FPGA-Based Upgrade of the Read-Out Electronics for the Low Energy Polarimeter at COSY/Jülich
Motivation

- Nonzero electric dipole moment (EDM) violates CP-symmetry
- EDM of charged hadrons could be measured at storage rings
- Small signal, susceptible to systematic errors
- Low Energy Polarimeter at COSY measures polarization before accelerator ring
Cooler Synchrotron

- Polarimeter located in injection beam line
- Deuterons at 75 MeV, protons at 45 MeV
Low Energy Polarimeter

- Selectable central target: Carbon, CH$_2$
- 8 flanges to attach detectors
- Detectors in groups of three
- Plastic scintillators + PMTs
Old Event Selection

- Measure ejectile recoil coincidence
- Smaller peaks from cyclotron frequency

- Pulse height spectrum
- Proton peak, two carbon peaks
- Scintillator resolution $\approx 5\%$

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New Electronics

- GANDALF module, Developed at University of Freiburg
- 8 ADC channels
- FPGA for readout, sampling rate 1 GHz
- USB for readout 20 MB s\(^{-1}\)
- Aim: online polarization measurement, rate \(\approx 1\) MHz
Firmware

I Constant fraction discriminator
   - Measures time and amplitude of each pulse
   - New: Measure time of flight using cyclotron HF-signal as reference

II Counters
   - Count number of events in right amplitude and time range

III Transfer to computer
   - Counts of signal events
   - Full event information for a fraction of events
Constant Fraction Discriminator

- Algorithm uses delay and inversion
- 1 GHz sampling rate
- Time resolution $\approx 50$ ps
- Particle identification over amplitude and time
Measurements in Summer 2015 Beamtime

- Experiments with polarized 75 MeV deuterons
  - Time and amplitude spectra
  - Polarization over time
  - Asymmetry as a function of amplitude and time

- Unpolarized protons
Deuteron Carbon Scattering

- Deuterons scattered off carbon target, $\theta = 40^\circ$
- Broad multimodal distribution in time, changed during measurement
Deuteron CH₂ Scattering

- Recoil and ejectile can be measured in coincidence
- Symmetrical measurements only at a few angles because of fixed detector positions
- Left: Recoil protons measured at 45.9°, deuterons were at 25.9°
Polarization Measurement

- Asymmetry \( \epsilon = \frac{N_L - N_R}{N_L + N_R} \)
- Counts in elastic channel, \(^{12}\text{C}(d,d)^{12}\text{C}, \theta = 40^\circ\)
Bin by Bin Asymmetry

- Asymmetry between positive and negative polarization for each bin
Proton Carbon Scattering

- Protons scattered off CH\textsubscript{2} target, $\theta = 52.5^\circ$
Summary

- New read-out electronics tested successfully
- Implemented time of flight measurement
- Measured polarization, proton and deuteron spectra
Outlook

- Constant polarization measurements in future beam times
- More extensive studies, longer measurements, influence of targets, systematic errors ...
- Aim: Measure deuteron tensor analyzing powers at 75 MeV, remeasure vector analyzing power