Deutsches Elektronen-Synchrotron (DESY), Hamburg, NIKHEF, Amsterdam

Double parton scattering session: experimental introduction

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Introduction and outlook

Many interesting experimental talks:

- ATLAS results on double parton scattering
  → Ewelina Lobodzinska
- DPS measurements at the CMS experiment
  → Ramandeep Kumar
- Measurement of four-jet production at CMS
  → Paolo Gunnellini
- Study of DPS processes at LHCb
  → An Liupan

N.B. 17 + 3 min. for each talk!

Prospects for the future:

1. **DPS energy dependence**
2. **New sensitive channels?**
3. **New sensitive observables?**
4. **New phase space?**

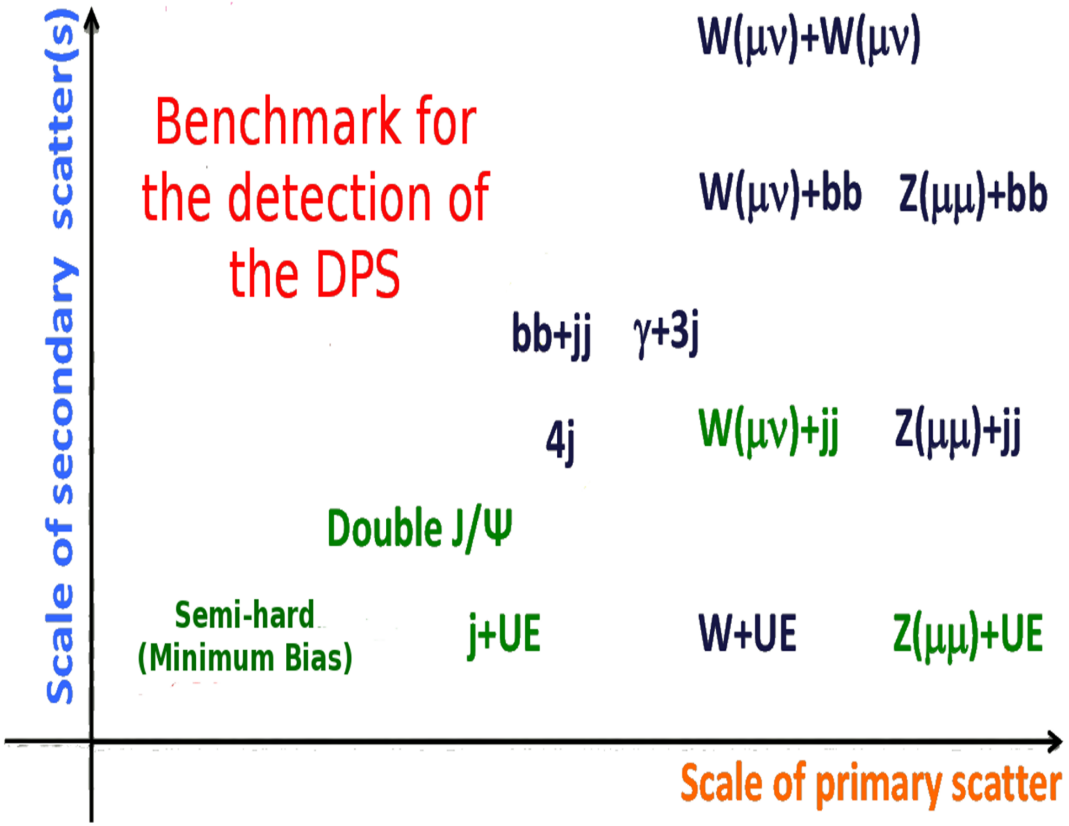
N.B. Very personal and (CMS-) biased view!

Experimental overview

$$\sigma_{AB}^{DPS} = \frac{m}{2}\frac{\sigma_A \sigma_B}{\sigma_{eff}}$$

Internal structure of the proton
DPS background for any physics channel

$\rightarrow$ Which channels can be used to look for DPS signals?

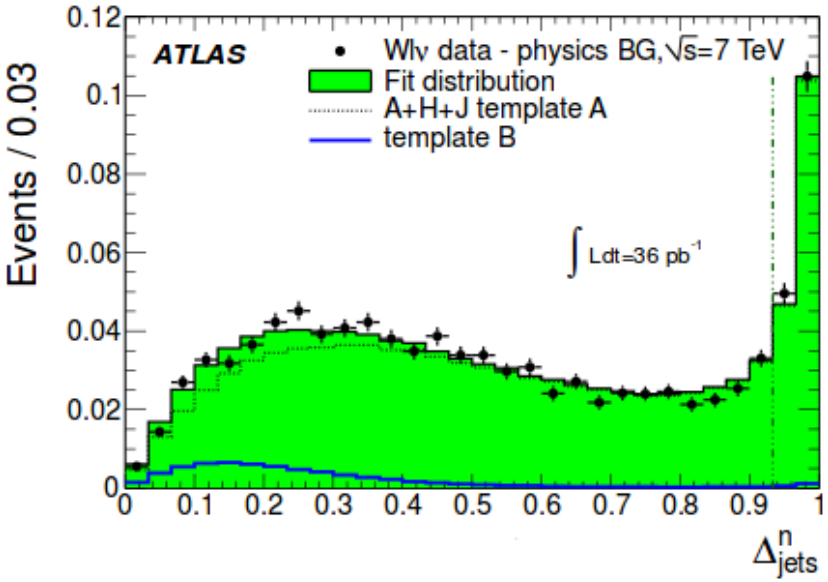


FEATURES OF THE FINAL STATE:

$\rightarrow$ **High multiplicity of physics objects**

Credits: Paolo Bartalini

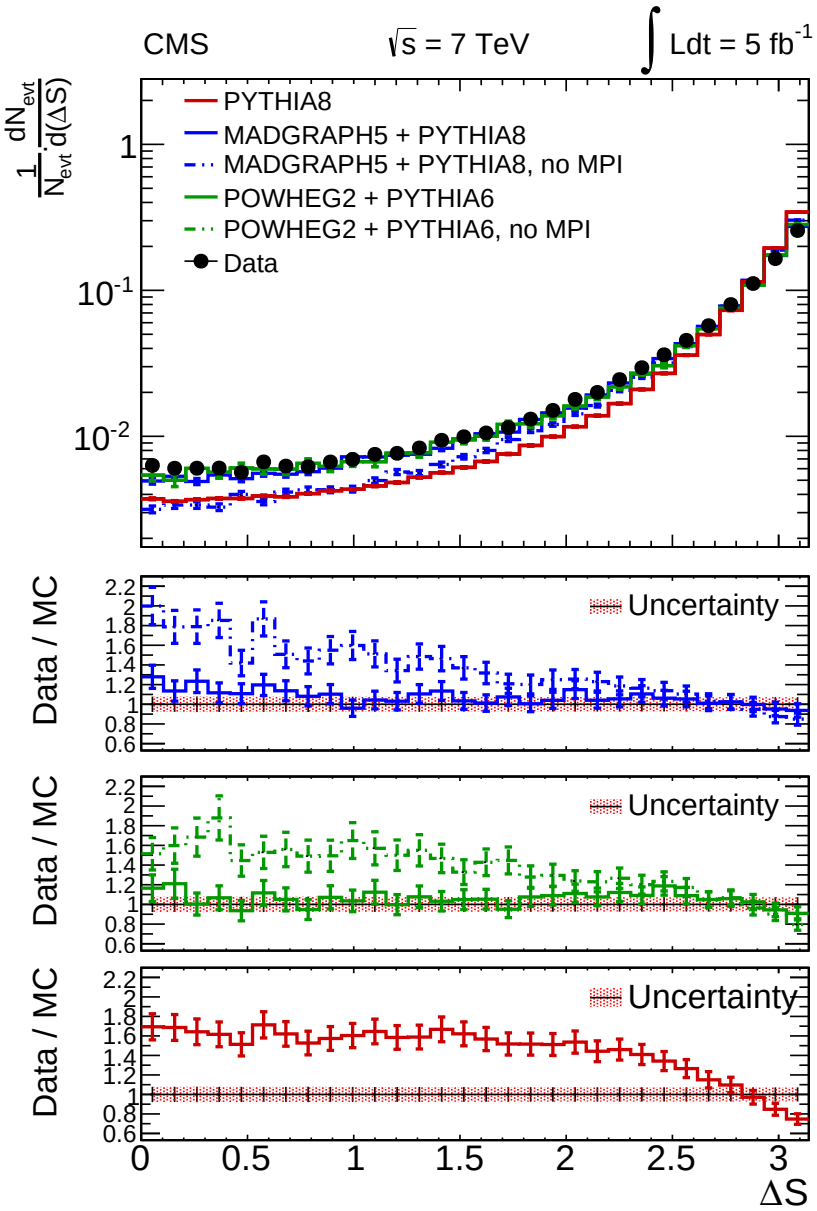
Is this not a clear evidence of DPS?



$$R^{\Upsilon(2S)/\Upsilon(1S)}_{D^+} = \mathcal{B}_{2/1} \times \frac{\sigma^{\Upsilon(2S)D^+}_{\sqrt{s}=7\,TeV}}{\sigma^{\Upsilon(1S)D^+}_{\sqrt{s}=7\,TeV}} = (22 \pm 7)\%\,,$$

$$R^{\Upsilon(2S)/\Upsilon(1S)}_{D^+} = \mathcal{B}_{2/1} \times \frac{\sigma^{\Upsilon(2S)D^+}_{\sqrt{s}=8\,TeV}}{\sigma^{\Upsilon(1S)D^+}_{\sqrt{s}=8\,TeV}} = (22 \pm 6)\%\,,$$

LHCb



ATLAS - CMS: DPS fraction 5-8%

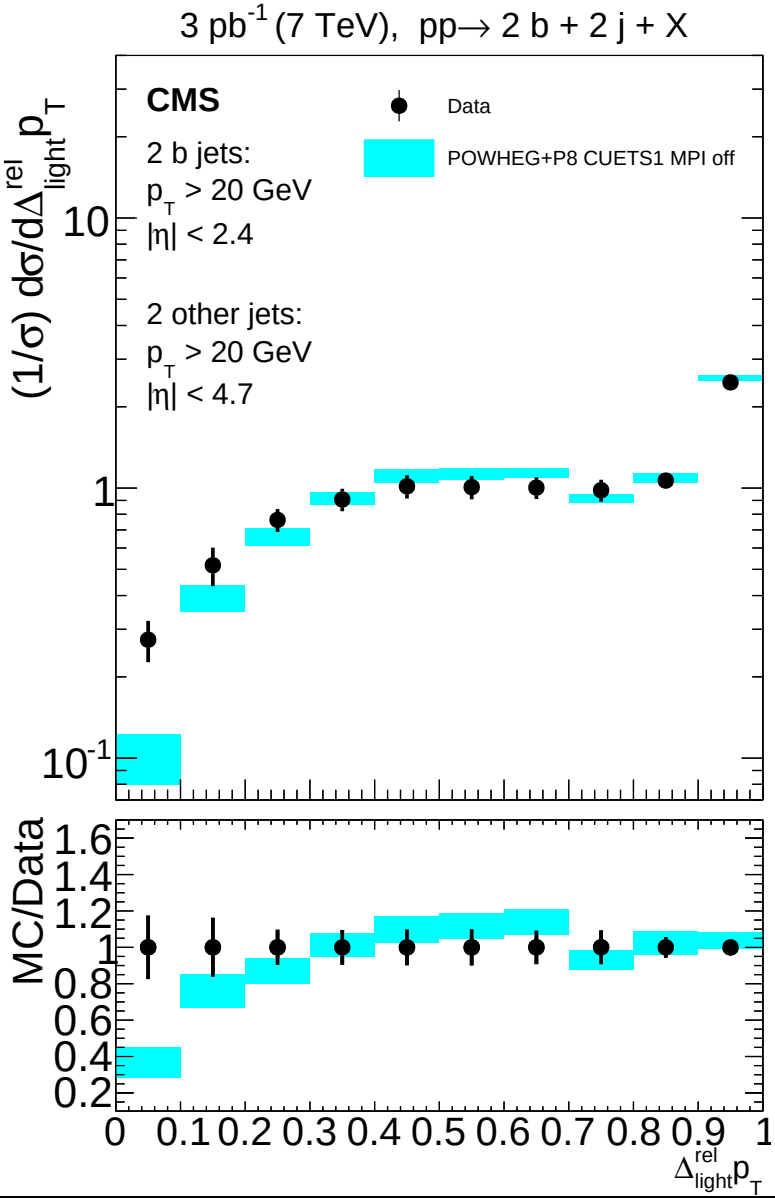
→ Diff. cross sections of DPS-sensitive observables

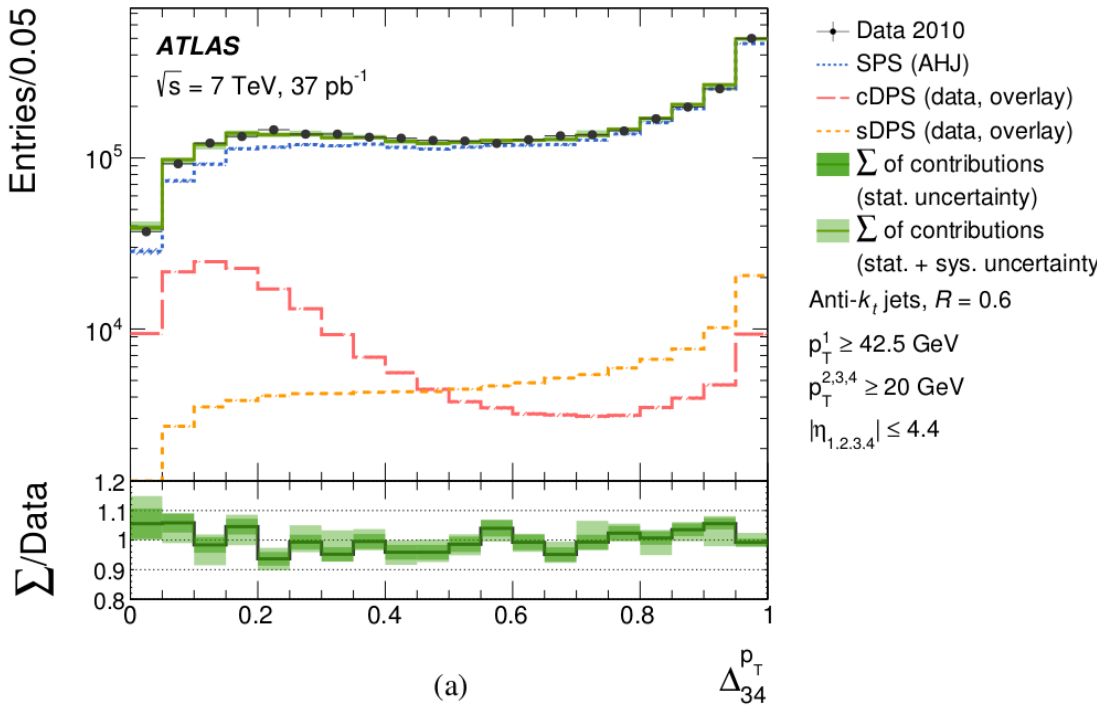
LHCb: DPS fraction 60 - 80%

→ Total production cross section for sensitive channels

Is this not a clear evidence of DPS?

More results (and new final states) continue to appear

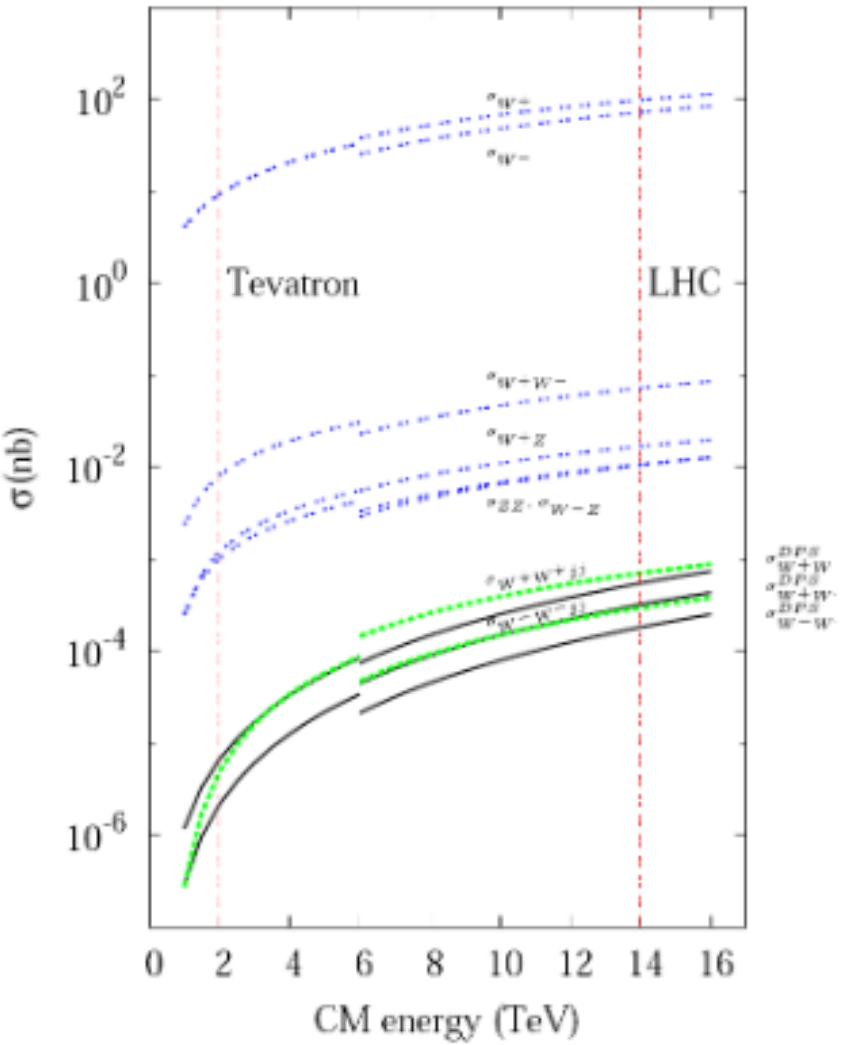


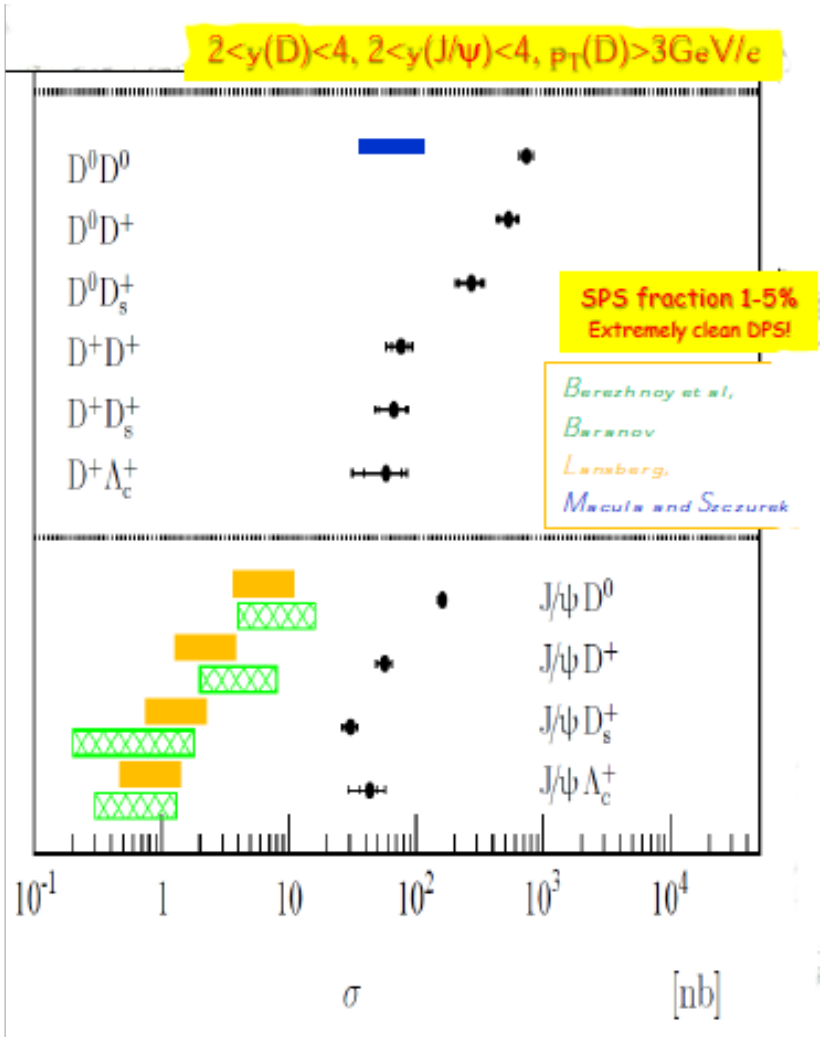


Similar amount of DPS contribution as in W+dijet (∼ 7-9%)!

Collection of several measurements (jet, charm and vector-boson sector) allows studies on channel-dependence

Experimental strategy for DPS measurements (I)





- Investigation of sensitive channels (same-sign WW, J/ψ+D,Λ)
- Analysis cuts which increase DPS sensitivity

Currently, measurements scan different (and complementary) regions of phase space

Experimental strategy for DPS measurements (II)

1st step

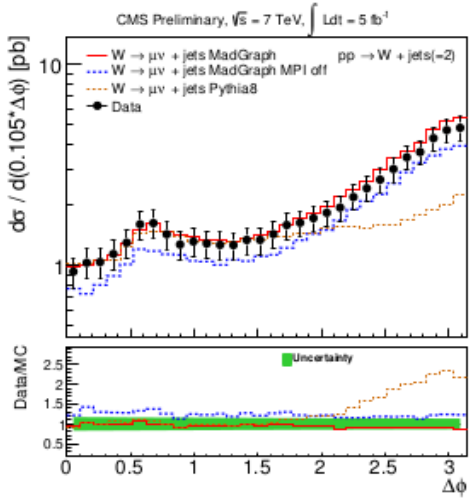
Corrected distributions DPS-sensitive variables

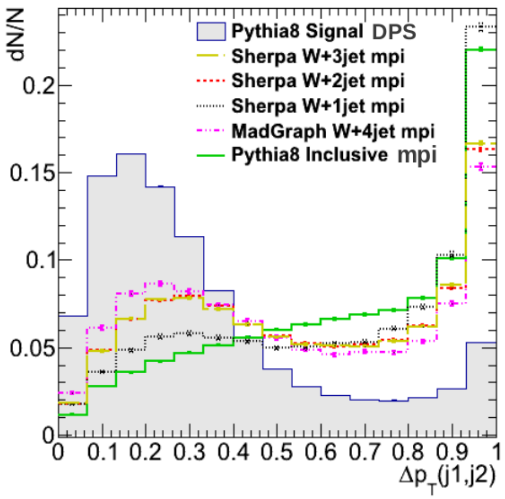
2nd step

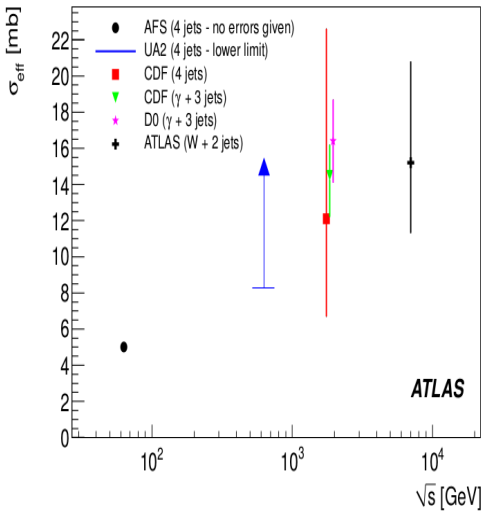
Data interpretation and unambiguous definition of signal and background templates

3rd step

Extraction of the DPS fraction and study of the process dependence





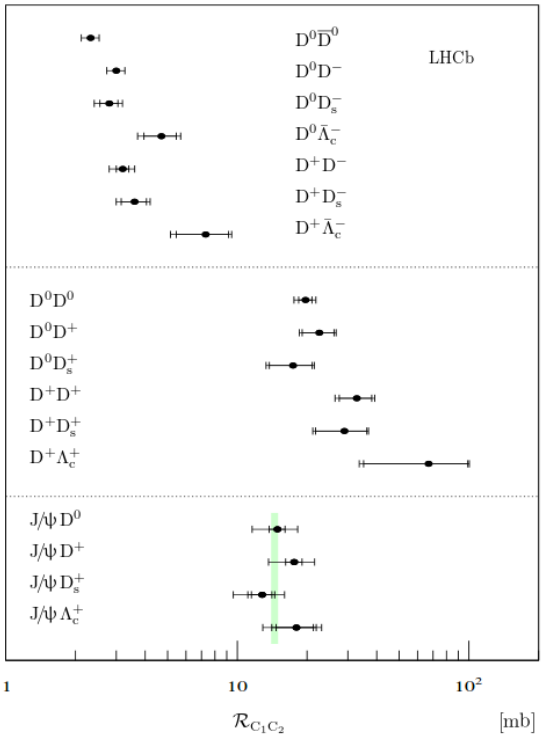


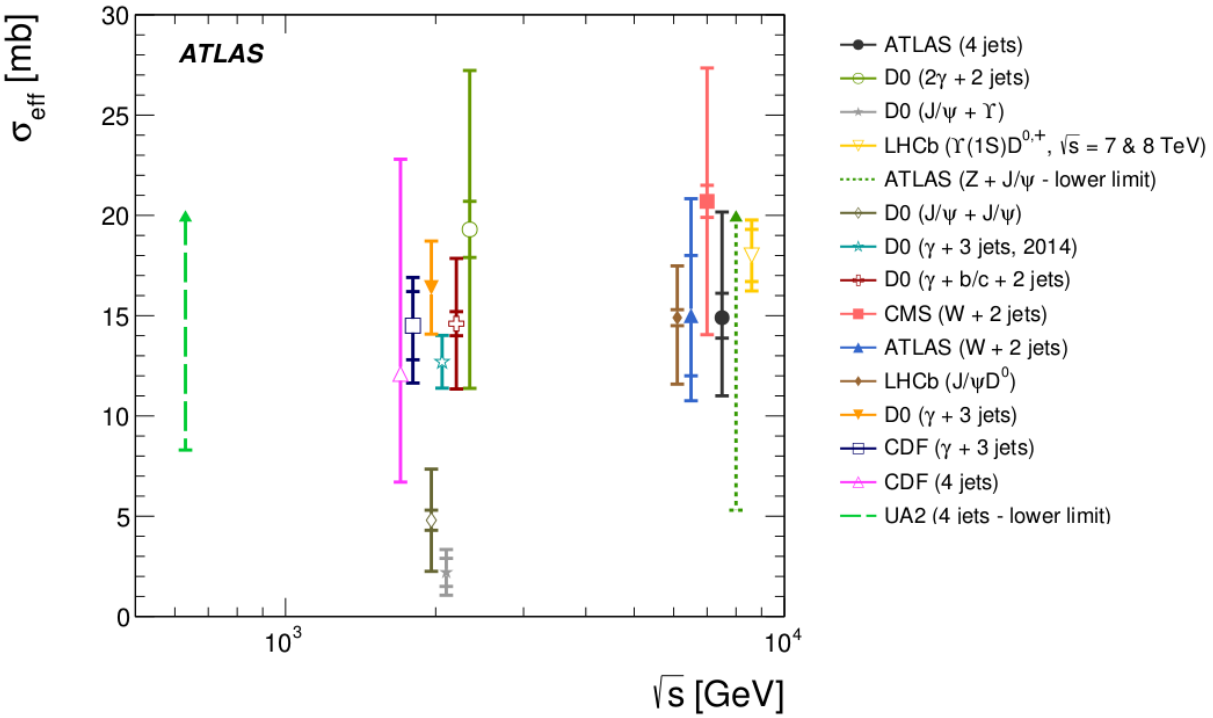
- Compare the data to your own favourite predictions!

4th (future) step: possibility to measure sensitive corners of phase space

Role of the quantity σ_{eff}

- Is the value for σ_{eff} a useful input?
- How can one reduce the exp. unc.?
- Should one try also a global extraction?





Combined extraction in different channels/energies?

LHCb results

Focus on associated charm production with some differential cross sections available

$\rightarrow$ double J/ψ

$\rightarrow$ Z + charm mesons

$\rightarrow$ Y + charm mesons

From Vanya last year's MPI@LHC:
"10% of "hard" events has additional charm!"

	measured	MCFM massless	MCFM massive	DPS
$Z + D^0$	$2.50 \pm 1.12 \pm 0.22$	$0.85^{+0.12\ +0.11}_{-0.07\ -0.17} \pm 0.05$	$0.64^{+0.01\ +0.08}_{-0.01\ -0.13} \pm 0.04$	$3.28^{+0.68}_{-0.58}$
$Z + D^+$	$0.44 \pm 0.23 \pm 0.03$	$0.37^{+0.05\ +0.05}_{-0.03\ -0.07} \pm 0.03$	$0.28^{+0.01\ +0.04}_{-0.01\ -0.06} \pm 0.02$	$1.29^{+0.27}_{-0.23}$

$\rightarrow$ **Why does LHCb use the CDF result for σ_{eff}?**

$\rightarrow$ I had some rumours that some results at 13 TeV will be presented. :)

Status of DPS analysis in Run II

- Not much more available at 13 TeV in terms of DPS understanding for the time being!

POSSIBLE (EXPERIMENTAL) REASONS:

- Poor low-PU runs (~ 2 pb^{-1} - in RunI was 36 pb^{-1})
- Jets (especially) at low p_T not very well understood
- People are generally happy with evaluation of DPS cross sections for background estimation through the pocket formula $\rightarrow$ little contamination, large uncertainties for σ_{eff} not an issue
- Missing person power

HOW TO MAKE DPS ANALYSES (EVEN MORE) ATTRACTIVE?

- New ideas and new channels to be looked for
- Development of new theoretical approaches
- Possibility of using more sophisticated models to be tested in specific channels
- Going further: triple parton scattering
- .... more ideas to be collected during this week's discussions!

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We hope to have a nice discussion during the DPS session!