Overview on diffraction

a theorist's perspective

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✓ **Definition and challenges of diffractive processes: “Mind the gap!”**

✓ **Historical outlook: The Pomeron**

✓ **Theoretical status and issues of hard diffraction: Are we satisfied?**

- ★ *Diffractive factorisation concept*
- ★ *Durham approach*
- ★ *Color Dipole approach*
- ★ *Soft Color Screening approach*

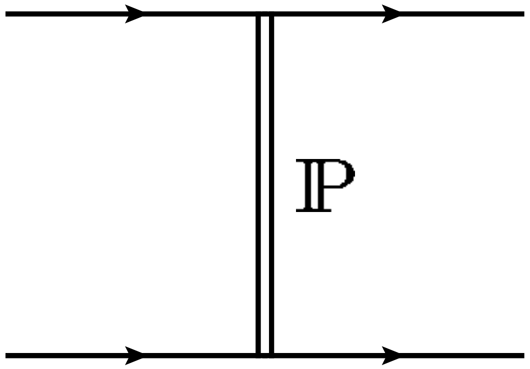
✓ **(Some) existing data on diffraction: What do we (want to) learn?**

- ★ *HERA*
- ★ *Tevatron*
- ★ *LHC*

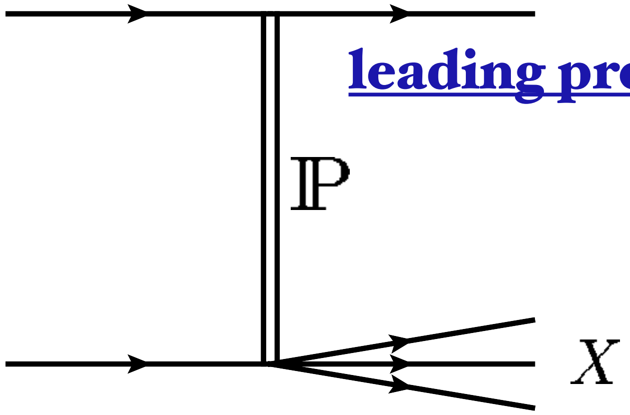
✓ **Summary**

Definition of diffraction

elastic

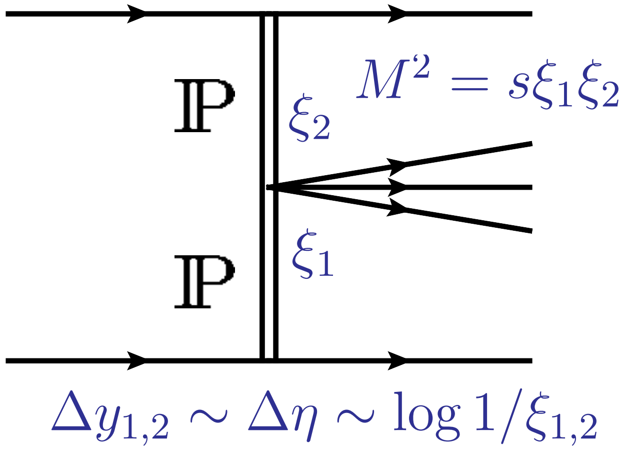


single diffractive

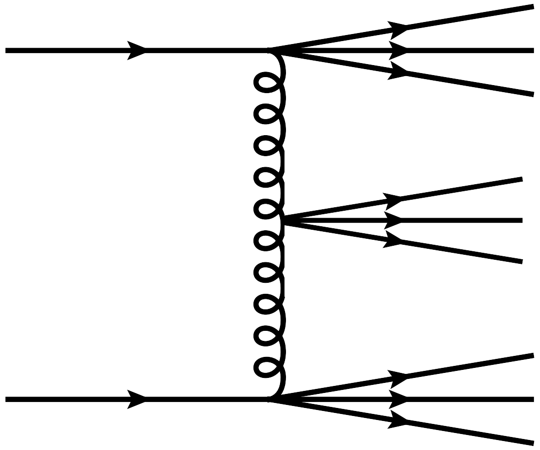


leading proton!

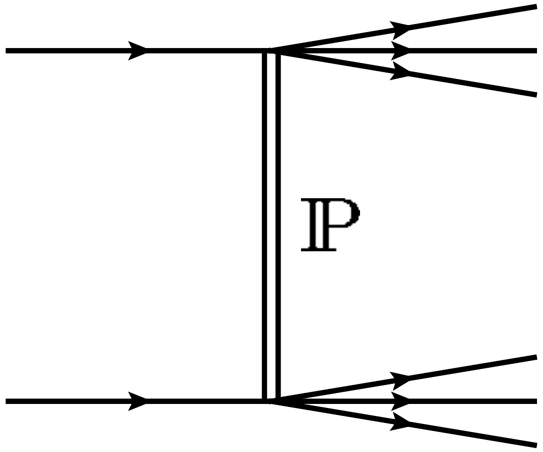
central exclusive



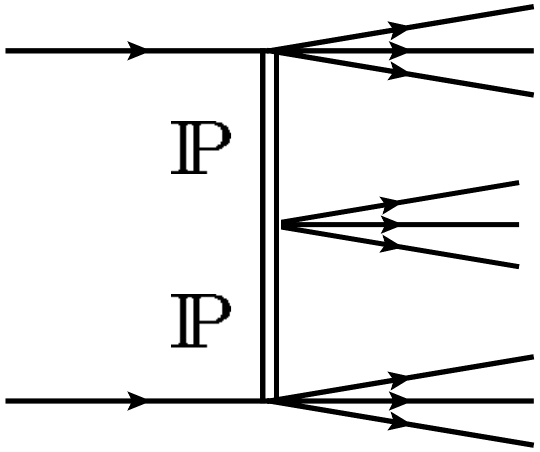
non-diffractive (inclusive)



double diffractive



DPE



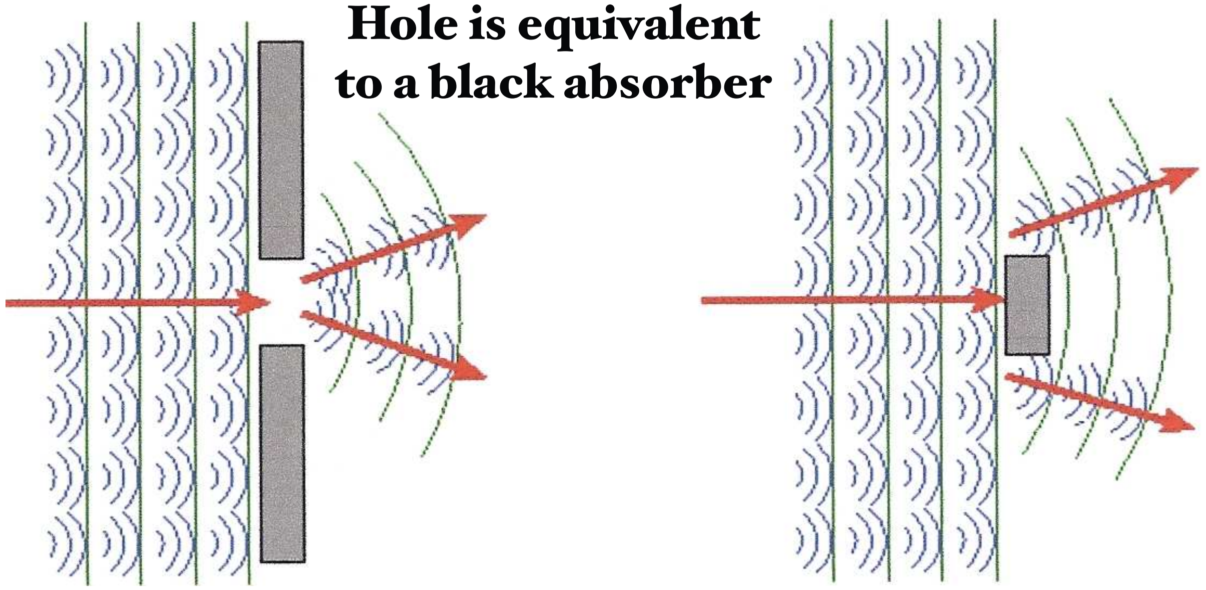
Basic features of diffraction:

- ★ *no quantum numbers are exchanged*
- ★ *a new (diffractive) state is produced*
- ★ *characterised by large LRGs*
- ★ *mainly peripheral phenomenon (large b)*

> "The diffractive process is caused by **t-channel Pomeron exchange** i.e. by the exchange corresponding to the rightmost singularity in the complex angular momentum plane with vacuum quantum numbers.." A. Martin

Analogy with optical diffraction

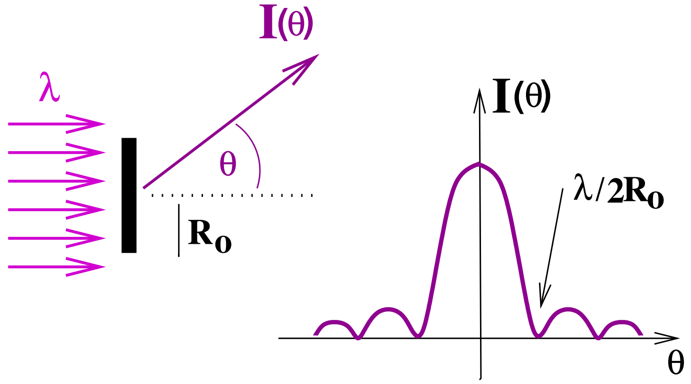
Hadronic diffraction is the shadow of absorption into inelastic channels



Hole is equivalent to a black absorber

Forward peak at small angles

$$\theta \sim \frac{\lambda}{\text{opening width}}$$



The intensity

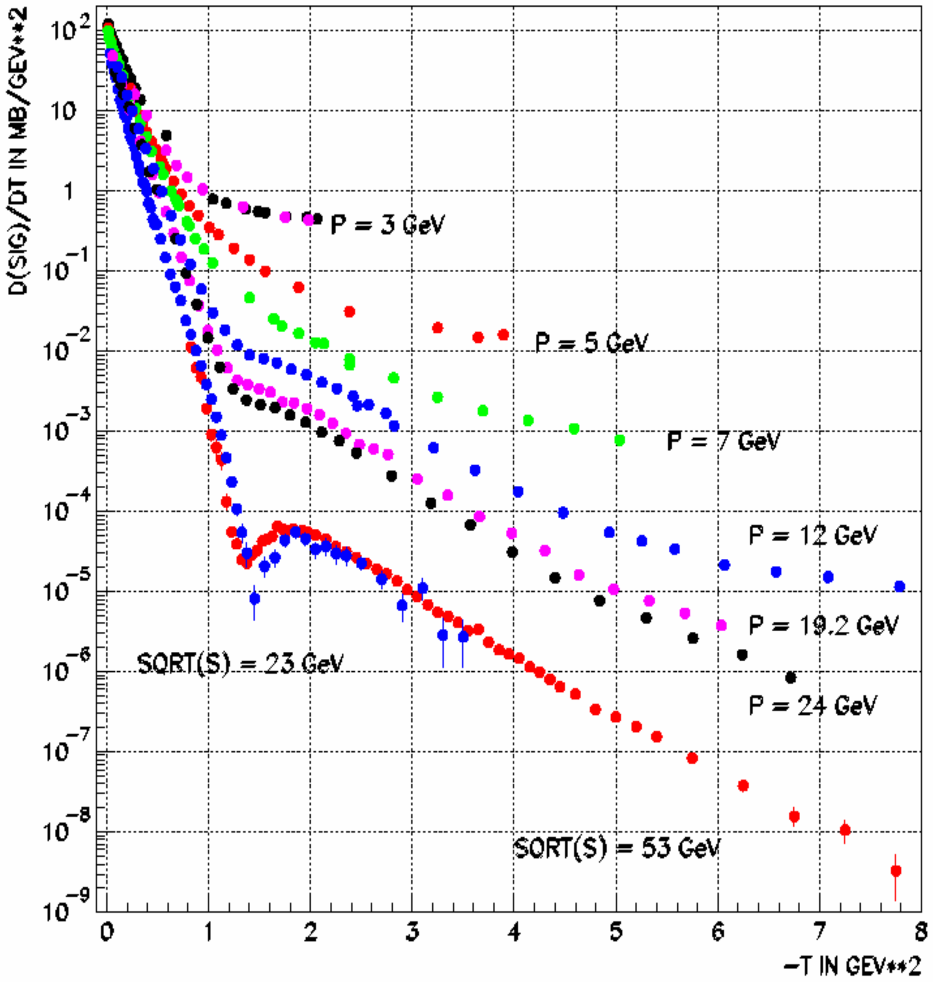
$$\frac{I(\theta)}{I(\theta=0)} = \frac{[2J_1(x)]^2}{x^2} \simeq 1 - \frac{R_0^2}{4}(k\theta)^2 \qquad k = 2\pi/\lambda$$

The diffractive cross section

The diffractive slope in terms of the target size

$$\frac{\frac{d\sigma}{dt}(t)}{\frac{d\sigma}{dt}(t=0)} \simeq e^{-b|t|} \simeq 1 - b\,(P\theta)^2 \qquad b = R^2/4,$$

scattering angle



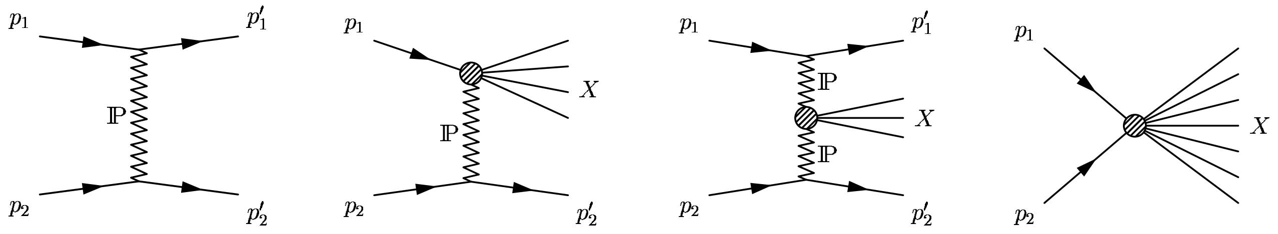
Arneodo and Diehl

Challenges: theory vs experiment

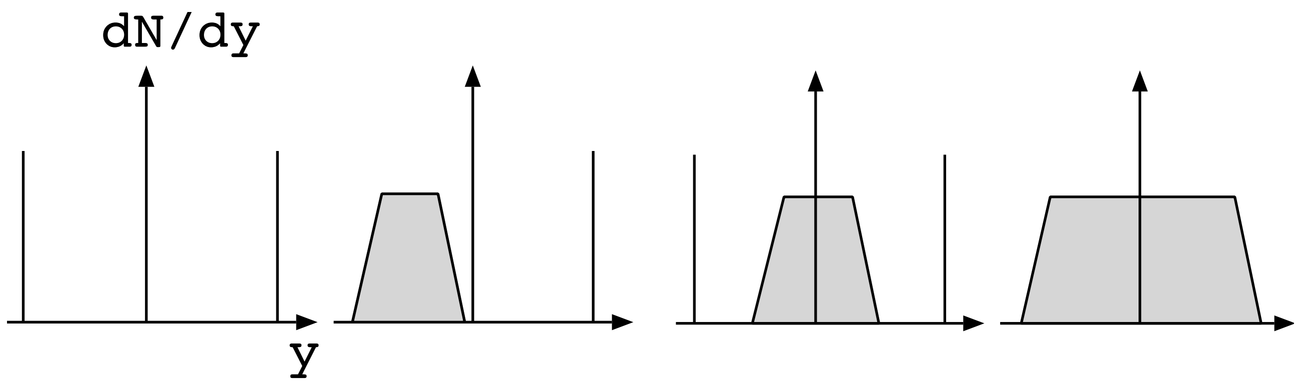
✓ **The definition of diffraction is not unique**

Theoretically:

★ *exchange of vacuum quantum numbers*



elastic scattering | single diffraction | double $I\!\!P$ exchange | inelastic scattering



Experimentally:

★ *intact protons and/or rapidity gaps (no hadron activity)*

★ *gap definition*

mapping is not one to one!

Rapidity $y = \frac{1}{2} \ln \frac{E+p_z}{E-p_z}$
$\approx -\ln \tan \frac{\theta}{2} = \eta$ pseudorapidity

✓ **QCD modelling of diffraction is a major problem**

★ *fluctuations during the hadronisation process (protons from recombination? gap size?)*

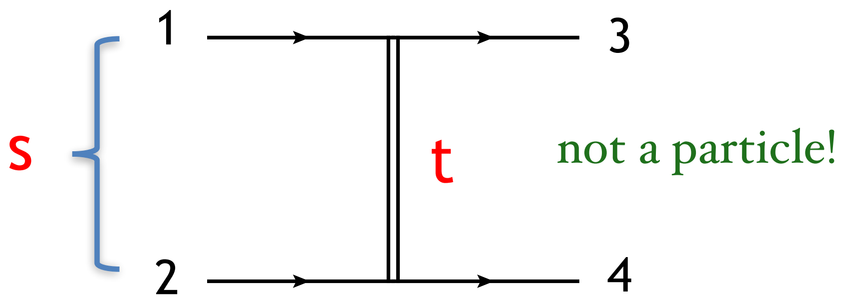
★ *low vs high mass diffractive dissociation*

★ *soft vs hard Pomeron*

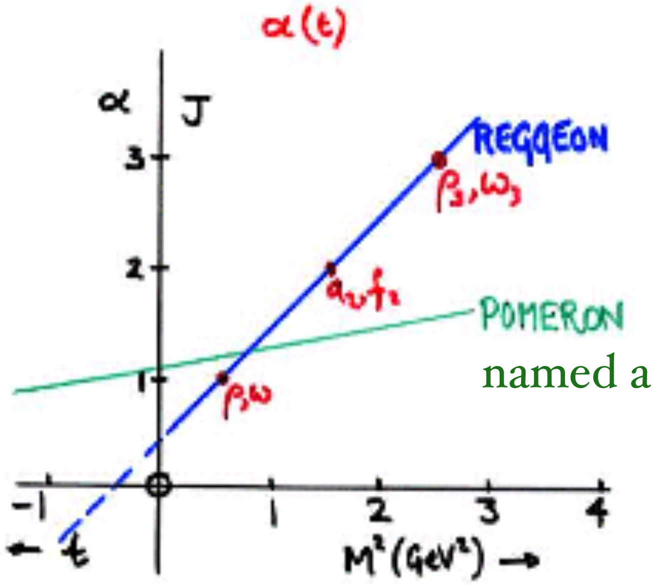
★ *hard-soft factorisation breaking, etc*

huge sensitivity to details!

Soft Donnachie-Landshoff Pomeron

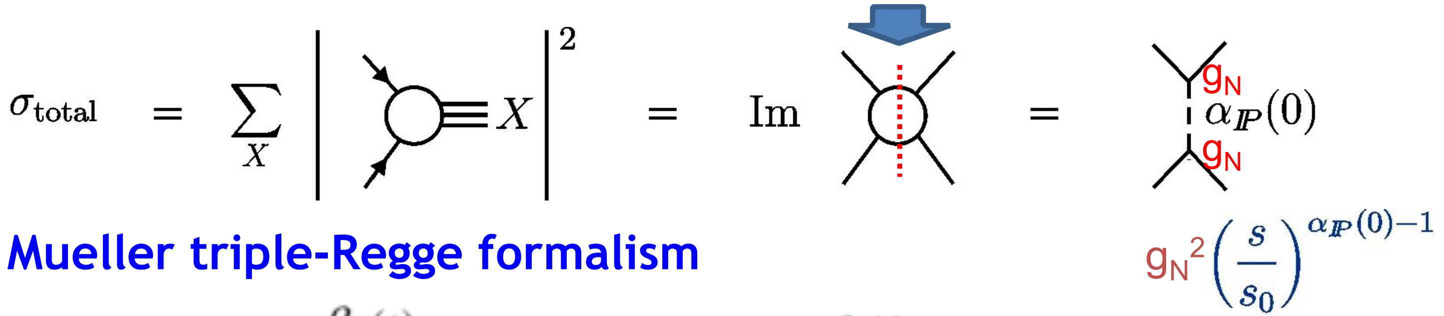


- **interpreted in QCD as a >two gluon exchange**
- **not a simple pole but enigmatic non-local object**

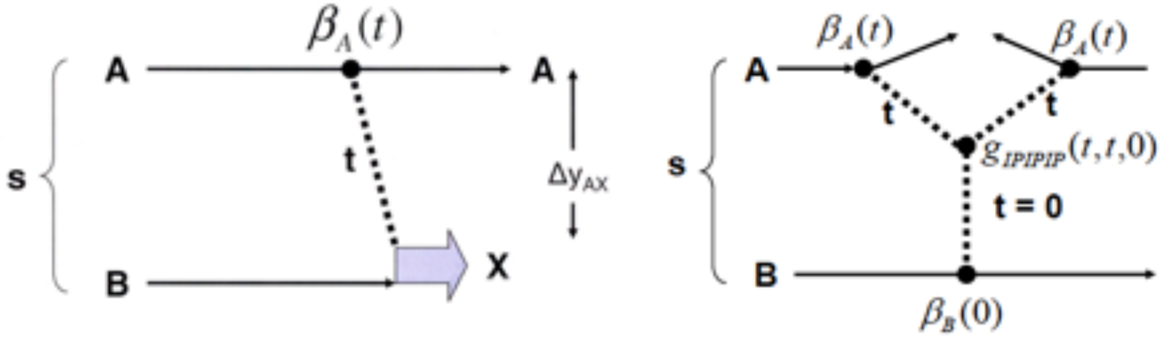


named after Pomeranchuk

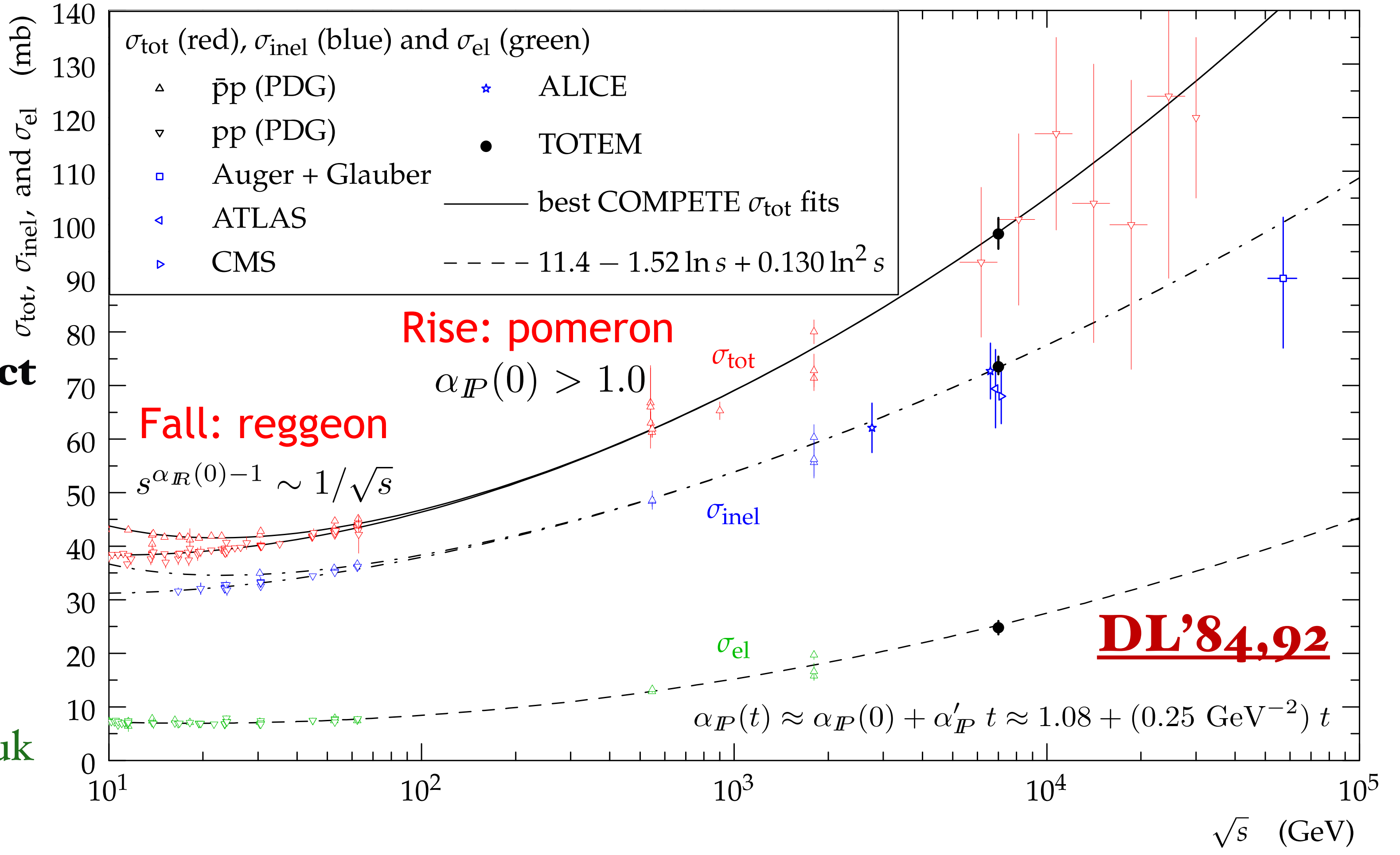
optical theorem



Mueller triple-Regge formalism



Albrow, Coughlin, Forshaw, Prog.Part.Nucl.Phys 65 (2010) 149



Rise in total and elastic CS: "discovery" of Pomeron!

Pomeron "flux"

$$\frac{d\sigma}{dt\,d\xi} = f_{I\!P/A}(\xi,t)\,\sigma_{BI\!P}(M_X^2,t) \qquad M_X^2 = \xi s$$

$$\sigma_{BI\!P}(M_X^2,t) \propto (M_X^2)^{\alpha_{I\!P}(0)-1}$$ **at large** M_X

$$\sigma \sim g_{pP}^2(t)\, g_{pP}(0)\, g_{3P} \left(\frac{s}{M_X^2}\right)^{2(\alpha(t)-1)} (M_X^2)^{(\alpha(0)-1)}$$

Good-Walker formulation

R. J. Glauber, Phys. Rev. 100, 242 (1955).
E. Feinberg and I. Ya. Pomeranchuk, Nuovo. Cimento. Suppl. 3 (1956) 652.
M. L. Good and W. D. Walker, Phys. Rev. 120 (1960) 1857.

Projectile has a substructure!

Diffractive excitation determined by the fluctuations

Hadron cannot be excited:
not an eigenstate of interaction!

$$|h\rangle = \sum_{\alpha=1} C^h_\alpha |\alpha\rangle \qquad \hat{f}_{el}|\alpha\rangle = f_\alpha |\alpha\rangle$$

Completeness and orthogonality

$$\langle h'|h\rangle = \sum_{\alpha=1} (C^{h'}_\alpha)^* C^h_\alpha = \delta_{hh'}$$

$$\langle \beta|\alpha\rangle = \sum_{h'} (C^{h'}_\beta)^* C^{h'}_\alpha = \delta_{\alpha\beta}$$

semi-hard/
semi-soft

soft

	$\lvert C_\alpha\rvert^2$	σ_α	$\sigma_{tot} = \sum_{\alpha=soft}^{hard} \lvert C_\alpha\rvert^2 \sigma_\alpha$	$\sigma_{sd} = \sum_{\alpha=soft}^{hard} \lvert C_\alpha\rvert^2 \sigma^2_\alpha$
Hard	~ 1	$\sim \frac{1}{Q^2}$	$\sim \frac{1}{Q^2}$	$\sim \frac{1}{Q^4}$
Soft	$\sim \frac{m_q^2}{Q^2}$	$\sim \frac{1}{m_q^2}$	$\sim \frac{1}{Q^2}$	$\sim \frac{1}{m_q^2 Q^2}$

Elastic and single diffractive amplitudes

$$f^{h\to h}_{el} = \sum_{\alpha=1} |C^h_\alpha|^2 f_\alpha$$

$$f^{h\to h'}_{sd} = \sum_{\alpha=1} (C^{h'}_\alpha)^* C^h_\alpha f_\alpha$$

Single diffractive cross section

$$\sum_{h'\neq h} \left.\frac{d\sigma^{h\to h'}_{sd}}{dt}\right|_{t=0} = \frac{1}{4\pi}\left[\sum_{h'} |f^{hh'}_{sd}|^2 - |f^{hh}_{el}|^2\right]$$

$$= \frac{1}{4\pi}\left[\sum_\alpha |C^h_\alpha|^2 |f_\alpha|^2 - \left(\sum_\alpha |C^h_\alpha| f_\alpha\right)^2\right] = \boxed{\frac{\langle f^2_\alpha\rangle - \langle f_\alpha\rangle^2}{4\pi}}$$

Dispersion of the eigenvalues distribution

Important basis for the dipole picture!

Unitarity corrections

DL Pomeron breaks the unitarity bound at small b at a few TeV already

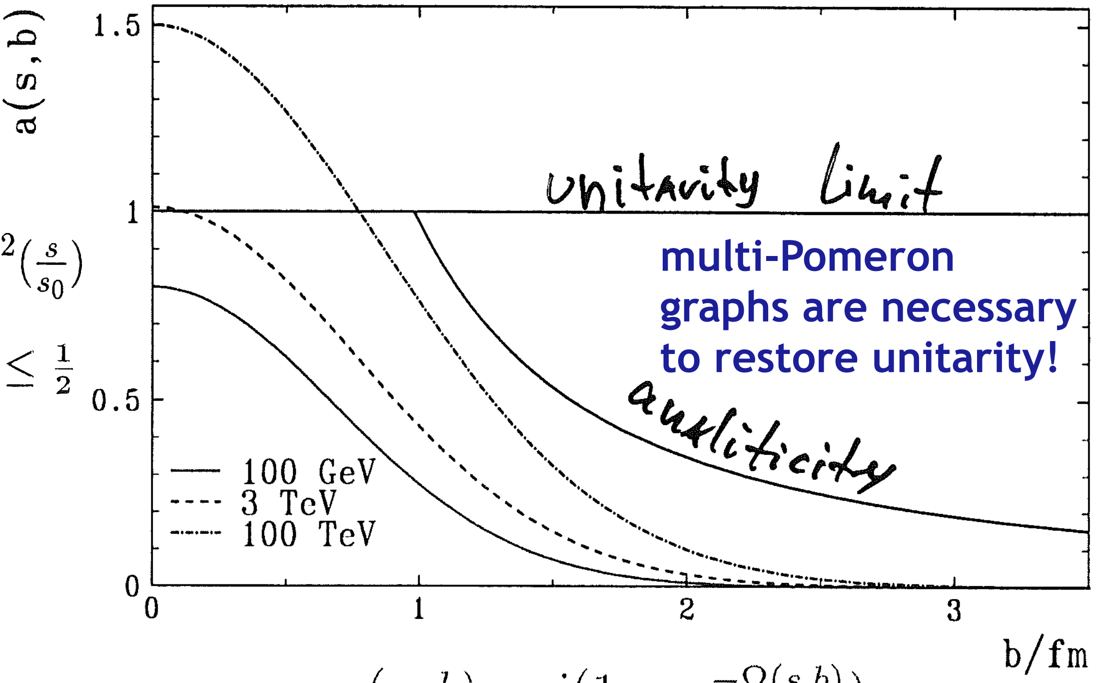
$\sigma_{tot} \propto s^{0.08}$

$\sigma_{el/diff} \propto s^{0.16+0.5t}$

violate bounds

Froissart $\sigma_{tot} \leq \sigma^{\mathrm{FR}} = \frac{\pi}{m_\pi^2} \ln^2(\frac{s}{s_0})$

Pumplin $(\sigma_{el} + \sigma_{diff})/\sigma_{tot} \leq \frac{1}{2}$



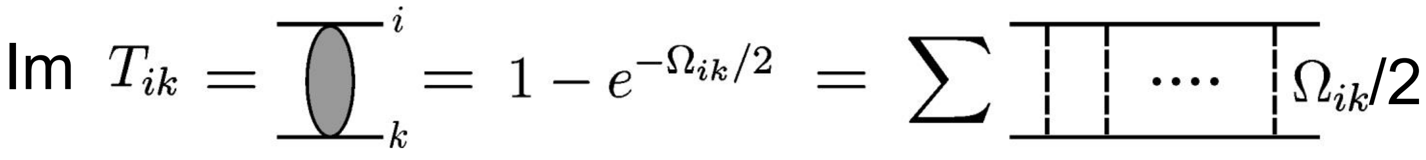
multi-Pomeron graphs are necessary to restore unitarity!

$$a(s,b) = i(1 - e^{-\Omega(s,b)})$$

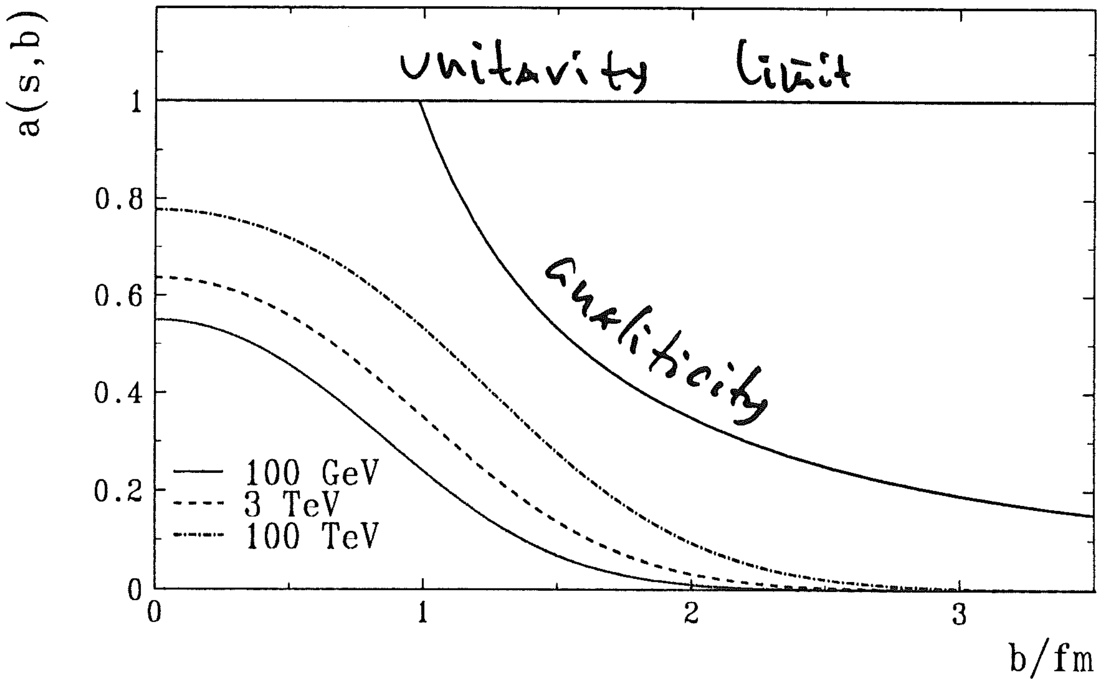
Unitarity can be restored by eikonalisation!

Reggeon Field Theory, Gribov- 1986

in terms of diffractive eigenstates ϕ_i, ϕ_k which undergo only elastic scatterings

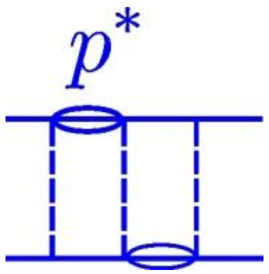


$$\text{Im}\ T_{ik} = \quad = 1 - e^{-\Omega_{ik}/2} = \sum \quad \Omega_{ik}/2$$

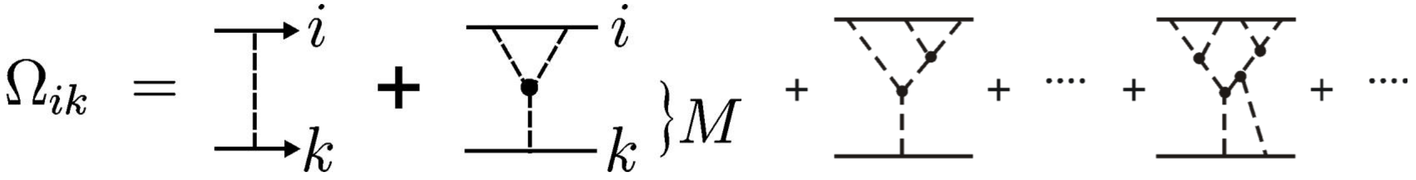


Low-mass diffractive dissociation

multichannel eikonal model



high-mass diffractive dissociation



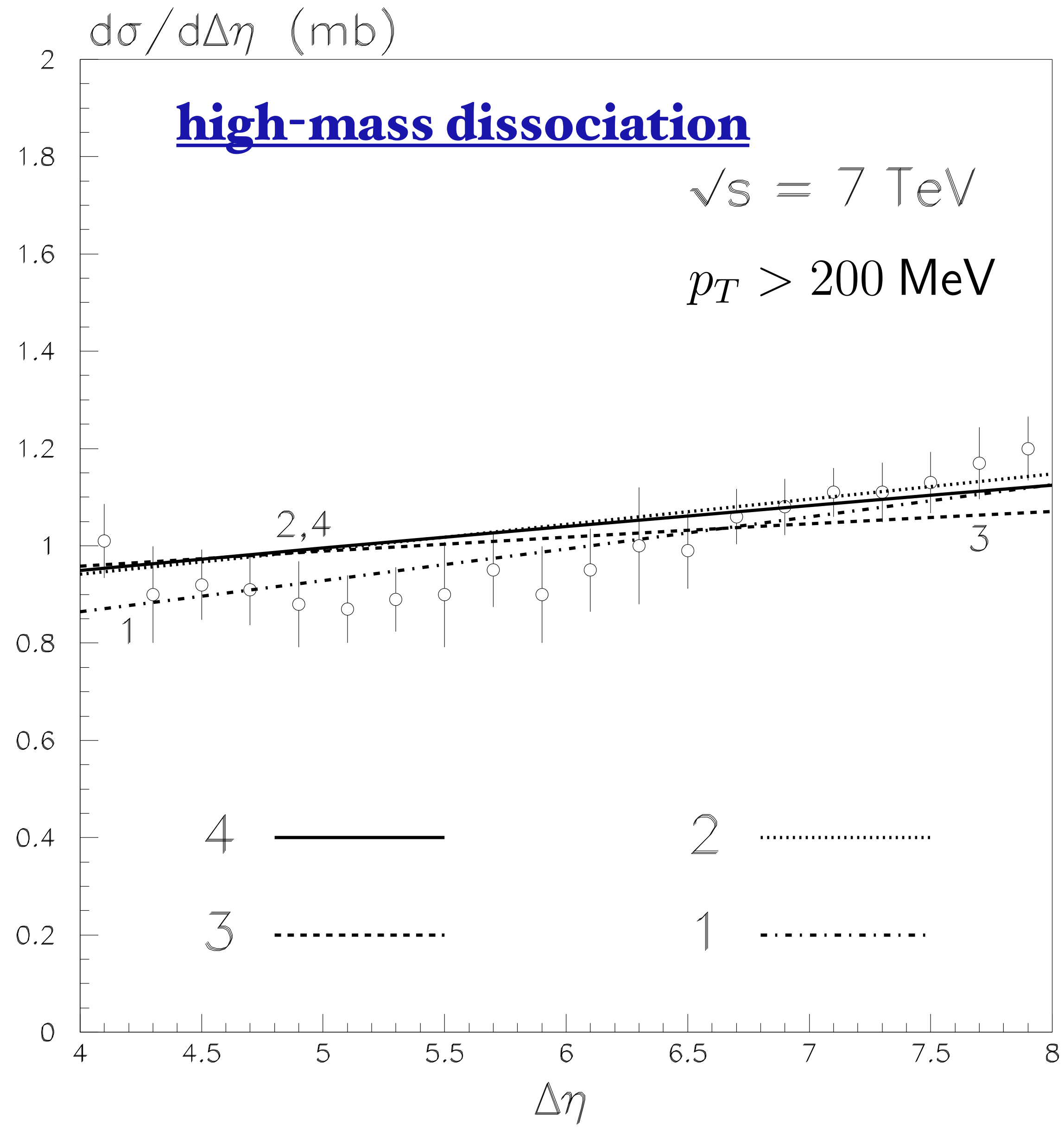
$$\Omega_{ik} = \quad + \quad \}M \quad + \quad + \cdots + \quad + \cdots$$

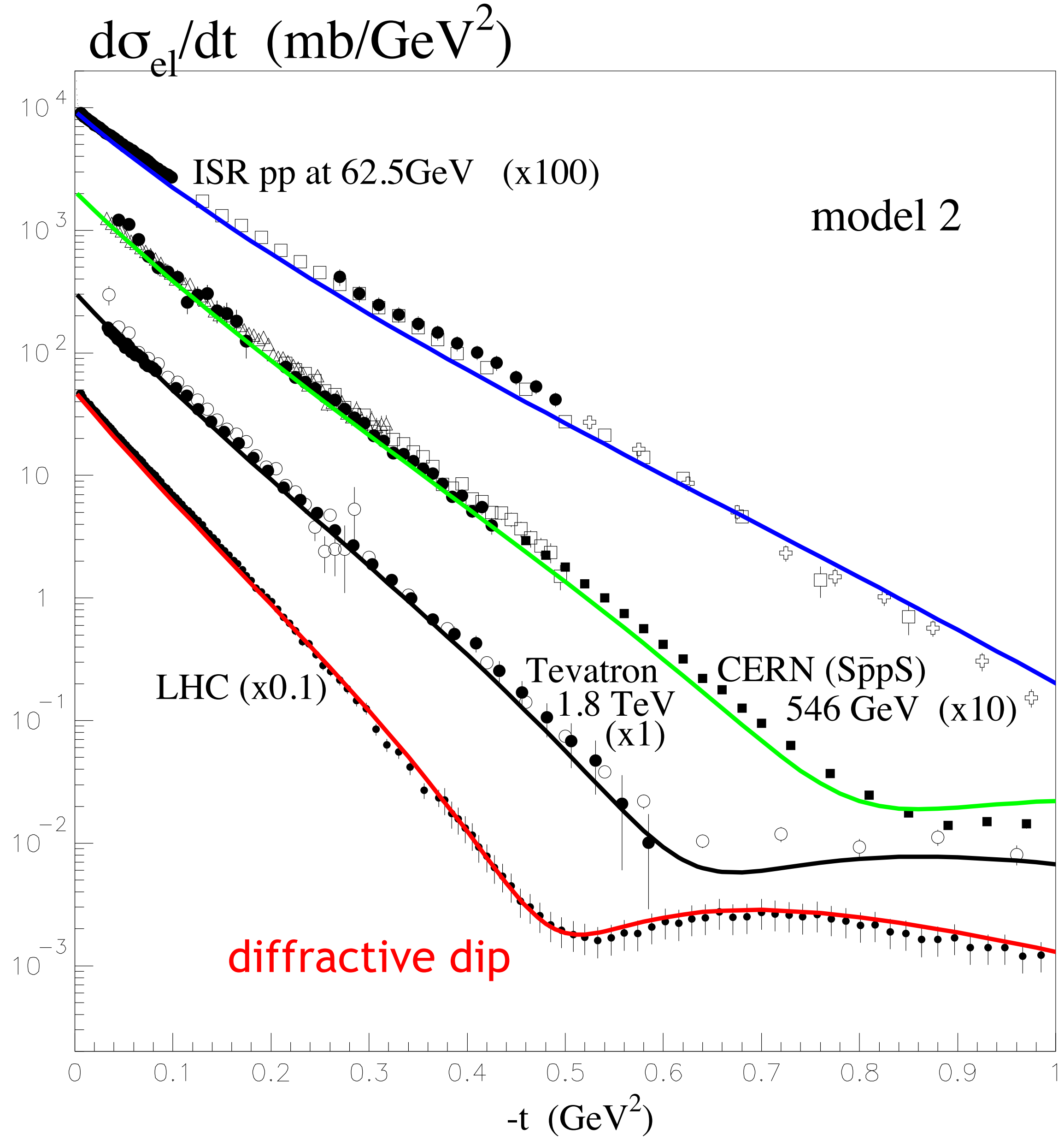
Ostapchenko (based on Kaidalov et al)
Durham (KMR group)
Tel Aviv (GLM group)

Soft diffraction via ”effective” Pomeron

KMR’13,14

rather successful!





Simultaneous fit of $\sigma_{\rm tot}$, $d\sigma_{\rm el}/dt$, as well as high and low mass dissociation data in two-channel eikonal model with single “effective” Pomeron

The “kT(s) effect”: dissociation is suppressed as collider energy increases

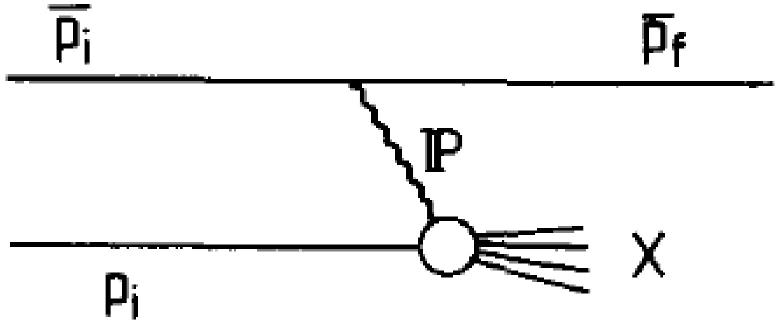
TOTEM

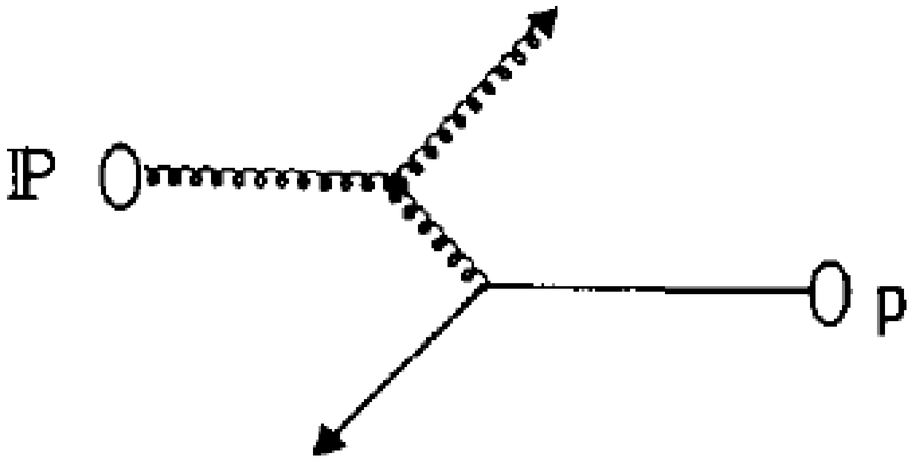
$\sqrt{s}$ (TeV)	$\sigma_{\rm tot}$ (mb)	$\sigma_{\rm el}$ (mb)	$B_{\rm el}(0)$ (GeV^{-2})	$\sigma_{\rm SD}^{{\rm low}\,M}$ (mb)	$\sigma_{\rm DD}^{{\rm low}\,M}$ (mb)	$\sigma_{\rm SD}^{\Delta\eta_1}$ (mb)	$\sigma_{\rm SD}^{\Delta\eta_2}$ (mb)	$\sigma_{\rm SD}^{\Delta\eta_3}$ (mb)	$\sigma_{\rm DD}^{\Delta\eta}$ (μb)
1.8	77.0	17.4	16.8	3.4	0.2				
7.0	98.7	24.9	19.7	3.6	0.2	2.3	4.0	1.4	145
8.0	101.3	25.8	20.1	3.6	0.2	2.2	3.95	1.4	139
13.0	111.1	29.5	21.4	3.5	0.2	2.1	3.8	1.3	118
14.0	112.7	30.1	21.6	3.5	0.2	2.1	3.8	1.3	115
7	98.6	25.4	19.9	2.6		1.8	3.3	1.4	116

Birth of hard diffraction: QCD modelling of Pomeron

Ingelman-Schlein, Phys. Lett. 1985

Introduce a hard scale to probe "parton skeleton" of the Pomeron!





Monte-Carlo model with effective

$I\!P$ flux $f_{I\!P/p}(x_{I\!P},t)$

$I\!P$ parton densities $f_{q,g/I\!P}(z,Q^2)$

$$\Rightarrow \boxed{d\sigma \sim f_{I\!P/p}\, f_{q,g/I\!P}\, f_{q,g/p}\, d\hat{\sigma}_{\text{pert. QCD}}}$$

Diffractive factorisation concept

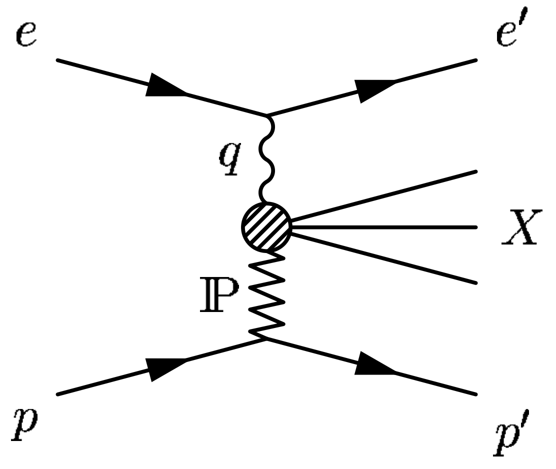
Implemented in POMPYT, CASCADE, and PYTHIA8 MC

Predictions for

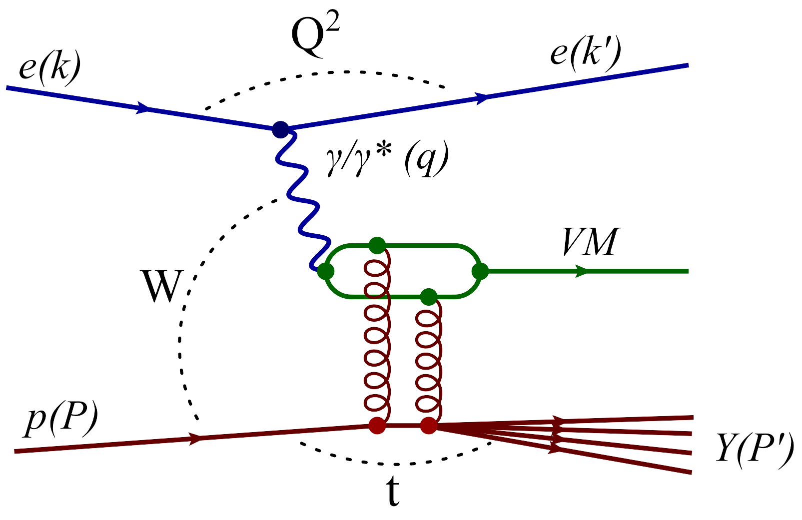
★ jets in diffractive $p\bar{p}$ scattering

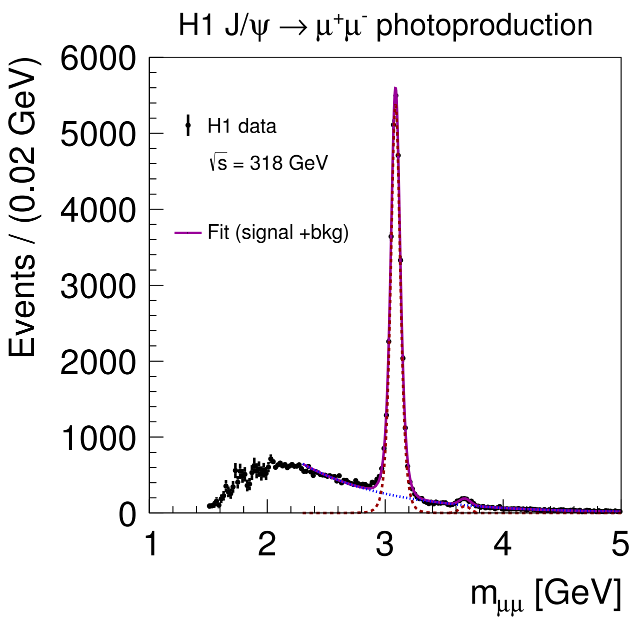
$\Rightarrow$ basis for UA8 experiment

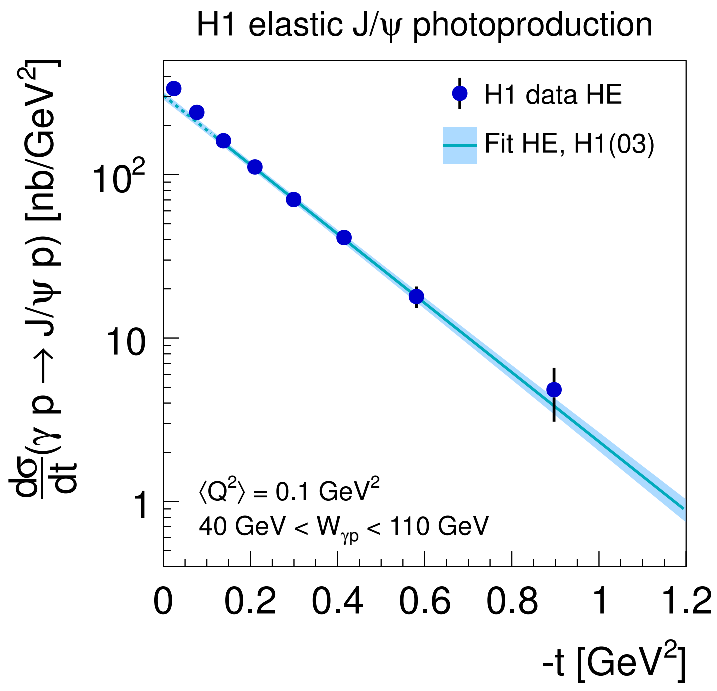
★ diffractive DIS at HERA

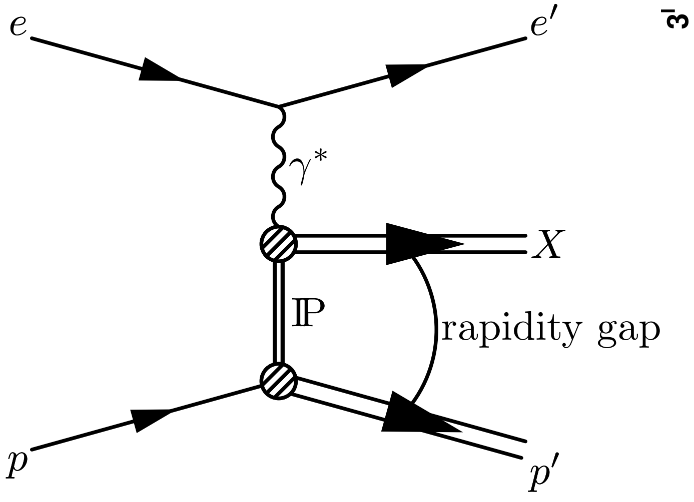


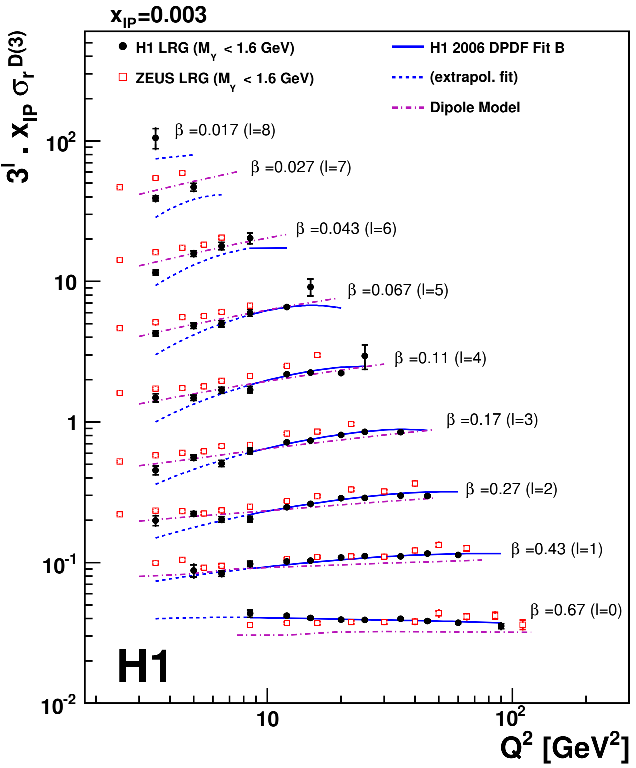
Diffraction at HERA

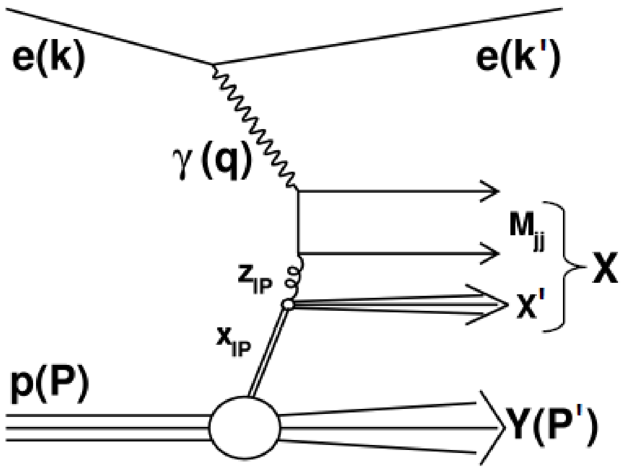


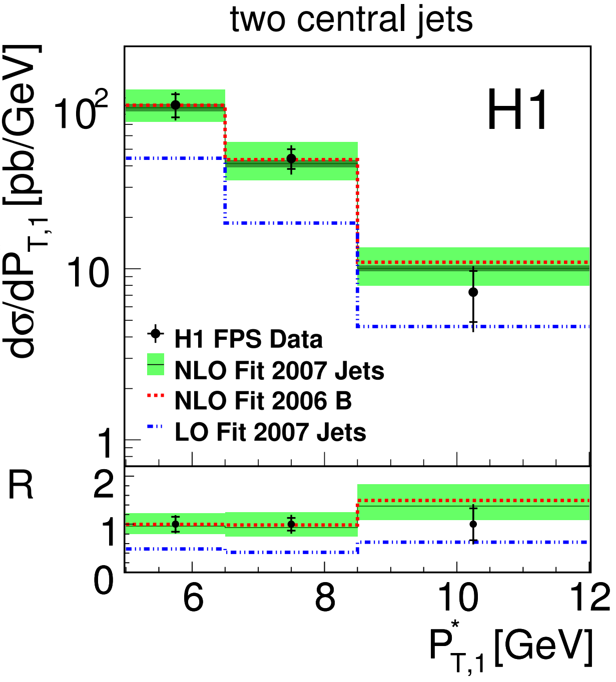






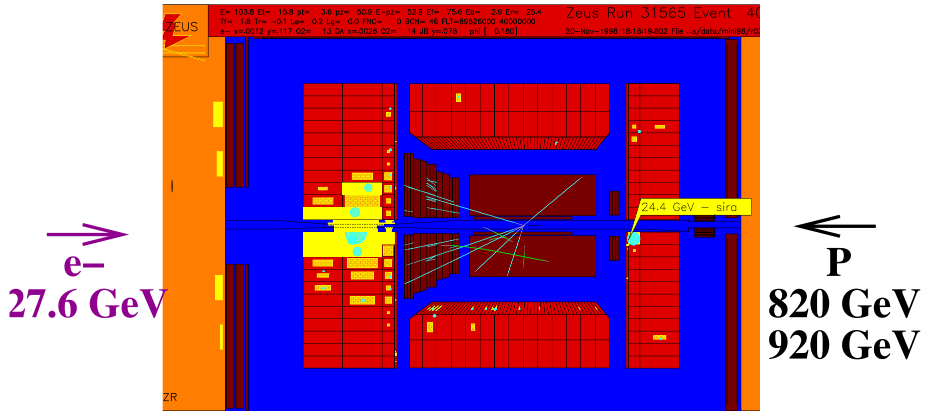


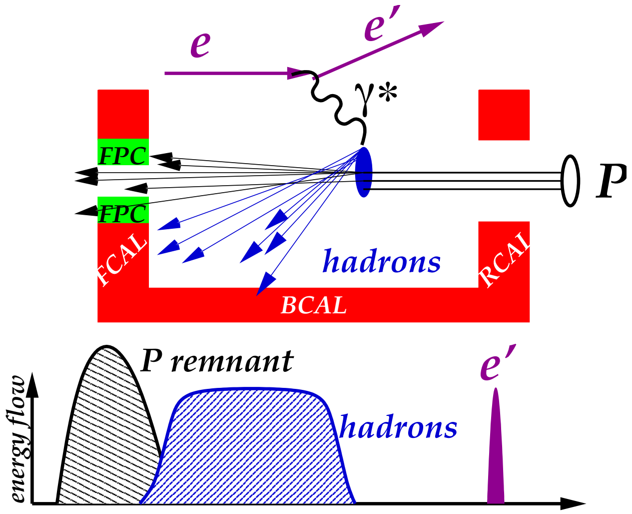




Diffractive DIS

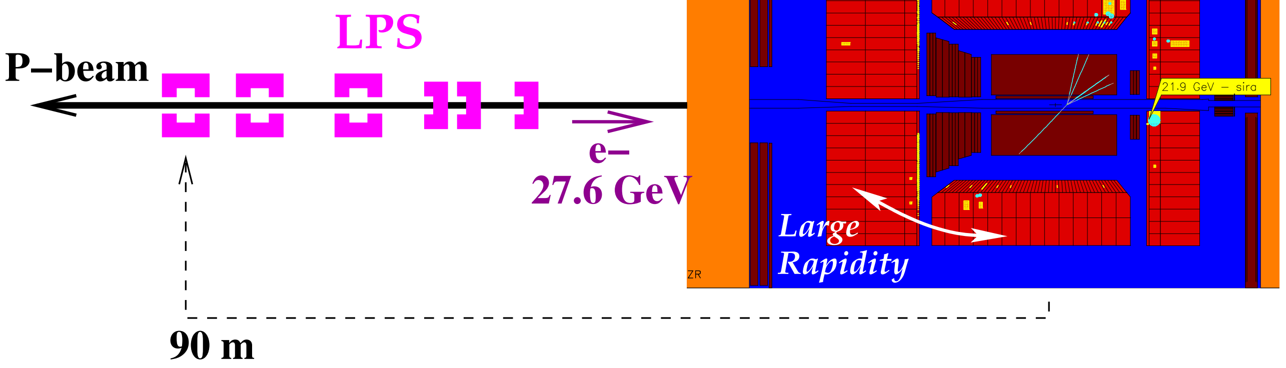
Non-diffractive scattering

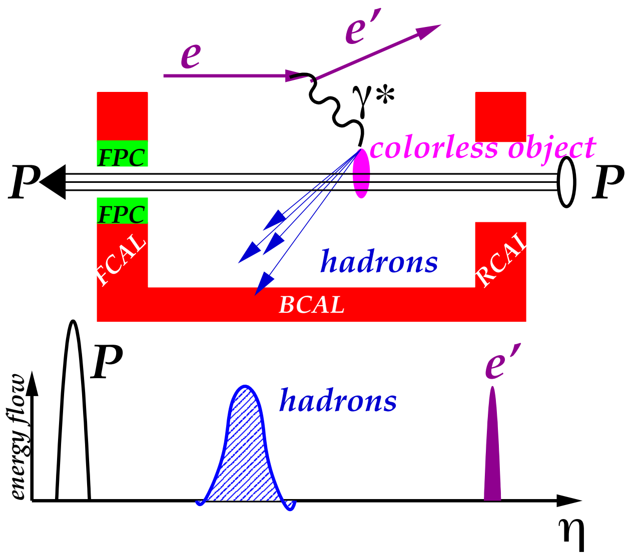




Diffractive scattering

~ 10 % of gap events!!!

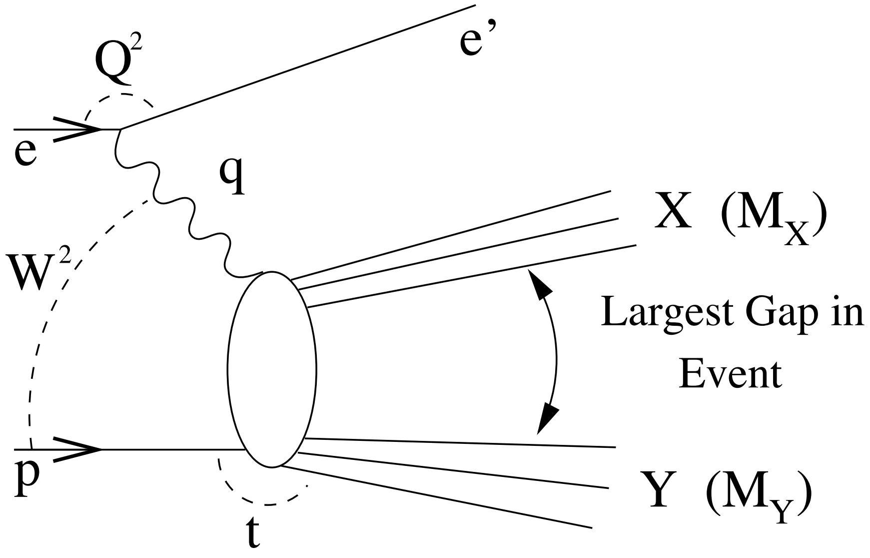




$$\frac{d\sigma}{dx\,dQ^2\,dx_{I\!P}\,dt} = \frac{2\pi\alpha^2}{xQ^4}\left(1+(1-y)^2\right)F_2^{D(4)}$$

in terms of diffractive structure function

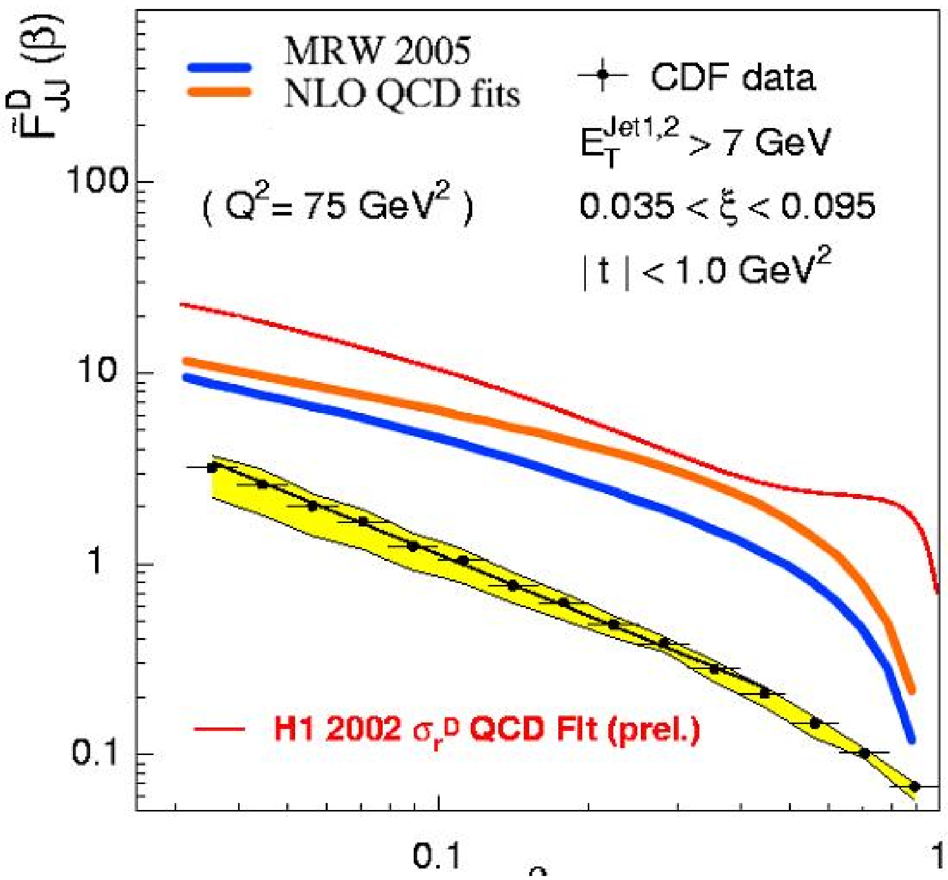
$$F_2^{D(4)}(x,Q^2,x_{I\!P},t) = \underbrace{f(x_{I\!P},t)}_{I\!P\ \text{flux}}\ \underbrace{F_2^{I\!P}(\beta,Q^2)}_{I\!P\ \text{structure}}$$

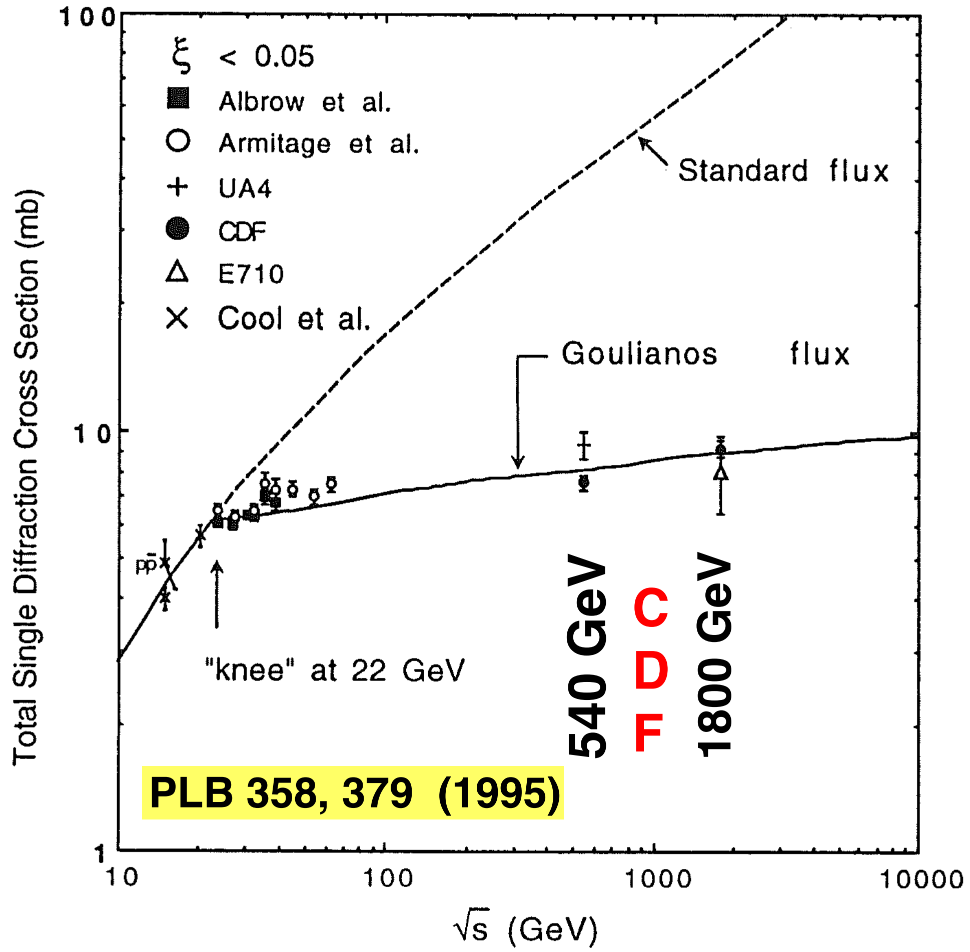


$$\beta = \frac{-q^2}{2q\cdot(p_p-p_Y)} = \frac{Q^2}{Q^2+M_X^2-t} \simeq p_{q,g}/p_{I\!P}$$

$$x_{I\!P} = \frac{q\cdot(p_p-p_Y)}{q\cdot p_p} = \frac{Q^2+M_X^2-t}{Q^2+W^2-M_p^2} = \frac{x}{\beta} \simeq p_{I\!P}/p_p$$

Single diffractive pp cross section at high energies





PLB 358, 379 (1995)

Tevatron

HERA

$$\frac{\sigma(\text{hard diffraction})}{\sigma(\text{hard})} \sim 1\% \quad \ll \quad 10\% \sim \frac{\sigma(\text{diffractive DIS})}{\sigma(\text{DIS})}$$

Non-universality!

$q_{I\!P}(x,Q^2)$ and $g_{I\!P}(x,Q^2)$ fitted to DIS F_2^D

factor 10-100 too large diffractive cross section at Tevatron!

interpret flux as gap formation probability that saturates when it reaches unity

Rockefeller Model (by K Coulianos)

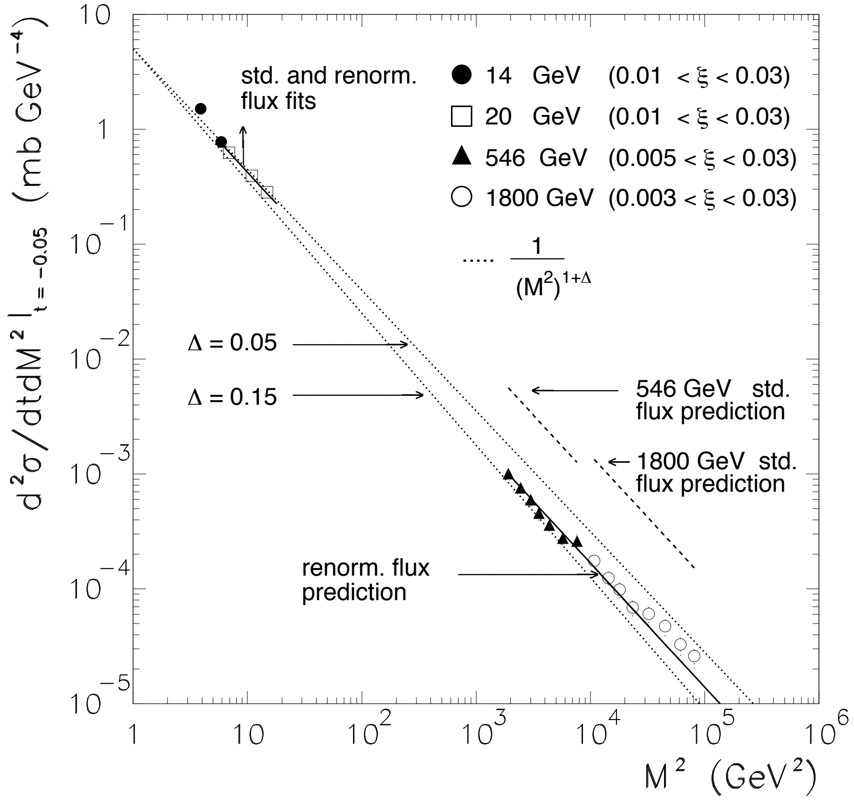
$$f_{I\!P/p}(\xi,t) \Rightarrow N_s^{-1} \cdot f_{I\!P/p}(\xi,t)$$

$$N_s \equiv \int_{\xi(min)}^{\xi(max)} d\xi \int_{t=0}^{-\infty} dt\, f_{I\!P/p}(\xi,t) \sim s^{2\epsilon}$$

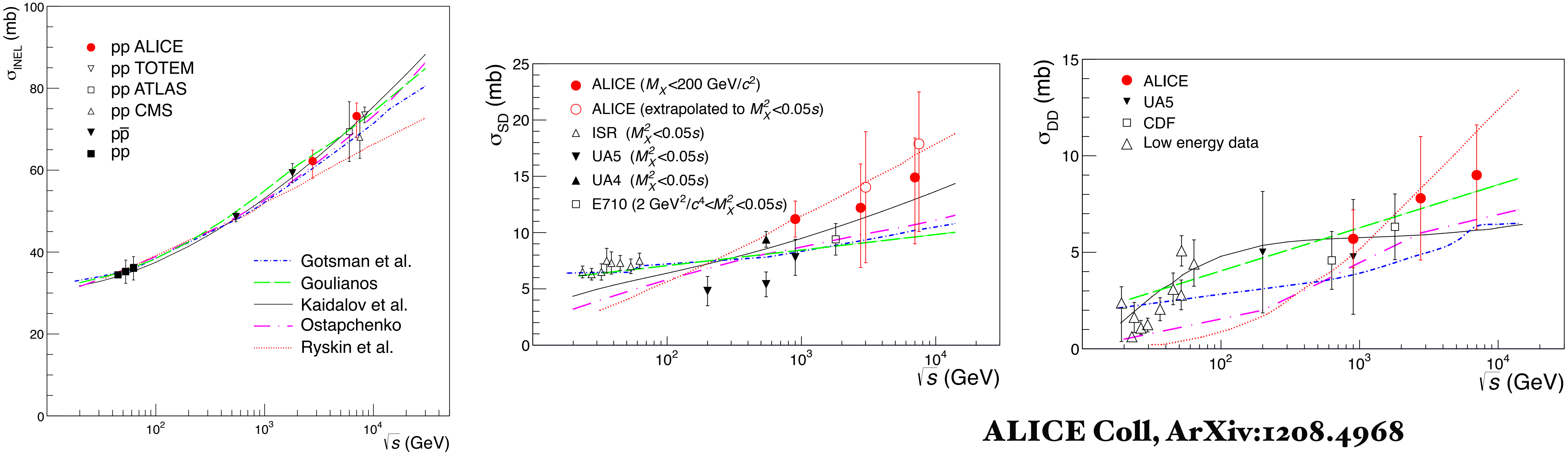
factorisation is broken by gap survival effects!

Factor of ~8 (~5) suppression at √s = 1800 (540) GeV

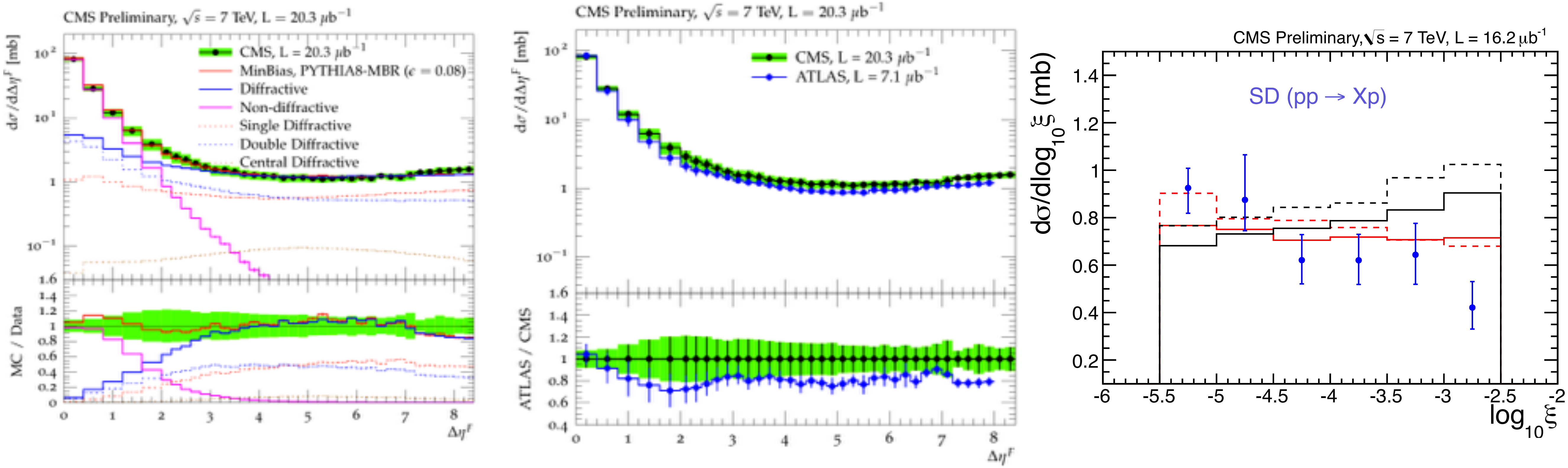
Pythia 8-MBR implementation



Diffractive cross sections at the LHC



ALICE Coll, ArXiv:1208.4968

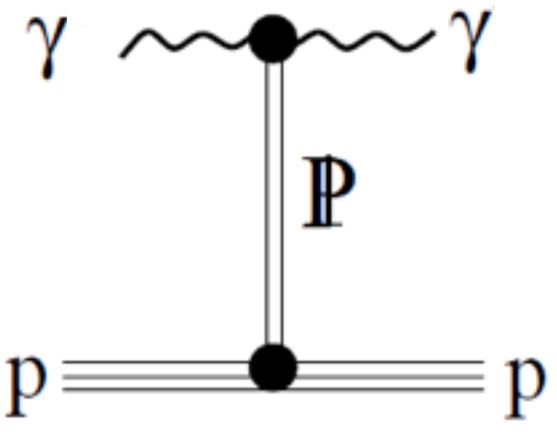


CMS Coll, CMS PAS FSQ-12-005

Soft vs hard Pomeron: KMR'14 model

Soft diffraction

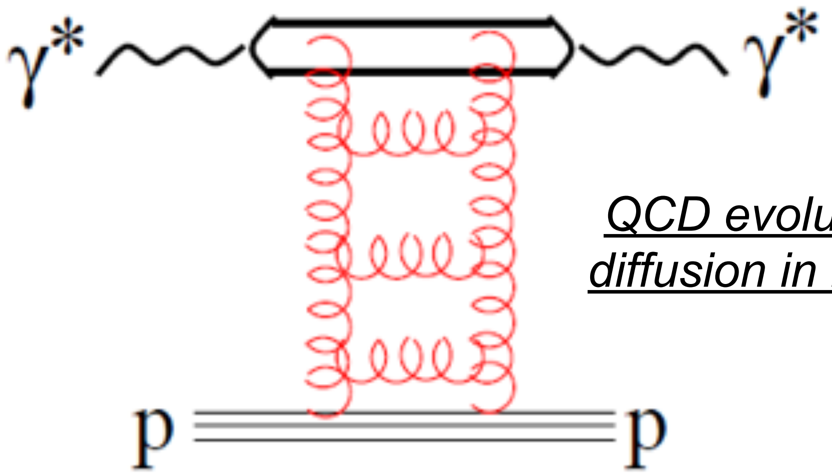
only soft scales $R \sim 1$ fm
elastic scattering, low mass diffraction etc



Continuous matching is necessary!

Hard diffraction

at least, one hard scale $\mu^{-1} \ll R$

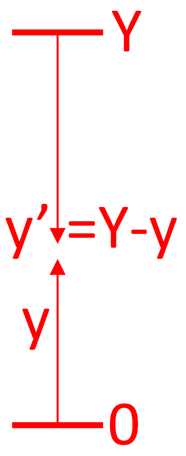


QCD evolution: diffusion in log kt

Regge Field Theory with
phenomenological DL Pomeron
$\alpha_P^{eff} \sim 1.08 + 0.25\,t$

perturbative QCD (BFKL) "bare" Pomeron
$\alpha_P^{bare} \sim 1.35 + 0\,t$

Rapidity evolution of opacity in absorptive background of both hadrons



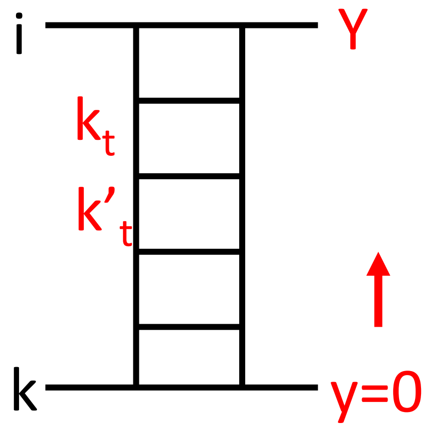
BFKL kernel

$$\frac{\partial\Omega^b(y,k_t)}{\partial y} = \frac{\alpha_s(k_t)}{2\pi}\int dk_t'^2\, S(y,y',k_t,k_t')\mathcal{K}(k_t,k_t')\Omega^b(y,k_t')$$

absorptive factor

$$\frac{\partial\Omega^a(y',k_t)}{\partial y'} = \frac{\alpha_s(k_t)}{2\pi}\int dk_t'^2\, S(y,y',k_t,k_t')\mathcal{K}(k_t,k_t')\Omega^a(y',k_t')$$

$$y' = Y_k = \ln(s/k_t'^2) \qquad \Omega(y) = \int_{k_t^2}\Omega(y,k_t')\frac{dk_t'^2}{k_t'^2}$$



$\lambda = N_c\alpha_S(k_t)\Theta(k_t' - k_t)$ **LLx 3P coupling**

$$\lambda\Omega^b(y,k_t') = N_c\pi^2\alpha_s(k_t')\frac{f^b(y,k_t')}{16\pi k_t'^2\; B_g}$$

flattening low kt dependence! Further tests are required..

Phenomenological dipole approach

Eigenvalue of the total cross section is
the universal dipole cross section

see e.g. B. Kopeliovich et al, since 1981

Eigenstates of interaction in QCD:
color dipoles

Dipole:
- cannot be excited
- experience only elastic scattering
- have no definite mass, but only separation
- universal – elastic amplitude can be extracted in one process and used in another

SD cross section

$$\sum_{h'} \frac{d\sigma_{sd}^{h\to h'}}{dt}\bigg|_{t=0} = \sum_{\alpha=1} |C_\alpha^h|^2 \frac{\sigma_\alpha^2}{16\pi} = \int d^2r_T \boxed{|\Psi_h(r_T)|^2} \frac{\sigma^2(r_T)}{16\pi} = \frac{\langle\sigma^2(r_T)\rangle}{16\pi}$$

wave function of
a given Fock state

total DIS cross section

$$\sigma_{tot}^{\gamma^* p}(Q^2,x_{Bj}) = \int d^2r_T \int_0^1 dx \left|\Psi_{\gamma^*}(r_T,Q^2)\right|^2 \sigma_{\bar{q}q,}(r_T,x_{Bj})$$

Theoretical calculation of
the dipole CS is a challenge

BUT! *Can be extracted from data and used in ANY process!*

Example: Naive GBW parameterization of HERA data

$$\sigma_{\bar{q}q}(r_T,x) = \sigma_0 \left[1 - e^{-\frac{1}{4} r_T^2 Q_s^2(x)}\right]$$

saturates at
large separations

$$r_T^2 \gg 1/Q_s^2$$

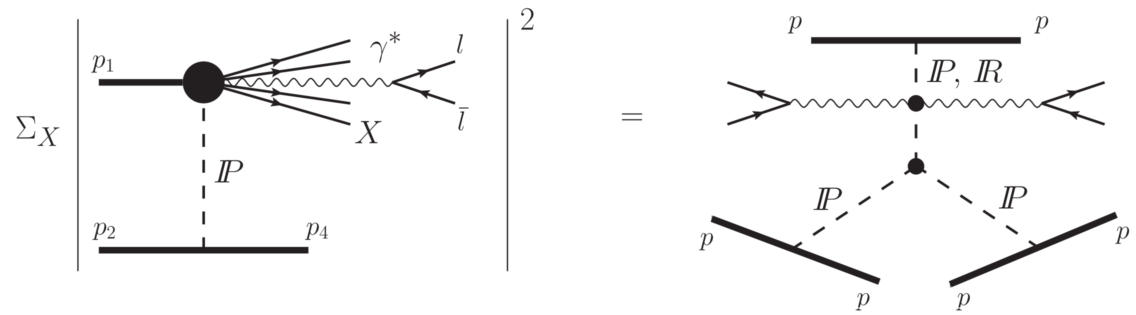
color transparency $\sigma_{\bar{q}q}(r_T) \propto r_T^2 \qquad r_T \to 0$

QCD factorisation $\sigma_{q\bar{q}}(r,x) \propto r^2 x g(x)$

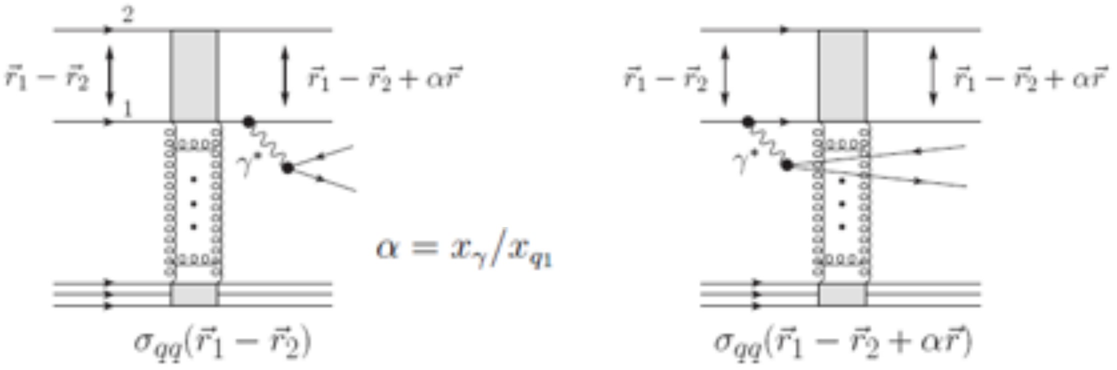
A point-like colorless object does not interact with external color field!

ANY diffractive scattering is due to a destructive interference of dipole scatterings!

Hadronic diffraction via dipoles



Diffractive Drell Yan (semi-hard)



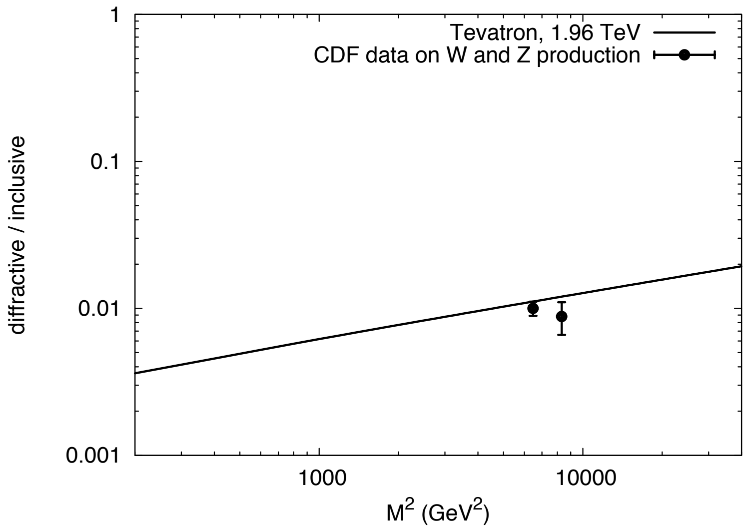
interplay between hard and soft fluctuations is pronounced!

superposition has a Good-Walker structure

$$\propto \sigma(\vec{R}) - \sigma(\vec{R}-\alpha\vec{r}) = \frac{2\alpha\,\sigma_0}{R_0^2(x_2)}\, e^{-R^2/R_0^2(x_2)}\,\left(\vec{r}\cdot\vec{R}\right) + O(r^2)$$

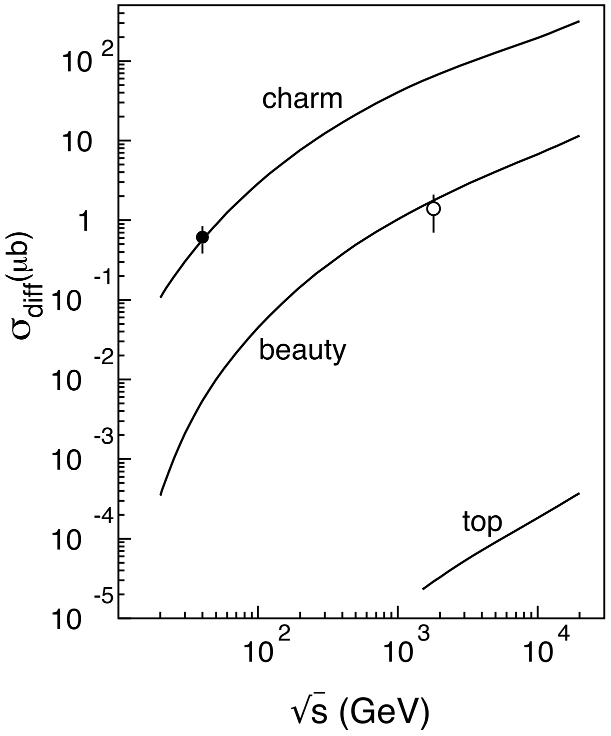
Diffractive DIS $\propto r^4 \propto 1/M^4$ vs diffractive DY $\propto r^2 \propto 1/M^2$

SD DY/gauge bosons



RP et al 2011,12

SD heavy quarks



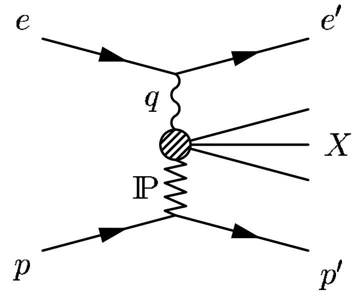
Kopeliovich et al 2006

- ★ *diffractive factorisation is automatically broken*
- ★ *any SD reaction is a superposition of dipole amplitudes*
- ★ *gap survival is automatically included at the amplitude level on the same footing as dip. CS*
- ★ *works for a variety of data in terms of universal dip. CS*

Sophisticated dipole cascades are being put into MC: Lund Dipole Chain model (DIPSY)
Ref. G. Gustafson, and L. Lönnblad

QCD structure of Pomeron: the role of color/hadronisation

Pomeron problems:



- $I\!P$ model fitted to HERA data
  $\rightarrow$ fails for Tevatron data
  σ(hard diffr) factor 6–100 too large
  $\rightarrow$ need 'damping' at high energies,
  e.g. $I\!P$ flux 'renormalisation'
- $I\!P$ flux & structure not universal
  ill-defined for virtual $I\!P$
- Factorisation broken in diffractive $p\bar{p}$
  – coherent interactions
- Improper with $I\!P$ 'emitted' from p
  soft, long space-time-scale interaction
  $\rightarrow$ $I\!P$–p cross-talk

Alternative approach:

- no 'initial' $I\!P$, not in proton wave fcn
- hard pQCD left unchanged
  – not affect by soft interactions
- non-pQCD below $Q_0^2 \sim 1$ GeV^2
- α_s large $\Rightarrow$ large interaction probability
  e.g. unity for hadronisation!
- colour exchange modifies colour/string
  topology $\rightarrow$ different final state
- single model describing all final states
  – diffractive $\leftrightarrow$ nondiffractive

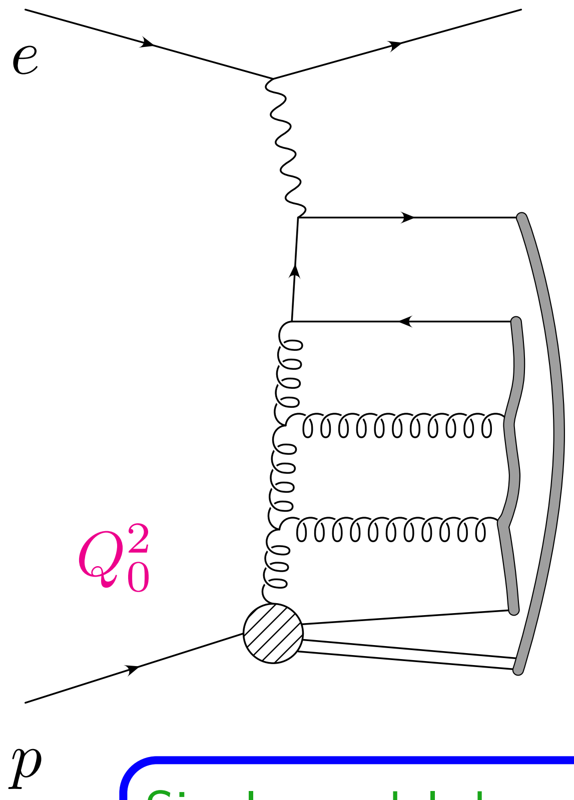
see G. Ingelman et al

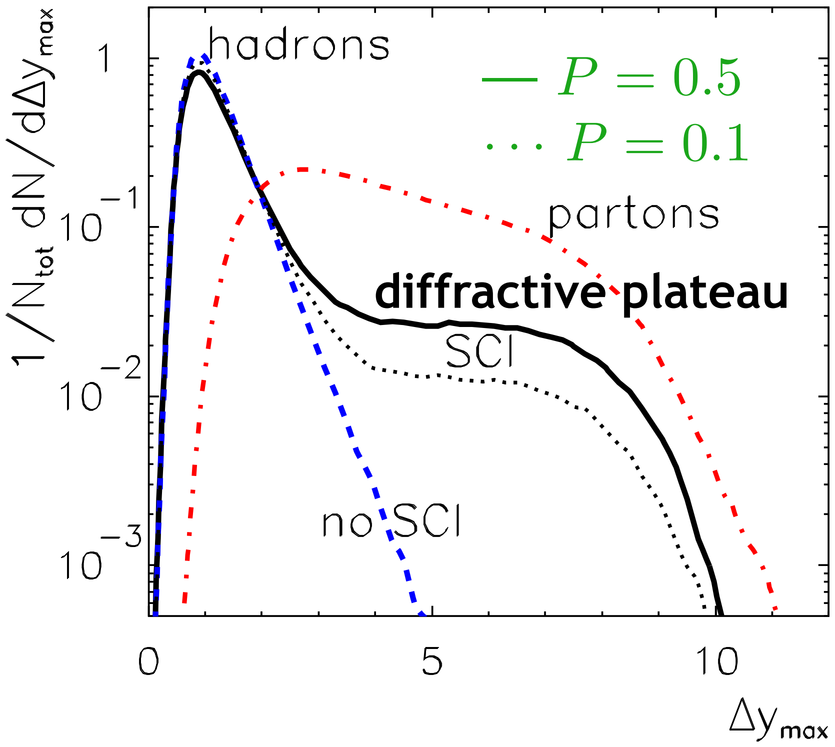
Sensitivity to the color string topology fluctuations

Edin, Ingelman, Rathsman

ME + DGLAP PS > Q_0^2 → SCI model → String hadronisation ∼ Λ

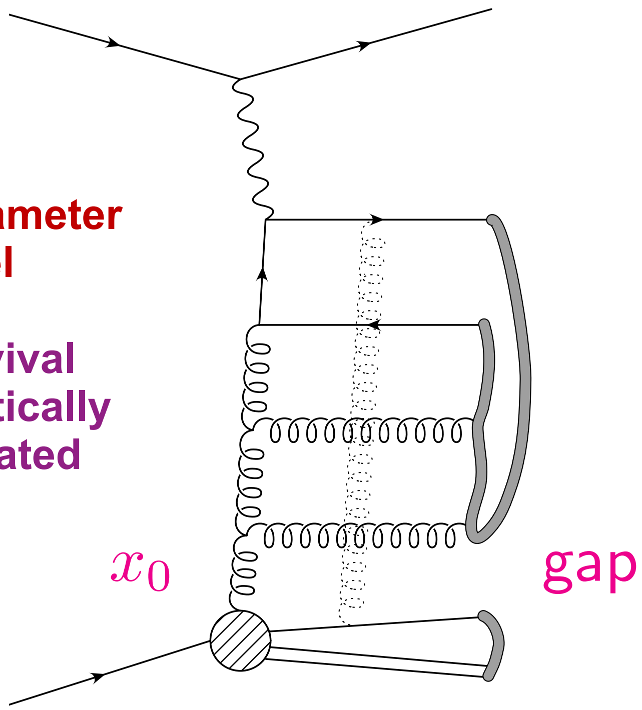
colour ordered parton state → rearranged colour order → modified final state





single parameter model

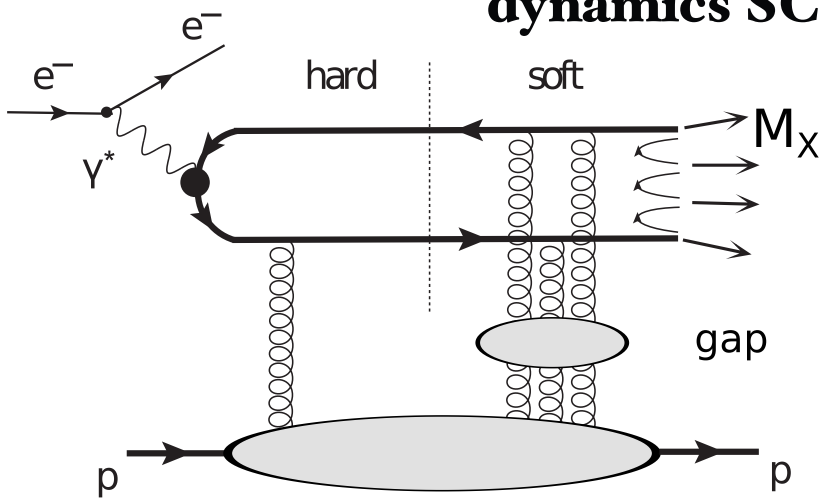
gap survival is automatically incorporated



Single model describing all final states: diffractive ↔ nondiffractive
Gap events not 'special', but fluctuation in colour/hadronisation

diffractive events from fluctuations in color string topology!

dynamics SCI



Soft gluons can only change phase of propagating quark and it's color — should be resumed!

$$M(\delta) = \int d^2b\, \exp^{-i\delta \mathbf{b}}\, \hat{M}^{\mathrm{hard}}(b)\hat{M}^{\mathrm{soft}}(b)$$

$$\hat{M}^{\mathrm{soft}}(\mathbf{b},\mathbf{r}) \propto \left(1 - e^{A \ln \frac{|\mathbf{b}-\mathbf{r}|}{|\mathbf{b}|}}\right)$$

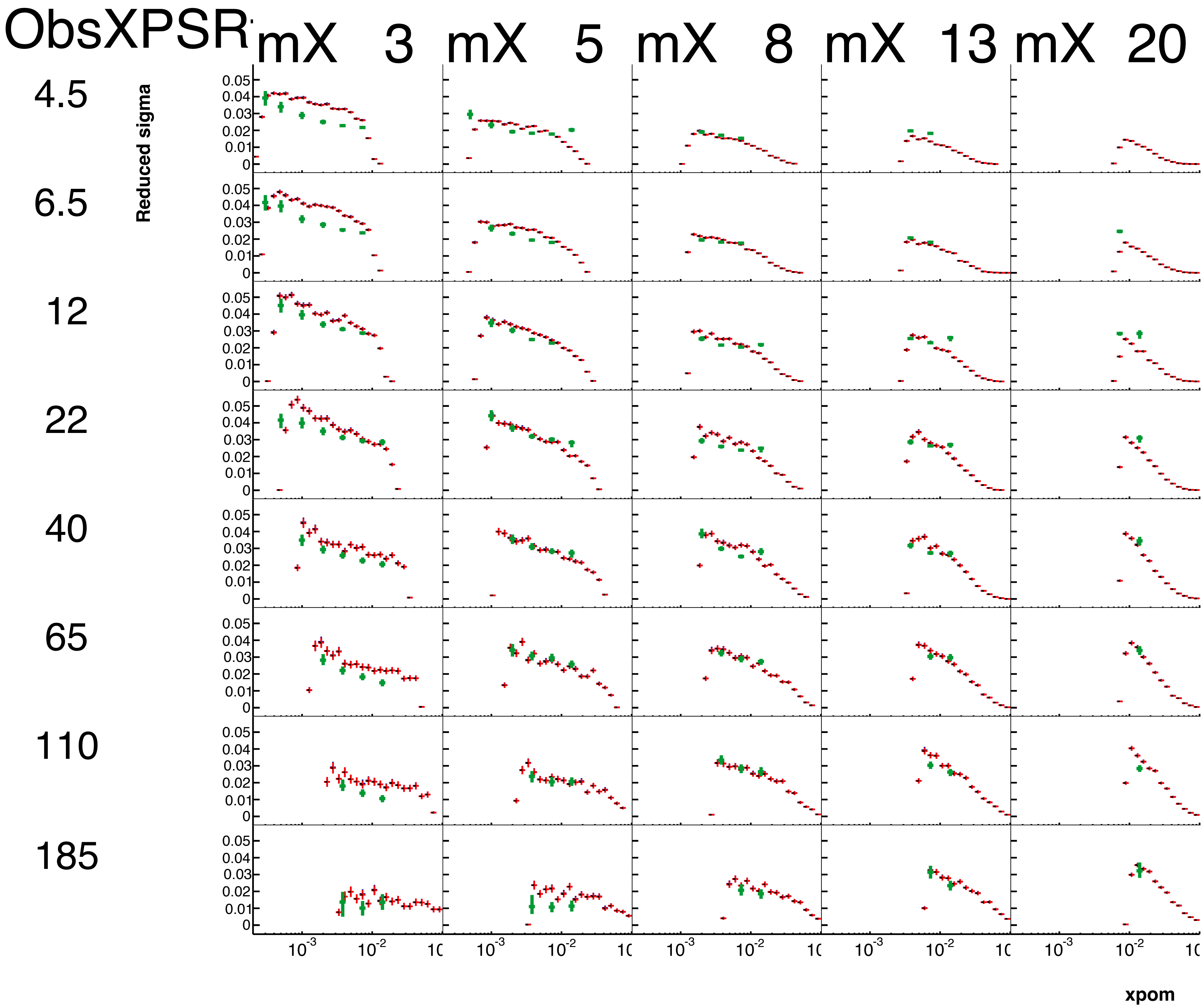
reconnection probability becomes dynamical

RP, Ingelman, Enberg

DynSCI Monte Carlo vs diffractive DIS

Werder, Ingelman, RP

Preliminary results!

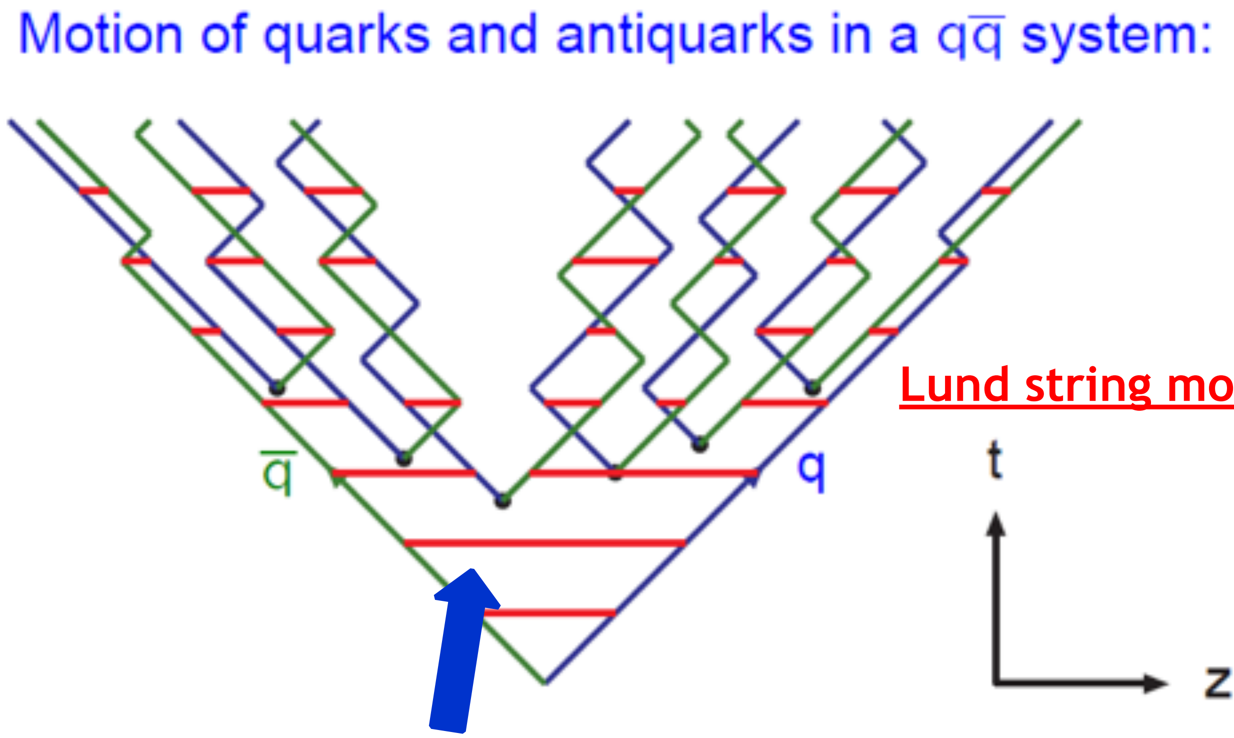


only physical parameters!

Dynamical color screening: Generalised Area Law model

Rathsman'99

dynamical string rearrangement



Lund string model

Area spanned by a string in momentum space

$$A(p_i, p_j) = 2(p_i \cdot p_j - m_i \cdot m_j)$$

Area difference between two string configurations

$$\Delta A = A^{\text{old}} - A^{\text{new}}$$

System prefers to turn to minimal area configuration!

GAL has been implemented to Pythia

Reconnection probability

$$\boxed{\begin{gathered} P_{\text{GAL}} = P_0 \left[1 - \exp(-b\Delta A)\right] \\ P_0 \sim 0.1 \end{gathered}}$$

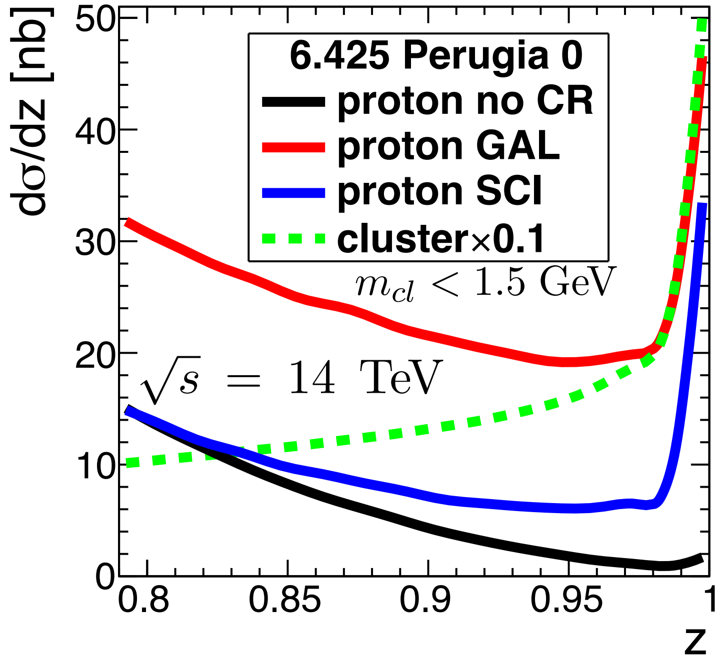
GAL has been successfully applied to inclusive and diffractive DIS

Diffractive W production in high-energy pp collisions

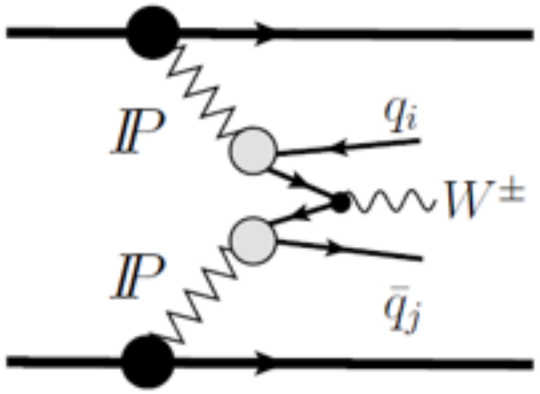
Features:

- ✓ clean environment (color singlet)
- ✓ well-defined hard scale (tests of QCD factorisation)
- ✓ high sensitivity to the production mechanism
- ✓ large enough cross section to be experimentally observed and tested

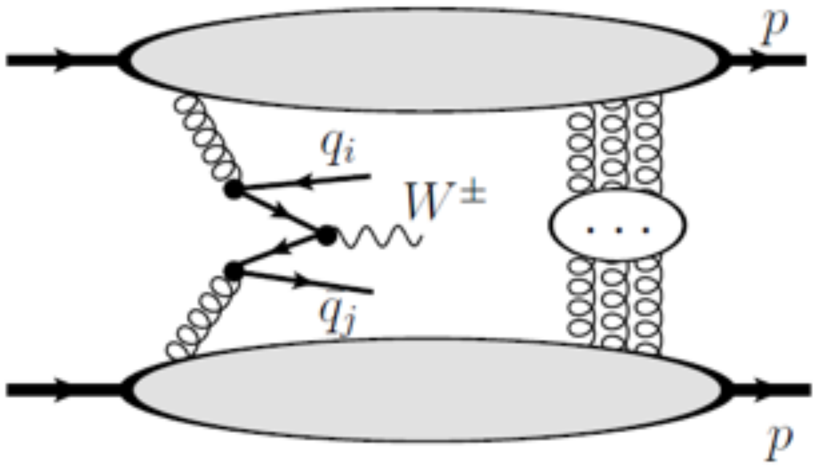
$$z = |p_z|/p_{\mathrm{beam}} \qquad pp \to p[W^\pm X]$$



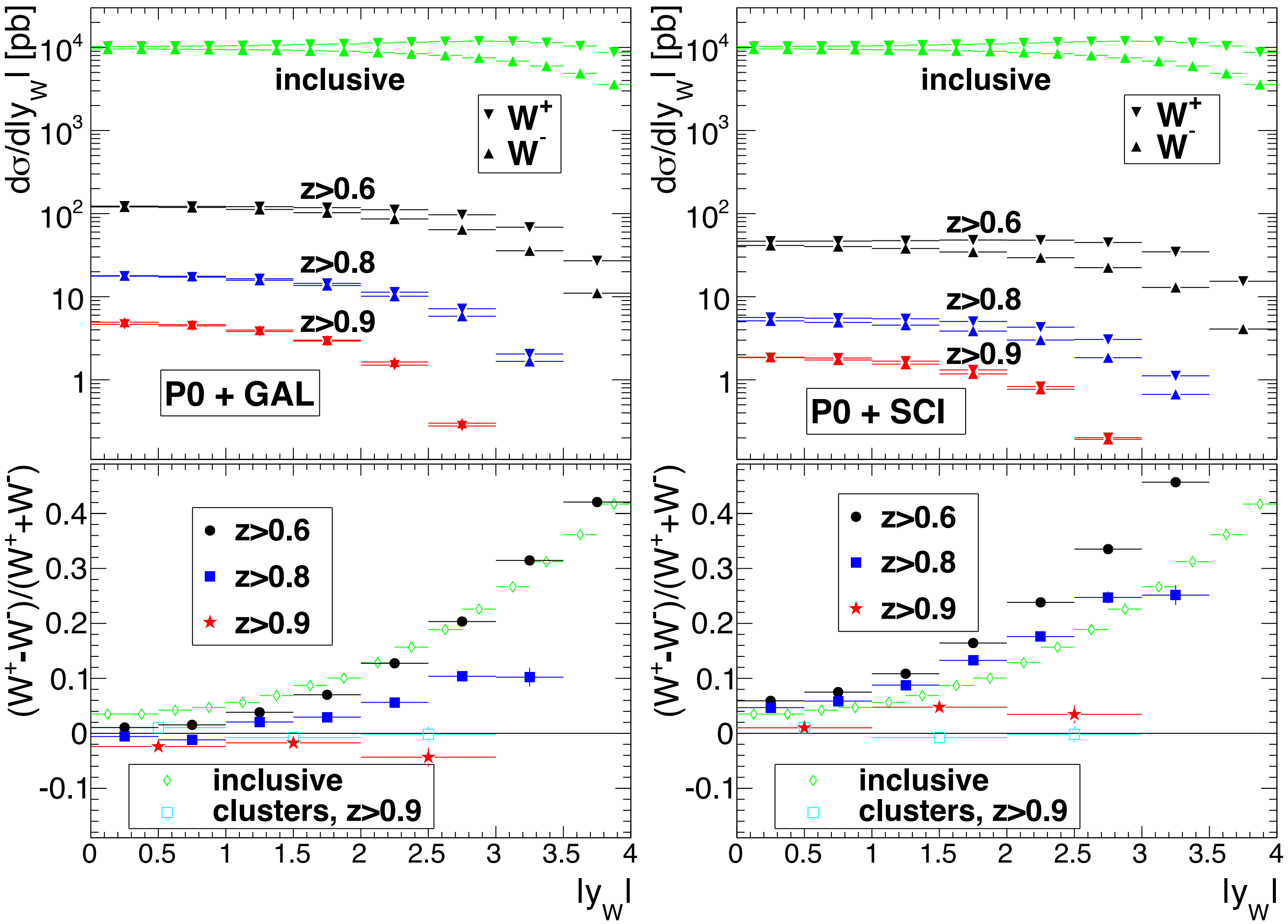
Regge models



QCD inspired models



Ingelman, RP, Rathsman, Werder



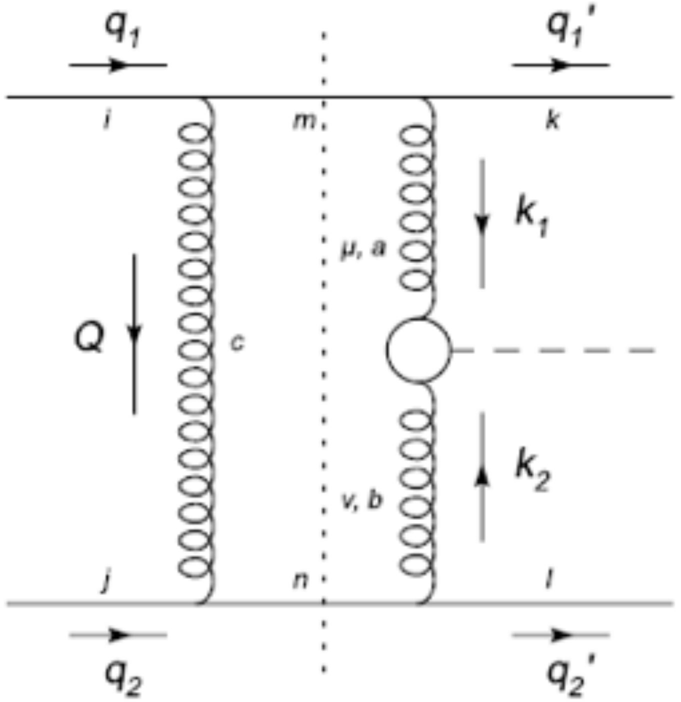
Mainly gluon-initiated diffraction at large Z!

background for anomalous couplings studies with forward detectors see C. Royon

SD/ND ~ 1 % for SCI/GAL close to Tevatron data!

Central exclusive Higgs... etc production

parton level



The Durham (KMR) model

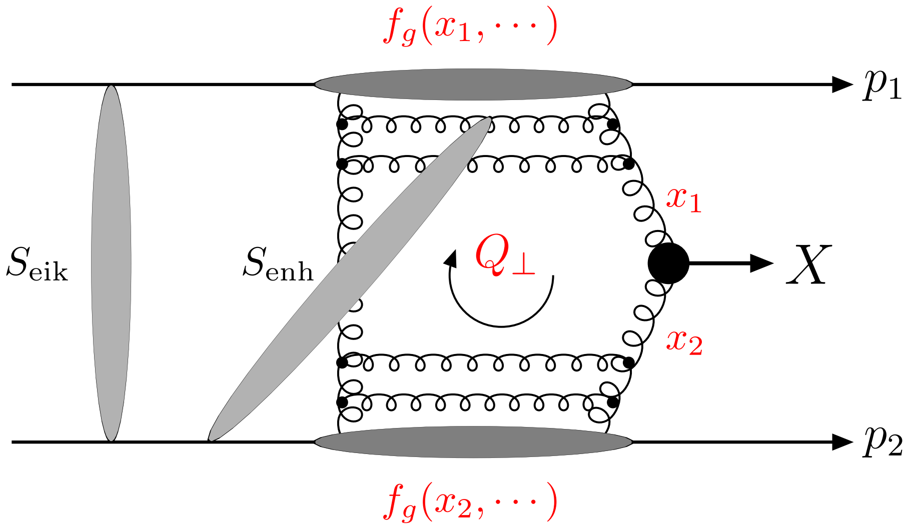
implemented in ExHuME MC

In the forward limit

$$\epsilon_i \sim k_{it}$$

$$Q_t = -k_{1t} = k_{2t}$$

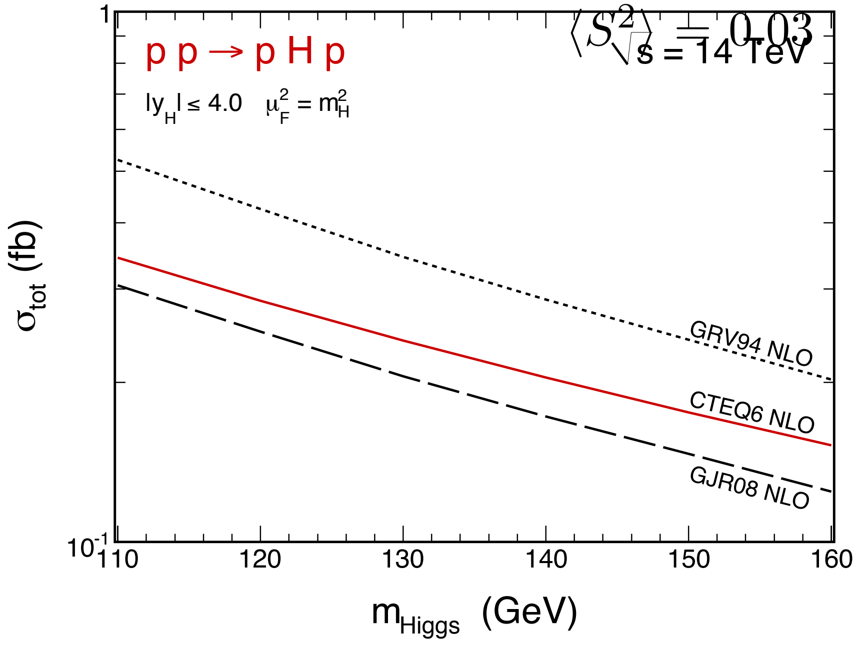
Spin-parity analyser!

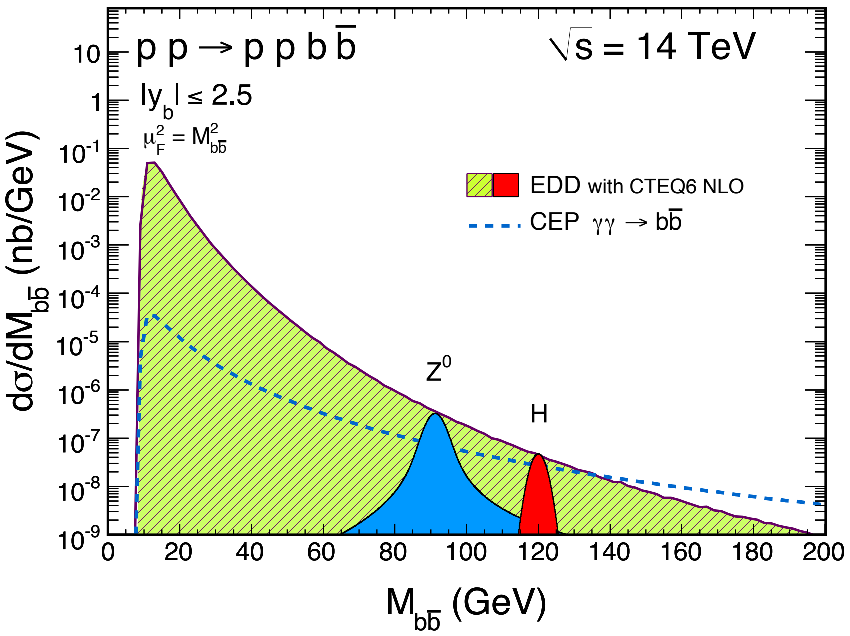


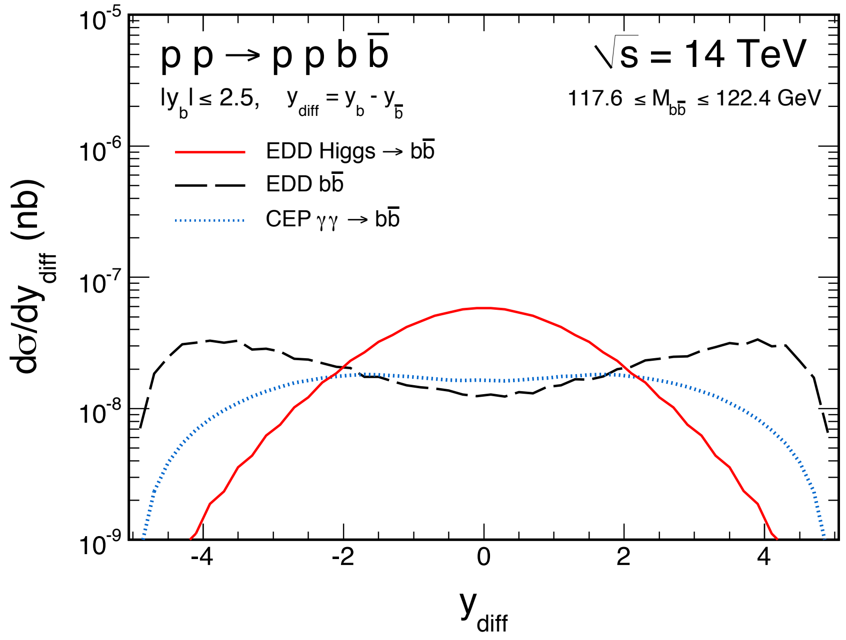
‣ Correct inclusion of Sudakov factor	JHEP 1001 (2010) 121
‣ Consistent treatment of 'skewed' gluon PDFs	Phys. Rev. D88 (2013) 034029
‣ Latest model of soft survival effects	Eur.Phys.J. C73 (2013) 2503

Small CS/large uncertainties

Large irreducible backgrounds







RP + Krakow group

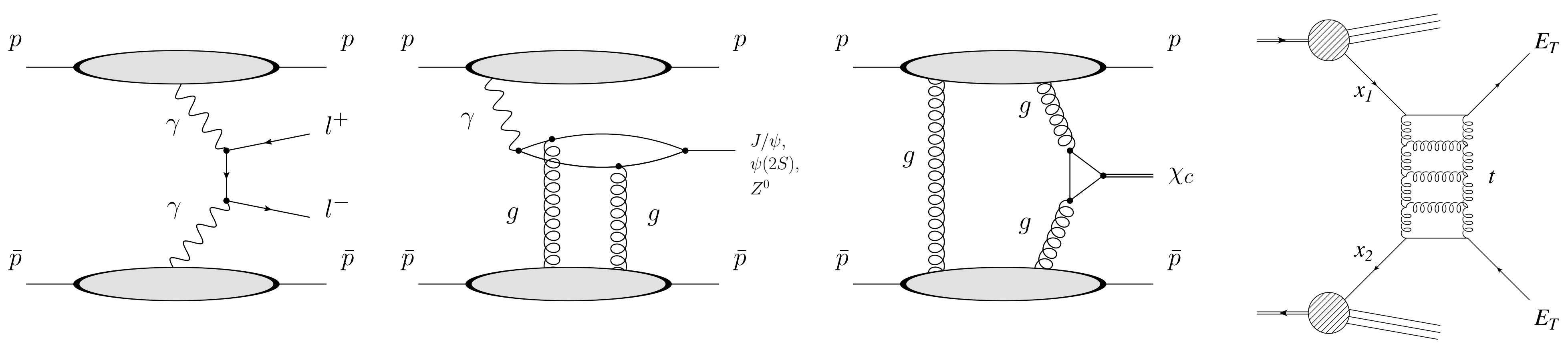
Higgs CEP was proven to be hardly feasible at the LHC...

More exclusive/diffractive reactions...

Examples of typical exclusive reactions studied so far...

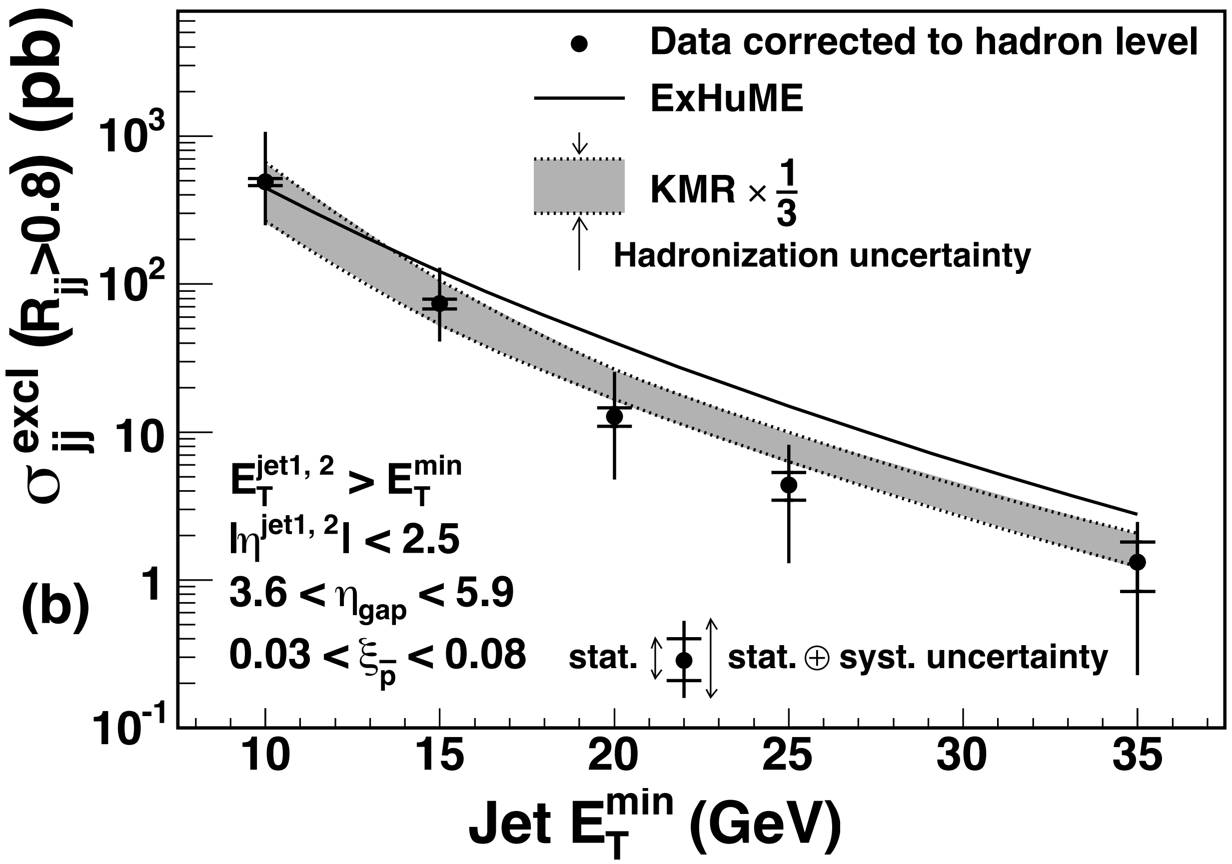
many covered in SuperChic/FPMC Monte Carlo

Laboratory of quarkonia, meson pair, exotics, gauge bosons, New Physics... production

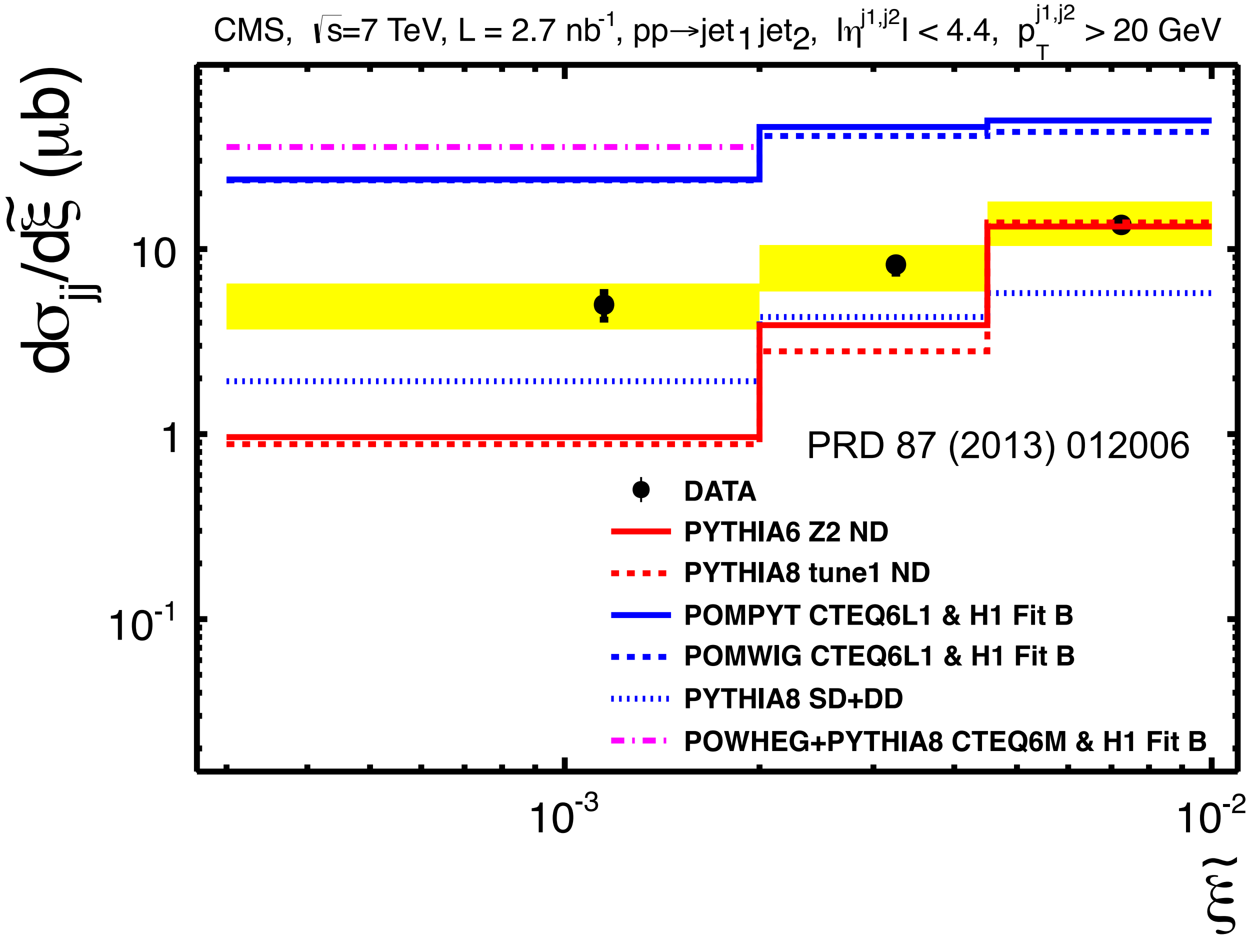


Diffractive di-jets at Tevatron

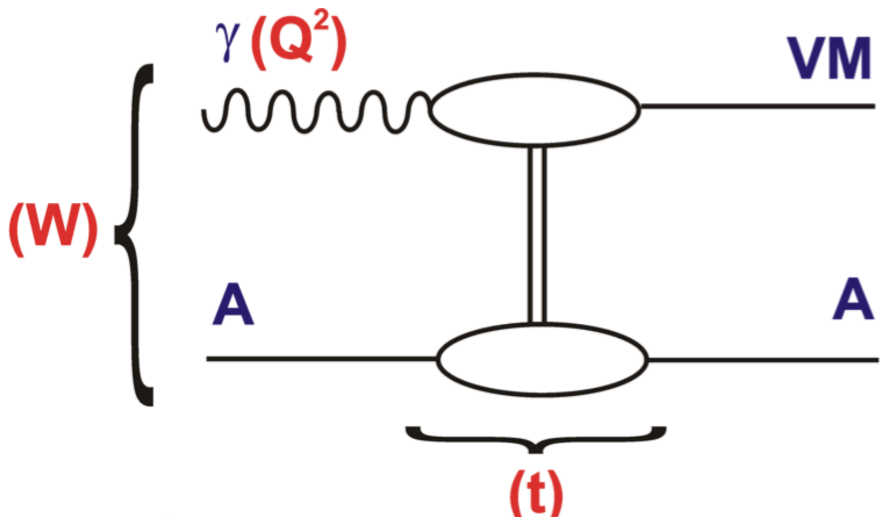
CDF Collab., Phys.Rev.D77:052004,2008

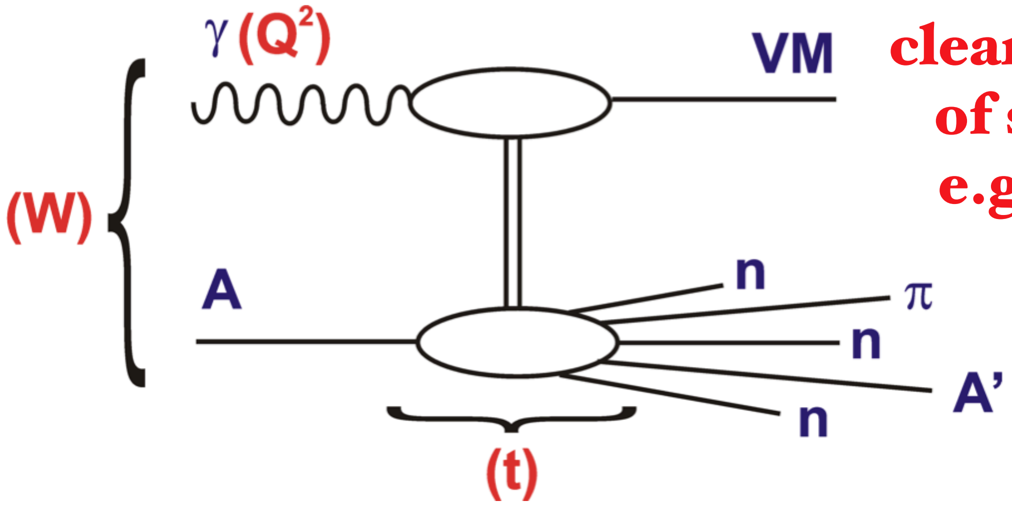


The first observation of diffractive di-jet at the LHC

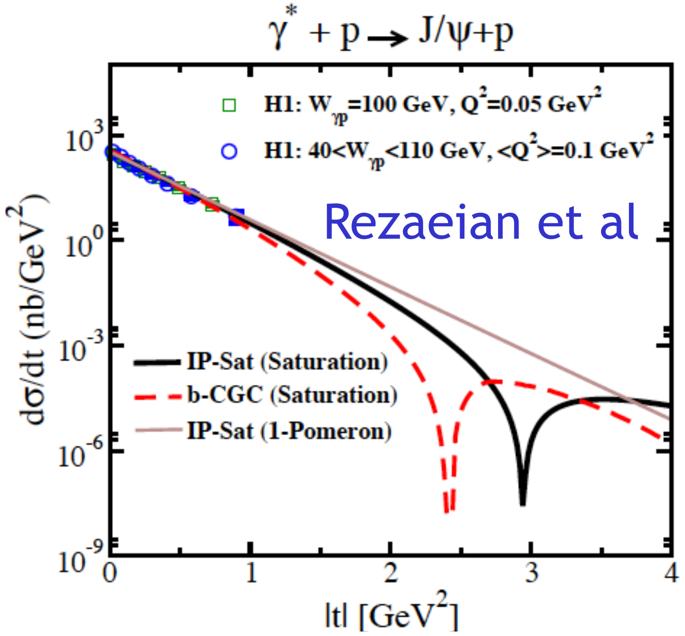


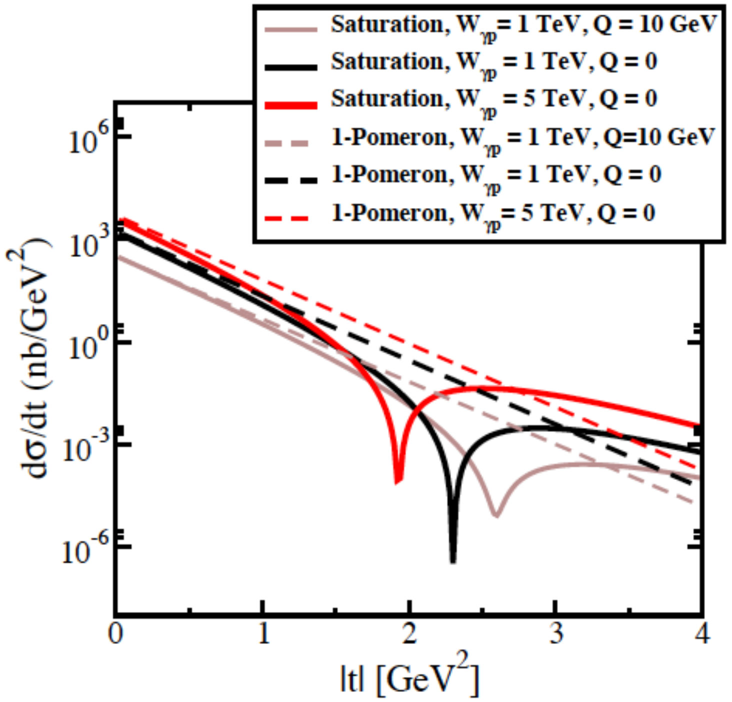
Saturation studies via coherent diffraction

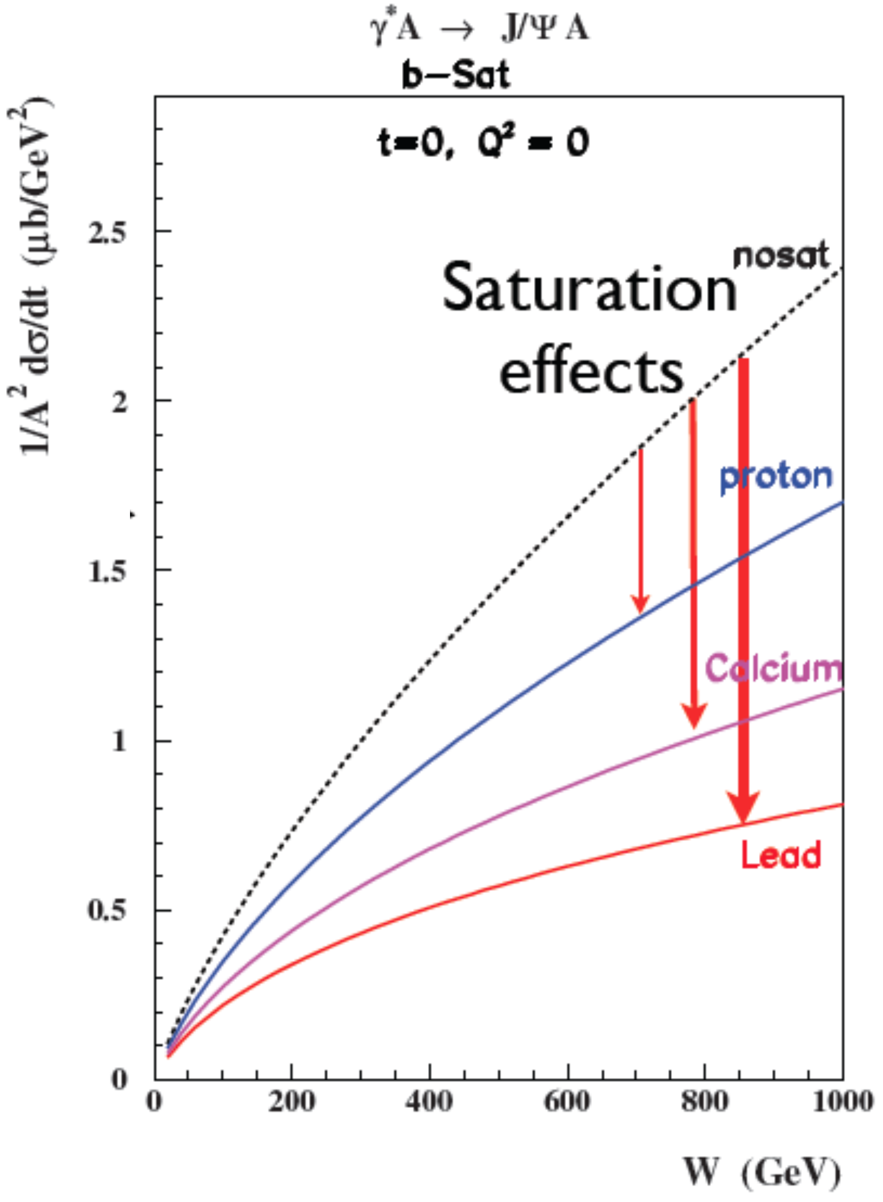


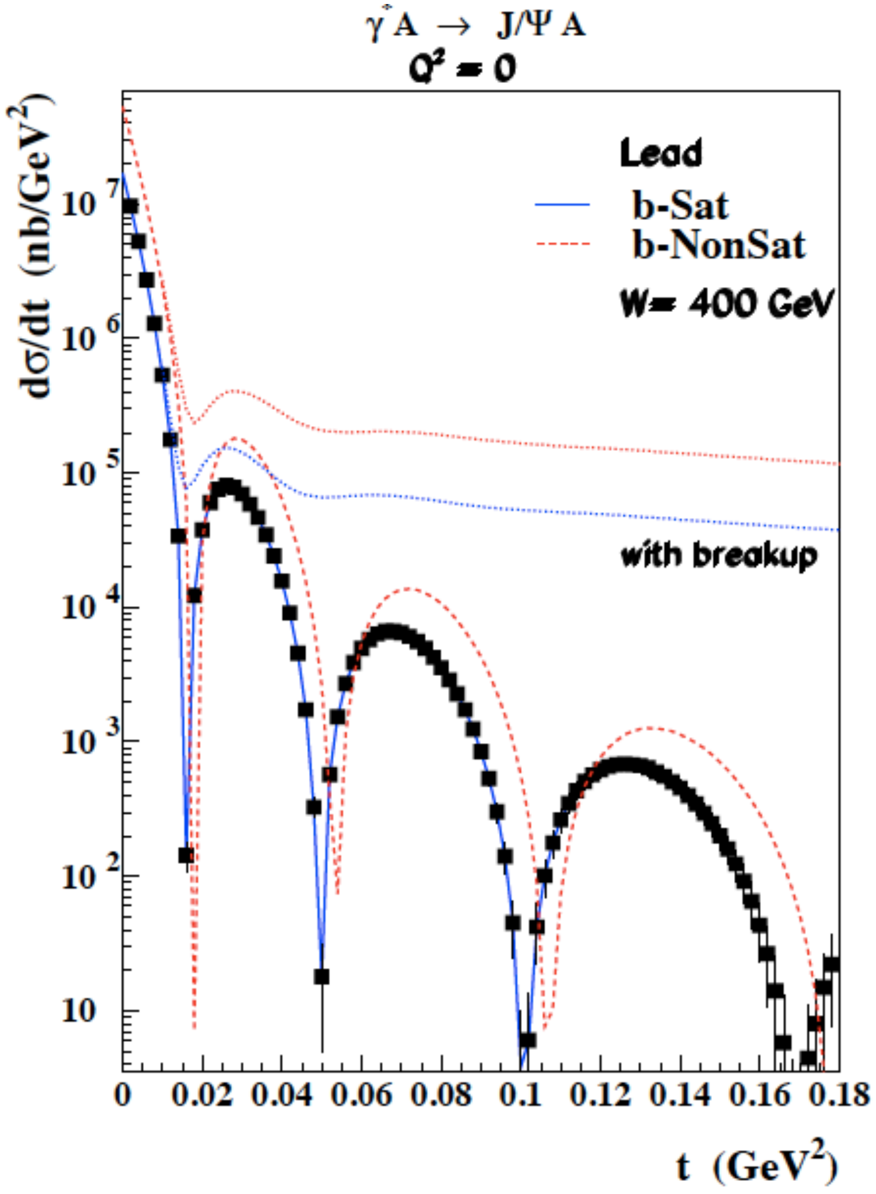


clean signatures of saturation e.g. at LeHC









Forward Physics Monte Carlo (FPMC project)

- FPMC (Forward Physics Monte Carlo): implementation of all diffractive/photon induced processes
- List of processes
  - two-photon exchange
  - single diffraction
  - double pomeron exchange
  - central exclusive production

Durham-based model with variations

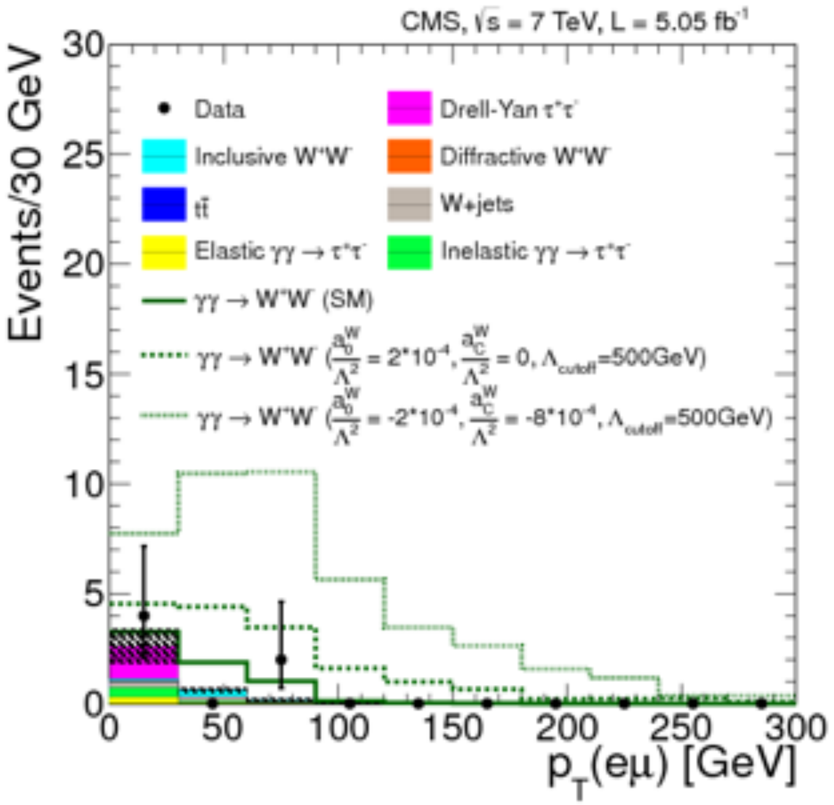
diffractive factorisation + gap survival!

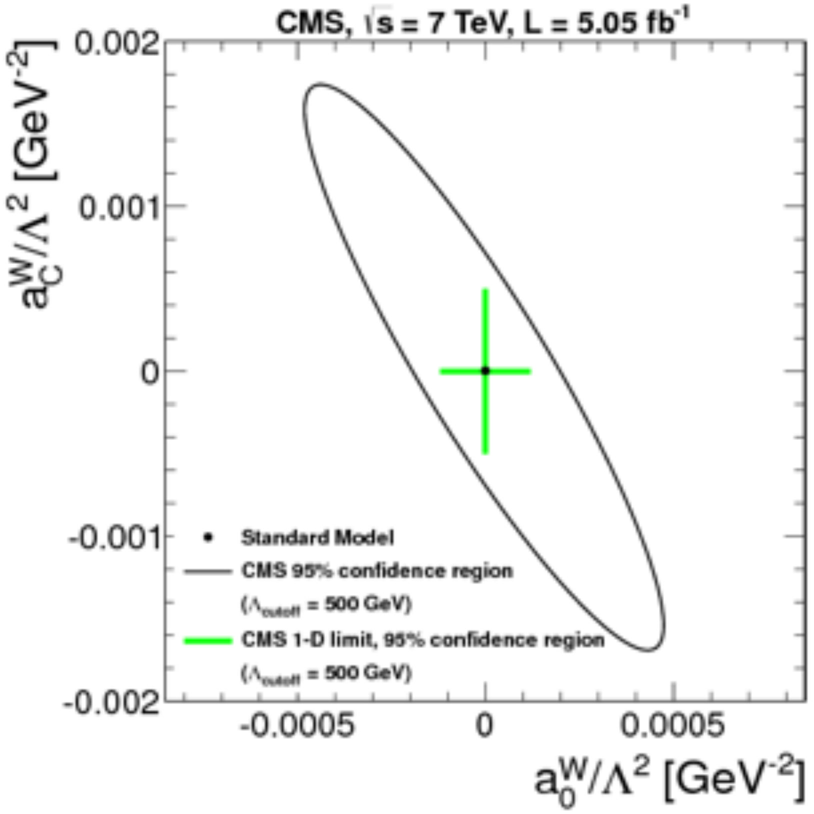
- Inclusive diffraction: Use of diffractive PDFs measured at HERA, with a survival probability of 0.03 applied for LHC
- Central exclusive production: Higgs, jets...
- FPMC manual (see M. Boonekamp, A. Dechambre, O. Kepka, V. Juranek, C. Royon, R. Staszewski, M. Rangel, ArXiv:1102.2531)
- Survival probability: 0.1 for Tevatron (jet production), 0.03 for LHC, 0.9 for γ-induced processes
- Output of FPMC generator interfaced with the fast simulation of the ATLAS detector in the standalone ATLFast++ package and also to the full simulation including pile up

taken from C. Royon, "Forward Physics using proton tagging at the LHC", 2014

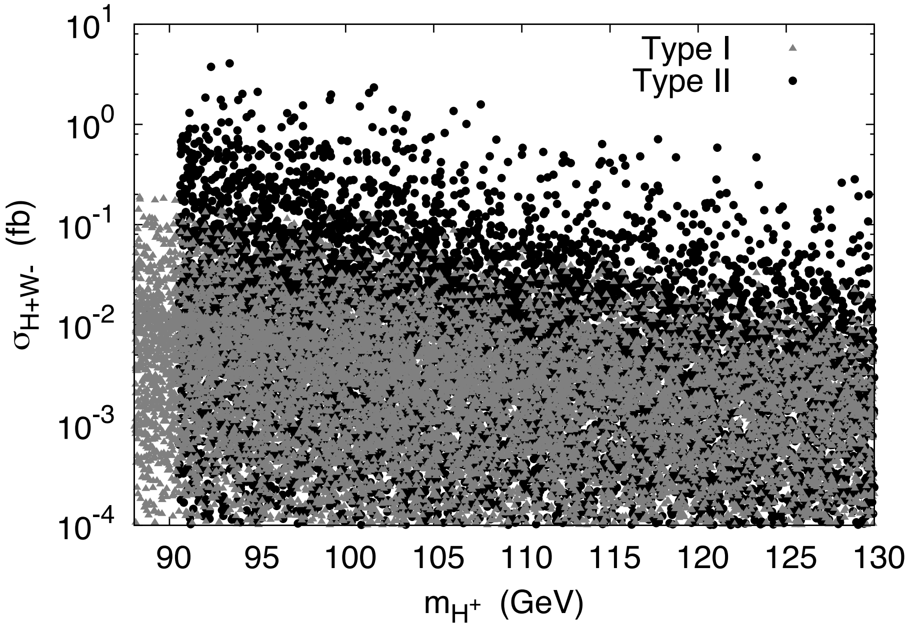
Search for New Physics with exclusive processes: examples

anomalous couplings JHEP 1307 (2013) 116





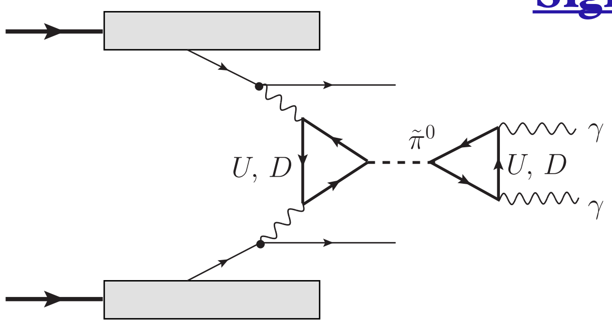
charged Higgs+W CEP

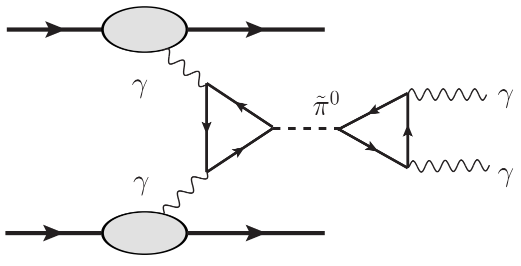


RP, R. Enberg PRD'11

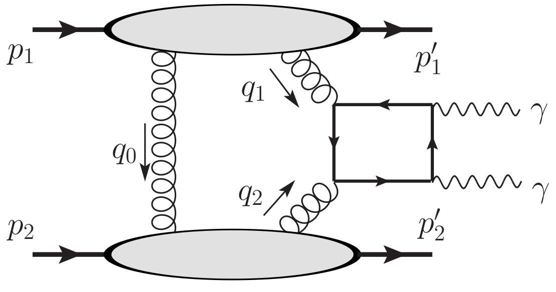
RP, Szczurek, Lebiedowicz, NP881, 288 (2014)

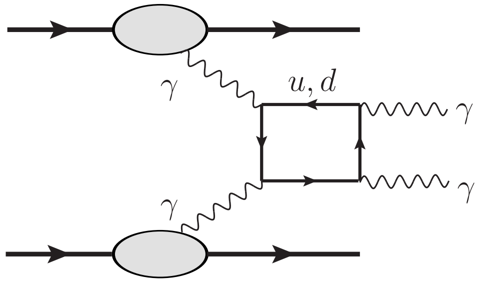
Signal

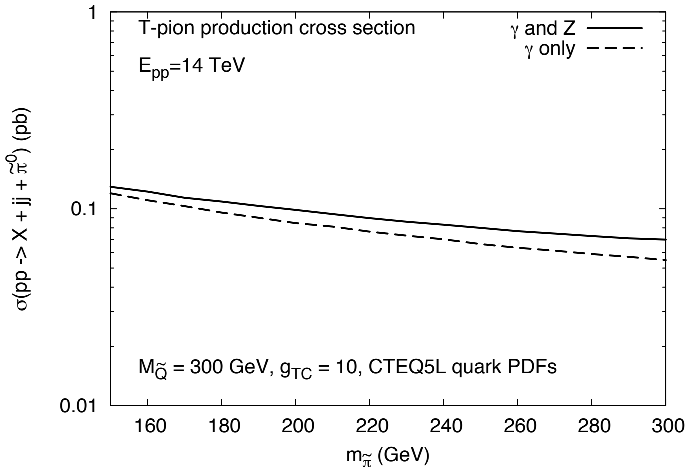


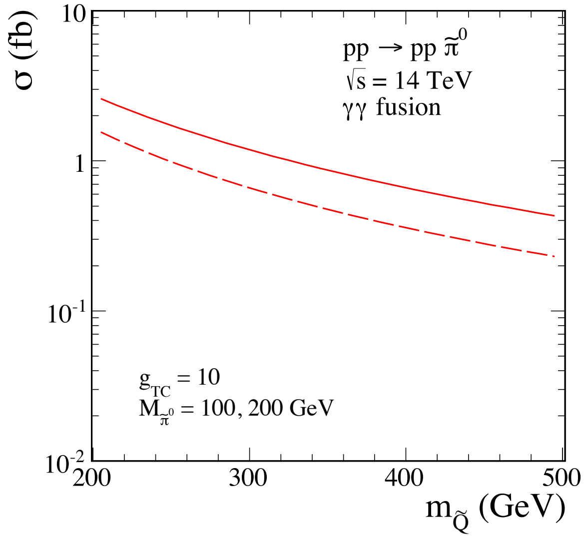


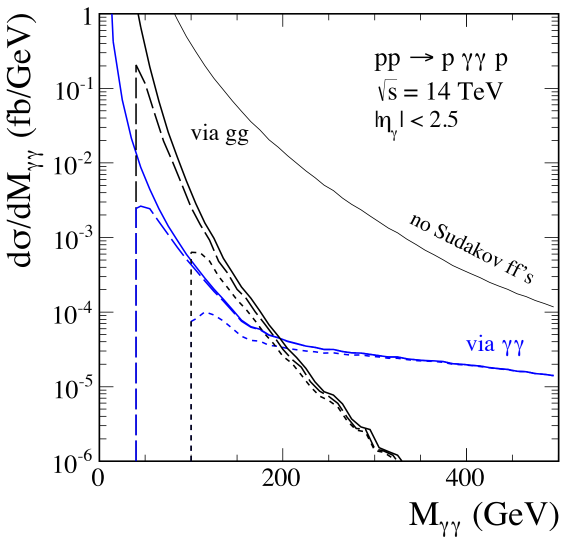
Background











see also Royon

Summary: Diffraction as a QCD laboratory

- ✓ Definition of diffraction is not unique but understood
- ✓ We have seen the Pomeron at work both in soft and hard regimes, as well as in the transition region — marginal agreement with data is achieved despite large uncertainties
- ✓ Matching between “soft” DL and “hard” BFKL Pomerons is a big challenge, but there is a progress
- ✓ Many theoretical developments in QCD-ish modelling of soft/hard Pomeron
- ✓ Diffraction is highly sensitive to small-x/long distance and multiple exchange physics
- ✓ Such effects as Regge/diffractive factorisation breaking, fluctuations in hadronisation, color screening need a proper universal treatment
- ✓ Further MC development/improvements and measurements are required
- ✓ Exclusive diffraction opens up new opportunities for New Physics searches due to reduced backgrounds

As long as QCD dynamics not understood, diffraction continues to be interesting