



How you can contribute to the CMS pixel detector

Jory Sonneveld



Universität Hamburg

DER FORSCHUNG | DER LEHRE | DER BILDUNG

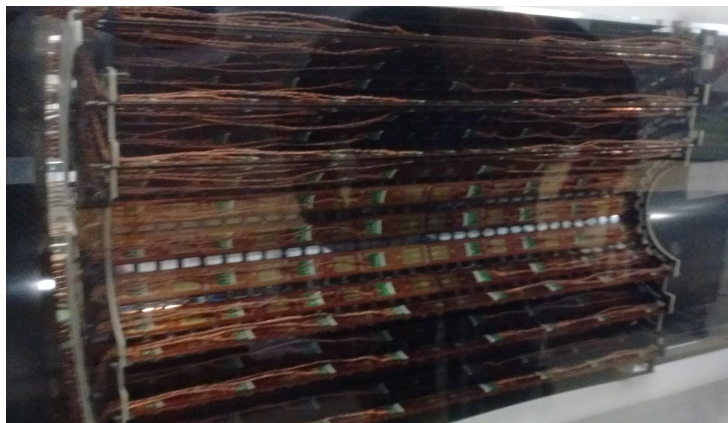


Status of CMS pixel

Current detector cold in clean room **except inner layer 1** which will be replaced

Need to **characterize radiation damage:**

Understanding important for run 3 and phase 2



Prepare for data taking: improve software, calibrations and monitoring tools

Accident with cooling pipes in endcaps, solutions are investigated. → **How much annealing time** can we afford?

UHH contributes here!



Phase 2 detector: **what sensor will we choose?**

The pixel plans ahead

Phase 1

September 2020:
Start replacement of phase 1 layer 1

Early 2021:
Start LHC run 3

Now would be the time to prepare for an excellent run 3

Phase 2

August 2020:
Sensor qualification:
start production

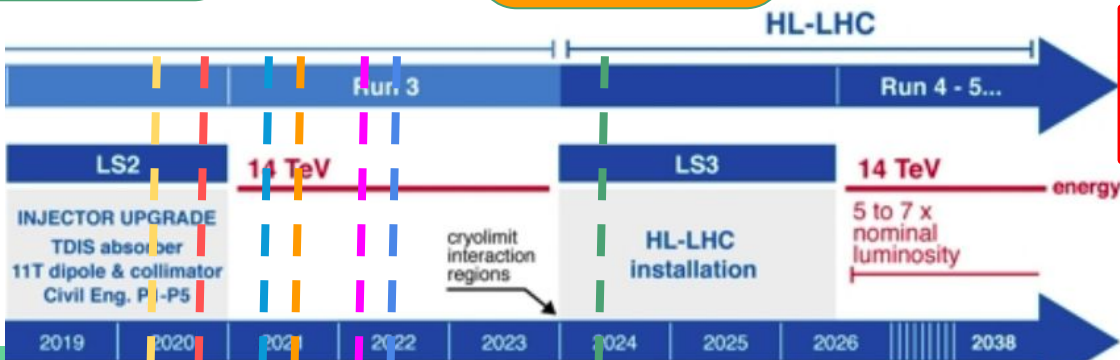
September 2021:
CROC=RD53B qualification

Early 2022:
Final CROC
Preproduction of final sensor

June 2022:
Preproduction of final module

June 2024:
Finish module production

Need test beam data to evaluate our future sensor and chip performance



How can you contribute?

CMS phase 2 pixels

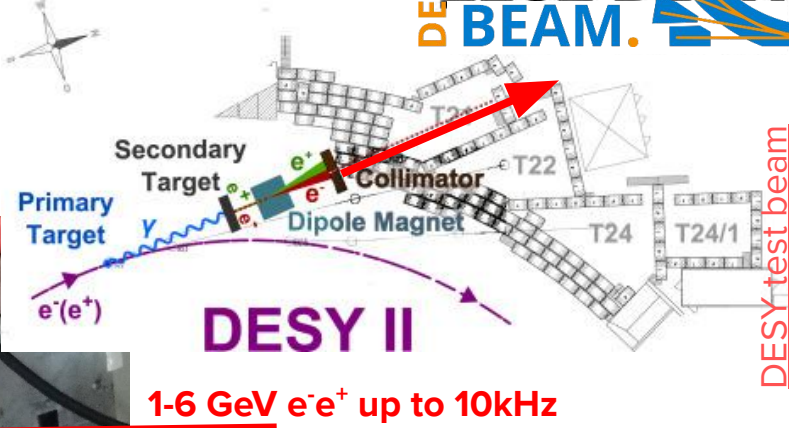
[DESY test beam meetings](#)
[CMS sensor meetings](#)



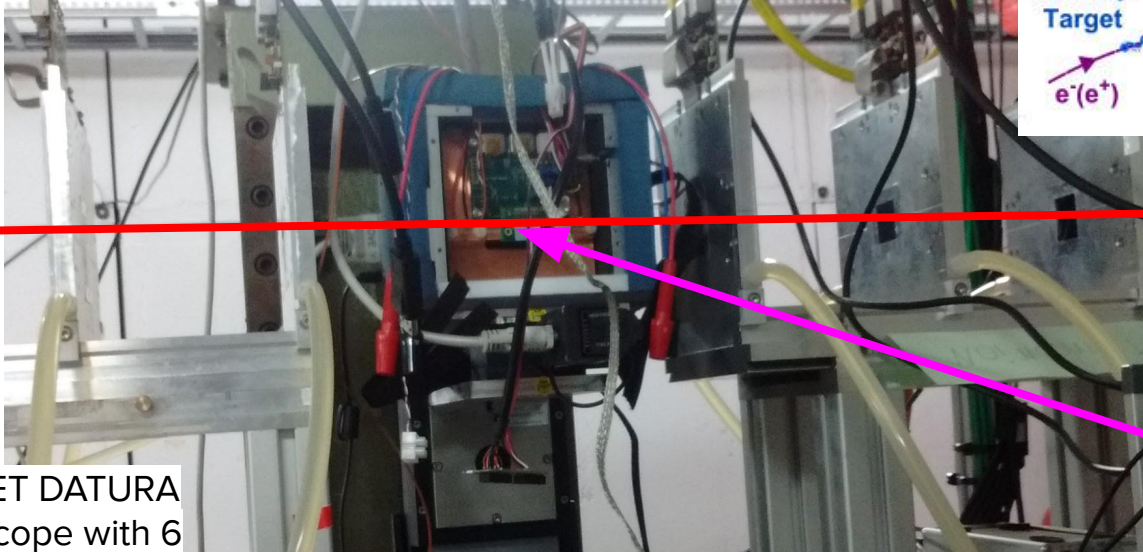
DESY test beam: a mini-experiment



Take shifts! For tests of CMS phase 2 planar and 3D sensors on [RD53A](#) or [ROC4SENS](#) (R&D) chip

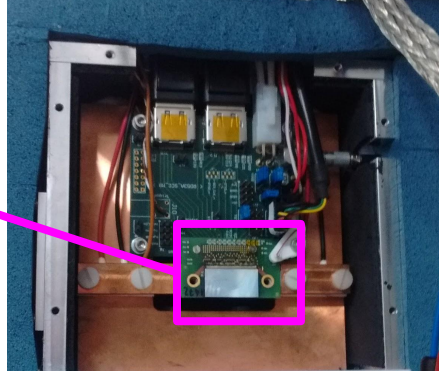


DESY test beam

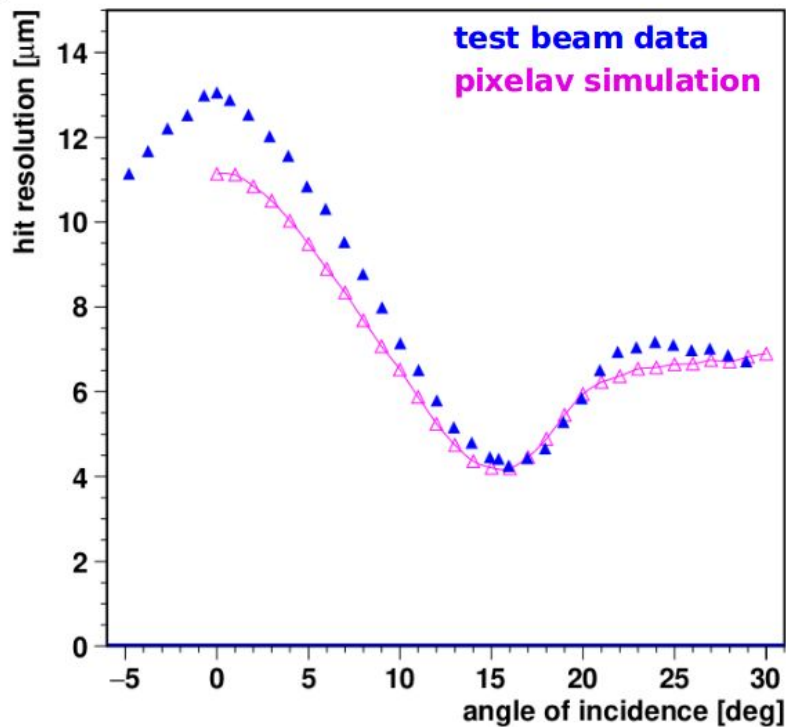


EUDET Datura telescope with 6 MIMOSA26 (MAPS for ILC, 50 μm thick, 18.4 μm^2) planes with resolution of 5.7 μm

[See also talk by Simon Spannagel](#)



DESY test beam: characterization of sensors



From Daniel Pitzl
and Finn Feindt

Test beam data can be used to show performance of different sensors like:

- Hit resolution vs angle of incidence
- Efficiency vs bias voltage

We need you to take the data! You will learn more about pixel modules and this CMS mini-experiment

People needed from this weekend!

Test beam schedule: **now** -- April 21, May 20 -- June 2nd, June 24 -- July 2nd, September 2nd -- 15, Oct 28 -- Nov 10, Nov 25 -- Dec 8

Shifts: 9-13, 13-17, 17-21:00

CMS phase 1 pixel detector

[Pixel offline reconstruction, data quality monitoring meetings](#)

[Pixel calibration, monitoring, operation meetings](#)

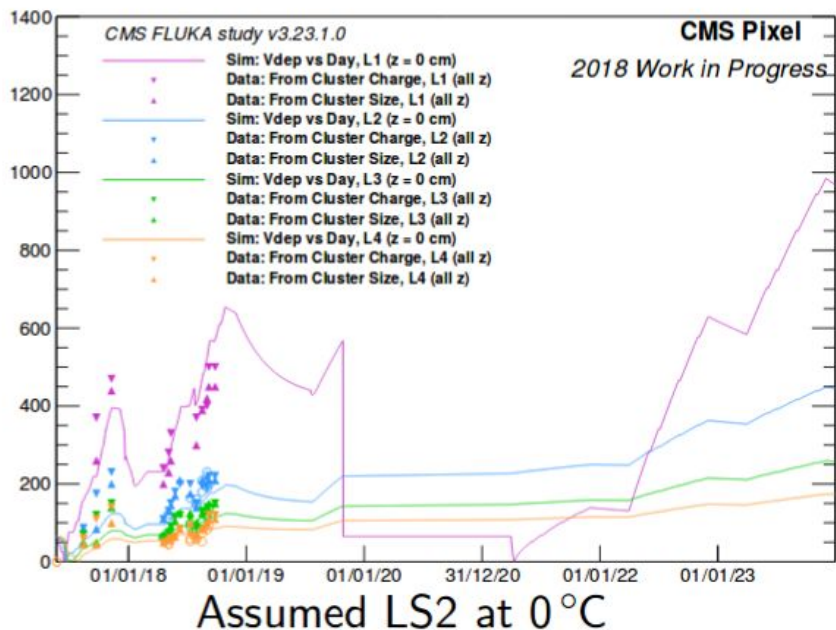
[Pixel data acquisition meetings](#)

[Radiation simulation meetings](#)

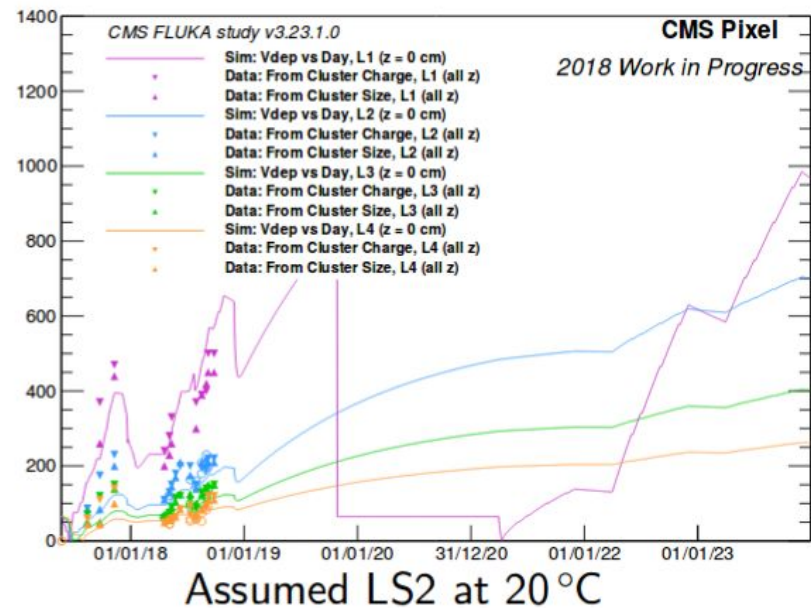
Radiation damage: depletion voltages

From Finn Feindt

Phase-1 Pixel - Full depletion voltage vs days

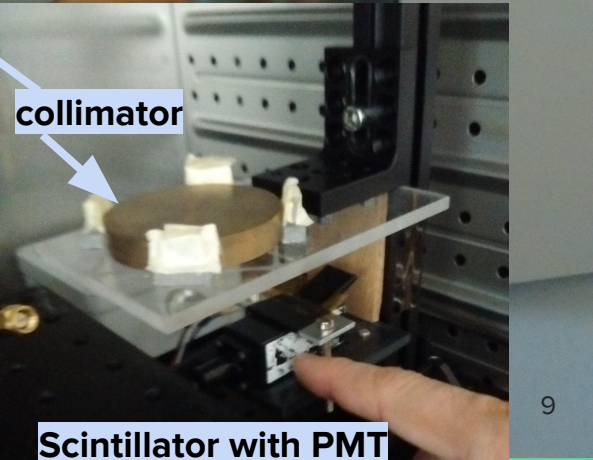
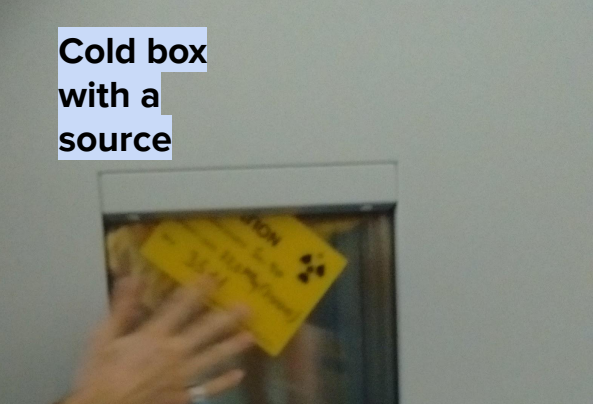
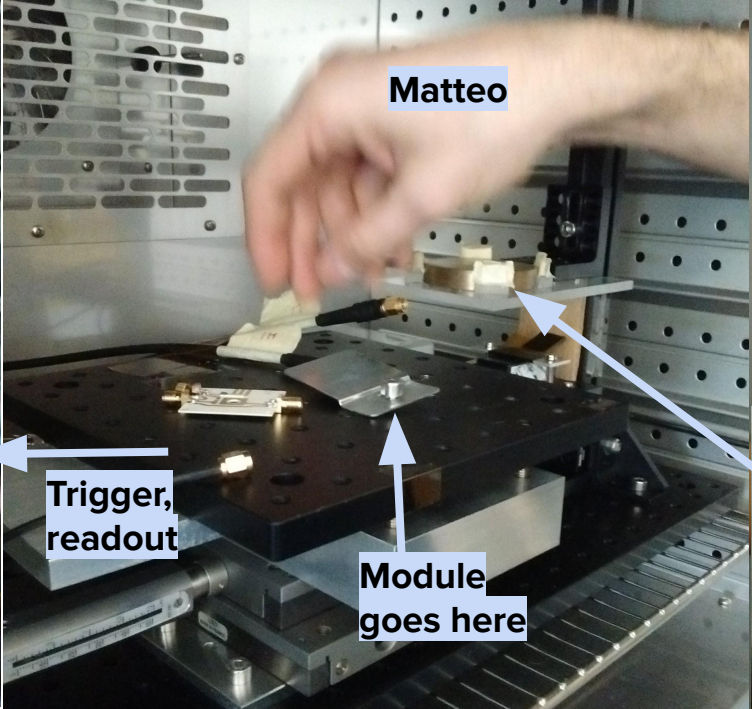
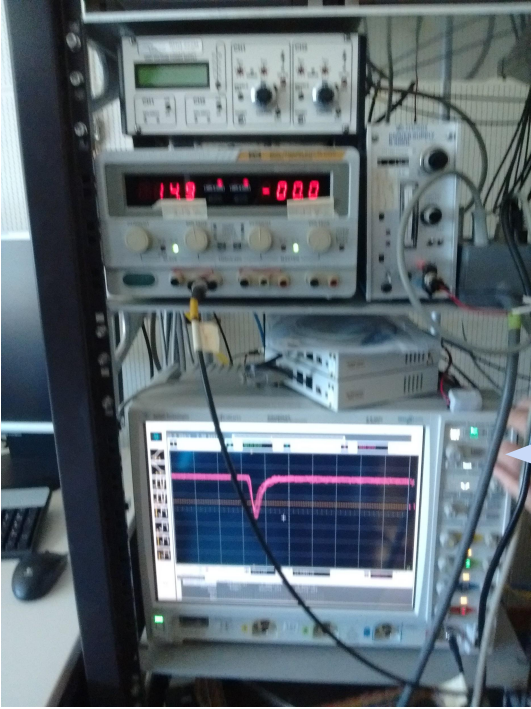


Phase-1 Pixel - Full depletion voltage vs days



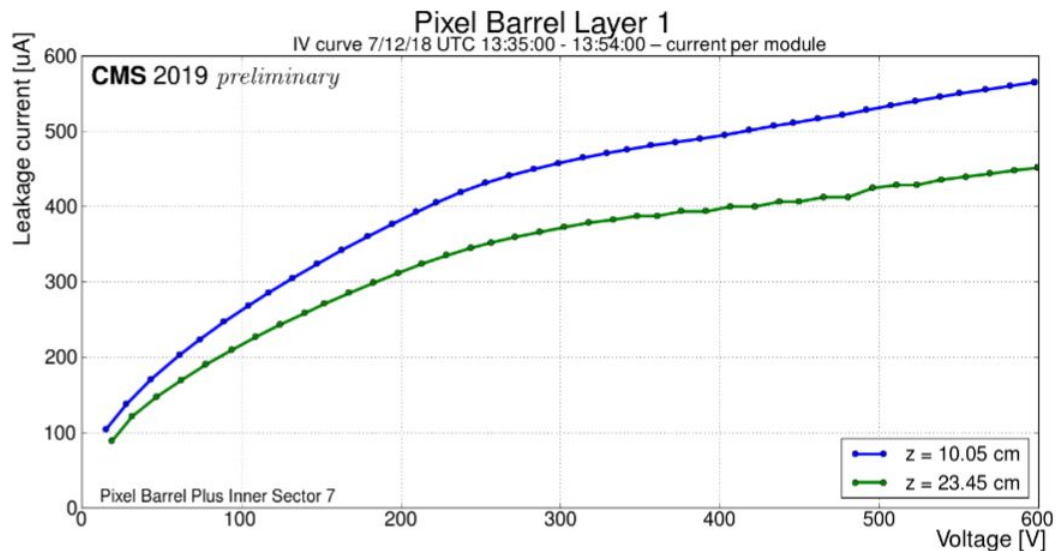
Will the pixel barrel layers survive run 3? **Will the pixel endcap rings survive run 3?**

Radiation damage: charge collection efficiency



Measure charge collection efficiency, depletion voltage, and leakage current for dismantled layer 1 modules in RD50 setup at CERN
→ possibly also at DESY test beam next year

Radiation damage: leakage currents

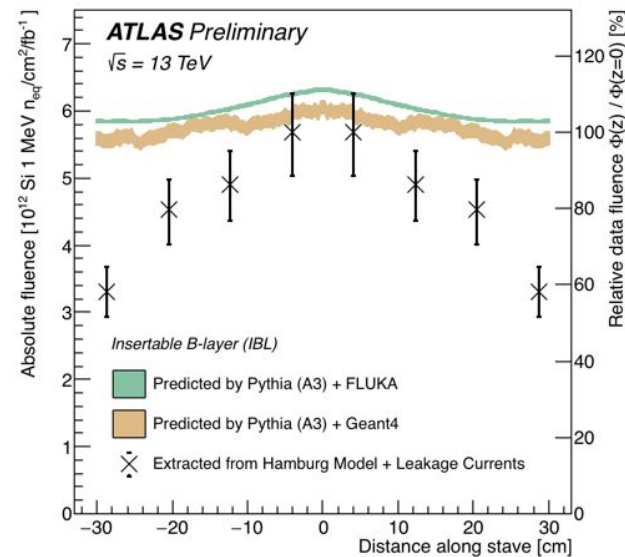


From Finn Feindt and Thenia Prousalidi

Is the fluence z-dependent?

→ The leakage current hints that

→ **but it might be a temperature effect**

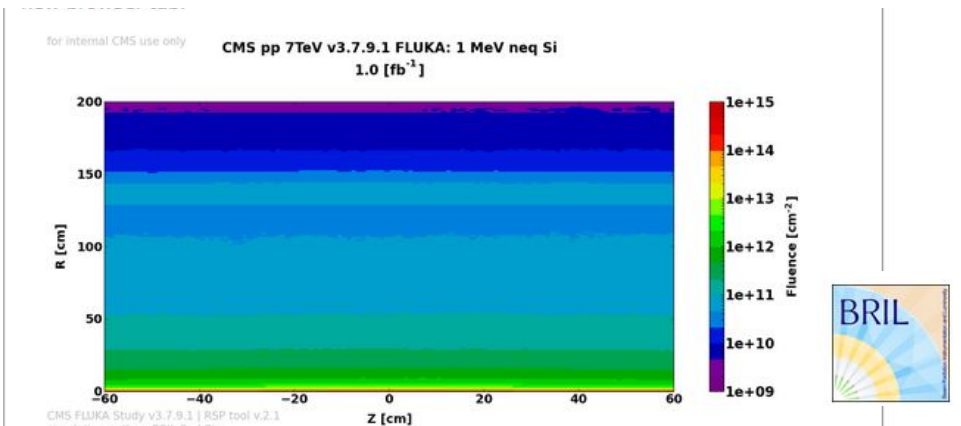


ATLAS radiation simulation results

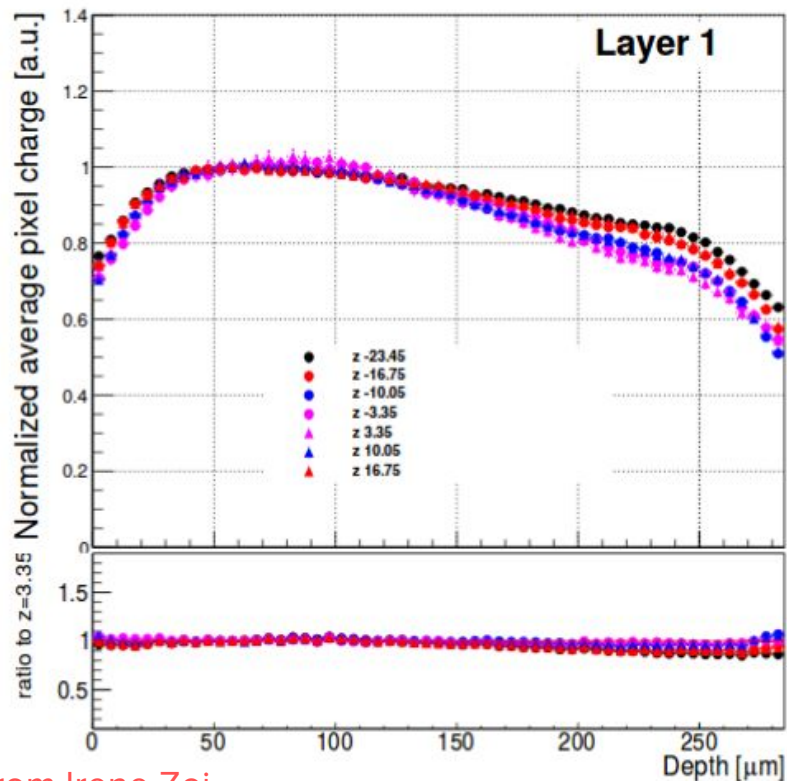
BRIL radiation simulation: particle rates in CMS vs z

Compare FLUKA simulation with particle rates from data

- Derive fluence from data (for different particle spectra)
- Derive fluence from Hamburg model and measured leakage currents
- Compare charged particle multiplicity with that from data
- Fluence as predicted from cluster charge vs depth vs z



Offline reconstruction: z-dependence

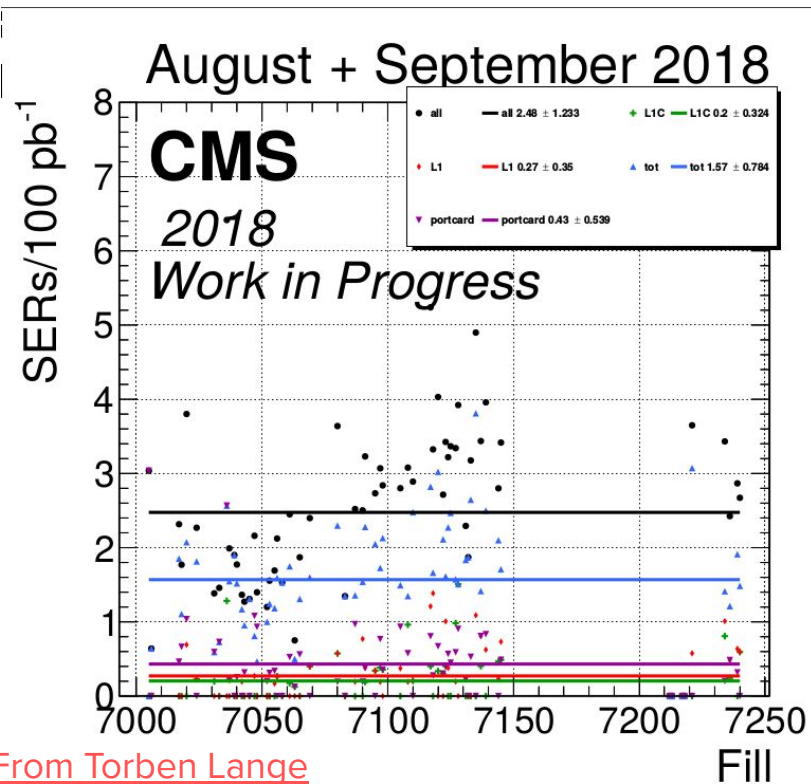


Z-dependence in quantities like

- Cluster charge vs depth
- Lorentz angle
- Depletion voltage
- Charge collection efficiency
- Resolution

→ simulate with PixelAV software like was done for resolution of next pixel sensors in DESY test beam

Data acquisition: soft error recoveries and monitoring

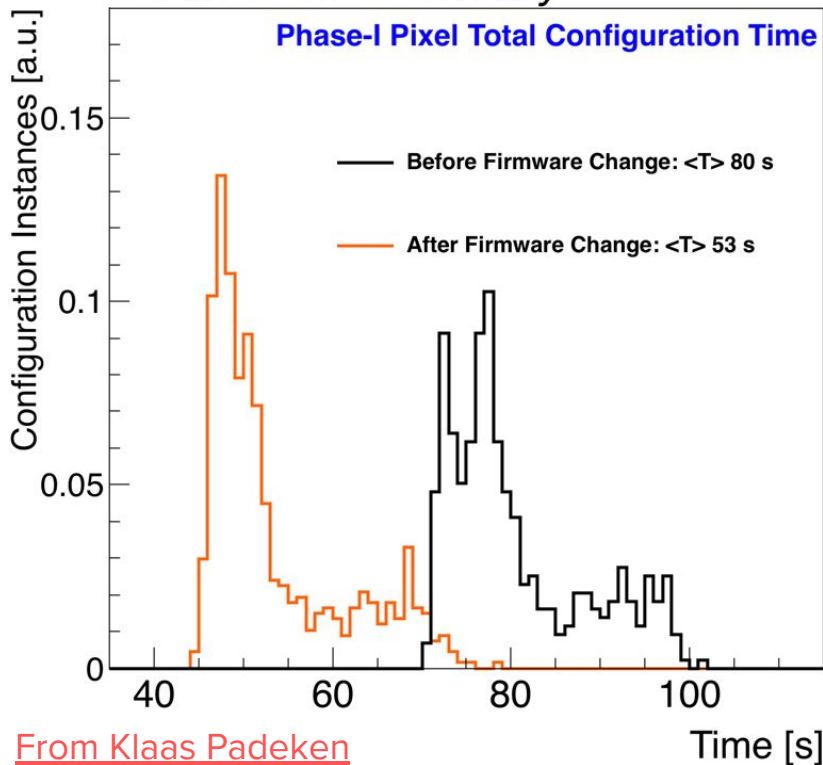


Get to know software beyond CMSSW:
software **important for CMS data taking!**

- What is the optimal rate of soft error recovery so that we have the least dead time and the most recovered detector parts?
- What are the FED error rates?
- How can we improve monitoring during running?

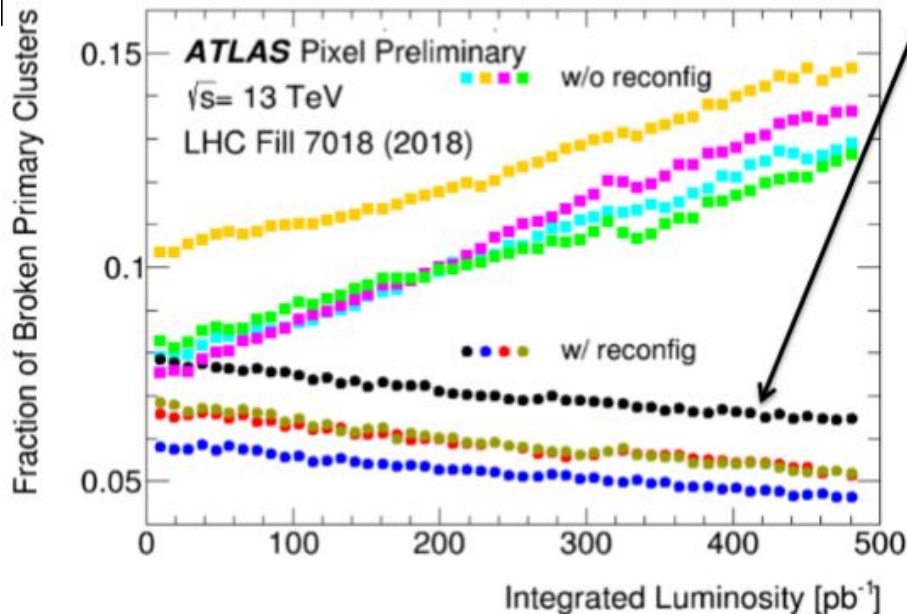
Data acquisition: configuration

CMS 2018 Preliminary



- Improved configuration times
- Configuration during data taking
- Configure from a database (now: files) → see also work by Alexander Froehlich and learn **SQL: useful in many applications!**
- Improve user interface
- More C++11 features
- Use of existing central software and methods like done our timing and control distribution system (TCDS)

Data quality monitoring: per pixel single event upsets



Single event upsets can

- disable a pixel
- change its threshold

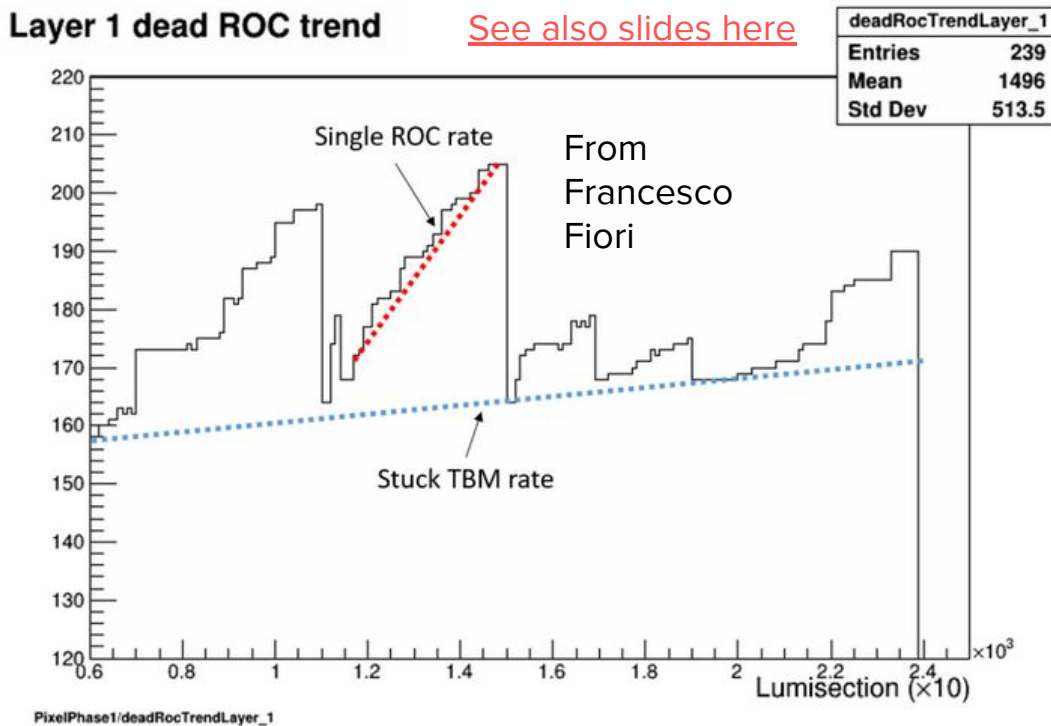
resulting in dead or noisy pixels.

Would CMS benefit from cyclic pixel reconfiguration like ATLAS does?

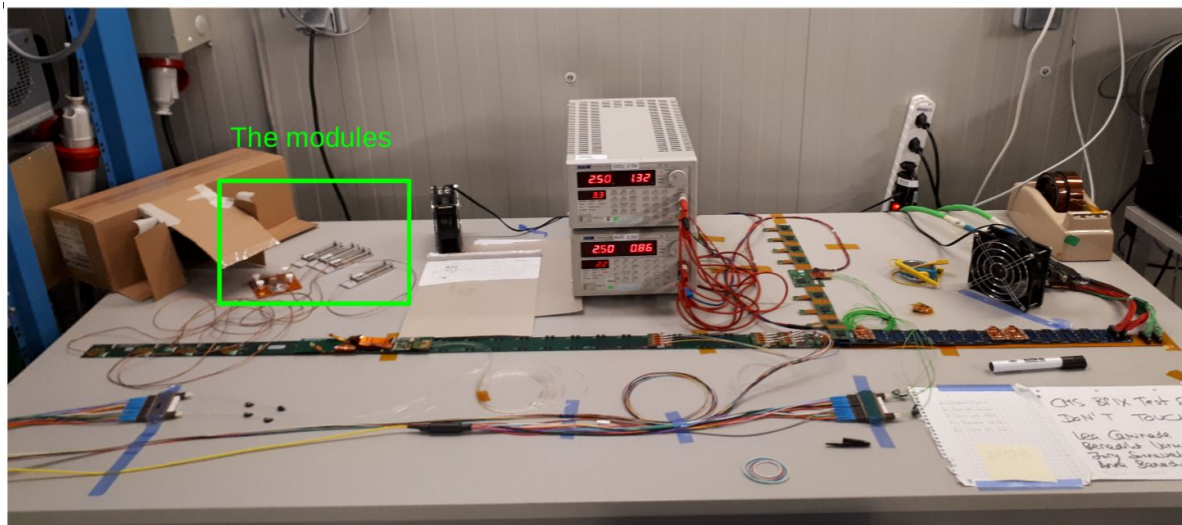
[From ATLAS talk at workshop on radiation effects at the LHC](#)

Data quality monitoring: dead ROC trend → dead pixel trend

- Dead ROC trend available in online DQM
- Gives an estimate of recovery success of soft error recovery (SER)
- **Need dead/noisy pixel trend**

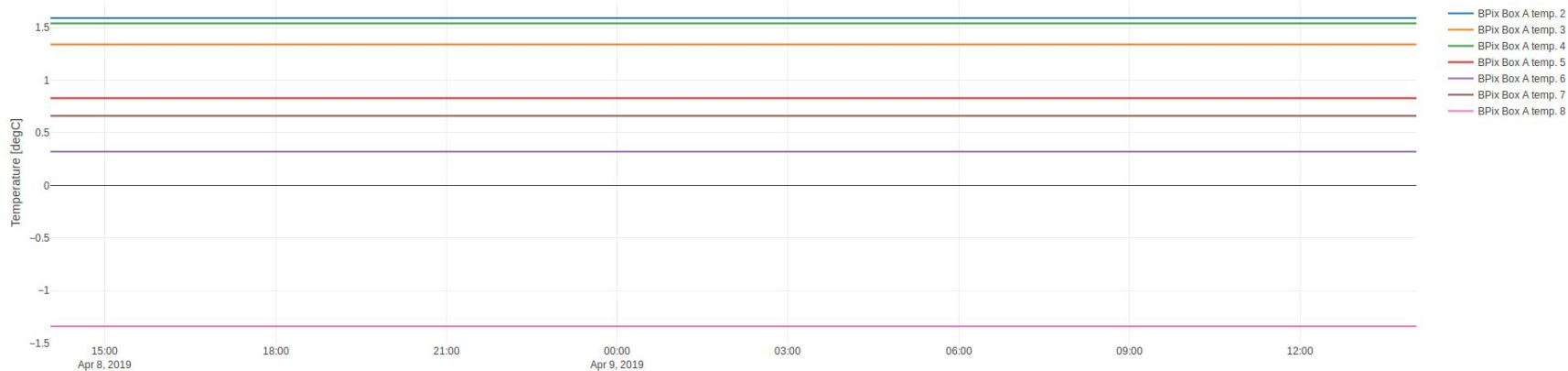


Commissioning and calibration: test setup



- CCUs were showing strange behavior sometimes disabling DCDCs or portcards. **Can we reproduce CCU hiccups in the lab?**
- **How can we properly cool these modules so that they can be operated with high voltage?**
- **Can we improve the functioning of these modules with further calibration?**

Detector monitoring pages



BPix Box A Temperatures

[Export data](#) [Plot info](#)

[From Yuval Nissan](#)

SQL + python

- Can we speed up these pages?
- Can we add strip tracker monitoring?
- Can we add calibration results?

Detector monitoring pages: tracker online monitoring

BPix_Bpl_SEC3_D12

[From Alexander Froehlich](#)

malfunctioning; probably due to flaky connection

Known Problems

2018-05-10 22:00:00

pixeldoc



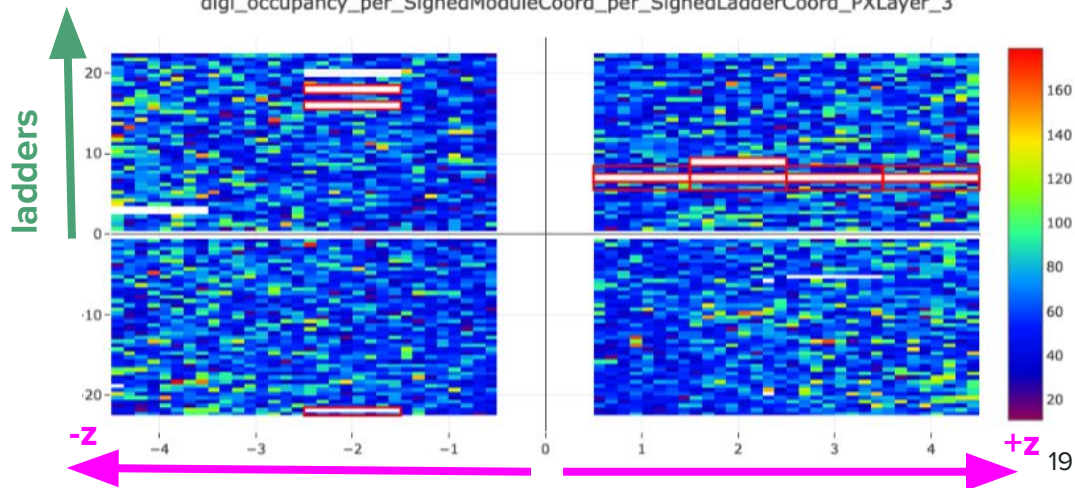
more information

Resolved Problems

nothing f

run 316111 (2018-05-10 22:45:55)

digi_occupancy_per_SignedModuleCoord_per_SignedLadderCoord_PXLayer_3

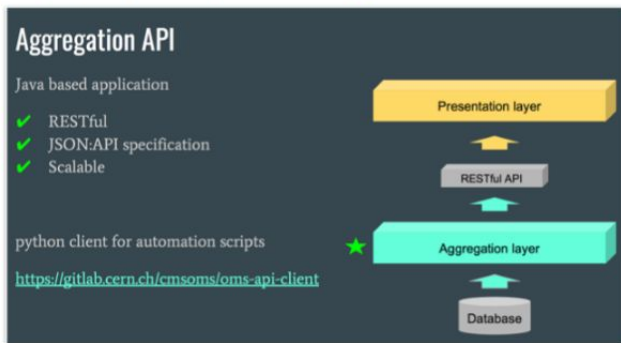


- Pixel database with pixel detector components
- Known problems stored in database
- Known problems are marked on occupancy plots of layers and rings

Detector monitoring pages

OMS and TOM data

- CMS OMS provides a stable, centrally-managed monitoring GUI for Run-3
 - test possible integration of data provided by TOM
 - need to export data via aggregation layer:

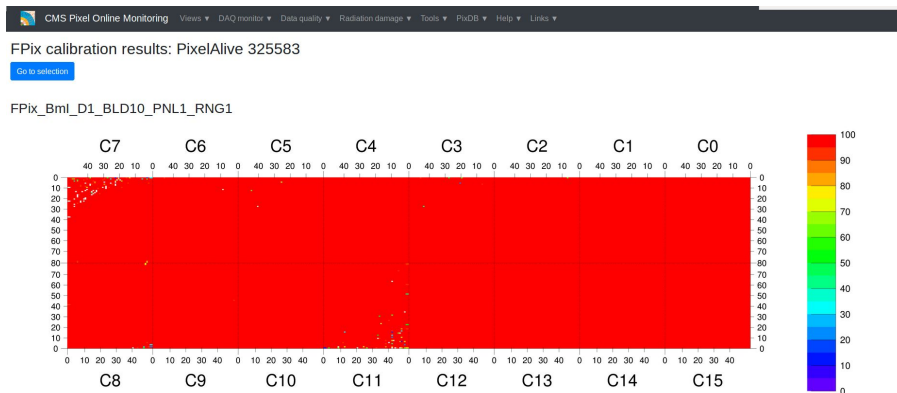


[See also here](#)

[From Viktor Kutzner](#)

New centrally developed framework for online monitoring: OMS

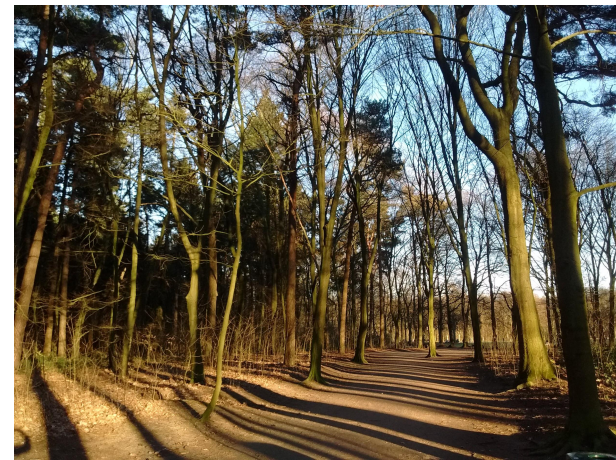
Still unsure whether this provides all features that our tracker online monitoring (TOM) has like our calibration display:



You can contribute to CMS pixel!

You can:

- Characterize phase 2 sensors in DESY test beams
- Improve data acquisition software
- Operate and improve test setups
- Test CCUs in the lab
- Investigate per pixel soft error recoveries with dead and noisy pixel trends
- Investigate leakage currents vs z
- Investigate particle rates and fluence vs z
- Simulate radiation damage
- Measure depletion voltage and charge collection efficiency in the lab
- Simulate and predict depletion voltages and leakage currents in the endcaps



Note: this list is not exhaustive!
And unpredictable events can expand this list anytime =>