



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

Helsinki – X Blois workshop

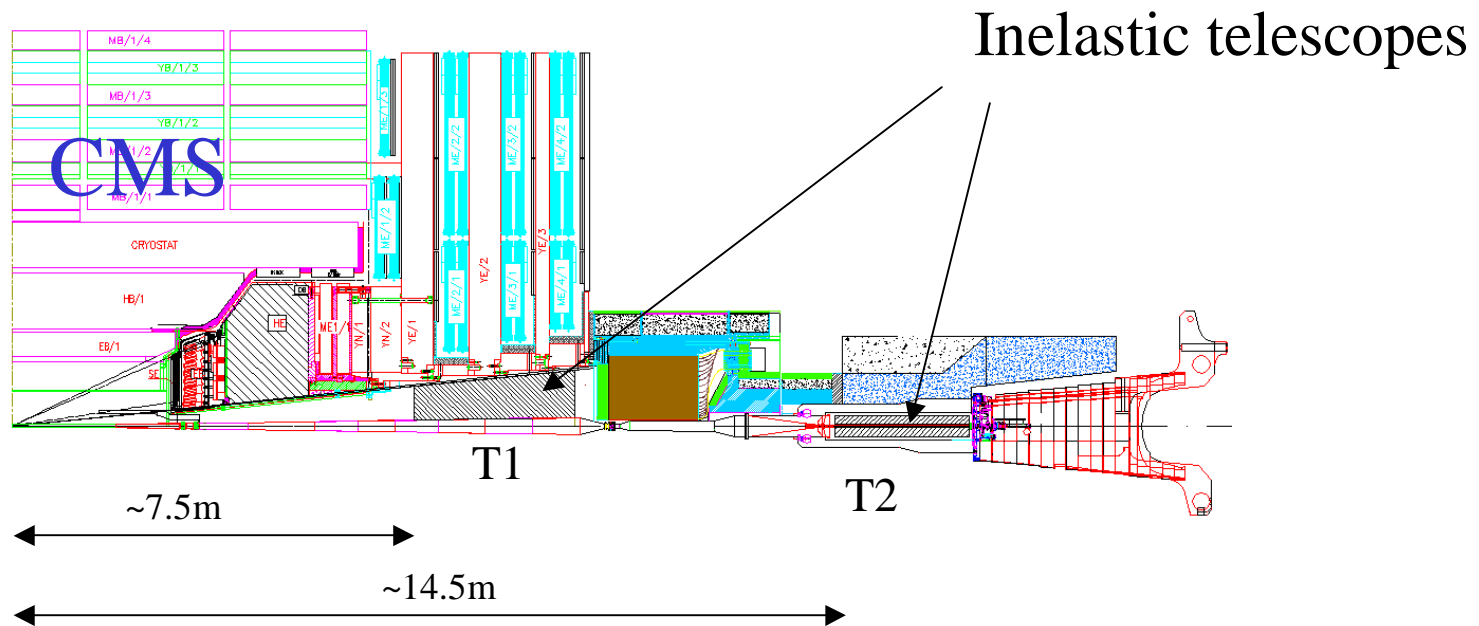
# Simulation of the TOTEM inelastic detector

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.





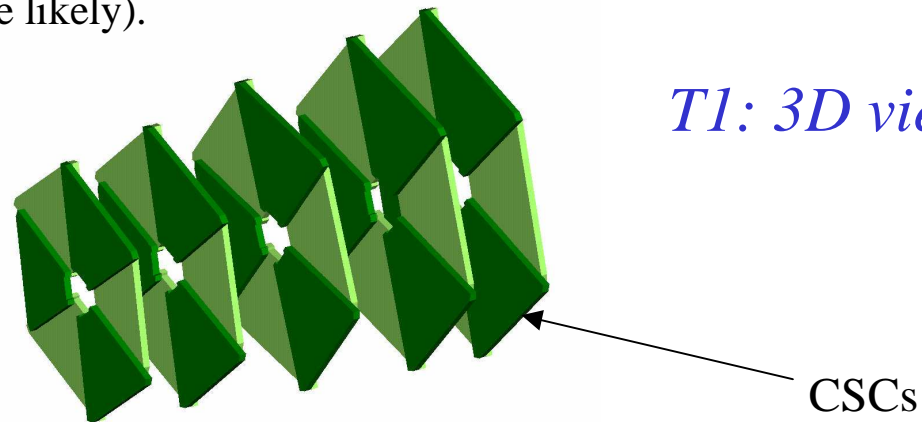
## T1 and T2

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:

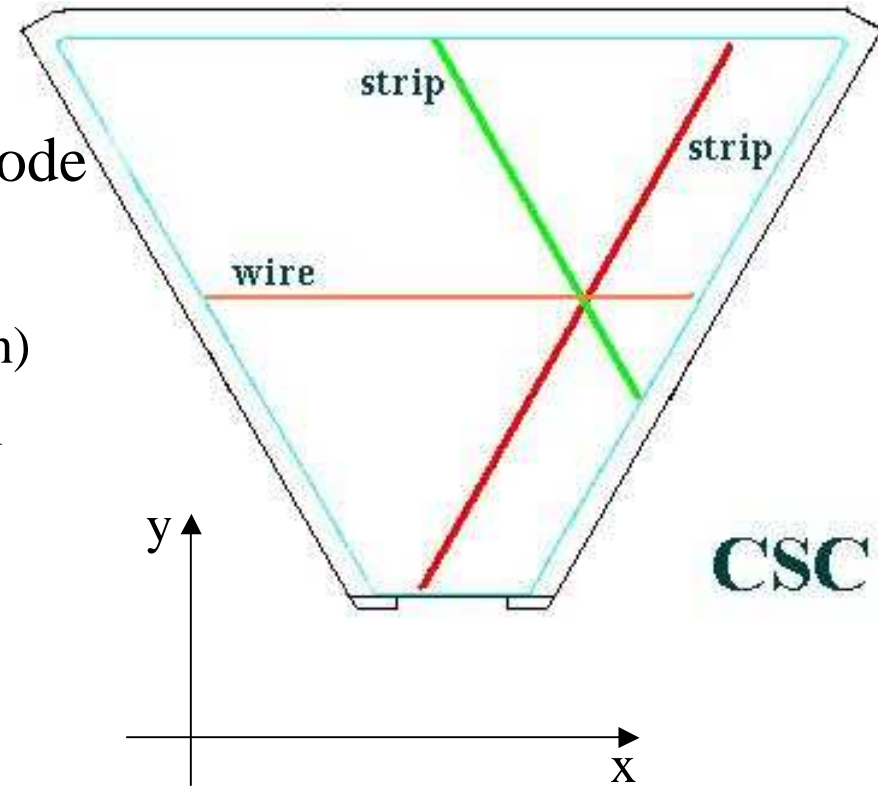
- two cylindrical telescopes (forward and backward) made of 5 CSC planes with  $2\pi \phi$  coverage and  $\sim 5 < |\eta| < \sim 6.5$ .
- Silicon detector (more likely).





## CSC detector

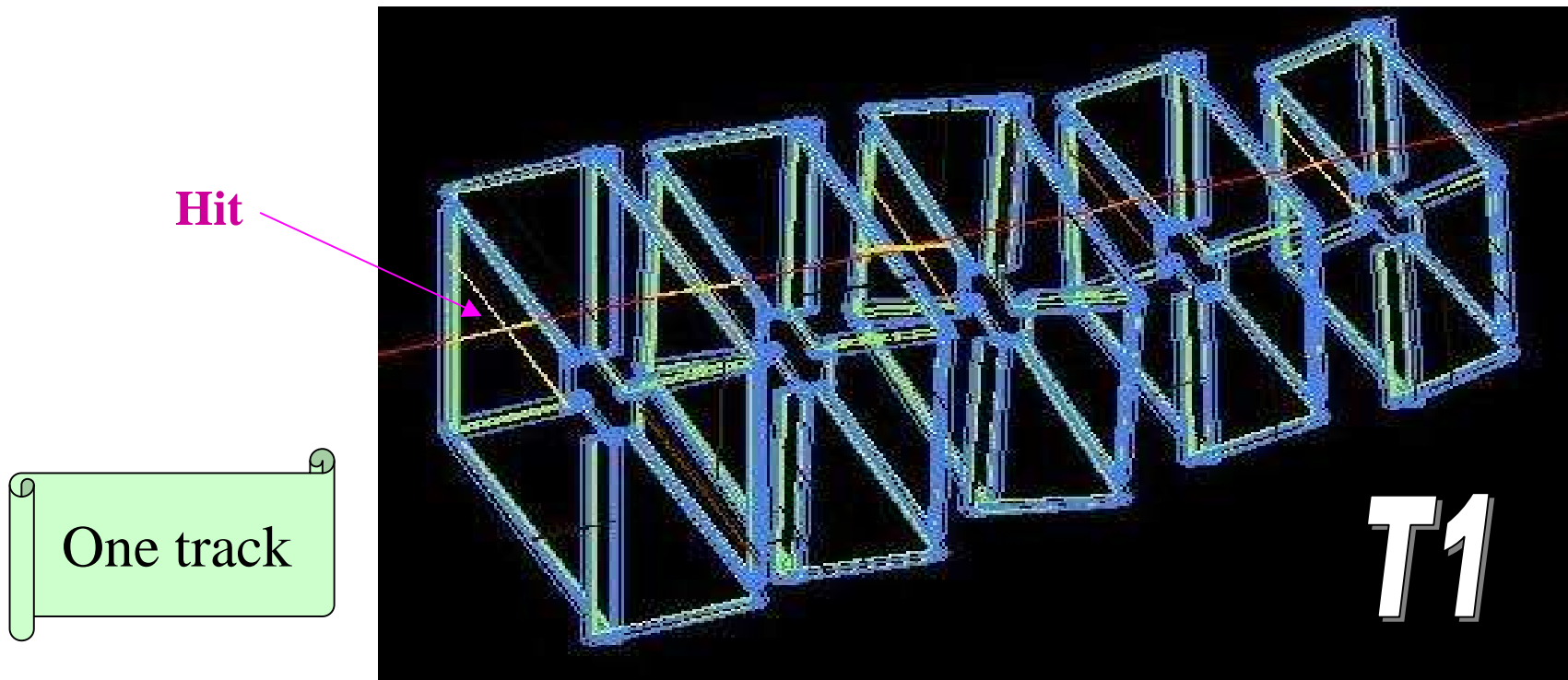
- Three coordinates
- Analog information from cathode strips (192 strips per plane)
- Anode wires ( $\text{Ø}30\mu\text{m}$ , 3mm pitch)
- Resolution:  $\sigma_x \sim 0.4\text{mm}$   $\sigma_y \sim 0.7\text{mm}$   
(test beam data)





# Simulation

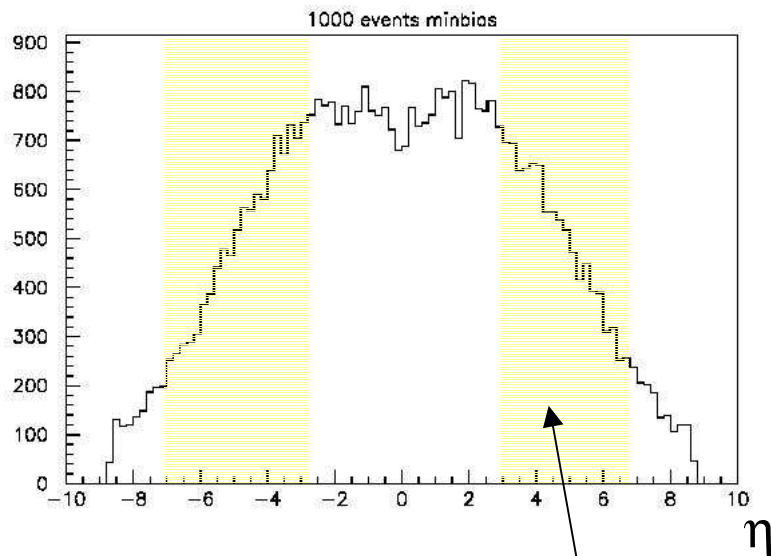
- The T1 and (CSC) T2 telescopes have been simulated with Geant4 in the CMS OSCAR framework.





# Event generation

‘Minimum bias’ events generated with Pythia 6.158.



Charged particle distribution at generation level.

TOTEM range

$$\langle n_{T1} \rangle \sim 15$$

$$\langle n_{T2} \rangle \sim 10$$

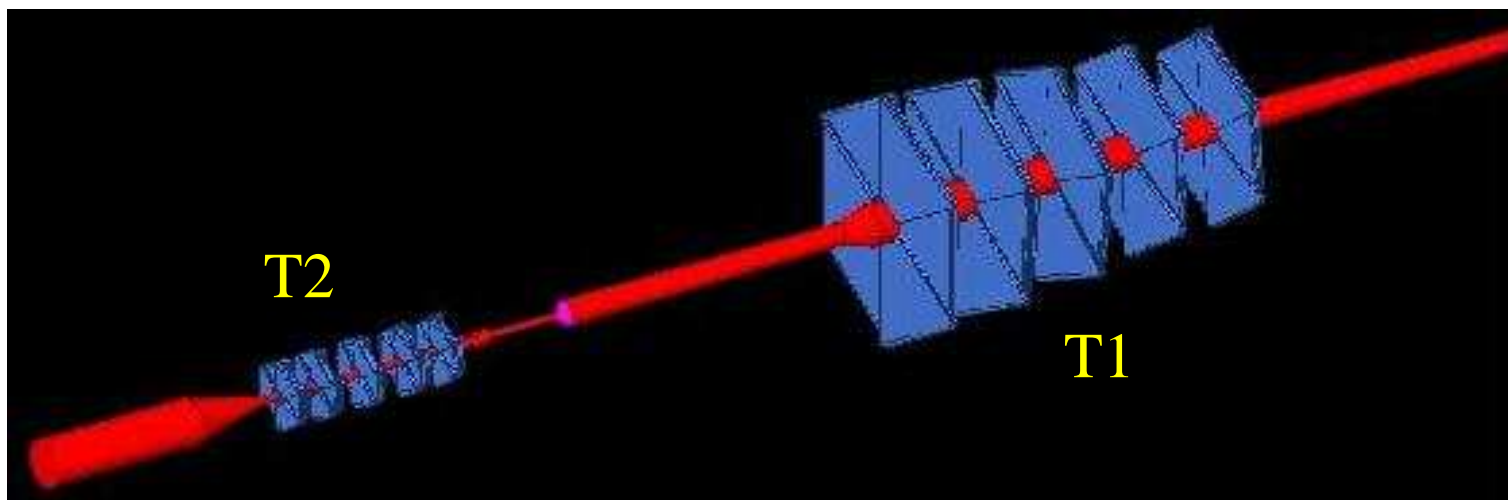
Requiring at least one particle in one arm of T1/T2 the loss is a few per mille.



## 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).

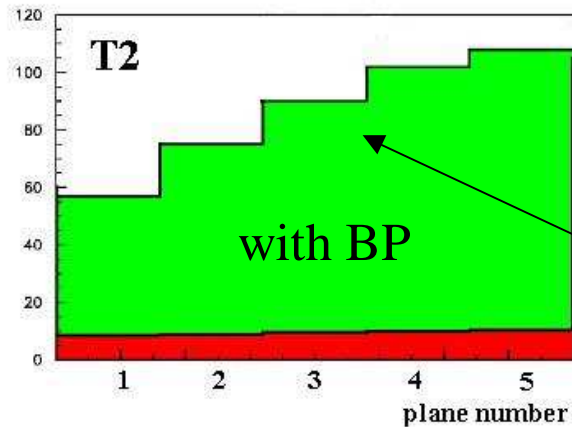
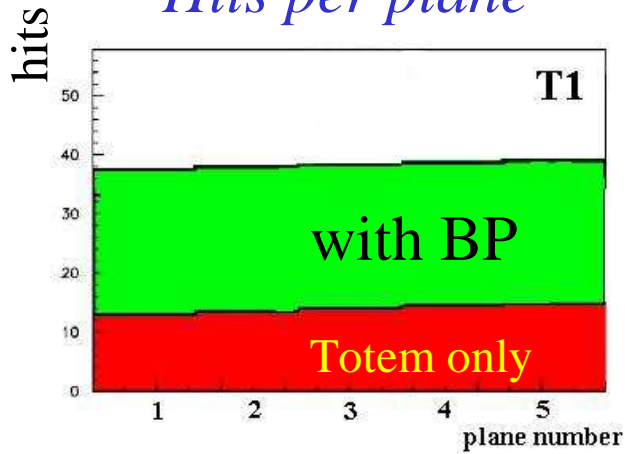


IP5

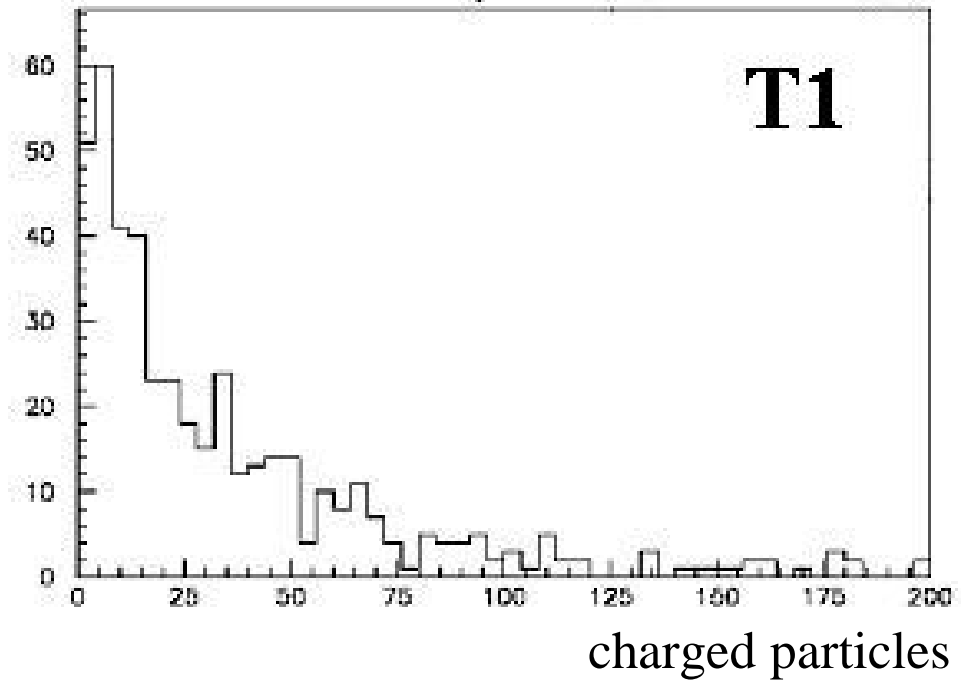


# Charged particle flux

*Hits per plane*



*Particles per event per arm*





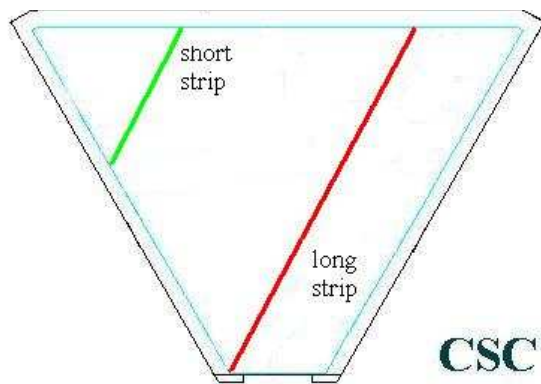
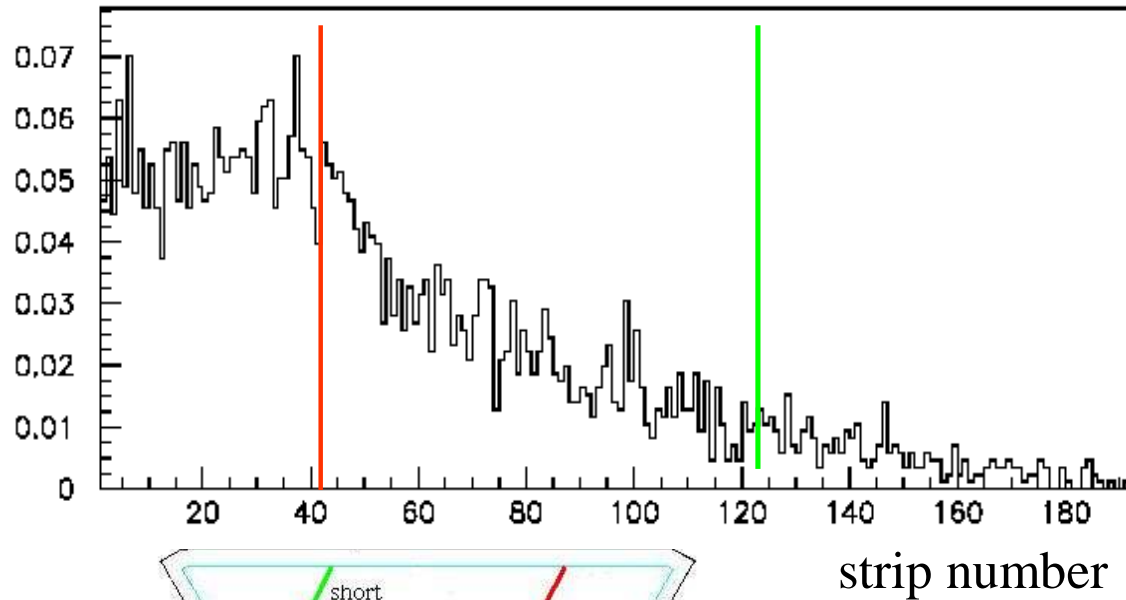


## Radiation hardness

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

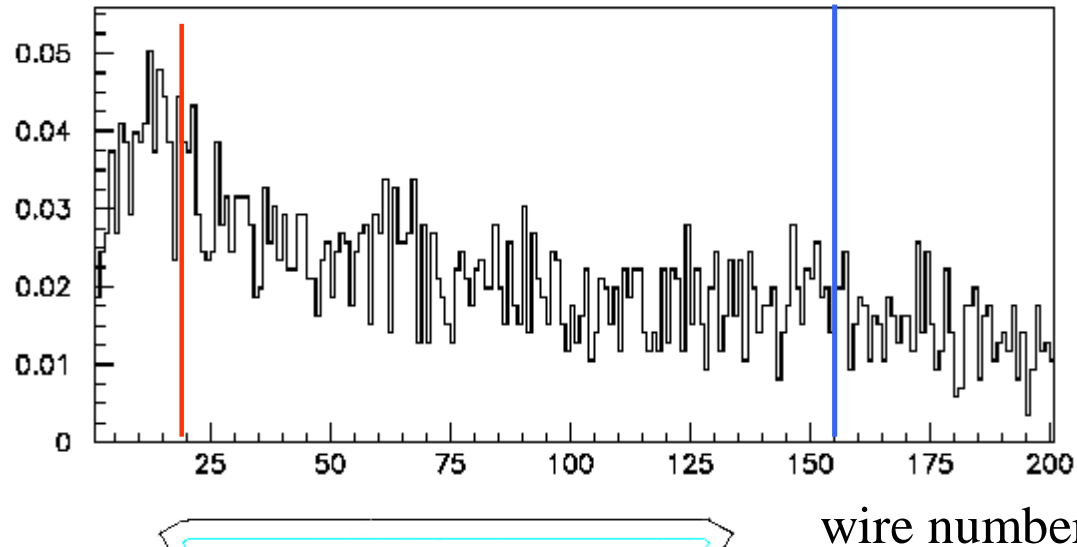


# T1 occupancy

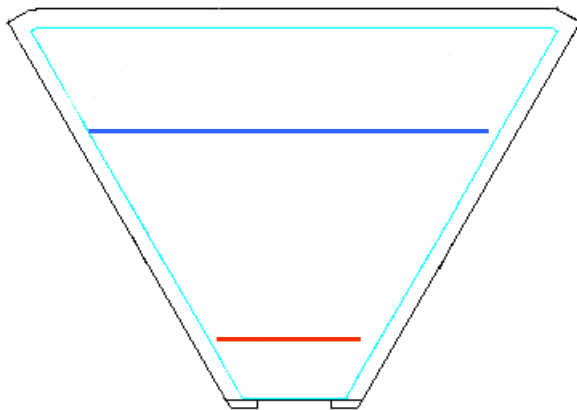




# T1 occupancy



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





## 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.



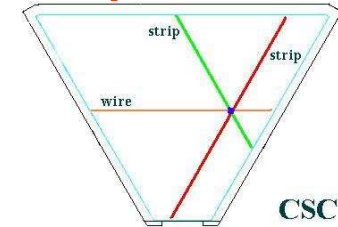
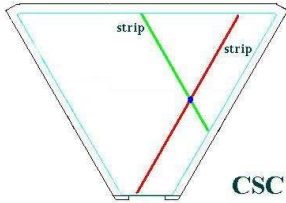
## Pattern recognition studies (preliminary)

- 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.



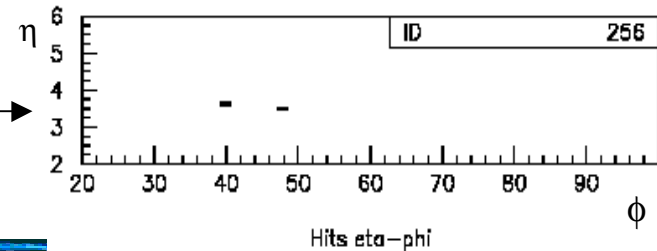
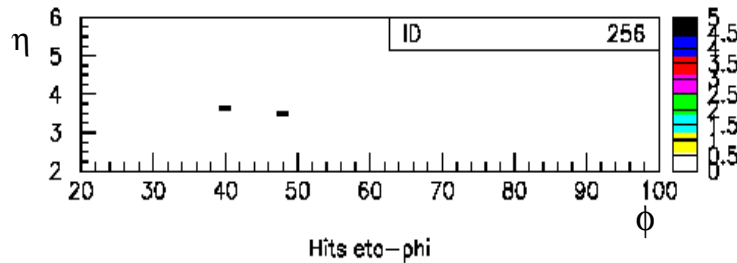
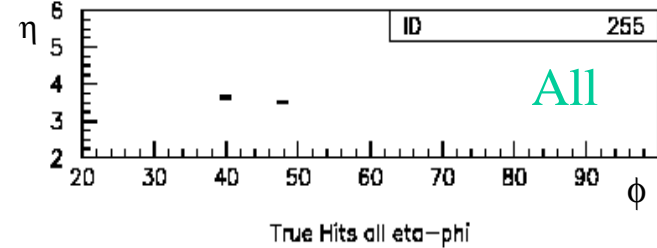
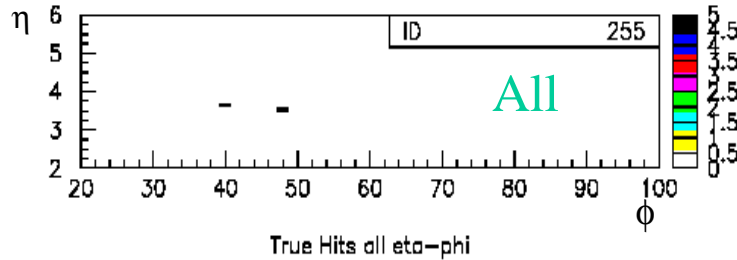
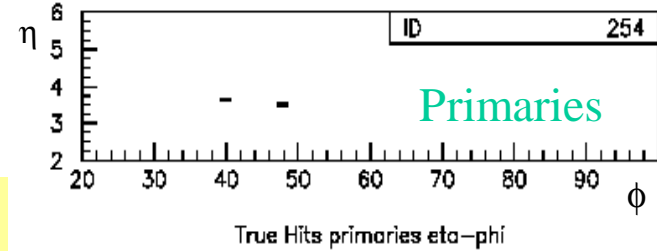
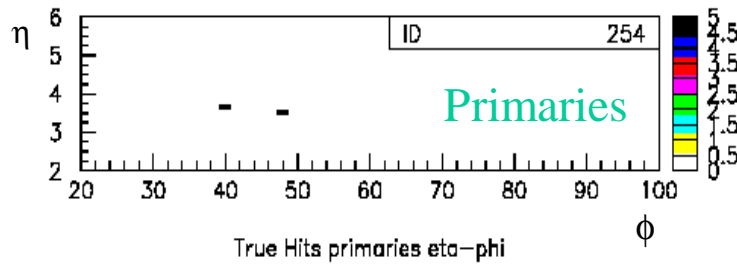
# Pattern recognition studies (preliminary):

## 2 tracks event



Using 2 coordinates (one sector)

Using 3 coordinates (one sector)



From simulation

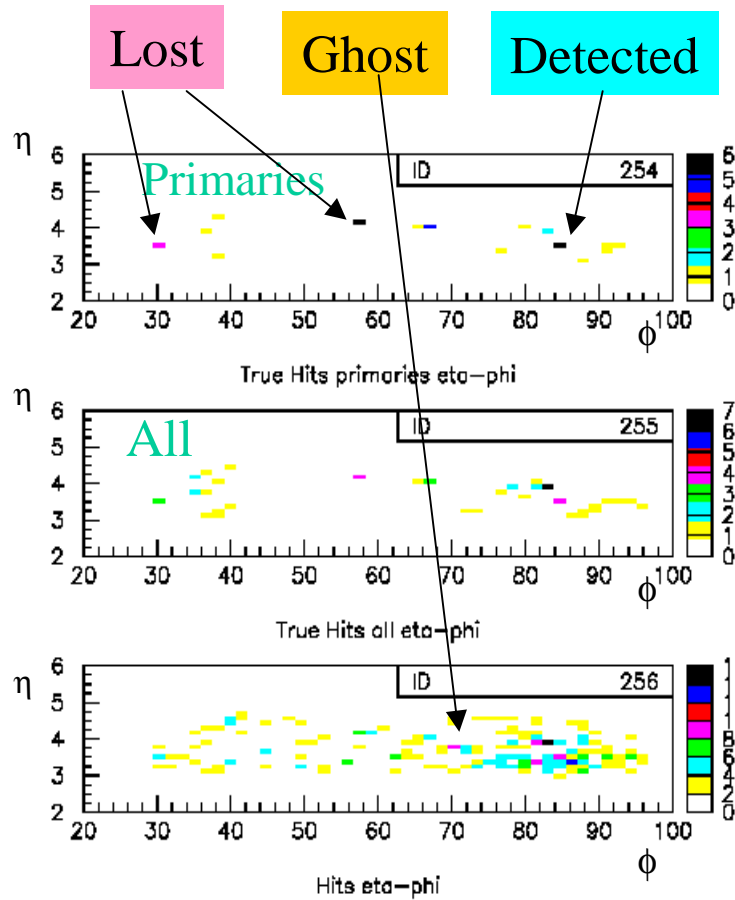
Pattern rec.



# Pattern recognition studies (preliminary): more complex event

Using 2 coordinates (one sector)

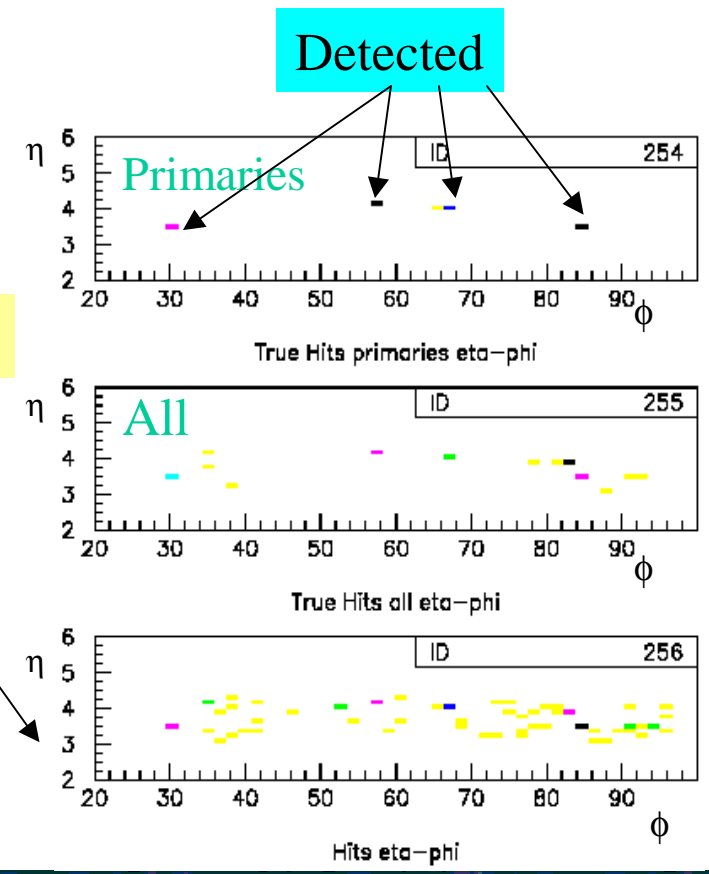
Using 3 coordinates (one sector)



From simulation

Pattern rec.

threshold





## 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  $6.5 < |\eta| < 8$ .





## 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.