

*measurements of exclusive processes
in
proton and ion collisions
implications workshop 2019*

Albert Frithjof Bursche¹,

17th October 2019



European Research Council



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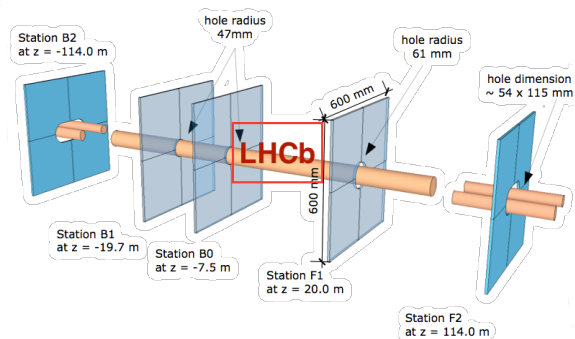
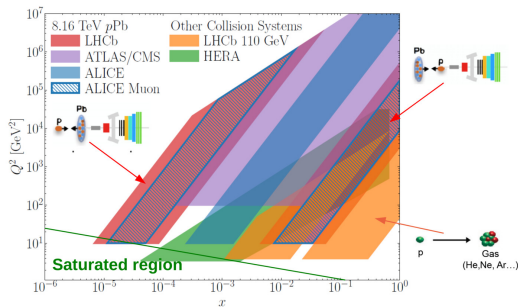
introduction

available results and LHCb potential

- proton–proton
 - largest statistics: 1 fb^{-1} at 7 TeV, 2 fb^{-1} at 8 TeV, $0.2 \text{ fb}^{-1} + 1.6 \text{ fb}^{-1} + 1.8 \text{ fb}^{-1} + 2.2 \text{ fb}^{-1}$ at 13 TeV
 - small samples: 900 GeV, 2.76 TeV, 5 TeV
 - already published: J/ψ at 7 TeV, 13 TeV, Υ at 7, 8 TeV, double J/ψ at 7 TeV and 13 TeV
 - more in the pipeline - also beyond muon final states
- proton–ion
 - actively analysed
- ion–ion
 - already public (preliminary): coherent J/ψ
 - more in the pipeline
- fixed–target

exclusive production of charmonia

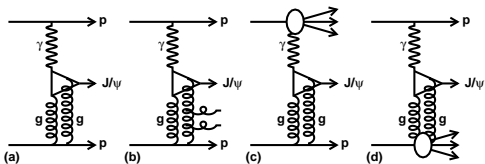
- Projectiles stay intact
- There can be no net colour exchange



central exclusive production of charmonia

JHEP 10 (2018) 167

- 13 TeV data ($204 \pm 8 \text{ pb}^{-1}$)

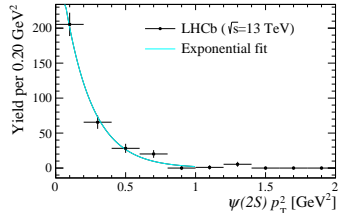
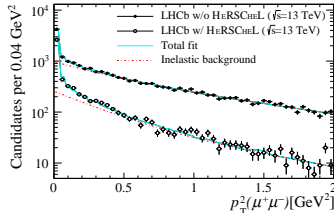
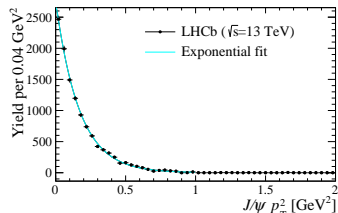
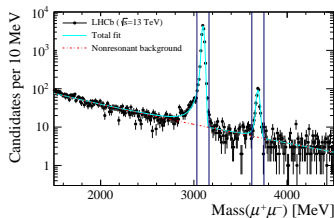


exponential fit

$$f(p_T^2) \sim e^{-b p_T^2}$$

$$b_{J/\psi} = 5.93 \pm 0.08 \text{ GeV}^{-2}$$

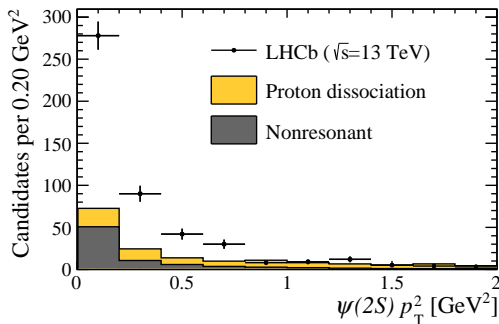
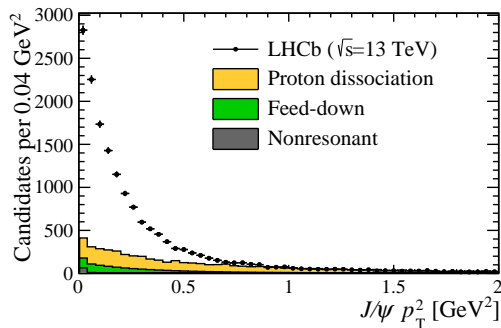
$$b_{\psi(2S)} = 5.06 \pm 0.8 \text{ GeV}^{-2}$$



more backgrounds

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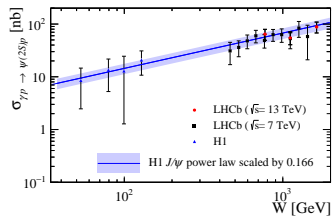
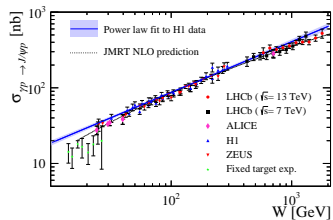
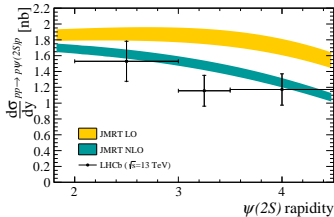
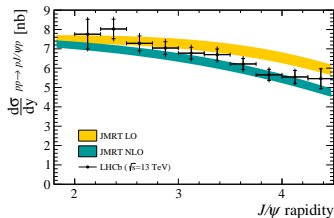
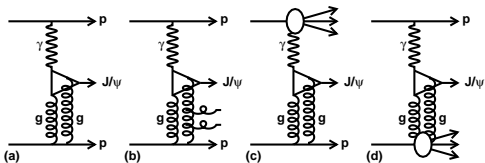
- Feed down from several states into J/ψ is considered
 - $\psi(2S) \rightarrow J/\psi X$ using ratio of J/ψ events passing the selection per $\psi(2S) \rightarrow \mu^+ \mu^-$ observed
 - $\chi_c \rightarrow J/\psi \gamma$ extrapolated using simulation from exclusive J/ψ plus photon events



central exclusive production of charmonia

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- 13 TeV data ($204 \pm 8 \text{ pb}^{-1}$)
- also measured in 7 TeV data
- exclusive Υ also available



$$\sigma_{J/\psi} = 307 \pm 21 \pm 36 \text{ pb}$$

$$\sigma_{\psi(2S)} = 7.8 \pm 1.3 \pm 1.0 \text{ pb}$$

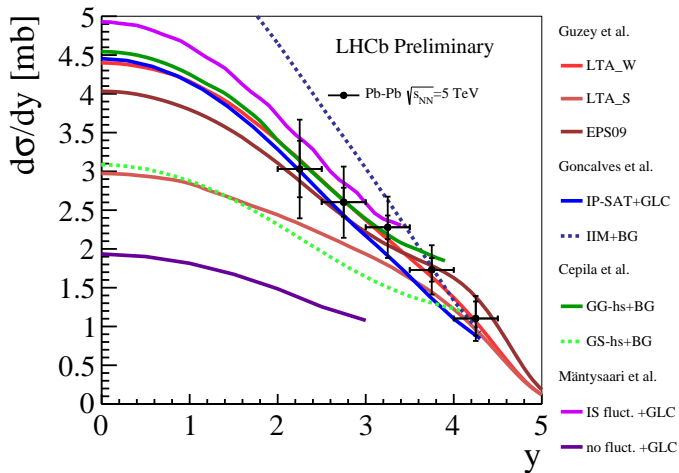
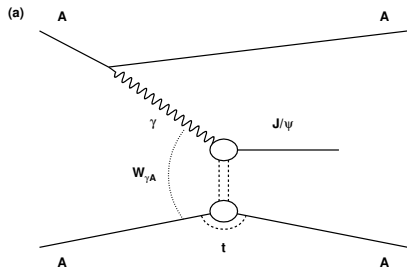
coherent J/ ψ differential coherent cross section

LHCb-CONF-2018-003

LHCb preliminary

$$\sigma = 5.27 \pm 0.21 \pm 0.49 \pm 0.68 \text{ mb}$$

stat *sys* *lumi*



publication in preparation

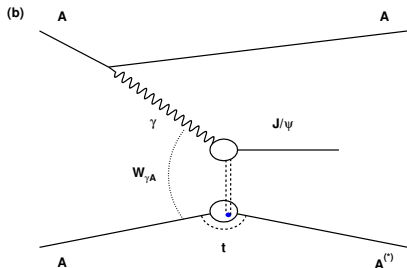
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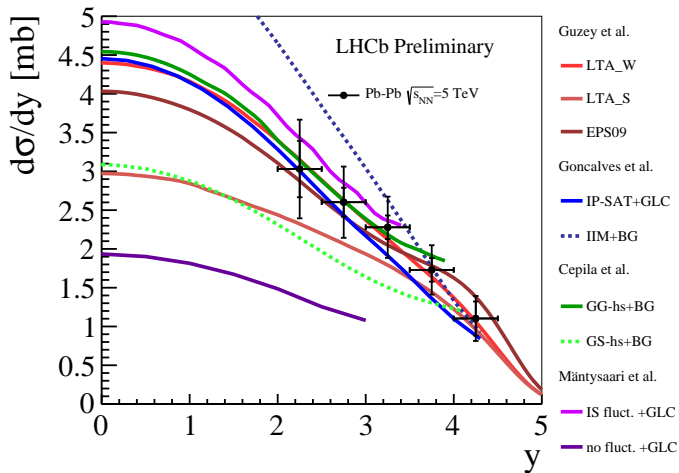
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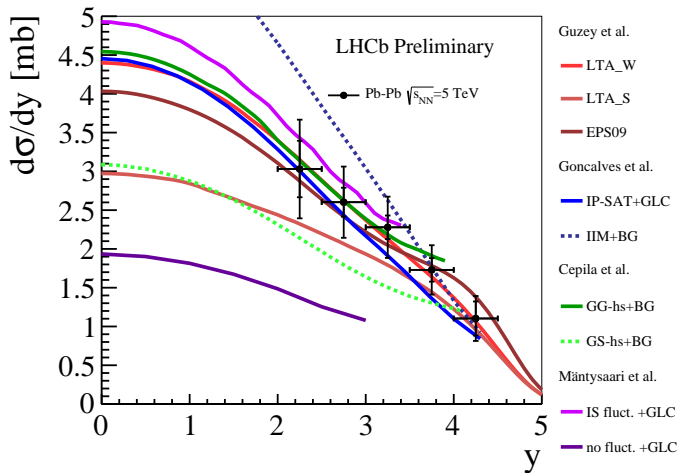
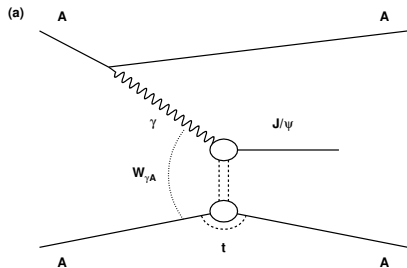
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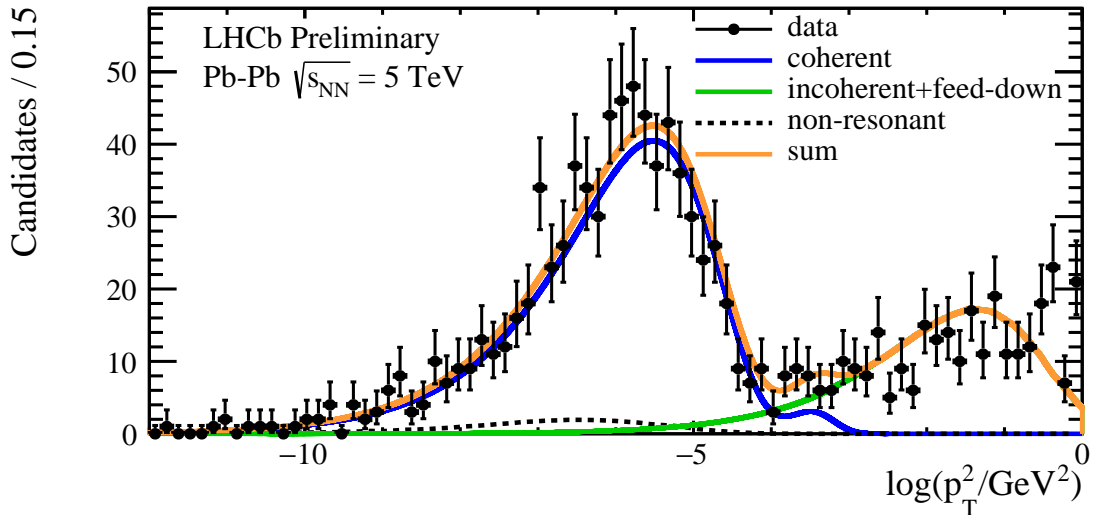
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coherent production of J/ ψ



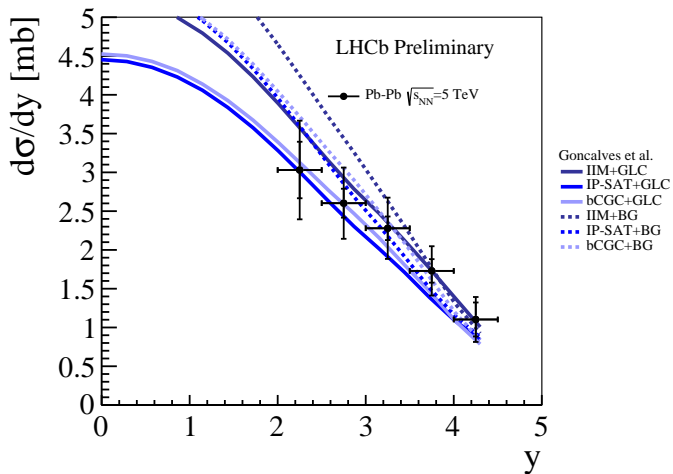
colour dipole model

LHCb-CONF-2018-003

- Three parametrisations for the dipole nucleon cross section
 - IIM
 - IP-Sat
 - CGC
- Two wave functions
 - Boosted Gaussian
 - Gauss LC

Gonçalves et. al.

Phys. Rev. D 96, 094027 (2017)



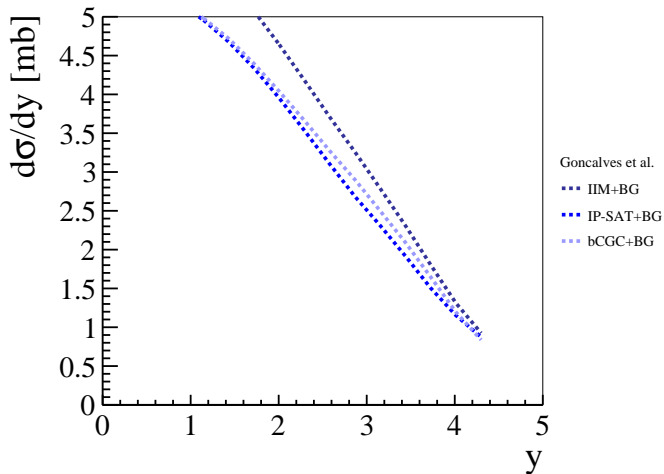
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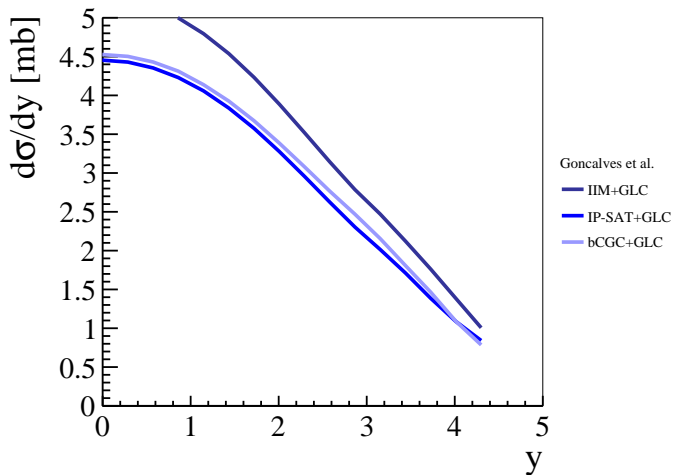
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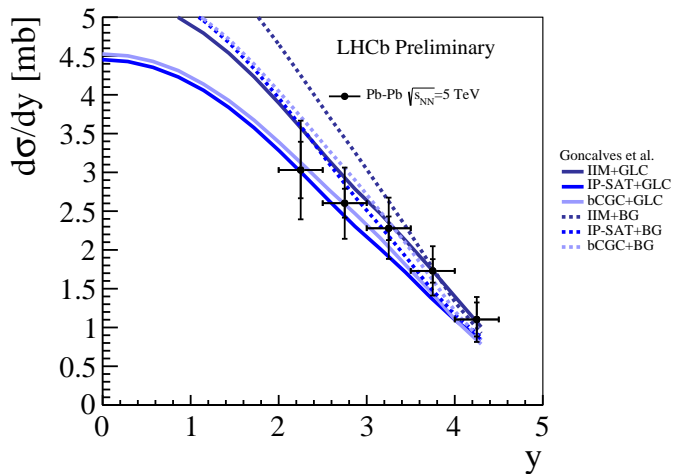
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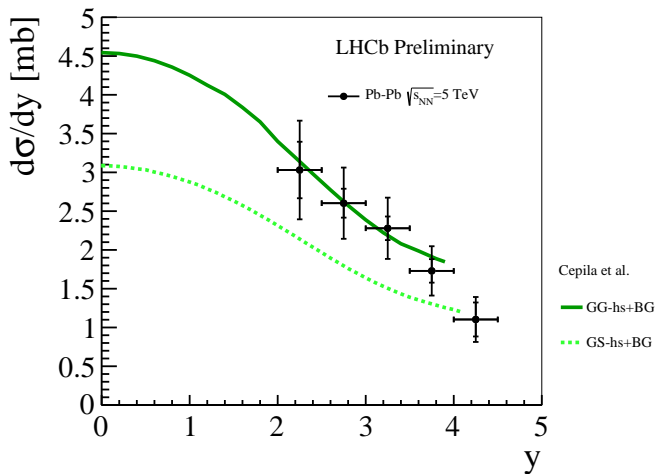


colour dipole model

LHCb-CONF-2018-003

- Similar Model
- Boosted Gaussian wave function
- Glauber Gribov methodology
- Geometric Scaling

J. Cepila et. al.
Phys. Rev. C97 (2018) 024901

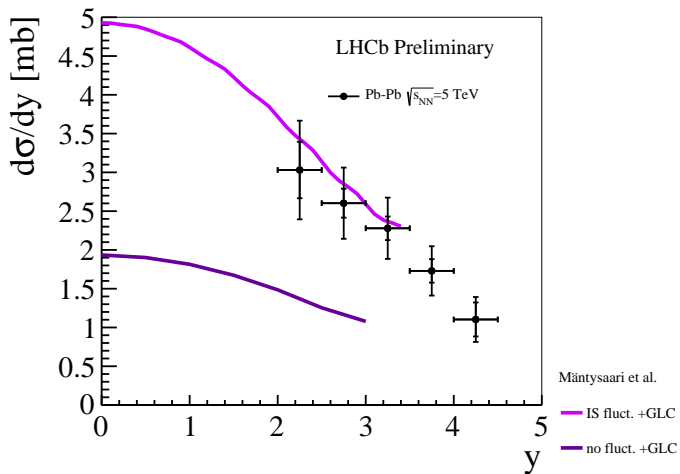


colour dipole model

LHCb-CONF-2018-003

- IP-Sat with
- Gauss LC wavefunction
- Calculations with and without nuclear fluctuations

H. Mäntysaari, B. Schenke
Phys. Lett. B772 (2017) 832



paper using 2015 dataset

the pathfinder

turning the preliminary result into paper

- Improved on most systematics (not lumi)
- Use of full simulation instead of smearing MC truth for templates
- Use of Herschel for better control of the background
- Luminosity uncertainty remains the limiting factor
- Internal review is progressing well

paper using 2018 dataset

the precision measurement

- Use the experience gained on 2015 to improve the result using an order of magnitude more data
- Start improvements at the trigger
- Will include $J/\psi / \psi(2S)$ cross section ratios
- Considering meson/non-resonant ratios as complementary luminosity determination
- Luminosity still to be determined
- Internal review started

conclusion

- Many published results in proton-proton and *more to come*
- Work has started to analyse proton-ion and ion-ion data
- Theoretical predictions remain crucial for the interpretation of the results and for the results themselves