DIS 2002

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HERA Upgrade and Prospects

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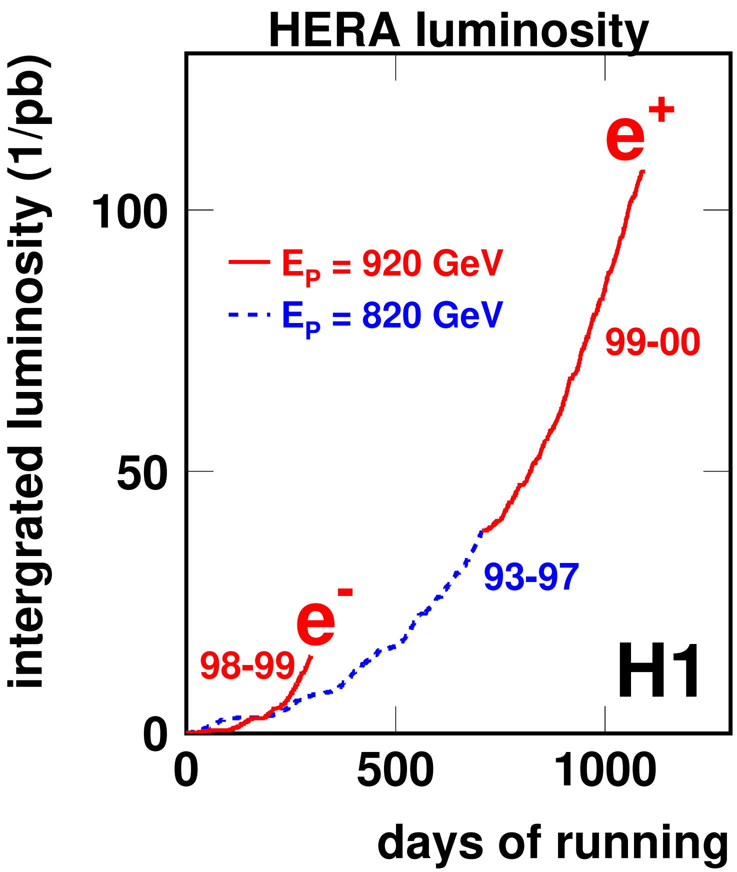
- HERA Upgrade
- Detector Upgrade
- Tests of the Standard Model
- Polarisation Measurements
- Searches Beyond the Standard Model
- Summary

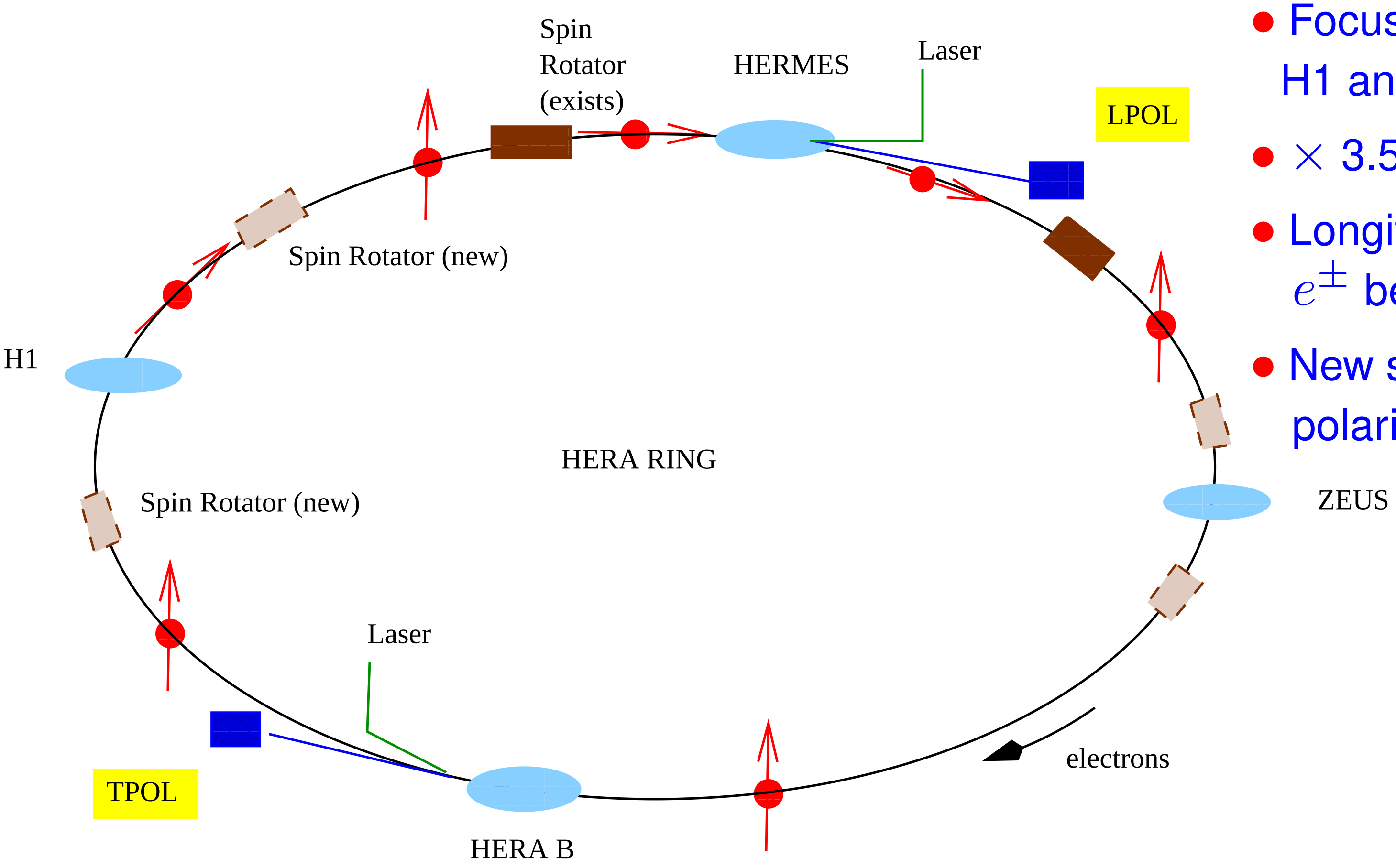
On Behalf of H1 and ZEUS Collaborations

The Story so Far



- HERA began operation in 1992 with $\int$ lumi 30 nb^{-1}
- Yearly improvement in luminosity
- Ran with e^- beams in 1998-99
- Ran $E_p = 920$ GeV 1998-2000
- 2000 saw design $\int$ lumi with $\simeq 60$ pb^{-1}
- Total HERA1 $\int$ lumi 100 pb^{-1} e^+p,
  15 pb^{-1} e^-p

HERA 2



- Major redesign of HERA
- Focusing magnets inside H1 and ZEUS
- $\times$ 3.5 increased lumi
- Longitudinal polarisation of $e^{\pm}$ beam
- New spin rotators and polarimeters

HERA 2 - Expected Performance

year	integ. luminosity (pb^{-1})
2002	120
2003	180
2004	240
2005	240
2006	240
sum	$\approx$ 1000 pb^{-1}

- Luminosity shared equally beteween e^+p and e^-p and L and R polarisations
- Some data taken at lower CMS energy for F_L and high x measurements

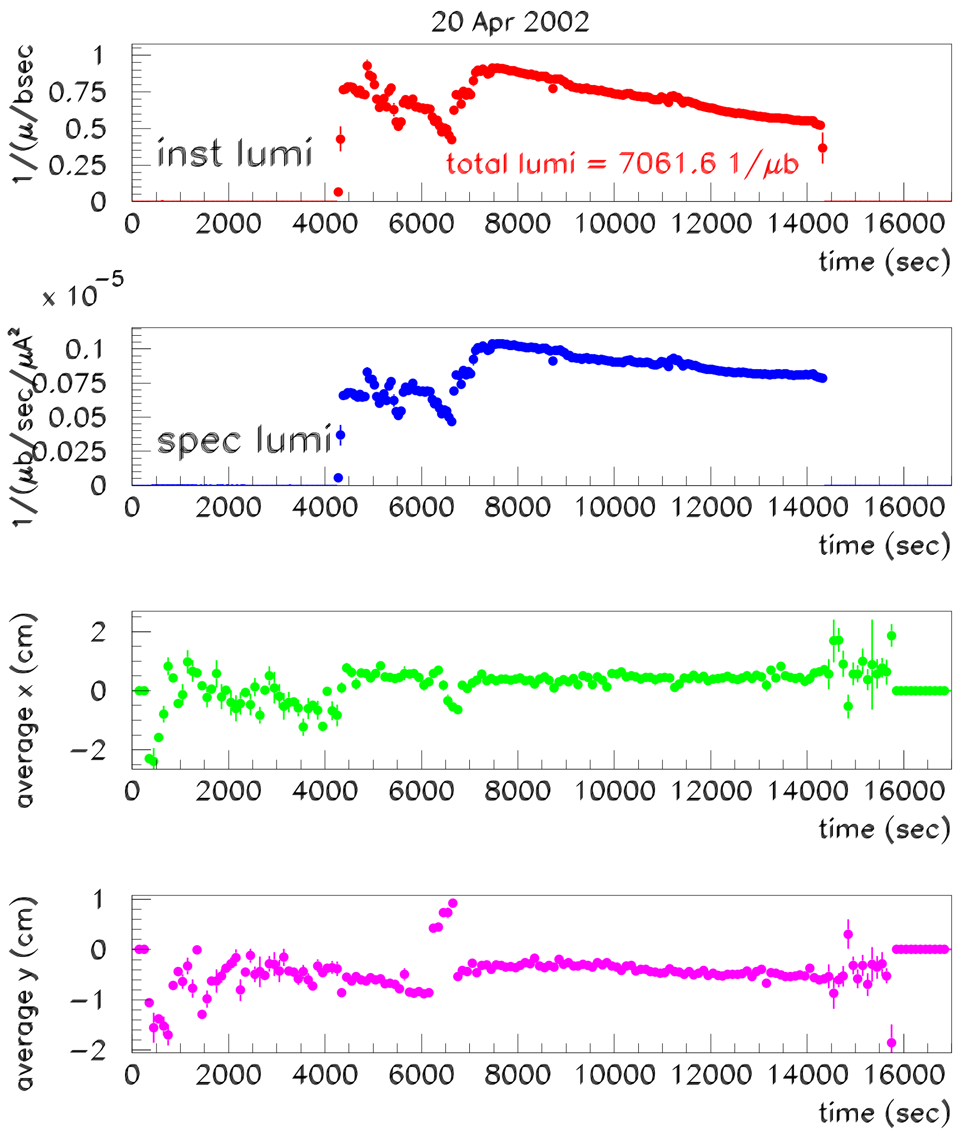
HERA 2 - Current Status

- Summer 2001 – detectors closed and machine operations began
- October 2001 – first ep collisions recorded at HERA 2
- November 2001 – Design specific luminosity reached
- Several problems with e and p rings $\Rightarrow$ several months delay
- Now – First stable luminosity at H1 and ZEUS

Major problems now hopefully solved. Working to increase currents and reduce background rates

Luminosity measurements

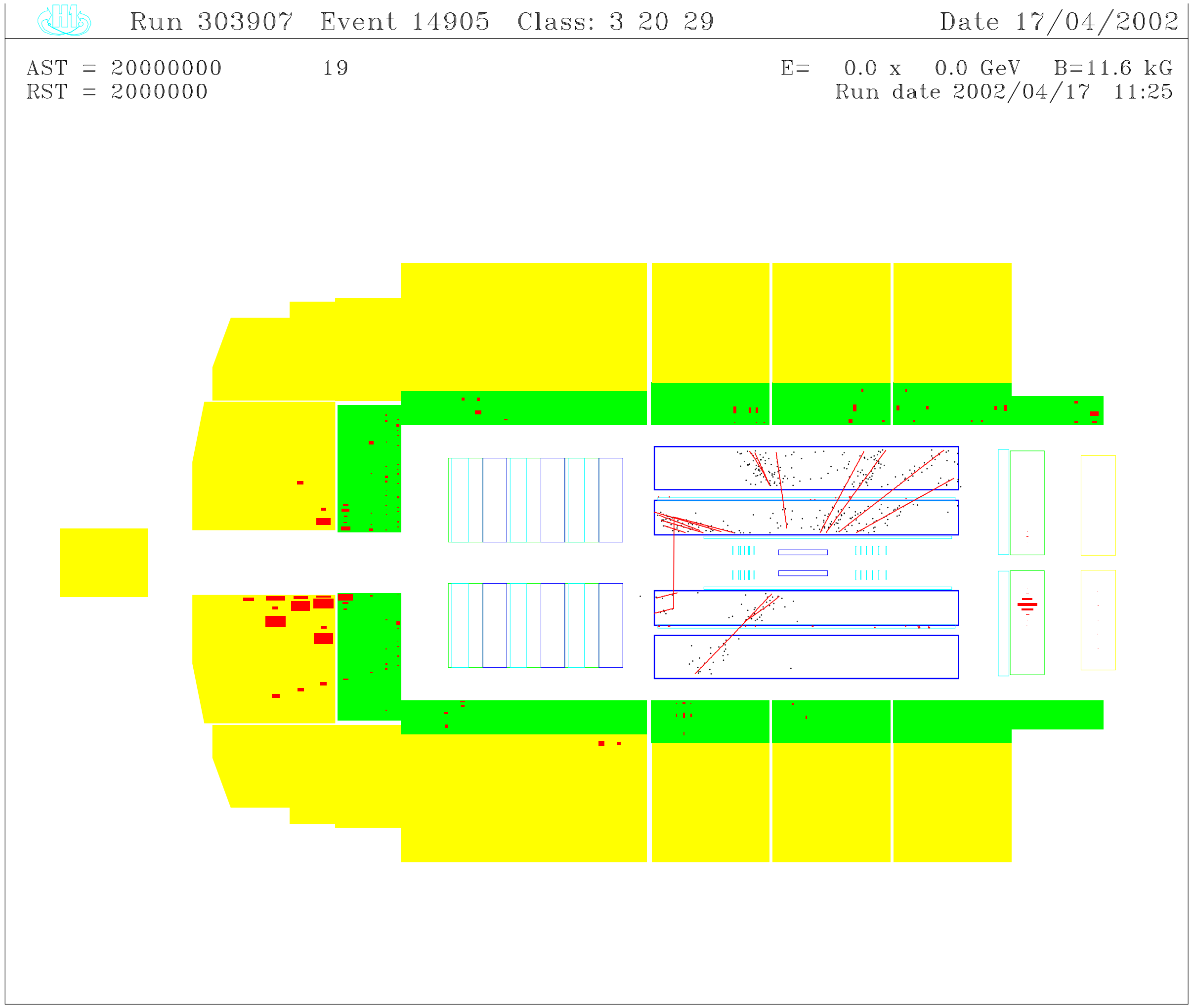
Luminosity measurements from a recent fill (ZEUS)



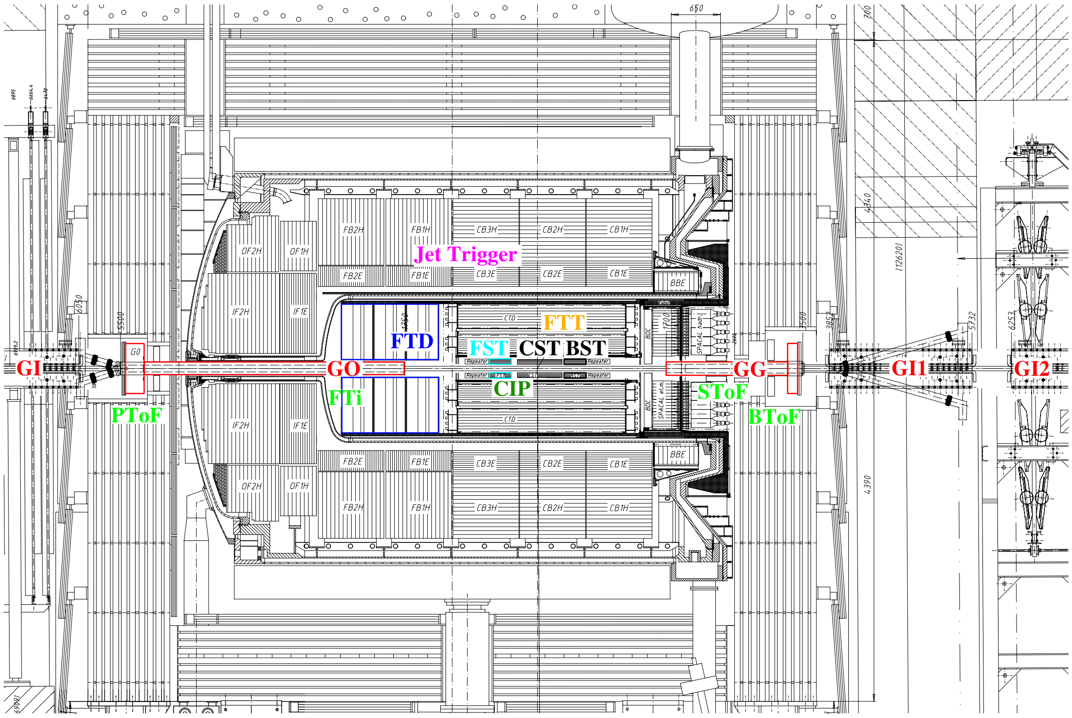
- HERA is able to deliver luminosity.

Work underway to improve background conditions

DIS Event from HERA 2 Data



Upgrade of experiments



- Magnets placed inside detector volume

$\Rightarrow$ redesign of forward and backward components

- Major upgrades of detectors:
  - Central micro-vertex detector (ZEUS)
  - Forward Silicon detector (H1+ZEUS)
  - Forward Tracking (H1+ZEUS)
  - New Lumi Systems (H1+ZEUS)
  - Improved Track Triggering (H1)

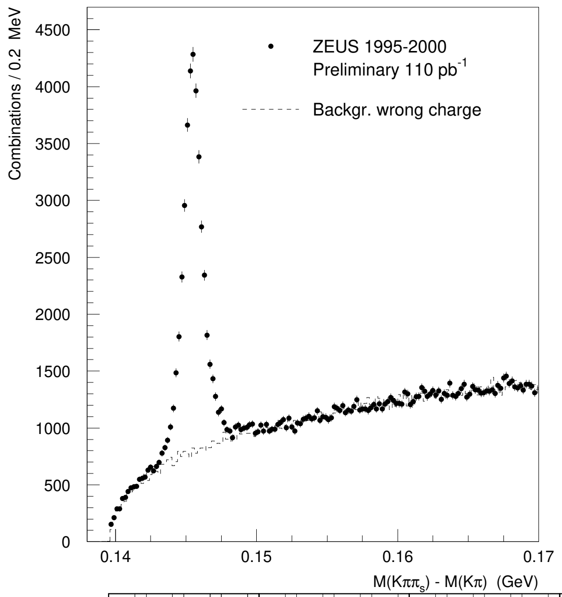
...and more...

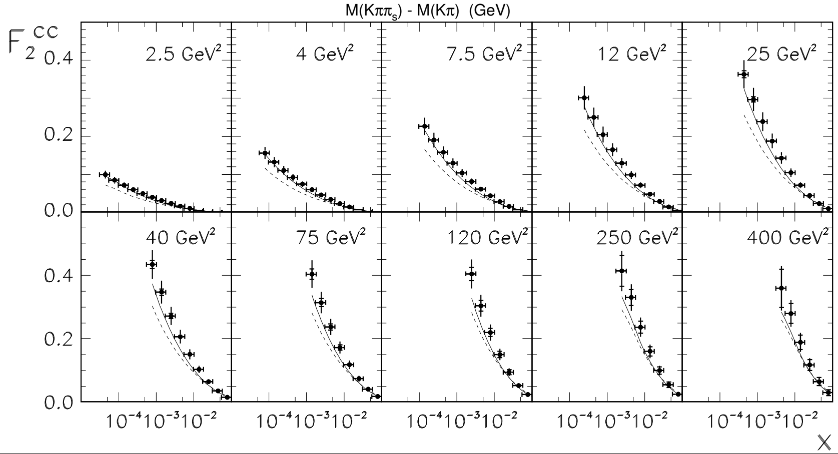
- H1 and ZEUS are operational and ready to take data

High P_T Physics at HERA 2

- e^+p NC + CC Cross sections
- e^-p NC + CC Cross sections
- Longitudinally Polarised $e^\pm$ measurements
- W production
- Z^0 and l^+l^- production
- High P_T jet production
- CC with γ
- CC with dijets
- Heavy Flavour at high Q^2

Heavy Flavours at HERA 2

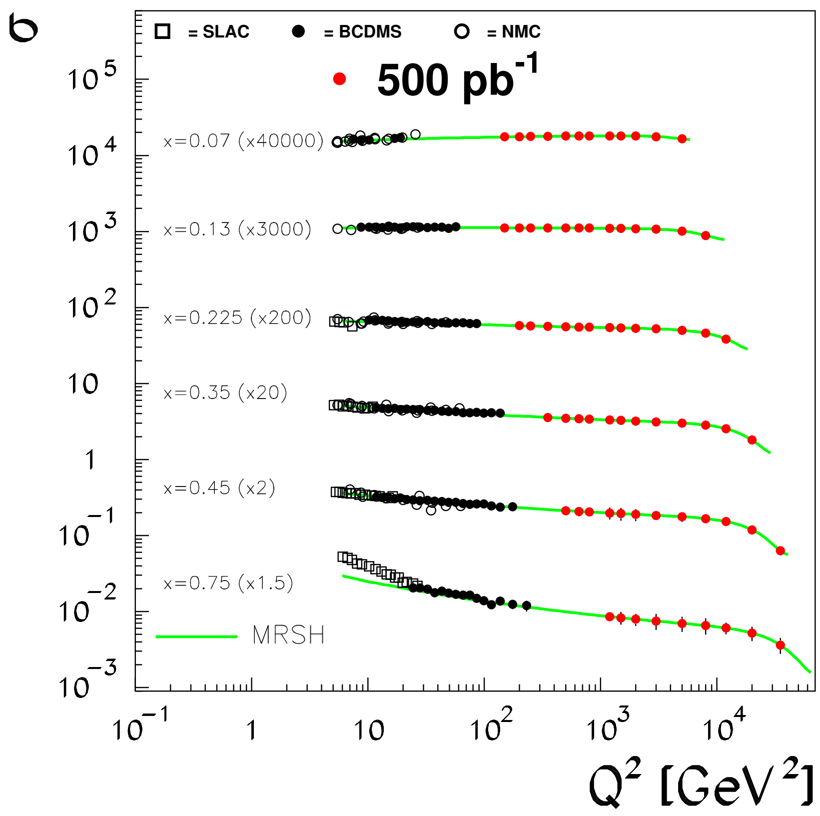




- HERA already a charm factory!
- New+upgraded silicon trackers $\Rightarrow$
  More channels to be accessed, smaller errors on existing channels
- Greatly improved b cross-sections and top sensitivity as well

e^+p NC Cross sections

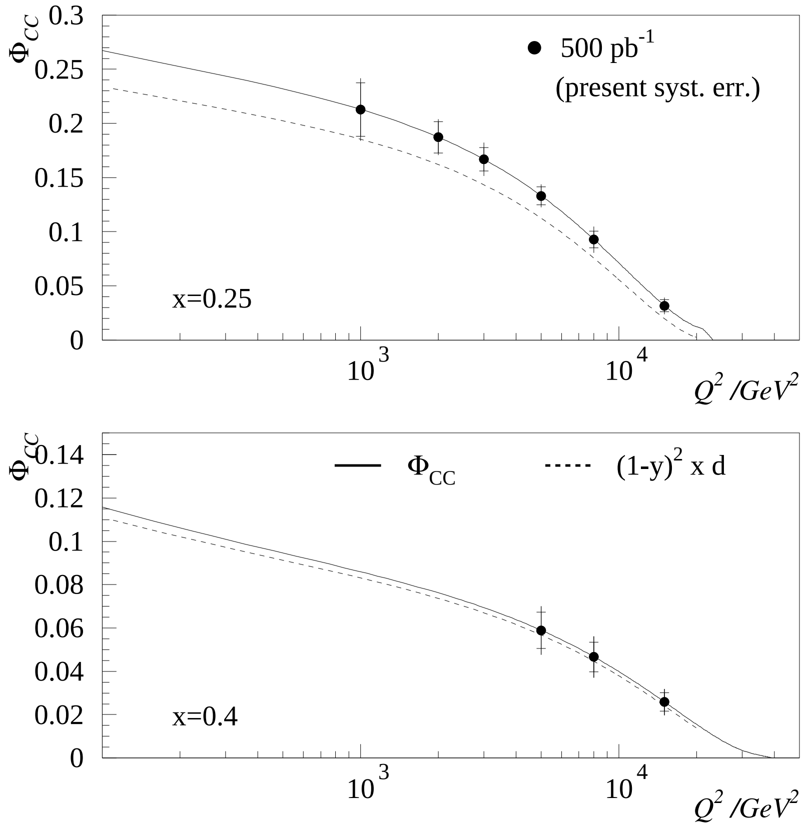
$> 500\ \mathrm{pb}^{-1}$ needed to make significant improvements



- $2-10\%$ u quark precision up to $x = 0.65$
- 10% error for cross section $Q^2 = 20\,000\ \mathrm{GeV}^2$
- 5σ discovery for deviations DATA/SM> 1.5

e^+p CC Cross sections

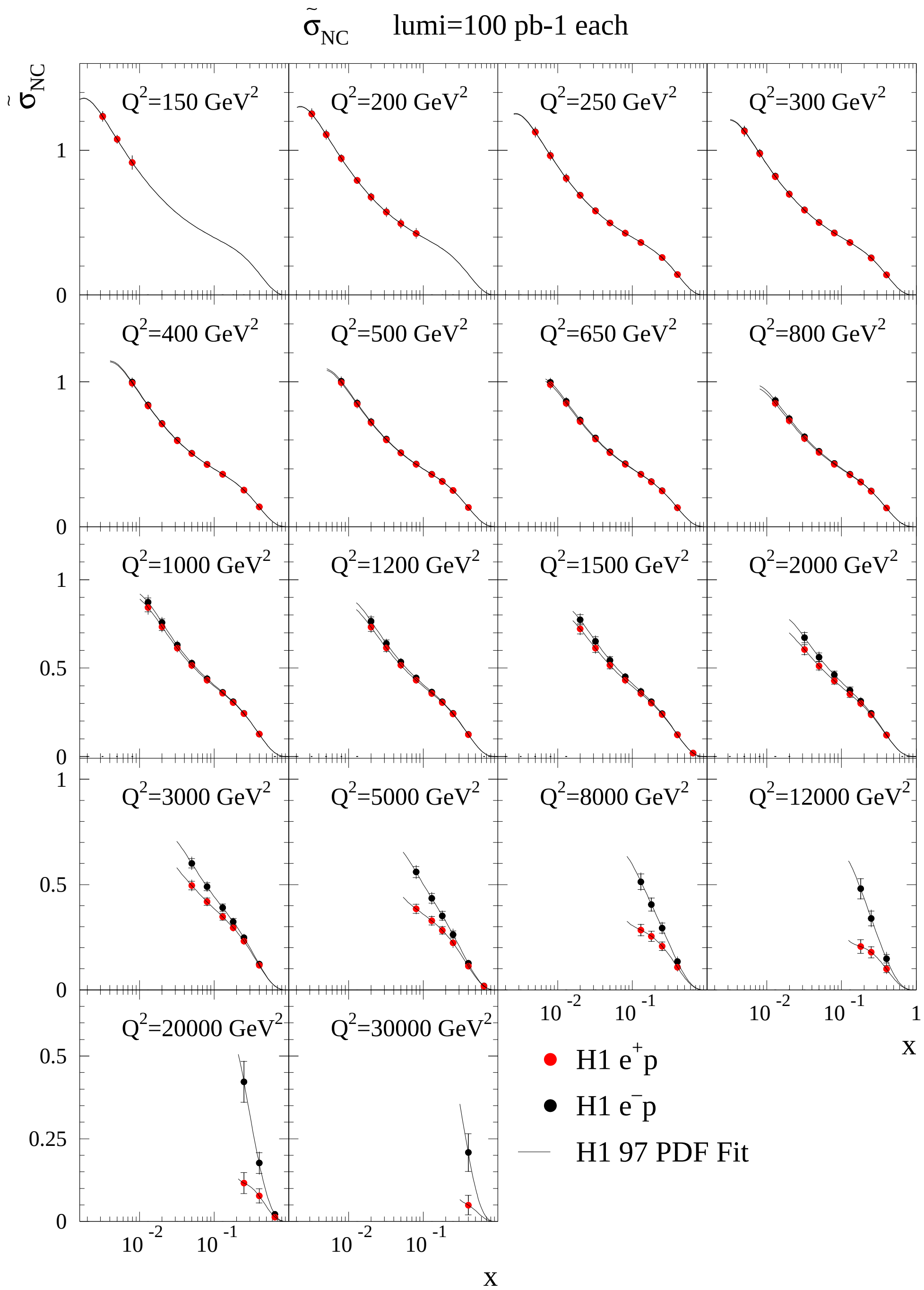
$> 500\ \mathrm{pb}^{-1}$ needed to make significant improvements



- 10% precision on d density up to $x = 0.4$
- extension of measurements to $x = 0.65$

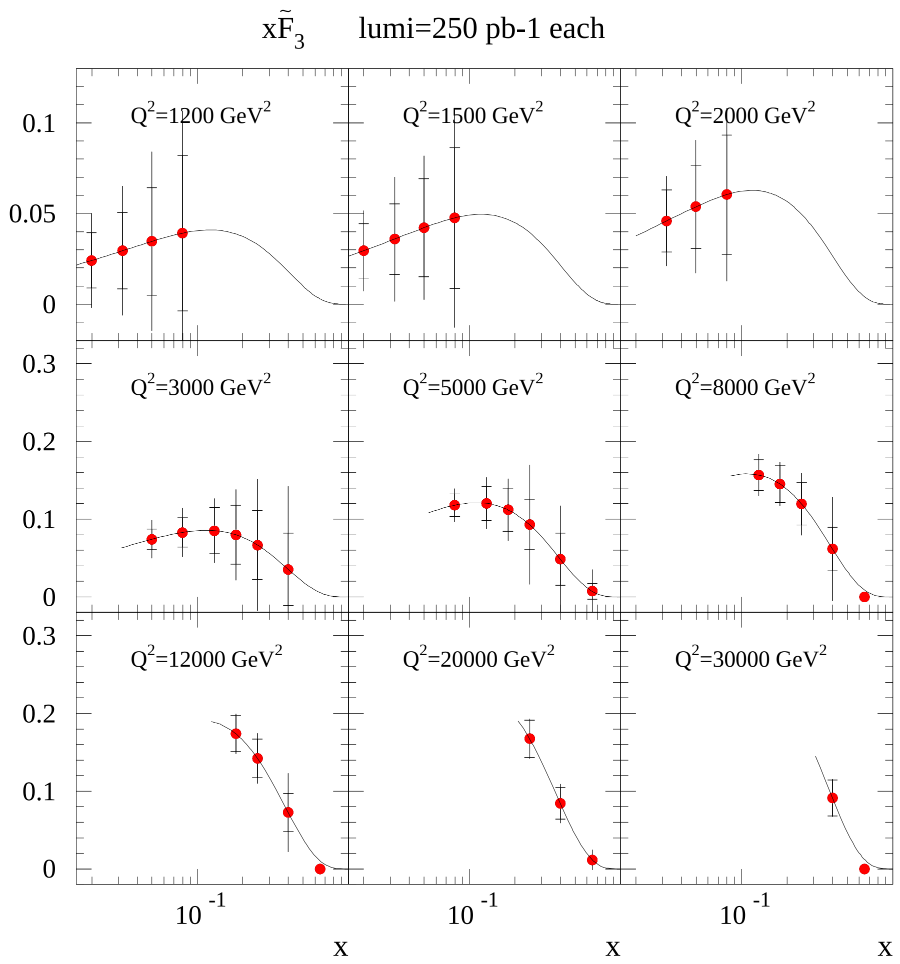
e^-p NC Cross section

$> 100\ \mathrm{pb}^{-1}$ needed to make significant improvements



xF_3

500 pb^{-1}



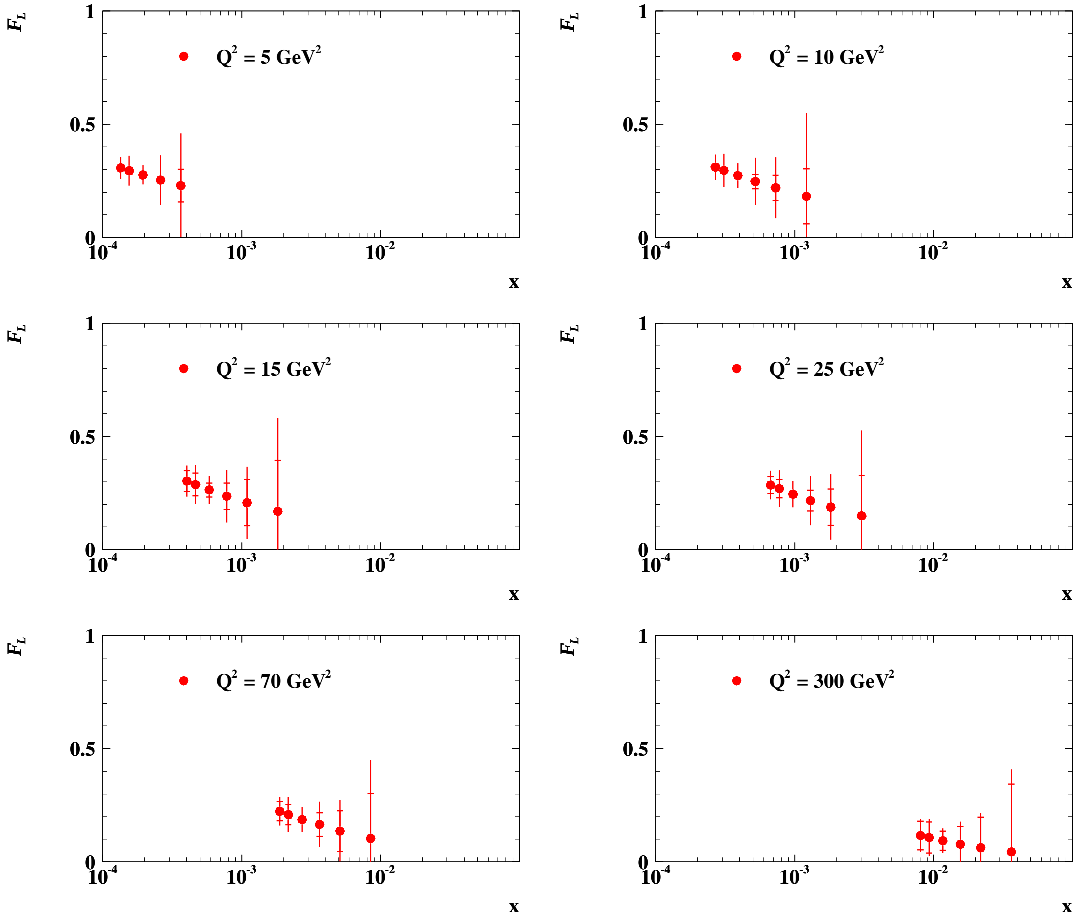
- Measurements of 10% accuracy

$0.05 < x < 0.3$

- Still statistically limited. More lumi would be nice!

Low Proton Energy Runs – F_L

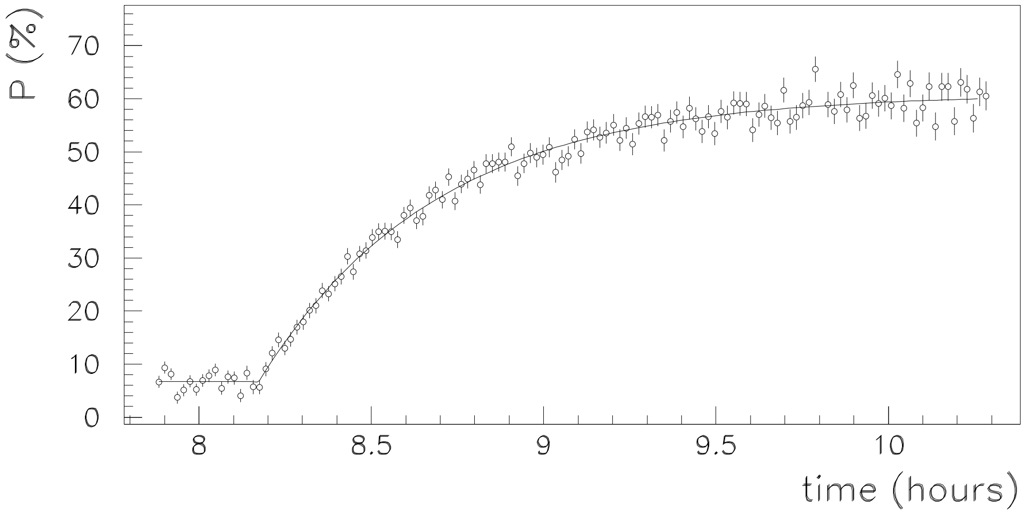
10 pb^{-1} with $E_p = $ 300,350,465,920 GeV



- Special runs needed at lower and if possible higher proton beam energy
- Allows a direct measurement of F_L
- Allows access to high x at low Q^2

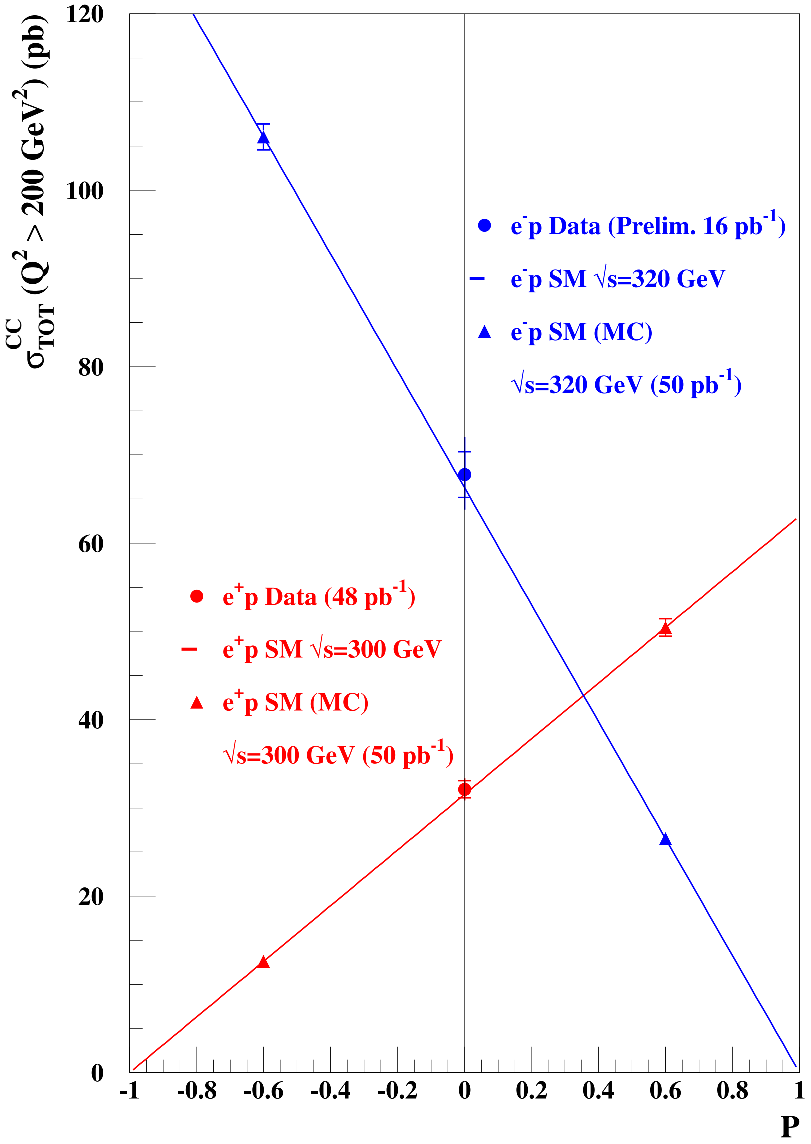
$\Rightarrow$ HERA will measure over full kinematic range for first time

Longitudinal Polarisation of $e^{\pm}$



- Routine polarisation already established at HERA for HERMES experiment
- Allows a full exploration of high Q^2 phase space
- Enhancement of statistics for SM processes
- Allows SM processes to be 'switched off' leading to enhanced sensitivity to BSM effects
- Will considerably aid identification of new physics if found

Polarised $e^{\pm}p$ CC Cross sections

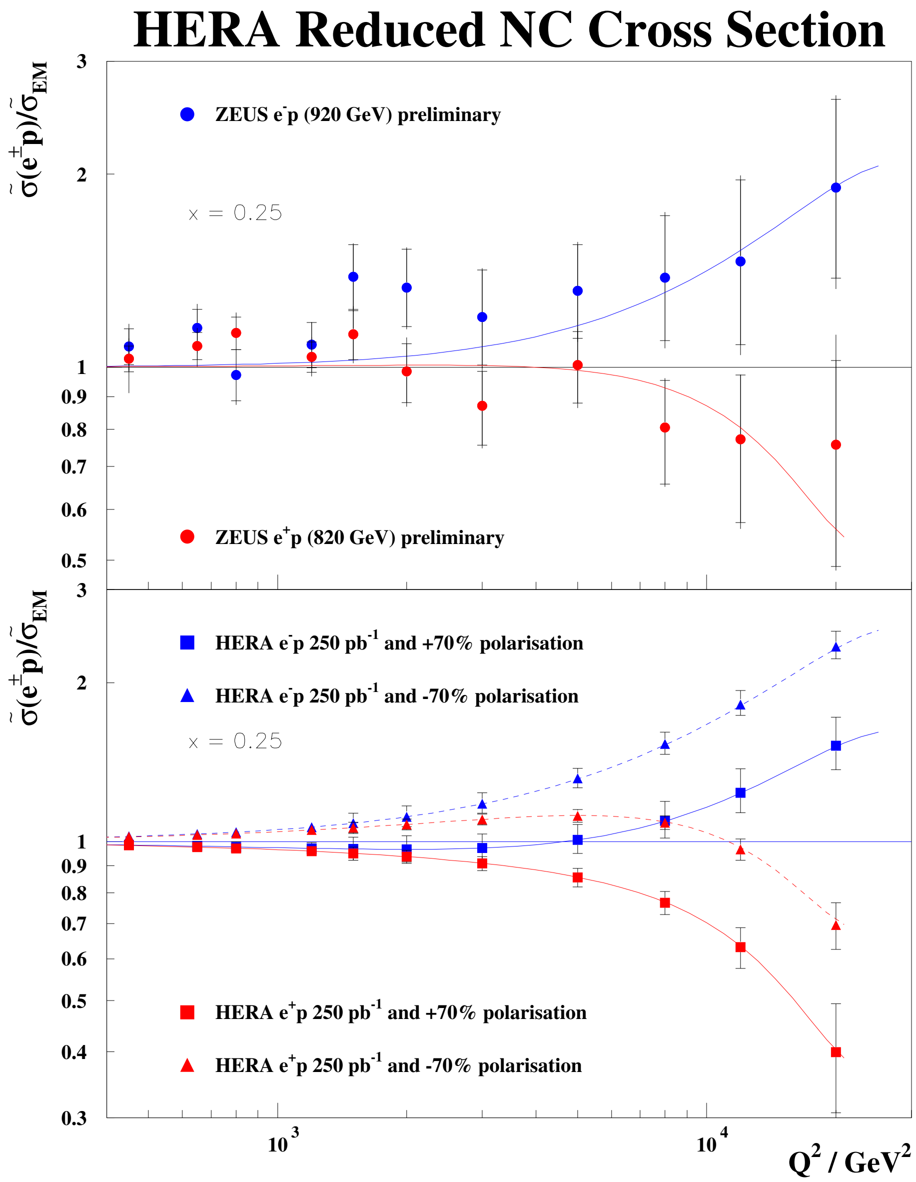


- Look for right handed charge currents
- Any deviation from straight line $\Rightarrow$ New Physics!

(no QCD or EW fits/parameters needed)

- Measurement can already be made with modest luminosity

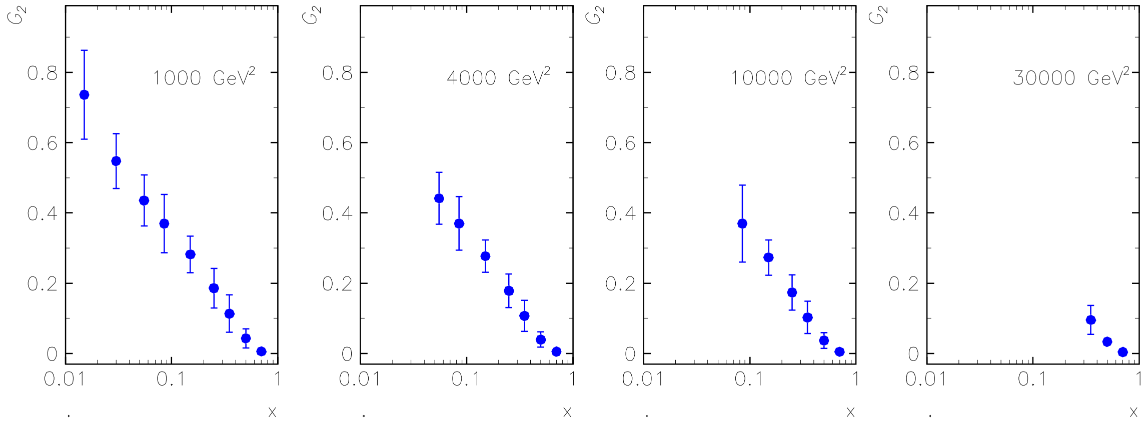
Polarised $e^{\pm}p$ NC Cross sections



- Measuements can be made with accuracy of $\approx 10\%$
- Considerable enhancement of NC cross section with L handed e^-p
- Running with R handed e^+p could reduce background for BSM processes!

Measurement of Parity Violation SF G_2

e^+p 200 pb^{-1} $\lambda \pm 0.5$



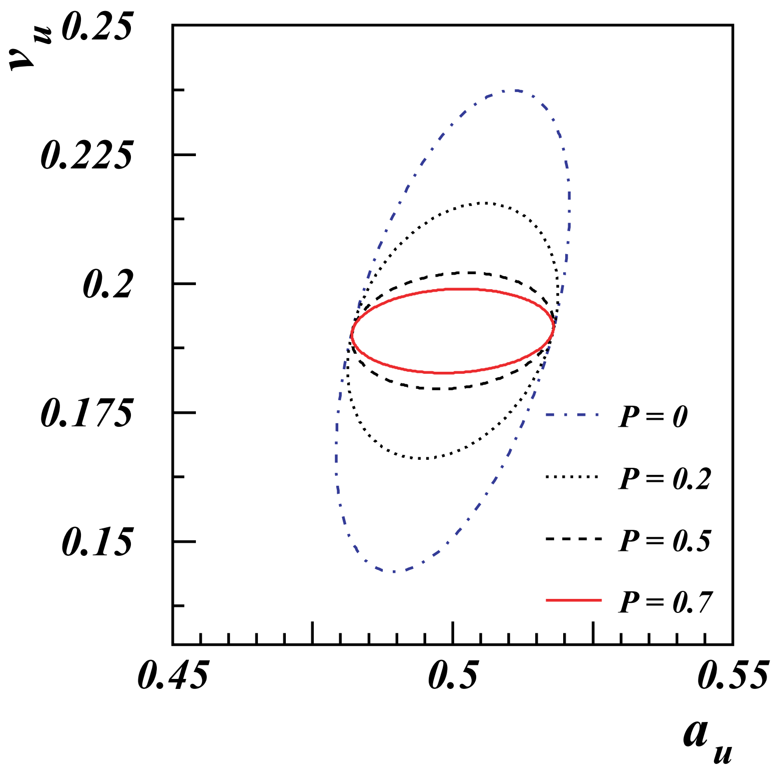
$$A = \frac{\sigma_{NC}(\lambda) - \sigma_{NC}(-\lambda)}{\sigma_{NC}(\lambda) + \sigma_{NC}(-\lambda)}$$

$$\simeq \mp\lambda\kappa_z a_e \frac{G_2}{F_2} \simeq \pm\lambda\kappa_z \frac{1 + d/u}{4 + d/u}$$

- Test of Electroweak theory
- Measurement of d/u density
- Similar results with e^+p or e^-p
- Can get first results with $50\mathrm{pb}^{-1}$

Light Quark Couplings to Z^0

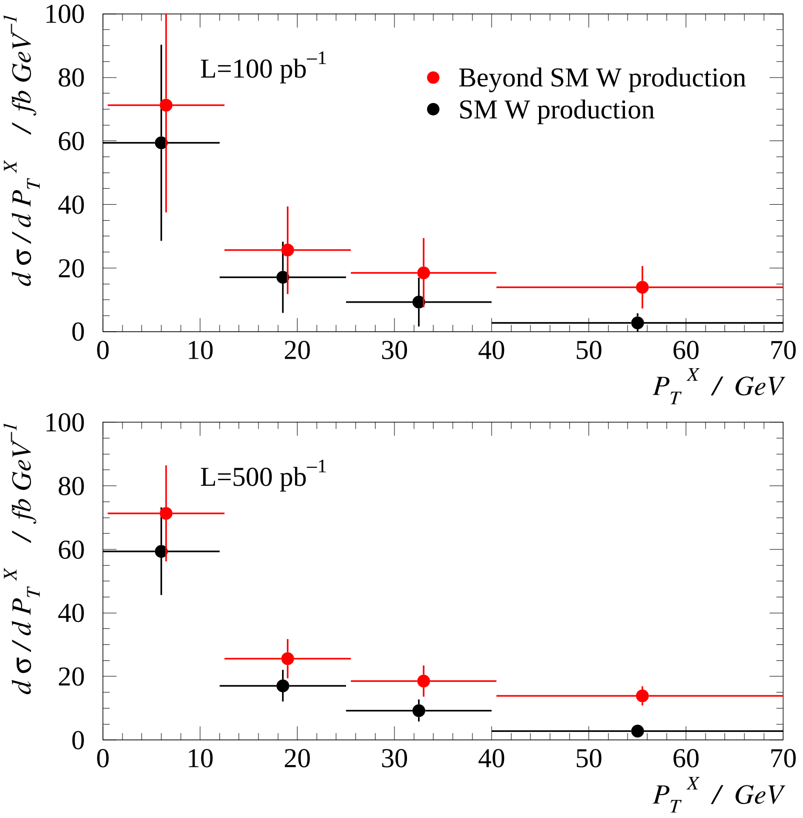
- HERA can make very competitive measurements of pure light quarks (LEP has b and c admixture)



- Polarisation significantly improves limits
- A 250 pb^{-1} polarisation run will give $\delta V_u = 0.015$, $\delta a_u = 0.04$, $\delta V_d = 0.04$, $\delta a_d = 0.10$
- 1 fb^{-1} will reduce errors by factor of 2

Isolated Leptons with P_T^{MISS}

> 500 pb^{-1} needed to make discovery if H1 effect persists



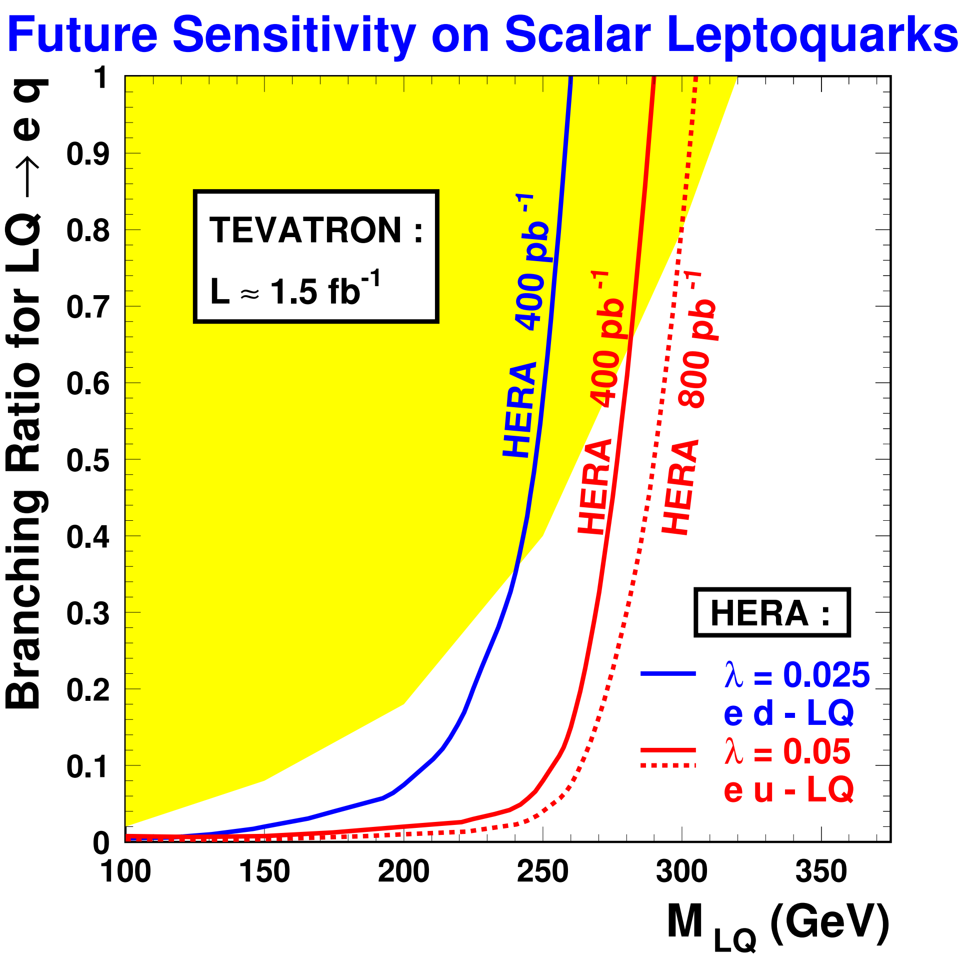
- Can make total cross section measurement with 15% error
- 5σ effect with 500 pb^{-1} ($\sim 3\sigma$ effect now)
- Different cross section with e^+/e^- or polarisation gives new physics evidence independent of SM calculations

Searches at HERA2

- HERA is 1 of only 2 running high energy facilities capable of producing new particles of high mass
- Essential to explore all possible channels and phase space
- Tough competition from Tevatron but HERA will search uncovered phase space for several years in many channels including:

- Lepton Flavour violation
- Leptoquarks
- Excited quarks and leptons
- Quark sub-structure
- R Parity violating SUSY

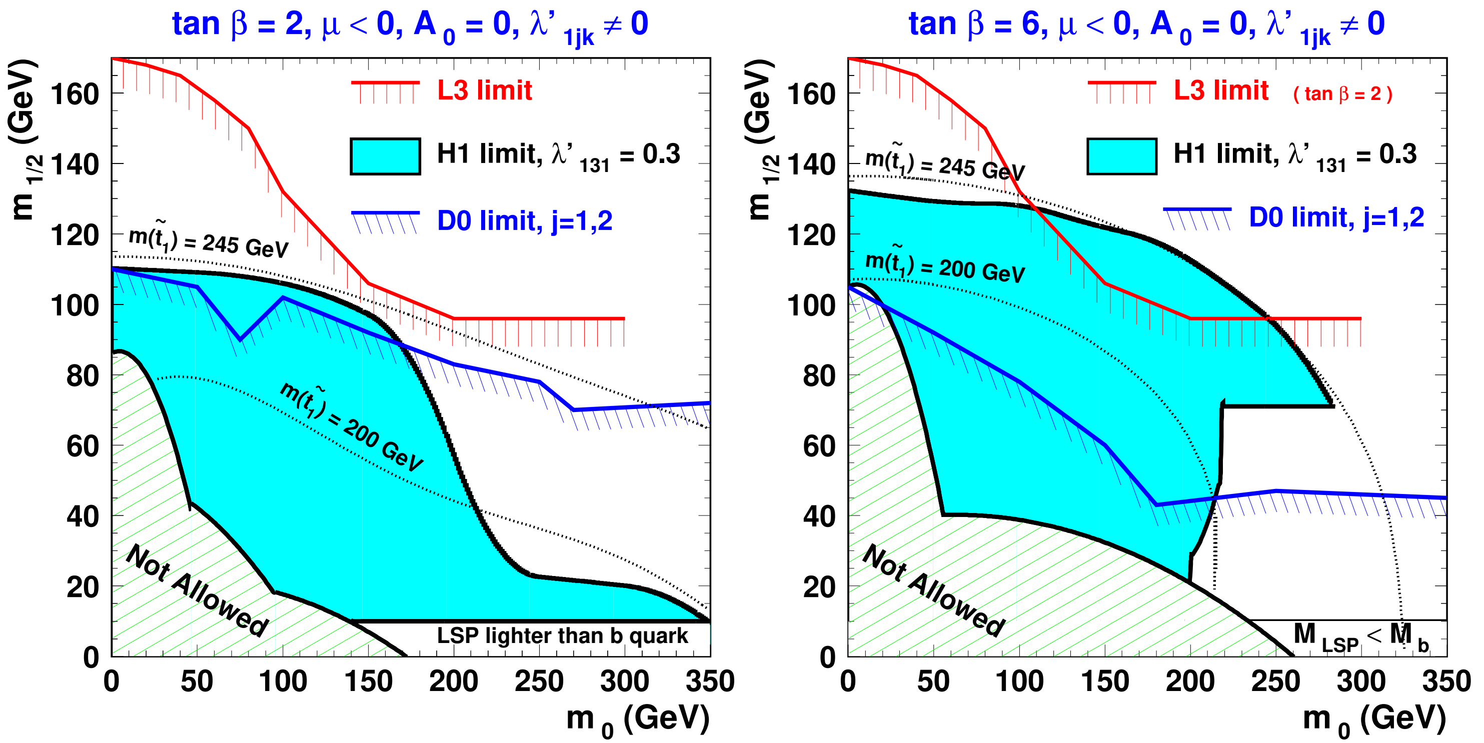
Leptoquarks



- HERA will continue to have best limits, especially at low branching ratios

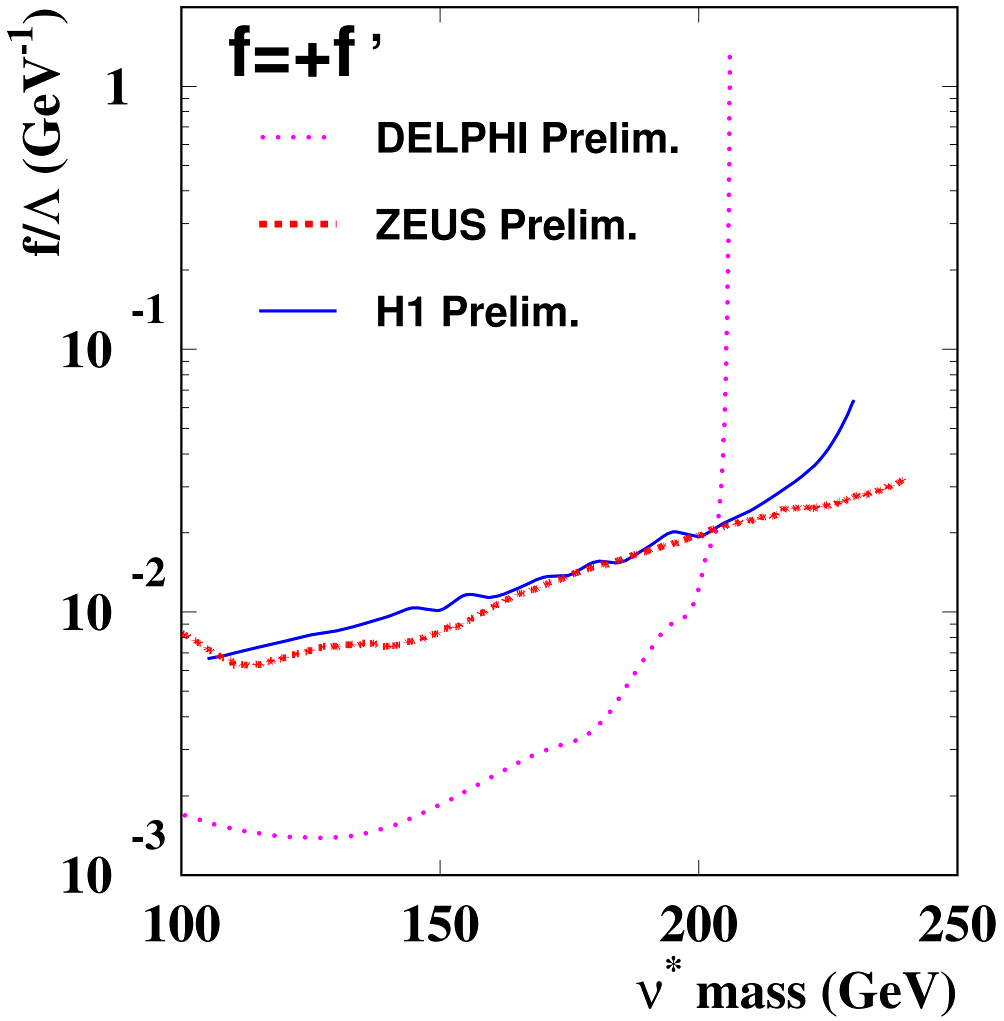
$\not R$ Parity violating SUSY

Minimal Supergravity + R_p Violation



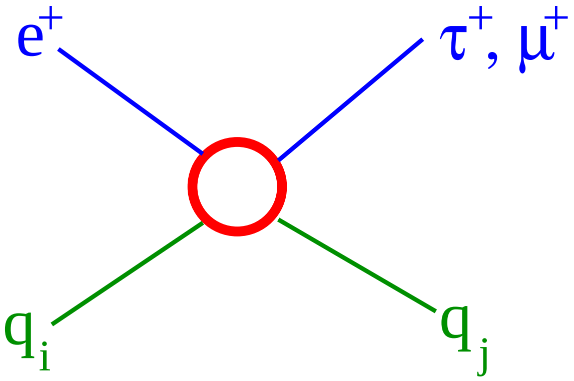
- HERA will continue to be competitive at high β

Excited Neutrinos



- No competition from Tevatron in this channel
- HERA has discovery potential beyond LEP II

Lepton Flavour Violation



Limits on $\frac{\lambda_{eq_i}\lambda_{\tau q_j}}{M_{LQ}^2}$ for F=0 LQ's:

$e \leftrightarrow \tau$

$q_i q_j$	$S^L_{1/2}$	$S^R_{1/2}$	$\tilde{S}^L_{1/2}$	V^R_0	V^L_0	$\tilde{V}^R_0$	V^L_1
1 1							
1 2							
1 3	-					-	
2 1							
2 2							
2 3	-					-	
3 1	-					-	
3 2	-					-	
3 3	-					-	

: HERA will set most stringent limit on $\frac{\lambda_{eq_i}\lambda_{\tau q_j}}{M_{LQ}^2}$

: HERA will set most stringent limit on $\frac{\lambda_{eq_i}\lambda_{\tau q_j}}{M_{LQ}^2}$
if limits from rare B-decays do not improve by factor > 2

- Main competition from rare b decays
- HERA 2 has significant discovery potentials in many channels

Searches at HERA2– Summary

model	beam charge	best polarization: left	best polarization: right
right handed currents (CC)	e^-	- -	$e^-_R \to \nu_R$ (W_R)
SUSY R_P Violating	e^+		$e^+_R \to$ $\tilde{u}_L, \tilde{c}_L, \tilde{t}_L$
	e^-	$e^-_L \to$ $\tilde{d}_R, \tilde{s}_R, \tilde{b}_R$	
anomalous top	$e^\pm$	$t_{L,R}$	
$F = 0$ Leptoquarks	e^+	$S_{1/2}, V_0$	
		$e^+_L \to \overline{\tilde{V}^R_0}$	$e^+_R \to \overline{V^L_1}$ $e^+_R \to \tilde{S}^L_{1/2}$
$F = 2$ Leptoquarks	e^-	$S_0, V_{1/2}$	
		$e^-_L \to S^L_1$ $e^-_L \to \tilde{V}^L_{1/2}$	$e^-_R \to \tilde{S}^R_0$
Contact Interaction	$e^\pm$	various	
Quark Radius	$e^\pm$	any	
Large Extra Dimens.	$e^\pm$	any	
Excited Fermions	$e^\pm$	$e^-_L \to f^*_R$	$e^+_R \to f^*_L$
Excited Neutrinos	e^-	$e^-_L \to \nu^*_R$	

- e^+p or e^-p L or R ? $\Rightarrow$ We need it all!

Summary

- HERA 2 upgrade complete. Work in progress to get machine working
- Detectors commissioned and ready for data
- HERA 2 will give us high precision DIS data at high Q^2 and x
- Polarisation gives us many new possibilities to test the standard model
- New detectors $\longrightarrow$ huge improvement in heavy quark measurements
- Lower energy runs needed for direct measurement of F_L
- Definite conclusion to isolated lepton story
- HERA has a real chance of discovering new physics