

Workshop on Multiple Partonic Interactions at the LHC
(Prague, Czech Republic, 18-22 of November 2019)

WG2: Double parton scattering

Conveners: Rafal Maciula, Arthur Marques Moraes, Daria Savrina

Summary

Three very productive sessions!

Mon. 18/11

Double parton scattering at CMS	Marc Dünser for the CMS Collaboration	09:10 - 09:30
Studies of double parton scattering at the LHCb	Daria Savrina for the LHCb Collaboration	09:30 - 09:50
Double parton scattering in jet production processes	Oleh Fedkevych	09:50 - 10:10
Models for the energy behaviour of MPS effective cross-section	Dr Giulia Pancheri	10:10 - 10:30

Tue. 19/11

ATLAS results on quarkonia and its associated production	Maria Smizanska for the ATLAS Collaboration	10:50 - 11:10
Probing double parton scattering via associated open charm and bottom production in ultraperipheral pA collisions	Roman Pasechnik	11:10 - 11:40
Double-Parton-Scattering studies with quarkonia	Jean-Philippe Lansberg	11:40 - 12:00
J/psi + Upsilon associated production and prospects to observe a new heavy tetraquark state	Dr Sergey Baranov	12:00 - 12:20
Double parton distributions and heavy-quark mass effects	Mr Riccardo Nagar	12:20 - 12:40

Thur. 21/11

Transverse partonic proton structure via double parton scattering at the LHC	Dr Matteo Rinaldi	14:00 - 14:25
Double Parton Distributions for the Nucleon on the Lattice	Christian Zimmermann	14:25 - 14:45
W+dijet production in pA collisions via DPS revisited	Federico Alberto Ceccopieri	14:45 - 15:05
Double parton distributions: evolution, initial conditions and transverse momentum dependence	Krzysztof Golec-Biernat	15:05 - 15:25
Simulating Double Parton Scattering with dShower	Baptiste Cabouat et al.	15:25 - 15:45

**Many results, very interesting content:
14 contributions (experimental + theory).**

Many thanks to all speakers!

Going deeper in the proton structure...

$$\sigma_{\text{DPS}} = \frac{1}{s} \frac{\sigma_A \sigma_B}{\sigma_{\text{eff}}}$$

Is it still process and energy independent?

Experiment (energy, final state, year)

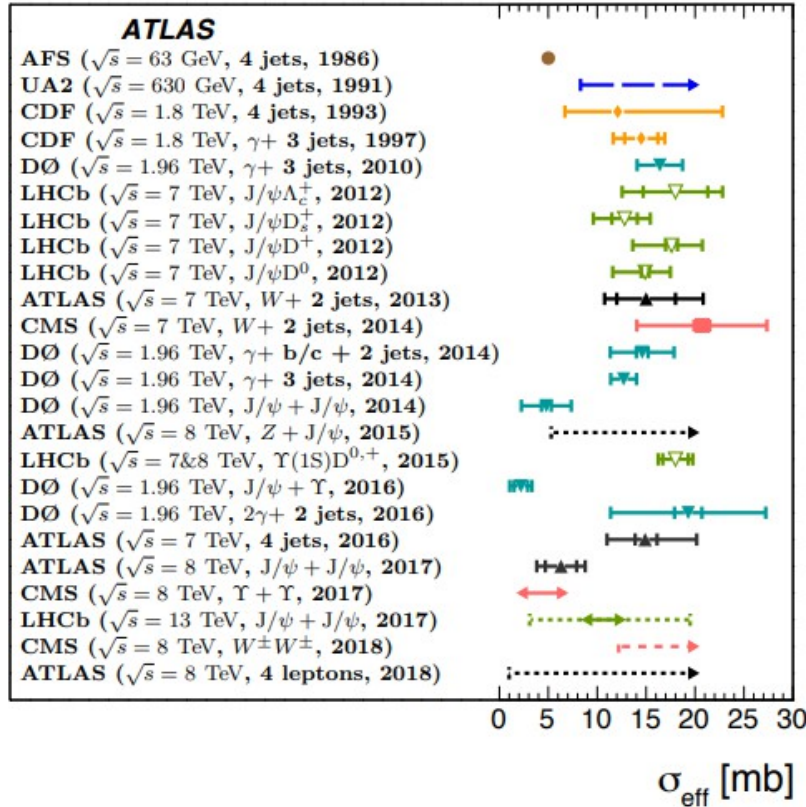
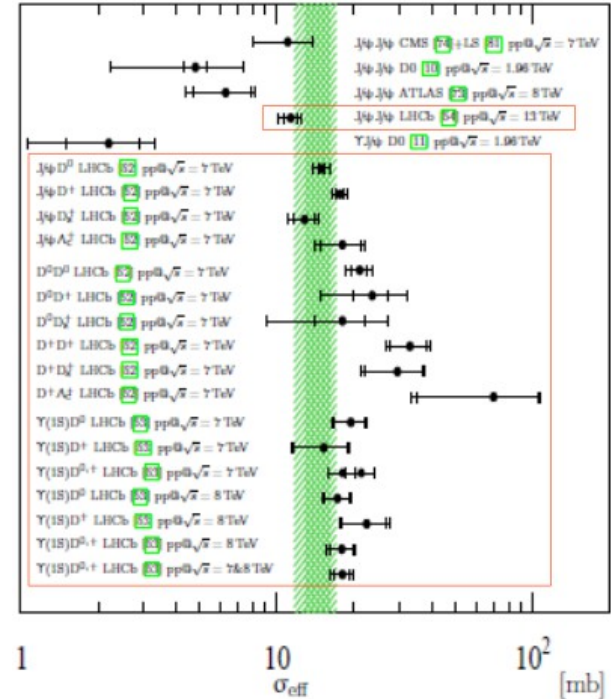
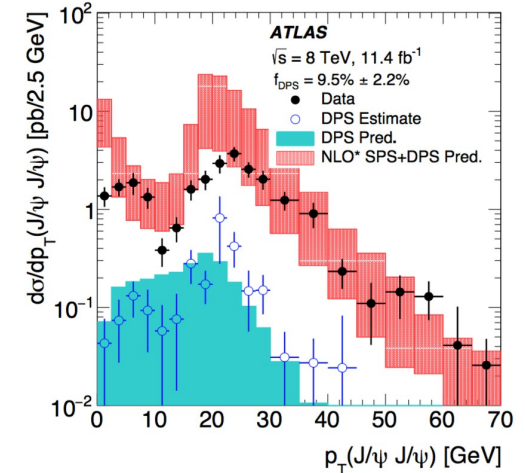
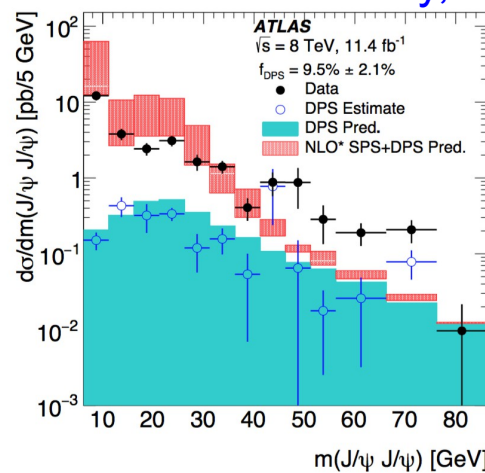


Figure: Compiled by the ATLAS Collaboration; PLB, 790, 595.

Daria Savrina (LHCb Collaboration)
Monday, 18th of November



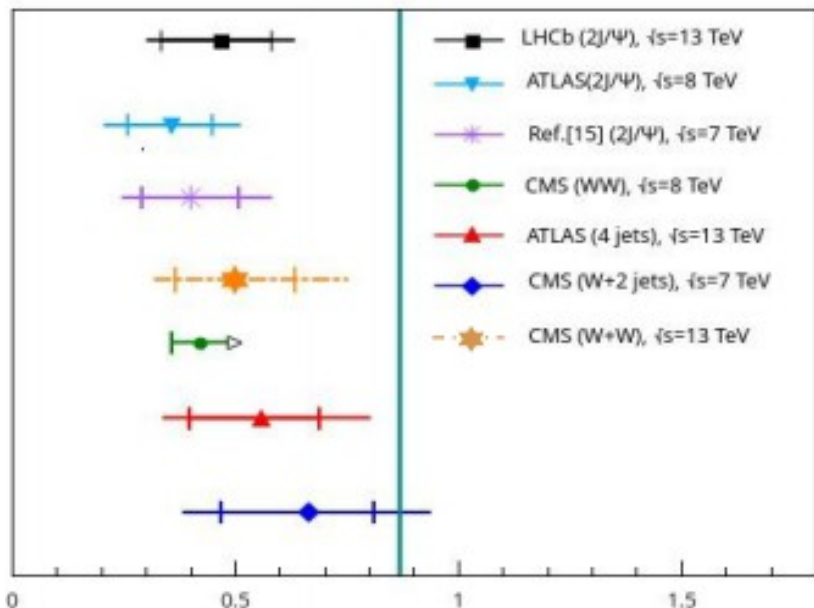
Maria Smizhanska (ATLAS Collaboration)
Tuesday, 19th of November



Correlations?

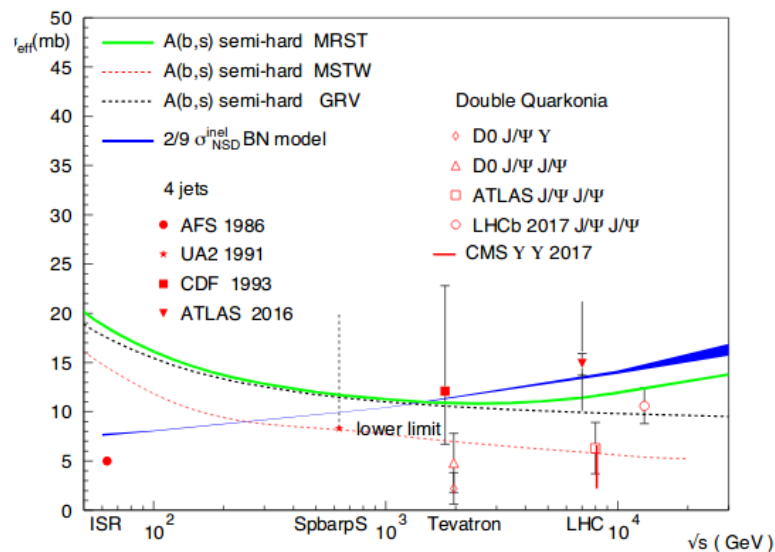
Matteo Rinaldi

Thursday, 21st of November



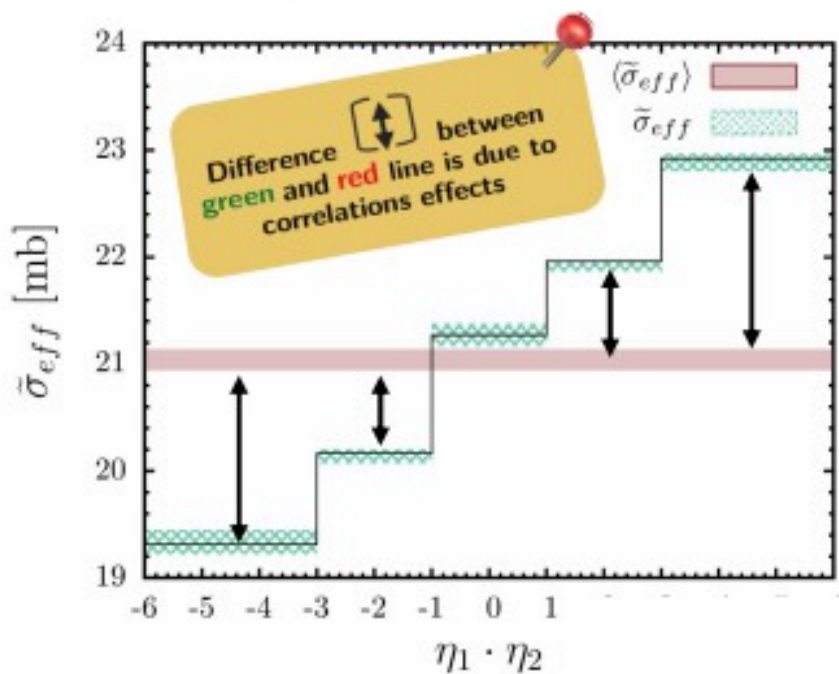
Gulia Pancheri

Monday, 18th of November

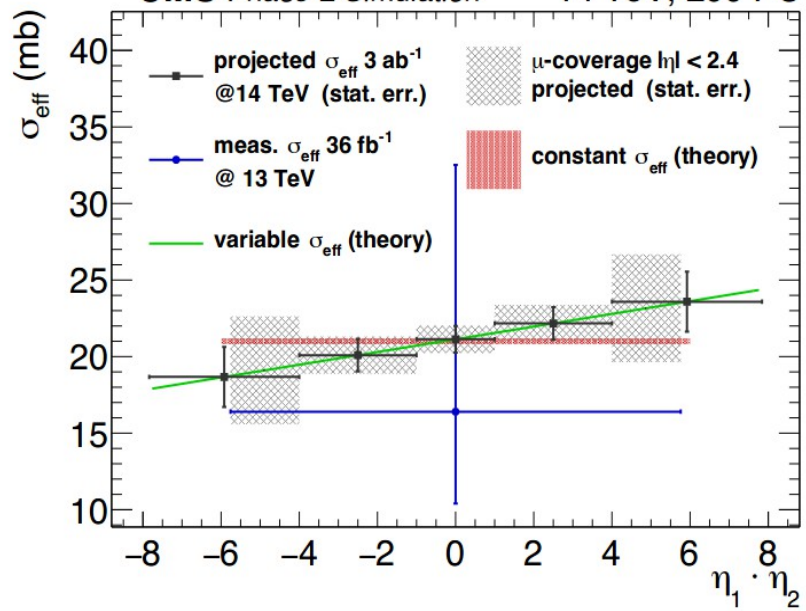


Marc Dünser for the CMS Collaboration

Monday, 18th of November



CMS Phase-2 Simulation 14 TeV, 200 PU



Many theoretical calculations/tools

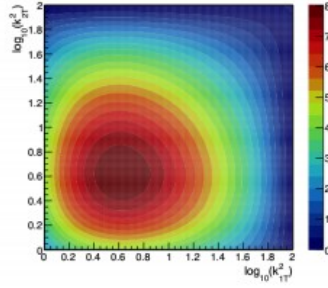
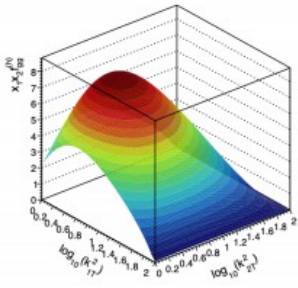
Jean-Phillipe Lansberg, Tuesday, 19th of November

- The quarkonium-inclusive-production mechanisms
not yet the object of a **consensus**
- QCD corrections via new **NLO**, and perhaps **NNLO** topologies,
matter much for some mechanisms and some observables
- Novel Observables are necessary:
pseudoscalar states and associated production
- Beside the production-mechanism debate, quarkonia **already** allow us to probe the **parton correlation** through **DPS studies**
- They also start to tell us new information on the **gluon Transverse Momentum Distribution distributions**

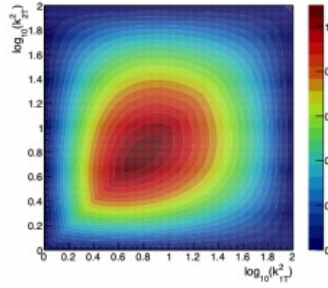
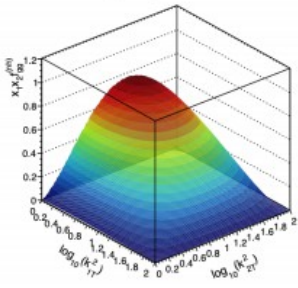
e.g. JPL, C. Pisano, F. Scarpa, M. Schlegel, PLB 784 (2018) 217; F. Scarpa *et al.* arXiv:1909.05769 [hep-ph]

Krzysztof Golec-Biernat, Tuesday, 19th of November

$Q^2=100 \text{ GeV}^2, x_1=0.01, x_2=0.01$ homogeneous



$Q^2=100 \text{ GeV}^2, x_1=0.01, x_2=0.01$ non-homogeneous



Going to NLO and NNLO

Testing the internal mechanisms

Evaluating DPDs

How do these results get along with each other?

As experimentalists, what should/can we measure?

Many theoretical calculations/tools

Riccardo Nagar, Tuesday, 19st of November

New DPD evolution code:

- ▶ **efficient and precise algorithm** for the solution of single and double DGLAP equations
- ▶ new library **ChiliPDF** intended for public release
- ▶ can evaluate **DPD luminosities** for the first time with NNLO DGLAP and flavor-matching
- ▶ a step towards full computation of DPS cross section...

Massive DPD splitting:

- ▶ **scale choices** in the massless DPD splitting formula can produce significant scale uncertainties
- ▶ adding the **mass-dependent terms** into the formulae, scale uncertainties are mitigated
- ▶ ongoing effort...
towards a **coherent factorization scheme with 2+ large scales** involved in the splitting ($1/y, m_b, m_c, \dots$)

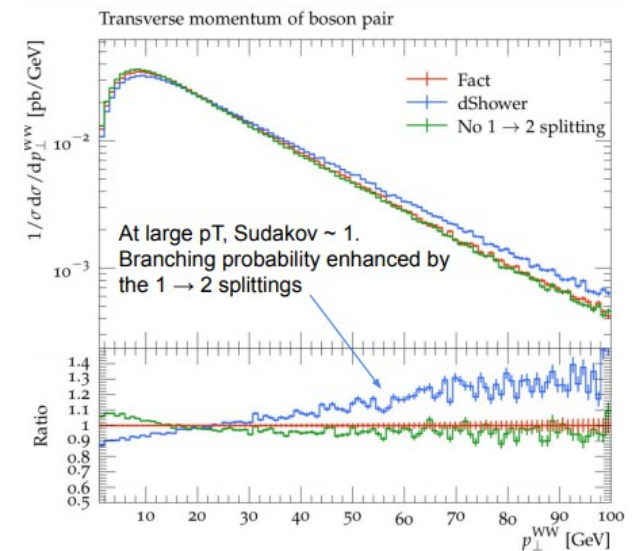
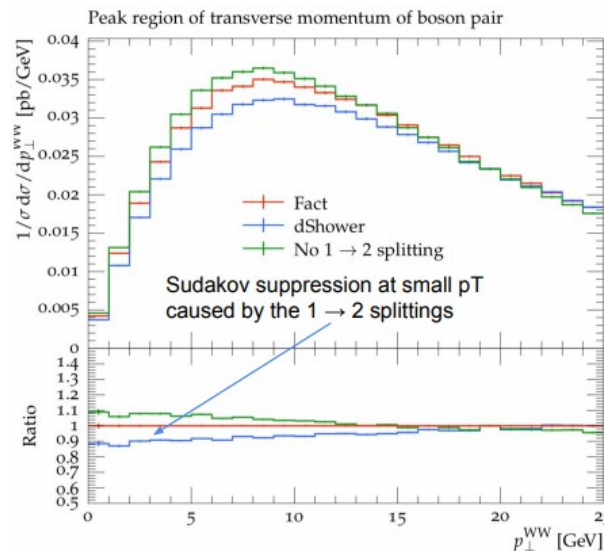
Simulation is important!

Great to have reliable and up-to-date tools

Lots of ongoing work

Thank you!

Baptiste Cabouat, Thursday, 21st of November



Many theoretical calculations/tools



Higher precision (always on top!)

Experiment → theory wish list:

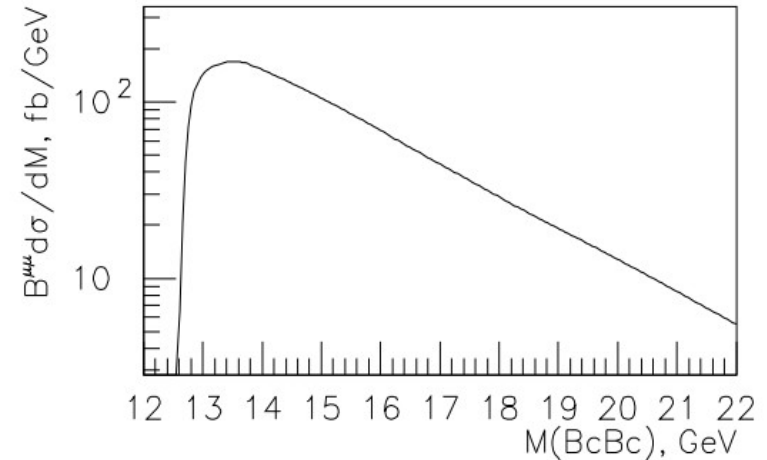
- DPS with open beauty
- Same-sign lepton pairs
- D-meson+2 jets
- W+2 jets
- Proton-ion collisions (AA?)
- WW kinematical properties
- 4 jets measurements
- Y+J/ψ

More?

Serguei Baranov, 19th of November, Tuesday

Numerical results at LHCb

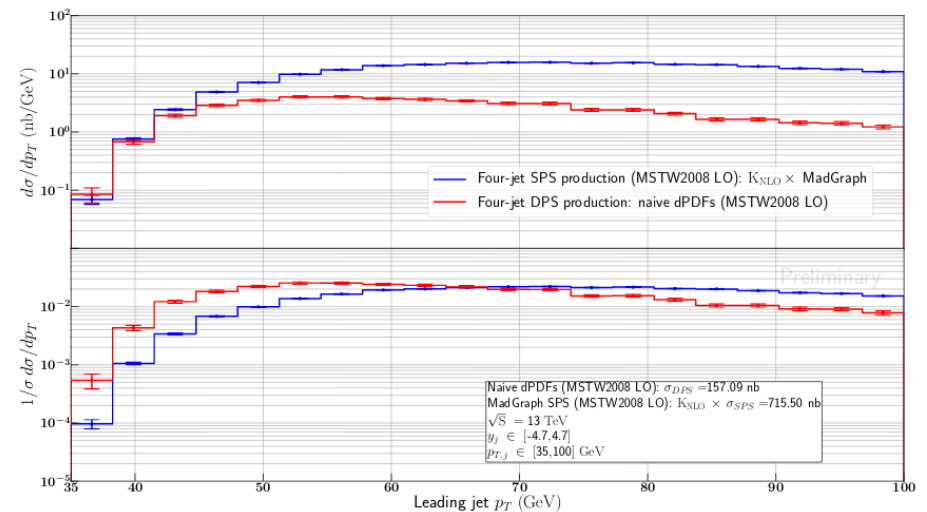
Four-quark invariant mass spectrum at $\sqrt{s} = 13$ TeV



Differential cross section times muon branching fraction

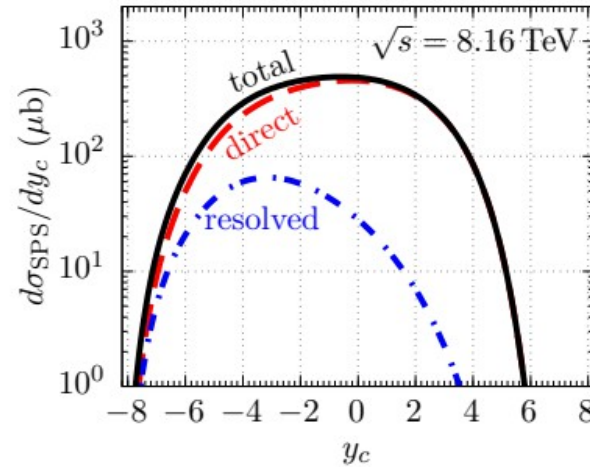
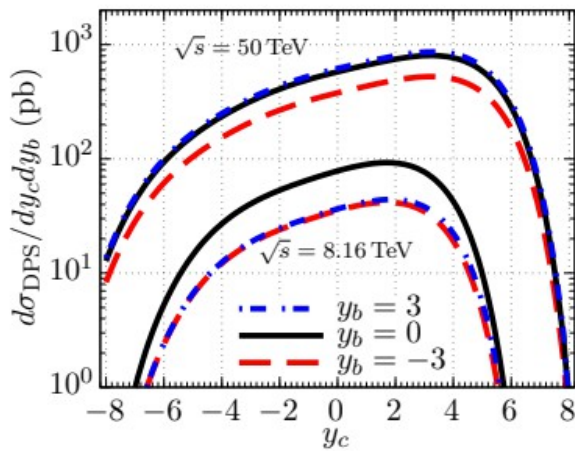
$$B_{\Gamma^{\psi \rightarrow \mu\mu}} B_{\Gamma^{\Upsilon \rightarrow \mu\mu}} d\sigma(pp \rightarrow B_c \bar{B}_c) / dM$$

Oleh Fedkevych, 18th of November, Monday



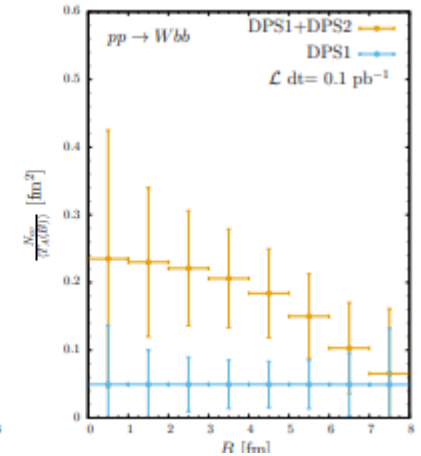
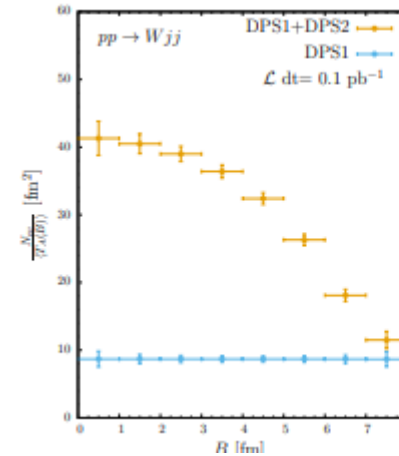
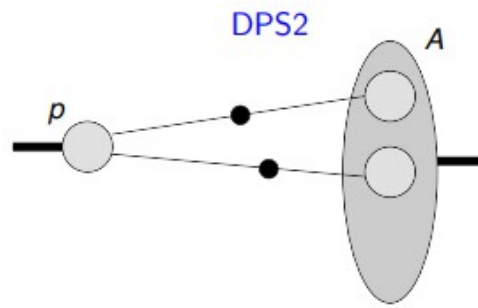
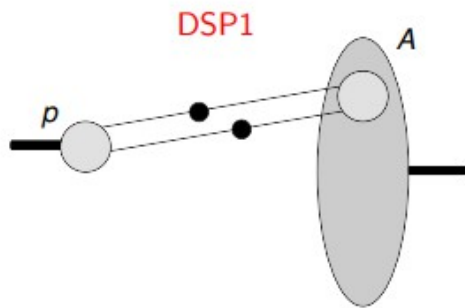
Large development for the pA collision studies

Roman Pasechnik, Tuesday, 19th of November



\sqrt{s} (TeV)	8.16	50	100
SPS UPC $c\bar{c}$ production in mb			
Direct	3.10	10.46	15.75
Resolved	0.35	1.81	3.03
Total	3.45	12.27	18.78
DPS UPC $c\bar{c}b\bar{b}$ production in nb			
Total	3.55	54.1	136

Federico Ceccopieri, Thursday, 21st of November



Some things would need big experimental efforts

Some can be tested already with Run1-2 LHC data!

Thank you!

