The CMS Tracker Performance in Run 3

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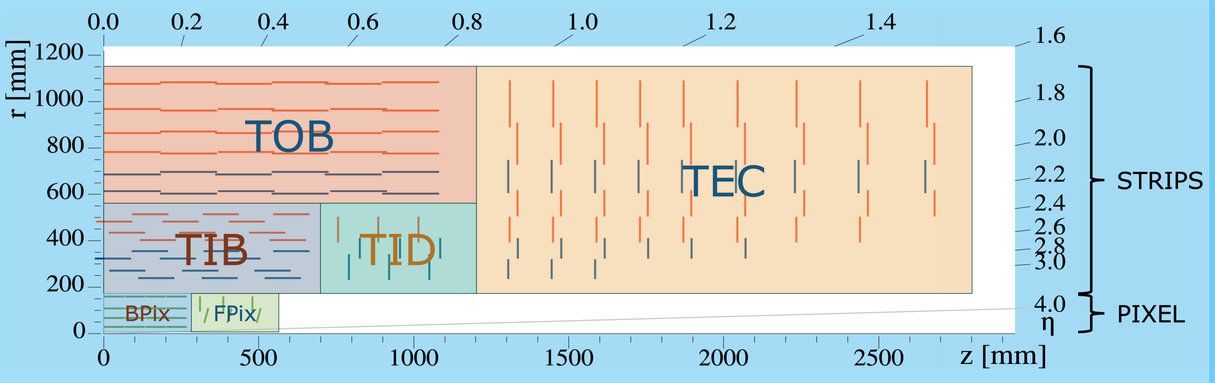
THE CMS TRACKER

- All-silicon, comprised of the **Pixel** (BPix, FPix) and the **Strips** (TIB, TID, TOB, TEC)
- Allows for **high-precision charged particle tracking**
- Essential in particle identification, heavy-flavour tagging, trigger decisions, vertex reconstructions



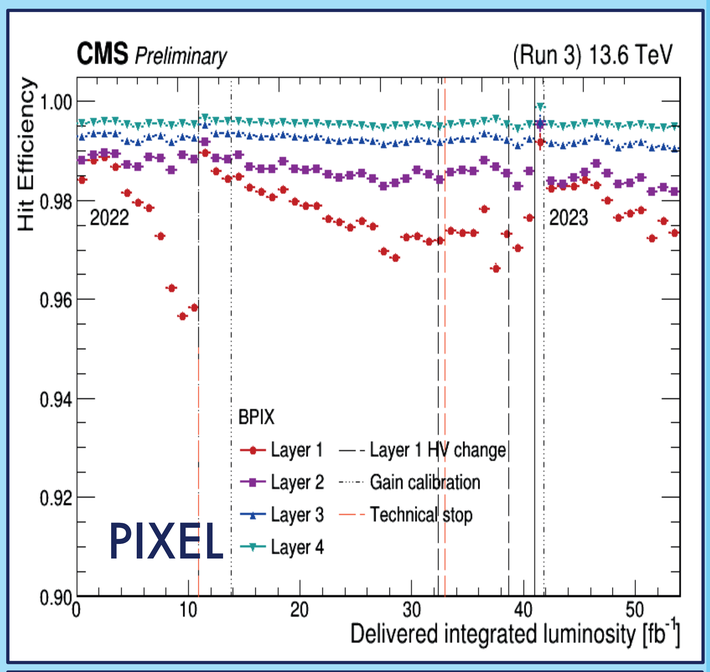
COPING WITH RADIATION

Degradation of performance due to radiation is **expected**

- Especially in BPix Layer 1, being just ~3 cm from the beam-pipe
- **Degradation visible** in hit efficiency and signal-to-noise ratio

Effects of radiation are closely monitored, and measures are taken to mitigate the degradation

- Routine bias voltage scans and increase of bias voltage when needed, along with routine calibrations for Pixel
- Adjusting temperature and bias voltage of the Strips to mitigate leakage currents
- **Beneficial annealing** during no-beam periods help improve performance



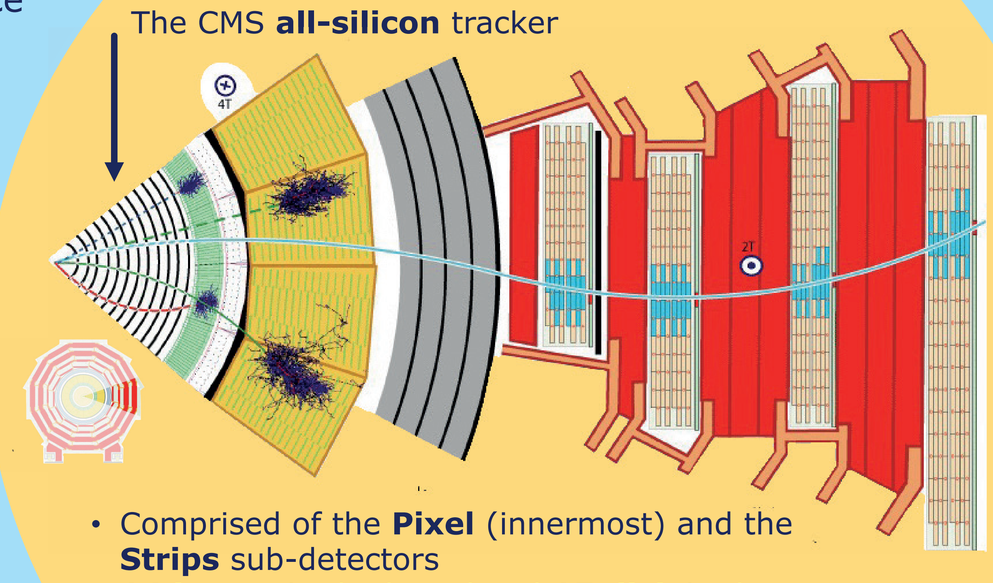
IMPROVEMENTS SINCE RUN 2

To prepare for Run 3's expected 250 fb^{-1} of integrated luminosity, upgrades and maintenance were performed to enhance the Tracker's data-taking capabilities

- **New Pixel Layer 1** installed in 2021
  - Able to be operated up to 800 V compared to 600 V during Run 2
  - Enhanced front-end ASICs to improve efficiency and increase resistance against single-event upsets [1]
- Various **upgrade and maintenance of the Strips service**
- More granular Online alignment procedure integrated in the Prompt Calibration Loop from **36 (LG-PCL) to ~5k parameters (HG-PCL)**

The innermost part of the CMS detector

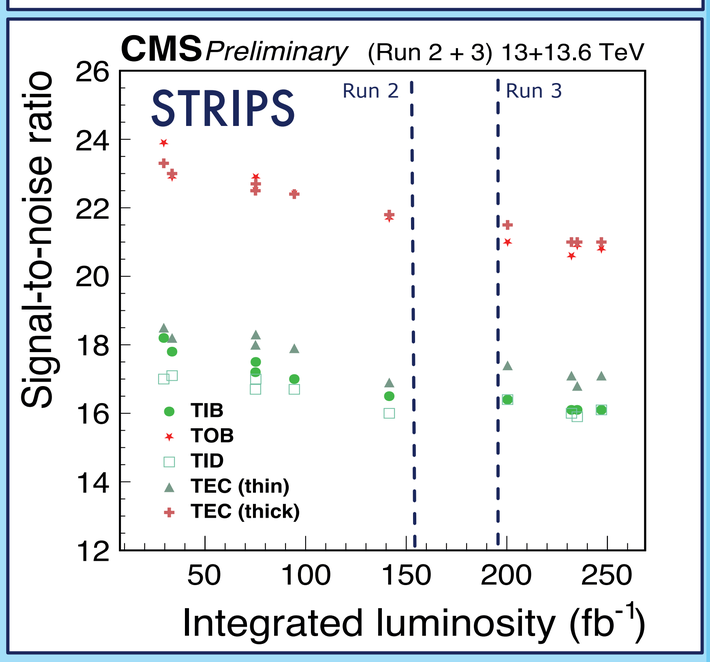
The CMS **all-silicon** tracker



- Comprised of the **Pixel** (innermost) and the **Strips** sub-detectors
- **14 layers** in the barrel and **15 disk** in the forward regions

1,856 Pixel modules and **15,148 Strips** modules

The **largest silicon tracker** in the world!



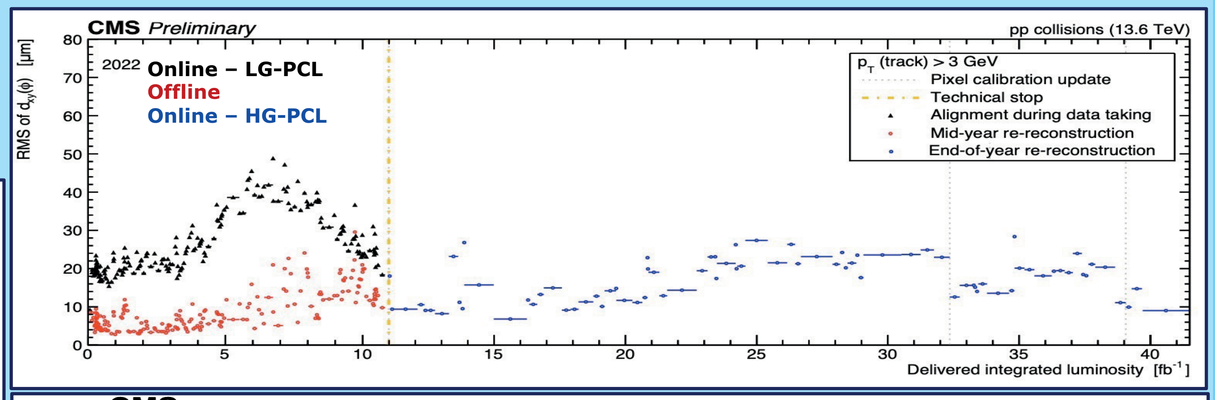
PERFORMANCE IN RUN 3

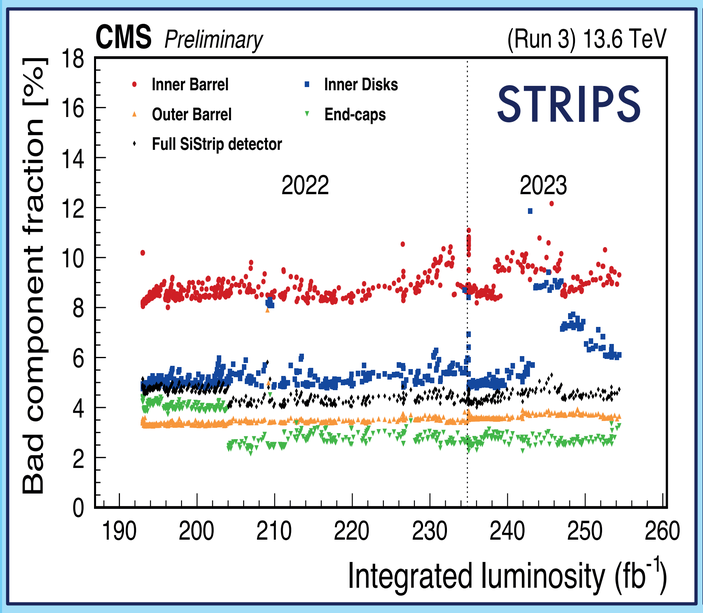
Throughout the 2022 and 2023 data-taking periods, both Pixel and Strips have been taking excellent data at high trigger rates and high pile-up conditions up to 65 PU

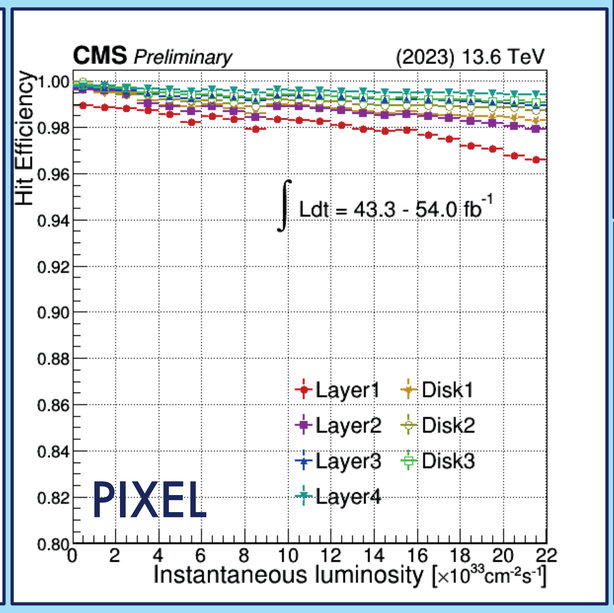
- The Tracker participated in all proton-proton data-taking runs, amounting to 42 fb^{-1} of data in 2022 and ~20 fb^{-1} in 2023 so far
- **Very high hit efficiency** with **more than 95% and 98% of active detector fraction** for Strips and Pixel respectively

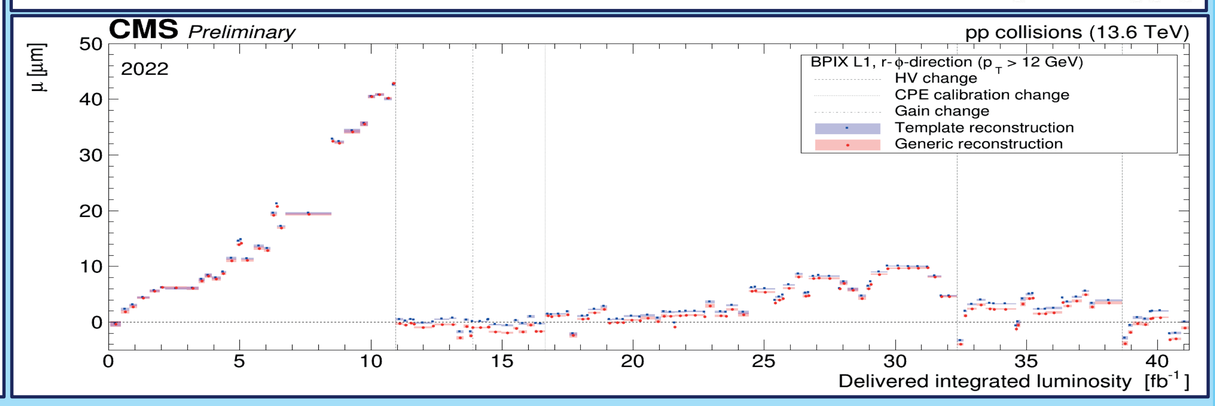
Precise measurements of the position and orientation of each silicon sensors are essential to utilize their excellent resolution in tracking charged particle trajectories

- The increasing offset of BPix hit residuals is recovered by increasing the sensor bias voltage and kept stable by the deployed HG-PCL [2]









CONCLUSIONS

Thanks to improvements made since Run 2 and continuous efforts in mitigating radiation effects, the CMS Tracker has been successfully acquiring valuable data. The CMS Tracker showed excellent tracking performance with very high hit efficiency and resolution despite the demanding conditions of Run 3, including high trigger rate and pile-up conditions.

References:
[1] JINST-17-C09017
[2] CMS-DP-2022-067
Plots taken from:
CMS Tacker Detector Performance Results (Public)

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