Observation of $B^0_{(s)} \to J/\psi p\bar{p}$ decays and precision measurements of the $B^0_{(s)}$ masses [1]

LHCC Students' Poster Session, 27 February 2019, CERN

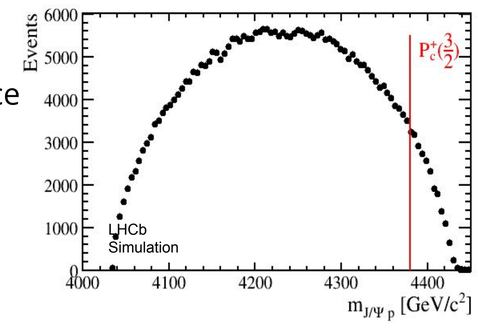
Elisabetta Spadaro Norella, Biplab Dey, Jinlin Fu, Nicola Neri
on behalf of LHCb Collaboration

Università degli Studi di Milano & INFN Milano

MOTIVATION

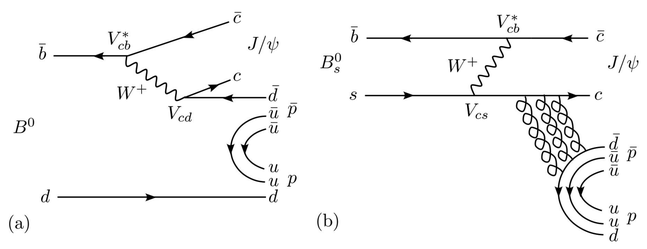
The $B^0_{(s)} \to J/\psi p\bar{p}$ decays are candidates for:

- independent observation of **pentaquark** states:
  - in [J/ψ p] and [J/ψ $\bar{p}$] systems
  - **$P_c^+(3/2)$** state [2] in allowed phase-space
  - other possible states?



- for **glueball** searches:
  - in p$\bar{p}$ system
  - prediction of $f_J(2220)$ by Hsiao [3]

They are suppressed decays:



Their branching fractions can be enhanced by the presence of these exotic structures:

- Naive estimation of BR [3]: $\mathcal{B}(\bar{B}^0_s \to J/\psi p\bar{p}) \leq 10^{-9}$

2011 / 2012 / 2015 / 2016

FIRST analysis of $B^0_{(s)} \to J/\psi p\bar{p}$ with 2011 dataset [4]

No observation, limits set to: @90% CL

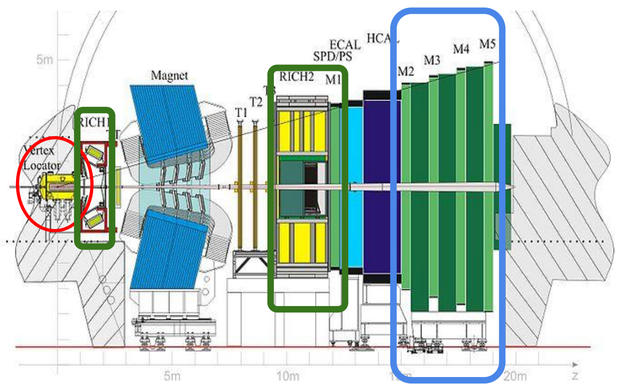
$$\mathcal{B}(B^0_s \to J/\psi p\bar{p}) < 4.8 \times 10^{-6}$$

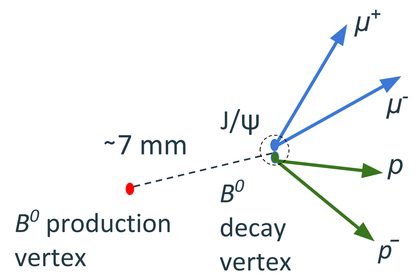
$$\mathcal{B}(B^0_d \to J/\psi p\bar{p}) < 5.2 \times 10^{-7}$$

PRESENT analysis:

- Dataset 2011-2016 collected by LHCb, corresponding to an integrated luminosity of 5.2 fb^{-1}
- Branching ratio measurement with respect to Control Sample of $B^0_{(s)} \to J/\psi(\Phi \to KK)$

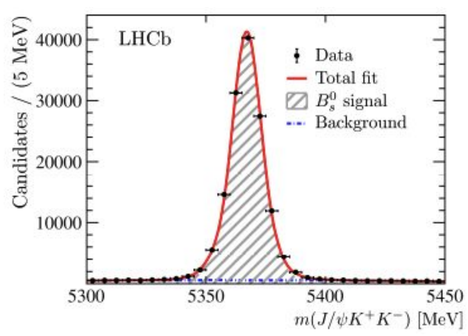
EVENT SELECTION





- 2 muons originating from detached J/ψ vertex
  - VELO, muon chambers and hardware trigger [5]
- 2 tracks consistent with protons originating from the same vertex
  - Tracking system and Cherenkov detectors for PID

Control sample: $B \to J/\psi(\Phi \to KK)$



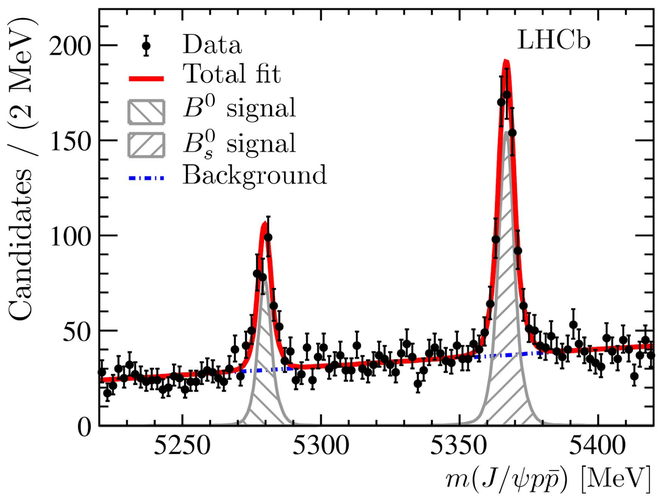
Yield: 136,800 ± 400 events

- High purity sample
- Similar kinematics
  - **BDT training** with B kinematic variables on MC of the Control Sample

BDT optimization:

- 2 steps: one BDT with kinematic variables and one with proton PID variables to optimize the FoM S/√(S+B).

$B^0_{(s)} \to J/\psi p\bar{p}$ INVARIANT MASS FIT



Fit Model

- Linear background
- Crystal Balls for signal

Results

Mode	Yield
$B^0 \to J/\psi p\bar{p}$	256 ± 22
$B^0_s \to J/\psi p\bar{p}$	609 ± 31

BRANCHING RATIO FORMULA

$$\frac{\mathcal{B}(B^0_s \to J/\psi p\bar{p})}{\mathcal{B}(B^0_s \to J/\psi\phi) \times \mathcal{B}(\phi \to K^+K^-)} = \frac{N^{\rm corr}_{B^0_s \to J/\psi p\bar{p}}}{N^{\rm corr}_{B^0_s \to J/\psi K^+K^-}}$$

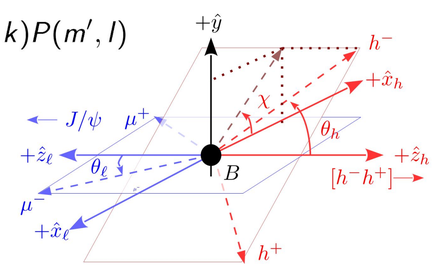
The number of events is corrected by the efficiency:

- Average efficiency for Control Sample of ~1%
- Event-by-event efficiency for signal

4D efficiency-parametrization with Legendre polynomial:

$$\varepsilon(\vec{x}) = \sum_{i,j,k,l} c_{i,j,k,l}\; P(\cos\theta_\ell, i) P(\cos\theta_V, j) P(\chi', k) P(m', l)$$

- θ_ℓ and θ_V: helicity angles
- χ': angle between decay planes
- m': di-hadron invariant mass



RESULTS

First observation of $B^0_{(s)} \to J/\psi p\bar{p}$ decays. The branching fractions are measured to be:

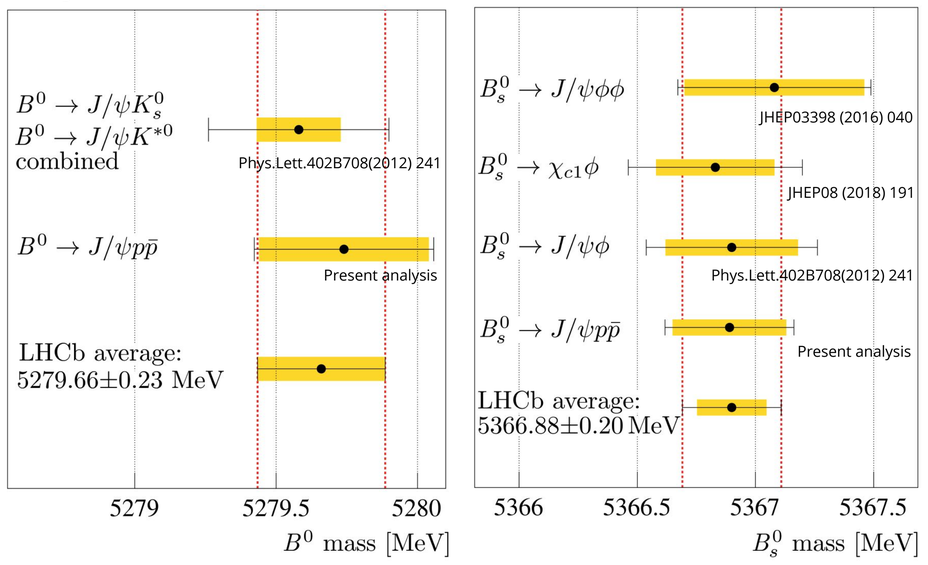
$$\mathcal{B}(B^0 \to J/\psi p\bar{p}) = (4.51 \pm 0.40\ (\text{stat}) \pm 0.44\ (\text{syst})) \times 10^{-7},$$
$$\mathcal{B}(B^0_s \to J/\psi p\bar{p}) = (3.58 \pm 0.19\ (\text{stat}) \pm 0.33\ (\text{syst})) \times 10^{-6},$$

- The B^0_s value is two order of magnitude higher than expectation.

Due to the low Q-value of the reactions, precise mass measurements are allowed:

$$m_{B^0} = 5279.74 \pm 0.30\ (\text{stat}) \pm 0.10\ (\text{syst})\ \text{MeV},$$
$$m_{B^0_s} = 5366.85 \pm 0.19\ (\text{stat}) \pm 0.13\ (\text{syst})\ \text{MeV},$$

The B^0_s mass is the **best single mass measurement**.



References

[1] LHCb collaboration, R. Aaij et al., arXiv 1902.05588 (2019)
[2] LHCb collaboration, Observation of J/ψp resonances consistent with pentaquark states in $\Lambda^0_b \to J/\psi p K^-$ decays, Phys. Rev. Lett.115(2015) 072001
[3] Y. K. Hsiao and C. Q. Geng, $f_J(2220)$ and hadronic B^0_s decays, Eur. Phys. J. C75 (2015), no. 3 101
[4] LHCb collaboration, R. Aaij et al., Searches for $B^0_{(s)} \to J/\psi p\bar{p}$ and $B^+ \to J/\psi p p\bar{p}\pi^+$, JHEP09(2013)006
[5] LHCb collaboration, LHCb detector performance, Int. J. Mod. Phys. A 30 (2015) 1530022

The authors acknowledge funding from *Fondazione F.lli Confalonieri*.