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On-line feature extraction for the PANDA Electromagnetic Calorimeter

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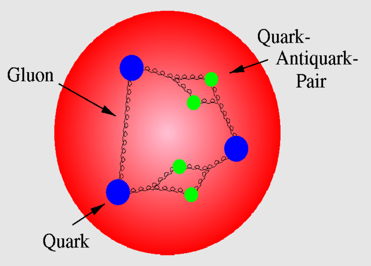
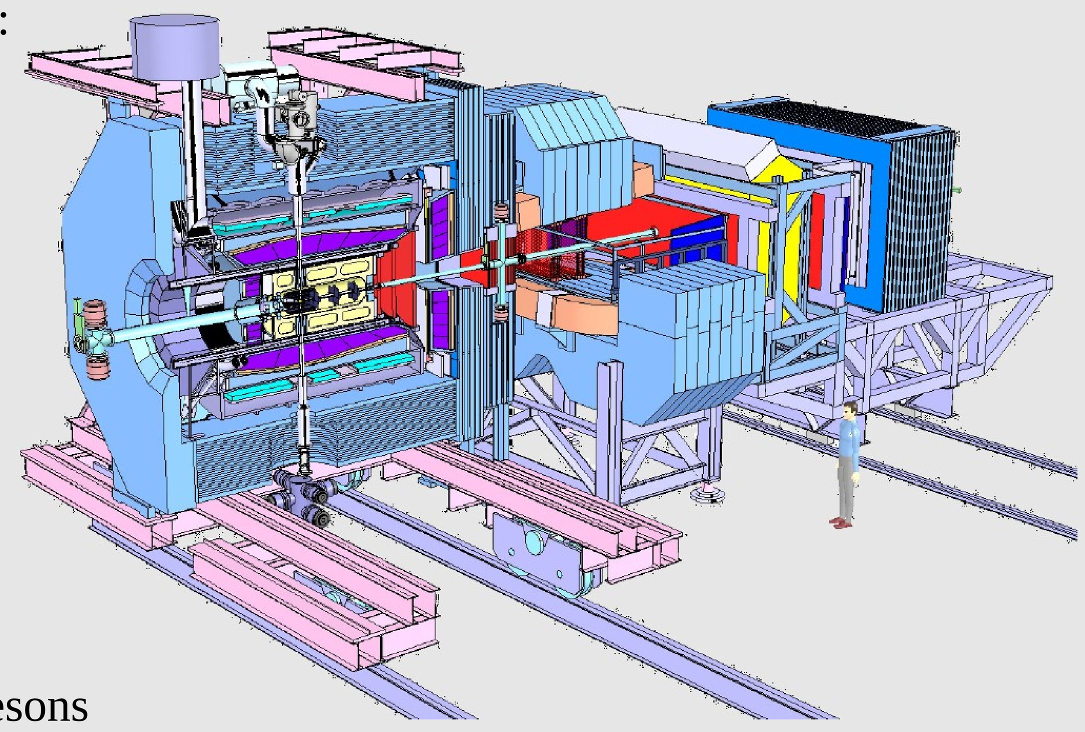
Introduction

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

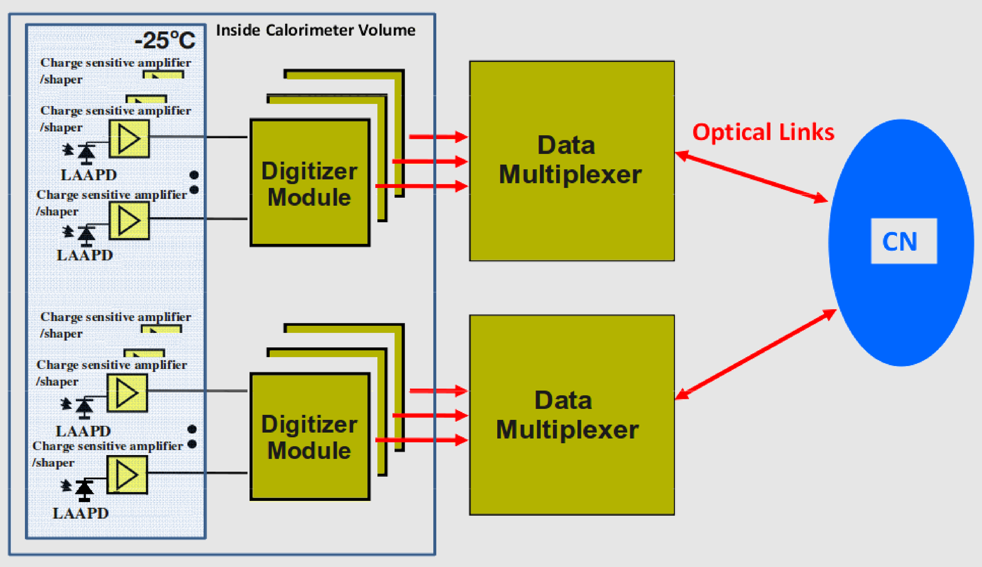


Spectroscopy of charm-quark mesons (e.g. charmonium) requires a high resolution ElectroMagnetic Calorimeter (EMC). The EMC detector uses $PbWO_4$ crystals with a light yield of 500 photons / MeV, which is about a factor two better than employed in CMS. Newly developed rectangular 7x14 mm^2 HAMAMATSU LAAPDs will be employed as light sensors.

Trigger-less Data Acquisition

Advantages:

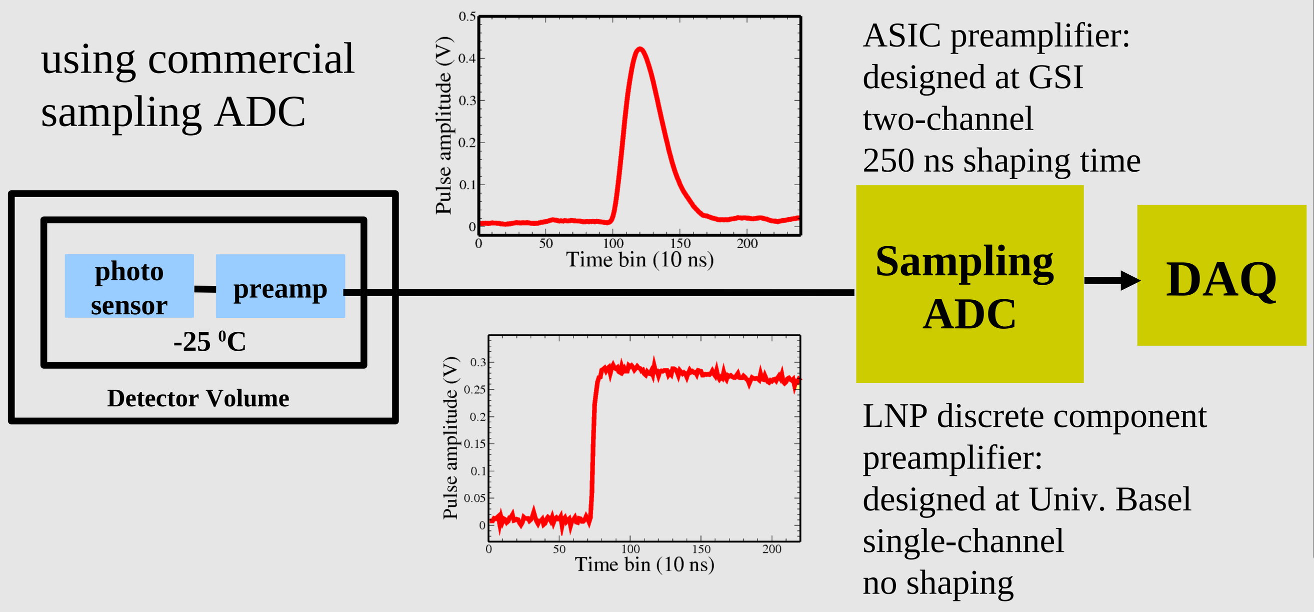
- Flexible event selection
- no analogue delays
- no dead time
- FPGAs on Digitizer module allow feature extraction algorithms for on-line data analysis



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

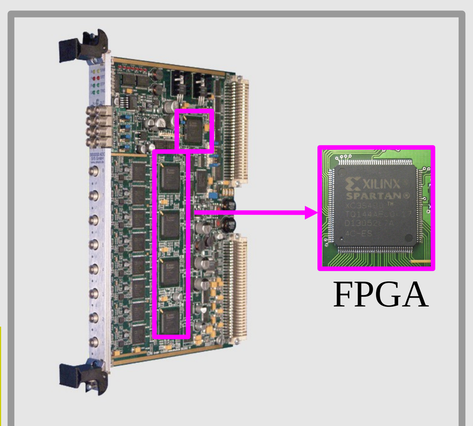
Test Experiment Readout Scheme

using commercial sampling ADC



ASIC preamplifier:
designed at GSI
two-channel
250 ns shaping time

LNP discrete component preamplifier:
designed at Univ. Basel
single-channel
no shaping



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

Feature Extraction Algorithm

Raw Trace (LNP preamplifier)
τ = 25 μs – decay constant

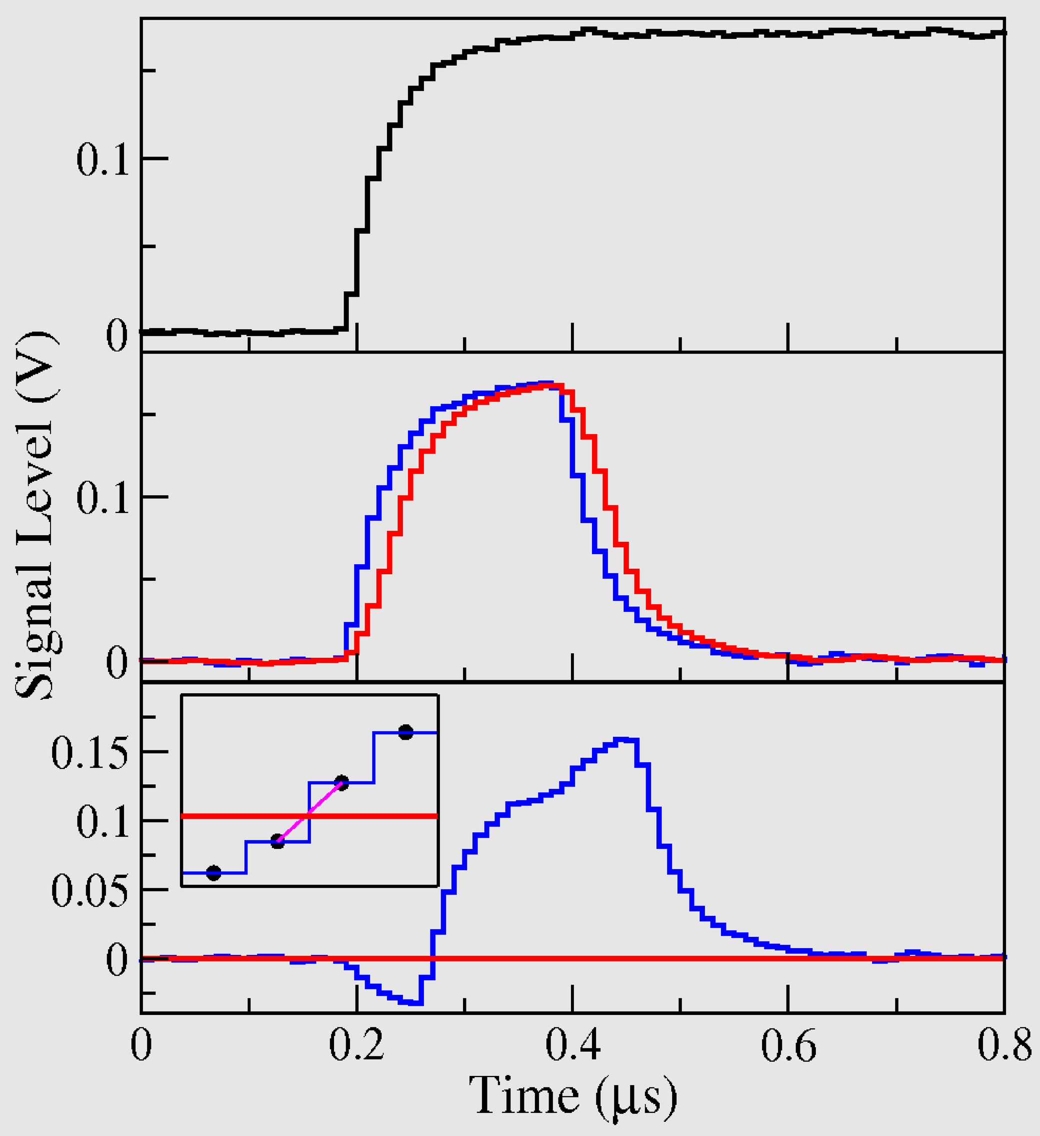
Moving Window Deconvolution (MWD) filtering:

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

n - number of samples
M – differentiation time

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

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



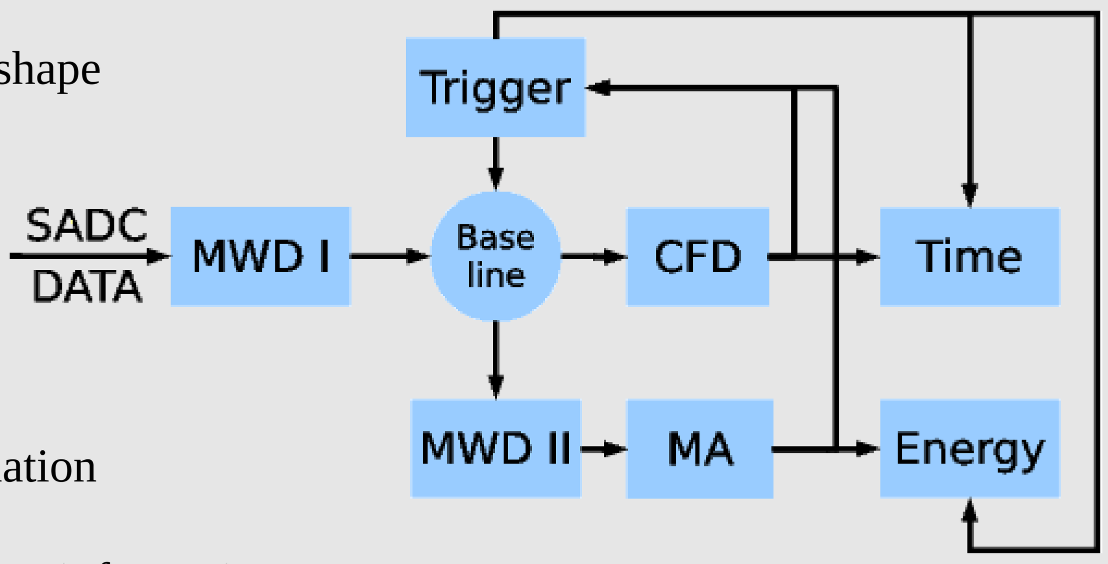
Block Diagram for Signal Processing

MWD I function produces a signal of trapezoidal shape

MA function suppresses noise by smoothing

Baseline Follower restores stable baseline to ensure precise energy determination

CFD provides the time-stamp information



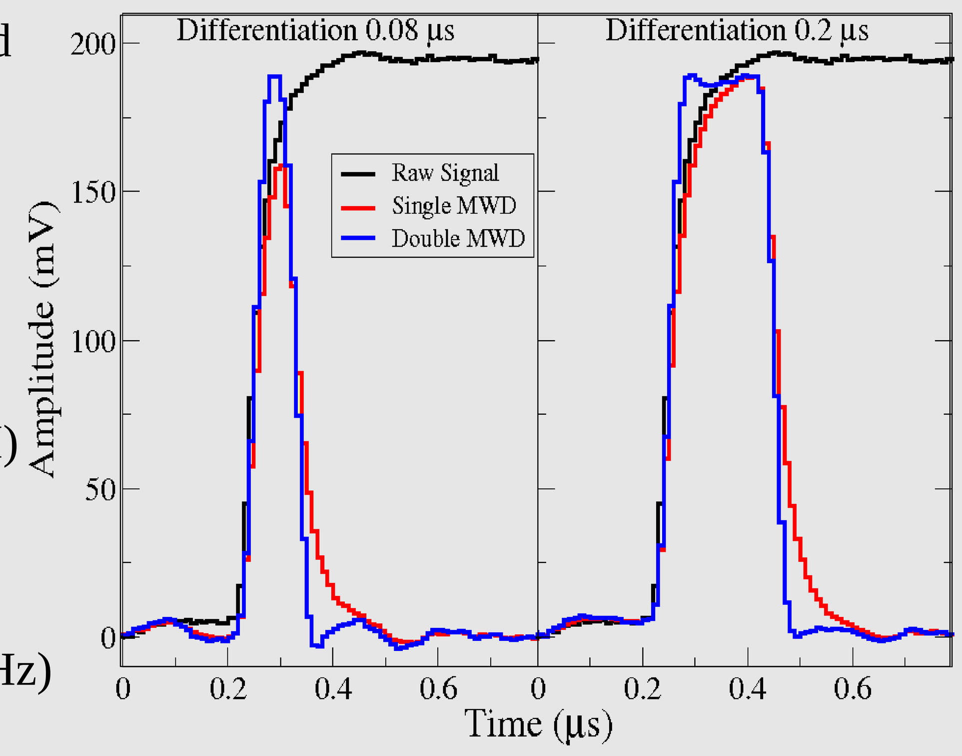
Double Moving Window Deconvolution

Lowest signal detection threshold requires MWD differentiation constant ≥ 200 ns

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

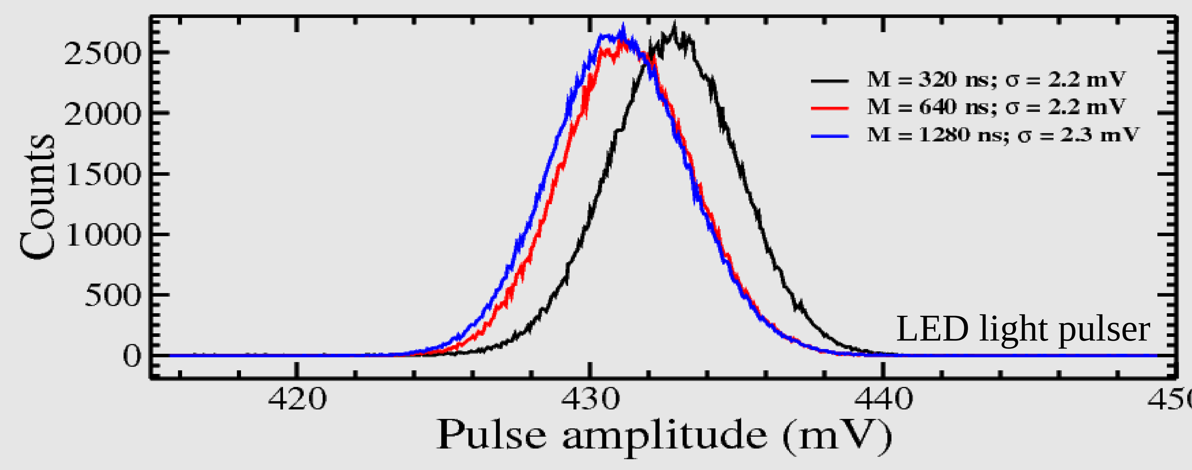
Double MWD filtering (MWD II) allows to operate with smaller differentiation

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

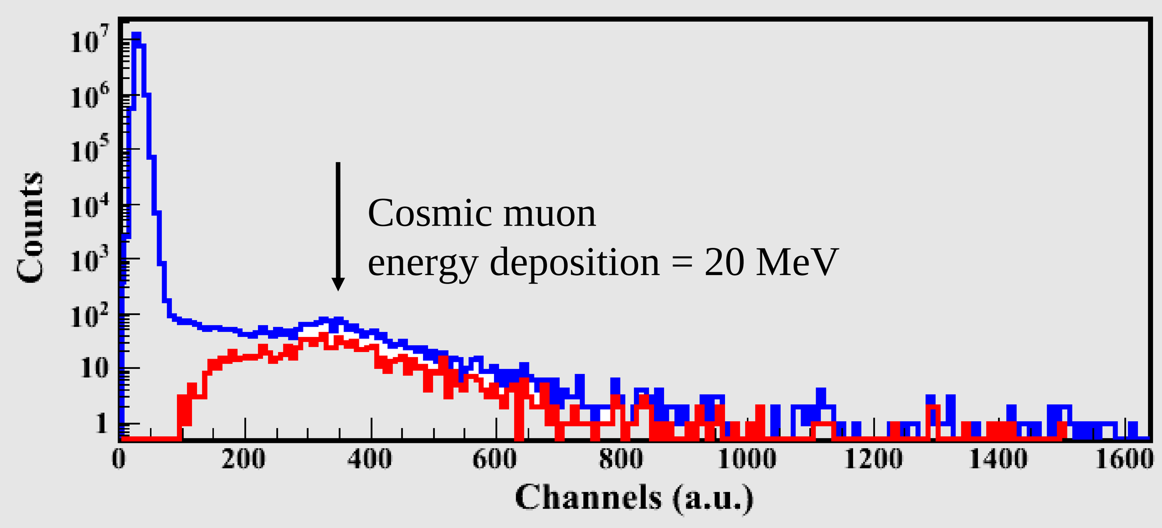


On-line data analysis

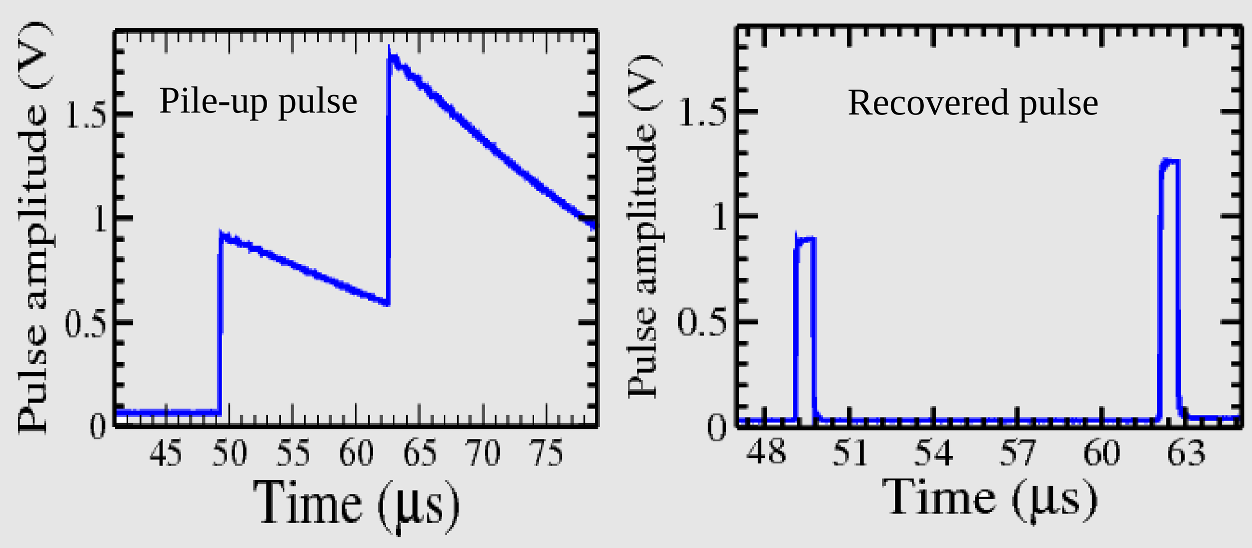
On-line pulse amplitude detection:
Optimization of differentiation
M = 320 ns value



Measurement with cosmic muons:
Raw and coincidence energy deposition spectrum
M = 320 ns
For better signal-to-noise ratio



Effect of MWD:
Separation of pulses is limited by the width of M value
Minimum separation time = 80 ns



Conclusion

1. *Feature extraction algorithm is developed for signal analysis for the PANDA EMC.*
2. *The algorithm is implemented in VHDL for XILINX FPGA.*
3. *The implementation is applied on a commercial Sampling ADC.*