Status of the CMS silicon strip tracker

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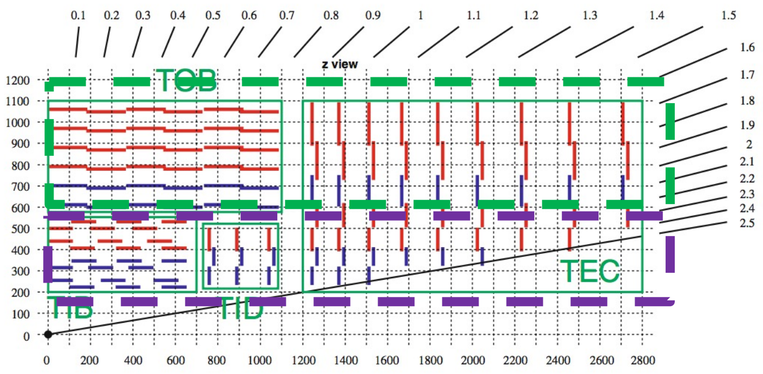
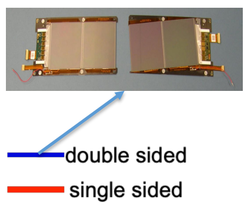
CMS silicon strip tracker

The CMS Silicon Strip Tracker (SST) is the second closest subdetector to the beam pipe in the CMS experiment at the CERN LHC. It provides measurements of charged particle trajectories up to $|\eta| < 2.5$. The detector has 9.3 million strips and 198 m^2 of active silicon area.

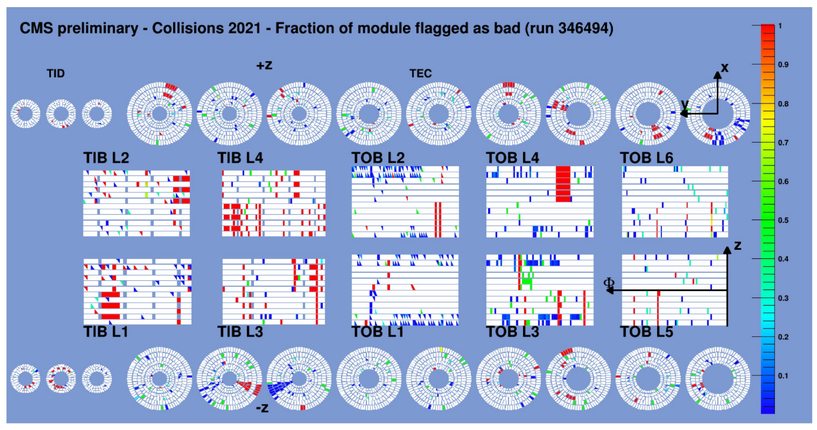




500 µm thick sensors
320 µm thick sensors

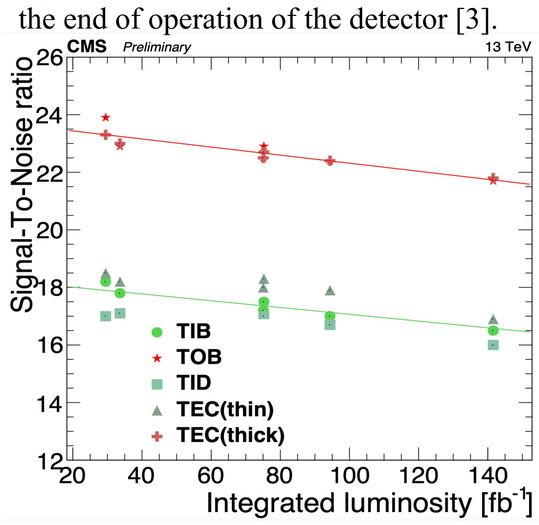
Detector status

The fraction of active channels of the detector is 96.5%. It remained stable over the LHC Run 2 period. The inactive channels include modules that have no active cooling, 3 control groups that are non-working – one in TIB layer 1, one in TIB layer 2, one in TOB layer 4, few modules that developed HV shorts, following an overpressure incident on the cooling system in 2009.

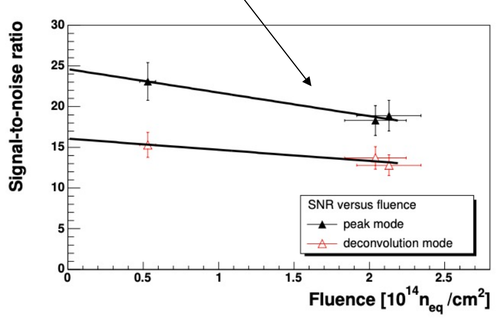


Signal-to-noise performance

The evolution of signal-to-noise ratio decreases with fluence (integrated luminosity). The signal to noise ratio is expected to decrease to 12 for thin sensors and to 17 for thick sensors by the end of operation of the detector [3].

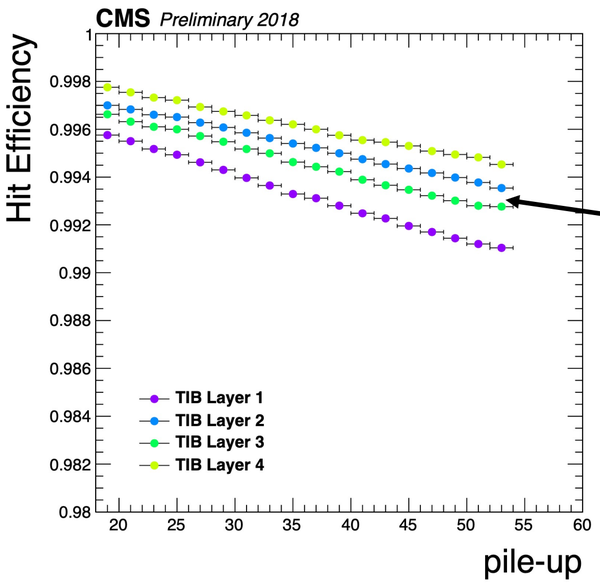


Expected performance after 500 fb^{-1} of integrated luminosity is that S/N > 10 [1].

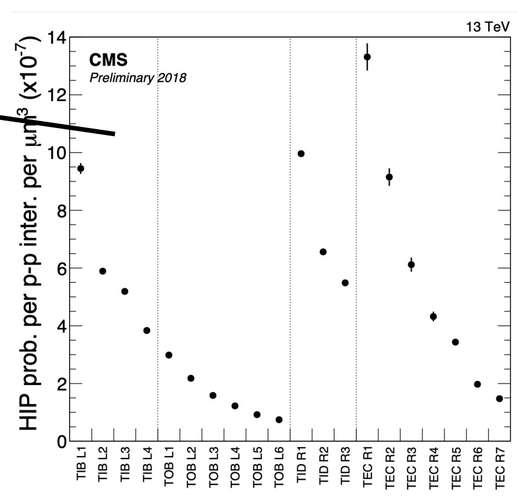


Hit efficiency

The single hit efficiency is more than 98 % for all layers. The hit efficiency depends on the detector layer and decreases linearly with pileup [2]. Events with Highly-Ionising Particles (HIP) are the main source of hit inefficiency.

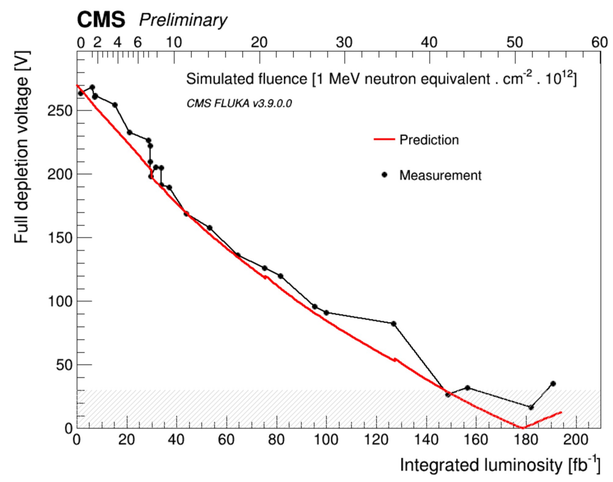


Average probability of events with HIP per p-p interaction per unit volume for all layers of the silicon strip tracker [2].



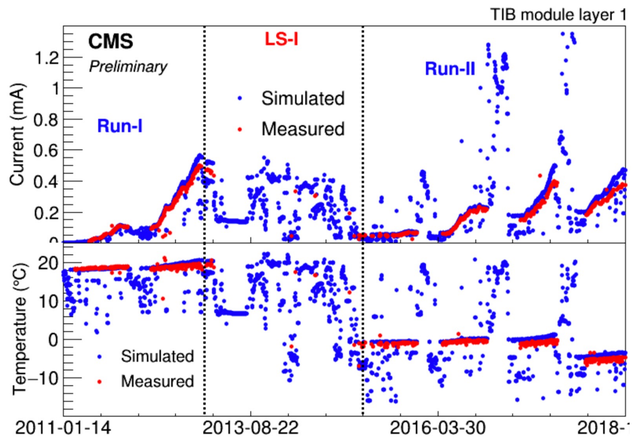
Radiation effects

Most of the modules of the detector are operated at 300 V in order to make sure that the sensors are over-depleted. The full depletion voltage is measured in bias scans.

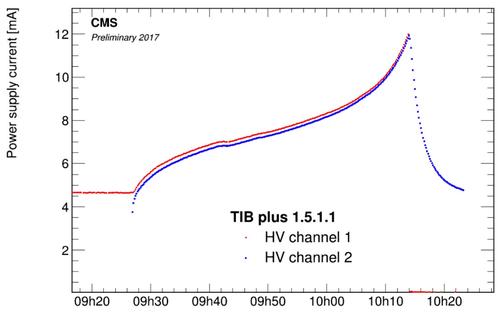


Evolution of the full depletion voltage of a sensor in the first layer of the TIB. The prediction from simulation is superimposed for comparison. It is based on a model which uses fluence and temperature history as inputs [4].

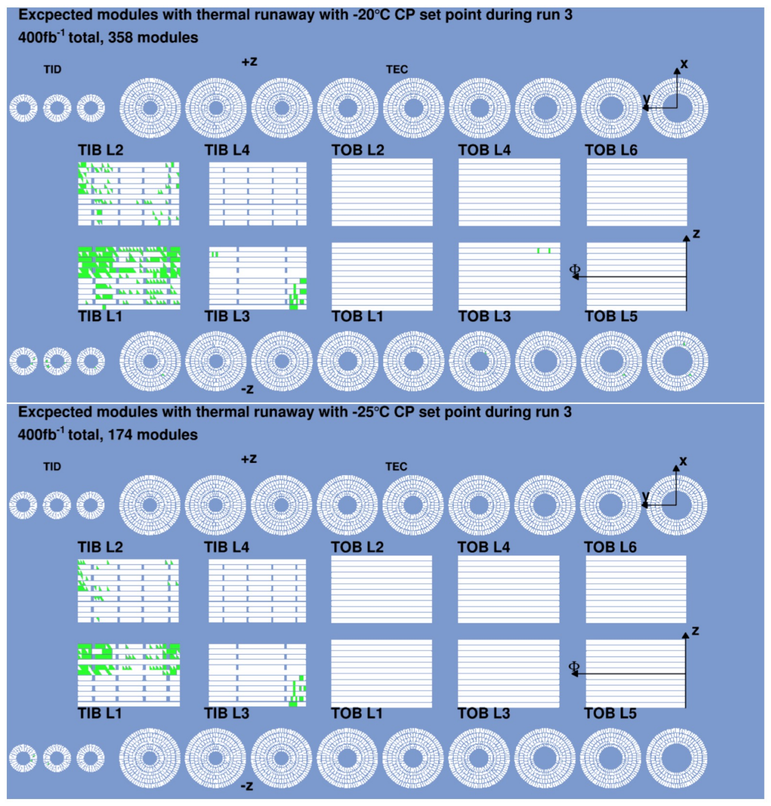
The leakage current evolution is an important ingredient for the operation of the SST. In 2018 the operational temperature has been decreased from -15°C to -20°C in order to decrease the leakage current which approached the power supply limit in the uncooled regions of the detector and regions with degraded cooling contacts.



In one power group in the TIB layer 1 with degraded cooling contact thermal runaway was observed in 2017 [3].



Conclusions



It is likely that the operational temperature of the detector will have to be decreased to -25 °C towards the end of Run 3 in order to reduce the number of thermal runaways. During Long Shutdown 2 the strip tracker has successfully taken cosmic data at -25 °C [3].

The strip tracker is about to start operation for the LHC Run 3, which is planned to last until 2025. The detector also participated successfully in the LHC pilot beam test in October 2021.

The strip tracker continues to perform well after more than 10 years of operation – signal-to-noise ratio and hit efficiency are compatible with expectations.

References

[1] CMS Collaboration, “The CMS experiment at the CERN LHC”, JINST 3 (2008) S08004.

[2] CMS Collaboration, *"Silicon Strip Tracker Performance results 2018"*, CMS-DP-2018-052, https://cds.cern.ch/record/2638062, 2018

[3] I. Shvetsov. Operational experience with the Silicon Strip Tracker at the CMS experiment. *CMS-CR-2019-012*, 2019. doi: 10.22323/1.348.0003. URL http://cds.cern.ch/record/2689274.

[4] https://twiki.cern.ch/twiki/bin/view/CMSPublic/StripsRadiationPlots2019