The TOTEM Experiment

Inelastic Telescopes:
T1: $3.1 < |\eta| < 4.7$
T2: $5.3 < |\eta| < 6.5$

Roman Pots:
RP1
RP2
Status of the TOTEM Experiment

- All Si detectors installed in the Roman Pots at 220m
  Infrastructure installed and Commissioning has started
- One T1 Telescope fully equipped and under test in H8
- Both T2 telescopes installed
  Infrastructure installed and Commissioning is well advanced
- Most of the Electronics running
delivery problems with some printed boards
- DAQ installed at point 5 for commissioning of the detectors
- Software well advanced
- to be ready for calibrations, alignments and data taking
The RP Stations at 220m sect 56 (April 09) and 45 (August 09) are fully equipped. (120 Si planes)

Production schedule presented in the previous meeting strictly respected !!!

Production of the other stations continues. At least 4 stations at 147m equipped soon
Installation of the Infrastructure is finished and commissioning at IP5 has started.

Far stations at 220 m

Near stations at 220 m
Connection of control cables and fibers in the tunnel
Control loop power-up and test
Access to the CCUs and DOHs registers
Power-up and calibration of the LV
Fibers connection in the CR
Hardware probing
Power-up of HV
VFATs Calibration
Roman Pot Hardware Overview (DCS)
Vacuum System

Final layout of the vacuum system installed on both sectors at the 220m RP Stations

It includes a local setup constraining the vacuum in the pots in a working range

Bourdon (2 set points)

Maximum allowed distortion for the thin window in the pot (POT also moved out)

Safe limit before glow discharge in the pot

All pots evacuated right after the insertion of the DPs
Cooling System

Plant operational and running on internal mode since long time

Cooling Test 56_220 of 28 August 2009

Temperatures on RPM8 (RadMon NTC)

Temperatures on Hybrids (PT100 on plane 8)

Stable: 10h30 to 16h30

-29.4 °C
Sensors

- Cables installed and tested
- Final R/O box for temp and pressure installed and tested
- Final R/O box for RadMon installed and tested
<table>
<thead>
<tr>
<th>High Voltage and Low Voltage</th>
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<tr>
<td><strong>High Voltage</strong></td>
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<tr>
<td>• All Power Supplies installed and tested</td>
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<tr>
<td>• All cables tested</td>
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<tr>
<td>• Distributor Box (240 to 24) installed and tested</td>
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<td><strong>Low Voltage</strong></td>
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<td>• All the chain installed</td>
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<tr>
<td>• All cables tested</td>
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<tr>
<td>• “2.5 V” tested at the Pots in 56</td>
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<tr>
<td>• Overcurrent still to be regulated</td>
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System Overview

Position requests

Alarms

FESA Server

single Extraction

emergency extraction

CCC

FESA ICD

Position requests + limits

emergency extraction

CIBU

Interlock control rack (common with CMS)

NI PXI

USER_PERMIT

INJECTION_PERMIT

Motor Control + Interlock card

Roman pots

TOTEM DCS
RP Movement Test in the CCC

Settings outside limits are REJECTED.

Beam Loss Monitor signal (empty since no beam)

Inner dump limit off-scale

Inner warning limit

Measured position (LVDT)

Outer warning limit

[Outer dump limit off-scale]

LHC RRB, 13 October 2009
K. Eggert
Available resources, available time…

<table>
<thead>
<tr>
<th>PH-TOT (+Collab.)</th>
<th>PH-DT</th>
<th>PH-ESE</th>
<th>OTHER DEPTs</th>
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<tr>
<td>G. Antchev</td>
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<td>I. Atanassov</td>
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<td>F. Lucas Rodrig.</td>
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<td>G. Ruggiero</td>
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<tr>
<td>V. Vacek +1</td>
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People (physicists, engineers, technicians, students…) helping in this phase of the project.

Some **30 people**, not all 100%!!!

- All efforts concentrated on the stations at 220m
- Most of the work limited by access to the tunnel (**these activities almost completed**).
T2 commissioning with cosmic rays

The tests have been performed with the readout chain, the HV and the LV supplies foreseen for the final system in IP5.

Detector Intrinsic Efficiency

T2 track reconstruction efficiency > 98%
All four T2 chambers installed at IP5

1° quarter
Installed in the minus far side

2° quarter
Installed in the plus far side

3° quarter
Installed in the plus near side

4° quarter
Installed in the minus near side
Mechanical structure and Magnetic field tests during summer

- Both halves of T2 inserted into HF plus and minus.
- Maximum lateral movement measured on the detector with nominal internal CMS field of 3.8 T is less than 2 mm.

Delta of T2+ side

3.8T

1mm
Commissioning of T2 in IP5: Services

- HV (all 40 chambers at nominal Voltage) integrated in DCS
- LV integrated in DCS
- Gas controlled remotely from CMS Gas system, no leak has been found.
- Cooling secondary circuit has been tested with magnetic field and fully debugged. It is working without interruption since one month.
Trigger and DAQ

• The control loops are closed, and all the I2C devices programmed correctly

• The DAQ data transmission has been tested, data acquired with internal trigger and calibration pulses.

• The Trigger signals are under test these days through a Spy program developed to debug the trigger setup.
T1 detector status

- **CSC production** completed at PNPI
  - all acceptance tests at CERN OK

- **Front-end electronics** production completed

- new anode boards; now inserting additional VFAT protection

- Two **half-arms** completely assembled and equipped
  - other two support “baskets” assembled and partially serviced

- All **services in IP5** ready on ‘–’ side
  - waiting for opportunity to complete ‘+’ side
Half detector mounted in H8
In order to test assembled quarters of T1, a Cu target has been placed on the test beam in H8, at the same distance from the detector as will be the IP.

- trigger on pion beam with scintillators before and after the target
Test beam data

Event display

Reconstruction of the target position (track intersection at $z = 0$)
The second arm

• Two remaining T1 “baskets” assembled with gas and cooling lines
  – one cooling line to be checked by CERN team next week (our check OK);
    small leak on other line, to be fixed
  – LV cabling partially done

• Preparation/assembly of two half-arms starting next weeks (with help from PNPI personnel)
  – 11 CSC ready with AFEC and shields
Support structure

- Test of insertion of 1 truss in YE2 in June 09:
  - trusses assembled;
  - required precision of rails’ position checked;
  - alignment of support mechanism done with a mock-up in IP5, tested and working properly;
  - installation tool built

- Truss installation and alignment reviewed in detail in a CMS-WOGEI meeting in August:
  - first installation of truss requires shimming in place and alignment to YE2 by geometers (vacuum pipe protection was used for welding the blocks in June and is already available)
Electronics system TOTEM Roman Pots

12 RP motherboards finished Feb 2009, units for 147 m under test

RP hybrid with VFATs and detector

Agreement with Cicorel on relaunch of production

HOST board: clear soldering problem, production relaunched

Tracking data

To DAQ

220 m
147 m

Trigger data

short cabling finished

Trigger and Timing

Control

TC data

FEC-CCS

OK

DOHM

OK

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K. Eggert
Electronics system overview CSC (T1)

Cathode frontend card with VFATs

Readout Card

Tracking data

Raw trigger data

TTC data

For T1 trigger formation in counting room only

To DAQ

HOST board: clear soldering problem, production relaunched

Trigger data

Detector Hybrids spares to be produced

AFEC with VFATs
Add spark protection

DOHM

OK

FEC-CCS

OK

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Electronics system overview GEM (T2)

11th card with coincidence chip

Rack near detector

Tracking data

- GOHs
- optoTX

Trigger data

- GOHs
- optoTX

TTC data

DOHM

OK

Counting room

To DAQ

HOST board: clear soldering problem production relaunched

Trigger and Timing

FEC-CCS

OK

Detector Hybrids spares in production

OK

horseshoe

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The Host Boards for T2 and RP trigger are ready.

The trigger mezzanine LONEG (L1gen..) has been delivered as scheduled early this summer. The board has been electrically tested and actually is in Siena where Maria Grazia is developing the control firmware.
DAQ infrastructure

- RP and T2 DAQ crates are installed at IP5 and connected to their readout PCs
- Infrastructure ready to receive the T1 crate from H8
- $\frac{1}{2}$ of the total storage capacity installed
- Private direct network connection to the surface being planned
TOTEM Offline Software

Proton transport

- MADX
- LHC optics models
- Proton transport param.

Simulation

- Generator input
- Smearing
- Geant4
- Detector response simulation
- VFAT simulation

Data

- Totem Data Reader
- Experiment Data
- TestBeam Data

Trigger

- CC Simulation
- Trigger Simulation

Reconstruction

- Clusters
- Pattern recognition
- Track reconstr.
- TOTEM physics reconstruction and analysis

Validation Suite
**Simulation**

- **Code completion:** 100%

  - **Work in progress:**
    - Tuning of the detector response following the detectors commissioning
    - Validation of the results for E=3.5 TeV

**Reconstruction**

- **Code completion:** 100%

  - **Work in progress:**
    - Optimization of the track reconstruction
    - Tools and procedures for the analysis

**Forward Proton Transport**

- Code completion: 100%

- Optics: $\beta^* = 1540, 90, 2$ m at E=7 TeV

- Work in progress: include $\beta^* = 90, 2$ at E=3.5 TeV

**Proton transport**

- MADX
  - LHC optics models
  - Proton transport param.

**Simulation**

- Generator input
  - Smearing
    - Geant4
      - Detector response simulation
      - VFAT simulation

**Reconstruction**

- Clusters
  - Pattern recognition
    - Track reconstr.
      - TOTEM physics reconstruction and analysis

**LHC RRB, 13 October 2009**

K. Eggert
Data Quality Monitor
Event Display

Based on FROG Framework

Code Completion: 60%
Database for the Offline

Transfer from different “Sources” to the DB (work in progress)

Examples:
- Detector conditions: Voltage, VFAT Threshold, Cabling....
- LHC conditions: beam energy, magnets settings, Beam Position Monitor, optics..

Alignment

Work in progress: Strategy for the global RomanPot alignment

Access to DB implemented

Work in progress:
Data Access implementation

Graphical Interface to inspect the DB contents
Physics of 2009-2010 runs

TOTEM will operate under all running conditions.

Physics at $\sqrt{s} = 900$ GeV:
Mainly set-up work of all detectors and systems
• poor elastic acceptance due to large beam size at Roman Pots and TAS / quadruple triplet aperture limitations
• RP alignment using beam halo and diffractive protons
• leading protons with momentum losses $\xi = \Delta p/p > 0.1$
• study of forward charge particles with T1 and T2

Physics at $\sqrt{s} = 7 – 10$ TeV:
• early low $\beta^*$ optics:
  – high–$|t|$ elastics
  – high mass SD & DPE
  – forward charged particle event topology & inelastic rates
• as soon as technically feasible: short LHC runs with $\beta^* = 90$ m
  $\rightarrow 1^{\text{st}} \sigma_{\text{tot}}$ measurement with T1, T2 & RP (precision: $\sim 5\%$)
Path to first measurements

- Exercise RP insertion
- Use first data to optimize simulation & reconstruction (realistic noise, track selection etc…) + for 1\textsuperscript{st} detector alignment.
- Select ”clean” event topologies & optimize their triggering
  - elastic: 1 proton in vert. RP on each side
  - DPE: 1 proton in horiz. RP on each side
  - SD: 1 proton in horiz. RP on one side, tracks in T1/T2 other side
  - MB: tracks in T1/T2 on each side
- RP global alignment
- First measurements in topologies with ”low” background:
  - high-|t| elastics & forward charged particles
- Measure beam induced proton background
- Proceed with other measurements: DPE, SD, inelastic rates
RP alignment strategy I

- use of any straight tracks
- SD or beam induced background protons at low $\beta^*$, + elastics at high $\beta^*$
- for vertical beam position use y-distribution w.r.t. beam center

Expected rate: SD protons $\sim$ few kHz for low $\beta^*$

Example: $\beta^* = 2$ m, $E_p = 7$ TeV, $L = 10^{30}$ cm$^{-2}$s$^{-1}$

SD protons@ RP220

y-distribution of SD protons

Nom. approach: $10\sigma_{\text{beam}} + 0.5$ mm

$\sigma$ (mean): $\sim 20$ $\mu$m in few s @ nom. approach
RP alignment strategy II

- for **horizontal** beam position use **high-|t| elastic tracks:**
  - expected rate ~ few tens of mHz at low $\beta^*$, high $\beta^*$ larger

  Example: $\beta^* = 2 \text{ m, } E_p = 7 \text{ TeV, } \mathcal{L} = 10^{30} \text{ cm}^{-2}\text{s}^{-1}$

  - elastic protons @ RP220

  - global (right arm vs. left arm)
    - track-based approach using **elastic events**
  - other information useful for RP alignment
    - BPMs: useful to monitor fast beam variations…
    - RP motor info: fill to fill variations

~15 $\mu$m in 6 min @ nom. approach

detailed RP alignment procedure developed from experience with real data !!
Summary

- RP at 220m and T2 are completely installed
- Commissioning is well advanced with the final DAQ
- T1 telescope for one side is under test in H8
  Additional spark protection for the VFAT will be installed
- Telescope for the other side will be assembled now
- Installation of T1 in coordination with CMS
- Offline software is prepared for simulations and data taking
- First alignment and calibration procedures, as well as the Physics program are defined.
- Ready for data taking at the start of the LHC