GlueX at High Intensity

June 25, 2018

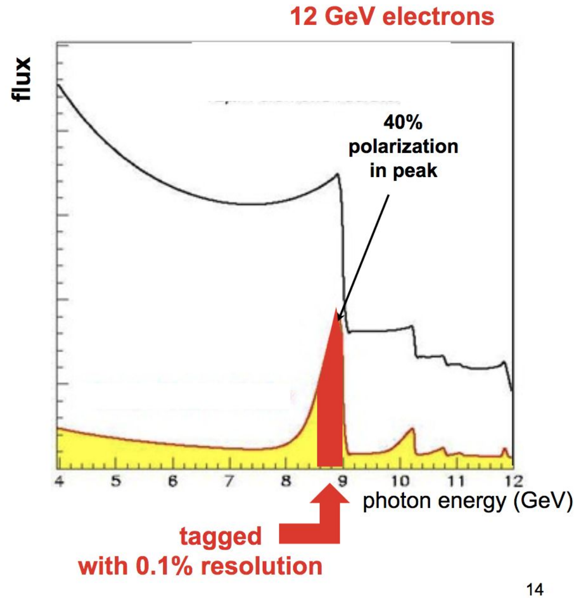
David Lawrence - JLab

Charge items addressed in this presentation

<u>From the Charge:</u>

7. Is trigger and DAQ configuration able to handle the event data rate expected for the high luminosity ($5x10^7$ photons/sec) running of the GLUEX detector in the Fall of 2019? Are the computing resources adequate?

8. Are the computing and manpower resources adequate for an expedient analysis towards timely publication?



$5x10^7$ γ/s = photons 8.5GeV-9GeV

Specifications for DAQ and Data Recording

	Proposal Avg.	Proposal Peak	Current Plan
Beam	5 x 10^7 γ/s	1 x 10^8 γ/s	5 x 10^7 γ/s
Trigger	100 kHz	200 kHz	90 kHz
Front End	1.5 GB/s	3 GB/s	1.2 GB/s
Disk	150* MB/s	300* MB/s	$^{\xi}$600 MB/s
Tape	2.5* PB (E12-12-002)		$^{\xi}$11.4 PB (E12-12-002)

DAQ needs to be capable of 1.5GB/s sustained (Front End)

raw data only (compressed) 34.8PB for everything (Tape)

** Assumes L3 trigger reduces data by factor of 10*

ξ Assumes factor 2 compression

GlueX + DIRC : E12-12-002 220 PAC Days

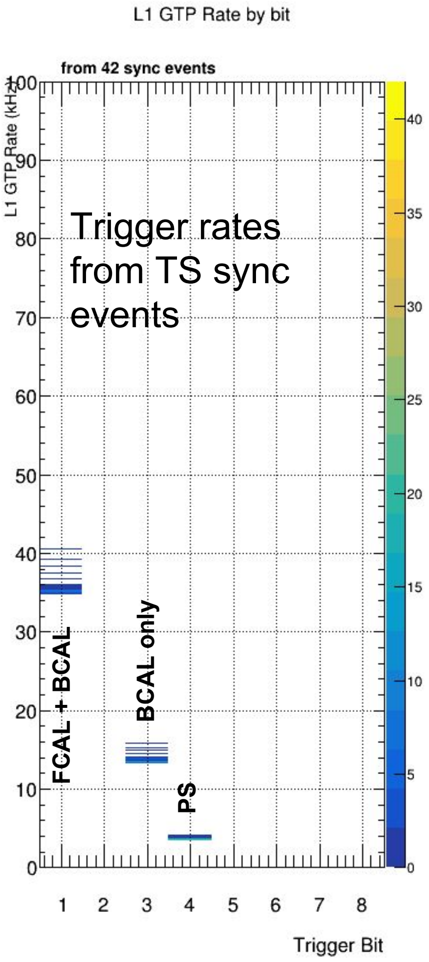
GlueX II : PR12-13-003 200 PAC Days

Triggers

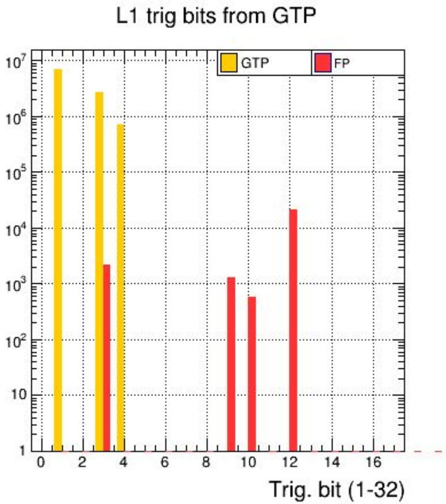
Primary Physics trigger based on calorimeter energies
- FCAL + BCAL
- BCAL only

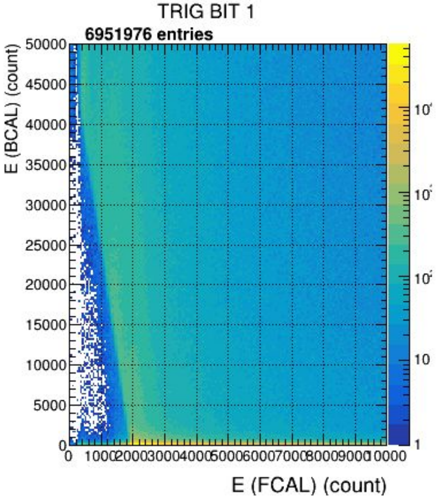
PS (pair Spectromer) trigger for normalization

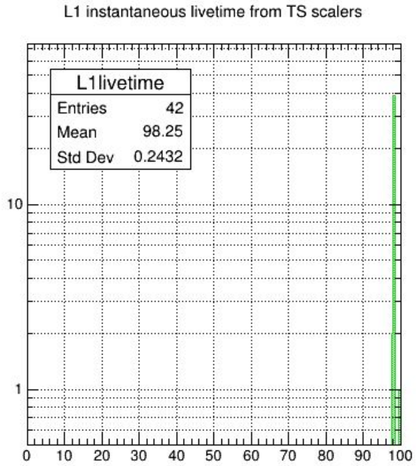
Random trigger
LED triggers



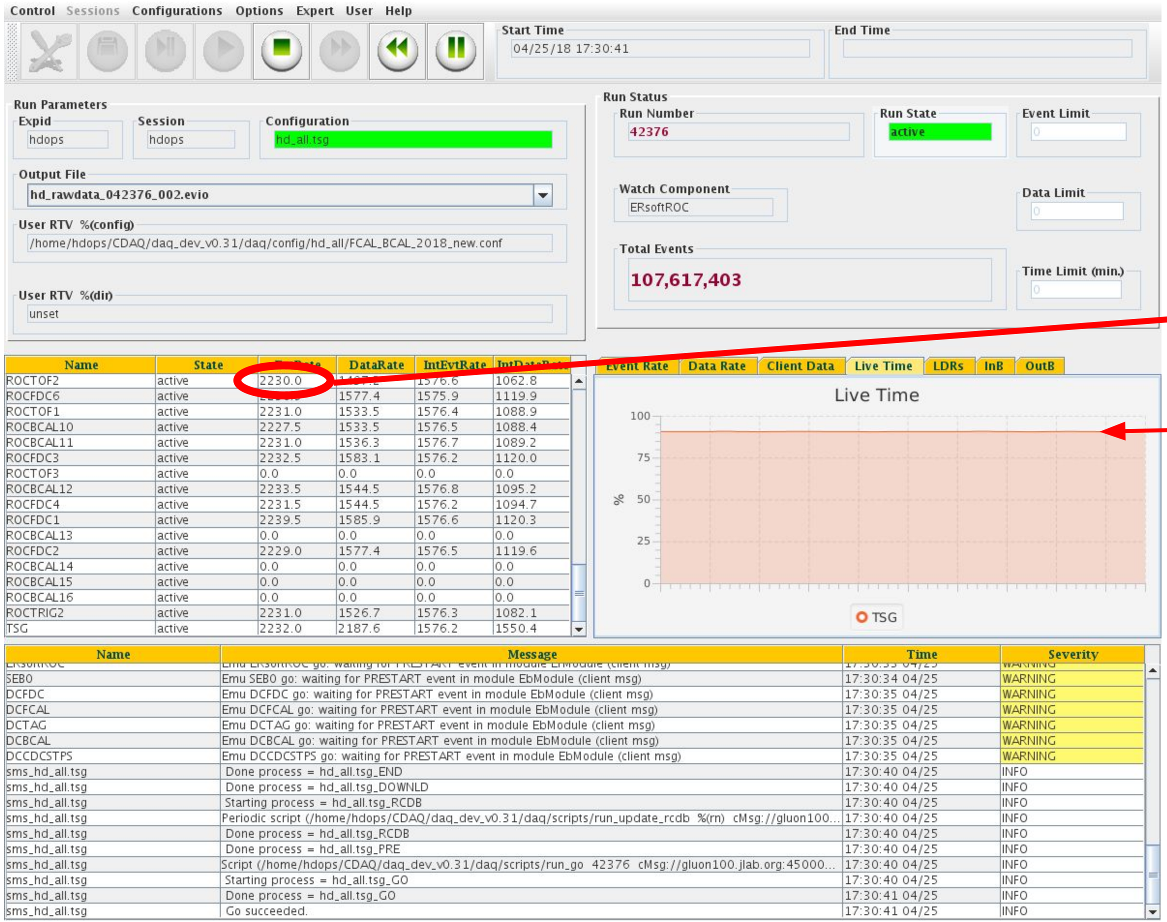
	trig 1	trig 3	trig 4
Triggers	6.95e+06 (82.0%) of all trigs	2.67e+06 (31.5%) of all trigs	7.1e+05 (8.4%) of all trigs
Hadronic triggers	4.71e+06 (67.8%) of trig 1's	2.41e+06 (90.0%) of trig 3's	4.01e+04 (5.6%) of trig 4's
Hadronic triggers in coh. peak	8.79e+05 (12.6%) of trig 1's	4.47e+05 (16.7%) of trig 3's	3.32e+03 (0.5%) of trig 4's







High Intensity Test Apr. 27, 2018



- 350nA
- 58µm JD701-100 diamond
- 5mm collimator
- > 5x10^7 γ/s
- **writing to network/disk disabled** (only read from VME)

evt rate: 2.23kHz x 40$_{\text{evt/block}}$ = 89.2kHz

livetime: ~90%

High Intensity Test Apr. 27, 2018

- 300nA
- 58µm JD701-100 diamond
- 5mm collimator
- ~ 5×10^7 γ/s
- **writing to disk enabled (single stream)**

Control Sessions Configurations Options Expert User Help

Start Time: 04/25/18 18:09:25

Run Parameters

Expid: hdops

Session: hdops

Configuration: hd_all.tsg

Output File: hd_rawdata_042377_024.evio

User RTV %(config): /home/hdops/CDAQ/daq_dev_v0.31/daq/config/hd_all/FCAL_BCAL_2018_new.conf

User RTV %(dir): unset

Run Status

Run Number: 42377

Watch Component: ERsoftROC

Total Events: 39,390,603

Time Limit (min.): 0

0.95GB/s

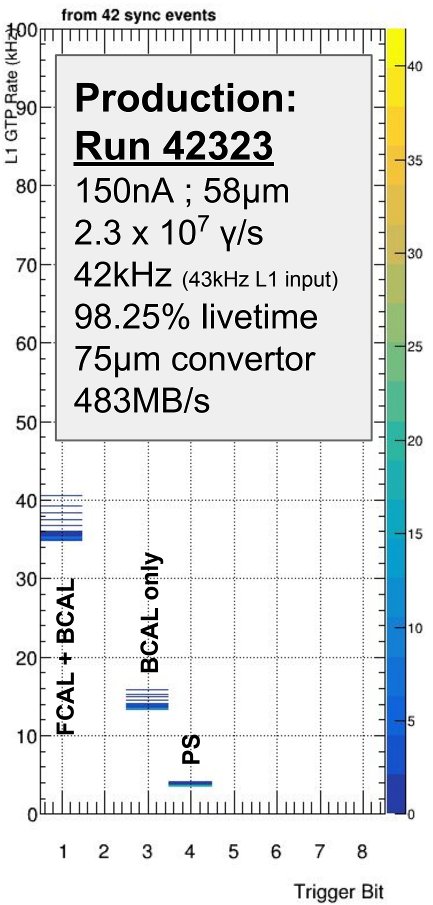
74kHz

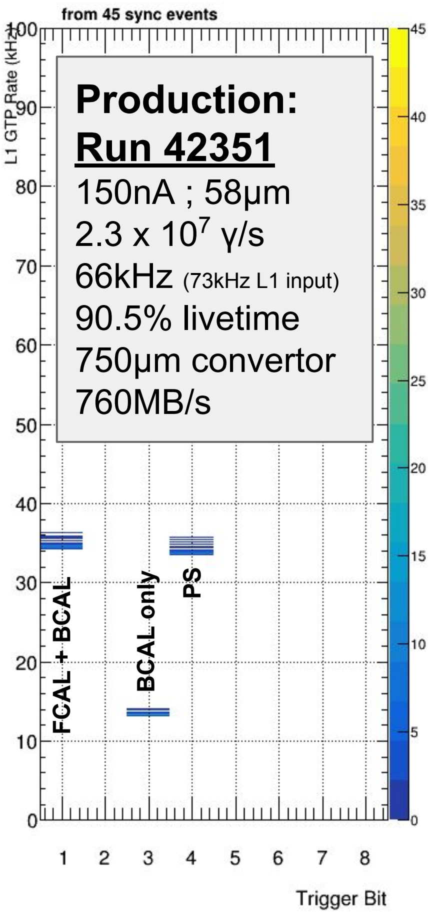
Name	State	EvtRate	DataRate	IntEvtRate	IntDataRate
ERsoftROC	active	74360.0	951619.1	66633.9	829953.6
SEB0	active	[illegible]	[illegible]	66766.1	841900.1
DCFDC	active	70000.0	337728.5	66887.6	316042.5
DCTAG	active	73960.0	[illegible]47419.0	66898.2	212160.0
DCBCAL	active	78680.0	1[illegible]1705.8	66954.1	128114.9
DCCDCSTPS	active	78040.0	175[illegible]93.5	66904.1	146294.1
DCFCAL	active	78240.0	3784[illegible].9	[illegible]	32238.4
ROCFCAL12	active	1954.0	2926.9	[illegible]	2513.8
ROCFCAL11	active	1951.0	5036.4	[illegible]	4271.6
ROCFCAL10	active	1954.0	2917.5	[illegible]	2501.9
ROCSTPSC2	active	0.0	0.0	[illegible]	0.0
ROCSTPSC1	active	1952.0	10446.0	1672.2	8765.2
ROCTAGMH	active	1955.5	56473.0	1673.0	46131.6

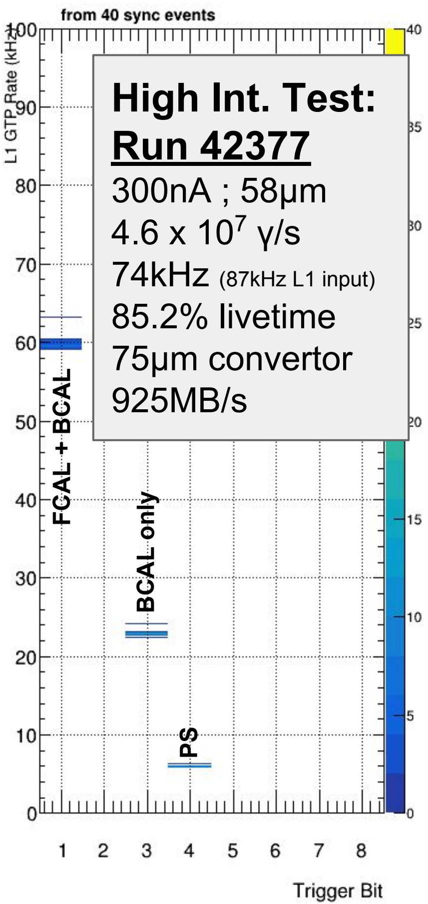
Event Rate | Data Rate | Client Data | Live Time | LDRs | InB | OutB

Name	Message	Time	Severity
sms_hd_all.tsg	waiting for... ERsoftROC,	18:09:08 04/25	WARN
sms_hd_all.tsg	waiting for... ERsoftROC,	18:09:13 04/25	WARN
SEB0	Emu SEB0 go: waiting for PRESTART event in module EbModule (client msg)	18:09:16 04/25	WARNING
DCCDCSTPS	Emu DCCDCSTPS go: waiting for PRESTART event in module EbModule (client msg)	18:09:18 04/25	WARNING
DCFCAL	Emu DCFCAL go: waiting for PRESTART event in module EbModule (client msg)	18:09:18 04/25	WARNING
DCBCAL	Emu DCBCAL go: waiting for PRESTART event in module EbModule (client msg)	18:09:18 04/25	WARNING
DCTAG	Emu DCTAG go: waiting for PRESTART event in module EbModule (client msg)	18:09:18 04/25	WARNING
DCFDC	Emu DCFDC go: waiting for PRESTART event in module EbModule (client msg)	18:09:18 04/25	WARNING
sms_hd_all.tsg	Done process = hd_all.tsg_END	18:09:25 04/25	INFO
sms_hd_all.tsg	Done process = hd_all.tsg_DOWNLD	18:09:25 04/25	INFO
sms_hd_all.tsg	Starting process = hd_all.tsg_RCDB	18:09:25 04/25	INFO
sms_hd_all.tsg	Periodic script (/home/hdops/CDAQ/daq_dev_v0.31/daq/scripts/run_update_rcdb %(rn) cMsg://gluon100.jlab.org:45000/c...	18:09:25 04/25	INFO

Production vs. High Intensity Spring 2018



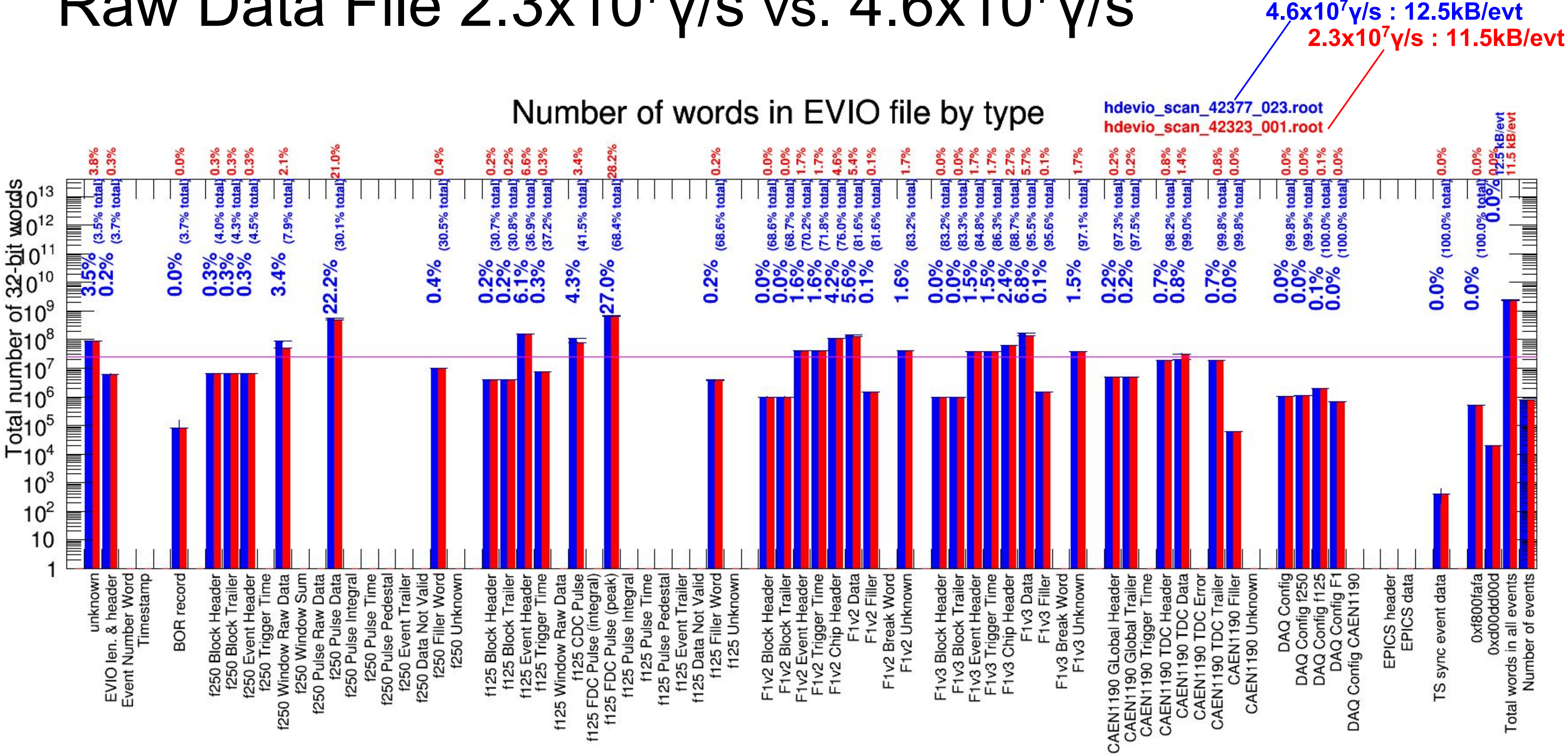




Two types of routine production running in 2018:

- 75µm and 750µm TPOL convertor (**T**riplet **POL**arimeter)
- Full detector read out in both cases, but one with higher trigger rate
- Livetime limited by disk write speed

Raw Data File $2.3 \times 10^7 \gamma/s$ vs. $4.6 \times 10^7 \gamma/s$



TOF at High Rate

- TOF rates close to limit
- Signal amplitudes drive current in PMTs
- Upstream plane most affected

from Beni Z. talk at GlueX collaboration meeting 6/22
https://halldweb.jlab.org/DocDB/0036/003680/001/zihlmann_collab_jun2018_TOF.pdf

Options

- Turn off central paddles
- Increase hole size of TOF
- Increase segmentation of central counters
- Continue investigation of preamps on bases

Useful Event Fraction

- Analysis trees produced for 160 “reactions”
- Fraction of events for which at least 1 reaction was a candidate counted for first 100M events of Spring 2017 run 31034
  - *150nA*
  - *58μm JD70-100*
  - *5mm coll.*
- At least 20% of events make it into a final stage analysis

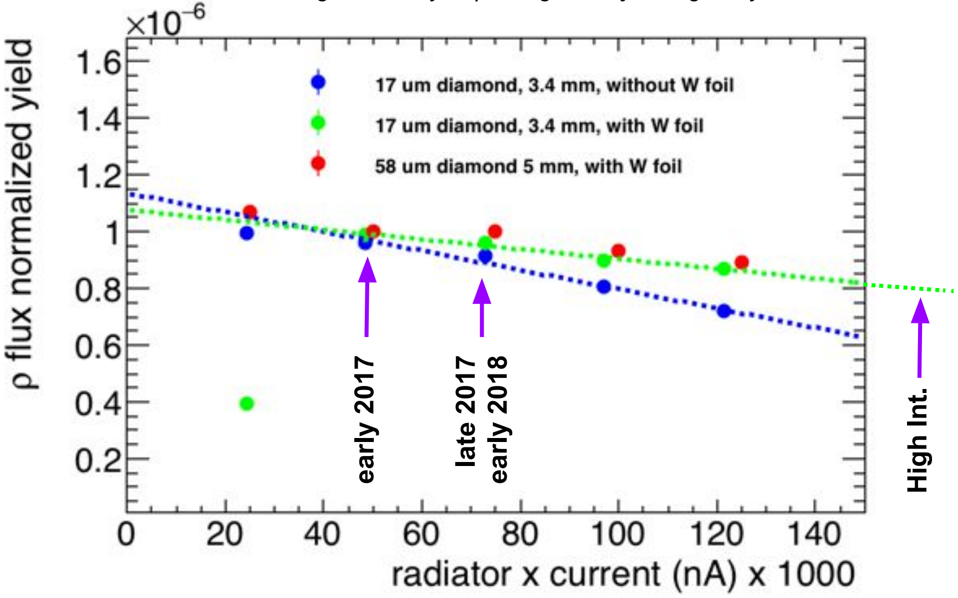
0.76% - jpsi__M83_Tree
0.77% - pi0pimpip_Tree ← $\gamma p \rightarrow p\pi^o\pi^-\pi^+$
0.79% - pi0pippim__B3_T4_M7_Tree
0.81% - pi0pippim__B4_M7_Tree
0.89% - gg__B4_Tree
0.96% - gg__B3_Tree
1.00% - jpsi__M83_B3_Tree
1.00% - gg__B5_T2_U1_Tree
1.16% - ggpippippimn_Tree
1.16% - ggpippim_Tree
1.27% - gpippim__B3_Tree ← $\gamma p \rightarrow p\gamma\pi^-\pi^+$
1.41% - ee_convert_Tree
1.44% - pimmissantin_Tree
1.47% - pimpipg_Tree
1.51% - pippim__B4_Tree
1.56% - pimpip_Tree
2.69% - pipn__F0_B3_Tree ← $\gamma p \rightarrow n\pi^+$
3.13% - kpkpinc_Tree
7.08% - gpippimmissprot_Tree

57.48% - SUM
18.16% - TOTAL (**--> 20.4% of physics triggers**)

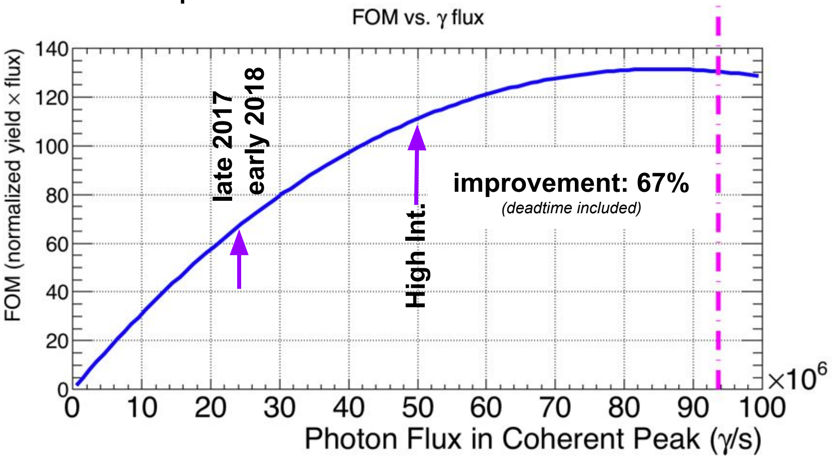
About 11% of triggers are non-physics (ps, random, LED, ...)

Optimization of Yield vs. Photon Flux

from J. Stevens logbook entry https://logbooks.jlab.org/entry/3571261



- Intensity scan from Spring 2018
- Backgrounds from higher intensity reduce normalized yield
- FOM indicates advantage in running up to ~5 x 10^7 γ/s



conversion: (4.8 x 10^{-4} r.l.)(150nA) = 2.3 x 10^7γ/s

Computing Resource Estimates 2017 + High Intensity

RunPeriod-2017-01

```
            RunPeriod-2017-01.xml
==============================================
          PAC Time: 2.9 weeks
      Running Time: 5.7 weeks
Running Efficiency: 48%
  ---------------------------------------
          Trigger Rate: 40.0 kHz
  Raw Data Num. Events: 56.4 billion (good production runs only)
  Raw Data compression: 1.00
   Raw Data Event Size: 12.7 kB
Front End Raw Data Rate: 0.52 GB/s
    Disk Raw Data Rate: 0.52 GB/s
       Raw Data Volume: 0.863 PB
  Bandwidth to offsite: 328 MB/s (all raw data in 1 month)
   REST/Raw size frac.: 14.60%
      REST Data Volume: 0.355 PB (for 2.82 passes)
 Total Real Data Volume: 1.2 PB
  ---------------------------------------
     Recon. time/event: 200 ms (5.0 Hz/core)
        Available CPUs: 4500 cores (full)
       Time to process: 8.3 weeks (all passes)
     Good run fraction: 0.85
  Number of recon passes: 2.0
Number of analysis passes: 2.82
     Reconstruction CPU: 6.3 Mhr
           Analysis CPU: 0.589 Mhr
        Calibration CPU: 3.0 Mhr
  Offline Monitoring CPU: 2.3 Mhr
          Misc User CPU: 9.0 Mhr
      Incoming Data CPU: 0.123 Mhr
    Total Real Data CPU: 21.3 Mhr
  ---------------------------------------
     MC generation Rate: 25.0 Hz/core
     MC Number of passes: 2.0
     MC events/raw event: 2.00
          MC data volume: 0.504 PB  (REST only)
       MC Generation CPU: 2.5 Mhr
   MC Reconstruction CPU: 12.5 Mhr
            Total MC CPU: 15.0 Mhr
  ---------------------------------------
                 TOTALS:
                    CPU: 36.3 Mhr
                   TAPE: 1.7 PB
```

High Intensity (projected)

```
              GlueX Computing Model
     HighIntensity_Projection_2018.06.04.xml
==============================================
          PAC Time: 14.0 weeks
      Running Time: 28.0 weeks
Running Efficiency: 50%
  ---------------------------------------
          Trigger Rate: 90.0 kHz
  Raw Data Num. Events: 647.7 billion (good production runs only)
  Raw Data compression: 2.00
   Raw Data Event Size: 13.0 kB (uncompressed)
Front End Raw Data Rate: 1.20 GB/s (uncompressed)
    Disk Raw Data Rate: 1.20 GB/s (compressed)
       Raw Data Volume: 5.072 PB (compressed)
  Bandwidth to offsite: 1929 MB/s (all raw data in 1 month)
   REST/Raw size frac.: 30.00%
      REST Data Volume: 4.291 PB (for 2.82 passes)
 Total Real Data Volume: 9.4 PB
  ---------------------------------------
     Recon. time/event: 182 ms (5.5 Hz/core)
        Available CPUs: 10000 cores (full)
       Time to process: 38.9 weeks (all passes)
     Good run fraction: 0.85
  Number of recon passes: 2.0
Number of analysis passes: 2.82
     Reconstruction CPU: 65.4 Mhr
           Analysis CPU: 6.765 Mhr
        Calibration CPU: 7.0 Mhr
  Offline Monitoring CPU: 13.0 Mhr
          Misc User CPU: 16.4 Mhr
      Incoming Data CPU: 0.629 Mhr
    Total Real Data CPU: 109.1 Mhr
  ---------------------------------------
     MC generation Rate: 25.0 Hz/core
     MC Number of passes: 2.0
     MC events/raw event: 2.00
          MC data volume: 6.087 PB  (REST only)
       MC Generation CPU: 28.8 Mhr
   MC Reconstruction CPU: 130.9 Mhr
            Total MC CPU: 159.6 Mhr
  ---------------------------------------
                 TOTALS:
                    CPU: 268.8 Mhr
                   TAPE: 15.4 PB
```

Computing Resource Estimates 2017 + High Intensity

RunPeriod-2017-01

```
          Trigger Rate: 40.0 kHz
  Raw Data Num. Events: 56.4 billion ---------------- actual: 50.1 billion
  Raw Data compression: 1.00
   Raw Data Event Size: 12.7 kB
Front End Raw Data Rate: 0.52 GB/s
    Disk Raw Data Rate: 0.52 GB/s
       Raw Data Volume: 0.863 PB --------------------- actual: 0.907 PB
  Bandwidth to offsite: 328 MB/s (all raw data in 1 month)
   REST/Raw size frac.: 14.60%
      REST Data Volume: 0.355 PB (for 2.82 passes)---- actual: 0.395 PB
 Total Real Data Volume: 1.2 PB
```

High Intensity (projected)

```
          Trigger Rate: 90.0 kHz
  Raw Data Num. Events: 647.7 billion (good production runs only)
  Raw Data compression: 2.00
   Raw Data Event Size: 13.0 kB (uncompressed)
Front End Raw Data Rate: 1.20 GB/s (uncompressed)
    Disk Raw Data Rate: 0.60 GB/s (compressed)
       Raw Data Volume: 5.072 PB (compressed)
  Bandwidth to offsite: 1929 MB/s (all raw data in 1 month)
   REST/Raw size frac.: 30.00%
      REST Data Volume: 4.291 PB (for 2.82 passes)
 Total Real Data Volume: 9.4 PB
```

← *DIRC adds ~2% to event size*

1 year (28 weeks)

Computing Resource Estimates 2017 + High Intensity

RunPeriod-2017-01

```
         Recon. time/event: 200 ms (5.0 Hz/core)
            Available CPUs: 4500 cores (full)
           Time to process: 8.3 weeks (all passes)
         Good run fraction: 0.85
    Number of recon passes: 2.0
 Number of analysis passes: 2.82
        Reconstruction CPU: 6.3 Mhr ---------- actual: 6.5 Mhr
              Analysis CPU: 0.589 Mhr -------- actual: 0.55 Mhr
           Calibration CPU: 3.0 Mhr
    Offline Monitoring CPU: 2.3 Mhr ---------- actual: 2.3 Mhr
             Misc User CPU: 9.0 Mhr
         Incoming Data CPU: 0.123 Mhr
       Total Real Data CPU: 21.3 Mhr --------- actual for 2017: 26.3 (includes some 2016)
```

High Intensity (projected)

```
         Recon. time/event: 182 ms (5.5 Hz/core)
            Available CPUs: 10000 cores (full)
           Time to process: 38.9 weeks (all passes)
         Good run fraction: 0.85
    Number of recon passes: 2.0
 Number of analysis passes: 2.82
        Reconstruction CPU: 65.4 Mhr
              Analysis CPU: 6.765 Mhr
           Calibration CPU: 7.0 Mhr
    Offline Monitoring CPU: 13.0 Mhr
             Misc User CPU: 16.4 Mhr
         Incoming Data CPU: 0.629 Mhr
       Total Real Data CPU: 109.1 Mhr
```

Computing Resource Estimates 2017 + High Intensity

RunPeriod-2017-01

```
MC generation Rate: 25.0 Hz/core
      MC Number of passes: 2.0
      MC events/raw event: 2.00
           MC data volume: 0.504 PB  (REST only)
        MC Generation CPU: 2.5 Mhr
    MC Reconstruction CPU: 12.5 Mhr
             Total MC CPU: 15.0 Mhr
```

High Intensity (projected)

```
       MC generation Rate: 25.0 Hz/core
      MC Number of passes: 2.0
      MC events/raw event: 2.00
           MC data volume: 6.087 PB  (REST only)
        MC Generation CPU: 28.8 Mhr
    MC Reconstruction CPU: 130.9 Mhr
             Total MC CPU: 159.6 Mhr
```

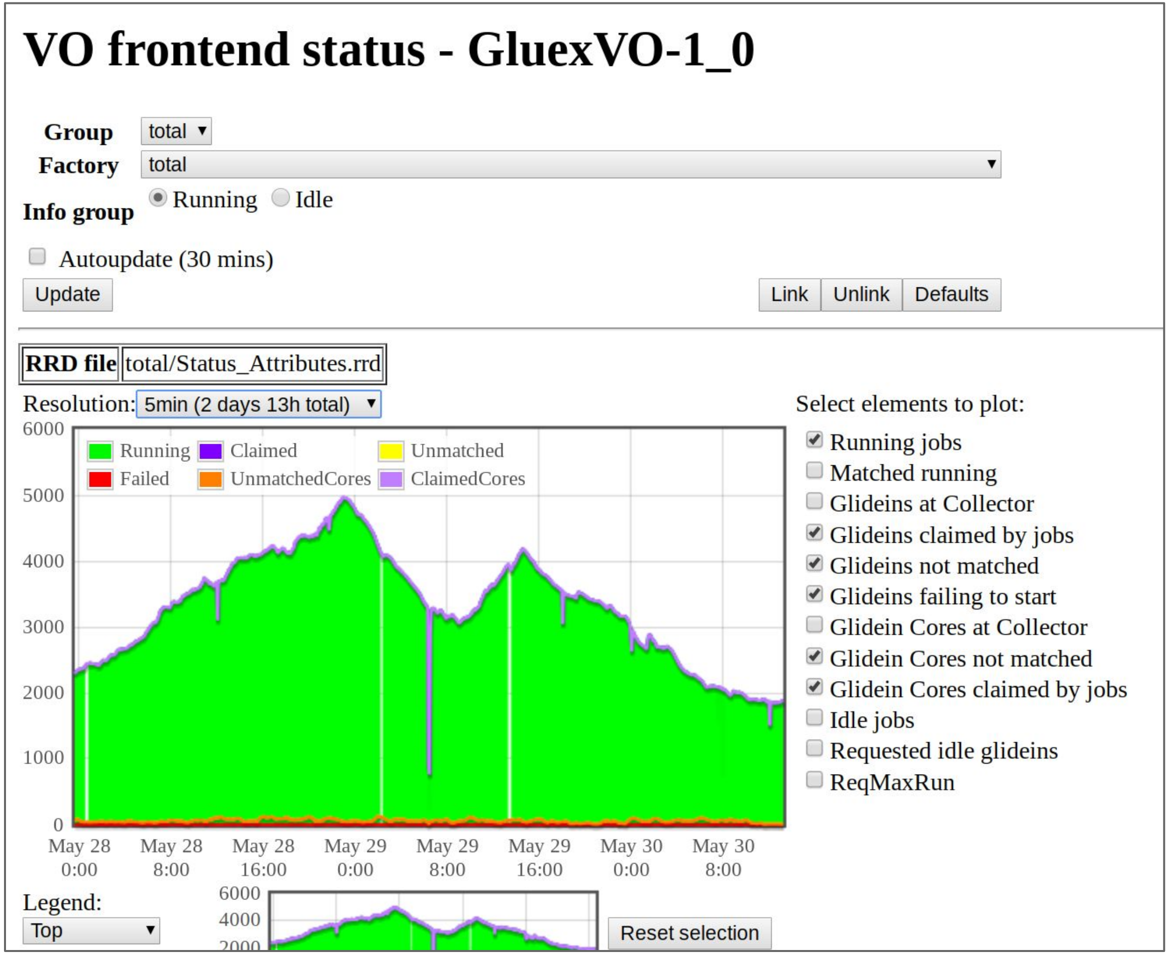
Resource Summary for High Intensity Running

	1 year	Total
Real Data Volume	9.4 PB	
MC Data Volume	6.1 PB	
Total Data Volume	**15.5 PB**	**34.8 PB**
Real Data CPU	109 Mhr	
MC CPU	160 Mhr	
Total CPU	**269 Mhr**	**603 Mhr**

Upper Limit (Real Data CPU, MC CPU)

1 year = 28 weeks of running
Totals for GlueX + DIRC :   E12-12-002 220 PAC Days only)

Simulation on OSG



- Nearly 1Mhr over 10 days runnings simulation jobs on OSG in late May 2018

screenshot by Richard Jones

GlueX Jobs on NERSC Cori (I & II)

Job ID	Run	Rate	Wall Hours	CPU Hours	Threads
9662111	30279.002	248Hz	1.325	42.41	64 (Haswell)
9654879	30279.002	104Hz	3.230	103.36	256 (KNL)
9654892	31034.002	229Hz	1.991	63.72	64 (Haswell)
9667013	31034.002	95Hz	4.862	155.58	256 (KNL)

Run 30279: 150nA , JD70-100 58um 0/90 PARA 1.2M events (single file) 2/4/2017
Run 31034: 150nA , JD70-100 58um 45/135 PERP 1.6M events (single file) 3/8/2017

KNL jobs run about 2.4 times slower = cost **2.4** times
as much from NERSC allocation

docker://jeffersonlab/hdrecon (2.83GB)
https://github.com/faustus123/hdcontainers

Offsite Computing Resource Utilization

NERSC - raw data

- Reconstruction of single 20GB raw data file in 2 hours by 32 core computer = 2.78MB/s
- With 10Gbps bandwidth offsite, we can process up to 720 files continuously (assuming factor of 2 compression)
- Each file processed on single 32 core computer means we can keep at most 23kcores busy
- We can utilize up to **16.6Mhr of offsite resources per month with a 10Gbps link**
- Need ~32.7Mhr for single recon pass of 1 years worth of data
- This year received 23Mhr allocation

Total anticipated per year: 70Mhr

OSG - simulated data

- UConn - 10M core hours
- FSU - 5M core hours (so far, more on the horizon)
- Northwestern - 2M core hours
- Regina - 2M core hours (so far, maybe more can be found)
- Indiana - 4M core hours
- Florida International - 2M core hours
- opportunistic cycles - 10M core hours (rough estimate, based on experience so far)

Total anticipated per year: 35-50Mhr

Summary of GlueX CPU for 1 year of running

<u>Need: **269** Mhr</u>
OSG: **50** Mhr
NERSC: **70** Mhr
JLab: **149** Mhr

if spread over 9 months of continuous computation, GlueX will need (149 Mhr) / (274 days) =

23k cores

Manpower

- CODA Group
- Fast Electronics Group
- IT Division
  - Networking, Sysadmin(Letta)
- Scientific Computing
  - NERSC - SWIF2 (Larrieu)
- GlueX Collaboration (including Hall-D staff) expected to contribute at similar level as what has been done in past

Publication Targets For High Intensity + DIRC

- Strange Hybrid program on which proposal based requires full 220 PAC days or 63 calendar weeks (=2.25 years @ 28 weeks/yr)
- Early publication targets after first run period (e.g. Fall 2019 run)
  - Excited hyperons : $\Xi^-(1820)$
  - Excited strangonium ($s\bar{s}$) : $\varphi(1680)$, $\varphi_3(1850)$
- Early publication timeline/milestones
  - Calibrations will be done continuously as data is collected with final calibrations for each chunk in place 2-3 months after data was collected
  - Reconstruction will require ~2 months for each year's data (*see slide 18*)
  - Timeline in months (M) from end of run:
    3M calib. + 2M recon. + 2M study + 2M recon + 4M analysis + 1M paper = **14M**
    - (*2017 experience is closer to **18M***)

Development of Analysis Software: See Cris Fanelli's User's meeting talk
https://www.jlab.org/conferences/ugm/talks/tuesday/fanelli.pdf

May 2017 High Intensity Review Results

Recommendations from Committee:

- ✔ Acquiring a second RAID array should be the highest priority (or a high priority) for DAQ related spending
- ✔ Continue to pay attention to networking to insure that it is not a limiting factor in the trigger and data rates
- * Do a full rate end to end test without beam and repeat the test with beam
- ** Continue to explore compression (and other techniques) to achieve additional headroom

Significant testing of components has been done but a full high rate test with beam and all components has not been completed

DAQ group has been investigating compression of data stream prior to writing to disk.

May 2017 High Intensity Review Results

- The current trigger rate estimate of 90 kHz and the physics efficiency seem to be based on qualitative arguments rather than on trigger tests and simulations. An effort should be made to quantify and document statements about various triggers and efficiencies through simulations or other means.
- The collaboration should establish a schedule with milestones, consistent with the experimental needs, for improvements to the data acquisition system. This schedule should include:

  - o **Deadline for making decision on TDC 1290 replacement.**
  - o **Deadline for acquisition of second RAID array.**
  - o **Schedule for component and system rate testing.**
  - o **Network upgrade schedule (particularly for tagger)**

Installation of additional fibers has been estimated by IT to cost ~$8k. This would allow several crates to have direct connections to counting house

May 2017 High Intensity Review Results

- The collaboration should develop prioritized wish list of things that could be purchased to improve things each year of the 5 year run if extra money shows up.
- In order to make data analysis more efficient, it may be desirable to do a relatively prompt filtering or reconstruction of data after it is written to tape. This would also have the benefit that a smaller volume of data would need to be kept online in the tape robot. Streamlining and stabilizing the calibration process would be required to gain these efficiencies and likely have other positive long term benefits.

**Calibration pass produces skim files for use in calibration process*

May 2017 High Intensity Review Results

Comment:

The collaboration is to be commended for recognizing that that an L3 trigger is no longer required for high intensity running, thus freeing up manpower and resources.

Summary

- Individual Trigger and DAQ components have been tested and shown capable to handle High Intensity Running
    - DAQ tested at 90kHz *(without writing to disk)*
    - 2018 Production running at 750MB/s (uncompressed) comparable to requirement of 600MB/s (compressed)
        - Compression has not yet been tested in Hall-D

- Counting house computing sufficiently provisioned
    - 504TB of RAID = ~10 days
    - Online monitoring: >400cores = ~2% of raw data full recon.

- Computing resource requirements tallied based on 2017 data experience and communicated to Scientific Computing/IT
    - 15.4PB/yr
    - 269 Mhr/yr (>~ 120 Mhr/yr offsite)

Remaining Issues

- Demonstrate 1.5GB/s sustained DAQ rate for full system to disk
- Demonstrate compression of data stream prior to writing to disk
- High rate TOF counters mitigated
- Reevaluate MC requirements to better estimate Computing requirements
- Perform Data Challenge for offsite reconstruction at NERSC

Backups

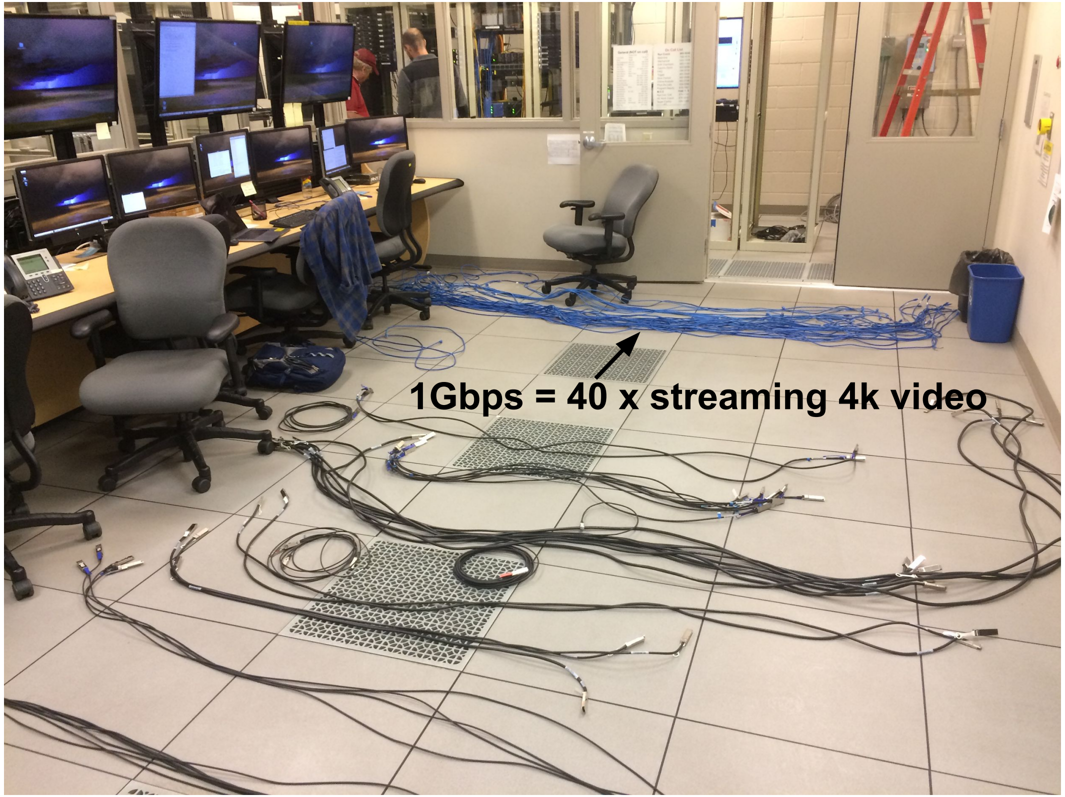
Spreadsheet tally of Scientific Farm usage 2017:

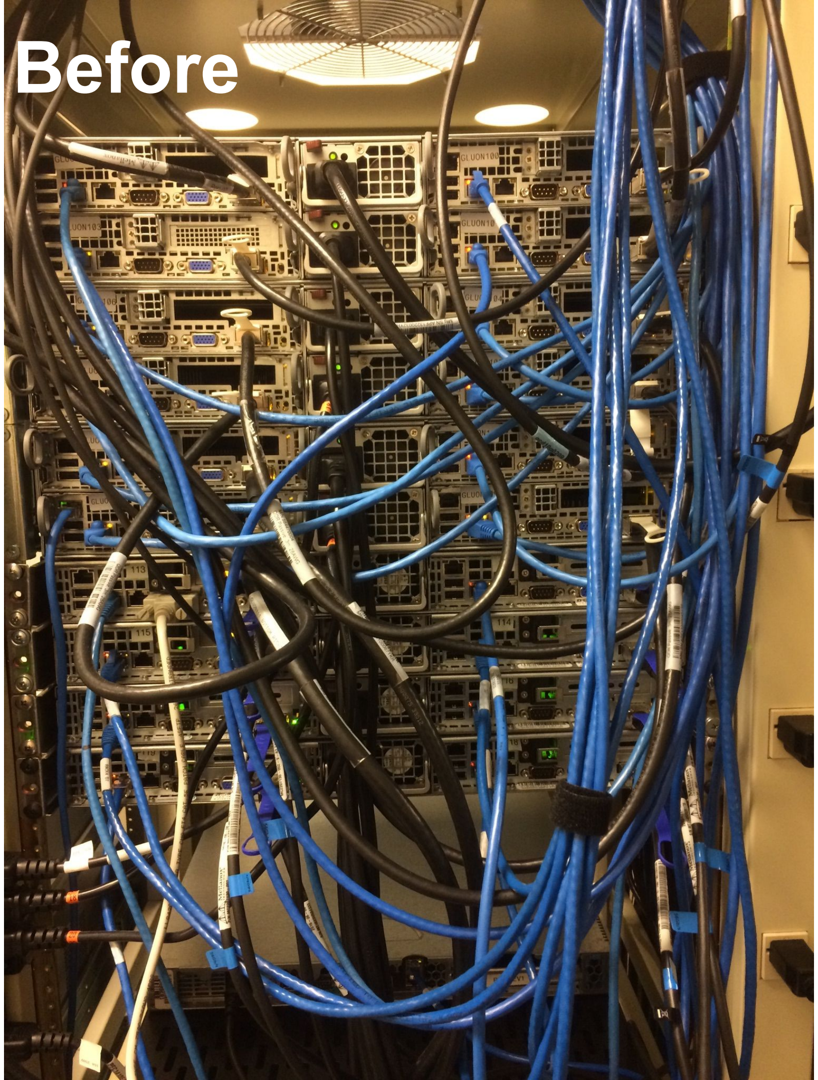
https://docs.google.com/spreadsheets/d/100TWVIGuA_yJou4V1To2vSCiGvv-a21FSbBQzytusJg/edit?usp=sharing

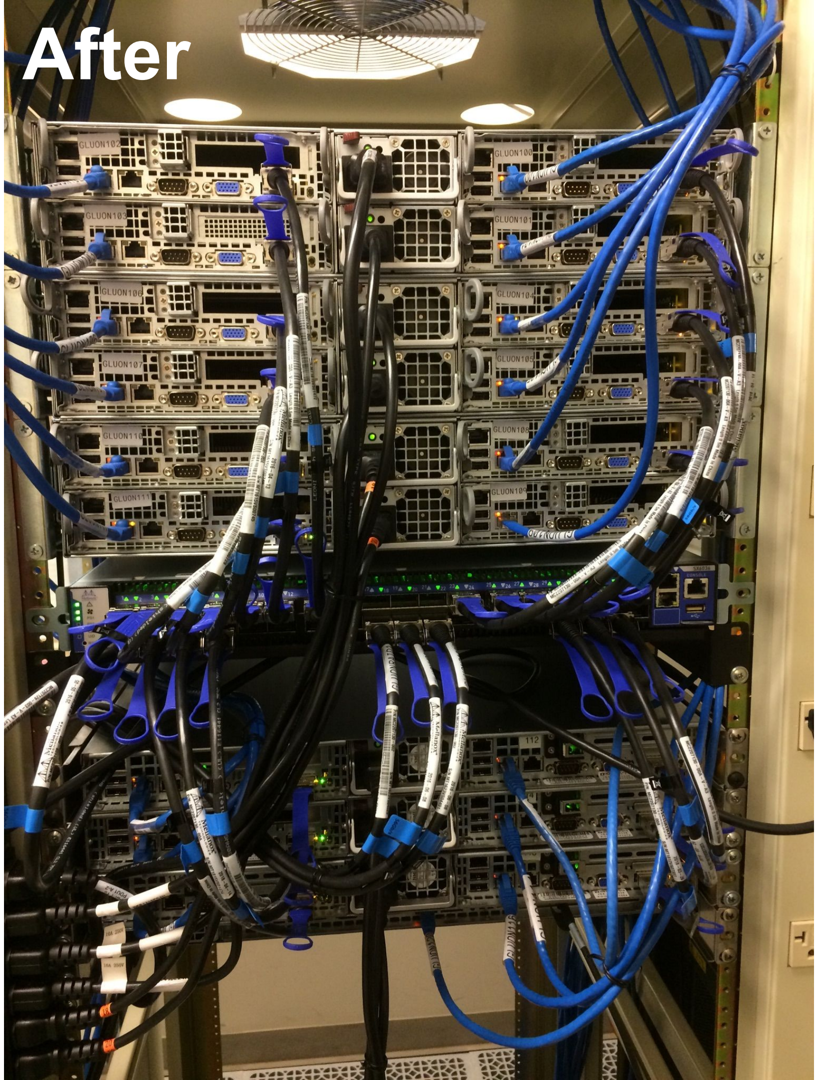
GlueX Computing Resource Model:

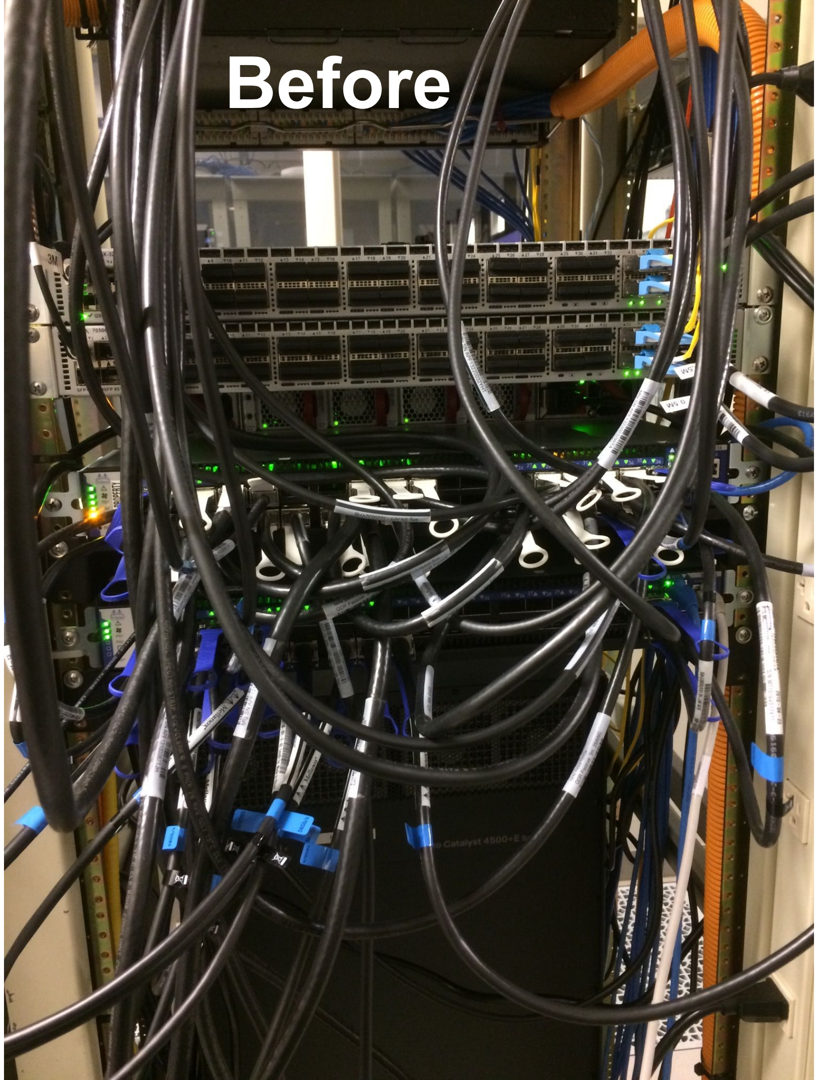
https://github.com/JeffersonLab/hd_utilities/tree/master/comp_mod

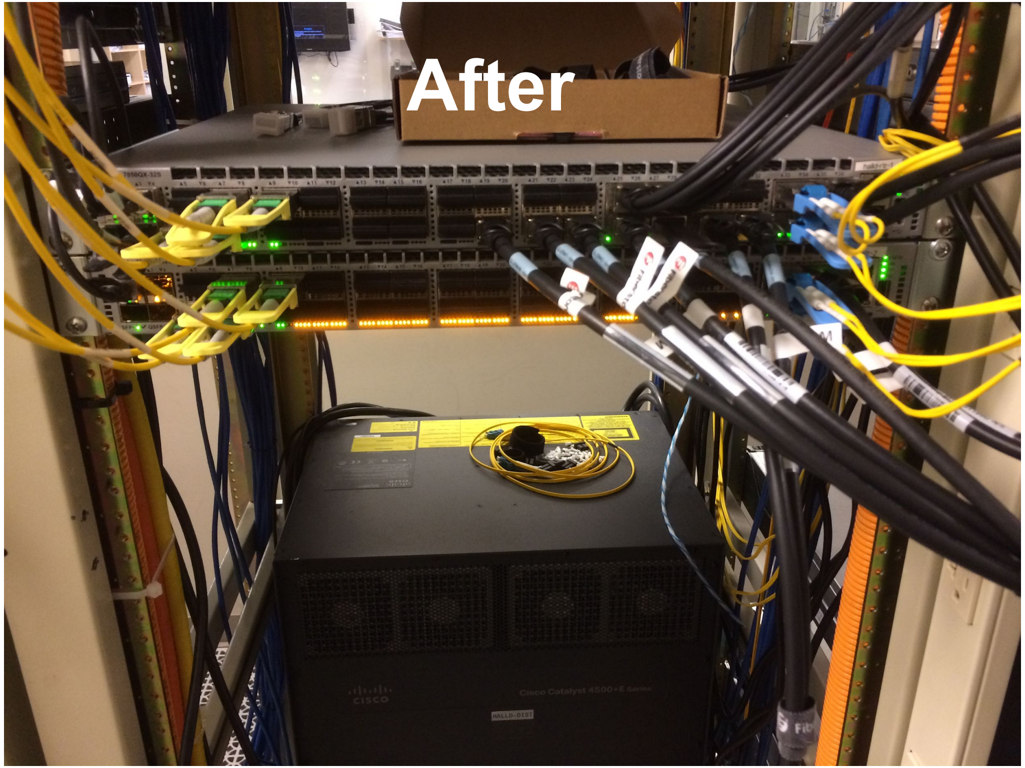
Hall-D Control Room Networking/Gluon Cleanup and DAQ Hardening




Before

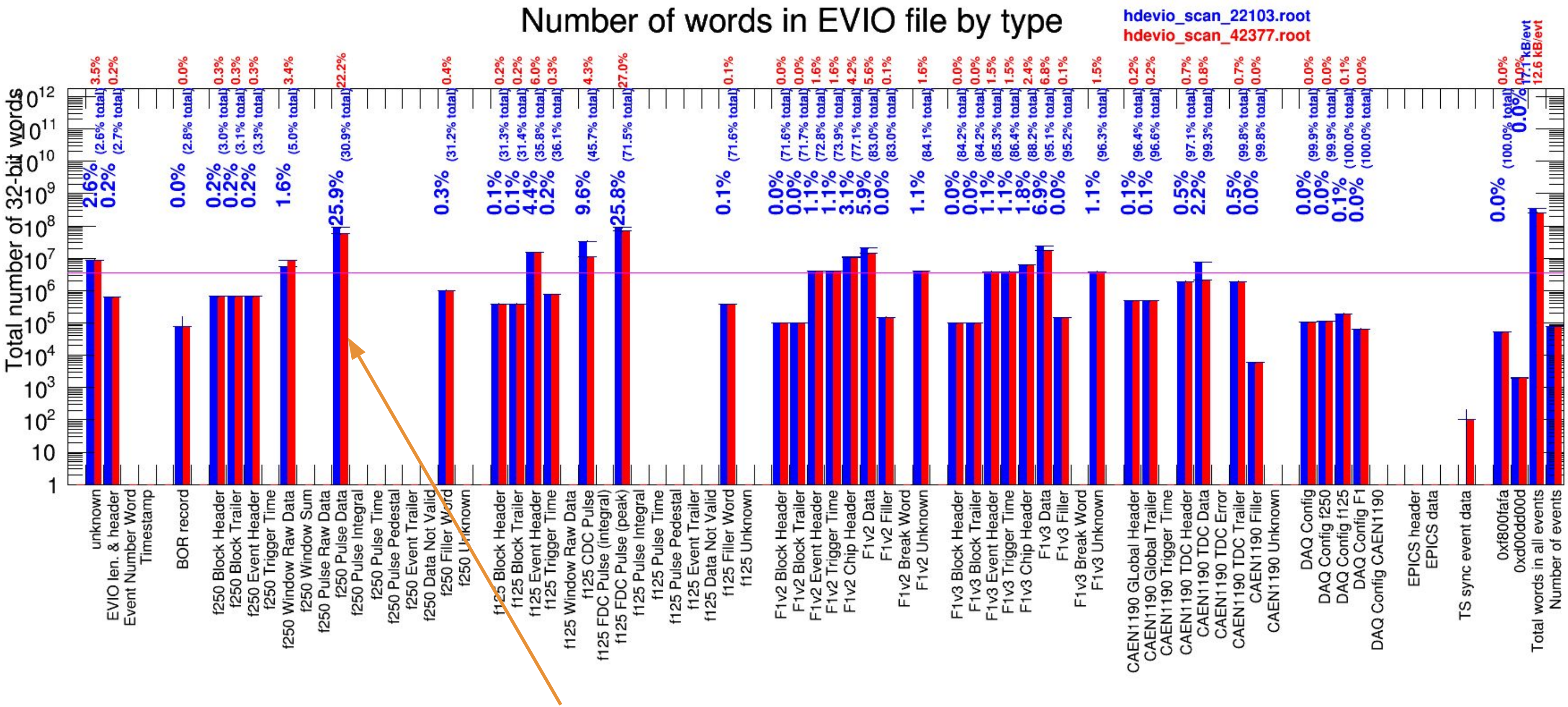

After


Before


After


Labels!
GLUON44-dac
GLUON43-dac
GLUON42-dac
GLUON41-dac
GLUON40-dac
Fiberstore


Labels!
GLUON43-IB
GLUON46-IB
GLUON47-IB
GLUON48-IB
GLUON49-IB
GLUONRAID3-IB
GLUONRAID4-IB
Mellanox



Number of words in EVIO file by type
hdevio_scan_22103.root
hdevio_scan_42377.root
Total number of 32-bit words
unknown
EVIO len. & header
Event Number Word
Timestamp
BOR record
f250 Block Header
f250 Block Trailer
f250 Event Header
f250 Trigger Time
f250 Window Raw Data
f250 Window Sum
f250 Pulse Raw Data
f250 Pulse Data
f250 Pulse Integral
f250 Pulse Time
f250 Pulse Pedestal
f250 Event Trailer
f250 Data Not Valid
f250 Filler Word
f250 Unknown
f125 Block Header
f125 Block Trailer
f125 Event Header
f125 Trigger Time
f125 Window Raw Data
f125 CDC Pulse
f125 FDC Pulse (integral)
f125 FDC Pulse (peak)
f125 Pulse Integral
f125 Pulse Time
f125 Pulse Pedestal
f125 Event Trailer
f125 Data Not Valid
f125 Filler Word
f125 Unknown
F1v2 Block Header
F1v2 Block Trailer
F1v2 Event Header
F1v2 Trigger Time
F1v2 Chip Header
F1v2 Data
F1v2 Filler
F1v2 Break Word
F1v2 Unknown
F1v3 Block Header
F1v3 Block Trailer
F1v3 Event Header
F1v3 Trigger Time
F1v3 Chip Header
F1v3 Data
F1v3 Filler
F1v3 Break Word
F1v3 Unknown
CAEN1190 GLobal Header
CAEN1190 Global Trailer
CAEN1190 Trigger Time
CAEN1190 TDC Header
CAEN1190 TDC Data
CAEN1190 TDC Error
CAEN1190 TDC Trailer
CAEN1190 Filler
CAEN1190 Unknown
DAQ Config
DAQ Config f250
DAQ Config f125
DAQ Config F1
DAQ Config CAEN1190
EPICS header
EPICS data
TS sync event data
0xf800fafa
0xd00dd00d
Total words in all events
Number of events
17.1 kB/evt
12.6 kB/evt