The LHCb Outer Tracker

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on behalf of LHCb Outer Tracker community

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Situation of the LHCb detector

Situated at IP8, the current DELPHI pit
LHC parameters at IP8

- **Nominal Luminosity**: $2 \cdot 10^{32} \cdot \text{cm}^{-2}\text{s}^{-1}$
  
  long-term performance basis: radiation damage, ageing

- **Maximum Luminosity**: $5 \cdot 10^{32} \cdot \text{cm}^{-2}\text{s}^{-1}$
  
  limited by detector occupancy and pattern recognition
LHCb detector

- Single-arm spectrometer covering 15 ... 300 mrad

- Total inelastic cross section: 80 mb
  Interaction rate: $1.6 \cdot 10^7 \cdot s^{-1}$ at nominal luminosity

- Dimension in $z$ is $\sim 20$ m
Station orientation

- Good spatial resolution in bending plane

- Pattern recognition in nonbending plane

→ Vertical oriented strips or wires with small stereo angles
LHCb Magnet

- Warm-coil dipole magnet
- Yoke closely follows acceptance
- Bending power is 4 Tm
Momentum resolution

\[ \left( \frac{\Delta p}{p} \right)^2 = 3.2^2 + (0.02^\ast p)^2 \]

\[ \frac{\Delta p}{p} \approx 0.3 - 0.5\% \text{ for } 5 < p < 200 \text{ GeV.} \]

Multiple scattering dominates for spatial resolution of < 200\,\mu m
Division between inner and outer tracker
LHC needs fast detectors

- Signal collection time $< 50$ns
- Fast drift gas: Argon-CF$_4$-CO$_2$ based
- Limited signal path, limited magnetic field
Technology choices

**Outer tracker detector elements**

- Starting point: honeycomb cells as used in HERA-B

- Various considerations led to carbon loaded Kapton as a cathode material

- Detector elements are 5mm diameter straws
Straw tube tests

Ageing tests:

- Foil Robustness
- Ageing tests with X-rays, $\beta^-$ source, low energy protons
- Full-scale prototype in HERA-B
Straw tube tests (2)

- Expected total dose in 10 years of LHCb operation is 2 \ldots 3 \, \text{C/cm}
  
safety factor included

- COMPASS collaboration has positive test results on Kapton XC straws up to 2 \, \text{C/cm} accumulated dose

- Conclusions from ageing tests indicate no serious problems with Kapton XC as a cathode in Ar-CF$_4$-CO$_2$ gas mixture
Preamplifier selection

“Market survey”: only the ASDBLR is a suitable candidate

• Handles high hitrates, fast response by active BLR circuitry

• High sensitivity and low noise

• Designed for radiation hard manufacturing process
Earthing and termination

- Straw tube wall defines electrostatics but is transparent for high frequency signals

- Separate signal transmission path is needed for signal guidance

- Self-shielding straws are under consideration

- Termination might not be needed
How to make an Outer Tracker

Modular construction of the outer tracker
Modular construction of the outer tracker (2)

- Module size: 2 monolayers of 64 straws each

- Long straws need wirelocator

- Straws need to be divided halfway the module

- Module stability is guaranteed by the plate material

- Gas hermiticity is guaranteed by the module, not by the straws

- Design goal: material budget is 2 % of $X_0$ /station
How to make an Outer Tracker

Module prototypes
How to make an Outer Tracker

Beam test results

Efficiency and resolution vs HV
Ar/CF₄/CO₂ = 65/30/5

- Data taken at T7 beam at CERN: 10 GeV/c π⁺
- Gas mixture: Ar-CF₄-CO₂=65-30-5
Beam test results (2)

\[
\text{Ar/CF}_4/\text{CO}_2 = 65/30/5
\]
How to make an Outer Tracker

Beam test results (3)

Single cell efficiencies

Cell efficiency

$U=1.80 \text{ kV}$

$U=1.65 \text{ kV}$
Beam test results (4)

Drift time spectra with different gas mixtures and magnetic fields

mag field, 3 gas mixtures

- 65/30/5
- 75/20/5
- 65/5/30
Conclusion on the results

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<th>Ar/CF₄/CO₂</th>
<th>B=0 T</th>
<th>B=0.72 T</th>
<th>B=1.0 T</th>
<th>B=1.37 T</th>
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<td>65/30/5</td>
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<td>31ns</td>
<td>34ns</td>
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<td>220μm</td>
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<td>190μm</td>
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<tr>
<td>65/5/30</td>
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<td>41ns</td>
<td>43ns</td>
<td>46ns</td>
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<tr>
<td></td>
<td>155μm</td>
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<td>145μm</td>
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</table>
Future steps

- Try different gas mixtures with low CF$_4$ content
- Step to full scale prototypes
- Continue ageing studies

And: Outer Tracker Technical Design Report is due in March 2001