Status Report
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US CMS Collaboration Meeting
Riverside, 19 May 2001

1. Civil Engineering and Magnet
2. Tracker
3. ECAL
4. Muon DTs and RPCs
5. Schedule, Milestones, Funding
6. Conclusions
1. Magnet and Civil Engineering
Surface and Underground Installations

Surface building (SX)

Experimental cavern (UX)

Service cavern (US)

Pillar

LHC tunnel
Civil Engineering: Overview

The Status

• Surface hall, SX5 - delivered on time
• Underground hall UX5 - an extra 4 mo. delay announced in Jan 01. (total delay is now 9 months w.r.t contractual planning)

Underground halls (UX5 & US5) will now be delivered in Apr 04!

• Serious implications for CMS installation and commissioning.

• UX5: move some UX activities to SX (surface) – will need extra resources
• USC: delay will be much harder to recover – activities cannot be moved to SX.

Move to V31 General Schedule (detailed consequences still being worked out)
Final L1, L2, L3 milestones will be given to LHCC in June.

Concerns

Further delays
Underground Civil Engineering

Excavation of the Pillar
Magnet: Overview

• Most of the major contracts have been placed (86% of budget committed, 104 MCHF). Estimated total cost of the magnet (122.9 MCHF) unchanged.

YOKE Status
• 3 of the 5 barrel yoke rings assembled at Point 5
• Assembly of 1st endcap disk started in April (2nd endcap @ CERN in 9/01)

COIL Status
• SC cable: Need 21 lengths of 2.65km (coil has 5 sections, 4 lengths/section + 1 spare)
• Produced: 8 cables worth of s.c. strands, 5x2.65km of Rutherford cable, 4x2.65km of real insert, 20 out of 40 lengths of Al alloy.
• EBW reinforcement tested with dummy insert.
• First full length of final conductor expected in June.
• Tests of winding machine started

Finish Magnet Test on the surface by July 2004
Magnet Yoke

YE-1 & nose trial assembly Nov ‘00
In Kawasaki (Japan)

YB-2, YB-1, YB0 ready, YB1 started.
Central wheel YB0, supporting the vacuum tank
1st Disk Assembly Point 5
Magnet: Coil

Electron Beam Welding at Techmeta
2. Tracker
Tracker Overview

The Status

• EDR passed in Nov 00
• Pre-production of 200 detectors to exercise automated assembly procedure
• Sensors tender opened recently – order will be placed soon
• Pixels: Final architecture ROC chip received recently – under test.

• Major Milestones in 2001:
  System test of final electronics chain followed by ESR in end 2001.
  Start production of final modules
  Pixel Layout optimisation end 2001 (workshop)

• Feb 2005 Tracker ready for installation
TOB Module with final hybrid

19 cm

10 cm

APV25

19 cm
Tracker: Si Module Production

To be updated based on 2001 pre-production experience
Several months time contingency in present manufacturing plan.
Pixel Readout Chip (ROC)

- 36x40 pixel chip
- 150µm pixel size
- Size: 8.4mm x 6.3mm
- # transistors ~ 240K
- ~ 450 chips in hand

- PSI41 pixel chip (DMILL) with final architecture received 03/2001. Testing just begun.
- Design of full size (52x53pixel), final architecture ROC (DM_PSI43) mostly finished. Submission only after careful checking of PSI41. ~ July 2001
- Allows construction of first full size pixel modules at end 2001.
- Translation of ROC into 1/4µm CMOS after submission (Aug. 2001).
- Allows probably smaller pixel size. → e.g. (125µm x 125 µm)
Pixel matching to ECAL super-cluster gives large jet rejection with high electron efficiency.
Global Efficiency = Rec. Tracks/Sim. Tracks

Simulated Tracks: Single Muons Pt>0.9 Gev

Reconstructed Tracks: 8 hits of which 2 are in pixels.

Optimisation of Pixel Layout is needed. Conclude by end 01.
Tracker Layout

TOB: Outer Barrel

TIB: Inner Barrel

TID: Inner Disks

TEC: End Caps

Central Support Tube removed
3. ECAL
ECAL

Barrel ECAL (EB) 3.045 m

Endcap ECAL (EE) 1.290 m

η = 3.0

η = 1.479

η = 1.653

η = 2.6

η = 2.6

61700 barrel crystals

16000 endcap crystals
ECAL Overview

The Status

• 7500 Russian crystals delivered.
• Contract signed with BTCP (Russia) for manufacture of 30k barrel crystals.
• A breakthrough in crystal growing in Russia: Large diameter ingots can be grown allowing two crystals to be cut from one ingot => Yield of crystals per oven is increased considerably. BUT larger crucibles needed.
• 0.25 µm serialiser (CERN) has been chosen.
• Issues of barrel mechanics and APDs resolved (cross-check on delivery of 1000 APDs)
• Tender for the remaining 40000 crystals opened on April 5

Milestone for 2001

• Module M0’ (400 crystals) + electronics chain for autumn 01.

Concerns

• Total cost of crystals likely to be higher - more investment needed (than foreseen) in order to hold to the schedule
• Crystals are priced in $/cc. Prevailing $/SFr higher than in Cost Book V9 (MoU).
• Start of production of electronics components – FPPA, serialiser
Large Diameter Ingots in Russia
Subject to outcome of contract negotiations
ECAL Electronics Chain

Hamamatsu
Delay in start of production - Breakdown under irradiation

Harris rad-hard technology - noise in latest iteration?

Analog Devices
Place contract soon

Move to 0.25µm serialiser - expect CMS version end-01

Start test of M0’ (400 channels) and chain in autumn ‘01
4. Muon System
Muons (DTs and RPCs) Overview

The Status
• **Barrel DTs (MBs):** 9 Super-Layers (SL’s), equivalent to 3 MB2 chambers, assembled in CIEMAT using final assembly tools and procedures.
  • Assemble at least 3 SL’s in Aachen and Legnaro (Padova) by May 01
  • Assemble around 20 MBs by end-01
• **RPCs:** Assemble 10 barrel RPCs by Jun 01. Determine target values of critical parameters using production chambers.

Concerns
• Logistics for DT chamber production – must assure on-time parts deliveries
• RPC chamber/trigger rate – decide to oil or not to oil – summer 01.
• Integration RE1/ME1
3 Assembly Lines in CIEMAT

Theta SL Table
Phi1 SL Table
Phi2 SL Table

Goal is 3 SL’s in 2 weeks. Achieved: 3 SL’s in 3 weeks
First MB2 Chamber ready (Feb 2001): Fully equipped with electronics. Passed QC specs, gas, HV and cosmic ray tests. Chamber is operational, shipped to CERN end of June.
3 Assembly Lines in Legnaro

Theta SL Table

Phi1 SL Table

Phi2 SL Table
4 Precision Tables in Aachen
The minimum number of chambers that MUST be installed underground because of wheel lifting points is between 30 and 60.

Availability of 38 out of 50 chambers of the wheel.

46 days/year assumed for maintenance/contingency.

~25 DT’s complete.

Based on: 3 days/SL 176 wd/year.

(Achieved in CIEMAT: 5 days/SL.)

250

chambers

125

25
## 5. Schedule and Milestones

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Activity</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/04/04 to 30/09/04</td>
<td>Octant test</td>
<td></td>
</tr>
<tr>
<td>31/03/05</td>
<td>Last dipole delivered</td>
<td></td>
</tr>
<tr>
<td>31/12/05</td>
<td>Ring closed and cold</td>
<td>Full access to experimental caverns</td>
</tr>
<tr>
<td>01/01/06 to 31/01/06</td>
<td>Full machine commissioning</td>
<td>Full access to experimental caverns</td>
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<tr>
<td></td>
<td>Beam pipes in place</td>
<td></td>
</tr>
<tr>
<td>01/02/06 to 31/03/06</td>
<td>1 beam (2 months)</td>
<td>Restricted access to experimental caverns</td>
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<tr>
<td>01/04/06 to 30/04/06</td>
<td>First Collisions</td>
<td>Luminosity: $5 \times 10^{32}$ to $2 \times 10^{33}$</td>
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<tr>
<td></td>
<td>1 month Pilot run</td>
<td></td>
</tr>
<tr>
<td>01/05/06 to 31/07/06</td>
<td>Shutdown</td>
<td>Full access to experimental caverns</td>
</tr>
<tr>
<td>01/08/06 to 28/02/07</td>
<td>Physics run: 7 months</td>
<td>Luminosity: $\geq 2 \times 10^{33}$ ($\geq 10$ fb$^{-1}$)</td>
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<tr>
<td>01/03/07 to 12/04/07</td>
<td>Lead ion run, 6 weeks</td>
<td></td>
</tr>
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</table>
V31 General CMS Schedule

New delivery dates for underground caverns announced in Jan 01:

UX, US delivery  
1 Dec 2003 → 1 Apr 2004  +4 mo
UX installation start  
1 May 2004 → 1 Sep 2004  +4 mo

Move activities from UX to SX  (will need more resources):

SX: Pre-cabling, pre-testing. Install services and local DAQ in SX.  
HF assembly on surface (instead of underground).  
EB+ installed in HB+ (lower as single unit).  (gain 1.5 mo)

Compress underground activities:

UX: Move some CMS infrastructure activities into civil engineering  
(e.g. shielding concreting, floor plates).  
EE- installed after pilot run  (gain 1.5 mo)  
SE- installed parasitically with TK  
Overlap b.p. installation & TK commissioning  (gain 1mo)  
Allow +z commissioning during -z installation.
V31 Milestones

For the last time CMS has presented to the LHCC a status of the detectors with respect to the old (Aug 99) V26 Milestones (Complete detector for July 2005). CMS reviews internally all milestones 4 times per year (Quarterly review).

We are finalising a revised set of Milestones consistent with the new V31 master assembly schedule (CMS ready for physics in Aug 2006). There will be a large number of new milestones. A draft version was given to all subdetectors PMs.

The proposed calendar is the following:

CMS week 18-22 June: Approval of V31 Milestones by CMS Collaboration
LHCC53 (week of 2 July): Deliver V31 Milestones to LHCC
LHCC54 (week of 1 October): CMS Comprehensive Review based on V31 milestones
89% of the L1/L2 V26 Milestones are complete. CMS can have the complete detector for the physics run starting August 2006, except for the 4th Endcap Muon station ME4, which is staged. The limitation comes essentially from funding shortfalls or cash flow problems.
Start to discuss a global plan aiming at a solution within 1 year. Consult funding agencies. Can they help complete those deliverables in which they are involved? Feedback from the RRB is needed.

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>Description</th>
<th>Cost</th>
<th>Major Contributors</th>
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</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>6.6, 6.7, 6.8</td>
<td>2.5</td>
<td>CERN, (+)</td>
</tr>
<tr>
<td>Surface Ops</td>
<td>5.1, 5.2, 5.3</td>
<td>4.0</td>
<td>CERN, (+)</td>
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<tr>
<td>Tracker</td>
<td>3.1</td>
<td>7.4</td>
<td>Italy, CERN, Germany, France, USA,...</td>
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<tr>
<td>ECAL</td>
<td>4.1, 6.2</td>
<td>18.0</td>
<td>Switzerland, CERN, France, USA,...</td>
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<tr>
<td>HCAL(HF)</td>
<td>3.5</td>
<td>2.0</td>
<td>USA, Russia</td>
</tr>
<tr>
<td>Muon DT</td>
<td>3.2, 6.3</td>
<td>2.8</td>
<td>Italy, Germany, Spain</td>
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<tr>
<td>MUON CSC</td>
<td>3.4</td>
<td>4.3</td>
<td>USA, Russia</td>
</tr>
<tr>
<td>MUON RPC</td>
<td>3.3, 6.4, 6.5</td>
<td>3.3</td>
<td>Italy, Pakistan, Korea, (+)</td>
</tr>
<tr>
<td>TOTALS (to cover)</td>
<td></td>
<td>44.3</td>
<td>MCHF</td>
</tr>
</tbody>
</table>
Conclusions

**Magnet** Project progressing well – (>85% committed)

**In mass production:** ME (forward CSCs), HB, HE (barrel&endcap HCAL)

**Ramping up production in 2001:** MB (barrel DTs), RB (barrel RPCs)

**Starting production in 2001:** EB(barrel ECAL SM), Tracker (Si modules)

Slopes of rate of production will be better known for almost all sub-detectors by next Spring

**Major concerns:** ECAL (Crystals, electronics), DTs (rate of production)

CMS has made plans for a complete detector (except for the 4th endcap muon station, which is staged) ready for the physics run starting Aug 2006.

The additional 4 month delay in the delivery of the underground caverns has serious implications for CMS installation and commissioning.

Discussions have started in the Resources Review Board on what is necessary to complete the CMS detector (by Aug 2006). We are investigating possible staging scenarios: reduce redundancy (L1 rate and DAQ bandwidth, nb of points, nb of samplings), keeping full acceptance for jets and leptons.
Physics Reach?

5σ Higgs Signals (statistical errors only)

LHC 14 TeV (SM NLO Cross Sections)

- LHC 14 TeV (SM NLO Cross Sections)
- H → γγ
- H → ZZ
- H → WW

lept. acceptance, lept. isol.

lept. isol., jet veto, \( E_T^{\text{miss}} \)

CMS

Discovery Luminosity [fb⁻¹]

\( \sigma_H \) = Higgs Signals (statistical errors only)

- \( \sim 1 \text{ year} \) @ \( 10^{34} \)
- \( \sim 1 \text{ year} \) @ \( 10^{33} \)
- \( \sim 1 \text{ month} \) @ \( 10^{33} \)

CMS \( q, g \) mass reach in \( E_T^{\text{miss}} \) + jets inclusive channel for various integrated luminosities

- CMS
- "L, b ≈ 1, 10, 100, 300 fb
- H → γγ, ZZ, WW
- \( \sigma_H \) = Statistical errors only
- \( E_T^{\text{miss}} \) = \( E_T \) + jets inclusive channel

~ one year @ \( 10^{34} \)
~ one year @ \( 10^{33} \)
~ one month @ \( 10^{33} \)

Cosmologically plausible region

Fermilab reach: < 500 GeV

EX

CMS q, g mass reach in \( E_T^{\text{miss}} \) + jets inclusive channel