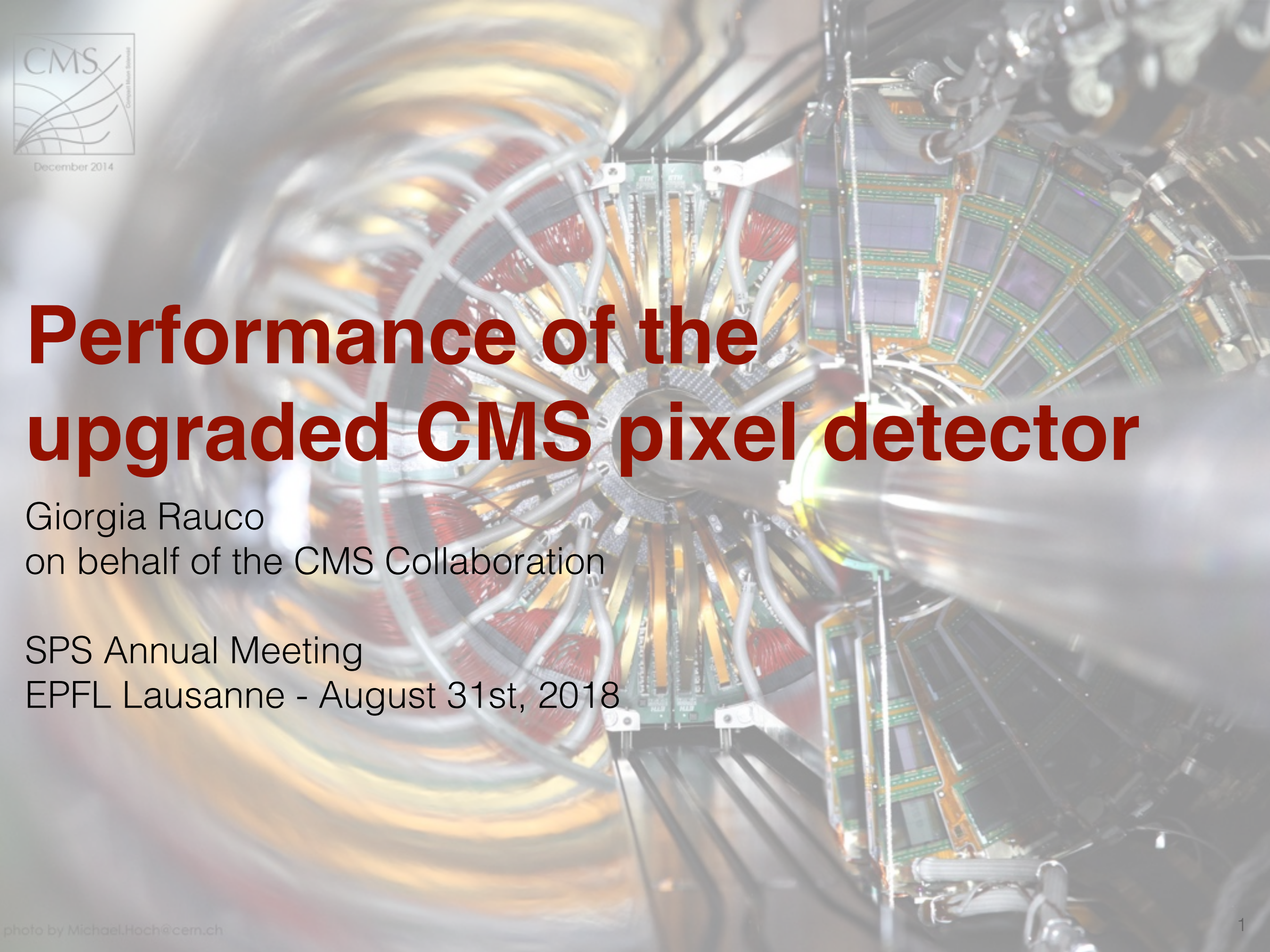


December 2014

Performance of the upgraded CMS pixel detector

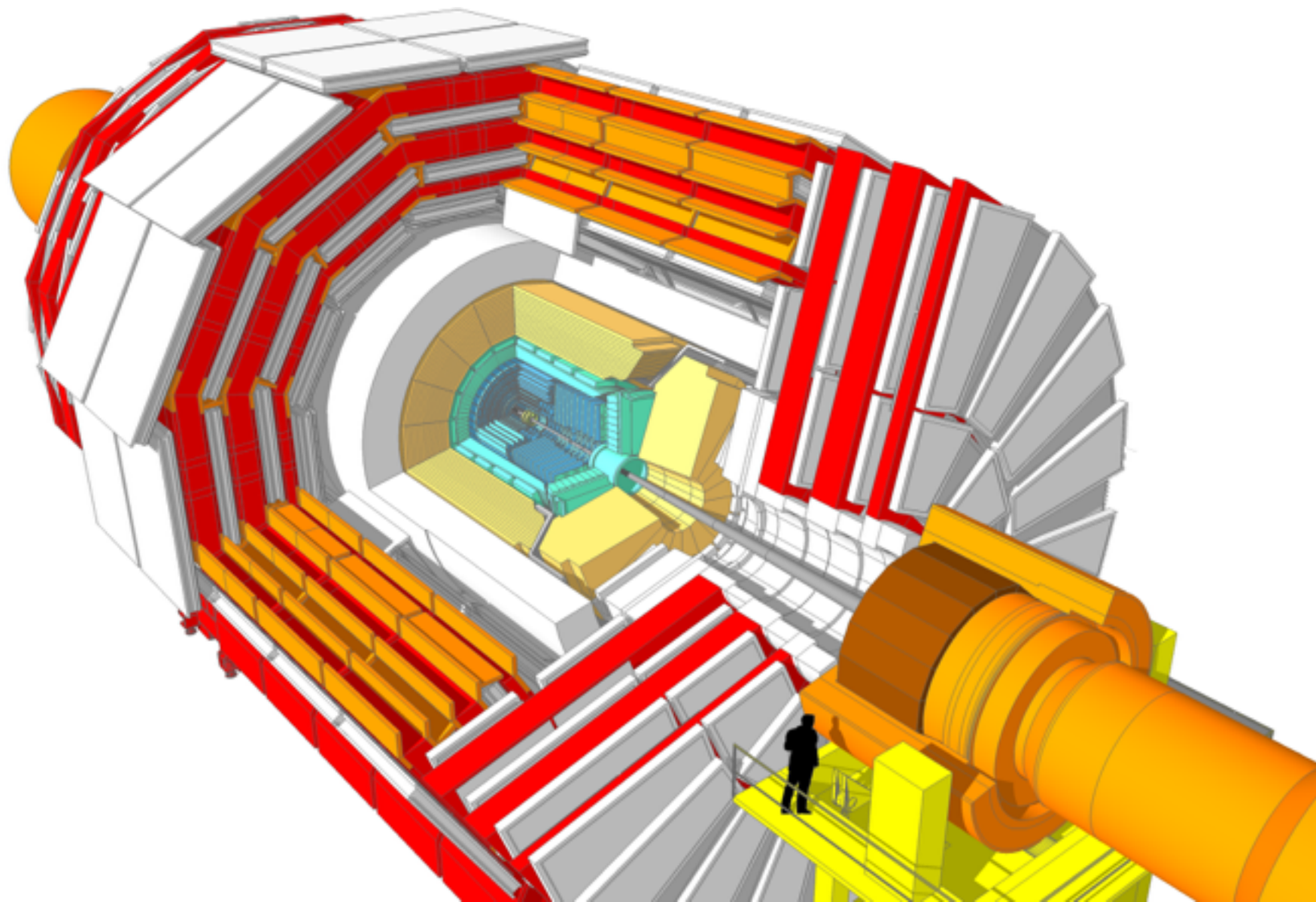
Giorgia Rauco
on behalf of the CMS Collaboration

SPS Annual Meeting
EPFL Lausanne - August 31st, 2018

photo by Michael.Hoch@cern.ch

The CMS detector

- one of the two multipurpose experiments located at the Large Hadron Collider
- symmetric cylindrical shape and its central feature is a superconducting solenoid generating a magnetic field of 3.8 T
- inside the solenoid several sub-detectors are installed



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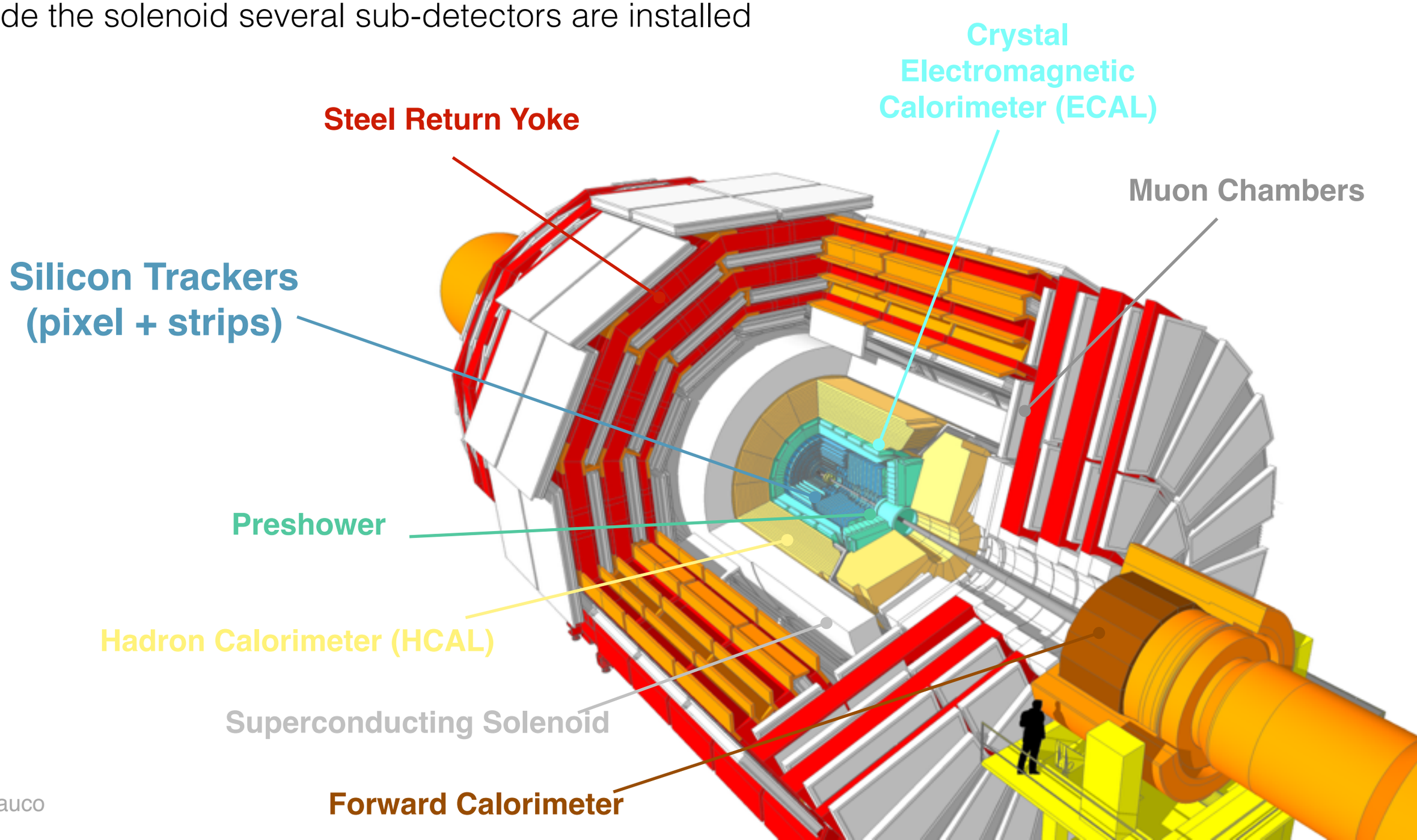
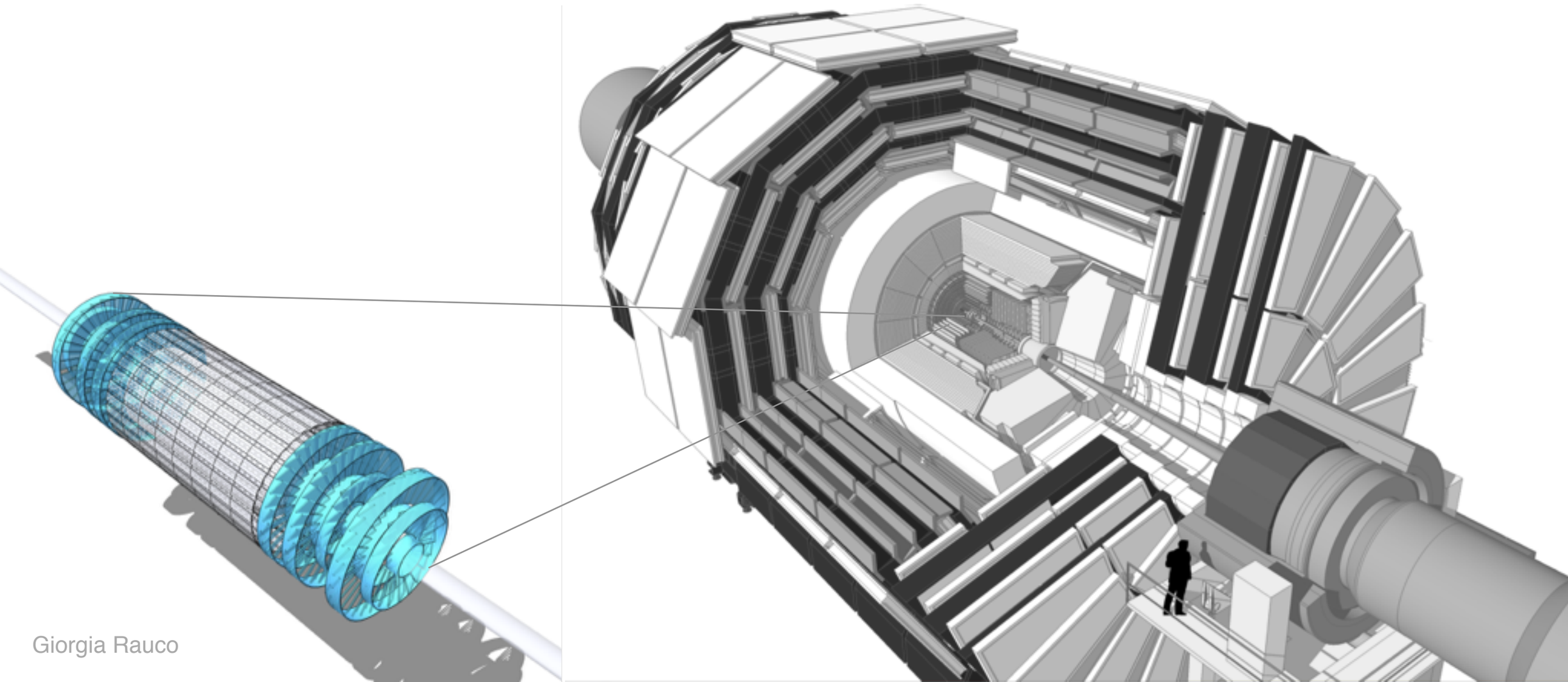


The Pixel detector

- It is the **innermost sub-detector**, closest to the interaction region
- Crucial role in track reconstruction and vertexing, and its high-quality performance is **fundamental for many physics analysis** (e.g. b-tagging)
- Split in Barrel and Forward Pixel
  - 4 layers located at r = 3, 7, 11, 16 cm
  - 3 disks local at z = 29, 40, 52 cm
- Pixel size of 100 x 150 μm^2



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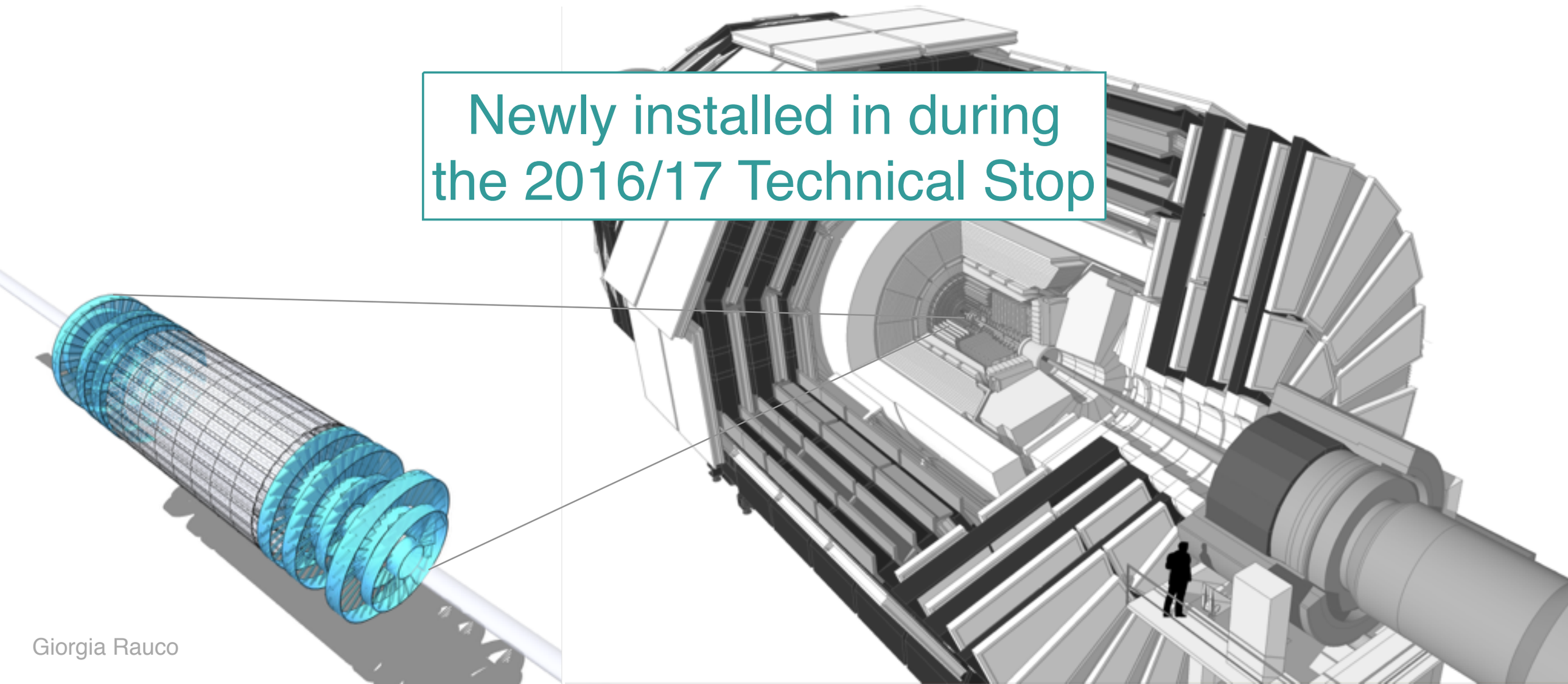
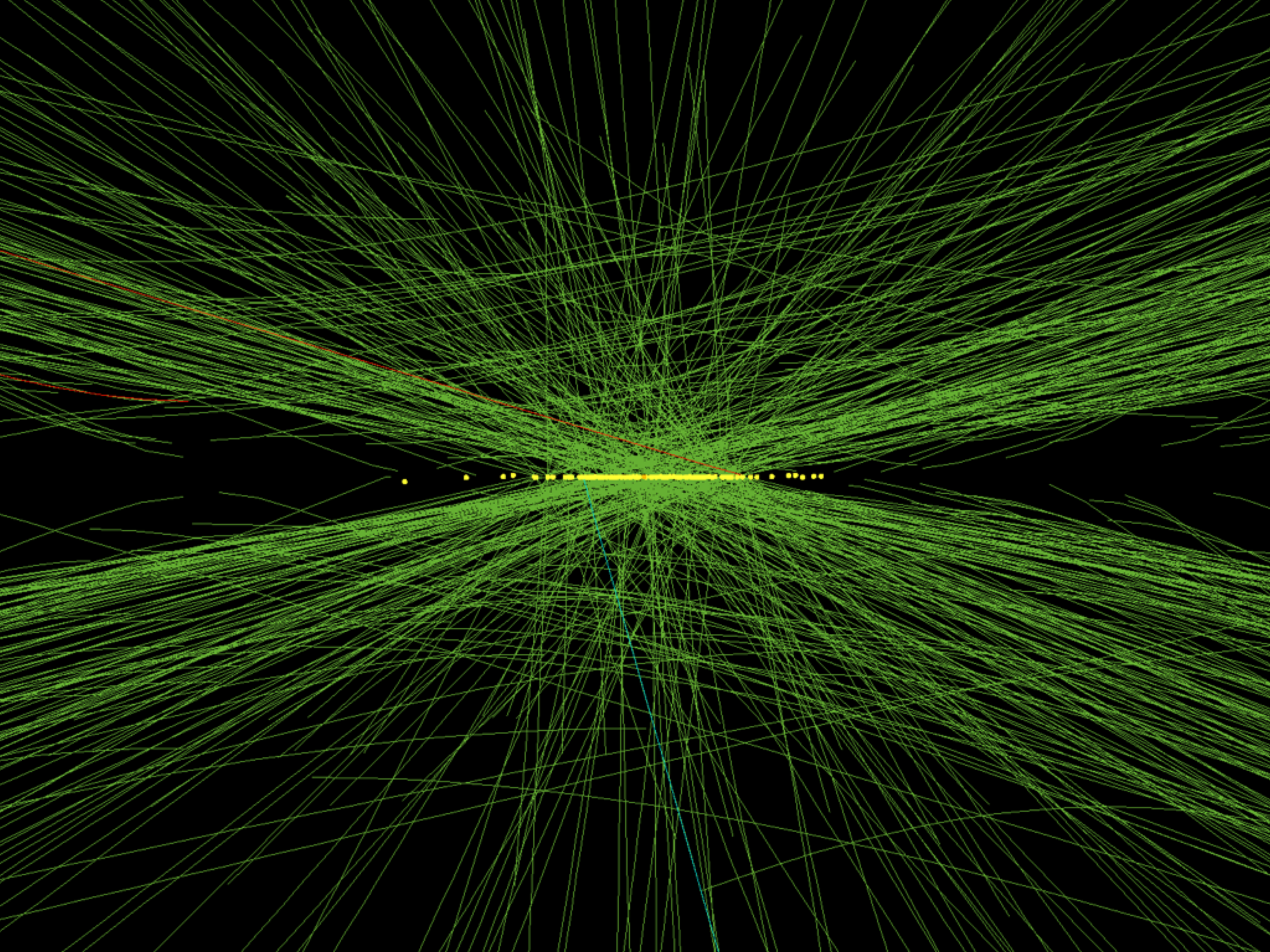
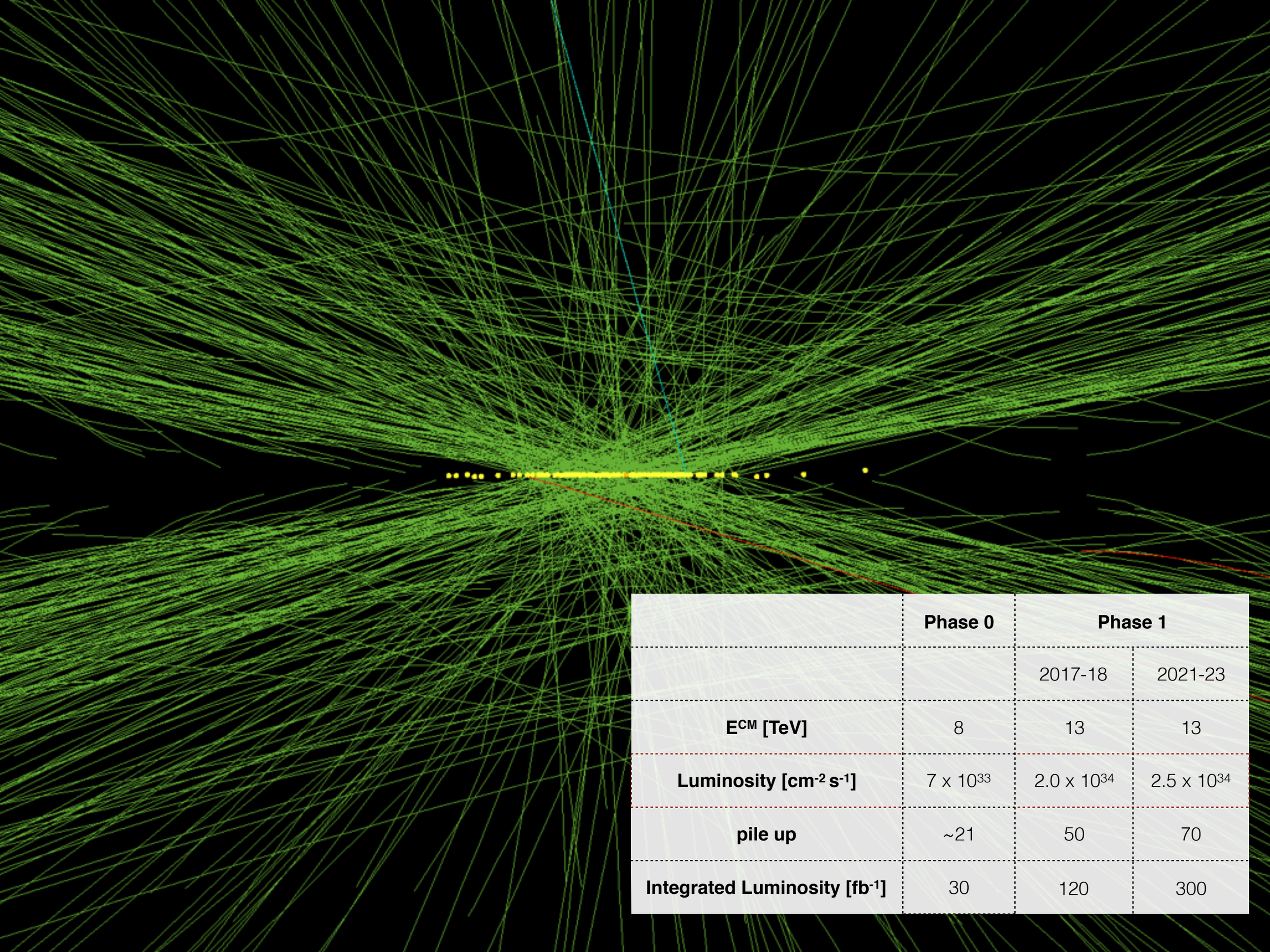
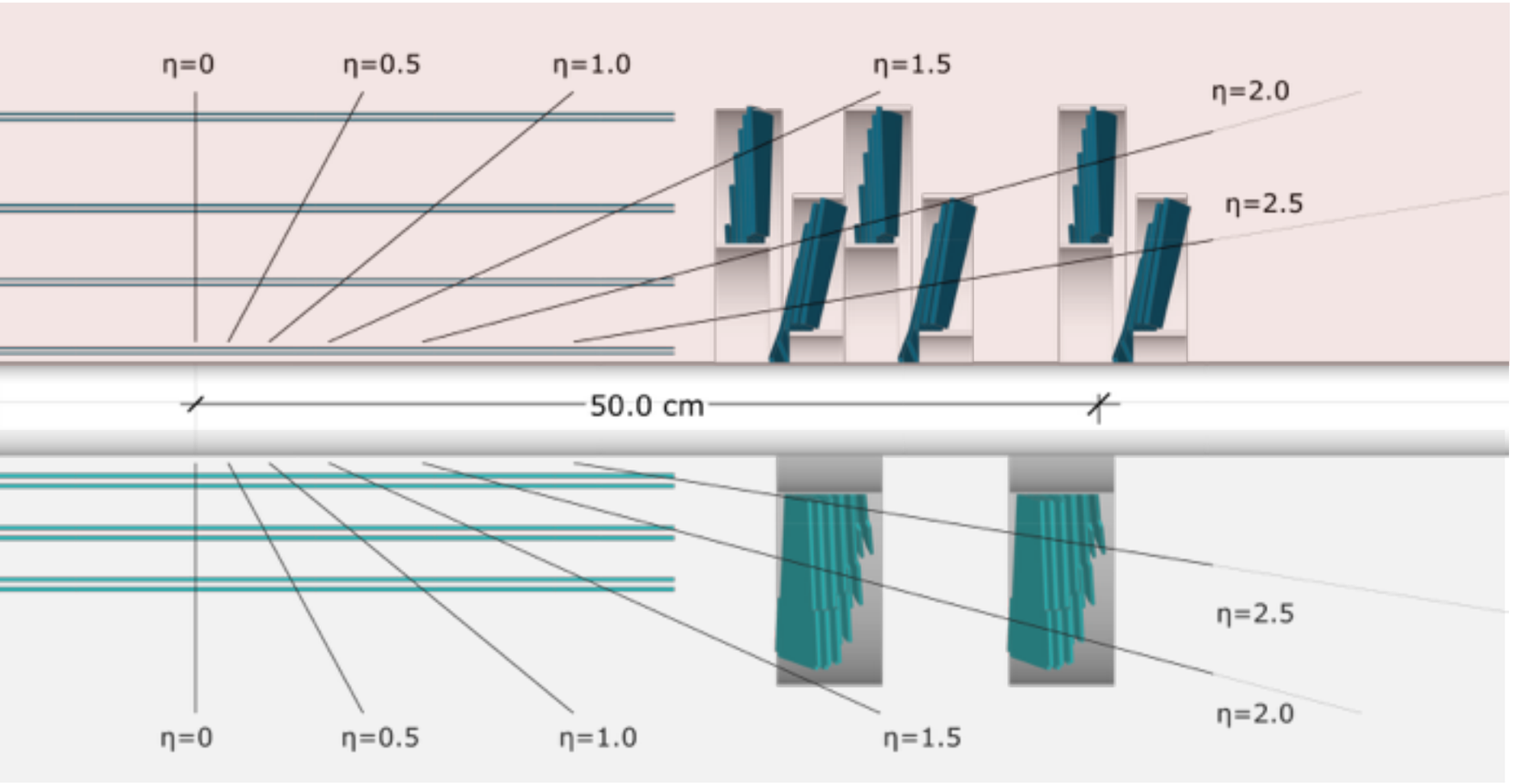






	Phase 0	Phase 1	
		2017-18	2021-23
E^{CM} [TeV]	8	13	13
Luminosity [$cm^{-2}\,s^{-1}$]	7×10^{33}	2.0×10^{34}	2.5×10^{34}
pile up	~21	50	70
Integrated Luminosity [fb^{-1}]	30	120	300

From Phase0 to Phase1



Phase 1 (new) detector

Phase 0 (old) detector

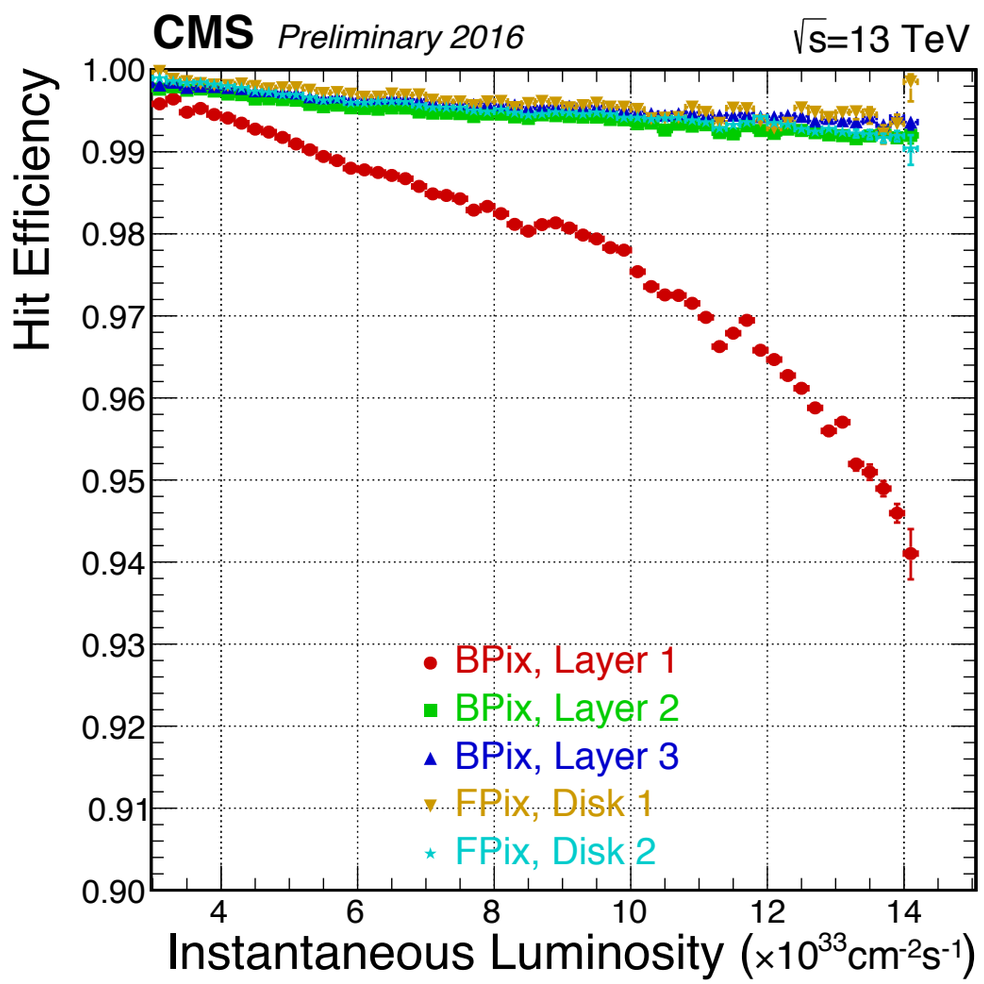
- One more barrel layer, one more forward disk
- Innermost barrel layer closer to the interaction point
- Improved readout electronics
- Lower material budget

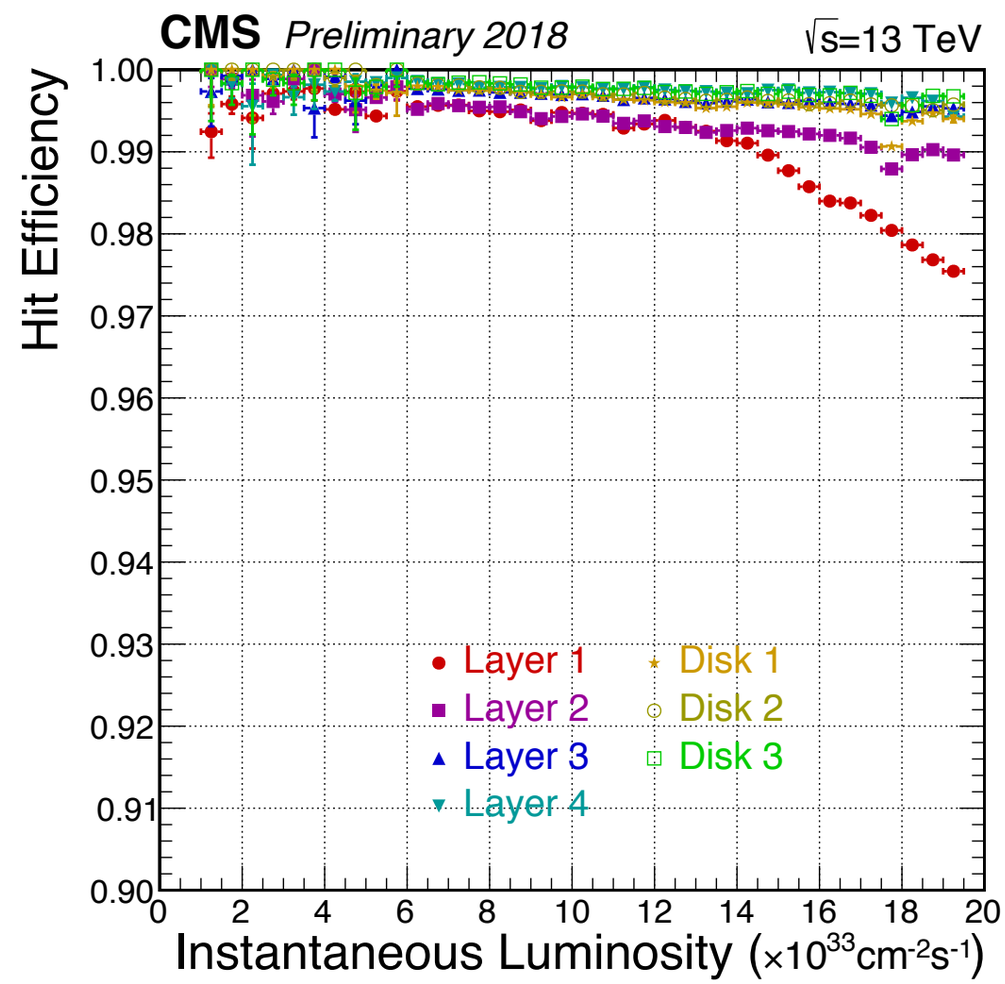
Sustain huge amount of data taking and improve tracking

Hit efficiency

Hit Efficiency is the probability to find any clusters within a 1 mm area around an expected hit

- it gives a measure of the **pure detector efficiency**

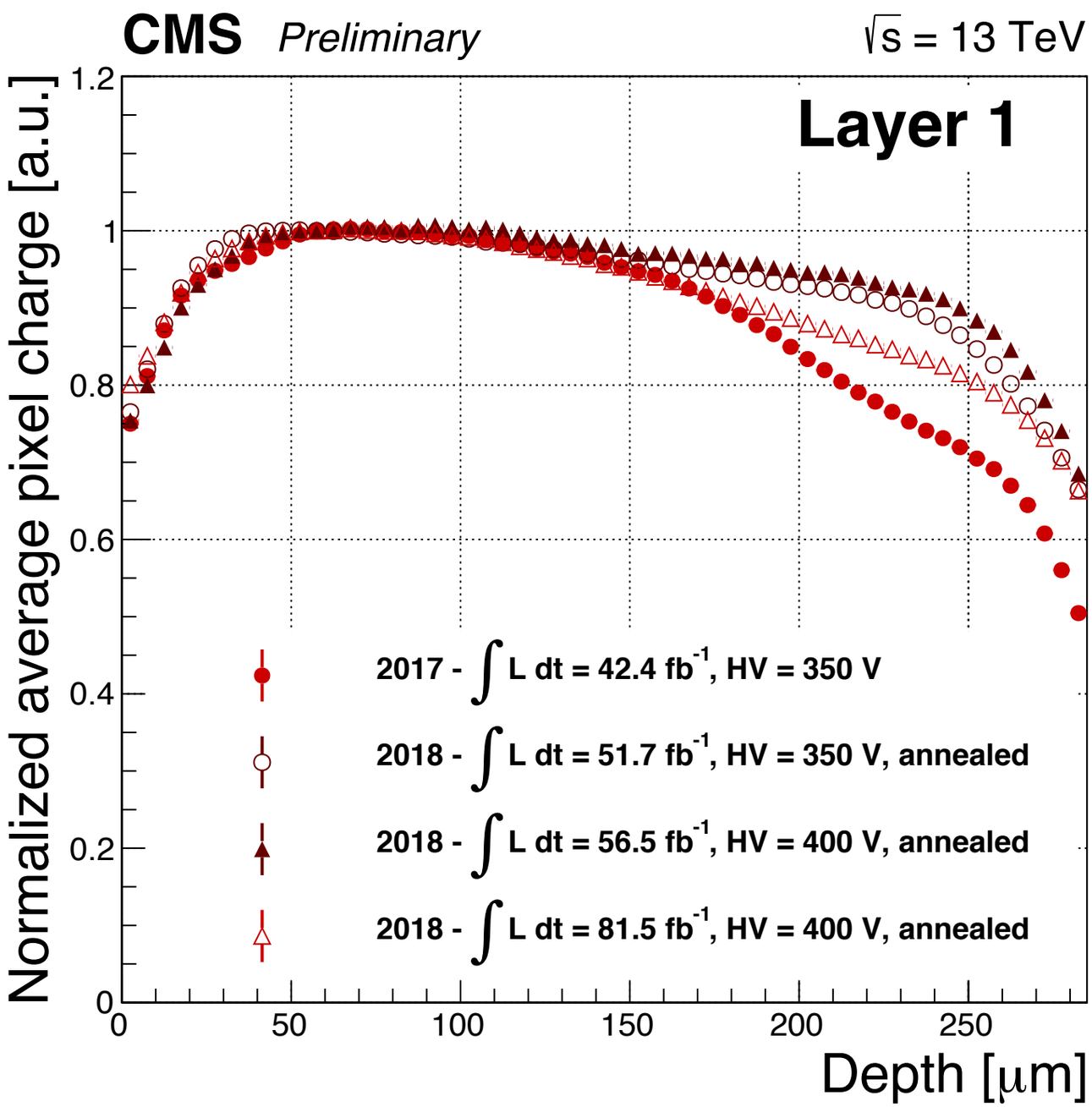




- Pixel hit efficiency stays **above 99%** for all layers and disks except for the first layer of the BPix, where temporary losses are observed
- Big **improvement** with respect to 2016 data taking!
- Dynamic inefficiency at high instantaneous luminosity reduced

Pixel Charge Profiles

- non-irradiated, fully depleted detector → profile expected to be flat
- irradiated detector → losses expected due to the **trapping**

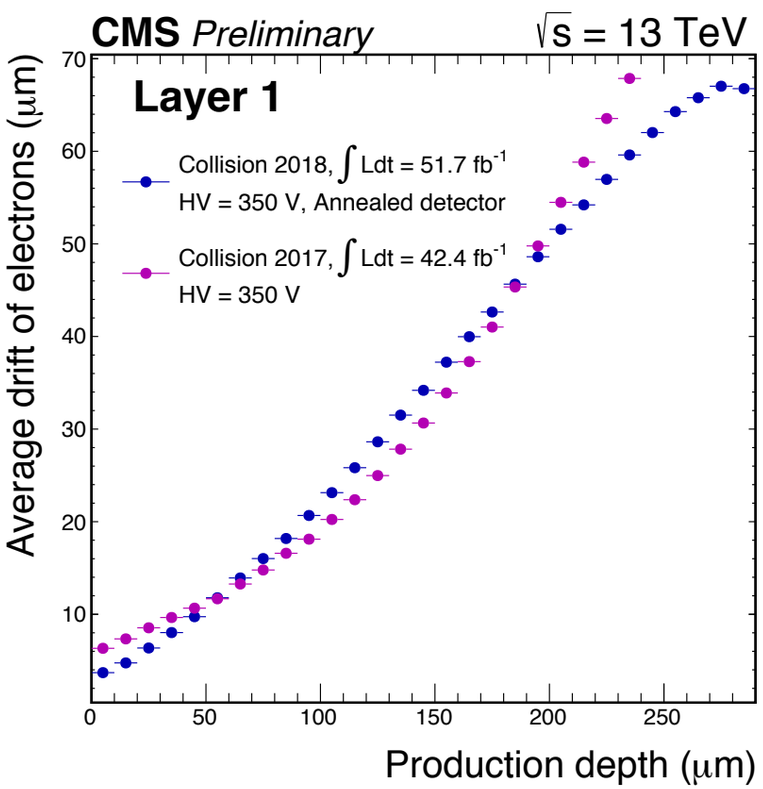


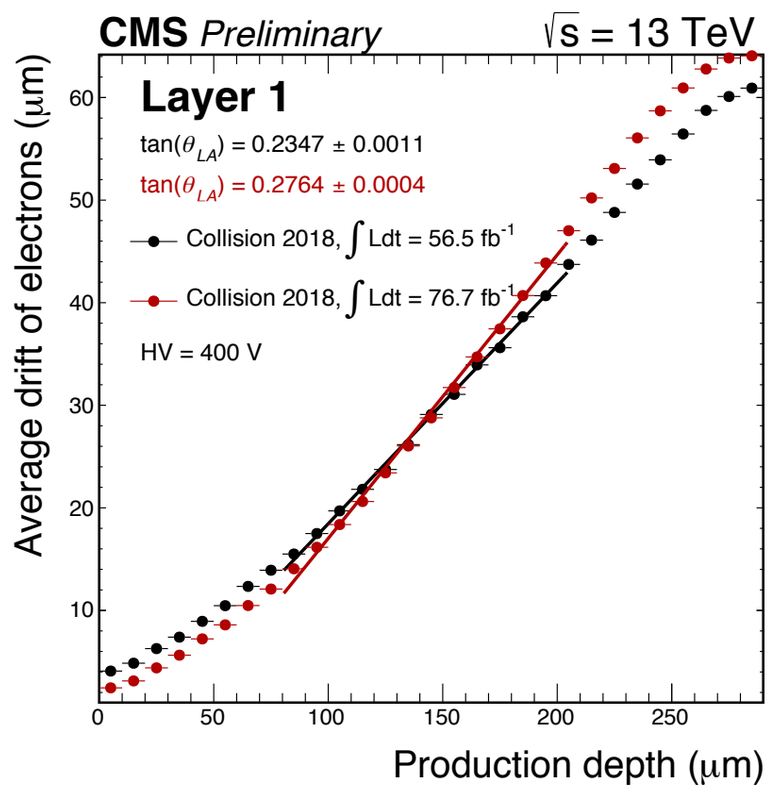
- During the 2017 Technical Stop an annealing was performed, resulting in the **flattening** of the pixel charge profile
- At the beginning of 2018, the charge collection was further increased in Layer 1 by **raising the bias voltage**
- Similar results are expected for the other three layers

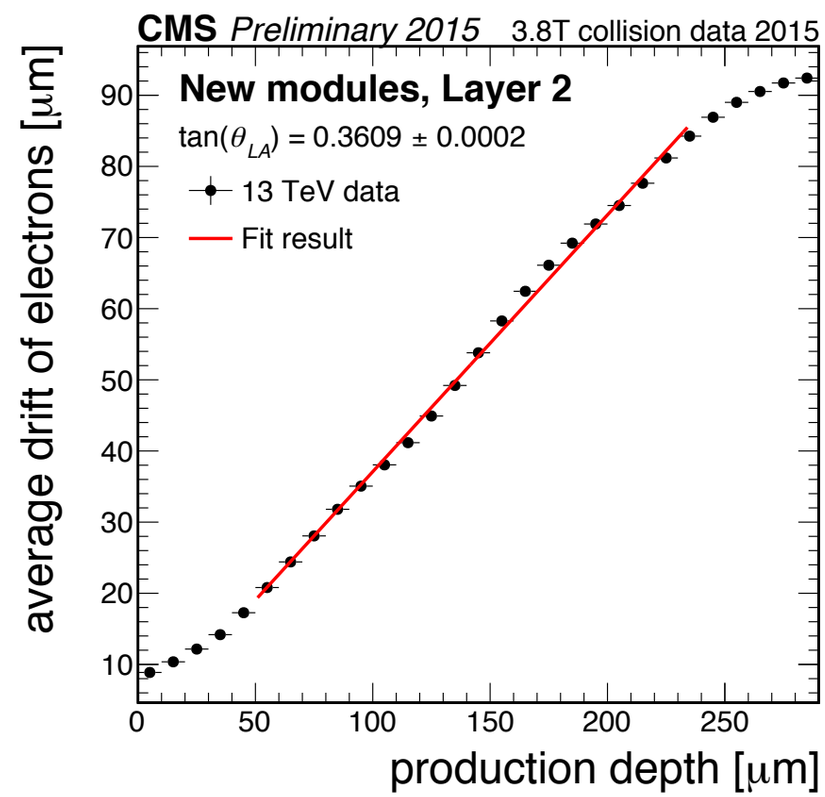
Lorentz Angle measurement

The measurement of the Lorentz angle for the BPix is performed using the **Grazing Angle** technique:

- Uses well measured tracks to determine the drift of the electrons in pixel sensors
- The curve in the range [80,205] um is then fitted





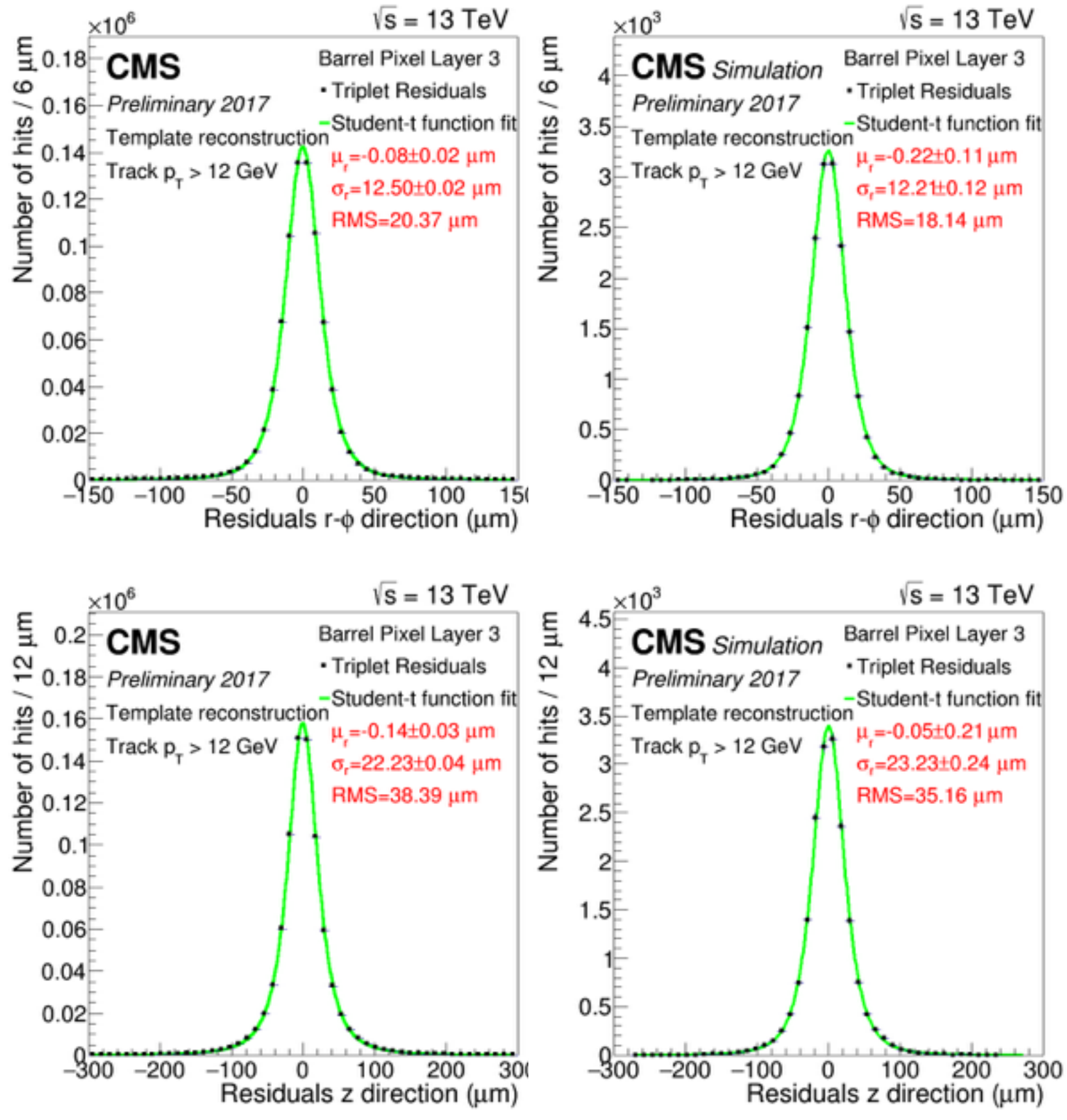


- Because of the **irradiation of the detector** both at the end of 2017 year and with more integrated luminosity in 2018 the shape of the drift vs depth curve changes and a larger Lorentz angle is obtained
- Much smaller LA compared to 2015 data taking!

Barrel Pixel Hit resolution

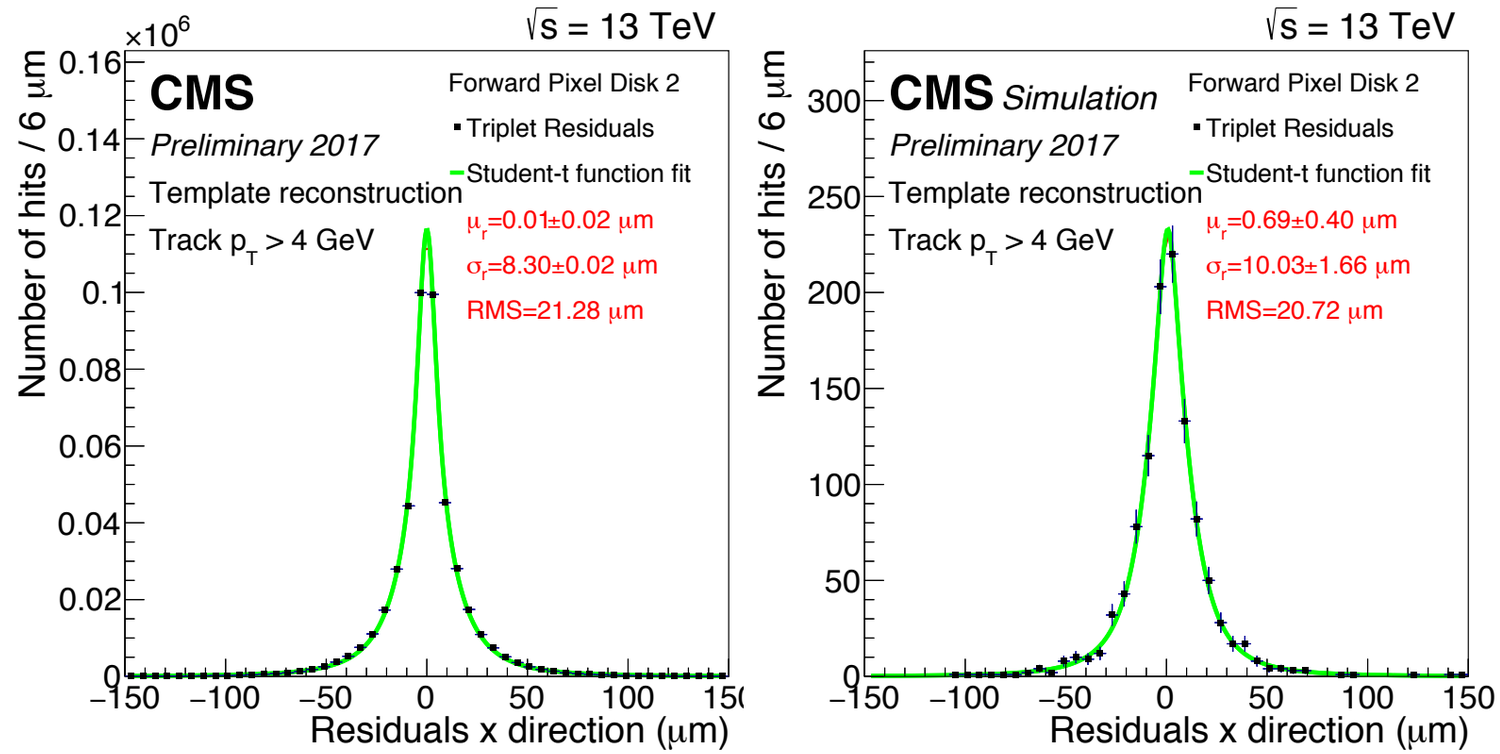
The resolution measurement is performed using the **Triplet method**:

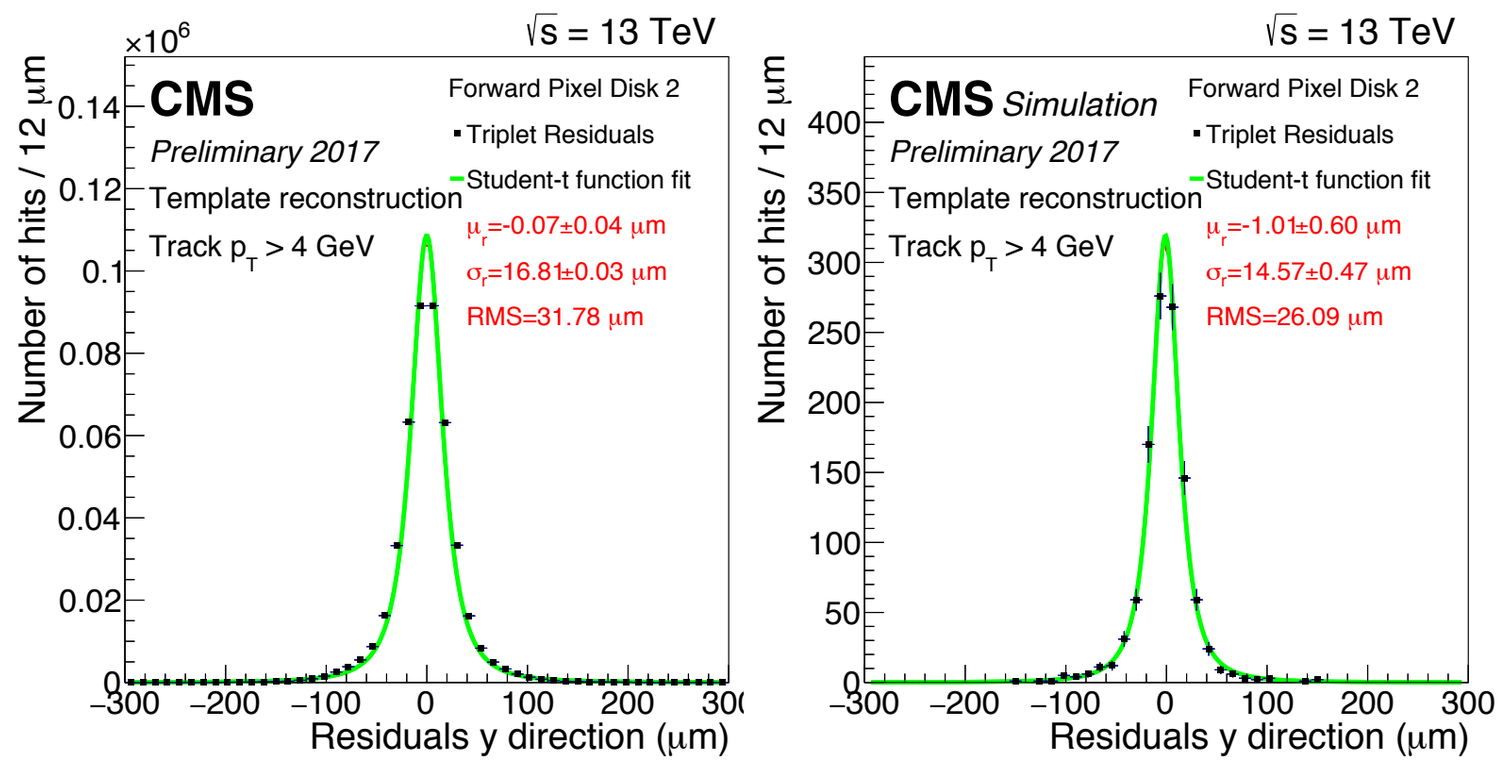
- Tracks with hits in 3 layers are selected and refitted using hits in two out of three layers
- Trajectory extrapolated to remaining layer, residuals with the actual hit are calculated
- Residual distribution fitted with a Student-t function
- **Good agreement between data and simulation** along both direction
  - Very good results achieved: 12 μm along r-ϕ and 22 μm along z



Forward Pixel Hit resolution

- The same approach used for the BPix resolutions is deployed in the forward region
- For Disk 2, **only hits on the disks are used**, reducing the smearing and the inference due to extrapolating the tracks or using the barrel layers
- Good agreement between simulation and data is obtained
  - 8 μm along the local-x direction and 16 μm along the local-y





For both BPix and FPix updated results with 2018 data are work-in-progress

Conclusions

- **New Pixel Detector successfully installed** during the Technical Stop in 2016/2017
  - Huge effort, allowing high-quality standard for the data-taking in harsher conditions

- Despite challenges, **very good performance** obtained
  - High hit efficiencies in all layers and disks
  - Smaller impact of the irradiation on charge profile and on the Lorentz angle
  - Small residuals and excellent hit resolution

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Thank you for the attention!