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FPGA-based read-out systems

FPGA-based read-out systems

- FPGA based systems
- HADES DAQ Upgrade
- Use cases
- Synergies between experiments
- New Developments

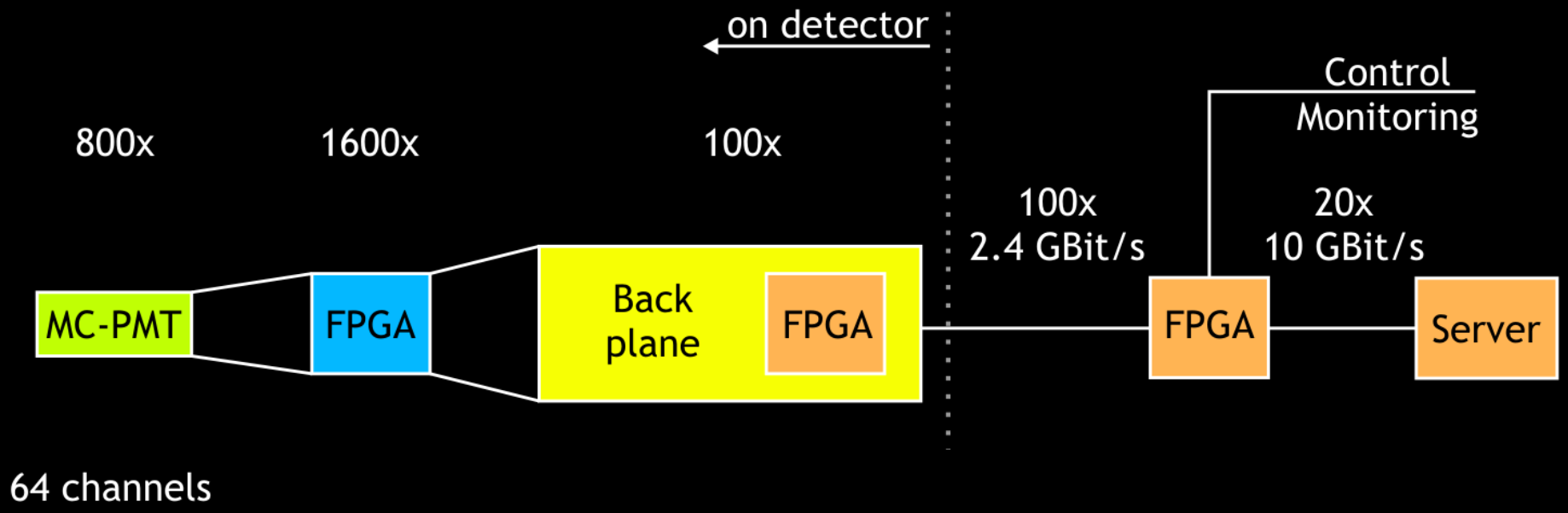
FPGA-based Data Acquisition

- A typical DAQ system comprises:
  - Very many channels (>100k)
  - which have to be read-out very often (> 100 kHz)
  - very well synchronized (< 100 ps)
  - producing lots of data (> 1000 MBit/s)

- Can not be done with regular CPUs, but by special ASICs
  - very expensive and complicated
- Perfect environment to employ programmable logic devices

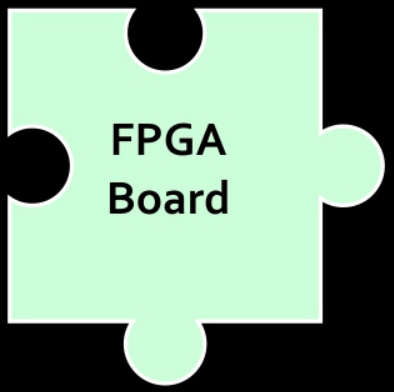
FPGA as Multi-Purpose Devices

CBM RICH: Planned read-out chain

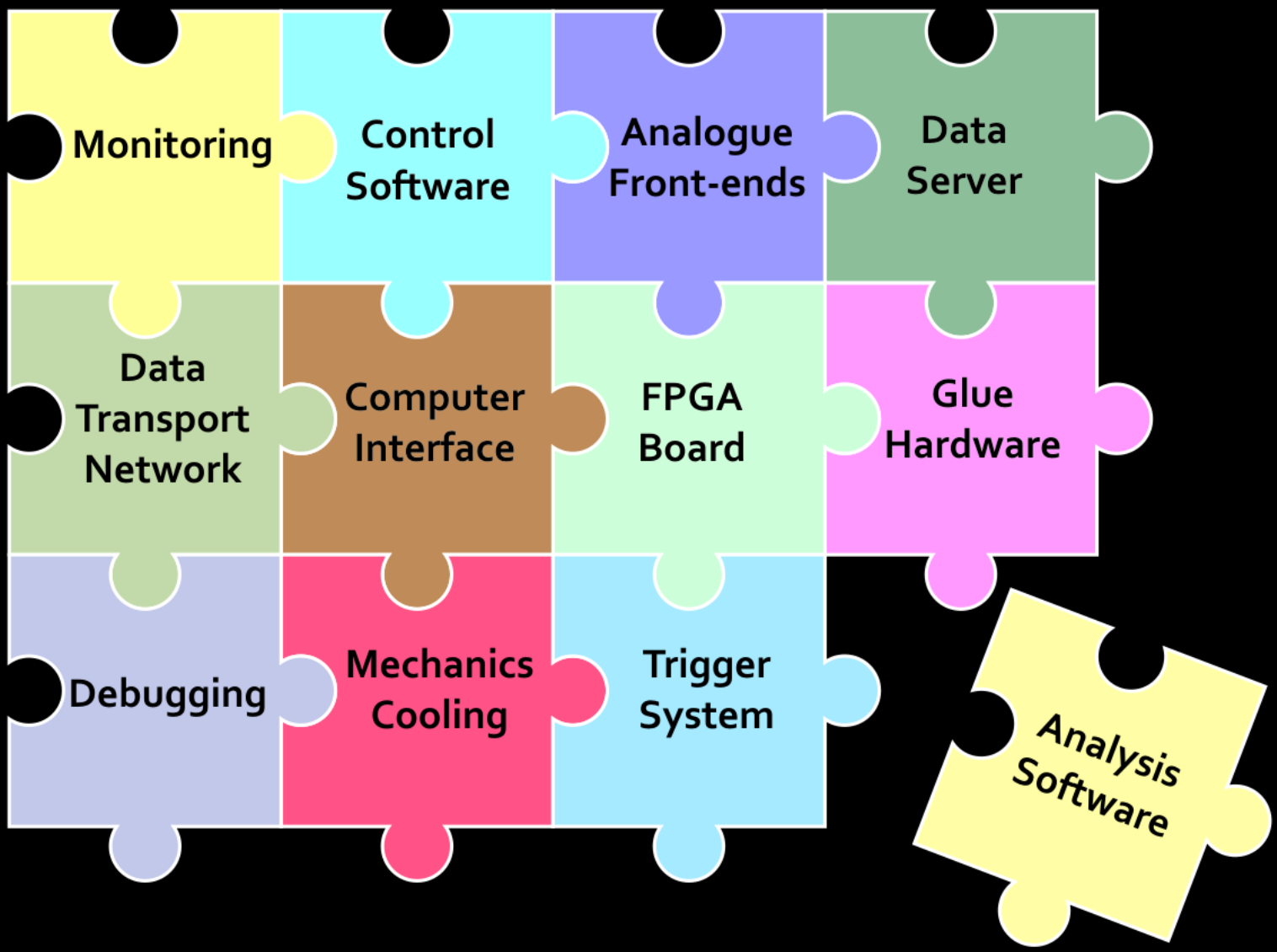


The DAQ Challenge

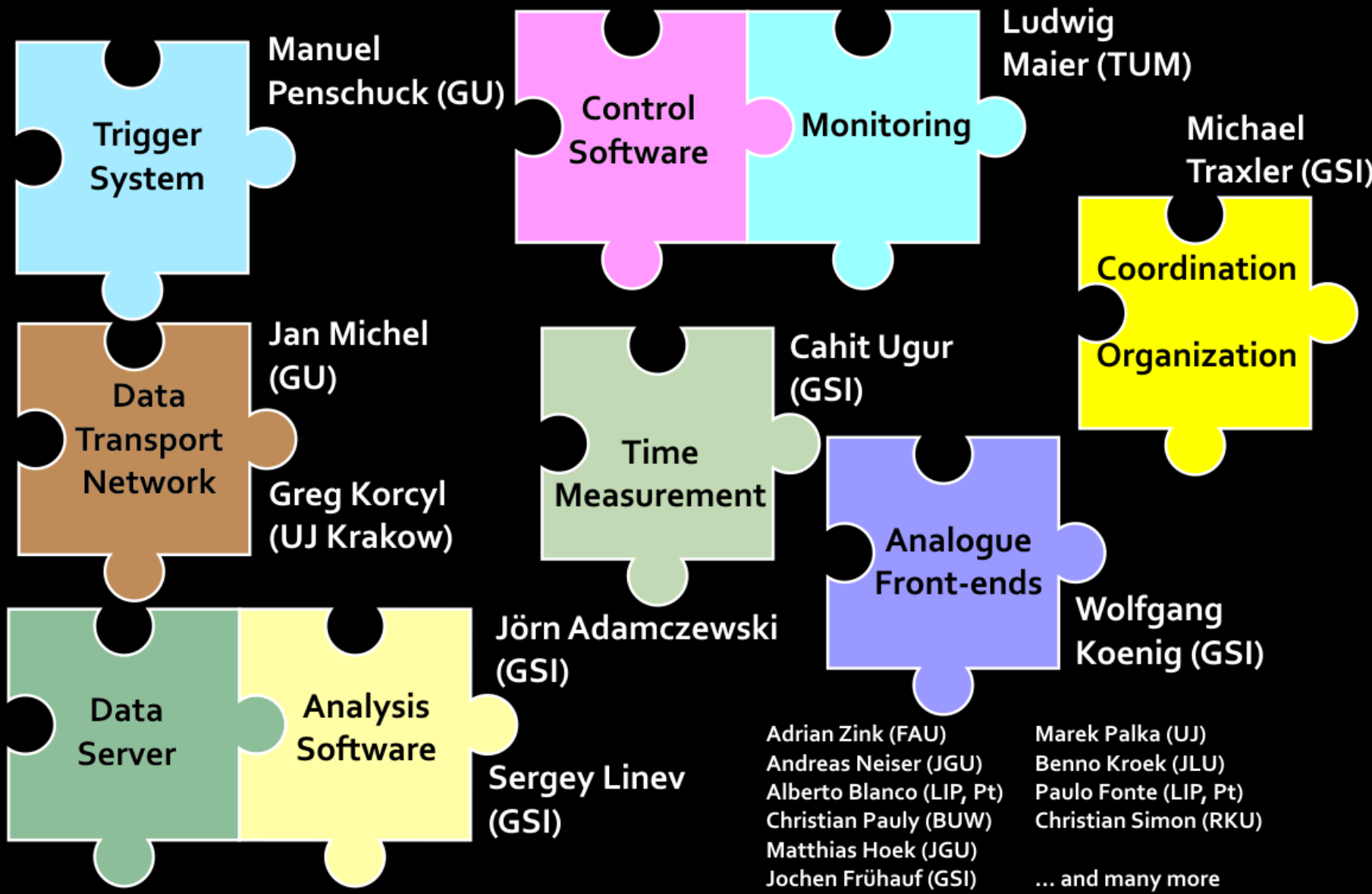
- Designing hardware is only one part of the story:



The DAQ Challenge

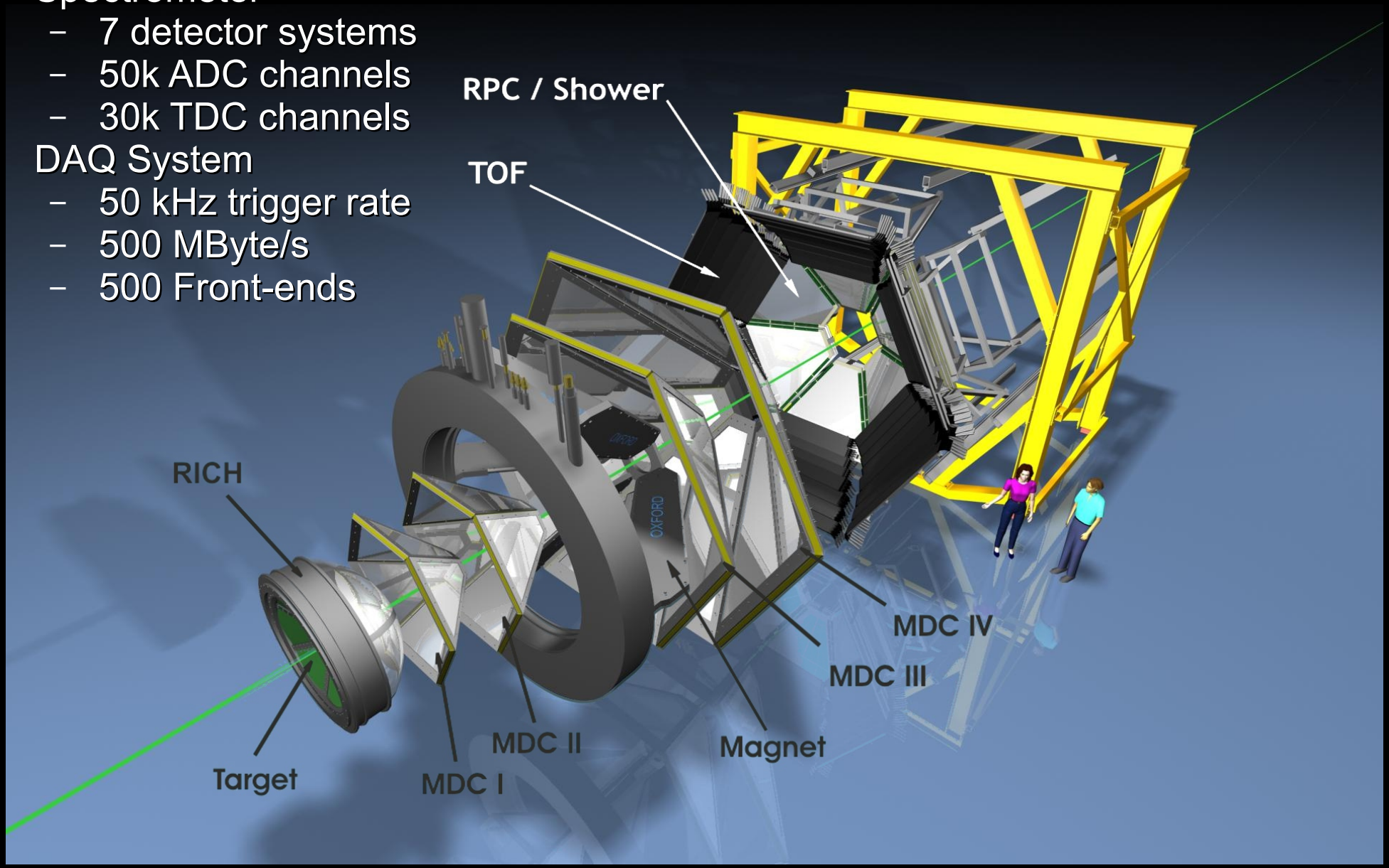


Divide and Conquer – The TRB concept



HADES

- Spectrometer
  - 7 detector systems
  - 50k ADC channels
  - 30k TDC channels
- DAQ System
  - 50 kHz trigger rate
  - 500 MByte/s
  - 500 Front-ends

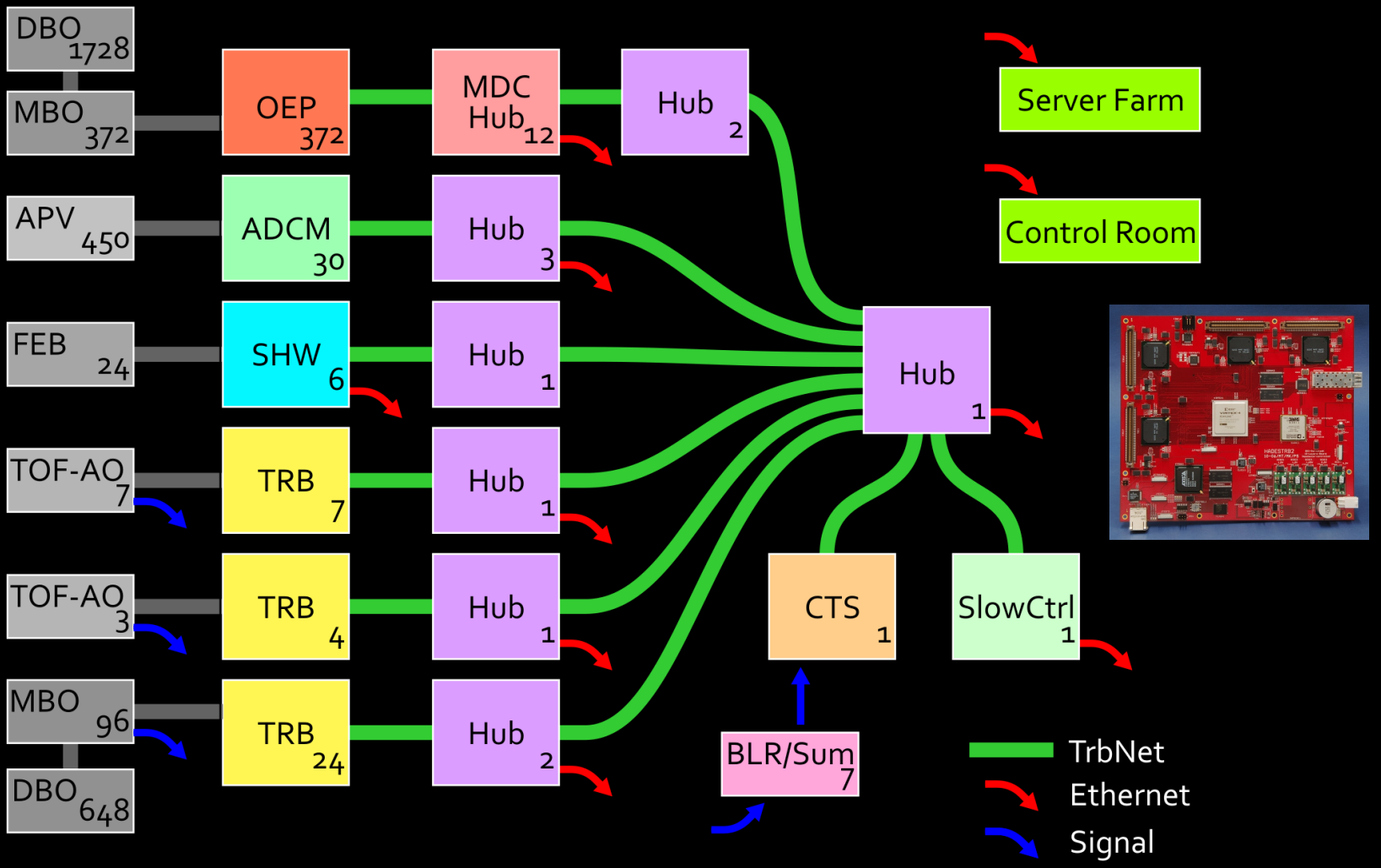


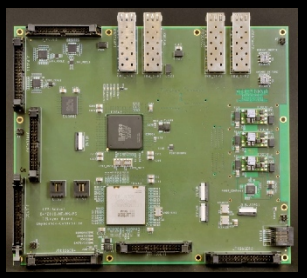
HADES Upgrade Program

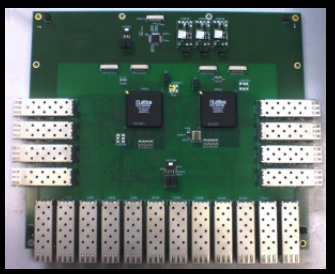
- Complete DAQ upgrade 2007 - 2012
  - preparation for gold beam in 2012 (20 kHz interaction)
  - increase data rate capabilities 30-fold
- Further upgrades planned for operation at FAIR
  - Calorimeter, drift chamber read-out

- Au+Au @ 1.23 AGeV/u in April 2012
  - 7 billion events, 150 TByte of data
- pi + p in August 2014

HADES Upgrade Developments

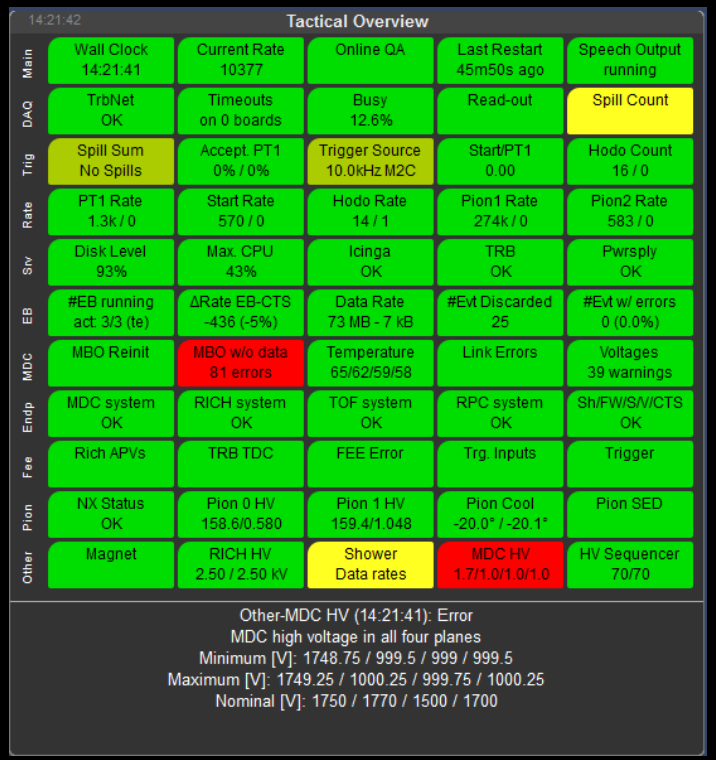


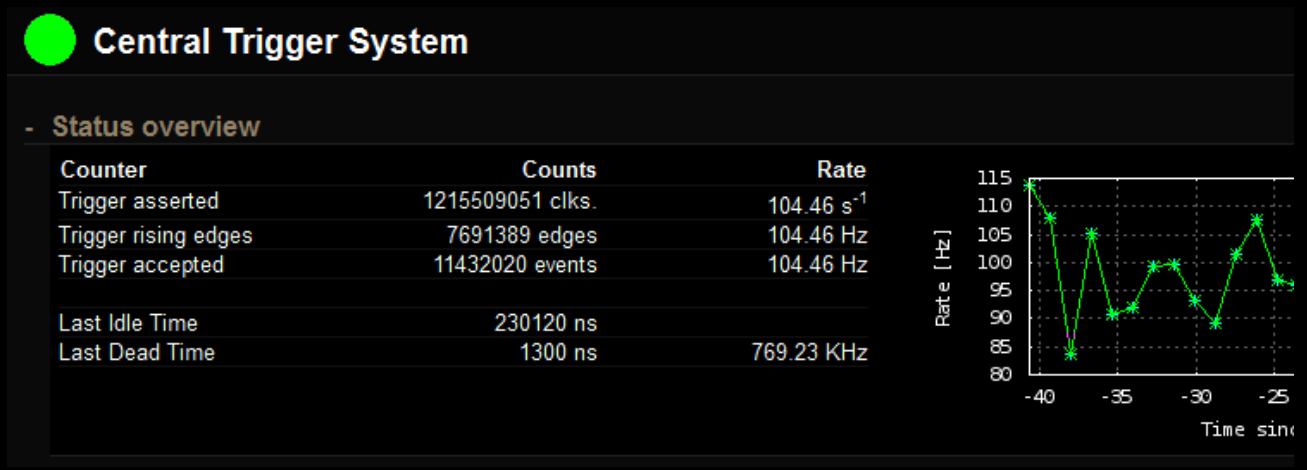




Slow-Control / Monitoring

- *Easy-to-use monitoring tools are very important, but often ignored*
  - *during experiments several weeks long, experts are rare!*
  - *Developments can be shared between users of similar systems*



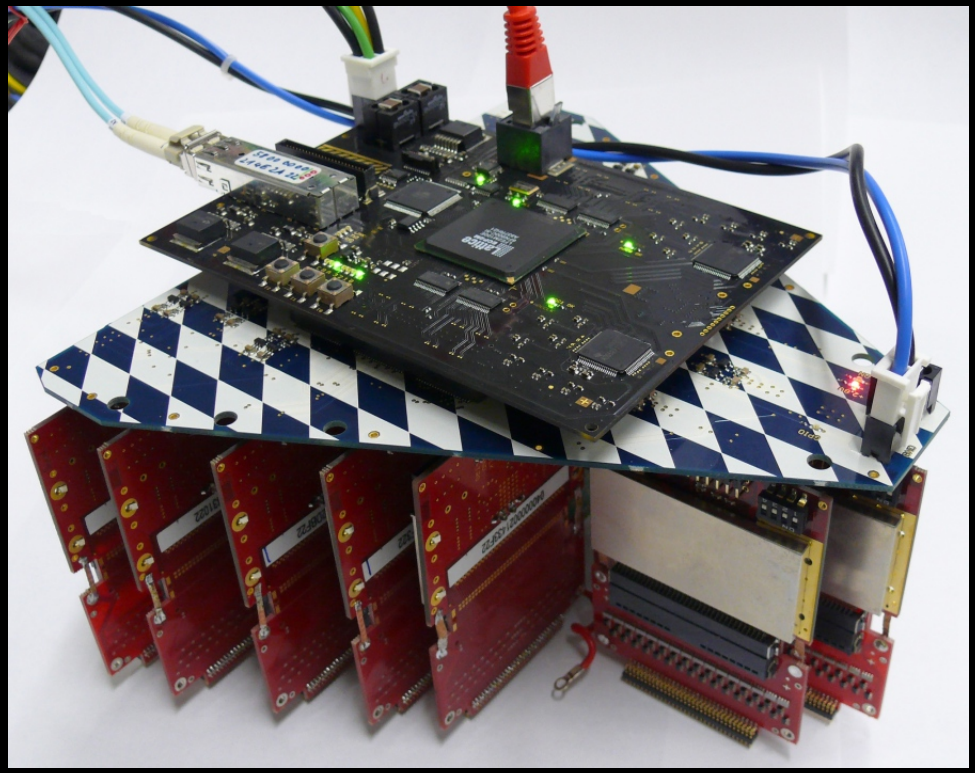


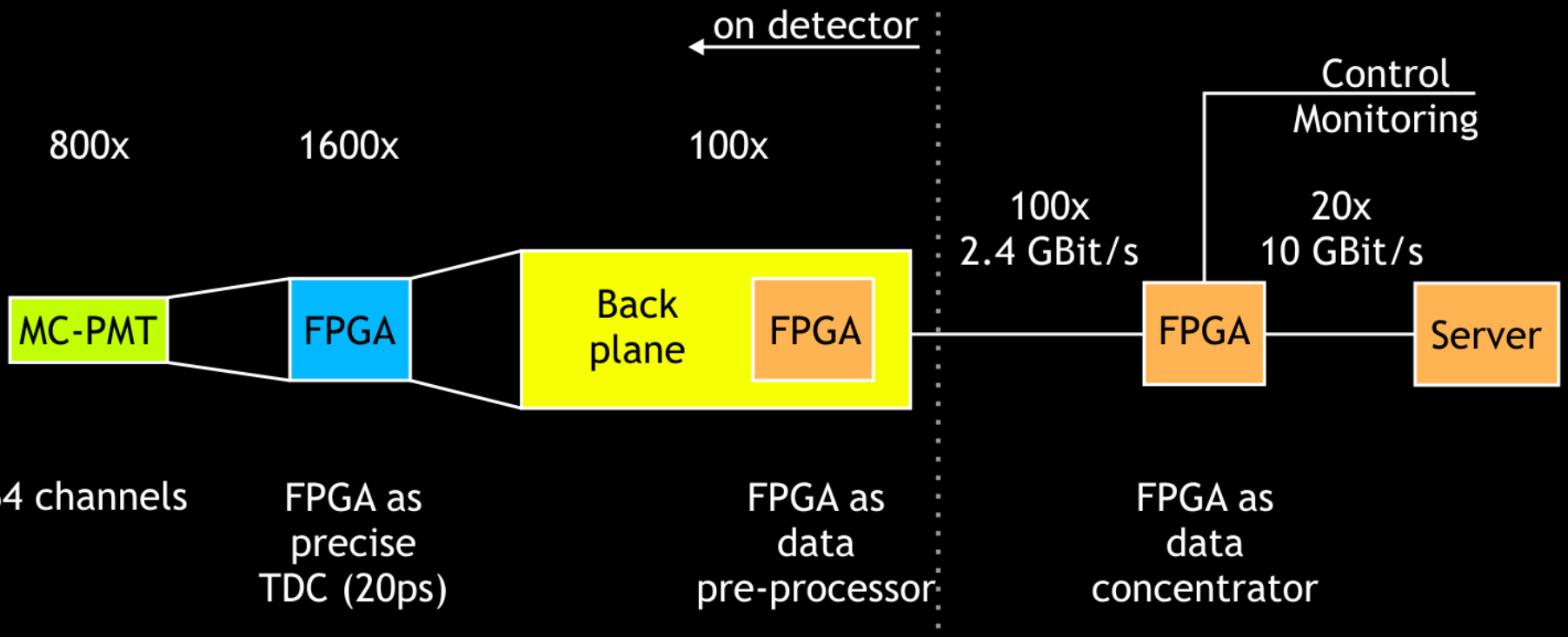
0240	0241	0242	0243	0250	0251	0252	0253
40.4	45.3	41.4	44.6	37.4	36.0	35.1	35.4
42.2	45.1	43.6	45.3	40.9	39.6	36.5	37.5
42.5	42.7	41.9	---	42.9	41.7	37.9	39.9
43.6	43.8	43.8	---	43.6	42.6	39.6	40.6

FPGA - "Traditional" Fields

- Bridge to other connections
  - Ethernet, PCIe
- Buffering & Transporting data
- Controlling external components
- Pre-processing of data

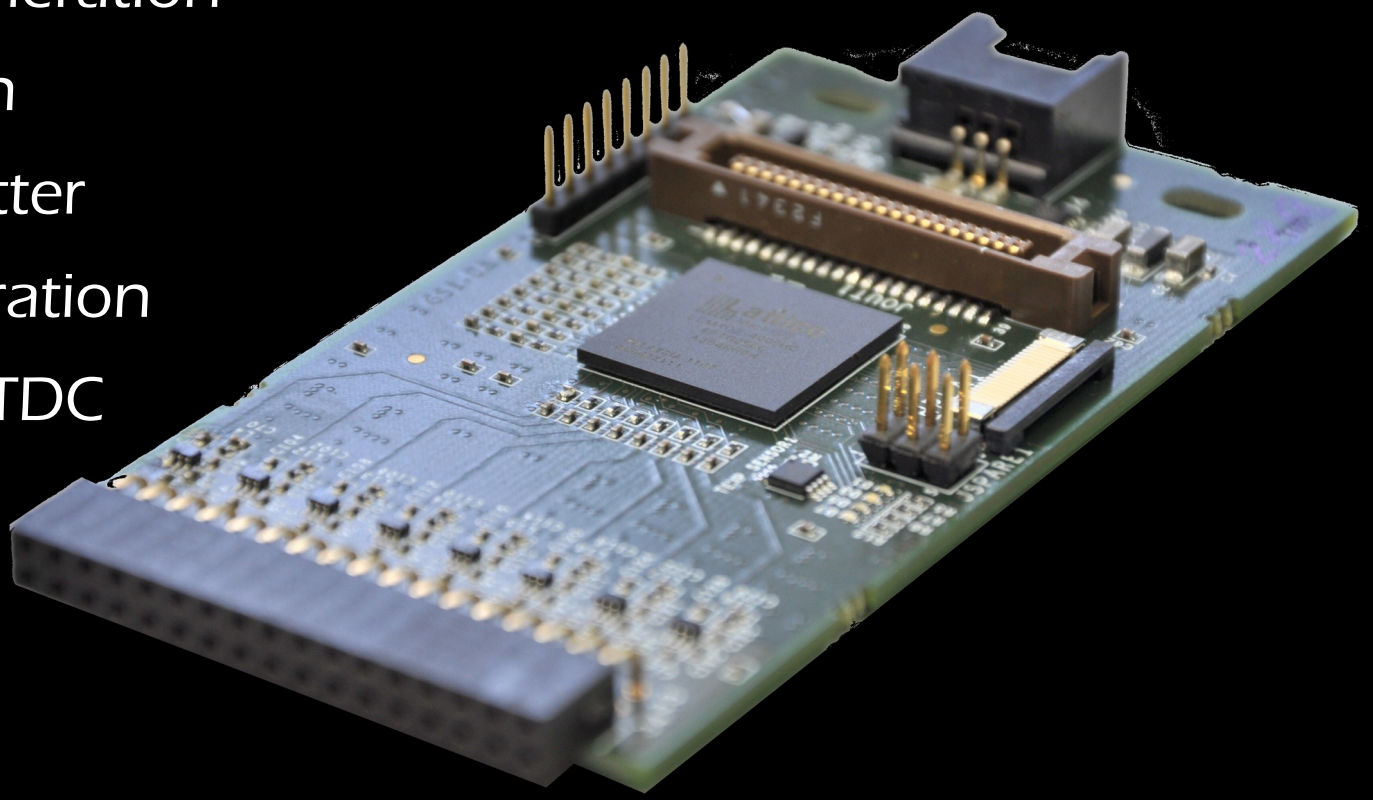
HADES RICH Electronics



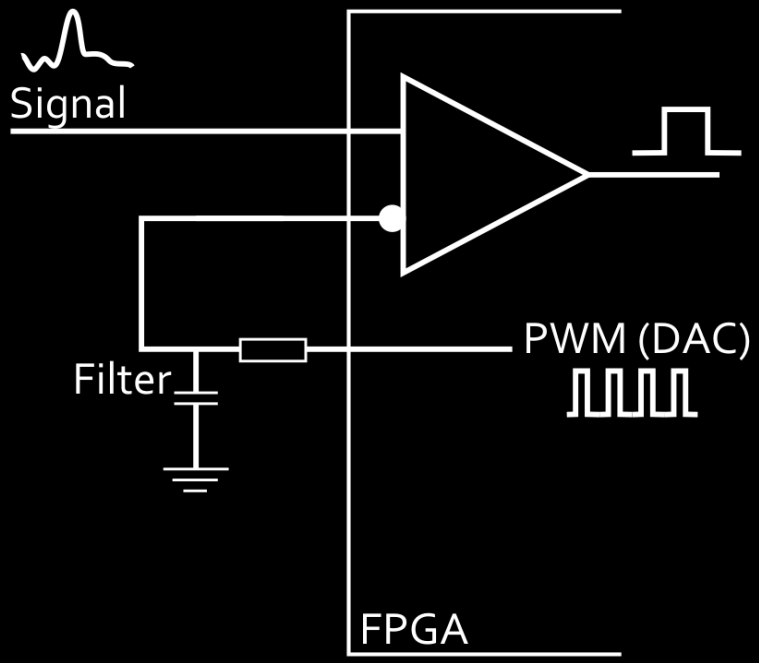

on detector
Control
Monitoring
800x
1600x
100x
100x
2.4 GBit/s
20x
10 GBit/s
MC-PMT
FPGA
Back
plane
FPGA
FPGA
Server
64 channels
FPGA as
precise
TDC (20ps)
FPGA as
data
pre-processor
FPGA as
data
concentrator

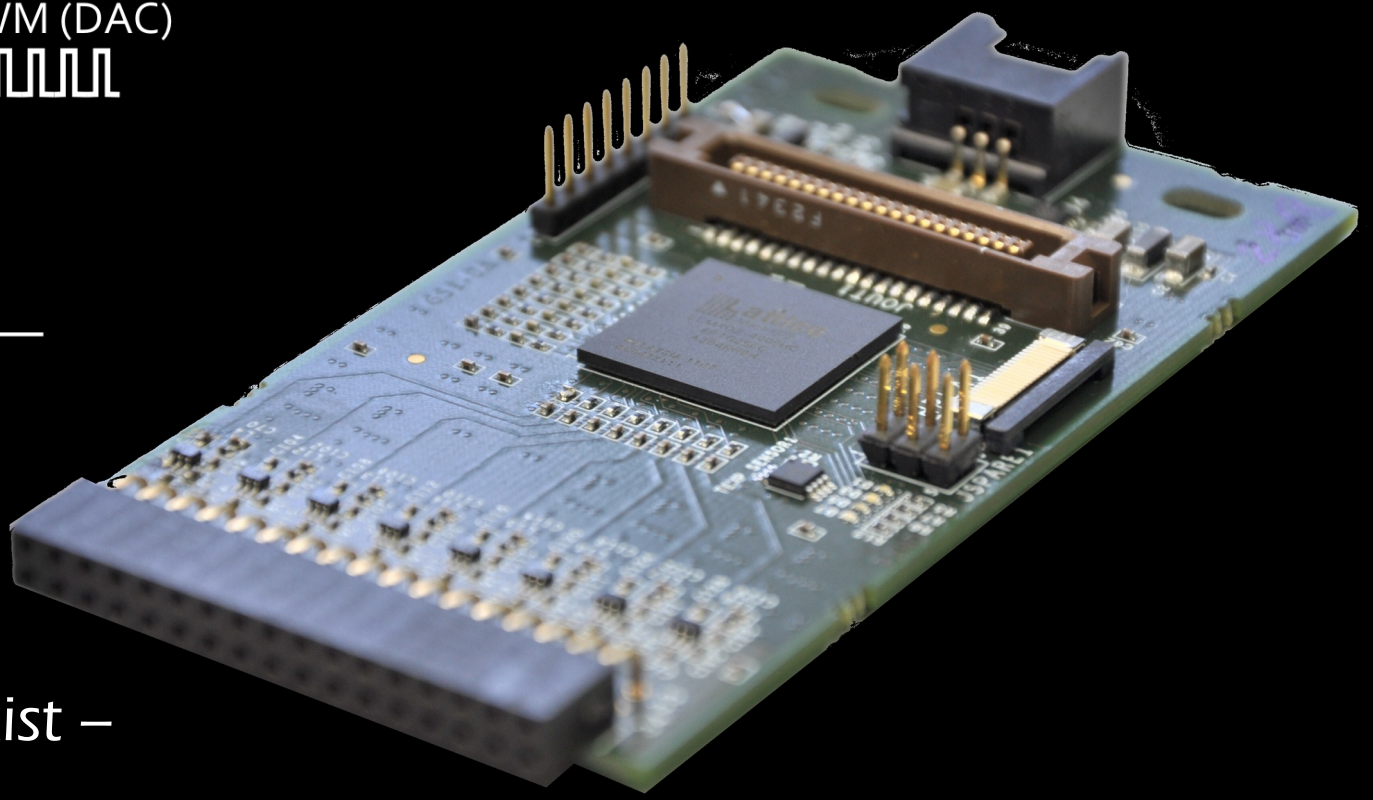
FPGA – replacing front-end electronics

- Plug-on module for e.g. MC-PMTs
- Amplifiers in discrete off-the-shelf components
- FPGA does everything else
  - Threshold generation
  - Discrimination
  - LVDS transmitter
  - Trigger Generation
- Could do 500ps TDC
- active comp.:
  < 3€ / chan.



FPGA – replacing front-end electronics

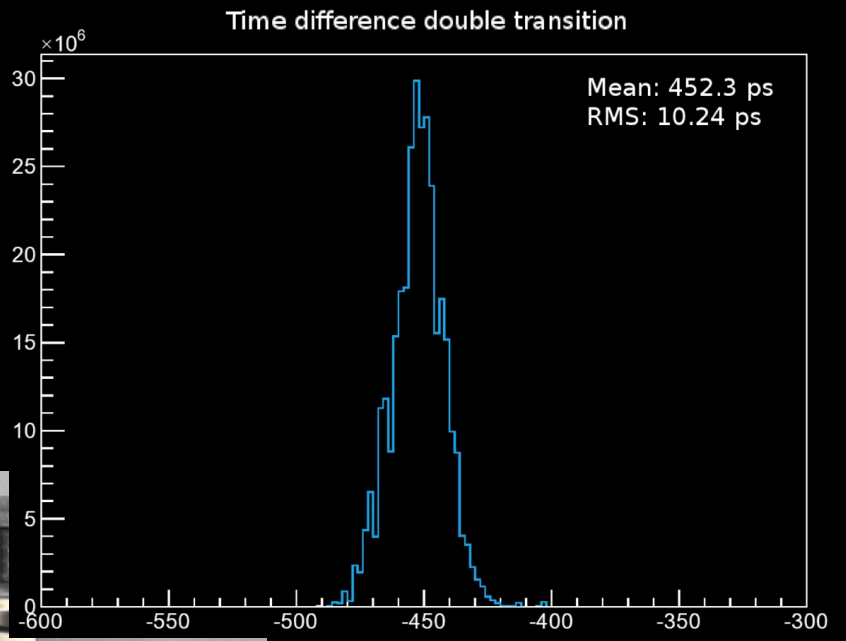


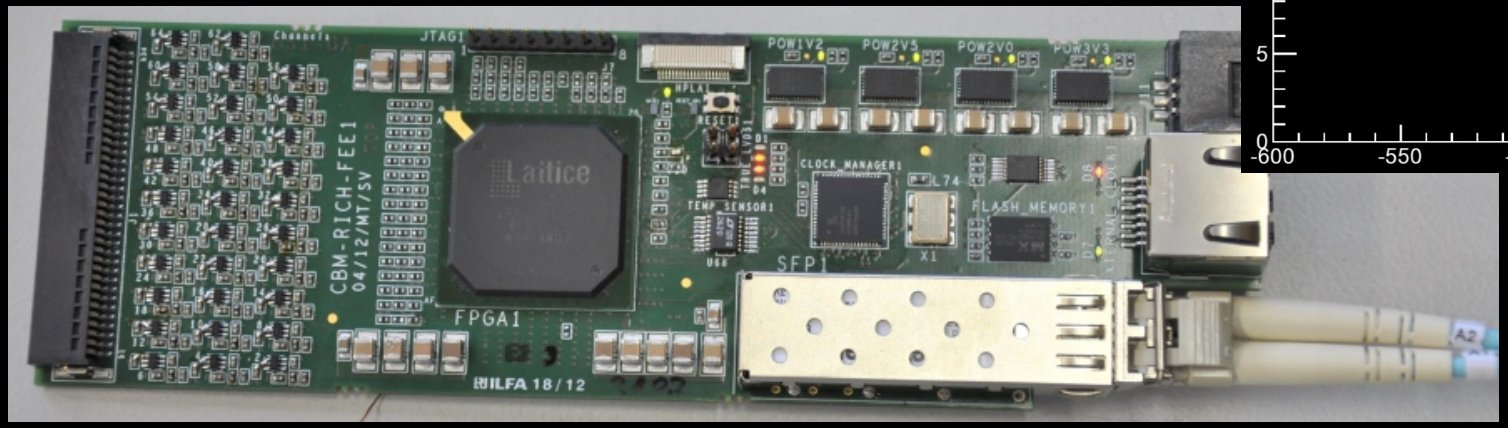


- Discriminators exist – for LVDS inputs

FPGA – Precision Time Measurement

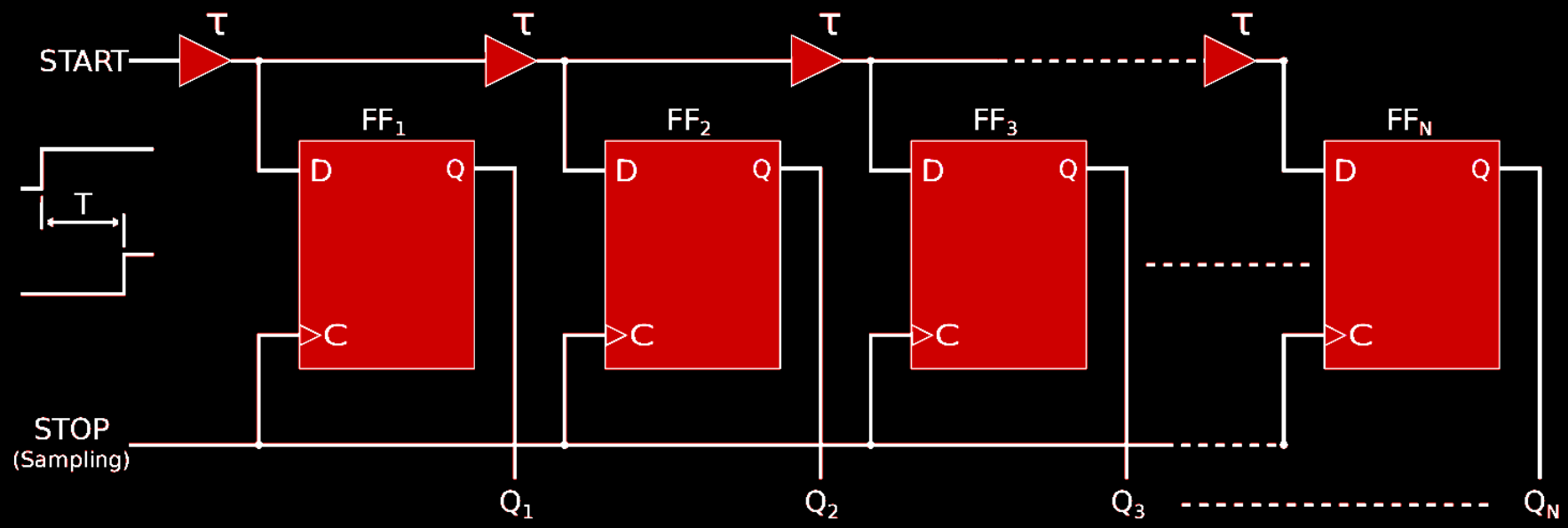
- TDC-in-FPGA technology now in use by many groups at GSI/FAIR
  - CBM, Hades, PANDA, R3B ...





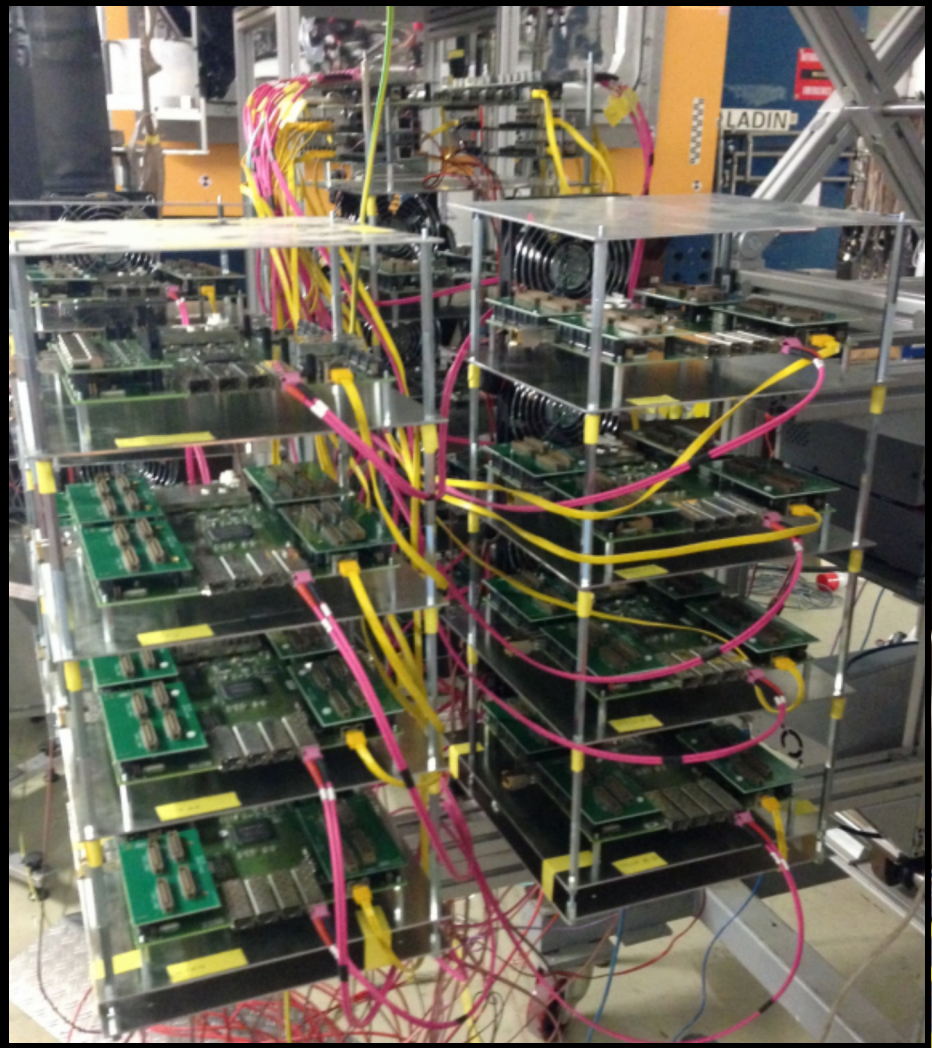
FPGA run at few 100 MHz – how can they measure 10 ps !?

FPGA – Precision Time Measurement



- Some key features for a “standard configuration”
  - < 20 ps precision (RMS)
  - up to 48 channels per FPGA, (<10€/chan incl. read-out)
  - high multi-hit capability
  - > 50 MHz/channel peak
- Everything subject to setup-specific adjustments

Synergies – not only in development



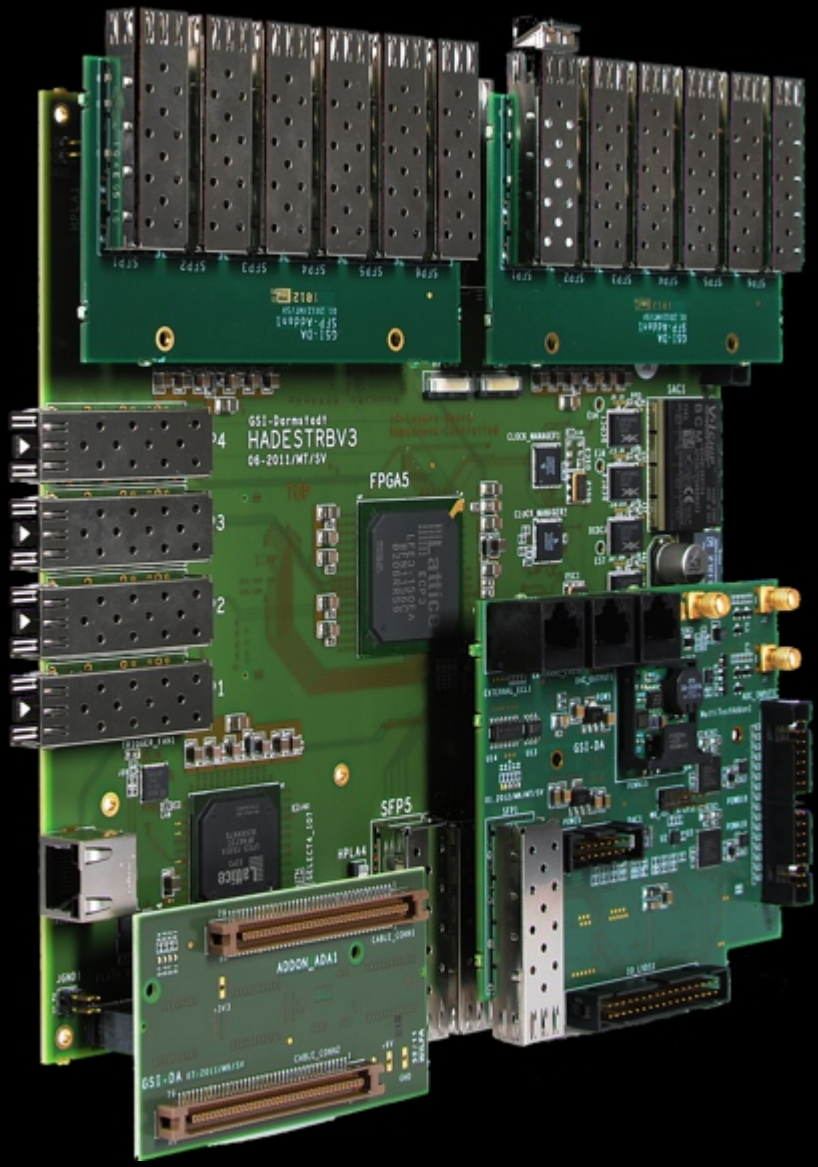
- Panda Barrel DIRC prototype test September @ GSI

  > 1000 channels PreAmp & TDC

- Same hardware currently being prepared for
  CBM RICH test, November @ CERN

Pictures: Jochen Schwiening

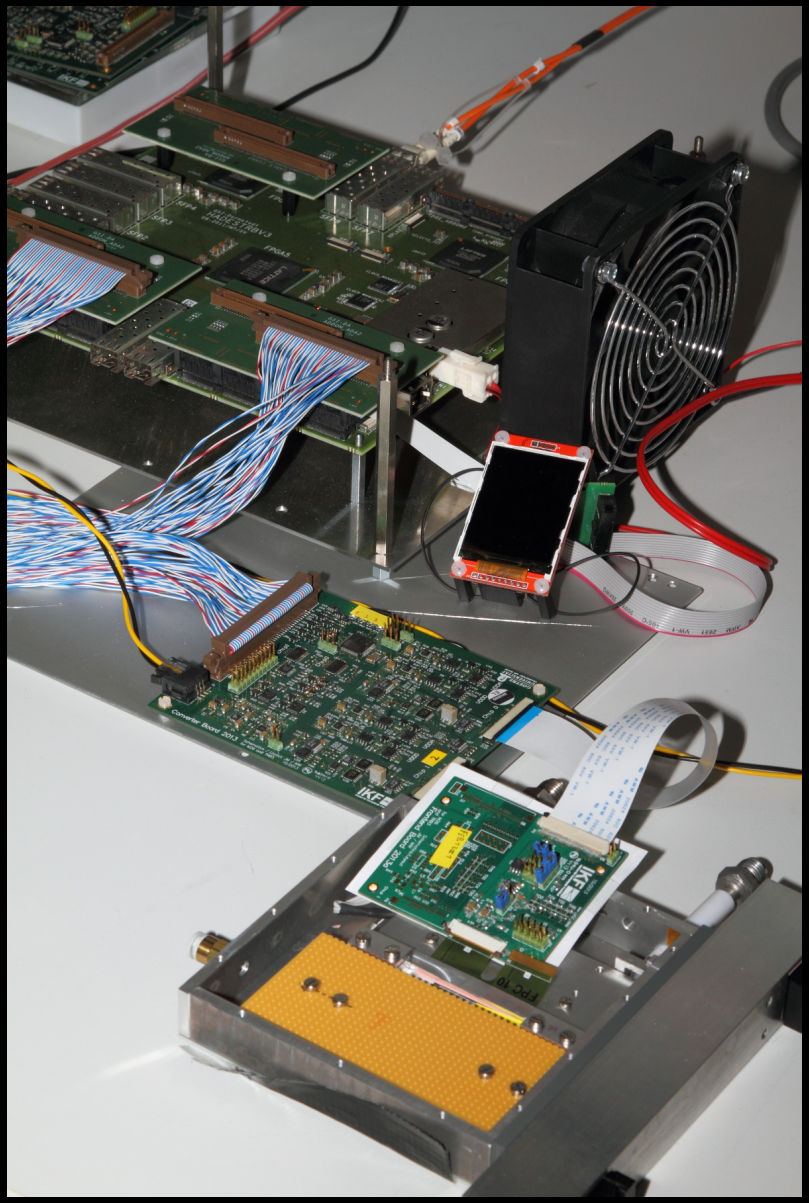
A general purpose platform: TRB3



- FPGA platform
  - 5 ECP3 FPGA
  - 8 SFP
- 5 AddOn connectors
  - 208 I/O incl. 6 Serdes
- Stand-alone operation
  - GbE for communication

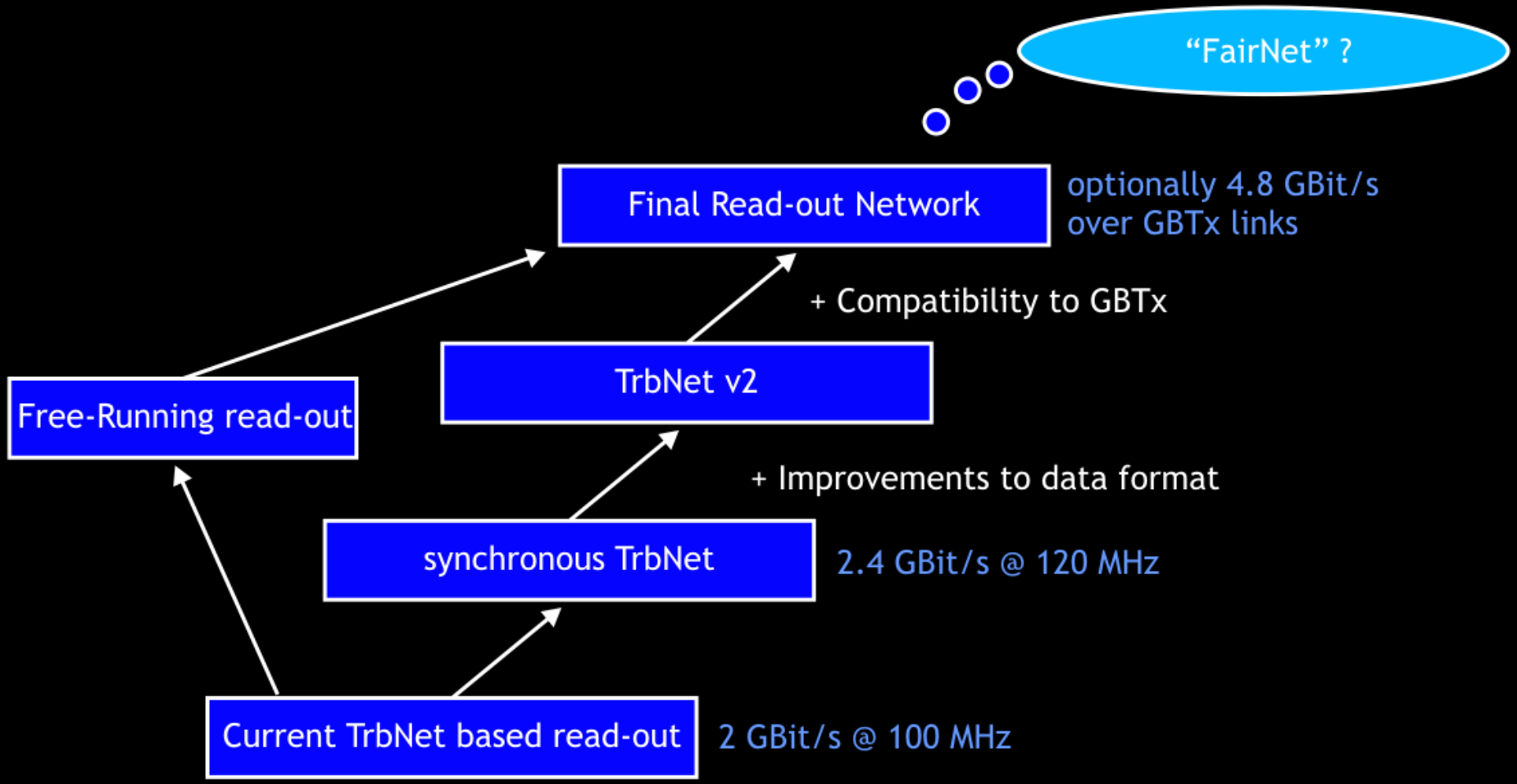
CBM MVD

- CBM RICH & CBM MVD
  - very different systems
  - 50k PMT channel vs.
    fully integrated MAPS pixel sensors
    (900 cm² / 150MPixel)
- Based on the same read-out platform
- Will use the same read-out network



Outlook: Network

- The existing programming does not fit to all needs of FAIR experiments, but can be adapted



Conclusion

- FPGA Platforms are a very versatile tool for many aspects of data taking.
  - can easily be adapted to any needs
  - can also serve to work in the analog world
- The TRB3 collaboration has become a huge project
  - > 20 user groups world-wide
  - lively discussion, many people testing new features
- Hardware from the TRB project - not only in physics
  - in medicine (human PET – LIP Coimbra) and
  - in geology (x-ray scanning of corals)