MPGD tracker calibration

a.k.a. pedestal run

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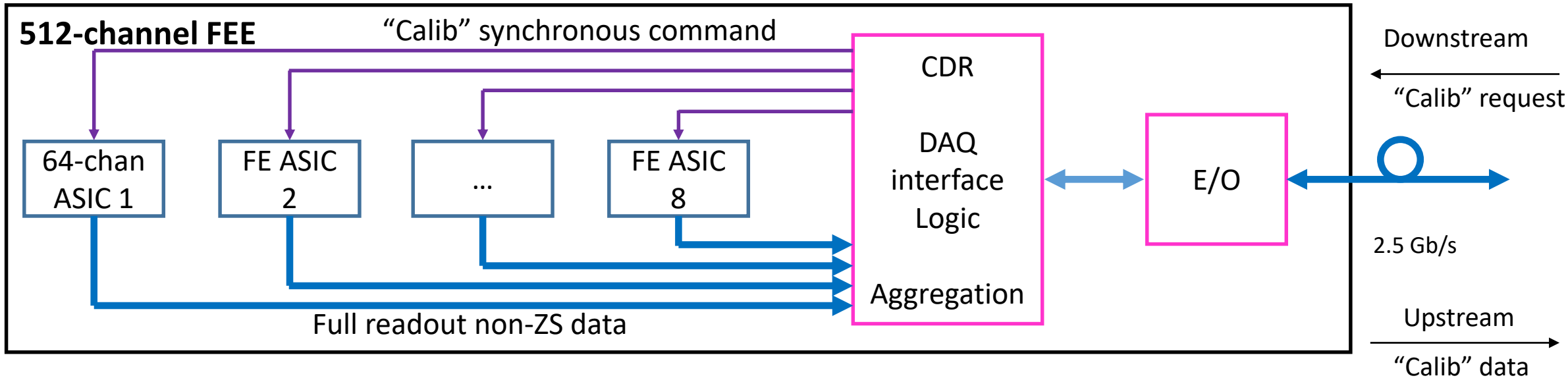
Goal, caution and conclusion

- Asses FEE output bandwidth needed for calibration
  - → Do the FEE calibration data influence the choice of the FEE output link bandwidth?
    - As a by product asses FEE and ASIC de-randomization buffer increase due to calibration
- Make some assumptions on
  - → FEE and FE ASIC operation
  - → Calibration sequence
- Though not definitive, the assumptions give a good idea about the expected calibration data volumes
  - → Typical calibration consists of taking non-ZS data to evaluate detector pedestals, noise and ZS thresholds
- A particular set of parameters is considered
  - → The set is deliberately chosen with not favorable parameters
    - e.g. low FEE output link speed, large number of samples
  - → An Excel file is shared for verification and for playing with the parameters
- Conclusions: under the posed assumptions the FEE calibration data are small and do not influence the choice of the FEE output link bandwidth

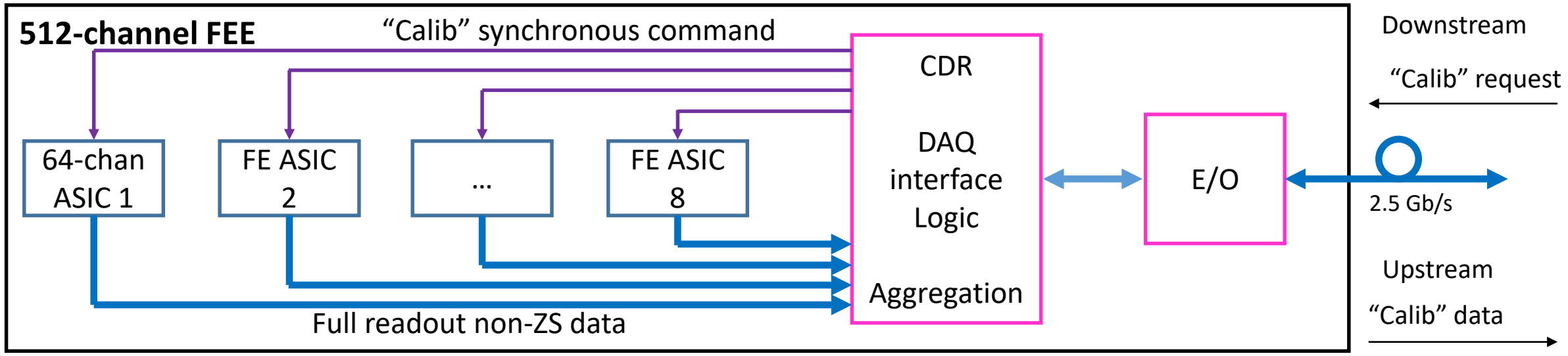
Calibration request and response

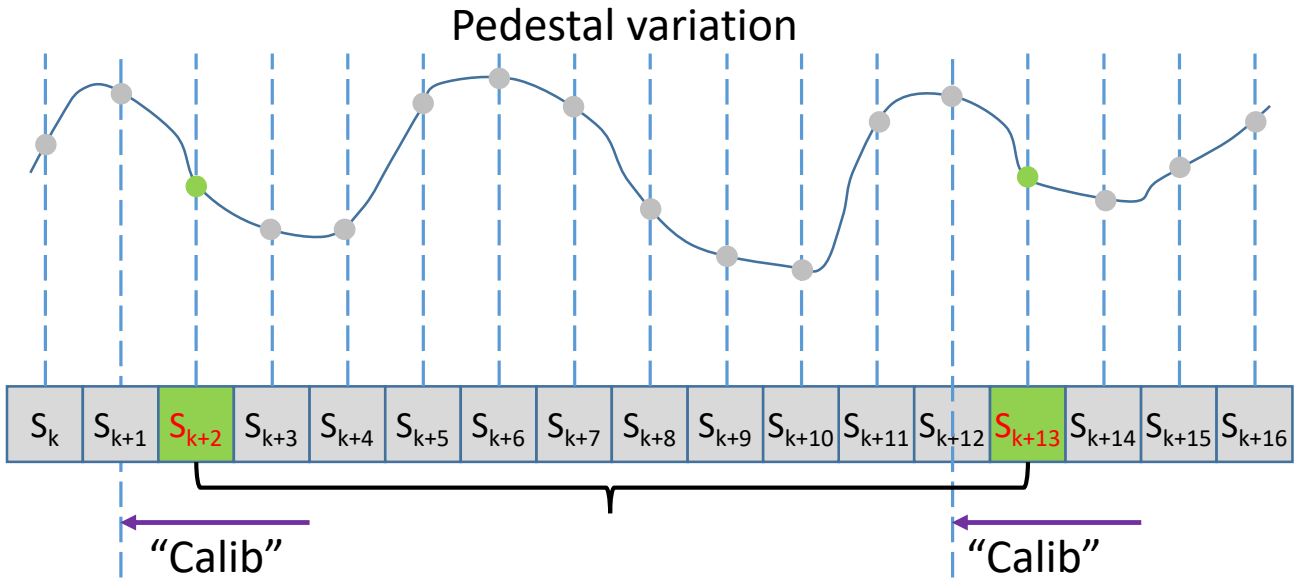
- DAQ sends calibration request to FEE
- FEE conveys calibration request to on-board ASICs
- FEE collects non-ZS calibration data from ASICs
- FEE forms calibration packet and sends it to DAQ



- This sequence repeats programmable number of times to form a complete calibration cycle
- Two calibration types are considered and one of them evaluated

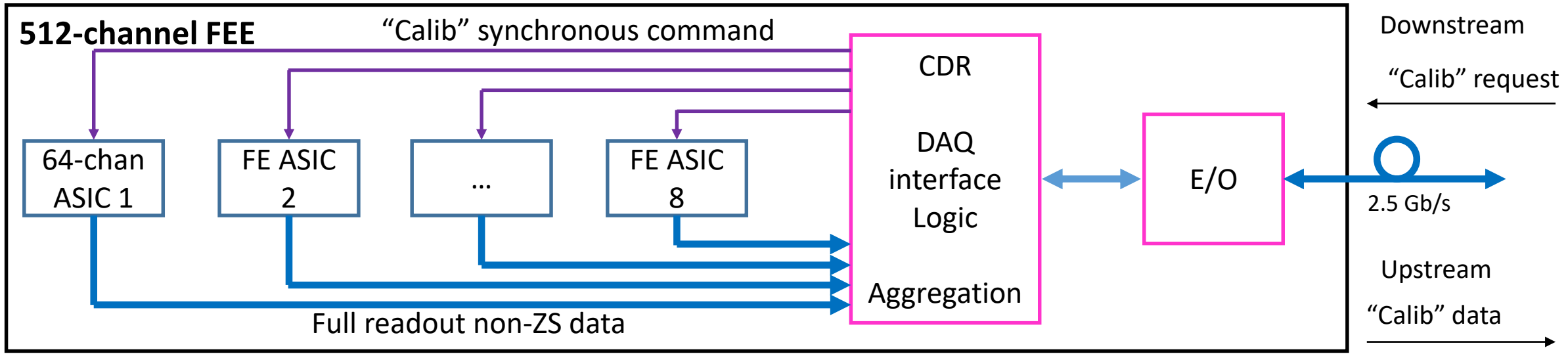
Calibration type: Single “Calib” request – Single Sample readout

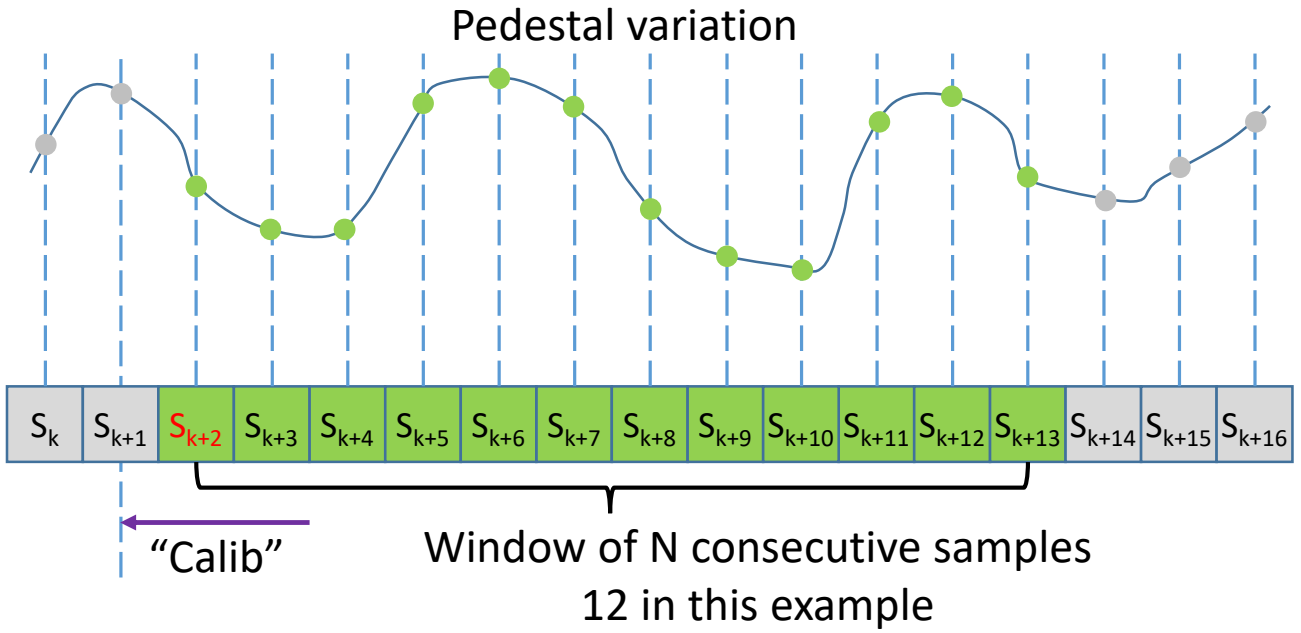




- A “calib” request results to one sample readout
  - → Full readout of non-ZS data
    - All channels of all ASICs
  - → “Calib” request frequency set by DAQ
  - → Consecutive samples cannot be read
    - Unless “Calib” requests pipelined
  - → Needs smaller de-randomizer buffers in ASICs
    - Absorb eventual ZS samples awaiting their turn to be sent
      - Determined by ASIC output throughput

Calibration type: Single “Calib” request – Window readout

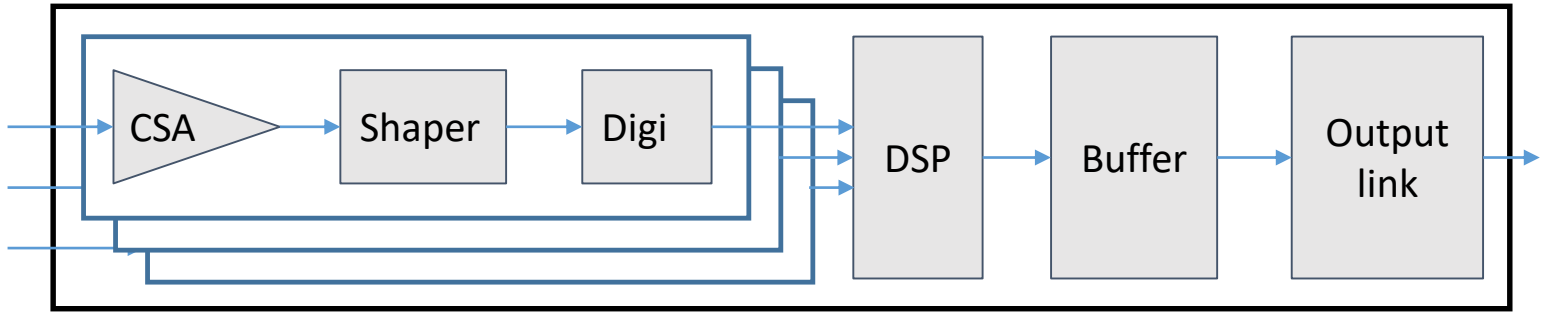




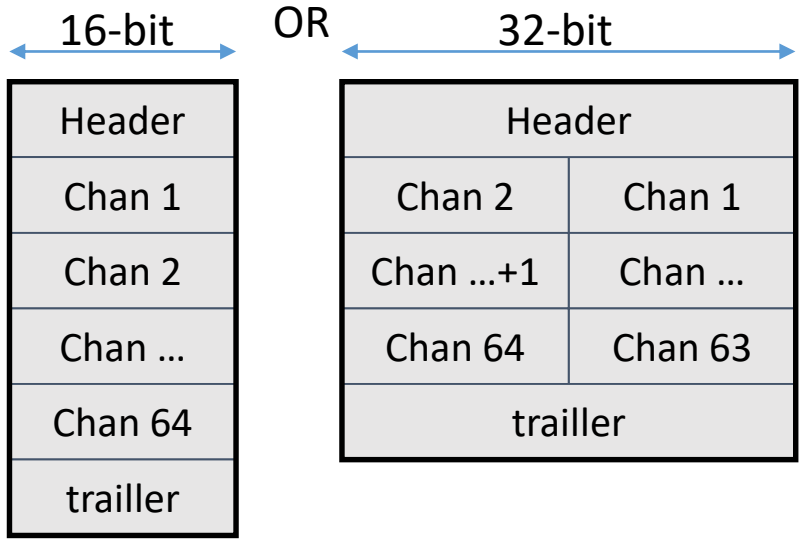
- A “calib” request results in a Window readout
  - → N consecutive samples
  - → Full readout of non-ZS data
    - All channels of all ASICs
  - → Window size programmable
    - Probably same as for ZS readout
      - e.g. able to contain a typical signal shape
  - → Needs larger de-randomizer buffers in ASICs
    - Samples pile up awaiting their turn to be sent
      - Determined by ASIC output throughput

64-channel ASIC for MPGD tracker

- ASIC characteristics relevant for calibration
  - → 64 channels
  - → 50 MSPS sampling frequency
  - → 12-bit ADC encoded over 16 bits
  - → 64-bit data overhead
    - Header and trailer
  - → 1 Gbit/s link speed

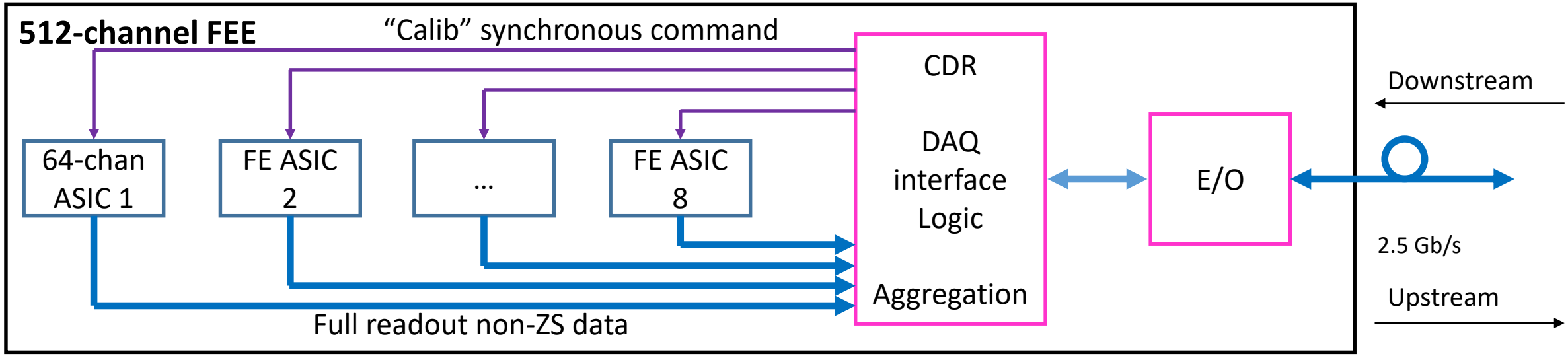


- ASIC full readout data for a sample
  - → Size: 1 088 bit = 136 bytes
    - 64 channels x 16-bit + 64-bit overhead
  - → TX time: 1.088 µs
    - 1 088 bit / 1 Gbit/s
    - 54.4 samples



- ASIC ZS de-randomizing buffer to be augmented by
  - → For single sample readout: as many extra samples as possible “calib” requests within 1.088 µs TX time
  - → For window readout: 1.088 µs * 50 MSPS = 54.4 samples
    - Per channel: 880 bits
    - ASIC: 64 x 880 = 55 Kbits

512-channel FEE

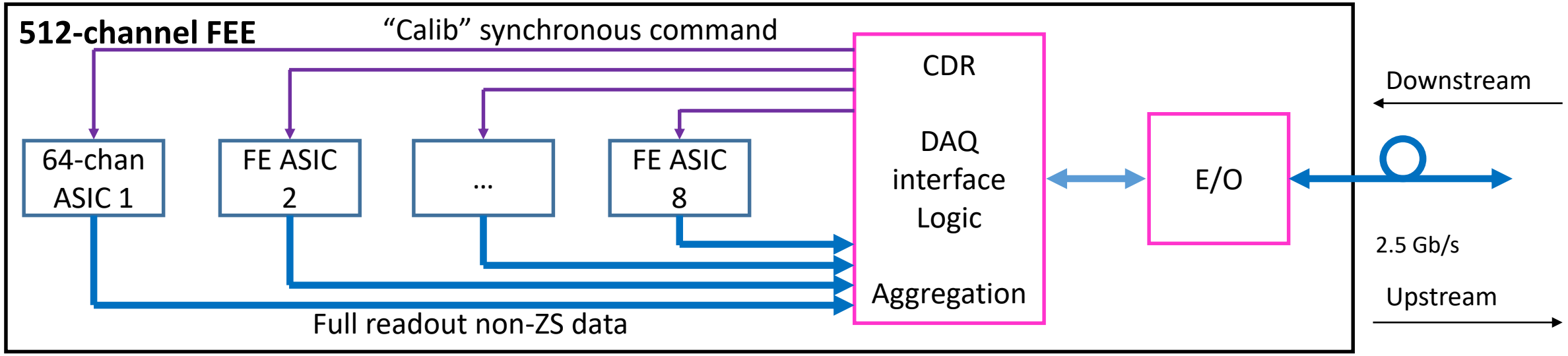


- FEE characteristics relevant for calibration
  - → 8 64-channel ASICs
  - → 256-bit data overhead
    - Header and trailer
  - → 2.5 Gbit/s link speed
    - 20% transport overhead e.g. 8b/10b encoding
  - → 1 µs pause forced between consecutive calibration packets

Header
ASIC 1: 1088 bits
ASIC 2: 1088 bits
ASIC …: 1088 bits
ASIC 8: 1088 bits
Trailer

- FEE full readout data for a sample
  - → Size : 8.75 Kbit = 1.09 Kbytes
    - 8 ASICs x 1088 bit + 256-bit overhead
  - → TX time : 4.3 µs
    - (8.75 + 20% transport overhead) Kbit / 2.5 Gbit/s

512-channel FEE



- FEE ZS de-randomizing buffer to be augmented by
  - → For single sample readout: as many extra samples as possible "calib" requests within 4.3 µs "calib" data packet sending time
  - → For window readout: ~5 sample
    - (4.3 µs + 1 µs) / 1.088 µs
      - (FEE calib data send time + forced pause) / ASIC calib data receive time)
    - Per ASIC: 5.3 Kbit = 680 byte
      - 5 x 1088 bit of ASIC calib sample size
    - FEE: ~44 Kbit = 5.5 Kbyte
      - 5 x 8.75 of FEE calib packet size

Header
ASIC 1: 1088 bits
ASIC 2: 1088 bits
ASIC …: 1088 bits
ASIC 8: 1088 bits
Trailer

Recapitulating the hypothesis

- Pedestal run consists of 1000 acquisition of 1 µs readout windows without ZS
  - → All channels of a FEE are read and sent to off-detector backend electronics
- A 512-channel FEE is composed of 8 64-channel MPGD front-end ASICs
- The 64-channel front-end ASIC is a sampling chip
  - → Sampling rate is 50 GSPS
  - → Channel ADC has 12 bits, but the channel data are sent as a 16-bit word
    - 12 bit ADC value + 4 bit encoding
  - → For each sample all 64 channels are read: 64 x 16-bit
  - → An ASIC overhead of 64 bits is added to the ASIC channel data
    - ASIC header + ASIC trailer
- For each sample FEE transmits the data of 8 ASICs and adds 256-byte overhead
  - → FEE header and trailer
  - → 256 + 8 x (64 + 64 x 16) bits
- FEE upstream link throughput is 2.5 Gbit/s
  - → Transport layer overhead is 20%
    - For example, 8b/10b encoding is used: for every 8 bits of user data 10 bits are transmitted
- FEE respects 1 µs pause between two successive calibration packets
- 1 µs Readout window corresponds to 50 samples at 50 GSPS rate
  - → For each readout window 50 consecutive samples are read

Window-readout calibration sequence

- Assume the following calibration protocol
  - → To send all samples forming a readout window the FEE needs to receive a single “Calib” command over the downstream link
    - Upon reception of the “Calib” command the FEE performs 50 times the following
      - Sends “calib” command to all ASICs
      - Collects “calib” data from all ASICS
      - Forms data packet containing data of all ASICs and its own overhead
      - Sends the packet over the upstream link
      - Observes 1 µs idle time to let backend electronics to do some housekeeping
  - → To perform complete calibration cycle the DAQ sends 1000 “Calib” commands to FEE at some pace
    - This results to 50k non-ZS samples (1000 x 50) acquired for each channel

- Questions and answers
  - → What is the FEE calibration data size? ~53.4 Mbyte
  - → What is the min calibration time? ~265 ms

  - → If DAQ sends “Calib” commands at 100 Hz pace
    - What will be calibration cycle duration? 10 secs
    - What will be occupancy of the 2.5 Gbit/s upstream link due to the calibration data : 2%

- Conclusions: under these assumptions the FEE calibration data are small and do not influence the choice of the FEE output link bandwidth