The TOTEM Detector at LHC

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on behalf of the

TOTEM Collaboration

Bari-KFKI Budapest-Case Western Reserve Univ.-CERN-Genoa-Helsinki-Pisa/Siena-Prague-Tallinn (~ 80 physicists)

http://totem.web.cern.ch/Totem/
The TOTEM Detector

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

Roman Pots:

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IEEE, Knoxville, 4 Nov. 2010
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TOTEM Physics

Total cross-section

Total cross-section

Elastic Scattering

~ ln² s

σ_{tot} ≈ 111.5 ± 1.2 mb

β^* = 1540 m

β^* = 90 m

β^* = 2 m
T1 Telescope with Cathode Strip Chambers (CSCs)

- 5 planes with measurement of 3 coordinates per plane (gap = 10 mm)
- 3 deg rotation and overlap between adjacent planes
- Primary vertex reconstruction allows background rejection
- Trigger with anode wires

3.1 < |\eta| < 4.7
T1 modules ready in the test beam

- Successfully tested with pion and muon beams in May – June
- Both arms are completely assembled and equipped in the test beam line H8.
- Foreseen vertex precision in the transverse plane ~ 5 mm, 1 mm (with, w/o B)
- Both telescope arms ready for installation
- TOTEM aims at the installation of both T1 telescope arms during the winter technical stop to enable first total cross-section measurements in 2011.
**T1 telescope performance**

Both arms successfully tested with pion and muon beams. Pions on copper target to get many-tracks events.

- CSC efficiencies with muons (triple coincidences)

**Longitudinal vertex**

**Cu target**

**Beam monitor frame**

**Transverse vertex**

- Event # 7
  - $\pi$ reconstructed hits
The T2 Telescope

Installation design together with CMS

5.3 < |\eta| < 6.6

10 triple-GEM planes on each side of the IP to cope with high particle fluxes.

80 µm strips/400 µm spacing 
\( \sigma = 100 \ \mu m \ \text{av.} \)

2x2 to 7x7 mm\(^2\) pads 
\( \sigma = 0.6 \ \text{to} \ 2 \ \text{mm} \)
The T2 Telescope installed

2 arms of GEMs for tracks and vertex reconstruction

\[ 5.2 < |\eta| < 6.5 \quad \Delta \phi = 2\pi \]

Both arms installed and taking data
Minimum Bias Event in T2 Telescope

T2 event at $\sqrt{s} = 7$ TeV
T2 Telescope Performance

Detector Cluster Pad Efficiency Normalized

Detector Cluster Strip Efficiency Normalized

Track $\eta$ resolution

Track $dN_{ch}/d\eta$ (Statistical error only)
Elastic Proton Scattering Observation with Roman Pots

BLM

BPM

Sector 45 (220m)
Near

Far

Sector 56 (220m)
Near

Far

BLM

Edgeless Silicon Detectors

4 Stations
→ 2 Units
→ 3 pots
1 BPM
(Beam Position Monitor)

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Silicon Edgeless Sensor for Roman Pots

Planar technology with CTS (Current Terminating Structure)

Efficiency at the edge

\[ \sigma = 20 \, \mu m \]
The Hybrid and the Assembly

Kapton hybrids laminated on CE7

Assembly of 10 detectors

VFAT

“Champignon”

Motherboard
System Test and Detector Performance in test beam

Signal = 25,000 e⁻
A single track event at 7 TeV

Hits in the 2 orthogonal projections $u$ and $v$

Near Top                      Near Horizontal                Far Horizontal                      Far Top

$\begin{align*}
\text{Near Top:} & & \text{Near Horizontal:} & & \text{Far Horizontal:} & & \text{Far Top:} \\
\text{Near Top:} & & \text{Near Horizontal:} & & \text{Far Horizontal:} & & \text{Far Top:}
\end{align*}$
Roman Pot Alignment with respect to Beam Center

Alignment is the central problem of Roman Pot measurements: test done at 450 GeV and 3.5 GeV.

Collimator cuts a sharp beam edge symmetrically to the centre

RP approaches this edge until it scrapes ...

... producing spike in BLM downstream

The second RP approaches

When both top and bottom pots “feel” the edge: they are at the same number of sigmas from the beam centre as the collimator and the beam centre is exactly in the middle between top and bottom pot.

After this exercise the RPs have been routinely inserted at 18 \( \sigma \), i.e. 7.2 cm from beam center
All 3 detector systems (RP, T1 and T2) controlled and readout independently. Make use of common electronic system architecture, based on VFAT chip. VFAT has trigger and tracking capabilities. Fully compatible with CMS readout.

DCS by F. Lucas Rodriguez on Nov. 2 at 9:42 in Ballroom E,
DAQ by F. Cafagna today at 17:06 in Ballroom E.
Observation of Elastic Proton Scattering

sector 45

sector 56

IP5
Elastic Scattering Analysis

Before any cuts the elastic scattering candidates are already visible

Reconstructed angle $\Theta_x$ at the RP stations

Reconstructed position $x$ at the RP stations
Summary

• RP at 220 m and T2 telescope fully operational and taking data.
• So far data collected for ≈ 2 pb$^{-1}$.
• ≈ 20,000 elastic scattering events a large t selected.
• Data analysis in progress and preliminary results are promising.
• During the next winter technical stop the T1 telescope will be installed and TOTEM will be ready to measure elastic scattering, total cross section and study diffractive physics.
• Important will be the running of the LHC at $\beta^* = 90$ m (later at $\beta^* = 1540$ m) such that elastic scattering can be measured at low t values.