university of groningen

kvi - center for advanced radiation technology

Readout of the PANDA Electromagnetic Calorimeter, Status

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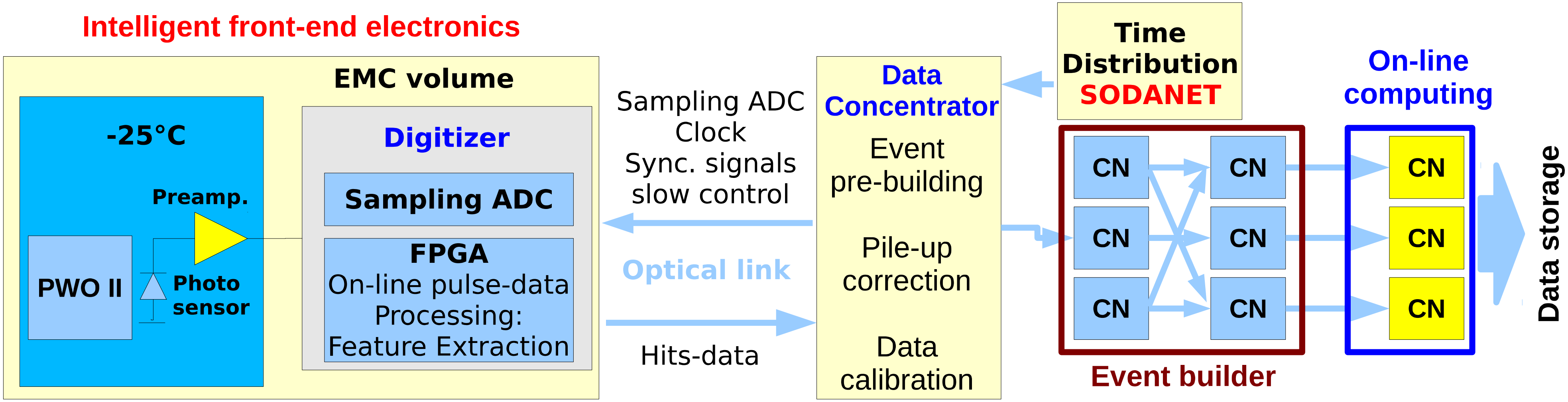
for the PANDA collaboration

EMC-Readout Scheme

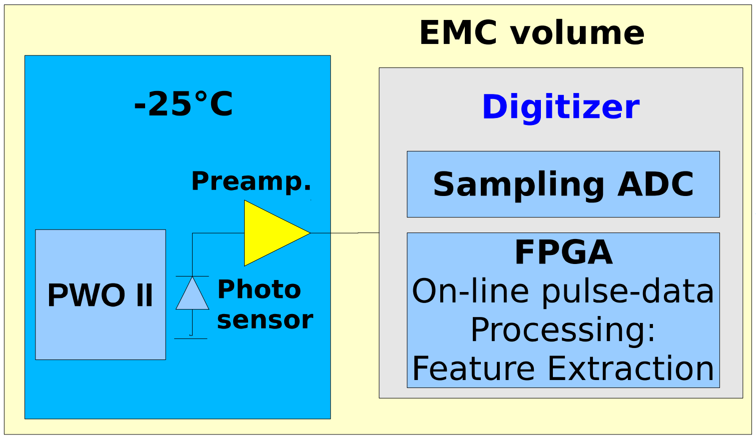


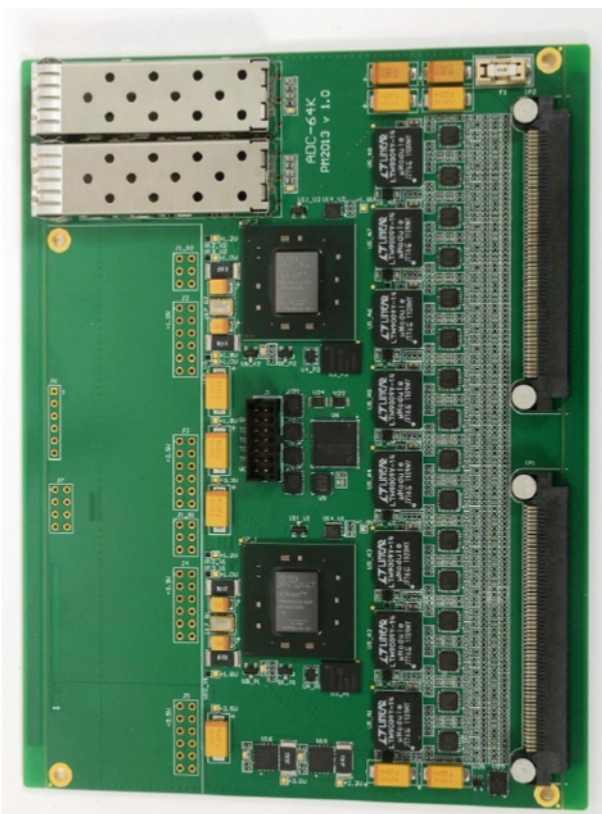
Components of the EMC readout:

- Intelligent front-end: **digitizer**
- Time-distribution system
- Data concentrators
- Burst-building network
- On-line computing

EMC Front-End Electronics

Intelligent front-end electronics





EMC digitizer:

- 64 ADC channels (32 dual-gain readout channels)
- 14 bit resolution
- 80 MHz sampling rate

- Exist two configurations:
  - APFEL – ASIC readout
  - LNP readout

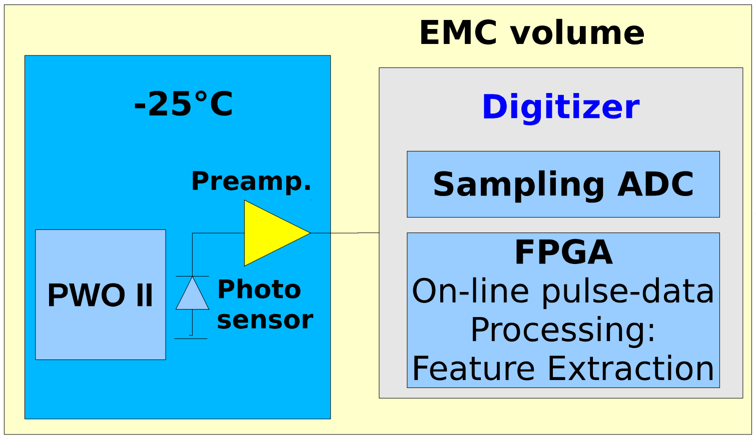
- Several (5) modules are produced

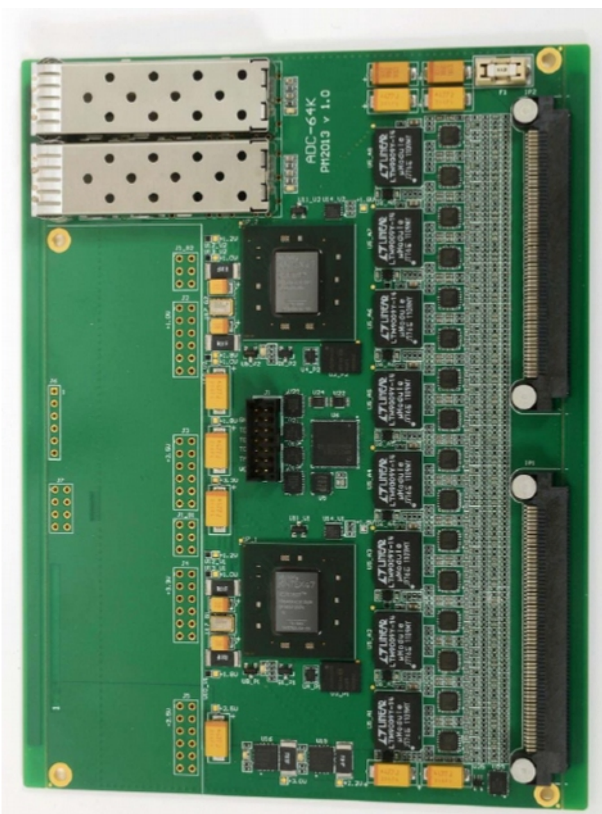
- Feedback from users is necessary to finalize digitizer:
  - Input buffers configuration (amplification, shaping, etc.)
  - Feature extraction (amplitude or integral measurement, etc.)

→ beamtime with EMC prototype?

EMC Front-End Electronics

Intelligent front-end electronics



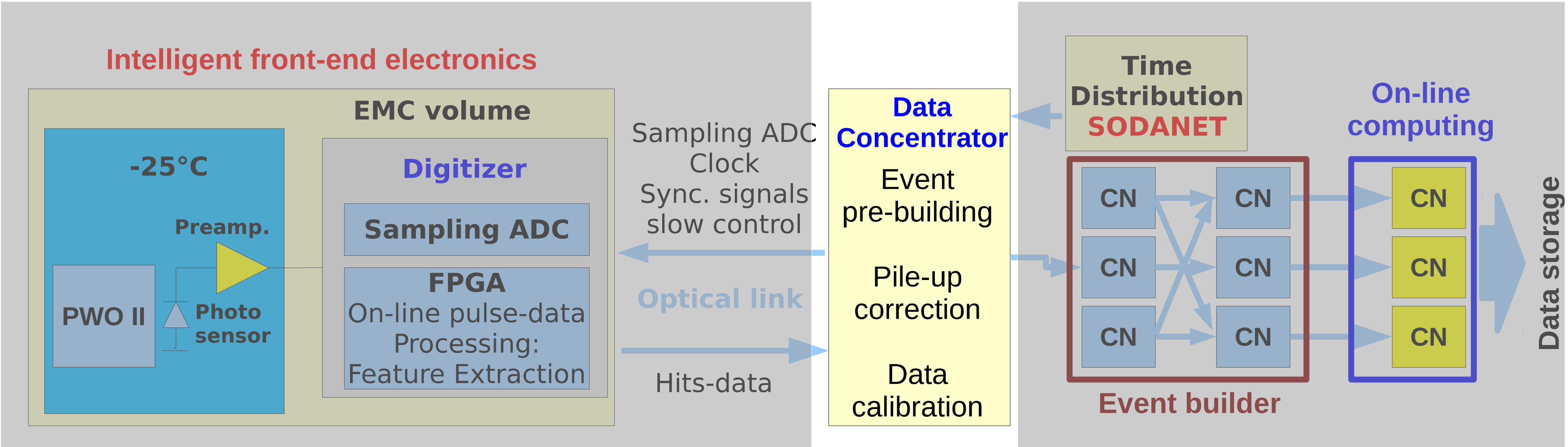


Feature Extraction:

- **MWD filtering** (programmable)
- Base-line follower
- Pulse detection
- Pile-up detection (output waveforms)
- Precise time
- Precise energy (amplitude, integral)
- Diagnostics: Possibility to readout raw ADC data (access to the noise-level measurement)
- **Controlled readout of waveforms (required for automatic determination of thresholds)**

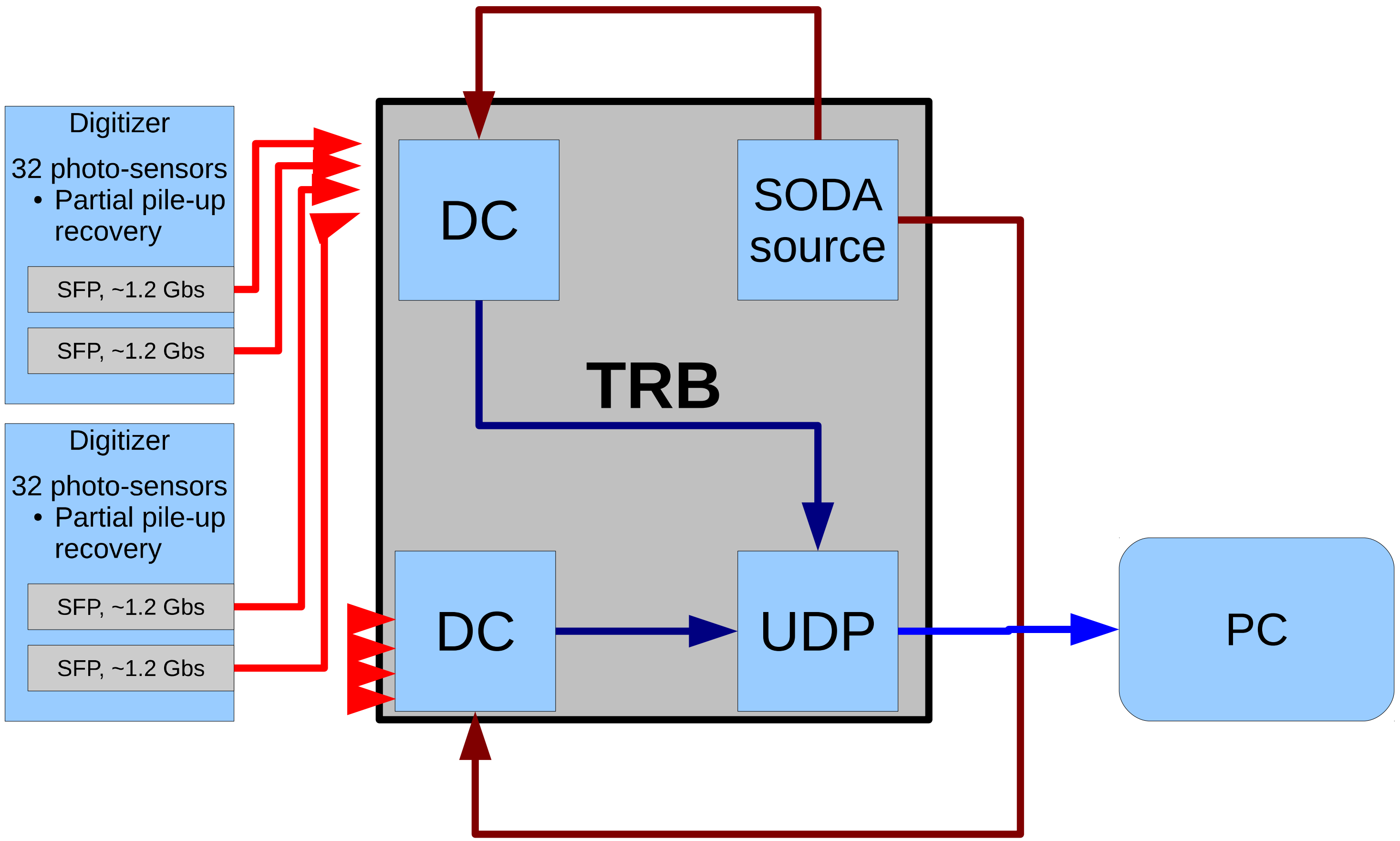
- **To be done**: self-monitoring for configuration errors, triple redundancy
  - Radiation-hardness beam-test at Uppsala is being prepared

Data Concentrator



- **Data concentrator:**
  - Running on TRB3 and **Xilinx Kintex-7 development** boards
  - Receiving Waveforms and Hit-data over fiber from FEE
  - **Energy calibration for each ADC channel (low and high gain separately)**
  - **Superburst building**
  - Put each Waveform in one Panda data-packet (debugging mode)
  - Send Panda data-packets over fiber to CN UDP translator
  - **Slow Control with SODA-NET**
  - **Combine hits from two digitizers corresponding to the same crystal**
  - Additional features: on-line histogram, data monitoring (hits and waveforms), error detection and counting

Readout Configuration with Single TRB DC



Single TRB board allows to read out up to 8 digitizers at low hit-rate

Readout Configuration with Single TRB DC

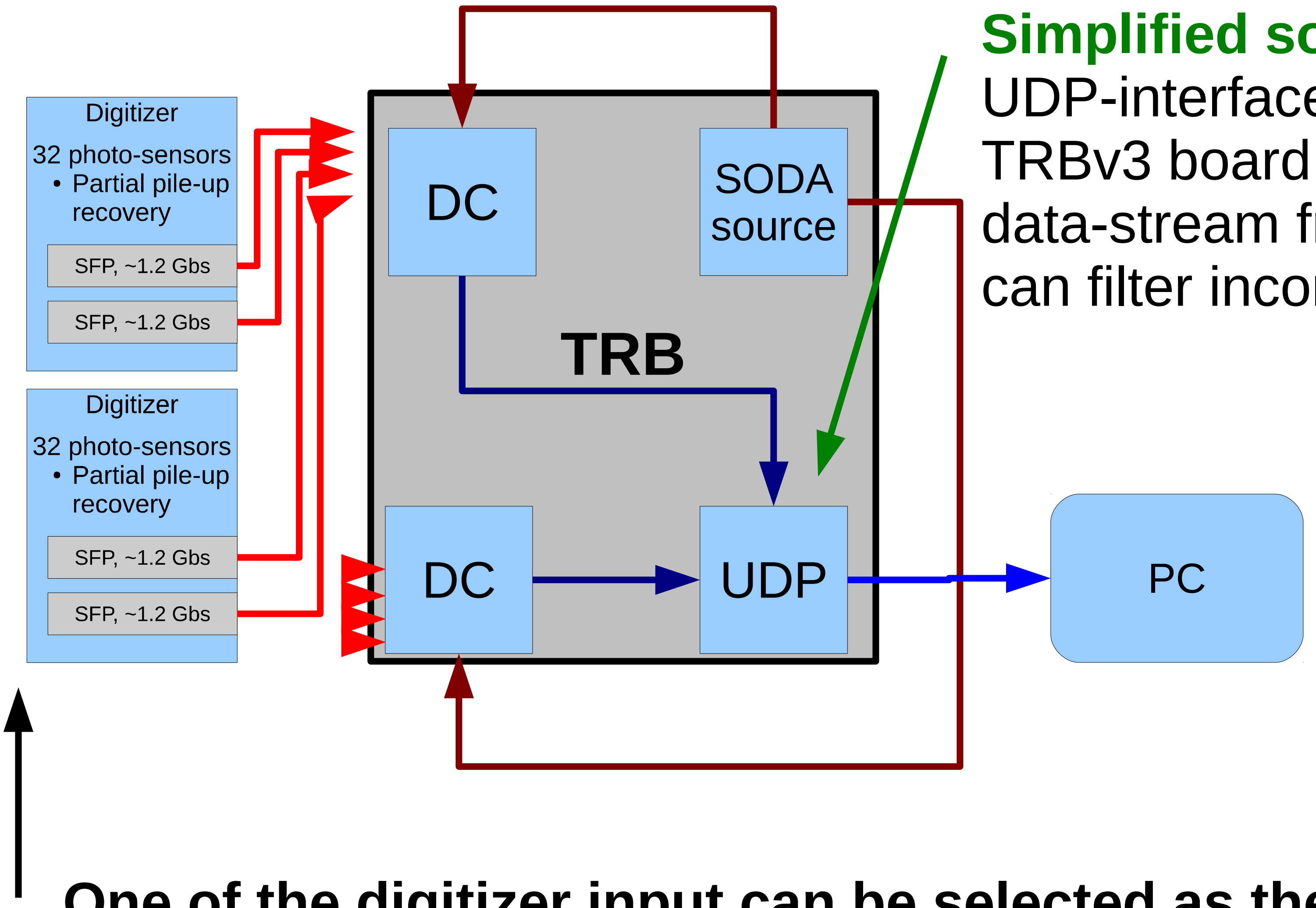
Measurements with a “trigger” signal

Design foresees reading out “trigger” signals with front-end boards (TDCs, digitizers) and at the compute-node level select only hits which are in coincidence with the “trigger”:

- Required burst building (compute node)
- Required event reconstruction/filtering (compute node)

Readout Configuration with Single TRB DC

Measurements with a "trigger" signal



Simplified solution:
UDP-interface board (part of the TRBv3 board which translates data-stream from DC to GbE) can filter incoming data

One of the digitizer input can be selected as the "trigger" input

Readout Configuration with Single TRB DC

Measurements with a "trigger" signal

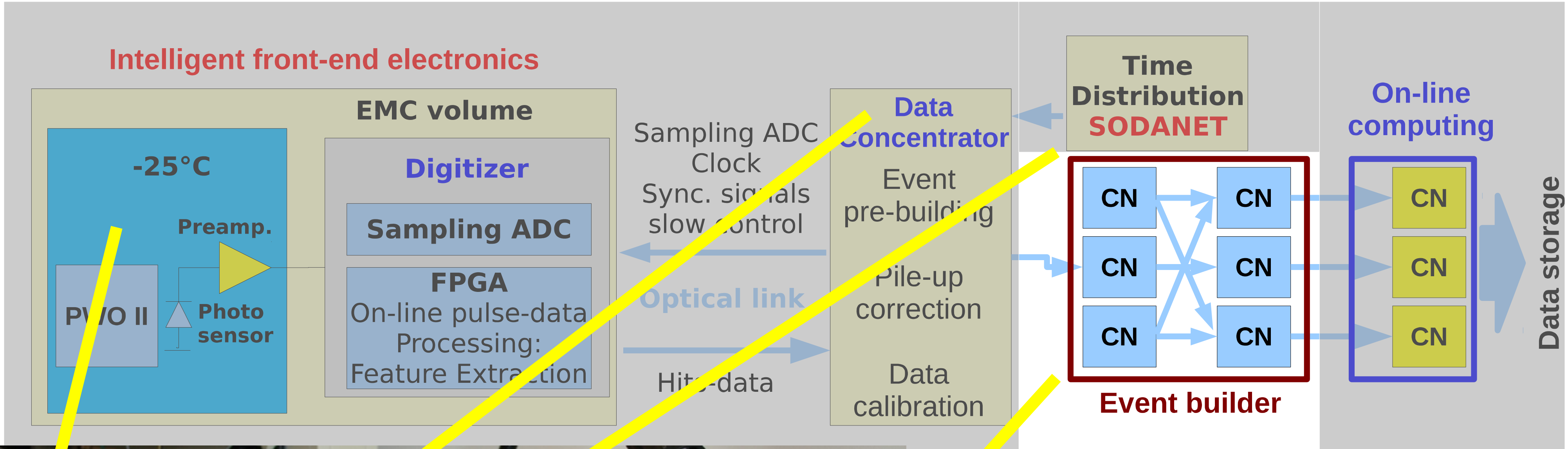
Data coming from DC are arranged in the super-burst packets (~16 μs)

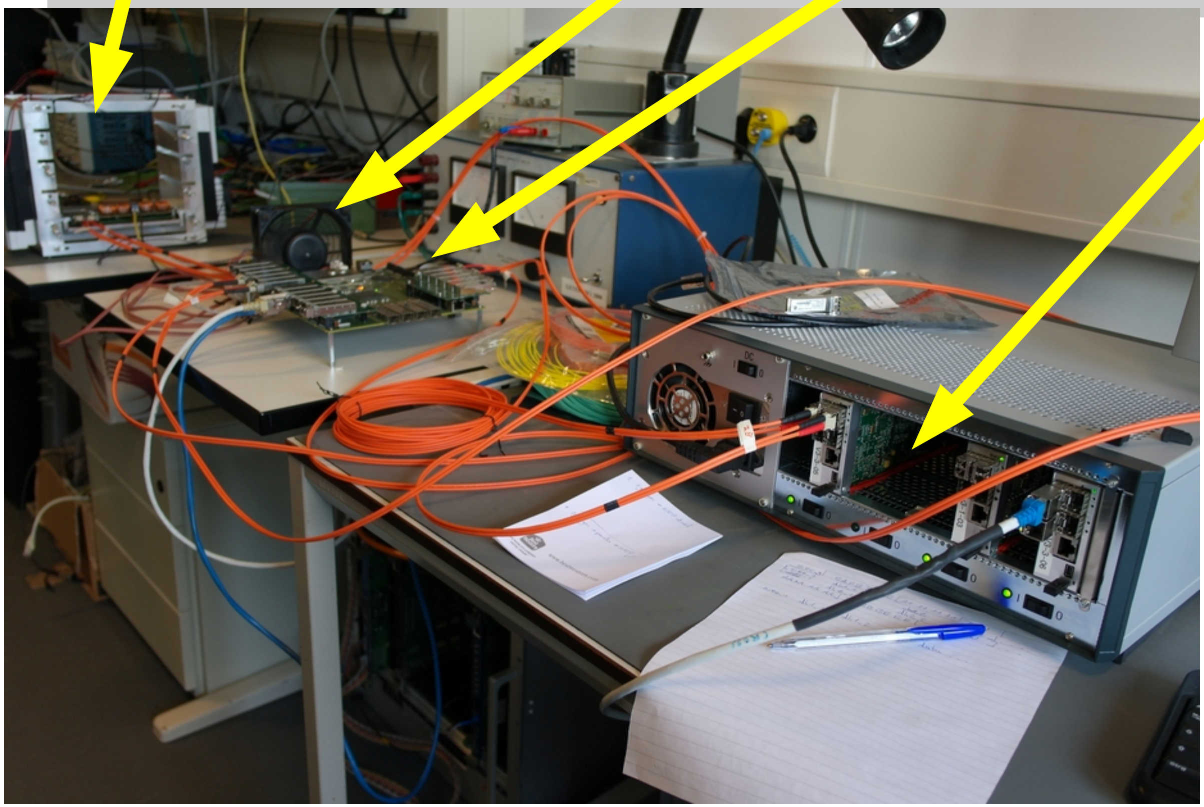
The on-line filtering will drop all packets which do not contain any hit from the "trigger" channel

This method does not provide a fixed-length "coincidence window" with trigger, however, precise data-selection can be done off-line

This readout will properly operate at any hit-rate of the readout channels, and with trigger rate till tens kHz

Event Building





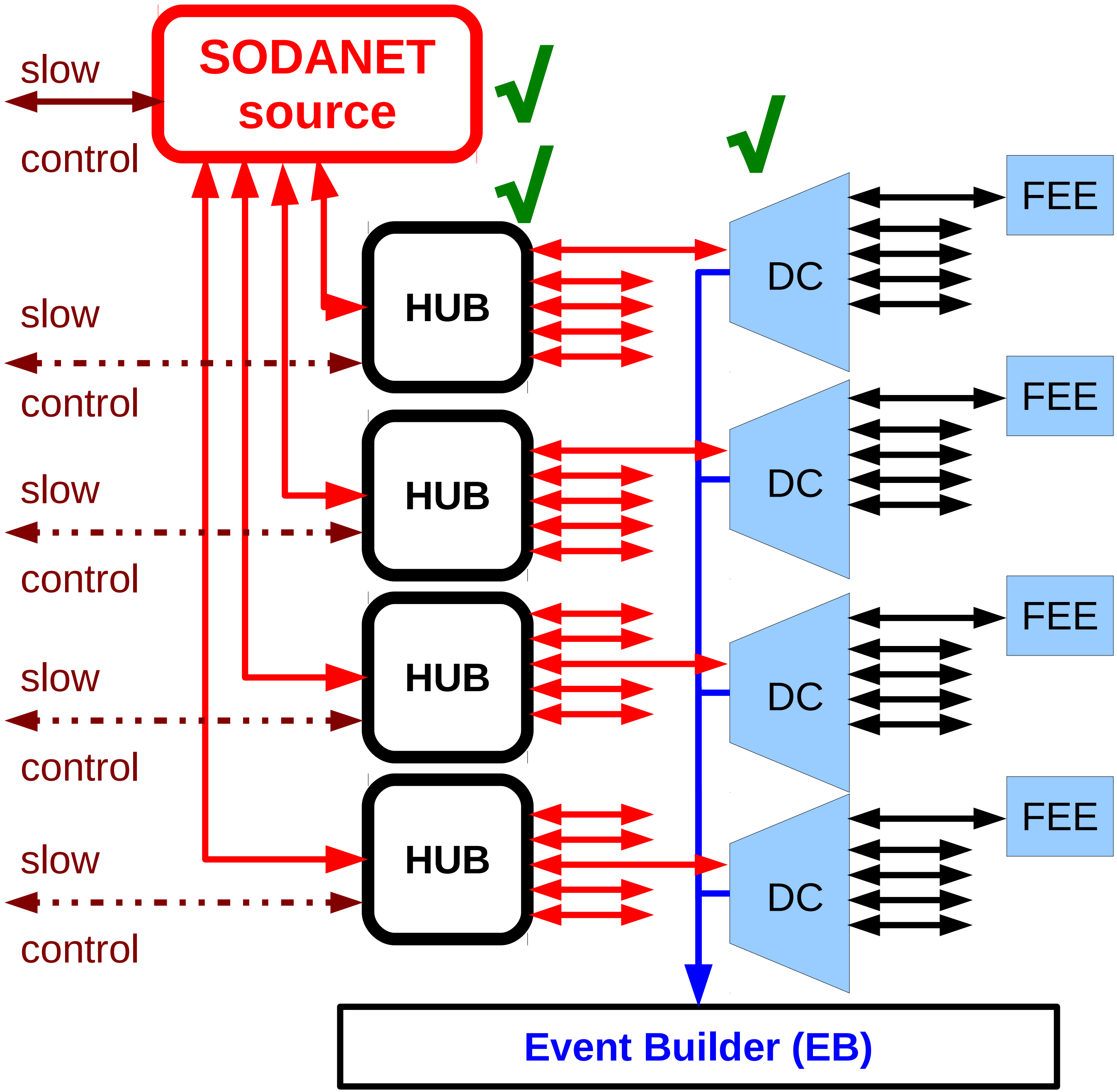
Event builder.

- is implemented on a compute node
- Tested with two EMC data concentrators and two digitizers

Limitations of the test system:

- can accept maximum 8 digitizers
- Limited bandwidth of the serial links (due to TRB3)

SODANET Topology



SODANET link:

- Bidirectional
- Synchronous (only in one direction)
- Transfer:
  - source → DC: synchronization information and FEE configuration
  - DC → source: slow control, used for time calibration

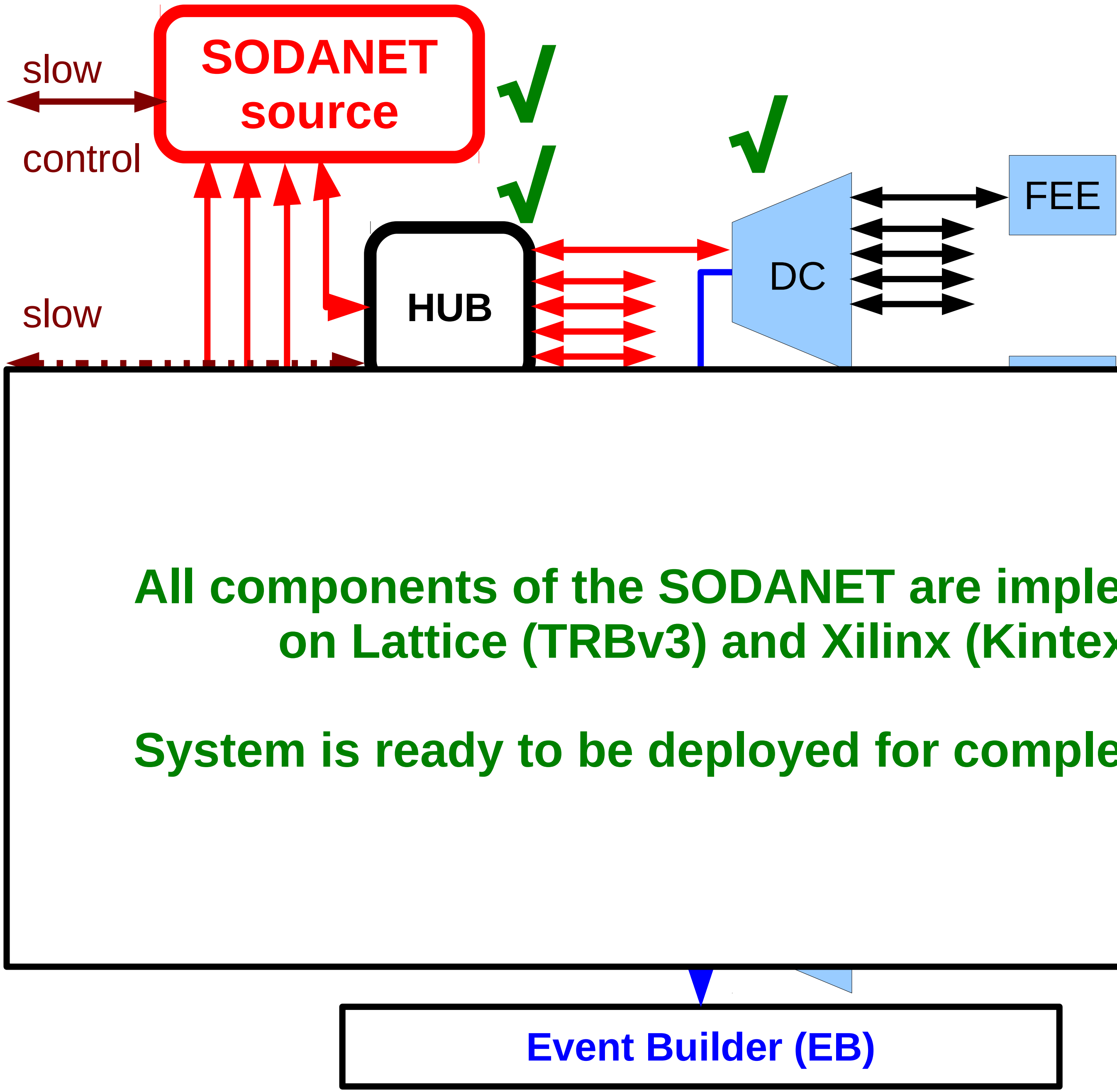
Data link (DC → EB):

- Unidirectional Ethernet

Link DC ↔ FEE:

- Bidirectional, synchronous
- Protocol up to subsystem

SODANET Topology



SODANET link:

- Bidirectional
- Synchronous (only in one direction)
- Transfer:
  - source → DC:
    synchronization

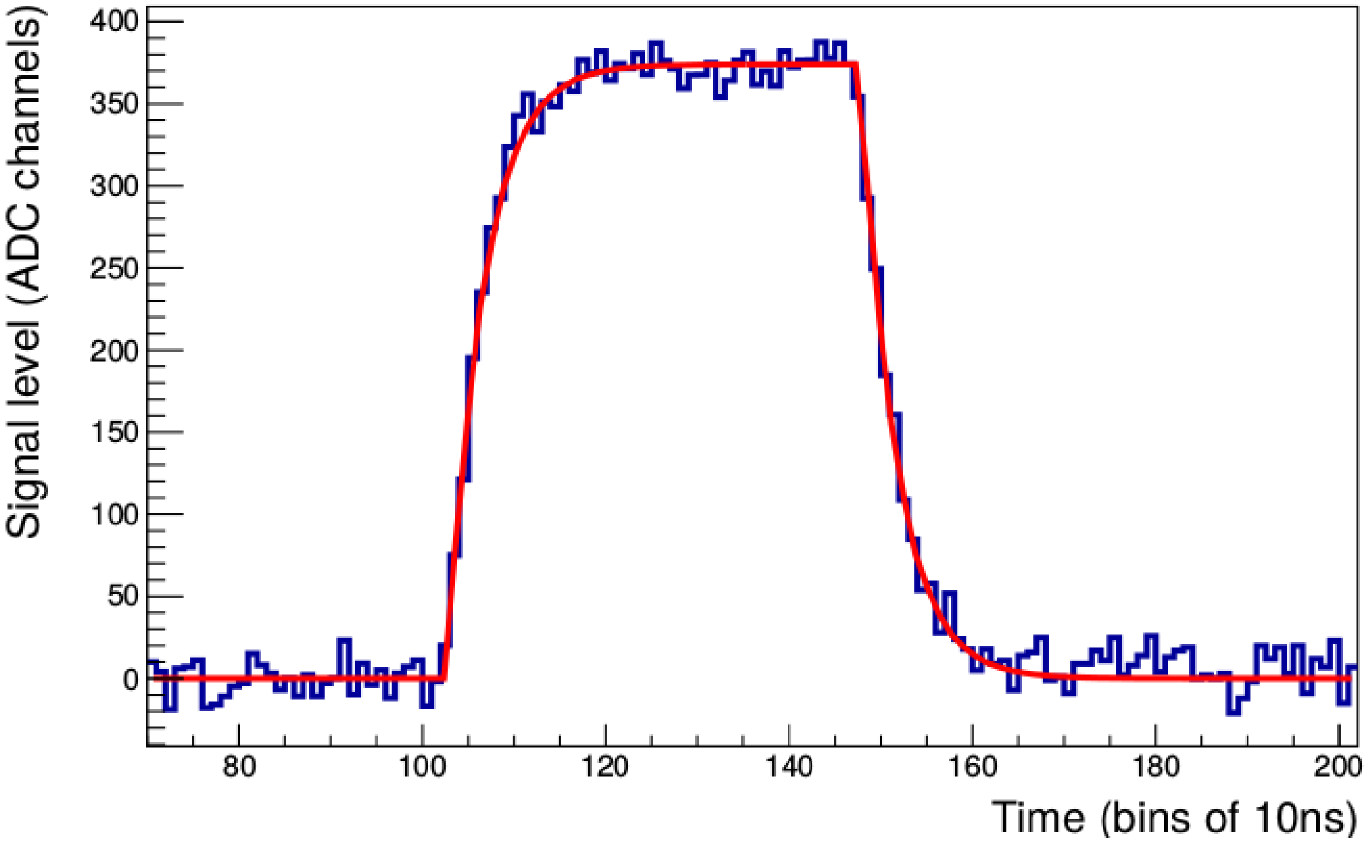
synchronous

- Protocol up to subsystem

All components of the SODANET are implemented and tested on Lattice (TRBv3) and Xilinx (Kintex7) platforms

System is ready to be deployed for complete PANDA readout

Pulse-shape Stability for the EMC



Pulse-Shape Stability

It is necessary to know how stable is pulse-shape after preamplifier in order to:

- Know up to which accuracy it is possible to recover pile-up
- Optimise signal shaping (too short shaping might be sensitive to pulse-shape variations)

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Such requirements fulfil only PROTO60 data (forward endcap)

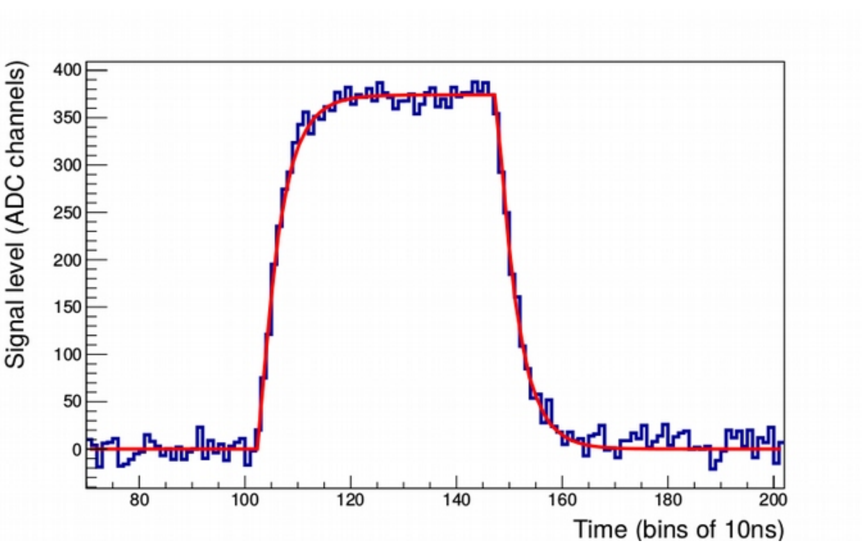
Waveform Measurements

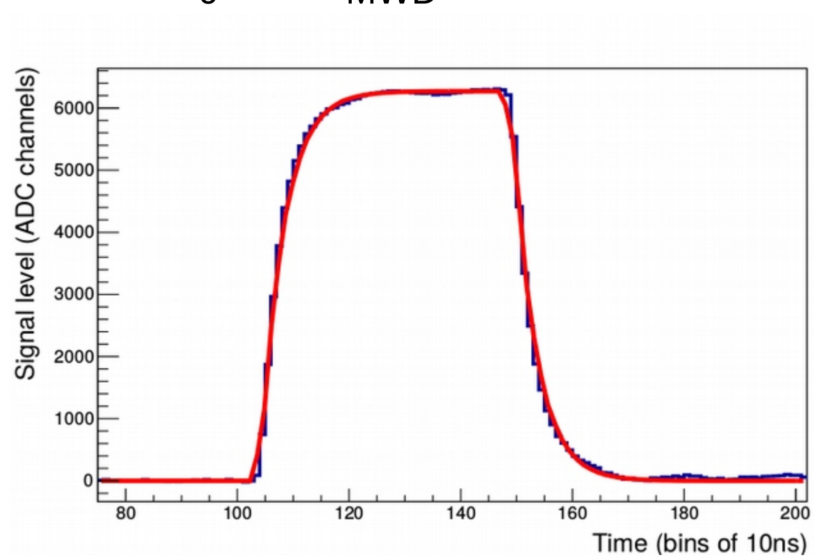
- Measurements were performed at Mainz (1.4 GeV tagged photo beams) with PROTO60 prototype (2009)
- Waveforms were filtered using MWD filter (preserves rising pulse-shape)
- Each pulse of a central crystal (with respect to the EM shower) was fitted by (**R** defines rising time):

  $V = 0;\qquad t < t_0$

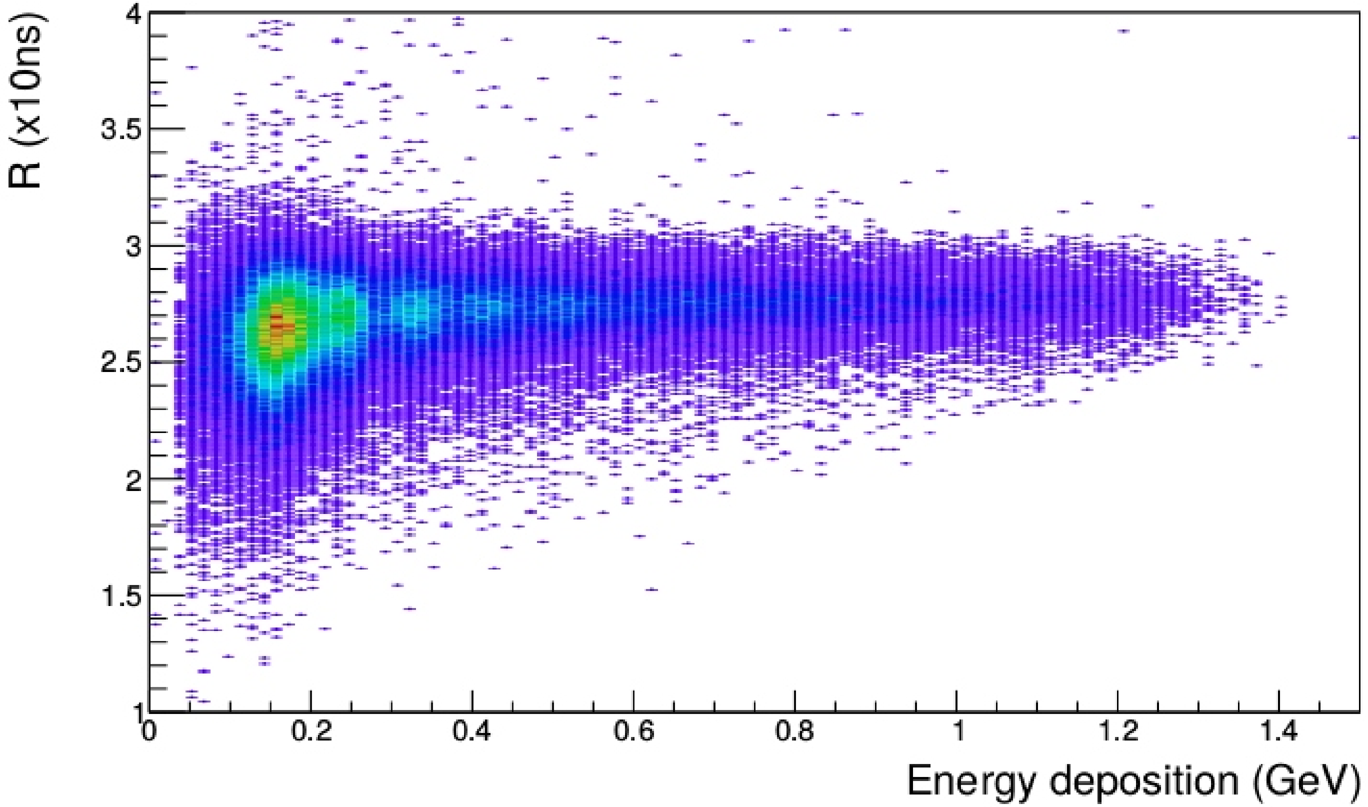
  $V = A\,(1 - \exp[-(t-t_0)\ln(2)/\mathbf{R}]);\qquad t \in [t0, t_0 + M_{MWD}]$

  $V = A\exp[-(t-M_{MWD}-t_0)\ln(2)/\mathbf{R}];\qquad t > t_0 + M_{MWD}$



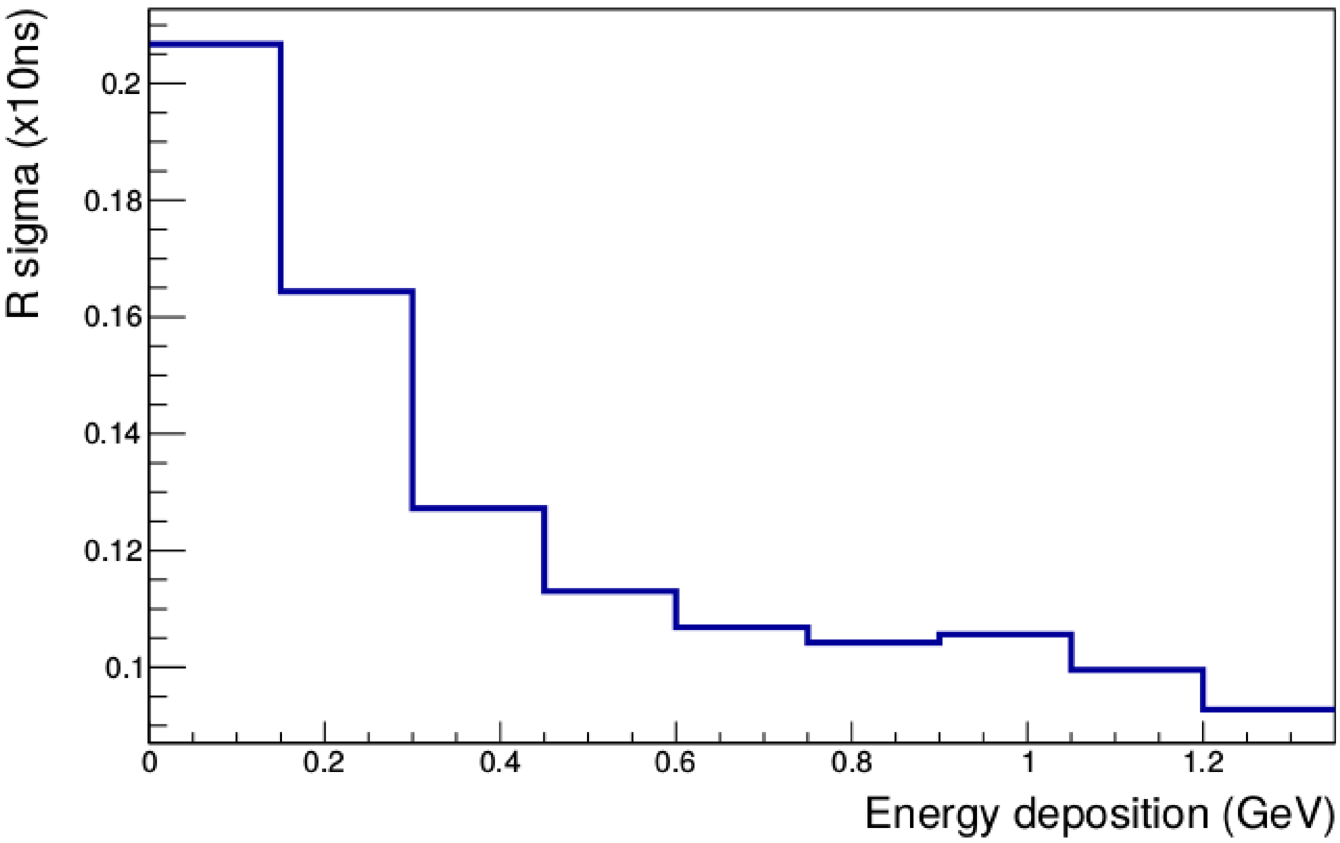


R Dependence on Energy



R Variance

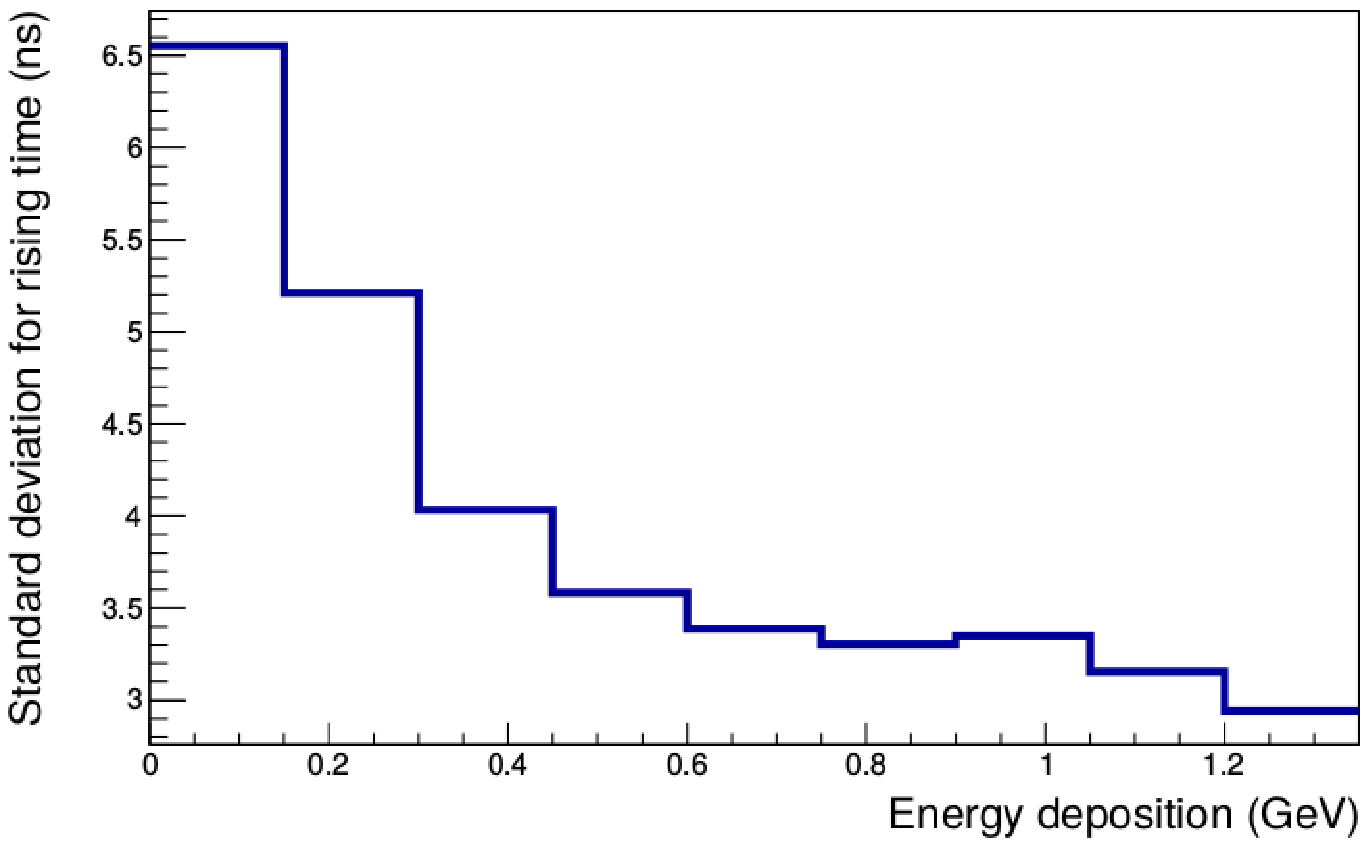
Standard deviation for R as function of energy deposition



Definition of rising time: time within the pulse reaches 90% of its amplitude starting from the 10% level (= 3.17 * **R**)

Rising-time Variance

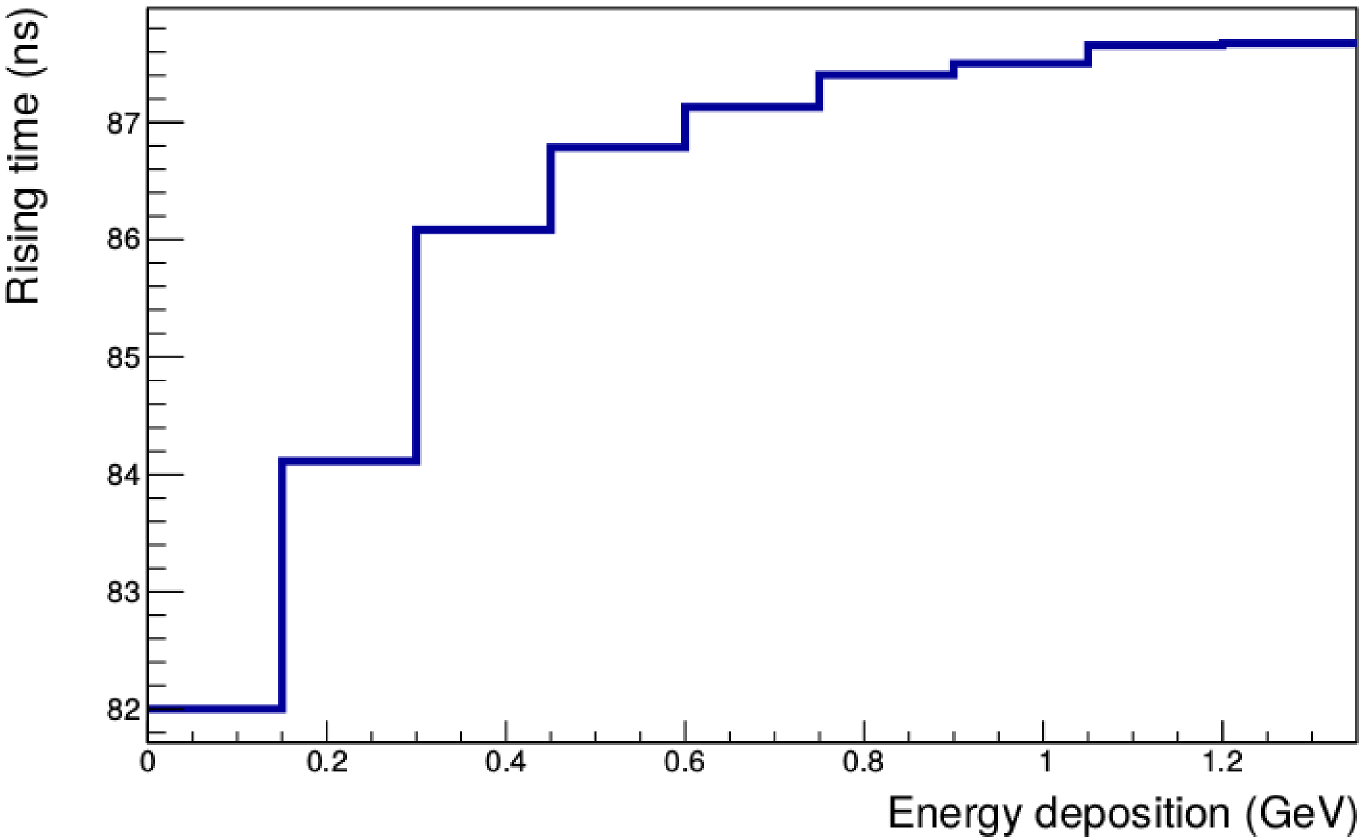
Standard deviation for rising time as function of energy deposition



Above 300 MeV energy deposition pulse shape is not sensitive any more to shower profile / preamplifier noise

Rising-time Mean

Rising time as function of energy deposition



Mean value of the rising time varies within 10% depending on the energy deposition

Summary

- **The EMC readout prototype is ready for system tests: feedback from users is required**
  → Users workshop at KVI-CART in October

- **SODANET is ready for implementation for ALL PANDA subsystems**

- **Pulse-shape stability was studied for the EMC with LNP preamplifier. Effect on the accuracy of pile-up recovery has to be investigated**