

Polarization at HERA



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V.Gharibyan

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Introduction

Transverse Polarimeter (TPOL)

Longitudinal Polarimeter (LPOL)

Cavity Project

Machine Aspects

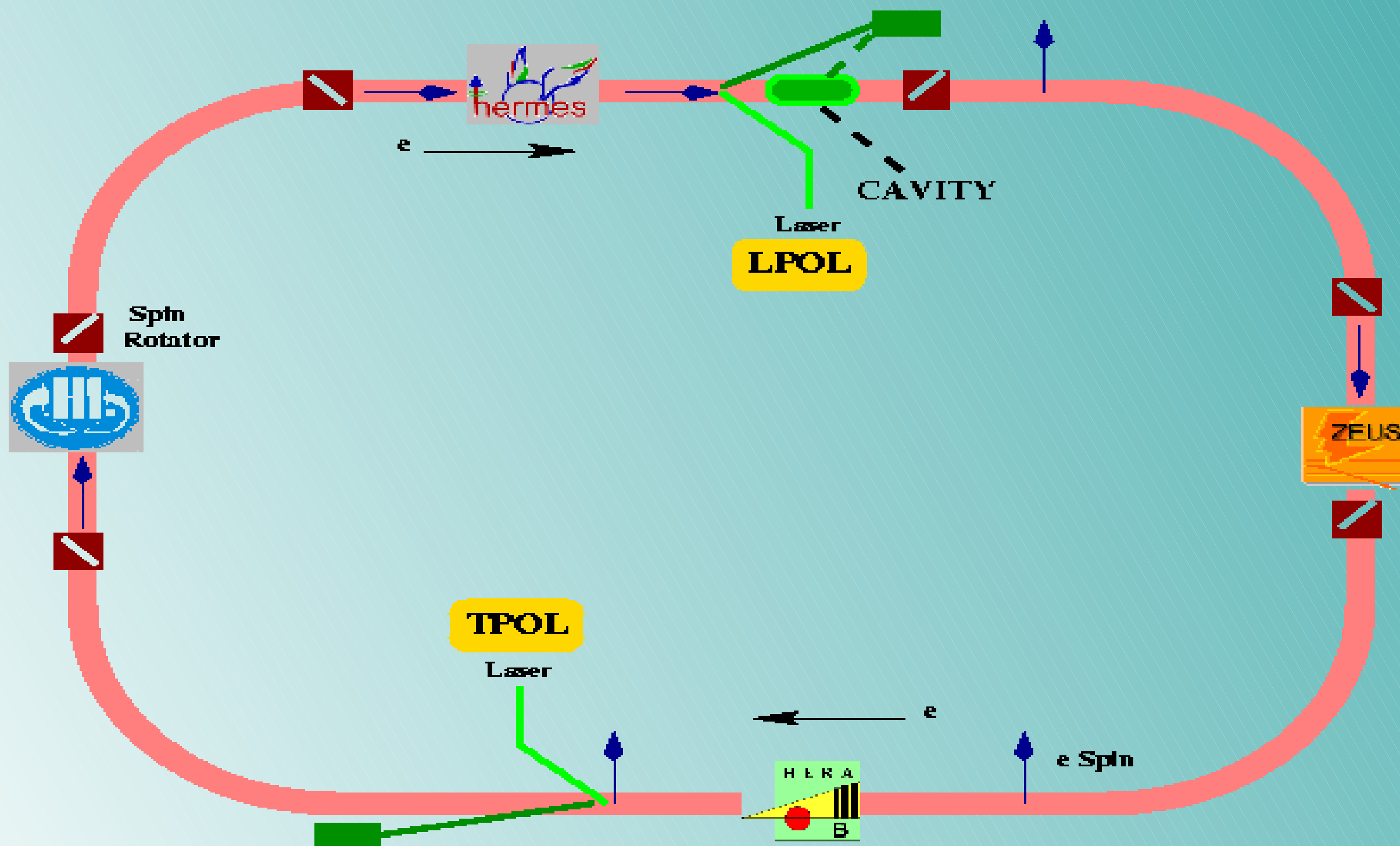
Summary

HERA II

Spin Configuration and Polarimeters

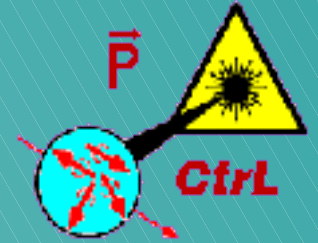


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HERA Compton Polarimeters

Operating Modes and Principles



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Laser Compton scattering off HERA electrons

TPOL

CW Laser - Single Photon

LPOL

Pulsing Laser - Multiphoton

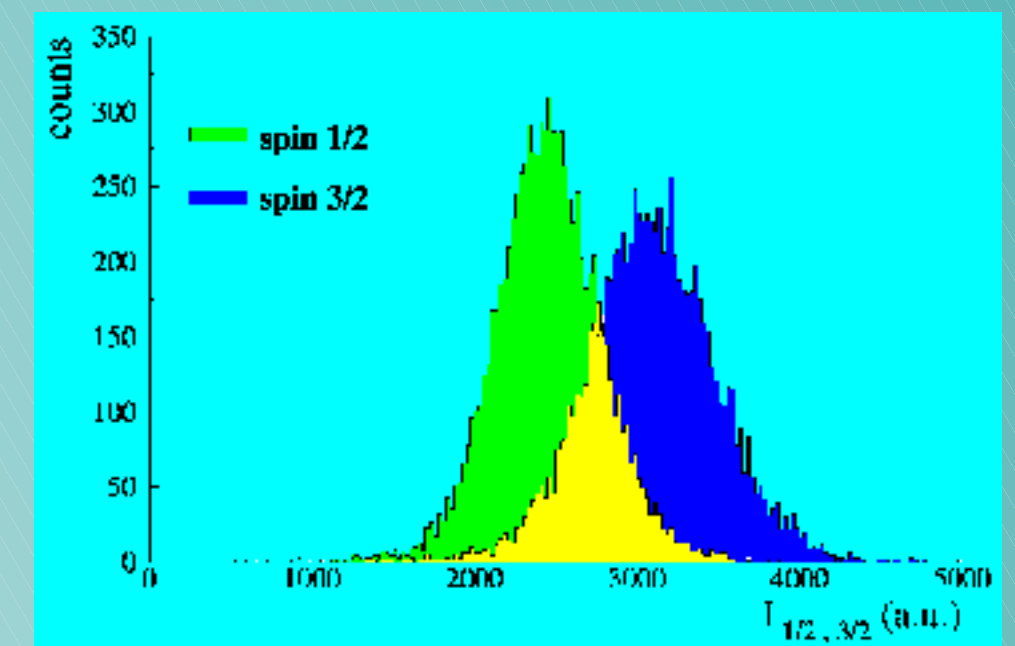
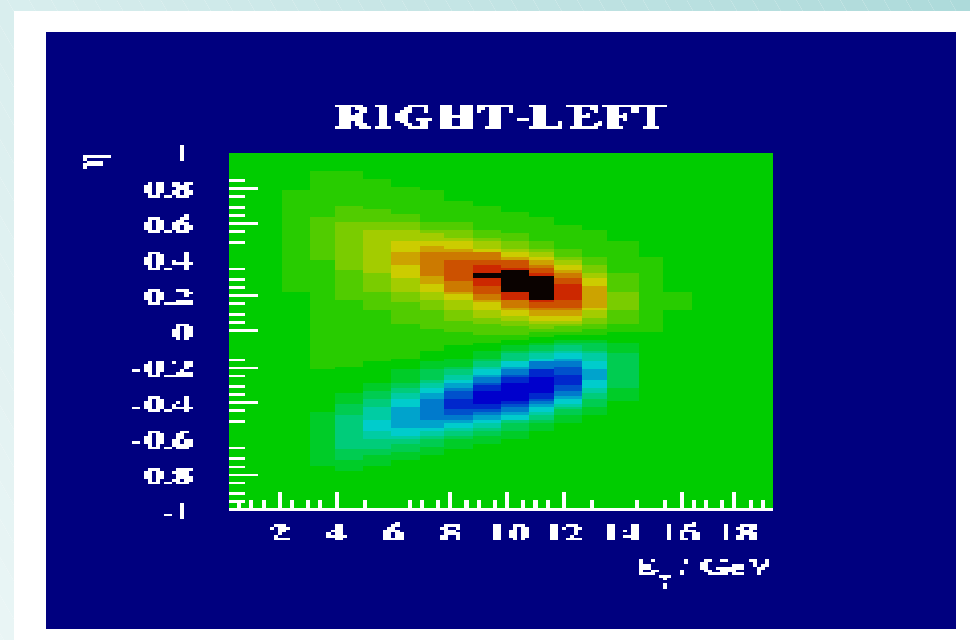
Flip laser helicity and measure scattered photons

$P_y = 0.59$

Spatial Asymmetry

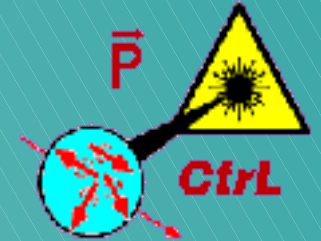
$P_z = 0.59$

Helicity Dependent γ Spectra



Statistical Error $\Delta P = 1\%$ per minute @ HERA average currents

Transverse Polarimeter Upgrade Goals



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Measure bunch by bunch and Reduce systematic error

Systematics @ HERA I

Improvements @ HERA II

Input Parameter Nominal Value	Max. and Min. Values	Resulting change in Polarisation (%)
Calorimeter Centering nominal: 0.00mm	0.03mm -0.03mm	+0.14 -0.19
Light Polarisation ΔS_1 nominal: 9%	12%	-0.34
Pedestal Position nominal: 0 ADC ch	23 ADC ch	+0.33
Electron Spot $\sigma_{e,y}$ nominal: 0.50mm	0.45mm 0.55mm	+1.10 -1.16
$\eta - y$ Transformation nominal: CERN 8 GeV	CERN 5 GeV† CERN 11 GeV	+0.69 -0.69

Online η - y => Converge better
Frequent Optimization with
light calorimetry
Event by event pedestals

2D fit

Online η - y

Silicon

SLOW Ctr
Optics
DAQ

Analysis

Silicon
Sci-Fiber

	Rise-Time Measurement Rotators Off	Rise-Time Measurement Rotators On	Monte-Carlo Calculation
Analysing Power (%)	9.608	9.608	8.936
Systematic Error (%)	3.4	1.8	1.95

0.891

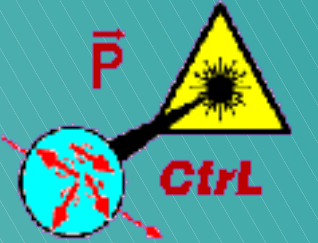
< 1%

Analysis

ALL

Transverse Polarimeter

Upgraded TPOL

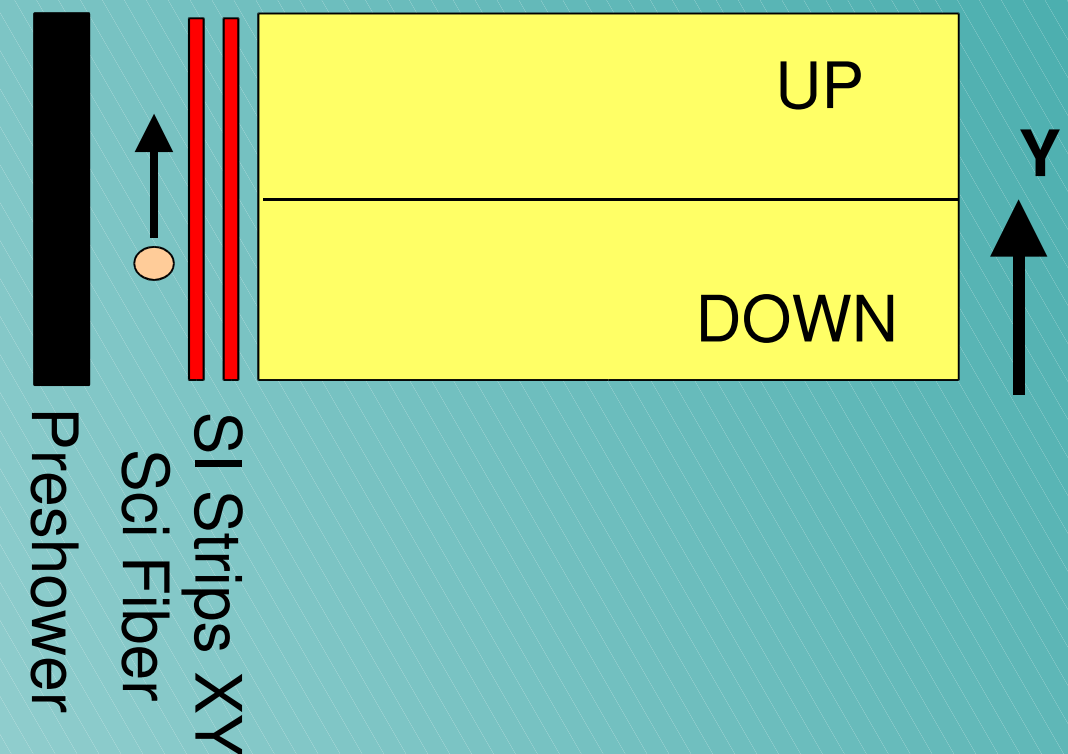


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New Position sensitive detectors-
Calorimeter spatial calibration
New DAQ - measure each
bunch polarization



Compton γ Beam



Calorimeter (100kHz) Energy-Position

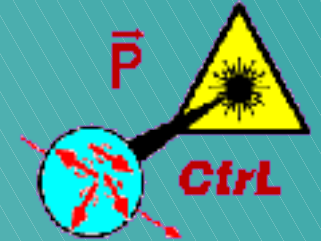
$$E_{\gamma} = E_{up} + E_{down}$$

$$h = (E_{up} - E_{down}) / (E_{up} + E_{down})$$

Silicon (1kHz) - Position

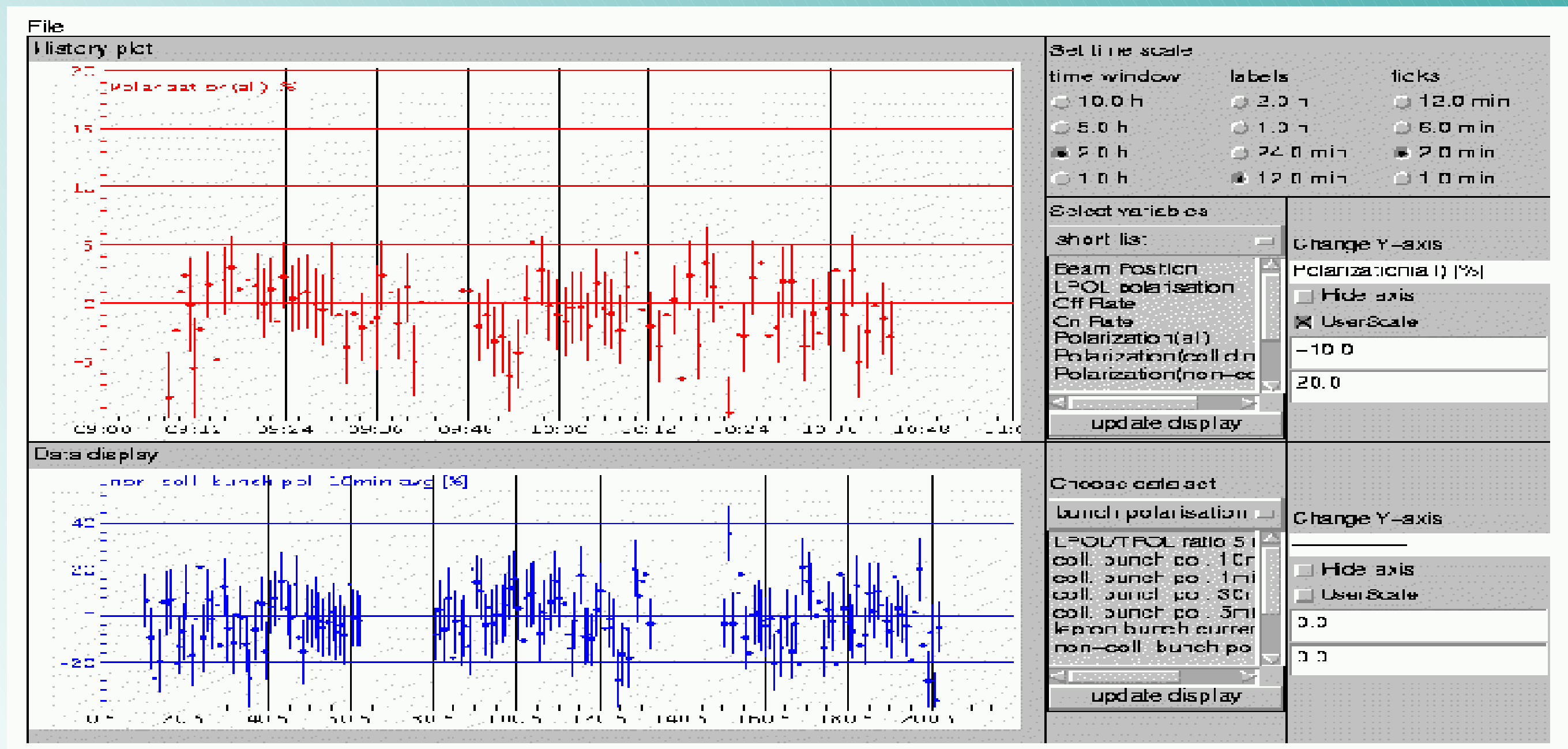
Transverse Polarimeter

Routine Operation (3 May 2002) with $I_e = 3.5\text{mA}$



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Online Display

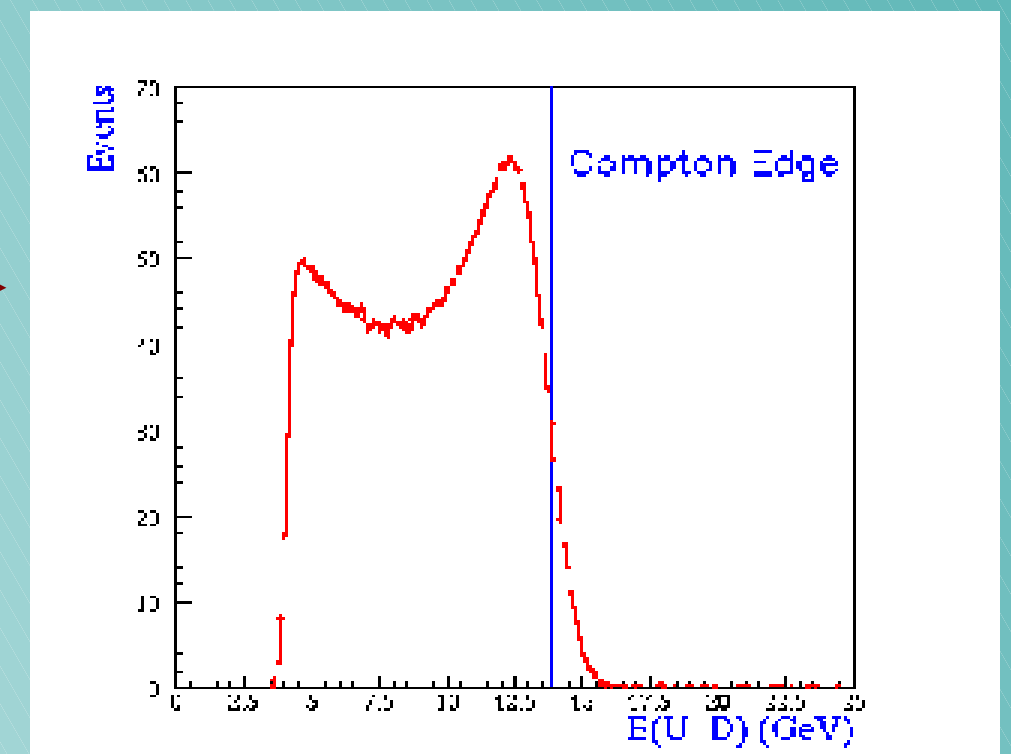
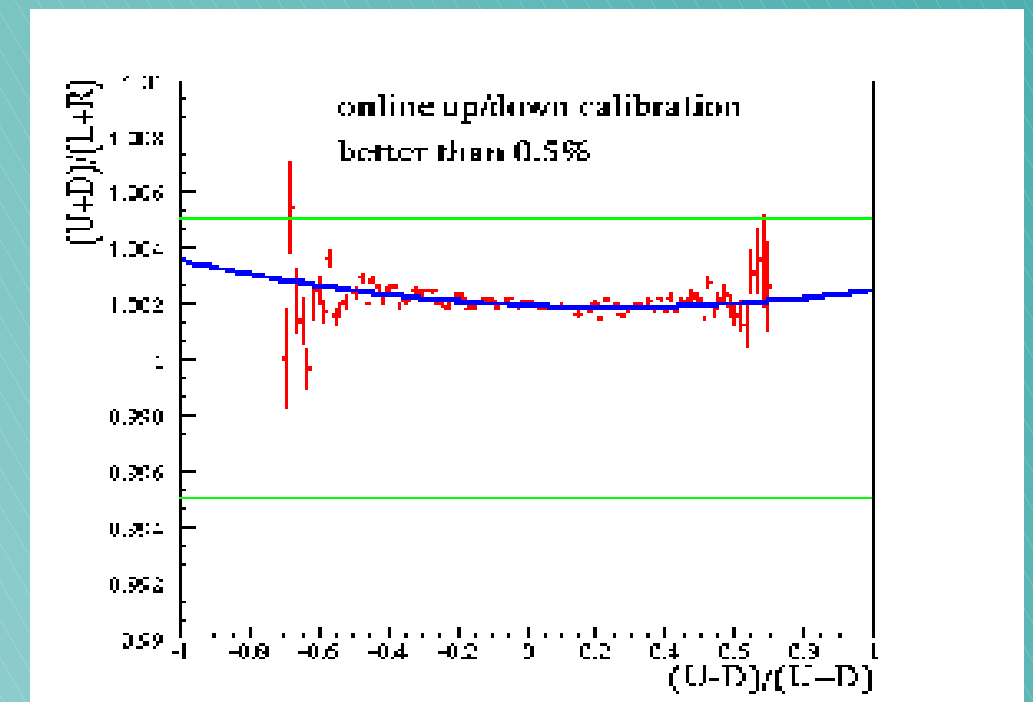
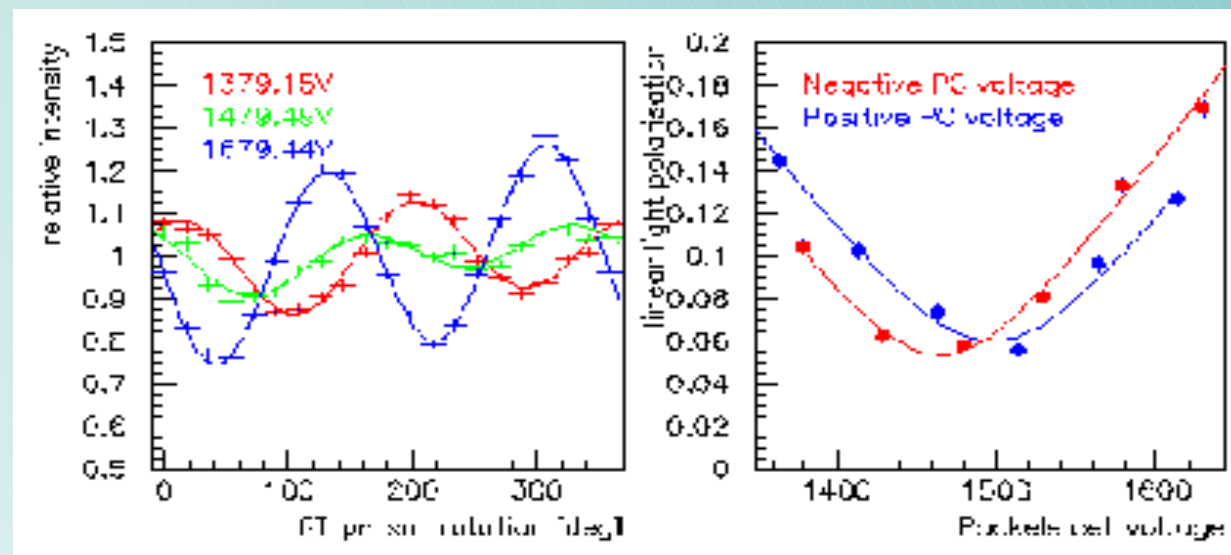


Transverse Polarimeter Calibrations



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Light Pol. Optimization



Calorimeter Gain matching
abs. Energy scale by Compton edge

Controlled per minute $< 0.5\%$ \Rightarrow

Contribution to beam polarization $< 0.1\%$

Transverse Polarimeter

Position Calibration

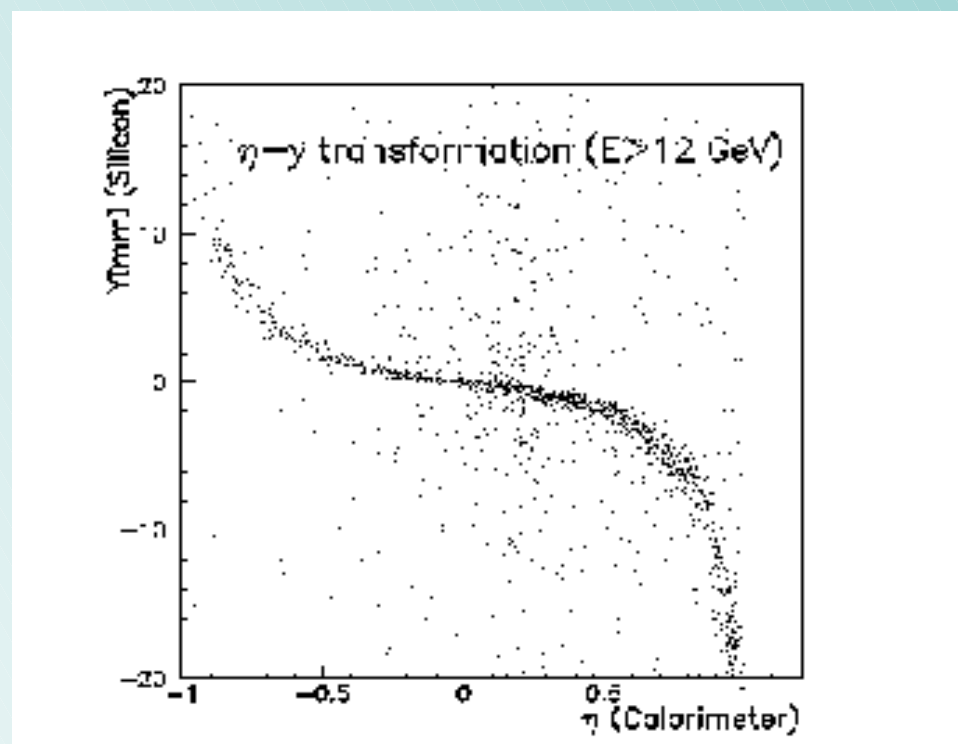


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Calibrated @DESY, CERN test beams=>
new AnalyzingPower=Old/1.078 (Preshower effect)

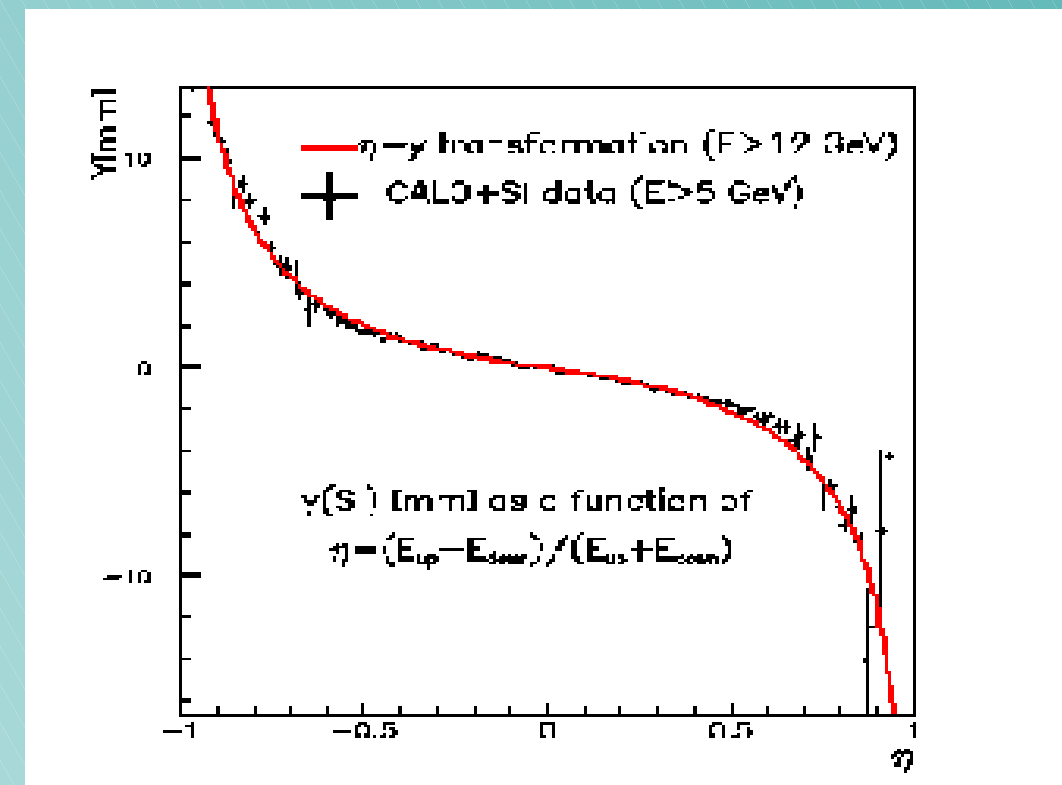
@ HERA

Compton Single photon
Y position by Silicon vs η



1kHz calibration data

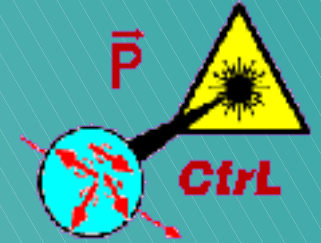
Parametrization



Input for Offline P extraction

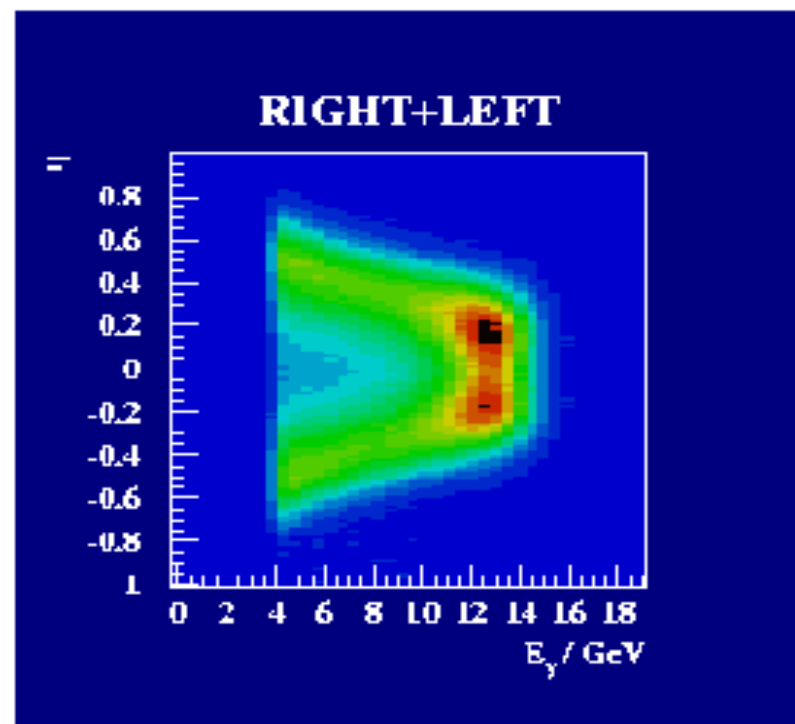
Transverse Polarimeter

New Offline Analysis

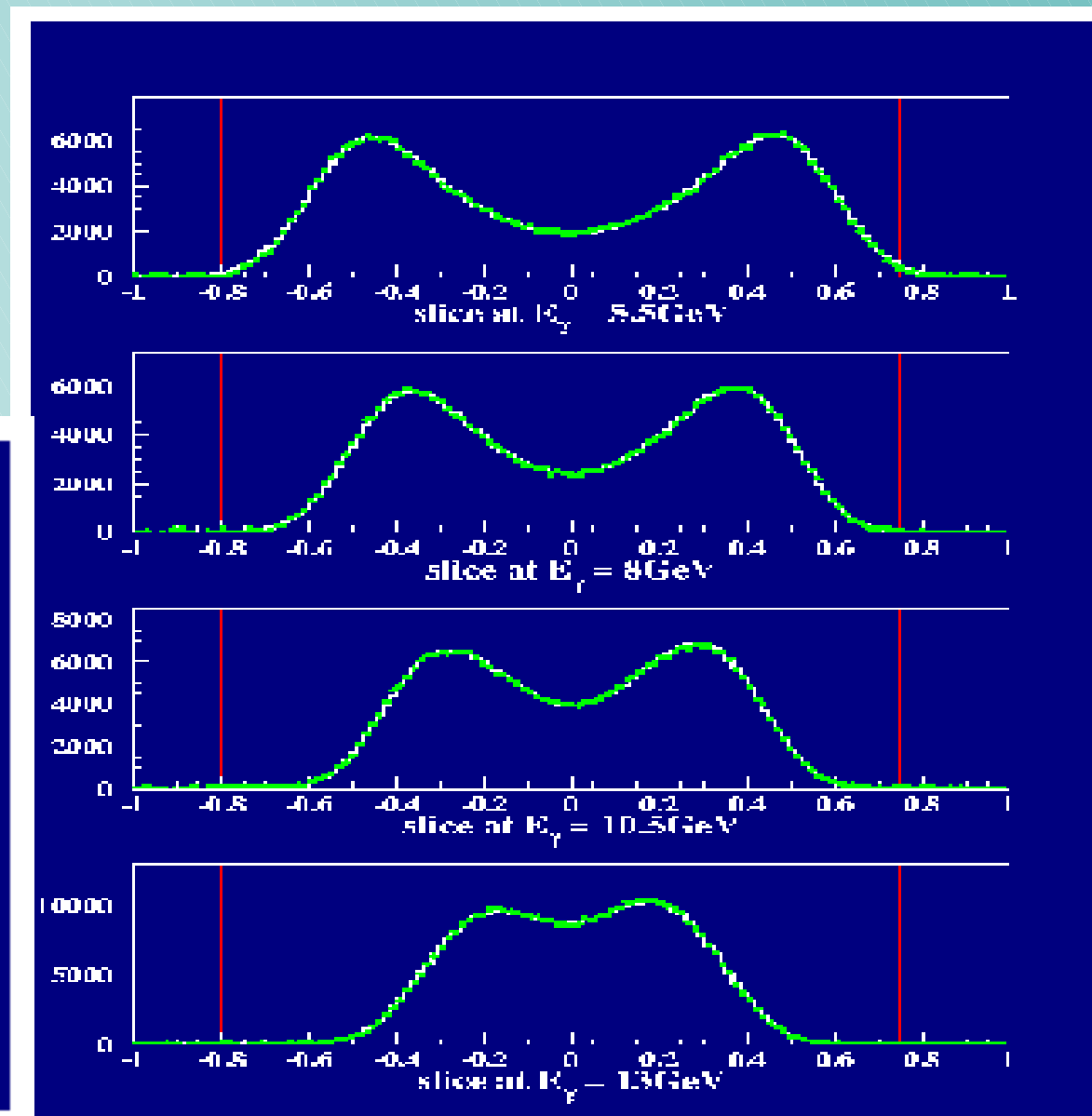


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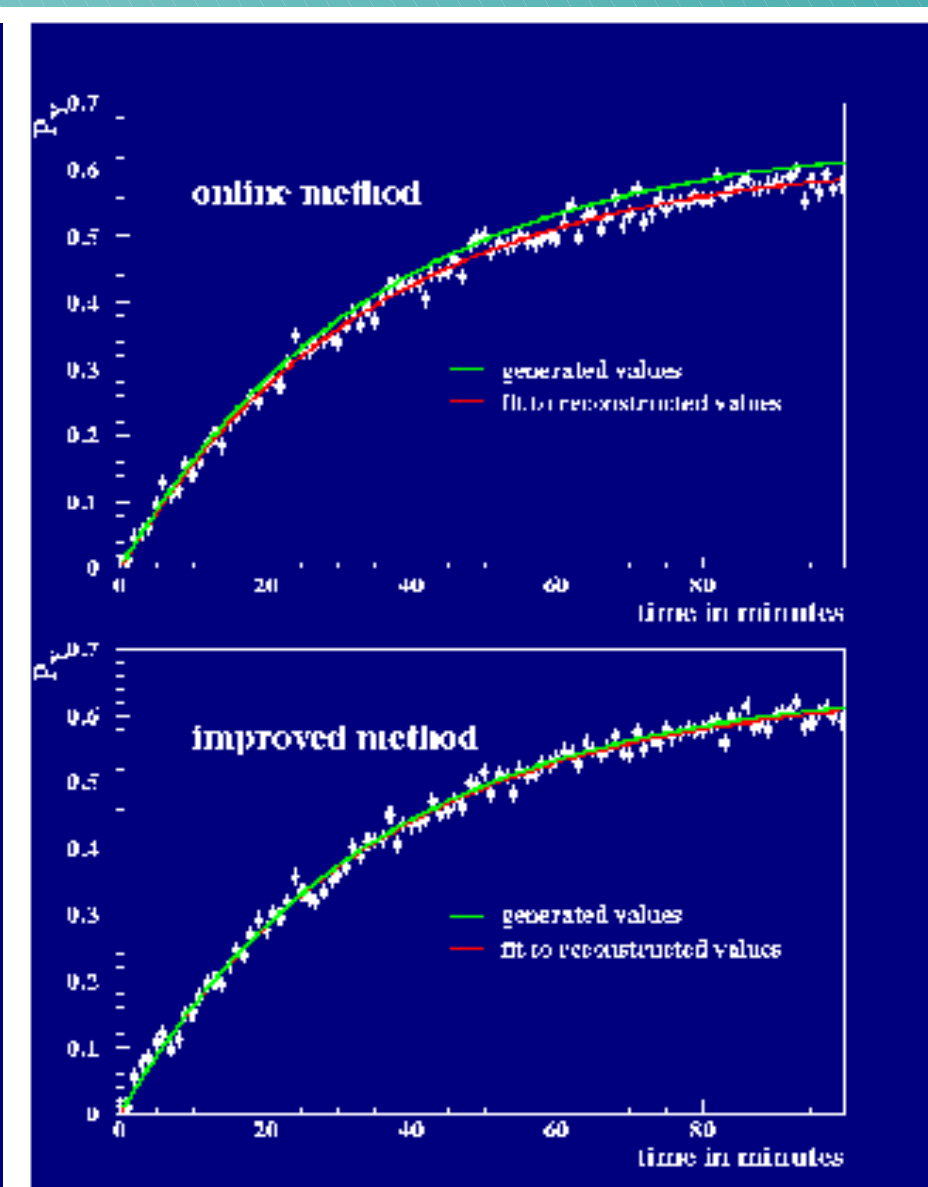
2D fit
Variable
Analyzing
Power



Fitted Energy Slices



Fit to MC Rise-Time



Longitudinal Polarimeter



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No major changes

- Has now two calorimeters which may be used alternatively: Crystal and Sampling with Scn. Fibers XY array in front.
- DAQ and SLOW control Software transported to faster computers.
- Online and Offline data are stored in HERA centralized database (similar to TPOL format) available to H1 and Zeus.
- Ready for polarization measurements.

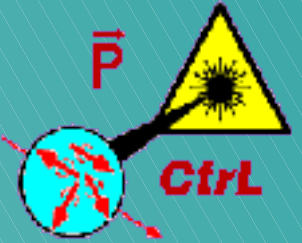
Achieved fractional systematic uncertainty 1.6%.

Nucl.Instrum.Meth.A479:334-348,2002

Upgrading to Cavity Polarimeter in progress.

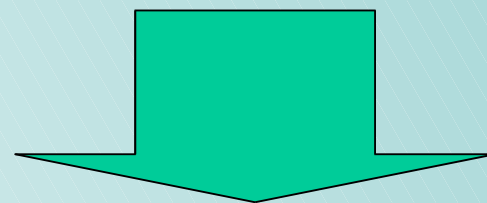
Cavity Polarimeter

Goals for LPOL upgrade

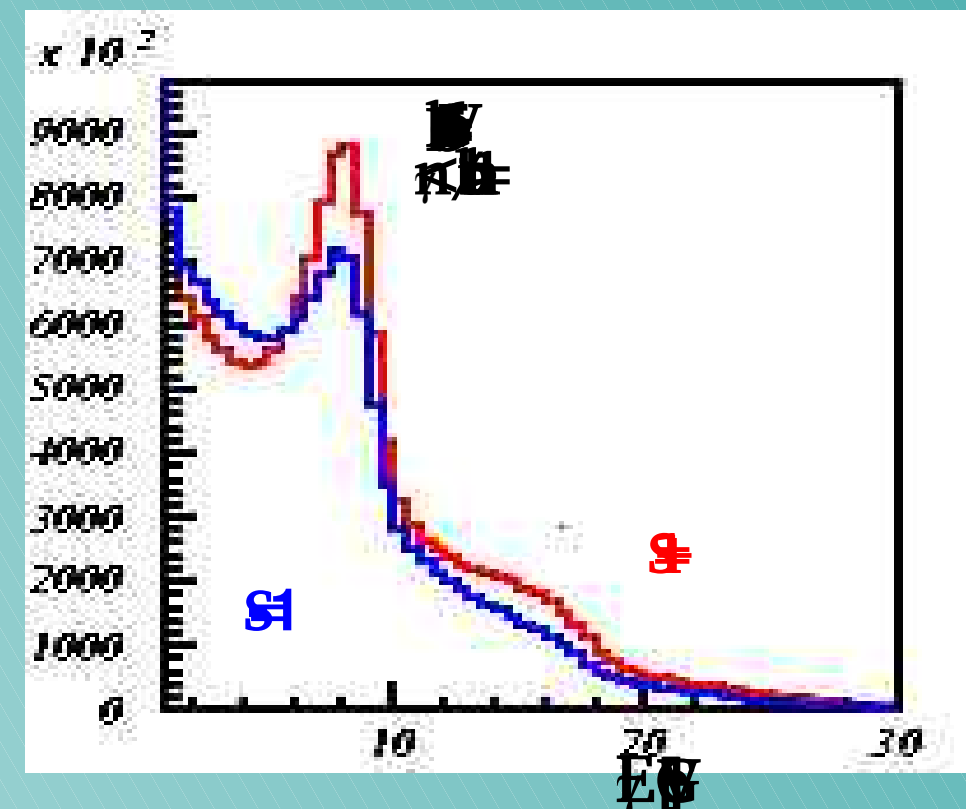
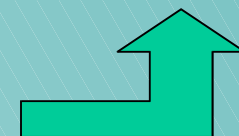


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- **Reduction of systematics (<1%)**
 - **Single photon mode**
 - Absolute scale calibration using Compton Edge
 - and Asymmetry 0 crossing.
- **Increase statistics**
 - **High laser power (cw)**
 - Large stat. \Rightarrow Fast measurement \Rightarrow
 - Fast optimisation of harmonic bumps \Rightarrow
 - Higher polarisation
 - Single bunch polarization error 1% per min

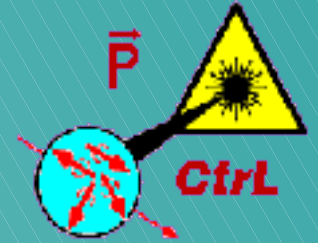


LPOL measurement in a few photon mode



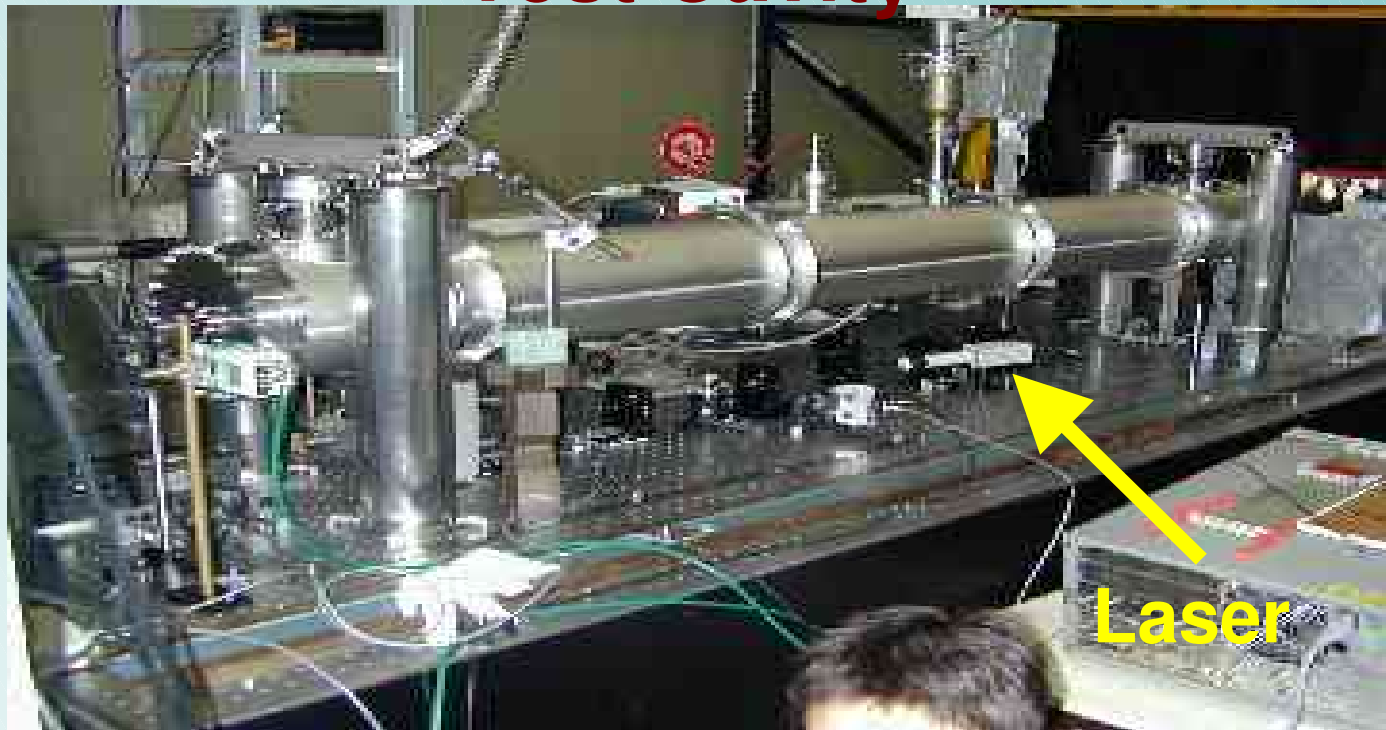
Cavity Polarimeter

Prototype Test Cavity

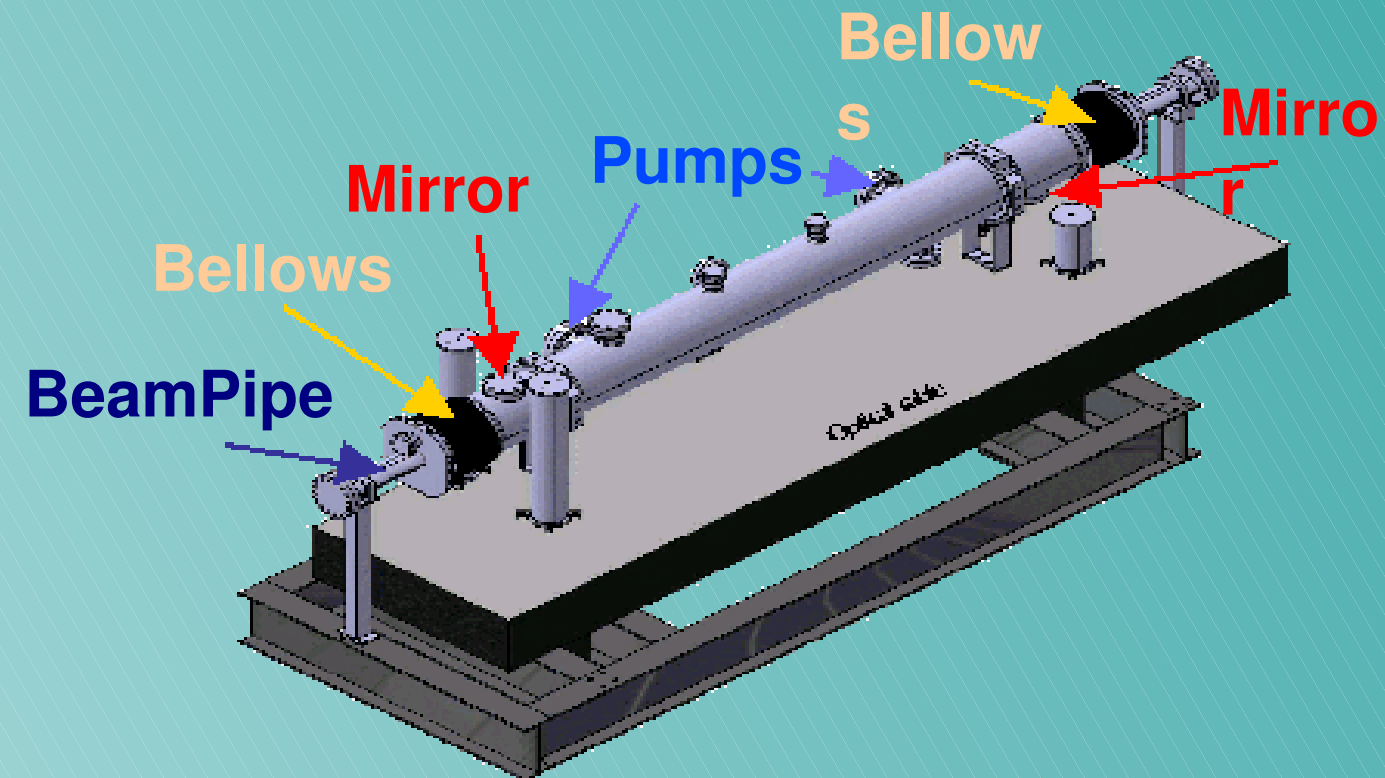


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Test Cavity



Final Cavity



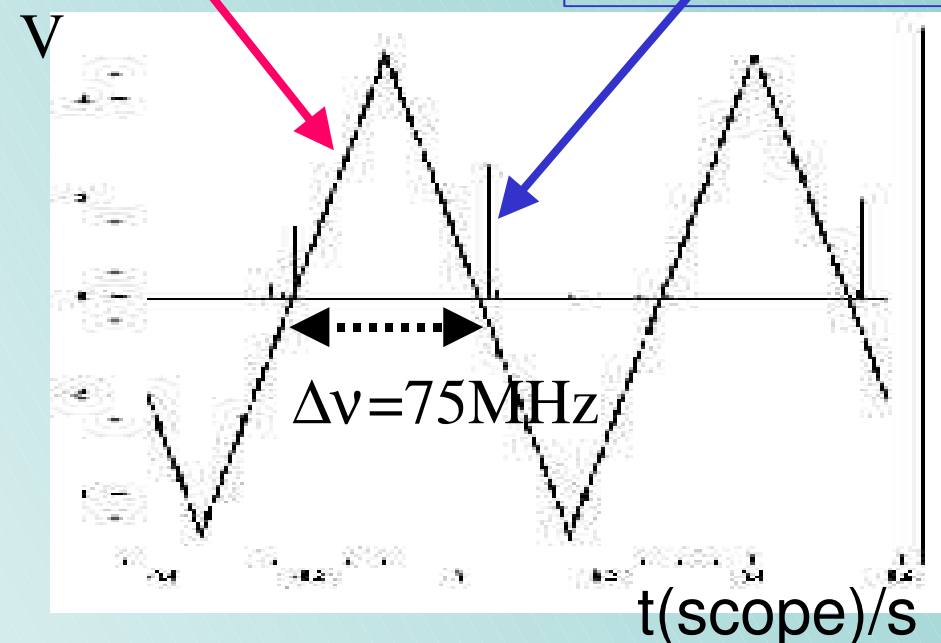
2Hz & 10V pic-pic Ramp
(+930kHz modulation)

Transmitted pics

Procedure:

I. 'Open loop':
ramp + modulation

II. 'Closed loop':
ramp Stopped &
servo active



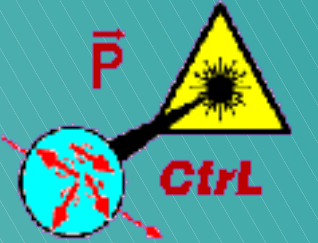
Achievements

← Resonance

Polarisation
Controlled at the
0.1% level

Cavity Polarimeter

Status and Timelines



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- Slow control procedure (Optics) almost done
- Mechanics of Final Cavity
 - In fabrication since feb. 2002,
 - at Orsay during June 2002 ...
- Then test of the whole setup at Orsay
- Calorimeter DAQ system
 - Under development ...

Cavity installation at HERA tunnel
Machine long shutdown @ end 2002

Polarization

Machine Aspects



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New Spin Rotators for H1 and Zeus =>
less polarization by ~ 5%
estimate for 0.7mm orbit flatness

No anti-Solenoids =>
new compensation scheme
still to be demonstrated

Orbit Flatness Control: 1.2 → 0.7mm (RMS)
will require implementation of
Beam Based Alignment

Harmonic Bump Control

Complex Amplitudes 4 → 8 → 16
Expected Average Polarization 55% (Hera I) → 50% (HERA II)

Summary



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TPOL

- successfully upgraded
- measures bunch by bunch polarization
- new Silicon and Fiber detectors providing data to reduce systematic uncertainties
- ongoing analysis to prove sub percent precision.

LPOL

- ready for polarization measurement
- **Cavity** upgrade:
- well advanced tests with full-scale prototype in Paris
- expect to be ready for installation at HERA at the end of 2002.