TOTEM STATUS REPORT

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133rd LHCC, OPEN SESSION

28 Feb 2018
TOTEM

• Preparation for high $\beta^*$ run:
  
  TOTEM + CMS dedicated to low mass central diffraction

• YETS activities

• Recent publications

Proton Precision Spectrometer (PPS)

• YETS activities

• Luminosity collected in 2017

• Detectors performance

• Recent publications
RP configurations: TOTEM

High $\beta^*$ runs

- 6 Vertical RPs
- 2 Horizontal RPs (only alignment)

4 Tracking (strip)
2 Timing (UFSD)
Tracking (pixel)

Expected after TS1 (July)
YETS activities: TOTEM Timing

Ultra Fast Silicon Detectors (UFSDs)
Thin (50 μm) silicon detectors with a gain layer

- 12 channels per plane
- 4 planes per package
- 2 packages per arm (top and bottom)
- Time precision better than 50 ps per plane

SAMPIC

- 16 channels/chip
- Up to 64 samples/hit @ 10 GSa/s
- 1.5 GHz bandwidth
- 8-11 bit resolution
- 0.2-1.6 µs channel dead time

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Trigger matching and event building done in the Digitizer Board

- Detectors installed
- DBs V3 with SAMPIC installed
- Final tests on-going...
- CMSSW update on-going...

- Strip detectors dismounted from vertical RPs
- UFSD planes prepared and tested
- Detector packages tested for vacuum, cooling and electrical functionality
- Digitizer Boards (DBs) V3 produced
- Firmware for SAMPIC ready
YETS activities: TOTEM Tracking

- Radiation shield near TCL6 installed
- Replaced electronics for RP movement
- Improved handling of movement
- Final tests done
YETS activities: gas telescopes

- T1 storage area prepared (radioactive area)
- T1 removed from the LHC

- T2 removed from the LHC
- T2 stored in special containers that allow storage in standard RP boxes
- T2 for HL-LHC: R&D started
RP configurations: PPS

Normal runs (high intensity)

- 4 Vertical RPs (only alignment)
- 2 Horizontal Shielded RPs
- Cylindrical RP

4 Tracking (strip)
2 Tracking (pixel)
Timing (Diamond)

PER ARM
YETS activities: PPS Tracking

- 2 strip detectors removed
- 4 pixel detectors ready
- Pixel detectors removed to be exchanged 45 with 56
- R&D to introduce a remotely controlled vertical micro-movement for larger radiation tolerance
- 4 Detectors installed: all PPS trackers
- CMSSW updated
- Final tests on-going...

Pixel detectors irradiated mostly in a thin region

Exchanging the detector packages between 45 and 56 the beam will be aligned with a non irradiated region

Track impact points reconstructed from the 3D pixel detector package (sector 45).
YETS activities: PPS Timing

Double Diamond detectors
Two scCVD diamond sensors read out in parallel with the same amplifier
- 12 channels per plane
- 2 planes per package (plus 2 single diamond)
- Time precision better than 50 ps per plane

- Timing detectors dismounted
- Digitizer Boards (DBs) V3 produced
- 2 UFSD planes removed
- 2 diamond planes reused
- 2 diamond planes prepared
- 4 “double diamond” planes prepared
- Detector packages tested for vacuum, cooling and electrical functionality
- DBs V3 tested
- Detectors installed
- DBs V3 installed
- CMSSW updated
- Final tests on-going...
Online Luminosity 2017

Starting from **CMS-online Luminosity** measurements, it is possible to measure the fraction collected with RPs inserted

* Luminosity collected by CMS with RPs inserted in the beam
Performance of the pixel detectors

Hit residuals for single planes are evaluated with respect to the local track reconstructed in the pixel RP.

Residuals are consistent with those obtained at the beam tests.

The pixel tracker works as expected.
Tracks with the timing detectors

The horizontal position of the reconstructed tracks in the timing detectors can be correlated with the tracks reconstructed in the pixel detectors.

Low pileup data ($<\text{PU}> \sim 0.8$) requiring:
- 1 vertex in CMS,
- 1 track (per arm) in Pixel Detector,
- 1 track (per arm) in Timing Detector,
- single hit per plane in the Timing Detectors
Performance of the timing (diamond) detectors

Selections:
- Pile up $\sim 0.8$
- RF precision clock
- single vertex reconstructed in CMS
- single track reconstructed in PPS pixel detector
- all PPS diamond planes with a single hit
- total mass of CMS particle flow objects reconstructed in each event greater than 320 and less than 1500 GeV (double arm acceptance region of PPS)

Precision per arm:
$$\sigma_{arm} \sim \frac{80 \text{ ps}}{\sqrt{2}} \sim 56 \text{ ps} \quad \rightarrow \quad \sigma_z \sim 17 \text{ mm}$$

Precision per plane:
$$\sigma_{plane} \sim \sigma_{arm} \sqrt{3} \sim 100 \text{ ps}$$

More statistics collected....

Poster (Diego Figueiredo):
Operation and performance of new detectors in the CMS-TOTEM Precision Proton Spectrometer
First measurement of elastic, inelastic and total cross-section at $\sqrt{s}=13$ TeV by TOTEM and overview of cross-section data at LHC energies

$\sigma_{el} = 31.0 \pm 1.7 \text{ mb}$

$\sigma_{inel} = 79.5 \pm 1.8 \text{ mb}$

$\sigma_{tot} = 110.6 \pm 3.4 \text{ mb}$

Submitted to Phys. Rev. D
First determination of the \( \rho \) parameter at \( \sqrt{s} = 13 \text{ TeV} \) – probing the existence of a colourless three-gluon bound state

Submitted to Phys. Rev. D
Observation of proton-tagged, central (semi)exclusive production of high-mass lepton pairs in pp collisions at 13 TeV with the CMS-TOTEM Precision Proton Spectrometer

CMS PAPER PPS-17-001
TOTEM-2018-001

Abstract

The process $p p \rightarrow p[\mu^+\mu^-]p$, with $\mu^+$ a muon or an electron pair produced at midrapidity and with $p_T > 150$ GeV, has been studied by the collaboration at the LHC in pp collisions at $\sqrt{s} = 13$ TeV. One of the two scattered protons is measured in the CMS-TOTEM Precision Proton Spectrometer (CPPS) while operated for the first time in 2016. The second proton either remains intact or is excised and then measured at LEP or LHC; it can be observed only in the semimixed event $p[\mu^+\mu^-]p$, which is understood. The measurement is based on an integrated luminosity of 9.4 fb$^{-1}$ collected during standard, high-luminosity LHC operation. In total, 32.2 $\mu^+\mu^-$ and $e^+e^-$ pairs with $m(TOTEM) > 10$ GeV are collected, where $m(TOTEM)$ is the transverse mass of the lepton pair, and 1.8 (1.0(stat)$\pm$0.3 syst)$\pm$0.5(stat)$\pm$0.4(syst) $e^+e^-$ events are identified. The combined significance of the signal over the background is greater than 5.1 $\sigma$. This measurement demonstrates that CPPS protons are well identified in the CMS acceptance.

12 matching $\mu^+\mu^-$ events
BG: 1.49 $\pm$ 0.07 (stat) $\pm$ 0.53 (syst)

8 matching $e^+e^-$ events
BG: 2.36 $\pm$ 0.09 (stat) $\pm$ 0.47 (syst)

Combined significance $> 5.1 \sigma$
Conclusions

• detector packages (4 technologies) installed and tested during YETS

• TOTEM

  successful installation of the detectors

  preparation for dedicated run ($\beta^* = 90\text{m}$)

  2 papers submitted for publication

• PPS

  >39 /fb collected in 2017

  successful commissioning of the detectors

  1 CMS and TOTEM paper ready for submission

  1 paper under preparation: $\gamma\gamma \rightarrow \gamma\gamma$