SBS DAQ GMn/Gen RP

July 13th 2020

Alexandre Camsonne

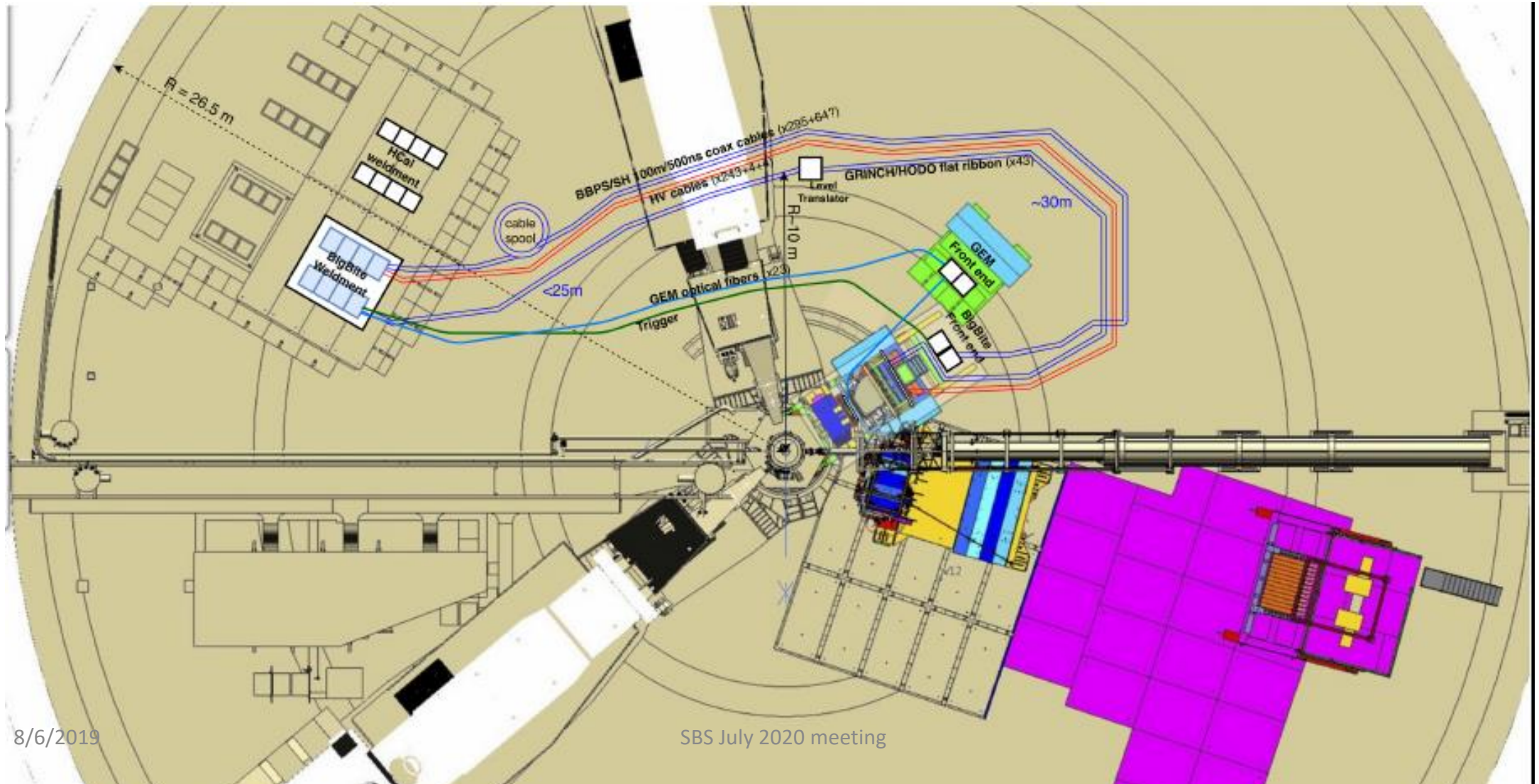
GMn / GEn RP

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

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
	CDet	2520	VETROC	13
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

Hall Layout


R = 26.5 m
HCal weldment
BigBite Weldment
cable spool
BBPS/SH 100m/500ns coax cables (x295+64?)
HV cables (x243+4+4)
GRINCH/HODO flat ribbon (x43)
Level Translator
~30m
R~10 m
<25m
GEM optical fibers (x23)
Trigger
GEM Front end
BigBite Front end

Procurement

- All fibers,optical transceivers ordered
- Most hardware on hand using ECAL/RHRS
- 3 VXS crates , 3 SDs and 3 TIs received
- 6 standard VME crates for GEMs in clean room

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	Total Hz
3.5	6700	0.35	235	12	2100
4.5	1015	0.7	70	12	1400
5.7	97.9	1.4	13.5	18	140
8.1	47.4	1.4	6.6	18	390
10.2	31.6	0.7	1.5	24	210
12	5.04	1.4	0.7	36	200
13.5	6.25	1.4	0.87	96	100

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

New trigger rates GMn

Gen/RP

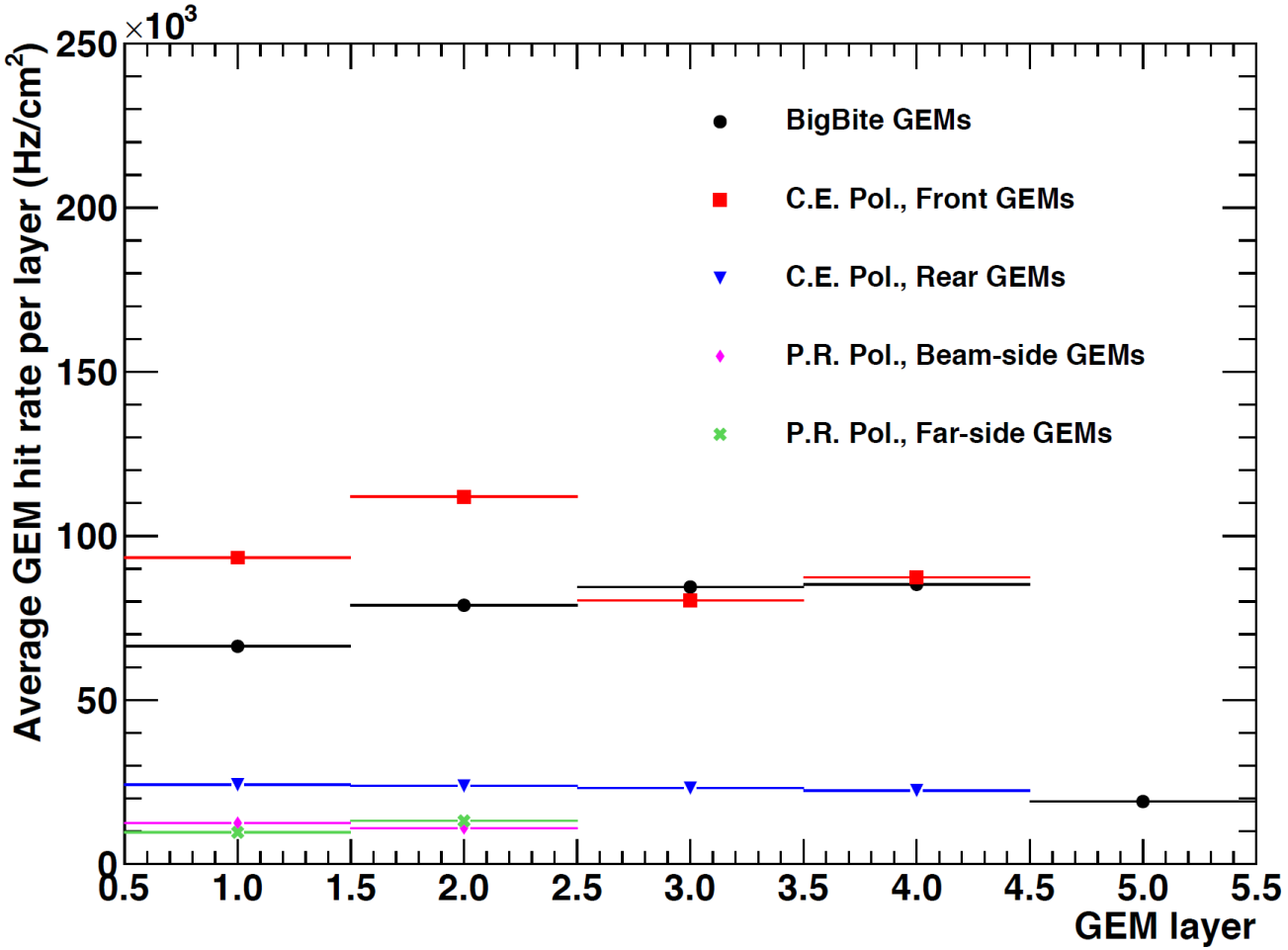
Q^2 (GeV^2)	E_e (GeV)	θ_{BB}/d_{BB} (deg)/(m)	E'_e (GeV)	Thrsh. (GeV)	Eff. %	Trig. Rate. (kHz)					Total (kHz)
						El.	Inel.	π^+	π^0	π^-	
3.5	4.4	32.5/1.80	2.18	1.81	96.9	0.8	5.3	0.04	3.5	0.1	9.7
4.5	4.4	41.9/1.55	1.70	1.35	94.0	0.2	2.3	0.2	7.3	0.2	10.2
5.7	4.4	58.4/1.55	1.14	0.89	94.8	0.02	0.6	0.4	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

New GEMs rates



- 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

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

Expected data rates GMn

Preferably single electron trigger to avoid biased in neutron detector

Q^2 GeV^2	QE rate Hz	Beam time Hours	Total Hz
3.5	235	12	9700
4.5	70	12	10200
5.7	13.5	18	14500
21	6.6	18	2100
10.2	1.5	24	600
12	0.7	36	1300
13.5	0.87	96	400

Trigger

- Baseline L1 (500 ns delay about 25 meters trigger cable)
  - Bigbite shower trigger
  - Coincidence BigBite shower and HCAL analog sum

- L2 triggers
  - HCAL cluster sum
  - GRINCH Cerenkov

GEM readout

- SSP based readout
- 3 + 1 VXS crates, SSP, TI and SD (3 TI and 3 SDs to be ordered)
- 101 MPDs
- 4 SSPs
- Received MPD transceivers and fibers

- System testing this August

SSP readout (Ben Raydo)

- SSP readout up to 32 MPD
- Being tested with 12 MPDs right now
- Zero suppression algorithm implemented
- Debugging (1 bad event every 1 M events)

- VTP fast readout might be available but risky if not enough time to test (1.25 GB/s)

HCAL FADCs

- All hardware on hand : 2 SD, 18 FADCs, 2VXS crates, 2 VTP, 2 CPU, 2 TI
- Single crate trigger available
- HCAL trigger needs transfer two FADCs through VTP optical link about 1 month

- Fast VTP readout most likely available

Gen RP data rates (625 Hz coincidence)

	Rate per cm2	Rate per plane	hits in 325 ns	occupancy	strip hits	XY	6 samples	bytes	Rate MB/s
1	65	390	126.75	20%	443.625	887.25	5323.5	21298	13.84
2	80	480	156	24%	546	1092	6552	26208	17.04
3	85	1020	331.5	51%	1160.25	2320.5	13923	55692	36.20
4	85	1020	331.5	51%	1160.25	2320.5	13923	55692	36.20
5	85	1020	331.5	51%	1160.25	2320.5	13923	55692	36.20
6	95	1140	370.5	57%	1296.75	2593.5	15561	62244	40.46
7	112	1344	436.8	77%	1747.2	3494.4	10483.2	41933	27.26
8	85	1020	331.5	58%	1326	2652	7956	31824	20.69
9	85	1020	331.5	58%	1326	2652	7956	31824	20.69
10	85	1020	331.5	58%	1326	2652	7956	31824	20.69
11	10	120	39	7%	156	312	936	3744	2.43
12	10	120	39	7%	156	312	936	3744	2.43
Samples	20								
FADC		Event size						Total	274.12
	288	13968	9.0792						
	128	6208	4.0352						
		Total	287.23						

Expect factor 3 reduction from SSP zero suppression about 100 MBs

Plan for factor 500 MB/s - 5 crates for SSP (can use VME64X crates – need 2 more SSPs)

Timeline

- HCAL FADC trigger September 2020
- Finish SSP readout August 2020
- TEDF GEM readout Summer / Fall 2020
- Network / SILO testing (after CREX Fall 2020)

Getting rid of Fastbus

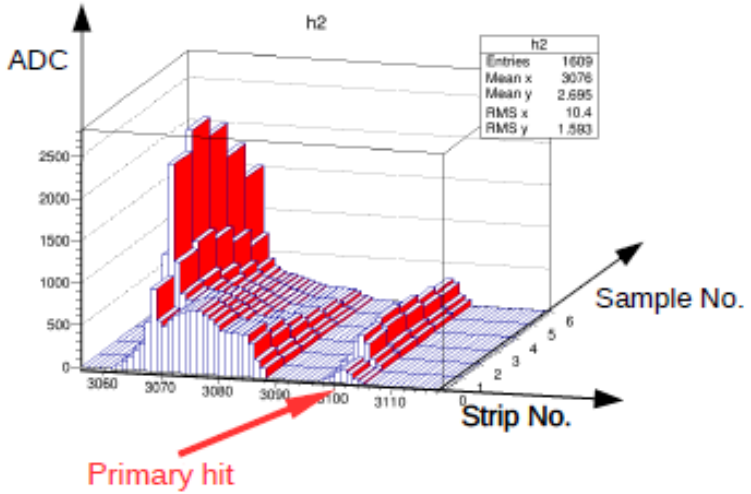
- If we have 16 FADCs : no more Fastbus
- Trigger rate capabilitily goes from 6 KHz to at least 20 KHz
- Can use Cerenkov trigger and HCAL trigger for L1 since no more requirement on delay
- HRS VDC still on Fastbus but not used for production (could upgrade to VETROC need 8 = 16 K$)

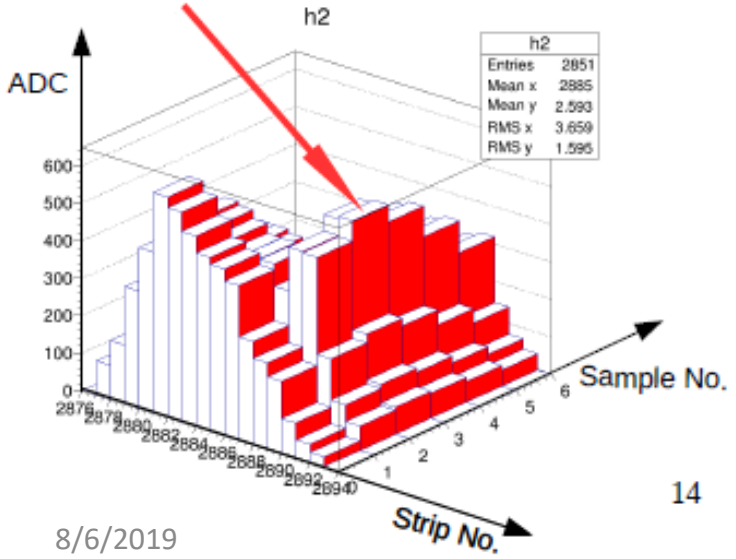
Conclusion

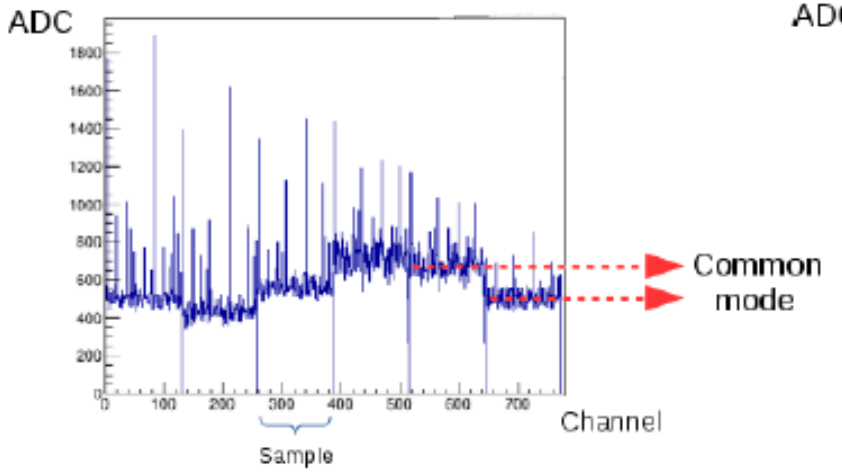
- Trigger rates higher because of pi0
- Plan for 5 GEM/SSP crates
- Works for Gen RP with coincidence trigger
- GMn a bit tough with single arm trigger
- Might be worth to check each kinematic to make sure zero suppression is sufficient to be able to handle data rate

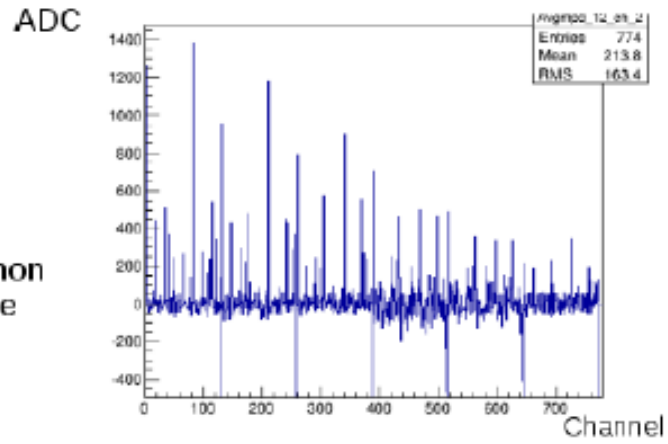
Backup

SSP data reduction







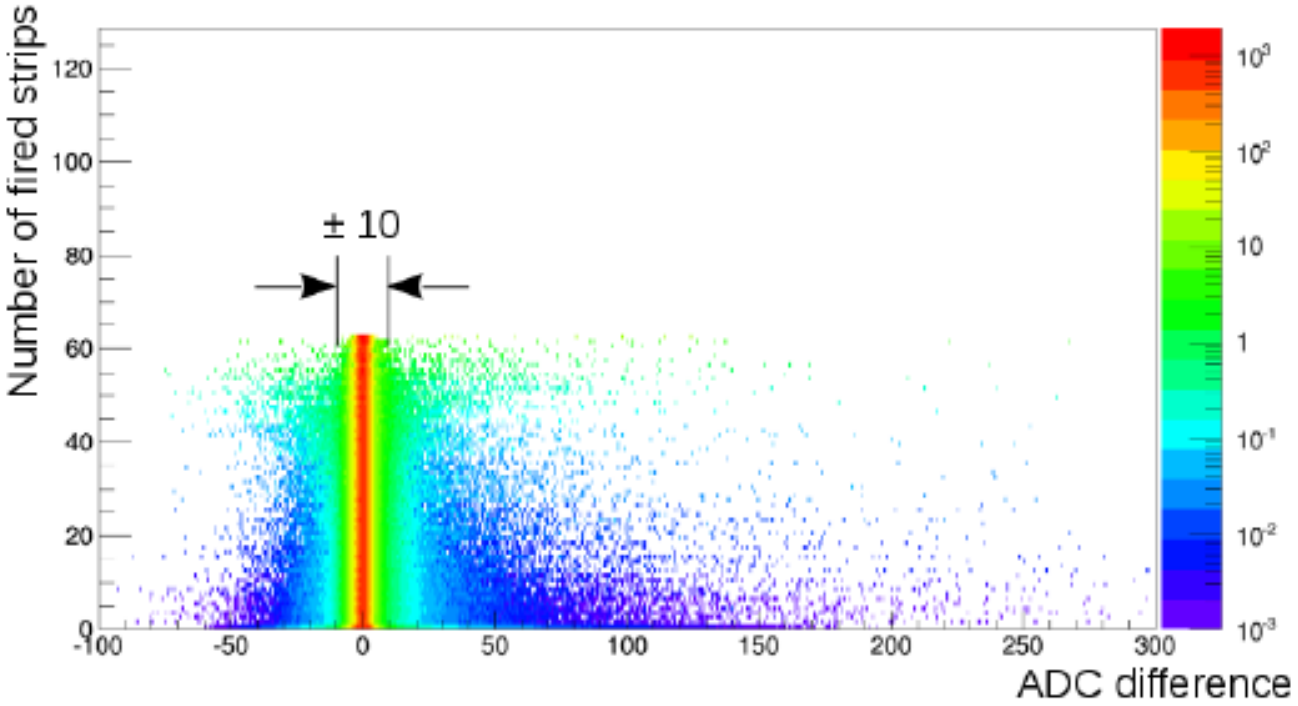


- Common noise subtraction
- Zero supression
- Transfer 6 samples

14

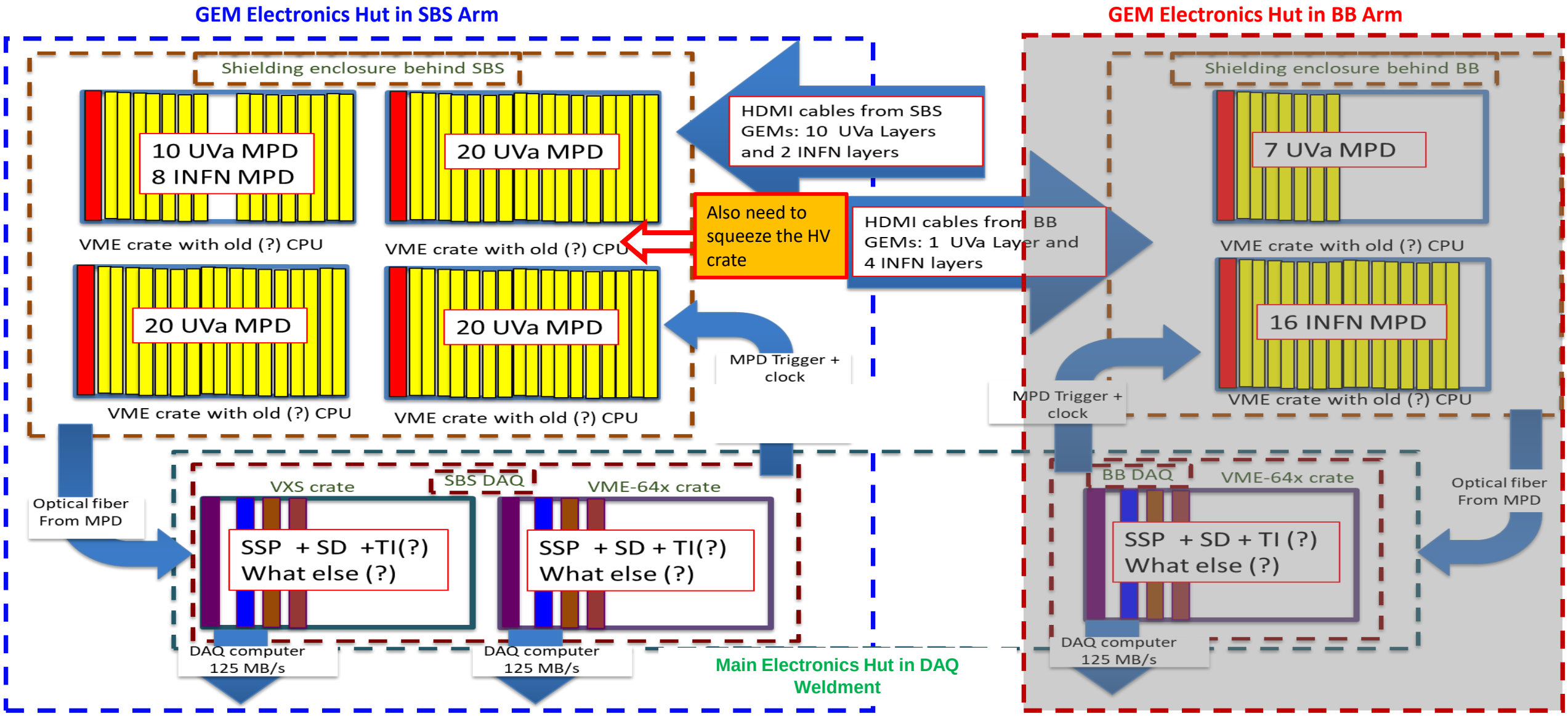
SSP implementation

- First implementation up to 4 MPDs



- Offline vsonline treatment
- Very good efficiency of online treatment

SBS GEM Electronics for Gen-RP



- JLab custom device to distribute the clock & trigger to the MPD from the SSP instead of the Phillips 757 modules to save money
- **Statements yesterday that these modules have 16 inputs, we would need 20 inputs according to this scheme**

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)

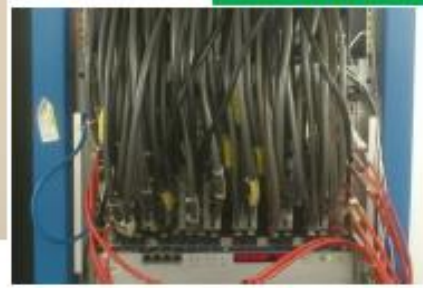
MPD Main Block

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

SSP data reduction