Detector Development for High Energy Polarimetry

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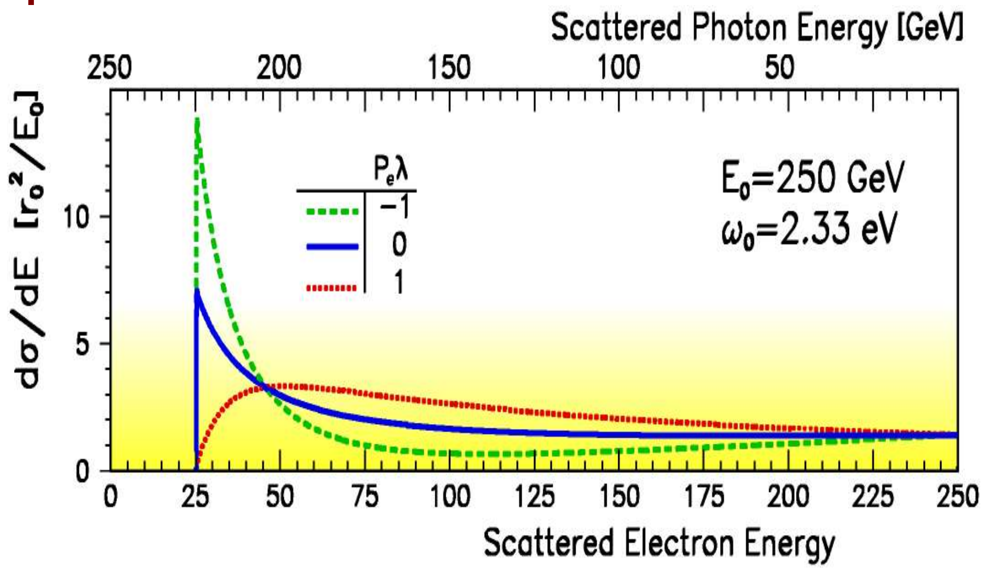
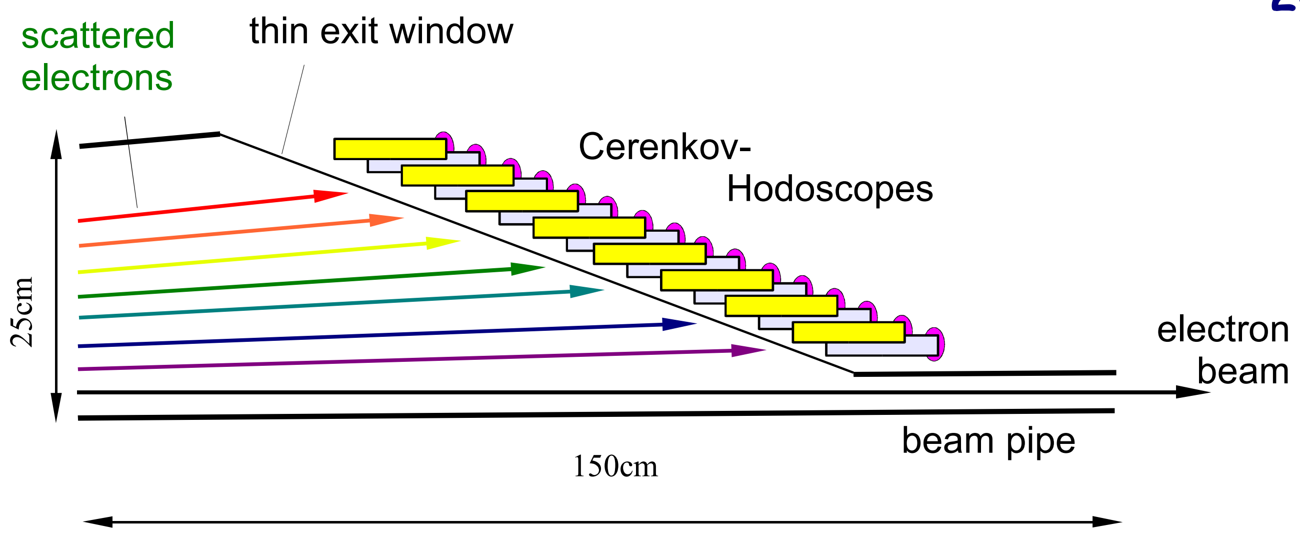
Outline:
- Introduction
- Hardware activities
- Simulation activities
- Summary

Introduction

- Motivation:
  - longitudinal beam polarisation important for many measurements
  - from physics requirements: $\delta P/P \lesssim 0.25\%$
  - best polarimeter sofar: SLD, $\delta P/P = 0.5\%$
- Measurement principle: Compton scattering
  - scatter circularly polarised laser off $e^{\pm}$ beam: $O(10^3)$ / BX
  - send scattered $e^{\pm}$s through spectrometer magnets ('chicane')
  - use Čerenkov counters to measure position distribution
  - asymmetry w.r.t. laser helicity ($\lambda = \pm 1$) ~ polarisation
  - location: upstream / downstream / both ? $\neq$ e^+e^- IP => spin transport!

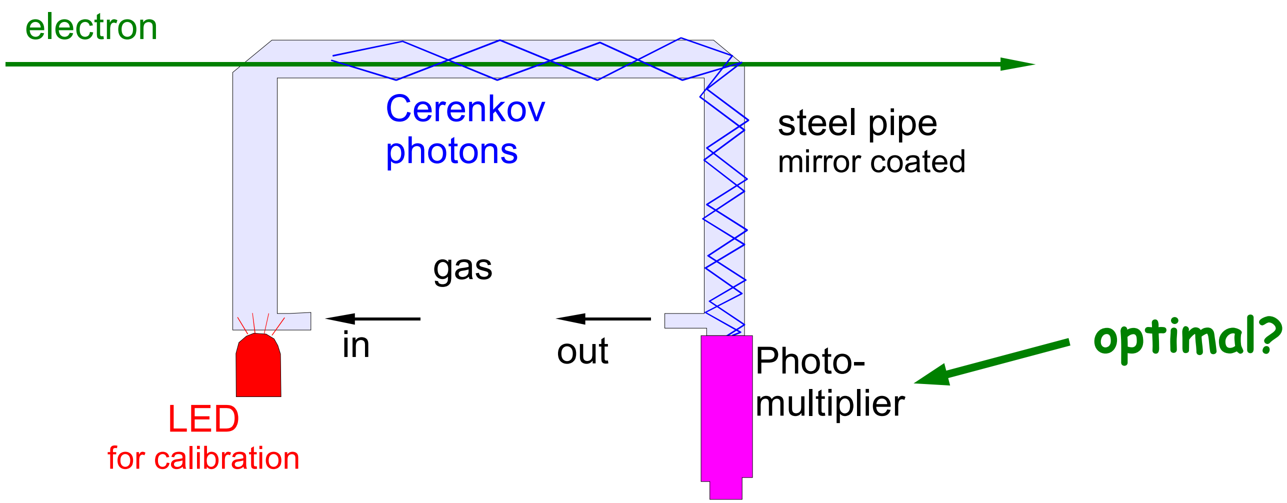


Current design of the electron detector



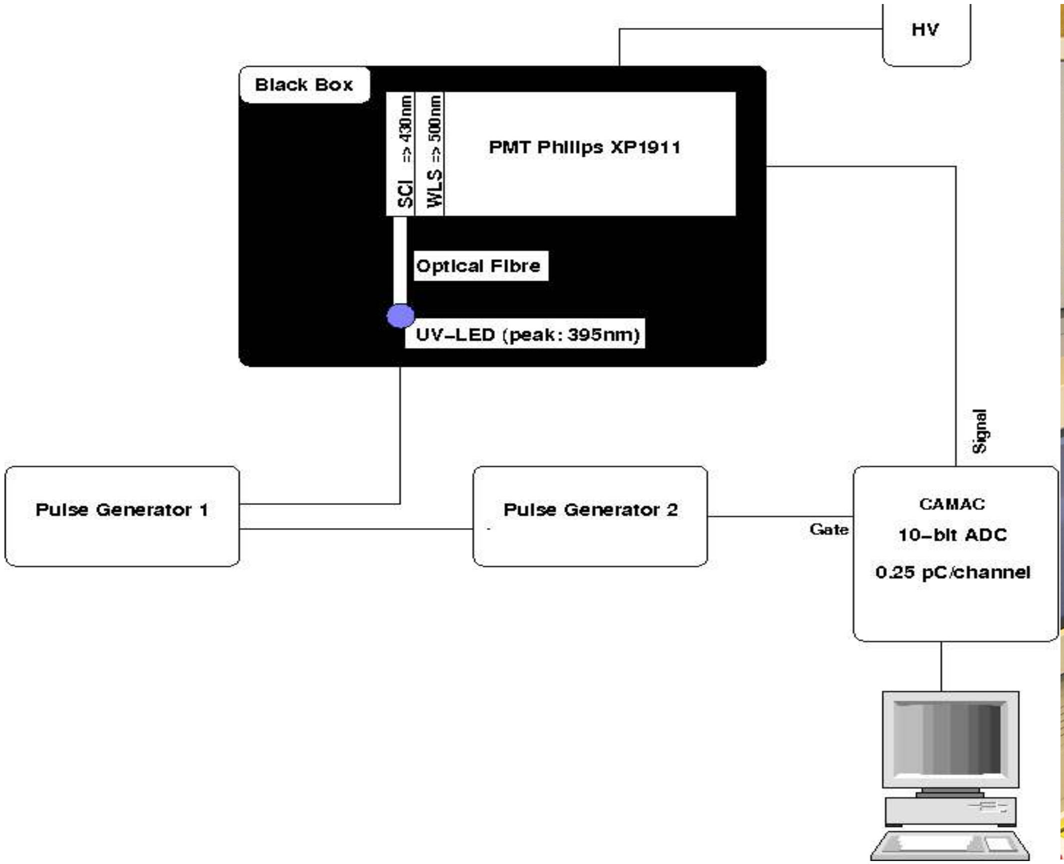
20 gas Čerenkov counters
- gas: C_4F_{10}
  (threshold ~ 10 MeV)
- photon detection:
  Photomultiplier,
  (Hamamatsu R6094)

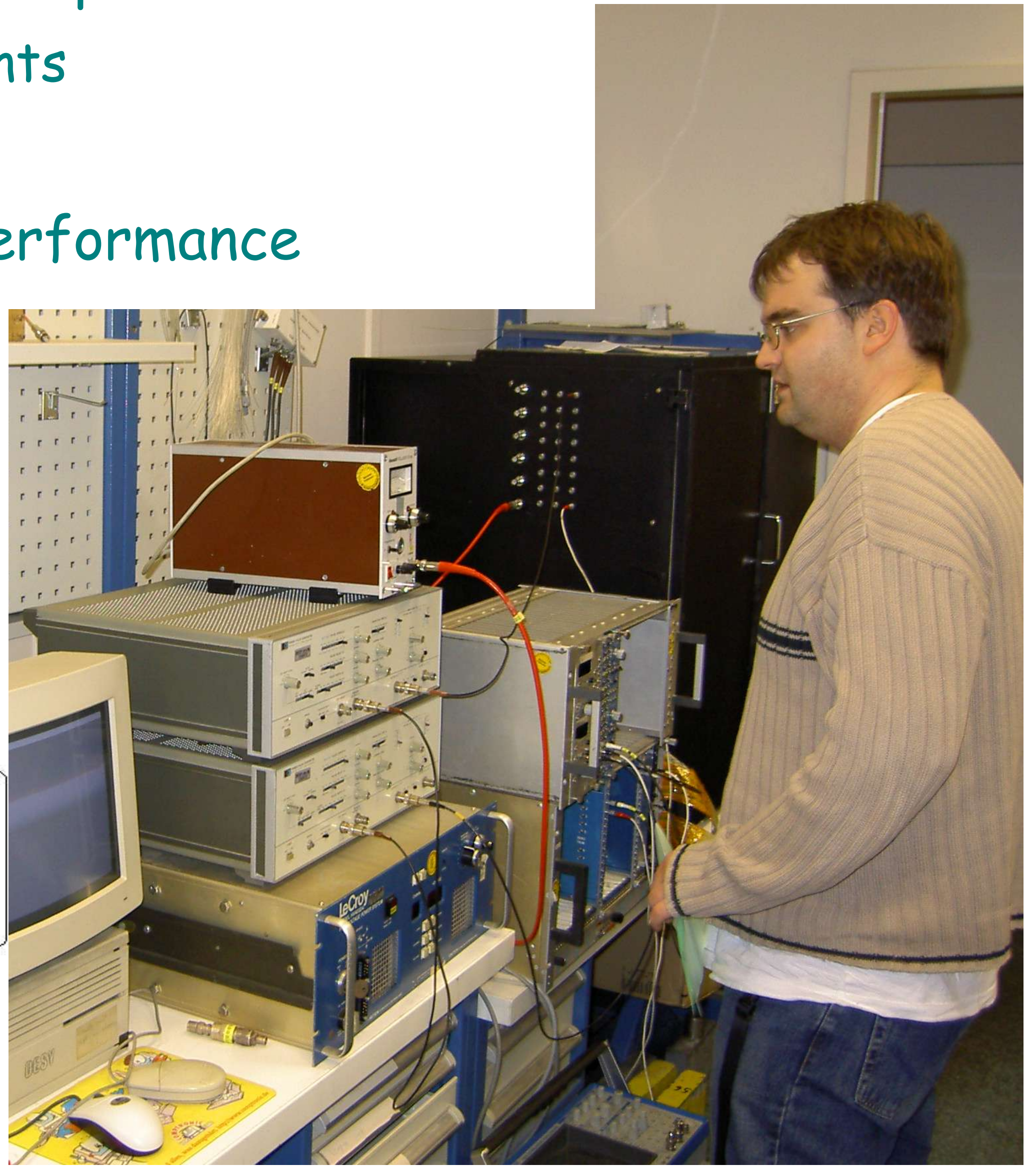
≈ as in TESLA TDR



Development of Čerenkov Detector

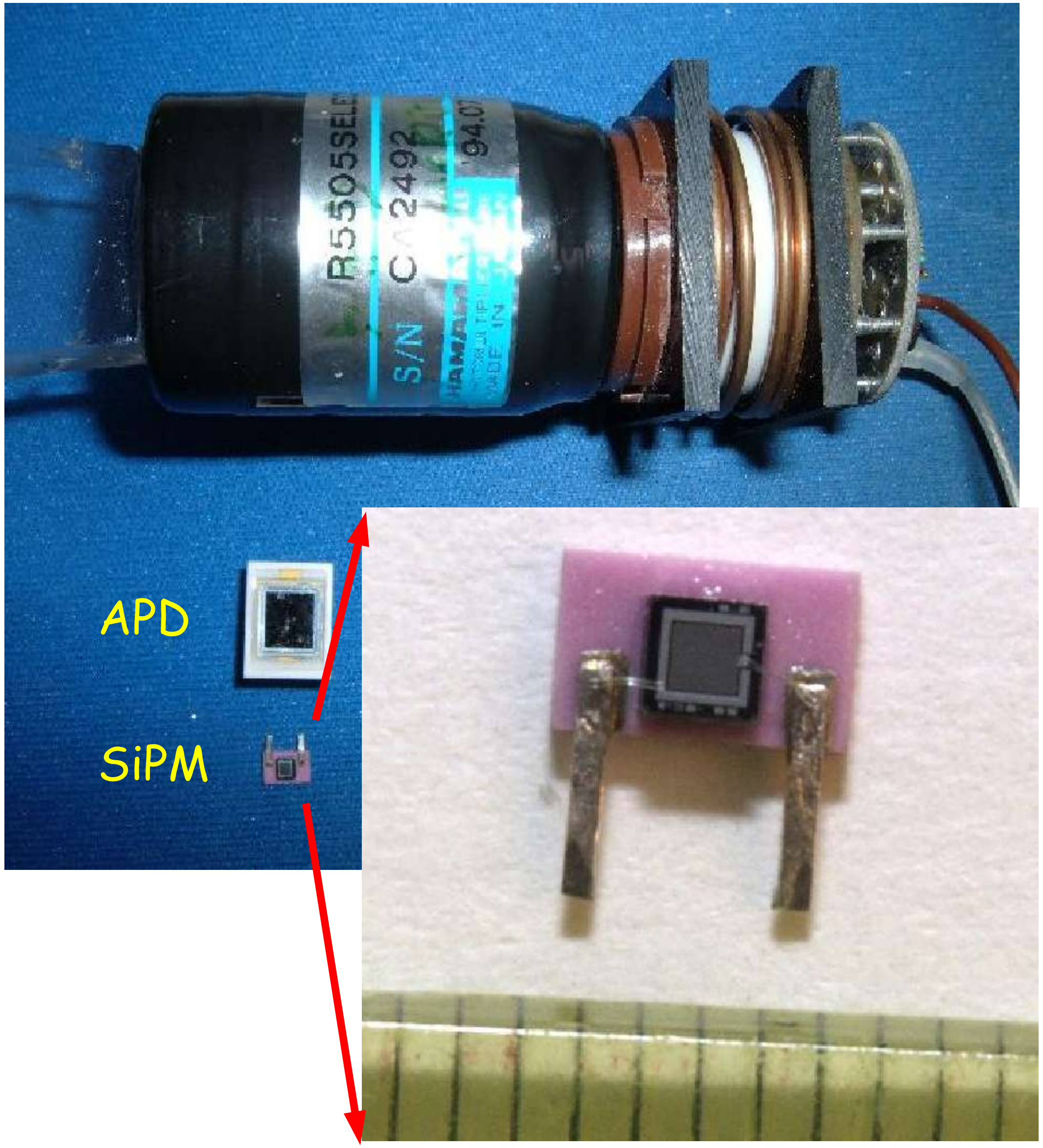
- Goals of new activity at DESY:
  - verify and/or improve existing proposal for detector
    - test various detector components
    - simulations
  - build prototype, demonstrate performance





Guinea Pigs....

- Optimal photodetectors for this application ?
  - Photomultiplier
  - Avalanche Photodiodes
  - Silicon Photomultiplier
- LED tests:
  - linearity
  - temperature effects
  - stability
  - ....
- later:
  build Cerenkov counters



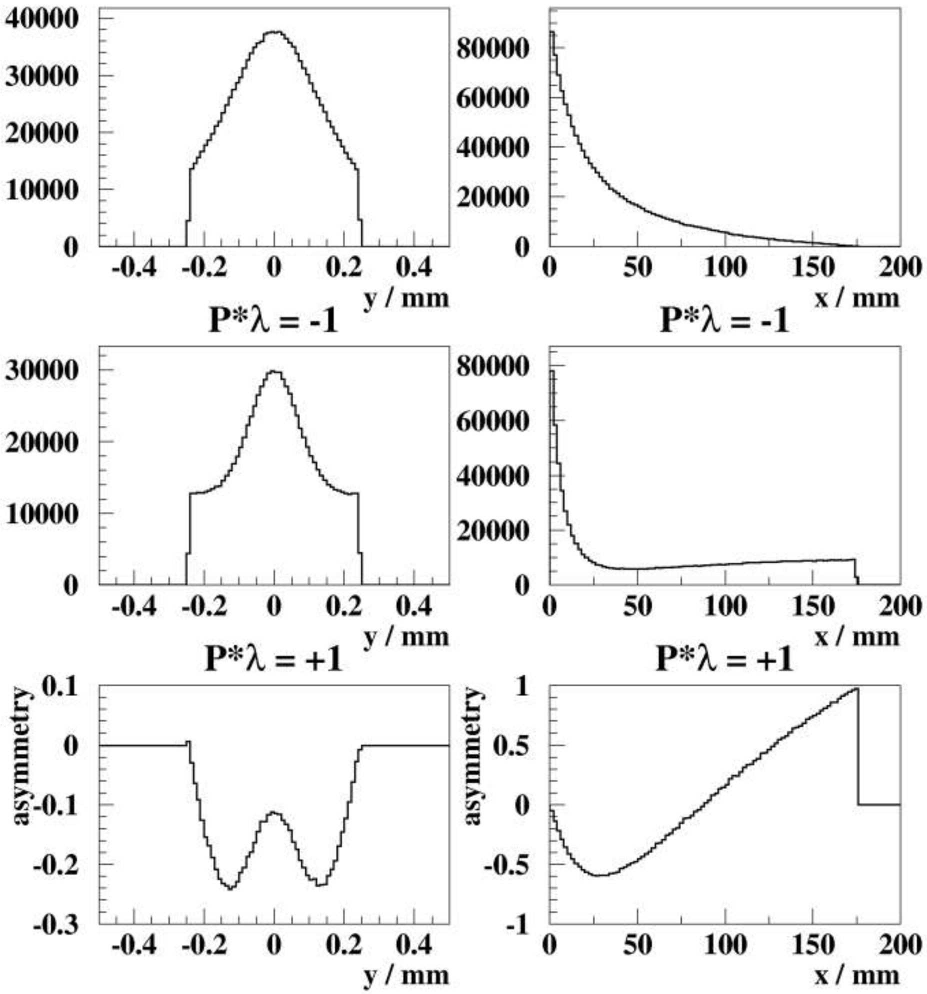
...accompanied by simulations

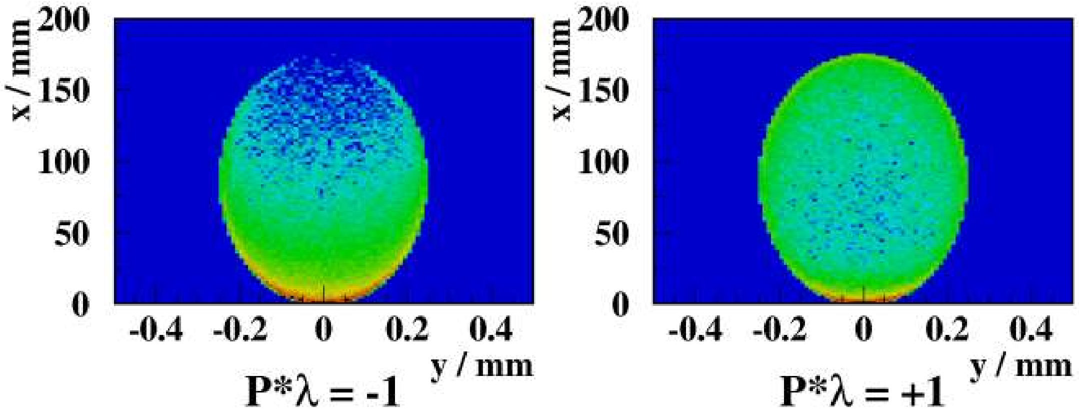
- starting point:
  - Compton generator
  - beam & laser parameters
  - magnet chicane

=> position distribution of scattered e's at detector surface:

y and x
PΛ = -1

y and x
PΛ = +1





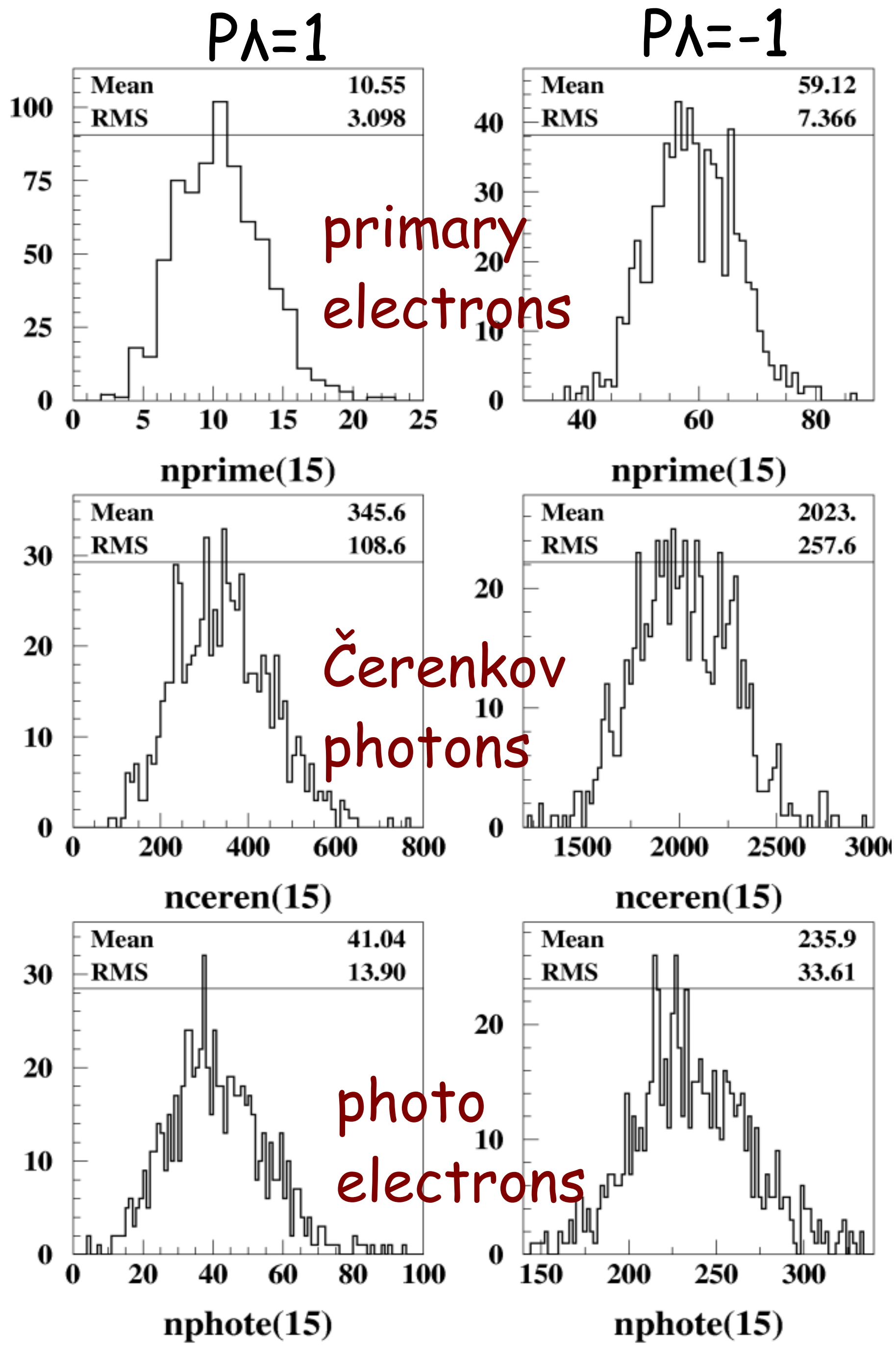
asymmetry in y and x

Status of Detector Simulation

- 'generic' detector:
  - channel size & geometry => number of primary e's per channel
  - output ~ # of primary e's + syst. effects
- Gas-Cerenkov-Detector & PM à la TESLA TDR
  - 20 channels
  - Cerenkov spectrum
  - reflection losses
  - quantum efficiency
  - non-linearities (PM, ADC):
    - same for all channels
    - different for each channel

Simulation cont'd: perfect detector

- no syst. effects
- pick one of the 20 channels for illustration:
  - 1 primary electron gives on average
    - ~ 30 Čerenkov photons (300...600 nm)
    - ~ 3-4 photo electrons
- all channels: # of primary e's 1....250 / per channel / BX
- next: vary design parameters, is it already optimal?



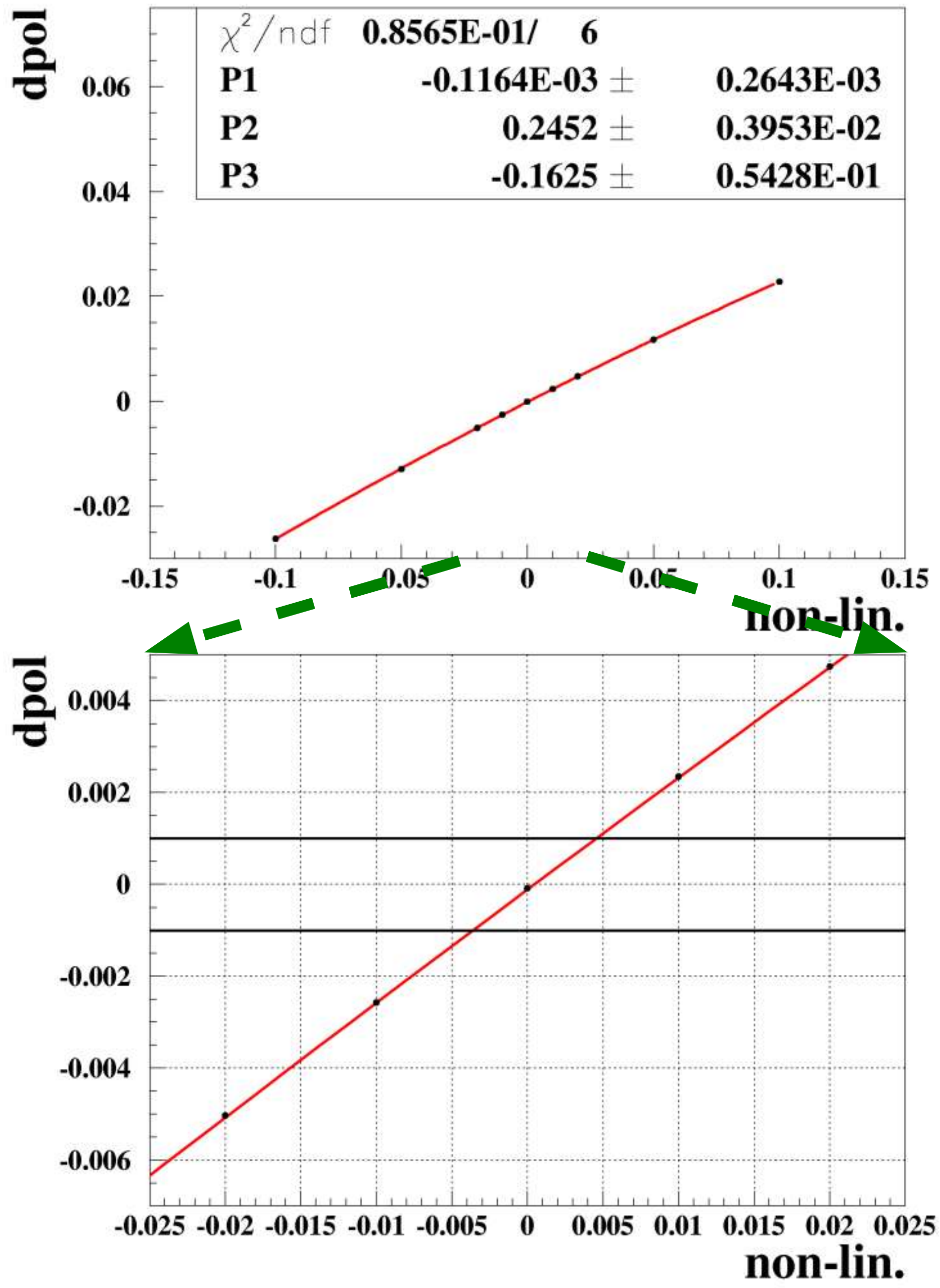
Simulation cont'd: Non-Linearity

example of simulation result:

- vary size of (quadratic) non-linearity: -10% ... +10%
- otherwise 'perfect' detector

=> for $\delta P/P = 0.1\%$ need to control non-lin. to at least 0.5%

next: look at more syst. effects!



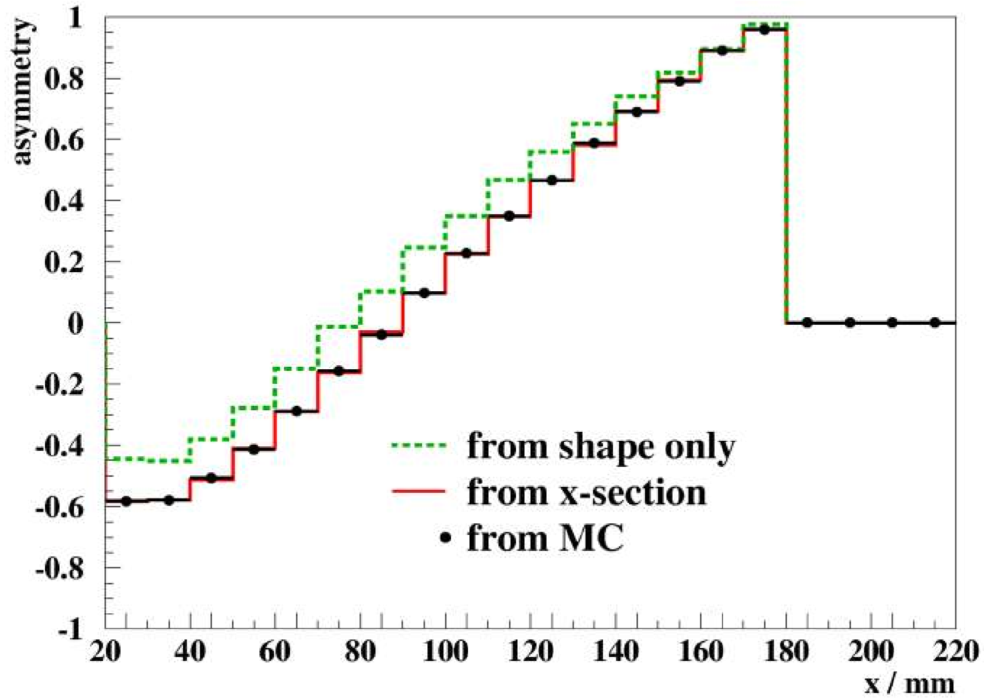
Optimizing the Measurement: Analysis

- total cross section different for the two laser helicities:
  - σ(Pλ=1) = 158 mb, σ(Pλ=-1) = 113 mb => difference 45 mb

=> cross section asymmetry ≠ shape asymmetry

- two possibilities:
  - collect equal number of e's for both helicities (over all channels), use shape asymmetry only
    => less analysing power (~17%)
  - collect same amount of luminosity use full x-section asymmetry
    => more sensitive to systematics?

=> take both possibilities into account in detector / DAQ design



Summary

- Polarimetry at the ILC is supposed to be at least a factor 2 more precise than what exists up to now
- activities up to now: design of chicane, laser, position in machine, backgrounds, spin transport...
- new effort just starting up: investigate Čerenkov detector
  - goal: make sure that necessary precision can be achieved
  - revisit design
  - test different types of photo detectors
  - detailed simulations
  - build prototype

=> ...stay tuned!