Performance of the TOTEM Triple-GEM T2 Telescope

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The TOTEM experiment is measuring the elastic scattering [1], the total cross-section [2] and the diffraction dissociation in proton-proton collisions at the LHC. While elastic and diffractive protons are measured by edgeless silicon detectors inside Roman Pots, the inelastically produced charged particles are being measured by two inelastic telescopes, T1 and T2 (consisting in Cathode Strip Chambers and Gas Electron Multiplier - GEM - technology respectively), placed in the forward region of the CMS experiment on both sides of the interaction point. The T2 telescope has tracking and triggering capabilities; each arm consists in a set of 20 triple-GEM detectors with a semicircular shape, with an inner radius matching the beam pipe (Fig.1). Every chamber has a double layered read-out board containing two columns of 256 concentric strips (400μm pitch, 80μm width) for the measurement of the radial coordinate and a matrix of 1560 pads, each one covering $\Delta\eta \times \Delta\phi \simeq 0.06 \times 0.018$ rad, for the measurement of the azimuthal coordinate and for triggering. Radial and azimuthal coordinate resolutions are about 110μm and 1°, respectively. The read-out of all TOTEM detectors is based on the "VFAT" front-end ASIC, which provides as output a digital signal and trigger.

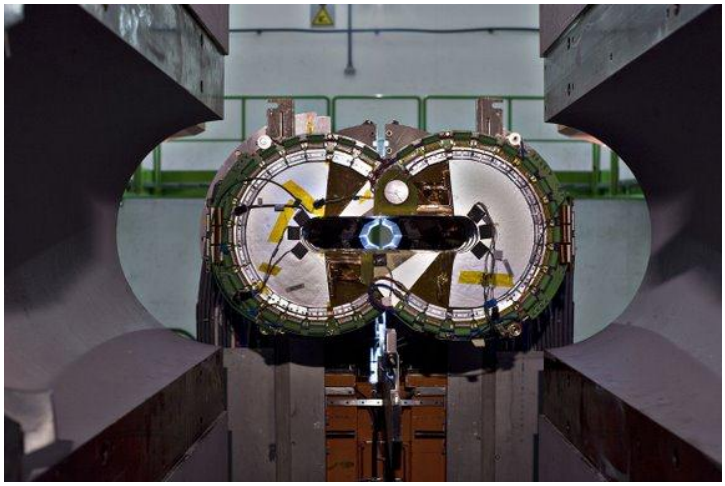

Fig.1: One arm of the T2 telescope during installation.

The T2 track reconstruction is based on a Kalman Filter-like algorithm that is simplified due to the small amount of material traversed by the particle crossing the 10 GEM planes and to the low local magnetic field in the T2 region. The particle trajectory can, therefore, be successfully reconstructed using a straight line fit. The relative position of the detector planes within a T2 quarter (internal alignment) and the overall alignment of all the detector planes with respect to their nominal position (global alignment) have been deeply investigated in order to define possible misalignment biases of the track measurements.
TOTEM has recently submitted its first measurement of the charged particle pseudo-rapidity density ($dN_{ch}/d\eta$) in the range $5.3 < |\eta| < 6.4$ [3], by using the data recorded by the T2 detector during a low pile-up run. Nevertheless, the amount of particles produced by the interaction of

primary particles with the material in front of and around T2 was found to be particularly challenging. The T2-triggered sample contains more than 99% of all non-diffractive events and all single and double diffractive events having at least one diffractive mass larger than ~3.4 GeV/c^2, corresponding to about 95% of the total inelastic cross-section. Since about 80% of the T2 reconstructed tracks are secondaries, it was very important to optimize the discrimination between them and primary charged particles, and the most effective parameters for the best primary/secondary particle separation have been studied in great detail. Primary tracks traversing T2 are reconstructed with an efficiency of about 95%, while a η resolution of 0.05 in the central acceptance region has been achieved.

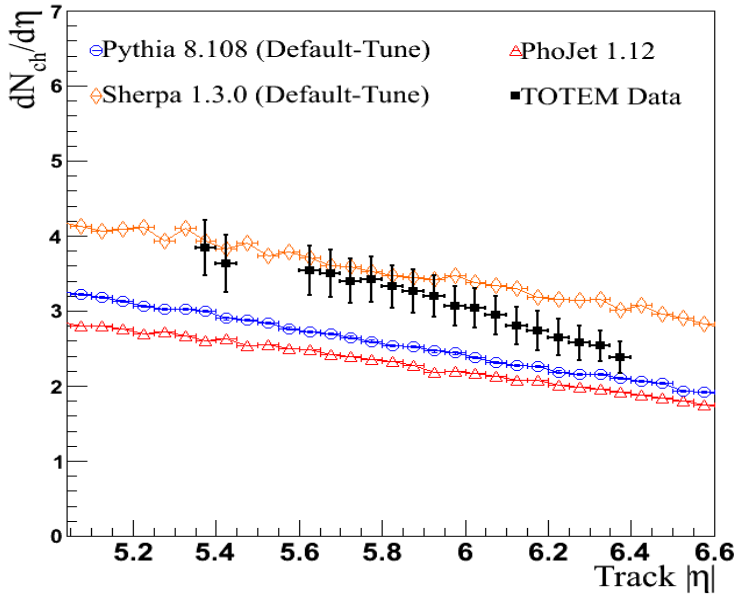

Fig.2: Charged particle pseudorapidity density distribution as measured by TOTEM-T2 (black squares).

The $dN_{ch}/d\eta$ has been found to decrease with $|\eta|$, from 3.84 $\pm$ 0.01(stat) $\pm$ 0.37(syst) at $|\eta|$ = 5.375 to 2.38 $\pm$ 0.01(stat) $\pm$ 0.21(syst) at $|\eta|$ = 6.375 (fig.2). Several MC generators have been compared to data; none of them has been found to fully describe the measurement. The systematic uncertainty is mainly related to the estimate of the primary track efficiency, the effect of the detector misalignment and to the subtraction of the secondary track contribution.

Details about the T2-GEM simulation, pattern recognition, tracking performance, alignment and absorbed radiation dose will be also presented.

[1] The TOTEM Collaboration, G. Antchev et al., Proton-proton elastic scattering at the LHC energy of 7 TeV, Europhys. Lett. 95 (2011) 41001, CERN-PH-EP-2011-101

[2] The TOTEM Collaboration, G. Antchev et al., First measurement of the total proton-proton cross section at the LHC energy of 7 TeV, Europhys. Lett. 96 (2011) 21002, CERN-PH-EP-2011-158

[3] The TOTEM Collaboration, G. Antchev et al., Measurement of the forward charged particle pseudorapidity density in pp collisions at 7 TeV with the TOTEM experimentl, CERN-PH-EP-2011-158