Selecting Diffractive Events at HERA

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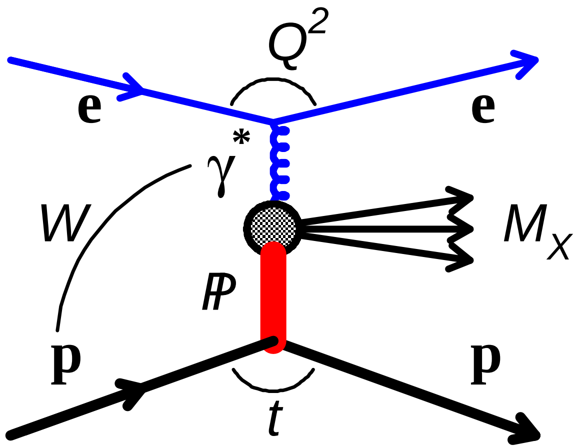

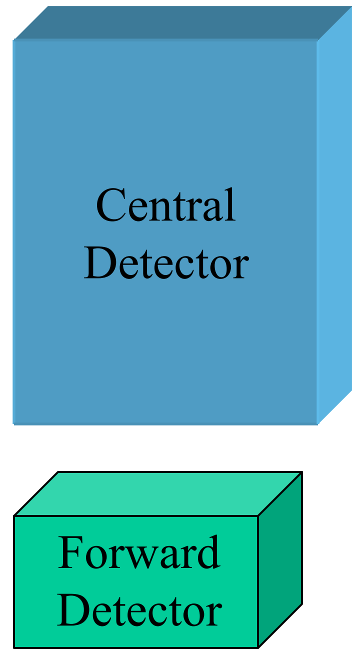

Pseudo-Rapidity or Rapidity Gaps --
$\Delta Y = \ln (W^2/M^2_X)$
----- this talk -------

Forward Protons with > 95% of the incoming-momentum

Q^2 - virtuality of the incoming photon
W - CMS energy of the incoming photon-proton system

M_X - invariant mass of all particles seen in the central detector
t - momentum transfer to the diffractively scattered proton

Non-Diffraction

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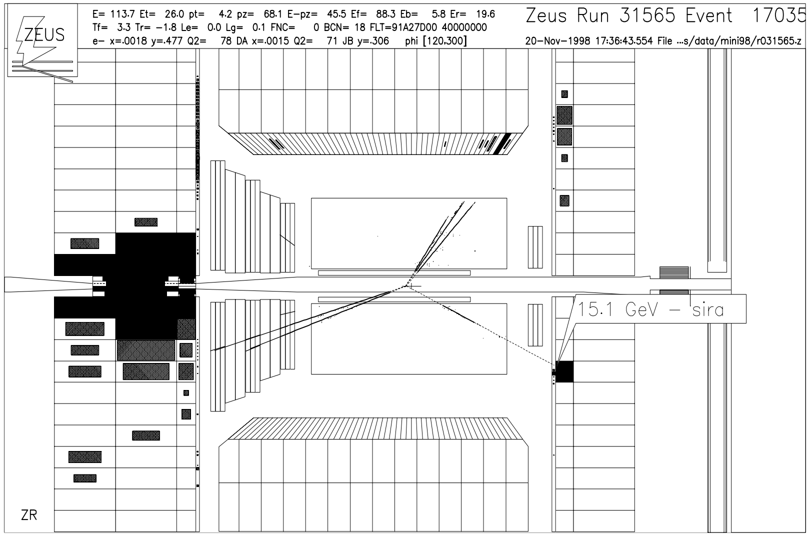

Diffraction

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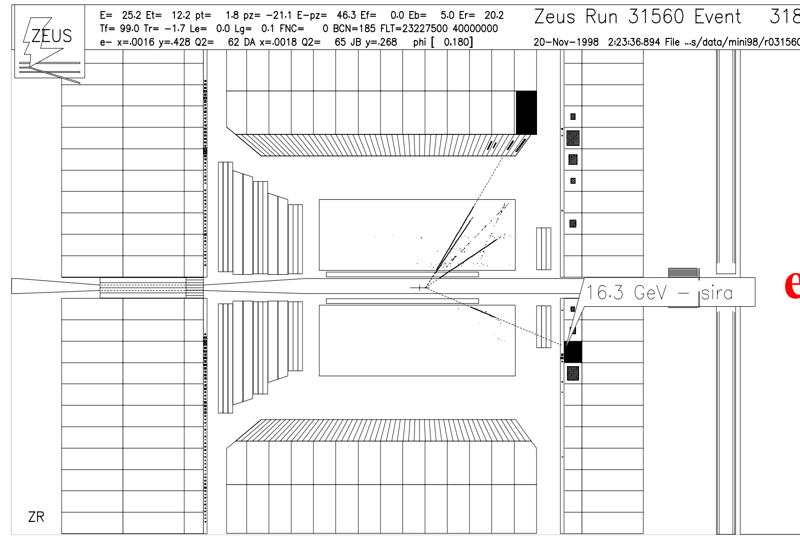


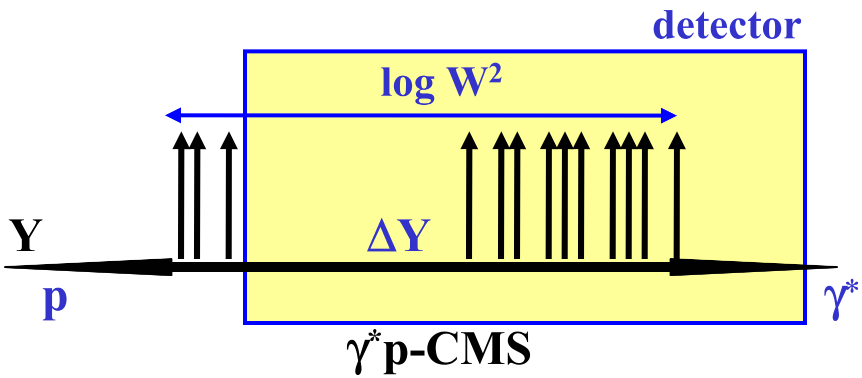
<=p e =>

Select diffractive events by requirement of
no forward energy deposition
called η_{max} cut

Q: what is the probability that a non-diff event has no forward energy deposition?

M_X Method

Non-Diffractive Event



non-diff events are characterized by uniform, uncorrelated particle emission along the whole rapidity axis => probability to see a gap ΔY is

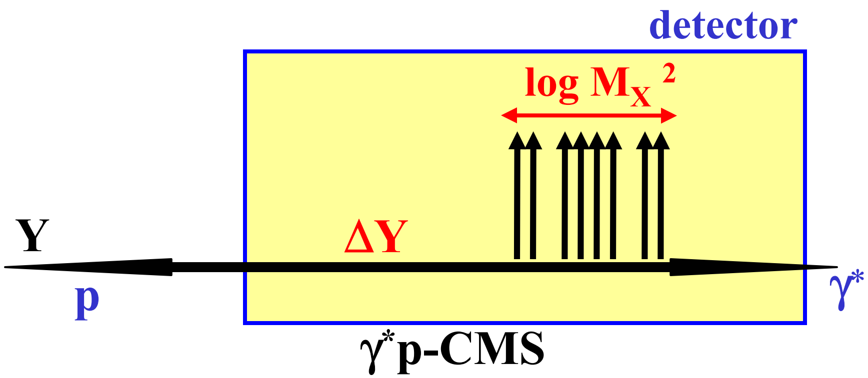
$\sim \exp(-\lambda\Delta Y)$

λ – Gap Suppression Coefficient

since $\Delta Y \sim \log(W^2/M^2_X) - \eta_0$

$dN/d\log M^2_X \sim \exp(\lambda \log(M^2_X))$

Diffractive Event



diff events are characterized by exponentially non-suppressed rapidity gap ΔY

$dN/dM^2_X \sim 1/M^2_X$ =>

$dN/d\log M^2_X \sim$ const

M_X Method

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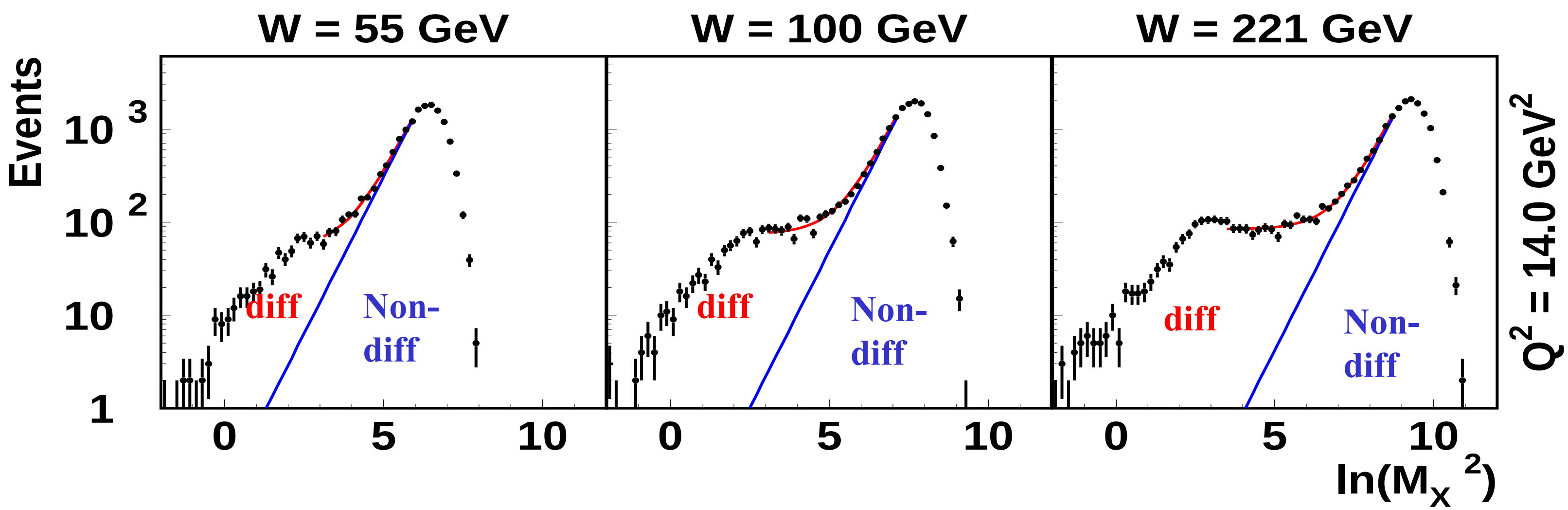


Non-Diffraction

$dN/dM^2_X \sim \exp(\lambda \log(M^2_X))$

Diffraction

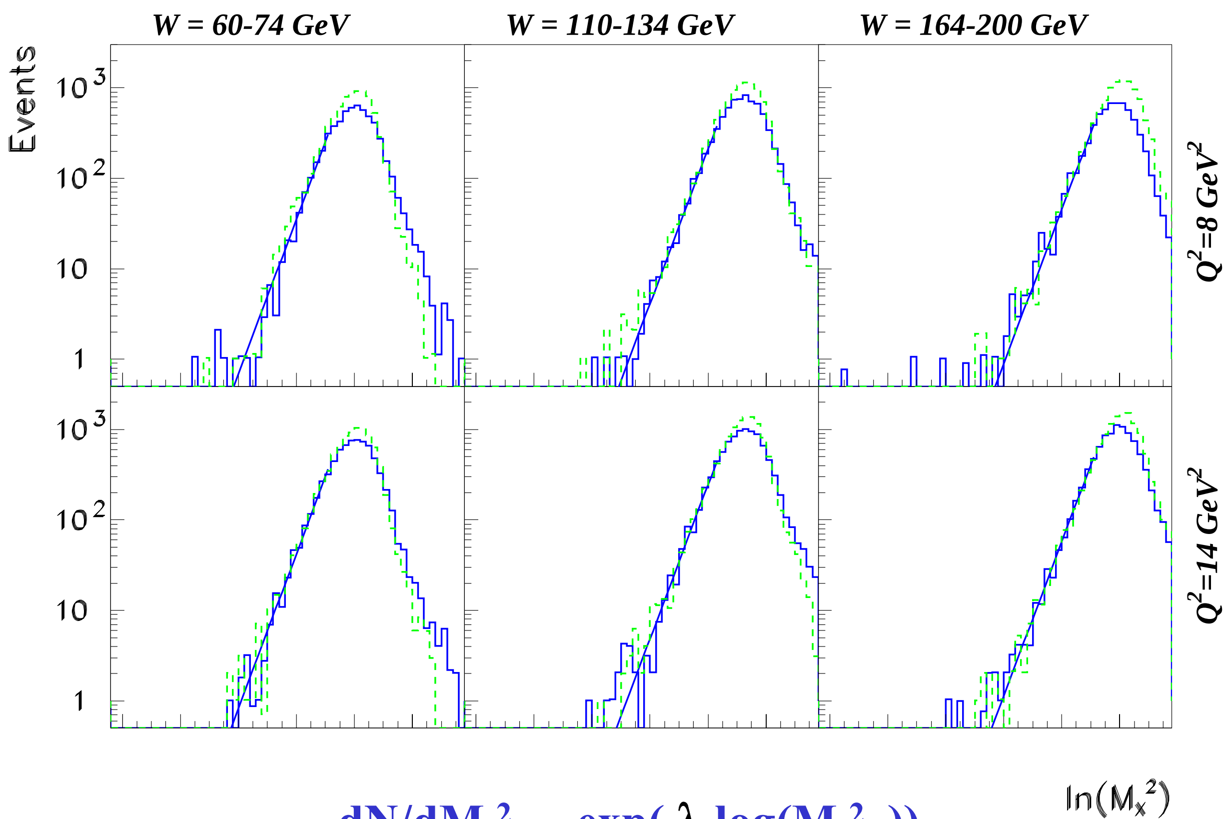
$dN/d\log M^2_X \sim const$

Gap suppression coefficient λ independent of Q^2 and W^2 for $Q^2 > 4$ GeV^2

Gap Suppression in Non-Diff MC

---- Generator Level CDM

---- Detector Level CDM



Detector effects cancel in Gap Suppression !

$dN/dM^2_X \sim \exp(\lambda \log(M^2_X))$

In MC λ independent of Q^2 and W^2

λ~ 2 in MC

λ~ 1.7 **in data**

Comparison of MC with data

Non-Diffractive MC ---- CDM

Diffractive MC ---- Satrap

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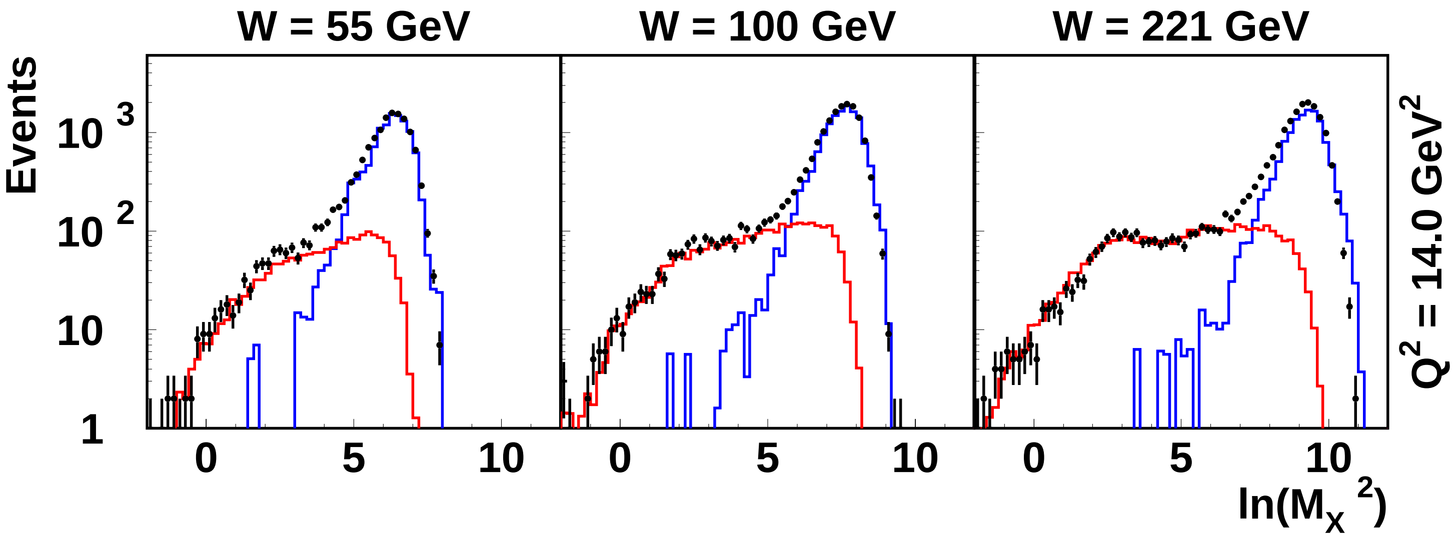

Rapidity Gap Selection ⟷ M_X Method

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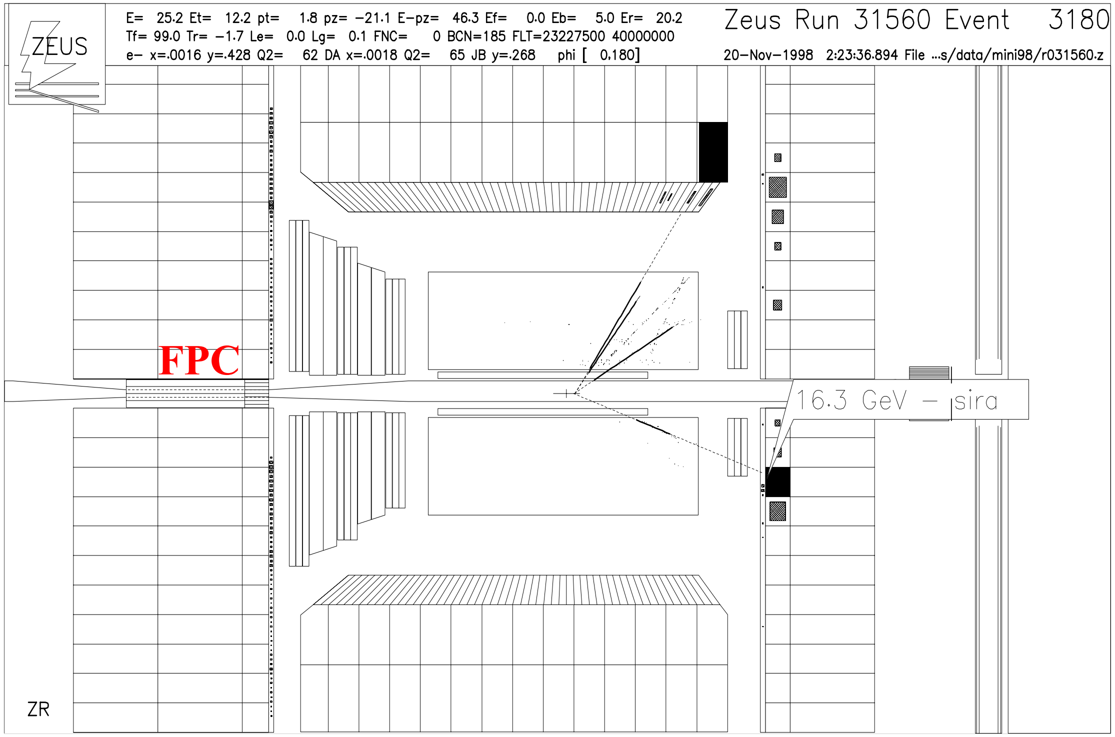
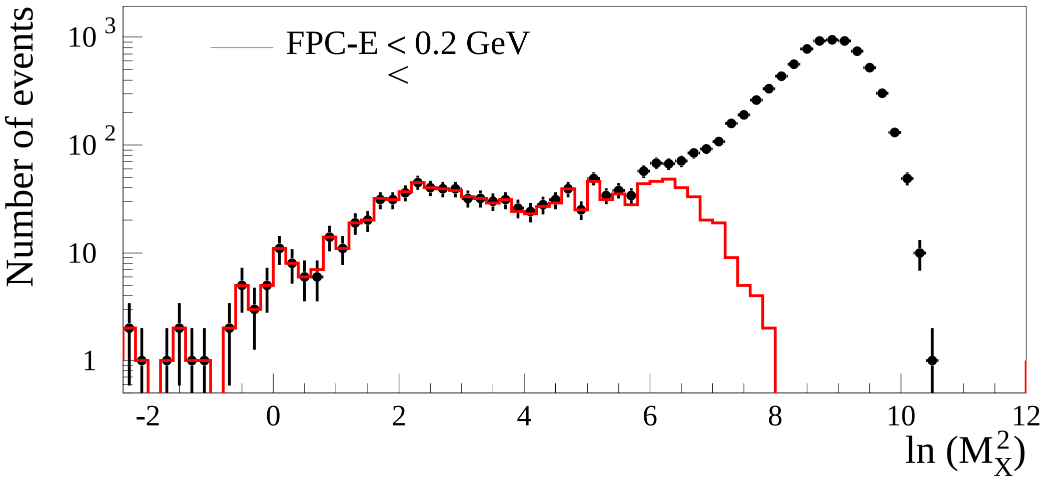
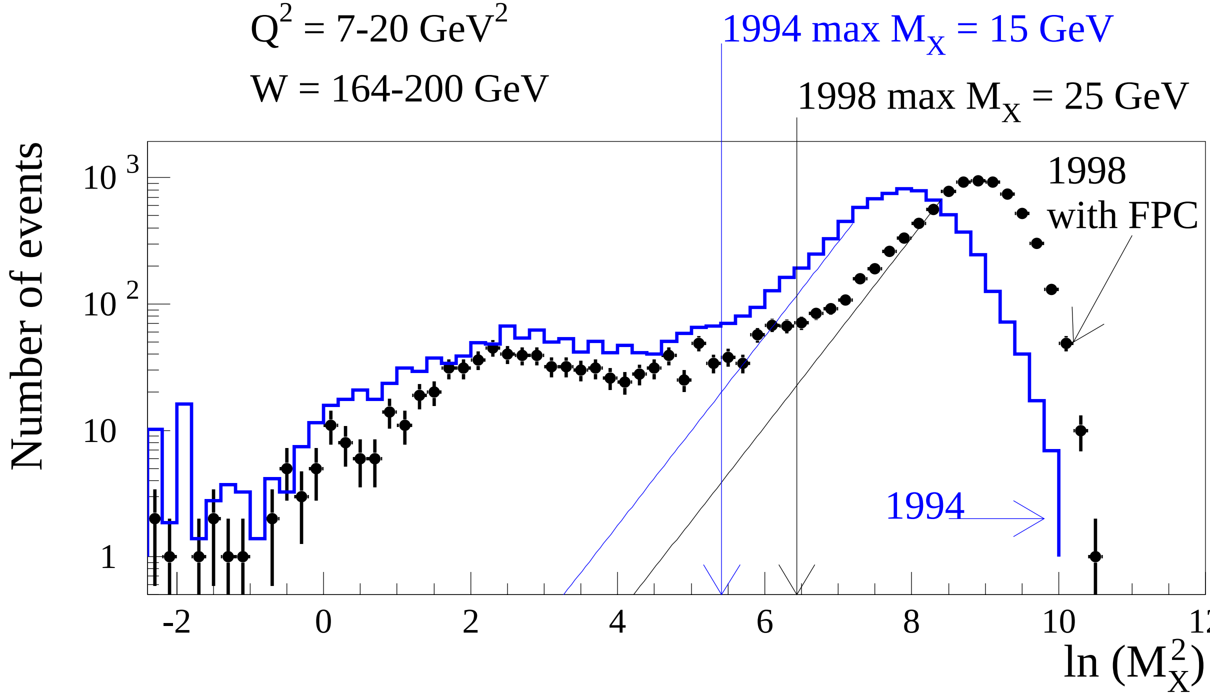




Effect of FPC on ZEUS Diffractive Measurement

FPC was added in 1998



Physical meaning of the Gap Suppression Coefficient λ

Uncorrelated Particle Emission (Longitudinal Phase Space Model)

λ – particle multiplicity per unit of rapidity

Feynman (~1970): λ depends on the quantum numbers carried by the gap

λ = 2 for the exchange of pion q.n.

= 1 for the exchange of rho q.n.

= 0 for the exchange of pomeron q.n.

More generally: λ is a measure of a correlation length -

it should be sensitive to saturation

λ– is well measurable provided good calorimeter coverage

Conclusions

Three methods used at HERA to select diffractive events:

Rapidity Gap Selection (called η_{MAX})	**H1 and ZEUS**
M_X - Method	**ZEUS**
Forward Protons Tag	**H1 and ZEUS**

Use of the selection method depends on detector properties:

Advantage of H1: detectors covers ~ 4.5 units by high quality calorimeter + ~ 3-4 units by particle detectors

Advantage of ZEUS: detector covers ~ 6.5 units of rapidity by high quality calorimetry

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Precise Diffractive Measurement difficult for both H1 and ZEUS detectors (the detectors were not build for this)

The agreement between H1 and ZEUS incl. diffractive measurements is fairly good although not as good as for F_2 .

Personal judgment: Main difficulty is due to the diffractive proton dissociation

Measurement of F_2^D is as fundamental as of F_2 . Combined effort using all methods (including forwards protons) is necessary.

Lesson for LHC: Extend good calorimeter coverage, build as many forwards detectors as possible

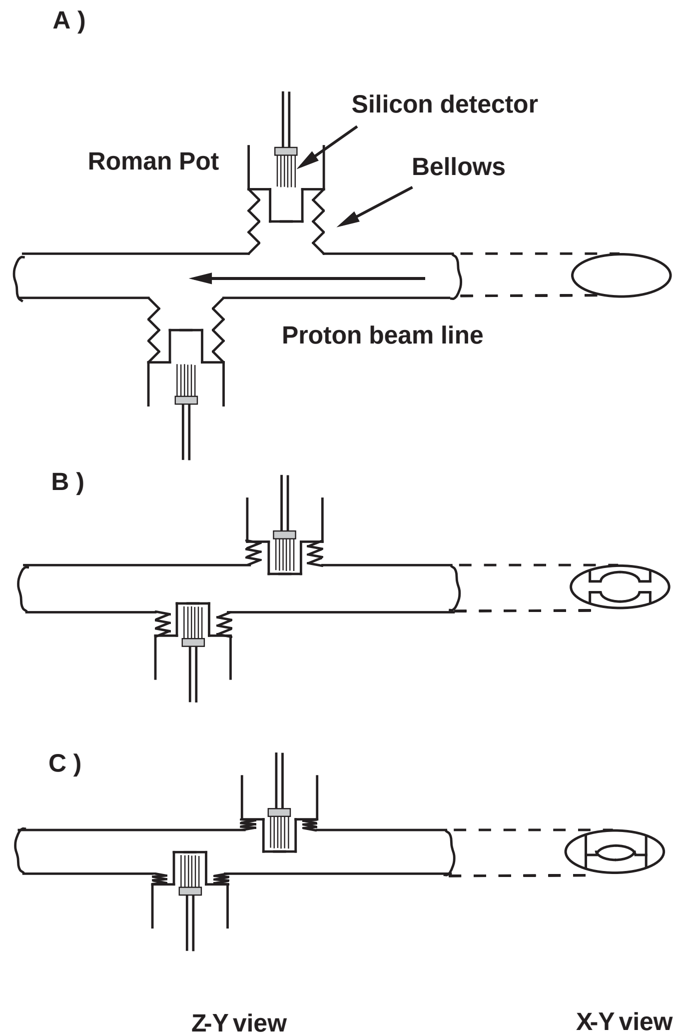
RESERVE

Leading Proton Spectrometer

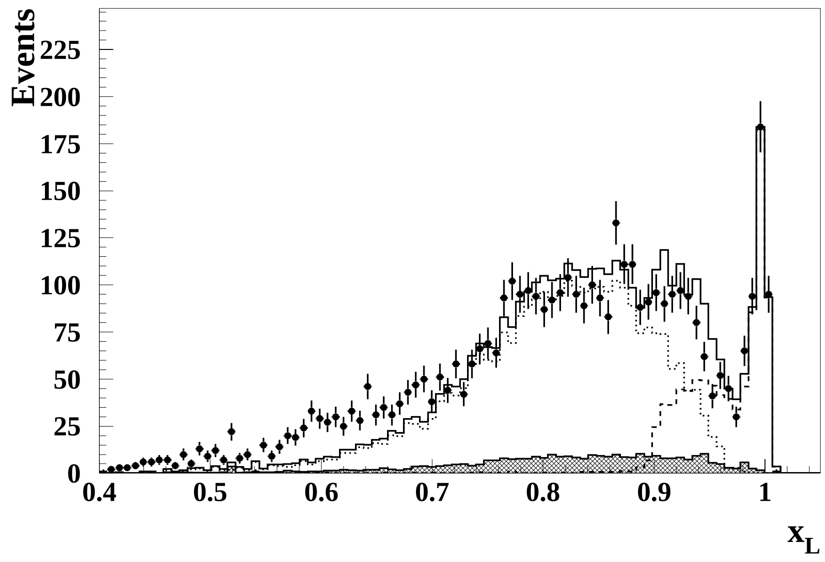
Detector operation using Roman Pots

6 Ro-Pots equipped with micro-strip silicon detectors

pitch 115 micron
3 different strip orientations



ZEUS 1994



Diffractive analysis using LPS detector allows :

Clean selection of the single diffraction processes (no proton dissociation)

Measurement of *t* in diffractive reactions

Good reconstruction of kinematical variables when combined with the central detector

Problem - limited statistics