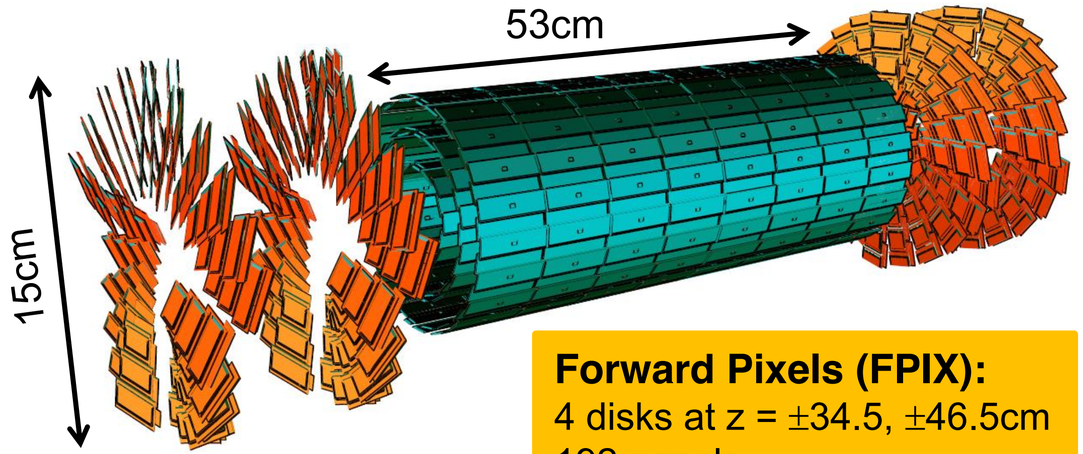
Phase-I Upgrade of the CMS pixel detector

Mia Liu
Fermilab
AEM Feb 20, 2017

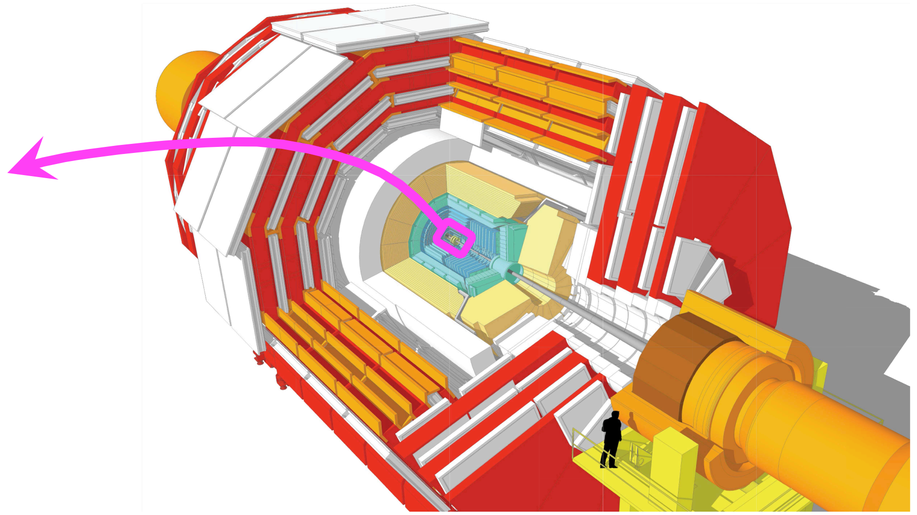
CMS Pixel Detector

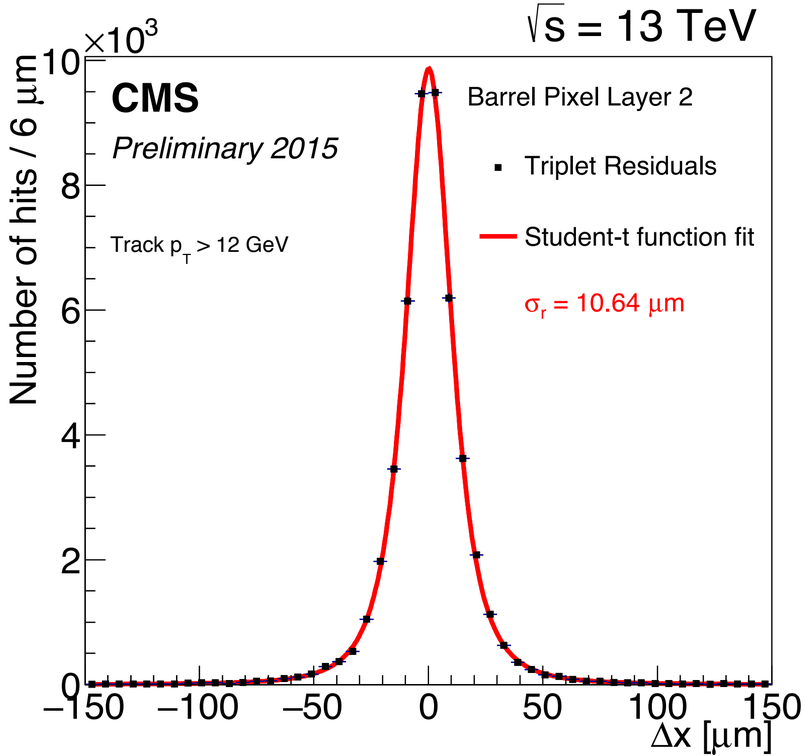
Barrel Pixels (BPIX):
3 barrel layers at 4.4, 7.3, 10.2cm
768 modules

Present detector designed for $10^{34}cm^{-2}s^{-1}$ and 25ns bunch spacing



Forward Pixels (FPIX):
4 disks at z = ±34.5, ±46.5cm
192 panels



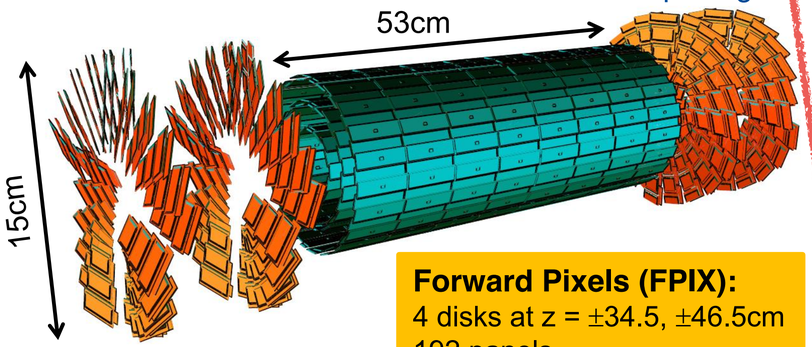


- **Most precise, 3-D measurement of hits on tracks.**
- **Crucial in tracking and vertex reconstruction**
- **Closest to beam-pipe: high occupancy and large radiation dose. Current detector designed for instantaneous luminosity of 10^34 cm^{-2} s^{-1}**

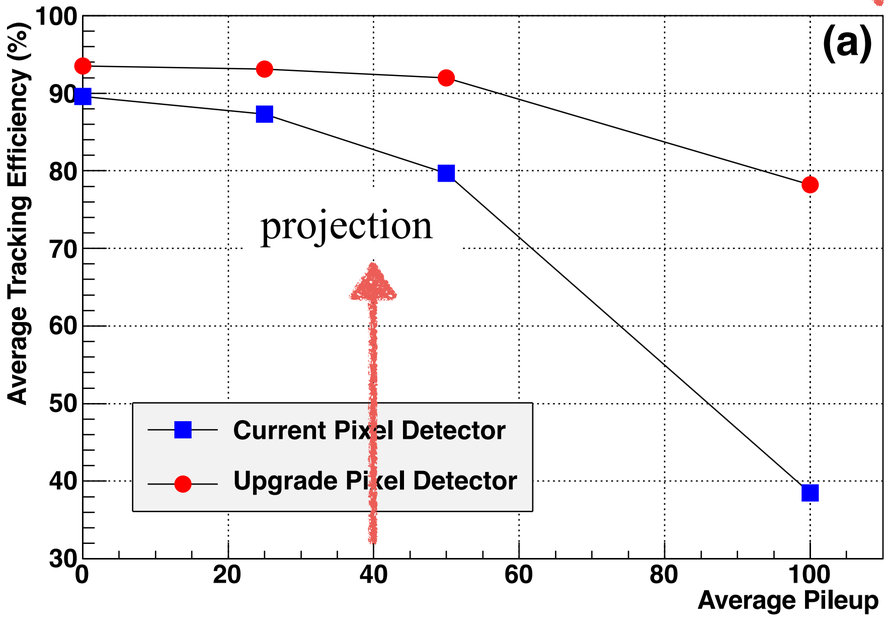
Reasons for upgrade

Barrel Pixels (BPIX):
3 barrel layers at 4.4, 7.3, 10.2cm
768 modules

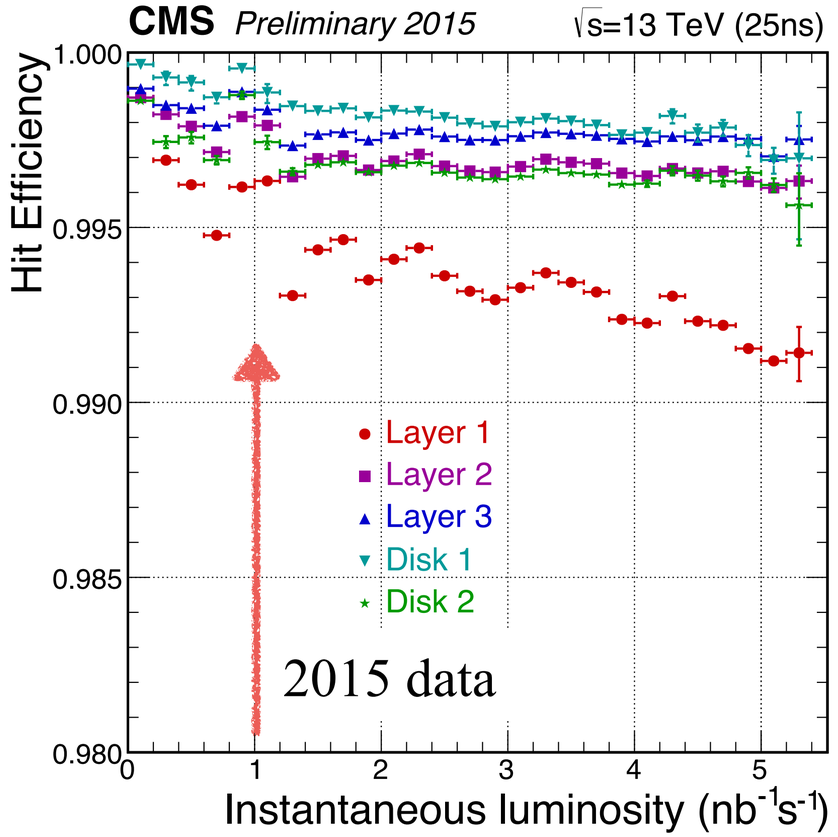
Present detector designed for $10^{34}cm^{-2}s^{-1}$ and 25ns bunch spacing



Forward Pixels (FPIX):
4 disks at z = ±34.5, ±46.5cm
192 panels



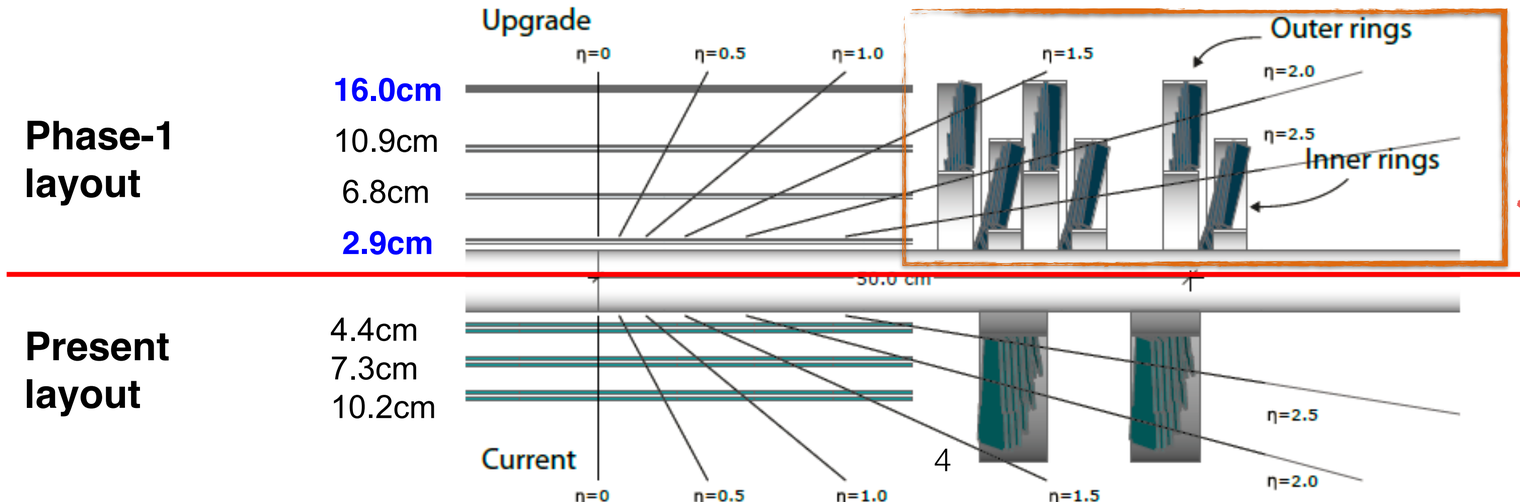
End of 2016



- **The LHC has exceeded its design instantaneous luminosity of 10^34 cm^{-2} s^{-1}**
- **Dynamic inefficiencies/ dead time caused by limited size of the readout bandwidth.**

The new phase 1 pixel detector

- **Installation during extended year-end technical stop 2016/17 in Feb/March 2017.**
- **Compared to the current detector:**
  - **Similar sensor design, pixel size, module design concept.**
    - **Change from analog readout chip to digital readout chip (ROC) —> reduced buffer overflow and inefficiency, increase data transmission speed**
  - **Added layers, channels doubled, closer to beam**
    - **3 to 4-hit coverage—> increase track finding efficiency**
    - **Closer to the beam —> improve vertex reconstruction**
  - **Single-phase fluorocarbon (C6F14) to evaporative, bi-phase CO2 cooling: lower mass.**

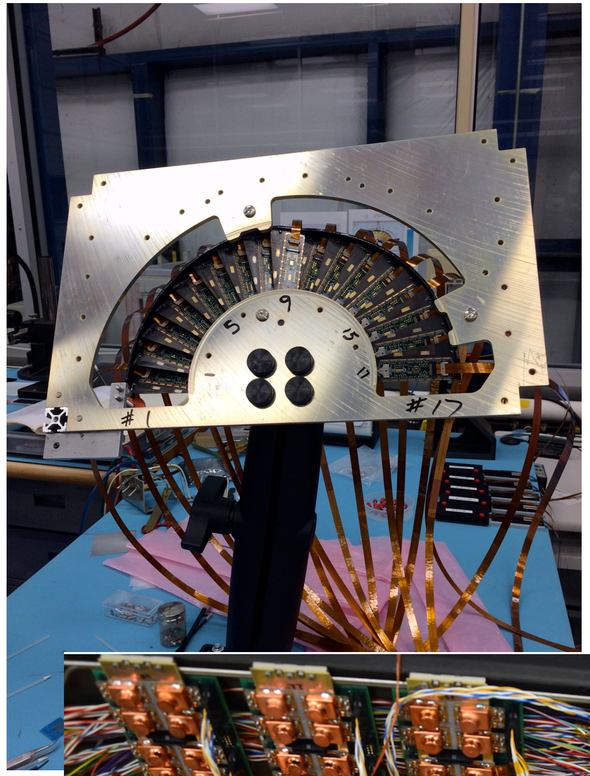


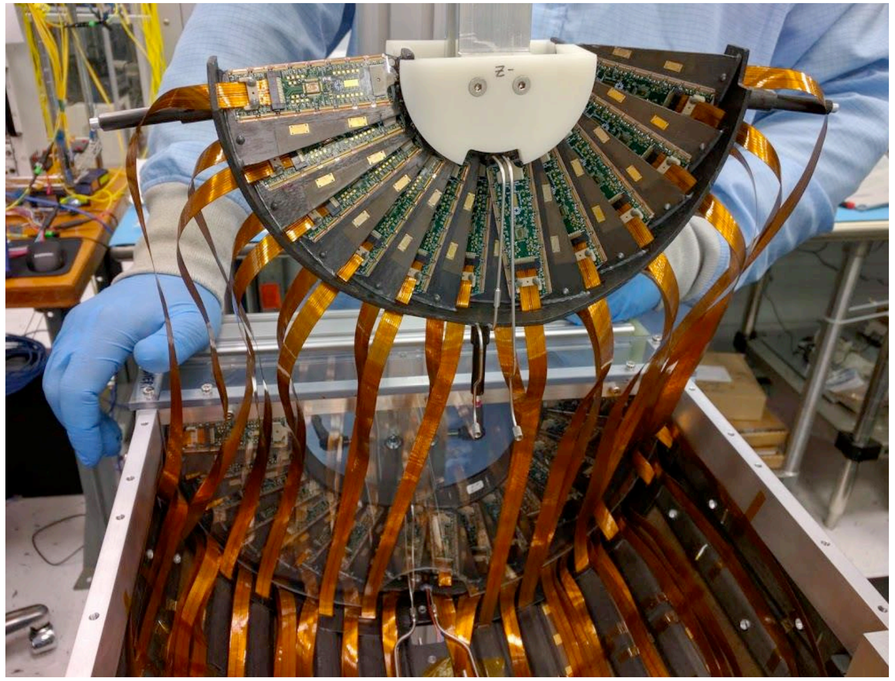
1856 modules
124M pixels

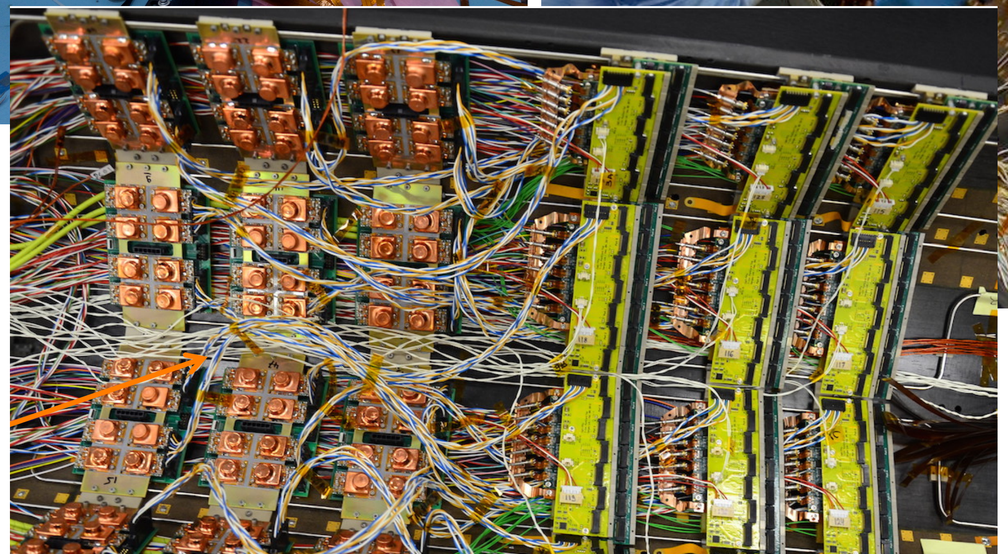
Fermilab

1440 modules
66M pixels

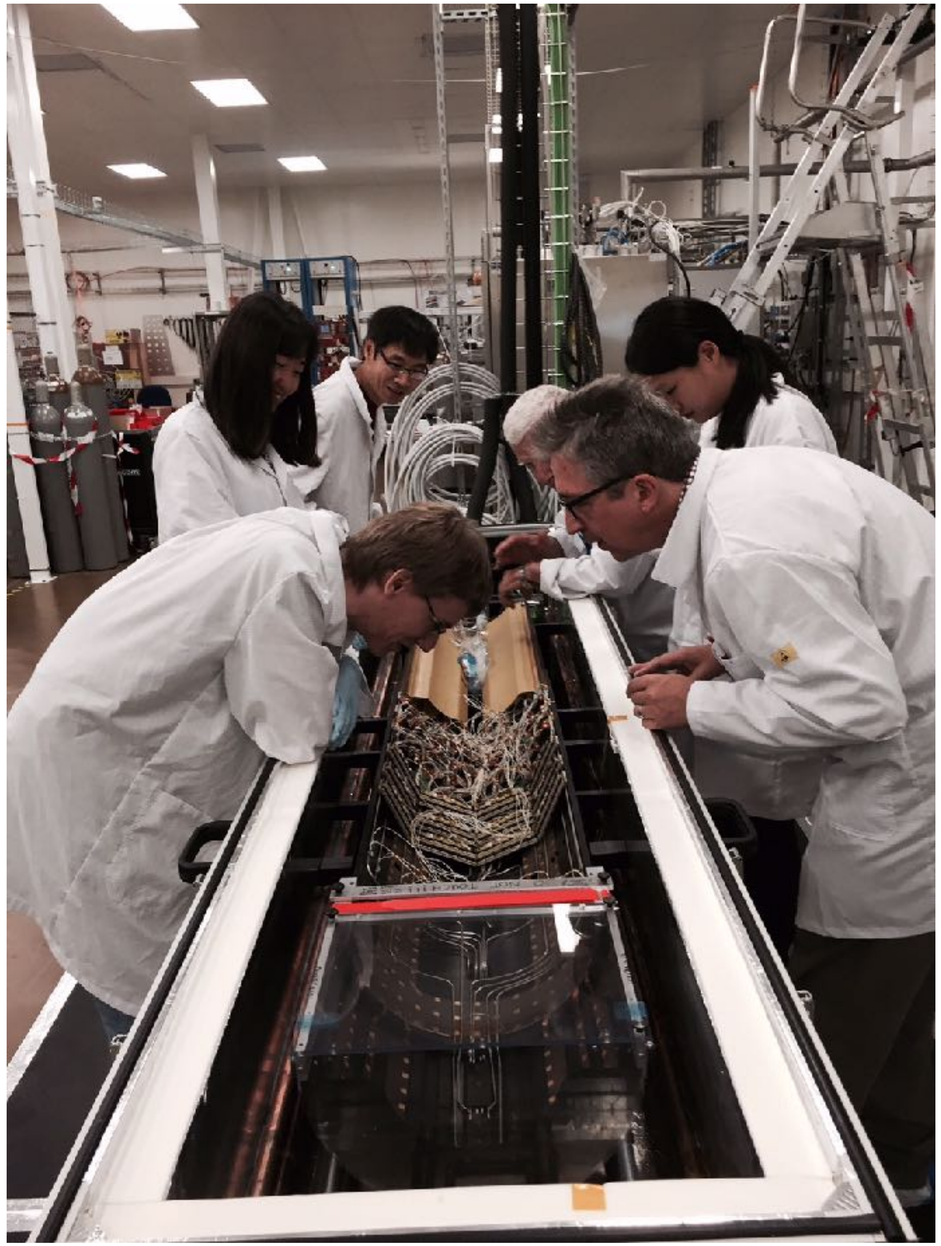
Building the forward pixel detector at Fermilab(SiDet)

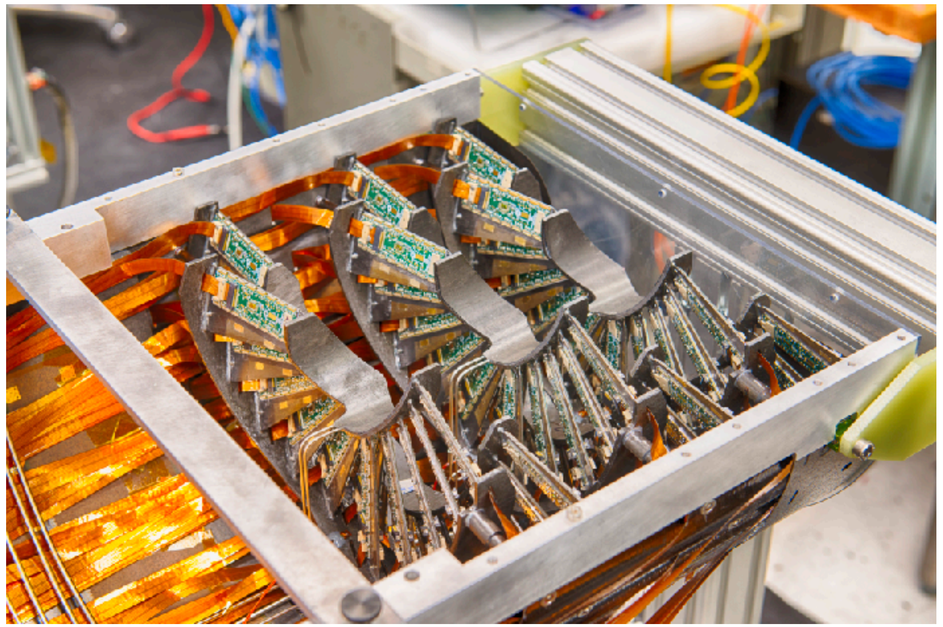






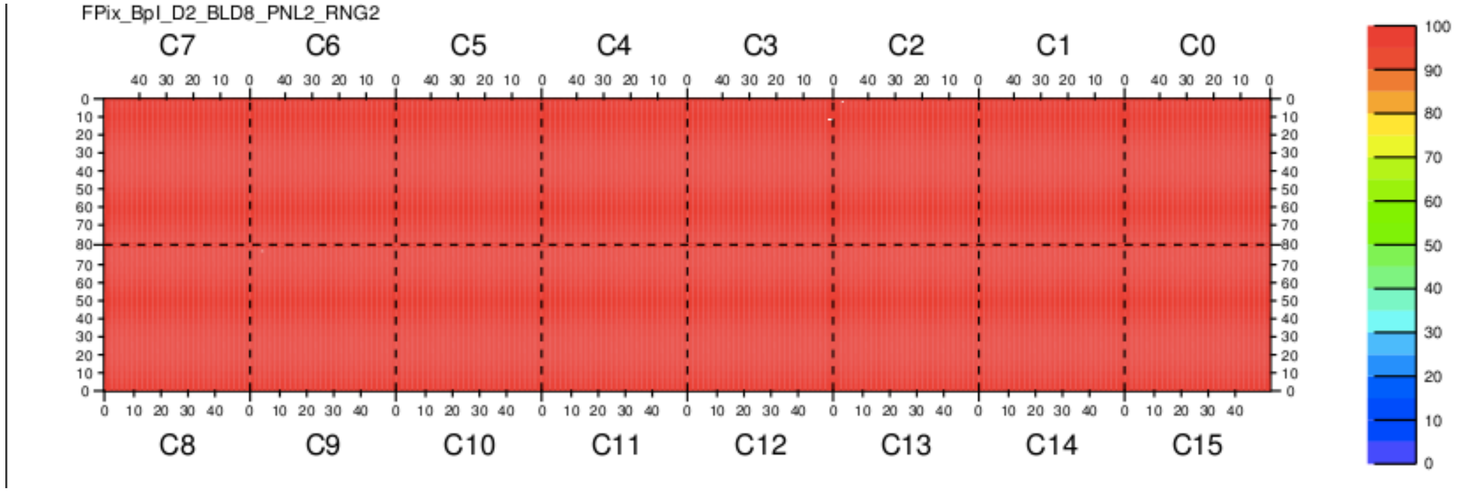
Arrival at CERN





- **Detector re-assembled after transportation at CERN main site.**
- **Detector tested/calibrated post-transportation.**

System testing at CERN



"PixelAlive" for
One module,
16 Readout chips

- **Very Tight schedule.**
  - First half cylinder arrived at CERN last September.
  - All four half cylinders tested within three months.—> allow for repairs after Christmas.
  - Checkout procedure shortened to less than one week.
- **Lots of work getting the detector to function properly**
  - Detector Checkout : Timing scan, adjust light level in optical fibers, adjust settings on the readout chip etc…
  - Exercised more advanced calibrations needed to have uniform response from all pixels.

Getting ready for collisions

- **Status as of today:**
  - All four half cylinders have been tested at CERN main site.
    - They were thoroughly tested at Fermilab before transported to CERN.
    - Three transported to CMS site, tested, ready for installation.
  - Barrel part transported to CMS site, half of the barrel tested.
  - **More than 99% working channels**
- **Installation in ~2 weeks!**
  - **Commissioning& calibration will follow**
  - **Need smooth transition from installation to physics data taking.**
- **Expecting LHC proton-proton beam for physics in June.**
  - **New detector is getting ready to see tracks for the first time!**