Systematic Uncertainties for the LPOL Polarimeter

Riccardo Fabbri (FLC, DESY-Hamburg)

- Released Systematic Uncertainties
- Calorimeter Analyzing Power
- Extra Scale Uncertainty after Replacement of Crystals
- Gain Mismatch of Calorimeter Channels
- Pockels Cell Misalignment
- IP Interaction, Laser Light Polarization
- New Contributions due to Hardware Aging
- Current Status of Studies

Released Systematic Uncertainties

Analyzing power (A.P.)	1.2%
– response function	0.9%
– single to multi photon extrapolation	0.8%
A.P. Long term stability	0.5%
Extra uncertainty on calo scale	1.2%
Gain mismatch	0.3%
Pockels cell misalignment	0.4%
IP interaction	0.8%
Laser light polarization	0.2%

References:

— M. Beckmann et al., 'The Longitudinal Polarimeter at HERA', NIM A **479** (2002) 334.

— A. Airapetian et al., 'Overview on Systematic Studies of the Longitudinal Polarimeter during the 2005 HERA Running Period, HERMES Internal Report 05-047.

Calorimeter Analyzing Power

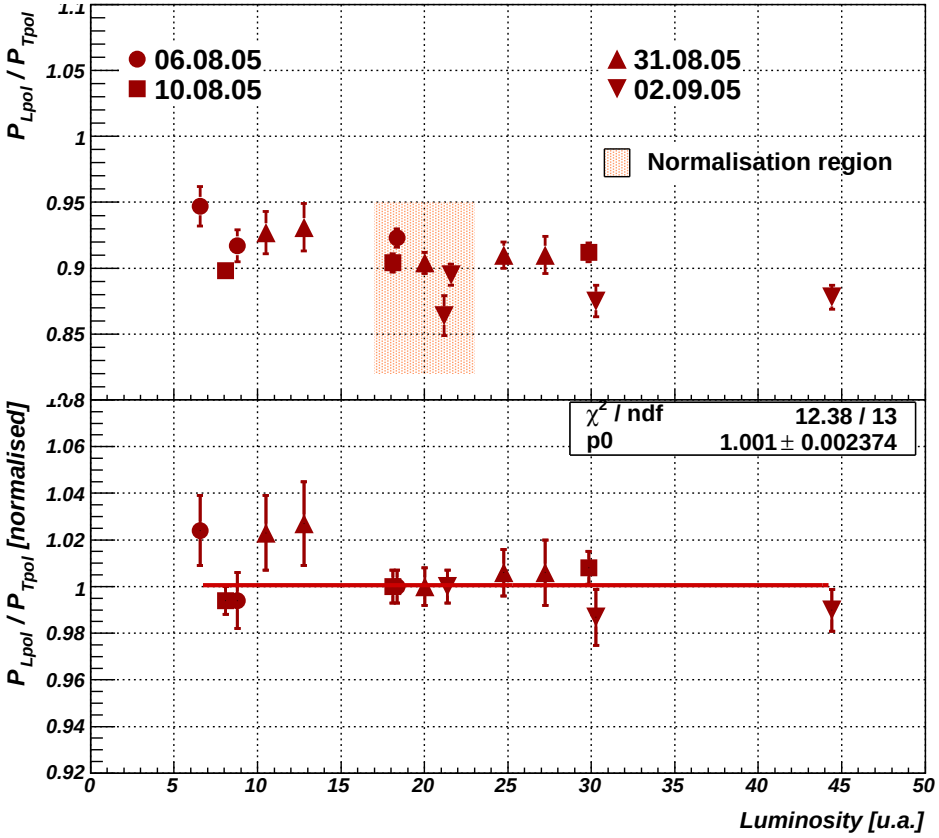
- **Response function: obtained using test beam data (up to 30 GeV) in 1998**
  - $\Longrightarrow$ **calorimeter operated in single-photon mode**
  - $\Longrightarrow$ **no possible to cross-check during normal running conditions**
- **Transition from single to multi-photon mode**
  - $\Longrightarrow$ **using 2005/2007 dedicated measurements changing the laser intensity**
  - $\Longrightarrow$ **no possible to cover the entire original luminosity range (up to a factor 10^3)**
- **Extra uncertainty after crystal replacement in 2005**
  - $\Longrightarrow$ **comparing measurements in 2005 with NBW and sandwich calorimeters**
- **Long term stability**
  - $\Longrightarrow$ **comparing measurements with NBW and sandwich calorimeters over ≈ 2 years of data taking (2005-06)**

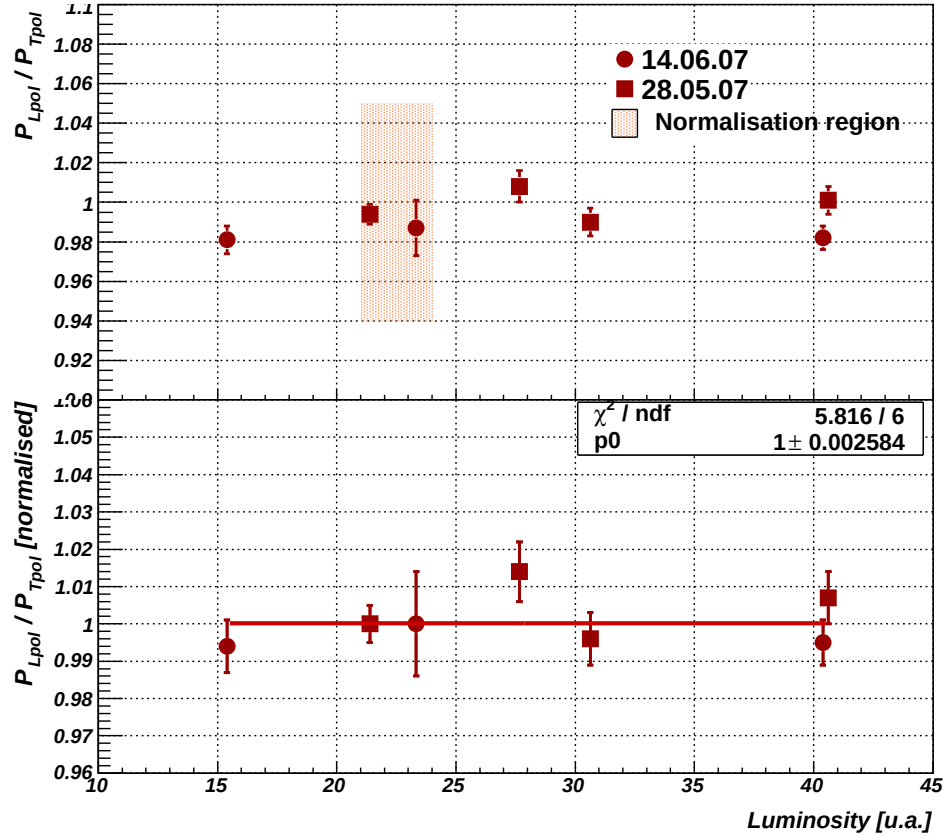
All considered analyses done considering the Tpol as reference beam polarisation measurement and requiring a stable polarisation (as measured by the Tpol)

A.P.: Transition to Multi-Photon Mode

Laser intensity changed over large luminosity range

- **Data cover different luminosity/ratio regions: $\Longrightarrow$ normalise data in common area**
- **Fitting the data with flat function: $\Longrightarrow$ testing no effect hypothesis**



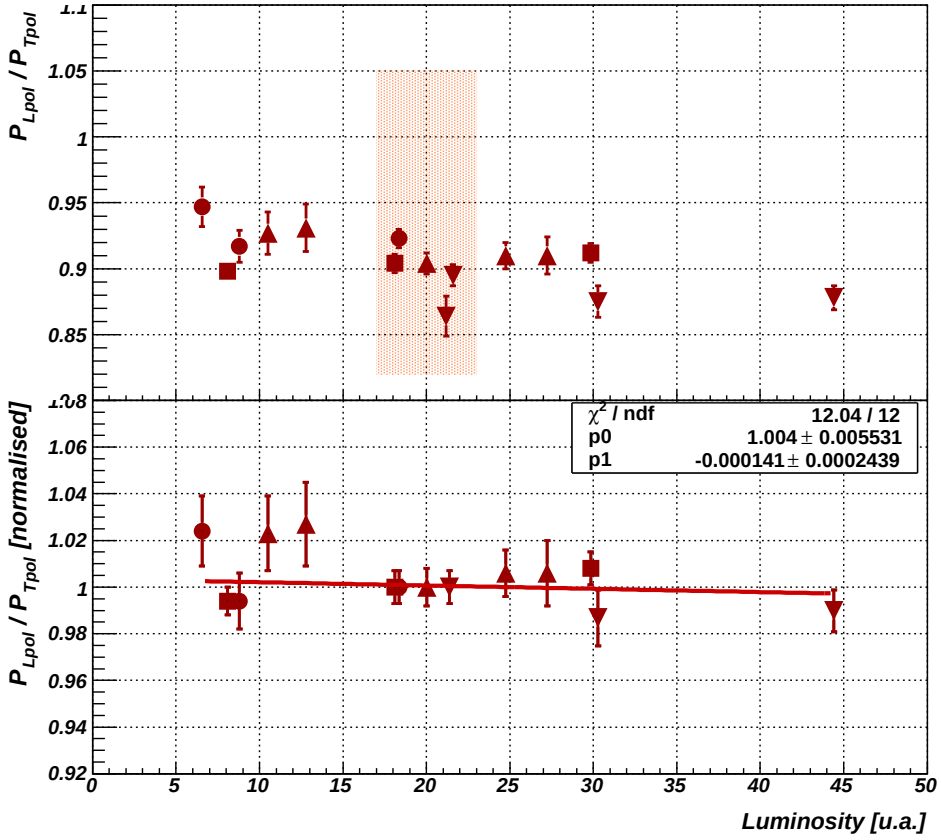


$\sigma_{SP \to MP} \approx 0.3\%$ **[plus contribution by changing normalisation regions]**

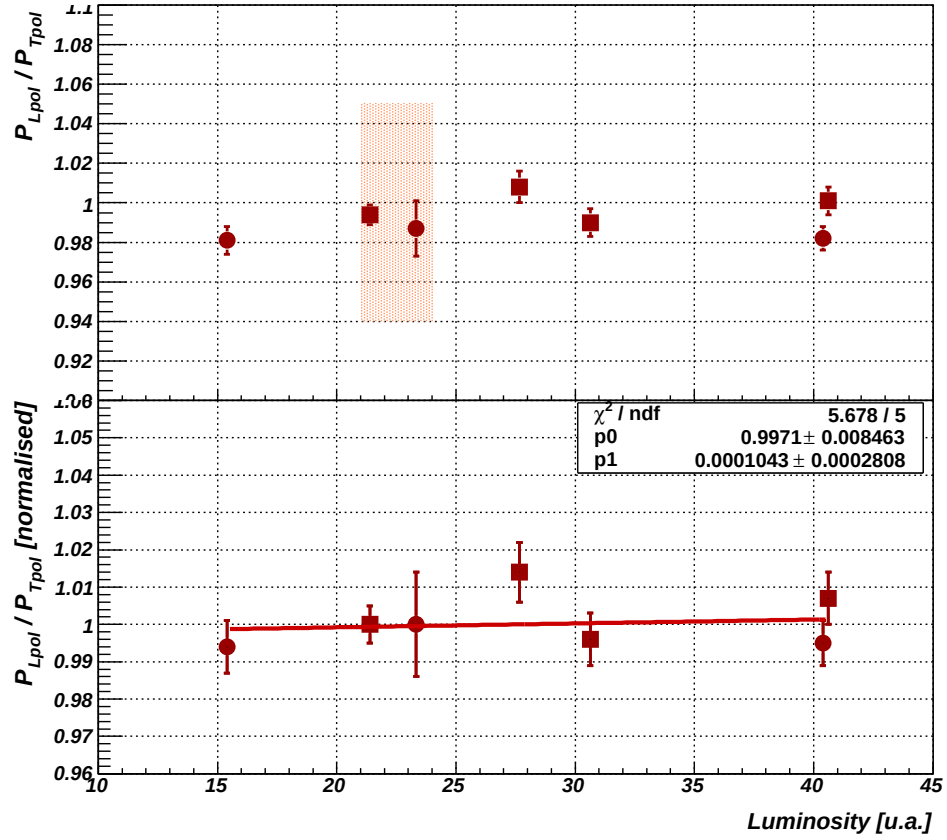
A.P.: Transition to Multi-Photon Mode

Allowing the linear fit for an arbitrary slope ...

2005



2007



Extra Uncertainty on A.P. Scale

After the calorimeter was rebuilt in 2005 its response was compared with measurements in 2005 of the sandwich calorimeter

- **Weighted mean calculated as**

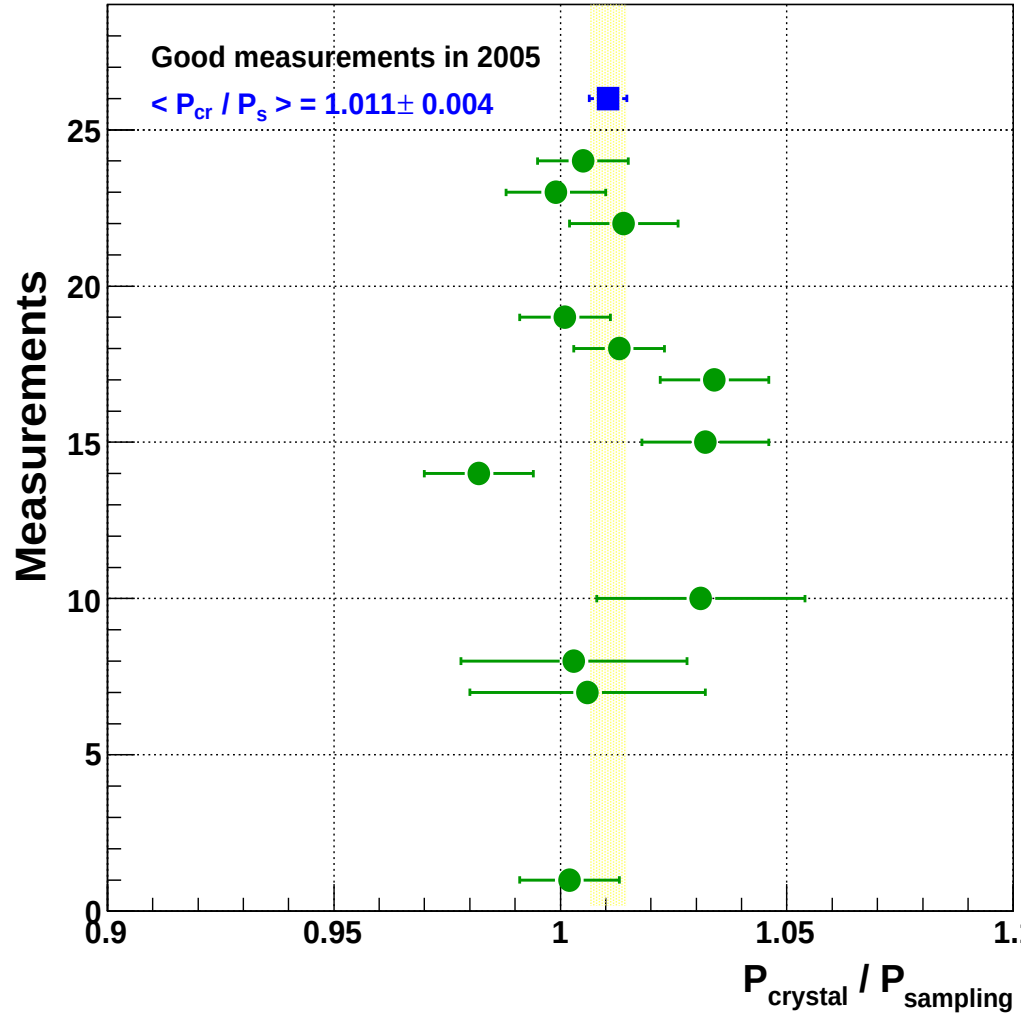
$$\langle P_{cr}/P_s \rangle = \frac{\sum_i \omega_i P^i_{cr}/P^i_s}{\sum_j \omega_j}$$

using N_{cr}+N_s as weights

- **Error on weighted mean obtained via error propagation**

$$\sigma_{extra} \approx (1.1 + 0.4)\% = 1.5\%$$

[plus contribution due to deviation from statistical fluctuations]



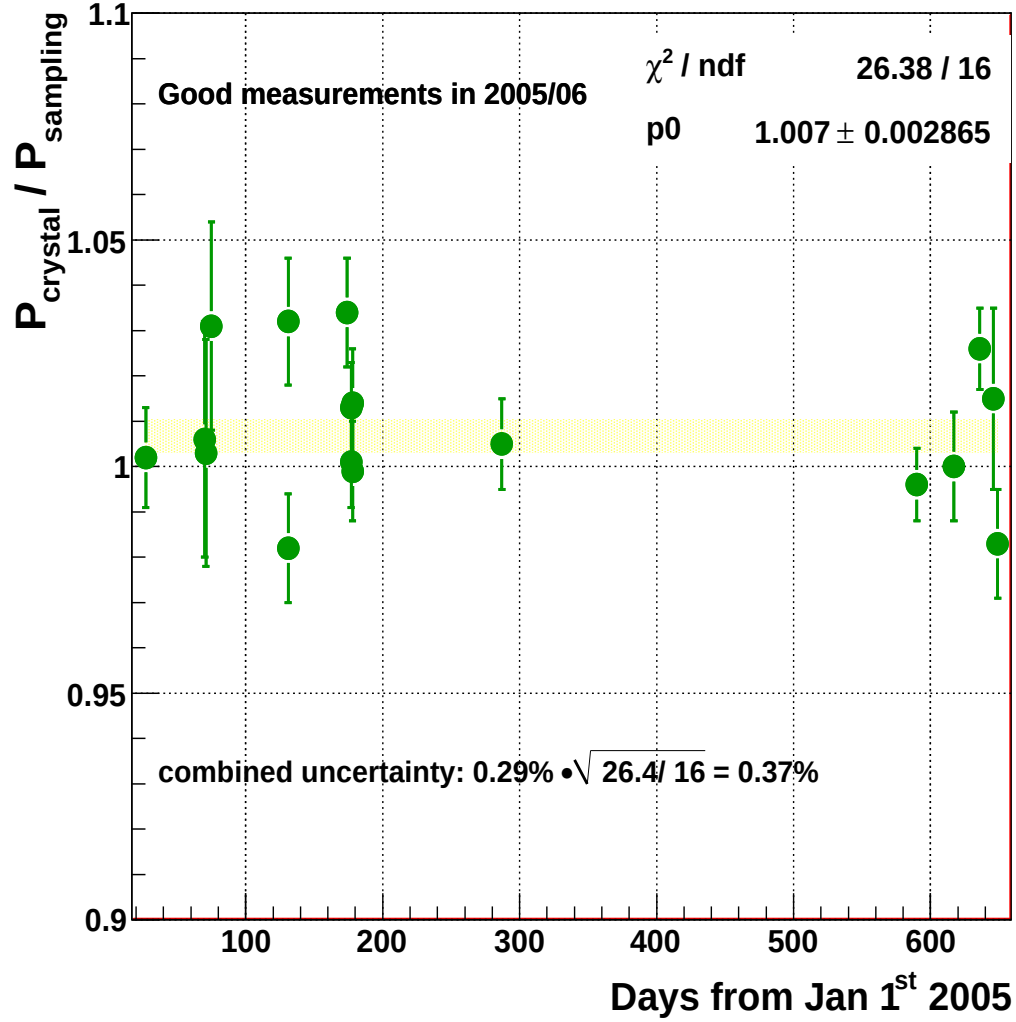
A.P.: Long Term Stability

Analyzing power could change on large time scales due to radiation damage to NBW crystals or other aging effects

- **Extending to 2006 data the comparison with SW calorimeter**
- **Fitting the data with flat function**

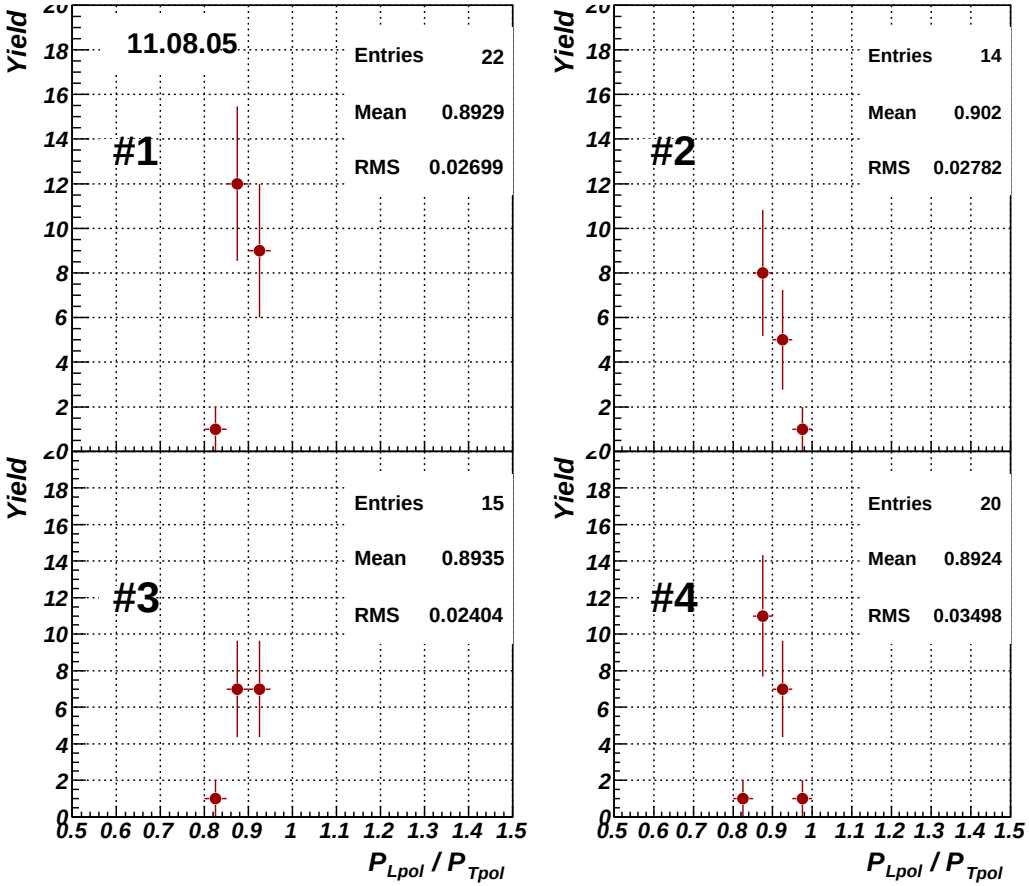
  $\Longrightarrow$ **testing no effect hypothesis:**

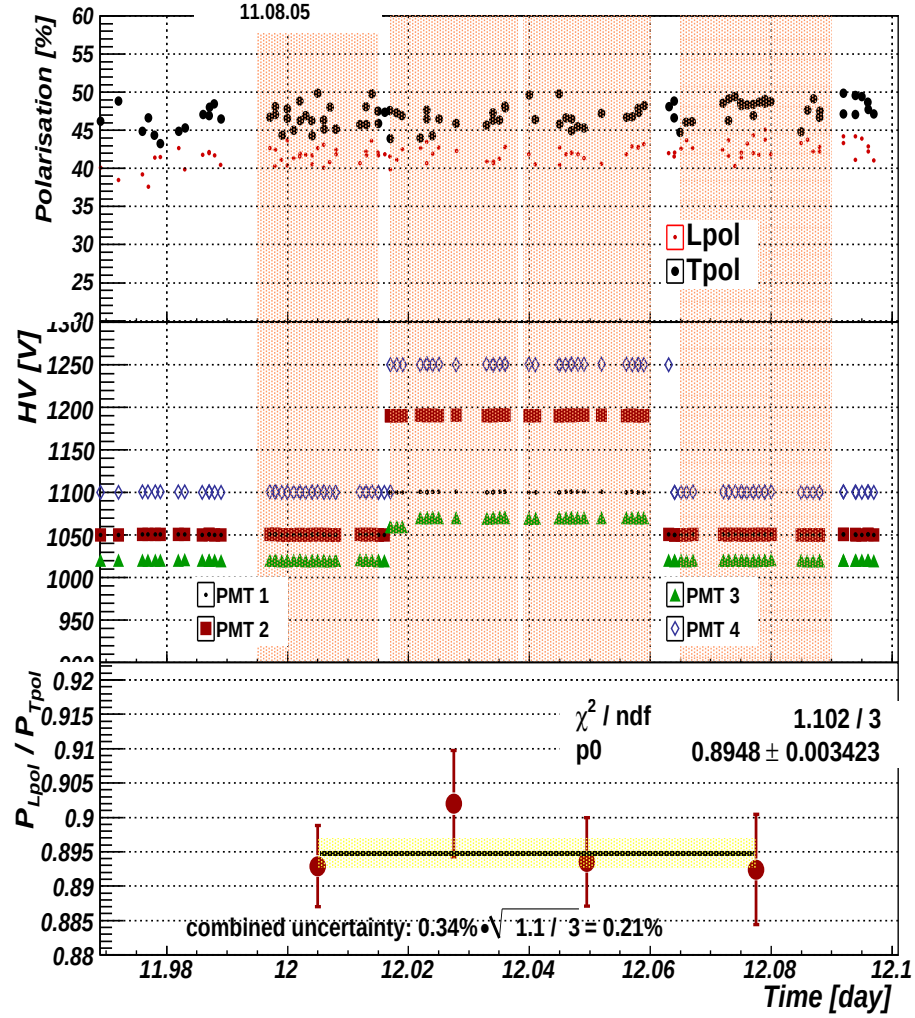
$$\sigma_{LTS} \approx 0.4\%$$



Gain Mismatch

Changing the gain of PMT channels varying the applied HV





☞ **Fitting the data with flat function (testing no effect hypothesis):** $\sigma_{GM} \approx 0.3\%$

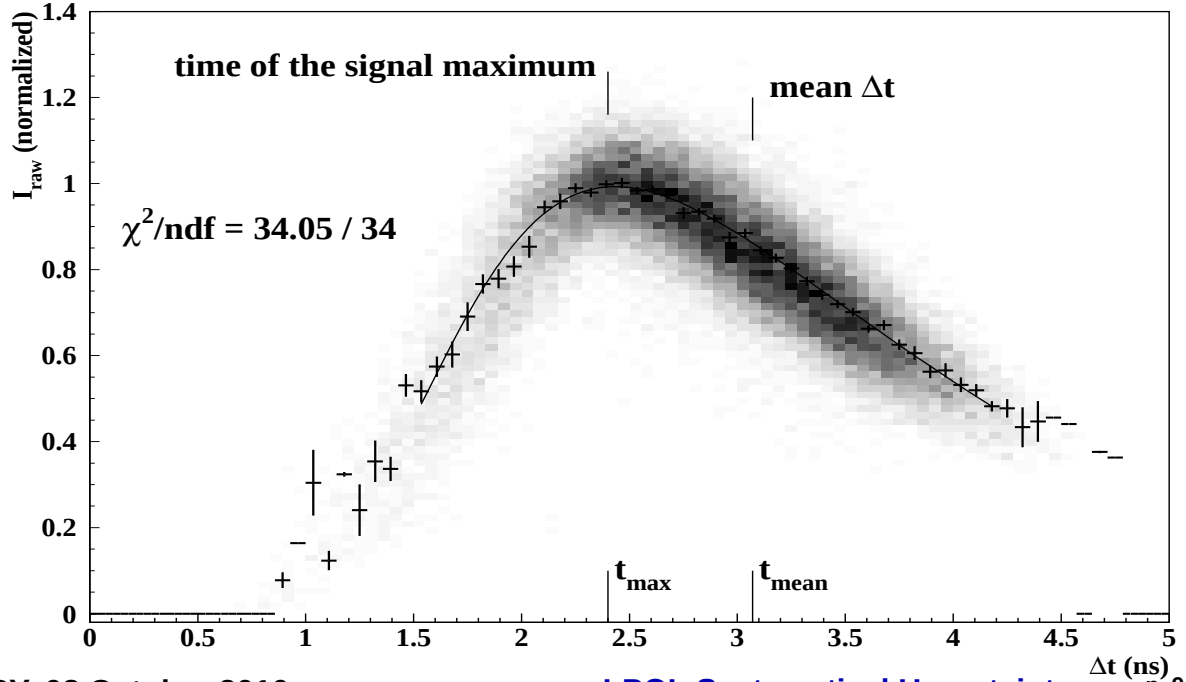
Pockels Cell Misalignment

Preamble: Timing Correction to ADCs

- Internal laser electronic jitter is $\pm 1.5ns$
- laser pulse ($3ns$ long) has non-constant lumi-profile
- due to jitter, sampling is at different lumi-profile "slides"

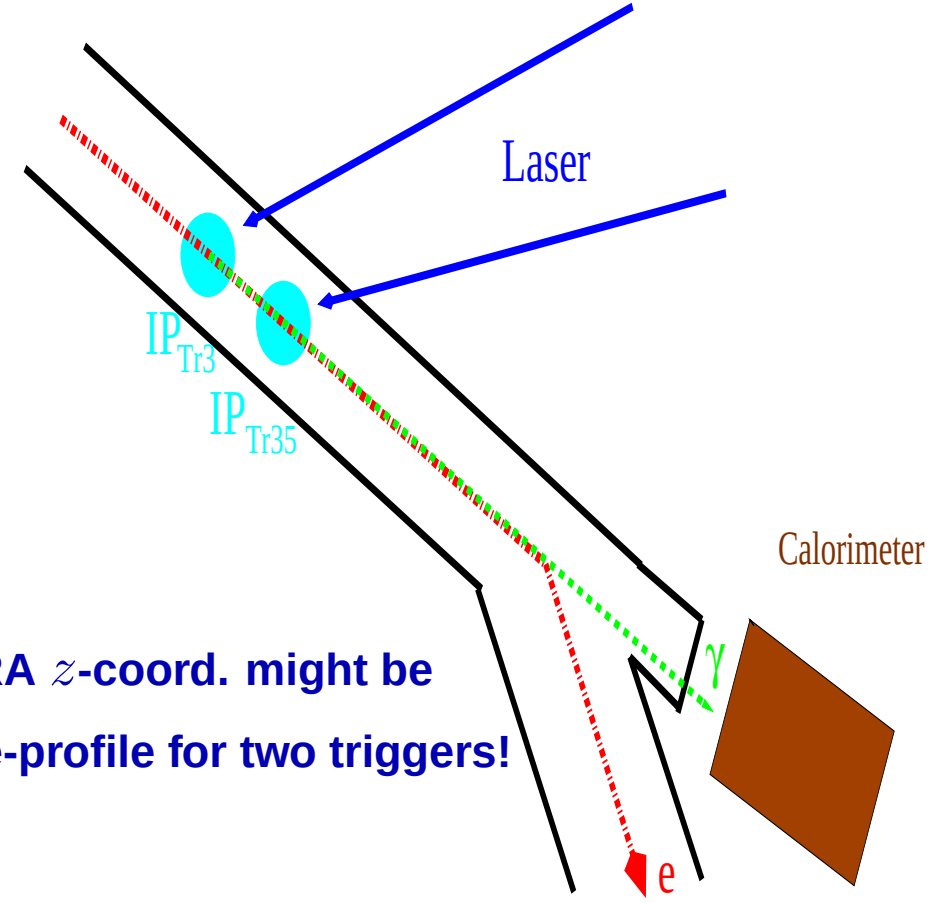
  $\Longrightarrow$ ADCs should be lumi-corrected to get physical asymmetries
- via TDC determine $\Delta t = t_{laser\_firing\_trigger} - t_{laser\_fired}$
- 1-min data fitted with laser pulse profile function

  $\Longrightarrow$ ADC-corr. factor to max.signal provided
- fit done considering only one helicity state
- fit results used to correct next 1-min events before (!) the polarization calculation



Pockels Cell Misalignment

PC misalignment could result in the IP displacement for the two laser trigger states



Displacement along HERA z-coord. might be revealed in different time-profile for two triggers!

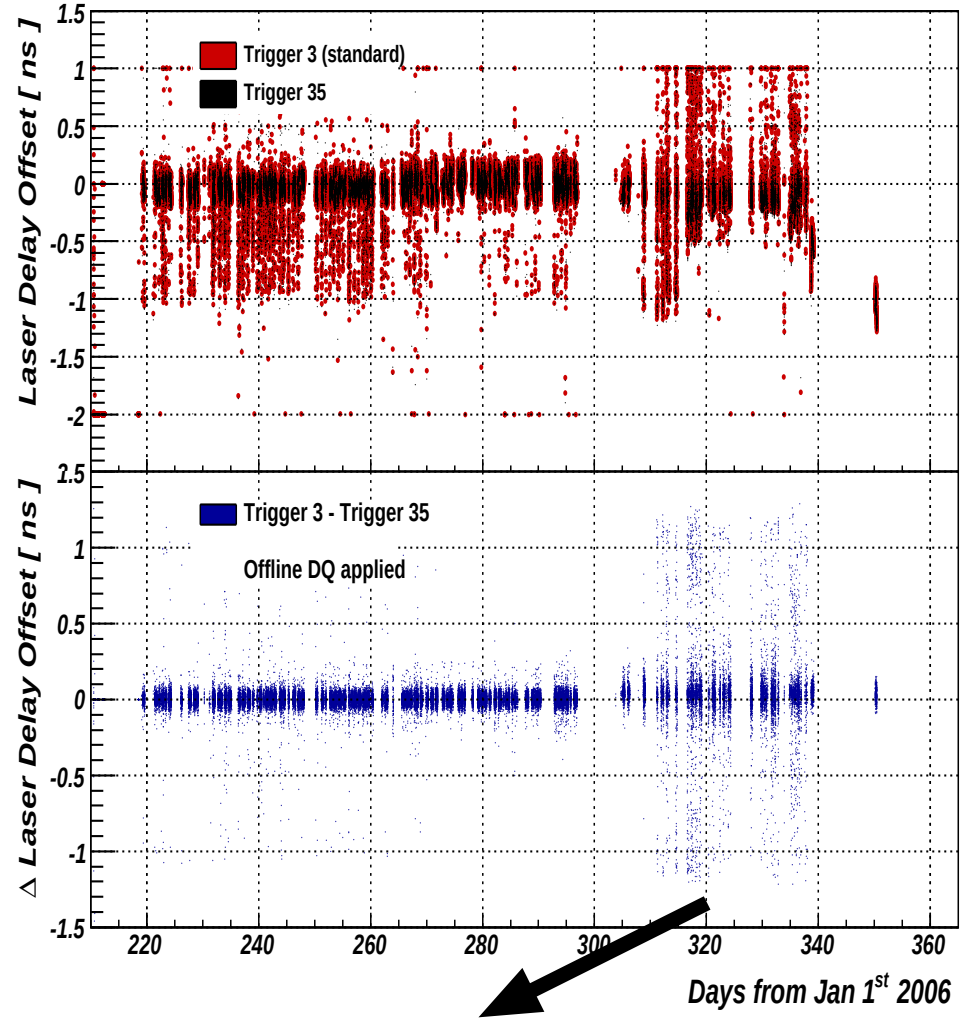
Displacement along HERA z-coord. could result in a wrong jitter corretion for one laser trigger state: $\Longrightarrow$ Possible false asymmetry induced?

Pockels Cell Misalignment

Analysing 2006 data

Laser Delay Offset:

timing adjustment of laser firing to maximise luminosity for backscattered Compton photons

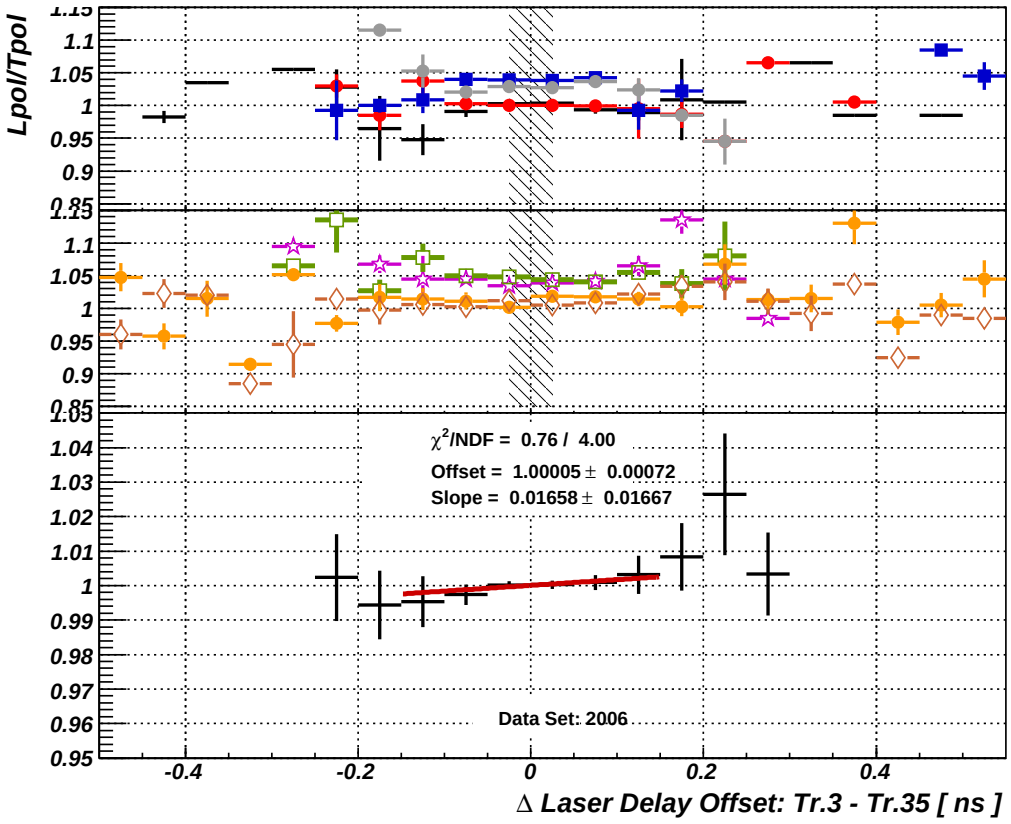


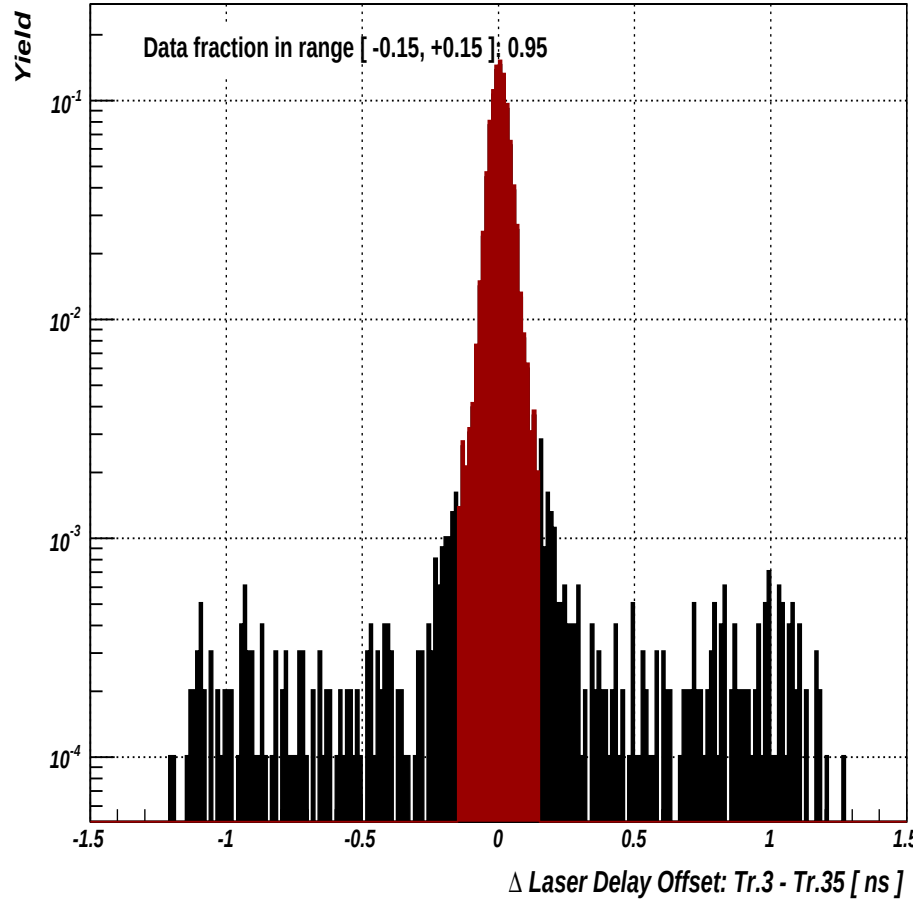
Laser hardware aging: deterioration of pulse profile

Pockels Cell Misalignment

Dividing all data in sub-periods with reasonably stable ratio Lpol/Tpol

- **Normalise data to a common region**
- **Merge normalised data into common profile histo**
- **Consider bin with more than 15 entries**





$$\sigma_{PC} \approx 0.01658 \cdot \Delta t_{95\% data} = 0.01658 \cdot 0.30 \approx 0.5\%$$

Systematic Uncertainty

Sources	Released values	Current analysis
Analyzing power (A.P.)	1.2%	1.2%
– response function	0.9%	NA
– single to multi photon extrapolation	0.8%	0.3%
A.P. Long term stability	0.5%	0.4%
Extra uncertainty on calo scale	1.2%	1.5%
Gain mismatch	0.3%	0.3%
Pockels cell misalignment	0.4%	0.5%
IP interaction	0.8%	on going
Laser light polarization	0.2%	on going

- Current analysis confirms released values
- Extra uncertainty on the analyzing power to be increased to 1.5%