PS Module Testing for the HL-LHC CMS Outer Tracker Upgrade

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The High Luminosity Large Hadron Collider (HL-LHC) Upgrade is expected to result in a fivefold increase of the current operating luminosity, to 7.5x10³⁴ cm⁻²s⁻¹. This increase will lead to a higher data rate and radiation level. The CMS will require an upgrade in order to cope with the more challenging experimental conditions. As part of this upgrade, on-board p_{τ} discrimination will be used for the first time in the outer tracker, providing information to be used by the Level-1 Trigger System.

Pixel Strip (PS) p_T discriminating modules

The outer tracker upgrade:

- Replacement of current 200 m² active sensor area
- Module types: Strip-Strip (2S, orange) and Pixel-Strip (PS, blue)

Pixel-Strip (PS) Modules:

- Silicon strip sensor on top of macro pixel sensor
- Readout via ASICS (16 MPAs, 16 SSAs) using binary readout





On-board p₊ discrimination:

- Correlation of hits from top and bottom sensors
- Stub sent to Level-1 Trigger to aid trigger decision



Testing environments and method

Testing objective:

S-curve measurement and module noise level extraction to define optimal readout threshold

Testing method:

- Firmware loaded onto FC7 board FPGA combined with software
- Binary search for threshold corresponding to 50% occupancy
- Scan across thresholds measuring occupancy









show_py_of_0_B(0)_O(0)_H(0)_SCurve_CP

7.068

Mean

Std Dev

Powered by low and high voltage power supplies, readout through optical link connected to FC7 board

Preliminary results

1) Module testing box:

Ideal results obtained



Results from tests performed at DESY, Hamburg

Module testing on the dee (strips only):



Scenario 1 (Outer PS position + screwed down):

- No s-curve
- Occupancy does not reach zero

Summary

The HL-LHC CMS Outer Tracker upgrade will see the installation of new 2S and PS modules to deal with an increase in data rate and radiation level. Tests performed on PS modules in a dedicated testing box gave expected results. Results from testing on an endcap dee suggest grounding is significantly better in the inner PS region. This result is currently under further investigation at **DESY**, Hamburg.



Scenario 2 (Outer PS position + screwed down + cooling pipes grounded):

- No s-curve
- Occupancy does not reach zero





Scenario 3 (Inner PS position + screwed down + cooling pipes grounded):

- Return of s-curve, occupancy zero at highest thresholds
- Result under further investigation

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