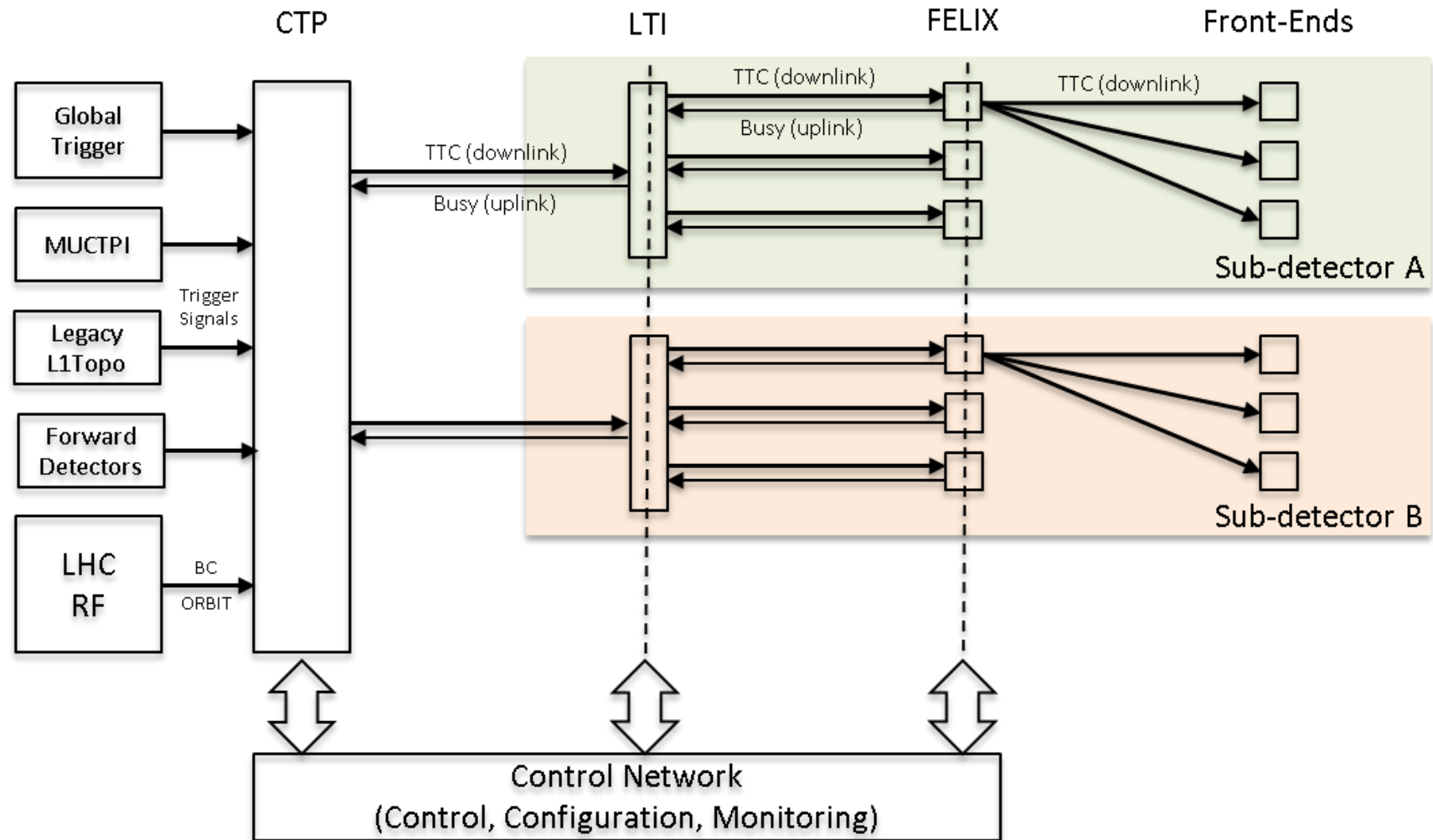# Updates on the TCLink evaluation for the ATLAS Phase-2 TTC distribution

Paschalis Vichoudis (CERN) on behalf of the ATLAS Central Trigger team

# ATLAS TTC
PHASE-II

PREVIOUSLY

end-2021 report on TCLink evaluation for ATLAS phase-II TTC distribution:

- Shown a 3-board/2-hop test setup

  -> based on Xilinx ZCU102 devkits and TTC PON FMCs

- Confirmed it is protocol agnostic

  -> implemented 8b10b encoding at 9.6Gb/s

- brought-up the links successfully

- Noticed phase uncertainty in the recovered clock -> ~25ps per hop

- Shown no correlation between DDMTD and phase uncertainty

  -> the DDMTD measurement cannot be used for correction

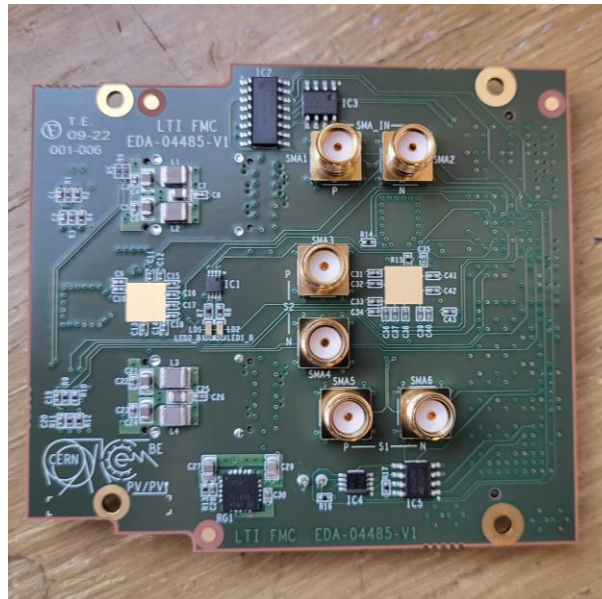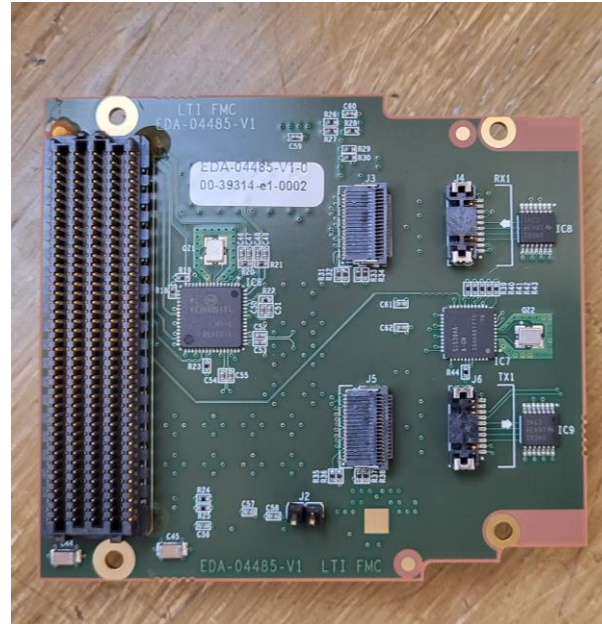- Promised test setup improvements -> new FMC w/ lower jitter

THE NEW FMC

DIAGRAM

EDA-04485-v1-0

Key improvements

- Firefly Optics

- Cleaner signal path (Removed switch ICs)

- More precise clock generator IC

- Lower crosstalk between Jitter Cleaner outputs

- Improved routing

- CLK40 TIE jitter: ~1ps (was ~2ps)
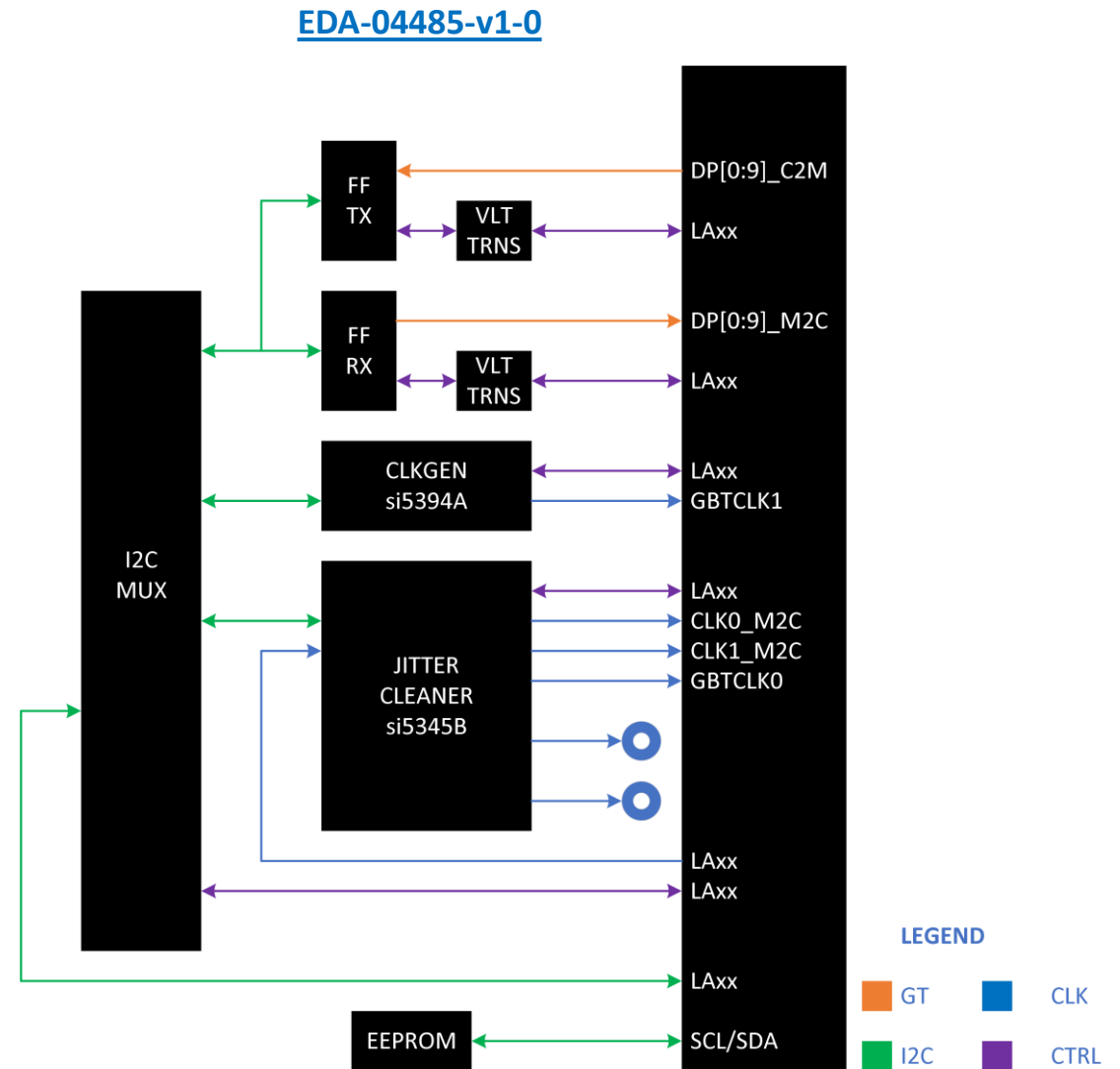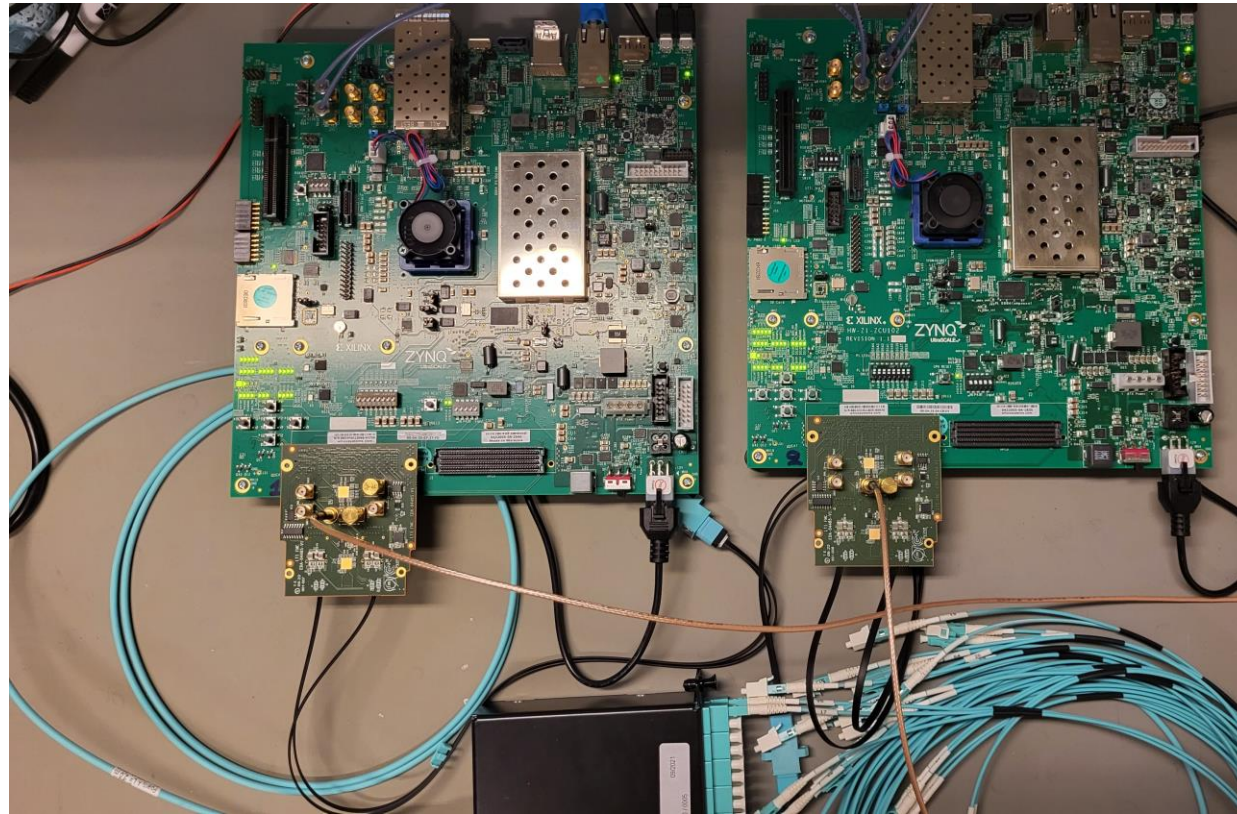
THE NEW FMC

PICTURES

THE NEW SETUP

PICTURES

2-board/1-hop setup

- 3-board/2-hop setup to follow

THE NEW SETUP

CLOCKING

ZYNQ PL

S GT (B129)

REC CLK40 LOGIC | QPLL | RX | TX | CPLL

M GT (B130)

CPLL | RX | TX | QPLL | DMTD

CLK40

CLKGEN
si5394A

JITCLN
si5345B

LTI FMC
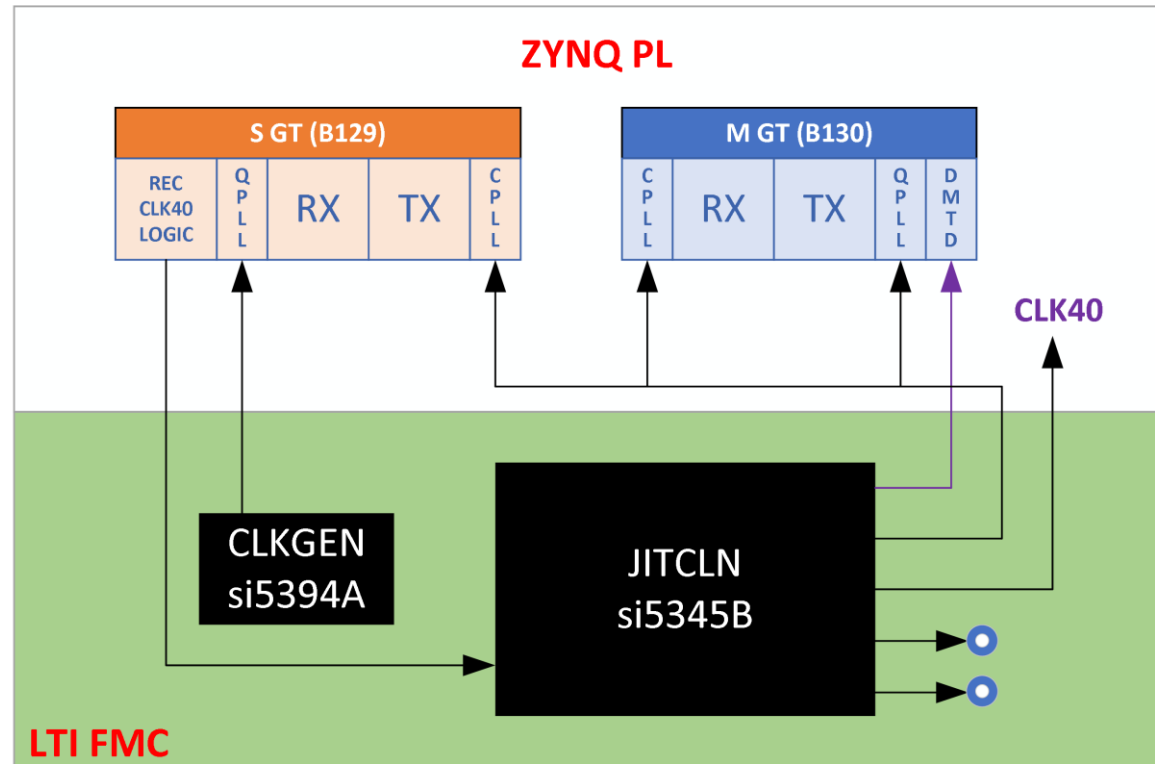
TXOUTCLK -> TXPLL REFCLK DIV1

RXOUTCLK -> RXOUTCLK PMA

THE NEW SETUP

CLOCK RECOVERY

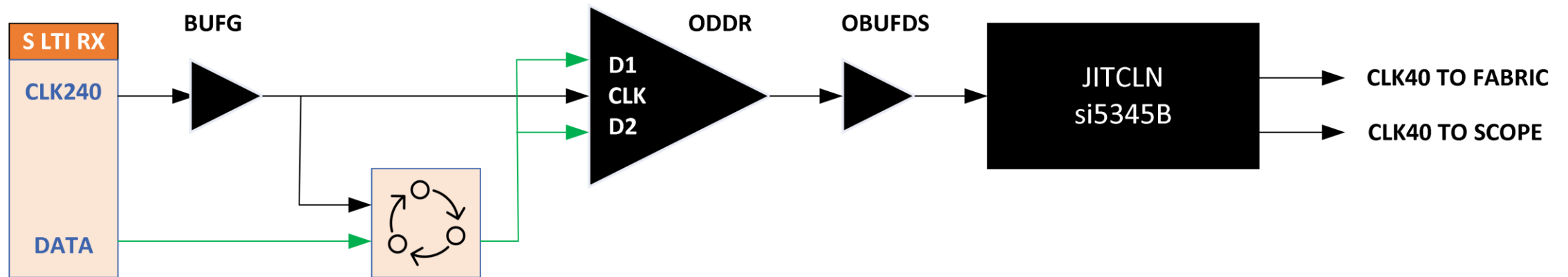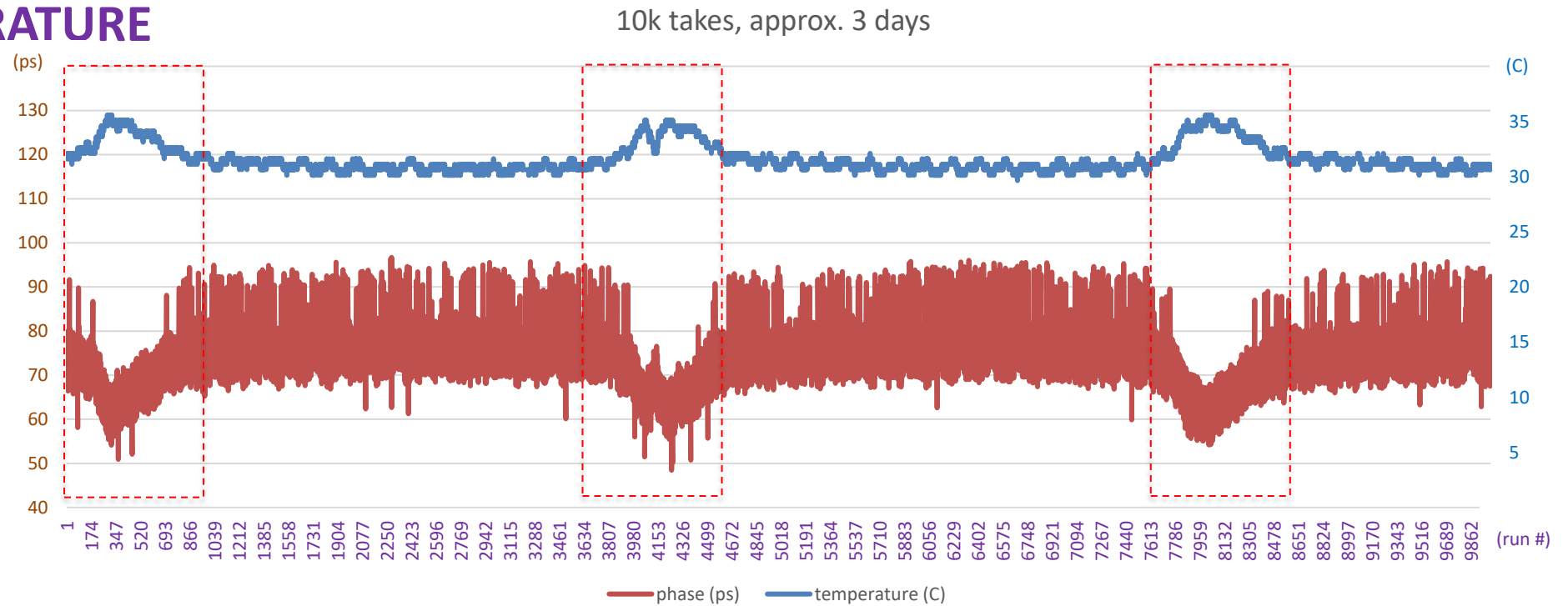Also examined alternative implementations: using CLKDIV or MMCM, all show similar behaviour

MEASUREMENTS

PHASE vs TEMPERATURE

+/- 0.5 degree C variation when taking out the red regions (equivalent to sensor's accuracy)

10k takes, approx. 3 days

- **Reset order**: *LTI-1 TX -> LTI-2 RX -> LTI-2 TX -> LTI-1 RX*
- **Data points**: *each one is the mean from ~100k scope measurements (sdev = ~2ps)*
- **Time between runs**: *~22 seconds*
- **Temperature**: *Stable (+/- 0.5 deg C)*

TCLink fw version used

MEASUREMENTS

PHASE HISTOGRAM
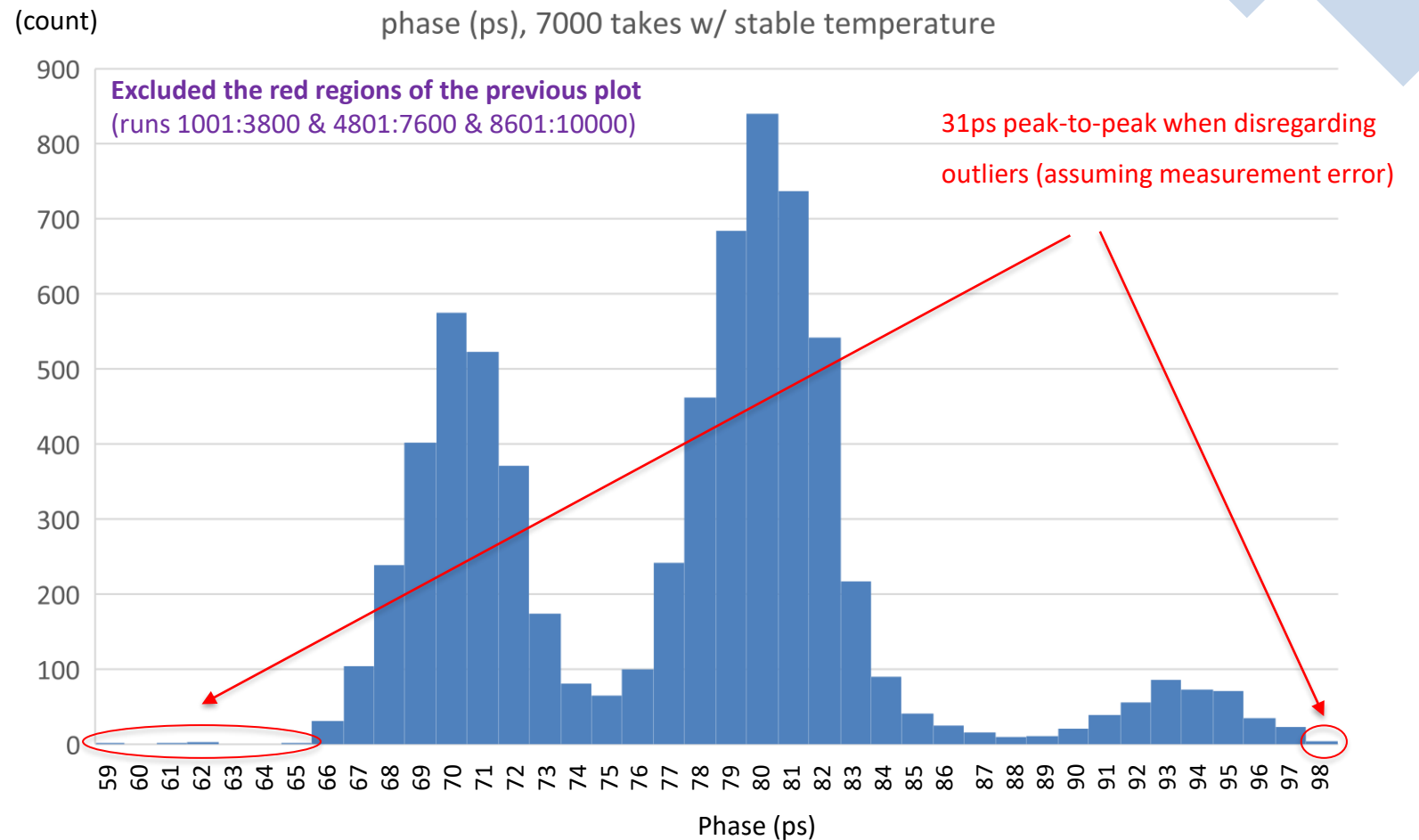
(count)

phase (ps), 7000 takes w/ stable temperature

Excluded the red regions of the previous plot (runs 1001:3800 & 4801:7600 & 8601:10000)

31ps peak-to-peak when disregarding outliers (assuming measurement error)

Phase (ps)

- **Reset order**: LTI-1 TX -> LTI-2 RX -> LTI-2 TX -> LTI-1 RX
- **Data points**: each one is the mean from ~100k oscilloscope measurements (sdev = ~2ps)
- **Time between runs**: ~22 seconds
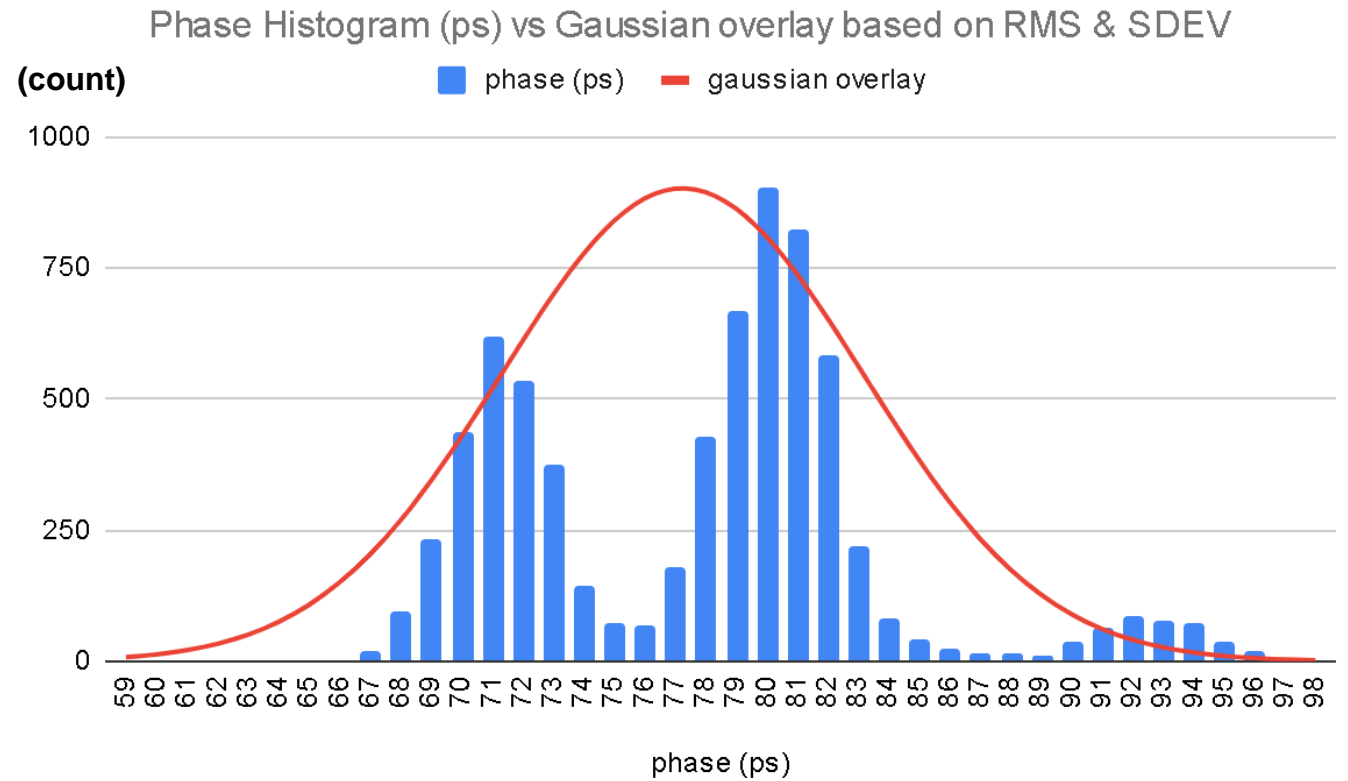- **Temperature**: Stable (+/- 0.5 deg C)

MEASUREMENTS

NOT A GAUSSIAN (OBVIOUSLY)

Phase Histogram (ps) vs Gaussian overlay based on RMS & SDEV

- **Reset order**: *LTI-1 TX -> LTI-2 RX -> LTI-2 TX -> LTI-1 RX*
- **Data points**: *each one is the mean from ~100k oscilloscope measurements (sdev = ~2ps)*
- **Time between runs**: *~22 seconds*
- **Temperature**: *Stable (+/- 0.5 deg C)*

SUMMARY

- Improved testbench with lower jitter

- Long measurements (10k over 3 days) reveal worse phase uncertainty than before -> 31ps peak-to-peak for 1 hop

- The distribution of the phase uncertainty is not gaussian

  -> detectors are interested in the peak-to-peak value

- Phase uncertainty not acceptable for certain ATLAS detectors

  -> e.g. the ATLAS HGTD

- Currently working on a method to measure the receiver phase in order to be able to compensate for the timing uncertainty

  -> This may however not work at all or not be accurate enough in order to be useful