Preliminary studies with the TOTEM T2 Detector

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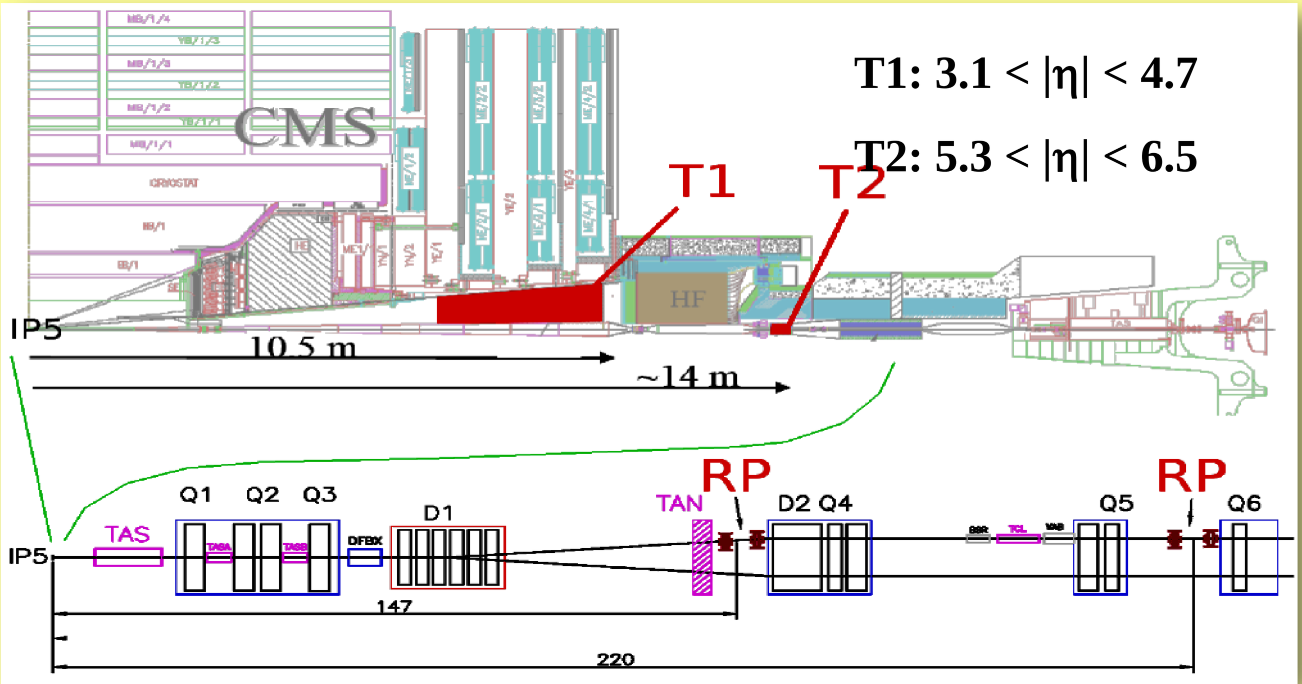
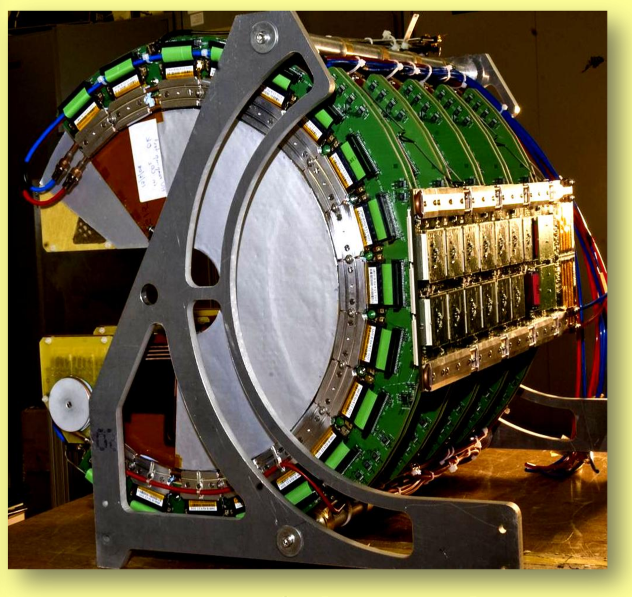
The TOTEM experiment and the T2 Telescope

The TOTEM experiment at the LHC is designed and optimized to measure the total proton-proton cross section with a precision of 1÷2%, to study the nuclear elastic proton-proton cross section over a wide range of the squared four-momentum transfer and to perform a comprehensive physics program on diffractive processes



Top: The TOTEM trackers T1 and T2 embedded in the CMS detector.
Bottom: The LHC beam line and the TOTEM Roman Pots (RP) at distances of about 147m and 220m.

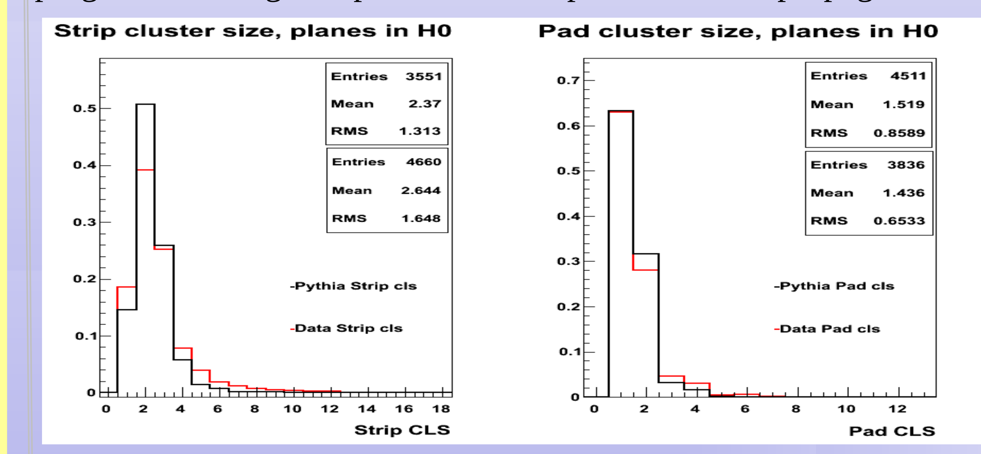
One T2 Quarter



One quarter of the T2 telescope equipped with 10 Triple GEM detectors.

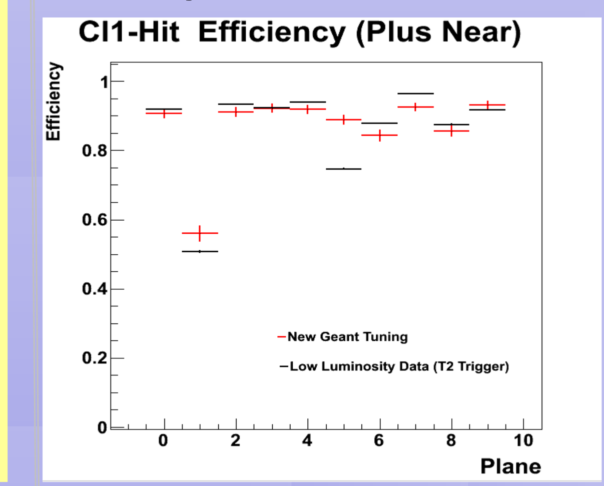
Detector Simulation and Tuning

An analytic model of the digital response of the detector has been obtained from dedicated simulation program allowing to reproduce the amplification and propagation of the charge inside the GEM foil

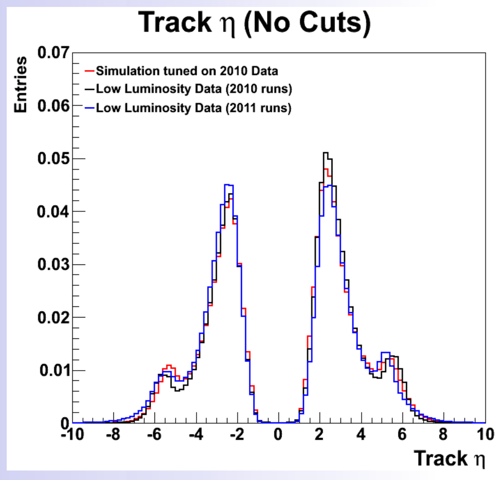


Left: distribution of strip (left) and pad (right) cluster size, cumulative for all the planes in the quarter. The simulation (red curve) has been tuned in order to reproduce the pp data (black curve).

The simulation of the detector efficiency response has been studied in order to take into account problems due to the DAQ (corrupted frames sent by some read-out chips or dead chips). The efficiency is therefore measured on data and reproduced at the chip-level.



Left: Measured and simulated detector hit (superposition of pad and strip cluster) efficiencies. Small differences can still be due to noise-related effects.
Right: cumulative distribution of tracks measured in pp data (black: 2010, blue: 2011 runs) and tuned simulation on 2010 run. Asymmetry has been well reproduced in terms of plane inefficiencies



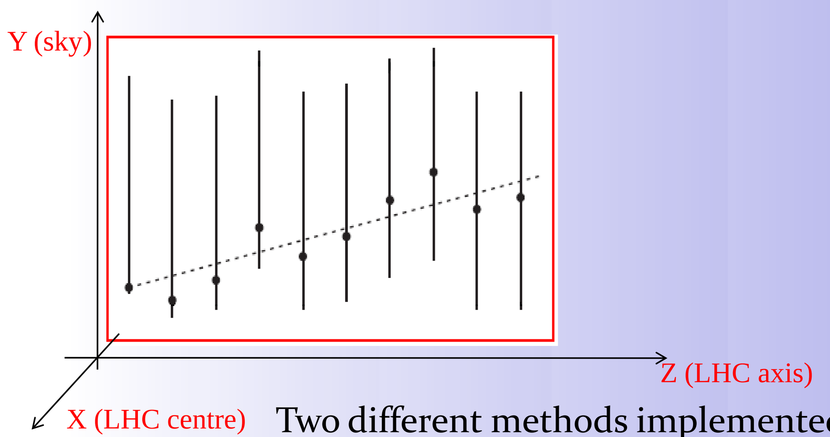
Alignment of the T2 telescope

STRATEGY:

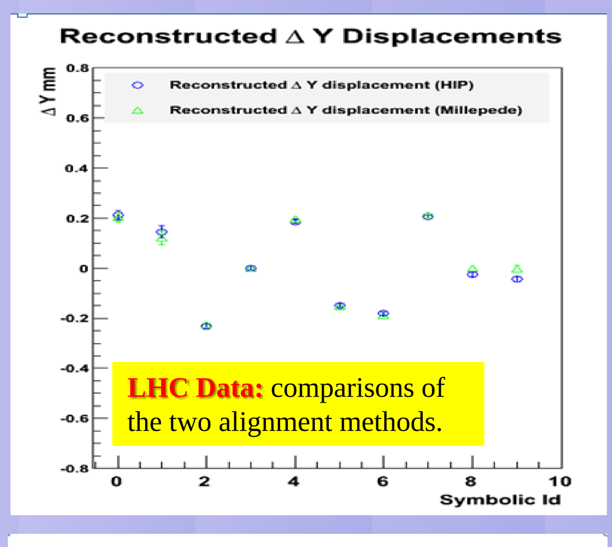
1- **INTERNAL ALIGNMENT** (between planes in a quarter) with two different methods
2- **QUARTER-QUARTER ALIGNMENT** (using overlapping region)
3- **GLOBAL ALIGNMENT** (respect to the vertex)

➢ Internal alignment

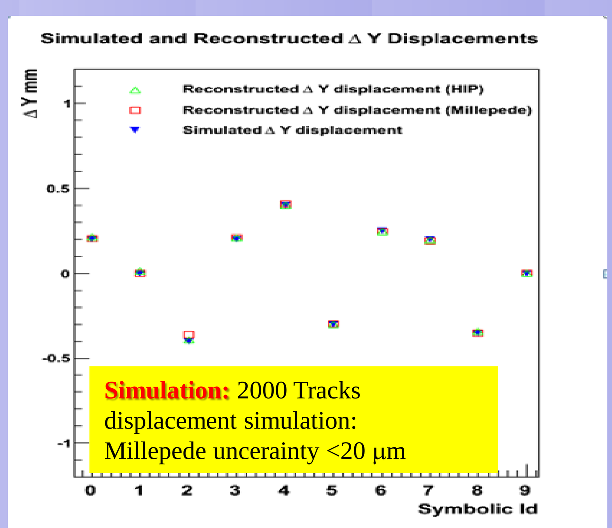
Relative shifts (ΔX,ΔY) between the planes are supposed to be the most important source of misalignment.



Two different methods implemented (HIP and Millepede in order to resolve the misalignment between planes)



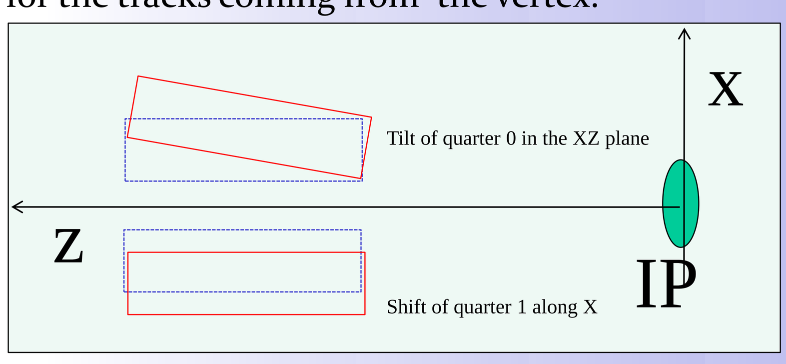
Reconstructed ΔY displacements of the 10 GEM detectors in the plus near quarter, obtained with the two correction methods (2010 pp runs)



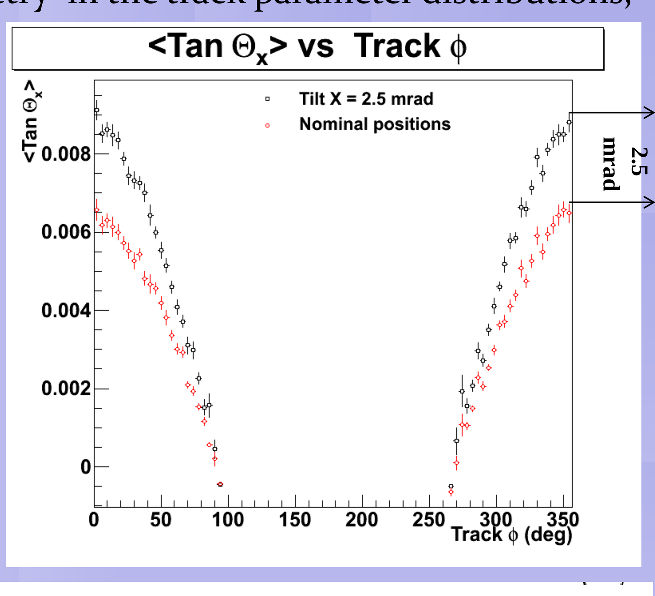
Simulated and reconstructed random DY displacements in a T2 quarter

➢Quarter-quarter and global alignment

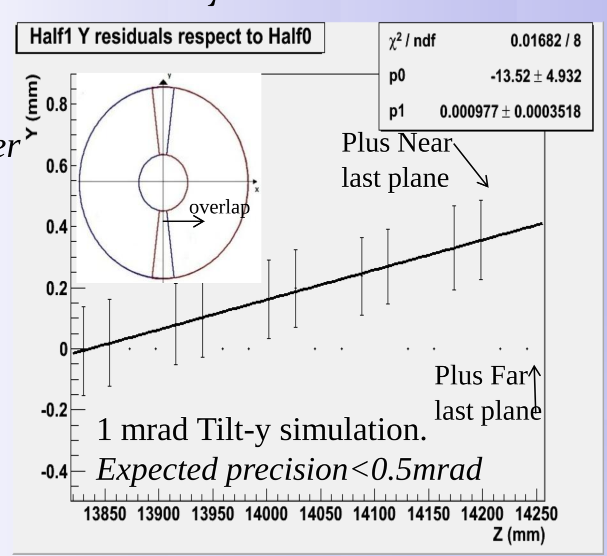
Global correction methods exploit the expected symmetry in the track parameter distributions, for the tracks coming from the vertex.



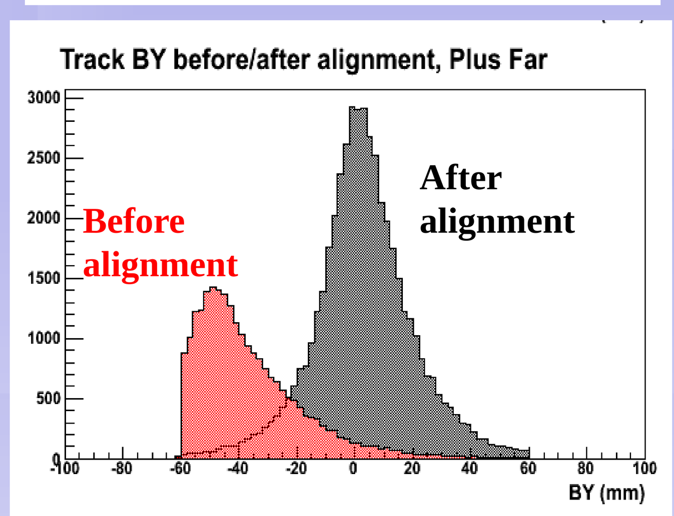
<u>Most important quarter global misalignment</u>: *tilts in the XZ-YZ plane and X-Y shifts.* Expected Tilt accuracy < 0.2 mrad, shift accuracy < 1mm



Left: Effect of a tilt misalignment in the distribution of the track projection slopes. Comparison with the ideal geometry allows to measure the value of the tilt misalignment

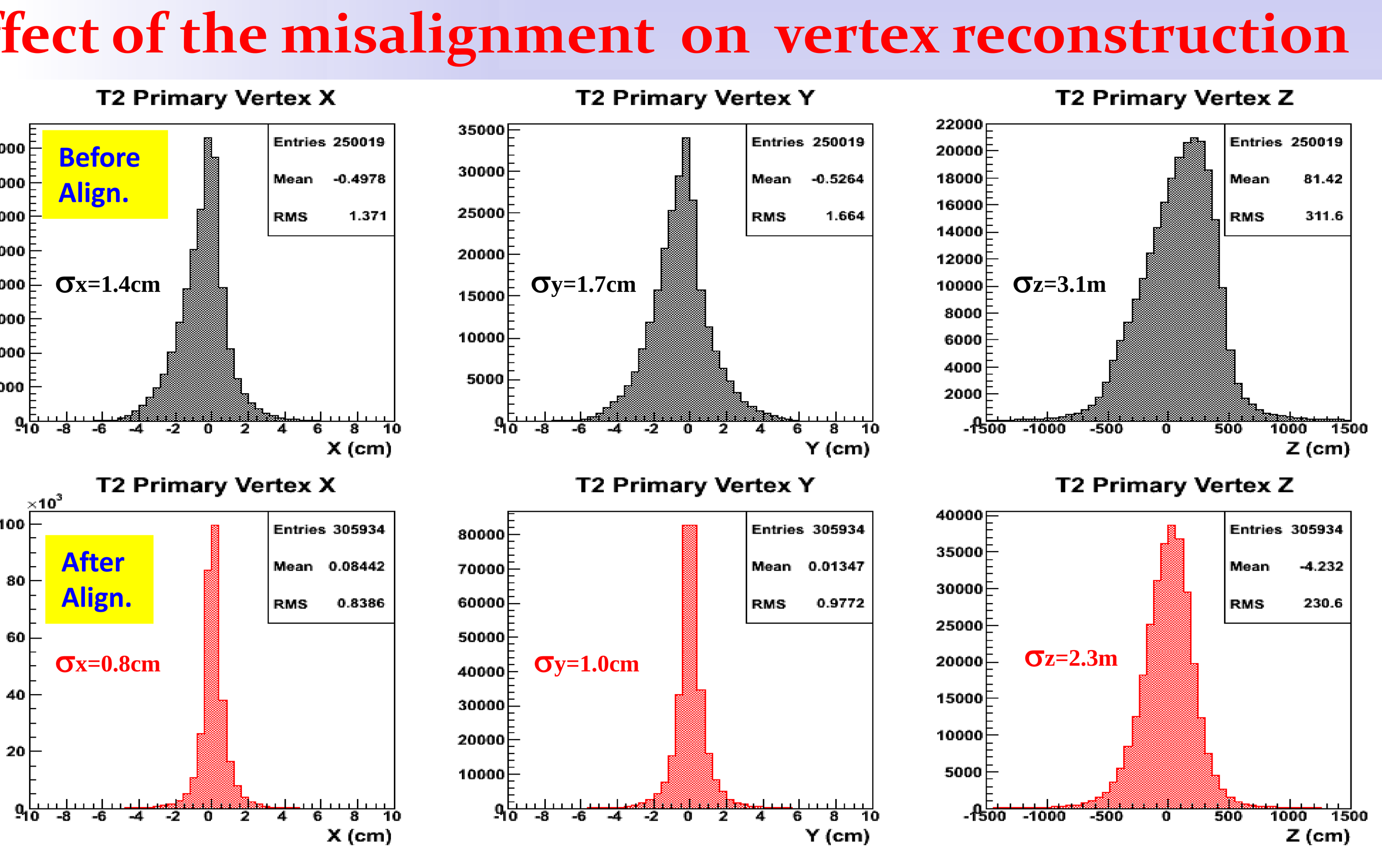


Right: Quarter-quarter alignment using the overlapping region



Left: Improvement in the track projection intercept after the misalignment correction (pp 2010 data)

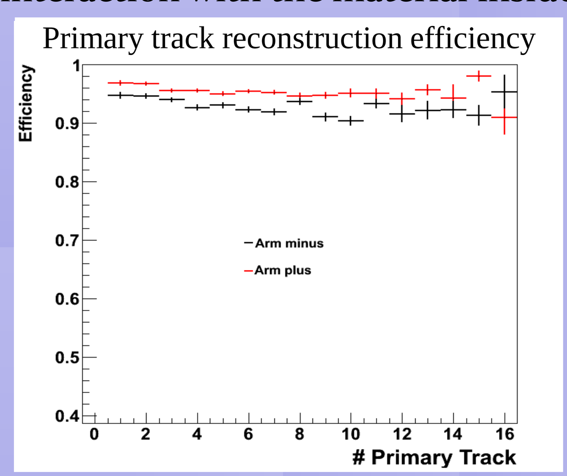
Effect of the misalignment on vertex reconstruction



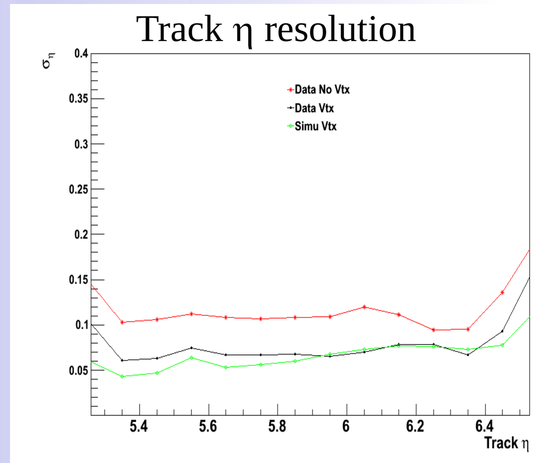
A good global alignment of the quarters is necessary in order to improve the capability of primary vertex reconstruction and background rejection. Left picture shows the improvement in the vertex reconstruction X-Y-Z coordinate (pp 2010 data) due to the misalignment correction.

Tracking efficiency and η resolution

Tracks reconstruction in T2 is a challenging task due to the high multiplicity of secondaries. Magnetic field and interaction with the material inside T2 can be neglected

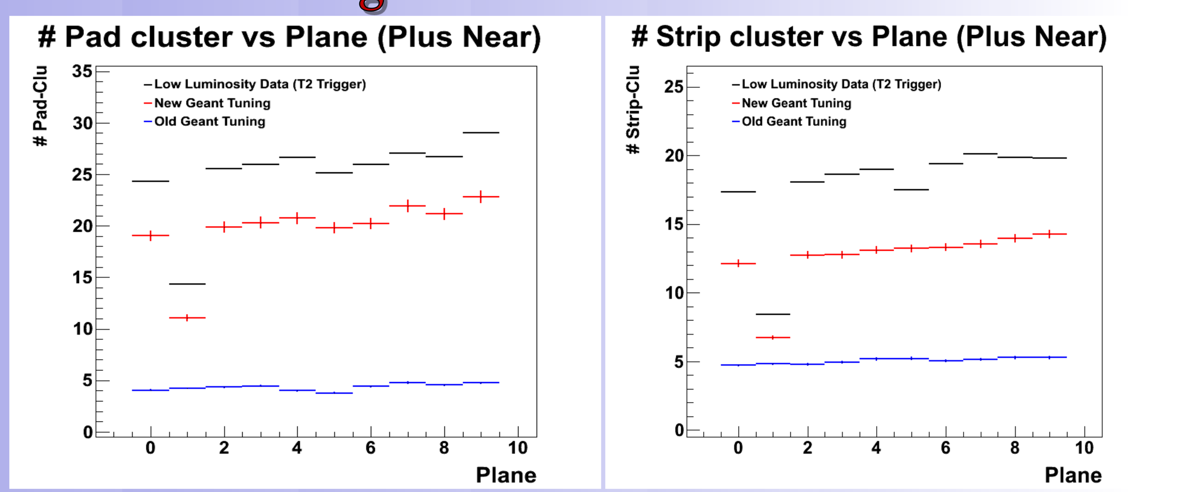


Left: Average track reconstruction efficiency as a function of the primary particle multiplicity going in the T2 arms. Tracking inefficiency is due to plane inefficiency or to higher occupancy produced by secondary interaction. Our definition of efficiency require the matching of at least 4 pads cluster between reconstruction and GEANT simulation.
Right: track η resolution measured in data imposing (black) or removing (red) the vertex constraint. Green curve is the simulation response.



Interaction with the material: GEANT Tuning and material revision

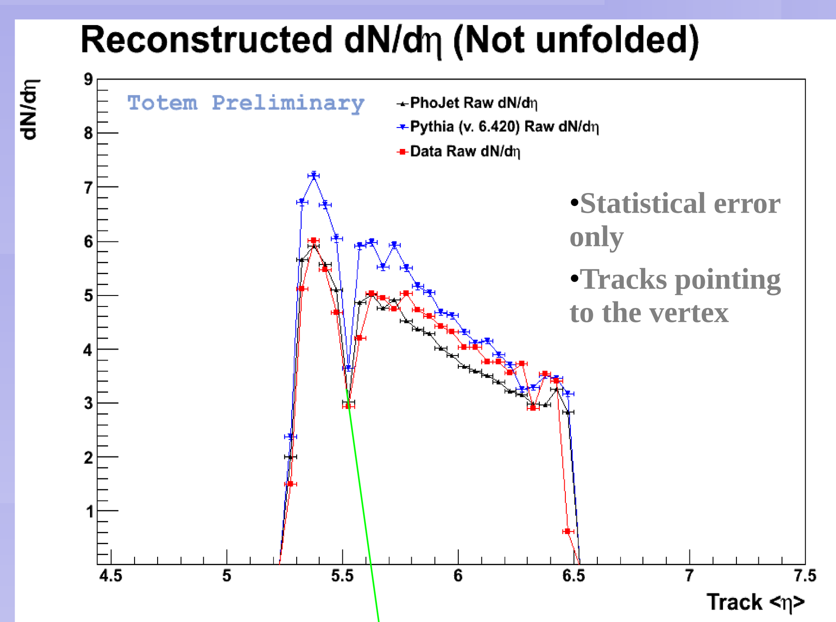
A deep review of the geometry of the materials placed between the IP and T2 has been done in order to simulate as better as possible the production of secondary particles going in T2. Left plot shows the average number of pad/strip cluster per plane in inelastic events. The improvement in the simulation results (blue and red curve) toward the data has been obtained changing the GEANT4 range cut and reviewing the geometry of the volumes. Roghly, we expect to have a ratio 1:5 between primary and secondary particle in T2.



Average pad (left) and strip (right) cluster multiplicity measured in data (black) and from simulation (red). The blue curve shows the multiplicity obtained using large GEANT range-cut which reduces the secondary production. The tuning is still ongoing but discrepancy can be also due to wrong MC multiplicty or not yet simulated noise effects.

dN/dη measurement (preliminary)

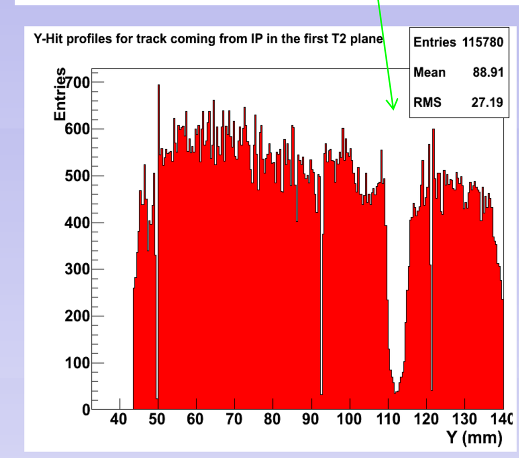
A dedicated low-luminosity run allowed TOTEM to make the first measurement of the charged particle dN/dη, for inelastic events having at least a track in 5.3<|η|<6.5 range, covered by T2.



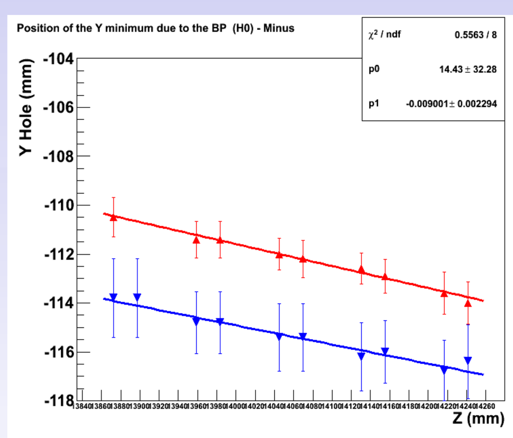
Left: Comparison of non-corrected dN/dη distribution for data, Pythia MC and Phojet MC.

Upper limit values for some of the systematics already investigated

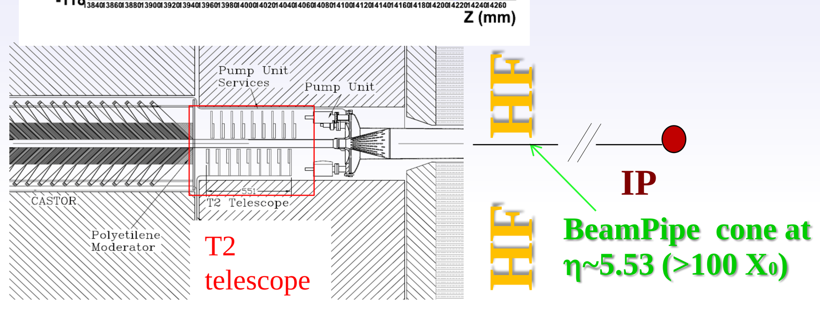
Nature of the systematics	Conservative average contribution (per bin)
Tracking Cut for primary selection	25% : it will be reduced by studing better the criteria of track selection on data, the misalignment and the MC secondary composition
M.C. Energy spectrum and secondary multiplicity	10%
Trigger Efficiency	<5%
B Field Modeling	<1%

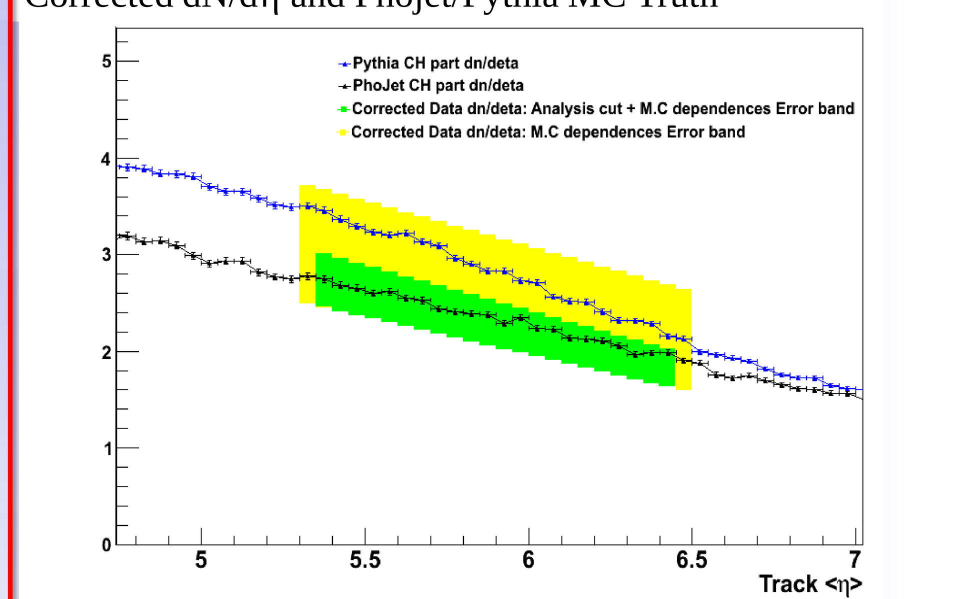


Deep produced in the hit profile in one of the T2 plane, from the interaction of the particles coming from the IP with the Beam pipe cone at η =5,53 (LHC 2010 data).



Position of the deep as a function of the plane number. Red: data, blue: MC simulation. The relative shift and tilt of the two lines allow to use this effect for an absolute quarter alignment.





Low luminosity data have been corrected for primary track reconstruction efficiency and secondary track contamination. Selection cuts on track parameter are changed in a wide range of values while the M.C. has been modified in order to simulate secondary particle production in a factor 2 smaller and higher; the energy spectrum of all the particles, as well as the magnetic field strenght has been increased and lowered by a factor 2. The yellow band shows the overall variation of the corrected data dN/dη because of the changes described above. The green band is instead showing the changing of the results once fixed the (strict) tracking cuts, due to the M.C. energy spectra and secondary multiplicity modification.