

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



Motivation

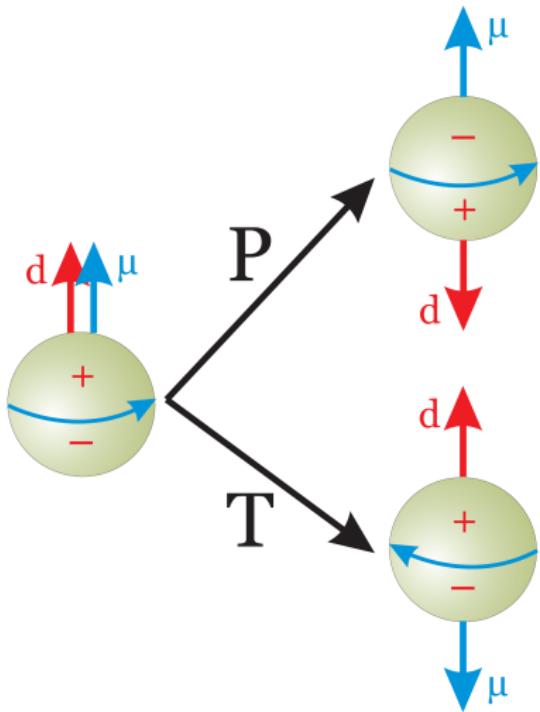
Low Energy Polarimeter

GANDALF

Test Measurements

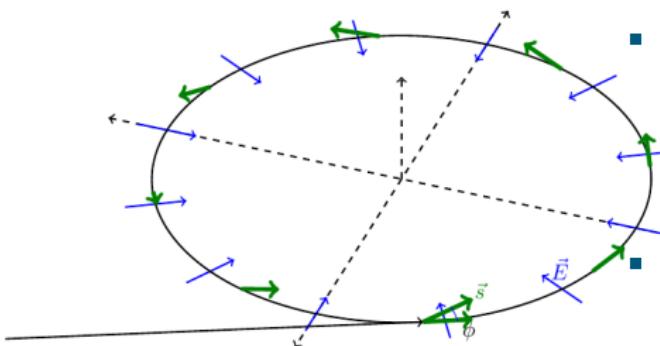
Summary & Outlook

EDM and Fundamental Symmetries



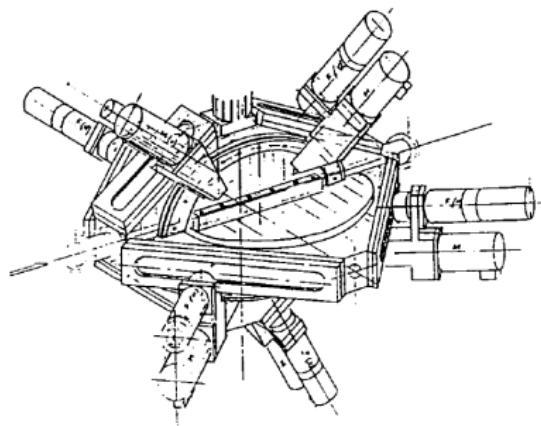
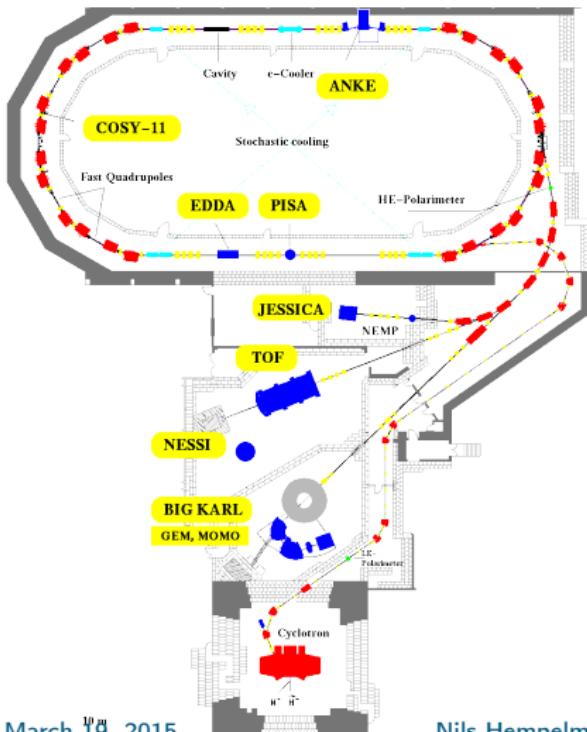
- Nonzero electric dipole moment (EDM) in elementary particle violates CP-Symmetry
- Standard-Model prediction: 10^{-32} to 10^{-31} e cm
- New Physics?

Measurement of Charged Hadron EDM at Storage Rings



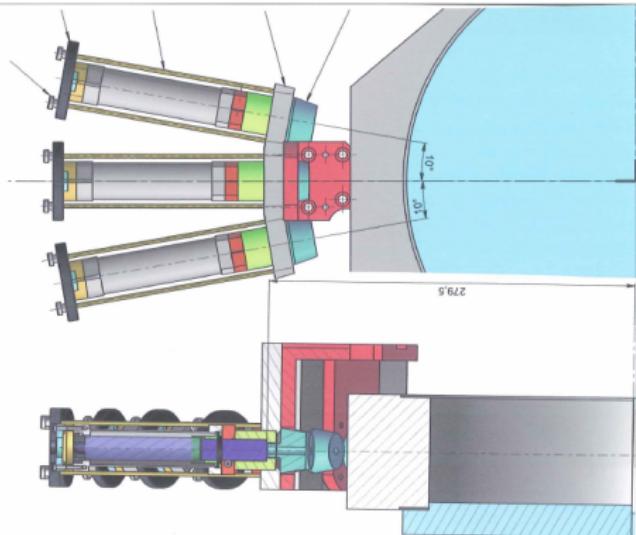
- Various Methods
 - E-Field (Pictured)
 - B-Field
 - Combination
- Measure left-right-asymmetries in cross section
- Precursor experiment at COSY, Forschungszentrum Jülich

Low Energy Polarimeter



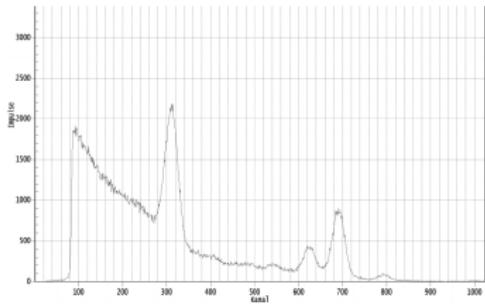
- 8 Flanges to attach detectors
- 75 MeV kinetic energy for deuterons, 45 MeV for protons

Detectors



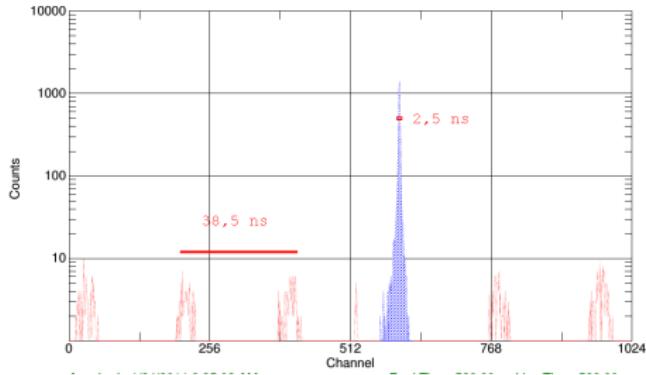
- Three detectors each for particles scattered left, right, up and down
- Plastic scintillators + PMTs spaced 10° apart
- Changeable collimators

Event Selection



- Pulse height spectrum

- proton peak on the left hand side
- carbon peaks on the right hand side



- Time spectrum

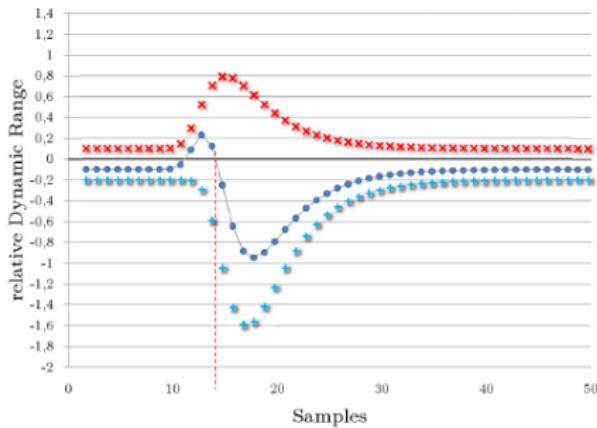
- Background at frequency of cyclotron output (38.5 ns)
- Time resolution ~ 2.5 ns

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

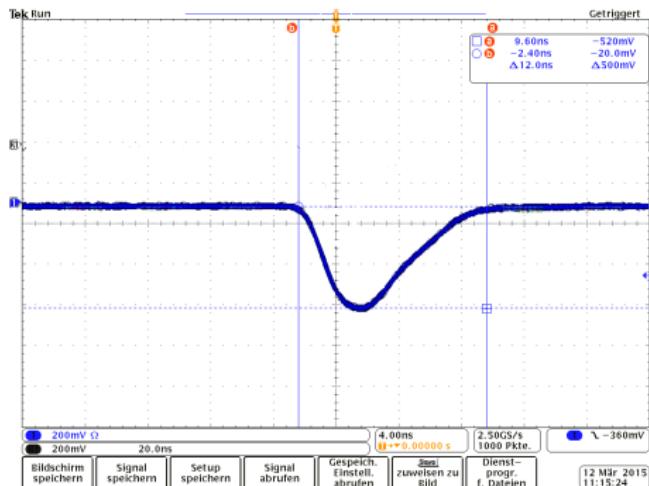


- Invert and delay signal
- Find zero-crossing of sum by linear interpolation
- Return pulse height and time

Firmware

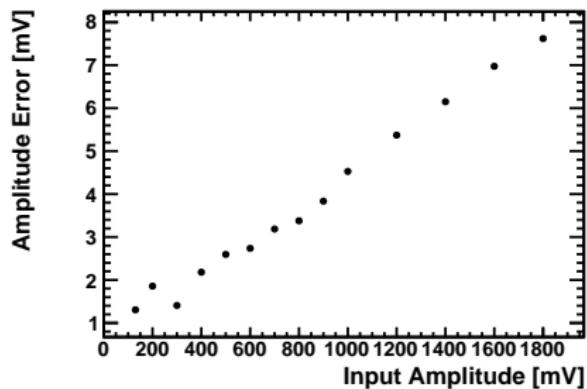
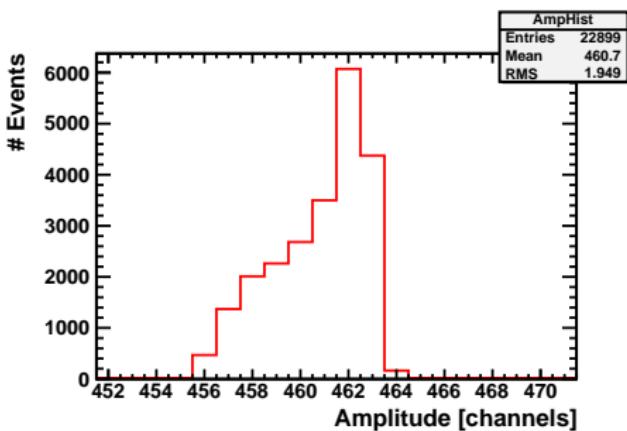
- Original firmware for COMPASS experiment, has to be adapted
- Implement self-triggered operation
- Implement direct output to USB: Done
- Implement amplitude discrimination and counter: more testing needed
- Implement time discrimination: simulated

Amplitude Measurement



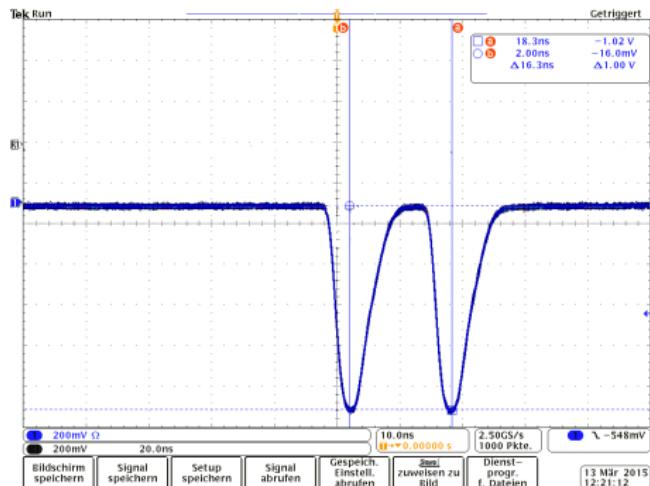
- Rise time 3.7 ns, total duration 12 ns
- Amplitude varied between 0.13 and 2 V

Amplitude Measurement



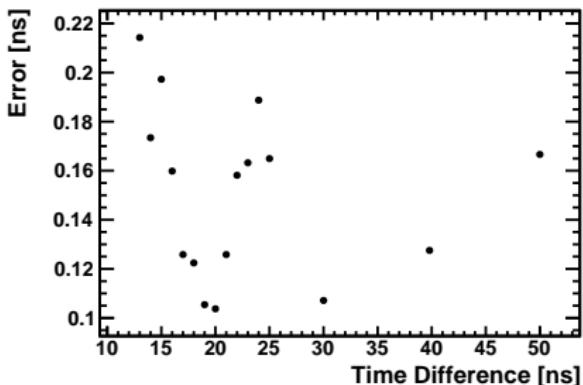
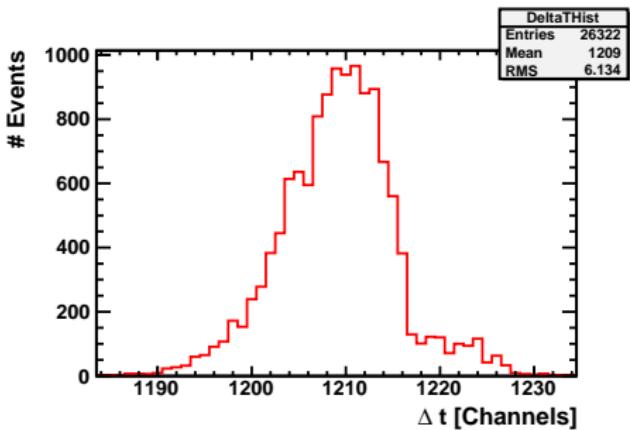
- Example at amplitude 1.8 V
- Amplitude RMS $\sim 5\%$

Timing & Pile-Up Separation Measurement



- 500 mV double pulse, same shape as before
- Vary time difference

Timing Measurement

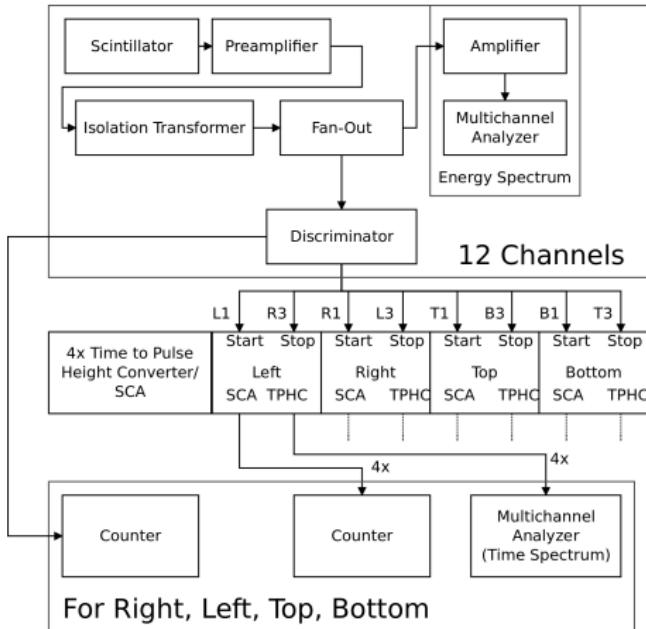


- Example at $\Delta t = 20$ ns
- Timing RMS ~ 150 ps, possibly instability of pulser

Summary & Outlook

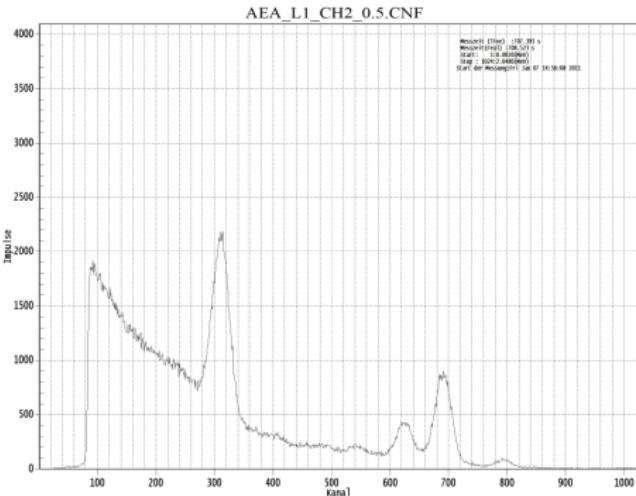
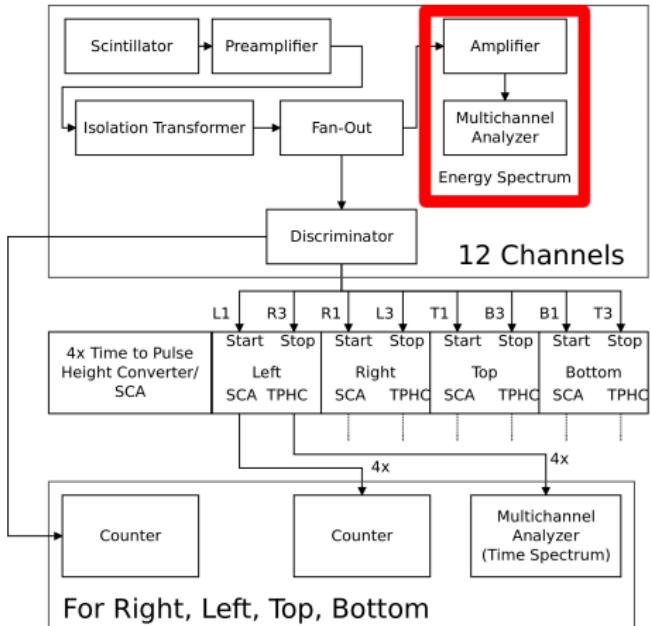
- Modification of firmware in progress
 - Self triggered measurement implemented
 - Counting on FPGA implemented
 - Still need time discrimination
 - Better user interface
- Integrate polarization state of particle source into measurement
- Final aim: tensor analyzing power measurement for deuteron scattering at 75 MeV, remeasure vector analyzing power

Current Read-Out



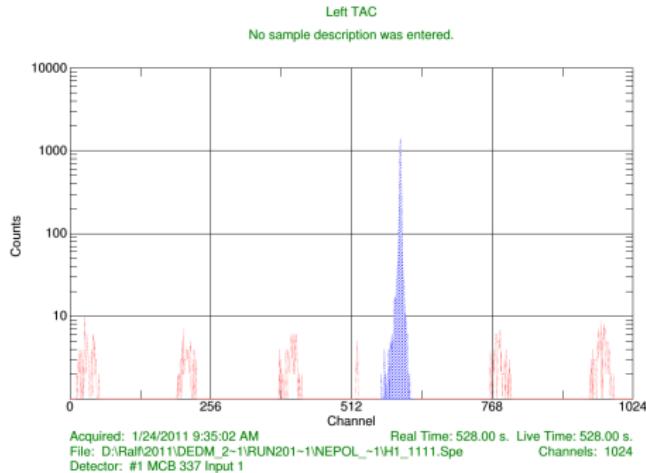
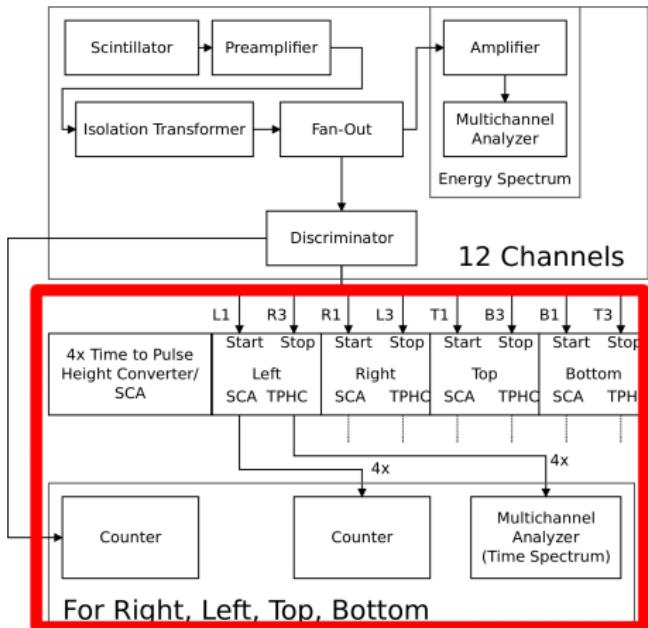
- Measure event rate, pulse height spectrum, coincidence
- Used to determine vector and tensor polarizations of beam

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 ~ 2.5 ns