Study of the $B_c \to [(\eta_c \to p\bar{p})\, \mu^+ \nu_\mu]$ decay

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Motivation: Why $B_c \to [(\eta_c \to p\bar{p})\, \mu^+ \nu_\mu]$?

- This decay mode will help to expand the knowledge of the B_c^+ meson, which is a particle with very interesting characteristics, for example, it is the only meson consisting of two heavy quark of different flavors.
- This decay mode can be used to perform a leptonic universality test.

$$\frac{B_c \to \eta_c\, \mu^+ \nu_\mu}{B_c \to \eta_c\, e^+ \nu_e} = ?$$

Analysis strategy

- Use $\eta_c \to p\bar{p}$ for η_c reconstruction.
- For branching fraction measurement
  - Use $B_c \to [(J/\psi \to p\bar{p})\,\mu^+\nu_\mu]$ as normalization channel
    - Same final state, similar kinematic distribution
    - Reconstruct and select together with the signal channel

$$\frac{N_{\eta_c}}{N_{J/\psi}} = \frac{\mathrm{BF}(B_c^+ \to \eta_c\,\mu^+\,\nu_\mu) \times \mathrm{BF}(\eta_c \to p\bar{p}) \times \epsilon(B_c^+ \to \eta_c\,\mu^+\,\nu_\mu)}{\mathrm{BF}(B_c^+ \to J/\psi\,\mu^+\,\nu_\mu) \times \mathrm{BF}(J/\psi \to p\bar{p}) \times \epsilon(B_c^+ \to J/\psi\,\mu^+\,\nu_\mu)}$$

Available in PDG.
Obtained by fitting $m(B_c^+)$ and $m(p\bar{p})$ distribution.
Obtained by MC

Data set and selection

Run 2 pp collision (2016+2017)

	VARIABLE	SELECTION CRITERIA
Trigger		L0_Hadron_TOS Hlt1(Two)TrackMVADecision_TOS Hlt2Topo(2,3,4)BodyDecision_TOS
Proton and anti proton candidates	P_T Track fit χ^2/NDF Track impact parameter χ^2 Probability that the candidate is a proton Probability that the candidate is a pion Probability that the candidate is a kaon	>1300MeV$/c$ <1.6 >9 >0.8 <0.3 <0.3
Charmonium candidates	Fit χ^2 for the secondary vertex Flight distance χ^2	<5 >50
Muon candidates	Track fit χ^2/NDF Probability that the candidate is a muon	<3.0 >0.5
Multiplicity	SPD hits	<500
	We are requiring common secondary vertex for charmonium and muon	<1.5σ

Invariant mass $p\bar{p}$

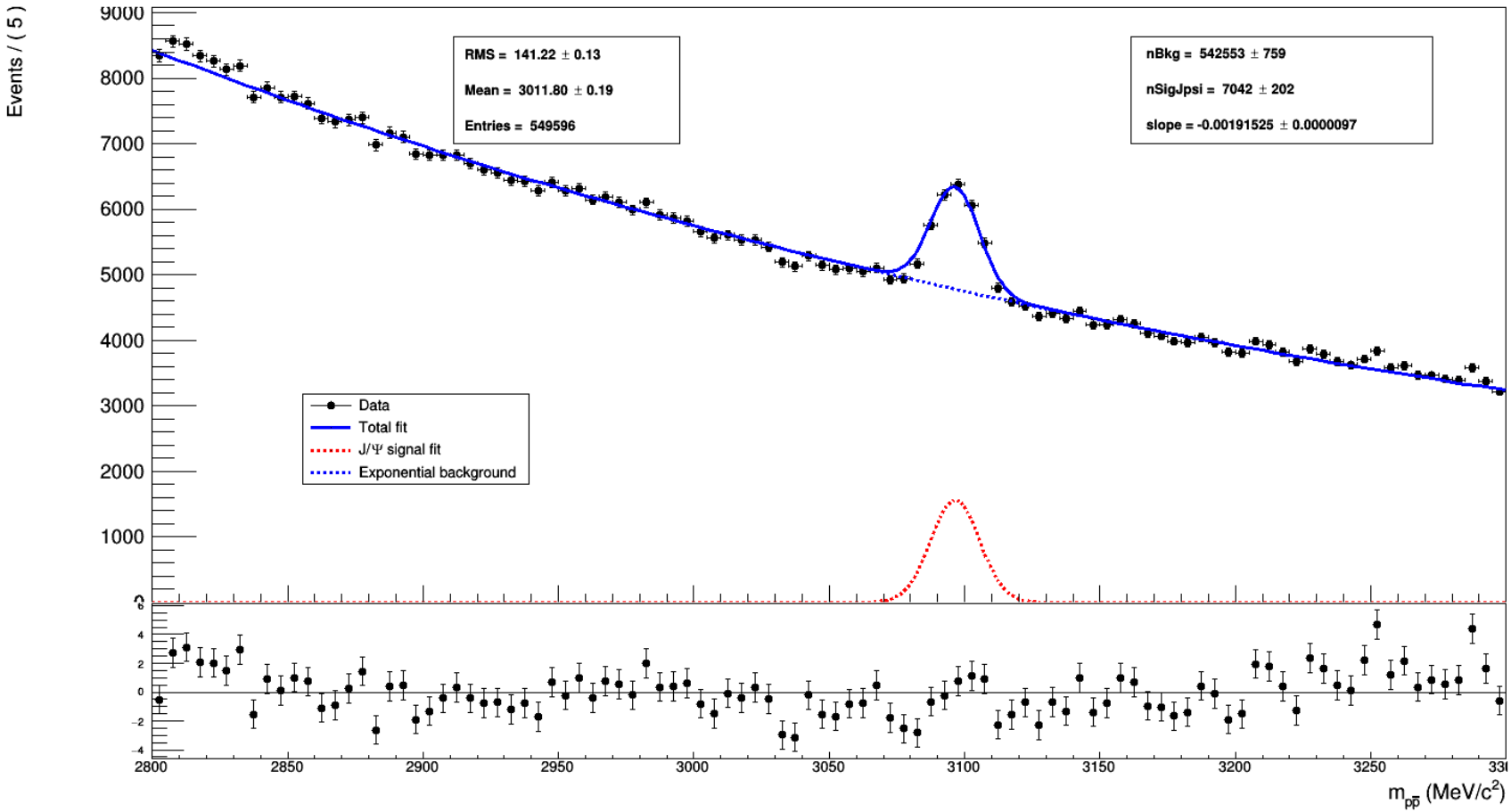


Figure: Histogram of the invariant mass $M(p\bar{p})$ without applying the cuts.

Invariant mass $p\bar{p}$ with cuts (PRELIMINARY)

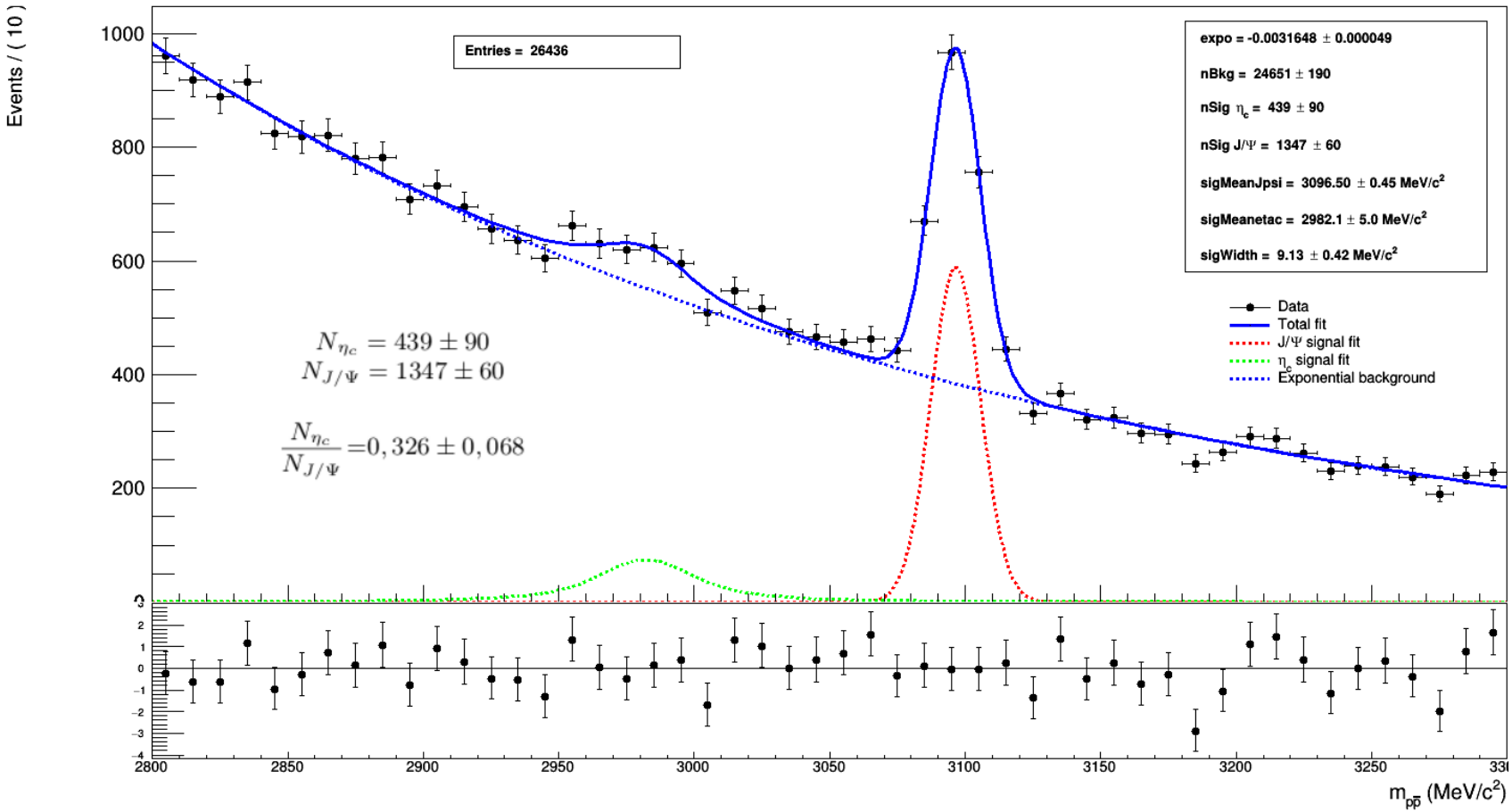
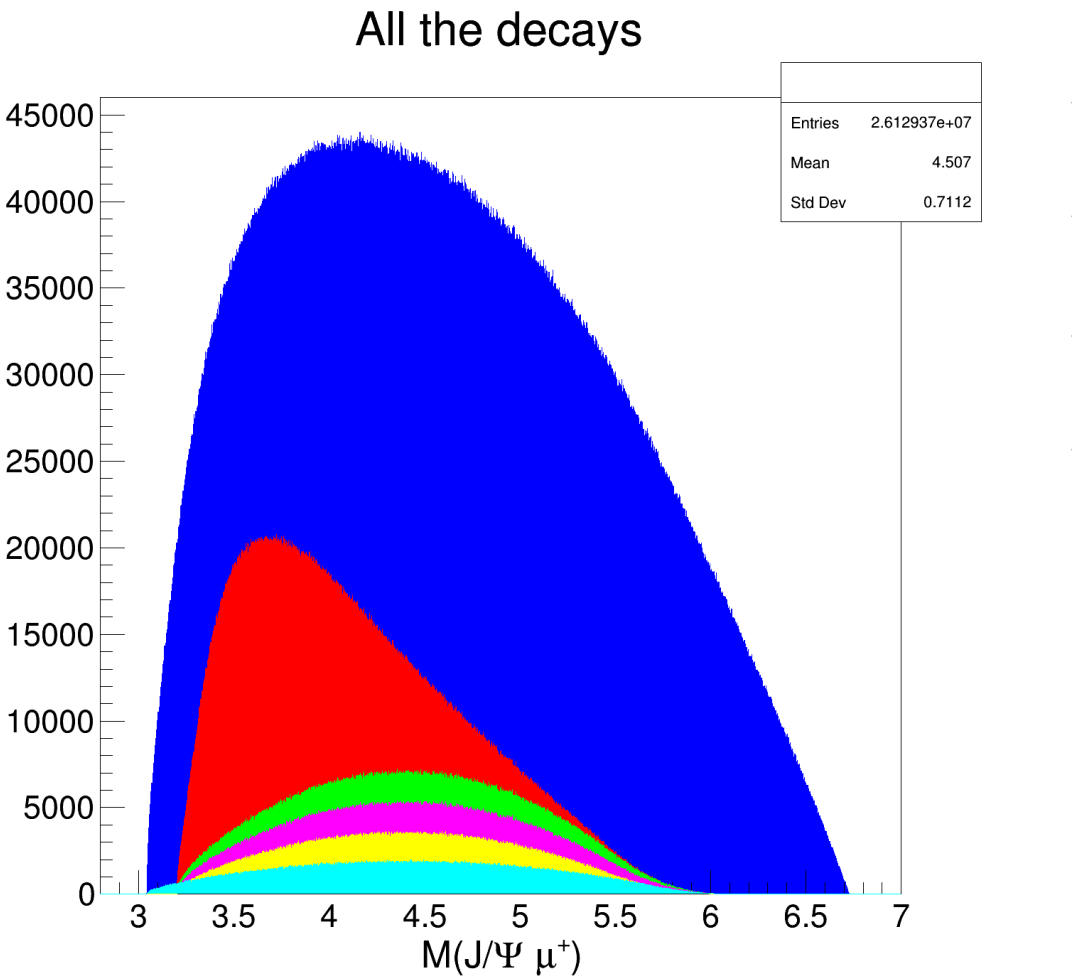


Figure: Histogram of the invariant mass $M(p\bar{p})$ applying the cuts.

Homemade Montecarlo

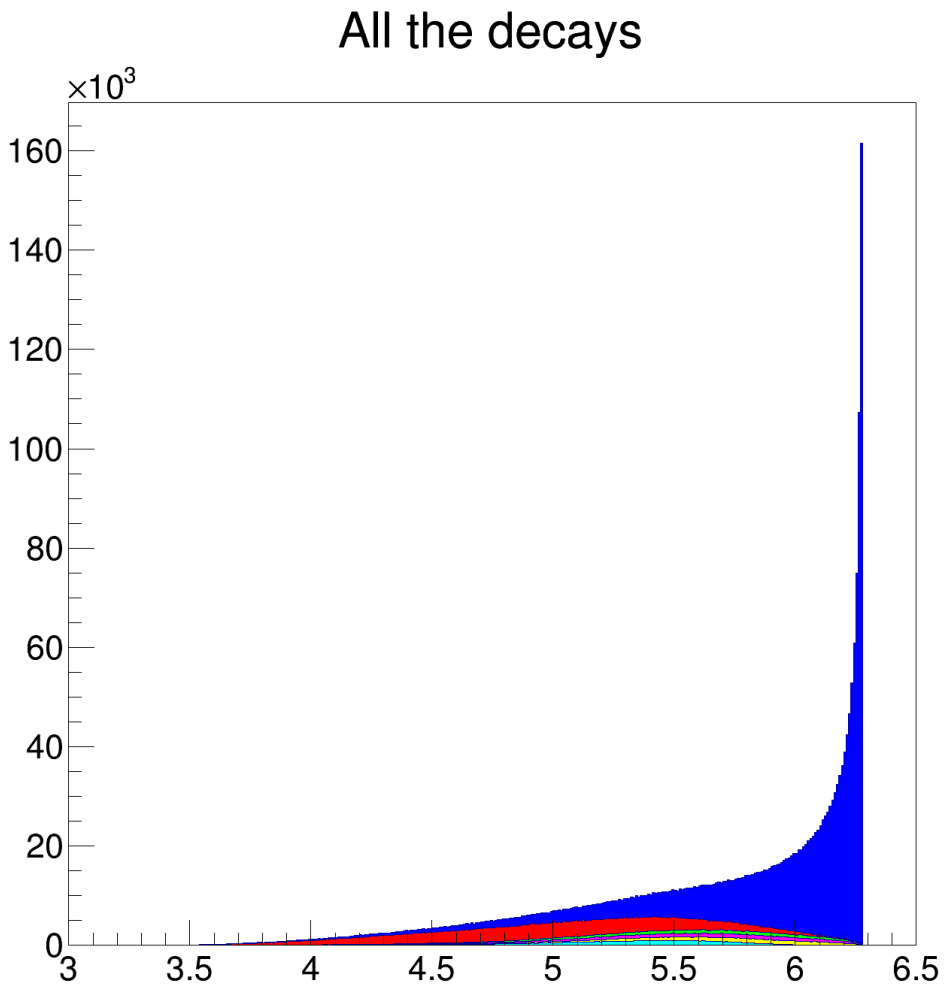
- With the use of pythia, the momenta of the B^+ meson were generated. These momenta were used in first approximation for the B_c^+ meson.
- The decays of B_c mesons were simulated through the use of EvtGen.
- Only events containing protons and muon within the detector's acceptance were allowed, that is between 10mrad and 400mrad.

Homemade Montecarlo: $M(p\bar{p}\mu)$



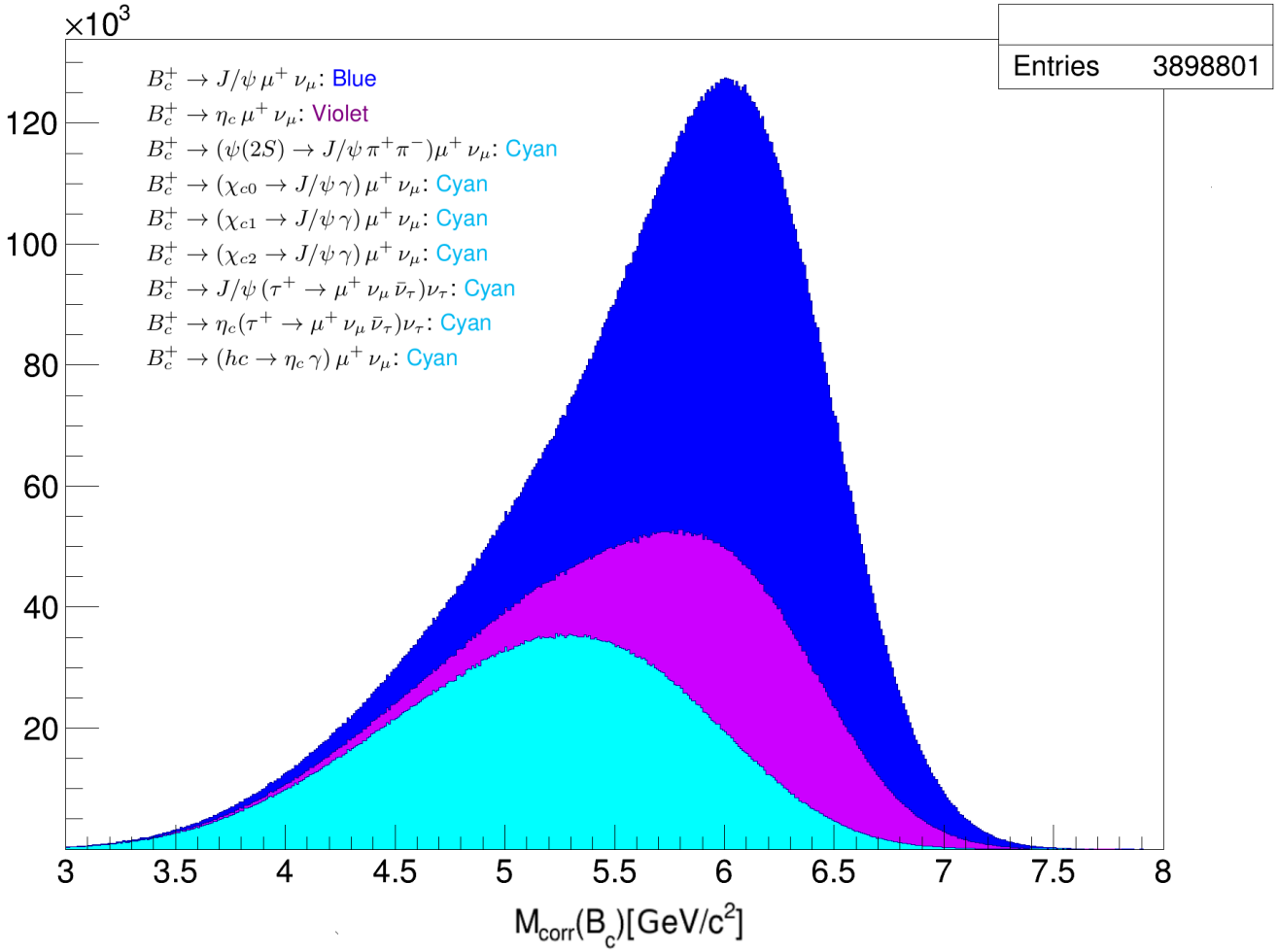
Homemade Montecarlo: B_c corrected mass

The histogram of the corrected mass was constructed using the definition, $M_{corr} = \sqrt{M^2(J/\psi\,\mu) + P_\perp^2} + P_\perp$. $P_\perp$ is the momentum component of $p\bar{p}\,\mu$ transverse to B_c flight direction.

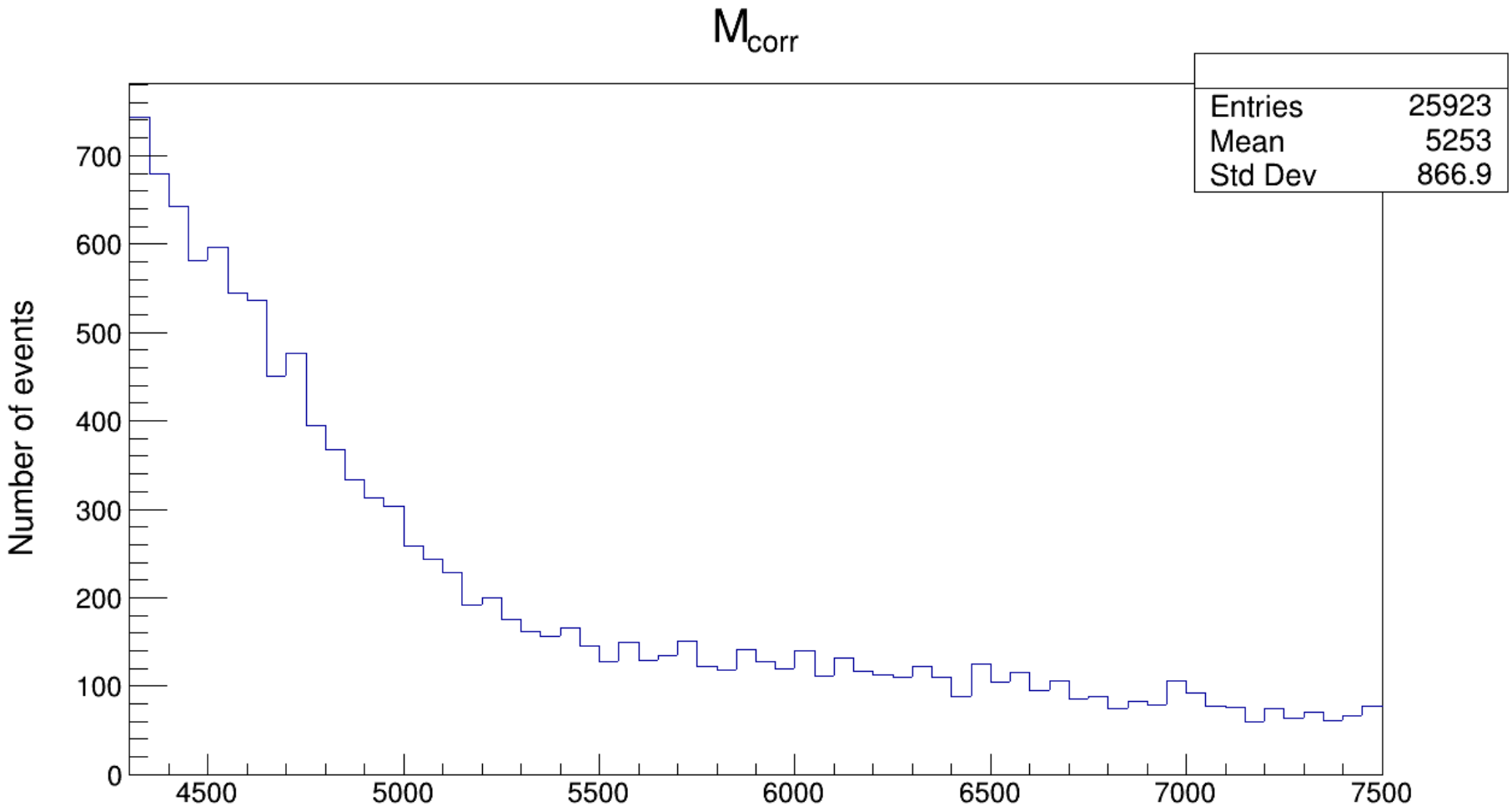


Homemade Montecarlo: B_c corrected mass

A convolution was performed between the histogram obtained in the previous step and a Gaussian function with $\sigma = 372,80 \pm 15,09$MeV (It is the resolution value in the M_{corr} distribution).



B_c corrected mass - $M_{corr} = \sqrt{M^2(J/\psi\,\mu) + P_\perp^2} + P_\perp$ (PRELIMINARY)



Corrected mass between 4200MeV/c^2 and 7500MeV/c^2 (PRELIMINARY)

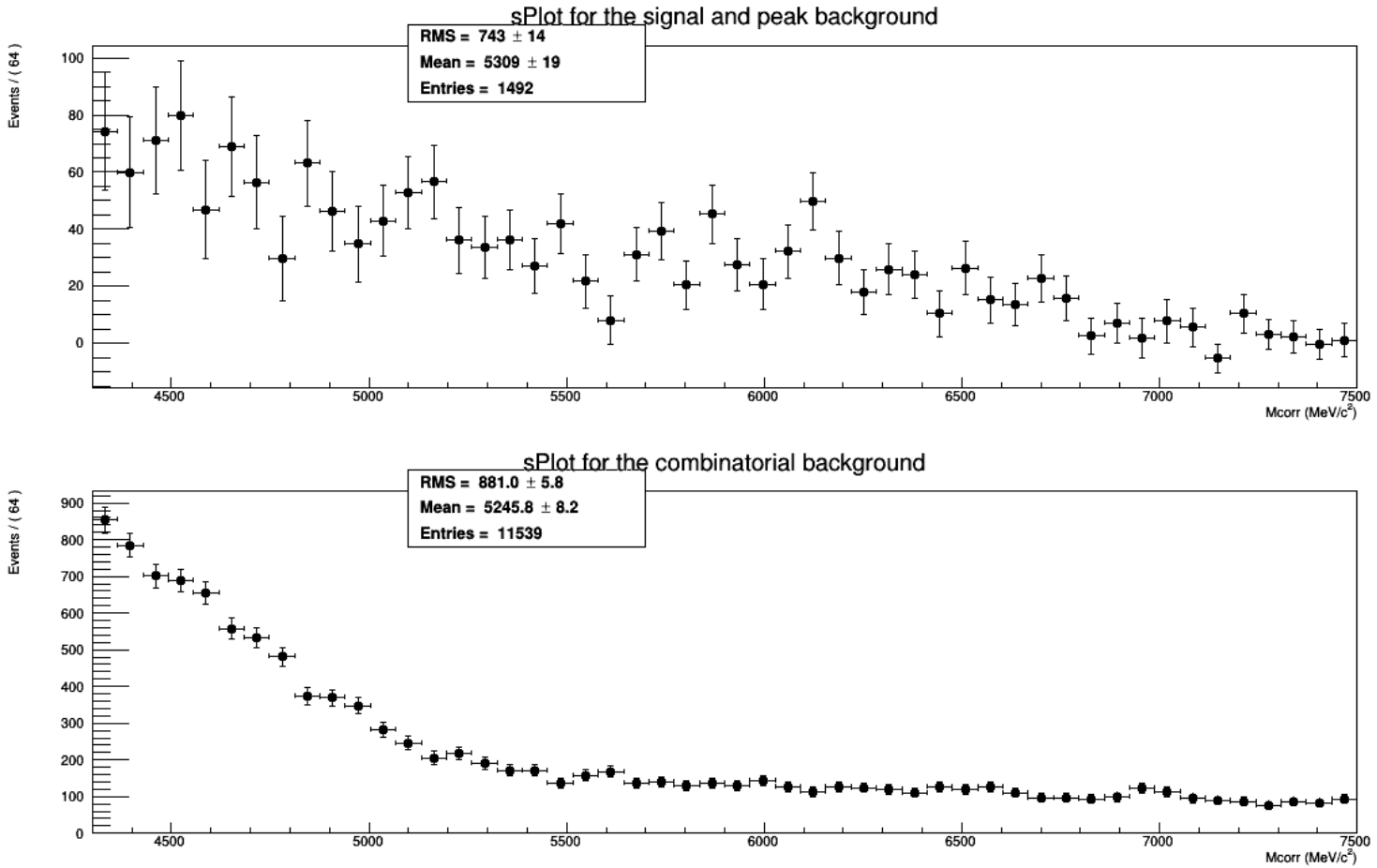


Figure: Histogram of the corrected mass between 4300MeV/c^2 and 7500MeV/c^2

Fit to the corrected mass between 4300MeV/c^2 and 7500MeV/c^2 (PRELIMINARY)

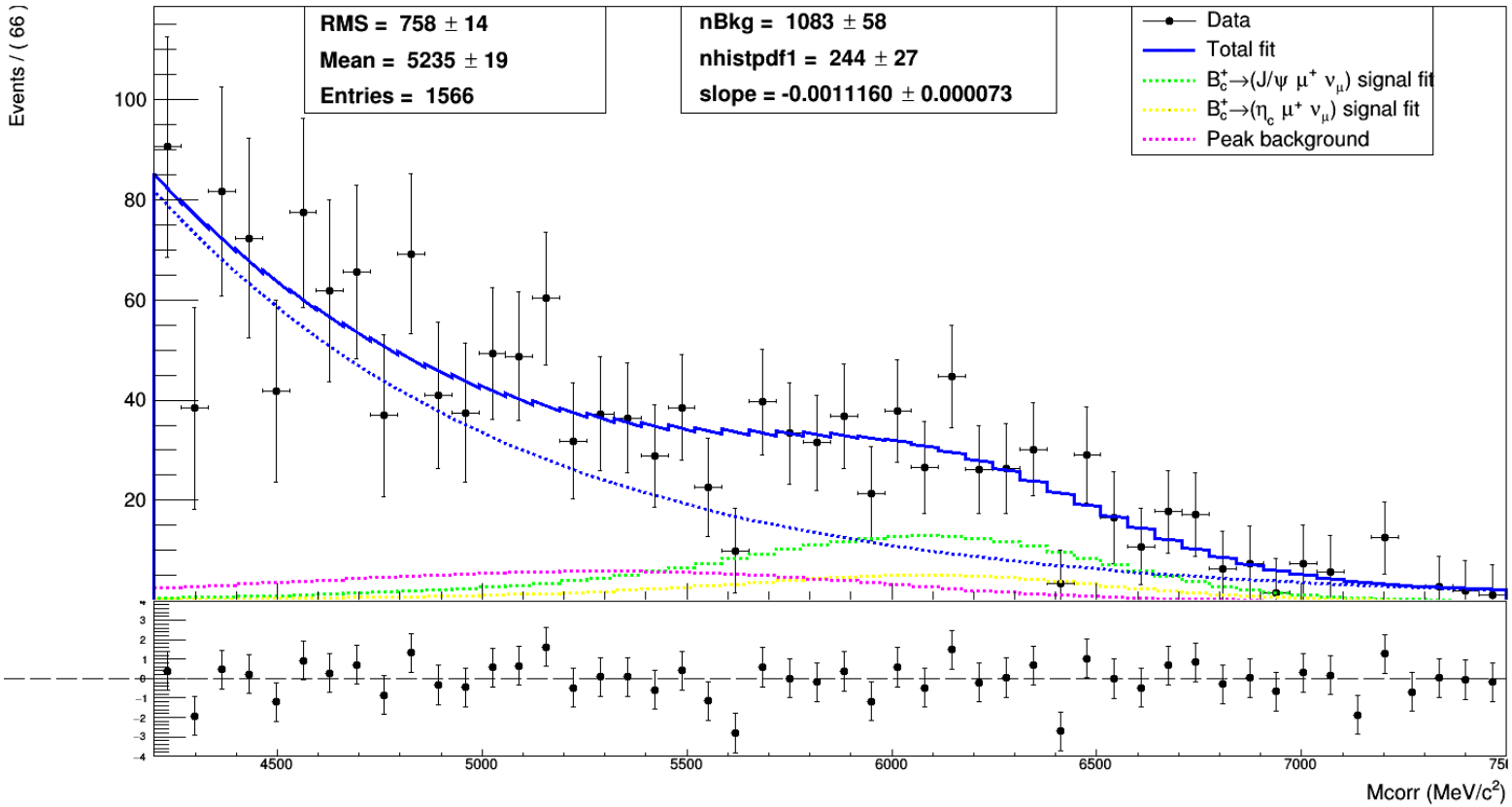


Figure: Histogram and fit to the corrected mass between 4300MeV/c^2 and 7500MeV/c^2 adding a exponential background

Conclusions and future objectives.

- The relationship between η_c signal events and J/ψ signal events is consistent with the theory.
- Better cuts will be made using MVA tools (for example Boosted decision trees) in order to maximize the signal-background ratio.
- When we get the Montecarlo samples, we hope to refine the analysis and calculate the efficiencies.

References I

A. Usachov , V. Zhovkovska, S. Barsuk, J. He: Measurement of η_c production via the decay $\eta_c \to p\bar{p}$ at $\sqrt{s} = 13$TeV.

Carlos Sánchez Mayordomo. Study of the $B_s \to \phi\gamma$ radiative decay at LHCb.

THANK YOU VERY MUCH