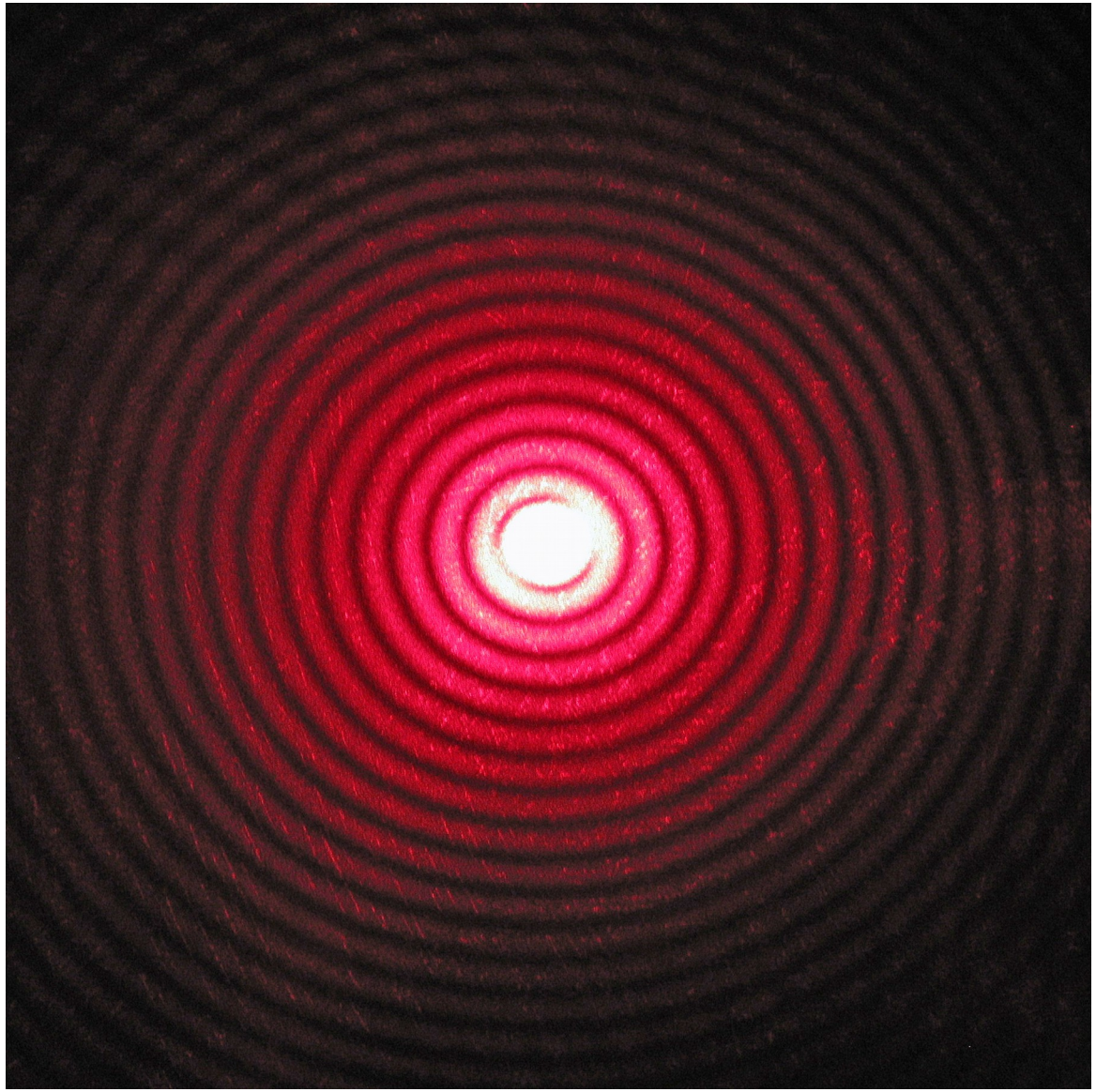
Low-x & MPI & Diffraction – Highlights & Discussion

Christine Rasmussen, Radek Žlebčík

Friday,
22. 11. 2019,
MPI@LHC 2019

Prague

Working group 4



Thanks to all speakers

Christine Rasmussen, Radek Žlebčík

MC developments in small-x and diffraction	*Patrick Kirchgaesser*	10:50 - 11:25
The electron-ion collider – A collider to unravel the mysteries of hadron structure	*elke-caroline Aschenauer*	11:25 - 11:50
Diffractive Bremsstrahlung in hadronic collisions	*Roman Pasechnik*	11:50 - 12:20
Measurements of single diffraction using forward proton tagging at ATLAS	*Maciej Trzebinski for the ATLAS Collaboration*	14:40 - 15:05
Diffractive excitation in pp and pA scattering at high energies	*Dr P.V.R.G. Silva*	15:05 - 15:30

CMS results on diffraction and exclusive production	*Ankita Mehta for the CMS Collaboration*	16:00 - 16:25
A complete picture of photon-initiated production at the LHC	*Dr Lucian Harland-Lang*	16:25 - 16:50
Very-forward neutral particles production measured by the LHCf experiment	*Alessio Tiberio*	16:50 - 17:15
Saturation in the impact-parameter plane through vector meson photoproduction	*Prof. Jesus Guillermo Contreras Nuno*	11:30 - 11:55
Determination of proton parton distribution functions using ATLAS data	*Josef Pacalt for the ATLAS Collaboration*	11:55 - 12:20
η_c(1S) and η_c(2S) production at the LHC	*Antoni Szczurek*	12:20 - 12:45

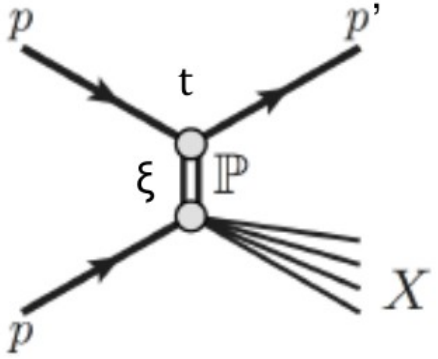
5 Experimental and 6 theory contributions

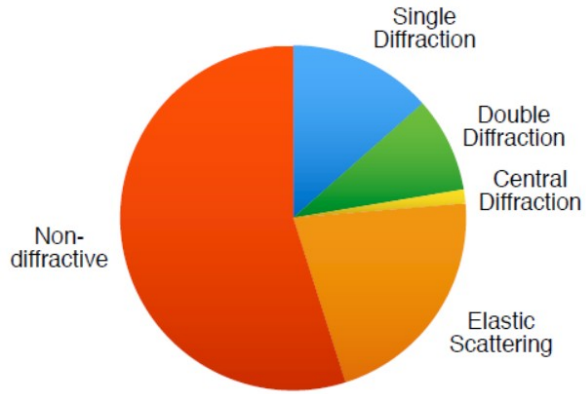
Not a summary, just few highlights for discussion
→ Apologies to all topics which are not mentions

Tagged diffraction at LHC

M. Trzebinski - ATLAS

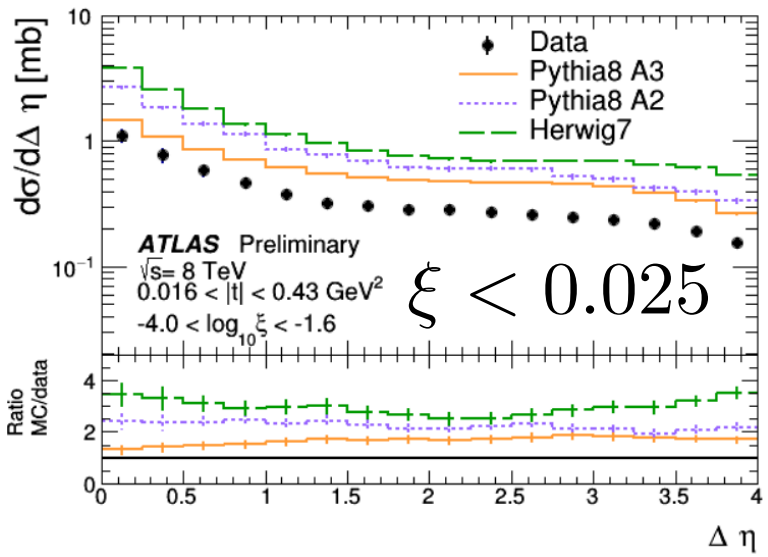
- Diffraction with proton measured in the proton spectrometer ALPHA
- MC overshoots MC by ~2times





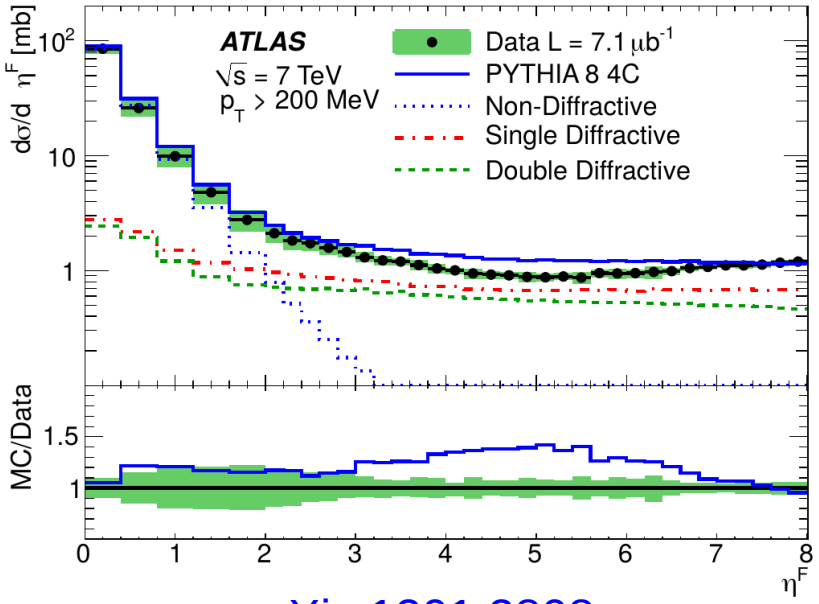
$$\xi = \frac{M_X^2}{s} \qquad \Delta\eta \approx -\log\xi$$

ATLAS+ALPHA (8 TeV)



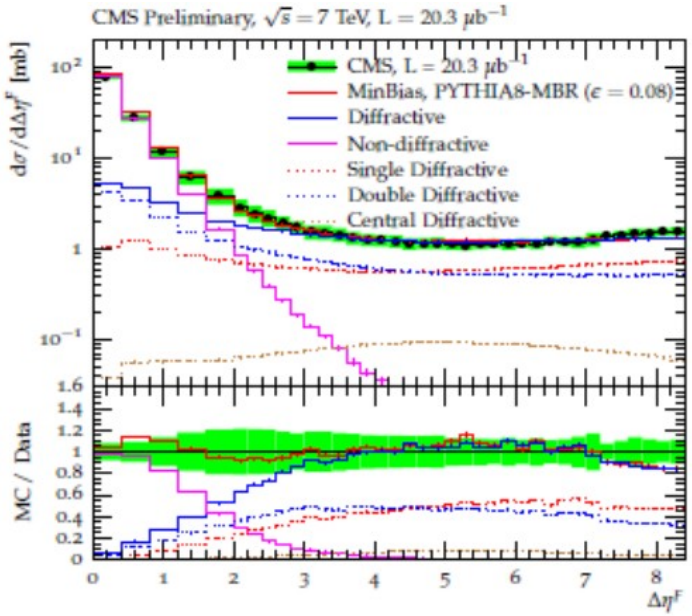
ATLAS-CONF-2019-012

ATLAS (7 TeV)



arXiv:1201.2808

CMS (7 TeV)



arXiv:1503.08689

Tagged diffraction at LHC

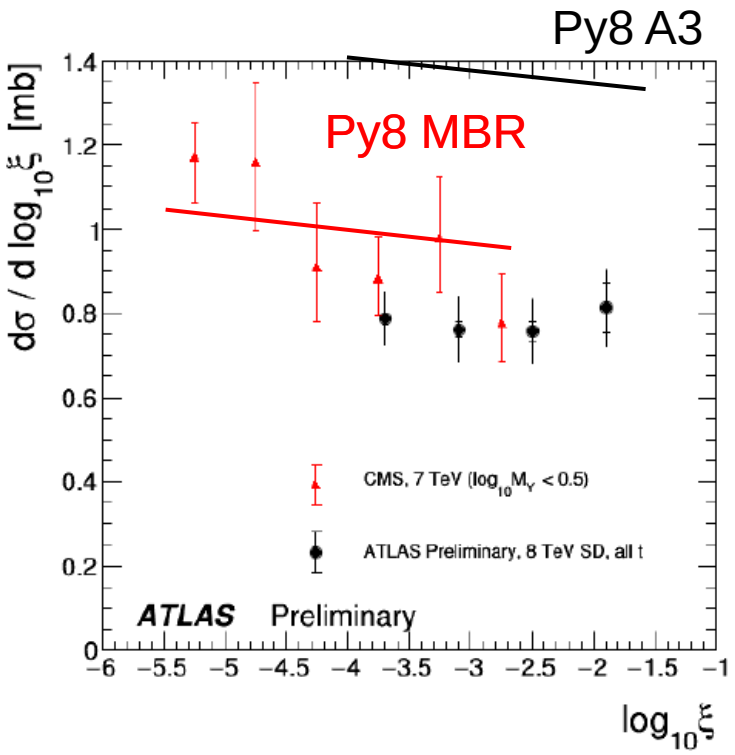
M. Trzebinski - ATLAS

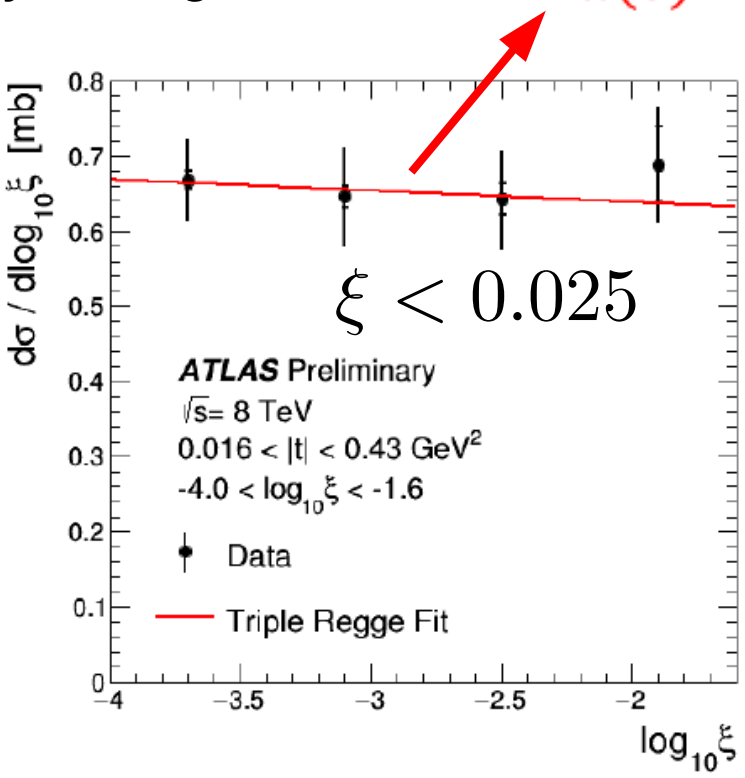
- What is the PD fraction at LHC?
- What about measuring α' from t-slope?
- Is single (Pomeron) trajectory enough?

$$\frac{d\sigma_{SD}}{d\log_{10}(\xi)} \propto \left(\frac{1}{\xi}\right)^{\alpha(0)-1} \frac{1}{B}\left(e^{Bt_{\text{high}}} - e^{Bt_{\text{low}}}\right)$$

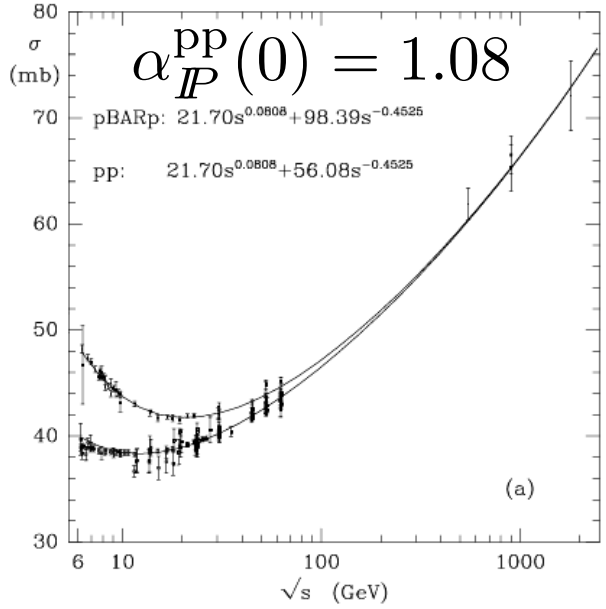
where $B = B_0 - 2\alpha' \ln(\xi)$; $\alpha(t) = \alpha(0) + \alpha' t$

$\alpha(0) = 1.07 \pm 0.02(\text{stat}) \pm 0.06(\text{syst}) \pm 0.06(\alpha')$





$\alpha_{I\!P}^{\text{HERA}}(0) = 1.10 \pm 0.04$



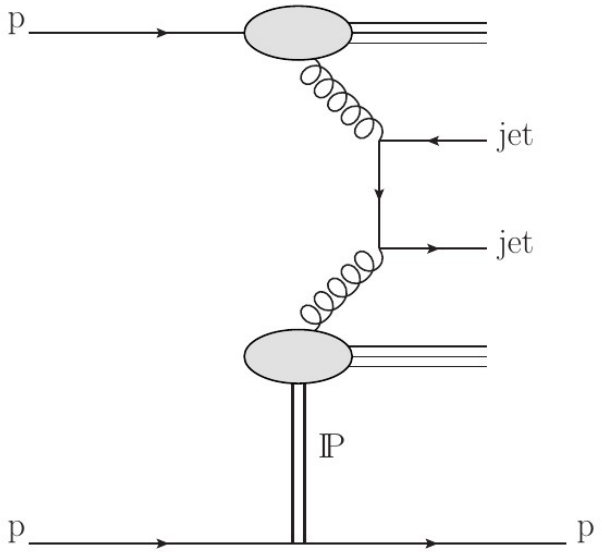
$\alpha_{I\!P}^{\text{pp}}(0) = 1.08$

Donnachie-Landshoff

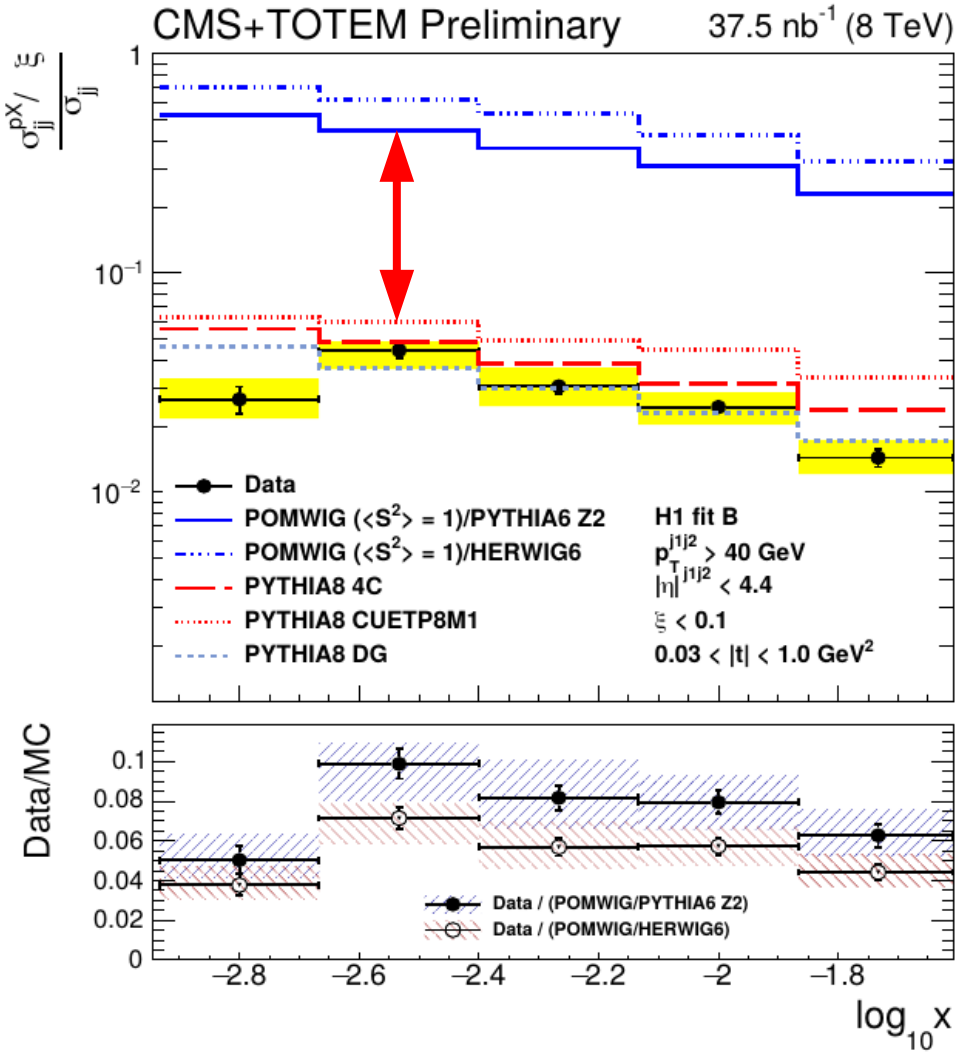
Tagged diffraction at LHC - Dijets

Ankita Mehta - CMS

- First measurement of “hard” diffraction with tagged proton at LHC
  (so far only LRG-based results)
- Predictions based on HERA DPDFs & factorization theorem ~10times above data



CMS + TOTEM (dijets in SD)
”hard” diffraction



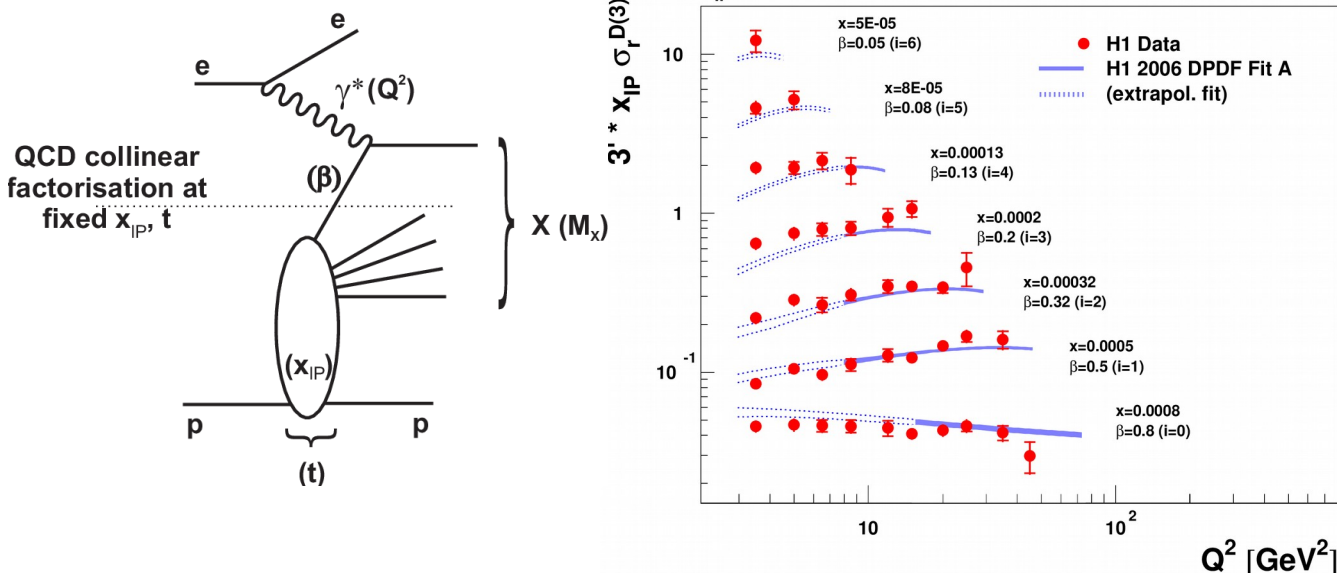
Tagged diffraction with Jets – Factorization breaking

Roman Pasechnik

Factorization in “hard” diffractive processes (Collins 1997)

$$\mathrm{d}\sigma(ep \to epX) = \sum_i f_i^D(x, Q^2, x_{IP}, t) \otimes \mathrm{d}\sigma^{ie}(x, Q^2)$$

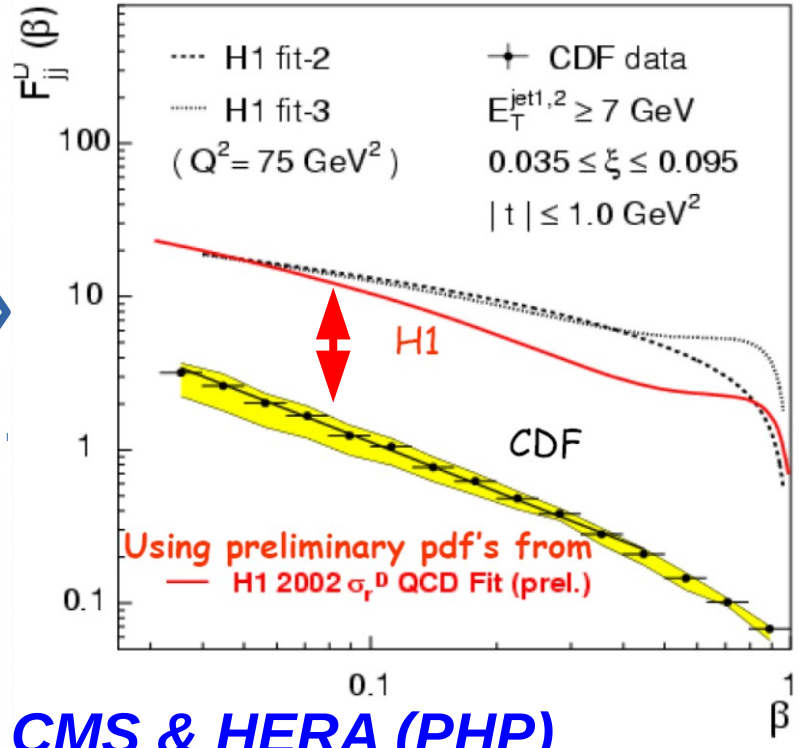
Inclusive DDIS at HERA



QCD fact.

Dijets in SD at Tevatron

Tagged anti-proton



Factorization breaking observed by CDF, ATLAS, CMS & HERA (PHP)

Factorization breaking – Possible solutions

Roman Pasechnik

Regge-corrected approach

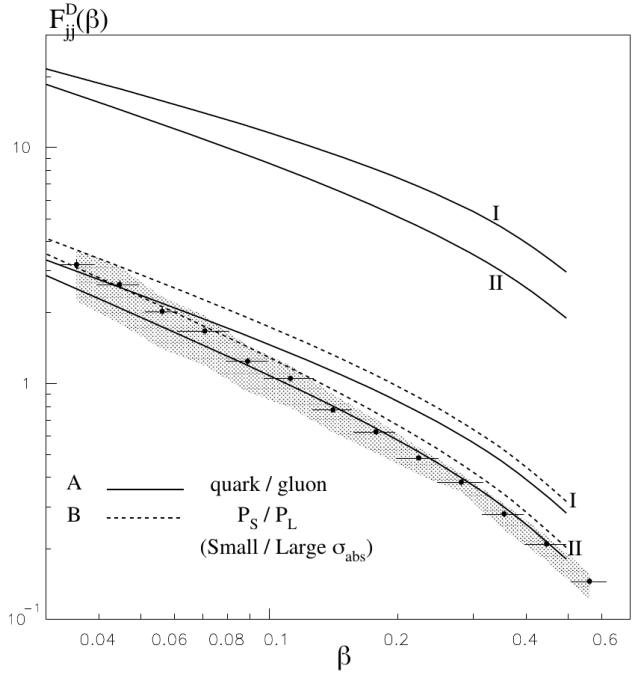
DPDF + soft survival probability (KKMR – hep-ph/0105145)
→ Dressing QCD factorisation formula by soft Pomeron exchanges (to conserve S unitarity)

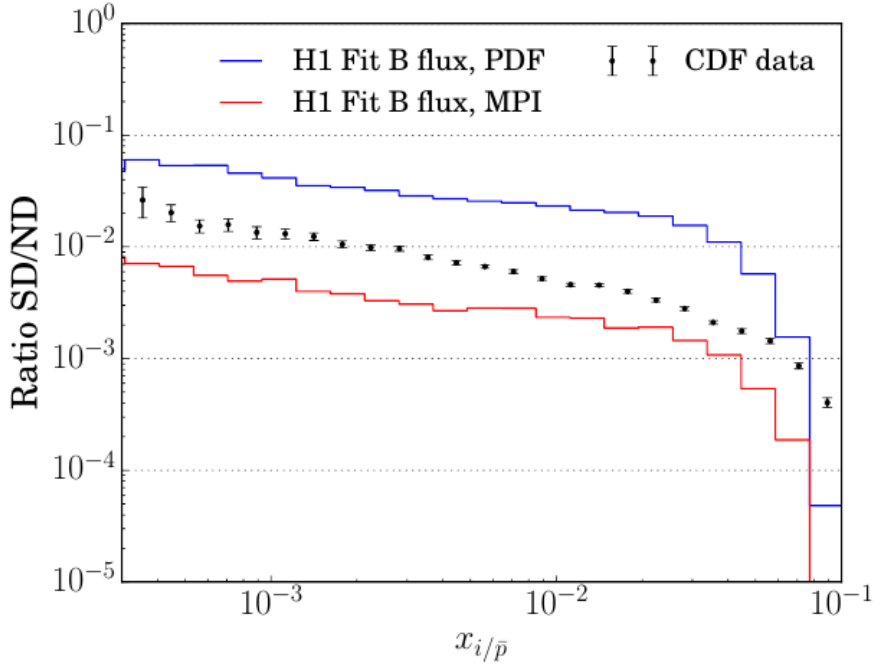
MPI-veto method

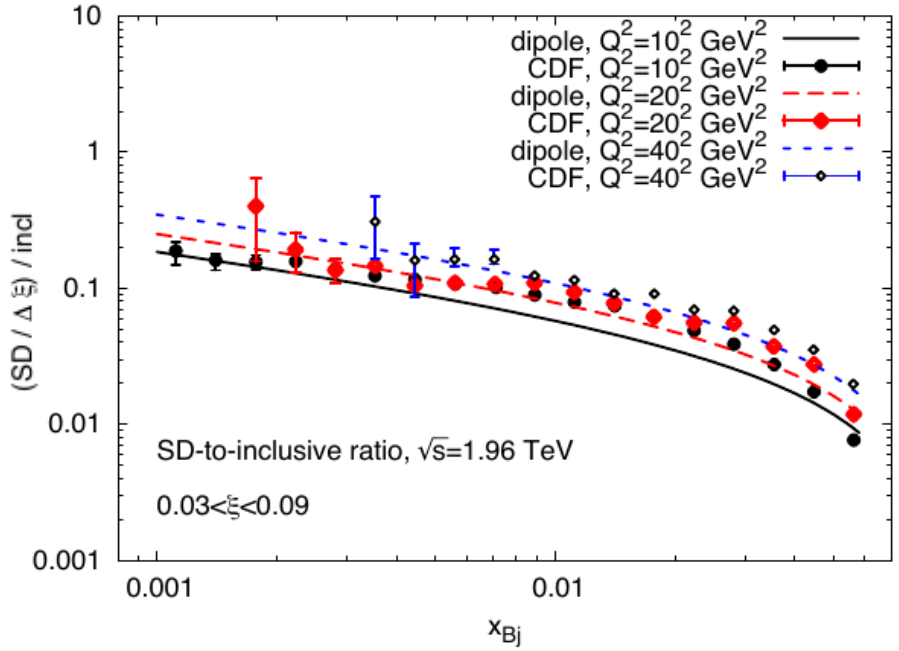
DPDF + dynamic S^2 from MPI (in Pythia8 arXiv:1512.05525)

Color dipole model

universal for inclusive/diffractive scattering, based on fits to F_2
(R. P. at all.)



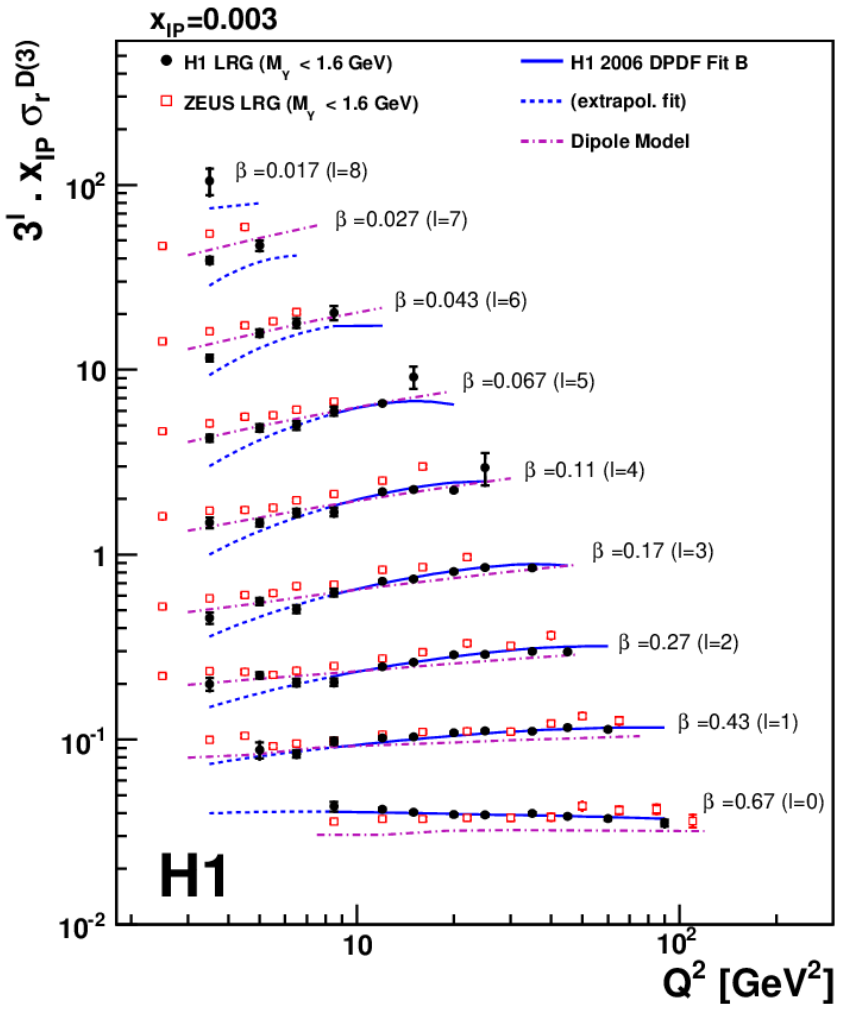




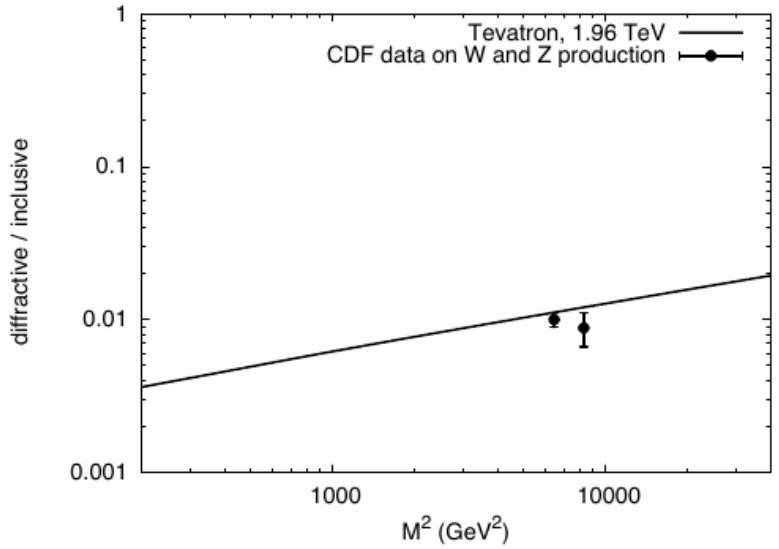
Color Dipole Model – Processes?

Roman Pasechnik

Phys.Rev. D76 (2007) 094017

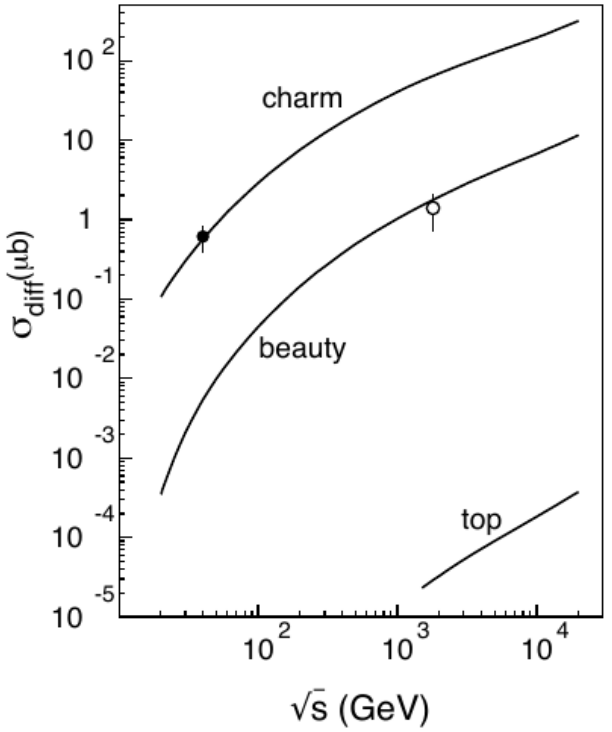


Z/W in Single-Diffraction



+Higgs in Single-Diffraction

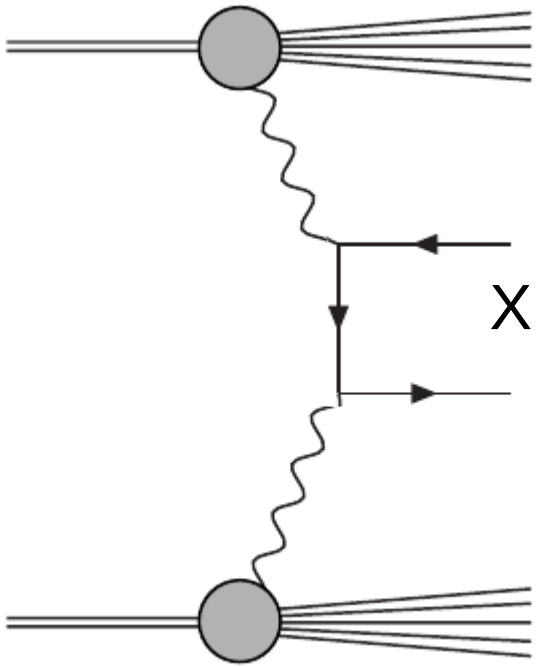
HF in Single-Diffraction



- What about other processes? (e.g. jets in ep)
- What are theoretical unc. (QCD scale...)?
- Monte Carlo for CDM? (DIPSY?)

Photon-Initiated processes in pp

Lucian Harland-Lang



~4% of low-mass DY

- Equivalent-Photon-Flux

$$\sigma_{pp} \approx \int \mathrm{d}x_1 \mathrm{d}x_2 \, f^{\mathrm{PF}}_{\gamma/p}(x_1, \mu^2) f^{\mathrm{PF}}_{\gamma/p}(x_2, \mu^2) \hat{\sigma}(\gamma\gamma \to X)$$

- Full formula based on F_2/F_L (ala VBF Higgs)

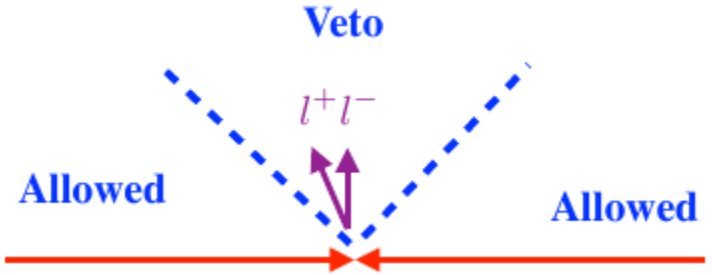
$$\sigma_{pp} = \frac{1}{2s} \int \overbrace{\mathrm{d}x_1 \mathrm{d}x_2 \, \mathrm{d}^2 q_{1\perp} \mathrm{d}^2 q_{2\perp}}^{\textbf{Photon } x, Q^2} \mathrm{d}\Gamma \, \alpha(Q_1^2)\alpha(Q_2^2) \frac{\overbrace{\rho_1^{\mu\mu'} \rho_2^{\nu\nu'}}^{\gamma^* p \to X} \overbrace{M^*_{\mu'\nu'} M_{\mu\nu}}^{\sim \sigma(\gamma^*\gamma^* \to l^+ l^-)}}{q_1^2 q_2^2} \delta^{(4)}(q_1 + q_2 - p_X)$$

$$\rho_i^{\alpha\beta} = 2 \int \frac{\mathrm{d}x_{B,i}}{x_{B,i}^2} \left[-\left(g^{\alpha\beta} + \frac{q_i^\alpha q_i^\beta}{Q_i^2} \right) F_1(x_{B,i}, Q_i^2) + \frac{(2p_i^\alpha - \frac{q_i^\alpha}{x_{B,i}})(2p_i^\beta - \frac{q_i^\beta}{x_{B,i}})}{Q_i^2} \frac{x_{B,i}}{2} F_2(x_{B,i}, Q_i^2) \right]$$

From HERA inclusive DIS

Photon-Initiated processes in pp

Lucian Harland-Lang

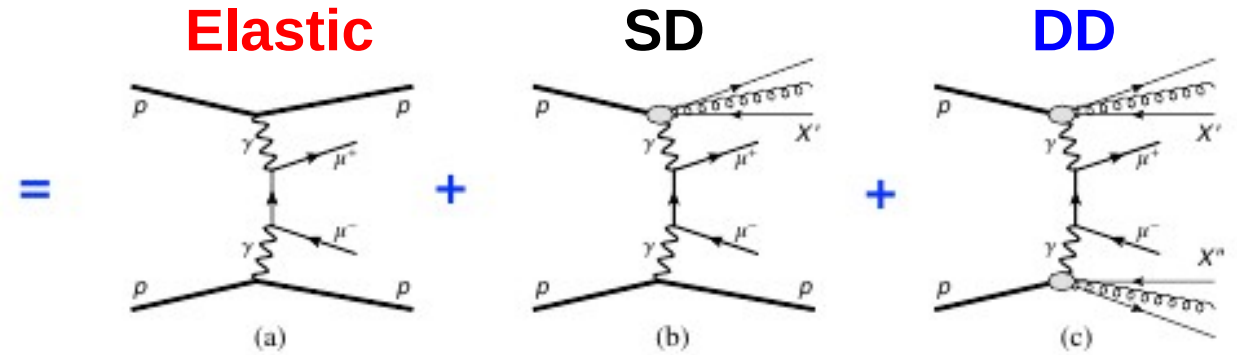


EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

Phys. Lett. B 777 (2018) 303
DOI: 10.1016/j.physletb.2017.12.043

CERN-EP-2017-151
8th January 2018

Measurement of the exclusive $\gamma\gamma \to \mu^+\mu^-$ process in proton–proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector



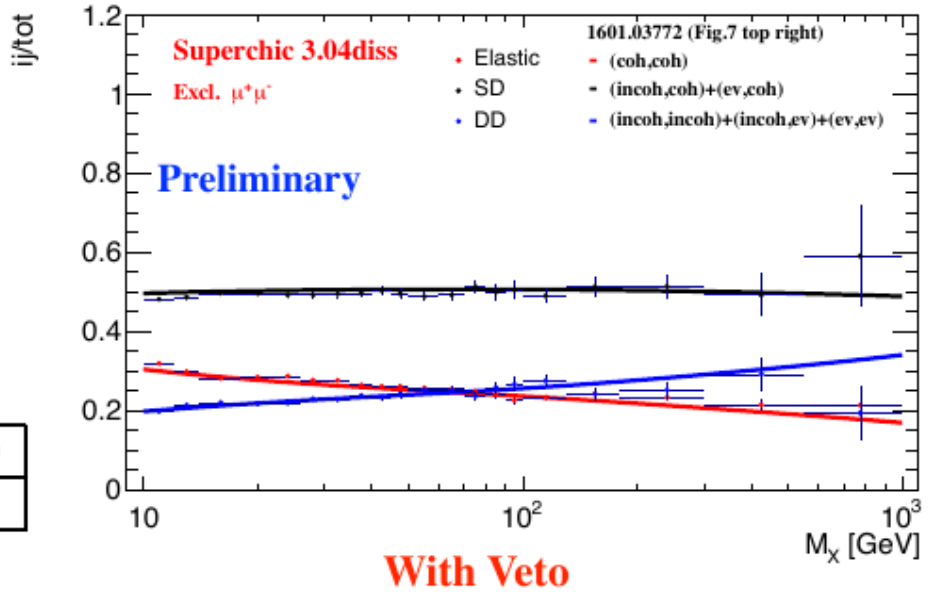
- Preliminary MC implementation in SuperChic3

Beware of Survival effects

Single	Low $M_{Y,Z}$ ($\lesssim 2.5$ GeV)	High $M_{Y,Z}$ ($\gtrsim 2.5$ GeV)	
S^2	0.86 ± 0.03	0.81 ± 0.03	
Double	(Low M_Y, Low M_Z)	(Low M_Y, High M_Z)	(High M_Y, High M_Z)
S^2	0.3 – 0.45	0.2 – 0.28	0.08 – 0.16

arXiv:1204.4803

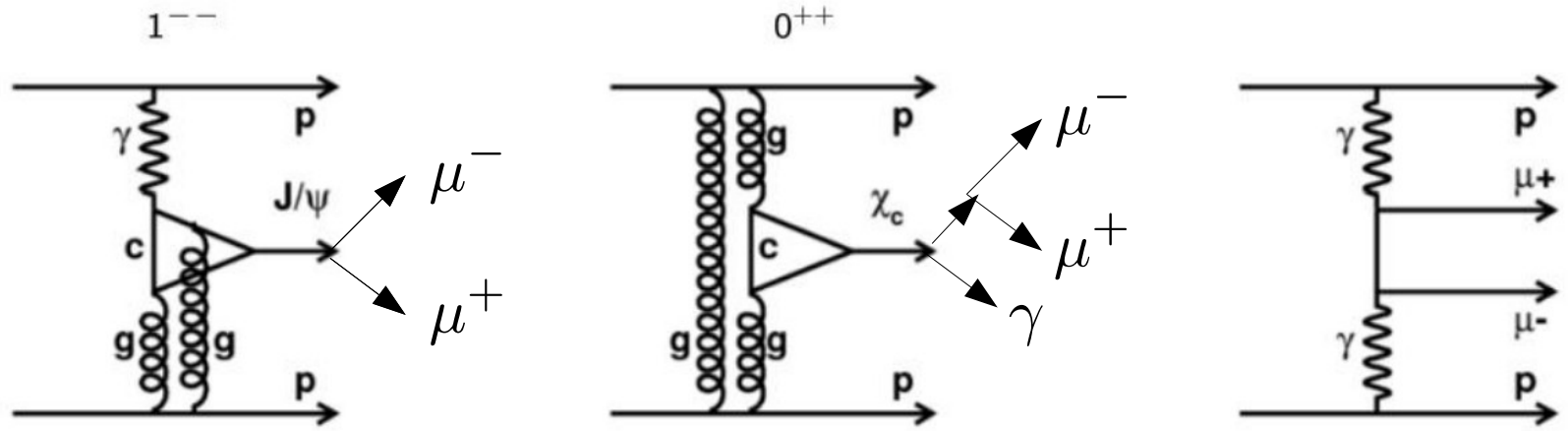
$$pp \to Y + \gamma\gamma + Z$$



Photon-Initiated processes in pp - J/psi

Lucian Harland-Lang

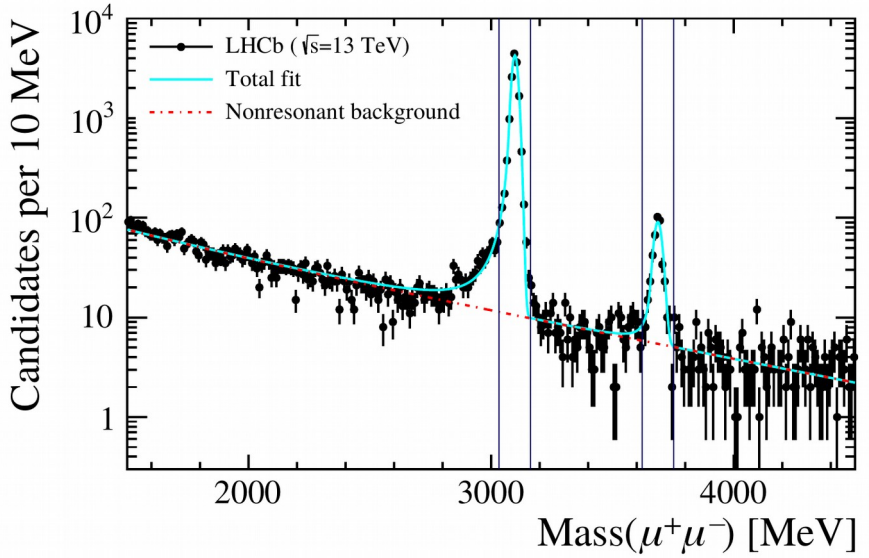
- Measured by LHCb & ALICE in pp, pA, AA

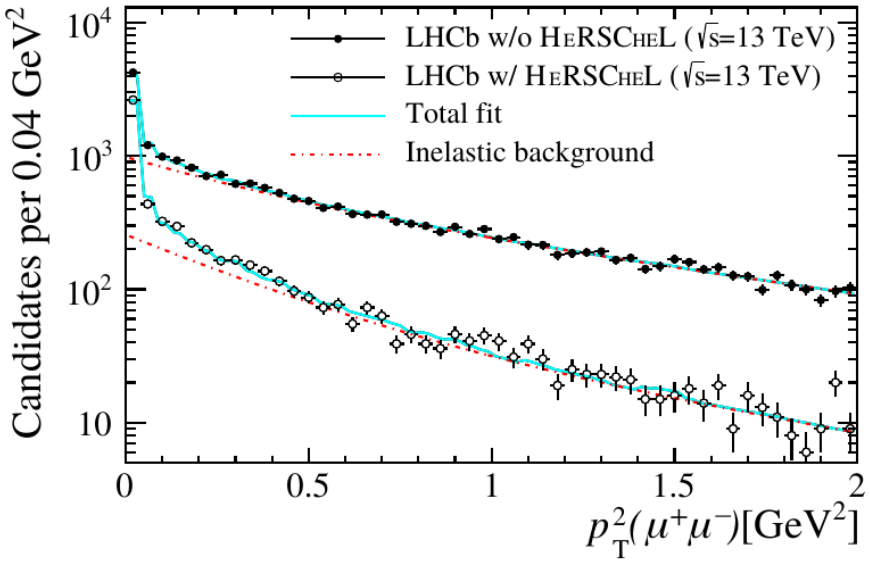


Photoproduction **QCD CEP** **QED CEP**

+ Processes involving proton dissociation

- Continuous pedestal from γγ → μμ
- Dissociative and chi$_c$ BG at higher $p_T(\mu\mu)$
- **Can it be described by MC?**

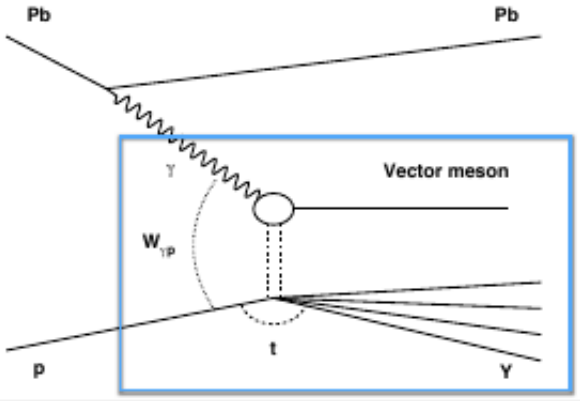


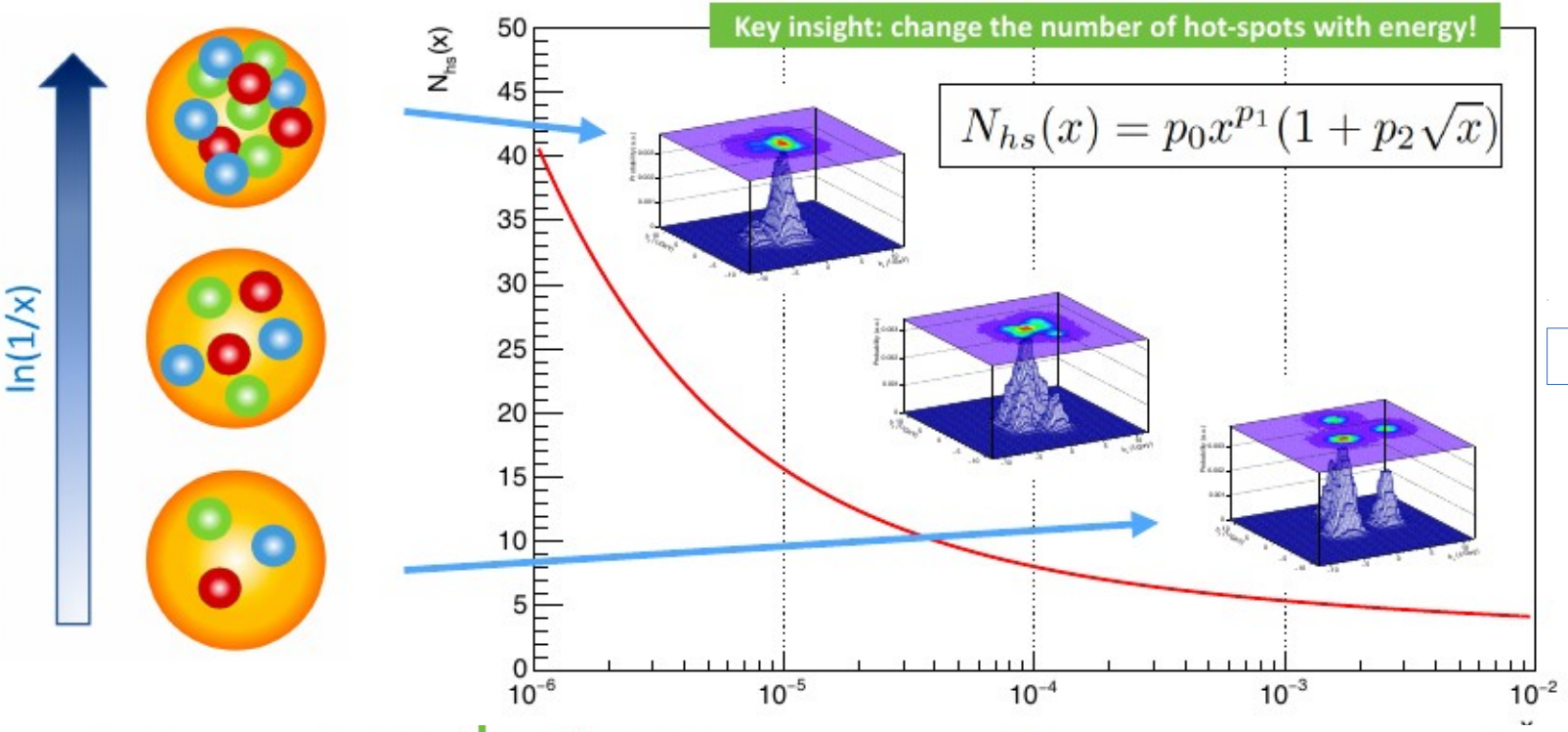


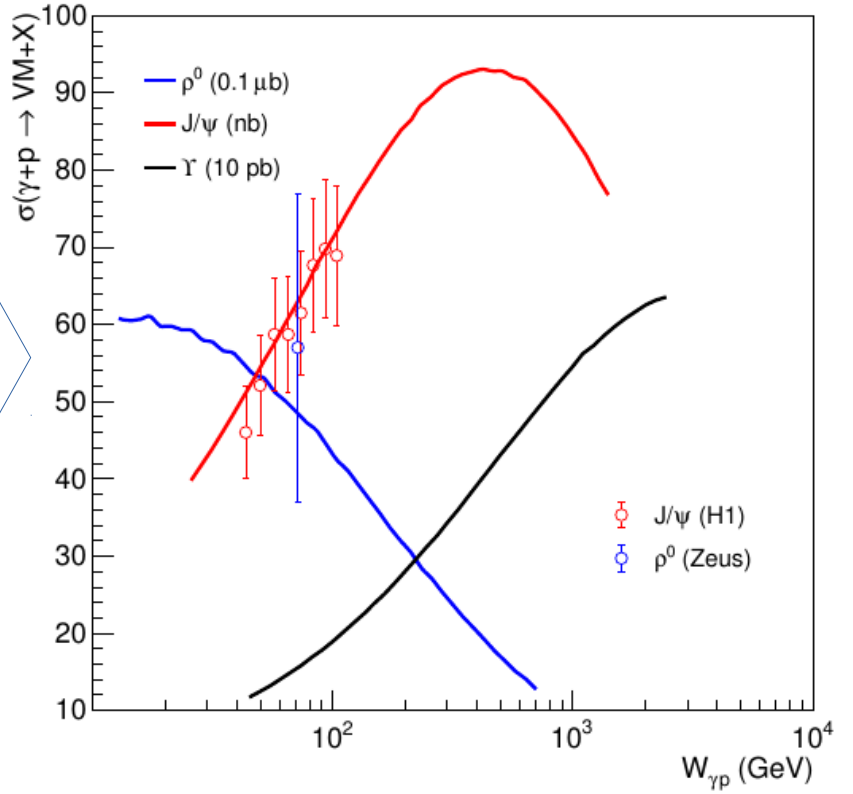
Saturation of the VM diss. x-section

J. Guillermo Contreras

- High #hot-spots at low-x make the Amplitude variance small → saturation





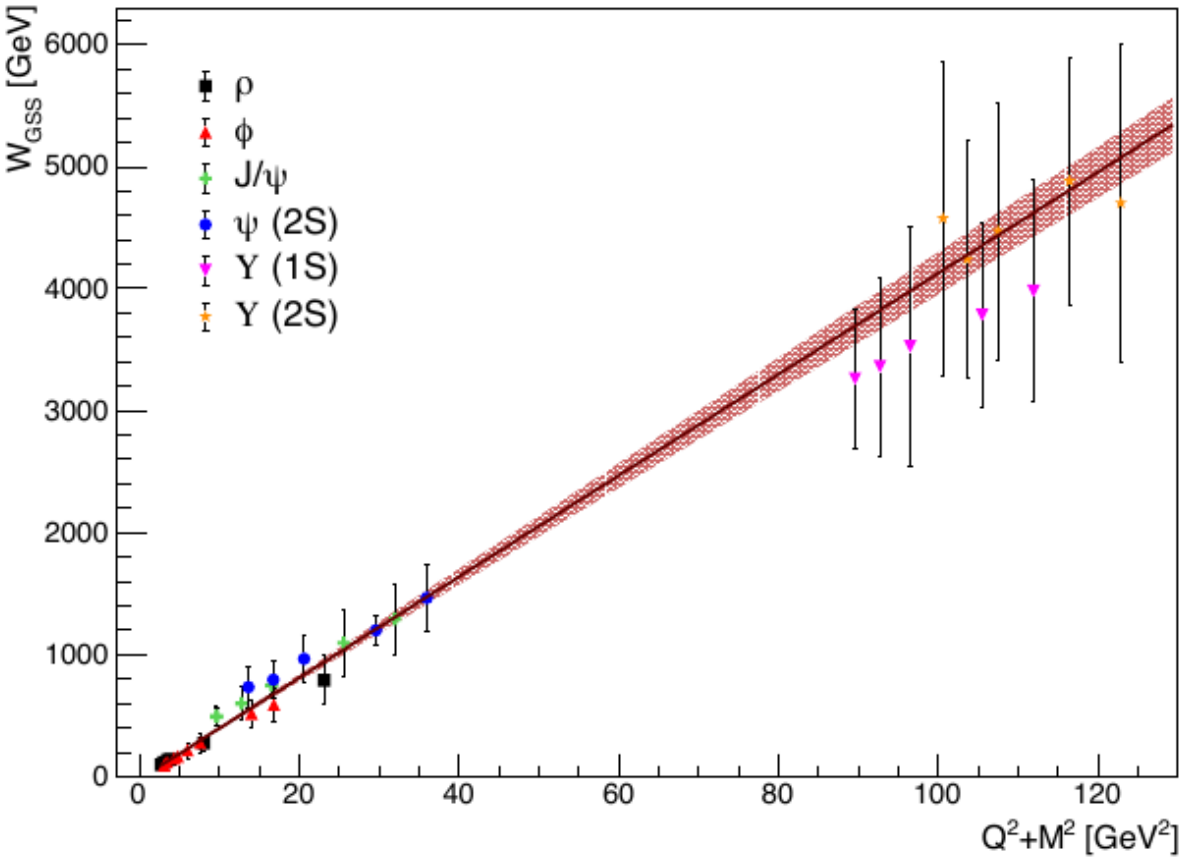


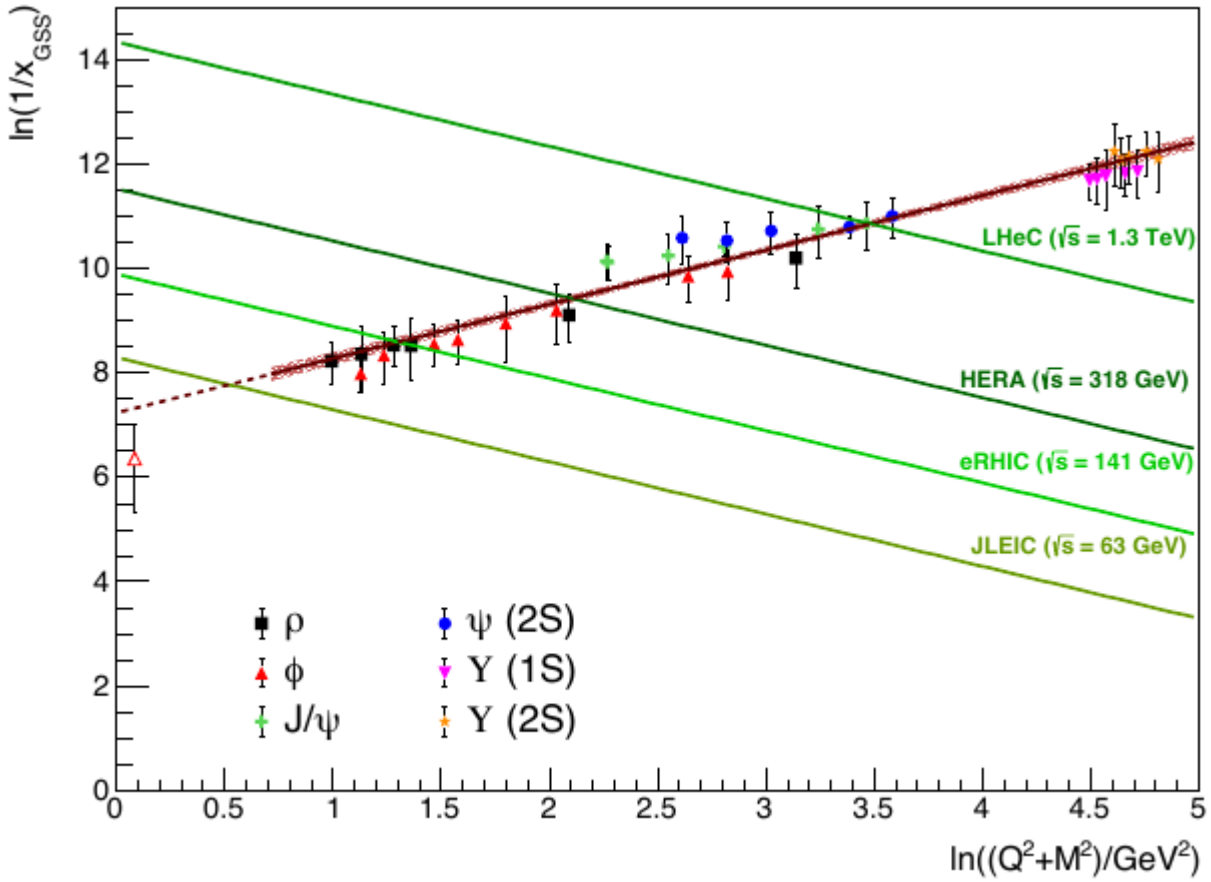
$$\frac{d\sigma(\gamma p \to \mathrm{J}/\psi Y)}{dt} \overset{\downarrow}{=} \frac{R_g^2}{16\pi}\left(\left\langle\left|A(x,Q^2,\vec{\Delta})\right|^2\right\rangle - \left|\left\langle A(x,Q^2,\vec{\Delta})\right\rangle\right|^2\right)$$

Saturation of the VM diss. x-section

J. Guillermo Contreras

- For VM of lower masses the maximum projected to be visible at HERA, for J/psi LHeC needed

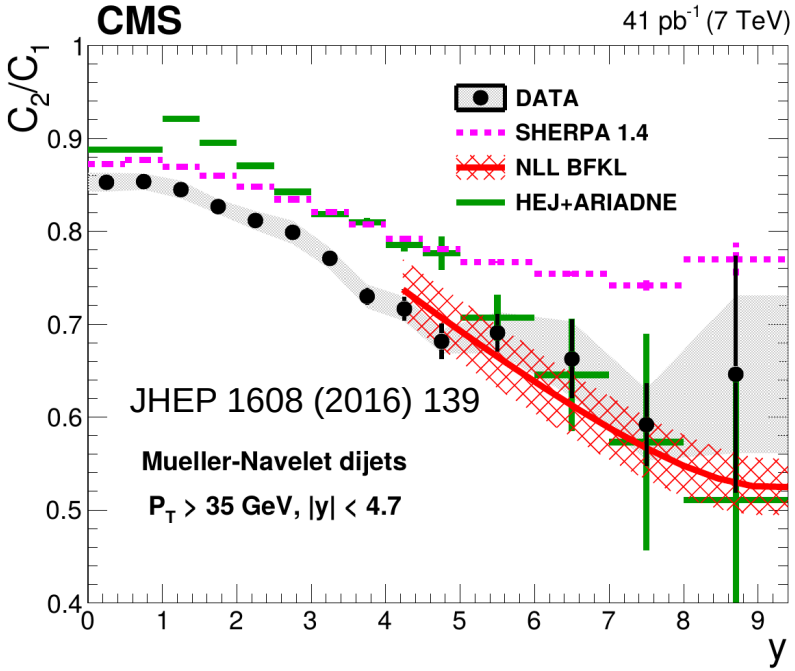




Need for low-x MC generator

- There are many PDF extractions including BFKL kernels, e.g KS-gluon (x<0.01) or NNPDF3.1sx (NNLO+NLLx)
- Do/can we have MC with shower consistent with the BFKL-like evolution at small-x?
  - → CASCADE + Katie
  - → HEJ (for Mueller-Navalet jets)
  - → CDM based MC?

Example: Forward-backward jets



For proper NLO asymmetric p_T cut needed!

In High Energy limit

$$y_1 \ll y_2 \ll \ldots \ll y_n$$
$$p_{Ti} \approx p_{Tj}$$
$$|M_{gg\to g..g}|^2 \sim \frac{1}{p_{T1}^2} \cdot \frac{1}{p_{T2}^2} \cdots \frac{1}{p_{Tn}^2}$$

Need for precision at low-x

mind the “collinear” NNLO revolution

$x \sim 5*10^{-5}$ for HERA DIS

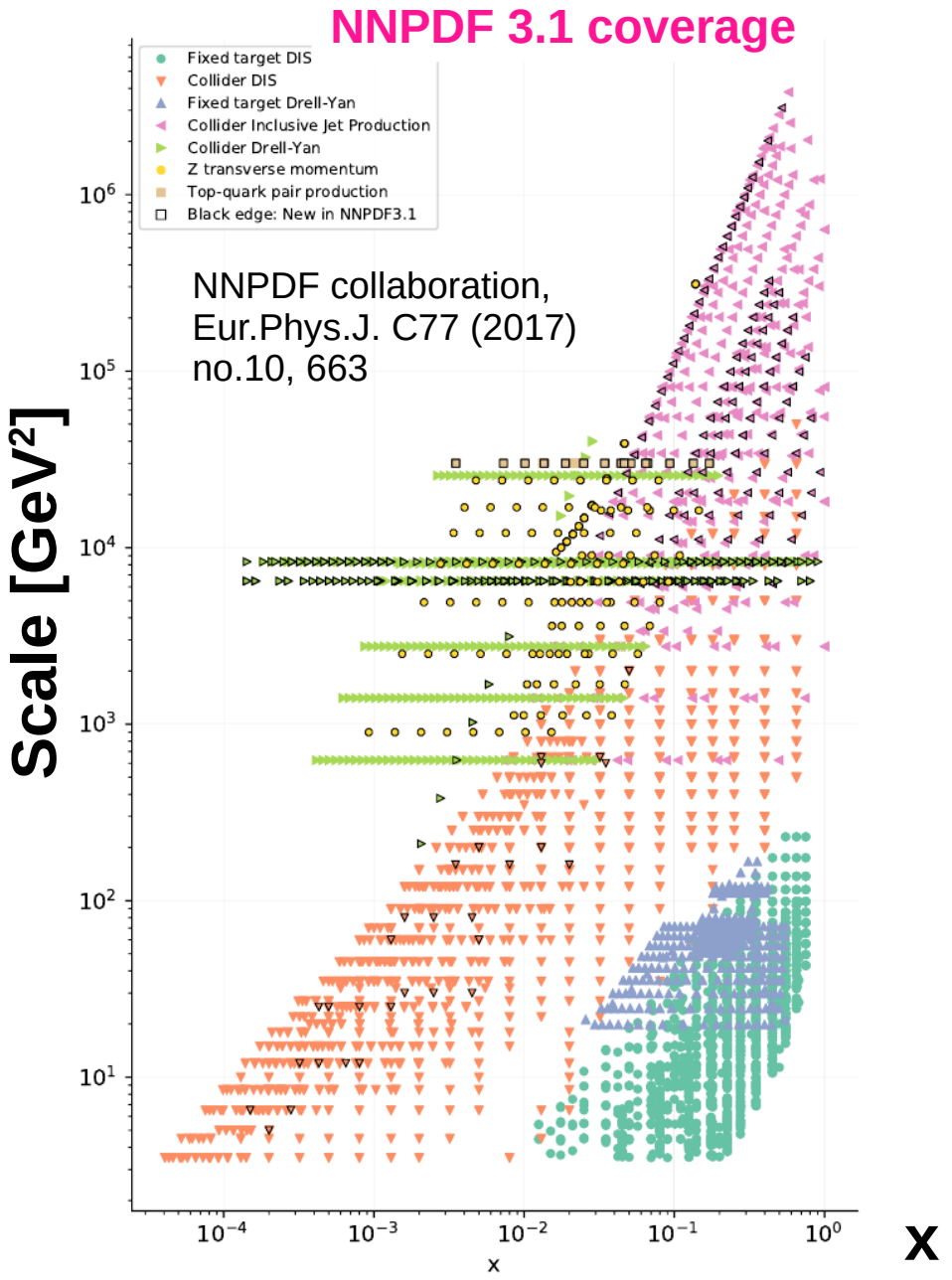
$x \sim 2*10^{-4}$ for LHC DY

...But nothing from our low-x world (J/psi PHP, CEP, η_c...), why?

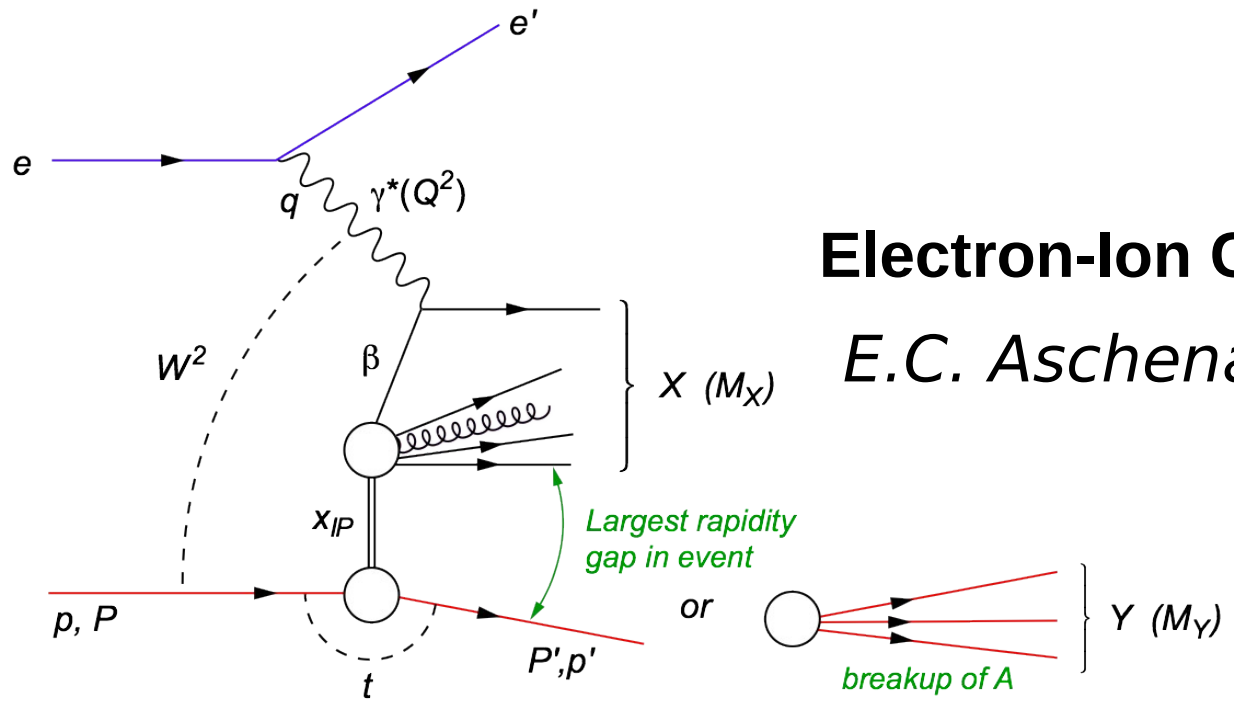
→ Higher model unc (often LO)?

→ Don't fit well with standard collinear DGLAP framework?

Probes of the small x gluon via exclusive J/ψ and Y production at HERA and the LHC
[Jones, Marin at al., arXiv:1307.7099]



Discussion & Future



Electron-Ion Collider

E.C. Aschenauer

Diffraction in e+p:

- coherent ⇔ p intact
- incoherent ⇔ breakup of p
- HERA: **15%** of all events are hard diffractive

Diffraction in e+A:

- coherent diffraction (nuclei intact)
- breakup into nucleons (nucleons intact)
- incoherent diffraction
- Predictions: $\sigma_{diff}/\sigma_{tot}$ in e+A ~**25-40%**