Precision Measurement with the Transverse Polarimeter@ HERA II

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- Introduction
- The Transverse Polarimeter
  - Setup & Measurement Principle
  - The HERA−II−Analysis
  - First polarised data from October 2002 and March 2003
  - Monte Carlo Studies
- Conclusions & Outlook

Introduction: Some History…

If depolarising effects are controled:

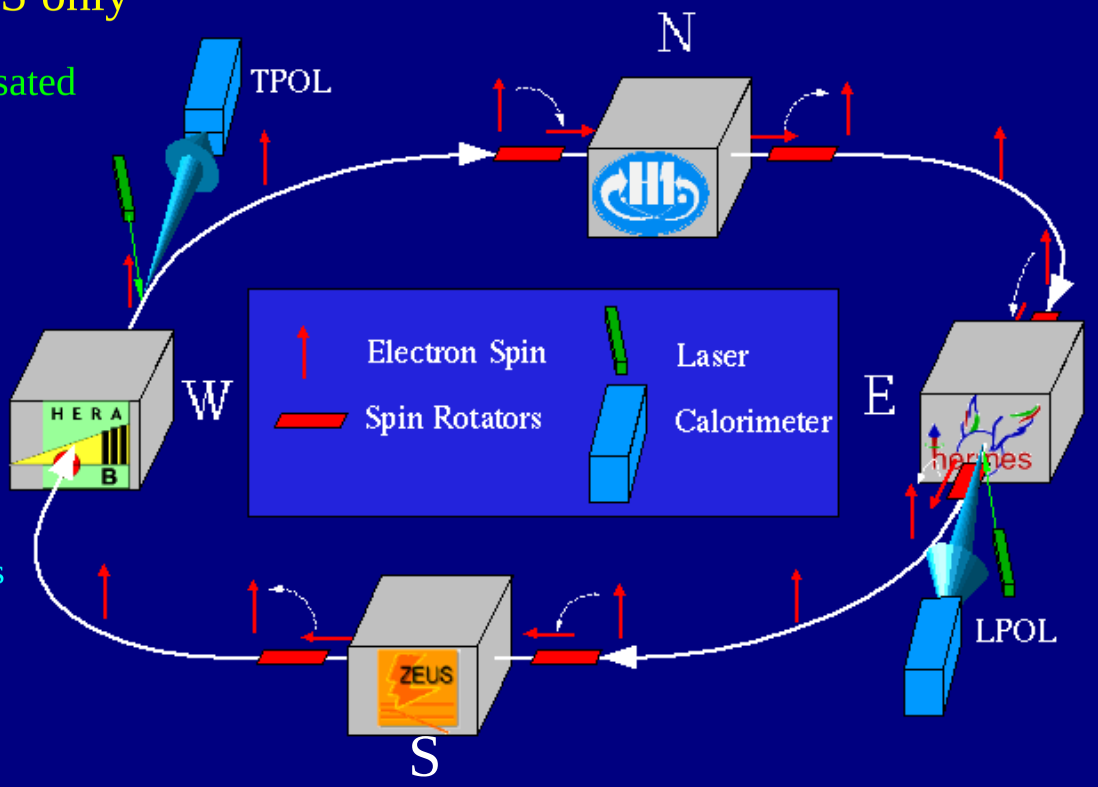
- Sokolov−Ternov effect: build−up of transverse polarisation
- Spin rotators: longitudinal polarisation

HERA I: spin rotators at HERMES only

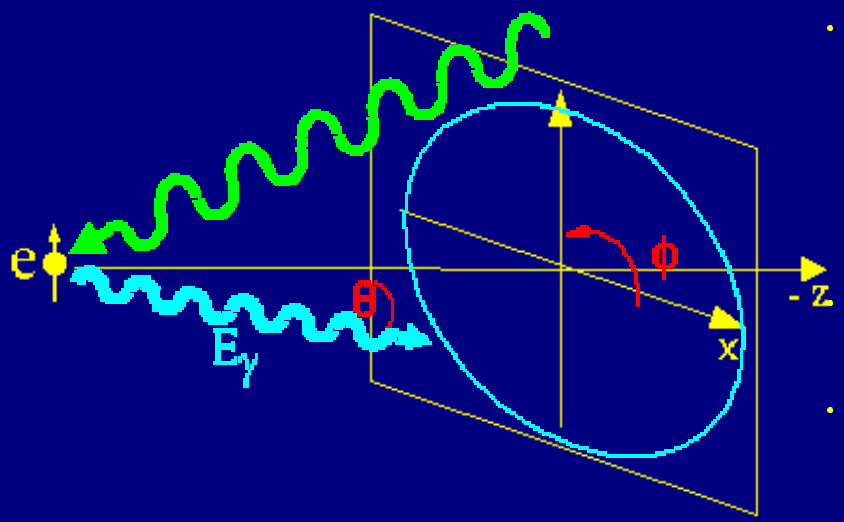
- H1 & ZEUS solenoid are compensated
- 65% polarisation routinely
- TPOL measures bunch averaged

HERA II: additional spin rotators at H1 & ZEUS

- experiments require $\delta P/P < 1\%$
- TPOL: major upgrade in 2001
  - "bunch by bunch" measurements
  - Si−strip & scintillating fiber
  - DAQ: better linearity
  - New Analysis
- LPOL: upgrade ongoing



Principle of Measurement: Compton−Scattering



- kinematics described by 2 variables:
  - polar angle θ <=> E_γ (photon energy)
  - azimutal angle ϕ => y (vert. position)
- S1, S3: lin. & circ. polarisation of laser
- P_Y,P_Z: transv. & long. beam polarisation

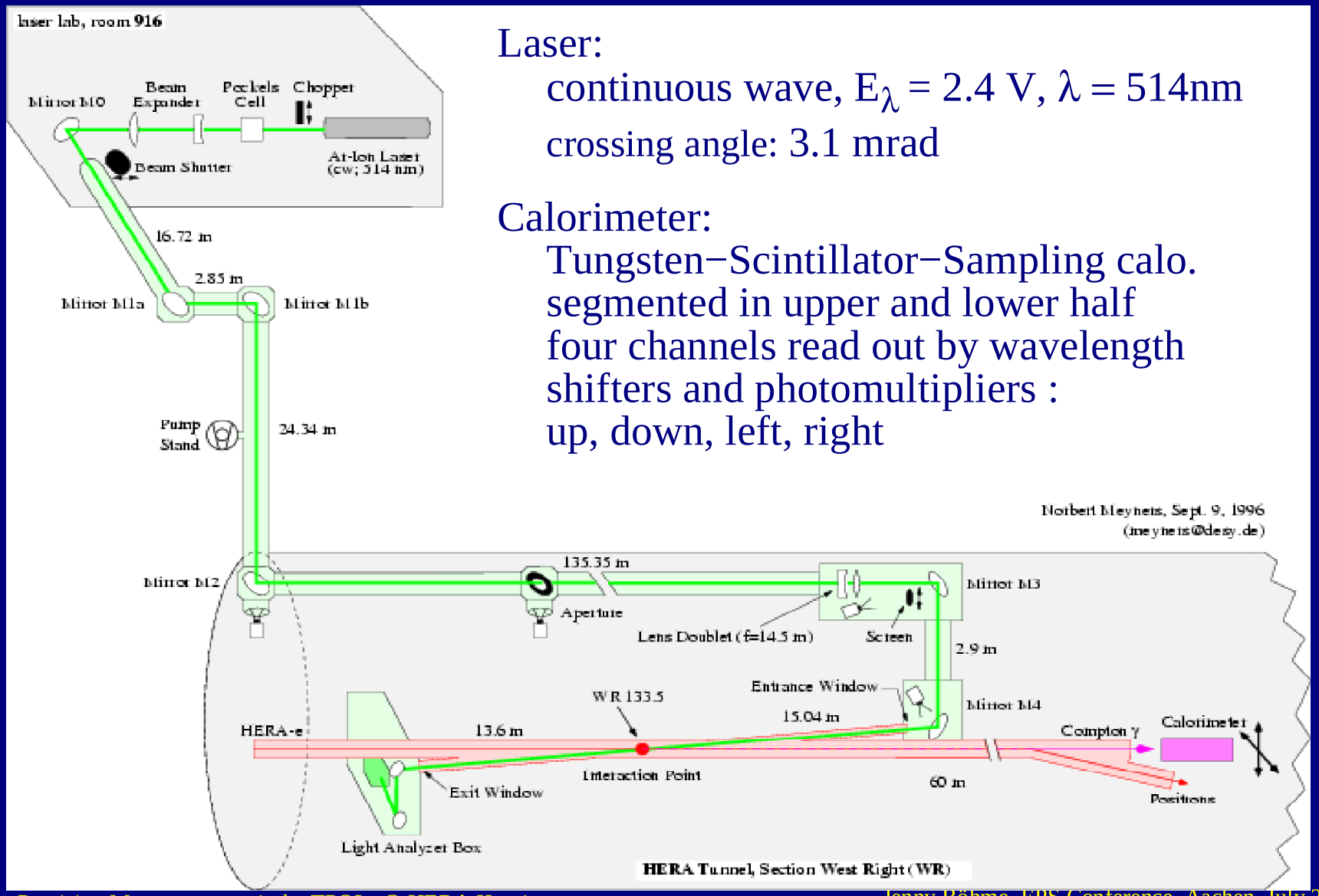
$$\frac{d^2\sigma}{dE\, d\phi} = \Sigma_0(E) + S_1\, \Sigma_1(E) \cos 2\phi + S_3\, (P_Y \Sigma_{2Y}(E) \sin\phi + P_Z \Sigma_{2Z}(E))$$

TPOL: measure (energy dependent) angular asymmetry

- up−down asymmetry very small (even at 65m!)
- need very precise position measurement (better than 10μm)

IMPORTANT: use asymmetry w.r.t. $S_3 = +1$ and $S_3 = -1$

TPOL: Setup (I)



Laser:

continuous wave, $E_\lambda = 2.4$ V, $\lambda = 514$nm

crossing angle: 3.1 mrad

Calorimeter:

Tungsten−Scintillator−Sampling calo.
segmented in upper and lower half
four channels read out by wavelength shifters and photomultipliers :
up, down, left, right

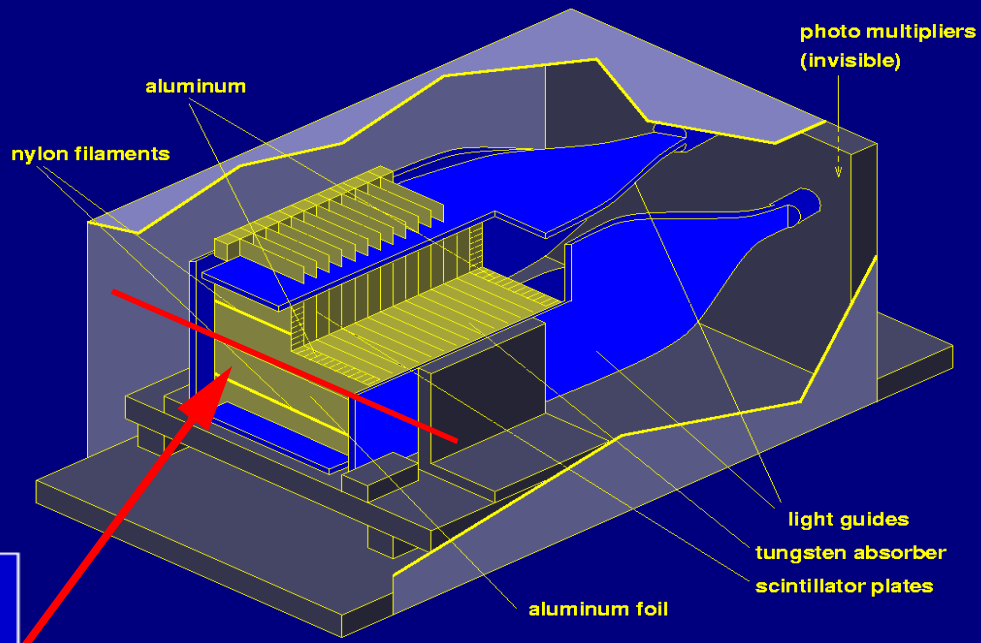
TPOL: Setup (II)

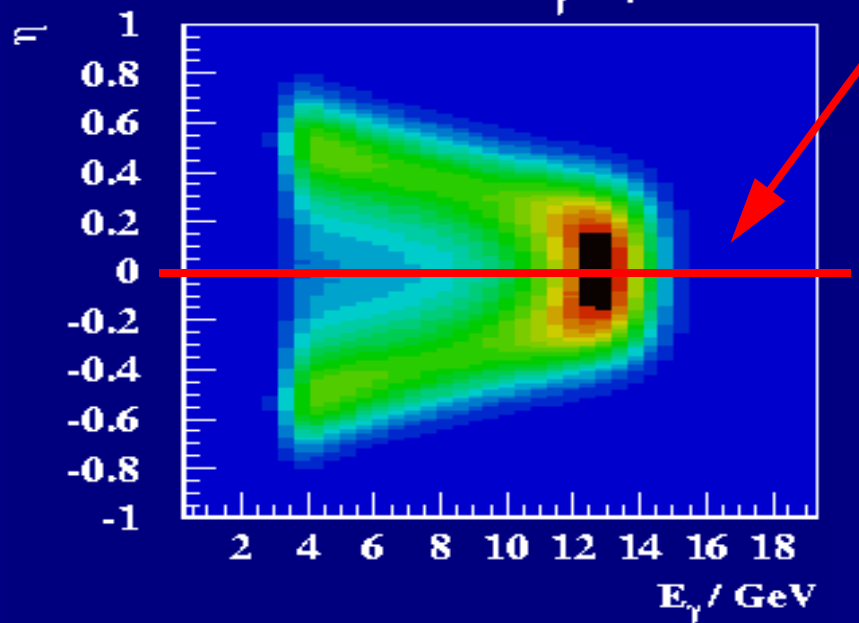
- measured quantities:

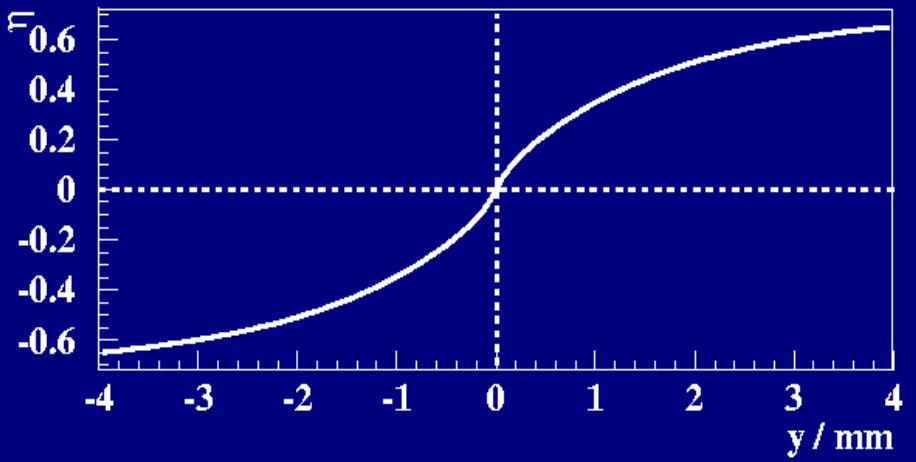
$E_\gamma = E_{up} + E_{down}$

$\eta = (E_{up} - E_{down})/(E_{up} + E_{down})$,

$y = y(\eta)$ <=main uncertainty!

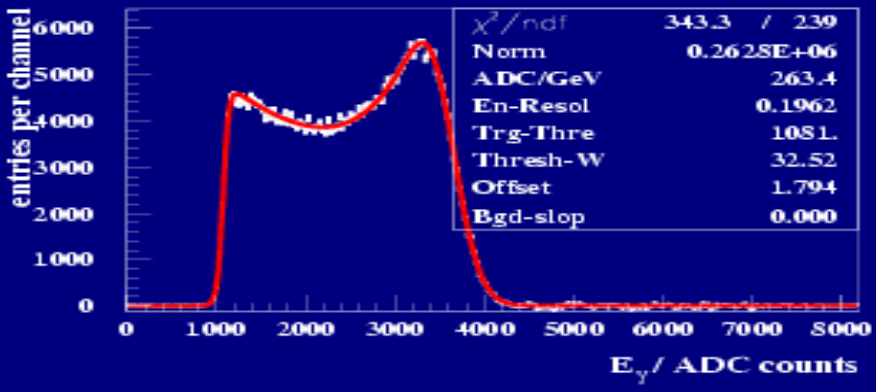


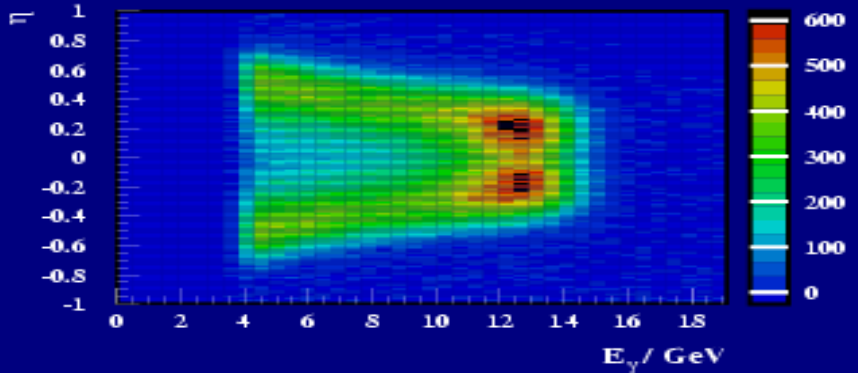


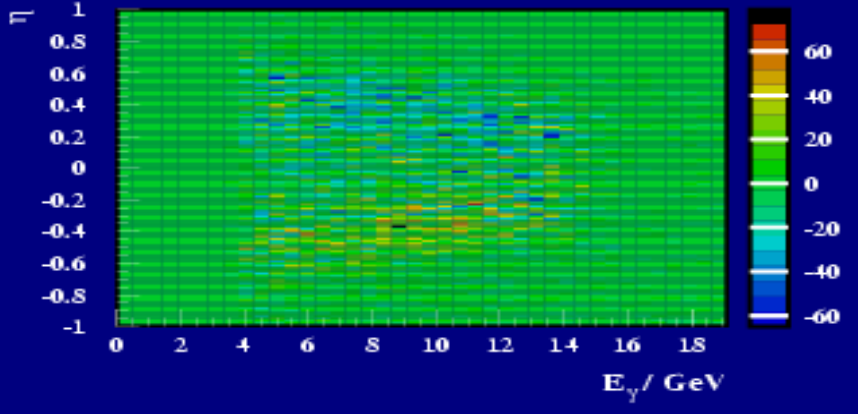


The New Offline Analysis

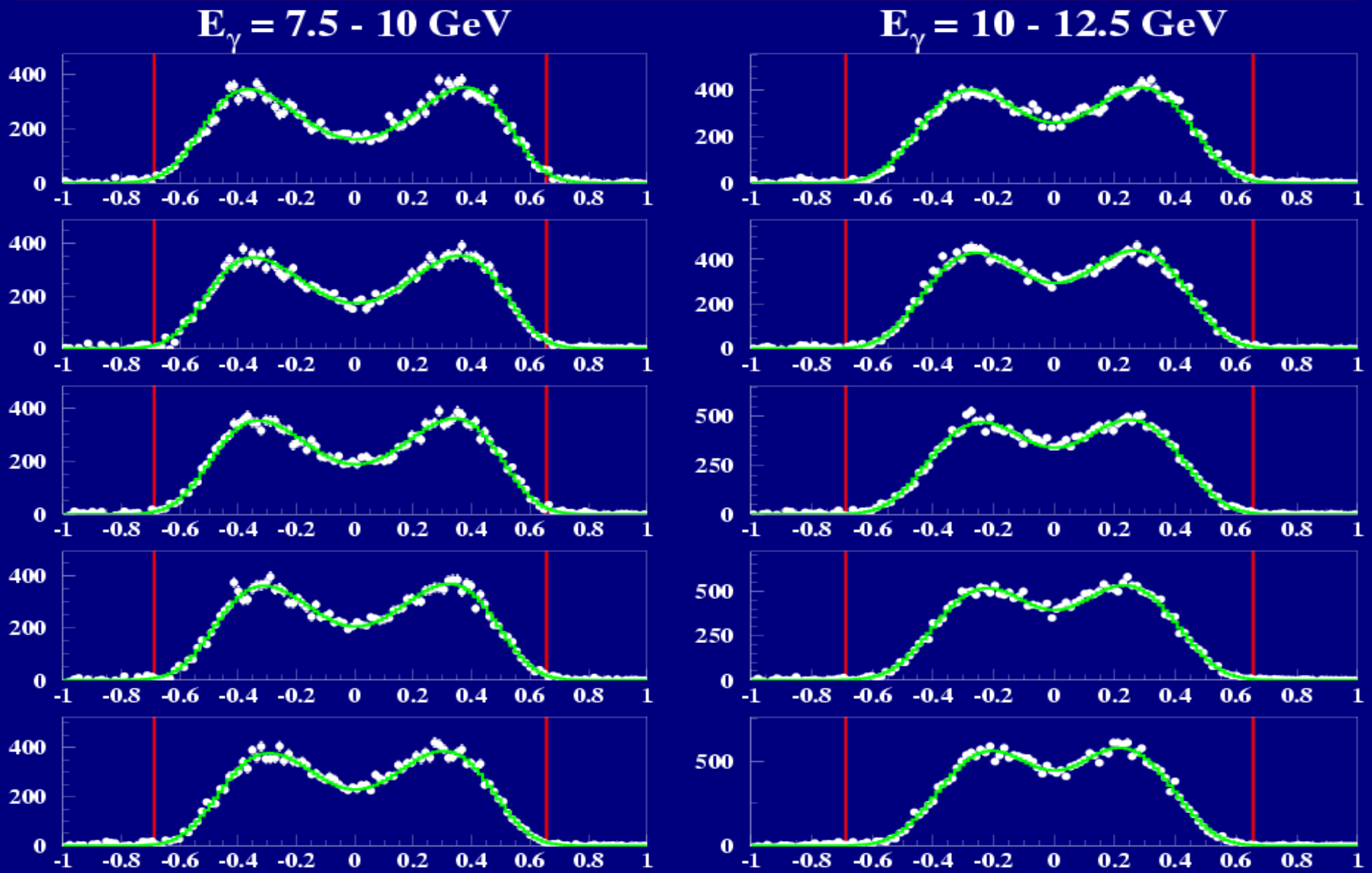
- Energy calibration:
  1D−energy spectrum provides Compton edge
- fit sum of 2D−spectra for laser "LEFT" and "RIGHT"
  $= 2\Sigma_0 + (S_{1R} + S_{1L})\,\Sigma_1$
  => determine system parameters independent from polarisation!
- fit difference of 2D−spectra for laser "LEFT" and "RIGHT"
  $= (S_{1R} - S_{1L})\,\Sigma_1 + 2\,S_3\,P_Y\,\Sigma_{2Y}$
  => all system parameters fixed, vary only polarisation!



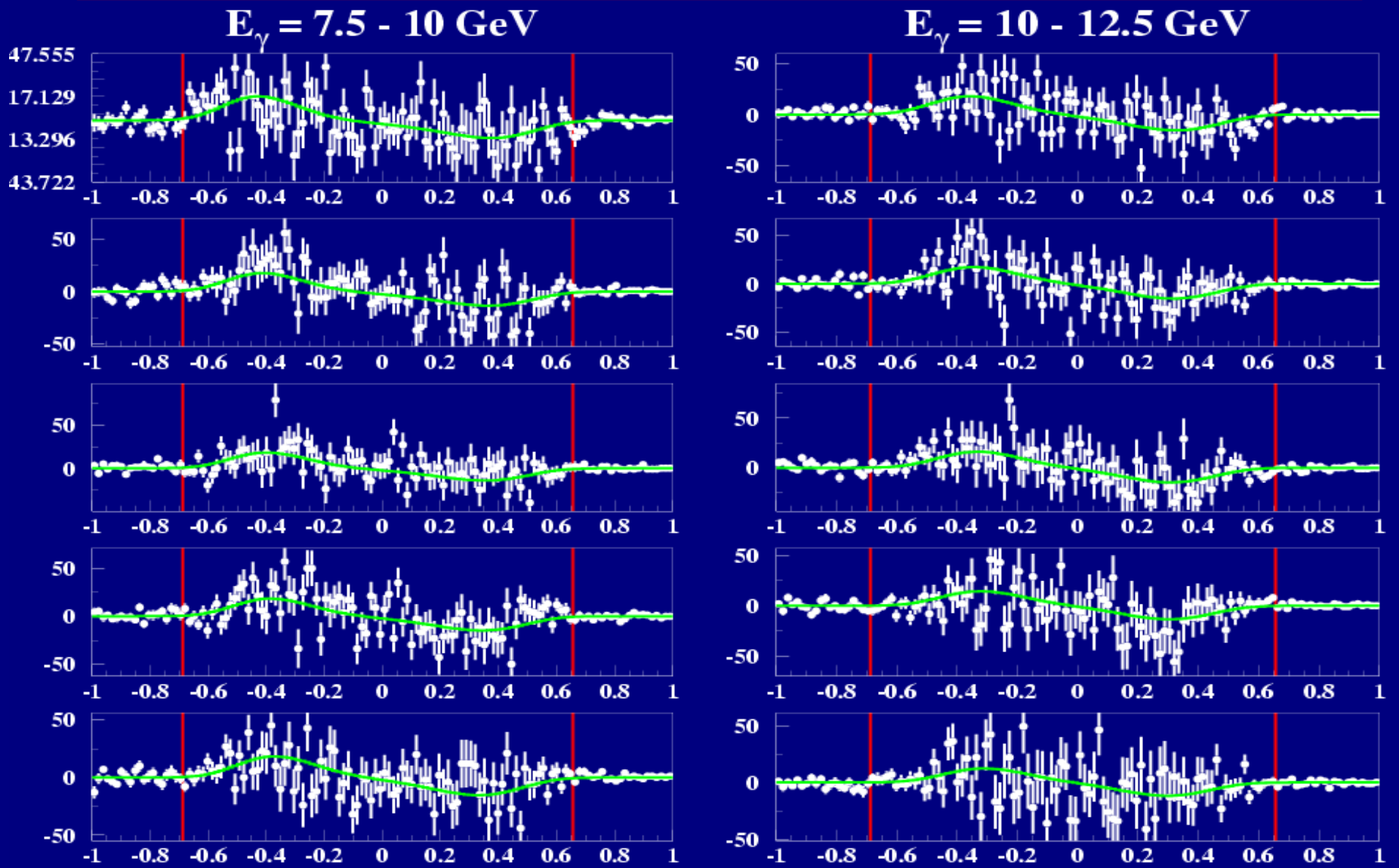




Data of 1 Minute (Oct. 17, 2002): Calibration Fit



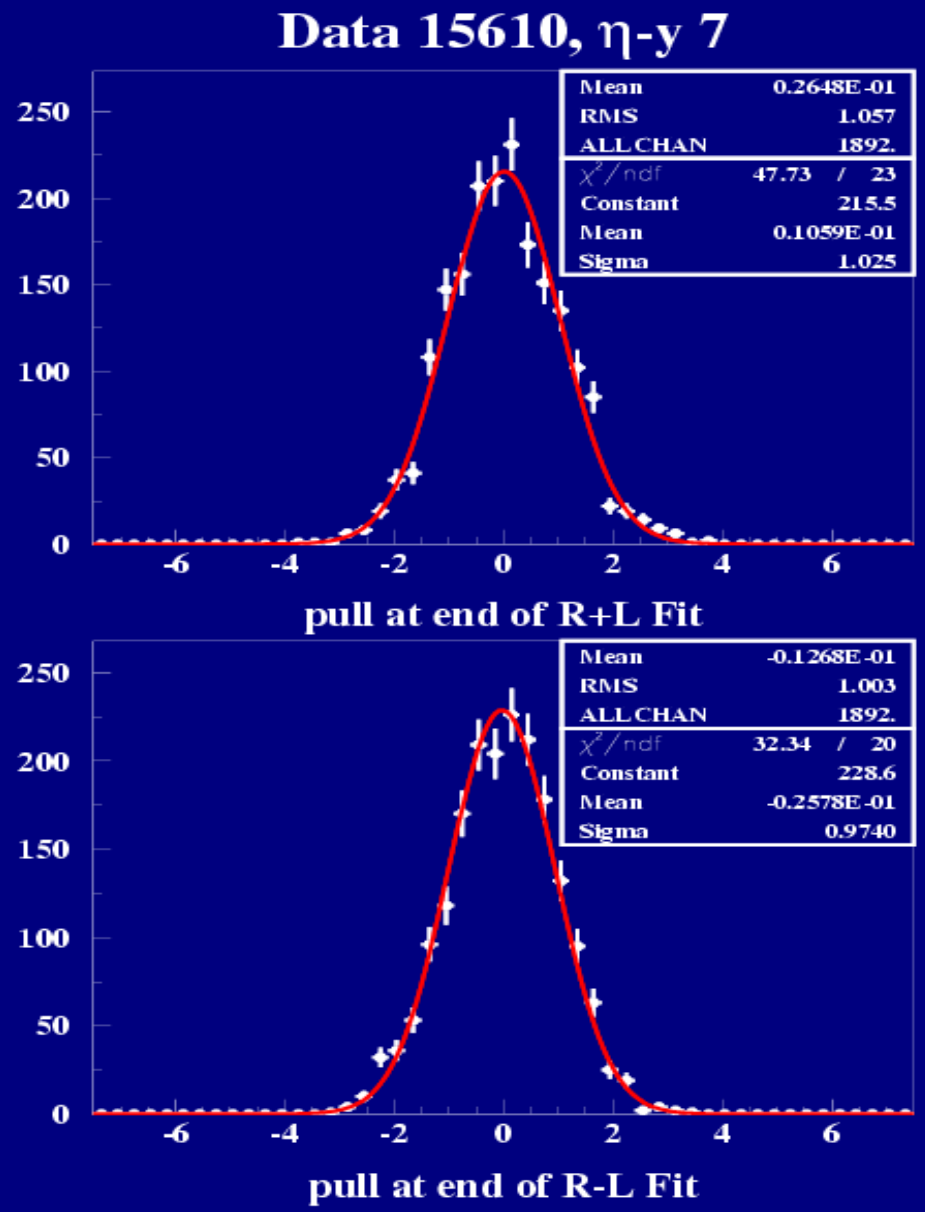
Data of 1 Minute (Oct. 17, 2002): Polarisation Fit



Pull Distribution of a 1−Minute−Fit

- reminder:
  - Pull = $(X_{data} - X_{fit}) / \sigma_{data}$
  - perfect fit: <pull> = 0

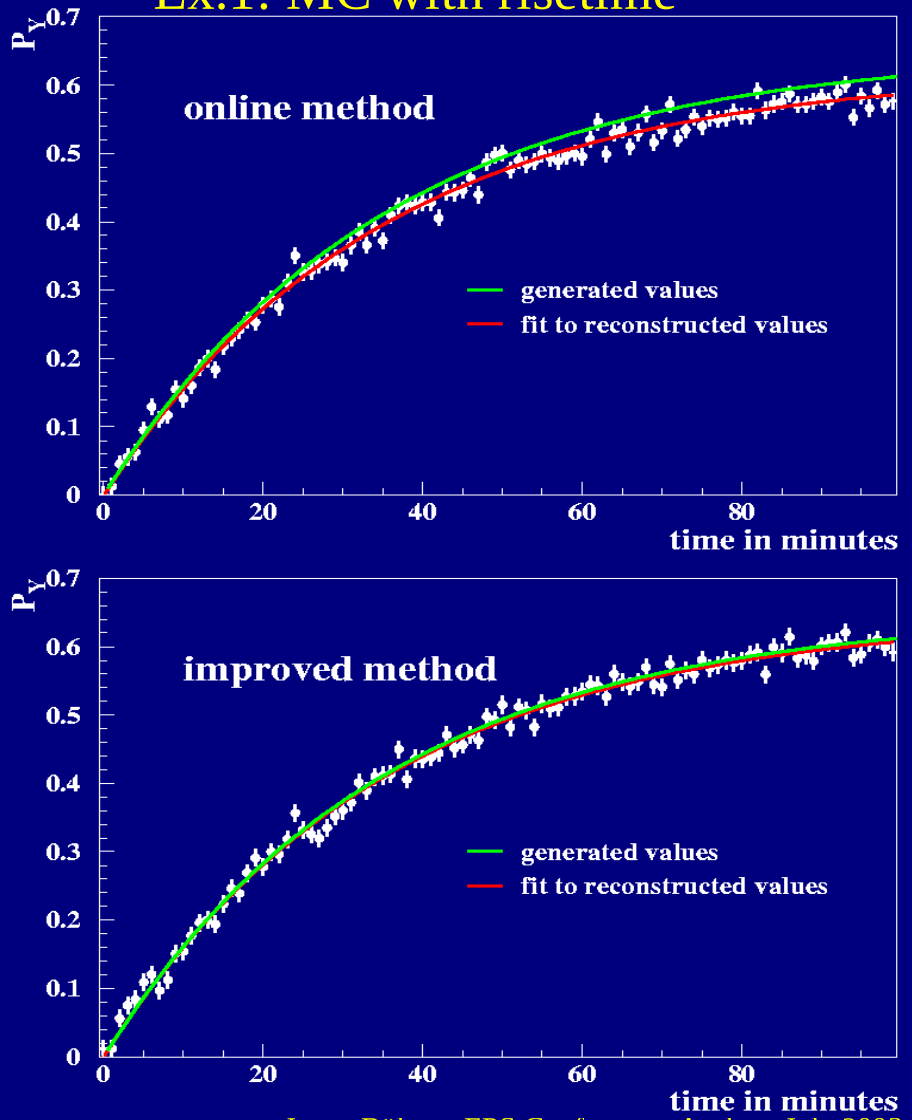
    $\sigma_{pull} = 1$
- here:
  - X = bin content
    each bin of
    2D histogram gives
    one entry in pull distribution
    (~ 2000 bins!)
- conclusion:
  - fit describes the data very well!



100 Monte Carlo Minutes (I)

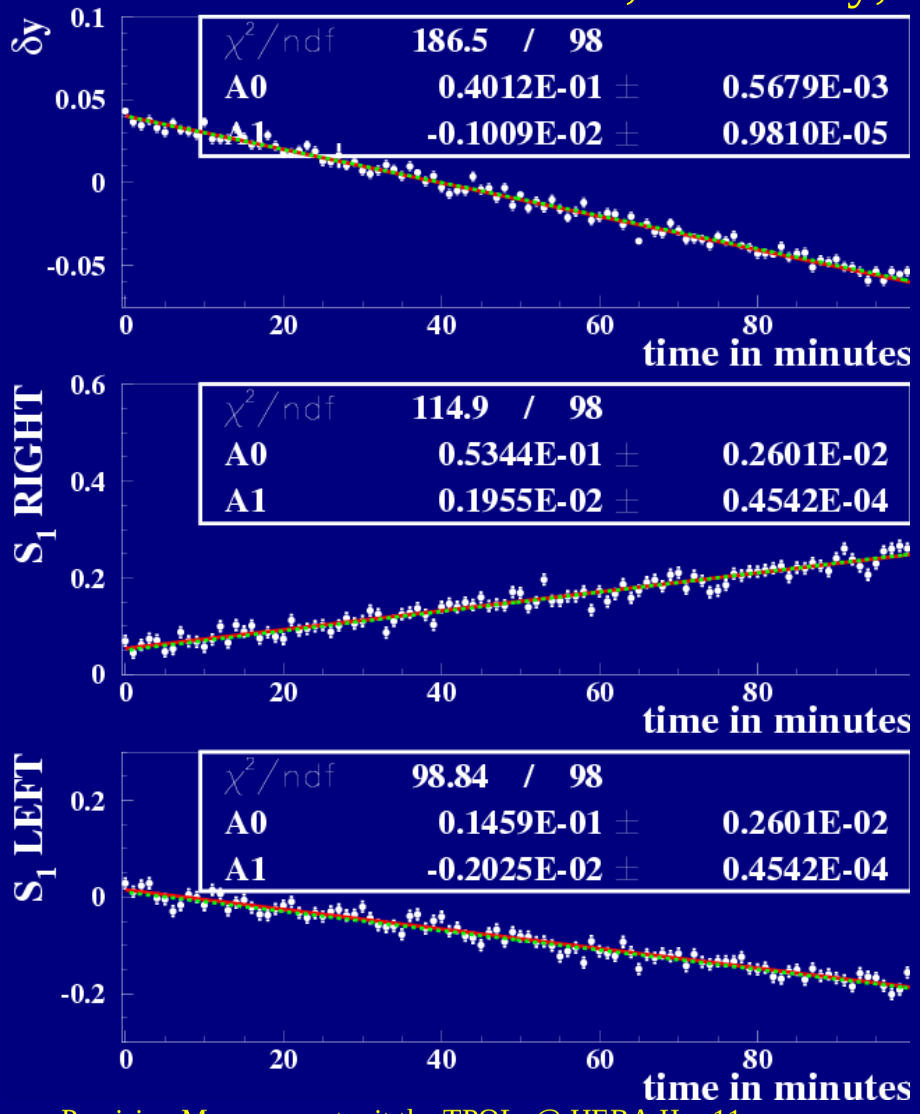
- generate and analyse MC runs with changes in one or more parameters:
  - polarisation
  - beam position
  - beam spot size
  - linear laser polarisation
  - rel. calibration of E_u vs E_d
  - $\eta-y-$transformation
- => gives "partial derivative" $\partial P/\partial x_i$, i.e. with resonable assumption on δx_i:
  - estimate of systematic effects
  - should be repeated with data!

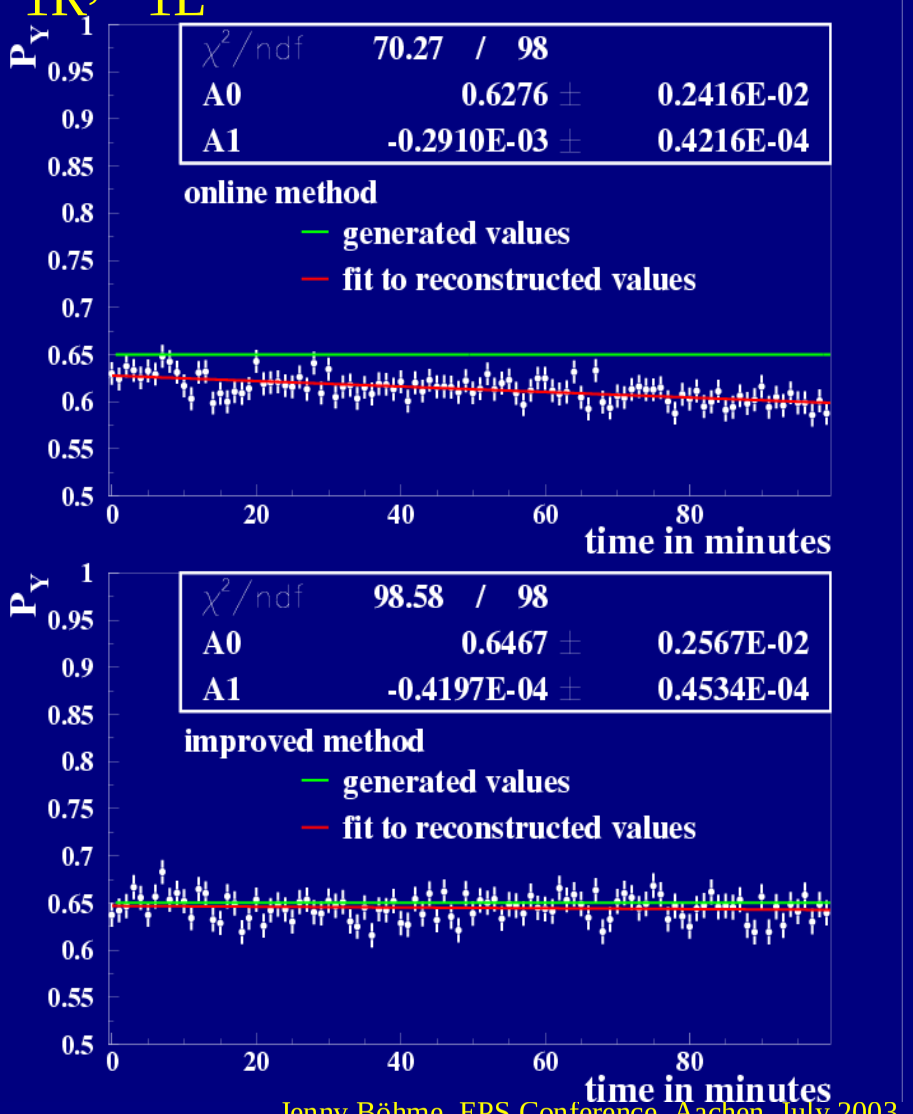
Ex.1: MC with risetime



100 Monte Carlo Minutes (II)

Ex.2: MC with P=65%, drift in δy, S_{1R}, S_{1L}:

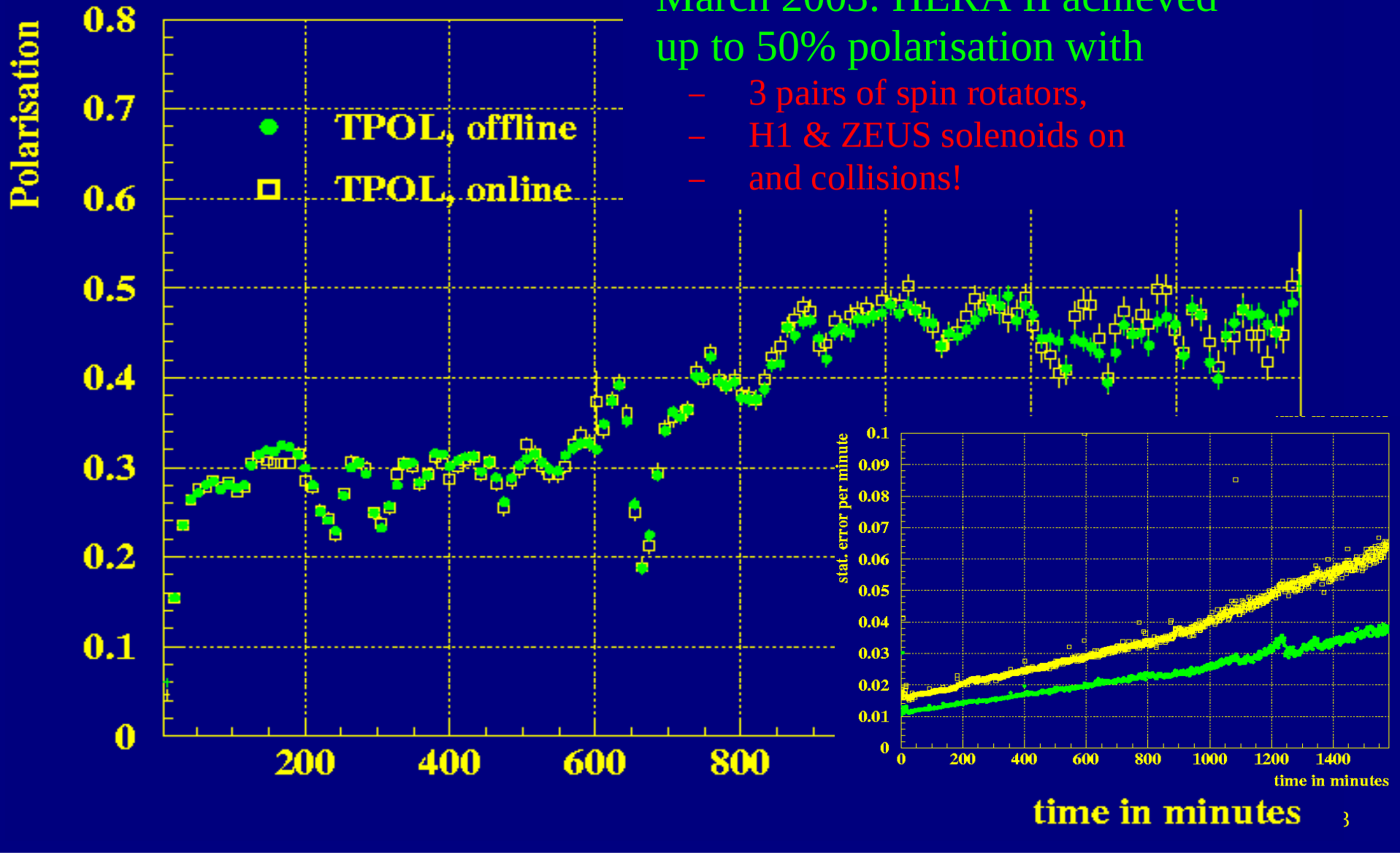




Highest Polarisation @ HERA II (so far!)

March 2003: HERA II achieved up to 50% polarisation with

- 3 pairs of spin rotators,
- H1 & ZEUS solenoids on
- and collisions!



Conclusions & Outlook

- $\delta P/P \leq 1\%$ required by physics programme of H1 & ZEUS
- upgrade of the Transverse Polarimeter:
  - not only hardware, but also analysis improved
  - understanding the TPOL to < 1% is within reach
- HERA II achieved 50% polarisation with 3 spin rotators, both solenoids and collisions (H1 & ZEUS)
- more polarised data under stable conditions are need for final calibrations and systematic studies
- Longitudinal Polarimeter major upgrade ongoing − looks promising!

=> the POL2000 group congratulates HERA to the success of 50% polarisation and is looking forward to more data after the shutdown!