Polarisation and future measurements

Alex Tapper

- Introduction
- HERA performance
- Charged current DIS
- Neutral current DIS
- Exotics searches
- DVCS
- Conclusions

Thanks to:

Uta Stoesslein

Kunihiro Nagano

Mayuko Kataoka

Catherine Fry

Lorenzo Bellagamba

Fabian Zomer

Zhiqing Zhang

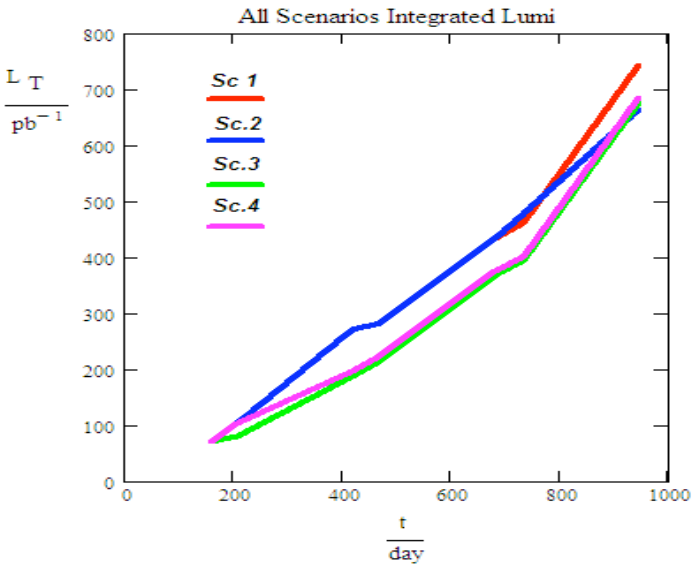
Introduction

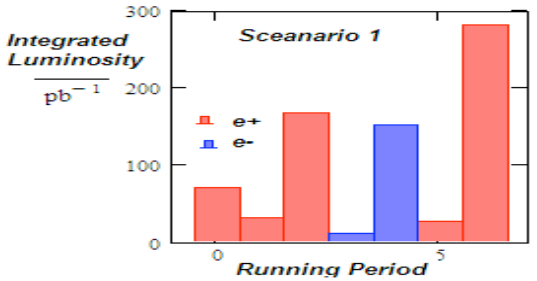
- Many studies of what measurements we can make with various luminosities and polarisations in future physics at HERA workshop and other sources
- Usually based on 1 fb^{-1} and polarisation of 70% with $\delta P/P=1\%$
- Update these studies for more realistic HERA running scenarios
- Do these change our requirements on the polarisation error?
- What is the optimal fraction of left and right-handed data?

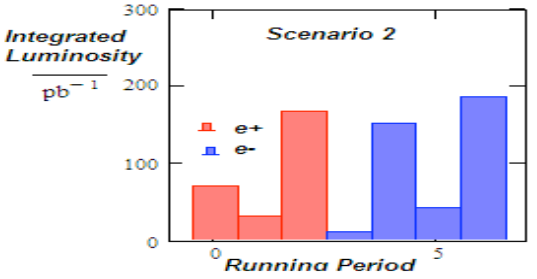
Luminosity

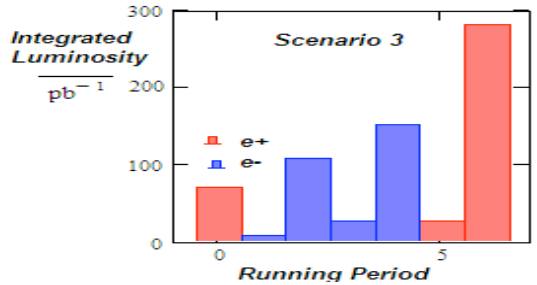
F. Willeke DIS '04

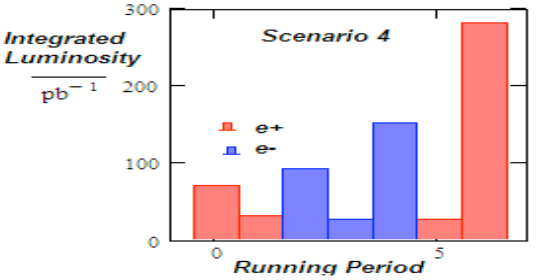
Scenario	1	2	3	4
1-8 2004	p	p	p	p
10-12 2004	p	p	e	p
1-8 2005	p	p	e	e
10-12 2005	e	e	e	e
1-8 2006	e	e	e	e
10-12 2006	p	e	p	p
1-8 2007	p	e	p	p



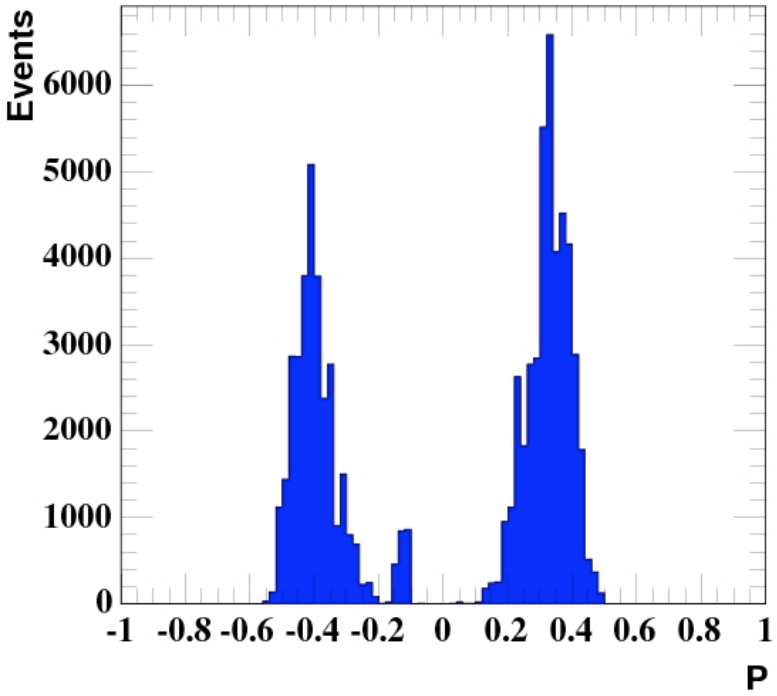


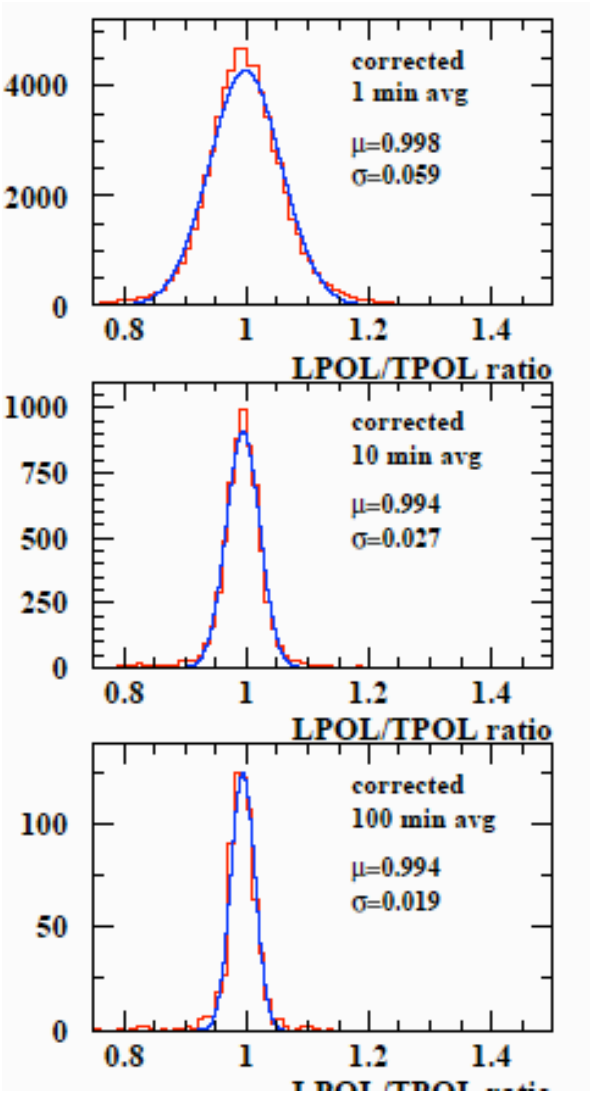






Polarisation

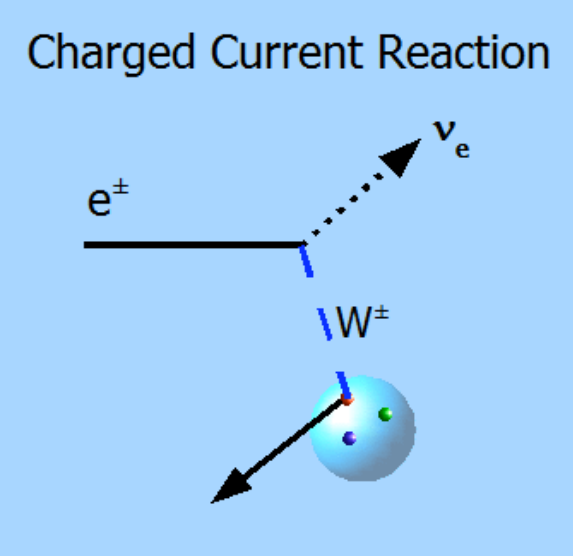




- Mean values -40% and +33%
- Peak values |P|>50%
- Error is 1.6% from LPOL and 3.5% from TPOL so far…

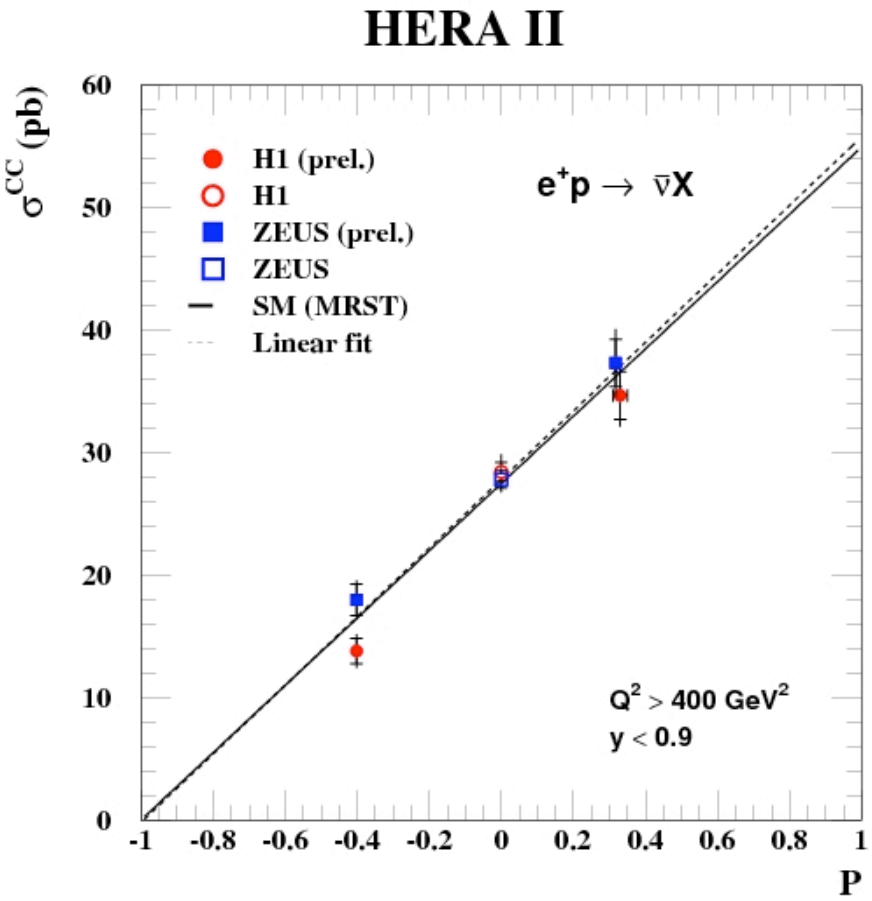
S. Schmitt

Charged current DIS



$$\sigma^{CC}(\mathrm{P}) = (1 \pm \mathrm{P}) \cdot \sigma^{CC}(0)$$

- Pure V-A structure of the SM predicts no right-handed charged currents



Charged current DIS

	P	Stat. (%)	Syst. (%)	δ P/P=1%	δP/P=2%
e^-p	-0.5	0.9	1.6	0.3	0.7
	+0.5	1.6	1.6	1.0	2.0
e^+p	-0.5	2.2	1.6	1.0	2.0
	+0.5	1.3	1.6	0.3	0.7

- CC total cross section $Q^2>400$ GeV^2 $y<0.9$
- Luminosity 4x200 pb^{-1} with error 1%
- $|P| = 0.5$

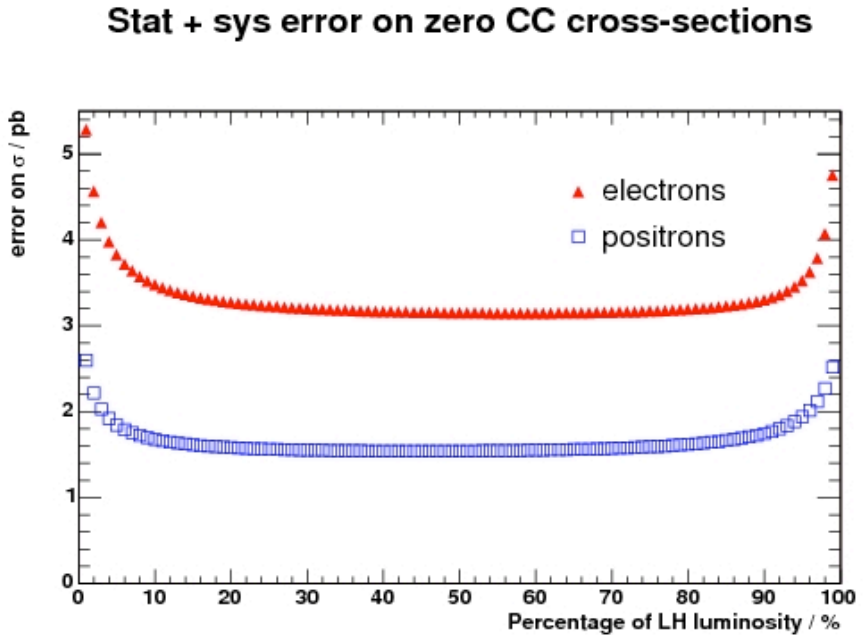
$$\frac{\partial\sigma}{\sigma} \propto \left(\frac{\partial P}{P}\right) \cdot \frac{P}{1 \pm P}$$

- Pol error largest contribution for δP/P=2% in RH e-p

Z. Zhang

Charged current DIS

- Start with measured HERA I points
- Assume |P|=50%
- Systematic uncertainty 2-3% from HERA I assumed for HERA II
- Does not include luminosity uncertainty
- Assumes scenario 3 luminosities
- Does not consider correlated systematics
- Fits e^+p and e^-p separately

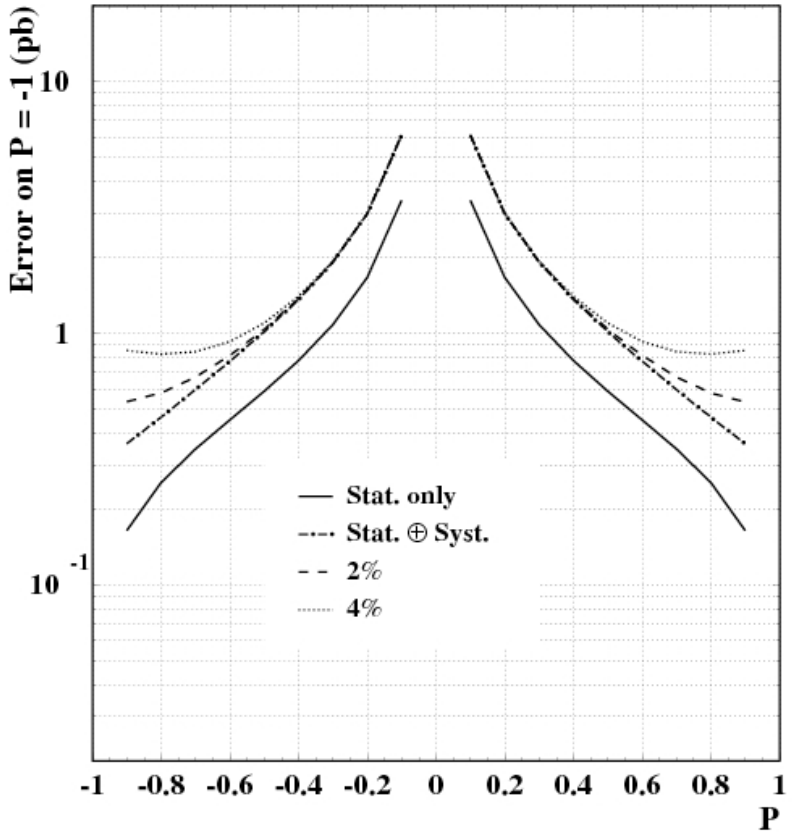


- e^+p data provides better limit than e^-p data
- Almost no dependence on fraction of left and right-handed data

C. Fry

Charged current DIS

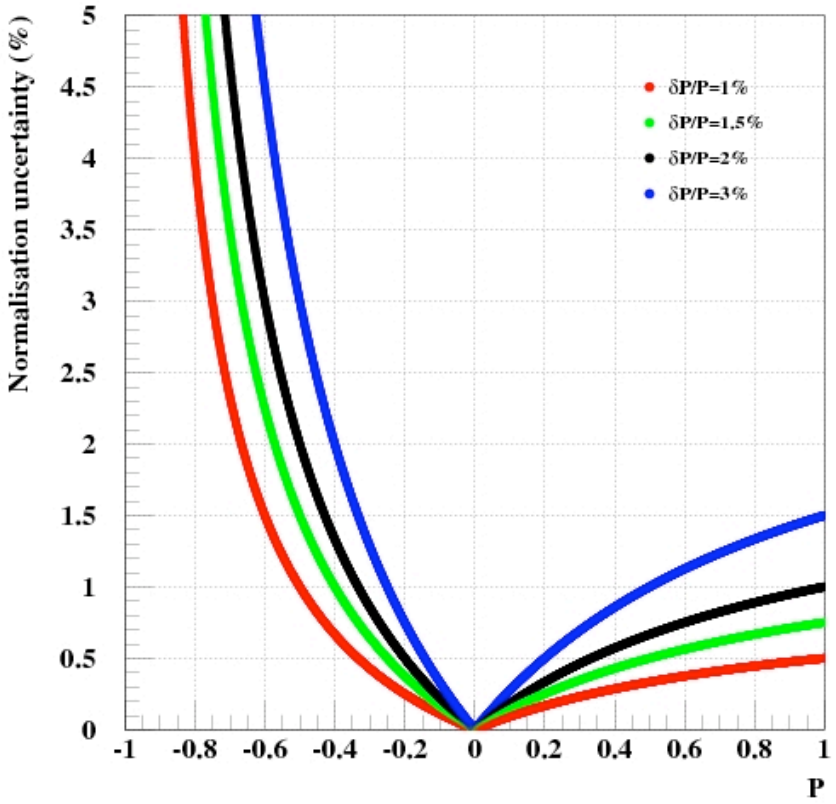
- Consider extrapolated limit on zero cross section
- 200 pb^{-1} each for right and left-handed data
- Limit strong function of polarisation but at expected polarisations relatively insensitive to error
- Need highest possible polarisation



M. Kataoka

Charged current DIS

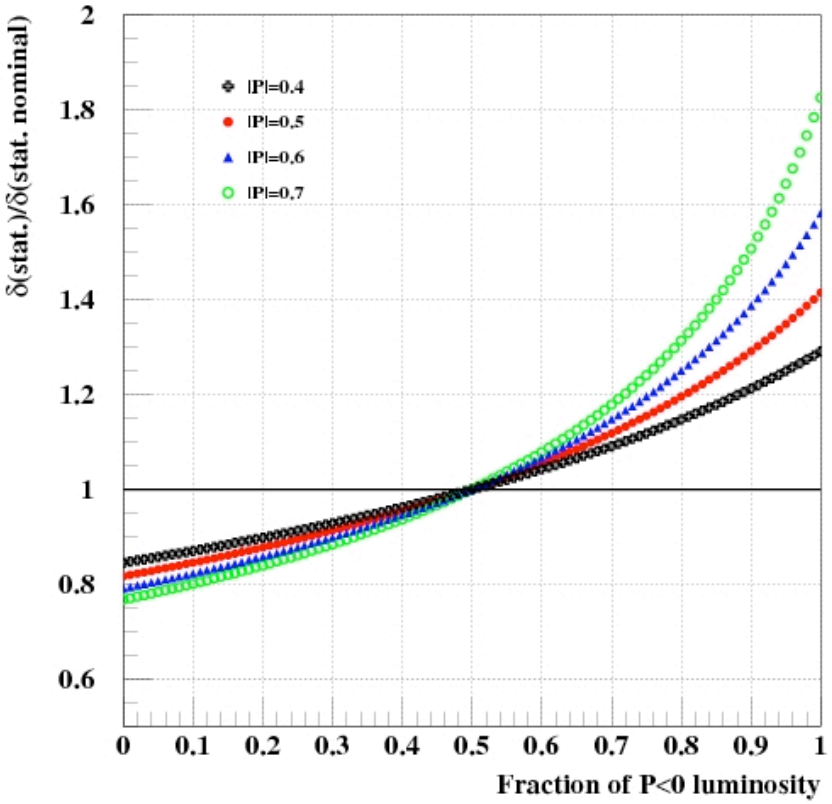
- Charged current, particularly e^+p because it probes d-quark, important input to QCD fits
- How does P as normalisation affect this?
- Plot $\delta P/(1+P)$ for different polarisations and different errors
- Plot of (1+P) is for e^+p so P>0 gives higher cross section
- Opposite for e^-p



- $\delta P/P$=1% for P=-70% gives a normalisation error of ~2.5%
- $\delta P/P$=2% for P=-50% gives a normalisation error of ~2%

Charged current DIS

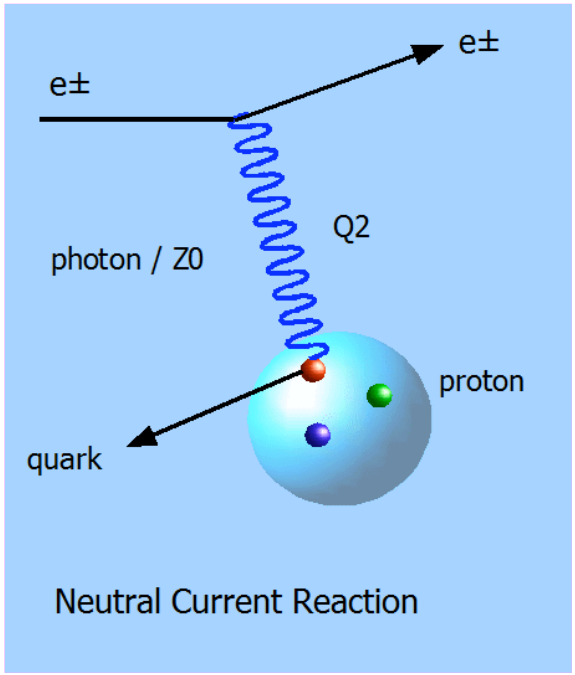
- Since CC EW studies are insensitive to fractions of left and right-handed data, how much can statistical precision profit from taking un equal shares of left and right handed data?
- Could get as much as 20%
- Rather modest improvement



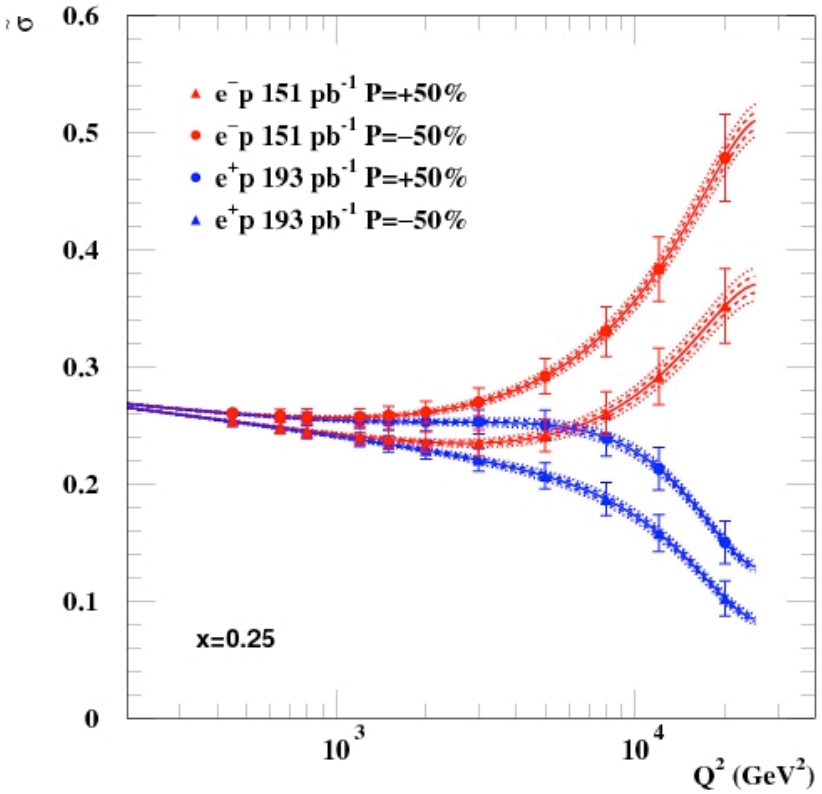
Neutral current DIS

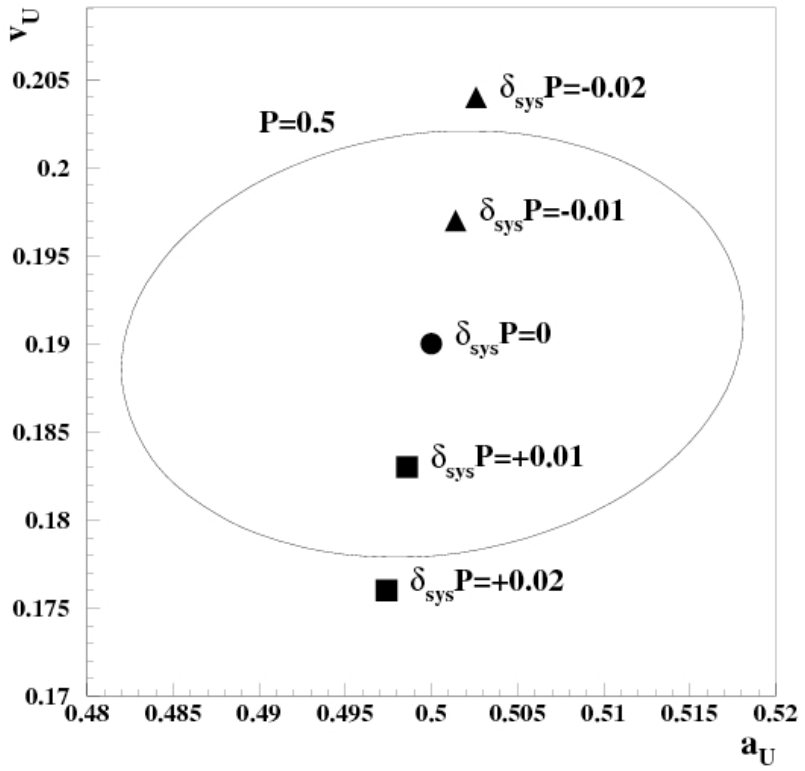
$$\frac{d^2\sigma^{\pm}}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[H_0^{\pm} + PH_P^{\pm}\right]$$

- Only terms with Z^0 exchange contribute
- Significant only at high Q^2
- Sensitivity to the couplings of the up and down quarks to the Z^0



Neutral current DIS





- Dashed (dotted) lines show change of 10 (20)% in P
- Couplings extraction for 1 fb^{-1} and P=±0.5

F. Zomer

L. Bellagamba

Exotics searches

- Leptoquark F=0 (e^+p) and F=2 (e^-p) states both have right and left-handed states so sensitivity can be improved using polarised beams
- For RPV SUSY squark production only left handed e^- and right-handed e^+ are involved so additional sensitivity using polarised beams
- Excited neutrinos are essentially like CC DIS so sensitivity can be increased with polarised beams

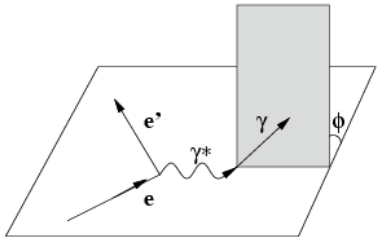
- The effect of increasing precision in the polarisation measurement is negligible for any exotic searches.

DVCS - Beam Spin Asymmetry

SSA ~ **Im** ($\tau_{BH} \cdot \tau_{DVCS}$)

varying beam polarization [HERMES, CLAS 2001]

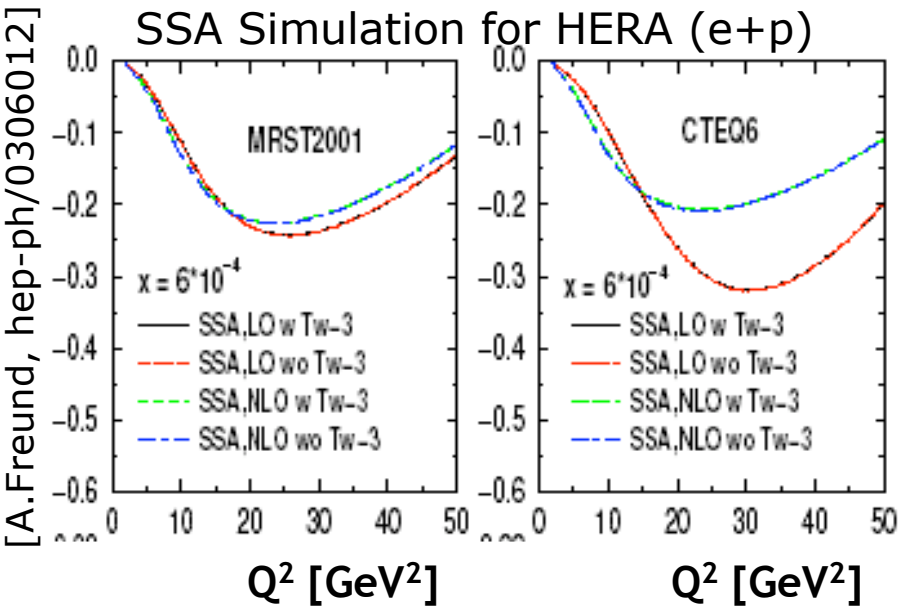
➔ one *beam spin asymmetry* (SSA) per beam charge

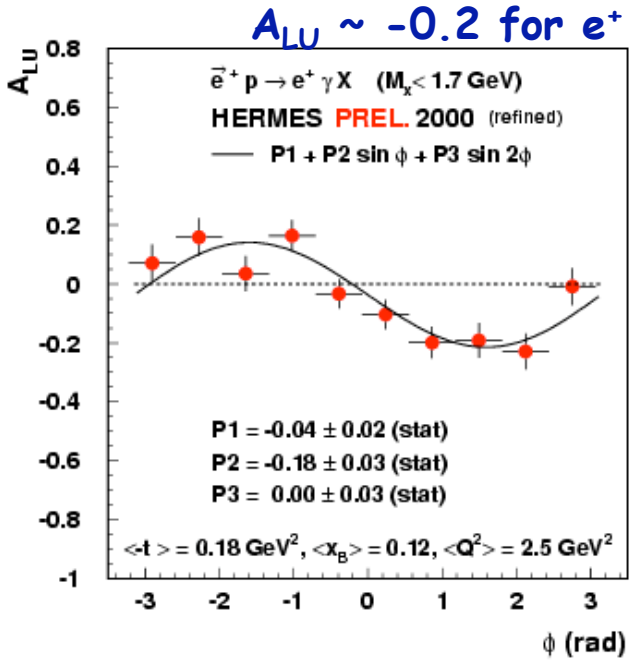


$$\Delta\sigma = d\sigma^{+} - d\sigma^{-}$$

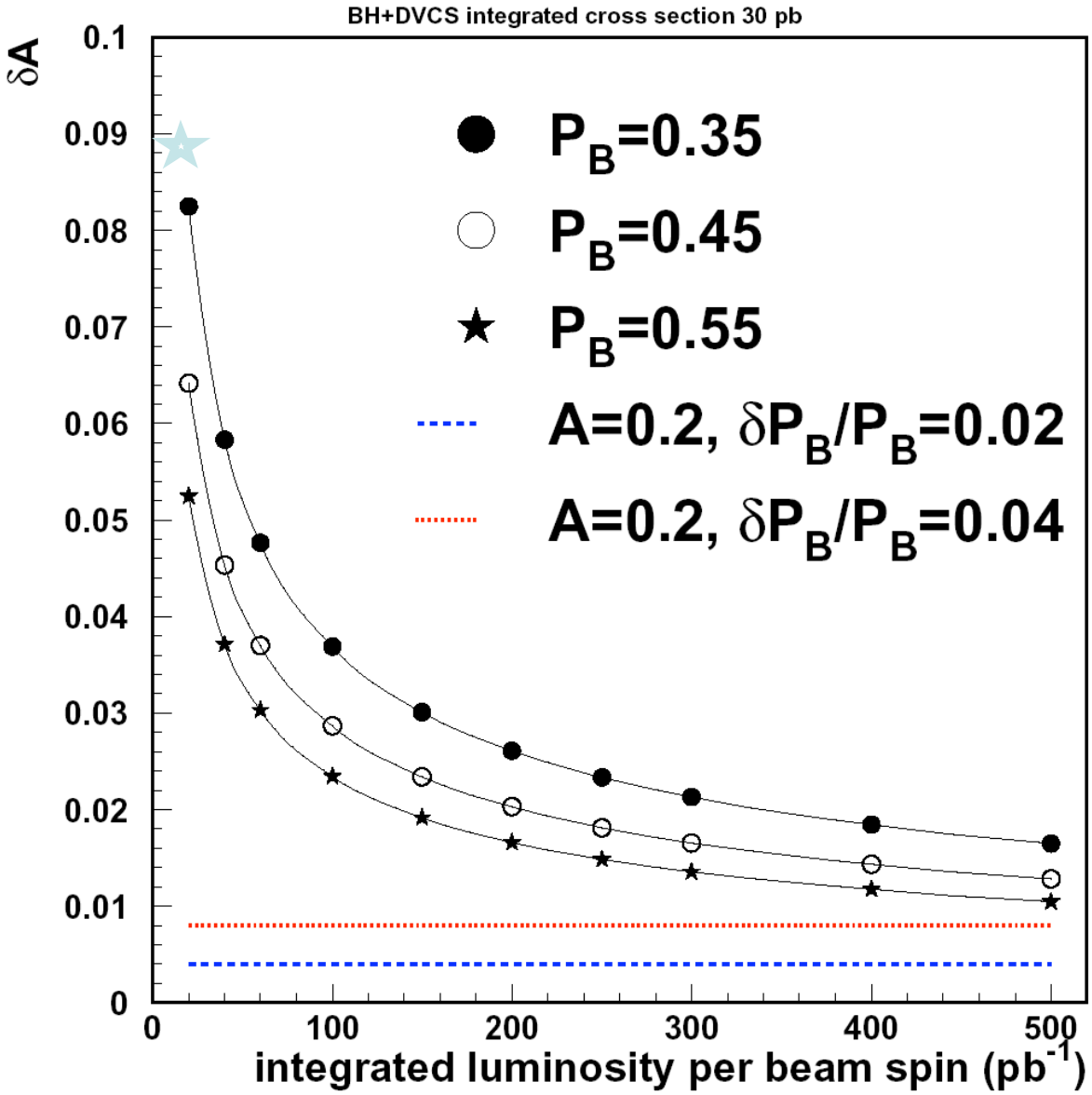
$$SSA = \frac{\int_0^{\pi} d\phi\ \Delta\sigma - \int_{\pi}^{2\pi} d\phi\ \Delta\sigma}{\int_0^{2\pi} d\phi\ d\sigma^{tot}}$$

or counting events scattered 'up' and 'below' rotated-by-90° lepton scattering plane (*left* and *right*) to get sinϕ weight ➔ 2 bins in ϕ





DVCS - Expected uncertainties for A_{LU}



03/04
app. error

- high pol. values needed → stat. error **δA** ~ $1/[\mathbf{P}(N^{+}+N^{-})^{1/2}]$
- syst. uncertainty **δA(P)** ~ δP/P * **A**

➔should be as good as 0.02 or better

U. Stoesslein

Conclusions

- Overall would like the highest possible polarisation and highest possible luminosity
- Sensitivity to polarisation error smaller at lower polarisations
- If we get full luminosities at the highest polarisations and make progress with luminosity uncertainties a 2% relative error on the polarisation is the largest uncertainty in some cross sections.

  A 1% relative error would be preferable.
- No significant benefit to be gained by taking unequal shares of left and right-handed data