

Benchmarking Streaming Readout Performance of CAEN Digitizers

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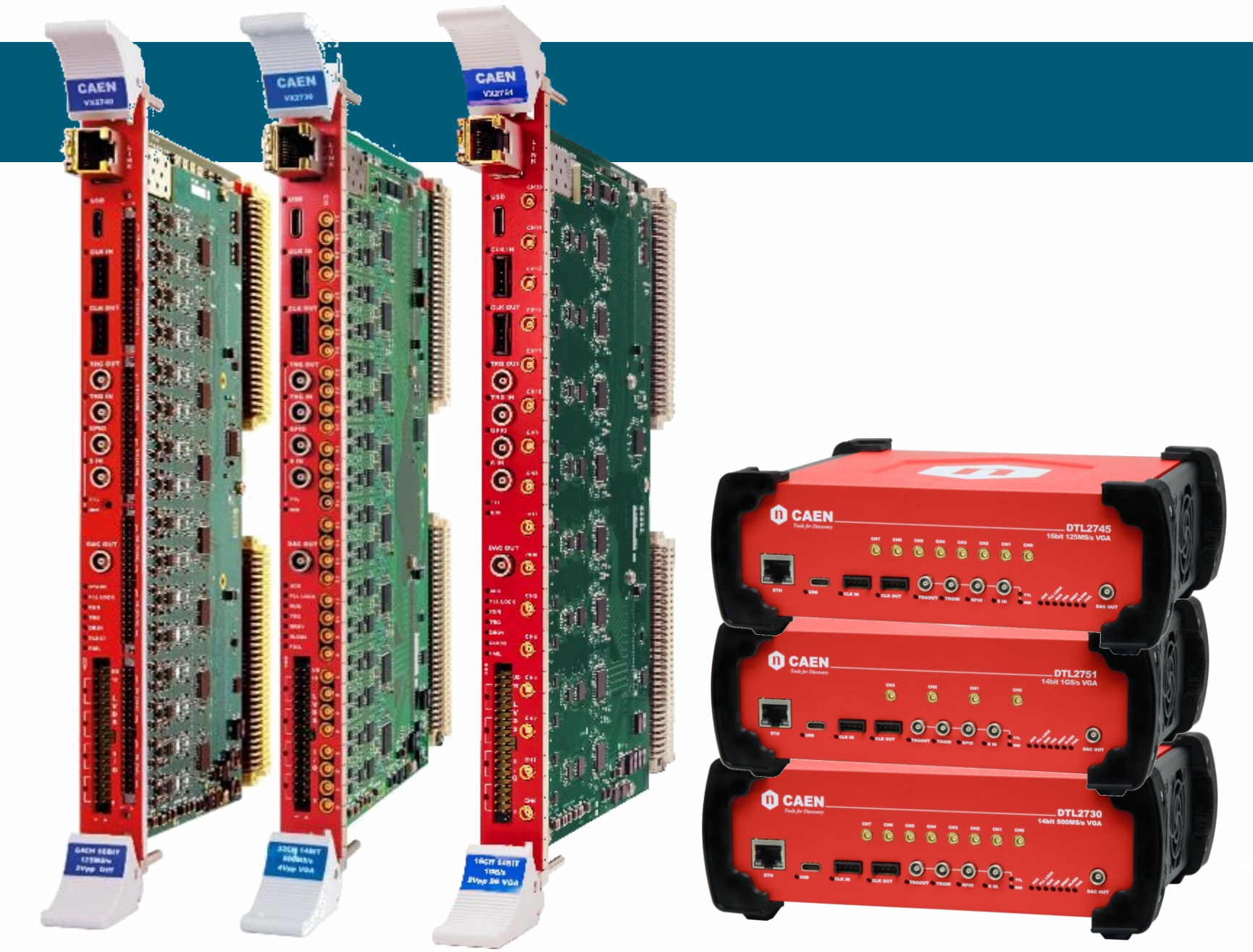
CAEN Digitizer 2.0

CAEN Digitizers family:

	2740/45	2730	2751
Channels	64	32	16
Sampling	125 MS/s @16 bit	500 MS/s @ 14 bit	1 GS/s @ 14 bit
Variable Gain Amplifier	x100 (2745 only)	x20	x10
Communication Protocol	USB 3.0, 1 GbE TCP, 10 GbE UDP		

Two readout options available:

- Triggered Readout (Scope): Common trigger, an event contains the samples of all the enabled channels
- Streaming Readout (DPP): Individual trigger, an event contains the data of only one channel. Small size of event (16 or 8 bytes).



10 GbE UDP Jumbo Frame Performance

The 10 GbE UDP link minimizes protocol overhead compared to TCP, providing low-latency, high-bandwidth data transfer ideal for streaming and triggered readout. Enabling 9K Jumbo Frames further reduces per-packet CPU and NIC processing, maximizing throughput efficiency on dedicated point-to-point connections [1].

Triggered Readout Performance

Experimental setup:

- Scope 10GbE UDP firmware
- $24+2*N_{CH}*N_{SAMPLES}$ bytes/event

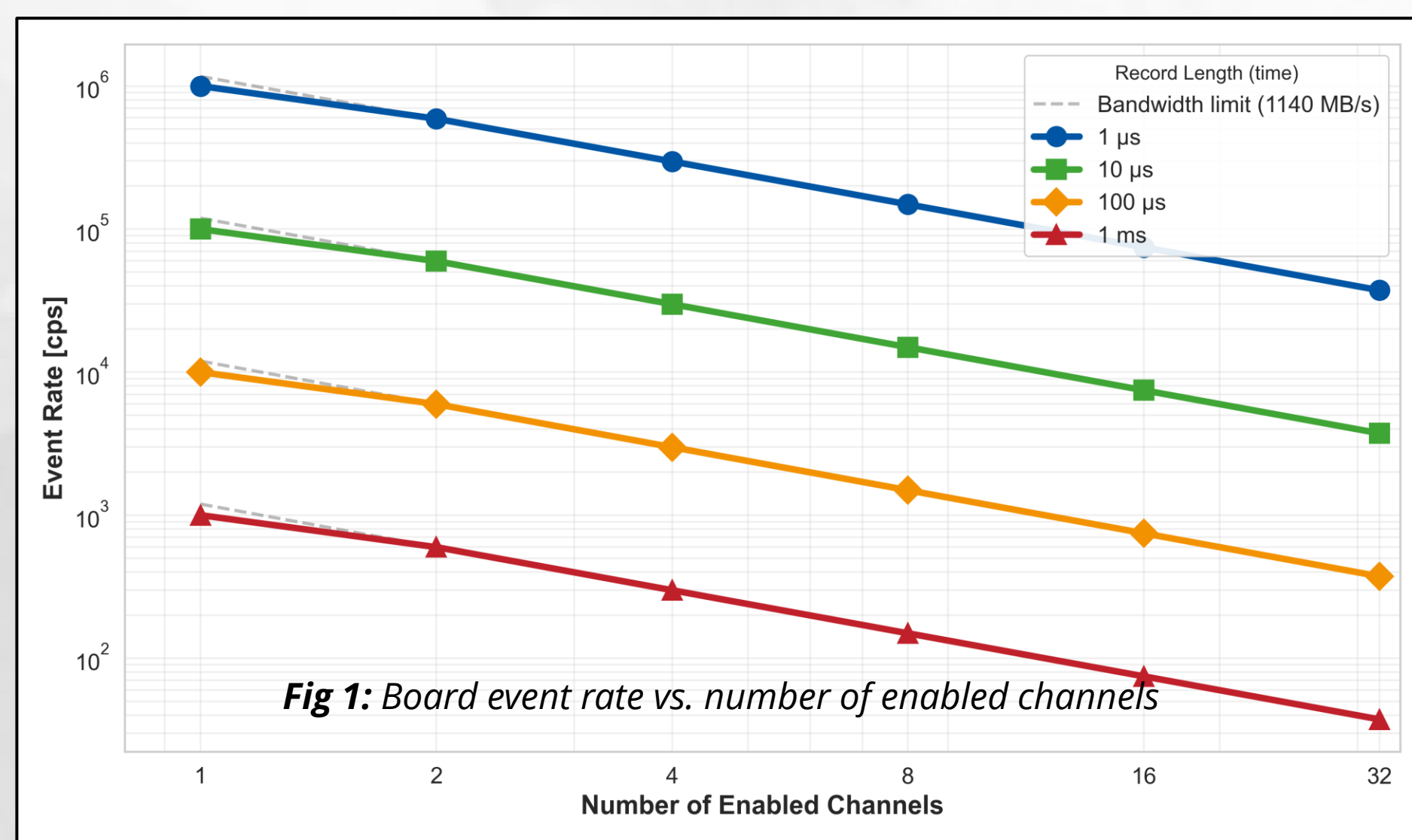


Fig 1: Board event rate vs. number of enabled channels

Measured data throughput:

- Board: **~1140 MB/s** – No UDP data losses detected

Streaming Readout Performance

Experimental setup:

- DPP-PSD 10GbE UDP firmware
- 16 bytes/hit (channel, timestamp, energy and PSD, flags)

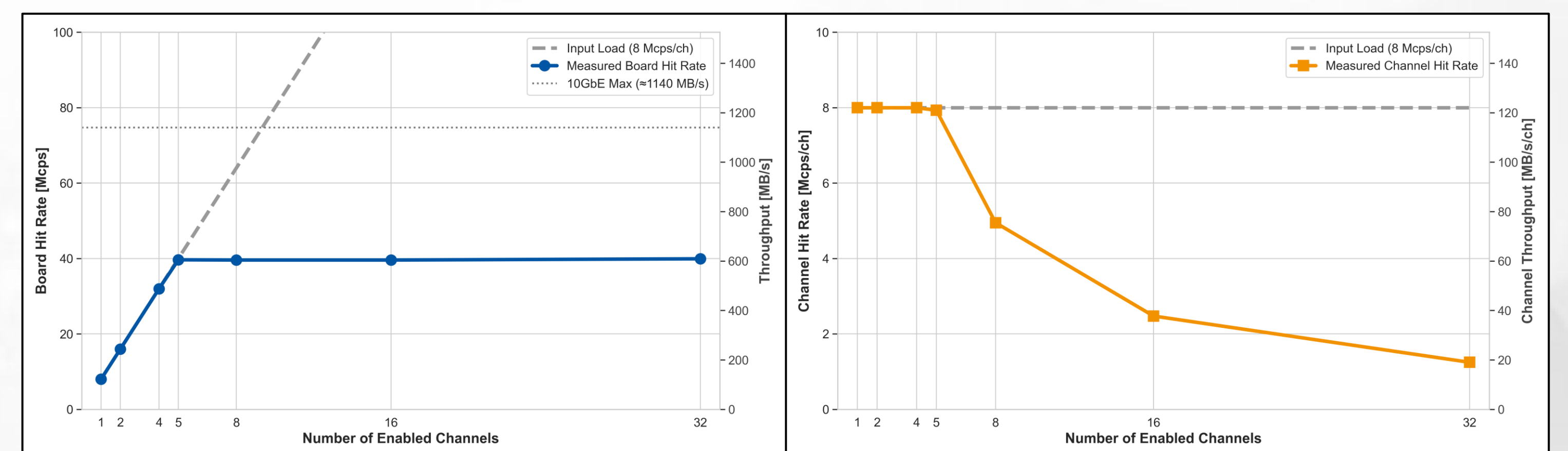
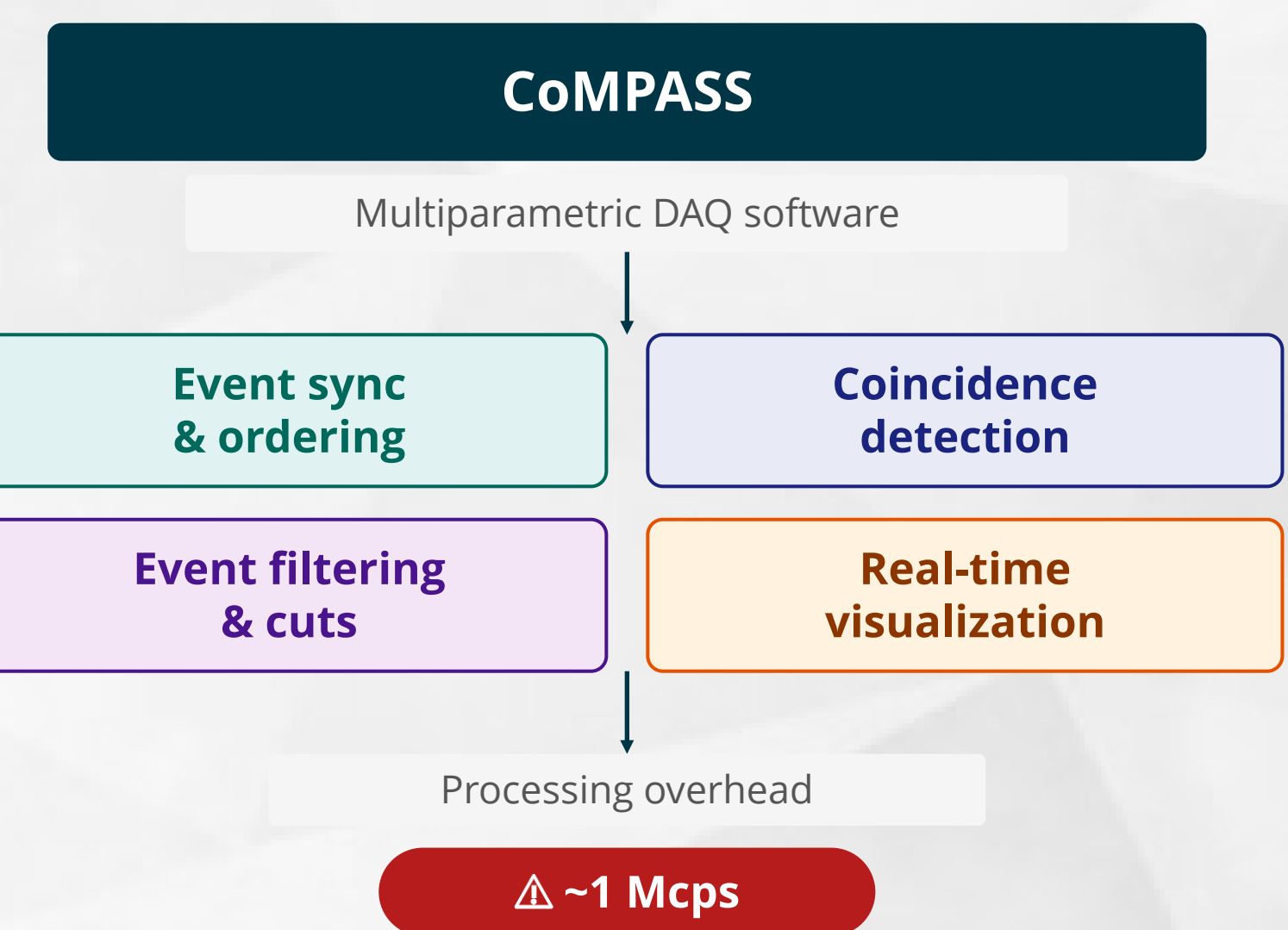
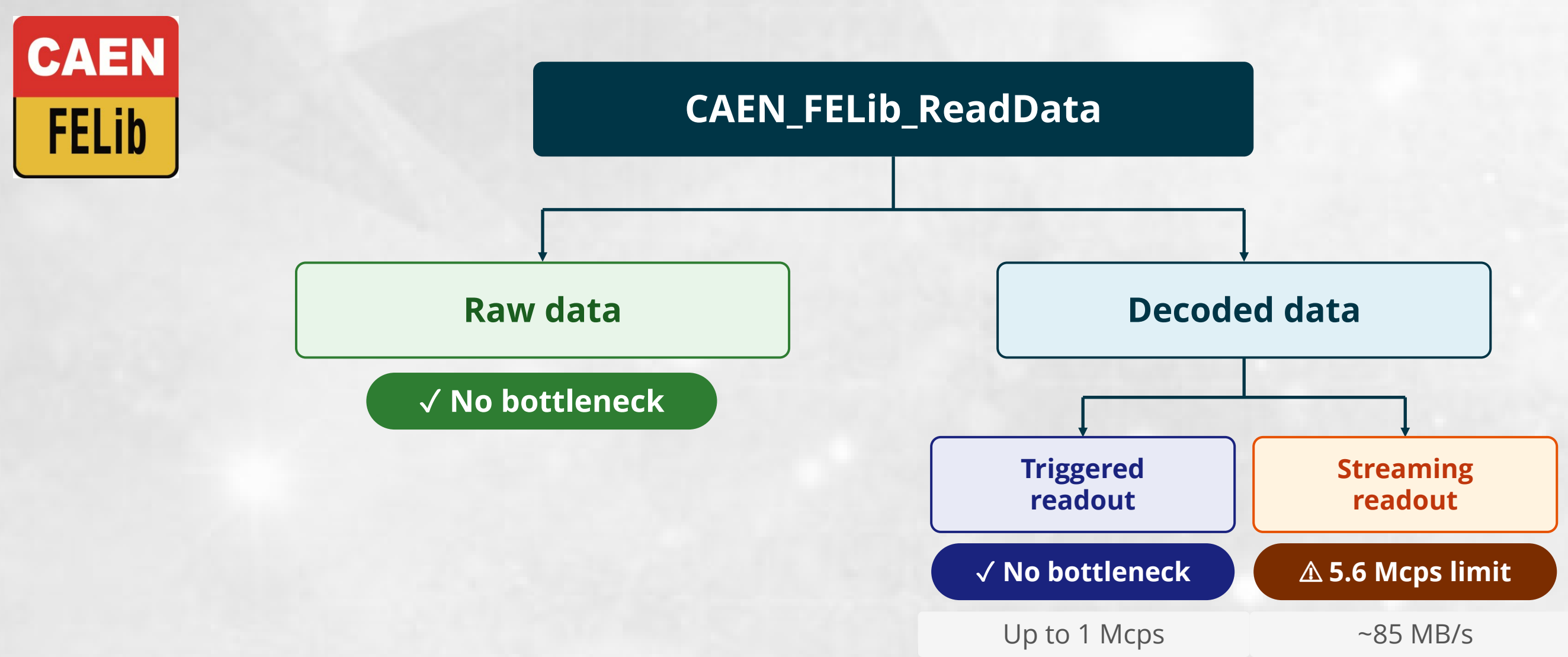


Fig 2: Maximum channel hit rate (left) and maximum board hit rate (right) vs. number of enabled channels

Measured throughput:

- Single channel throughput **up to ~10 Mcps/ch**, tested with external trigger, but board still limited at ~40 Mcps - No UDP data losses detected
- Rate limited by event sorting algorithm within the FPGA

Readout Software



Summary

Jumbo Frame Support: Added support for MTU 9000 bytes, reducing per-packet overhead and improving 10 GbE readout efficiency.

Throughput Analysis: Characterized performance across triggered and streaming readout firmware versions, identifying bottlenecks and opportunities for further optimization.

	Max Board Rate	Throughput	Bottleneck
Triggered Readout Scope, decode ON	Depends on record length	~1140 MB/s	10GbE UDP (physical layer)
Streaming Readout DPP, decode OFF	40 Mcps	~600 MB/s	Firmware (event sorting algorithm)
DPP List Mode, decode ON	5,6 Mcps	~85 MB/s	Software (context switches)
CoMPASS	~1 Mcps	~15 MB/s	Software (complex data processing)

Possible improvements:

- Improving sorting algorithm
- Implementing batch processing on Raw data (multiple hits per API call) to reduce context switch overhead