

Performance of the 2S Modules of CMS Phase2 Tracker in a Test Beam Environment





Tuesday: 06/10/2020



Gourab Saha, Saha Institute of Nuclear Physics, India [On behalf of CMS Tracker collaboration]







2 Phase 2 (HL-LHC) Upgrade of CMS Outer Tracker

- requirements :
 - Radiation hardness
 - High granularity
 - Compatibility with high data rates
- Outer Tracker (OT) :

 - It will supply tracking information to the CMS Level-1 trigger system for event selection



Performance of the 2S p_T modules of Phase 2 CMS Tracker under test beam environment : Vertex 05 - 08 October' 2020

To operate over the HL-LHC period, CMS will install a new silicon tracking detector with the following major

OT modules will consist of 2 closely spaced silicon sensors read out by common Front End (FE) chip These FE chips will be programmed to discriminate tracks based on their transverse momentum (pT)





P_T discrimination :

- Charged particles bend in magnetic field and the bending radius depends on their pT
- If a particle passes through a 2S module, some 1 strips of both the sensors get fired and when the signals from those strips cross a threshold, the CBCs (CMS Binary Chip) send binary information of the hits
- The combination of hits on the bottom and the top sensors within a predefined window forms a stub
- The main logic behind this pT discrimination lies / in the predefined window programmed in the chip
- Stubs will be used for Level-1 tracking.









Test Beam Setup

Electron beam : 4 GeV

4

- Telescope System : Six MIMOSA26 active pixel devices were used as beam telescope for tracking the beam particles with high precision.
- ✓ **Detector Under Test (DUT)** : 4 DUTs (2S p_T modules) were used here. DUT-Box1, contains one DUT placed in the middle, can be rotated in order to emulate track bending in magnetic field. **DUT-Box2** contains three modules
- Timing Detector : An FEI4 layer was used as a trigger system placed in between 5th and 6th telescope layers



Performance of the 2S p_T modules of Phase 2 CMS Tracker under test beam environment : Vertex 05 - 08 October' 2020



Mode of studies:

Threshold Scan: Choose optimal threshold point to get high S/N ratio

Angular Scan: To verify pT discrimination logic of CBC



5 Results :: Threshold (V_{Cth}) Scan

Number of tracks matched with stubs Stub Efficiency = Total number of tracks



Stub Efficiency Map

Stub efficiency mostly at about 99%, exceptions especially in beam boundary areas

Performance of the 2S pT modules of Phase 2 CMS Tracker under test beam environment : Vertex 05 - 08 October' 2020

Offline Stub Reconstruction :

• Stubs are reconstructed offline from the hits on the DUT emulating the stub logic programmed on the CBC





6 Results : Angular Scan



Efficiency drops at around 16 deg : as expected due to the acceptance of matching window [± 5 Strips]

Turn-on at around 1.5 GeV

Performance of the 2S p_T modules of Phase 2 CMS Tracker under test beam environment : Vertex 05 - 08 October' 2020





7 Conclusion

The performance of 2S prototype modules has been evaluated in a test beam environment.

 \checkmark p_T discrimination logic has been verified through angular scan.



Performance of the 2S p_T modules of Phase 2 CMS Tracker under test beam environment : Vertex 05 - 08 October' 2020



Backup:1

8



Performance of the 2S p_T modules of Phase 2 CMS Tracker under test beam environment : Vertex 05 - 08 October' 2020

Results :: Cluster & Track Reconstruction

Track Reconstruction:

- Reference Tracks: Hit on telescope pixel detectors + hit on FeI4 plane
- Residual check: [The extrapolated reference track position on DUT - the nearest strip (within a cluster) fired] < 150 μ
- Those tracks are used to compute the Stub-Track matching efficiency





Backup:2 9

 $\epsilon_{stub} = p_0 + p_1 \times erf(\frac{x - p_2}{p_3})$

CBC stub efficiency 0.8

0.2

Performance of the 2S p_T modules of Phase 2 CMS Tracker under test beam environment : Vertex 05 - 08 October' 2020



