SoLID DAQ
for Transversity

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SIDIS: Single Electron Trigger

- Large Angle: 65 kHz @ 11 GeV
  - Calorimeter only
  - Electron: 11 kHz
  - High energy photon: 51.5 kHz
    - (possible to be rejected by including GEM in trigger, need study)
  - Hadron: <3 kHz (energy cut)
- Small angle: 120 kHz @ 11 GeV
  - Calorimeter + Gas Cherenkov
  - Electron: 90 kHz
  - High energy photon: 16 kHz (after Gas Cherenkov)
  - Hadron: 15 kHz (after Gas Cherenkov and Calorimeter)
- 8.8 GeV gives about 240 kHz

SIDIS: Hadron trigger

- Calorimeter + MRPC + Scintillator
- Hadron rate : 7.7 MHz
  – Charged hadron: 6.1 MHz (dominated)
  – Electron: 0.1 MHz
  – Photon: 1.5 MHz (after MRPC and Scintillator)
- Dominated by inclusive hadrons

SIDIS: Coincidence @ 35 ns window

- Coincidence rate: 50 kHz
- Given the safety margin, expected to handle about 100 kHz.
  - Include some single trigger to study detector performance etc.
- 4kB * 100 kHz ~ 400 MB/s to disk
  - Goal to reduce things to 50 MB/s by L3 farm

SIDIS channel count

Detector	Module type	Number of channels	Number of FADC
Forward Calorimeter	FADC	1896	119
Large angle calorimeter	FADC(+TDC)	920	58
Light Gas Cerenkov	FADC	120	8
Heavy Gas Cerenkov	FADC	270	17
Scintillator	FADC	120	8

The FADC of LC can be programmed to produce timing signals with ~400ps resolution (already demonstrated by simulation) to remove the needs of TDC.

APV25 readout

- Buffer length 192 samples : 4.8 us Look back 160 samples : 4 us

- Estimated occupancy : 220 hits per trigger, X Y data, 440 strips

GEM : 6 Layers 164 000 channels total, 28 000 channels per planes

Occupancy : 1.6 %

- APV readout time :

t_APV = 141 x number_of_sample / 40 MHz

t_APV(1 sample) = 3.7 us.

Max rate APV front end :

270 KHz in 1 sample mode

90 KHz in 3 samples mode

Will be triggered by coincidence trigger around 50 KHz

APV25 VME readout

- 220 hits x 2 x 2 bytes / 200 Mb

Average readout time for GEM
4.4 us / 11 crates

Readout time negligible and no dead time with buffering

More detailed simulation of APV25 and background being implemented will give confirmation in about 1 month

GEM in trigger

- Use signal of 5th GEM plane for fast trigger
- Quality of signal to be tested
- Could reduce rate in Large Angle from photon calorimeter by 50 KHz
- Additionnal FADC channels to put in trigger

Standard electronics

- Pros
  - Possibility for reuse of existing electronics

- Cons
  - Delay lines
  - Dead time :

    Encoding time min 2.2 us

    Electronic deadtime 30 ns

  - Trigger logic complicated

  - Splitting signal

  - Fastbus limitation to 40 Mb/s
  - Sensitive to pile-up

Standard electronics

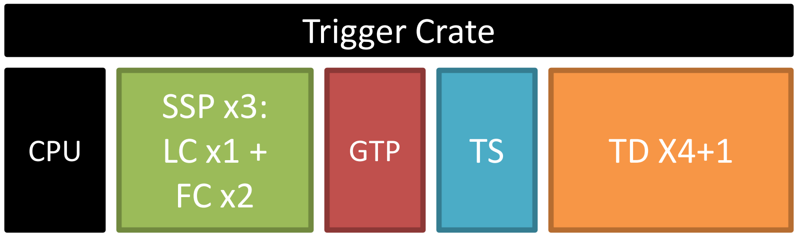
- Costs
  - About 500 summing modules : 750 K$
  - 25 Or modules : 30 K$
  - 25 And module : 30 K$

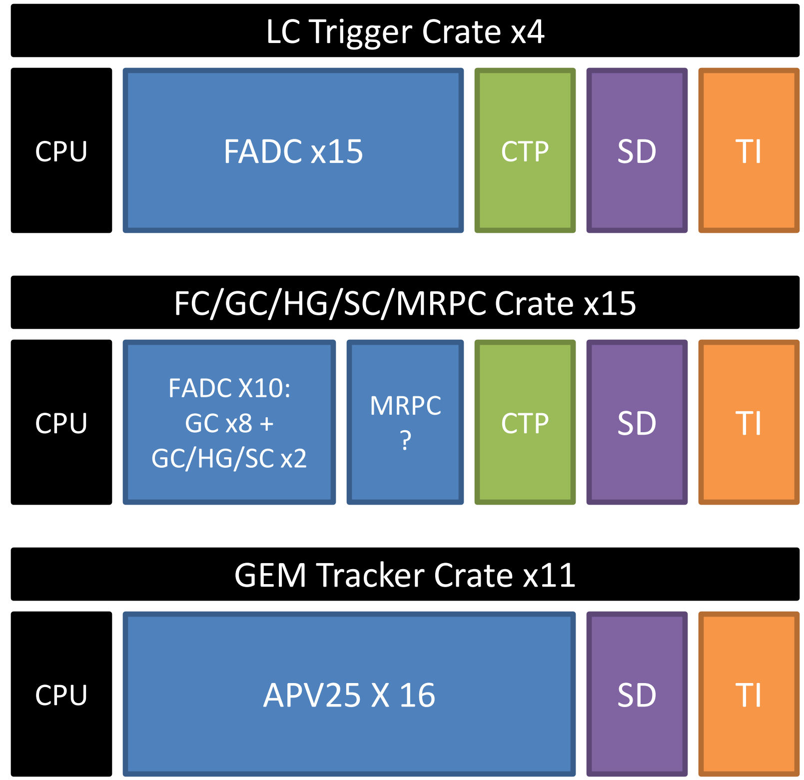
Total around 800 K$ not including cabling

SIDIS electronics

Module	Unite price	Quantity	
FADC 250	4500	210	$945,000
CTP	5000	19	$95,000
SSP	5000	3	$15,000
GTP	5000	1	$5,000
VXS crate	11500	1	$11,500
TS	3500	1	$3,500
TI	3000	30	$90,000
TD	3000	4	$12,000
SD	2500	30	$75,000
VXS crate	11500	30	$345,000
VME CPU	3400	31	$105,400
L3 farm node	5000	12	$60,000
		Total detectors	$1,762,400
VXS crate	11500	1	$11,500
Discriminators	2500	60	$150,000
VME64X crate	8100	3	$24,300
V1190	11010	15	$165,150
VME CPU	3400	4	$13,600
TID	3000	1	$3,000
SD	2500	1	$2,500
			$370,050
		Grand Total	$2,132,450

DAQ/Trigger for SoLID SIDIS

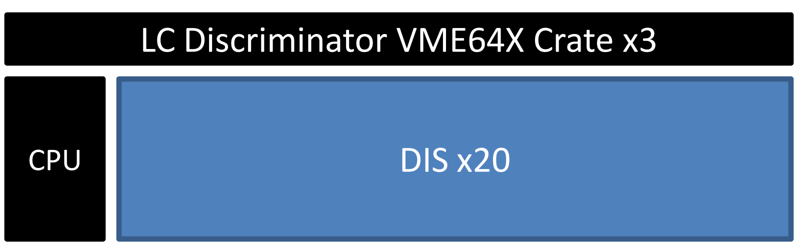


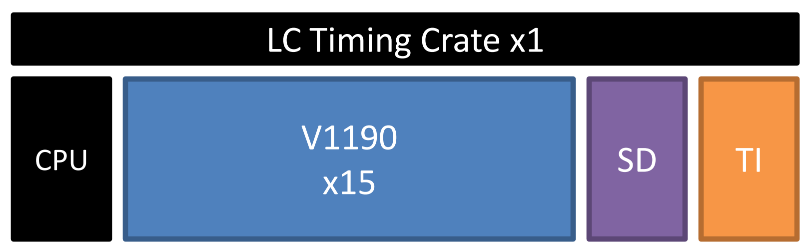


Total Crate + CPU: 31+4

FADC: 210	TI: 30+1
DIS: 0+60	SSP: 3
F1TDC: 0+30	GTP: 1
CTP: 19	TS: 1
SD: 30+1	TD: 4+1

+ ?





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Other projects

- SuperBigBite
  - 242 hadron calorimeter
    - 16 FADC
- Hall 12 GeV upgrade
  - VDC 2944 channels
    - 24 V1190 TDC
  - 50 FADC
  - Additionnal Jlab modules

- Other experiments : Primex ?

SIDIS electronics

Modules	Unit price	Quantity	Price	Borrow
FADC 250	4500	144	$648,000	HRS + SBS
CTP	5000	15	$75,000	HRS
SSP	5000	2	$10,000	HRS
GTP	5000	0	$0	HRS
VXS crate	11500	0	$0	SBS
TS	3500	0	$0	HRS
TI	3000	24	$72,000	HRS
TD	3000	2	$6,000	HRS
SD	2500	24	$60,000	HRS
VXS crate	11500	24	$276,000	HRS
VME CPU	3400	19	$64,600	HRS
L3 farm node	5000	12	$60,000	
		Total	$1,271,600	
VXS crate	11500	0	$0	HRS
Discriminators	2500	50	$125,000	HRS
VME64X crate	8100	0	$0	HRS
V1190	11010	0	$0	HRS
VME CPU	3400	0	$0	HRS
TID	3000	0	$0	HRS
SD	2500	0	$0	HRS
		Total timing	$125,000	
				With 20 % spare
		Total detectors	$1,396,600	$1,675,920

Conclusion

- APV25 limiting DAQ rate
- Coincidence trigger to reduce rate to about 50 KHz
- Timing needed for Large Angle Only for TOF
- Use of standard electronics doable but not very convenient and not that much cheaper
- Overlap of electronics with other experiment
- Around 1.7 M $ including spares for PVDIS and SIDIS

Backup

SoLID SIDIS Detector Rates

- In 50 ns windows, 11 GeV

Detector	Rate	Hits	Type	Data Size per hit
GEM	4.4 GHz	220	Hits (time)	4 Byte x 2 (X/Y)
LC	120 kHz	1	Energy, Hits	8 Byte x 2 (PS/SH)
FC	200 MHz	10	Energy, Hits	8 Byte x 2 (PS/SH)
LGC	40 MHz	3	Energy, Hits	8 Byte x 2 (split)
HGC	60 MHz	4	Energy, Hits	8 Byte x 2 (split)
MRPC	850 MHz	45	Hits	4 Byte
SC	300 MHz	15	Energy, Hits	8 Byte
Total				2.5 kB

With header and other over head
event size is ~ **4 kB**

L1 Trigger

- Electron Singles Trigger:
  - LC > 400 MeV | | (FC > 400 MeV && LGC)

$$T_L^e|_{11(8.8)GeV} = Y_L^e + Y_L^\gamma + \frac{Y_L^h}{R_{LC}} = 11 + 52 + \frac{56}{20} = 66(55)kHz$$

$$T_F^e|_{11(8.8)GeV} = Y_F^e + \frac{Y_F^\gamma}{R_{LGC}} + \frac{Y_F^h}{R_{LGC} \cdot R_{FC}} = 89 + \frac{620}{40} + \frac{6100}{40 \cdot 10} = 120(180)kHz$$

  - Total event rate: 190 - 240 kHz
  - Frontend data rate: 800 – 1000 MB/s
  - ROCs can barely handle this rate
    - Assuming 10 VME crates, 100 MB/s per ROC
    - add more crates since PVDIS uses > 30
  - Maybe a little bit too much to write to the tape
  - Not much room for improvement, already very close to electron yield.

Reduce L1 Trigger: Two Options

- Make coincidence with another charged particle in Forward detector
  - FC > 200 MeV && MRPC && Scintillator

$$T_F^h|_{11(8.8)GeV} = Y_F^h + Y_F^e + \frac{Y_F^{\gamma all}}{R_{MRPC} \cdot R_S} = 6 + 0.1 + \frac{200}{20 \cdot 6.5} = 7.7(6.9)MHz$$

  - Coincidence rate with 35 ns window ~ 50 kHz
- Use L3 farm
  - With powerful parallelism computing, we can easily reduce the rate by a factor of 5
  - Reduce the difficulty to put MRPC (customized VME board) into the trigger logic
- Both options give 200 MB/s data rate to the tape

Trigger using standard electronics

- 1. Electron trigger
- 1.1. Large angle side: 30 discriminators for Calorimeter (< 20 ns signal width)
- 1.2. Forward region: 30+30 discriminators for Calorimeter and Gas Cherenkov (< 10 ns signal width), 30 coincidence channels (20 ns window)
- 2. Hadron trigger
- 2.1 Forward region: 180+180+30 discriminators for Calorimeter, MRPC and Scintillator (<5 ns signal width), 180+30 coincidence modules (15 ns window)
- 3. Coincidence trigger 3.1 450 coincidence channels (20+15=35 ns window)
- So in total, we need at least 480 discriminators and 690 coincidence modules and some logic and summing modules. Pipeline technique can really help a lot here.

Use of standard electronic

- Electron Trigger
  - 1896 FC calorimeter channels
    - 352 summing modules
    - 15 discriminators
    - 16 or module
  - 120 channels GC
    - 30 summing modules
    - 2 discriminators
    - 2 coincidence modules
  - 920 LC calorimeter channels
    - 115 summing modules
    - 8 discriminators

Use of standard electronic

- Hadron trigger
  - Coincidence FC + Scintillators + MRPC
    - 8 discriminators for Scintillators
    - 32 Coincidence modules

- Coincidence trigger
  - 6 Or modules (4 electron trigger + 2 hadron trigger)

Fastbus

- About 3200 channels of detector to be readout using Fastbus 1877 + MQT
  - 3200 delay lines
  - ADC encoding deadtime 2.2 us
  - Front end dead time 11 %

Use of standard electronic

- Conclusion
  - Large amount of modules needed about twice more than Gep5 BigCal

  - Not optimal because of OR and sums will be more sensitive to background
  - Doable but trigger complicated
  - Cost including cable of similar order