The CMS Tracker performance in Run 3

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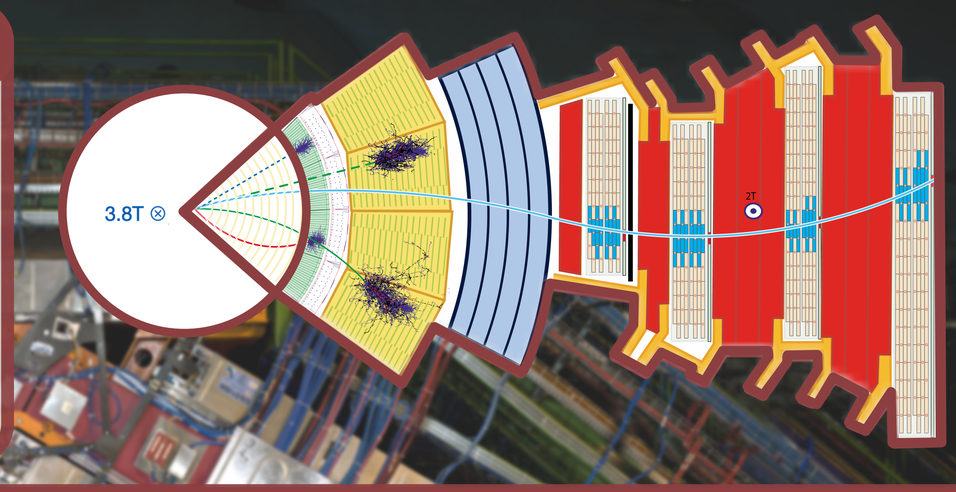
The CMS Tracker

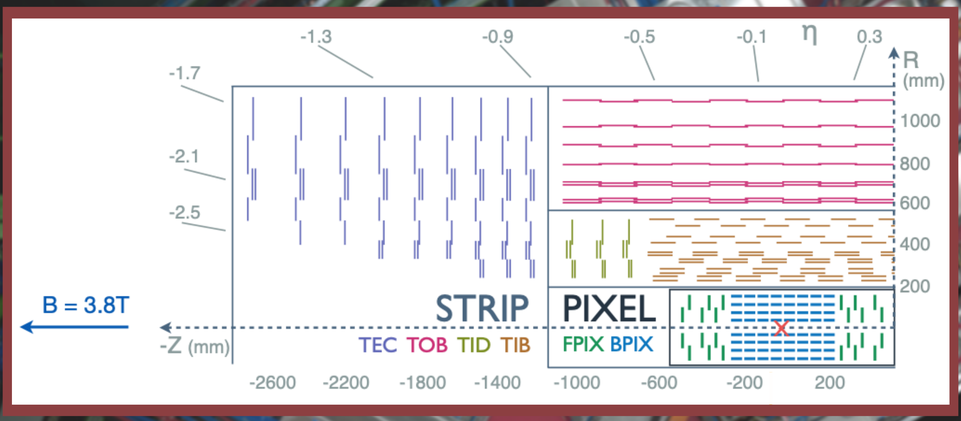


Innermost part of the CMS detector

- Provides a precise measurement of the trajectories of charged particles.
- High granularity and fast response.
- Composed of 1856 pixels (4 layers and 3 disks) and 15148 strips modules.

Crucial component for event reconstruction and trigger

- p_T measurement, particle ID, vertex identification, heavy flavour tagging.



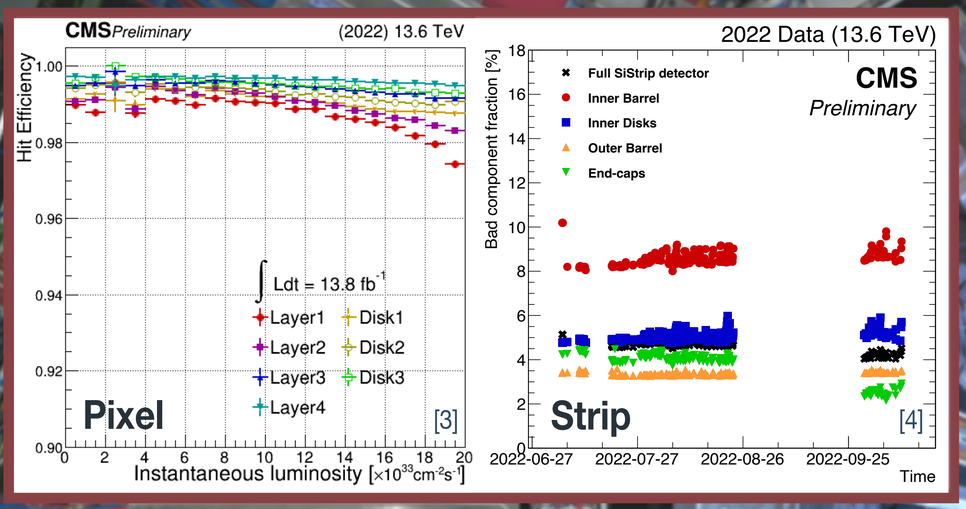
Phase-1 Pixel Detector refurbishment

Enhanced detector performance leads to improved quality of collected data.

The innermost barrel pixel layer has been replaced in 2021 featuring:

- Redesign of the readout chips for a better S/N and components with increased HV tolerance up to over 800 V, compared to 450 V in Run 2.
- The entire readout chain of the innermost layer is designed to cope with a particle hit rate of up to 600 MHz/cm^2 during Run 3.

Repair of system-level issues and individual modules in other pixel layers/disks. [1][2]



Run 3 Pixel and Strip Tracker performance

Throughout 2022 data taking period the performance of CMS tracker was optimal, showing consistent behaviour also at highest instantaneous luminosity and pile-up conditions.

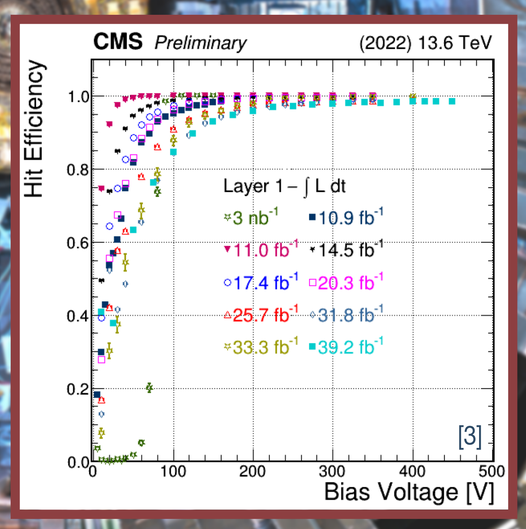
- More than 98 (95)% of channels working in the Pixel (Strip) Tracker.
- Hit Detection Efficiency greater than 98 (99)% for the Pixel (Strip) Tracker.

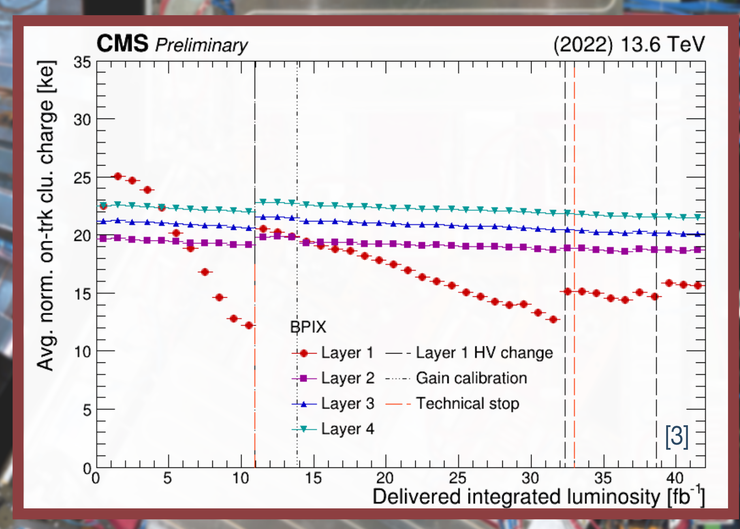
[3][4]

Radiation effects

The pixel detector operates in an extremely harsh radiation environment due to its location close to the collision point. This requires mitigation of radiation effects during data-taking.

- Radiation effects most dominant in innermost layer (13 Mrad or 3x10^{14} neq in 2022), visible in degradation of hit efficiency and average cluster charge.
- Compensation by increasing reverse bias voltage and continuous calibrations over the course of the year.
- Beneficial annealing in periods without beam.



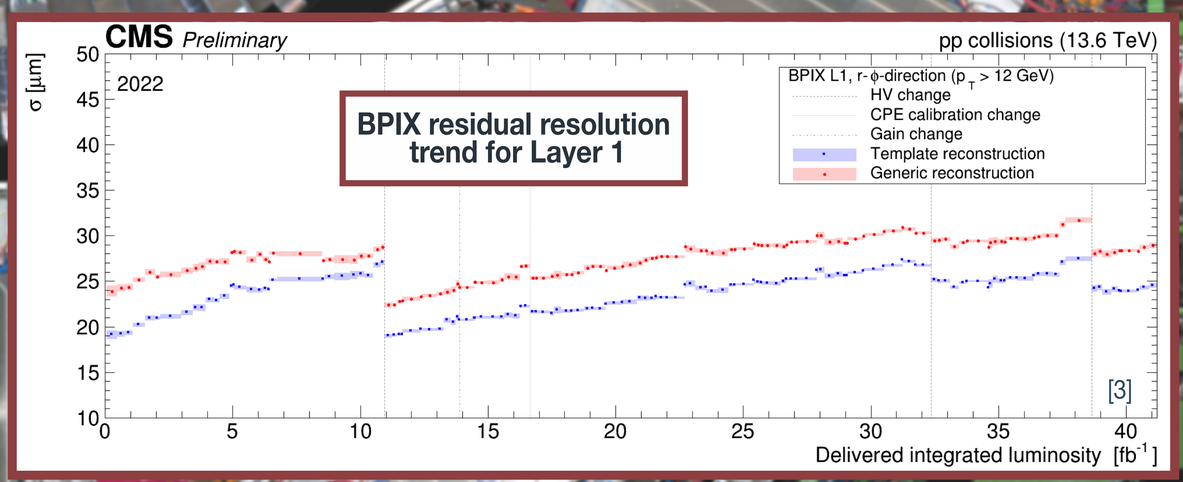


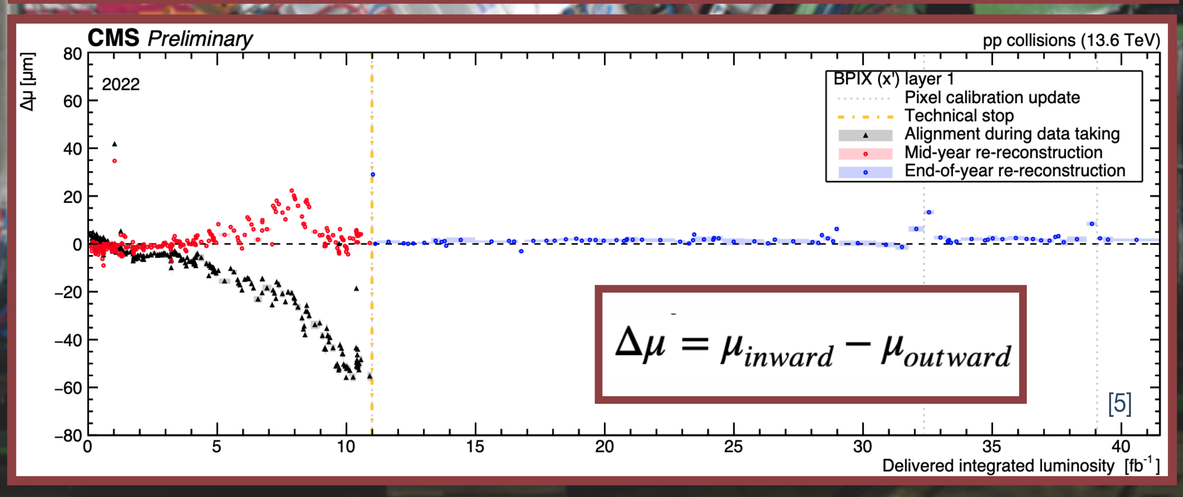
Tracker alignment

An accurate determination of the geometry of the tracking system is of vital importance for measuring the momentum of charged particles and precisely reconstruct vertices.

- Align position, rotation and curvature of each module (*O(10^5)* parm.).
- Global track fit of all parameters minimising sum of squares of normalised track-hit residuals.
- Movement can arise from magnet cycles (*O(mm)*), cooling operations (*O(100 μm)*, irradiation (*O(μm)*).
- Alignment is performed both online, with a limited statistics and track kinematic variety and offline (increased granularity).
- Starting from Run 3 a more granular calibration is in place also online, integrated in the Prompt Calibration Loop (HG-PCL), with significant improvement.

[5]





references

agenda

LHCP Conference
Belgrade, May 2023

Conclusions

The **CMS tracker** detector system has been **succesfully operated** during the first year of Run 3 data taking. In particular the **refurbishment of the pixel detector** and the **improvements in the alignment procedure** have **granted optimal performance** despite the high pile-up conditions in which the LHC operated in 2022.