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19. Oct. 2000

PRC open session

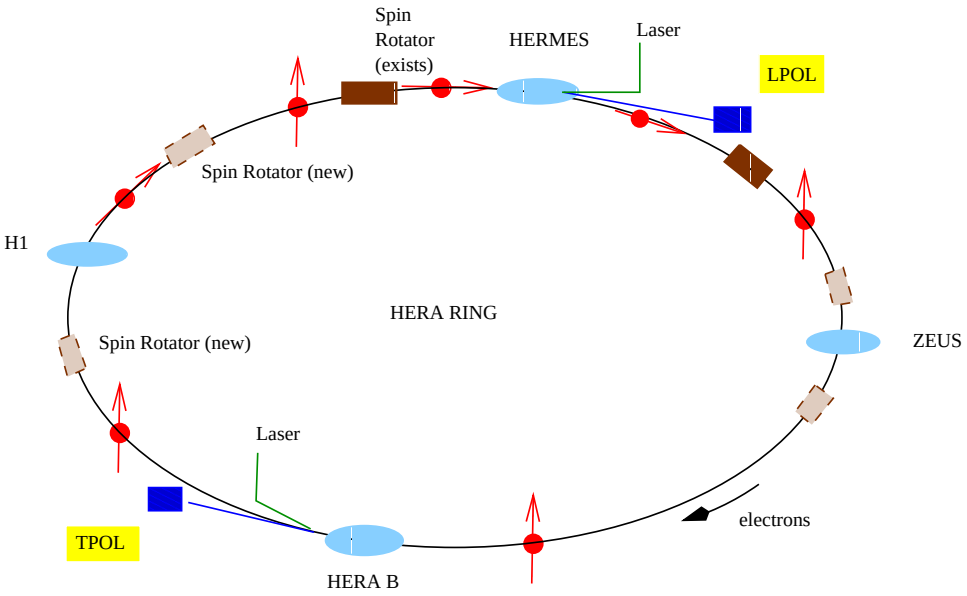
The POL2000 group

status report

- Introduction: Polarization at HERA after the upgrade
- The POL2000 group
- Polarimeter upgrade projects

Introduction

Lepton-spin in the HERA ring after the upgrade

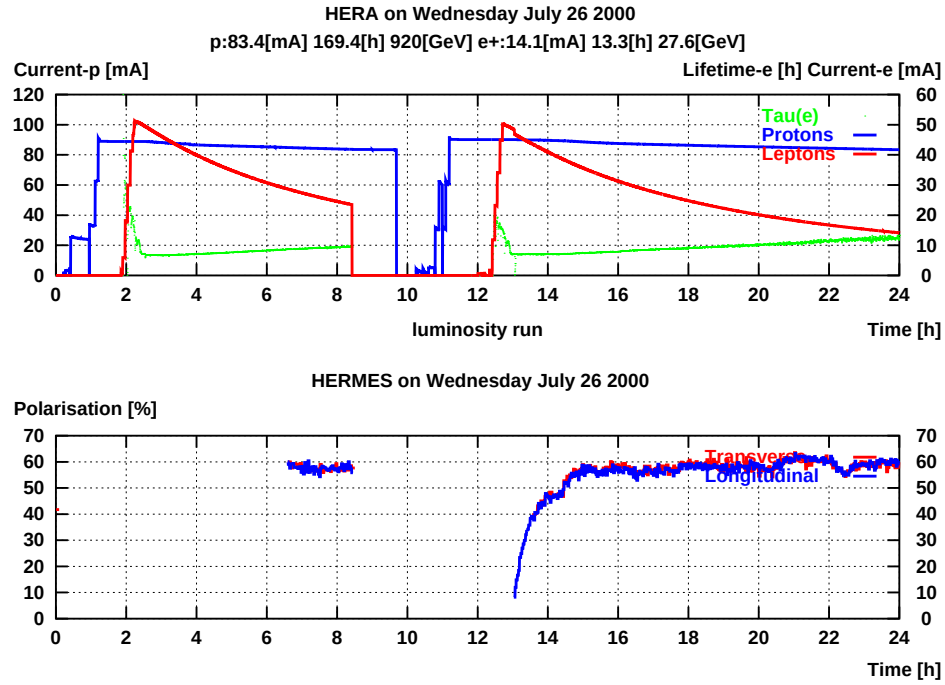


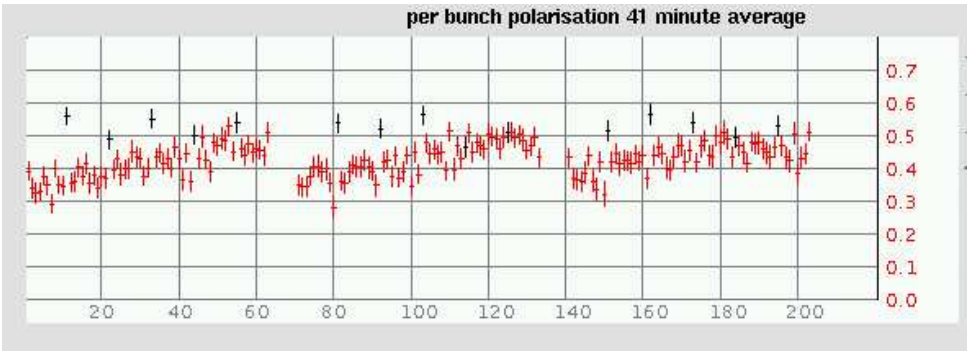
Polarization measurement

- LPOL: measure longitudinal polarization between HERMES' Spin-rotators.
- TPOL: measure transverse polarization far from spin-rotators (detector is located near HERA-B in the tunnel)

Polarization during a HERA fill

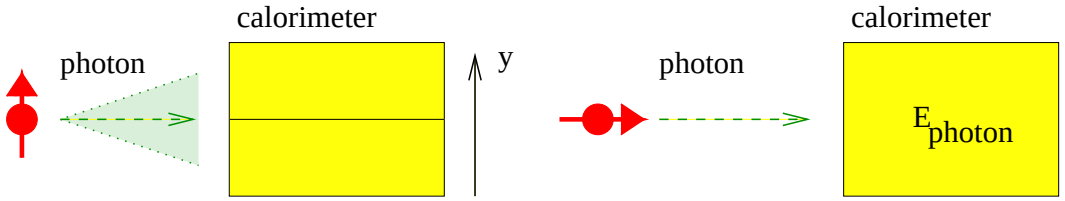
- Rise-time 40 minutes
- Maximum polarization achieved $\mathcal{P} = 0.5 \ldots 0.7$
- Polarization might vary from bunch to bunch



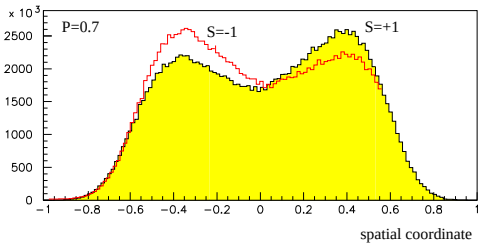


The polarimeters at HERA

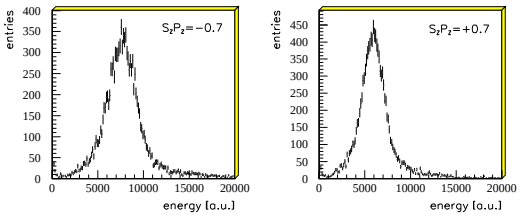
- TPOL: vertical asymmetry of scattered photons. Continuous laser, $1 \ldots 2$ scattered γ in 200 bunch crossings
- LPOL: characteristic energy spectra of scattered photons. Pulsed laser with high intensity but low repetition rate. Scatter $100 \ldots 1000$ photons per pulse and measure mean of energy-distribution.



TPOL



LPOL



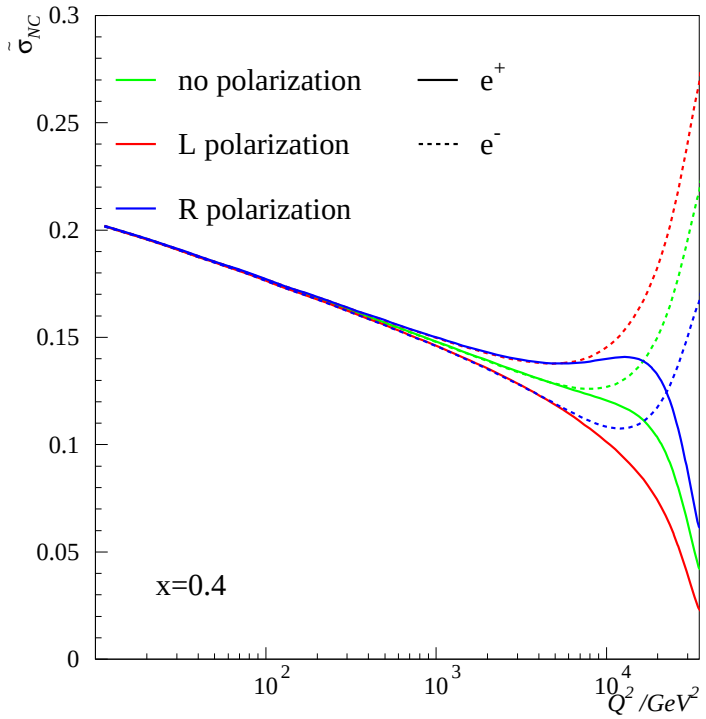
Statistical precision: $\Delta\mathcal{P} = 0.01 \ldots 0.02$ averaged over all bunches for one-minute intervals

Systematic uncertainty: $\Delta\mathcal{P} = 0.03 \ldots 0.04$ (TPOL)
$\Delta\mathcal{P} = 0.02 \ldots 0.04$ (LPOL)

Physics with polarization at HERA

- HERMES: measure the spin-structure of the nucleon
- H1, ZEUS: Z and W exchange is sensitive to the polarization of the incoming lepton

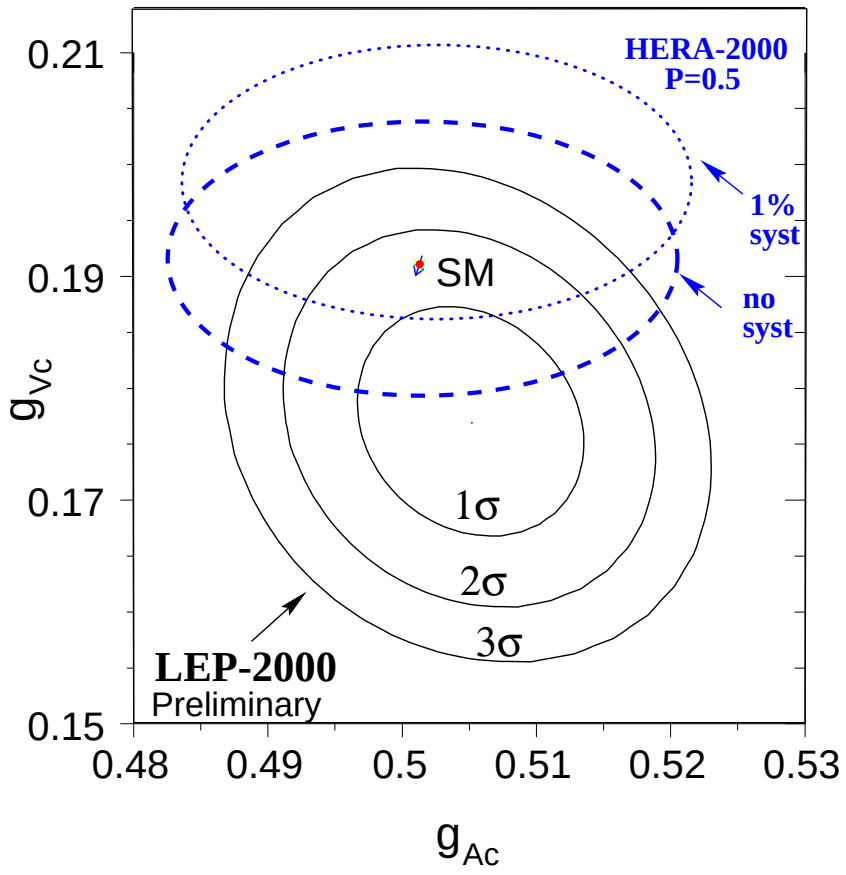
Neutral current reduced cross-section



momentum-transfer Q^2 at $x = 0.4$

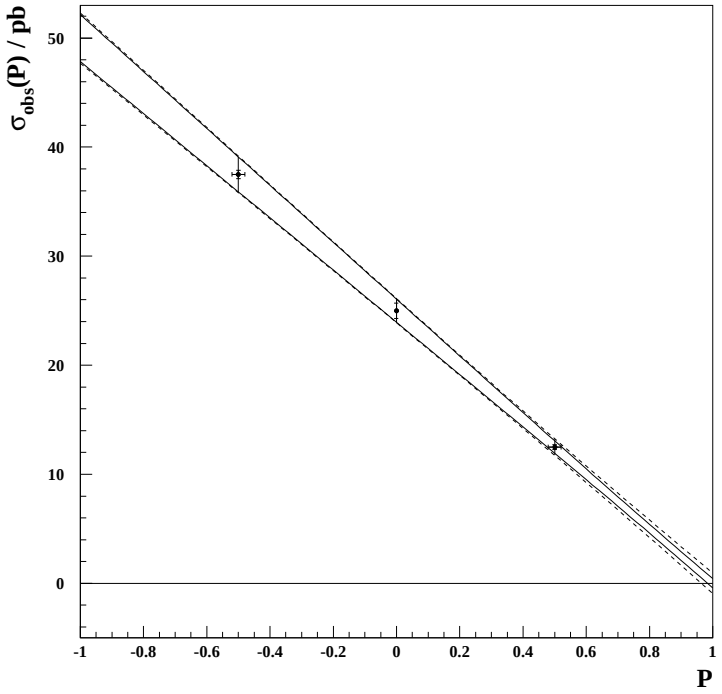
$\rightarrow$ measure axial and vector couplings of the quarks, disentangle u, $\bar{u}$, d, $\bar{d}$ quark densities

Accuracy of $g_{V,u}$ and $g_{A,u}$ with $\int \mathcal{L} = 4 \times 250\,\mathrm{pb}^{-1}$ compared to LEP results on $g_{V,c}$ and $g_{A,c}$



$\rightarrow$ HERA with high $\int \mathcal{L}$ and high $\mathcal{P}$ can achieve a precision on the u and d axial and vector couplings that is comparable to the LEP results on b and c quark couplings

CC cross-section for $Q^2 > 1000\,\mathrm{GeV}^2$ as a function of $\mathcal{P}$

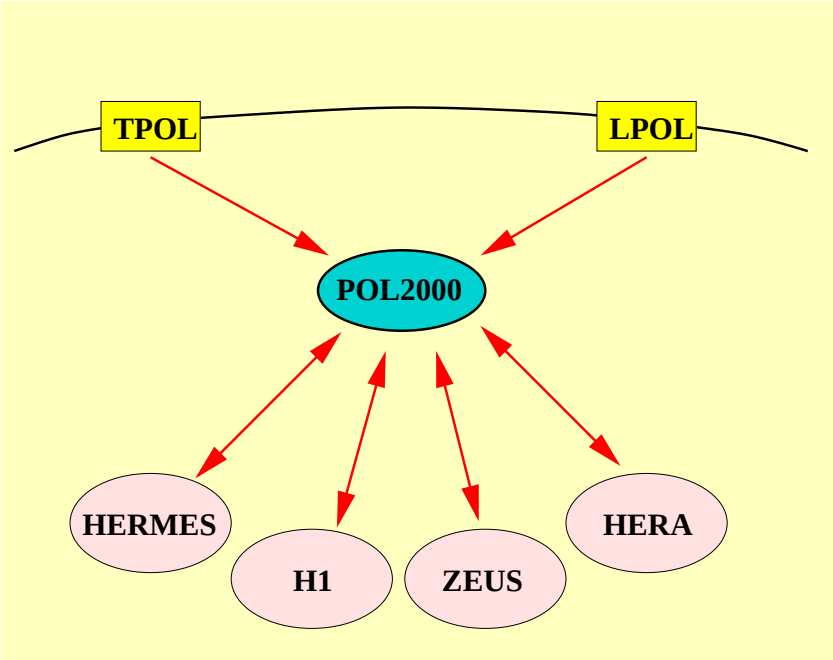


$\rightarrow$ Charged current cross section is a linear function of the polarization $\mathcal{P}$. Set limits on right-handed charged currents

HERA will make important contributions to precision tests of electroweak physics.

The error on the polarization $\Delta\mathcal{P}$ should not limit the accuracy of these measurements. Go for $\Delta\mathcal{P} \ll 0.01$!

The POL2000 group



Active members of the group:

Convener	Ties Behnke
Hermes	Freiburg, Michigan
	contact person: Peter Schüler
H1	LAL and Ecole Polytechnique (Paris), Lebedev
	Contact person: Nelly Gogitidze
Zeus	IC London, Tokyo
	contact person: Ken Long
DESY	

Activities of the POL2000 group

Coordinate and initiate the necessary activities to provide reliable polarization measurements to HERA and to the experiments.

Upgrade projects

- TPOL: operate with a new DAQ system from 2001 onwards. Add a position-dependent detector in front of the TPOL to get an online calibration of the position measurement (improve systematic uncertainties).
- LPOL: prepare for an upgrade with a Fabry-Perot cavity to gain the ultimate precision for polarization measurements from 2002 onwards (PRC 00/06).

TPOL DAQ upgrade

Electronics as for the new H1 luminosity system

- fast (pipelines → no dead-time)
- improved energy measurement (pulse shape sampling)
- HERA bunch identification (important for H1 and ZEUS)

A prototype system was tested in parallel to the existing TPOL DAQ during the last 10 weeks of HERA.

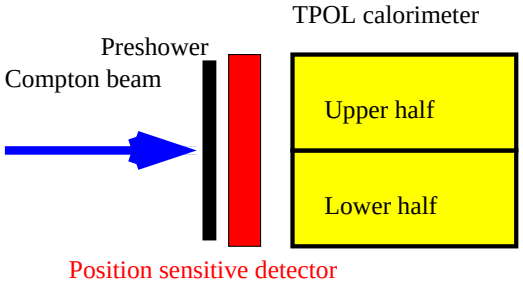
→ Running stable, polarization in agreement within 1%

→ The final system will be commissioned next year in time for the HERA startup.

TPOL position-sensitive detector

- The transverse polarization is measured from a spatial asymmetry of the scattered photons.
- The spatial coordinate is calculated from an energy asymmetry (test-beam and "rise-time" calibration).

Add a position-dependent detector (silicon strips or scintillating fibers) and a pre-radiator in front of the calorimeter.

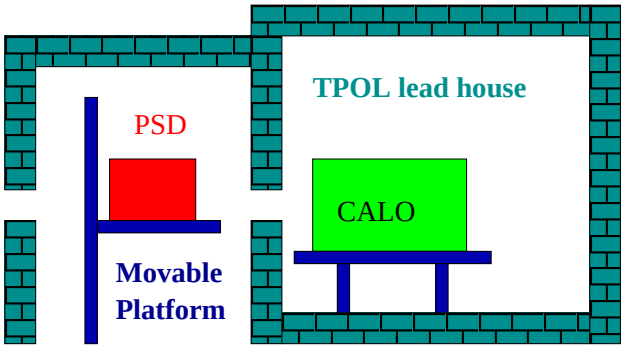


→ online-calibration of the asymmetry-to-position transformation, independent of test-beam and rise-time calibration.

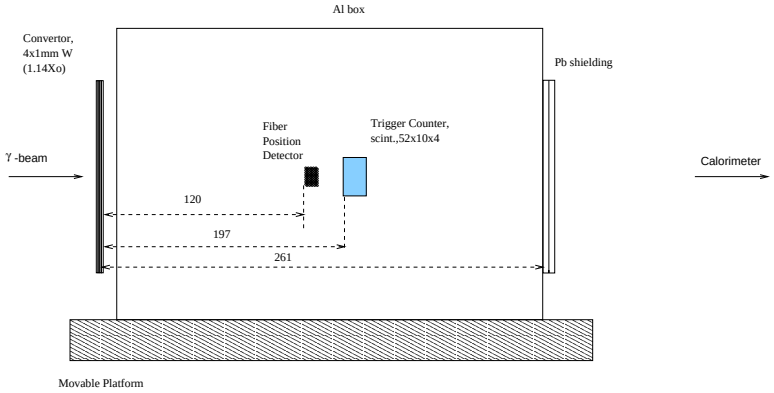
TPOL position-sensitive detector studies

- Tests with a fiber-detector early this year
- Tests with a silicon-detector the last month of HERA operation
- Detailed Monte Carlo studies

Position-sensitive detector test setup

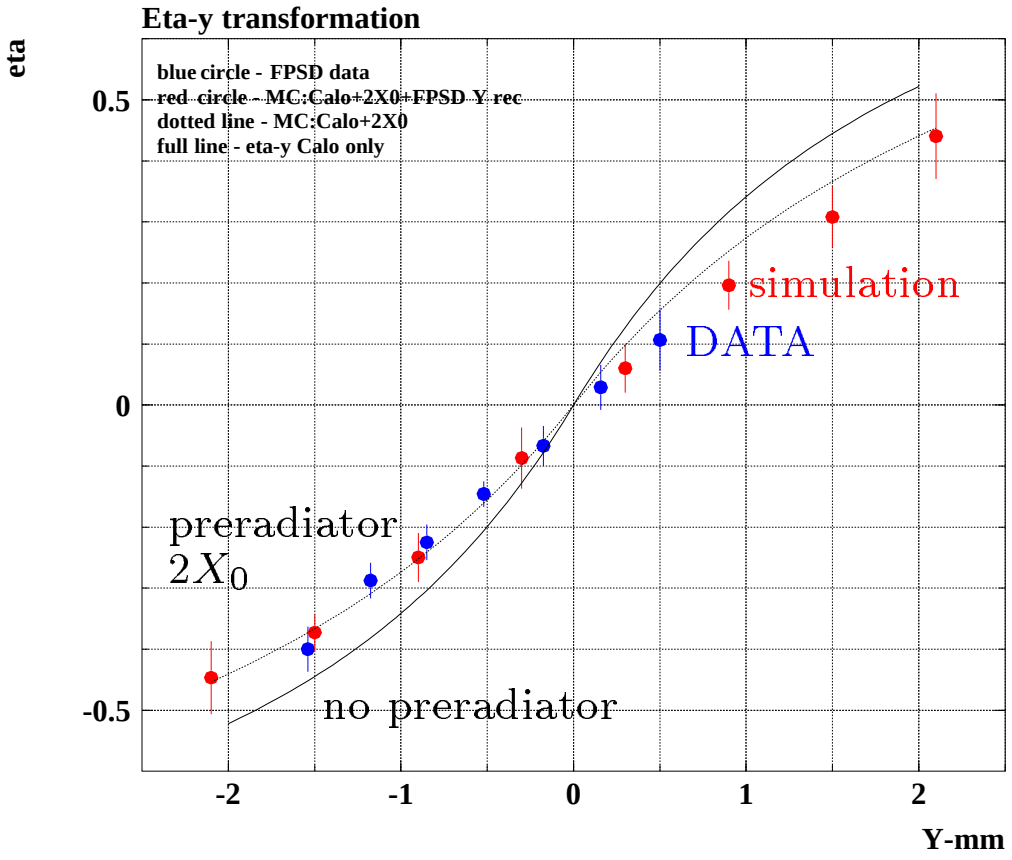


Fiber detector



First results

Asymmetry-to-position transformation measured with the fiber detector



The asymmetry-to-position transformation can be measured with both devices (scintillating fiber and silicon strip detector).

The detector should be as close as possible to the calorimeter, to obtain the best precision.

Further studies: radiation hardness

Both detectors can survive many years in the beam without suffering severe radiation damage.

Estimated dose from Compton beam and Bremsstrahlung

pre-radiator thickness	dose (200 days)
$1X_0$	1.9 MRad
$2X_0$	5.7 MRad

The calculation is based on calorimeter measurements in conjunction with MC studies.

Inversion dose of the silicon detector considered: 100 . . . 200 MRad

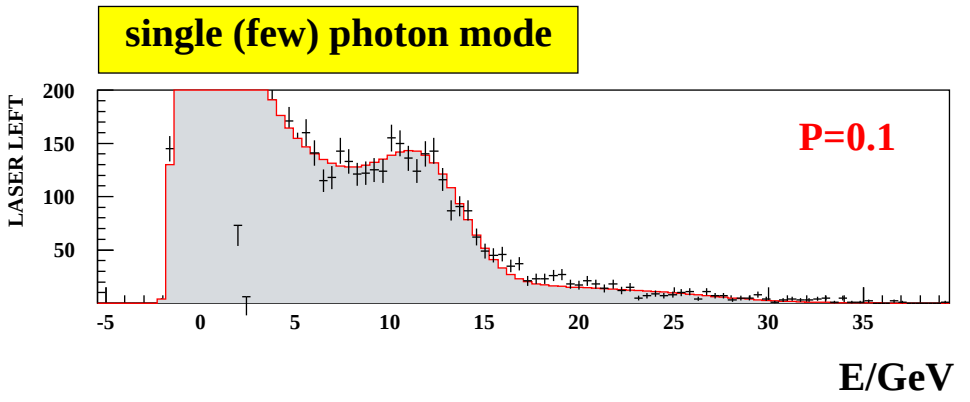
→ A device that can be installed in front of the TPOL spare calorimeter is currently being designed. We plan to have it operational for the HERA startup.

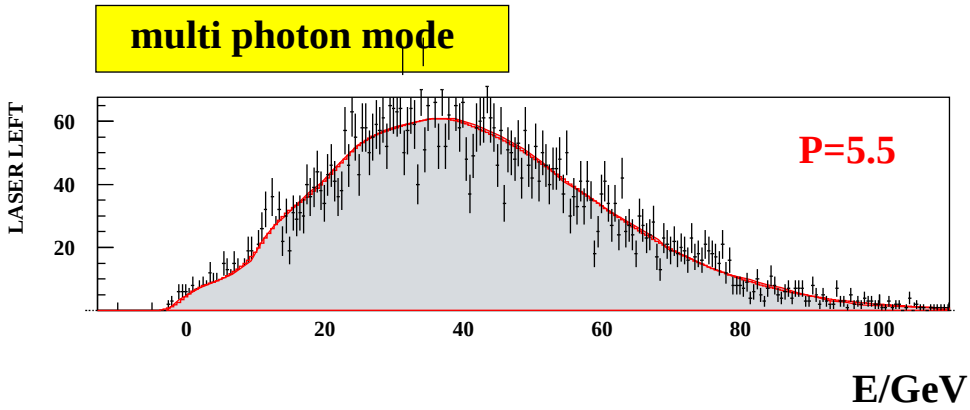
LPOL upgrade

The LPOL is operational as a stand-alone device since 1999 due to tremendous effort by HERMES.

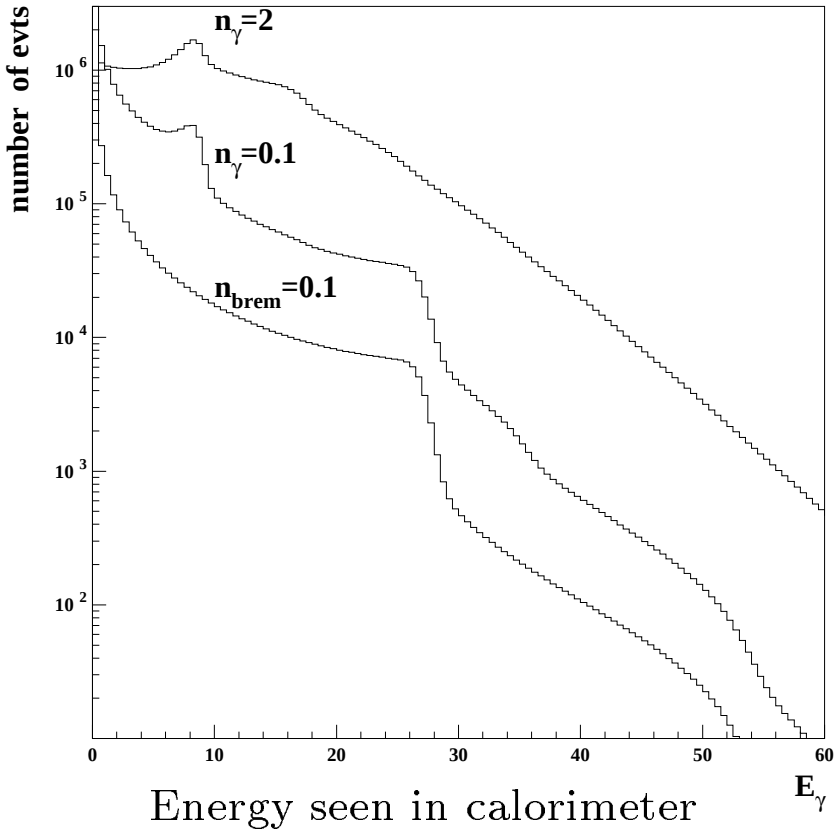
Studies have been done since how to further improve the LPOL performance:

- **New calorimeter**
- **Operate the LPOL in single (few) photon mode**





LPOL in single photon mode



Several characteristic points in the energy spectra (Compton edge, Bremsstrahlung)

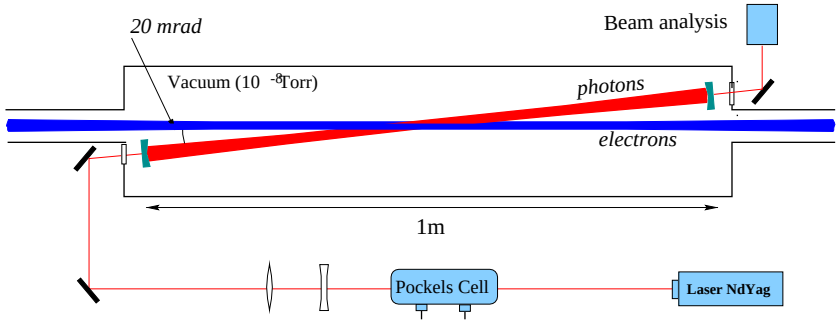
Operating the LPOL in single photon mode gives a unique handle on the energy-calibration
→ minimize the systematic uncertainties.

Note: high statistical precision is needed

LPOL upgrade: Fabry-Perot cavity

LPOL in single photon mode → continuous high-power laser needed.

Solution: Fabry-Perot cavity around the interaction point multiplies the initial laser-Power ($\approx 1\,\mathrm{W}$) by a factor 1000

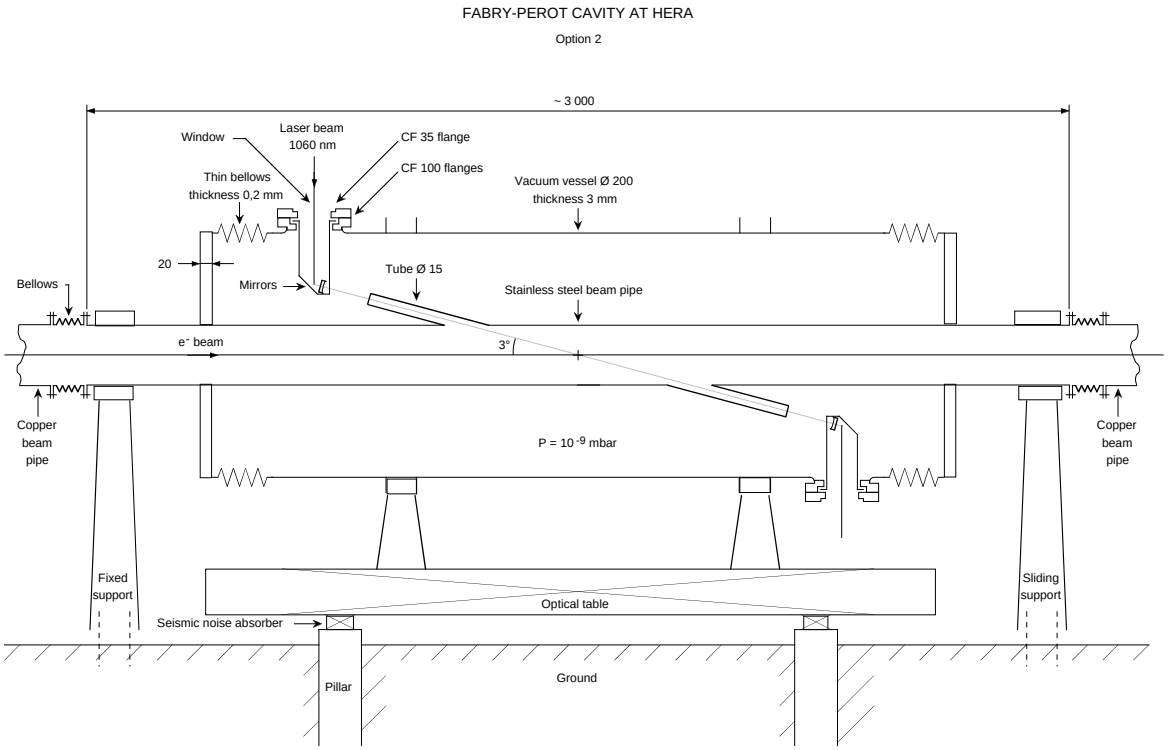


- such a device is operating reliably at CEBAF
- a detailed proposal to install such a device in 2002 at HERA has been submitted (PRC 00/06)

Statistical precision on the polarization measurement:
$\Delta\mathcal{P} = 0.01$ **per single bunch** per minute

→ high-precision measurement of polarization at HERA

LPOL upgrade: design of the cavity



Design of the cavity for the HERA environment is well advanced:

- temperature stability
- vibration stability
- radiation effects to the mirrors
- optical system

Summary

- after 2001 Polarization will be a major part of the physics program at HERA.
- DESY, H1, HERMES, ZEUS are already now active in several projects to improve the quality and the reliability of the polarization measurement for the HERA operation in 2001 and beyond
- TPOL DAQ upgrade: first tests look very promising. Will be ready in time for the HERA startup.
- TPOL position sensitive detector: online calibration of the TPOL, expect significant improvements in the systematic uncertainties. Can be ready in time for the HERA startup.
- LPOL Fabry-Perot cavity: highest precision polarization measurements in conjunction with the highest possible luminosity. Installation forseen in the 2001/2002 shutdown.