Measurement of the t dependence in exclusive photoproduction of Upsilon (1S) mesons at HERA

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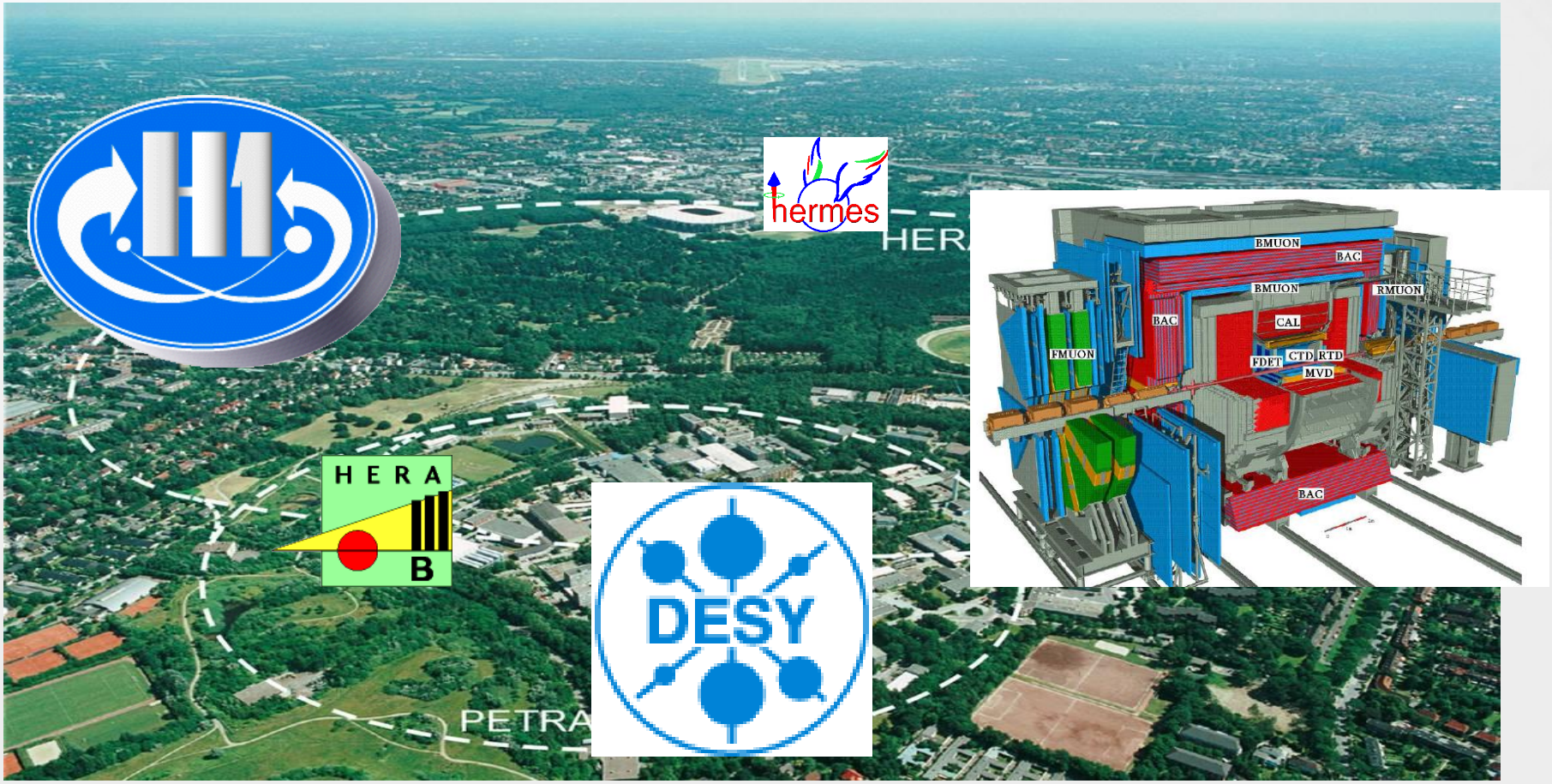
on behalf of the ZEUS Collaboration

HERA and ZEUS

HERA was an *ep* collider, (*27.5GeV electrons/positrons , 920GeV protons beam ,CMS energy 318 GeV*) running ended mid 2007

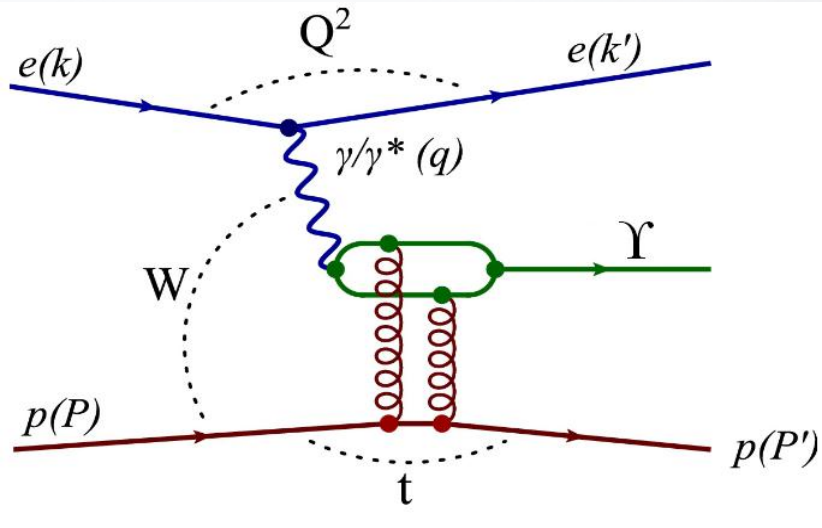
HERA and ZEUS

ZEUS was a large multipurpose experiment, integrating all the data taken since 1996: 11 years of activity and 468 pb^{-1} of integrated luminosity

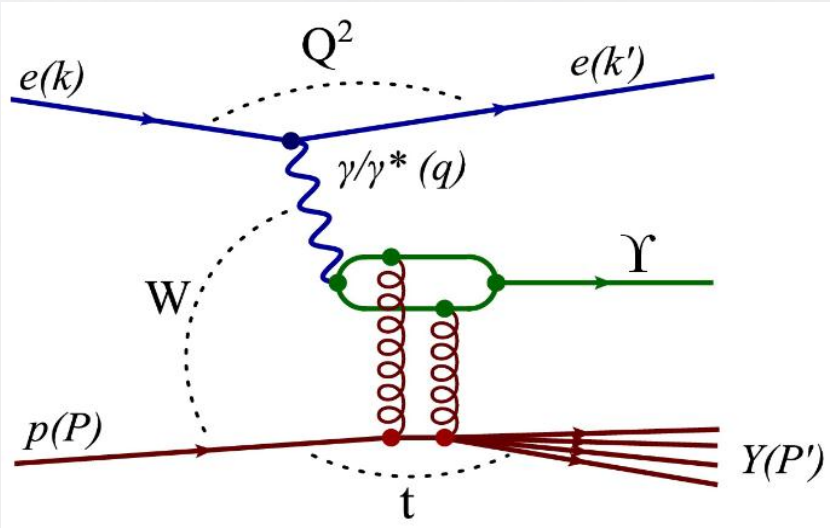


Diffractive ϒ production

exclusive



proton-dissociative



Q^2 - photon virtuality $Q^2=-q^2=-(k-k')^2$

($Q^2 \approx 0$ – photoproduction , $Q^2 > 0$ – electroproduction)

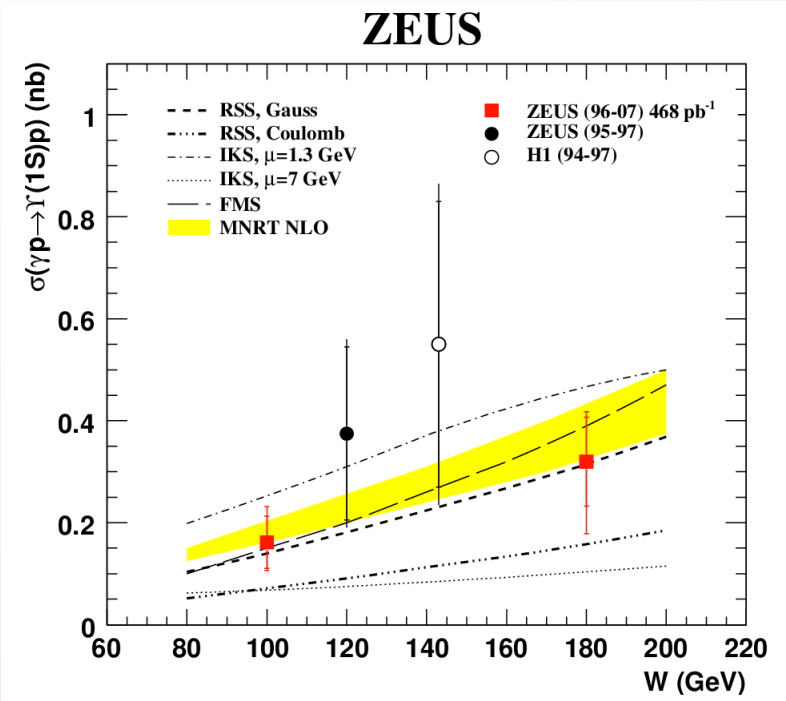
W - c.m. energy of γp system $W=(q+p)^2$

t - (4-mom. transfer)² at p-vertex $t = (P - P')^2$

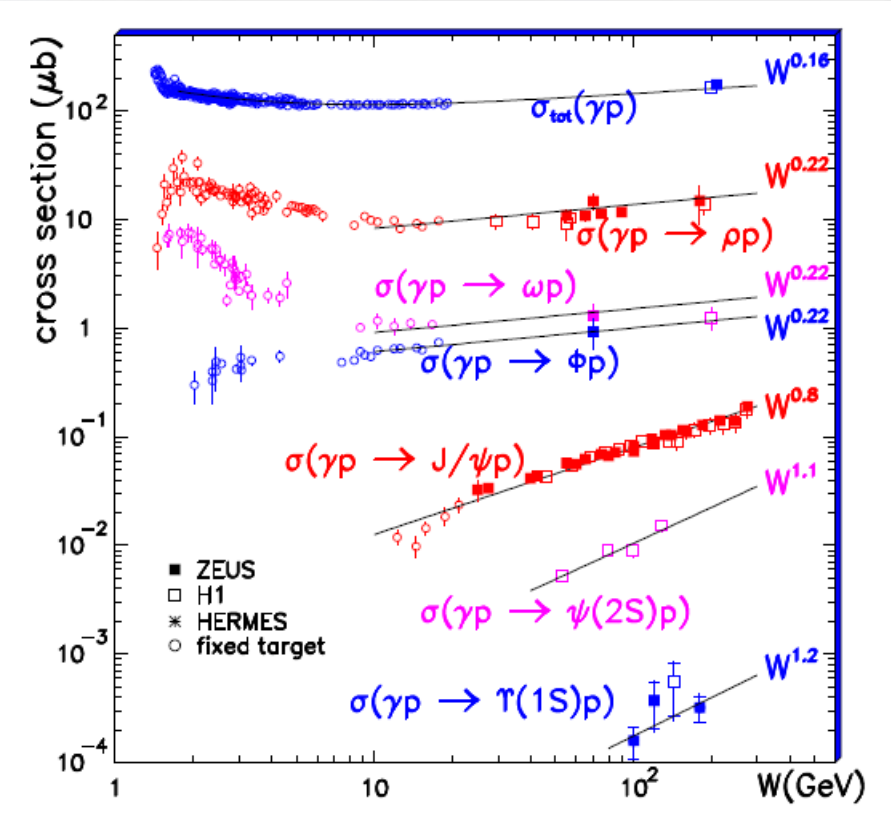
The proton can stay intact p(P') or dissociate Y(P')

W – dependence

Upsilon PHP



Compilation PHP



$\sigma(\gamma p) \sim W^{\delta}$

$\delta = 1.2 \pm 0.8$

δ increases with the mass of vector meson

Motivation for t-dependence (exponential slope)

$d\sigma/d|t| \sim \exp(-b\,|t|)$

$b = b_V + b_p$

$b_V \sim 1/(Q^2+M_{VM}^2) \sim 0$

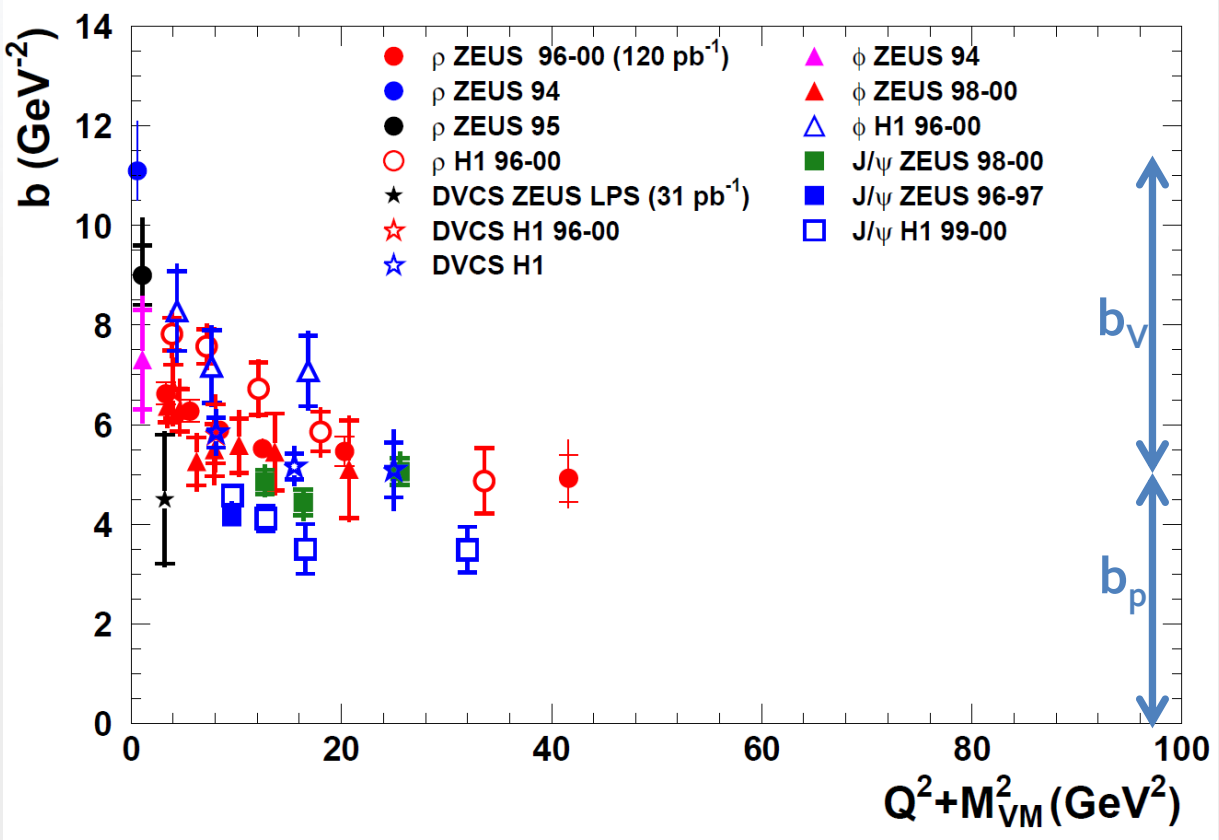
$\rightarrow b \sim b_p \sim 5\ \mathrm{GeV}^{-2}$

Relation to transverse size of the interaction region, R_T:

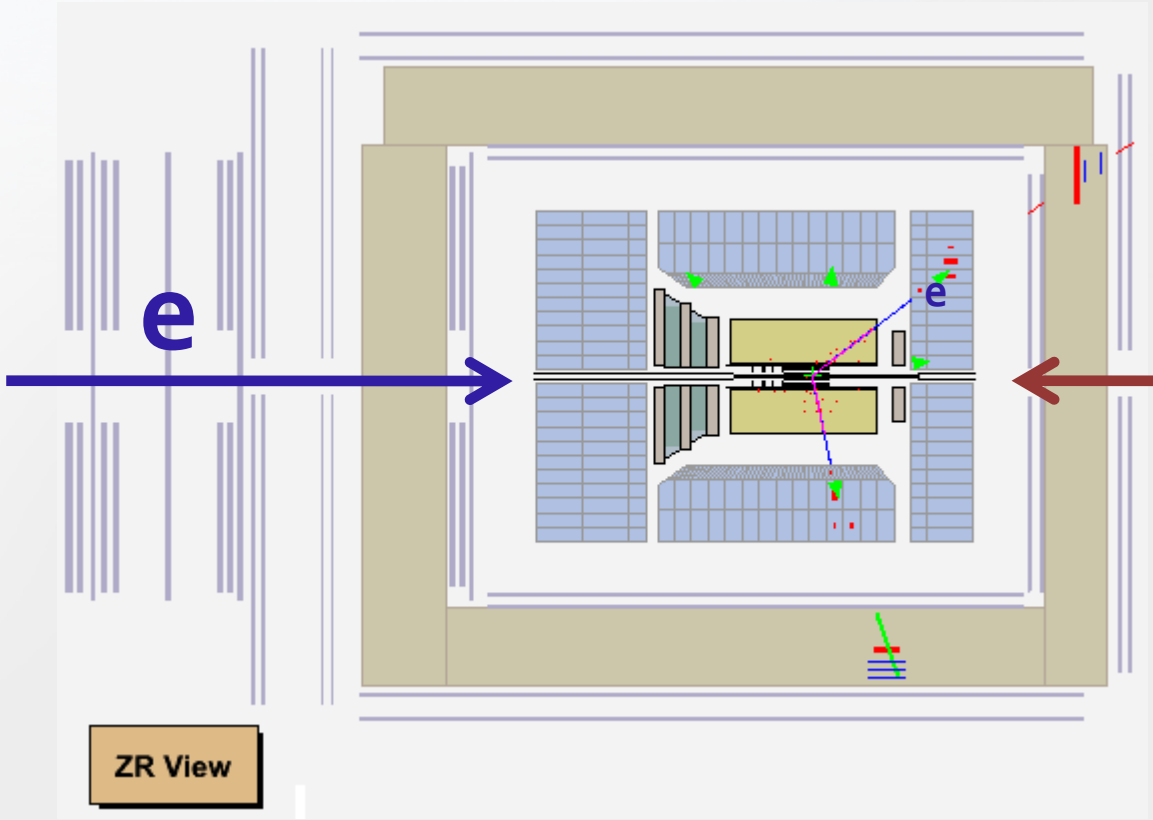
$b_p = R_T^2/2$

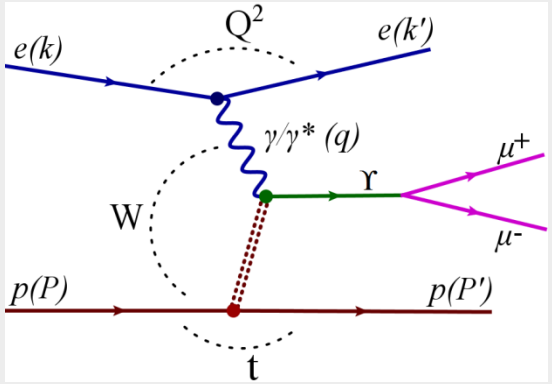
$\rightarrow R_T \sim 0.6$ fm

Gluon radius of the proton



Elastic ϒ event as seen in the ZEUS detector





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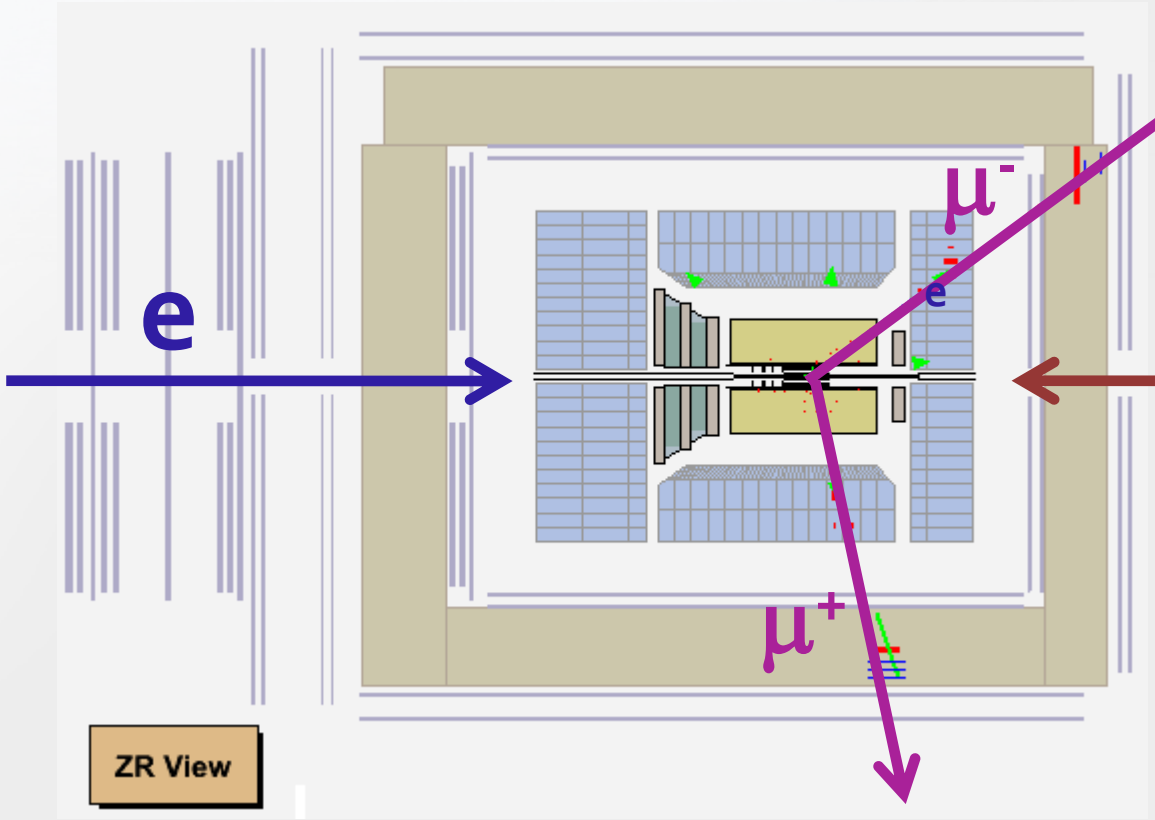
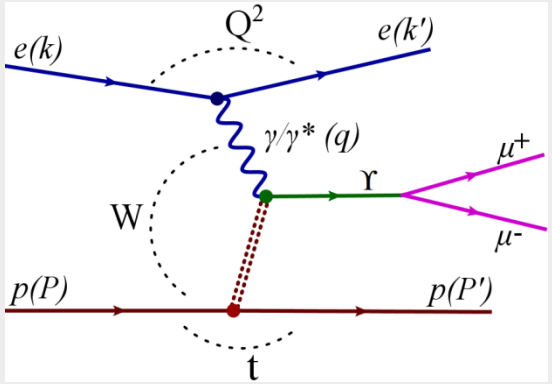
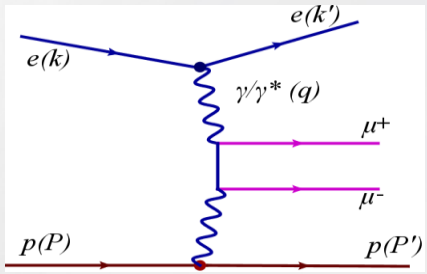
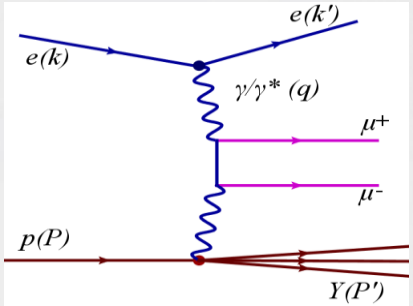




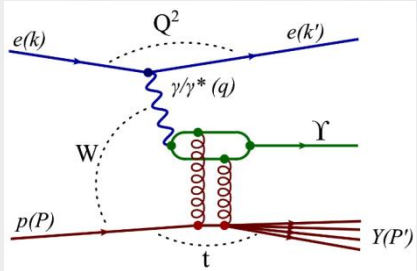
Background processes

- Bethe-Heitler $\gamma\gamma \rightarrow \mu+ \mu-$

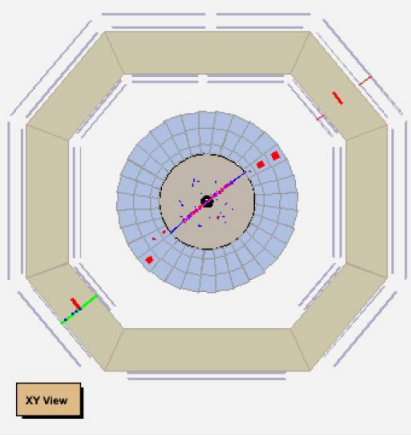




- Upsilon production with proton dissociation



- Cosmic muons passing near to the interaction point



Monte Carlo

- $\gamma p \rightarrow \Upsilon p$ elastic and pdiss DIFFVM 2.0 (Regge+ VDM)
  pdiss + JETSET 7.3

SCHC (s-channel helicity conservation) assumed

$d\sigma/d|t| \sim \exp(-b\,|t|)$ $b=4.5\ \mathrm{GeV}^{-2}$ (as for J/ψ);

$\sigma(\gamma p) \sim W^{1.2}$

Radiative corrections O(1%) not included

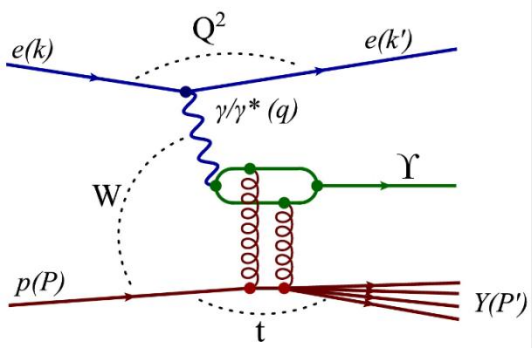
- Bethe-Heitler $\mu+\mu$-GRAPE v1.1k

Proton dissociation contribution

- Definition of the fraction:

fpdiss= Npdiss/(Nelastic+ Npdiss)

- Small statistics for a standalone measurement of fpdiss in this analysis



- Earlier measurements show: fpdiss similar for all VM

Justified to assume: fpdiss= 0.25 ±0.05 (result for J/ψ)

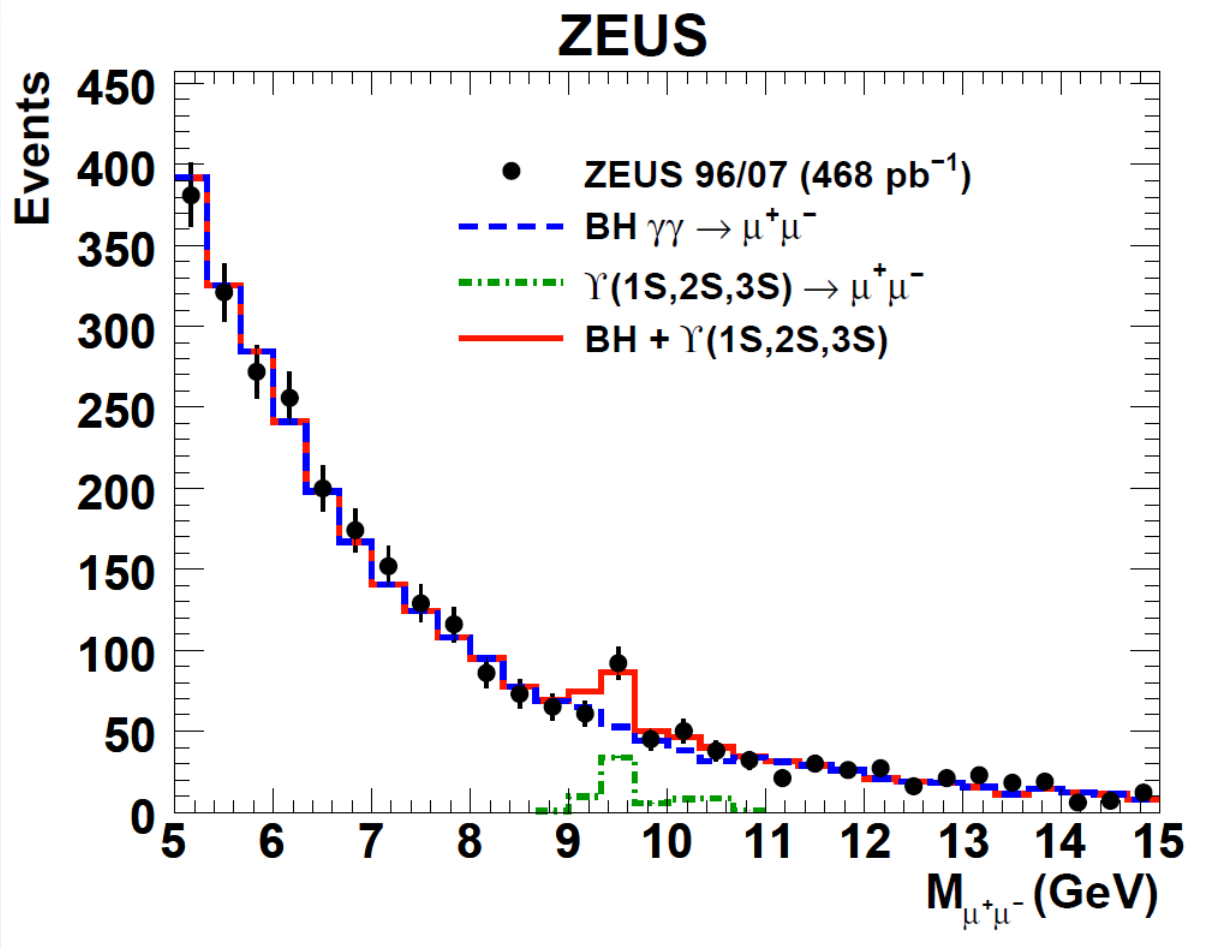
dσ/d|t| ~exp(-b |t|) contains elastic and proton diss. contributions

- Assume for pdiss: bpdiss = 0.65±0.1 GeV^{-2} (result for J/ψ)

Invariant mass distribution

- mass range: 5-15 GeV
- BH normalised excluding 9-11 GeV mass range
- Signal mass window: 9.33-9.66 GeV (scanned–no cosmic)

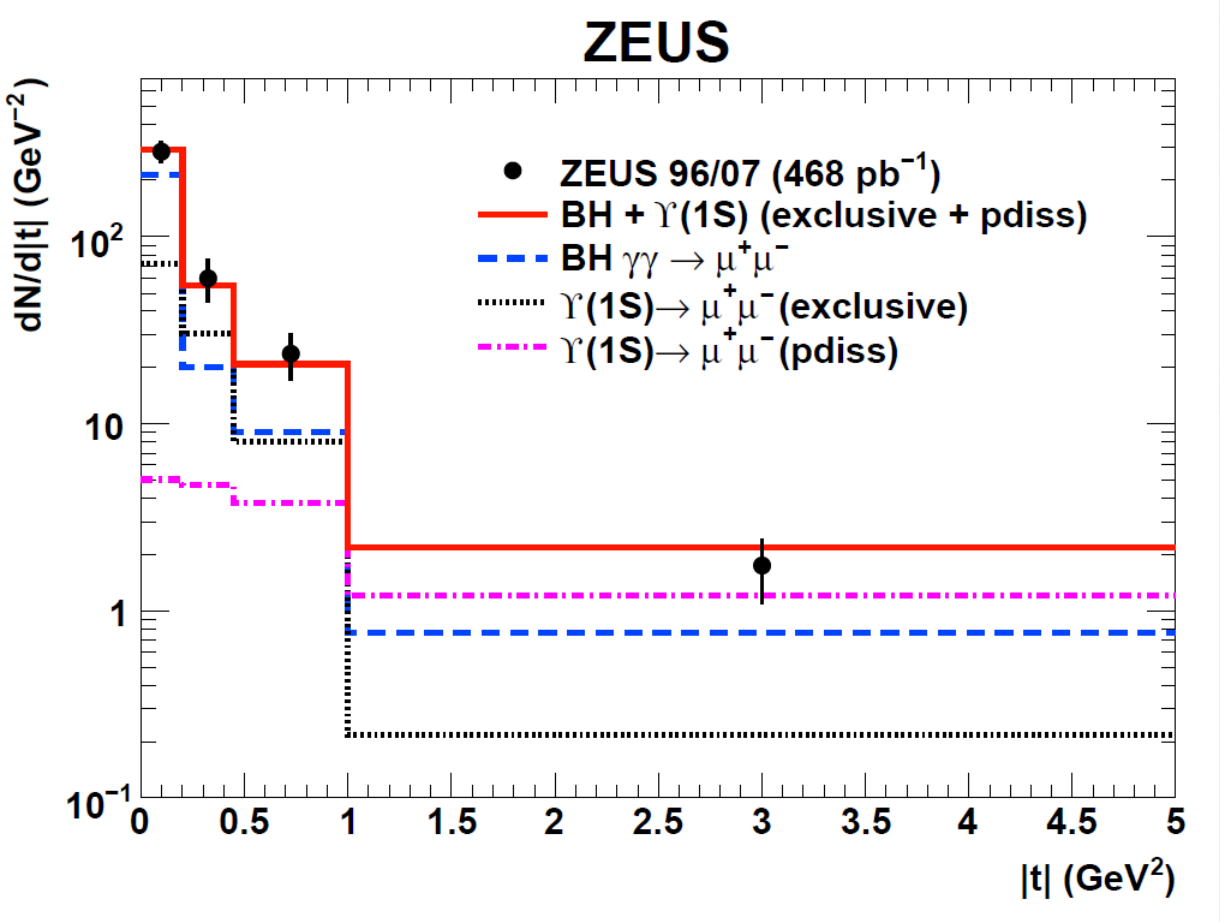
Upsilon 1S:2S:3S ratios from CDF: 0.73 : 0.19 : 0.08



dN/d|t| and slope measurement

- Binned Poissonian maximum log-likelihood fit → elastic b, N(1S)

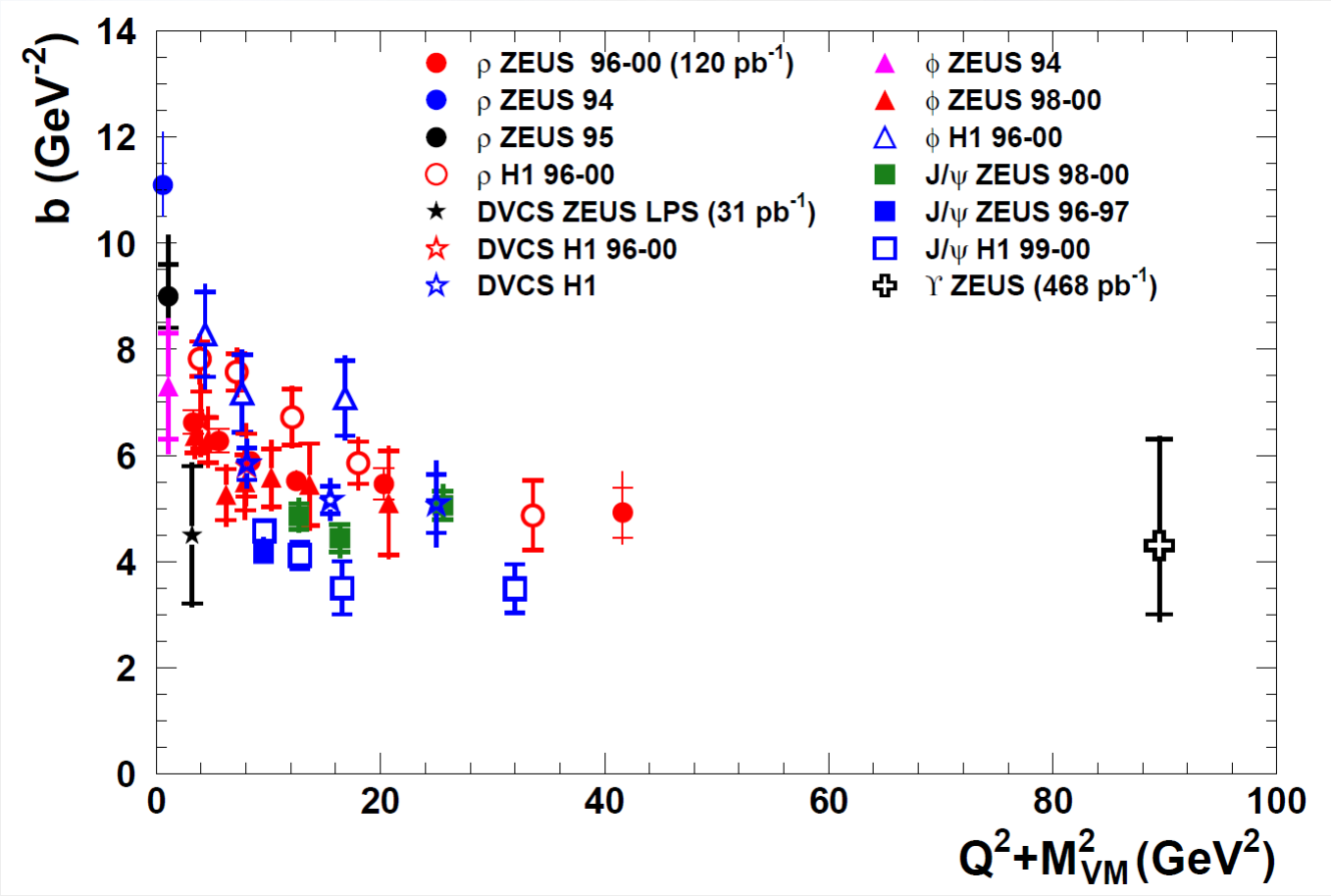
- N(1S)= 41 ±10 events(44% of all events in the mass window)



- ZEUS RESULT:

$$b = 4.3^{+2.0}_{-1.2}{}^{+0.5}_{-0.6}\ \mathrm{GeV}^{-2}$$

Compilation for elastic b slope



Universal behaviour observed

Summary

- Υ (1S) t-slope measured for the first time
- Doubles the range of the Q^2+M^2 scale
- In agreement with asymptotic behaviour
- Consistent with expectations from the proton radius and QCD