# The LPS in diffractive physics with HERA upgrade.

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The functions of the LPS in the analysis of diffractive events are twofold:

1. To measure the transverse momentum of the proton and thus obtain a direct measurement of t.
2. To measure the mass, $M_X$ of the diffractively produced state and/or tag its diffractive nature.

To perform either of these tasks well requires a good geometric acceptance for the proton.

This contribution contains an updated summary of the verbal presentation and further information is appended to the ZEUS interaction region study.

## 1 Transverse momentum measurement

The conclusions are that a HERA upgrade with a low-$\beta$ solution will introduce serious and probably unacceptable systematic errors in measurements of $t-$slope parameters. Because these uncertainties are due to the transverse momentum spread (??) within the emittance of the incident proton beam, they will be present in any method of measuring $t-$distributions so measurements of slope parameters should be completed before the upgrade.

There may remain some possibilites of measuring lower slopes if they are found above $p_T = 1GeV$ since in the low-$beta$ upgrade the LPS acceptance will extend above $1GeV$, but with reduced acceptance.

Table 1: Emittance parameters of the proton beam

| Normalized emittance | | 2.000e-5 | metres |
|---|---|---|---|
| Quantity | Horizontal | Vertical | units |
| $\beta$ | 3.00 | 0.15 | metre |
| $\sigma_{space}$ | 0.131 | 0.0293 | mm |
| $\sigma_{angle}$ | 0.0437 | 0.1953 | milli radian |
| $\sigma_{transverse-momentum}$ | 0.036 | 0.160 | GeV |

## 2 $M_X$ measurement.

Measurements of $x_L$ on the other hand will not deteriorate with the upgrade. At lower values of $M_X$ the kinematics are such that a measurement showing that the proton momentum is close to 1.0 (e.g. ¿0.99) gives a clear tag of a quasi two-body low-t event. At higher values of $M_x$ and provided that $Q^2$ is not very high, $M_X$ can be measured using the LPS momentum measurement.

These statements are quantified by the expression:

$$M_X^2 \;=\; Sy(1 - x - x_L) \;+\; t \;-\; 2p_T^{proton}p_T electron \tag{1}$$

where $x$ and $y$ are the deep inelastic parameters, $x_L$ is the leading proton momentum/incident proton momentum, $p_T$ are the momentum components transverse to the incident beam.

The uncertainty in $M_X$ resulting from the transverse momentum spread in the beam is then

$$\Delta M_X \;=\; \frac{\Delta p_T^{beam}}{M_X}\left\{\frac{p_T^{leading-proton}}{x_L} \;+\; p_T^{scattered-electron}\right\} \tag{2}$$

## 3 Statistical accuracy

Geometrical acceptance in the spectrometer is restricted by the aperture between the beam and the vacuum system. Detectors cannot be placed closer to the beam line than the beams $10\sigma$ profile. When a low-$\beta$ optics is introduced, it modifies the phase space in such a way that the minimum $p_T$ which can be accessed by the detectors is increased and for the proposed upgrade this results in about a factor of two loss in events rate. For events which will need pre-scaling with the higher luminosities, this can be recuperated by introducing a suitable trigger and reducing the scaling factor.

The upper limit to the aperture affects the upper limit of t which can be reached. It depends on the details of the magnet and vacuum chamber design and this is being studied in collaboration with the upgrade designers.