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Simulation of the TOTEM inelastic detector

Fabrizio Ferro
University of Genova and INFN
Inelastic detector

The inelastic detector is made of two telescopes: T1 and T2. It covers approximately 4 \( \eta \) units and it is aimed to provide a fully inclusive trigger and to reconstruct collision vertices.
T1 and T2

T1 is made of two telescopes (forward and backward) of 5 planes of cathode strip chambers (CSC) with $2\pi \phi$ coverage and $3 < |\eta| < 4.7$. In order to improve pattern recognition, a small 3 deg angle from plane to plane has been foreseen.

Two different solutions are under study for T2:
- two cylindrical telescopes (forward and backward) made of 5 CSC planes with $2\pi \phi$ coverage and $\sim 5 < |\eta| < \sim 6.5$.
- Silicon detector (more likely).
CSC detector

- Three coordinates
- Analog information from cathode strips (192 strips per plane)
- Anode wires (Ø30µm, 3mm pitch)
- Resolution: $\sigma_x \sim 0.4\text{mm}$, $\sigma_y \sim 0.7\text{mm}$ (test beam data)
Simulation

- The T1 and (CSC) T2 telescopes have been simulated with Geant4 in the CMS OSCAR framework.
Event generation

‘Minimum bias’ events generated with Pythia 6.158.

\[ <n_{T1}> \approx 15 \]
\[ <n_{T2}> \approx 10 \]

Charged particle distribution at generation level.

TOTEM range

Requiring at least one particle in one arm of T1/T2 the loss is a few per mille.
Simulation setup

Beam pipe included to simulate a real scenario and to estimate its background. B field turned off (studies with B on are in progress).
Charged particle flux

Hits per plane

Particles per event per arm

TOTEM Total Cross Section, Elastic Scattering and Diffraction Dissociation at the LHC

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University of Genova and INFN
Radiation hardness

- In the real scenario: ~37 hits per plane in T1 and ~55-105 in T2.
- The charged flux (@$10^{28}$ luminosity) in T1 is ~1.5 Hz/cm$^2$ for the 1$^{\text{st}}$ plane and ~0.6 Hz/cm$^2$ for the 5$^{\text{th}}$. For the 1$^{\text{st}}$ plane of T2 it is ~40 Hz/cm$^2$.
- at $L=10^{33}$ a charged particle flux for T1 reaches ~100 kHz/cm$^2$ → the detector will be able to operate for a few months. Years if $L=10^{32}$. 
T1 occupancy

Mean strip occupancy per event depends on the CSC geometry

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T1 occupancy

- Wire occupancy depends on the particle density (higher at higher $\eta$).

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Event counting

- In order to measure the inelastic rate TOTEM needs to count events.
- For this purpose a complete event reconstruction is not necessary.
- In order to separate inelastic events from (beam-gas) background a few tracks coming from the interaction point as well as the primary vertex should be reconstructed.
Pattern recognition studies (preliminary)

- Main aim: find track candidates and evaluate event multiplicity.
- Method: group hits in *roads* to reduce hit combinations and to simplify track fitting.
- Idea: tracks coming from the interaction point travel with constant $\eta$ and $\phi$ (magnetic field off).
- Procedure: project on a $\eta$-$\phi$ plane the hits of the detector 5 planes.
Pattern recognition studies (preliminary):
2 tracks event

Using 2 coordinates (one sector)

Using 3 coordinates (one sector)

From simulation

Pattern rec.

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University of Genova and INFN
Pattern recognition studies (preliminary):
more complex event

Using 2 coordinates (one sector)

Lost    Ghost    Detected

Primaries

From simulation

Using 3 coordinates (one sector)

Detected

Pattern rec.

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Pattern recognition studies (preliminary)

- Using the three measured coordinates in each plane the pattern recognition provides an effective primary track *road* detection and a low ghost rate.
- Angular shift between planes helps to eliminate ghosts.
- Track fitting will be done only in/near the selected roads.
- More powerful pattern recognition in very high multiplicity events could be done with a *seed* information from CMS HF calorimeter. Moreover, the TOTEM telescopes would provide tracking to CMS up to $|\eta| \sim 6.5$.
- A possible microstation at $\sim 18$ m could also provide tracking in the range $6.5 < |\eta| < 8$. 

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Conclusions

• The inelastic TOTEM detector has been simulated with Geant4.

• Minimum bias events have been used to test the detector capabilities.

• The T1 telescope will be able to operate for years at very low luminosity ($10^{32}$) and for some months at intermediate ($10^{33}$).

• The main aim of the telescopes is event counting. At a generation level it has been estimated a loss rate well below the 1%.

• Preliminary pattern recognition studies reveal a good capability of detecting primary tracks also in (not too) complex events.