N28-339

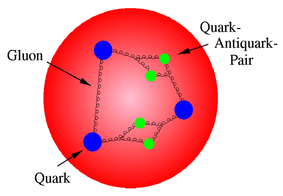
VHDL Implementation of Feature-Extraction Algorithm for the PANDA Electromagnetic Calorimeter

E. Guliyev, M. Kavatsyuk, P. J. J. Lemmens, H. Löhner, T. Poelmann, G. Tambave

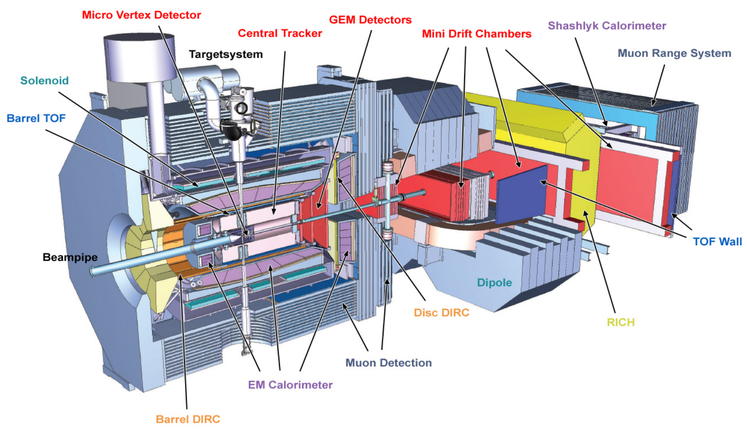
Kernfysisch Versneller Instituut, University of Groningen, The Netherlands
for the PANDA Collaboration

PANDA, the detector for antiProton ANnihilation at DArmstadt at the Facility for Antiproton and Ion Research (FAIR) in Germany, will allow to perform crucial tests of QCD, the theory of strong interactions, in the regime of strong coupling:

precision studies of charm-quark mesons, discovery of glue-balls and hybrid-mesons.



strong coupling in the proton



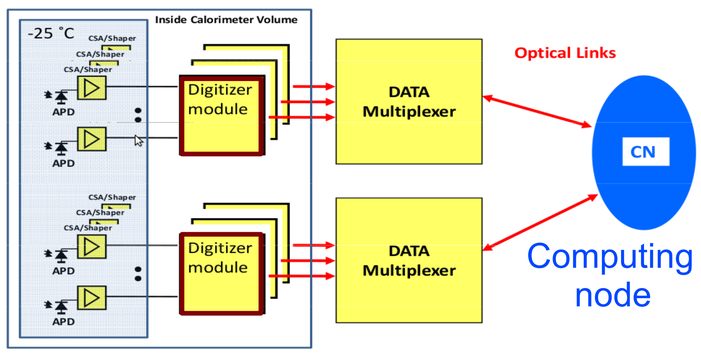
PANDA spectrometer in 2T solenoid magnet:
vertex detection, tracking, particle identification, calorimetry.

Spectroscopy of charm-quark mesons (e.g. charmonium) requires a high resolution ElectroMagnetic Calorimeter (EMC). The EMC detector uses PWO crystals with a light yield of 500 photons / MeV, which is about a factor two better than employed in CMS. Newly developed rectangular 7x14 mm^2 HAMAMATSU APDs will be employed as light sensors.

Trigger-less Data Acquisition

Advantages:

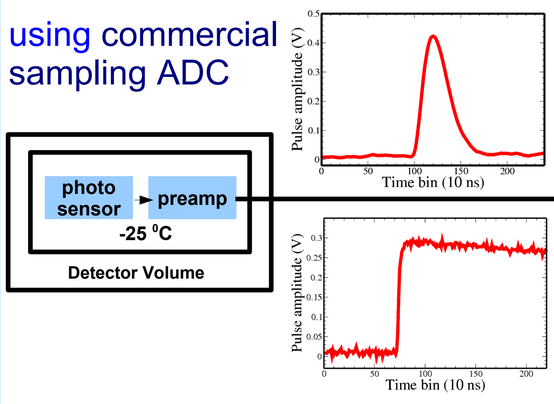
- Flexible event selection
- no analogue delays
- no dead time
- FPGAs on Digitizer module allow feature extraction algorithms for online data analysis



Sampling Analogue to Digital Converters (SADC) are employed for digitization

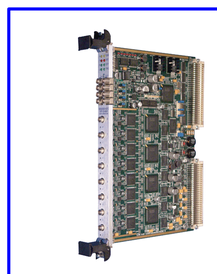
Test Experiment Readout Scheme

using commercial sampling ADC



ASIC preamplifier,
two-channel,
250 ns shaping time.

LNP discrete component preamplifier, single-channel, no shaping.



Sampling ADC
16 bit resolution and
100 MHz sampling rate
SIS3302 STRUCK

Feature-Extraction Algorithm

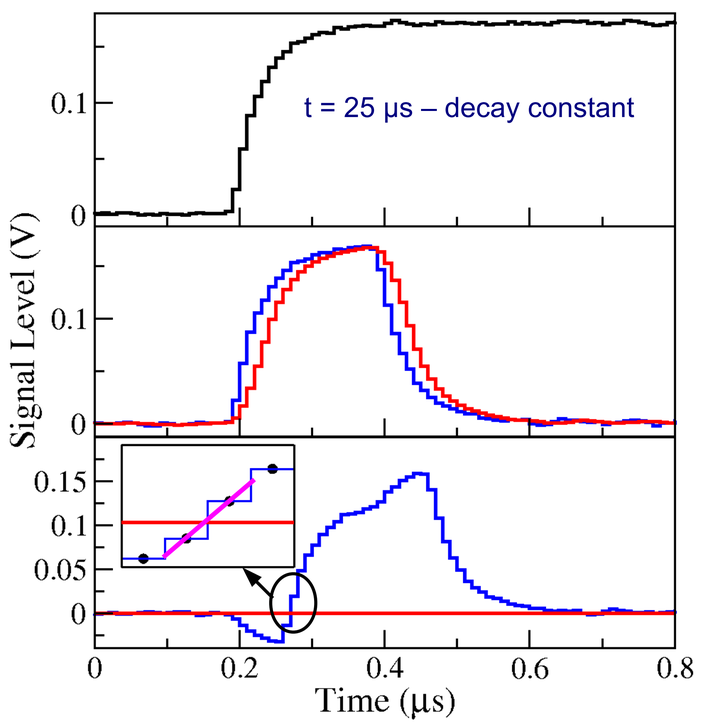
Raw Trace (LNP preamplifier)

Moving Window Deconvolution (MWD) filtering:

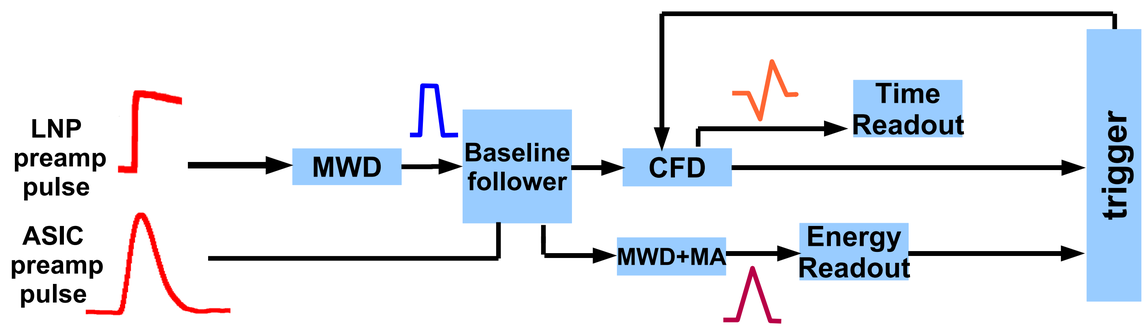
$$MWD_M(n) = x_n - x_{n-M} + \frac{\ln 2}{\tau} \sum_{i=n-M}^{n-1} x_i$$

Moving Averaging (MA) for noise reduction: (smoothed MWD signal)

Constant Fraction Discrimination (CFD) for precise time information:
time stamp:
zero-crossing
by linear interpolation



Block Diagram for Signal Processing



MWD function produces a trapezoidal shaped signal
MA function suppresses noise by smoothing
Baseline Follower restores stable baseline to ensure precise energy determination
CFD provides the time-stamp information

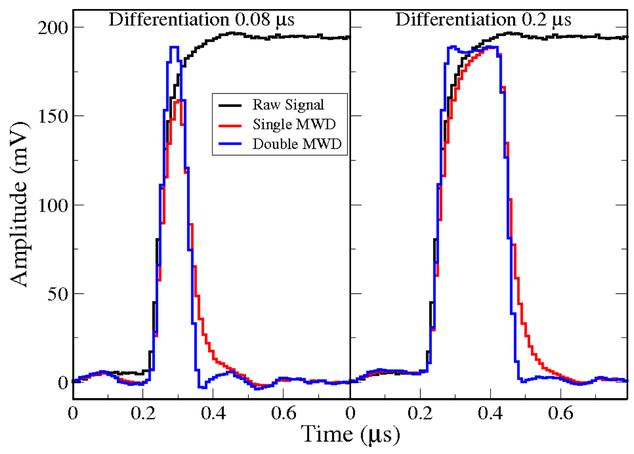
Double Moving-Window Deconvolution

Lowest signal detection threshold requires MWD differentiation constant ≥ 200 ns

→ risk of pulse pile-up at high hit rates (~ 250 kHz)

Double MWD filtering allows to operate with smaller differentiation

→ reduces pulse width (~ 400 kHz)
→ restores original amplitude

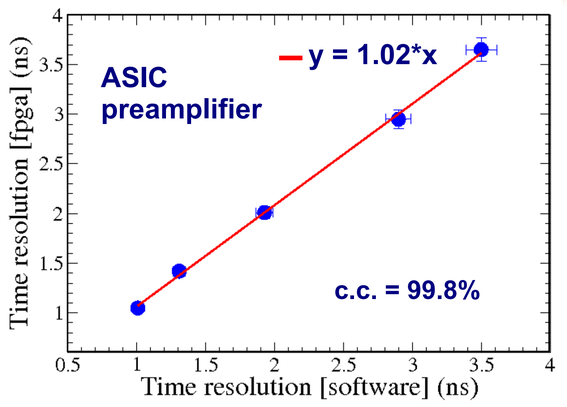


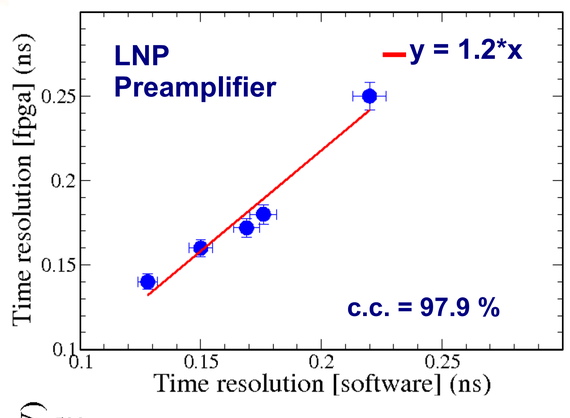
Test of VHDL Implementation

Measured Data

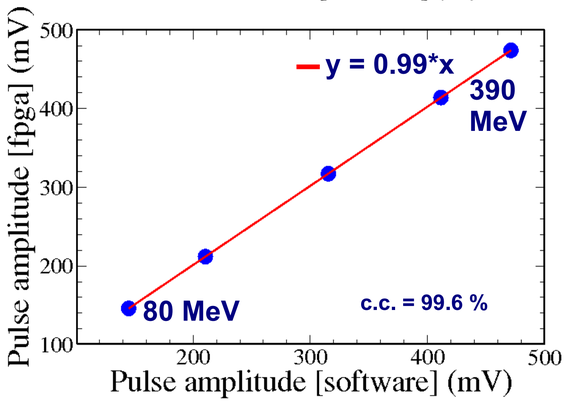
Time, Energy

XILINX Spartan development board





FPGA processing compared to the software analysis results: linear correlation observed with correlation coefficients
c.c. ~ 98 – 99.8%



CONCLUSIONS

- Feature-extraction algorithm was developed using test-beam data
- VHDL code was implemented in FPGA
- VHDL code was tested successfully with shaped and un-shaped preamplifier signals
- Feature-extraction algorithm implemented in STRUCK SIS3302 SADC
- PANDA is ready for test of trigger-less data acquisition