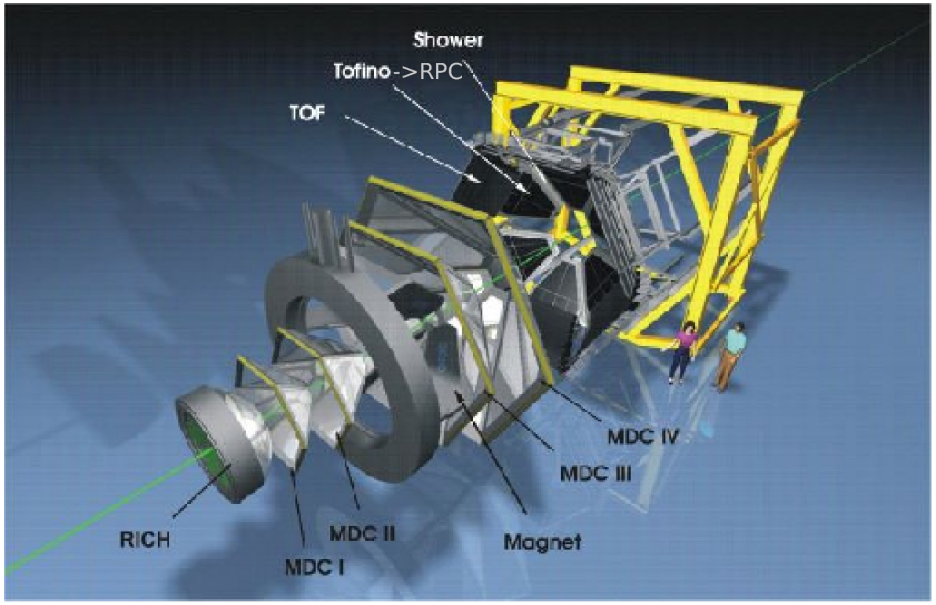
The Multipurpose Trigger Readout Board (TRB)

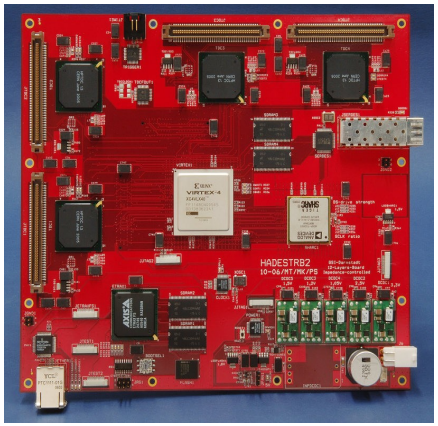
Marek Palka for the HADES collaboration

RPC Workshop
GSI Darmstadt, 9.02.2010 - 12.02.2010

The Multipurpose Trigger Readout Board TRB



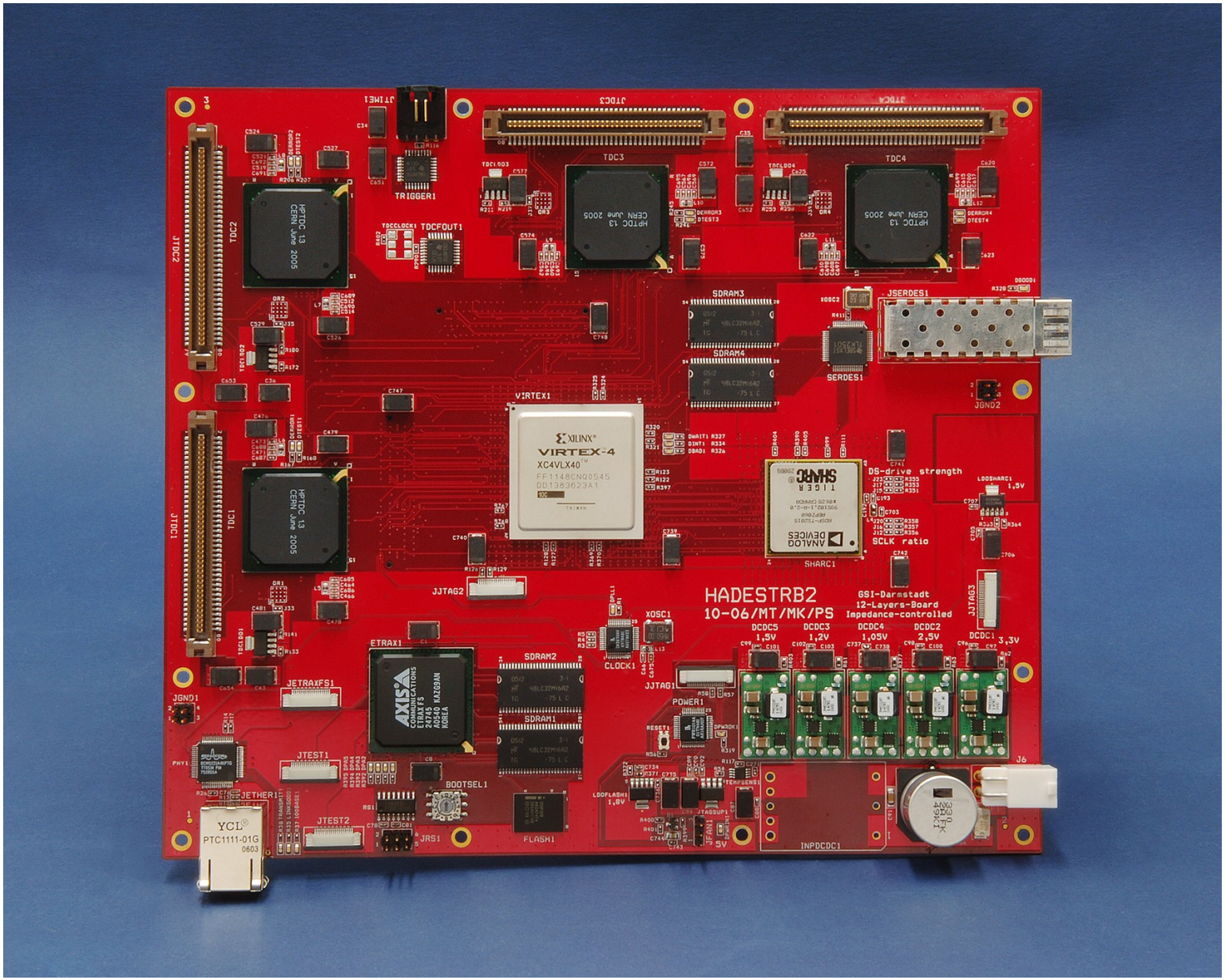
HADES spectrometer



TRB

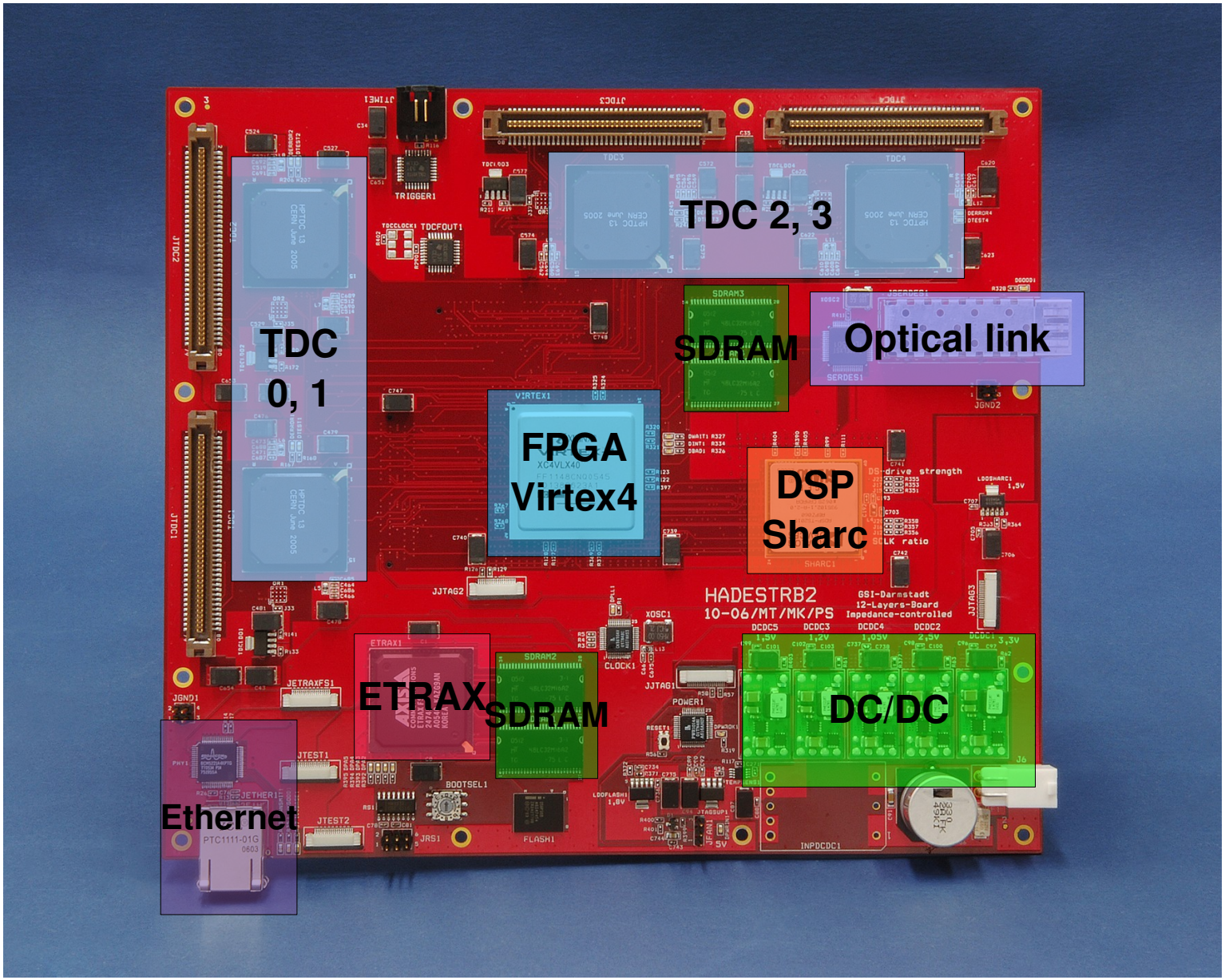
- TRB is serving as a base platform for all detector subsystems
- In total there are 80 thousand electronic channels
- The data acquisition system has to cope with high multiplicity events – 300MB/s for heavy systems

The Multipurpose Trigger Readout Board TRB



- 4 TDC – 128 channels
- 4x512Mb SDRAM
- FPGA – Virtex4LX40
- ETRAX FS – 4 processors
- 100Mb/s,TCP/IP
- 2,5 Gb/s optical link
- DSP TigerSharc
- DC/DC converters
- AddOn connector

The Multipurpose Trigger Readout Board TRB



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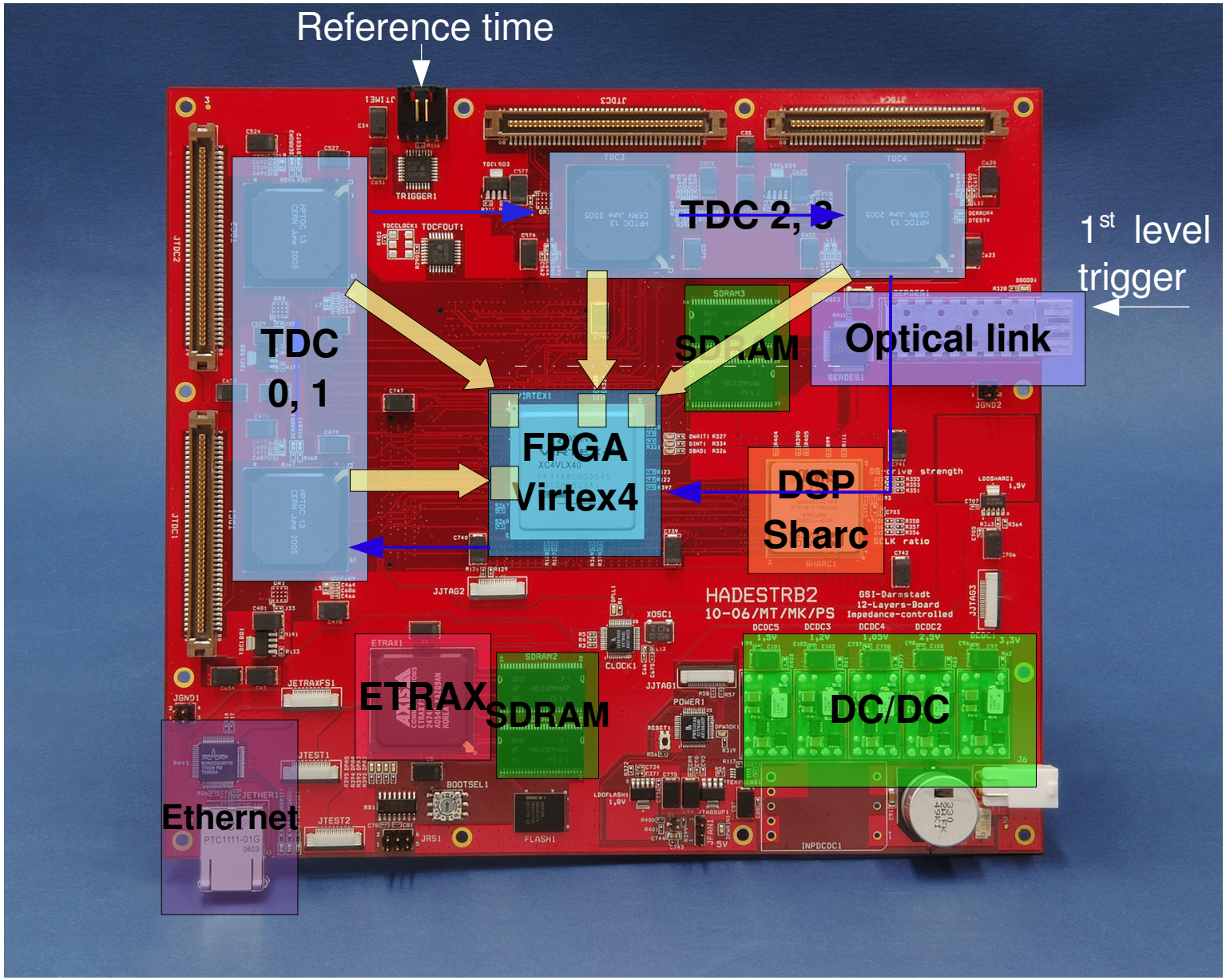
The Multipurpose Trigger Readout Board
The readout – First Level Trigger

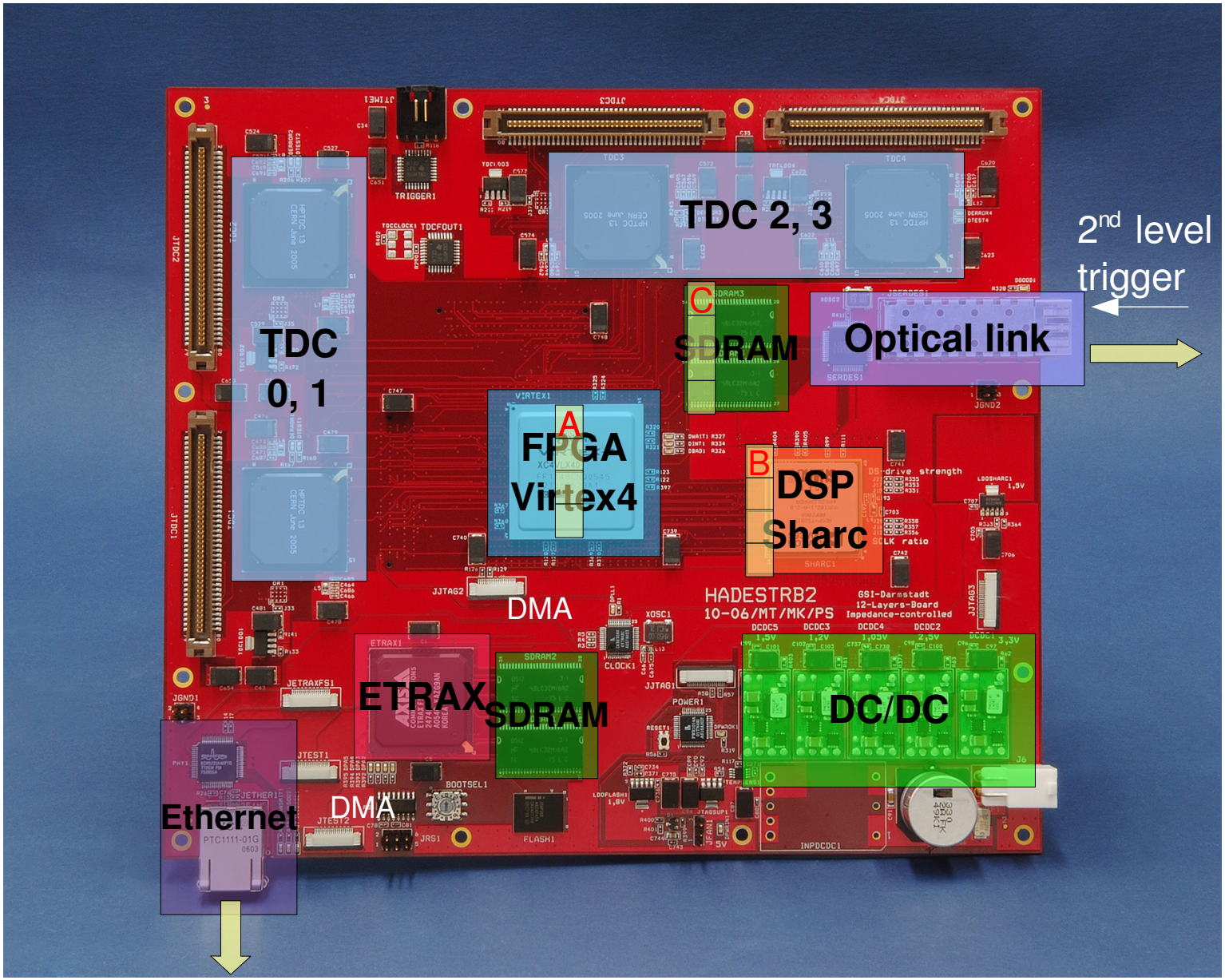


Token

Data

- The readout is started after receiving first level trigger
- Token is passed to the TDCs and data flows to the FPGA
- Reference time is going to all 4 TDCs

The Multipurpose Trigger Readout Board
The readout – Second Level Trigger

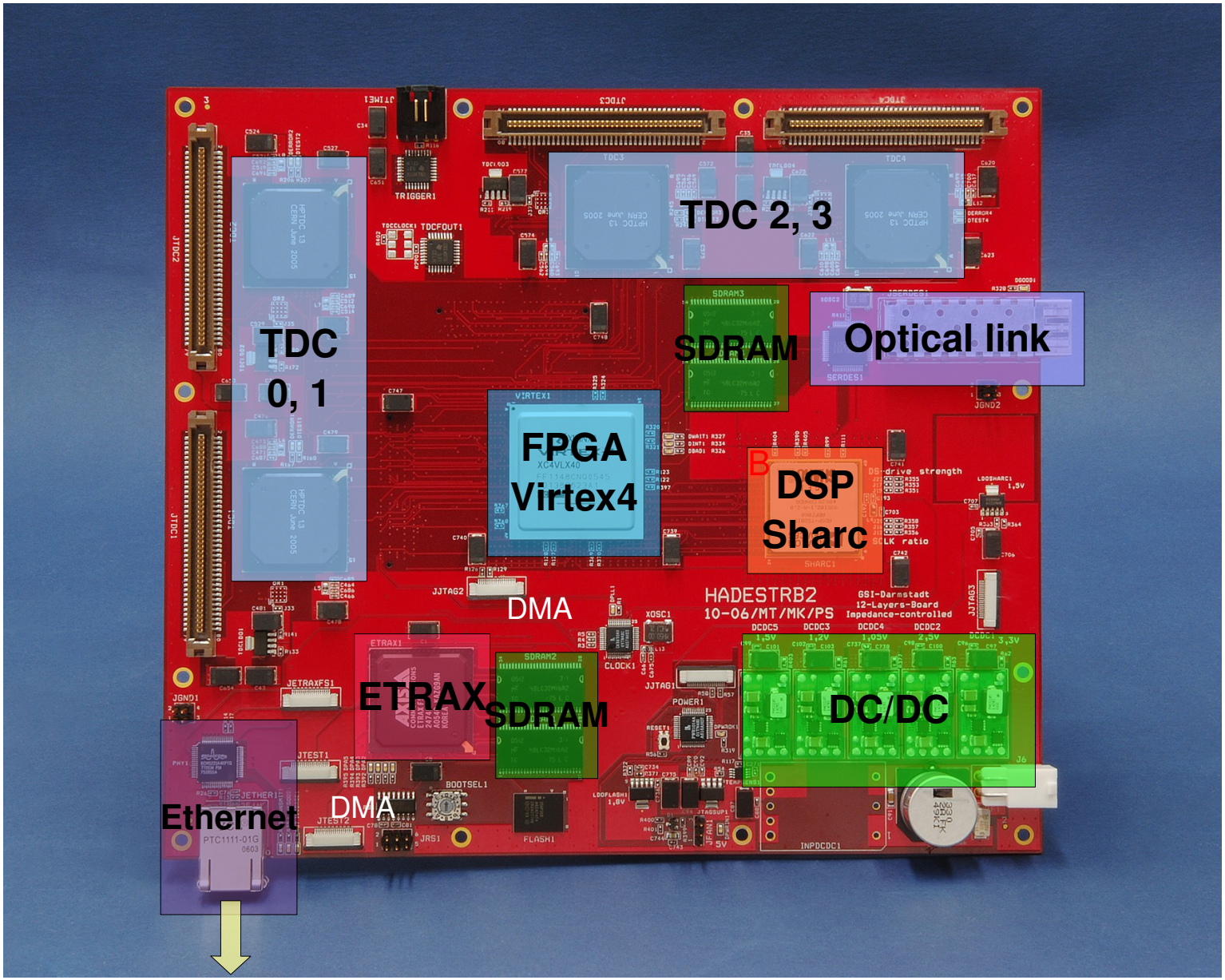


Data

- Data can be stored and preprocessed in the FPGA (A), DSP (B). To store larger amount of the data SDRAM (C) can be used.

- After 2nd level trigger data can be send through:
  - Etrax Ethernet
  - 2.5 Gbit/s optical connection

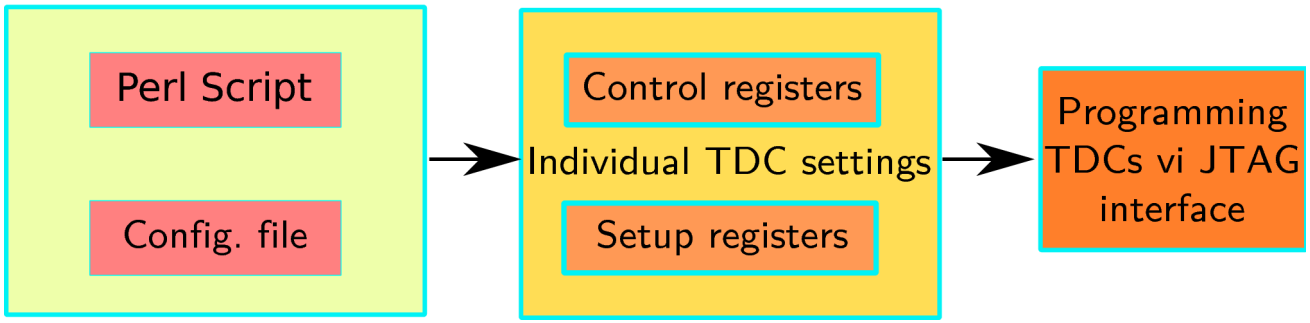
The Multipurpose Trigger Readout Board
The Readout – Second Level Trigger



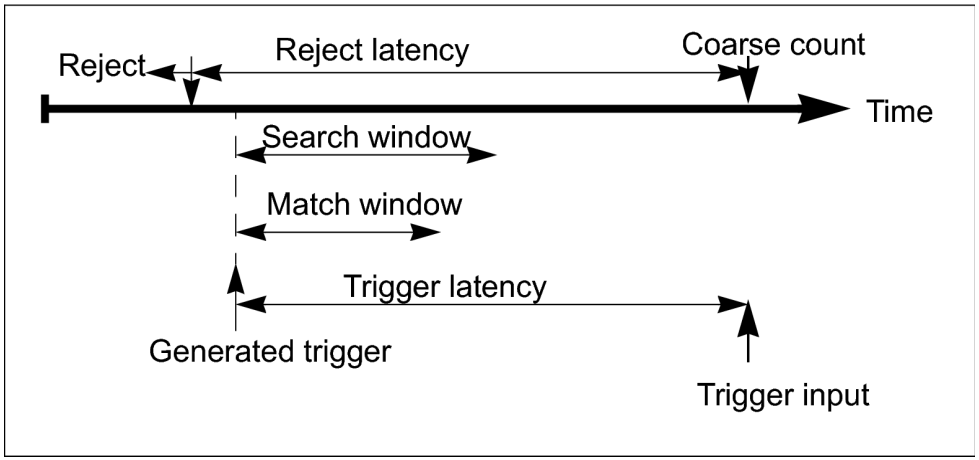
Sending data with Ethernet (there is still room for improvements):

32bit words/ event	f[kHz]	MB/s
14	124	11
22	82	9.2
38	44	8.5
64	27	8.1
110	18	7.9
170	10.5	7.8
640	3	7.7

The Multipurpose Trigger Readout Board
HPTDC* Settings



Settings of TDCs parameters



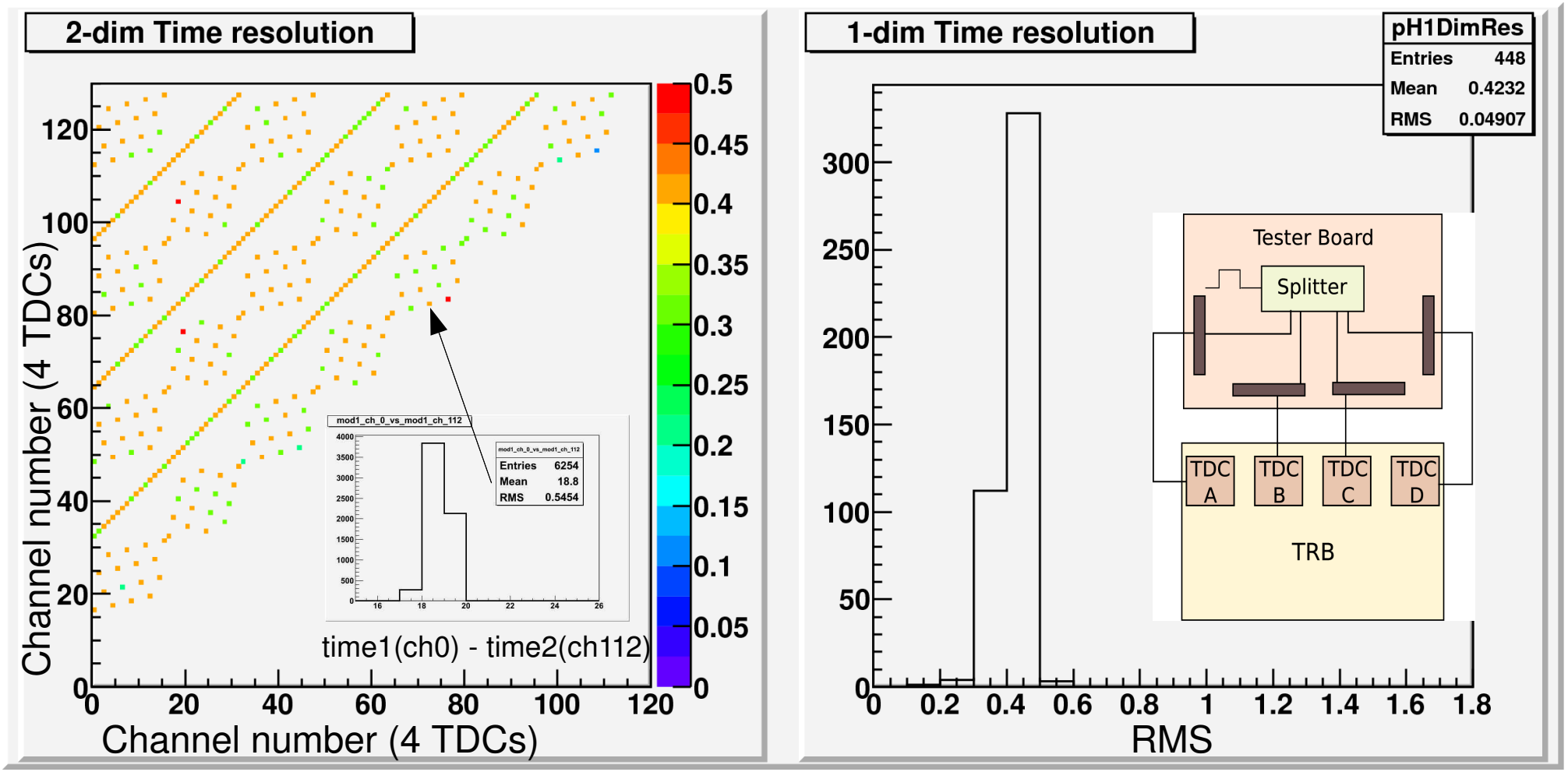
Main TDC configuration parameters

Main values of the TDCs registers are set in one configuration file which has quite easy structure to cope:

```
...'
TRB_000' => {
    'TDC' => {
        'TDC_A' => {
            'mode_rc_compression'    => 1,
            'mode_rc'                => 1,
            'trigger_count_offset'   => 1200,
            'matching_window'        => 1000,
            'pulse_length'           => 0,
            'rc_adjust'              => ['010','100','111','111'],  #[tap3,tap2,tap1,tap0]
        },
        'TDC_B' => {
            'mode_rc_compression'    => 1,
            'mode_rc'                => 1,
            'trigger_count_offset'   => 1200,
            'matching_window'        => 1000,
            'pulse_length'           => 0,
            'rc_adjust'              => ['010','100','111','111'],  #[tap3,tap2,tap1,tap0]
        },
        'TDC_C' => {
            'mode_rc_compression'    => 1,
            'mode_rc'                => 1,
            'trigger_count_offset'   => 1200,
            'matching_window'        => 1000,
            'pulse_length'           => 0,
            'rc_adjust'              => ['010','100','111','111'],  #[tap3,tap2,tap1,tap0]
        },
        'TDC_D' => {
            'mode_rc_compression'    => 1,
            'mode_rc'                => 1,
            'trigger_count_offset'   => 1200,
            'matching_window'        => 1000,
            'pulse_length'           => 0,
            'rc_adjust'              => ['010','100','111','111'],  #[tap3,tap2,tap1,tap0]
        },
    }
...
```

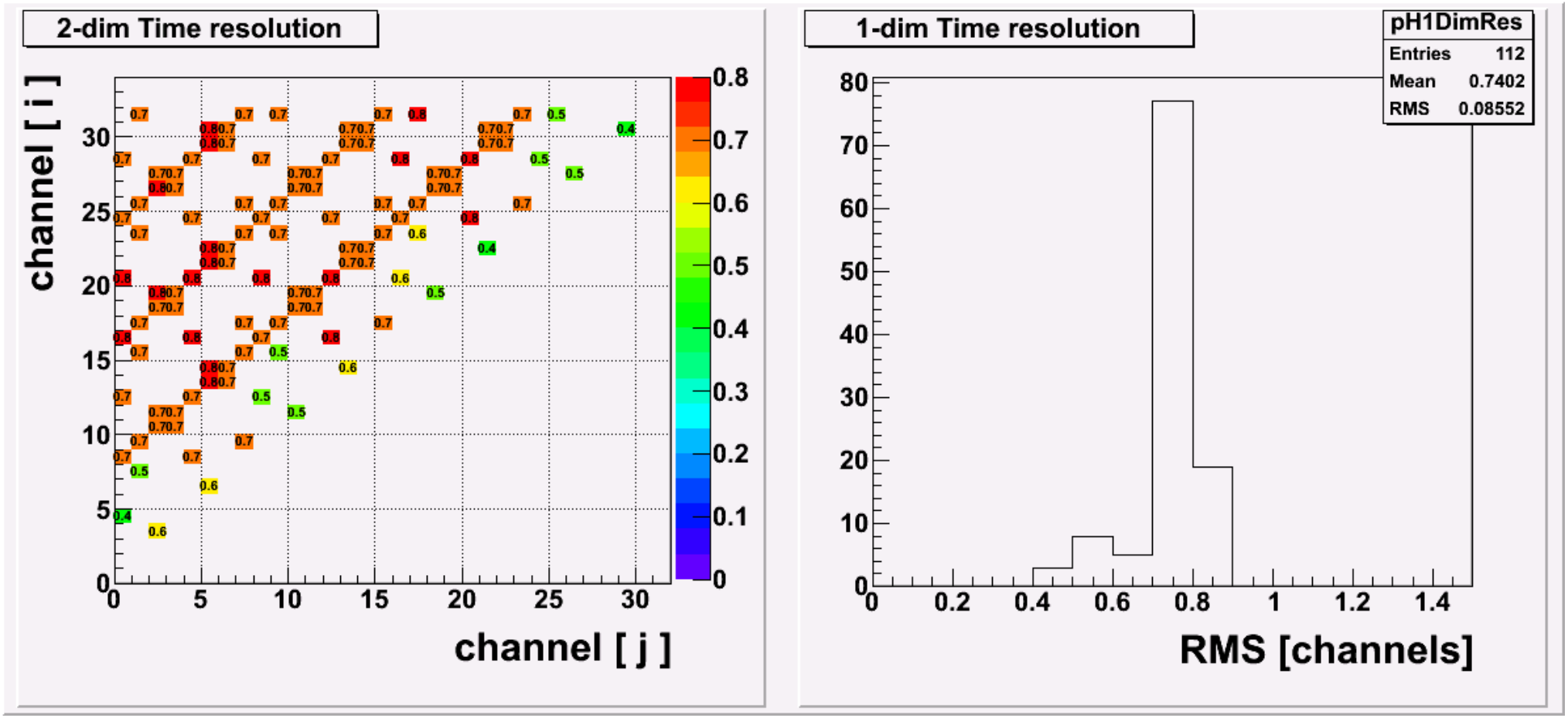
* HPTDC – J. Christiansen, CERN/EP – MIC.
Used in Alice and CMS experiment.

The Multipurpose Trigger Readout Board
High Resolution Mode (100ps/bin)



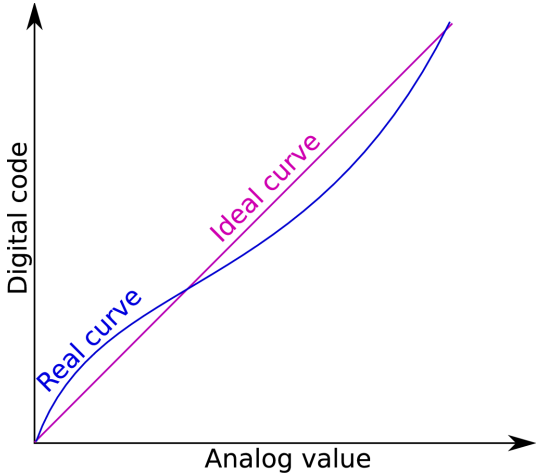
Resolution plots for all 128 channels (100 ps binning), single channel average resolution ~ 30 ps

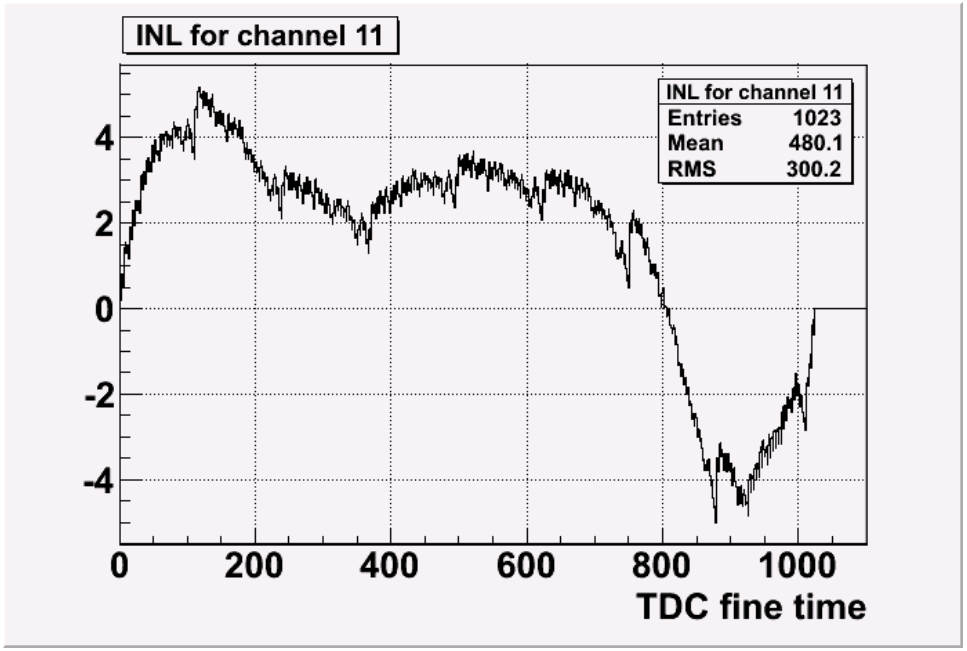
The Multipurpose Trigger Readout Board
Very High Resolutions Mode (25ps/bin)



Resolution plots for all 32 channels (25 ps binning), single channel average resolution ~ 13.5 ps

The Multipurpose Trigger Readout Board
HPTDC INL Corrections

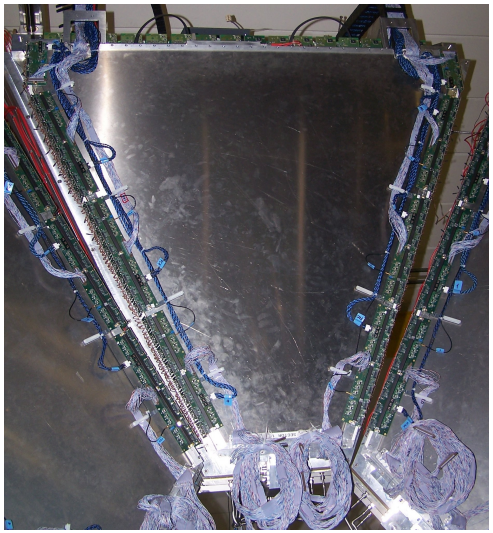


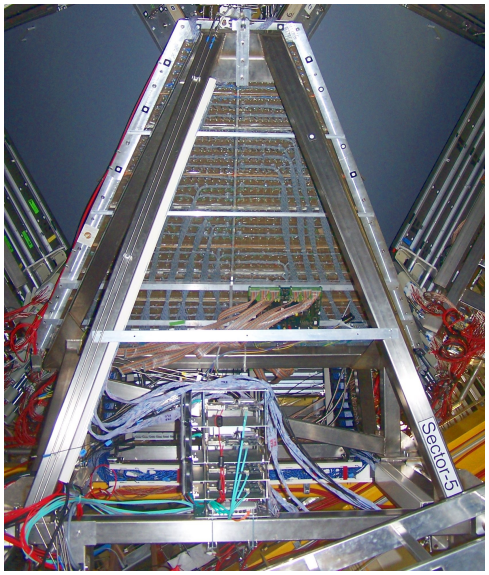


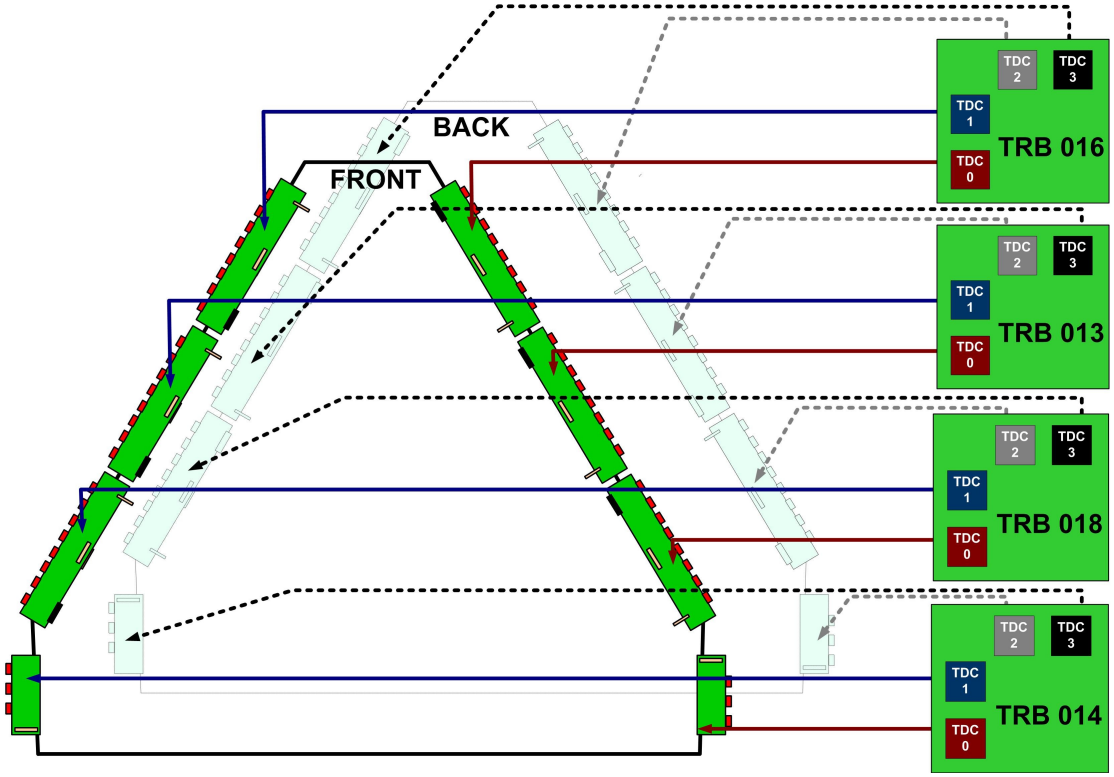
INL pattern for 25ps/bin

Integral Nonlinearity (INL) corrections are essential for high and very high resolution measurements

The Multipurpose Trigger Readout Board
Measurements with the HADES RPC Detector

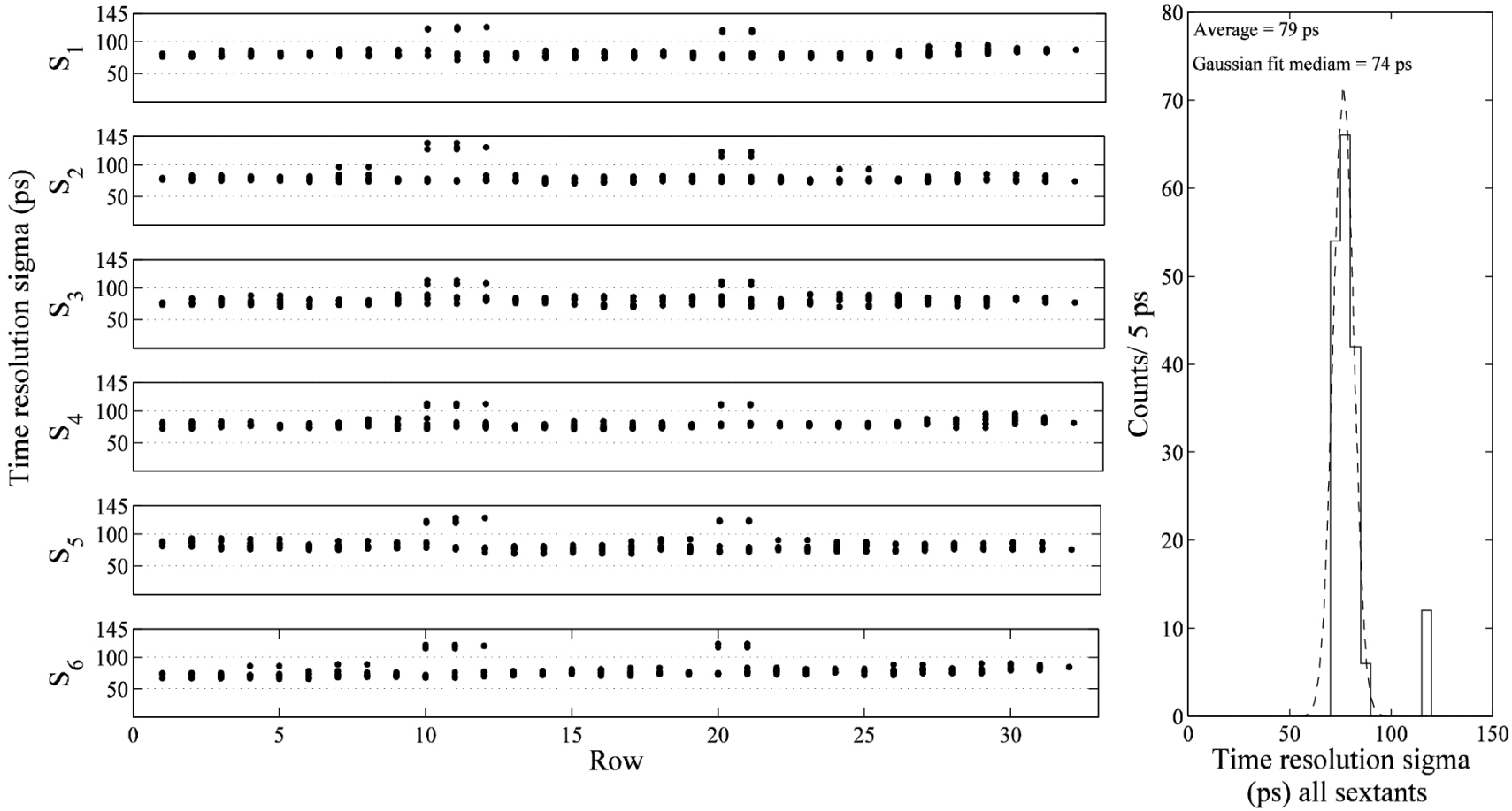






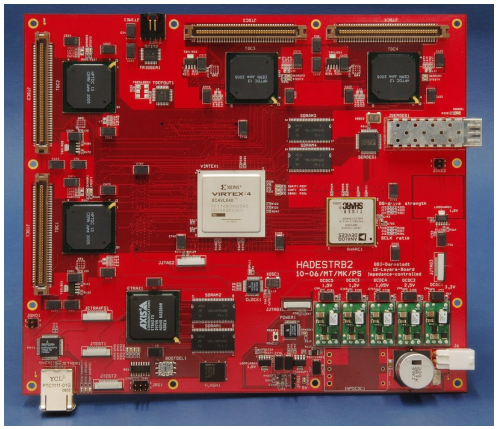
RPC setup together with all front-end
and readout electronics .

The Multipurpose Trigger Readout Board
Measurements with the HADES RPC Detector

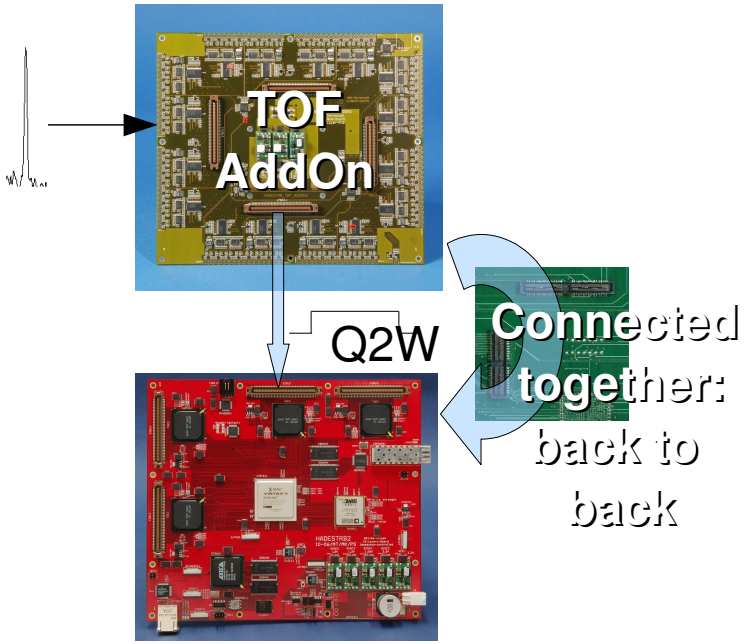


Resolution with full path of readout electronics, front-end and detector itself
[Status of the HADES RPC Time of Flight wall , GSI Annual Report 2009].

The Multipurpose Trigger Readout Board Applications



TRBv2 – Trigger and Readout Board

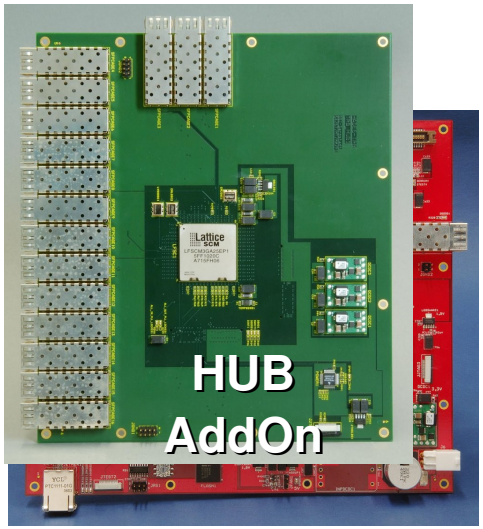


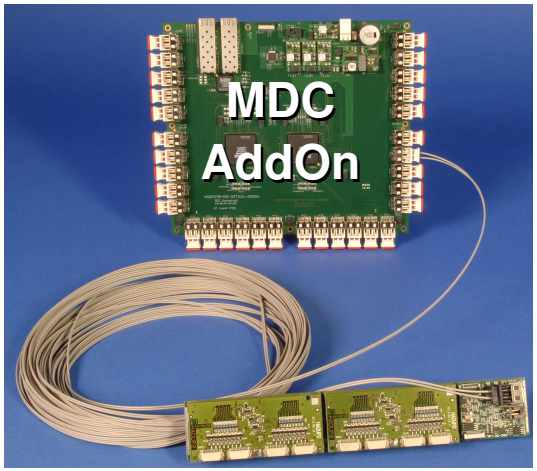
The board itself can be used to measure timing signals.

TOF AddOn can be used to convert pulse into timing Signal (charge to width)

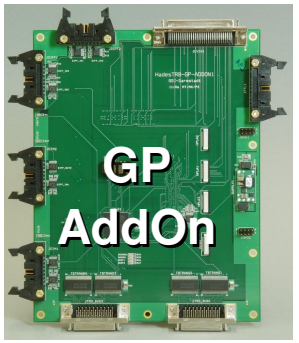
Shower AddOn with 96 ADC channels

The Multipurpose Trigger Readout Board Applications





Trigger Box AddOn

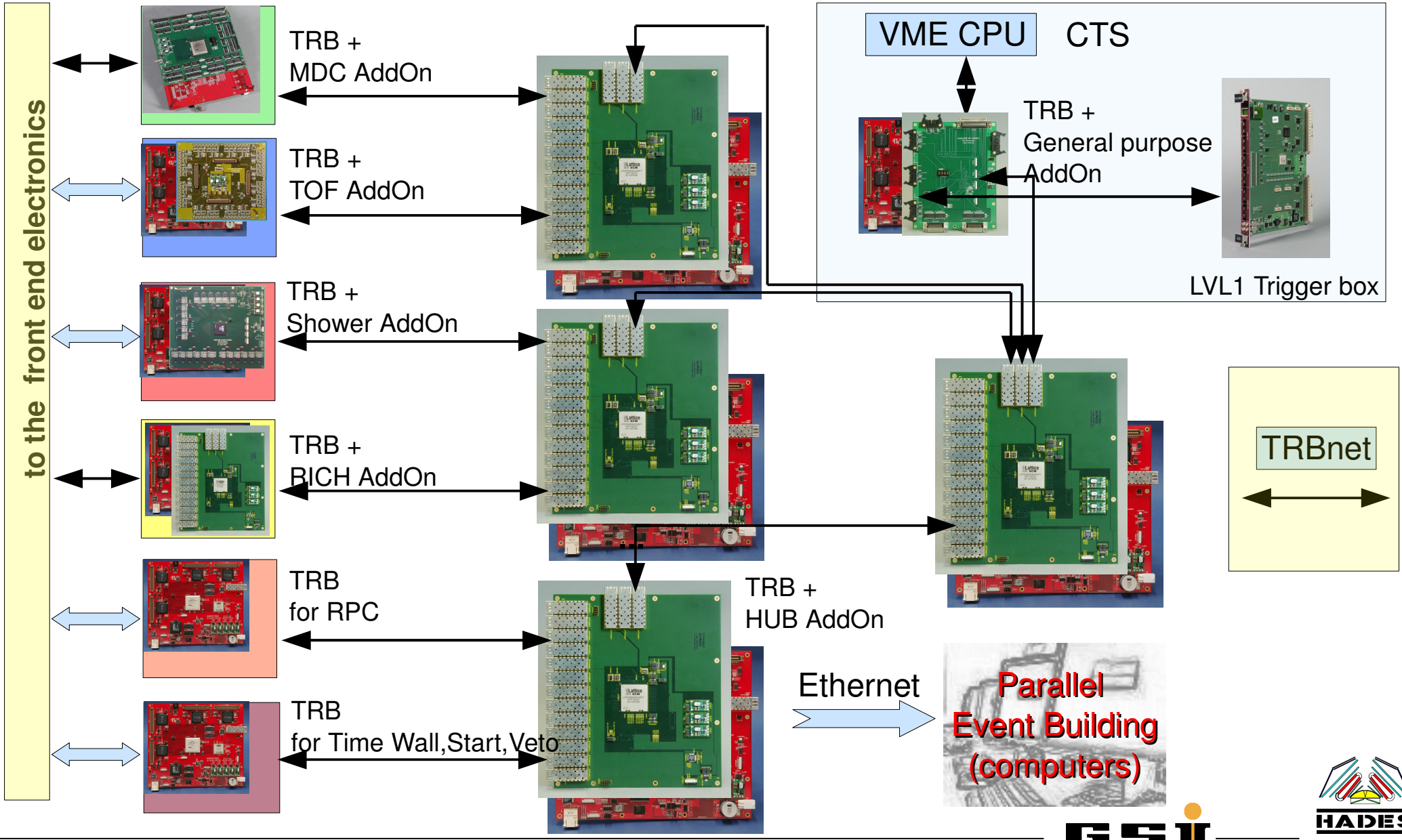


When several TRBs are working in one readout scheme, synchronization can be achieved by using one source of the trigger (Trigger Box).
In such situation the optical HUB can distribute triggers.

This AddOn is also a HUB. Quite new technology, plastic optical fiber (POF), is used for optical data transmission:
- Small volume
- Low power consumption
- Robust (optical cable doesn't need special connector)

Trigger Box board, for HADES first level trigger decision, is under development. Currently General Purpose AddOn with TRB is used as a source of the trigger.

Summary

- The TRB board has performance which fully covers all needs for HADES experiment.
- We successfully used some configurations of this hardware for production and test beams
- The TRB is used not only by HADES:
  PANDA - DIRC detector
  PANDA - MDC readout
  CBM - detector development
  PET- scanner prototype in Coimbra
  KVI - development of FPGA algorithms
  HPLUS - in China, Lanzhou Institute

The HADES DAQ