Photodetector Studies for an ILC Polarimeter
Christian Helebrant
DESY, Hamburg

ILC Polarimeters
- energy of Compton-scattered beam electrons depends on relative polarisation of electron and photon
- transfer to spatial distribution by magnetic chicane
- detection in multi-channel Cherenkov detector
- determine polarisation by measuring asymmetry in spectrum (switching laser polarisation between $+1$ and $-1$)
- aim: $\Delta P/P \approx 0.25\%$
- limiting factor: systematics, esp. linearity of photodetectors (PD)

Multi-Channel Cherenkov Detector

Cherenkov Detector Layout
- conventional
  - PMT or Multi-Anode PD: well-established technology, but several downsides like susceptibility to magnetic fields, high bias voltage, etc
  - gas tubes ($C_2F_{10}$, $1 \text{ cm}^2$): high Cherenkov threshold (10 MeV)
- novel
  - Silicon based PM (SiPM): robust, tiny (better spatial resolution, more precise polarisation measurement), low price; but little field experience
  - quartz fibers: low Cherenkov threshold (background radiation!)

Test Bench for PD Studies
- light tight box (with light fibers, optical filters, mountings for different PD types, ...)
- blue LED (470 nm) with function generator
- VME-DAQ (incl. double range 12-bit QDC, 200 and 25 fC LSB)
- PDs: conventional PMT, 2x2-MAPM, several SiPMs (400 - 3600 pixels)
- aim: control PD linearity to an order of 0.1%

Linearity of QDC - INL
- FSR sine wave input (10 Hz)
- short random gate (50 ns)
- 25 million samples
- code probability density $P(i) = N / \pi \cdot \sqrt{(A/2)^2 - (i - (A/2))^2}$
  - input: $A \sin(x) / \sqrt{A^2 / 2}$, $A=$FSR, $N=25$ million
  - ratio of measured and ideal distribution is equal to code bin width
  - differential non-linearity: deviation from ideal bin width (1 LSB)
  - summing up yields integral non-linearity

Optical Filters LED light attenuated by calibrated optical fibers; 3 filters → 8 series of measurements
Pulse Length varying length of rectangular LED pulse ensures linear variation of light on photo cathode; 5 ns steps between 30 ns and 100 ns
- measurements done with 2x2-MAPM
- 1 million single measurements
- Poisson fit of QDC spectrum → number of photoelectrons

Linearity of PD - INL
- optical filters
  - errors too large
  - dominated by systematics (insufficient knowledge of transmittance)
  - need to recalibrate filters first!
- Pulse Length
  - errors small, not limited by systematics
  - permille level non-linearity of PD can be seen

Test Bench for PD Studies

Results
- errors too large
- dominated by systematics (insufficient knowledge of transmittance)
- need to recalibrate filters first!

Analysis of SiPM spectra
- fit single photoelectron peaks
- determine area for each peak
- Landau fit of resulting histogram to determine MPV for number of photoelectrons
- errors on MPV way too large
- method needs serious refining

Conclusion and Outlook
- excellent control of PD non-linearity is crucial to high precision polarisation measurements at ILC
- appropriate test bench has been set up
- achieved desired sensitivity with one method
- other methods to be tested/improved
- comparison with other PD types