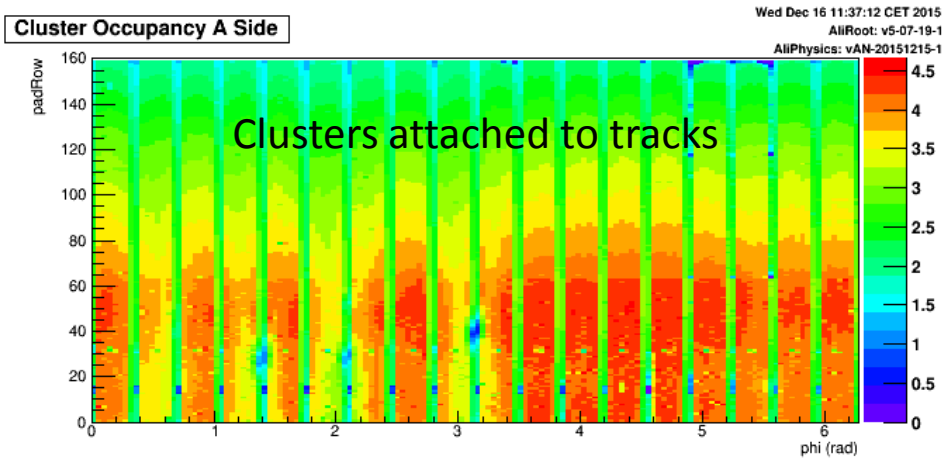
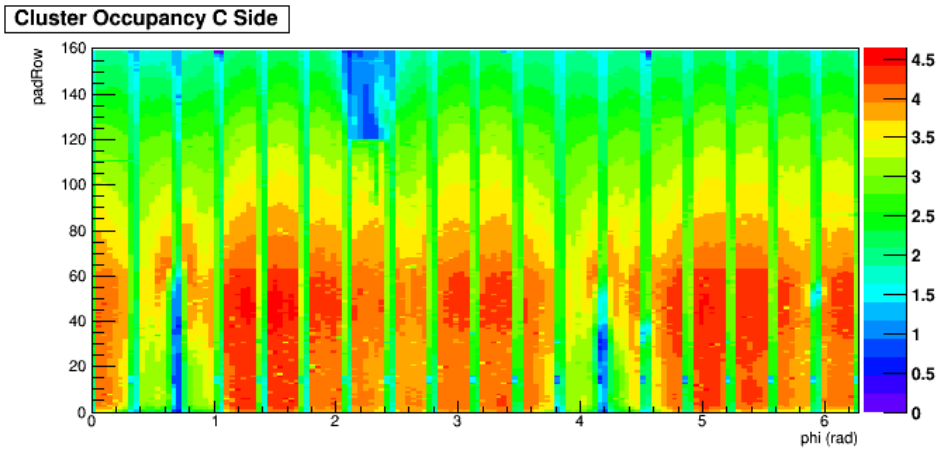
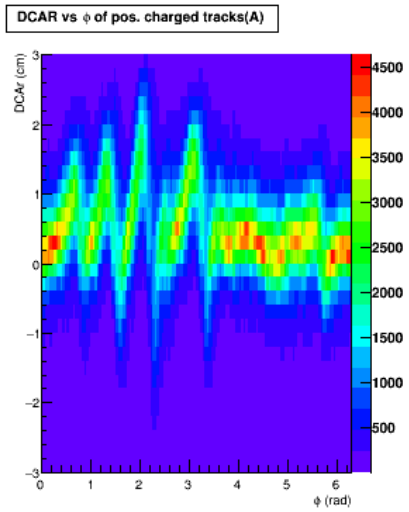
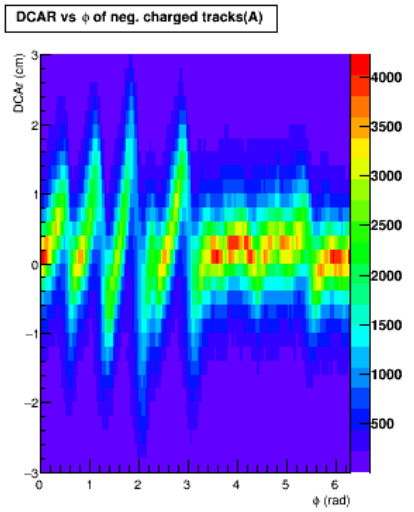
TPC distortions correction
and
readiness for 2015 data processing

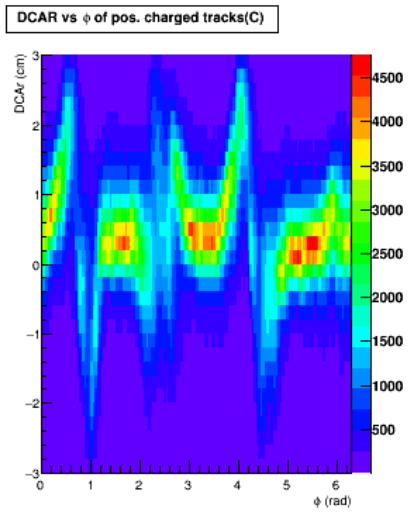
PbPb, 245231, 5.5 kHz

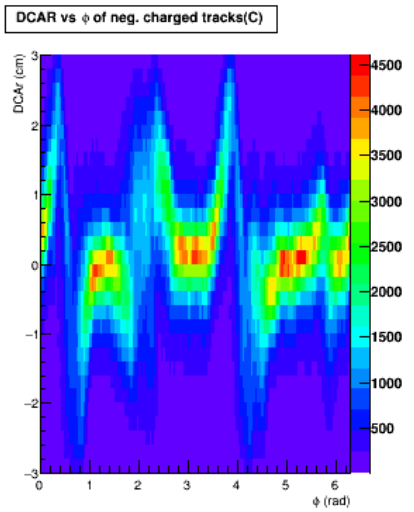






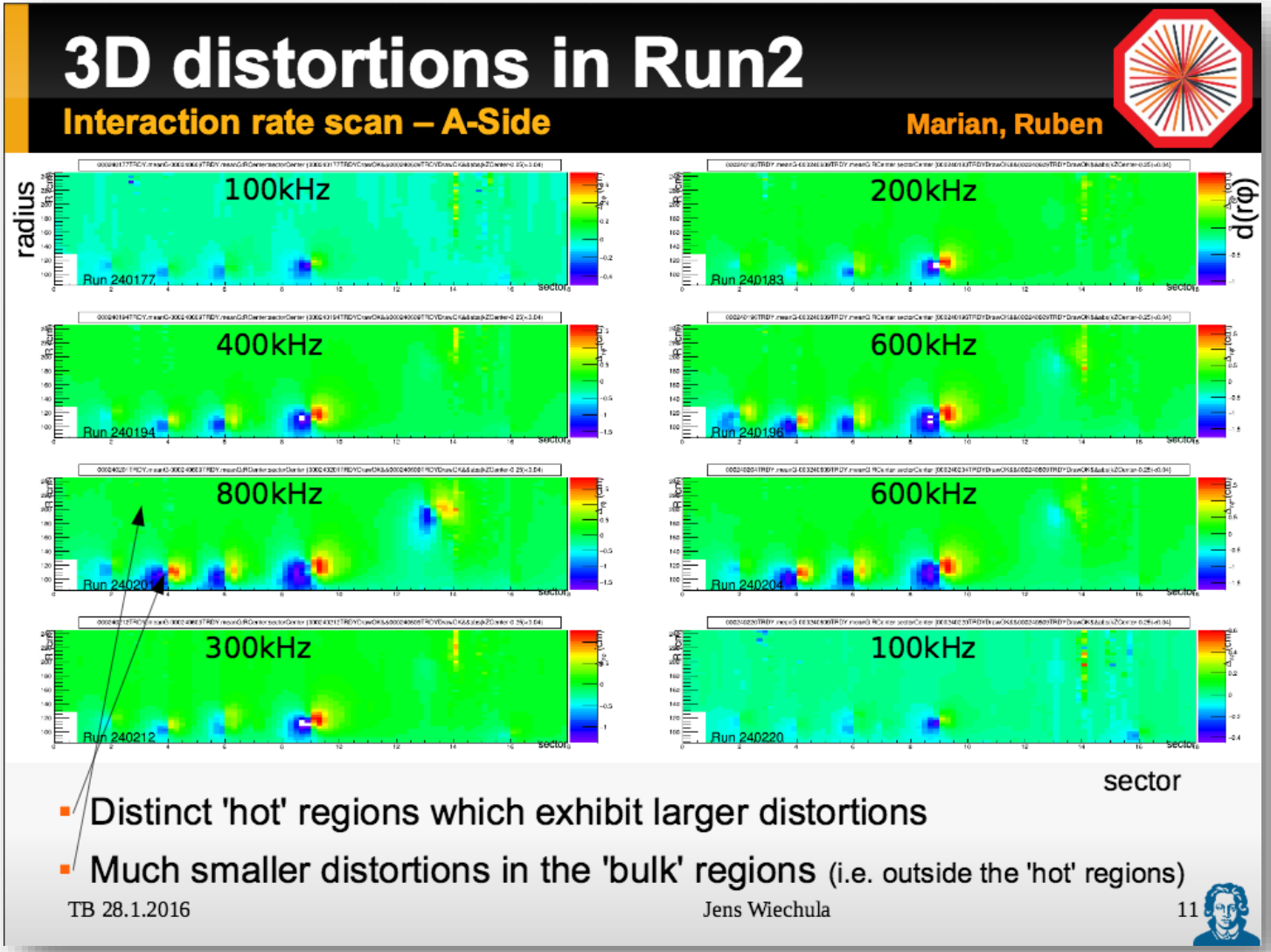






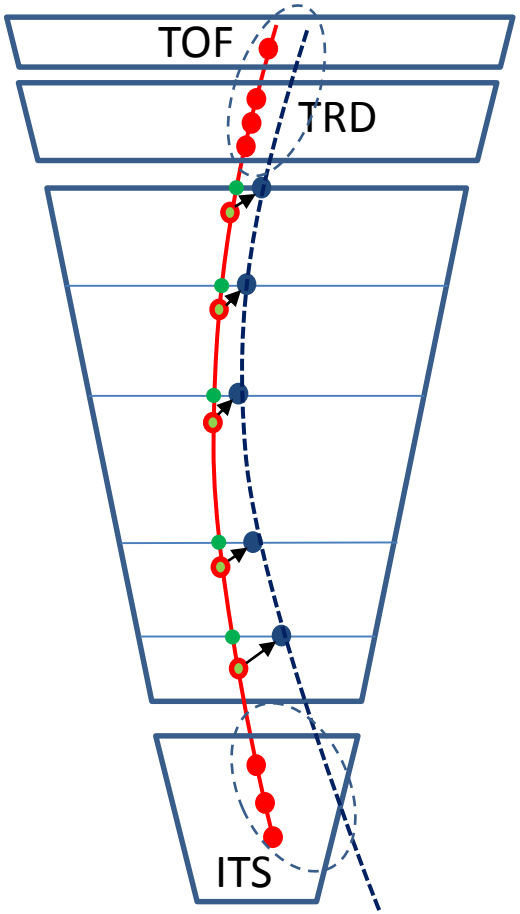
- ❑ Strong (up to 5cm) distortions in TPC cluster position leading to
  - TPC track loss and shortening
  - Distorted extrapolation to vertex ⇒ ITS matching degradation
- ❑ ~3.5-4 stronger than expected from Run1 extrapolation
- ❑ **See detailed presentation at TB (J.Wiechula) on systematics and possible origins**

Interaction Rate Scan, pp LHC15l



- Bulk distortions as expected for Ar – CO_2
- Excess in the hotspots on the sector edges

Outline of the correction method:

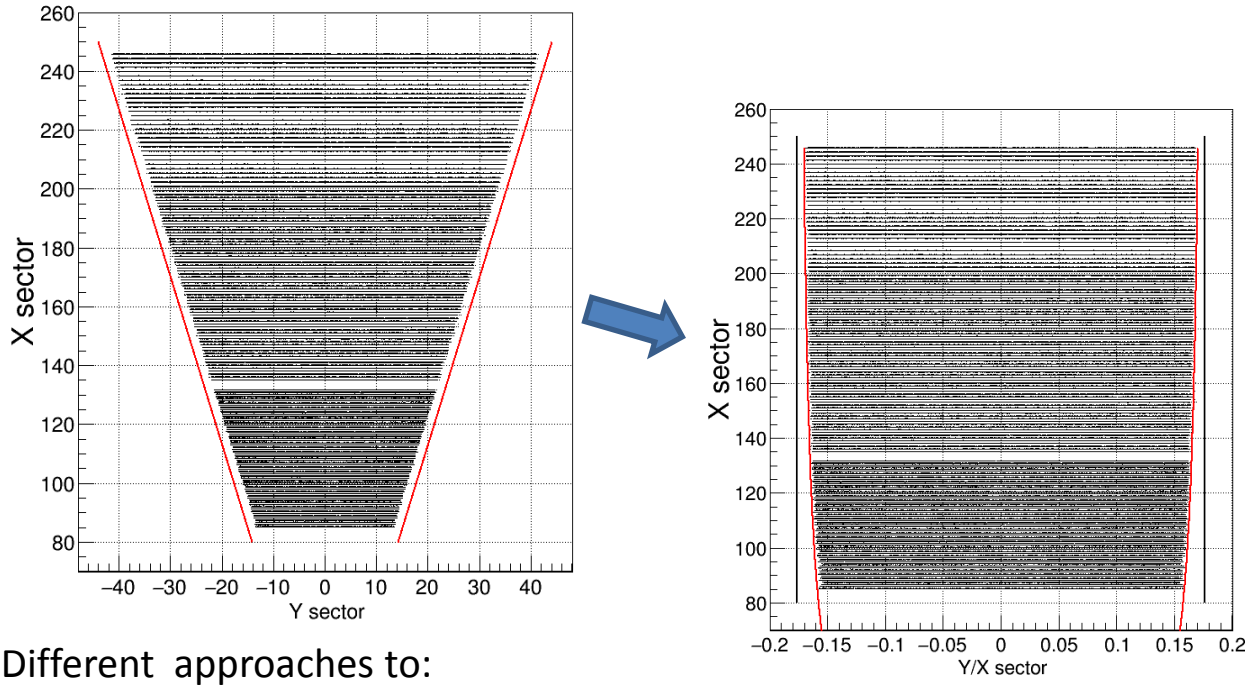


- Reconstruct TPC with large road-widths to not loose TPC clusters attachment
- Match to ITS and TRD/TOF with relaxed tolerances
- Refit ITS-TRD-TOF part and interpolate to TPC as a **reference** of **true track** at every pad-row (good alignment is prerequisite!)
- Collect Y, Z differences between **distorted clusters** and **reference** points in sub-volumes (voxels) of TPC
- Extract 3D vector of distortion in every voxel
- Create smooth parameterization (OCDB object) to use for correction during following reconstruction

- Distortions change with time (interaction rate): do this procedure in short time intervals (~20 min)

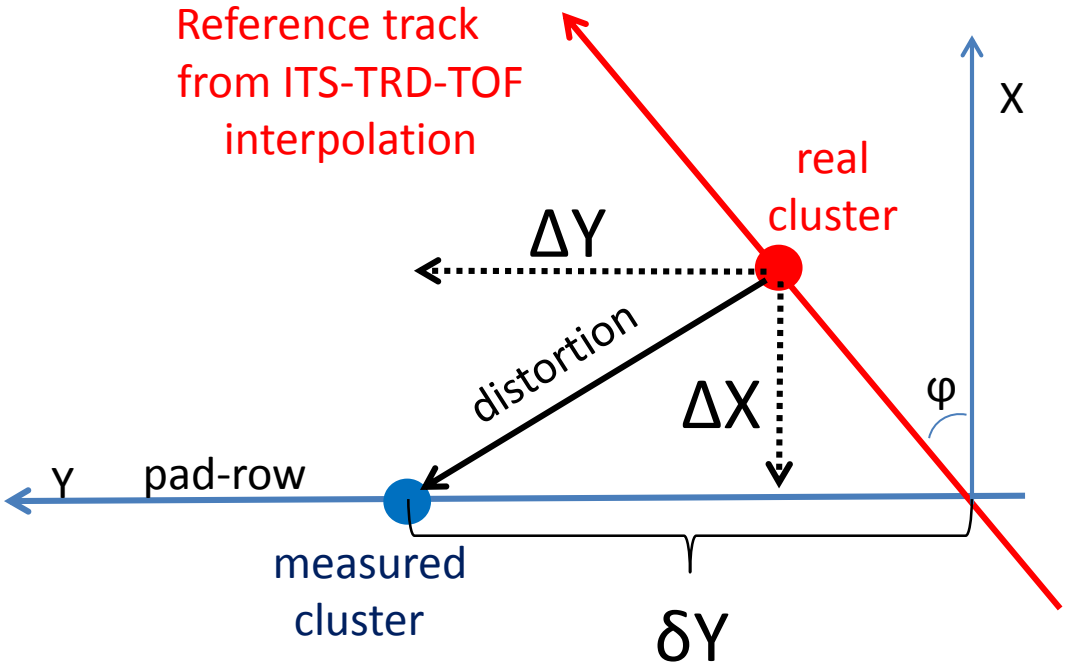
- Procedure planned for Run3 SCD corrections, developed since October for Run2
- Recently split to 2 alternative implementations

Binning in sector coordinates X, Y/X, Z/X
≃190K voxels for TPC acceptance volume



Different approaches to:

- radial distortions extraction
- sector edges description: including dead zones into binning with “smoothing” between the sectors
  vs
  X-dependent Y/X ranges to exclude dead-zones, no attempt to describe distortions w/o data
- smoothing: piece-wise parabolic (from kernel smoothed estimate) with additional smoothing by constraints on bin boundaries
  vs
  point-by-point kernel smoothing difference in radial distortions extraction



$$\delta Y = \Delta Y - \Delta X\, tg(\varphi)$$

$$\delta Z = \Delta Z + \Delta X\, tg(\lambda)$$

We measure Y distortion δY as a difference between track intersection with pad-row and measured cluster
□ strong bias due to the X distorions

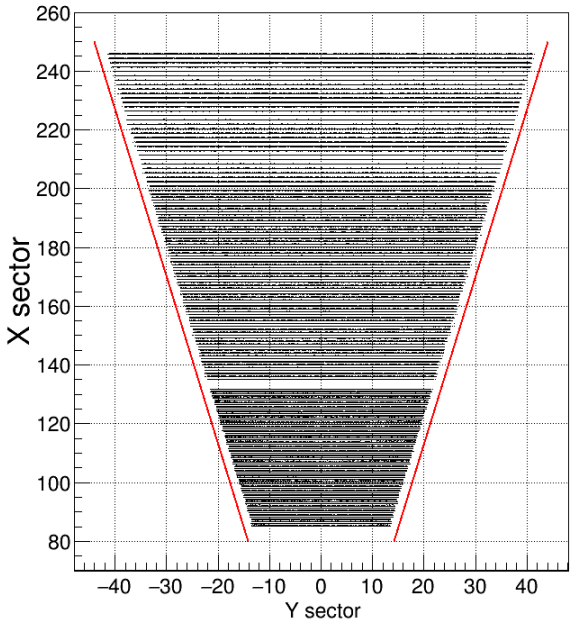
Same space $\{x,y,z\}$ point is probed by tracks at different inclinations φ wrt sector axis but with single dip anlge □
" deconvolute real ΔX and ΔY distortions using δY dependence on tg(φ) then extract Z distortion

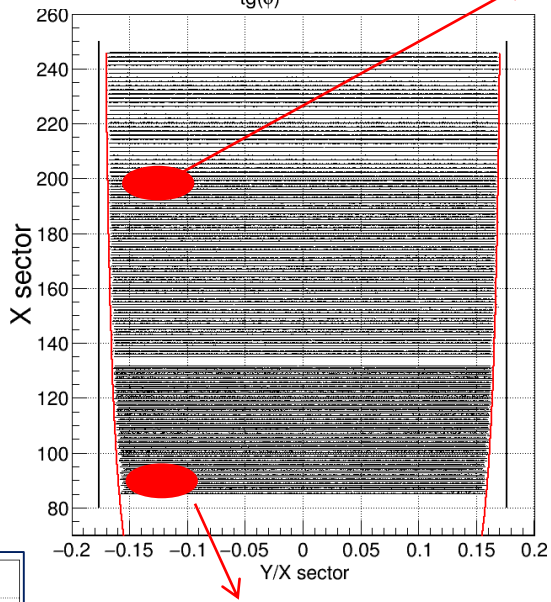
$$\sin(\varphi) = \tfrac{1}{2}\left(y\sqrt{4/r^2 - c^2} + c\,x\right)$$

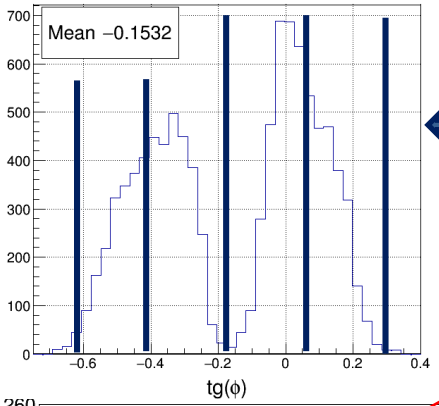
$$c = -k\,B_z\,q/\,p_T$$

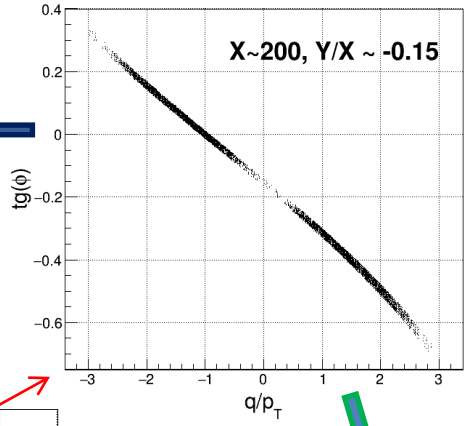
(for primary tracks)

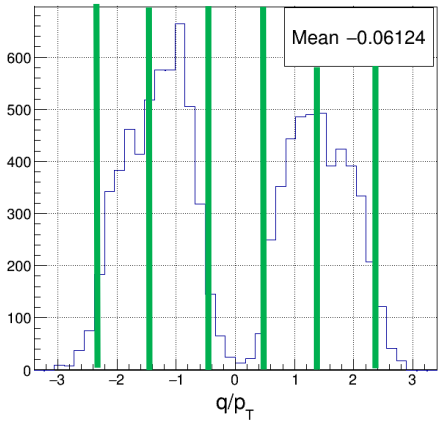
On top of geometric binning bin in track inclination: **q/pT** or directly in **tg(φ)**
(position dependent bins)

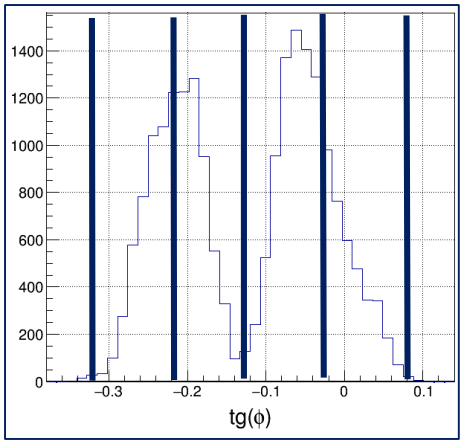


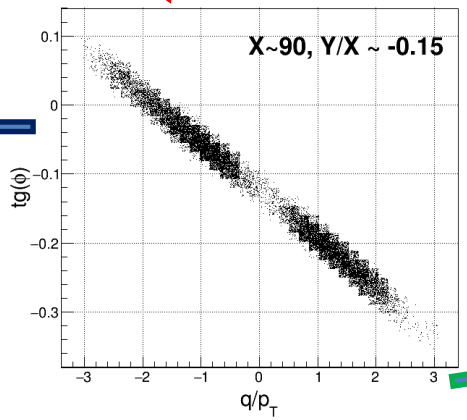


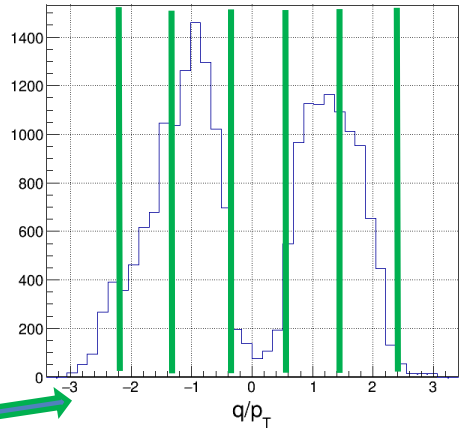






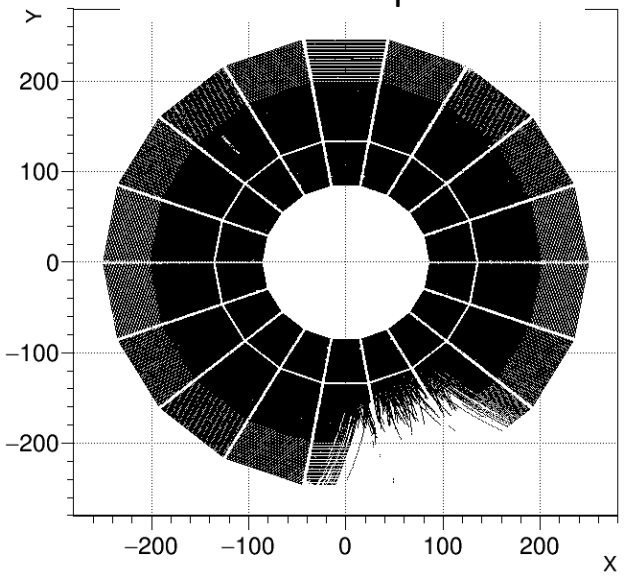




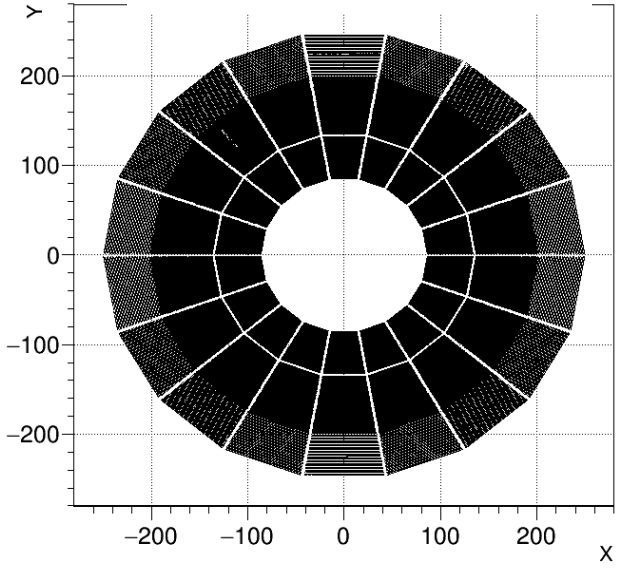


Part of volume cannot be covered by the reference ITS-TRD-TOF tracks (PHOS-hole)

ITS-TRD interpolation

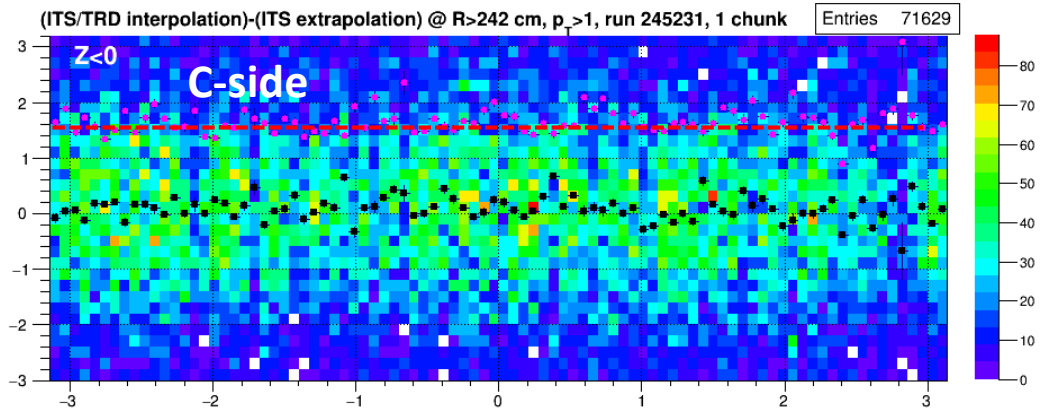


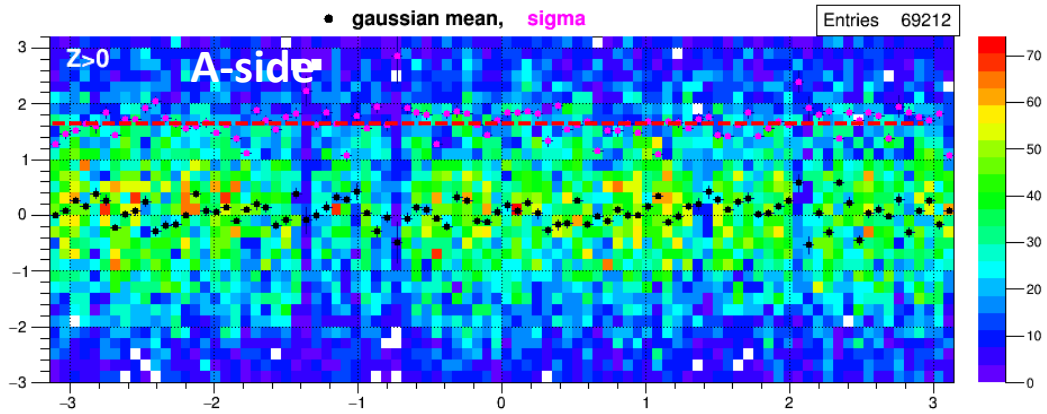
ITS extrapolation



ITS sees whole volume but:

- extrapolation precision is bad (>1.5cm) at large R (could be compensated by larger statistics)
- risk of amplification of residual angular misalignments

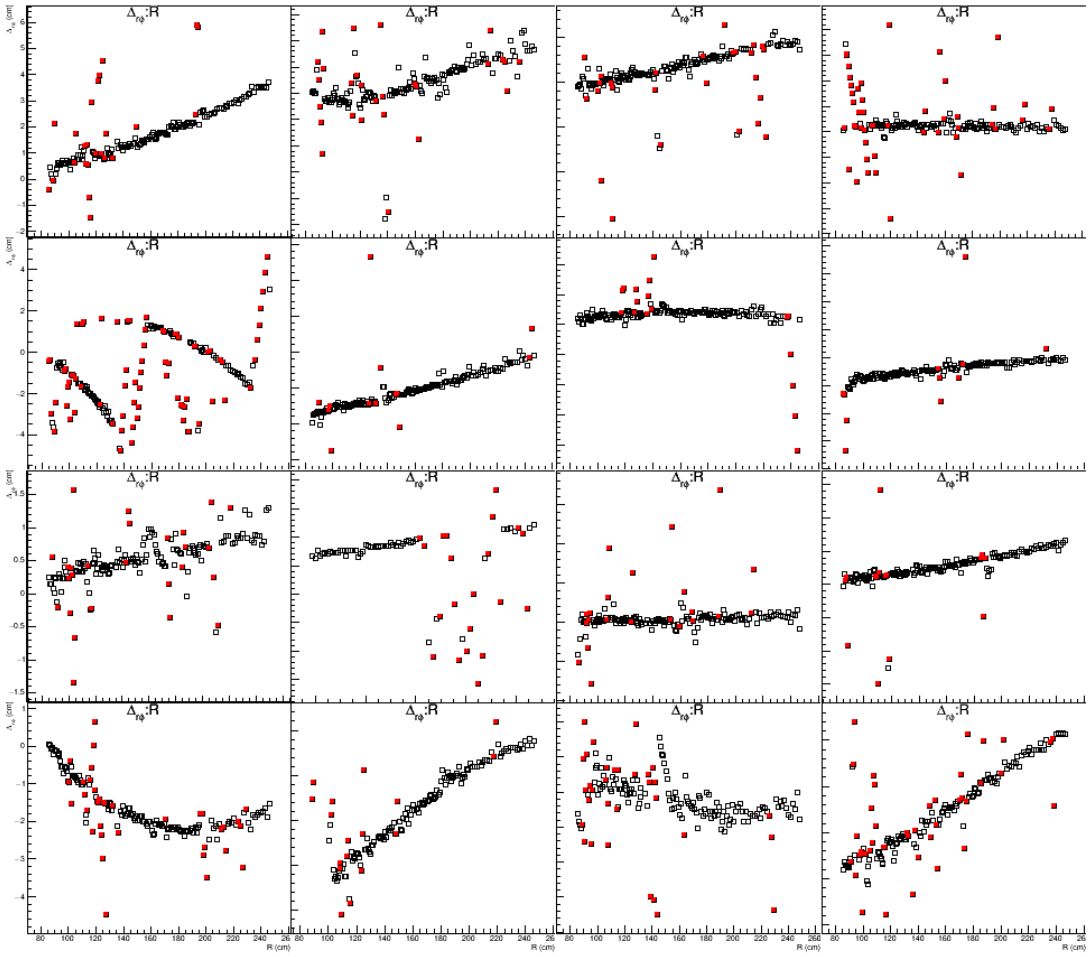




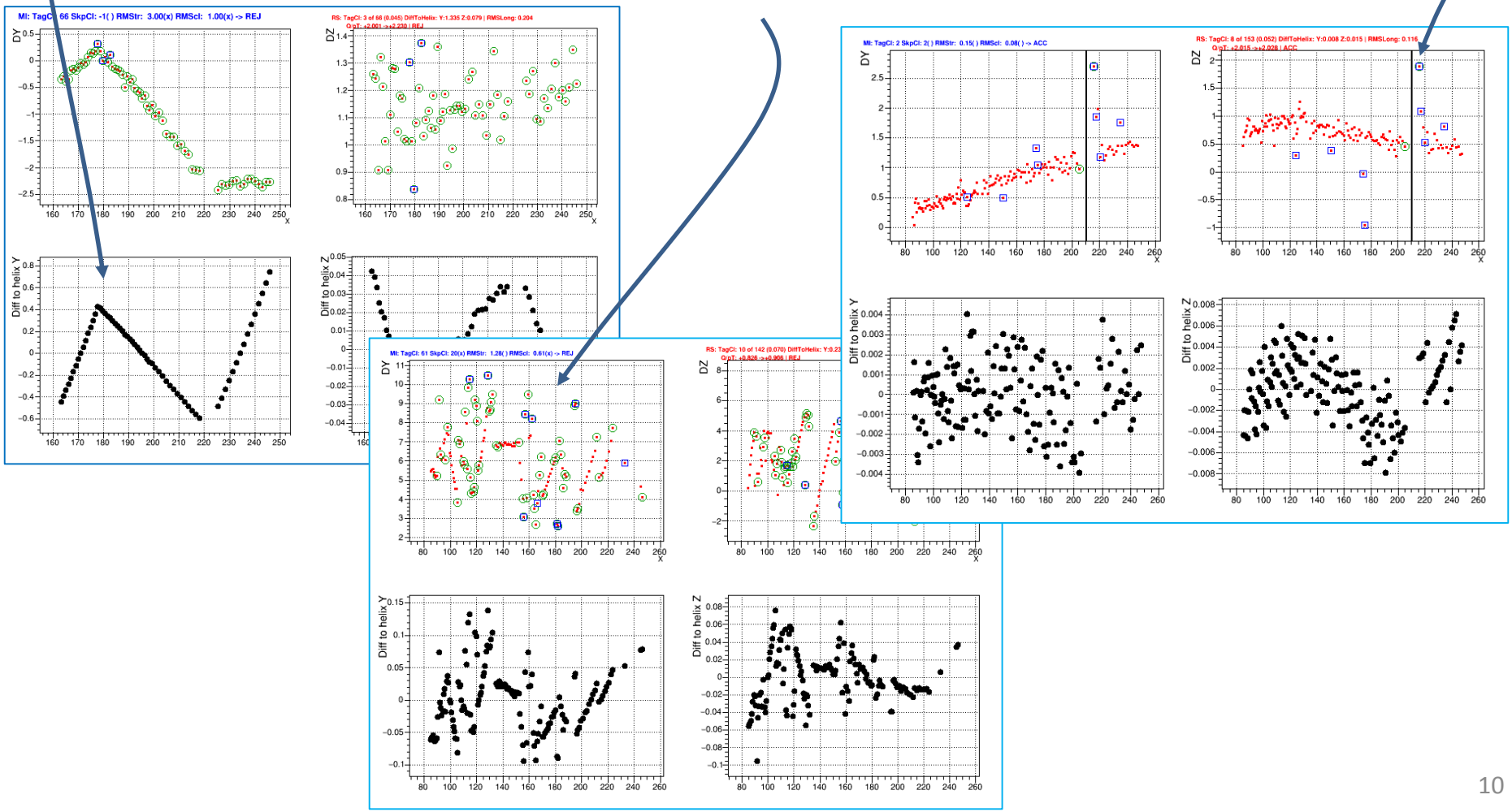
Different approaches: fill holes by values from neighboring bins (weight dumped with distance) or inter/extrapolalte from good regions

- Reconstruction with loose tolerances leads to many fakes clusters attached to TPC track and to fake matching to ITS, TRD
- Especially bad in low-IR run in the beginning of LHC15o – MB trigger was used as kCalibBarrel instead of dedicated “low-multiplicity” trigger (<~600 tracks)

 Partially cured by special procedure to filter fakes by cutting on residuals local smoothness and discrepancy between the ITS and ITS-TRD residuals (Marian)

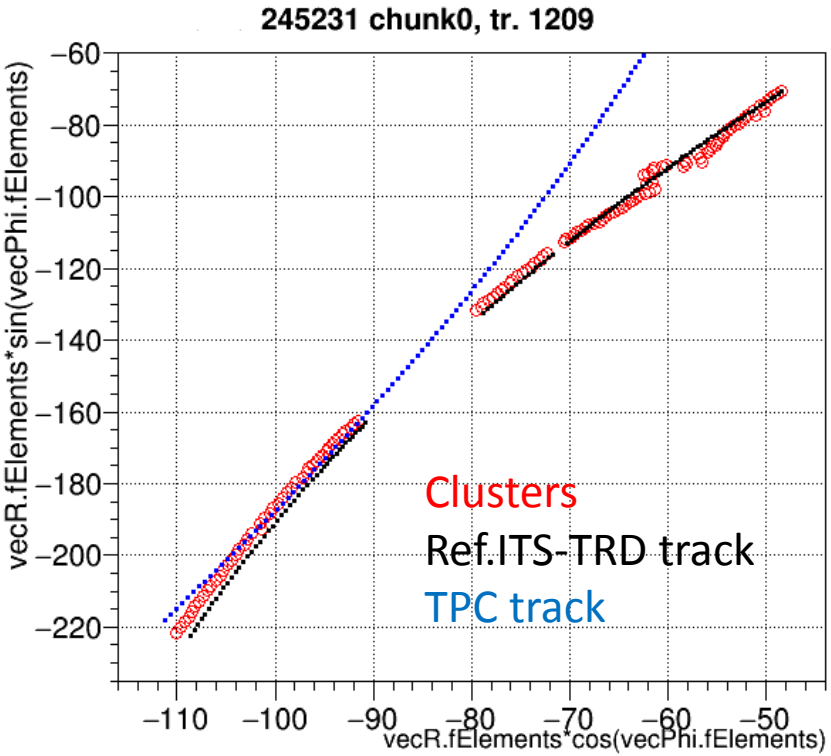


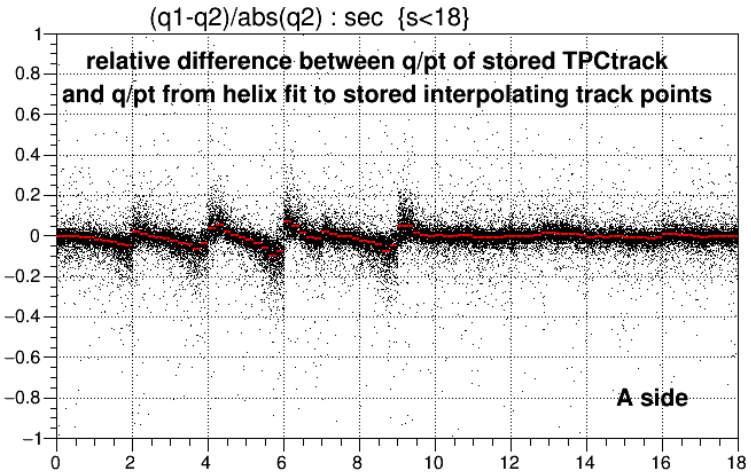
- Alternative version of outlier tagging:
  - Refit reference track points by circle in Y vs X and line in Z vs S(circular path), cut on the residual between points and fit ⇒ rejects wrong ITS – TRD matches
  - Cut on 5σ of Y, Z residuals wrt their short-range (±3 neighbours) moving average ⇒ rejects single fake clusters
  - Cut on RMS (>0.8cm) of residuals wrt their long-range (+-15 neighb) moving average ⇒ rejects wrong ITS-TRD matches and TPC track composed of different track pieces

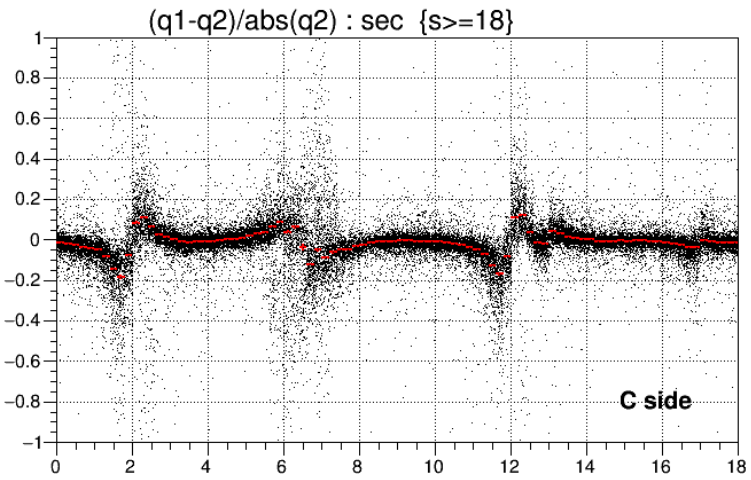


- Kinematics stored in the residual trees corresponds to distorted TPC track:
  in bad regions pT can be wrong by ~20%
  ⇒ bias in estimate of the track slope at pad-row
  ⇒ bias in X-distortions extraction

- Fit of the reference ITS-TRD track
  (done for outliers rejection)
  is also used for more precise estimate of the track momentum and inclination at pad-rows



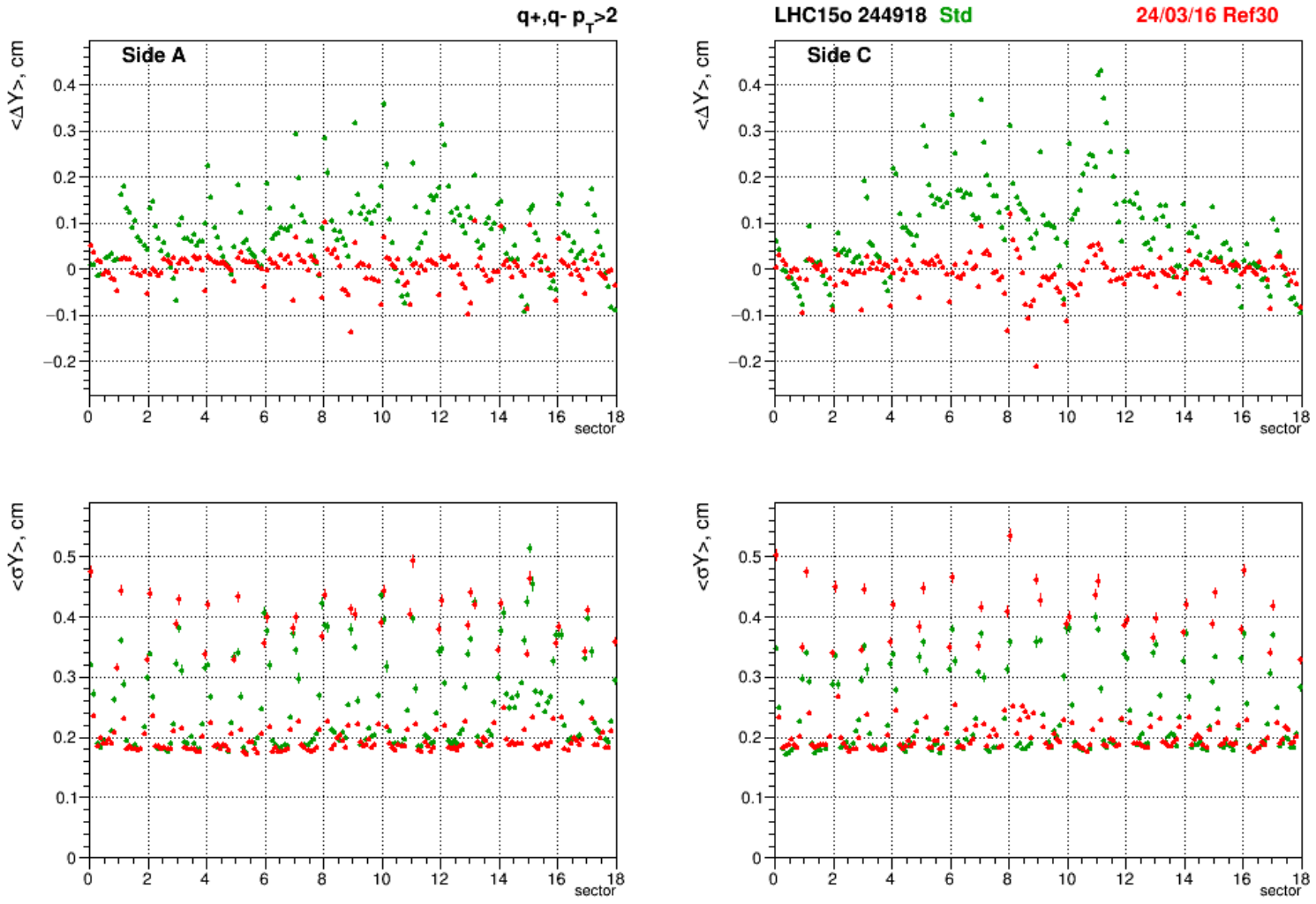




Status of distortions correction

Low-intensity (30Hz IR) LHC15o run 244918: no SC related distortions

$p_T > 2$



Standard CPass0 calibration

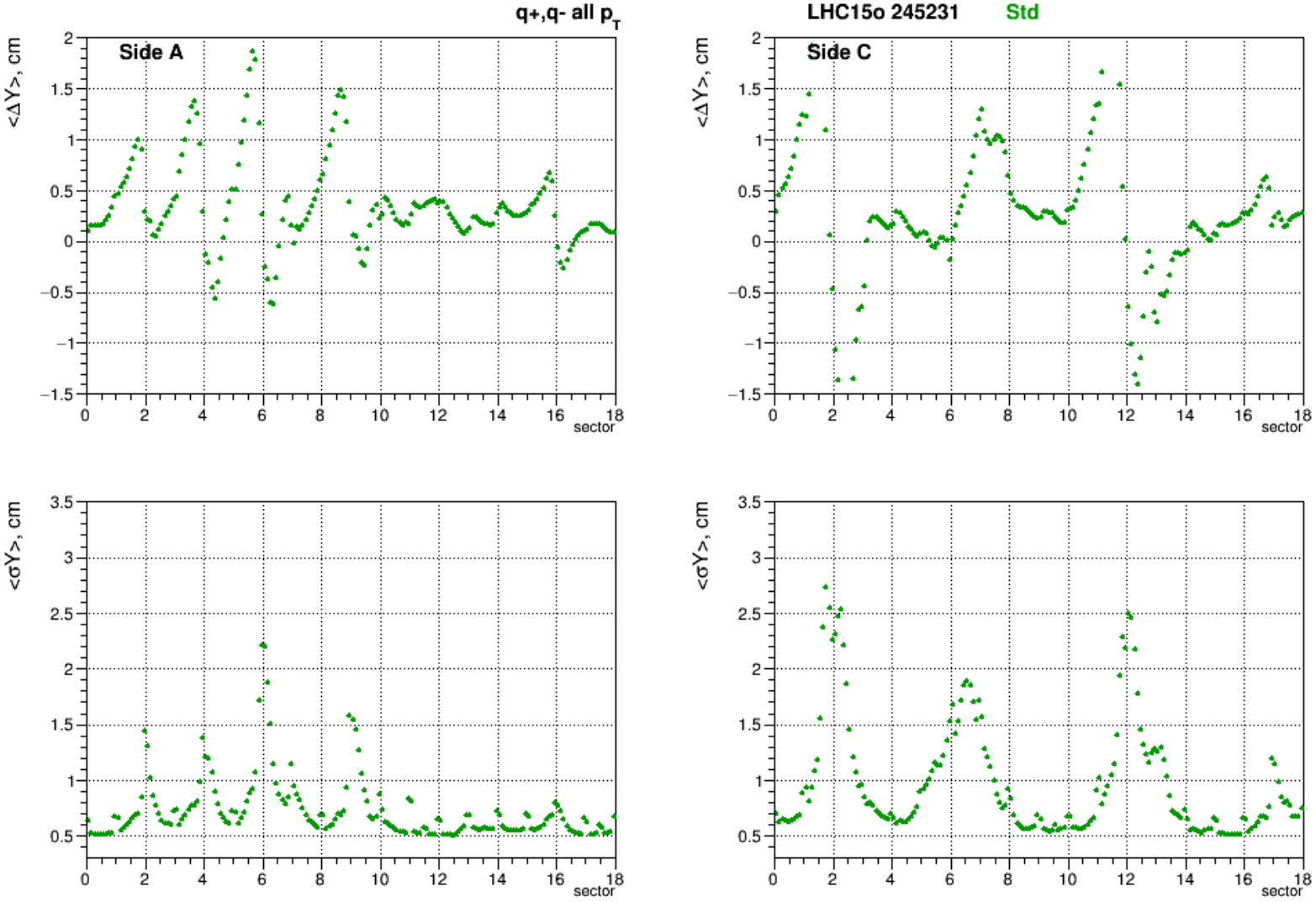
Calibration with residual trees

⇒ At low-IR new calibration is better than in Run1

Typical high-IR (5kHz) LHC15o run (245231)

no p_T cut

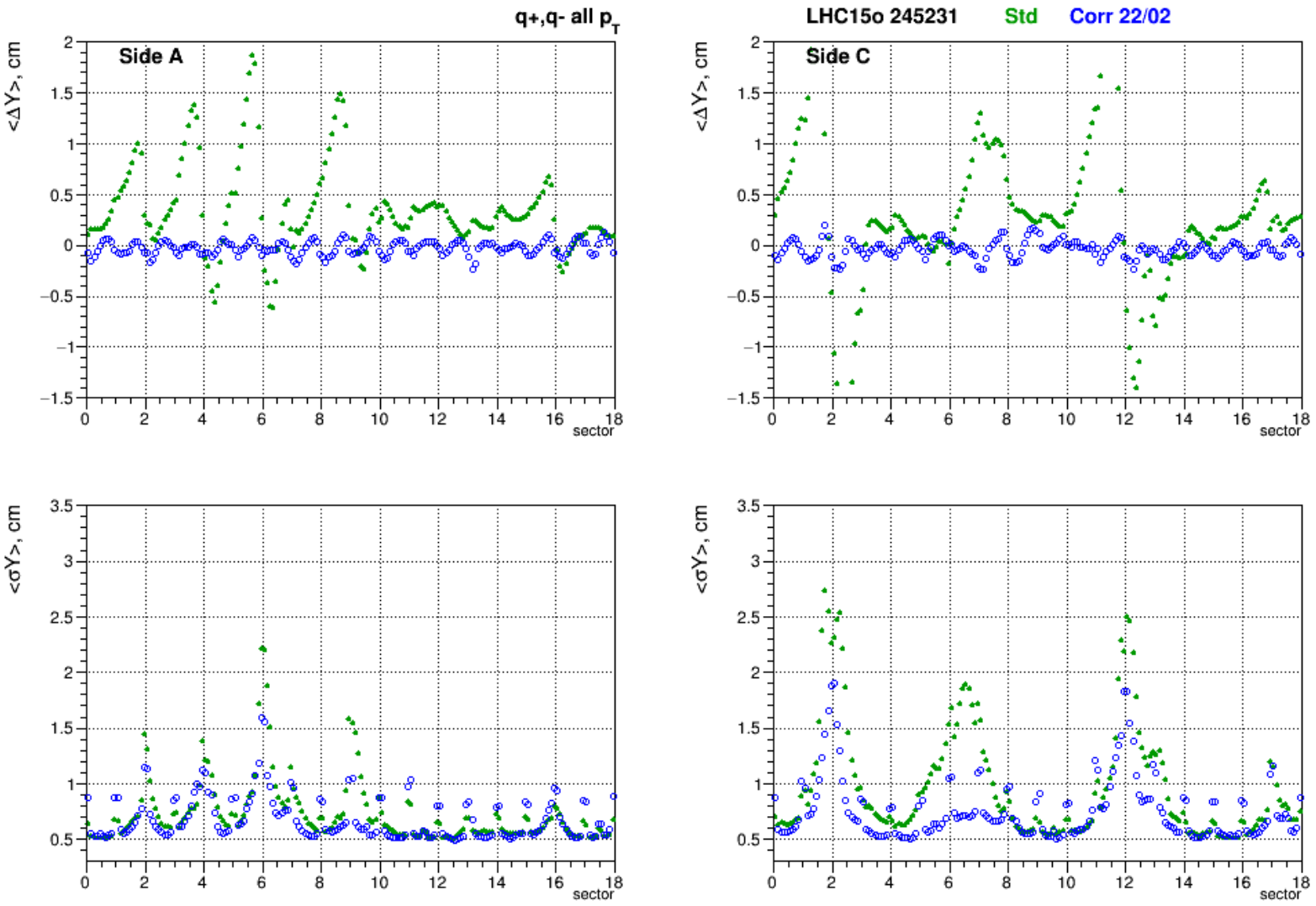
TPC tracks DCA to vertex as a measure of distortions



Reconstruction with **standard settings (relaxed tolerances, CPass0)**

Typical high-IR (5kHz) LHC15o run (245231)

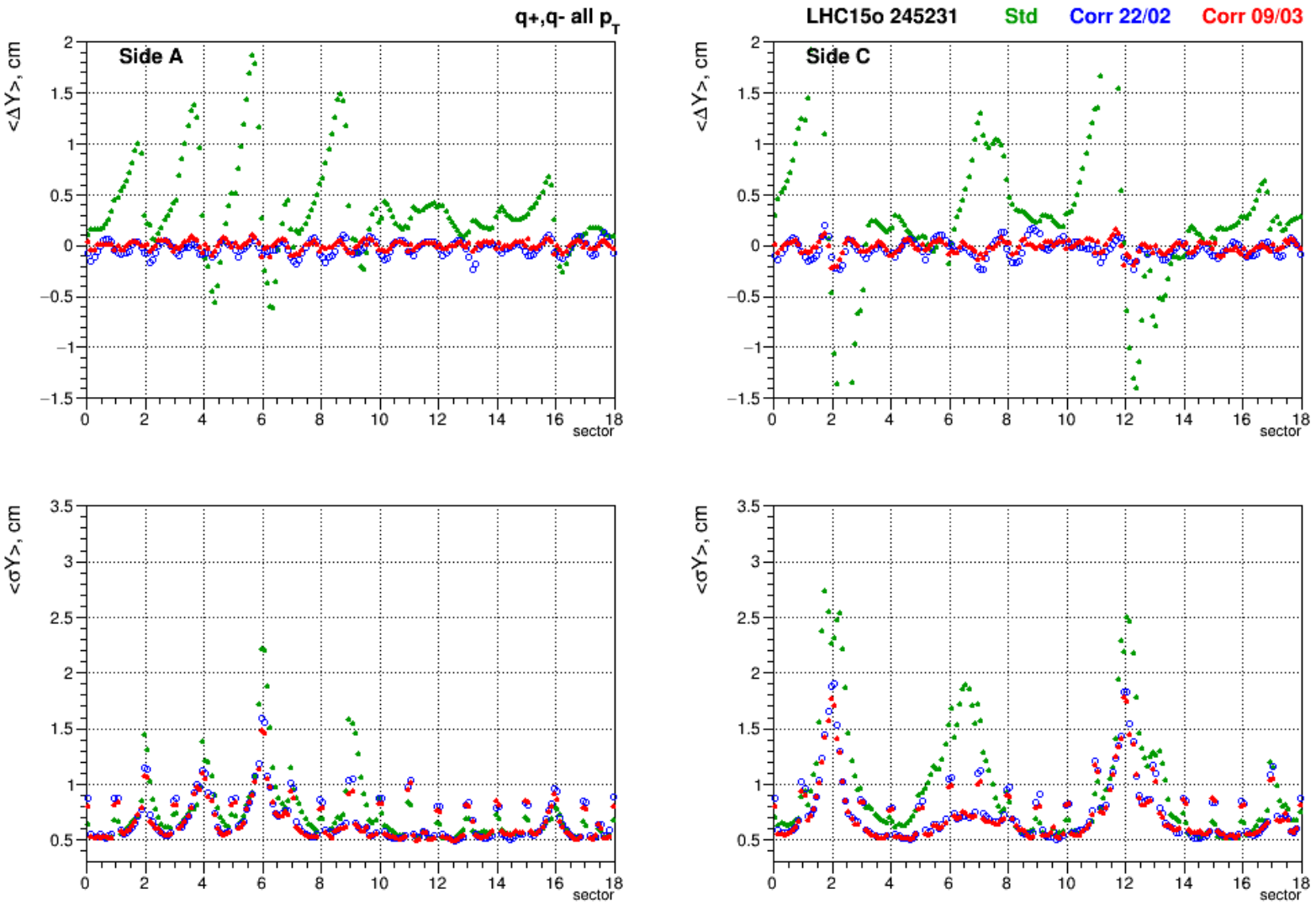
no p_T cut



Reconstruction with **standard settings (relaxed tolerances, CPass0)**
Corrections status as of the **end of February**

Typical high-IR (5kHz) LHC15o run (245231)

no p_T cut



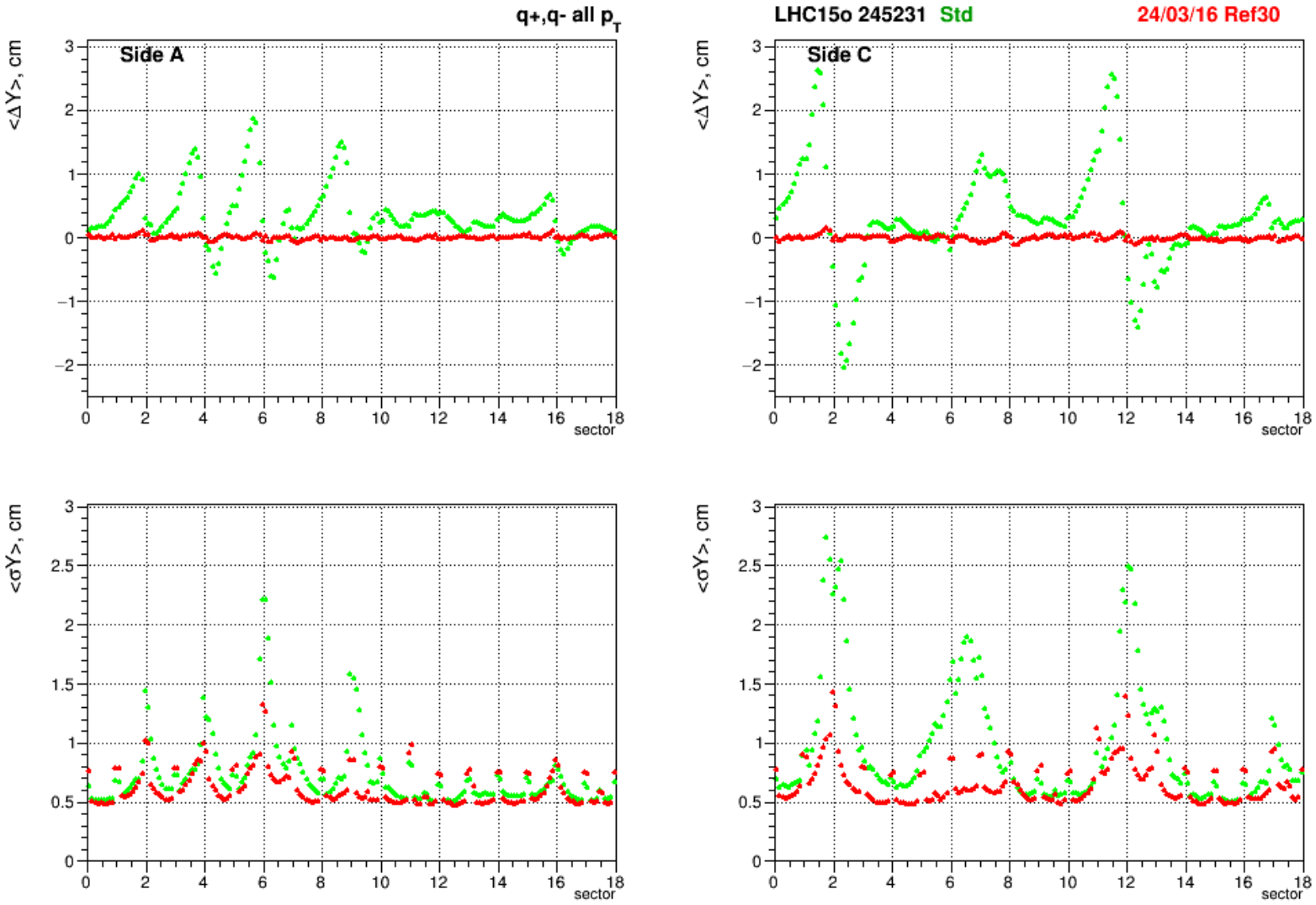
Reconstruction with **standard settings (relaxed tolerances, CPass0)**

Corrections status as of the **end of February**

1st results from **alternative approach**

Typical high-IR (5kHz) LHC15o run (245231)

no p_T cut

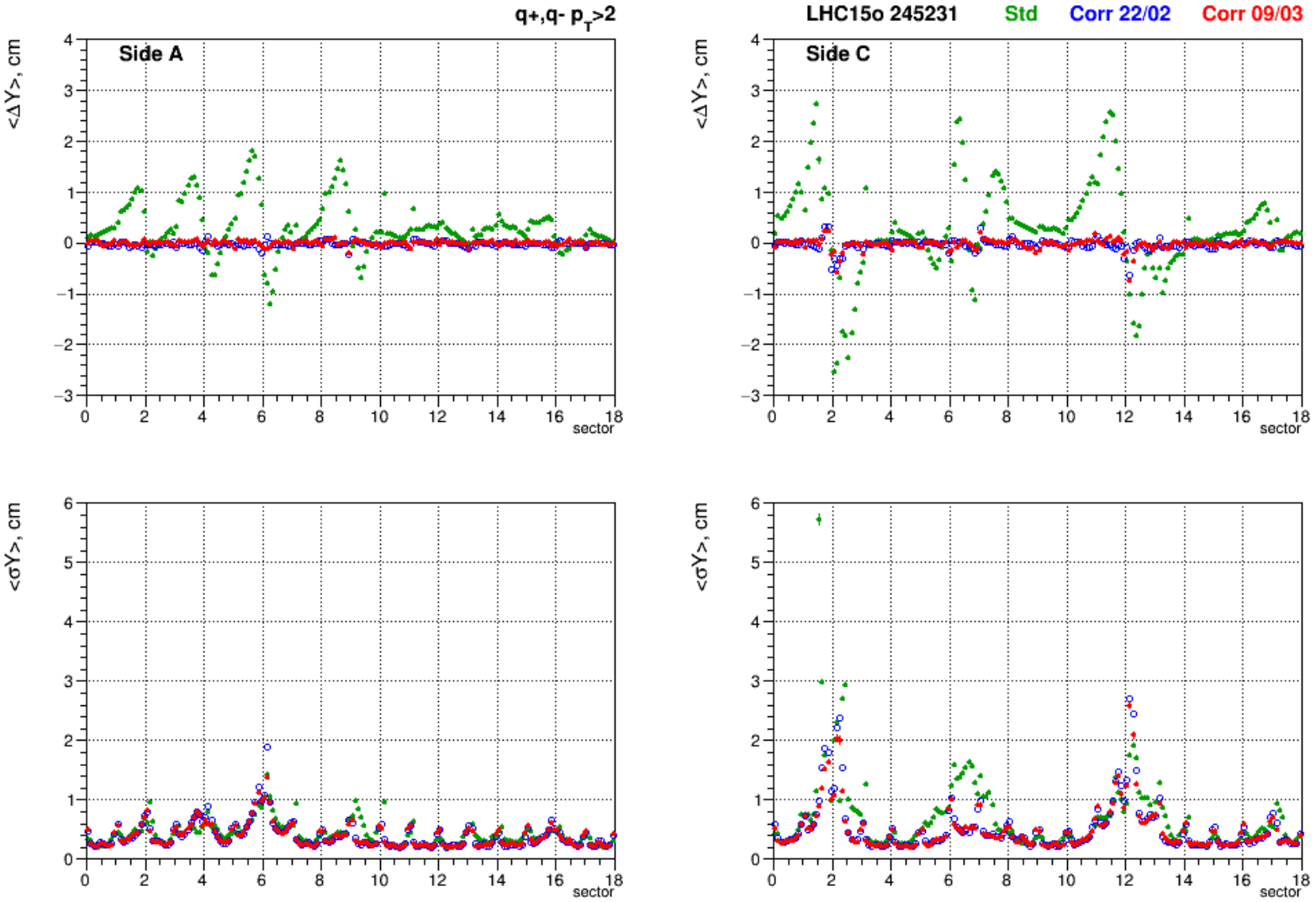


Reconstruction with **standard settings (relaxed tolerances, CPass0)**

Recent results from **alternative approach**

Typical high-IR (5kHz) LHC15o run (245231)

$p_T > 2$



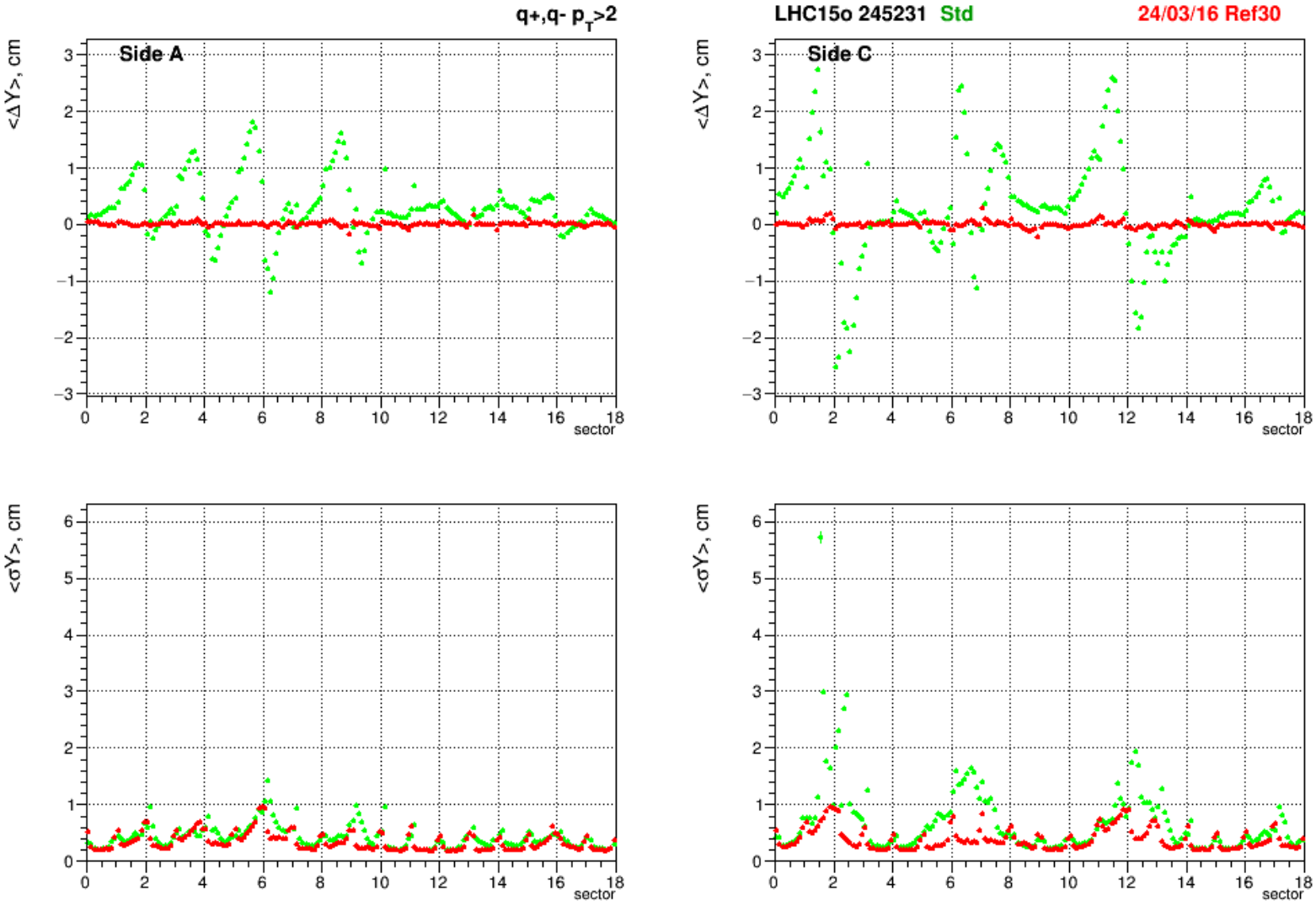
Reconstruction with **standard settings (relaxed tolerances, CPass0)**

Corrections status as of the **end of February**

1st results from **alternative approach**

Typical high-IR (5kHz) LHC15o run (245231)

$p_T > 2$



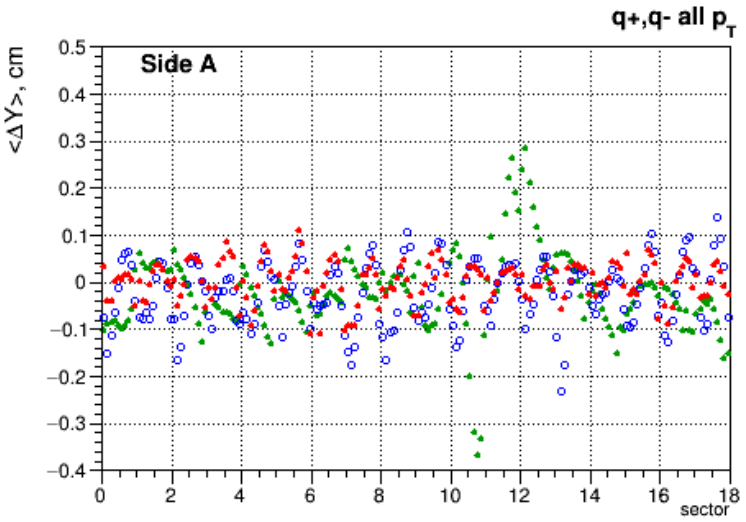
Reconstruction with **standard settings (relaxed tolerances, CPass0)**

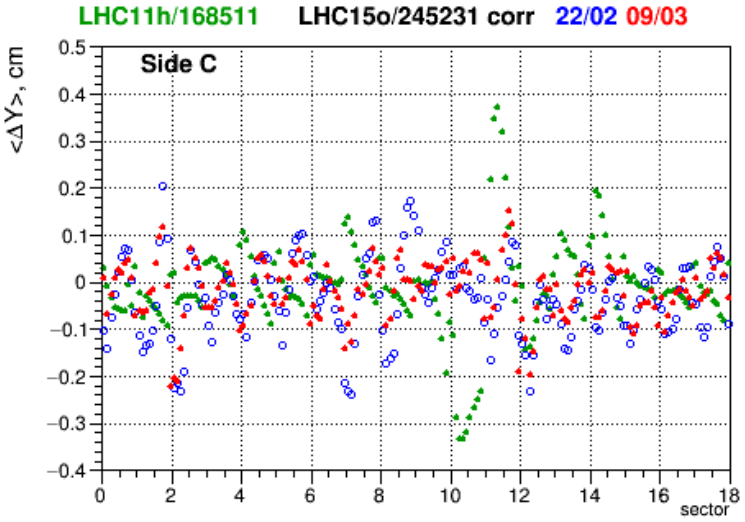
Recent results from **alternative approach**

Main remaining problem: large dispersion of DCA in corrected regions

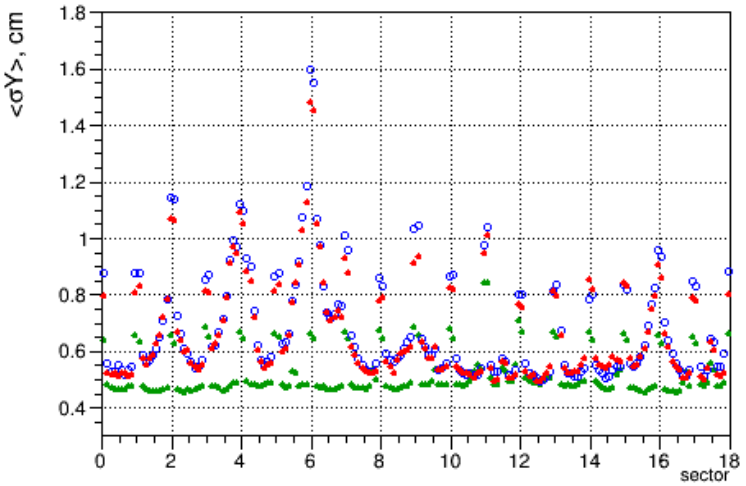
Run2 LHC15o (245231, 5kHz) vs Run1 LHC11h (168511, 2.5kHz)

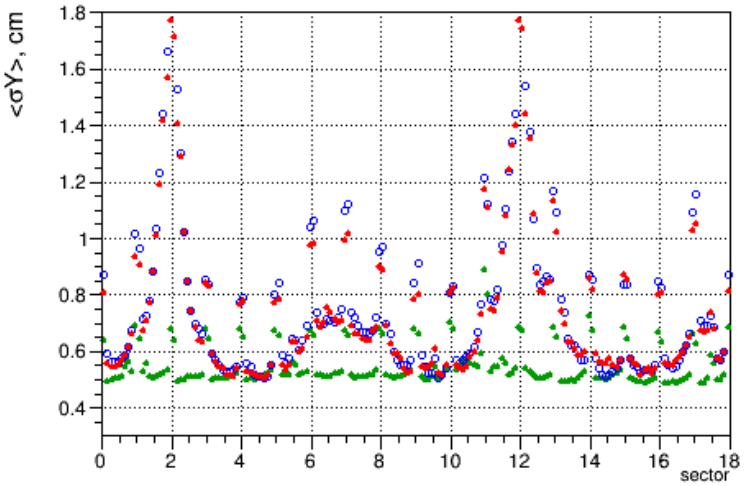
no p_T cut





at low pT we are in similar situation as in Run1, except some regions + larger RMS





Run 1 with standard CPass0/Cpass1 calibration (*)

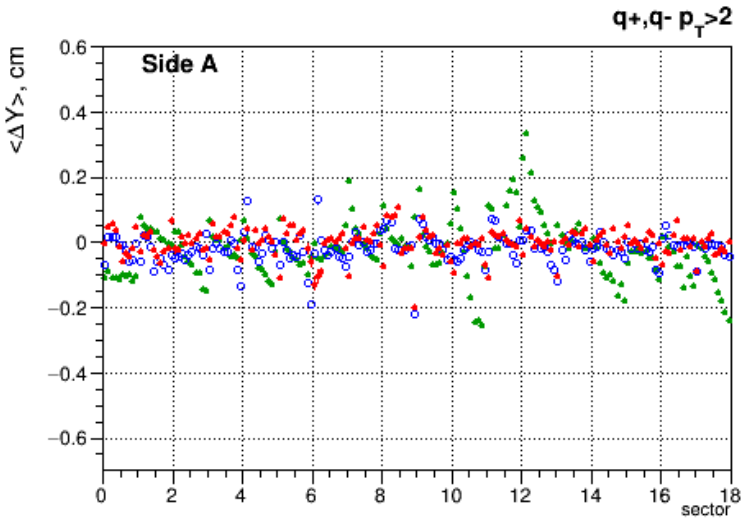
Corrections status as of the **end of February** (same as on previous slide)

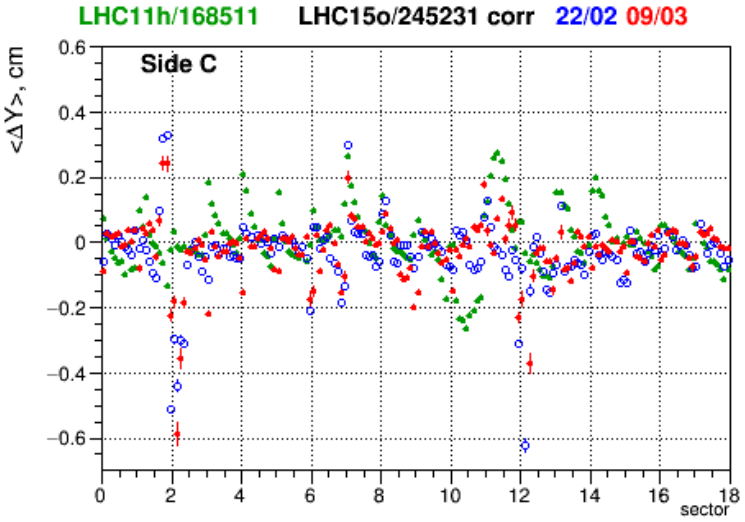
1st results (already obsolete) from **alternative approach**

* old reconstruction is done with additional errors on the clusters, to mask effect of residual miscalibrations

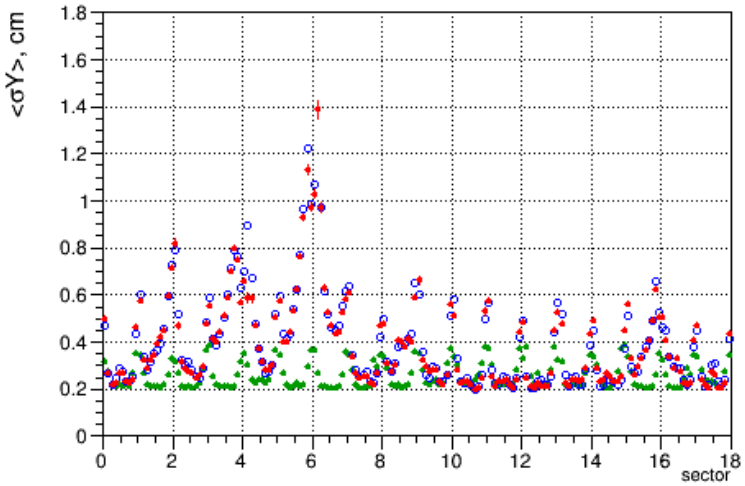
Run2 LHC15o (245231, 5kHz) vs Run1 LHC11h (168511, 2.5kHz)

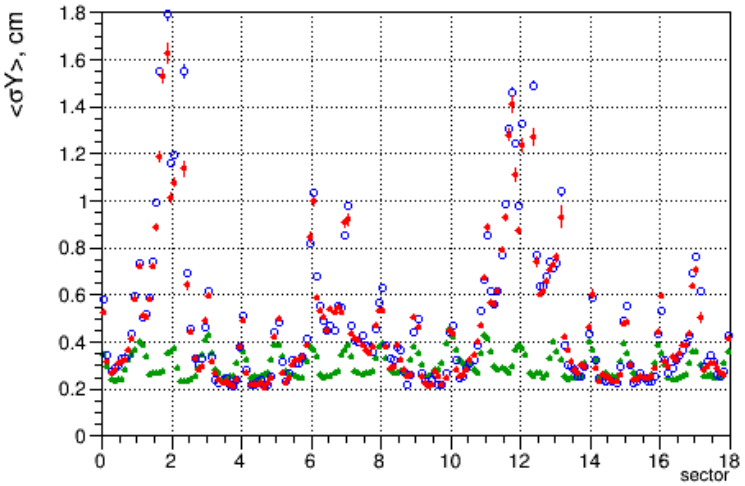
$p_T > 2$





at high pT we are somewhat better than in Run1, except some regions + larger RMS





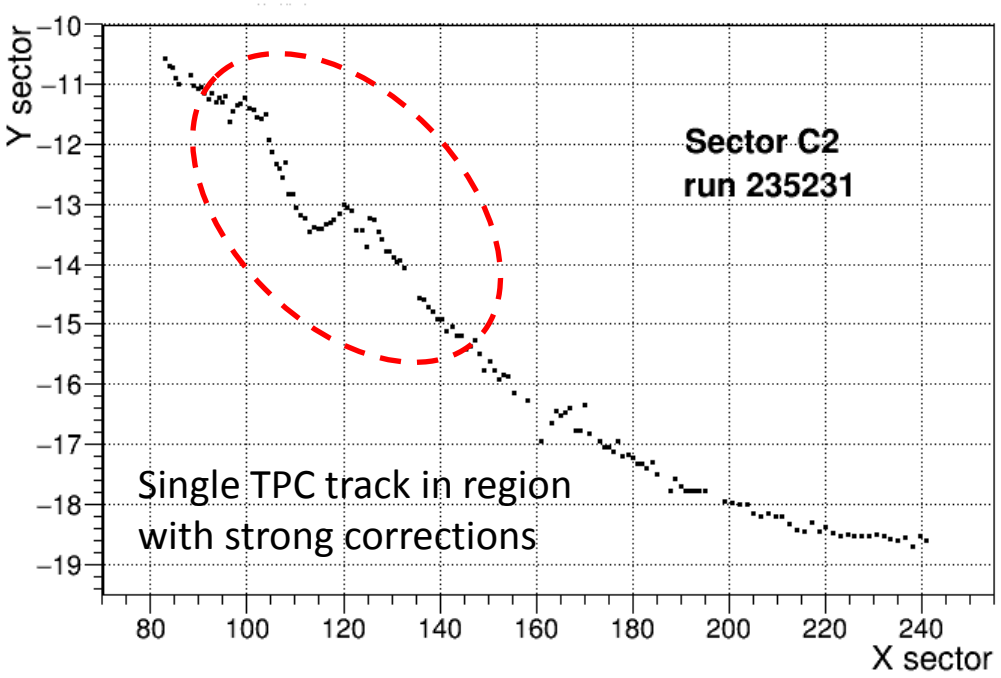
Run 1 with standard CPass0/Cpass1 calibration (*)

Corrections status as of the **end of February** (same as on previous slide)

1st results from **alternative approach**

* old reconstruction is done with additional errors on the clusters, to mask effect of residual miscalibrations

- The reason of large residual dispersion of DCA around 0 in regions with large correction is not yet fully understood.
- Suspicion of bad description of X-distortions (not measured directly) since they show largest variance between smoothed and (jumpy) point-to-point values
- Checks and closure tests are in progress…

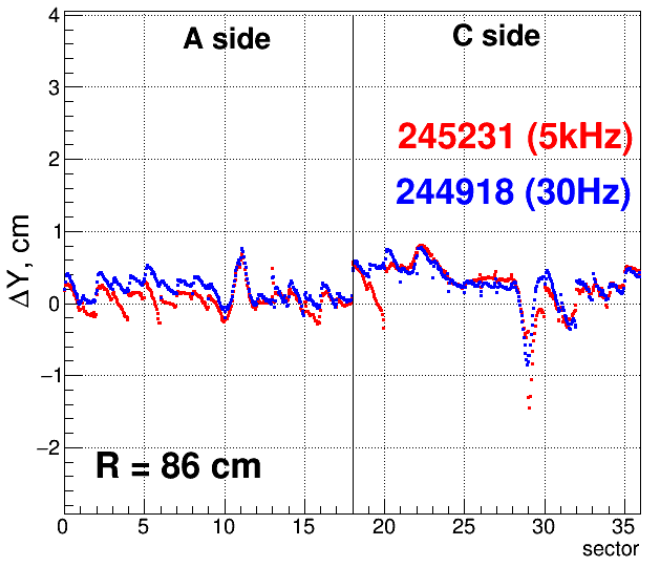


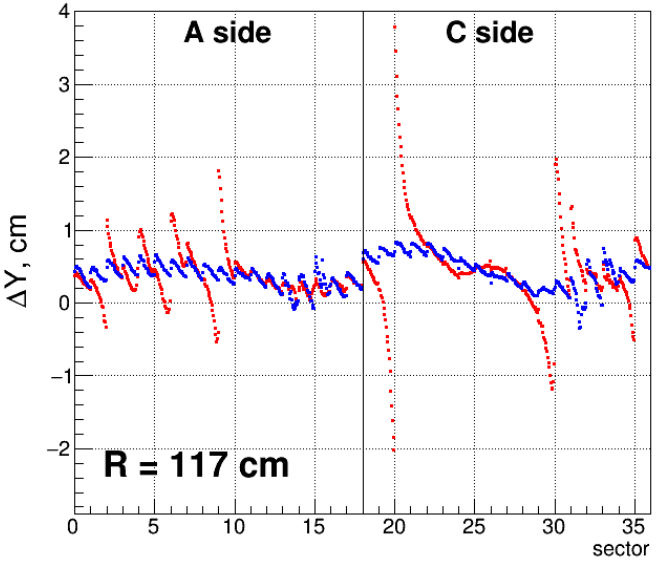
Accounting for the time evolution of distortions within the run

See presentation by Marian

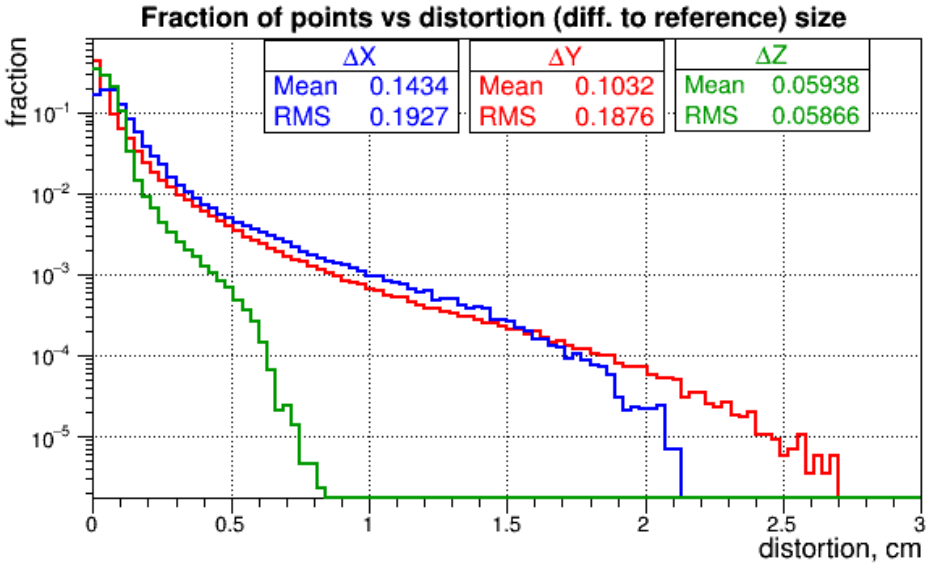
Alternatives (orthogonal):

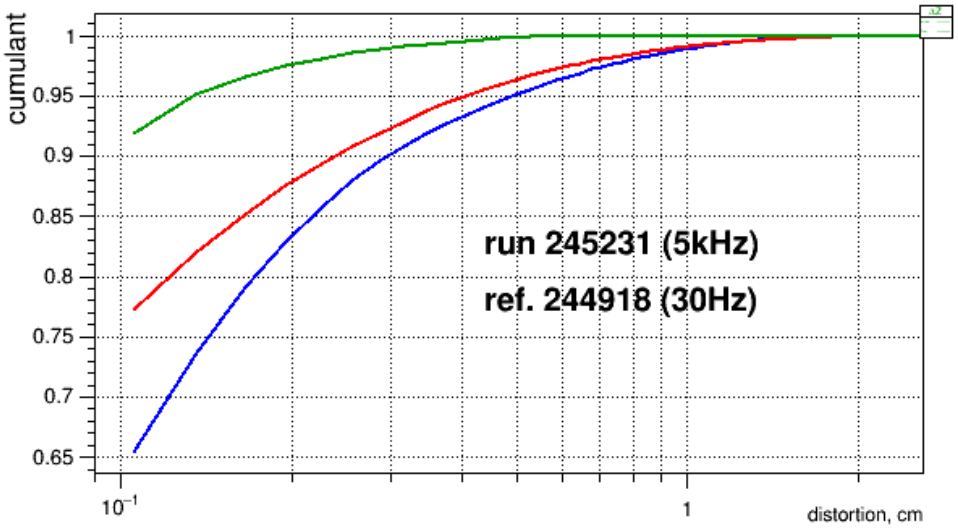
- Keep in memory correction maps for 2 nearest time bins (~20min each) and for every event interpolate between them.
  - currently implemented in the code, but ignores local IR fluctuations
- Rescale correction value by the ratio of instantaneous and average (over time-bin) luminosities
  - more precise but requires reliable luminosity estimate (on ~100 ms scale, studied by Marian)
  - rescaling should be applied only to SC-related distortions, e.g. difference between run specific map and “reference” low-IR map (ExB, misalignments effect)





Accounting for fluctuations and residual distortions



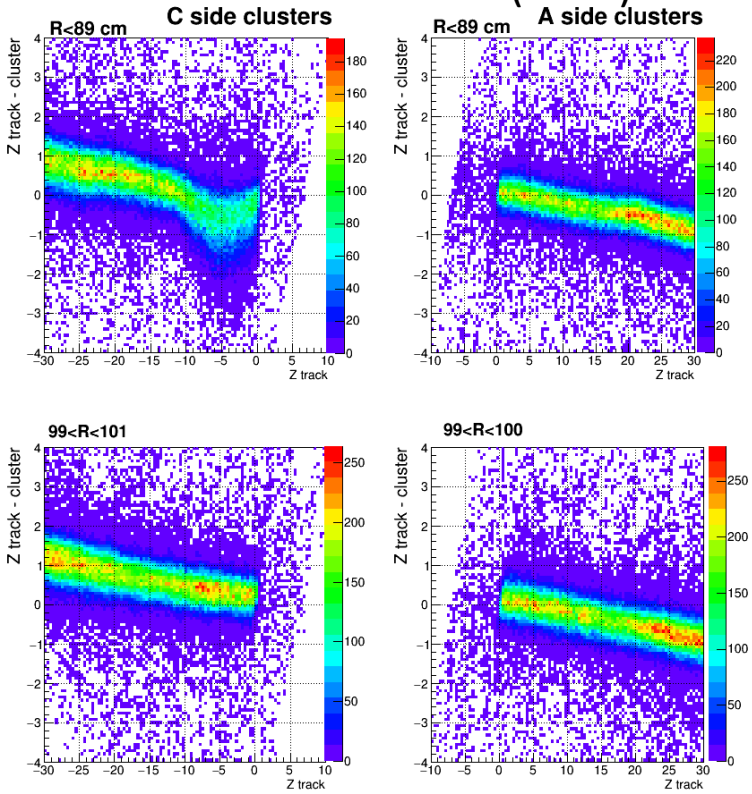


Fraction of clusters assigned large errors is a few %: only 5% of clusters have distortions >4mm (in Y)

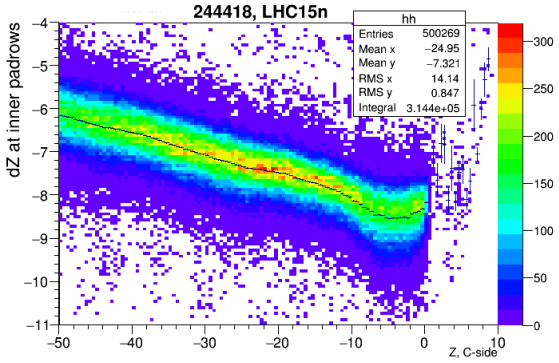
What we cannot correct (currently)

- Kink in distortions C-side distortions at ~5cm from the CE
  ⇒ apparently causing the “small-radius charging-up” distortions seen in Run1.
- With 0.1 binning in Z/X the 1st bin at small radii covers -9<Z<0, i.e. fully includes the kink
  ⇒ would need 2-3 extra bins in Z/X to describe the kink
- Alternative: assign large errors in affected region
- !! This kind of distortion breaks scalability of maps with IR, since reaches its maximum in the end of the fill (was seen in Run1, to be verified in Run 2)

LHC15o 245231 (5kHz)

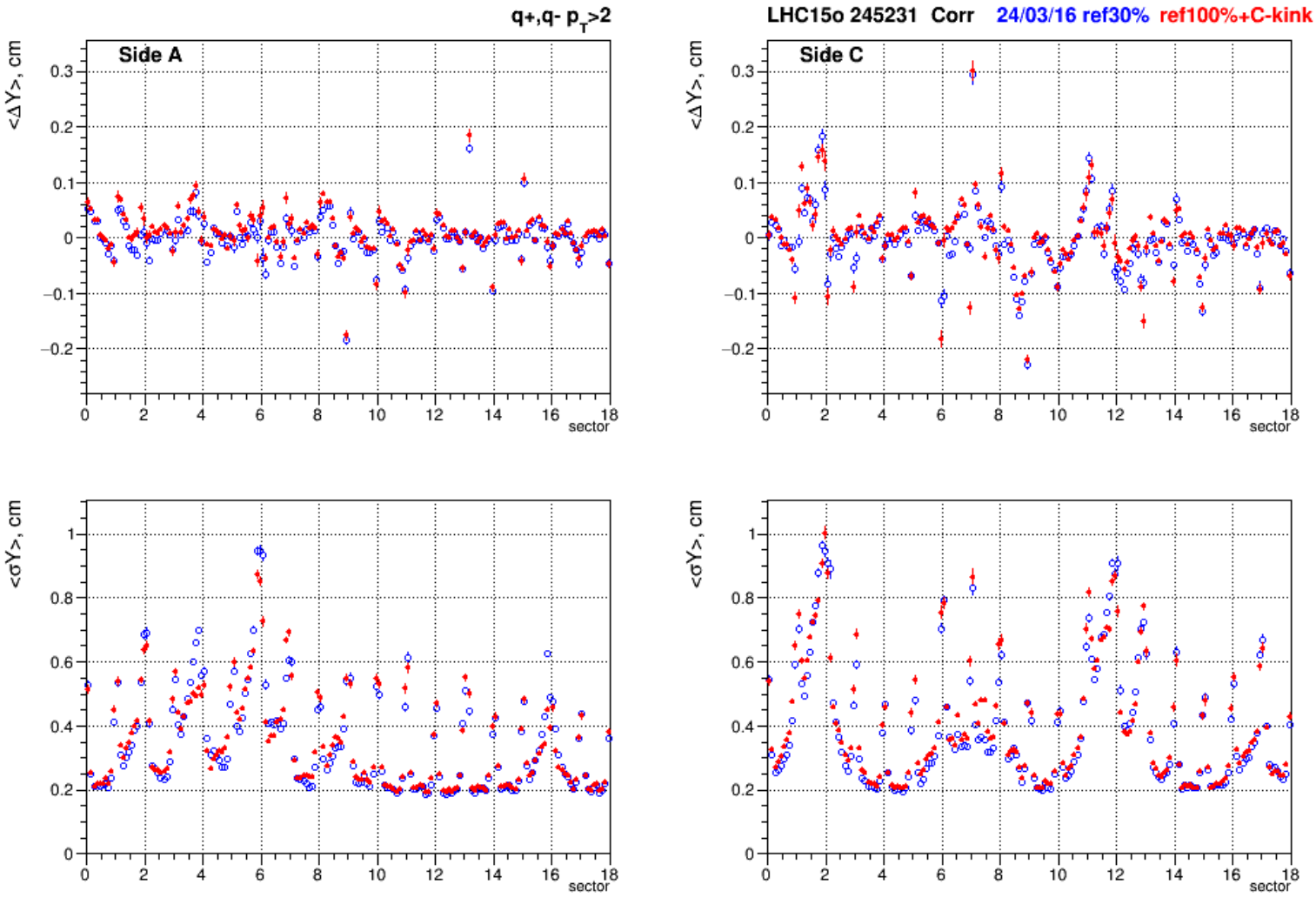


Seen also in pp:
pp LHC15n 244418 (100kHz)



1st test of masking the C-side kink by $1.5\exp\{-\frac{|r-85|}{5}-\left(\frac{z+5}{2.5}\right)^2/2\}$

+ applying 100% of run-distortions – reference (low-IR) distortion as a syst. error did not show good result compared to previous test with just using 30% of distortions as syst. error



After solving current technical problems:

To be exercised before LHC15o production:

- Full chain of multiple time-bins processing, collecting the outputs of multiple jobs in single distortions correction OCDB object (Chiara)
- Test reconstruction of full high-IR run with multiple time-bins (>1h coverage)