LUMINOSITY AT 3.5 TeV

Luminosity: from number of CALO triggers (LHC stable beams, data sent OFFLINE)

Integrated luminosity [µb⁻¹]

807 µb⁻¹
Trigger Strategy

L0: Based on Calo, Muon and Pile-up

MB triggers: HCAL, SPD, CALO, MUON, Pile-Up ...

c,b triggers: Electron, Photon, Hadron, Muon, Di-Muon, $\pi^0$

Luminosity: Muon, Di-Muon, Beam-Gas

Readout Supervisor: Passes on L0 decision and adds random triggers

- Knows about bunch structure.

HLT: Software based on “everything”

Micro-Bias: At least one track in velo (RZ), or T stations

No-Bias: 100 Hz of random
**Minimum bias:** We can take minimum bias at full rate at the moment

**No bias:** 100 Hz of no bias events (including 1 Hz beam-gas)

**Hlt1:** Standard selections in parallel with pass-all
Magnet Polarity

- We can swap the magnet polarity
  - Important for systematic studies of CP effects
  - So far have taken 10% data with field Up. Will catch up soon

- Primary vertex in Beam Gas events for Beam1 and Beam2
  - z coverage due to velo acceptance
  - Crossing angle due to $B$ field

- Beam profiles used to determine luminous region
  - Luminosity
Magnet Polarity

- We can swap the magnet polarity
  - Important for systematic studies of CP effects
- So far have taken 10% data with field Up. Will catch up soon

3.5 TeV, Field Down
3.5 TeV, Field Off
3.5 TeV, Field Up
450 GeV, Field Down
Velo sensors all powered
99.3% are operational
With 450 GeV beams we could not fully close the Velo
...but we see where the beams are
- Velo closed for the first time on 1. Apr
- Closing procedure now takes routinely < 15 minutes
- Stability in \((X, Y, Z)\) : \((10, 4, 10) \mu m\)
Velo

✅ Hit residuals as expected

MC survey alignment
track alignment
Velo

- Hit residuals as expected
- Align Velo halves using Primary Vertex from each side

$\textit{MC survey alignment}$
$\textit{track alignment}$

$\textit{difference in } x_{PV}$
$\textit{difference in } y_{PV}$
$\textit{difference in } z_{PV}$
**VELO**

- Hit residuals as expected
- Align Velo halves using Primary Vertex from each side
- Impact parameter resolution $\propto 1/p_T$

![Graphs showing IPx and IPy resolutions vs. 1/pT](image)
**VELO**

- Hit residuals as expected
- Align Velo halves using Primary Vertex from each side
- Impact parameter resolution $\propto 1/p_T$
- Decay length as expected

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**two-prong decay length**

- Graph showing data and MC for two-prong decay length at 7 TeV, with a peak around 0 mm.

**Highest Mass 2-prong**
Silicon Trackers

- >99.5% TT and IT channels operational.
- Signal to noise ratio as expected
- Alignment ongoing.
  - Still something to gain:
  - Residual width is 65 $\mu$m. MC expectation is 50 $\mu$m

![Graph of residuals for TT and IT channels]
Outer Tracker

- Detector is 100% efficient and running at nominal threshold with low noise.
- $O_2$ was added to the gas mixture in order to mitigate ageing effects. No effect on hit efficiency is observed.
- Space vs drift-time relation fits expectation from test beam.
- Alignment is getting close to MC.

hit efficiency versus distance

No effect caused by addition of $O_2$

Drift-time space relation ($R(t)$)

Residuals [mm]

Patrick Koppenburg

LHCb Status Report

101st LHCC — 5 May 2010 [15/39]
Long Tracks (Velo & T stations)

- Good agreement between data and MC
Zoology 1 — $K^0_S$, $\Lambda$, $\Xi$, $\Omega$

$K^0_S \rightarrow \pi\pi$
$\sigma = 6.6$ MeV

$\Lambda \rightarrow p\pi$
$\sigma = 2.8$ MeV

$\Xi \rightarrow \Lambda\pi$
$\sigma = 2.5$ MeV

$\Omega \rightarrow \Lambda K$
$\sigma = 2.8$ MeV
2009 data — Open Velo

XY projection

\[ K_0 \text{ mass} = (491.8^{+6.0}_{-6.0}) \text{MeV/c}^2 \]
\[ \text{momentum p} = 37.96 \text{ GeV/c} \]
\[ \text{pt} = 2.00 \text{ GeV/c} \]
\[ \text{decay length} = 475.74 \text{mm} \]
\[ \cos(\alpha) = 0.99987 \]

YZ projection

- \( 6.8 \pm 1.0 \mu b^{-1} \) at \( \sqrt{s} = 900 \text{ GeV} \) with Velo 15 mm from nominal position
- We have taken \( \mathcal{O}(300 \mu b^{-1}) \) this week-end with Velo 10 mm from nominal position and both magnet polarities
**K_{s}^{0} Production at \( \sqrt{s} = 900 \text{ GeV} \)**

- Measure \( K_{s}^{0} \) without using VeLo
- \( K_{s}^{0} p_{T} \) distributions in 3 rapidity bins
- Compare to Pythia 6.4 with Perugia0 tuning
- Luminosity determined through LHCb measurement of beam-beam and beam-gas profile
  - Achieved 15% precision (dominant uncertainty LHC currents)
- \( \Lambda, \bar{\Lambda} \) and \( p, \bar{p} \) also in the pipeline
RICH1 and RICH2 being aligned wrt tracking system

- Nice kaon and pion rings seen in both systems
Zoology 2: $\phi$ and $K^*$

$\phi \rightarrow KK$ ('09)

$K^* \rightarrow K\pi$

$\phi \rightarrow KK$ ('10)
Zoology 3: $D \rightarrow K\pi$ and $D^*$

Untagged $K\pi$ mass

$LHCb$ Preliminary

$\sqrt{s} = 7$ TeV Data

$N_{\text{raw}} = 1530 \pm 46$

Mass $\mu = 1663.30 \pm 0.27$ MeV/$c^2$

Mass $\sigma = 0.24$ MeV/$c^2$

Tagged $K\pi$ mass

$LHCb$ Preliminary

$\sqrt{s} = 7$ TeV Data

$N_{\text{raw}} = 389 \pm 22$

Mass $\mu = 1653.63 \pm 0.49$ MeV/$c^2$

Mass $\sigma = 0.41$ MeV/$c^2$

$m_{K\pi}$ vs $\Delta m$

Tagged $K\pi$ mass

$LHCb$ Preliminary

$\sqrt{s} = 7$ TeV Data

$N_{\text{raw}} = 255 \pm 19$

Mass $\mu = 145.466 \pm 0.057$ MeV/$c^2$

Mass $\sigma = 0.743 \pm 0.050$ MeV/$c^2$

$\Delta m$
Zoology 3: $D \rightarrow K\pi$ and $D^*$

Untagged $K\pi$ mass

Tagged $K\pi$ mass

$m_{K\pi}$ vs $\Delta m$

$m_{K\pi}$ with $\Delta m$ cut

$\Delta m$

$\Delta m$ with $m_{K\pi}$ cut
Zoology 3: $D \rightarrow KK$ and $D^*$

Untagged $KK$ mass

$m_{KK}$ vs $\Delta m$

$m_{KK}$ with $\Delta m$ cut

Tagged $KK$ mass

$\Delta m$

$\Delta m$ with $m_{KK}$ cut
Proton-ID efficiency and mis-ID using protons from $\Lambda$$$

We will use tagged $D \rightarrow K\pi$ decays to calibration kaon-ID: work ongoing

$\Delta \log L(p - \pi) > 0$
**Zoology 4: $D^+, D_s^+, \Lambda_c$**

### $D \rightarrow KK\pi$

- **$D^+$**: $N_{\text{signal}} = 48 \pm 8$
  - $m_0 = 1866.1 \pm 1.0 \text{ MeV}/c^2$
  - $\sigma_{\text{Gauss}} = 5.3 \pm 0.8 \text{ MeV}/c^2$

- **$D_s^+$**: $N_{\text{signal}} = 59 \pm 8$
  - $m_0 = 1968.3 \pm 1.0 \text{ MeV}/c^2$
  - $\sigma_{\text{Gauss}} = 6.3 \pm 0.8 \text{ MeV}/c^2$

### $D^+ \rightarrow K\pi\pi$

- **$\Lambda_c \rightarrow pK\pi$**

- **$\Lambda_c$**: $N_{\text{signal}} = 51.1 \pm 9.5$
  - $m_0 = 2296.1 \pm 0.72 \text{ MeV}$
  - $\sigma_{\text{Gauss}} = 3.67 \pm 0.79 \text{ MeV}$

**Patrick Koppenburg**

LHCb Status Report

101st LHCC — 5 May 2010 [26/39]
Zoology 5: $D^0 \rightarrow K\pi\pi\pi$

Untagged $K\pi\pi\pi$

$\Delta m$

$m_{K\pi\pi\pi}$ with $\Delta m$ cut
Calorimetry

- The calorimeters systems work very effectively, providing the principal trigger at LHCb.
- Time alignment now 1 ns.
- PS/SPD calibration using MIPs.
- ECAL Energy calibration ongoing. Need 50M events to achieve 1% with $\pi^0$.

$e^\pm \frac{E}{p}$ (conversions)
Zoology 6: Using $\pi^0$

$\eta \rightarrow \pi\pi\pi^0$
$\sigma = 17$ MeV

$\omega \rightarrow \pi\pi\pi^0$
$\sigma = 52$ MeV

$\chi^2 / \text{ndf} = 7.951 / 15$
$\text{Prob} = 0.9257$
$\text{Nb} \eta = 458.4 \pm 53.9$
$\mu = 547.2 \pm 1.9$
$\sigma = 16.64 \pm 1.92$
$\text{Constant} = -273.8 \pm 11.1$
$\text{Quad Term} = 0.001426 \pm 0.000044$

$D^0 \rightarrow K\pi\pi^0$
$\sigma = 40$ MeV
Muons works very well. Now tuning muon-ID.
Not enough $J/\psi$ to measure $\mu$-ID efficiency.
$K_S^0$ and $\Lambda$ used as a clean samples of $p$ and $\pi$.

Proton Mis-ID: $(0.18 \pm 0.02)\%$. MC: $(0.21 \pm 0.04)\%$.
Pion Mis-ID: $(2.38 \pm 0.02)\%$. MC: $(2.34 \pm 0.02)\%$.

$\rho \rightarrow \mu$

$\pi \rightarrow \mu$
Zoology 7: $J/\psi \rightarrow \mu\mu$

LHCb Preliminary
$\sqrt{s} = 7$ TeV Data

$N_{\text{Signal}} = 128 \pm 13$

$m_0 = 3093.6 \pm 1.6$ MeV/c$^2$

$\sigma_{\text{Gauss}} = 14.1 \pm 1.4$ MeV/c$^2$
Very Nice Peaks!

...but we're a B physics experiment...
B+ CANDIDATE
Well identified muons and kaon.

- $m_{J/\psi} = 3097.90$ MeV, $m_{B^+} = 5319.90$ MeV
- Proper time $= 0.6 \text{ ps}$ (26 $\sigma$ from PV)
- Angle of flight and momentum of $B^+ = 0.7^\circ$
Looking at \( D \to KK\pi \) with a \( \mu \) tag forming a secondary vertex

Classify by \( KK\pi \) mass

3 Candidates:

- One background
- One \( B_d \to D^+\mu\nu \)
- One \( B_s \to D_s\mu\nu \)
Offline Computing

- Data processing chain works well. Several reprocessings already done.
- New data is distributed to the Tier1s
- Some issues with Tier1 stability regarding storage
  - So far CERN had highest share of CPU
- 2010 Simulation campaign will start soon
LHCb Trigger (2010)

- Hardware-based L0 trigger: moderate $p_T$ cuts: 40 MHz $\rightarrow$ 300 kHz
- The whole data is sent at up to 300 kHz to a farm of $\mathcal{O}(500)$ CPUs
- HLT1 tries to confirm a L0 decision by matching the L0 candidates to tracks. $\rightarrow \mathcal{O}(10 \text{ kHz})$

- HLT2 does the full reconstruction and loose selection of $B$ and $D$ candidates $\rightarrow$ 2 kHz
  - This is less than the $b\bar{b}$ rate
Trigger Outlook

- Can write up to 2 kHz. Did not yet have to cut...
- Soon will need to switch on Hlt1
  - IP resolution under control
  - $\mu$ efficiency being monitored
  - L0xHlt1 efficiency on unbiased $D^*(60 \pm 4)\%$
    (MC: 66\%)
- Then will need Hlt2

<table>
<thead>
<tr>
<th>Collisions</th>
<th>L0</th>
<th>Hlt1</th>
<th>Hlt2</th>
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<td>&lt; 300 kHz</td>
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Conclusion

- LHCb in a good shape
- Some more work needed to iron out small problems
- We see all the particles we expect to see
  - Including B mesons!
  - V0 analyses on their way to publication
- Future prospects for B and c-physics: See Guy Wilkinson’s talk this afternoon.