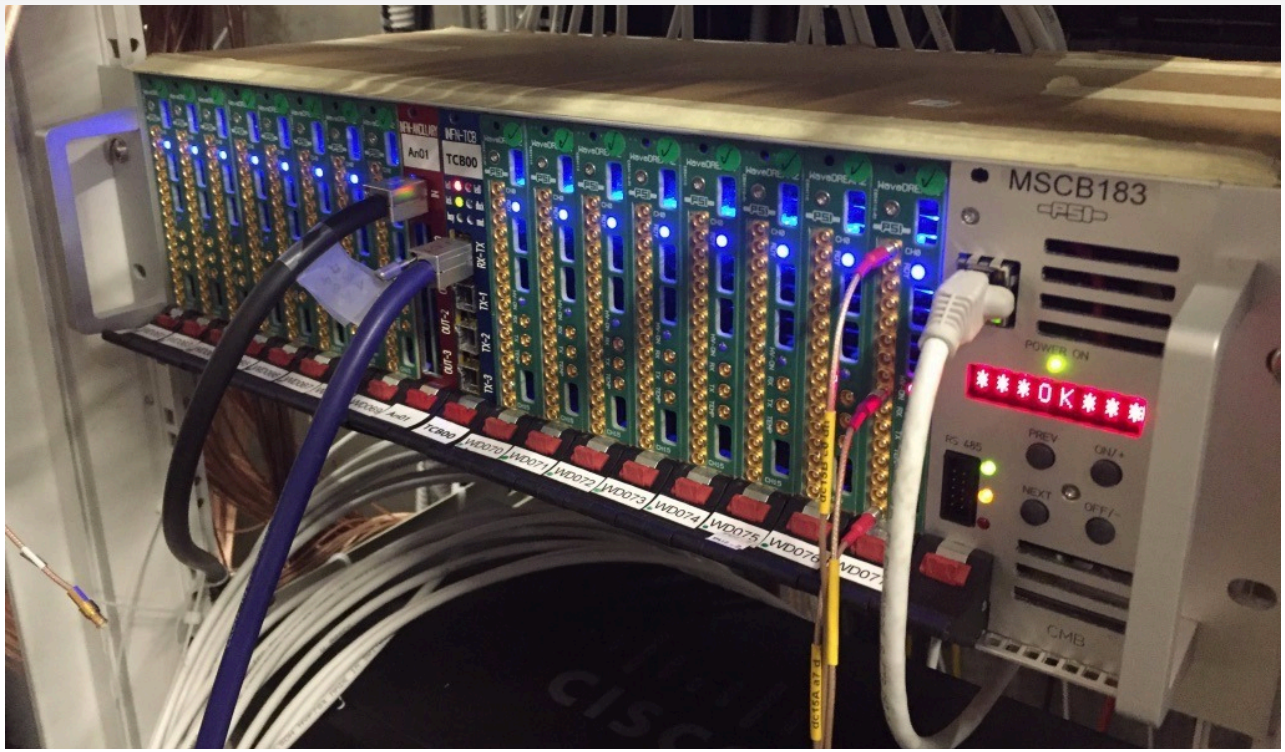
The TDAQ for the ΔE-TOF detector and start counter



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Bologna 04-12-2017

Istituto Nazionale di Fisica Nucleare

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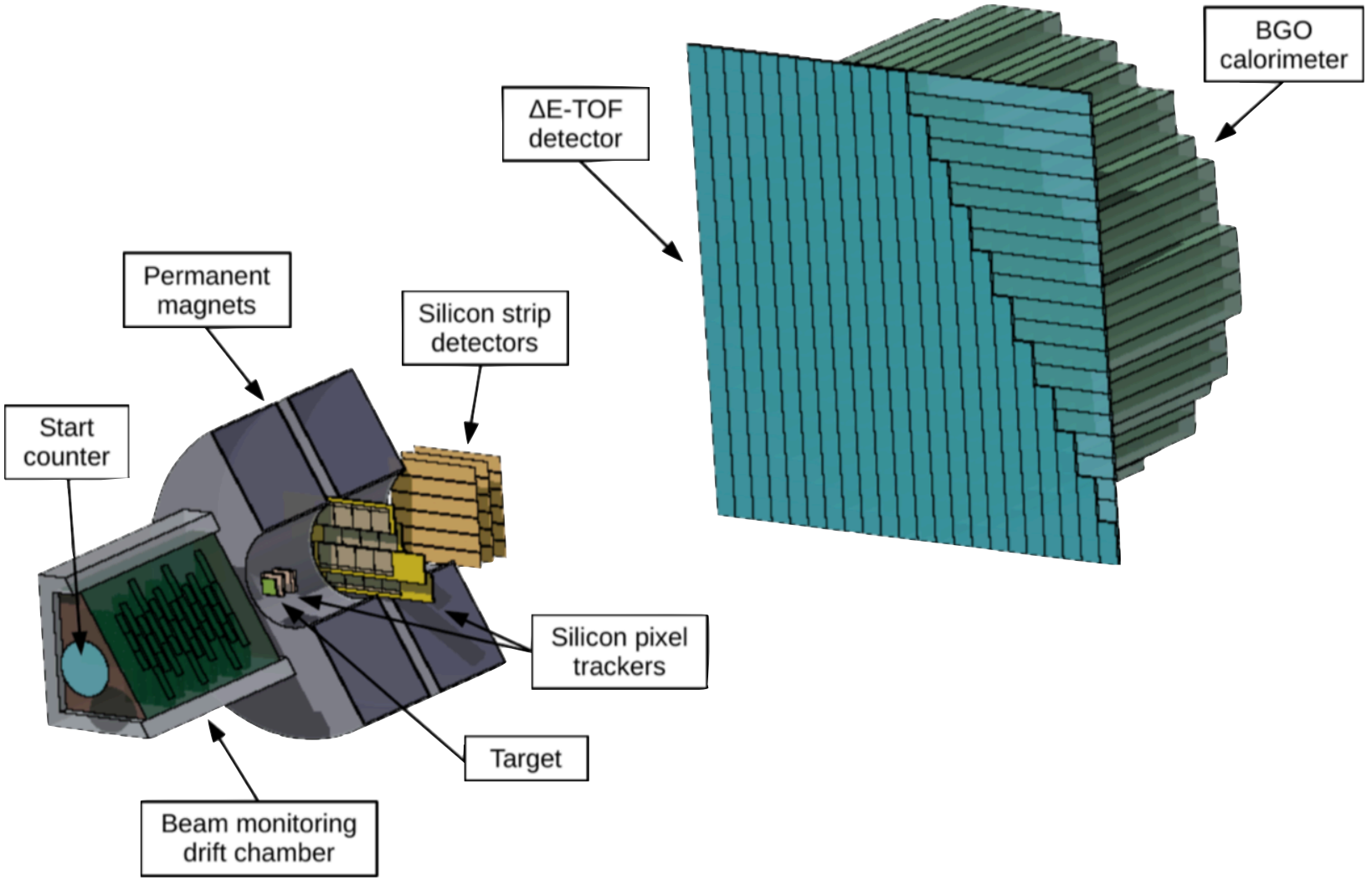
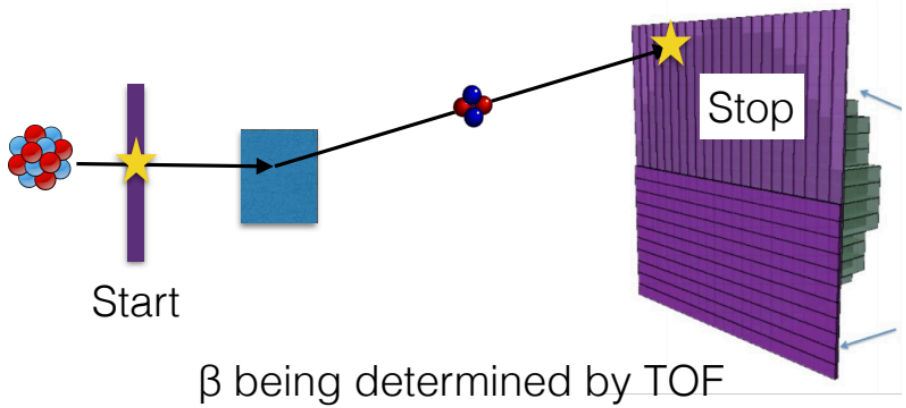
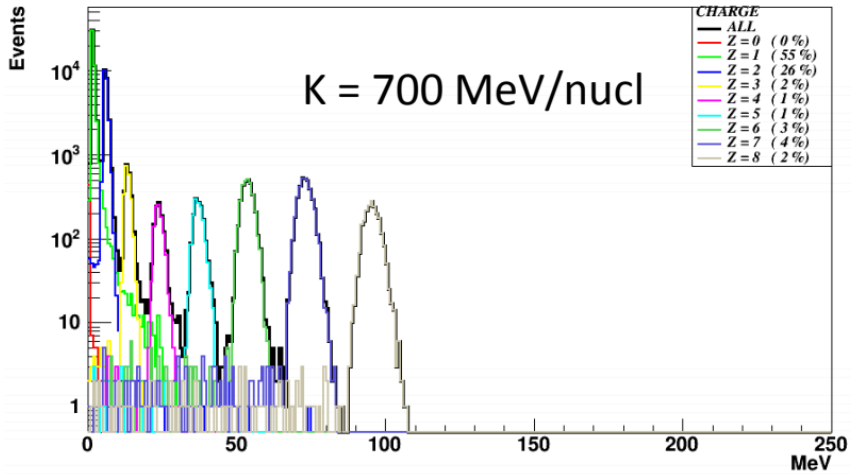
FOOT


BGO calorimeter
ΔE-TOF detector
Permanent magnets
Silicon strip detectors
Start counter
Silicon pixel trackers
Target
Beam monitoring drift chamber

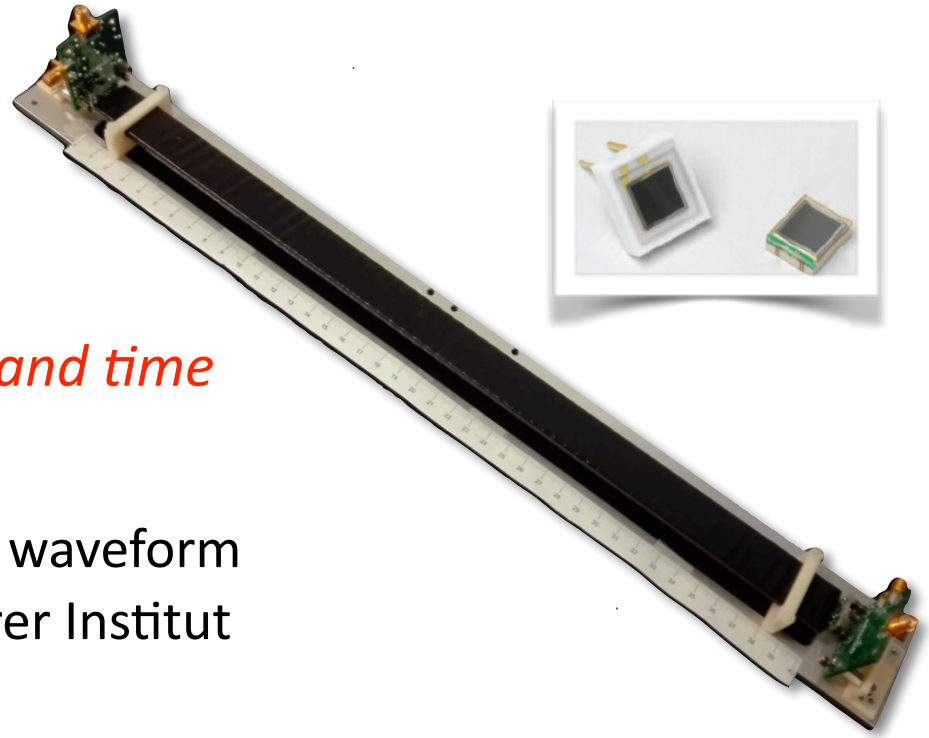
ΔE-TOF detector

- Fragment mass determination by simultaneous measurement of
  - *time-of-flight*
    - w.r.t. to start counter
  - *dE/dx*
    - Z^2 dependence from Bethe-Block distribution

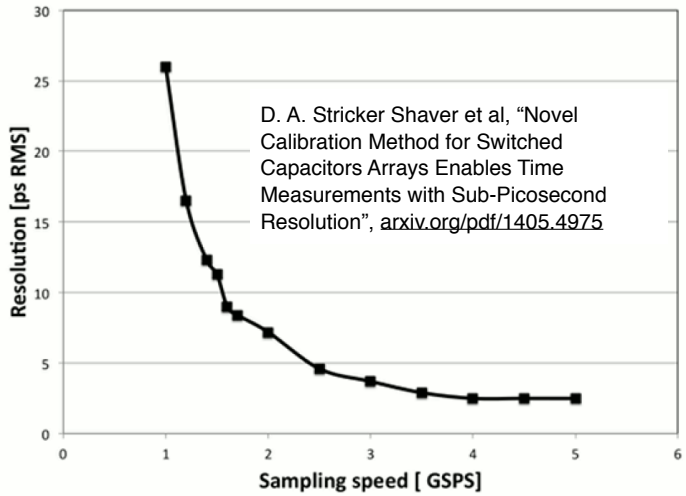




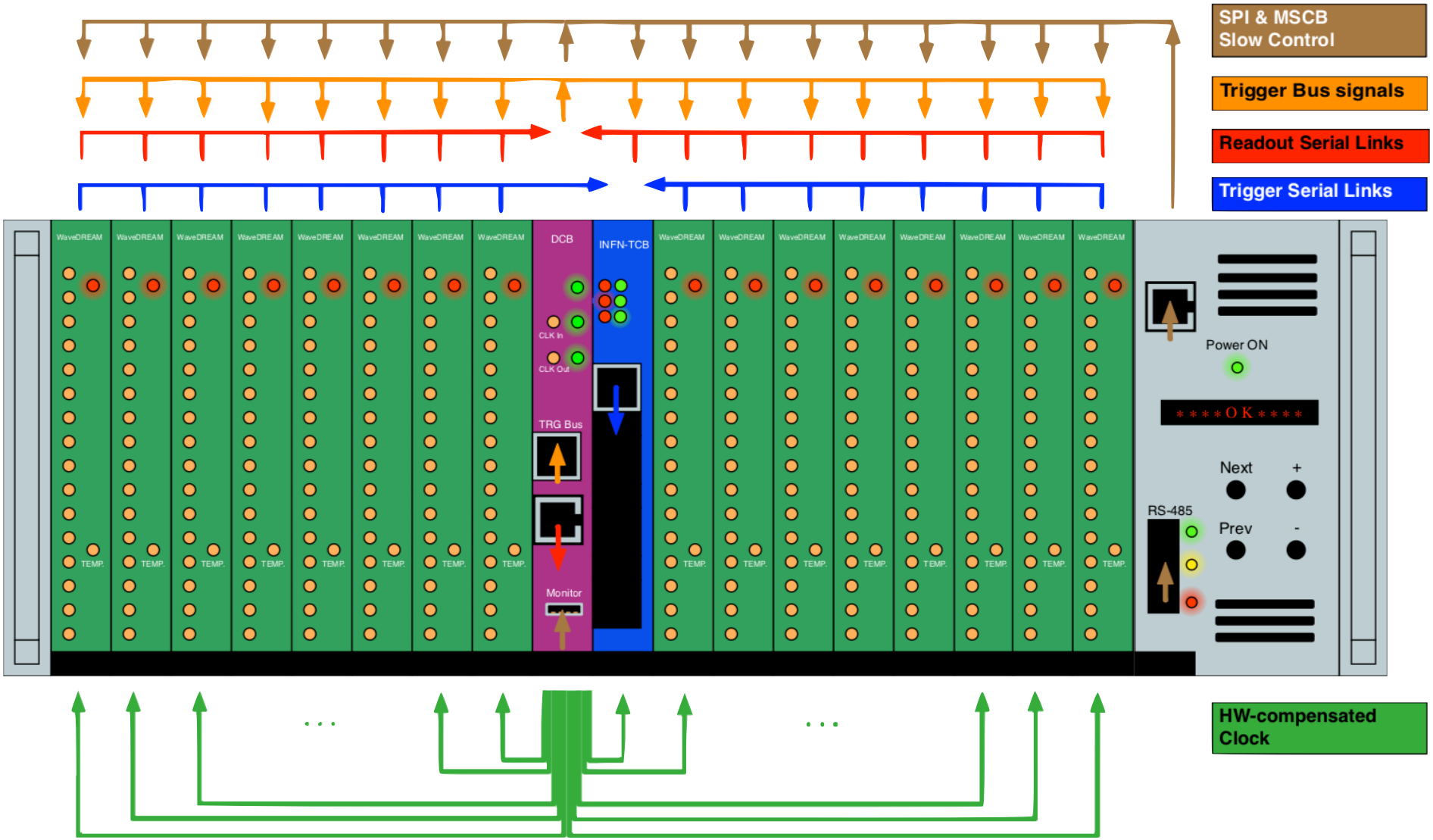
Requirements from the detector



- The TDAQ system to:
  - *connect to SiPM*
  - *simultaneous measurement of charge and time from fast scintillation bars*
    - use a Giga Sample Per Second (GSPS) waveform digitiser developed at the Paul Scherrer Institut
      - *Domino Ring Sampler chip (DRS)*
        - designed by Stefan Ritt
  - *integrated read out and possible complex trigger*
    - the WaveDAQ system developed by INFN and PSI groups

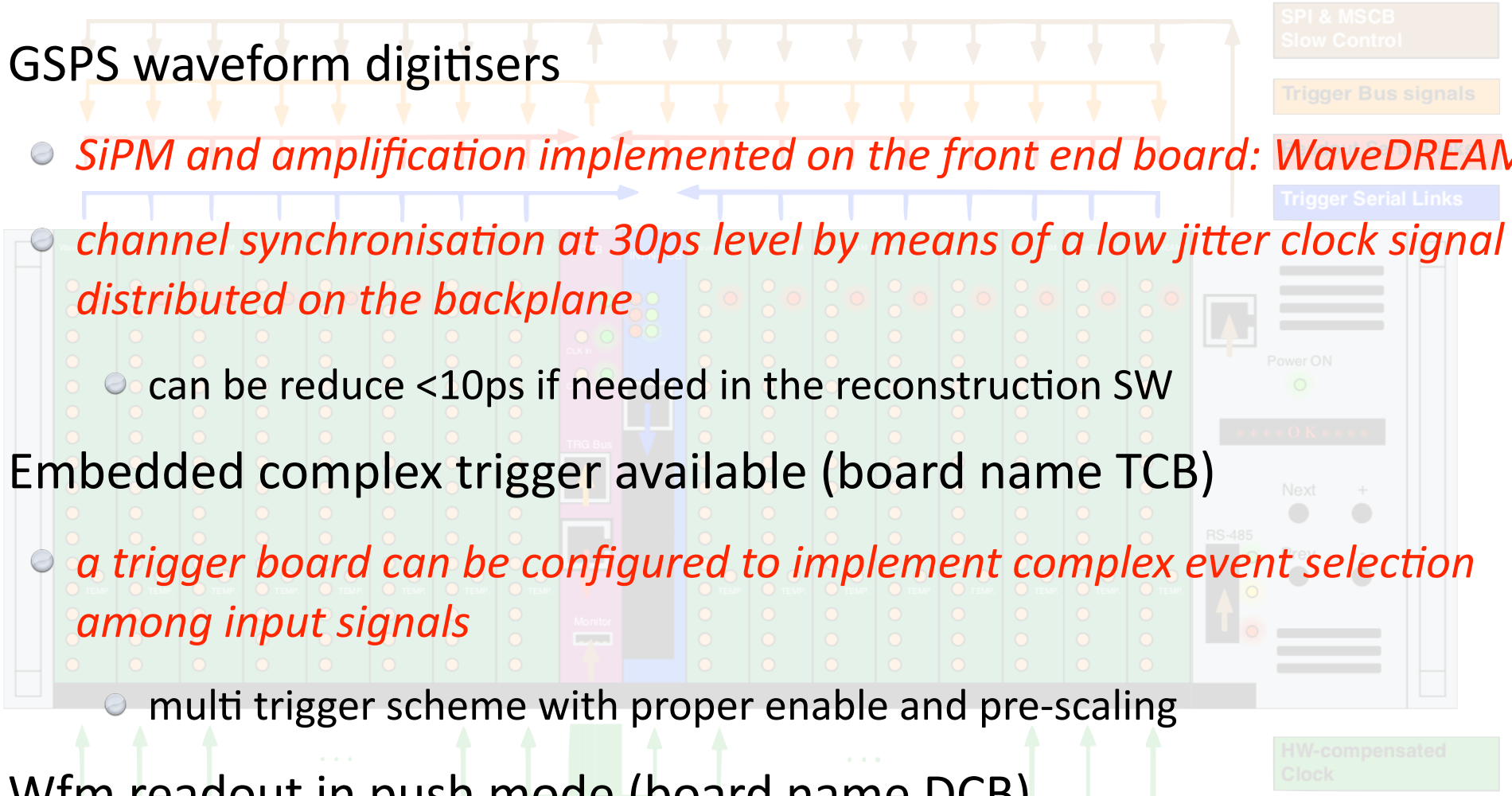


The WaveDAQ

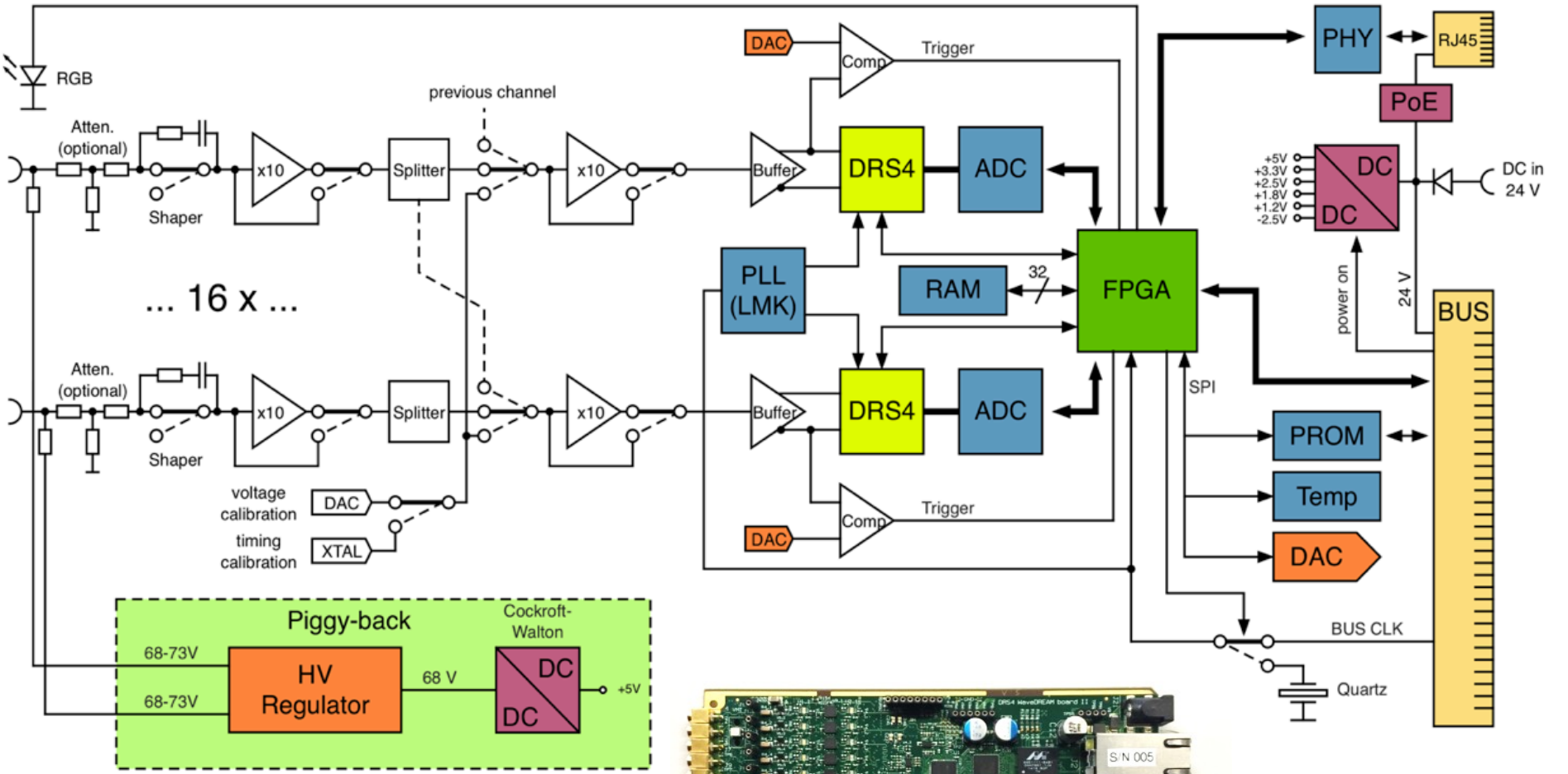

SPI & MSCB
Slow Control
Trigger Bus signals
Readout Serial Links
Trigger Serial Links
WaveDREAM
TEMP.
DCB
CLK In
CLK Out
TRG Bus
Monitor
INFN-TCB
Power ON
* * * * O K * * * *
Next
+
Prev
-
RS-485
HW-compensated
Clock

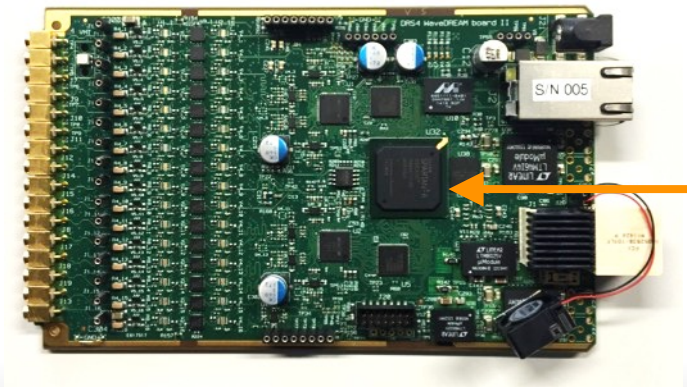
The WaveDAQ

- GSPS waveform digitisers
  - *SiPM and amplification implemented on the front end board: WaveDREAM*
  - *channel synchronisation at 30ps level by means of a low jitter clock signal distributed on the backplane*
    - can be reduce <10ps if needed in the reconstruction SW
- Embedded complex trigger available (board name TCB)
  - *a trigger board can be configured to implement complex event selection among input signals*
    - multi trigger scheme with proper enable and pre-scaling
- Wfm readout in push mode (board name DCB)
  - *Gbit ethernet link to online machines*



The WaveDREAM board

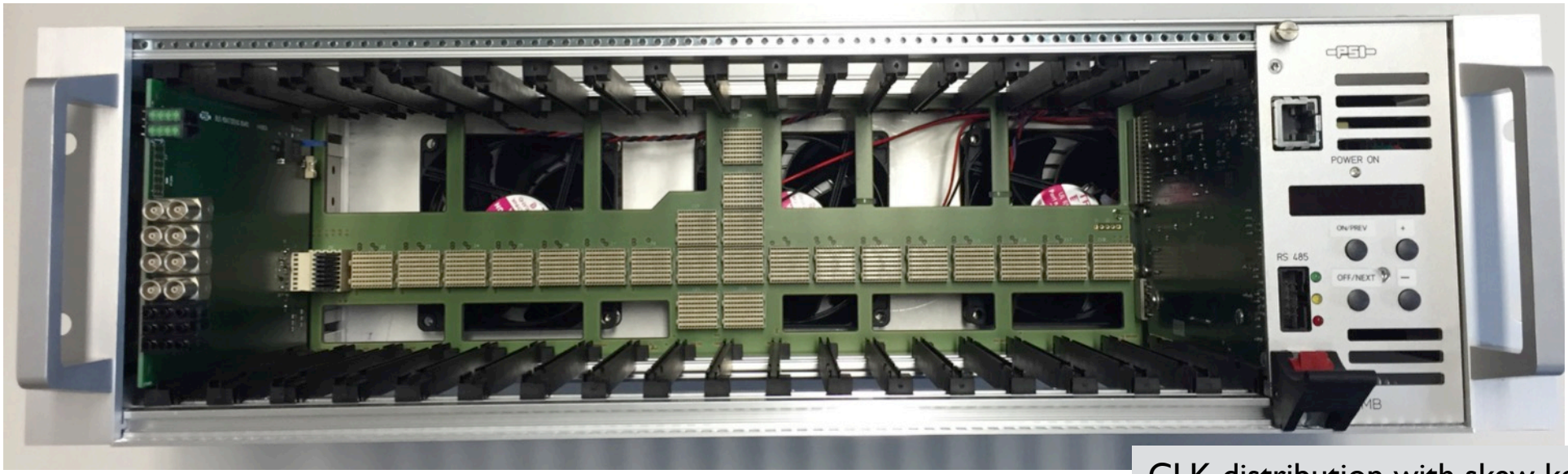




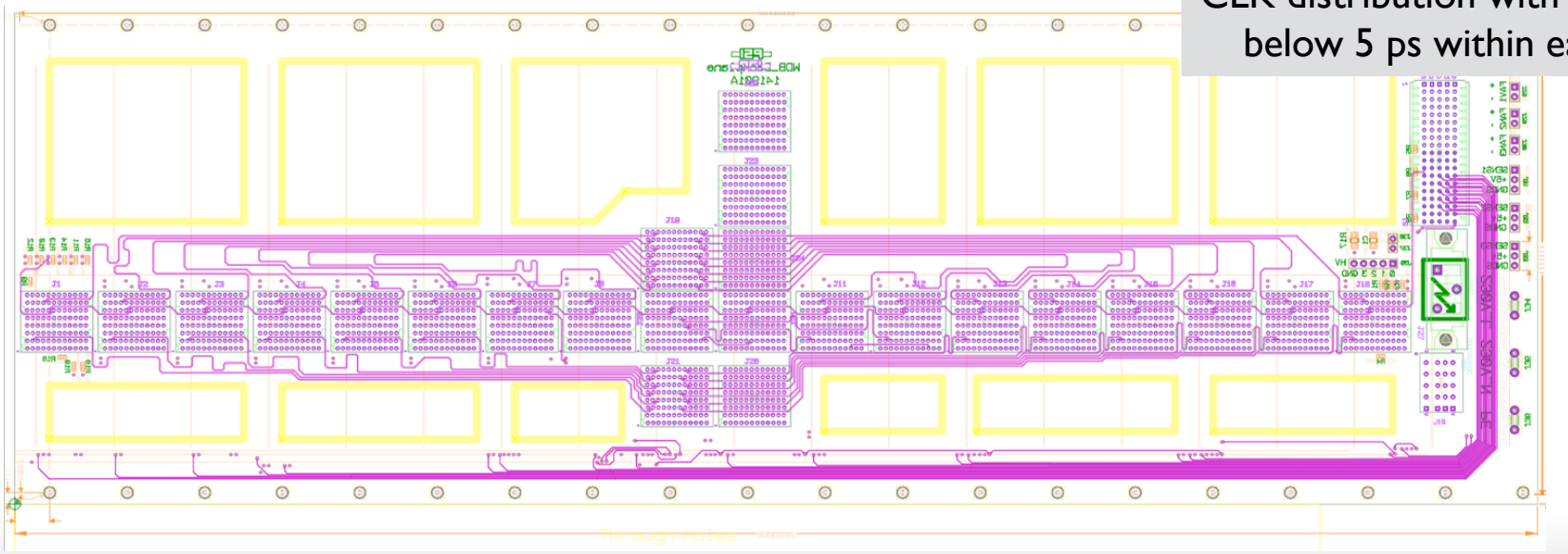
Xilinx Spartan6

WaveDREAM board (WDB):
Drs4 based **REA**dout **M**odule

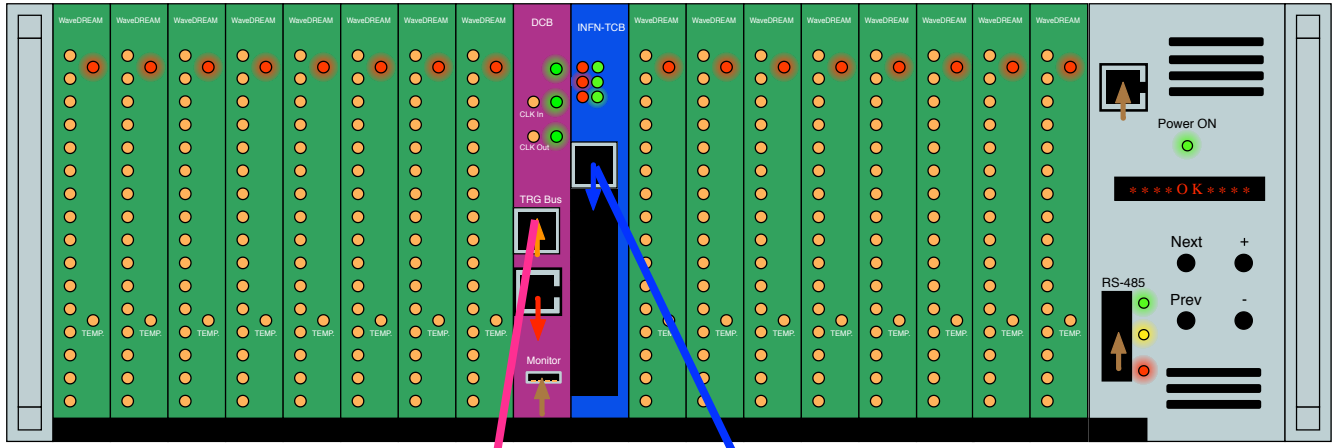
The crate



CLK distribution with skew kept below 5 ps within each slot

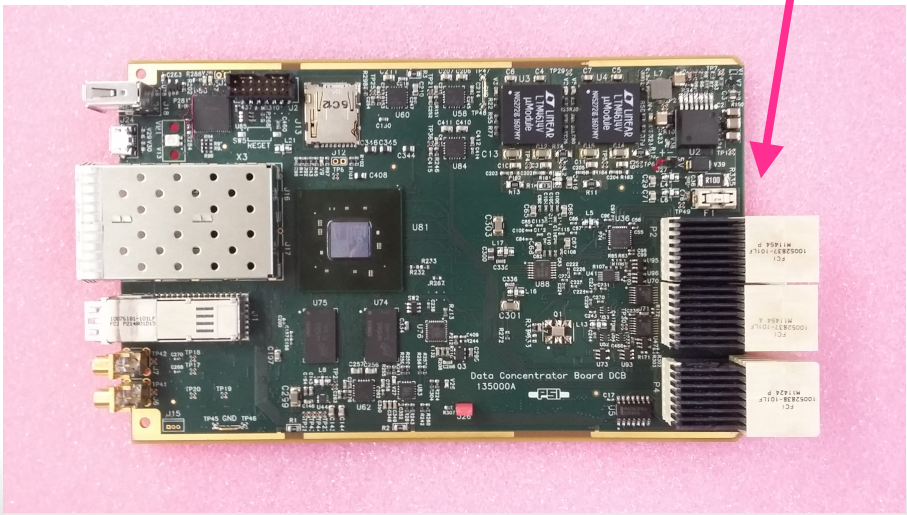


Trigger and data managers



Data Concentrator Board (DCB)

- Based on SoC Xilinx Zynq 7030
- Data read out with 1Gb serial links and Gb ethernet to storage
- Trigger bus signal distribution

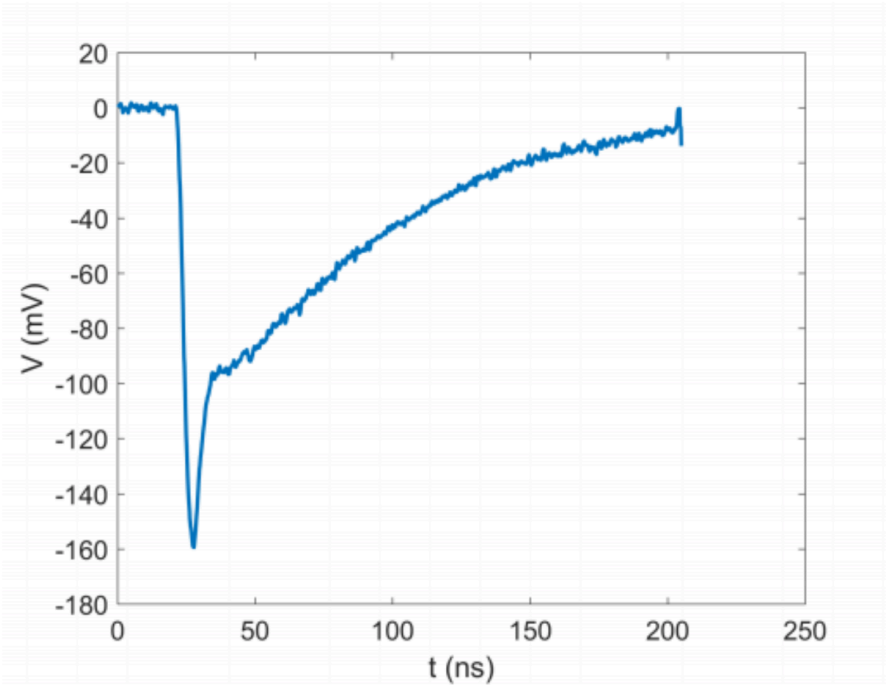


Trigger Concentrator Board (TCB)

- 8 Gbit link to any WaveDREAM
- Event reconstruction on FPGA Xilinx Kintex7

Wfms digitisers issues

- Complex wfm analysis to extract best resolutions from detector
  - *analysis tools and calibrations can be developed anytime after data collection*
    - time extraction example: single threshold, constant fraction, rising edge fit….
  - *pile-up rejection capability*
- data size ~10^3 larger than a TDC-QDC read out
  - *a DRS Wfm has 1024 bins (i.e. 4 bytes words)*



Some numbers

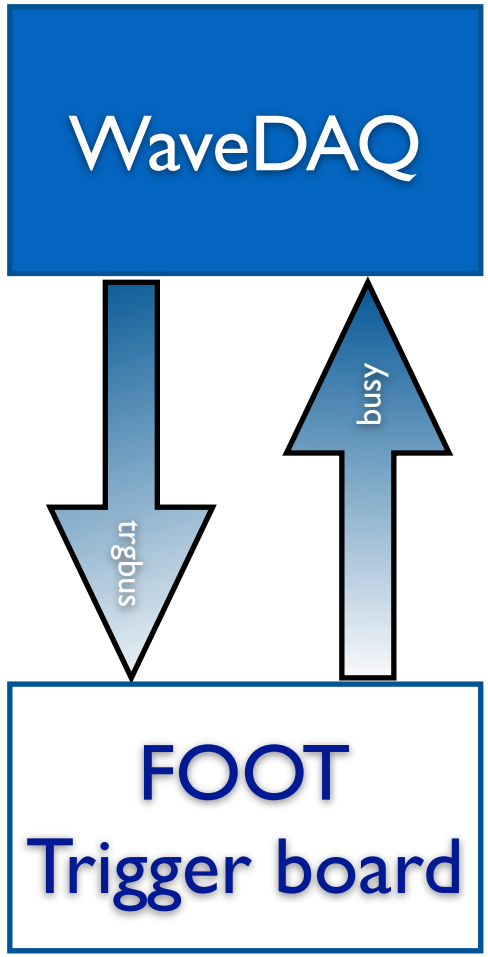
- The DRS chip must be stopped and read out every event
  - *associated dead time ~100usec -> maximum possible trigger rate 10kHz*
    - should be within FOOT requirements
- Event size
  - *ΔE-TOF: 88 channels*
  - *start counter: 8 channels (?)*
    - total number of channels: 96 -> ~400kB per event (if all read)

Data flow and trigger rate

- a zero suppression HW will be implemented in the WDB firmware
  - *only channels with a hit will be read out*
- As an average ~15% of the channels will have an hit:
  - *8 from start counter + 8 from ΔE-TOF*
- 60kB per event are then expected, which translate into:
  - *600kB/s with a trigger rate of 10Hz*
  - *….*
  - *60MB/s with a trigger rate of 1kHz*
- The combination of minimum bias (start counter only) and coincidence triggers between start counter and ΔE-TOF may be tested
  - *would help in reducing the DAQ rate without introducing significant bias from the trigger*

Possible WaveDAQ HW interface

- The trigger signal and the event information (trgbus) are distributed inside the crate and can be made available on LVDS pairs
  - *to be connected to the FOOT trigger board*
- the busy can be received and the trigger generation disabled within the same connection
  - *in this case we receive from the trigger board*
- Other schemes are possible and under studies



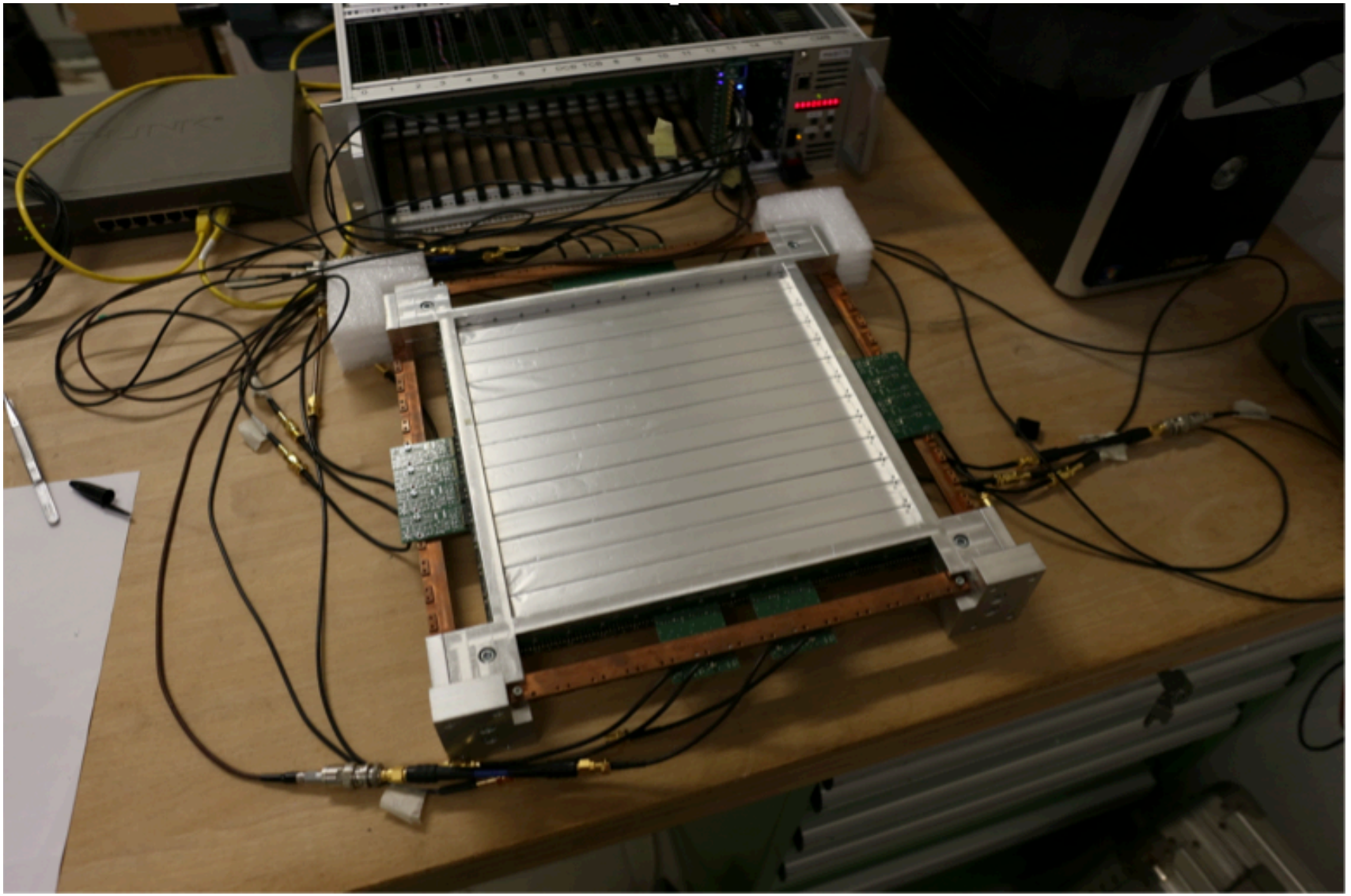
SW interface

- WaveDAQ will have a C++ library to be imported in the DAQ
  - *connection to the crate*
  - *system configuration*
  - *waveform readout*
    - collection and write to disk
- The library can be included in the FOOT DAQ

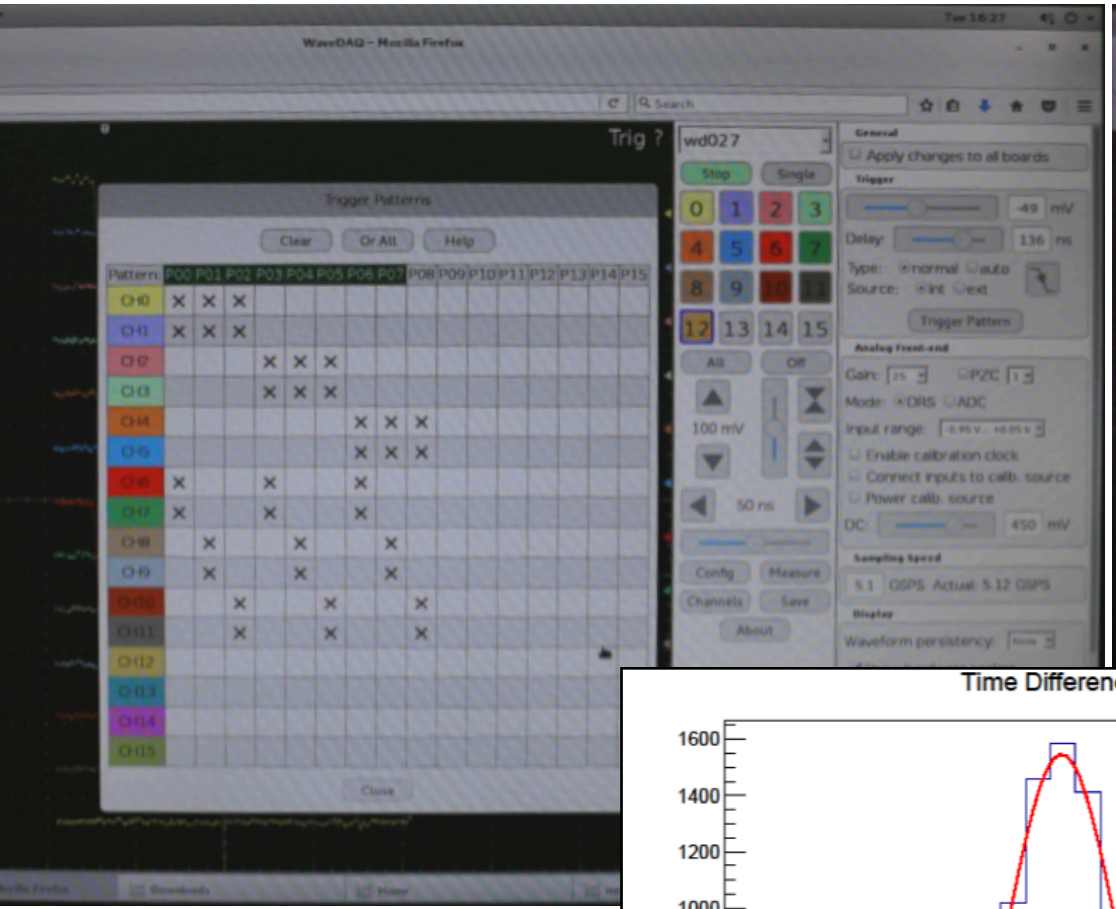
Board productions schedule

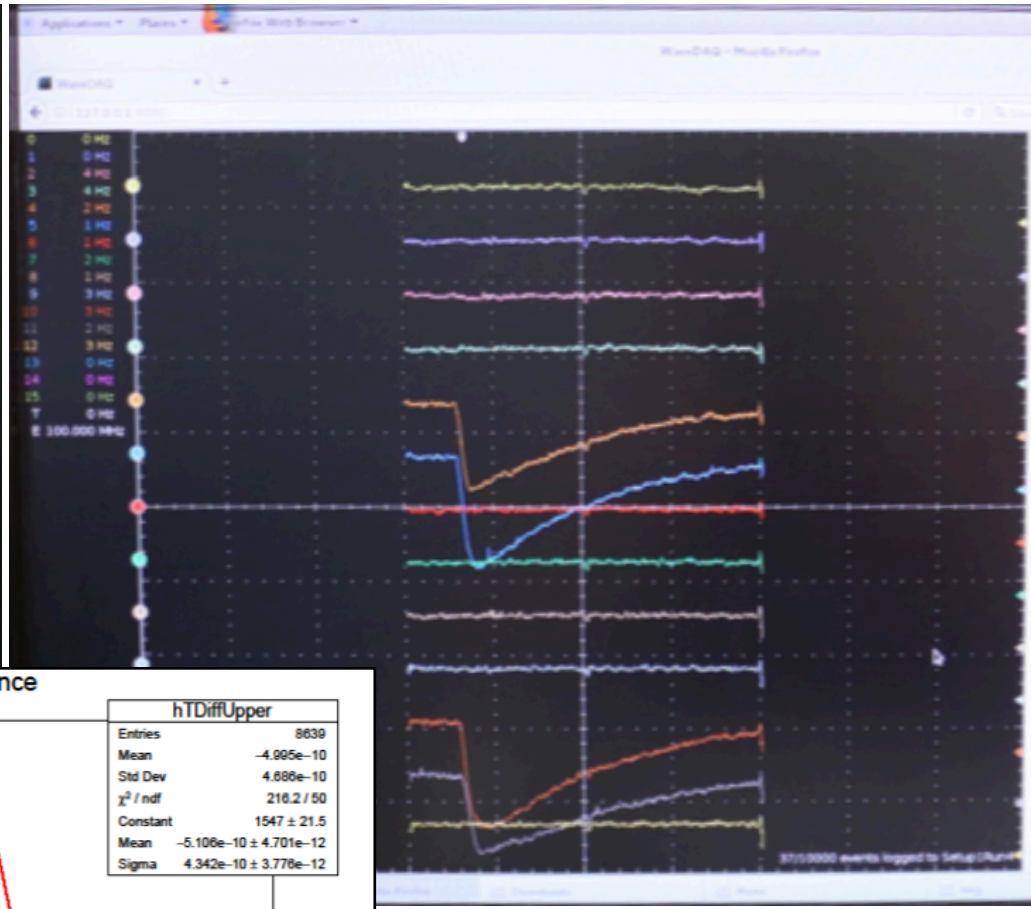
- The WDB is still in prototyping phase
  - *this system will be used also in there projects and we are collecting all the requests*
    - production sometime in the middle of next year
    - we can have in Pisa a few (~4) WDBs for lab studies with the current version
      - *already OK for FOOT needs*
- The TCB will be ordered soon
  - *chip procurement already started*
    - ready for middle-end of 2018
- The first DCB prototype just assembled
  - *production in parallel to WDBs*

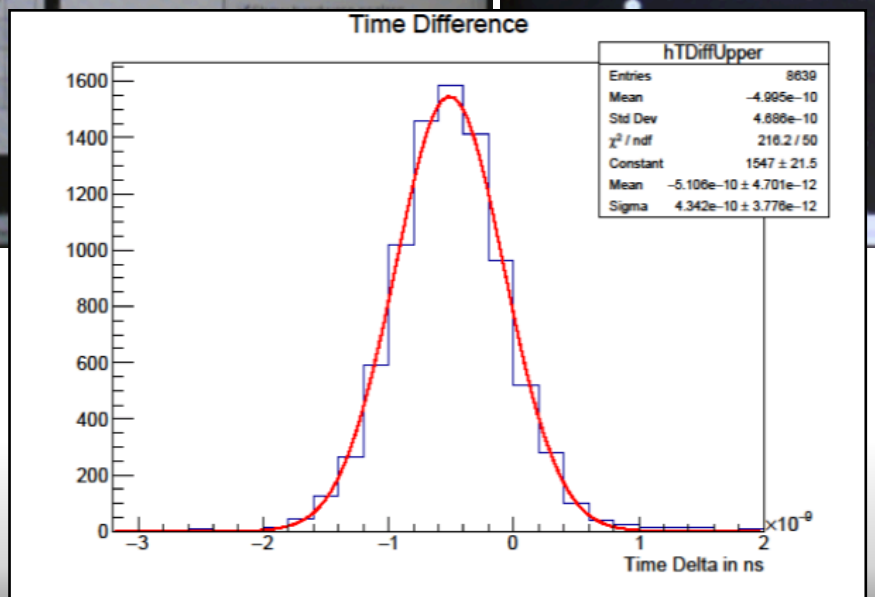
Addendum: test with M. Emde's setup



WDB web interface and trg setup







Conclusions

- The ΔE-TOF detector and the start counter will adopt the WaveDAQ as TDAQ system
  - *time and energy information by mean of waveform analysis*
  - *possible complex trigger set up*
  - *data flow ~1-50 MB/s depending on the DAQ rate*
- Electronics performance tested with ΔE-TOF prototypes
  - *see M. Morrocchi's slides*