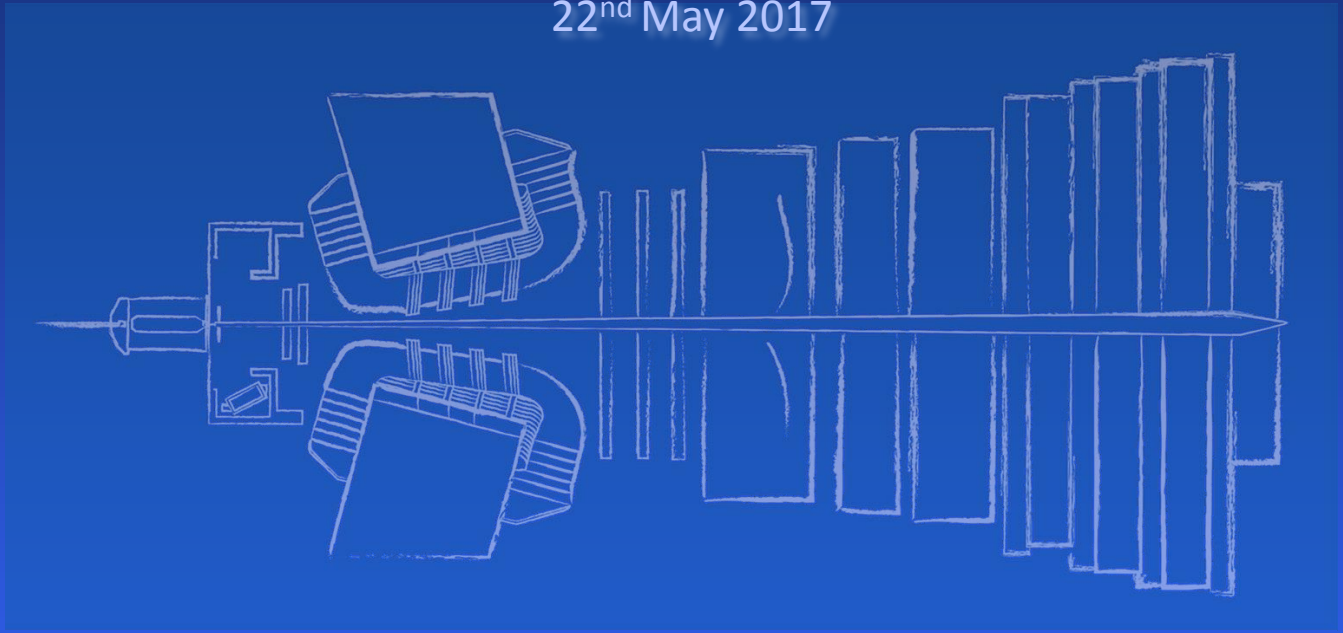
CWP Meeting

22nd May 2017

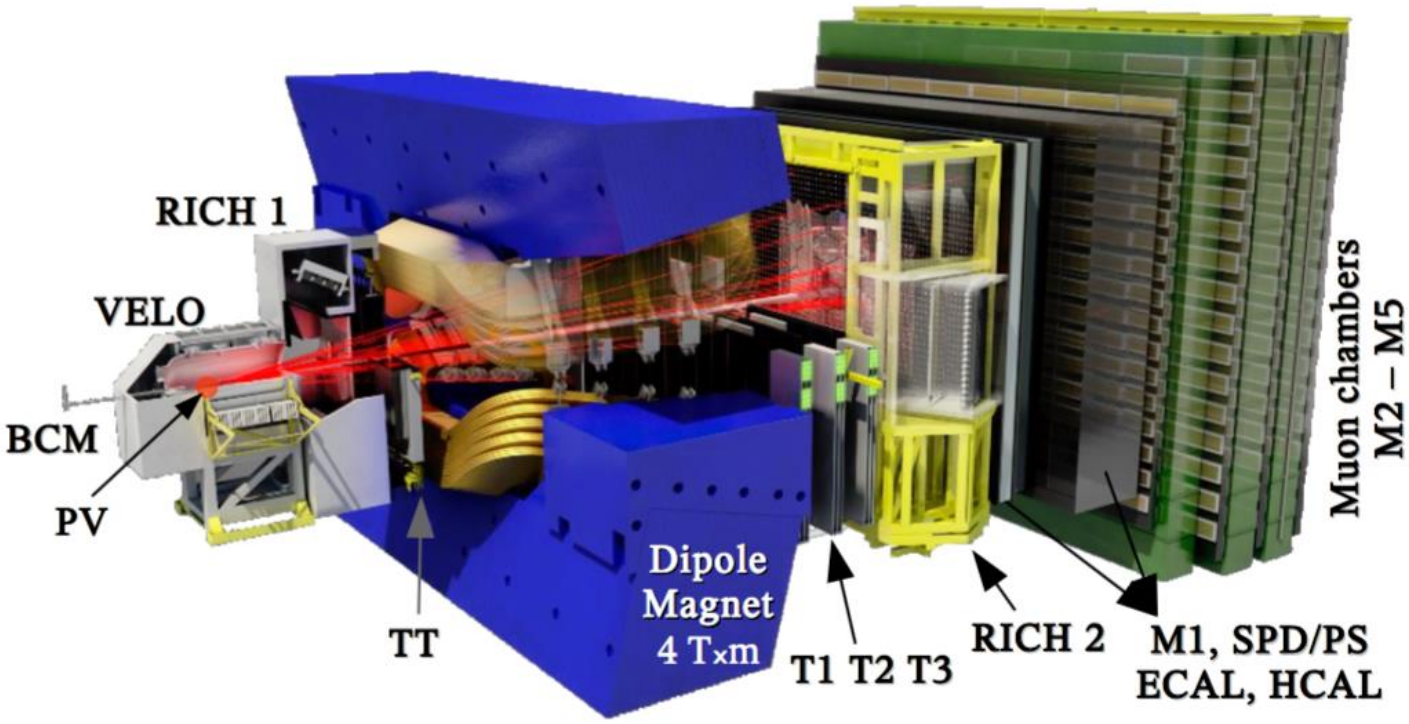


LHCb: Physics Models

Gloria Corti, CERN

R. Cenci, INFN Pisa – **D. Popov**, MPI Heidelberg – **S. Easo**,RAL

LHCb detector's characteristics



High precision tracking & vertexing

Impact Parameter (IP) resolution ~20 μm at high-p_T

Excellent Momentum resolution (Δp/p)

from 0.5 % below 20 GeV/c to 1.0 % @ 200 GeV/c

Very good PID:

– π, **p, K**: Two RICHes (C_4F_{10} & CF_4 gas) from 2 to 100 GeV/c

– e, γ, μ: CALO/M1-M5

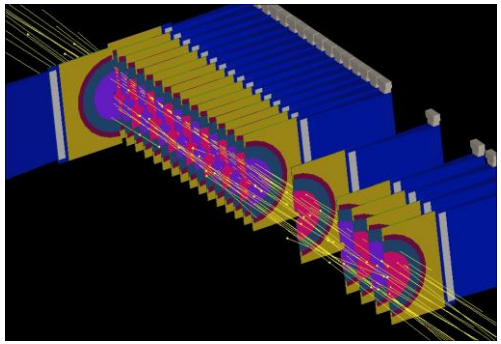
Physics Models in Simulation have to match

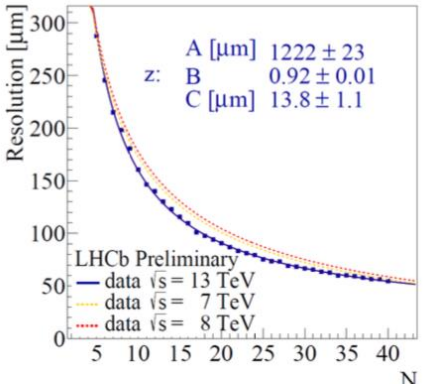
Overview of physics list

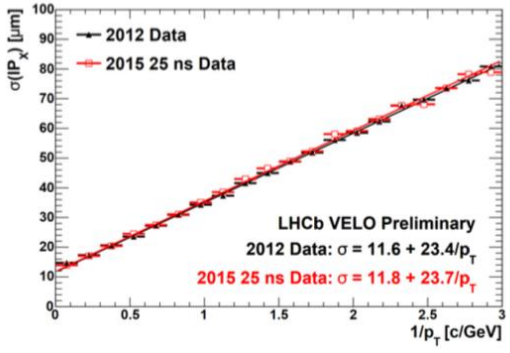
- Current production for Run1&Run2 (Sim09) still uses Geant4 9.6.p04 but next major version (Sim10) expected to start end of Summer will use G4 10.3
  - Keep FTFP_BERT for hadronic modelling, but **patch provided to us for Kaon cross sections in 9.6 should be the default**
  - Use **LHCbEmNoCuts** for electromagnetic modelling, but **modified to match changes in EmOpt1** from which it originated. Will give it to G4 for long term.
  - Use Geant4 **Cerenkov** and scintillation processes in RICH with additional **custom made** GEANT4 physics process for the **creation of photoelectrons**

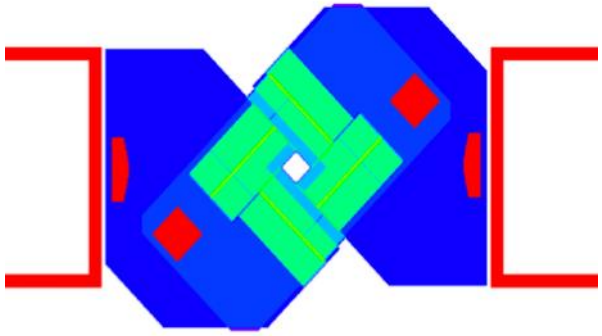
EM – IP resolution and Multiple Scattering

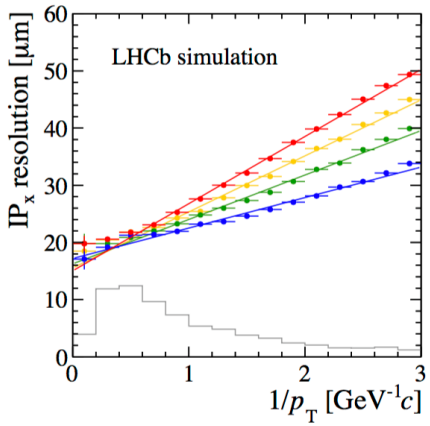
- The Vertex Locator (VELO) is an extremely precise detector and it will become even more so with the LHCb Phase 1 upgrade





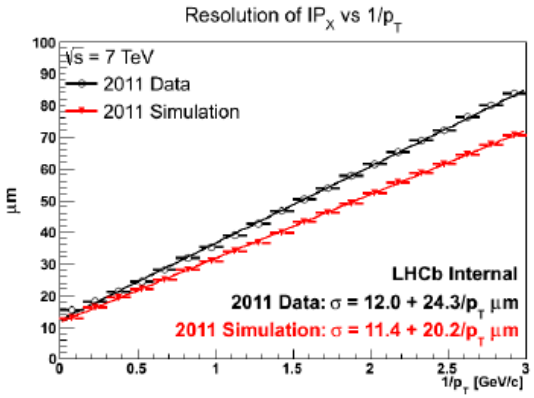




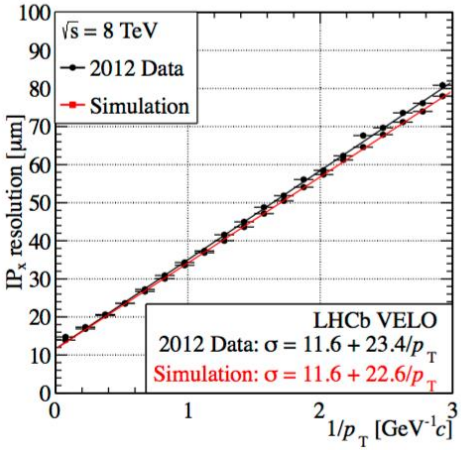


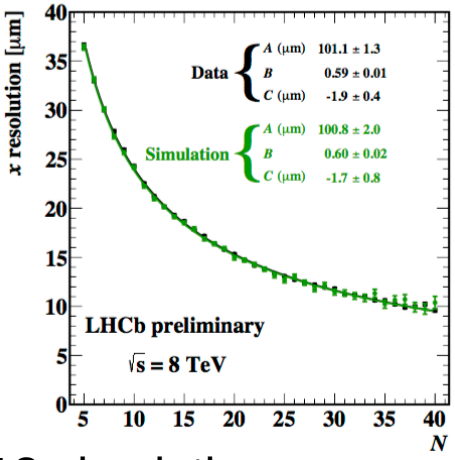
EM – IP resolution and Multiple Scattering 2

- Three main factors contribute to IP resolutions:
  - Single hit resolution
  - Material budget - multiple scattering in detector material introduces 1/pT dependence
  - Extrapolation distance - amplifies the effects of hit resolution & multiple scattering



Issue with 2011 simulation



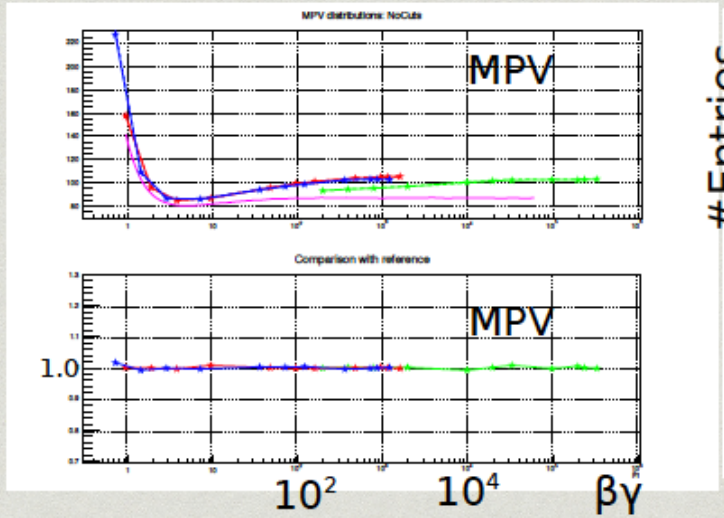


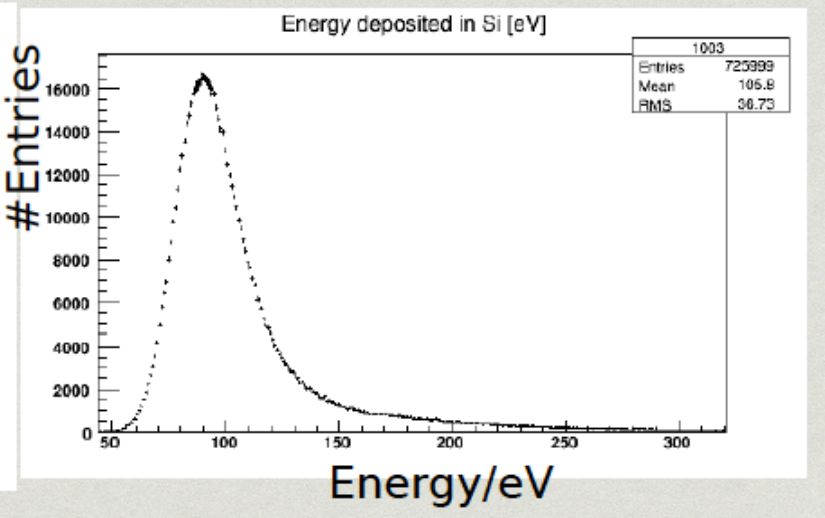
Much better with 2013 simulation

Checked with all new simulations put in production

Energy deposition in thin layers

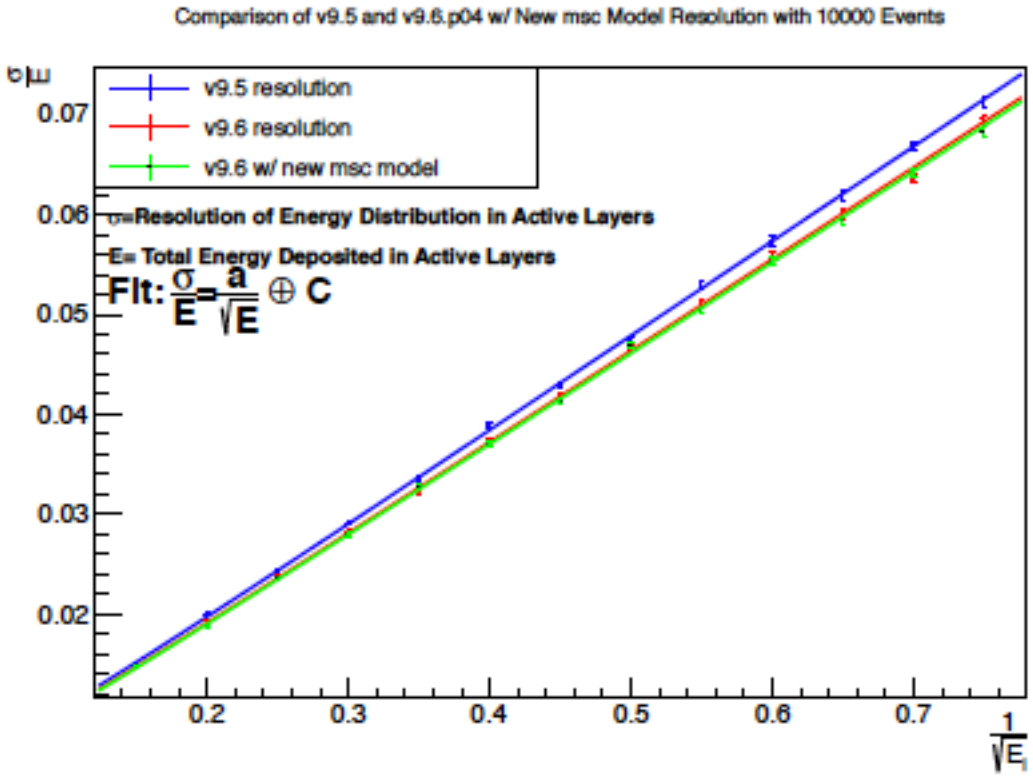
- Important for the whole silicon based trackers
  - Keep it monitored for all new version of simulation but also look at what else Geant4 provides within reasonable CPU





Being deployed in LHCbPR2 automatic tests

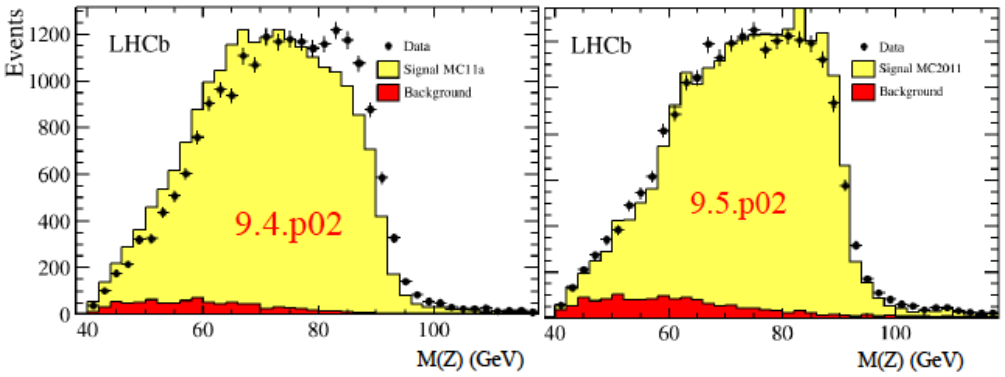
and in calorimeters as it requires calibration



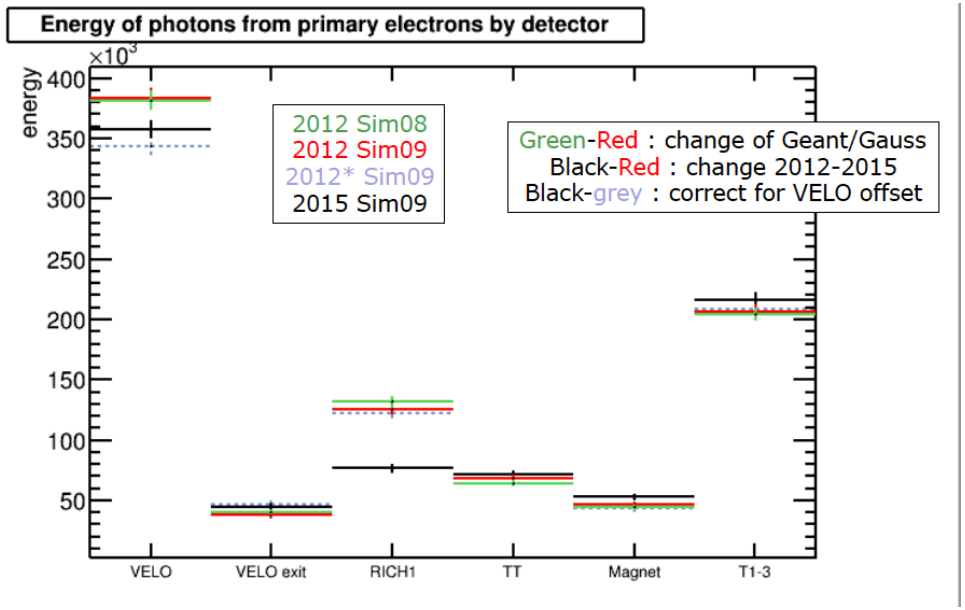
More complex Msc model increases CPU time for LHCb-ECAL-like example by a factor of 6-8

Bremsstrahlung on physics

- Bremsstrahlung energy can only be partially recovered using the calorimeter
- Z mass shift to lower values Ok as long as the shape is understood

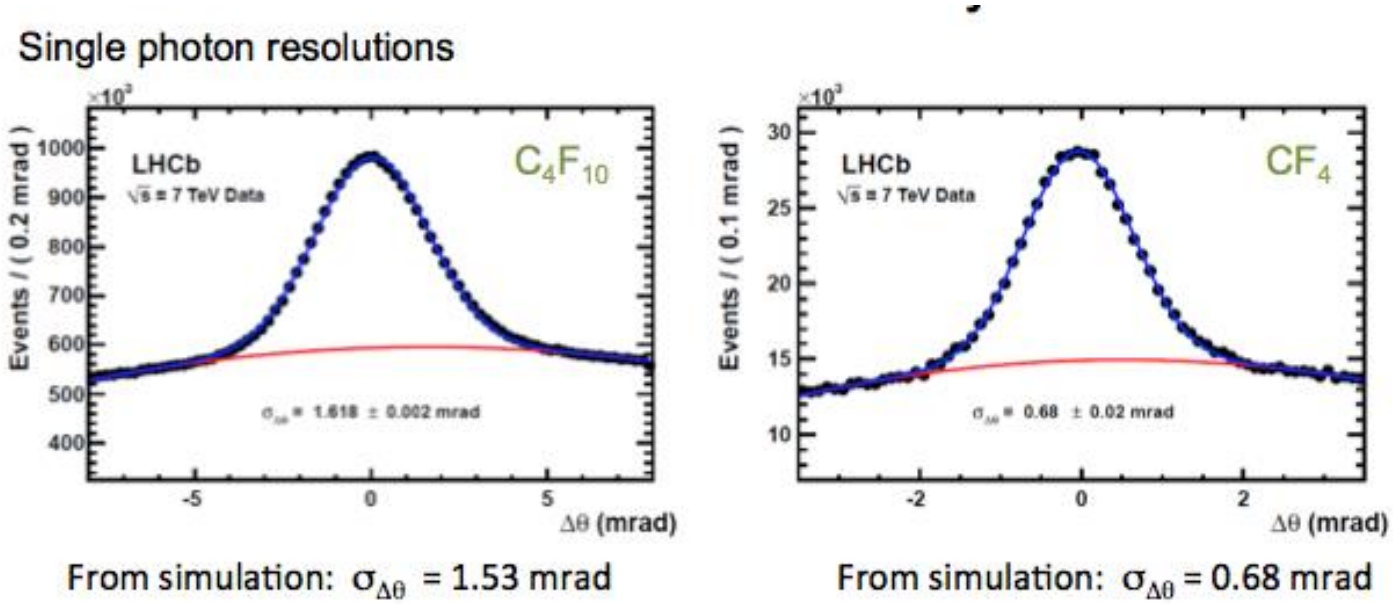


Set up a test to check with a simple particle gun in the LHCb setup



Cherenkov and RICH

- Contribution of RICH system to particle identification vital for LHCb physics
  - PID calibration data driven
  - But simulation also very important, although it also depend on external input as track multiplicity



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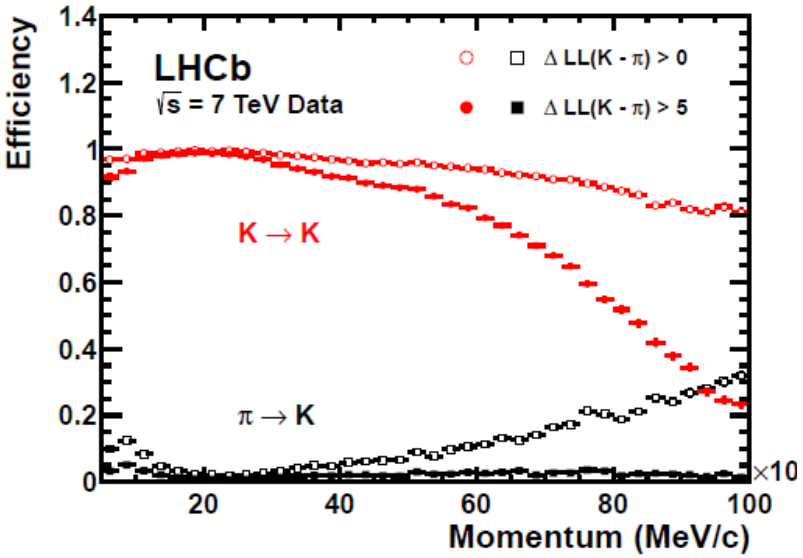
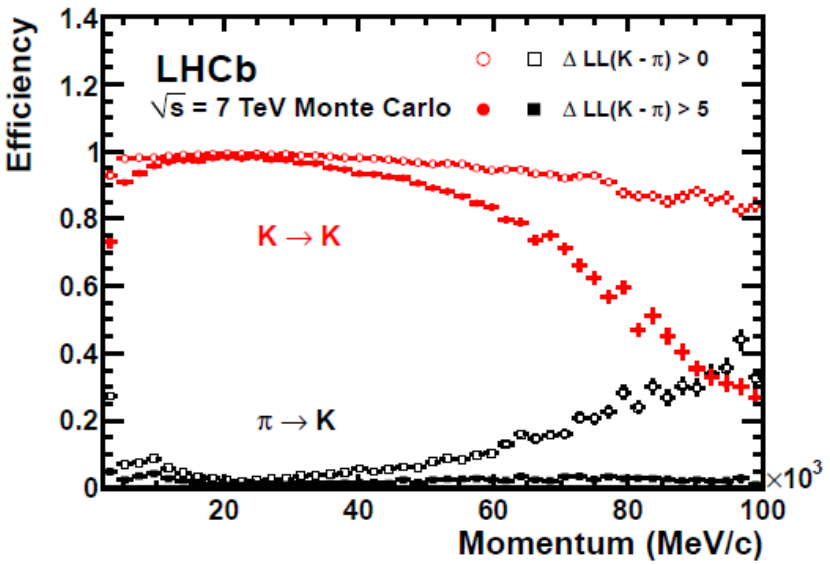




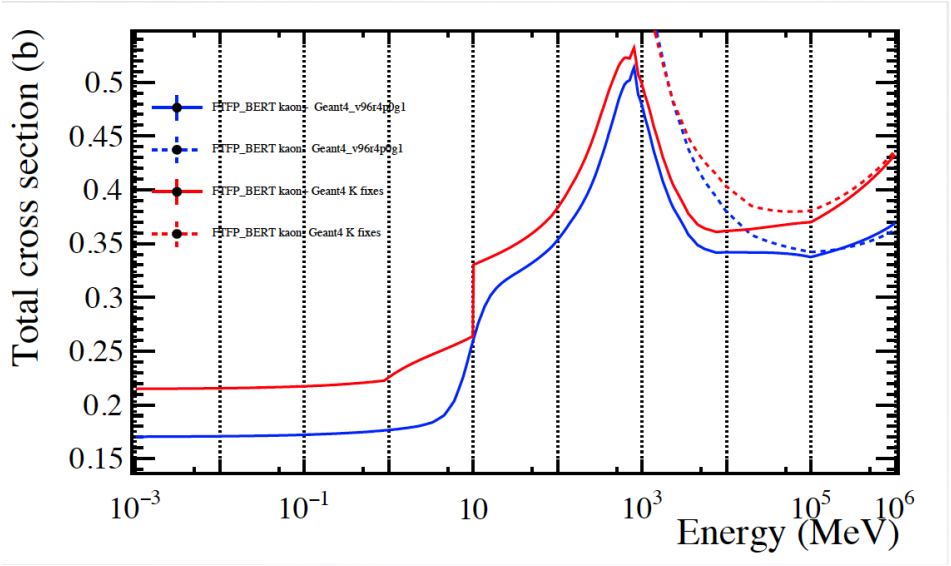
Hadronic physics

- Main focus for LHCb:
  - Single particle interactions
  - Particle/antiparticle asymmetries
  - Low p_T
- Many of LHCb measurements are related to asymmetries and detector modelling enters in systematics
  - Reliable simulation can help to lower systematic
- Important quantities to keep under control:
  - Particle/antiparticle cross section ratio
  - Multiplicity and particle composition

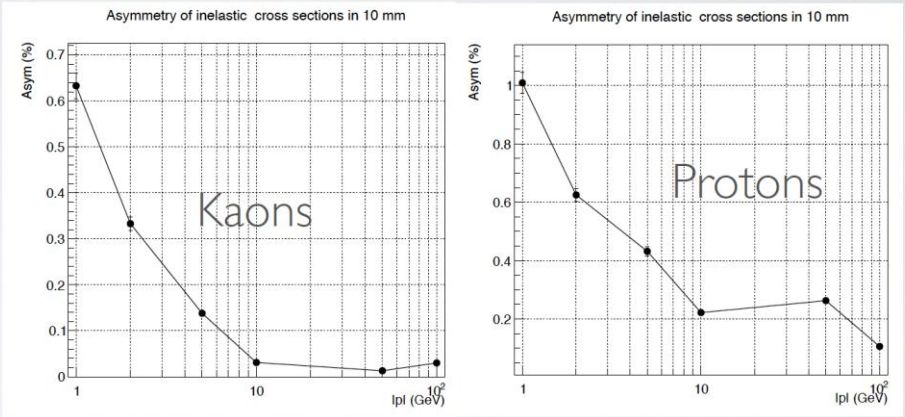
Cross section and their effect

In 9.5.p02 Kaon asymmetries too low vs. PDG especially at high momentum
In 9.6 + patch for LHCb they are closer

We are now looking into the proton/anti-proton asymmetries

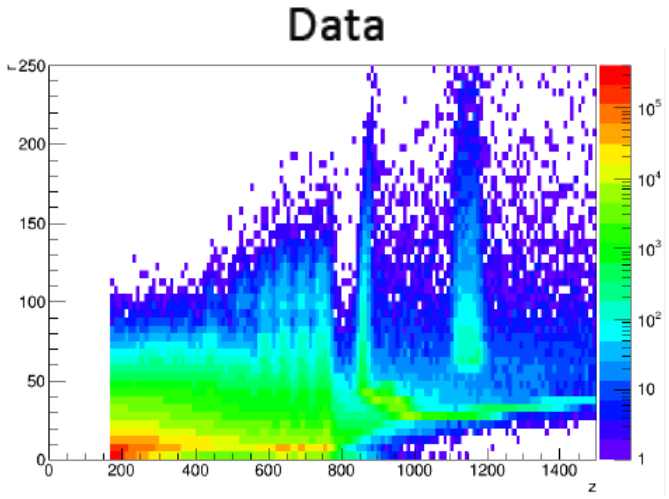


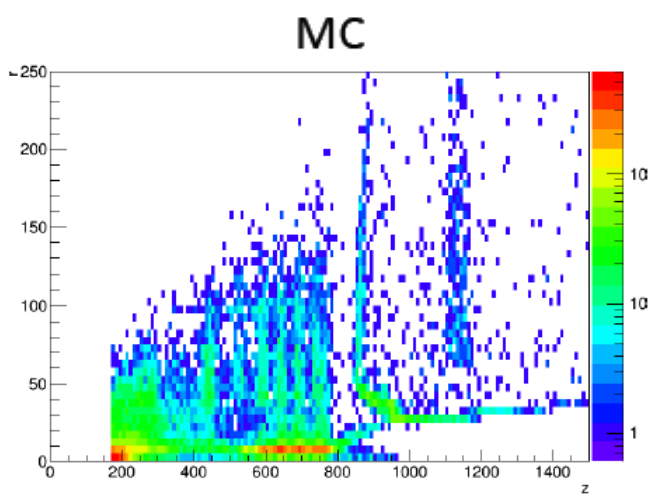
$$A = \frac{N^{+}_{int} - N^{-}_{int}}{N^{+}_{gen} + N^{-}_{gen}}$$

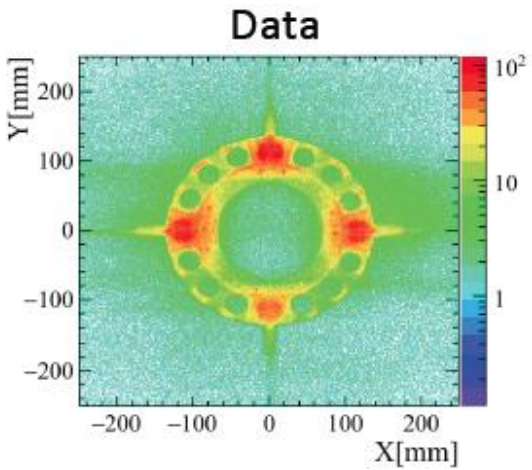


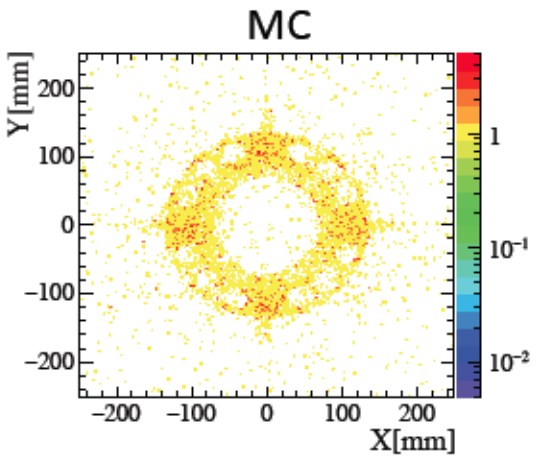
Cross sections and multiplicities folded together

Tomography w downstream and T tracks, γ conversions and hadronic interactions









Outlook

- New test beam for upgrade detectors mostly for characterization in higher radiation environment
- Different focus that ATLAS & CMS since LHCb measurements rely on tracking and particle ID
- Lowering measurements systematics will likely put more demands on simulation precision
- But we also need to reduce CPU/event wherever possible
  - Fast simulations for calorimeters being worked for the upgrade