SoLID DAQ update

Alexandre Camsonne

SoLID Collaboration meeting

December 3th 2016

Overview

- Recommendations for Director’s review
- Hardware available
- Document
- Updated trigger rates
- New FADC readout
- PVDIS deadtime
- SIDIS event size and data rates
- Cerenkov readout
- TOF readout options
- Simulations needs
- L3 farm

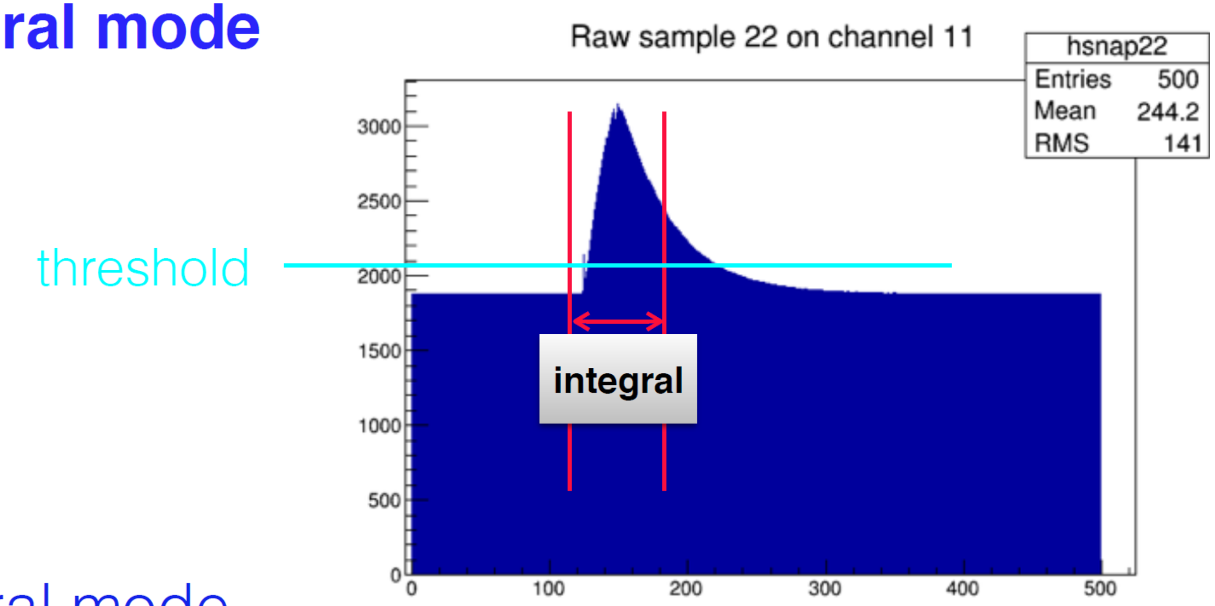
Dead time correction PVDIS 1b.2

- Test with small scale setup (Compton)
- Simulation
- Discuss with DAQ group for particular features needed
    - Example : helicity gated deadtimes
- Rework CDR to add parity specific electronics

- Need to write a separate document about DAQ requirements for DAQ group, Electronics group and potential collaborators on electronics (Saclay)

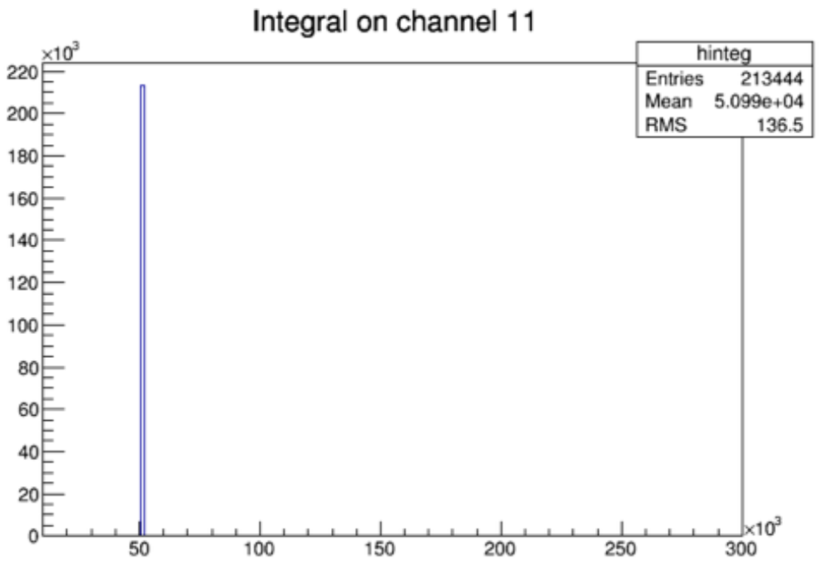
Dead time correction PVDIS 1b.2

FADC integral mode



Pulse integral mode

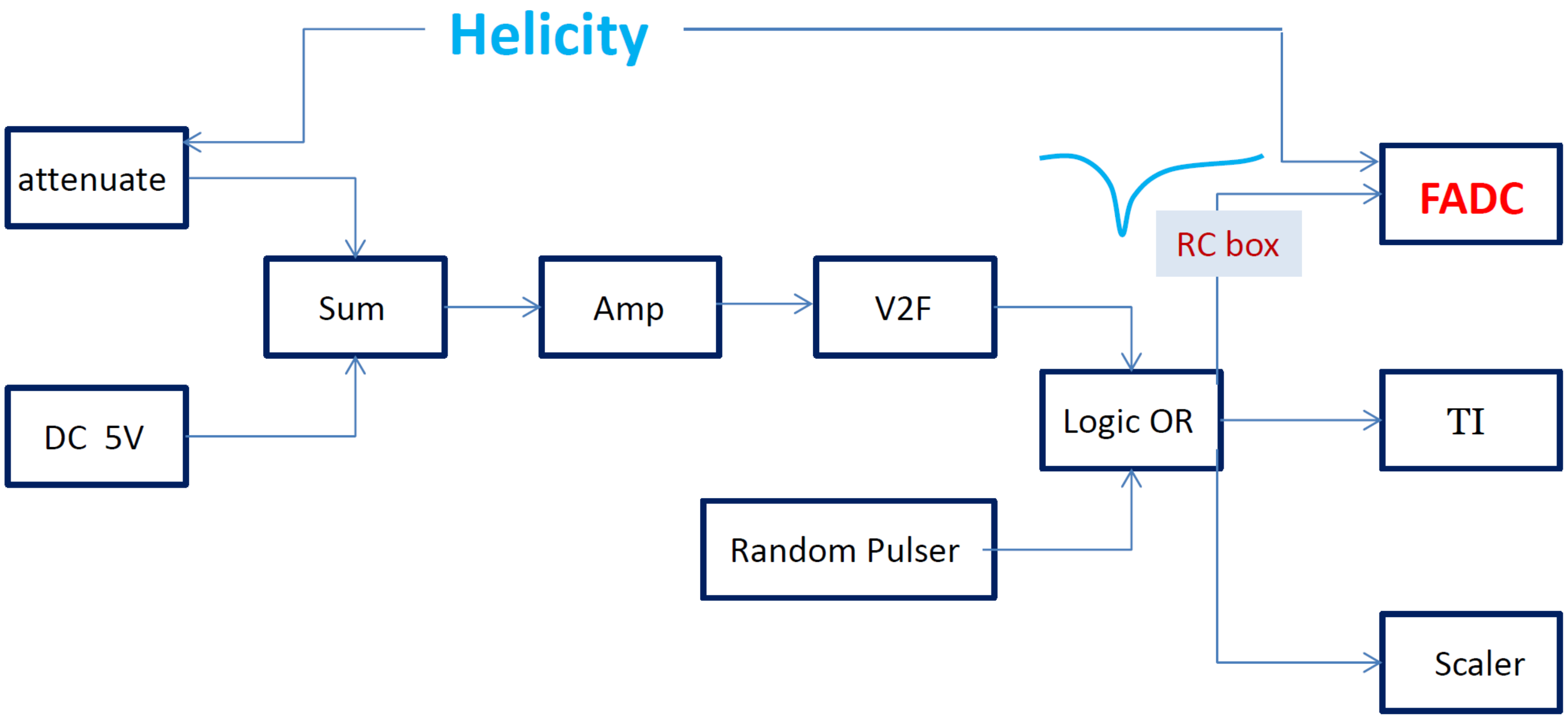
- integral number
- time begin to integrate



- Deadtime :
  - -- accuracy needed << 1%
  - – using Buffering & multiblock modes **eliminates** DT if frequency $f < f_{critical}$
  - – Observe: $f_{critical}$ = **300 kHz** where DT skyrockets
  - – 277 kHz DT = zero
  - – 410 kHz DT = 20 %
  - – ~600 kHz DT > 30 % and very hard to measure

These are mostly random rates

Tests of Counting-Mode FADC DAQ



Test Procedure : **Trigger with a high-random rate R**

which has a helicity – correlated asymmetry A

0.1% < A < 5 %

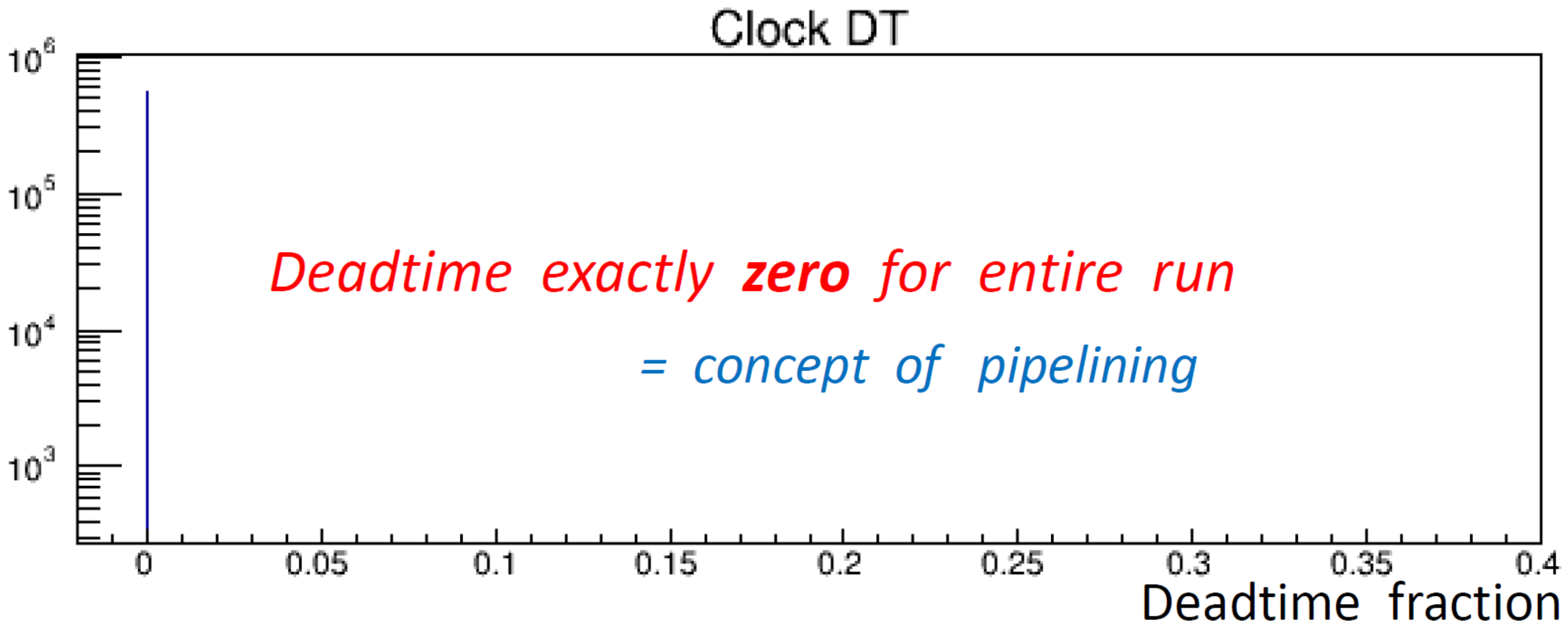
0 < R < 3 MHz

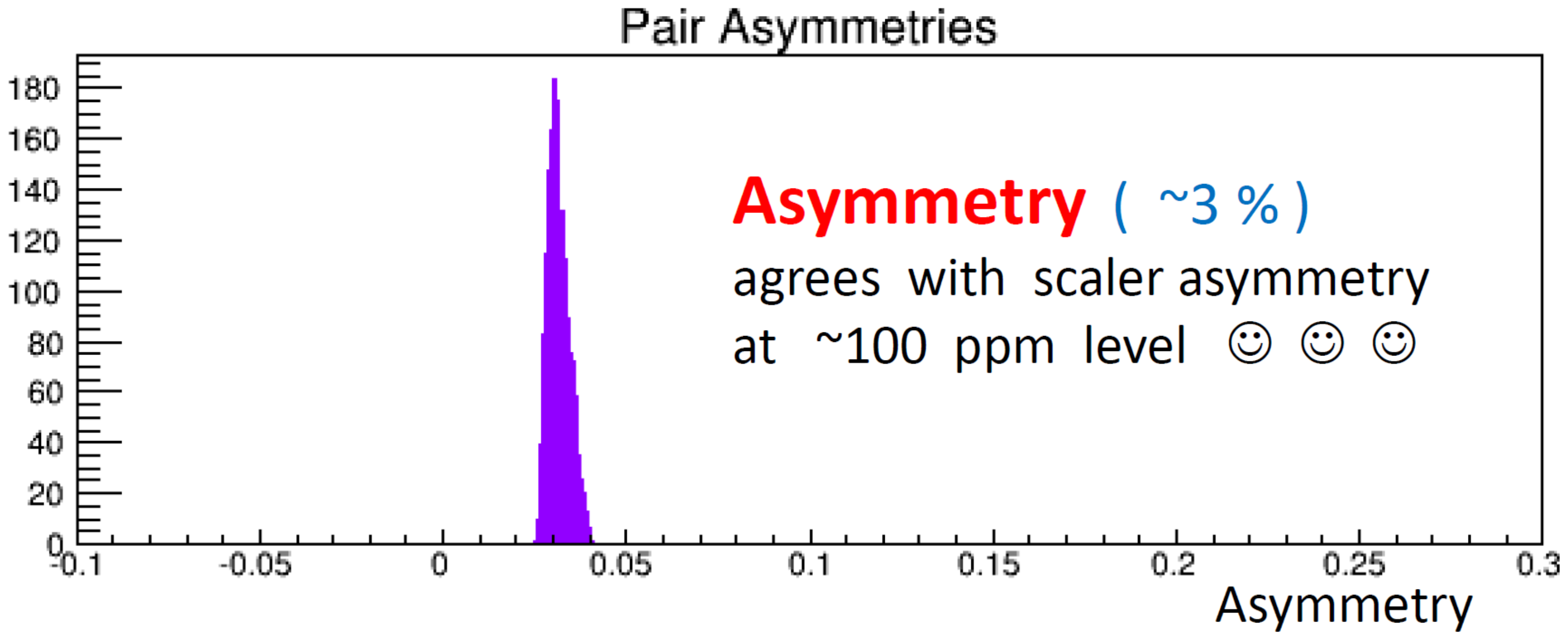
https://hallaweb.jlab.org/wiki/index.php/Compton#Compton_Meetings

See also the 2013 Hall A Annual Report

Run #1590 Rate = 277 kHz **zero deadtime**

Helicity flip 60 Hz

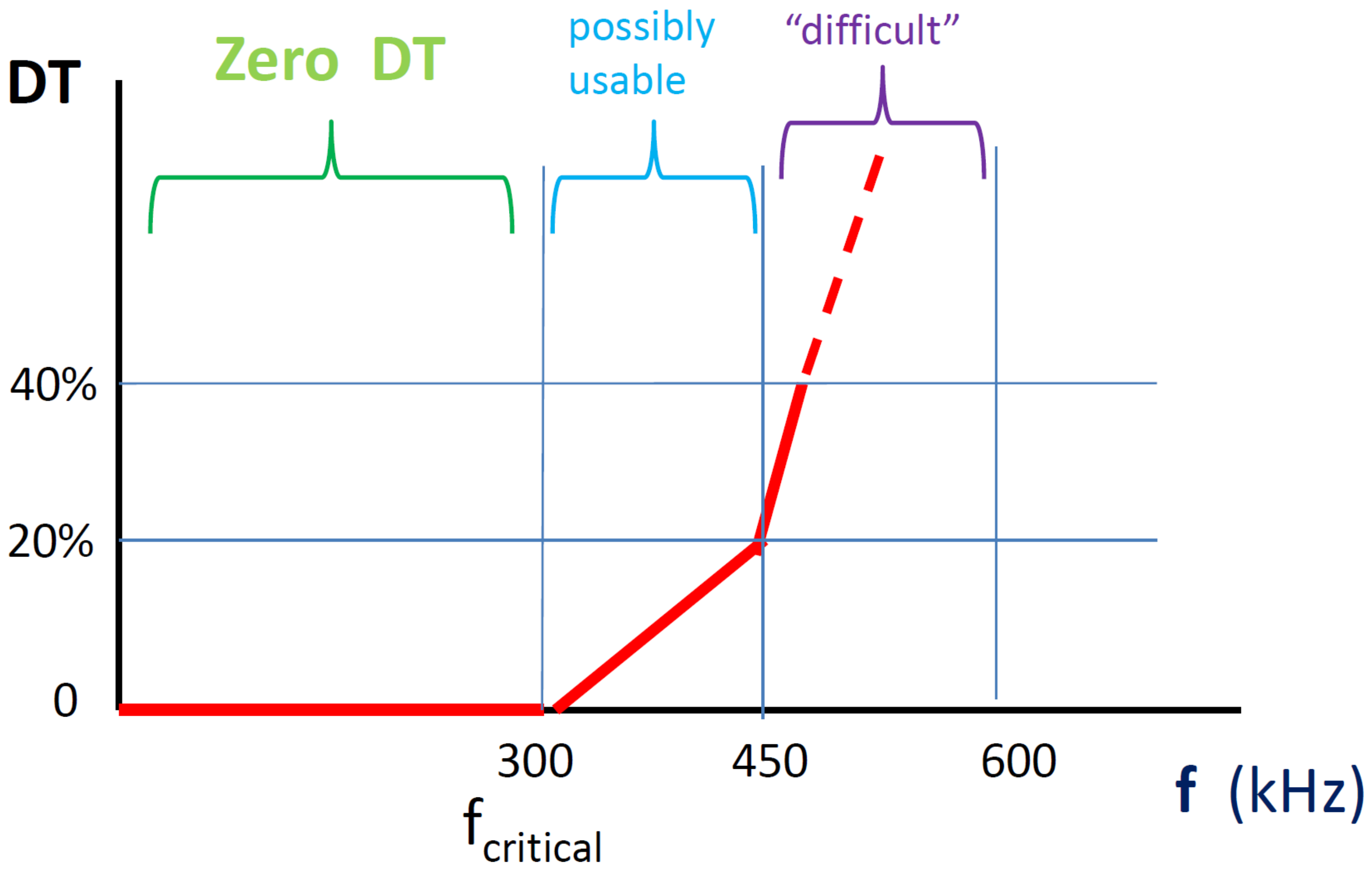




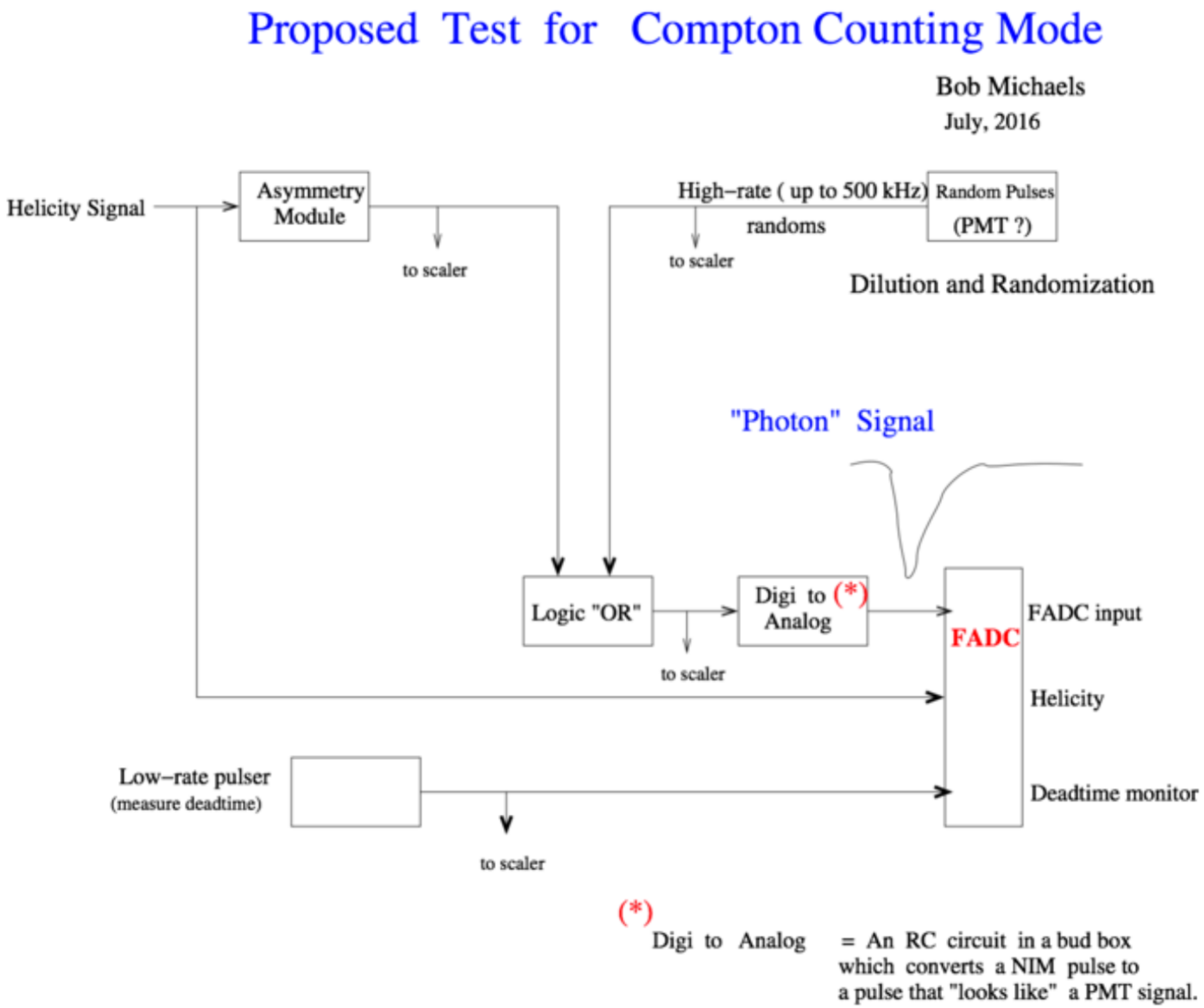
Exploring the regime f > $f_{critical}$

Deadtime vs readout rate.

Sorry I don't have a proper data plot



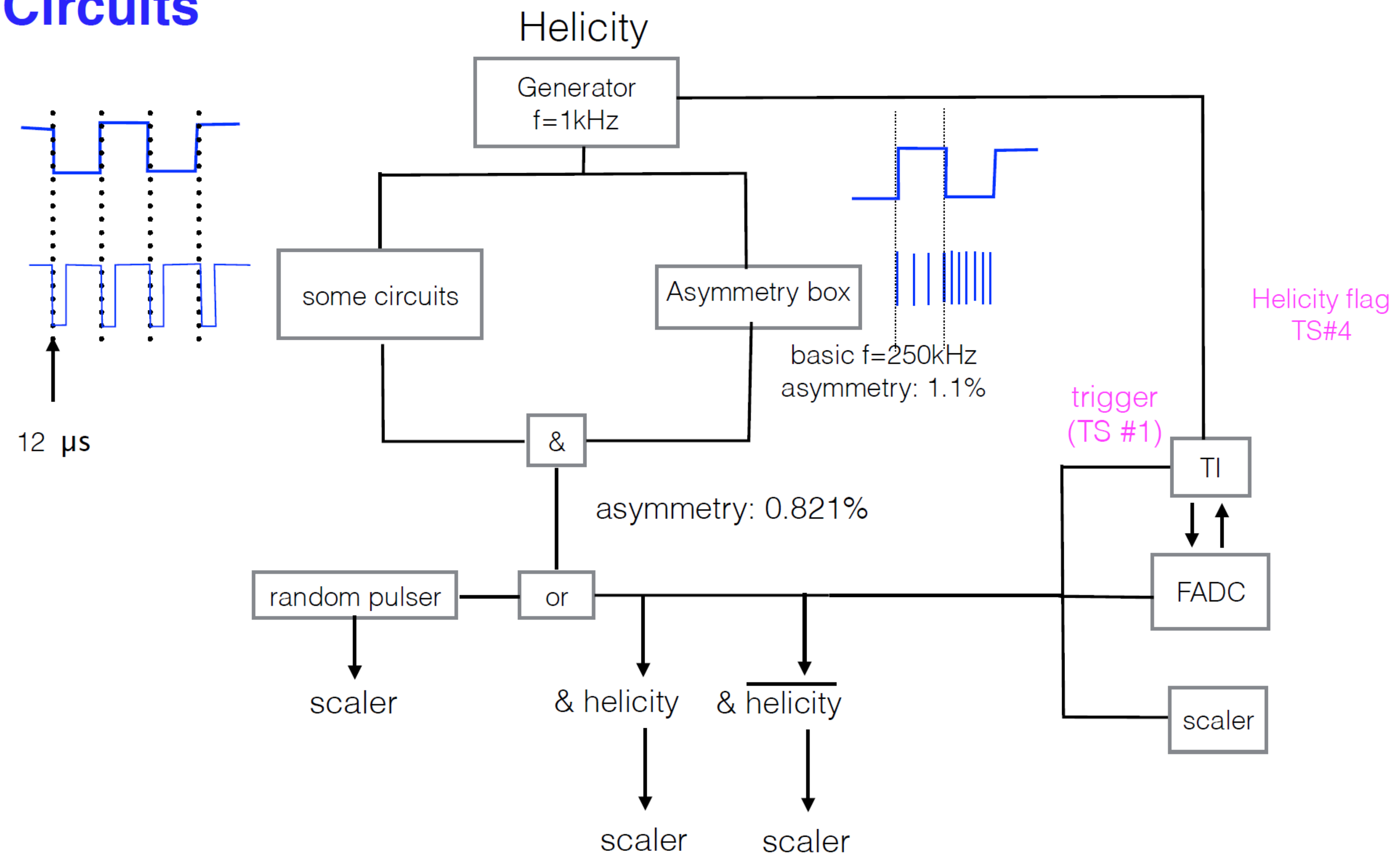
Dead time correction PVDIS 1b.2



Purpose:

1) measure an asymmetry by FADC
2) find a method to correct the asymmetry

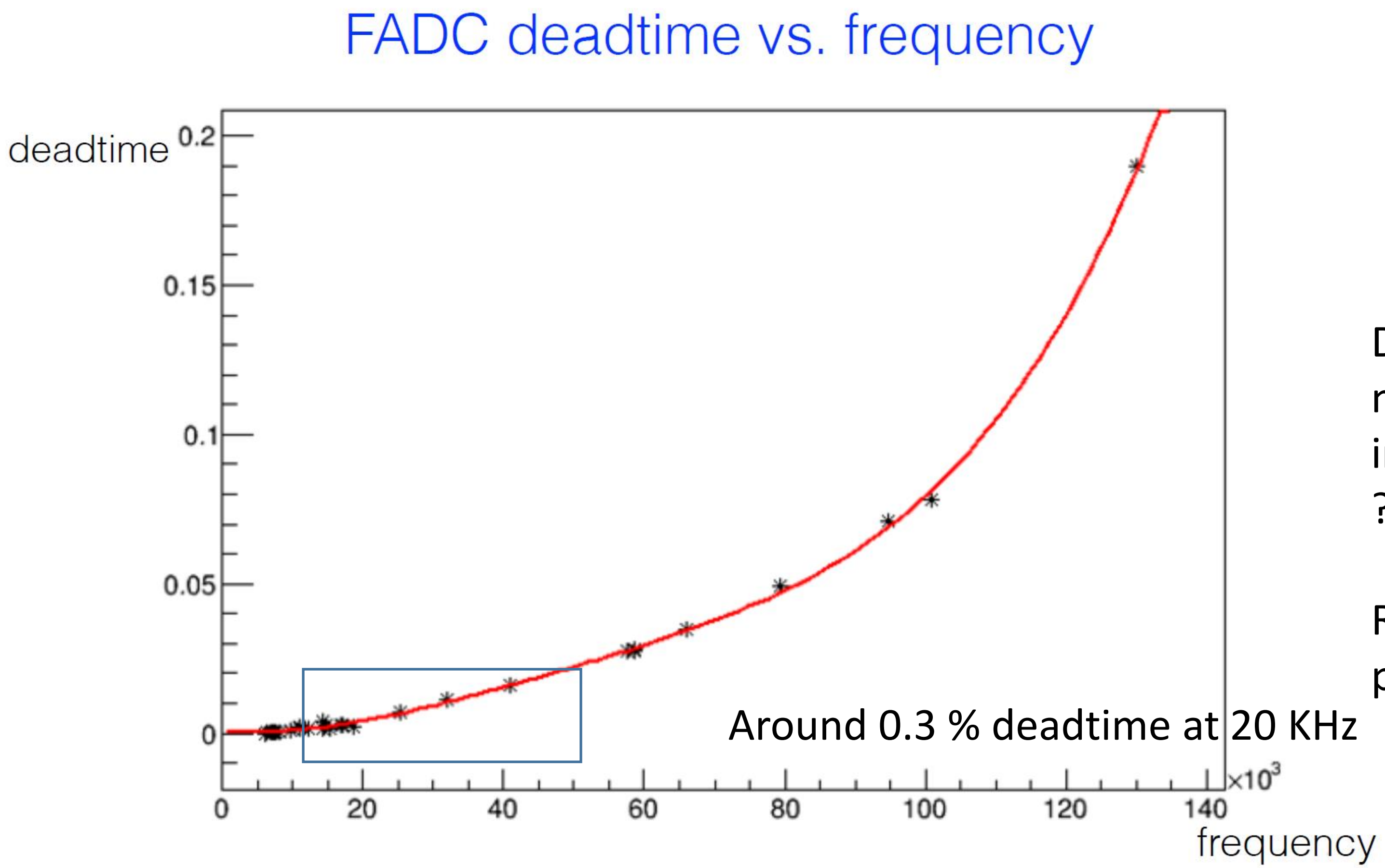
Circuits



- change the frequency of random pulser
- calculate asymmetry from scaler and FADC respectively

FADC deadtime measurement

FADC deadtime = total counts from FADC/counts from scaler



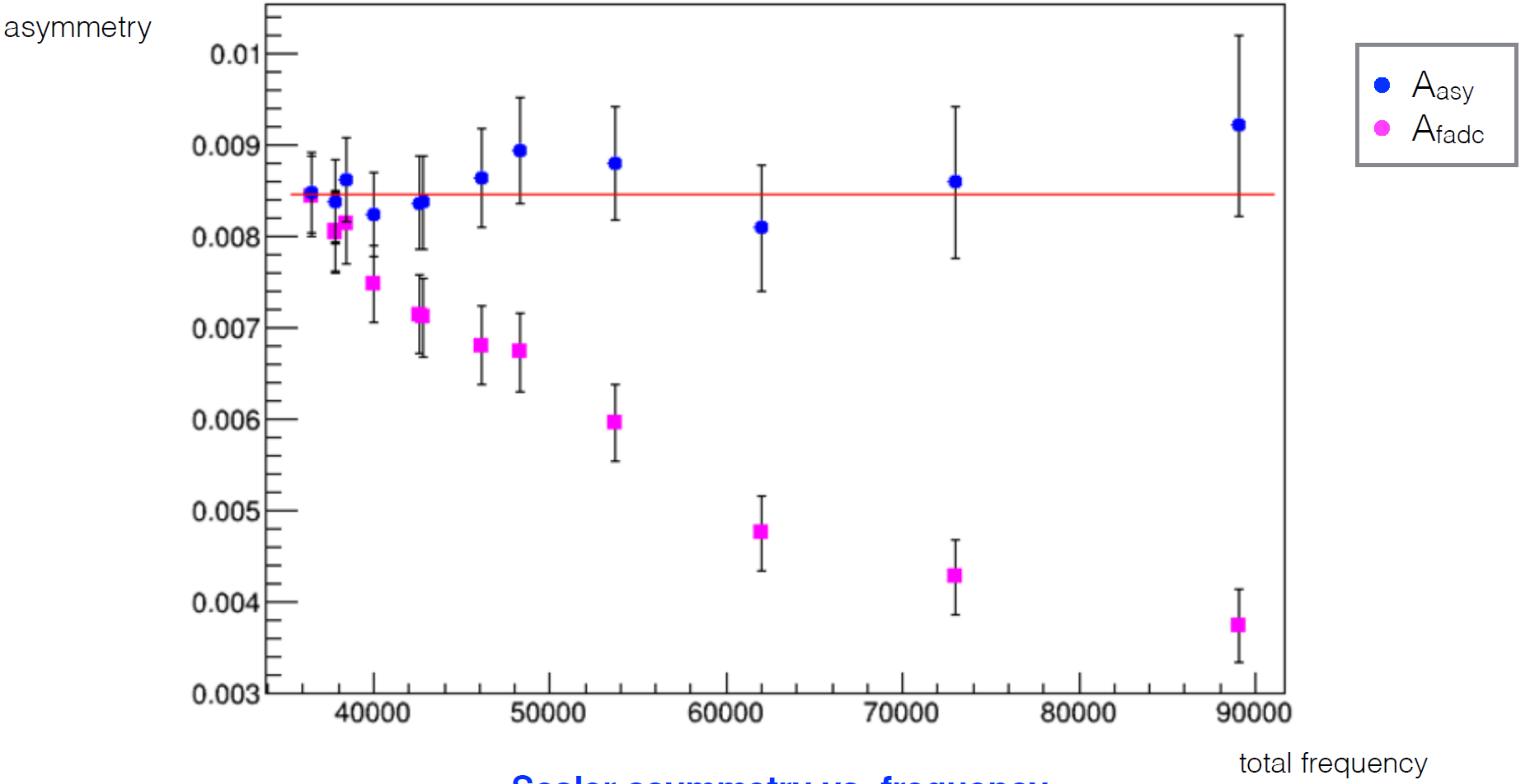

```
Minimizer is Linear
Chi2                      =   3.50342e-05
NDf                       =            30
p0                        =   0.000914936    +/-    0.000900636
p1                        =  -2.22178e-07    +/-    1.11363e-07
p2                        =   2.51556e-11    +/-    3.58349e-12
p3                        =  -3.37321e-16    +/-    4.23316e-17
p4                        =   1.86471e-21    +/-    1.62946e-22
```

Do we need to improve it ?

R&D possible

Measured asymmetry

$$A_{FADC} = A_{asy} \times (1 - \frac{N_{rdm}^{total}}{N_{total}})$$

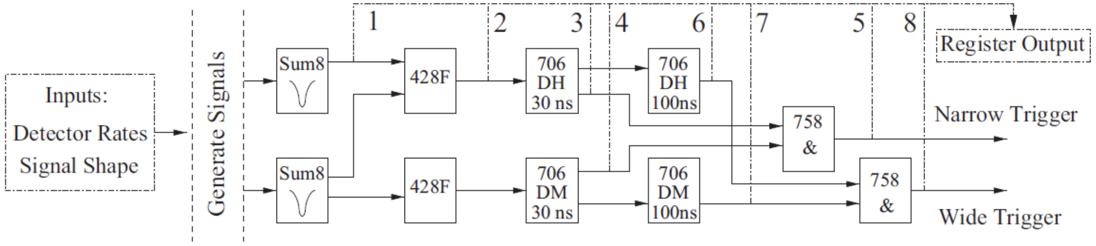


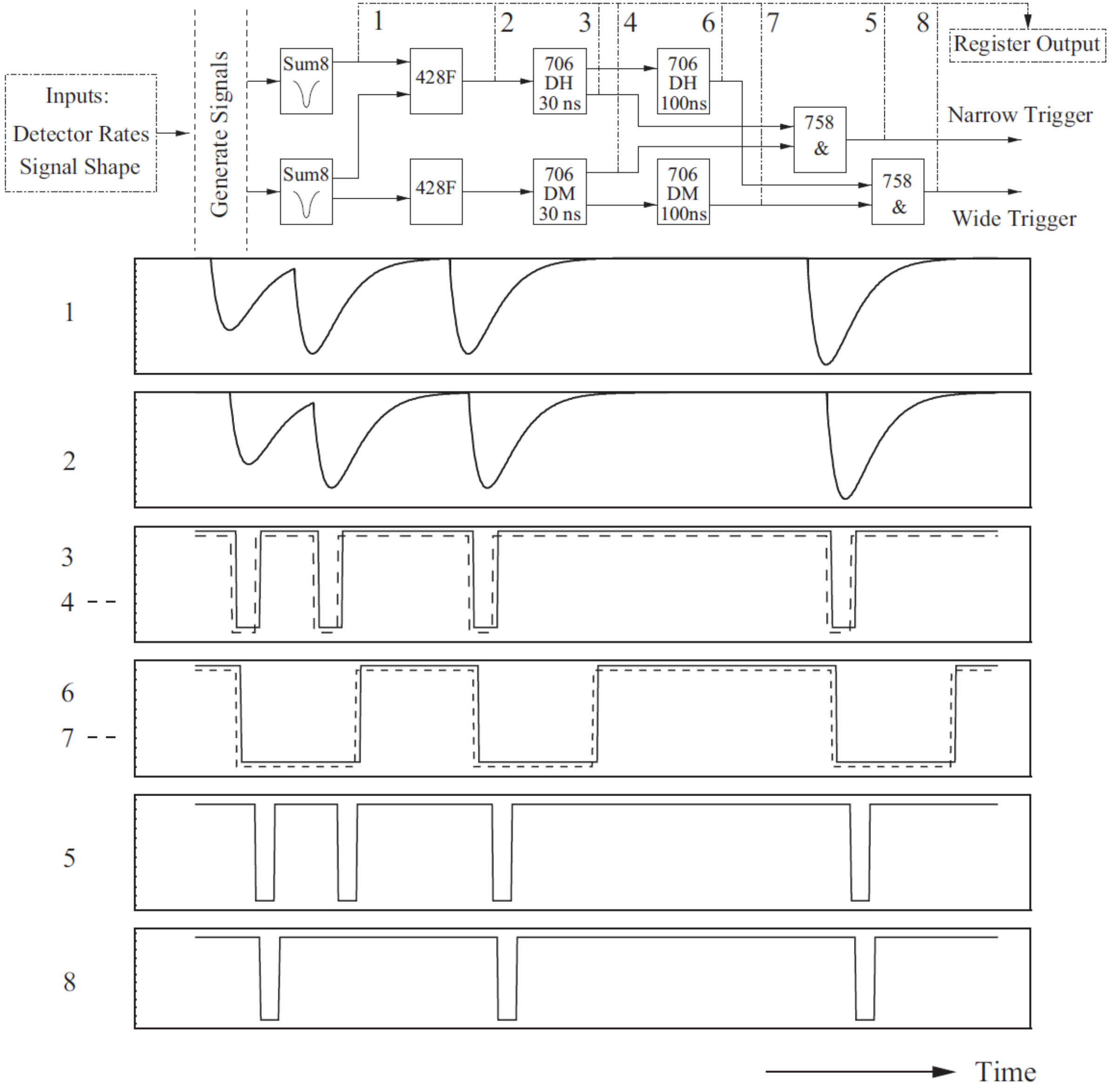
Scaler asymmetry vs. frequency

Dead time modelling

- Still need to put together full system / program FPGA
- First approximation : fixed dead time 150 ns for each trigger
- Expected deadtime : 20 KHz * 150e-9 = 0.3 %
- Accuracy of measurement 10 % level typical
- Correction 0.03 % error sastify PVDIS requirements
- Simulation similar to PVDIS (need to modify)

6 GeV PVDIS





Narrow width 30 ns
Wide width 100 ns

Replace discriminator by Trigger Supervirsor
150 ns width

Results for 6 GeV experiment

600 KHz , 50 ns width

Kinematics	Path	fractional contribution			Total deadtime
		Group	GATE	OR	loss at 100 μA
DIS#1, Left HRS	n	$(20.6 \pm 2.1)\%$	$(51.3 \pm 3.5)\%$	$(28.1 \pm 4.7)\%$	$(1.45 \pm 0.09)\%$
	w	$(29.5 \pm 2.4)\%$	$(45.3 \pm 3.1)\%$	$(25.3 \pm 4.6)\%$	$(1.64 \pm 0.10)\%$
DIS#2, Left HRS	n	$(5.4 \pm 0.8)\%$	$(81.1 \pm 5.5)\%$	$(13.5 \pm 7.0)\%$	$(0.50 \pm 0.04)\%$
	w	$(8.4 \pm 0.4)\%$	$(77.3 \pm 5.3)\%$	$(14.3 \pm 8.0)\%$	$(0.52 \pm 0.05)\%$
DIS#2, Right HRS	n	$(4.6 \pm 0.4)\%$	$(72.9 \pm 6.0)\%$	$(22.6 \pm 17.4)\%$	$(0.57 \pm 0.10)\%$
	w	$(6.9 \pm 0.7)\%$	$(71.0 \pm 5.8)\%$	$(22.1 \pm 17.9)\%$	$(0.58 \pm 0.11)\%$
RES I, Left HRS	n	$(26.3 \pm 3.8)\%$	$(39.3 \pm 2.7)\%$	$(34.4 \pm 1.8)\%$	$(1.45 \pm 0.07)\%$
	w	$(37.2 \pm 2.1)\%$	$(34.3 \pm 2.3)\%$	$(28.5 \pm 3.1)\%$	$(1.66 \pm 0.07)\%$
RES II, Left HRS	n	$(27.6 \pm 4.3)\%$	$(38.8 \pm 2.7)\%$	$(33.6 \pm 7.5)\%$	$(2.19 \pm 0.20)\%$
	w	$(38.3 \pm 1.9)\%$	$(33.2 \pm 2.3)\%$	$(28.5 \pm 7.0)\%$	$(2.56 \pm 0.19)\%$
RES III, Right HRS	n	$(22.9 \pm 1.8)\%$	$(60.0 \pm 4.9)\%$	$(17.1 \pm 18.48)\%$	$(1.96 \pm 0.38)\%$
	w	$(30.8 \pm 3.1)\%$	$(51.8 \pm 4.3)\%$	$(17.4 \pm 12.73)\%$	$(2.27 \pm 0.31)\%$
RES IV, Left HRS	n	$(14.5 \pm 1.9)\%$	$(63.7 \pm 4.4)\%$	$(21.9 \pm 3.0)\%$	$(0.75 \pm 0.04)\%$
	w	$(21.5 \pm 1.0)\%$	$(58.2 \pm 4.0)\%$	$(20.3 \pm 2.9)\%$	$(0.82 \pm 0.04)\%$
RES V, Left HRS	n	$(15.5 \pm 2.1)\%$	$(68.3 \pm 4.7)\%$	$(16.2 \pm 5.7)\%$	$(1.03 \pm 0.08)\%$
	w	$(22.7 \pm 1.1)\%$	$(61.7 \pm 4.2)\%$	$(15.6 \pm 3.0)\%$	$(1.14 \pm 0.06)\%$

DAQ observations

Observations

- SoLID plans to use much of the current 12-GeV electronics from Jefferson Lab.
- Plans for using the APV25 chip for GEM readout were presented.
- The Level 3 trigger was not described and no costs were included.
- The slow control needs of the experiment were not presented and no costs were included.
- The SoLID collaboration currently has some simulation and limited reconstruction.
- The manpower currently associated with software for SoLID is estimated to be 6 FTE-years. Numbers from both Hall-B/CLAS-12 and Hall-D/GlueX are in the range of 30 to 50 FTE-years.
- The data scale expected from SoLID is similar to that anticipated in Halls B and D, while that in the early Hall-A experiments have a much smaller data footprint.
- No plan for data handling was presented.
- Data storage needs for Monte Carlo simulations were not included.

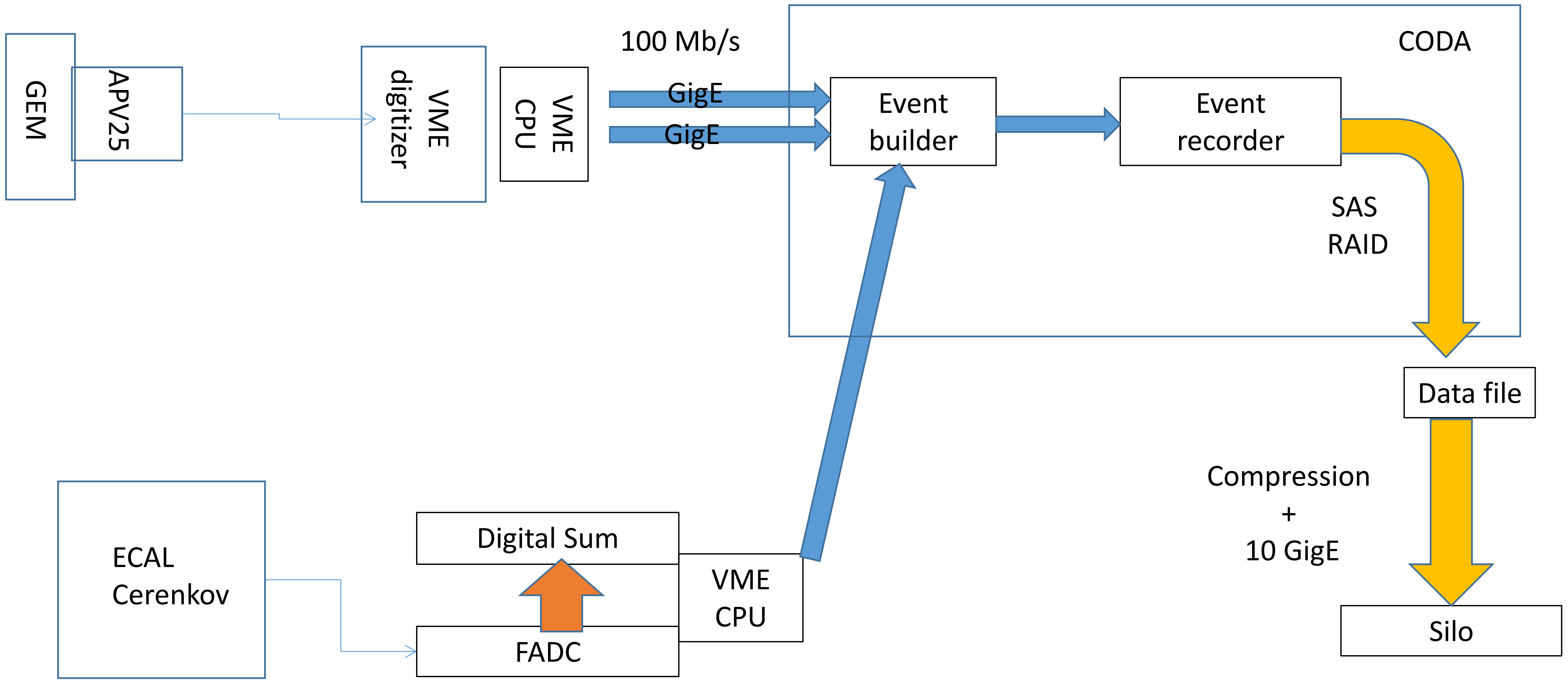
Findings

- Consultation with appropriate people from the other halls would be useful to get a more accurate estimate of software needs, including manpower.
- Early exploration of the tools available at Jefferson Lab that can handle the data at the expected scale of SoLID will be crucial in minimizing the false starts in software development

Recommendations 2c

1. a)The plans for the High Level Trigger and b) the needs for slow control (Brad) need to be worked out in detail and the implications for resources need to be evaluated.
2. The implications of the need for these resources in the context of availability of resources at the laboratory need to be understood.
3. Closer communication with the other JLab experiments and the JLab computing center is strongly encouraged.
4. Having a functional simulation and reconstruction routines as soon as possible should be a high priority in the software effort. Such software will pay off many times over in experimental design and avoiding pitfalls. (Ole)

Data flow



GEM
APV25
VME
digitizer
VME
CPU
100 Mb/s
GigE
GigE
CODA
Event
builder
Event
recorder
SAS
RAID
Data file
Compression
+
10 GigE
Silo
ECAL
Cerenkov
Digital Sum
FADC
VME
CPU

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**

SIDIS_He3 trigger rate summary

- Single e 116+46=162kHz

- Random coin 97kHz
- True coin rate <70kHz
  - electron trigger self coin 6kHz
  - coin from SIDIS 36kHz
  - coin from hadrons 28kHz (still missing window)

Total coin rate 167kHz + from hadrons of windows

All three true coin rate has overlaps but can’t know how much without a complete generator!

JPsi_LH2

hallD generator, SIDIS generator & Jin's EC Wiser trigger

hit matching

e_FA(kHz)	EC	EC+LGC	EC+LGC+SPD
electron	355	321	300
Pim	588	10.2	9.4
Pip	674	8.5	7.5
P	207	0	0
Pi0	1762	48	26.4
all hadrons, no electron	3690	81	56
Total:			356

Coincidence trigger searches through all possible candidates (N) and find pairs N*(N-1)/2

Self Coin prescaled by 100

(356+433)/100=8kHz

e_LA(kHz)	EC	EC+SPD
electron	21	19
Pim	117	106
Pip	179	164
P	123	114
Pi0	306	11
all hadrons, no electron	814	414
Total:		433

Coin trigger rate (kHz)	e_FA	e_LA	(e_FA + e_LA) & (e_FA + e_LA)
e+pip	250	24	5
e+pim	185	18	3.5
e+pi0	217	19.5	3.6
e+p	120	13	1.8
all hadrons, no electron	56	414	0.3
Total			14.2

Random coin (356+433)*(356+433)*1e3*30e-9=19KHz

True coin 14.2kHz

Total 52kHz

SIDIS event size

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

GEM	Occupancy	Number of strips	XY strips	Strips per chambers	Event size (bytes)	Data rate 100 KHz	MB/s
1	2.21	453	906	27180	2402.712	240271200	240.2712
2	8.78	510	1020	30600	10746.72	1074672000	1074.672
3	3.63	583	1166	34980	5079.096	507909600	507.9096
4	2.31	702	1404	42120	3891.888	389188800	389.1888
5	1.78	520	1040	31200	2221.44	222144000	222.144
6	1.3	640	1280	38400	1996.8	199680000	199.68
Total	20.01	3408	6816	204480	26338.656	2633865600	2633.8656

GEM dominating (35 bigger than initial proposal) 2.6 GB/s same requirement as PVDIS for L3

Need to look at FADC occupancies

J/Psi event size (preliminary)

Occupancies with one sample readout by Weizhi , rates for 50 KHz

	50000 KHz	Strip	Total strips	MPDs	Hits	strip detectors	Rate MB/s	Rate per MPD
GEM								
1	11.7	453	13590	6.635742188	106.002	3180.06	700.6069688	70.06069688
2	22.8	510	15300	7.470703125	232.56	6976.8	1537.07625	153.707625
3	15.3	583	17490	8.540039063	178.398	5351.94	1179.099281	117.9099281
4	12.7	702	21060	10.28320313	178.308	5349.24	1178.504438	117.8504438
5	13	520	15600	7.6171875	135.2	4056	893.5875	89.35875
6	10.8	640	19200	9.375	138.24	4147.2	913.68	91.368
Total	86.3	3408	102240	49.921875	968.708	29061.24	6402.554438	

J/Psi event size deconvoluted

Occupancies with 3 sample readout by Weizhi , rates for 50 KHz

J/psi deco								
GEM Weiszhi	50000	Strip	Total strips	MPDs	Hits	strip detectors	Rate MB/s	Rate per MPD
GEM								
1	2.4	453	13590	6.635742188	21.744	652.32	431.14275	43.114275
2	5.1	510	15300	7.470703125	52.02	1560.6	1031.459063	103.1459063
3	3.2	583	17490	8.540039063	37.312	1119.36	739.827	73.9827
4	2.6	702	21060	10.28320313	36.504	1095.12	723.805875	72.3805875
5	2.6	520	15600	7.6171875	27.04	811.2	536.1525	53.61525
6	2.1	640	19200	9.375	26.88	806.4	532.98	53.298
Total	18	3408	102240	49.921875	201.5	6045	3995.367188	

PVDIS GEM event size (Ole's occupancy)

PVDIS									
					Total strips				
Sector	Rate	X		Y			XY	Bytes	3 samples
0		81.7		88.3			170	680	2040
1		73.3		75.6			148.9	595.6	1786.8
2		68.3		72.5			140.8	563.2	1689.6
3		56.4		58.2			114.6	458.4	1375.2
4		54.5		56.9			111.4	445.6	1336.8
Total hits / sector	0						574.3	2742.8	8228.4
								10971.2	32913.6
Data rate / sector	20000							54856000	164568000
Data rate (sector Mb/s)								54.856	164.568

L3 farm (2c1)

- Have digitized data for GEM for SIDIS and PVDIS
- Weizhi has tracking algorithm take 2 to 10 ms to process one event so about 1000 nodes for 100 KHz
- Need :
  - Other include detector data
  - Additionnal reduction algorithm
  - Implement tracking
  - Test on Hall D or DAQ cluster
- Discussion with HPC/IT
  - Current 5000 cores
  - Upgrade to 10000 cores (170 $ per cores currently)
  - Seems reasonable to expect 20000 cores by 2023 (operation upgrade)

L3 trigger (2c1)

- 2.5 to 10 ms for tracking using Kalman Filter (preliminary)
- PVDIS : 20 KHz

200 cores per sector

6000 cores total

- SIDIS
  - 20 ms
  - 4000 cores for 200 KHz

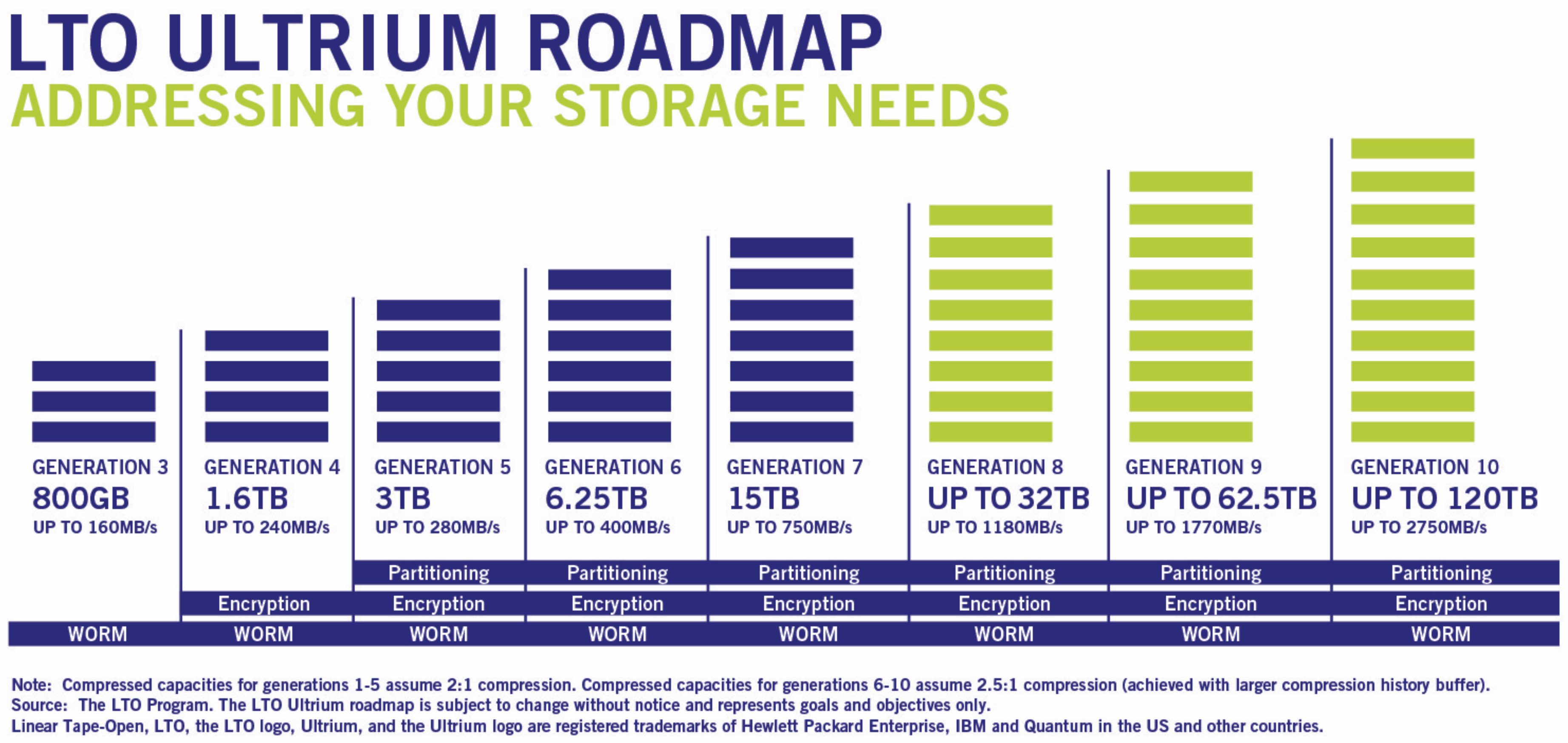
L3 trigger (2c1)

- Discussed with HPC and IT
  - Network upgrade :
    - Current : 2 x 10 Gbit /s = 2 * 1.2 GB/s from counting house to Computer center
    - Can be upgrade to 2x40 Gbit/s = 10 GB/s when cost go down (~5 years)
  - Tape SILO TS3500
    - 16 drives :
      - 6 LTO6 200MB/sx6 + LTO7 300 MB/sx8 = 3.6 GB/s
      - LTO7 300 MB/s x16 -> 4.8 GB/s
      - LTO8 472 MB/sx16 -> 7.5 GB/s
    - Could add second library (150 K$ and each drive 28 K$)

  - L3 could be located in CC and dynamically allocated (free !)

  - Need to let IT know the requirements, could invest yearly, need about 2000 today cores

LTO timeline



Bottomline : 3 GB/s is reasonable by 2020, L3 farm optional

Tape costs (2c2)

		Days	Data rate	Seconds	Total data TB	Double	LTO5 in $ 2010	LTO6 in $ 2012	LTO7 in $ 2015	LTO8 in $ 2018	LTO9 in $ 2020	LTO10 in $ 2023
E12-11-108	Pol proton	120	250	10368000	2592	5184	259200	155520	62208	30375	15552	8100
E12-12-006	J/Psi	60	250	5184000	1296	2592	129600	77760	31104	15187.5	7776	4050
E12-10-006	Transv. Pol. 3He	90	250	7776000	1944	3888	194400	116640	46656	22781.25	11664	6075
E12-11-007	Long. Pol. 3 He	35	250	3024000	756	1512	75600	45360	18144	8859.375	4536	2362.5
E12-10-007	PVDIS	169	250	14601600	3650.4	7300.8	365040	219024	87609.6	42778.125	21902.4	11407.5
	Total	474		40953600	10238.4	20476.8	1023840	614304	245721.6	119981.25	61430.4	31995
Actual days	Actual years		Time in s			Per year	394200	236520	94608	46195.3125	23652	12318.75
948	2.60	474	40953600									

About 17K$ per PB, 11K$ per PB for tapes about 250 K$ for 20 PB
Cynthia would like about 70 K$ per year in tape (50 K$ per year at 250 MB/s), but 300 K$ is not unreasonable if planned in advance
Numbers don’t include compression (additionnal factor of 2)
Expected to go down by a factor 5 by 2020

Updated realistic (not crazy) data rates

							2010	2012	2015	2018	2020	2023
		Days	Data rate	Seconds	Total data TB	Double	DLO5 in $	DLO6 in $	DLO7 in $	DLO8 in $	LTO 9	LTO10
E12-11-108	Pol proton	120	300	10368000	3110.4	6220.8	311040	186624	74649.6	36450	18662.4	9720
E12-12-006	J/Psi	60	3000	5184000	15552	31104	1555200	933120	373248	182250	93312	48600
E12-10-006	Transv. Pol. 3He	90	3000	7776000	23328	46656	2332800	1399680	559872	273375	139968	72900
E12-11-007	Long. Pol. 3 He	35	3000	3024000	9072	18144	907200	544320	217728	106312.5	54432	28350
E12-10-007	PVDIS	169	3000	14601600	43804.8	87609.6	4380480	2628288	1051315.2	513337.5	262828.8	136890
	Total	474		40953600	94867.2	189734.4	9486720	5692032	2276812.8	1111725	569203.2	296460
Actual days	Actual years		Time in s			Per year	3652587.342	2191552.405	876620.962	428037.5791	219155.2405	114143.3544
948	2.60	474	40953600									

300 K$ of tape over 3 years

Simulations needs

- GEM occupancies and digitization SIDIS for event size, occupancy and tracking (Ole, Zhiwen, Weizhi Duke) ✓
- Updated trigger rates PVDIS, SIDIS(Zhiwen, Rakitah) ✓
- FADC digitization PVDIS : realistic PID (?)
- Cerenkov simulation only timing readout no FADC(?)
- Effect 1 sample vs 3 samples GEM (Weizhi) and 20 samples vs time integral SIDIS (?) ✓
- Full FADC trigger simulation
- MRPC simulation : response to background

Communication with other groups 2c3

- Try collaborate with Hall D
- Constant communication with JLAB DAQ and electronics group
- Hall C, SBS interested in using VETROC for logic and readout
- check experience with APV and FADC from HPS and PRAD
    - Already planning to reuse HPS trigger scheme

Recommendations 2c

1. a)The plans for the High Level Trigger and b) the needs for slow control (see Brad's talk) need to be worked out in detail and the implications for resources need to be evaluated. ✓

2. The implications of the need for these resources in the context of availability of resources at the laboratory need to be understood. ✓

   Counting house network expected to be 10 GB/s

   Assuming progresses : around 100 K$ / year for tape at 3 GB/s

   CPU requirements about 5000 cores : can be absorbed ✓

3. Closer communication with the other JLab experiments and the JLab computing center is strongly encouraged. ✓

DAQ, Fast electronics, Hall D

4. Having a functional simulation and reconstruction routines as soon as possible should be a high priority in the software effort. Such software will pay off many times over in experimental design and avoiding pitfalls. (Ole's talk)

On going work

- SBS
  - MPD optical readout
  - SSP data reduction
  - HCAL FADC trigger with VTP
  - VTP readout
- Compton
  - Systematic on dead time correction
- SoLID (when preRD)
  - Test stand
  - Trigger programming and simulation

Plan

- Compton deadtime measurement setup (3 months)
  - High statistics to measure ppm level asymmetry
  - Improve deadtime measurement (dead time from scaler)

- SoLID trigger implementation (electronics groups when done with SBS ~ March)

- Test stand if preRD (SBS can give preliminary results)

Short term plan On going work

- SBS
  - MPD optical readout 3 months March 2017 (Ben Raydo, Alexandre Camsonne, UVA, INFN)
  - SSP data reduction 6 months to 1 year September 2017 (Ben Raydo, Alexandre Camsonne, UVA, INFN)
  - HCAL FADC trigger with VTP 6 months Mid 2017 (Ben Raydo, Alexandre Camsonne)
  - VTP readout 6 months Mid 2017 (Ben Raydo, Bryan Moffit)
  - Deadtime studies, readout optimization (Bob Michaels)
- Compton
  - Systematic on dead time correction (Bob Michaels, ? Lost students)
- SoLID (when preRD)
  - Test stand
  - Trigger programming and simulation

Conclusion

- New results from Simulation
  - PVDIS rate lower 12KHz, not an issue
  - SIDIS :
    - 1 sample GEM readout seems to work and with occupancies similar to PVDIS data rate
- Up to 3 GB/s most likely can be handled by SILO, L3 most likely not required and could be available mostly for free (optimize tape cost vs CPU investment)
  - To do :
    - TOF background
    - Need to check J/Psi and TCS occupancies, rates and efficiencies
- PVDIS deadtime : hardware setup, ongoing study preliminary results promising, need conclusive study with test setp