# Test Stand Measurements for an ILC Polarimeter

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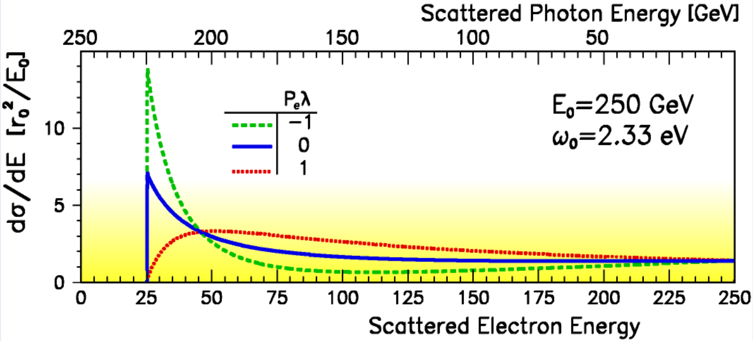
# Measurement Principle

# Determination of the Beam Polarisations

## What do we want to measure? → Asymmetry




Precise measurement of the Compton cross sections for different config. of the laser light and $\mathrm{e}^+/\mathrm{e}^-$ spin helicities → Asymmetry

$\Longrightarrow$ Level of beam Polarisations ! $\Longleftarrow$

# Measurement Principle: Compton-Polarimetrie

## Compton scattering of laser photons:

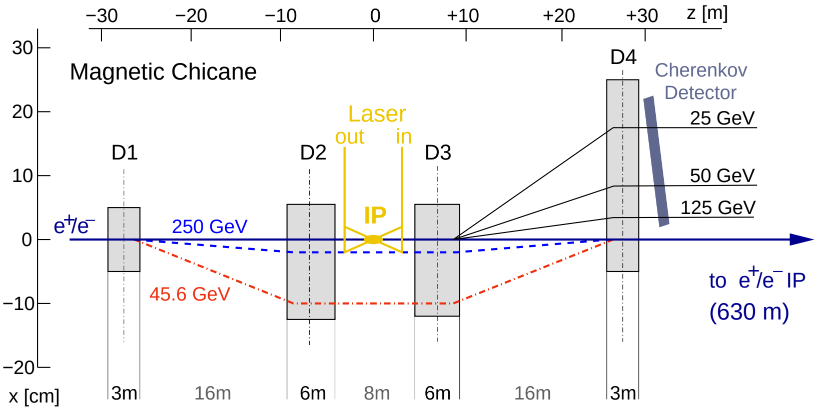
- scatter circularly polarised laser light of $\mathrm{e}^+/\mathrm{e}^-$ bunches
- ca. $10^3$ $\mathrm{e}^+/\mathrm{e}^-$ are scattered per beam crossing
- the scattered $\mathrm{e}^+/\mathrm{e}^-$ are deflected by dipole magnetic fields ("magnetic chicane")

## Measurement of the energy distribution via Cherenkov detectors

- incident $\mathrm{e}^+/\mathrm{e}^-$ generate Cherenkov radiation
- detection of Cherenkov photons via photo detectors
- count photo electrons per channel → linearity is extremely important! (The size and shape of possible non-linearities must be measured precisely & corrected if necessary.)

Required precision: $\delta P/P \leq 2.5$ ‰ (2-times more precise than SLD)

# The Magnet Spectrometer

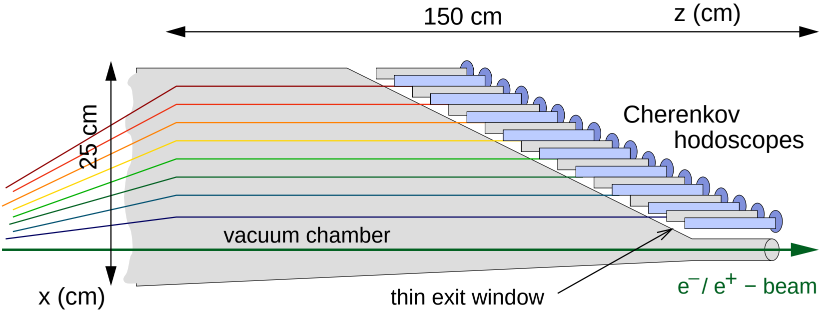



The Compton-IP lies within the magnet spectrometer

$\rightarrow$ scattering of about $10^3$ $\mathrm{e}^+/\mathrm{e}^-$ per beam crossing

$\rightarrow$ the Compton edge is always at the same place in the detector

# Measurement Principle: Cherenkov Detector




Energy/position measurement via a Cherenkov detector:
Compton electrons → Cherenkov radiation → photo electrons

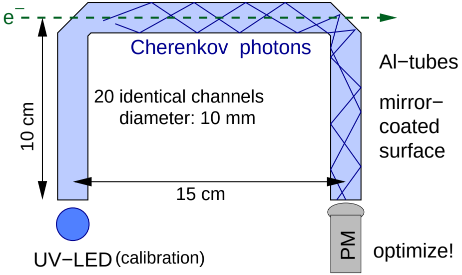
Cherenkov effect: $N_\gamma^{\text{Ch}} = \varepsilon^{\text{Ch}} N_e^{\text{Co}}$ (length of hodoscpe/refraction index)

Photo electrons: $N_e^{\text{Ph}} = \varepsilon^{\text{PM}} \varepsilon^{\text{Att}} N_\gamma^{\text{Ch}}$ (type of photo detector)

# Precision $\leftrightarrow$ Design/Requirements

Two alternative designs for the electron Cherenkov detector:
one conventional, the other with newly developed photo detectors

- Design 1:
  gas tubes + PMs (conventionel)
  $\longrightarrow$ gas? mirror-coating?
  similar to the SLD detector
- Design 2:
  Quartz fibers + SiPMs (new!)
  sensitive area? dyn. range?




**Detection method $\longleftrightarrow$ Precision: $\delta P/P \leq 2.5$ ‰**

Quantum efficiency, sensitive area, light extraction, dynamic range (i.e. range of detectable wavelengths)... all need to be optimised.

# Component
# Test Stand

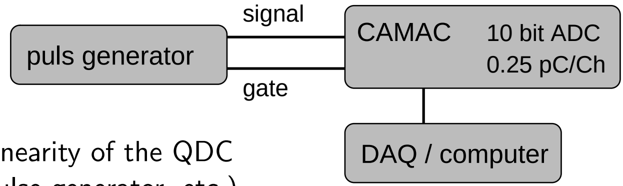
# Test Bench - Photos


Photo session:

- software/DAQ development
- mostly still old hardware
- new parts expected to arrive during the next few weeks

# Test Bench Setup I

## Test of the electronics components alone




- linearity / non-linearity of the QDC (including the pulse generator, etc.)
- time effects (?)

## Idea: Method 1

Use a sine wave function of the pulse generator as input to the QDC and compare the measured transition codes with the output of an ideal QDC.

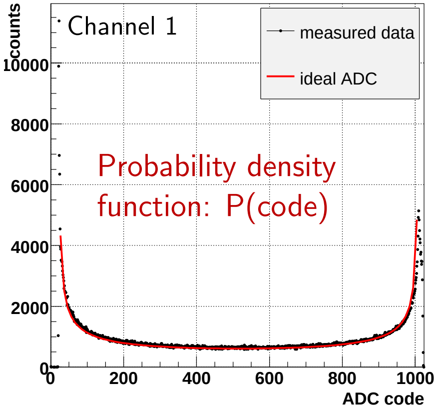
charge at full scale range
ideal code width (LSB)
} transition steps (codes)
} integral and differential non-linearity: INL, DNL

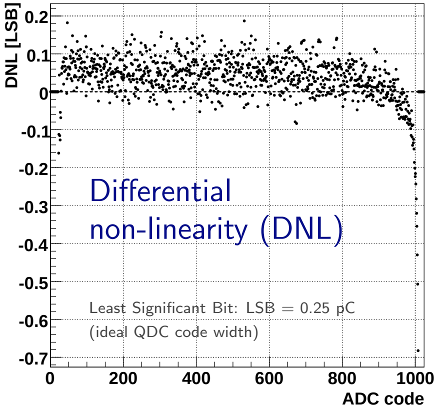
# Transition Codes → DNLs

DNL: difference between ideal & measured probability density function of QDC codes $P(code)$ for a sine wave input (to a 10-bit QDC):

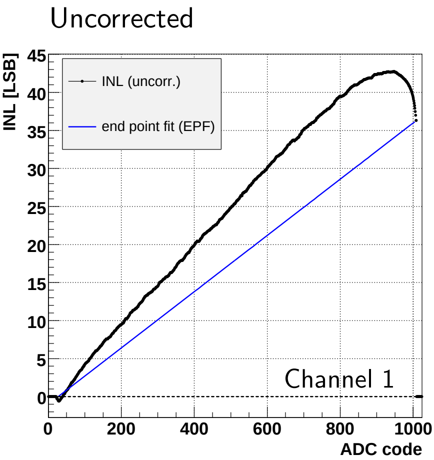
$$\mathrm{P(code)} = \frac{N_{\mathrm{meas}}}{\pi \cdot \sqrt{\frac{A}{2}^2 - (code - offset)^2}}$$

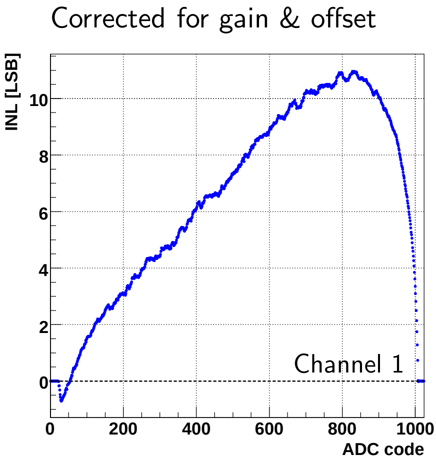
Amplitude: A = 256 pC (codes: 0..1024)
(charge at full scale range)



# Integral Non-linearity: End-Point-Fit



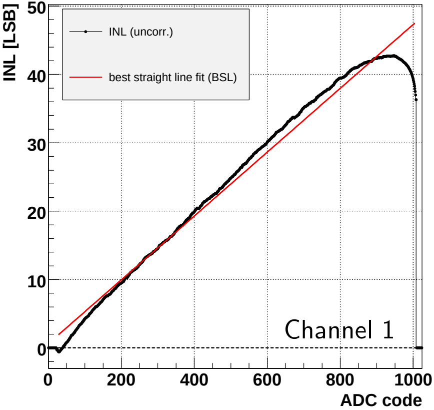




Measurement time: 1/2 . . . 1 h

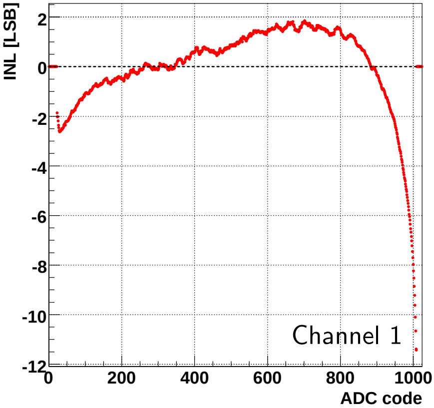
Need $\approx$ 1 million samples for 0.1 bit precision at 99 % confidence level.

# Integral Non-linearity: Best Straight-Line-Fit

Uncorrected




Corrected for gain & offset

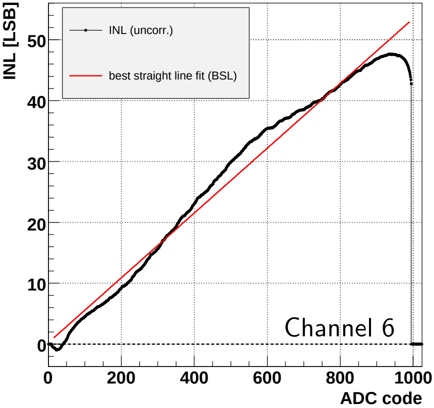



If fitted only in the mid-range (≈ 200..800 ADC-counts), the differences between ideal and measured INLs range only in between 1 to 2 LSBs $\longrightarrow$ ≈ 0.1 - 0.2% of full scale range (FSR = 256 pC).

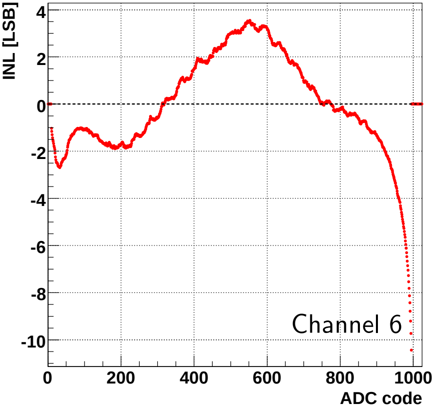
# Worse Example: Channel 6

Using the best Straight-Line-Fit:

Uncorrected

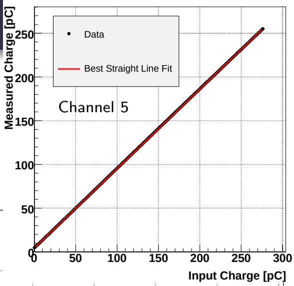



Corrected for gain & offset



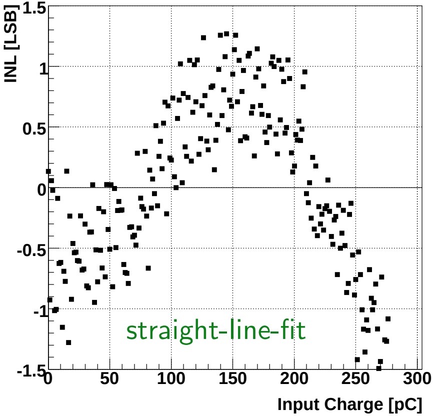

Example for larger differences between the ideal and measured INLs: ranging from 1 to 4 LSBs $\longrightarrow$ $\approx$ 0.1 - 0.4% of full scale range (256 pC).

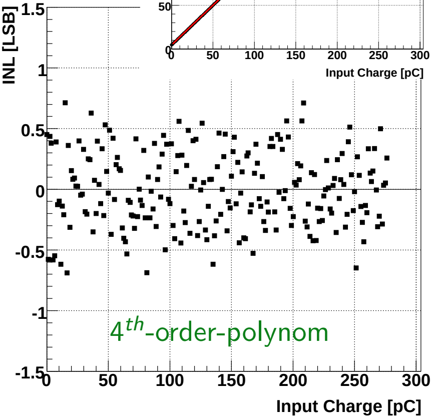
# Alternative Method: Self Test




DC voltage: 0...20 V (stable power supply)

per 1 V $\rightarrow$ 12.5 pC covers full scale range



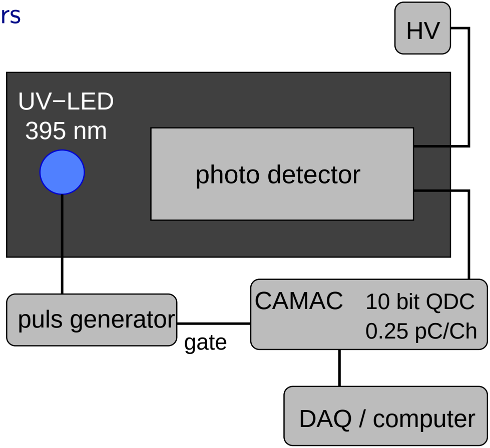




Many ($\approx$ 1000) steps necessary: long measurement time $\rightarrow$ Not as precise!

# Test Bench Setup II

## Analysis of different photo detectors

- characterisation of different photo detectors (conventional, SiPMs, . . . )
- linearity / non-linearity of the photo detectors and the entire readout chain
- temperature effects, gain stability, etc.

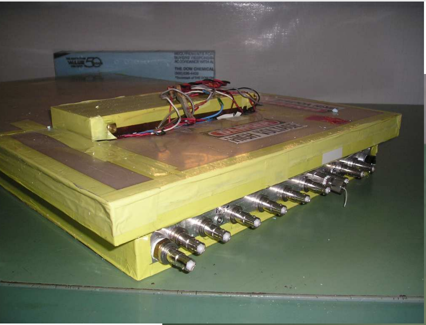


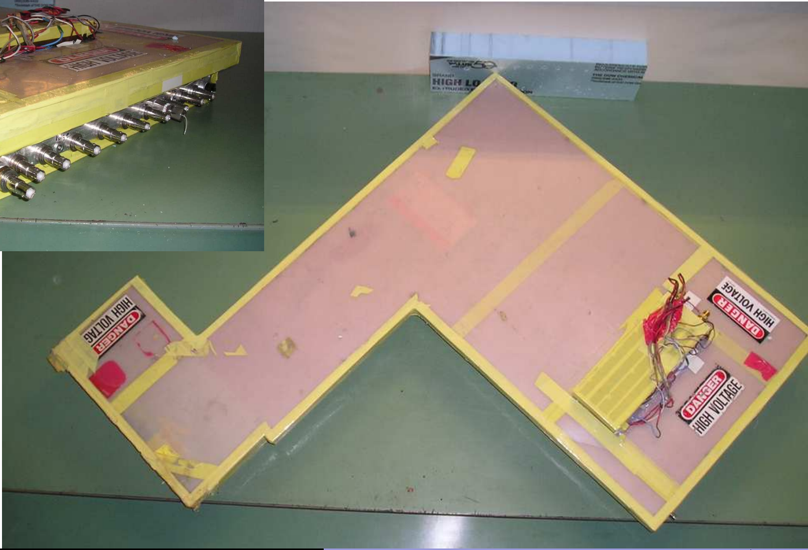

- later: Assembly of Cherenkov counters, etc.
- . . . and. . . . . . some time in the future: a first proto type.

# SLD Cherenkov Detector

## Test Stand

# SLD Cherenkov Detector: Photos



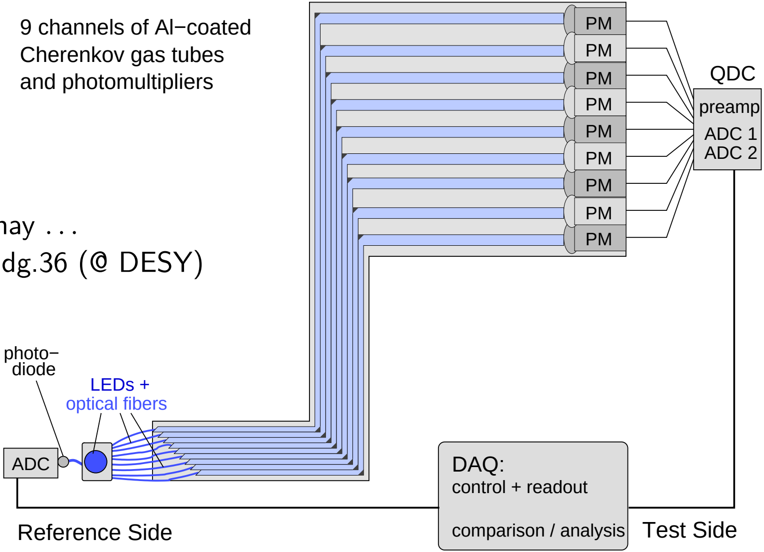




April 2007

# Scheme & Setup of the Detector

9 channels of Al−coated Cherenkov gas tubes and photomultipliers

As of early may . . .
located in Bldg.36 (@ DESY)

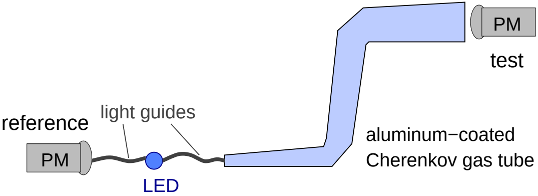


# Comissioning of the Detector

Hardware components for complete setup are not all available yet
VME-PCI interface and QDC ordered – they should arrive soon . . .

- test all channels for functionality, but with a system of blue LEDs (light-tight box / cloth for the LED-system)
  - ▷ no electron test beam operation
  - ▷ and no gas system necessary !
- reflectivity ↔ geometry (light yield, etc.)
- sensitivity of photo detectors
- light extraction from gas tubes
- later: temperature sensors or even active regulation/stabilisation (e.g. thermo-electric elements mounted on top of the gas tubes)

# Planned Measurements (Proposal, April 18)




perform component & readout tests as a reference for new design features (channels need to be similar)

- Characterisation of diff. types of photomultipliers: (sensitivity)
  - ▷ dark rate / light response;
  - ▷ voltage and/or temperature dependence;
  - ▷ dynamic range / sensitivity;
- Pros/Cons of diff. types of photo detectors and connecting fibers:
  - ▷ photo detectors: conventional PMs, APDs, and SiPMs;
  - ▷ fiber types: optical, wavelength-shifting fibers;
- Analysis of different couplings: (direct, air gap, . . . ) between gas tubes & fibers, and between fibers & photo detectors;
- Linearity / non-linearity measurements for diff. configurations

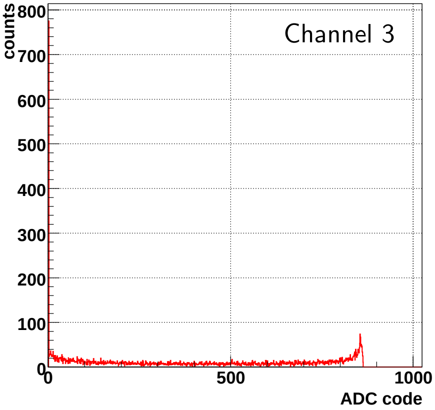
# Conclusion

# Outlook

- Two test stands are setup and operated:
  - ▷ one for component tests (small test bench);
  - ▷ one for the old SLD Cherenkov detector
    component tests / reference measurements / readout chain;
- First linearity measurements of electronics components at the small test stand were presented;
- Methods for on- and off-line measurements are being established;
- Many different measurements (component-wise, but also regarding the entire detector setup & operation) are planned for the future.

# BACKUP

# Channel 3: even worse




sine wave with:

$V_{\mathrm{input}} = 0 \ldots - 465$ mV

Input voltage ($\rightarrow$ charge) drops down to zero, but:

There is no real peak on the left, just a number of entries at zero.

$\Rightarrow$ Channel 3 of the (old) QDC is most probably broken ...