Status report from the Tracker DPG Group

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Tracker General meeting

Recap of the past period

- Since the last Tracker General talk (link) we had
  - Several software developments
  - Installation of the pixel detector
  - Commissioning work for both pixels and strips
  - Condition preparation for data taking
  - Preparation for Run-3 MC campaigns
  - Joining CRUZET global runs

- In this talk, current status, developments and plans will be presented

Pixel detector

Calibrations – Local reconstruction

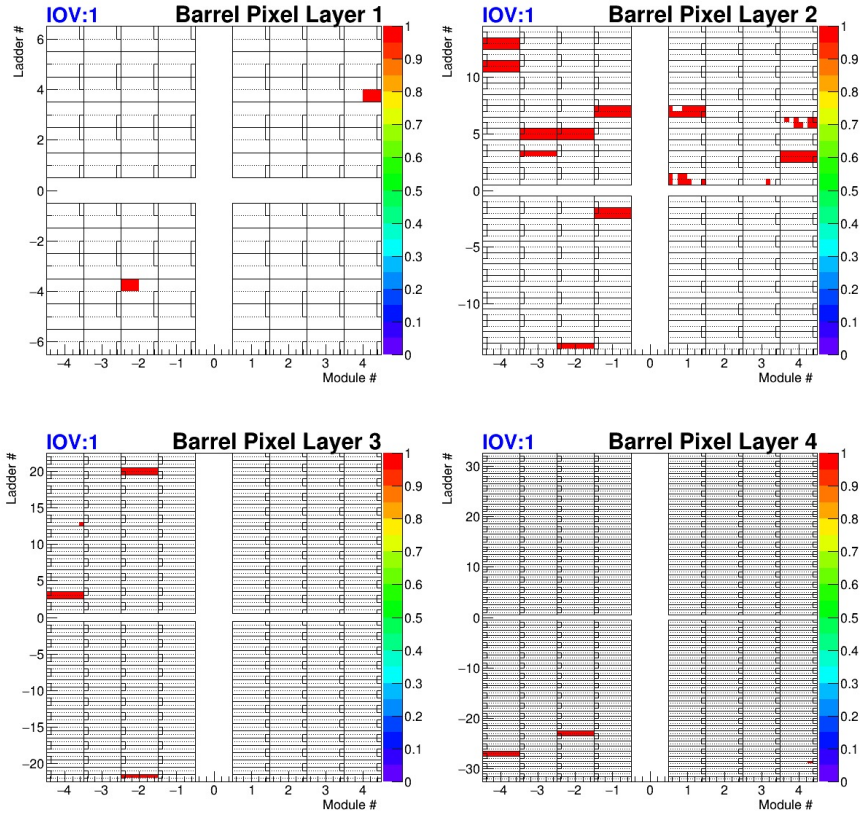
- Changes in the detector:
  - L1 was replaced with new modules and improved ROCs (operated at 150V)
  - L2 has 8 new modules (everything operated at 300V)
  - L2 old and L3/L4 + FPix have been annealed since the end of Run-2
- Annealing will improve E-field profiles by an unknown amount but will not improve the signal trapping rates
- However, CRUZET is very insensitive to E-field profiles and only slightly sensitive to signal trapping
  - We can use the 0T calibrations for new detectors

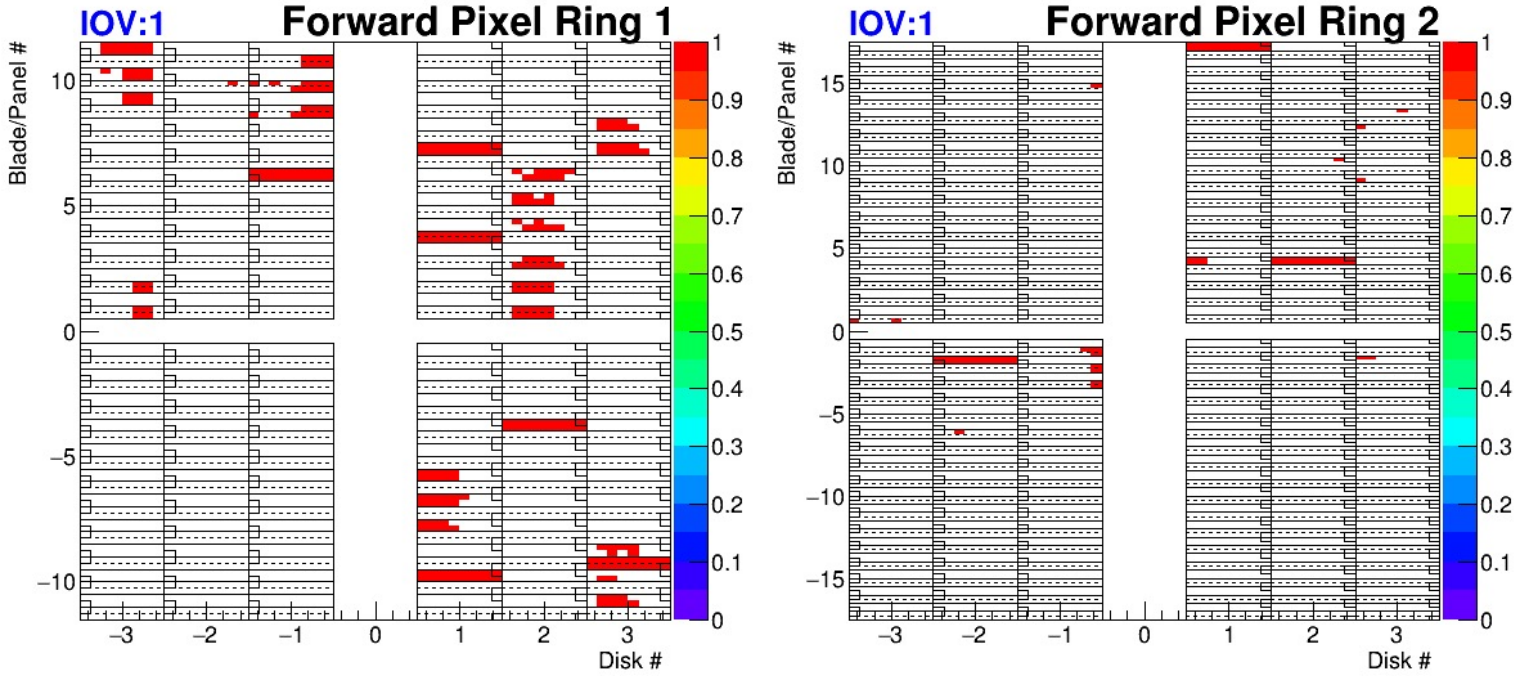
New models were created for L1 and new L2 modules, while for the rest the 2018 v9 models were reused

Calibrations – Latest bad ROC list

Modules recognized as bad from commissioning
plus **selected ROCs** from the DCDC problem

SiPixelQuality_phase1_2021_v1_mc



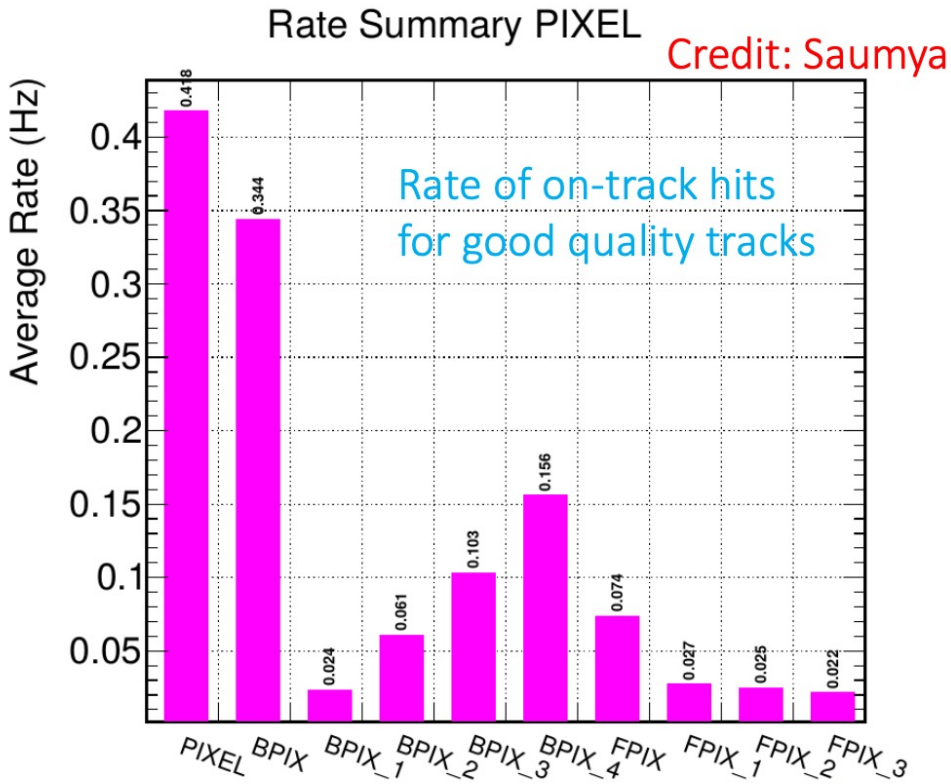


- *BPIX: Total bad #ROCs: 176, percentage: 0.6%*
- *FPIX: Total bad #ROCs: 146, percentage: 1.4%*
- *Total percentage: 0.8%*

Calibrations – Gain calibrations and timing scans

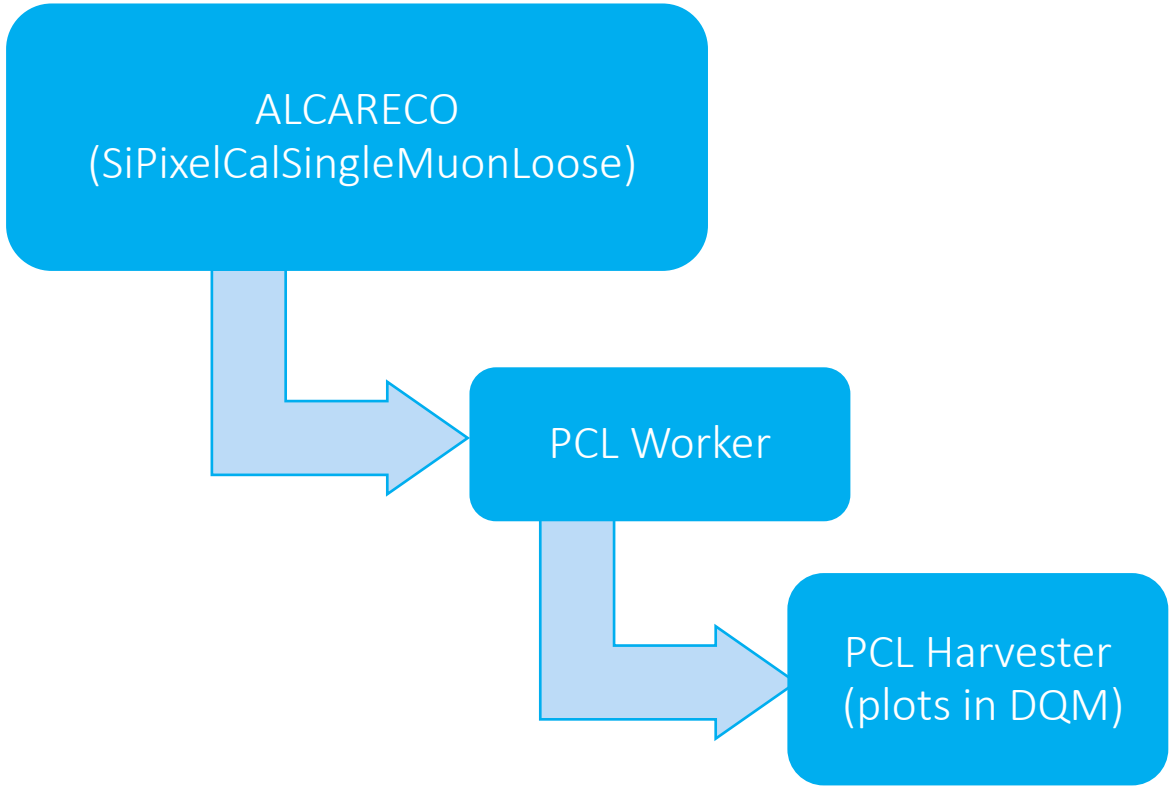
- Gain calibrations
  - Change in the method: factor out the VCal calibration to better handle the radiation damage in the chips
  - An old gain calibration was redone and is currently being used
  - New gain calibration to be taken

- Timing scan
  - After the new gain is appended, we will carry out a coarse timing scan
  - Goal: ~6 ns relative alignment
  - Estimate time to collect enough statistics: ~1 week (~12 h per scan point)



Monitoring – Lorentz Angle and Templates

- Ongoing project about including the LA monitoring in the PCL workflows
  - ALCARECO is done
  - LA measurement more in line with Morris' methods
- Expect several updates with templates
  - first from estimation for CRAFT,
  - then a tuning from CRAFT data,
  - realistic modelling with the 900 GeV collisions

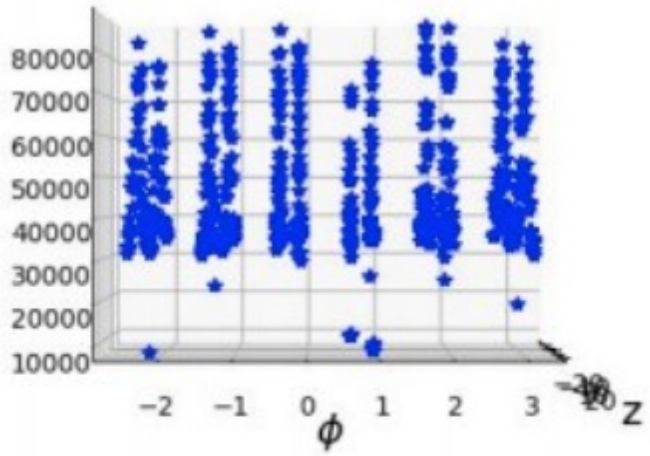


Monitoring – Tracking independent beamspot

- Goal to measure beamspot using only L1 pixel occupancy
- Next steps are to test robustness to pileup, benchmark precision of method

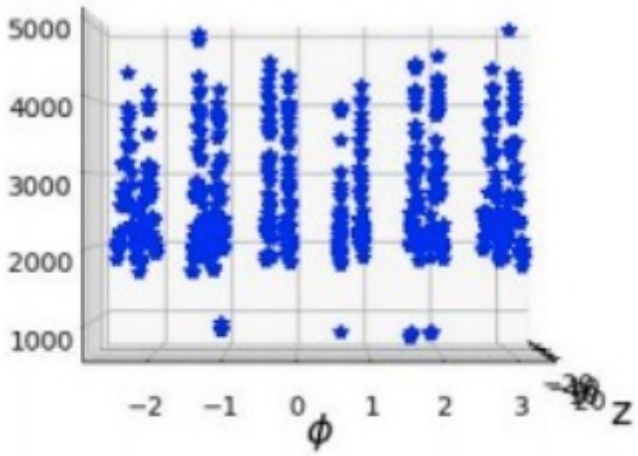
SingleMuon

Pixel Occupancy



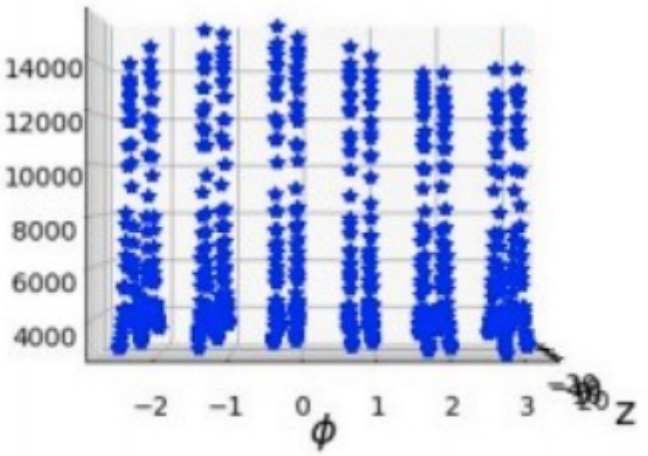
ZeroBias

Pixel Occupancy



TTbar, z-smeared

Pixel Occupancy



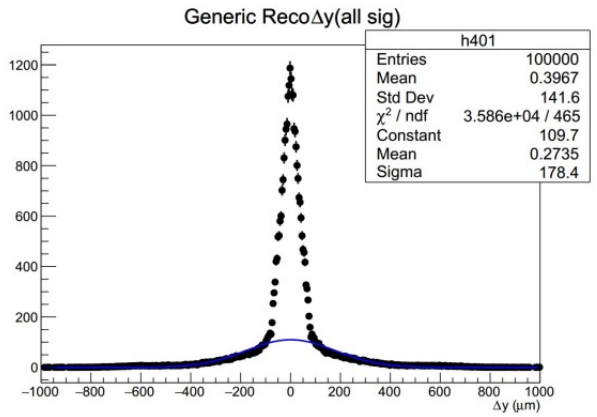
Ongoing development – Cluster healing + Repair

- Cluster healing: New clustering algorithm to recover split clusters caused by 2024 radiation damage (about 10% of the clusters)

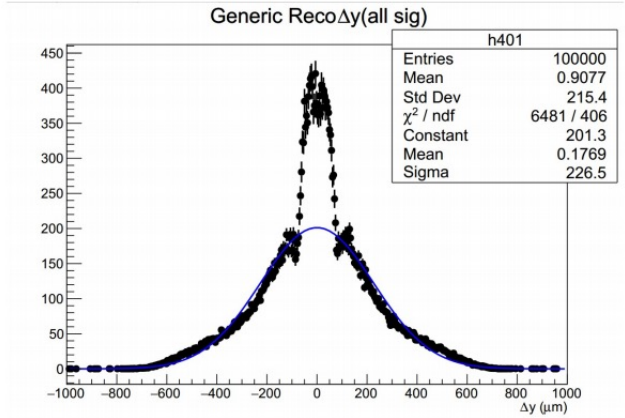
- Steps:
  - Reserve one bit for flagging individual pixels
  - Run morphing to flag which clusters are broken
  - Feed this information into Cluster Repair

- Initial studies show the resolution worsen after morphing, which was due to CPE not being trained with Cluster Healing => now fixed

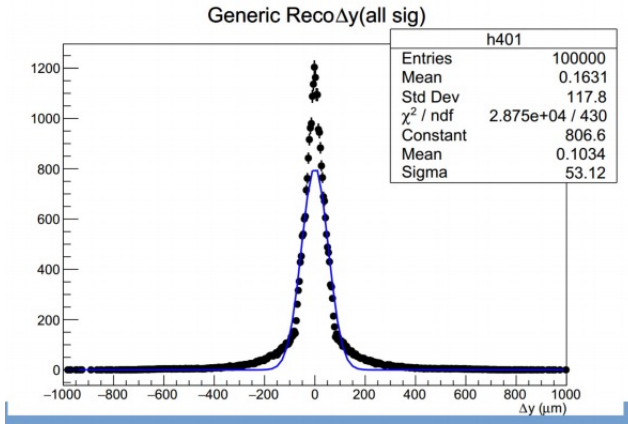
No CH, yes IBC



Yes CH, no IBC



Yes CH, 'old' IBC



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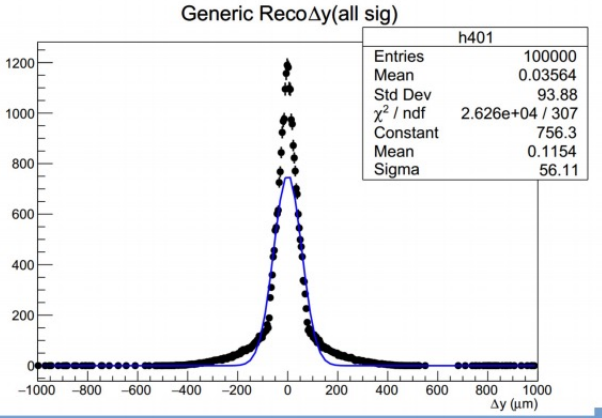
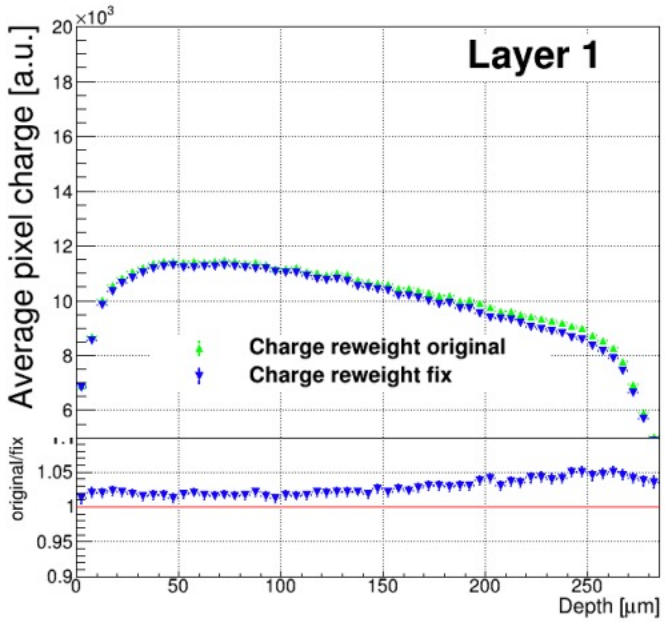
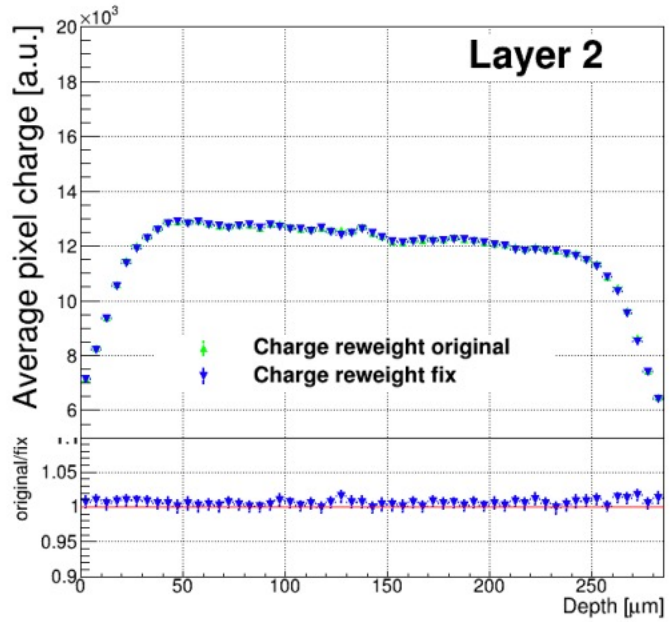


Ongoing development – Charge reweighting

- Run-dependent MC will only use one PREMIX library, so we need to move the charge reweighting to a later step in the simulation
- Ongoing development to do this by adding a needed info (entry and exit points and angles)





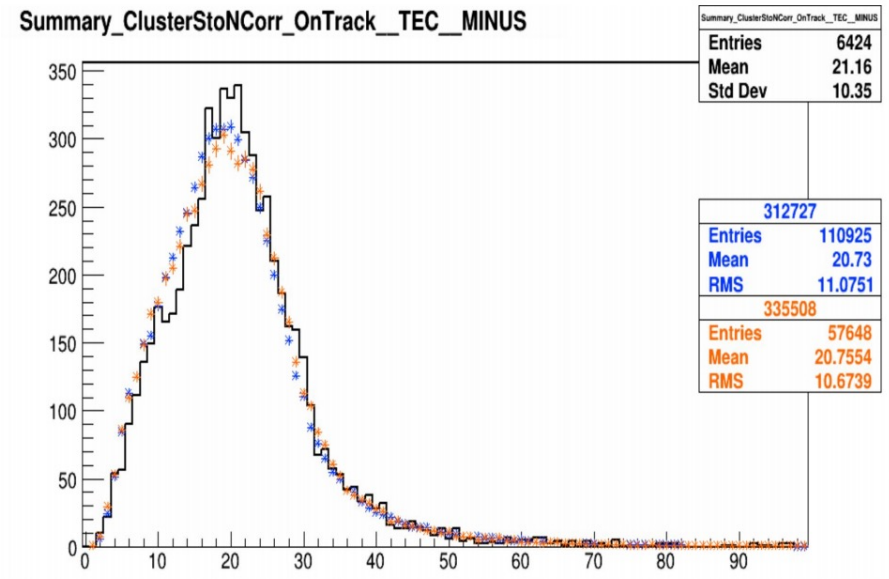
- Updated pixel charge reweighting strategy for secondaries
  - The original strategy for the case of a non-Primary particle is to use the first hit of the collection for that detID.
  - In general this hit has no overlap with the cluster and the CR is not applied.
  - The new strategy for the case of a non-Primary particle is to search for the primary hit with same trackID and use it for the CR. In case no such hit is found, then use the first hit of the collection for that detID, as in the original strategy.
  - The Consequence: The new strategy allows to apply CR in more cases than with the original one -> a lower averaged value of the charge and more digis in total.

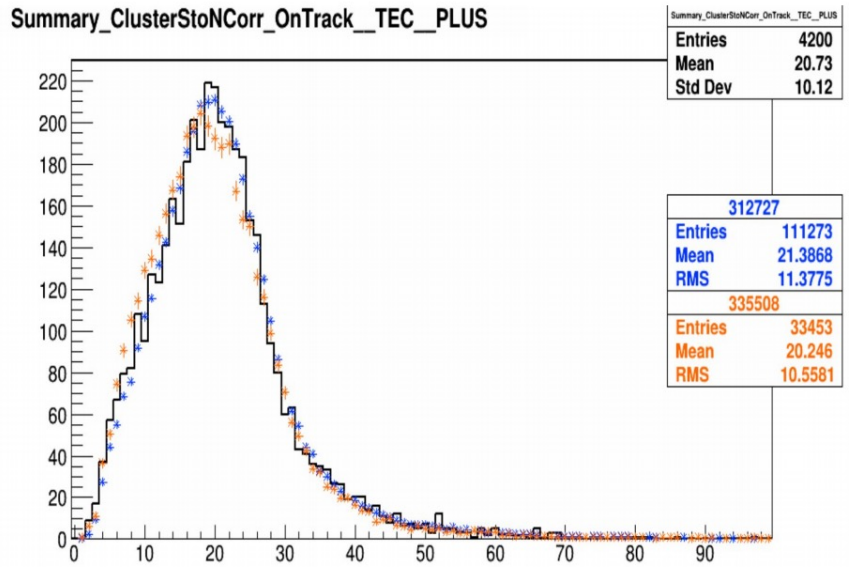
Strip detector

Calibrations – Commissioning

- Calibrations happening this week
- Most processes are automated, PCL and O2O populates the conditions

- G2 is one of the payloads that needs manual update, but that wont happen until significant amount of collision data is collected



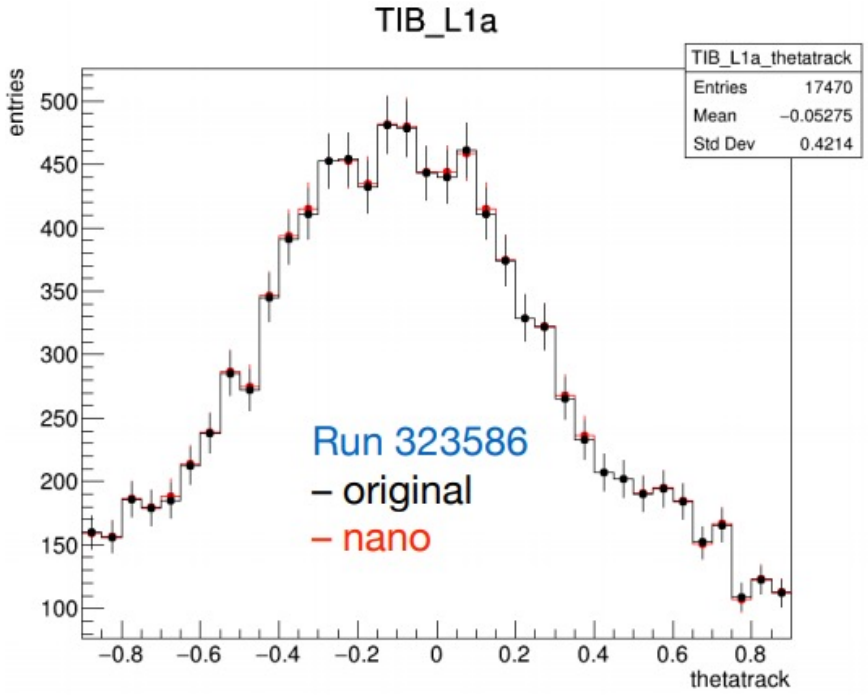


- First run with TEC in
- S/N plots look great

Ongoing development – Calibrations

- Calibration trees based on NanoAOD framework
  - Validation ongoing for cosmics
  - Other trees in progress
- Integration of hit efficiency and resolution monitoring in DQM infrastructure ongoing
- Update of resolution measurement to check the CPE parameterization
  - Good agreement between data and MC full report

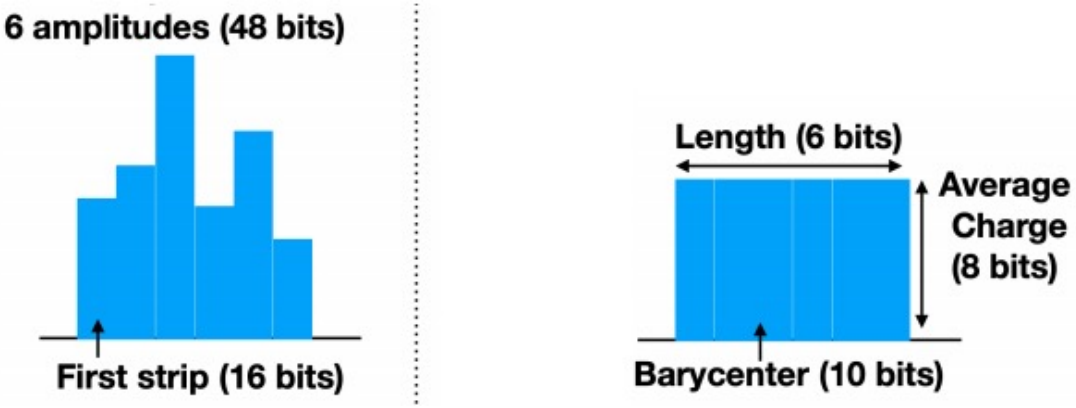
Detector Group	Cluster Width Per Ring	2018 RunD Data Resolution [μm]	MC RelValZMM_14 Resolution [μm]
TID	1	38.4431 ± 0.306784	41.8329 ± 0.353971
	2	33.5724 ± 0.234419	34.82949 ± 0.2456182
	3	32.6713 ± 0.221445	35.9445 ± 0.2610349
TEC	1	33.2137 ± 0.23018	32.40530 ± 0.213093
	2	33.6201 ± 0.234144	35.5901 ± 0.255617
	3	32.7046 ± 0.22288	34.80979 ± 0.2461010
	4	32.5086 ± 0.220023	34.0128 ± 0.2346629
	5	32.3735 ± 0.217964	33.4756 ± 0.2268869
	6	33.5567 ± 0.233122	36.09471 ± 0.26318
	7	33.8044 ± 0.236057	32.3485 ± 0.212334



Ongoing development – Local reconstruction

- Unpacking and clustering on GPU:
  - Implemented, and largely validated.
  - A PR is expected soon, see also the latest report

- Reduced cluster format for heavy ion data taking:
  - Under development by the HI group
  - Several approaches under evaluation (reports here and here)



Strip Cluster Kernel Timing, TTbar PU 50-75

Operation	Time (µs/event)	Sum
memcpy HtoD	219	
memcpy DtoH	284	
		503
unpackChannels	90	
checkClusterCondition	37	
findLeftRightBoundary	21	
setSeedStrips	15	
setNCSeedStrips	20	
DeviceScanKernel	10	
setStripIndex	9	
		202

Alignment

Calibrations – Tk alignment errors

- It is usual to increase the tracker alignment errors (APE) when we are in the beginning of the cosmics data taking in order to mitigate misalignment effects that can sensibly reduce the track reconstruction efficiency.

- The TkAlignment team proposed to reuse the the tag used in beginning of 2017 (so the tag is tested, no need for validation):
  TrackerAlignmentExtendedErrors_BPIX500_FPIX500_TIB20_TOB20_TID40_TEC40
  - It was append it to the relevant multi-IOV tags

- Will need to be reduced as soon as the alignment performance allows.

Plans for Cosmics

- First derivation tracker alignment calibration as soon as a few runs (0.5M CRUZET) in stable conditions have been collected after gain or timing scans have been performed
- Expect successive refinements as more data is being collected.

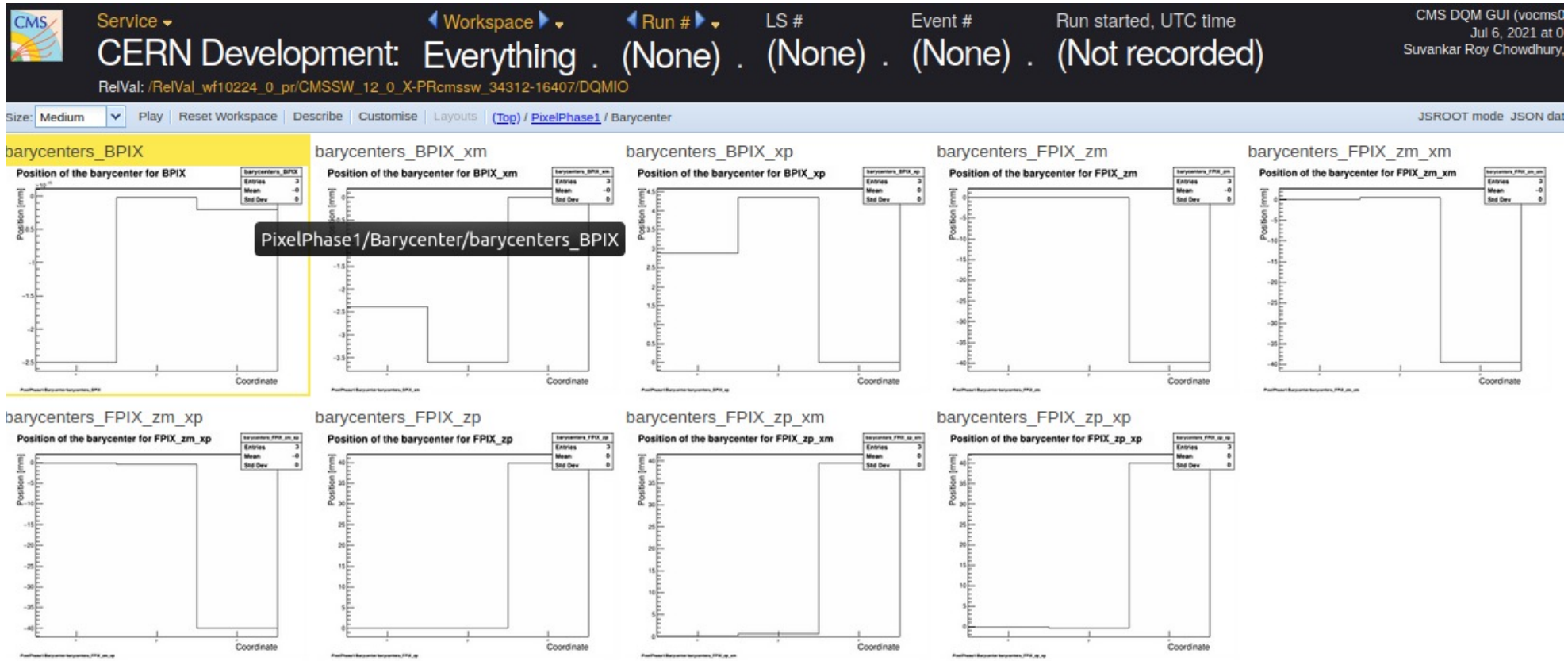
- The surface deformations might be updated once we have enough statistics to perform module-level alignment (likely only for the pixel), namely close to the end of CRUZET.

- During CRAFT tracker alignment record will be updated to correct for possible movements induced by the B field change

- More info here

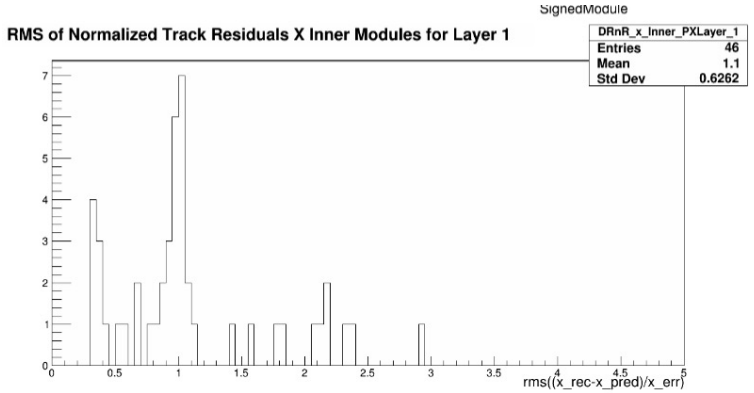
Monitoring – Pixel Barycenter plots

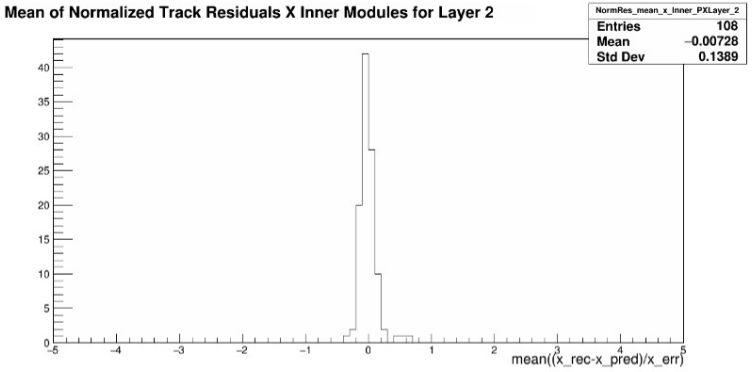
- Nine histograms have been added showing the barycenter derived from BPIX, BPIX(x-), BPIX(x+), FPIX(z-), FPIX(z+), FPIX(z-,x-), FPIX(z-,x+), FPIX(z+,x-), FPIX(z+,x+).

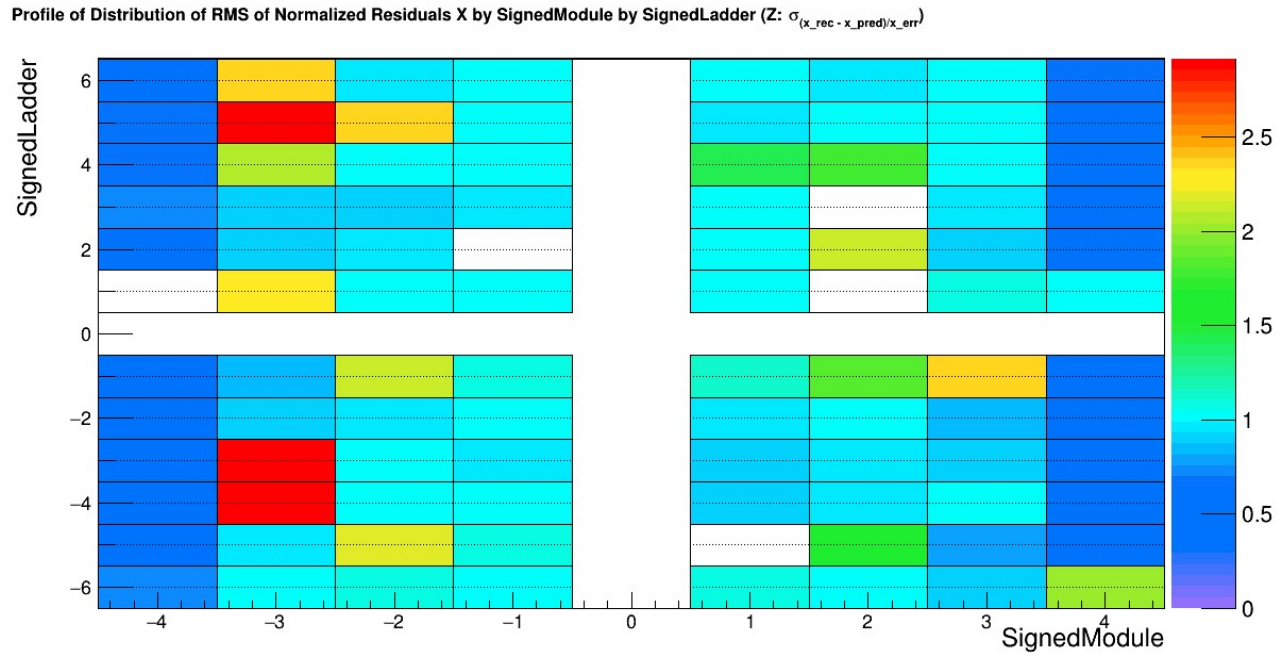


Monitoring – Monitoring of DRnR

- Plots added:
  - 2D Map of the DRnR by module by layer/ring
  - 1D DRnR for each layer/ring divided by inner/outer module
  - 1D mean of Norm. Residuals for each layer/disk divided by inner/outer
  - All the Normalized Residuals distribution (by layer/disk/ring etc…)



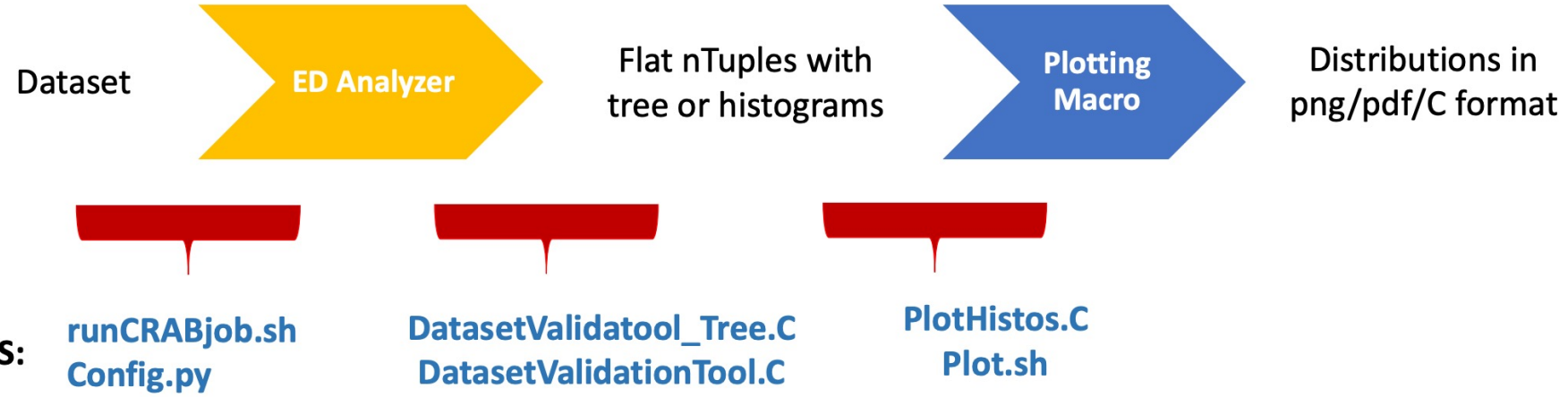




Ongoing development – Validation

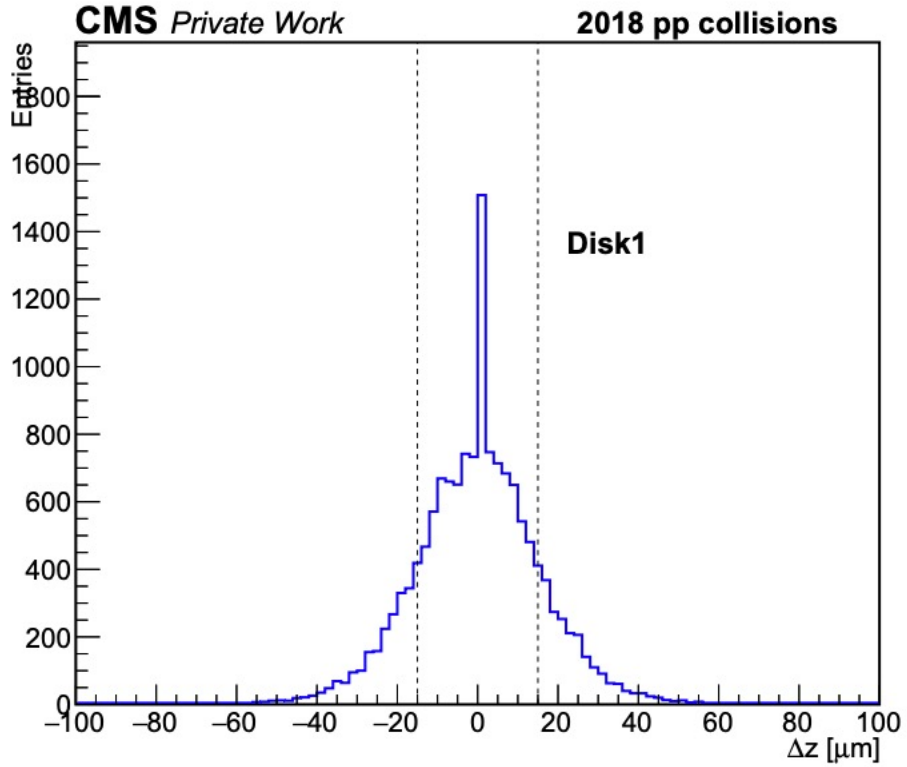
- Introduce new common, more user-friendly interface for all standard validation tools
  - DMR, PV, geometry comparison, track split, split vertex validation ported
  - Z(μμ), Jet HT, overlap ongoing
  - Dataset validation tool ongoing
  - More info here and here

- **Workflow:**



Ongoing development – HG PCL

- High granularity PCL to absorb radiation effects during data taking and replace manual HG alignments after new pixel calibration
- Now working on tuning of thresholds for the update and veto of too large movements
- Histograms show movement of each ladder/panel for all alignments in the study
  - Vertical dashed lines show thresholds used to trigger new alignments in LG PCL
  - This is now used for the HG PCL too
- HG PCL shows significant improvement in DMR validation compared to LG PCL
- ⇒ Unlike LG PCL, the HG PCL alignment seems to be able to correct ”bad” starting geometry after one run



More info here

Ongoing development – LA from alignment

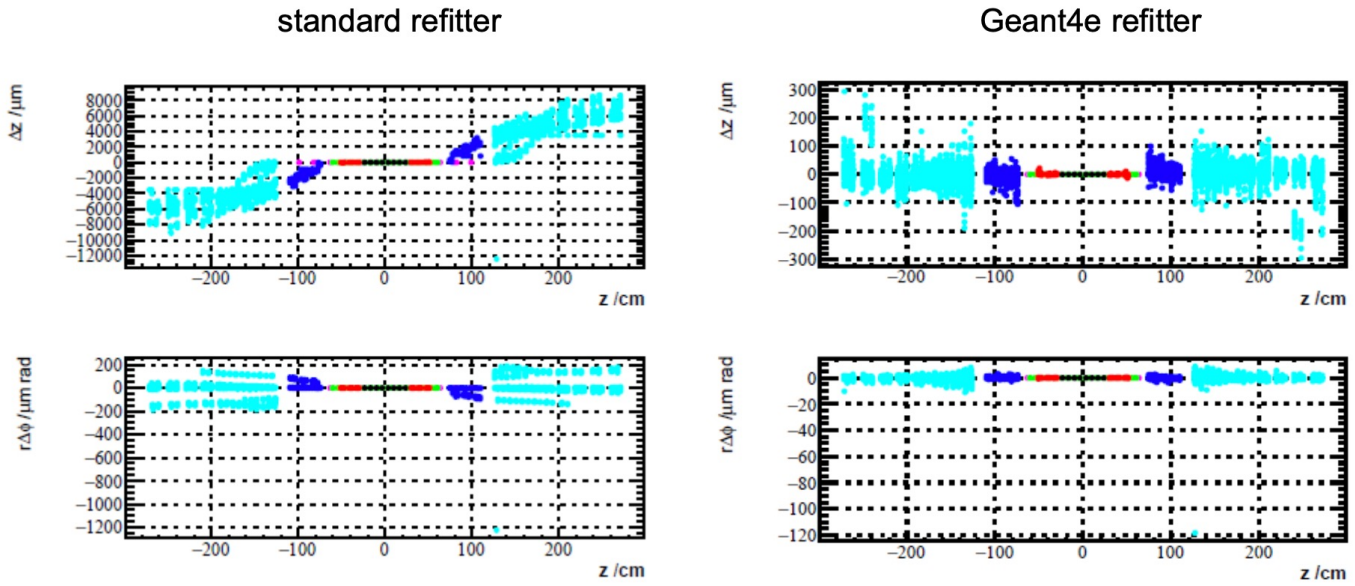
- Determine the Lorentz angle parameter from the alignment fit
  - Alignment sensitive to shifts Δμ in DMR
  - In Legacy alignment, changes of LA absorbed in HG alignment of the pixel HLS
  - Test if this can be avoided when adding the dedicated LA parameter
  - Cross-checks ongoing with 2018 Legacy campaign w/o LA parameter,

I would like to have a plot here

Ongoing development – Better fits

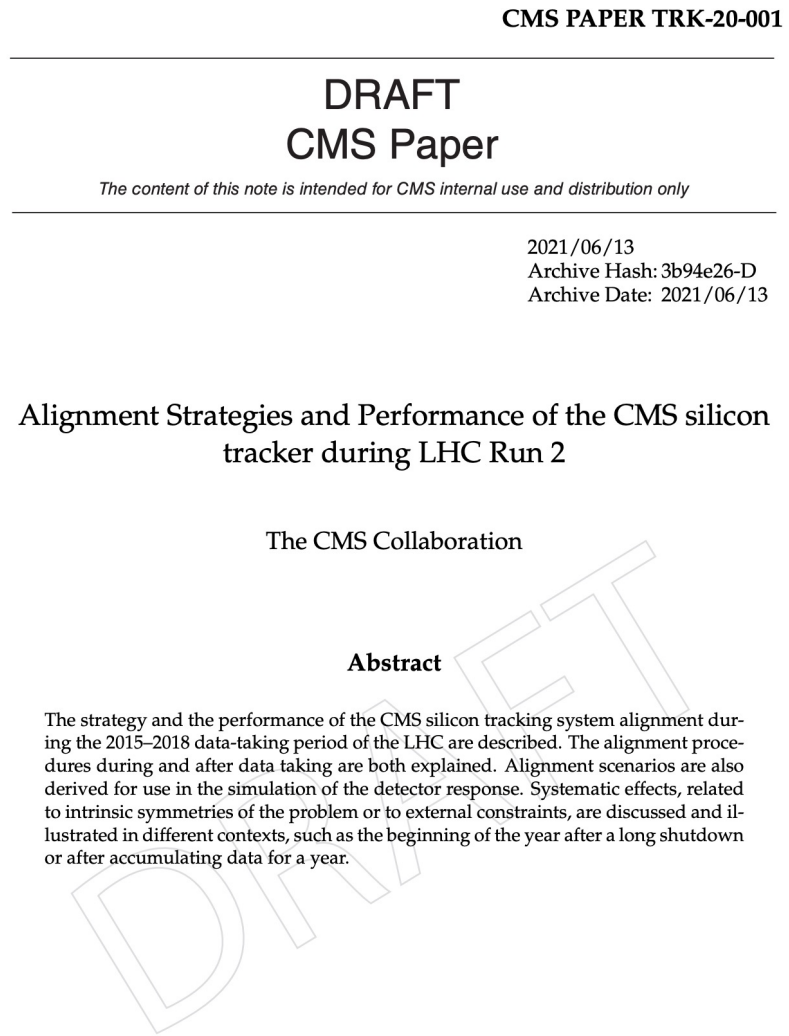
- Employ external linear algebra library fullLAPACK in Millepede fit
  - Approximate method was used so far for huge problems (npar >>10k)
  - Exact solution with fullLAPACK using Cholesky decomposition is studied (more info here)

- Use Geant4e refitter in the context of weak modes and bias
  - Both twist and z expansion disappear
  - Performance studies in real data alignment campaign ongoing
  - Remaining failures with alignment fit being investigated, see talk



Run 2 Performance Paper (TRK-20-001)

- "Alignment strategies and performance of CMS silicon tracker during LHC Run 2"
  - Approval on April 29th
  - Latest draft uploaded on June 13th
  - First round of ARC comments implemented
  - Targeting second round by end of August
  - Link to CADI line



CMS PAPER TRK-20-001

DRAFT
CMS Paper

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2021/06/13
Archive Hash: 3b94e26-D
Archive Date: 2021/06/13

Alignment Strategies and Performance of the CMS silicon tracker during LHC Run 2

The CMS Collaboration

Abstract

The strategy and the performance of the CMS silicon tracking system alignment during the 2015–2018 data-taking period of the LHC are described. The alignment procedures during and after data taking are both explained. Alignment scenarios are also derived for use in the simulation of the detector response. Systematic effects, related to intrinsic symmetries of the problem or to external constraints, are discussed and illustrated in different contexts, such as the beginning of the year after a long shutdown or after accumulating data for a year.

DQM

Plans for Cosmics

- Operations mode with full remote shift crew (leader + shifter + on-calls [usign the new Cern Phone app])
- In order to train newcomers and also to serve as a refresher to experienced shifters, TkDQM had organized two tutorials.
  - One was dedicated to Certification Helper usage (link)
  - The other was a basic shift tutorial explaining the roles of shifters and shift leaders (link)
  - Video recording of each tutorial is available on the indico page
  - In order to give a flavor of the day to day activities during data taking
  - We encourage colleagues to be a take a look at the tutorials and come back to us with suggestions to improve.
  - Remember, we shall need a much bigger crew to operate in 2022.

Conclusions

Conclusions

- Our activities are focused on the upcoming operations
- Several developments are also ongoing for both CMSSW software and the tools needed

Backup slides