Summary of Working Group 4: Diffraction

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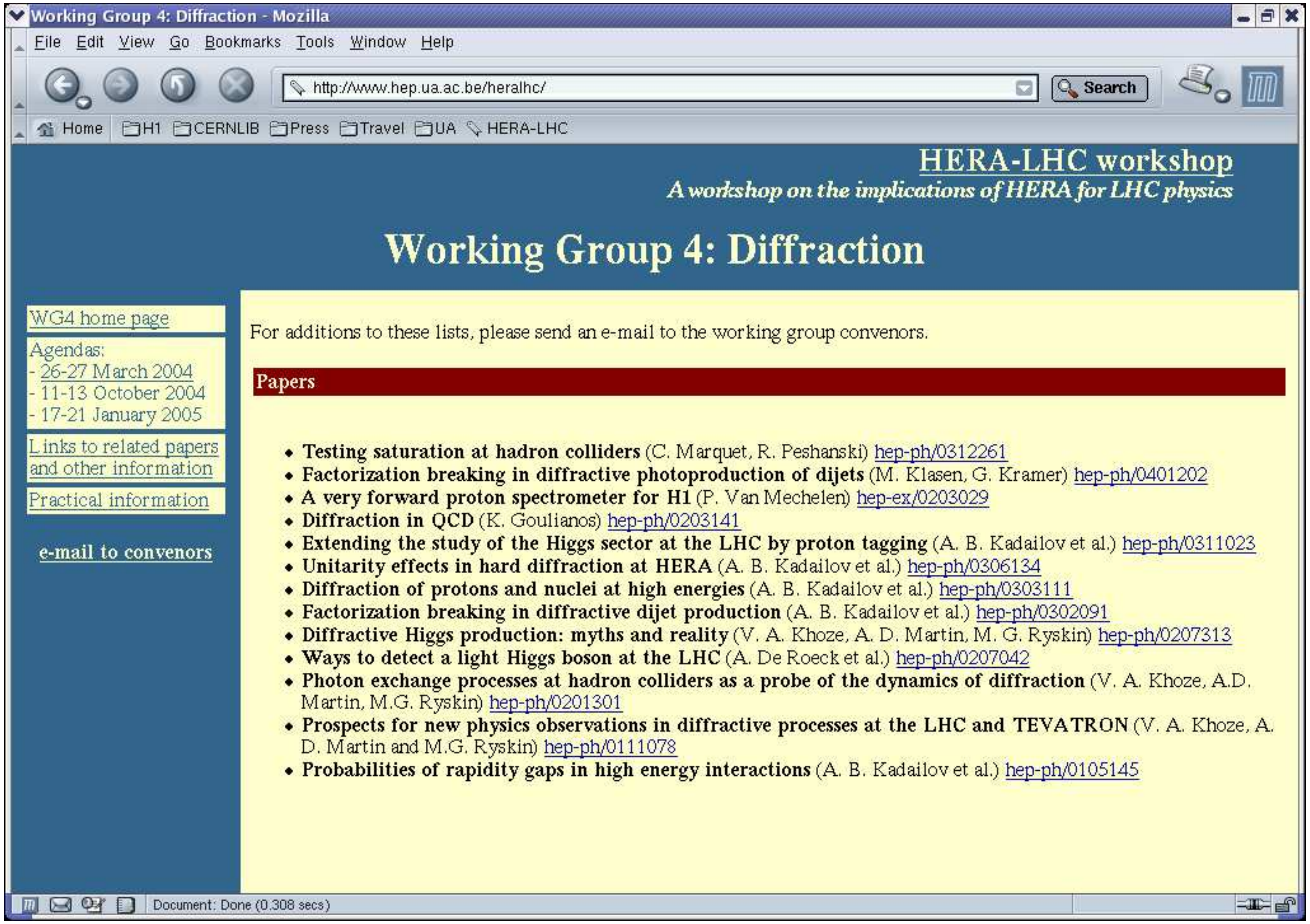
Disclaimer

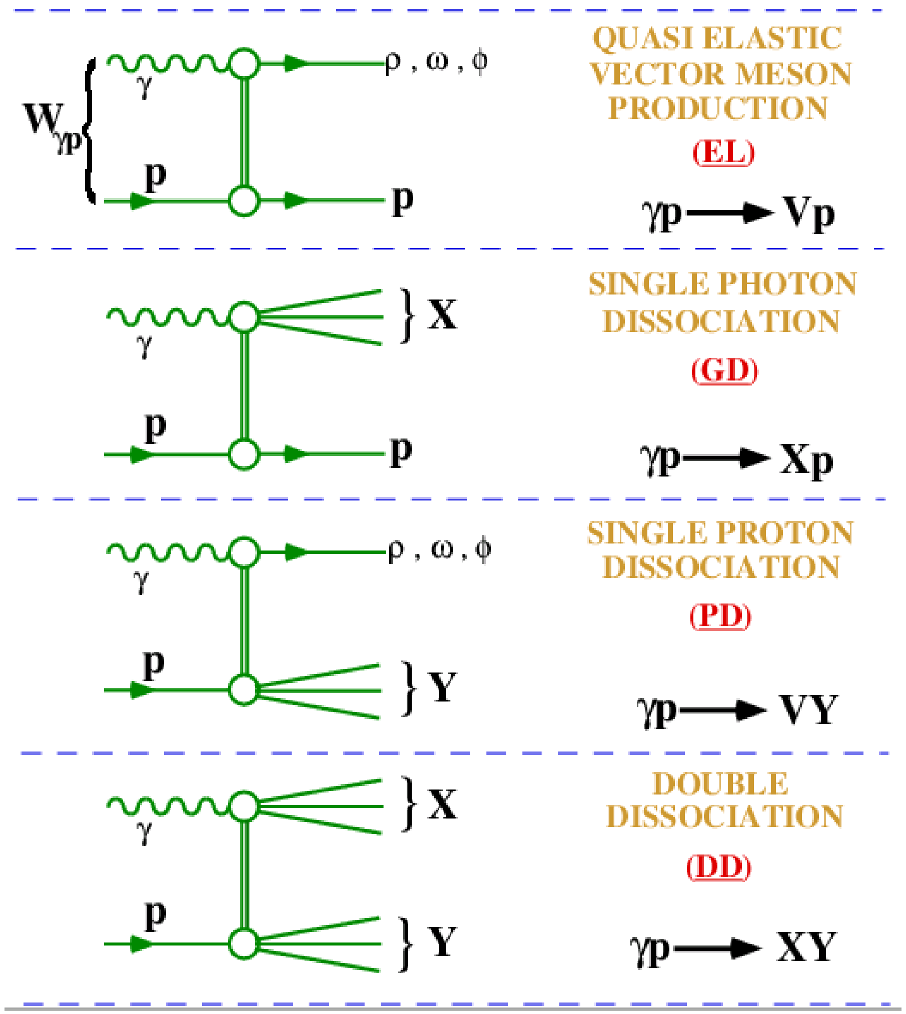
As this is a summary talk, it is impossible to give all the details!

➔ please refer to the web for: • transparencies of talks • related papers, etc.

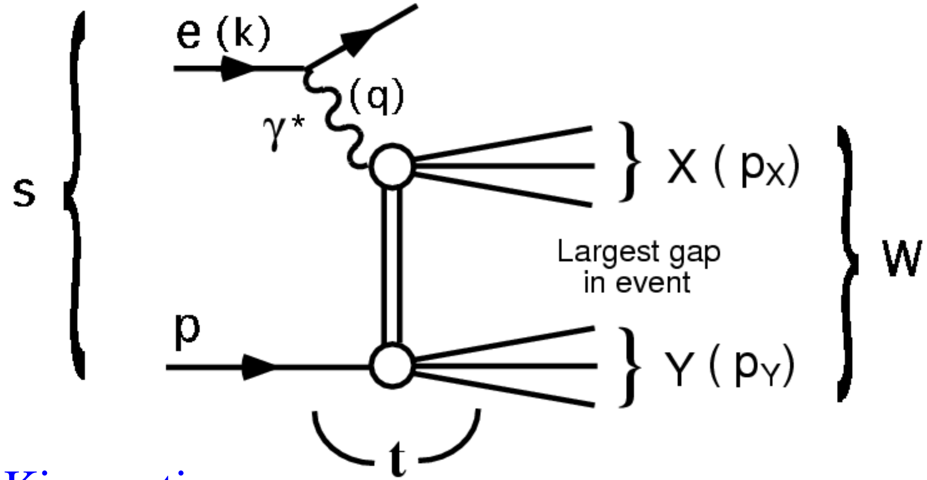


Physics Analyses
(theory and experiment)

Diffraction at HERA



(Schilling)



Kinematics:

- longitudinal momentum fraction of the proton carried by the colourless exchange:

$$x_{IP} = \frac{q \cdot (P - p_Y)}{q \cdot P} \approx \frac{Q^2 + M_X^2}{Q^2 + W^2}$$

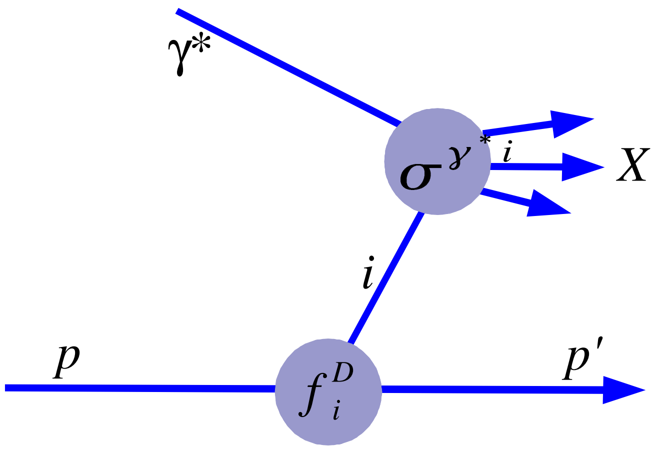
- longitudinal momentum fraction of the colourless exchange carried by the struck quark:

$$\beta = \frac{x}{x_{IP}} \approx \frac{Q^2}{Q^2 + M_X^2}$$

QCD and Regge factorisation

QCD hard scattering factorisation:

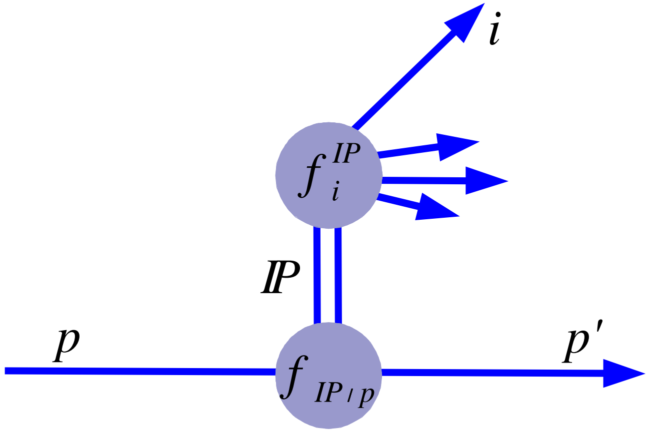
$$\sigma^{\gamma^* p \to p'X} = \sigma^{\gamma^* i} \otimes f_i^D$$



- $\sigma^{\gamma^* i}$ the universal partonic cross section (same as in inclusive DIS)
- f_i^D the parton distribution function for a parton *i* under the constraint that the proton survives the diffractive scattering (f_i^D should obey the DGLAP evolution equations)

Regge factorisation:

$$f_i^D(x, Q^2, x_{IP}, t) = f_{IP/p}(x_{IP}, t) \,.\, f_i^{IP}(\beta = x/x_{IP}, Q^2)$$

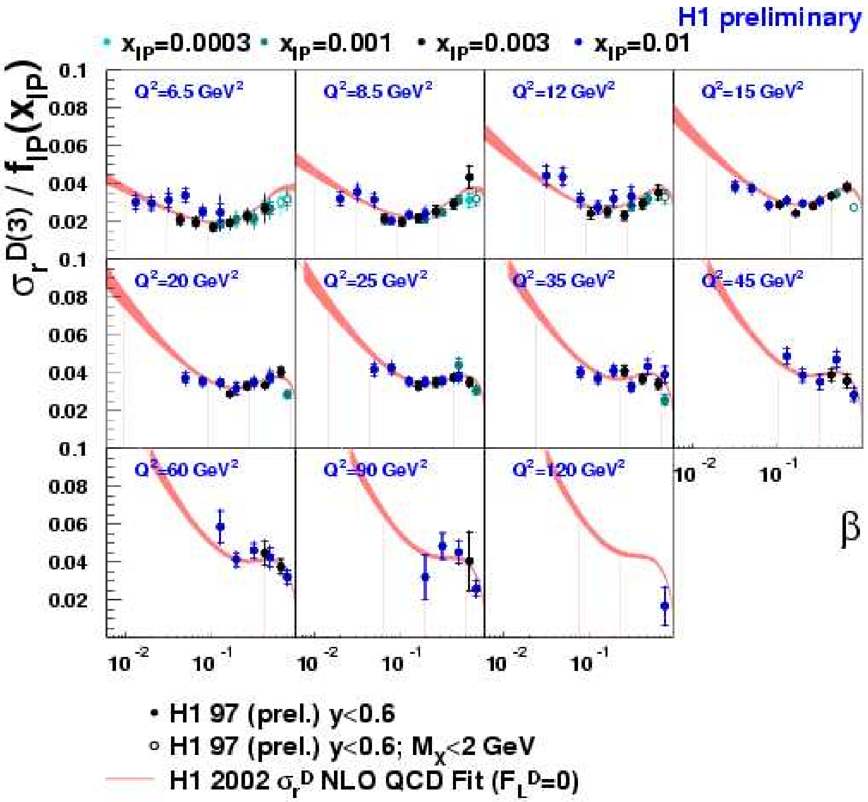


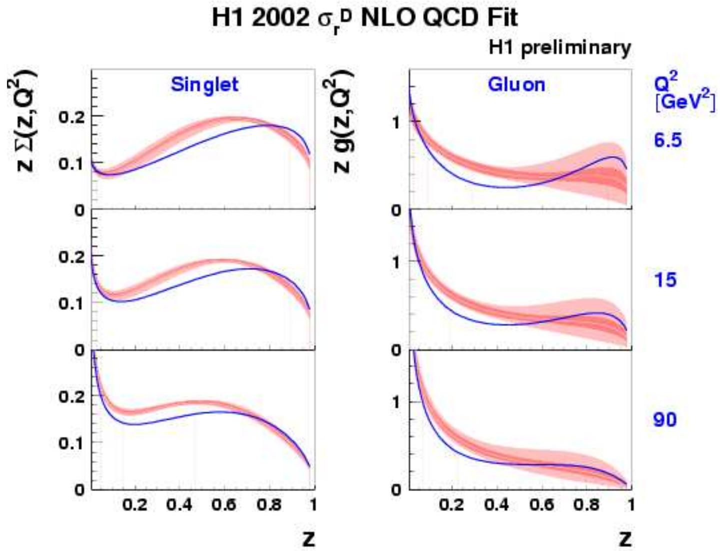
- $f_{IP/p}$ "pomeron flux factor" (can be parameterized according to Regge theory)
- f_i^{IP} "pomeron parton distribution"

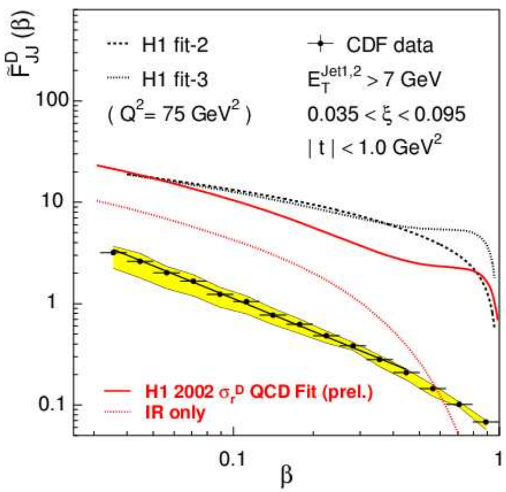
Extrapolating HERA pdf's to Tevatron

(Schilling)

- Apply diffractive PDFs from HERA to Tevatron diffractive jets data:





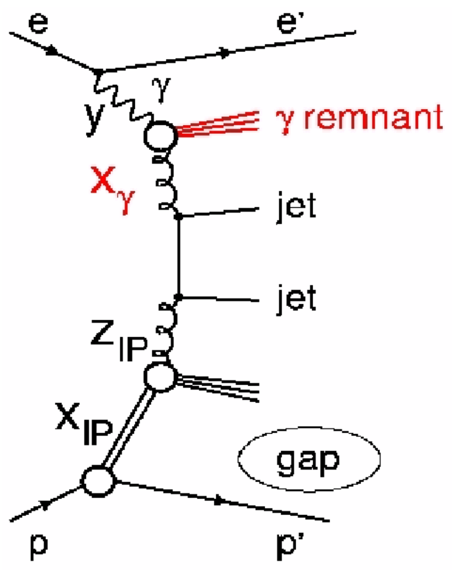


factor 10 discrepancy!

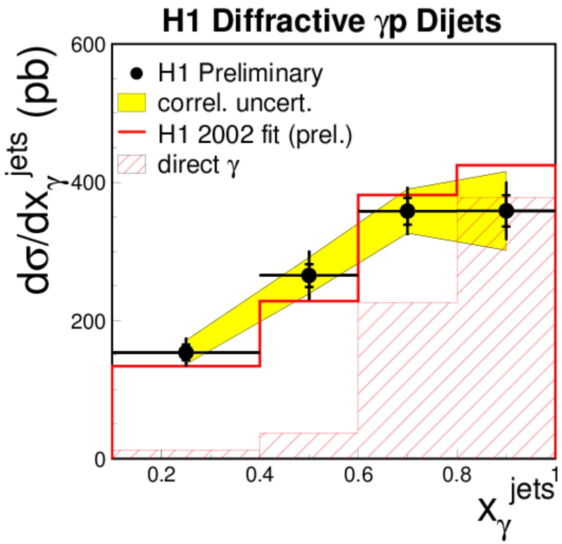
Testing QCD factorization at HERA

(Schilling, Klasen)

- Rapidity gap survival in direct vs. resolved photoproduction:



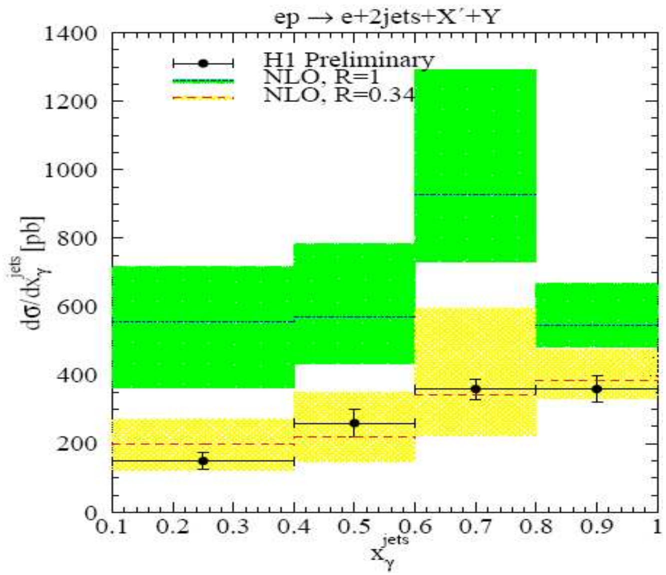
LO



suppression factor relative to DIS: 1.25±0.30

→ no suppression needed

NLO



suppression of resolved part with 0.34 yields a better description

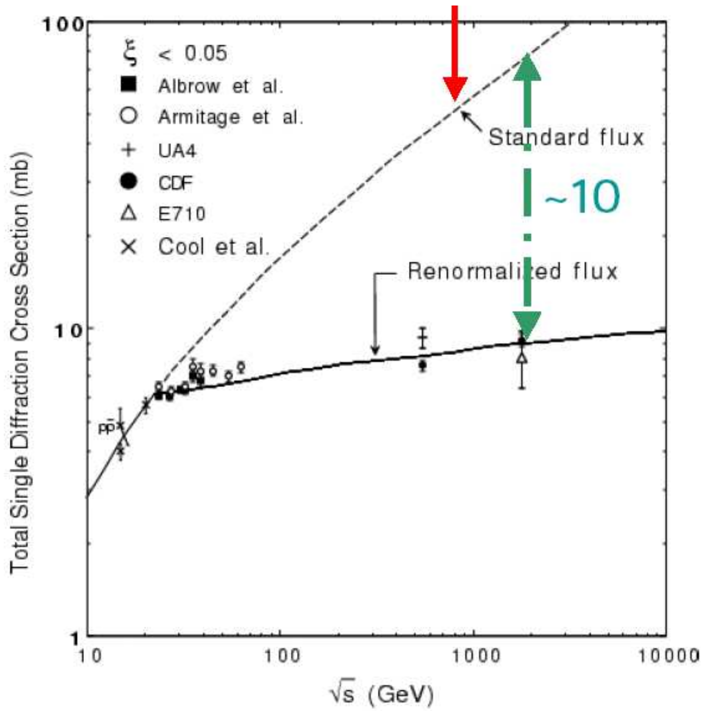
→ BUT: fact. scale dependent!

Diffractive gap probabilities

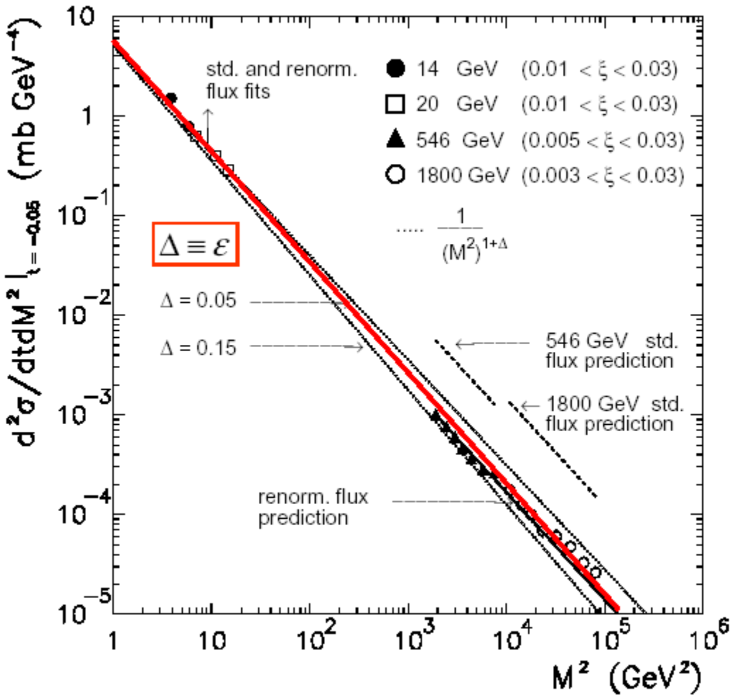
(K. Goulianos)

- Renormalization of Pomeron Flux:

$$\int_{\xi_{min}}^{0.1} \int_{t=-\infty}^{0} f_{IP/p}(t,\xi)\, d\xi\, dt = 1$$



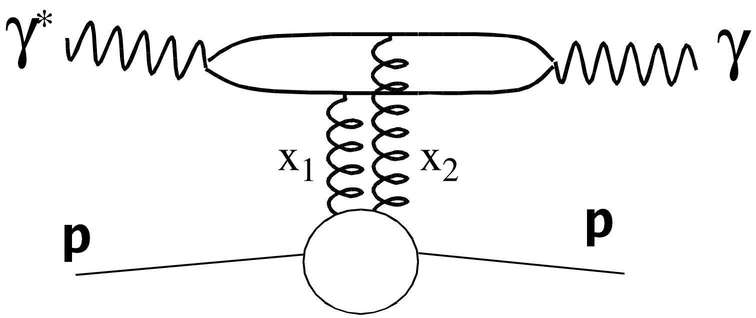
- solves unitarity problem (single-diffractive cross section would exceed total cross section at s = 2 TeV)
- results in scaling of $d\sigma/dM^2$
- yields universal, s-independent gap probability factor, applicable to mutliple gap configurations and x-section ratios

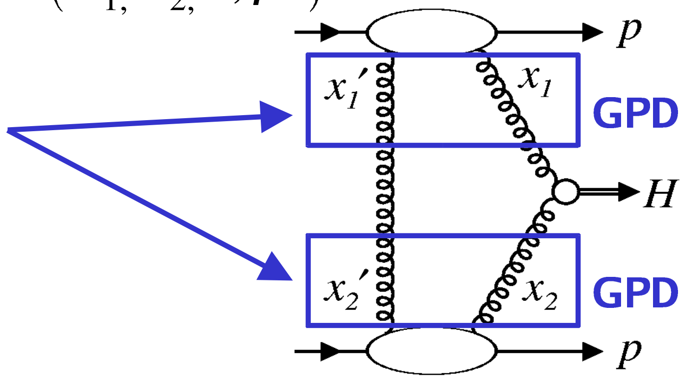


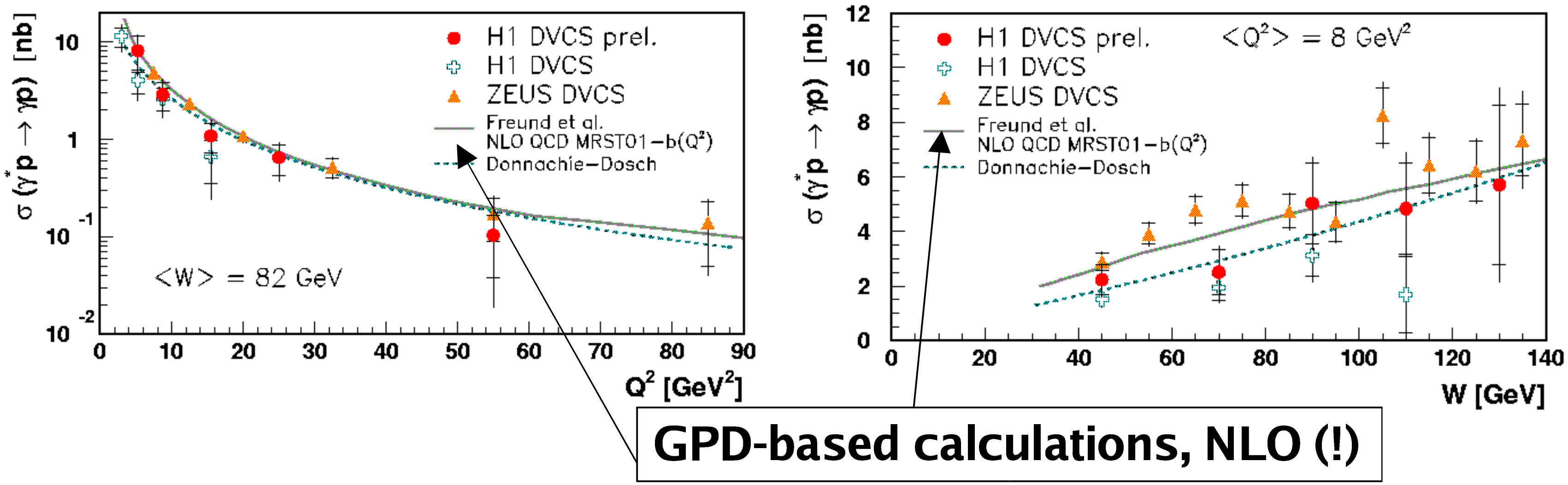
Generalized parton densities

(Arneodo)

- Use deeply virtual compton scattering or exclusive VM production to access parton correlations: $g(x,\mu^2) \rightarrow H(x_1, x_2, t, \mu^2)$







Low *x* and saturation

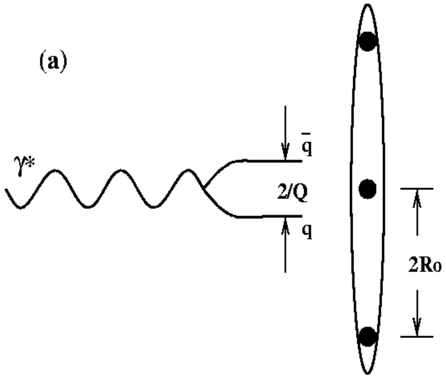
(Arneodo, Munier)

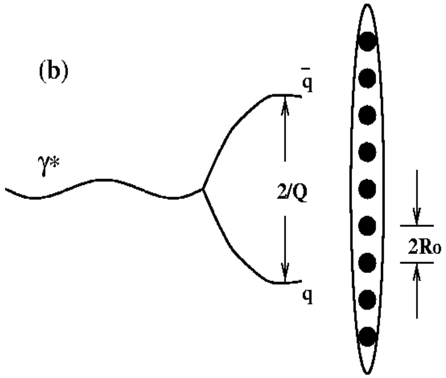
At low x, DGLAP should break down because of large log(1/x) terms

→ visible in specific small-x processes: hard diffraction, forward jets, Mueller-Navelet jets

Various approaches to small x:

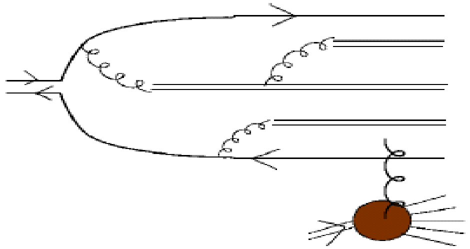
- BFKL, CCFM: → fine, but no unitarity corrections
- Dipole formalism:

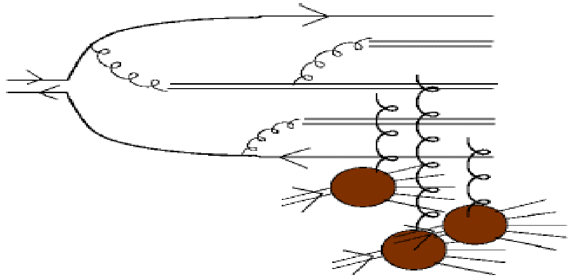




single dipole interaction
~ BFKL

multiple dipole interactions
→ saturation





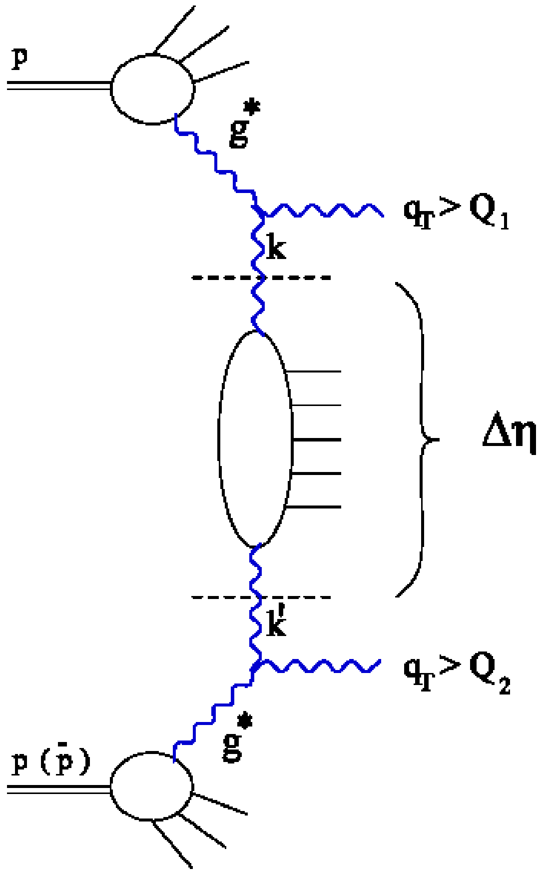
- Colour Glass Condensate: new phase at very high densites → classical strong field?

Saturation at hadron colliders

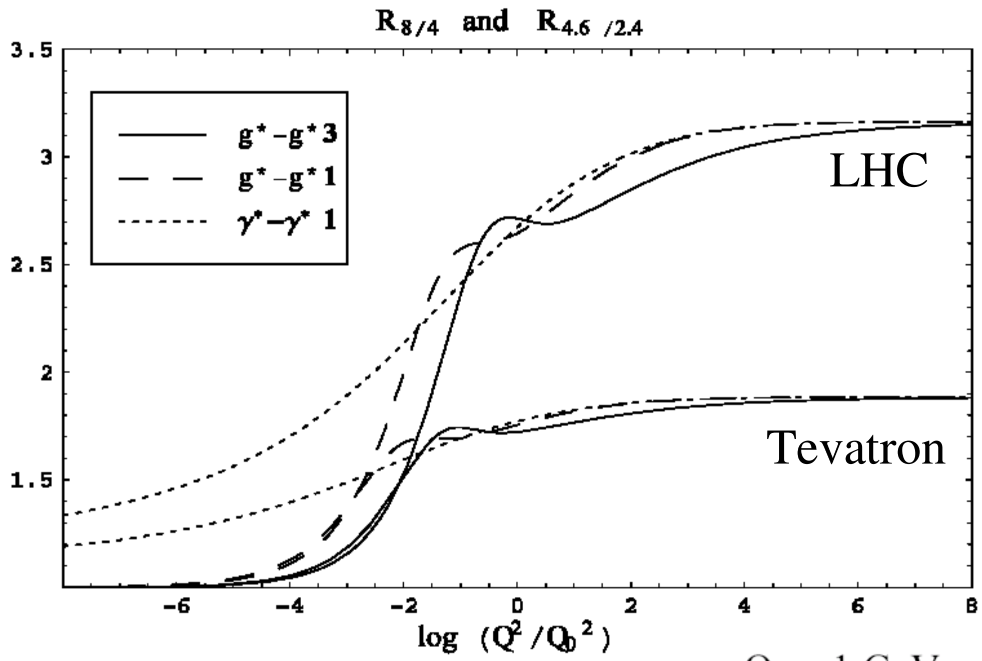
(Marquet)

- Apply GBW model to g* probes

Mueller-Navelet jets:



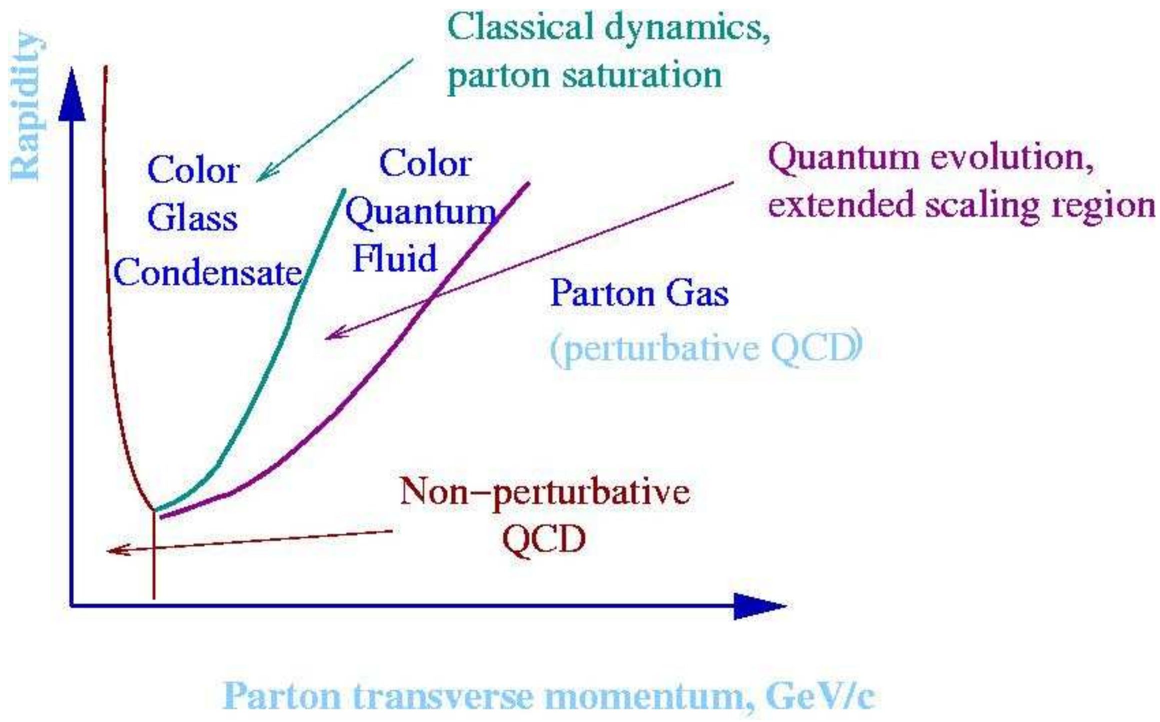
$$R_{i/j} = \frac{\sigma(Q_1, Q_2, \Delta\eta_i)}{\sigma(Q_1, Q_2, \Delta\eta_j)}$$



Other possibilities: heavy VM, charmed and beaty hadrons

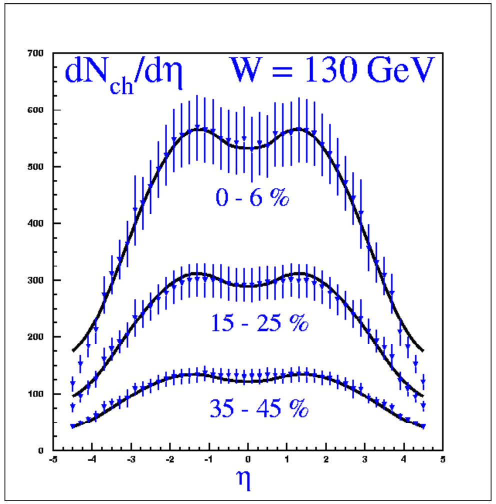
Heavy Ions and High Density QCD

(Kharzeev)



Recent results from RHIC indicate strong non-linear effects at small x!

Color Glass Condensate describes the Au-Au data:



DPE, Diffractive Higgs and All That

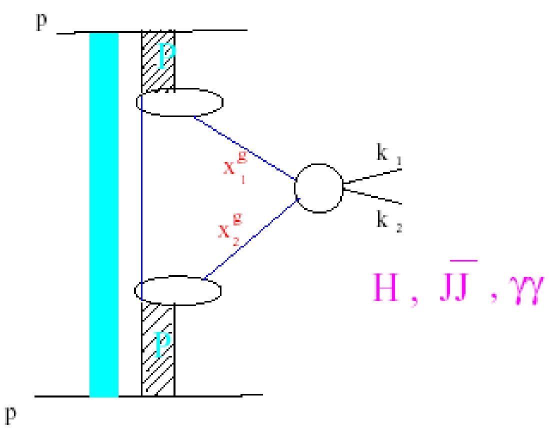
(Cox, Boonekamp, Peschanski, Maor...)

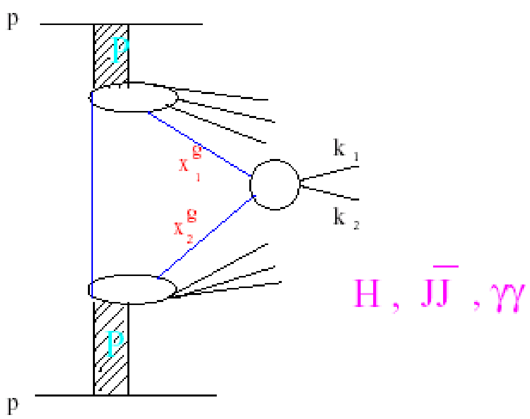
Central exclusive double pomeron exchange pp → p gap X gap p

- improved mass resolution for the centrally produced system
- complementary to standard searches

Diffractive Higgs production:
How reliable are the predictior

→ many models, but they are converging (Maor: “We are not fighting about numbers.”)





What can be done experimentally?

→ DPE at HERA: ep → e' VM gap X gap p'

Experimental feasibility at LHC? (trigger, mass resolution)

Experimental Setups
and Techniques

ZEUS Leading Proton Spectrometer

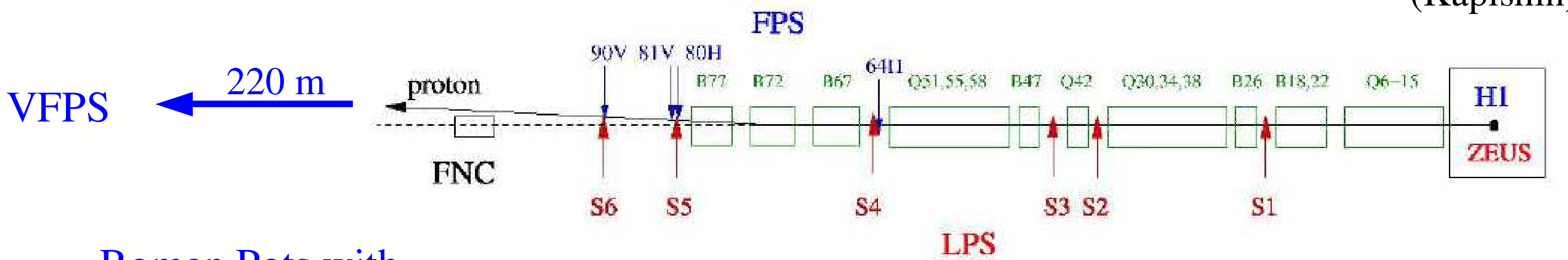
(Sacchi)

- Roman Pots with elliptical shape to fit beam
- 6 detector stations equipped with microstrip silicon detectors (3 orientations each)
- moving into beam is sometimes painful (also at H1)
  ➔ ~50% operation efficiency (close collaboration with HERA operators)
- acceptance: 3-6% for diffraction, ~20% at low x_L
- remove beam halo background with E+pz method

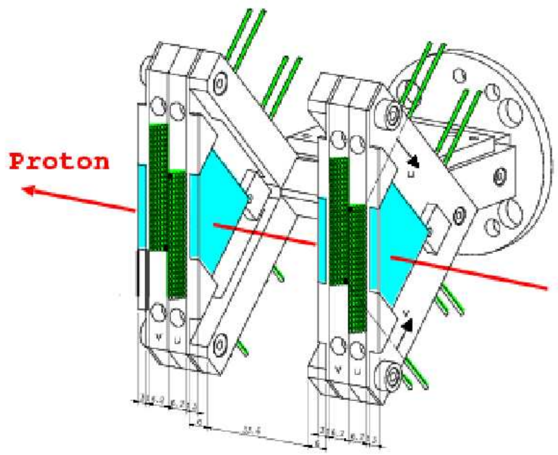
➔ no continuation for HERA-II

H1 (Very) Forward Proton Spectrometer

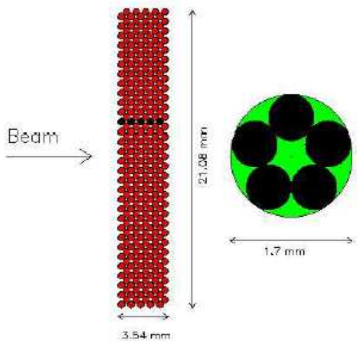
(Kapishin)



Roman Pots with scintillating fibres + PSPM:

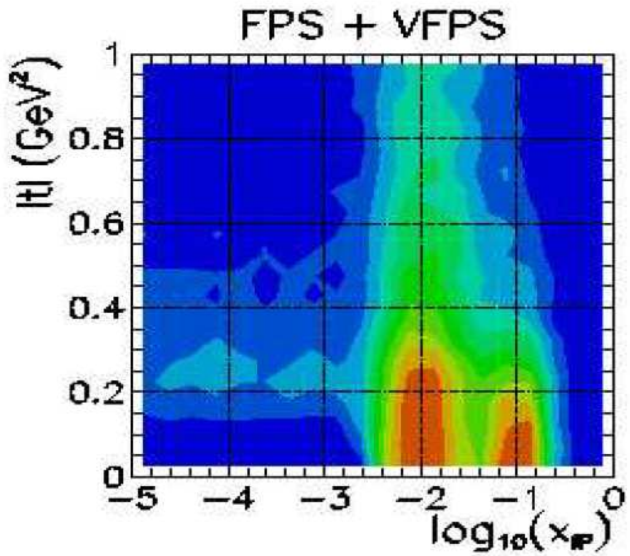


Detector upgrade:



- radiation resistant fibres
- fibre diameter 0.480 mm
- 5 fibres -> 1 light guide
- VFPS

HERA-II acceptance:



Important aspects: • radiation hardness • alignment • reliability • monitoring • redundancy

Forward Neutron Detectors at HERA

(Bunyatyan)

Requirements common to both experiments:

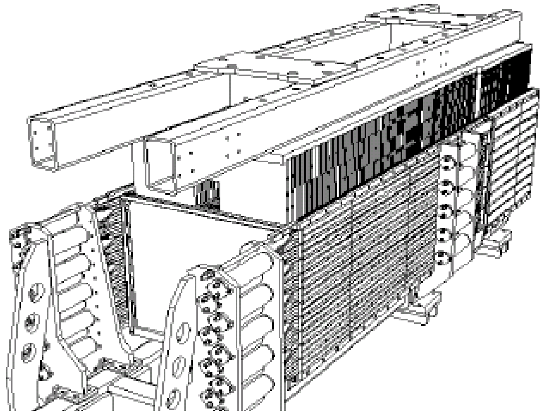
- space limitation: 100 m from IP: 70x70x200 cm^3
- geometrical acceptance defined by beamline (< 0.8 mrad)
- high radiation environment

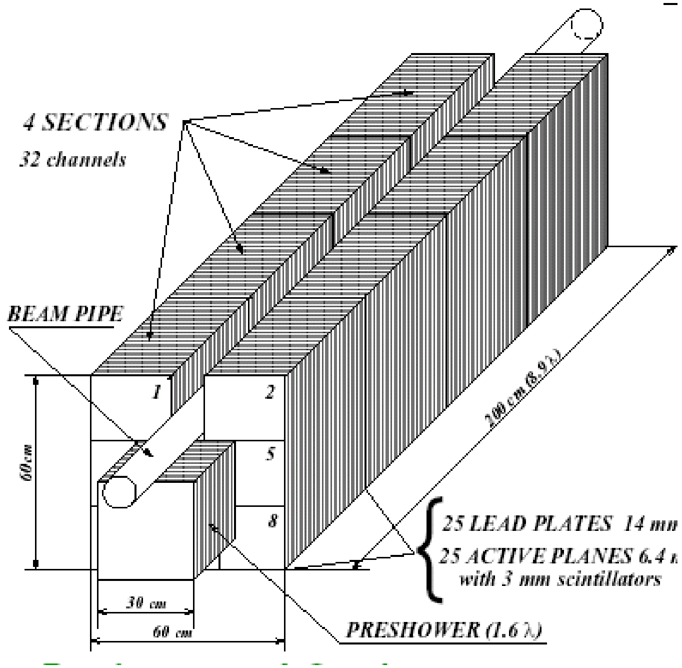
ZEUS

- sampling lead calorimeter
- segmented in front section of 7 λ and read section of 3 λ (separation em/hadronic showers)
- tracker

H1

- HERA-I: Spaghetti-type calorimeter
- HERA-II: lead/scintillator (8 towers) + preshower detector

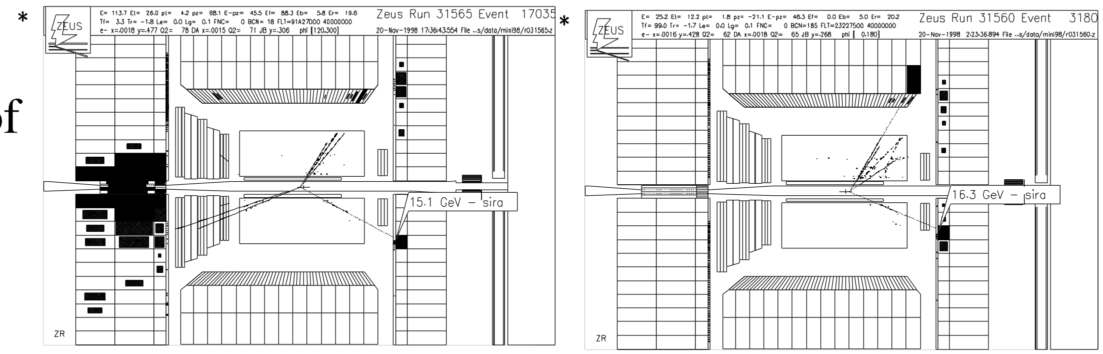




Selecting Diffraction at HERA

- Proton tagging (H1, ZEUS)
  → LPS, (V)FPS
- Rapidity gaps (H1, ZEUS)
  → select events by requirement of no forward energy deposit

Non-Diffraction **Diffraction**



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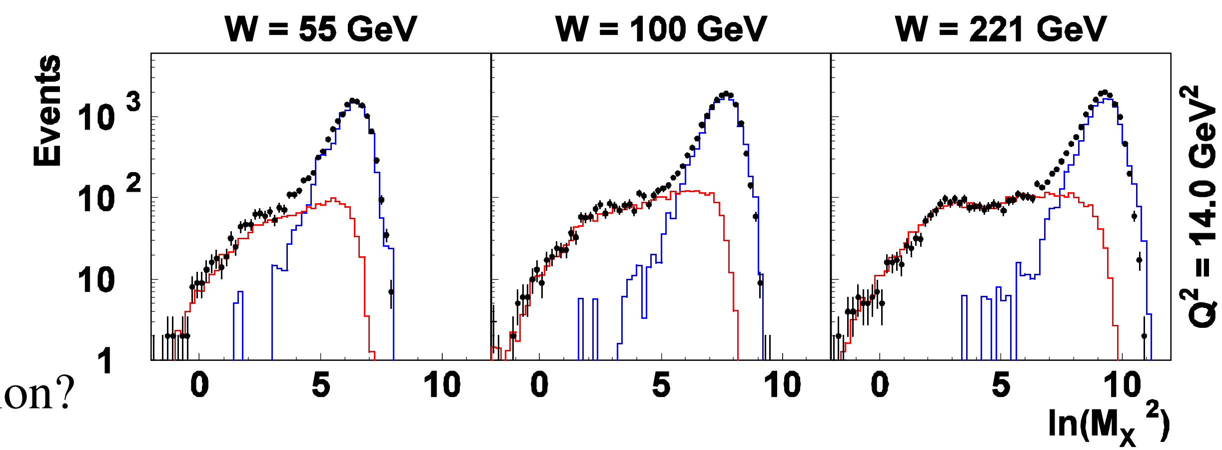
- Invariant mass (ZEUS)
  → subtract non-diffraction using exponenital mass spectrum
- What with proton dissociation?



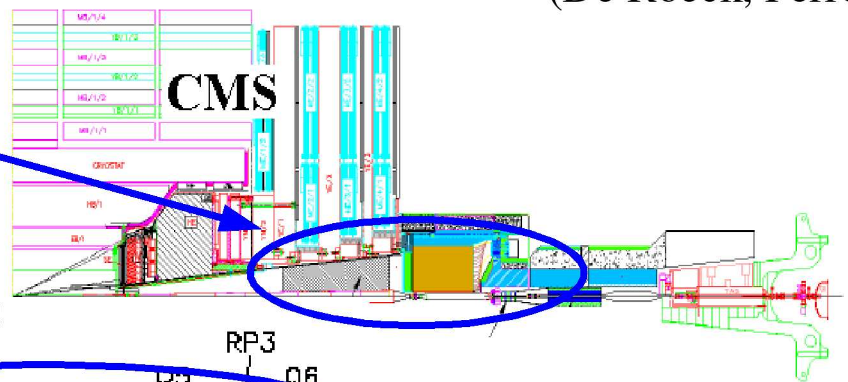
Lesson for LHC: Extend good calorimeter coverage, use as many forwards detectors as possible

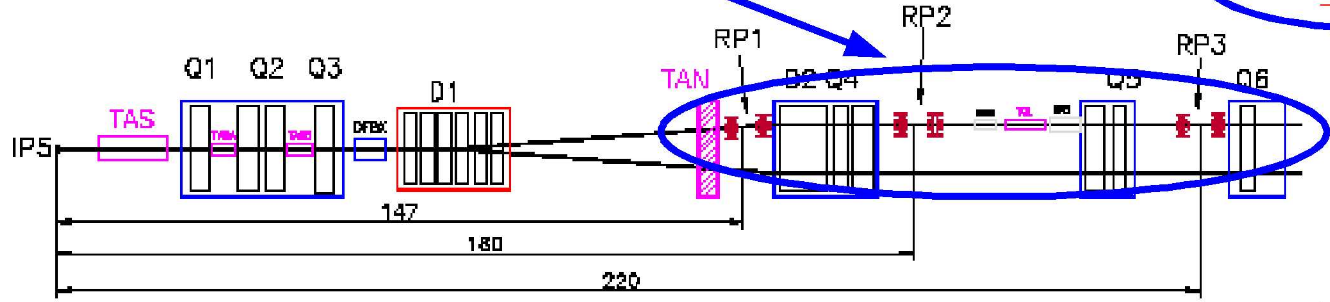
TOTEM

(De Roeck, Ferro)

What is TOTEM?

- T1, T2 trackers to suppress beam-gas bg
- Roman Pots with silicon detectors to measure proton kinematics

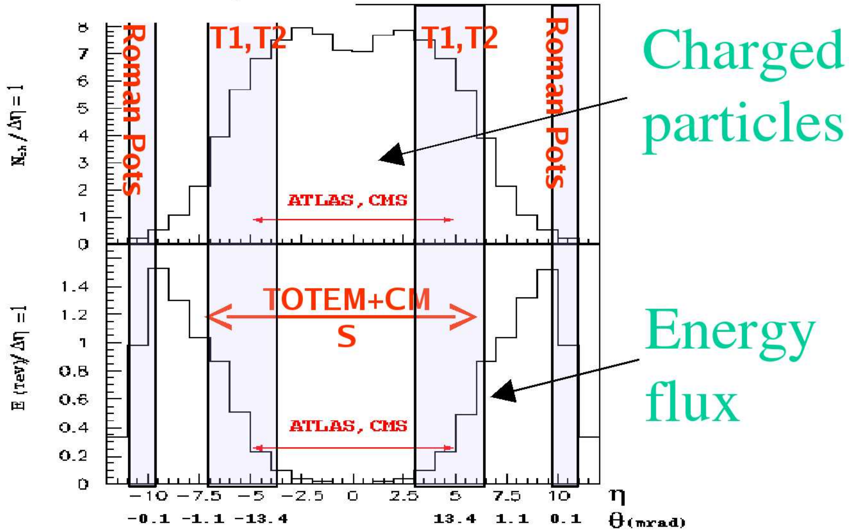




Goal:

- measure σ_{tot} @ 14 TeV to 1% accuracy
- measure σ_{el} for $10^{-3} < -t < 10$ GeV^2
- measure diffractive events in collaboration with CMS

  ➜ **CMS/TOTEM is the largest acceptance detector ever built at a hadron collider**

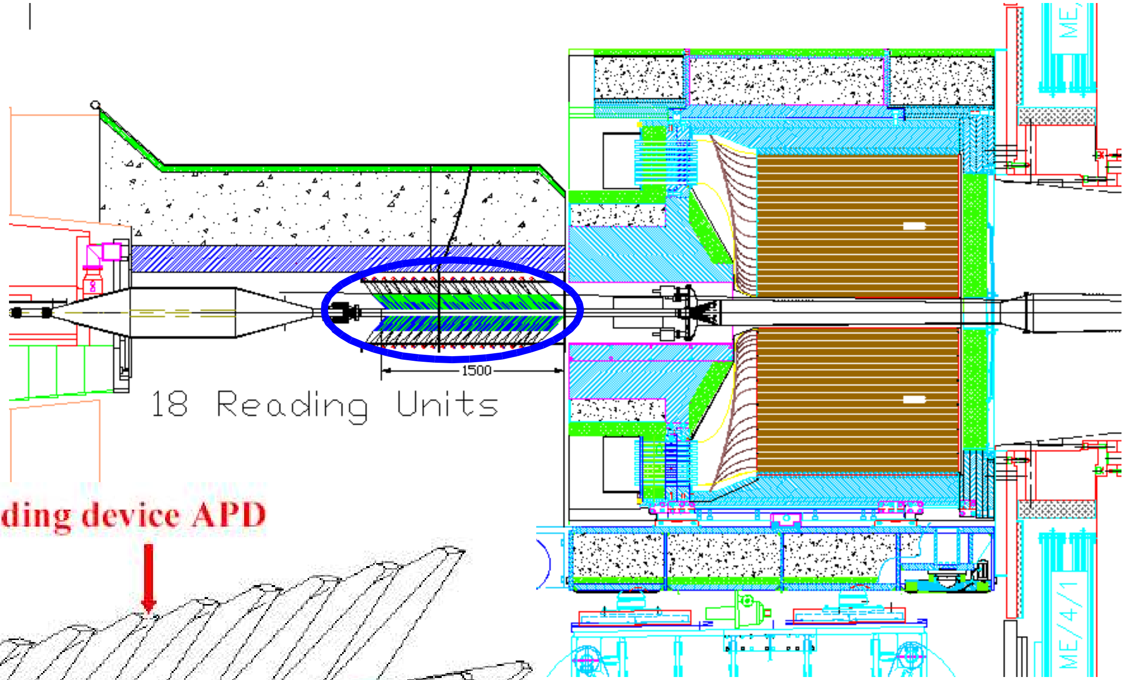


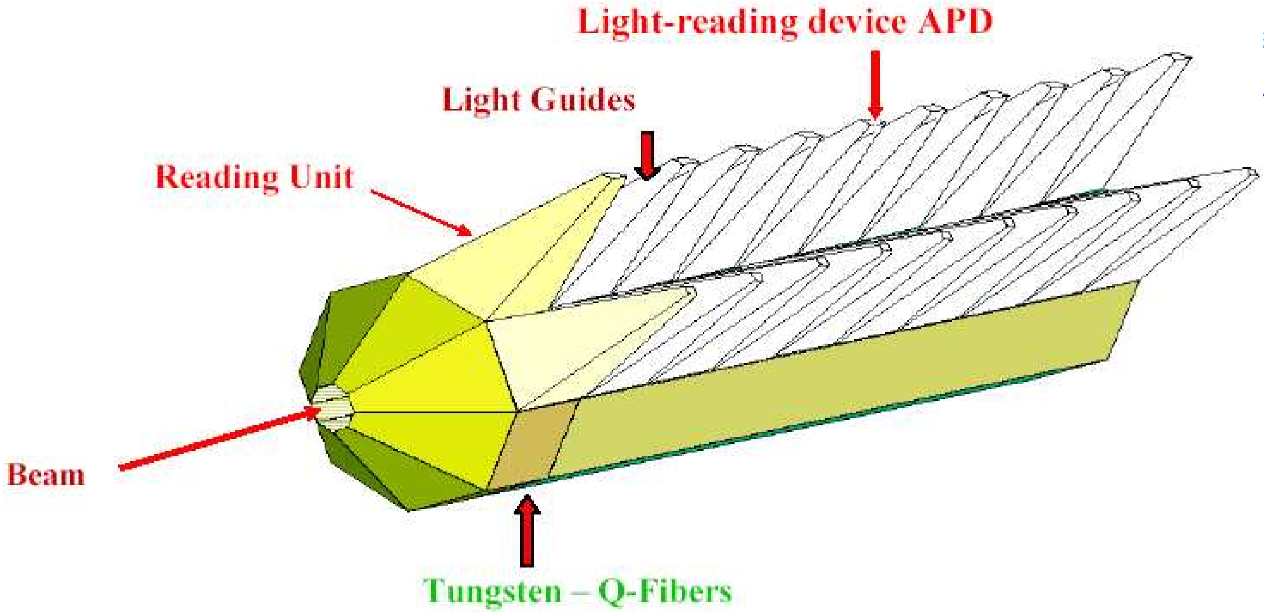
CASTOR

(De Roeck, Panagiotou)

Physics case:

- low-x
- BFKL
- diffraction
- forward energy for cosmics and exotics
- luminosity





- 8 sectors in phi
- 9.7 λ
- $5.3 < |\eta| < 6.6$
  $\rightarrow x = 10^{-5} - 10^{-7}$

Triggering diffraction at CMS

(Grothe)

Aim: L1 trigger (based on calo and muon systems)

Info at L1:

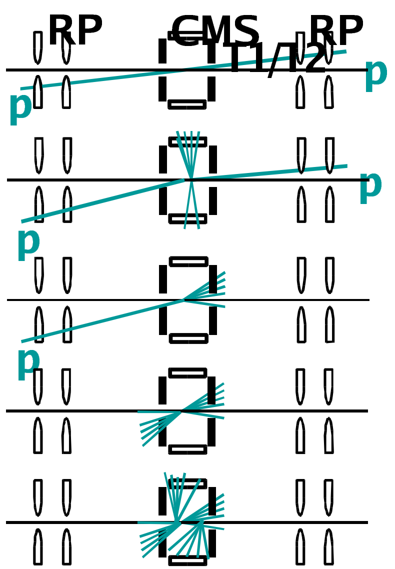
- 4 highest E_T central jets (ECAL and HCAL, |η| < 3)
- 4 highest E_T forward jets (HF, 3 < |η| < 5)
- Ht = sum E_T all jets above threshold

Cut on ratio of sum of 2 E_T jets in central part over Ht

→ exclude jets in forward region (min. rapgap of 2)
→ also true for pile-up events because Ht excludes low E_T
→ problem with energy threshold and rates (t.b.i.)

Alternatives:

- cross-correlating CMS and TOTEM triggers
- CASTOR



Conclusion

Important topics that I did not cover

- Gap survival probability from the Tevatron
- Physics topics in photon-proton and photon-ion interactions at LHC
- Photon and W exchange at the LHC: experimental view

→ I am very, very sorry...

(Biased) homework assignment

(... seen from Hamburg by an experimentalist)

- Have we seen breaking of QCD factorization in diffraction at HERA?
- Unify H1 and ZEUS results
- Saturation: to be picked up at the next meeting!
- Get those new detectors at H1 working...

- Identify benchmark processes for DPE and diffractive Higgs
- Investigate experimental issues for diffractive Higgses at LHC

- Contact the convenors about ideas, opinions, suggestions and tasks for the next meetings!