Probing Quark Hadronization with B mesons

Ye Jinghao

Prof. Dr. Nuno Leonardo
Prof. Henrique Legoinha

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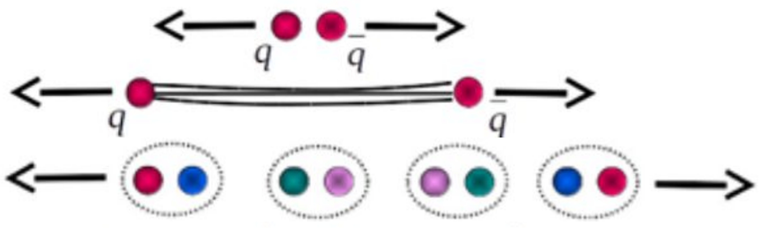
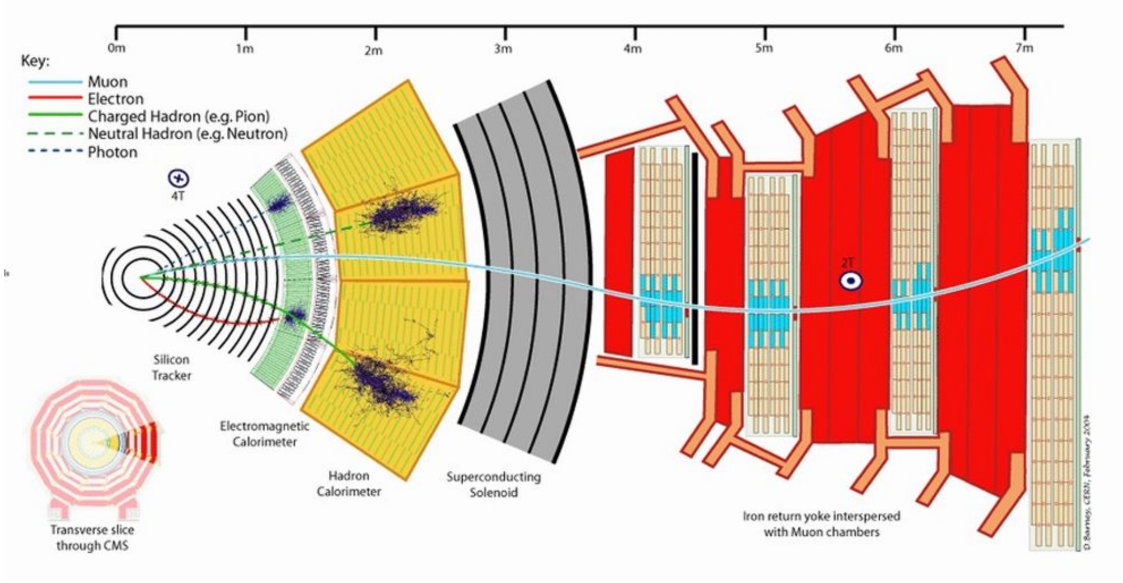
Hadronization

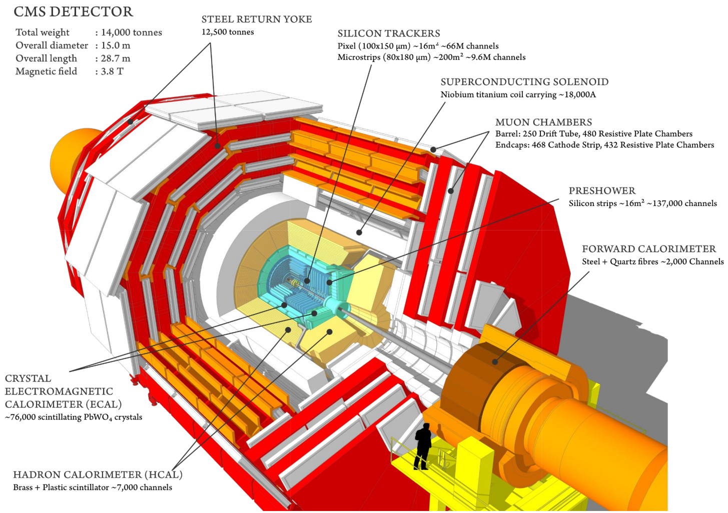
- Hadronization: quarks bound together via the strong force to form hadron.
- Colour confinement: Quarks cannot exit by themselves
- The hadronization mechanism (QCD) is not fully understood



A simple depiction of hadronization process

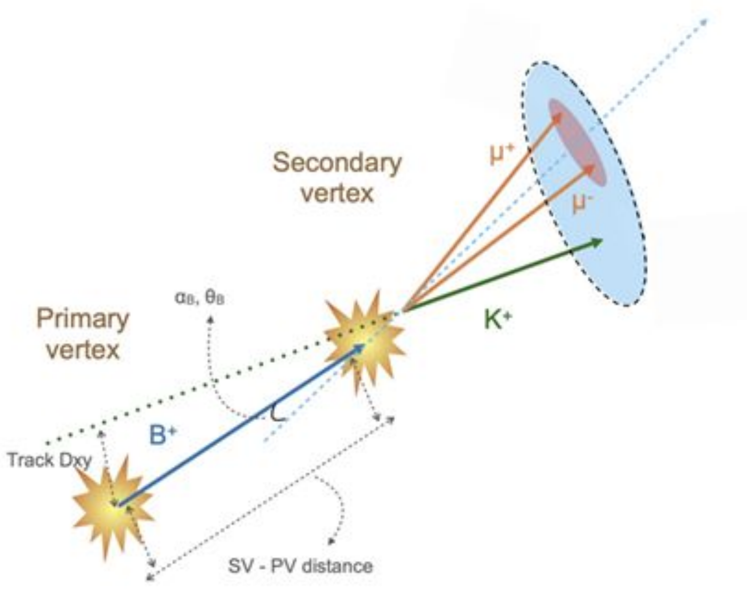
CMS (Compact Muon Solenoid)





- **CMS is a general purpose detector located at the LHC**
- Dataset: pp collisions at 5.02TeV, luminosity=302.3pb-1
- Silicon Tracker (measures charged particles) and Moun Chambers (measures muons) are the main CMS sub-detectors used in this analysis

B mesons as the object of study of Hadronization



Particle	Symbol	Composition	Charge
Charged B meson	B^+	$u\bar{b}$	+1
Neutral B meson	B^0	$d\bar{b}$	0
Strange B meson	B_s^0	$s\bar{b}$	0
Charmed B meson	B_c^+	$c\bar{b}$	+1

$$B^+ \to J/\psi\, K^+ \to \mu^+\mu^- K^+$$

The leading-order Feynman diagram of the Bs (left) and Bs (right)

Differential cross section

$$\frac{d\sigma}{dp_T} = \frac{1}{\epsilon L B}\frac{dN_S}{dp_T}$$

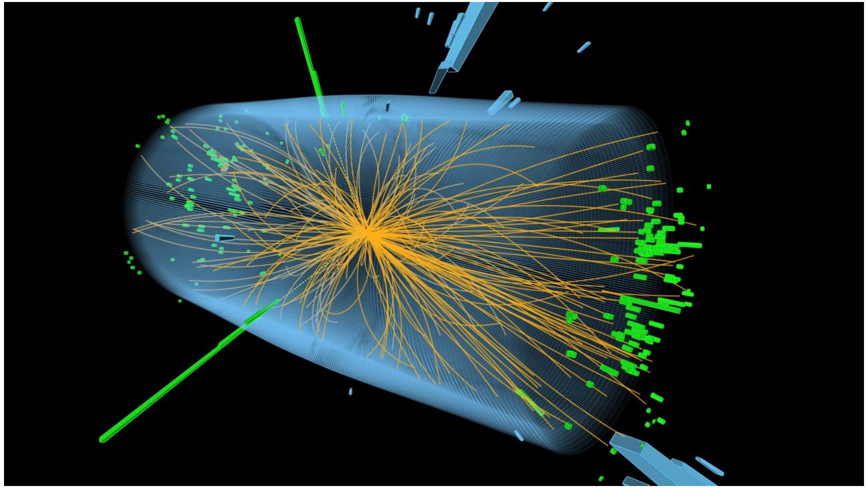
- σ: Cross Section
- B: Branching Fraction of B meson decay (from PDG)
- L: Luminosity (L = 302.3 pb^-1)
- N_s : **Signal Sield** (number of signal events in data)
- **ε**: **Selection Efficiency × Detector Acceptance**

The production of B mesons can be studied employing:

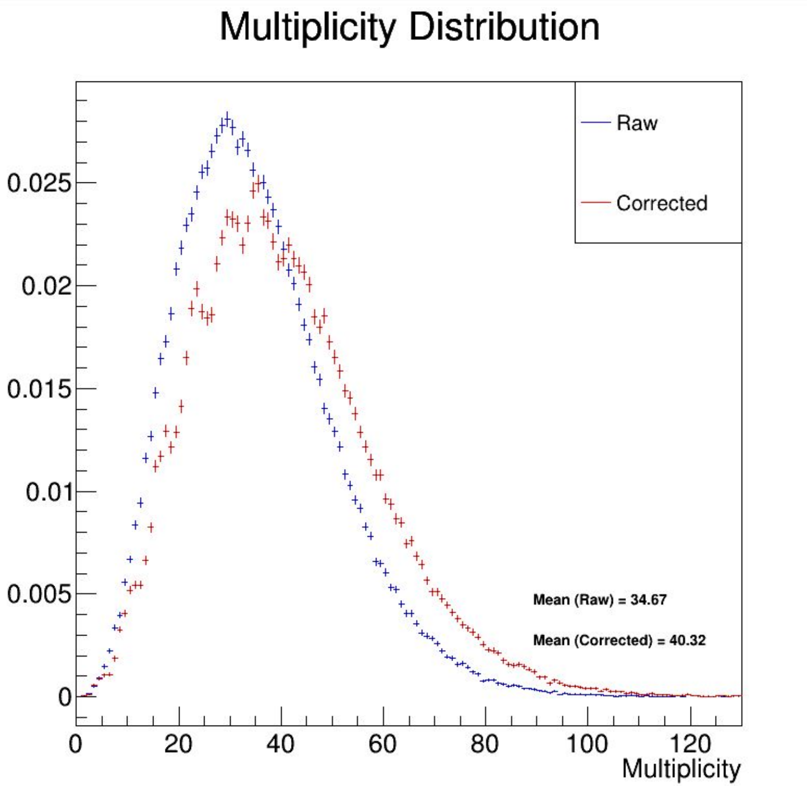
- B kinematic variables:
  - transverse momentum
  - rapidity

- **environment** variables
  - multiplicity

Multiplicity: number of final charged particles in the event.



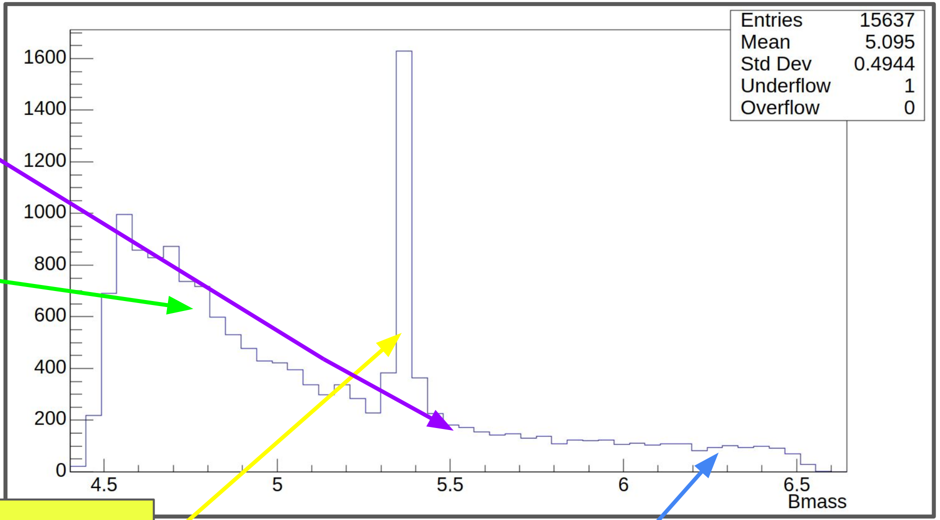
Corrected multiplicity distribution



Visualizing the Data

Cabibbo suppressed background

Partially reconstructed Background



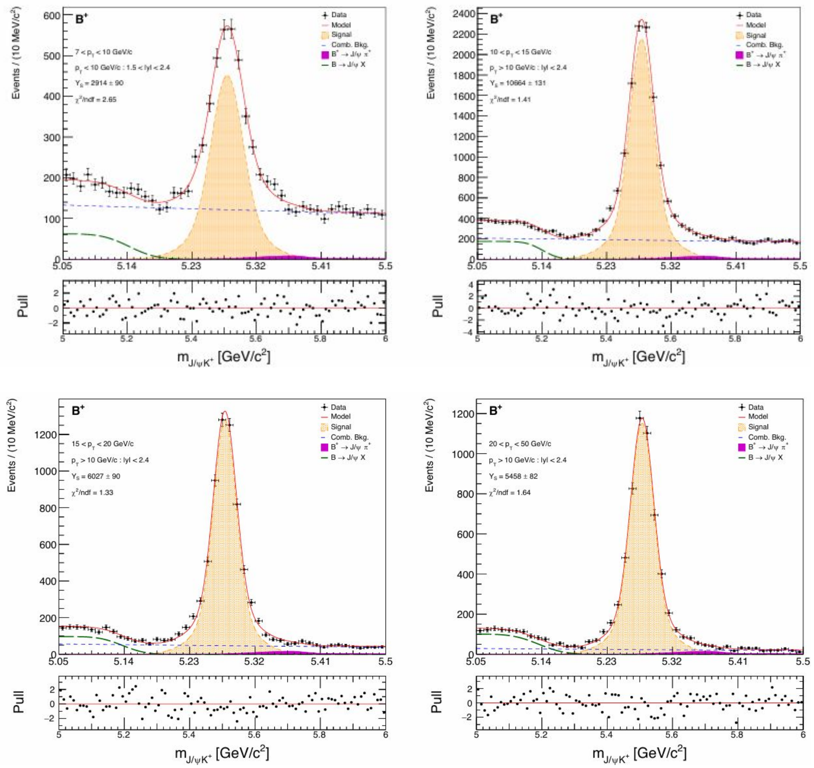
Mass Resonance
=> Signal Peak appearing around the B meson mass

Random combination of tracks
=>Combinatorial background appearing over the whole mass range

Fit to invariant mass distribution in data

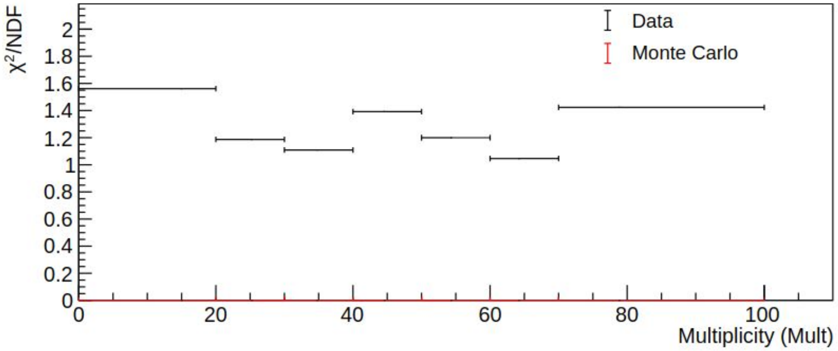
Fit model used:

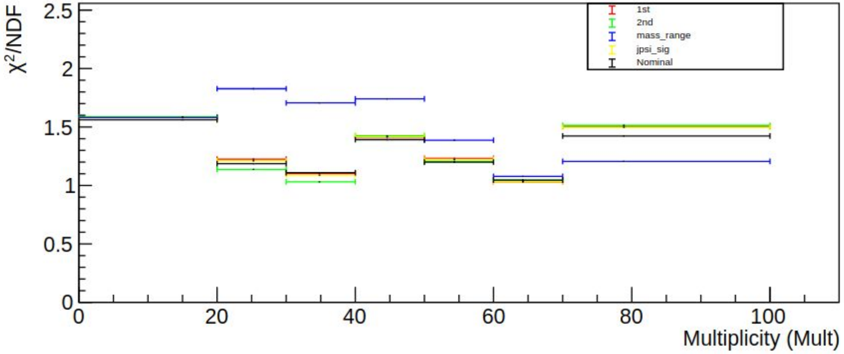
- 2 Gaussian for signal
- Exponencial for background
- Error function for partially reconstructed background
- Assymetric gaussian for Cabibbo suppressed background



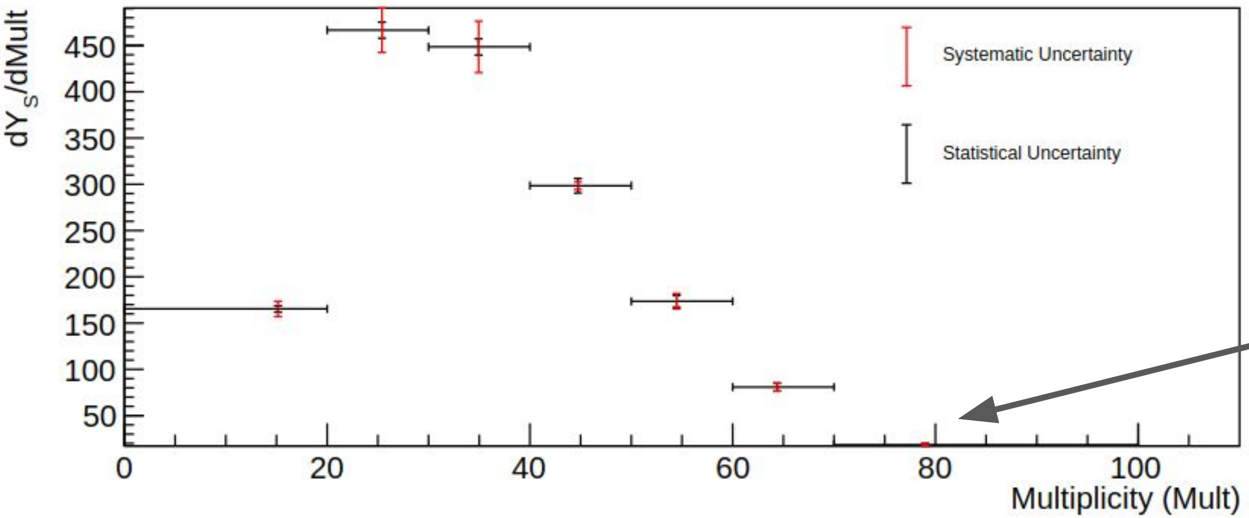
Fit quality

- Chi squared are close to 1 => good fit
- Various models are employed to determine the systematic uncertainty





Diferential signal yield VS Multiplicity



diferential signal yield = 18.599

Total Efficiency

The Detector **Acceptance**,

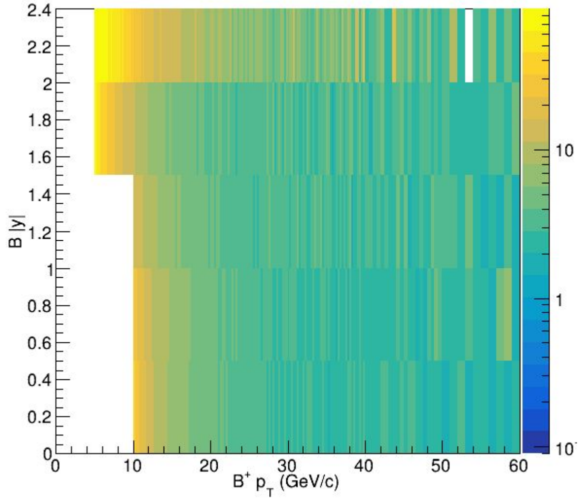
$$\alpha = \frac{N_{pass}}{N_{Gen}}$$

is the **ratio** between the number of **generated events passing** the *muon* and *kaon* **acceptance thresholds** and the total number of generated events

The Selection **Efficiency**,

$$\epsilon = \frac{N_{ANpass}}{N_{pass}}$$

is the **ratio** between the number of **events passing** the analysis **selection criteria** and the number of **generated events passing** the *muon* and *kaon* **acceptance thresholds**



Dependence on rapidity and transverse momentum

$$\varepsilon = \alpha \times \epsilon \rightarrow \boldsymbol{\varepsilon(p_T, y)} = \alpha(p_T, y) \times \epsilon(p_T, y)$$

Summary and next steps

What I have done:

- Extract the B+ meson signal yield vs event multiplicity
- Determine analysis efficiency from Monte Carlo simulation

Next step:

- Combine those to calculate the differential cross section