Working Group on Diffraction

Theory Part

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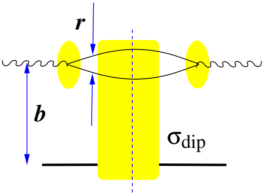
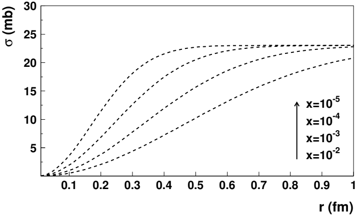
Topics (schematically)

- parton saturation and the dipole picture
  G. Shaw, L. Motyka/H. Kowalski, A.v.Manteuffel
- exclusive Higgs production, input from HERA and Tevatron
  K. Goulianos, M. Taševský, A. Pilkington, V. Khoze, M. Strikman, U. Maor
- searching the odderon
  C. Ewerz

Apologies to those whose work I will hardly/not review here

QCD at high parton densities





tool to describe/quantify in ep collisions: dipole picture

- describes inclusive DIS ($\gamma^* p \to X$), diffractive DIS ($\gamma^* p \to Xp$), exclusive channels ($\gamma^* p \to$ meson p, $\gamma^* p \to \gamma p$) with common non-perturbative input

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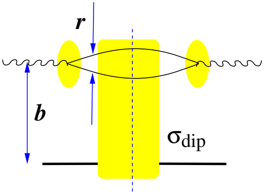
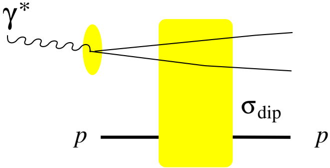




tool to describe/quantify in ep collisions: dipole picture

- describes inclusive DIS ($\gamma^* p \to X$), diffractive DIS ($\gamma^* p \to Xp$), exclusive channels ($\gamma^* p \to$ meson p, $\gamma^* p \to \gamma p$) with common non-perturbative input
- key observation at HERA: same energy dependence of inclusive and diffractive DIS but not for exclusive channels

has natural explanation in saturation model

Inclusive hard diffraction

[K. Golec-Biernat and M. Wüsthoff]

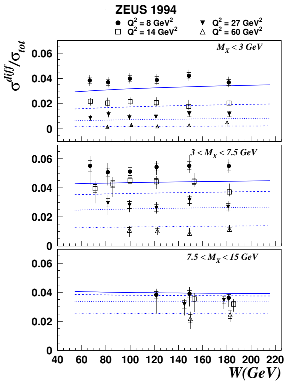
Naively, in perturbative (or Regge) approach

$$\sigma_{\rm tot}(W^2,Q^2) \sim {\rm Im}\mathcal{T} \sim (W^2)^\lambda$$
$$\sigma_{\rm diff}(W^2,Q^2) \sim |\mathcal{T}|^2 \sim (W^2)^{2\lambda}$$

At HERA $\lambda \simeq 0.25$ for large Q^2 but

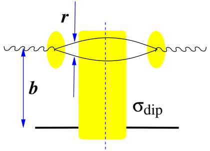
$\sigma_{\rm diff}/\sigma_{\rm tot}$ is flat!

The flat ratio $\sigma_{\rm diff}/\sigma_{\rm tot}$ is obtained only if the lower momentum cut-off scale grows as a power of W^2



... but

- numerical study: can describe inclusive and diffractive DIS
  with our without saturation G. Shaw
- except if include DIS data for $Q^2 \leq 1\,\mathrm{GeV}^2$
  "uncomfortable region" for theory
- numerical accident?
  $\rightsquigarrow$ precision and kinematical reach of data
- important: proper inclusion of impact parameter dependence
  proton more dense in center L. Motyka/H. Kowalski
  affects inclusive and diffractive DIS differently



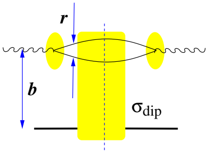
Test dipole description

A.v.Manteuffel

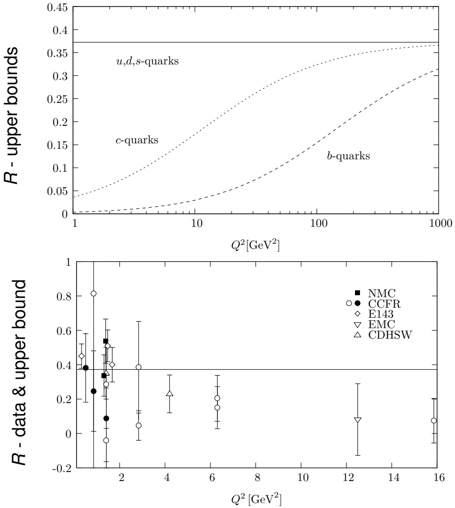
$$F_T(x,Q^2) \propto \int d^2r\, \sigma_{\mathsf{dip}}(r,x)\, \left|\psi_{\gamma_T^*}(r,Q^2)\right|^2$$

$$F_L(x,Q^2) \propto \int d^2r\, \sigma_{\mathsf{dip}}(r,x)\, \left|\psi_{\gamma_L^*}(r,Q^2)\right|^2$$

$\rightsquigarrow$ bounds for ratio $R = F_L/F_T$



C. Ewerz, O. Nachtmann (2006)



Ratio $R = \sigma_L/\sigma_R$: upper bounds from dipole picture and data.

plans to investigate saturation at LHC

huge step in kinematics from HERA

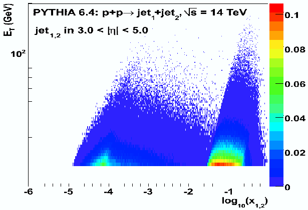
“Prospects for diff and fwd physics at the LHC” - Part 2: “Forward physics” part

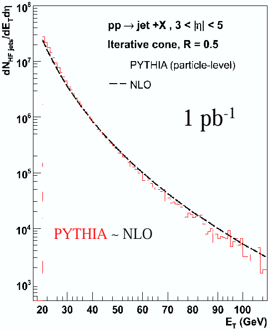
Low-x QCD: Forward jets

Inclusive forward “low-E_T” jet (E_T ~20-100 GeV) production:

$$p + p \to jet1 + jet2 + X$$

Sensitive to gluons with: $x_2 \sim 10^{-4}$, $x_1 \sim 10^{-1}$

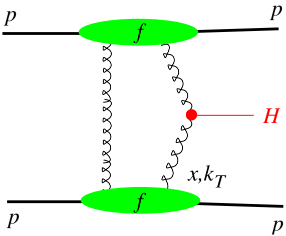




Large expected yields (~10^7 at ~20 GeV) !

Monika Grothe, Prospects for diff and fwd physics at the LHC, HERA-LHC workshop March 2007 14

$p + p \to p + H + p$

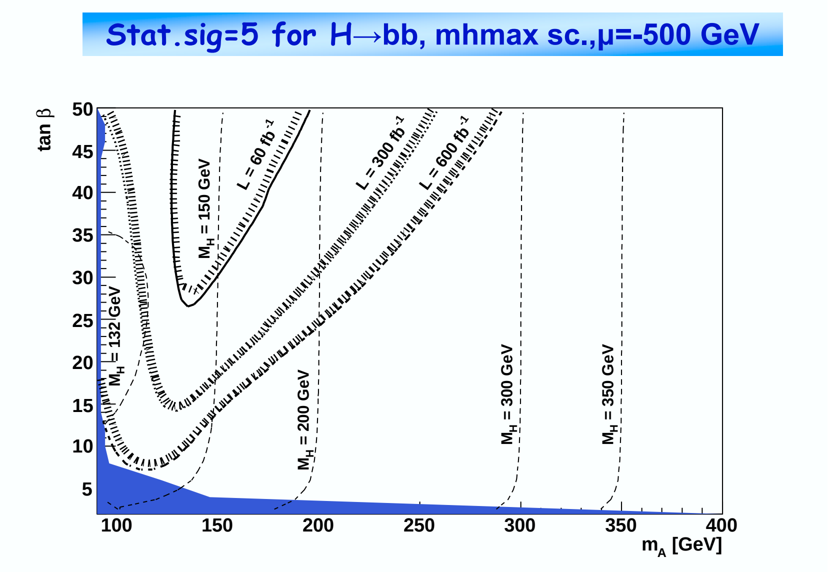


can it be

- measured at LHC?
- calculated?

decay channel $H \to b\bar{b}$

- SM cross section small $\sim 3\,fb$ for $M_H \approx 120\,\mathrm{GeV}$
  $\rightsquigarrow$ very difficult: cuts, triggers, pileup . . . → next talk
- detailed higher-order background calculations
  $gg \to b\bar{b}$, $gg \to b\bar{b} +$ gluons V. Khoze
- enhanced in SUSY scenarios (ggH coupling)
  parameter scan M. Taševský


Stat.sig=5 for H→bb, mhmax sc.,μ=-500 GeV
tan β
m_A [GeV]
L = 60 fb-1
L = 300 fb-1
L = 600 fb-1
M_H = 132 GeV
M_H = 150 GeV
M_H = 200 GeV
M_H = 300 GeV
M_H = 350 GeV
50
45
40
35
30
25
20
15
10
5
100
150
200
250
300
350
400

Higgs production is not everything

gluino production $p + p \to p + \tilde{g}\tilde{g} + p$

A. Pilkington

- if long-lived, gluinos $\tilde{g}$ hadronize
  see two high-p_T "muon-like" particles
- precise mass measurement from outgoing protons and η of gluinos

- The gluino mass can be obtained by just measuring the pseudo-rapidity of the outgoing R-hadrons.
- After applying the trigger and forward detector acceptance, we find for high luminosity statistics ($300 fb^{-1}$):

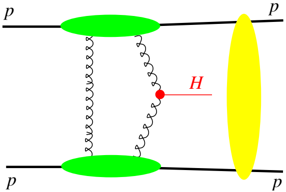
$m_{\tilde{g}}$ (GeV)	$\sigma_{m_{\tilde{g}}}$ (GeV)	$\frac{\sigma_{m_{\tilde{g}}}}{\sqrt{N-1}}$ (GeV)	N
200	2.31	0.19	145
250	2.97	0.50	35.0
300	3.50	1.10	10.2
320	3.61	1.54	6.5
350	3.87	2.45	3.5

- It is possible to measure the gluino mass to approximately 1% using forward detectors up to $m_{\tilde{g}} \sim 350\text{GeV}$.

How reliable are the rate predictions?

rescattering $\rightarrow$
gap survival probability

closely related to
multiple interactions



- impact parameters selected by hard subprocess
  $\rightarrow$ rescattering rate
- transverse distribution of partons correlated with x
  - J/Ψ production (gluons),
    hope for more data on $\gamma^* p \rightarrow J/\Psi\, p$ and $\gamma^* p \rightarrow \gamma p$
  - lattice calculations (quarks at large x)

  important for gap survival prob. M. Strikman
- description of soft rescattering from pp data
  model dependence in extraction of parameters U. Maor

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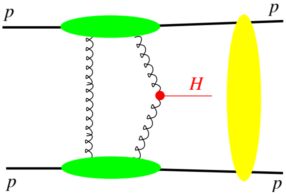

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  important for gap survival prob. — M. Strikman
- description of soft rescattering from pp data
  model dependence in extraction of parameters — U. Maor
- do we understand the dynamics at all?

validate models using data from HERA and Tevatron

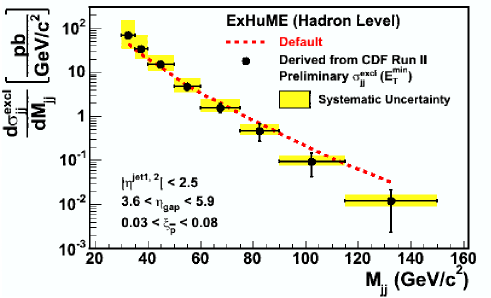
K. Goulianos, V. Khoze

JJ_{excl} : cross section predictions

ExHuME Hadron-Level Differential Exclusive Dijet Cross Section vs Dijet Mass

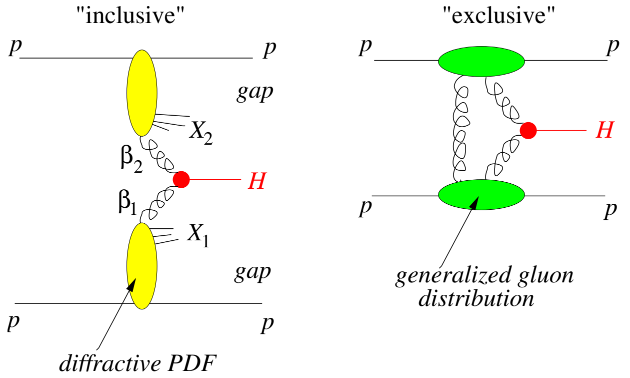
(dotted/red): Default ExHuME prediction

(points): Derived from CDF Run II Preliminary excl. dijet cross sections



Statistical and systematic errors are propagated from measured cross section uncertainties using ExHuME M_{jj} distribution shapes.

non-exclusive background



- dangerous region: $\beta_{1,2} \to 1$
- input: diffractive PDFs from HERA
- backg'd estimate significantly lower with new (2006) H1 fits

but caveats remain P. Newman, M. Mozer

large mom. fractions not constrained by inclusive diffract. DIS

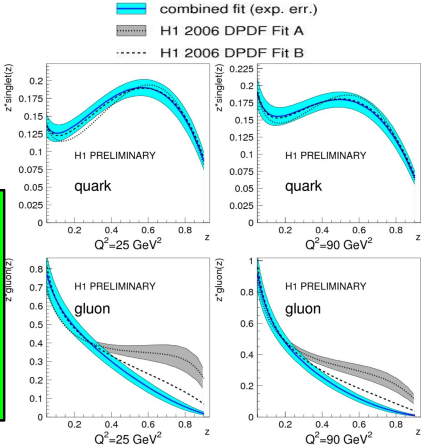
⇝ dijets

Improved parton densities

- χ^2/ndf=196/217
- χ^2/ndf (dijets)=27/36
- χ^2/ndf (F_2^D)=169/190

- χ^2(Fit A)=158
- χ^2(Fit B)=164

- good agreement for singlet and low z_{IP} gluon
- improved measurement of high z_{IP} gluon
- soon to be published



side remark:

H1 analysis of diffractive structure function — P. Newman

- use standard NLO DGLAP formalism
  only data with $M_X > 2\,\mathrm{GeV}$, $\beta < 0.8$
  usual DIS: W x_B
- finds problems when fitting data with $Q^2 < 8.5\,\mathrm{GeV}^2$
  not localized at particular β
  - NNLO effects ? $\rightsquigarrow$ can be included
  - higher twist ??
  - implications for DIS ???

Conclusions

Saturation

- to establish saturation at HERA remains hard
- no huge effects $\rightsquigarrow$ demand on
  precision and kinematic coverage of data
  many observables $\rightsquigarrow$ cross checks of theory framework
- prospects to study high-density regime in pp LHC

Exclusive diffraction at LHC

- may offer valuable information on physics $>$ SM
- continuing efforts to calculate signal and background
  important part of physics connected with multiple interactions
- essential input from HERA and Tevatron data