Nuclear Instruments and Methods in Physics Research A 617 (2010) 134–137

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

# The TOTEM T2 telescope based on triple-GEM chambers

M.G. Bagliesi [a,*], M. Berretti [a], E. Brucken [c], R. Cecchi [a], E. David [b], F. Garcia [c], V. Greco [a], J. Heino [c], T. Hilden [c], K. Kurvinen [c], R. Lauhakangas [c], S. Lami [a], G. Latino [a], G. Magazzù [a], E. Oliveri [a], E. Pedreschi [a], L. Ropelewski [b], A. Scribano [a], F. Spinella [a], N. Turini [a], M. Van Stenis [b]

[a] University of Siena and INFN Pisa, Italy
[b] CERN, Geneva, Switzerland
[c] Helsinki, Finland

ARTICLE INFO

Available online 9 July 2009

*Keywords:*
GEM
Tracking detectors

ABSTRACT

The TOTEM experiment at LHC has chosen the triple Gas Electron Multiplier (GEM) technology for its T2 telescope which will provide charged track reconstruction in the pseudorapidity range $5.3<|\eta|<6.5$ and a fully inclusive trigger for inelastic events. GEMs are gas filled detectors which combine good spatial resolution with very high rate capability and a good resistance to radiation. Preliminary results of cosmic ray tests performed at CERN on final T2 modules before installation are here presented. Comparisons between real and simulated detector performance are also shown.



## 1. Introduction

The TOTEM experiment will measure the total pp cross-section with the luminosity independent method and study elastic and diffractive scattering at the LHC [1]. To achieve optimum forward coverage for charged particles produced in pp collisions, two tracking telescopes, T1 and T2 (made with Cathode Strip Chambers (CSC) and GEM technology respectively), and Roman Pots (instrumented with edgeless silicon detectors) have being installed on each side of the interaction point IP5 (the same as for CMS). T1 and T2 will cover the pseudorapidity range $3.1<|\eta|<6.5$, while the RP stations will be placed at distances of $\pm 147$ and $\pm 220$ m. Being an independent experiment, but technically integrated into CMS, TOTEM will first operate in standalone mode to pursue its own physics programme and at a later stage together with CMS for a common physics programme. The T2 telescope will be placed 13.56 m away from IP and the GEMs employed will have an almost semi-circular shape, with an inner radius matching the beam pipe. Each arm of T2 will have a set of 20 triple-GEM detectors combined into 10 aligned semi-planes mounted on each side of the vacuum pipe (Fig. 1). The signals from each detector quarter ($512 \times 10$ strips and $1650 \times 10$ pads) are collected via the VFAT readout chips on the 11th card and sent to the opto transmitters. The trigger signals from the pads are logically combined on the 11th card by the coincidence chips. Their outputs are sent to the opto transmitter and to the trigger VFATs on the 11th card.

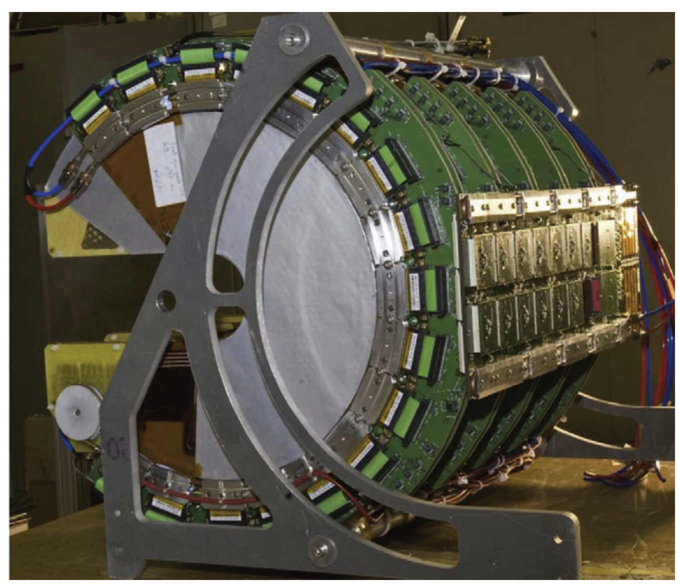

**Fig. 1.** One-half arm of TOTEM T2 telescope equipped with 10 triple GEM detectors. The 11th card is visible on the right.

## 2. The T2 triple GEM detector

The GEM technology has been adopted for the TOTEM T2 telescope thanks to its characteristics: large active areas, good position and timing resolution, excellent rate capability and radiation hardness [2]. Each T2 GEM foil consists of thin copper

* Corresponding author.
*E-mail address:* mg.bagliesi@pi.infn.it (M.G. Bagliesi).

0168-9002/$ - see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.nima.2009.07.006

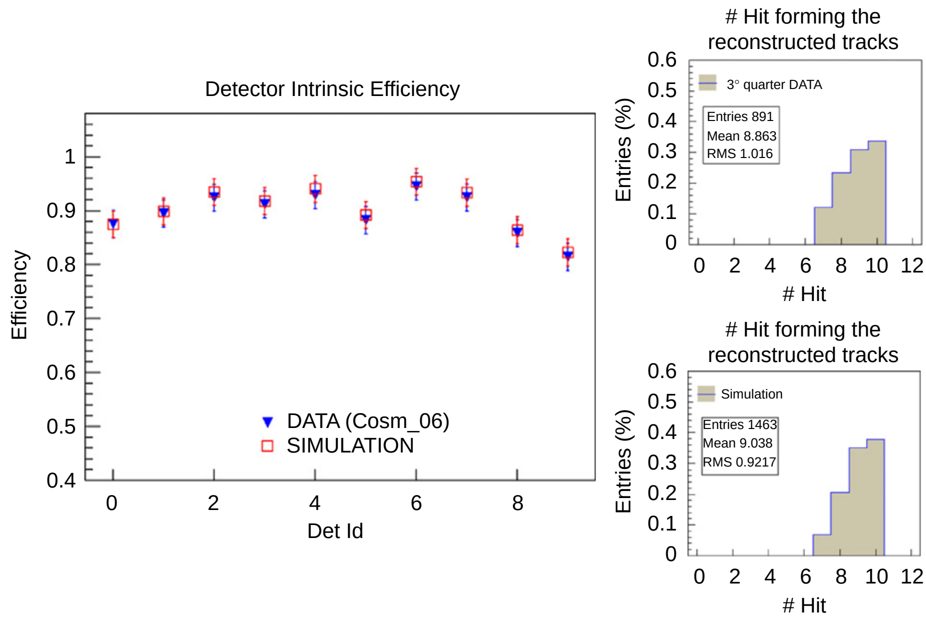


**Fig. 2.** Left: measured and simulated detector efficiencies. Right: track hit multiplicity for data (top) and simulation (bottom).

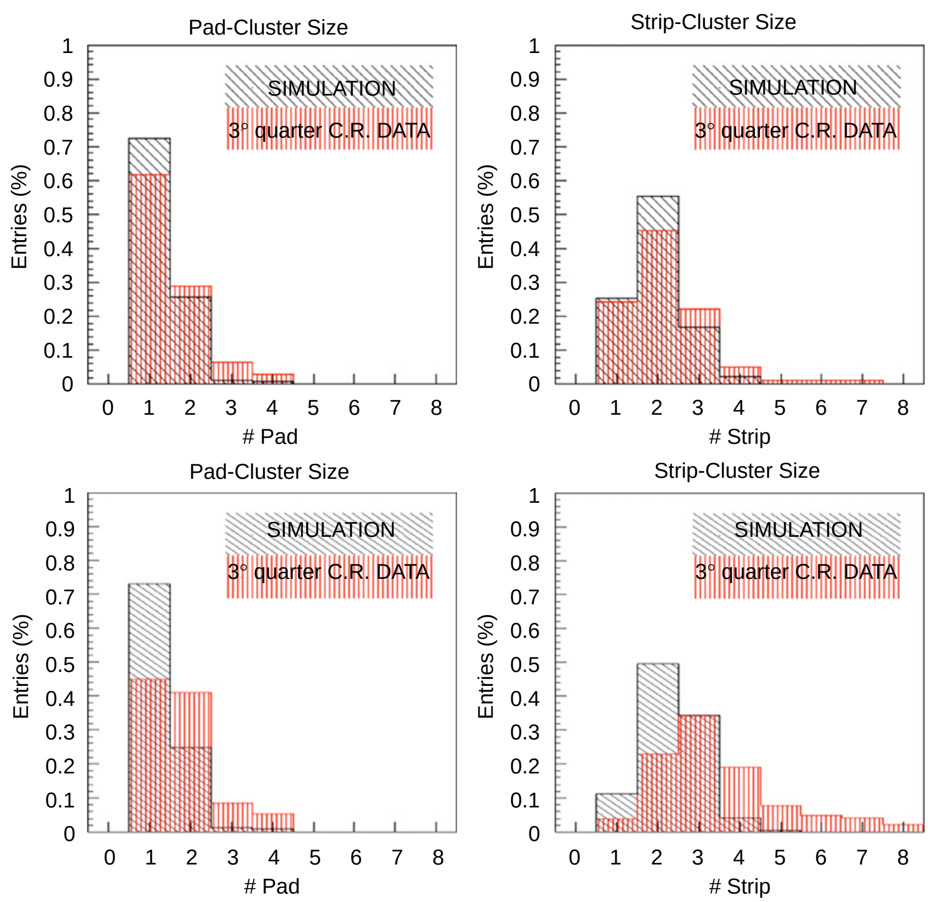


**Fig. 3.** Data/simulation comparison of pad and strip cluster size.

clad polymer foil of 50 μm chemically perforated with a large number of holes of 70 μm in diameter [3]. A potential difference around 500 V applied between the two copper electrodes generates an electric field of about 100 kV/cm in the holes which therefore can act as multiplication channels (gains of order $10-10^2$) for electrons created in the gas ($Ar/CO_2$(70/30%) for T2) by an ionizing particle. The triple-GEM structure, realized by separating three foils by thin (2−3 mm) insulator spacers, is adopted in order to reduce sparking probabilities while reaching high total gas gains, of order $10^4-10^5$, in safe conditions.