Computing,
DAQ and Trigger

Brad Sawatzky

Computing

Computing

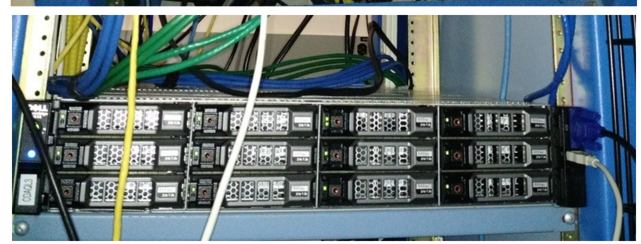
- Upgraded Network
  - → New fiber tying SHMS ↔ CH ↔ HMS
  - → Upgraded network switches in SHMS, HMS, CH
  - → New network run to Hall C gas shed
    - » remote monitoring, EPICS logging, controls
- Also new CAT6 (copper) runs from SHMS ↔ Hall ↔ CH (multi-function, low V signalling, etc)

Computing

- Upgraded Servers
  - → New Fileserver [cdaqfs1]
    - » 6 core, 32 GB, 10TB RAID6 '/home', “system”
  - → New 'Workhorse' [cdaql1]
    - » 20 core, 64GB, 20TB RAID6 'scratch'
  - → New magnet controls [skylla7, cmagnets]
- New console/operator comp. [x4]
  - » Dual monitor displays for shift crew
  - » 4 core, 8 GB
- New big-screen wall monitors for system displays [x2]

Computing

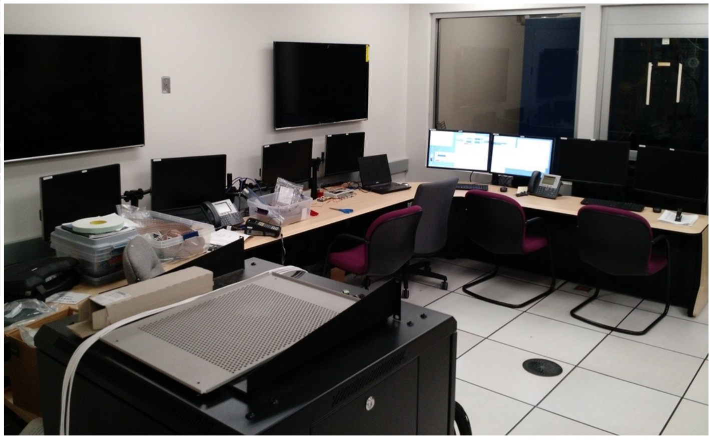
- “Best of” existing machines repurposed
  - → cdaql2, cdaql4
    - » SHMS, HMS DAQ
  - → cdaql5
    - » Moller DAQ
  - → cdaql3
    - » alt. 'workhorse' machine
    - » compute, scratch, DB server
  - → all RAID1/RAID6, dual power supply
- New machines RHEL6/RHEL7
  - → legacy machines → RHEL6
  - → keep one machine RHEL5/32
- Compute racks backed by dual high-capacity UPSs



Updated Counting House Consoles

Differences between this image and as-ordered:

- Two new 55" 1080p big displays on the wall
  - instead of the 3 smaller displays shown
- 5 desktop consoles are planned (4 user machines + target computer)
  - 1 on each short leg, 2 along long section
- We'll get a different table than shown in this image



Data Acquisition / Trigger

Baseline Trigger Requirements

- Trigger is simple
  - → Based on successful 6 GeV HMS+SOS triggers
  - → 'discrete' NIM logic (no firmware-trigger)
    - » nominal logic signal & gate widths: 40–60 ns
  - → Simple combinatorics For example:
    - » AND of right/left PMTs
    - » OR of paddles in each hodoscope plane
    - » Trigger DAQ on 3 of 4 of Scint Planes, etc.

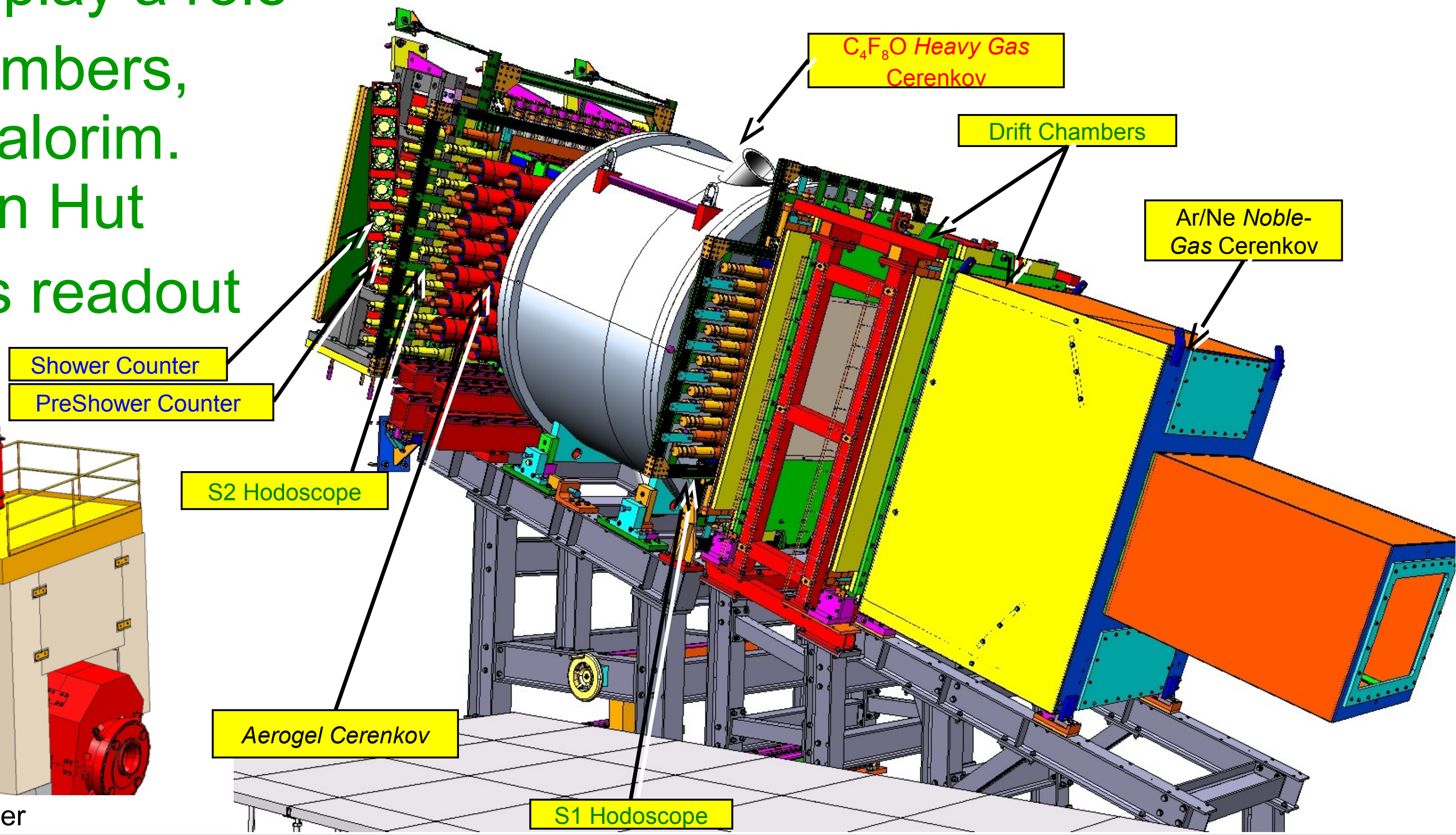
- Rates are modest
  - → Comparable to 6 GeV HMS operation
  - → 10s of kHz (typ.) in individual PMTs
  - → Final trigger rate ~ 2–5 kHz with
  - → Deadtimes < 15%

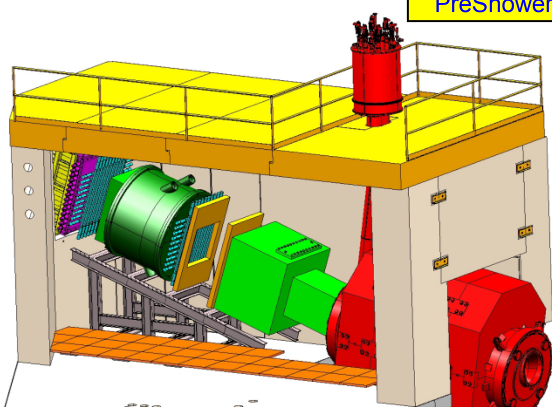
- Data rates are low (by modern standards)
  - → ~ 1 kB/event per spectrometer
  - → ~ few MB/sec to disk

SHMS Detector Layout

- Hodoscopes are basis for all triggers
  - →Cerenkov, Shower can also play a role
  - →Wire chambers, SHMS Calorim. readout in Hut
  - →All others readout in CH

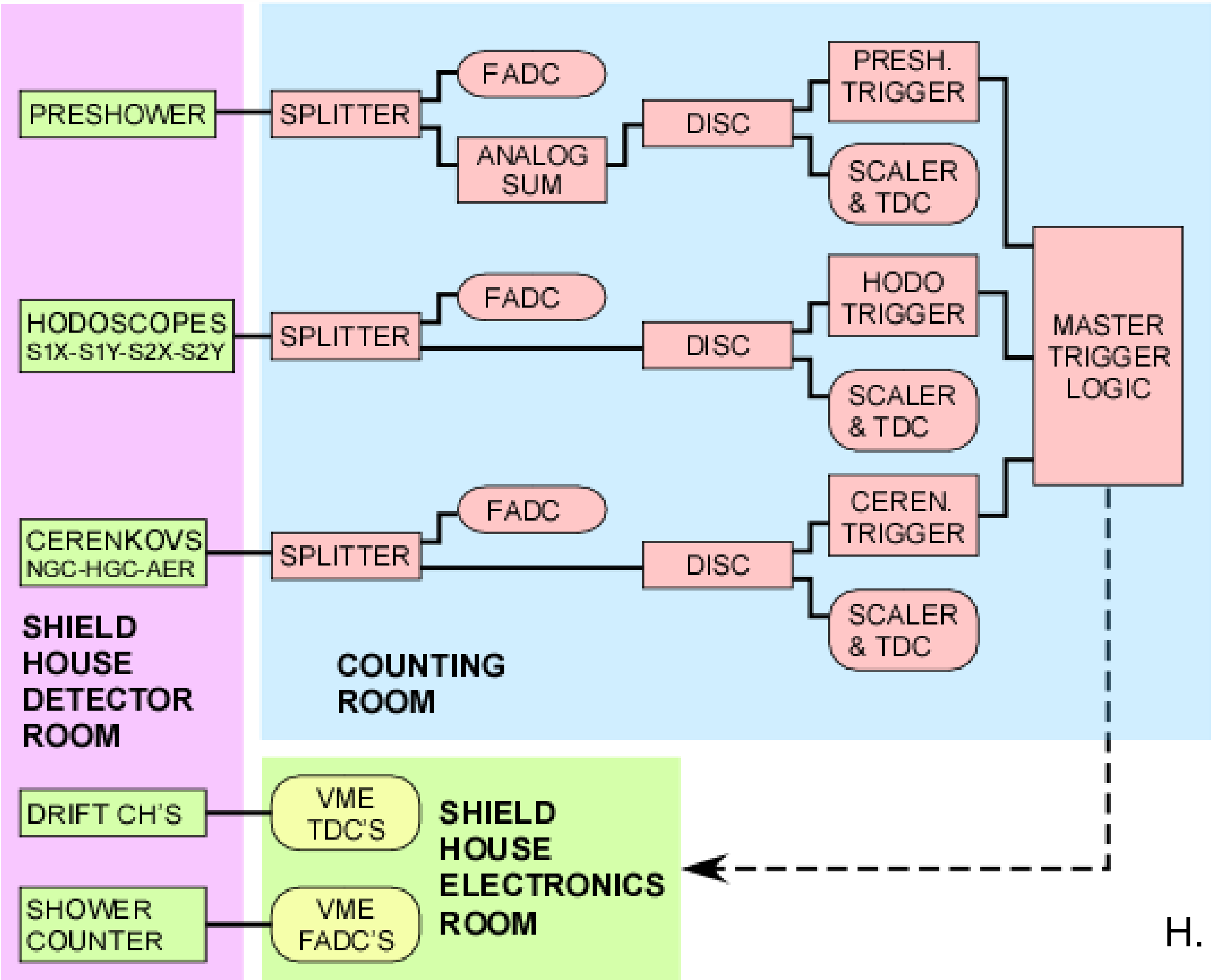
- HMS detector layout and trigger designs are conceptually similar





Slide graphics: H. Fenker

SHMS/HMS Trigger/Electronics



H. Fenker

SHMS / HMS Triggers

- Ultimate triggers in use driven by experimental requirements/request
  - →SCIN = 3 of 4 hodoscope planes
  - →CER = Cerenkov(s)
  - →STOF = S1 + S2
  - →EL-Hi = SCIN + PSh_Hi
  - →EL-Lo = 2/3{SCIN, STOF, PSH_Lo}.AND. CER
  - →EL-Real = EL-Hi + EL-Lo
  - →PION = SCIN .NOT. CER
  - →[etc...]
  - →Pulser/Random trigger
    - » EDTM injection for deadtime monitoring

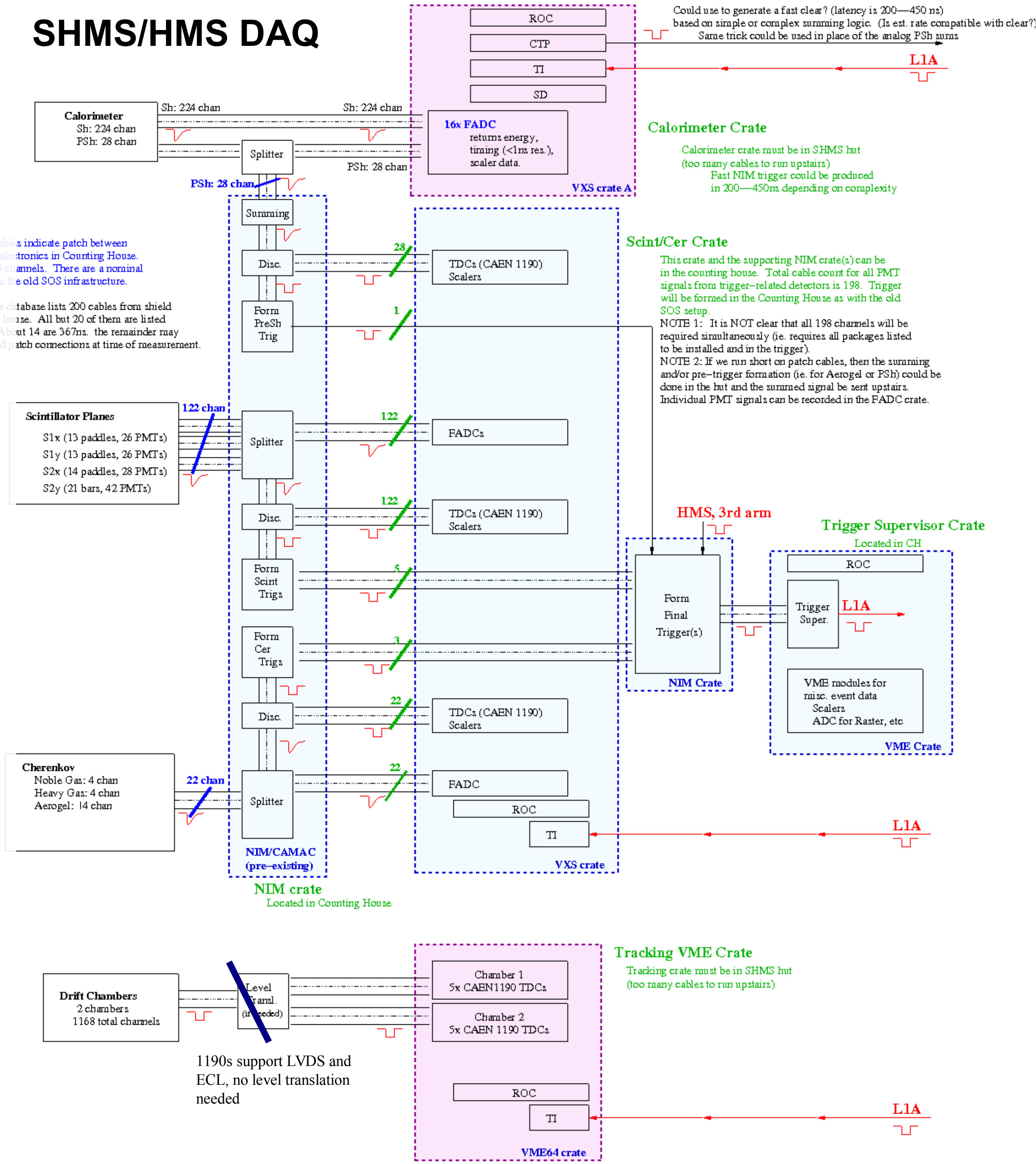
- Each arm has its own TS
  - → Both coincidence and independent/parallel operation available

- NOTE: There is *no* Calorimeter Sum for SHMS trigger
  - → SHMS Pre-Sh sum *does* exist for trigger

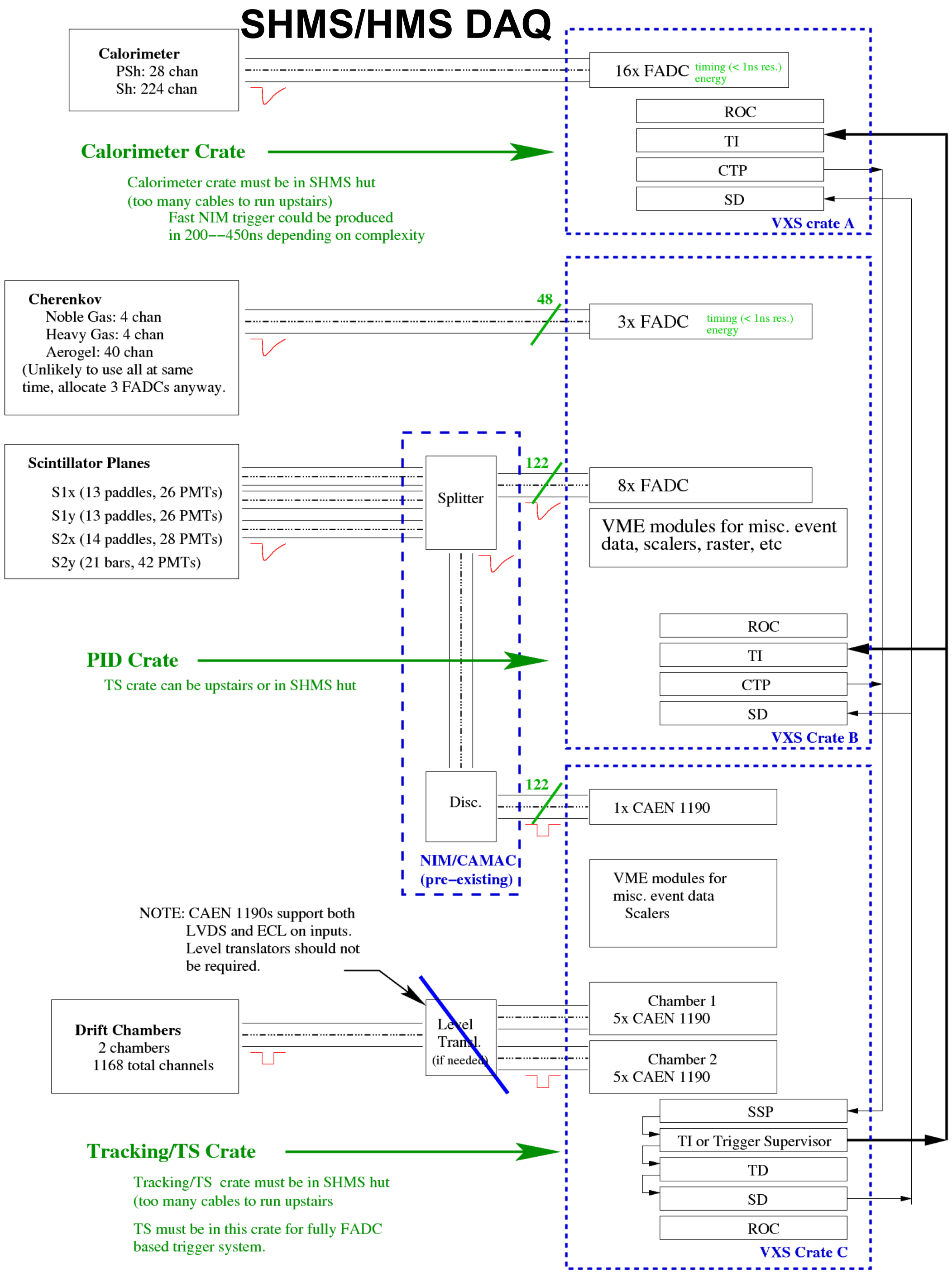
Initial Production Config

SHMS/HMS DAQ

- Will restore HMS trigger; SHMS has same logical design.
  - → FASTBUS electronics for HMS replaced with FADCs and CAEN 1190 TDCs
  - → A “legacy” NIM trigger will be implemented.
  - → This is our 12 GeV starting point.
- FADCs will provide ADC, TDC (~1 ns res.), and scaler data
- CAEN 1190 TDC: 100 ps res.
- If desired, Calo. FADCs could provide a simple sum, or more sophisticated cluster trigger with latency of ~200—400ns
  - – somewhat slow for main trigger, but could be used as a fast clear
  - [No requests as yet.]



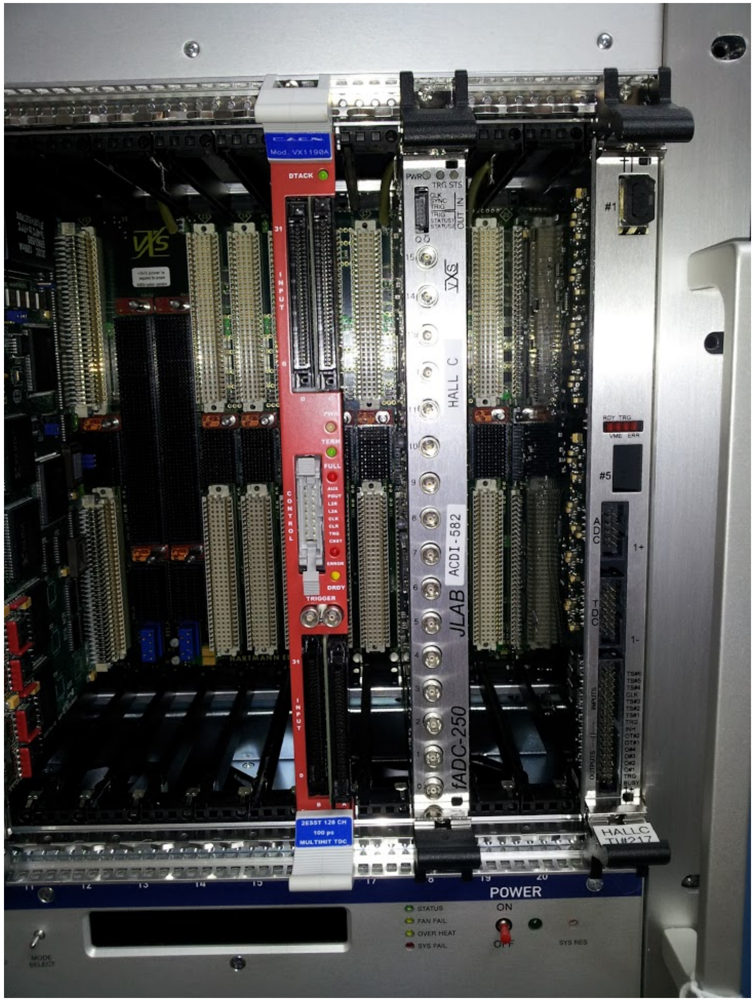
"Modern" Trigger/DAQ



- "Stage 2" evolution of system
  NOT desired for first set of experiments
  - fully pipeline capable
  - 'deadtimeless' operation at >10kHz possible
- Legacy/NIM logic will be left in place and can be used as either primary or auxiliary trigger.
  - (Will need legacy trigger to debug/cross-check any FADC logic anyway)
- DAQ can be configured for:
  - high-speed fully-pipelined mode
    - trigger can be generated in NIM logic, *or* in firmware
  - "Hybrid mode"
    - ie. in conjunction with non-pipelined 3rd arm, etc.

New Inventory

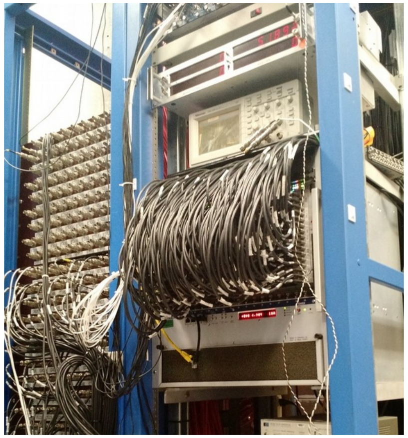
- 4 new VXS crates
  → primarily used to support FADCs (special J0 backplane bus)
- 640 ch JLab FADC [40 mod]
  → SHMS: ~422 ch / HMS: ~200 ch
- 3072 ch CAEN 1190 TDC [24 mod]
  → SHMS: ~1200 ch / HMS: ~1200 ch
- 2 New Trigger Supervisor (TS) boards
- 5 New Trigger Interrupt (TI) boards
- 2 Trigger Distribution (TD) boards
  → fans triggers/clocks out to crates
- 2+2 Signal Distribution (SD) board
  → fans triggers/clocks out to FADCs
- 3 Crate Trigger Processor (CTP) boards
- 1 Sub-System Processor (SSP) board



- 'Special' multi-fiber optical cable run SHMS ↔ HMS ↔ CH for DAQ

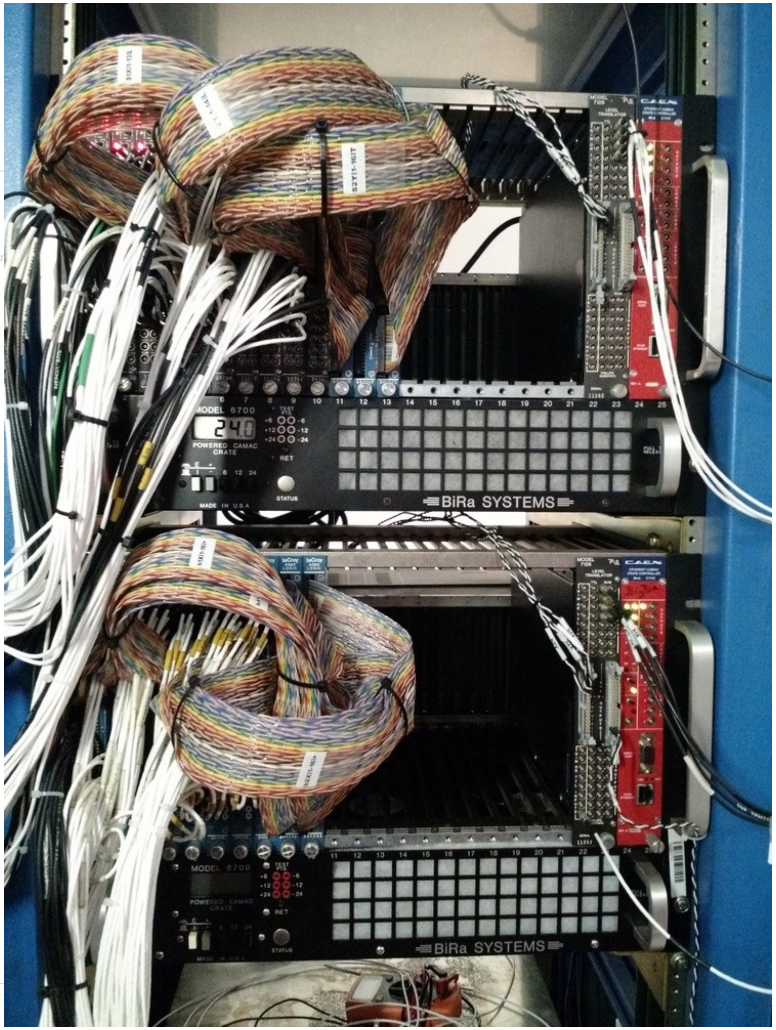
Parallel DAQ Setups

- **SHMS Hut**
  - → FADC/VXS for calorimeter readout
- **HMS Hut**
  - → CAEN 1190/VXS for wire chamber readout
- **Counting House**
  - → 2x VXS crates for SHMS/ HMS hodoscope, calorim 1190 + F250 readout
- **Equipment Staging Building**
  - → 1190 TDC readout for SHMS + (new) HMS chambers
  - → will move to SHMS Hut along with chambers



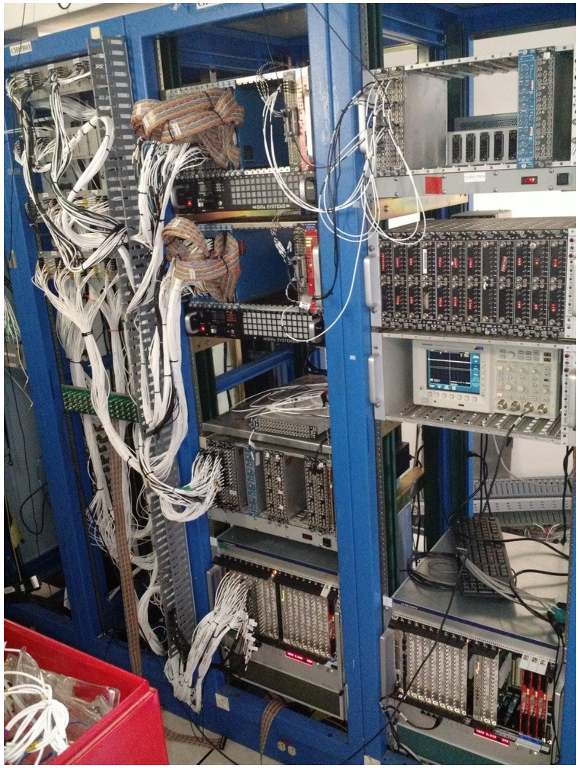
DAQ Trigger Status

- End-to-end checkout of RG-8 patch between detectors → CH has been completed for both Spectrometers
- 'NIM' trigger established for HMS and SHMS
  - → Discrimination and sub-detector combinatorics done in CAMAC
  - → Construction of production triggers in adjacent NIM bin
    - » 3/4{s1x,s1y,s2x,s2y}
    - » “SCIN”, “CER”, etc.
-



DAQ Consolidation Underway

- Primary demand has been for independent DAQs (see earlier slide)
  - → Appropriate signals from NIM trigger are patched back to 'standalone', single-crate DAQs
- Consolidation/integration of the "mini-DAQs" underway
  - → Last significant step is completing cabling from CH patch → FADCs
- CODA 2.6.2 is presently in use for single-crate systems
  - → CODA 3.x will be tested during integration tests



Compute/DAQ To-Do List

- General
  - → Complete/Repeat clean-up of Counting House operations and electronics rooms
- Complete / Test integration of full single-arm DAQ (SHMS, HMS)
  - → Use 'faked' EDTM signal to test dual-arm coincidence DAQ
  - → Rates, bandwidth, sustained load tests
    - » Crates → Hall C cluster → Tape System
- Beamline / Slow controls integration into DAQ
  - → BPM signal readouts
  - → Harp status / controls
  - → Raster control / readout
  - → BCM readout
  - → Helicity reporting / gated scalers
  - → EPICS variables
    - » Verify all relevant EPICS PVs are in MCC Archiver, screens updated with any changed names, etc
    - » Magnet readbacks interfaced with MCC Archiver?
    - » Target logging
    - » High-voltage logging

Aug/Sept

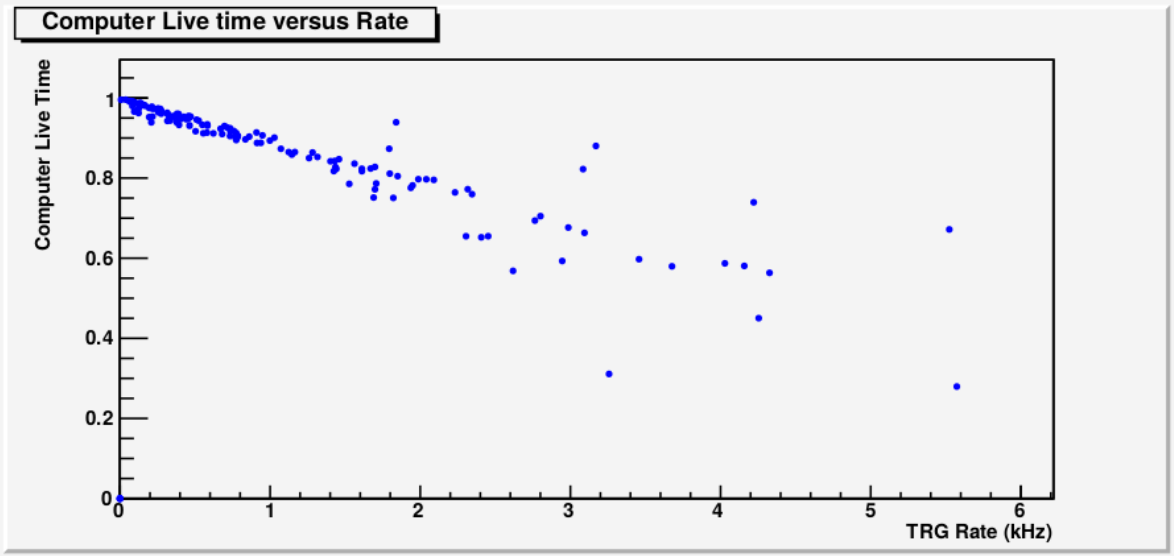
(Sawatzky, Pooser, Yero, Basnet)

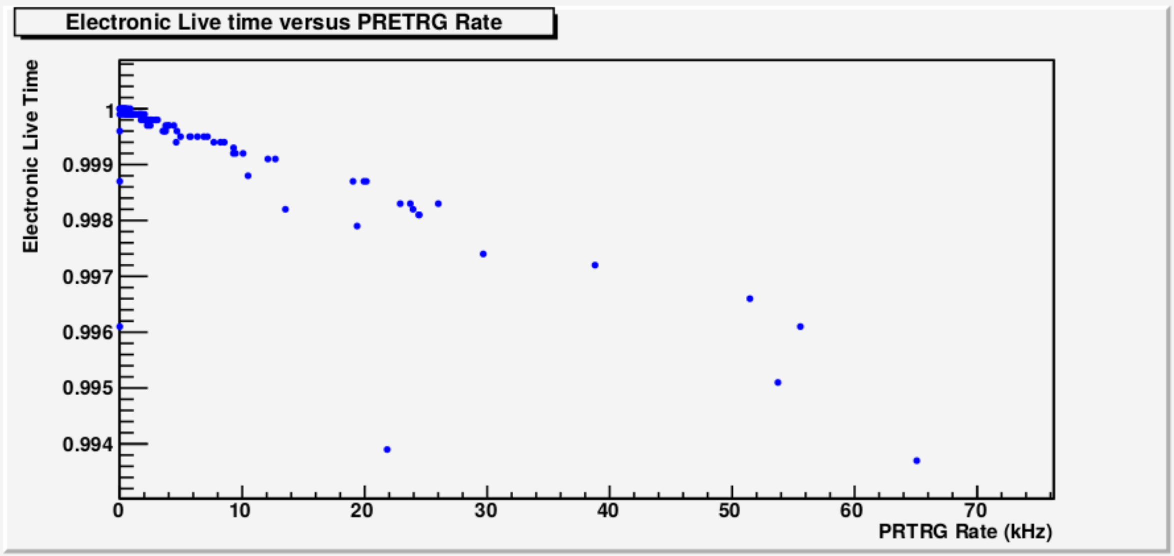
Oct/Nov

(Sawatzky, Wood, Pooser)

Misc/Backup Slides

Electronic & Computer Deadtimes





- Examples from "Measurement of R in the Nucleon Resonance Region on Deuterium and the Non-Singlet Moments of the Nucleon" – Albayrak (E02-109 Dissertation; 6 GeV)
- Computer live time dominated by FASTBUS readout times.
  - → all now replaced by (much) faster F250s, C1190s, Intel VME computers
- Electronic live times are for the same NIM circuit implemented now.
  - → Note > 99.5% live for pre-trigger rates up to 50 kHz

Electron Trigger Efficiency

- Example from "Measurement of R in the Nucleon Resonance Region on Deuterium and the Non-Singlet Moments of the Nucleon" – Albayrak (E02-109 Dissertation; 6 GeV)
  - → Primary trigger > 99.8% efficient for HMS
  - → SHMS trigger based on same design, equivalent detectors

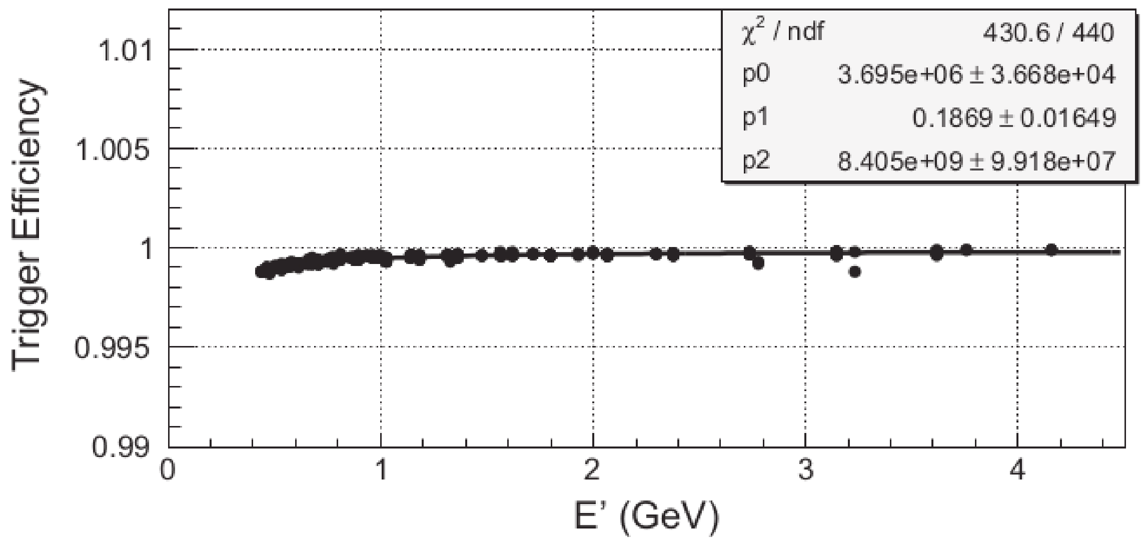
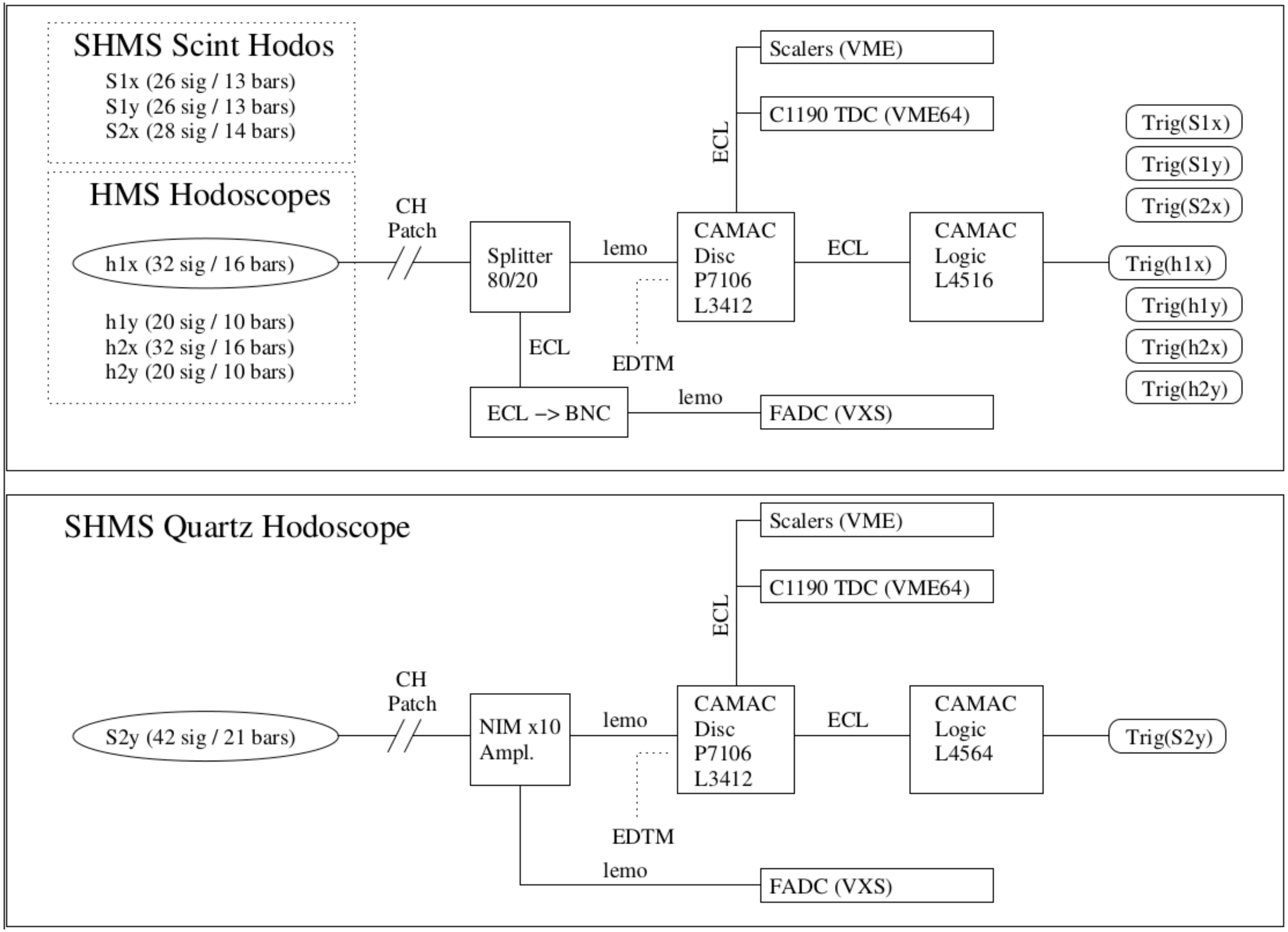
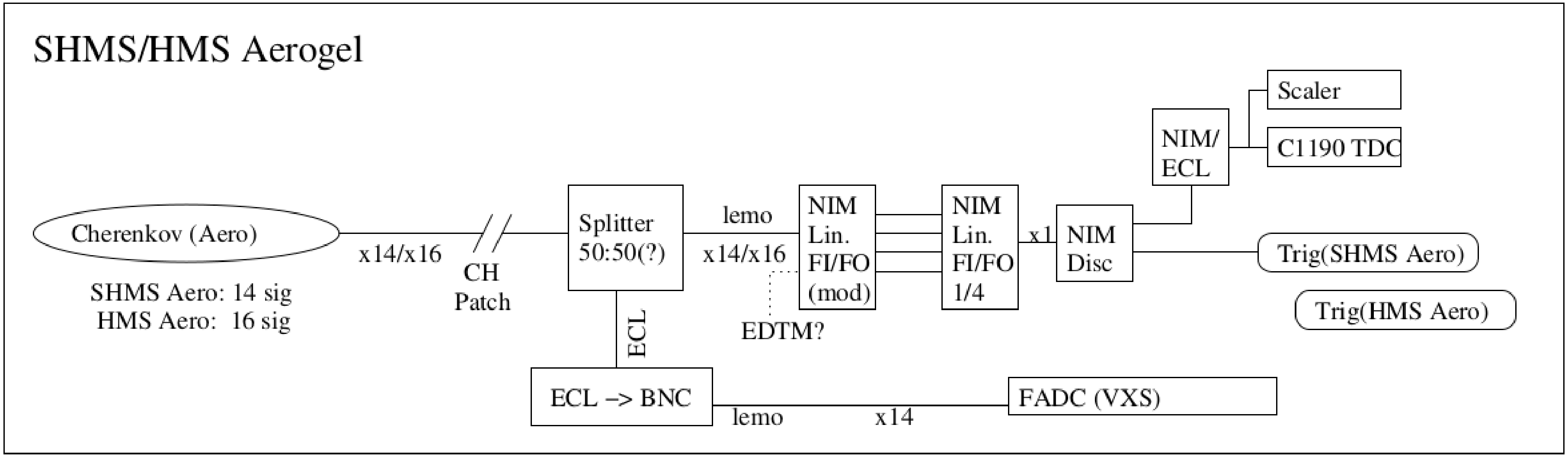


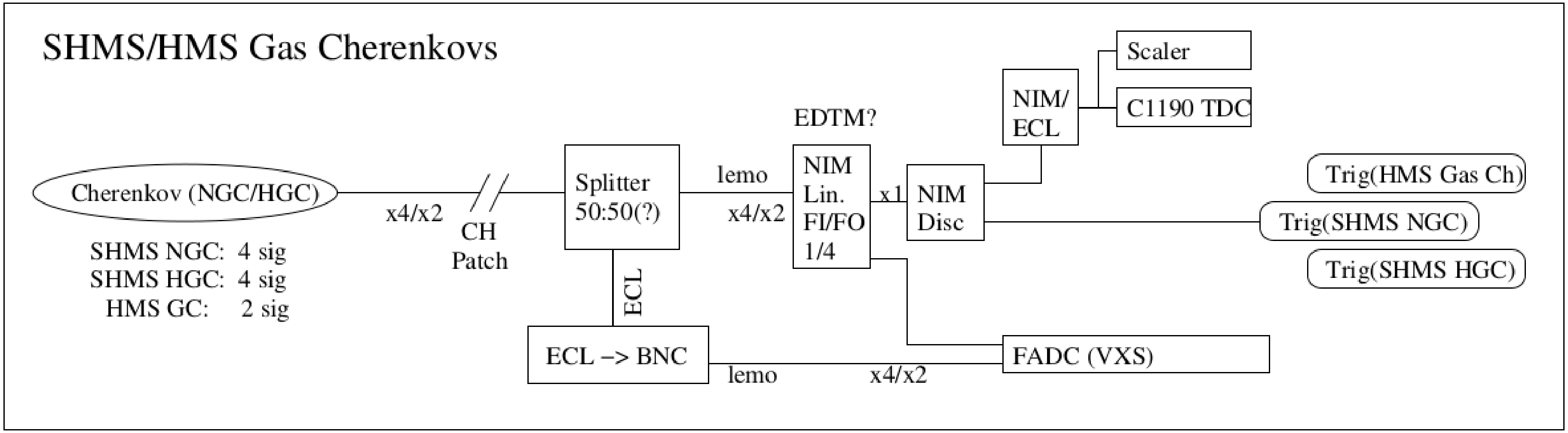
Figure 4.36: HMS electron trigger efficiency as function of scattered electron energy.

Hodoscopes

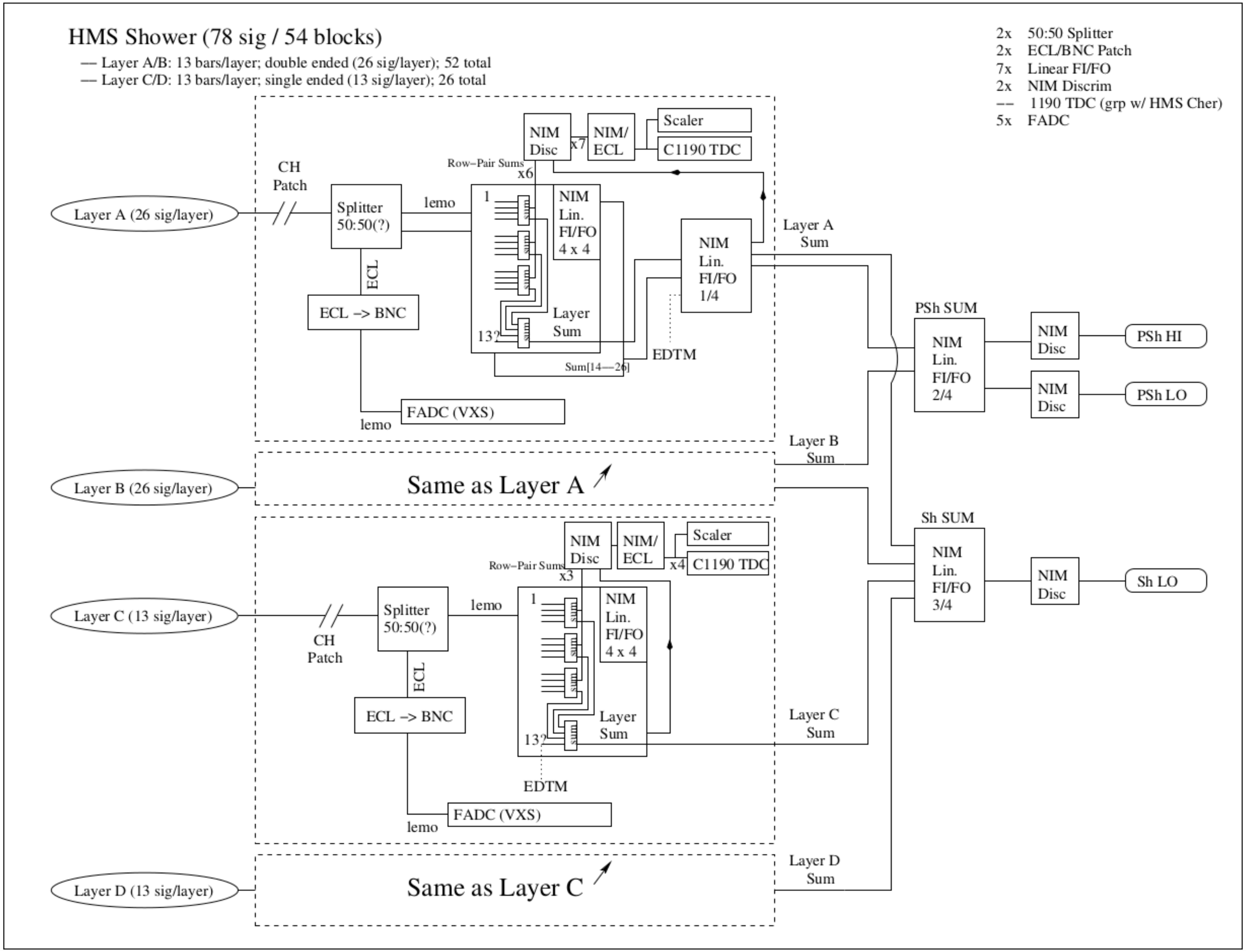

SHMS Scint Hodos
S1x (26 sig / 13 bars)
S1y (26 sig / 13 bars)
S2x (28 sig / 14 bars)
HMS Hodoscopes
h1x (32 sig / 16 bars)
h1y (20 sig / 10 bars)
h2x (32 sig / 16 bars)
h2y (20 sig / 10 bars)
CH Patch
Splitter 80/20
lemo
ECL
ECL –> BNC
lemo
FADC (VXS)
EDTM
CAMAC Disc P7106 L3412
ECL
Scalers (VME)
C1190 TDC (VME64)
ECL
CAMAC Logic L4516
Trig(S1x)
Trig(S1y)
Trig(S2x)
Trig(h1x)
Trig(h1y)
Trig(h2x)
Trig(h2y)
SHMS Quartz Hodoscope
S2y (42 sig / 21 bars)
CH Patch
NIM x10 Ampl.
lemo
CAMAC Disc P7106 L3412
ECL
Scalers (VME)
C1190 TDC (VME64)
ECL
CAMAC Logic L4564
Trig(S2y)
EDTM
lemo
FADC (VXS)

Cherekovs


SHMS/HMS Aerogel
Cherenkov (Aero)
SHMS Aero: 14 sig
HMS Aero: 16 sig
x14/x16
CH
Patch
Splitter
50:50(?)
ECL
ECL -> BNC
lemo
x14/x16
EDTM?
NIM
Lin.
FI/FO
(mod)
NIM
Lin.
FI/FO
1/4
x1
NIM
Disc
NIM/
ECL
Scaler
C1190 TDC
Trig(SHMS Aero)
Trig(HMS Aero)
FADC (VXS)
lemo
x14

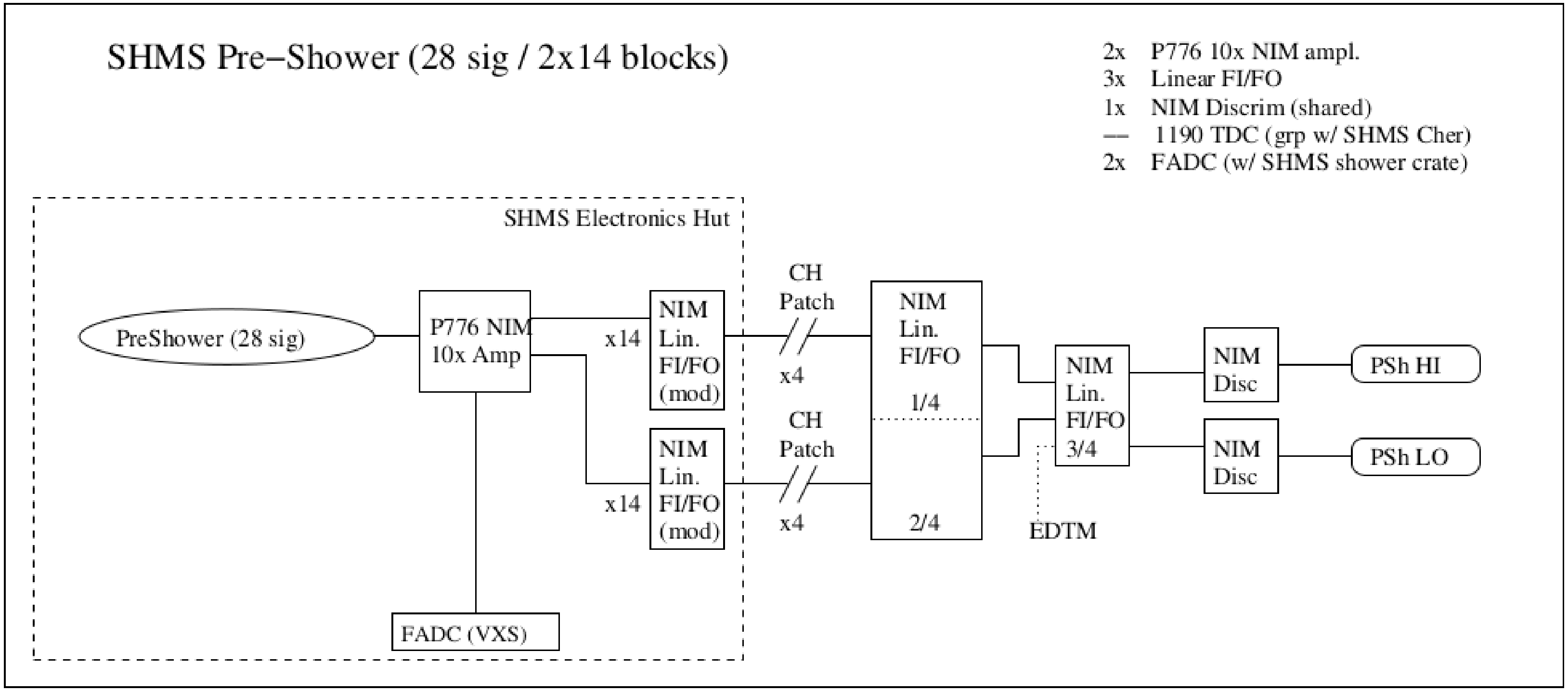

SHMS/HMS Gas Cherenkovs
Cherenkov (NGC/HGC)
SHMS NGC: 4 sig
SHMS HGC: 4 sig
HMS GC: 2 sig
x4/x2
CH
Patch
Splitter
50:50(?)
ECL
ECL -> BNC
lemo
x4/x2
EDTM?
NIM
Lin.
FI/FO
1/4
x1
NIM
Disc
NIM/
ECL
Scaler
C1190 TDC
Trig(HMS Gas Ch)
Trig(SHMS NGC)
Trig(SHMS HGC)
FADC (VXS)
lemo
x4/x2

HMS Shower

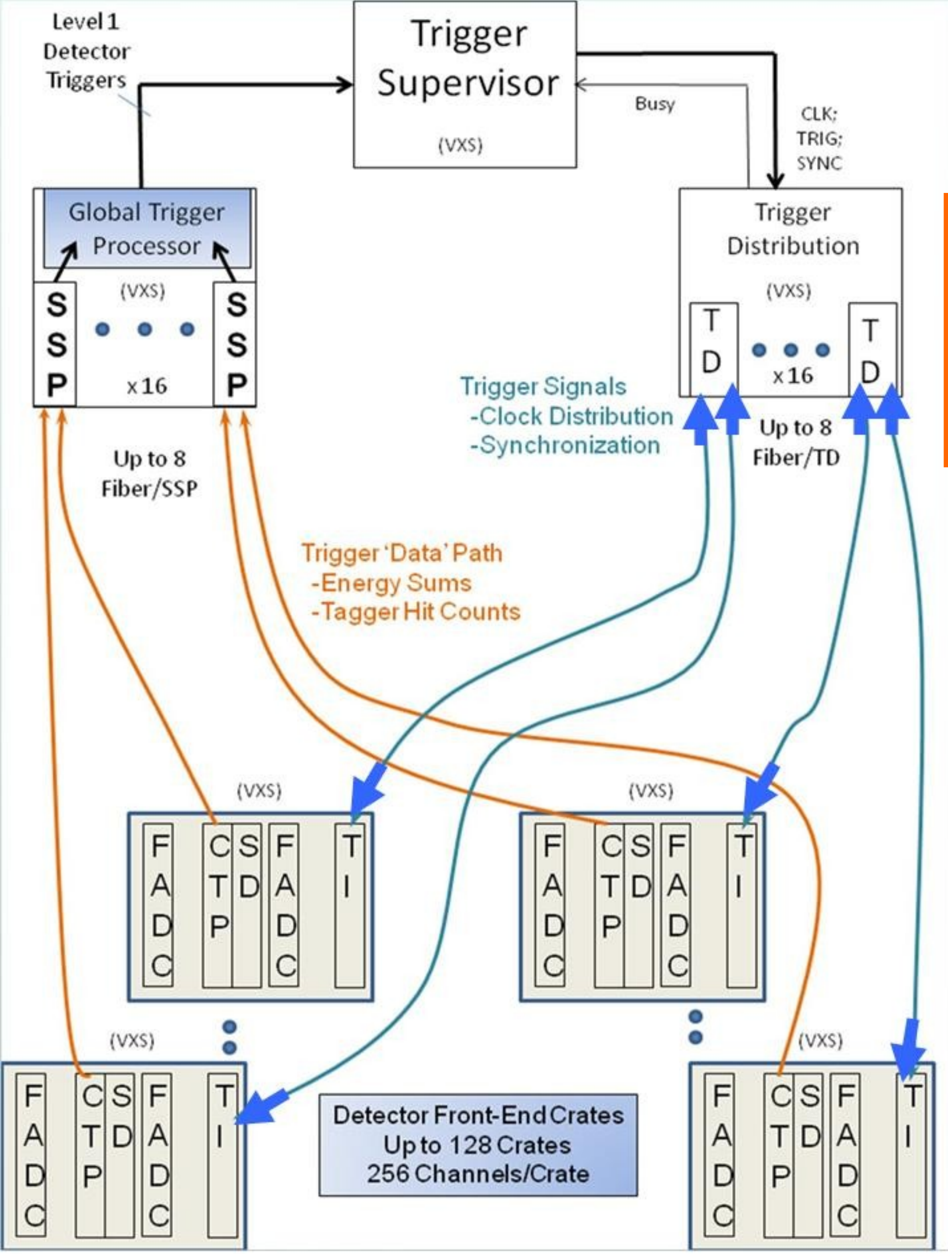


HMS Shower (78 sig / 54 blocks)
— Layer A/B: 13 bars/layer; double ended (26 sig/layer); 52 total
— Layer C/D: 13 bars/layer; single ended (13 sig/layer); 26 total
2x 50:50 Splitter
2x ECL/BNC Patch
7x Linear FI/FO
2x NIM Discrim
–– 1190 TDC (grp w/ HMS Cher)
5x FADC
Layer A (26 sig/layer)
CH Patch
Splitter 50:50(?)
lemo
ECL
ECL –> BNC
FADC (VXS)
lemo
Row–Pair Sums
x6
NIM Disc
x7
NIM/ ECL
Scaler
C1190 TDC
NIM Lin. FI/FO 4 x 4
Layer Sum
13?
Sum[14—26]
NIM Lin. FI/FO 1/4
EDTM
Layer A Sum
PSh SUM
NIM Lin. FI/FO 2/4
NIM Disc
PSh HI
NIM Disc
PSh LO
Layer B Sum
Layer B (26 sig/layer)
Same as Layer A
Sh SUM
NIM Lin. FI/FO 3/4
NIM Disc
Sh LO
Layer C (13 sig/layer)
CH Patch
Splitter 50:50(?)
lemo
ECL
ECL –> BNC
Row–Pair Sums
x3
NIM Disc
NIM/ ECL
x4
Scaler
C1190 TDC
NIM Lin. FI/FO 4 x 4
Layer Sum
13?
EDTM
FADC (VXS)
lemo
Layer C Sum
Layer D (13 sig/layer)
Same as Layer C
Layer D Sum

SHMS Pre-shower



Trigger System Diagram

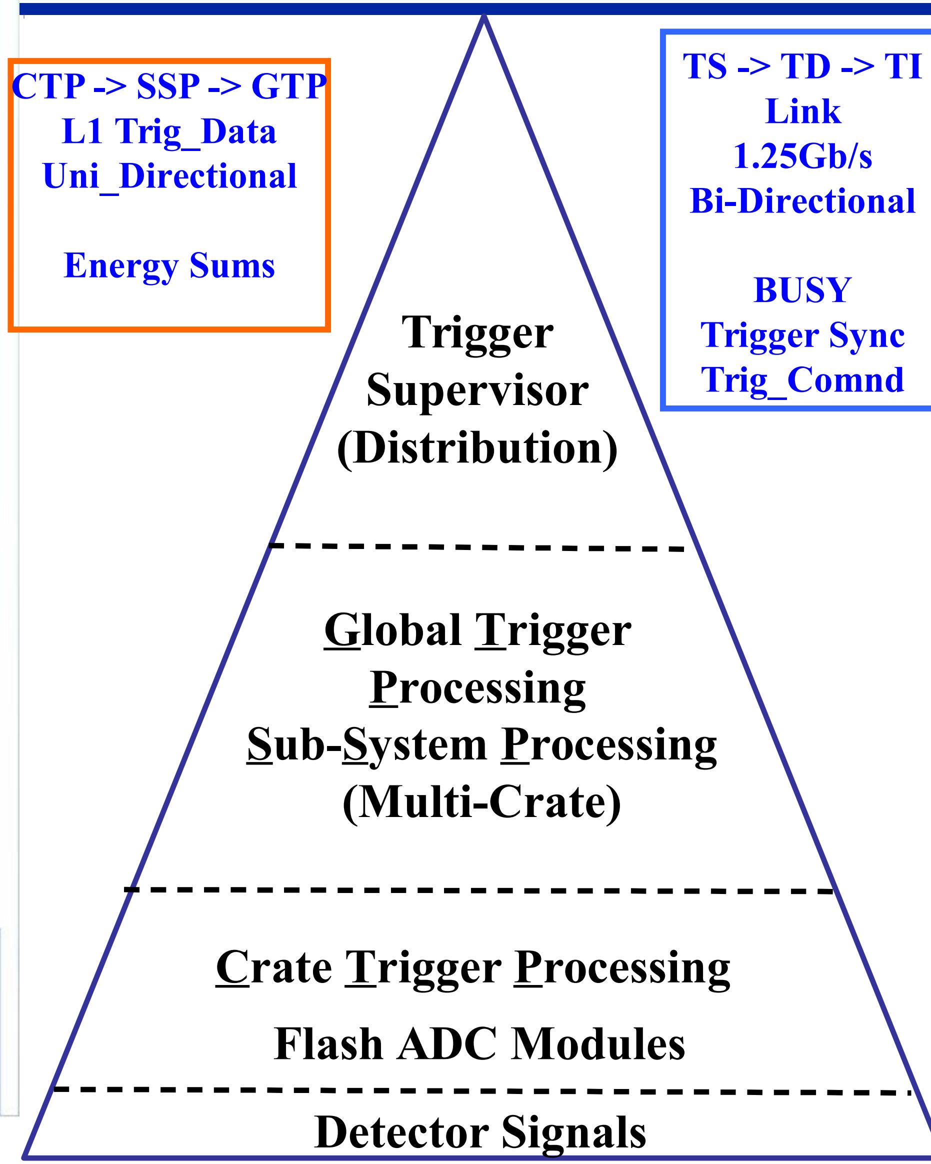


CTP -> SSP -> GTP
L1 Trig_Data
Uni_Directional

Energy Sums

TS -> TD -> TI
Link
1.25Gb/s
Bi-Directional

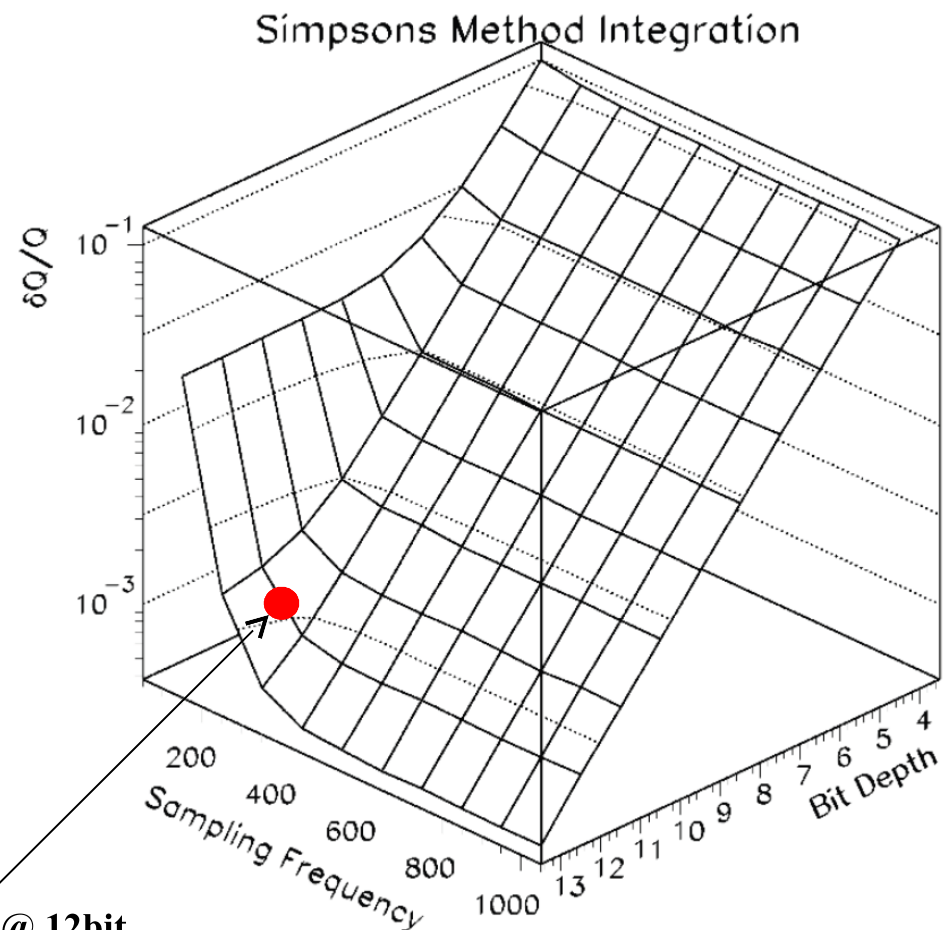
BUSY
Trigger Sync
Trig_Comnd



3.4 FADC Sampling – Charge Accuracy

Hall D FCAL PMT: FEU 84-3

- **10,000 Random height pulses 10-90% full scale of ADC range simulated**
- **Sampling frequency makes little difference beyond 250MHz at 12bit, providing ~0.1% charge resolution**
- **PMT pulse shape dominates sample frequency and bit depth of ADC**



250MHz @ 12bit

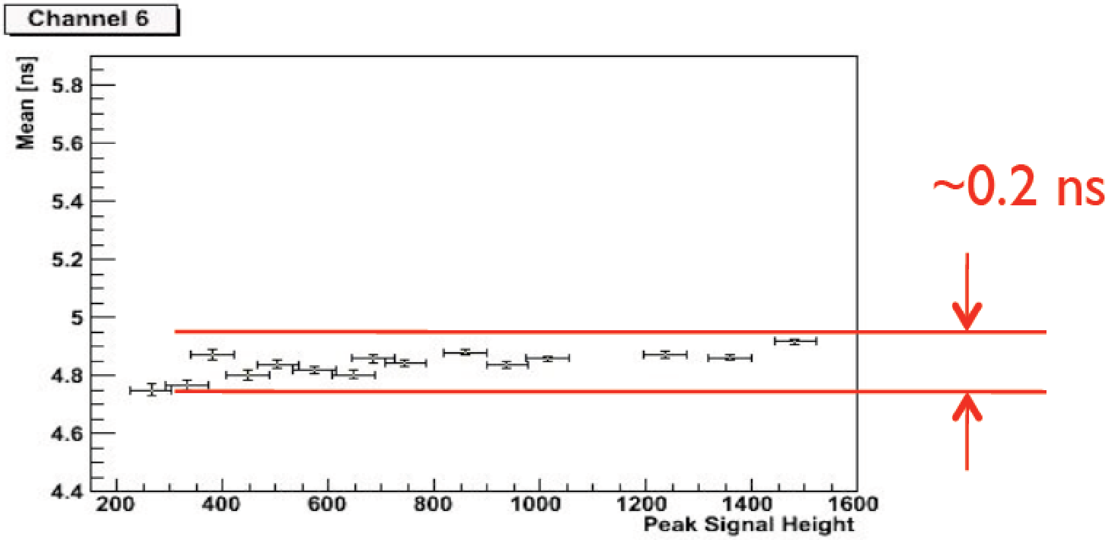
From: 27 Doc# 425-v1

FADC Sampling – Timing Accuracy

Hall D FCAL PMT: FEU 84-3

- **Timing algorithm developed & tested by Indiana University for the Hall D forward calorimeter.**
- **Implemented on the JLab FADC250 hardware achieving <300ps timing resolution on 50% pulse crossing time with varied signal heights.**

- Resolution allow reliable information to link calorimeter with tagged electron bunch.



Typical timing resolution achieved ~1/10 the sample rate. The PMT shape will drive the ADC sample rate & depth requirements.

From: GlueX Doc# 1258-v1