Extracting signals from busy LHC heavy-ion collisions

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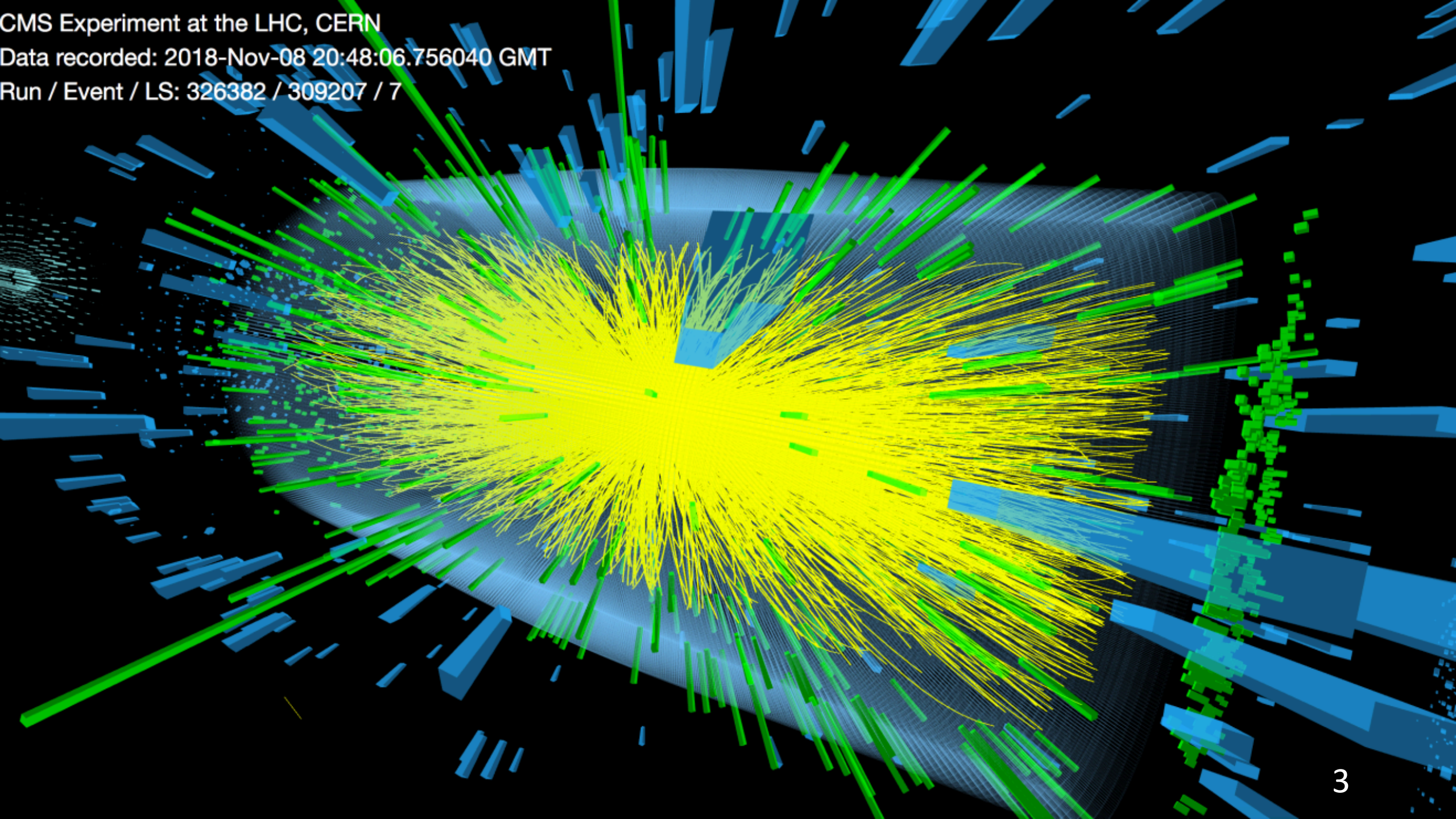
Introduction

- We study B mesons (eg B^+ : $\bar{b}u$)
- Produced in PbPb collisions at the LHC
- Use the large PbPb dataset collected by the CMS experiment in the last LHC run (November 2018)
  - Luminosity: 1.5 nb^{-1}
  - Total centre of mass energy: 5.02 TeV


CMS Experiment at the LHC, CERN
Data recorded: 2018-Nov-08 20:48:06.756040 GMT
Run / Event / LS: 326382 / 309207 / 7

- our signal (B meson) can be spotted in the invariant mass distribution (of the B decay products), reconstructed by CMS

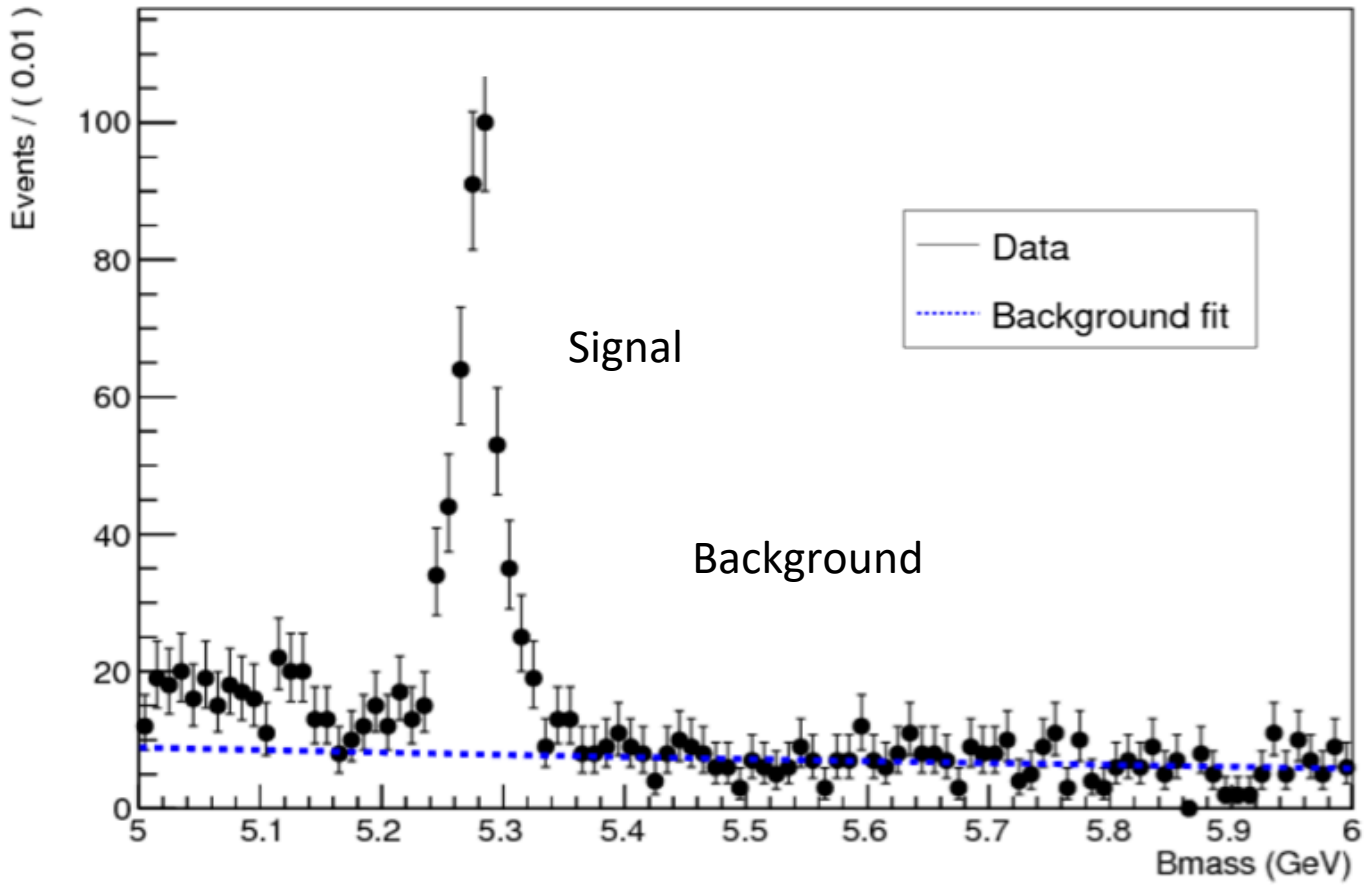


Figure 1: Invariant mass of reconstructed candidates and background fit.

Problem…

- The environment is not “clean”.
- Objective: To obtain the distributions for signal variables
  - *eg. B meson’s transverse momentum, rapidity, etc*
- How?
- We need to remove the background.
- How?
- Methods: Sideband subtraction or Splot.

Sideband Subtraction Method

- The invariant mass of reconstructed candidates is used as a separation variable.
- We assume variables of interest are uncorrelated with invariant mass.
- Two regions in the invariant mass plot:
  - Sideband: There is just background (B)
  - Peak zone: Signal and background (S+B)

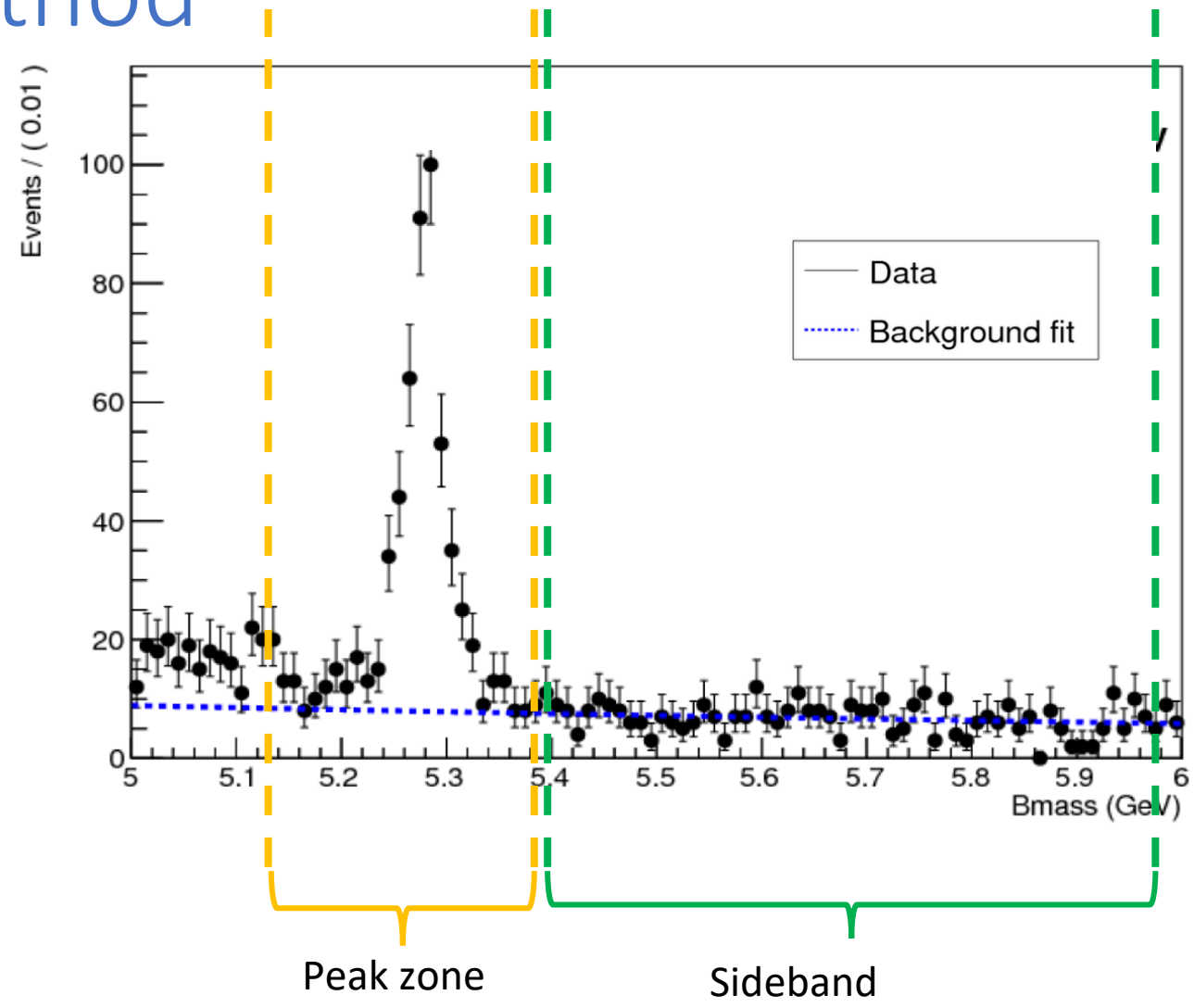


Figure 1: Invariant mass of reconstructed candidates and background fit.

Sideband Subtraction Method

- In order to obtain the signal distribution for variable V
  - we start from the V distribution obtained from the peak region
  - … and subtract the background obtained from the sideband region
  - $V_S = V_{S+B} - \alpha V_B$
- α = ?
- The fitted background distribution is integrated over two regions:
  - ▷P: Integral in the peak region
  - ▷R: Integral in the sideband region

- α = P/R

Sideband Subtraction Results

We will now present the results of the application of the sideband subtraction method in some of the variables we are studying.

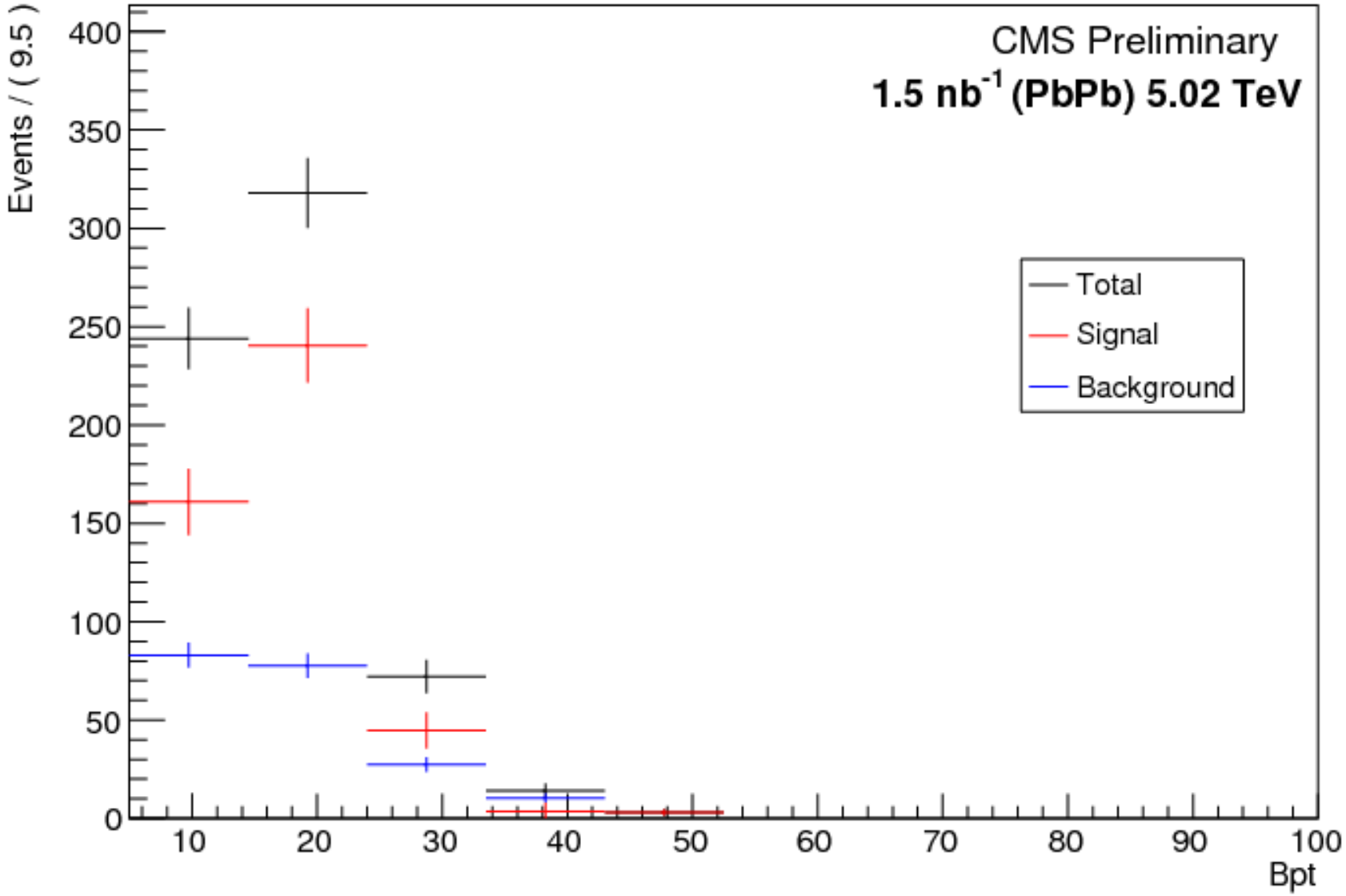


Figure 2: Transverse momentum of the B meson

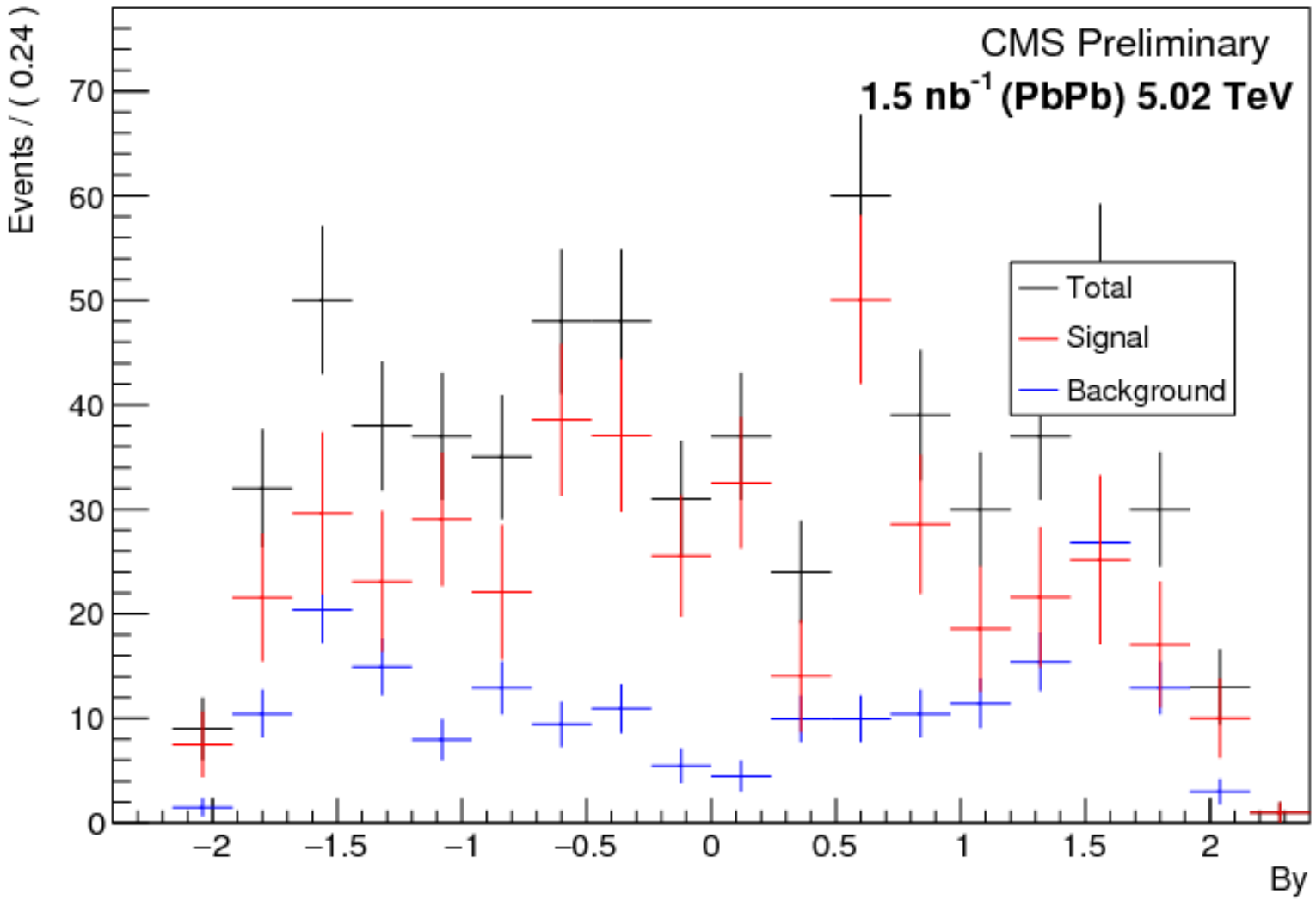


Figure 3: Rapidity of the B meson

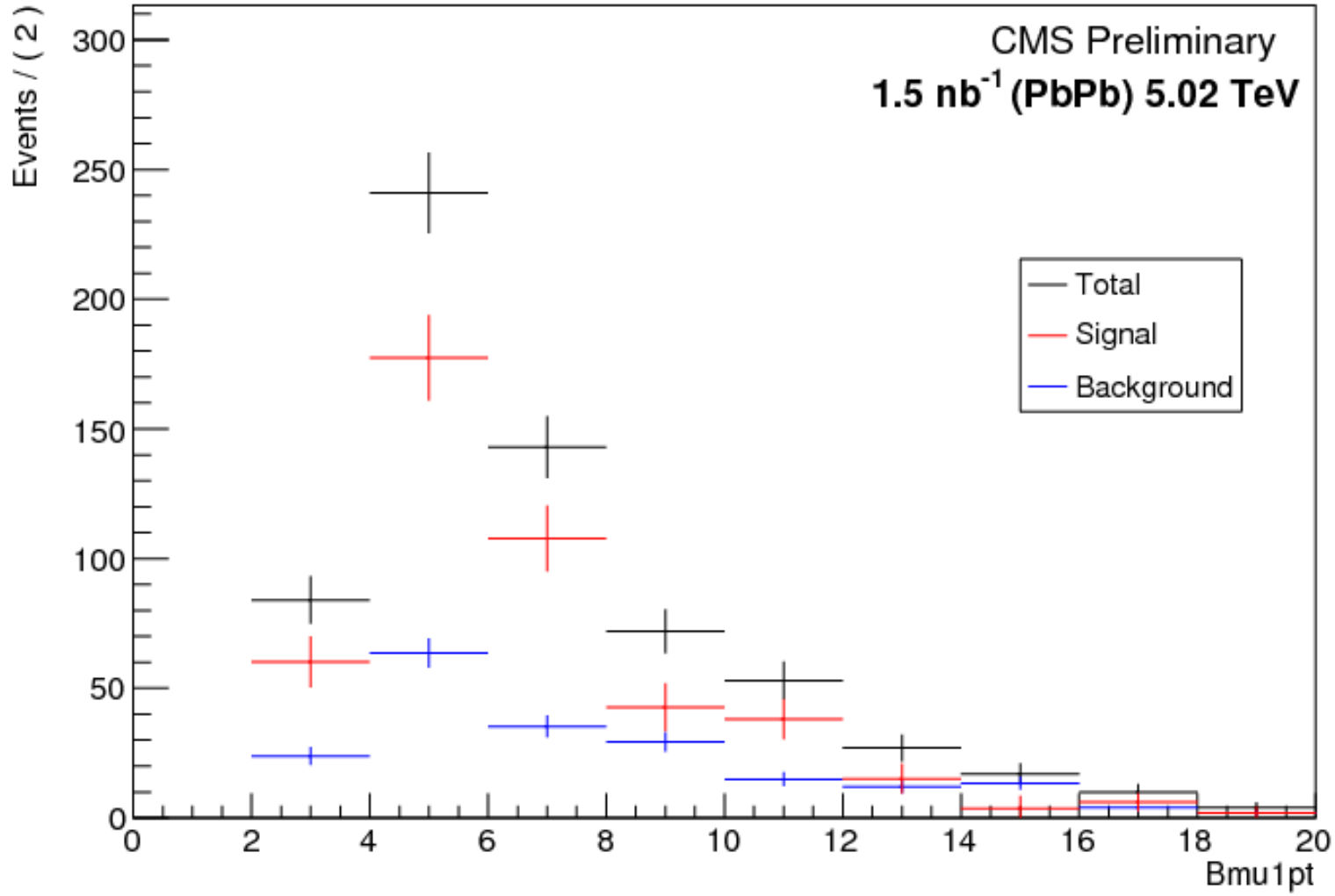


Figure 4: Transverse momentum of the muon (from B decay)

- Great!, we managed to obtain the signal distributions from data
- What good is that?
- Example: verify whether MC simulation of the signal process matches the LHC data — ie to validate the MC

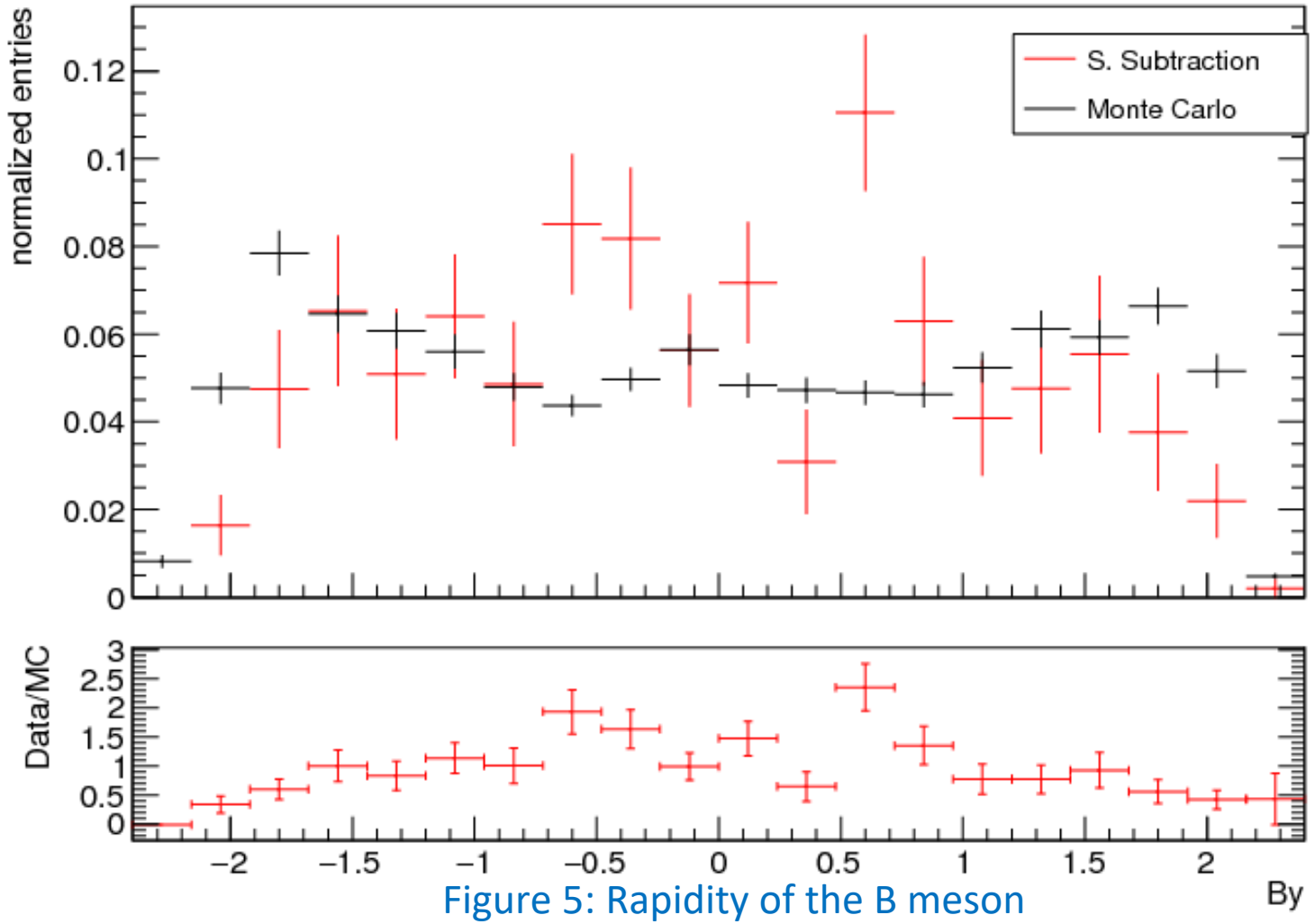


Figure 5: Rapidity of the B meson

Further goals

- Use the RootStats class SPlot to fit the data and compare the result with the one obtained with the sideband method.
  - idea: the event likelihood (from fitting) is used to project the signal component of the dataset

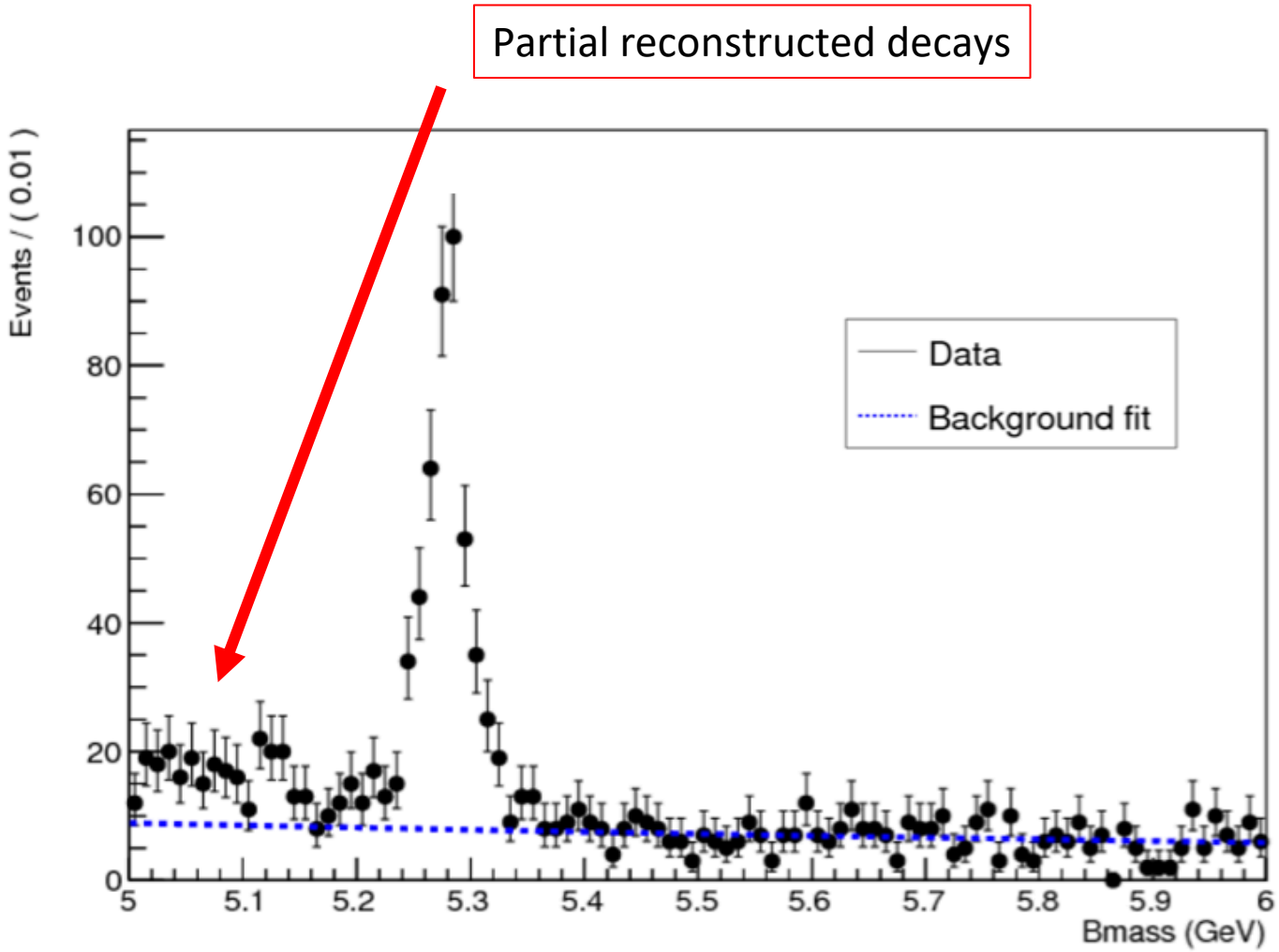
- Apply the above methods to the complete data and MC datasets.
  - and evaluate the induced systematic uncertainty on our B meson production analysis in heavy ions

Questions?

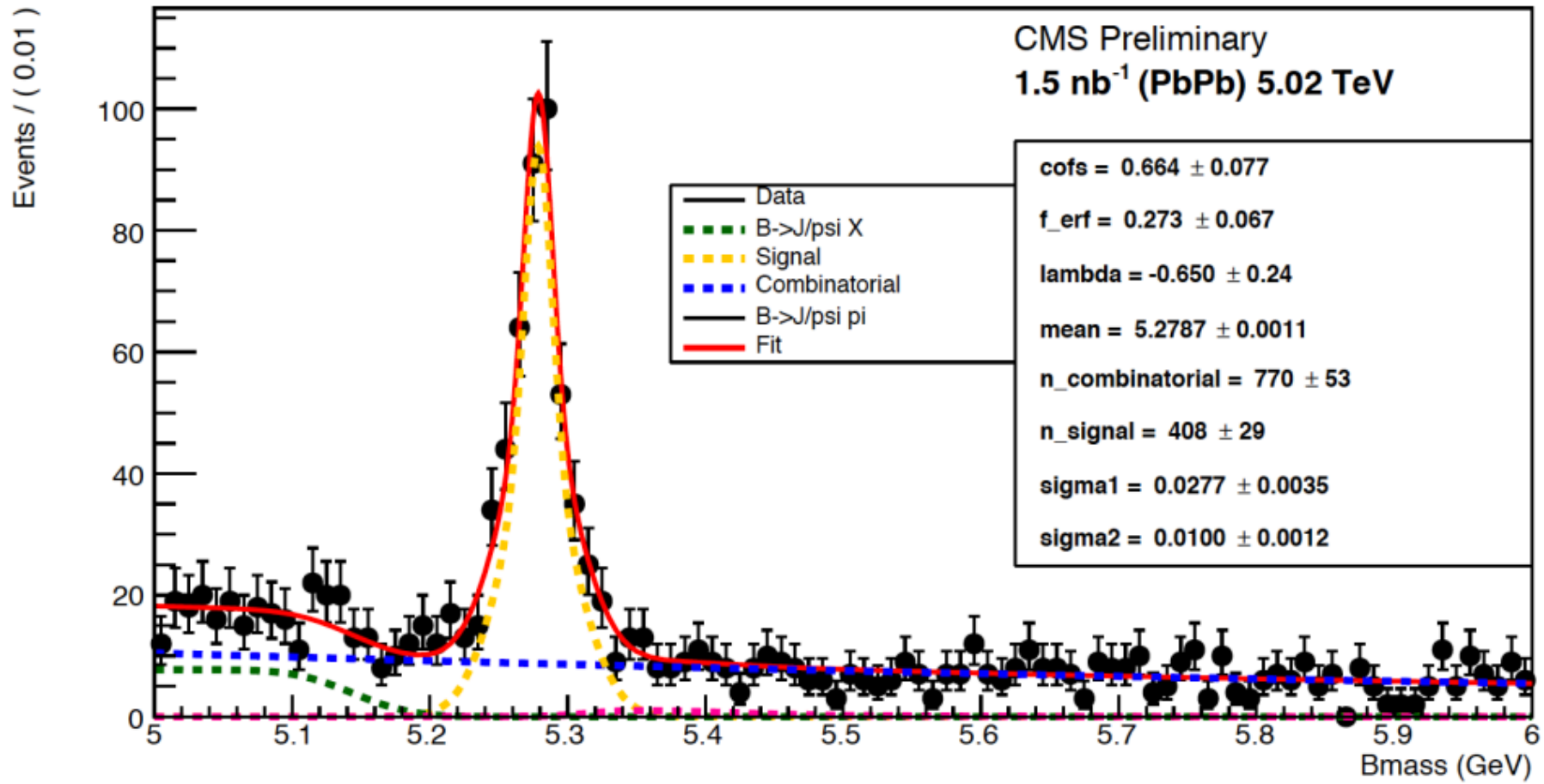
Backup

”Special background”

- $B^+ \rightarrow J/\psi\, K^+$
- $B_S^0 \rightarrow J/\psi\, K^+ K^-$



Fit


CMS Preliminary
1.5 nb^{-1} (PbPb) 5.02 TeV
Data
B->J/psi X
Signal
Combinatorial
B->J/psi pi
Fit
cofs = 0.664 ± 0.077
f_erf = 0.273 ± 0.067
lambda = -0.650 ± 0.24
mean = 5.2787 ± 0.0011
n_combinatorial = 770 ± 53
n_signal = 408 ± 29
sigma1 = 0.0277 ± 0.0035
sigma2 = 0.0100 ± 0.0012
Events / (0.01)
Bmass (GeV)
0
20
40
60
80
100
5
5.1
5.2
5.3
5.4
5.5
5.6
5.7
5.8
5.9
6