Summary of the Diffraction and Vector Meson Working Group *(part I)*

Deep-Inelastic Scattering and Related Subjects
25 -30 April 2009, Madrid

Paul Laycock

UNIVERSITY OF LIVERPOOL

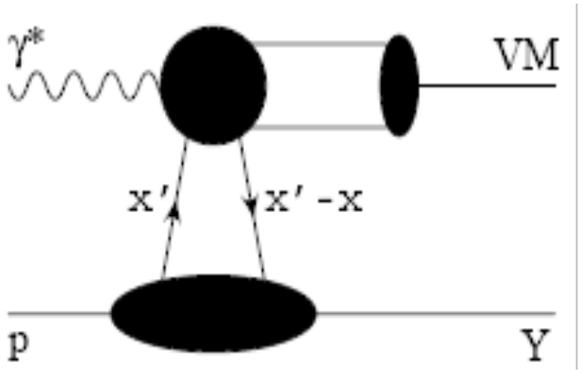
Overview - 23 talks from experiments

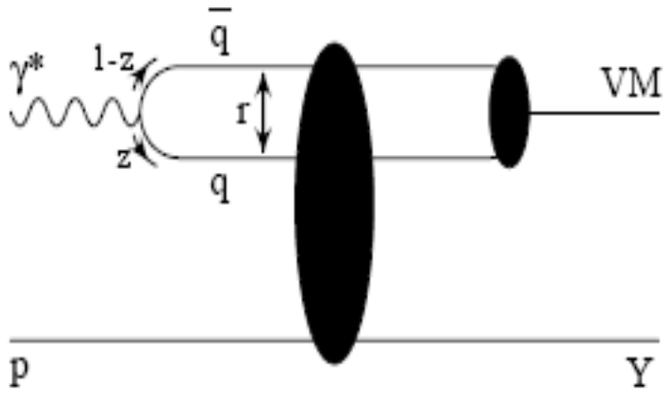
- Zeus inclusive diffractive data (Marta Ruspa)
- First measurement of FLD (David Salek)
- QCD fits and factorisation tests (Wojtek Slominski)
- Dijets in photoproduction and factorisation tests (Paul Newman)
- Leading protons (Mikhail Kapishin)
- Leading baryons (Graziano Bruni)
- Leading neutrons (Vitaliy Dodonov)
- Pomeron trajectory (Benno List)
- VM production and DVCS (Aharon Levy)
- DVCS and VM production (Pierre Marage)
- High t photons (Tomas Hreus)

Overview

- Exclusive rho0 production at COMPASS (Guillaume Jegou)
- GPD Projects at COMPASS (Etienne Burtin)
- Forward neutron asymmetries generated in polarised pp collisions at RHIC (Manabu Togawa)
- Ultra peripheral Au Au collisions at RHIC (Mate Csanad)
- Diffractive W, Z, dijet and jet-gap-jet production at CDF (Christina Mesropian)
- Exclusive diffraction using the rapidity gap method in CDF (Christina Mesropian)
- Observation of hard diffraction at LHC (Maria Margherita Obertino)
- ATLAS forward physics and diffractive program (James Pinfold)
- FP420 and 240 diffractive projects (Krzysztof Piotrzkowski)
- Status and early program of TOTEM (Hubert Niewiadomski)
- Forward detectors in ATLAS (Laura Fabbri)
- CMS capabilities with CASTOR and ZDC detectors (Benoit Roland)

Vector Meson Production

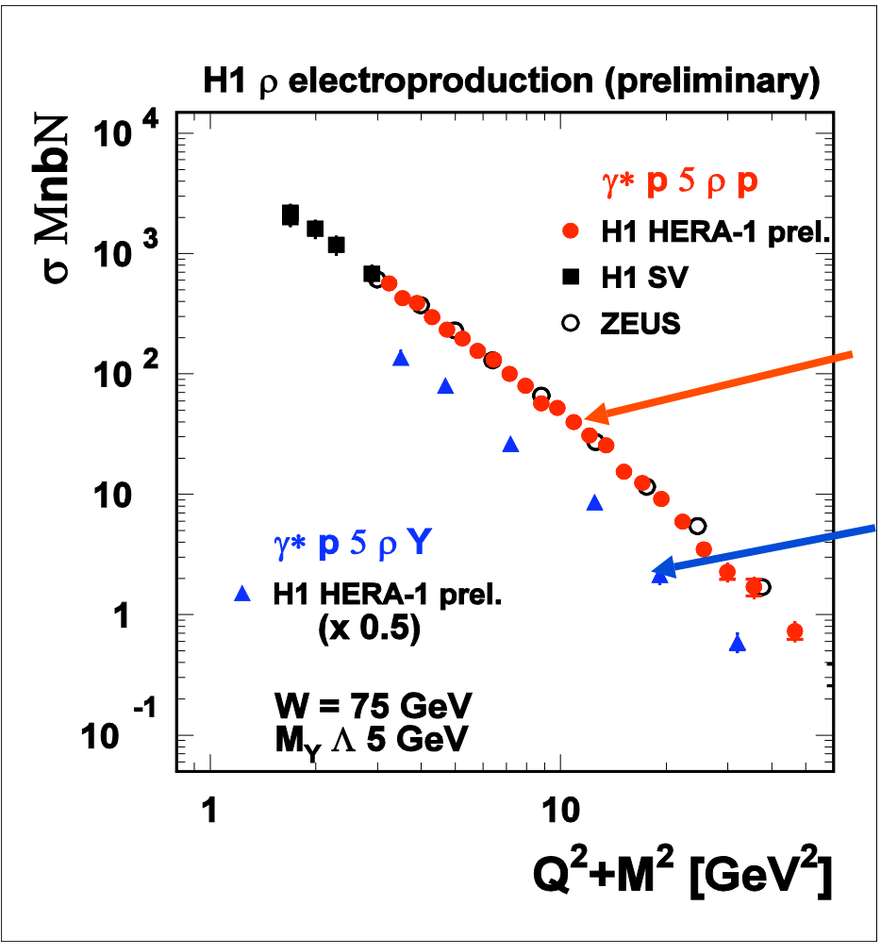




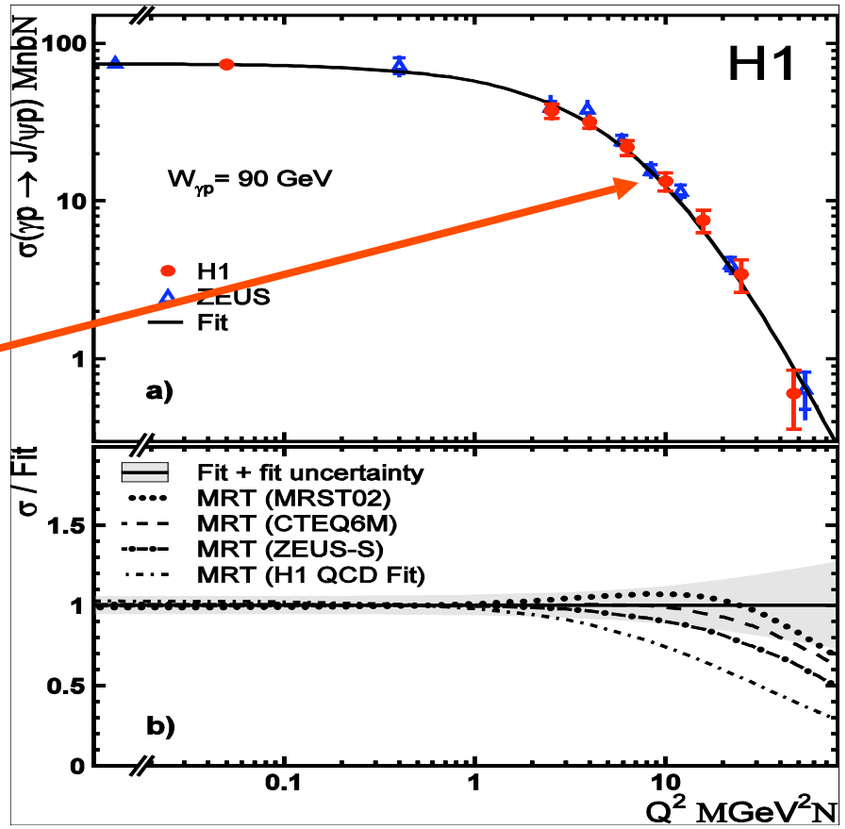
Aharon Levy

Pierre Marage

GPD



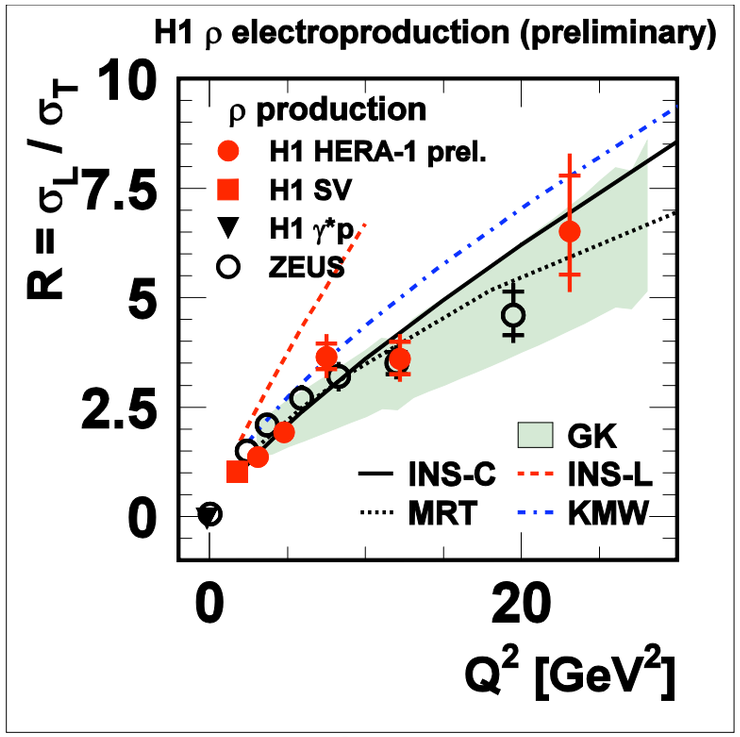
Dipole

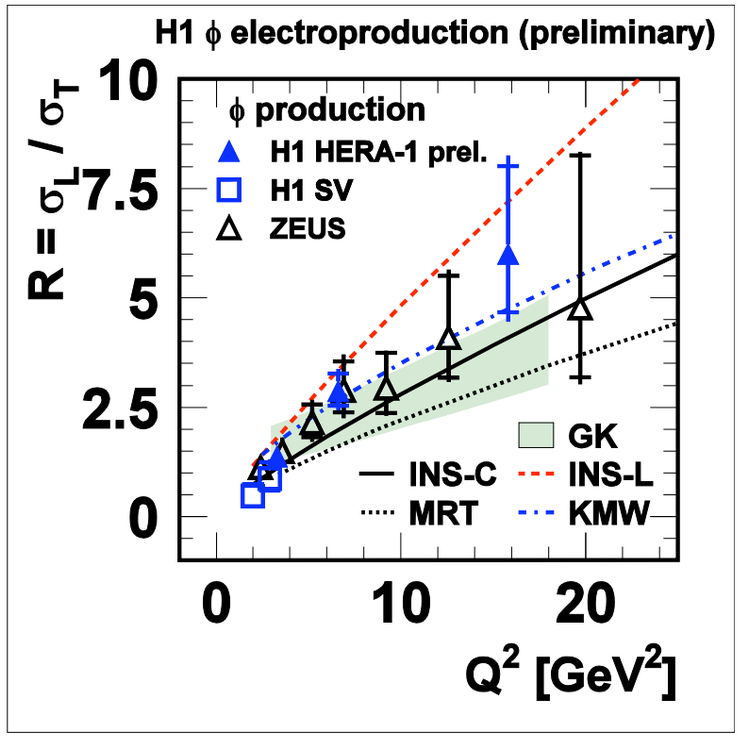


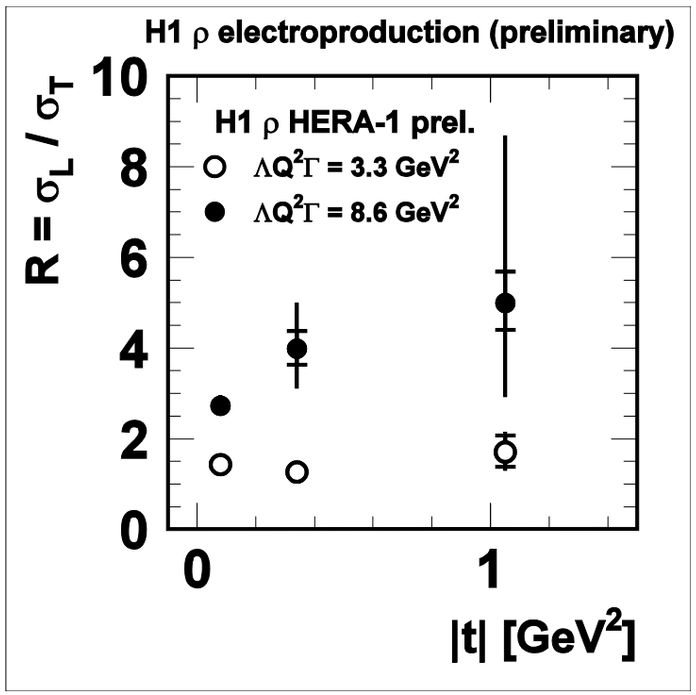
Excellent agreement between H1 and Zeus

Longitudinal vs Transverse rho

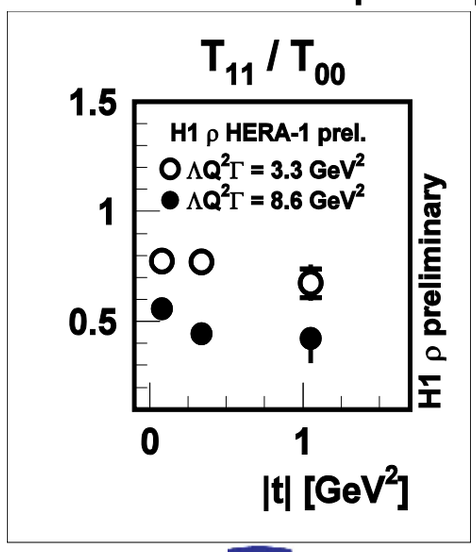
Pierre Marage

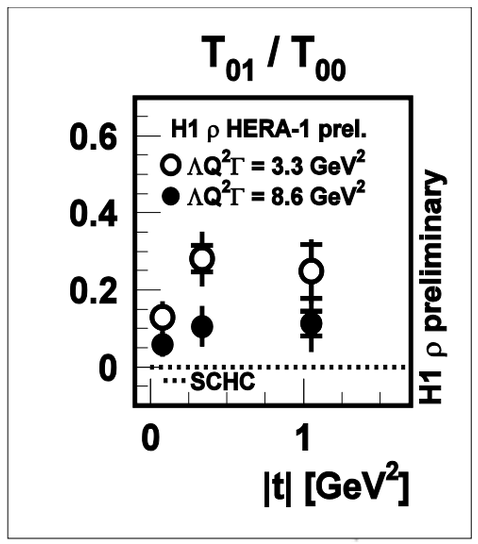


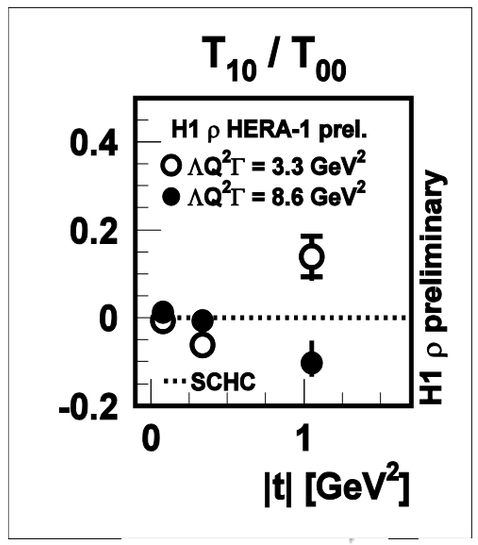


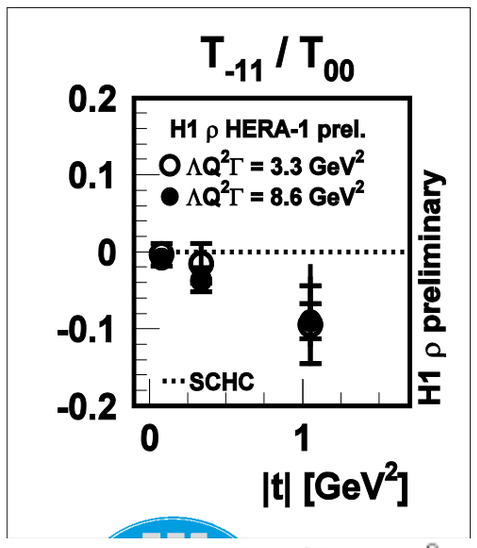


- Ratio of longitudinal to transverse cross-sections sees a t-dependence at high Q^2
- Spin amplitude ratios measured as a function of t
- double-flip amplitude non-zero





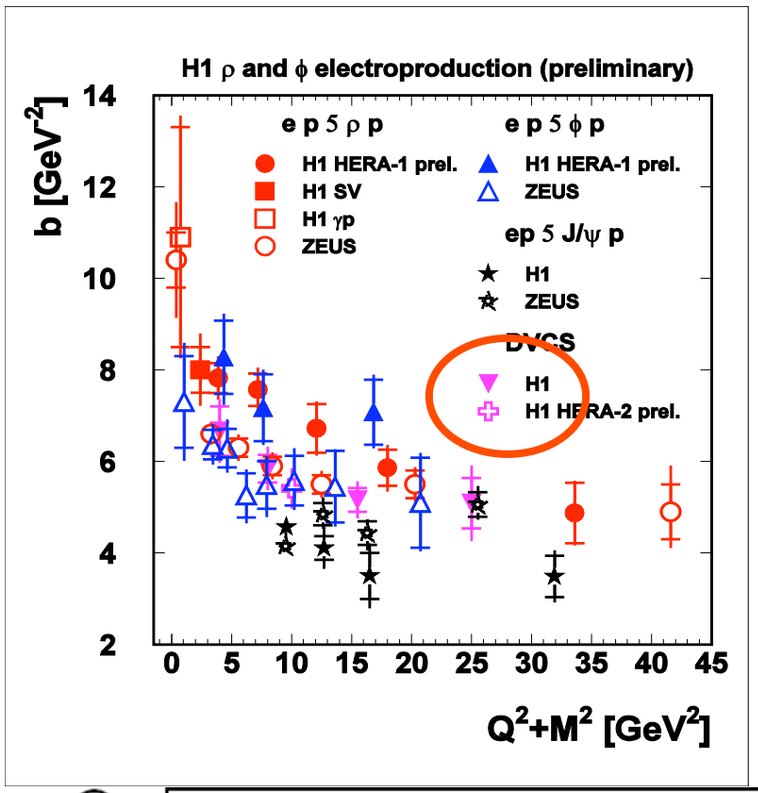


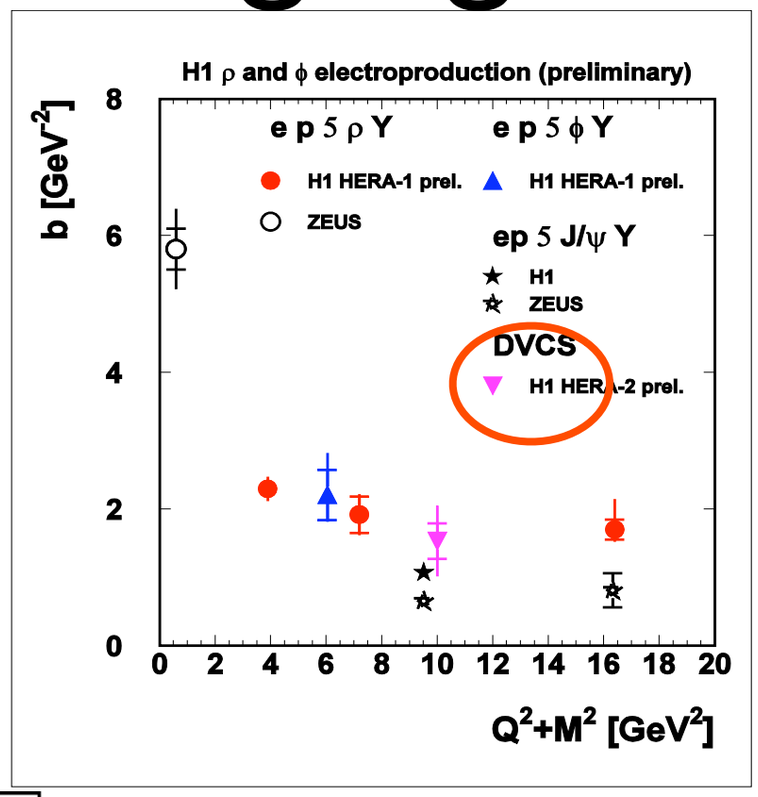


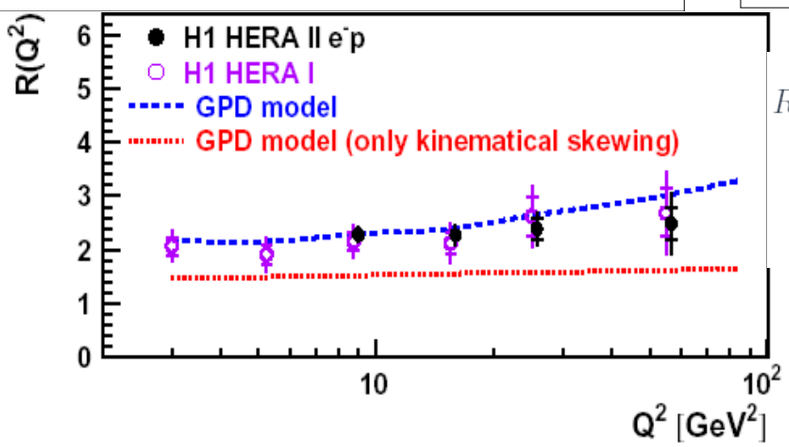
Vector Meson highlights

Aharon Levy

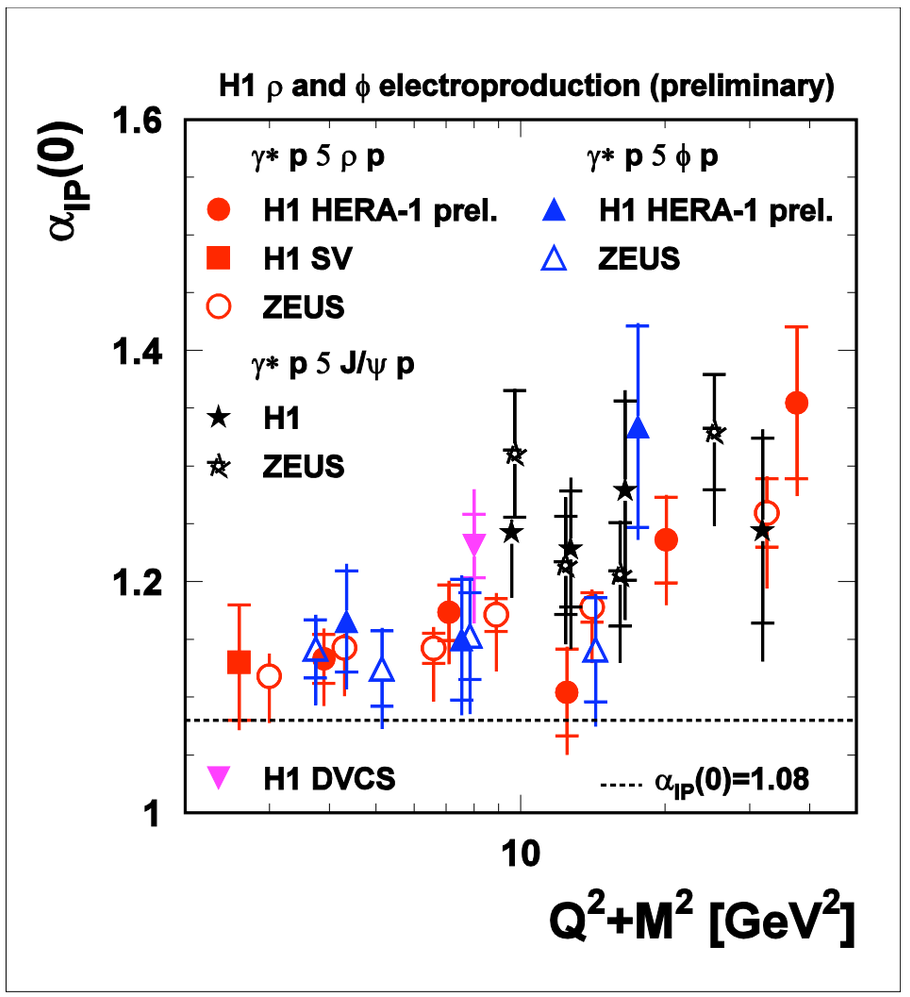
Pierre Marage







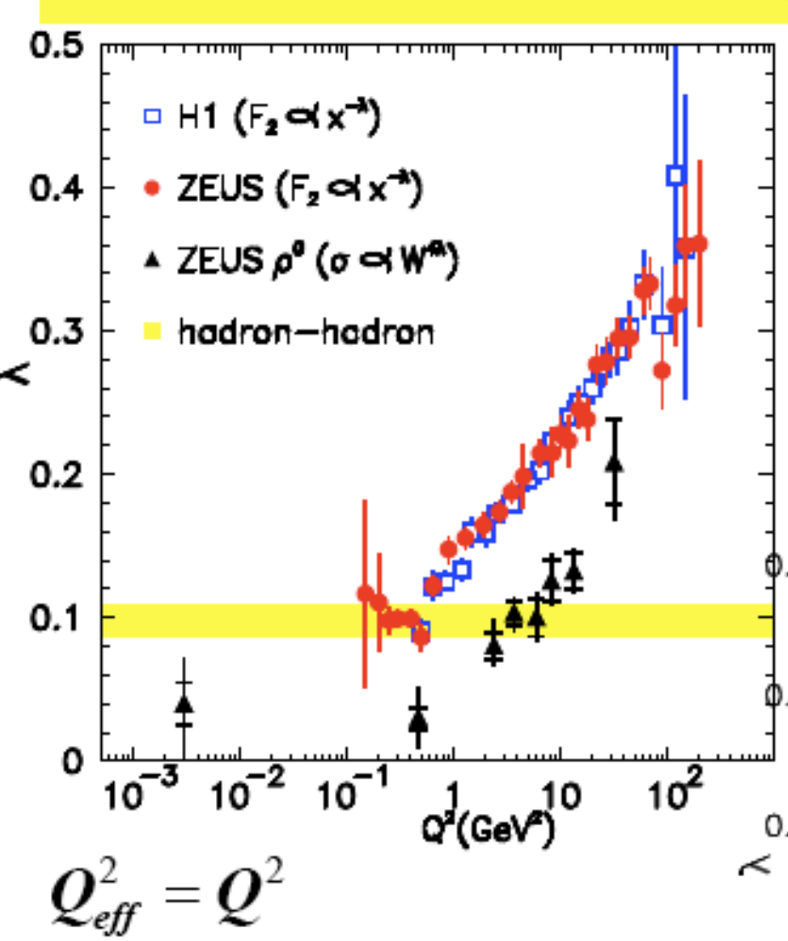
$$R = \frac{\mathcal{I}m\ A(\gamma^* p \to \gamma p)}{\mathcal{I}m\ A(\gamma^* p \to \gamma^* p)} = \frac{4\sqrt{\pi\ \sigma_{DVCS}\ b(Q^2)}}{\sigma_T(\gamma^* p \to X)\sqrt{(1+\rho^2)}}$$



- DVCS precision measurements from Hera II has sensitivity to GPD models
- Visible transition from soft to hard, what's the scale for entering the perturbative regime?

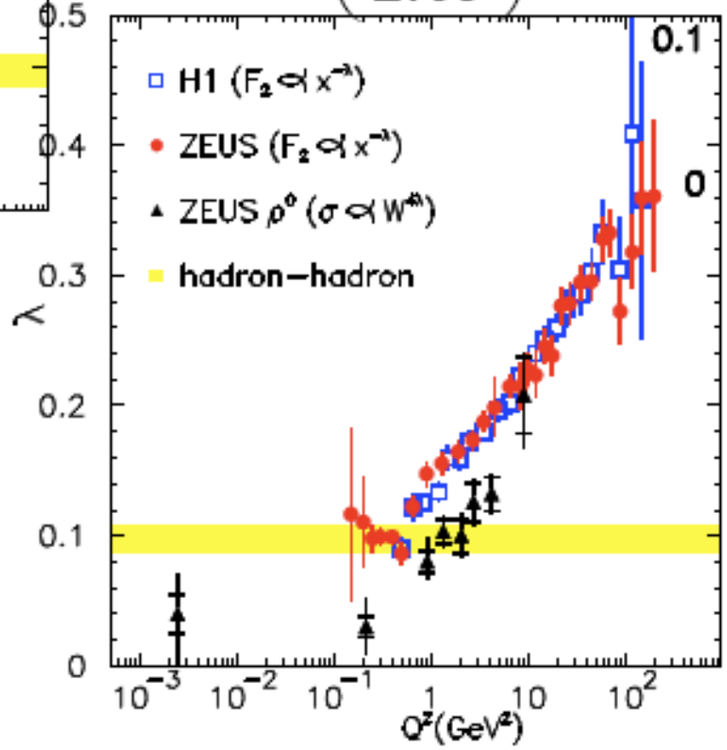
λ plots (ρ)

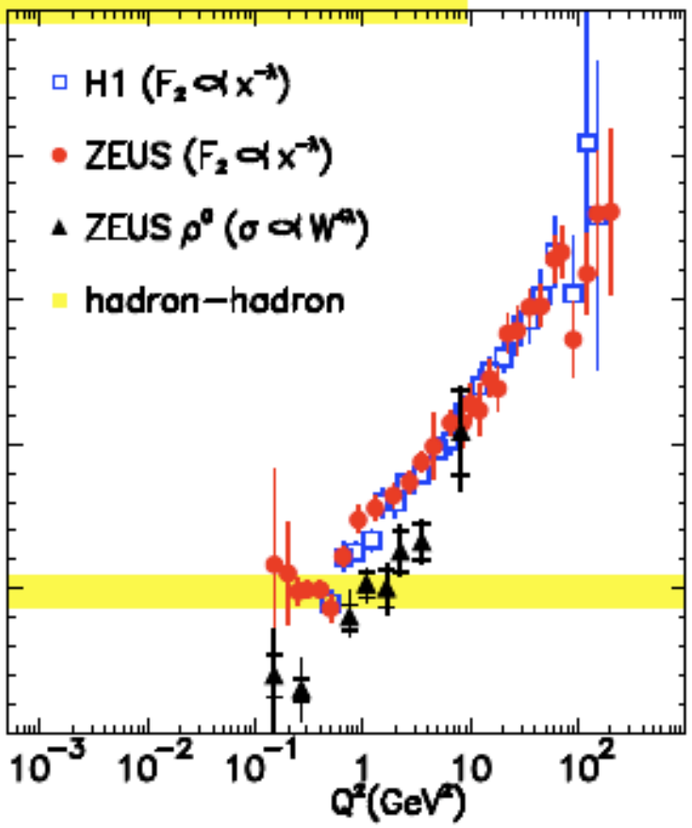
Aharon Levy



$$Q^2_{eff} = Q^2$$

$$Q^2_{eff} = \left(\frac{Q^2}{2.65} \right)^{0.887}$$



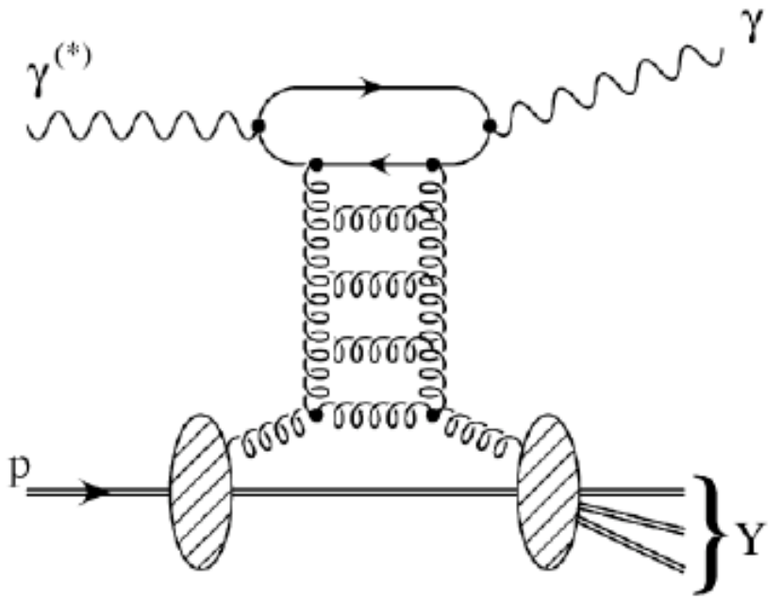


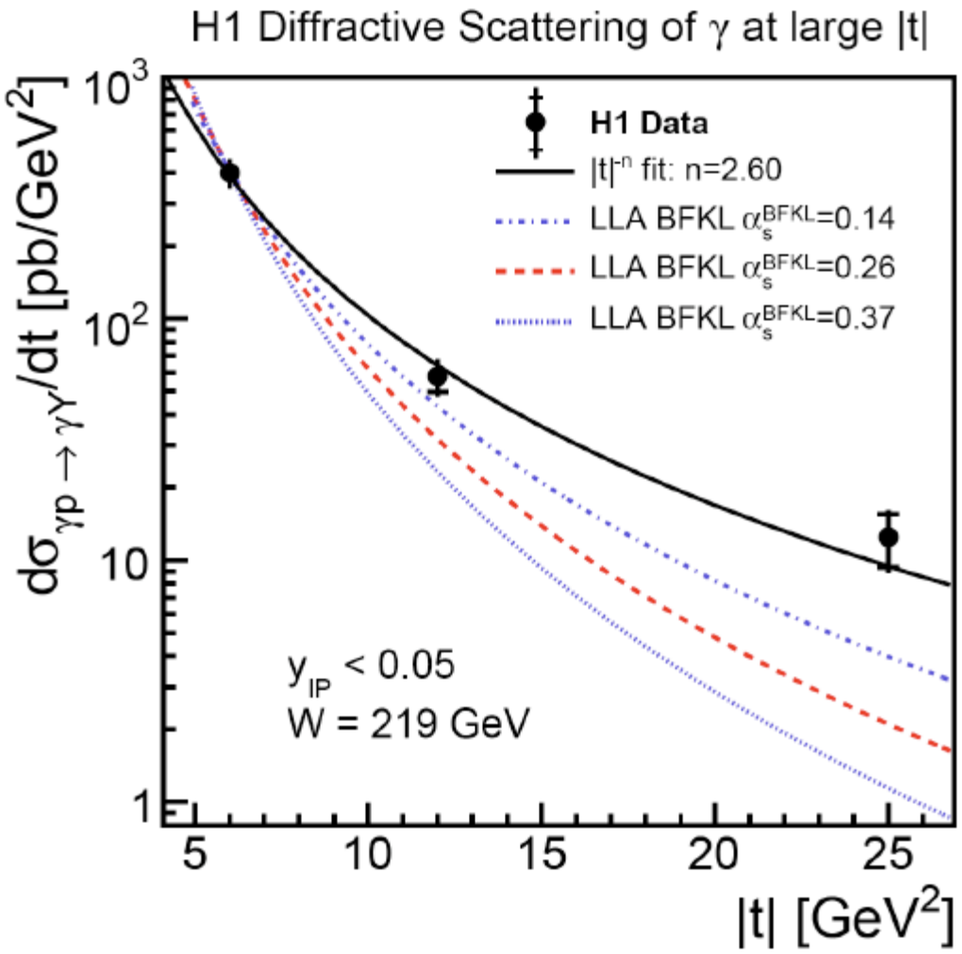
$$Q^2_{eff} = \frac{Q^2 + M^2}{4}$$

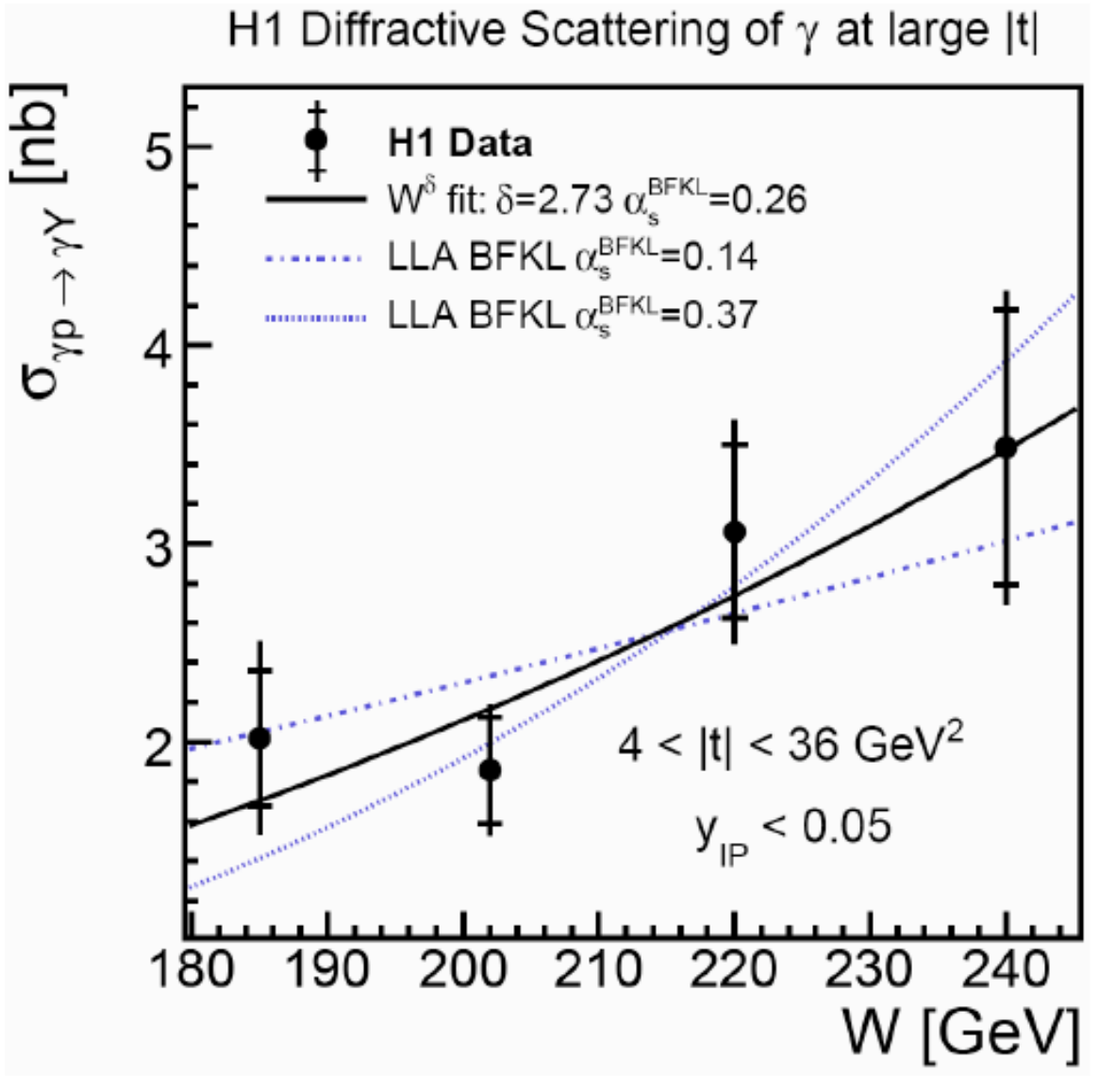
- Certainly not Q^2 for all processes, $(Q^2+M^2)/4$ looks better but still expect a reduction from the transverse part...

High t photons

Tomas Hreus





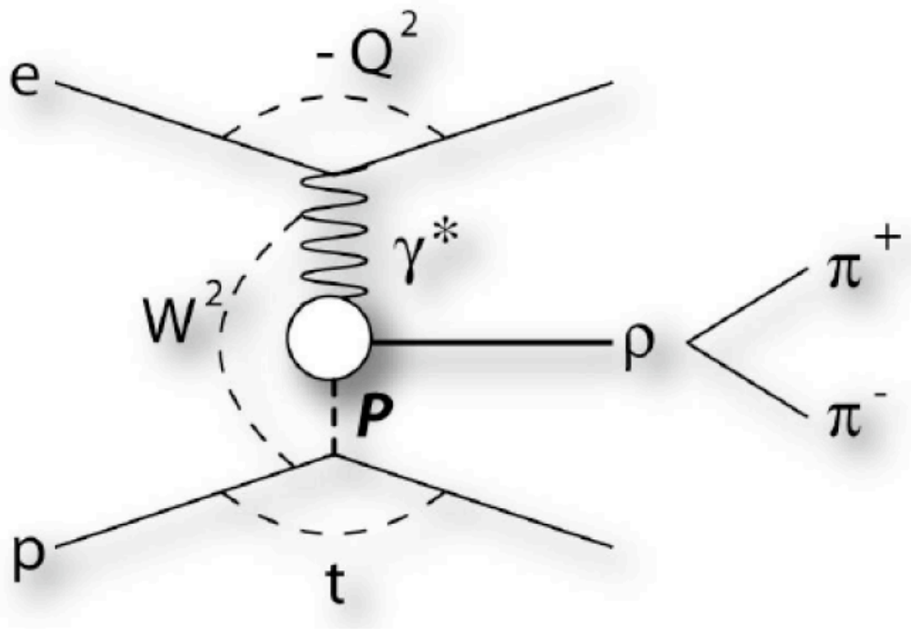


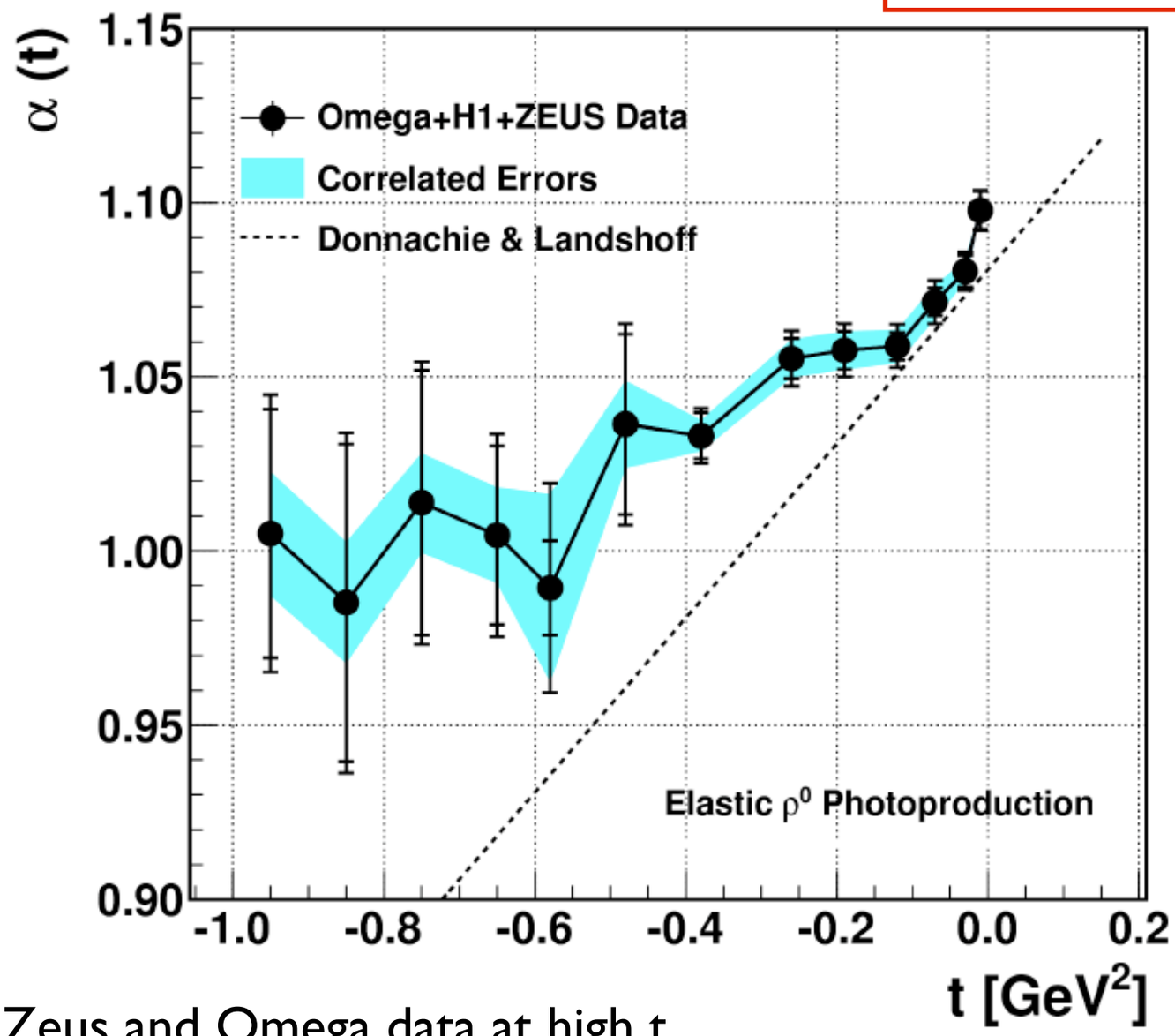
- W-dependence
  - one of the hardest processes observed (large t)
- t-dependence - power law fits data better than "LLA BFKL"

Pomeron trajectory in rho photoproduction

Benno List

$$\frac{d\sigma^{elas}}{dt} \propto W^{4(\alpha(t)-1)}$$

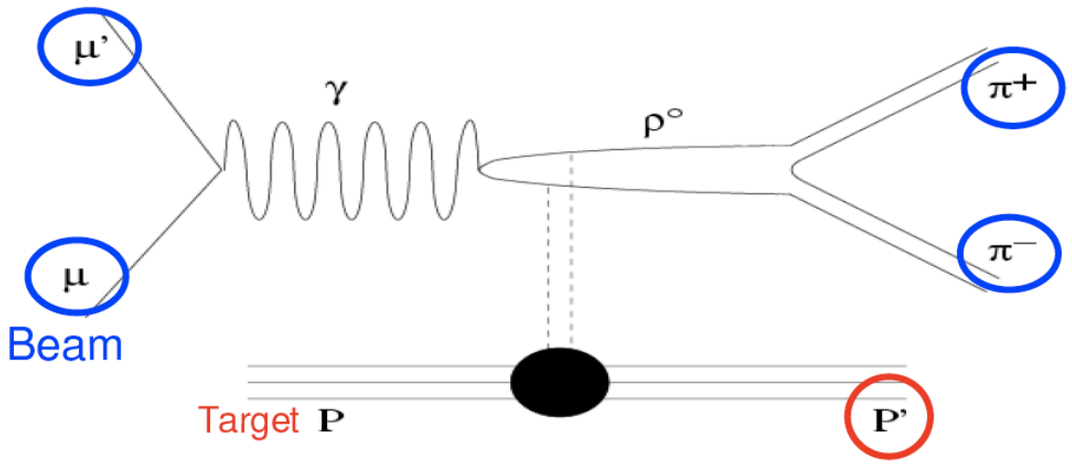




- Fit the W dependence in bins of t
- New global fit including published Zeus and Omega data at high t
- Fit dominated by very precise H1 data at low t
- Very suggestive of a non-linear trajectory

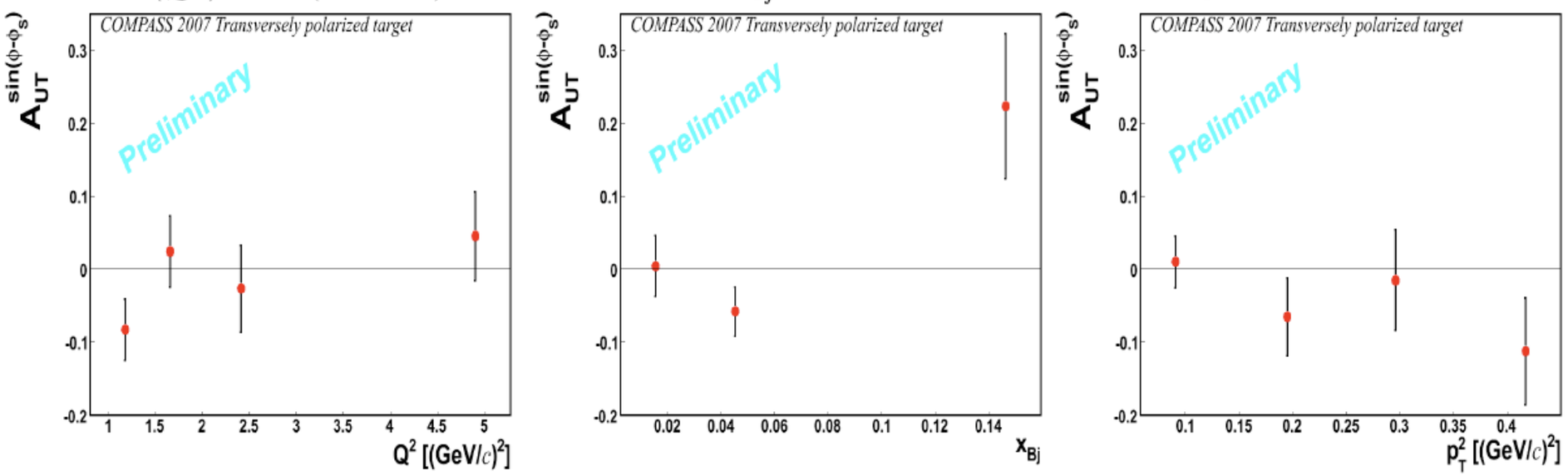
rho at COMPASS

Guillaume Jegou



$$A_{UT}(\phi-\phi_S)\sim\frac{\sigma(\phi-\phi_S)-\sigma(\phi-\phi_S+\pi)}{\sigma(\phi-\phi_S)+\sigma(\phi-\phi_S+\pi)}$$

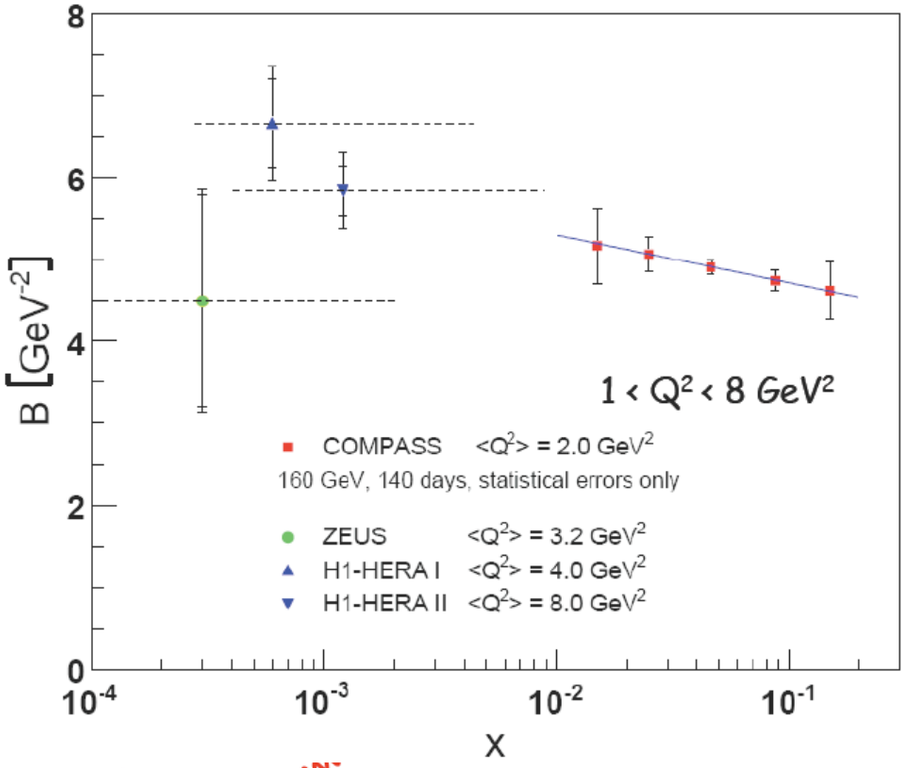
$\langle Q^2\rangle\simeq 2.2\,(GeV/c)^2$ $\langle x_{Bj}\rangle\simeq 0.04$ $\langle p_T^2\rangle\simeq 0.18\,(GeV/c)^2$

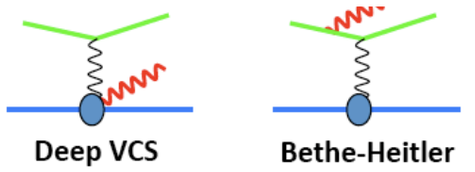


- Redundancy in experimental apparatus (three ammonia targets) used to construct asymmetry where detector effects cancel
- Asymmetry consistent with 0 (0.02 predicted)

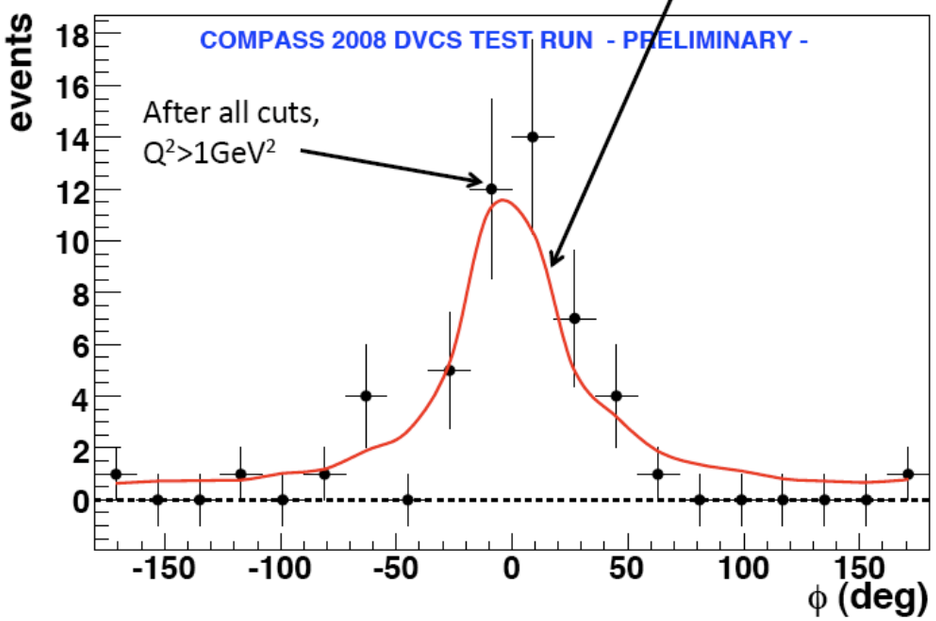
(Future) DVCS at COMPASS

Etienne Burtin

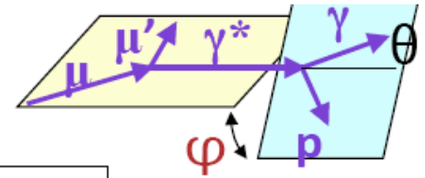


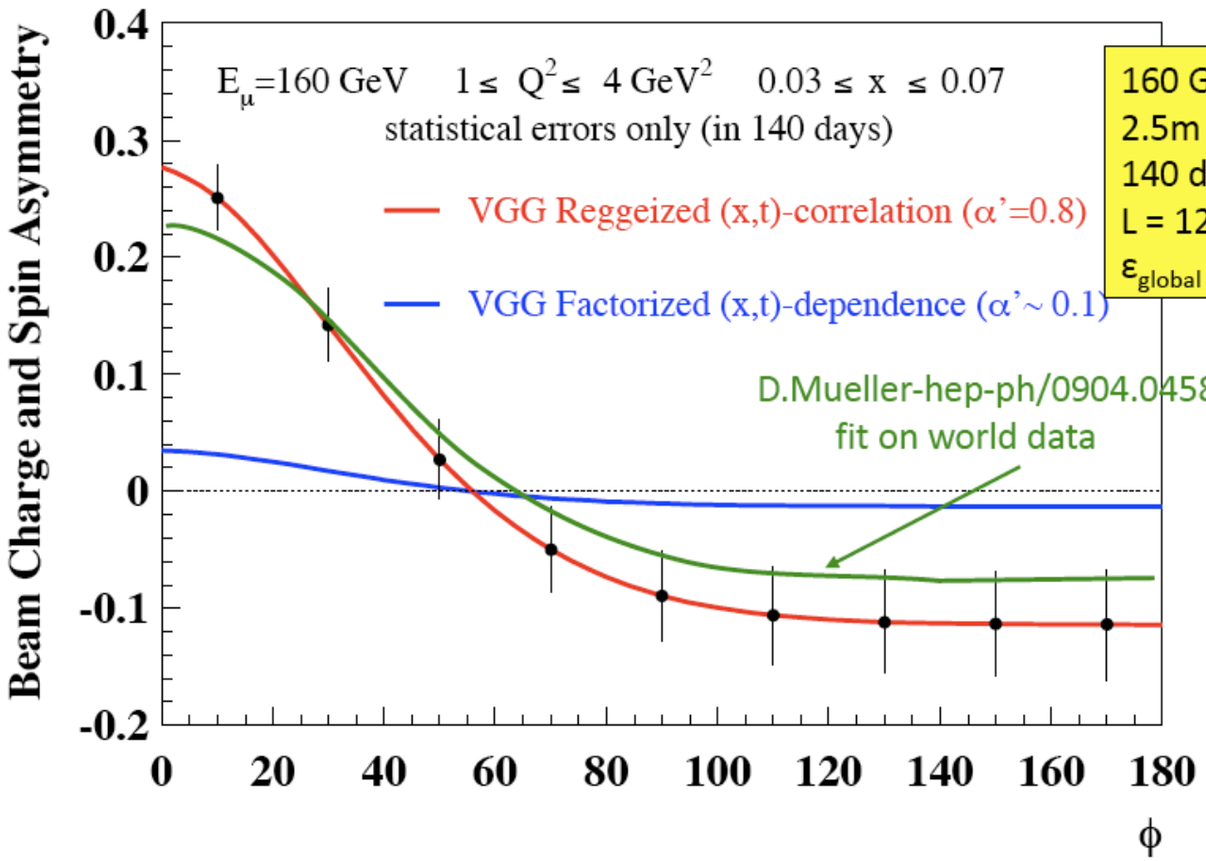


Monte-Carlo simulation of BH (dominant) and DVCS



$BCSA = \mathcal{D}_{U,cs} / S_{U,cs}$



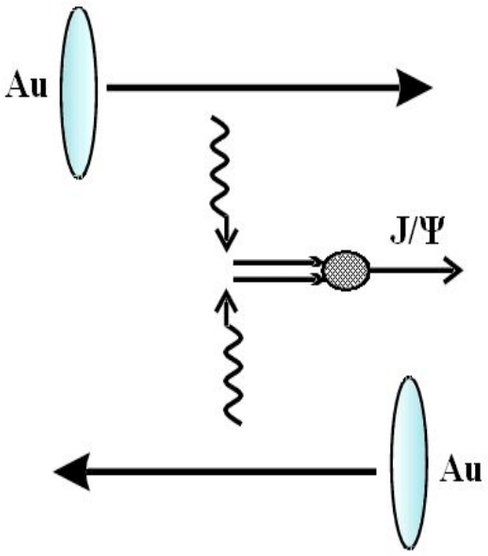


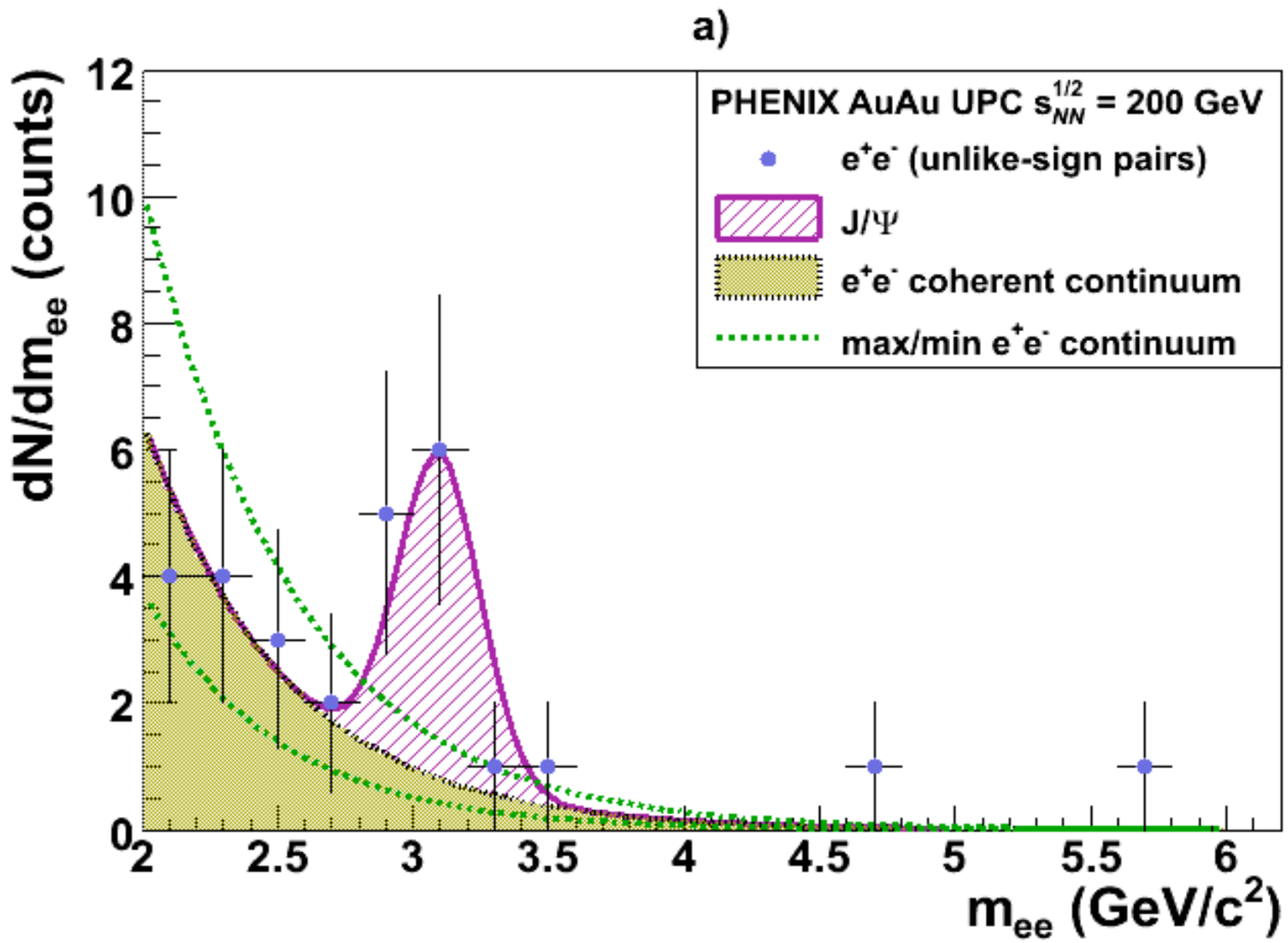
160 GeV muon beam
2.5m LH_2 target
140 days
L = 1222 pb^{-1}
ε_{global} = 10 %

- Good precision achievable (stat. errors only) for both BCSA and t-slope measurement
- BH signal seen in 2 day run - performance consistent with expectation of TDR

J/Psi at PHENIX

Mate Csanad

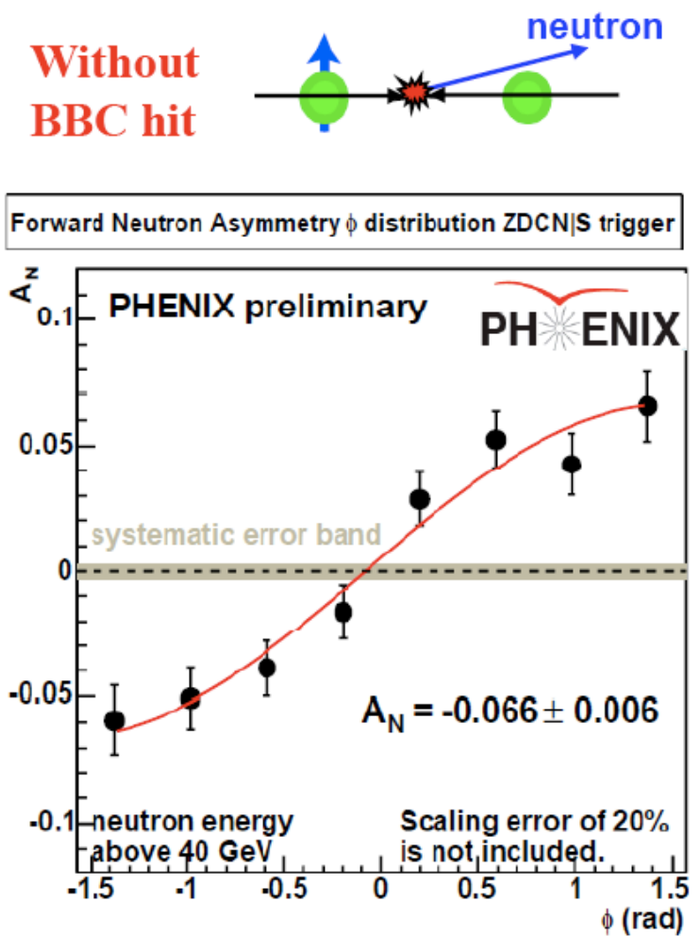


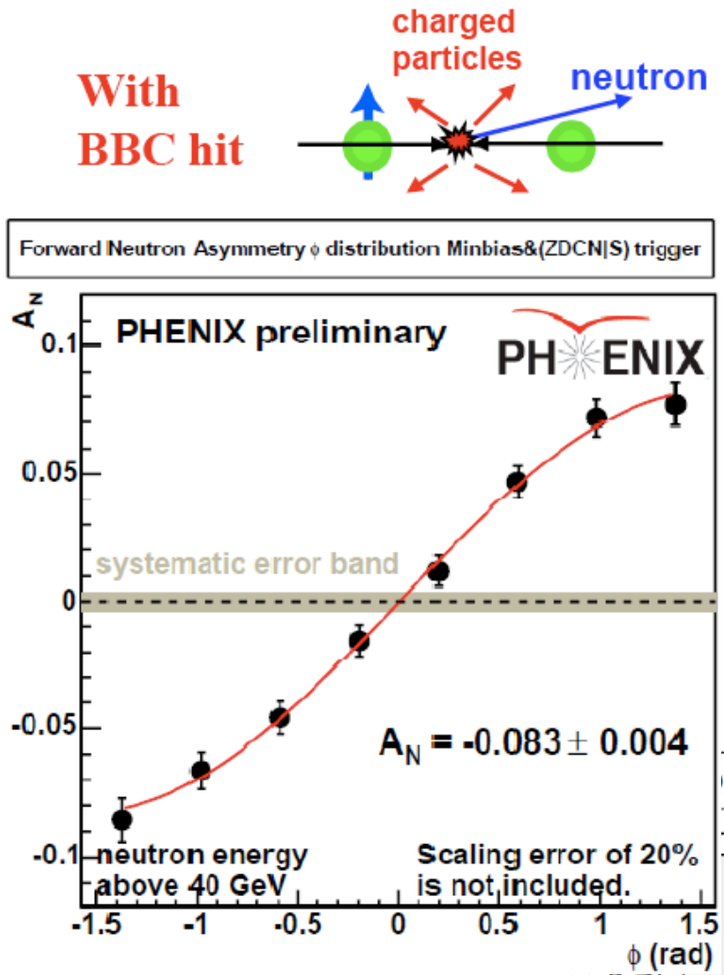


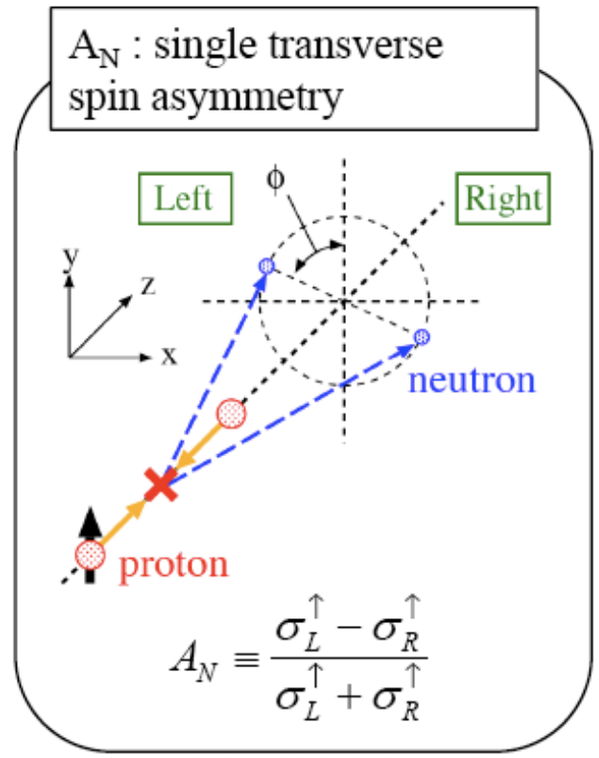
- Ultra-peripheral gold-gold collisions at RHIC (impact parameter > size of nucleus)
- Signal extracted, although statistically limited (and largest systematic comes from statistical uncertainty on continuum background)
- Cross section agrees with prediction - good prospects for the LHC where this process would be explored in a new energy regime

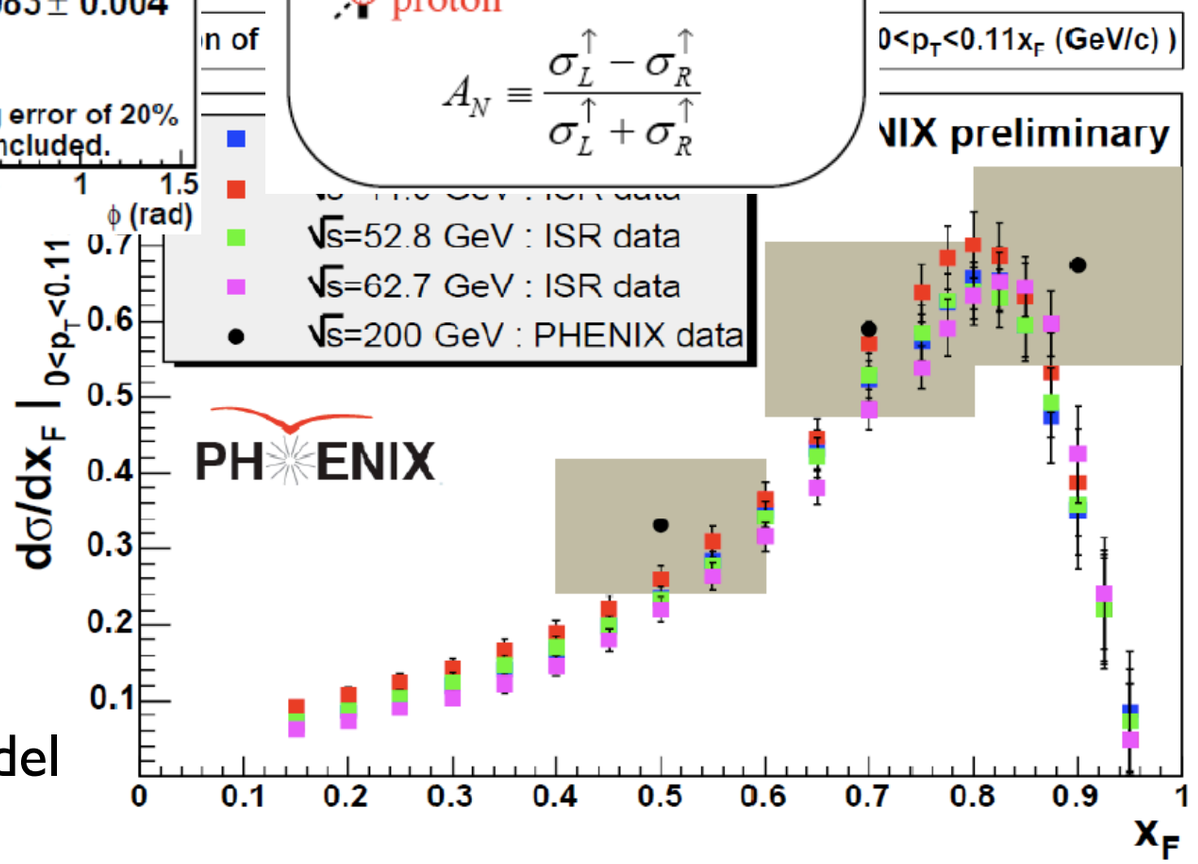
Leading neutrons in polarised pp at RHIC

Manabu Togawa









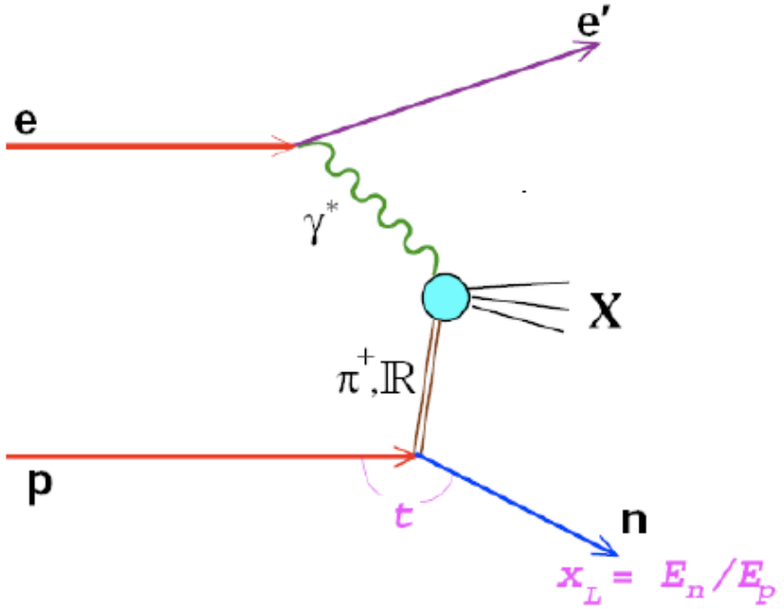
Significant asymmetry measurement

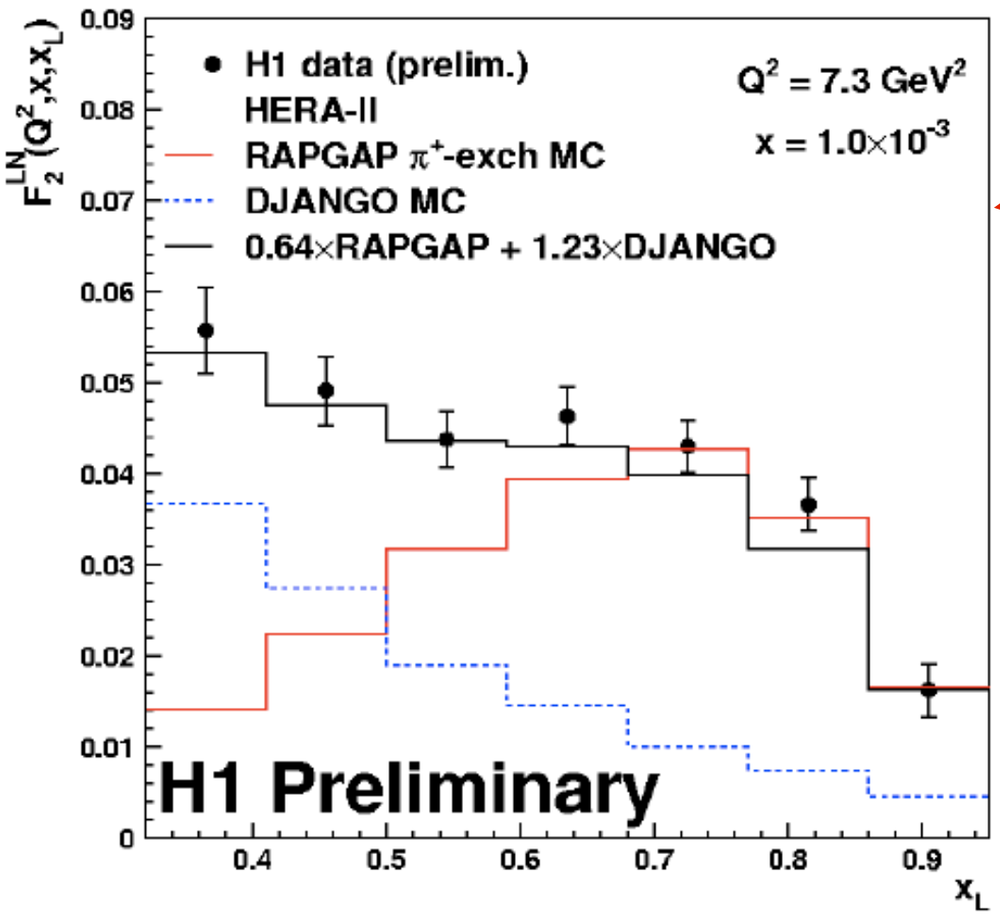
BBC dependence consistent with pion exchange mechanism

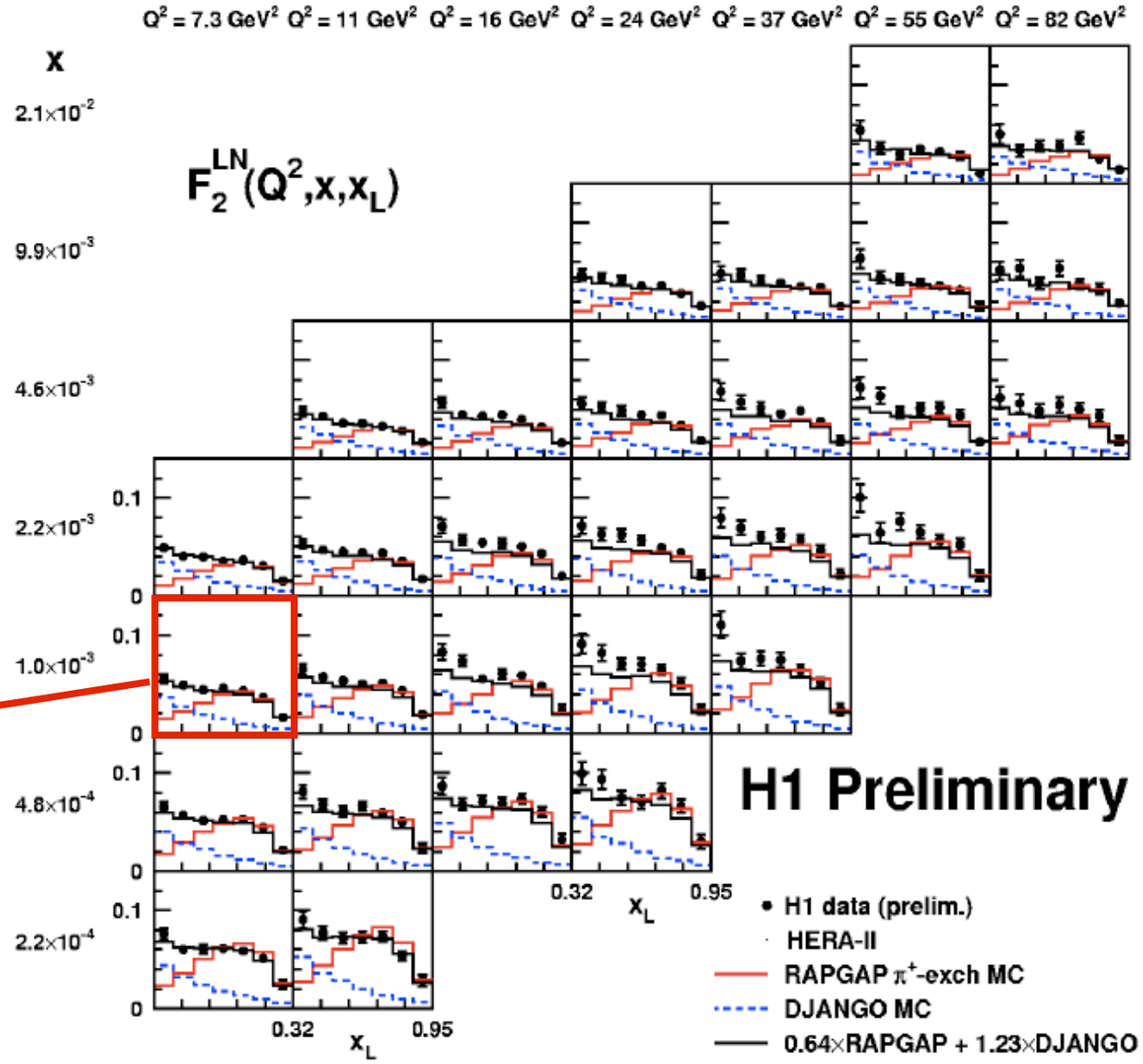
Cross section consistent with one pion exchange model

Leading neutrons at H1

Vitaliy Dodonov



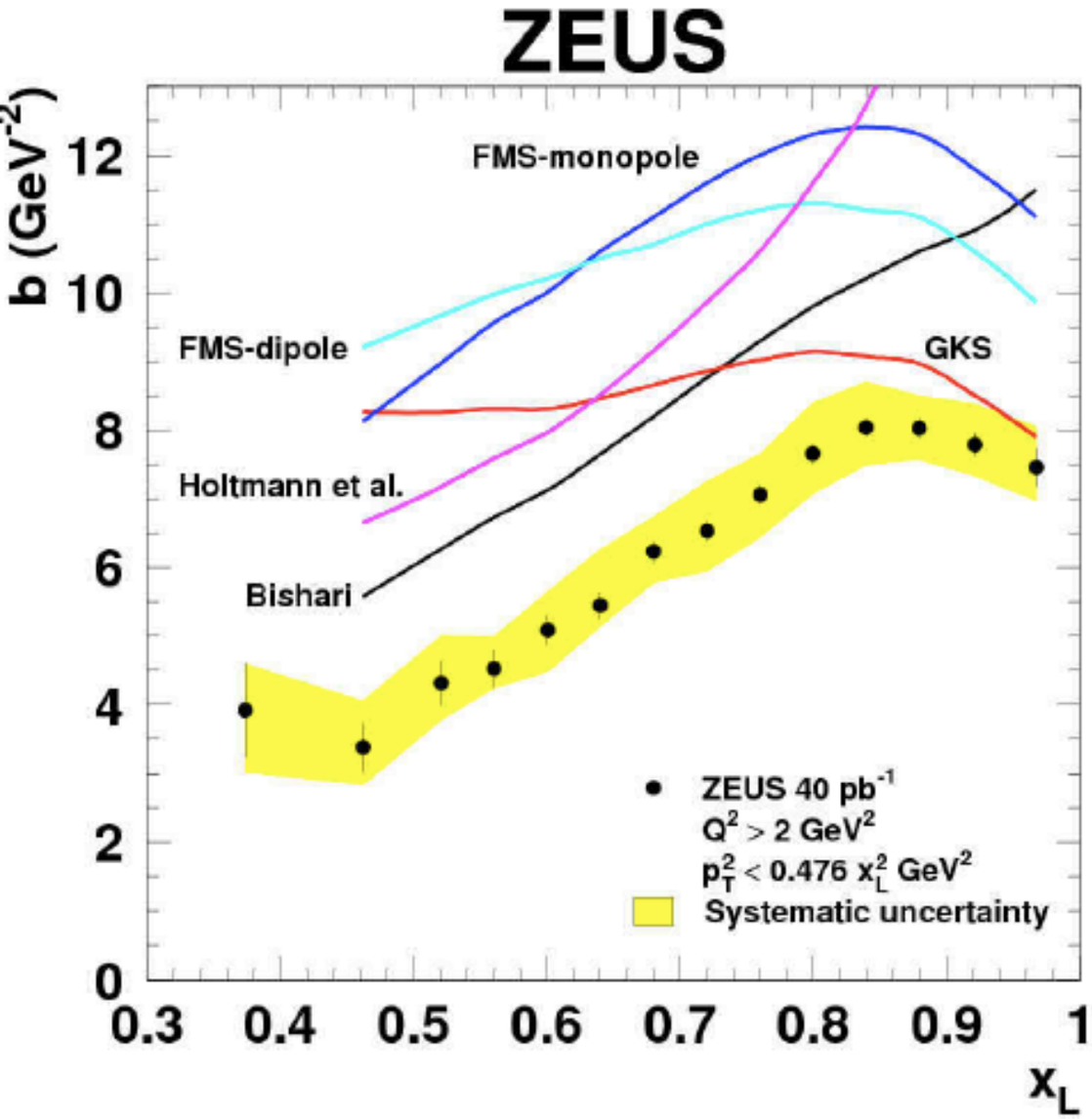


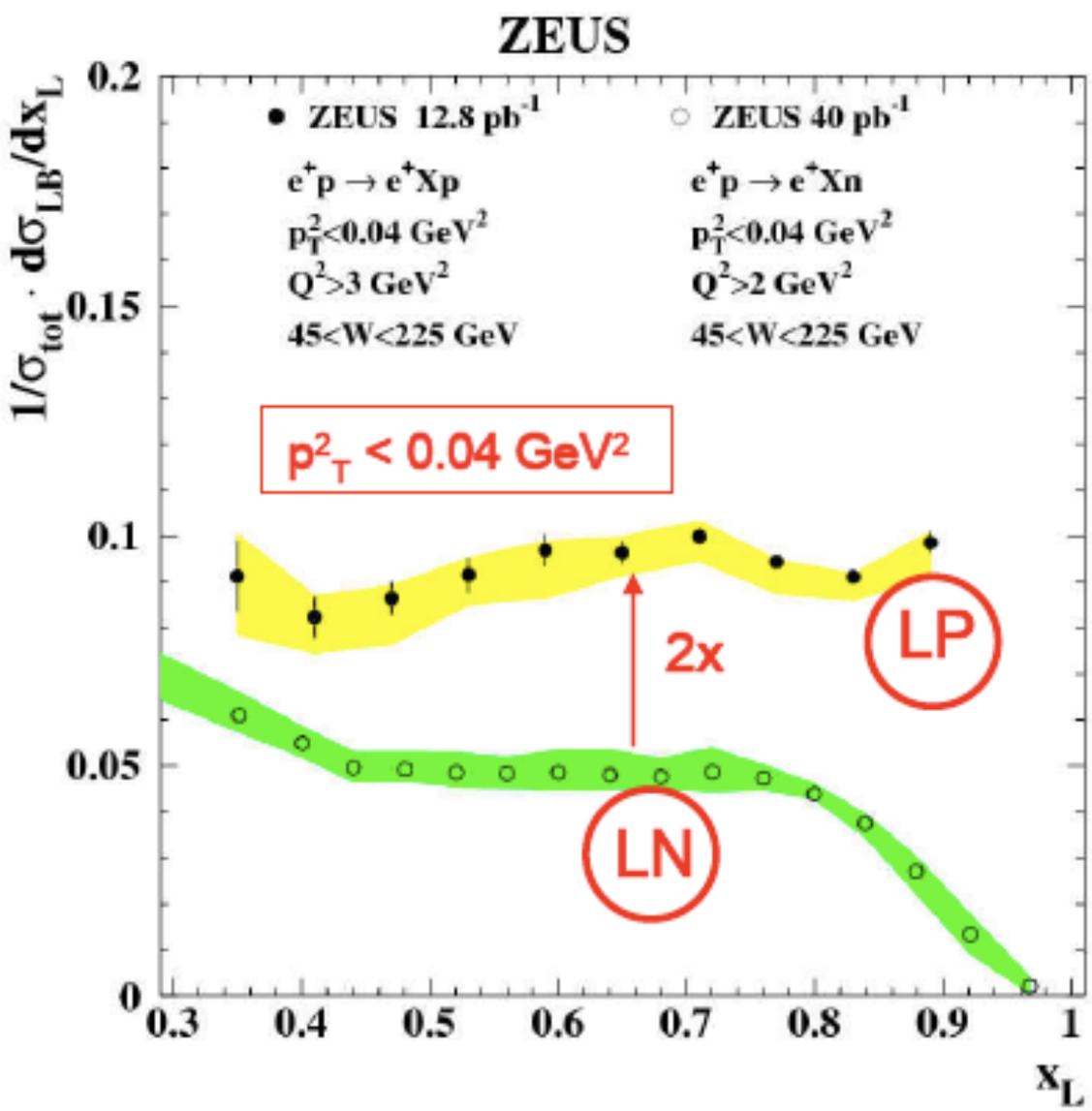


- Pion exchange + inclusive DIS model works
- Ratio of F_2^{LN} with inclusive F_2 largely flat vs Q^2, x
- F_2 pion also extracted following flux assumption

Leading baryons at Zeus

Graziano Bruni

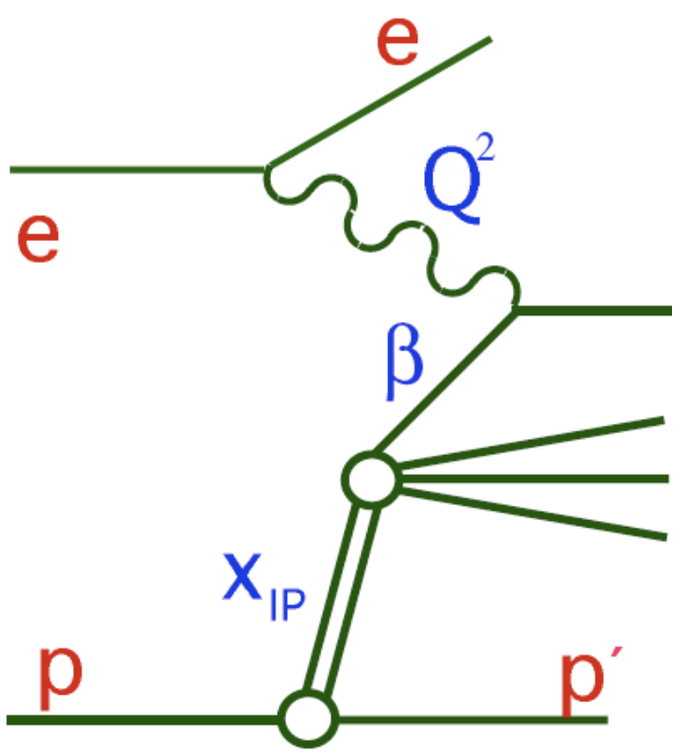


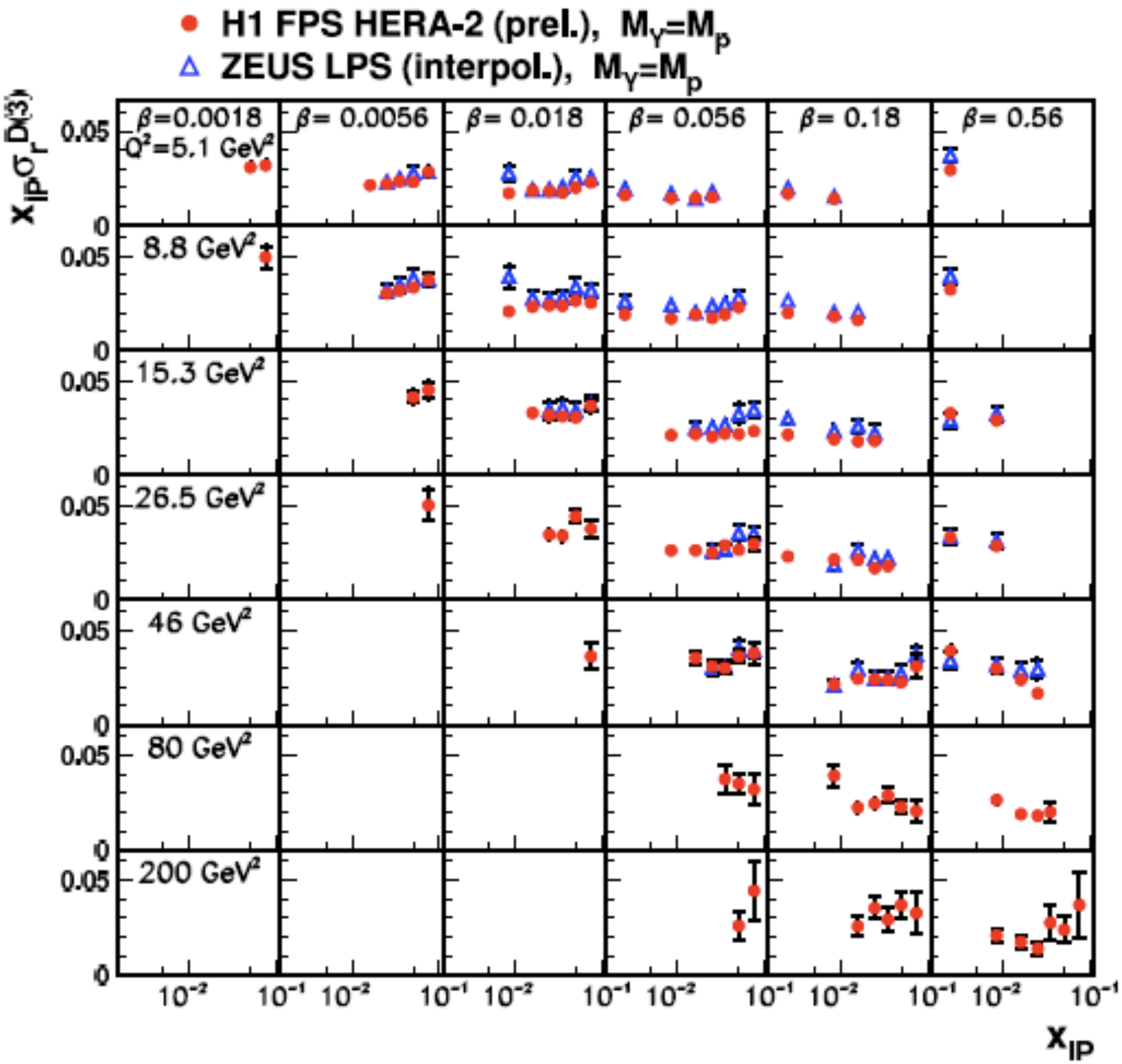


- Would expect LN~2*LP but see LP~2*LN --- other isoscalar IR contributions needed to explain the LP rate

Leading protons at H1

Mikhail Kapishin

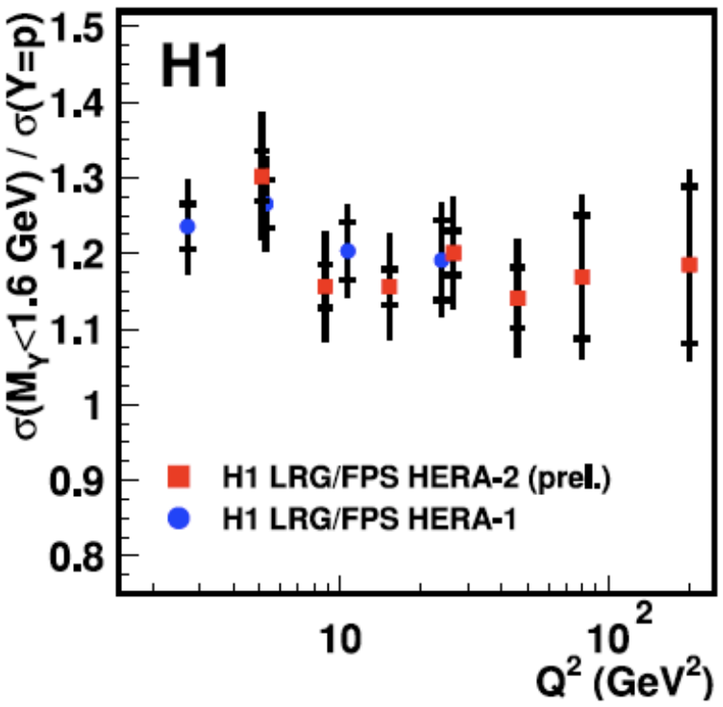


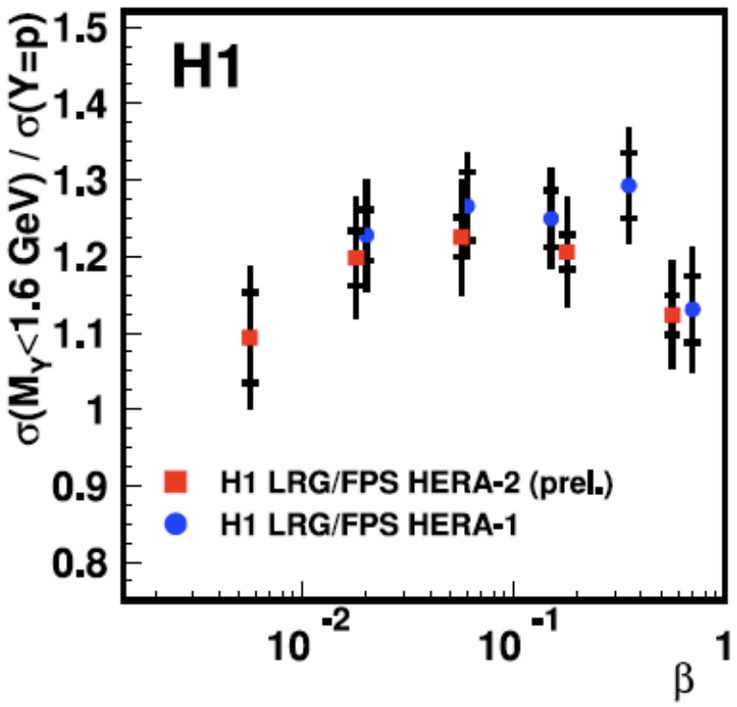


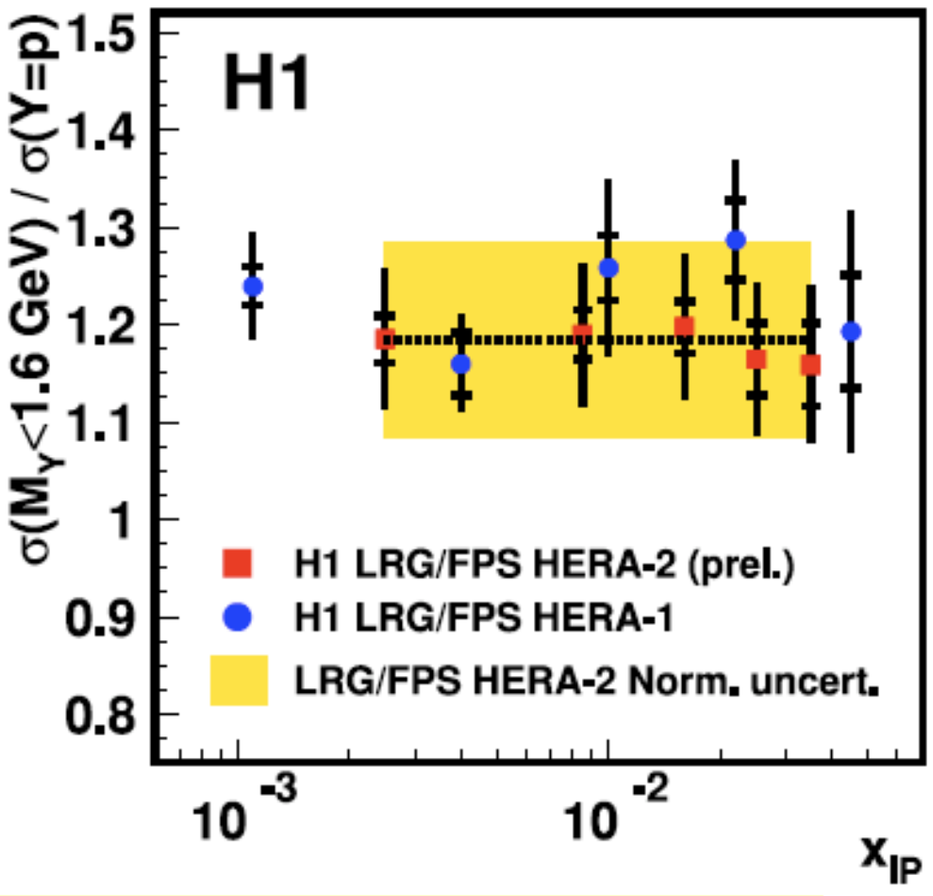
- LPS (Zeus) and FPS (H1) in fair agreement but large normalisation uncertainties

Leading protons vs LRG

Mikhail Kapishin







H1: $\sigma(M_Y<1.6\ \text{GeV})/\sigma(Y=p) = 1.18 \pm 0.01(\text{stat}) \pm 0.06(\text{syst}) \pm 0.10(\text{norm})$

Compared to H1 HERA-1 result: $1.23 \pm 0.03(\text{stat}) \pm 0.16(\text{syst})$

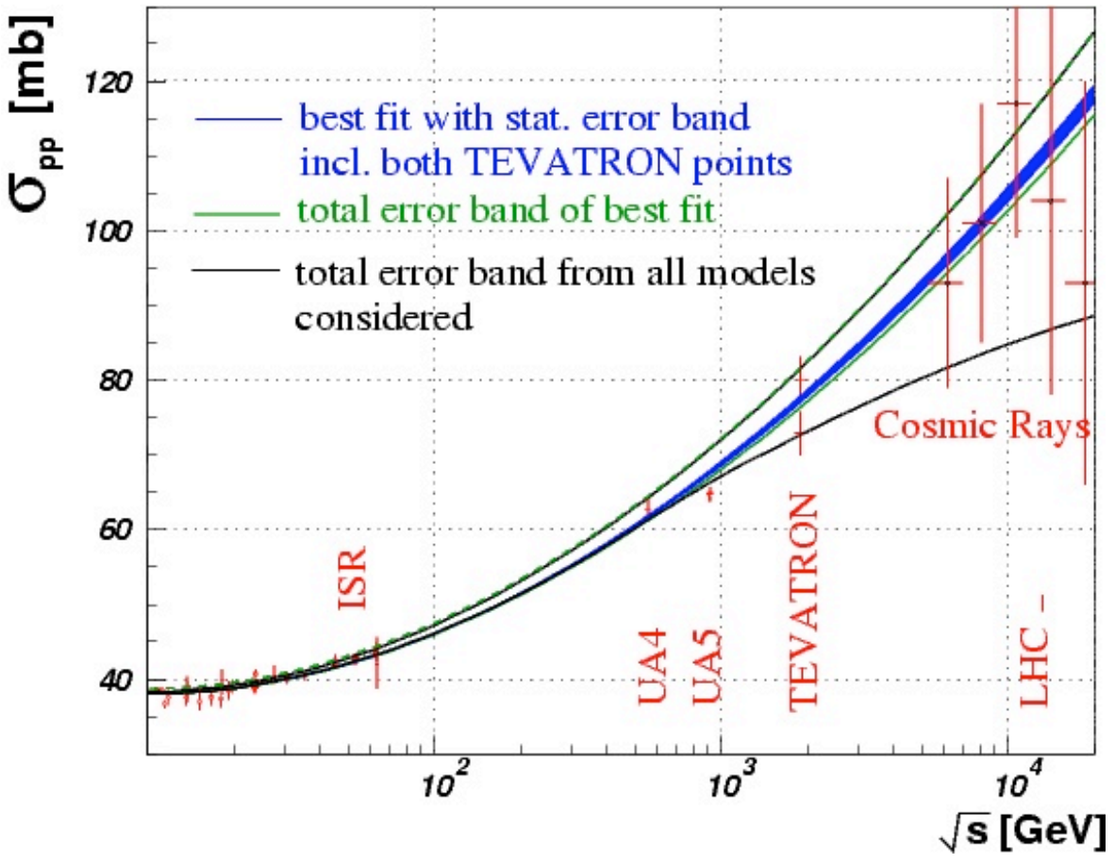
→ common norm. uncertainty of H1 LRG data ~6% included

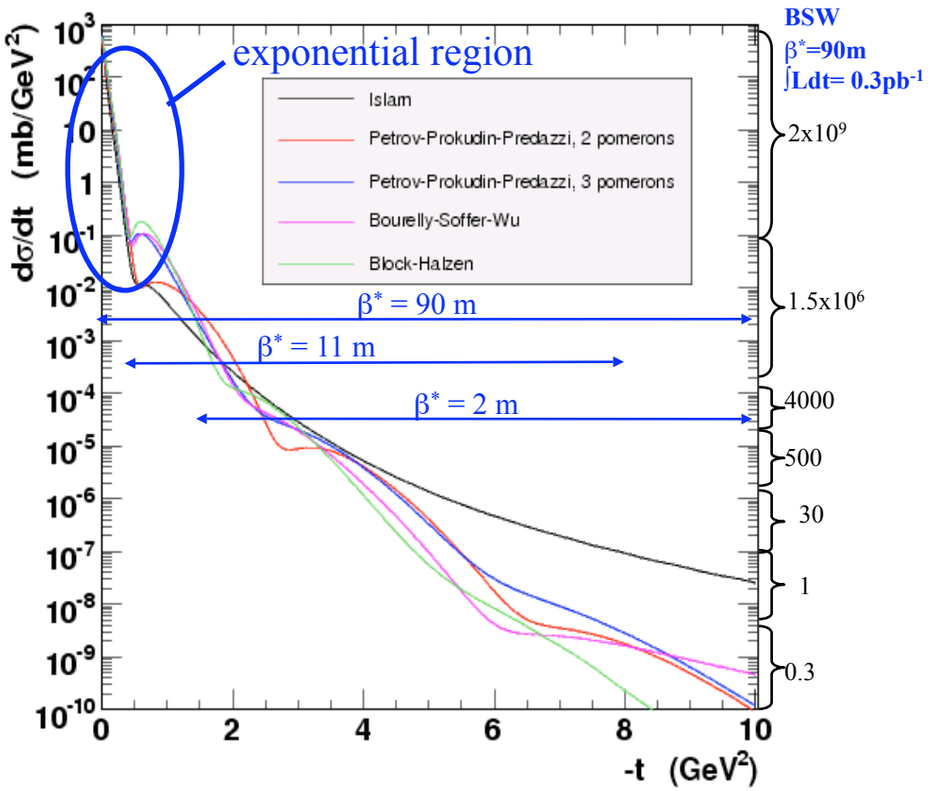
- Consistent with proton vertex factorisation
- Note the large normalisation uncertainties

Laura Fabbri

LHC Lumi

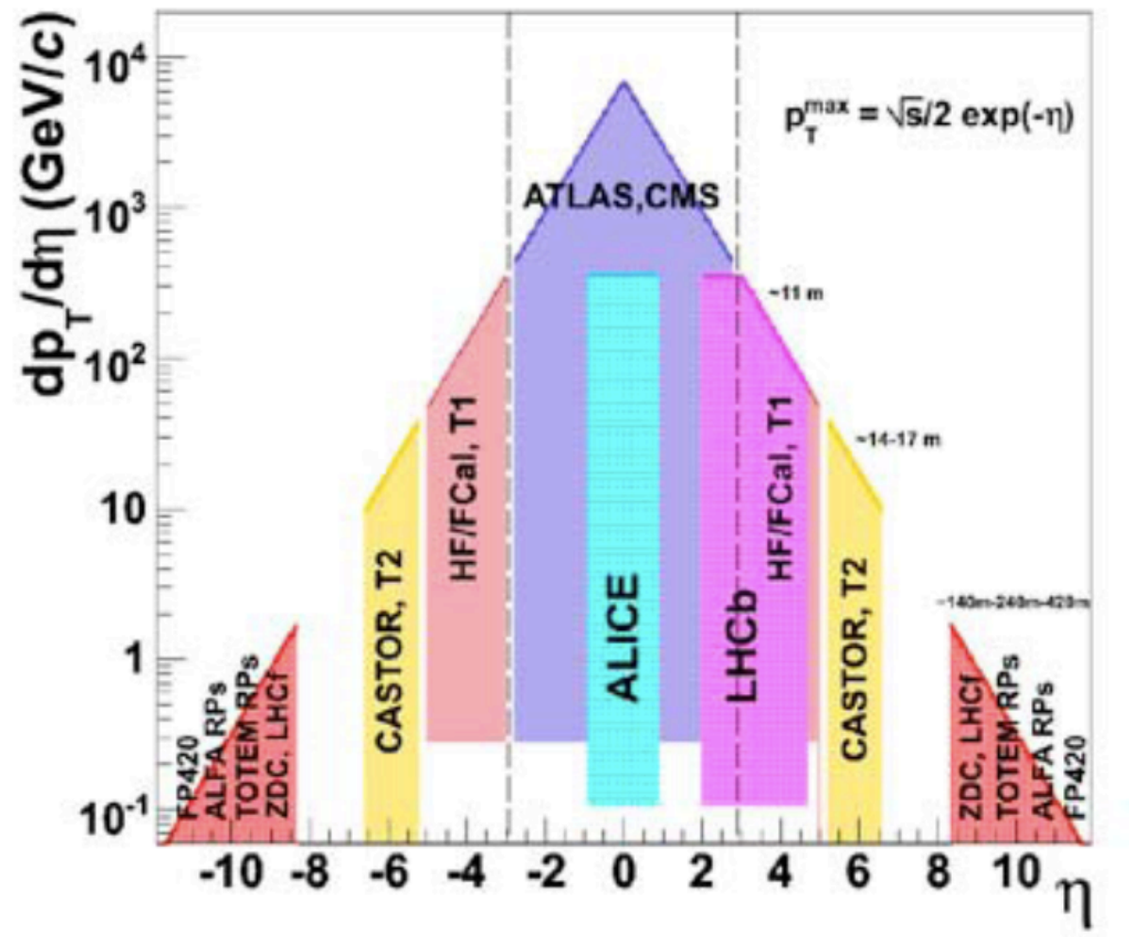
Hubert Niewiadomski





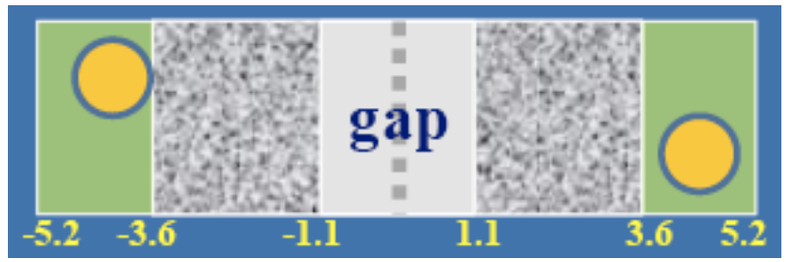
- Lumi measurements from elastic cross-section measurements with TOTEM and ALFA
- Calculate total cross section using optical theorem
- Needs special runs with unsqueezed optics to get full acceptance to optical point at t=0
- Relative luminosity measurements needed at Atlas, LUCID, ZDC for beam monitoring

Huge pseudo-rapidity coverage of the forward detectors of both Atlas and CMS



Benoit Roland

James Pinfold

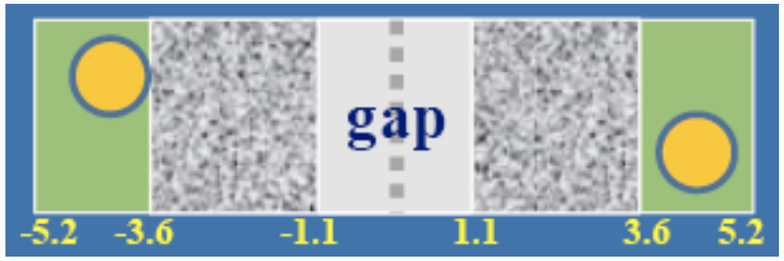


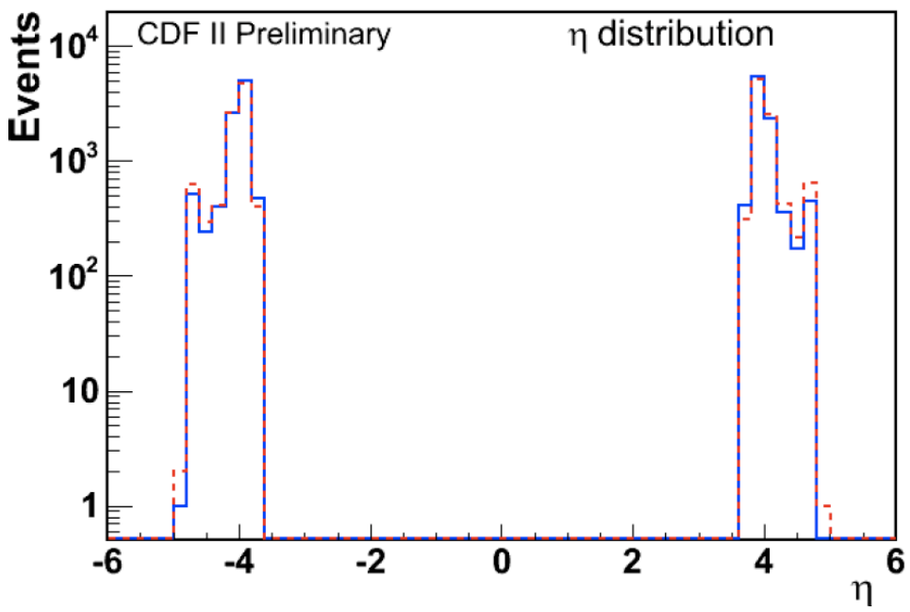
Tag forward jets, very sensitive to QCD dynamics

- Rich diffractive physics program, e.g.:
  - Use forward detectors to veto non-diffractive events
  - forward jets, forward particle production, gaps between jets, gamma-gamma...
- No time to do it justice!

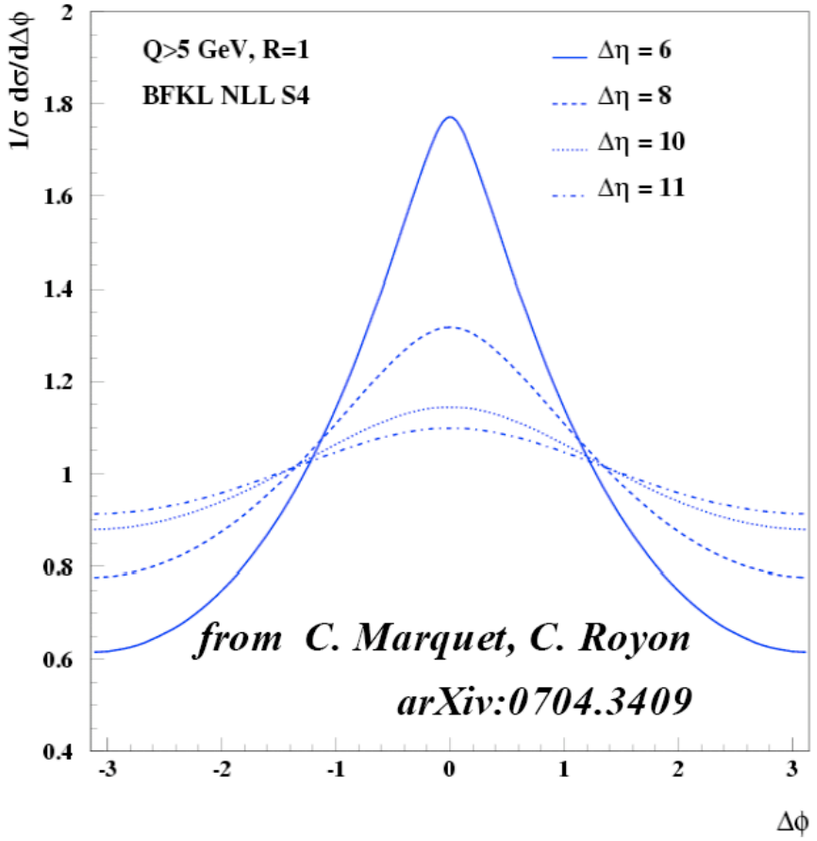
Jet-gap-jet at CDF

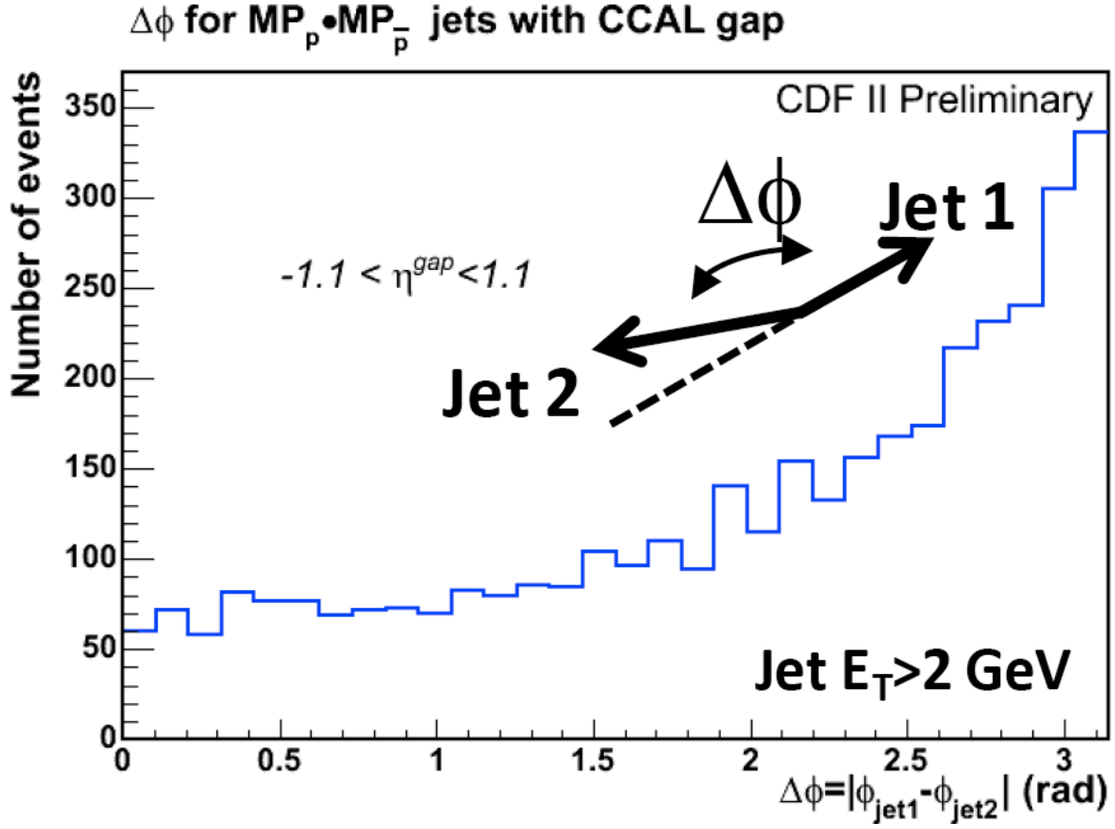
Christina Mesropian





- Analysis to look for BFKL-like effects by studying the azimuthal decorrelations between forward jets separated by a large rapidity gap (enhance BFKL radiation)



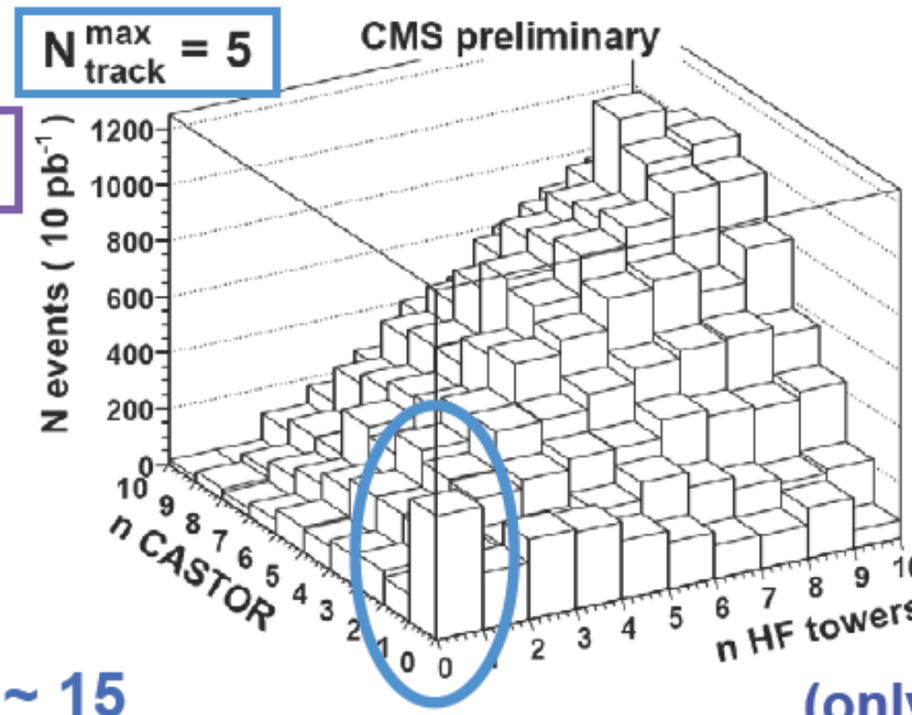


LHC early data

Maria Margherita Obertino

O(300) evts/10 pb^{-1} ← **[n(Castor), n (HF)] = [0,0] bin** → **O(100) evts/100 pb^{-1}**

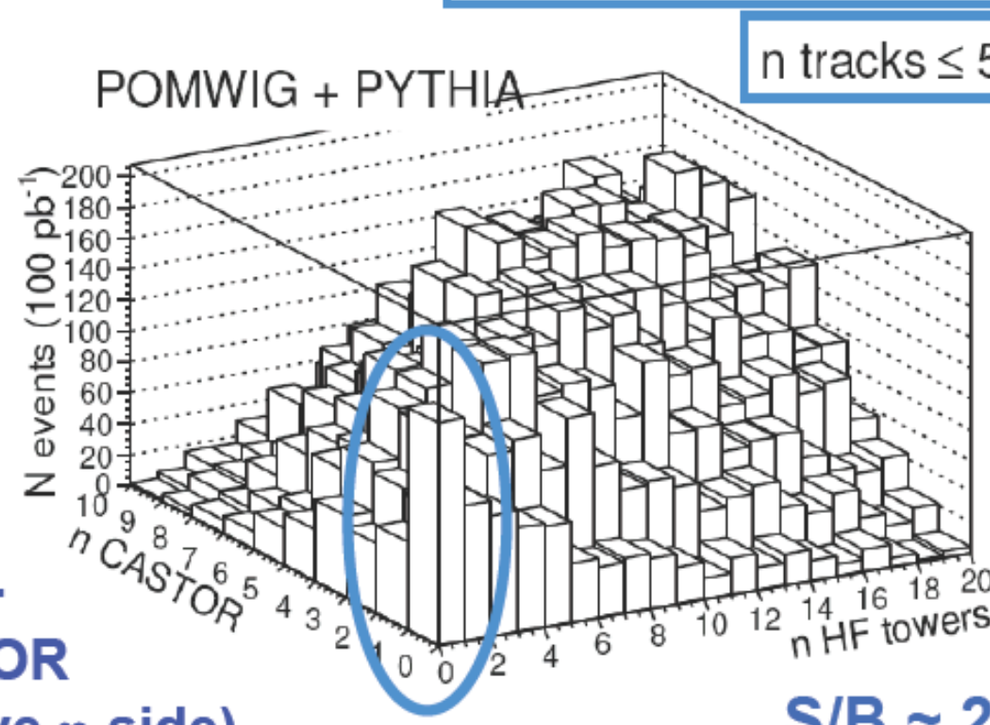
DIJET



S/B ~ 15

HF+ CASTOR (only negative η side)

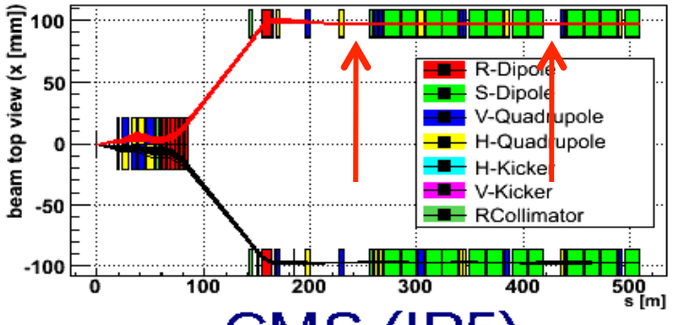
W



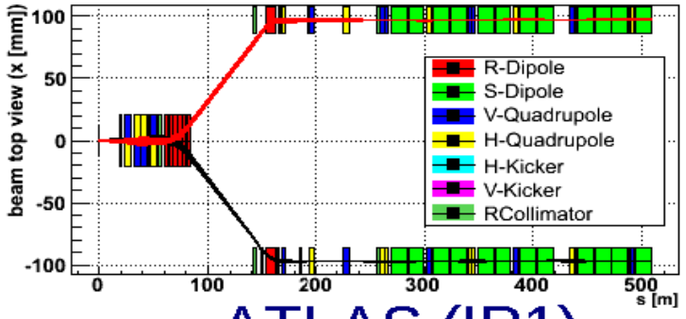
S/B ~ 20

- Identify single diffractive events by spike in the zero multiplicity bin in these forward detectors
- Measure rate of single diffractive dijets and W and compare to prediction
- First estimates of suppression factor at LHC from single diffraction with only 10pb^{-1}

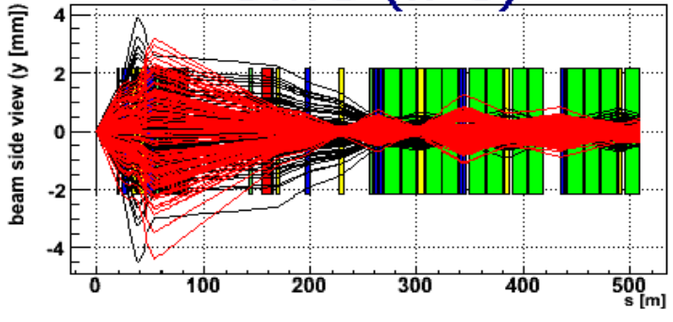
FP420 / 240 Project (Atlas and CMS)



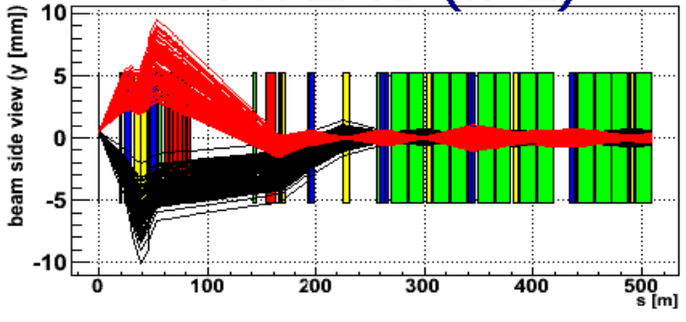
top



CMS (IP5)

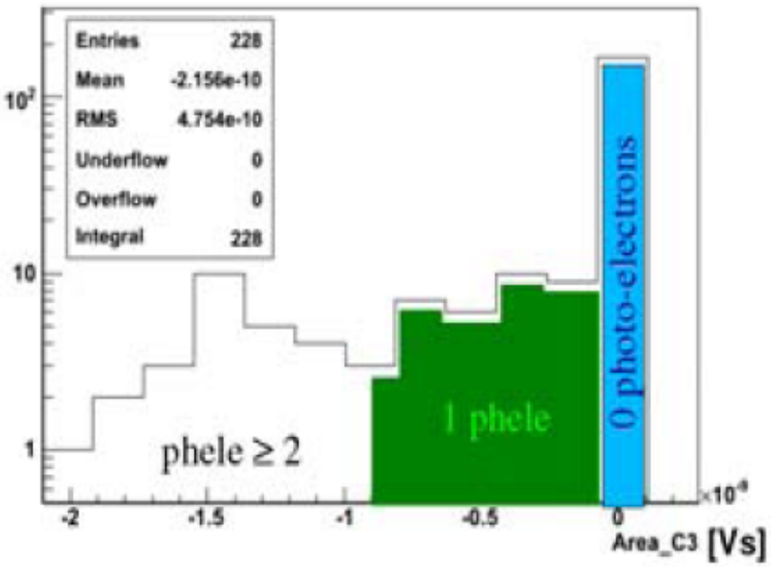


side

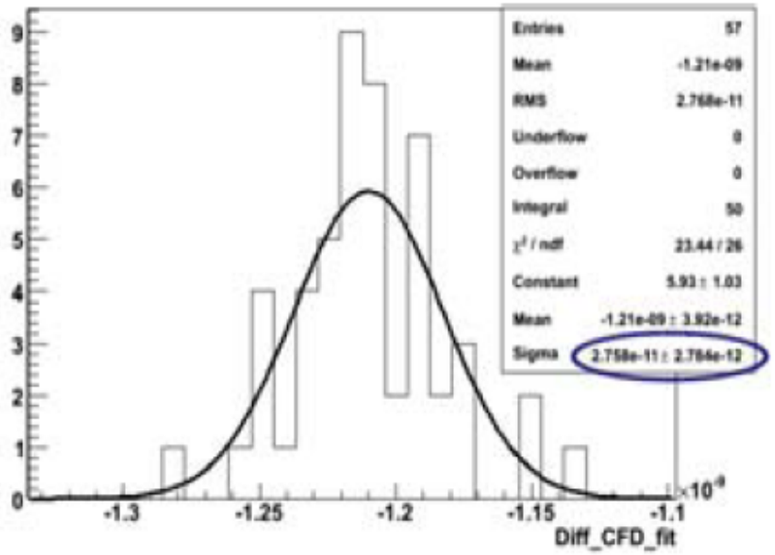


ATLAS (IP1)

Horizontal crossing plane

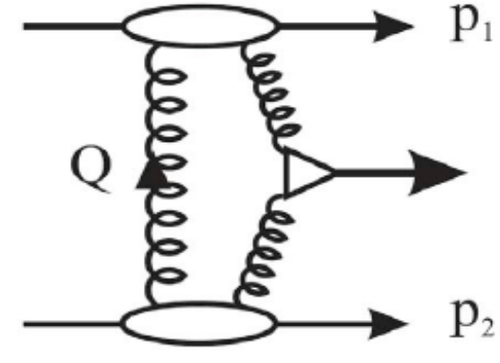


Vertical crossing plane



Two Gastof detectors are coupled to R3809U-50 MCP-PMTs. Anode charge distribution (on 50 Ω) of a Gastof detector (left plot) shows two peaks corresponding to 1 and 2 photoelectrons, and the measured time difference spread (right plot) corresponds to a single detector resolution below 20 ps. The MCP-PMTs were operated at 3000 V.

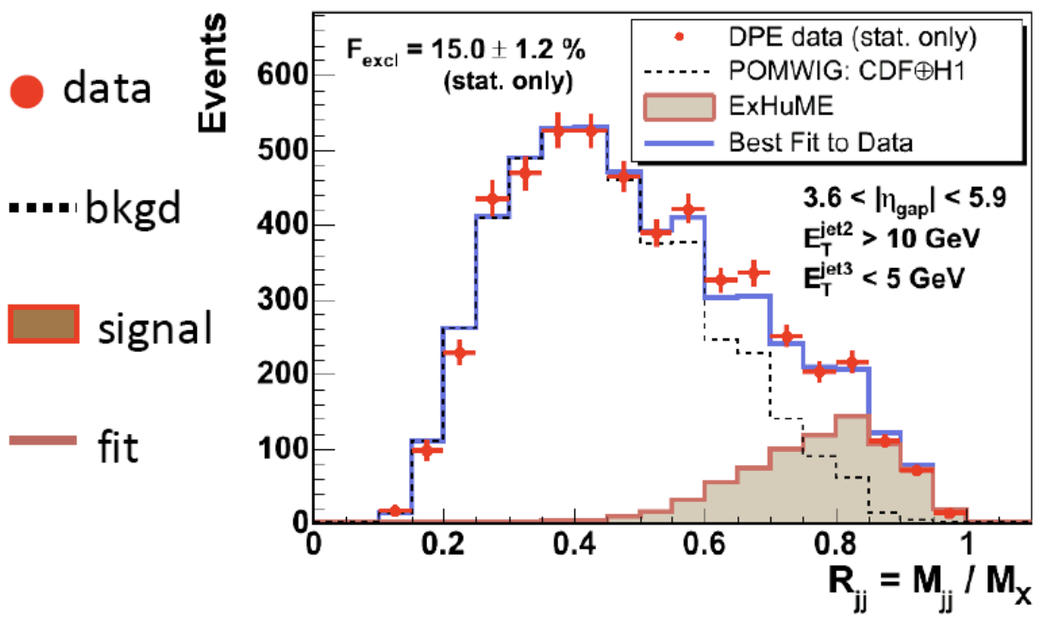
Krzysztof Piotrzkowski

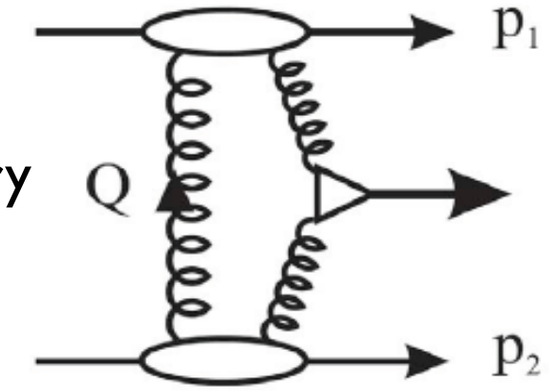


Better than 20 ps timing resolution proven - crucial for dealing with pile-up

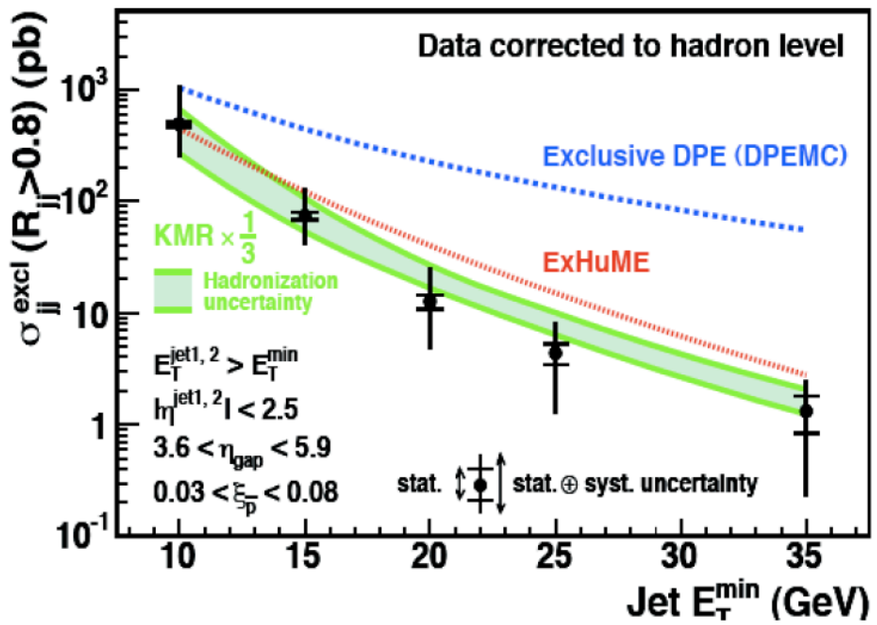
Exclusive central production at CDF

Christina Mesropian

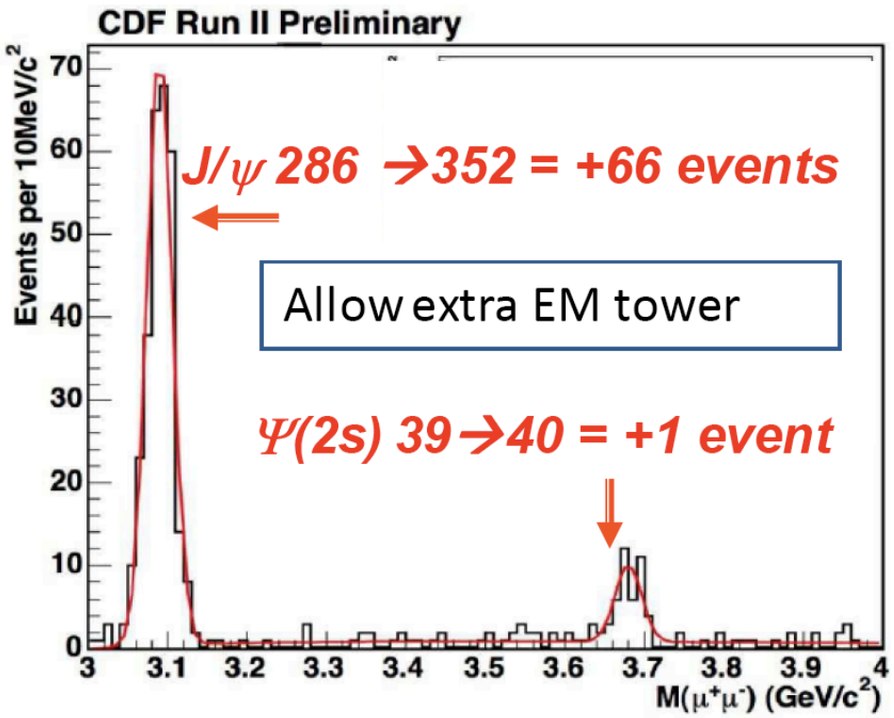




Good agreement between theory and experiment for exclusive central dijet production



$$\chi_c \rightarrow J/\psi + \gamma$$



Observation of rare decay, rate in agreement with theory

Lends confidence in the predictions for the LHC (particularly calculation of survival probability)

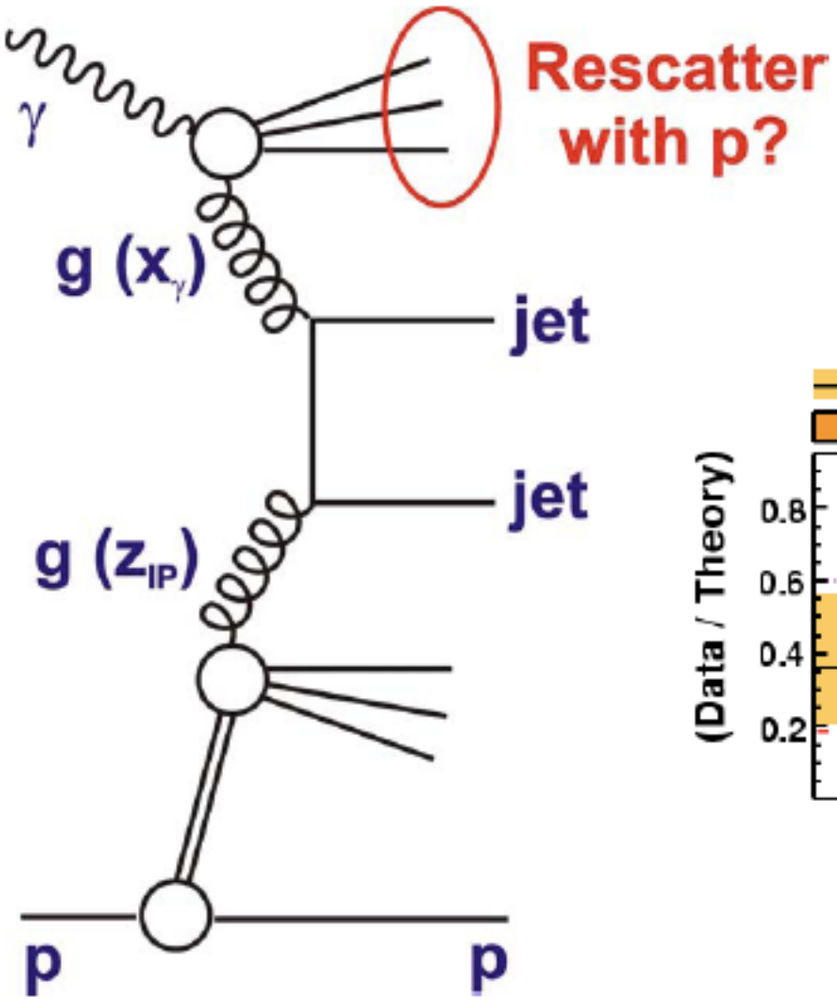
Caveats in Markus' talk

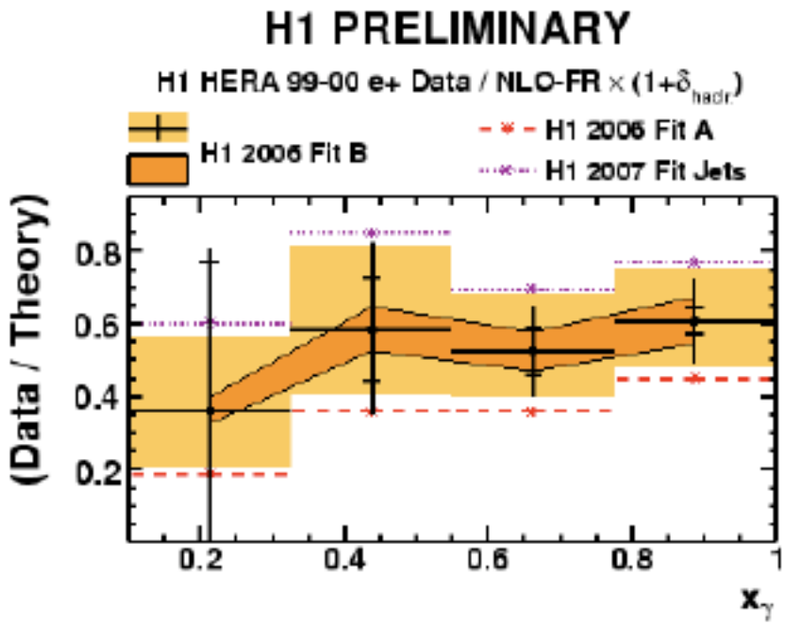
UNIVERSITY OF LIVERPOOL

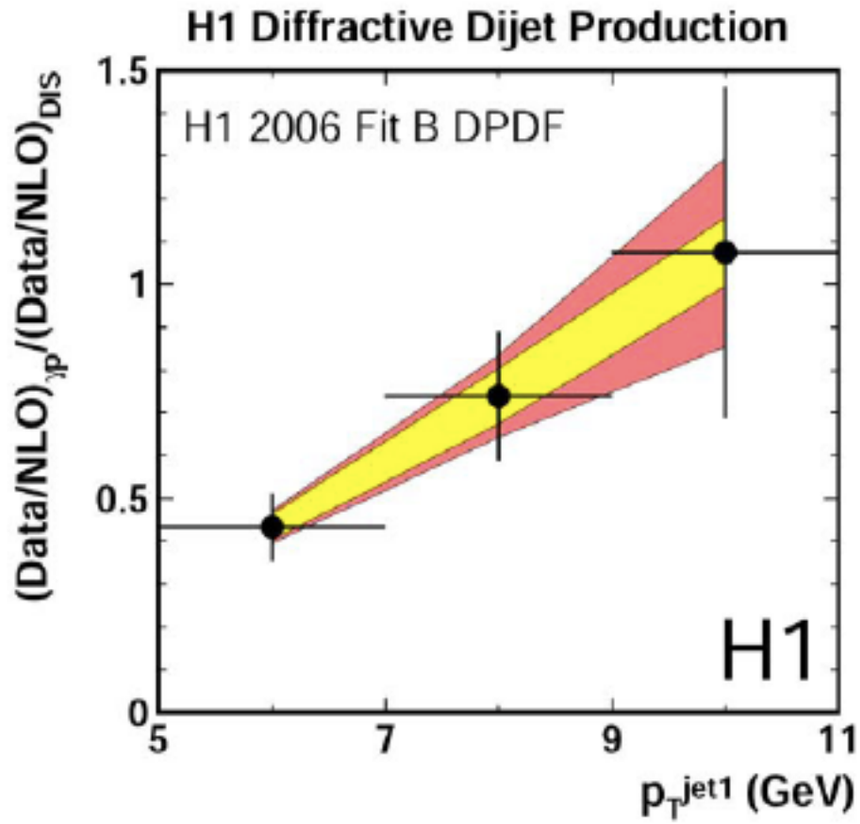
Paul Laycock

Factorisation tests

Paul Newman





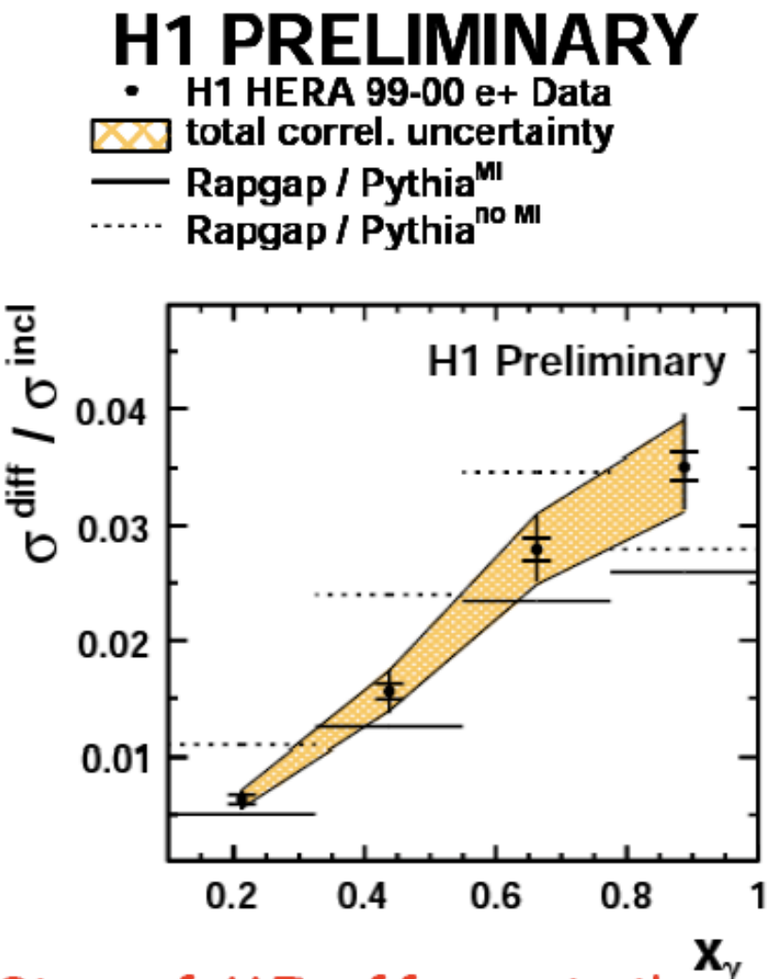


- Strong suggestion of an E_T dependence of suppression in double ratio (right)
- Overall suppression seen independent of x_{gamma}
- Mechanism behind suppression of photoproduction cross section here not identical to that at hadron-hadron collider - should be understood

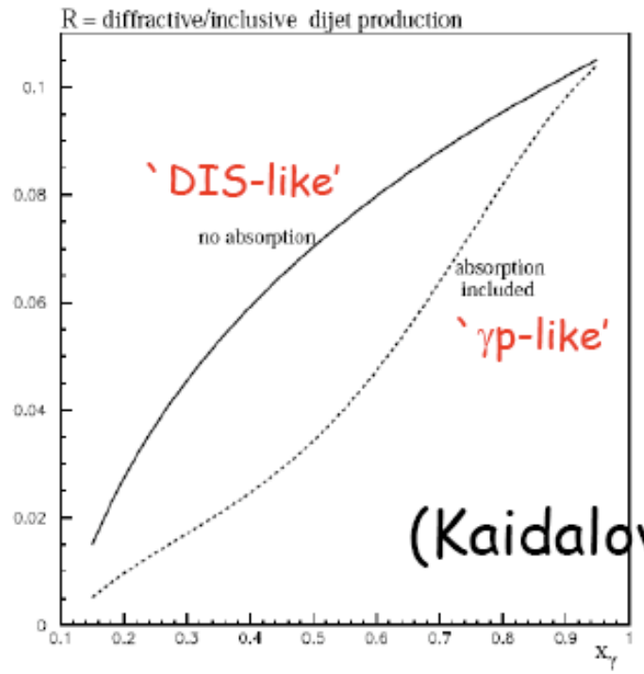
Ratio of diffractive / Inclusive diffractive dijet cross sections in photoproduction

Paul Newman

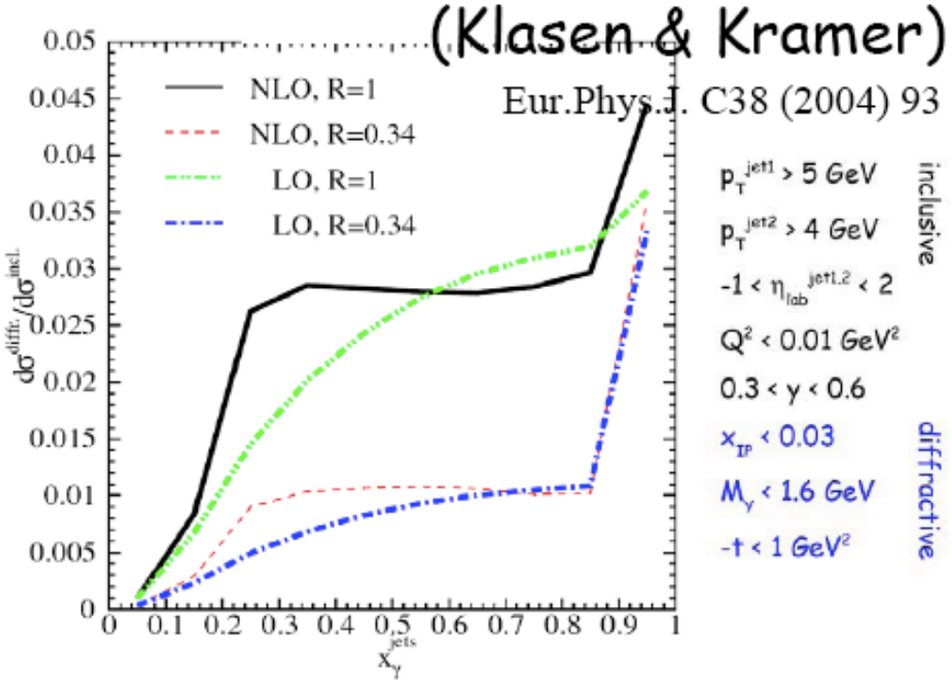
Diffractive / Inclusive



- Size of MI effect similar to that of absorption.
- MI Model → fair description

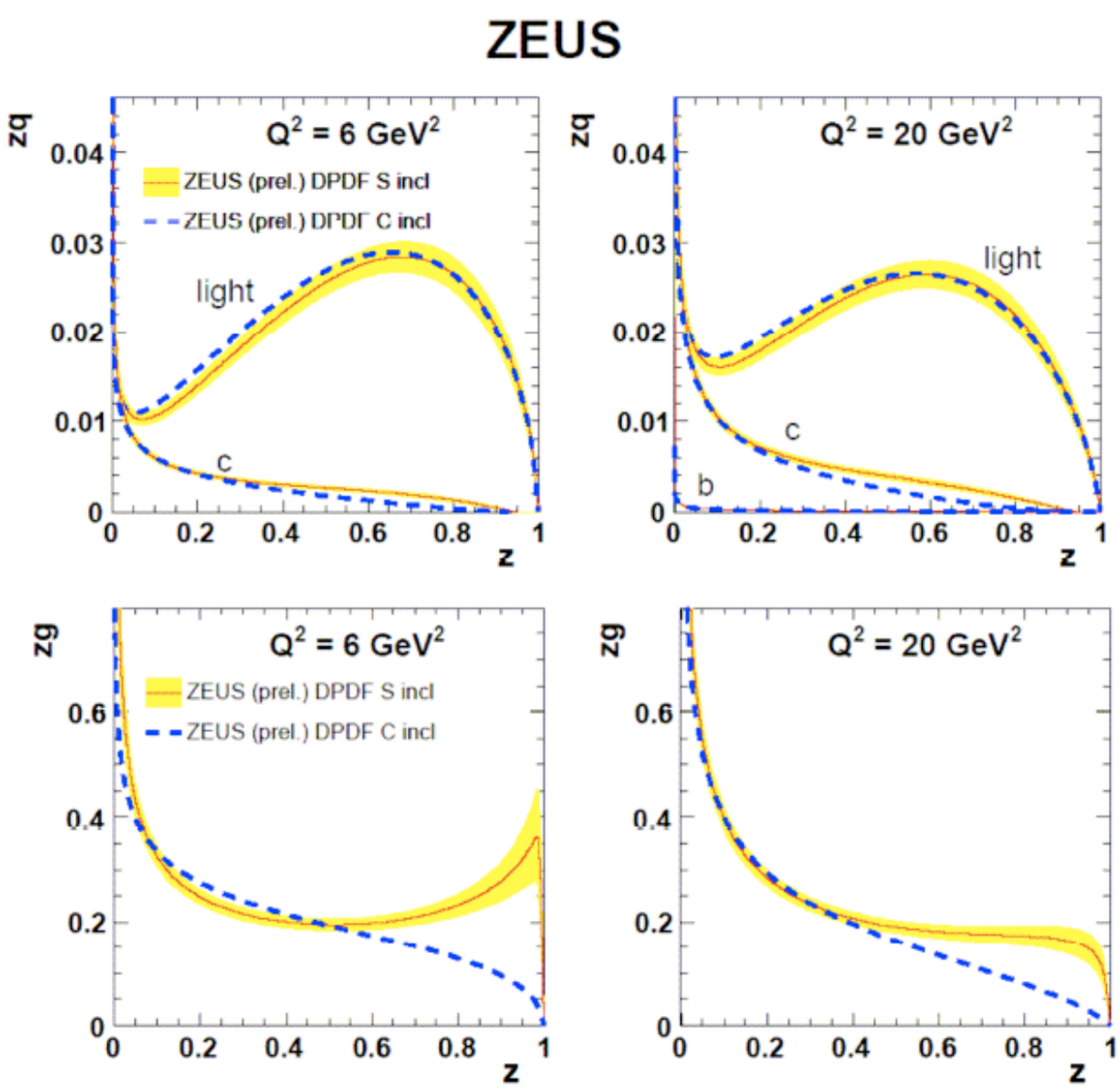


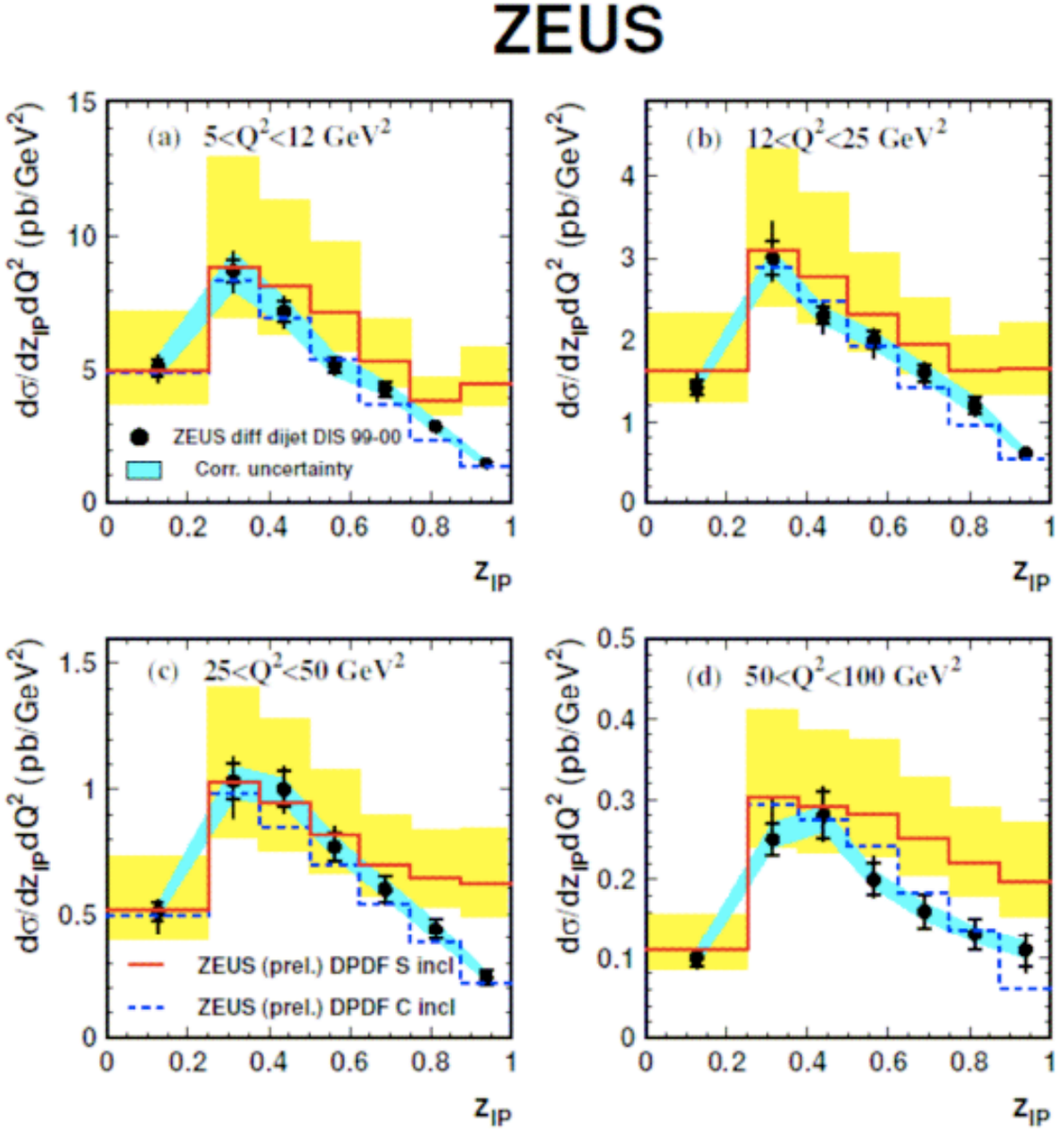
Strong conclusions precluded because of influence of multiple interactions



New Zeus QCD fits

Wojtek Slominski

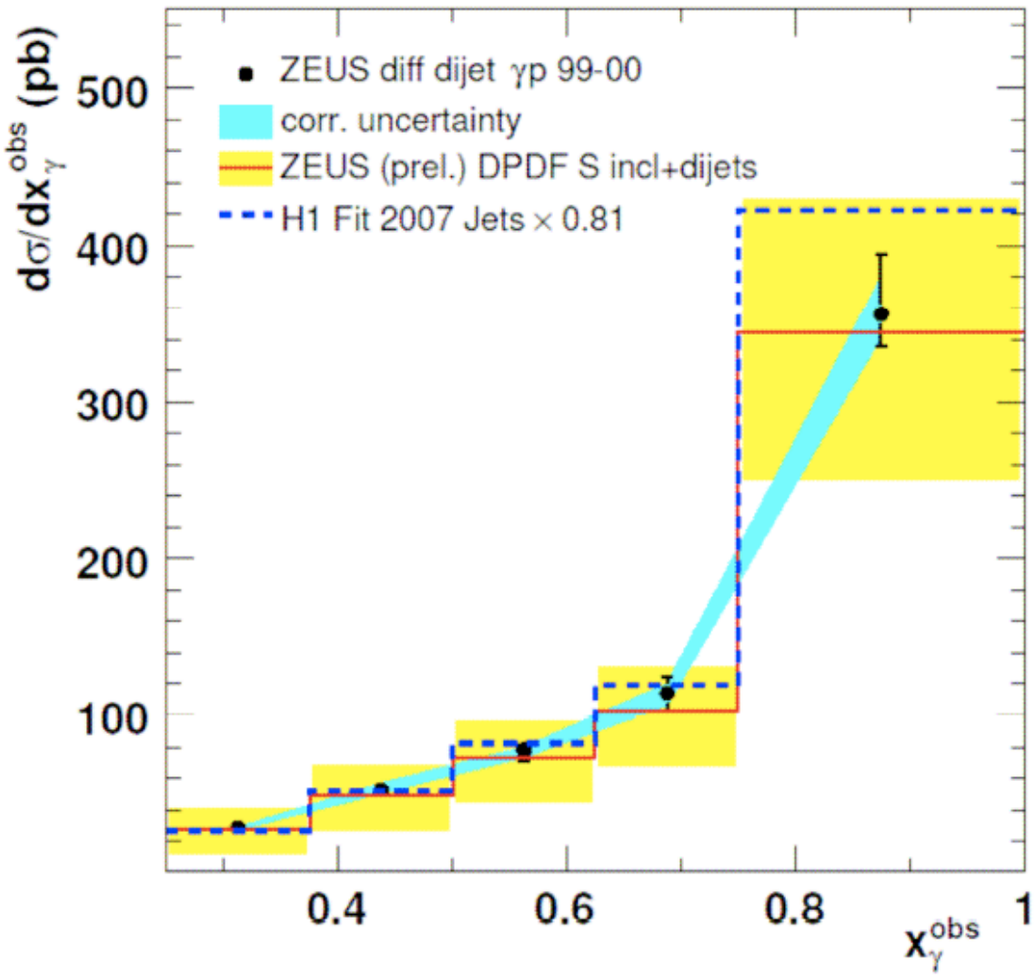


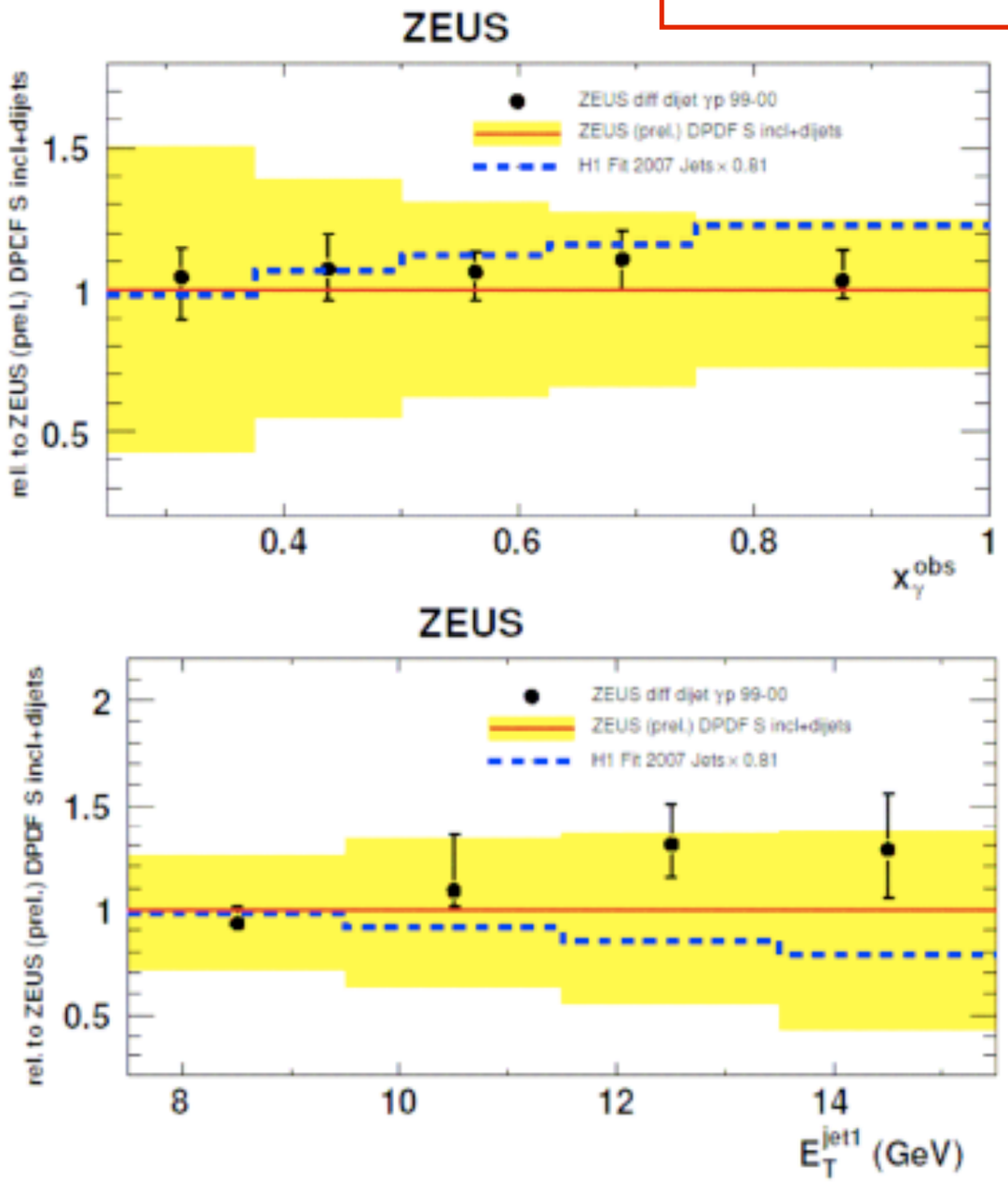


- Significant improvements in theory, especially regarding inclusion of dijets (ZFNS)
- Very similar observations to H1 on instability of the gluon at high fractional momentum

New Zeus QCD fits with dijets

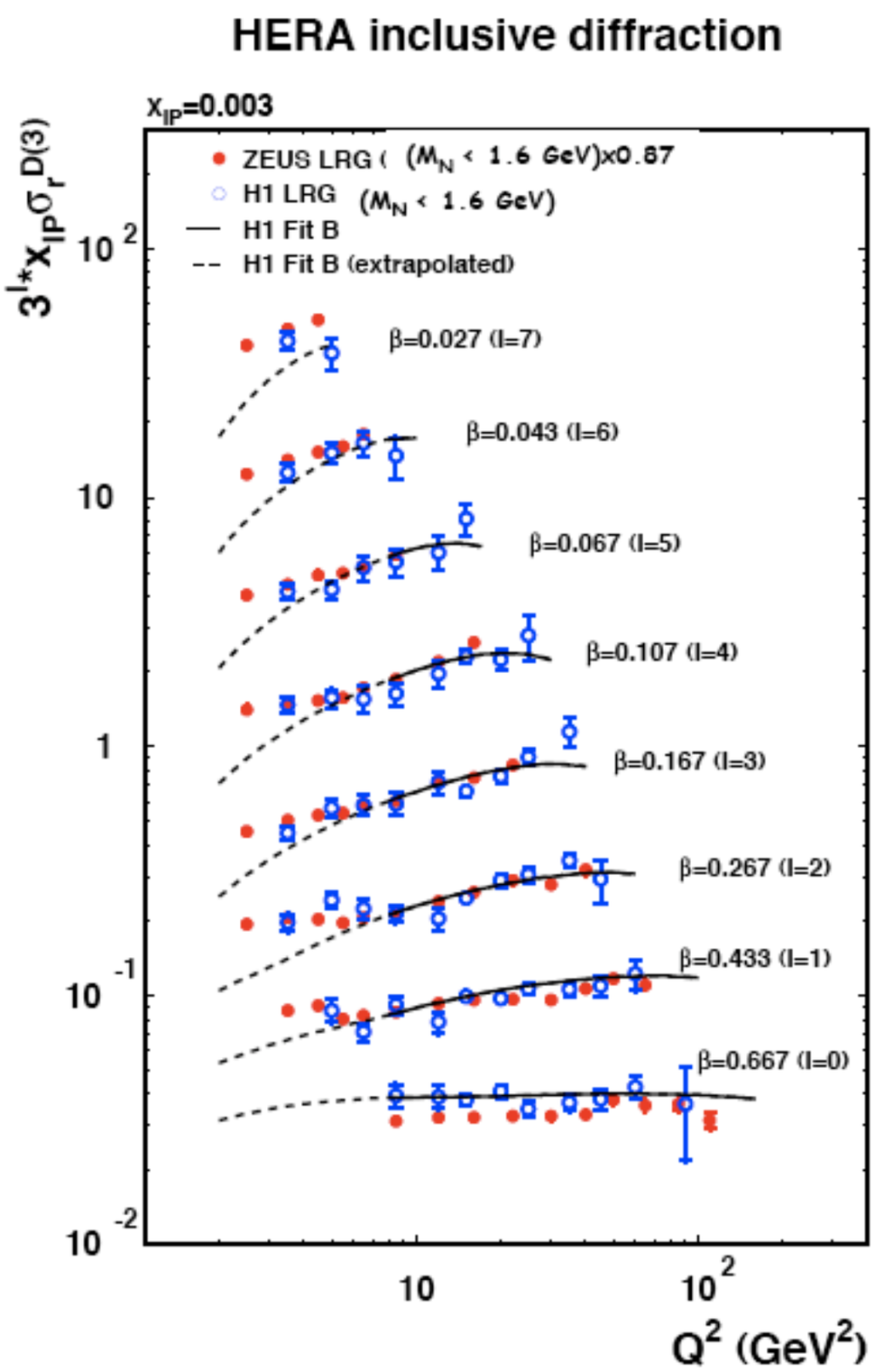
Wojtek Slominski





- Zeus and H1 fits with dijets agree very well (factor 0.81 to correct to same M_Y range)
- Zeus see overall no suppression, possible E_T dependence

Final Zeus measurements of F_2^D



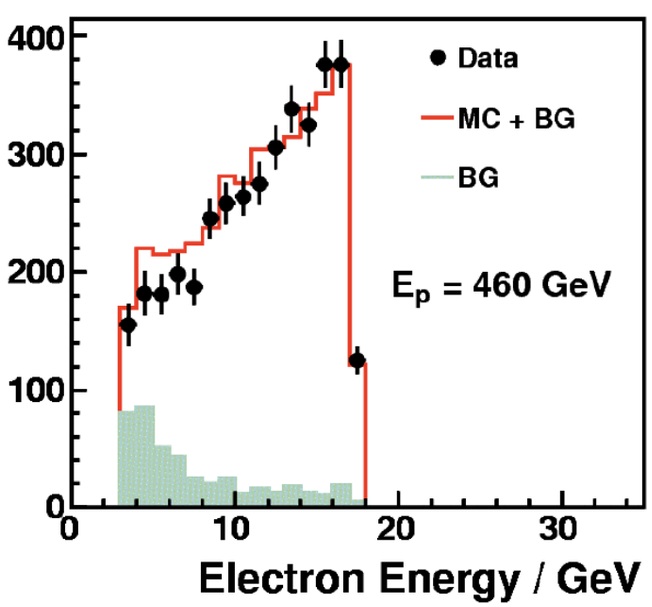
Marta Ruspa

- Final word on inclusive diffraction from Zeus compared to published H1 data
- Discussion on combinations: (thanks to all!)
- Good agreement but
  - Shape discrepancy
  - normalisation differences although large normalisation uncertainties
- Wait for the final H1 data
- Knowledge exchange on proton dissociation
- The H1 VFPS to provide a normalisation constraint at the level of 5%?

$$\sigma_r^D = F_2^D - \frac{y^2}{Y_+} F_L^D$$

F_L^D

David Salek

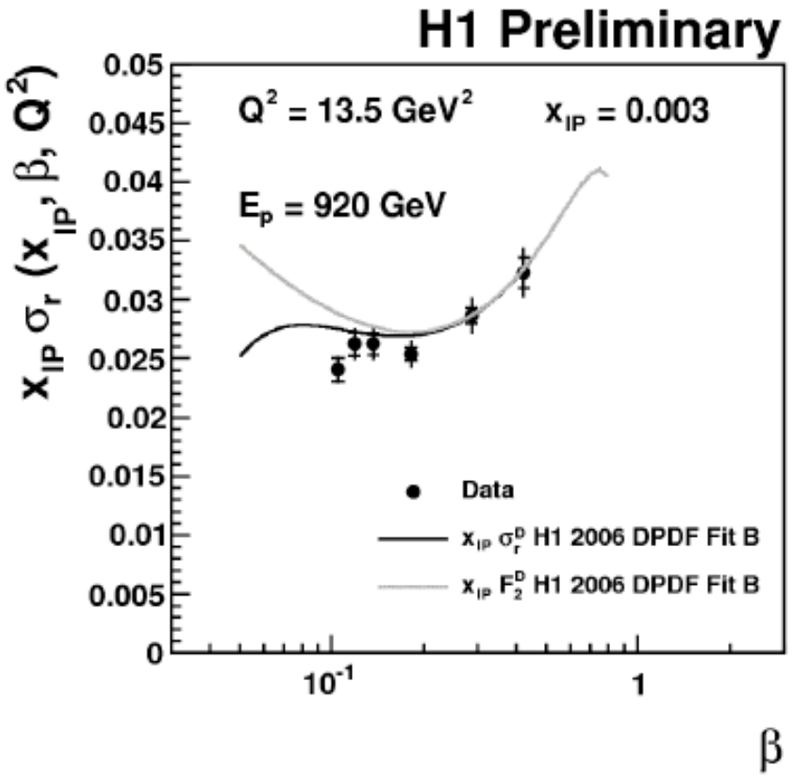


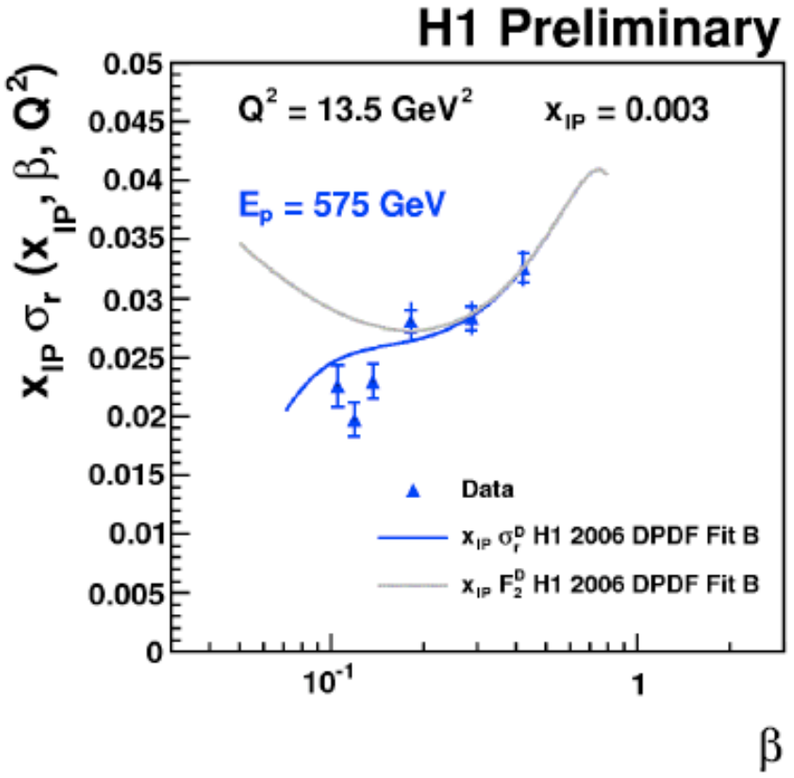
Very challenging measurement, requiring very good understanding of the detector down to low energies

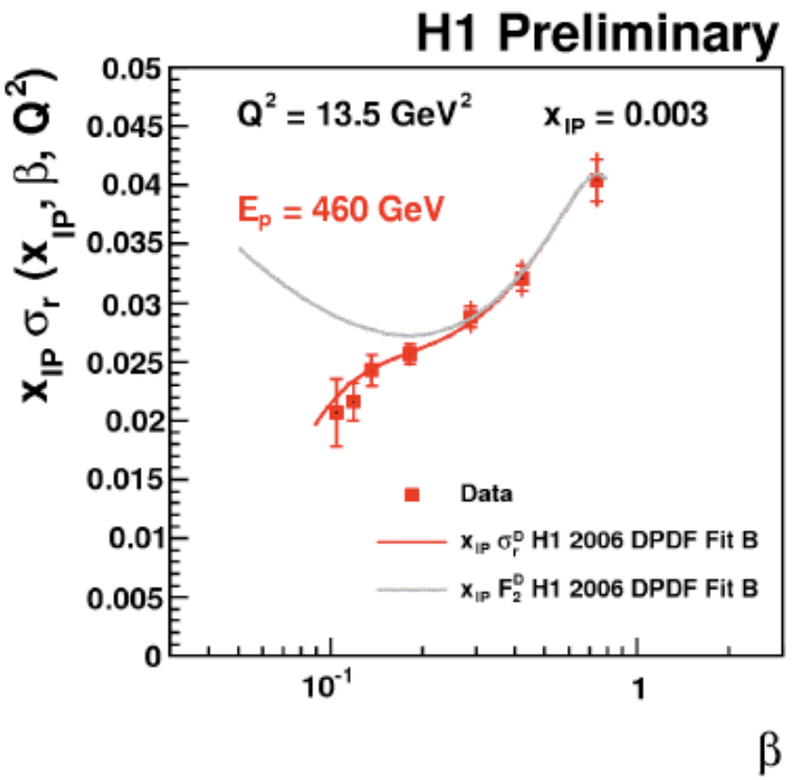
Photoproduction background estimated from the (wrong-charge) data

Reduced cross section measurements at three proton beam energies made, E_p=460 GeV has access to nearly the full y range (0.1 < y < 0.9)

E_p=460 and 575 GeV normalised to E_p=920 at low y (1 and 3%, smaller than the normalisation uncertainties and ~ the statistical precision)



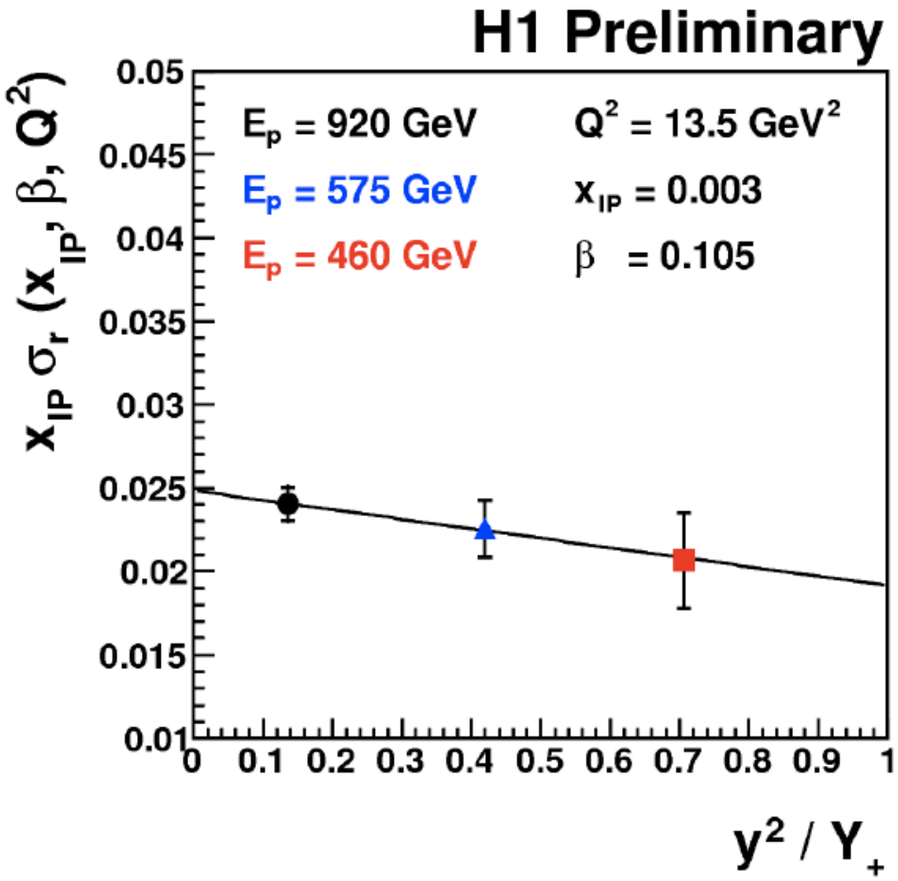


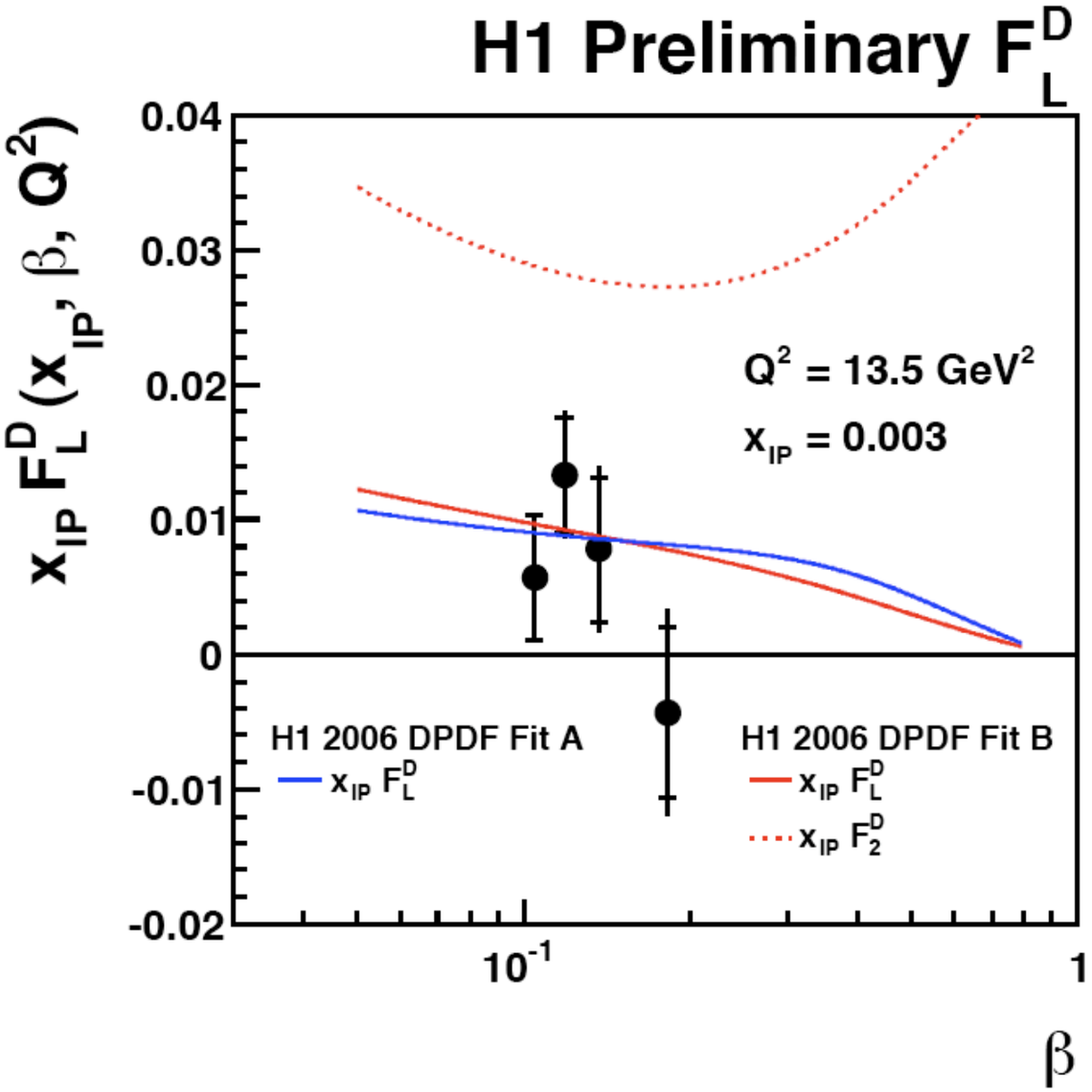


$$\sigma_r^D = F_2^D - \frac{y^2}{Y_+} F_L^D$$

F_L^D

David Salek

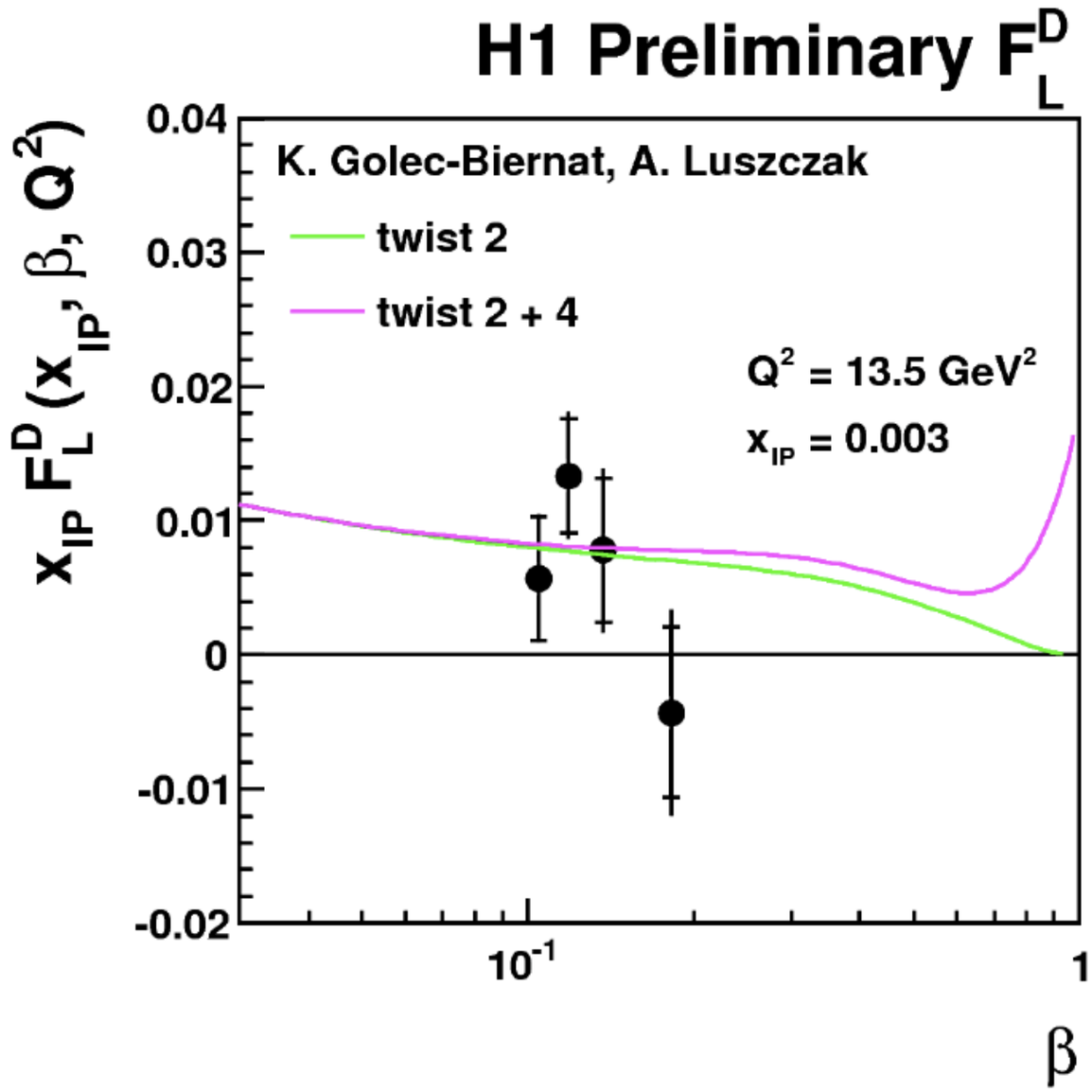




- Rosenbluth plot (left) shows linear structure of the reduced cross section
- Straight line fits allow a direct extraction of F_L^D at greater than 3 sigma
- Agreement with NLO prediction from H1 2006 Fits - consistent picture of diffraction in QCD

F_L^D comparison with dipole model

David Salek



- Consistent with the predictions of dipole models, but would need higher Q^2 to access "interesting" region

Summary

- We can (and do) all look forward (!) to the LHC and the exciting physics program that brings with it

- Current experiments measure rare processes that give us confidence in our predictions

- We have reached an era of unprecedented agreement between H1 and Zeus, vital to exploit the very best from the HERA bounty
    - We still have work to do!

Thank you for your attention!