XXIX International Workshop on Deep Inelastic Scattering and Related Subjects

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Measurement of exclusive vector meson photoproduction in pPb collisions with the CMS experiment

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on behalf of the CMS Collaboration

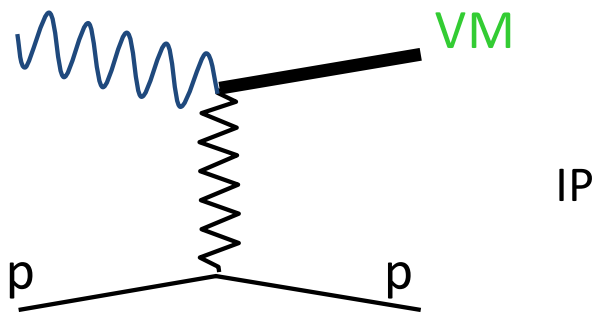
Outline

- Introduction
- CMS detector and forward instrumentation
- Exclusive Υ production in pPb at 5.02 TeV
  [Eur. Phys. J. C **79**, 277 (2019)]
- Exclusive $\rho 0(770)$ production in pPb at 5.02 TeV
  [Eur. Phys. J. C **79**, 702 (2019)]

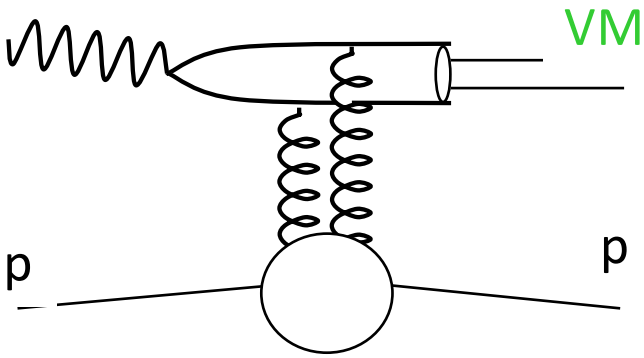
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN#CMS_Heavy_Ion_Public_Physics_Res

Transition soft → hard

Soft - Regge



Hard - QCD



VM ($J^{PC}=1^{--}$): γ, ρ, ϕ, J/ψ,Υ,...

Cross section proportional to probability of finding 2 gluons in the proton

$$\sigma(W) \propto W^{\delta}$$

With **W** the γ-proton center of mass energy

With increasing scale (Q^2, M_{VM}, t) :

- Expect δ to increase from soft (~0.2, 'soft Pomeron' value) to hard (~0.8,) reflecting large gluon density at low x

  With **x** the fractional momentum of the proton carried by the struck parton

$$\frac{d\sigma}{dt} \propto e^{-b|t|}$$

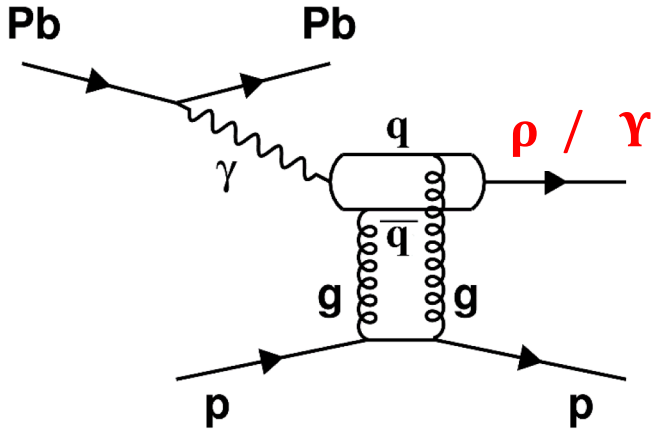
With **t** the 4-momentum transfer squared

- Expect **b** to decrease from soft (~10 GeV^{-2}) to hard (~4-5 GeV^{-2})

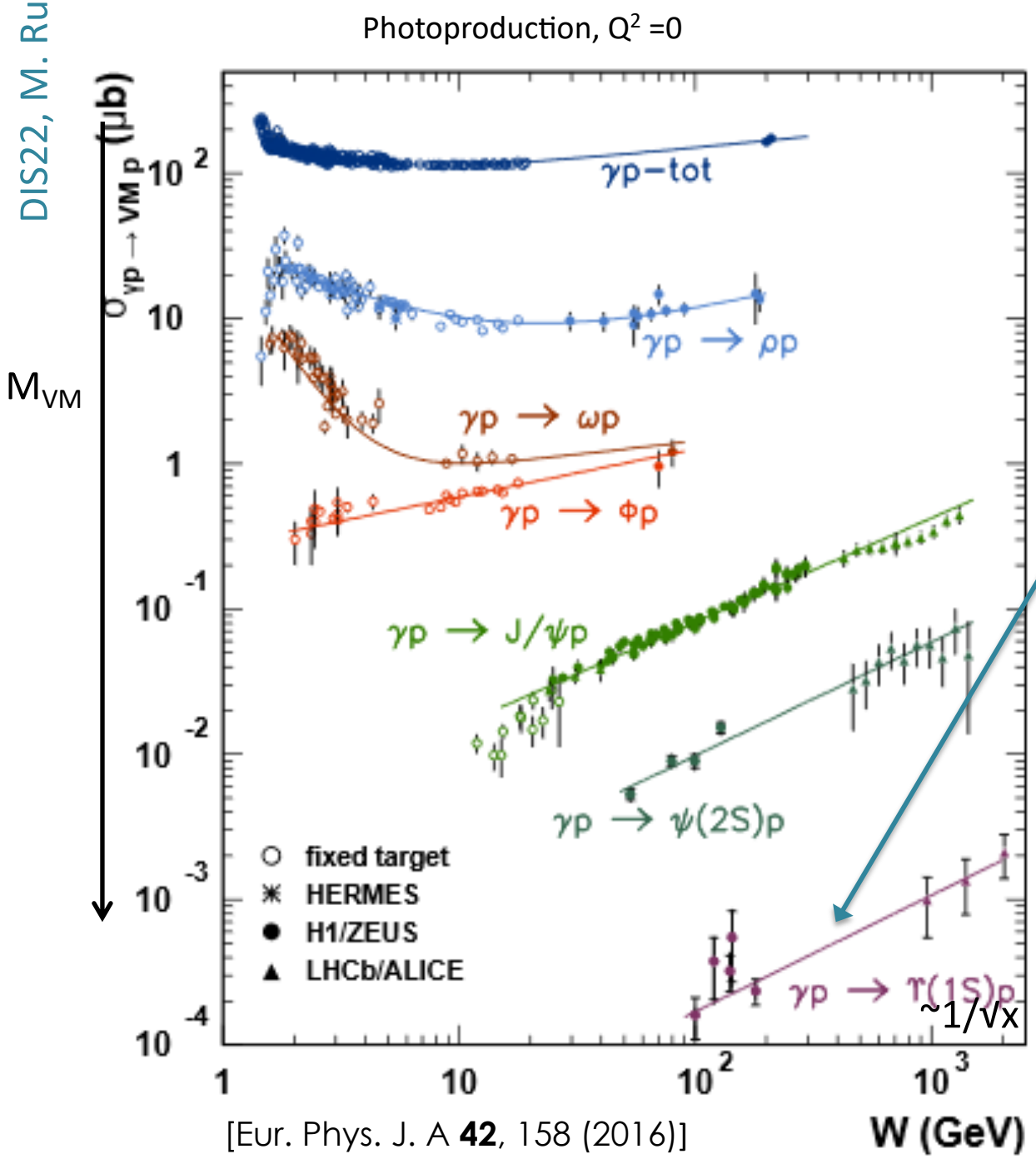
Ultraperipheral collisions at LHC

- Photon flux grows with the square of the charge, Z^2

- Sensitivity to gluon density in nucleon (nucleus)



Ultraperipheral collisions at LHC



[Eur. Phys. J. A **42**, 158 (2016)]

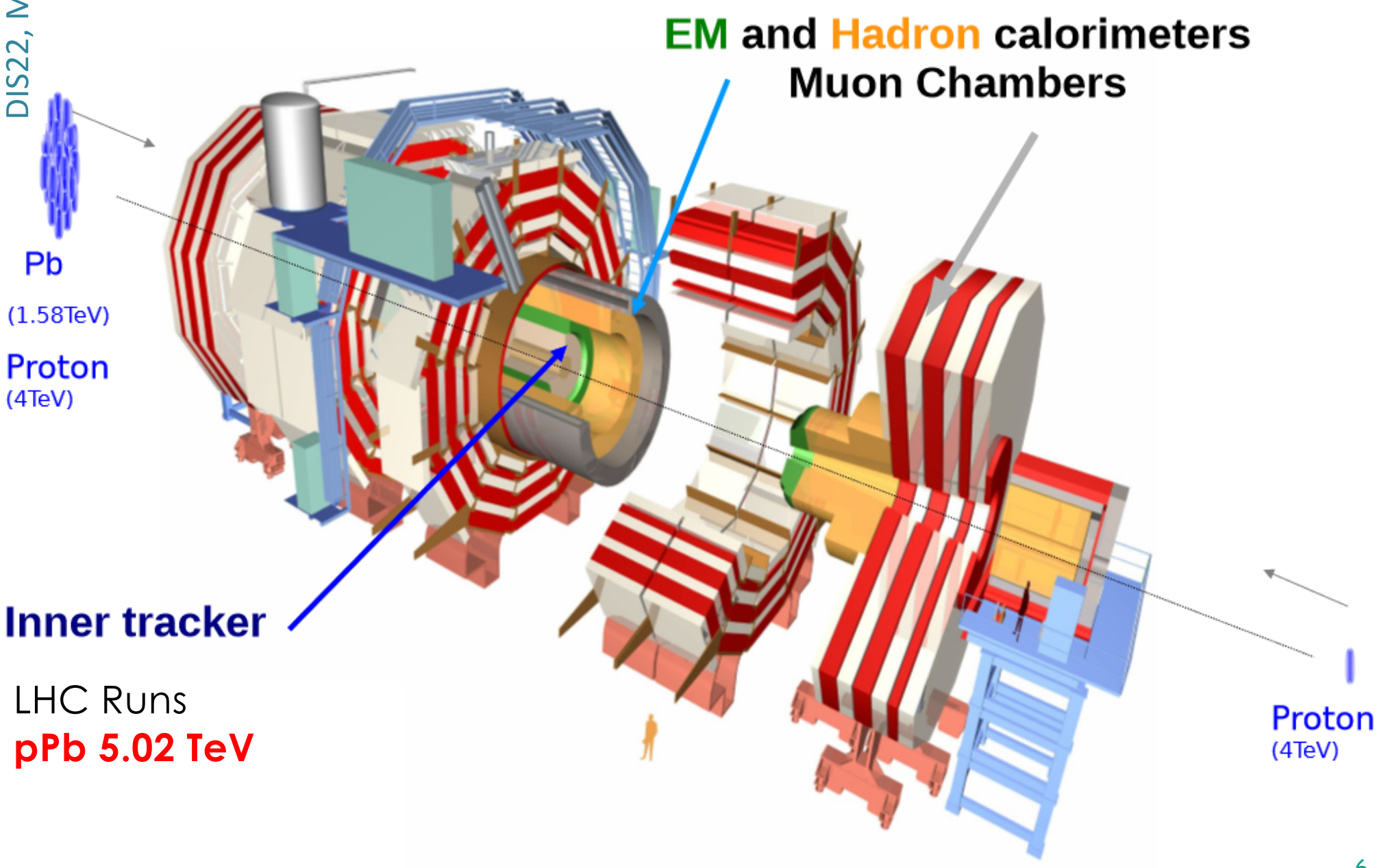
- CMS kinematics bridges earlier measurements

x : $10^{-4} \div 2*10^{-2}$
W: 29 ÷ 213 GeV for **ρ**
81 - 826 GeV for **ϒ**
(at 5.02 GeV)

$$x = (M_{VM}/W_{\gamma p})^2$$

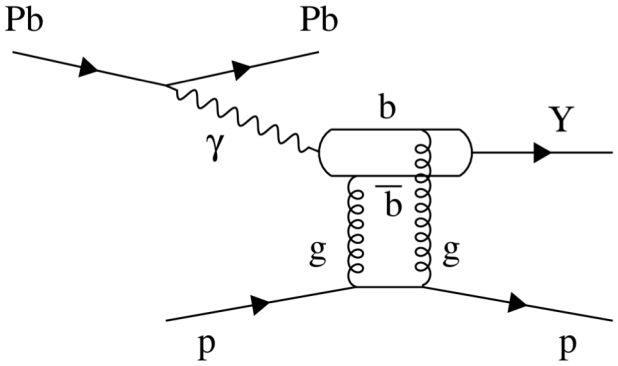
$$W_{\gamma p}^{\,2} = 2E_p M_{VM} exp(\pm y)$$

CMS detector



LHC Runs

pPb 5.02 TeV



Exclusive upsilon at 5 TeV

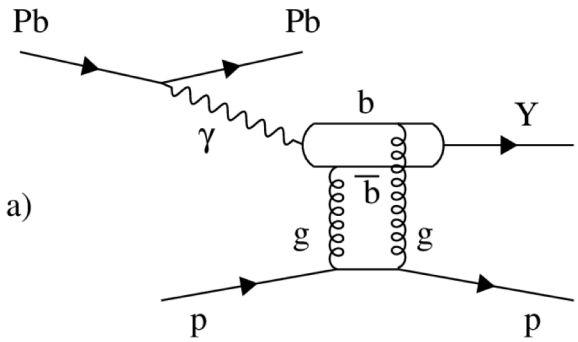
[Eur. Phys. J. C **79**, 277 (2019)]

Data

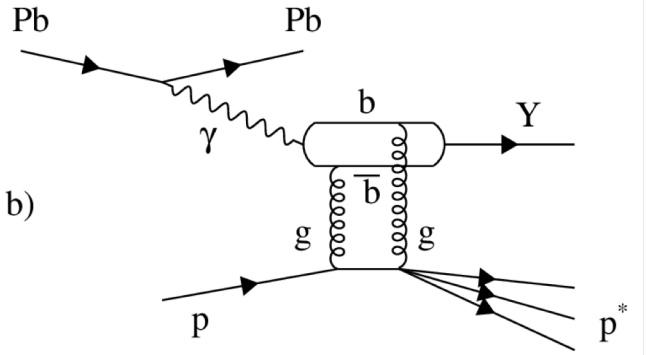
2013 pPb data @5.02 TeV, L ~ 33 nb^{-1}

Two muons with $p_T(\mu)$> 3.3 GeV, |eta|<2.2, 0.1< pT(μμ)<1 GeV, 9.1<Mμμ<10.6 GeV, no extra tracks

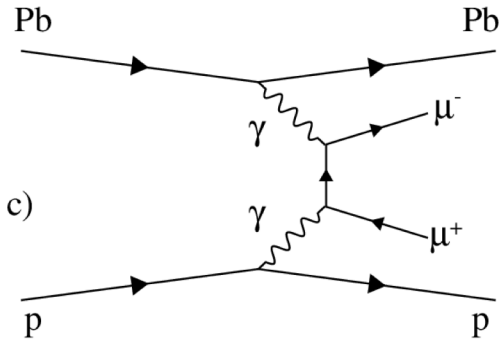
STARLight for signal, QED continuum and γPb
Data-driven subtraction of proton-dissociation background



Signal



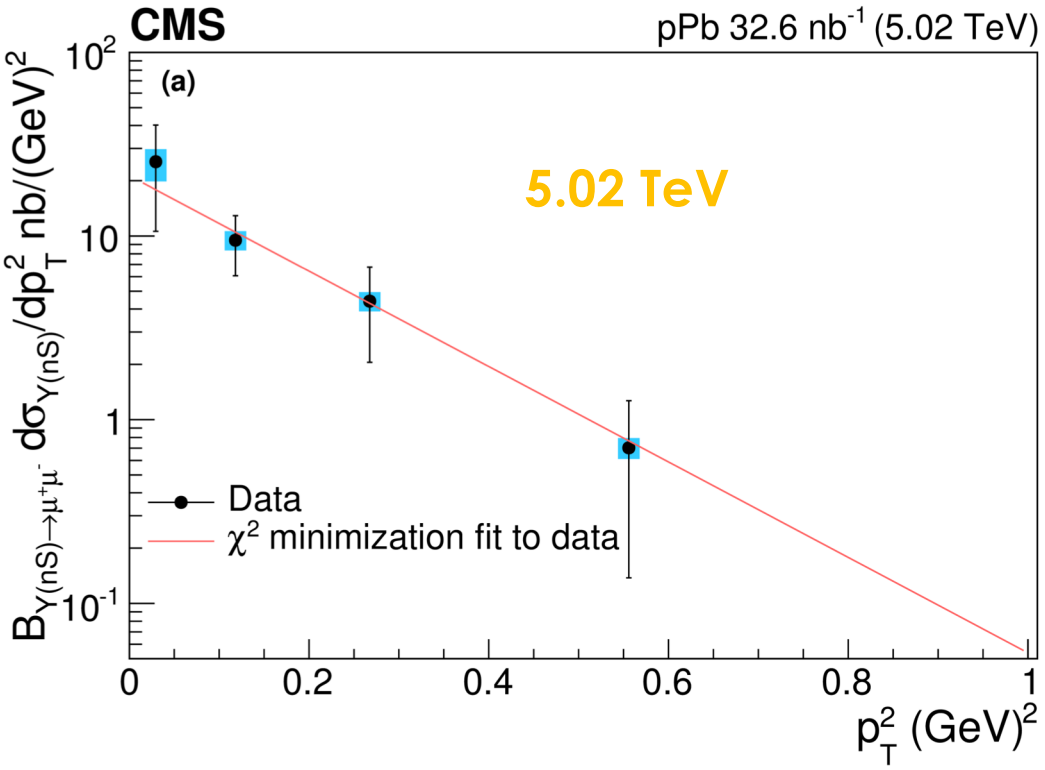
Proton and/or lead dissociation



γγ interaction

Background

|t| dependence



Fit to an exponential function → provides infos on the transverse profile of the interaction region

→ b = 6.0 ± 2.1 (stat.) ± 0.3 (syst.) GeV^{-2}

Data is in agrement with ZEUS measurements and consistent with predictions based on pQCD models

ZEUS for Υ(1S)
b = $4.3^{+2.0}_{-1.3}$ (stat)
Phys.Lett.B 708 (2012) 14

[JHEP **11** 085 (2013)]

$W_{\gamma p}$ dependence

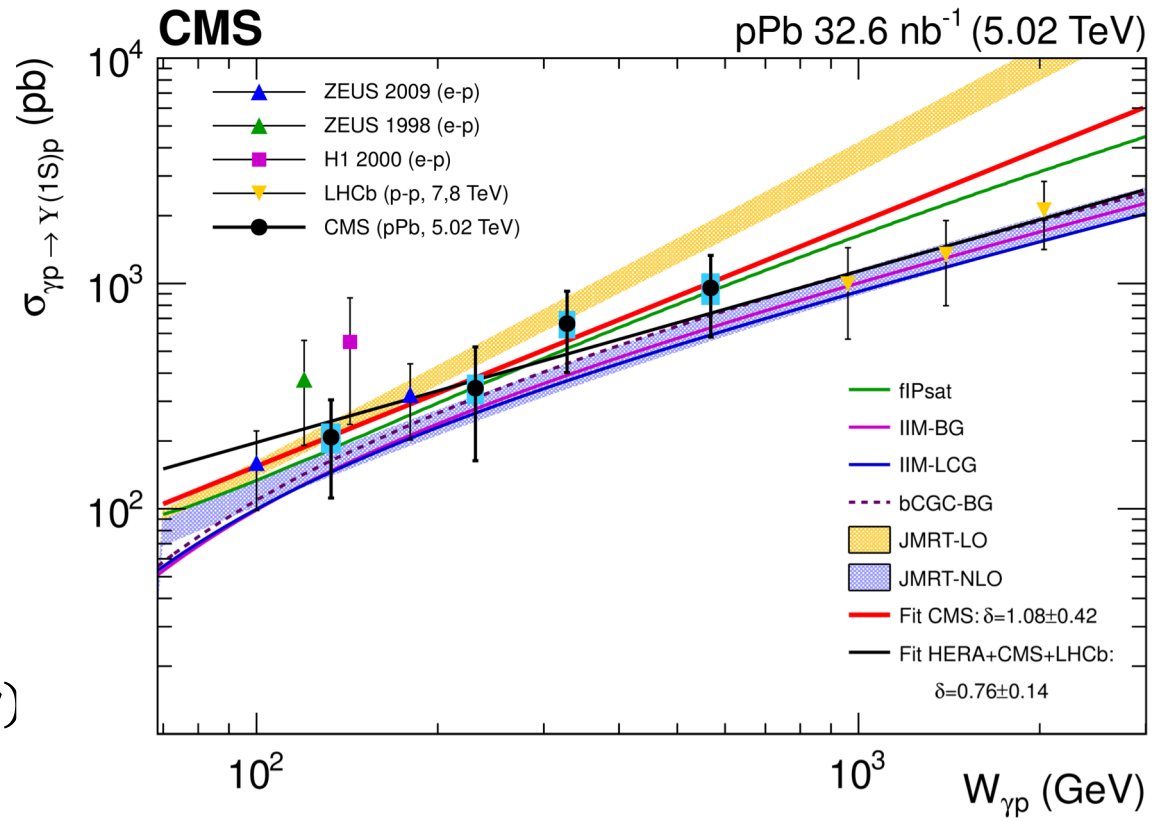
Cross section estimated by

$$\sigma_{\gamma p \to \Upsilon(1S) p} = \frac{1}{\Phi} \frac{d\sigma_{\Upsilon(1S)}}{dy}$$

With **Φ** photon flux

Cross-section corrected for muonic branching ratio, feed-down, upsilon (1S) fraction

$$W^2_{\gamma p} = 2 \cdot E_p \cdot M_Y \cdot exp(+/-y)$$

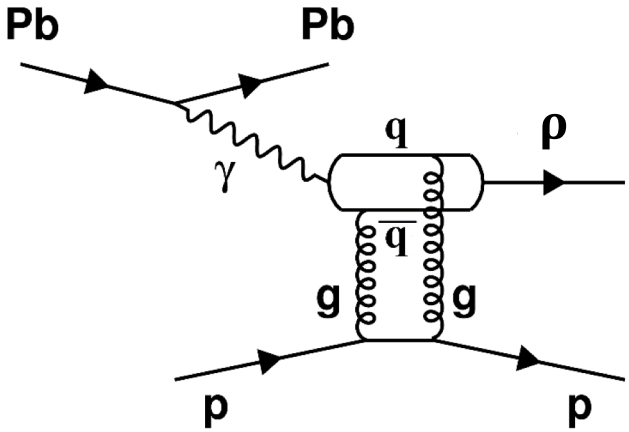


Fit to a power-law A(W/400)$^{\delta}$
→ δ = 1.08 ± 0.42, A = 690 ± 183

ZEUS
δ = 1.2 ± 0.8
[PLB 680(2009) 4-12]

Data compatible with power law dependence, in agreement with previous LHC/HERA measurements

LO pQCD predictions disfavoured



Exclusive rho(770) at 5 TeV

[Eur. Phys. J. C **79**, 702 (2019)]

Data

2013 pPb data @5.02 TeV, L ~ 16.9 μb^{-1}

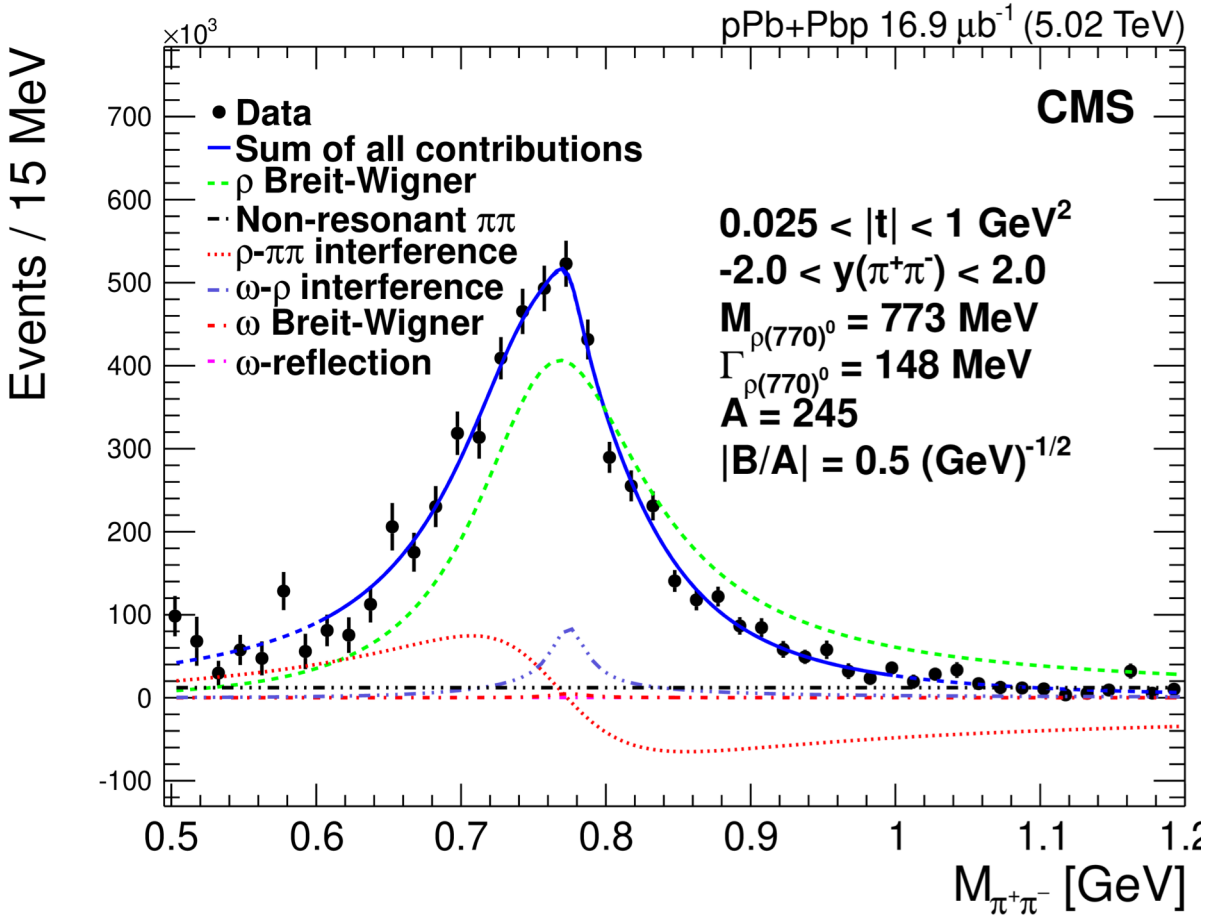
Signal ρ → $\pi^+ \pi^-$:
two charged particle with $p_T(\mu)$> 0.2 and 0.4 GeV, |eta|<2.2
No activity in calorimeter

STARLight for signal,

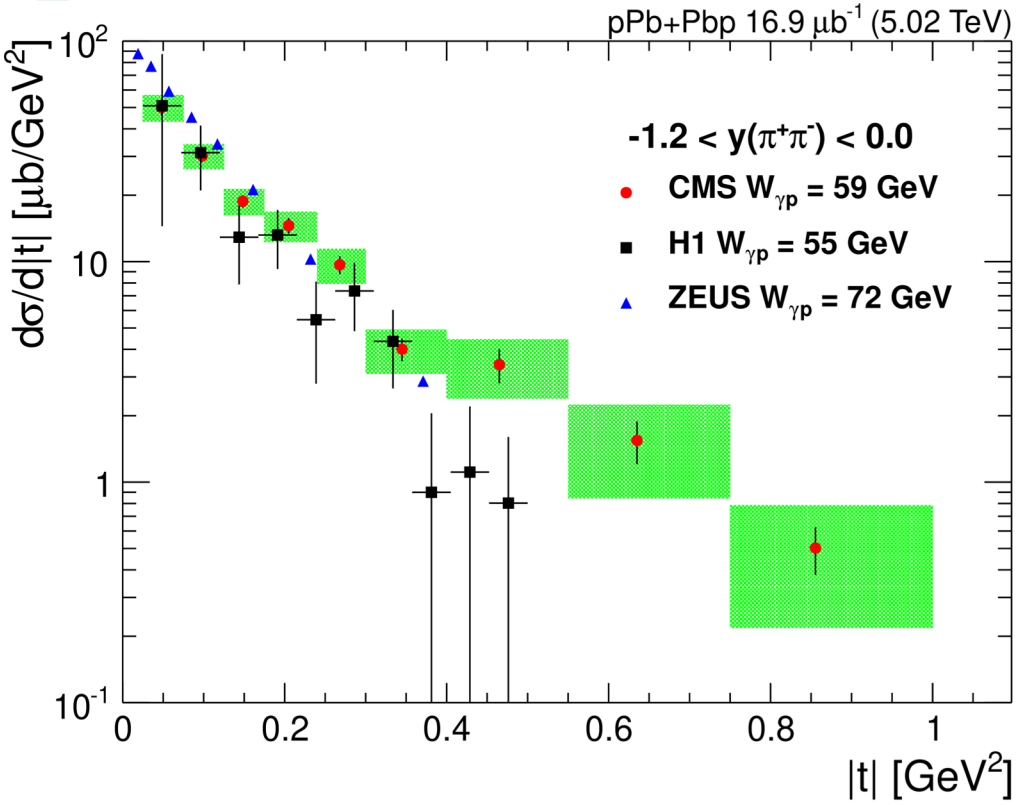
Template built for
proton dissociation

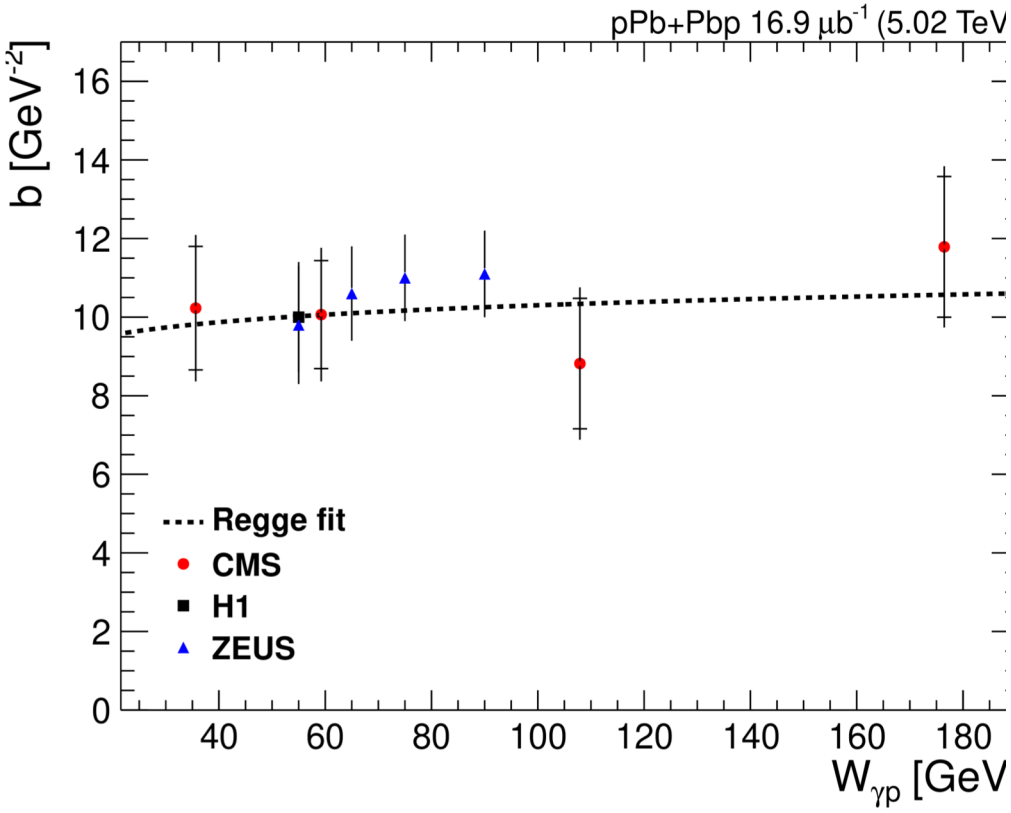
Complex extraction due to
due to interference with ω

Fit also in rapidity and y bins



|t| dependence





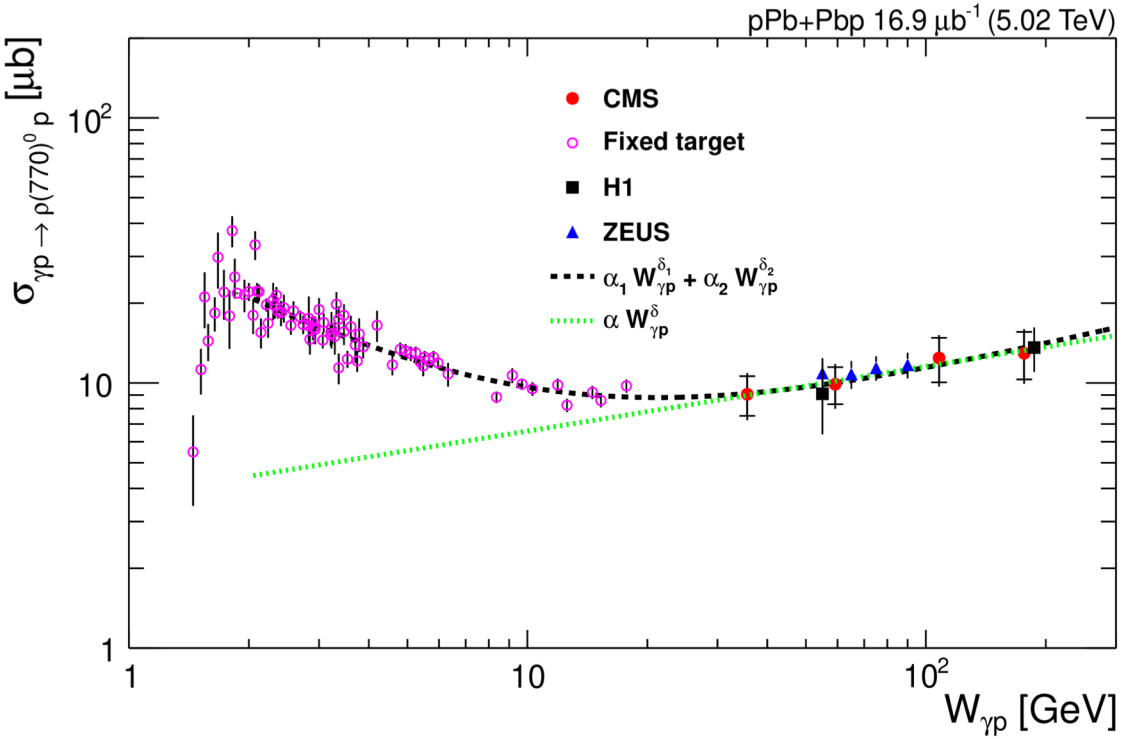
Exponential fit in different rapidity/W intervals → extraction of slope b for different energies

From Regge formula $b = b_0 + 2\,\alpha'\,\ln (W_{\gamma p}/W_0)^2$

→ $\alpha' = 0.28 \pm 0.11(\text{stat.}) \pm 0.12\ (\text{syst.})\ \text{GeV}^{-2}$

consistent with ZEUS measurement and Regge expectation of 0.25 GeV^{-2}

$W_{\gamma p}$ dependence



Fit to a power-law aW^{δ}

→ δ = 0.23 ± 0.14 (stat.) ± 0.04 (syst.)

Data compatible with power-law dependence and with previous HERA data

[EPJC 2 (1998) 247, NPB 463 (1996) 3]

Shallower dependence than for upsilon as expected

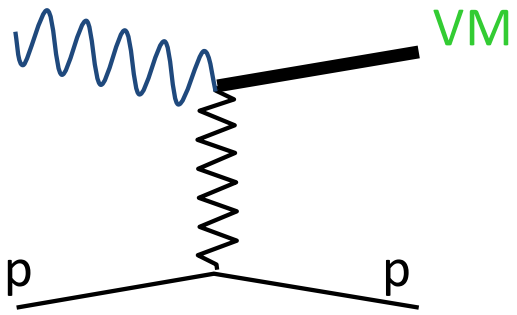
Summary

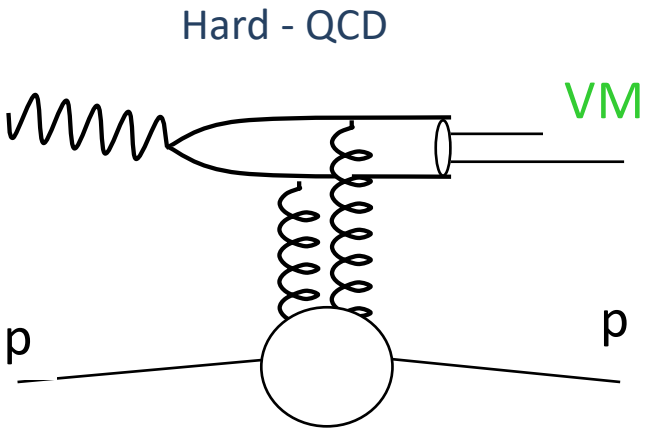
- **Mesurement of rho and upsilon photoproduction in pPb**

- Data in agreement with previous HERA and LHC (for upsilon) measurements

- Rho data in agreement with Regge theory

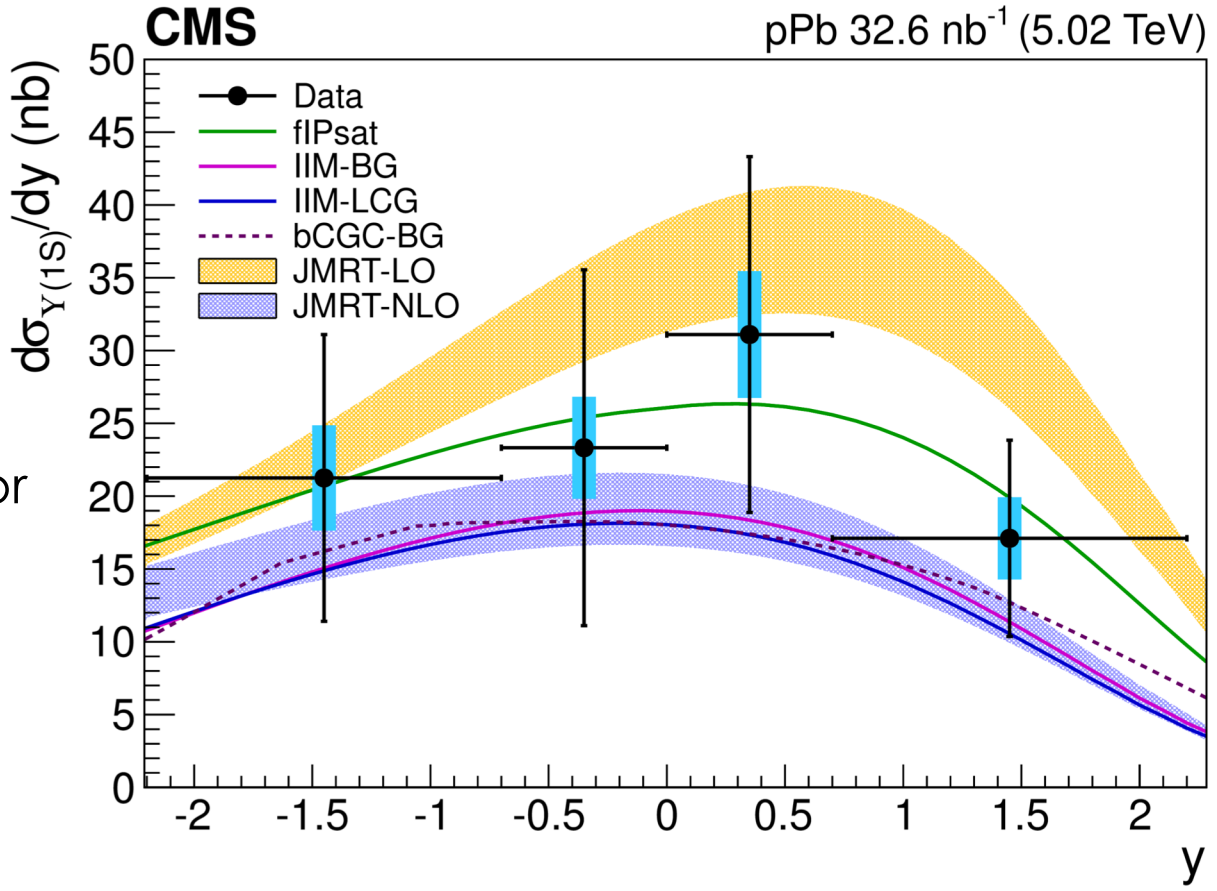
- Upsilon data in agreement with pQCD predictions





VM ($J^{PC}=1^{--}$): γ, ρ, ϕ, J/ψ,Υ,...

Rapidity dependence



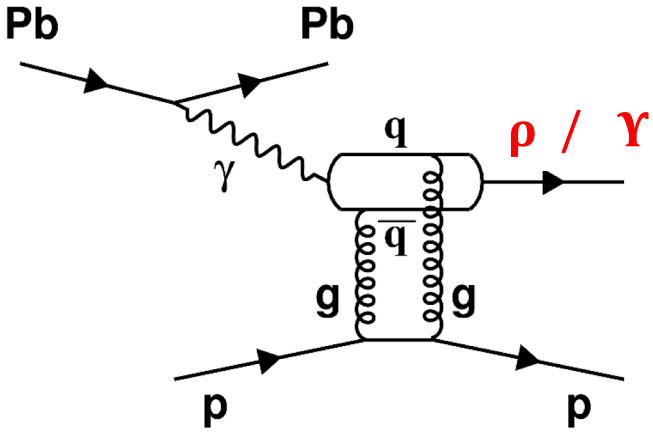
Cross-section corrected for muonic branching ratio, feed-down, upsilon (1S) fraction

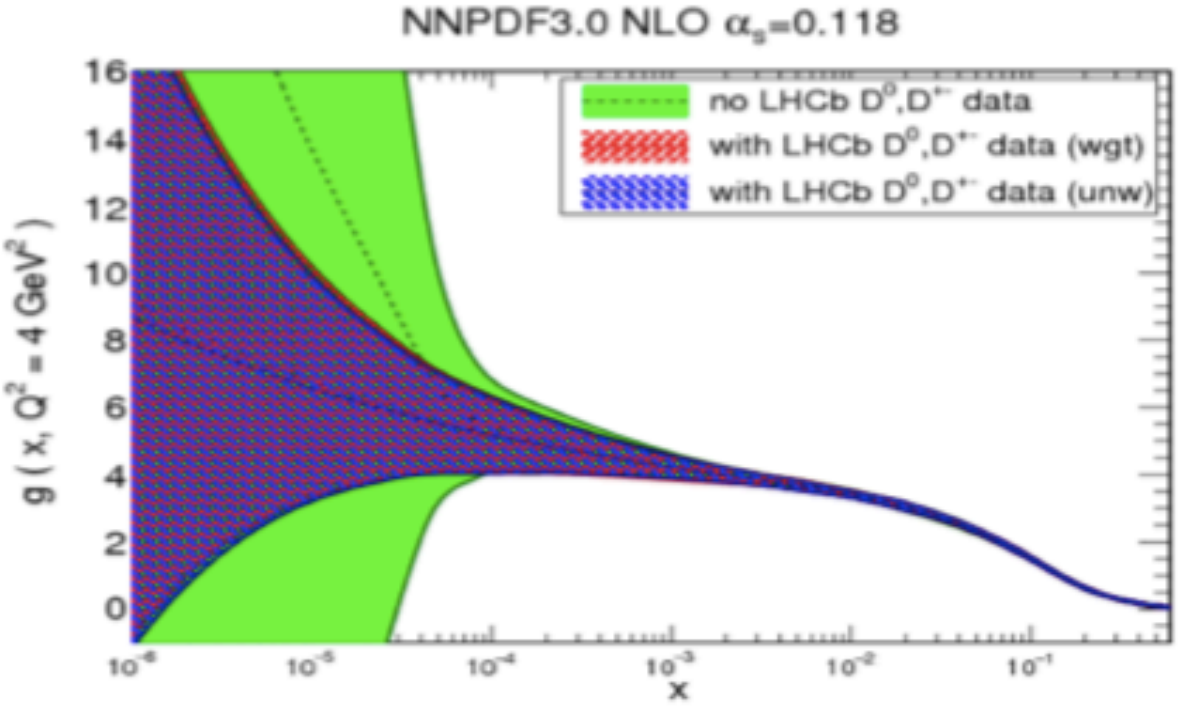
JMRT-LO systematically higher than the data

Ultraperipheral collisions at LHC

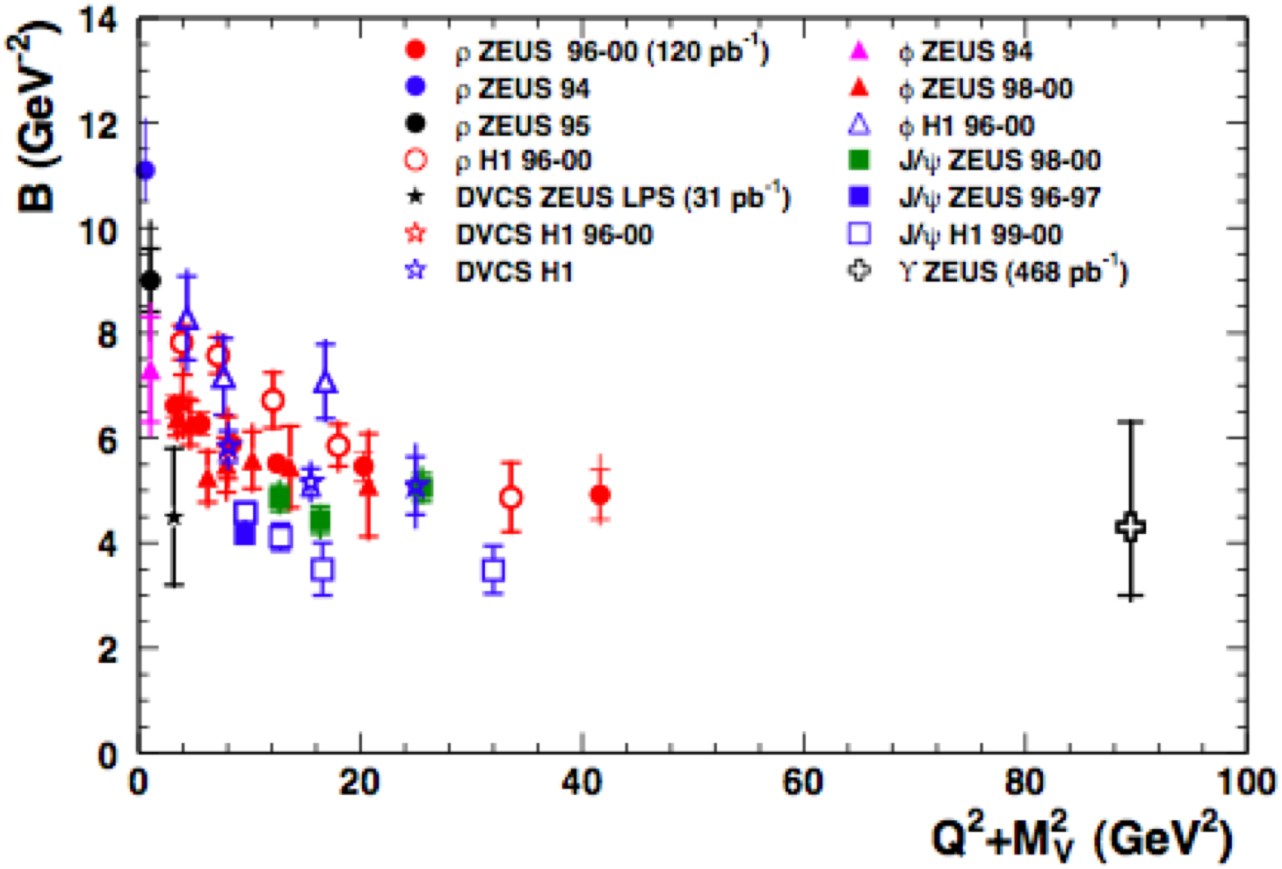
- Photon flux grows with the square of the charge, Z^2

- Sensitivity to gluon density in nucleon (nucleus)





Transition soft → hard: t-slope dependence



$$\frac{d\sigma}{dt} \propto e^{-b|t|}$$

As in optical diffraction, size of diffractive cone related to size of interacting objects

$b \approx b_{VM} + b_p$