

# Overview of the LHCb Tracking System and its Performance

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on behalf of the LHCb collaboration

## Outline

- LHCb tracking system
- tracking algorithms
  - performance on simulated data
- results with data
  - beam induced events
  - cosmic muons
- summary

(CHEP 2009, March 24th 2009, Prague)

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# The LHCb Tracking System

## Vertex Locator (VELO)

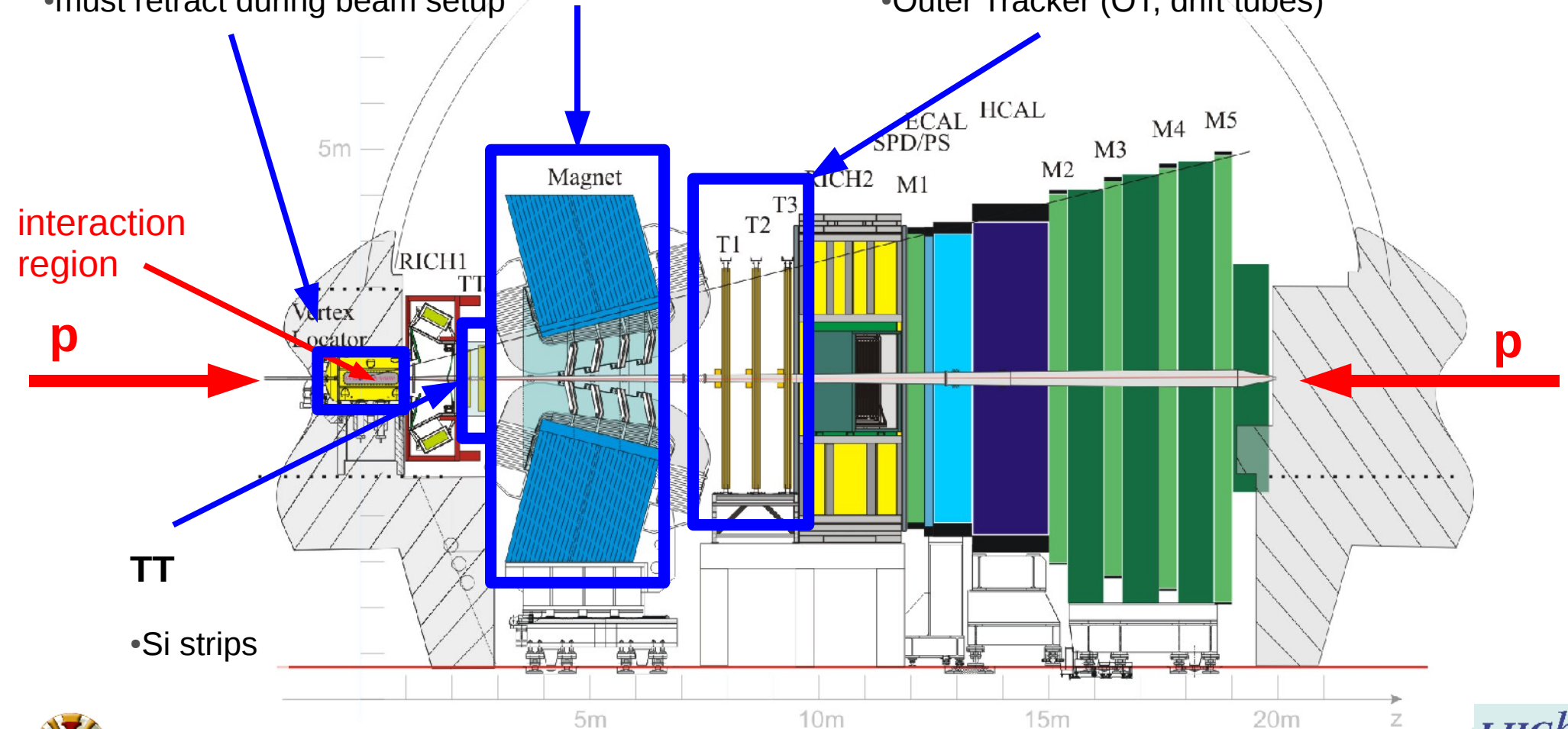
- Si strip detector
- must retract during beam setup

## Dipole Magnet

4.2 Tm integrated field

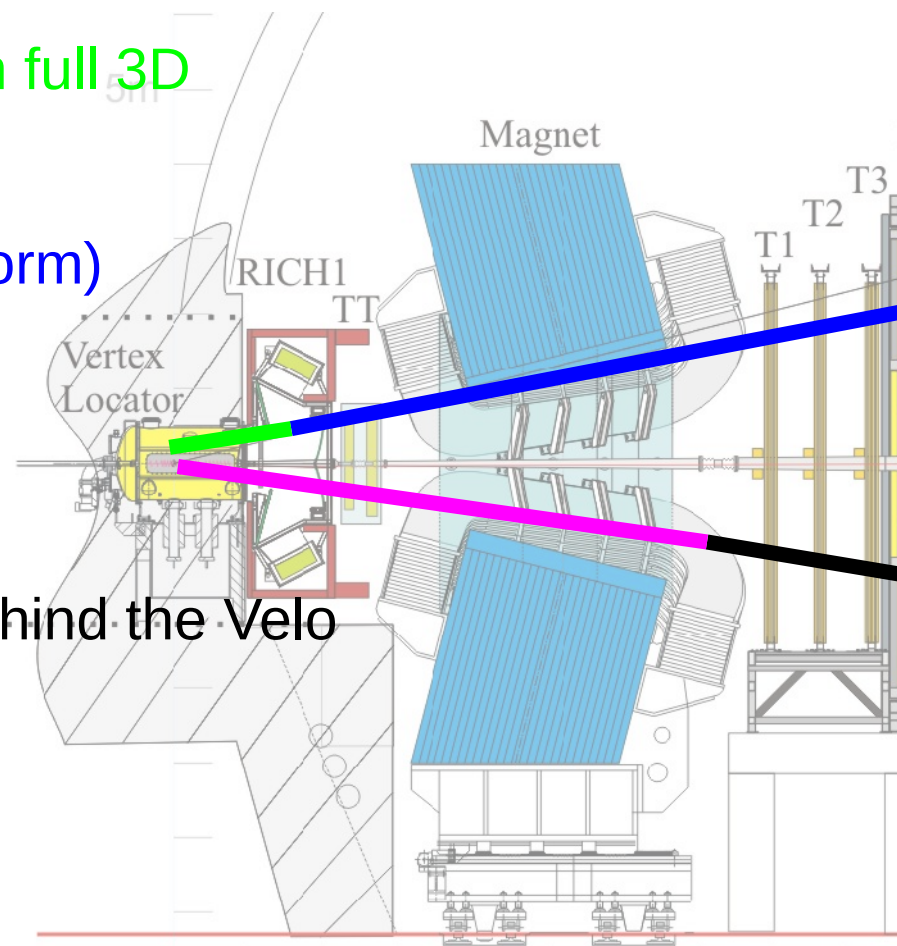
## Main Tracker (T)

- Inner tracker (IT, Si strips)
- Outer Tracker (OT, drift tubes)



# Tracking Strategies

- **Velo tracking**
  - straight lines in 2D (rz-plane) first, then full 3D
- **forward tracking**
  - extend Velo track into T (Hough transform)
  - add TT hits
- **standalone T station reco**
  - recovers daughters of  $K_s$  decaying behind the Velo
- **track matching**
  - match Velo and T segments
  - add TT hits

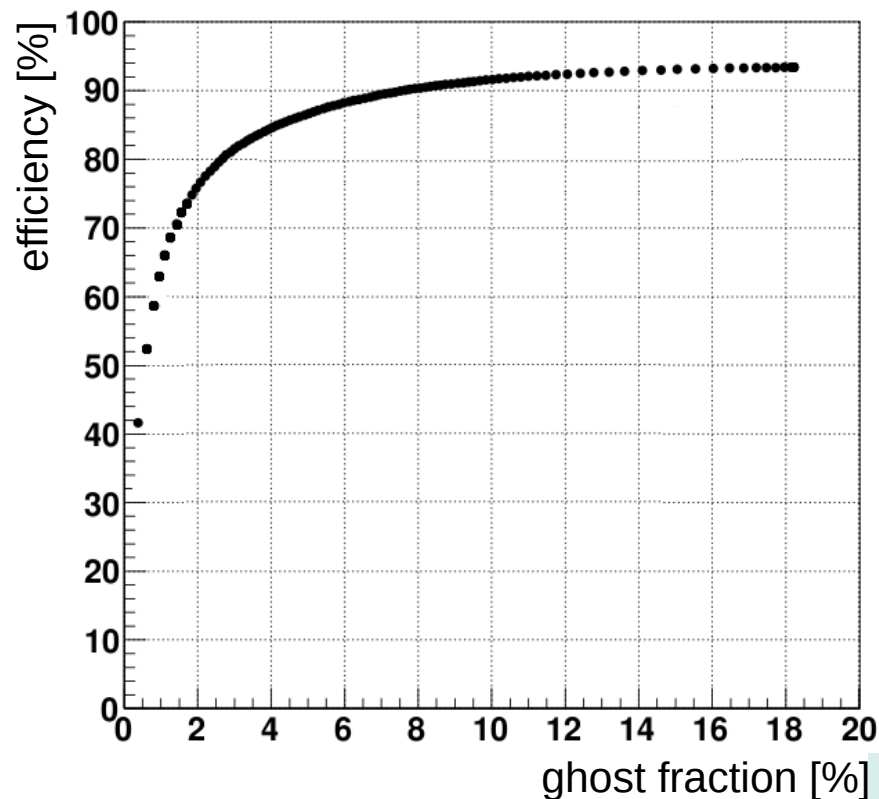
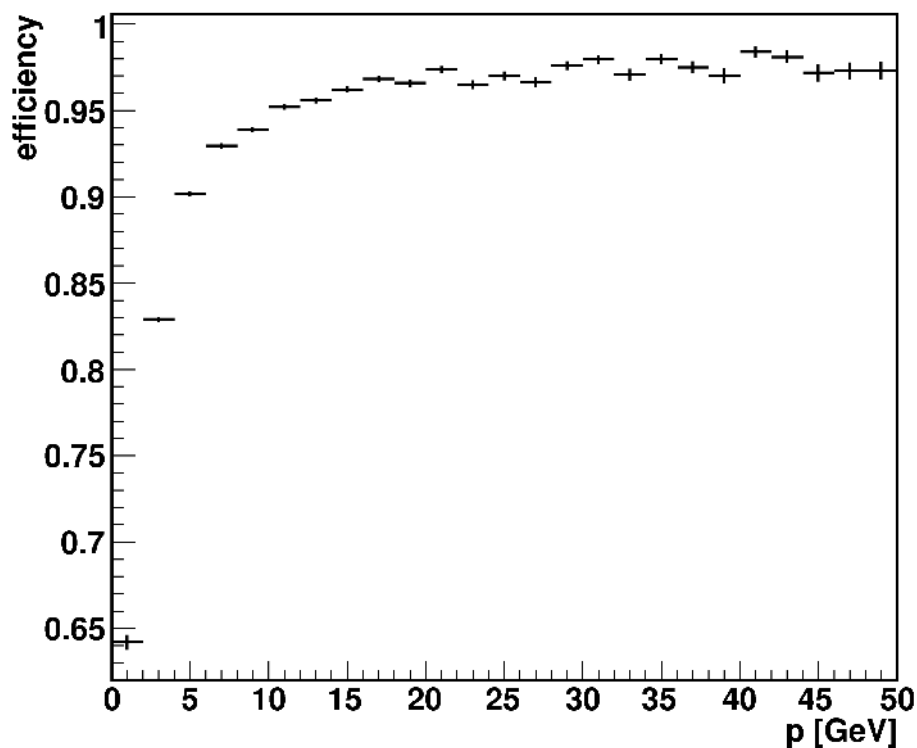


redundant set of algorithms



# Tracking Performance in Simulation

- long tracks (Velo + T stations)
  - efficiency: 95.0 % ( $p > 5$  GeV)
  - ghost fraction: 14.4 % (event averaged)  
18.8 % (track averaged)



# Tracking Performance in Simulation

- total reconstruction time in tracking detectors:

0.66 s/event total

0.01 s/event decoding

0.10 s/event pattern recognition

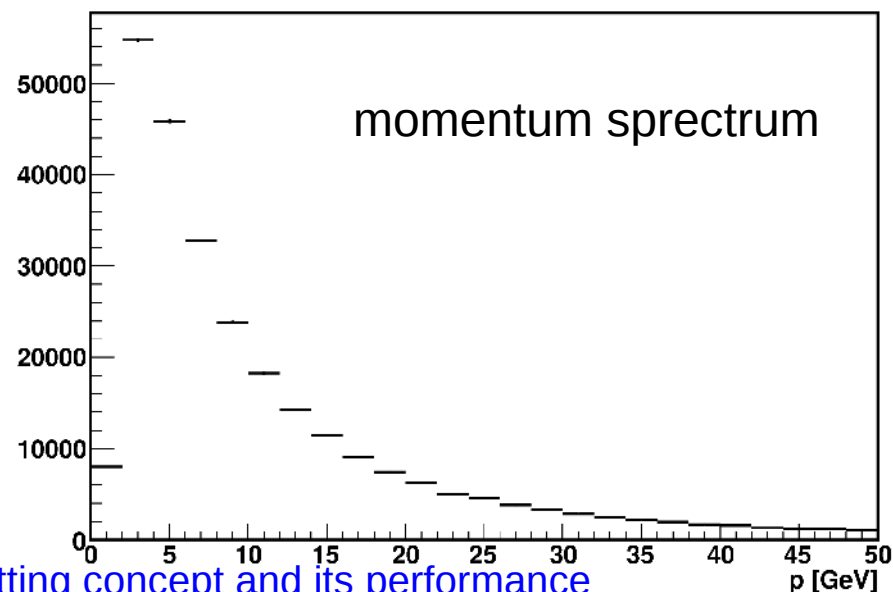
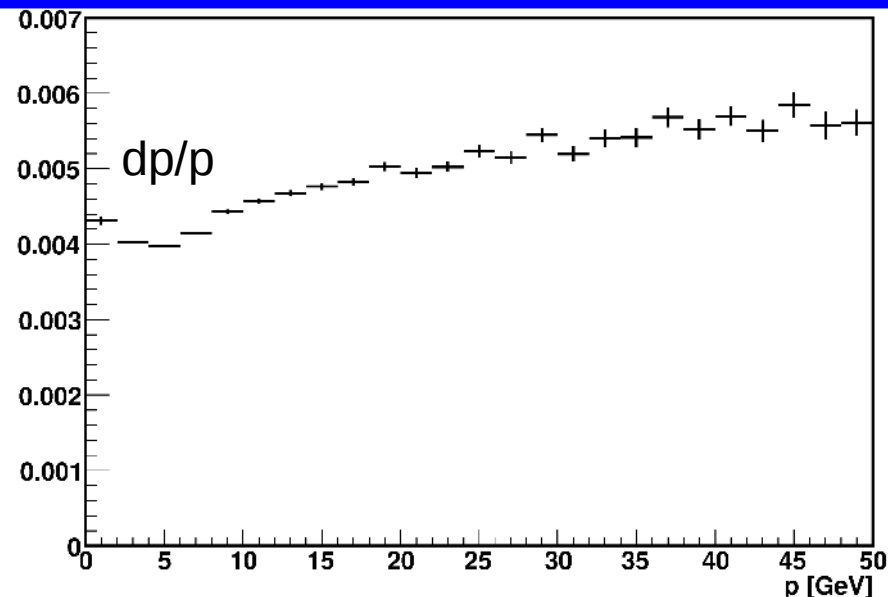
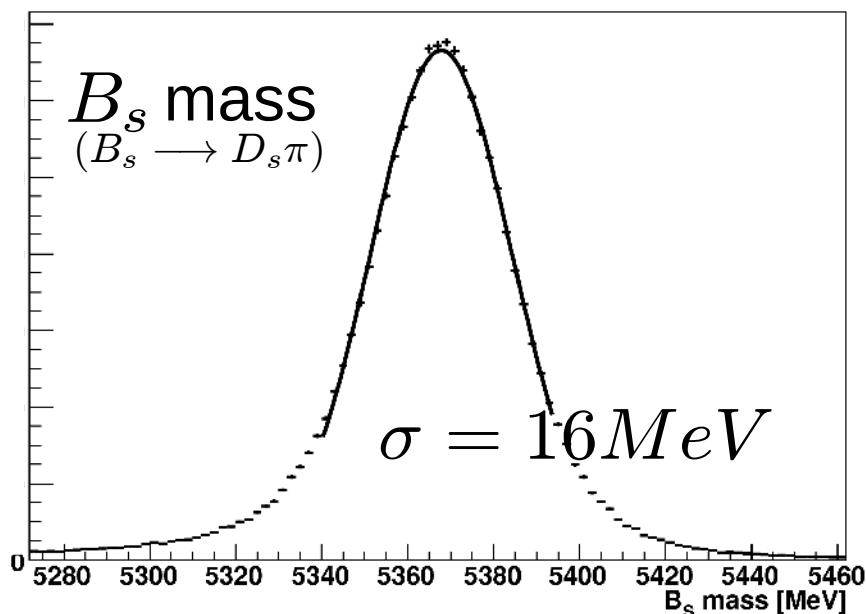
0.50 s/event track fitting

(run on AMD Opteron @ 2.2 GHz)



# Performance in Simulation

- Kalman filter fit\* applies corrections for multiple scattering, dE/dx
- dp/p about 4.5 ‰
- B mass resolution about 16 - 20 MeV
- $\sigma_{IP} \approx 14\mu\text{m} + \frac{35\mu\text{m GeV}/c}{p_T}$



\* see poster by Eduardo Rodrigues: [The LHCb track fitting concept and its performance](#)

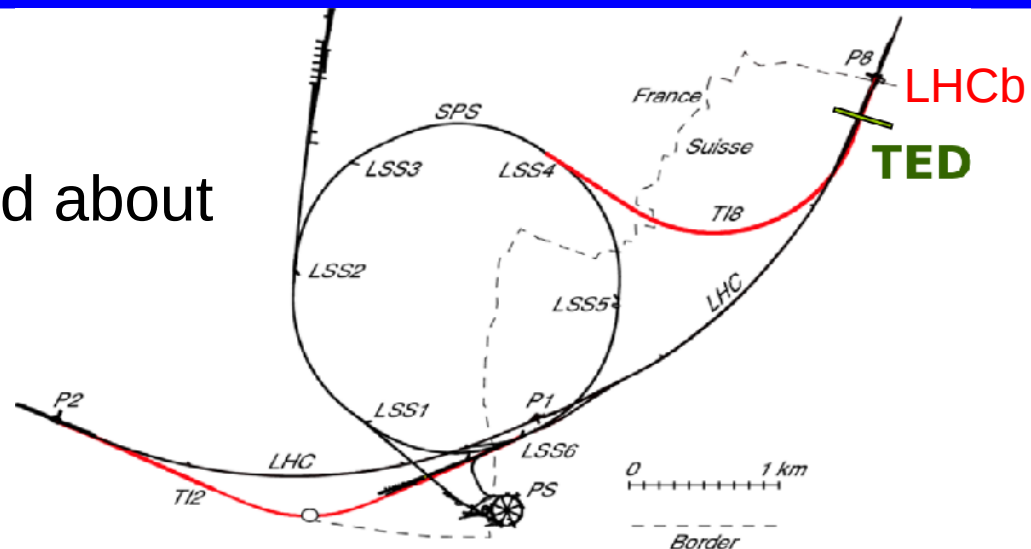
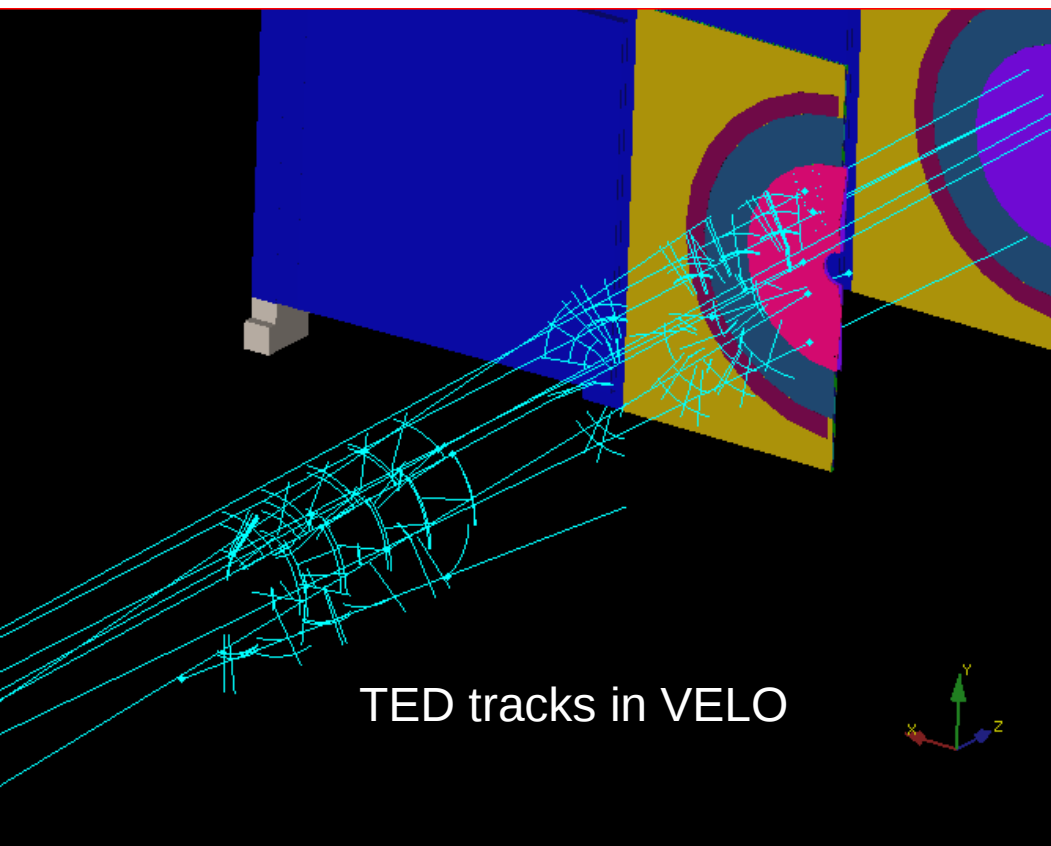
# Available Data

- “TED shots” (about 1400 tracks)
  - from injection tests
- beam splash events (6 events)
  - taken with beam 1 circulating on September 10th, 2008
- cosmic muons (1.2 M events)
  - low rate (LHCb geometry!)
  - always available



# TED data

- TED data:
  - injection test with beam stopped about 300m away from LHCb

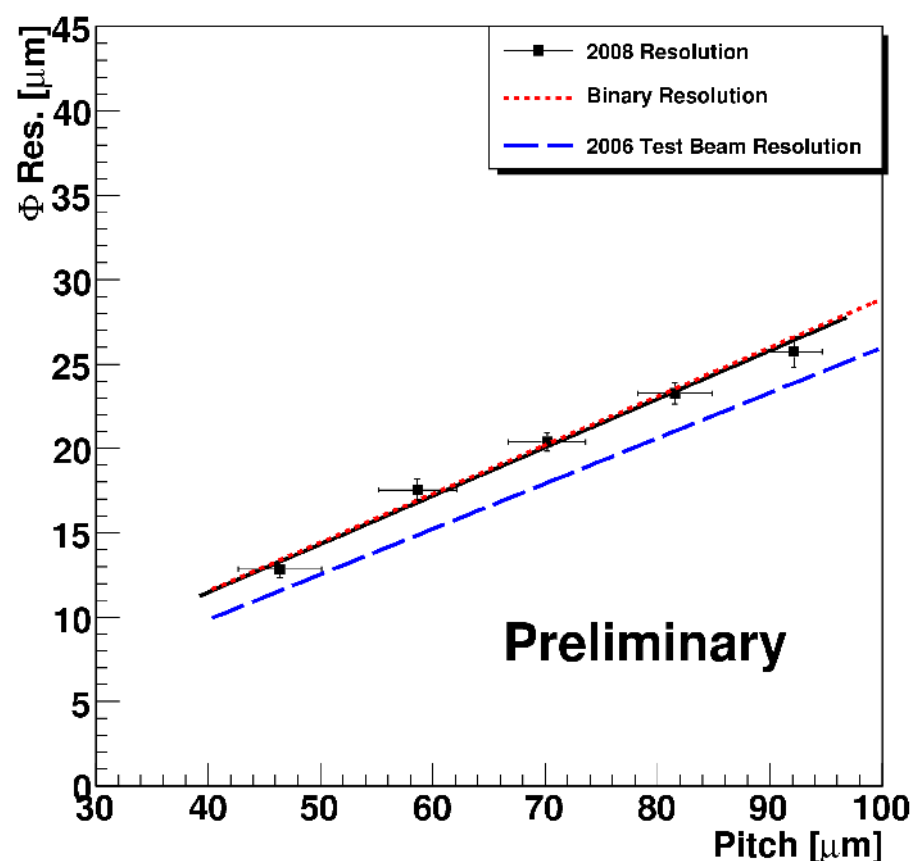
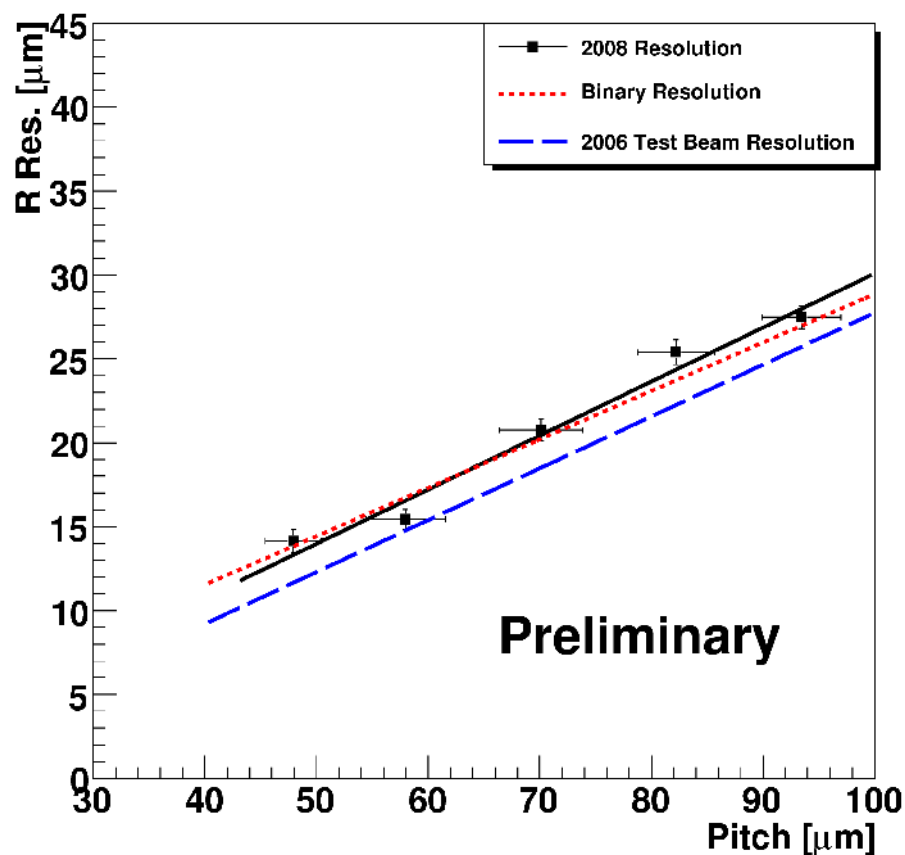


- first TED shots:  
Friday, 22 August 2008
- about 1400 Tracks



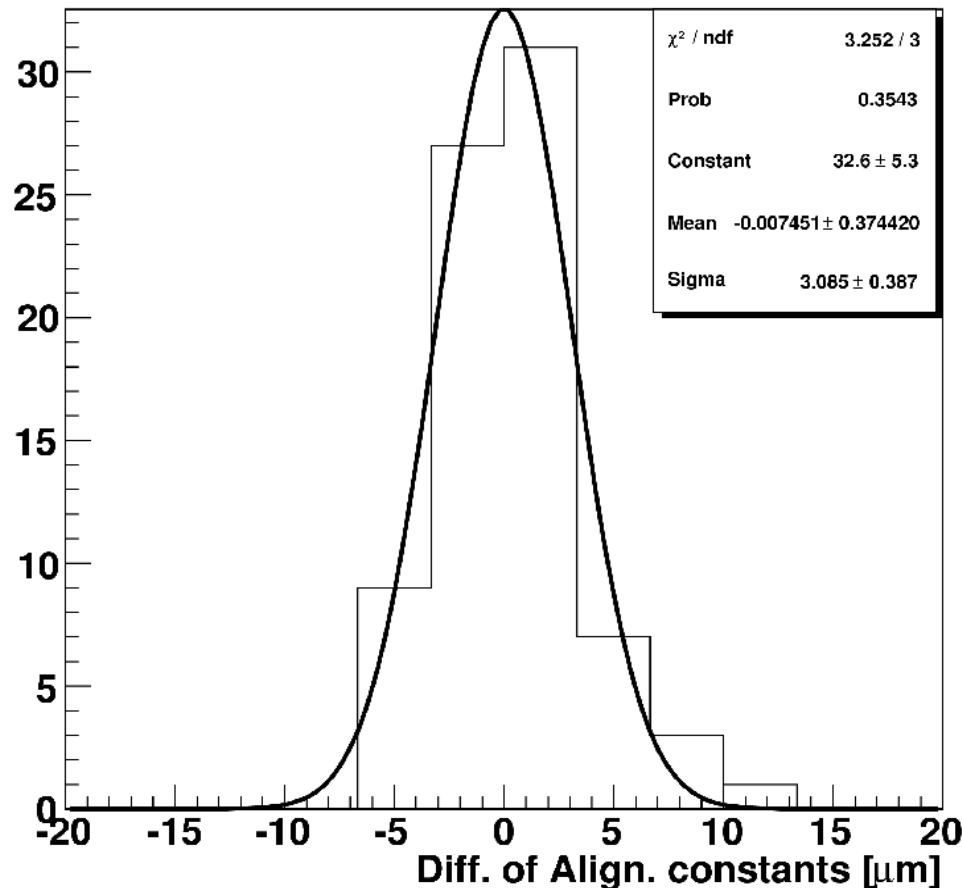
# Velo resolution in TED data

- binary resolution achieved
- expect further improvement once Velo fully calibrated



# VELO Alignment results with TED data

- split track sample in two (August/September)
  - about 700 tracks each



difference in  
alignment constants  
(August-September)

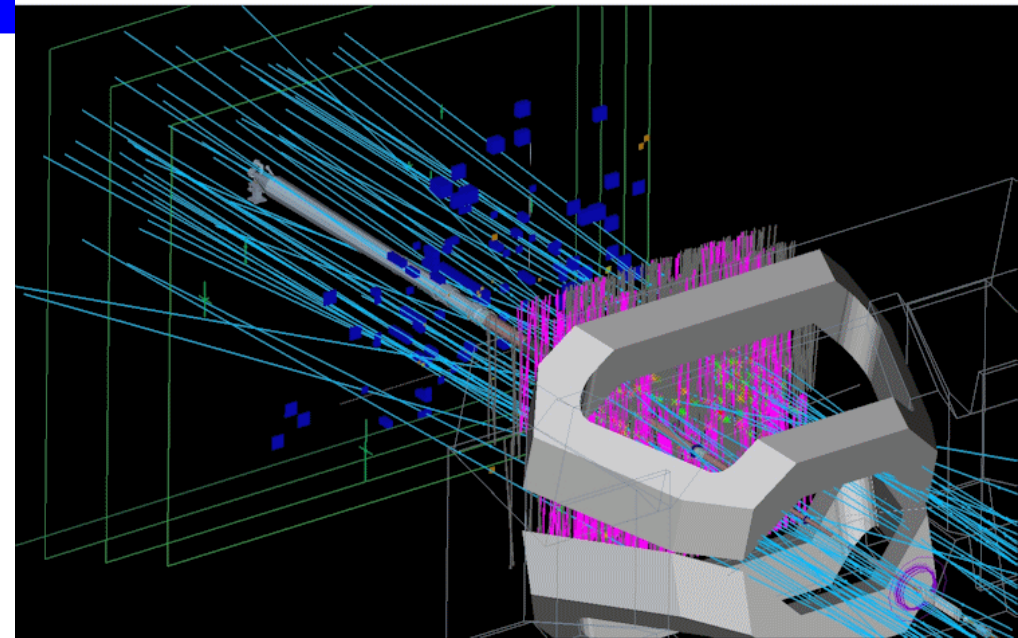
alignment precision  
5  $\mu\text{m}$  with 700 tracks!



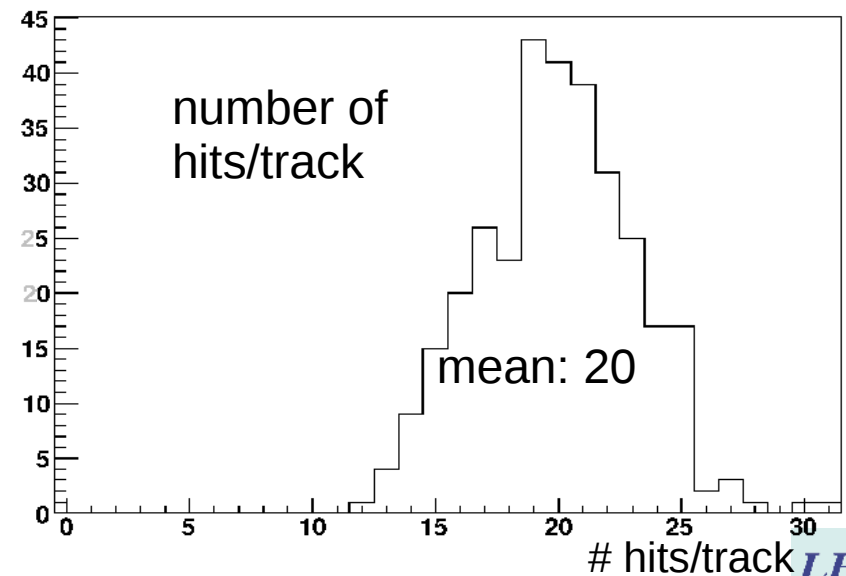
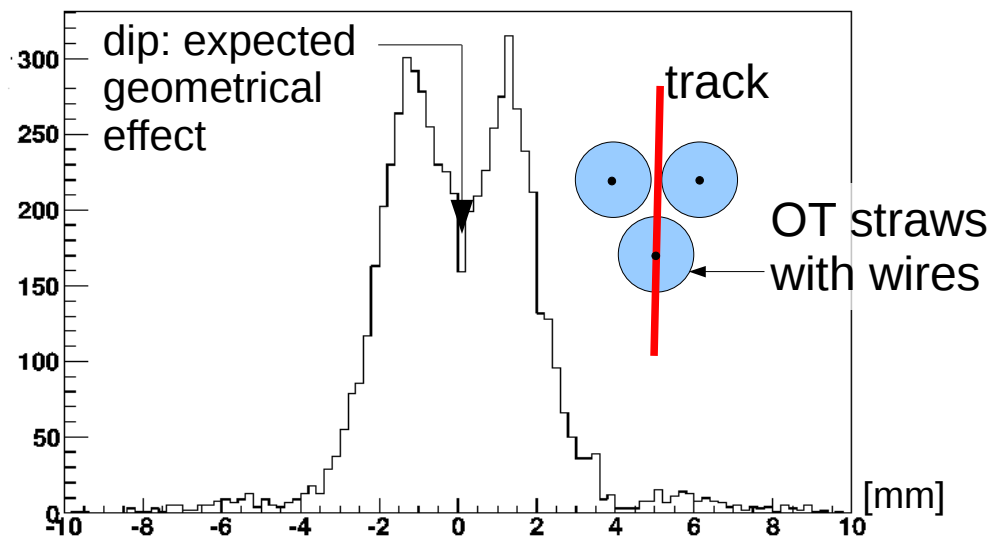
# beam splash events in OT

10.9.2008 11:25:26 0ns

- 6 events from “first beam day” in OT
  - number of hits/track and residuals as expected

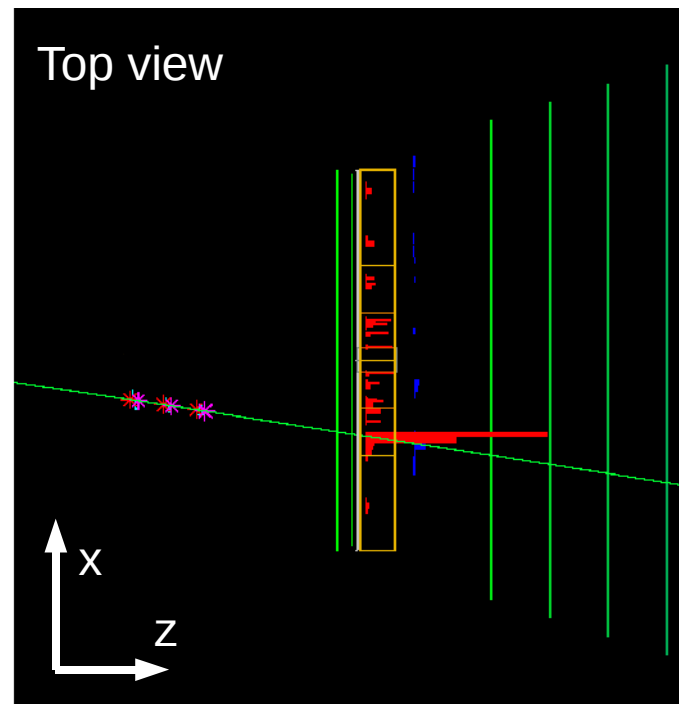
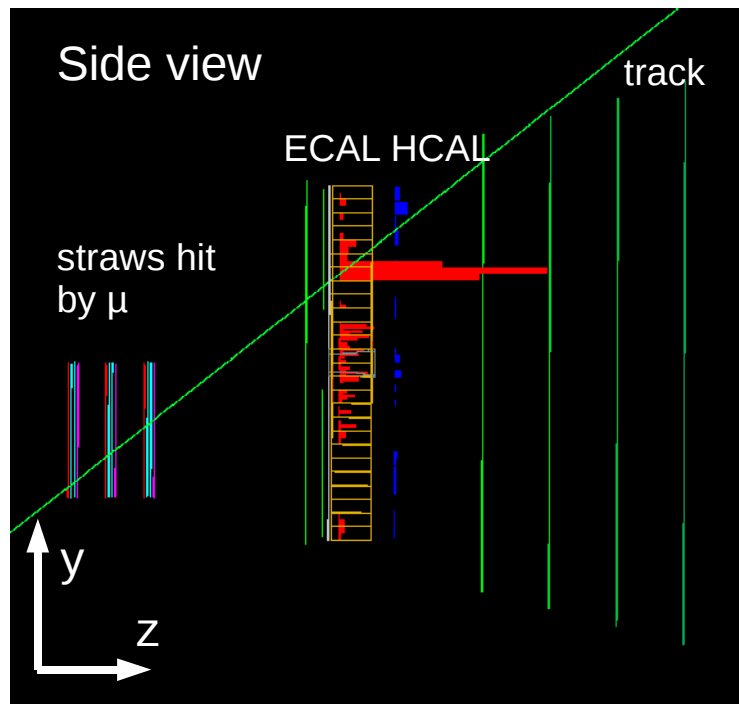


Residual distribution

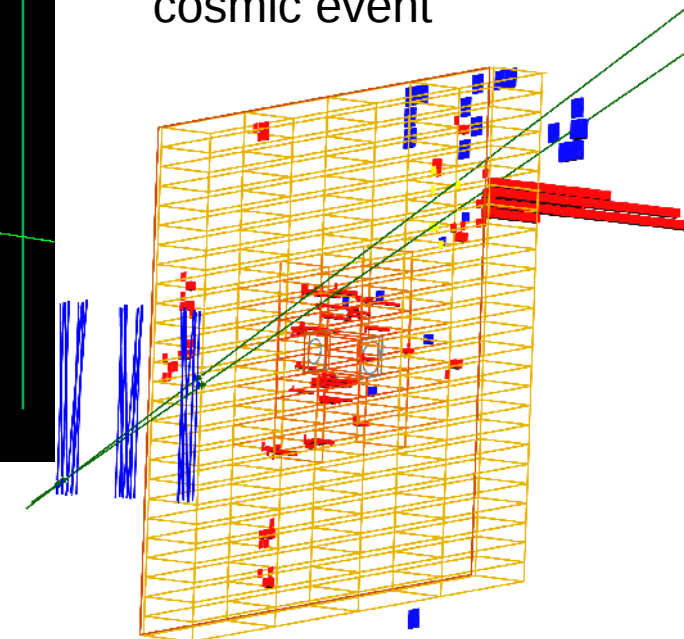


# Cosmics in OT

- reconstructed with standard algorithm
  - open cuts, don't use drift times (OT not yet calibrated)



3D view of 2 track cosmic event



First cosmic reconstructed in the OT view in xz and yz projections



# OT Alignment with Cosmics

- Use 2 complementary approaches

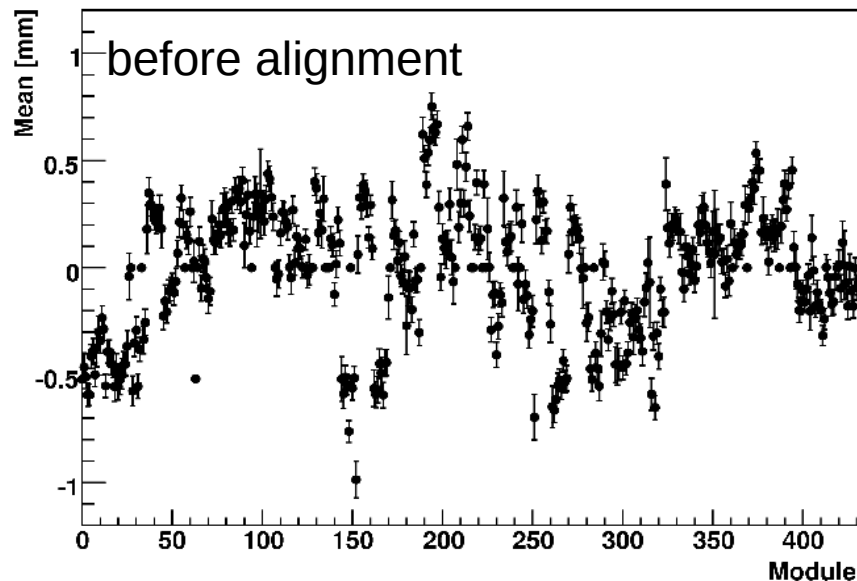
- $\chi^2$ -minimization using residuals from Kalman fit
- Millepede based

For details, see posters by

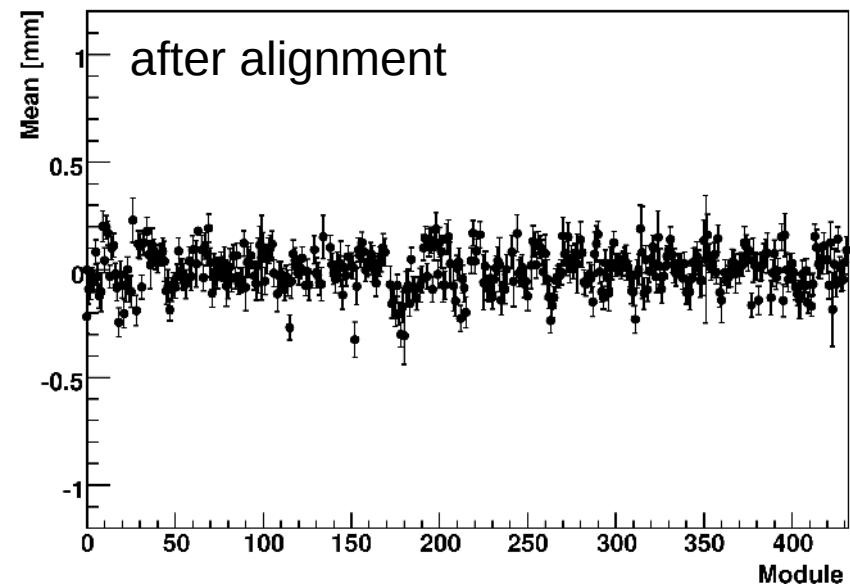
- Jan Amoraal:  
Alignment of the LHCb detector with Kalman fitted tracks
- Marc Deissenroth:  
Experience with LHCb alignment software on first data

- both give compatible results

Mean residual per module



Mean residual per module



# Summary

- tracking performance in simulated events:
  - 95.0 % efficiency,  $dp/p$  about 4.5‰
- reconstruction algorithms have successfully been tested on
  - TED data
  - cosmics
  - Monte Carlo
- first alignment possible
  - already good resolution achieved, but still limited by statistics

