

BMN & MPD Data Acquisition in 2018

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BMN & MPD DAQ Collaboration

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The first Collaboration meeting of the MPD and BM@N
experiments at the NICA Facility

Outline

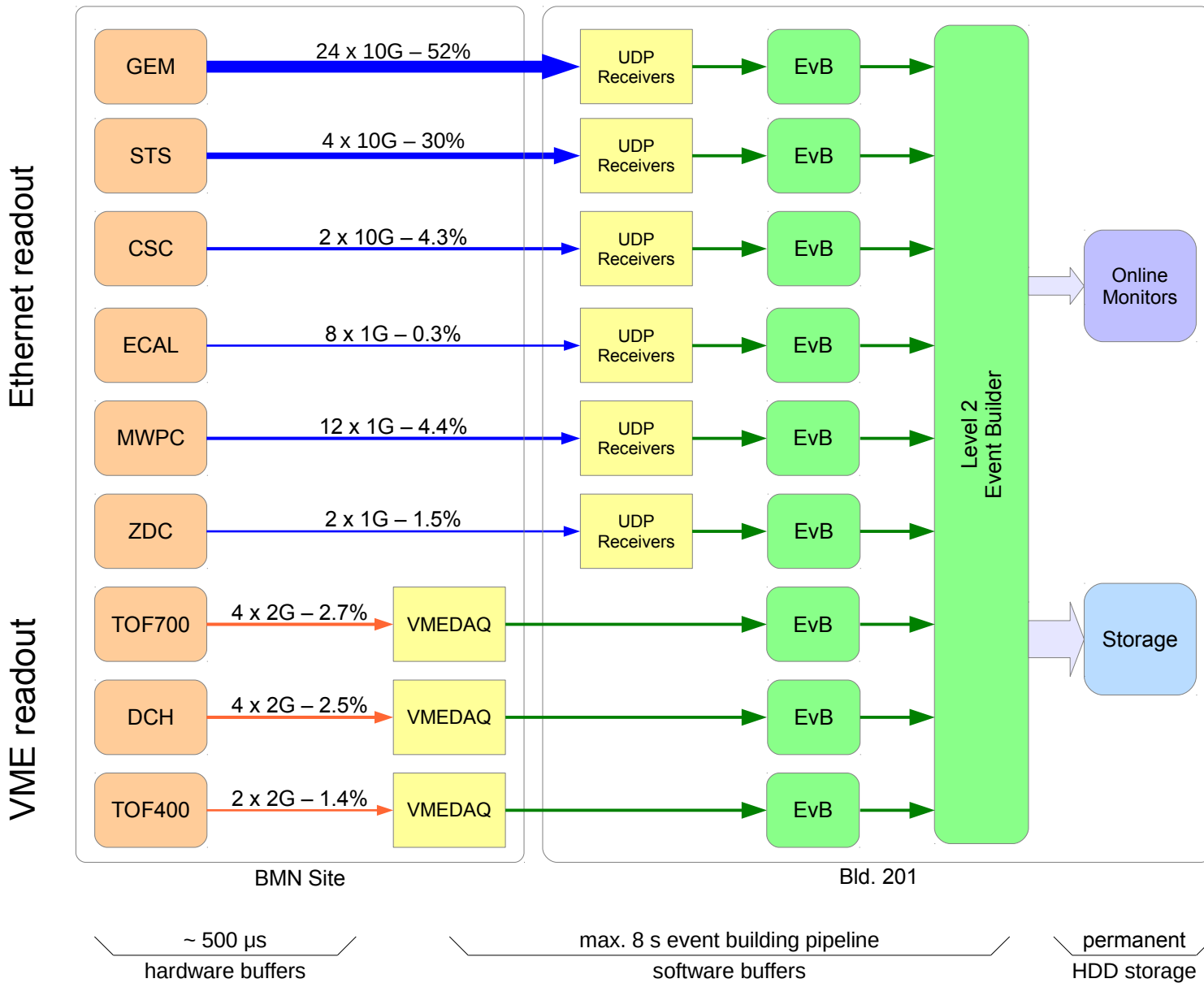
- ▶ DAQ parameters
- ▶ DAQ performance in 2018 BMN Run
- ▶ Time Synchronization and Run Control
- ▶ Readout Electronics
- ▶ Data transfer, processing, storage
- ▶ IT Infrastructure

** More details in MPD DAQ TDR*

BMN DAQ parameters

	March 2017	Mar–Apr 2018	2020 – 2021
Raw event size, Bytes	120 000	225 000	~ 300 000
Trigger rate	5k	10k	20k / 50k
Before / After Protection	none	3 μ s / 0.5 μ s	
DAQ missed triggers	> 50 %	< 15%	
GEM / STS / CSC zero suppression	none (Off-line)	none (Off-line)	On-line
Event readout time	100 – 300 μ s	35 μ s	15 μ s
Total raw data volume	7.6 TiB	66.4 TiB	150 – 500 TiB
DAQ FLP network bandwidth	20 Gb/s	90 Gb/s	800 Gb/s

BMN DAQ setup in March 2018



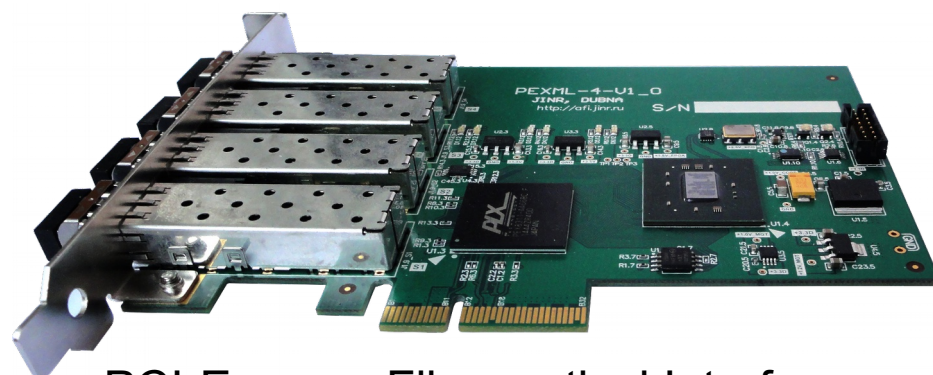
Readout and Control Electronics

Detector	DAQ Function	Readout card	Standard	Readout
BMN GEM, CSC, STS (prototype)	Charge, 32 or 128 channel multiplexed readout + waveform digitizer	VME ADC64VE-10GE	VME64x	Ethernet 10G
BMN TOF-400, T0 — MPD TOF	Two-edge Pulse Timestamping	VXS TDC72VHE – 25 ps TDC	VXS	VME64 — Ethernet
BMN TOF-700	Two-edge Pulse Timestamping	TDC64VHLE – 25 ps TDC	VXS	VME64
BMN DCH	Pulse Timestamping	TDC64VL – 100 ps TDC	VME64x	VME64
BMN ECal, ZDC — MPD ECal	Charge, waveform digitizer with DSP	ADC64S2 v5.0	standalone	Ethernet
Time Synchronization	WR Time receiver, VME clock distribution	FVME2-TMWR	VXS	Ethernet
Control and Monitoring	UT24VE-RC	UT24VE-RC	VME64	Ethernet
Interfaces	VME control and readout	FVME2, PEXML-4	VME64, PCIe	PCI-Express

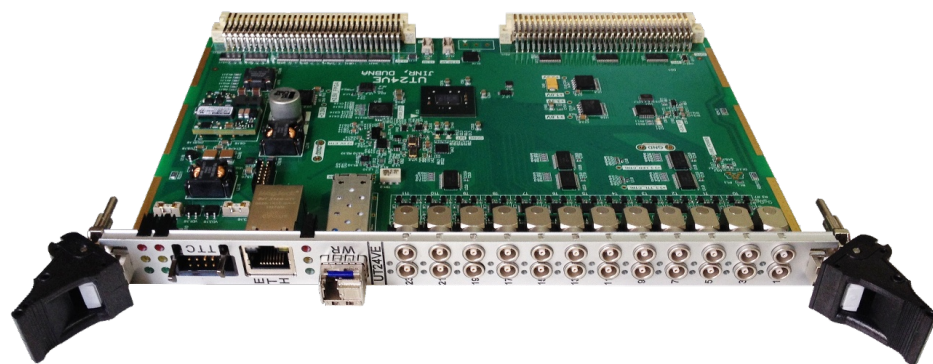
DAQ Electronics – made in Dubna



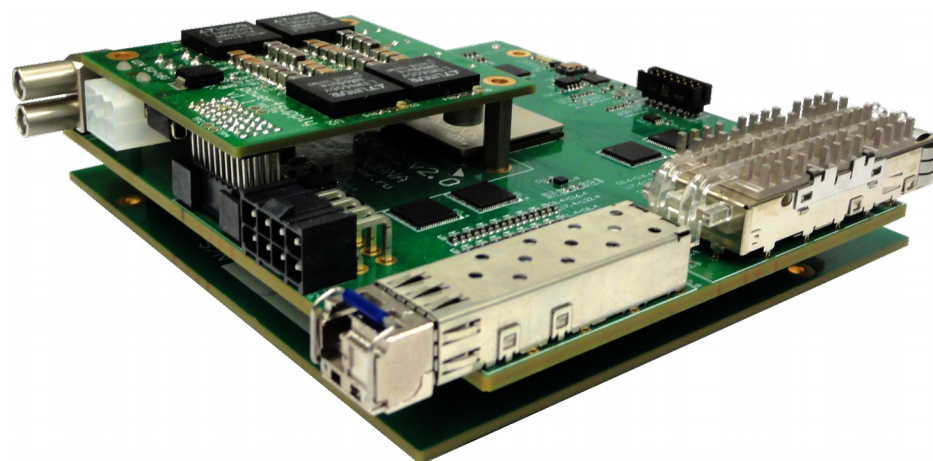
Timestamping TDC – TOF, FFD, T0



PCI-Express Fiber-optical Interface



Trigger Distribution and Control



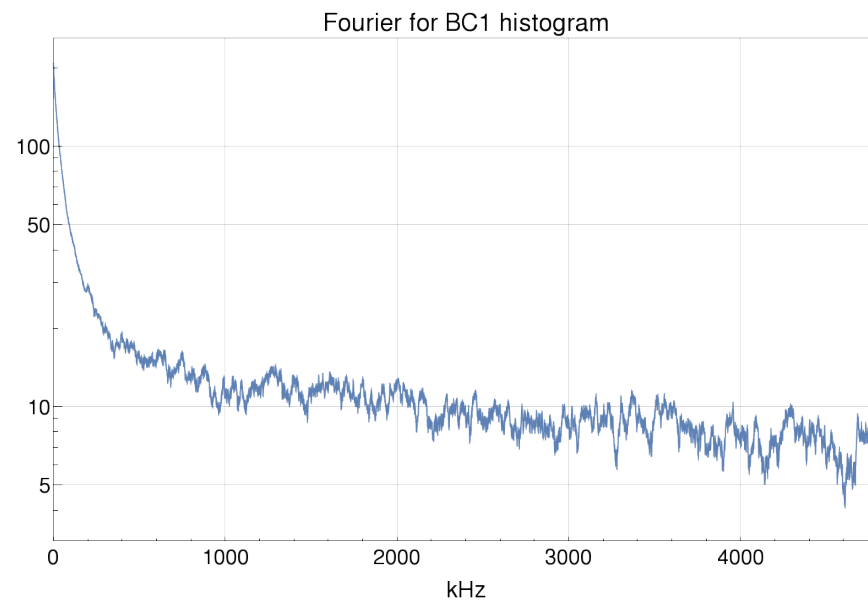
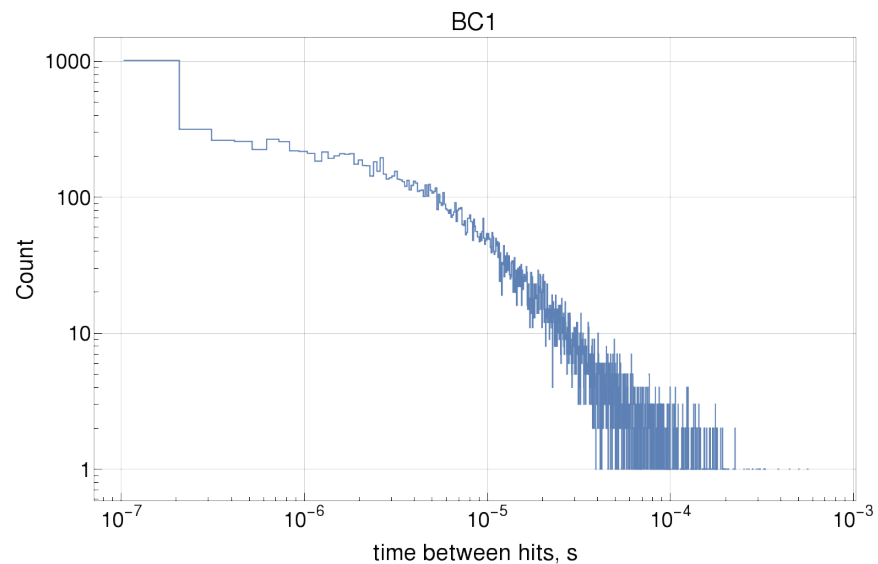
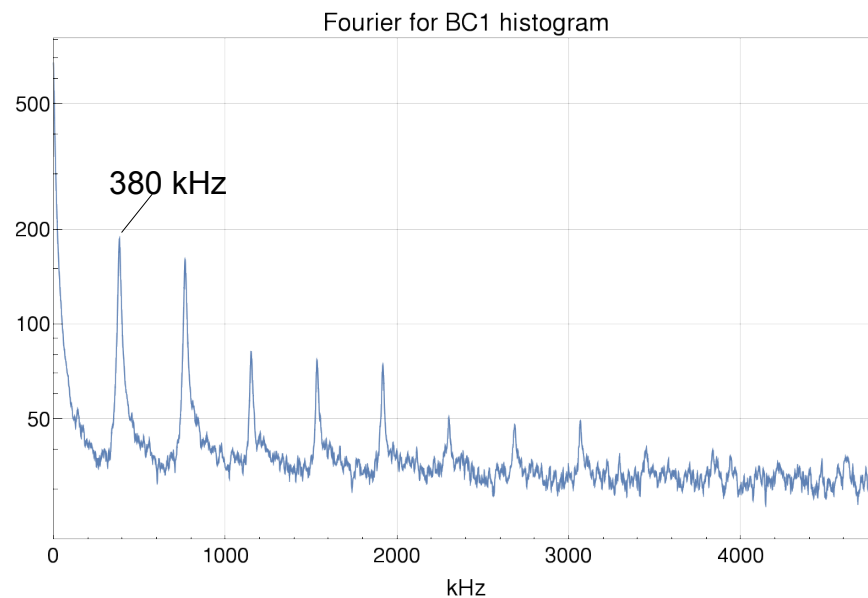
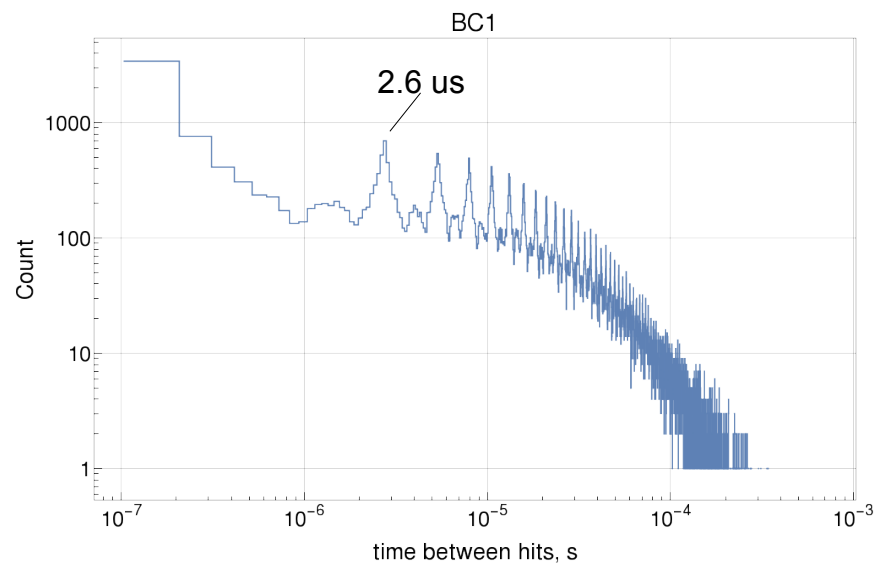
Waveform Digitizer – ECal, ZDC

DAQ Performance in BMN run 2018

- ▶ Improvement in extracted beam structure since 2017 BMN run. Trigger Time Interval Histograms.
- ▶ DAQ channel occupancy, ~ 100 runs processed
- ▶ DAQ event readout (busy) time
- ▶ DAQ efficiency

BMN BC1 Time Interval Distribution

measured by MSC16VE hardware histogrammer



BMN – Kr run, DAQ channel occupancy

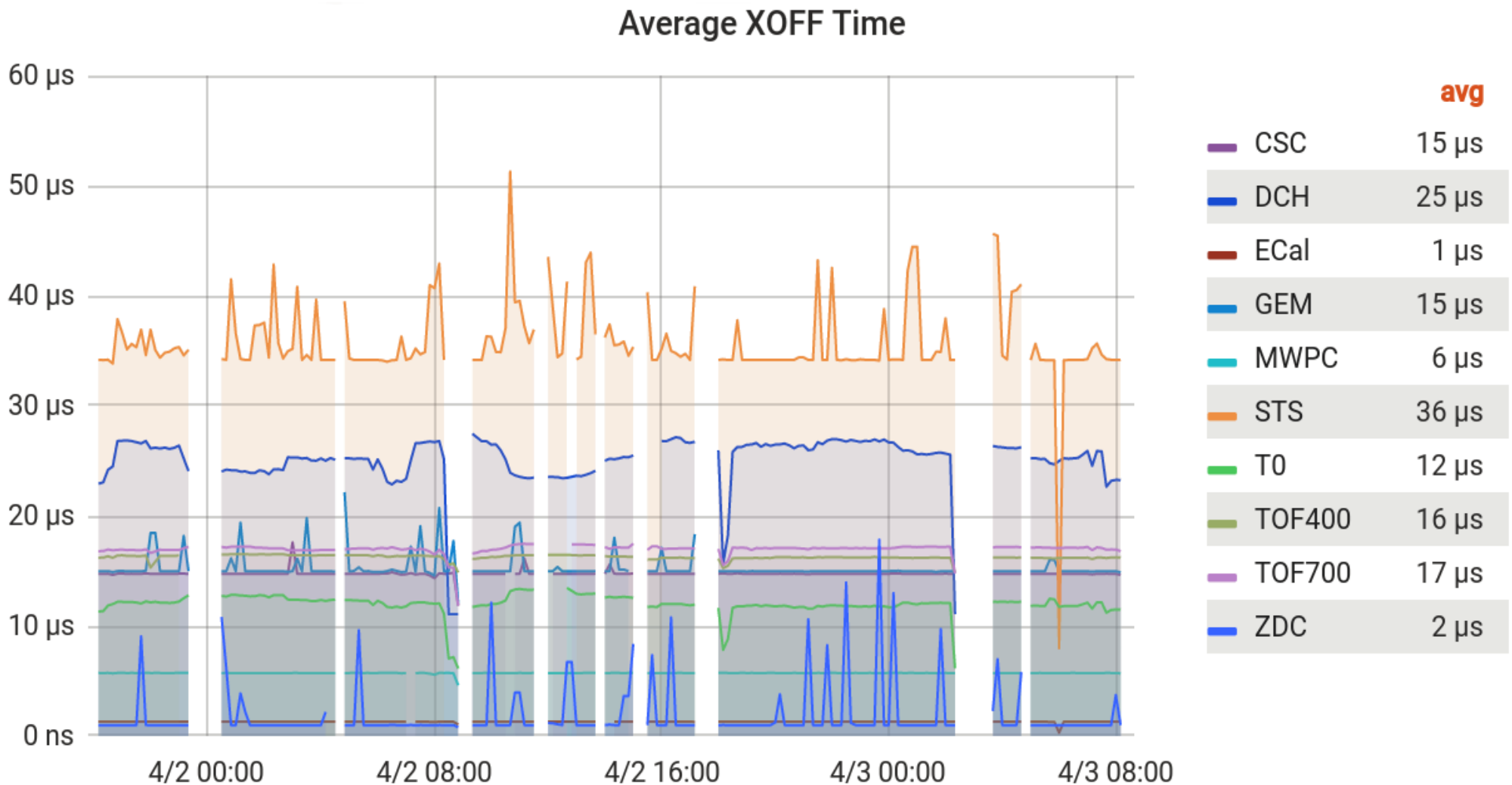
Average Occupancy in Detectors, Krypton run



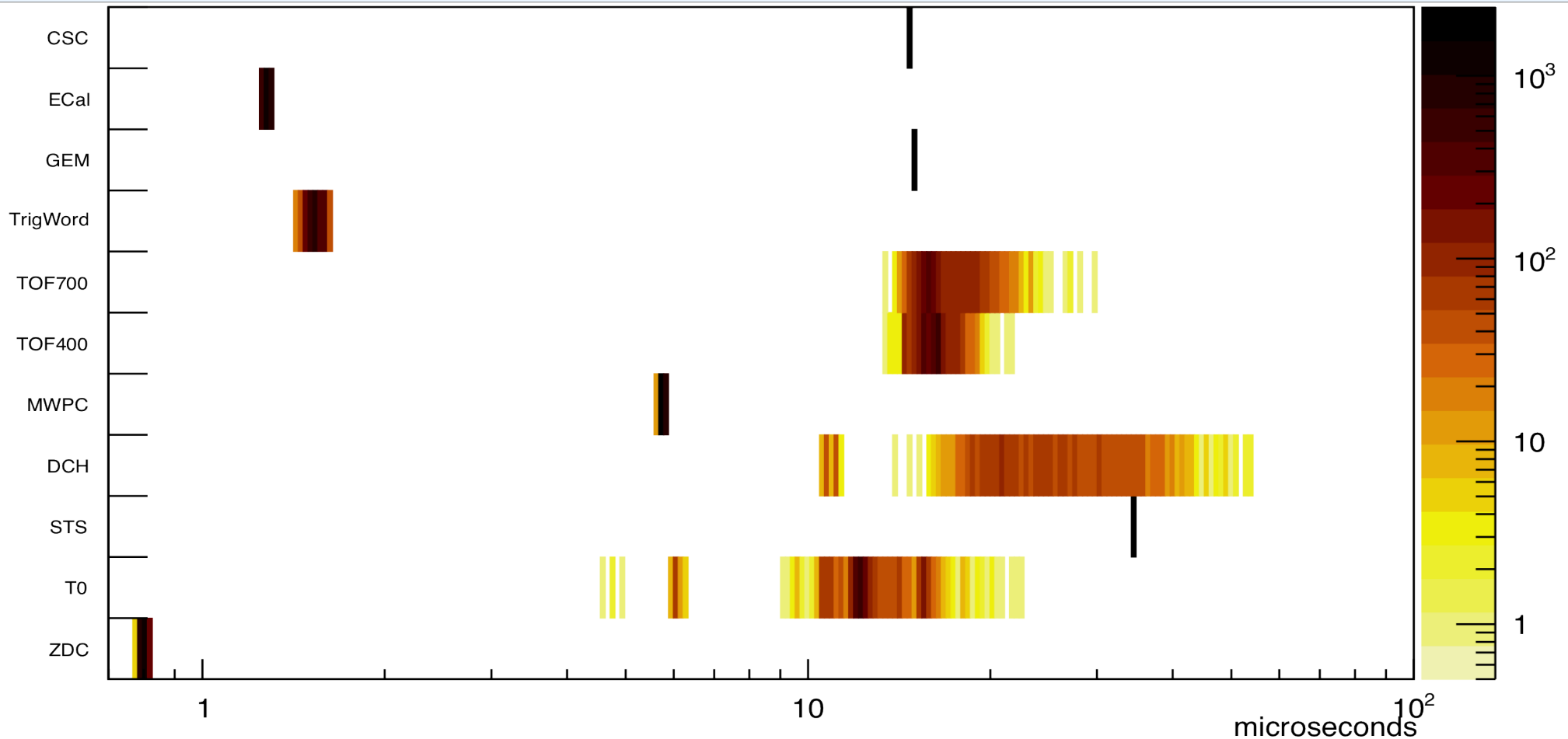
* GEM, STS, CSC – no hardware zero suppression, occupancy 100%

* Data from RAW file analysis

BMN – Kr run, DAQ busy time



BMN – Kr run, DAQ busy time



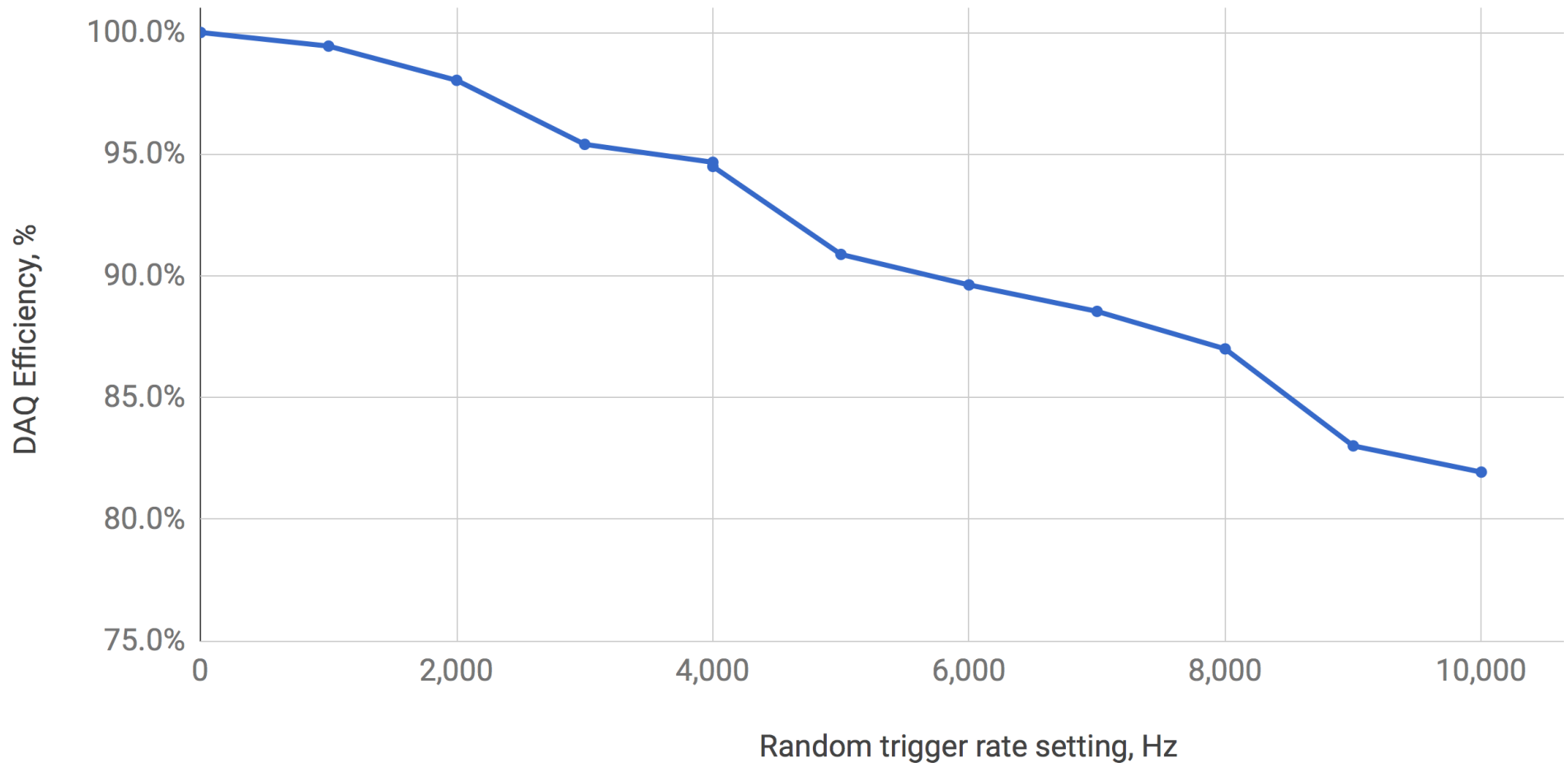
* STS – 35 μs all channels multiplexed readout at max speed, ASIC limitation

* CSC, GEM – 16 μs multiplexed readout

* DCH, TOF400, TOF700, T0 – enabled HPTDC debug headers / trailers, readout is not pipelined (implementation is planned)

* MWPC – zero suppression may be implemented in hardware (if necessary)

DAQ Efficiency (accepted triggers)

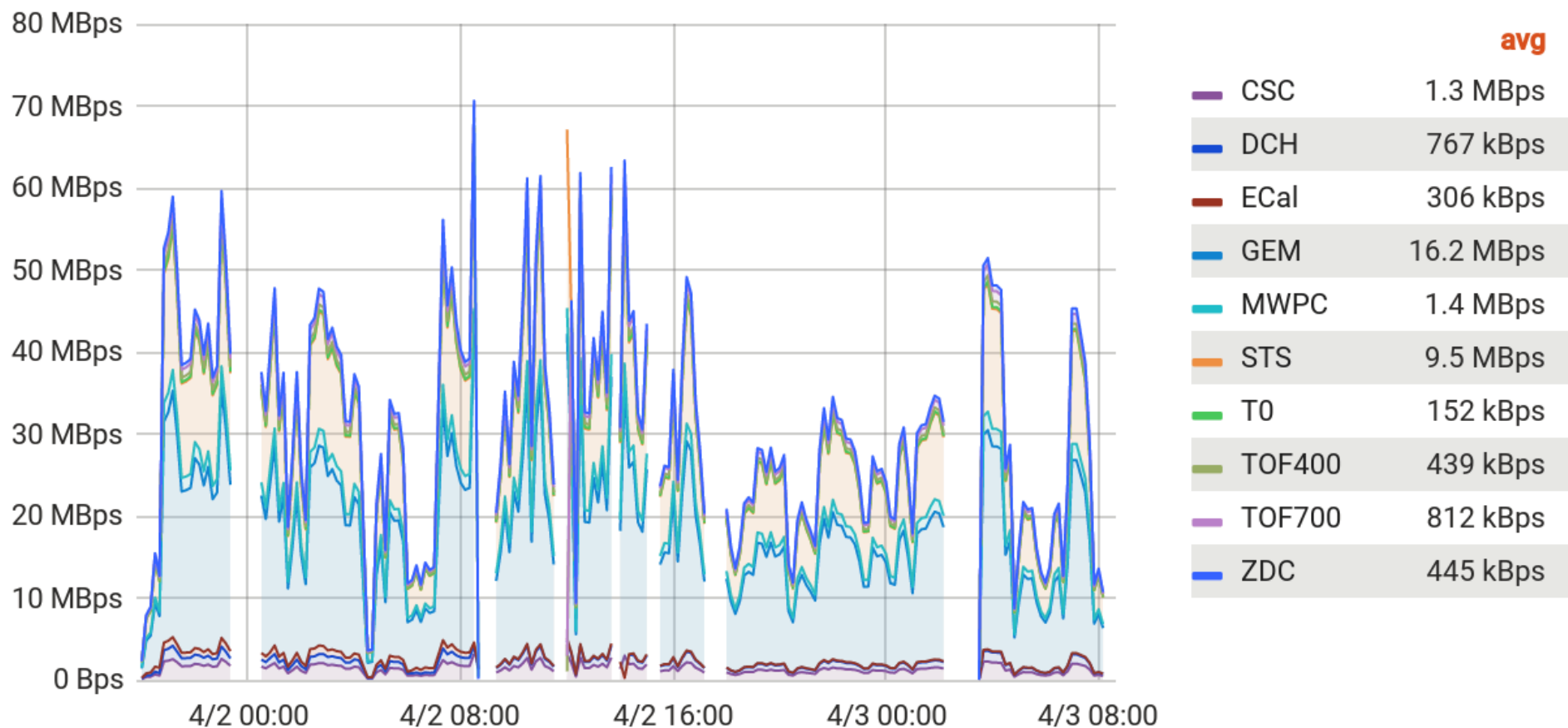


- * Trigger source: UT24VE-RC Random Trigger Generator
- * All detectors enabled
- * No beam, dummy data

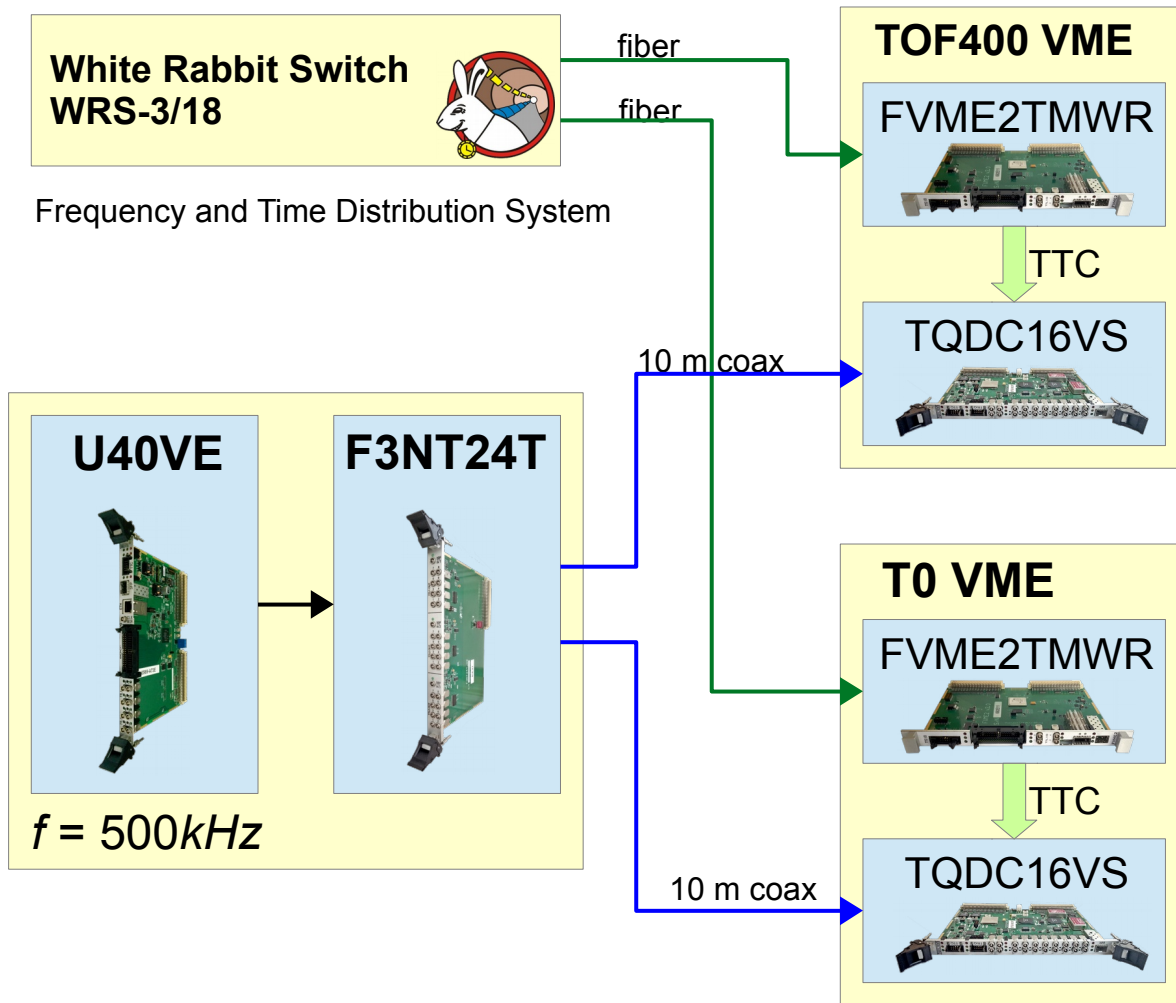
- Not 100% efficiency due to trigger throttling
- * sub-optimal, lossy network (packet drops observed)
- * insufficient STS readout bandwidth

BMN Kr run – data rate to storage

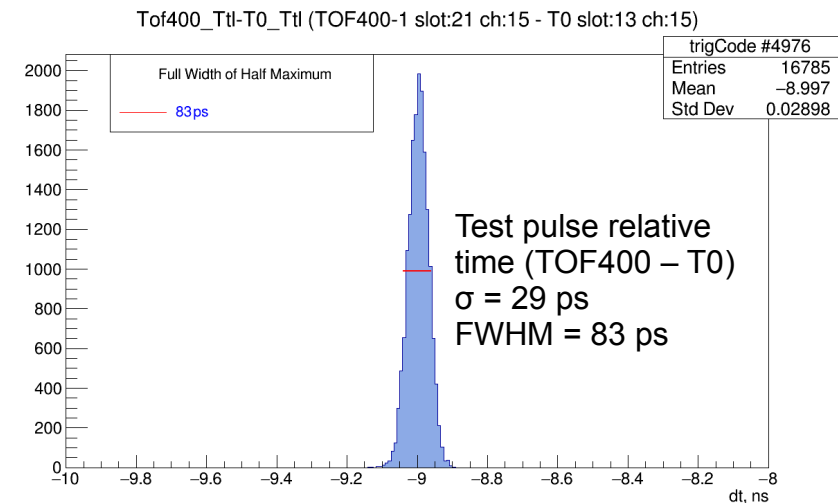
EvB TCP Output Rate



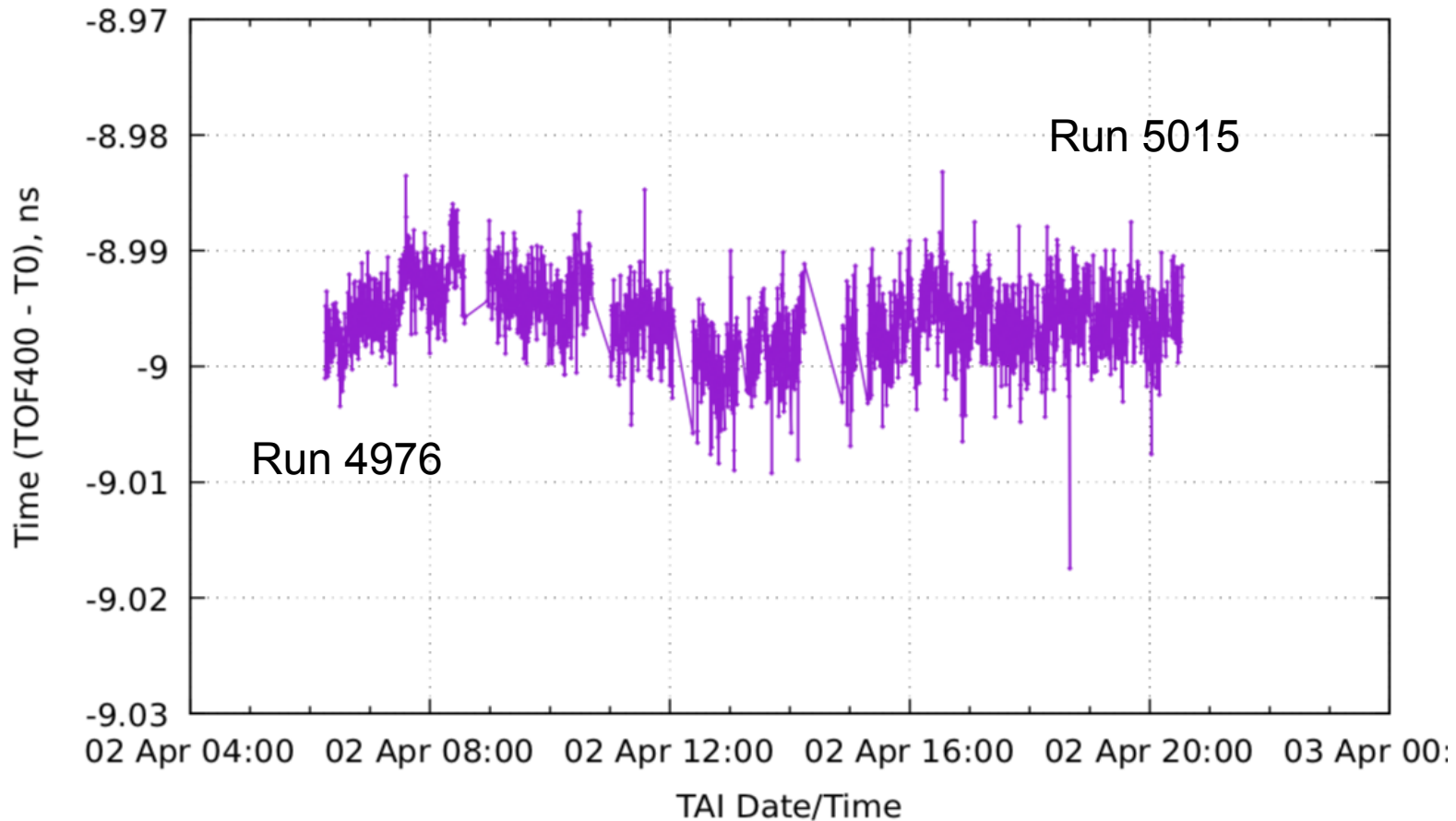
In-Run Time Synchronization Measurement



- 1) U40VE used as source of 500 kHz periodical TTL pulses
- 2) F3NT24T — 1-to-8 fanout
- 3) All FVME2TMWR modules sourced from same White Rabbit Switch
- 4) Match window for all TQDC16VS modules set to 2 μs



Time Synchronization Measurement



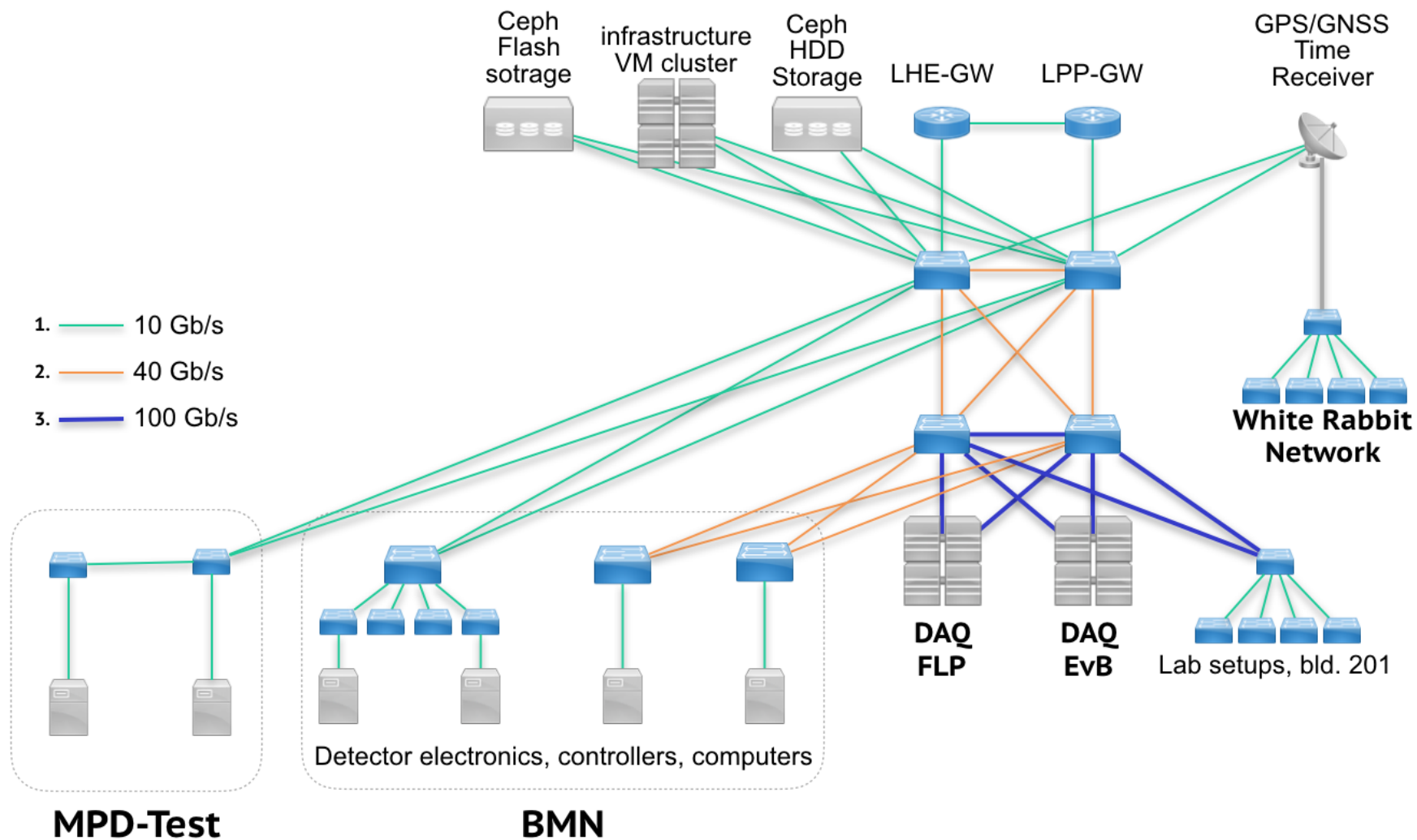
Time difference
averaged by spill

BMN Kr run

Long-term drift is caused by 25 ps/°C temperature coefficient of PLL used in TQDC16VS measurement board.

DAQ IT Infrastructure

DAQ Technical Network in 2018



DAQ IT Hardware

FLP, event builder nodes

- ▶ 16 nodes, each equipped with:
- ▶ Two 16-core CPUs (Intel Xeon 2.6 GHz Broadwell)
- ▶ 512 GB RAM (16 GB/core)
- ▶ 2 x 100 Gb/s network

Ceph Flash storage

- ▶ 32 SATA and SAS SSD in 8 nodes
- ▶ 6.5 TB useable space
- ▶ Houses all virtual machine disks

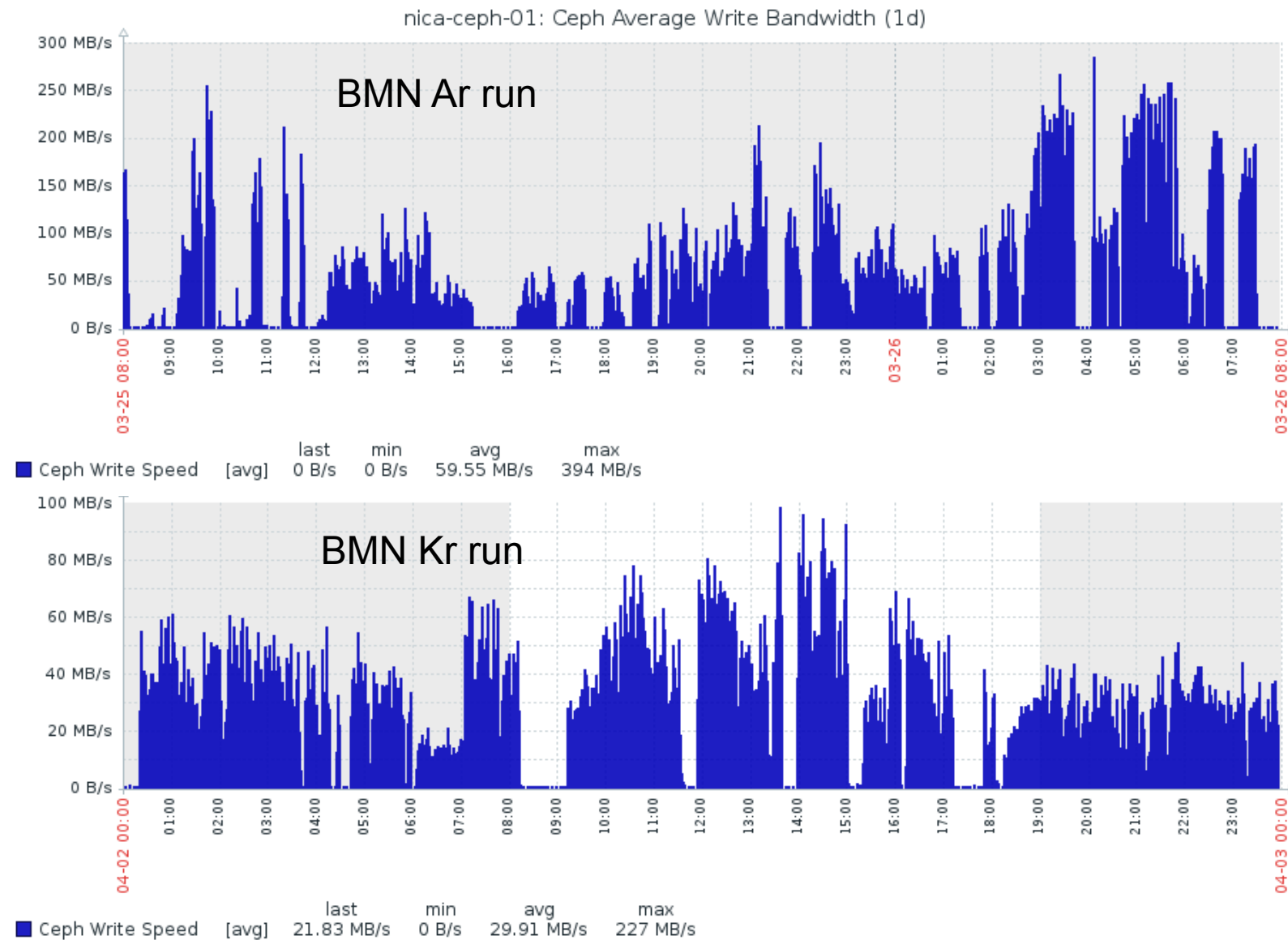
Network

- ▶ Cisco Nexus 5000 / 9000 switches
- ▶ Fault tolerant, redundant topology
- ▶ Bidirectional multicast capable (DAQ software requirement)

Ceph HDD storage

- ▶ 108 disks in 4 nodes
- ▶ 143 TB useable space (3x replicated)
- ▶ 4 GB/s read/write throughput
- ▶ Fault tolerant (multiple HDD failures has occurred while BMN data taking)

BMN Run 2018 – Storage Write Bandwidth



Thank you!

Extra slides

Run Control GUI for UT24VE

Trigger Source

External TTL
 LVDS
 Timer 1997.0 Hz
 Random 1000.0 Hz
Dead Time 10.000 us

Trigger State

Open Close

Spill Source

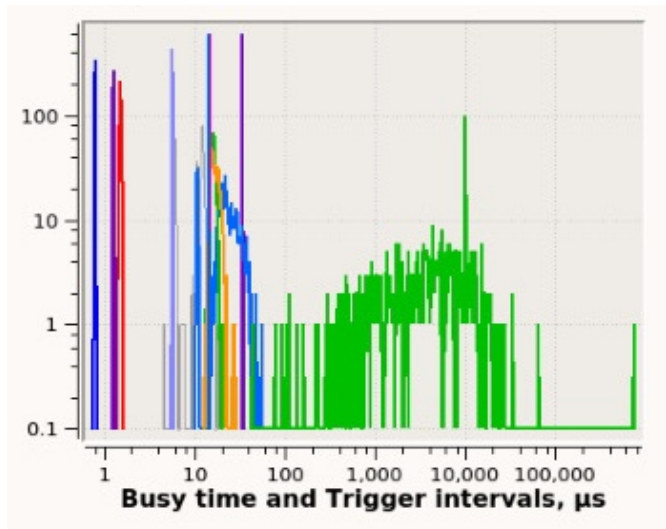
Auto
 Timer 7 ms
 External TTL 13993 ms
 External Gate

WAIT READOUT

Standby time	0:00:00.000
Run time	0:24:44.474
Run Readout time	0:07:51.713
Run XOFF time	0:00:02.415
Trig	83,372
Trig & Run	83,359
Trig & Spill	83,350
Trig & R & S	83,350
Trig Accepted	68,593
L0 Cnt	73,770
Before errors	7,147
After errors	5,122

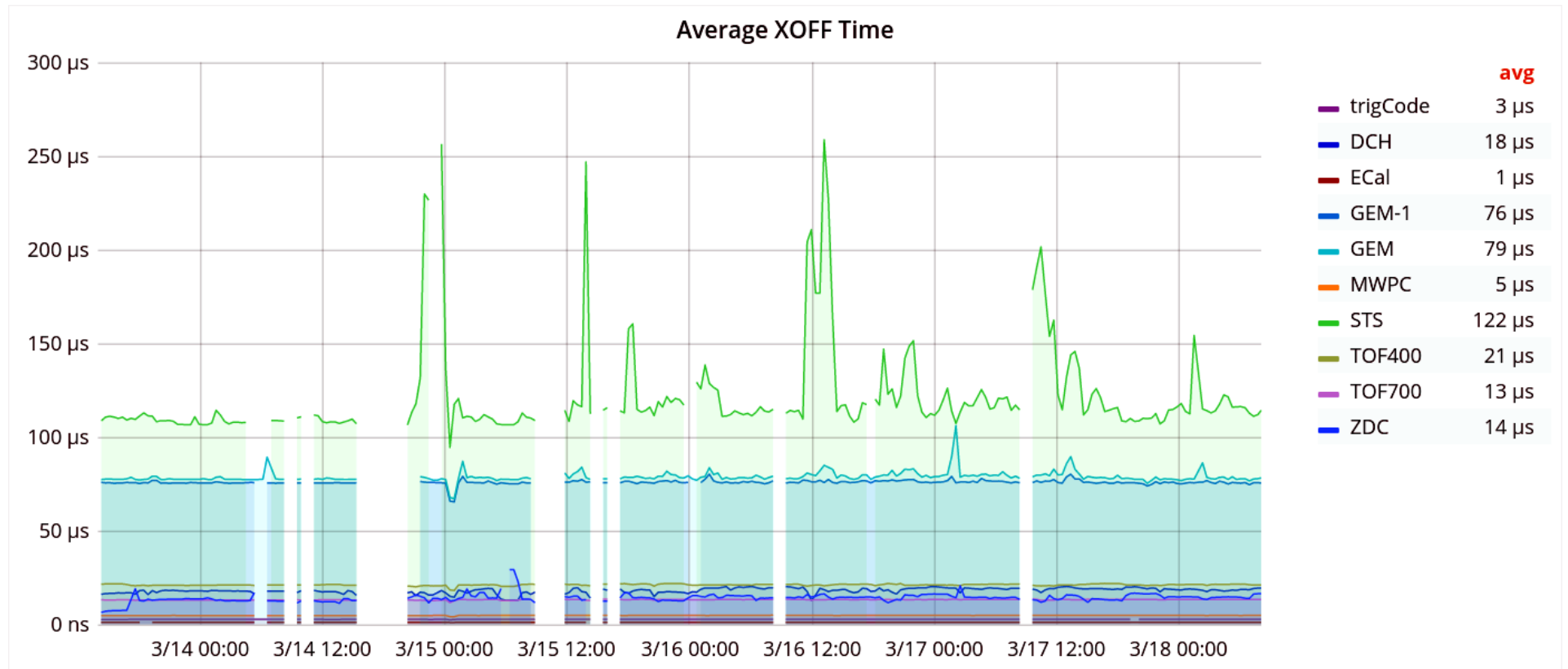
L0 settings

Trig word mask: 0x2000
Trig reject delay: 32 ns
 Chk before 3008 ns
 Chk after 432 ns
 Check Block



- ▶ Run Start/Stop control
- ▶ Subdetector status monitoring
- ▶ 14 busy backpressure channels
- ▶ Hardware histograms:
- ▶ Trigger Time Intervals (Log scale)
- ▶ Busy Time per channel
- ▶ Triggers vs Time plot
- ▶ Live counters
- ▶ Programmable periodic and random test trigger generator

BMN – Mar 2017 run, DAQ busy time



Time Synchronization Measurement

Tof400_Ttl-T0_Ttl (TOF400-1 slot:21 ch:15 - T0 slot:13 ch:15)

