FPGA-Based Upgrade of the Read-Out Electronics for the Low Energy Polarimeter at the Cooler Synchrotron

March 19, 2015 | Nils Hempelmann for JEDI collaboration |
Motivation

Low Energy Polarimeter

GANDALF

Test Measurements

Summary & Outlook
EDM and Fundamental Symmetries

- Nonzero electric dipole moment (EDM) in elementary particle violates CP-Symmetry
- Standard-Model prediction: $10^{-32}$ to $10^{-31} \text{ e cm}$
- New Physics?

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Measurement of Charged Hadron EDM at Storage Rings

- Various Methods
  - E-Field (Pictured)
  - B-Field
  - Combination
- Measure left-right-asymmetries in cross section
- Precursor experiment at COSY, Forschungszentrum Jülich
Low Energy Polarimeter

- 8 Flanges to attach detectors
- 75 MeV kinetic energy for deuterons, 45 MeV for protons
Detectors

- Three detectors each for particles scattered left, right, up and down
- Plastic scintillators + PMTs spaced 10° apart
- Changeable collimators
Event Selection

- **Pulse height spectrum**
  - proton peak on the left hand side
  - carbon peaks on the right hand side

- **Time spectrum**
  - Background at frequency of cyclotron output (38.5 ns)
  - Time resolution $\sim 2.5$ ns
GANDALF

- 8 analog input channels for ADC in interleaved mode (1 GSample/s), need two modules
- FPGA for readout
- time resolution $\mathcal{O}(50 \text{ ps})$
- USB connection: $\sim 20 \text{ MB/s}$
Constant Fraction Discriminator

- Invert and delay signal
- Find zero-crossing of sum by linear interpolation
- Return pulse height and time
Firmware

- Original firmware for COMPASS experiment, has to be adapted
- Implement self-triggered operation
- Implement direct output to USB: Done
- Implement amplitude discrimination and counter: more testing needed
- Implement time discrimination: simulated
Amplitude Measurement

- Rise time 3.7 ns, total duration 12 ns
- Amplitude varied between 0.13 and 2 V
Amplitude Measurement

- Example at amplitude 1.8 V
- Amplitude RMS $\sim 5\%$
500 mV double pulse, same shape as before
Vary time difference
Timing Measurement

- Example at $\Delta t = 20 \text{ ns}$
- Timing RMS $\sim 150 \text{ ps}$, possibly instability of pulser
Summary & Outlook

- Modification of firmware in progress
  - Self triggered measurement implemented
  - Counting on FPGA implemented
  - Still need time discrimination
  - Better user interface

- Integrate polarization state of particle source into measurement

- Final aim: tensor analyzing power measurement for deuteron scattering at 75 MeV, remeasure vector analyzing power
Current Read-Out

- Measure event rate, pulse height spectrum, coincidence
- Used to determine vector and tensor polarizations of beam
Energy Spectrum

- Proton scattering peak on the left
- Carbon peaks on the right
Time Spectrum

- Background at frequency of cyclotron output (38.5 ns)
- Time resolution $\sim 2.5$ ns