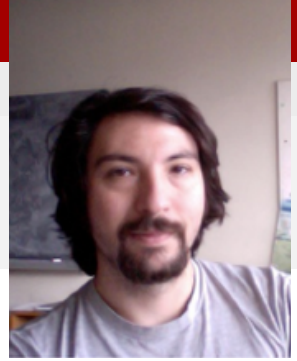
Performance of the LHCb Tracking System in Run I of the LHC



- LHCb Detector is a forward arm mass spectrometer at the LHC
- Goal: Search for indirect evidence of new physics in CP violation and rare decays of b and c hadrons
- Geometry is chosen to utilize the production correlation of $b/\bar{b}$ hadrons, which are predominantly produced in the same forward region
- Need a high performance detector, with spacial resolution of 4 μm near the primary interaction region, 50 μm resolution elsewhere, over 99% cluster finding efficiency and high momentum resolution over a wide range of momentum

The LHCb Tracking System Consists of

- Vertex Locator (VELO): 42 Silicon Modules, $r\phi$ Segmentation
  8 mm inner radius, halves are retractable to 29mm
- Tracker Turicensis (TT): 4 Silicon Microstrip planes, arranged in x-u-v-x geometry, 5° stereo angle
- Tracking Stations (T1-T3): Silicon Microstrip inner region (IT), Straw drift tube outer region (OT), x-u-v-x geometry, 5° stereo angle
- Warm Dipole Magnet with reversible polarity

Hit efficiencies exceed 99% in general

Resolution

- VELO has 4 μm hit resolution at lowest pitch
- TT and IT have 50 μm hit resolution
- Momentum resolution: ~ 5 per mille for particles with $p < 20$ GeV/c and 8 per mille for particles around 100 GeV/c
- Primary Vertex resolution: ~ 13 μm in x and y and about 71 μm in z for 25 tracks used in reconstruction, varying with number of tracks
- Impact Parameter resolution: varies linearly with $1/p_T$ due to multiple scattering, 15 μm at $p_T \sim 10$ GeV/c

Track Reconstruction

- Long tracks used for a lot of physics (have hits in all tracking stations), most precise momentum information
- VELO tracks used for PV reconstruction
- Downstream tracks used for long lived particle reconstruction (K_s^0, Λ)

Track Reconstruction Efficiency $> 95\%$ for long tracks over a large momentum range, number of tracks, pseudorapidity and number of primary vertices

Physics Results

- Precision decay time allows
  - Accurately resolve B_s^0 mixing as a function of decay time
  - Search for CPV and Mixing in the charm sector
- Precision momentum resolution allows
  - High mass resolution and efficient signal and background separation, illustrated in $B_s \to \mu\mu$

2015 and Run II of the LHC hold new challenges and new approaches

- $\sqrt{s} = 13$ TeV, 25 ns Bunch Spacing
- A larger timing budget for the High Level Trigger and a large gain in speed of track reconstruction allow for the same online and offline reconstruction.