CAEN Electronic Instrumentation

Tools for Discovery

Time measurements with picoTDC

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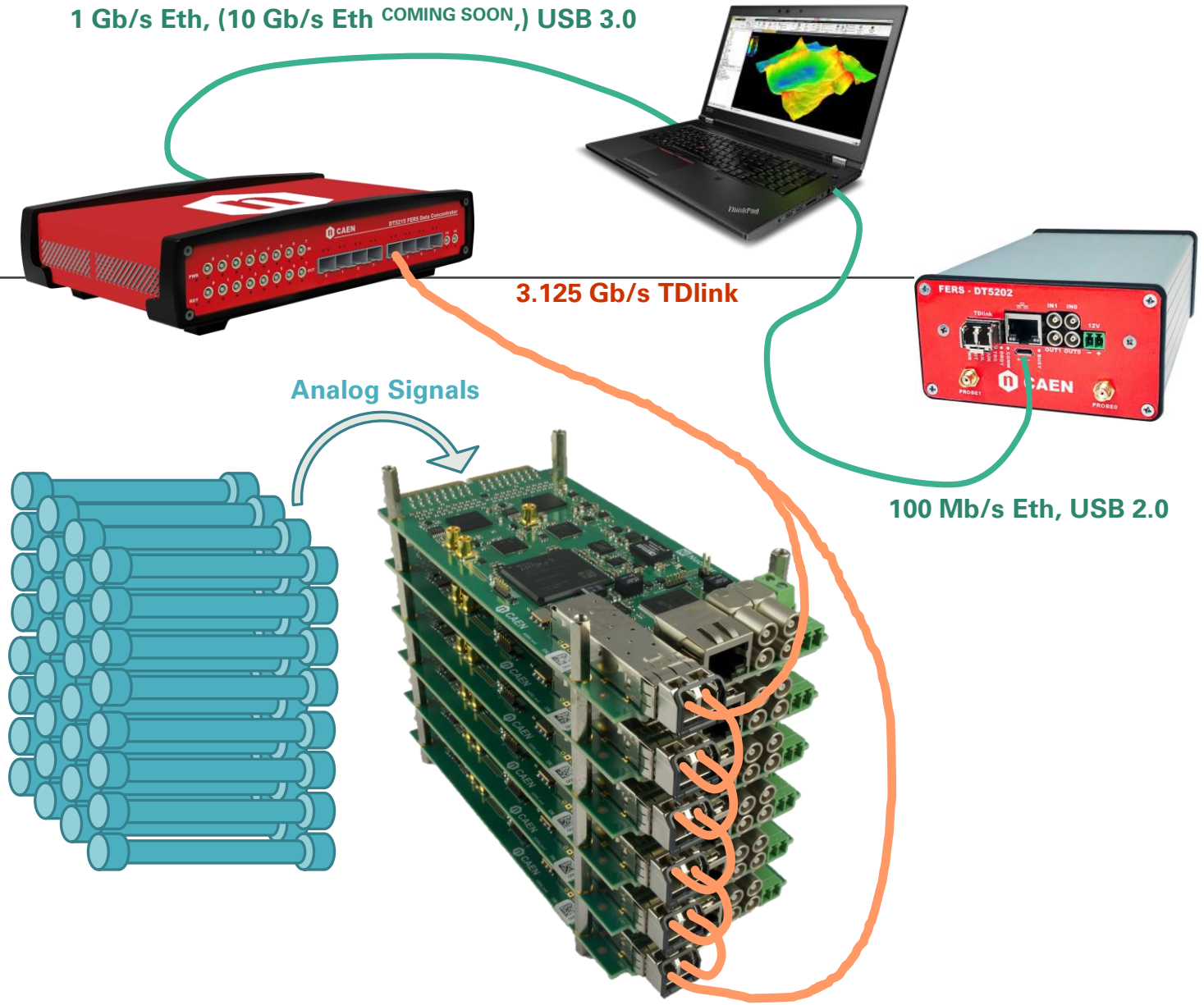
2023 ISOLDE WORKSHOP AND USER MEETING

Summary

- Intro to the FERS
- picoTDC and FERS 5203
- A5256 – a discriminator for the A5203/DT5203
- Test results

FERS concept

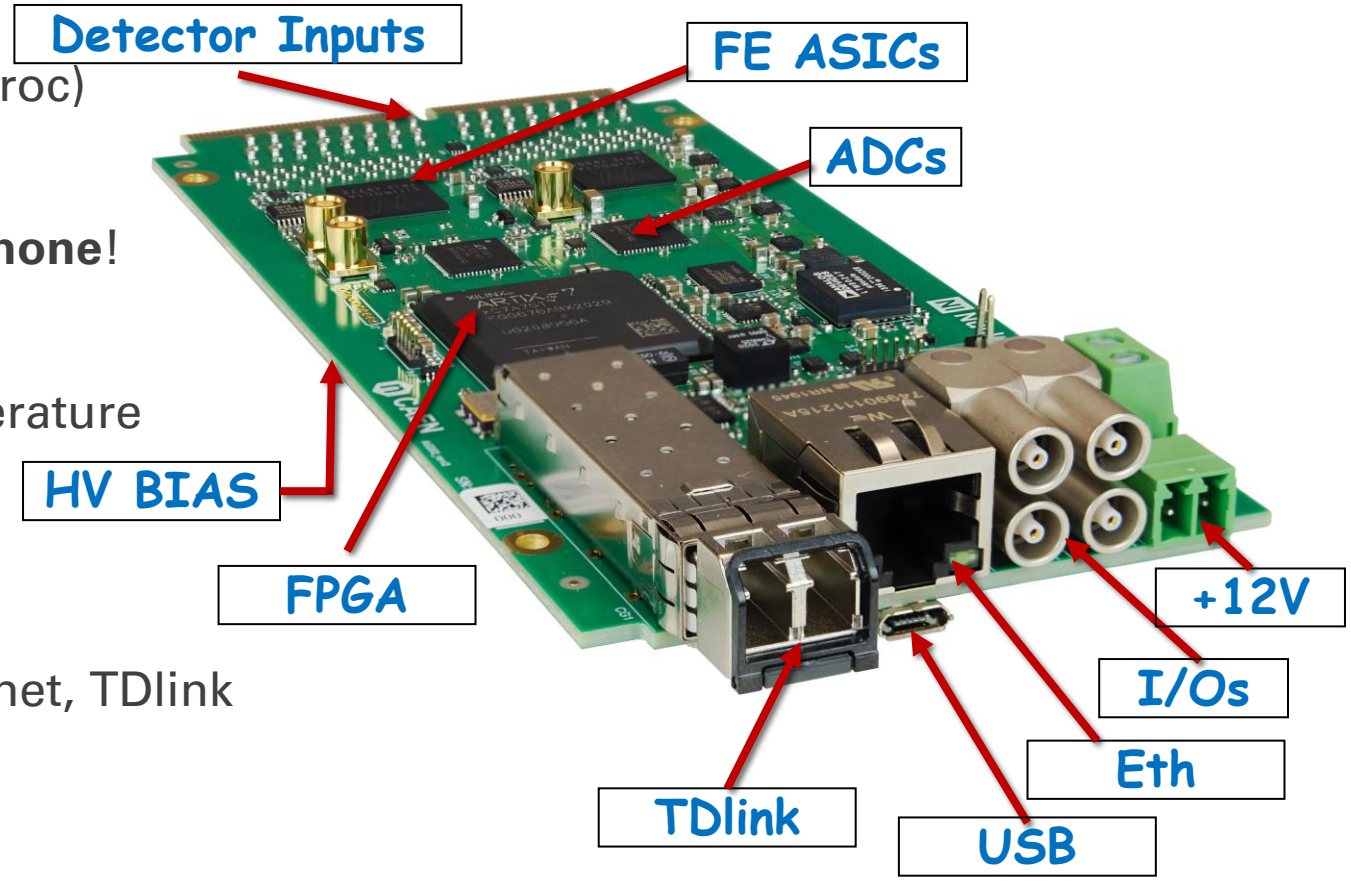


- **FERS:** Front End ASIC + A/D + Scalable Readout Infrastructure
- **Easy integration of new ASICs =>** Compact solutions, tailored to the application
- **Scalability: f**rom single stand-alone version for evaluation, to 10k/100k channels with same electronics
- **TDlink:** daisy chainable optical link protocol with data+sync
- **Readout Tree:**
  1 FERS unit = 64(/128 ch for FERS 5203 type only)
  1 link = 16 FERS units
  1 Concentrator = 8 links = 128 FERS = 8k(/16k channels for FERS 5203 type only)

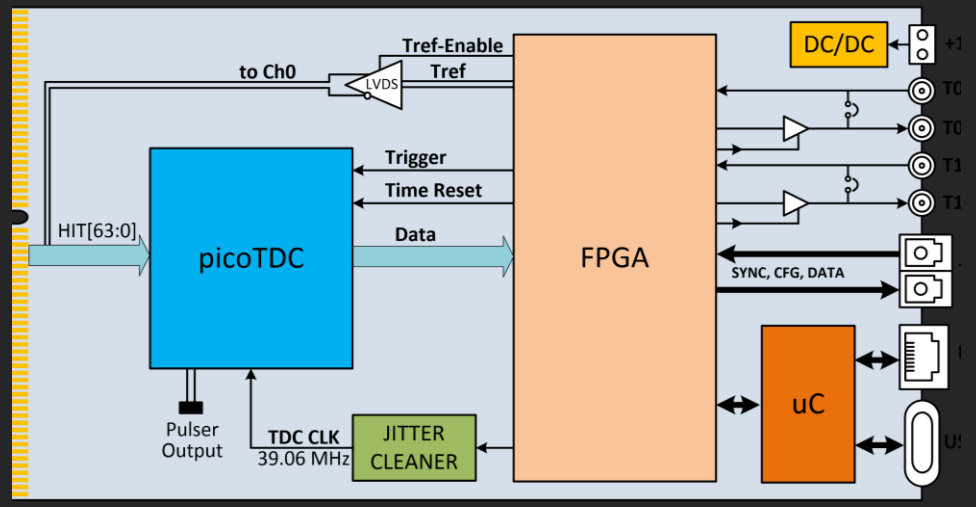
Multiple Concentrators for unlimited readout

A5202 - the first member of a family

- Based on two ASICs **Citiroc 1A** (by Weeroc)
- A5202 is nearly the **size of your smartphone**!
- Embedded **HV bias** (20-85V) with temperature feedback
- Different readout protocols: USB, Ethernet, TDlink



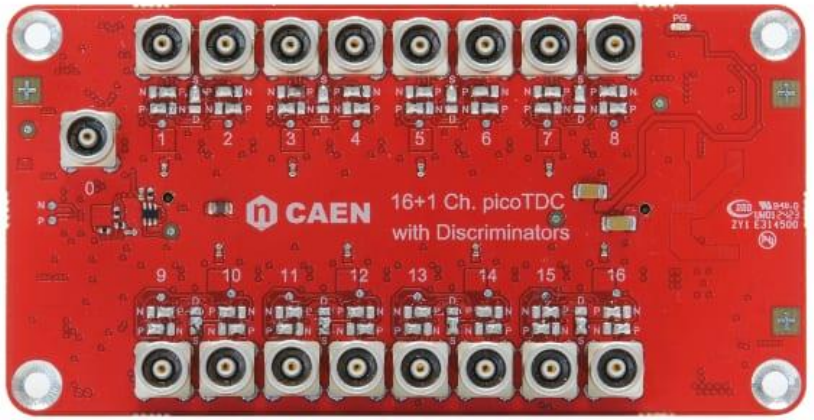
The picoTDC and the FERS 5203

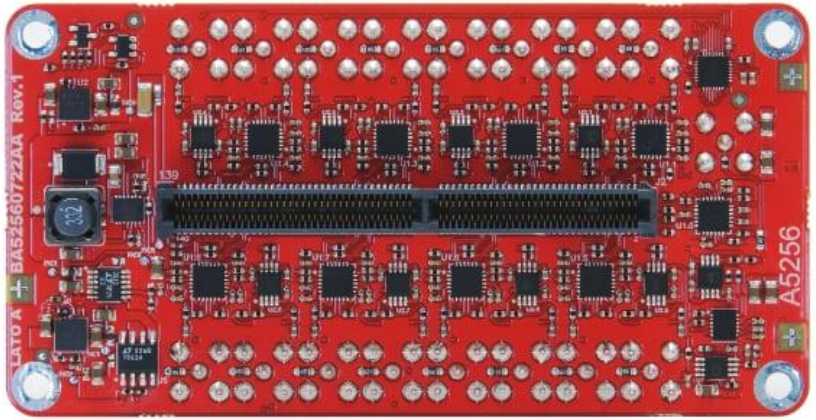


On the same platform we have implemented the picoTDC chip developed by CERN for high resolution timing applications

A5256 – 16 channels discriminator

- ✓ 16 channels + 1 Tref channel leading edge discriminator for A5203/DT5203
- ✓ Single/Dual threshold discrimination (16/8 ch + 1 ch)
- ✓ Analog/NIM/TTL input signals - LEMO connectors
- ✓ Threshold offset calibration at software level
- ✓ Possibility to correct for walk effect at software level
- ✓ Ideal timing performances of A5203/DT5203 using signals from real detectors (tens of ps after walk correction)





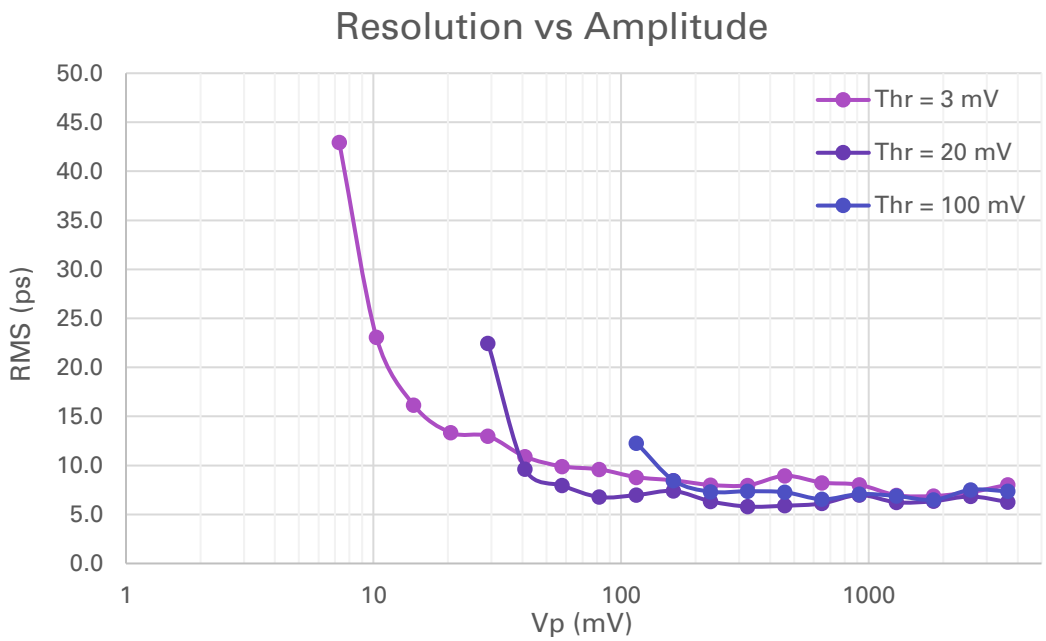
Timing resolution

Stop Channel	Resolution (ps RMS)	Polarity
1	5.5	POS
2	5.8	POS
3	6.1	POS
4	5.8	POS
5	6.0	POS
6	5.9	POS
7	6.4	POS
8	5.6	POS
9	5.5	NEG
10	5.7	NEG
11	5.7	NEG
12	5.7	NEG
13	6.2	NEG
14	6.1	NEG
15	5.7	NEG
16	5.7	NEG

Overall resolution is 5.8±0.3 ps.

Agilent 81110A pulser.
Start-stop measurements with pulses:

- amplitude = 0.5 Vpp
- rise time = 0.8 ns
- width
  - 50 ns for start
  - 5 ns for stop

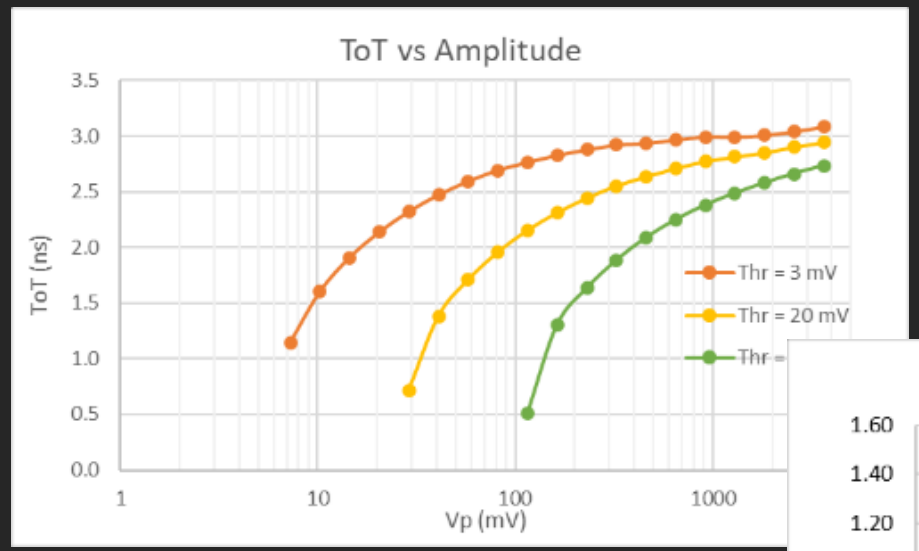


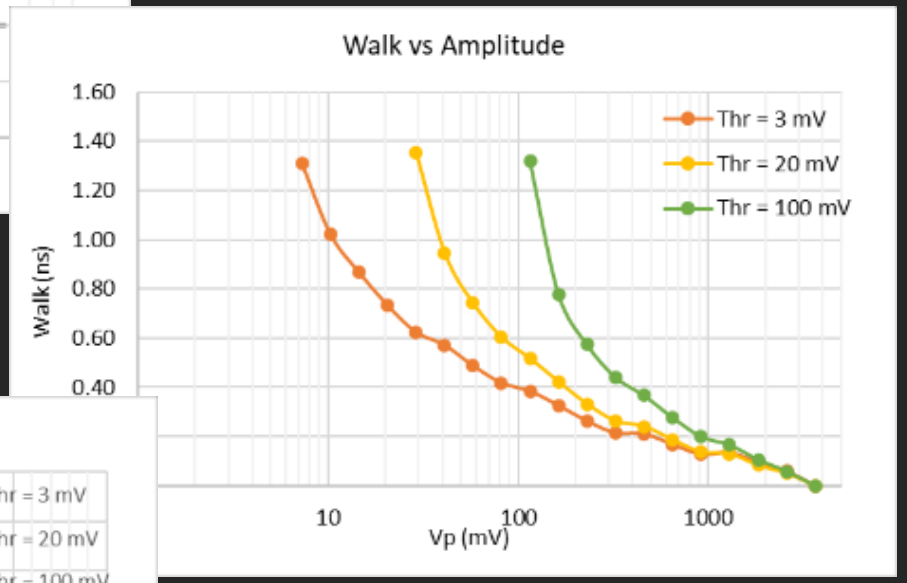
Tested the dependence of resolution on amplitude

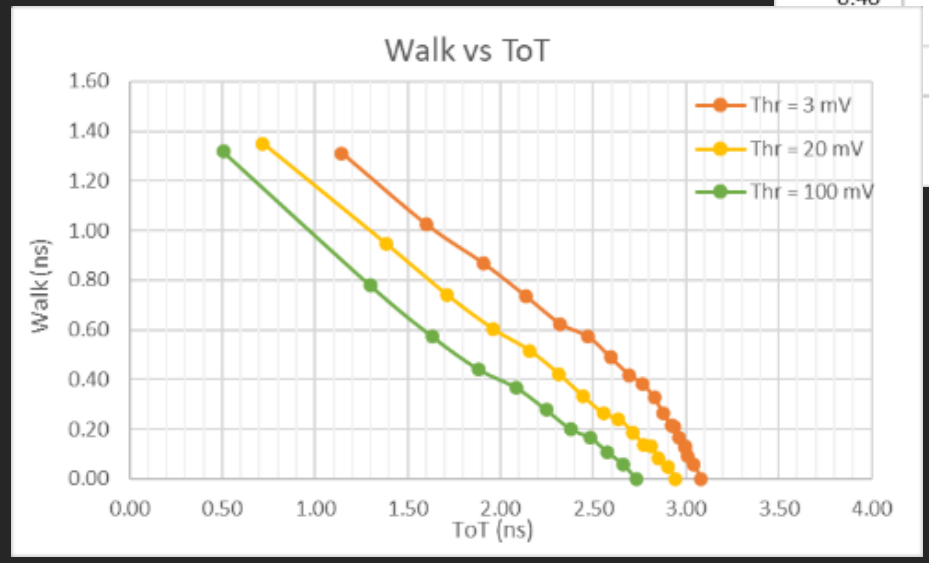
Walk (time slewing)

Input signal: quasi-triangular pulse

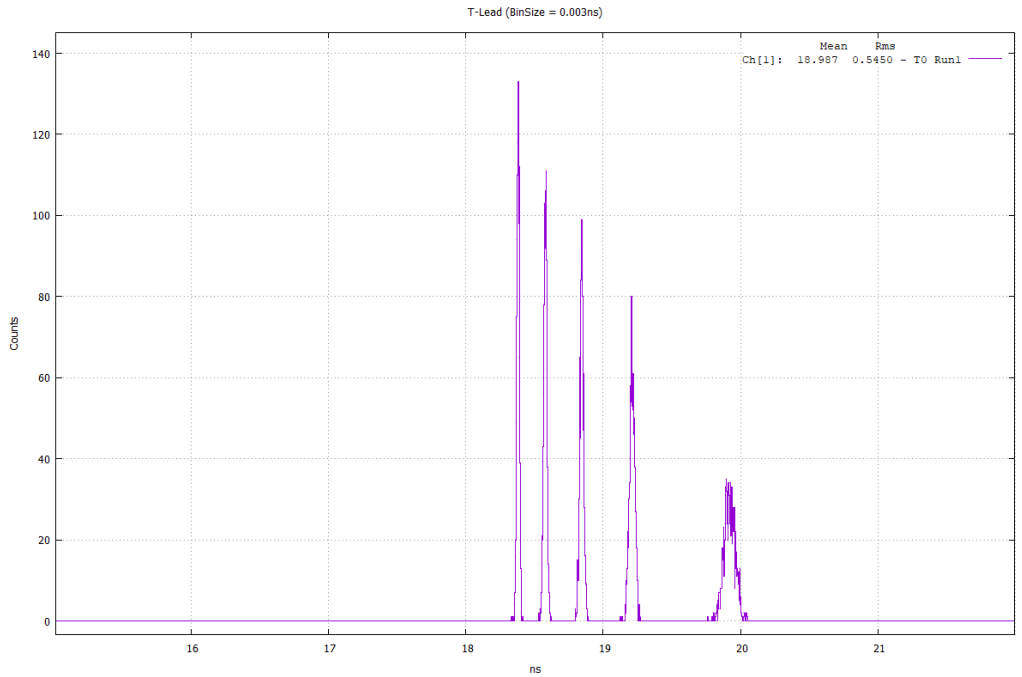
The amplitude and the threshold variations in this test are only applied to the stop signal, while the start signal on channel 0 has fixed amplitude (500 mV) and fixed threshold (100 mV).

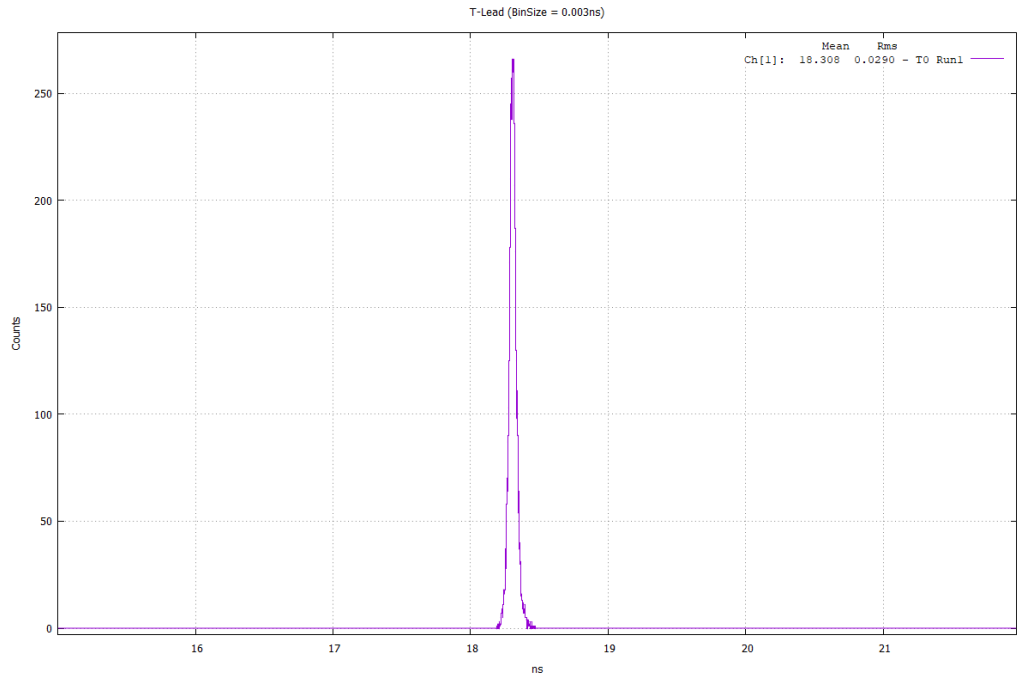






Walk correction

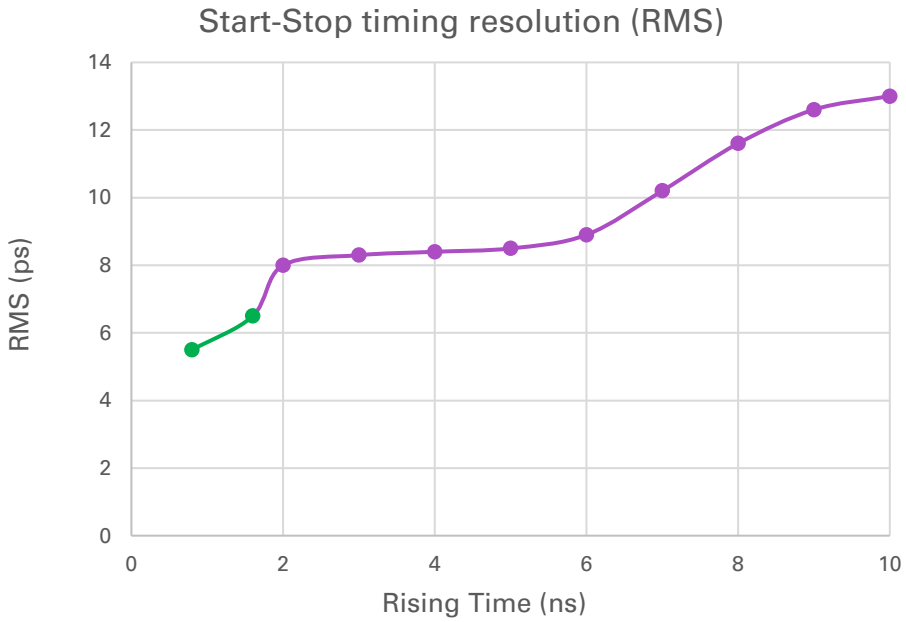


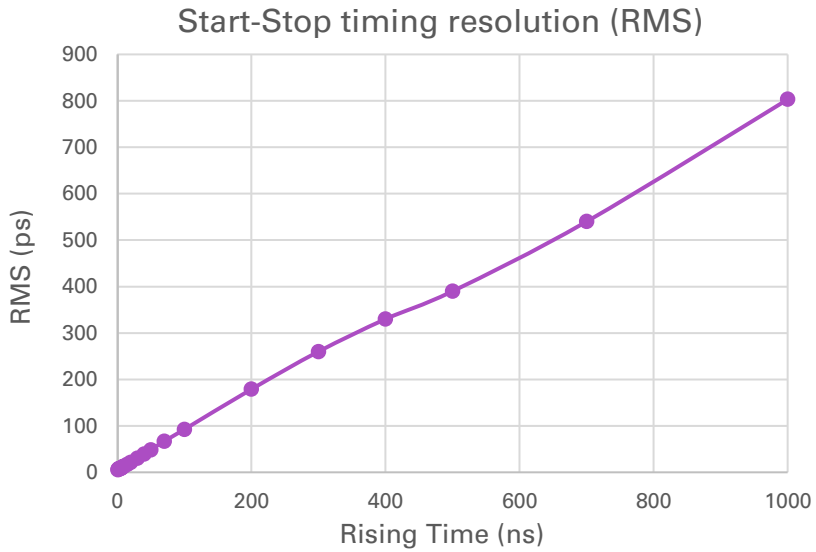


ΔT spectra **left** before walk correction – **right** after walk correction based on ToT

The RMS time resolution goes from ~540 ps to less than 30 ps.

Timing resolution as a function of rising time





Discontinuity between the two points taken with Agilent 81110A pulser, while the others with the AFG31000 generator.

Start-stop measurement from ch0 to ch1.

Fixed amplitude pulses (0.5 Vpp) with 100 mV threshold.

5 ns delay between start and stop

The rise time of the stop signal sweeps from 0.8 ns to 1 us, while the start signal remains at the fastest rise time of 0.8 ns

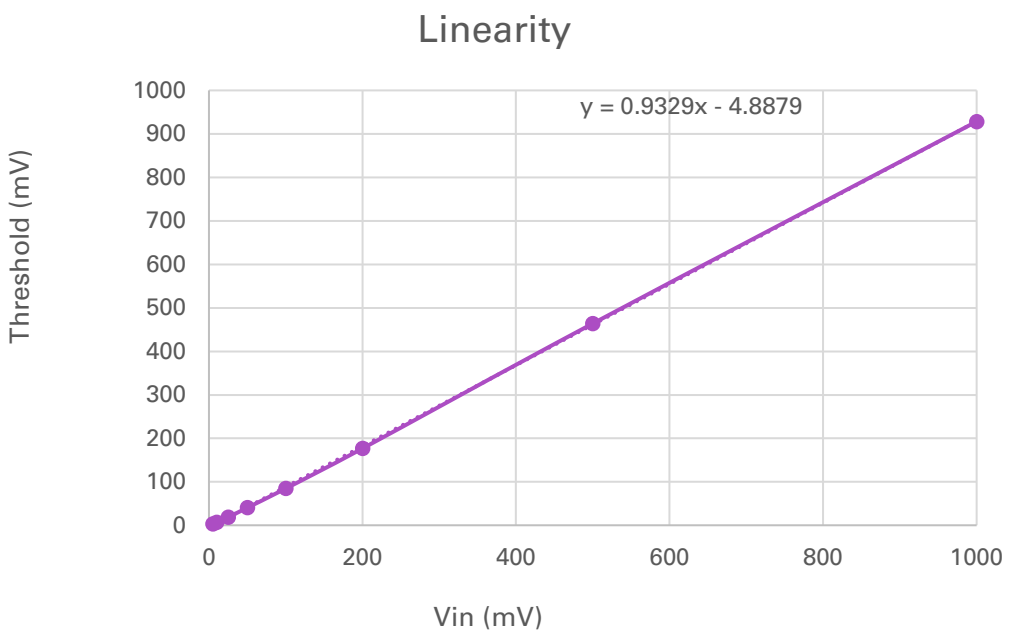
Threshold and minimum detectable signal

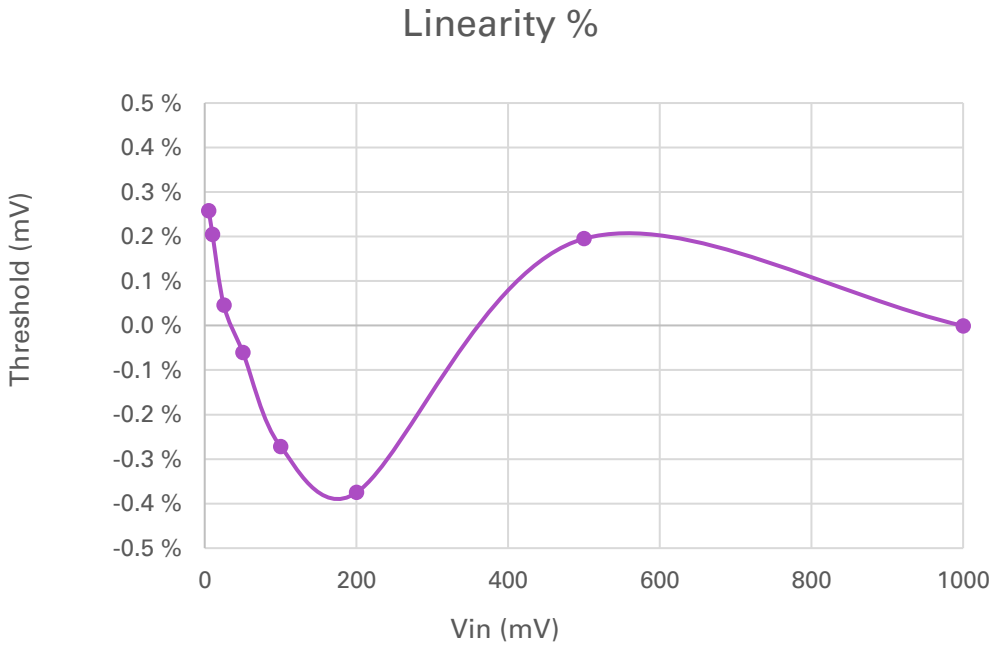
The purpose of this test is to measure the minimum signal amplitude to have 100% efficiency, i.e., same number of sent pulses and acquired pulses (no lost pulses).

- Tests made at thermal equilibrium
- Janus 5203 runs in Trigger Matching mode using the internal periodic trigger PTRG at 10 kHz
- Threshold from 0 up to no noise detected in 10 sec in steps of 1 LSB (0.61 mV)
  - **Minimum Threshold = 1.5 mV**
- To measure the minimum signal, Janus 5203 runs in Common Start mode
- The start is fixed (1 kHz, 500 mV), while the stop signal is a fast pulse (rise=fall=0.8 ns, width = 5 ns) with variable amplitude
  - **Minimum detectable signal @ efficiency=99.9% = 3 mV**
  - **Minimum detectable signal @ efficiency=50% = ~2 mV**

Linearity

The linearity of the discriminator represents the relationship between threshold and pulse amplitude at 99.9% efficiency





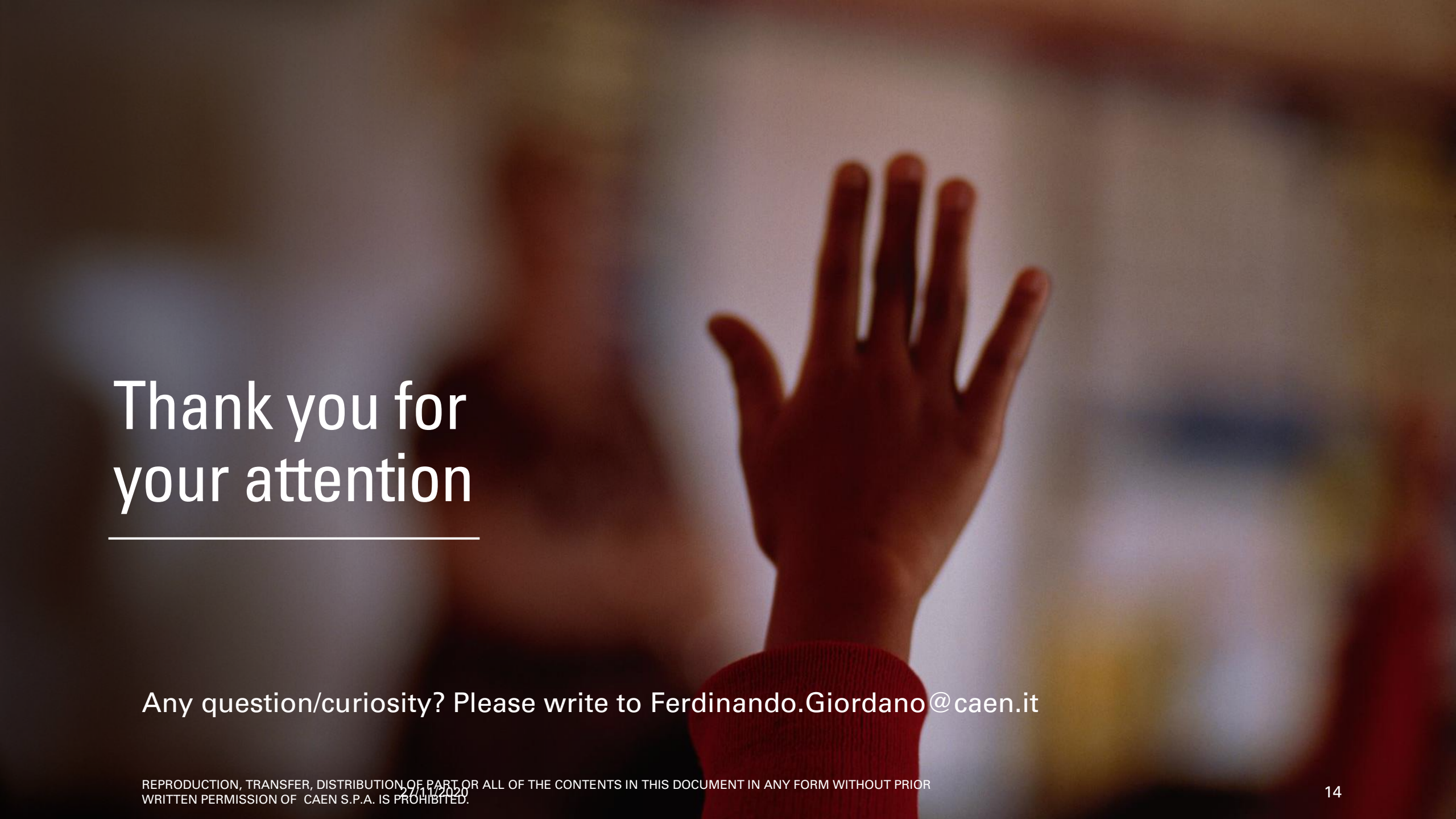
Conclusion

Our solution with the picoTDC and its companion discriminator has been extensively tested.

We have reached excellent results, and all automatic corrections work as expected.

We have also tested speed performance for the 64 ch board read via the DT5215 on USB 3, it is able to acquire hits at 1 Mcps per channel (i.e. 64 **Mcps per board**).

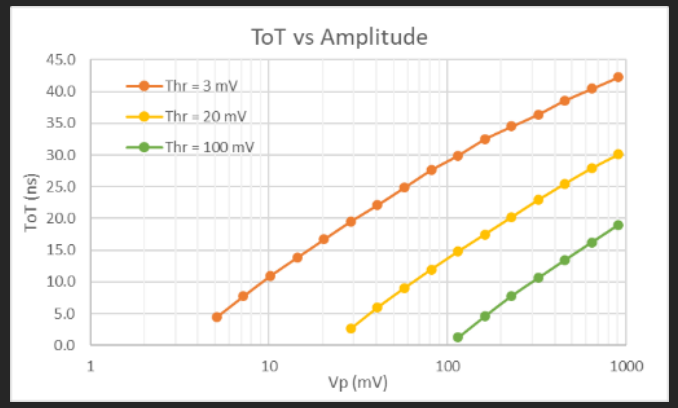
The FERS platform will continue expanding with **more ASICS** designed and manufactured by our partners.

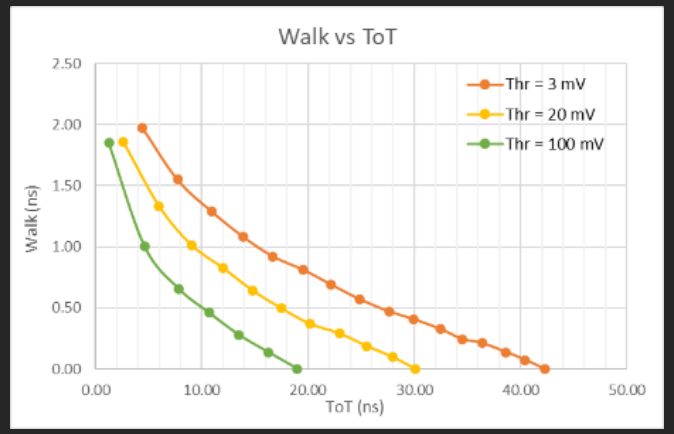


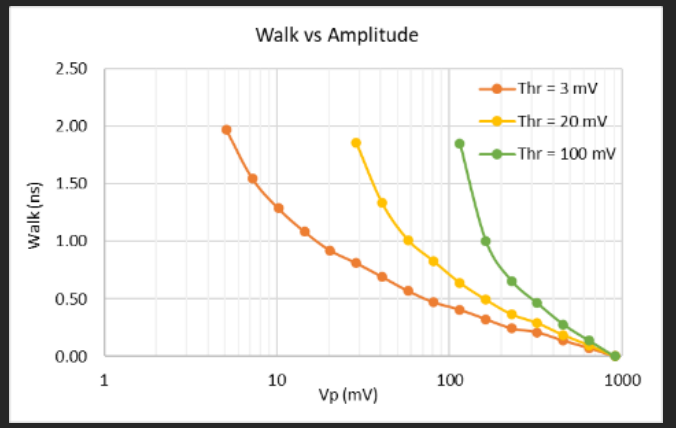
Thank you for your attention

Any question/curiosity? Please write to Ferdinando.Giordano@caen.it

Backup slides







Walk with exponential tail pulse