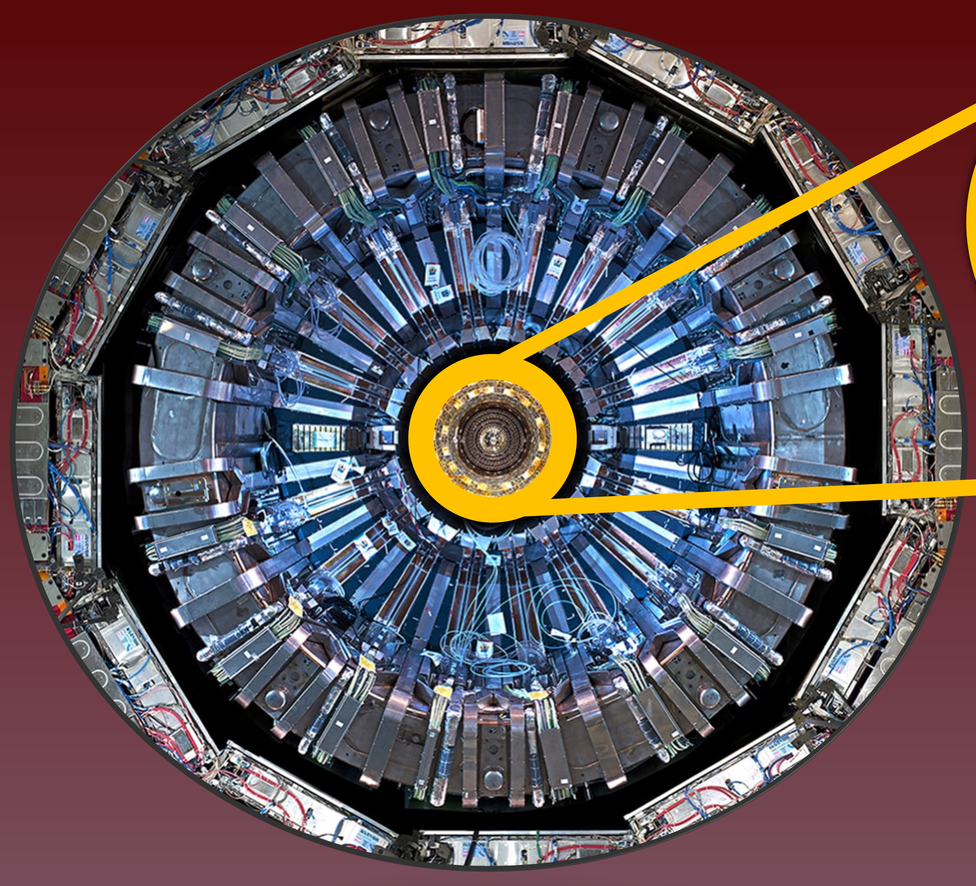
Performance of CMS Pixel Tracker During Run 3

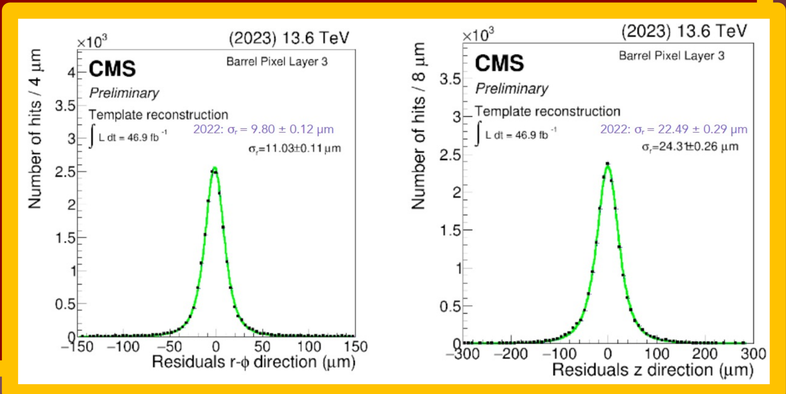
Steffi Bower on behalf of the CMS Tracker Group



The Pixel Detector

Innermost subdetector in the CMS Experiment, which tracks the path of charged particles along with the strip tracker

- Composed of 120 million 100x150 μm^2 pixels
- 280 µm thick n^+-in-n Si diodes
- Excellent spatial resolution maintained despite high levels of radiation



Detector Geometry

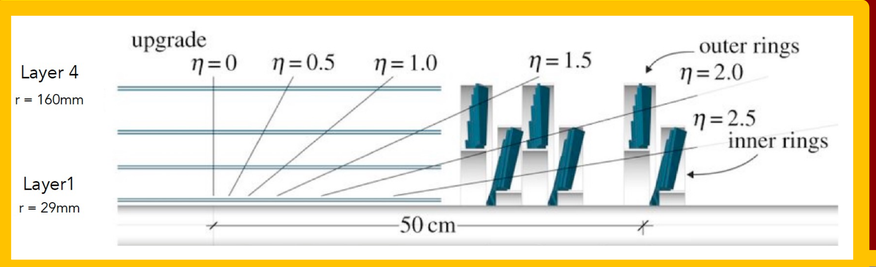
Tracker composed of 2 parts with 4 hit coverage out to |η|<3

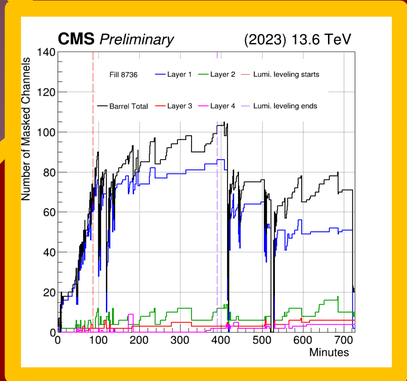
Barrel Pixels (BPix)

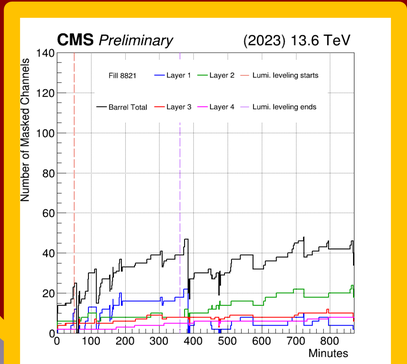
- 0< |η| <1.5
- 4 layers
- 1184 total modules

Forward Pixels (FPix)

- 1.5< |η| <3
- 3 disks × 2 rings on each end
- 672 total modules





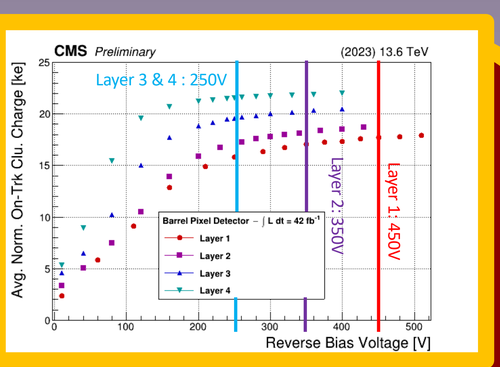


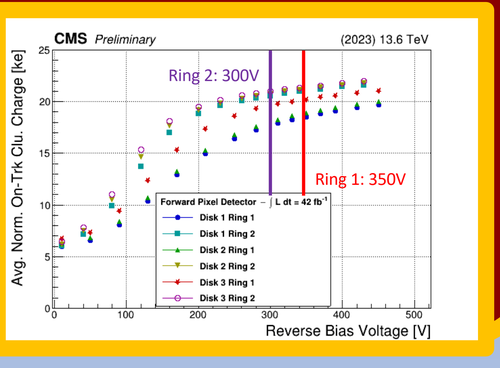
Automasked Channels

- In late 2022 the pixel detector had high numbers of auto masked channels
  - ➢ 10% of BPix L1 [Top Plot]
- Adjusting phase of 400MHz data transmission reduced fraction of masked channels per fill
  - ➢ Reduced to 2% of BPix L1 [Bottom Plot]

HV Bias

- Si diodes must be operated at a reverse bias voltage to act as particle detector
- Radiation damage increases the minimum voltage required to maximize signal reconstruction
- We chose our setting to maximize response while minimizing noise
  - Current settings on plot



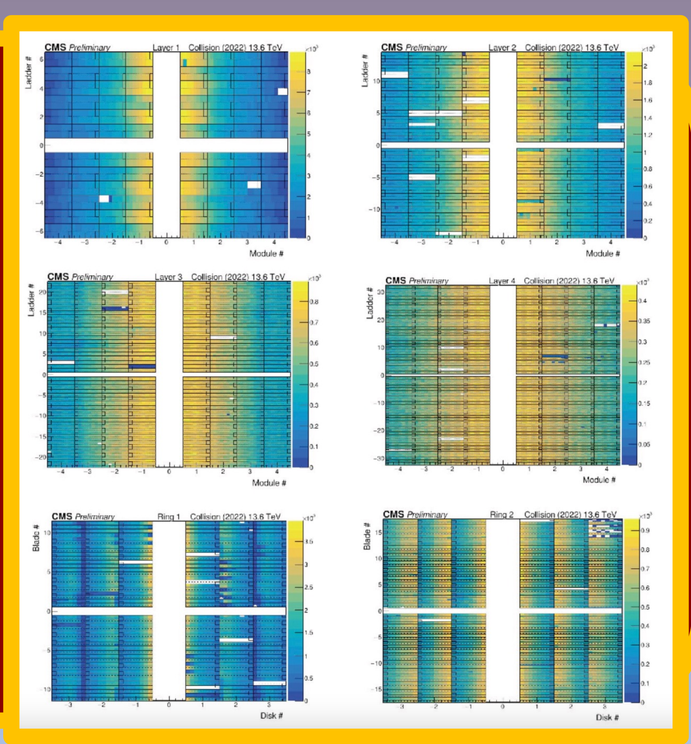


Active Pixels

Active detector fraction at the beginning of June 2023

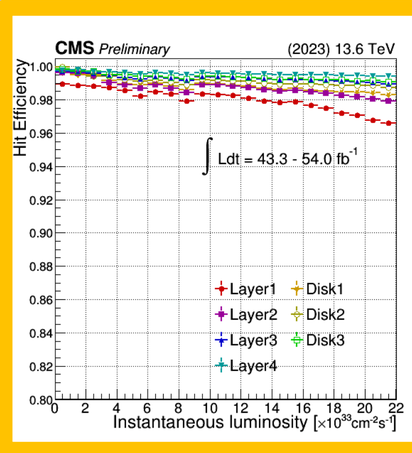
- BPix: 98.4 %
- FPix: 97.9 %

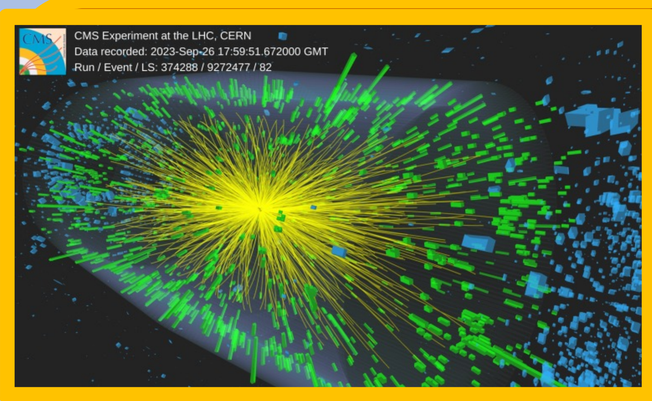
A problem with a readout group in BPix has decreased its fraction to 96.2% since June 2023



Run III proton-proton (pp)

- Detector healthy throughout data taking
- Shows excellent efficiency with inst. lumi. up to 2.1×10^{34} cm^{-2} s^{-1}





Run III Heavy Ions

- Increased buffers for larger event readout
- Low lumi. leads to fewer errors than pp collisions
- Contributed <2% of total CMS downtime

Conclusions:

The pixel detector delivered high-quality data in both proton-proton and heavy ion collisions with high hit efficiency, precise position resolution, and a large active detector fraction. The operations team worked tirelessly to monitor and calibrate the detector ensuring its crucial contributions to the CMS experiment.

References:

[1] *CMS-DP-2022-067*
[2] *JINST-17-C09017*
[3] Haza; 16 Oct. 2023, "Operation and performance of the current CMS Pixel Detector" (Vertex Conference)

Images from:
CMS Tacker Detector Performance Results (Public)