Central Exclusive Production studies at LHCb [1]

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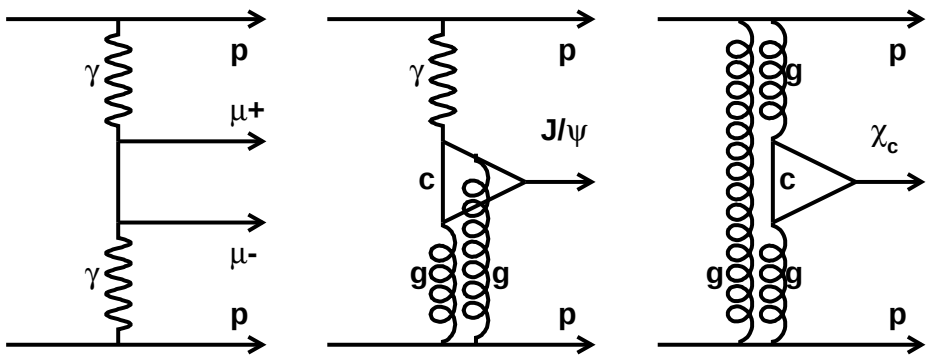
[1] For details about the 2010 analysis, please see CERN-LHCb-CONF-2011-022

Introduction

- *Central exclusive production (CEP)*: Proton collisions where...
  - Protons remain intact after the interaction
  - A simple “central” system is produced
- All final state particles except the protons can be measured (“exclusive production”)

CEP processes:

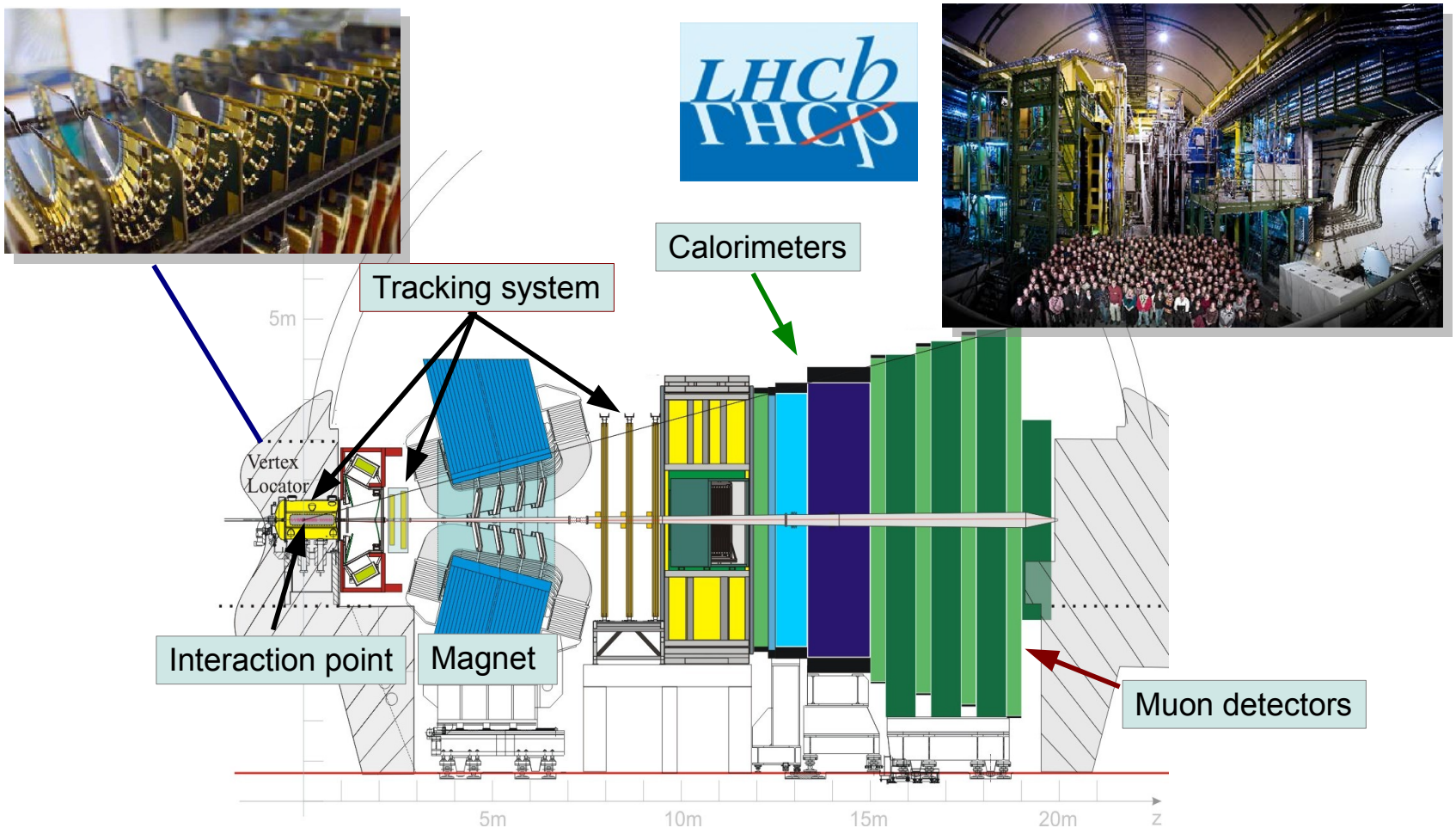


- (A) Non-resonant dimuon production
- (B) Vector meson (J/ψ, $\psi(2S)$) production (“photoproduction”)
- (C) χ_c production (Double Pomeron Exchange)

Motivation

- (A) Non-resonant dimuon production
  Theory is well known, we can reproduce this result
- (B) Vector meson (J/ψ, $\psi(2S)$) production ("photoproduction")
  Measured at HERA with photon instead of one proton. Can probe generalised PDFs.
- (C) χ_c production (Double Pomeron Exchange)
  Measured by CDF, but relative proportion of different χ_c states is not known. Analogous to exclusive Higgs production, and probes PDFs, pomeron physics.

The LHCb Experiment



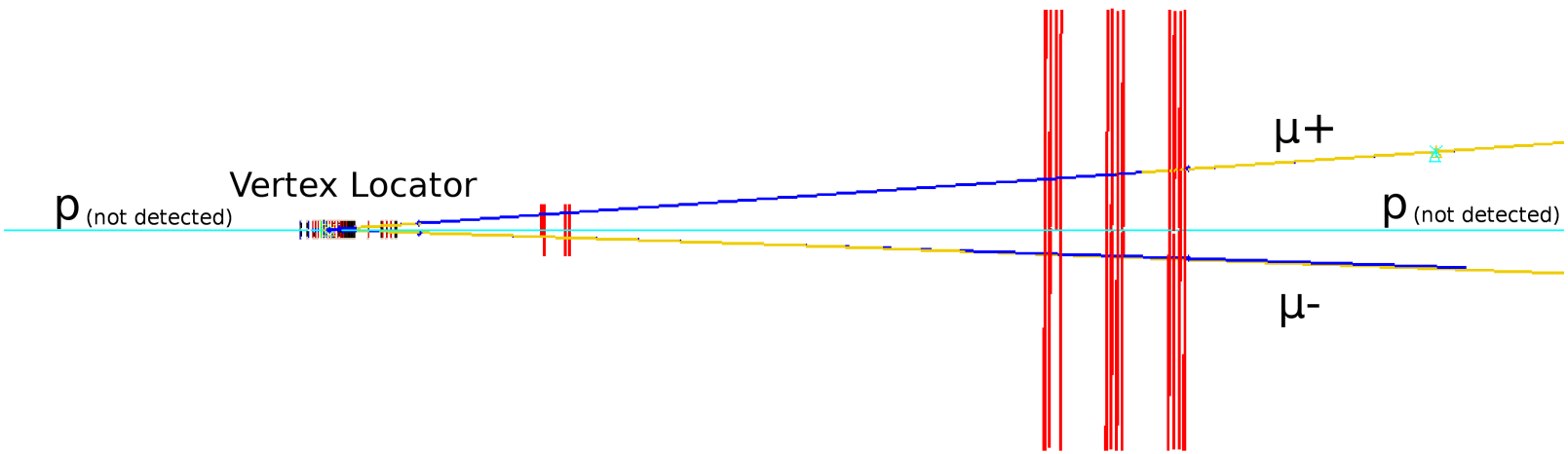
Reconstructed objects in this analysis:

1. TRACK: Sequence of hits through one or more tracking detectors. LHCb can track and trigger on particles with $p_T \sim 200\,\mathrm{MeV}$
2. MUON: Track + hits in the muon chambers
3. PHOTON: Deposit in calorimeter consistent with photon, with no track

Analysis overview

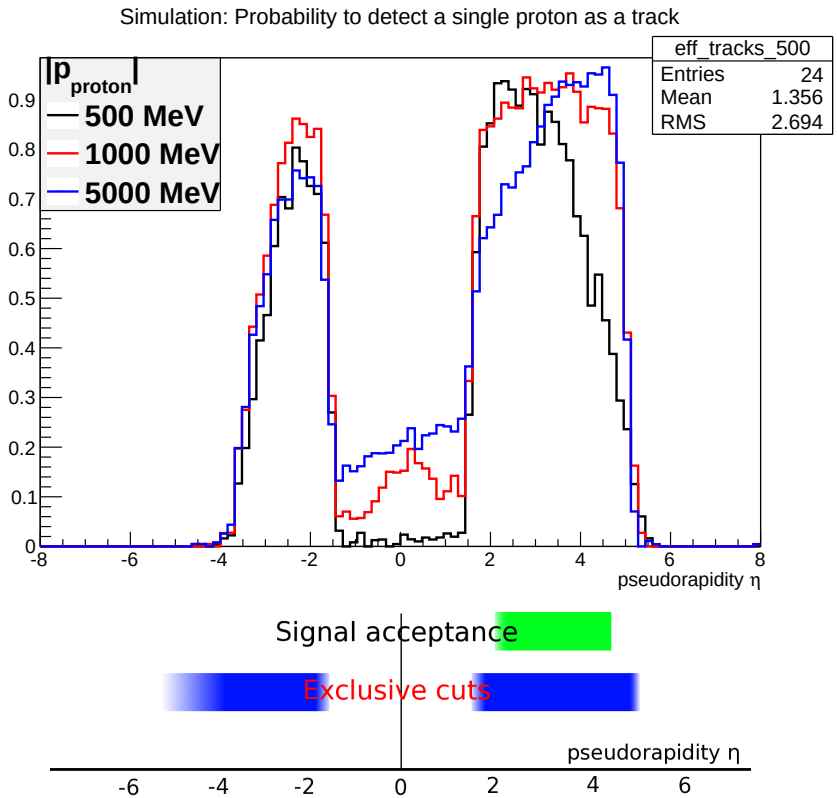
We look for events with two muon tracks

- Select Central Exclusive Production (CEP) event by requiring
  - No activity except for the signal process!
  - ... that is, exactly two tracks in the detector
- Because we see no other particles, the events are candidates for CEP
- There may be additional particles produced outside of LHCb, and this background has to be estimated



Tracking acceptance

- Main LHCb pseudorapidity range is $1.9 < \eta < 4.9$
  1. We use muons with $p_T > 650\,\mathrm{MeV}$, photons with $E_T > 200\,\mathrm{MeV}$
- Can detect additional tracks in a larger range (events with additional tracks are rejected as CEP candidates)

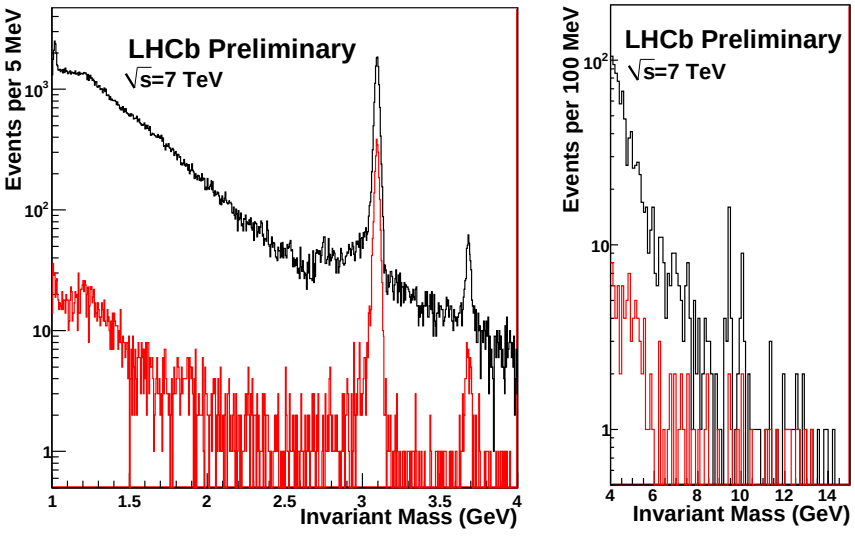


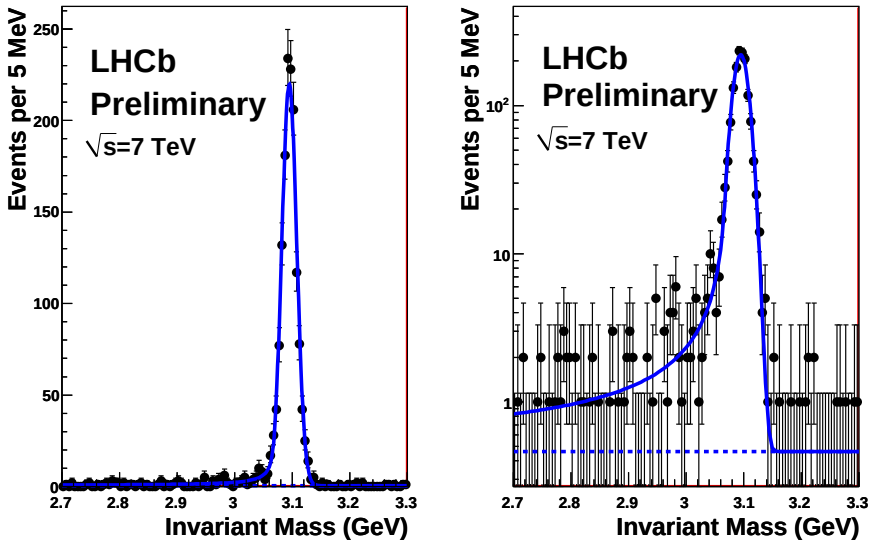
- The main background is from the same final state as the signal (J/ψ, etc), but produced in a different way

2010 Signal processes

Dimuon mass spectrum overview

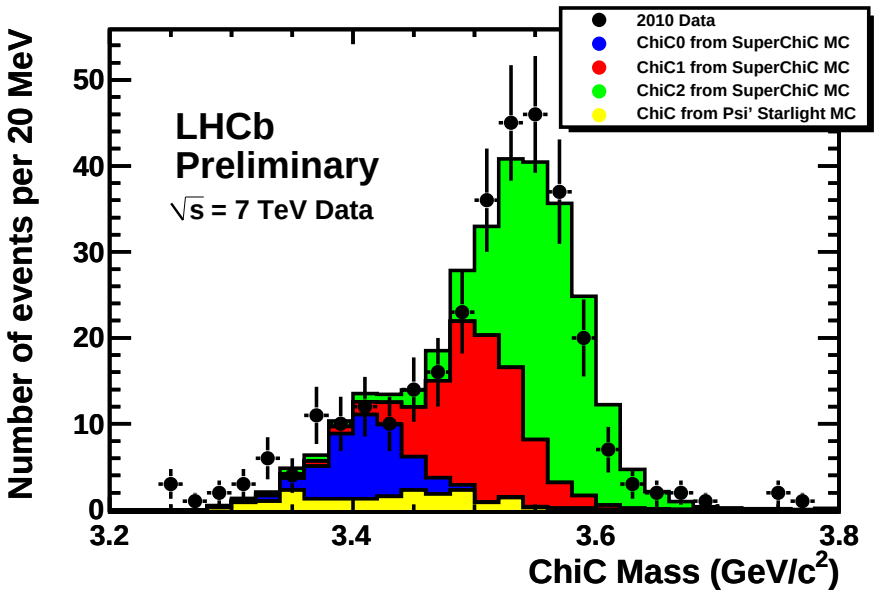
J/ψ



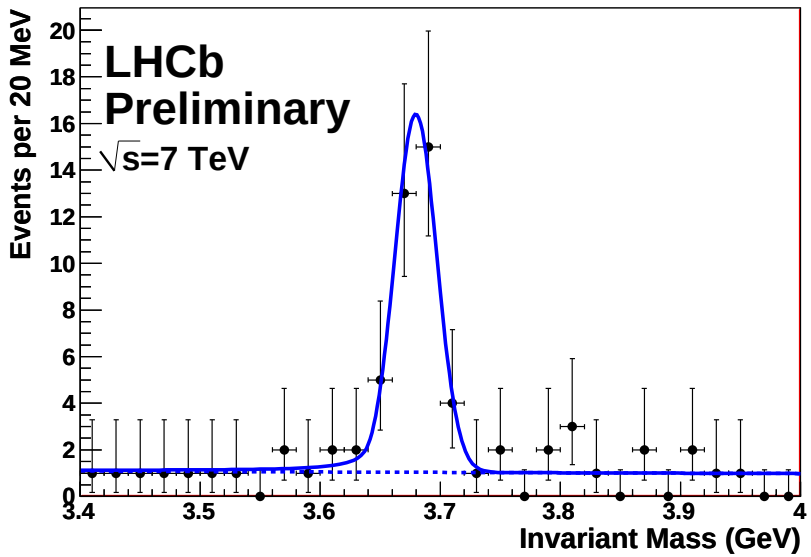


2010 Signal processes

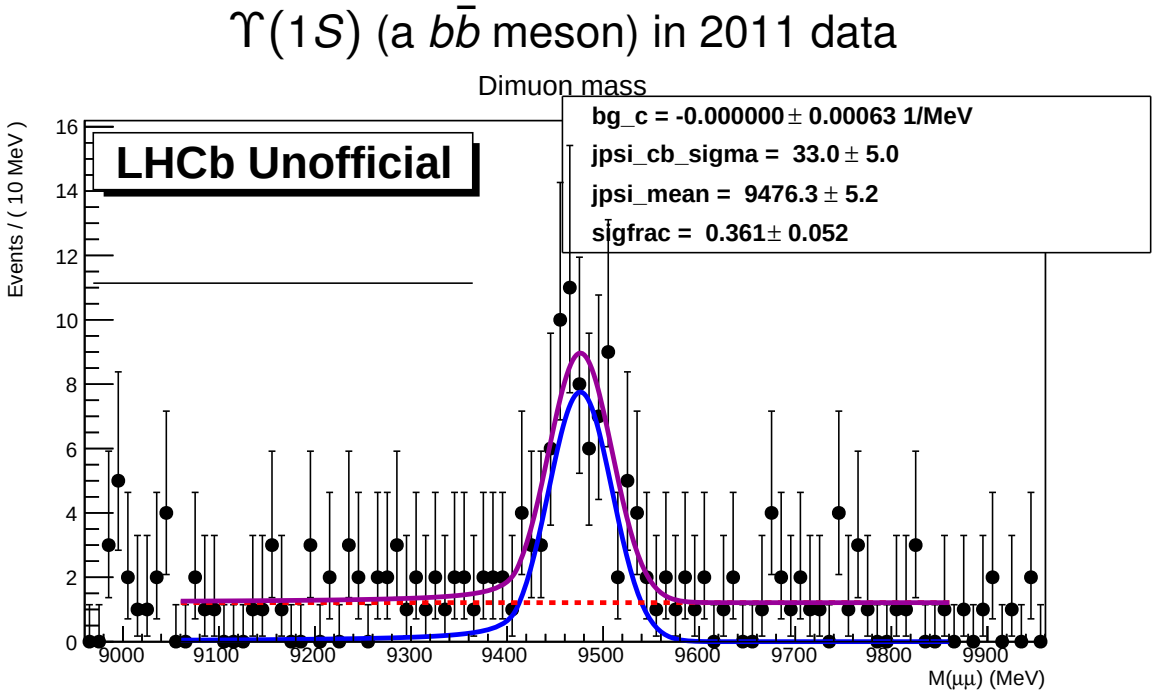
$\chi_{c0}, \chi_{c1}, \chi_{c2}$



$\psi(2S)$

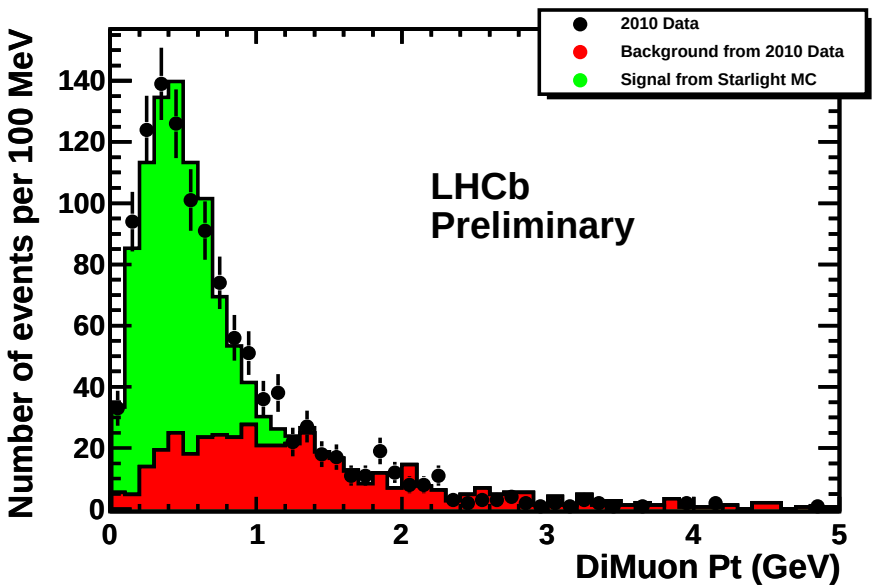


2011 Signal process!



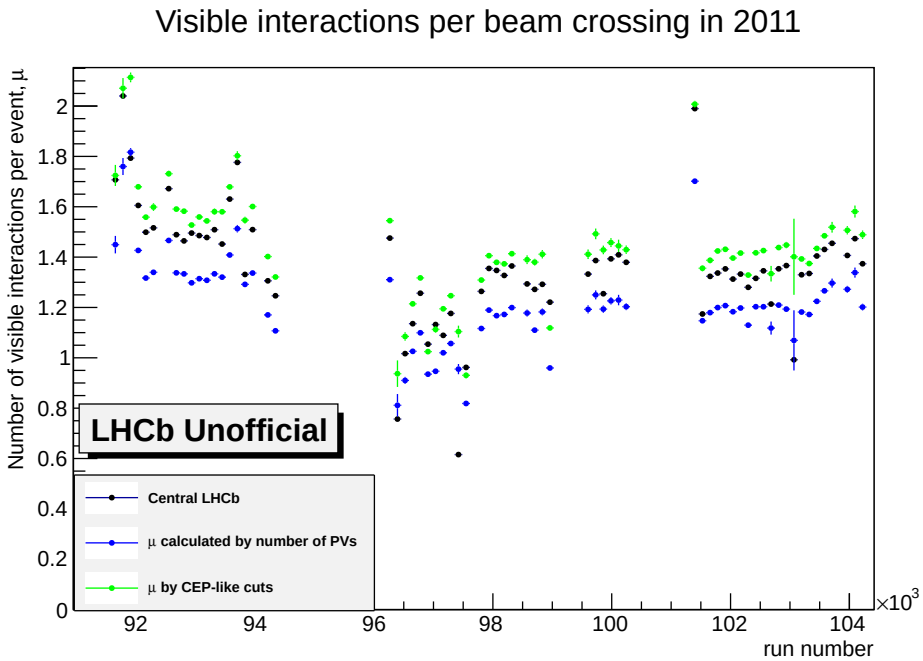
Non-exclusive background estimation

- CEP Signal and “inelastic” production of the same final state give rise to different p_T-distributions
- Can measure p_T-distribution for background in events with n additional tracks
- Extrapolate to $n = 0$ (2 signal tracks only) for background p_T-spectrum in CEP candidate events
- Extract signal and background fractions using a fit to the p_T of the dimuon



Luminosity

- We need to exclude events with multiple interactions (pile-up)
- Number of collisions per event follows a Poisson distribution
  - Huge number of protons per beam
  - Each proton pair has a very small probability of colliding
  - Probability to have one collision is $P(1) = \mu \exp(-\mu)$, with μ being the mean number of interactions per event
- We calculate the number of interactions per event in different ways and compare:



- At LHCb we have relatively low μ, so we can use about 22 % of the interactions (32 % of the events)

Conclusions

- CEP gives us a very pure signal
- Some challenges related to non-exclusive background
- On track for a measurement based on 2011 data