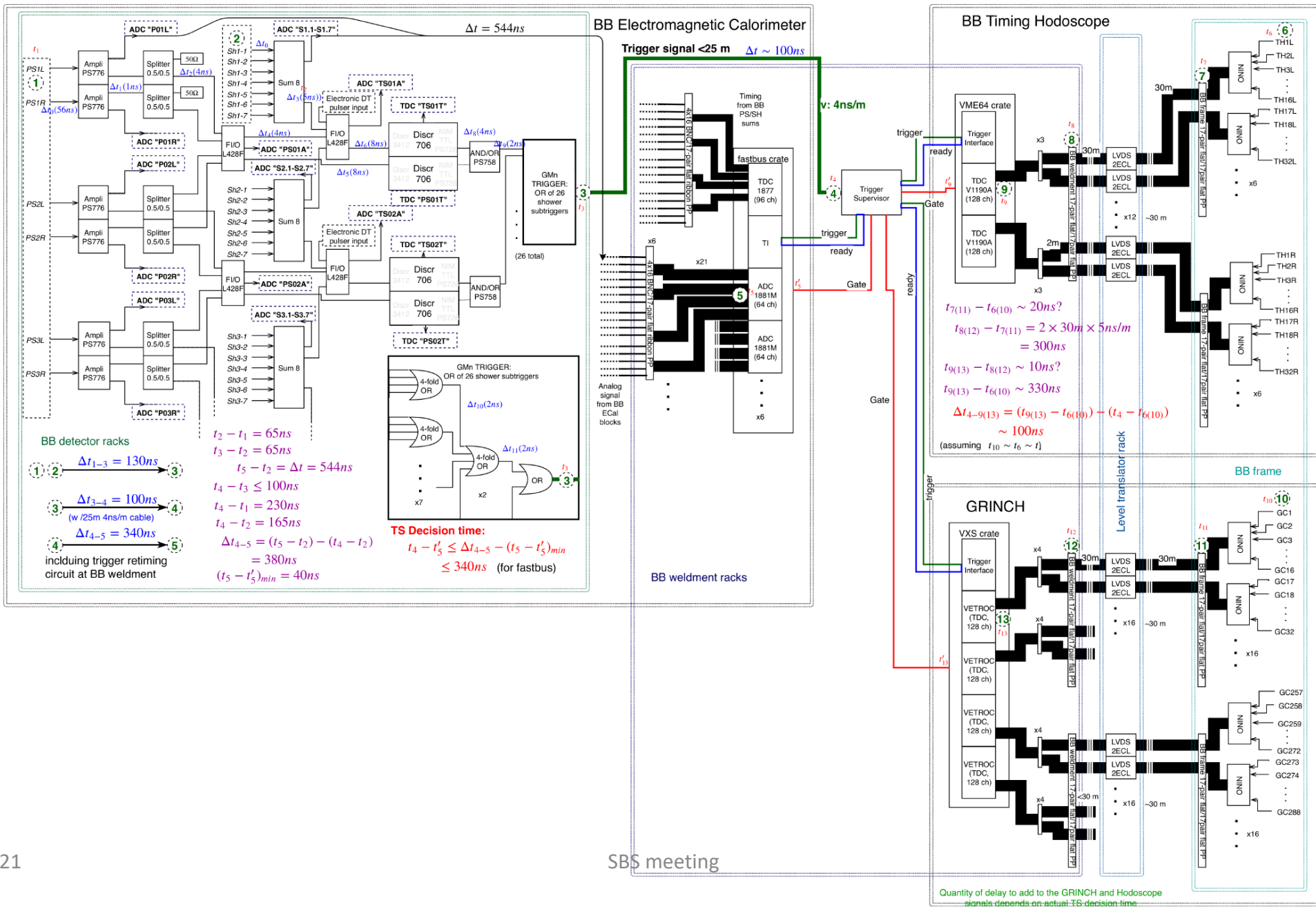
Shower

- 243 channels lead glass
- FADC readout : 10 FADC from electronics group + 6 Glasgow FADC ordered
- VXS received
- SoLID crate for testing with 4 FADC and VTP
- Need add TDC for sums : F1
- Fastbus testing with cosmics
- CODA3 setup complete
- Started looking at FADC preshower on FADC
- To do :
 - Install other FADC
 - Setup with TS
 - Setup FADC trigger (optional)

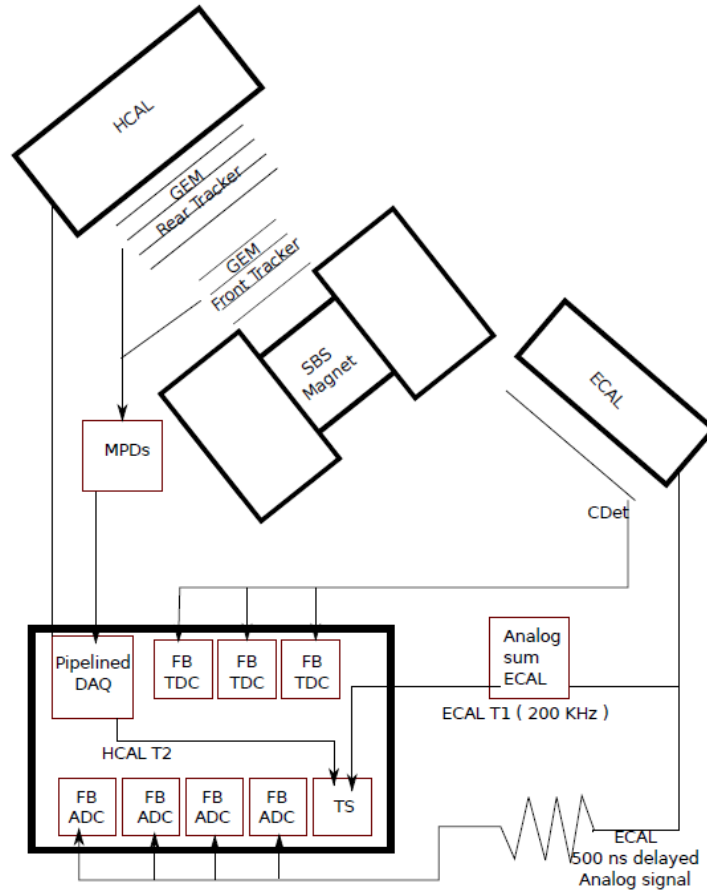
Bigbite DAQ (non GEM) Full inventory

		Type	Channels	Model	Number	On-hand	Ordered	Installed	Needed
BigBite	Shower	VXS			1	1		1	
		CPU			1	1		1	
		TI			1	1		1	
		SD			1	1		1	
		VTP			1	1		1	
		FADC	243	FADC	12	1	6	0	9
	Scintillator	VME64X			1	1		1	
		CPU			1	1		1	
		TI			1	1		1	
		TDC	180	V1190	2	2		2	
		ADC	64	V792	4	2		2	
		Clock dist			1	0			
	GRINCH	VXS			1	1		1	
		CPU			1	1		1	
		TI			1	1		1	
		SD			1	1		1	
		TDC	550	VETROC	6	6		6	
		ADC	64	V792	4	4		4	

Bigbite trigger and timing



L1 logic for non pipelined electronics



- Scheme for GEp5, replace ECAL by BB shower
- Fast L1A
- Fast clear if no L2, he L2 is accepted trigger by TS
- For Fastbus ADC / TDC , V792

FADC inventory

FADC list				
				Compton
			1ACDI-814 HALLA	HCAL
			2B21595_25R ACC	HCAL
			3ACDI-807 HALLA	HCAL
			4ACDI-412 PHY	HCAL
			5ACDI-407 PHY	HCAL
			6ACDI-806 HALLA	HCAL
			7ACDI-823 HALLA	HCAL
			8ACDI-809 HALLA	HCAL
			9ACDI-812 HALLA	HCAL
			10ACDI-420 PHY	HCAL
			11ACDI-818 HALLA	HCAL
			12ACDI-820 HALLA	HCAL
			13ACDI-821 HALLA	HCAL
			14ACDI-813 HALLA	HCAL
			15ACDI-822 HALLA	HCAL
			16ACDI-824 HALLA	HCAL
			17ACDI-864 HALLA	HCAL
			18ACDI-863 HALLA	HCAL
			19ACDI-811-HALL-A	HCAL
			20ACDI-817-HALL-A	HCAL sum
LHRS			19ACDI-762 PHY	S2ML
			20ACDI-786 PHY	S2MR
			21ACDI-201 HALL A	Gas Cerenkov S0
			22ACDI-783 PHY	A1
			23ACDI-748 PHY	Raster/BPM
			24ACDI-794 PHY	PRL
			25ACDI-819-HALL-A	PRL
			26ACDI-807-HALL-A	PRL
			27ACDI-862-HALL-A	PRL
SBS			28ACDI-237-HALL-A	Raster BPM
02/17/2021			29ACDI-211-HALLA	Hall C

Grinch

- 550 channels with NINO
- VXS crate, TI and SD
- 6 VETROC readout
- CODA3 upgrade complete

Hodoscope

- 180 channels scintillator readout with NINO
- CAEN TDC V1190
- 1 VME64X crate with TI
- 2 V792 ADC for calibration

- CODA3 upgrade complete
- Data taking on going

- To do :
 - Fast clear with TS
 - Add FADCs if available

- V792 in high background : either use Fastbus or FADC

HCAL

- 288 channels
- FADC readout : 16 + 2 FADC
- 5 F1 TDCs
- CODA3 setup
- Taking cosmics and LED
- Need setup DAC
- Digital trigger (optional)

Recoil polarimeter

- 96 + 32 channels
- FADC readout
- Crate will be installed in Bigbite weldment

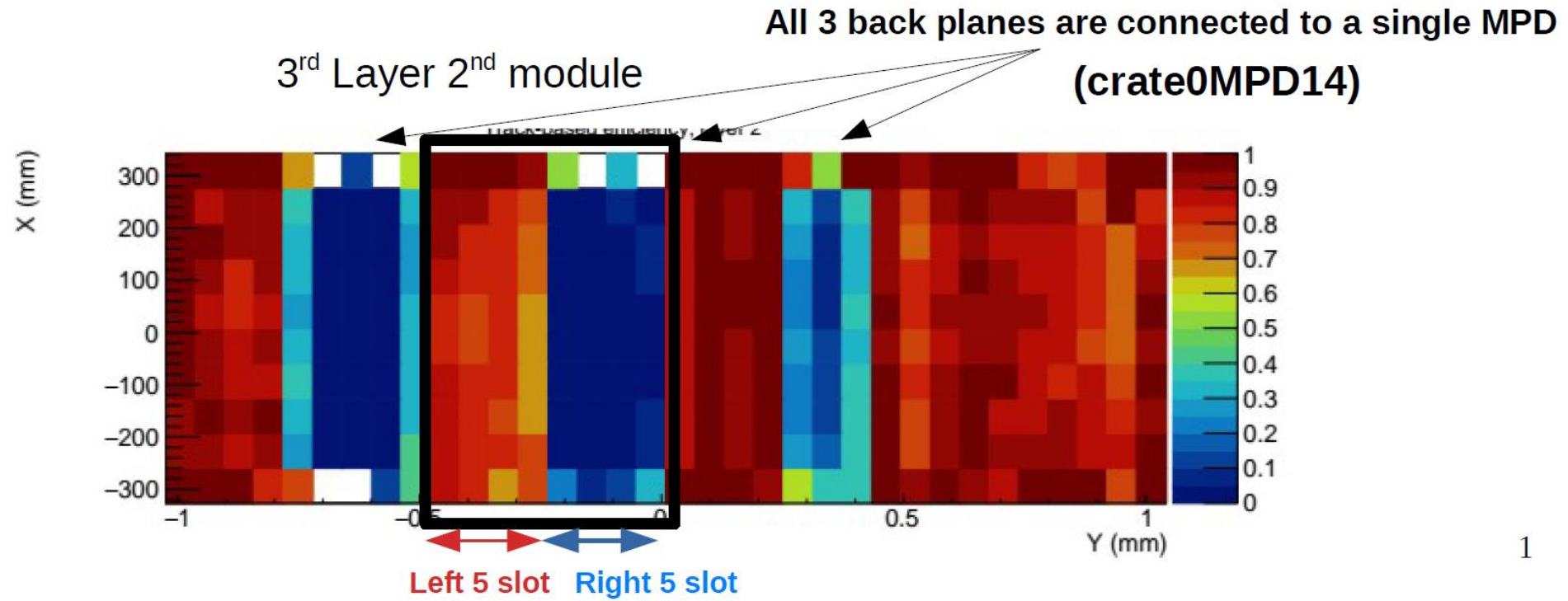
CDet

- 2520 channels
- MAPMT readout and NINO readout
- Fastbus for testing
- VETROC ordered
- VXS ordered
- Starting CODA3 setup and testing VETROC

GEM

- UVA clean room
 - Taking cosmics using VME readout
 - CODA3 setup
 - Optical readout set up but not in use
 - Issue of low efficiency in some module being investigated
- INFN clean room
 - Taking cosmics using VME readout
 - Optical readout set up but not in use
 - Instabilities issues solved with hardware replacement and increase of low voltage
 - Starting using CODA3

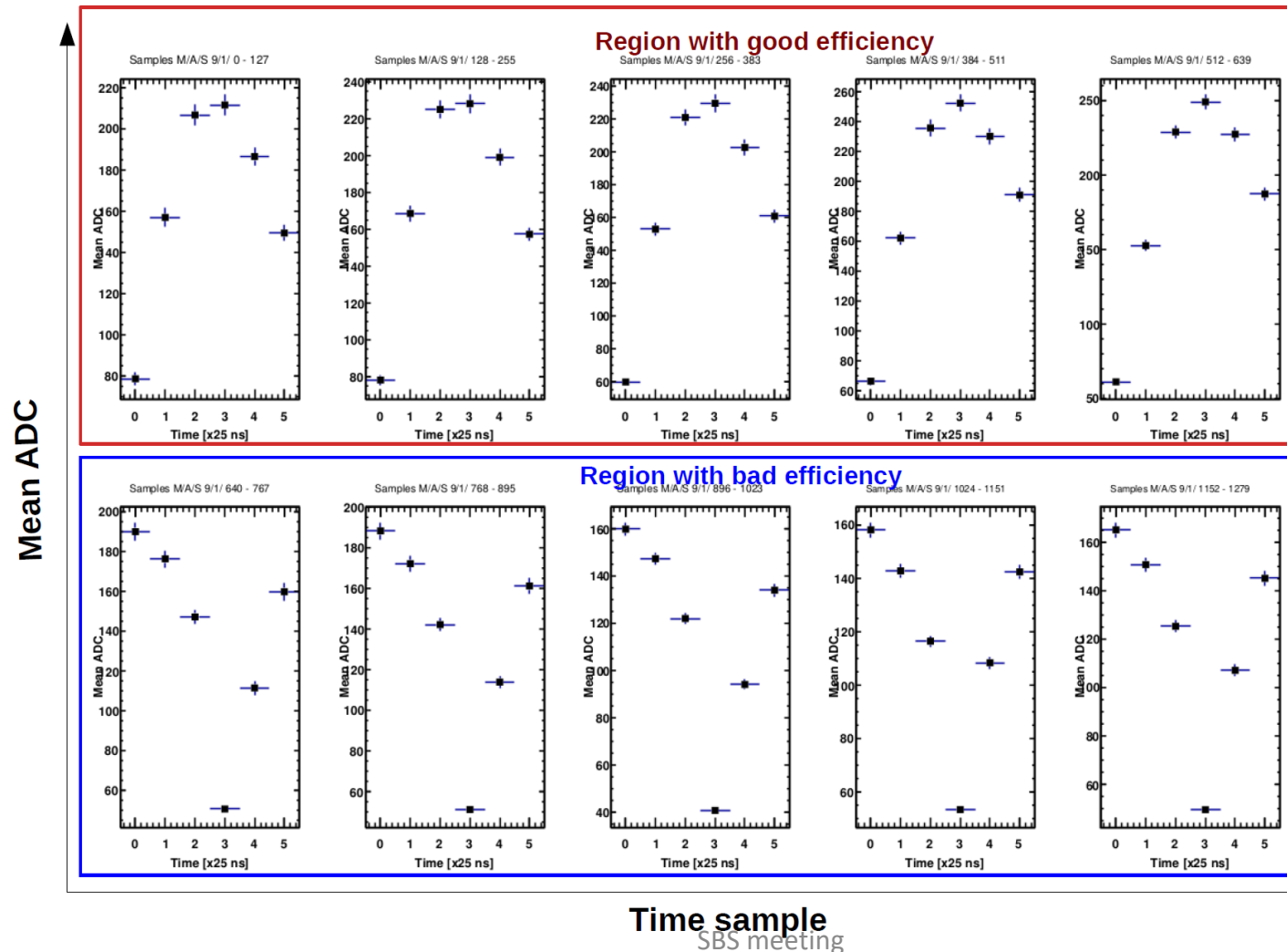
GEM continued



1

GEM continued

ADC vs time



GEM continued

- BB GEM setup
 - 1 VME crate
 - 1 VXS crate with SSP TI and SD
- GEM readout being setup on tedbbdaq
- Space in TEDF being cleaned up for GEM layer installation in BigBite in December
- 3 VXS crate on site
- Optical to VXS adapter ordered : 80 MPDs per VXS crate
- Need 3 VTPs
- 16 Optical to VXS adapter : $400 \$ \times 16 = 6400 \$$

GEM

MPD optical output

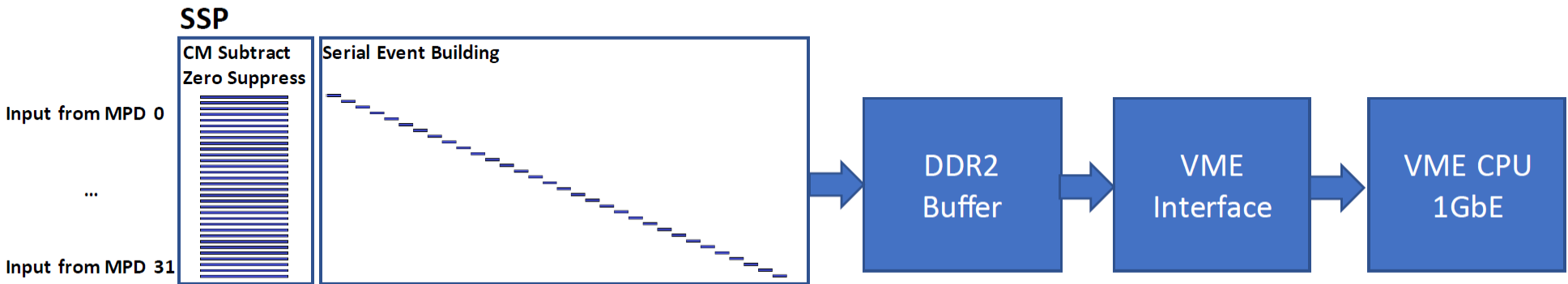
For each trigger an MPD sends:
 $128\text{ch} \times 6\text{samples} \times 15\text{APV}/25 = 11520 \text{ 32bit words} \Rightarrow 11520 \times 32\text{b} \times 10\text{b}/8\text{b} = 460800\text{bit}$

At 2.50Gbps => 185µs per event => 5.4kHz limit
At 1.25Gbps => 370µs per event => 2.7kHz limit

- We had to lower from 2.5Gbps -> 1.25Gbps after realizing large jitter on MPD data transmission.
- At 1.25Gbps link is reliable, but we need to pack 2 samples per 32bit on MPD data to go back to 5.4kHz limit

On the SSP, common-mode/zero suppression is processed on all 32 fibers from MPD in parallel, but was event building result in serial:

442kB per event from SSP (32 MPD, 100% occupancy)
132kB per event from SSP (32 MPD, 30% occupancy)

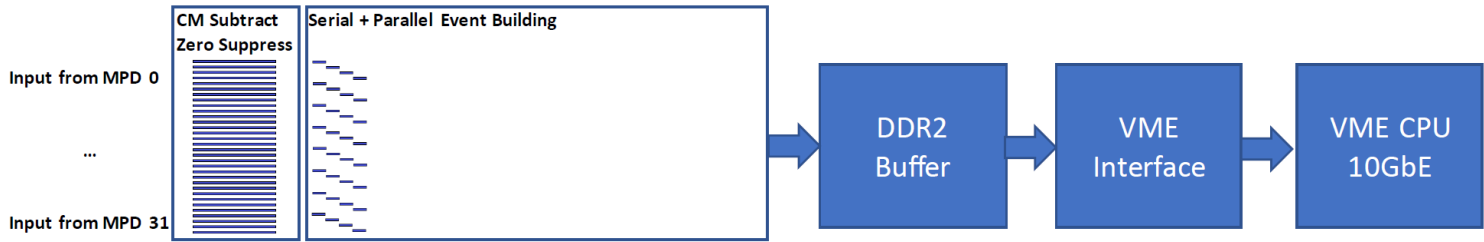


				Trig rate limit (30% occupancy, 32MPD, 15APV)	MPD Limit (30% occupancy, 4.5kHz, 15APV)
Previous (w/2.5Gbps links):	125MB/s throughput	200MB/s 2eSST	~100MB/s throughput	754Hz	5
Previous (w/1.25Gbps links):	62.5MB/s throughput	200MB/s 2eSST	~100MB/s throughput	471Hz	Not possible

GEM

To achieve 4.5kHz trigger rate capacity, so changes are necessary:

- 1) Partial parallelize event building
- 2) Pack 2 samples per 32bit word on MPD
- 3) Increase VME readout bus speed
- 4) Switch to 10GbE network on CPU

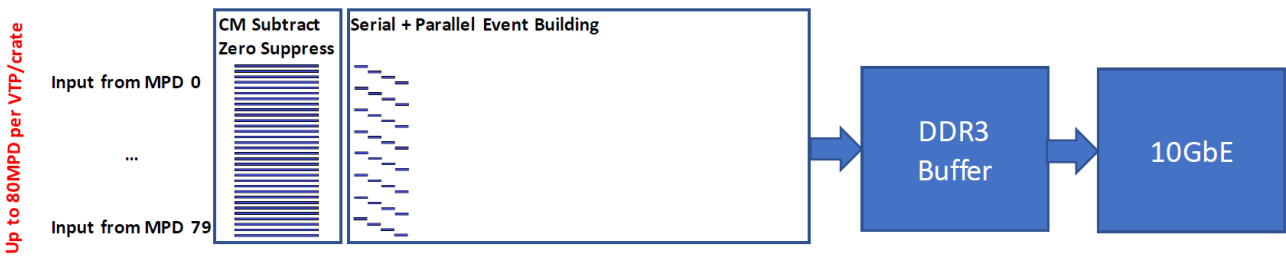


				Trig rate limit (30% occupancy, 32MPD, 15APV)	MPD Limit (30% occupancy, 4.5kHz, 15APV)
1.25Gbps links 1 sample per word:	500MB/s throughput	320MB/s 2eSST*	~1000MB/s throughput	1.8kHz	Not possible
1.25Gbps links 2 sample per word:	1000MB/s throughput	320MB/s 2eSST*	~1000MB/s throughput	1.8kHz	13

* 250MB/s expected due to VME overhead

To pack more MPD per crate/module:

- 1) Use VTP instead of SSP (abandons VME bus)



			Trig rate limit (30% occupancy, 32MPD, 15APV)	Trig rate limit (30% occupancy, 80MPD, 15APV)	MPD Limit (30% occupancy, 4.5kHz, 15APV)
Feb. testing					
1.25Gbps links 1 sample per word:	5GB/s throughput	~1000MB/s throughput	2.7kHz	2.7kHz	Not possible
1.25Gbps links 2 sample per word:	10GB/s throughput	~1000MB/s throughput	5.4kHz	3.0kHz	38

GEM timeline

- Zero-suppression and common mode suppression ongoing
- Debugging INFN, UVA chambers
- VTP readout testing : end of April
- GEM move and cabling in Hall A
- High rate test around May

MPD

- Issue of noise on optical link
- Need (small redesign of board)
- Nilanga ordering 5 MPDs, will order 3 for SOLID

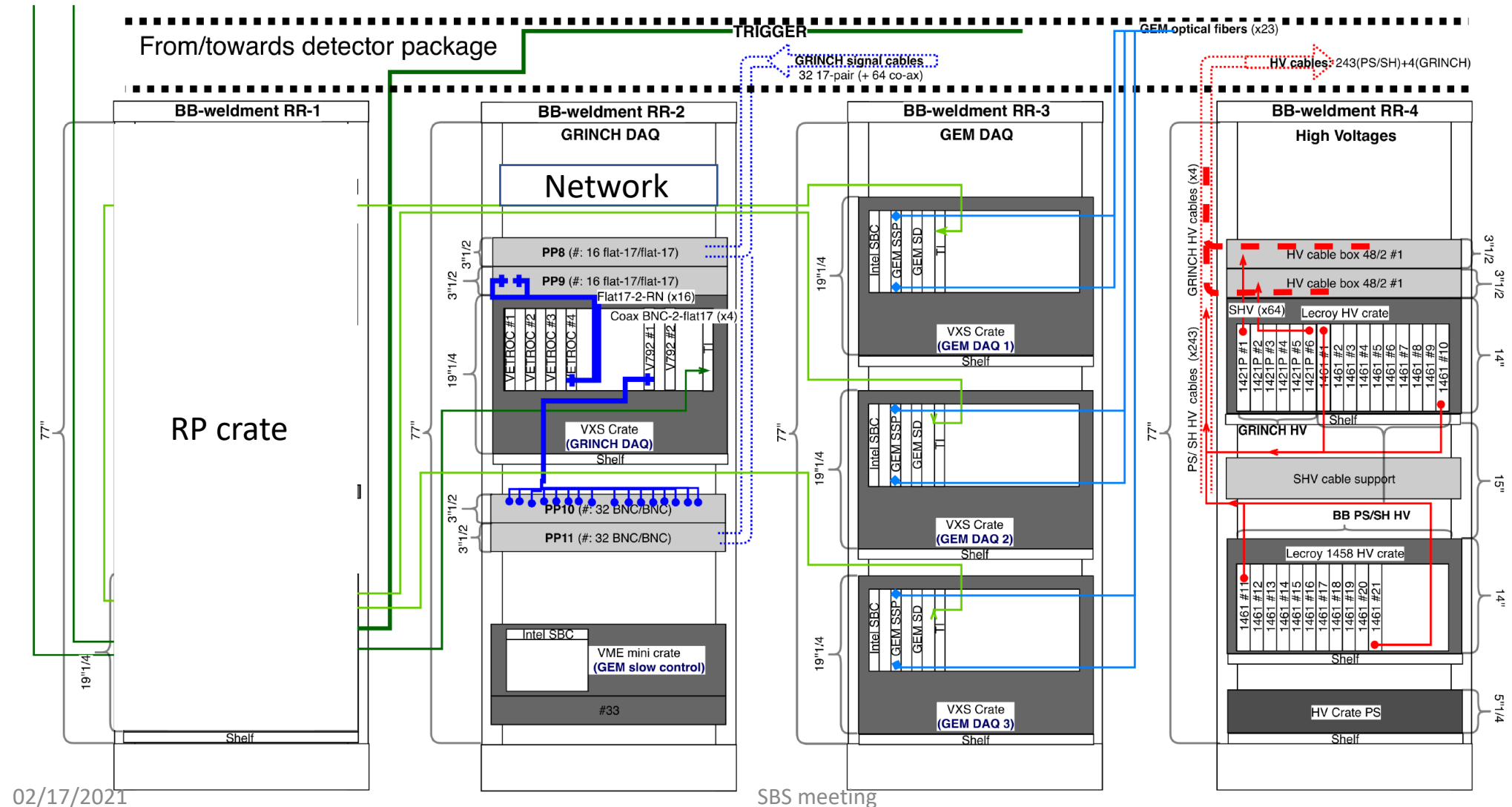
LHRS

- S0 2PMTs : FADC
 - S2m 16 PMTs : FADC
 - PRL 68 channels : FADC
 - 768 VDC channels : 3 Fastbus
-
- Upgrading to CODA3, intel CPU and new TI
 - Need fiber trunk for TI fiber installed

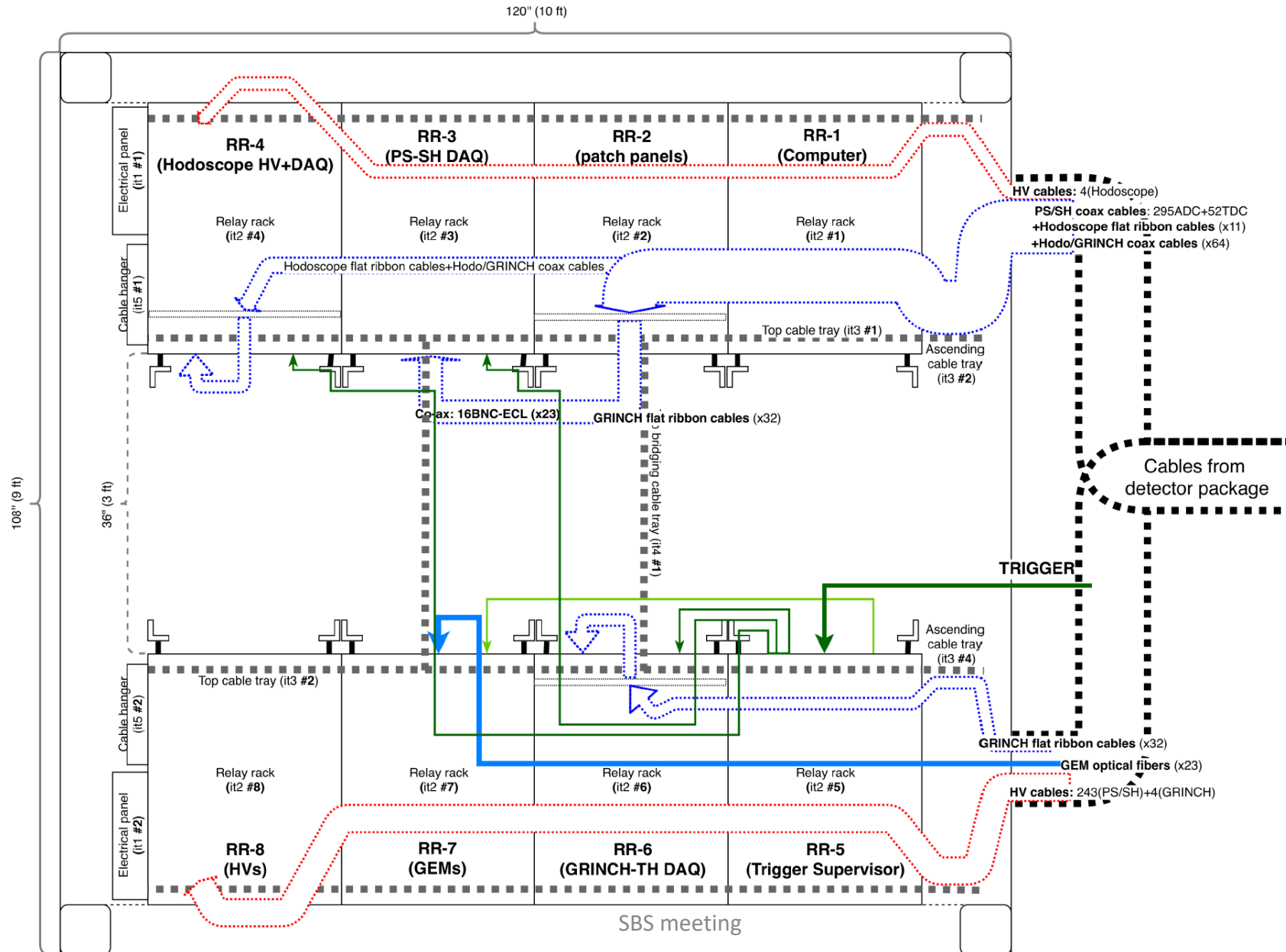
Cable list

- <https://docs.google.com/spreadsheets/d/1gPhDCgyxigeVbjGXxMINCIUUzg42ZZZJy8PBZF-zLAc/edit?usp=sharing>

Cable and rack layout from Eric



Bigbite weldment cable trays



Network upgrade

- Install new router and fibers in March
- 10 gigE available in Hall A, 40 gigE to DAQ computer
- Need buy install fibers to SBS weldment

Timeline

- TS setup End of February
- Network upgrade March
- Move to Hall A April
- Cabling SBS helicity crates / BPM / scalers
- Stand alone DAQs running May
- Test high rate data May

Purchases

- Required
 - TI fibers installation for HRS
 - 3 VTP for GEMs = $3 \times 10\text{K\$}$
 - FADCs
- Useful / practical
 - Router SBS weldment 10 K\$
 - GEM VME readout / firmware update
 - 6 TI = $6 \times 3\text{K\$} = 18\text{ K\$}$
 - 6 VME CPU = $6 \times 3\text{K\$} = 18\text{ K\$}$

Documentation

- No special safety documentation, included in other detectors
- Wiki documentation for test stands
 - https://hallaweb.jlab.org/wiki/index.php/SBS_DAQ_meetings
 - [https://hallaweb.jlab.org/wiki/index.php/SBS_DAQ: GEM EEL Cleanroom setup](https://hallaweb.jlab.org/wiki/index.php/SBS_DAQ:_GEM_EEL_Cleanroom_setup)
 - [https://hallaweb.jlab.org/wiki/index.php/SBS_DAQ: GEM TEDF BigBite setup](https://hallaweb.jlab.org/wiki/index.php/SBS_DAQ:_GEM_TEDF_BigBite_setup)
- Need to finalize documentation of Hall data taking after move in Hall A in May

Conclusion

- Most hardware on hand
- FADC for hodoscope and Grinch would be nice but shower has priority (Shortage of Hall A FADCs)
- All systems taking data now
- Network upgrade and VTP readout gives headroom for rate
- Some items to be ordered
 - 3 VTP = 30 K\$
 - Optical to VXS adapter = 6.4 K\$
 - TI fiber installation ~ 10 K\$
 - GEM VME readout : 36 K\$