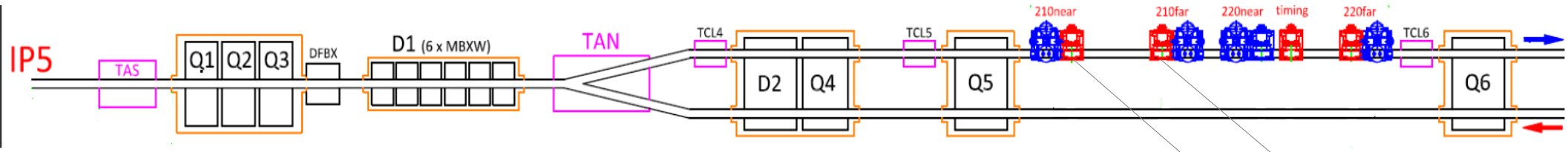
PPS – Precision Proton Spectrometer

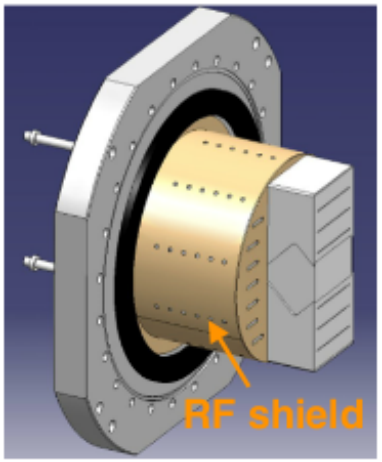
RUN II – brief review

V. Avati (AGH)

On behalf of CMS – TOTEM collaborations

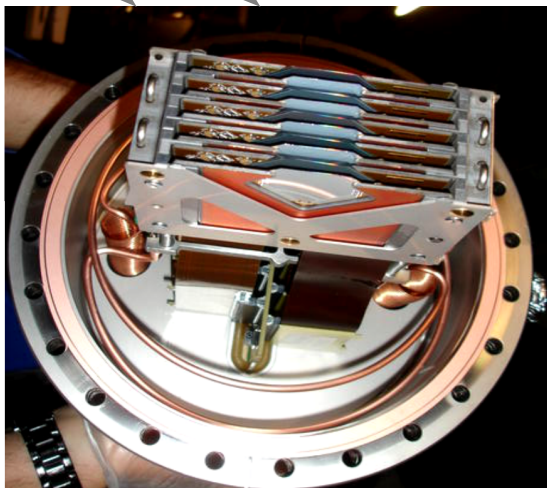
PPS – Year 2016



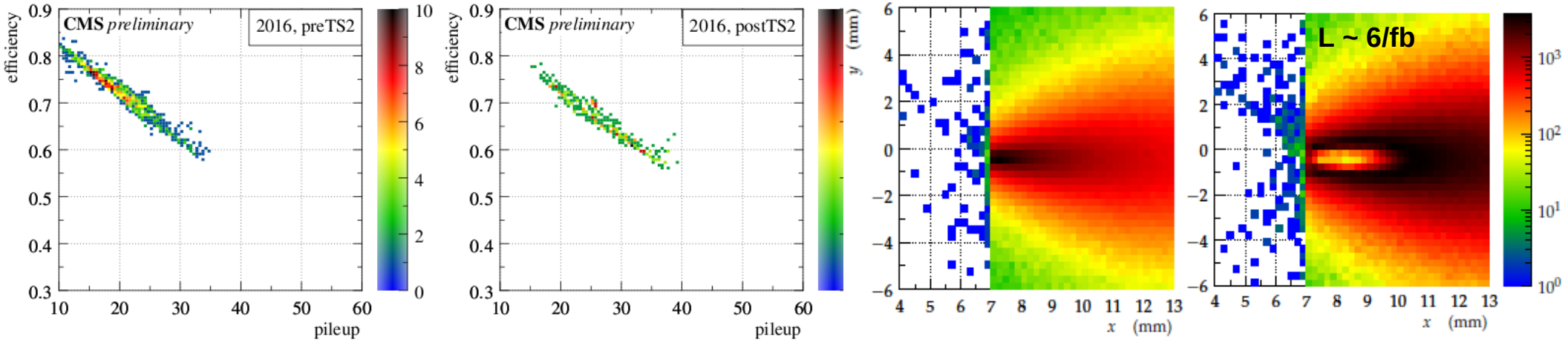


2 horizontal pots equipped with RF shields hosting 10 planes of micro-strip silicon detectors with edgeless technology
(TOTEM tracking detectors)

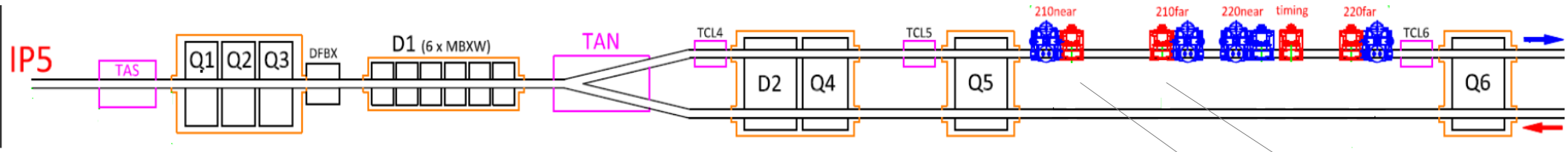
First time diamond detectors installed at LHC

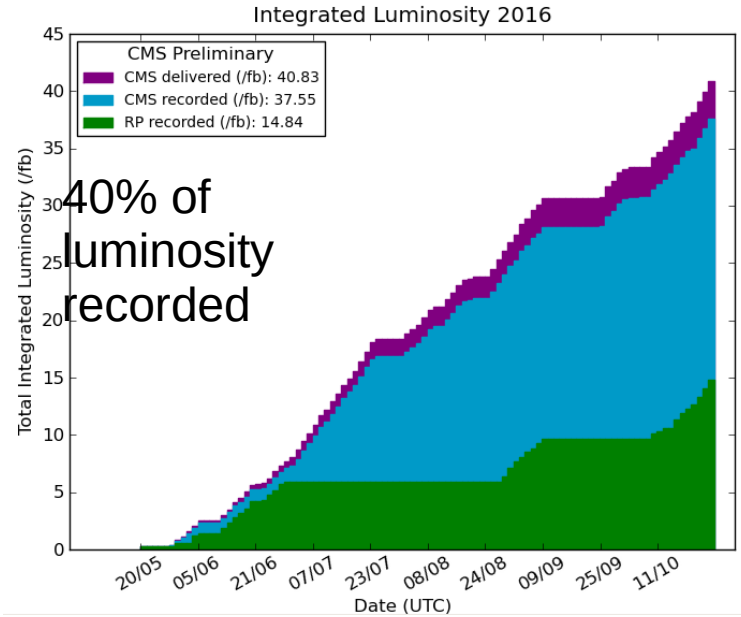


Strip efficiency limited
- by large amount of multi-track events due to high pile-up
- by radiation damage

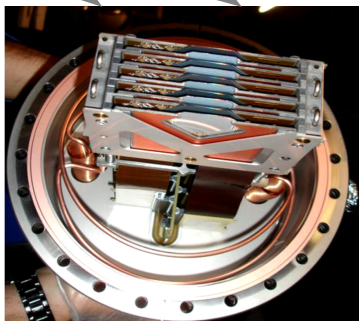


PPS – Year 2016





40% of luminosity recorded



Establish procedure for :

- RP insertion in high luminosity fills
- RP alignment
- Optics determination

(First) Observation of proton-tagged, central (semi) exclusive production of high-mass lepton pairs in pp collisions

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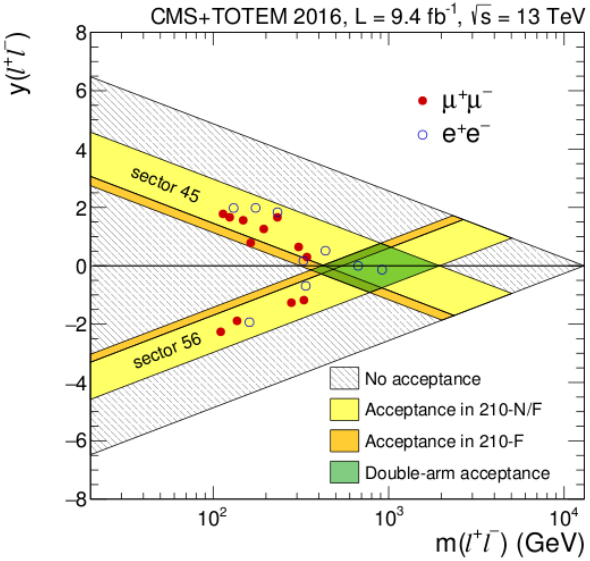
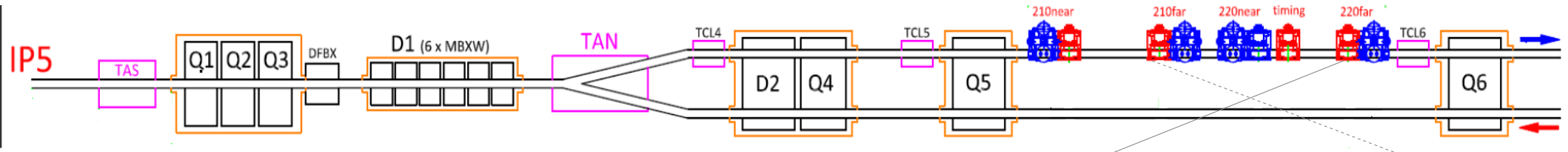


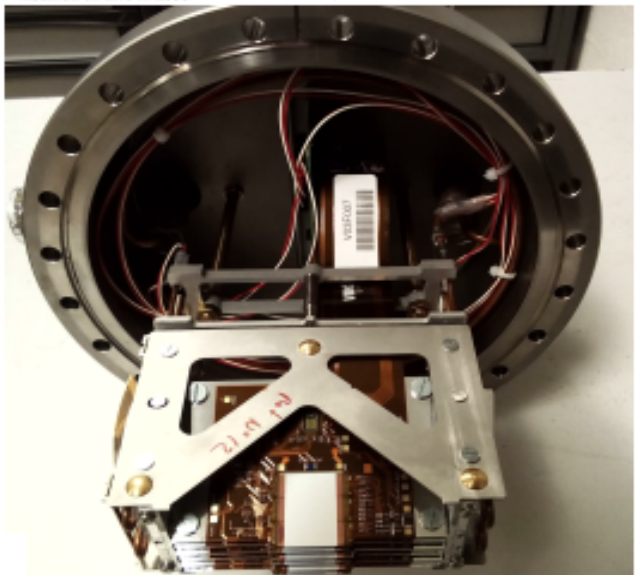
PPS – Year 2017: pixel

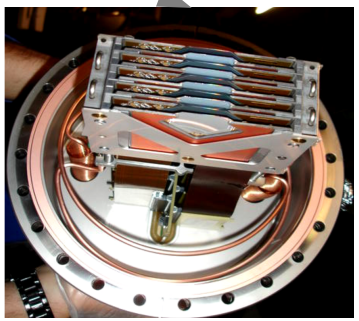


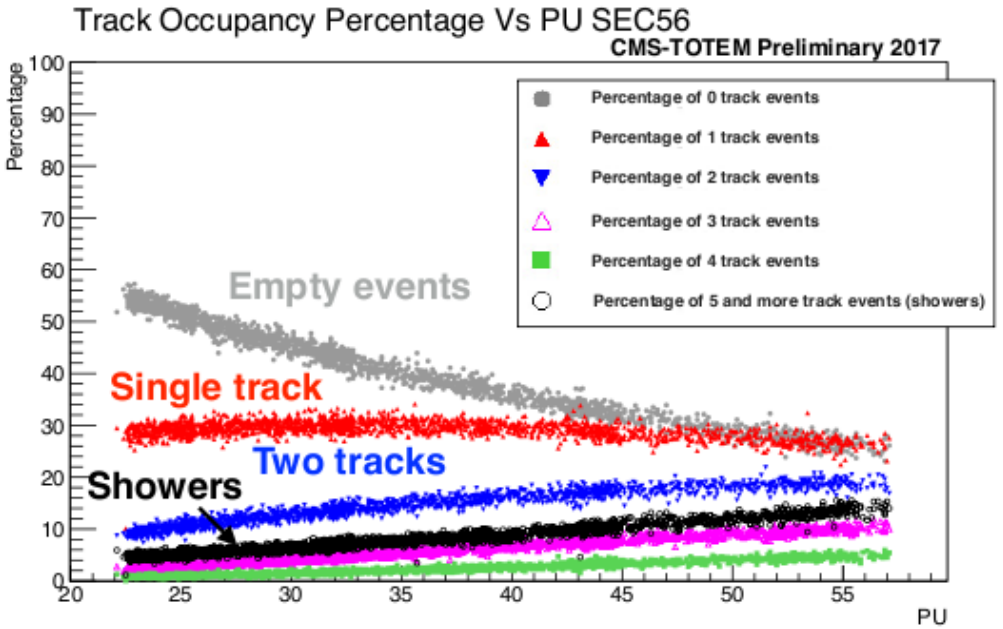
6 planes of “slim-edge” silicon pixel detectors with 3D technology

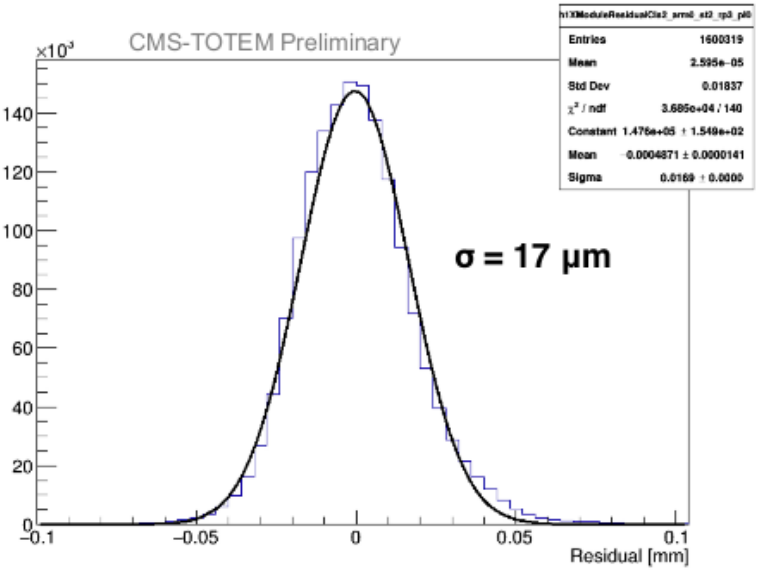
Pixel size: 100 μm × 150 μm;
Track resolution ~20 μm

Designed for high-luminosity
⟹ multi-track capability

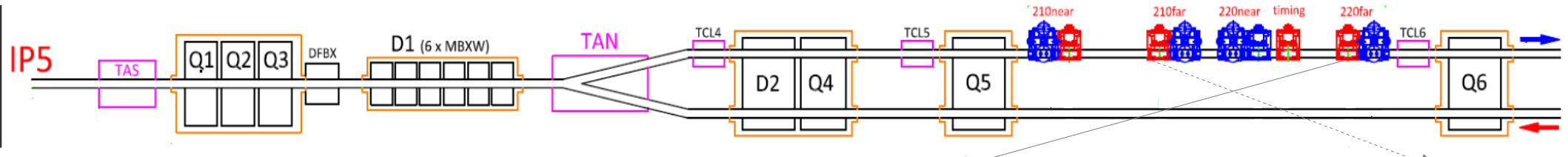








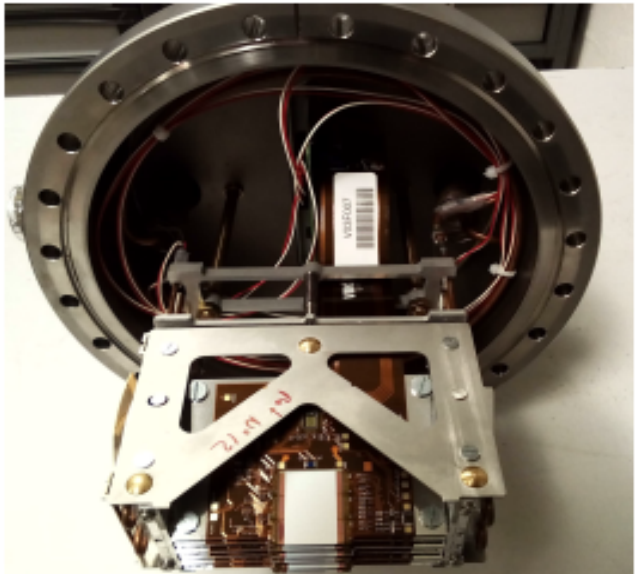
PPS – Year 2017: pixel

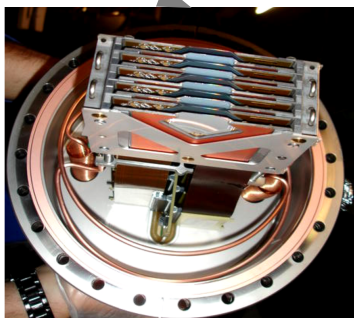


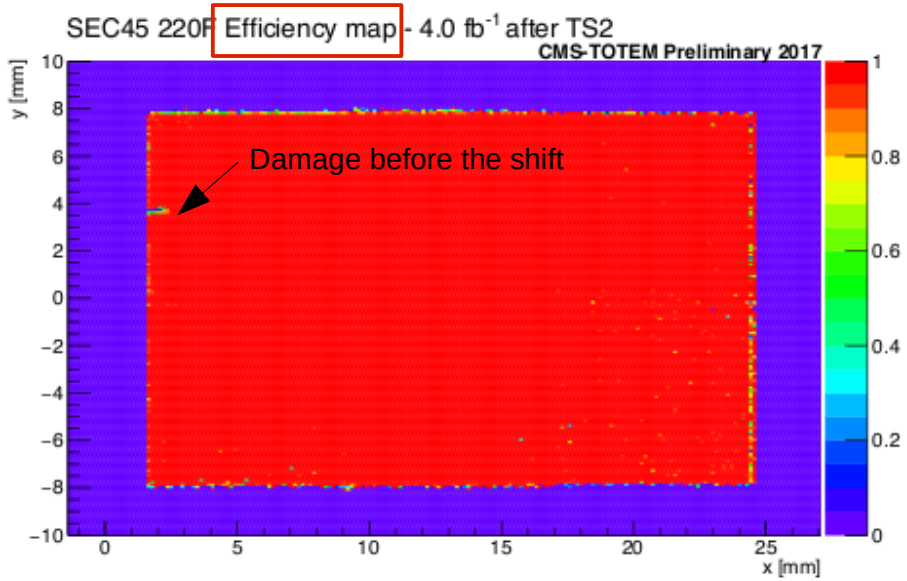
Sensor radiation hardness : good till ~ 100/fb

Readout chip radiation damage due to non-uniform irradiation

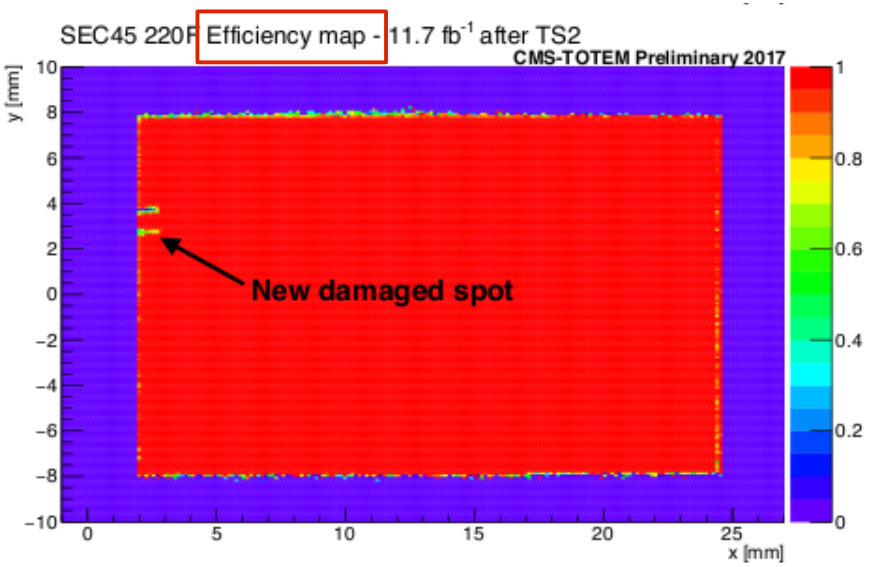
The effect appears after an integrated luminosity ~8/fb. To mitigate the impact on the data quality, the tracking stations were lifted to shift the occupancy maximum away from the damaged region.



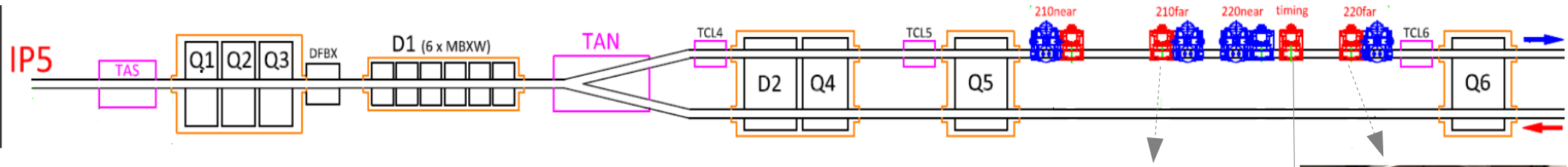


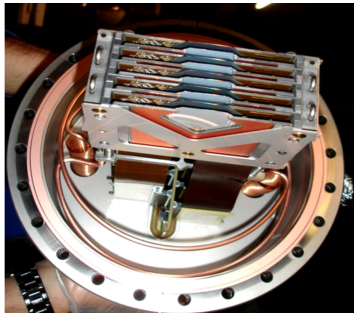


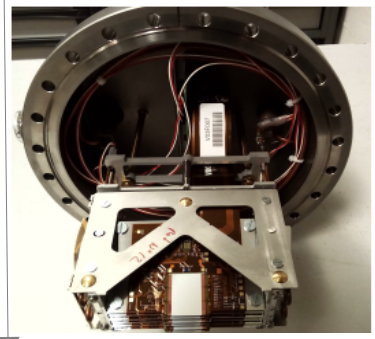
~ 8/fb later

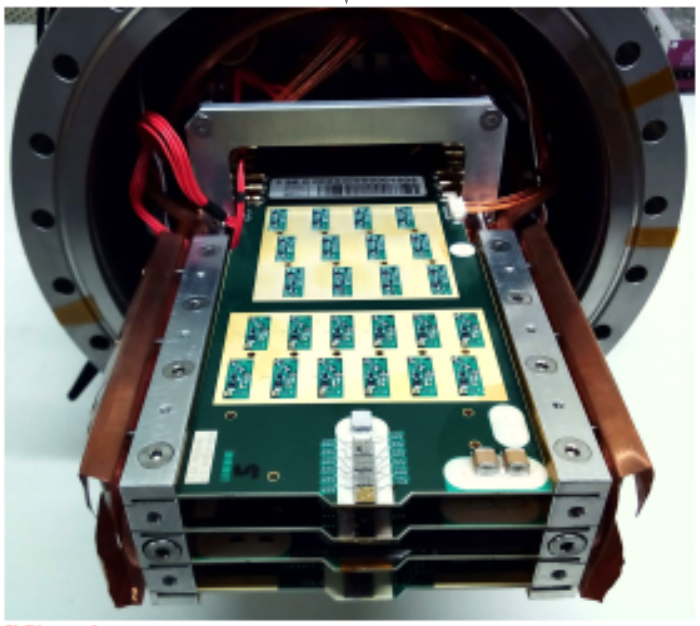


PPS – Year 2017: timing









TOF measurement to reduce background from pileup (uncorrelated proton tracks)

Diamond sensors:

3 planes of CVD with macro-pixels of varying size to match the proton occupancy as a function of the distance from the beam

single-plane resolution: ~80 ps

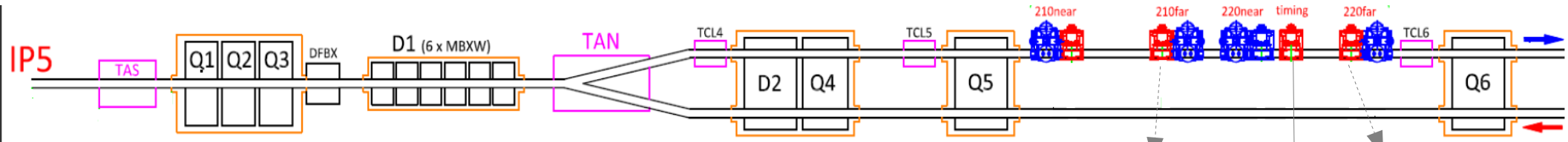
Intrinsic radiation hardness → to withstand overall integrated flux of 5×10^{15} p/cm^2

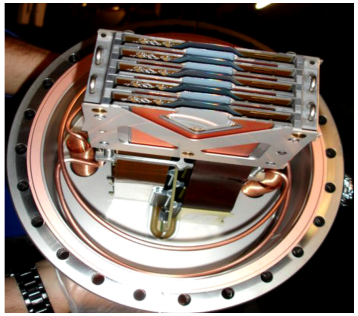
Ultra-Fast Silicon Detectors:

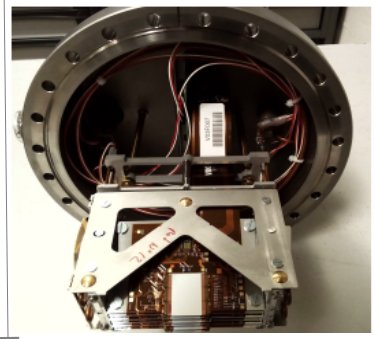
1 plane based on LGAD technology
single-plane resolution in test beam: ~30 ps

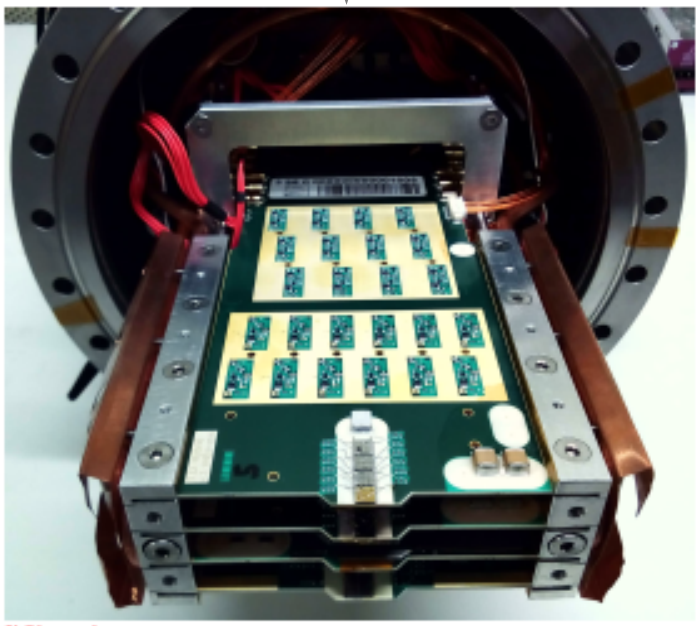
Precise clock distribution (few ps jitter) is obtained with a design adapted from the “Universal Picosecond Timing System” (optical network) or with RF-feedback with low-loss coaxial cable.

PPS – Year 2017: timing

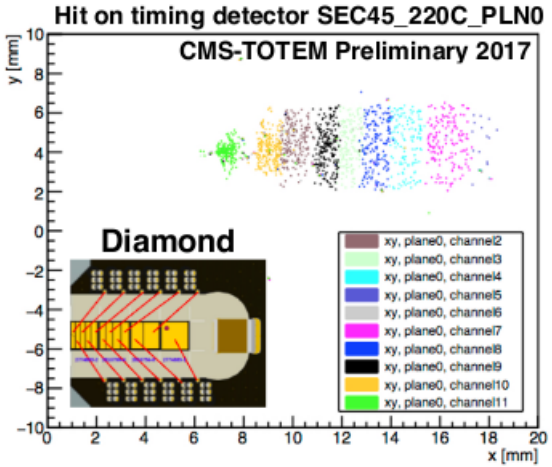


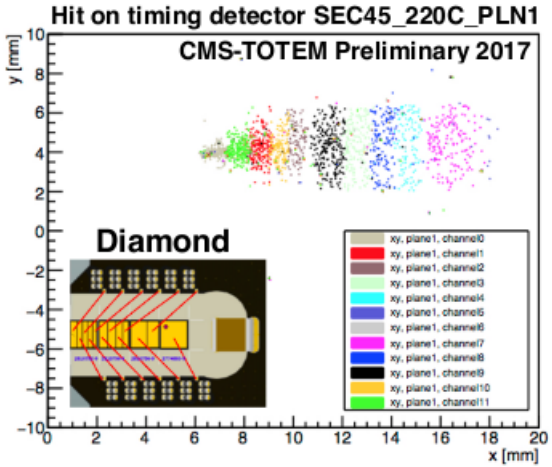


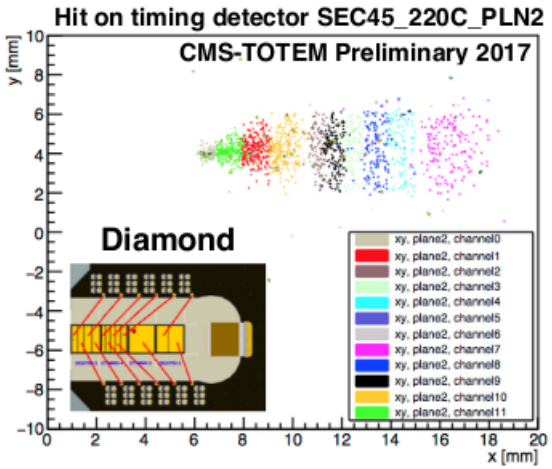


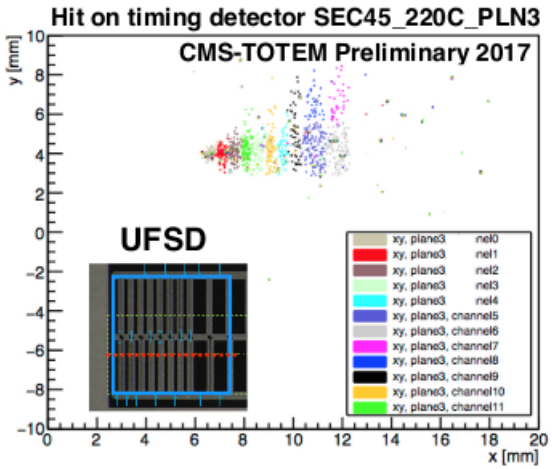


Timing - Tracking coincidence



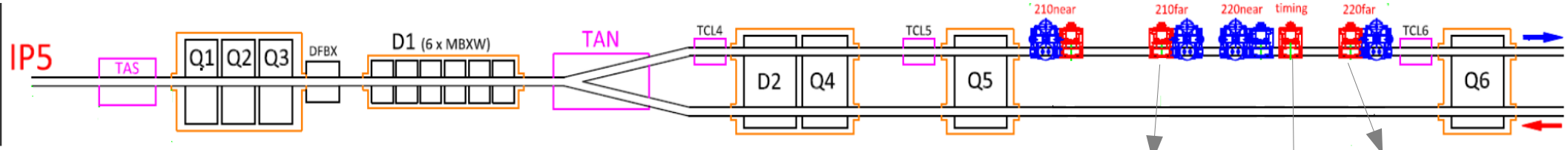


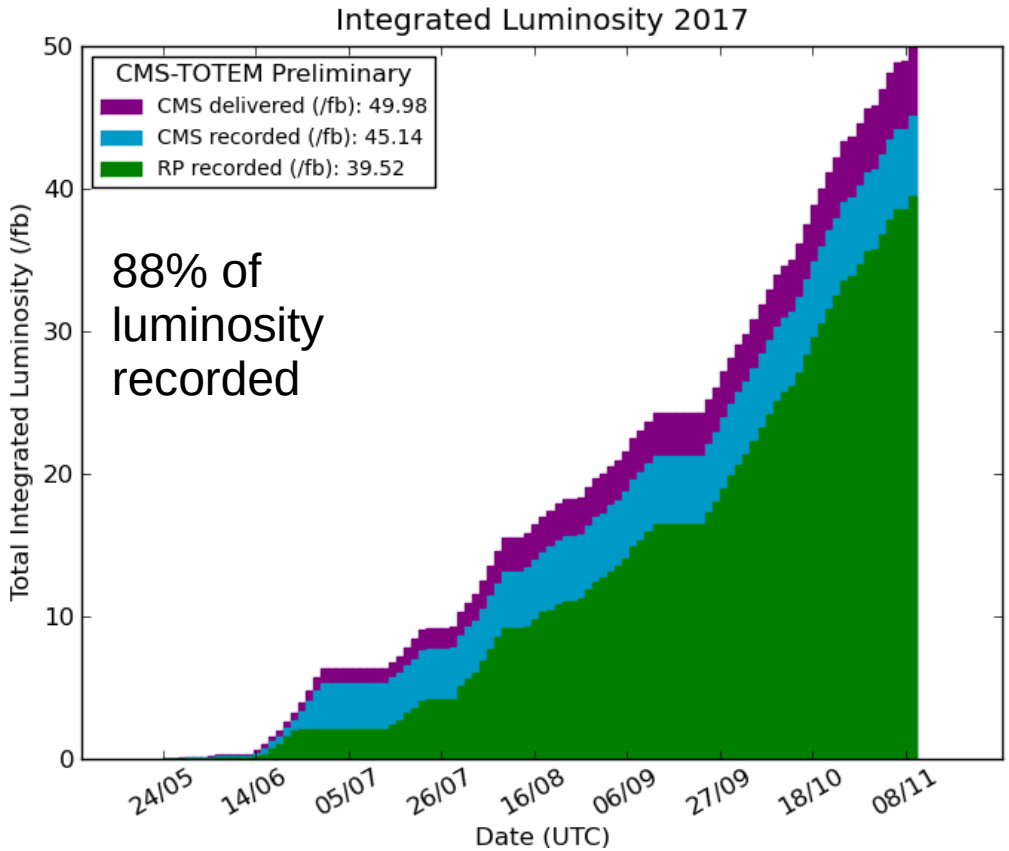


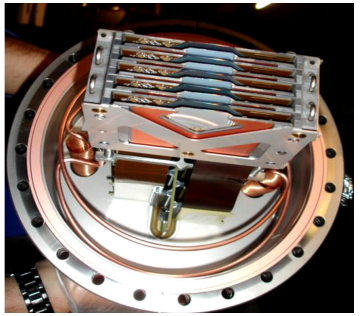


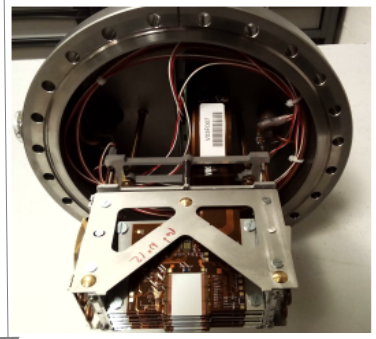
Detailed study of the time resolution of the entire system with LHC data is in progress

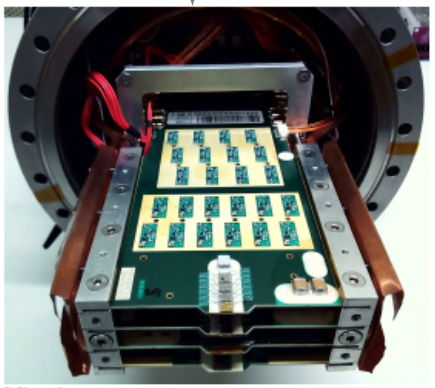
PPS – Year 2017: luminosity





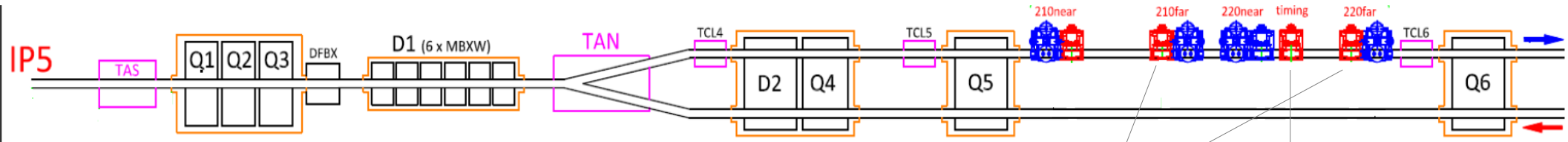






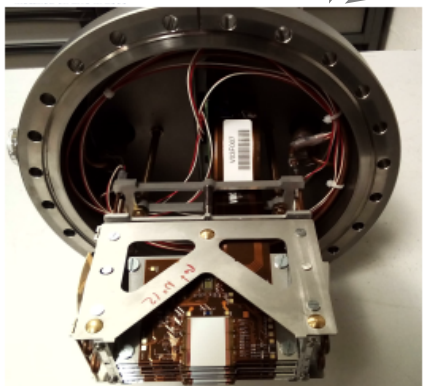
Alignment, optics determination completed

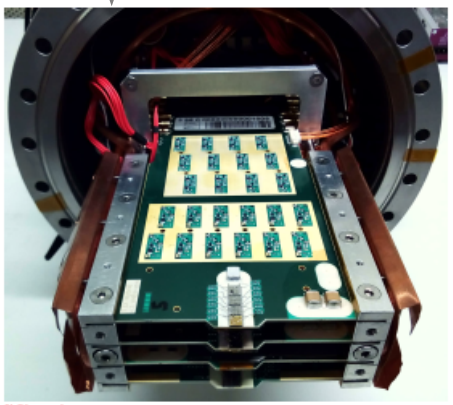
PPS – Year 2018 : new setup

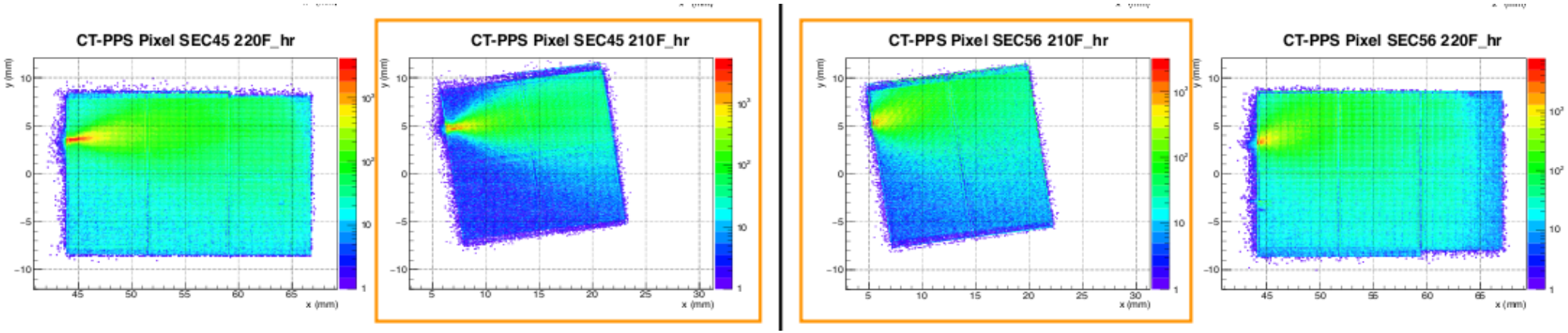


Tracking

2 RP equipped with 3D pixel sensors

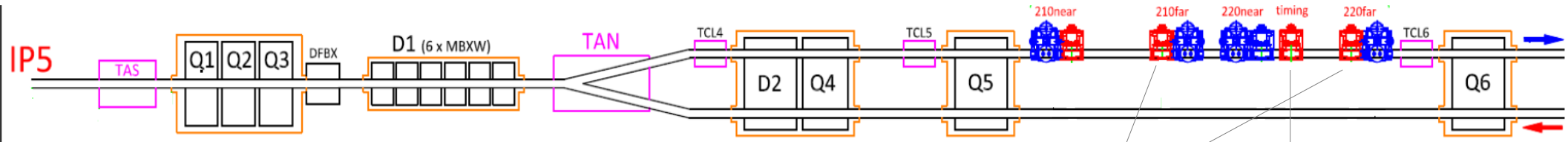






Detailed study of efficiency is in progress

PPS – Year 2018 : new setup

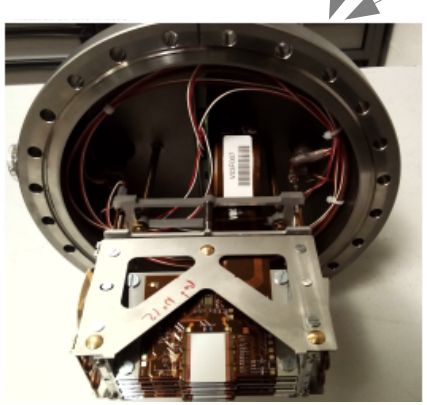


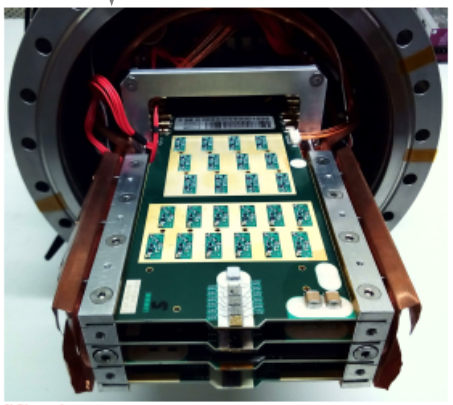
Timing

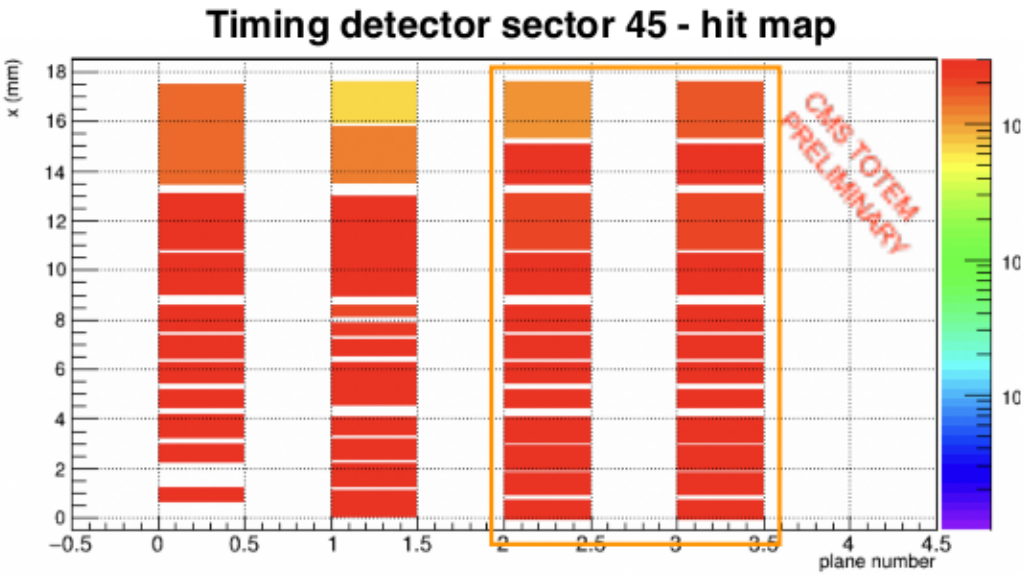
2 double diamond + 2 single diamond per RP

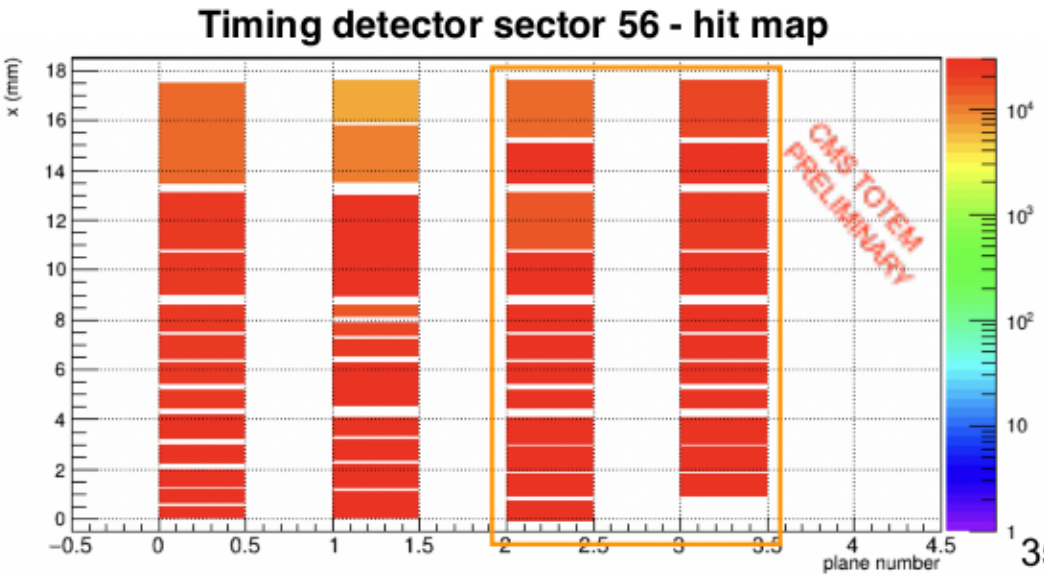
Two scCVD sensors installed back to back
and connected in parallel to the same amplifier channel

Time precision evaluated in test-beam showed an
improvement of 1.6 with respect to single crystals (50ps)

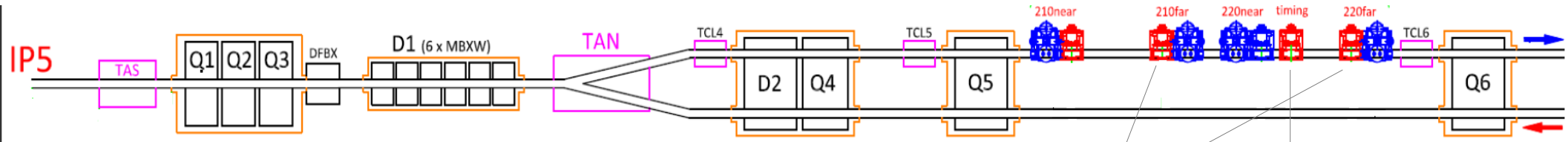


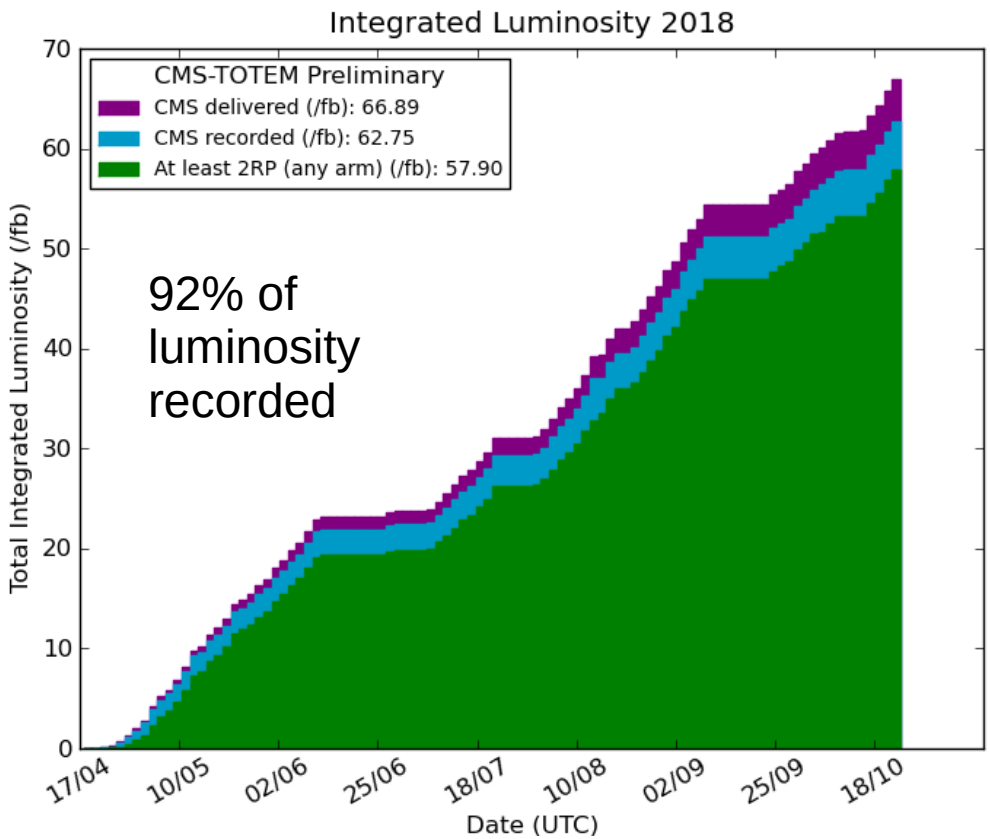


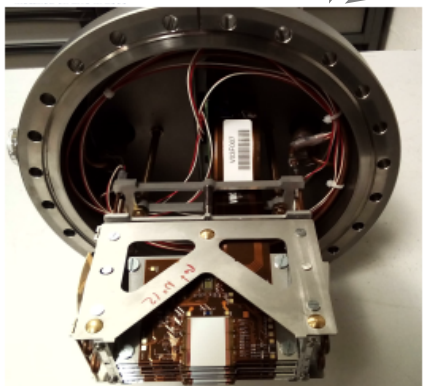


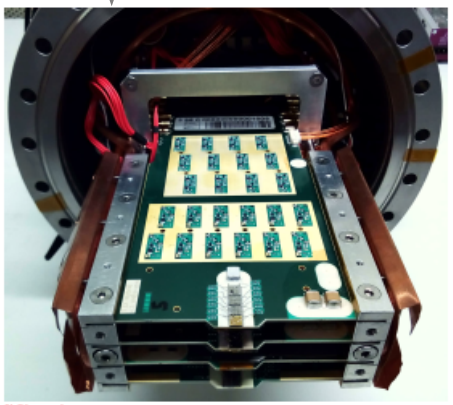


PPS – Year 2018 : luminosity









Alignment, optics determination, proton kinematic reconstruction is ongoing

Large complexity due to the luminosity leveling : continuous crossing angle and β^* tuning

PPS – Run II

Total of ~110/fb collected in Run 2 !

<u>Several analyses ongoing:</u>

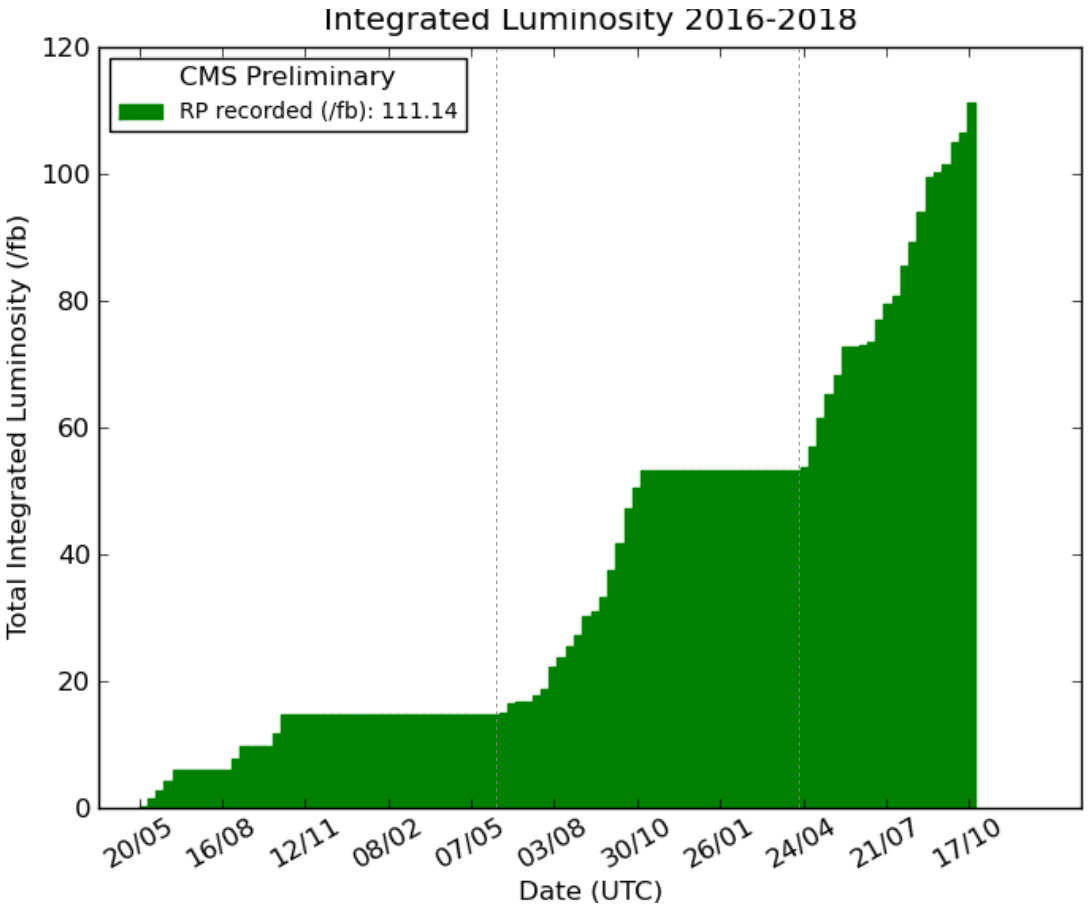
Central (semi)exclusive production of high mass lepton pairs

Anomalous Quartic Gauge Couplings

Central production of γγ, WW, ZZ, γZ, $t\bar{t}$

Missing mass searches

Search for axion-like particles



PPS has demonstrated the feasibility of studying forward proton-tagged events at high luminosity

PPS future: Run III

Continuation of the PPS program has been approved for LHC Run 3 (2021-2023) at $\sqrt{s}$ = 14 TeV: goal 300/fb

New detectors needed, to replace current ones damaged by radiation

Tracking: new 3D silicon pixel detectors

- technology very similar to existing one
- same geometry/granularity
- new detector package with internal movement system, to cope with the non-uniform radiation damage

Timing: double diamond sensors to be installed in **two** Timing stations per arm

Run II is just over and only a small part of the data has been fully analyzed
Looking forward to new results and future challenges !