Status of the LHCb Experiment
LHCb RRB at CERN
20 April 2005

on behalf of the LHCb Collaboration

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CERN
and
EPFL
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I) Construction Status
II) Current Organisation
III) Cost and Funding
IV) Conclusions
I) Construction Status

LHCb Spectrometer

- OT
- Magnet
- RICH1
- VELO
- TT
- RICH2
- Muon System
- Calo. System
1) Experimental Area

LHCb experimental cavern at point 8
2) Beam Pipe

VELO vacuum tank exit window

Al flanges and bellows

Al bellow + flanges

Al-stainless steel bimetallic flange

25 mrad Be section

10 mrad Be sections

completed by industry ready for fabrication at CERN being fabricated by industry being ordered

stainless steel bellows, flange and beam pipe
delivery in May and Oct ‘05
3) Magnet

magnet assembled, positioned, aligned and switched on
First field map in December ’04

Comparison along beam axis

Inside RICH2 shielding box
Compares well with simulation
Maximum 6 Gauss

Further magnetic field measurements:
- RICH1/VELO region in May ’05 with RICH1 shielding in place
- Full field map in tracking region with all magnetic structures in place in October ‘05 before the critical electricity period starts

timely completion of the cryo-line required
4) VErtex LOcator

Mechanics; good progress

- vacuum vessel arrived
- support frame with moving mechanism
- rectangular bellow
- detector hood with transporter
Production run of Beetle Chip completed (also for Silicon Tracker)
Hybrid final prototype production
Module EDR on 21 April ’05
Production of modules to start in Liverpool in May ‘05
First batch of modules June ’05, last batch in Feb ’06
tight schedule
5) RICH

Magnetic Shield  
Gas Enclosure  
Beam Pipe  
Spherical Mirror  
Flat Mirror  
Photodetectors  
Readout Electronics

Shields at CERN

Be mirror prototype production in Russia

Gas enclosure tender in progress

Overall schedule very tight manpower limited
**RICH2**

- Flat mirrors
- Spherical Mirrors
- Support Structure
- Central Tube
- Photon Funnel + Shielding
- Spherical mirror

**Shielding box**

Mounting and alignment of mirrors in hall 156
Transport and installation in UX85 in July ’05
HPD and electronics

Preseries modules  HPD test setup  readout chain

Preseries of 9 HPDs received and tested
Series production of HPDs at DEP starting
~480 tubes needed
Delivery July ’05 to November ’06
~30 tubes/month planned

No margin in schedule of last tubes for installation
6) Outer Tracker

OT Module Production

Production Fraction (%)

NIKHEF
Heidelberg
Warsaw

March 2005
50% milestone

February 2004
10% milestone

December 2005
100% milestone

Delay has been recovered
Frame and support structure

full scale prototype fully loaded

EDR in May ’05
Installation of support structures and OT half stations to start in Nov ’05
7) Silicon Tracker

Trigger Tracker

CMS OB-2 sensor (HPK)
First 100 sensors just arrived (loan from CMS)
1000 needed.

Inner Tracker

Custom-made (HPK) sensors
Preseries 49 sensors arrived in January, 531 needed
Prototype ladders have been constructed with sensors from ST.

Ready for the preproduction as soon as the sensors are ready

Delivery schedule is far from optimal due to the CMS order

Remaining 900 all arrive in September/October

discussion with CMS to receive further 100-200 sensors before summer
Inner Tracker Preproduction started

Prototype support
suspended from the rail
IT boxes
carbon fibre pillars
8) Calorimeter System

E-cal and H-cal systems are being assembled in Pit-8

PMT + CW base completed

fibre bundles for monitoring in preparation
Preshower and SPD modules

Super Module with 2×13 modules

Assembly cradle

SM support structure

super module
E-cal and H-cal electronics balconies

under construction
9) Muon System  

chamber production
Reached the nominal production yields at all the sites
However, manpower is critical to maintain them
First three Muon filter wall assembled

Last Muon filter against beam background

Engineering run of the three types of ASIC’s successful

Installation and commissioning will continue till Q1 07

Cryo installation (LHC) in Q2 05 must be done on time
10) Trigger and Online

Level-0 Trigger:
hardware trigger by custom-built electronics cards

Calorimeter
Muon
Pile-up

Decision Unit

Level-0 decision

<table>
<thead>
<tr>
<th>PRR</th>
<th>Calo</th>
<th>Muon</th>
<th>Pile-up</th>
<th>Decision Unit</th>
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<tbody>
<tr>
<td>Oct 05</td>
<td>Dec 05</td>
<td>Oct 05</td>
<td>Q3 06</td>
<td>Q4 06</td>
</tr>
<tr>
<td>Q2 06</td>
<td>Q2 06</td>
<td>Q3 06</td>
<td>Q4 06</td>
<td></td>
</tr>
<tr>
<td>Q1 07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1 quadrant)
(4 quadrants)
Level-1 and High Level Trigger: software trigger by the DAQ CPU farm

Preparing for
- event selection algorithms
- performance monitoring
- overall trigger optimization

Real-time Trigger Challenge for a system test Summer 05
Real-time Trigger Challenge hardware

network switches

CPU farm

Farm monitor and control software
Tell1: LHCb common readout board

17 preseries board produced
working well
Subsystem specific firmware to be developed
Total number needed 350 boards
11) Computing

Software Framework and Distributed Computing
Computing Resource
Physics Application Software

Major ongoing work
Adaptation of software framework to online environment
Adaptation of distributed computing to LCG services
LHCb computing model → Computing TDR June 05
Framework for alignment and calibration
Overhaul of event reconstruction
Subsystem software responsibility ⇒ subsystem projects
- geometry
- simulation
- decoding
- alignment and calibration
- and others...

Some projects have manpower problems

Data Challenge Phase II
-fast offline selection of data at various Tier I centres-
-interfacing problem between LCG software (Storage Resource Manager) and Tier Centres prevented us to use LCG software
⇒ now solved...
II) Current Organisation

Recent changes

- New CB chair (two years)
- Renewed appointment (three years) for Spokesperson and Technical Coordinator
- Enlarging the management
  Deputy Spokesperson (three years) installed
- Preparation for first day physics
  Physics Planning Group chaired by Physics Coordinator
- Simplification of Trigger and Computing organisation
  Computing Physics and Core Software, and offline computing resources
  Trigger HLT selection algorithms and overall optimization
Collaboration Board Chair: E. Aslanides (Marseille)

Physics and Subsystem Projects:
Physics Coordinator: O. Schneider (EPFL)
Subsystem Coordinators:
- VELO: J. van den Brand (NIKHEF)
- Silicon Tracker: O. Steinkamp (Zurich)
- RICH: N. Harnew (Oxford)
- Outer Tracker: A. Pellegrino (NIKHEF)
- Calorimeter: A. Schopper (CERN)
- Muon: G. Carboni (Rome II)
- L0 Trigger: R. Le Gac (Marseille)
- Trigger: H. Dijkstra (CERN)
- Online: B. Jost (CERN)
- Computing: N. Brook (Bristol)

Management:
Spokesperson: T. Nakada (CERN and EPFL)
Deputy Spokesperson: R. Forty (CERN)
Technical Coordinator: W. Witzeling (CERN)
Resource Coordinator: A. Smith (CERN)
III) Cost and Funding

In the construction MoU
Total cost of the experiment: 75.05 MCHF
Total requested funding: 73.30 MCHF

<table>
<thead>
<tr>
<th>MoU under funded detector (MCHF)</th>
<th>Cost</th>
<th>Under-Funding</th>
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</thead>
<tbody>
<tr>
<td>IT</td>
<td>5.15</td>
<td>0.11</td>
</tr>
<tr>
<td>OT</td>
<td>10.10</td>
<td>0.33</td>
</tr>
<tr>
<td>Calo</td>
<td>15.36</td>
<td>0.42</td>
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<tr>
<td>Muon</td>
<td>7.45</td>
<td>0.62</td>
</tr>
<tr>
<td>DAQ</td>
<td>6.80</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(without Fe)</td>
</tr>
</tbody>
</table>

Signed MoU contribution is less than requested:

73.3 → 70.26  Total under-funding 4.79 MCHF

<table>
<thead>
<tr>
<th></th>
<th>request</th>
<th>signed</th>
<th>affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>1.70</td>
<td>0.00</td>
<td>Muon, ComF</td>
</tr>
<tr>
<td>China</td>
<td>0.25</td>
<td>0.10</td>
<td>OT, ComF</td>
</tr>
<tr>
<td>Germany(BMBF)</td>
<td>4.80</td>
<td>3.76</td>
<td>OT, ComF, Trigger, DAQ</td>
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<tr>
<td>Russia(+CERN)</td>
<td>3.00</td>
<td>2.85</td>
<td>Calo, Muon, ComF</td>
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</table>
## Situation after re-optimization (April 2005)

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Cost Now</th>
<th>MoU-fund Requested</th>
<th>MoU-fund Signed</th>
<th>MoU funding sources</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>little affected by the re-optimization</td>
<td></td>
<td></td>
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<tr>
<td>Muon detector</td>
<td>8.560</td>
<td>6.830</td>
<td>5.590</td>
<td>BR CERN IT RU</td>
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<tr>
<td>Muon Fe</td>
<td>4.000</td>
<td>4.000</td>
<td>4.000</td>
<td>CERN</td>
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<tr>
<td>Magnet</td>
<td>6.000</td>
<td>6.000</td>
<td>6.000</td>
<td>ComF</td>
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<tr>
<td>Experiment infra.</td>
<td>4.000</td>
<td>4.000</td>
<td>4.000</td>
<td>ComF</td>
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<tr>
<td>L0 Trig</td>
<td>2.260</td>
<td>2.630</td>
<td>2.630</td>
<td>FR IT NL</td>
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<td></td>
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<tr>
<td>affected by the re-optimization</td>
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<tr>
<td>VELO</td>
<td>4.822</td>
<td>4.850</td>
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<td>CH DE GB NL</td>
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<tr>
<td>RICH</td>
<td>9.744</td>
<td>7.700</td>
<td>7.700</td>
<td>CERN GB IT</td>
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<tr>
<td>ST</td>
<td>5.970</td>
<td>5.040</td>
<td>4.996</td>
<td>CH DE ES UA</td>
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<tr>
<td>OT</td>
<td>6.230</td>
<td>9.760</td>
<td>9.899</td>
<td>ComF CERN CN DE NL PL</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>affected by all the shortfall in the common fund</td>
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<td></td>
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<tr>
<td>Online</td>
<td>7.996</td>
<td>7.550</td>
<td>5.642</td>
<td>ComF CERN CH DE ES GB IT</td>
</tr>
<tr>
<td>Total</td>
<td>74.512</td>
<td>73.300</td>
<td>70.257</td>
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</tr>
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</table>

MoU cost 75.05 MCHF
We cannot avoid (unfortunately) to ask funding beyond the current funding commitments

Shortfall known now = 4.255 MCHF

Is this all?

Calorimeter, Magnet, Infrastructure, L0, VELO, ST, Online
-no indication of cost increase

OT
Infrastructure and services such as support frame and cooling system, underestimated
-an increase of $O(700 \text{ kCHF})$ to the current cost expected

Final overall missing funds will be \(~5\) MCHF
Solve first the subsystem not affected by the reoptimization

Muon system shortfall 2.970 MCHF
Our proposed solution:
Funding reduction (Brazil and Russia+CERN): 1.240 MCHF
To be compensated by the common fund
Rest 1.730 MCHF
Funding beyond the current MoU commitments by two groups responsible for the muon system, CERN and INFN, proportional to their original contribution

Reduce the total shortfall by 1.730 MCHF
Increasing the shortfall in Online by 1.240 MCHF
Then...

RICH system shortfall 2.044 MCHF due to material reduction
increased cost of service items
better trigger performance (B field)

Propose to consider
-partly compensated by the common fund
(items for the overall benefit)
-partly new funding from the RICH project groups
(items under the project responsibility)
CERN, GB, IT

discussion in progress
ST shortfall 0.974 MCHF due entirely to the increased surface of Si resulting from the reoptimization
-to be covered by the gain from OT saving

OT cost increase of ~0.7 MCHF,
-solutions are being discussed

Finally shortfall in Common Fund giving under-funding in Online Project (mainly for CPU’s) to be financed by a collaboration wide effort to ask funding beyond the current commitment
The final detector cost (~75.2 MCHF) is essentially unchanged from the MoU in 2000

For solving the funding shortfall of ~5 MCHF, we would like to request that the RRB agrees to:
1) the Muon and ST solutions
2) that we put forward the RICH, OT and Online solutions in October, following the philosophy presented here

Modest luminosity required by LHCb will allow full physics programme from day one.
→ We have to make sure that the detector construction is not delayed.
IV) Conclusions

1) Production, installation and commissioning of many subsystems are progressing well: beam pipe, magnet, VELO mechanics, RICH2 and Calorimeter

2) Delay in the OT module production fully recovered

3) Delivery schedule for TT sensors not optimal

4) Tight schedule for VELO sensors, RICH1 mechanics and HPD’s

5) Muon chamber production almost at the nominal rate, but the end of production will slip to early 2007

6) A funding short fall (~5 MCHF) to be solved

7) We are fully committed to be ready for the collisions in 2007 and see no technical problem, but manpower is critical everywhere

8) Help by RRB for 6) and 7) would be highly appreciated