Status of the LHCb experiment

Andrey Golutvin (Imperial College & ITEP & CERN) on behalf of the LHCb Collaboration

Outline:

- Subsystems
- LHCb operations
  - At the Pit
  - Data processing & Computing
- Detector performance
- Physics results from 2010
- Preparation of the LHCb upgrade
- Financial and collaboration matters
LHCb operation

LHCb limitations:

✓ limit the number of visible pp-collisions/bunch crossing to \( \mu_{\text{max}} \sim 2 \) (2.5 at start-up)
✓ limit the peak luminosity to \( L \sim 3 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1} \)

→ need to increase number of bunches to \( \geq 700 \) to reach “nominal” LHCb luminosity
→ luminosity leveling essential to keep \( \mu \) and lumi to optimal value
→ will run with flat luminosity throughout most of the year, so cannot “catch-up” on integrated luminosity during the year
→ need to continue to increase number of bunches (even at nominal lumi) to reduce \( \mu \)
→ expect \( \geq 200 \text{ pb}^{-1} \) by end of June and \( \sim 1 \text{ fb}^{-1} \) by the end of 2011
March 2011

Detector status

Efficiency (channels)

- Muon system 2.5: 99.9%
- Muon station 1: 99.78%
- Hadron Calorimeter: 99.93%
- Electromagnetic Calorimeter: 100%
- PreShower: 100%
- Scintillator Pad Detector: 100%
- RICH 2: 99.79%
- Outer Tracker: 98.68%
- Inner Tracker: 100%
- RICH 1: 99.8%
- Tracker Turicensis: 99.29%
- Vertex Locator: 100%

Note that for the RICHes the "channels" are given in HPDs.
Activities during 2010 / 2011 Technical Stop

- **Silicon Tracker**: Exchange and repair of modules with broken bonds
- **RICH**: Replacement of ~7% of HPDs
- **Outer Tracker**: Repair FE, disconnect a few broken channels
- **CALO**: Replacement of a few PMTs
- **MUON**: Replacement of a few non-fully operational chambers

Overall very small changes in the detector

Major improvement of the HLT farm

HLT: Addition of 100 boxes (400 nodes) for a total of 50 subfarms × 27 nodes × (8 to 20) HLT tasks running = 24600 HLT tasks!

A lot of work also on infrastructure, maintenance and safety.
Detector related concerns & Plans

- **Breaking (at a low frequency) VCSELs**
  - Order new VCSELs of a different production type and test these under radiation

- **High current in some Tracker Turicensis modules**
  - Careful monitoring of the problem
  - Continue further investigation in situ and on a test module

- **Uncertainty in the long term behavior of the gain loss in the Outer Tracker remains main concern**
  - Periodic threshold / HV scans in order to measure 2D gain maps and monitor aging effects

- **Design and construction of the aerogel box**

- **Complete the VELO spare during first half of 2011**
Status of Aerogel (RICH 1)

The Box:
- Company found that promised to respect the specification
- The same for the O-ring to be placed between the window and the carbon fiber box
- A couple of month to receive the prototype
- Pressure tests for this box will then follow
- Engineering Review envisaged for May 2011

Very fresh results: Data taken with CO₂ as radiator:

Alignment for the tracking not yet done
→ can not give numbers now, but improvement clearly visible!
Operations at the LHCb Pit

- **LHCb detector is fully operational and in good shape**

- **LHCb detector is efficiently operated by only two people on duty** (complemented by weekly experts-on-call for each subsystem). Weekly appointed “Run Chief” oversees the global strategy for data taking. *LHCb central shifter situation is acceptable but requires attention during the year*

- **High Level Trigger framework completely revised to improve reliability and speed**

- **“Luminosity leveling” is vital for LHCb in order to maximize integrated luminosity collected in the optimal conditions.**
  - Highest priority is given to its commissioning
  - Looks very encouraging!
A total of 155 TB of raw data collected in 2010

Reconstruction and stripping of raw data done at Tier1 sites (50% user jobs, 25% simulation, 25% reconstruction)
The CPU usage efficiency – 85% at Tier1 and 90% at Tier2

Several reconstruction and stripping cycles (more than foreseen in steady state)

Computing model has been updated to accommodate changing running conditions. The average event sizes increased by 60% and the trigger output rate by 50%

Shortfall in CPU and disk space resources in 2011 / 2012
→ Delay in processing
→ Require additional resources in 2012, in particular disk space
Detector performance

LHCb detector is ready for the core measurements in 2011!

- Flexible and efficient trigger
- Vertex and Impact Parameter (IP) resolution
- Tracking & PID
- Proper time resolution
- Flavour tagging
*Trigger*

**L0**

**Trigger efficiencies very close to expectations**

<table>
<thead>
<tr>
<th></th>
<th>Muon trigger ($J/\psi$)</th>
<th>Hadron trigger ($D^0$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data</strong></td>
<td>94.9±0.2%</td>
<td>60±4%</td>
</tr>
<tr>
<td><strong>MC</strong></td>
<td>93.3±0.2%</td>
<td>66%</td>
</tr>
</tbody>
</table>

*Physics analysis*

**LHCb trigger is fully functional and was capable to cope with harsh running conditions in 2010**

**The extension of LHCb physics programme to accommodate charm physics requires higher trigger output rate of 3 kHz**
Primary Vertex (PV) & Impact Parameter (IP) resolution

Best IP resolution ~15 \( \mu m \)

Primary vertex resolution:
~ 15 (75) \( \mu m \) in transversal (longitudinal plane)
Tracking: excellent mass resolution demonstrated

Evolution of $J/\psi \rightarrow \mu^+\mu^-$ mass resolution with time ($MC \sim 12 \text{ MeV}/c^2$)

May: $\sigma \sim 18 \text{ MeV}/c^2$

August: $\sigma \sim 16 \text{ MeV}/c^2$

November: $\sigma \sim 13 \text{ MeV}/c^2$

Different B hadron species in $J/\psi X$ final states

$B^+ \rightarrow J/\psi K^+$

$B^0 \rightarrow J/\psi K^{*0}$

$B_s \rightarrow J/\psi \phi$

$\Lambda_b \rightarrow J/\psi \Lambda$

Signals are as clean as at the $e^+e^-$ - machines !!!

CERN RRB April 2011
Clean reconstruction of various hadronic decay channels of $D_{(s)}$ and $B_{(s)}$ mesons.
**PID with Calorimeter and MUON**

**Photon PID: Important for B,D reconstruction and spectroscopy studies**

\[ \chi_c \rightarrow J/\psi \gamma \]

L\(\sim\) 2 pb\(^{-1}\)

Excellent Muon PID is vital for the LHCb key measurements with dimuons

CERN RRB April 2011
Proper time resolution

Lifetime measurements

<table>
<thead>
<tr>
<th>Decay channel</th>
<th>Yield</th>
<th>LHCb result $\tau[\text{ps}]^*$</th>
<th>PDG $\tau[\text{ps}]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B^+ \to J/\psi K^+$</td>
<td>$6741 \pm 85$</td>
<td>$1.689 \pm 0.022_{\text{stat.}} \pm 0.047_{\text{syst.}}$</td>
<td>$1.638 \pm 0.011$</td>
</tr>
<tr>
<td>$B^0 \to J/\psi K^{*0}$</td>
<td>$2668 \pm 58$</td>
<td>$1.512 \pm 0.032_{\text{stat.}} \pm 0.042_{\text{syst.}}$</td>
<td>$1.5252 \pm 0.009$</td>
</tr>
<tr>
<td>$B^0 \to J/\psi K^0_S$</td>
<td>$838 \pm 31$</td>
<td>$1.558 \pm 0.056_{\text{stat.}} \pm 0.022_{\text{syst.}}$</td>
<td>$1.525 \pm 0.009$</td>
</tr>
<tr>
<td>$B_s^0 \to J/\psi \phi$</td>
<td>$570 \pm 24$</td>
<td>$1.447 \pm 0.064_{\text{stat.}} \pm 0.056_{\text{syst.}}$</td>
<td>$1.477 \pm 0.046$</td>
</tr>
<tr>
<td>$\Lambda_b \to J/\psi \Lambda$</td>
<td>$187 \pm 16$</td>
<td>$1.353 \pm 0.108_{\text{stat.}} \pm 0.035_{\text{syst.}}$</td>
<td>$1.391_{+0.038}^{+0.038} -0.037$</td>
</tr>
</tbody>
</table>
Flavour Tagging (LHCb)

Same Side K tagger studies are in progress. Need larger data samples.

$B^0_d - \bar{B}^0_d$ oscillations

$\Delta m_d = 0.499 \pm 0.032 \text{(stat)} \pm 0.003 \text{(sys)} \text{ ps}^{-1}$

($\Delta m_d = 0.507 \pm 0.005 \text{ ps}^{-1}$ world average, PDG [1])

$B^0_s - \bar{B}^0_s$ oscillations

$\Delta m_s = 17.63 \pm 0.11 \text{(stat)} \pm 0.04 \text{(sys)} \text{ ps}^{-1}$

($\Delta m_s = 17.77 \pm 0.10 \text{(stat)} \pm 0.07 \text{(sys)} \text{ ps}^{-1}$ CDF, 2006)

asymmetry modulo $2\pi / \Delta m_s$
Physics results from 2010 Run

- Production studies

- Core LHCb measurements
  - $B_s$ mixing phase
  - $B_s \rightarrow \mu\mu$
  - $B_d \rightarrow K^*\mu\mu$
  - Towards the measurement of the UT angle gamma (reconstruction of hadronic $B$ decays)
  - CPV studies in charm sector
Production measurements

- Many results reported on open $b$ and $c$-production at LHC and exclusive $b$-hadron cross-sections (including $B_c$ production). LHC luminosity is known to 3.5% accuracy. First evidence for $D^0$ production asymmetry at LHC

→ Important testing ground for QCD calculations!

- Cross-sections are large as expected (charm > 20 × beauty)
  → More confidence to LHCb projections in heavy flavour physics

- Extensive studies of $J/\psi$, Upsilon and other quarkonia started; polarization studies are still to come...
  Double $J/\psi$ production observed by LHCb.
  → Understanding of onia production mechanism in progress!

- Very interesting possibilities to study $W/Z$ in the forward direction
  Experiments are requested to provide data in the ATLAS / CMS / LHCb rapidity overlapping region
Z & W in the forward direction

Z: 2 \( \mu \), each with \( P_t > 20 \text{ GeV/c} \)

W: single isolated \( \mu \) with \( P_t > 20 \text{ GeV/c} \) & small \( P_t \) opposite

- Measurement of \( A_{FB} \) in future
  In LHCb acceptance Z production occurs predominantly through collision of valence and sea quark, so axis of \( A_{FB} \) measurement is well defined, and dilution low.

- Knowledge of PDF
  Will help to improve accuracy on \( A_{FB} \) and \( M_W \).
  LHCb is complementary to GPDs and may provide vital input with high statistics data samples.

LHCb preliminary

\( \mathcal{L} = 16 \text{ pb}^{-1} \)

\( M_{\mu\mu} \), GeV

Acceptance of GPDs

CERN RRB April 2011
Measurements of $f_d / f_s$ fragmentation fraction (LHCb)

In particular important to measure $BR(B_s \rightarrow \mu \mu)$

- **fragmentation fractions, $f_s/f_d$:**
  - $B^0 \rightarrow D K^+$
    - $f_s/f_d = 0.242 \pm 0.024 \pm 0.018 \pm 0.016$
  - $B^0 \rightarrow D \pi^+$
    - $f_s/f_d = 0.249 \pm 0.013 \pm 0.020 \pm 0.025$
  - $B^0 \rightarrow D h^+$
    - $f_s/f_d = 0.245 \pm 0.017 \pm 0.018 \pm 0.018$
  - $B^0 \rightarrow D X \mu^+ \nu$
    - $f_s/f_d = 0.260 \pm 0.008 \pm 0.026$

  (stat) (sys) (theo)
Search for $B_s \to \mu\mu$

- Super rare decay in SM with well predicted $BR(B_s \to \mu\mu) = (3.2\pm0.2)\times10^{-9}$
  $BR(B_d \to \mu\mu) = (1.1\pm0.1)\times10^{-10}$
  (Buras et al., arXiv:1007.5291)

- Sensitive to NP, in particular new scalars
  In MSSM: $BR \propto \tan^6 \beta / M_A^4$

Regions compatible with $BR(B_s \to \mu\mu) = 2\times10^{-8}, 1\times10^{-8}, 5\times10^{-9}$ and SM

5σ discovery contours for observing the heavy MSSM Higgs bosons $H, A$
in the three decay channels $H,A \to \tau^+\tau^- \to \text{jets}$ (solid line), jet+$\mu$ (dashed line), Jet+$e$ (dotted line) assuming 30-60 fb$^{-1}$ collected by CMS.

O. Buchmuller et al, arxiv:0907.5568

CERN RRB April 2011
$B_s \rightarrow \mu\mu$

**LHCb UL is based on 0 events in the most sensitive signal bins**

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Today, $37 \text{ pb}^{-1}$</th>
<th>@ 90% CL</th>
<th>@ 95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHCb</td>
<td></td>
<td>&lt; 43 x10^{-9}</td>
<td>&lt; 56 x10^{-9}</td>
</tr>
<tr>
<td>D0</td>
<td>World best, $6.1 \text{ fb}^{-1}$</td>
<td>PLB 693 539 (2010)</td>
<td>&lt; 42 x10^{-9}</td>
</tr>
<tr>
<td>CDF</td>
<td>Preliminary, $3.7 \text{ fb}^{-1}$</td>
<td>Note 9892</td>
<td>&lt; 36 x10^{-9}</td>
</tr>
</tbody>
</table>

**LHCb prospects for the 2011/2012 LHC Run**

- **exclusion**
  - LHCb proj. from $37 \text{ pb}^{-1}$
  - $\sqrt{s} = 7 \text{ TeV}$
  - $95\% \text{ C.L. excl.}$
  - $90\% \text{ C.L. excl.}$

- **observation**
  - LHCb proj. from $37 \text{ pb}^{-1}$
  - $\sqrt{s} = 7 \text{ TeV}$
  - $5\sigma$ observation
  - $3\sigma$ observation

**ATLAS and CMS in particular should be very competitive !!!**

**Very exciting sensitivity expected**
$\phi_s^{J/\psi \phi} = -2\beta_s$ in SM is the $B_s$ meson counterpart of $2\beta$

penguin contribution $\leq 10^{-3}$

$\phi_s^{J/\psi \phi}$ is not really constrained so far

*Theoretical uncertainty is very small:* $-2\beta_s = -0.0368\pm0.0017$ (CKMfitter 2007)

- CDF: based on 5.2 fb$^{-1}$ with improved particle Id, NN, flavour tagging (SST) and contribution of S-wave included.
- DØ: based on 6.1 fb$^{-1}$ with improved side selection and no same side tagger anymore.
**$B_s$ mixing phase**

$B_s \rightarrow J/\psi \phi$

Unbiased trigger

Unbiased trigger

$N_{\text{sig}} = 570 \pm 24$

$\sigma_m = 7 \text{ MeV}$

36 pb$^{-1}$

**CERN RRB April 2011**

$\phi_s \in [-2.7, -0.5]$ rad at 68% CL

$\phi_s \in [-3.5, 0.2]$ rad at 95% CL

**LHCb 36 pb$^{-1}$**

$B_s \rightarrow J/\psi \phi$

<table>
<thead>
<tr>
<th>Proper time resolution</th>
<th>LHCb 36 pb$^{-1}$</th>
<th>CDF 5.2 fb$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 fs</td>
<td>836</td>
<td>6500</td>
</tr>
<tr>
<td>100 fs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**OS tagging power**

2.2 ± 0.5%

1.2 ± 0.2%

**SS tagging power**

work ongoing

3.5 ± 1.4%

**SM**

SS tagging will significantly improve sensitivity

→ Exciting prospects for the nearest future

Expect $\sigma(\phi_s) \sim 0.1$ with about 1 fb$^{-1}$
Future prospects on $A_{SL}$

- **CDF measurement**
- **D0 update** (with 9 fb$^{-1}$)
  - IP cut and improved data selection
- **LHCb prospects**
  - (with 1 fb$^{-1}$)

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![Graph showing future prospects on $A_{SL}$](image)

- **CDF $\mu\mu$** (Run I)
- **CDF $\mu\mu$** (1.6 fb$^{-1}$) prel.
- **D0 $\mu\mu$** (6.1 fb$^{-1}$)
- **D0 $D_s\mu X$ (tagged)** (5 fb$^{-1}$)

**Average**

-0.08 to 0.08

**Heavy Flavour Averaging Group**

**$A_{SL}(B_s)$**

**CERN RRB April 2011**

**NB:** This is MC, scaled to real data
Helicity structure of the decay amplitudes in $B_d \to K^*\mu\mu$

Forward backward asymmetry, $A_{FB}$, is extremely powerful observable for testing SM vs NP

Intriguing hint is emerging!!!

- BELLE, BaBar and CDF consistent with each other and SM

- Flipped $C_7$ scenario looks however more favoured from $A_{FB}$ data

With 1 fb$^{-1}$ LHCb expects $\sim$1400 events, and should clarify existing situation. Expected accuracy in $A_{FB}$ zero crossing point is $\sim$0.8 GeV$^2$ in 1 fb$^{-1}$
Towards the measurement of the UT angle $\gamma$

Reconstruction of hadronic $B$ decays

- $B_s \rightarrow D_sK$ final state under study
- Expect world’s first time-dependent CPV analysis for $B_s \rightarrow D_sK$ analysis in 2011

**LHCb** yield: $444 \pm 30 / 34 \text{ pb}^{-1}$
**CDF** yield: $516 \pm 37 / \text{ fb}^{-1}$

Combined estimated sensitivity for $\gamma$
in 2011/2012 Run is $\sim 5^\circ$
(Current accuracy in $\gamma \sim 20^\circ$)

- LHCb yields: $275\pm24 \ B_d \rightarrow \pi^+\pi^- \ \& \ 333 \pm 21 \ B_s \rightarrow K^+K^- \ \text{in} \ 37 \ \text{pb}^{-1}$
c.f. CDF in 1 fb$^{-1}$ $1121\pm63 \ B_d \rightarrow \pi^+\pi^- \ \text{and} \ 1307\pm64 \ B_s \rightarrow K^+K^-$
Direct CPV seen by LHCb:

**LHCb preliminary:**

\[ A_{CP}(B^0 \rightarrow K^+\pi^-) = -0.074 \pm 0.033 \pm 0.008 \]
\[ A_{CP}(B_s^0 \rightarrow \pi^+K^-) = 0.15 \pm 0.19 \pm 0.02 \]

Competitive with world’s best measurement by CDF:

\[ A_{CP}(B_s \rightarrow \pi^+K^-) = 0.39 \pm 0.15 \pm 0.08 \]

Excellent prospects for \( A_{CP} \) observation in \( \Lambda_b \) baryons with \( L \sim 1 \text{ fb}^{-1} \)

LHCb yields in 37 pb\(^{-1}\):

\( \Lambda_b \rightarrow pK \) yield: 76 ± 12 events
\( \Lambda_b \rightarrow p\pi \) yield: 41 ± 10 events
CP Violation with charm

Excellent prospects for CPV studies: Expect about a few millions tagged $D^0 \rightarrow KK$ with $L \sim 1$ fb$^{-1} \rightarrow$ Very sensitive to CPV in $D$-mixing!

Sample sizes in low multiplicity decay modes with low mis-tag rate already similar to those of $B$-factories!

$A_\Gamma$ is well in progress!

Control channel: ("$A_\Gamma$" in $D \rightarrow K\pi$)

$A_\Gamma = (-2\pm4) \times 10^{-3}$

407.6 ± 2.4 fs

409.2 ± 2.4 fs
**CP Violation with charm**

- Time integrated CPV asymmetries in $D \rightarrow hh'$ decays: 
  \[ A_{CP}(f) = \frac{\Gamma(D^0 \rightarrow f) - \Gamma(D^0 \rightarrow f)}{\Gamma(D^0 \rightarrow f) + \Gamma(D^0 \rightarrow \bar{f})} \]

  Expect mixing induced CPV to cancel out in the difference as well as many other systematics (e.g. production and tracking asymmetries):

  \[ A_{CP}(KK) - A_{CP}(\pi\pi) = A_{CP}^{RAW}(KK)^* - A_{CP}^{RAW}(\pi\pi)^* \] (very clean measurement !)

**Sensitivity to penguins is retained !**

Measure raw asymmetries in flavour tagged samples

\[ A_{CP}^{RAW}(f)^* = \frac{N(D^{*+} \rightarrow D^0(f)\pi^+)}{N(D^{*+} \rightarrow D^0(f)\pi^+)} - \frac{N(D^{*-} \rightarrow \bar{D}^0(f)\pi^-)}{N(D^{*-} \rightarrow \bar{D}^0(f)\pi^-)} \]

\[ A_{CP}(KK) - A_{CP}(\pi\pi) = -0.275 \pm 0.701 \pm 0.250\% \]

Expect a factor 5 better sensitivity with 2011 data


**Preparations towards LHCb upgrade**

**Purpose of upgraded LHCb detector**
→ collect ~50/fb with a general purpose detector in the forward region

- Which requires:
  - running at luminosity of $L \sim 1 \times 10^{33}$ cm$^{-2}$ s$^{-1}$
  - with full software trigger (40 MHz)

- Physics program will include:
  - Quark flavour physics (CORE program!)
  - Lepton flavour physics
  - Electroweak physics
  - Exotic searches

- **Aim**
  - Run with current detector and collect ~5/fb till second long shutdown
  - Upgrade to 40 MHz in ~2018 and collect ~50/fb thereafter

⇒ Submitted upgrade LOI to LHCC beginning of March
⇒ Physics case well received!
## Sensitivities of the LHCb upgrade to key observables

<table>
<thead>
<tr>
<th>Type</th>
<th>Observable</th>
<th>Current precision</th>
<th>LHCb (5 fb⁻¹)</th>
<th>Upgrade (50 fb⁻¹)</th>
<th>Theory uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gluonic penguin</td>
<td>( S(B_s \to \phi\phi) )</td>
<td>-</td>
<td>0.08</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>( S(B_s \to K^*0K^*0) )</td>
<td>-</td>
<td>0.07</td>
<td>0.02</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td></td>
<td>( S(B^0 \to \phi K_s^0) )</td>
<td>0.17</td>
<td>0.15</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>( B_s ) mixing</td>
<td>( 2\beta_s (B_s \to J/\psi\phi) )</td>
<td>0.35</td>
<td>0.019</td>
<td>0.006</td>
<td>( \sim 0.003 )</td>
</tr>
<tr>
<td>Right-handed</td>
<td>( S(B_s \to \phi\gamma) )</td>
<td>-</td>
<td>0.07</td>
<td>0.02</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>currents</td>
<td>( A^{\Delta T_s}(B_s \to \phi\gamma) )</td>
<td>-</td>
<td>0.14</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>E/W penguin</td>
<td>( A_T^{(2)}(B^0 \to K^*0\mu^+\mu^-) )</td>
<td>-</td>
<td>0.14</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>( s_0 A_{FB}(B^0 \to K^*0\mu^+\mu^-) )</td>
<td>-</td>
<td>4%</td>
<td>1%</td>
<td>7%</td>
</tr>
<tr>
<td>Higgs penguin</td>
<td>( B(B_s \to \mu^+\mu^-) )</td>
<td>-</td>
<td>30%</td>
<td>8%</td>
<td>&lt; 10%</td>
</tr>
<tr>
<td></td>
<td>( \mathcal{B}(B_s \to \mu^+\mu^-) )</td>
<td>-</td>
<td>-</td>
<td>( \sim 35% )</td>
<td>( \sim 5% )</td>
</tr>
<tr>
<td>Higgs penguin</td>
<td>( s_0 \mathcal{B}(B_s \to \mu^+\mu^-) )</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Unitarity angles</td>
<td>( \gamma (B \to D(<em>)K(</em>)) )</td>
<td>( \sim 20% )</td>
<td>( \sim 4% )</td>
<td>0.9°</td>
<td>negligible</td>
</tr>
<tr>
<td></td>
<td>( \gamma (B_s \to D_sK) )</td>
<td>-</td>
<td>( \sim 7% )</td>
<td>1.5°</td>
<td>negligible</td>
</tr>
<tr>
<td></td>
<td>( \beta (B^0 \to J/\psi K^0) )</td>
<td>1°</td>
<td>0.5°</td>
<td>0.2°</td>
<td>negligible</td>
</tr>
<tr>
<td>Charm CPV</td>
<td>( A^\Gamma )</td>
<td>( 2.5 \times 10^{-3} )</td>
<td>2 \times 10^{-4}</td>
<td>4 \times 10^{-5}</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( A^\text{dir}<em>{CP}(KK) - A^\text{dir}</em>{CP}(\pi\pi) )</td>
<td>( 4.3 \times 10^{-3} )</td>
<td>4 \times 10^{-4}</td>
<td>8 \times 10^{-5}</td>
<td>-</td>
</tr>
</tbody>
</table>
Detector upgrade to 40 MHz requires:

- Readout detector at 40MHz to run full software trigger

- Replacement of all sub-detector Front-End electronics to 40 MHZ readout; RICH photo-detectors

- Replacement of all Si detectors directly attached to the current 1MHz electronics
  - VELO, IT, TT

- Remove some detectors due to increased occupancies at higher luminosity
  - RICH1-aerogel, M1, possibly PS&SPD

- Eventually improve PID at low momenta by introducing TORCH

⇒ R&D has started and is expected to ramp-up significantly this year towards producing TDRs in time for installing the detectors & electronics in 2018
Collaboration matters

- The status of the accounts healthy. No cash flow problems foreseen

- New resources need to be spent on R&D for LHCb Upgrade

- Pierluigi Campana (INFN) will start his three years SpokesPerson mandate on June 1, 2011
  
  - Roger Forty (CERN) has been appointed as Deputy SP
  
  - Burkhard Schmidt (CERN) has been appointed as Deputy SP
  
  - Andreas Schopper (CERN) has been appointed as the Upgrade Coordinator starting from June 1, 2011
  
  - Carmelo D’Ambrosio (CERN) has been appointed as the RICH Project Leader for two years starting from July 1, 2011
Conclusions

- **LHCb has demonstrated excellent performance**
  - A concept of the forward spectrometer at the LHC has been proven with data
  - Heavy flavour resonances and mesons have been reconstructed (Z & W candidates as well); cross-sections measured
  - First measurements of the core LHCb physics programme have reached TEVATRON sensitivity

- **LHCb data sample should be increased by a factor of 25-30 by the end of 2011**

- **Very interesting sensitivity reach in the nearest future is guaranteed!**
  - \( B_s \rightarrow \mu\mu \)
  - \( \phi_s \) in \( B_s \rightarrow J/\psi\phi \)
  - \( A_{FB} \) in \( B_d \rightarrow K^{*}\mu\mu \)

- **Long term future of LHCb looks healthy (if you help!!!) LOI is being approved by LHCC**