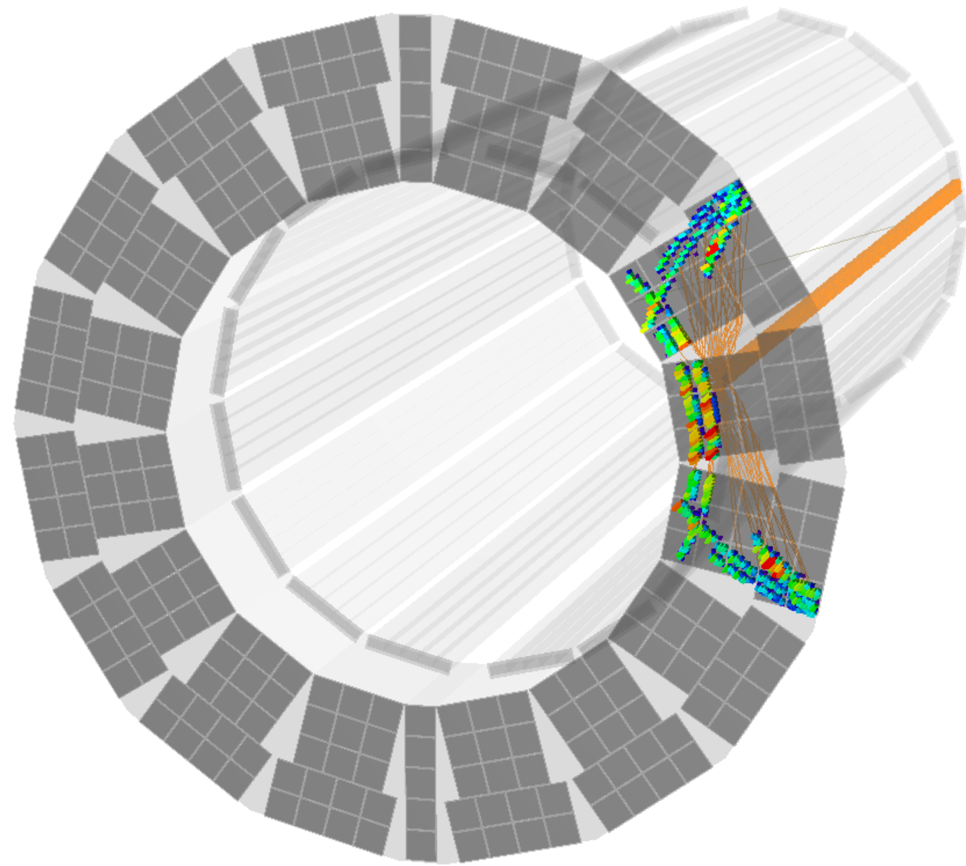
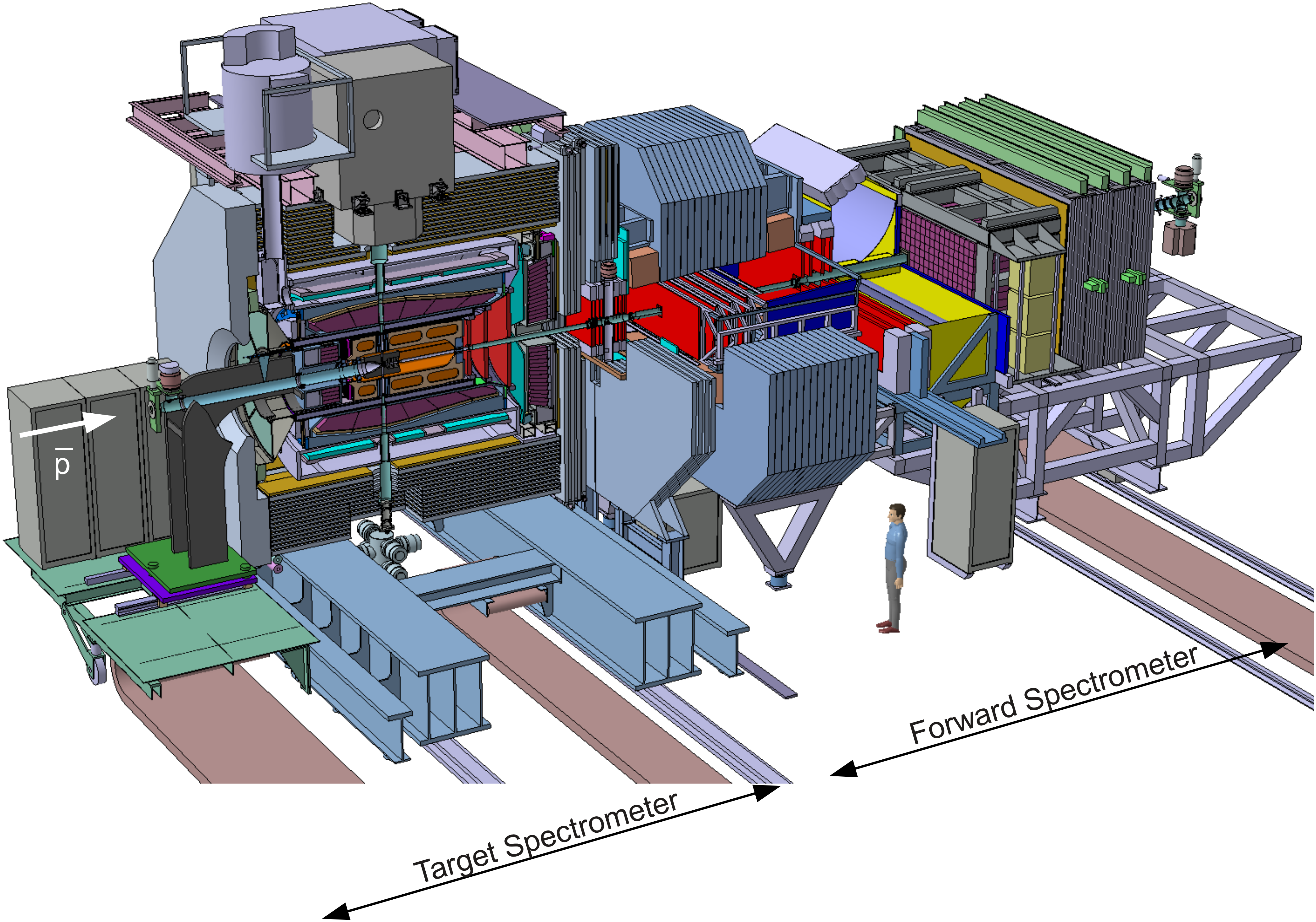
Readout of the Barrel DIRC system

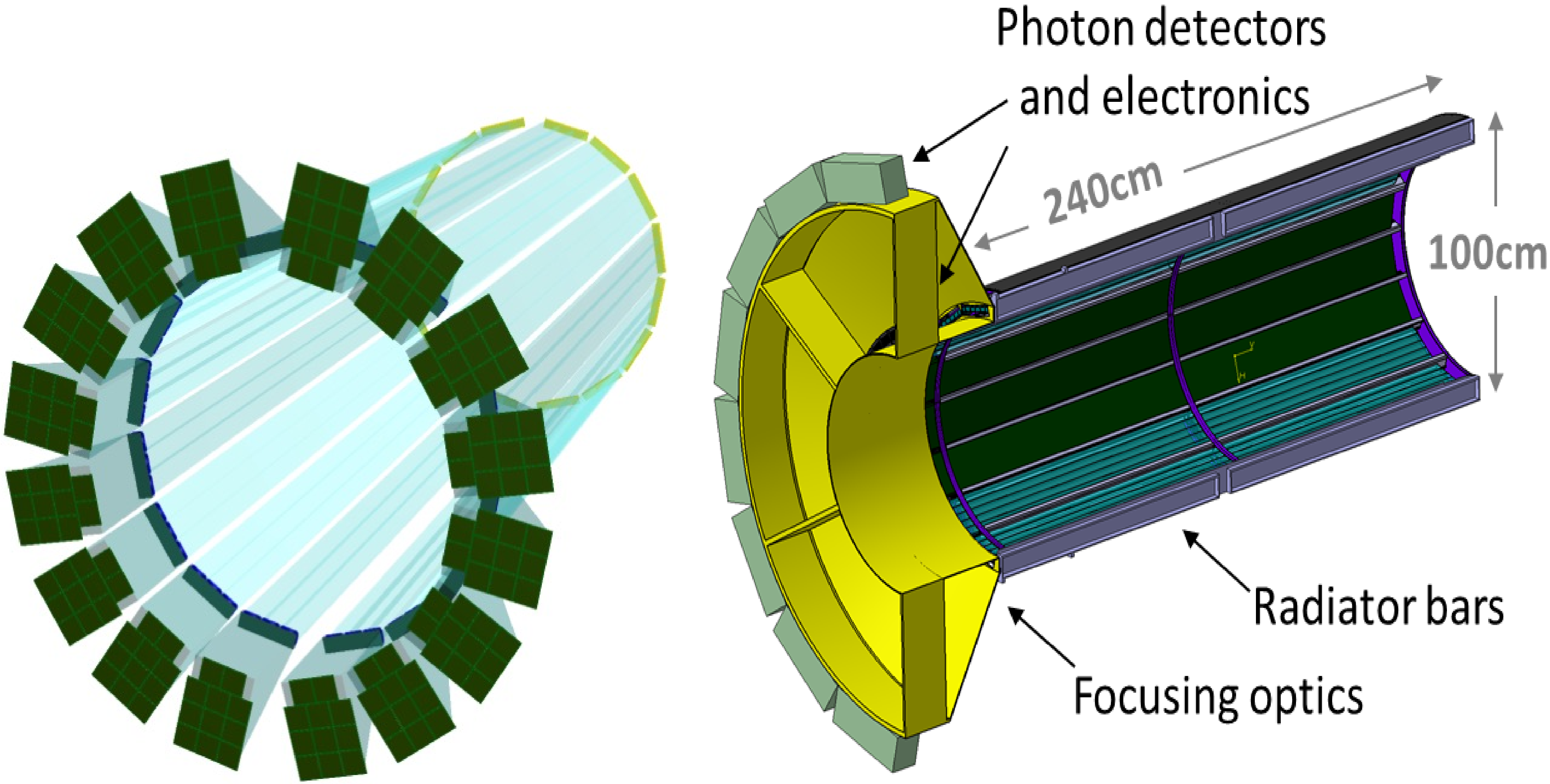
Carsten Schwarz, GSI

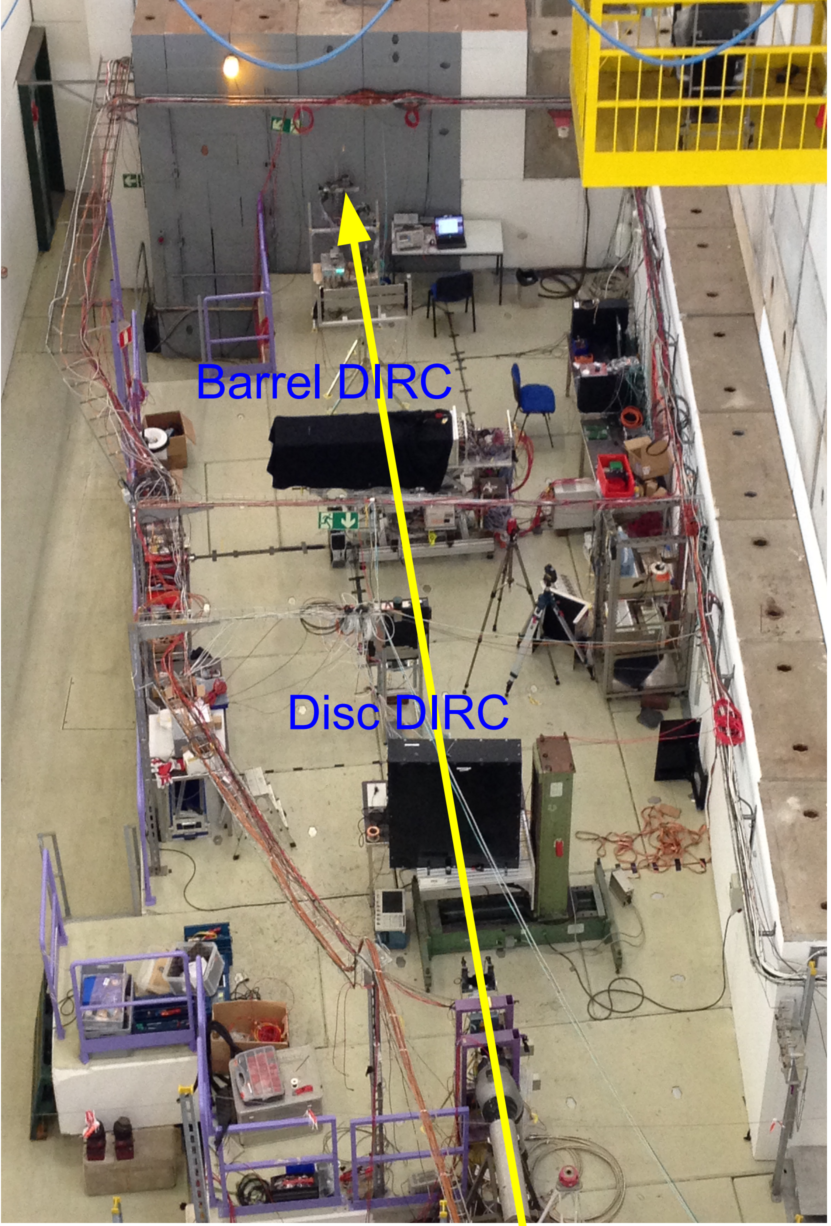
- Introduction
- Beam experiments
- PADIWA3 + TRB3
- Outlook DIRICH



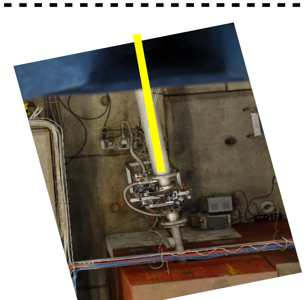


$\bar{p}$
Target Spectrometer
Forward Spectrometer


Photon detectors
and electronics
240cm
100cm
Radiator bars
Focusing optics

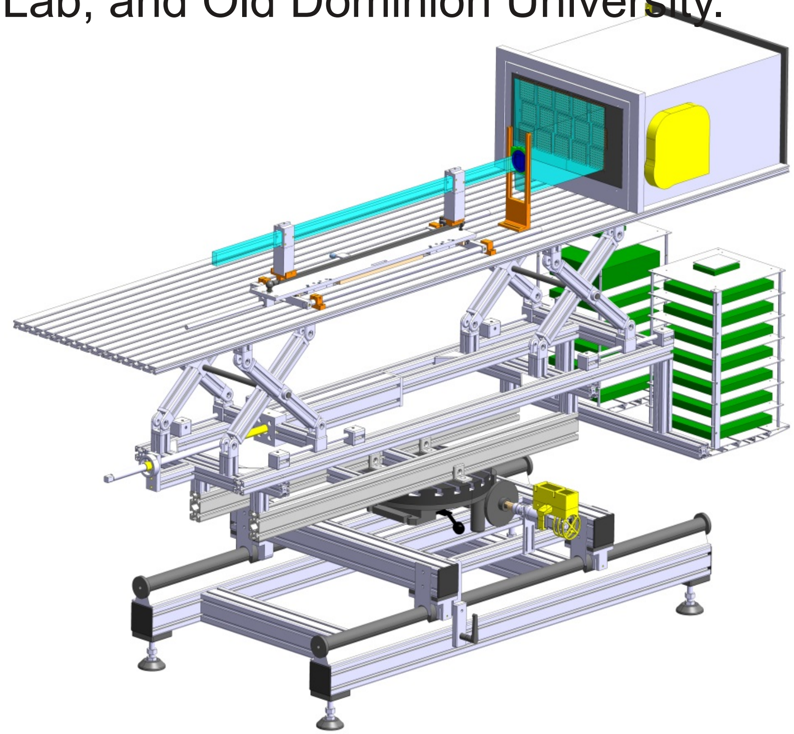


29 m TOF

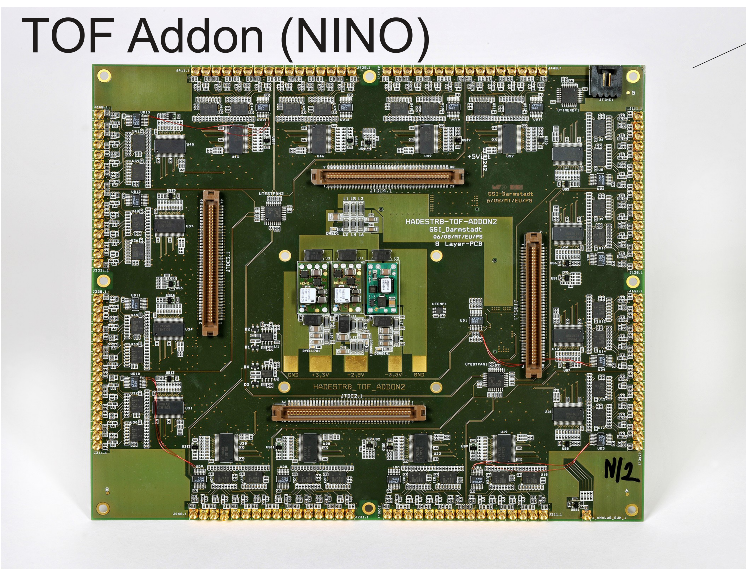


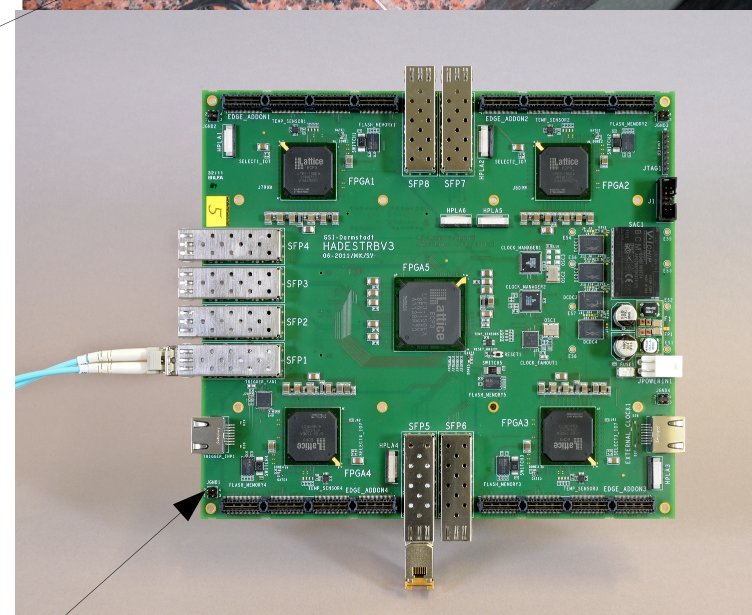
Experiments,
2008 – GSI
2009 – GSI
2011 – GSI, CERN
2012 – CERN
2013 – Mainz
2014 – GSI
2015 – CERN

2015: Joint effort of groups from
GSI, Uni Mainz, Uni Giessen, Uni Erlangen,
JLab, and Old Dominion University.



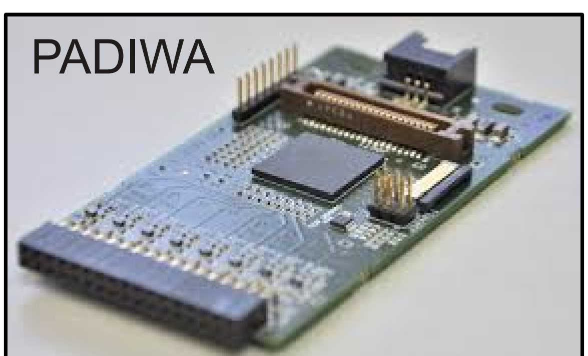
TRB 2

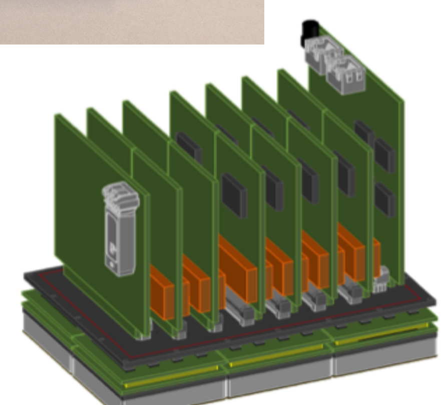




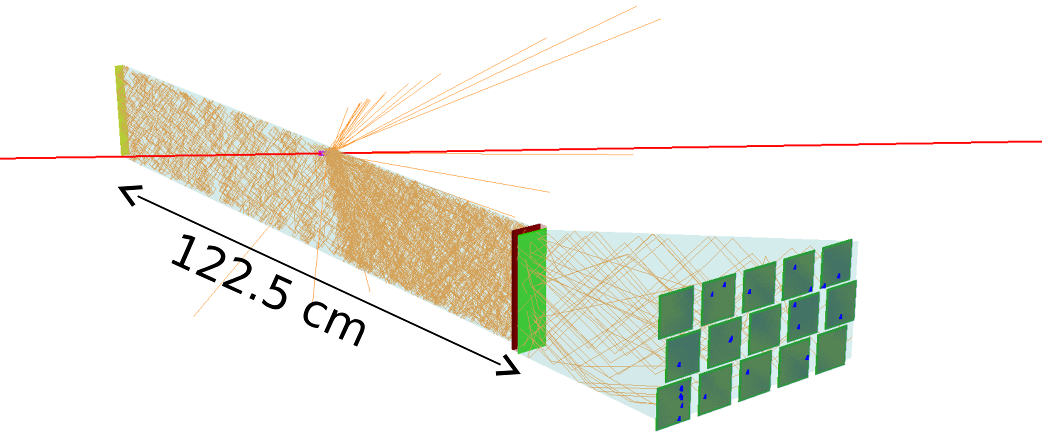
TRB 3

DIRICH





Photon detector

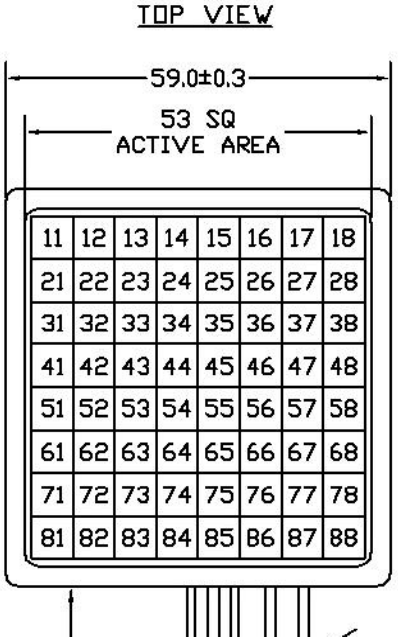


5 x 3 Planacon MCP-PMT (XP85012/A1-Q, Photonis)
960 pixels (in total >1200 readout channels)

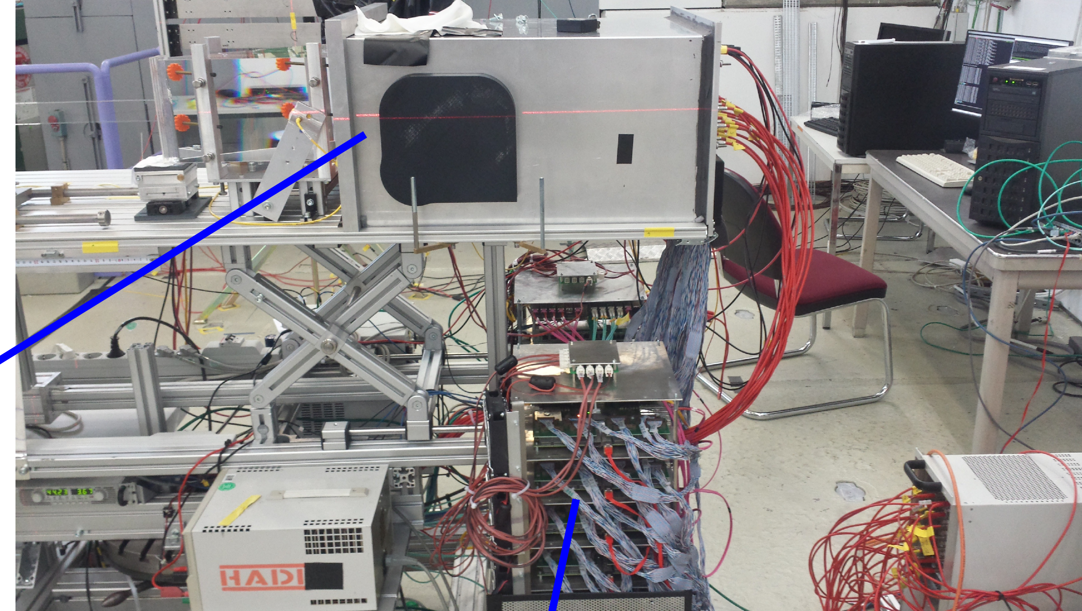
with **pixel size 6.5 x 6.5 mm²**

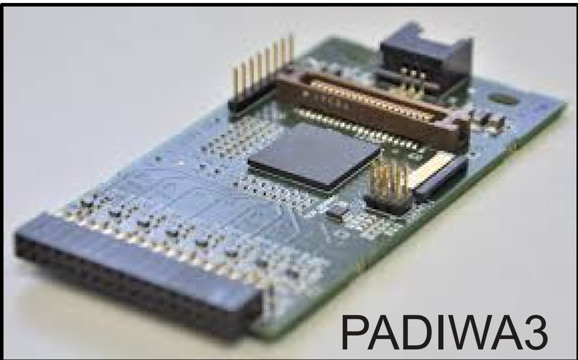
Work in **1T magnetic field**

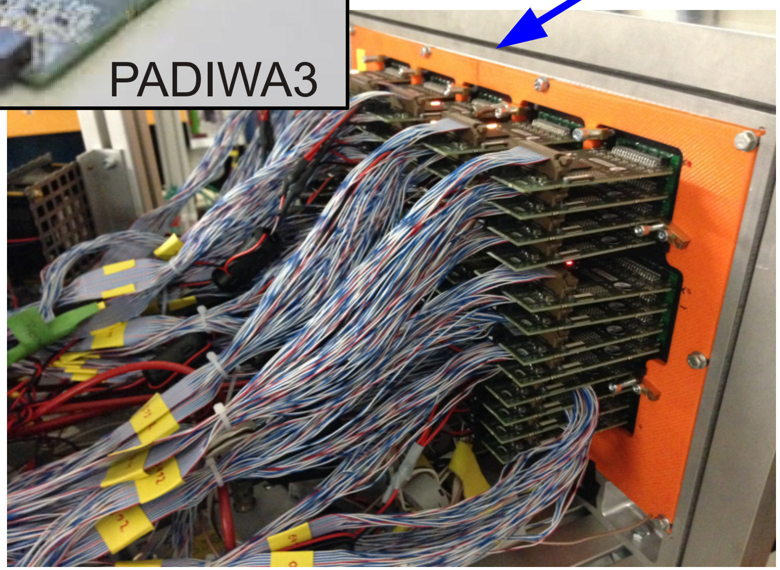
Survive **10 years** of PANDA (ageing)

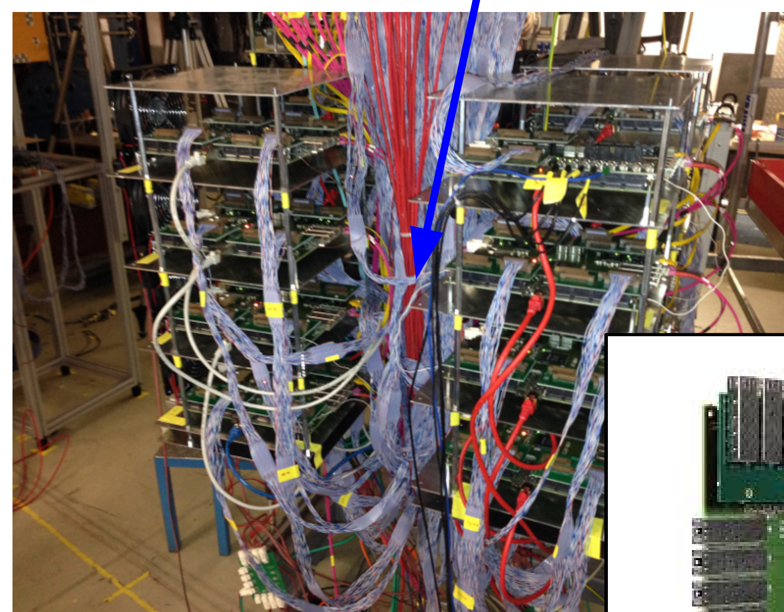


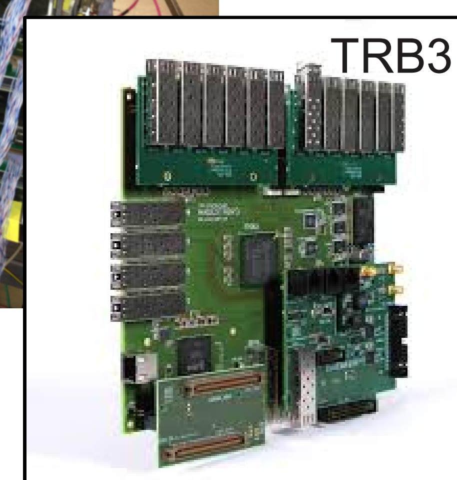
Readout chain











PADIWA3 discriminator
- Keep It Small & Simple = KISS
- Amplifier + LVDS discriminator

TRB3 TDC board
- Leading edge → timing (~10ps)
- Trailing edge → TOT → walk correction

Walk correction by TOT

Time spectra (Leading Edge) show modulation which we ignore for **walk correction**

Understood:
TOT + small high frequency noise

NIM A791 (2015) 16, Gonella et al.

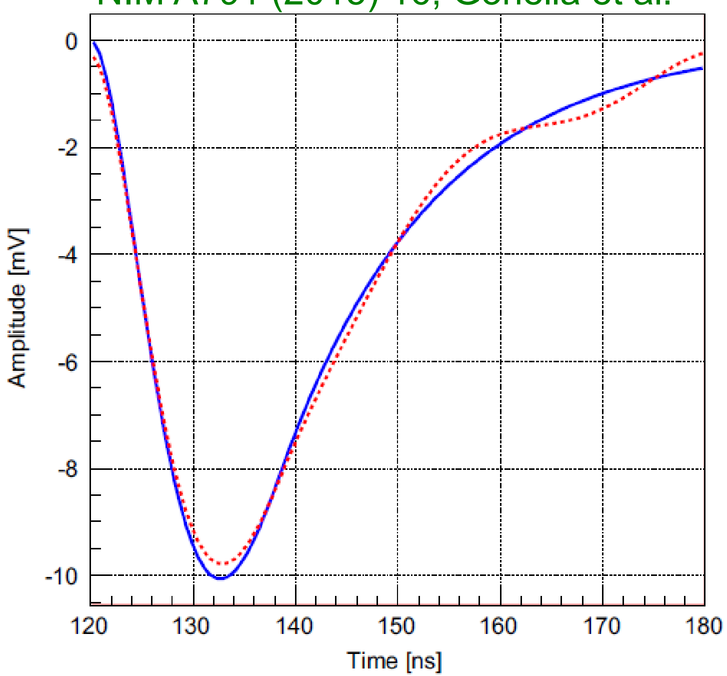
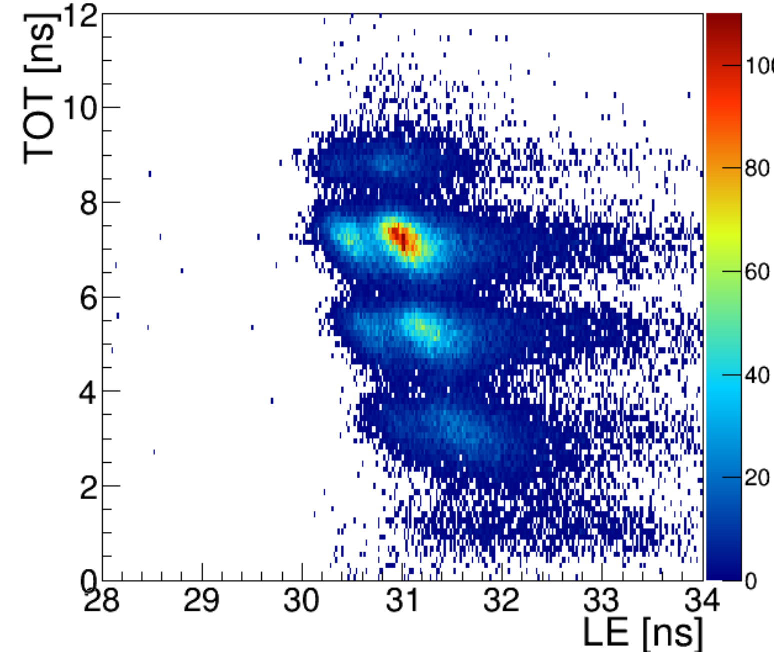
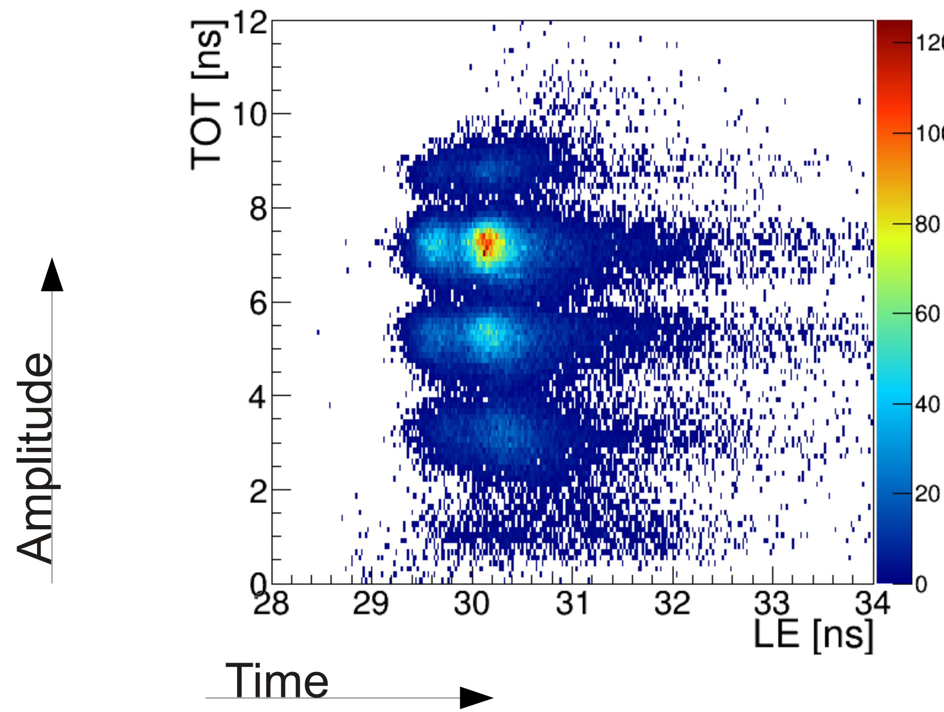


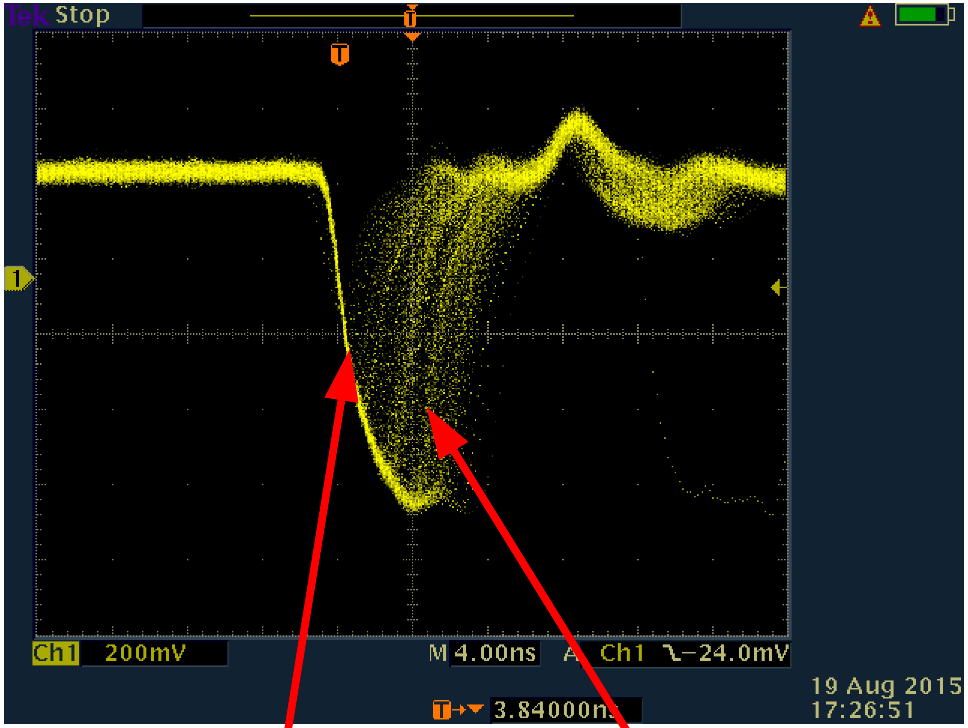
Fig. 5. Simulated shape of the output signal of the system lead-glass block – PMT without (solid curve) and with addition of 300 μV noise at 40 MHz frequency (dashed curve).





Peak structure of TOT

LVDS output (PADIWA)

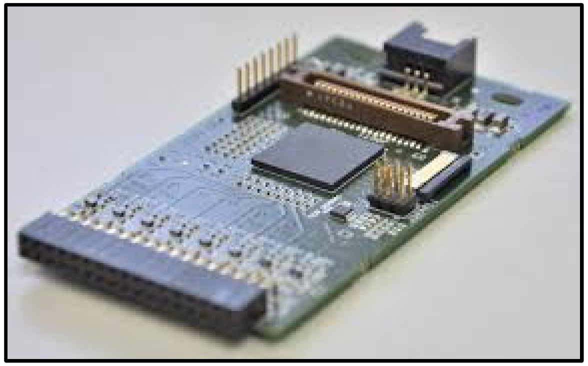


This is a **digital signal**

Peak structure visible with oscilloscope

Long cables (2m) damp the signal away.
Larger effective thresholds? (No, we see all photons.)
Better skip cables...

- The FEE is stable in the lab in small setups
- In a larger setup (GSI 2014 beam) a high frequency feedback from the FEE to the MCP-PMTs and back to other channels of the FEE has been observed
- Result: high frequency oscillation forced the use of unreasonable high thresholds



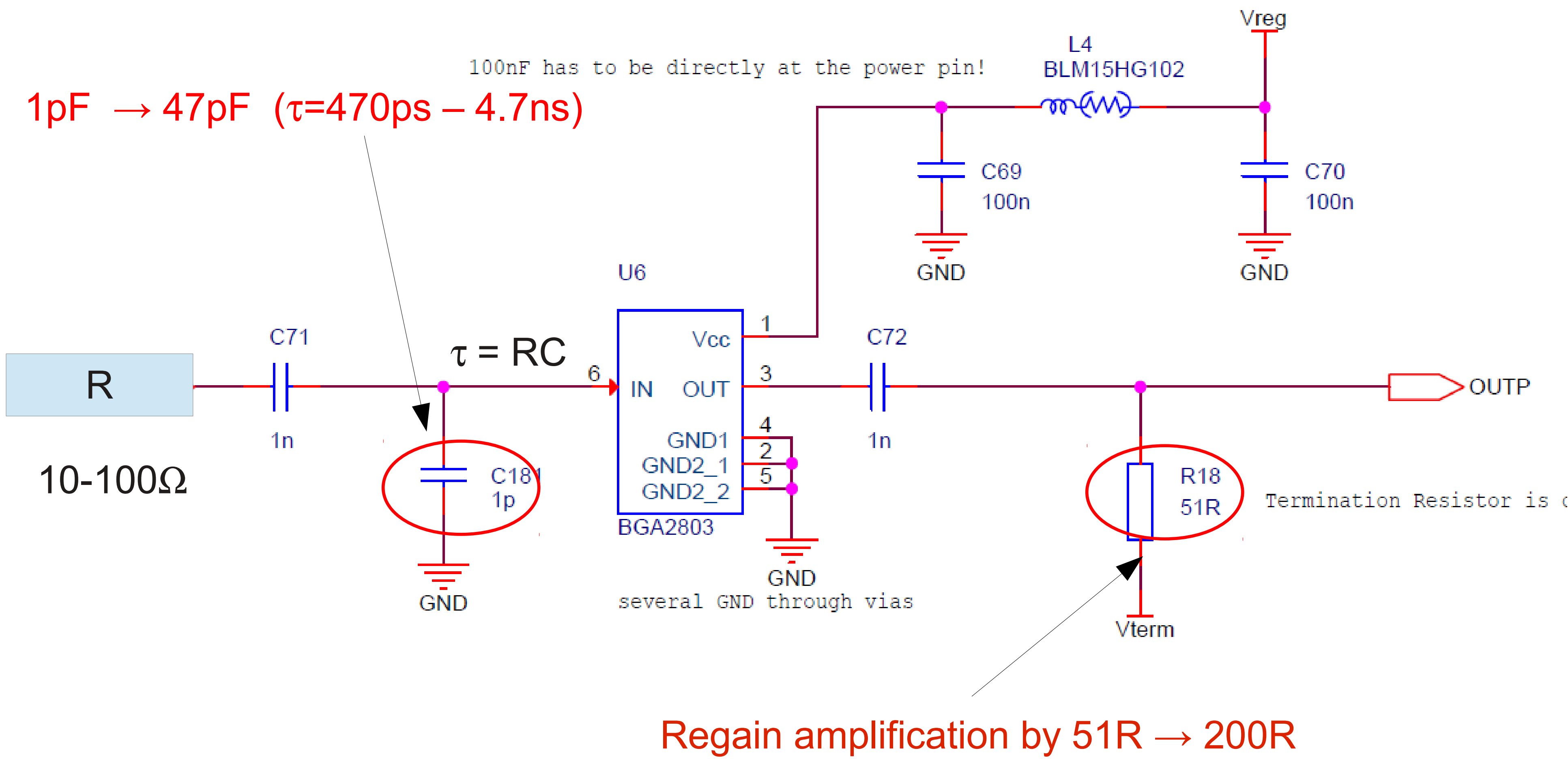
- Only solution available:

  attenuate high frequency noise at the input of the 3GHz amplifiers

  disadvantage: slower rise time of the signal + smaller amplitude needs higher amplification and is more affected to lower frequency noise

Padiwa modification

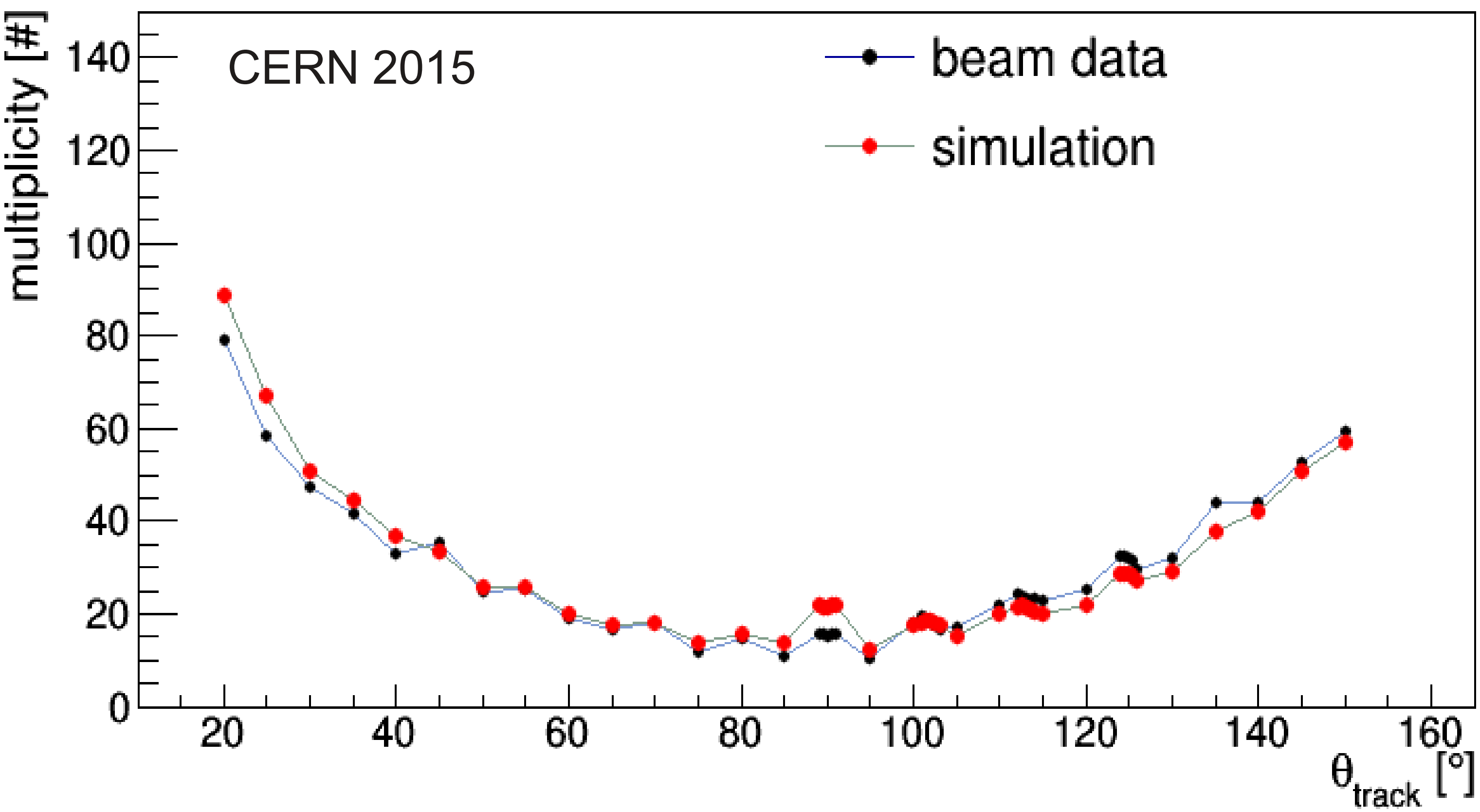
Bandwidth reduced PADIWA → prevent oscillations observed @ GSI 2014 beam time



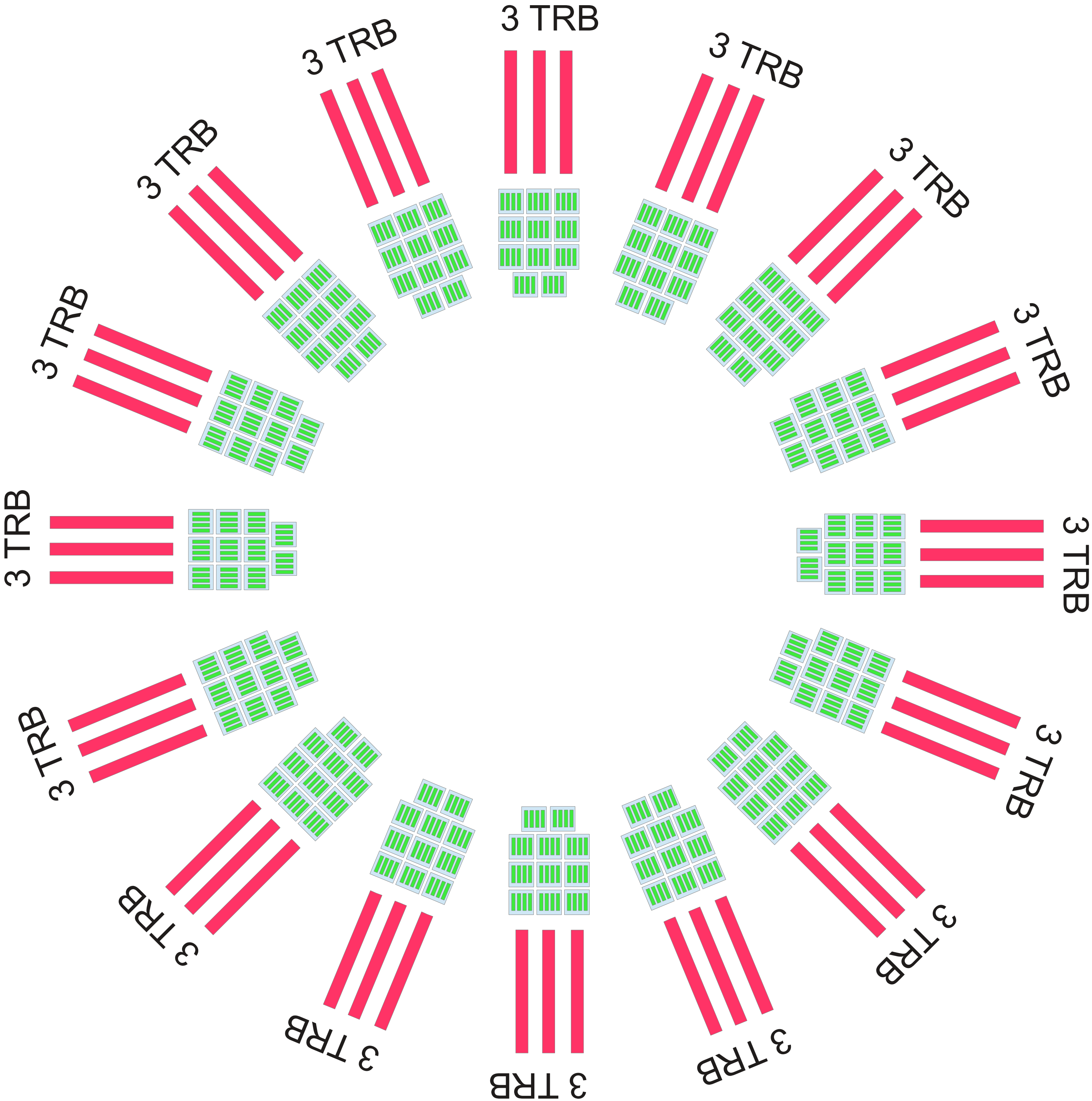
After this modification
The system of 60 PADIWA did not oscillate and low thresholds <1mV were used.
The timing resolution became worse > 200ps (CERN2015 beam time)

→ investigated in electronic lab. (Mainz, GSI)

Beside of electronic issues, measurements have been successful.

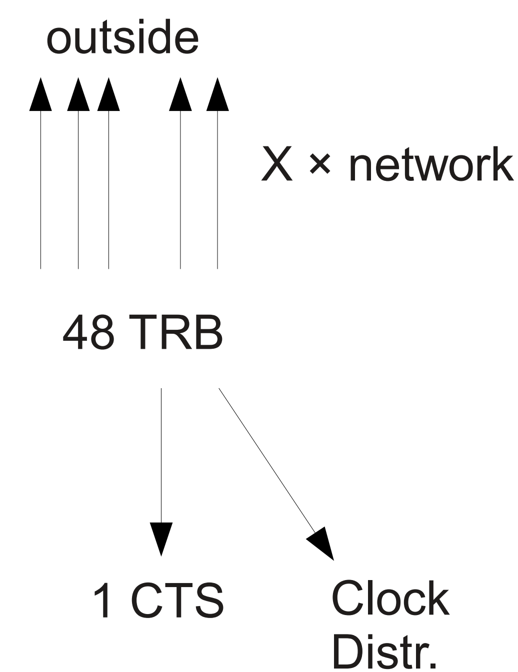


Number of measured photons as function of polar angle of charged particle.
Good agreement between data and simulation.



16 sections
X 11 MCP-PMT
X 64 pixels

→ **11264 channels**



20 Mhz interaction rate
x 2 charged particles (barrel)
x 50 detected Cherenkov photons

→ $2\ 10^9$ hits/s

Leading edge (32 bit)
+ trailing edge (32 bit)
+ overhead (32 bit)
for TOT → 96 bits (12 bytes)

→ 200 Gbit/s
- 1,2,4,... copper Ethernet links
  (routing geometry to outside)

CERN 2015

10 Gb/s

PADIWA

80 mW / channel

11264 * 80 mW

= 900W

= 4.4 V x **200 A**

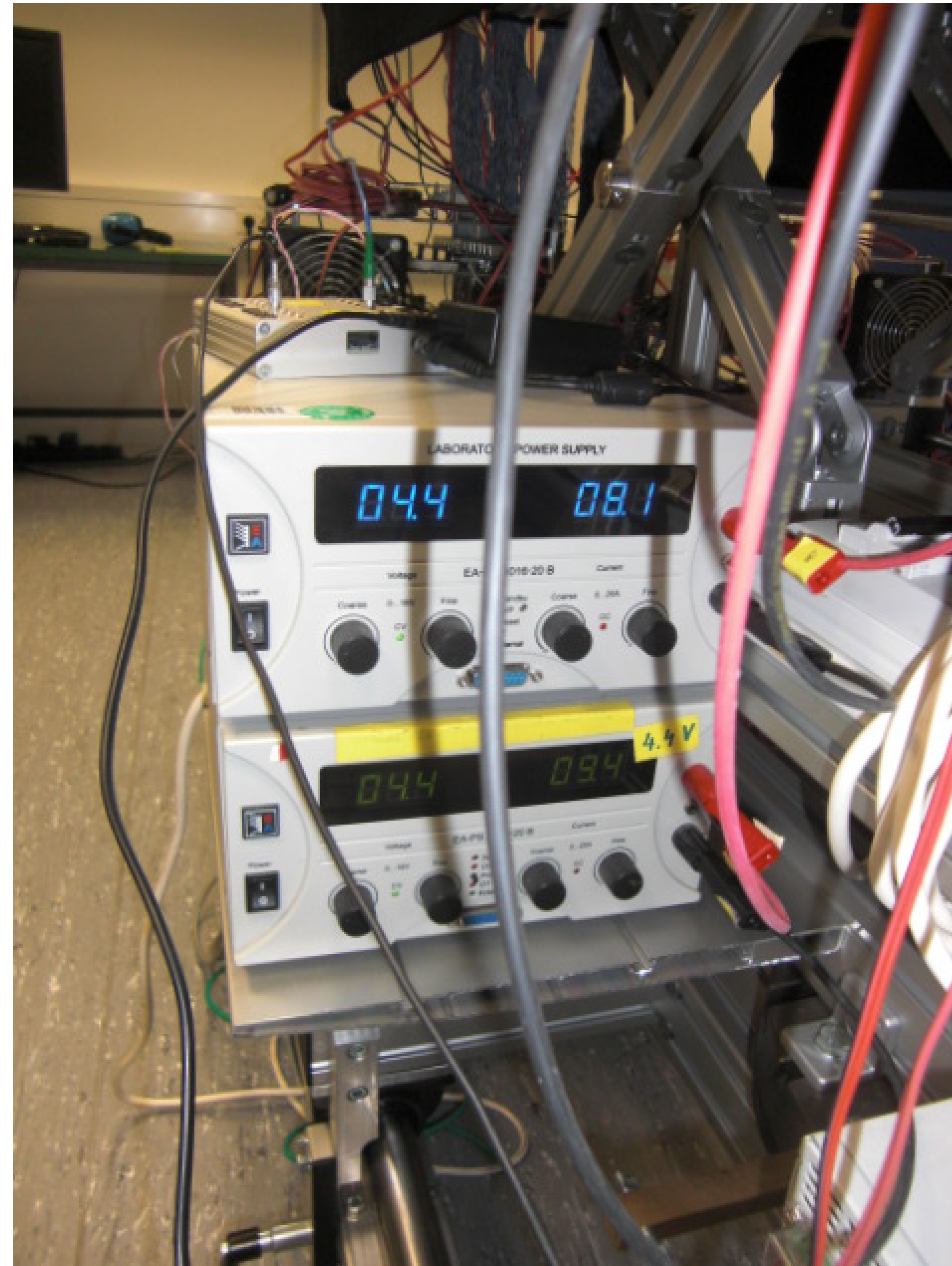
Free copper cable 2 x 10mm diameter
Ampacity @ 75 degree → 200 A

https://en.wikipedia.org/wiki/American_wire_gauge

TRB

48 x 20 W = 960 W

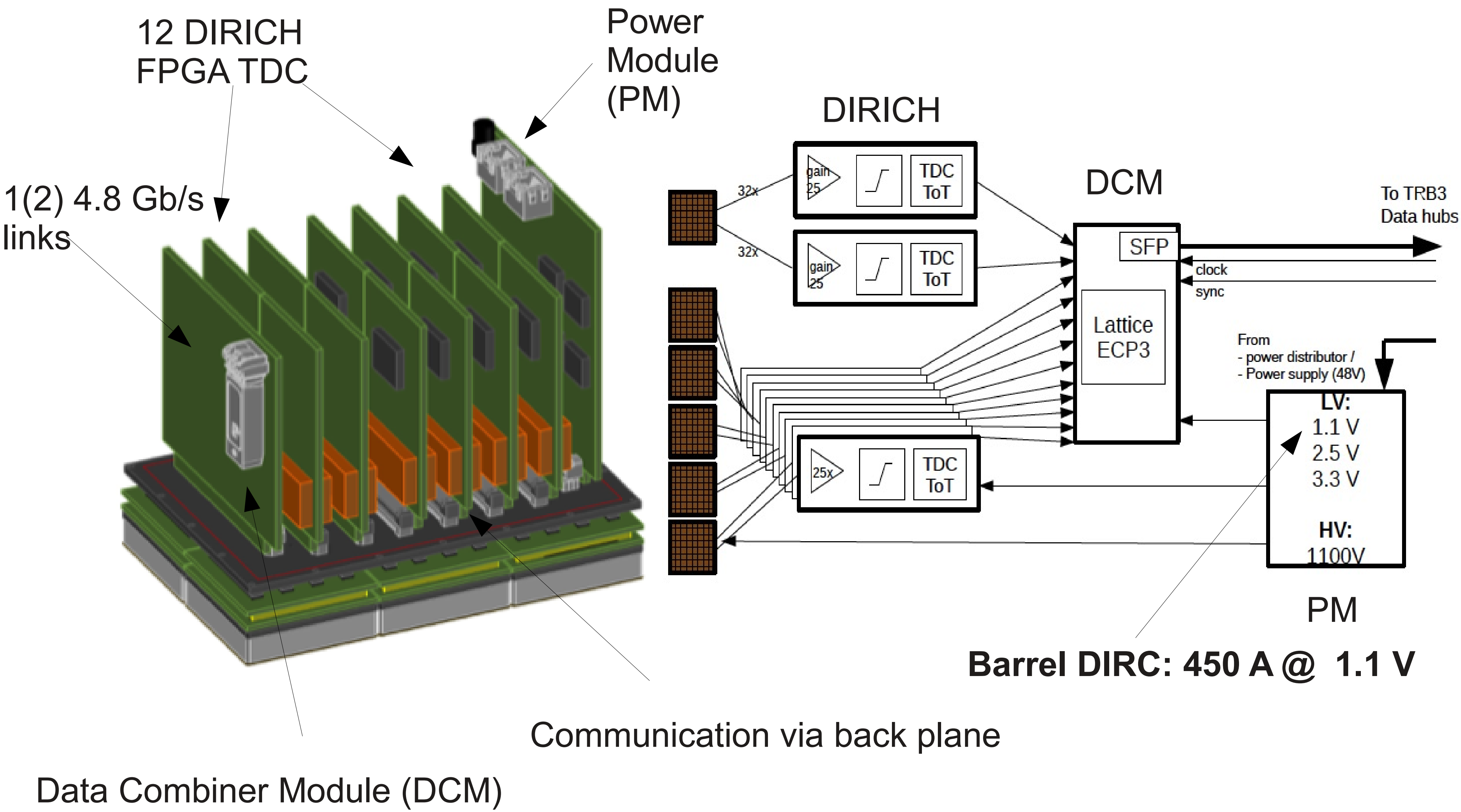
About the same as above...



DIRICH

PANDA-DIRC/CBM-RICH and HADES-RICH

In design phase: DIRICH, Successor of PADIWA3 + TRB3



Summary

Barrel DIRC FEE

- based on PADIWA3 + TRB3
- CERN 2015 readout of 960 pixels
  1500 channels total
- Results agree with simulation
- Option DIRICH