CMS/TOTEM Upgrade proposal

- Proposed Roman Pot layout of TOTEM after LS1
- Roman Pots @ LHC – [IP5] LHC operation
- Optimization of Roman Pots
- Rates
Overview

Consolidation program
- approved by TOTEM management & LHCC deliberations - 16. April 2013

Upgrade program proposal:
http://cds.cern.ch/record/1554299
- given to LHCC on 13. June 2013

-> Layout of RP stations - combination of consolidation program with upgrade program

-> Observations during insertion of horizontal RPs in November 2012 (high luminosity, low $\beta^*$) had impact on consolidation & upgrade program

-> optimization of Roman Pot for consolidation & upgrade
-> requirements on detectors and
Presentation of TOTEM Roman Pot consolidation & upgrade plans in different meetings

1) CMS-TOTEM (management) meeting on 5.10.2012  -> TOTEM proposal for future forward physics program
2) 14th LTEX meeting on 8.11.2012
3) 1st LHC workshop on Collider Experiment Interface on 30.11.2012 (CERN)
4) Results and prospects of forward physics at the LHC on 12.2.2013  
   Implications for the study of diffraction, cosmic ray interactions, and more (CERN)
5) 16th LTEX meeting 14.2.2013
6) 113th LHCC meeting 13.3.2013  -> LHCC deliberation for TOTEM consolidation
7) 19th LTEX meeting 16.5.2013
8) TOTEM referee/LHCC meeting 11.6.2013  -> presentation of upgrade proposal
9) 20th LTEX meeting 11.7.2013  -> review of TOTEM consolidation & upgrade with LHC experts

+ several CMS-TOTEM technical meetings, TOTEM collaboration upgrade meetings (2012-2013), ATLAS-AFP (February 2013), ATLAS-ALFA (January 2013)

Start with development of new Roman Pot
Roman Pot at 147m & 220m

Relocation of RPs & patch panel from 147m to 210m

patch panel (relocated from 147m)

Position of relocated RPs from 147m

Position of new RPs

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Roman Pot consolidation & upgrade overview (schematic)

- Relocated RP-147m -> RP-210 m (near-far)
- Existing RP-220 m (near-far)

- New Si pixel tracking detectors in horizontal RPs
- New timing detectors

- Only selected Roman Pots will be inserted depending on running scenario & alignment
  High luminosity runs foreseen with 4 horizontal Roman Pots (210_near, 220_near, Timing1, Timing2)

- New LHC component
- Outgoing beam
- TCL-4
- Q5
- ~ 5-10 m

- 2 vertical RP 1 horizontal RP TRACKING Detector
- v & h rotated by 8° around beam axis

- Near 2 vertical RP top/bottom 1 horizontal RP TIMING Detector

- Existing RP-220 m (near-far)
- New RP stations
- New timing detectors
- Far 2 vertical RP top/bottom 1 horizontal RP TIMING Detector

- CMS ip5
- ~ 220 m

- TCL-6
- Q6
- ~ 5 m

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Running scenarios <-> RP layout

Table 1: Overview of expected running scenarios with their respective ranges of inelastic pileup $\mu$ and delivered luminosity. The precise values depend on the bunch size, the number of bunches, and the emittance.

Flexibility of RP system
In 2011 and 2012 specific RP tests & insertions were performed at standard LHC settings to study:

- Roman Pot <-> LHC: RP heating & beam stability
- Roman Pot detector: rates & background

Observations during low $\beta^*$ run (2012):
[LHC-MPP M. DEILE, December 2012]

Insertion of RP horizontal at 220m ->
List of Insertions at $\beta^* = 0.6 \text{ m}$ in 2012

<table>
<thead>
<tr>
<th>Date</th>
<th>Pots involved</th>
<th>min. dist.</th>
<th>Observations, Result</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.10.</td>
<td>all V, all H</td>
<td>12 $\sigma$, 30 $\sigma$</td>
<td>no problem dump on XRPH.A6R5.B1 (slow losses, 5s)</td>
<td>no UFO activity</td>
</tr>
<tr>
<td>05.11.</td>
<td>all H</td>
<td>30 $\sigma$</td>
<td>dump on XRPH.A6R5.B1 (slow losses, 5s)</td>
<td>no UFO activity</td>
</tr>
<tr>
<td>14.11.</td>
<td>all H</td>
<td>32mm $\sim$ 270 $\sigma$</td>
<td>dump on XRPH.A6R5.B1 (fast losses)</td>
<td>UFO activity in 6L5 (*)</td>
</tr>
<tr>
<td>16.11.</td>
<td>H, not A6R5.B1</td>
<td>14 $\sigma$, 2mm</td>
<td>no problem, beams separated by 4$\sigma$</td>
<td>slow losses (5s) in each ramp until conditioning (heat up) of beam screen in Q6</td>
</tr>
</tbody>
</table>

(*) The (fast) UFOs in 6L5 were later found to originate from TCL5 [Tobias]
Comparison BLMs & Beam Vacuum

Note: no pressure increase in any gauge further upstream (cell 5R5).
Temperature Sensors on Detector Hybrid Boards: Sector 5-6 (Beam 1)

- Insertion at low $\beta^*$
- Beam heating – LHC vacuum – RP optimization rates
Main temperature effect from chips changing to run mode; small additional increase (3 deg.) from pots moving very close to the beam. UFOs cannot be resolved.

Highest temp. ever measured

beam heating – LHC vacuum – RP optimization rates
Fill 3188 with RP Insertion, Cell 6R5


BLM and vacuum spike, no dump

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insertion at low $\beta^*$ beam heating – LHC vacuum – RP optimization rates
The temperature in the Roman Pot increases due to the EM coupling with the LHC.

- Cooling of RPs is mandatory when LHC beam is injected.
- Modification of evaporative cooling system by integrating a safe mode to operate above dew point in case of vacuum problem.

Cooling of RP was switched off.
RP optimization

RF study

GEANT – FLUKA study

dimensions-engineering-design of new RP + location of RP in experiment

Production drawing
Optimization of RF characteristics

(first preliminary results B. Salvant, BE-ABP-ICE)

Present RP housing

Study of new RP housing

Study of possible RF shielding for existing RP

Study is ongoing
Not all issues are solved yet!

Rectangular (rotated-90°) RP with ferrite
- > ~ 300 W

Ideal cylindrical RP (without gap cylinder/flange)
no ferrite
- > < 10 W

insertion at low $\beta^*$
beam heating – LHC vacuum – RP optimization-rates
From box shaped RP to cylindrical: study of RP box (normal & rotated)

Box Roman Pot

The present RP is box shaped
Simplified model:
- PEC and Ferrite only
- Geometrical impedance
- No thin windows
  Small effects on the results

Heating of the box RP

Rotation by 90° to house timing detector

Unacceptable heat intake
Advantage of cylindrical geometry
RF & space for detector & components

From Box to Cylinder

The main problem is the vacuum cavity between the RP and the flange: box RP and cylindrical flange.

With a cylindrical RP the cavity is filled:
• Better RF behaviour
• More space available inside the RP (detector, cooling, power line, ...)

Nicola Minafra - TOTEM
13 June 2013 • 20
## Comparison of different RP designs

### IMPEDANCES OF THE TOTEM RPs (2/3)

<table>
<thead>
<tr>
<th></th>
<th>$Z_{\parallel}^{\text{eff}} / n$ (m$\Omega$)</th>
<th>% to total LHC current impedance (90 m$\Omega$)</th>
<th>$Z_{\perp}^{\text{eff}}$ (K$\Omega$/m)</th>
<th>% to total LHC current impedance (25 M$\Omega$/m)</th>
<th>Heating (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present RP 1)</td>
<td>1.7</td>
<td>1.9%</td>
<td>80</td>
<td>&lt; 0.3%</td>
<td>62</td>
</tr>
<tr>
<td>Rotated RP 2)</td>
<td>2.6</td>
<td>2.9%</td>
<td>20</td>
<td>&lt; 0.1%</td>
<td>241</td>
</tr>
<tr>
<td>Cylindrical RP 3)</td>
<td>1.1</td>
<td>1.1%</td>
<td>50</td>
<td>&lt; 0.2%</td>
<td>13</td>
</tr>
<tr>
<td>Cu shielded RP 4)</td>
<td>1.2</td>
<td>1.3%</td>
<td>70</td>
<td>&lt; 0.3%</td>
<td>10</td>
</tr>
</tbody>
</table>

- 35% better
- ~ × 5 better
- 30% better
- ~ × 6 better

**Results for 1 RP with the beam at 1 mm**

Elias Métal, TOTEM collaboration

### Notes

1) and 2) Π / 2 rot.

3) Forward Physics at the LHC
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TOTEM Upgrade Proposal J. Baechler
CONCLUSION

- 3 or max 4 H RPs for high-intensity runs => Should be OK but depends also on all the other impedance contributors => Imagine 10 impedance contributors each increasing by 5%... The other equipments linked to the RPs need to be also considered (collimators, etc.)
- Detailed heat transfer studies to be done with the ferrite
- Recommended Cu coating for the Resistive-Wall impedance: > ~ 5 μm is OK (10 μm if possible)
- EM simulations based on several assumptions => Measurements on a prototype should be performed as a final check / validation!

ACKNOWLEDGEMENTS

- Many thanks to Nicola Minafra for all his nice studies over the past few months with Benoit Salvant and the impedance team
- A lot of collaboration with ALFA which was very positive and useful
Choice of Ferrite Material

1. **Old material: 4S60 (Ferroxcube)**
   
   unacceptable due to low Curie temperature (~100 °C)
   
   but: low outgassing after bake-out at 1000 °C
   
   for diagnostic purposes: test outgassing of the old TOTEM ferrites after removal from RPs

2. **TT2-111R (TransTech)**
   
   already chosen by collimation group, hence baseline solution
   
   Curie temperature = 375 °C
   
   Outgassing tested and acceptable but worse than 4S60
   
   Contact to TransTech established, quote imminent

3. **4E2 (Ferroxcube)**
   
   alternative material
   
   Curie temperature ~450 °C
   
   Small samples available
   
   Outgassing to be tested (discussed with G. Cattenoz):
   
   - as received from production
   
   - after bake-out at 1000 °C (@ BrevettiBizz, San Bonifacio - Verona, Italy; offer received)

   Contact to Ferroxcube established, waiting for quote
RF optimization

RF study

Ferrite

Cylindrical RP

RF shield:
Box RP & cylindrical housing with ventilation holes

Cylindrical geometry with standard flange
- general dimensions
- ferrite + location
- ferrite shape + dimension
- material -> electrical conductivity

Cylindrical Geometry needs to integrate the present RP box:
- general dimensions
- ferrite + location
- ferrite shape + dimension
- material -> electrical conductivity
- vacuum + outgasing openings allowing to vent the volume – without pressure gradient

Cylindrical Shape outgassing C-temp.
GEANT simulation:
Secondary particles created in Roman Pot housing

TOTEM upgrade proposal

Figure 17: Left: distribution of the secondary particles created by a horizontal standard RP and recorded in a scoring plane 6 m farther. Right: corresponding energy flow distribution. The particle generator is based on the measured rate profile. The white circle around the origin with radius 40 mm indicates the beam pipe.
Material budget of timing detector (preliminary results)

Study of total secondary production
-> TCL6 – Q6
-> cross talk (light)
time resolution <-> material budget

1000 Protons (7 TeV) on quartz bar

Ratio of charged particles inside the Cherenkov bar with respect to the total number of charged particles

Charged particles $N_{\text{ch,all}}$ (inside + outside) as a function of distance $z$
Operation limitation

Performance limitation

RP operation
performance & operation limitation -> LHC & Roman Pot

- BLM signal increase due to secondaries produced in RP material & LHC gas
- Local LHC vacuum degradation
- RF RP heating: ferrite performance, temp increase - outgassing - Curie temp, thermal run away

Insertion of RP:
- Distance to beam
- Beam optics
- Luminosity
- Collimators

Eff Z - Transverse Impedance
LHC beam stability

Eff Z - Longitudinal Impedance

RF - heating
RP electronics impact
RP housing impact

TOTEM RP development: multi parameter optimization
Development of new cylindrical Roman Pot
New (cylindrical) housing design

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Integration study of QUARTIC L-bars in cylindrical Roman Pot
Integration of cylindrical Roman Pot in station

Placement of Timing detector in the Housing and in the RP vacuum chamber

First prototype

RP vacuum chamber

housing

L-bars 5x5

$P^+$

RP 220 m $\rightarrow R = 0.6$ m

$3.6$ space for LED

$\phi 14.0$

$1.0$

$3.0$ space for LED

$\phi 15.0$ ID

RP-flange

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Roman Pot in garage position

Garage position
Approach of Roman Pot
10 \sigma to LHC beam
Placement of Timing detector in the Housing and in the RP vacuum chamber

NEG coating (?)
Production of cylindrical RP prototype @ CERN EN-MME

The design and technology of PROTOTYPE are adjusted; the material is ordered for 4 PROTOTYPE housings (for follow-up inspection and tests); expected date of performance ~ August 2013. F. Bertinelli & D. Perini
Placement of Timing detector in the Housing and in the RP vacuum chamber

NEG coating (?)

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For produced housing the following tests are planned:
1) Geometry verification (flatness of windows; surface roughness; tolerances, ...);
2) Strength structural tests for 1 bar; deflection measurement; cycles loading test;
3) Gas permeability (diffusion through the window material);
4) Mechanical tests in assembly with the Roman Pot (moving test, safety mech., compensation mech., stoppers, and the like). Adjustment and tuning.
Thin window 0.2mm

316LN (20°C)
\[ \Sigma_{0.2} = 607 \text{ MPa}; \]
\[ \Sigma_U = 812 \text{ MPa}; \]
\[ E = 193 \text{ GPa}. \]
316LN (20°C)

\[ \Sigma_{0.2} = 607 \text{ MPa}; \]
\[ \Sigma_U = 812 \text{ MPa}; \]
\[ E = 193 \text{ GPa}. \]

Crush test (as for present rectangular housing)
Present (rectangular) housing with RF shield

- Ferrite Ø195/Ø162x5
- Copper 1mm
TOTEM RF shield

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Horizontal Roman Pot station

1. Horizontal Roman Pot
   a) mech. Structure – VACUUM PRAHA sr.o (present design & safety);
   b) housing – CERN (new design);
   c) timing detector.
2. Frame – VACUUM PRAHA sr.o (modified design)
3. Support plate – CERN (present design)
4. Bellows – CERN (Standard BP bellows 300mm)
Location of new RP in LHC beam line

Cylindrical RP  RF shield & standard box RP
Rate & background measurement

Diffractive processes & their TOTEM trigger

- Elastic Scattering
- Single Diffraction (SD)
- Double Diffraction (DD)
- Central Diffraction (CD)

Cross-section large (≥ 5 µb), even TOTEM acceptance included for any $\beta^*$

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## Horizontal RP Rate at 14 σ

<table>
<thead>
<tr>
<th></th>
<th>56-F</th>
<th>45-N</th>
<th>45-F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate for 1368 b with beam separation</td>
<td>2 MHz</td>
<td>1 MHz</td>
<td>3 MHz (incl. showers from N)</td>
</tr>
<tr>
<td>separation lumi factor</td>
<td>1 / 15.7</td>
<td>1 / 18.6</td>
<td>1 / 22.6</td>
</tr>
<tr>
<td>Rate for 1368 b without separation</td>
<td>31 MHz</td>
<td>19 MHz</td>
<td>68 MHz (22.6* 3 MHz)</td>
</tr>
<tr>
<td>Rate for 1 b without separation</td>
<td>23 kHz</td>
<td>14 kHz</td>
<td>50 kHz</td>
</tr>
<tr>
<td>Hits per bx w/o separation</td>
<td>2.0</td>
<td>1.2</td>
<td>4.4 (50 kHz/11.2kHz)</td>
</tr>
</tbody>
</table>

**Beam conditions (fill # 3288):**
- $1.6 \times 10^{11}$ p/b
- $E = 4$ TeV
- $\beta^* = 0.6$ m
- $\varepsilon_n = 2.8$ μm rad
- $\mu = 31$ (without separation)
- $L = 6.7 \times 10^{33}$

**Revolution frequency:** 11.2 kHz
- average crossing rate : $11.2 \times 1368 = 15.3$ MHz
- average interaction rate (without separation) : $15.3 \times 31 = 47.4$ MHz

**expected SD rate per arm within acceptance:**
- $\sim 0.4 / \text{bx}$ (event rate / bunch crossing)

**Expected rates after LS1 are different (L, bunch scheme)**
Roman Pot detector system

study of combination: Si strip - Si pixel - timing (schematic)
Background study -> ongoing activity

- GEANT – FLUKA simulation
  TCL4 <-> TCL6 settings
- Background studies:
  LHC components:
    SEU downstream of RP_220m far - alcove Q6
  Roman Pot:
    background estimation
    timing detector efficiency – pixel size etc.
    trigger

Preparing the field for Roman Pots study in Cell6

- Recall results presented at Frascati 2012
- TCL4 at 10/15 sigmas

L.S. Esposito, F. Cerutti, EN-STI-EET, CERN
-> TIMING detector

- TIMING measurement components
  - clock distribution
  - TDC
  - Timing Detector
Sharing of work overview with CERN groups

EN-MEF-LE (LTEX coordination, synchronization with LHC planning & scheduling)
PH-DT (RP mechanics, vacuum, motor, services, cable production .. ..)
PH-ESE (electronic issues, fibers, HV cables, clock distribution...)
EN-CV-DC (RP cooling system)
EN-MEF-SI (cables)
EN-MME-DI (new RP production)
EN-STI-EET (background, TCL4, TCL6)
EN-ICE-SIC (FESA)
TE-VSC-LBV (ferrite – vacuum measurements, beam pipe)
TE-MPE-PE (LHC machine protection)
DGS-RP-AS (radiation protection)
PH-UCM (RP engineering, integration,...)
BE-ABP-ICE (RP – RF study & optimization)
BE-OP-LHC (Operation of RP – CCC)
BE-ABP-LCU (collimators)
BE-CO-HT (clock distribution)
MAIN Work packages
LS1 and beyond

• **TOTEM** -> **consolidation**
extraction & service of RP147 m
re-installation of RP147 m at 210 m (upstream of RP220 m near)
extension of services from 147 m to 210 m
extraction & re-installation of RP220 m & service work
service work on RP 220 m vacuum
service work on RP 220 m motor drive (hardware & software)
service work on RP (ferrite, RF housing)

• **TOTEM** -> **upgrade**
installation of 2 new RP horizontal stations on each side of IP5 (downstream of RP 220 m near, upstream of RP 220 m far)
adaptation of horizontal RPs to be used for low $\beta^*$
production new RP housing, optimized for RF heating and beam feedback
installation of electrical services for new detectors (standard services will be re-used from RP147)
installation of new tracking/timing detectors

• **LHC beam line modifications & RP integration** at +/- 210-220 m -> **consolidation + upgrade**
adaptation of beam line for installation of RP147m at 210m (consolidation) and new horizontal RPs (upgrade)

• **LHC collimators** -> **consolidation + upgrade**
installation of TCL4 (4/5, 5/6)
installation of TCL6 (4/5, 5/6) + relocation of cooling components close to +/- RP220m far.
Roman Pot
consolidation & upgrade strategy

CONSOLIDATION
- Remove RP147 m stations & patch panel (allows installation of TCL4)
- Relocation of RP147 m stations (including Si strip detectors) in +/- 210 m region & rotation of RP 210 m (far) by 8° around beam axis
- Exchange of ferrites of all RPs

UPGRADE (Roman Pot station)
- Installation of additional new RP stations (horizontal) in +/-220 m region (2 new RP stations in each sector (4/5), (5/6))

UPGRADE (Roman Pot detector)
- Integration of new pixel detectors in the (relocated RP147m) RPs in 210 m region
- Integration of new timing detectors in the new horizontal RPs

Guideline:
- Reinstallation of RP 147m stations with Si strip detectors in +/- 210m region (during LS1)
- The relocated horizontal RP station (147 m) can be equipped with Si pixel detectors
- The new horizontal RPs could be installed during LS1 and equipped immediately/successively with new timing detectors.
- The present 220 m stations must not be affected (touched) by any upgrade activity, until the high beta special runs after LS1 are finished. (Research Board approved stand alone program of TOTEM at full LHC energy)
- The timing detectors are installed downstream relative to the tracking detectors. (high material budget).
- Depending on the running scenario after LS1 (physics high $\beta*/$low $\beta*$, calibration, alignment), relevant RPs are inserted or retracted (parking position).
LS1 activity consolidation -> TIMELINE

(main activities)

- All RP stations and detector packages were extracted by 10.5.2013 ECR – consolidation. To be ready by 14.6.2013.
- Ferrite outgassing RP220m scheduled for June 2013?
- Ferrite material for exchange (incl. bake out) available (TT2-111R) 15.8.2013.
- Start to work on detector packages control from 3.6.2013.
- Anti collision switch & exchange of ferrite starting by 15.8.2013 in TIF.
- Validation of detector packages (vacuum test & cool down) in H8 starting by 15.8.2013.

Ferrite study & replacement

anti collision system calibration

- Extraction of detector packages 147 m / 220 m.
- Patch panel RP147 m dismounted 29.5.2013.
- Production of new RP cylindrical RP prototype (low RF, low material) started 3.6.2013.
- Decision to order new RP station from Vacuum Praha by 20.6.2013.

Installation of detector packages & movement tests & re commissioning of RPs & laser calibration.

- Re installation of RPs 220 m / 147 m/ new RP station?
- Installation of services lines in tunnel cables - cooling.
- Installation of detector packages & movement tests & re commissioning of RPs & laser calibration.

Work packages & schedule

- Extraction of detector packages 147 m / 220 m.
- Break vacuum 147 m/ 220 m.
- June 2014.
- 1. September 2014.
- Work packages & schedule.

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Upgrade -> TIMELINE

(main activities)

1. June 2013
   - Order of RP station
   - Order of ferrite elements
   - Start production of RP housing

2. July 2013
   - Cylindrical RP prototype mechanical & vacuum test
   - Assembly and test

3. August 2013
   - Installation of services lines in tunnel
cables - cooling – patch panel
   - Installation in tunnel

4. November 2013
   - Movement test & calibration of new RP station
   - Bake out starts

5. January 2014
   - End of work in tunnel

6. June 2014
   - order of RP station
   - order of ferrite elements
   - start production of RP housing

7. 1. September 2014
   - Work packages & schedule

Forward Physics at the LHC
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The Roman Pot upgrade is planned in two different phases

Phase 1
Installation of new cylindrical Roman Pot in a new horizontal station to allow the study of the RF impedance characteristics, the impact of the material budget on the operation of the LHC (high $\beta^*$, and low $\beta^*$) and the testing of different timing detector technologies (1-2 years after LS1). In addition the low material budget RF shield can be implemented in the horizontal RP 210 far (rotated) to test the effectiveness of this innovative RF shield in combination with the ultra low material budget RP (box shape).

Phase 2
Integration of new cylindrical RP in the vertical station of RP220 far allowing the use of timing detectors for high $\beta^*$ and low $\beta^*$ runs (installation in TS 2015/2016).

- The development aims to combine timing detectors and tracking detectors in a cylindrical Roman Pot which allow the approach the sensors to the closest distances of the LHC beam.

- In the present TOTEM upgrade philosophy we aim to insert at maximum 3 cylindrical Roman Pots per beam. All effort will be invested to develop low mass timing detectors, that allow to limit the number of Roman Pots per LHC beam line to 2.
RP upgrade
timeline of incremental strategy

• Cylindrical RP:
  Prepare at minimum 1 horizontal cylindrical RP to house any timing detector as demonstrator (carrier of new technology)
  -> installation during LS1
• Timing detector components & services
  - clock distribution
  - TDC
  - detector
  - laying of services/pachtpanel
  -> partially during LS1
• The RP equipped with timing detector will be operated in combination with strip detector therefore the very first test might take place with high $\beta^*$ runs, or low luminosity - low $\beta^*$ runs
• The next step might allow to integrate the timing detectors in RP 220 (far) vertical detectors
  -> start technical stop 2015/2016
• In parallel to all activities horizontal RP 210 can be equipped with the RF shield this will require to machine a groove in the flange of the existing RP
  -> during LS1
• The acceptance of the horizontal timing detector needs be confirmed for the high beta star run und low beta star run
Next steps (1)

Consolidation:
• Completion of ECR_consolidation (July 2013)

Upgrade:
• LHCC deliberations of June_2013 session --> evaluation of TOTEM upgrade proposal
• Completion of ECR_upgrade
• Collaboration decision by TOTEM and CMS
Conclusions

• TOTEM consolidation & upgrade program reviewed by LHC (LTEX)
• New Roman Pot with optimized RF characteristics was developed
• Prototype of cylindrical Roman Pot under production
• The installation of an optimized Roman Pot during LS1 would give the possibility of fundamental tests after the restart of LHC
TOTEM Roman Pot @ LHC

new physics + target for applications & development of forefront spin-off technologies

Timing detectors
~ 20 ps
Si pixel detectors
rad hard

TDC chip
5 ps resolution

Clock distribution
< 5 ps jitter

rapid prototyping (thin window)
New mechanical production methods

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TOTEM Upgrade Proposal J. Baechler
PRINCIPAL LHCC DELIBERATIONS

12TH MEETING OF THE TOTEM RESOURCES REVIEW BOARD
16 APRIL 2013

EMMANUEL TSESMELOS
SCIENTIFIC SECRETARY, LHCC

GENERAL

This document summarises the principal LHCC deliberations concerning TOTEM at the Committee’s sessions in December 2012 and March 2013.

https://indico.cern.ch/getFile.py/access?contribId=21&sessionId=3&resId=0&materialId=0&confId=233492
• TOTEM provided a detailed description of the consolidation and upgrade plans, to be carried out during LS1. The consolidation work approved by the Collaboration includes: (i) the removal of the RP147 m stations and patch panels (allowing installation of the TCL4 collimator), (ii) the relocation of the RP147 stations (with Si-strip detectors rotated by 8° to improve tracking performance) to the ±210 m region, and (iii) the exchange of ferrites of all RPs to avoid beam-induced heating and vacuum degradation. Associated work-packages and scheduling had been defined with all relevant CERN groups.

• Upgrade plans for the RP stations have also been reviewed by the LHCC. TOTEM proposes the installation, in a few months during LS1, of two new additional RP horizontal stations in the ±220 m region, followed by the integration of new pixel detectors in the relocated RPs in the ±210 m region, as well as of new timing detectors in the ±220m horizontal RPs (downstream relative to the tracking detectors to avoid the large material budget of the former). The new tracking and timing detectors can be installed inside the RPs during end-of-year technical stops after LS1 (as the installations require a vacuum break).

• The physics case of the upgrade plans was only generically justified as having the goal to be capable of doing diffractive and exclusive (gluon- or gamma-induced) physics at low β* and high luminosity. TOTEM will present the required upgrade project documentation (Letter of Intent and Technical Design Report) to the LHCC following deliberations with CMS on similar forward-physics plans (including tracking and timing detectors in the LHC tunnel). TOTEM insisted that, in any case, the present 220m stations must not be affected by any upgrade activity, until the high-β special runs after LS1 are complete and the approved baseline TOTEM physics programme is fulfilled.

• The specific request from TOTEM to the LHCC with respect to the experiment’s consolidation plans includes the following points:
  • Relocation of the RPs from 147m (full station) to upstream of RP220, which would allow for enhanced physics opportunities for a minimal cost through improved proton momentum tracking by a simple 8° rotation.
  • Provision of services and infrastructure (patch-panels and cooling) for the installation of possible new RP stations at 220 m to host detector upgrades such as the pixel and timing detectors currently under discussion with CMS.
  • Installation of the TCL6 collimator during LS1.
  • The LHCC concluded that the consolidation requests seem reasonable as all work-packages are ready …..
TOTEM & PH/DT – LS1 WORK PACKAGE

Technical Description

Abstract

This work package describes the M&O tasks foreseen by the TOTEM experiment for LS1 (2013/2014) where the group PH/DT will get involved providing resources and expertise. This work package complements the existing agreement for the Maintenance and Operation of TOTEM Detectors 2012 to 2016 (EDMS 1230888)

https://edms.cern.ch/document/1282777/1
Main issues to be reviewed by LHC

Consolidation – mainly operation @ special runs

- Relocation of Roman Pots & rotation of RP 210m far by 8°
- Concentration of RP detectors between Q5 and Q6 RP210&RP220
- Beam pipe elements & RF fingers
- RF issues related to inter distance of RPs (garage position)
- Vacuum issues (concentration of ferrites & heating of ferrites)
- Vacuum estimation (simulation, pump performance)
- Insertion of RP – beam protection rotated non rotated
- Collimator settings – Q6

Upgrade - operation @ standard runs & special runs

- Installation of new horizontal cylindrical Roman Pots & RF shield standard RP
- RF issues related to distance between RPs (garage position)
- RF issues related to insertion at close distance to LHC
- Vacuum issues due to heating of ferrite (garage position & insertion)
- Vacuum issues due to proposed Cu coating
- Insertion of RP – beam protection
- Collimator settings – Q6
LHC without TOTEM RP

Forward Physics at the LHC
Reggio Calabria (ITALY) 15th-18th July 2013
TOTEM Upgrade Proposal J. Baechler
TOTEM Roman Pot @ LHC
now for service work in H4/Prevessin

horizontal & vertical
RP in LHC

All RP detector packages & stations are now in H4/Prevessin for service work
Roman Pot -> detector packages in H4 (Prevessin)
Roman Pot -> stations in H4 (Prevessin)
New two horizontal RP equipped with timing detectors (216m)

Existing TOTEM RP-220m (far) (220m) refurbished

New PP for timing detectors

Existing TOTEM RP-220m (near) (215m) refurbished

Moved PP for RP 220m and 215m (only for 4-5)

New PP for RP 212m and 203m

Displaced RP From 147m (212m) 8˚-turned

Displaced RP From 147m (203m)
Rotation of RPs

insertion of RP horizontal in outgoing beam
view from outgoing beam for each side

Sector 4-5
rotation anti clockwise
top of the unit away from QRL
outgoing beam

Sector 5-6
rotation clockwise
top of the unit away from QRL
outgoing beam

RP 220m
RP 215m
RP 202m
RP 213m
RP 220m
RP 215m
RP 202m
RP 213m
Roman Pot -> TOTEM RF studies (RF simulation N. Minafra & LHC impedance team)

From Box to Cylinder

The main problem is the vacuum cavity between the RP and the flange: box RP and cylindrical flange.

With a cylindrical RP the cavity is filled:
- Better RF behaviour
- More space available inside the RP (detector, cooling, power line, ...)

Heating of the box RP

Effective $Z_{long}$

RP 220 m near inserted on 16.11.2012
2.0 mm @ displaced beams -> no LHC instabilities were observed
Consolidation -> next steps (1)

ECRs - consolidation

ECR – relocation of Roman Pots @ 210m – beam pipe elements

• Position of relocated Roman Pots confirmed (3.6.2013)
• Rotation of Roman Pots fixed (3.6.2013)
• Mechanical design for rotated design ready (collective rotation of vertical and horizontal RP 210 far)

ECR – services of Roman Pots @ 210m & patch panel

• Cables defined + Cooling services defined (work package approved)
• Position of patch panel defined
Consolidation -> next steps (2)
RP modifications @ 210m & 220m

- Exchange of ferrites -> study & choice (?) & conditioning
  Ferrites extracted RP220 (3. June 2013)
  Measurement / classification of radioactivity (ongoing)
  Start with outgassing test (scheduled for
Sample of 4E2
- Anti collision switch optimization
  stopper and electrical switches were ordered
- NEG coating of RPs (?)
  under discussion with vacuum group/technical workshop
- RF fingers in bellows (not present now) (?)
  will be installed in all RPs
- Vacuum tests & qualification for re installation
- RP movement system
RP optimization

RF study

GEANT – FLUKA study

dimensions-engineering-design of new RP + location of RP in experiment

Production drawing
Conclusions

• Consolidation program
  ➢ RP service work is following timeline - on schedule
  ➢ Work in tunnel on schedule
  ➢ ECR -> RP location & beam pipe is ready
  ➢ TCL6 integration work is ongoing

• Upgrade program
  ➢ Design of new Roman Pot optimized with regard to RF & material budget was performed.
  ➢ Production drawing of new Roman Pot ready
  ➢ Prototype production started at CERN
  ➢ Review with LHC scheduled for end of July 2013