TOP commissioning status

Roberto Mussa

Before vs After Roll-In
Firmware Saga
Rate Capability
TimeBase Calibration
LV struggles
DAQ for Cosmic Ray Running
Plans for MCPPMT replacement

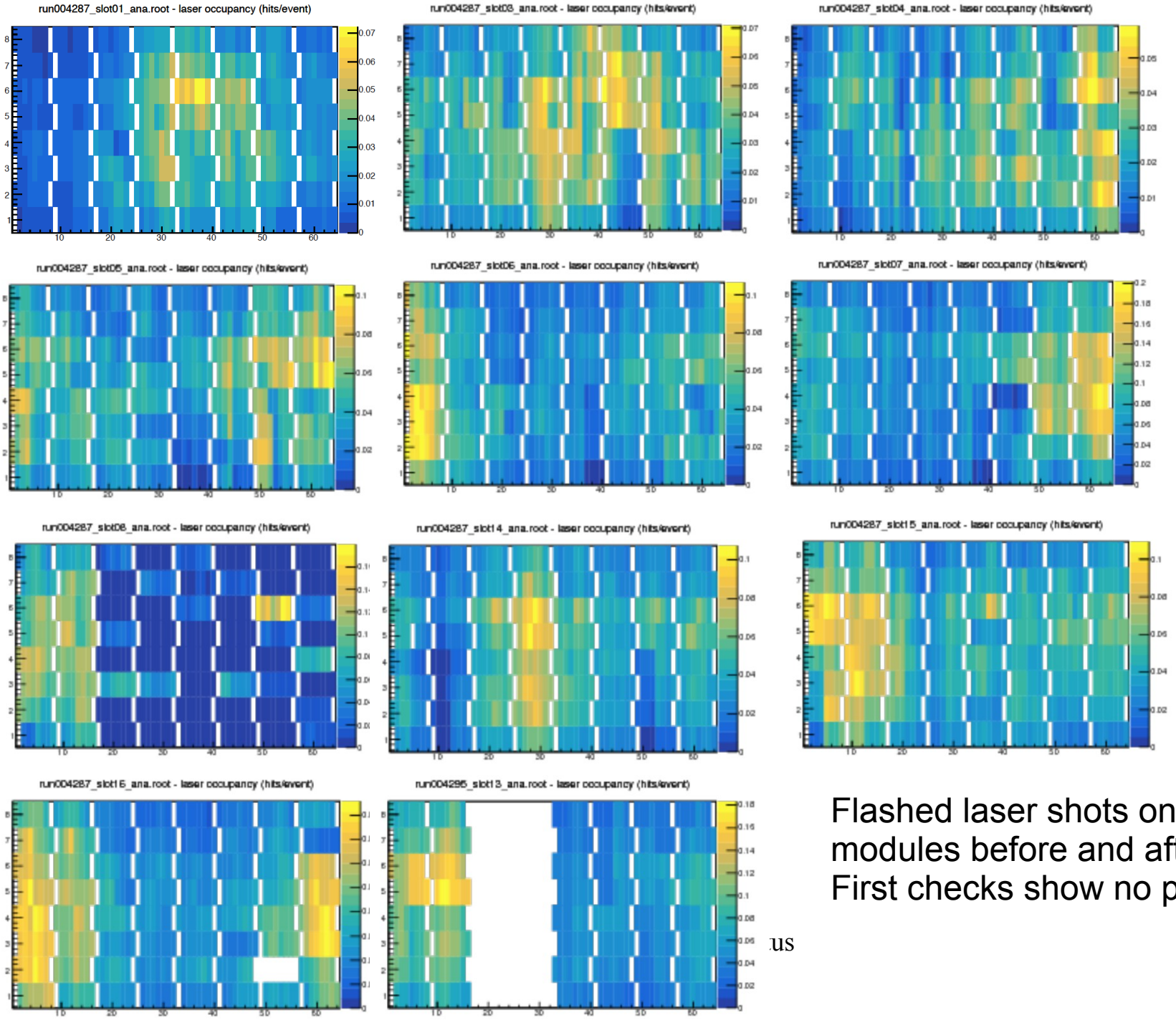
Belle-II Italy 7th Meeting , Trieste , 5/5/2017

Recovery after Roll-in

- N2 gas line changed to normal line. Worked with cryogenic group.
  - Current flow rate is about 0.16L/min/module.
- E-hut electricity is recovering.
  - Problem on one big breaker, which affects to 100V of TOP and SVD racks.
    - Connected with temporary lines, by the end of May?
  - Basically recovered TOP racks in E-hut and FTSWs on the detector.
- TOP chiller is working now.
- PC topslc01 moved to E-hut and now working as well as toptest01.
- Network connection of DAQnet is ready.
  - Not ready around HLT, will recover in Apr.28.
  - Pocket DAQ mode should be OK.

- Need to check COPPER/FTSWs in E-hut with DAQ group.

Laser Calibration: signal spread across modules



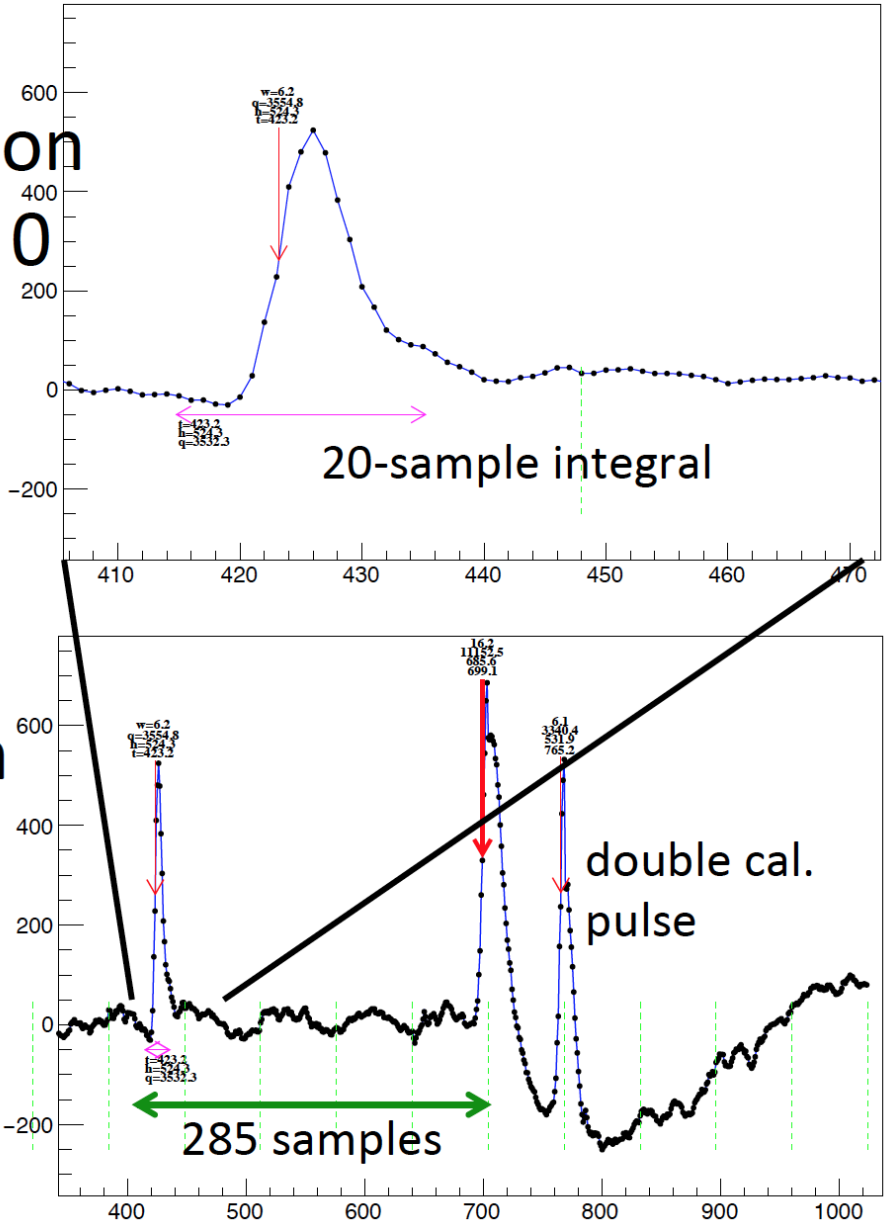
Flashed laser shots on 11 modules before and after roll-in. First checks show no problems

Signal processing: Feature extraction (FE)

- fit charge or height distribution to extrapolate the it close to 0
  - efficiency = (# of events after selection) /(integral of $P(x)$)
- update
  - use new parameterization by Marko

$$P(x) = p_0 (x/x_0)^{p_1} \exp(-(x/x_0)^{p_2})$$

  - fitting height distribution



Firmware Saga: feature extraction

FE Data Reduction

- Oskar implemented spreadsheet to evaluate data rates, based on expected rates in global cosmic ray test
  - Feature extraction reduced data rate, but still too large for proper running in global DAQ (expects 96MB/sec max from iTOP)
  - Recall that we're still outputting waveforms when a pulse is found
- In current FW, 64-byte FE header produced for every channel, whether a pulse is present or not – ok for debug, but wasteful
- Lynn implemented "short" FE header (12 bytes) when no pulse found
  - Total data rate ~1/3 of the worst-case for iTOP – ok for global CRT?
  - Testing at PNNL and KEK now
- **Other low-hanging fruit:**
  - No reason to output 4 windows when only 2 are relevant now
    - Lynn looking into this improvement (fairly straightforward)

DAQ issues on 30 kHz running

30kHz Support

- Luca has resolved compiling and timing issues in the design
- Testing underway on actual boardstack
- This version uses new AXI-DMA updates to copy raw data from carrier to UART for debugging
- Next steps:
  - Start working on other modules that need to be included
  - Proposed (carrier-SCROD) data format needs to be supported

Configuration Script Rewrites (python → C)

- Tobias has written C versions of all the python configuration scripts
  - 2x faster overall (some delays required in the configuration process)

HSLB Firmware Update

- DAQ group provided new version of HSLB firmware to resolve CRC errors seen on multiple subdetectors
- Tested at KEK on iTOP; some CRC errors still seen?
  - Reported to DAQ group

DAQ issues on 30 kHz running

30kHz Support

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- Testing underway on actual boardstack
- This version uses new AXI-DMA updates to copy ra… …arrier to UART for debugging
- Next steps:
  - Start working on other modules that
  - Proposed (carrier-SCROD) dat…

Configuration Script R…

- Tobias has writ…
  - 2x fast… …guration scripts …figuration process)

HS…

- …on of HSLB firmware to resolve CRC …odetectors
- …P; some CRC errors still seen?
  - …AQ group

Lettura di tutti gli slots attualmente utilizzabili (9 o 10 , limitati dai problemi ai Low Voltage Supplies della Wiener) quasi stabile fino a un massimo di 400 Hz.

Lettura effettuata in modalita' ibrida, per validazione della Feature Extraction (FE) : 4 windows (256 bins ~ 91 ns)

Local CalPulse + Laser Runs

- Less data size reduction than assumed last week
- Still significant (~factor 4) reduction in data size to previous baseline
  - Assuming shortened headers, 128samples/pulse, one calpulse/carrier

Proposal:

- One large laser dataset before the start of GCRT
  - ~3M events -> ~120k photons/channel -> 1TB data set
  - Few hours of data taking
- Daily crosscheck runs
  - ~250k events -> ~10k photons/channel -> 75GB data set
  - <15minutes of data taking
  - Should be enough to see significant deviations in TBC (if occuring)

- Reminder: data taking limited by disk I/O
  -> reduction in file size = less time needed for calibration runs

Cosmics Running

- Assuming 100Hz cosmic trigger rate
  - Shortened headers, 128samples/pulse
  - Injecting calpulse into each carrier on cosmic trigger
- 20MB/s for full TOP system during GCRT
  - 15MB/s when not injecting calpulses
  - Linear dependence on actual cosmic trigger rate
  - <<96MB/s as assumed by DAQ group for full B2 running

LV struggles

In the last months only 11 slots were running, due to LV supply problems:
s01, s03, s04, s05, s06, s07, s08, s13, s14, s15, s16

- s02 was out for a broken LV module

- s09,10,11,12 were out due to o broken LV crate

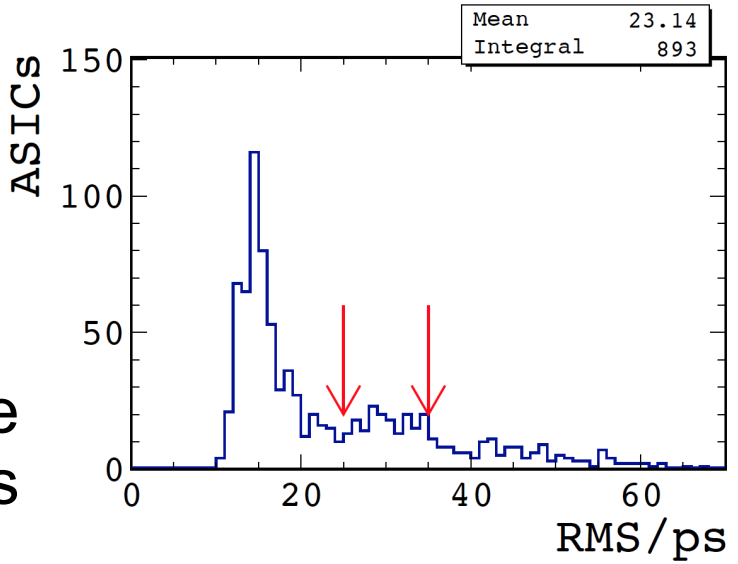
Indiana has ordered:
- 3 spare 10Amp modules (Wiener MPV8008) : 2.6 k$ each
- 2 spare 20Amp modules (Wiener MPV4008) : 2.9 k$ each
- 1 spare crate power supply (Wiener UEP6021) : 3.6 k$

Torino is ordering one more Wiener UEP6021

Repaired modules from Wiener arrived at KEK on May 1st.

TimeBase Calibration (TBC): problems ranking

- All the 960 ASCIs of the 16 SLOTs except SLOT09 have been checked
  - 893 of the 960 ASICs have TBC constants.
  - $RMS < 25$:"agree"
  - $25 < RMS < 35$: "acceptable"
  - $RMS > 35$: "bias"

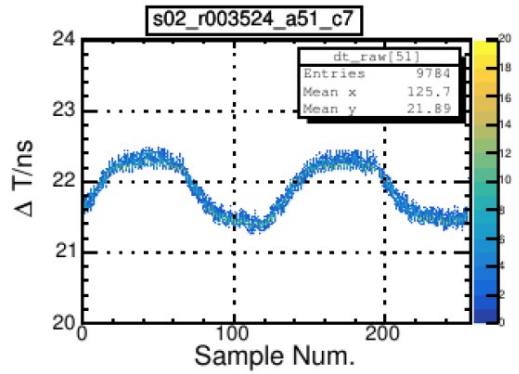


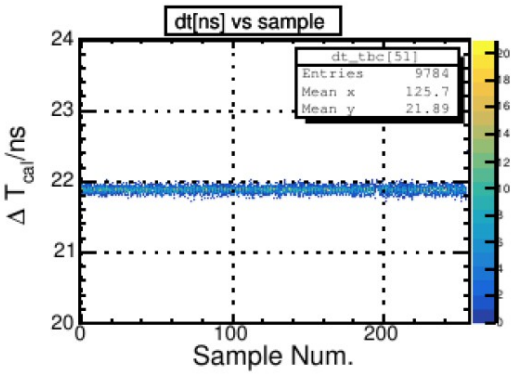
- Analysis based on TBC of Calibration Pulse on data taken before the failure of LV supplies

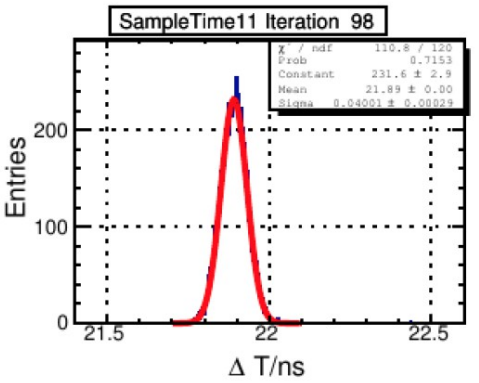
- All the 960 ASICs have been checked manually with TBC.
  - We should automate this process.
  - About 751 ASICs with their TBC constants are reliable in the testing.
  - 142 ASICs have bias in input-output testing.
  - 67 ASICs have no TBC constants. $\rightarrow$ Criteria used to mask?

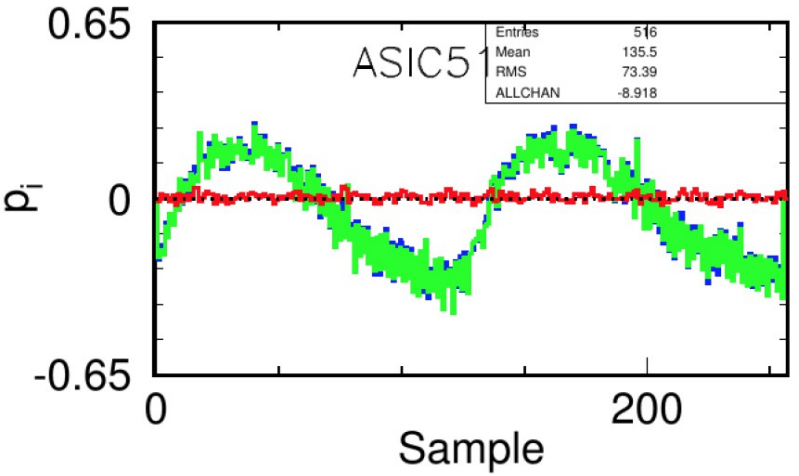
Type 1: Excellent agreement

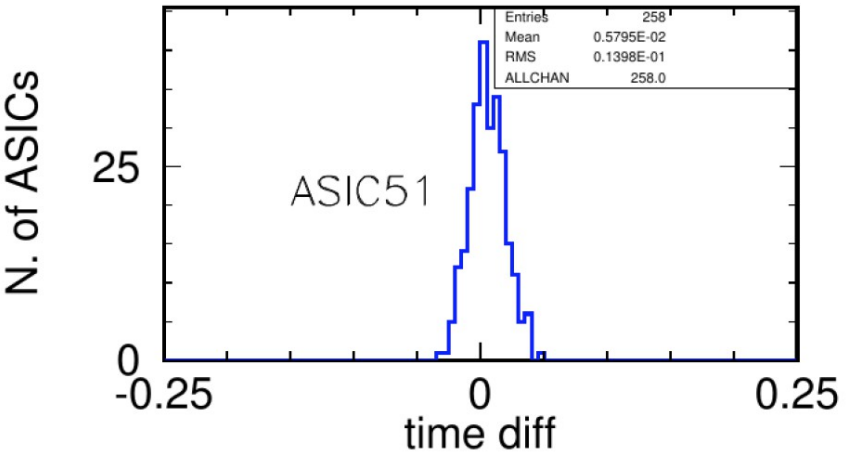
- Good ΔT input data: changing with samp smoothly, small spread ($\Delta T_{max} - \Delta T_{min}$).
- Excellent agreement in input-output testing.
- Number of the ASICs: 597.
- 'Quality = 1' asigned.





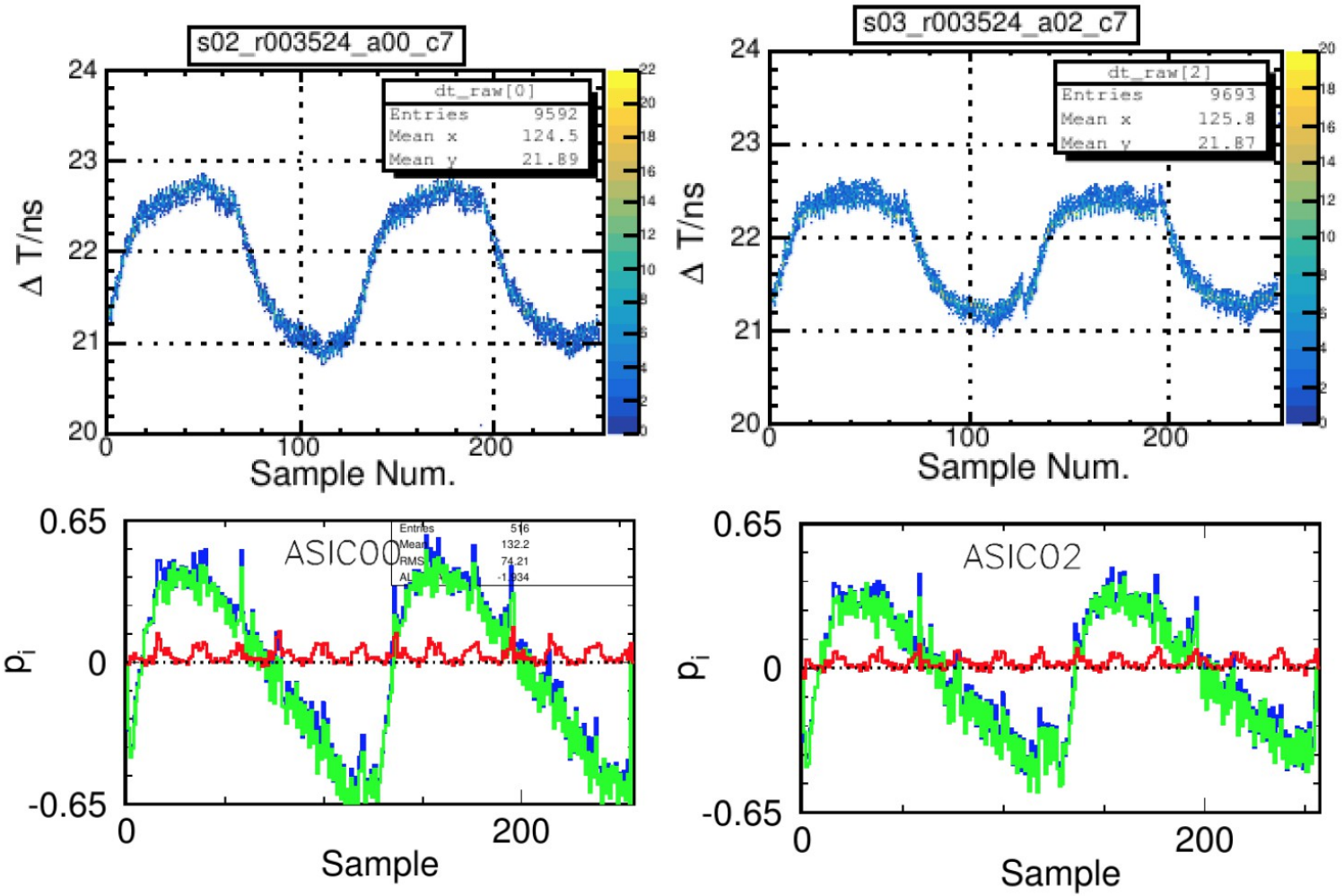






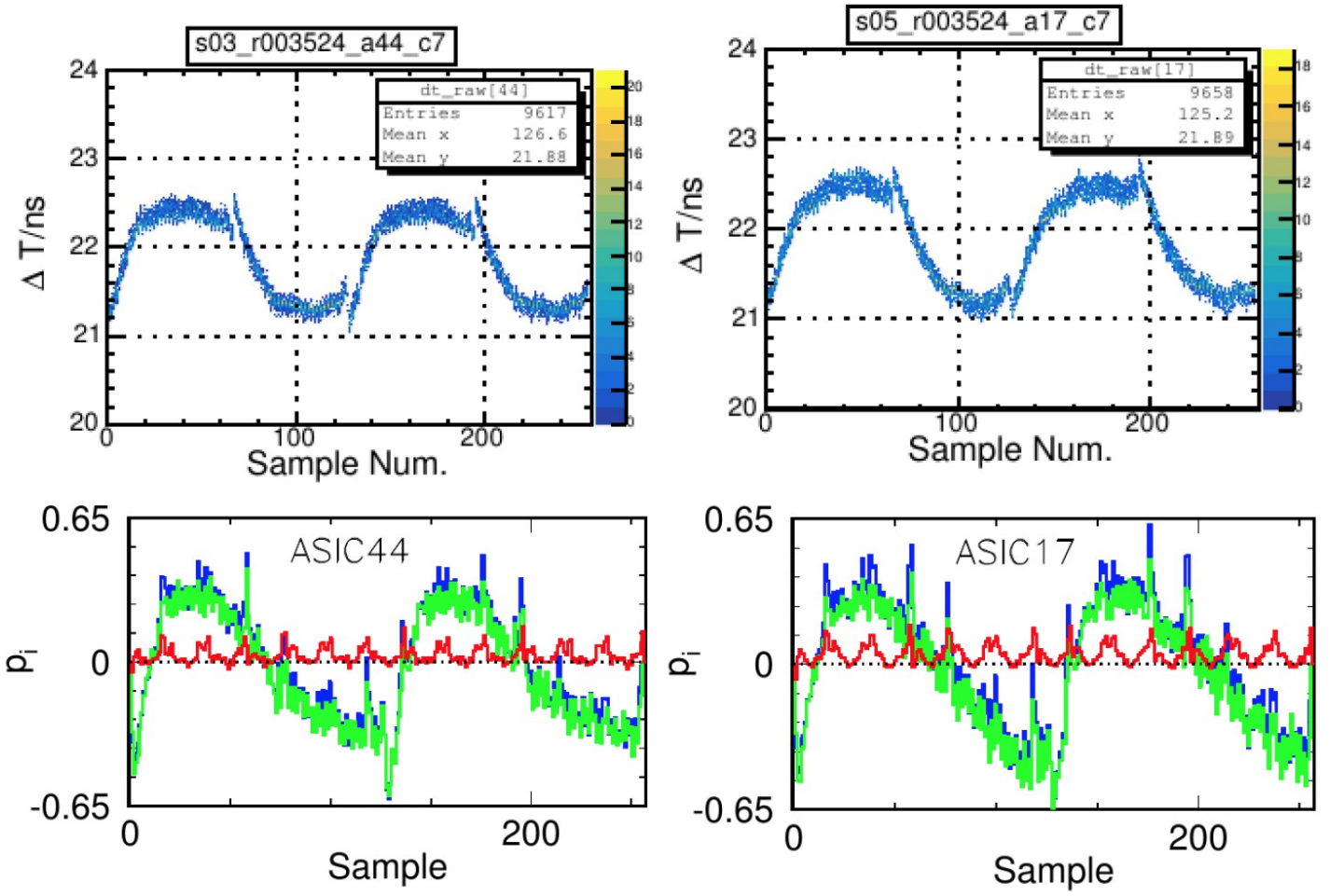
Type 2: Acceptable agreement

- Shape of ΔT input from data is not perfect, typically having spikes and/or large $\Delta T_{max} - \Delta T_{min}$ spread.
- The difference from input-output testing looks acceptable.
- Number: 154.
- 'Quality = 1' asigned.



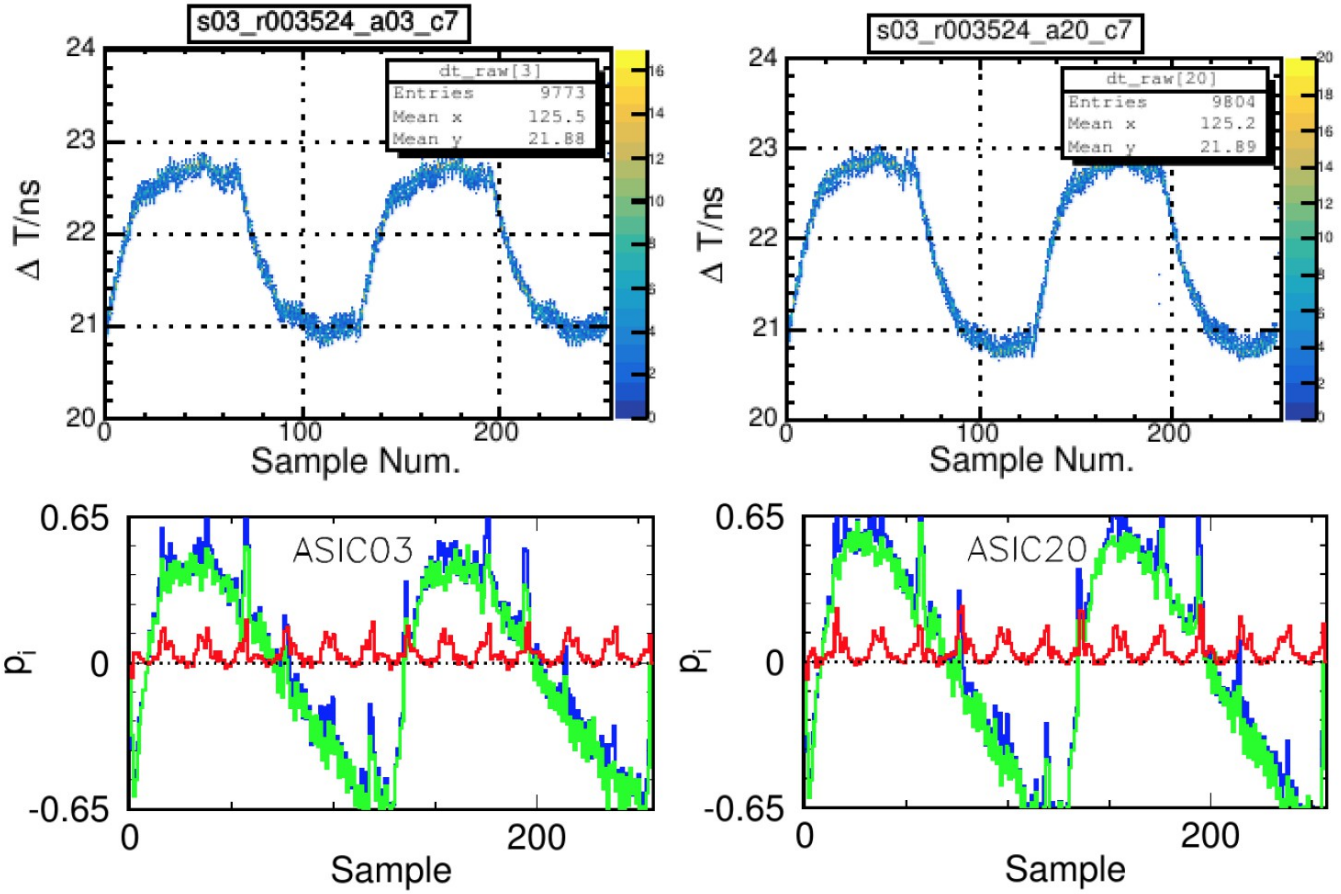
Type 3: Bias due to spikes

- Serious spikes in ΔT input shape leads to bias in input-output testing.
- Not all spikes cause bias.
- 'Quality = 2' asigned.



Type 4: Bias due to large ΔT spread

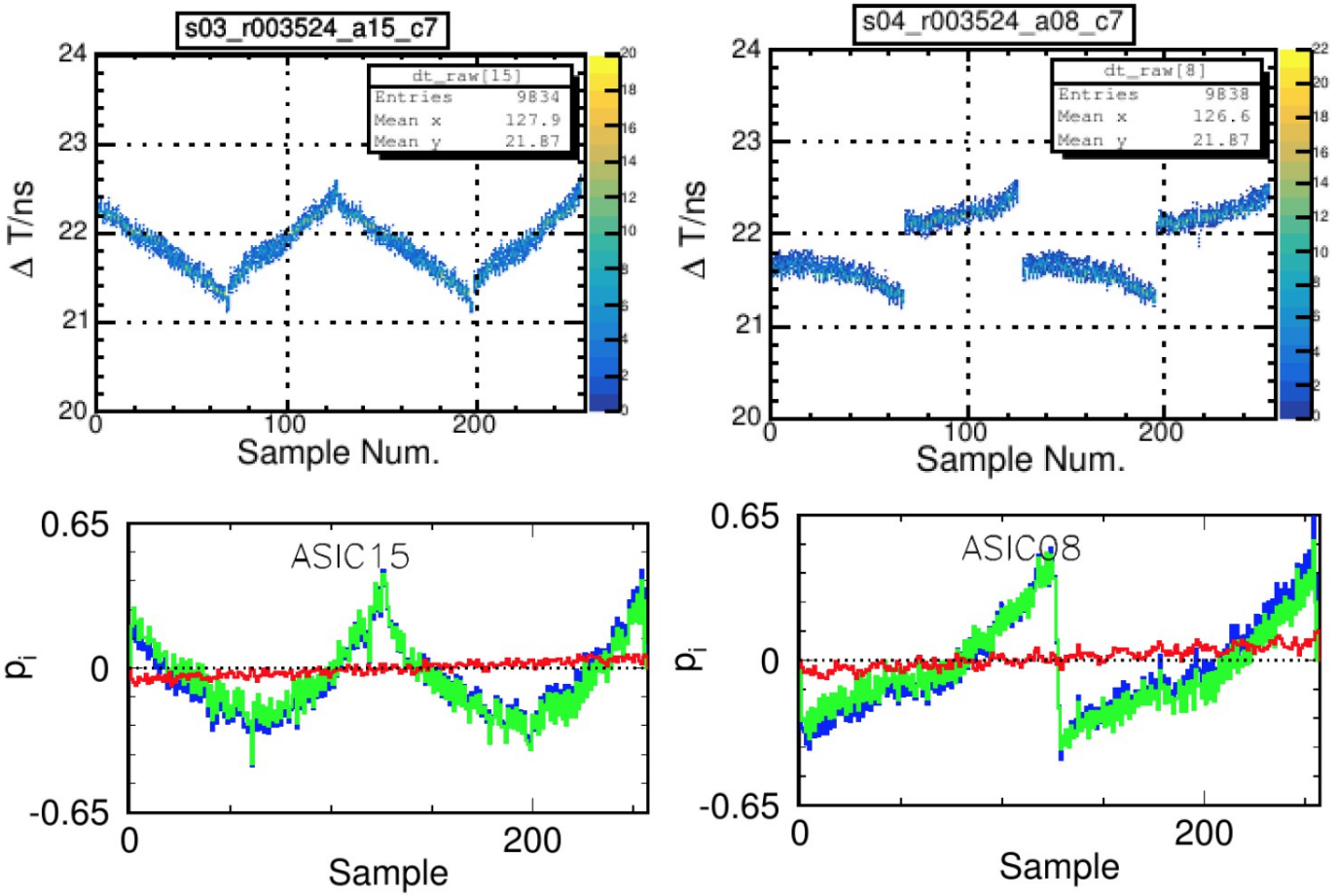
- ΔT ($\Delta T_{max} - \Delta T_{min}$) could be quite large in some ASICs, and cause bias in input-output testing.
- 'Quality = 3' asigned.
- More popular than the cases of spikes.



TimeBase Calibration (TBC): problems ranking

Type 5: slope bias of TBC constants

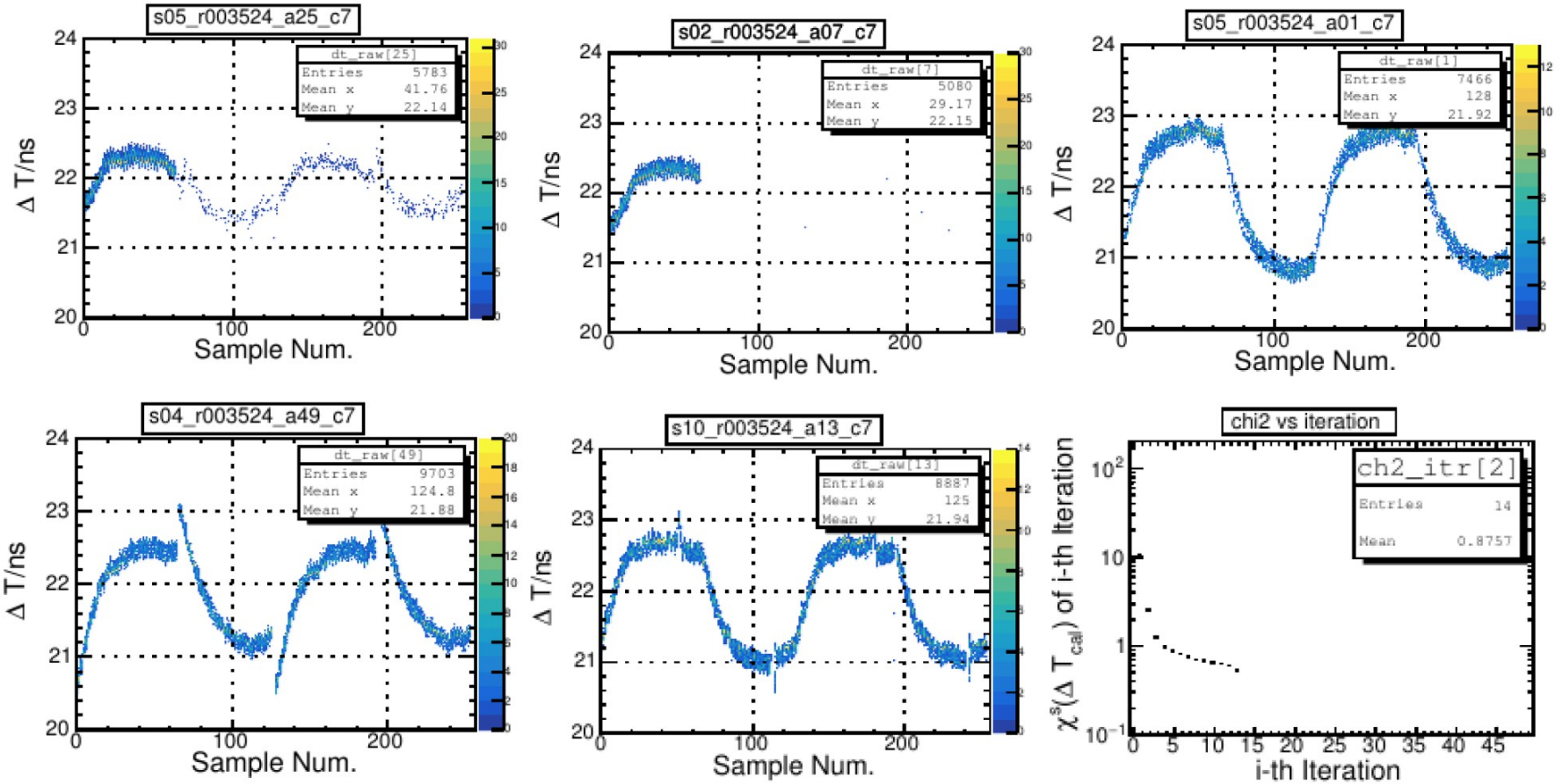
- Some cases, ΔT shape looks divided.
- 'Quality = 4' asigned.



TimeBase Calibration (TBC): problems ranking

Type 6: no TBC constants

- Negative integer asigned for Quality.
- Number: 67.



Trying to spread Firmware Know-how

Partecipazione italiana:
TO: U.Tamponi+*1 Tech*
PD: *1 Tech*

Are you ready? (no experience needed – but you will work)

➔ **Goal is to expand group of people functional at different levels**
- **Read/basic understanding of code and how it works**
- **Simulate/verify existing/new functionality**
- **Debug problems encountered in the future**
- **Develop new code for improved performance, new functionality**

- Week after June B2GM (June 26-30)
- Intro/warm-up session Saturday, June 24

MCPPMT Replacement plans

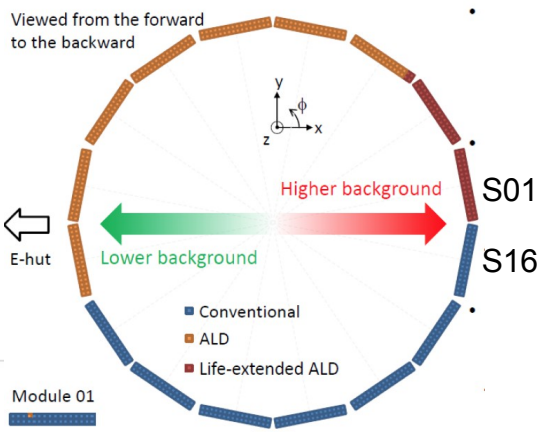
The 224 conventional MCP-PMTs in the 7 slots have to be replaced due to the QE degradation by the beam background.

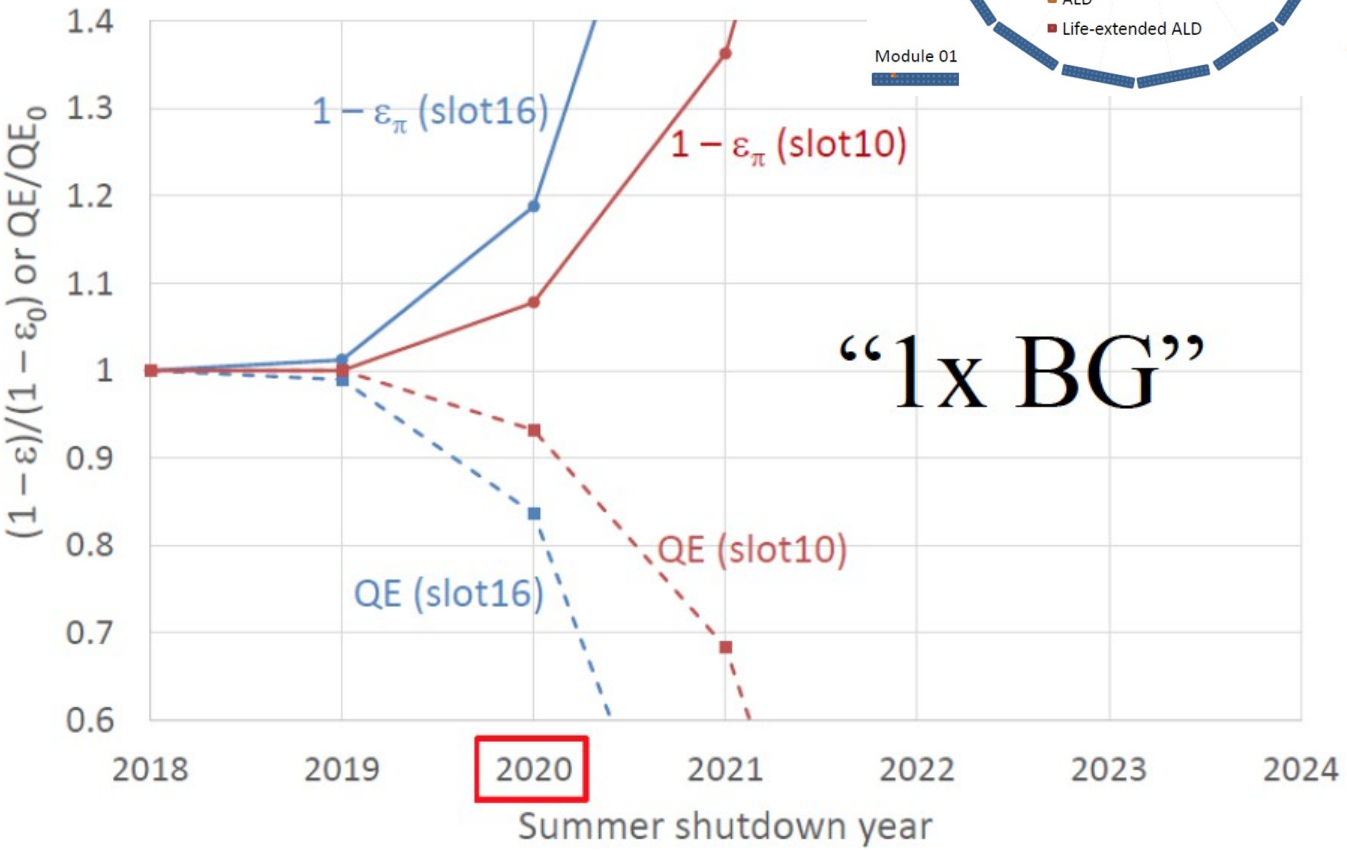
In 2015 the time of the replacement was estimated as the 2020 summer shutdown.

→ Revisit the estimation.

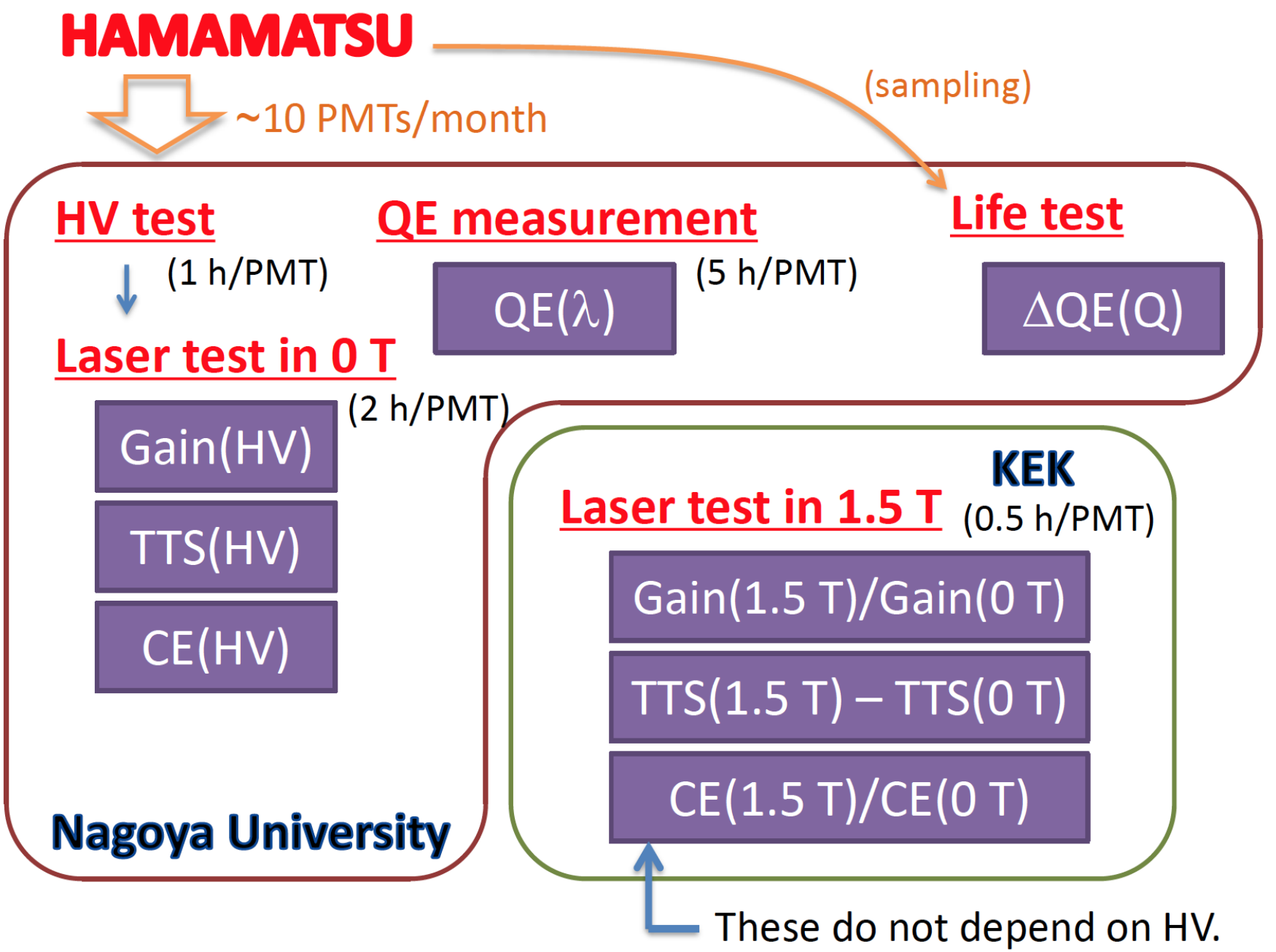
Need additional mass production of the MCP-PMTs for the replacement.

→ Discuss the production plan.





MCPPMT Replacement plans



Test plan (draft)

Year	2017				2018				2019				2020		
Month	1	4	7	10	1	4	7	10	1	4	7	10	1	4	7
Global schedule					Phase 2				Physics run			Physics run			
PMT production	Current production														
			Another small production												
							Mass production if necessary								
New PMTs (prospect)	28	26		5 /month			10 PMTs/month								
PMT test at Nagoya	10 /month			5 /month			10 PMTs/month								
PMT test at KEK							~100 PMTs				~100 PMTs				
PMT installation													Assy	Install	
Available PMTs	37	63	Unclear (depends on budget situation)												

Maximum rate:

- QE measurement: 2 PMTs/day = 40 PMTs/month
- HV test: 8 PMTs/day = 160 PMTs/month
- Laser test in 0 T: 5 PMTs/day = 100 PMTs/month

Test plan in 2017 (draft)

Year	2017																							
Month	3			4				5				6				7				8				9				10			
Events				Roll-in			Holidays					B2GM								Holidays			JPS				B2GM			
PMT production	Current production																													
																Another small production														
New PMTs (prospect)	28					10				10				6				5				5				5				5
QE measurement			10		10	8		10			10				6				5				5				5		
HV test			28					10			10				6				5				5				5		
Laser test in 0 T			25		3			10			10				6				5				5				5		
Available PMTs	37													63		Unclear (depends on budget situation)														

Maximum rate:

- QE measurement: 2 PMTs/day = 10 PMTs/week
- HV test: 8 PMTs/day = 40 PMTs/week
- Laser test in 0 T: 5 PMTs/day = 25 PMTs/week

MCPPMT Replacement plans

- HV, laser (0 T), QE tests at Nagoya
  - Test PMTs after delivery as quickly as possible to find out and feed back any problem to the production.
  - Measure the QE of each PMT at least two times (just after delivery and several months later) to check the QE stability.
- Laser (1.5 T) at KEK
  - Need two persons to use the magnet (safety regulation).
  - Test a batch of PMTs (>100 PMTs/month), one month in 2018 and another month in 2019.
    - This is because the setup has to be uninstalled when other groups use the magnet, and a large overhead is needed to reinstall and tune the set up.

MCPPMT Replacement plans

PMT to be replaced: 161 PMT Production: 200
Test at Nagoya: Continuous test starting from April 2017 for 3 years
Test at KEK: 100 PMT Oct.-Dec. 2018 , 100 PMT Oct.-Dec. 2019

Man Power:
Test at Nagoya: 36 months * (2/3 working weeks when PMTs are available ?) * 1 person = 24 FTE per month
Test at KEK: 6 months * 2 persons = 12 FTE per month

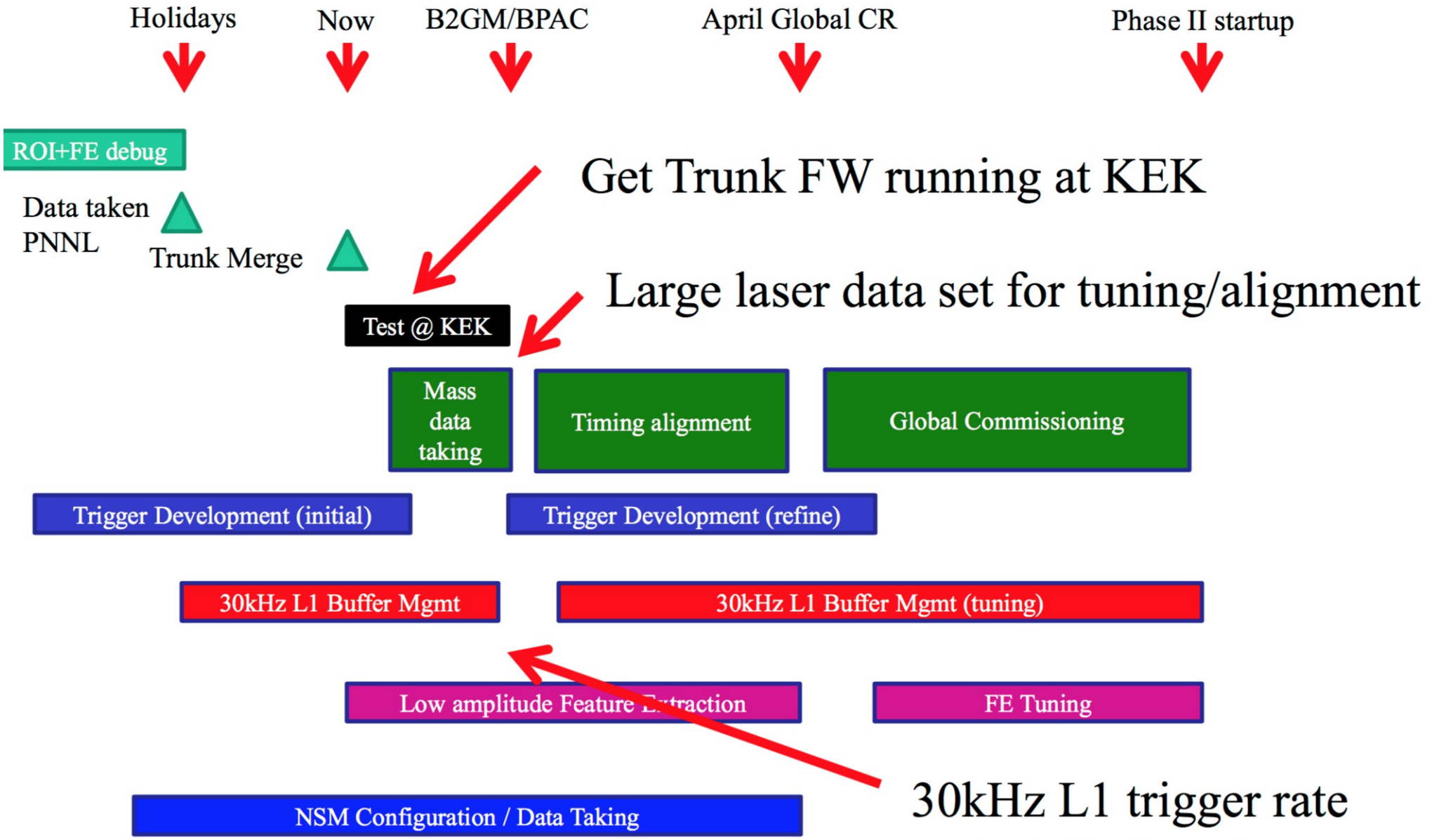
Tot: 36 FTE per month

Italian proposal for manpower (baseline : 25% of the activity):

9 FTE per month = 1 person x 1.5 months x 3 years (Padova)
+ 1 person x 1.5 months x 3 years (Torino)

Backup

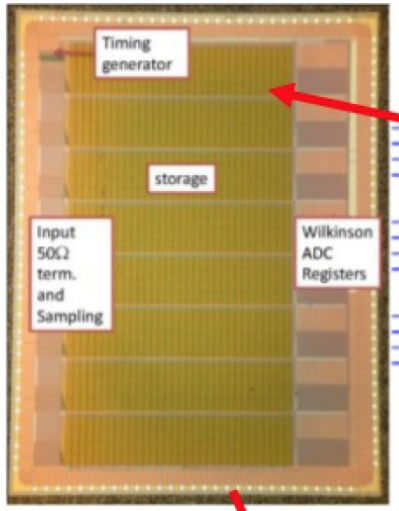
Critical Path

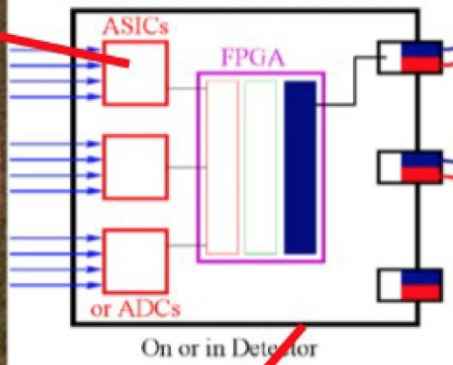


TOP DAQ

Waveform sampling ASIC

64 DAQ fiber transceivers

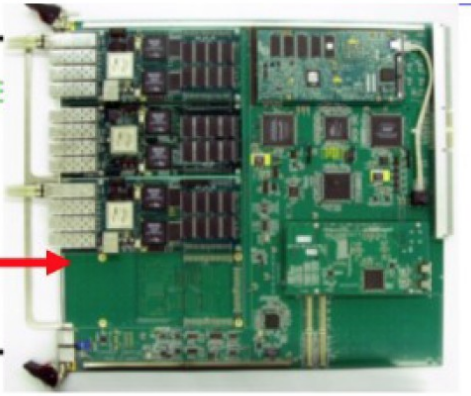




Giga-bit Fiber Transceiver Links

COPPER

FINESSE



64 FINESSE
16 COPPER

Global Decision Logic

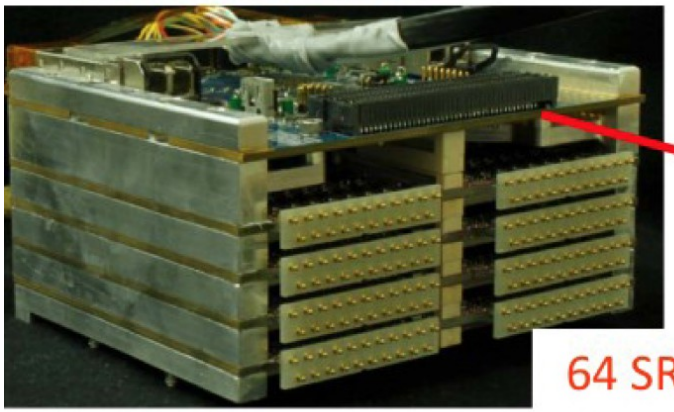
2x UT3 Trigger modules

FPGA firmware consists of 3 parts:
1) ASIC/ADC driver (common)
2) Trigger feature extract (subdet. specific)
3) Unified DAQ transport protocol

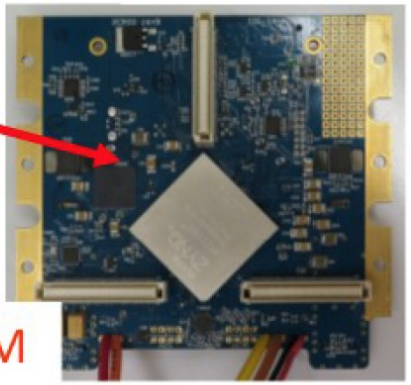
8k channels
1k 8-ch. ASICs
64 "board stacks"

Low-jitter clock

Clock/Event Timing Distribution



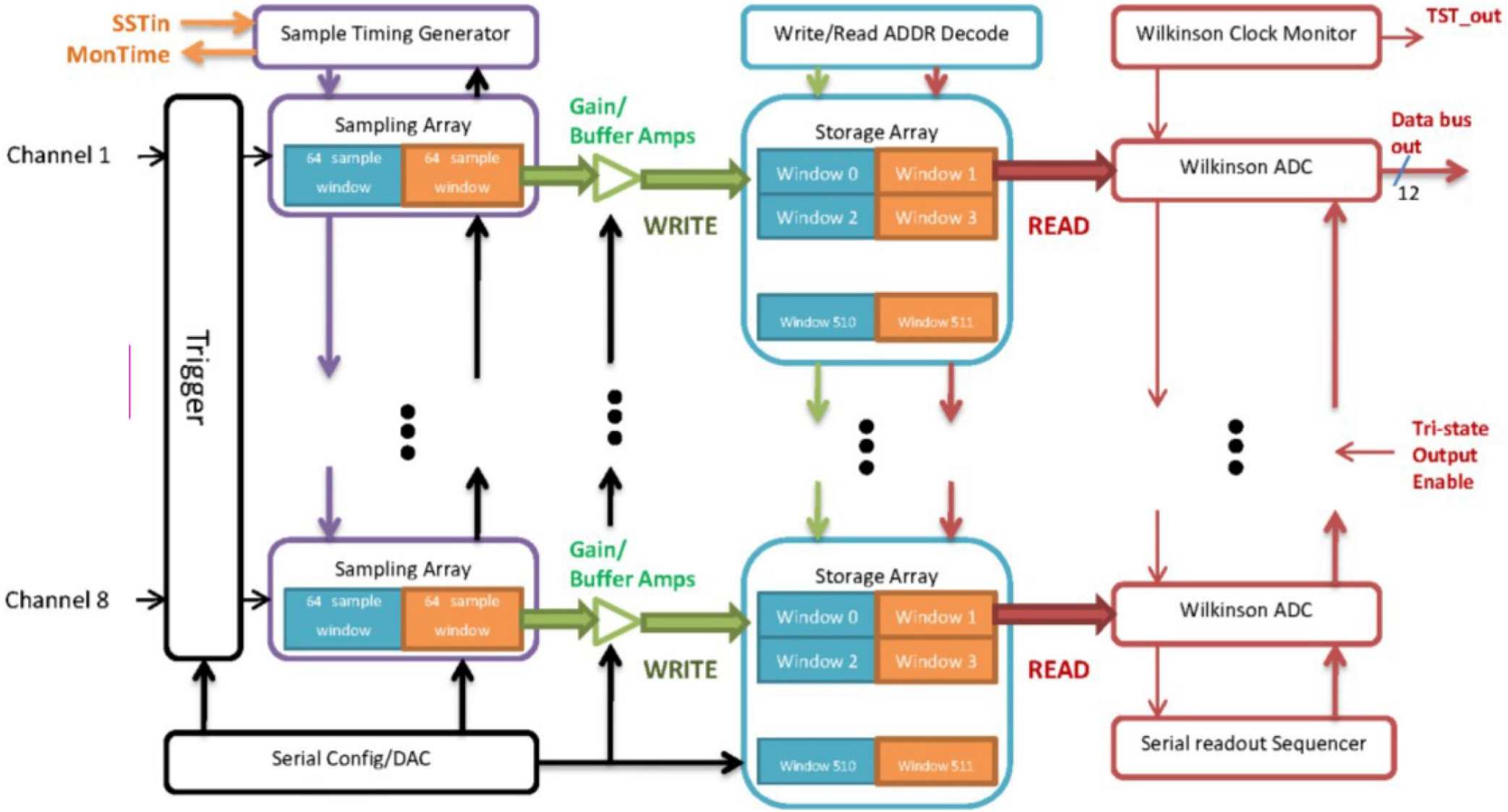
64 SRM



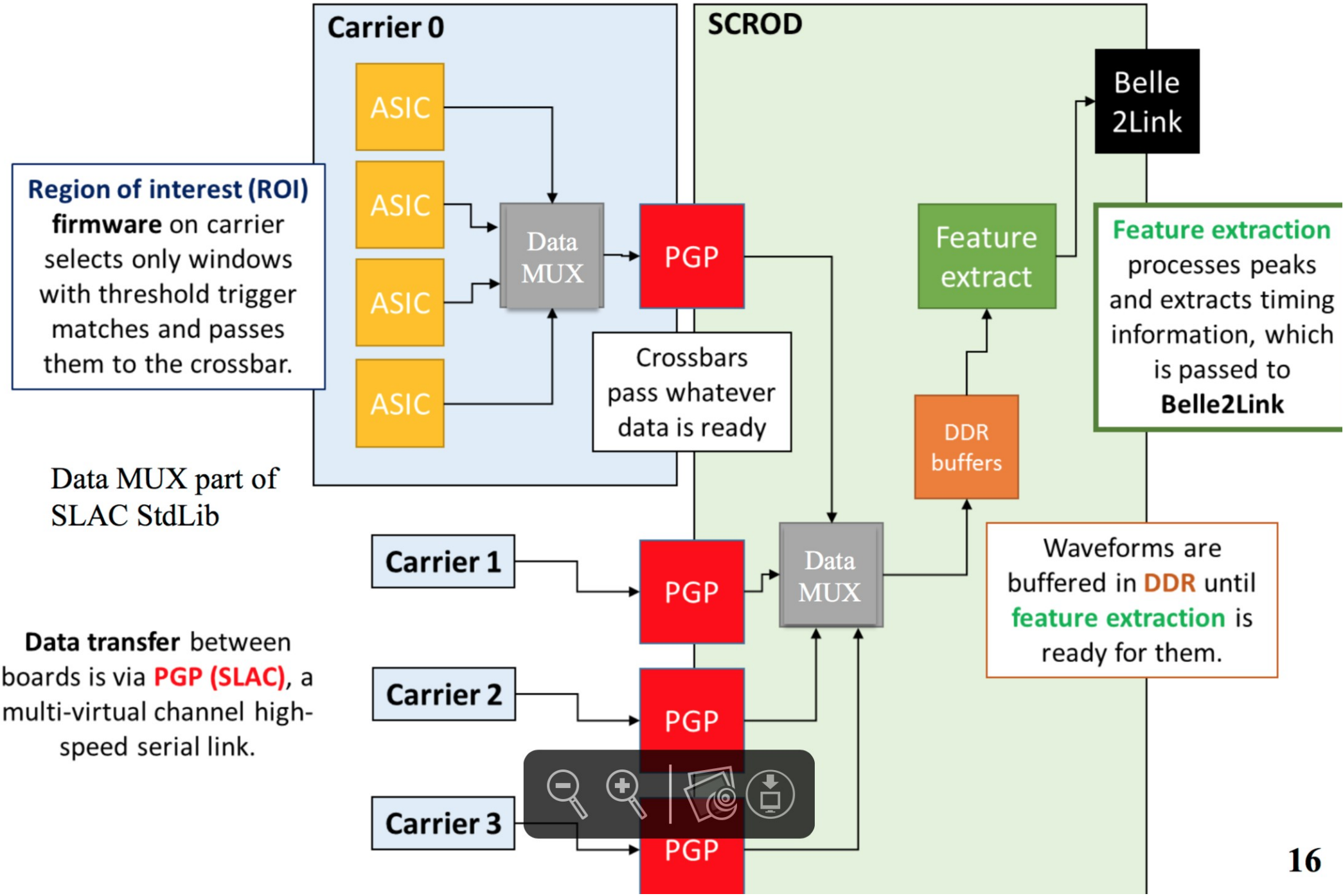
Clock, trigger, programming module (FTSW)

8 FTSW

TOP FEE: a scope on a chip

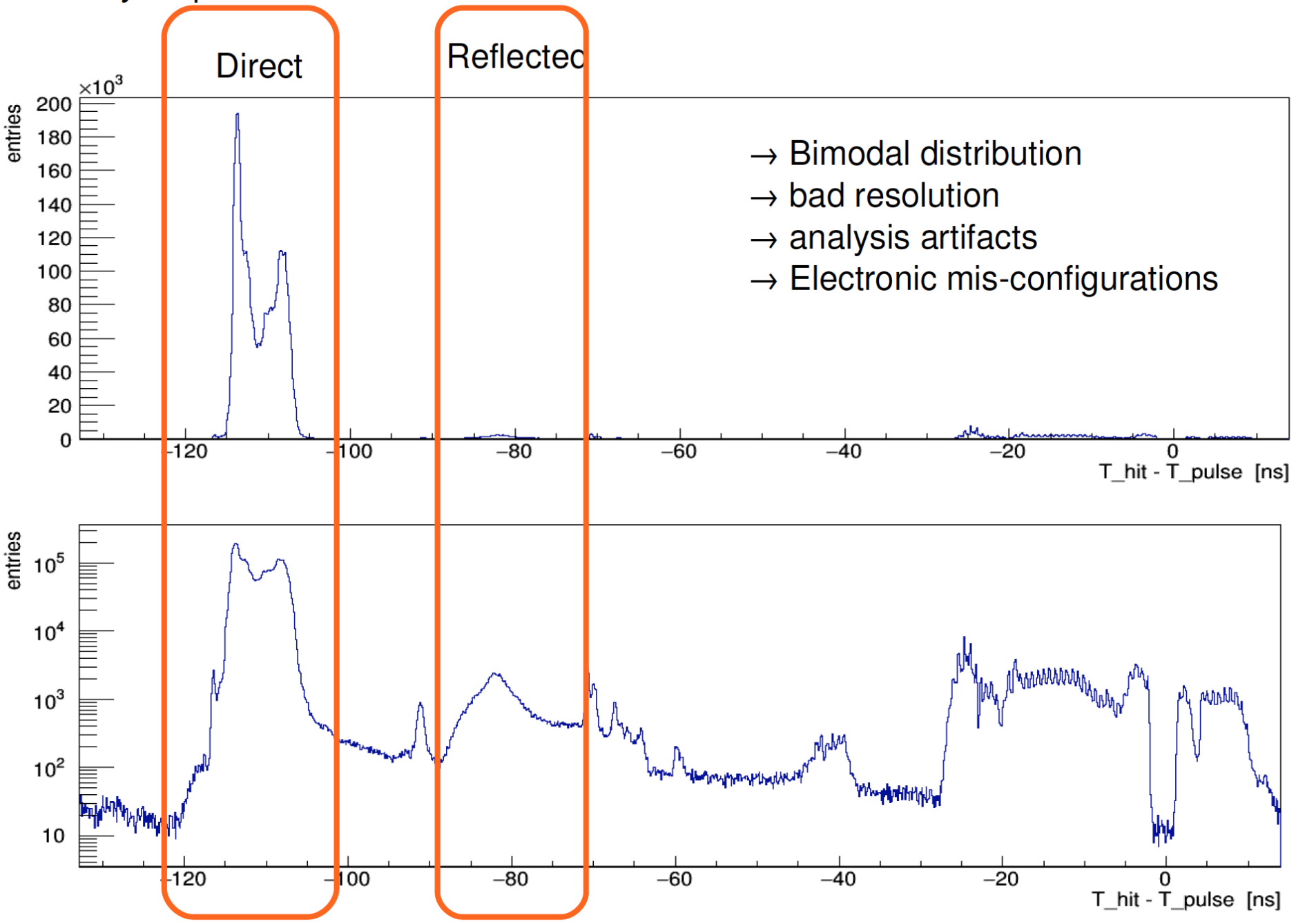


FW Functional Overview

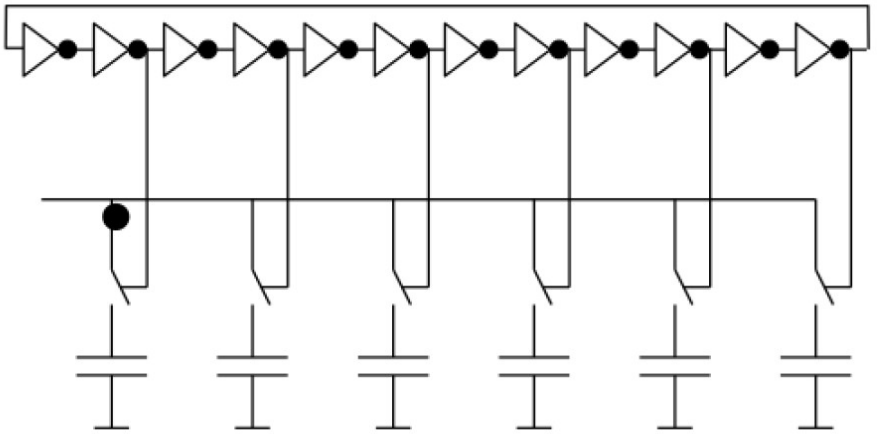


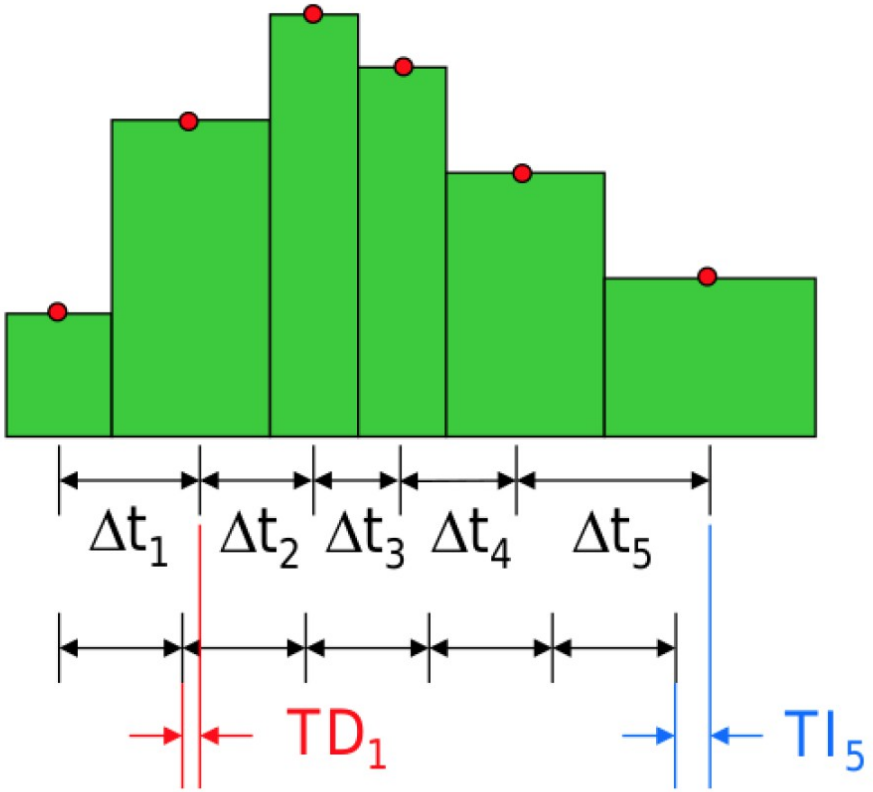
TOP tomography: real data

Reality is quite different from the ideal MC



TOP readout: Time base calibration





- Inverter chain has transistor variations
  → Δt_i between samples differ
  → "Fixed pattern aperture jitter"
- "Differential temporal nonlinearity"
  $TD_i = \Delta t_i - \Delta t_{nominal}$
- "Integral temporal nonlinearity"
  $TI_i = \Sigma \Delta t_i - i \cdot \Delta t_{nominal}$
- "Random aperture jitter" = variation of Δt_i between measurements

TOP Organization

- Leader: Toru Iijima
- Deputy: Gary Varner
- Gemba leader: Kenji Inami
  - Supervision to all Gemba works
  - Liaison to KEK