SBS GMn/GEn RP DAQ

SBS review

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October 30th 2018

Outline

- GMn data rates
- Gen RP
- Network
- Computer
- Disks
- Tape
- Conclusion

Experimental setup GMn

- BigBite
  - Shower
  - Preshower
  - Scintillator
  - GRINCH

Detector	Channels	NINO	Readout	ADC	TDC
Shower	7x27 = 189 27 sums		Fastbus	X	
Preshower	2x27 =54 2 sums		Fastbus	X	
Scintillator	200 x 2	X	VME	X	X
GRINCH	550	X	VME		X
GEM	5 planes		VME		

- Neutron detector
  - CDET
  - HCAL
- LHRS

Detector	Channels	NINO	Readout	ADC	TDC
HCAL	288		VME	X	X
CDET	2352	X	Fastbus		X

SBS GMn DAQ Overview

- Calorimeter
  - ECAL : Fastbus
  - HCAL :FADC , F1 or VETROC TDC
- SBS GEM
  - APV25 INFN MPD
- BigBite
  - Scintillator
  - Shower preshower
  - Fastbus
- Coordinate detector
  - Fastbus

SBS Gen RP DAQ Overview

Additional detectors

- 2 Hodoscope arrays 24+24 scint bars from (Old) BB Hadron stack 2 PMTs/bar 96 HV, signal channels)
- 10 'Rear' GEM planes 6 in-line with SBS detector stack 2 in front of 'left' hodoscope array (proton pol.) 2 in front of 'right' hodoscope array (proton pol.)

Electronics

- 6+2 F250 FADC Draw from 'NPS/LAD' FY19 plans (*)
- 1 C1190 TDC In hand (1+spare: Glasgow + Hall C spares)
- 6+2 CAMAC Discrim. 4 in hand; 4 to locate
- 1 VXS crate In hand (1+spare: Glasgow + Hall C spares**)

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

GEM occupancy and data rates GMn

- occupancies from Q2 = 13.5 GeV2, with luminosity 2.8 10^38 A^{-1} cm^{-2} s^{-1} (44uA on 10cm LD2 target) and rates from low Q2 point : 1.3 KHz

	Rate per (KHz/cm2)	Rate per plane (MHz)	hits in 325 ns	Occupancy (%)	strip hits	x2 XY (strips)	x6 samples	Evt size (bytes)	Rate MB/s
1	86	516	167.7	26%	586.95	1173.9	7043.4	28178	118.35
2	94	564	183.3	28%	641.55	1283.1	7698.6	30794	129.34
3	93	558	181.35	28%	634.725	1269.45	7616.7	30467	127.96
4	92	552	179.4	28%	627.9	1255.8	7534.8	30139	126.58
5	54	324	105.3	16%	368.55	737.1	4422.6	17690	74.30
								Total	**577**

Worse case scenario using High Q2 occupancies with low Q2 rates

Deconvolution on SSP : **expect factor of 3 reduction about 190 MB/s**

Expected trigger rates GMn

Preferably single electron trigger to avoid biased in neutron detector

Q^2 GeV^2	QE rate Hz	Beam time Hours	Total Hz	Max data rate MB/s	Expected data rate MB/s
3.5	235	12	2100	300	150
4.5	70	12	1400	130	65
5.7	13.5	18	140	13	6.5
8.1	6.6	18	390	36	18
10.2	1.5	24	210	19	9.5
12	0.7	36	200	18.5	9.5
13.5	0.87	96	100	9.15	4.6

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

Inventory GMn/GEn

- TS : VXS crate, TS, TD, 1 Intel CPU
- HCal
  - 288 channels : 18 FADCs, 2 VXS crates (JLAB + UVA), 2 VTP, 2SD, 2 CPU, 2 TI, 5 F1 TDC
- BigBite
  - 243 shower channels : 4 Fastbus ADC, 1 SFI (from ECAL), 1 TI (from ECAL)
  - 200 hodoscope : NINO + 4 V1190 (Glasgow) (December 2018) (in HCal crate)
  - 550 GRINCH : 3 or 5 VETROC + VXS crate + 1 GTP + 1 CPU + 1 TI
  - 4 INFN GEMs 1 UVA GEM : 1 VXS crate (UVA)+ 2 VME 64 X crate (JLAB + UVA) + 20 MPDs + 4 SSP (Hall A+C) + 1 SD (SBS) + 3 CPUs + 3 TI
- Cdet
  - 2520 channels
    - NINO + 9 Fastbus crates +9 SFI +9 INTEL CPU + 27 TDC 1877S (3 per crate)
- LHRS
  - 768 VDC channel on 3 Fastbus crates, 3 SFI, 3 TI
  - 2 S0, 32 S2m on F1 ,10 Cerenkov ,68 channels Pion Rejector

Gen RP data rate

Use 3.4 KHz and highest Q2 occupancies

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

311 MB/s
100 MB/s after SSP reduction

Total GEMs about 200 MB/s

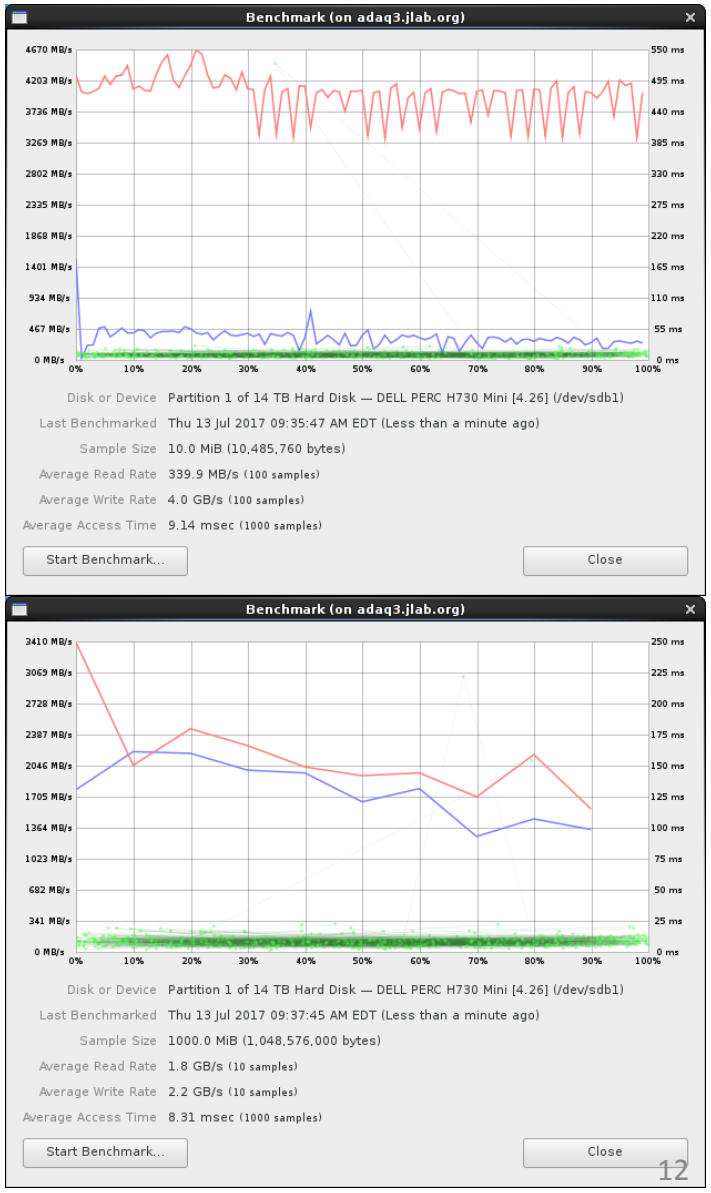
GEn RP polarimeter GEM chambers

	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 286 MB/s for RP chambers
SSP reduction by factor of 3 : 95 MB/s
final number need to be finalized from simulation

Hard drives

- SAS/SATA
  - 10TB GB 200 MB/s 500 $
  - Current raid array performance 2GB/s
- SSD SATA
  - 960 GB 500 $ 480 MB/s
- SSD PCIe
  - 1.6 TB 1.2GB/s 3.5 K$
  - 375 GB 2 GB/s 1.1 K$
- Hard drive upgrade : 8 SSD = 10 K$
- Raid array (3 days of data) : 1 PB = about 300 K$ off the shelf



Network upgrade

- Replace hall A router with an Arista switch, reuse existing hall A router as the switch for the racks. This provides dense 10Gig aggregation, with 40Gig expandability. Estimate $30K, 3 month lead time.

- Single Mode Fiber Installation in the hall (required for any speeds>1Gbit/sec), rough estimate $30K, 6 month lead time.
  Counting House to left arm, 24 strand
  Counting House to right arm, 24 strand
  Counting House to Labyrinth, 24 strand
  Counting House to Hall Floor Rack Area, 24 strand

- 40Gig uplinks to CEBAF center ($20K upgrade to item 2).

- Bottom-line : 10 Gig capability 30 K$ + temporary fiber 10 gigE for GMn
- Partial upgrade : 10 Gig capability 30 K$ + fiber upgrade 60 K$
- Full upgrade : for Gep, SIDIS, TDIS additional 80 K$

SILO capabilities

- Mix of LTO 5 to LTO 8 : 24 drives total
  - Current 5 GB/s
    - 8 drives LTO5
    - 8 drives LTO6
    - 4 LTO7 (300 MB/s)
    - 4 LTO8 (360 MB/s)
  - each LTO8 drive is 360 MB/s about 10 K$ each
  - Max : 24 * 360 = 8.64 GB/s
  - to handle 1 GB/s : 4 drives about 40 K$
  - increase to 4 GB/s (1GB + dup + read) about 120 K$
  - can upgrade all to LTO8 more : 200 K$ -> 8.64 GB/s
  - need to write and read at same time
  - LTO8 available in 2017
  - Need to let IT know our real needs might need more drives
  - could do 8.64 GB/s for 200 K$

Hardware

- For GMn
  - Network upgrade : 30 K$ (should)
  - 4 Intel CPUs HRS : 16 K$ (like)
- For GEp5
  - 12 intel CPUs : 36 K$ (must)
  - 1 VXS crate : 15 K$ (like)
  - Network upgrade 50 K$ -> 2x40 Gb/s = 10 GB/s
  - Silo upgrade (should)

CODA3 VTP readout

- CODA3
  - no more vxworks CPU support
- CODA3 will support serial VXS readout with VTP
  - 10 GigE for HCal, GEM readout
  - (just need one crate instead of 3)
- Very useful for Gep, would like to use Gen as testbed

Man power

- DAQ computing / network : IT, Alexandre Camsonne, Robert Michaels, Ole Hansen
- Fastbus/ECAL
  - M. Jones, B. Michaels, J. Gu, B. Moffit
- HCAL
  - B. Raydo, A. Camsonne, J. Cornejo, M. Carmigiotto
- GEM readout
  - E. Cisbani, B. Moffit, A. Camsonne, P. Musico, B. Raydo, S. Riordan, D. Di
- BigBite :
  - D. Higginbotham,E. McLelan, Eric Fuchey
- CDET :
  - Peter Monaghan, Ed Brash

Timeline

Year	7	8	9	10	11	12
2018	HCAL FADC cosmics 16 ch INFN GEM cosmics VME	INFN GEM SSP readout cosmics UVA GEM cosmics	Hodoscope done Preshower stacking start	CDET crates Test L2 MPD logic Finalize layout GMn		Hodoscope electronics
2019	1	2	3	4	5	6
Jan June	Hodoscope cosmics Finalize Gep trigger		DAQ rate test validate 300 MB/s to silo			
2019	7	8	9	10	11	12
July Dec	Start BigBite cabling	Cosmics Full BigBite				

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	1000	3888000	3888	7776	97	49
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

Infrastructure status (500 MB/s)

Item	Status
LHRS DAQ	1 intel CPU 4 Vxworks CPU
Computer disks	2 raid arrays 2000 MB/s
Network	Gigabit Ethernet in Hall (100 MB/s) 10 GigE router 10 Gig adapter on adaq1 and adaq2 (1000 MB/s) 1 fibers 10 Gig Ethernet to Silo (1000 MB/s)
Silo	8 drives LTO5 8 drives LTO6 4 LTO7 (300 MB/s) 4 LTO8 (360 MB/s) -> 5 GB/s

Current infrastructure should satisfy GMn and Gen close from limit for only high rate point

Infrastructure should (1GB/s)

Item	Status	Cost
LHRS	1 intel CPU 4 intel CPU	15 K$
Computer disks	2 raid arrays 2GB/s 8 SSD (8x 2GB/s)	20 K$
Network	1 Gigabit Ethernet in Hall 40 GigE router 40 Gig adapter on adaq1 and adaq2 (1000 MB/s) 2 fibers 10 Gig Ethernet to Silo (2000 MB/s)	30 K$ 5 K$
Silo	8 drives LTO5 8 drives LTO6 4 LTO7 (300 MB/s) 4 LTO8 (360 MB/s) 4 LTO8 (360 MB/s) -> 6.2 GB/s	40 K$ (IT)

Moderate upgrade 70 K$: can easily handle GMn and GEn, can test CODA3, should be ok for Gep unless bad background surprise

Easy upgrade to 40 gigE, can take full advantage of VTP readout

Infrastructure like (5 GB/s capability)

Item	Status	Cost
LHRS	1 intel CPU 4 intel CPU	 15 K$
Computer disks	2 raid arrays 2GB/s 8 SSD (8x 2GB/s) 1 PB disk array	 20 K$ 300 K$
Network	10 Gigabit Ethernet in Hall 40 GigE router 40 Gig adapter on adaq1 and adaq2 (5000 MB/s) 2 fibers 40 Gig Ethernet to Silo (8000 MB/s)	30 K$ 30 K$ 5 K$ 20 K$
Silo	8 drives LTO5 8 drives LTO6 4 LTO7 (300 MB/s) 4 LTO8 (360 MB/s) 14 LTO8 -> 11.2 GB/s	 40 K$ (IT) 140 K$ (IT)

Safe for Gep, TDIS and future program, can use fast VTP readout
120 K$ upgrade + 300 K$ disk + 140 K$ silo
(could delay silo and large disk for better cost and upgrade every year)

Conclusion

- GMn ready by mid 2019
- Gen RP adds about 100 MB/s additional data
- Current network/computing sufficient plan for max 300 MB/s
- Would like to try 1 GB/s capability
- Ideally 10 GB/s

Backup

GRINCH readout

- 6 VETROC ordered for Compton
- 6x128 = 768 channels
- Backplane board ordered for 192 channels
- 4 boards for Compton
- Existing initial prototypes : 2 x 192
- Using spare Compton crate 1 VXS crate spare desired (15 K$)

Glasgow Hodoscope readout

- VME based
  - V1190 TDC
  - V792 QDC
  - VME64X crate

- Existing drivers already
- Install end of 2018

HCAL readout

- 288 channels
- 2 VXS crates , 18 FADCs
- need more FADCs or FADCs back (5 in HRS)
- 1.5 MHz singles
- 16 block clusters
- FADC 250 MHz 12 bit = 2 bytes
- 10 samples : 320 bytes , 57.6 MB/s at 100 % occupancy
- VETROC or F1 : high resolution TDC, need NINO
- VTP : clustering done (coincidence for Gep : 2 weeks)
- 2 VETROC for ECAL sums input and MPD fast clear

Fastbus readout

- Time : 1877S
- Amplitude 1881M
- Fastbus max transfer speed : 40 MB/s can use either Intel or Old vxworks VME CPU
- ECal : 4 sets of 3 crates, will be able to test performance about 50 MB/s at 100 % occupancy
- Cdet : 9 Fastbus crates about 11 MB/s at 10 % occupancy
- Need 12 intel CPU for ECAL to use CODA3 for GEp5 (36 K$)

Number of tapes

		Days	Weeks	Data rate	Seconds	Total data TB	Double	LTO5	LTO6	LTO7	LTO8
E12-12-09-019	GMN	25	3.57	100	2160000	216	432	288	173	72	36
E12-09-016	GEN	50	7.14	500	4320000	2160	4320	2880	1728	720	360
E12-07-109	GEP/GMP	45	6.43	1000	3888000	3888	7776	5184	3110	1296	648
E12-09-018	SIDIS	64	9.14	1000	5529600	5529.6	11059.2	7373	4424	1843	922
E12-15-006	TDIS	27	3.86	6000	2332800	13996.8	27993.6	18662	11197	4666	2333

8597 tapes if LTO7, SILO contains up to 19 000 tapes
with migration to LTO8 , new SILO might not be needed