High Intensity Running in Hall-D

Outline

- Response to previous review recommendations
- Requirements for approved experiments
- Hardware Limitations
- Plan for High Intensity Running

Response to recommendations from June 2016 review

- fADC125 Performance issues at high rates needs to be addressed
  - ***Firmware upgrades have been implemented and tested to work at 100kHz with 95% livetime***
- Understand L1 trigger and optimize
  - ***Numerous L1 trigger studies completed. Report available on GlueX DocDB as doc 3239***
- 10GB/s link from crate must be tested with full DAQ rate to ensure adequate CPU
  - ***Card installed and tested with CODA to operate above 1GB/s link rate with no issues. Full rate tested with iperf and no issues observed***
- ***Impact of higher data volumes for offline analysis. Discuss with IT.***
  - ***<see spreadsheet>***
- L3 specific
  - Are timing algorithms understood for high intensity events with greater multiplicity
  - Are algorithms that reduce event size being considered (in addition to just filtering events)
  - Prediction of rates per farm node and reduction factor by extrapolating Spring 2016 data. (How many nodes for 9GB/s?)
  - Are alternatives to original design being considered given parameters have changed (estimated data rate and potential reduction factor)
    - Should L3 farm be housed in Computer Center?
  - ***Changes to parameters have made L3 rejection no longer a requirement***

Report on the 12 GeV Software and Computing Review

Nov. 2016

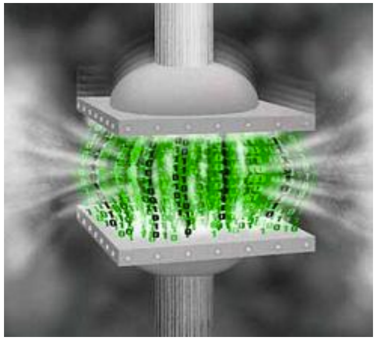
Recommendations

The extrapolations from early engineering runs show that the overall and per-crate data rates are higher than the available bandwidths, which are typically 1Gb/s uplinks from the crates. A test is planned if an upgrade to 10Gb/s links would actually increase the throughput or merely expose the next-in-line bottleneck. To address the problem more generally, a Level-3 trigger will be run to trim the data rate down below the limits.

We recommend to explore the possibility of trading CPU power used for data *reduction* for data *compression*. Data files on disk were found to be gzip-compressible by about a factor of 2, so substantial gains could be realized by compressing the data stream at an early stage with an efficient algorithm. In this way, more data could get through the bottlenecks, which will increase the statistics for physics processes for which no fast trigger algorithm can be developed, and in general relax the demands for the L3 reduction factors.

While it was noted that this will not reduce the tape usage because the tape drives already perform what amounts to a late-stage compression, the compression at an early stage will

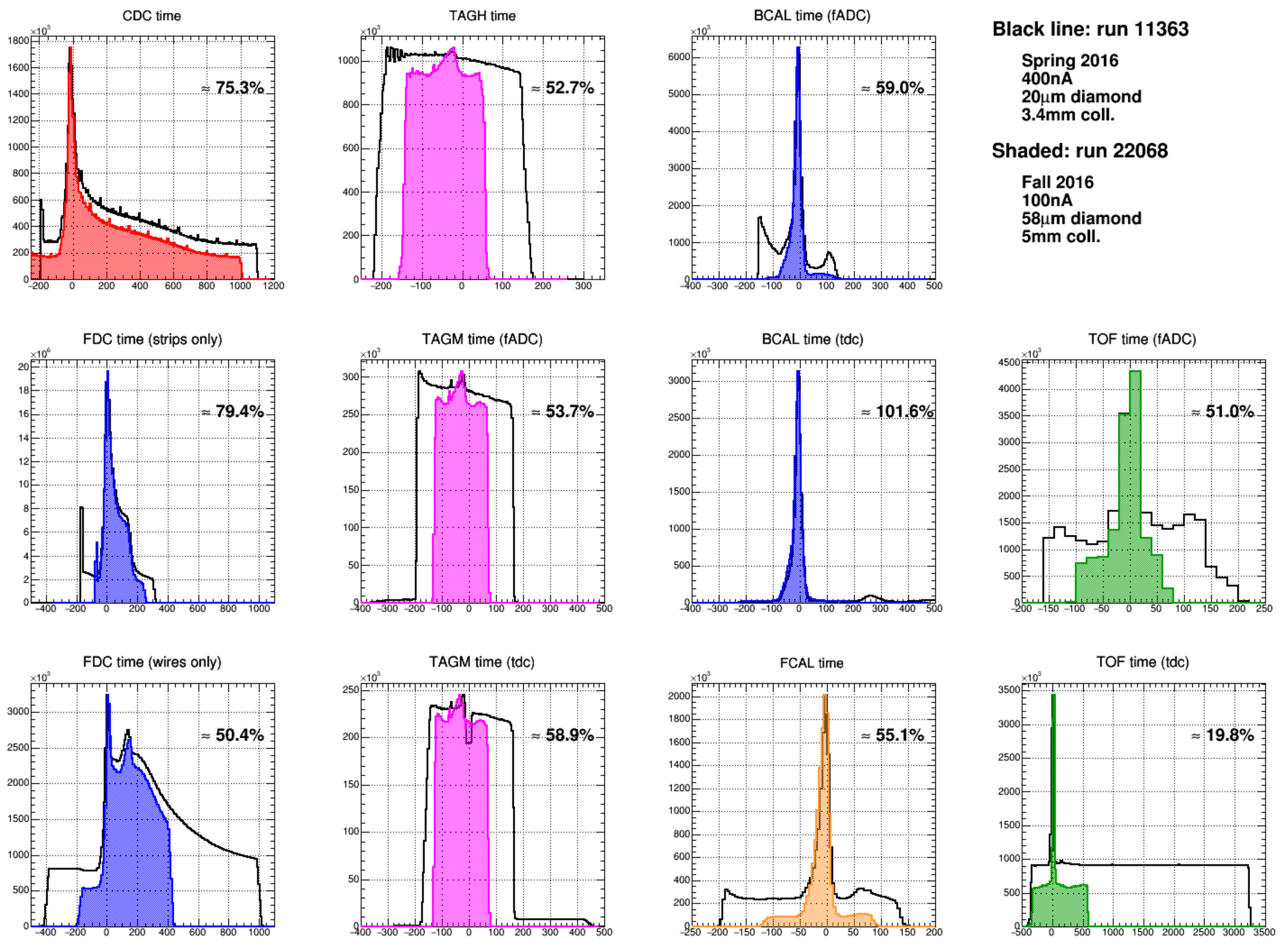
reduce the overall throughput upstream. Other experiments have found that the reduced data sizes per event speed up the later analysis, because I/O is usually a major component of the overall analysis time. Savings here usually overcompensate the penalty for having to decompress the data.



Compression of Data Stream

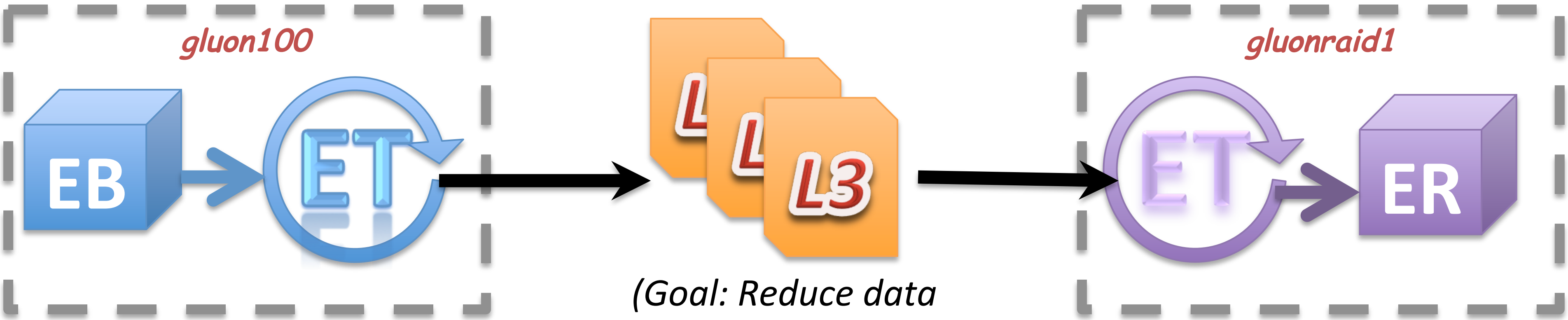
- Suggestion at Software Review to compress data stream to conserve bandwidth from ROC
- EVIO files can be compressed by factor of ~2
- BUT: to compress at ROC level one must compress smaller buffers which is less efficient
- Tested by using LZ4 compression on individual ROC buffers in file from run 11667.
- Overall file size reduced by 20%

	parameter	fy17	fy18	fy19	units	comments
4	event rate	50000	50000	95000	events/s	raw data rate out of the counting room when beam is on
5	annual running	14.6	10.4	10.4	weeks	amount of running in a year, fy17: 35+67 days, fy18: 42+10+21 days (see Eugen
6	running efficiency	0.5	0.5	0.5		fraction of wall time when beam is on, either due to beam unavailable or detecto
7	effective event rate (per second)	6981.52	4996.578	9493.498	events/s	Event rate averaged over time
8	effective event rate (per year)	2.20E+11	1.58E+11	2.99E+11	events/year	Event rate averaged over time
9	CPU time per event	0.102041	0.178571	0.178571	CPU-s/event	Oct. 2016 David benchmark 2016-Broadwell real cores for FY17 and FY18. Ben
10	single Pass 1 CPU needed	712.3999	892.246	1695.267	CPU's	number of threads to keep up with the raw event rate
11	raw event size	16100	16800	16800	bytes	size of a single raw event. Actual Spring 2016 data is 16.4kB+4.6kB/10^7 g/s. Es
12	raw instantaneous storage rate	805	840	1596	MB/s	data rate when beam is on
13	raw effective storage rate	3.5E+15	2.6E+15	5.0E+15	bytes/year	average data volume rate
14	raw effective storage rate	3544.724	2647.211	5029.701	TB/year	average data volume rate
15	pass 0 event fraction	0.05	0.05	0.05		fraction of events from raw data stream to perform calibrations
16	pass 1 repetition factor	2	2	2		number of times event reconstruction will be repeated
17	pass 0 repetition factor	2	2	2		number of times calibration will be repeated
18	pass 0 CPU need	71.23999	89.2246	169.5267	CPU's	number of threads of calibration to keep up
19	pass 1 CPU need	1424.8	1784.492	3390.535	CPU's	number of threads of reconstruction to keep up
20	stream/pass-1 CPU ratio	0.1	0.1	0.1		ratio of CPU time required for a skim stream to that needed for reconstruction
21	stream output to input size ratio	0.1	0.1	0.1		ratio of data volume output for a stream to that of input
22	stream multiplicity factor	5	5	5		number of streams to be produced
23	single stream CPU need	71.23999	89.2246	169.5267	CPU's	number of threads for one stream to keep up
24	stream repetition factor	2	2	2		number of times streaming will be repeated
25	stream CPU need	712.3999	892.246	1695.267	CPU's	number of threads for streaming to keep up
26	single stream output data rate	2.248049	1.67885	3.189815	MB/s	
27	total stream output data rate	0.70943	0.529805	1.006629	PB/year	


CDC time
≈ 75.3%
TAGH time
≈ 52.7%
BCAL time (fADC)
≈ 59.0%
Black line: run 11363
Spring 2016
400nA
20μm diamond
3.4mm coll.
Shaded: run 22068
Fall 2016
100nA
58μm diamond
5mm coll.
FDC time (strips only)
≈ 79.4%
TAGM time (fADC)
≈ 53.7%
BCAL time (tdc)
≈ 101.6%
TOF time (fADC)
≈ 51.0%
FDC time (wires only)
≈ 50.4%
TAGM time (tdc)
≈ 58.9%
FCAL time
≈ 55.1%
TOF time (tdc)
≈ 19.8%

From PR12-13-003 (GlueX strangeness proposal)

… we propose a gradual increase in the photon flux towards the GlueX design of 10^8 γ/s in the peak of the coherent bremsstrahlung spectrum (8.4 GeV < Eγ < 9.0 GeV). Yield estimates, assuming an average flux of 5×10^7 γ/s, are presented.

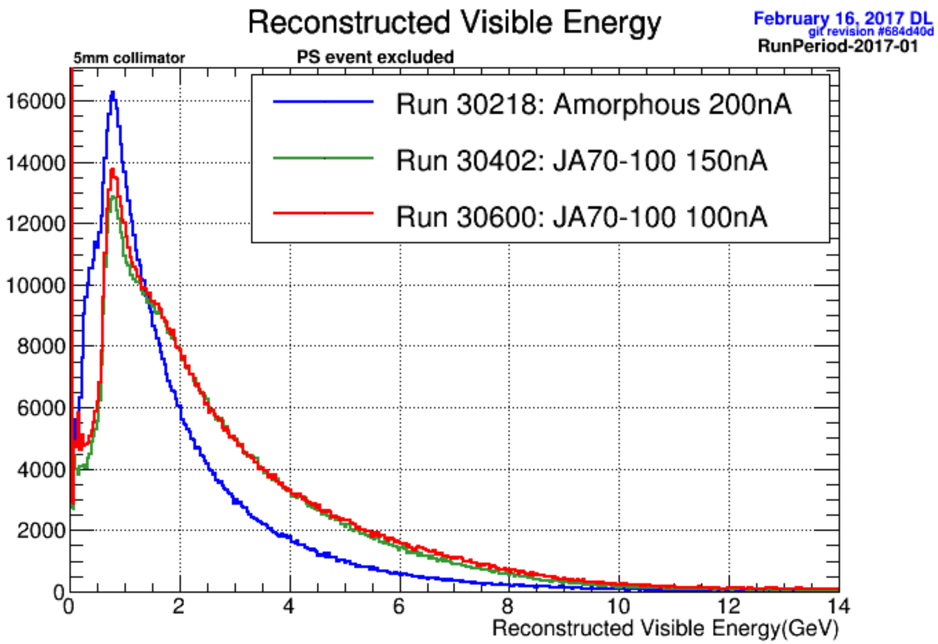


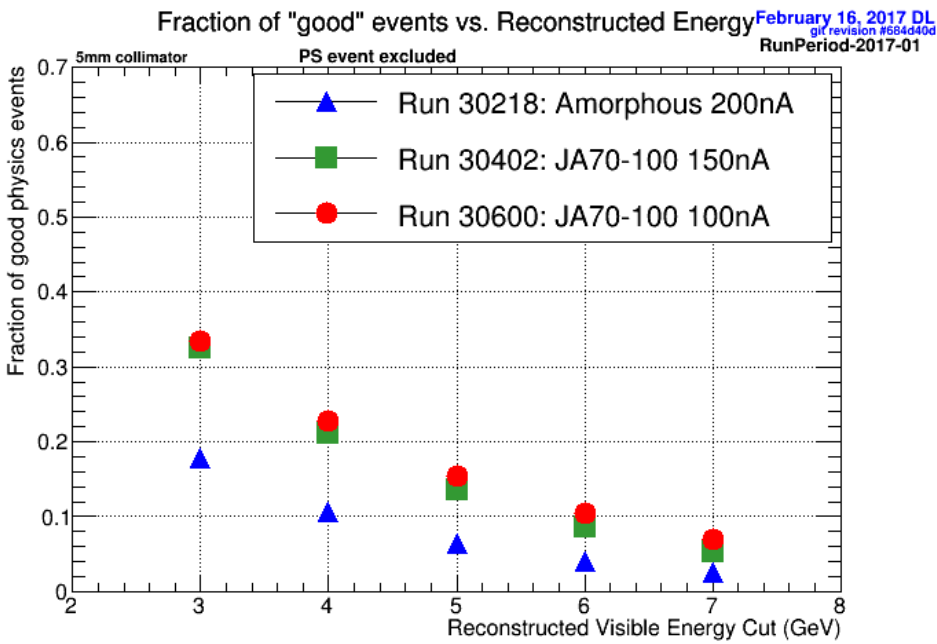
(Goal: Reduce data volume by factor of 10)

- L3 = Level-3 trigger
  - Sometimes called *High Level Trigger*
- What it is:
  - Computer farm used to make *keep/discard* decision for each event as it is acquired before writing to disk

Reconstructable Events

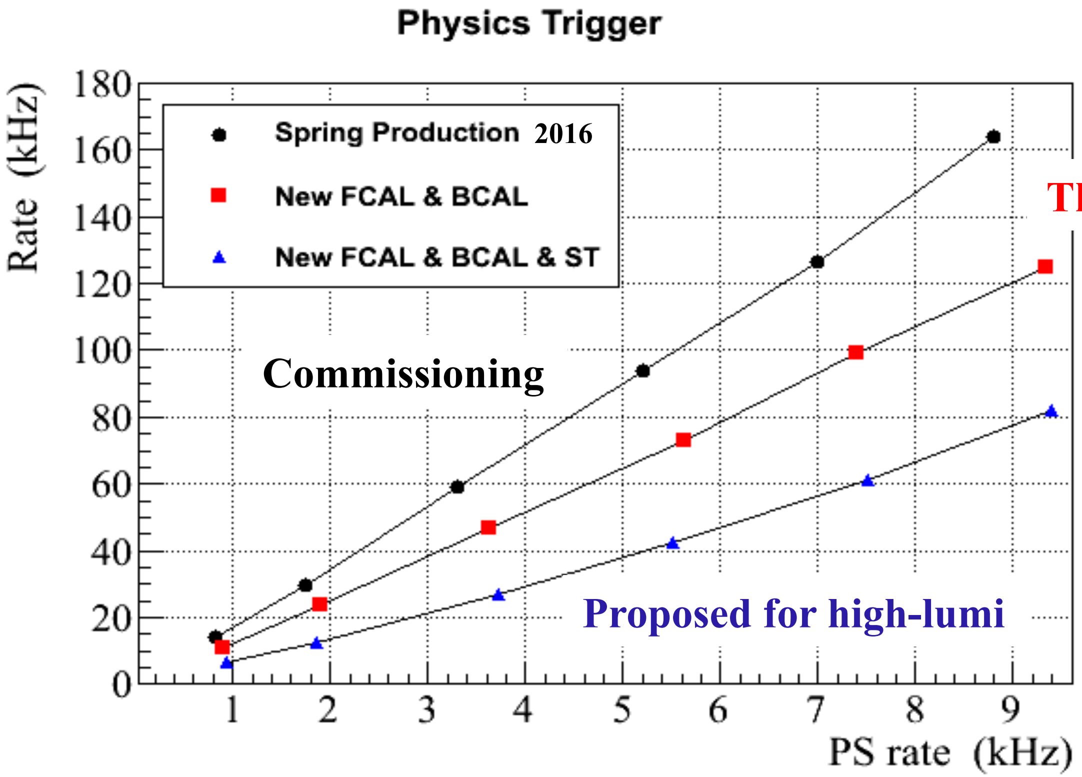
Using fully reconstructed events, add up all visible energy from all DChargedTrack (best tracking FOM) and DNeutralShower objects





events with >1 PS hit are excluded

Trigger Rates



50 nA 100 nA 200 nA 300 nA 400 nA 500 nA

This run, Spring 2017

$$\frac{R^{Spring}}{R_{FCAL\ \&\ BCAL}} \sim 1.3$$

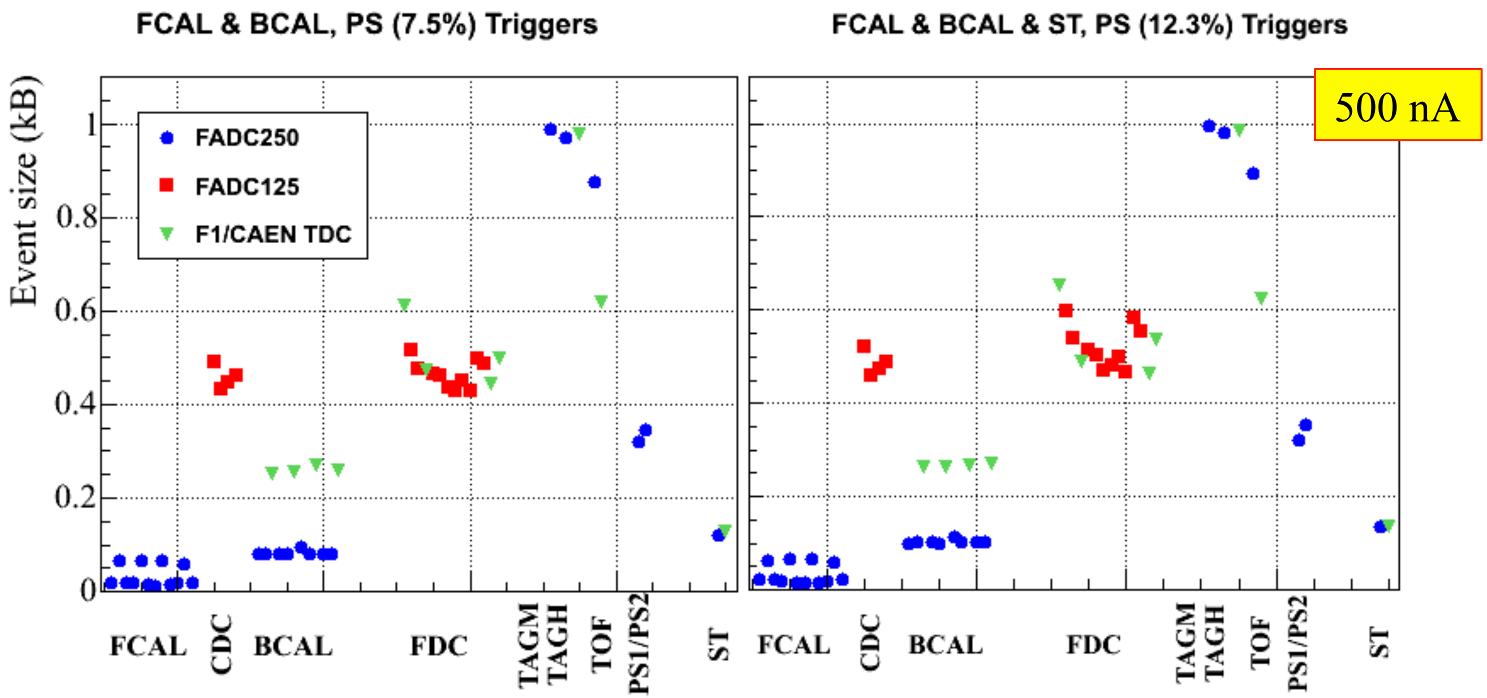
$$\frac{R_{FCAL\ \&\ BCAL}}{R_{FCAL\ \&\ BCAL\ \&\ ST}} \sim 1.6$$

- FCAL & BCAL is a simple trigger, but not optimal for high luminosity
- FCAL & BCAL & ST seems to be a good trigger candidate for production at high lumi
  (it was originally proposed)

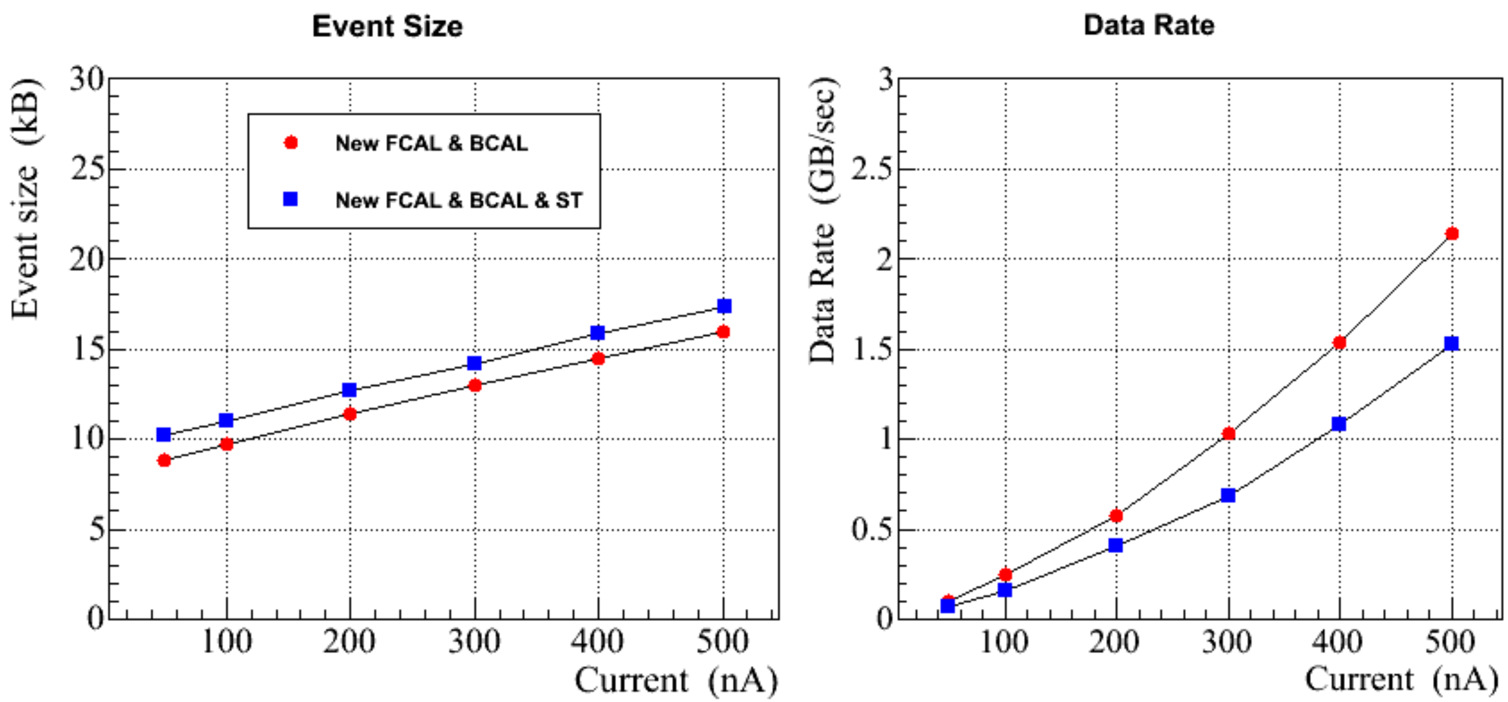
  - we need to study impact of coincidental hits in the ST (is estimated to be less than 10 % now) and adjust trigger parameters

Event Size

- Measure data size (block size = 40) read out from electronics modules in the crate
- Compute average size of the event



Event Size and Data Rate

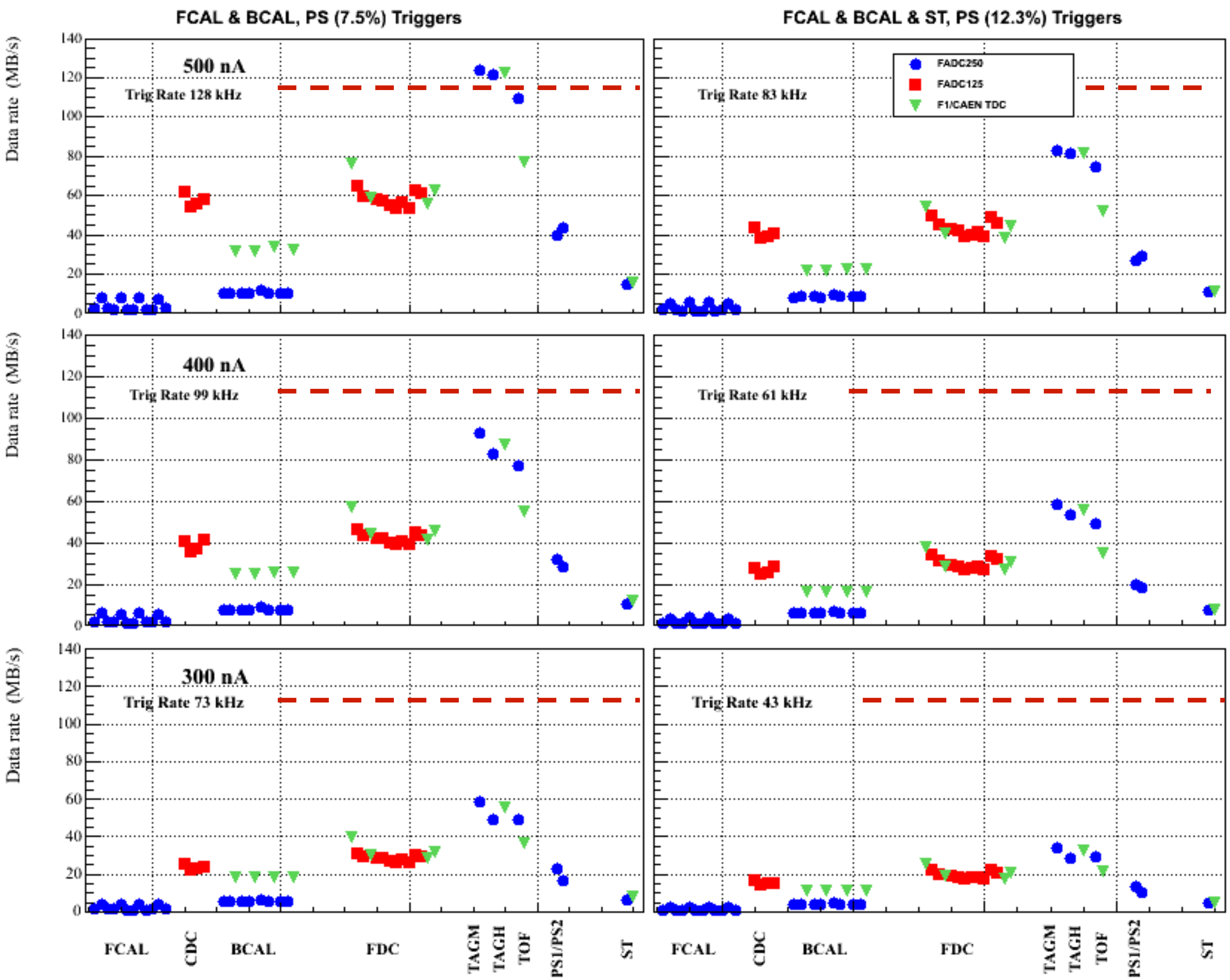


- Average event size (no coincidental hits):

FCAL & BCAL (+ 7.5 % PS):	8 kB
FCAL & BCAL & ST (+ 12 % PS):	9.2 kB

- Slightly larger event size for the FCAL & BCAL & ST trigger
(the data rate is smaller for this trigger type as the L1 rate is smaller)

Data Rate in Crates



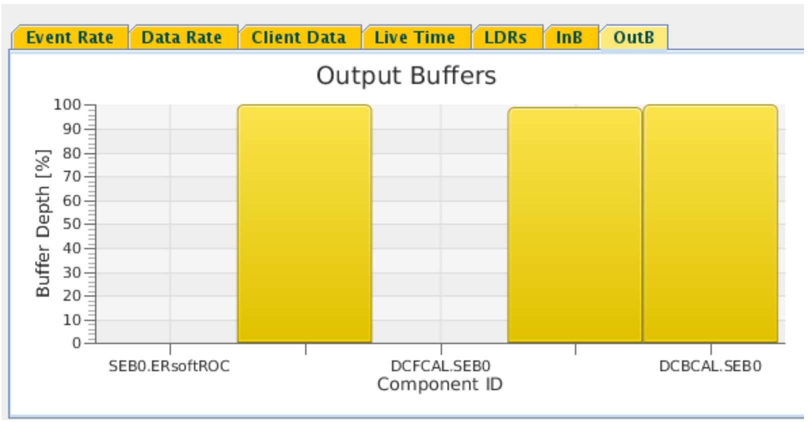
115 Mb/sec
(1 GB/sec link)

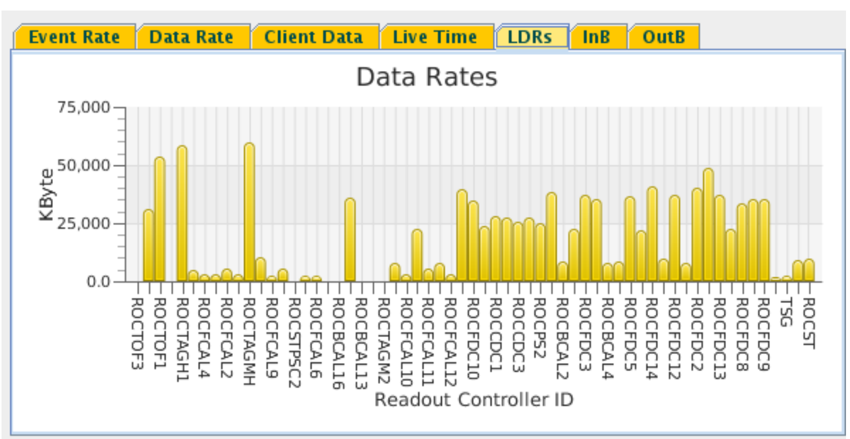
115 Mb/sec

- Reduce sizes of read out windows for TAGH/TAGM/TOF
- Consider to install 10 Gbps links on these crates

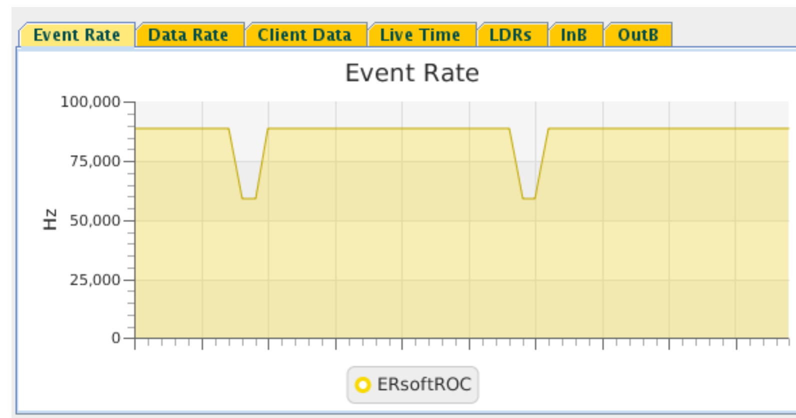
Run at 90 kHz Trigger Rate

- Increase thresholds on TOF discriminators
- Unstable DAQ (L.T. 80 – 90 %)
- Data rate about 1.1 Gb/sec





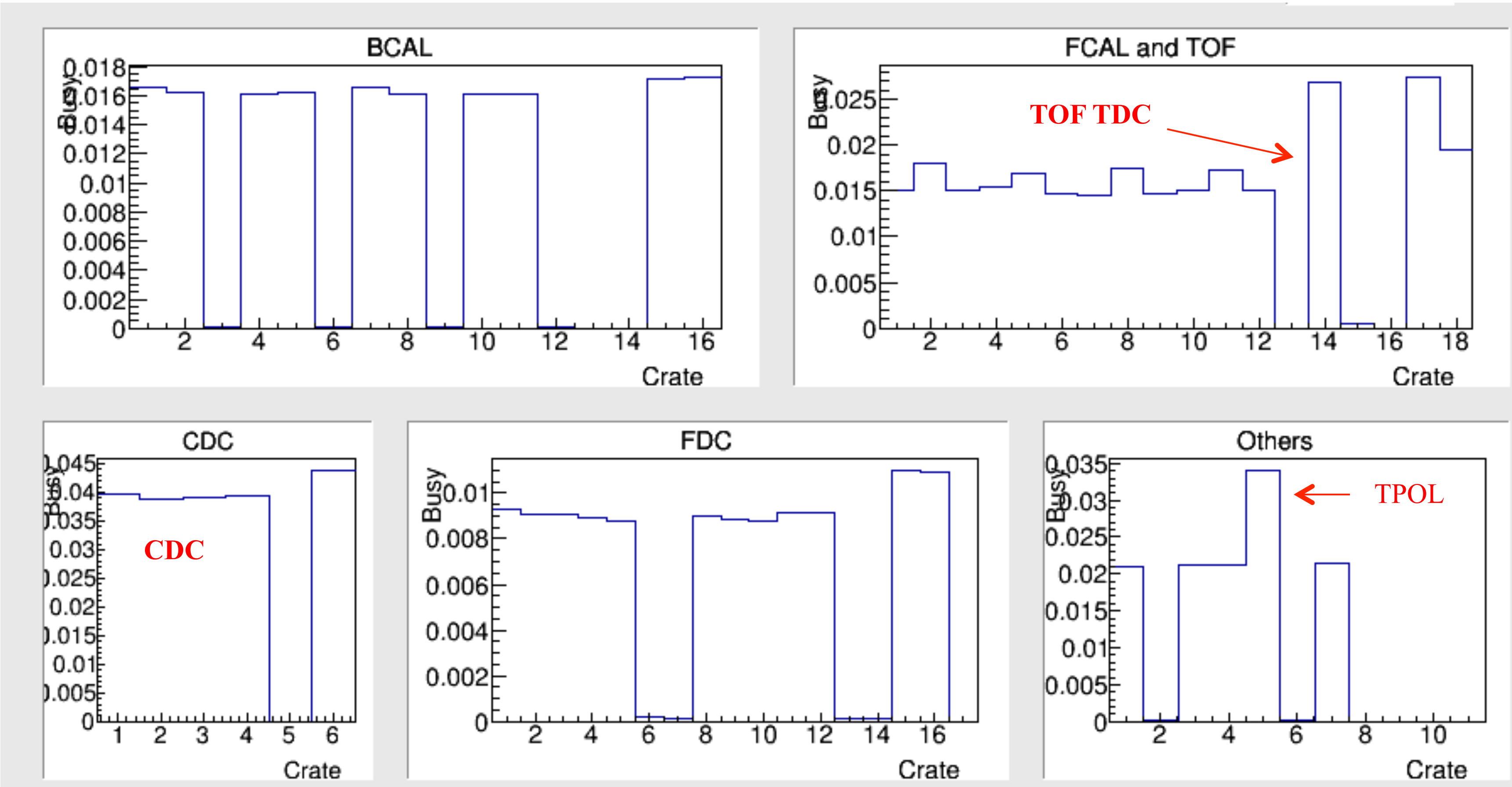
Stable performance
when data is not transmitted from the crate



~95 kHz Input Trigger Rate

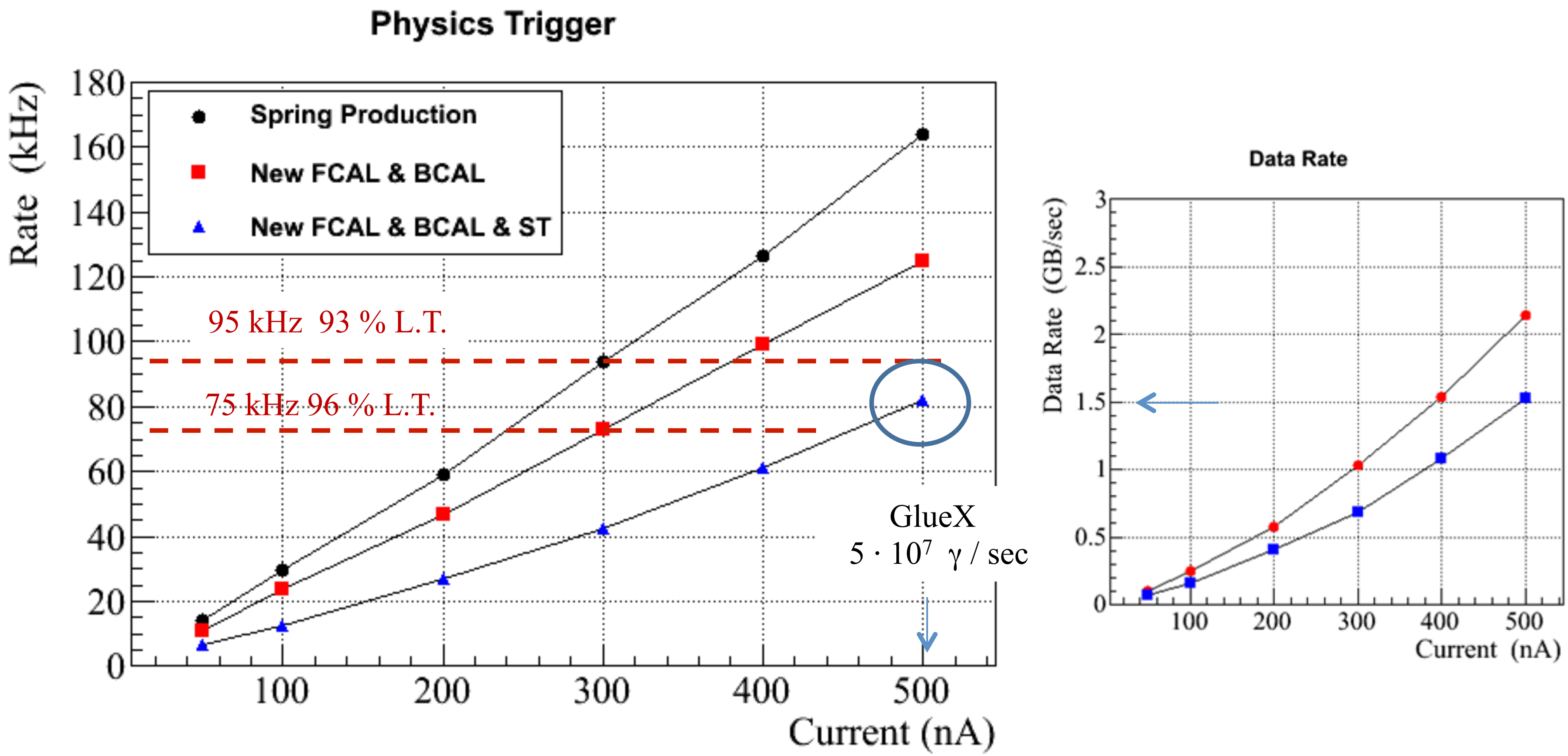
93 % L.T.

Run at 90 kHz Trigger Rate: Current Hardware Limitations



CDC: 4 % dead time
TPOL: 3.5 % dead time
TOF fadc : 2.5 %
We need to optimize thresholds (size of readout window for TOF)

Rate Limitations: Fall 2016



- Need to understand / tune performance of the TOF TDC crate

- We will be able to use FCAL & BCAL & ST trigger at the nominal luminosity of $5 \cdot 10^7$ γ / sec in the coherent peak region.
  - trigger rate 80 – 90 kHz, data rate 1.5 Gb/sec