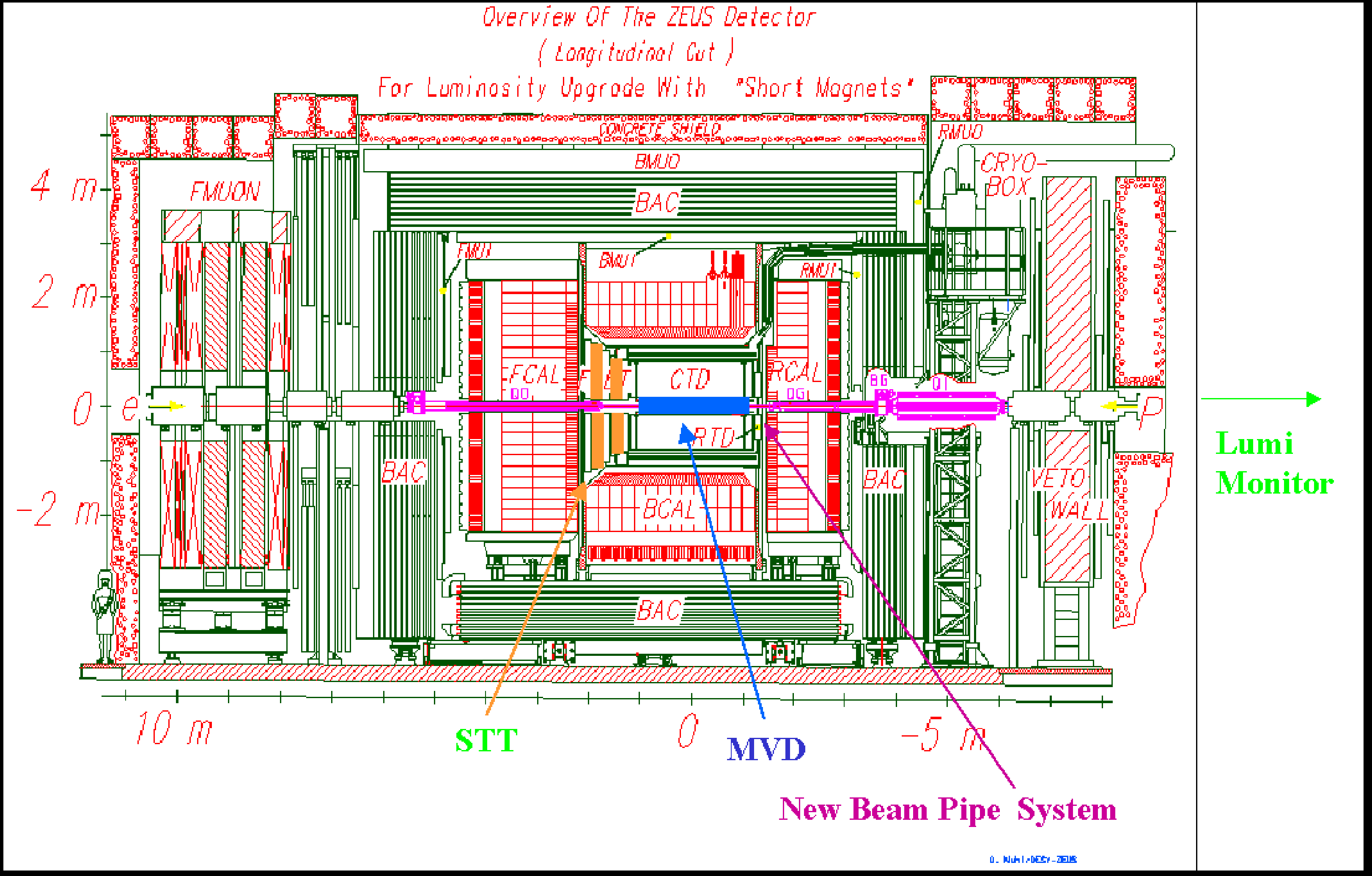
HERA II Physics

- Both ZEUS & H1 have made major upgrades in order to utilise the increase in HERA luminosity to the full.



HERA II Physics

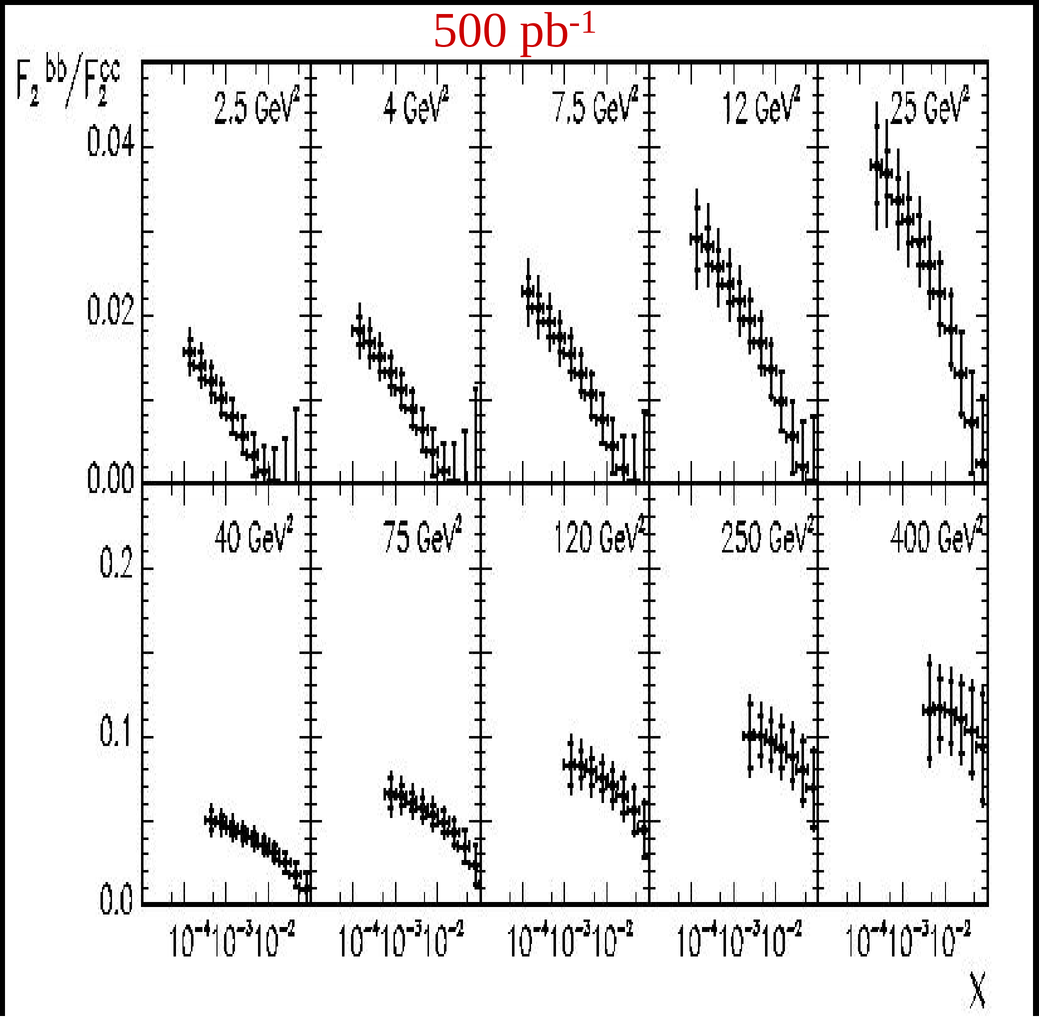
- The upgrades concentrate mainly on the following areas:
  - Vertex region (MVD) - Studies of heavy quarks, exotics, etc.
  - Forward region (STT) - Improved kinematic reconstruction of both jets and scattered electron.
  - Luminosity monitor - Cope with greatly increased synchrotron background + likelihood of multiple overlapping Brems. Photons + physics payoff for improved lumi. precision ~ 1%
  - Trigger & electronics - Important for all physics. On ZEUS, triggering stage between Levels 1 & 2 - “Fast Clear” that has been available but never needed to be used; and including MVD in Level 2.
  - Polarimeter - ZEUS involved with TPOL position measurement.

Vertex Region

- The ZEUS MVD is a silicon strip detector constructed from n-type silicon with p+type implants and 20μ pitch strips, readout with 120μ pitch. There are 712 sensors and > 200K readout channels.

Vertex Physics

- The major physics topic will be the flavour composition breakdown of the proton (and indeed the photon). We already have quite precise measurements of the charm-quark structure from HERA I.



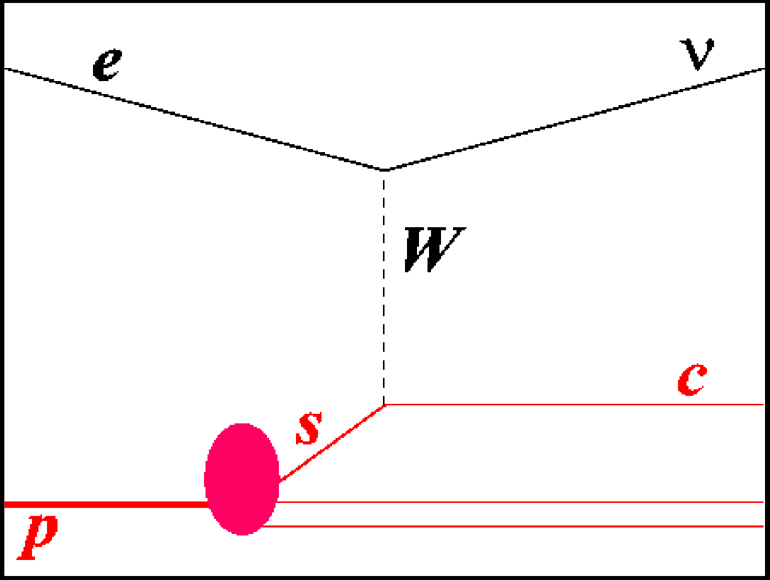
- Very precise measurements will be possible for HERA II; also gives accurate gluon determination.

- Accurate b contribution to F_2 will become possible

Vertex Physics

- A high-precision, high-acceptance vertex detector will allow both collaborations to make a full flavour decomposition of the inclusive F2 structure function.

- For example, charm signal in charged currents in principal measures the s-quark density (+ leading particles in NC etc.; but also competing non-s digrams in CC)

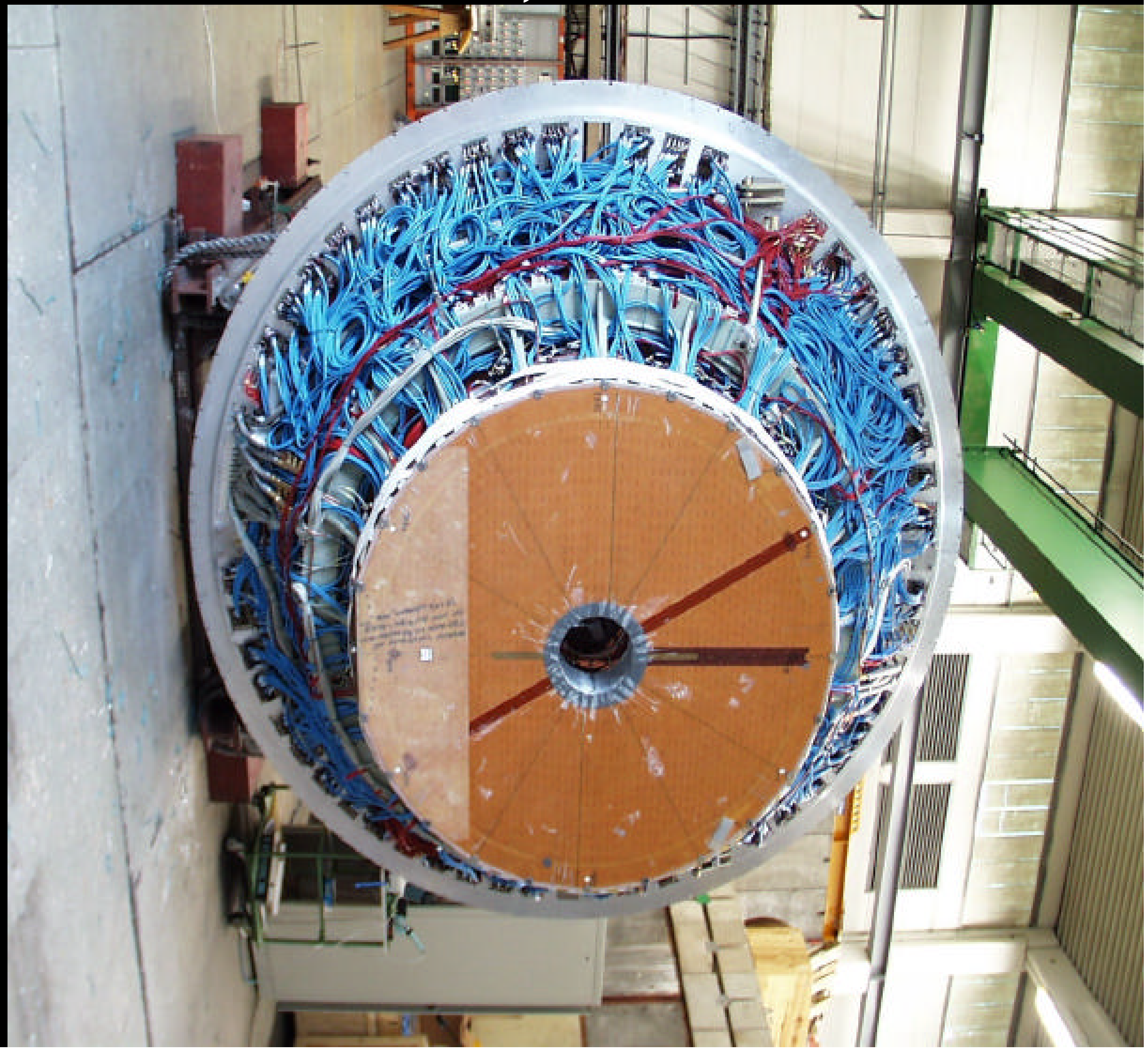


- At HERA II, both singlet & non-singlet pdfs
  u, d, s (CC DIS)
  c, b, g (NC DIS)
  can be determined with good accuracy.

Forward Physics

- ZEUS major upgrade in forward direction replacement of TRD's with two stations of straw-tube chambers, each with 3 stereo layers.

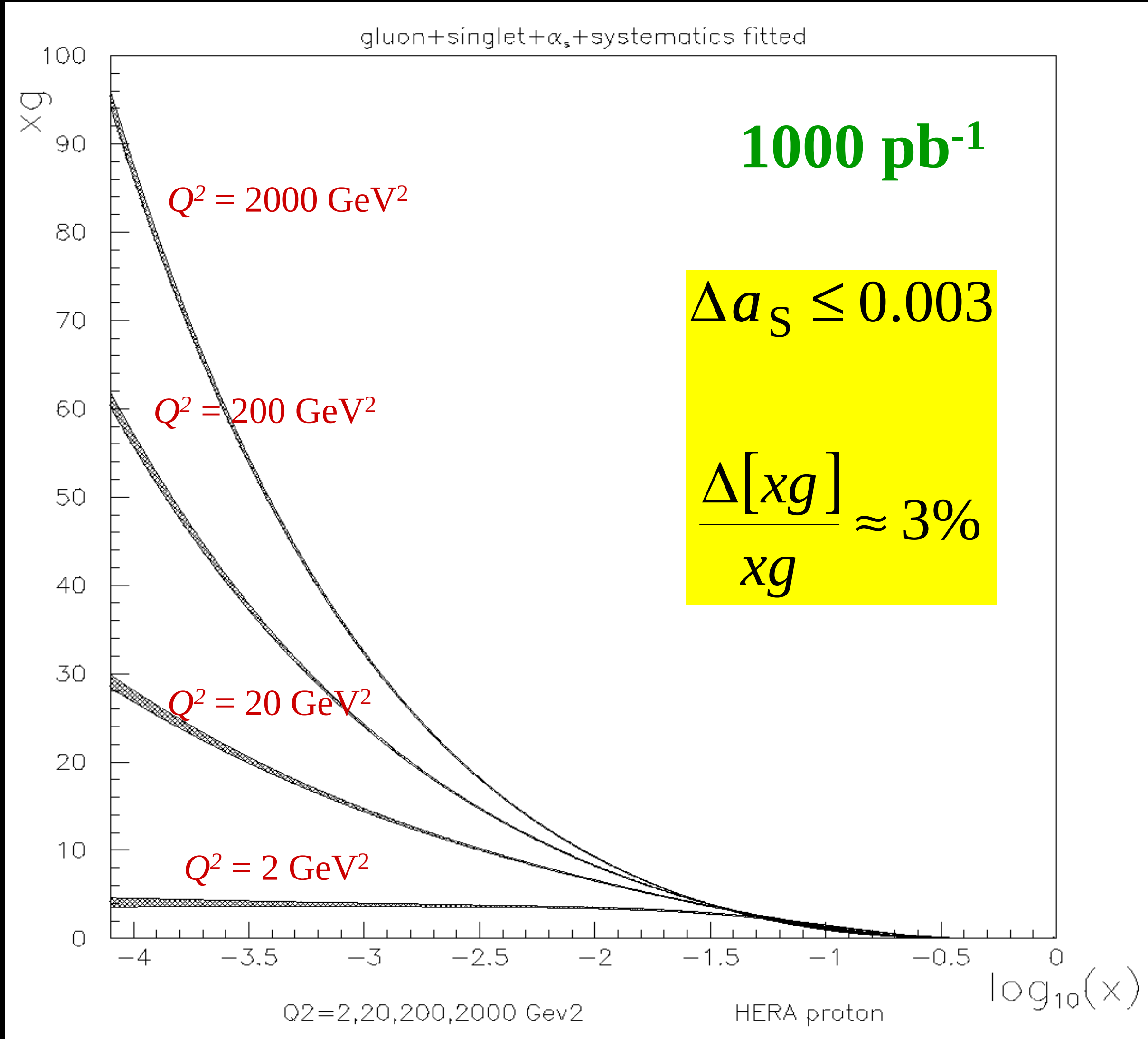
- The forward wheels in the MVD also give improved resolution in forward direction.



Forward Physics

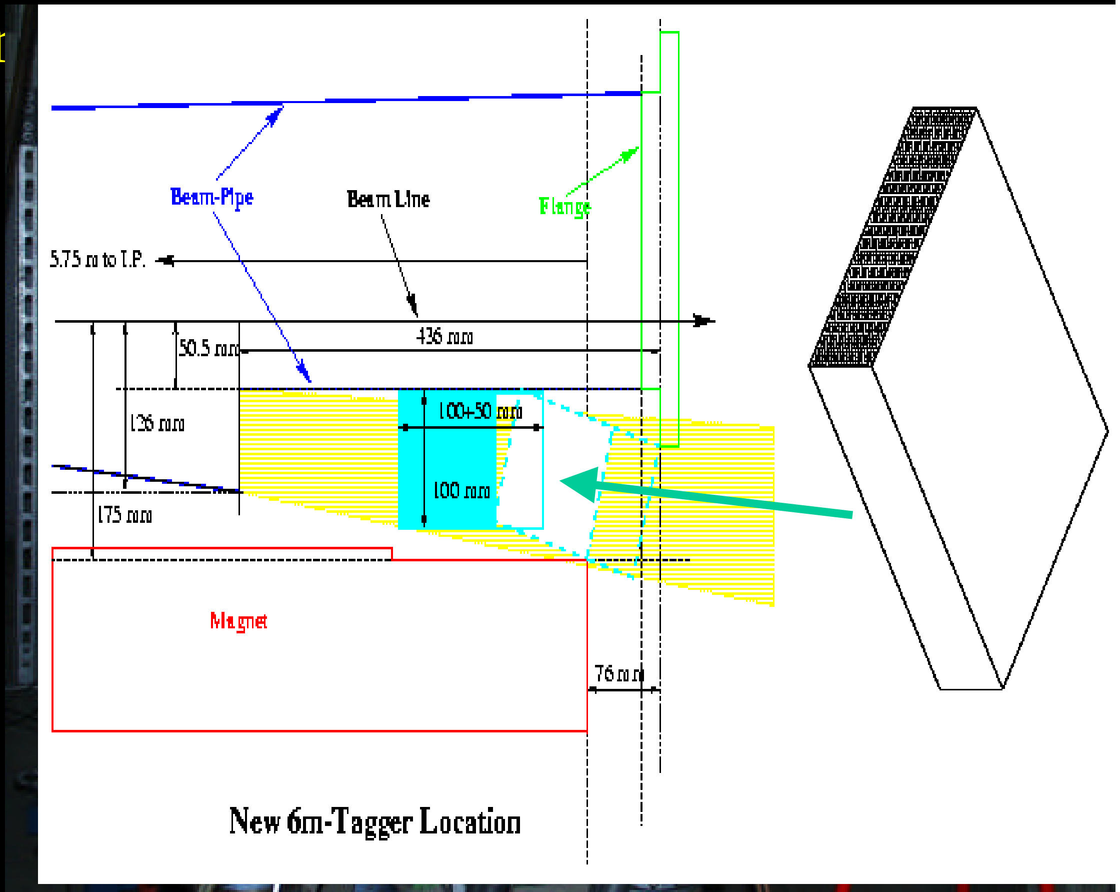
- Major payoff in increased accuracy for high-Q^2 NC

- The improved accuracy in forward direction will also greatly improve resolution on forward jets etc. and therefore “BFKL” non-DGLAP evolution studies.



Lumi Monitor

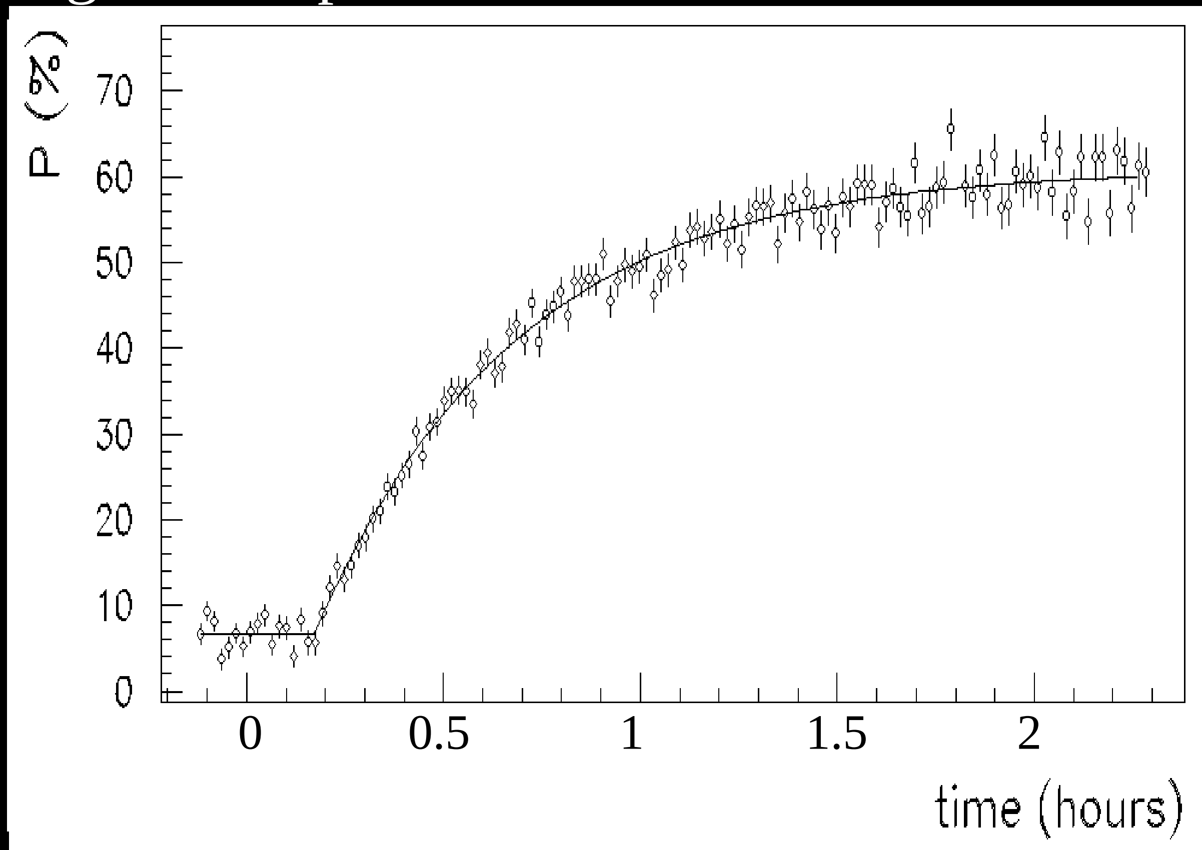
- ZEUS went for "belt & braces" approach: two devices with very different systematics plus precision electron tagger.
- "Standard" Pb/scintillator calorimeter plus "active filter" of aerogel.
- Dipole spectrometer to measure converting e^+e^- pairs.
- "6m tagger" W/fibre to measure the energy after the bremms.



- Aim is to get to around 1% error in luminosity.

Polarisation

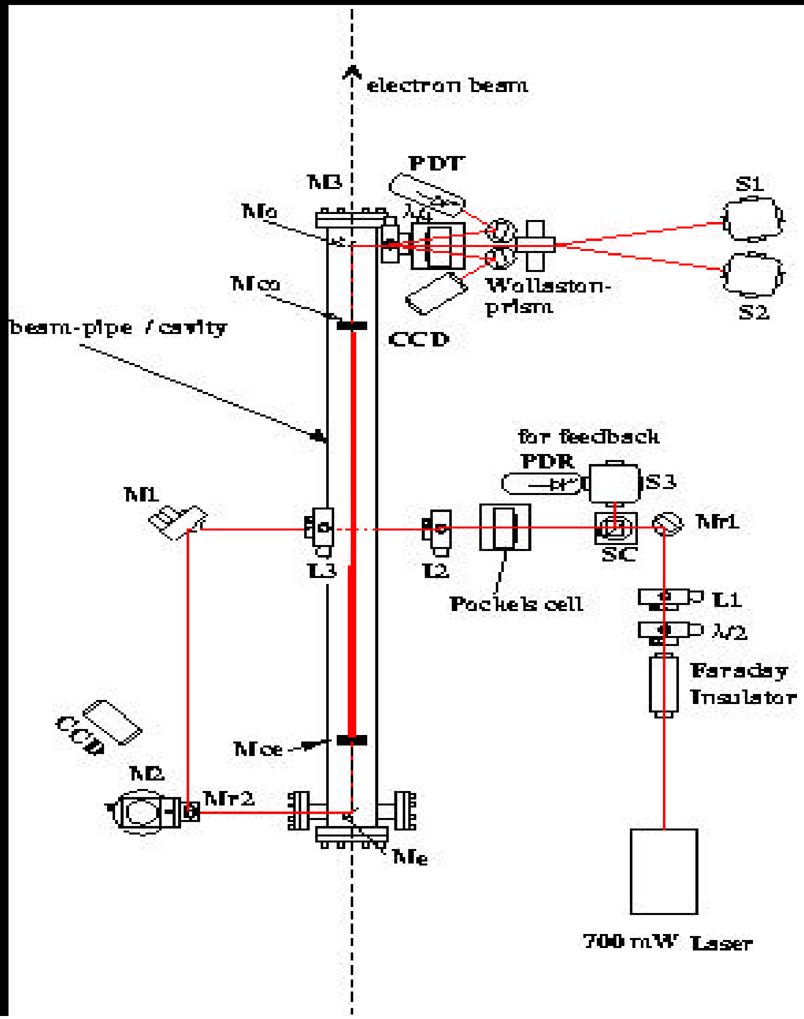
- HERA II will give us access to a qualitatively new region of physics via longitudinal polarisation.
- Spin rotators will be commissioned around H1 & ZEUS IRs.



- Although the theoretical attainable polarisation will fall somewhat because of the new lattice, we expect similar performance to that enjoyed until now by HERMES

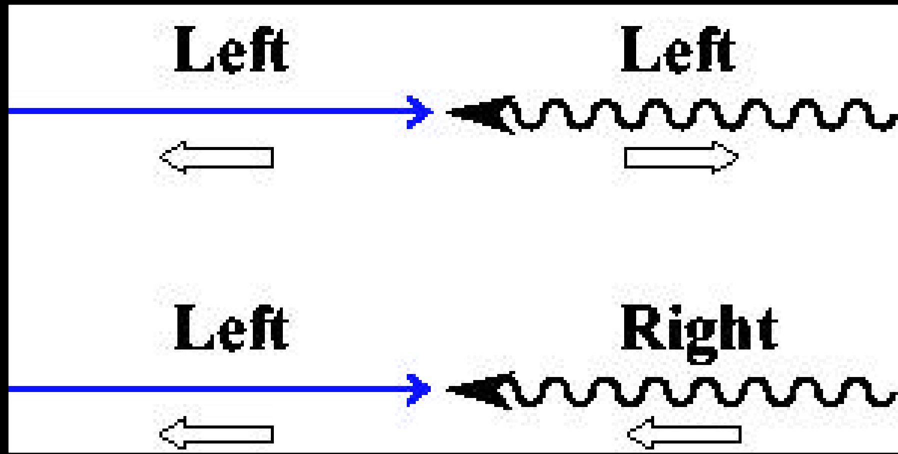
Polarisation

- Accurate measurement of both transverse (TPOL) and longitudinal (LPOL) polarisation plus machine lattice simulation will give us confidence in an accurate measurement at IP.
- To do this we need accurate, short-time scale, determination of the polarisation, ideally bunch-by-bunch. This is a challenge in high synchrotron radiation environment.
- Key is to use back-scattered laser light and precision detectors and DAQ.



Polarisation

- For longitudinal polarisation, consider situation in the photon-electron CM frame

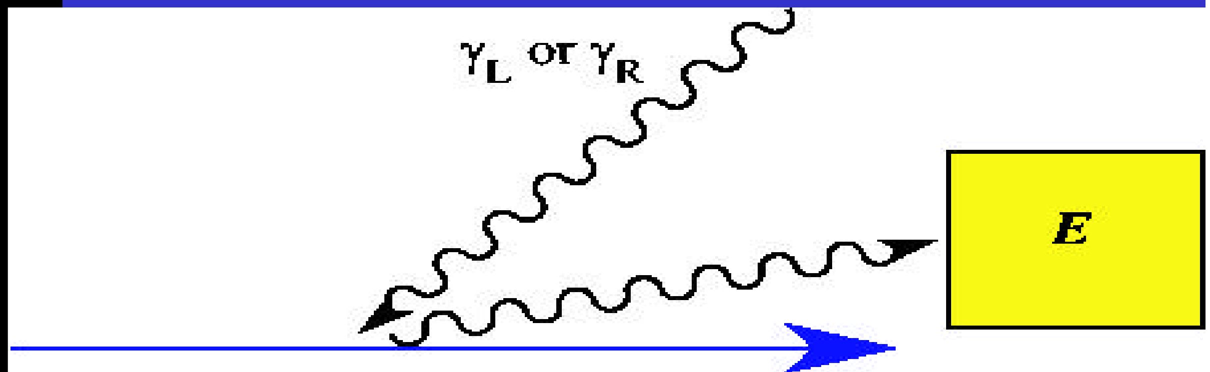


$L_Z = \frac{1}{2}$

$L_Z = -\frac{3}{2}$

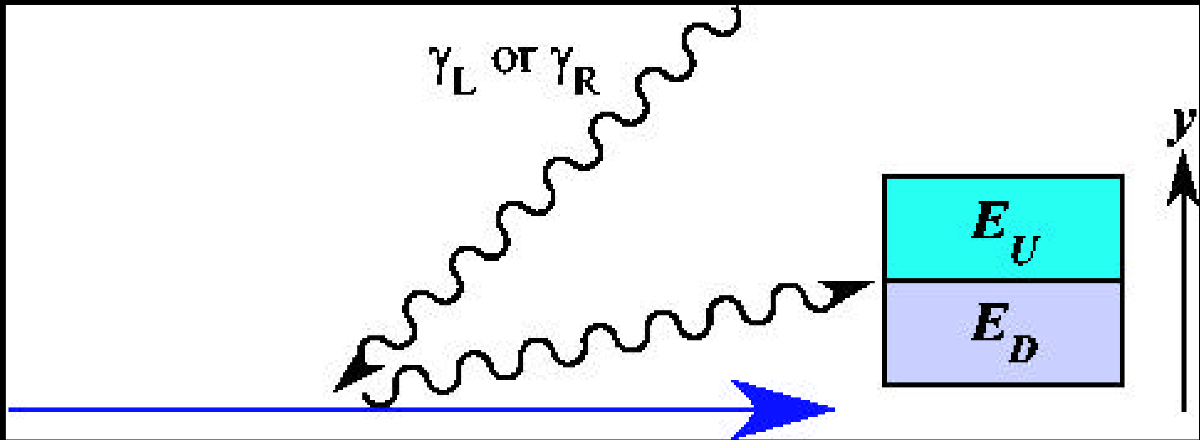
- Angular dependence of scattering in CM system depends on degree of pol. Boosting back to lab converts this angular asym. to an energy asymmetry. Measure with accurate calorimetry, preferably bunch-by-bunch.

Measure *ENERGY* asymmetry of back-scattered Compton photons:



Polarisation

- For transverse polarisation, the spin direction already defines a spatial axis wrt the beam direction, so that it is clear that there will be asymmetries in this axis depending on the relative fraction of up- and down-polarised electrons.



$$P = \left(\langle y \rangle_L - \langle y \rangle_R \right) K_h$$

- Requires high-precision radhard position detector to detect the up-down asymmetry.

Polarisation

- LPOL implementation (and overall DAQ) responsibility of French groups in H1; uses Fabry-Perot cavity to increase continuous laser power to allow operation in single-photon mode.

- Advantages are in-situ calibration using Compton edge, high rate and thereby bunch-by-bunch measurement.

- TPOL implementation - position-sensitive detector responsibility of IC London & Tokyo ZEUS groups.

Polarisation physics

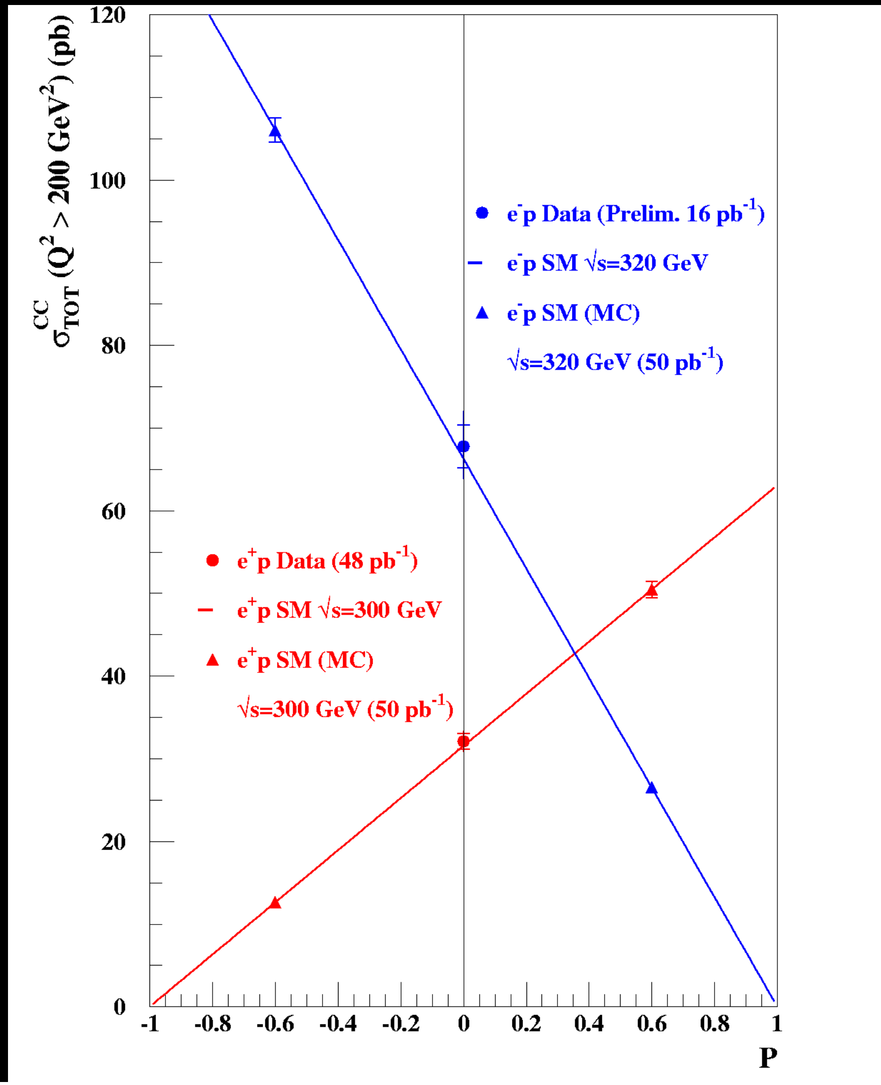
- The accurate measurement of polarisation opens up a completely new domain of HERA physics at high Q^2.

$$s^{CC}_{e^{\pm}p} \propto (1 \pm P)$$

P = polarisation

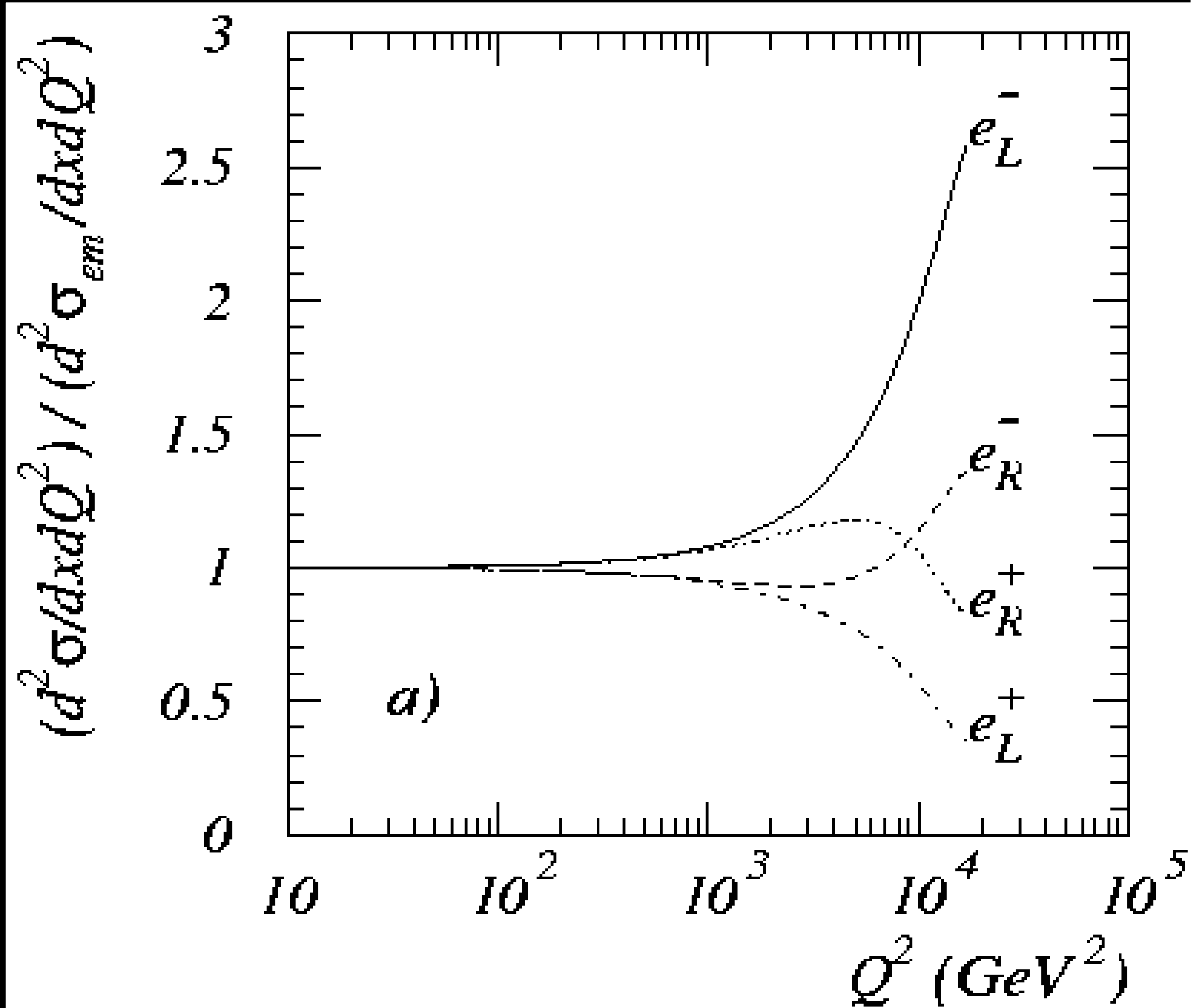
Exclusion limit

$M_W(R) > 400$ GeV



Polarisation physics

- Polarisation dependence of cross-sections is a LARGE effect
- For example, @ $Q^2 = 10^4$ GeV^2, $x = 0.2$, $\sigma(e_L^-) / \sigma(e_R^-)$ is almost a factor 2, and can be measured to about 10% tot. uncertainty



Polarisation physics

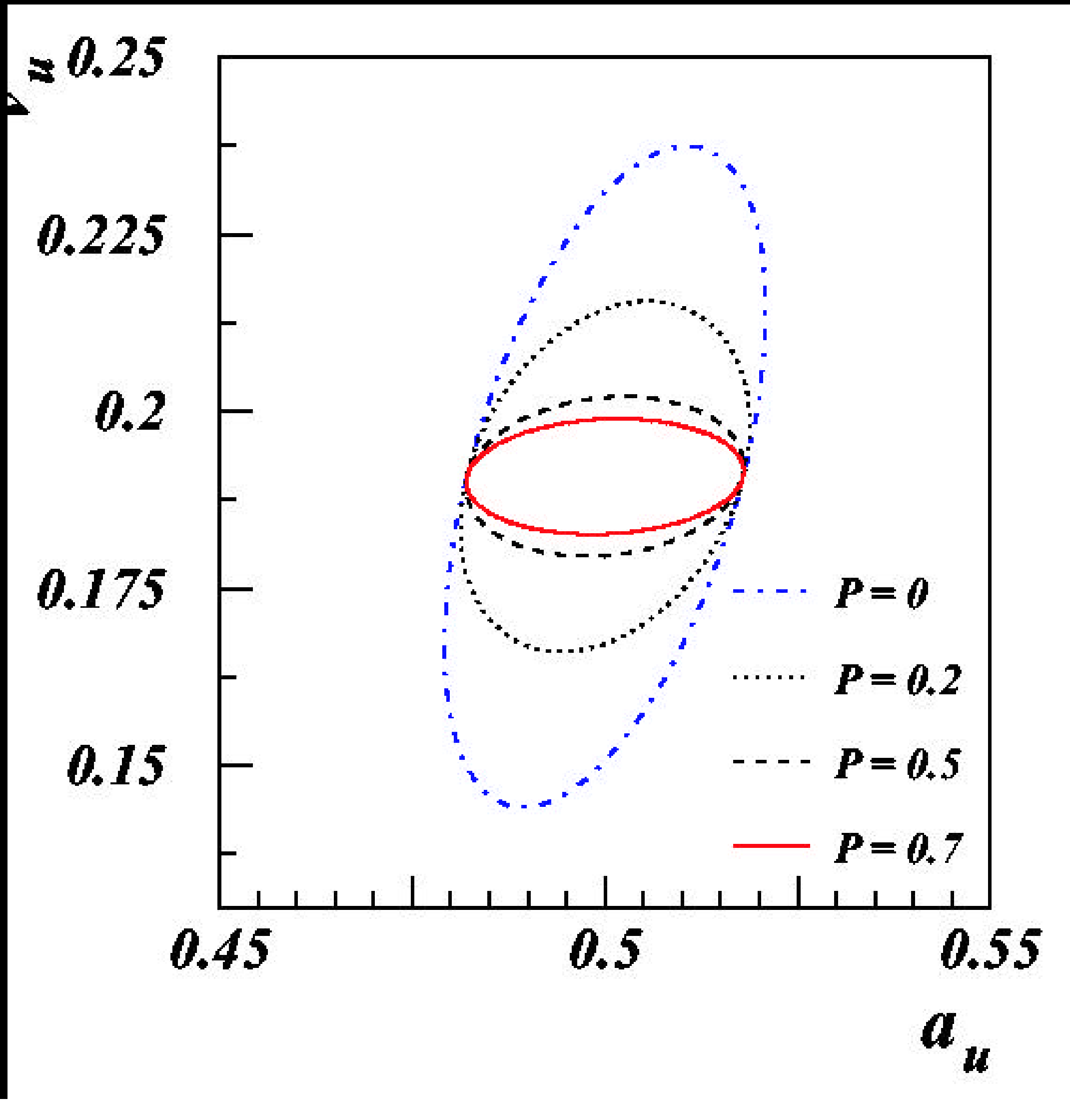
- Quark coupings can be accurately measured, e.g. light quark couplings by looking at differences between σ(L,R).

- Great improvement over unpolarised case.

- $e^{\pm}_{L,R}$, $P = \pm 70\%$

  250 pb^{-1} per beam

	v	a
u	13%	6%
d	17%	17%



Beyond SM & Pol.

- Beyond SM - maybe one will see new right-handed particles!

- For any new physics signal, polarisation is a very precise and flexible tool - one can ~ "turn off" SM backgrounds by varying polarisation - if the new physics has different couplings to SM - which seems very likely - that the S/B will be enhanced.

- HERA is a unique facility for probing some aspects beyond the SM - it is our duty to ensure that we exhaust the phase-space it can reach - e.g. in CM energy, in pol. and charged lepton states - to maximise discovery potential.