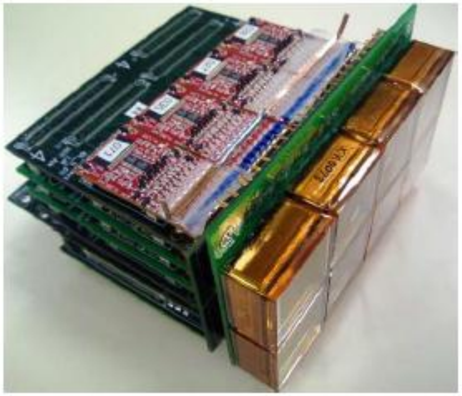
(Some) T1019 Beam Test Experience

January 19, 2012

University of Hawaii

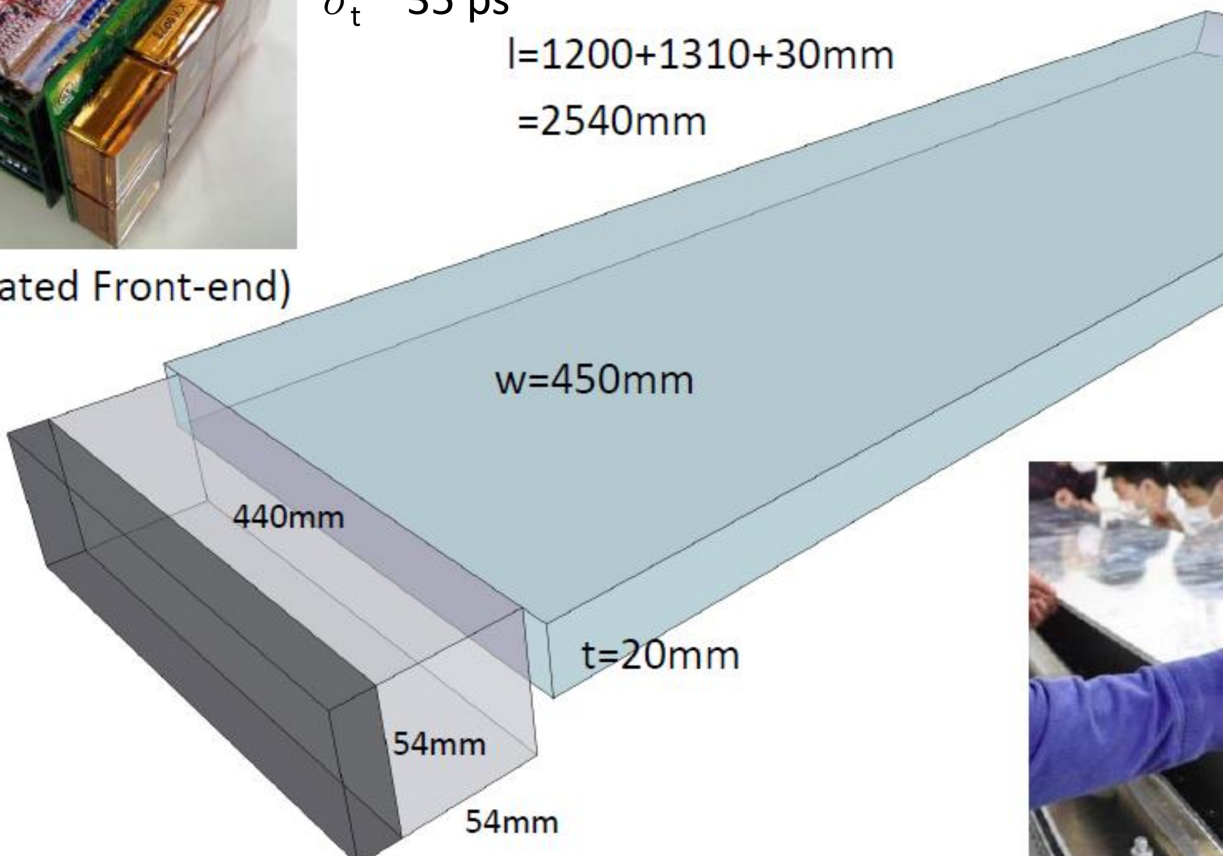
LAPPD Electronics Meeting

What to test – detector components



SL10 MCP-PMTs
4x4 anode structure
$\sigma_t \sim 35$ ps

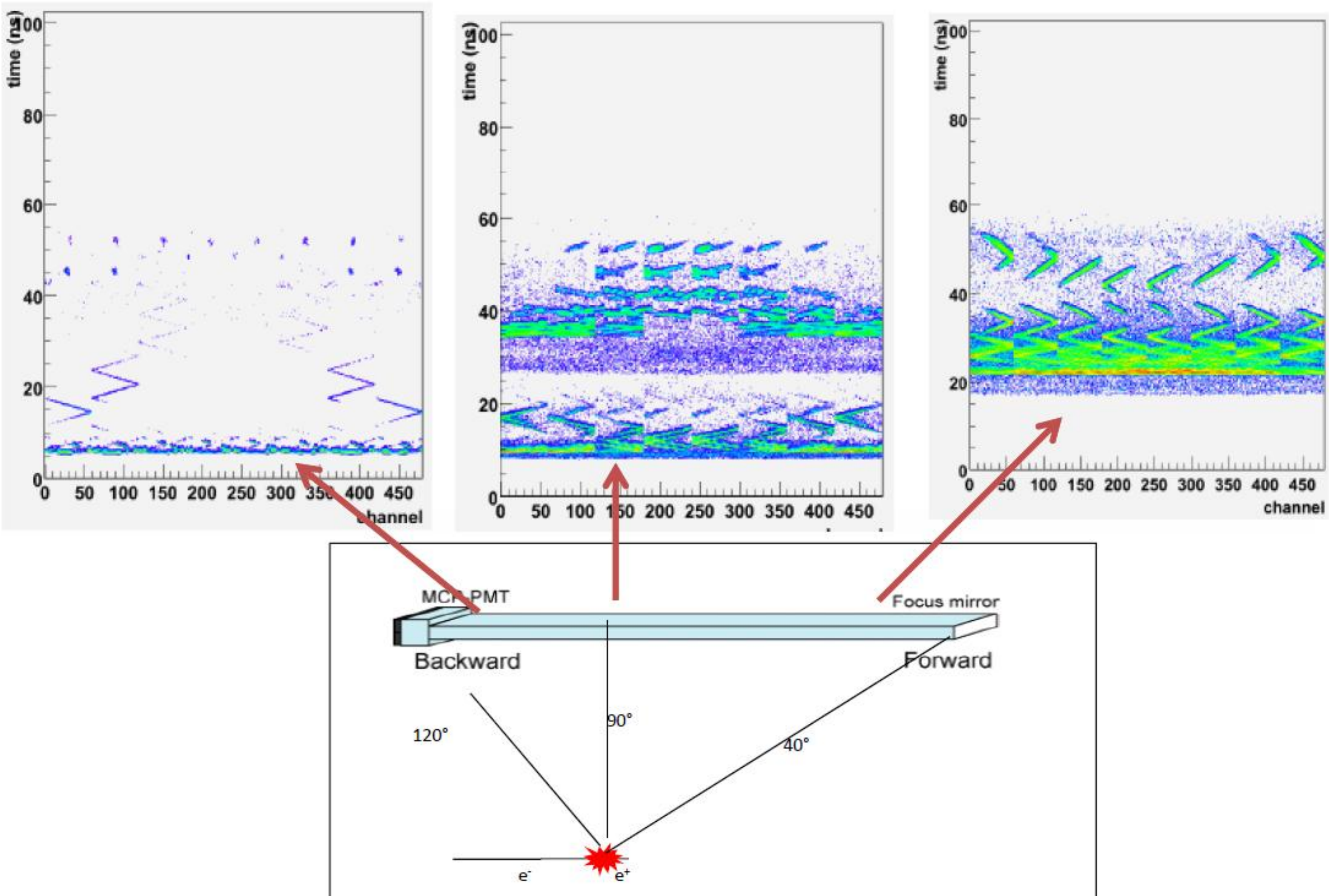
(Integrated Front-end)

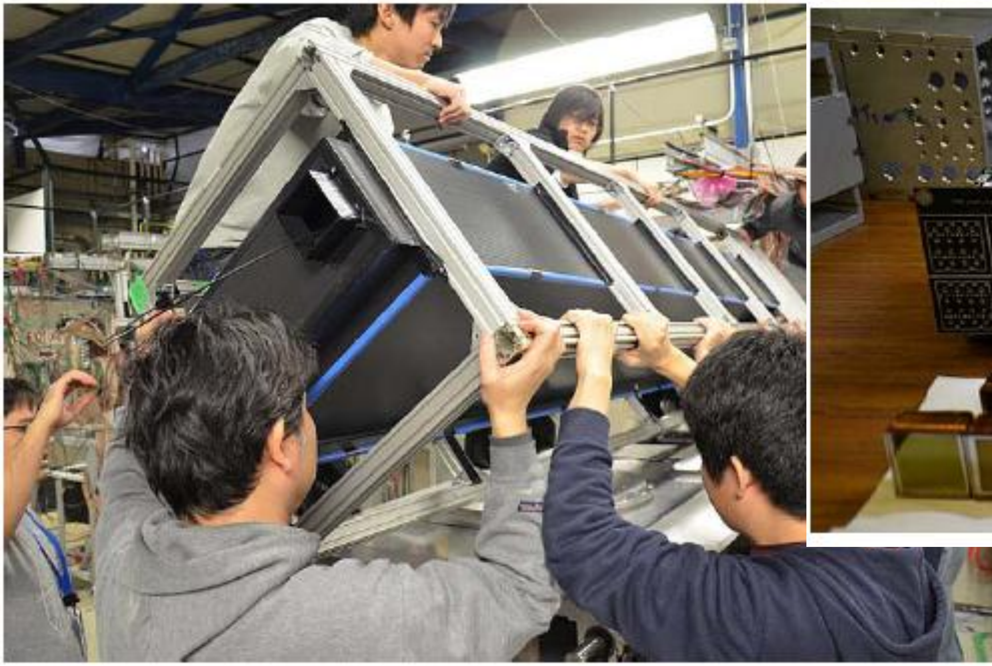


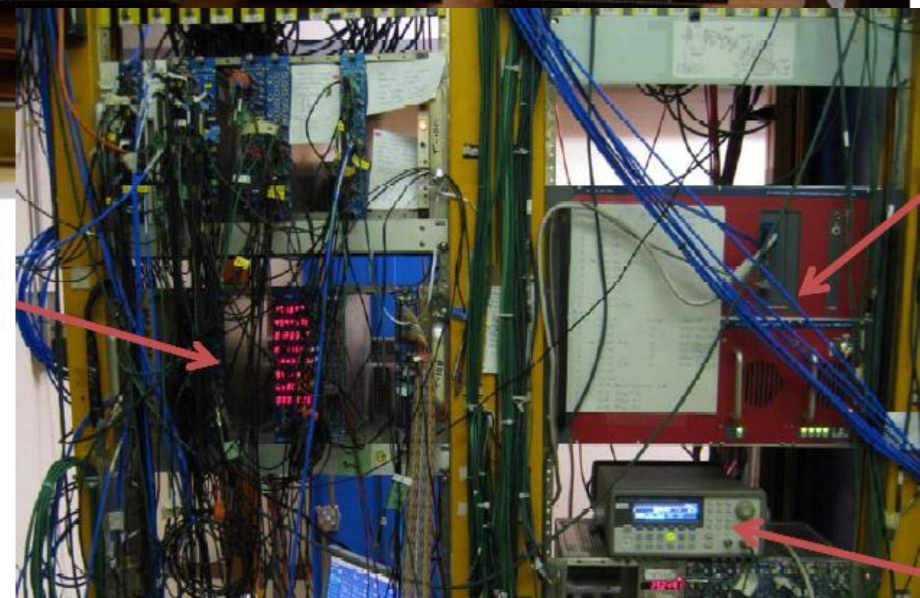
(Integration at Nagoya University)

Belle II Particle Identification (p/K separation) upgrade
Start running at SuperKEKB in 2015

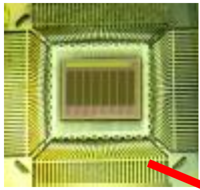
Cherenkov Photon Arrival Patterns (MC)



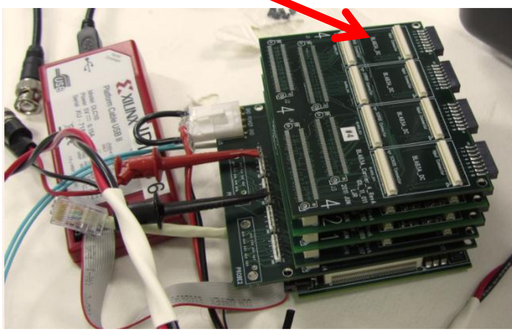




Beam Test Electronics Elements

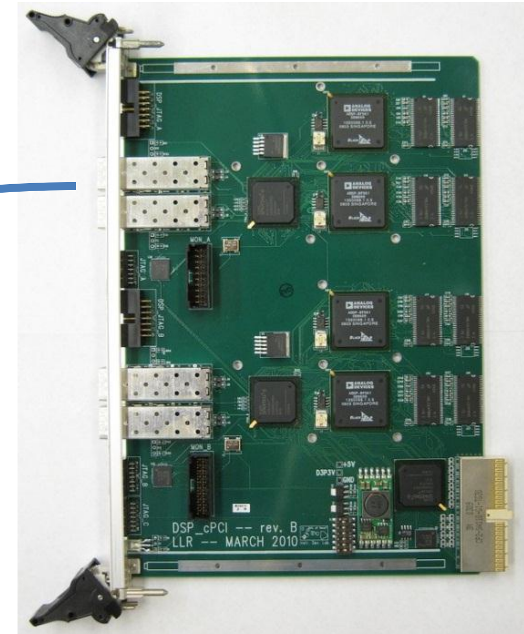


Waveform sampling ASIC (IRS2/3)



SCROD-based board stack (Spartan-6) (x3, total 384 channels, 320 instrumented)

Aurora-based fiberoptic data

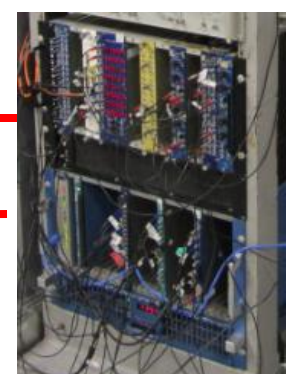


DSP_cPCI (Spartan-6)

Timing/trigger distribution (CAT-6)

Remote programming link (CAT-6)

FTSW (timing distr. + remote JTAG)



NIM trigger logic

CAMAC TDC (trigger phase alignment)

Timing/Trigger Distribution

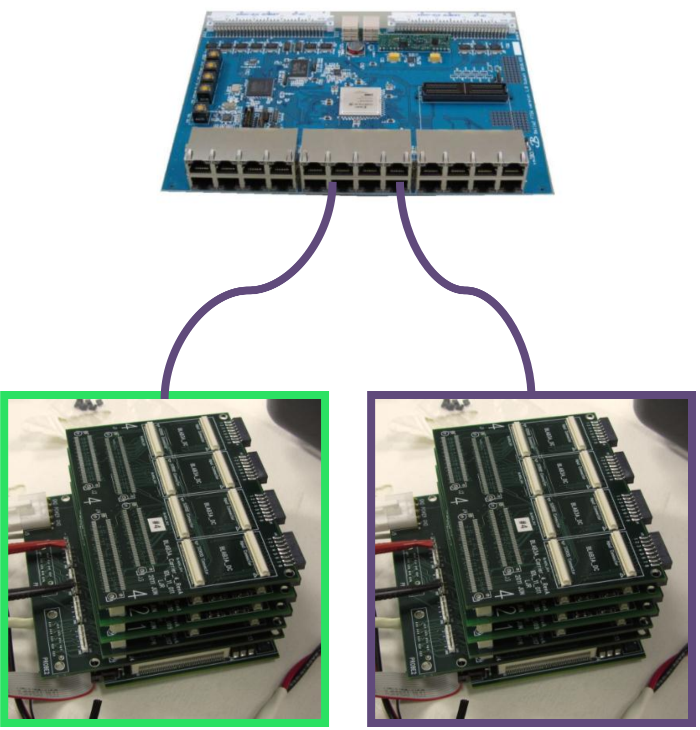
- Clock strategy:
  - Derive 21 MHz clock from FTSW-distributed 127 MHz (for final system, this is RF clock / 4; for now, it's from a dedicated oscillator on FTSW).
  - 21.2 MHz clock must be phase aligned across all modules.
- Serial data stream from FTSW is used to divide and synchronize clocks across all modules. Some caveats:
  - Timing constraints are very tight.
  - Could only get this firmware to act stably by manually specifying the location of the PLL:

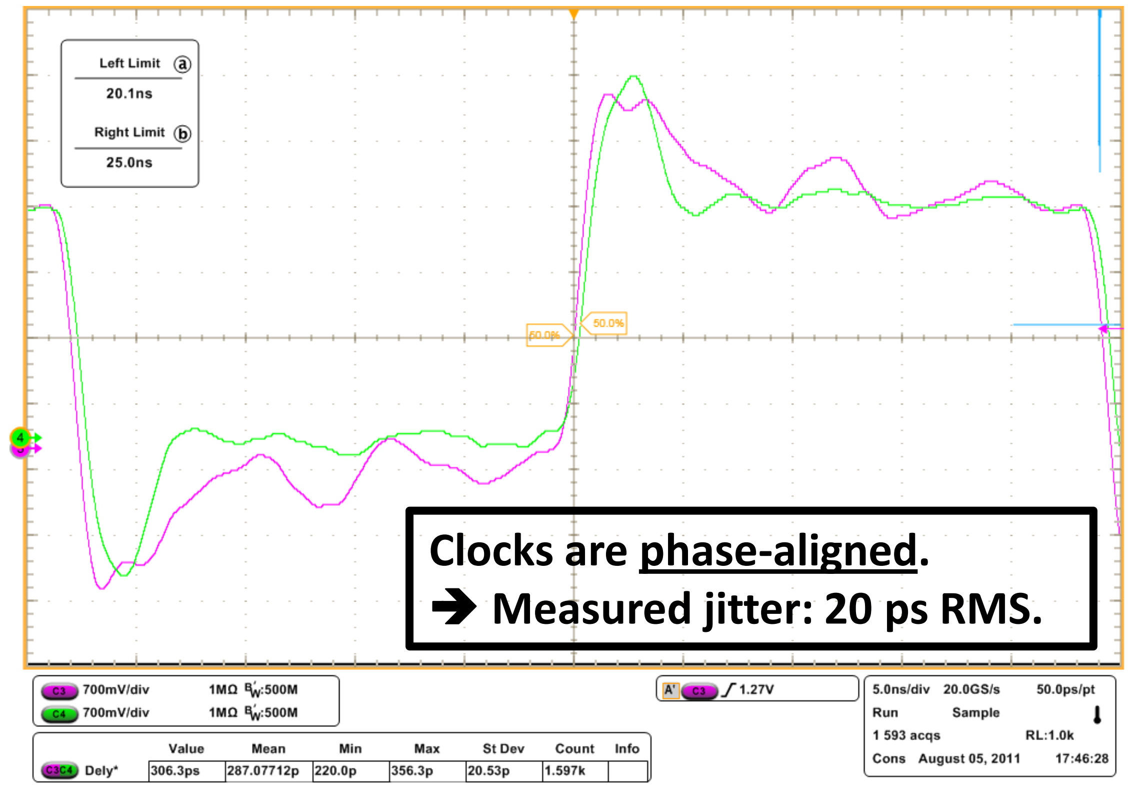
```
#The location of the FTSW receiver PLL seems to only work in specific locations.
#The one below is verified working... others may also work but have not been
#systematically tried.
INST map_clocking_and_ftsw_interface/map_FTSW_interface/map_belle2clk/map_pll/map_pll  LOC = PLL_ADV_X0Y0;
```

  - If this timing link is ever lost (cable unplugged, high noise, etc.), it never recovers. Could be Spartan-6 limitation?
  - When timing link is down serial trigger stream decoder finds triggers constantly.
  - CAT-6 cable was found to be much more reliable than CAT-7.

Timing/Trigger Distribution

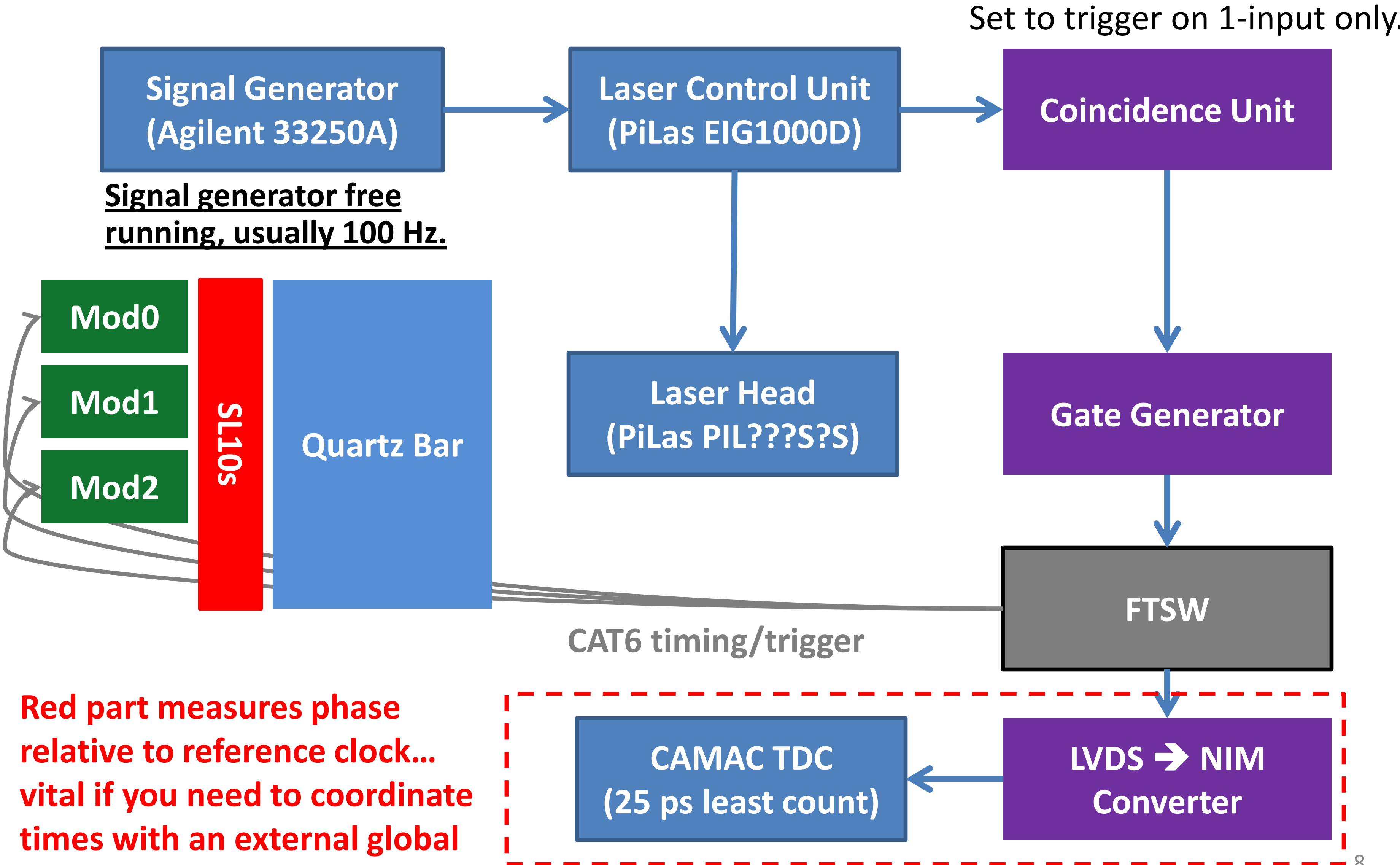
- Timing results from bench test between two SCRODs in August 2011:





Measured phase and jitter of 21.2 MHz clock from two SCRODs (on oscilloscope)

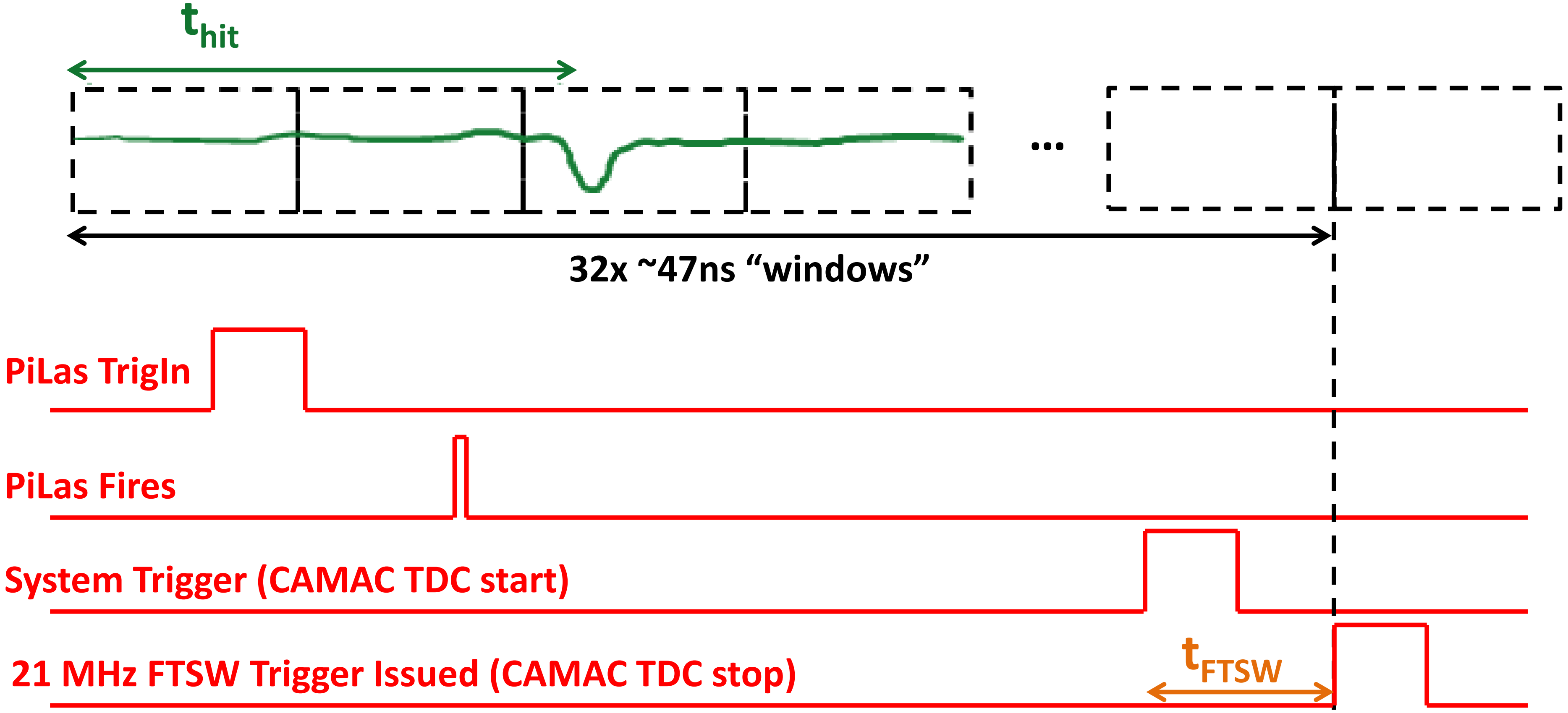
Beam Test Timing - Standard Laser Runs



Red part measures phase relative to reference clock… vital if you need to coordinate times with an external global trigger.

Standard Laser Runs - FTSW Timing

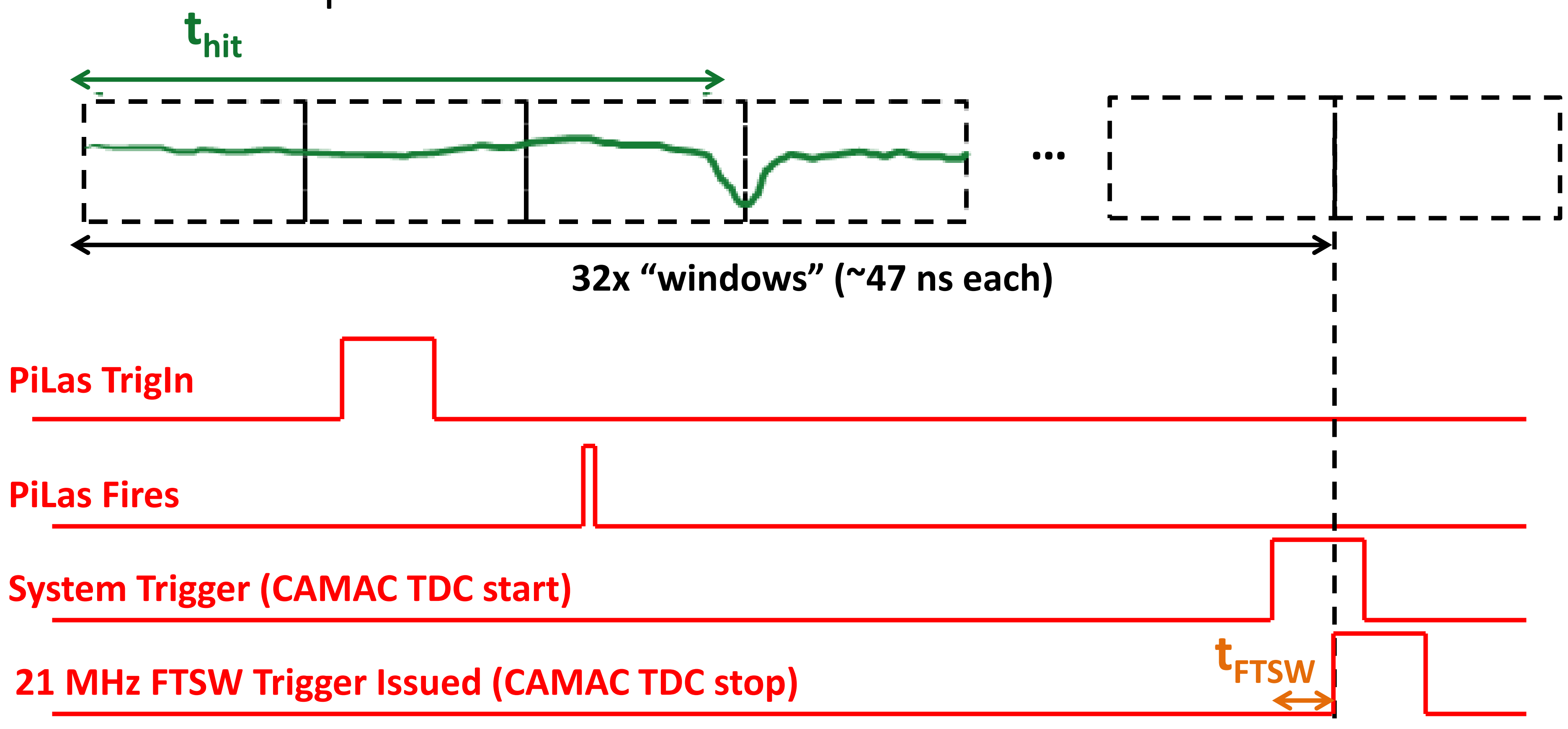
- Events are random with respect to FTSW trigger…
  - …but laser fires at a fixed time relative to the global trigger.
  - Example 1:



Smaller t_{hit} ➔ larger t_{FTSW}

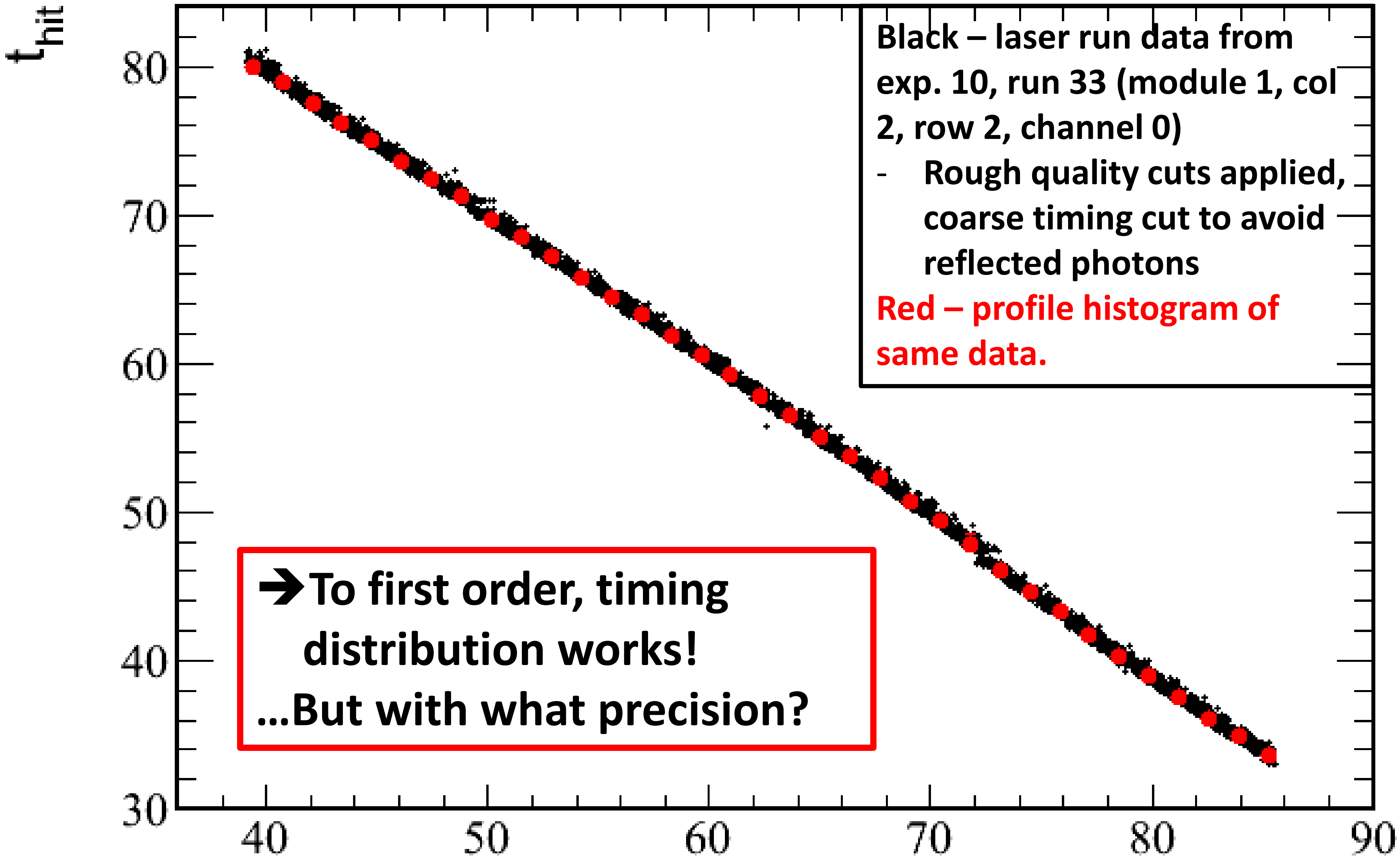
Standard Laser Runs - FTSW Timing

- Events are random with respect to FTSW trigger…
  - …but laser fires at a fixed time relative to the global trigger.
  - Example 2:



Larger t_{hit} ➔ smaller t_{FTSW}

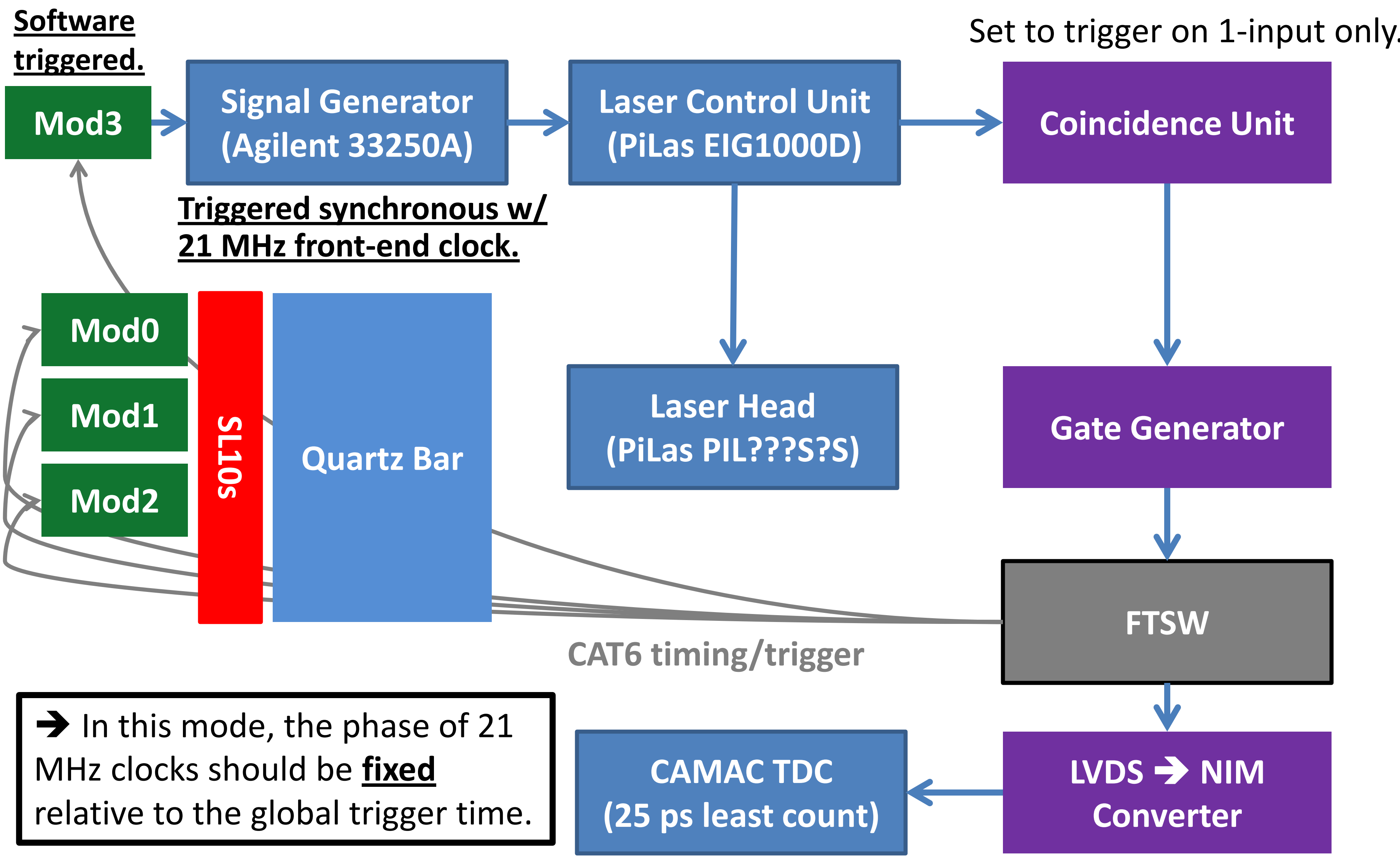
Standard Laser Run - Distributions



No fine calibration applied: assumed 2.7 GSa/s for all samples; 25 ps / count for CAMAC TDC.

Time extracted by software fixed threshold discrimination (-40 ADC counts).

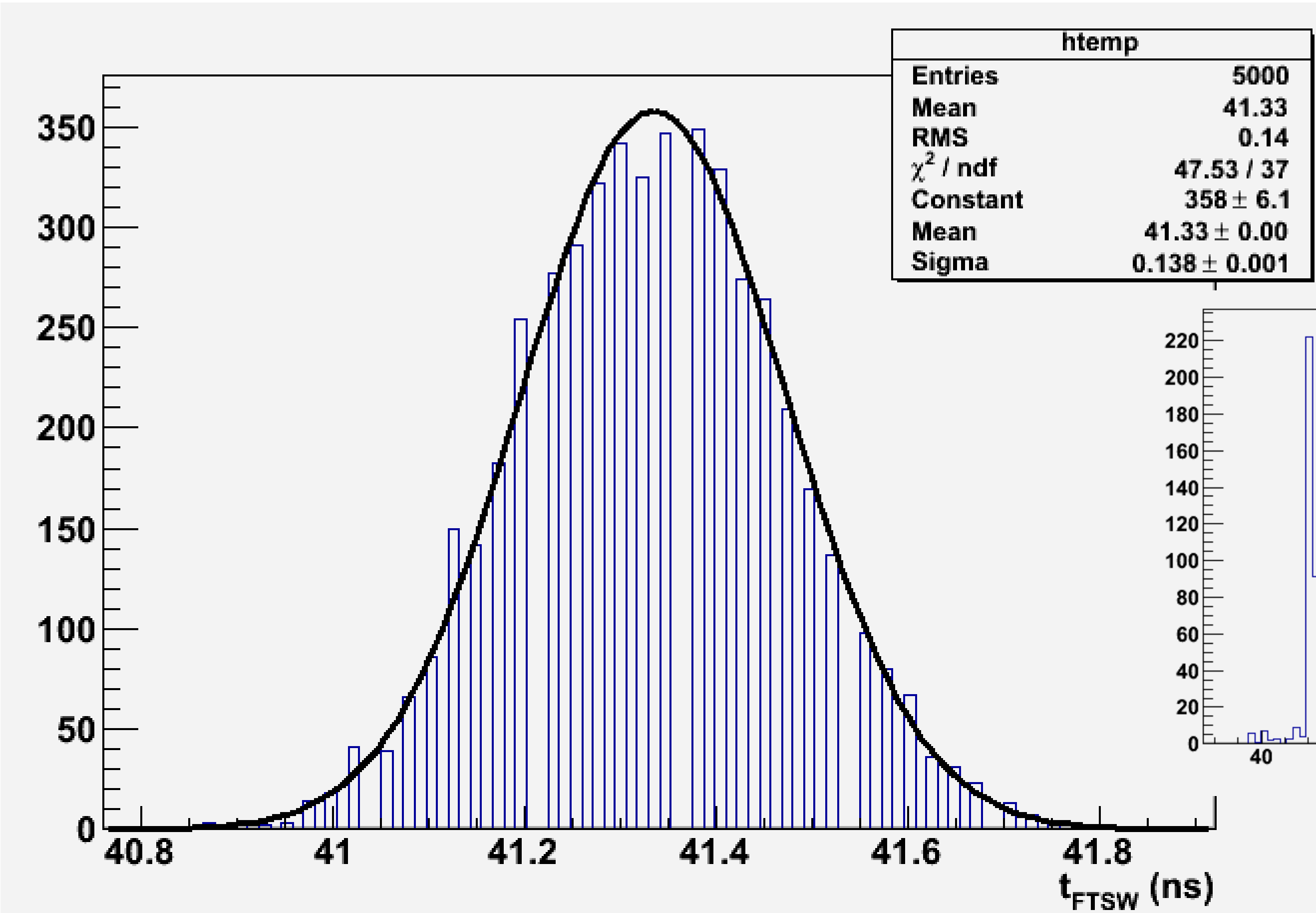
Beam Test Timing – “Special” Laser Runs



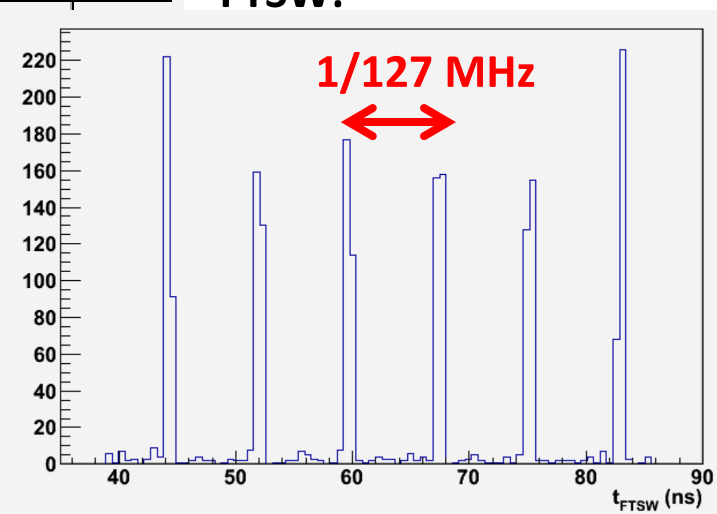
→ In this mode, the phase of 21 MHz clocks should be **fixed** relative to the global trigger time.

Measured FTSW Timing - “Special” Laser Runs

- Typical TDC distribution of trigger phase:



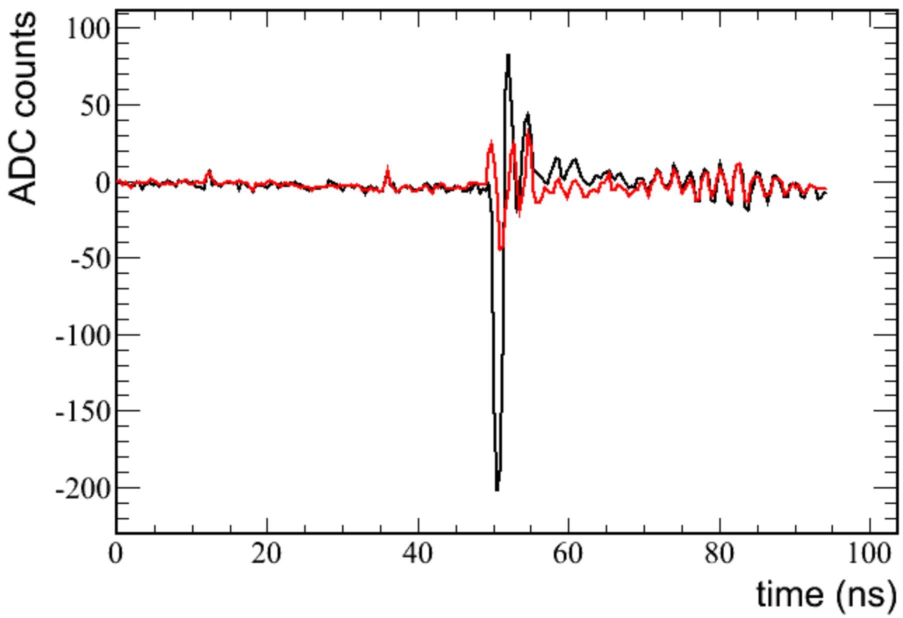
Trigger phase measurements when module loses its synchronization with FTSW:



➔ Absolute global time resolution will never be better than this!

Is this due to intrinsic jitter in timing distribution, or jitter in the measurement?

Other issues: Waveform Processing



Example SL10 waveform from beam data:

Black – primary hit
Red – cross talk on an adjacent channel

- Simplified waveform processing plan:
  - Each DSP core feature-extracts hits from a single SCROD.
    - One waveform in ➔ apply pedestal/timing cal. ➔ one time+charge out.
- More realistic plan:
  - DSP cores need to be aware of potential cross-talk hits from other anodes in the MCP-PMT. Feature extraction proceeds based on all available waveforms from a given PMT.

➔ **Integrated front-end waveform processing may be more complex than anticipated…**

T1019 Summary

- T1019 beam test at Fermilab:
  - First system-level test of many components & features.
  - Lots of data, millions of photon candidates.
  - Analysis will be ongoing for some time… but we already some valuable feedback:
    - Timing distribution issues: requires a lot of care and attention.
      - Are event-by-event phase measurements necessary?
    - Distributed timing jitter: still under investigation… much worse than originally thought? If so, why?
    - Front-end waveform processing schemes may need to be considerably more complicated than 1 waveform ➔ 1 time/charge.
- Now duplicating as much as possible the beam test setup in Hawaii for further studies.
  - Will report more as we learn it…

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National Science Foundation: Science Hard

INDIANAPOLIS—The National Science Foundation's annual symposium concluded Monday, with the 1,500 scientists in attendance reaching the consensus that science is hard.

"For centuries, we have embraced the pursuit of scientific knowledge as one of the noblest and worthiest of human endeavors, one leading to the enrichment of mankind both today and for future generations," said keynote speaker and NSF chairman Louis Farian. "However, a breakthrough discovery is challenging our long-held perceptions about our discipline—the discovery that science is really, really hard."

"My area of expertise is the totally impossible science of particle physics," Farian continued, "but, indeed, this newly

see SCIENCE page 5

Right: Farian explains the NSF findings.