Detector overview

LHCb is an experiment under construction at point-8 on the LHC collider at CERN. It is conceived to take advantage of the large number of B-mesons (10^{12}/year) produced in the 14TeV proton-proton interactions.

The study of B-mesons depends on efficient resolution of displaced vertices. B-mesons produced at LHC fly several produced in the 14TeV proton-proton interactions.

- **Left-Right staggered in Z**
- **n + in n-bulk sensors**
- **Second metal layer for signal routing**

### Silicon design

- **Baseline VELO design**
  - 21 stations. Each station measures r and φ
  - Left Right staggered in Z
  - n + in n-bulk sensors
  - Second metal layer for signal routing
  - 2048 micro strips per sensor (Over 170 000 channels in total)
  - 35 – 100 µm pitch (To keep occupancy reasonable at low r)

- **Non uniform radiation environment**
  - 1.3 x 10^{14} neq/cm^2/year at r = 8 mm
  - 5.0 x 10^{12} neq/cm^2/year at r = 42 mm

- **Silicon sensor**
  - n-in-p supports sensors
  - 200 – 300 microns thick
  - n-on-p shows most tolerance to radiation damage
  - Needs cooling (< 0º) to minimize radiation damage
  - Bias voltage < 600V (after 3 years of radiation)

- **Front-end analogue read-out**
  - Beetle chip
  - Fast (LHC bunch-crossing freq. = 25ns)
  - Low noise

- **Module production**
  - State-of-the-art silicon detectors, their fast, front-end electronics and the high-precision supports on which they sit are assembled at Liverpool before shipment to CERN. A construction cycle includes:
  - 1. receive and validate components
  - 2. populate hybrids with Beetle FE chips and pitch adaptors (PA)
  - 3. bond back-end of chips to the hybrid and the front-end to the PAs
  - 4. glue n-measuring and s-measuring sensors on double-hybrids
  - 5. bond PAs to sensors
  - 6. glue double-hybrid to carbon-fibre paddle and base
  - 7. final QA, metrology and burn-in

### Successful system test

After 10 years of R&D, the LHCb VELO has taken its first data, seen its first tracks and made its first vertices. The construction of the two VELO halves is now completed. These will be installed in the vacuum tank in 2007. The vacuum tank is already in place in the LHCb experiment.

- **One VELO – half with a complement of 10 modules was operated in a beam of high-energy charged particles for three weeks in November 2006. Two Pb-targets were used to test vertex reconstruction, and to emulate the open and closed VELO.**
- **All major components destined for the final experiment were used, including the software framework. More than 50 millions events on disk.**
- **Measured S/N: 24-29.5 for φ-sensors, and 20-24 for r-sensors.**

### Becoming a reality

The VELO vacuum tank sitting in front of the RICH and the LHCb magnet.

**REAL DATA** taken at 06.17.09 on 19 November 2006

### Physics motivation

At LHCb, the VELO has three vital roles:

1. Trigger on a B decay of interest (the VELO is part of the online software trigger)
2. Suppress multiple interactions (A pile-up veto in the hardware trigger)
3. Track reconstruction: used to seed the tracking in the rest of LHCb.

- VELO tracking can also provide an absolute measurement of the LHC beam’s movement – even when the VELO-chambers are retracted

- Precise vertexing and reconstruction of decays as a function of the B meson’s time of flight (offline reconstruction)

- An example is the measurement of B_s mixing. Because the B_s oscillate very fast, excellent vertexing is required to resolve the time (and, because of the boost at LHC, energies, distance)-dependent decay distribution

### VELO vacuum tank

The VELO vacuum tank sits in front of the RICH and the LHCb magnet.

** counts

1. Precision-made base
2. Module production
3. PCB substrate
4. Cooling unit
5. Aluminium "cookies" are the heat-sink for R-sensors, and 20-24

### Tracking in the rest of LHCb.

- Look for displaced vertices whose momenta sum to the B mass

- B decay vertices: (typically 20-50)
- -sensor: 0 - 10
- -sensor: 8 - 20

- Closest active element
- Beam-pipe
- Maximum opening of the RICH and the LHCb magnet

- RMIN = 8.2 mm
- RMAX = 42.1 mm

- Silicon sensors, front-end analogue electronics and associated cooling units are housed in a secondary vacuum contained by an Aluminium RF-shield

- Each entire VELO-half is mobile. It is required to retract away from the beam-line by 3cm during beam-filling

- Bonding Front-end Beetle chips to hybrid

- Silicon strips
- Readout lines

### Module production

- ‘Dog-leg’ to give a stereo angle
- Low noise
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