# Exclusive diffraction at HERA and perspectives for LHC

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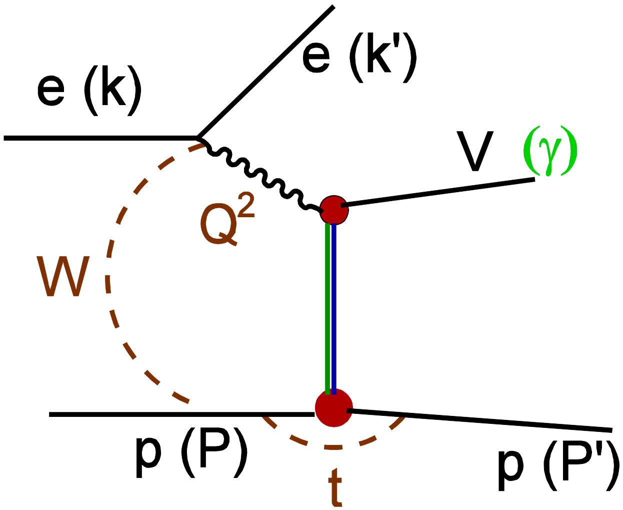
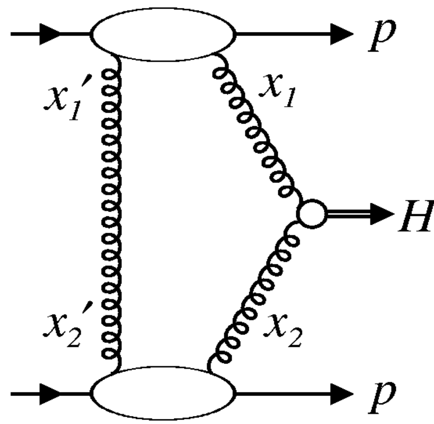



**Brookhaven National Laboratory**
**Long Island, NY (USA),** ***March 18, 2010***

# Planing of the talk

- Exclusive Diffraction
- Vectror meson production
- Real photon production (DVCS)
- Pomeron trajectory (new predictions)
- Forward Physics at LHC
- Summary

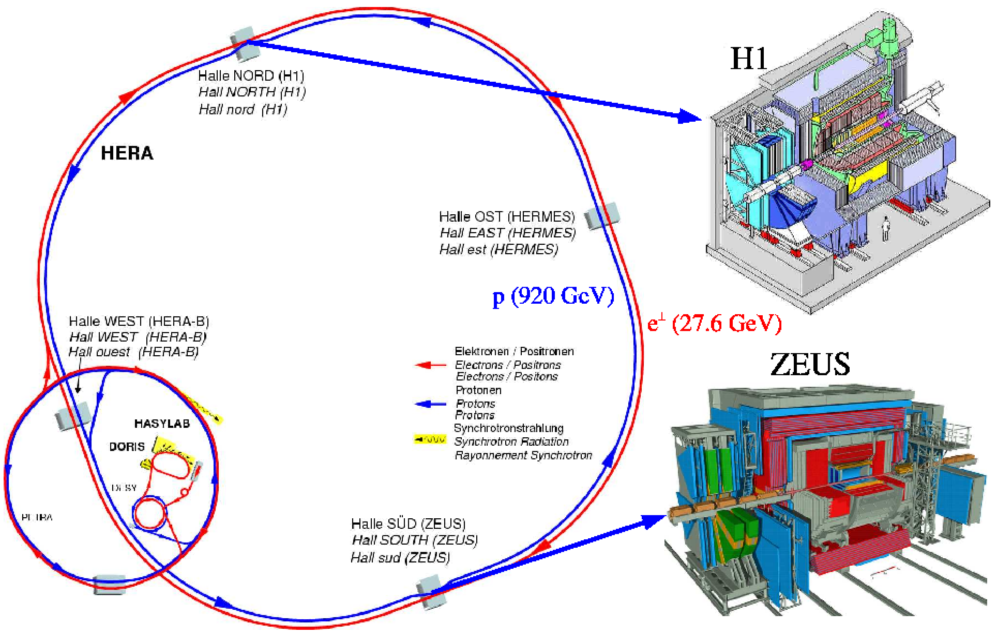
# HERA colliding experiments

- 27.5 GeV electrons/positrons on 920 GeV protons → $\sqrt{s}$=318 GeV
- 2 collider experiments: **H1 and ZEUS**
- HERA I: 16 $pb^{-1}$ e-p, 120 $pb^{-1}$ e+p
  HERA II (after lumi upgrade): 500 $pb^{-1}$, polarisation of e+,e-

hermes

- **Fixed target experiment**
- **Intense program on DVCS!**

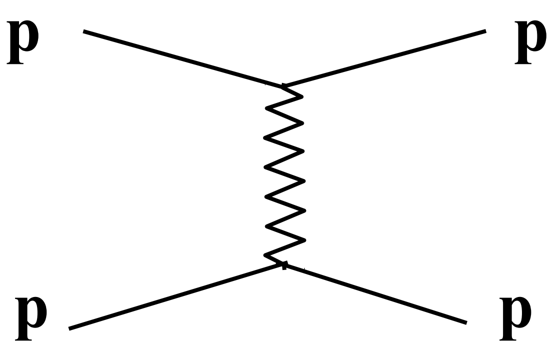
**Closed July 2007, still lot of excellent data to analyse…**

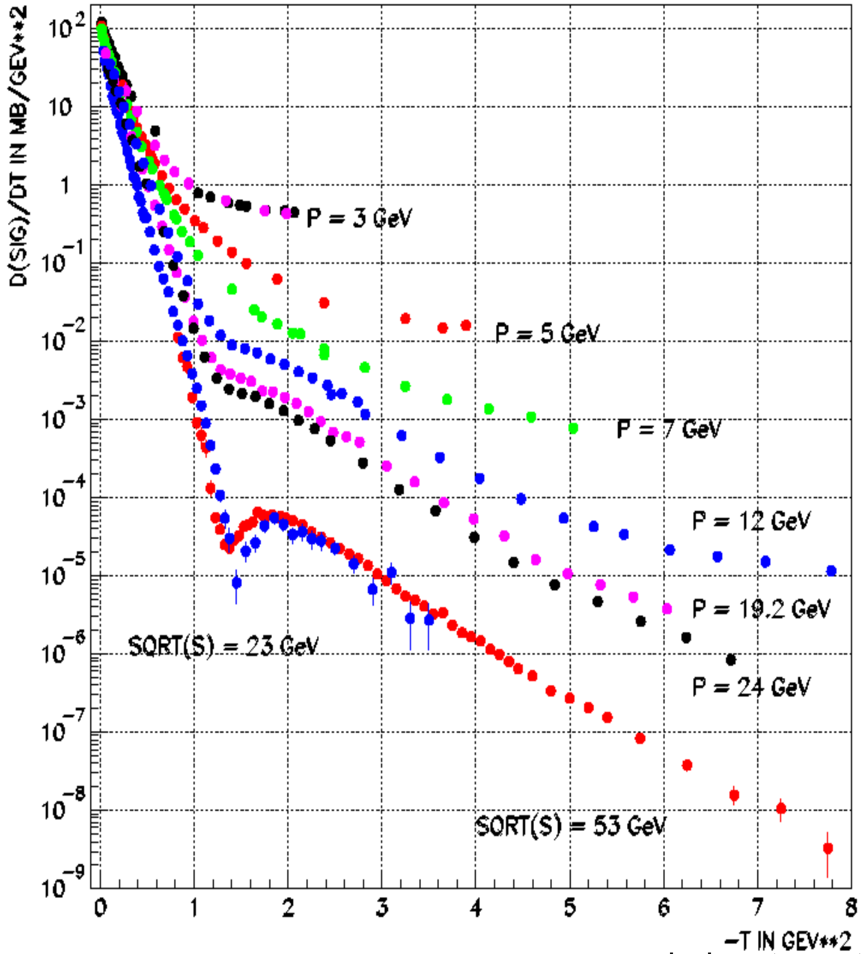



**Detectors not originally designed for forward physics, but diffraction at HERA is great success story!**

**ZEUS forward instrumentation no longer available in HERA II**

# Diffraction in hadron scattering




$$\frac{d\sigma/\mathrm{d}t(t)}{Id\sigma/\mathrm{d}t(t=0)} \approx \exp(bt) \approx 1 - b(p\theta)^2$$

$|t| \approx (p\theta)^2$

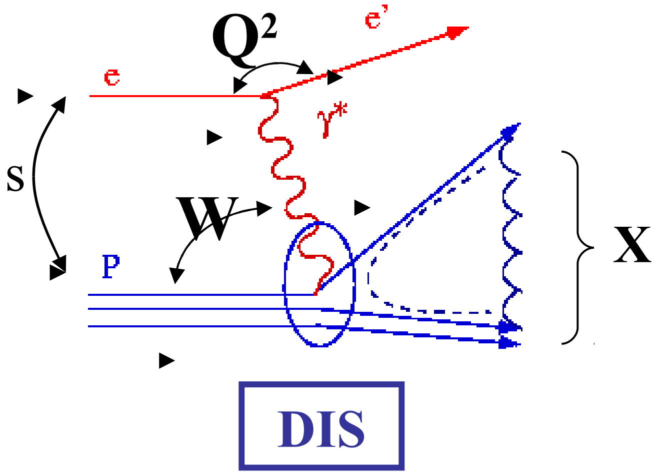
$\theta$ = scattering angle

$p$ = incident momentu

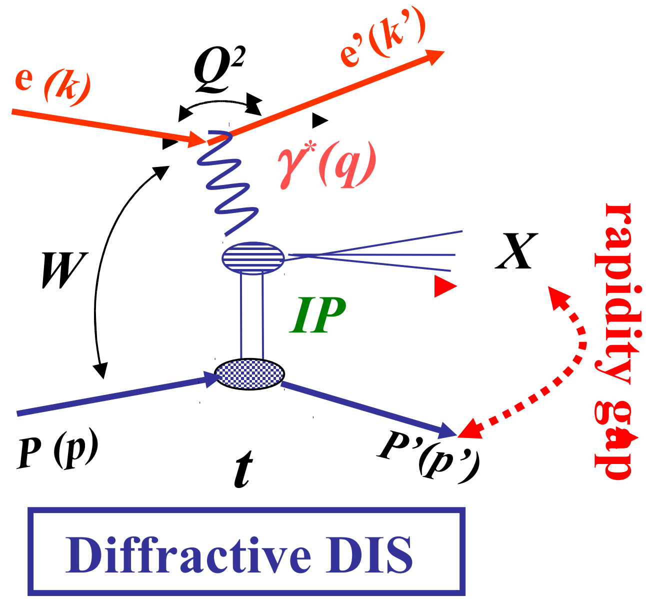
$b = R^2/4$

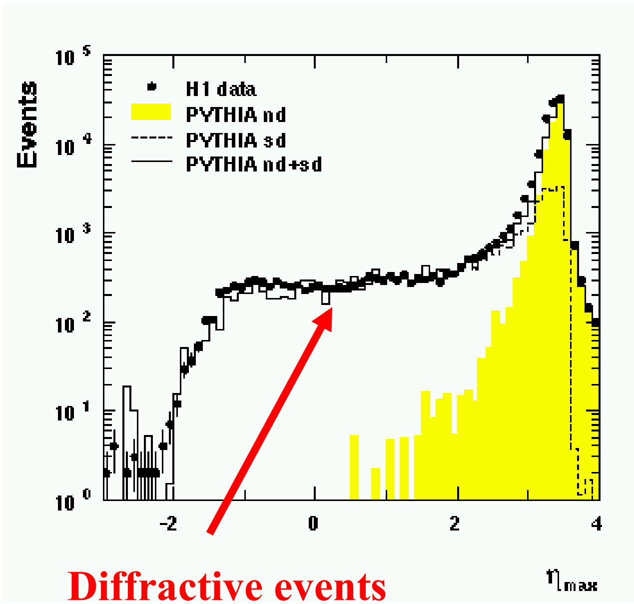
$R \approx$ quadratic sum of sizes of the interacting hadrons

# Diffraction in ep collisions at HERA





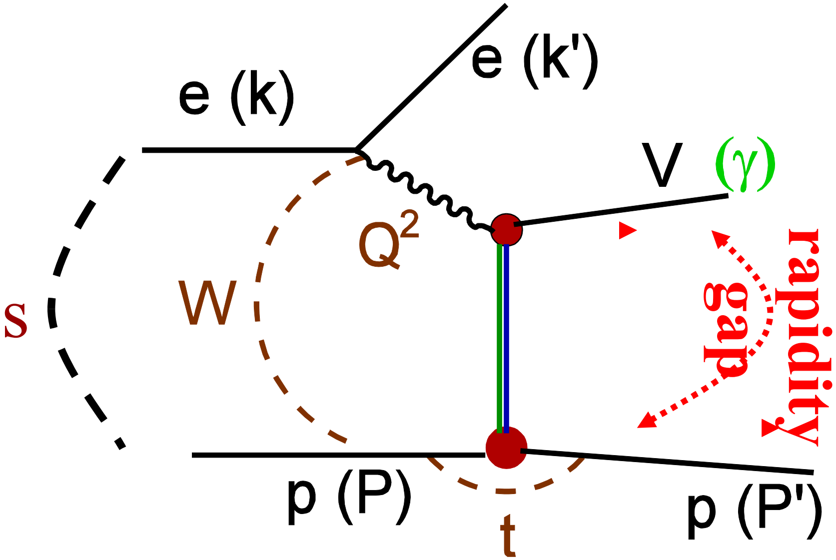



- *p* escapes in the beam pipe
- no quantum numbers exchanged btw $\gamma^*$ and *p*

  **-> no colour flux →large rapidity gap**
- Providing a perturbative QCD motivated description of strong interactions

# Exclusive diffraction




**Main kinematic variables**

**electron-proton centre-of-mass energy:**

$$s = (k+p)^2 \approx 4 E_e E_p$$

**photon virtuality:**

$$Q^2 = -q^2 = -(k-k')^2 \approx 4 E_e E'_e \sin^2 \frac{\theta}{2}$$

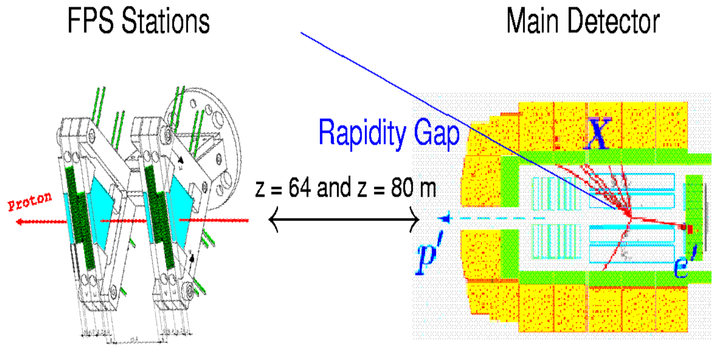
**photon-proton centre-of-mass energy:**

$$W^2 = (q+p)^2, \text{ where: } m_p < W < \sqrt{s}$$

**square 4-momentum at the *p* vertex:**

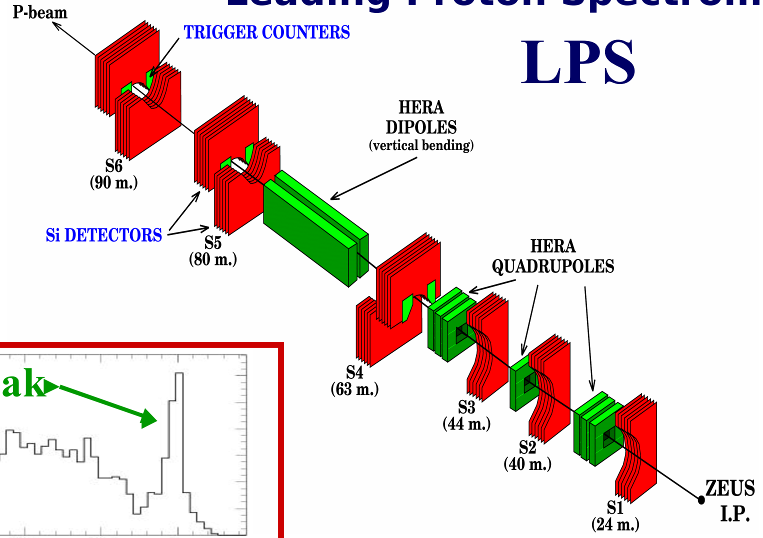
$$t = (p' - p)^2$$

- **Vector Mesons production in diffraction**
- **Deeply Virtual Compton Scattering**




# Leading Proton Spectrometer

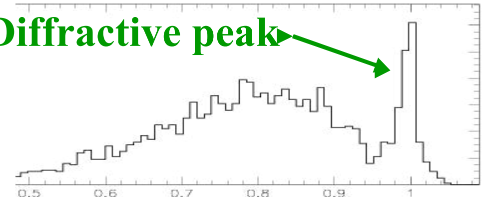
# LPS




## *p* tag method

- Measurement of *t*
- Free of p-diss background
- Higher $M_X$ range
- Lower acceptance

**Diffractive peak**

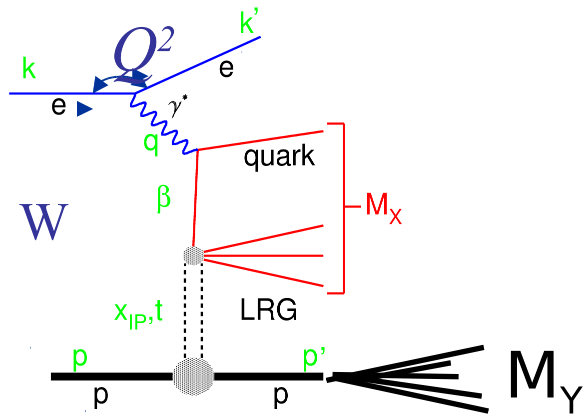



$$x_L = \frac{p'_z}{p_z} \approx 1 - x_{IP}$$

NB: if scattered proton not detected, background from proton dissociative events

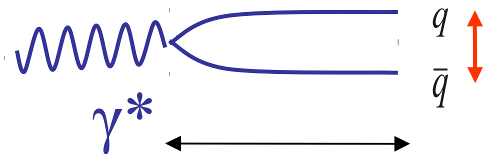
## Large Rapidiy Gap method

- *X* system and e' measured
- System *Y* not measured, some theoretical and experimental uncertanties
- Integrate over $t<1 GeV^2$ and $M_Y<1.6$ GeV
- High acceptance



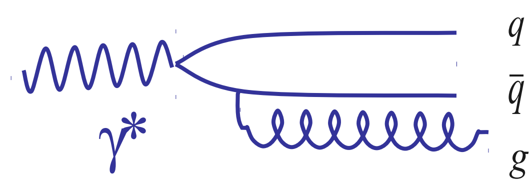
# The colour dipole picture

**Virtual photon fluctuates to $q\bar{q}$, $q\bar{q}g$ states (colour dipoles)**




$$\frac{1}{\sqrt{Q^2+M^2_{q\bar{q}}}}$$

$$E_\gamma \sim W^2 \sim 1/x$$

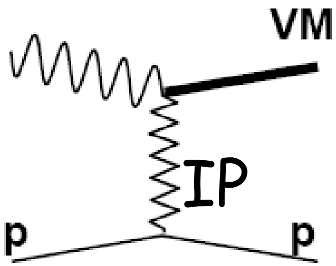



- **Lifetime of dipoles very long → it is the dipole that interacts with the proton** **This is why can do diffraction in ep collisions!**
- **Transverse size $1/\sqrt{(Q^2+M_{q\bar{q}}^2)}$**

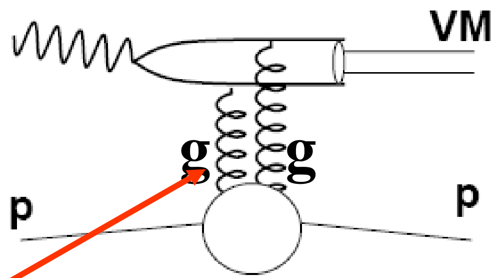
**Transverse size of incoming hadron beam can be reduced at will. Can be so small that strong interaction with proton becomes perturbative!**

# Soft and hard diffraction

**Vector Meson production (ρ, φ, J/ψ, Υ, γ)**




'soft'




2-gluon exchange (pQCD)

'hard'

**Cross section proportional to probability of finding 2 gluons in the proton**

Gluon density in the proton

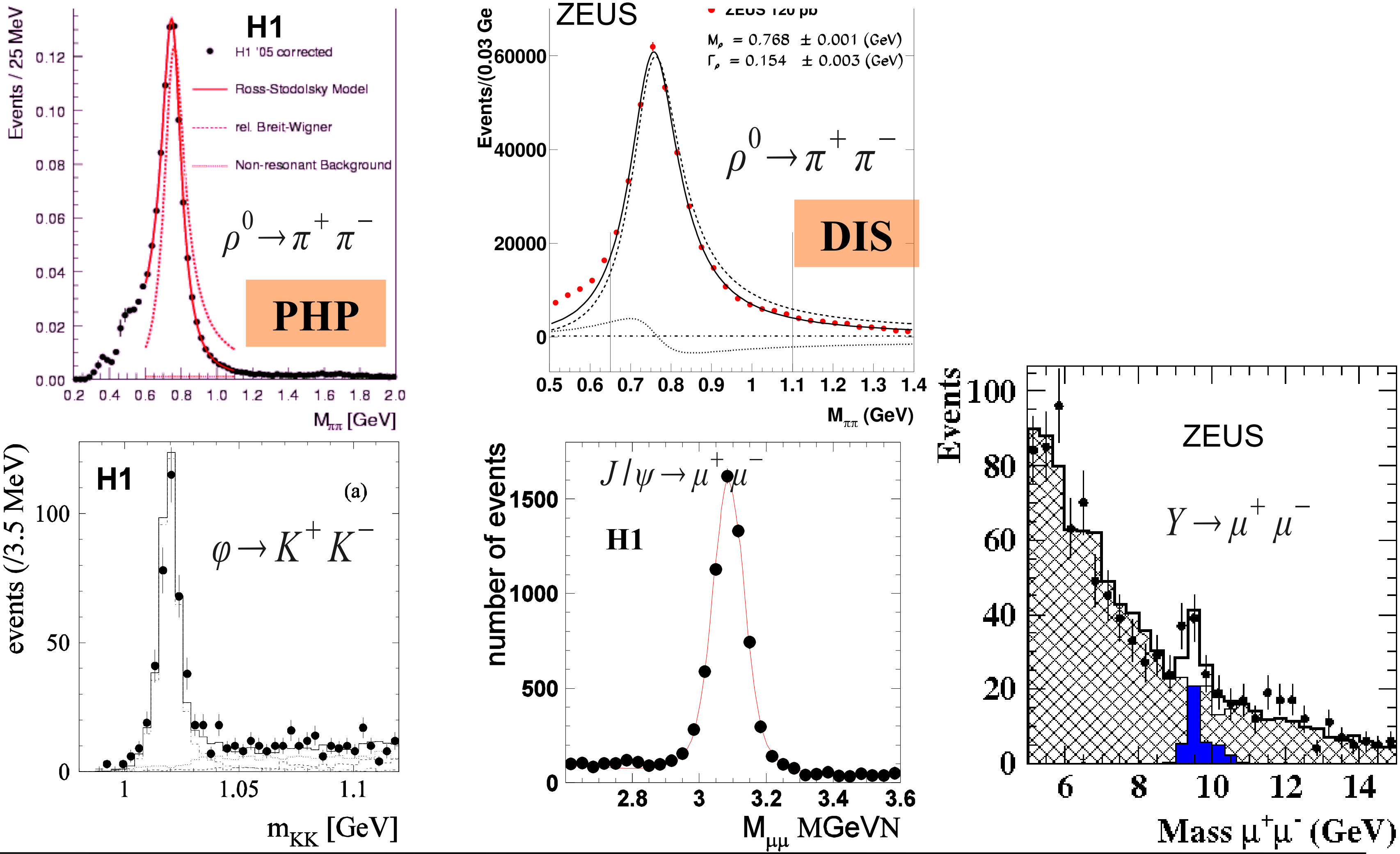
$$\begin{cases} \sigma \propto \left[ xg\left( x,\mu^2 \right) \right]^2 & ! \\ \mu^2 \propto \left( Q^2 + M^2 \right) & ? \end{cases}$$

$\sigma(W) \propto W^{\delta}$ ➡ δ Expected to increase from soft (~0.2, "soft Pomeron") to hard (~0.8, "hard Pomeron")

$\frac{d\sigma}{dt} \propto e^{-b|t|}$ ➡ *b* expected to decrease from soft (~10 GeV$^{-2}$) to hard (~4-5 GeV$^{-2}$)

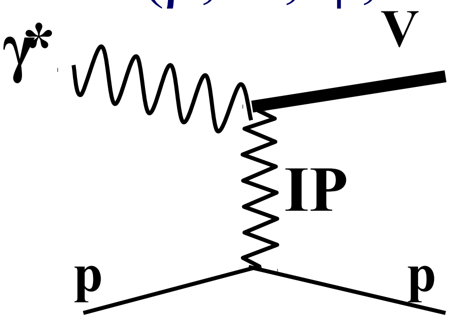
# VM mass distributions

Large variety of processes to study dynamics versus scales: $M_V^2$, $Q^2$, $t$

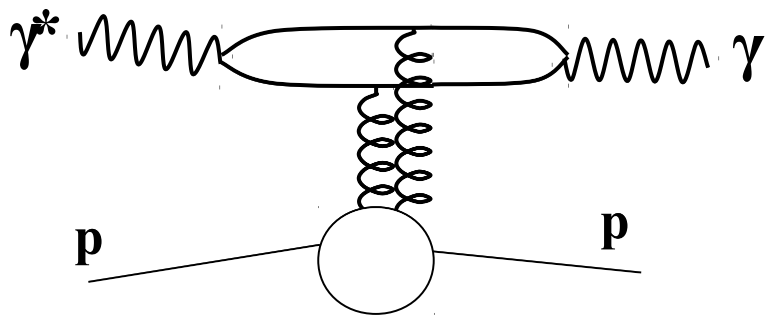


# Deeply Virtual Compton Scattering

VM (ρ, ω, φ, J/ψ, Υ)

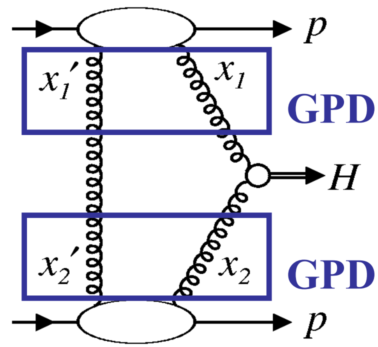



DVCS (γ)



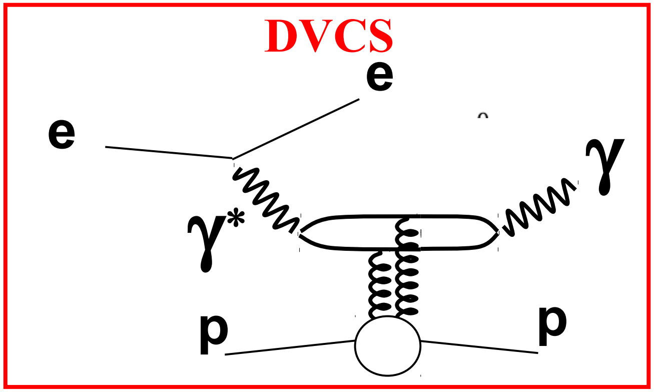

**Scale:** $Q^2 + M^2$ ⟷ $Q^2$

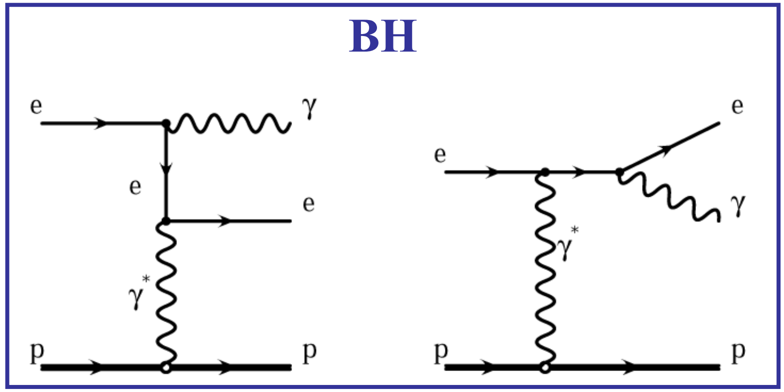
## DVCS properties:

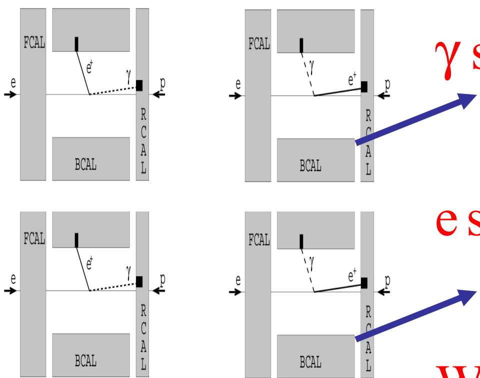



- **Similar to VM production, but γ instead of VM in the final state**
- **No VM wave-function involved**
- **Important to determine Generalized Parton Distributions sensible to the correlations in the proton**
- **GPD$_s$ are an ingredient for estimating diffractive cross sections at LHC**

# DVCS @ ZEUS - Strategy




γ sample: no tracks matching to the second candidate (DVCS+BH)

e sample: a track match to the second candidate (BH+ dilepton + J/ψ)

Wrong-sign sample: a negative track match to the second candidate (dilepton + J/ψ)

# DVCS @ ZEUS – Selection criteria

$\mathcal{L}$ = 61.14 $pb^{-1}$

- 99$e^+$-00 ZEUS data
- Two Sinistra candidates
- First candidate in RCAL
- Second candidate in RCAL or in BCAL
- 1 or 0 tracks
- rear box cuts
- Elasticity cut
- Energy in FCAL < 1 GeV and in FPC < 1GeV
- -100 < Zvtx < 50 cm

**Monte Carlos:**

| | |
|---|---|
| GenDVCS | (400k DVCS events ) |
| Grape-Compton | (400k el. BH events<br>400k inel. BH events) |
| Grape-dilepton | (150k dilepton events<br>150k inel. dilep. events) |
| DiffVM $J/\Psi$ ⟶ | $e^+e^+$ |

**JHEP05(2009)108**

**Kinematic region:**

$1.5 < Q^2 < 100$ GeV$^2$

$40 < W < 170$ GeV

**Energies & angle:**

$E_1 > 10$ GeV

$E_2 > 2$ GeV

$\theta_2 < 2.85$

**PLB 573 (2003) 46-62**

**Pub. Kin. region:**

$5 < Q^2 < 100$ GeV$^2$

$40 < W < 140$ GeV

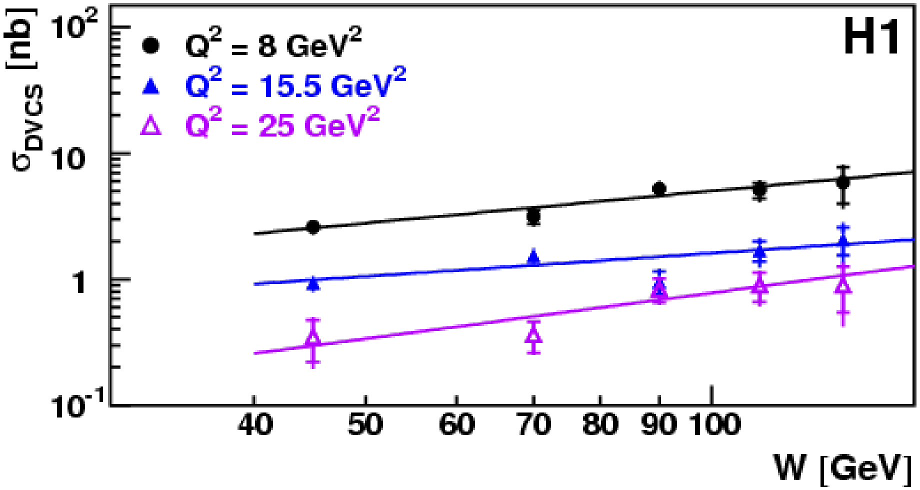
**Energies & angle:**

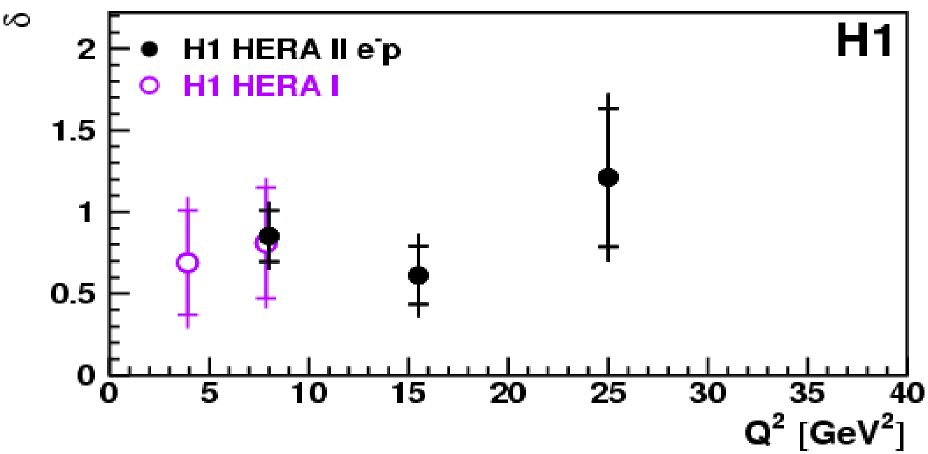
$E_1 > 15$ GeV

$E_2 > 2.5$ GeV

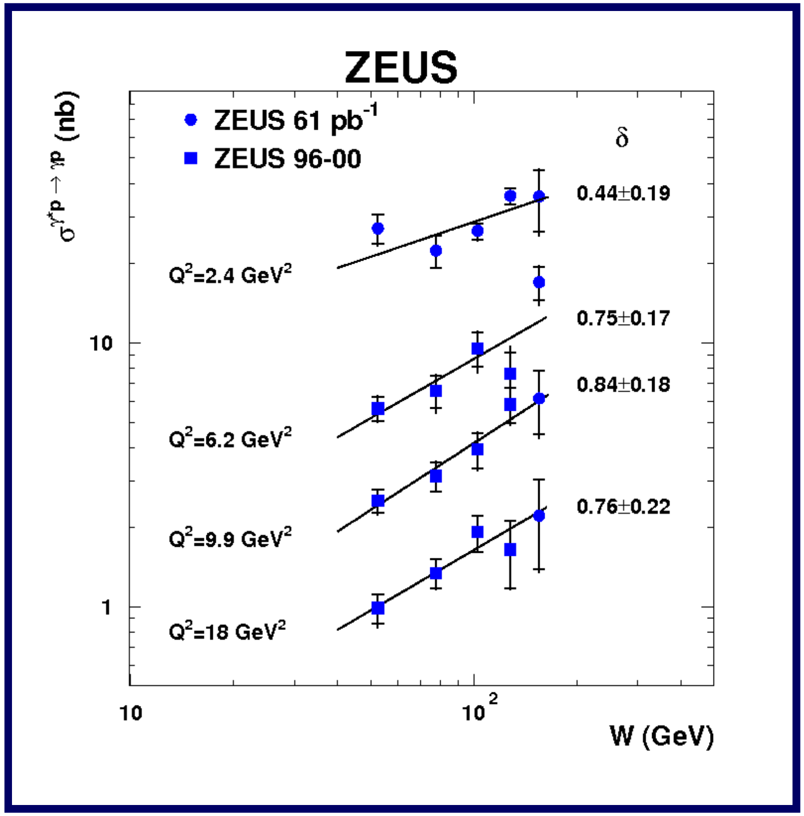
$\theta_2 < 2.75$

# DVCS: *W*-dependence




**Fit: $\sigma \sim W^{\delta}$**




**ZEUS meas. Indicate a dependence for the *W* slope at low $Q^2$ values ...but large uncertainties!**

# VM: W-dependence

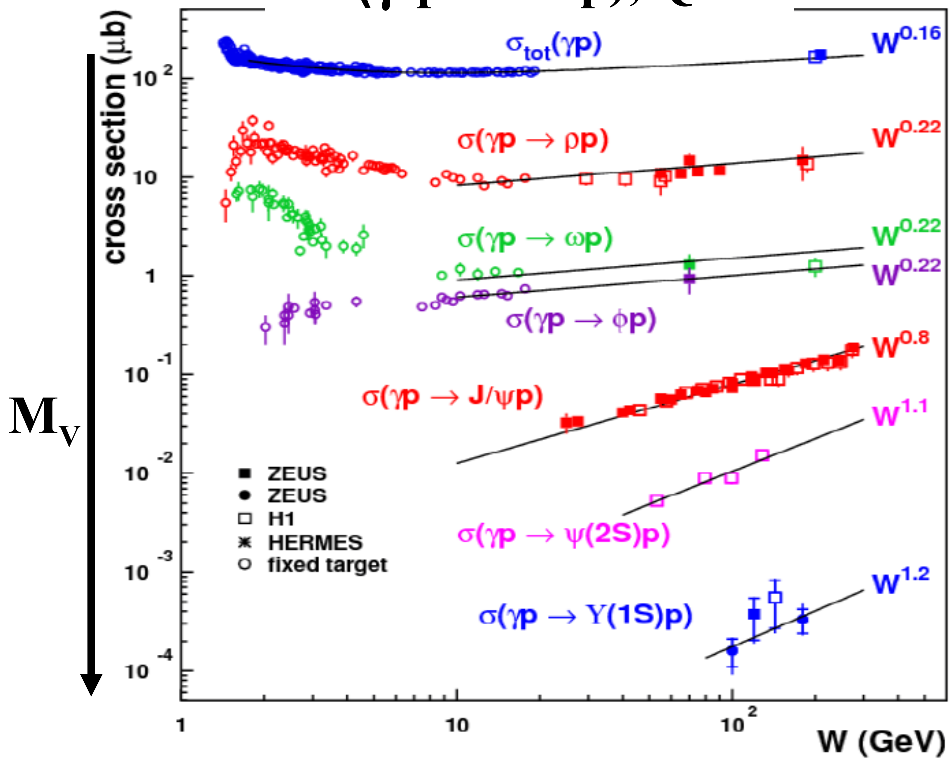
**Large $M_V$ supplies a scale for hard processes → apply pQCD models**

**Fit: $\sigma \sim W^{\delta}$**

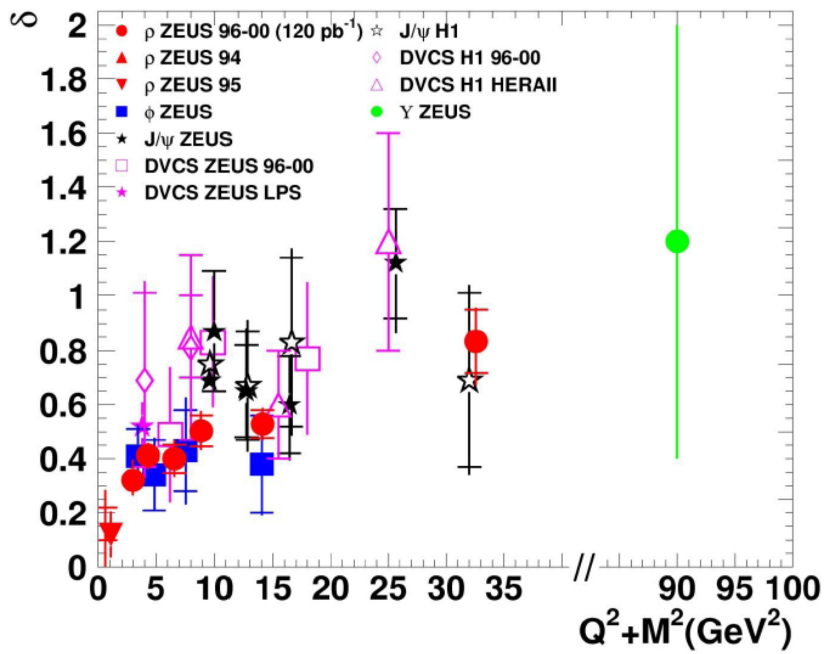
**$W$-slope is $(Q^2 + M_V^2)$ scale dependent**

$$\delta \propto \ln\left(Q^2 + M^2\right)$$

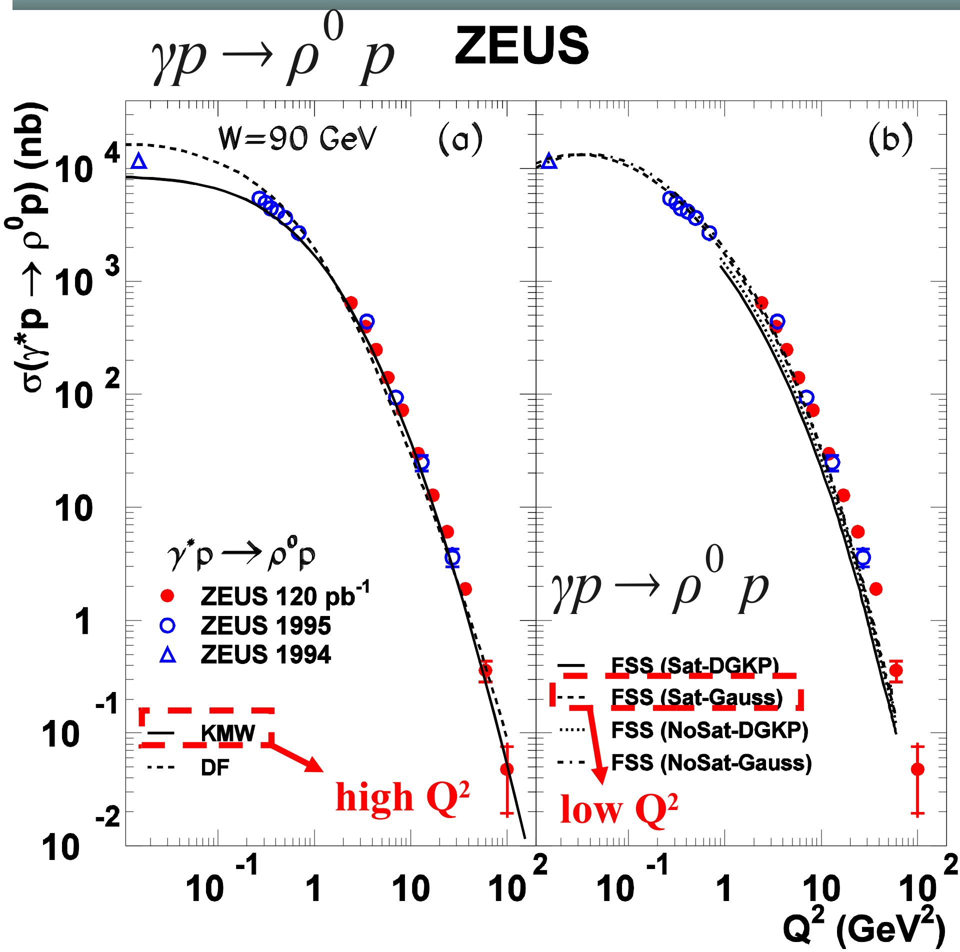
**σ (γ p → V p), Q²=0**




**$W \propto 1/\sqrt{x}$**



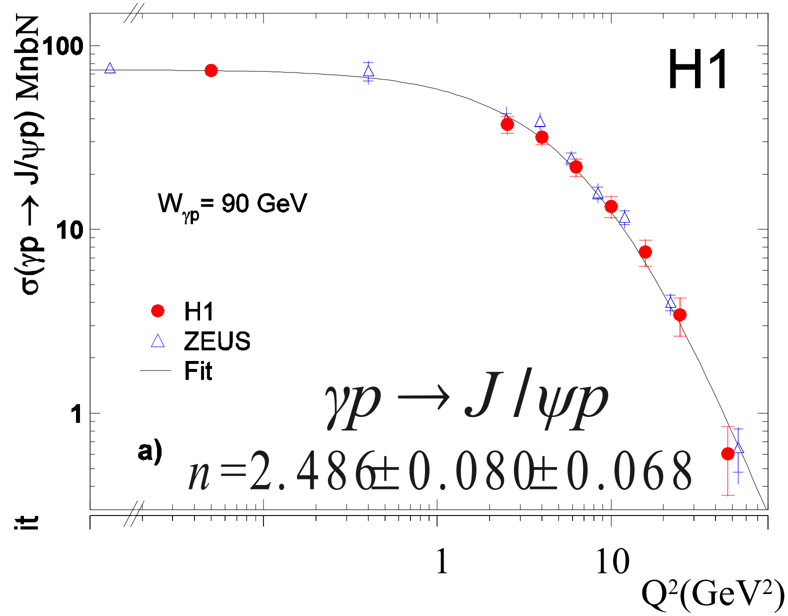
# $\rho^0$: cross section




$$\sigma \propto \left(Q^2 + M^2\right)^{-n}$$

**Fit to whole $Q^2$ range gives bad $\chi^2$/df (~70)**

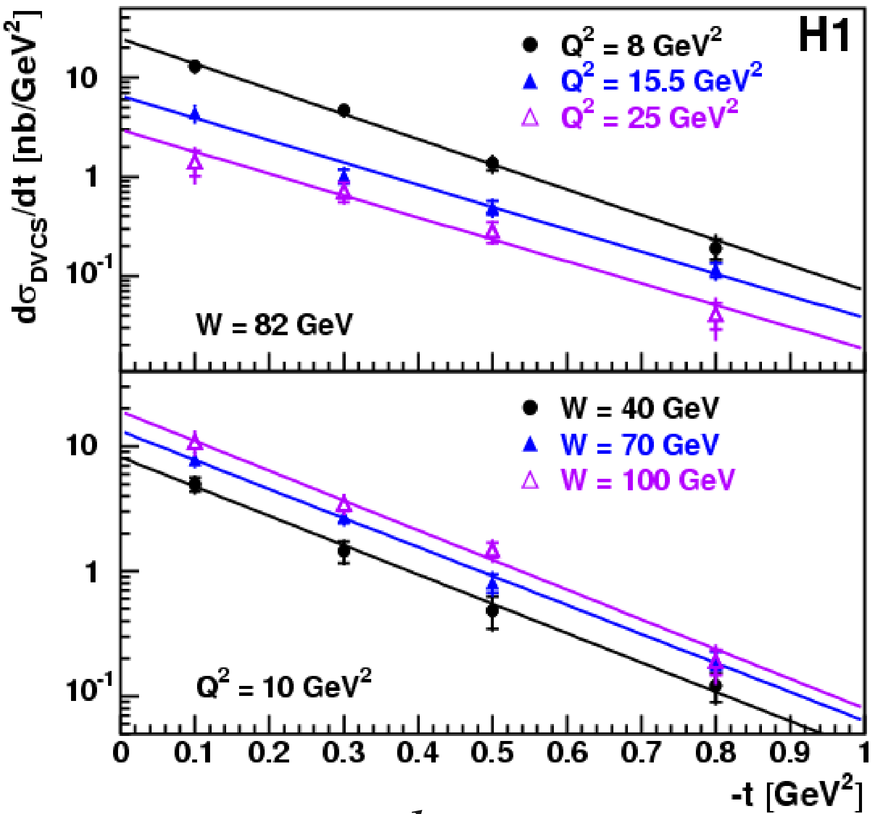
***n* increasing with *$Q^2$* appears to be favoured**



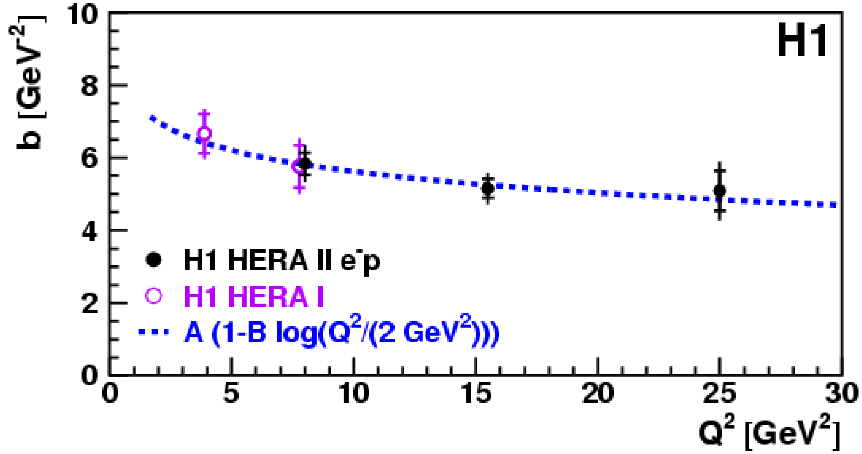

**For DVCS: n= ~1.5**

# DVCS: *t* dependence

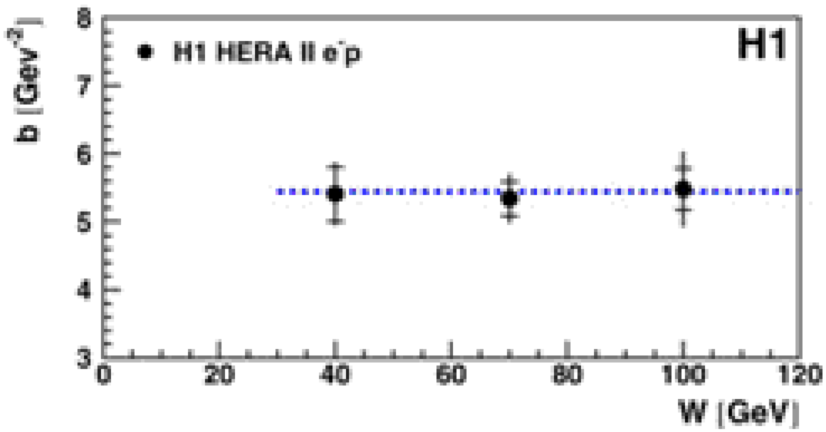
## H1 DVCS




$$Fit: \frac{d\sigma}{dt} \propto e^{-b|t|}$$




***b* decreases with increasing *Q*²**

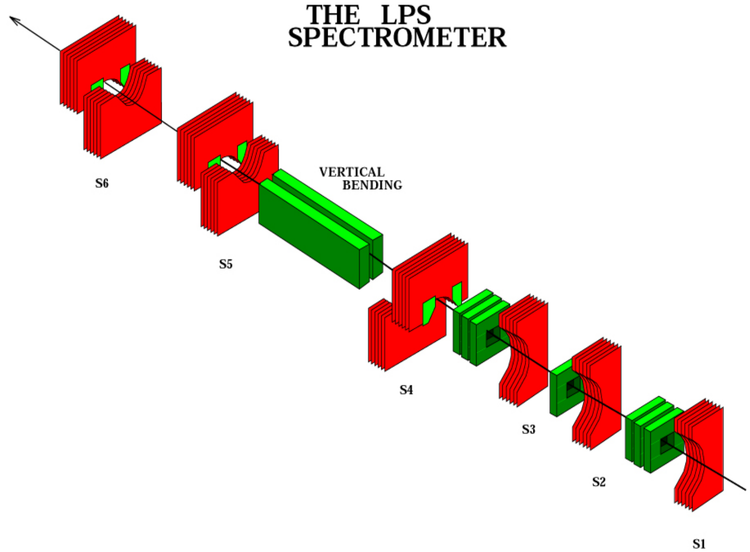



**No evidence for *W* dependence of *b***

# LPS selection criteria

- $3 < Q^2 < 100$ GeV$^2$
- $40 < W < 170$ GeV
- ZEUS selection cuts

$\mathcal{L} = 27.77$ pb$^{-1}$




**LPS selection Cuts:**

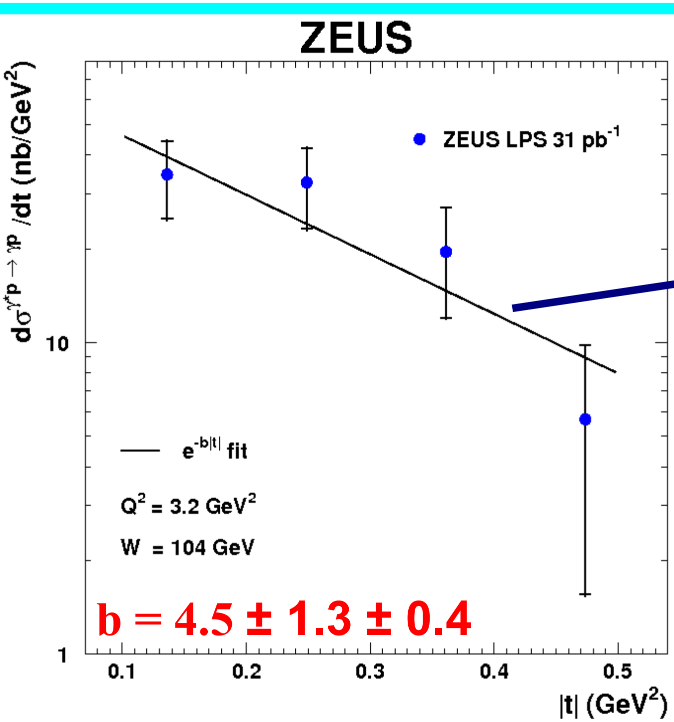
- 2000 data only
- $0.96 < x_L < 1.04$
- $0.08 < |t| < 0.53$ GeV$^2$
- LPS track position cut
- $E+p_z + 1840 \cdot x_L < 1865$ GeV
- docap > 0.04 cm

$$t = -\frac{p_t^2}{x_L} = \frac{\sqrt{p_x^2 + p_y^2}}{x_L}, \quad x_L = \frac{p'}{p}$$

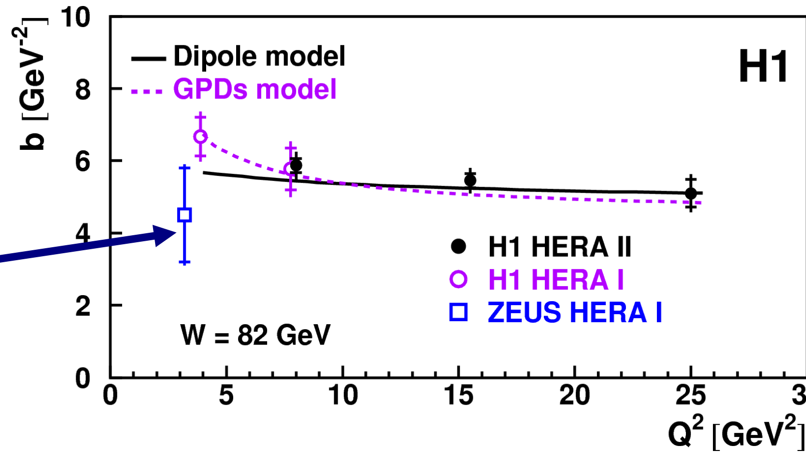
No p dissociation background → Clean measurement

Low detector acceptance → low statistics

# DVCS: *t* dependence




**dσ/dt measured for the first time by a direct measurement of the outgoing proton 4-momentum using the LPS spectrometer**

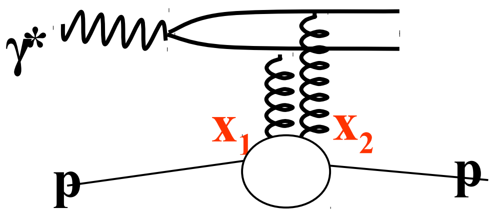



**The ZEUS result is in agreement with H1**

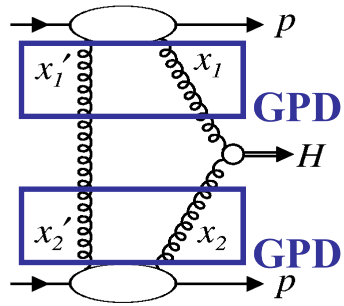
**Measuring the t slope without the LPS but with much more statistics could help the discussion!**

S. Fazio, M. Capua

# The DVCS and GPDs




x1 ≠ x2 → **Generalized Parton Distributions: sensitive to the correlations in the proton**




**GPDs are important also for the diffractive Higgs production**
**at the future LHC experiments at CERN in Geneva**

$$|A|^2 = |A_{DVCS}|^2 + |A_{BH}|^2 + |A_I|^2$$

## DVCS and BH: identical final state → they Interfere

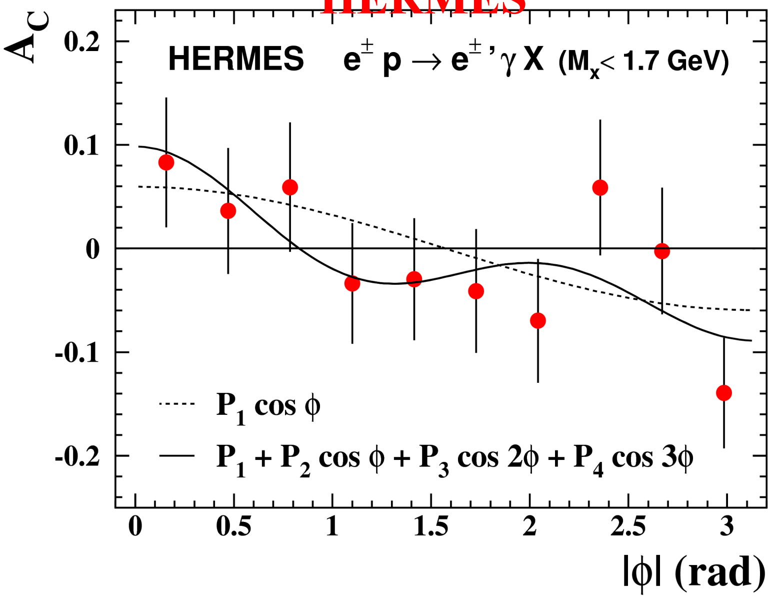
**Interference term:** $A_{INTER} \propto Re\left(A_{DVCS}\right) + Im\left(A_{DVCS}\right)$

**Beam charge asymmetry:** $A_C = \dfrac{d\sigma^{+} - d\sigma^{-}}{d\sigma^{+} + d\sigma^{-}} \propto Re\left(A_{DVCS}\right)$

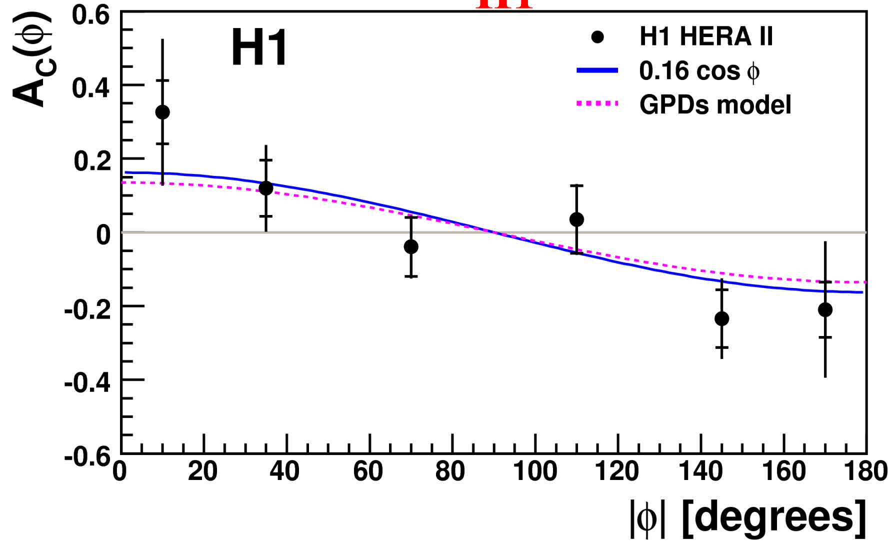
# DVCS: the beam-charge asymmetry

## The beam charge asymmetry as a function of phi

HERMES

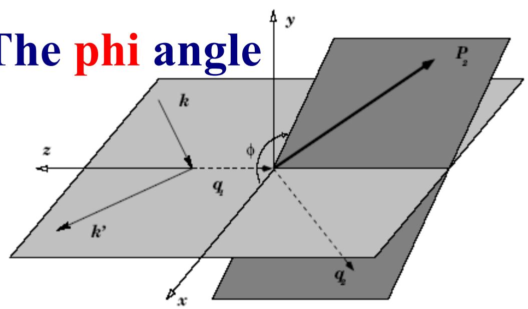



H1




$$A_C = \frac{d\sigma^{+\cdot} - d\sigma^{-\cdot}}{d\sigma^{+\cdot} + d\sigma^{-\cdot}}$$

The phi angle

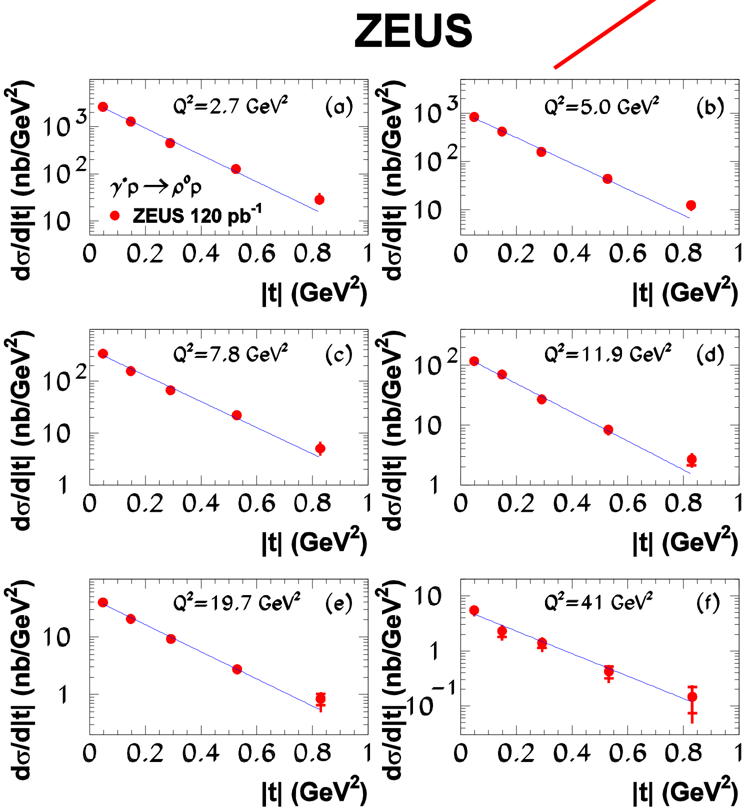


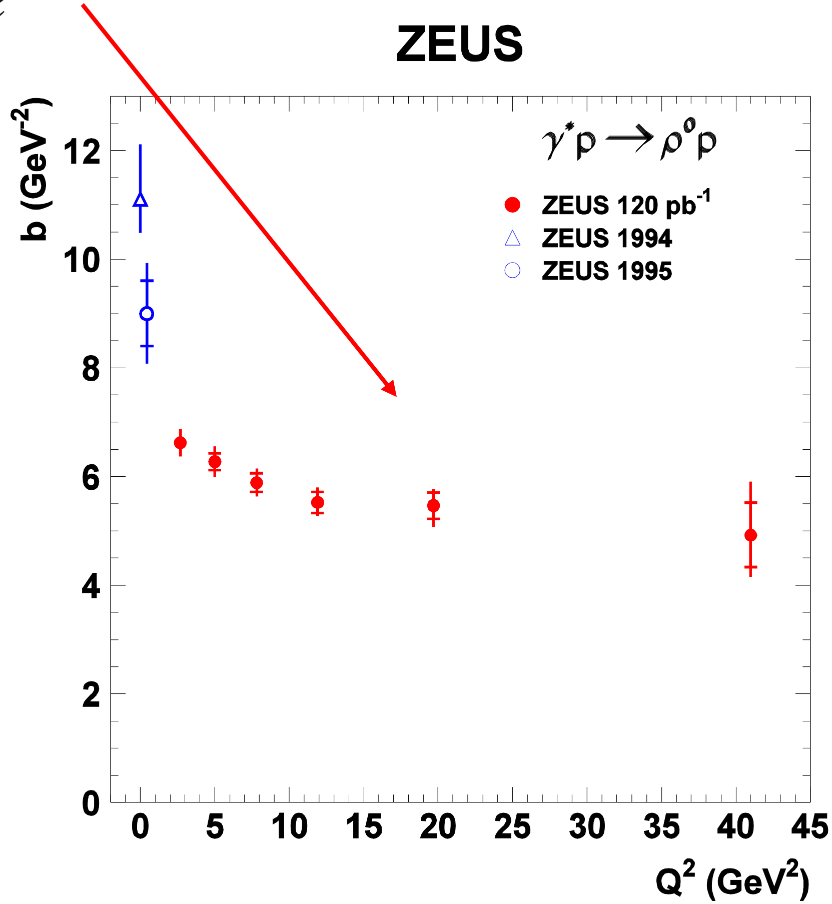

At ZEUS: S. Fazio, M. Capua

# $\rho^0$: *t* dependence

$$\gamma p \to \rho^0 p$$

$$Fit: \frac{d\sigma}{dt} \propto e^{-b|t|}$$




***b* decreases from soft values to pQCD expected values (~4-5 GeV$^{-2}$)**

# VM: *t* dependence

**Same slope for all VM vs ($Q^2 + M^2$)**

**Size of the gluons:**

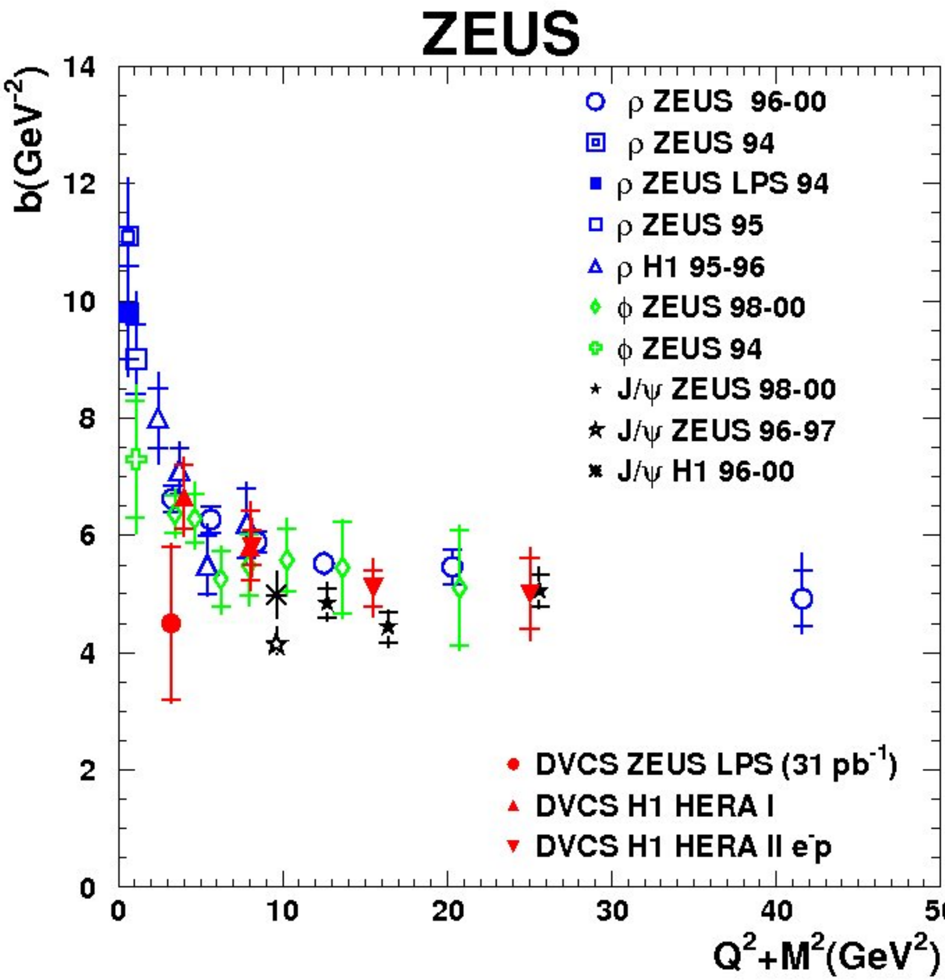
$$\langle r^2 \rangle = 2 \cdot b \cdot (\hbar c)^2$$

$$r_{glue} = 0.56 \text{ fm}$$

**Proton radius:**

$$r_{proton} = 0.8 \text{ fm}$$

**Gluons confinement area is smaller than proton**



# Pomeron trajectory

**Regge-type:** $$\frac{d\sigma}{dt}(W) = \exp(b_0 t) \cdot W^{2[2\alpha_{IP}(t)+2]}$$

**First measured in h-h scattering**

**Linear Pomeron trajectory**

$$\alpha(t) = \alpha(0) + \alpha'(t)\, t$$

**Soft Pomeron values**
**$\alpha(0) \approx 1.08$**
**$\alpha' \approx 0.25$**

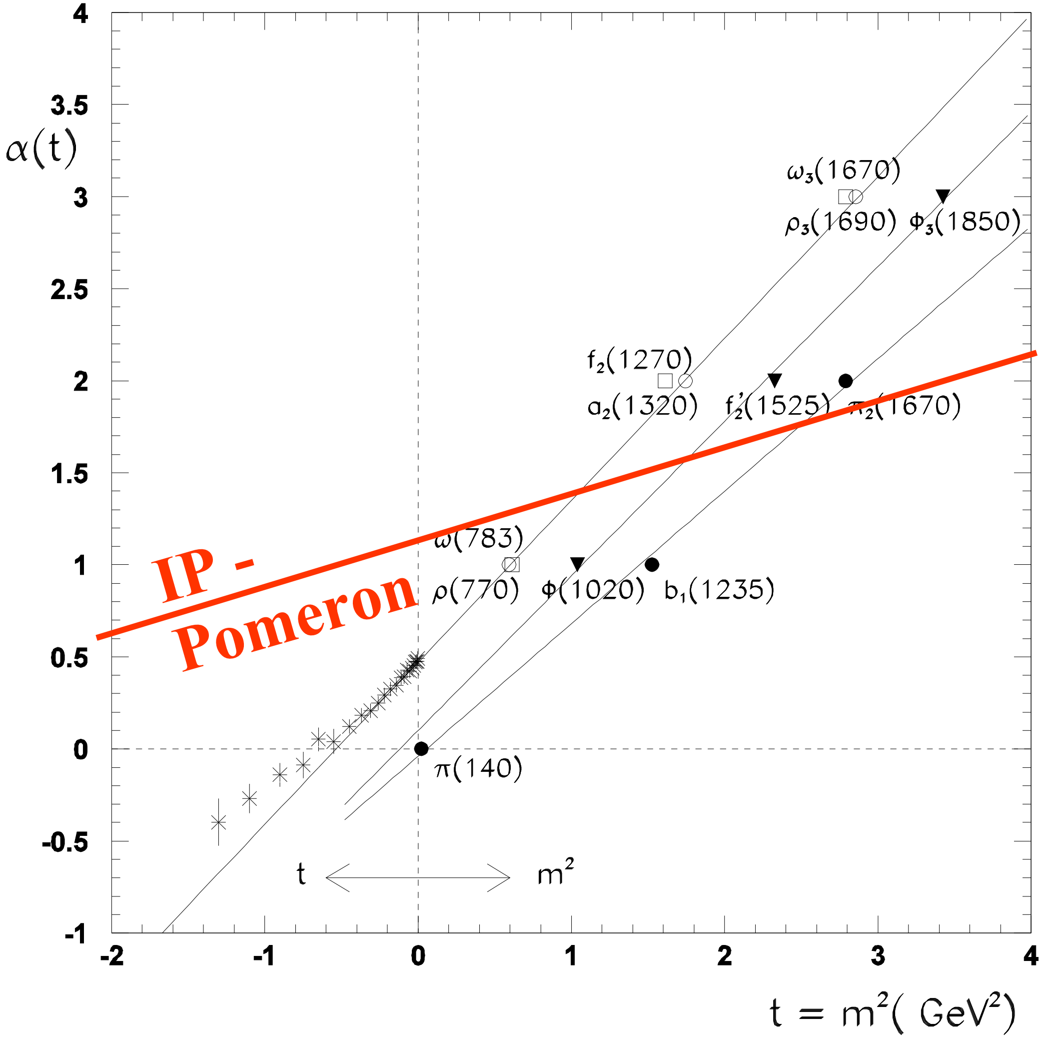
*α(0)* and *α'* are fundamental parameters to represent the basic features of strong interactions

**α(0): determines the energy dependence of the diff. Cross section**

$$\frac{d\sigma}{dt} \propto \exp(b_0 t) \cdot W^{4\alpha(t)-4} = W^{4\alpha(0)-4} \cdot \exp(bt); \quad b = b_0 + 4\alpha' \ln(W)$$

**α': determines the energy dependence of the transverse extension system**

# Pomeron trajectory in hh collisions




$$\alpha(t) = \alpha(0) + \alpha' t$$

$$\sigma_{tot}(h-h) = As^{\alpha_{IP}(0)-1} + Bs^{\alpha_{IR}(0)-1}$$

**Pomeron:**

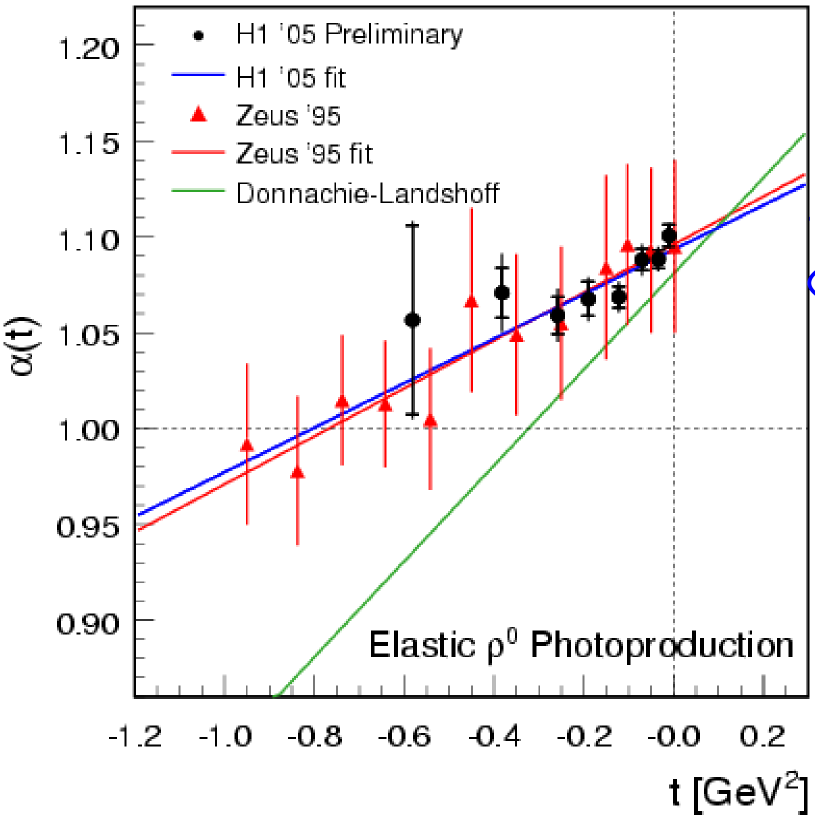
$$\alpha_{IP}(t) = 1.08 + 0.25t$$

**Reggeon:**

$$\alpha_{IR}(t) = 0.45 + t$$

# Pomeron trajectory in ep collisions

$\rho^0$ photoproduction ($Q^2$=0) → $Q^2+M^2 = 0.6$ GeV$^2$ (SOFT regime)




$$\alpha(t) = \alpha(0) + \alpha'(t)\,t$$

$\alpha(0)\ (\gamma p) = 1.093 \pm 0.008 \approx \alpha(0)\ (pp)$

$\alpha'\ (\gamma p) = 0.116 \pm 0.05 \approx 0.5\ \alpha'\ (pp)$

**Two different soft Pomeron trajectories?**

**Size of two protons system growing twice faster with energy than a single proton ($\gamma p$ system) ?**

*Comments and remarks are really welcome!*

# Pomeron trajectory in ep collisions

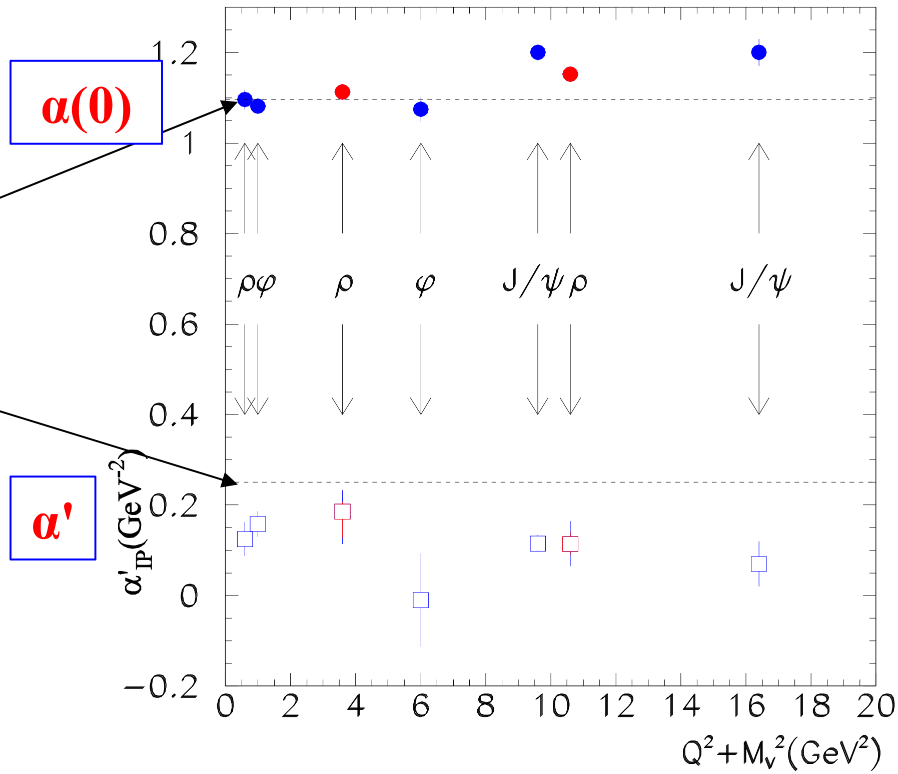
VM electroproduction ⟹ From SOFT to HARD.....

$$\alpha(t) = \alpha(0) + \alpha' t$$

As the scal gets harder the interceps grows up to 1.2

Soft Pomeron values measured in hh scrattering

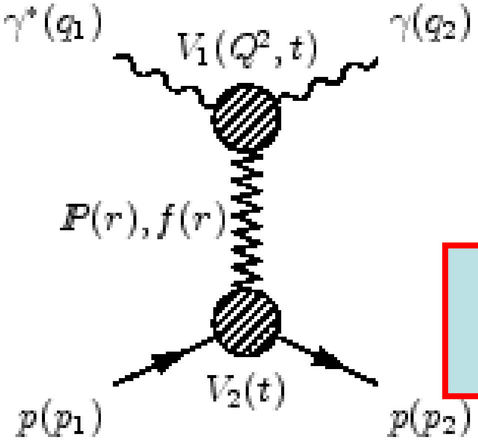
The Pomeron slope is around ~0.1 at hard scale




Now the question is: "is the Pomeron "universal" or its slope changes with $Q^2$?"

# A theoretical model

M. Capua, S. Fazio, R. Fiore, L.L. Jenkovszky, F. Paccanoni
Published in: Physics Letters B645 (Feb. 2007) 161-166




$$V_1 = e^{b\beta(z)}$$

$$V_2 = e^{b\alpha(t)}$$

**A new variable is introduced: $z = t - Q^2$**

**Applications for the model can be:**

- **Study of various extreme regimes of the scattering amplitude vs *Q2, W, t* (perturbative –> unperturbative QCD)**
- **Study of GPD$_s$**

## DVCS amplitude:

$$A(s,t,Q^2)_{\gamma p \to \gamma p} = -A_0 V_1(t,Q^2)\, V_2(t)(-is/s_0)^{\alpha(t)}$$

**the *t* dependence at the vertex *pIPp* is introduced by:**

$$\alpha(t) = \alpha(0) - \alpha_1 \ln(1 - \alpha_2 t)$$

$$\beta(z) = \alpha(0) - \alpha_1 \ln(1 - \alpha_2 z)$$

**the DVCS amplitude can be written as:**

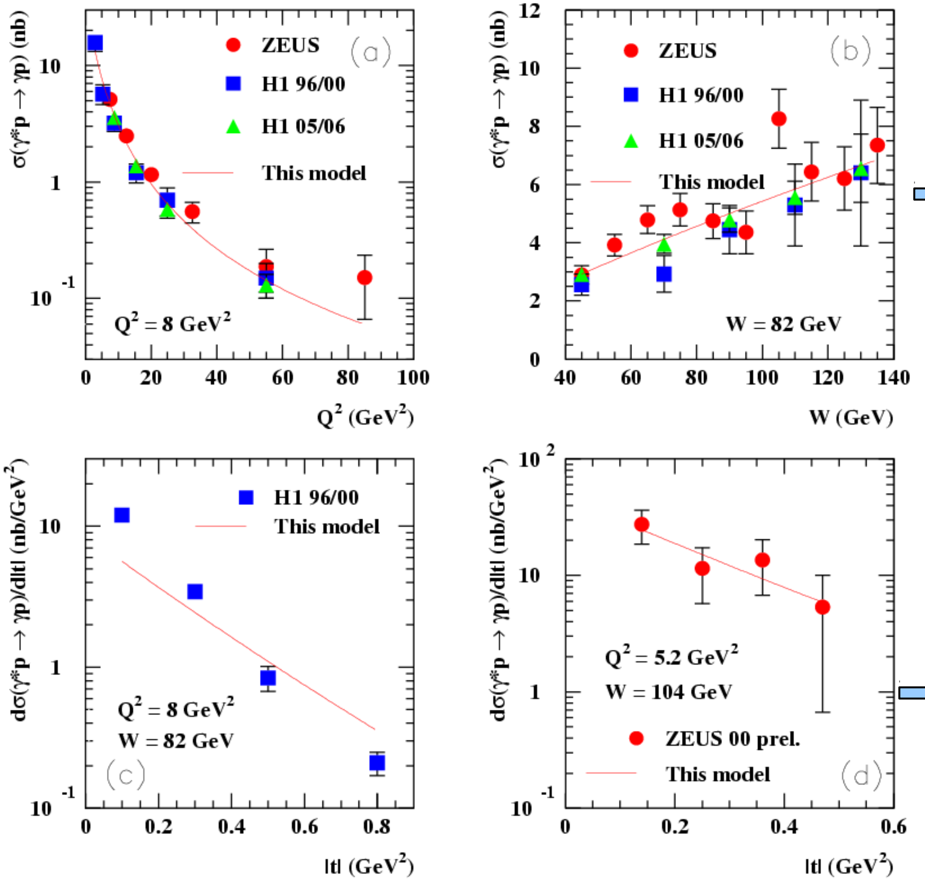
$$L = \ln(-is/s_0)$$

$$A(s,t,Q^2)_{\gamma p \to \gamma p} = -A_0 e^{b\alpha(t)} e^{b\beta(t)} (-is/s_0)^{\alpha(t)} = -A_0 e^{(b+L)\alpha(t) + b\beta(z)}$$

# Pomeron in DVCS

## DVCS data collected at HERA

$$\frac{d\sigma}{dt}\left(s,t,Q^2\right)=\frac{\pi}{s^2}\left|A\left(s,t,Q^2\right)\right|^2$$




**Fit was performed on $\sigma(Q^2)$ and $\sigma(W)$**

**$\alpha(0) \sim 1.2 \approx \alpha(0)$ hard**

**$\alpha' \sim 0.25 \approx \alpha'$ pp coll.**

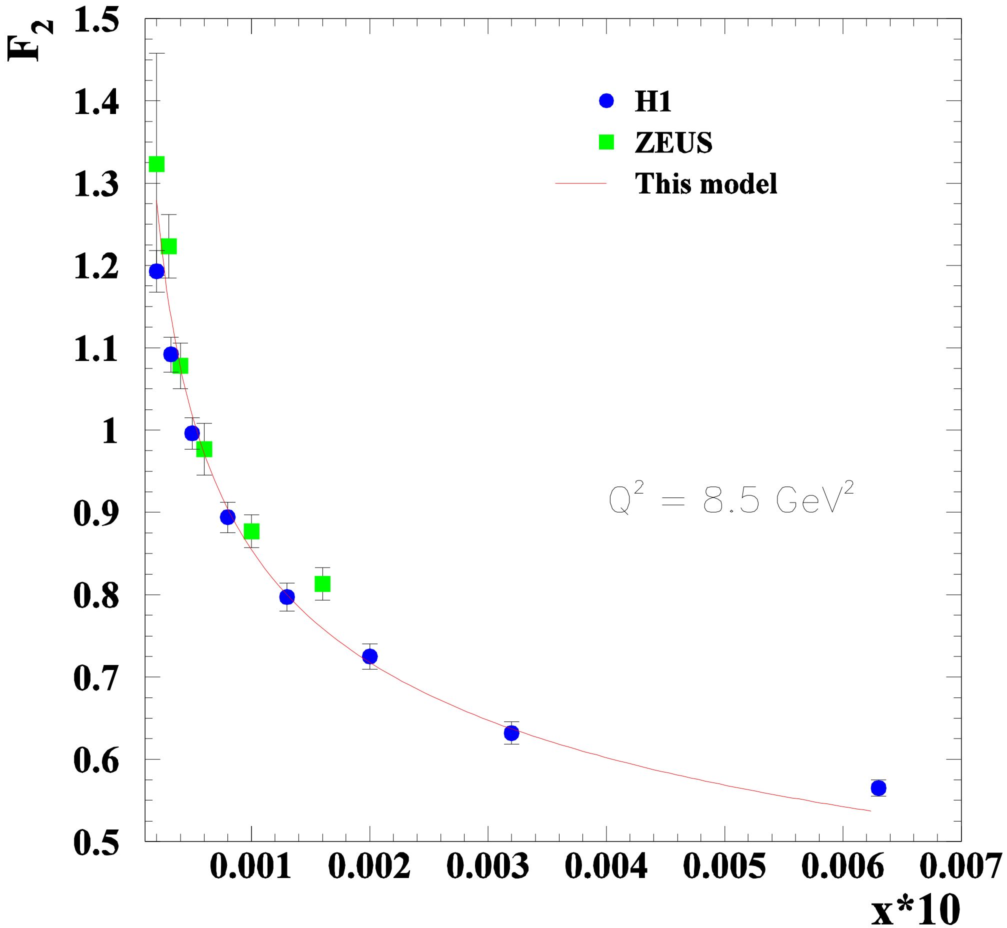
**Model compared to $d\sigma/dt$ with all param. fixed and anly norm. free**

**The model disagrees with H1**

***t* was calculated in H1 by the approximation:** $t \sim \left(P_{T_\gamma}^2 + P_{T_e}^2\right)^2$

# $F_2$ stucture function

***Comparison between HERA data and the model for***
***$F_2(s,Q^2)$* DIS structure function**




$$F_2(s,Q^2) \approx \frac{(1-x)Q^2}{\pi\alpha_e} \Im A(s,Q^2)/s$$

**All parameter fixed like in our model**

**Really good agreement!**

**The model reproduces experimental data at small *x* and moderate *Q²***

# Extension of the model

S. Fazio, R. Fiore, L.L. Jenkovszky, A. Lavorini
First presented at: Blois pre-conference, CERN (Geneva), may 2009

**We may consider the Pomeron as an "effective" one containing the contribution from many particles, each one with a $Q^2$-independent trajectory**

$$A_{tot} = A_s + h \cdot A_h$$

$$A_i(s,t,Q^2)_{\gamma p \to \gamma p} = -A_0 e^{b\alpha(t)} e^{b\beta(t)} (-is/s_0)^{\alpha(t)} = -A_0 e^{(b+L)\alpha(t)+b\beta(z)}$$

$$\alpha_i(t) = \alpha(0) - \alpha_1 \ln(1 - \alpha_2 t)$$

$$\beta_i(z) = \alpha(0) - \alpha_1 \ln(1 - \alpha_2 z)$$

*i = soft; hard*

**Soft Pomeron:**

$$\alpha_{soft}(t) = 1.09 + 0.25\, t$$

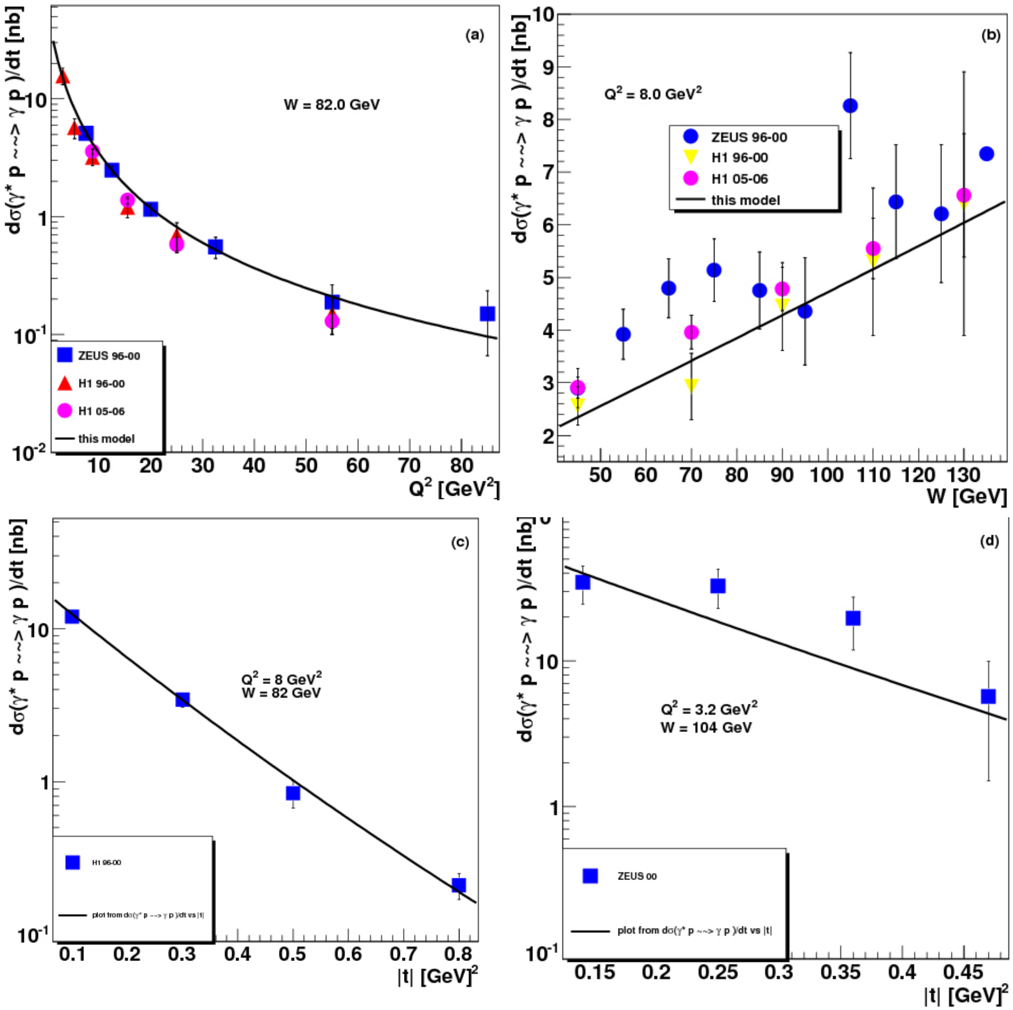
**Hard Pomeron:**

$$\alpha_{hard}(t) = 1.30 + 0.02\, t$$

**Now we have two "universal" Pomerons!**

# DVCS (two Pomerons contribution)

## DVCS data collected at HERA




$$A_{tot} = A_s + h \cdot A_h$$

**Reggeon contribution found to be negligible at the HERA energy scale**

Model compared to dσ/dt with all param. fixed and anly norm. free

**dσ/dt agreement with H1 improved**

$\alpha_s(0) = 1.09$ $\alpha'_s = 0.25$

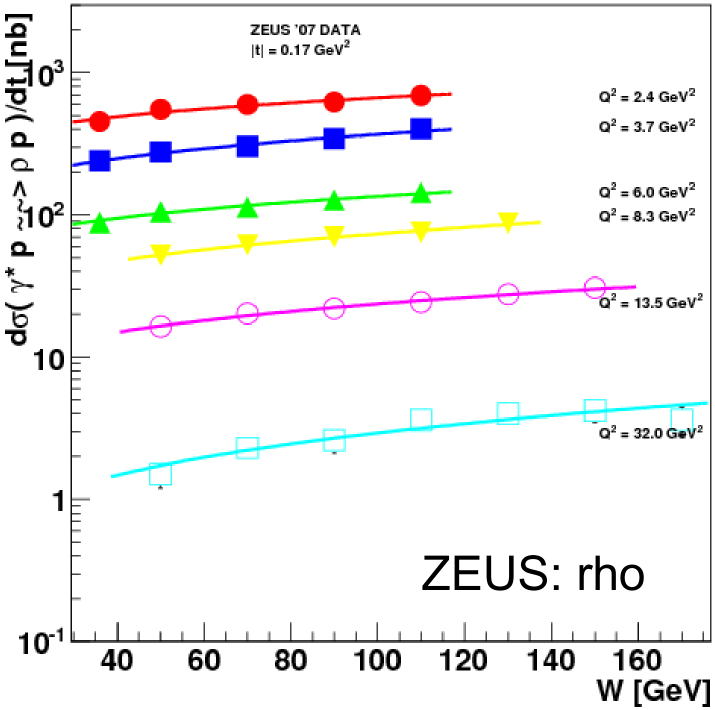
$\alpha_h = 1.30$ $\alpha'_h = 0.02$

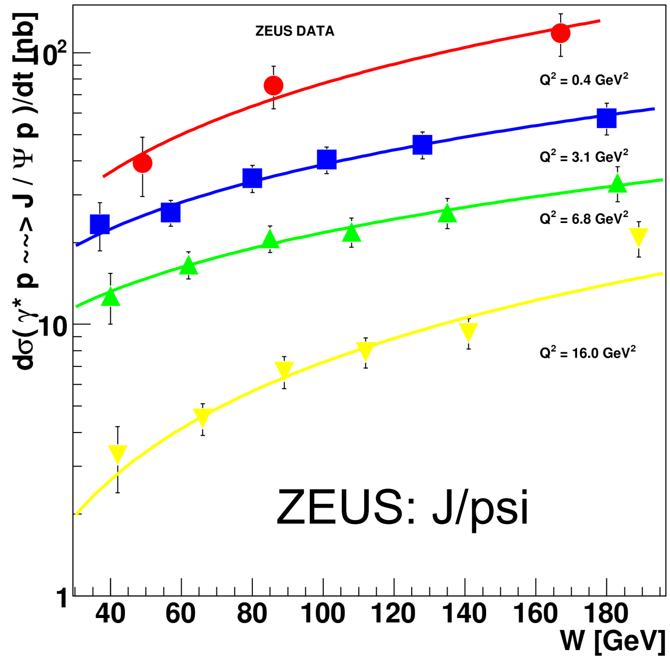
# VM (two Pomerons contribution)

$$A_{tot} = A_s + h \cdot A_h$$

$$Q^2 \rightarrow \tilde{Q}^2 = Q^2 + M_V^2$$

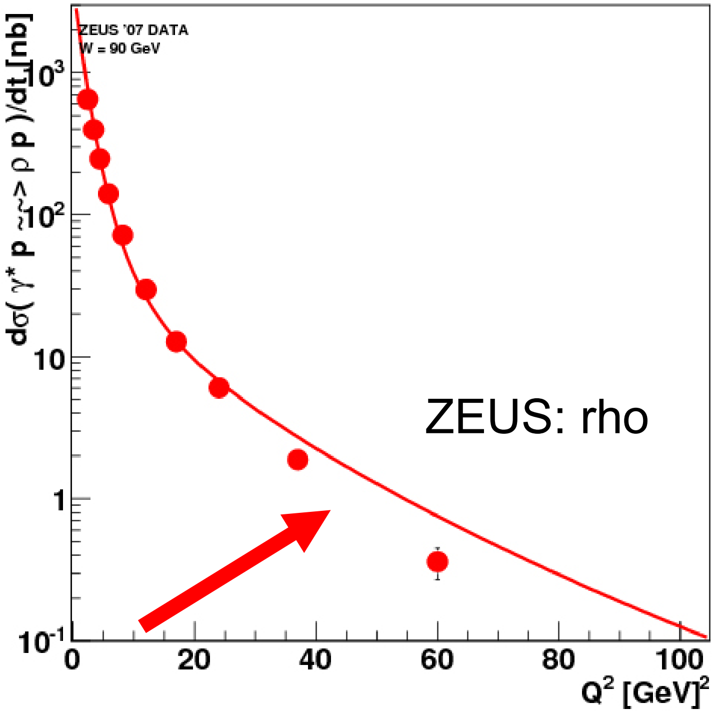
**Model is general:**
**it can be easily extended to VMP**

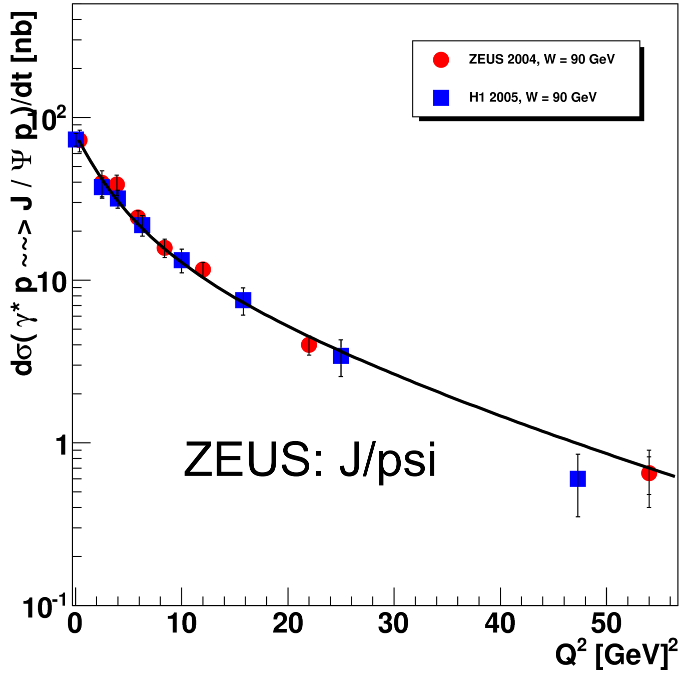



**Successful description of the total xsec. in energy**

# VM (two Pomerons contribution)



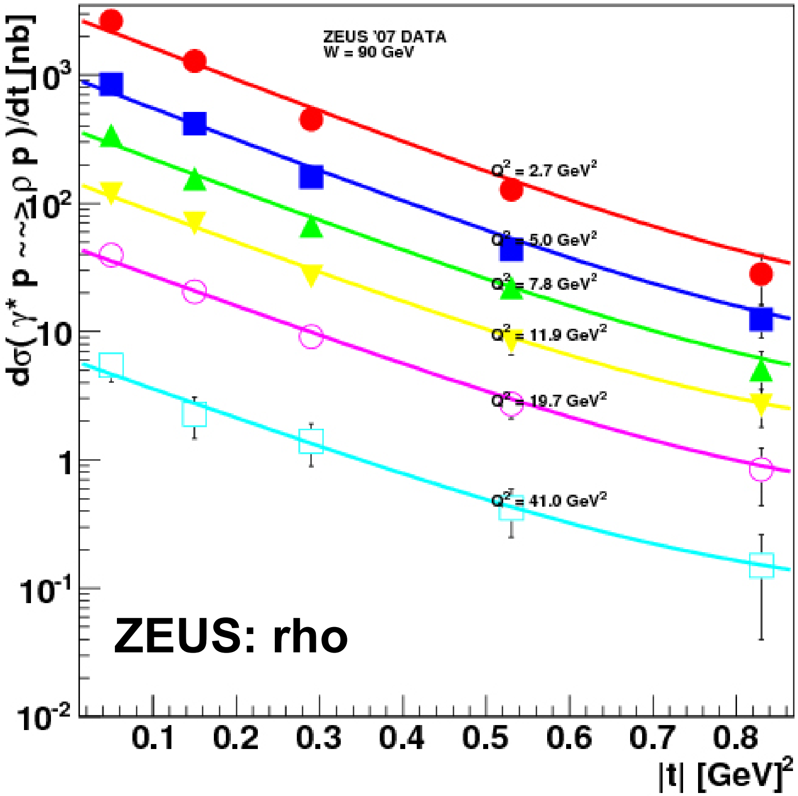



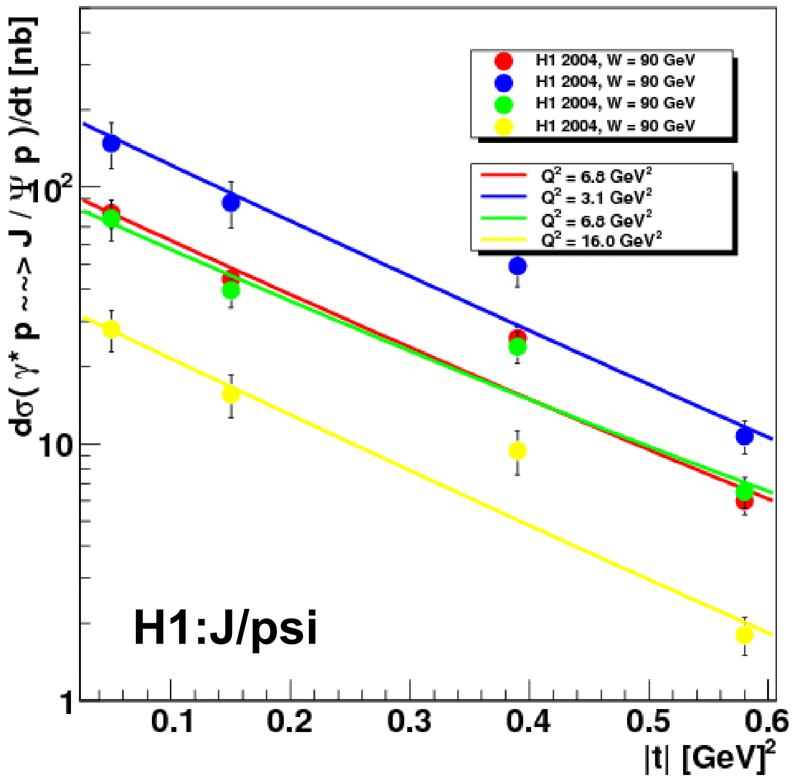

**The model provides a good description of the $\sigma(Q^2)$ for J/ψ but it still fails to describe $\rho^0$ at high $Q^2$**

**… but remember slide #16 !**

# VM (two Pomerons contribution)

**Model compared to dσ/dt with all param. fixed and only norm. free**

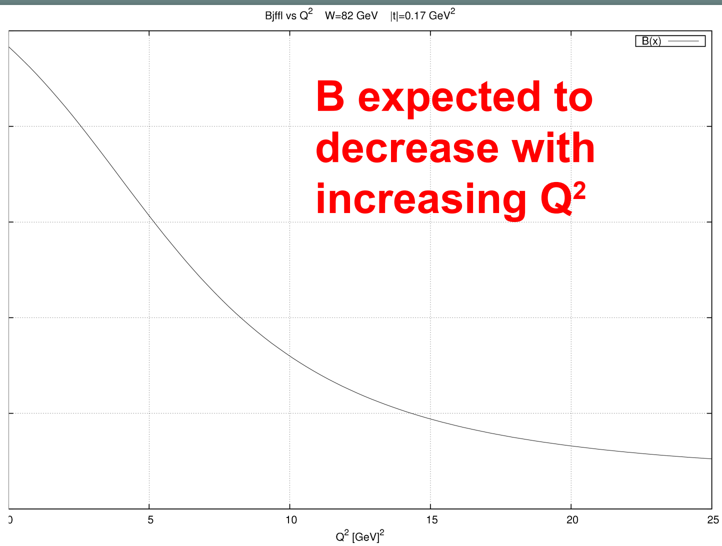


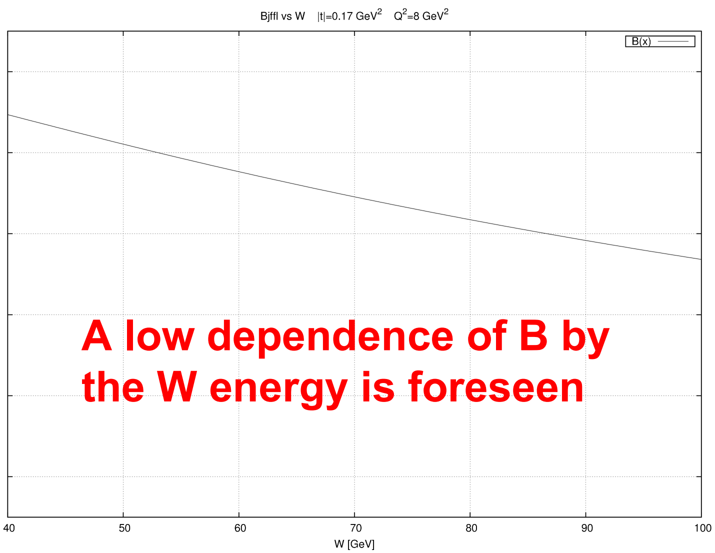

**The model reproduces the dσ/dt, especially at high $Q^2$**

# B dependence

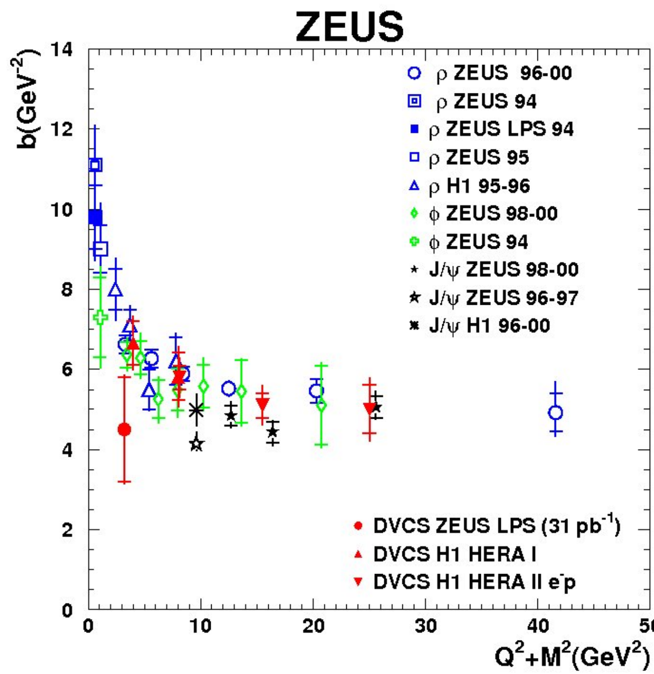
$$B = \frac{d}{dt} \ln\left(\frac{d\sigma}{dt}\right)$$




B expected to decrease with increasing Q²




A low dependence of B by the W energy is foreseen



# The LHC Machine and Experiments

ATLAS/CMS Coverage

Tracking $0 < |\eta| < 3$

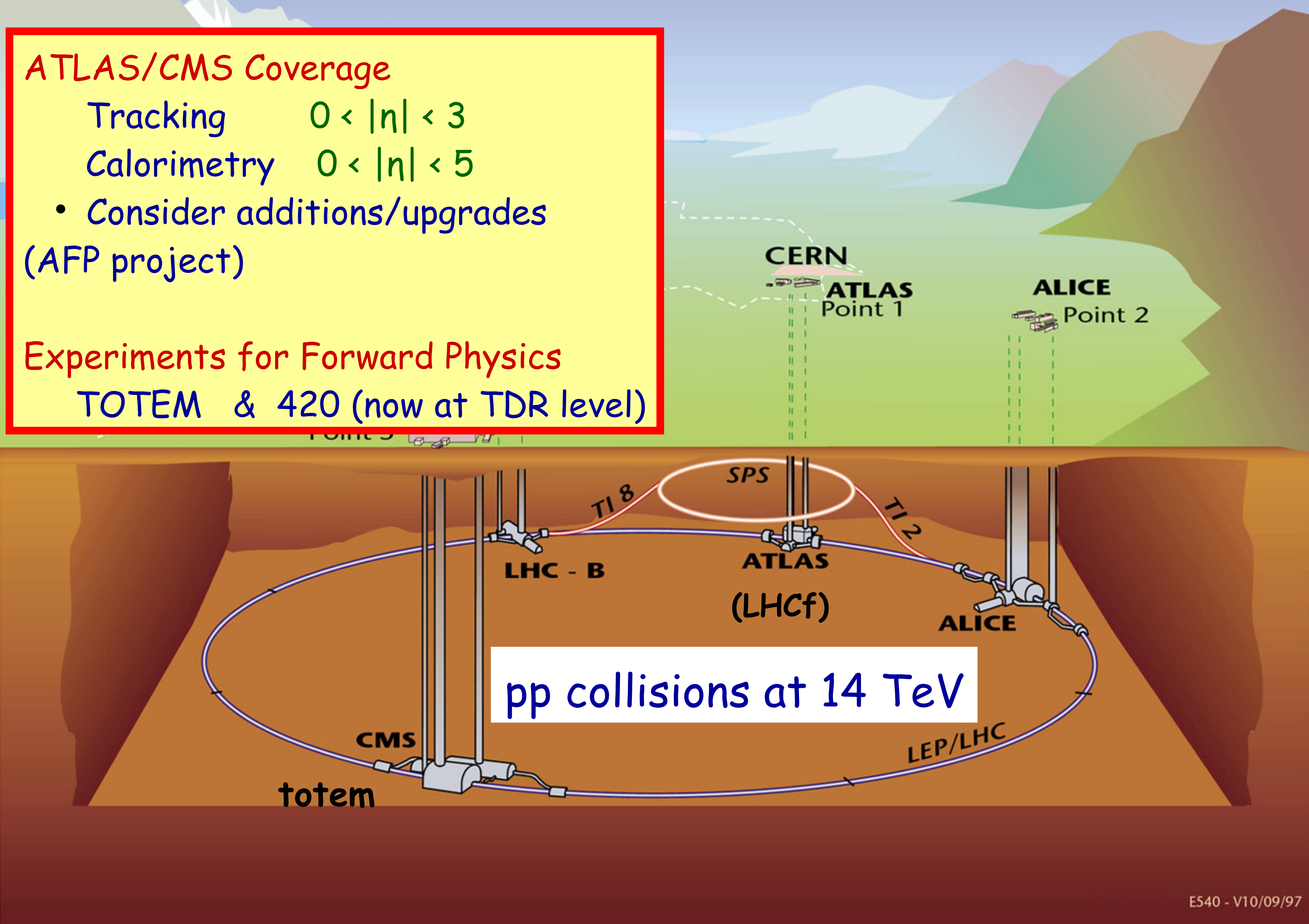
Calorimetry $0 < |\eta| < 5$

- Consider additions/upgrades

(AFP project)

Experiments for Forward Physics

TOTEM & 420 (now at TDR level)




pp collisions at 14 TeV

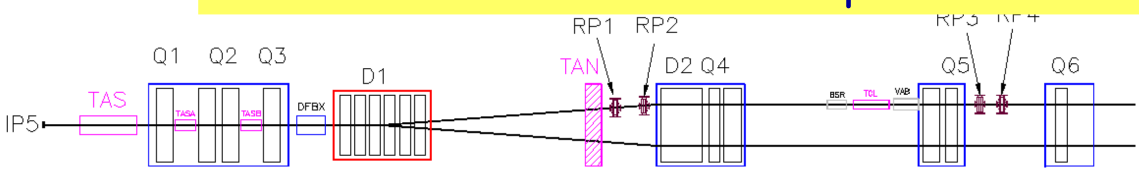
# Forward instrumentation @ CMS: TOTEM

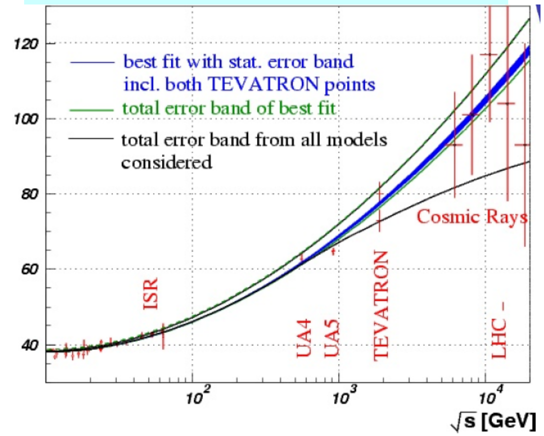
TOTEM: measuring the total, elastic and diffractive cross sections

Add Roman pots at 150-220m to CMS interaction regions.

⇒ Common runs with CMS planned

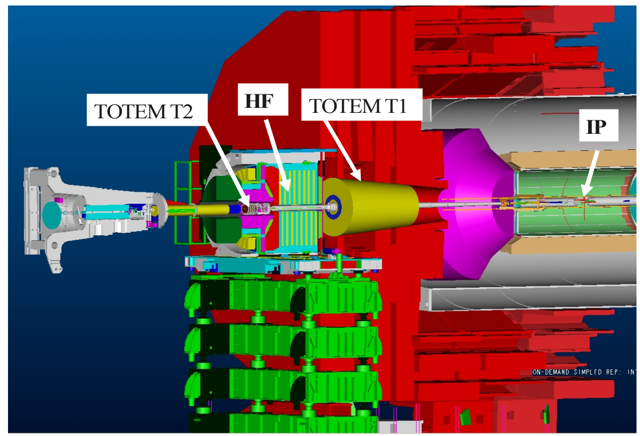
$\sigma_{tot}$ ~ 1% precision



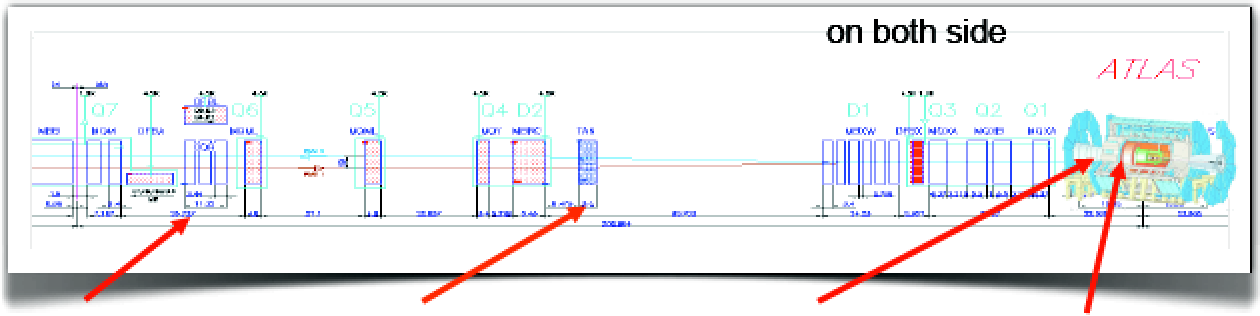

IP5

TOTEM: T1 $3.1 < \eta < 4.7$
TOTEM T2 $5.3 < \eta < 6.7$
CMS Castor $5.25 < \eta < 6.5$

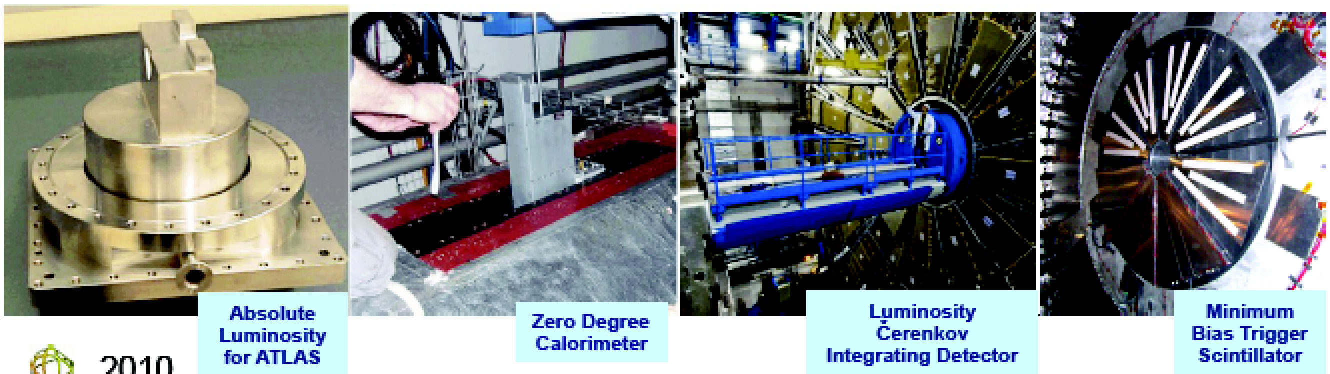



CMS/TOTEM: Extend the rapidity from $|\eta|<5$ to $|\eta|<6.7$

# Forward instrumentation @ ATLAS



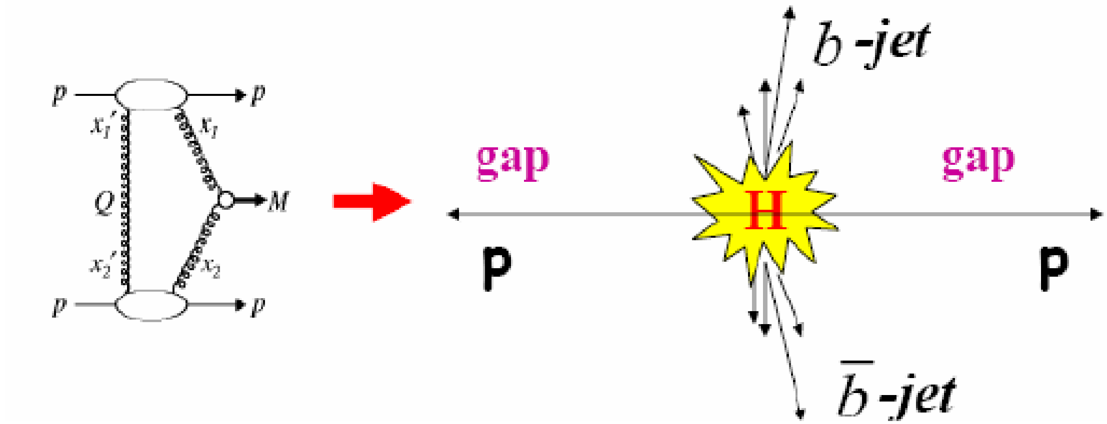

ALFA at 240 m | ZDC at 140 m | LUCID at 17 m | MBTS at 3.6 m




2010

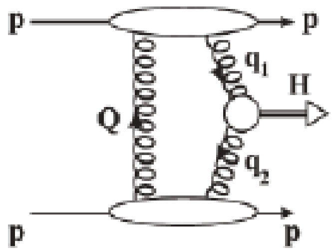
# Afp Upgrade: the idea

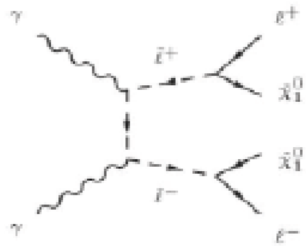
Measure forward protons on both side of the detector for CEP and DPE studies
Provide a trigger for the diffractive physics (LVL1 + HLT)




Detector requirements:
- Tracking system to detect and reconstruct the 2 leading protons (1μrad. angular resolution) → Si detector
- Timing system (10-20ps resolution) to identify the primary vertex → Cerenkov photon detectors
- Beam proximity → Radiation hardness

# Physics case



- Two new-physics production processes : CEP and γγ

- CEP leads to quantum number selection rules / high precision mass measurement irrespective of decay channel / bb channel open in wide range of MSSM scenarios

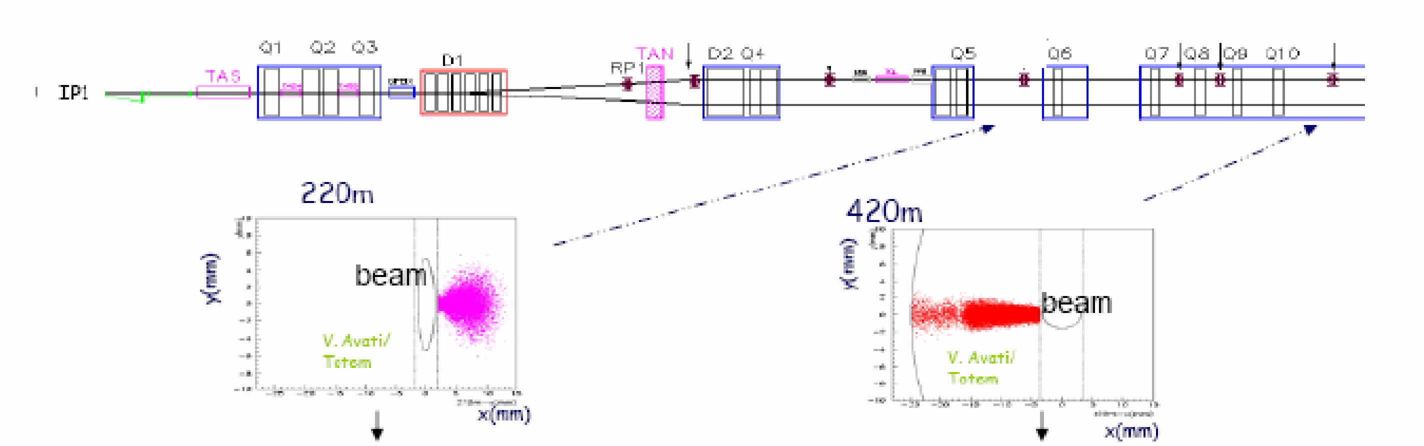
- In MSSM, very important that pseudo-scalar production heavily suppressed, important in scenarios where scalar and pseudo-scalar masses are close

- γγ production very large, theoretically well known cross sections for SM and BSM processes: SUSY production, anomalous gauge couplings

- Wide "bread and butter" physics program in QCD and photoproduction

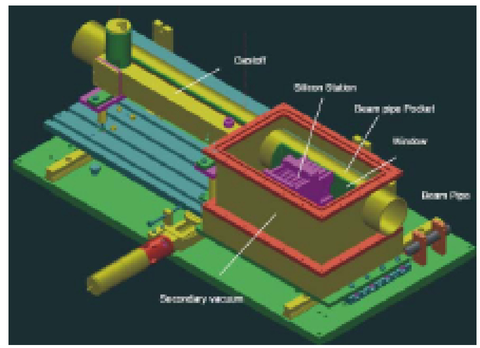
- Useful service tasks including high precision calibration of jet energy scale

# AFP a future possible Detector



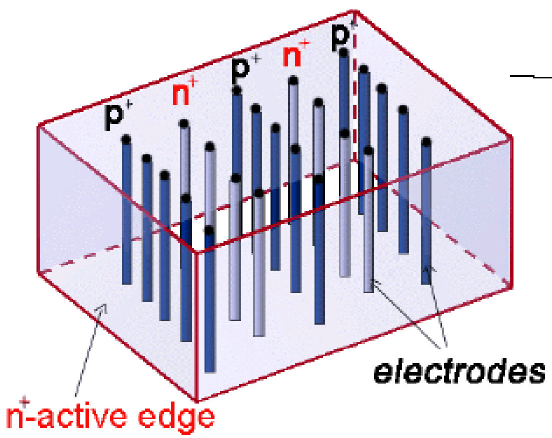

Two stations at 220 and 420m to detect leading protons, integrated in LHC
Very good mass resolution for forward Protons

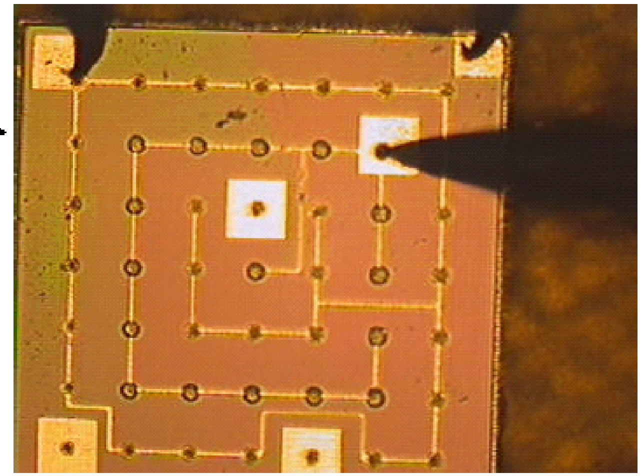
But VERY Challenging !



# 3D DETECTORS AND ACTIVE EDGES

Brunel, Hawaii, Stanford



Need to approach beam to mm level

## "Hamburg" movable beam-pipe

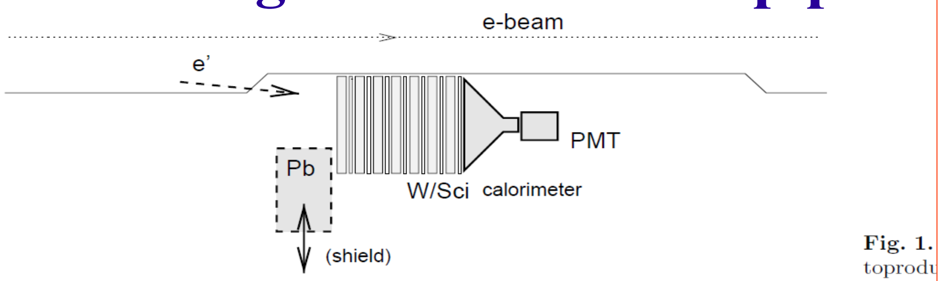
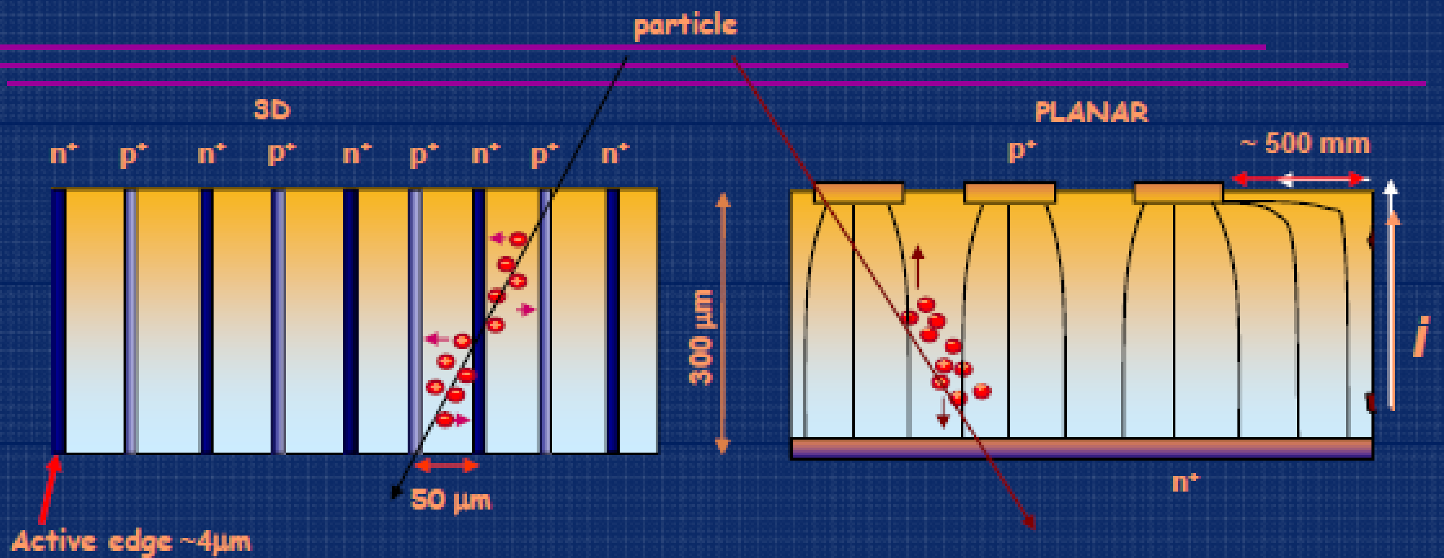
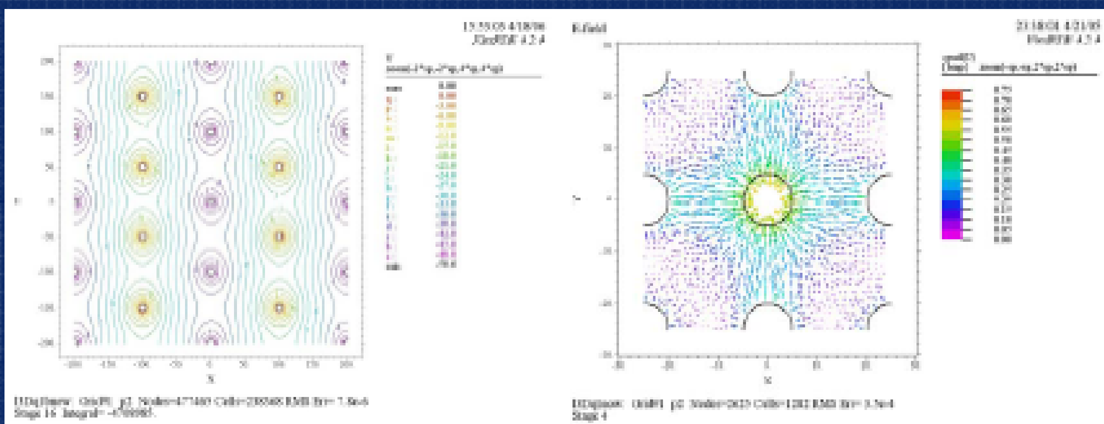



Fig. 1.
toprodu

# What's different→3D versus planar



| | 3D | planar |
|---|---|---|
| $V_{dep}$ | < 5-10 V | 50-70 V |
| $Q_{1mip}$ | 24000e⁻ | 24000e⁻ |
| C | 40-80fF | 50-200fF |
| Lorentz angle | no | yes |

Simulations using FlexPDE by S. Watts (Manchester)

# Hit efficiency measurement
# 2009 test beam @ CERN - SPS

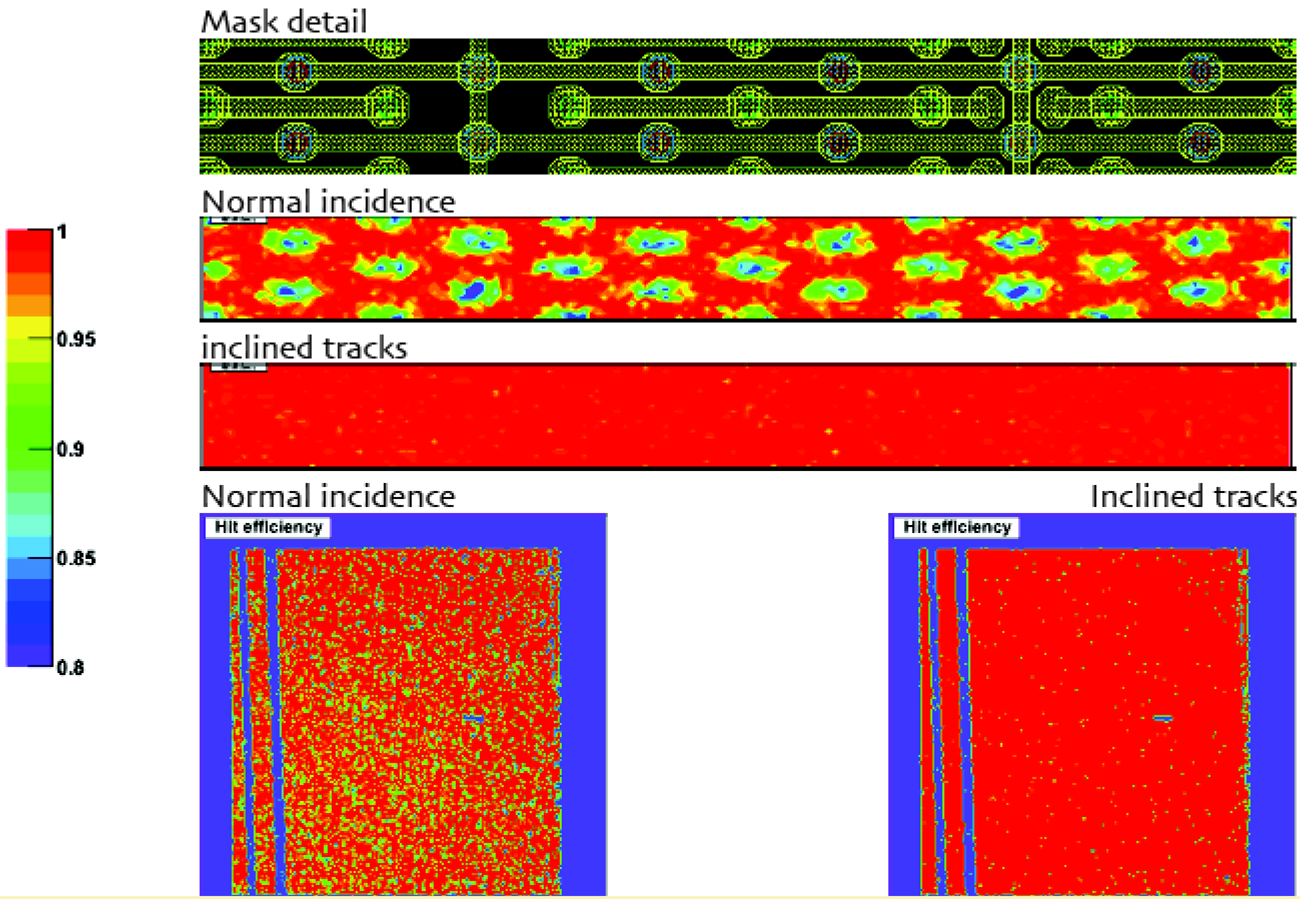
**The partially inactive columns are expected to cause some loss of efficiency**

**Analysis procedure:**
- **Apply strick track cleaning cuts**
- **Extrapolate track to Device-under-Test**
- **Discard tracks that pass close to masked pixels**
- **Search for hits in window of 3 × 5 cells**

**Nominal tilt for inclined tracks: 15°, actual tilt estimated to 11.4° - 14.1°**
°


E. Bolle[9] M. Borri[12] M. Boscardin[15] G.-F. Dalla Betta[14] G. Darbo[13] C. Da Vià[7] S. Dong[10] O. Dorholt[9] S. Fazio[3] C. Gemme[13] H. Gjersdal[9] P. Grenier[10] S. Grinstein[6] P. Hansson[10] J. Hasi[10] F. Huegging[2] P. Jackson[10] C. Kenney[10] M. Kocian[10] A. La Rosa[4] A. Mastroberardino[3] P. Nordahl[9] F. Rivero[12] O. Røhne[9] H. Sandaker[1] K. Sjøbæk[9] T. Slaviec[5] J. Tsung[2] D. Tsybychev[11] N. Wermes[2] C. Young[10]

[1]University of Bergen [2]Bonn University [3]Calabria University
[4]CERN [5]Czech Technical University
[6]IFIC Barcelona [7]University of Manchester [8]University of New Mexico [9]University of Oslo [10]SLAC
[11]Stony Brook University [12]Torino University [13]INFN Genova
[14]Università di Trento and INFN Trento [15]FBK Trento




| | Hit efficiency (%) | |
|---|---|---|
| | B = 0.0 T | |
| | $\phi = 0^\circ$ | $\phi = 15^\circ$ |
| Planar | 99.9 | 99.9 |
| STA 3E | 96.7 | 99.8 |
| FBK 3E7 | 99.0 | 99.8 |
| FBK 3EM5 | 90.2 | 97.7 |

The low efficiency in FBK 3EM5 is understood in terms of inferior operating characteristics of that particular device.



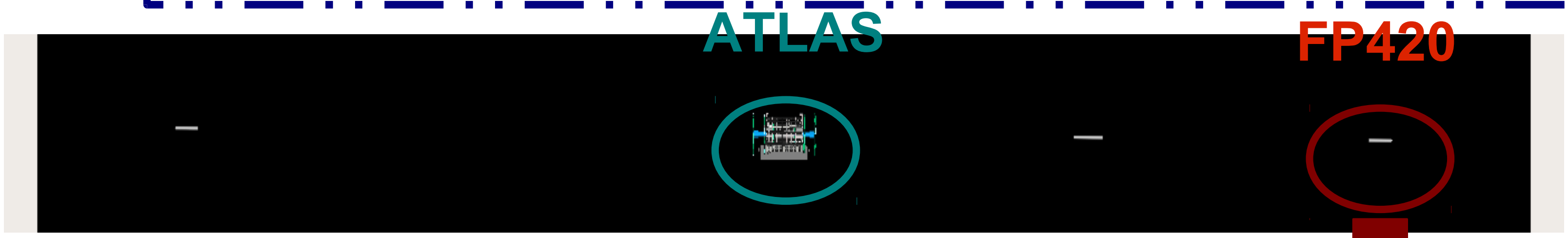
Fully efficient for inclined tracks

# The ATLAS ("Athena") framework

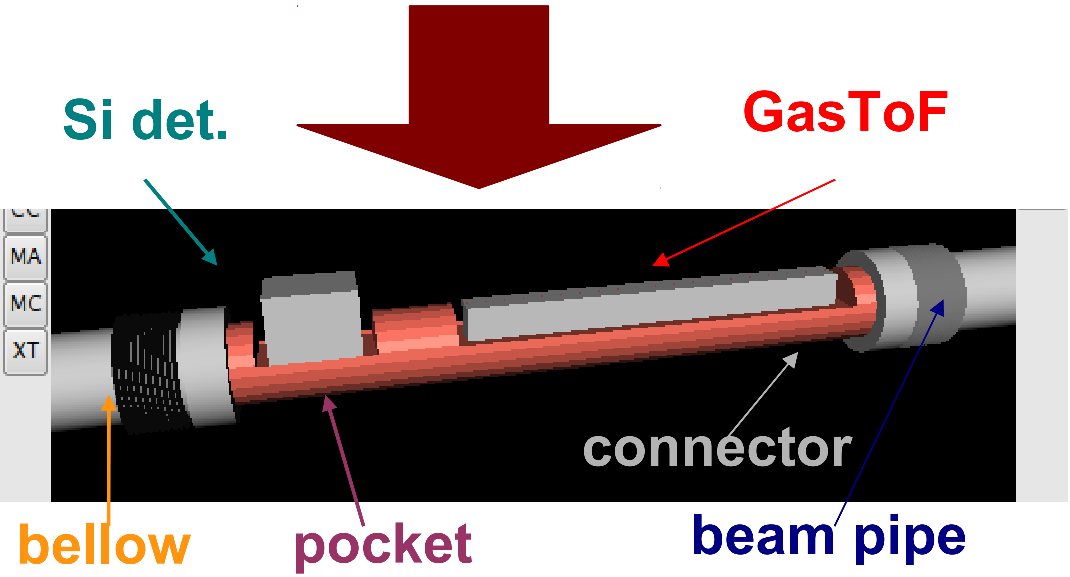
- CVS package: off-line
  - Forward detectors
    - LUCID
    - ALFA
    - Zero degree calorimeter
    - AFP
      - FP220
      - FP420

- One common AFP directory containing simulation of both FP220 and FP420 detectors
- Two different mother volumes for the two AFP detectors

# Interactive visualization: Virtual Point 1 (vp1)



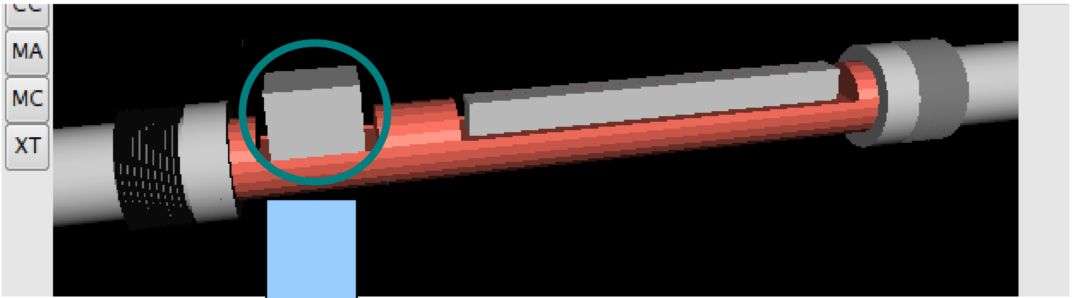


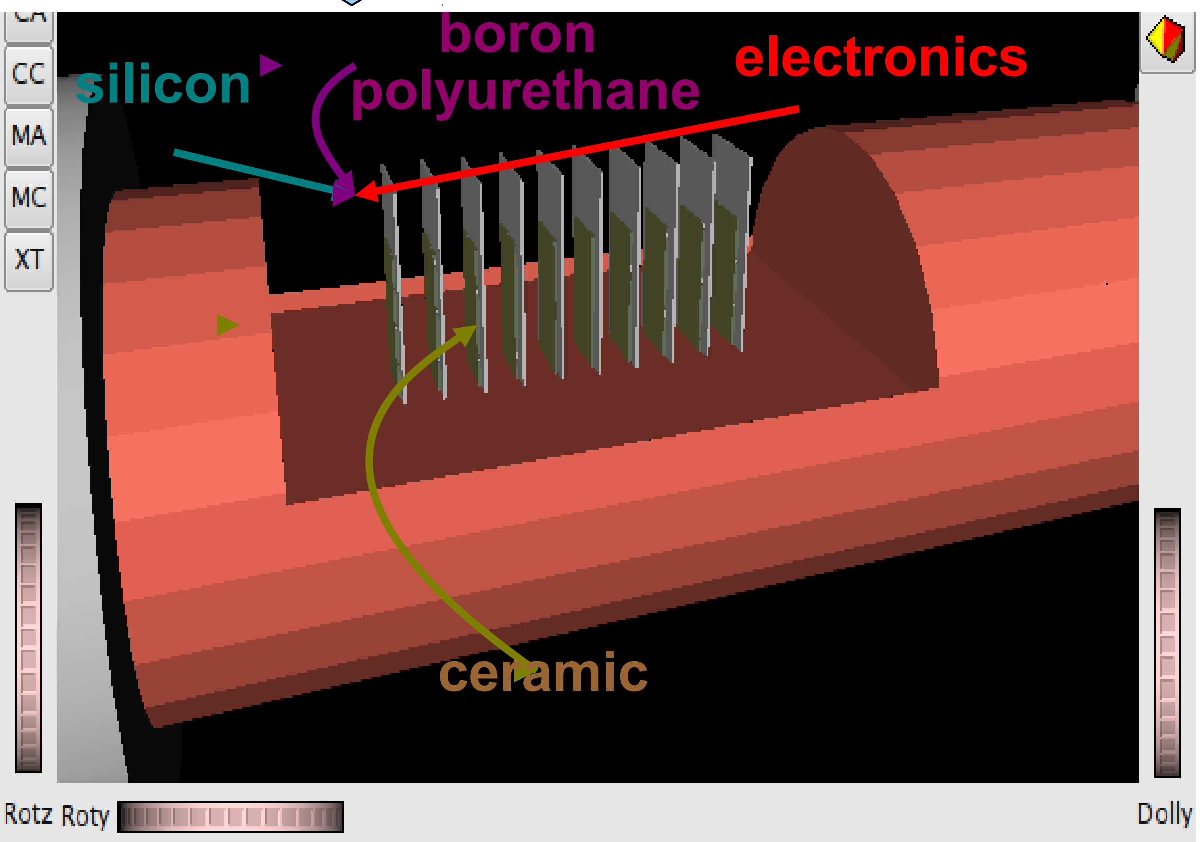



**Materials:**

Air in the mother volume
vacuum inside beam pipe
GasTof box: stainless steel
GasToF: perfluorobutane - $C_4F_{10}$
beam pipe: stainless steel
bellows: stainless steel
connectors: stainless steel
pockets: stainless steel layer + copper layer

# Interactive visualization: vp1




**Materials:**

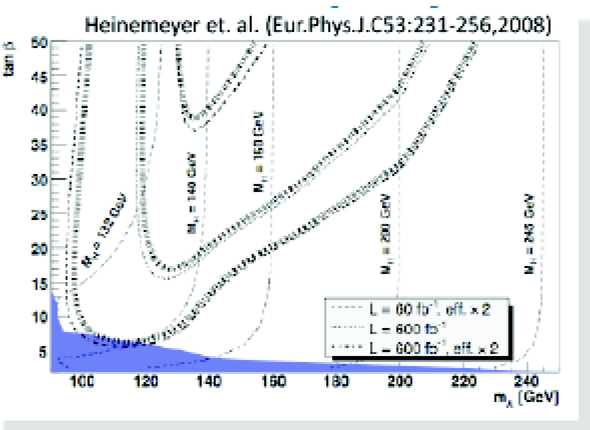
Air in the mother volume

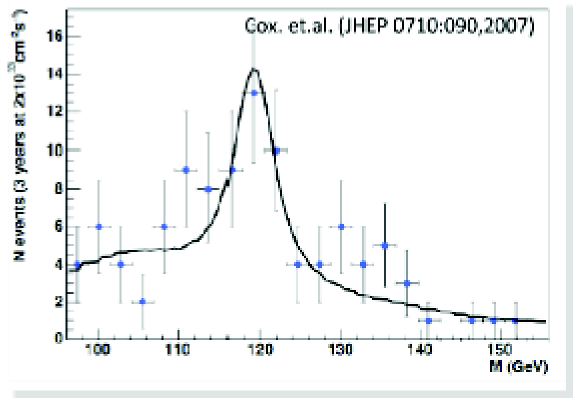
vacuum inside beam pipe

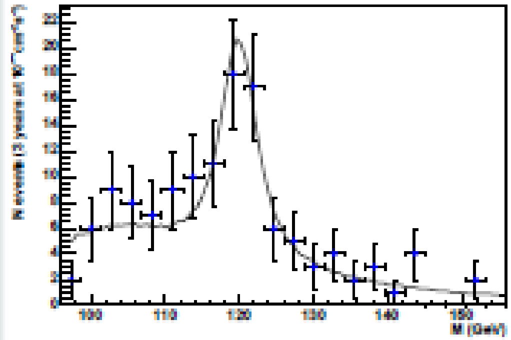
ceramic: Si(71%)+Al(29%)

electronics: silicon

# Previsions for CEP Higgs discovery @ AFP



Higgs signal and background obtained for MSSM Higgs production for neutral light CP-even Higgs bosons

**Signal significance > 3.5** for L=60 $fb^{-1}$ (central plot)

**> 5** three years of data taking at high lumi and using timing detectors with a resolution of 2 ps (right plot).

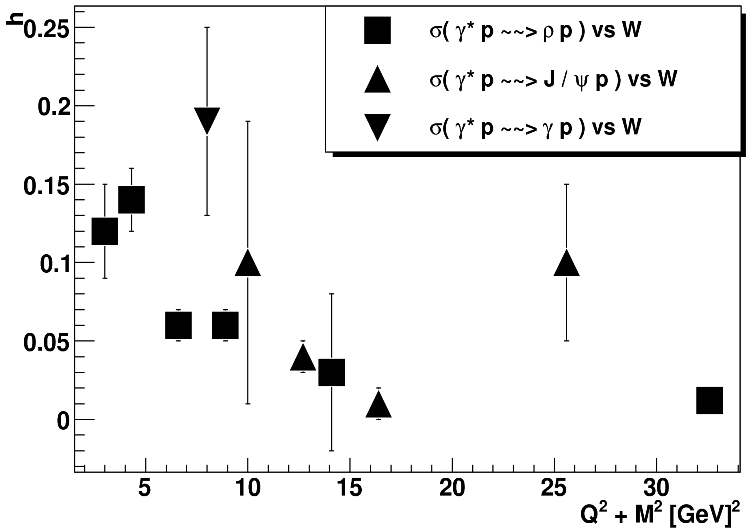
# Summary

- A lot of new HERA data on exclusive diffraction, still waiting for a better understanding
- A logarithmic Pomeron trajectory can reproduce DVCS data.
- The contribution of a soft and a hard Pomeron with fixed Regge trajectories describes the exclusive electroproduction on VM
- A rich diffractive physics program under development at LHC

# Back up

# Dependence of the h parameter

$$A_{tot} = A_s + h \cdot A_h$$

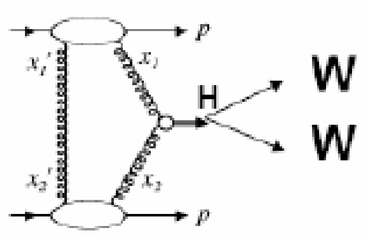


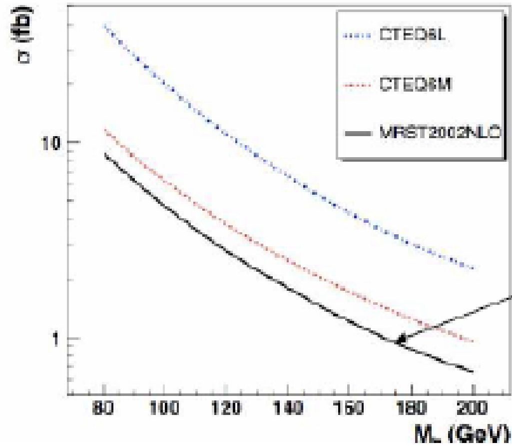

**The h parameter seems to depend by $Q^2+M^2 \rightarrow$ surprising**

**room for improvements**

**Q2 dependence may enter also in the b slope of each exponential outside the Regge-trajectory**

# Higgs Physics




**Take more conservative MRST PDFs**
**$\sigma$= 3 fb for $M_H$=120 GeV**

CEP calculation uncertain by a factor of 2-3

- CDF measurements in both di-photon and di-jet channels imply CEP cross section is at upper end of the theoretical uncertainty
- Overlap background has uncertainty due to lack of knowledge regarding underlying event activity at the LHC, total cross section, single-diffractive cross section