SoLID DAQ update
SoLID collaboration meeting

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June 7th 2018

Outline

- Outstanding issues
- PVDIS / SIDIS data rates
- DAQ preR&D and R&D request
- FADC dead time simulation
- MRPC
- SAMPA test stand

Outstanding issues

- PVDIS
  - trigger rate ok
  - GEM ok (3 samples readout do we need more ?)
  - calorimeter resolution and pion rejection (pile-up, 3 samples readout sufficient)
  - finalize Cerenkov readout
  - data reduction (improve trigger with Cerenkov pixel readout)
  - data transfer
- SIDIS
  - demonstrate 100 KHz rate capability with 1 sample
  - finalize Cerenkov readout
  - can we take all singles : 200 KHz several samples
  - SPD background (pile up and photon rejection)
  - MRPC timing resolution with background
- J/Psi
  - ok in triple coincidences
  - trigger rates with 3 samples in double coincidence
  - reconstruction efficiency tracking

PVDIS electron trigger

- Coincidence ECAL and Gas Cerenkov

	Old	Hall D
Singles ECAL	290 KHz	230 KHz
Singles rates Cerenkov	1.9 MHz	803 KHz
Accidental 30 ns	16.5 KHz	4.1 KHz
DIS electron	10 KHz max	7.7 KHz
Total rate	**27 KHz**	**12.1 KHz**

Event size data rates PVDIS

				Event size		Data rate MBs	After noise cut	strips firing	event size bytes		MB/s
1	1156	21.17	244.73	3038.03	3038.03	60.76	9.97	115.25	1430.76	1430.76	28.62
2	1374	10.35	142.21	1765.39	1765.39	35.31	5.11	70.21	871.61	871.61	17.43
3	1374	8.81	121.05	1502.71	1502.71	30.05	4.42	60.73	753.92	753.92	15.08
4	2287	3.07	70.21	871.60	871.60	17.43	1.64	37.51	465.61	465.61	9.31
5	2350	2.79	65.57	813.93	813.93	16.28	1.50	35.25	437.60	437.60	8.75
					Total	159.83				Total	79.19
FADC											
	20000						10				
	Event size FADC	Nb channel	Header			Trailer	Sample				
	Calorimeter	14	4			4	12	280			
	Preshower	9	4			4	12	180	400		
	Cerenkov	9	4			4	12	180			
									11600000		
								740	11600000	11.6	
									Total rate	94	MB/s

About 2.9 GB/s for PVDIS at 20 KHz

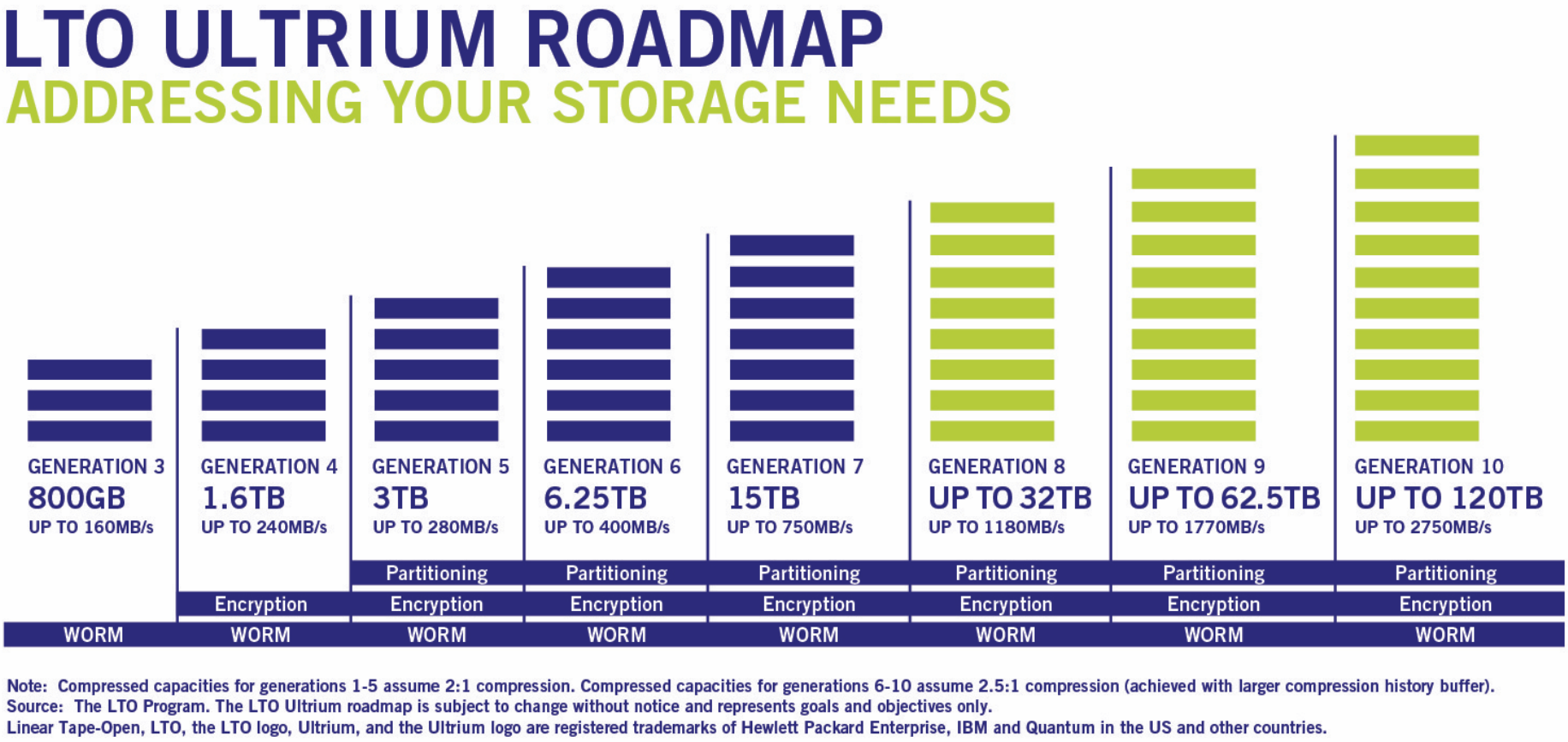
SIDIS event size

Occupancies with one sample readout by Weizhi , rates for 100 KHz

GEM	Occupancy	Number of strips	XY strips	Strips per chambers	MB/s
1	2.21	453	906	27180	245
2	8.78	510	1020	30600	1184
3	3.63	583	1166	34980	559.5
4	2.31	702	1404	42120	428.7
5	1.78	520	1040	31200	244.71
6	1.3	640	1280	38400	220
Total	20.01	3408	6816	204480	2901

GEM dominating (35 bigger than initial proposal) 2.9 GB/s same requirement as PVDIS

LTO timeline



Currently : 14 drives give 2.24 GB/s (LTO4 to LTO6) up to 16 drives for now. With LTO8 could be up to 0.36 GB/s per drive max 5.78 GB/s for 16 arms

Bottom-line : 3 GB/s is reasonable by 2020

Silo current status

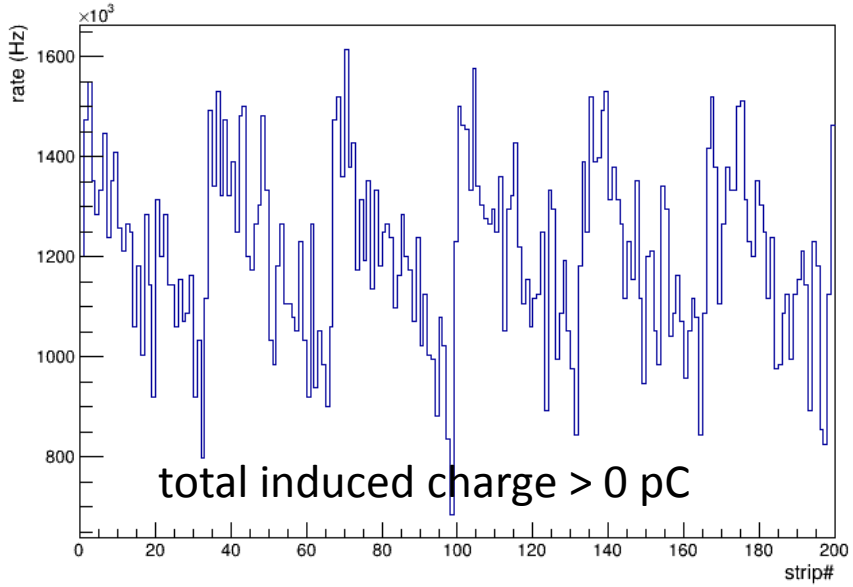
- 12,500 slots in 11 frames, with 16 frame maximum
- 24 tape drives
  - 8 LTO-5 drives, 140 MB/s 1.5 TB raw per LTO-5 cartridge, reads and writes LTO-4
  - 8 LTO-6 drives, 160 MB/s 2.5 TB raw per LTO-6 cartridge, reads and writes LTO-5, reads LTO-4
  - 4 LTO-7 drives, 300 MB/s 6 TB raw per LTO-7 cartridge; reads and writes LTO-6, reads LTO-5
  - *4 LTO-8 drives, 360 MB/s 12 TB raw per LTO-8 cartridge; reads and writes LTO-7 (coming online Spring 2018)*
- potentially :
  - 8.64 GB/s with all 24 to LTO8
  - 11.52 GB/s with 32 LTO8

Time of flight MRPC

- Simulation
  - TDC vs sampling
- Hardware
  - need new chip to handle rate DRS5 or AARDVARC or other
  - Beam test : ensure time resolution reachable in realistic condition

Time of flight MRPC
Single rate

- Beam on target
- Average rate/channel:
  - total induced charge > 0.0 pC: 1.2 MHz
  - total induced charge > 0.5 pC: 893.2 kHz



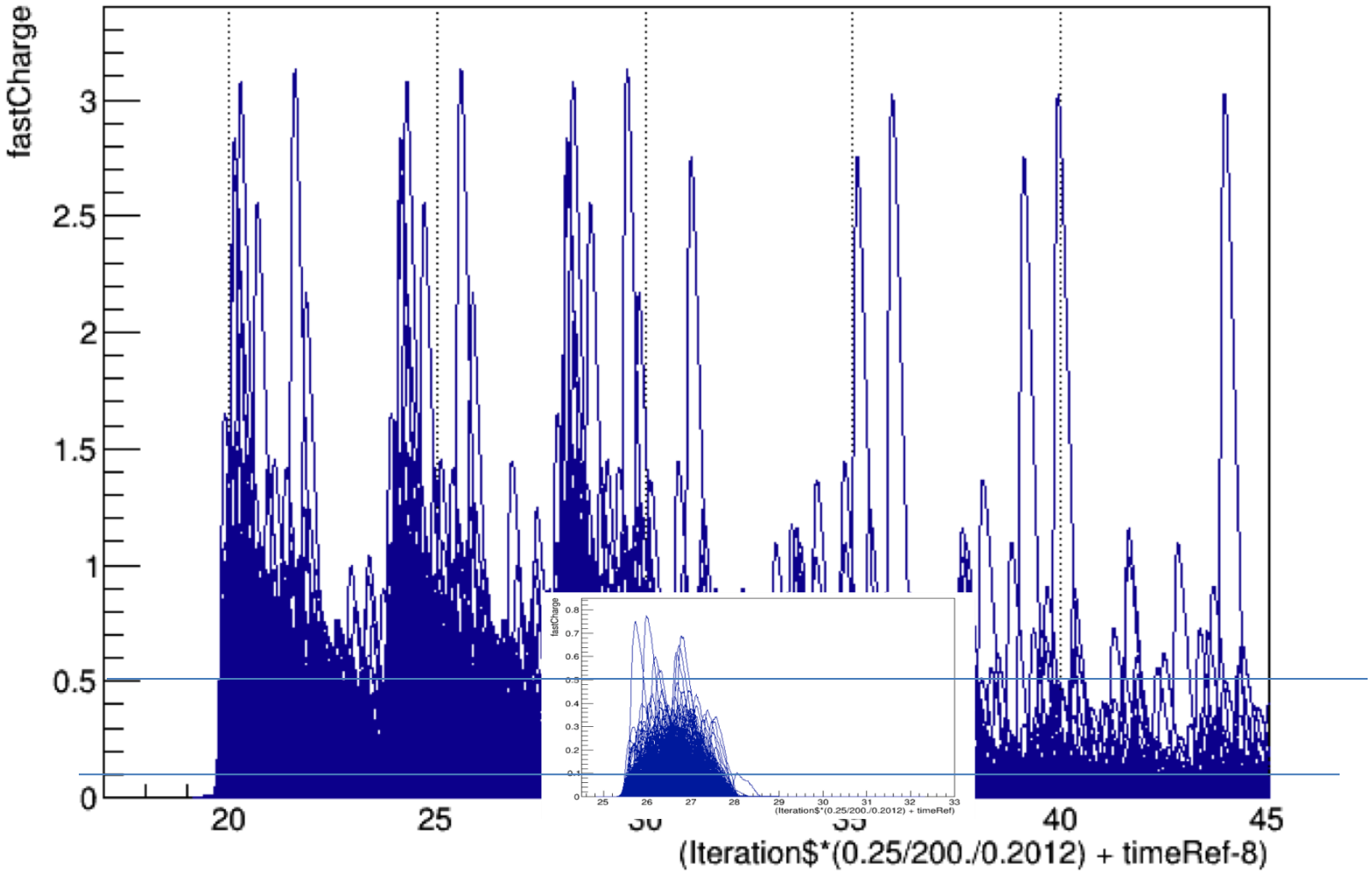
total induced charge cut (pC)	Average rate / channel (MHz)
0.0	1.20
0.1	1.11
0.2	1.06
0.3	1.00
0.5	0.95
0.6	0.84
0.7	0.80
0.8	0.76
0.9	0.72
1.0	0.69
1.1	0.65

Time of flight MRPC
Rate (kHz)/cm^2

Charge > cut	Rate (kHz)/cm^2	
	R = 96 cm	R = 105 cm
No cut	656	539
Charge > 0.00	38.7	36.3
Charge > 0.10	37.1	34.8
Charge > 0.20	35.6	33.0
Charge > 0.30	33.8	31.5
Charge > 0.40	32.3	30.1
Charge > 0.50	31.0	28.4
Charge > 0.60	29.6	27.5
Charge > 0.70	28.1	26.4
Charge > 0.80	27.0	25.6
Charge > 0.90	26.1	24.7
Charge > 1.00	25.2	23.6

Time of flight MRPC

Pulse background beam on target shifted -4ns -8ns



Cerenkov PMT readout

- MAROC3 close to what we need
  - 64 channels
  - Variable gain
  - Discriminated fast logic signal
  - Missing : analog sum of 8, need sum of 64

  8 sum of 8 available just need to sum them, will check with INFN for modified RICH board, requested 10 K$ preRD money
  - Radiation hardness is pretty good, need to be tested, possibility of new version to handle Single Event Upset
  - MAROC default option
  - MAROC test board available

  - Will check design with electronics group for FADC analog output
- Possible readout schemes
  - FADC only (default)
  - FADC + VETROC
  - VETROC only : needs to be evaluated

  - Preferred : Add TDC readout for each Cerenkov channel 232 VETROC additional 700 K$, could improve Cerenkov trigger

  - Need simulation to evaluate options
  - Need to follow with electronics group to start testing (anyone from Cerenkov group interested ?)

TOF options

- Expected timing resolution 80 to 50 ps
- Default readout
  - NINO + TDC : 20 ps timing resolution
- R&D MRPC : 20 ps
  - Sampling TDC ASICs : PSEC4/5, SAMPIC, DRS4 give 5 to 1 ps resolution
  - Need new chip DRS5 or PSEC5 (AARDVARC NALU) to handle SoLID trigger rate (analog pipeline) first prototypes for 2018
- Depends on final detector choice
- sPhenix solution: DRS4 system , existing chip but not optimal

- Need to determine effect of photon background, might need sampling to deal with pile up

GEM readout

- SRS deployed in Hall B Prad
- MPD implemented in CODA
  - BLT testing few KHz
  - Optical fiber readout to be implemented for high rate test (100 MB/s to 1.6 GB/s)
- Preliminary results from Weizhi : one sample no deconvolution not sufficient, new occupancy number
- Data reduction on SSP for SBS
- On chip deconvolution (implemented in MPD) still an option if needed
- preRD to get VMM3 chip
- SAMPA chip from ALICE

preRD request

- GEM SAMPA test stand
- Calorimeter trigger and readout
- Coincidence trigger Cerenkov SPD MRPC
- Dead time measurements
- Cerenkov MAROC readout
- MRPC readout and test

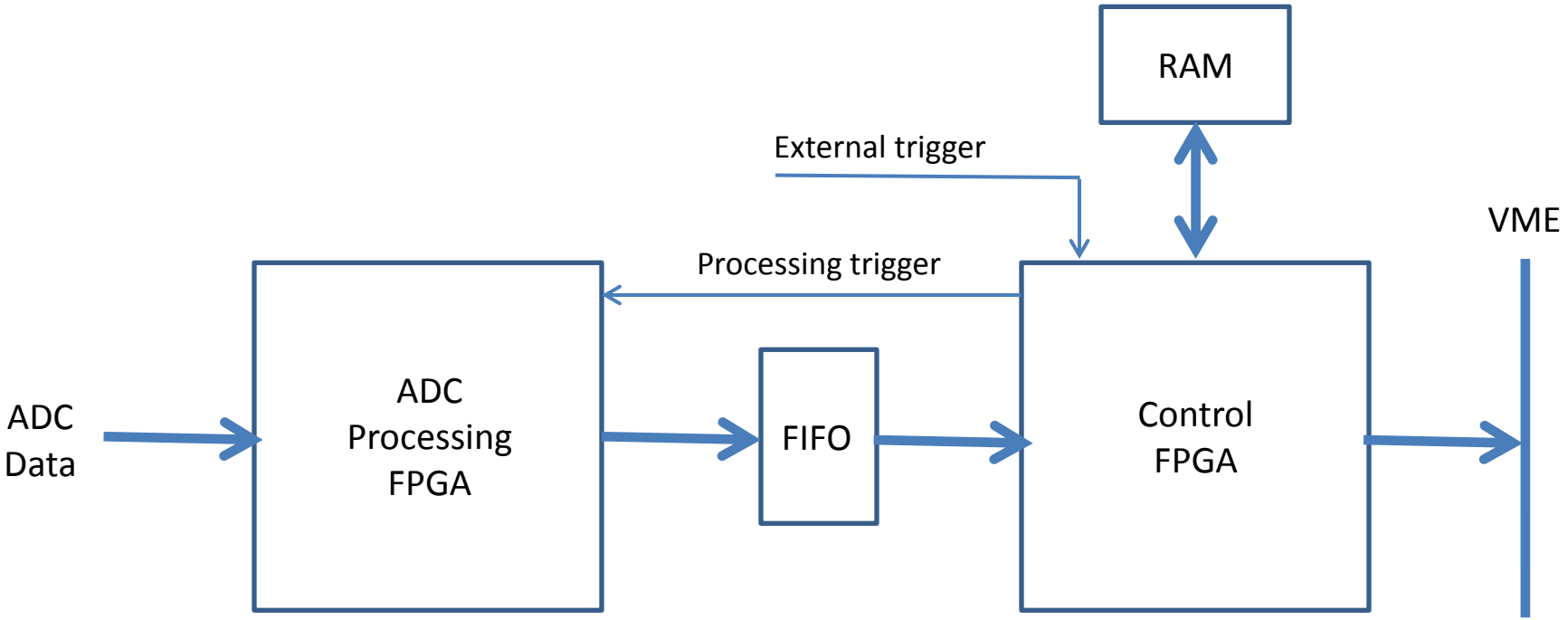
preRD request

FADC 250	4500	4	18000	Cerenkov	4	18000
VETROC	4500	2	9000			
TD	3000	1	3000			
VTP	7000	1	7000			
SSP	5000	1	5000		1	5000
TID	3000	1	3000		1	3000
SD	2500	1	2500		1	2500
FADC trigger Dist	4000	1	4000		1	4000
VXS crate	15000	1	15000		1	15000
VME CPU	4500	1	4500		1	4500
Optical fiber	100	20	2000			
Computer	3000	1	3000			
APV readout	4500	1	4500			
Network router	10000	1	10000			
Total			72500			
GEM VMM3 eval	10000	1	10000			
MAROC eval	10000	1	10000			
		Total	92500		Total	52000

preRD and RD request

Tasks	R&D	preR&D
Ecal trigger	3	3
GEM performance	3	3
PVDIS trigger prototype	3	3
SIDIS trigger prototype	3	3
FADC performance	3	
Data transfer test to SILO	1	1
Dead time for PVDIS	3	
Data reduction	6	
L3 farm need evaluation	3	
Cerenkov readout	3	3
Test stand - beam test	6	
Total months	37	16

FADC Trigger Dead Time
(Ed Jasztrembski)



FADC Trigger Dead Time
(Ed Jasztrembski)

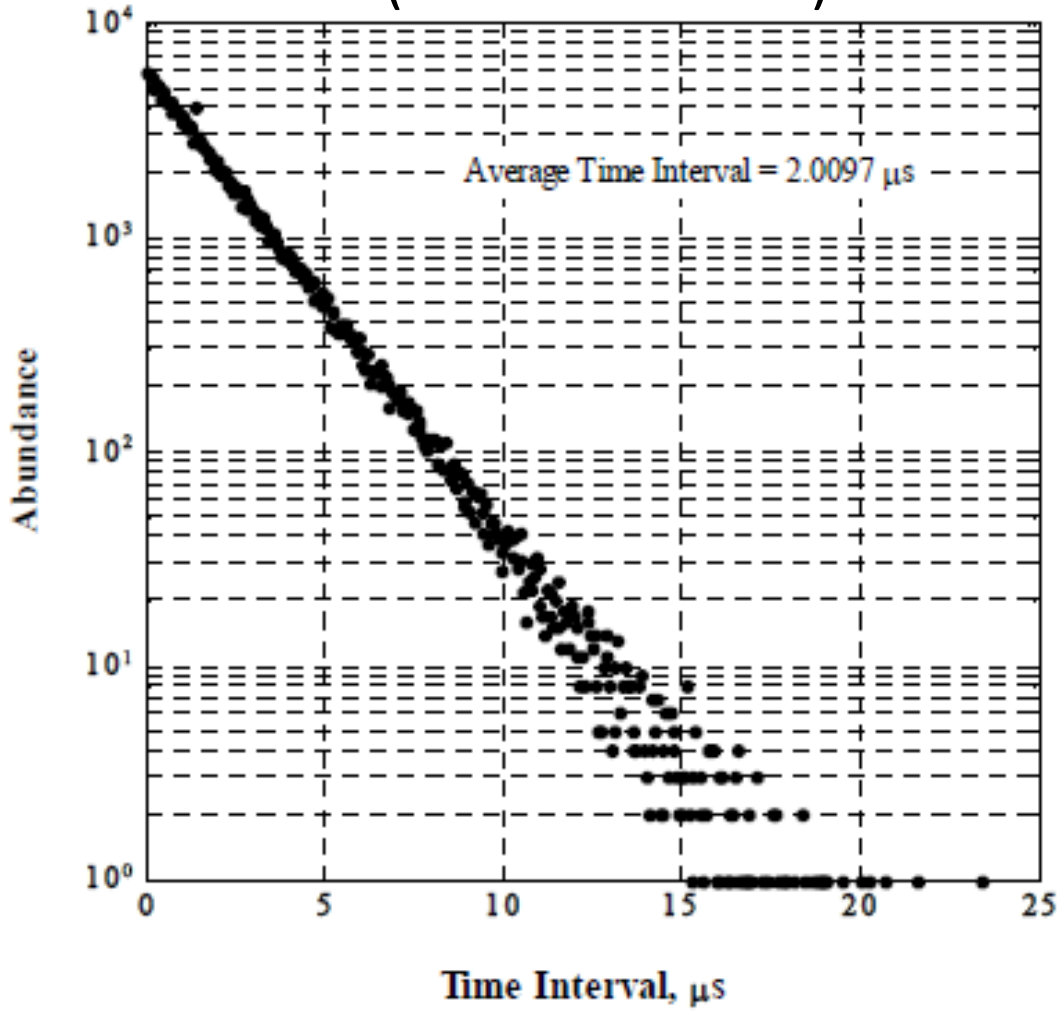


Figure 7. Histogram of the time intervals of the output pulses with Poisson PDF (GR_{set} = 500 kP/s, N.S. = 2×10^5, 400 bins).

FADC Trigger Dead Time
(Ed Jasztrembski)

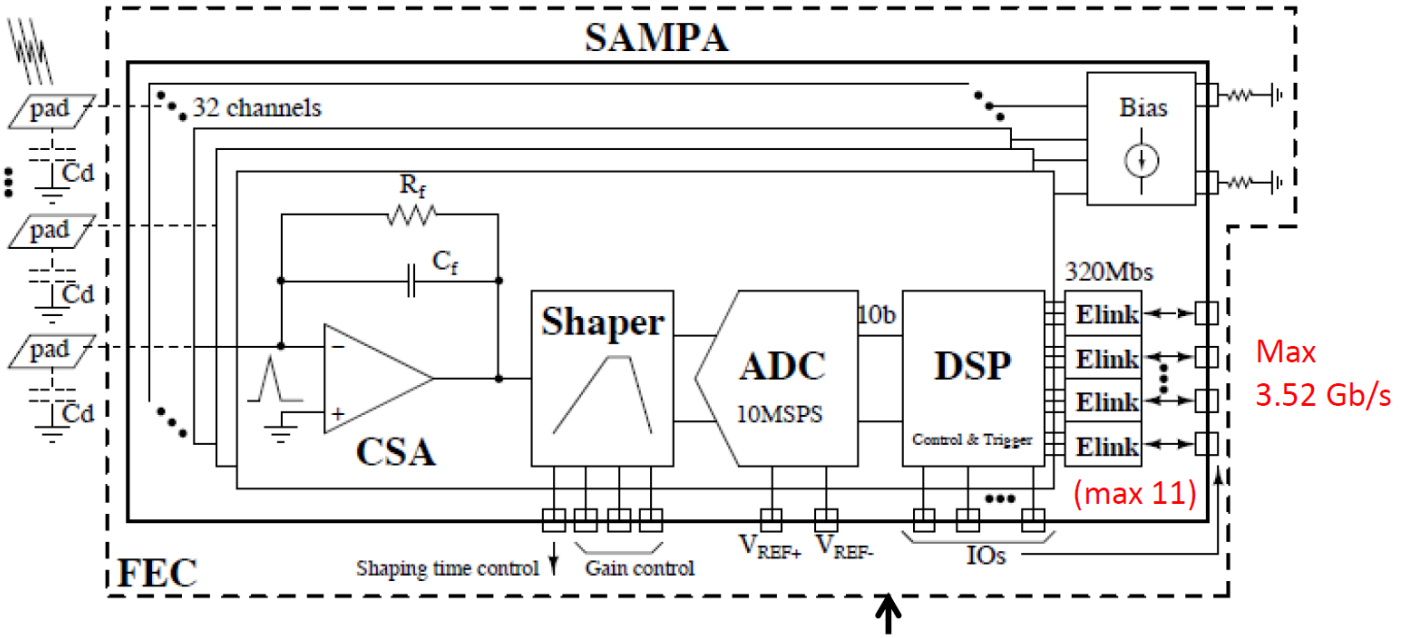
Test of Simulation Code

100K triggers, Processing time per trigger = 6 us, Maximum stored triggers = 4

Trigger rate (KHz)	Trigger dead time (%)
50	0.2
75	0.6
100	2.0
125	4.6
150	9.2

SAMPA

SAMPA ASIC



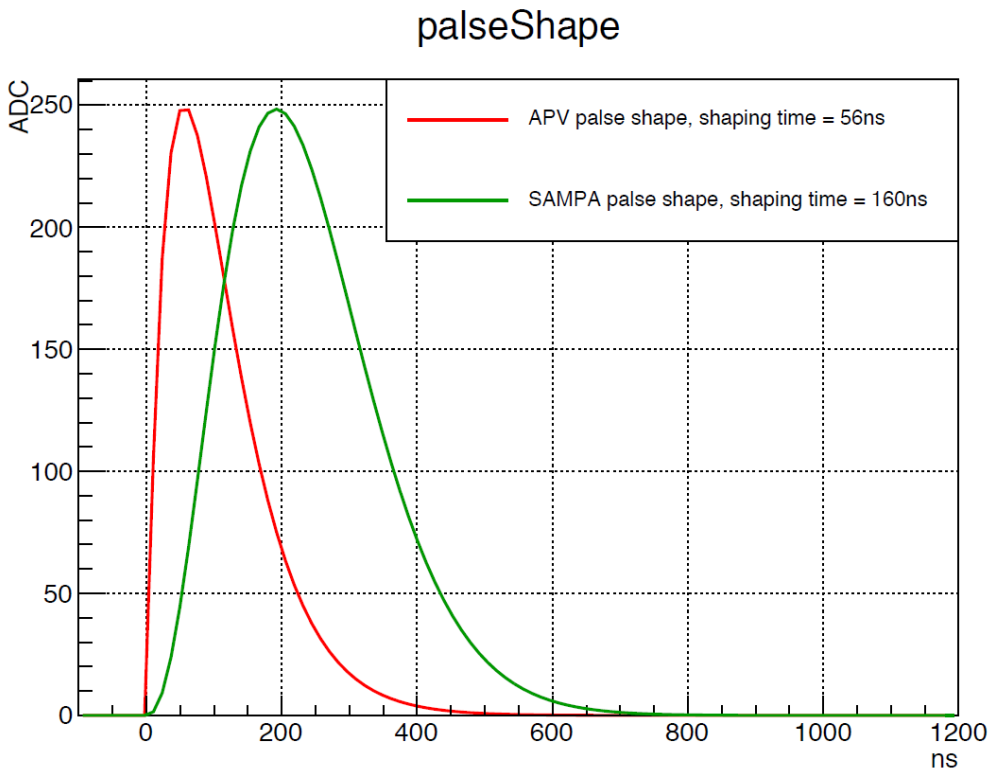
Raw data rate (10MHz) = 32ch x 10b x 10M/s = 3.2Gb/s

(20MHz) = 6.4Gb/s

SAMPA study by Weizhi

Response function comparison: SAMPA vs APV25

- The SAMPA response curve is much longer than APV25
- The shortest sampling time for SAMPA is 50ns while APV25 uses 25ns
- These two reasons will likely increase the pile-up effects and occupancies
- It is unlikely we will have good results (>90%) for tracking if we only take 1 sample with SAMPA
- It will be better to have at lest 3 samples using SAMPA
- For current study, I use 6 time samples



Occupancy - 1 sample

- Raw occupancy means the # of strips above threshold cut / total # of strips
- Noise rejected occupancy means the # of strips above threshold cut and out-of-time noise rejection cut / total # of strips
- For 1 sample, raw occupancy would be the same as noise rejected occupancy

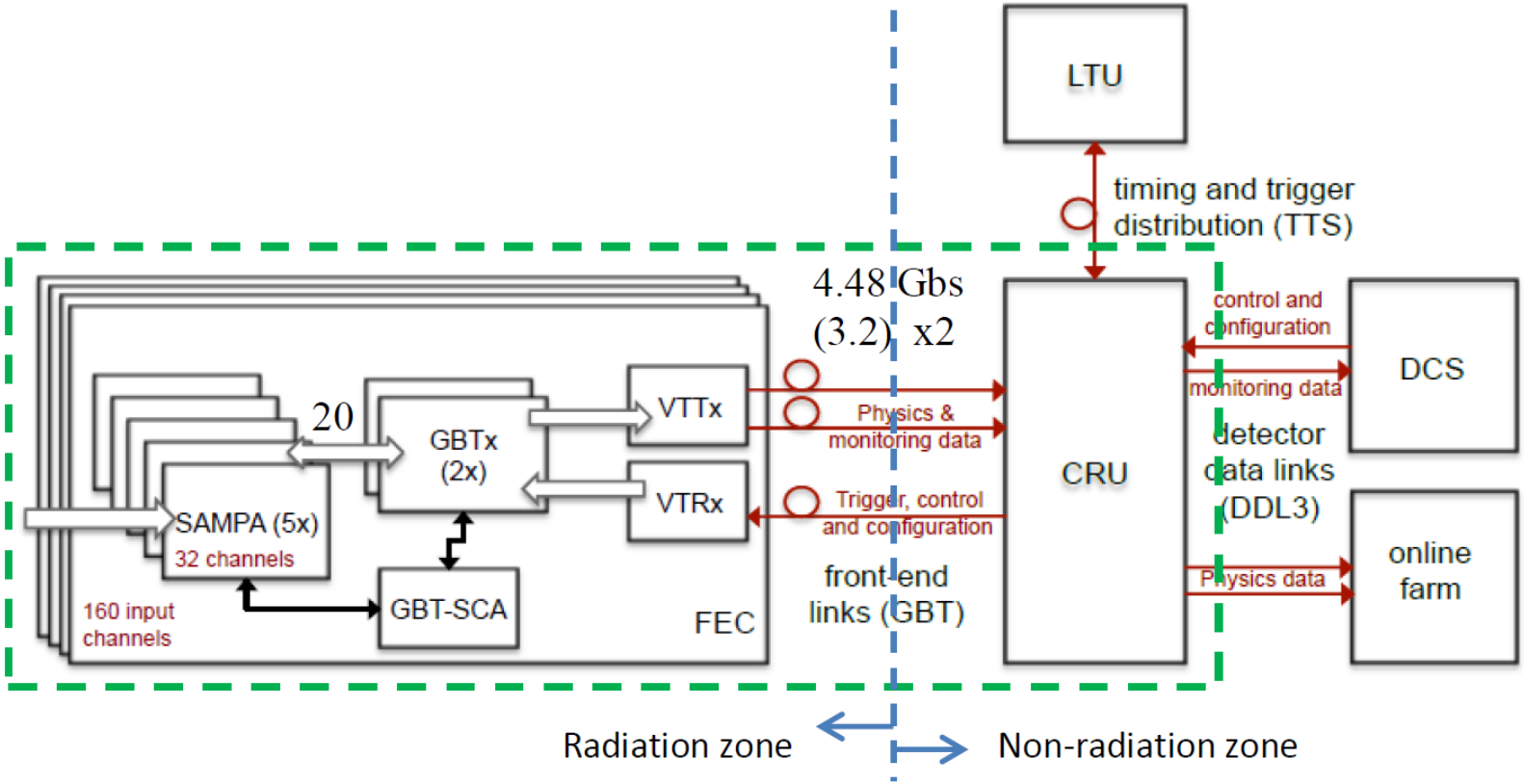
	Raw occupancy	Noise-rejected occupancy
SIDIS plane 1	4.00%	-
SIDIS plane 2	13.7%	-
SIDIS plane 3	5.79%	-
SIDIS plane 4	3.76%	-
SIDIS plane 5	3.36%	-
SIDIS plane 6	2.50%	-

Occupancy - 6 sample

- Raw occupancy means the # of strips above threshold cut / total # of strips
- Noise rejected occupancy means the # of strips above threshold cut and out-of-time noise rejection cut / total # of strips

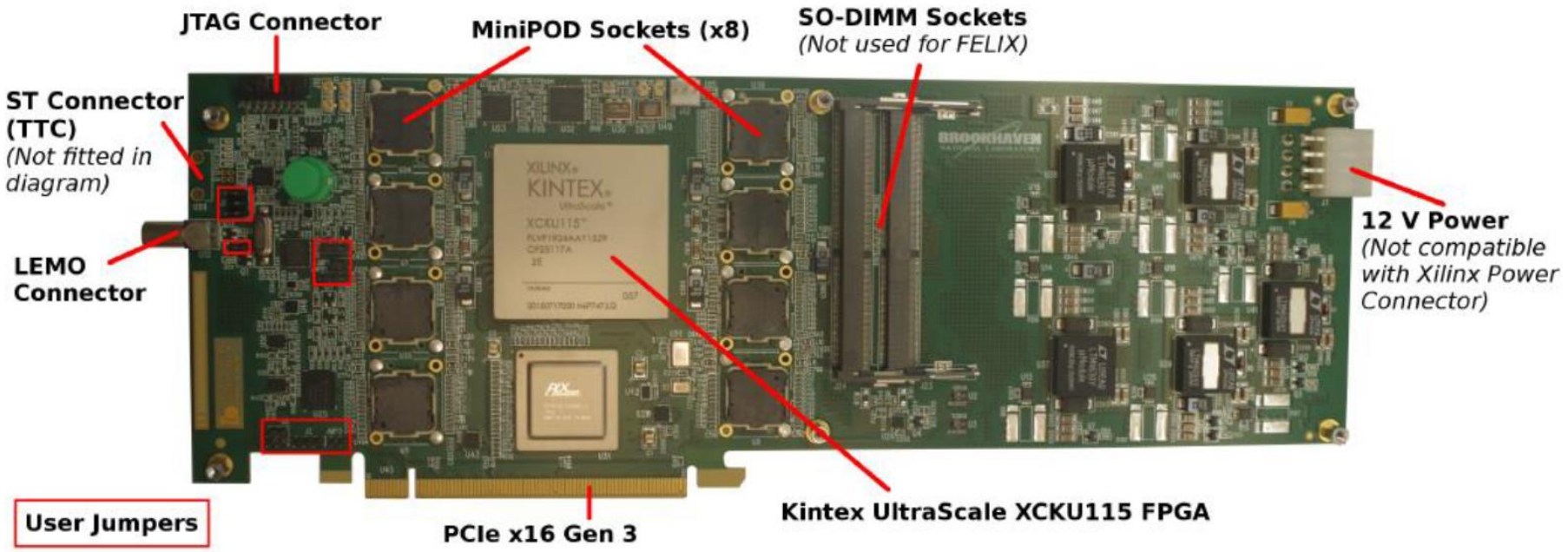
	Raw occupancy	Noise-rejected occupancy
SIDIS plane 1	10.0%	4.33%
SIDIS plane 2	26.3%	11.0%
SIDIS plane 3	14.2%	6.14%
SIDIS plane 4	9.20%	3.93%
SIDIS plane 5	8.67%	3.80%
SIDIS plane 6	6.50%	2.85%

SAMPA readout (Ed Jasztrembski)



Readout board

BNL-711 V1.5



SAMPA test stand

- Status as of 6/4/18:
  (1) SAMPA chips - Acquiring tested chips has been difficult since ALICE is in the process of instrumenting a complete sector of their TPC. Marco Bregant (SAMPA designer) has just obtained 50 chips from the Lund test facility; he is shipping these to us.
  (2) CERN custom ICs (GBTx, GBT-SCA, VTTx, VTRx) - ordered; should arrive within the next week.
  (3) Front-End Cards (FEC) - We delayed construction until components (1) and (2) were available. Requisition will be placed in the next week. 4 week fabrication/assembly time has these ready by mid July.
  (4) Common Readout Unit (CRU) - ATLAS BNL-711 PCIe card delayed until mid July.
  (5) FEC power supplies - in place
  (6) High performance PC - in place

SAMPA budget

Test Stand Cost

PC – Dell 7920 Dual Processor (Silver, 6x8GB)			**$4,500**
Ethernet Adapter - Mellanox MCX4131A-BCAT ConnectX-4 Lx EN Network Interface Card 40GbE Single-Port QSFP28 PCIe3.0 x8			**$400**
Optical Transceiver - Mellanox MC2210411-SR4L Optical Transceiver 40Gb/s QSFP MPO 850nm up to 30m			**$155**
Power Supply – Keysight E3633A 200W (0 - 8V, 20A)	($1519 x 2)		**$3,038**
Common Readout Unit – ATLAS BNL-711 (24 links)			**$10,600**
Fiber Optic Cable Assembly – FEC → CRU (5m)			**$200**
Custom Integrated Circuits (6 FEC)			
SAMPA	$40 x 30	= $1200	
GBTx	$50 x 12	= $600	
GBT-SCA	$35 x 6	= $210	
VTRx	$200 x 6	= $1200	
VTTx	$150 x 6	= $900	**$4,110**
Front End Card – (**$3114** x 5)			**$15,570**
		Total	**$38,573**

JLab contribution to SoLID

- Ed Jasztrembski : dedicated for Hall A
  - FADC dead time
  - SAMPA test stand
- William Gu
  - VETROC for MRPC readout
- Ben Raydo
  - FADC VXS readout
  - Calorimeter Cluster trigger
  - FPGA trigger in VTP for PVDIS and SIDIS trigger
  - MAROC readout

Conclusion

- preRD hardware and manpower request
- PVDIS mostly ok : dead time / data rates
- SIDIS : GEM rate capability, TOF
- Finalize Cerenkov readout
- preR&D and R&D allows to book time with JLAB DAQ and electronics group
- SAMPA study by Weizhi
- SAMPA test stand ready by mid July