First Prototype of Planar Edgeless Detectors for the TOTEM Experiment

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The TOTEM Experiment and the Roman Pots
Planar Edgeless Detectors:
  Current Terminating Structure
Prototype of the TOTEM Edgeless Detector
Experimental confirmations
Conclusions

TOTEM TDR is fully approved by the LHCC and the Research Board

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The TOTEM Experiment

- total pp cross-section
- elastic scattering
- diffractive dissociation

T1: $3.1 < \eta < 4.7$
T2: $5.3 < \eta < 6.5$

Beampipes
RP1 (147 m)
RP2 (180 m)
RP3 (220 m)

CMS
~3 m

T1 (CSCs)
T2 (GEMs)

Roman Pot Station
IP5

Vertical Roman Pot
Horizontal Roman Pot
Beampipes
4 meters
The Roman Pots & Edgeless Detector

Roman Pots with thin window (200 μm thick with planarity of 20 μm) to approach the 10σ of the beam

Vertical Pots (top and bottom)

Horizontal Pot

Si detectors in the Roman Pots

2004 - TOTEM ROMAN POT IN COASTING SPS BEAM
Si Edgeless Detectors in the RPs

Stack of modules connected to the motherboard

Edgeless detector module

- Vacuum flange
- Flexible connections
- Readout chip VFAT
- 66 μm pitch
- Active edges (“planar/3D”)
- 10 μm dead area
- 50 μm
- Planar tech. with CTS (Current Terminating Structure)
Planar Edgeless Detectors

the idea...

Current Terminating Structure

...the proof!!!

Efficiency at the edge

Developed by:
CERN/TOT
Ioffe PTI, St. Petersburg
RIMST, Zelenograd

Surface Current Suppression

Testbeam scheme (X5, Summer ‘03)

Planar Edgeless Detectors

Distance from the cut edge, µm

50 µm

Distance across the cut, µm

50 µm

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Radiation Tests on Edgeless Planar Detectors

• Expected fluence in the silicon detectors after the 3 years of operation will be $\sim 10^{12}_{\text{1MeV}} \text{n cm}^{-2}$ (calculations with MARS code).

• However accidents and unforeseen beam losses in the neighbourhood of the detector could lead to drastically enhanced radiation level.

Damage Factor

$$\alpha = \frac{\text{Current}}{\text{Volume} \times \text{Fluence}} = 5 \times 10^{-17} \text{ A/cm}$$

These data suggest a radiation hardness for the Edgeless Planar detectors equal to the standard planar detectors up to $10^{14}_{\text{1MeV}} \text{n cm}^{-2}$. 
Planar Edgeless Detectors
the TOTEM Detector
from test size to full size

Surface Current Suppression

Integration of traditional voltage terminating structure with the Current Terminating Structure

Strips’ end 50 μm away from the cut
Detector performance in X5 (muon beam)

- Triggering: VFAT digital chip and/or scintillators
- Tracking readout: APV25 analog chip

Set-up used in a high energy (120 GeV) muon beam
Hit distributions of reference and test detectors

Coincidence plot of reference detectors and scintillators

Top and Bottom test

Top and Bottom reference RP

Scintillator

Typical S/N distribution

S/N vs Bias Voltage

G. Ruggiero / TOTEM
Tests of full size detectors in coasting beam:

- High energy (200 GeV) proton beam
- Beam halo particles detected for various $d_1$, $d_2$ distances
- Typical event rate of 3 kHz
Planar Edgeless Si Detectors:

Dead region at the edge can be minimized to 50um, equipping the device with a Current Terminating Structure.

The TOTEM Coll. has checked in different test beams the functionality of these edgeless detectors.

Their production will start at the beginning of the 2006 RP test in the SPS has been successful:

Final RP prototype ready at the end of 2005.

Installation in the LHC tunnel mid2006
**Two different type of Si Edgeless Detectors**

- **Based On Two Different Technologies**
  - Similar, but different advantages
    - CTS is less “edgeless” than 3D edges
    - CTS has bigger S/N ratio than 3D edges
- **Both fulfill the requirements of the Roman Pots**
  - Structure of both detectors is identical for electronics

**S/N distribution (X5 test beam October 2004)**

- **Planar with CTS edge**
  - S/N of 24 for a thickness of ~350μm
- **Planar with 3D edge**
  - S/N of 16 for a thickness of ~210μm
the Roman Pot hybrid

Flexible connections

detector

Readout chip VFAT

hybrid

66 mm pitch

active edges ("planar/3D")

planar technology with CTS (Current Terminating Structure)

Pitch adapter on detector

66 mm pitch

10 μm dead area

50 μm
• shape and size of the window is defined
• Welding technology of the thin window is the main issue
• Brazing (used for the SPS) can be improved
• TIG welding gives better results, (i.e. planarity of 100 microns)
• Laser and Electron-beam welding are considered for a new prototype in 2005