CMS/LHC Report

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All Experimenters’ Meeting
September 14, 2009

Outline:

• LHC Status
• CMS Status and Global Runs with Cosmics
• HCAL Upgrade : Silicon Photomultipliers
LHC : Current Status

- There have been major upgrades of the quench protection system
  - Protection of all main quadrupoles and dipoles
- Massive measurement campaign to identify and repair bad splices:
  - Two bad cases found and repaired in 6 sectors: 50 nΩ (1-2) and 100 nΩ (6-7)
  - Two sectors still to be measured cold (4-5, 3-4)
- Copper Stabilizer problems:
  - 10 dipole and 10 quadrupole joints are repaired
  - sectors 7-8 and 8-1 are still to be measured
  - a lot of efforts in modeling the problem
- Measures taken to mitigate collateral effects in case of problems:
  - Additional release valves (“DN200”) installed to improve the pressure relief system (to eventually cope with maximum He flow of 40 kg/s in the arcs)
  - Reinforcement of the quadrupole supports (Arc quadrupoles, Semi-stand alone magnets ...)
  - Energy extraction times lowered (Faster discharge of the energy from circuits ...)
LHC Initial Operations

- Simulations show that resistances of 120 micro-ohm are safe from thermal runaway under conservative assumed conditions of worst case conditions for the copper quality and no cooling to the copper stabilizer from the gaseous helium.

Decision: Operation initially at 3.5 TeV (energy extraction time of 50 s) with a safety factor of more than 2 for the worst stabilizers.

Ramp up the energy to 4-5 TeV.
**LHC 2009 : First Beam in Mid-November**

<table>
<thead>
<tr>
<th>Week</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mo</td>
<td>40</td>
<td>41</td>
<td>42</td>
</tr>
<tr>
<td>Tu</td>
<td>5</td>
<td>12</td>
<td>25</td>
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<tr>
<td>We</td>
<td>13</td>
<td>26</td>
<td>2</td>
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<tr>
<td>Th</td>
<td>48</td>
<td>47</td>
<td>23</td>
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<tr>
<td>Fr</td>
<td>47</td>
<td>46</td>
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<td>Sa</td>
<td>46</td>
<td>45</td>
<td>44</td>
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<td>Su</td>
<td>45</td>
<td>44</td>
<td>43</td>
</tr>
</tbody>
</table>

- **Hardware Commissioning**
  - **October 2009**
    - **Essential 450 GeV Commissioning**: Week 47-48 (Nov 16-23 & 24-29)
    - **450 GeV Collisions & Ramp to 1 TeV**: Week 49 (Nov 24 - Dec 06)
    - **Ramp to 3.5 TeV**: Week 50 (Dec 07 - Dec 14)
    - **Collisions at 3.5 TeV**: Week 51 (Dec 14 - Dec 20)

**Stop LHC with beam ~19th December 2009, restart ~ 4th January 2010**
LHC 2010 – Very Draft

2009
• 1 month commissioning

2010
• 1 month pilot & commissioning
• 3 month 3.5 TeV
• 1 month step-up
• 5 month 4 - 5 TeV
• 1 month ions

Peak Luminosity : $10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
Potential performance : 200-300 pb$^{-1}$
CMS Status

- CMS was closed in July for global running with full magnetic field on CRAFT09 - Cosmic Run At Four Tesla

- Goals of CRAFT09
  - Collect at least 300 Million triggers with B=3.8T
  - Include Tracker and Pixel detectors in global runs
  - Stress test ‘final’ firmware (for Tracker, Preshower) at highrate
  - Check tight muon trigger roads – LHC like muon triggers
  - Extensive run with LHC like Level-1 trigger rates
  - Commission central Detector Control System > 90% efficiency

CRAFT09 is carried out successfully

- 160 Million Triggers B = 0 T + tracker
- 320 Million Triggers B =3.8 T + tracker

Huge trigger rate, DAQ/HLT/SM ok

Monday, September 14, 2009
Status of SubDetectors in CRAFT09

• All the subdetectors were operational in the global running.
• Tracker
  • Cooling plants were refurbished before CRAFT09
  • 98% of tracker was alive during CRAFT
  • 100 kHz trigger readout successfully
  • HV trips affected 0.5% of tracker - problem under investigation
  • Pixel detector : 99% Barrel Pixel and 97% Forward Pixel were active
• Electromagnetic Calorimeter (ECAL)
  • Preshower included in global data taking for first time
  • EndCap(+) - Trigger Timing and Control (TCC) boards and Data Concentrator Cards commissioned
• Hadron Calorimeter (HCAL)
  • Barrel, EndCap and Forward calorimeters are in good shape
• Muon Detectors
  • Drift Tubes : Expected performance in CRAFT09 (98% efficiency)
  • Cathode Strip Chambers : 99% operational
  • Resistive Plate Chambers : Fully operational, temperature and current for both barrel and endcap quite stable during full operation
Performance: Dataflow/Trigger

- Performance of Tier 0: 2.3 billion events processed including all streams with an uptime of 98% (including upgrades and CERN computing downtimes)

- Full offline chain of reconstruction tested including proper input from Alignment-Calibration (AlCa) process with expected latency ~50 hours.

Trigger:

- All Level-1 Trigger algorithms were used in CRAFT09
- ECAL EndCap(+) used for Electron Trigger
- Stable rates were observed in CRAFT09 (with some occasional noisy calorimeter towers)
**Run Time Logger (RTL)**

RTL is a tool developed (at Fermilab) to analyze the efficiency of operations at CMS. Keep track of sources of downtime and identify the sources which have maximum impact on data taking.

RTL is commissioned and used extensively to understand downtimes during CRAFT 09.

[Graphs and data showing downtime categories and durations]

http://www.uscms.org/roc/RTLSummary/RTLSummary.html
Efforts on HCAL Upgrade

Photodetectors used for HCAL Barrel, EndCap and Outer: Hybrid Photo Diodes (HPD)
Possible upgrade to Silicon PhotoMultipler (SiPM)
Prototype SiPM are tested with Outer HCAL towers.

- Excellent S/N and no effect of magnetic field
- Significant progress on temperature stabilization - tested during Testbeam 2009

Temperature stability 0.2°C (external temperature varied nearly 8 °C over the testing period)
Summary

• It is decided to start LHC with 3.5 TeV and possible constraints are enumerated.

• LHC is well into cool-down phase and is ON schedule for mid-November beam startup. Expecting to have first high energy collisions before Christmas.

• CMS detector successfully finishes global running with cosmics (CRAFT09) with all the subdetectors functioning properly.

• Express data stream, Alignment-Calibration data streams and full reconstruction chain with prompt calibration are exercised during CRAFT09.

• CMS is ready to get into beam commissioning phase.

• Efforts for upgrade are on the way and there is already a significant progress towards upgrade of HCAL photodetectors to SiPMs.
Copper Stabilizer problem

Bad surprise after gamma-ray imaging of joints: Void is present in most of the bus extremities because SnAg flew out during soldering of the joint.

- Measurements done in 6 sectors, missing 7-8 and 8-1
- 10 dipole (> 35 $\mu$Ω) and 10 quadrupole (> 80 $\mu$Ω) joints repaired
- Lot of effort has gone into modeling the problem...

- Case 1 - Joint quenches in 1.9 K environment (within 1 sec from start of the current decay). QPS triggers because magnet reaches 100 mV or bus reached 3 mV-s. Worst scenario - quench happens without cooling Helium.

- Case 2 - Joint quenches in gaseous warm He environment (after time tJQ from the start of quench)
### 3.5 TeV limits

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limit</th>
<th>Reason(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Intensity</td>
<td>~6 e13</td>
<td>collimation cleaning efficiency</td>
</tr>
<tr>
<td>□* - crossing angle off</td>
<td>1 m</td>
<td>aperture</td>
</tr>
<tr>
<td>□* - with crossing angle</td>
<td>2 – 3 m</td>
<td>aperture, long range beam-beam</td>
</tr>
<tr>
<td>Crossing angle [50 ns]</td>
<td>~300 µrad</td>
<td>□*, aperture, long range beam-beam</td>
</tr>
<tr>
<td>Peak luminosity</td>
<td>~1 e32</td>
<td></td>
</tr>
</tbody>
</table>

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**Given these constraints what can we do?**

- Fill length: 8 hours
- Turnaround time: 5 hours
- 20 hours luminosity lifetime
- 30 day months.
- 40% machine availability
- Nominal crossing angle assumed for 50 ns.
- Nominal transverse emittance
- Total intensity limited to around 12% of nominal
- No squeeze beyond 2 m. with 156 bunches, crossing angle off - conservative
## Plugging in the numbers – 3.5 TeV

<table>
<thead>
<tr>
<th>Month</th>
<th>OP scenario</th>
<th>Max number bunch</th>
<th>Protons per bunch</th>
<th>Min beta*</th>
<th>Peak Lumi</th>
<th>Integrated</th>
<th>% nominal</th>
<th>events/X</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Beam commissioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Pilot physics combined with commissioning</td>
<td>43</td>
<td>$3 \times 10^{10}$</td>
<td>4</td>
<td>$8.6 \times 10^{29}$</td>
<td>$\sim 200 \text{ nb}^{-1}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>43</td>
<td>$5 \times 10^{10}$</td>
<td>4</td>
<td>$2.4 \times 10^{30}$</td>
<td>$\sim 1 \text{ pb}^{-1}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>156</td>
<td>$5 \times 10^{10}$</td>
<td>2</td>
<td>$1.7 \times 10^{31}$</td>
<td>$\sim 9 \text{ pb}^{-1}$</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>5a</td>
<td>No crossing angle</td>
<td>156</td>
<td>$7 \times 10^{10}$</td>
<td>2</td>
<td>$3.4 \times 10^{31}$</td>
<td>$\sim 18 \text{ pb}^{-1}$</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>5b</td>
<td>No crossing angle – pushing bunch intensity</td>
<td>156</td>
<td>$1 \times 10^{11}$</td>
<td>2</td>
<td>$6.9 \times 10^{31}$</td>
<td>$\sim 36 \text{ pb}^{-1}$</td>
<td>4.8</td>
<td>1.6</td>
</tr>
<tr>
<td>6</td>
<td>partial 50 ns – nominal crossing angle</td>
<td>144</td>
<td>$7 \times 10^{10}$</td>
<td>2-3</td>
<td>$3.1 \times 10^{31}$</td>
<td>$\sim 16 \text{ pb}^{-1}$</td>
<td>3.1</td>
<td>0.8</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>288</td>
<td>$7 \times 10^{10}$</td>
<td>2-3</td>
<td>$8.6 \times 10^{31}$</td>
<td>$\sim 32 \text{ pb}^{-1}$</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>432</td>
<td>$7 \times 10^{10}$</td>
<td>2-3</td>
<td>$9.2 \times 10^{31}$</td>
<td>$\sim 48 \text{ pb}^{-1}$</td>
<td>9.4</td>
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</tr>
<tr>
<td>9</td>
<td></td>
<td>432</td>
<td>$9 \times 10^{10}$</td>
<td>2-3</td>
<td>$1.5 \times 10^{32}$</td>
<td>$\sim 80 \text{ pb}^{-1}$</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>432</td>
<td>$9 \times 10^{10}$</td>
<td>2-3</td>
<td>$1.5 \times 10^{32}$</td>
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<td>432</td>
<td>$9 \times 10^{10}$</td>
<td>2-3</td>
<td>$1.5 \times 10^{32}$</td>
<td>$\sim 80 \text{ pb}^{-1}$</td>
<td>12</td>
<td></td>
</tr>
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### Plugging in the numbers with a step in energy

<table>
<thead>
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<th>OP scenario</th>
<th>Max number bunch</th>
<th>Protons per bunch</th>
<th>Min beta</th>
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<th>% nominal</th>
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<tr>
<td>1</td>
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<td>$3 \times 10^{10}$</td>
<td>4</td>
<td>$8.6 \times 10^{29}$</td>
<td>~200 nb$^{-1}$</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>43</td>
<td>$5 \times 10^{10}$</td>
<td>4</td>
<td>$2.4 \times 10^{30}$</td>
<td>~1 pb$^{-1}$</td>
<td></td>
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<tr>
<td>4</td>
<td></td>
<td>156</td>
<td>$5 \times 10^{10}$</td>
<td>2</td>
<td>$1.7 \times 10^{31}$</td>
<td>~9 pb$^{-1}$</td>
<td>2.5</td>
</tr>
<tr>
<td>5a</td>
<td>No crossing angle</td>
<td>156</td>
<td>$7 \times 10^{10}$</td>
<td>2</td>
<td>$3.4 \times 10^{31}$</td>
<td>~18 pb$^{-1}$</td>
<td>3.4</td>
</tr>
<tr>
<td>5b</td>
<td>No crossing angle – pushing bunch intensity</td>
<td>156</td>
<td>$1 \times 10^{11}$</td>
<td>2</td>
<td>$6.9 \times 10^{31}$</td>
<td>~36 pb$^{-1}$</td>
<td>4.8</td>
</tr>
<tr>
<td>6</td>
<td>Shift to higher energy: approx 4 weeks</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>7</td>
<td>4 – 5 TeV (5 TeV luminosity numbers quoted)</td>
<td>156</td>
<td>$7 \times 10^{10}$</td>
<td>2</td>
<td>$4.9 \times 10^{31}$</td>
<td>~26 pb$^{-1}$</td>
<td>3.4</td>
</tr>
<tr>
<td>8</td>
<td>50 ns – nominal Xing angle</td>
<td>144</td>
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<td>~23 pb$^{-1}$</td>
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<td>9</td>
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<td>288</td>
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<td>50 ns</td>
<td>432</td>
<td>$7 \times 10^{10}$</td>
<td>2</td>
<td>$1.3 \times 10^{32}$</td>
<td>~69 pb$^{-1}$</td>
<td>9.4</td>
</tr>
<tr>
<td>11</td>
<td>50 ns</td>
<td>432</td>
<td>$9 \times 10^{10}$</td>
<td>2</td>
<td>$2.1 \times 10^{32}$</td>
<td>~110 pb$^{-1}$</td>
<td>12</td>
</tr>
</tbody>
</table>
Runtime Logger Reporting Tool

Downtime by categories

UNDECIDED: UNDECIDED - 19%
GENERAL: HUMAN_ERROR - 0%
GENERAL: PLAYTIME_DOWN - 9%
DAQ: CONFIG - 17%
DAQ: CDAQ_HW - 1%
DAQ: CDAQ_SW - 2%
DAQ: CDAQ_RCMS - 0%
PWR_SUPPLY: HCAL_PWR - 18%
PWR_SUPPLY: ECAL_PWR - 14%
PWR_SUPPLY: TRK_PWR - 10%
PWR_SUPPLY: PIX_PWR - 10%
PWR_SUPPLY: DT_PWR - 7%
PWR_SUPPLY: RPC_PWR - 7%
PWR_SUPPLY: CSC_PWR - 7%
TRIGGER: L1_ECAL_TPG - 7%
TRIGGER: L1_CSC_TFT - 7%
DAQ: ECAL_DAQ - 7%

INFRA: SOLENOID - 5:35:33
INFRA: POWER_OUT - 10:10:57
INFRA: COOLING - 17:10:52
PWR_SUPPLY: HCAL_PWR - 1:17:02
PWR_SUPPLY: ECAL_PWR - 0:14:50
PWR_SUPPLY: TRK_PWR - 1:49:05
PWR_SUPPLY: PIX_PWR - 5:10:17
PWR_SUPPLY: DT_PWR - 4:48:02
PWR_SUPPLY: RPC_PWR - 1:08:38
PWR_SUPPLY: CSC_PWR - 0:13:05
TRIGGER: L1_DTTF - 7:46:27
TRIGGER: L1_CSC_TFT - 0:44:50
TRIGGER: L1_RCT - 0:36:11
TRIGGER: L1_GCT - 0:42:48
TRIGGER: L1_GT - 1:32:23
TRIGGER: CONFIG - 4:33:25
TRIGGER: L1_TS - 0:59:14
TRIGGER: L1_DT_TPG - 0:29:48
TRIGGER: L1_ECAL_TPG - 1:47:22
DAQ: DQM_DAQ - 0:15:10
DAQ: TRIG_DAQ - 2:25:53
DAQ: SCAL_DAQ - 1:43:10
DAQ: TRK_DAQ - 2:13:44
DAQ: ES_DAQ - 2:29:02
DAQ: PIX_DAQ - 3:31:51
DAQ: DT_DAQ - 5:23:52
DAQ: RPC_DAQ - 1:51:11
DAQ: CSC_DAQ - 3:37:45
DAQ: HCAL_DAQ - 4:21:40
DAQ: ECAL_DAQ - 17:31:23
DAQ: CDAQ_RCMS - 0:57:14
DAQ: CDAQ_SW - 6:17:00
DAQ: CDAQ_HW - 2:54:54
DAQ: CONFIG - 43:21:50
GENERAL: PLAYTIME_DOWN - 22:09:31
GENERAL: HUMAN_ERROR - 1:15:22
UNDECIDED: UNDECIDED - 48:27:26

Monday, September 14, 2009