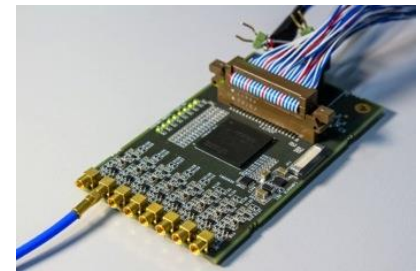


QDC and TDC for understanding QGP

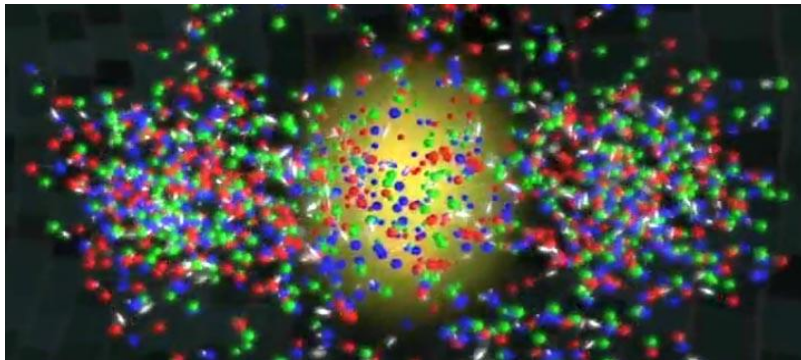


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DPG-Frühjahrstagung (HK) 2016, Darmstadt



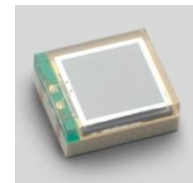
PaDiWa-AMPS
front-end



Adrian Rost
for the **HADES** and **CBM**
collaborations



PMT

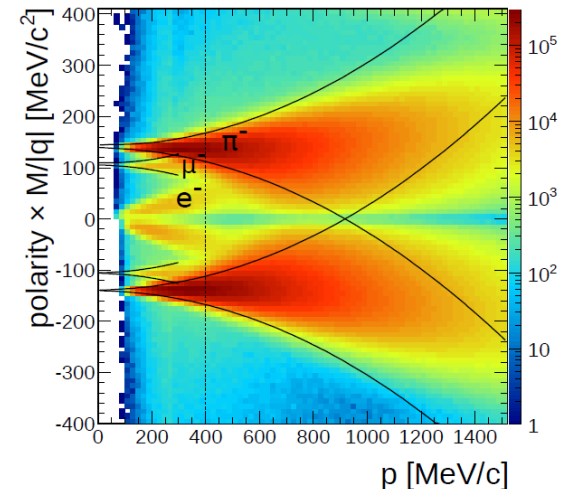
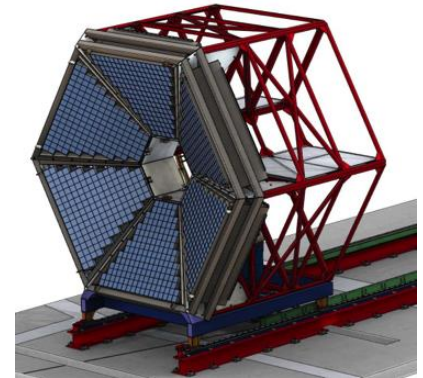


Si-PM (MPPC)

- **Motivation for a PMT read-out application**
HADES electromagnetic calorimeter (ECAL) upgrade
- **The QDC and TDC measurement principle**
PaDiWa-AMPS front-end for the TRB3 platform
- **PaDiWa-AMPS performance under beam conditions**
EACL module tests with secondary gamma beam at the MAMI facility
- **Motivation for a Si-PM read-out application**
CBM Projectile Spectator Detector (PSD) $\approx$ NA61/SHINE PSD at CERN
- **Analog scheme and VHDL code optimizations for more flexibility**
- **Summary and outlook**

Motivation for an ECAL upgrade in HADES

- **2017-2018:** HADES at GSI (SIS18) and in **future** at FAIR (SIS100)
- For beam energies between 2 – 11 AGeV the data base for π^0 and η production is not complete
→ interpretation of di-lepton data depends on models!
- Role of the ECAL:
 - Measurement of π^0 and η via $\gamma\gamma$ -decay channel
 - Additional improvement of e/π separation at large momenta ($p > 400$ MeV/c)



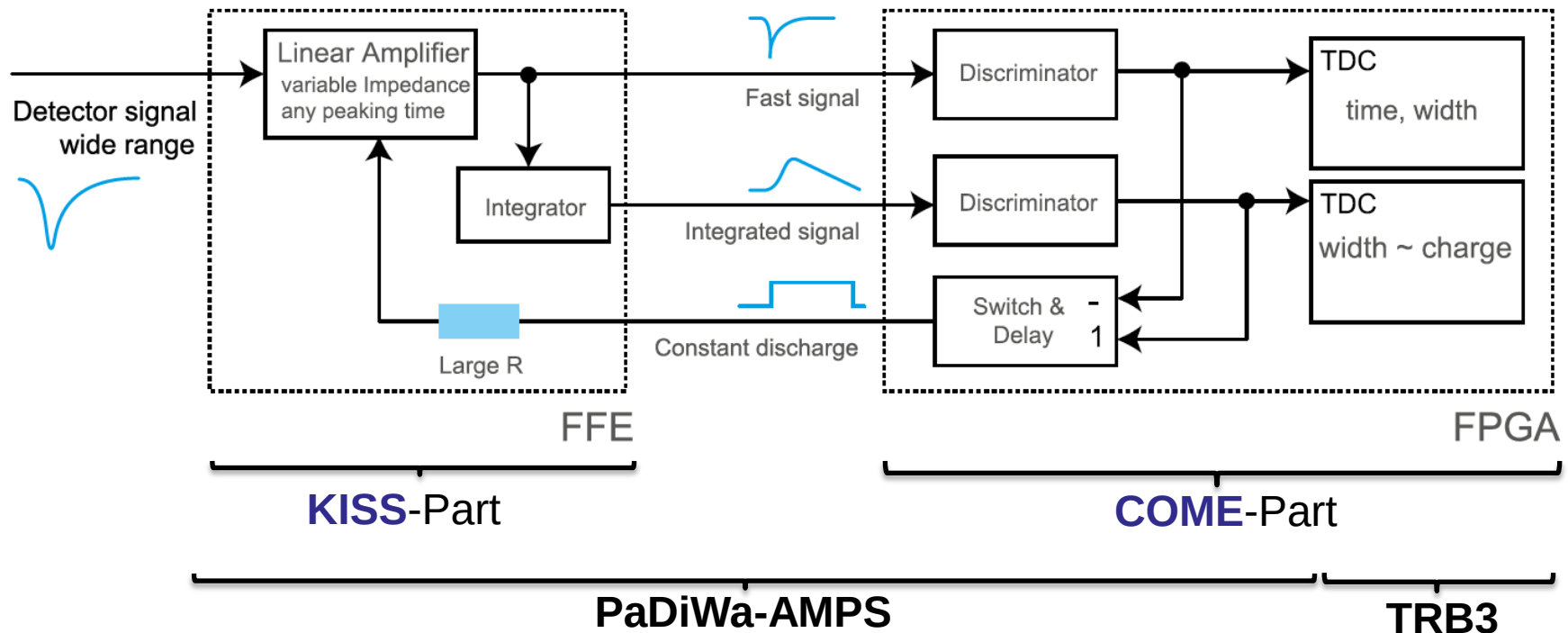
Mass vs. momentum distribution
Au+Au at 4 GeV/u (RPC Region)

→ Precise charge and time measurement needed

Further HADES talks: HK 63.5, HK 65.3, HK 65.4, HK 65.6

The COME & KISS* charge and time measurement principle

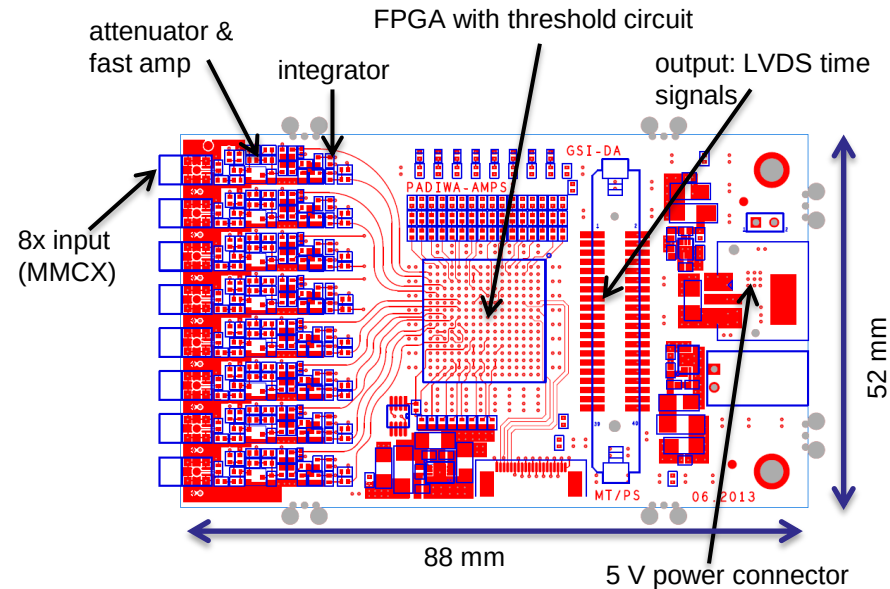
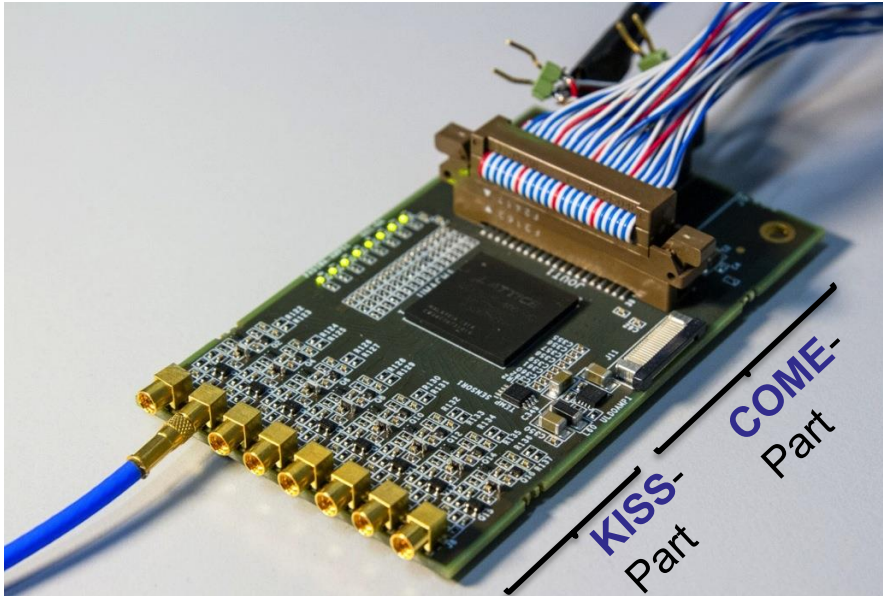
* use **commercial** elements and **keep it small & simple**



- **FAST signal:** leading edge (fast_LE) → **timing**
- **SLOW signal:** slow_LE, slow_TE → **charge-to-time-over-threshold (Q2ToT) ~ Q**
- TRB3 platform used as FPGA-TDC and DAQ

(developed at GSI, see: <http://trb.gsi.de/>)

PaDiWa-AMPS front-end prototype board for the TRB3 platform



- 8 MMCX input channels → at least 24 TDC channels on TRB3 needed
- Time Precision: ~ **19 ps**
- Relative charge resolution: < **0.5 %** (for pulser signals >1 V)
- Dynamic range: ~ **250**
- Max. rate capability: ~ **100 kHz** (optimization ongoing!!!)
- *Universal read-out applications due to the flexible analog part*

TRB3 platform

FPGA TDC and multi purpose DAQ

Time precision
10 ps RMS

4 FPGAs with
260 TDC channels

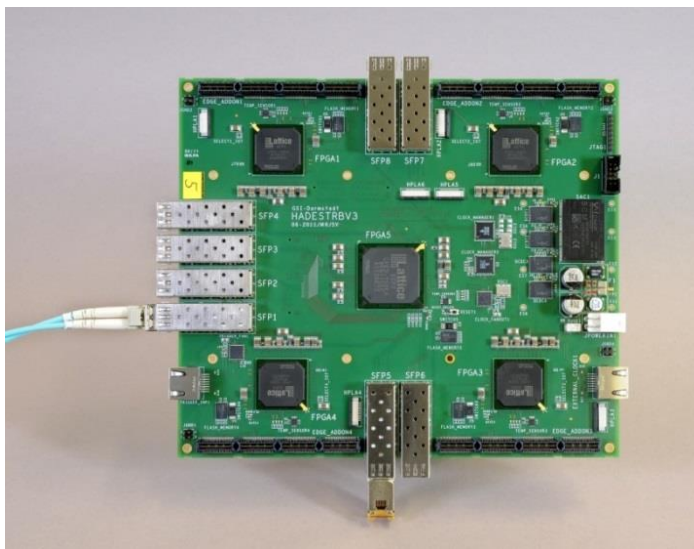


Single edge & ToT
measurements

Usable in large systems
& stand alone

50 MHz hit rate
per channel

Only 48 V and GbE
needed to take data



Internal trigger system
and slow control

Expendable by Add-Ons and
FEEs → i.e. PaDiWa-AMPS

(developed at GSI, see: <http://trb.gsi.de/>)

PaDiWa-AMPS under beam conditions:

Calorimeter PMT read-out



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HADES ECAL module

- EM shower produces Cherenkov light in the lead glass
- Read out by 3" Hamamatsu R6091 PMT

Beam-time at MAMI facility in Mainz

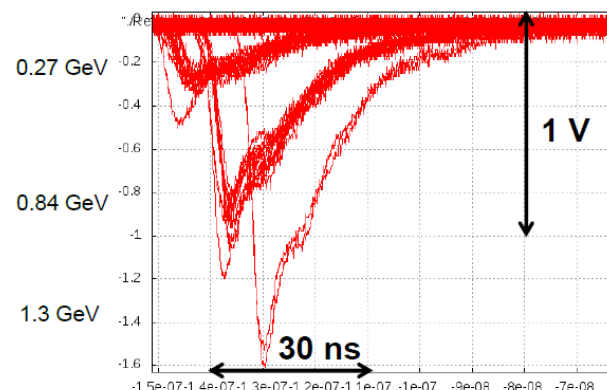
- Secondary gamma beam: $E_\gamma \sim (100 - 1400)$ MeV
- Test of ECAL modules with 1", 1.5" and 3" PMTs

Signal key facts:

- Signal amplitude: 50 - 2000 mV
- Signal rise time: ~ 2 ns, width: ~ 50 ns
- Rate: ~ 5 kHz (100 Hz trigger)



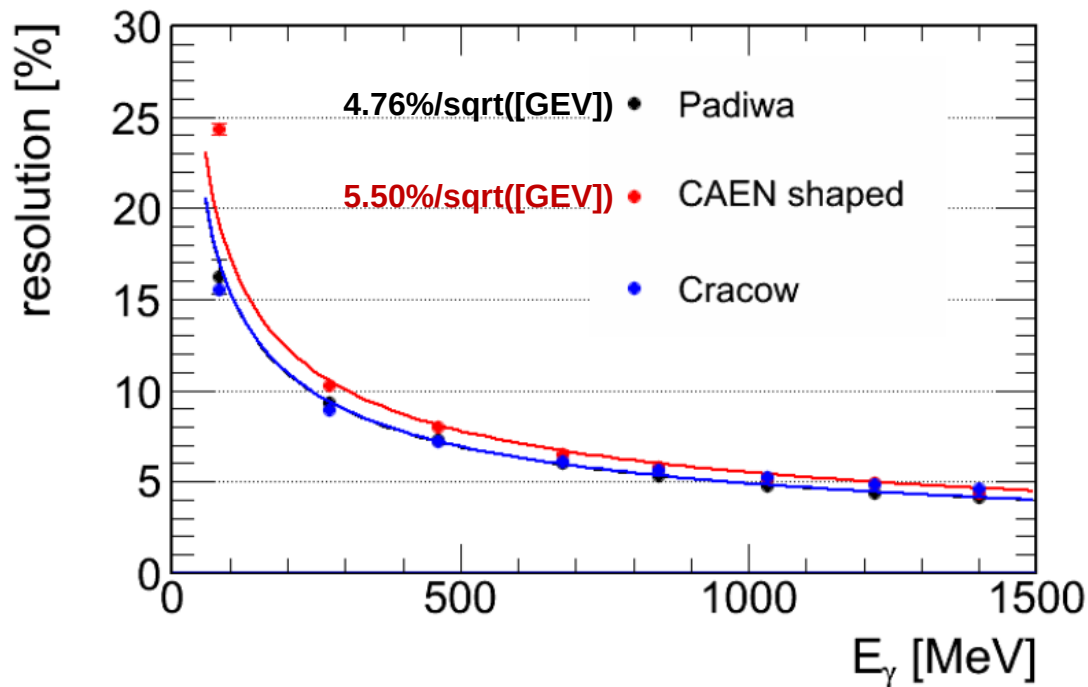
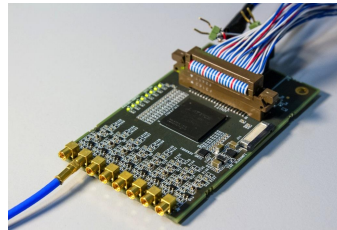
42 cm



Relative energy resolution of an ECAL module

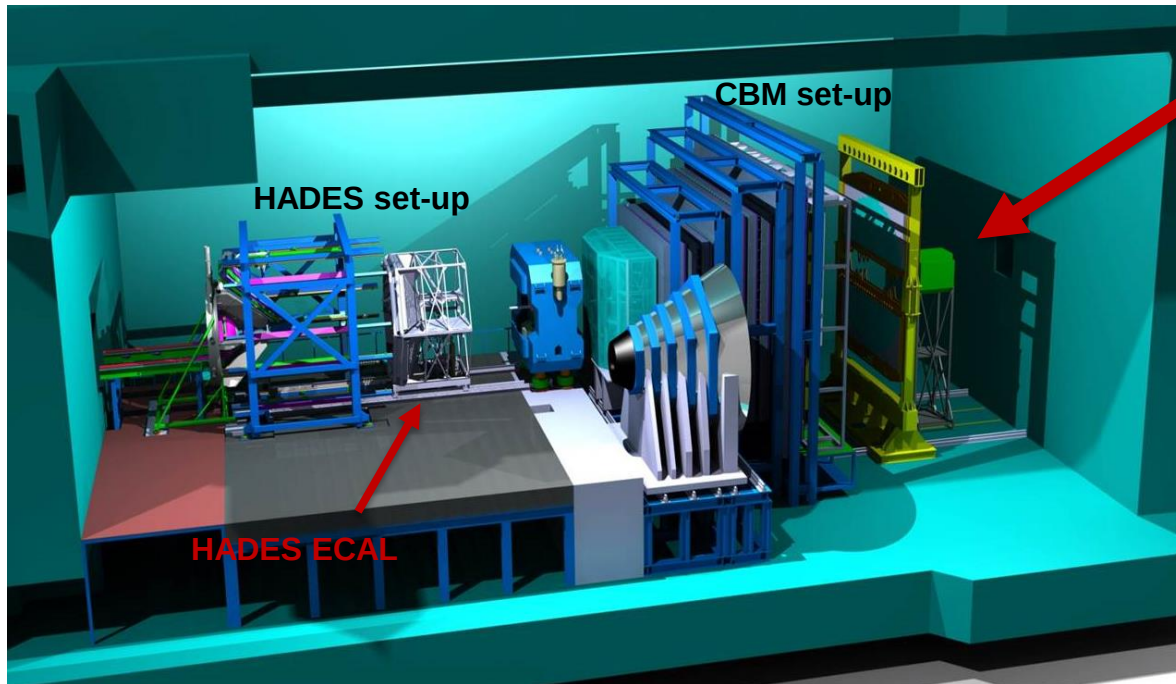


3" Hamamatsu PMT



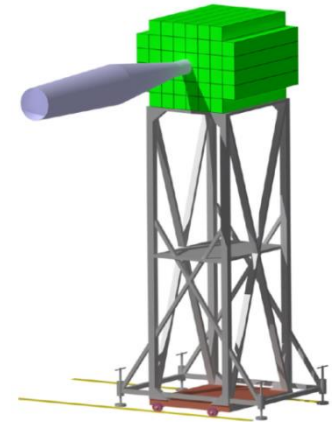
- PaDiWa-AMPS Q2ToT
 - “Cracow” ADC
 - Reference: CAEN DT5742
5 GS/s Waveform digitizer with
GSI MA8000 shaper
- Measurements are in line with
reference CAEN system

The Projectile Spectator Detector (PSD) of the CBM experiment at FAIR



Future location: FAIR, Darmstadt, Germany

Projectile Spectator Detector (PSD)



Determination of:

- Collision Centrality
- Event-plane

→ Measure energy distribution of projectile nuclei fragments (spectators) by a hadron calorimeter

CBM group report see: HK 66.1, DAVID EMSCHERMANN

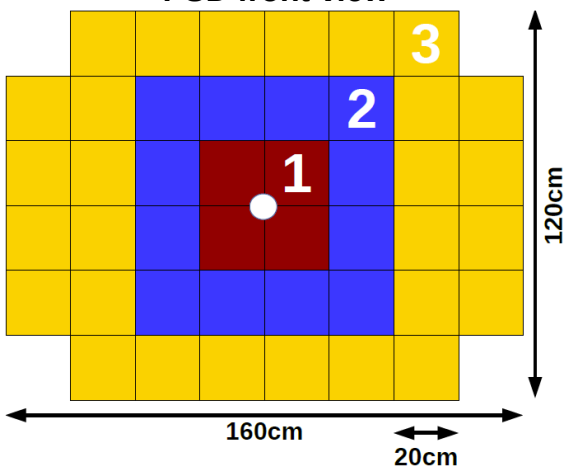
CBM PSD structure

Lead-scintillator sandwich hadron calorimeter



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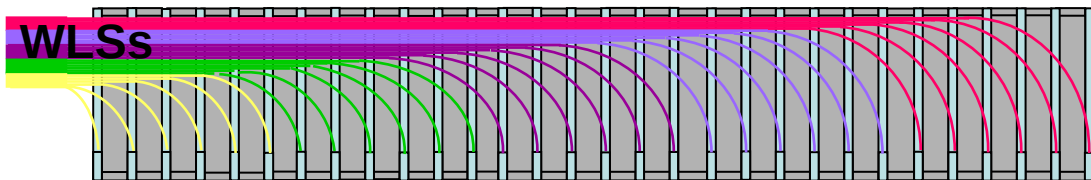
PSD front view



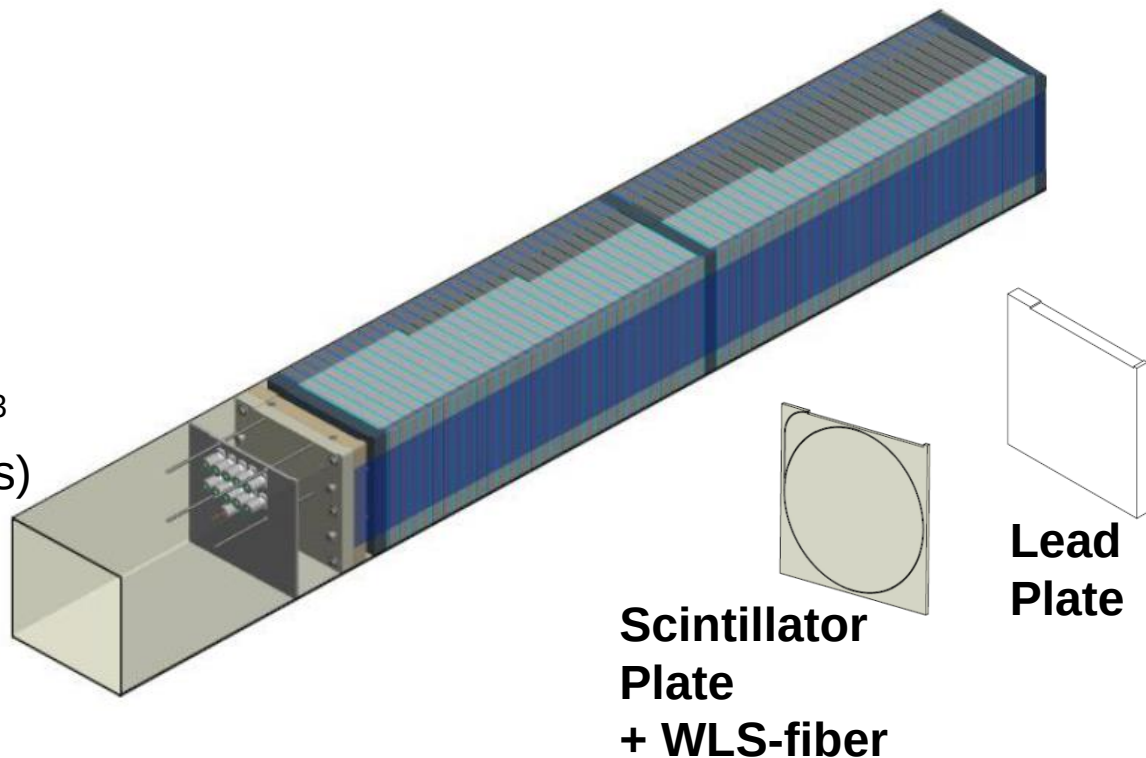
Top view of ½ module

Si-PMs

WLSs



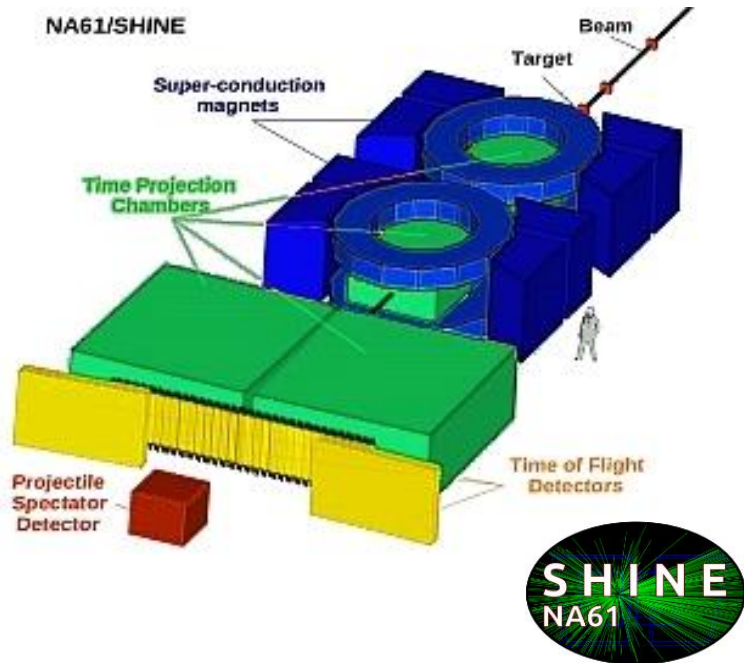
- 44 modules a 60 sections
- Dimensions: 20x20x120 cm³
- Readout via Si-PMs (MPPCs)



The PSD of the NA61/Shine experiment at the CERN SPS

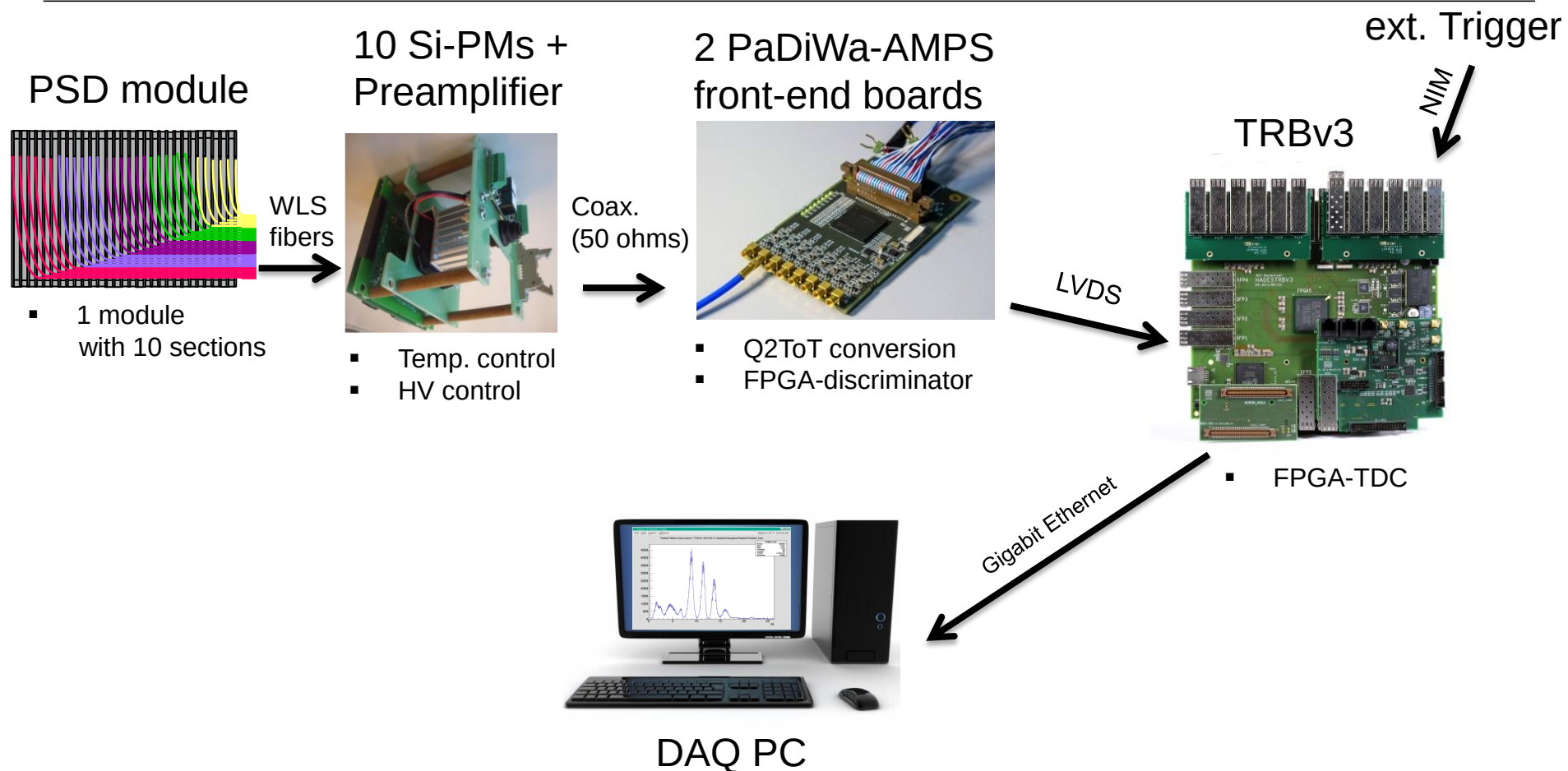


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- The module structure is **identical** to the CBM PSD
- Beam tests are possible on a running system!!!
→ PaDiWa-AMPS read-out tests are planned for mid of 2016

PaDiWa-AMPS test read-out scheme of the NA61/SHINE PSD



PSD read-out requirements/challenges

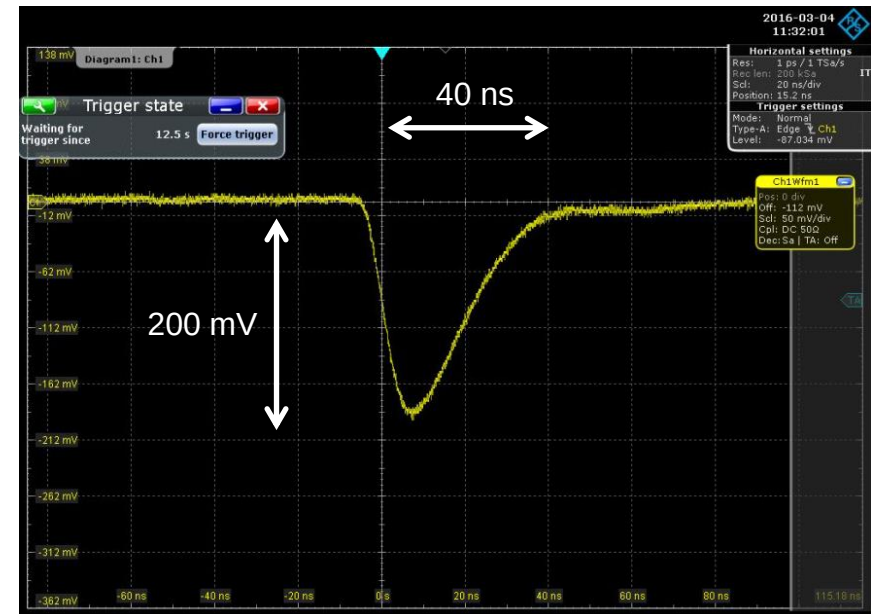
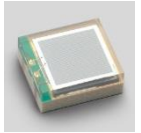
Signal key facts:

- Signal amplitude: 5 mV – 2000 mV
- Signal rise time: ~ 10 ns, width: ~ 40 ns
- Rate: up to 1 MHz (in CBM PSD)
- noisy MPPC signals

→ Adaption of the PaDiWa-AMPS analog stage needed

→ Proper filtering of noise needed

Hamamatsu S12572-010P MPPC
+ NA61 pre-amplifier
irradiated with a LED flash

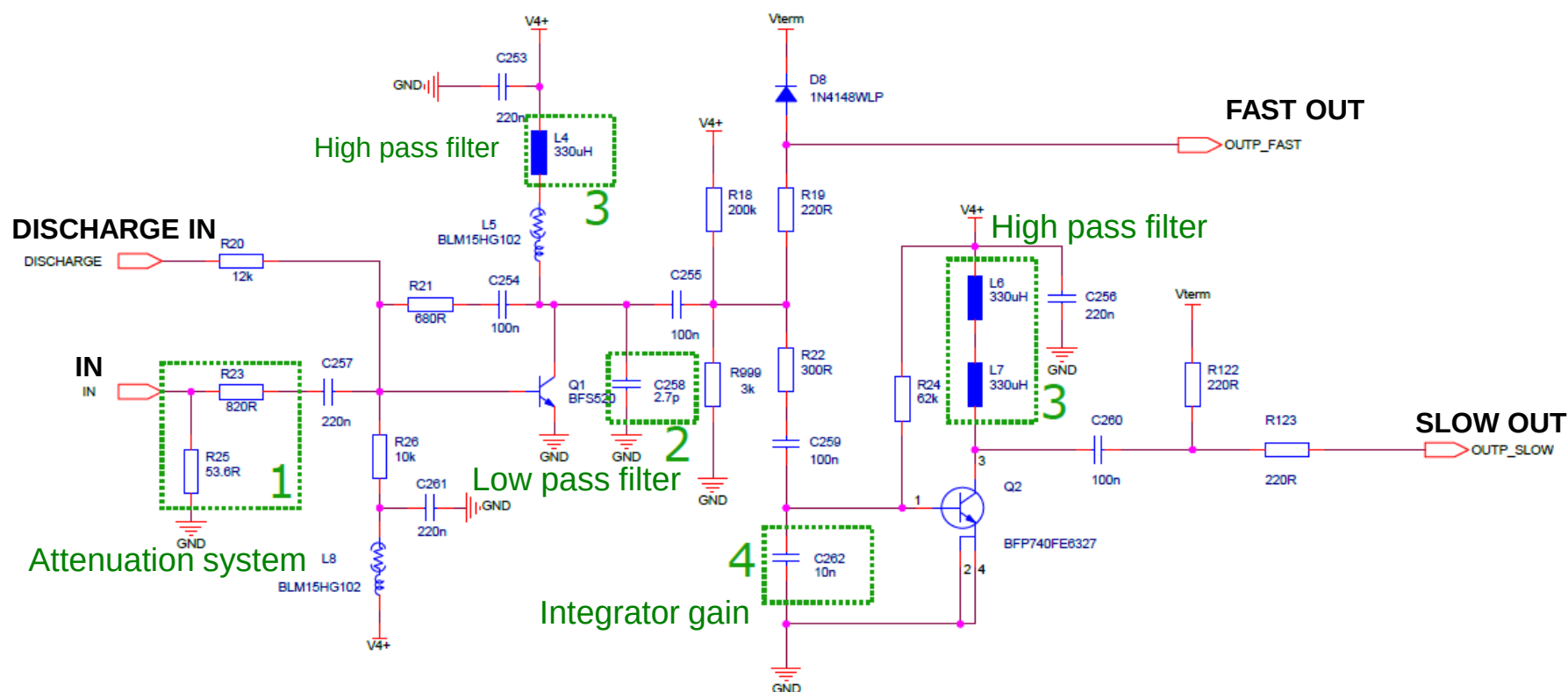


PaDiWa-AMPS flexible KISS analog schematics

Analog stage without FPGA



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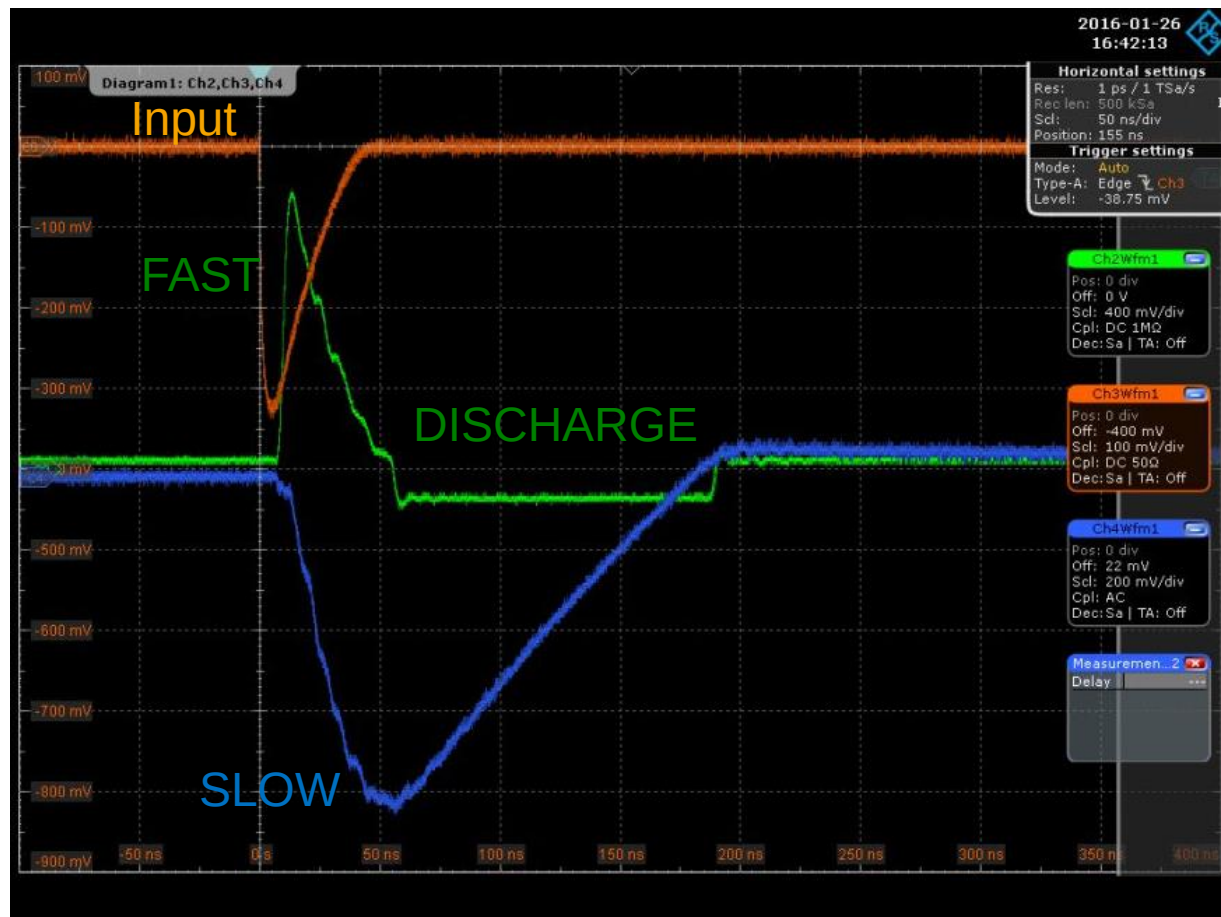
→ Amplification and S/N ratio can be easily adapted to different detector pulse shapes by changing some resistors, capacitors and inductors

Optimization of the DISCHARGE generation

More flexibility for different pulse shapes (width)



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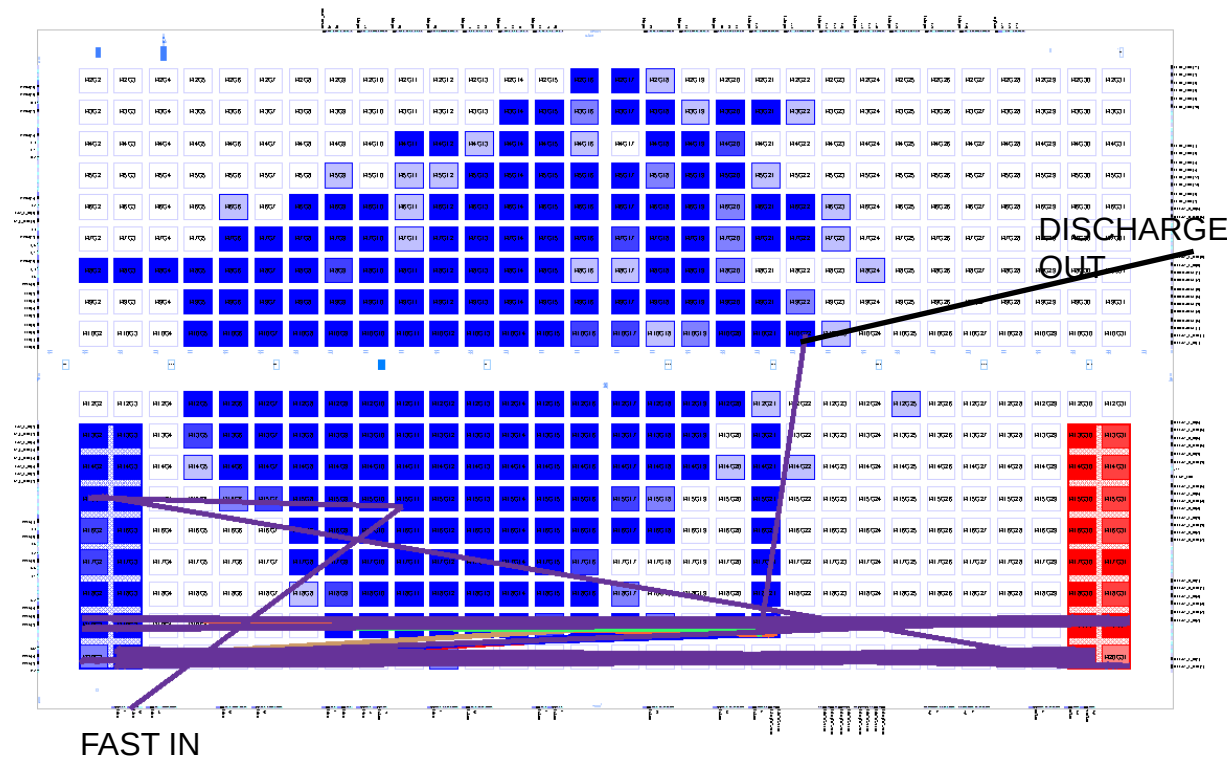


- DISCHARGE is used to discharge the integration capacitor
- Start triggered by a logical & between the integrated discriminated SLOW signal and a delayed discriminated FAST signal

→ Should be matched to the input signal width

Start of the DISCHARGE is delayed inside the FPGA via routing

FPGA floorplan view and
placement of the instances



- Multiplexer allows the selection of delay lines which generate an delay of 15 ns - 65 ns

→ Longer delays can be easily added, shorter delays are possible with optimized placement

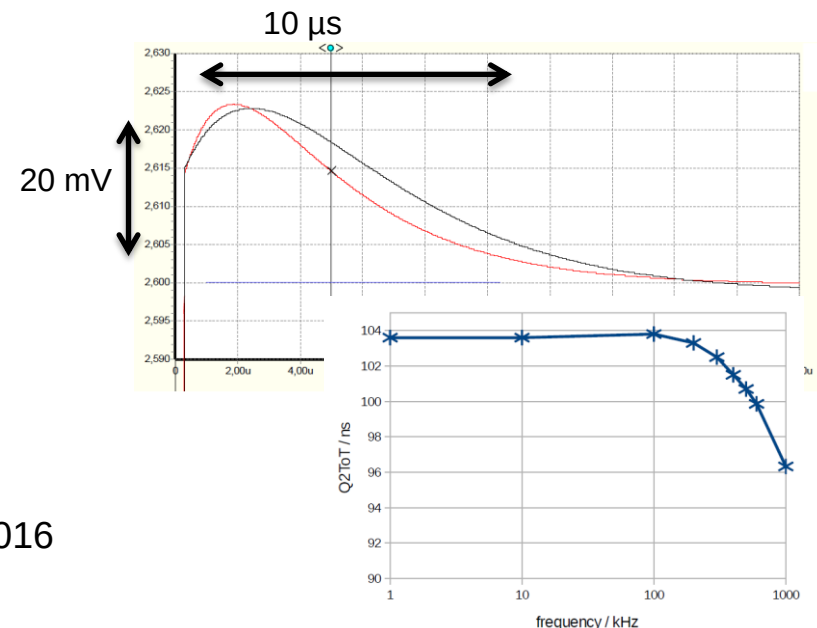
Summary and Outlook

COME and KISS Q2ToT principle is working and proofed:

- ✓ Laboratory
 - Time precision of **~19 ps**,
 - Electronics resolution **<0.5%** (for ECAL signals > 1 V)
 - Dynamic range: **~250**
- ✓ ECAL energy resolution tests at MAMI
 - Results are in agreement with reference DAQ

ToDo List:

- Implement an active baseline restorer in the FPGA to increase rate capability
 - Further S/N ratio improvements
- PSD read-out test at NA61/SCHINE (CERN) in mid 2016



Thank you for your attention!!!

