Status and Expected Performance of the LHCb Tracking System

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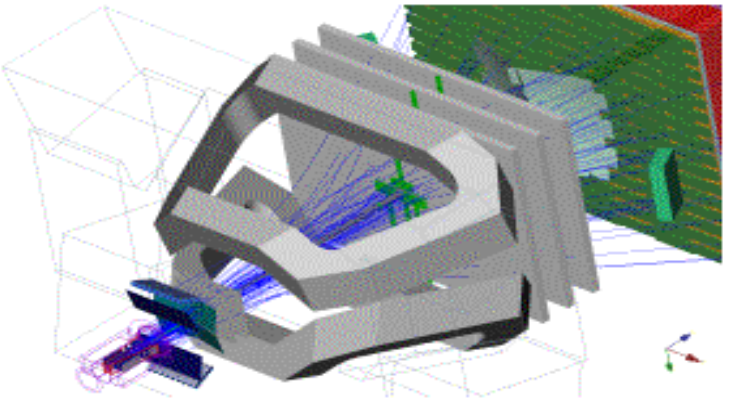
University of Zurich

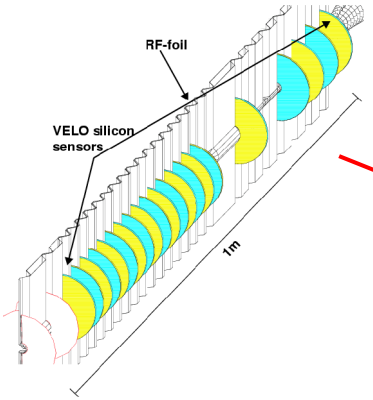
On behalf of the LHCb collaboration

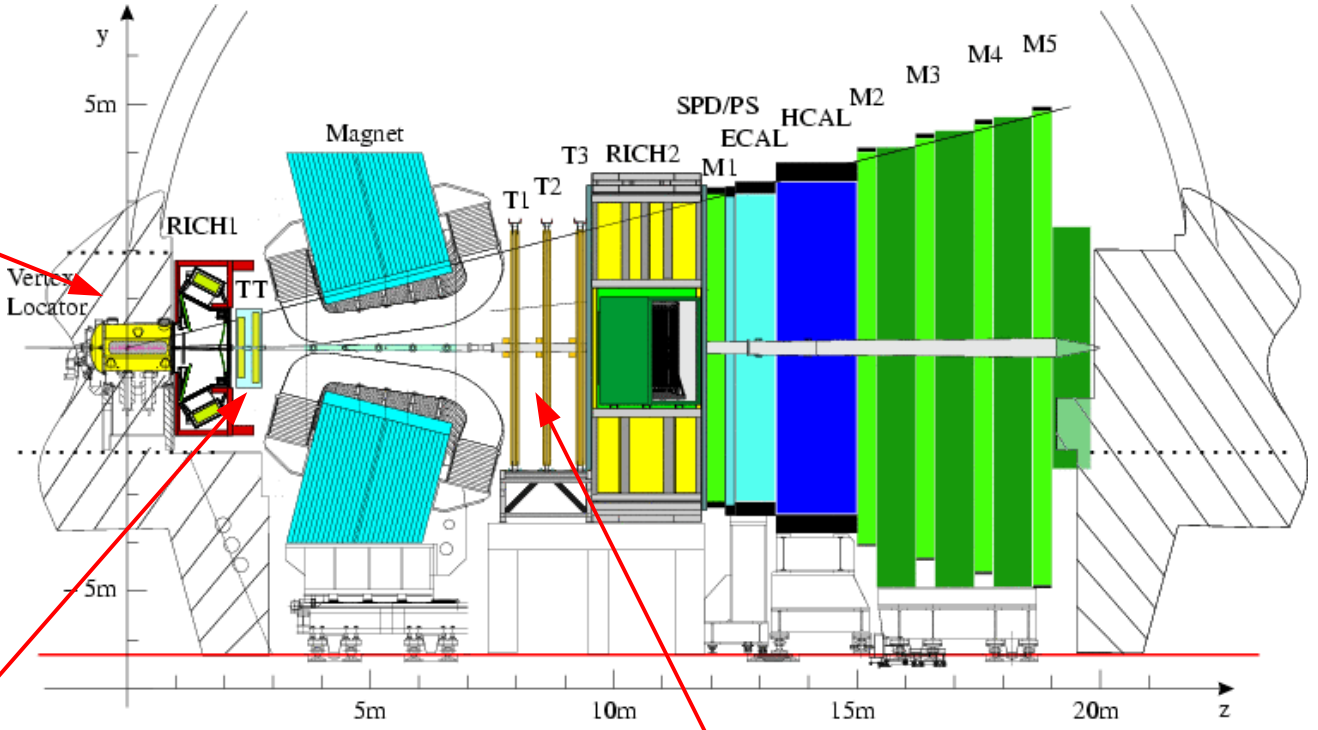


Beauty 2005, Assisi, June 20th -24th

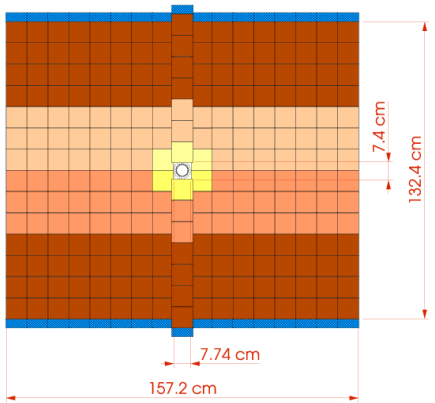
The LHCb Tracking System

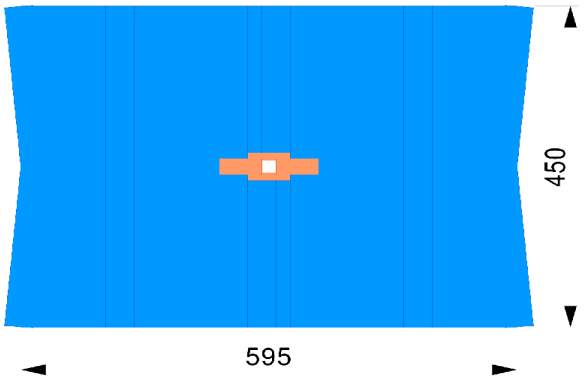
Velo





Trigger Tracker



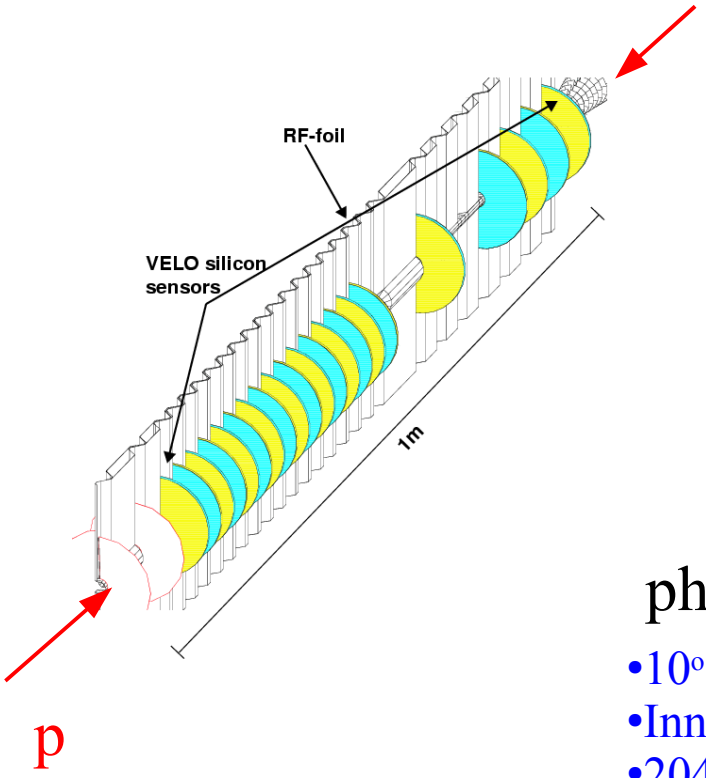


T Stations

- Outer Tracker
- Inner Tracker

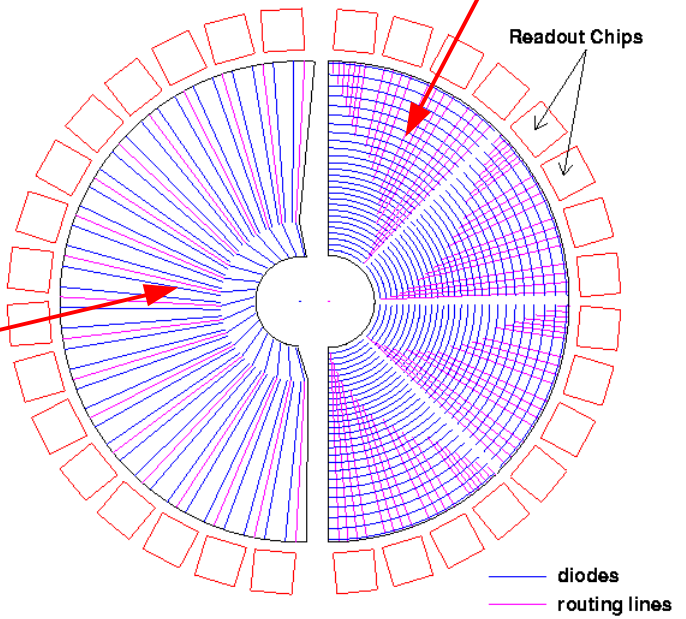
Vertex Locator (VeLo)

- 21 stations
- Each station measures r and phi
- 300 μm thick n-on-n Silicon
- Low occupancy 0.5 %



r sensor

- 4x45° sectors
- 2048 strips
- Pitch: 40 to 100 μm

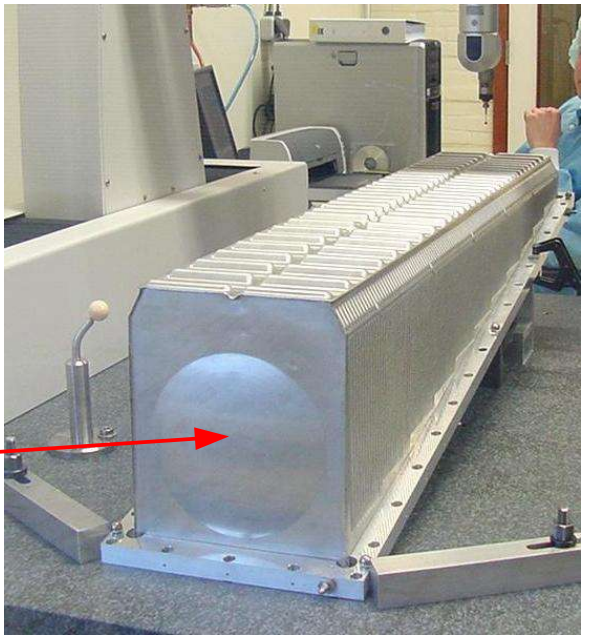


phi sensor

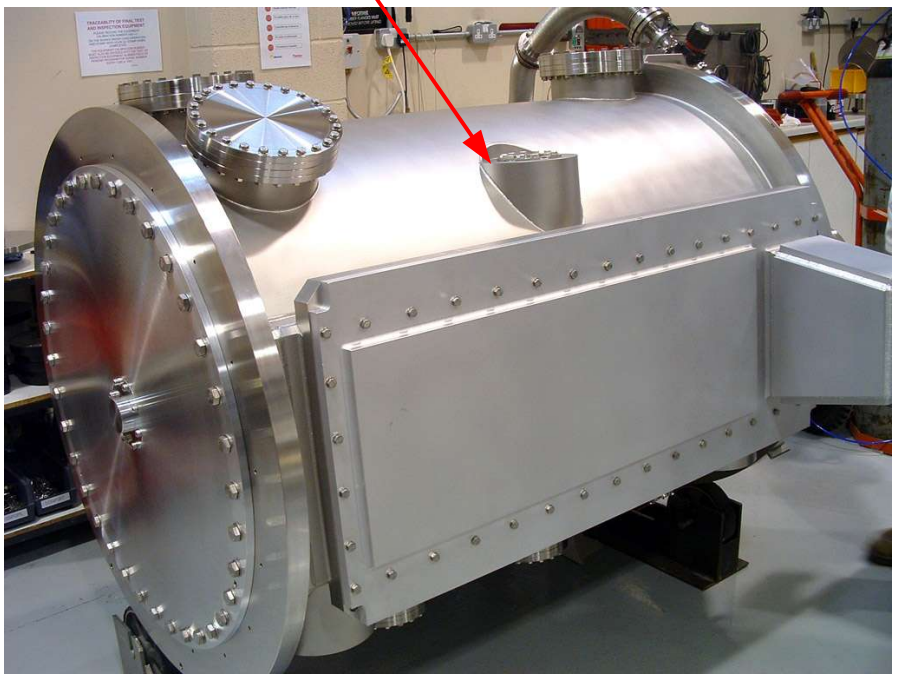
- 10°-20° stereo angle
- Inner and outer region
- 2048 strips
- Pitch: 35 to 100 μm
- Longest strip 2.4 cm

Vertex Locator (VeLo)

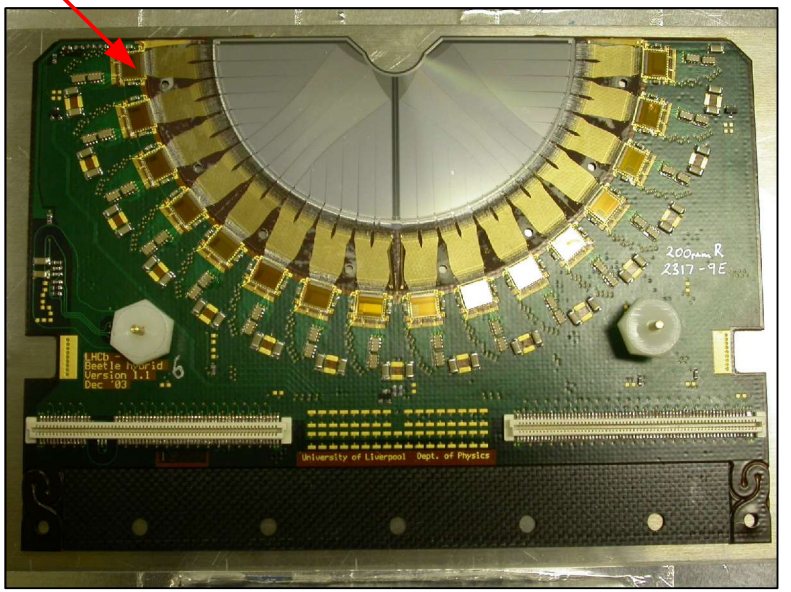
- Construction of Mechanics progressing
- Module production to start soon
- Full system test in 2006 in testbeam at CERN



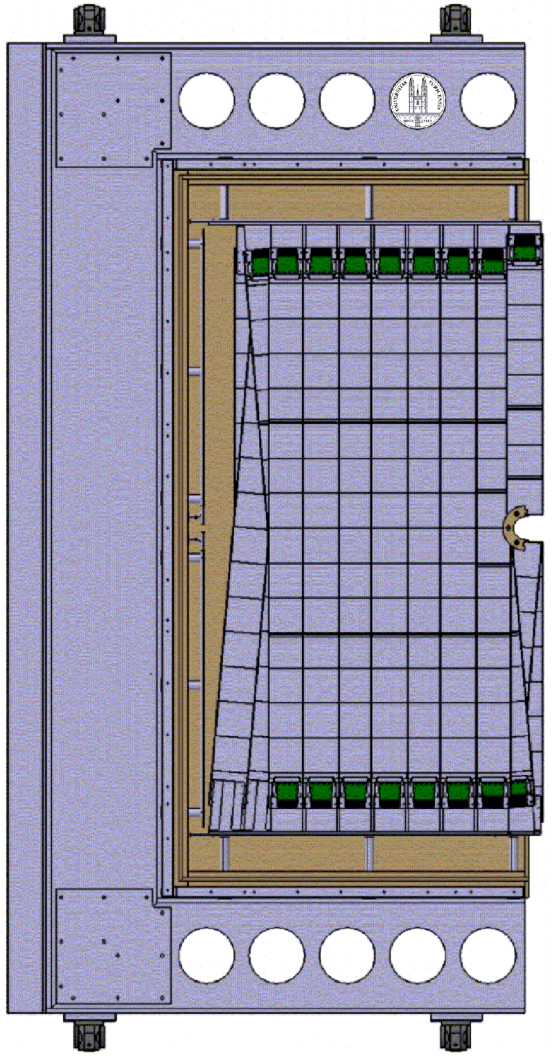
Vacuum vessel



Module



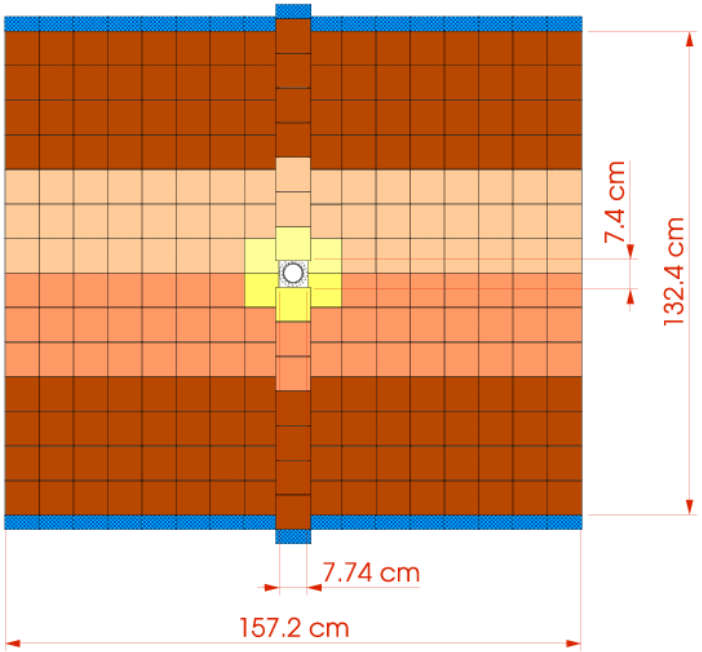
Trigger Tracker (TT)



- Silicon microstrip detector covering full acceptance
- Located in fringe field of magnet pt determination in L1 trigger
- K_s decays after Velo
- 4 layers (0, 5, -5, 0 degrees)
- 14 sensor long ladders L/R of beam-pipe
- 7 sensor long ladders above/below beam-pipe
- Max occupancy 2 %

Sensors CMS-OB2 type

- 500 μm thickness p-on-n
- 183 μm pitch
- 91.57 mm long strips

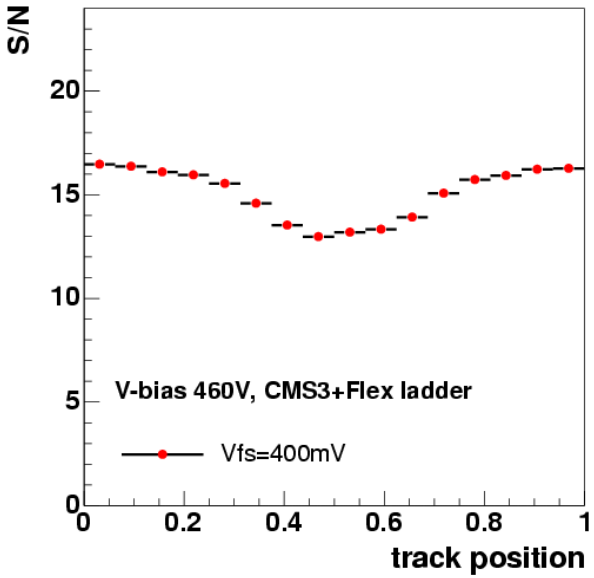


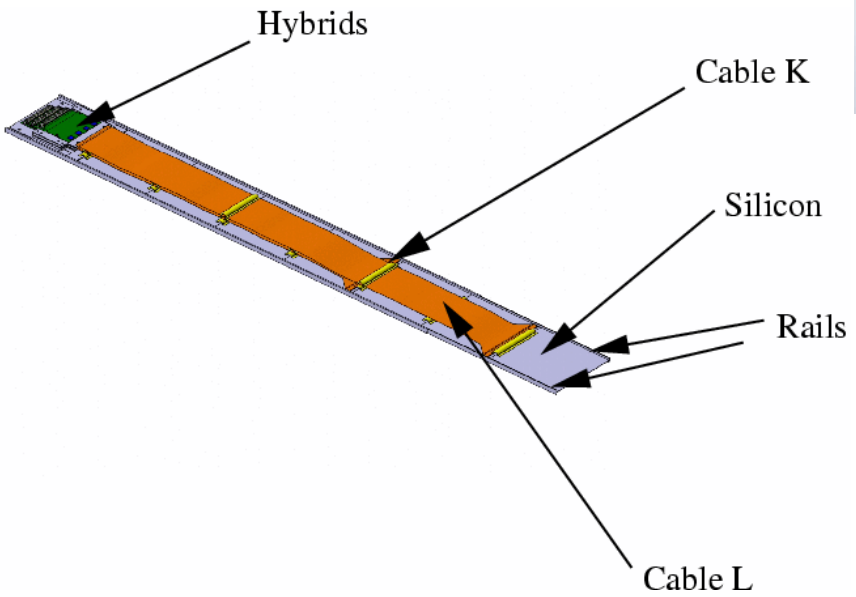
Trigger Tracker (TT)

- All hybrids and cooling outside acceptance
- Long Kapton cable to take out signal
- Capacitive loads up to 57 pF

Status

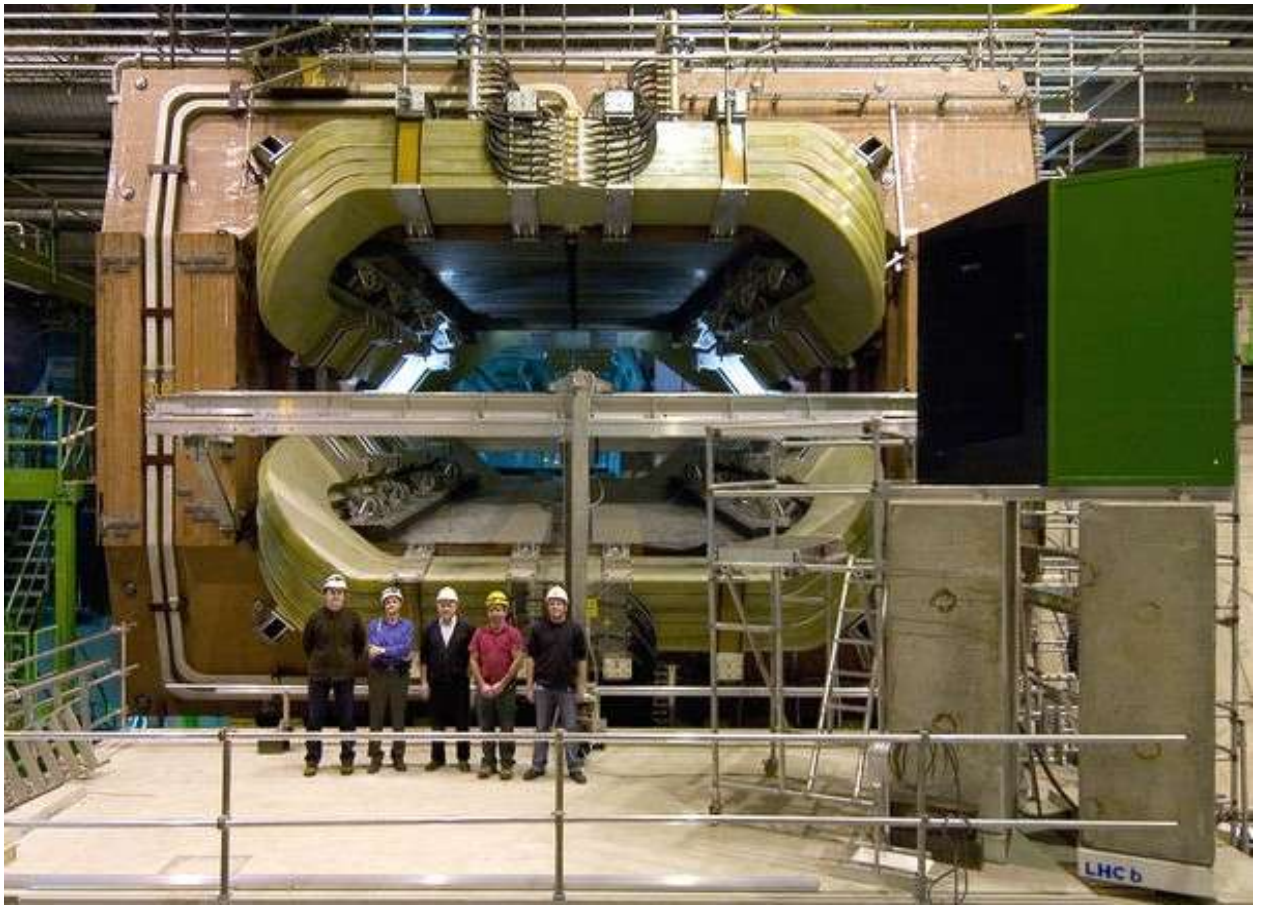
- Final prototypes finished
- Good Performance of prototype ladder in testbeam
- Pre-series of sensors delivered and tested
- Module production starting
- Detector ready for installation in June 2006





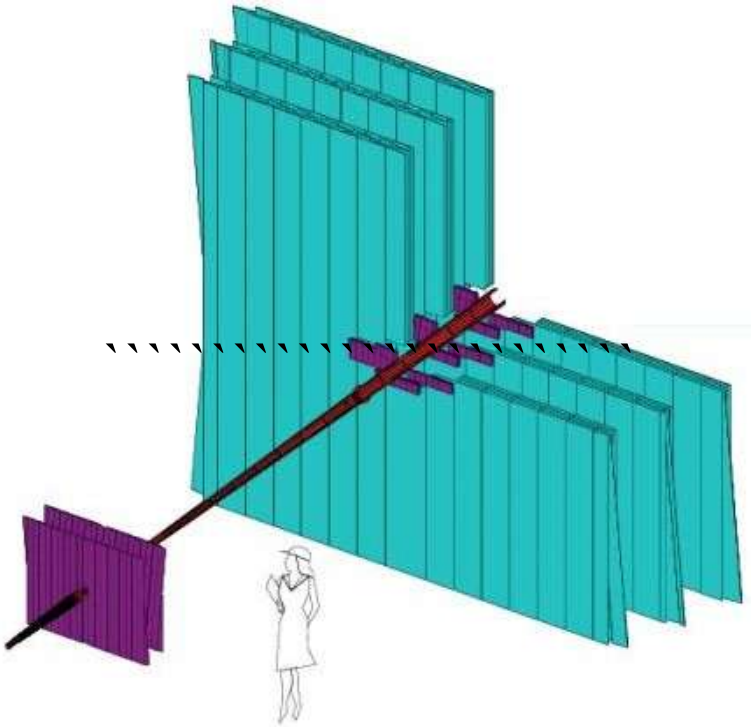
Magnet Status

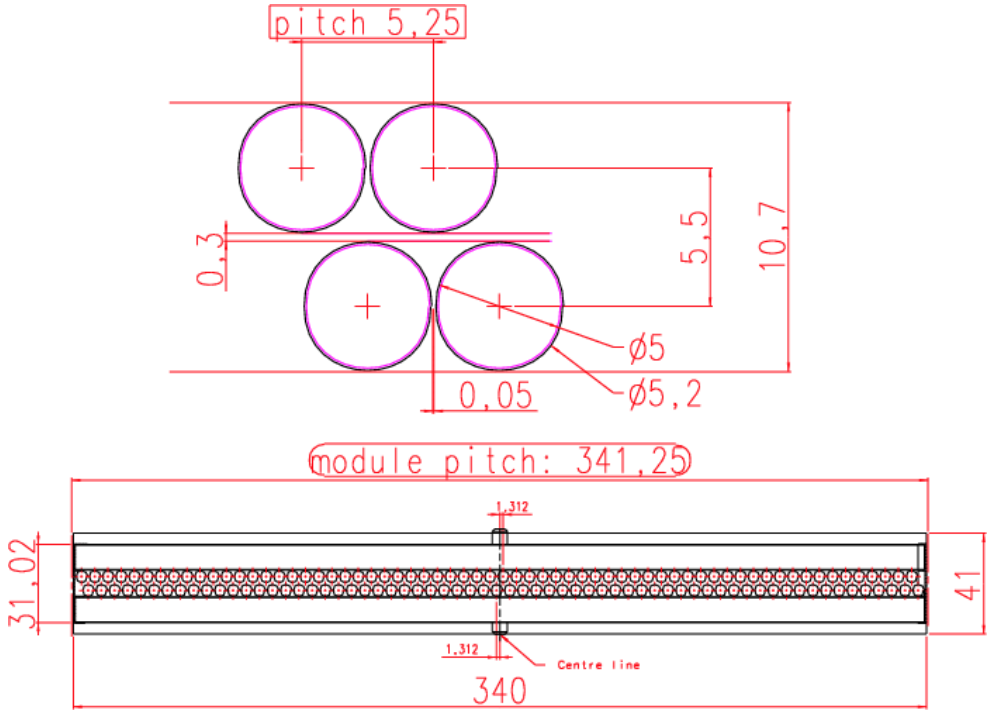
- Warm magnet
- Coils follows acceptance → trapezoidal shape
- Bdl = 4 Tm
- Nominal current achieved Nov '04
- Field mapping campaigns in progress

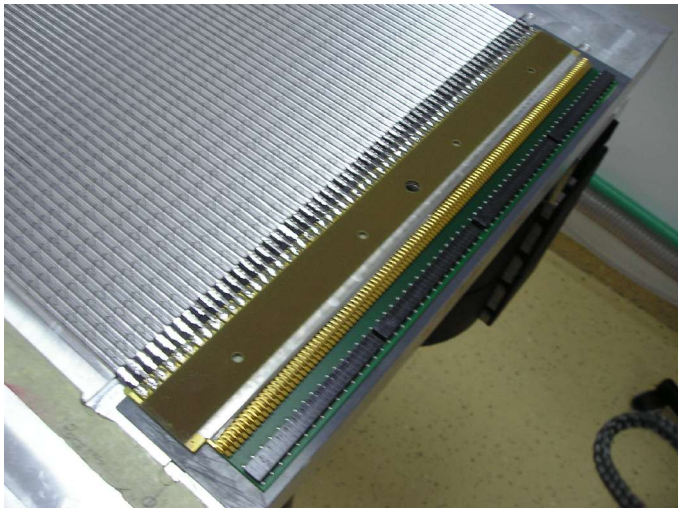


Outer Tracker

- Outer part of 3 stations after the magnet
- Each station 4 double planes of straw tubes
- Largest straws 4.7 m long with two sided readout
- Cell diameter 5 mm , pitch 5.25
- Straws made from Kapton XC with Al winding
- 60 % of modules produced

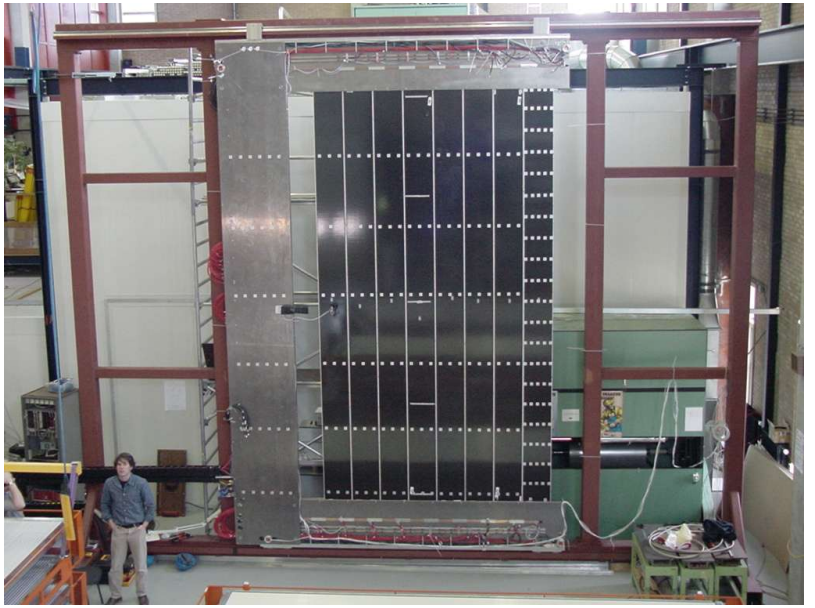




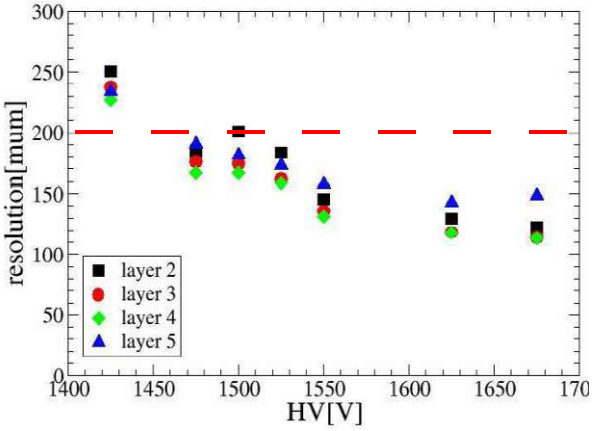


Outer Tracker

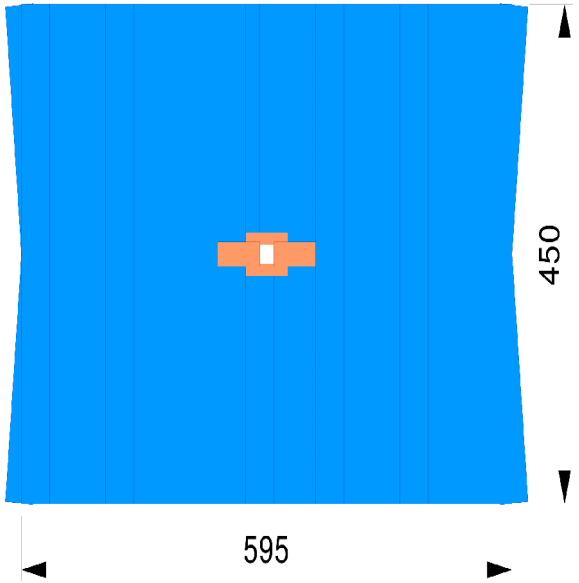
- Medium Scale Test
  - Final modules
  - Prototype frame
  - Mechanic stability of system
  - System integration

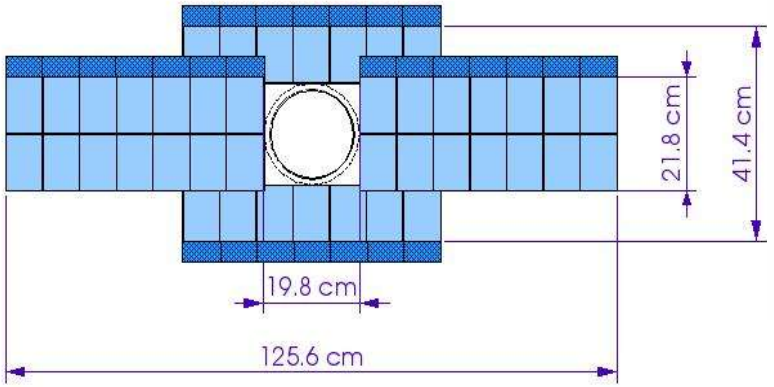


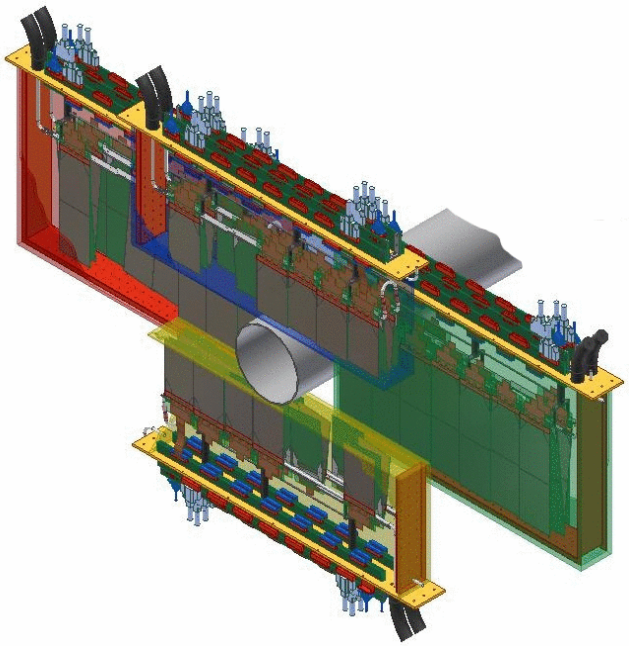
- Test beam with 6 GeV electron beam at DESY
  - Cell efficiency 98 %
  - Resolution better than 200 μm at 1550 V
  - Cross talk 5 %

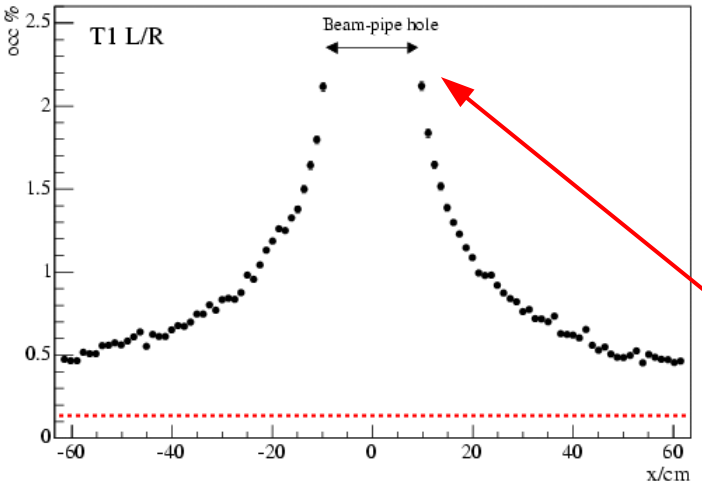


Inner Tracker (IT)





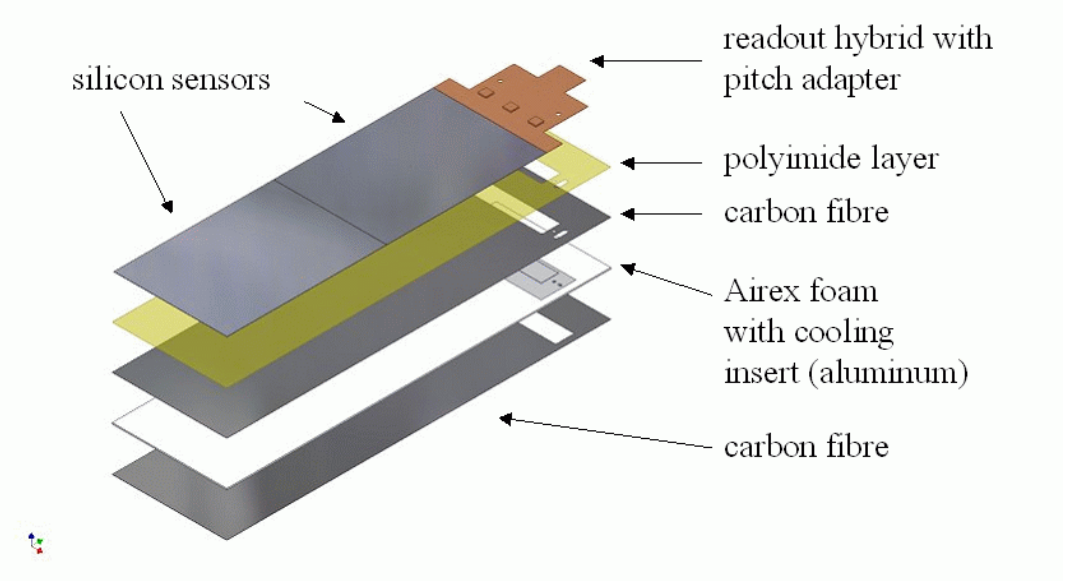




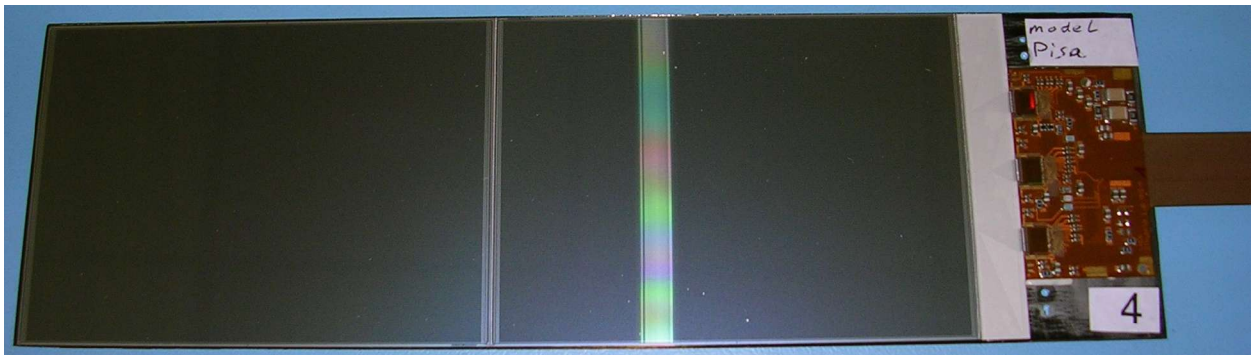
- Innermost part of 3 stations after magnet
- 2 % of the surface area but 20 % of the tracks
- Each station consists of 4 boxes
- Box contains 4 layers (0, 5,- 5, 0 degrees)
- Ladders mounted on cooling rods and operated at 10 °C
- Max occupancy 2.3 %

Inner Tracker (IT)

- Sensors 11 cm by 7.8 cm
- Top/Bottom boxes 320 μm thick Silicon
- L/R boxes 410 μm thick Silicon
- Pitch 198 μm, implant width 50 μm



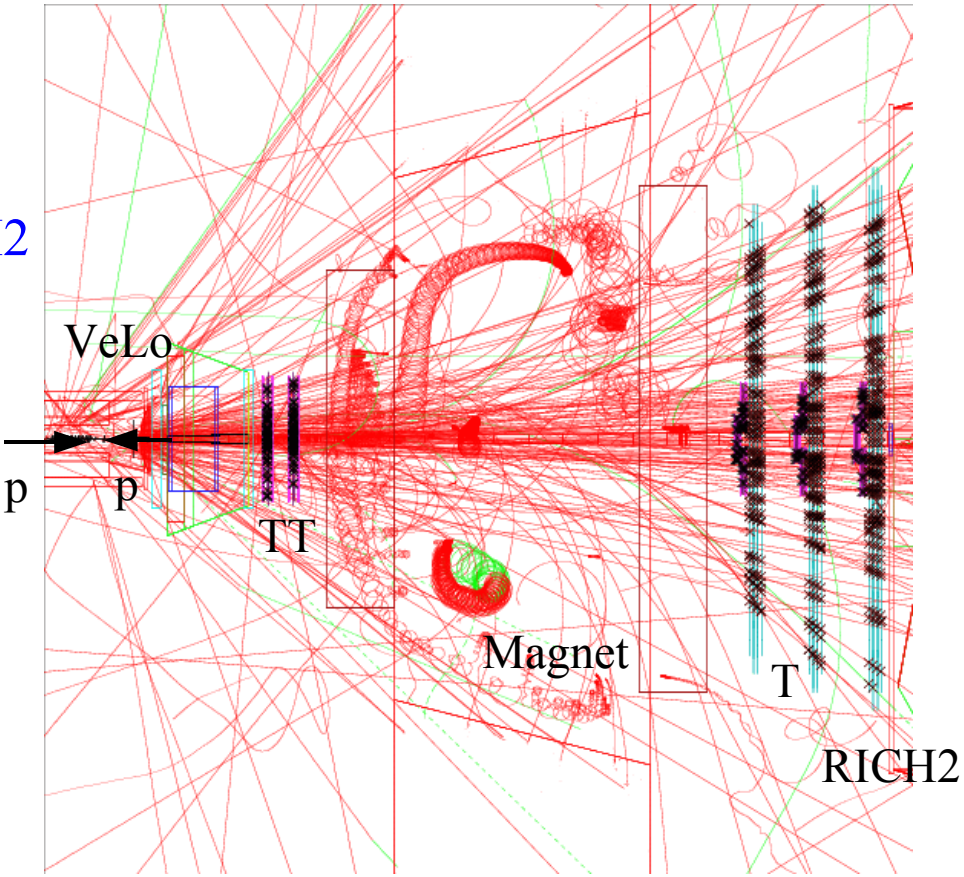
- Pre-series of sensors delivered and tested
- Quality excellent
- Ladder production starting



Tracking Environment

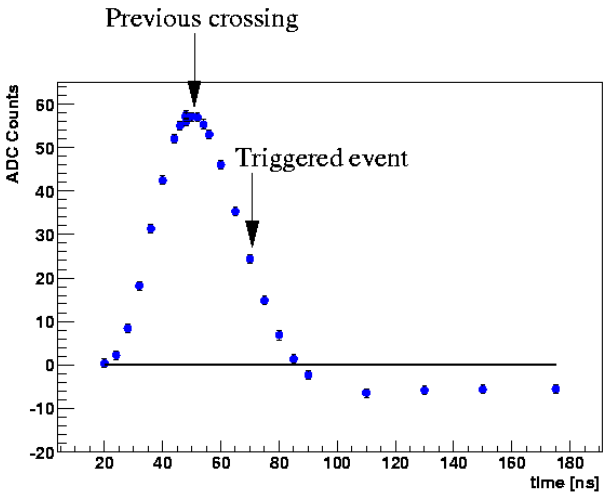
LHCb challenging environment for tracking

- 50 charged primary particles per event
- Particle see 40 % of a radiation length up to RICH2
  - Generation of secondary particles
  - Multiple scattering

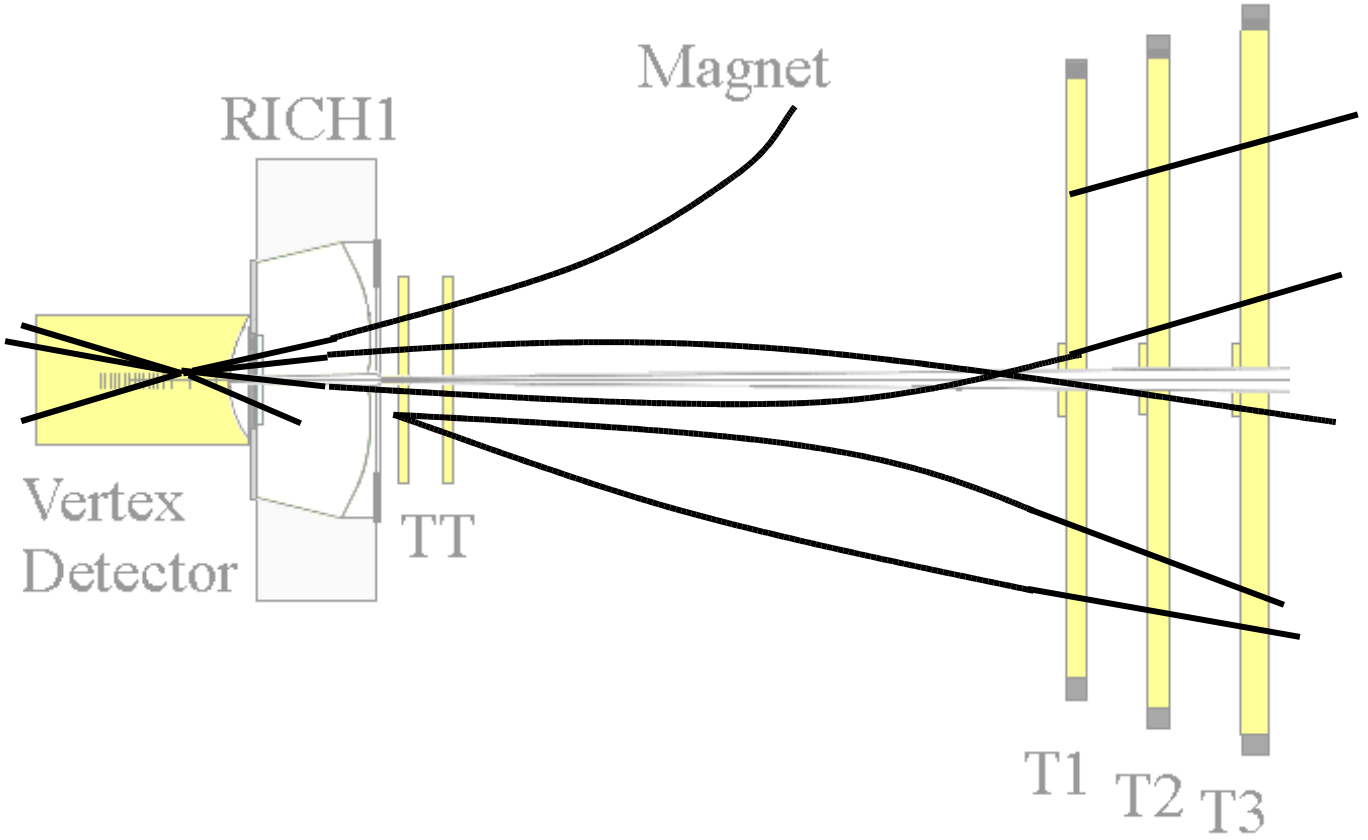


LHC 40 MHz bunch crossing rate

- Spillover signals from previous crossings
- Contribute 10 – 20 % of detector occupancy



Tracking Strategy

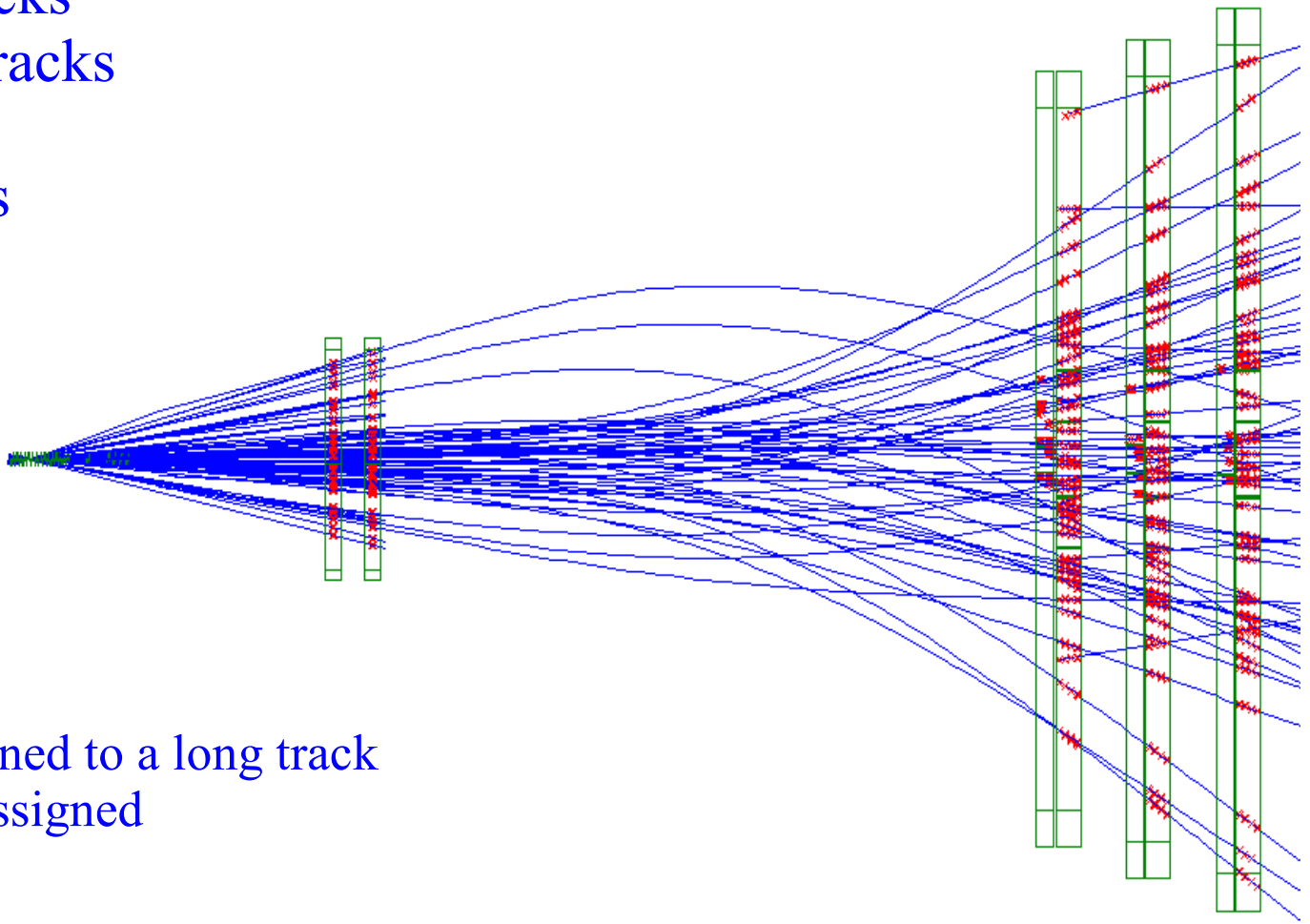


Multiple pass track finding strategy:

- Long tracks that traverse entire detector. Two algorithms:
  - Optical method using Velo tracks as seeds
  - Matching of Velo and T track segments
- Downstream tracks (K_s decaying outside VeLo)
- Upstream tracks (Low p tracks with hits only in VeLo and TT

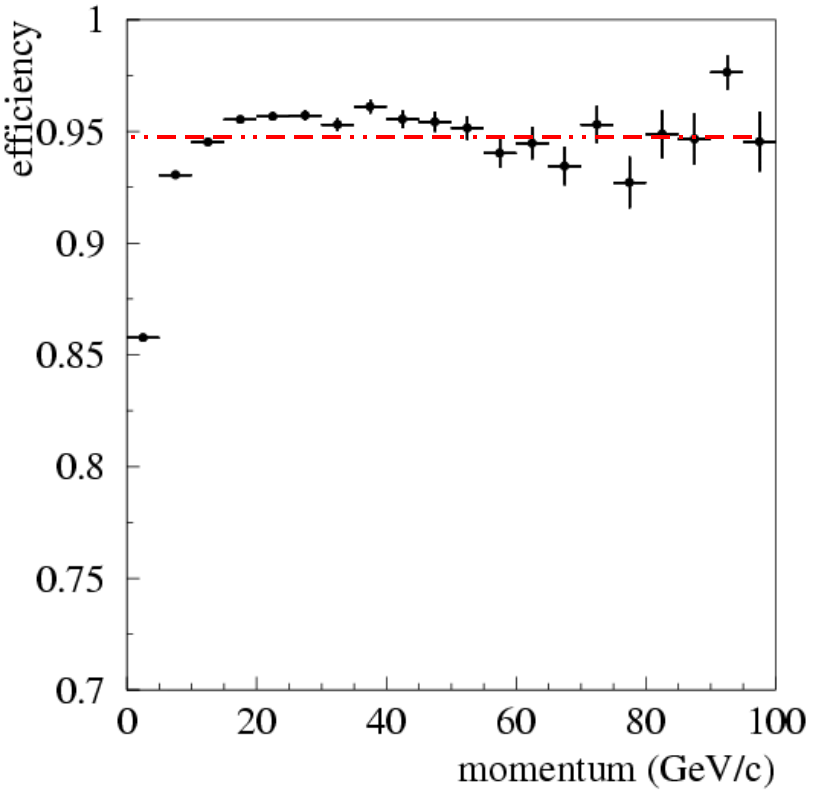
Track Finding results

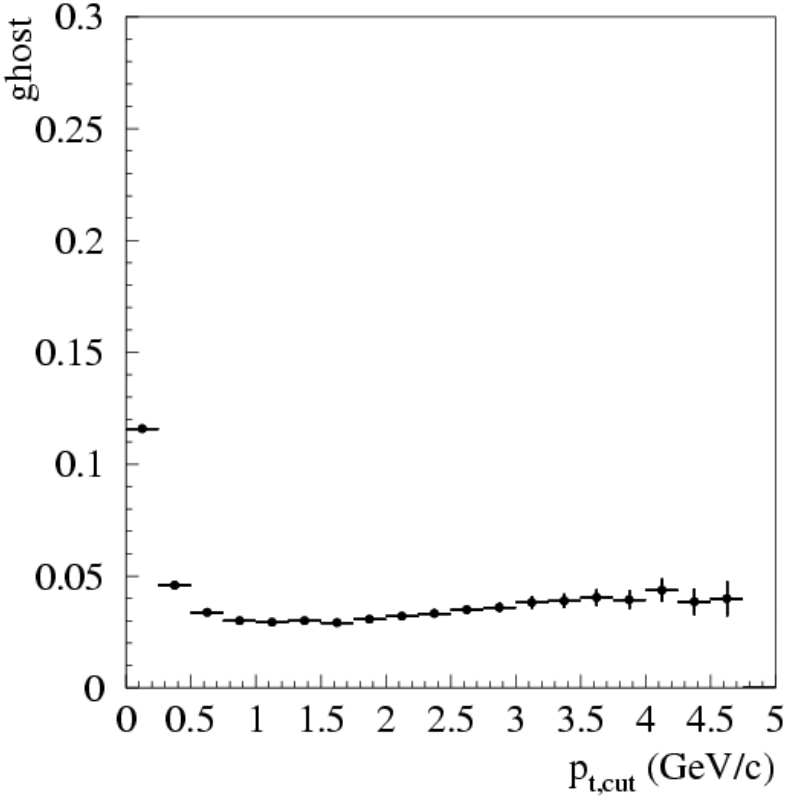
On average:
26 long tracks
11 upstream tracks
4 downstream tracks
5 T tracks
26 VELO tracks



20 to 50 hits assigned to a long track
98.7% correctly assigned

Performance for Long Tracks



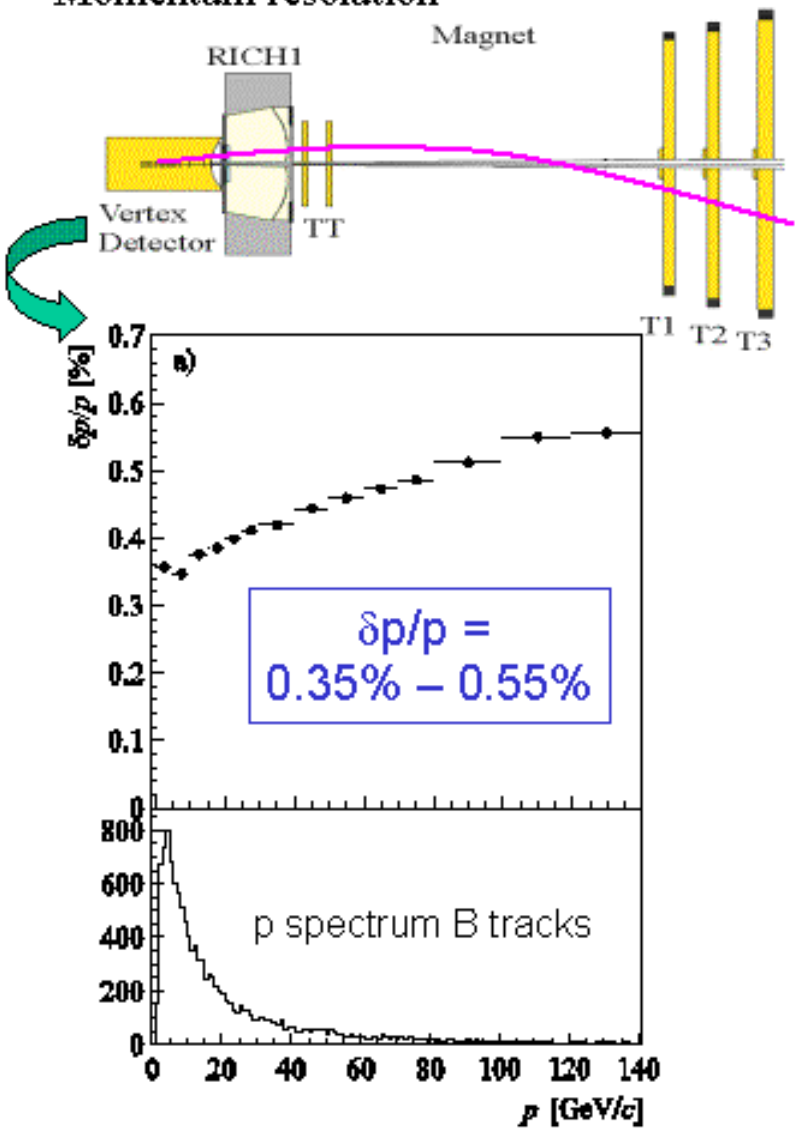


- Efficiency for Long tracks 90 %
- B decay products 95 % (higher p)

- Ghosts mainly at low pt
- Ghost rate 4 % for pt cut > 0.5 GeV

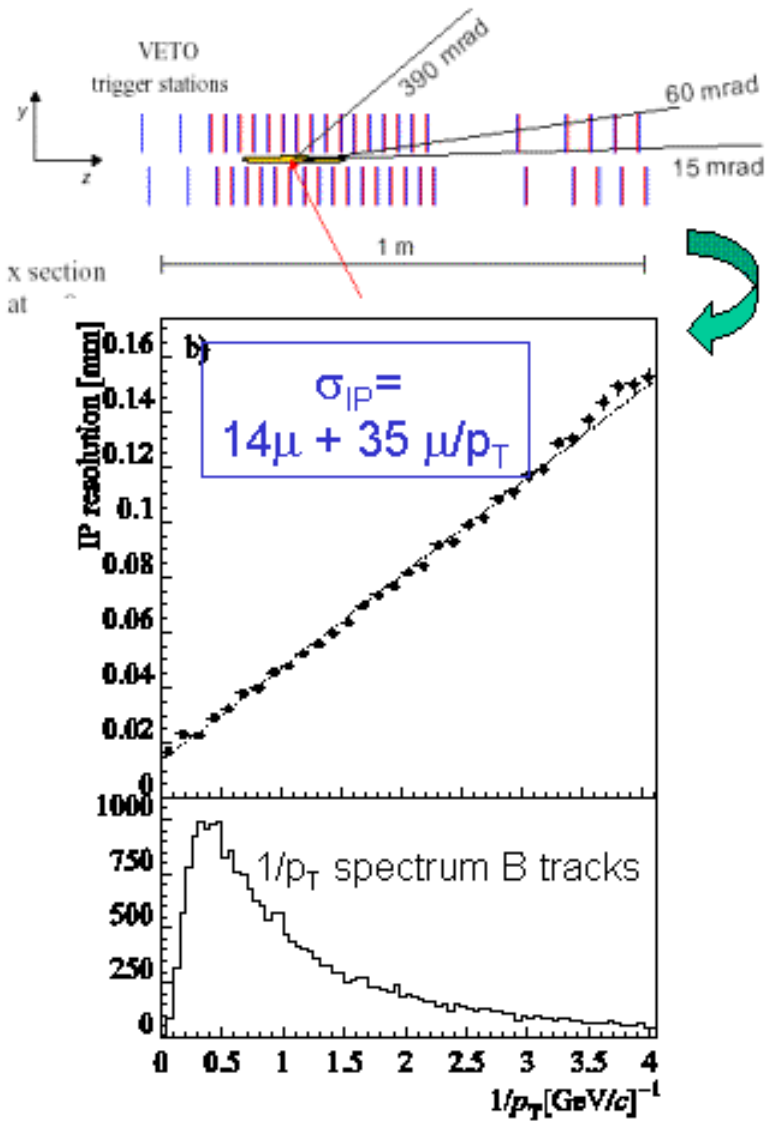
Performance for Long Tracks

Momentum resolution



Resolution dominated by multiple scattering up to 80 GeV

Impact parameter resolution

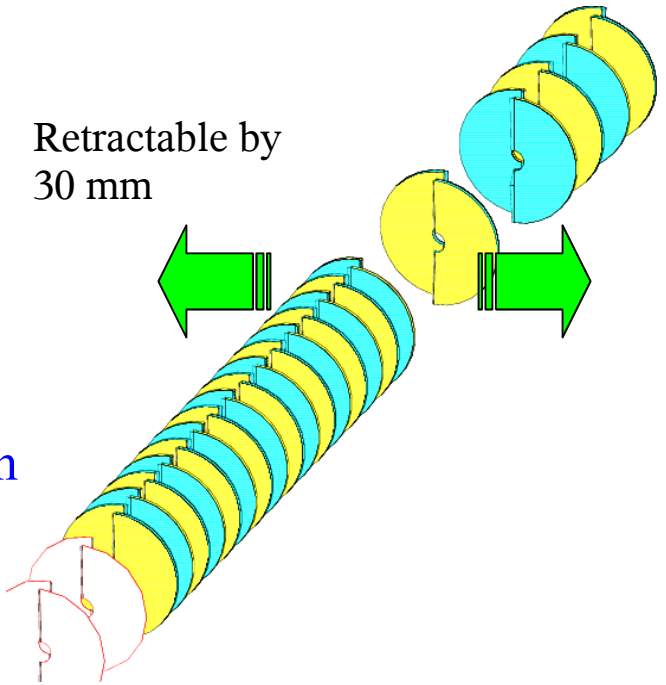


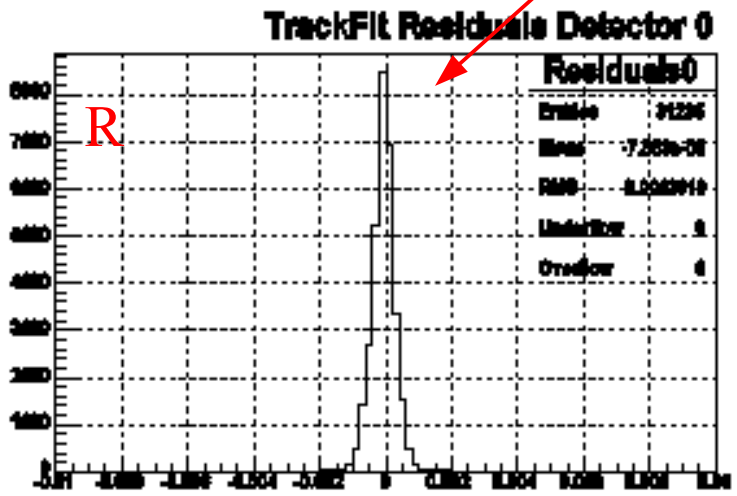
Dominated by material before first measured point

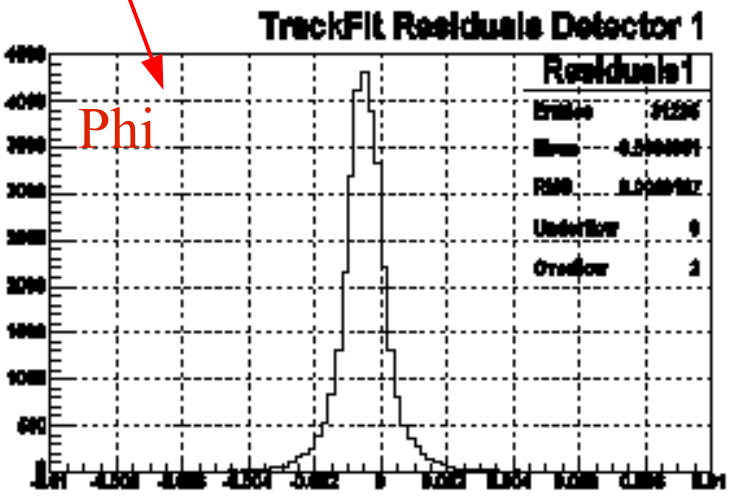
Tracking and Alignment

Next challenge for reconstruction software: Misalignment

- Misalignments should not spoil excellent detector resolution
  - e.g. VeLo inner region resolution 10 μm
- VeLo retracted every fill → must be re-positioned
- For VeLo key ingredient in alignment metrological surveys
  - Testbeam data show gives initial alignment good to few μm
- Studies of software alignment started







Summary

- Construction of the LHCb tracking system advancing
  - Magnet: nominal current achieved
  - 60 % of Outer tracker modules produced
  - Production for silicon detectors about to start
- Detector installation in 2006
- Ready for physics in 2007
- Expected Tracking performance
  - Efficiency for B decay products 95 %, ghost rate 4 %
  - Momentum resolution 3.5 per mille