FPGA-based Readout for Double-Sided Silicon Strip Detectors

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TWEPP 2010, Aachen, poster session, ID: 96

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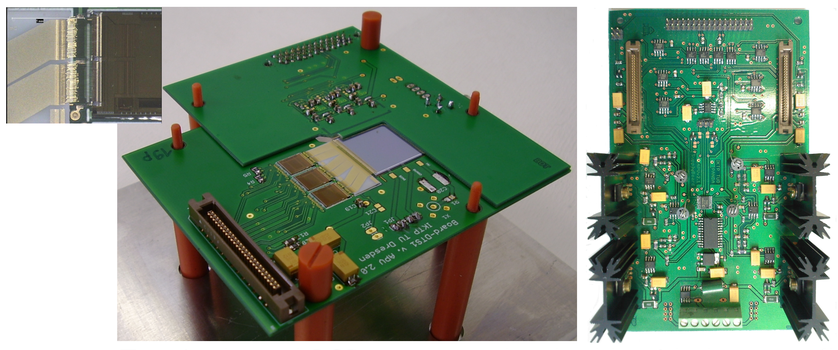
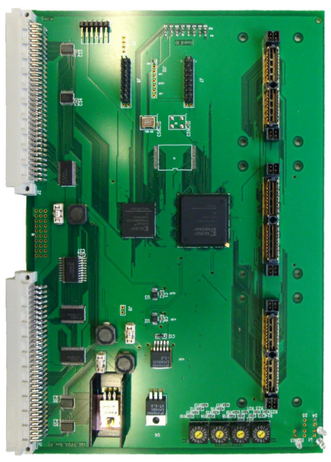
Motivation

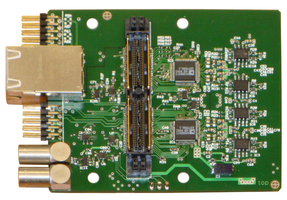
- Initial situation
  - software data processing based upon PCI-ADC card
    → very inefficient, low readout rate
- Objective
  - implement first level readout structures in FPGA
    → obtain effective data reduction, low latency, short deadtime



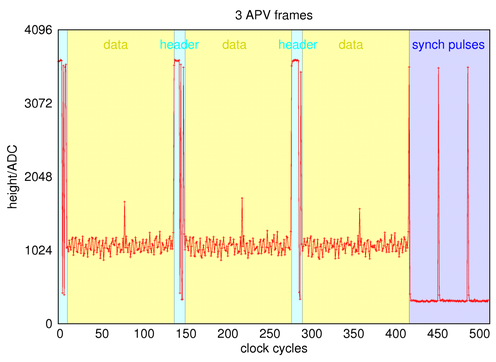
Two L-shaped PCBs support the double-sided sensor (left). Board to supply voltages to the sensor board (right).



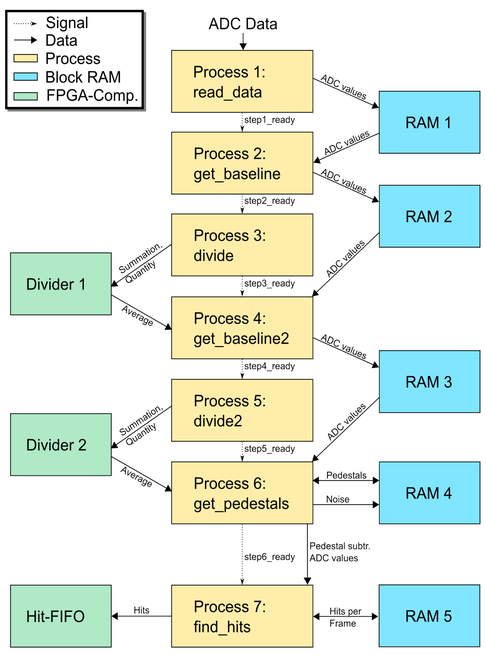
Elektroniklaboratorien Bonn UG (haftungsbeschränkt)



FPGA based VME module with mezzanine expansion slots (left) and sampling ADC mezzanine card (right).



Response to a single trigger of an APV25 in 3-sample-mode.



Scheme of the data processing implemented for every frontend.

Hardware

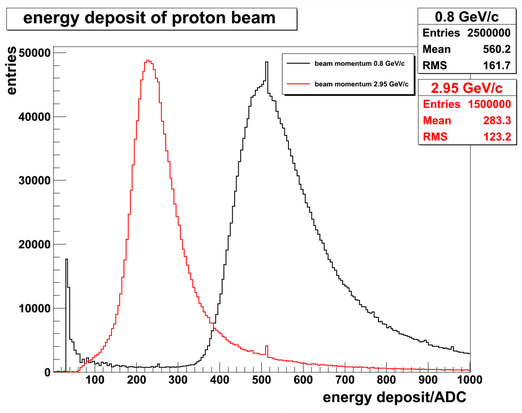
- Test setup
  - support: L-shaped PCB boards on both sensor sides
  - frontend chip: APV25-S1
  - sensor: *TELESCOPE* ITC irst (2x2 cm^2; 50 µm pitch)
  - assembly: RHe Microsystems Radeberg
- DAQ hardware
  - FPGA based VME module (Spartan-3, 3x 80pin mezzanine slots)
  - sampling ADC mezzanine card (4 channel, 12 bit, 65 MSPS)

FPGA Processes

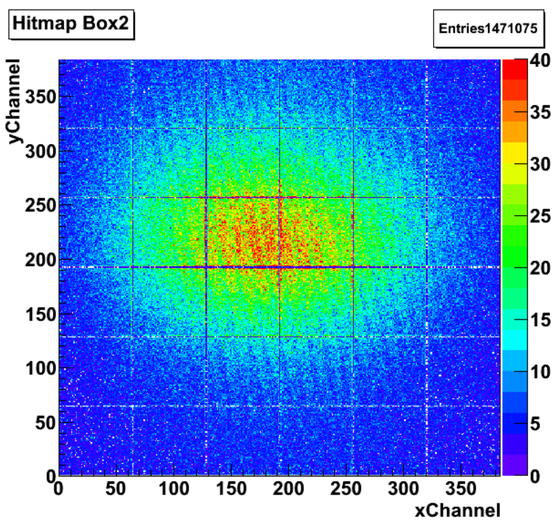
- Pipelined data processing consists of
  - separation of data and header
  - two step baseline determination
  - pedestal calculation
  - hitfinder
  - clusterfinder
- Parameters adjustable via VMEbus
  - frontend I^{2}C-register settings
  - trigger pattern
  - phase shift between frontend clock and sampling clock
  - hitfinder criteria

Results

- demonstrated powerful readout system
  - realtime data processing
  - significant low latency data reduction by a factor of 1:100
  - readout rates up to 30 kHz achievable
  - no deadtime caused by readout → limited by APV25-S1
  - reliability validated in various measurements



Energy loss for different beam momenta - data from FPGA cluster finder (top).
Hit pattern on sensor caused by a converted photon beam (right).



Applications

Test stand for evaluation in Bonn (top); tracking station at COSY, FZ Jülich (left).

- measurements with a tracking station
  - COSY, FZ Jülich - proton beam up to 3 GeV/c
  - DESY, Hamburg - electron beam up to 5 GeV
  - ELSA, Bonn - electron and photon beams up to 3 GeV
- stand-alone test stations
  - prototyping
  - detector tests
- adaptation to various detector types, e.g. GEM

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