

Current measurements of production fractions and heavy flavor cross sections from CMS

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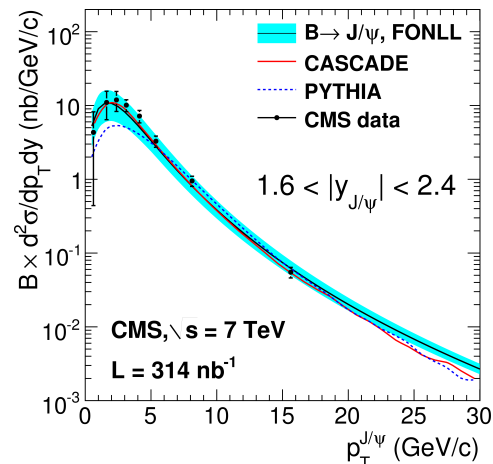
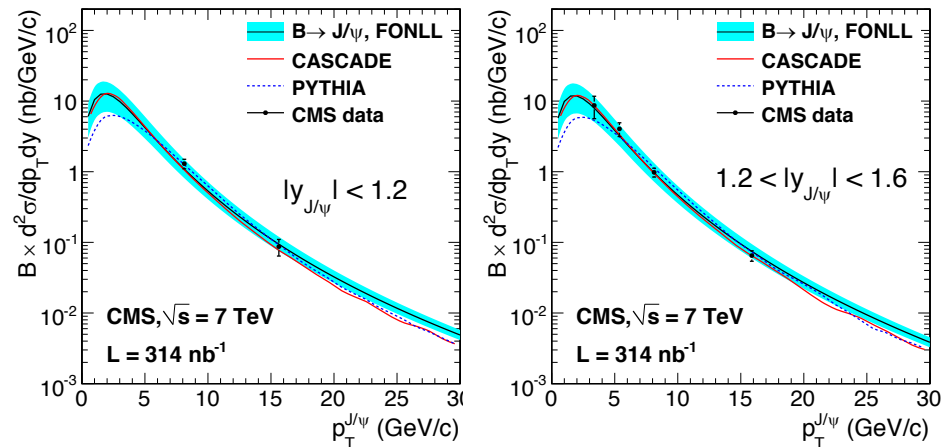
Overview of heavy flavor production cross section measurements at CMS

- ✓ non-prompt J/ψ production
- ✓ non-prompt $\psi(2S)$ production
- ✓ Inclusive b-hadron production cross section with muons
- ✓ Inclusive b-jet production
- ✓ cross section for production of $b\bar{b}X$, decaying to muons
- ✓ $B\bar{B}$ angular correlations based on secondary vertex reconstruction
- ✓ B^+ production cross section
- ✓ B^0 production cross section
- ✓ B_s^0 production cross section
- ✓ Λ_b cross section and the $\Lambda_{\bar{b}}$ to Λ_b ratio with $J/\psi\Lambda$ decays
- ✓ B_c^+ production cross section

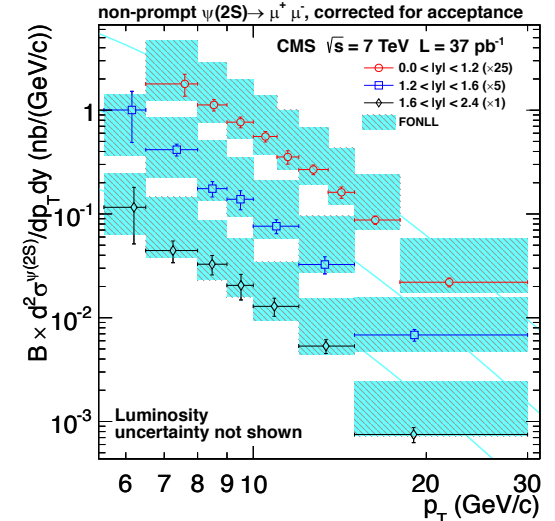
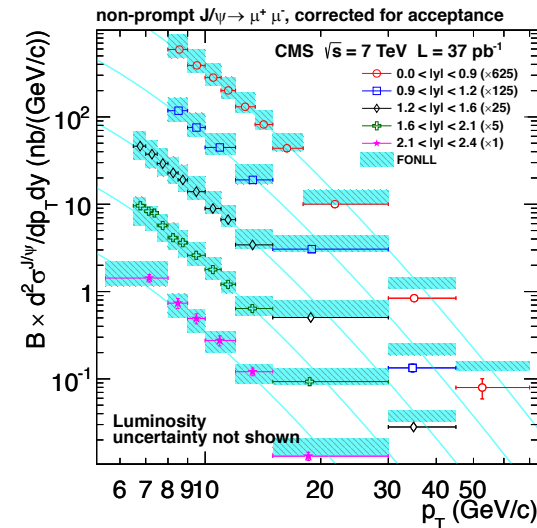
Non-prompt production:

7 TeV measurements:

- ✓ **Prompt and non-prompt J/ψ production in pp collisions at $\sqrt{s} = 7$ TeV** - [Eur. Phys. J. C 71 \(2011\) 1575](#): With 314 nb^{-1} of data the prompt and non-prompt J/ψ production cross sections are presented in three rapidity bins as function of p_T . The non-prompt J/ψ production fraction is also presented.
- ✓ **J/ψ and $\psi(2S)$ production in pp collisions at $\sqrt{s} = 7$ TeV** - [J. High Energy Phys. 02 \(2012\) 011](#) With 37 pb^{-1} of data the prompt and non-prompt J/ψ and $\psi(2S)$ production cross sections are presented in five rapidity bins as function of p_T . The non-prompt J/ψ and $\psi(2S)$ production fraction are also presented, together with the $\psi(2S)$ over J/ψ cross section ratio



Non-prompt
cross section
measurements

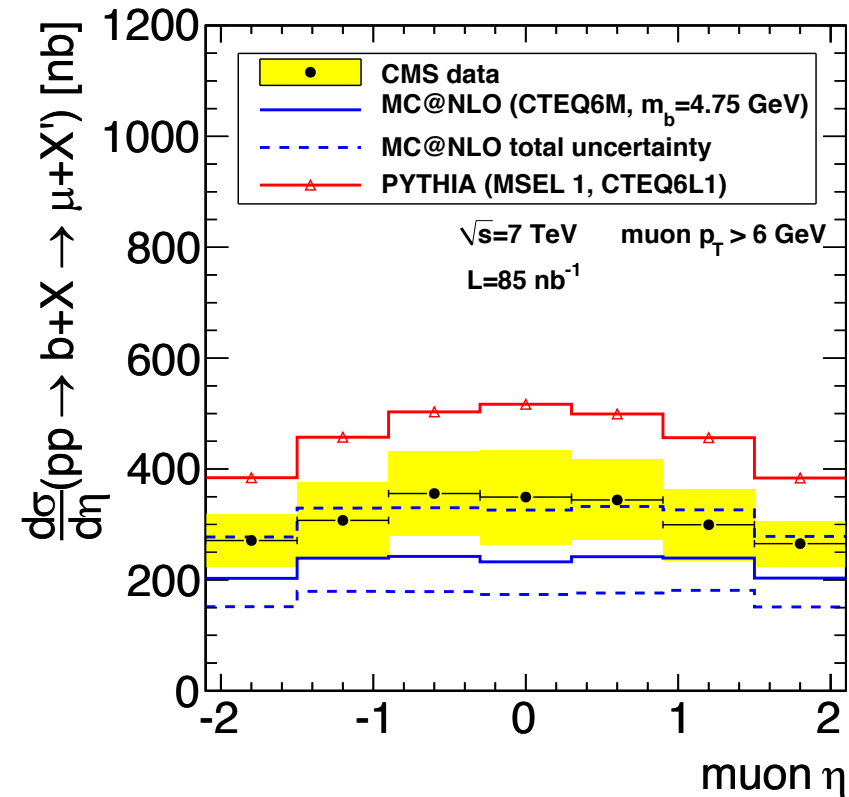
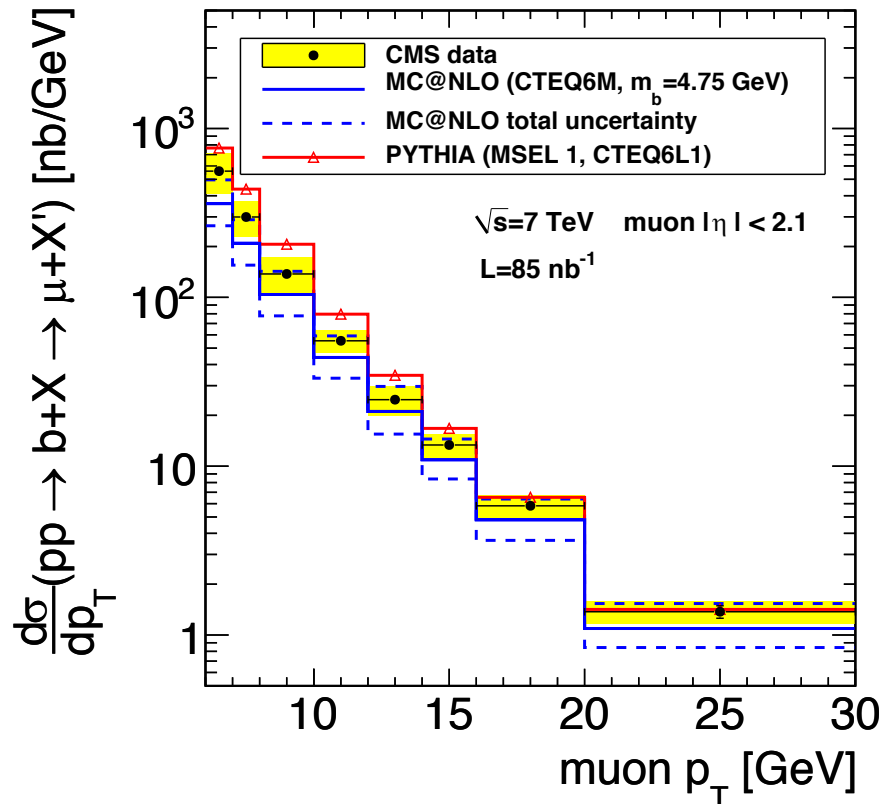


Dominated by systematic uncertainties. Apart from luminosity, the systematic uncertainty is dominated by the muon efficiency determination from data.

Inclusive b production:

7 TeV measurements:

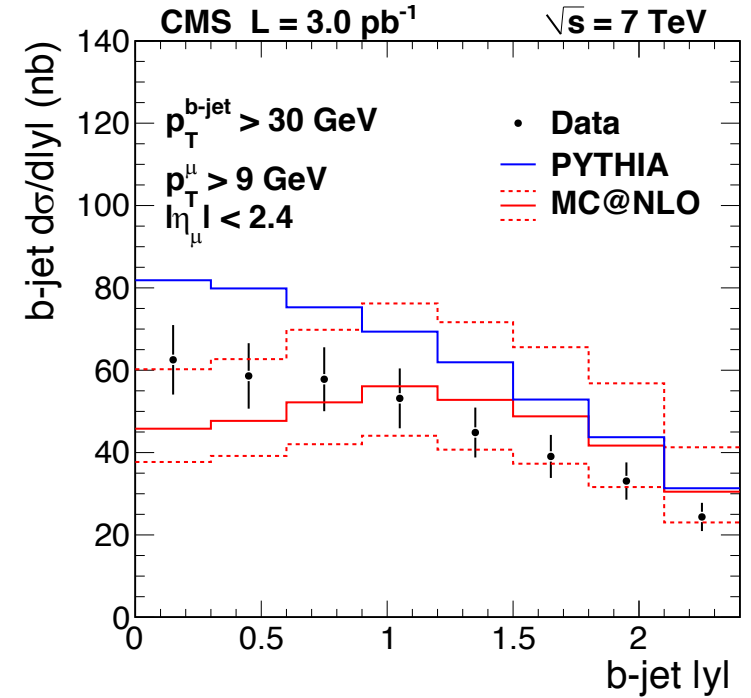
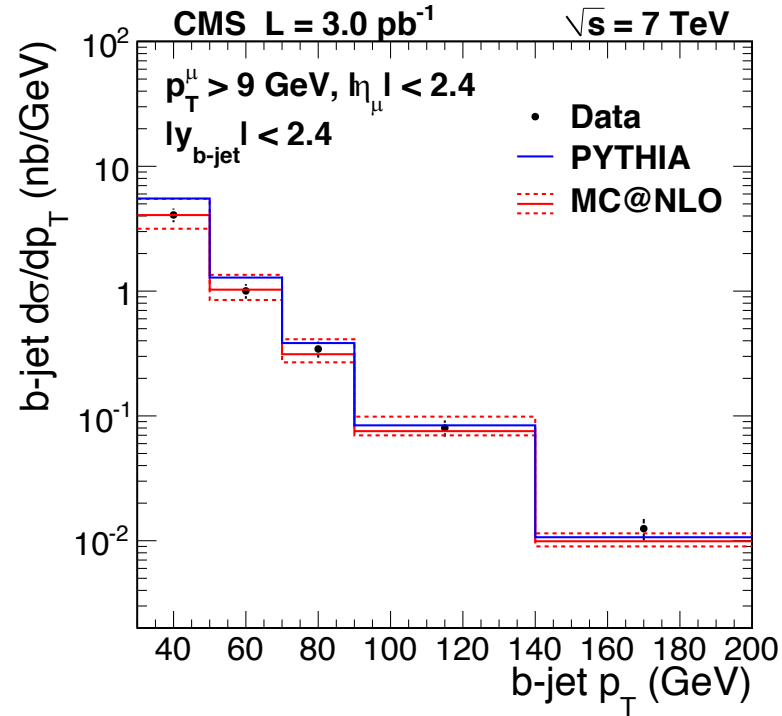
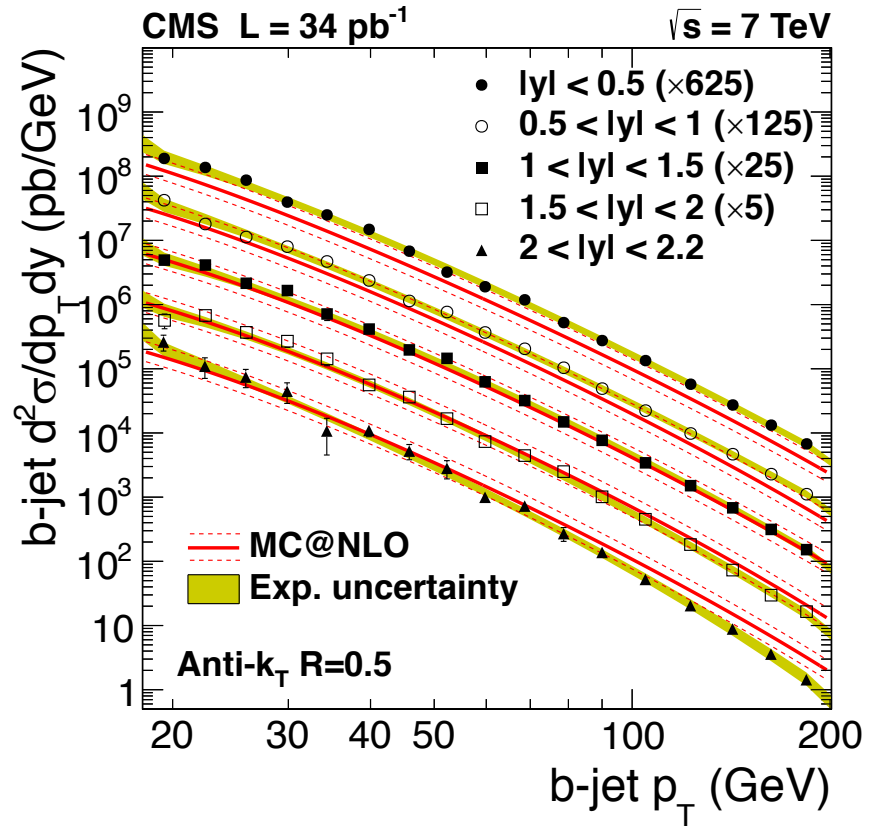
- ✓ **Inclusive b-hadron production cross section with muons in pp collisions at $\sqrt{s} = 7$ TeV - [J. High Energy Phys. 03 \(2011\) 090](#)** : With 85 nb⁻¹ of data the b-hadron production cross section is presented, using events with single muon $p_T > 6$ GeV and $|\eta| < 2.1$.



Measurement is dominated by systematic uncertainties, of which the modeling of the underlying event is the leading one. Here the evaluation is performed using different MC tunes, which could change the cross section determination up to 10%. Contribution from b quark fragmentation range from 1-4%

7 TeV measurements:

- ✓ **Inclusive b-jet production in pp collisions at $\sqrt{s} = 7$ TeV - [J. High Energy Phys. 04 \(2012\) 084](#) :** The inclusive b-jet production cross section in the range $18 < p_T < 200$ GeV for several rapidity intervals with 34 and 3 pb⁻¹ of data



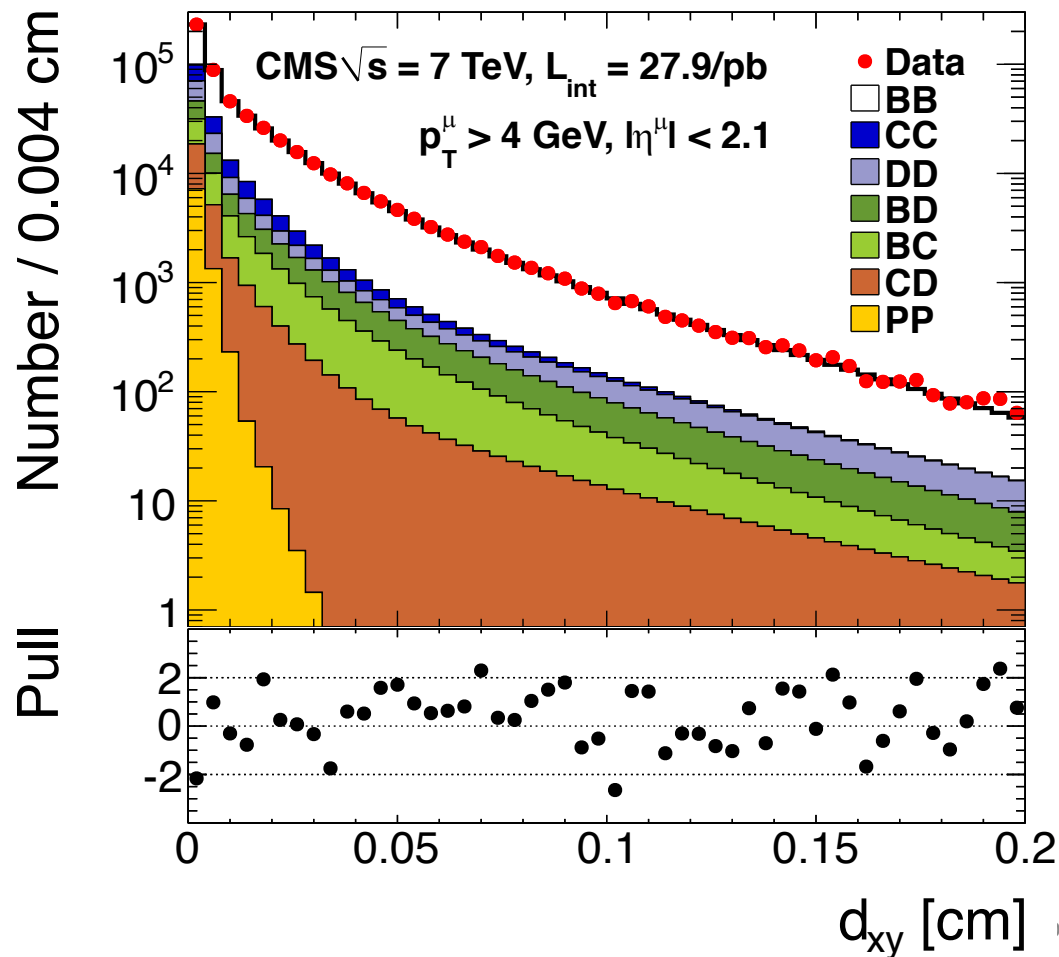
The systematic uncertainties are dominated by the b-tagging efficiency. Contributions from BR are of the order of 2.5% (an order of magnitude lower than the dominant one). The uncertainty of the b-quark fragmentation is of the order of 4%

b b-bar production:

7 TeV measurements:

- ✓ **Measurement of the cross section for production of $b\bar{b}X$, decaying to muons in pp collisions at $\sqrt{s} = 7$ TeV - [J. High Energy Phys. 06 \(2012\) 110](#) : With 27.9 pb⁻¹ of data inclusive cross section for the process pp to $b\bar{b}X$ to muons**

$$\sigma(pp \rightarrow b\bar{b}X \rightarrow \mu\mu X') = 26.4 \pm 0.1 \text{ (stat.)} \pm 2.4 \text{ (syst.)} \pm 1.1 \text{ (lumi.) nb}$$



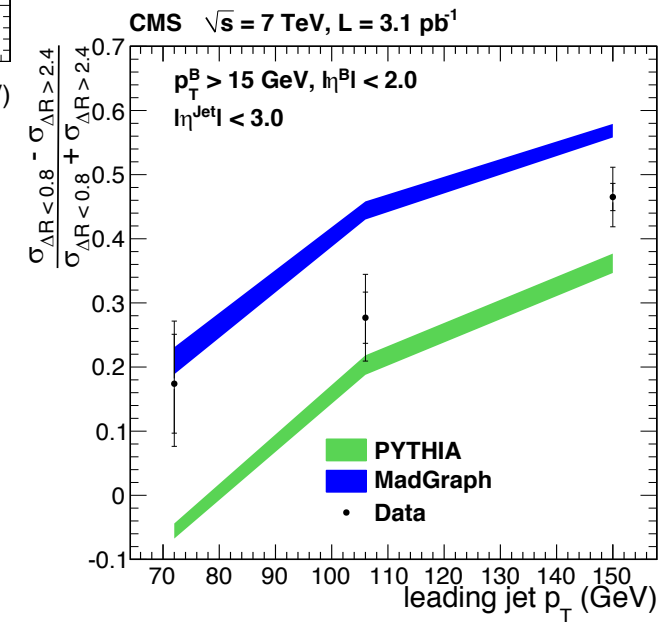
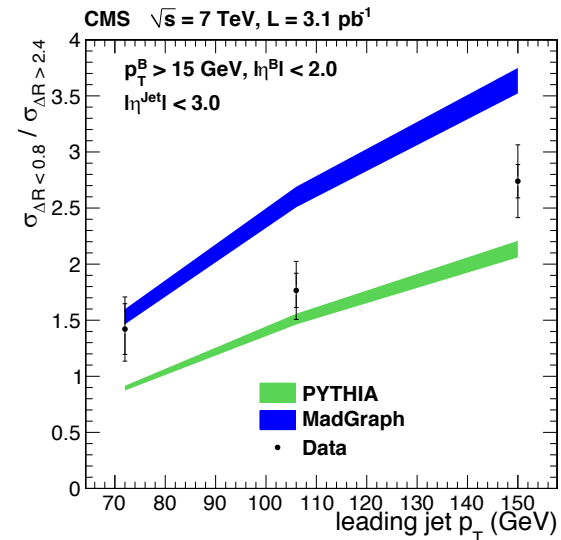
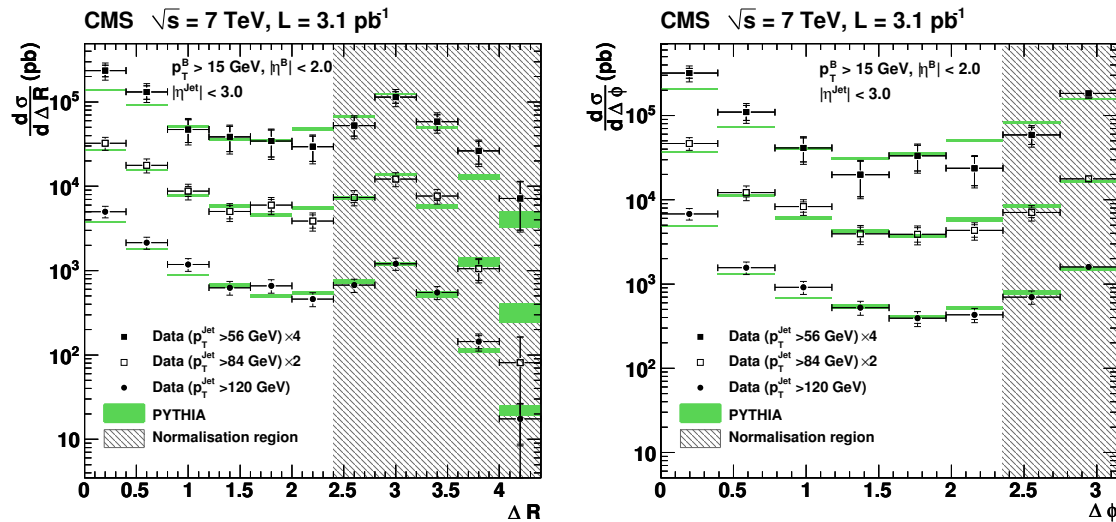
Measurement is performed as function of the impact parameter

Measurement is dominated by systematic uncertainties, of which the determination of the acceptance is the leading one. f 's uncertainties contribute 2-3% in comparison to 6% of the dominant source.

Fractions were varied from LEP to LHCb determinations, specially for $f/\Lambda_b = \Lambda_b / (B_u + B_d)$

7 TeV measurements:

- ✓ **Measurement of BB-bar angular correlations based on secondary vertex reconstruction at $\sqrt{s} = 7$ TeV - [J. High Energy Phys. 03 \(2011\) 136](#):** Using B hadrons from displaced secondary vertices, the differential BB-bar production cross section was measured from 3.1 pb^{-1} of data

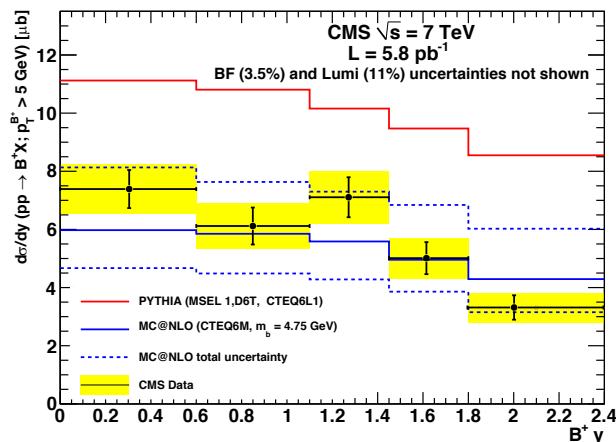
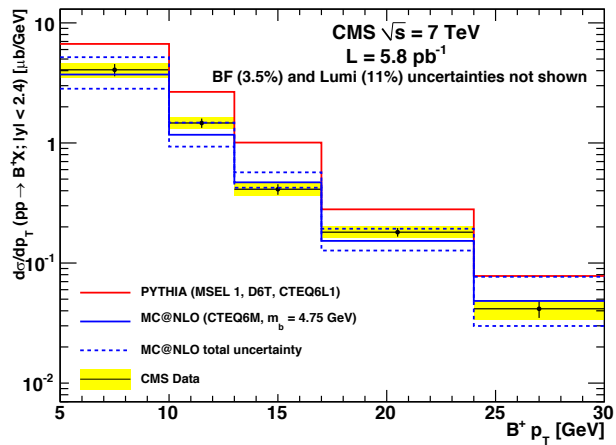


Measurement dominated by systematic uncertainties of which the absolute normalization (47% not shown in figures) is the leading one. The systematic uncertainties on the shape determination are dominated by MC statistics. Another significant contribution comes from the b-hadron p_T spectrum modeling

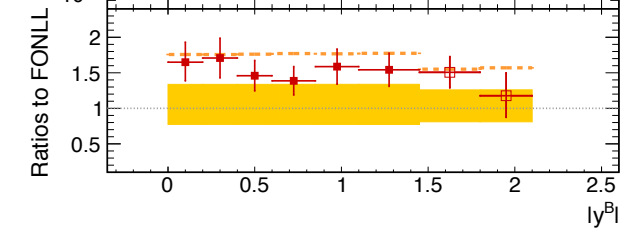
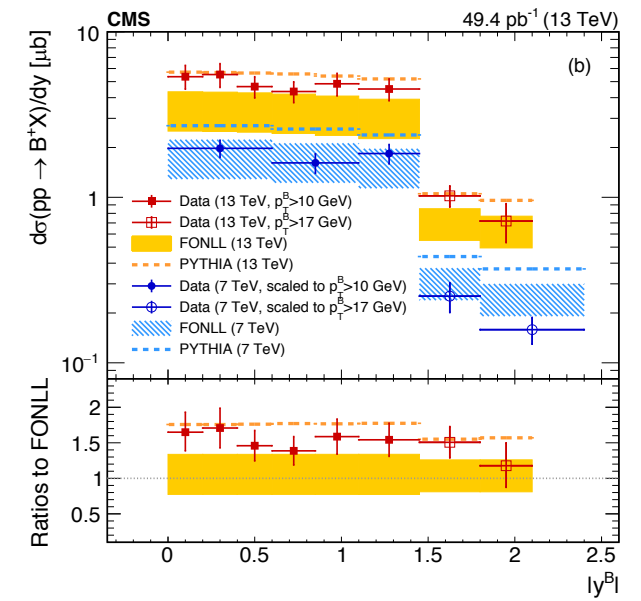
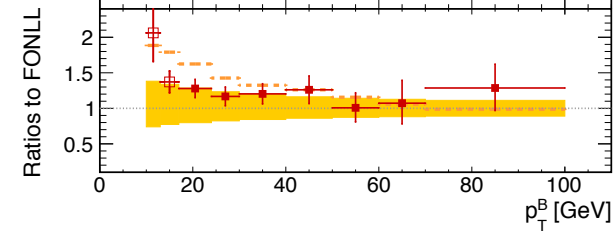
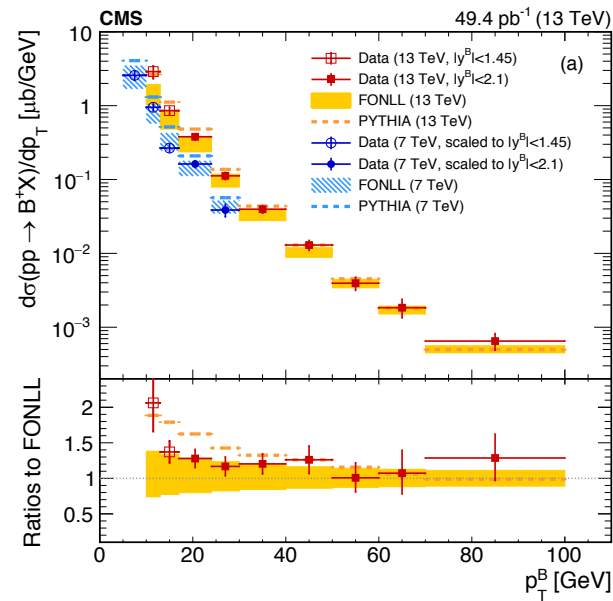
Heavy Flavor production:

7/13 TeV measurements:

- ✓ **Measurement of the B⁺ Production Cross Section in pp Collisions at $\sqrt{s} = 7$ TeV** - [Phys. Rev. Lett. 106 \(2011\) 112001](#): the total and pT- and y- differential cross sections of B⁺ hadrons are measured using 5.8 pb⁻¹
- ✓ **Measurement of the total and differential inclusive B⁺ hadron cross sections in pp collisions at $\sqrt{s} = 13$ TeV** – accepted to [PLB arXiv:1609.00873](#) : The total and differential cross sections for inclusive production of B⁺ hadrons are measured as function of the pT and rapidity using 49.4 pb⁻¹



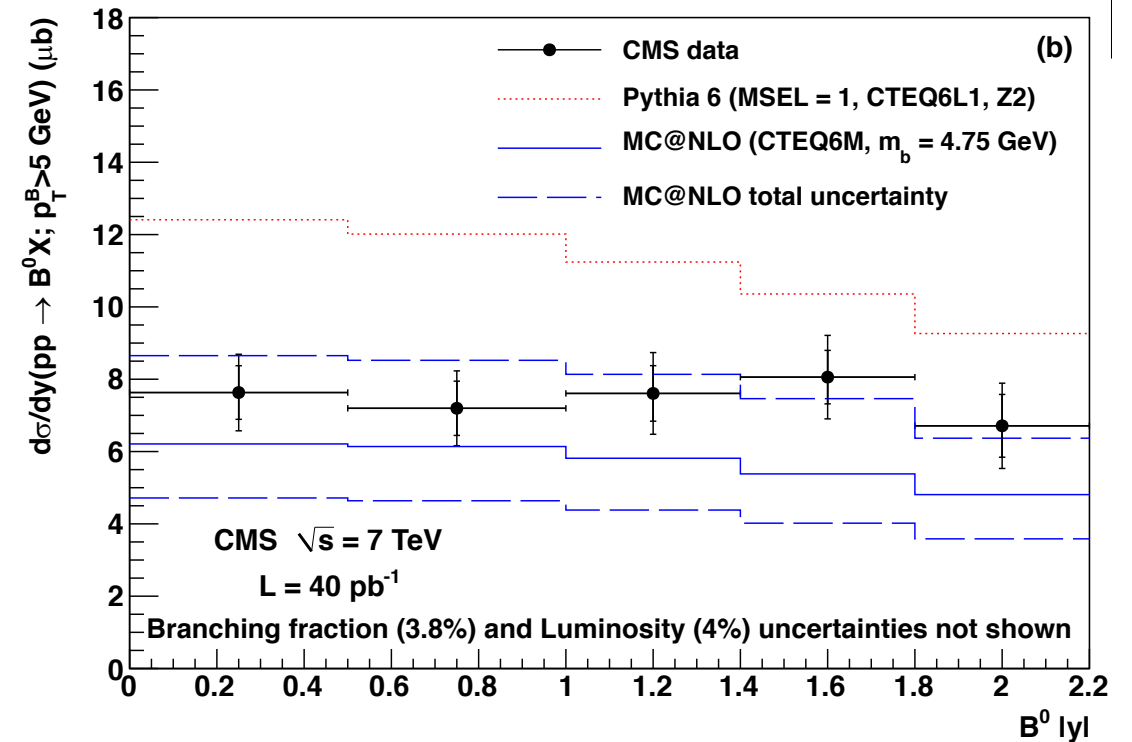
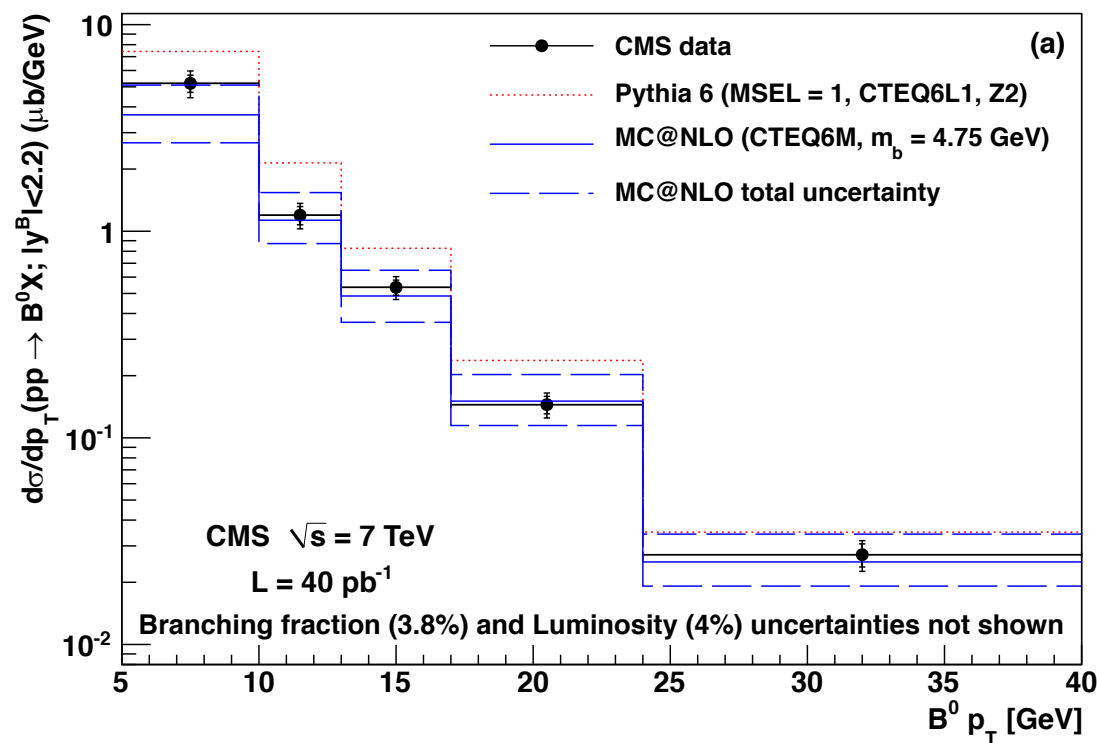
Using B⁺ \rightarrow J/ ψ K⁺ decay mode



Dominated by systematic uncertainties of which the total muon uncertainties are the leading ones, while those associated to the BRs are at the order of 3-4%, in both measurements

7 TeV measurements:

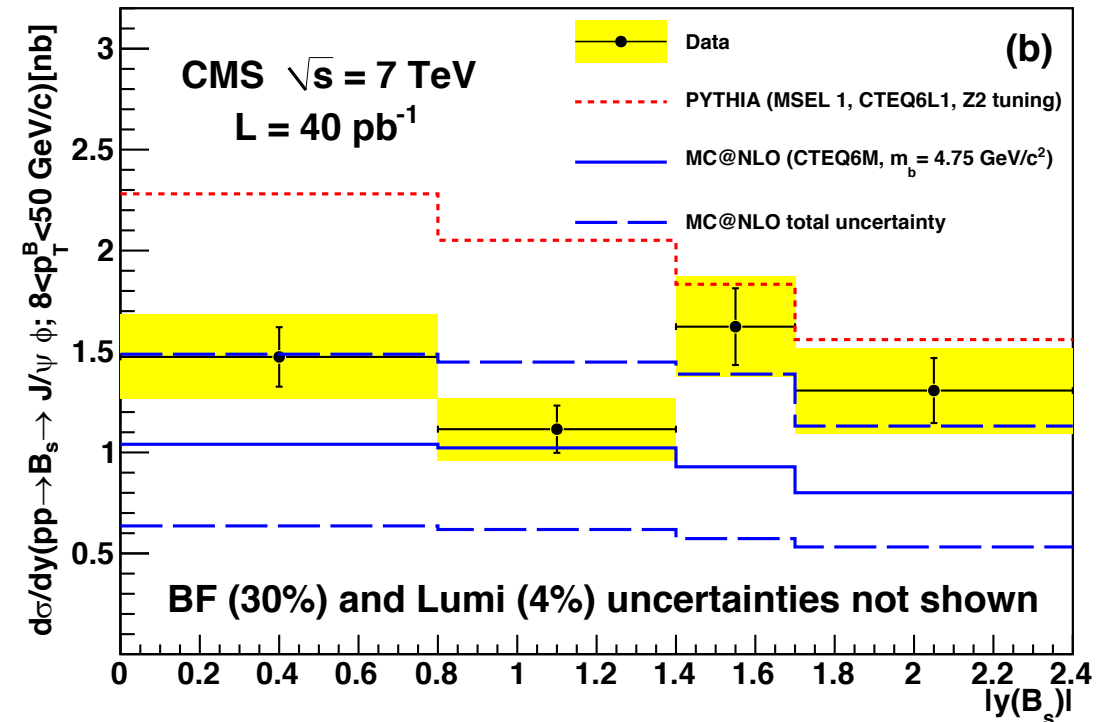
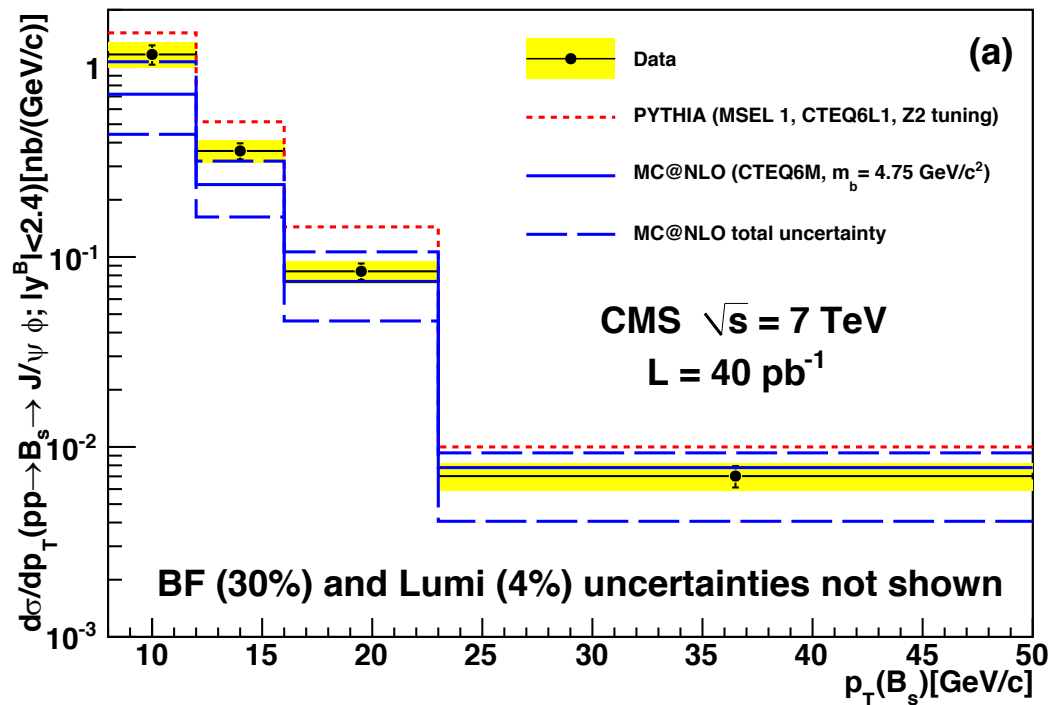
- ✓ **Measurement of the B^0 Production Cross Section in pp Collisions at $\sqrt{s} = 7$ TeV** - [Phys. Rev. Lett. 106 \(2011\) 252001](#): Using 40 pb⁻¹ of data the differential B^0 production cross sections as function of pT and rapidity are presented with $J/\psi K_s^0$ decays



Dominated by systematic uncertainties
Uncertainty coming from BR is 3.8%

7 TeV measurements:

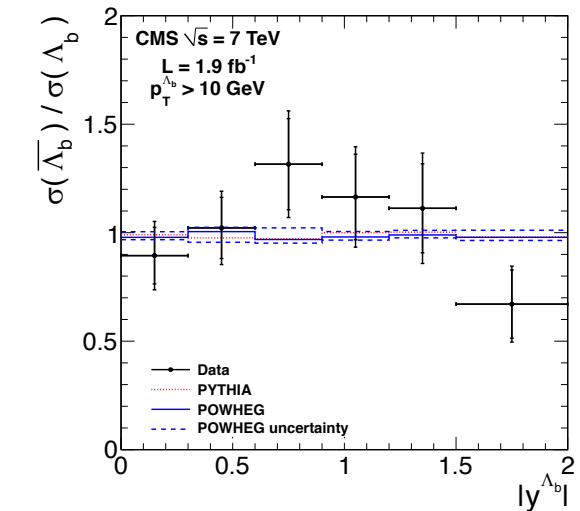
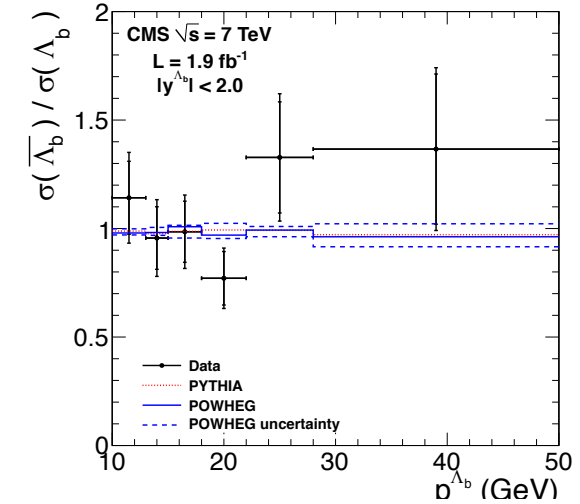
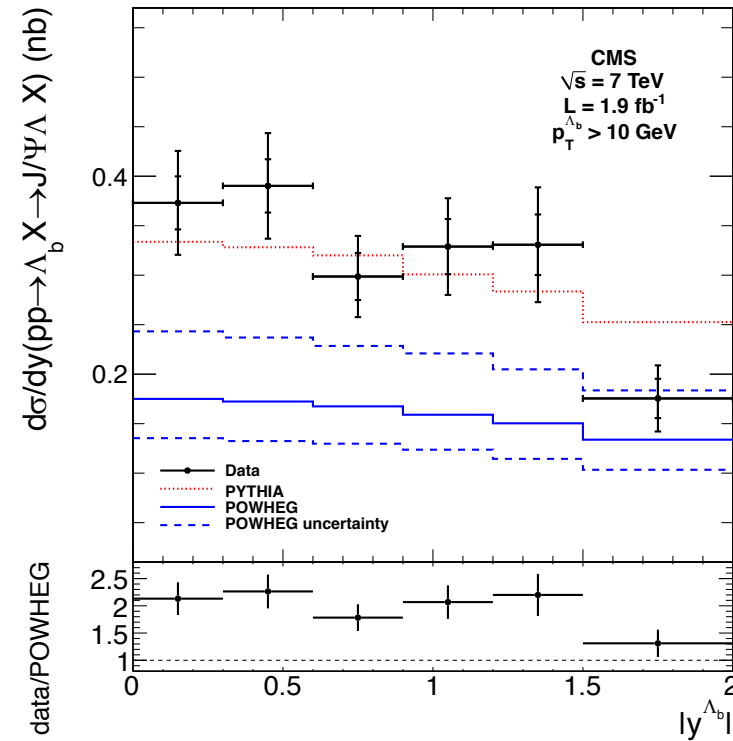
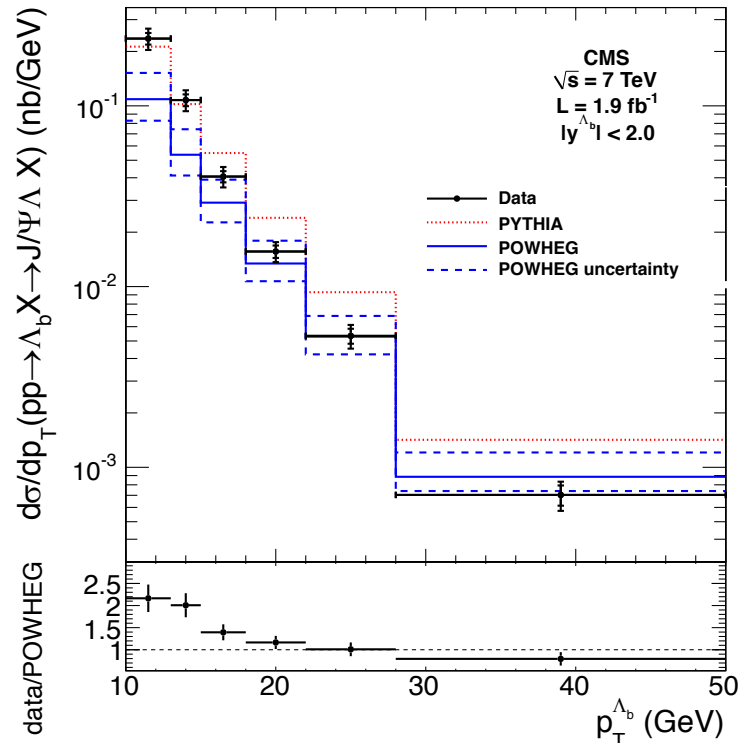
- ✓ **Measurement of the B_s^0 Production Cross Section with $B_s^0 \rightarrow J/\psi \phi$ Decays in pp Collisions at $\sqrt{s} = 7$ TeV - [Phys. Rev. D 84 \(2011\) 052008](#):** The B_s^0 differential production cross section is measured as functions of p_T and rapidity using 40 pb^{-1}



The measurement is dominated by systematic uncertainties, being the ones from BRs the most dominant. Uncertainty on $BR(B_s^0 \rightarrow J/\psi \phi) \sim 30\%$ not shown in the plots.

7 TeV measurements:

- ✓ **Measurement of the Λ_b cross section and the Λ_b -bar to Λ_b ratio with $J/\psi\Lambda$ decays in pp collisions at $\sqrt{s} = 7$ TeV - [Phys. Lett. B 714 \(2012\) 136-157](#): With 1.9 pb⁻¹ of data the Λ_b differential production cross section and the cross-section ratio for Λ_b -bar / Λ_b production are measured as functions of p_T and rapidity**



Systematic uncertainties dominate, of which the modeling of the pion/proton reconstruction efficiency evaluated from GEANT simulation is the leading one. Contributions from the BR are small.

7 TeV measurements:

- ✓ Measurement of the ratio $\mathcal{B}(B_c^+ \rightarrow J/\psi \pi^+ \pi^+ \pi^-) / \mathcal{B}(B_c^+ \rightarrow J/\psi \pi^+)$ and the production cross sections times branching fractions of $B_c^+ \rightarrow J/\psi \pi^+$ and $B^+ \rightarrow J/\psi K^+$ in pp collisions at $\sqrt{s} = 7$ TeV - [J. High Energy Phys. 01 \(2015\) 063](#): B_c^+ mesons with $p_T > 15$ GeV and $|y| < 1.6$ are studied in a data sample with an integrated luminosity of 5.1 fb^{-1}

$$R_{c/u} = \frac{\sigma(B_c^+) \mathcal{B}(B_c^+ \rightarrow J/\psi \pi^+)}{\sigma(B^+) \mathcal{B}(B^+ \rightarrow J/\psi K^+)} = \frac{Y_{B_c^+ \rightarrow J/\psi \pi^+}}{Y_{B^+ \rightarrow J/\psi K^+}},$$

Systematic uncertainties in the measurement

Systematic source	%
Fit variant	5.3
MC sample size	2.1
Efficiency binning	3.1
Total uncertainty	6.5
B_c lifetime	10.4

$$R_{c/u} = [0.48 \pm 0.05(\text{stat}) \pm 0.03(\text{syst}) \pm 0.05(\tau_{B_c})]\%$$

Systematic uncertainties dominate of which the lifetime variation is the leading. This large uncertainty is the difference between world average and LHCb measurement.