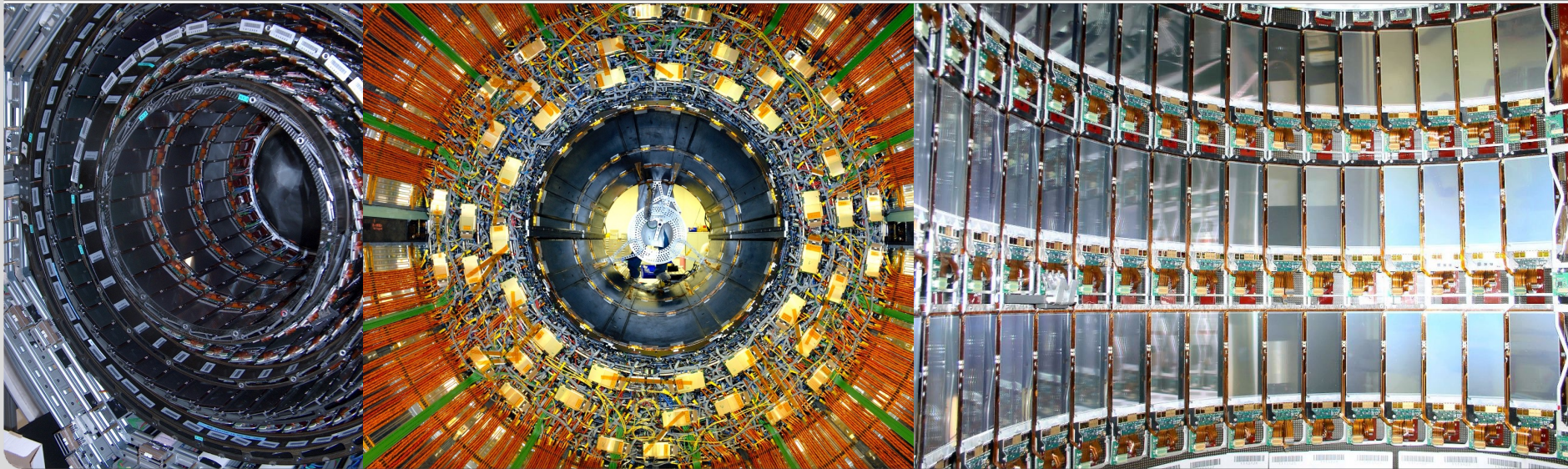


CMS tracker operation

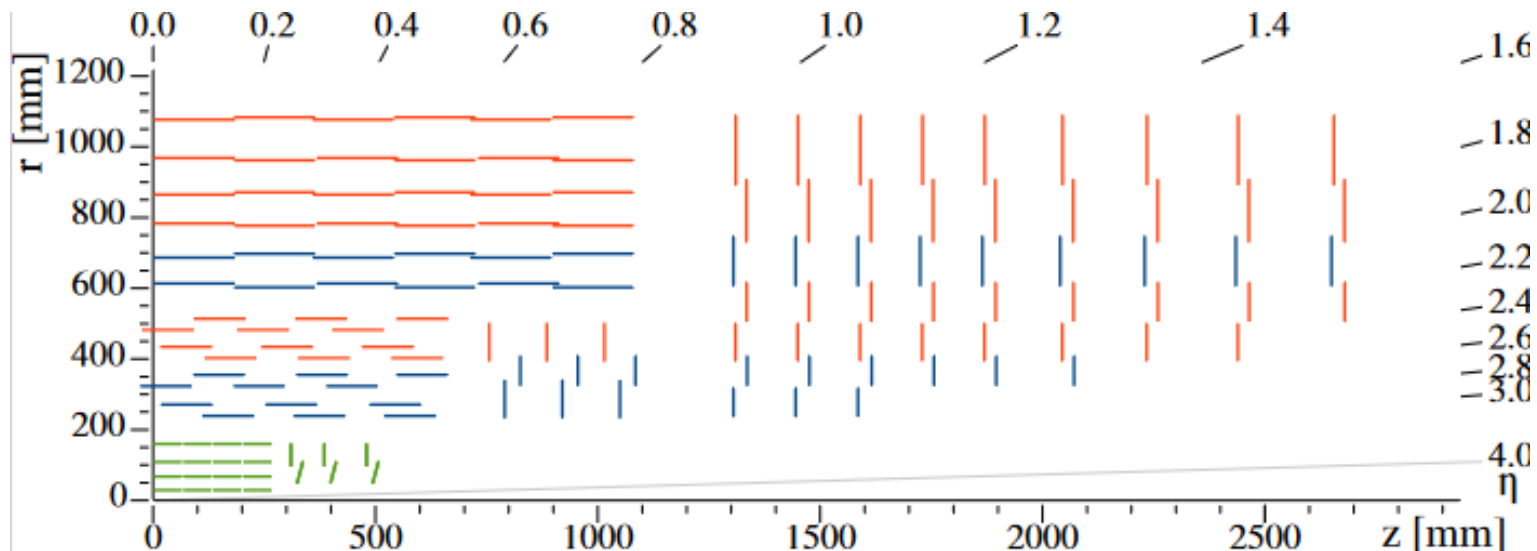
Ivan Shvetsov

Institut für Experimentelle Teilchenphysik Karlsruhe Institut für Technologie

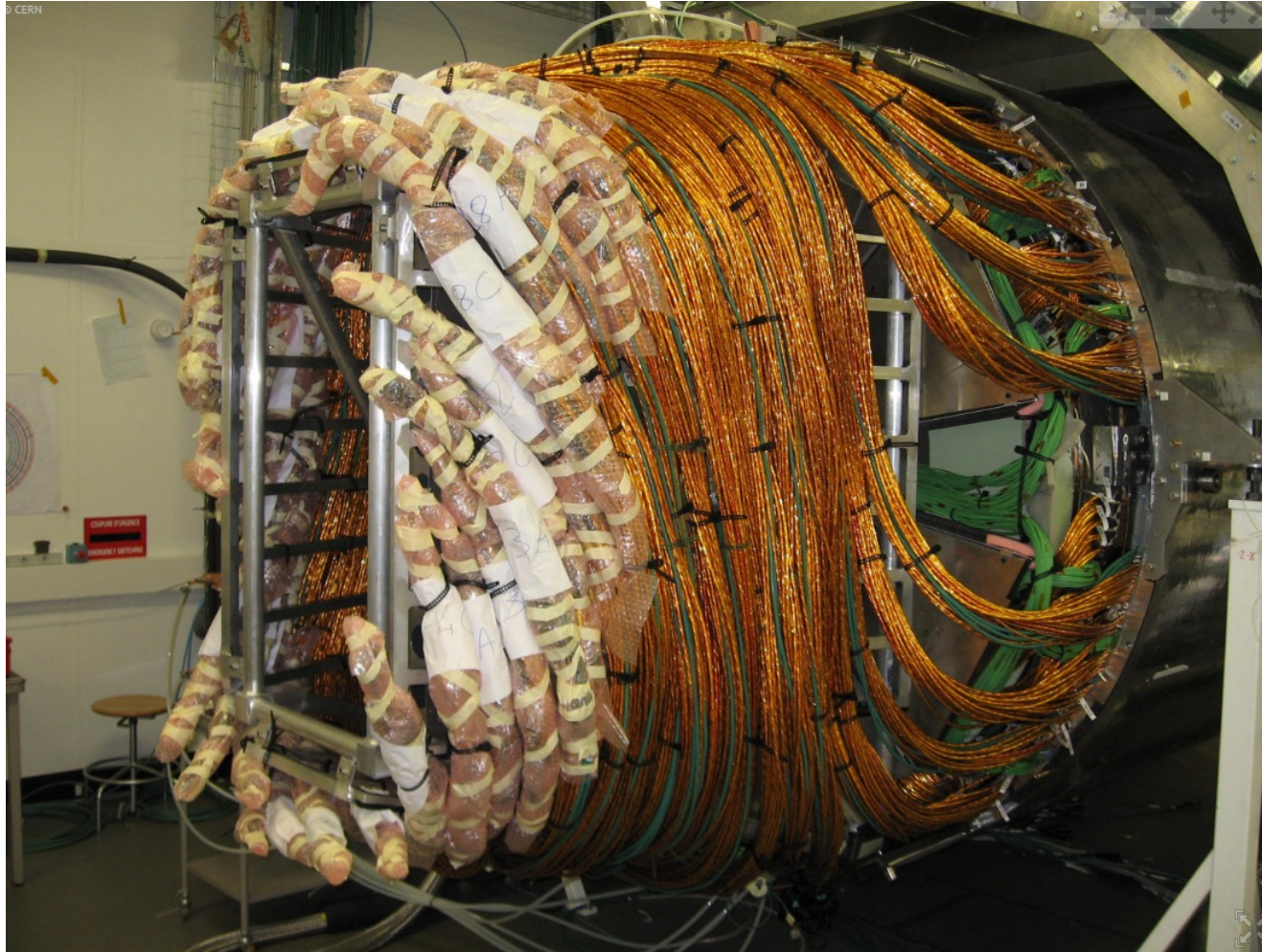


CMS tracker

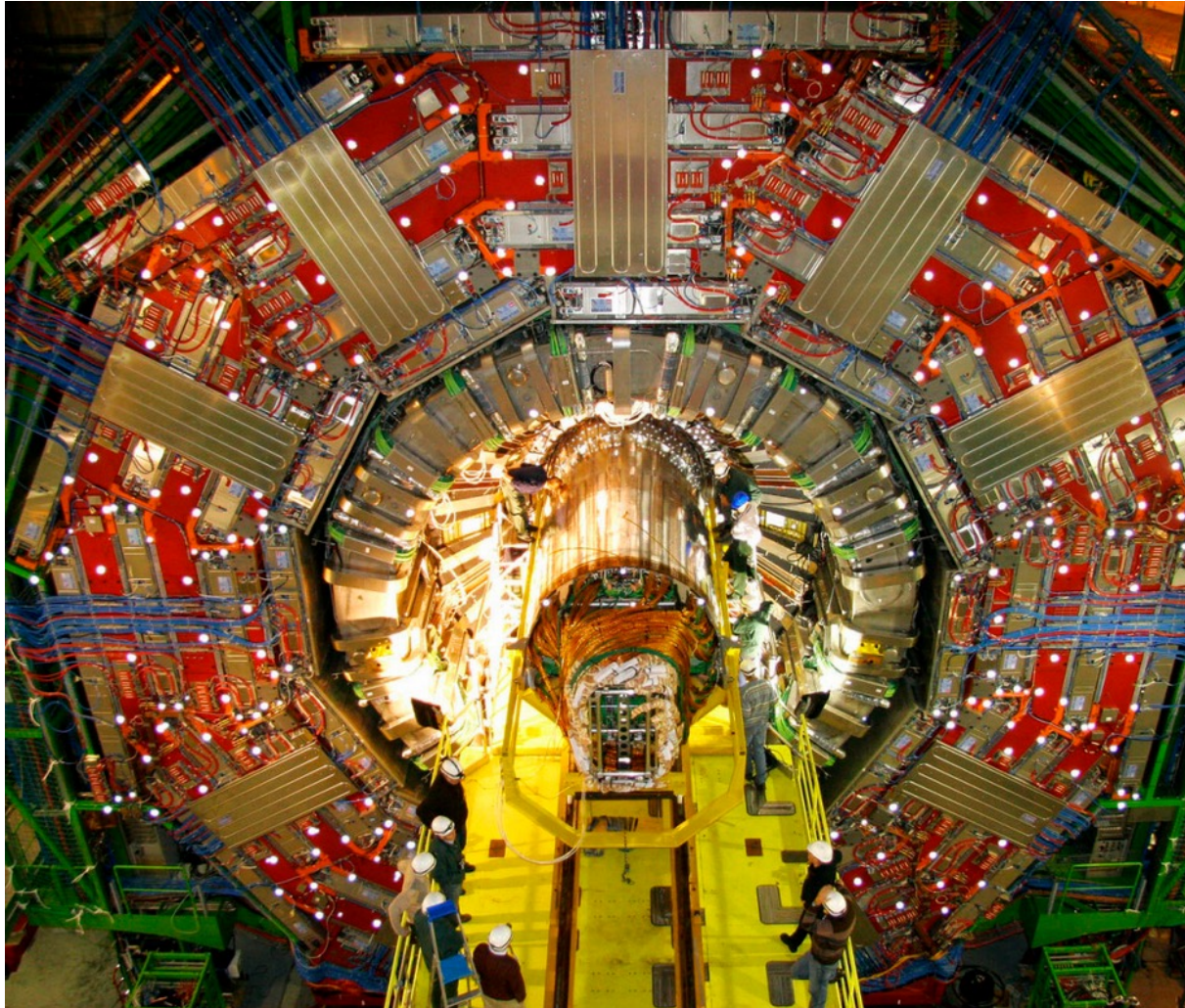
- CMS tracker has two sub-detectors:
 - Pixel detector (phase 1 detector, installed in 2017)
 - Silicon strips (phase 0 detector, installed in 2007)



CMS tracker at TIF



Installation inside CMS



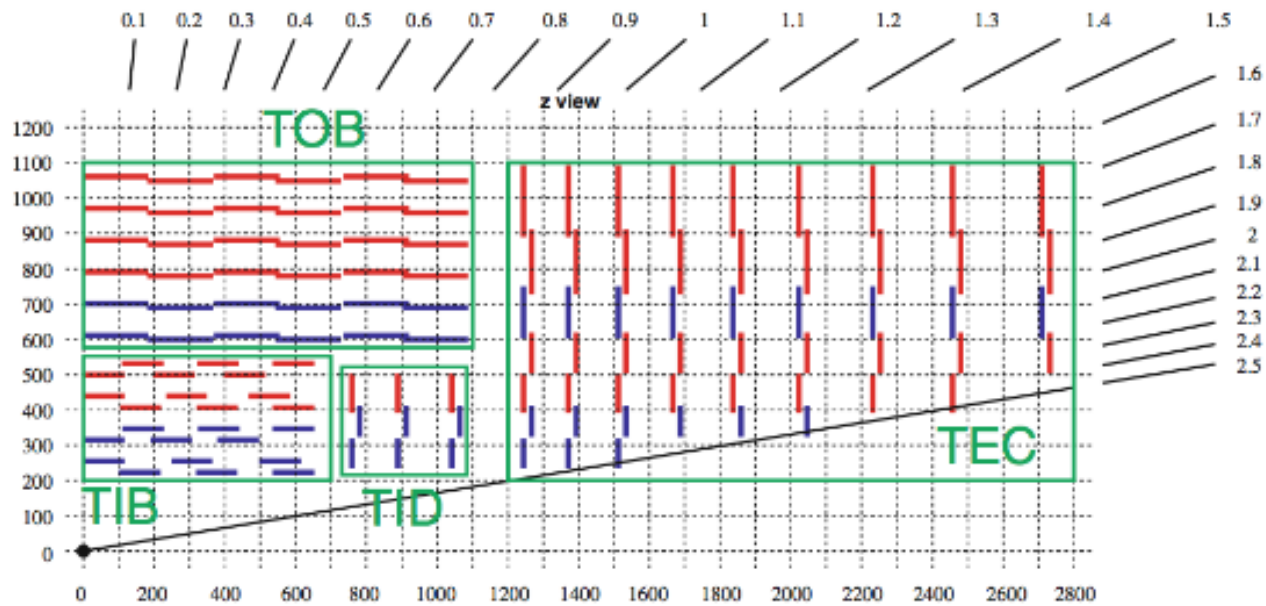
Operation of the CMS tracker

- CMS tracker has been installed in CMS more than 10 years ago
- The detector has been operated successfully since then

- What makes this detector special?
 - Most of the detector is not accessible since installation in 2008
 - The detector is operated at cold temperatures (-20C)
 - ~15000 detector modules, covering ~200 m² of silicon
 - Largest data output in CMS

CMS silicon strip tracker

- 9.3 million strips
- 5 m long, 2.5 meters in diameter
- 10 layer in the barrel region, 4 inner barrel layers (TIB) and 6 outer barrel layers
- 3 inner disks (TID) and 9 endcap disks (TEC)



What are the main concerns of running the detector?

- Safety of the detector must be always maintained
- Tracker Safety System is responsible for safety of the detector
- Operation at cold temperatures requires constant flushing of the detector and service channels of the detector
- 3 layers of safety are established here



**MEMBRANE
PLANT**



**DETECTOR
DRY AIR**



BOTTLES

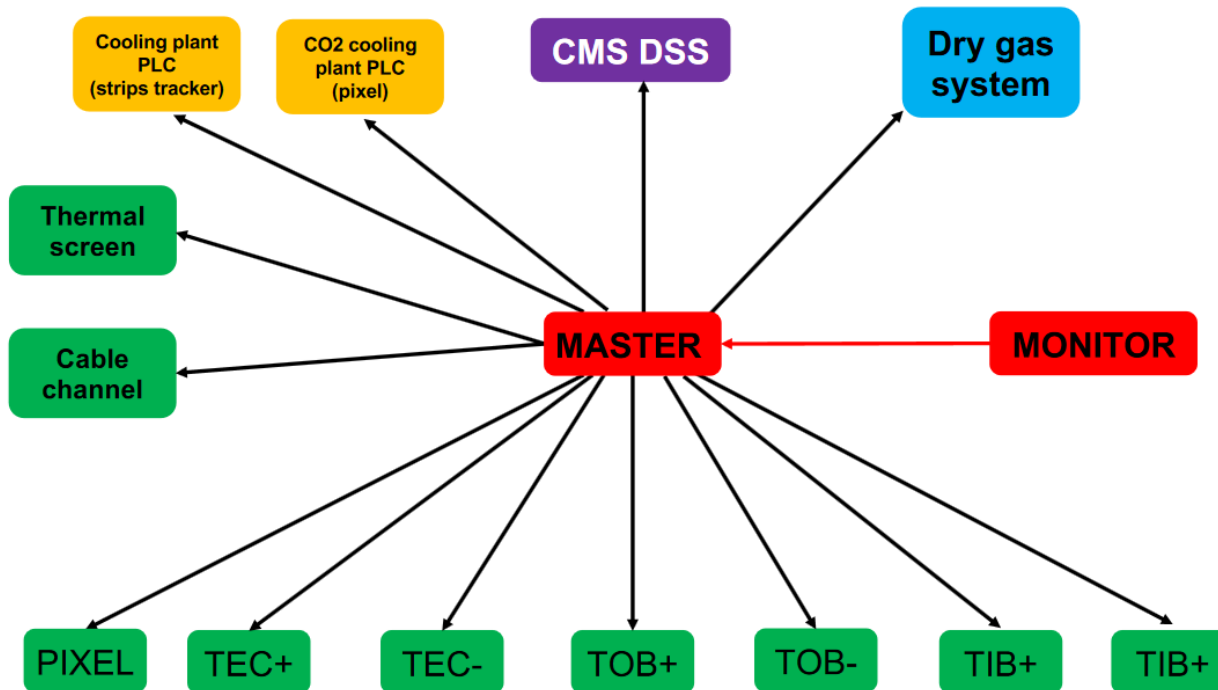
Dry gas system

- Membrane plant is able to provide dry air or O₂-depleted air
- Dew point about -70C



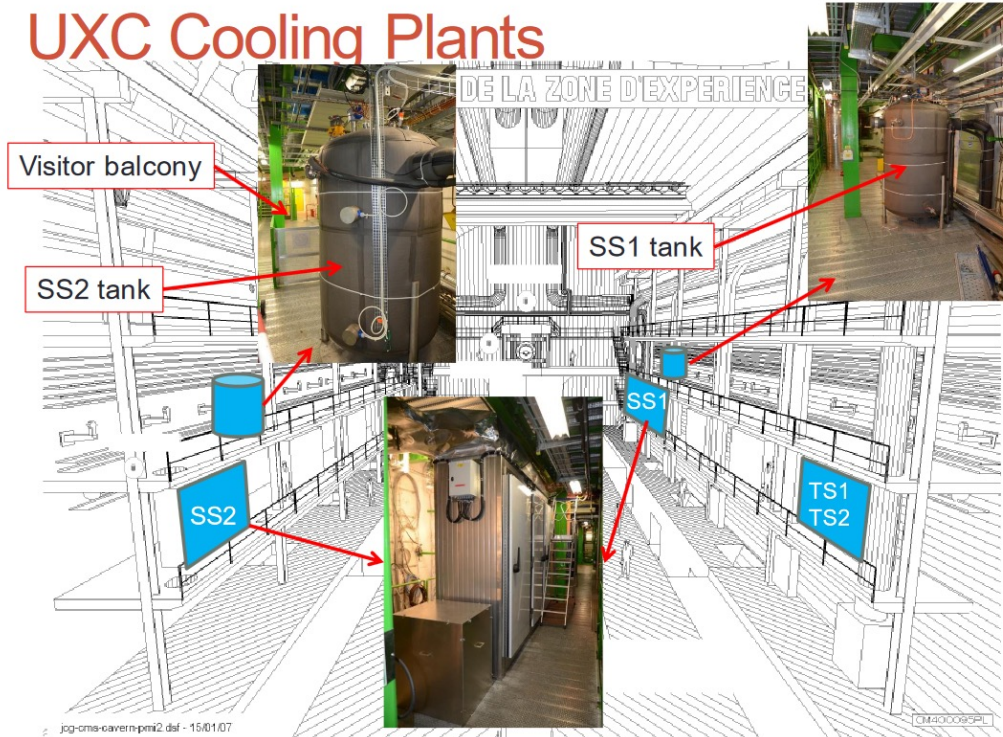
Tracker safety system (TSS)

- The key component of safety system is PLC = Programmable Logic Controller (PLC)



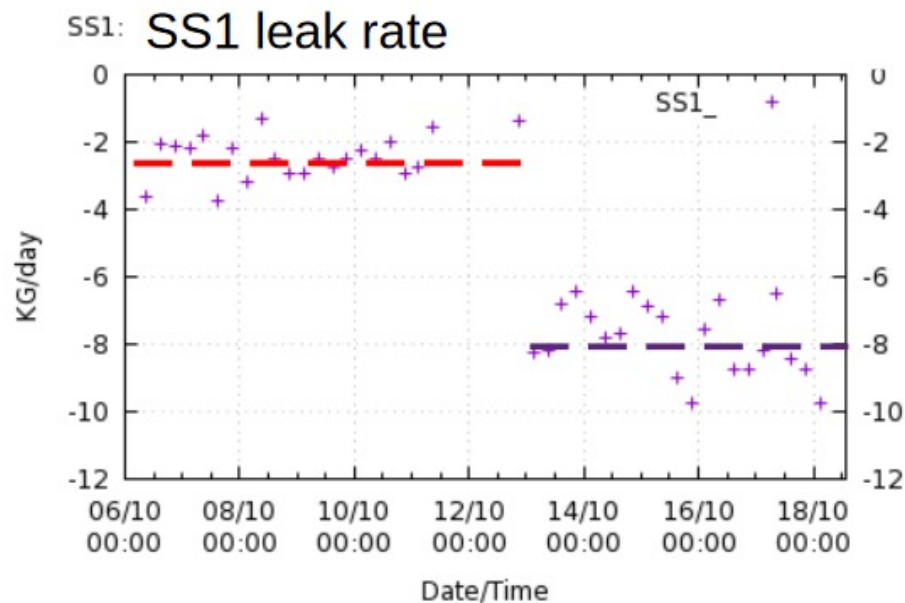
Cooling system

- Tracker is cooled down by 2 cooling stations (SS1 and SS2) located in the experimental cavern + 2 thermal screens (TS1 and TS2)
- All 4 stations are circulating C6F14
 - SS1+SS2 at -20C
 - TS1+TS2 at -10C
 - SS1+SS2: 180 loops
 - TS1+TS2: 16 loops



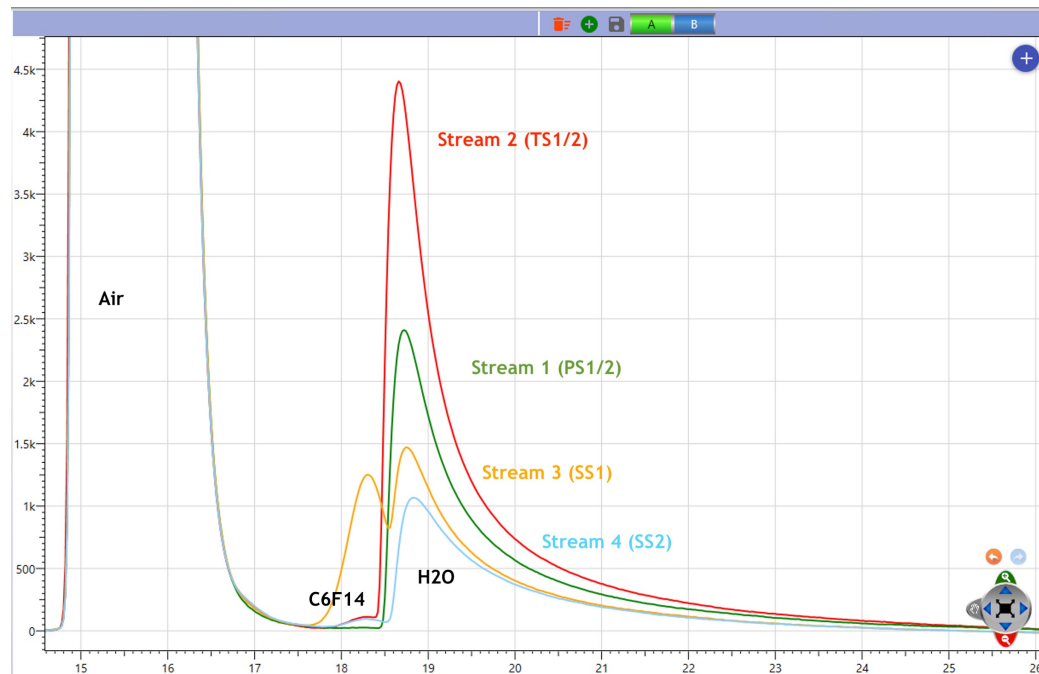
Cooling system

- SS2 has suffered from overpressure incident in 2009
- This resulted in closure of 5 cooling loops
- SS1 has never had overpressure problems and had always acceptable leak rates (0.5 kg/d)
- Leak rate increase has been observed in 2021
- After that leak search campaigned were carried out



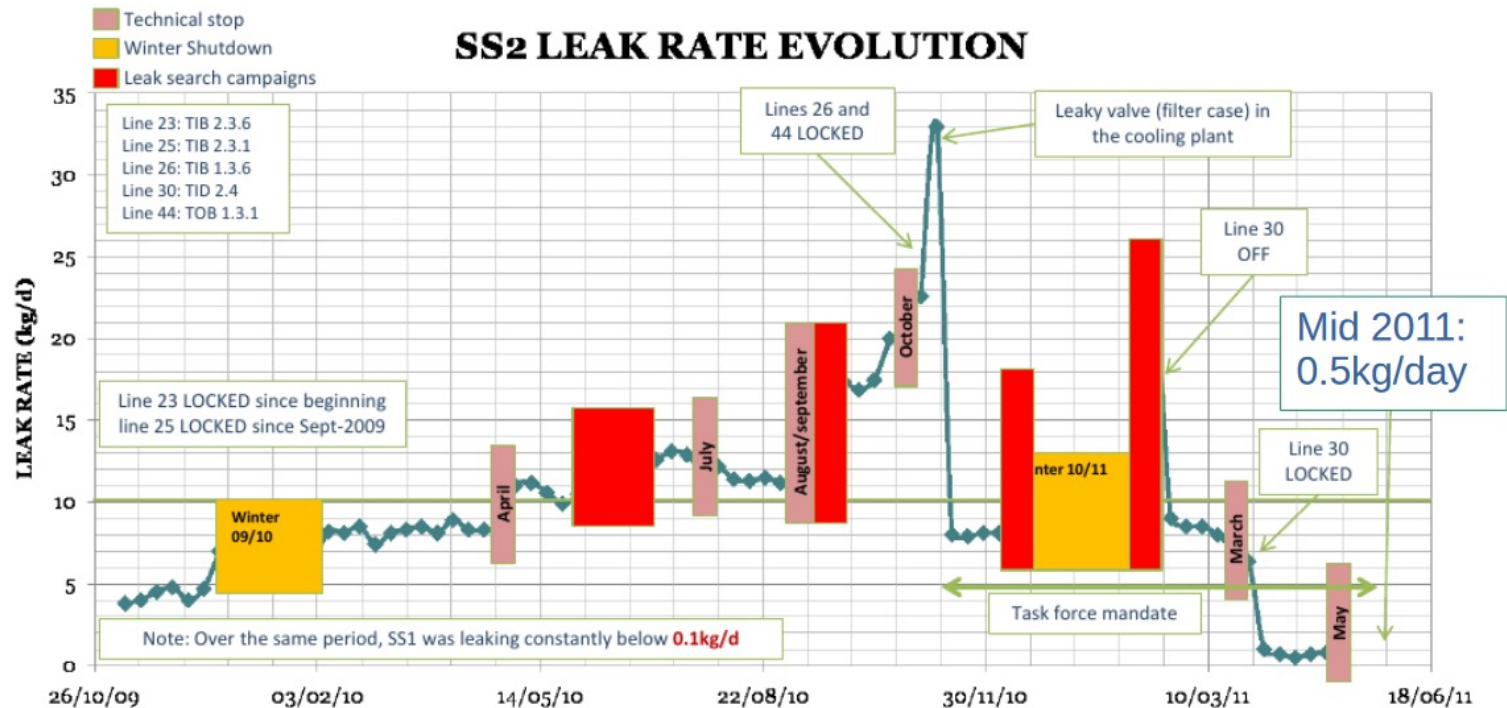
Gas chromatography

- Another way for “detect” leaks
- Not obvious to interpret results
- The method was used to validate the leak rate measurements



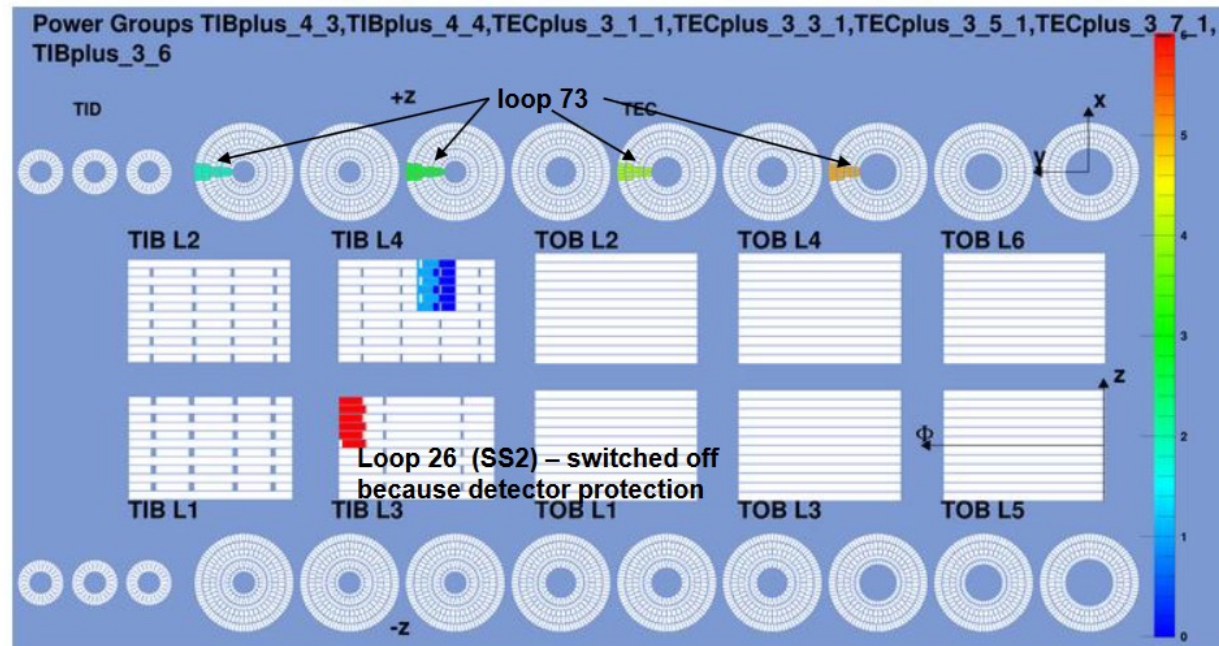
What did we do to reduce the leak rates in the past ?

SS2 "historic" leak rates in 2009 -2011

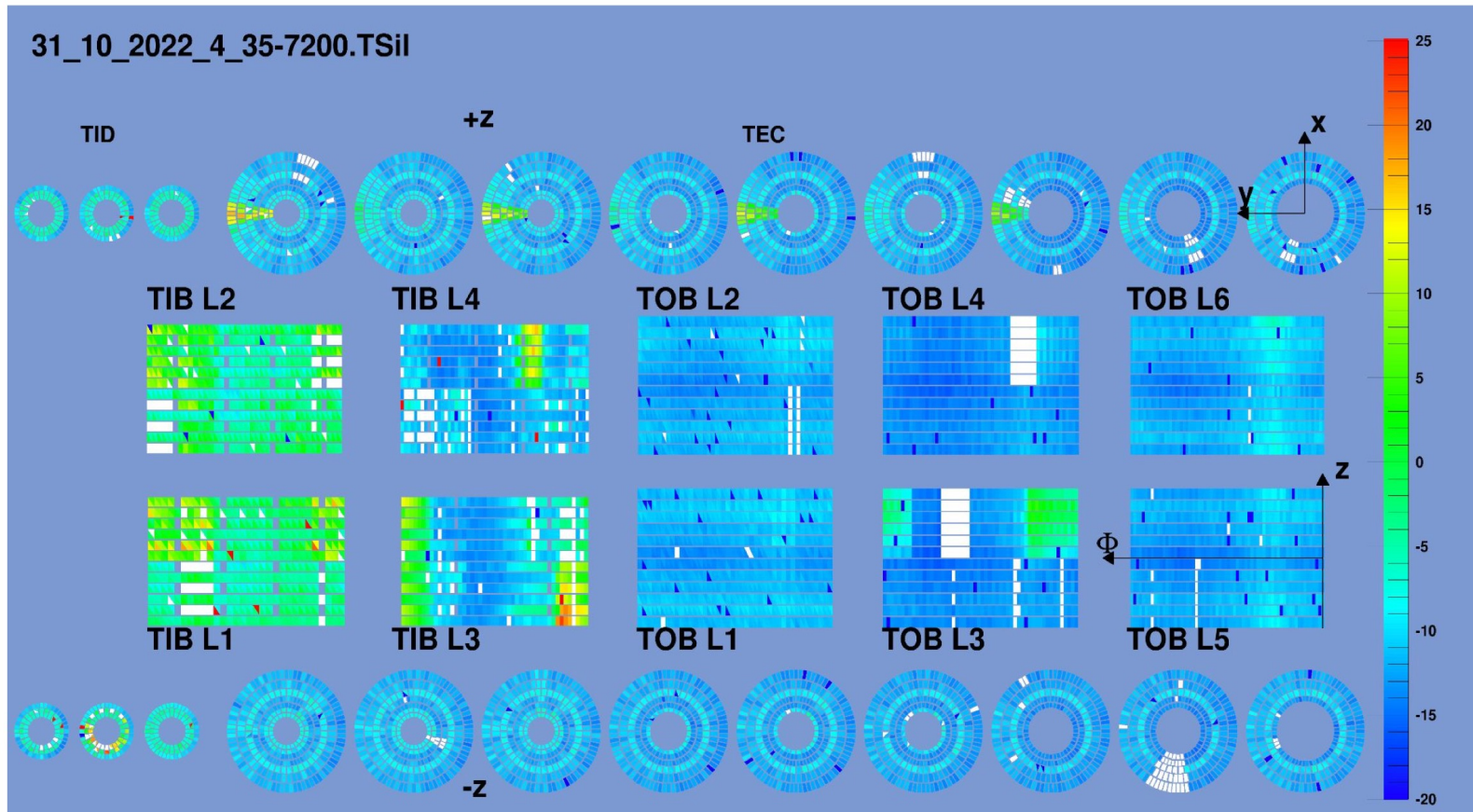


Regions affected

- Following regions are affected - they are cooled only by surrounding structure at the moment
- Several tests were done to make sure these modules can be operated

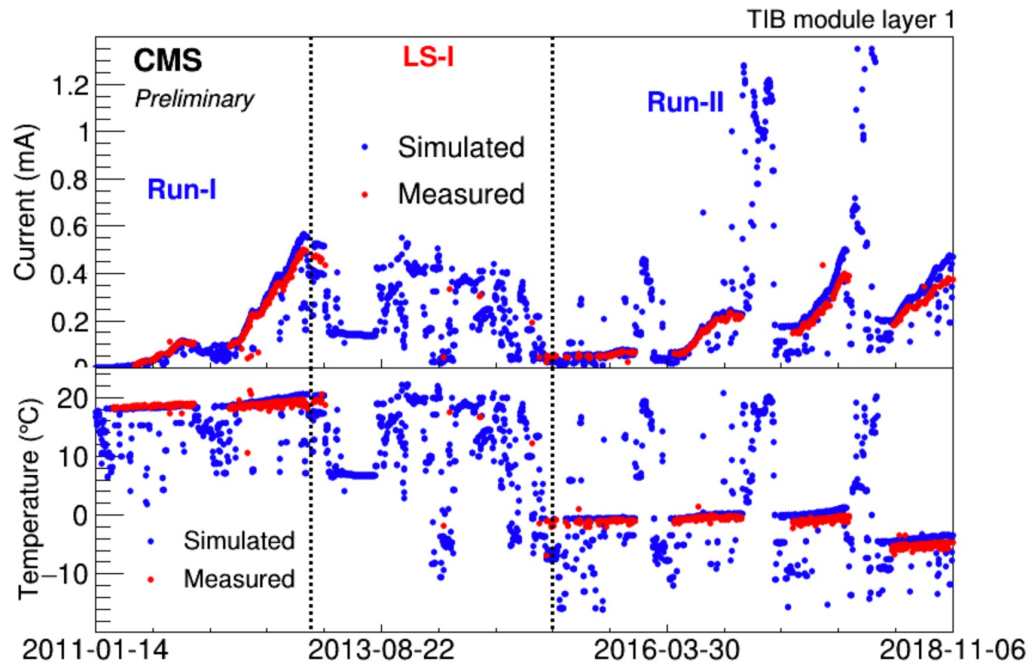


Detector temperatures



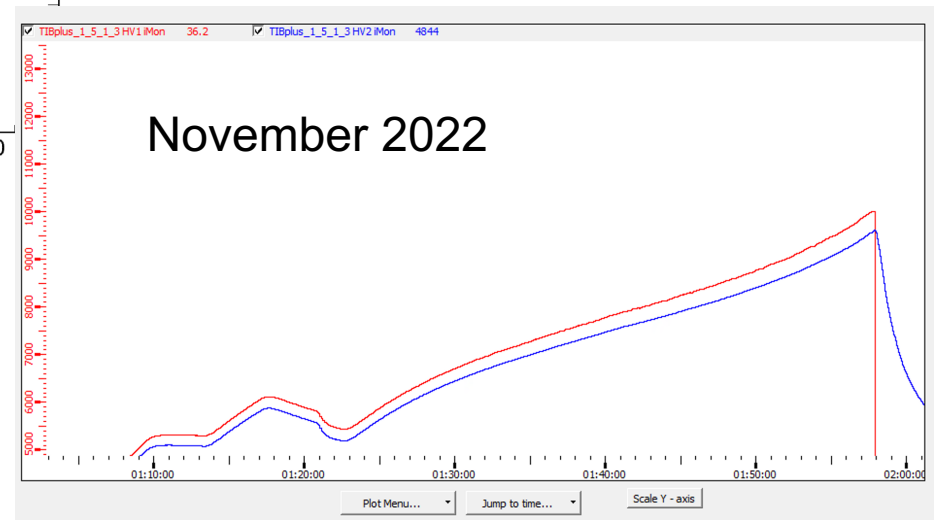
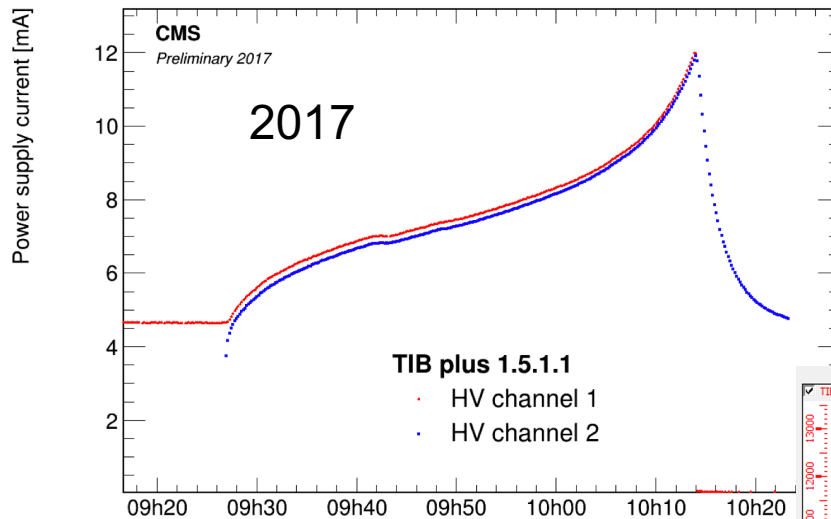
Evolution of the leakage current

- Leakage current in silicon is increasing with luminosity



Thermal runaway

- First thermal runaway has been observed in 2017 – temperature was lowered from -15°C to -20°C

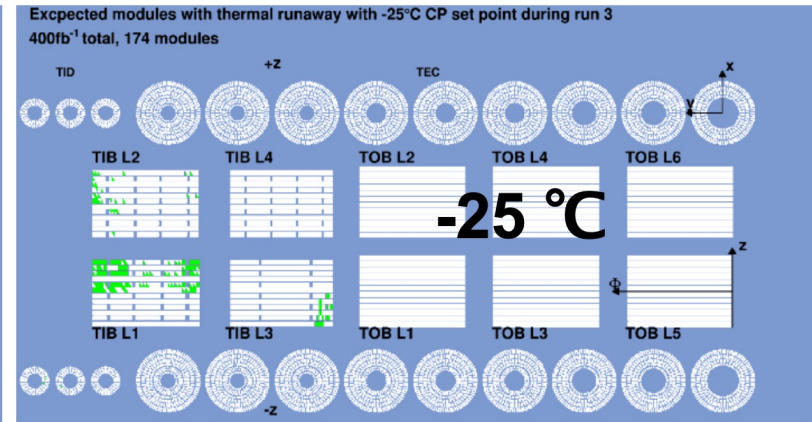
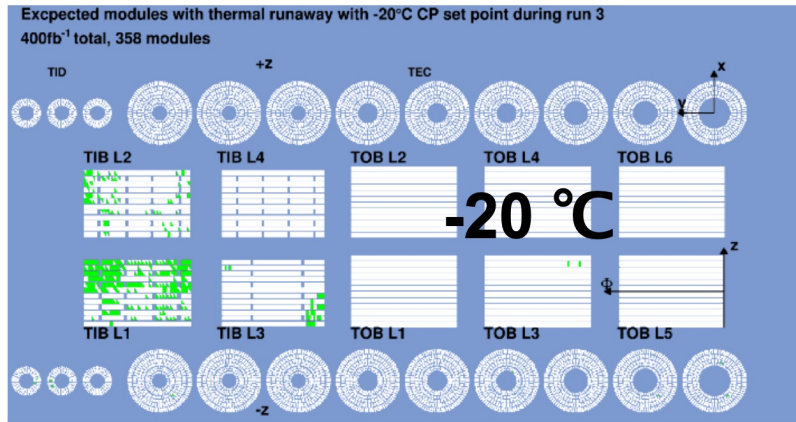


Leakage currents

- Leakage currents are increasing in the uncooled regions
- We have some ways of dealing with this:
 - Disconnecting modules electrically (remove jumpers in HV line)
 - Switching off stereo modules
 - Lowering depletion voltage (quite limited long term)
 - Lowering temperature – to be avoided as long as possible (-25C)

Lowering temperature of tracker to -25°C

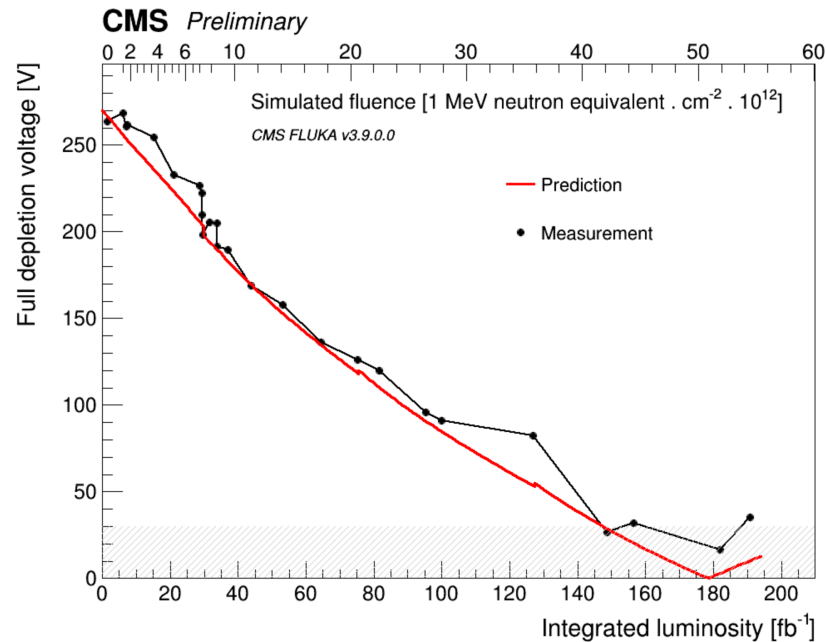
- Expected number of thermal run aways at different temperatures



- Test of -25°C performed during LS2

Full depletion voltage evolution

- By the end of 2022 layer 1 of TIB is expected to be around 100V



Operation of the CMS tracker

- It is critically important for the CMS experiment that tracker is providing good data
- In order to make sure this happens we have a crew of usually one shifter per week and experts available to intervene in case of problems
- Experts cover typically following areas: DAQ, DCS, power system
- If you are interested to participate in tracker operations please contact ivan.shvetsov@cern.ch



Conclusions

- Overall CMS tracker is a good shape
- Leak search has been concluded before start of data-taking
- Uncooled modules are being delivered data, though leakage currents have been approaching hardware limits (12 mA)
- Shift crew has been established, new people trained; if you are interested to join the team please let me know
- Good detector fraction about 95%

