



MEASURING THE PROTON DETECTION ASYMMETRY AT LHCb

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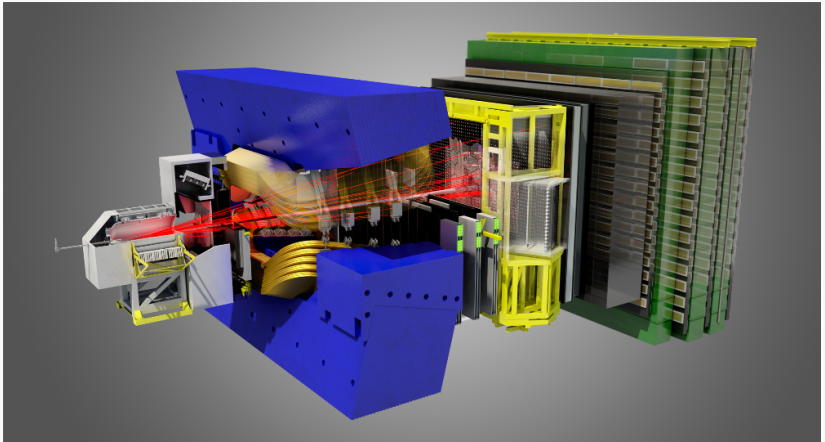
CERN Summer Student Sessions

August 13, 2015

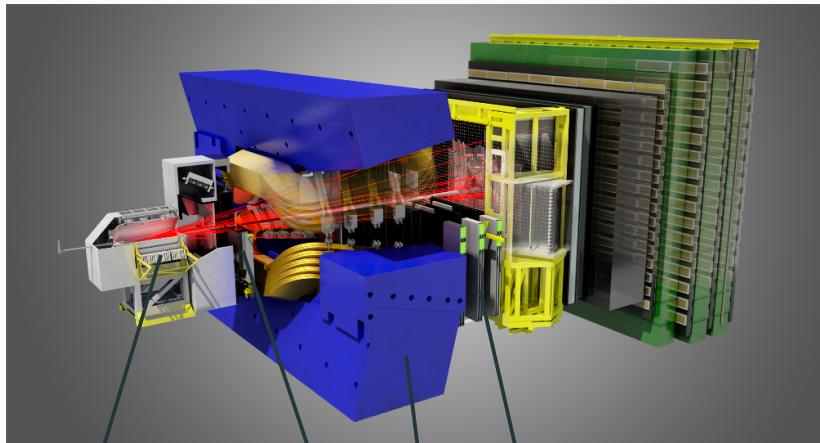
Vrije Universiteit Brussel/CERN

LHCb & CP VIOLATION

THE LHCb DETECTOR



THE LHCb DETECTOR



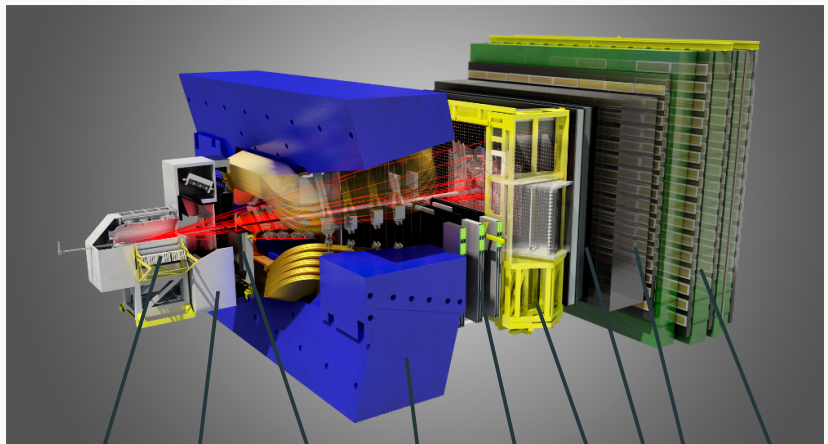
Vertex Locator

Trigger Tracker

Magnet

T-Stations

THE LHCb DETECTOR



Vertex Locator

RICH1

Trigger Tracker

Magnet

T-Stations

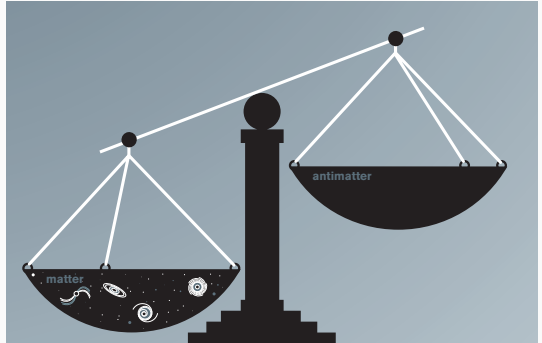
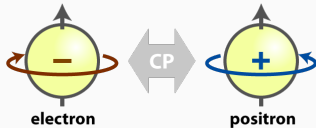
RICH2

ECAL

HCAL

Muon
Stations

CP VIOLATION



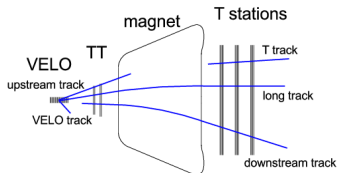
CP symmetry must be violated to explain our Universe

→ Nature treats matter and antimatter differently

PROTON DETECTION ASYMMETRY

ASYMMETRIES

- **Physics** asymmetry
- **Production** asymmetry
- **Detection/Tracking** asymmetry



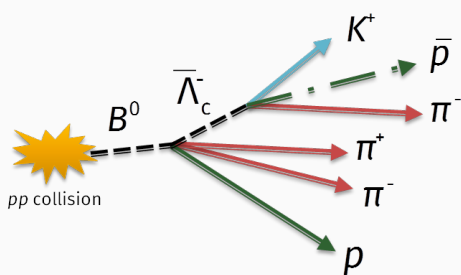
- Tracking efficiency: $\varepsilon(h\pm) = N_{Reconstructed}/N_{Reconstructible}$
- Instrumental asymmetry due to interactions with detector:

$$A_{det} = \frac{\varepsilon(h+) - \varepsilon(h-)}{\varepsilon(h+) + \varepsilon(h-)}$$

- Depends on
 - Particle type and kinematics (alters σ for material interaction)
 - Particle path (non-uniform detector geometry)
 - Data-taking conditions (\sqrt{s} , magnet polarity)

TAG-AND-PROBE METHOD

How to determine **tracking efficiencies** from real data?



Fully hadronic decay, no ν

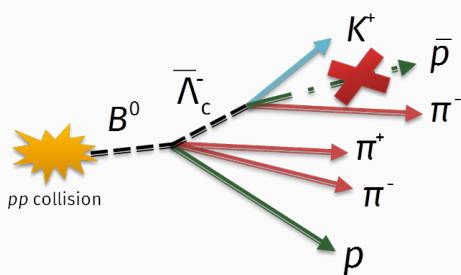
Tag Reconstructed p
with high p_T

Probe 'Missed' \bar{p}

Goal Find true number of
signal events before
track reconstruction

TAG-AND-PROBE METHOD

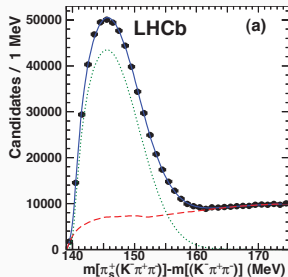
How to determine **tracking efficiencies** from real data?



Fully hadronic decay, no ν

- \bar{p} momentum reconstruction in kinematic fit
- B^0 mass distribution: signal peak \leftrightarrow combinatorial background
- Tracking efficiency $\varepsilon = N_{full\ reco}^{signal} / N_{partial\ reco}^{signal}$

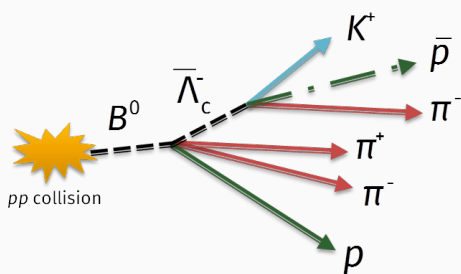
- Tag Reconstructed p with high p_T
- Probe 'Missed' \bar{p}
- Goal Find true number of **signal events** before track reconstruction



arXiv: 1205.0897v2

TAG-AND-PROBE METHOD

How to determine **tracking efficiencies** from real data?



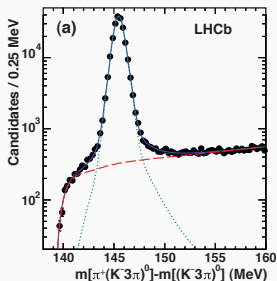
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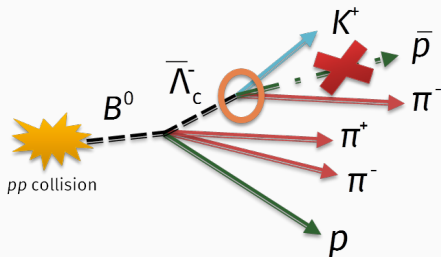
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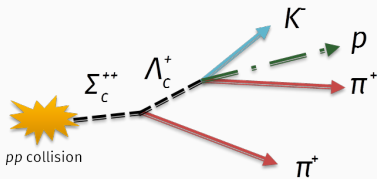
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CHALLENGES

- High-multiplicity decay
 - Reconstruction of 5-6 stable charged tracks
- $\bar{\Lambda}_c^-$ vertex uncertainty
 - Limits resolution on reconstructed momentum

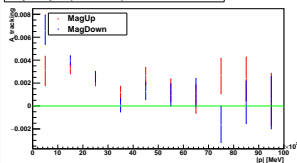


OUTLOOK



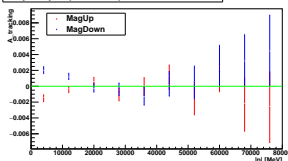
- Σ_c^{++} decay with final-state p, K, π
 - Analysis of **Monte Carlo data**
 - Efficiencies and asymmetries in $|\vec{p}|, p_T, \eta$ bins
 - Reasonable results: detector material only contains u, d
 - Low trigger efficiencies when 'missing' p or \bar{p}
- B meson study on **Run I data**

Asymmetry comparison in L_c, p momentum bins for 2012



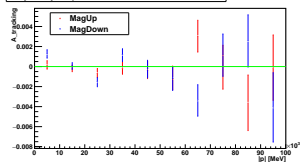
p

Asymmetry comparison in L_c, π momentum bins for 2012



π

Asymmetry comparison in L_c, K momentum bins for 2012



K

QUESTIONS?

Slide 3 **Material for Presentations**, LHCb Speakers' Bureau

Slide 4 Sandbox Studio/Symmetry Magazine

Slide 6 **Measurement of the track reconstruction efficiency at LHCb**, LHCb Collaboration, arXiv:1408.1251 [hep-ex]

Slide 7 **Measurement of the production asymmetry in 7 TeV $D_s^+ - D_s^-$ pp collisions**, LHCb Collaboration, arXiv:1205.0897v2 [hep-ex]