Hit maps and efficiency histories for the CMS tracker in Autumn 2010

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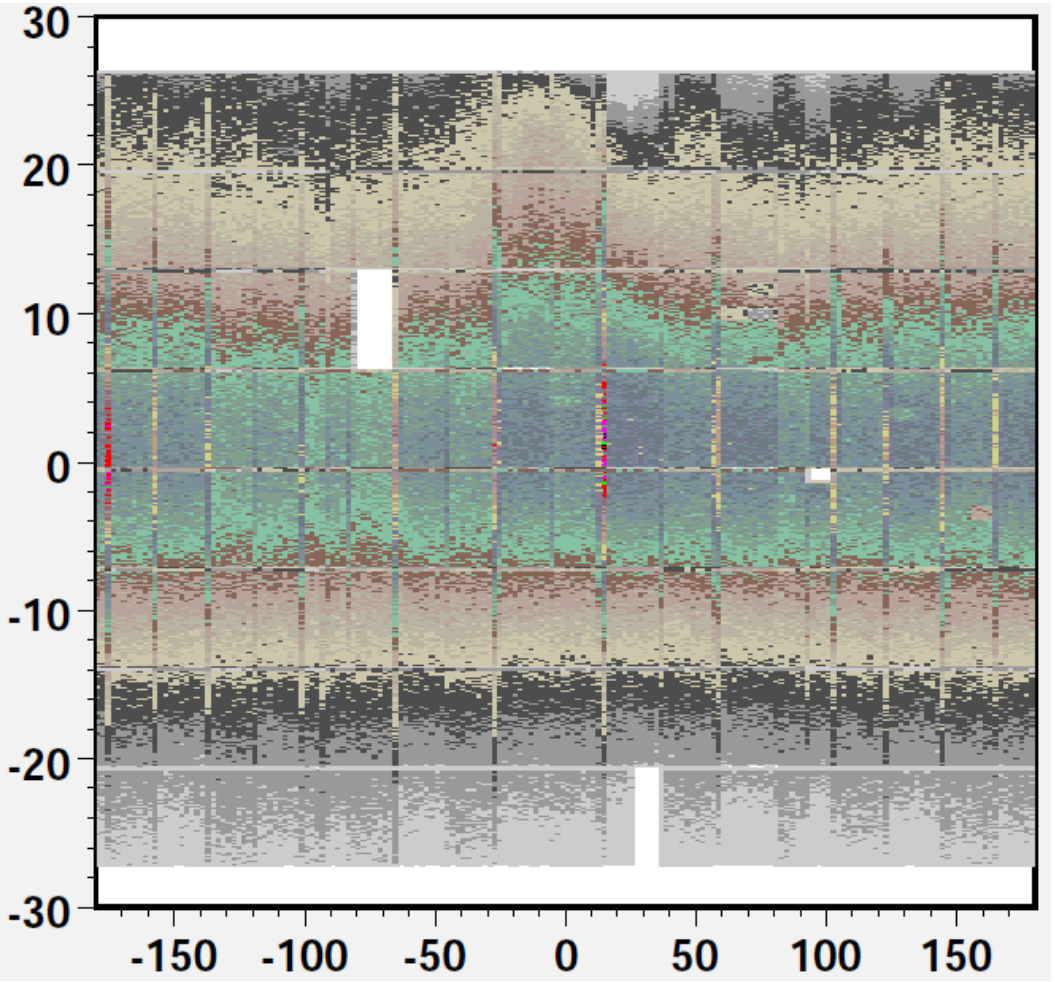
Tracker Upgrade 8.2.2011



- Hits on tracks
- Rapidity coverage
- Hit maps
- Efficiency history

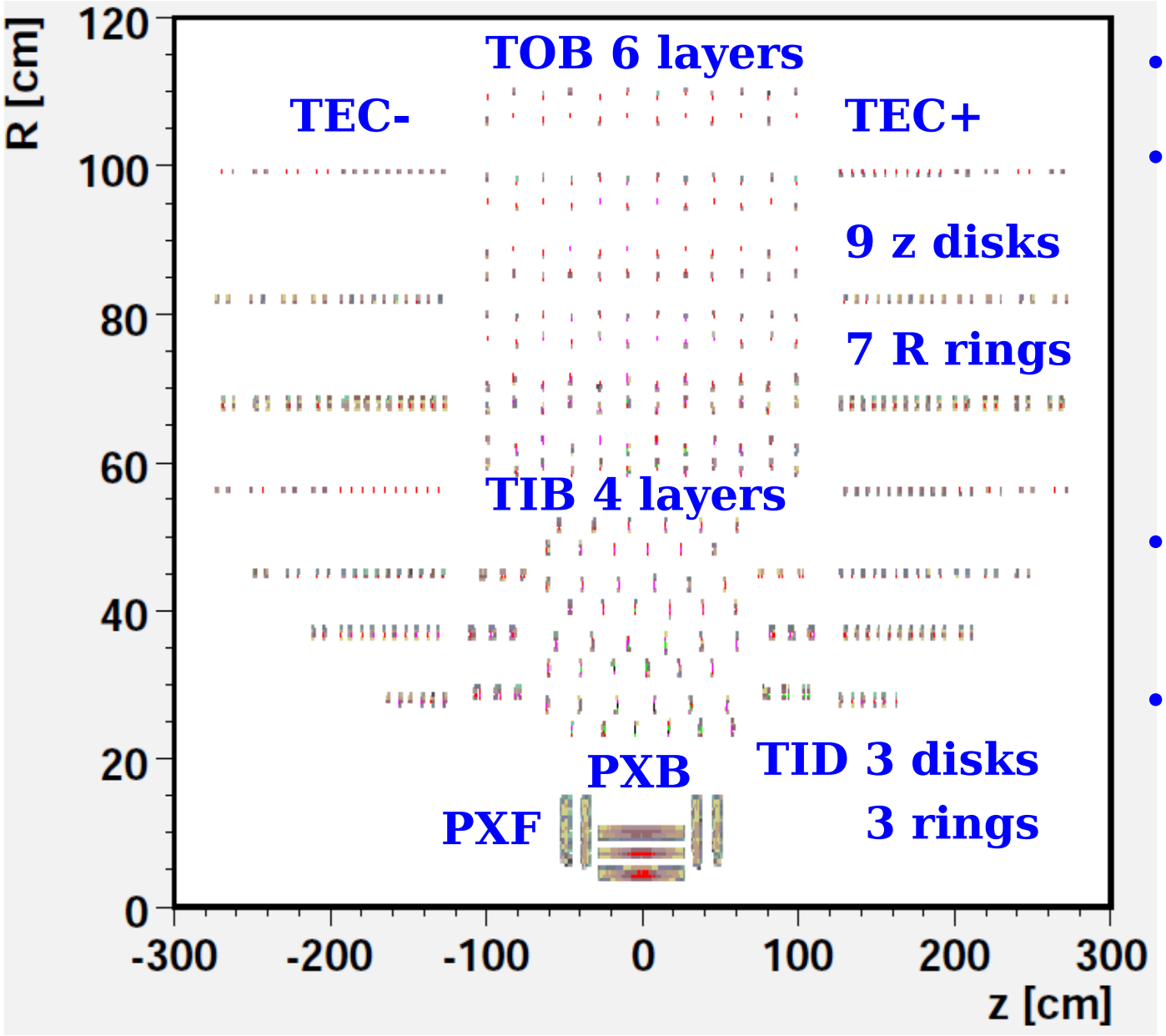
Questions

- Pixel detector is accessible:
  - How much should be replaced in 2013 shutdown?
  - Performance at high data rate? Confirmation of chip simulation?
- Radiation effects?
- TIB defects:
  - motivation for 4^{th} pixel layer upgrade?

Tools

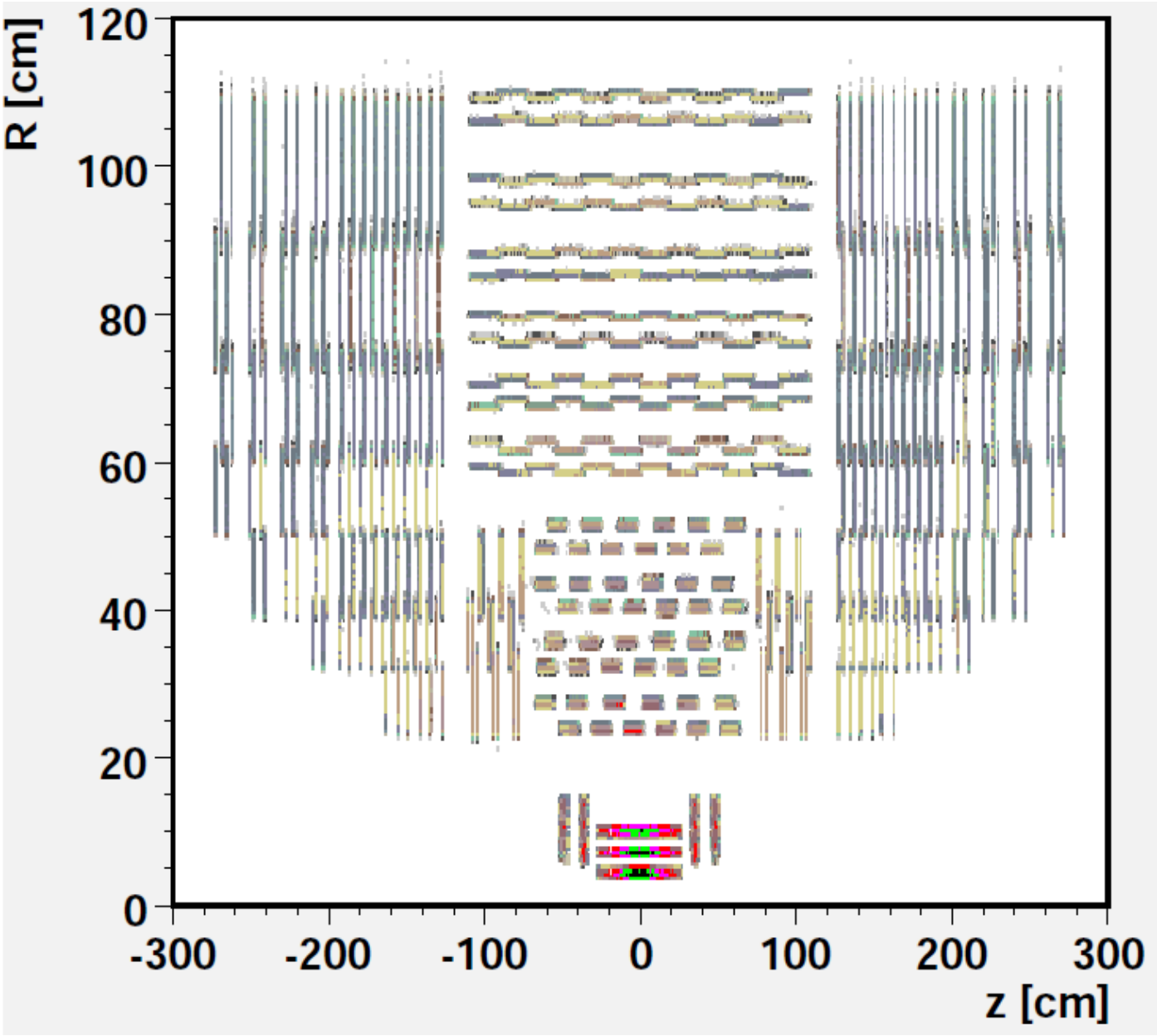
- Hits maps for dead channel monitoring
- Efficiency vs time for long-term trends

TransientRecHits



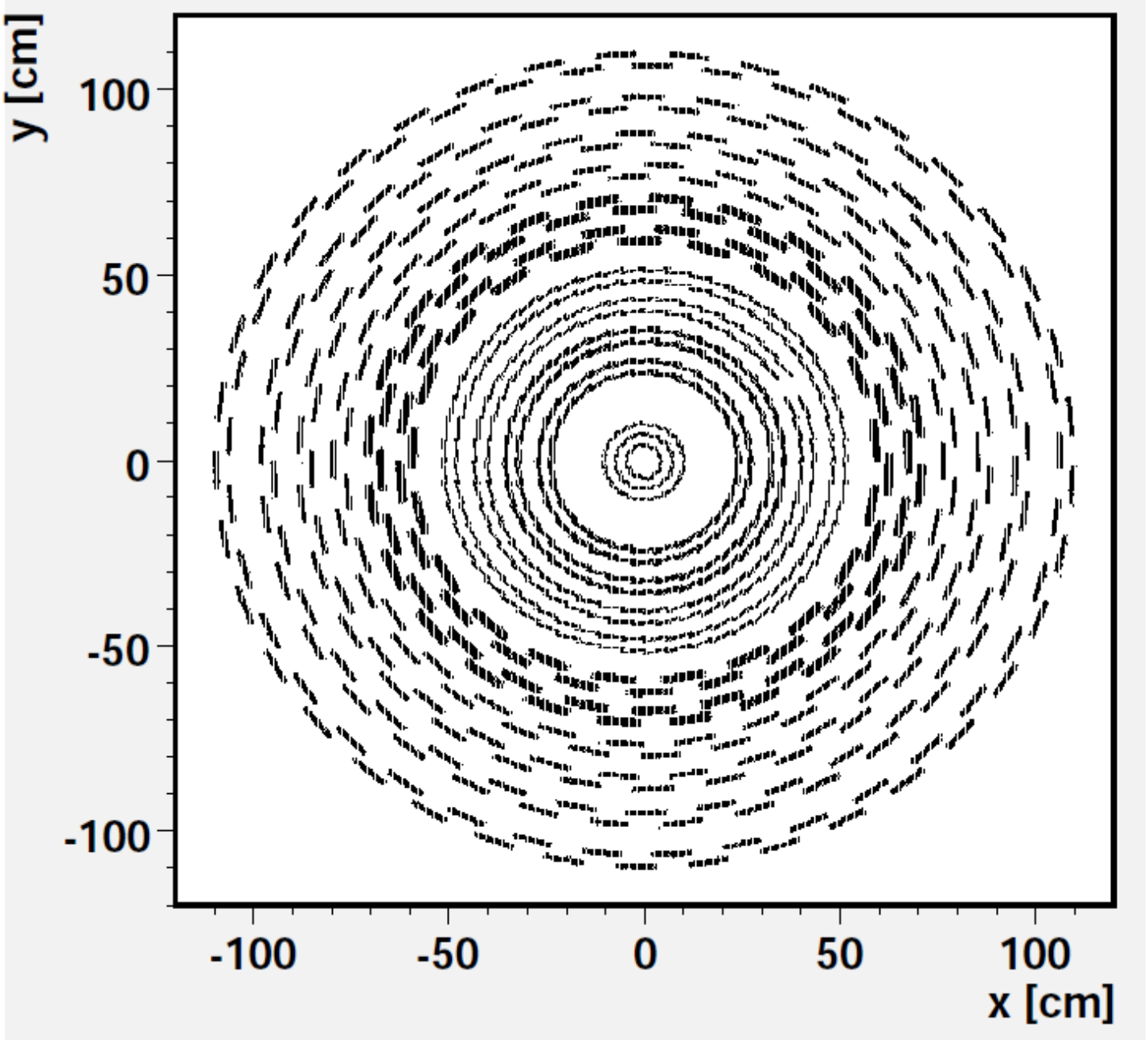
- Data from Oct 2011.
- Hits are stored in TrackExtra:
  - Not available on AOD.
  - Have to use RECO
- Pixel detectors provide space points.
- Strip detectors measure φ at fixed R (barrel) or *z* (endcap).

Hits on tracks



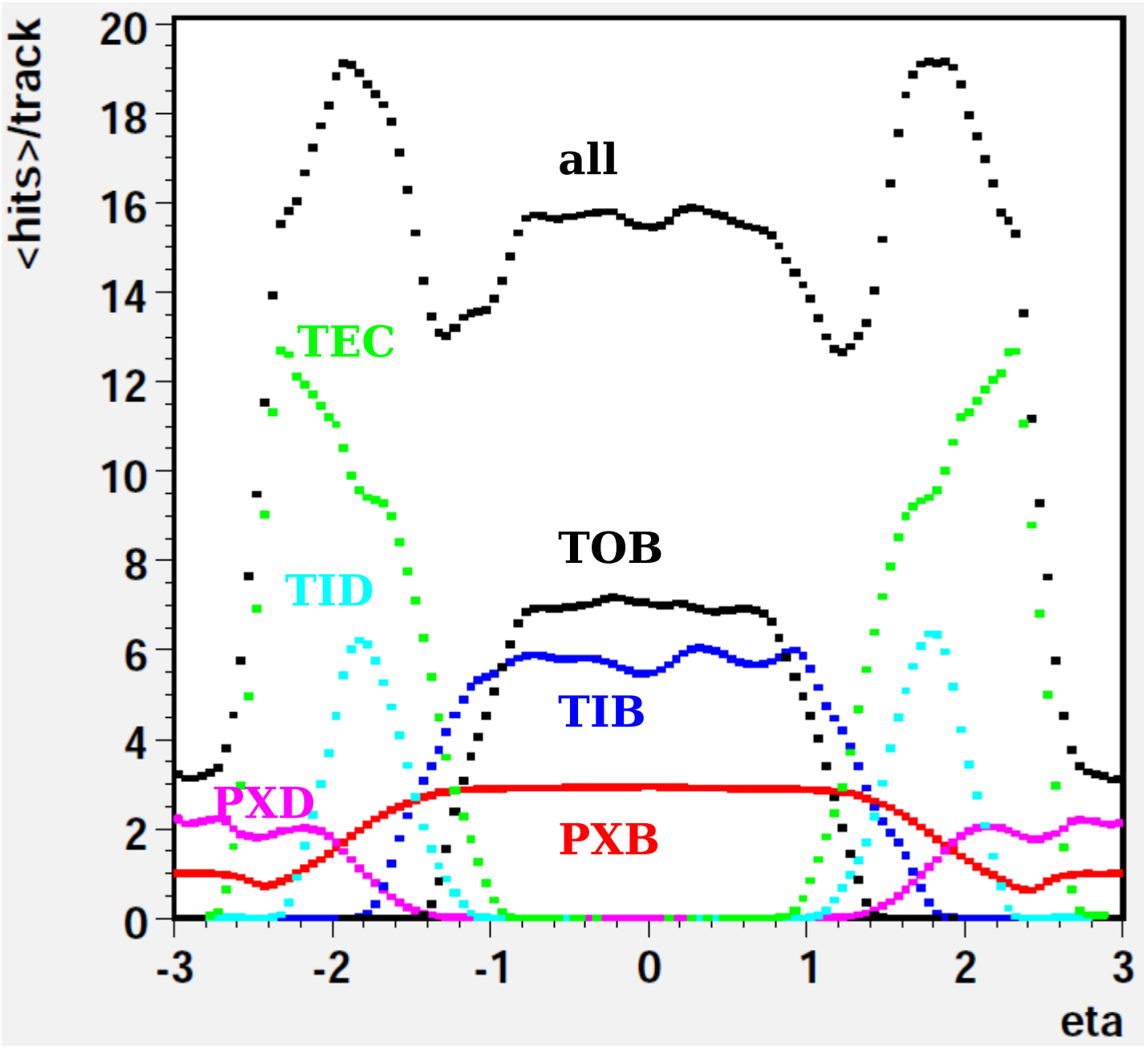
- Use track parameters to find hit location in space.
  - Requires B-field information from data base: use TransientTrack.
- This method can be used for detailed hit maps.

Hits on tracks in barrel



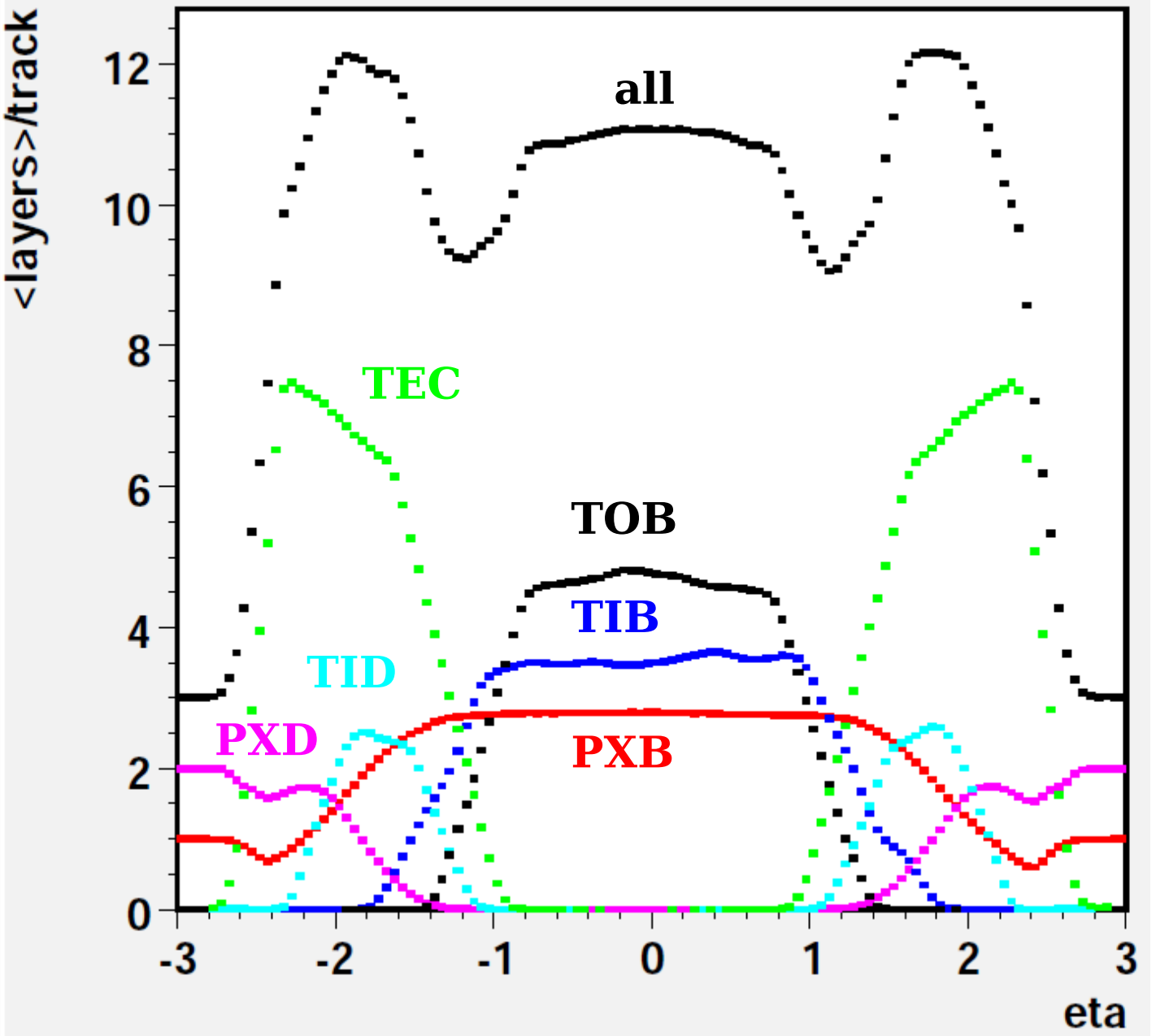
- Each layer has complete ϕ coverage.
  - except for a hole in TIB3.
- The first two layers in TIB and TOB have axial and stereo sensors (counted separately).
- Large gap between PXB and TIB: lots of space for a 4th pixel layer...

Hits on tracks vs pseudo-rapidity



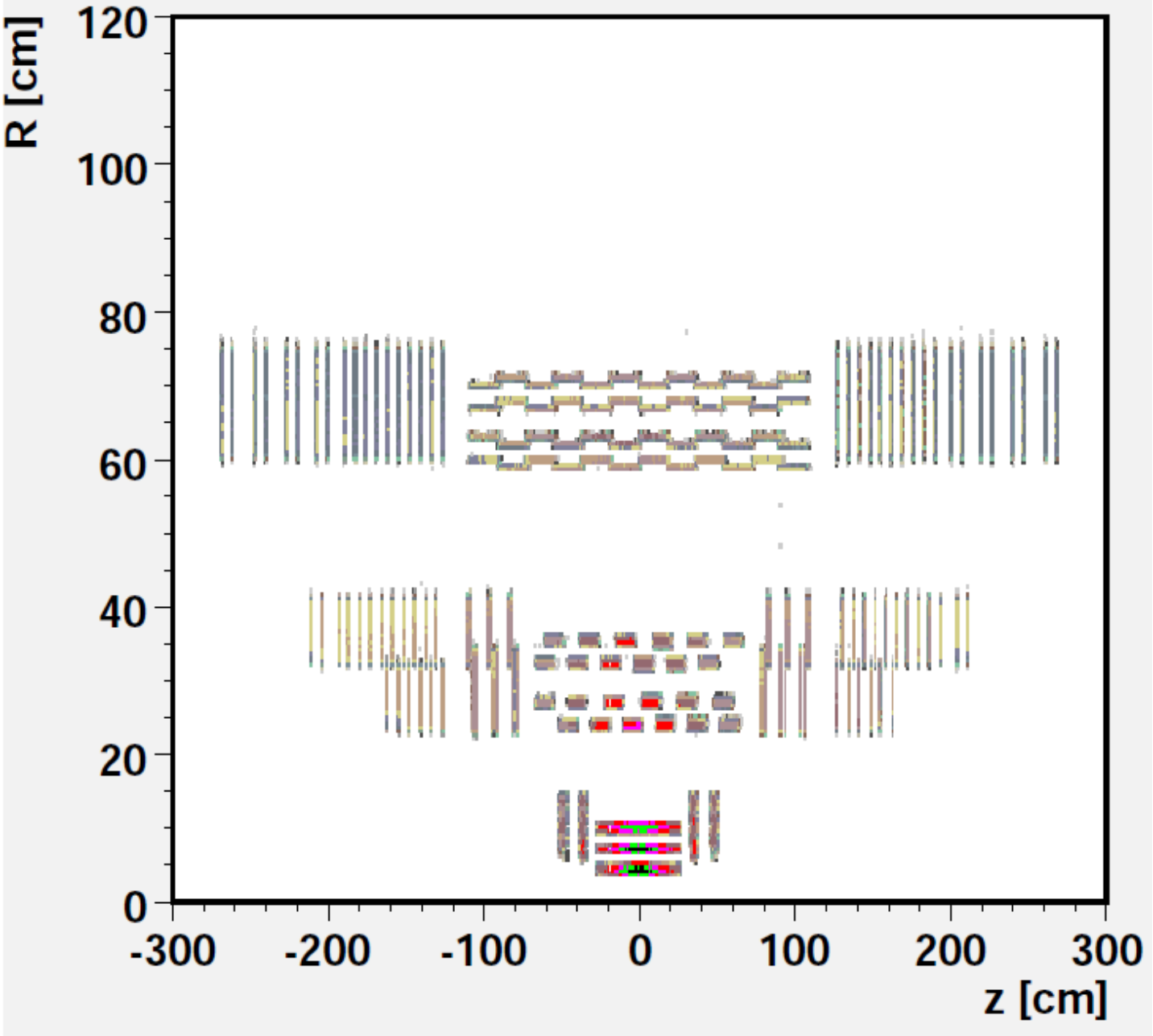
- p_t > 0.75 GeV:
  - can reach R = 130 cm in B = 3.81 T.
- Count all hits on a track, ϕ and stereo separately, and overlaps.
- Expect up to **3+6+8=17 hits** in the barrel.

Layers per track



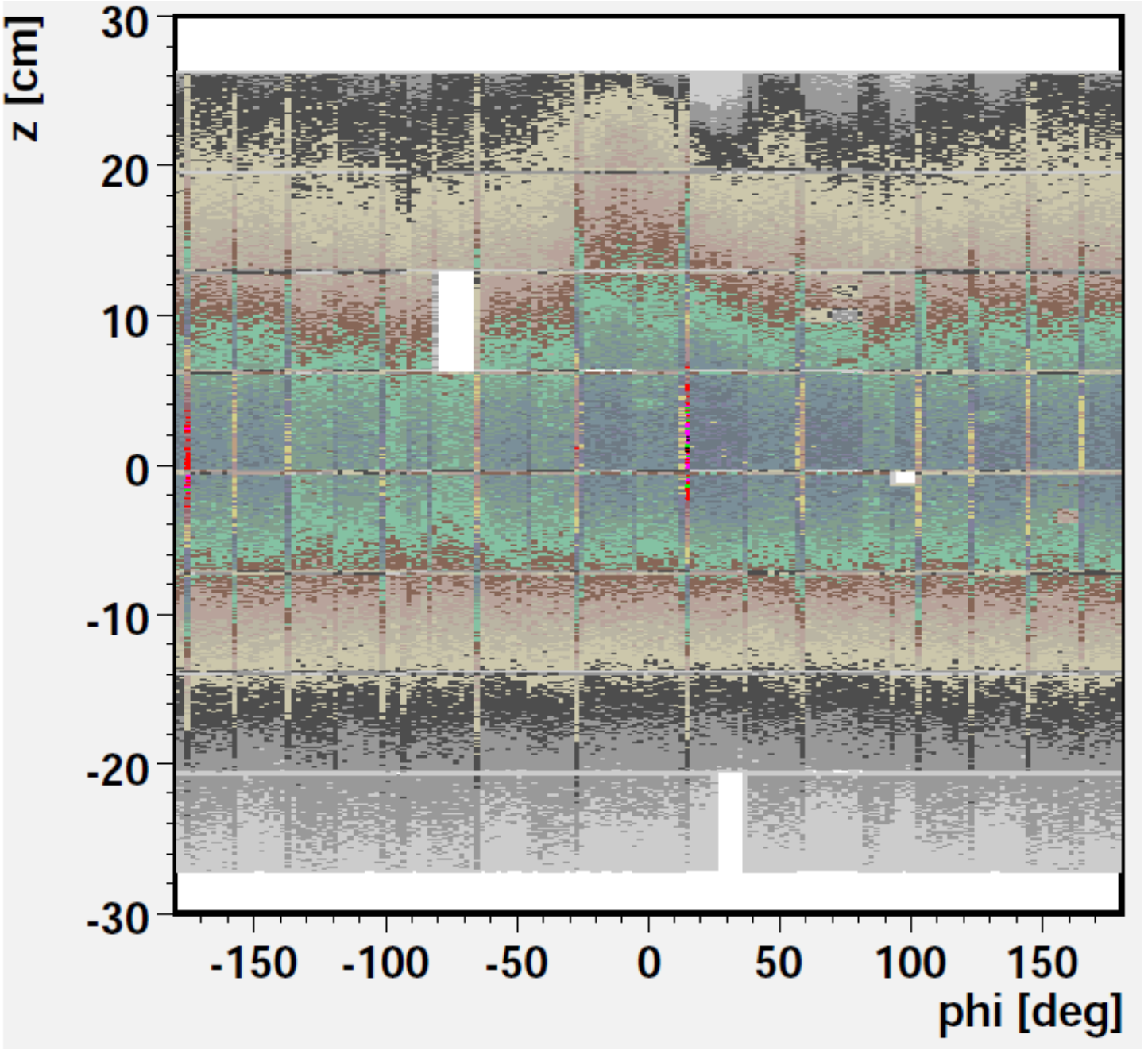
- p_t > 0.75 GeV:
  - can reach R = 130 cm in B = 3.81 T.
- Count layers only once, ϕ or stereo, without overlaps.
- Expect up to **3+4+6=13 layers** in the barrel.
- A 'track' requires at least 3 layers.
- Occupancy at edges is small...

Stereo hits on tracks



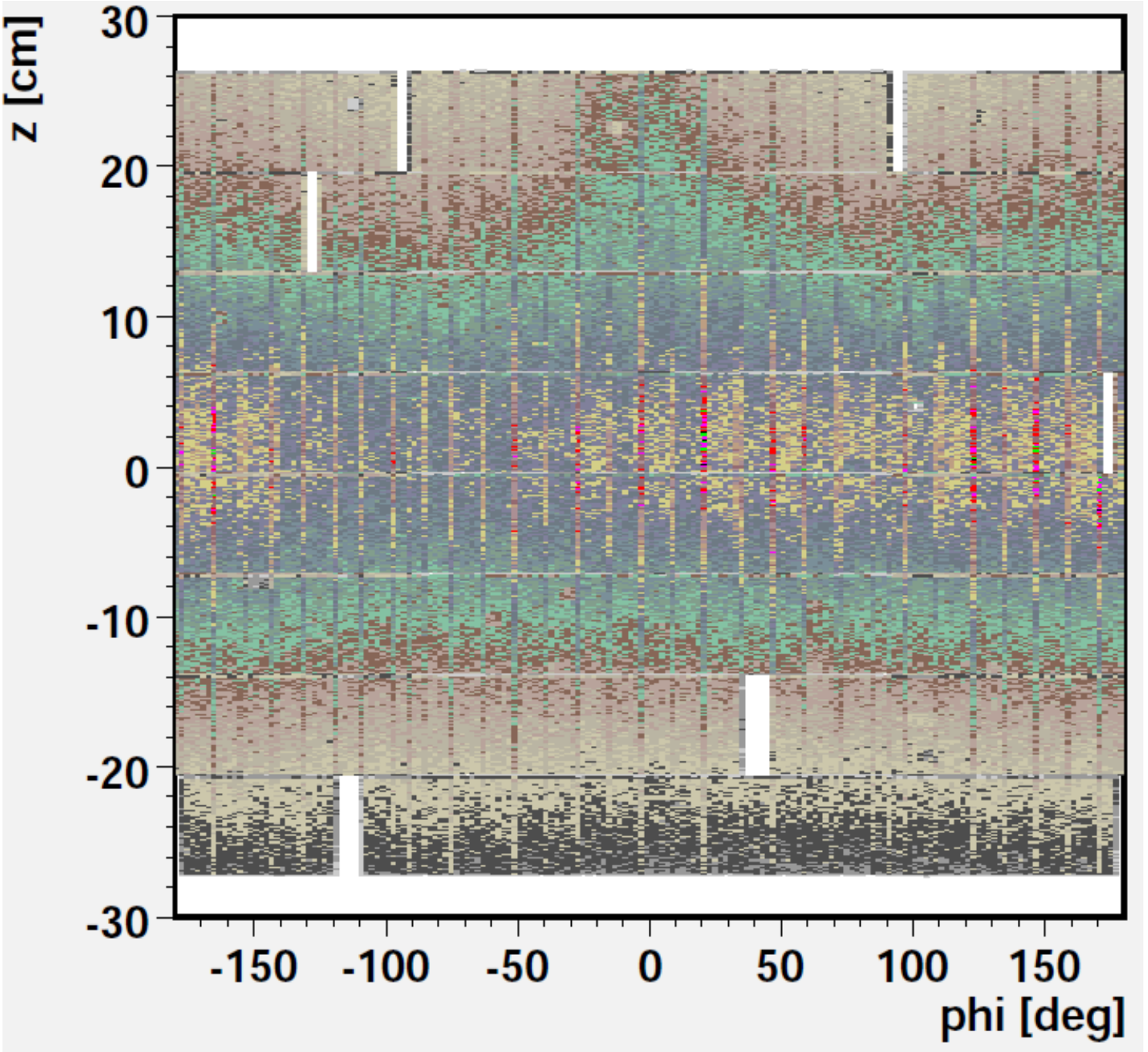
- Small-angle (0.1 rad = 5.7°) stereo:
  - Layers 1 and 2 in TIB and TOB.
  - Ring 1,2, and 5 in TID, TEC.
- (Pixel layers and disks are truly 2-D).

PXB1 in Oct 2010



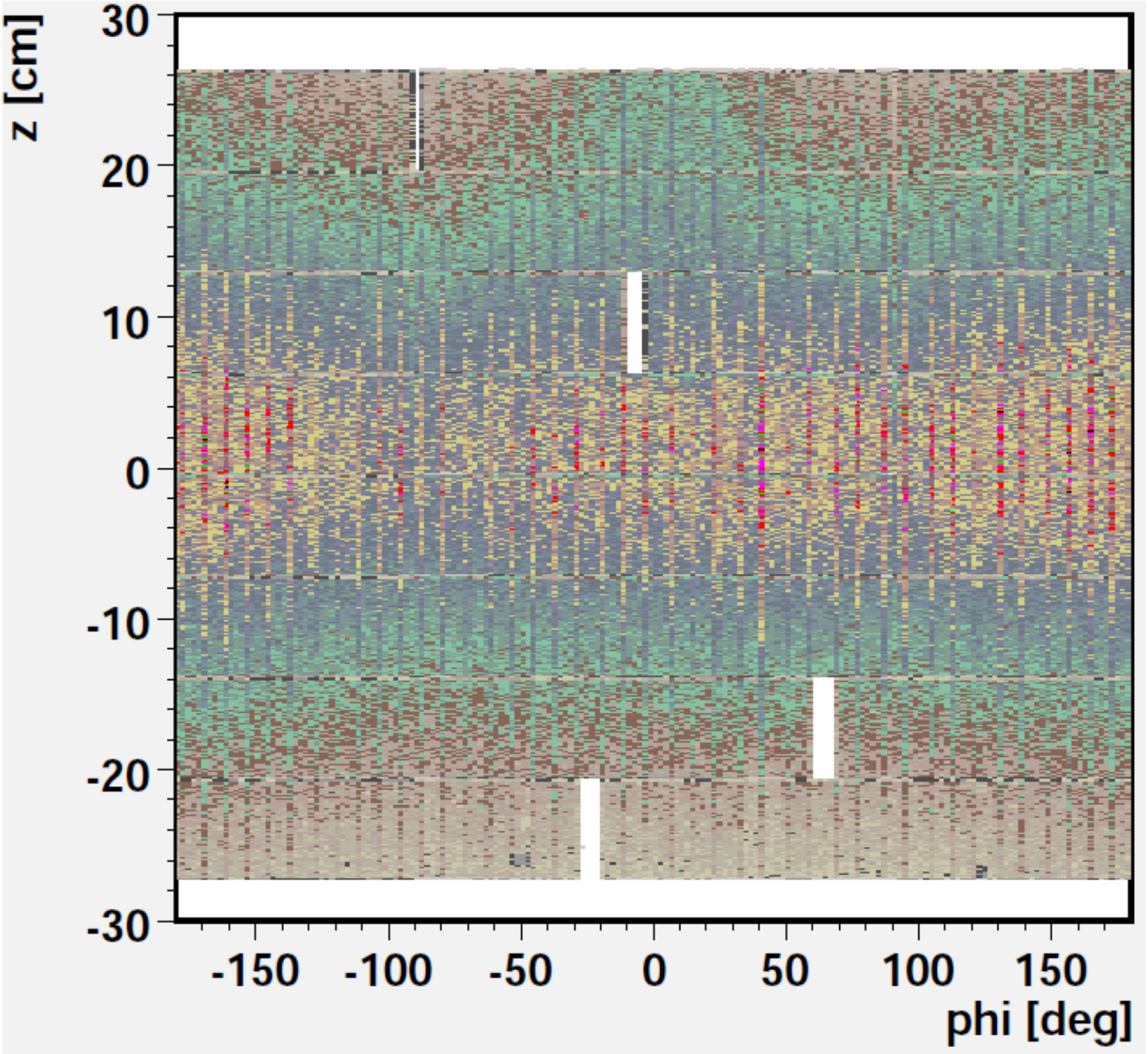
- Rolled-out hit map:
  - 8 modules in z, with gaps.
  - Covering ±26 cm.
- Layer 1:
- 20 overlapping ladders in ϕ.
  - Half-modules at ±90°.
- 160 modules.
- 1.5 dead modules.
- 1 dead ROC.

PXB2 in Oct 2010



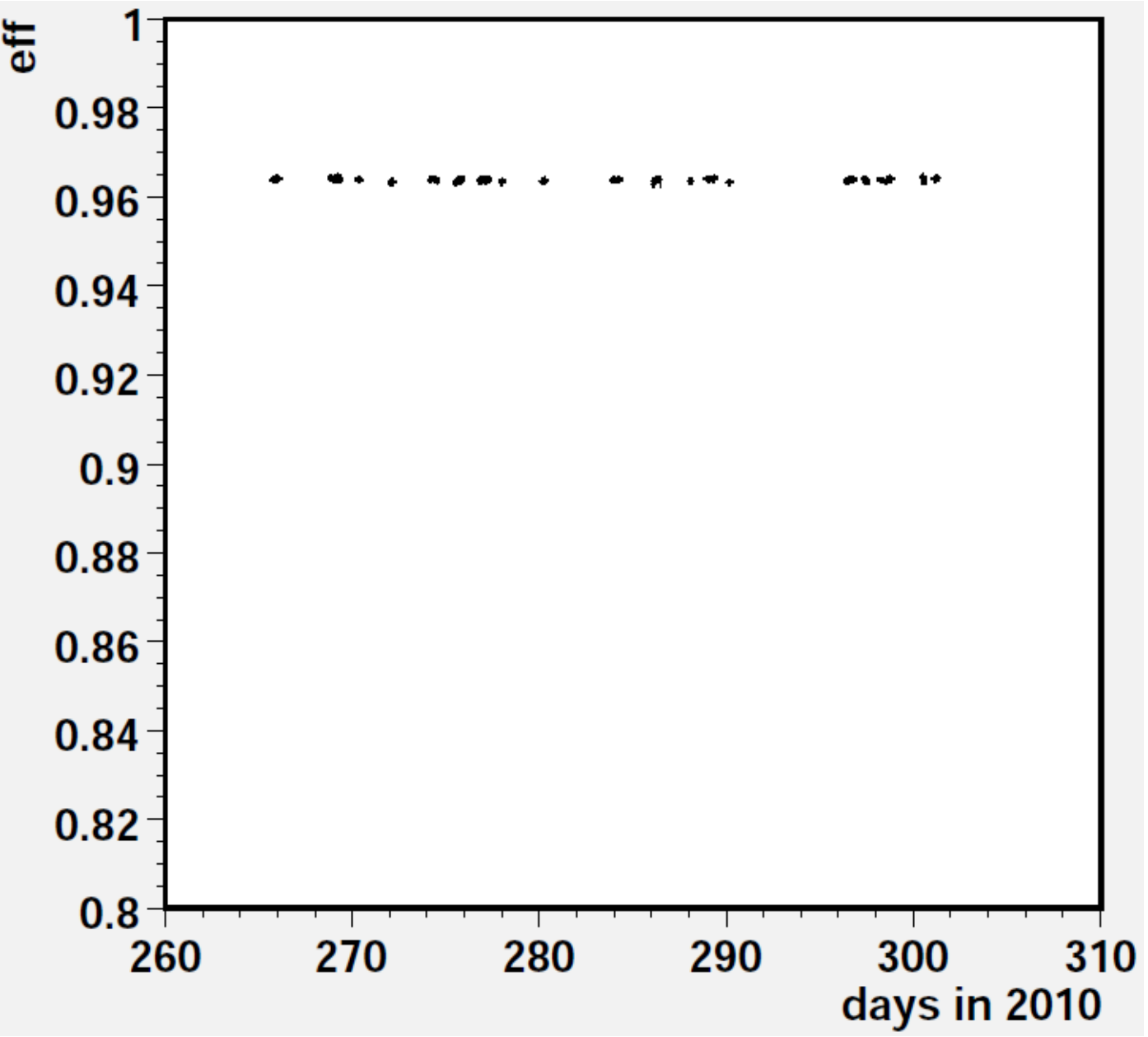
- Layer 2:
- 32 ladders in ϕ.
- 256 modules.
- 2 dead modules,
- 4 dead halves.

PXB3 in Oct 2010



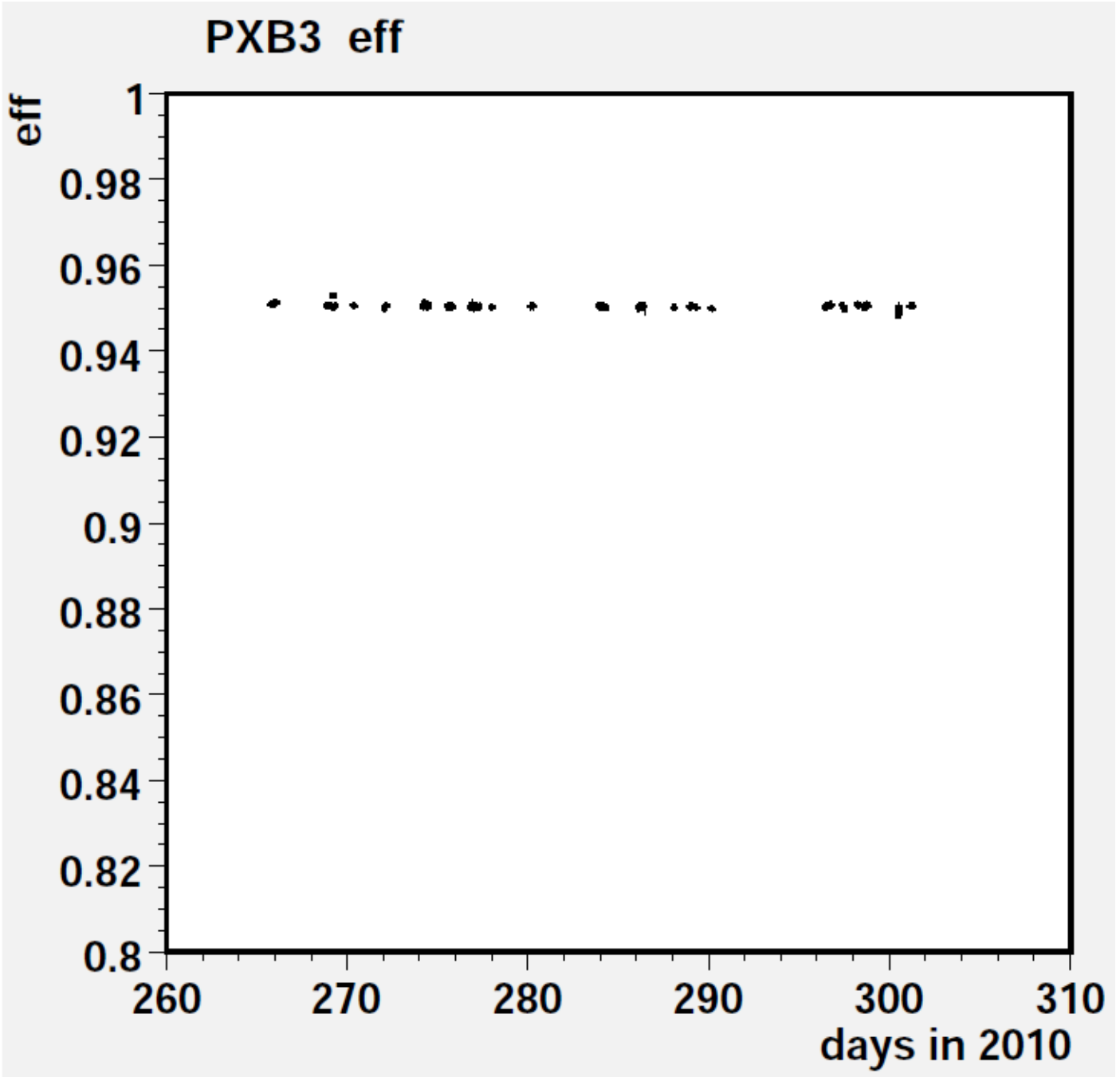
- Layer 3:
- 44 ladders in ϕ.
- 352 modules.
- 3 dead modules,
- 1 dead half.

PXB2 in Oct 2010



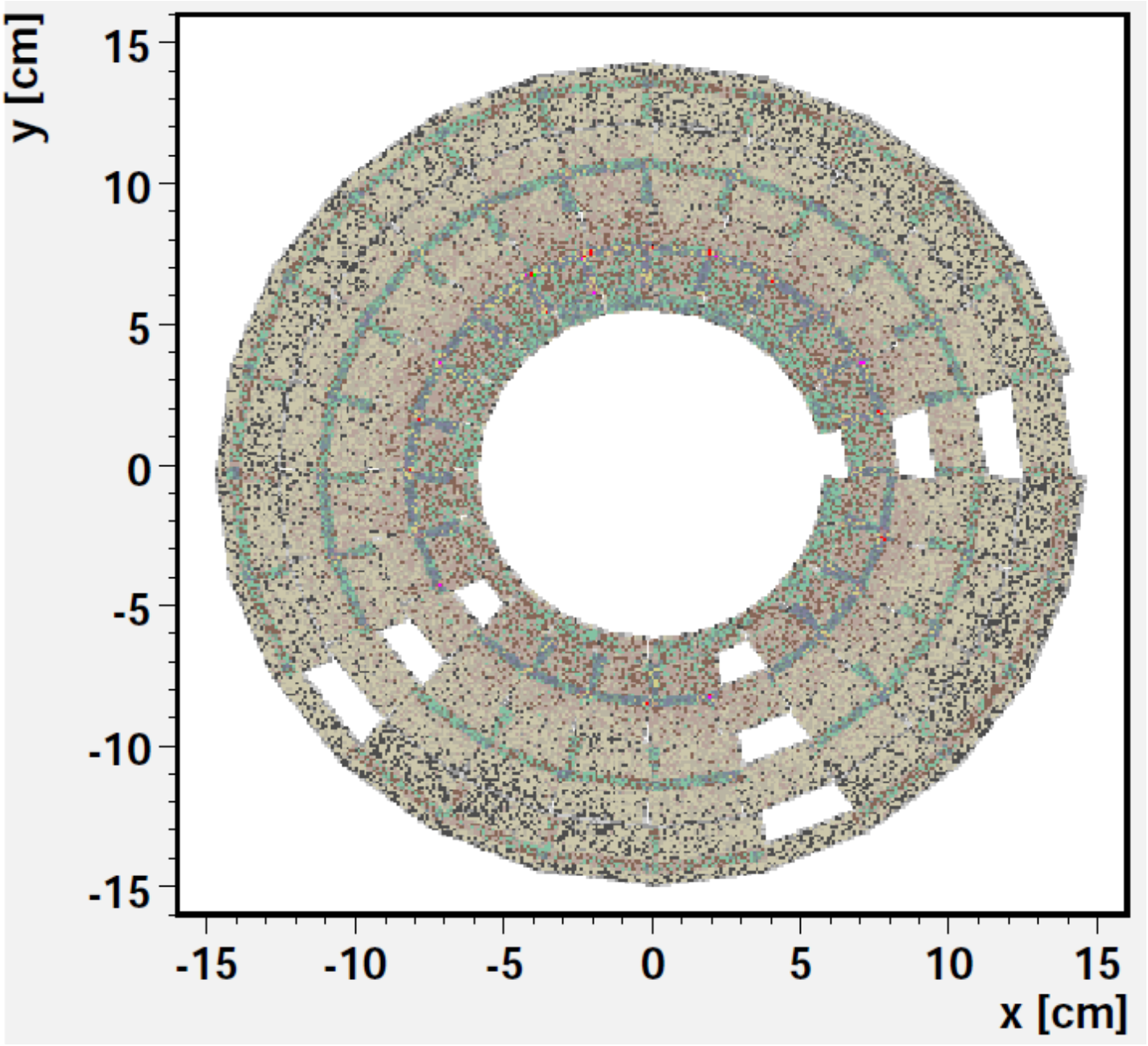
- ε = hits / expected.
- Track.HitPattern:
  - Info on hits and internal misses,
  - not for first and last layer.
  - available on AOD.
- Data 2010B: end Sep – end Oct 2010.
- 1-hour bins.
- PXB2: 96.5%:
  - z-gaps,
  - dead modules.
  - stable.

PXB3 in Oct 2010



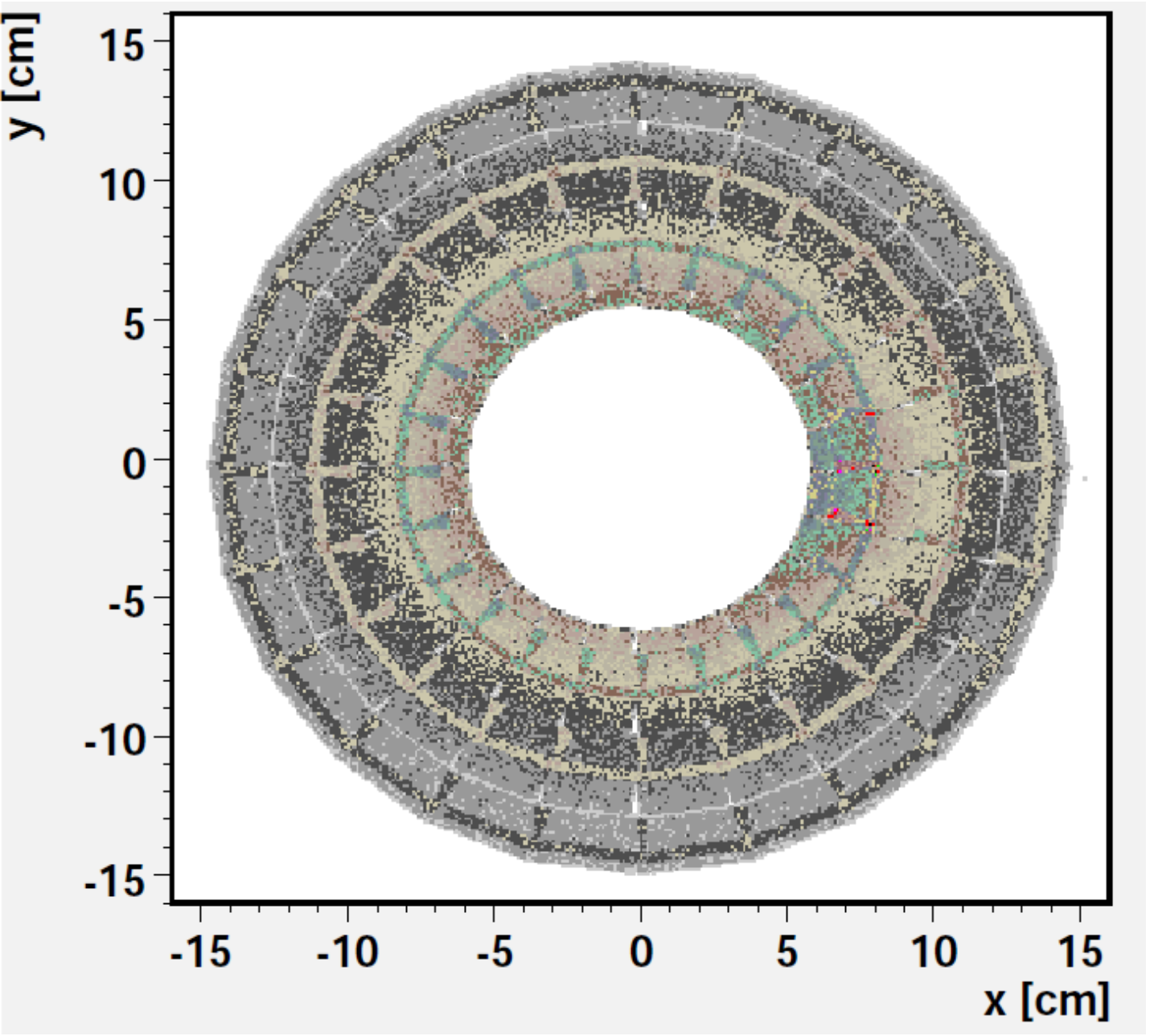
- PXB2: 95%
  - z-gaps,
  - 4 dead modules.
  - stable.

PXD1- in Oct 2010



- 3 rings in R,
- 24 blades in phi.
- 9 dead modules

PXD1+ in Oct 2010

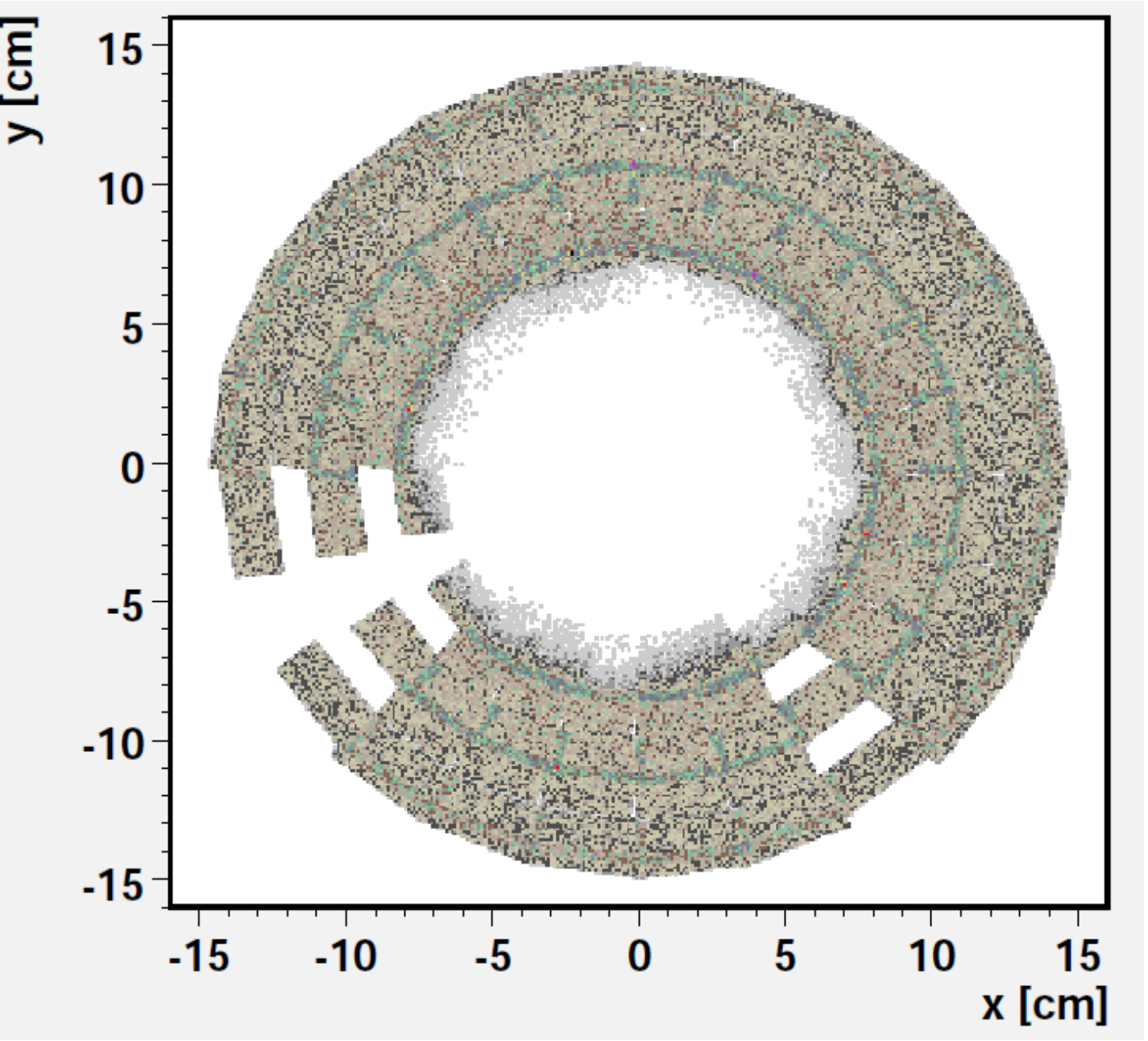


- 3 rings in R,
- 24 panels in phi.
-

PXD1 in Oct 2010

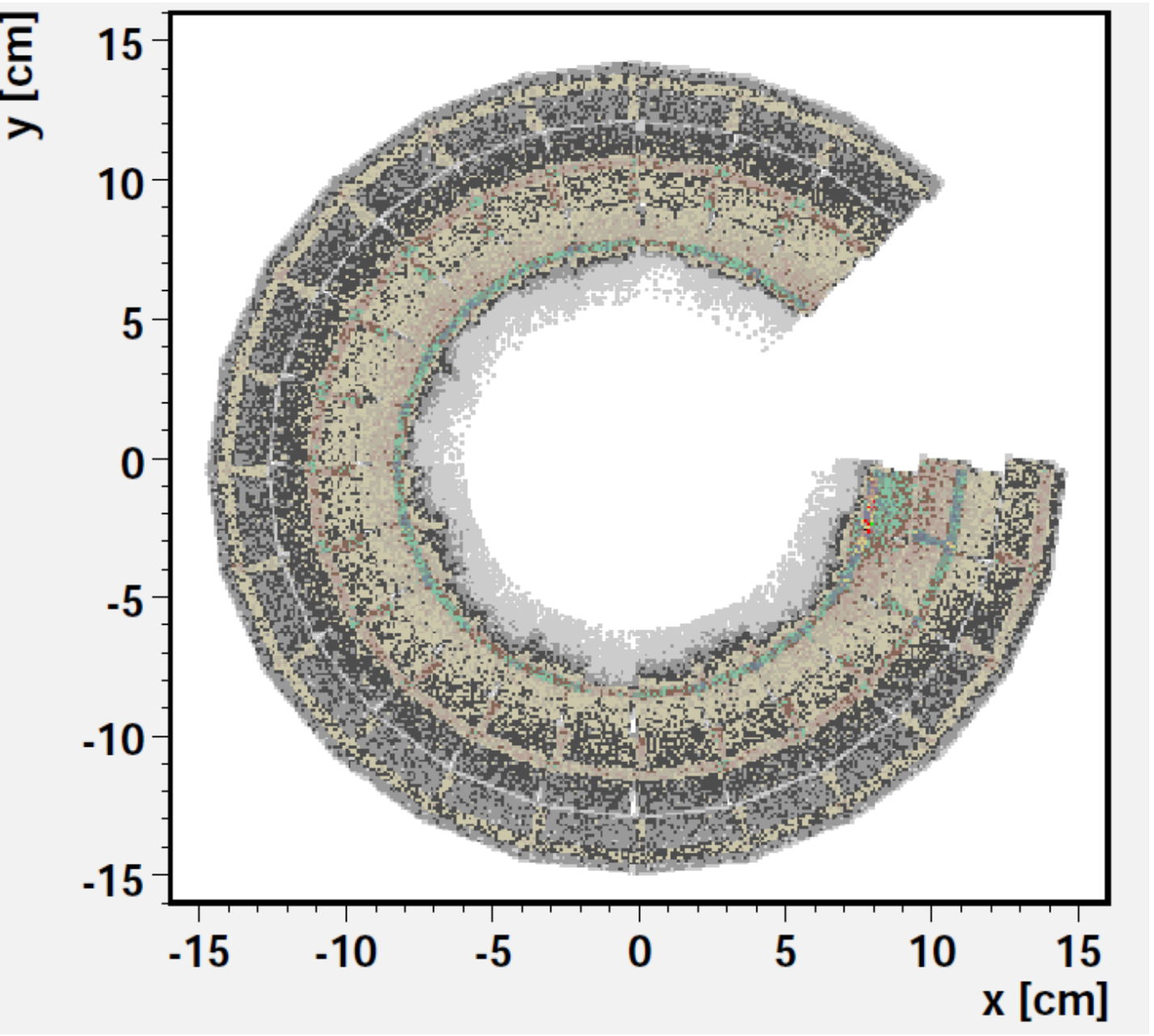
- HitPattern does not distinguish $+z$ and $-z$
  - averaged.
- PXD1: 95%
  - 9 dead modules.
  - stable.

PXD2- in Oct 2010



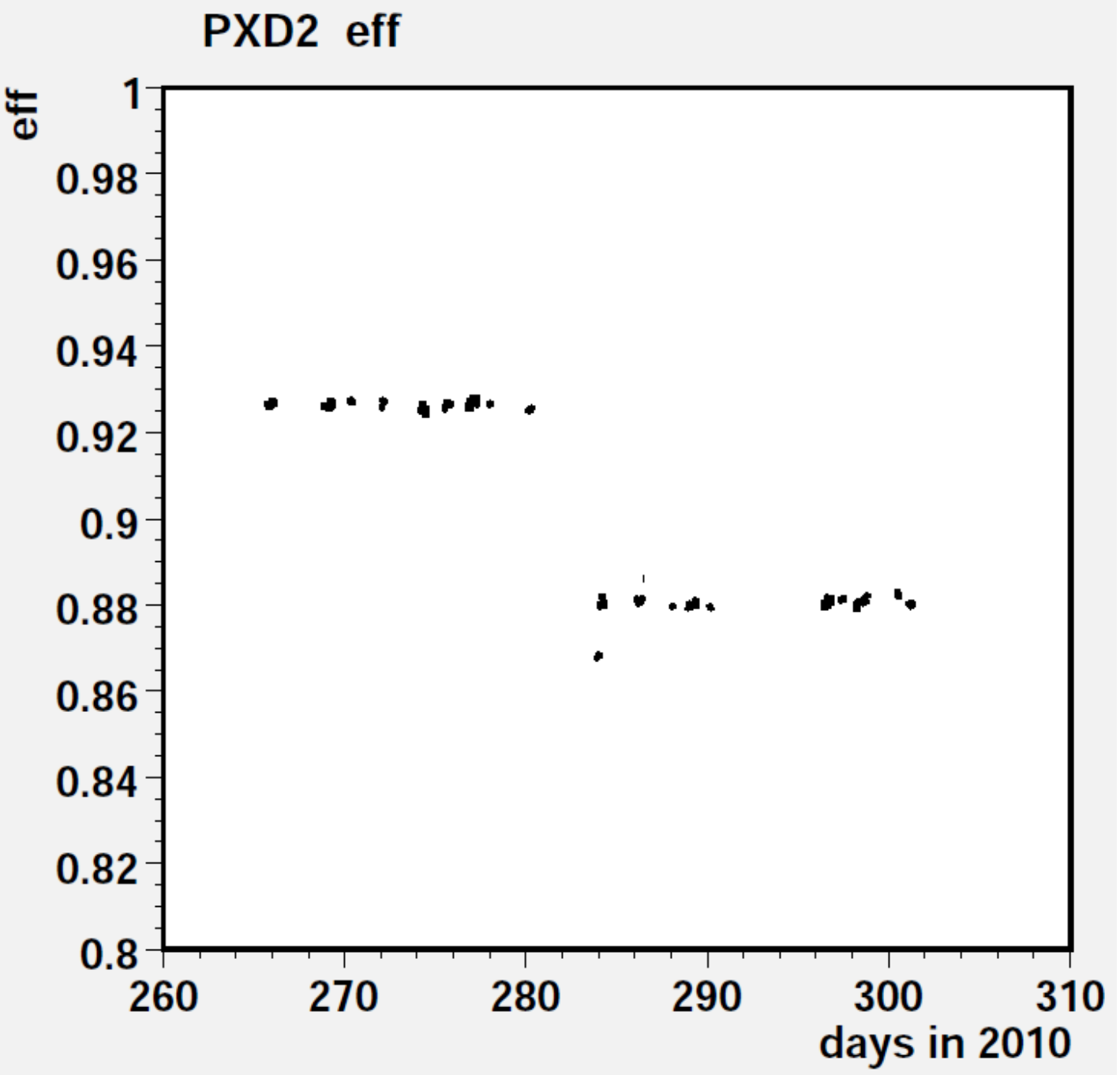
- 2 rings in R,
- 24 blades in phi.
- 1 dead blade
- 6 dead modules

PXD2+ in Oct 2010



- 2 rings in R,
- 24 blades in phi, overlapping.
- 3 dead blades (one octant).

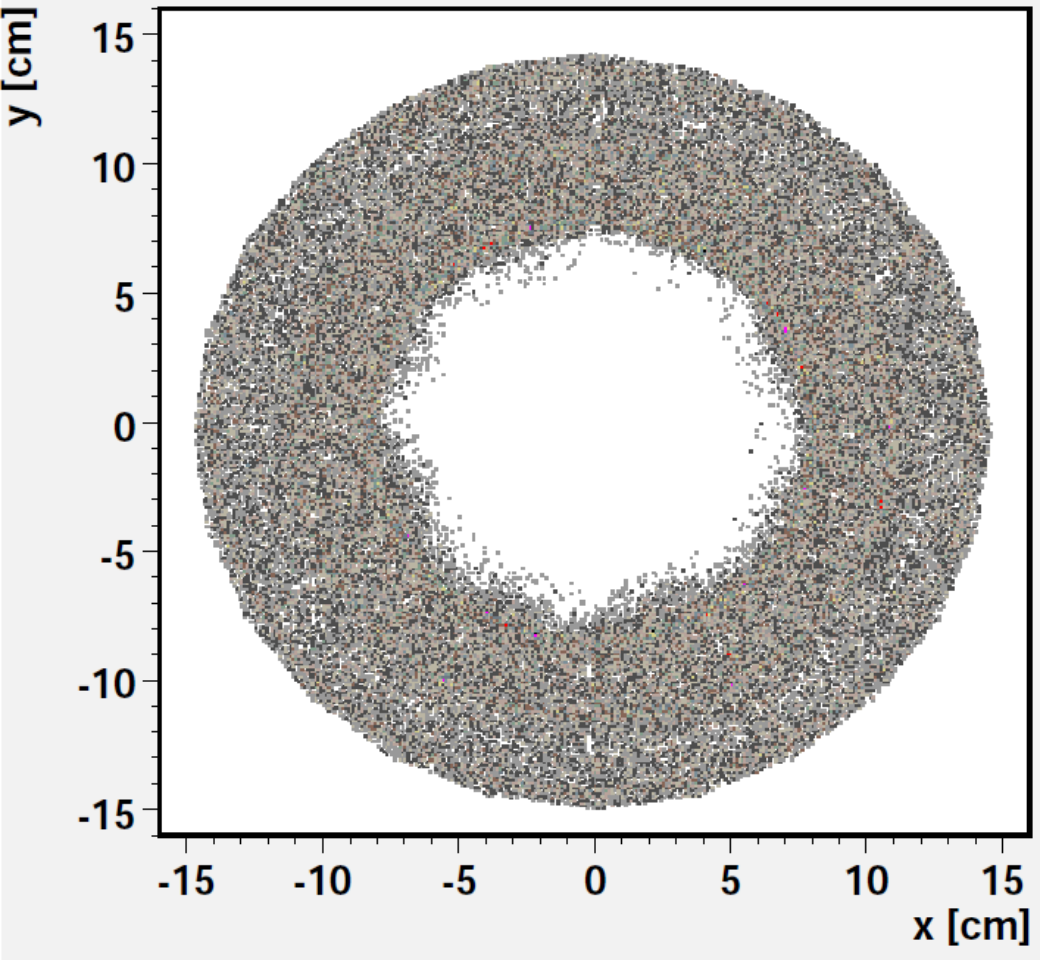
PXD2 in Oct 2010



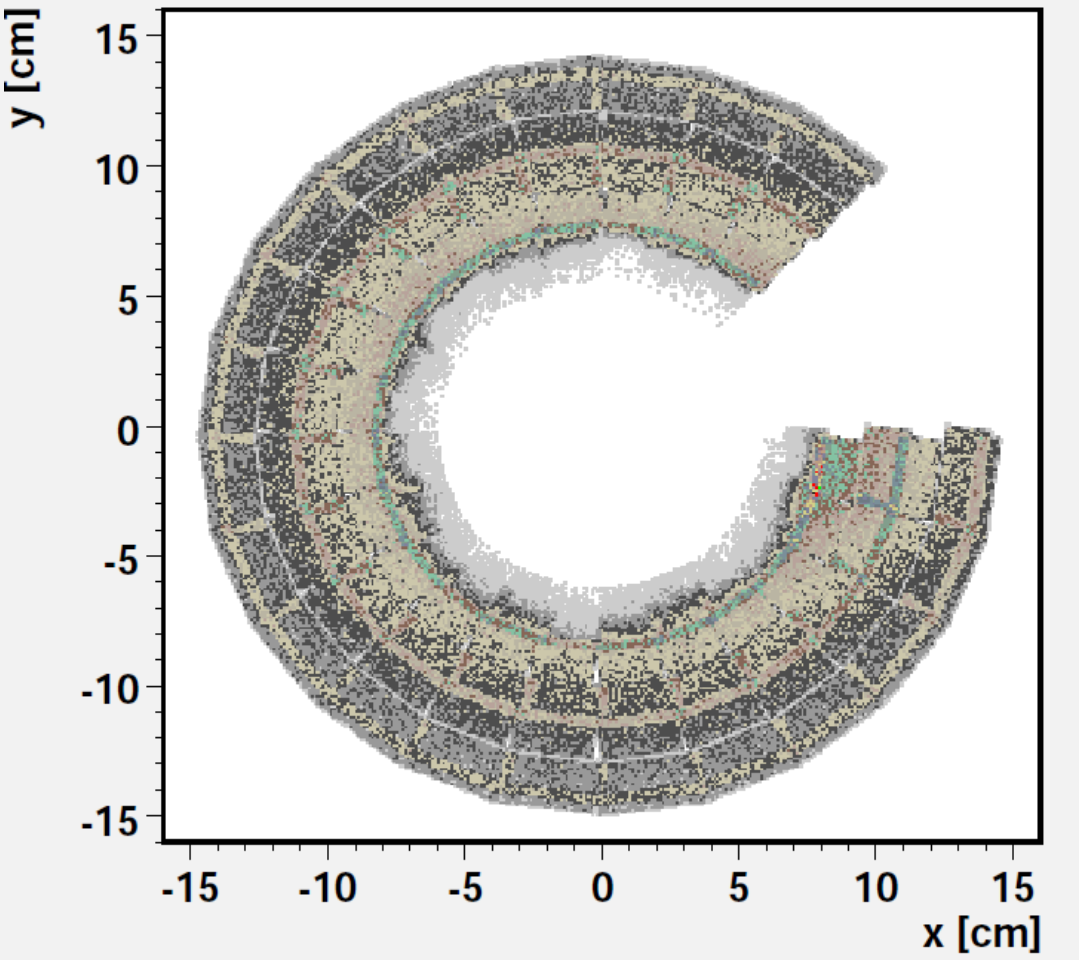
- PXD2: $\pm z$ averaged.
- PXD2: 93% → 88%
  - octant in PXD2+ died in early Oct.

PXD2+ in autumn 2010

run 146804 (26.9.2010)

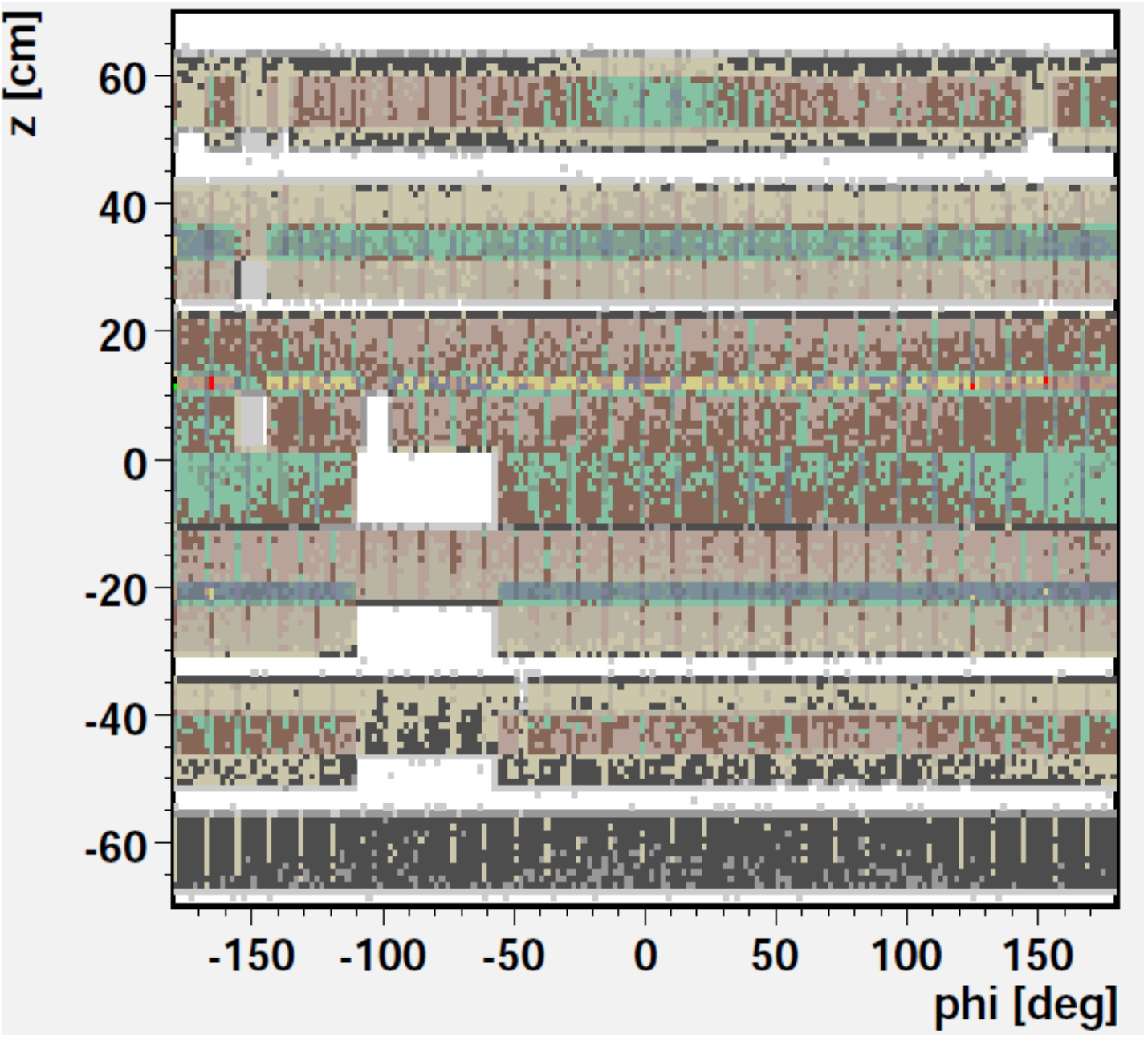


run 149442 (30.10.2010)



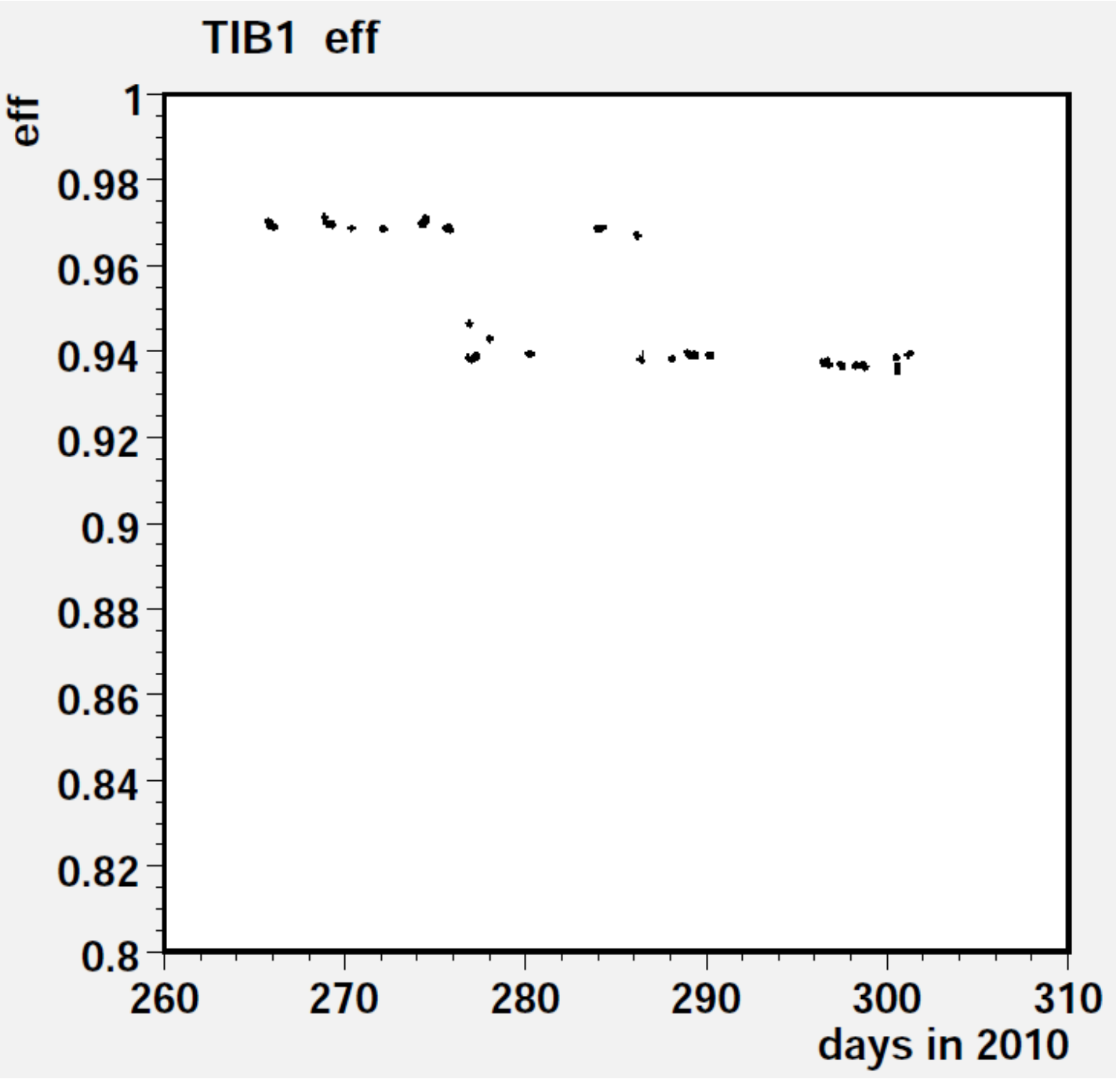
×15 higher statistics

TIB1 in Oct 2010



- TIB1:
  - 26 or 30 strings in phi,
  - 12 modules in z.
  - z-gaps are artifact of the staggering.
  - full coverage in eta as seen from IP.
-

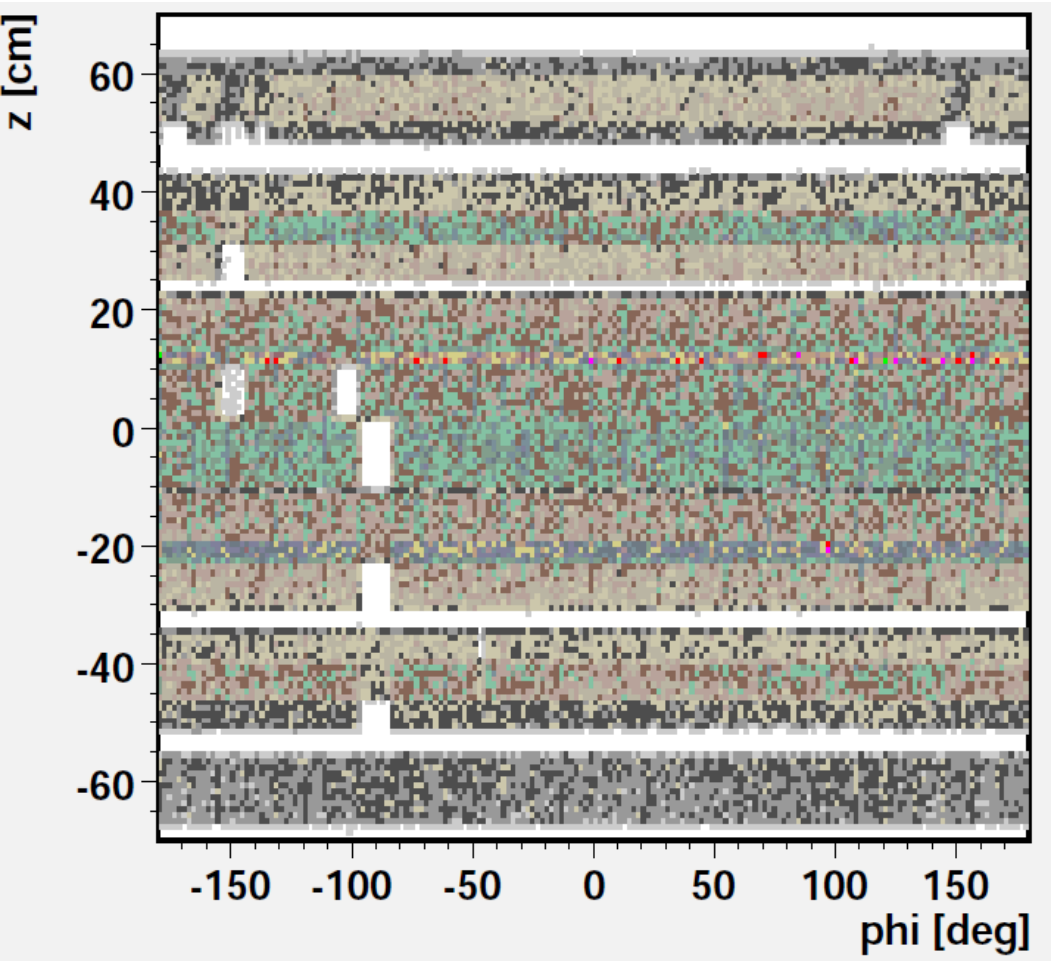
TIB1 in Oct 2010



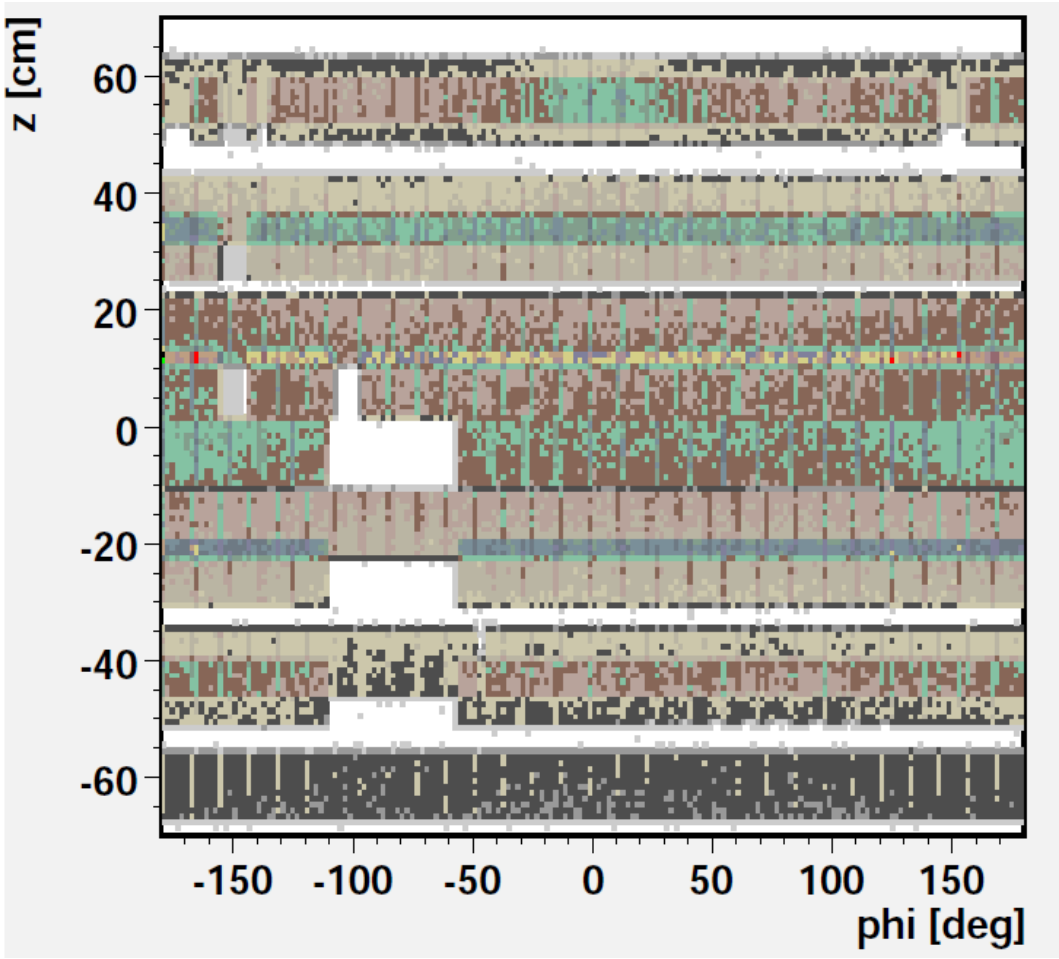
- TIB1: 97% → 93.5%
  - modules died in early Oct.

TIB1 in autumn 2010

run 146804 (26.9.2010)

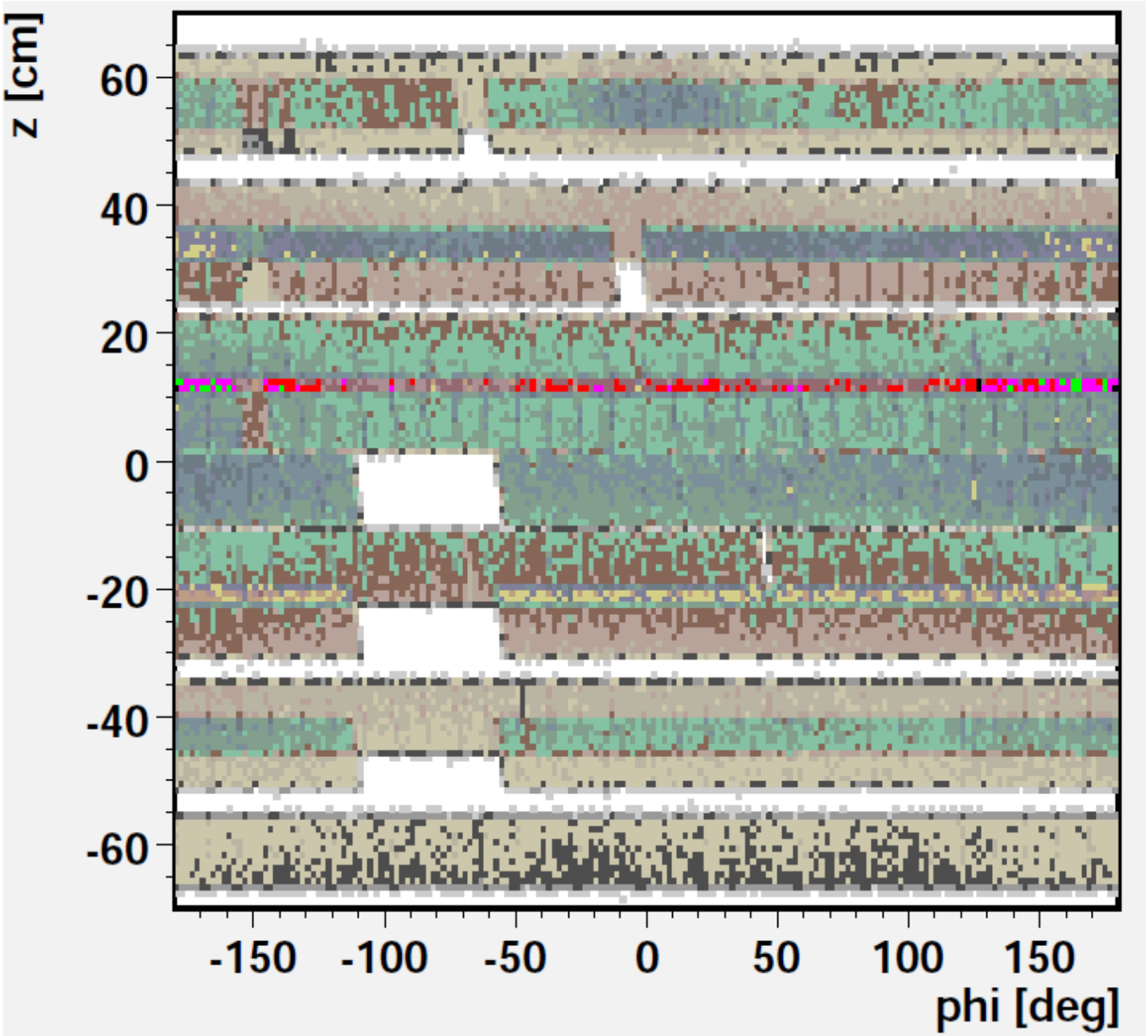


run 149442 (30.10.2010)



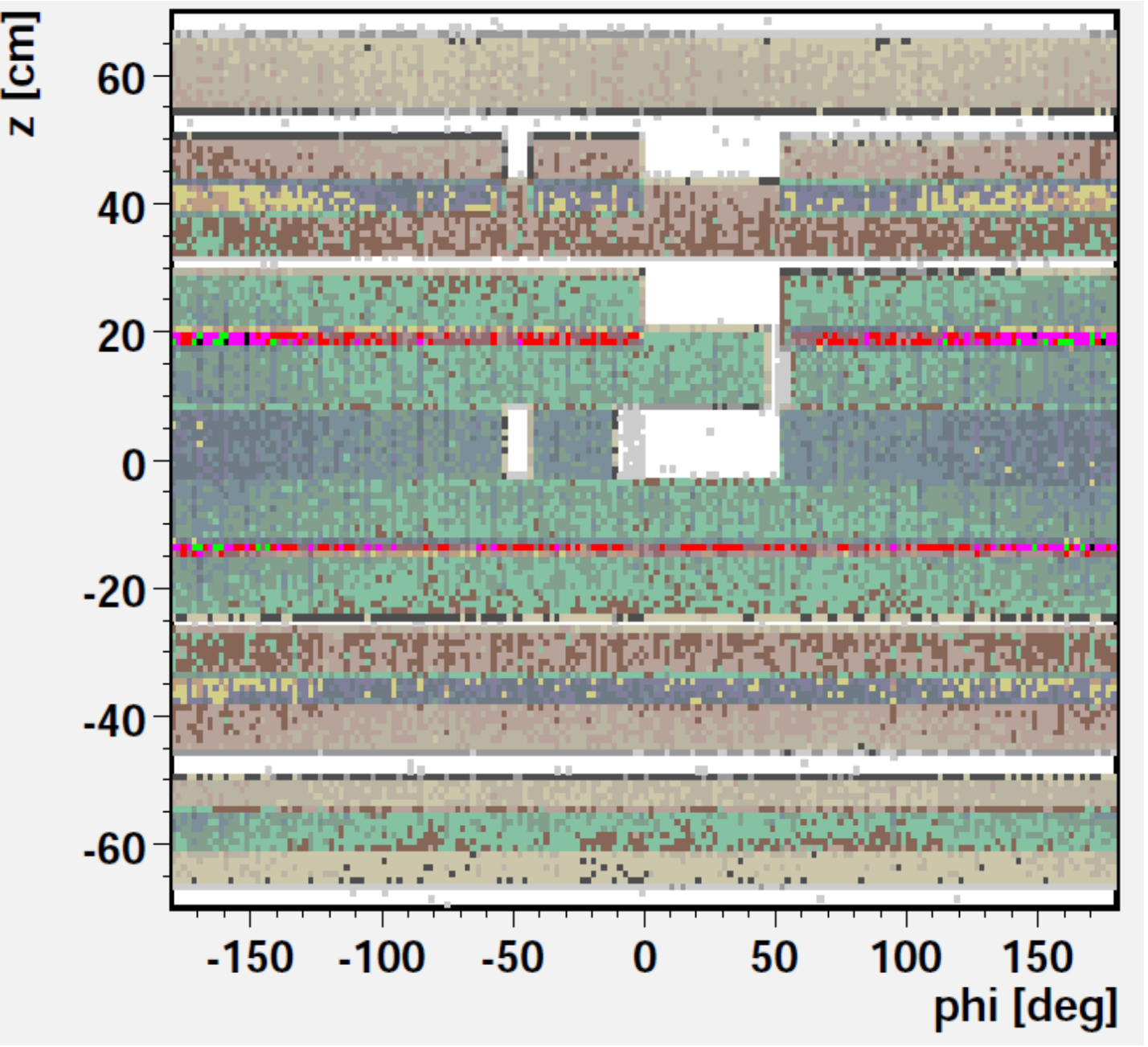
×9 higher statistics

TIB1 stereo in Oct 2010

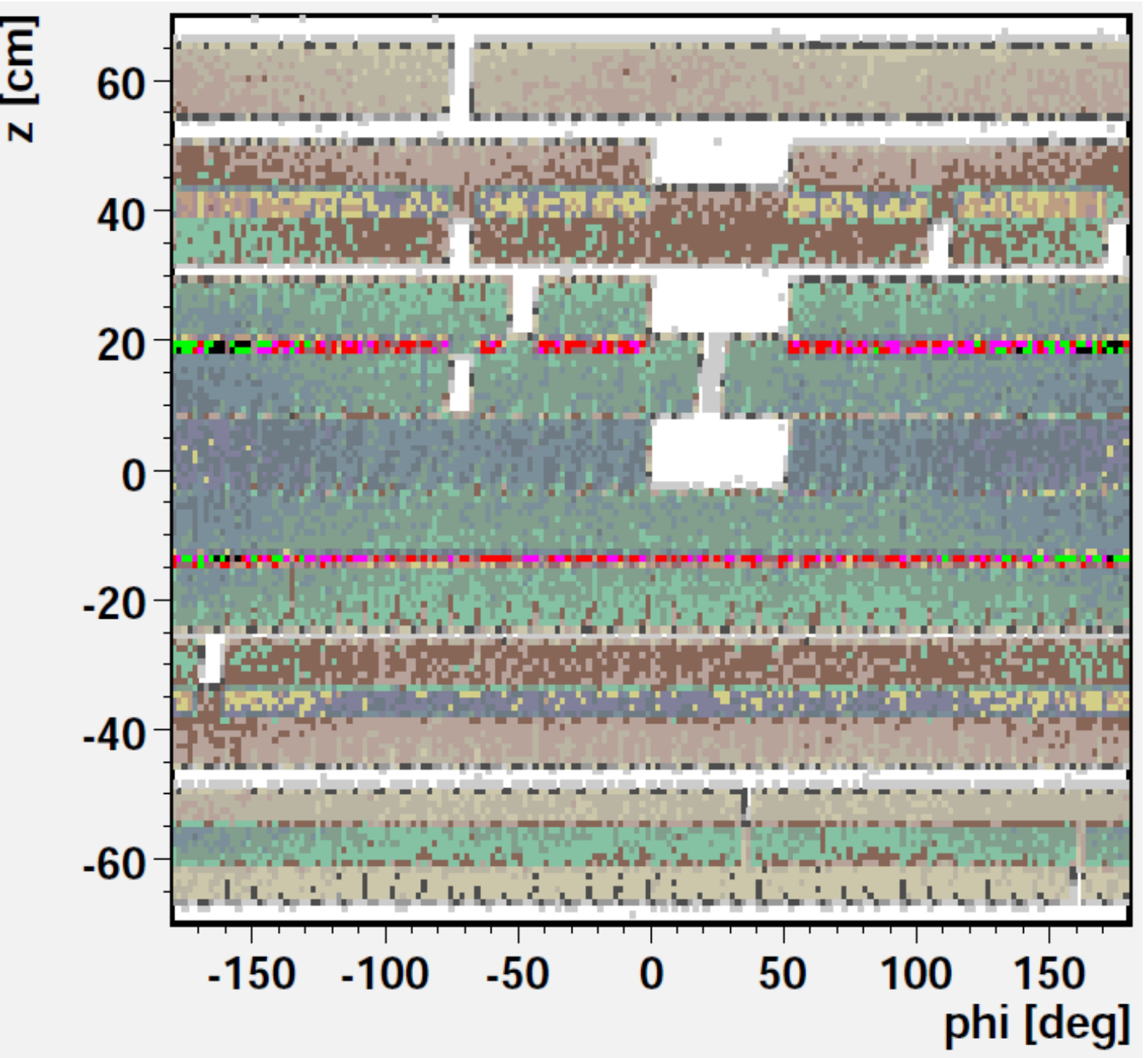


- TIB1 stereo:
  - Modules are rotated by 100 mrad = 5.7° stereo angle.
  - Similar holes as in the axial layer.

TIB2 in Oct 2010

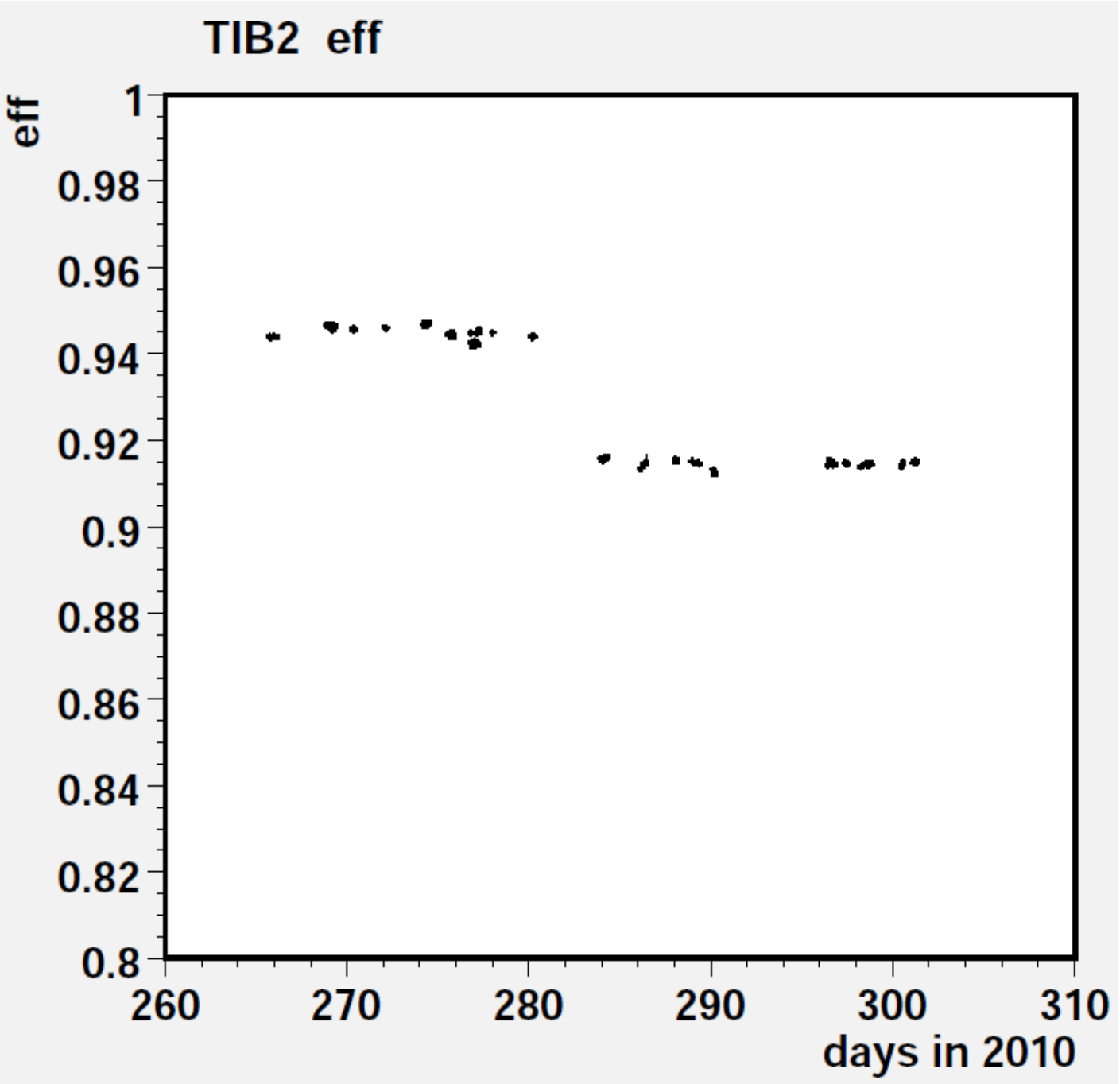


TIB2 stereo in Oct 2010



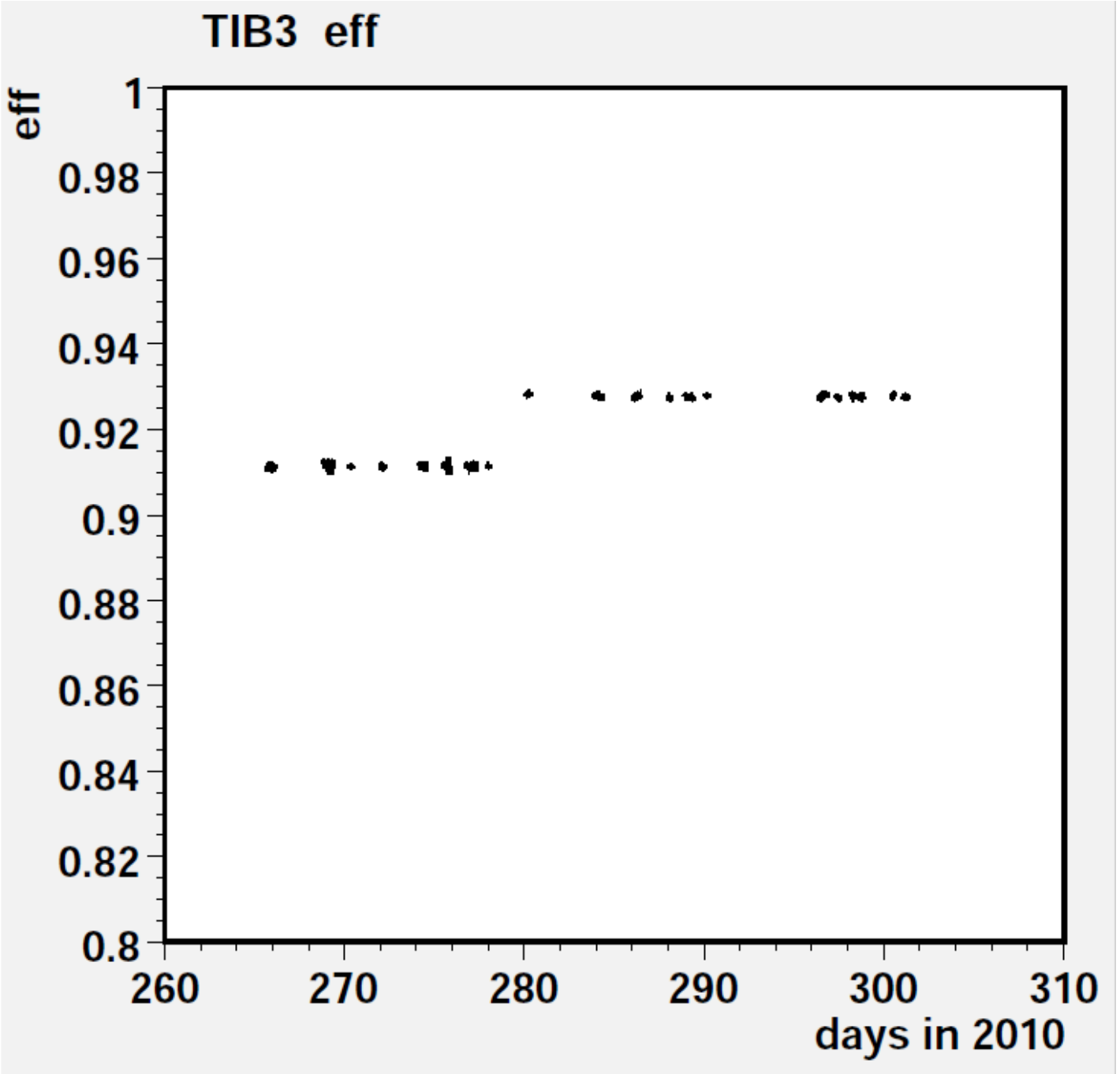
- TIB2 stereo:
  - Opposite stereo angle as TIB1.

TIB2 in Oct 2010



- TIB2: 94.5% → 91%
  - modules died in early Oct.

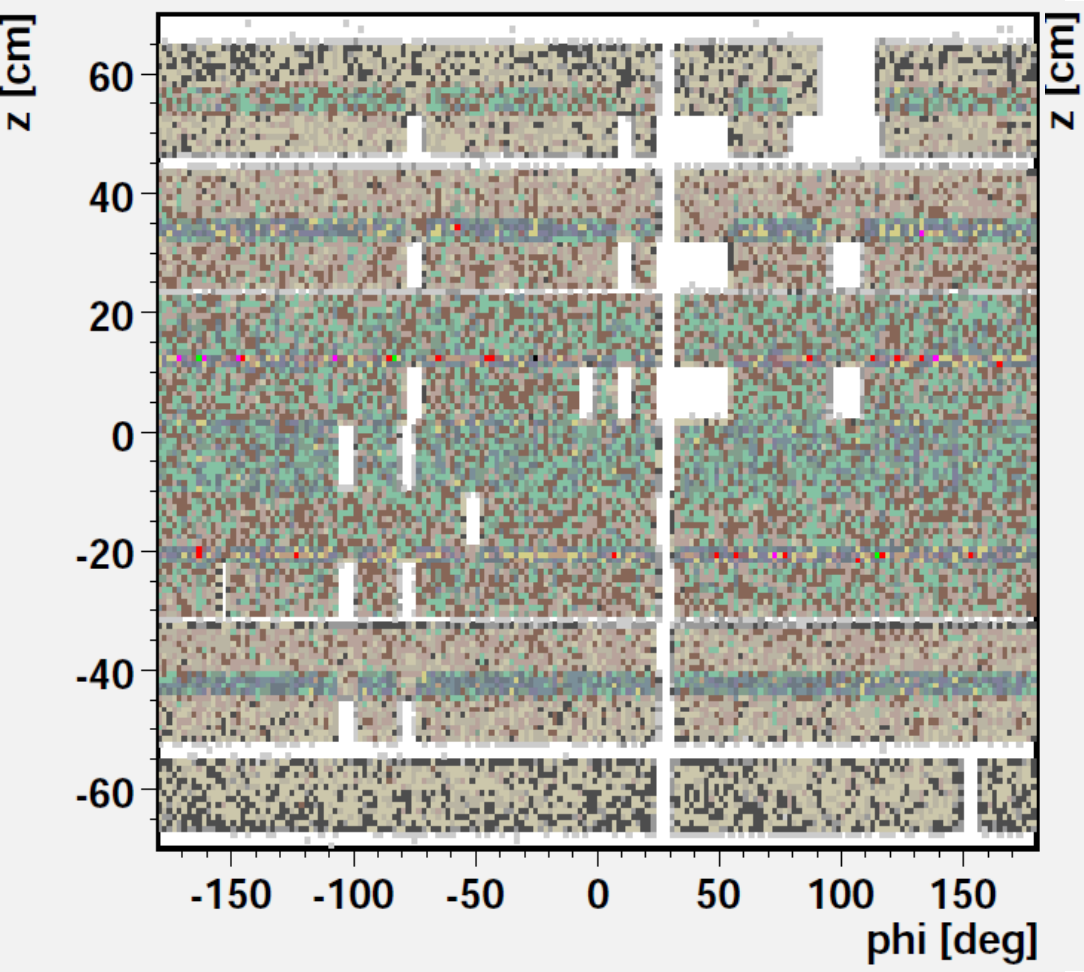
TIB3 in Oct 2010



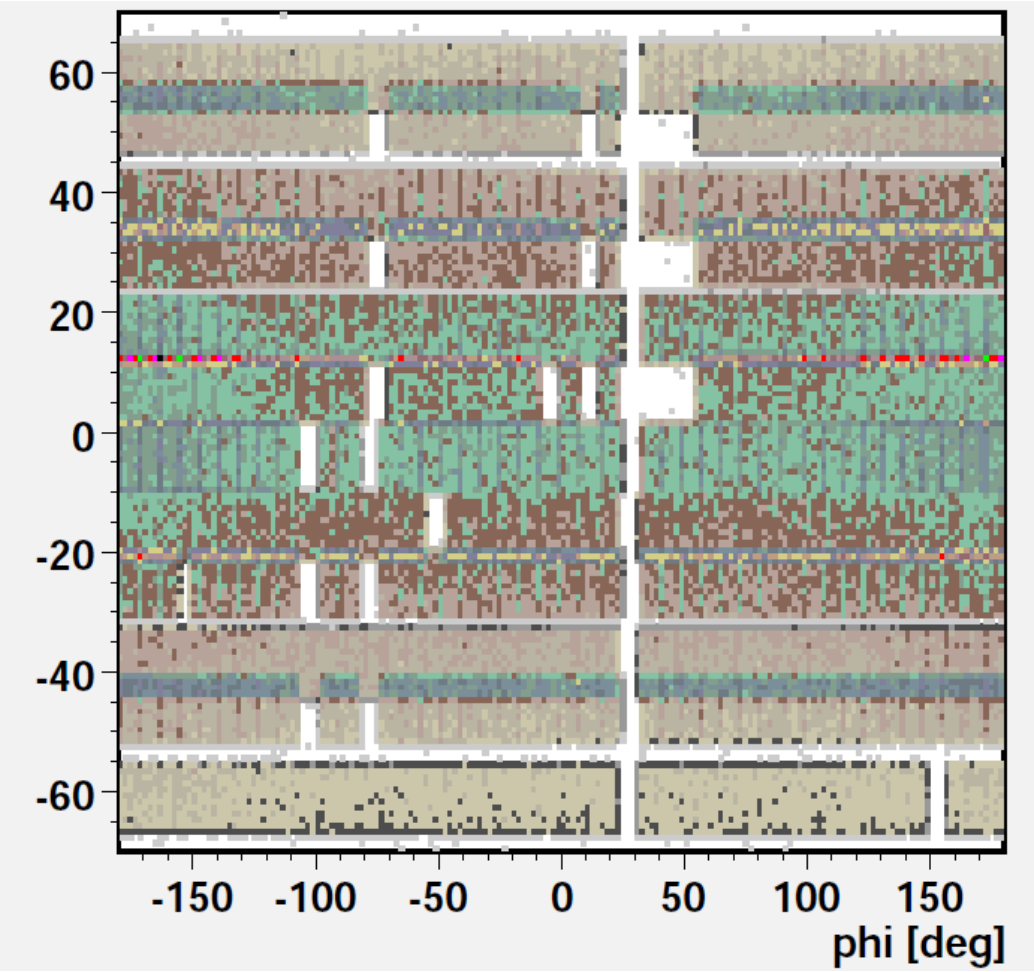
- TIB3: 91% → 93%
  - modules resurrected in early Oct.

TIB3 in autumn 2010

run 146804 (26.9.2010)

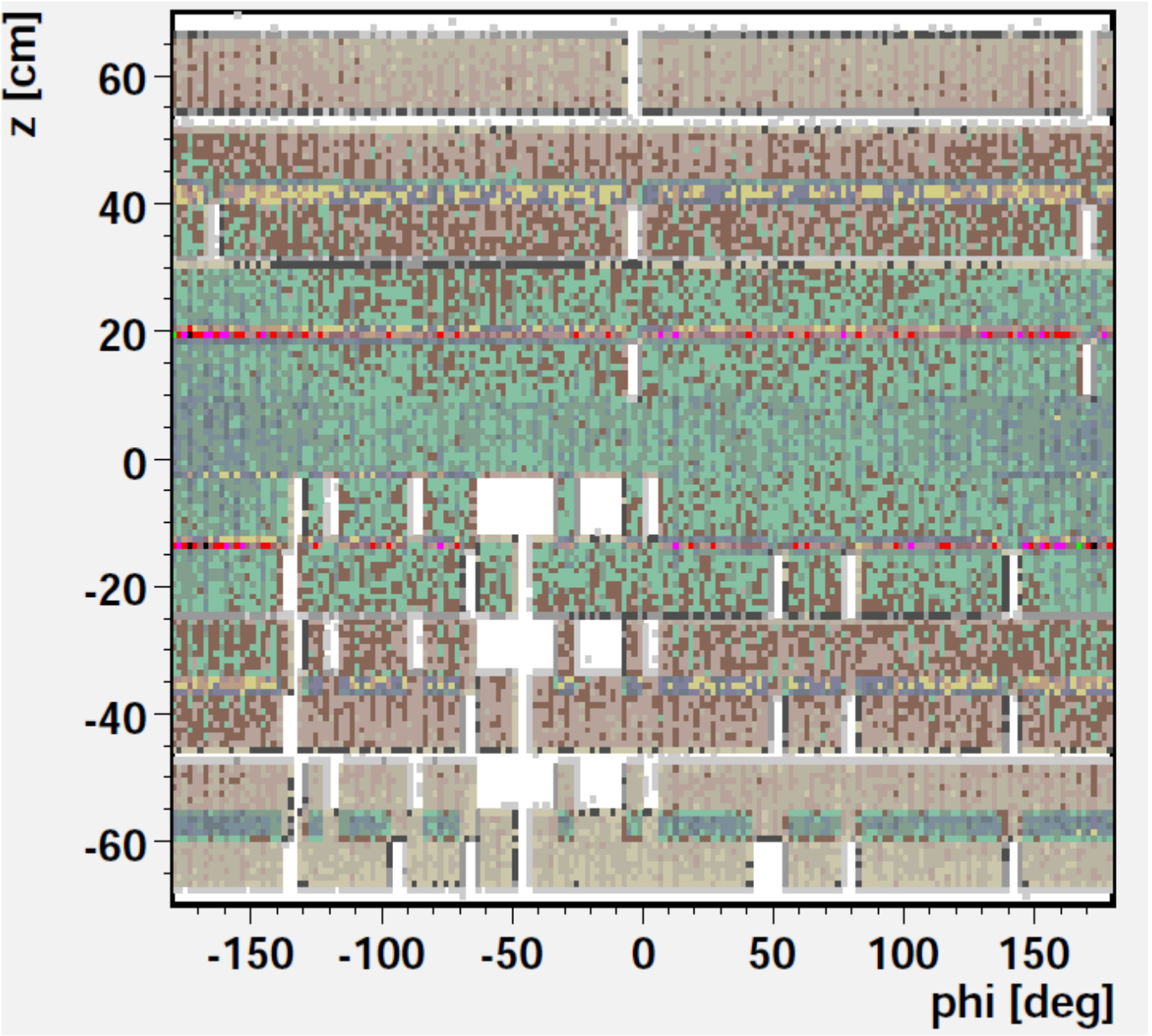


run 149442 (30.10.2010)



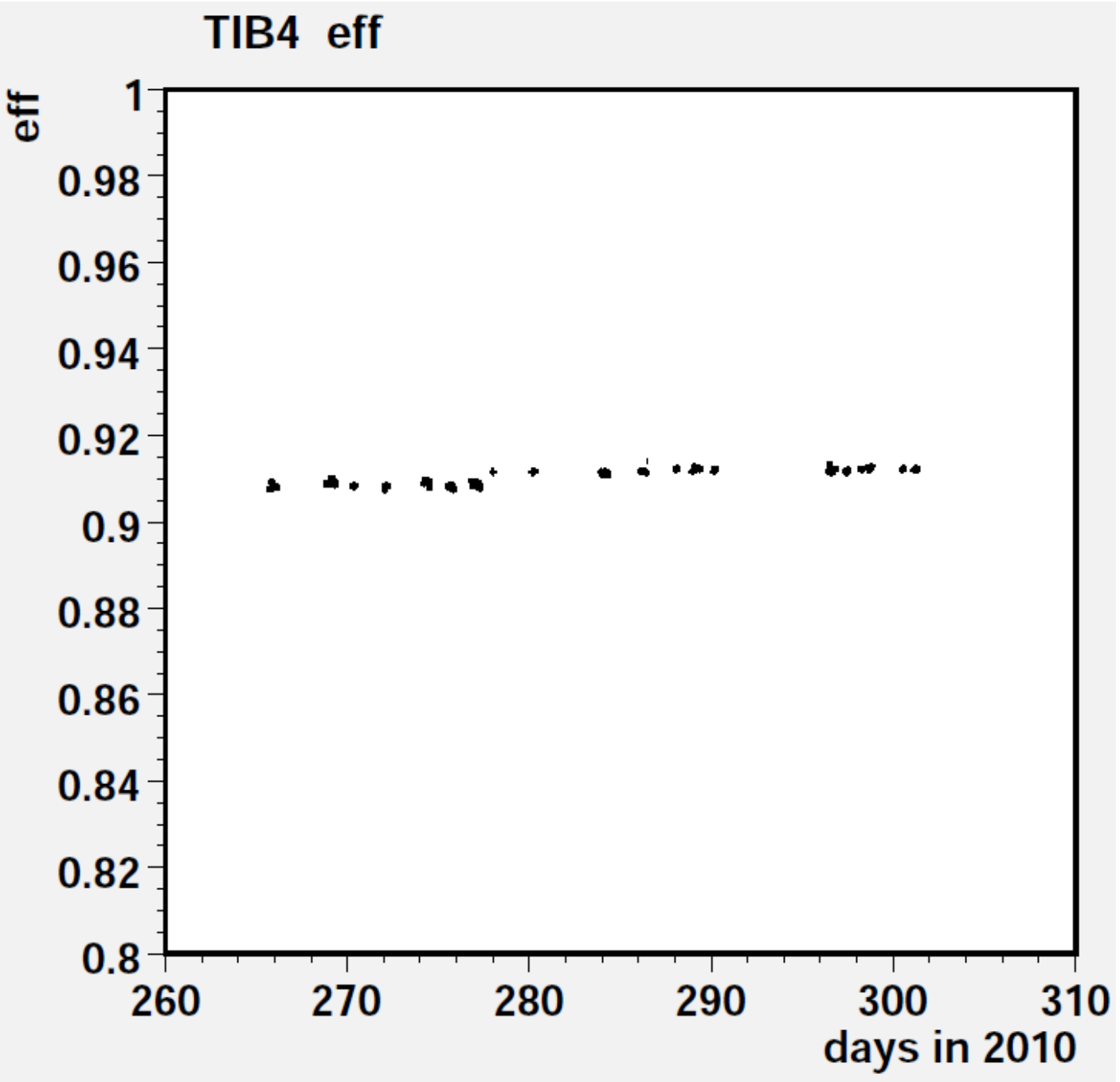
×9 higher statistics

TIB4 in Oct 2010



- TIB4:
  - holes lead to 91% efficiency (according to HitPattern).

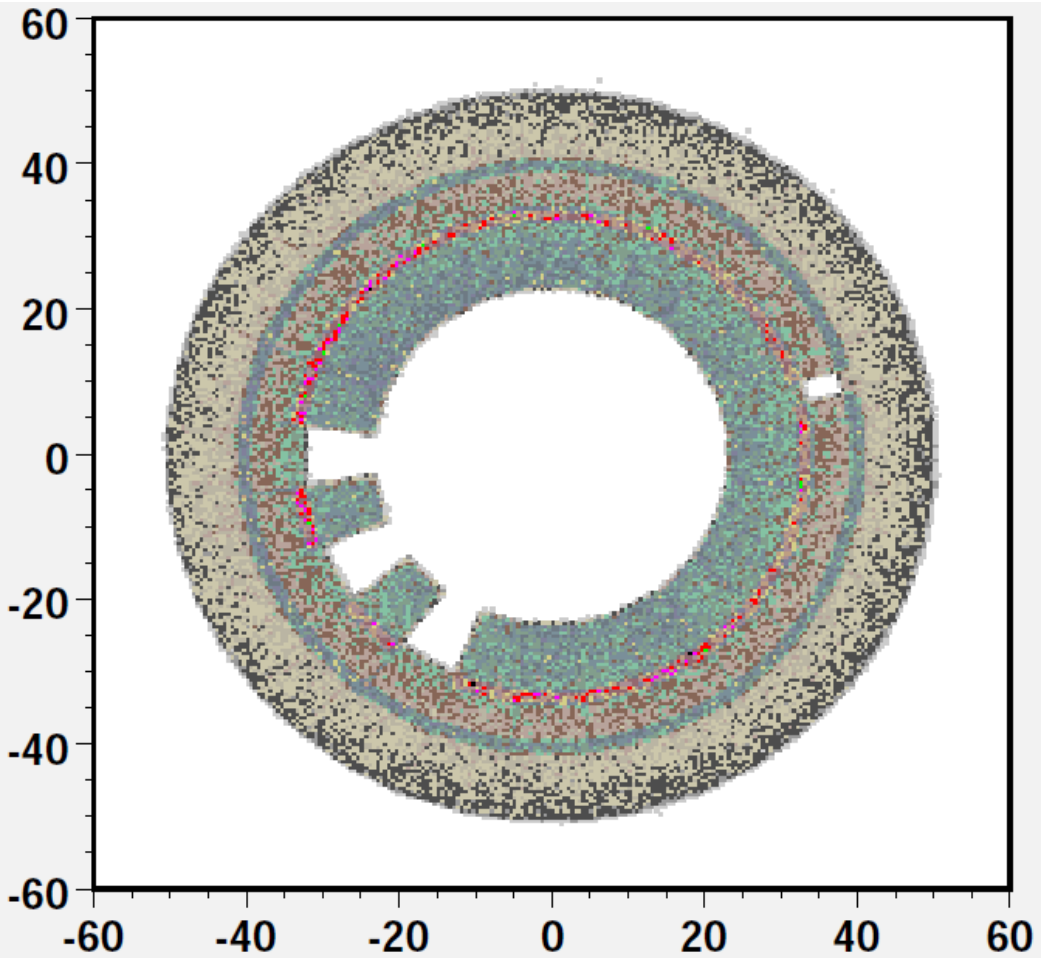
TIB4 in Oct 2010



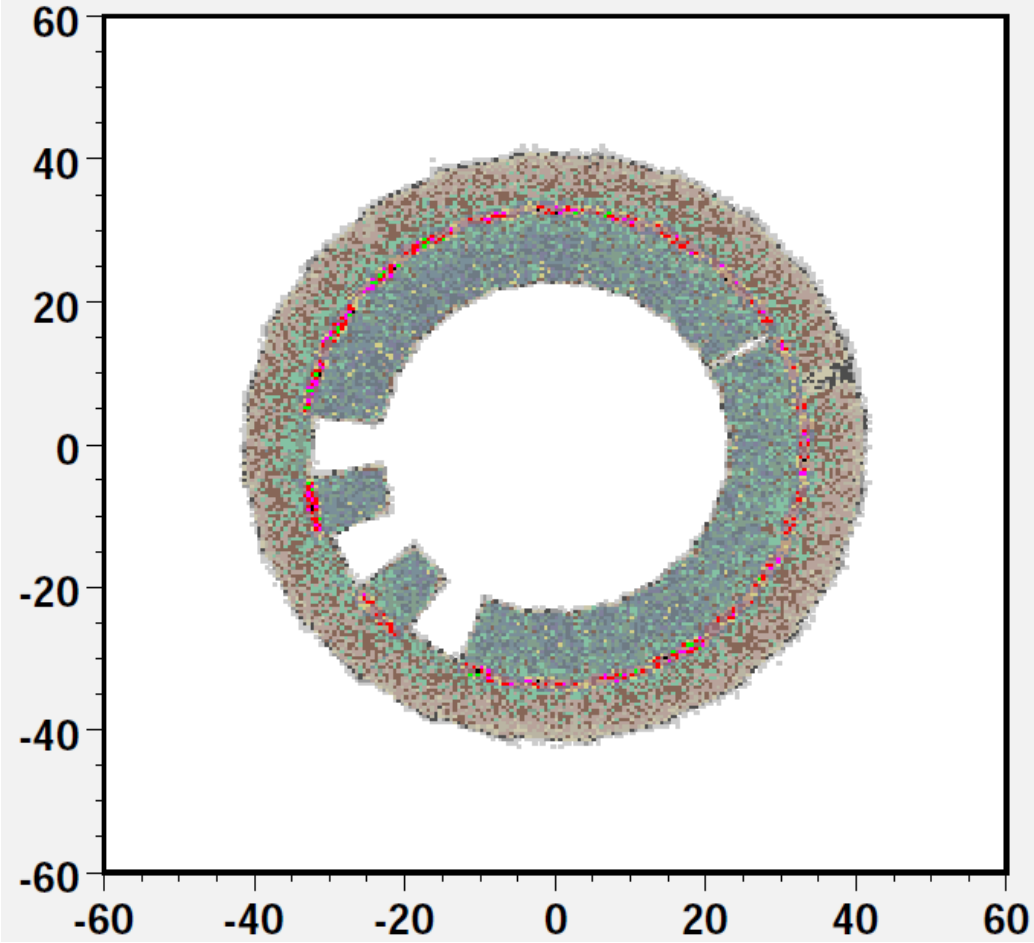
- TIB4: 91% stable.

TID1- in Oct 2010

phi



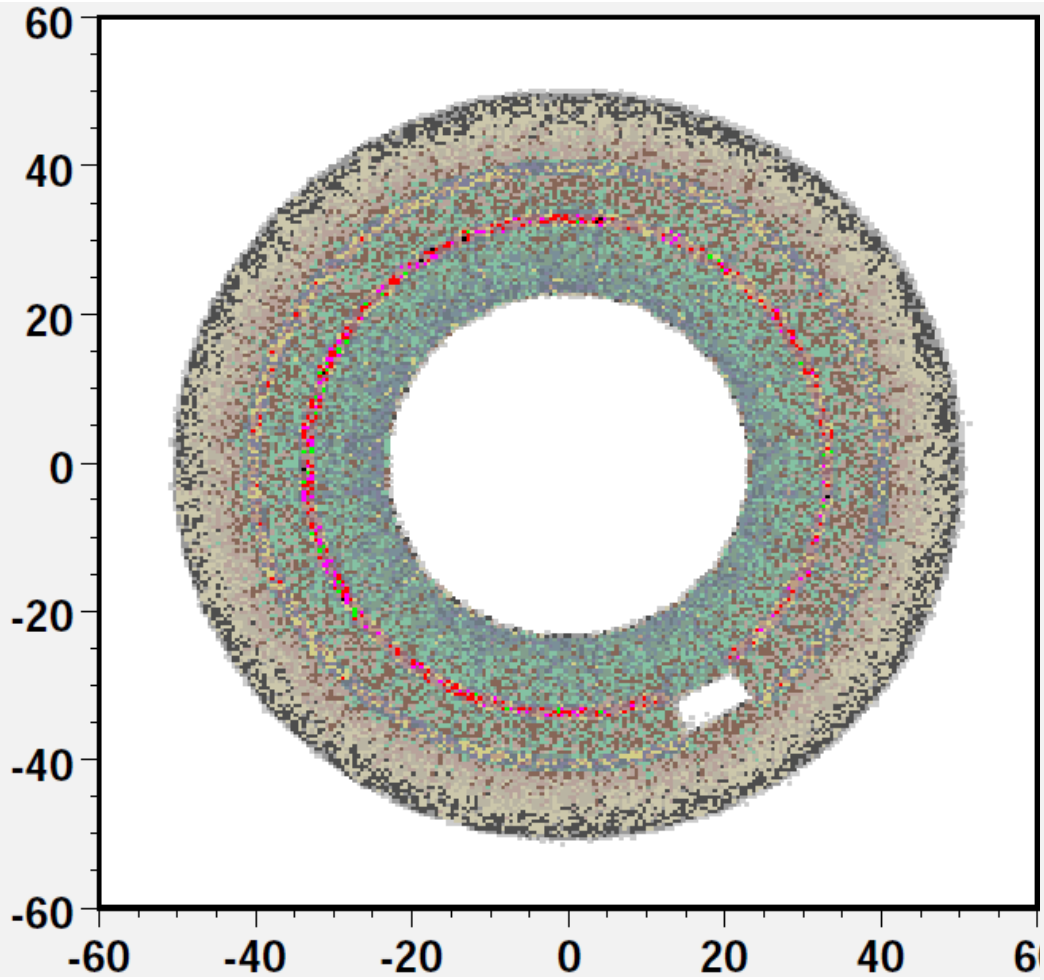
stereo



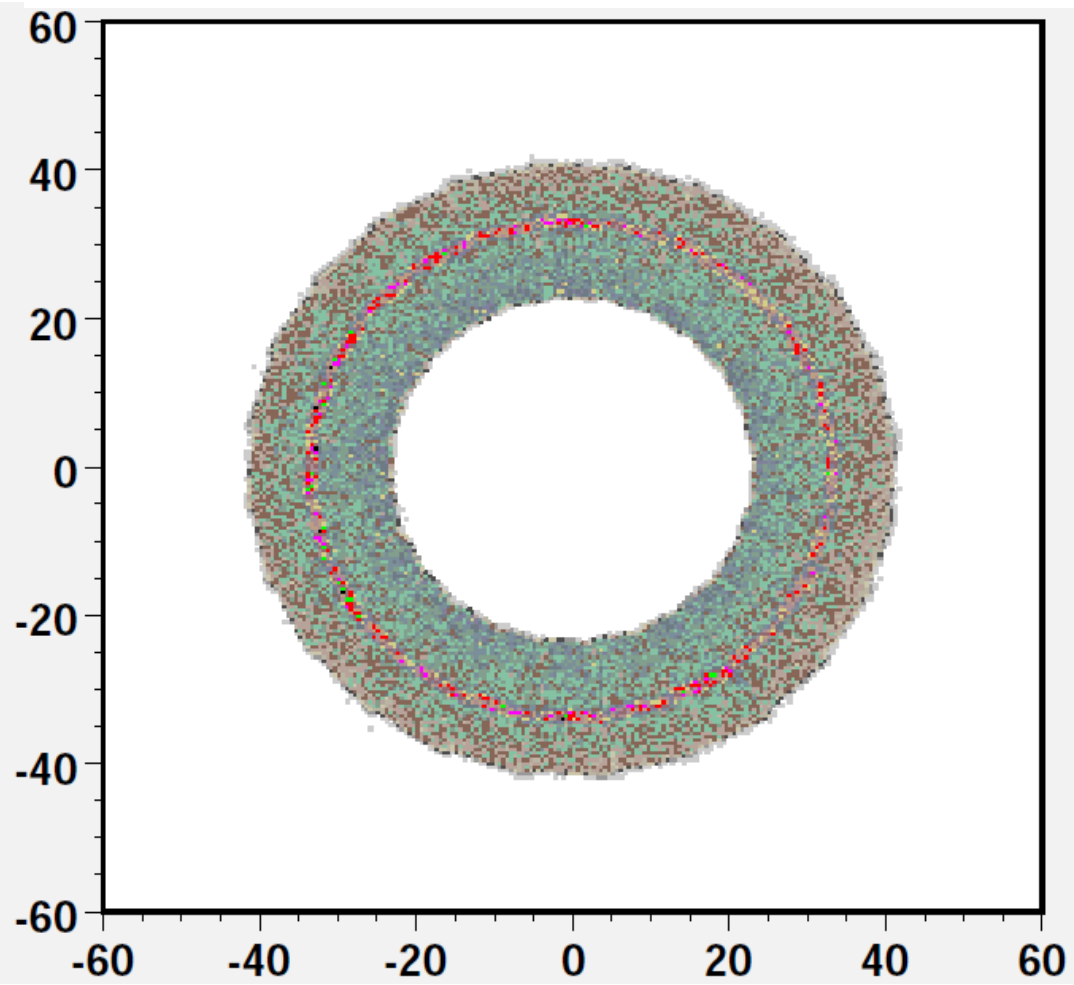
- **TID1: 92% stable.**

TID2- in Oct 2010

phi



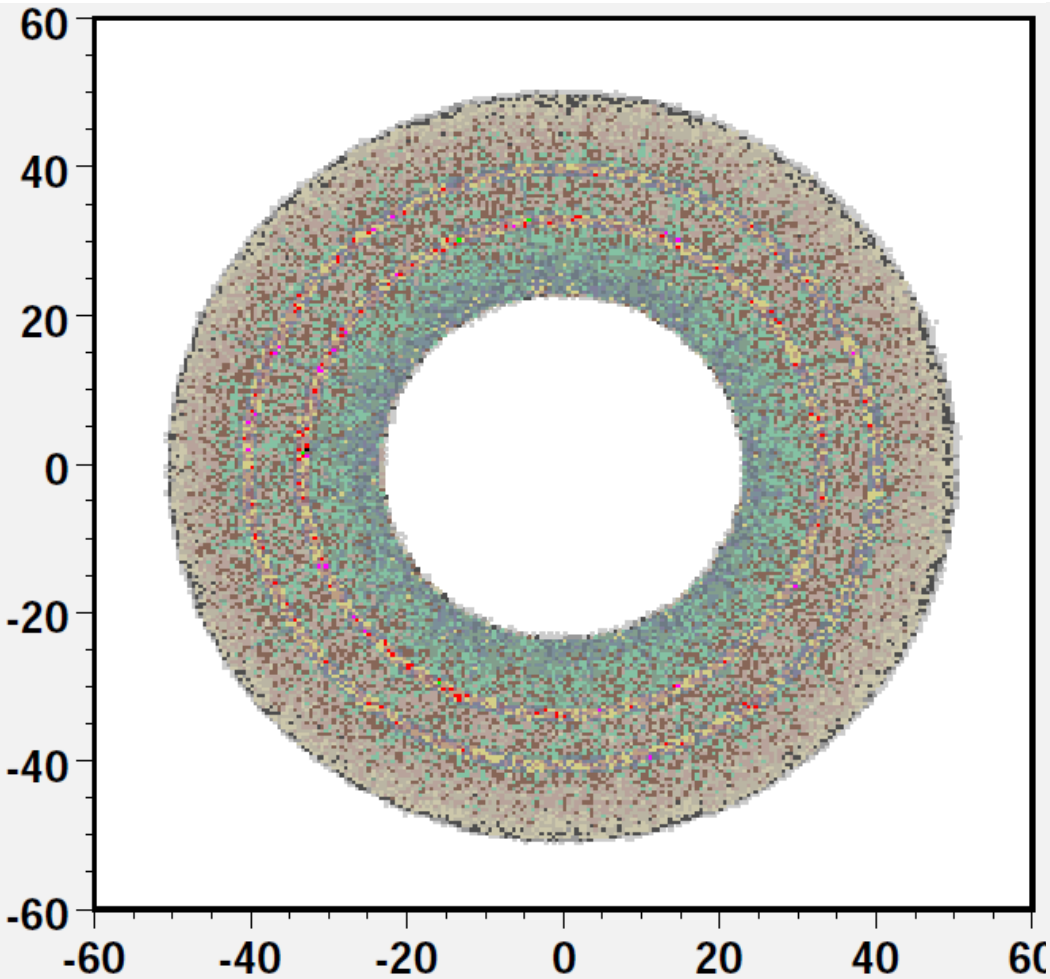
stereo



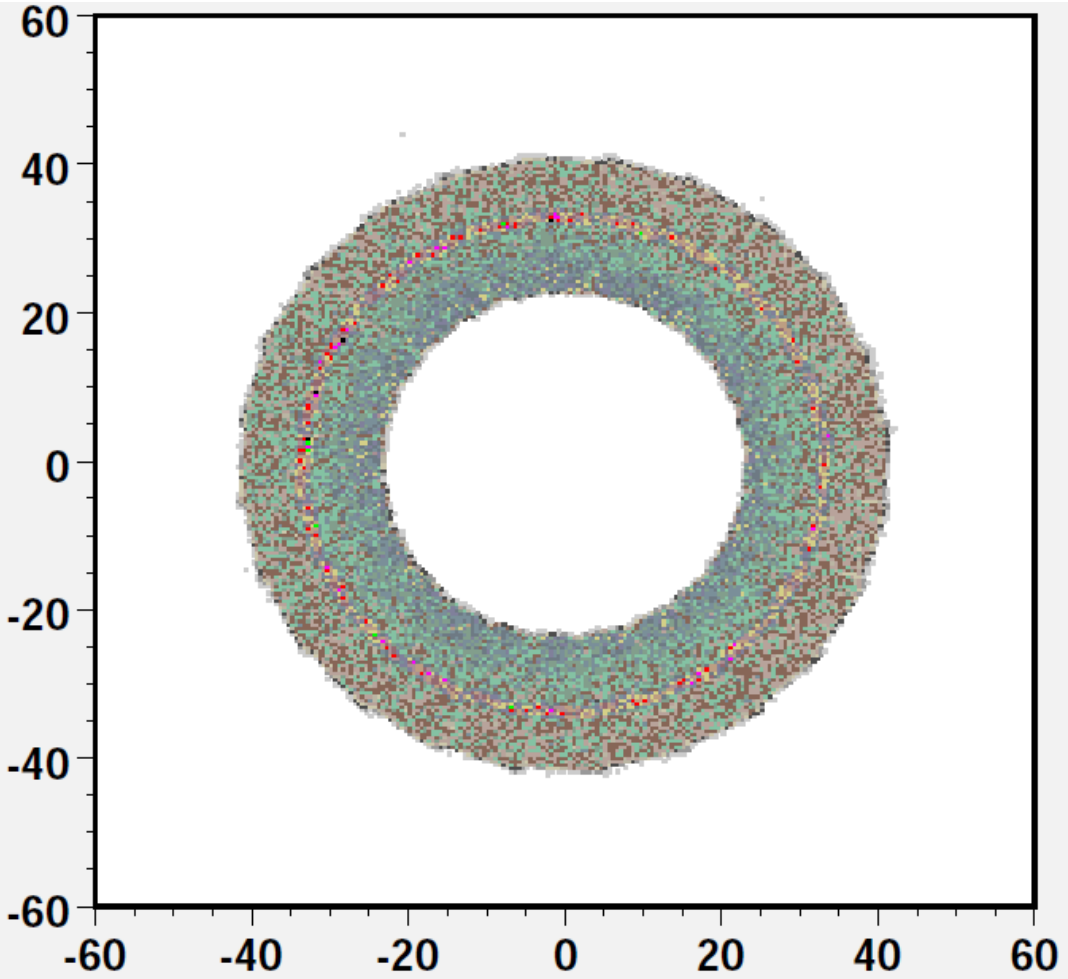
- **TID1: 94.5% stable.**

TID3- in Oct 2010

phi

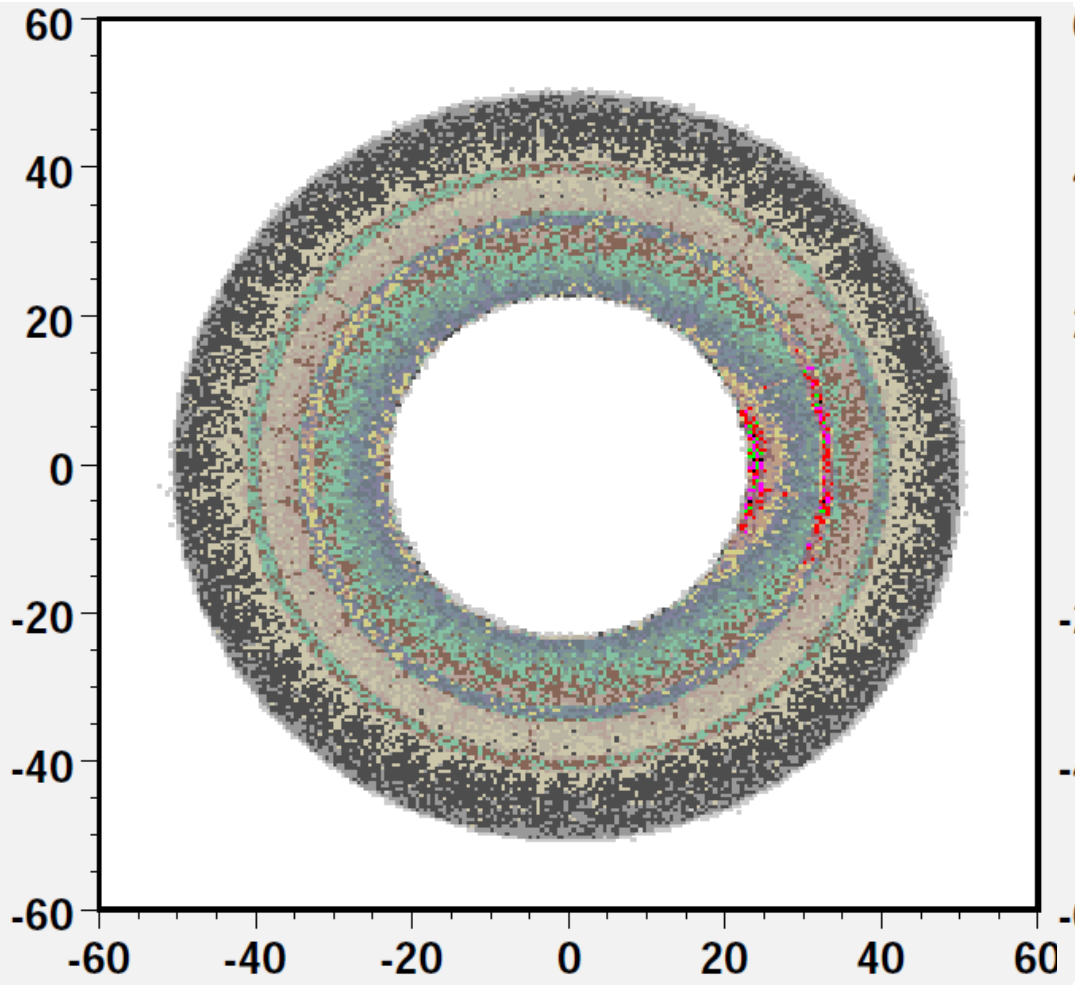


stereo

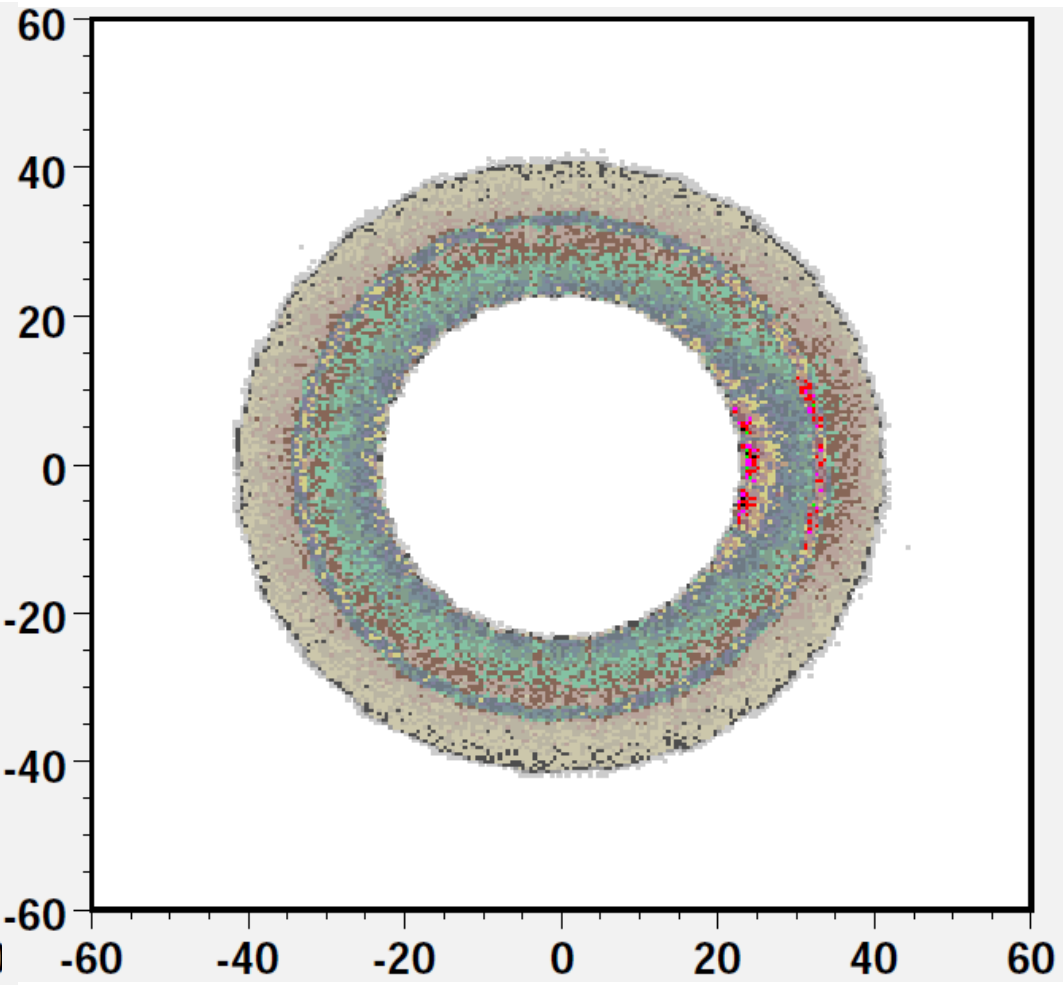


TID1+ in Oct 2010

phi

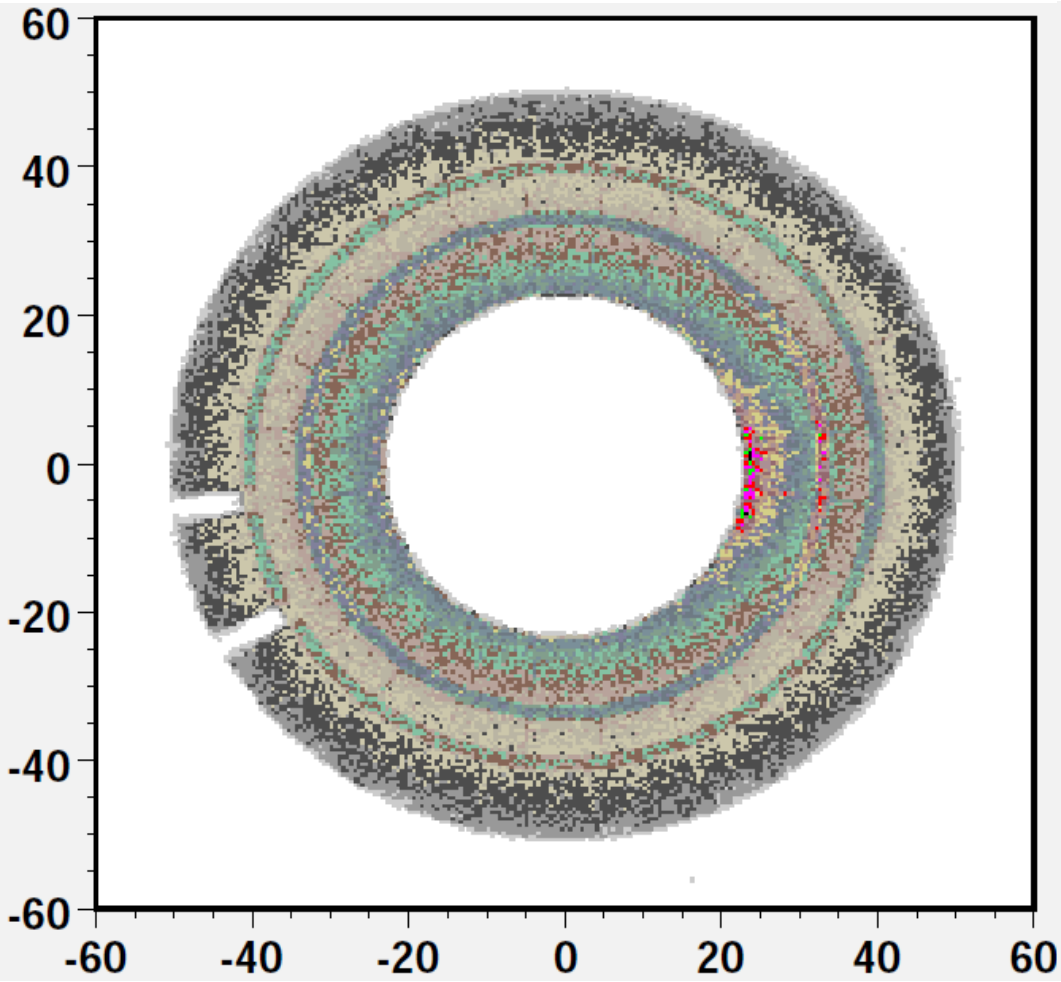


stereo

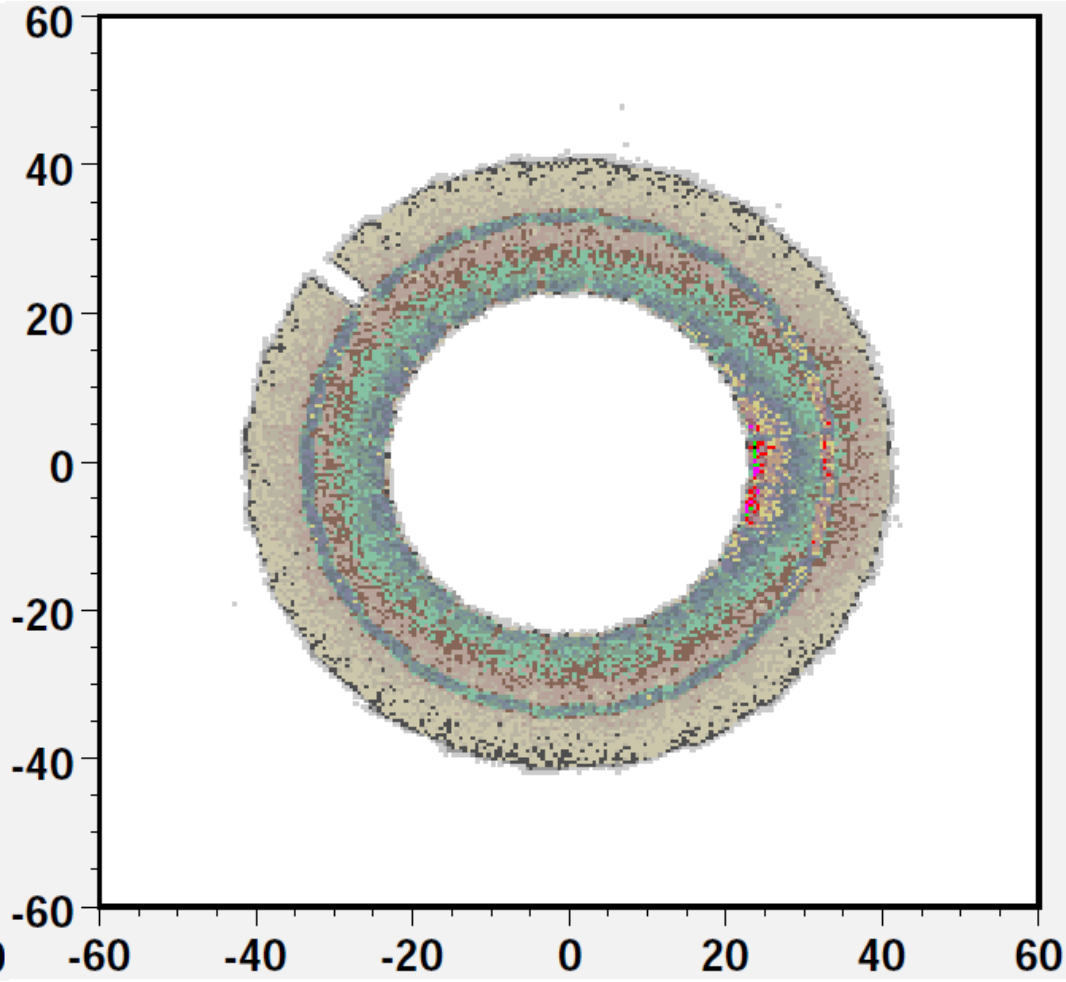


TID2+ in Oct 2010

phi

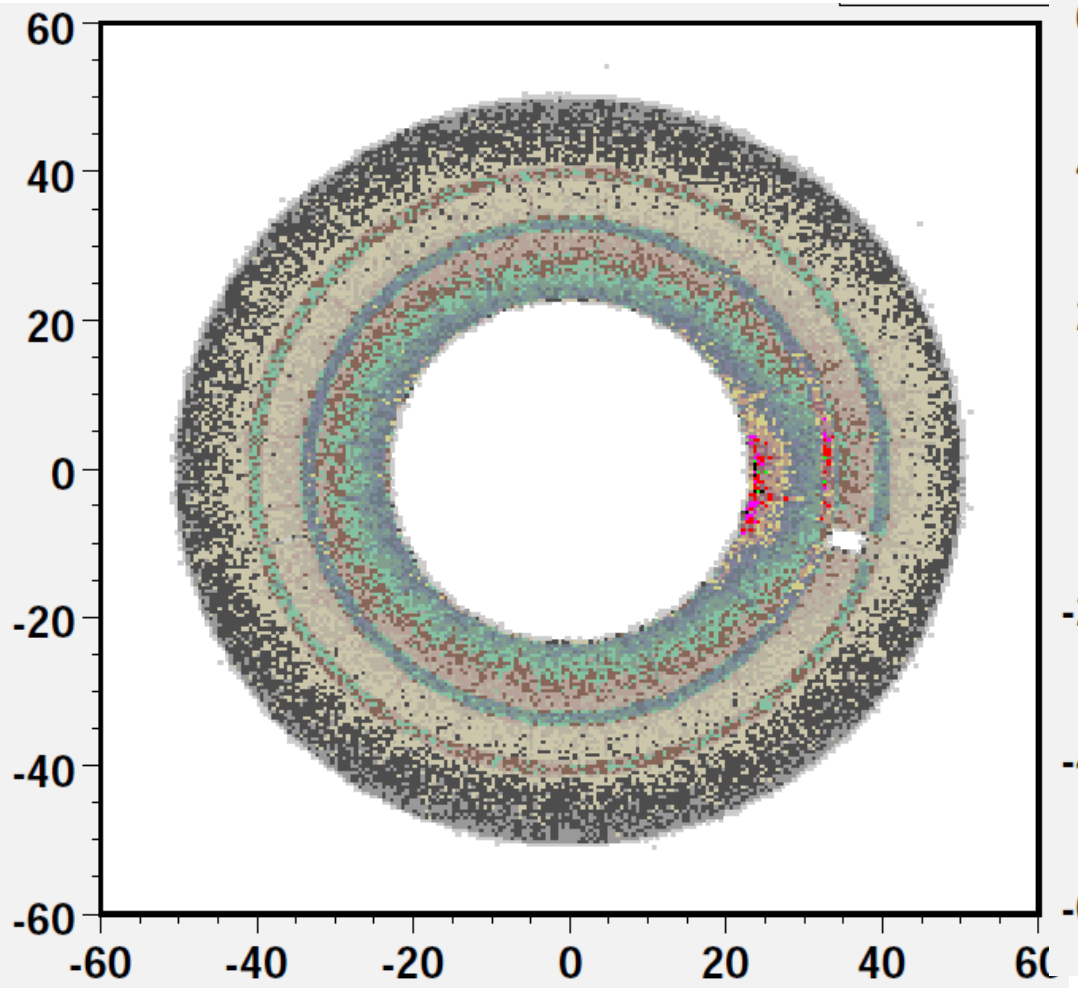


stereo

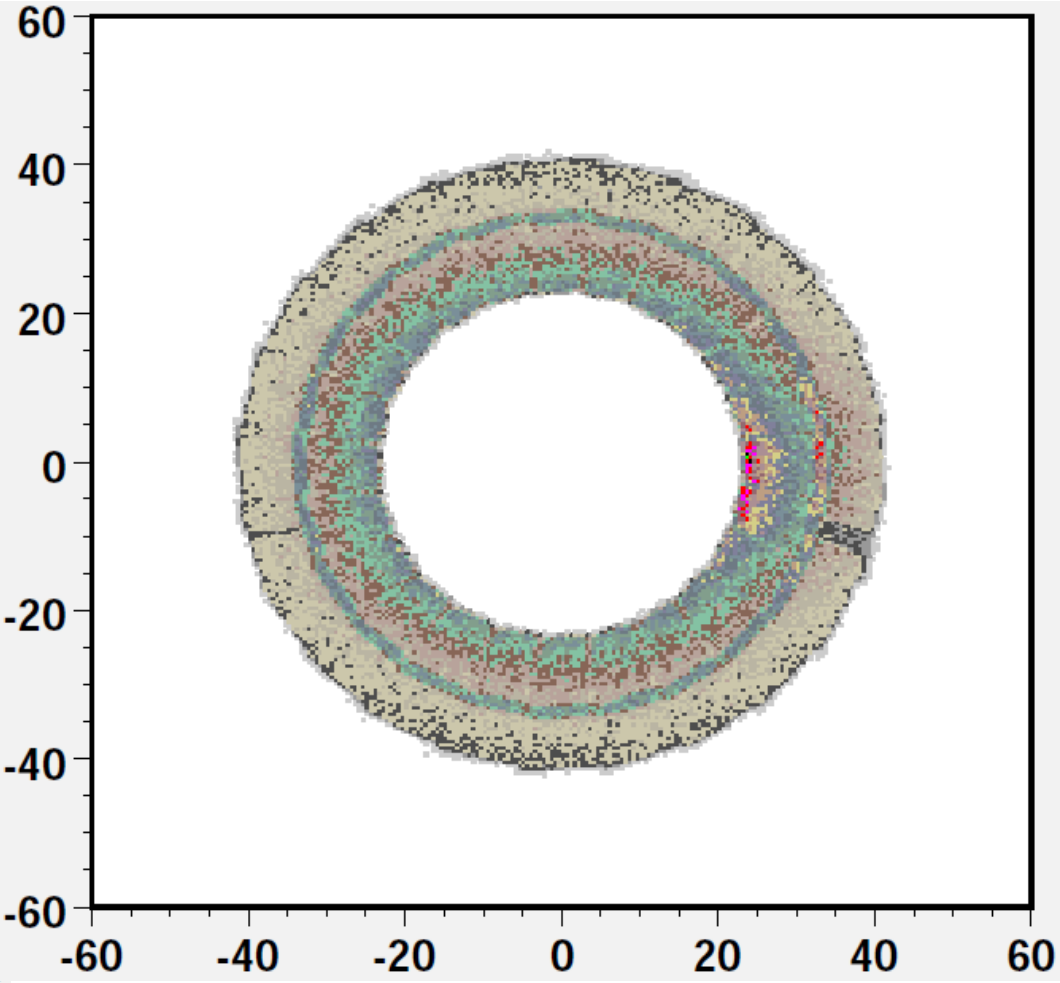


TID3+ in Oct 2010

phi

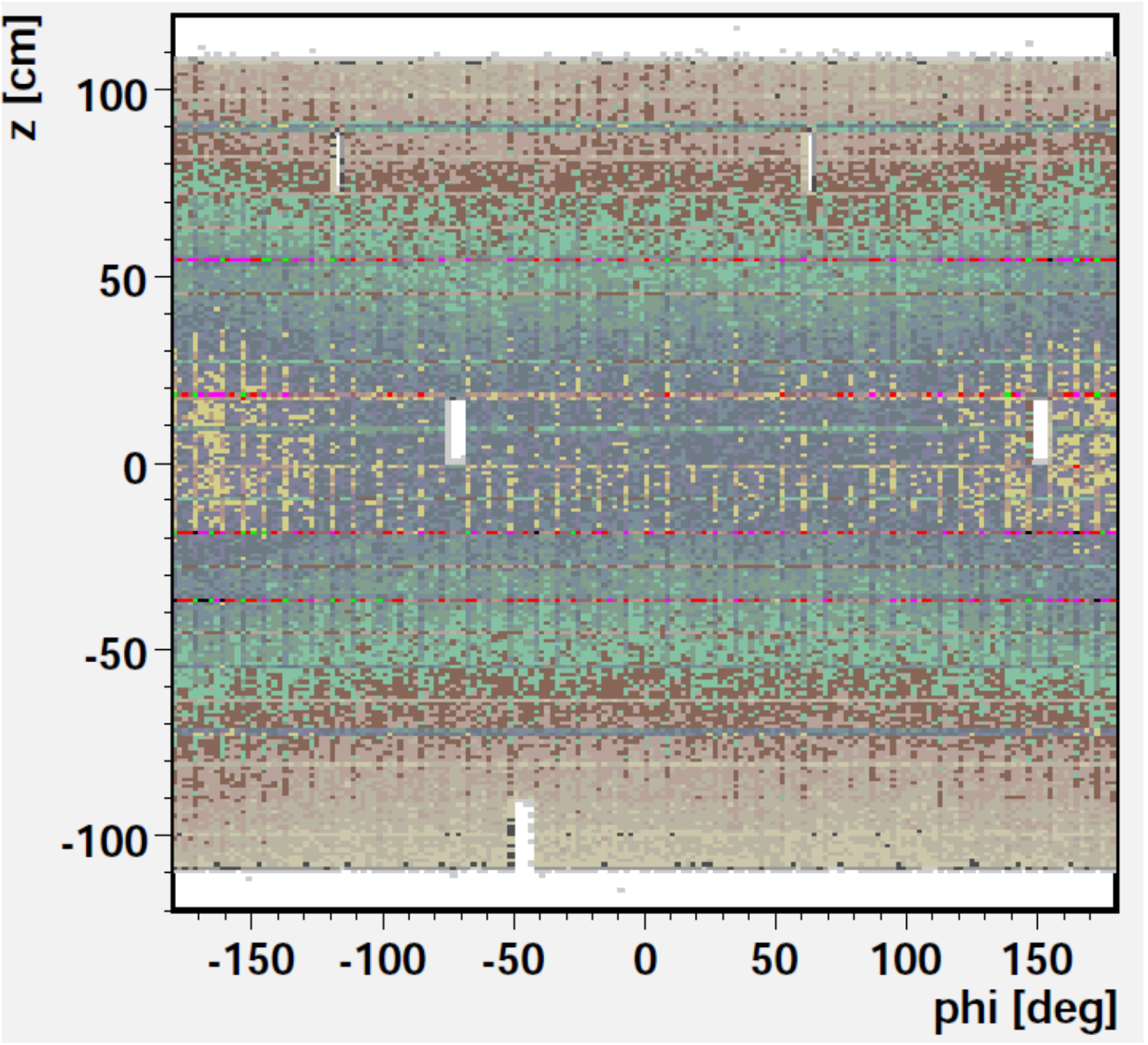


stereo



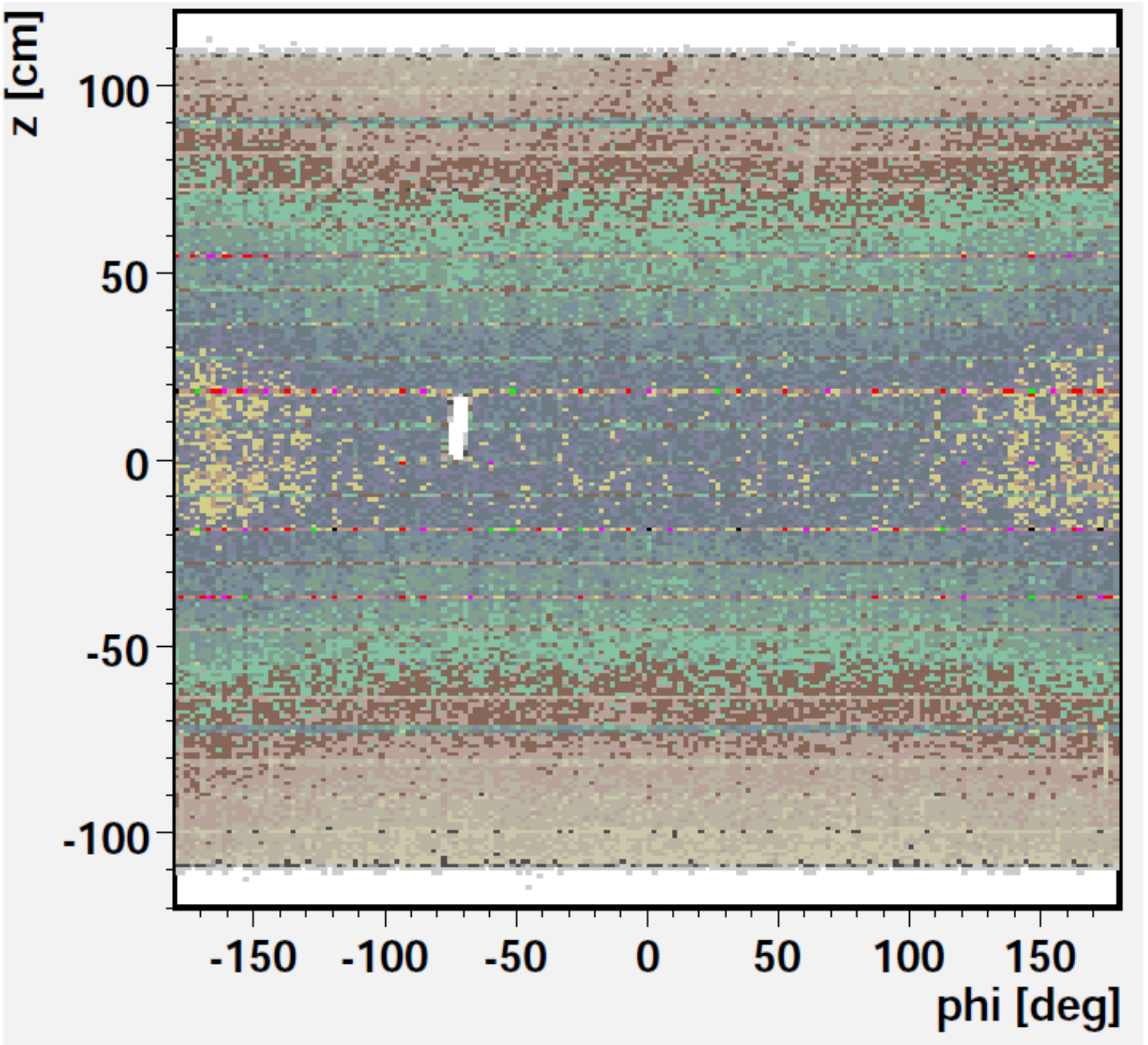
- **TID3: 95% stable.**

TOB1 in Oct 2010

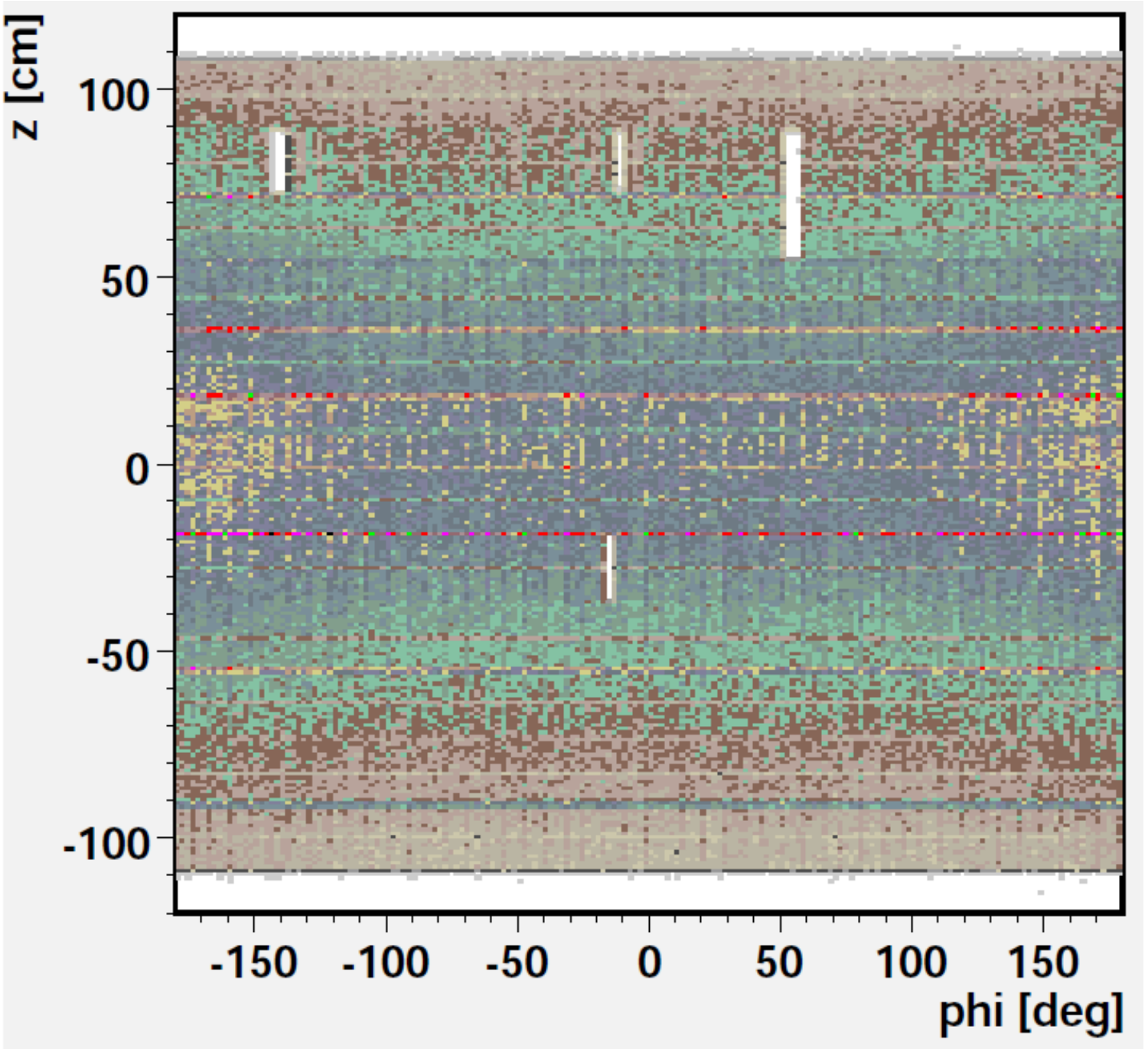


- **TOB1: 96.5%**
- **0.5% variation.**

TOB1 stereo in Oct 2010

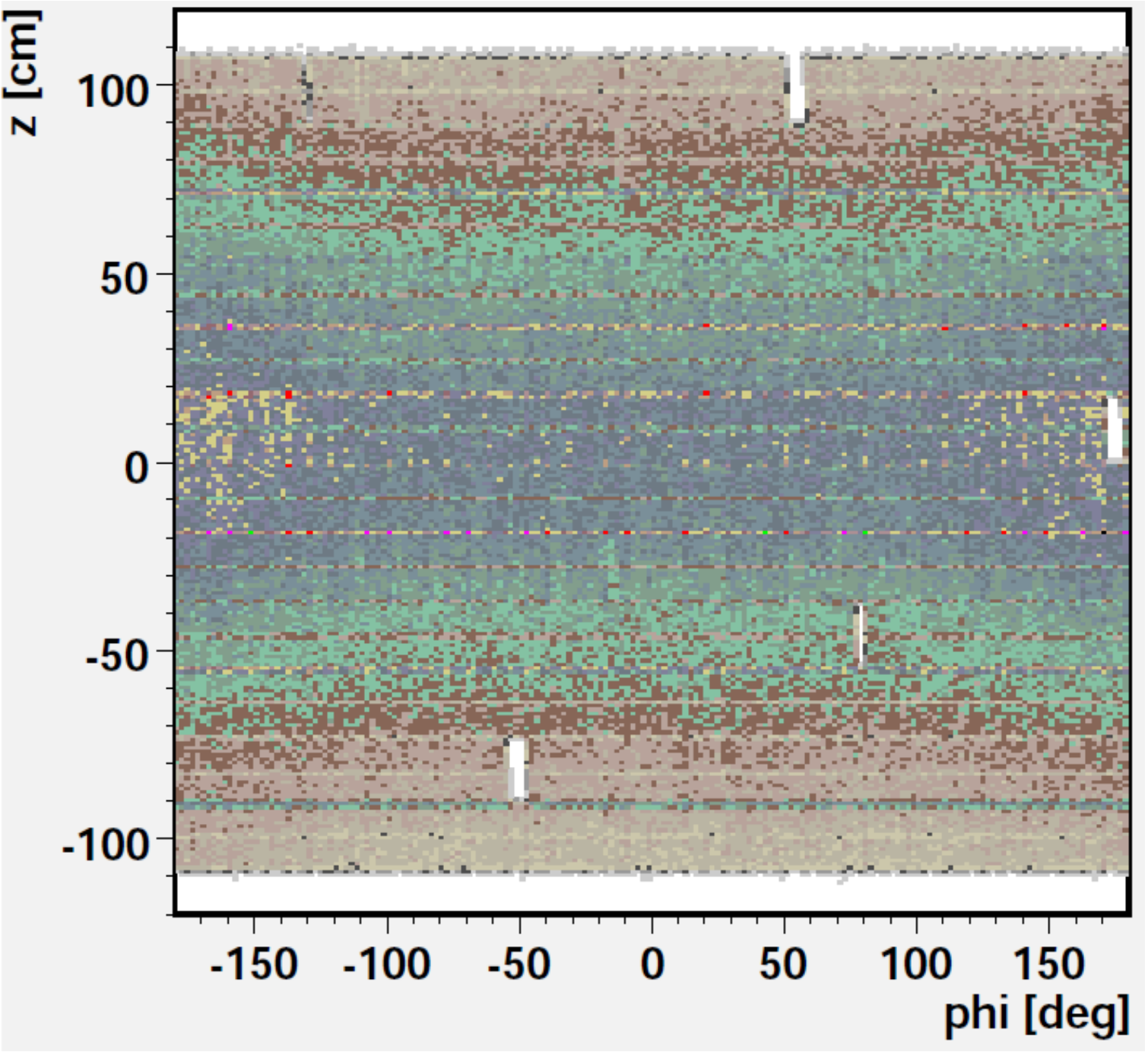


TOB2 in Oct 2010

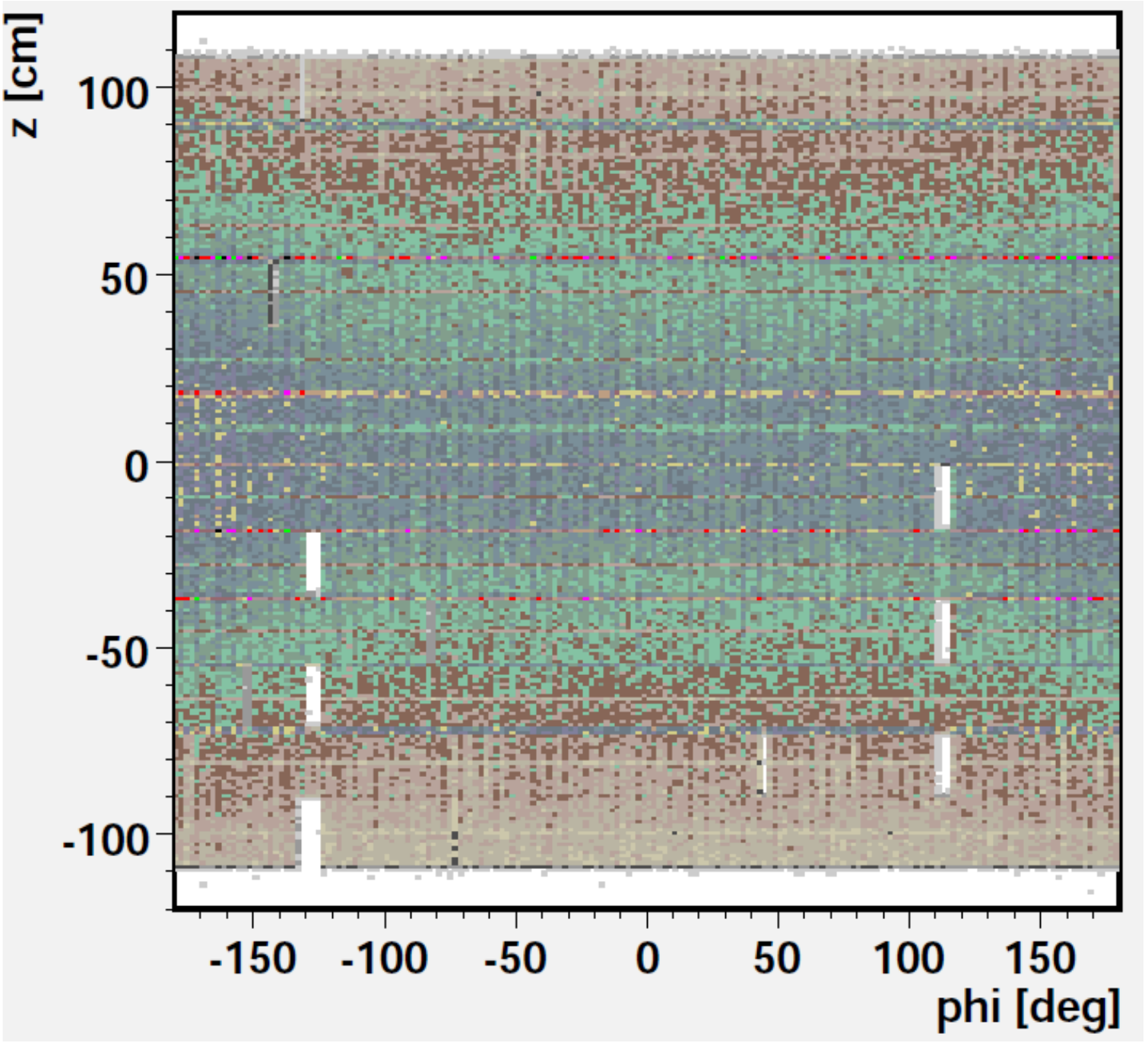


- **TOB2: 96.5%**
- **stable.**

TOB2 stereo in Oct 2010

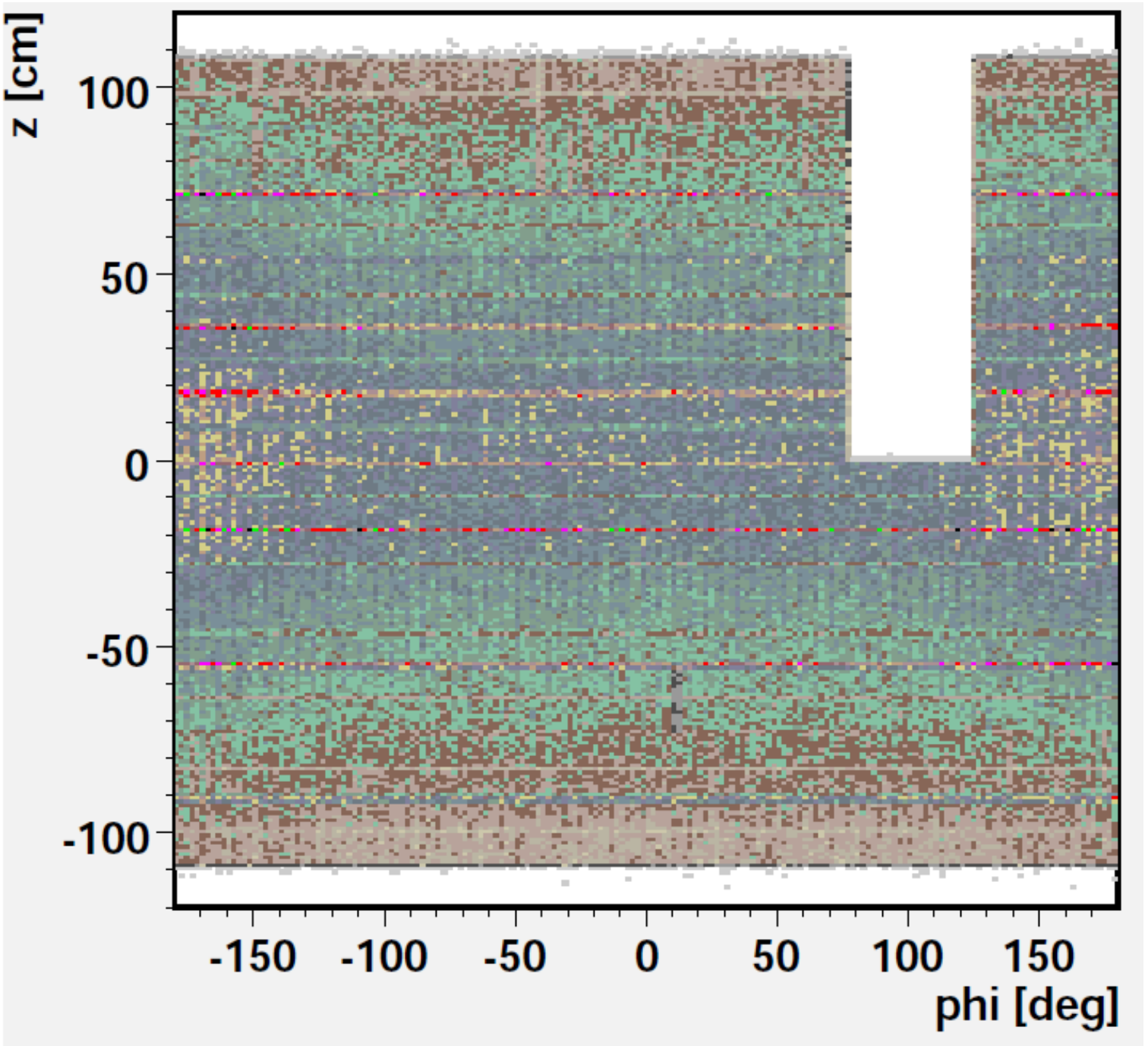


TOB3 in Oct 2010



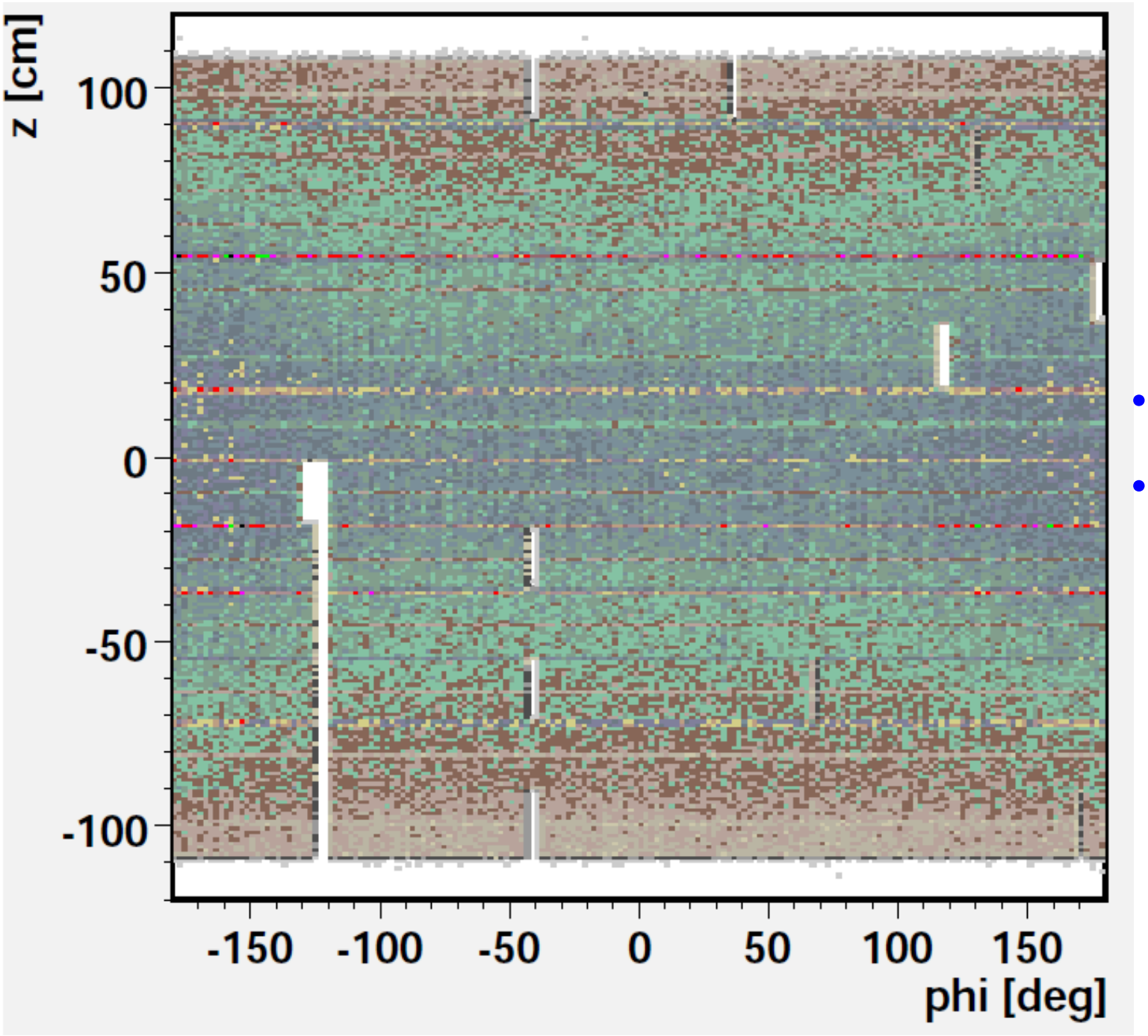
- **TOB1: 96.5%**
- **stable.**

TOB4 in Oct 2010



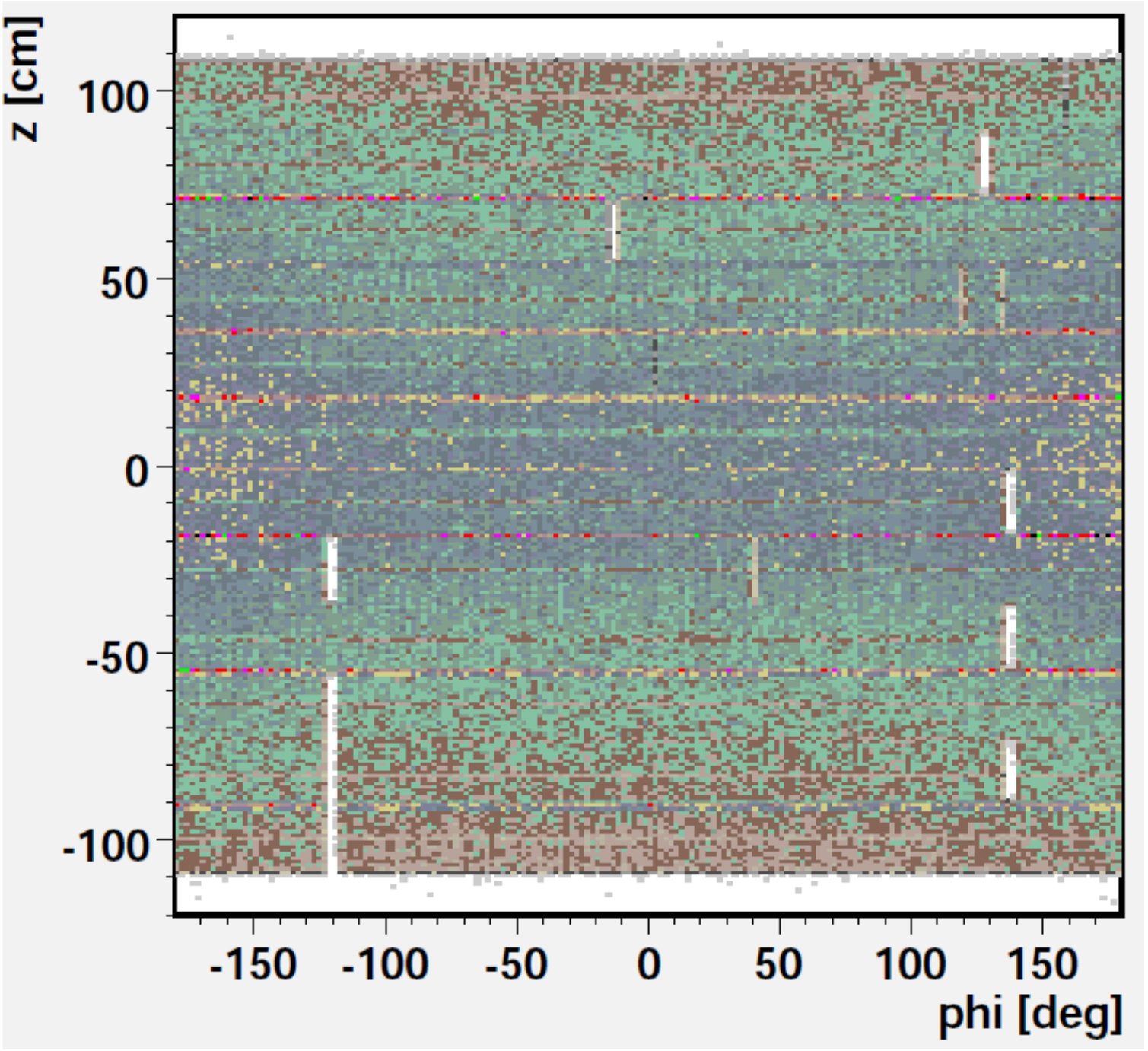
- **TOB4: 91.5%**
- **stable.**

TOB5 in Oct 2010

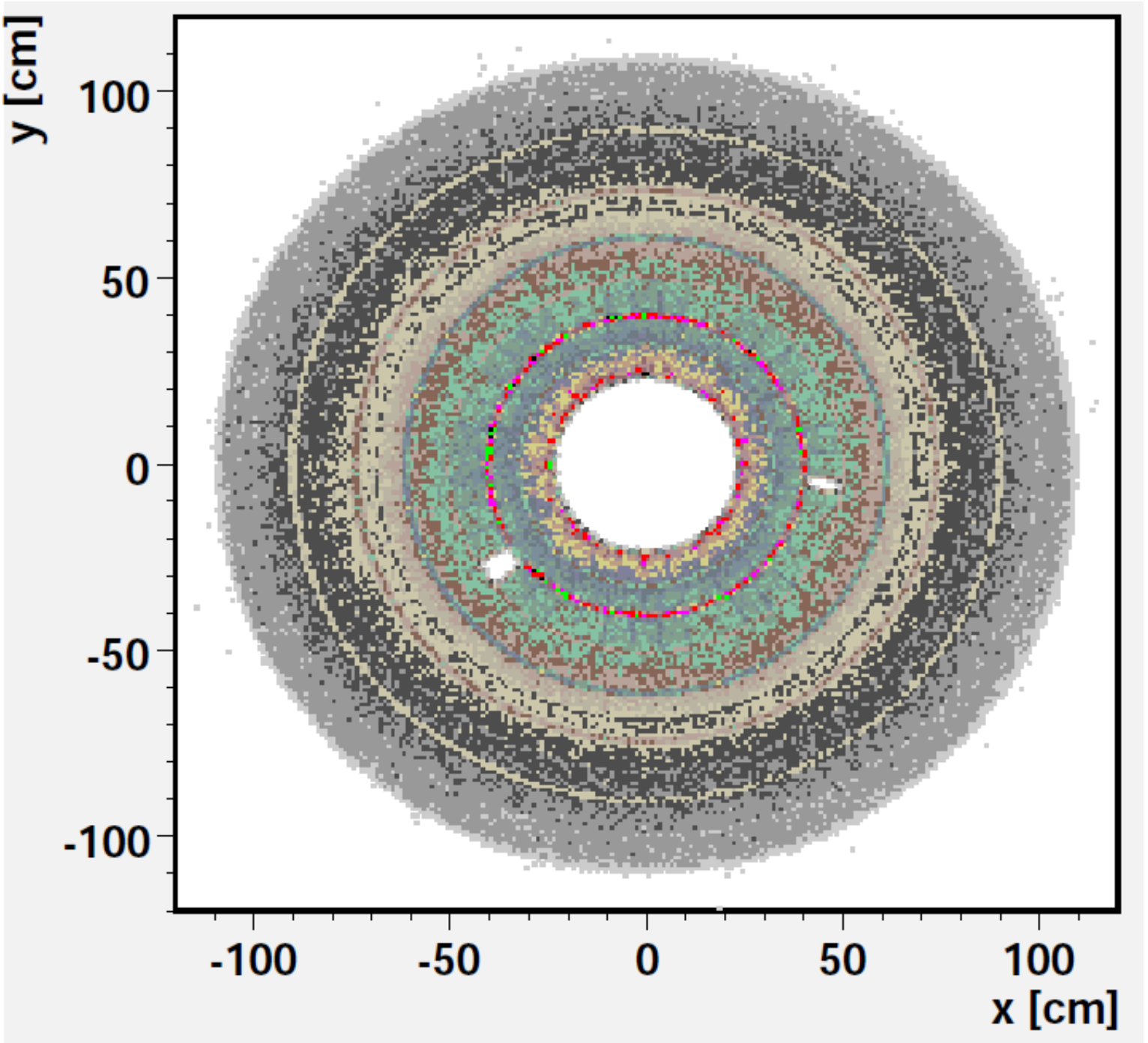


- **TOB5: 97%**
- **stable.**

TOB6 in Oct 2010

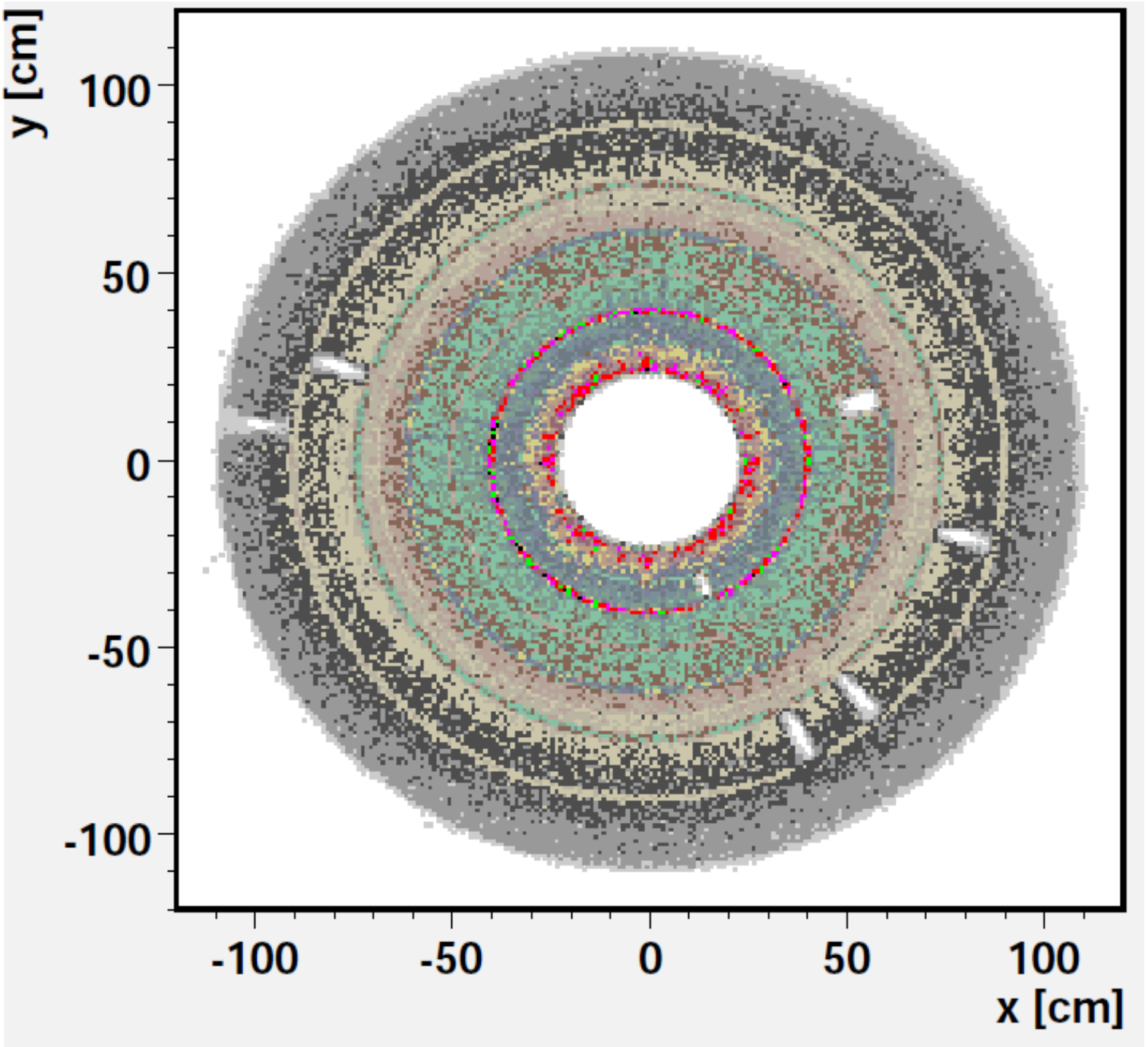


TEC-1 in Oct 2010



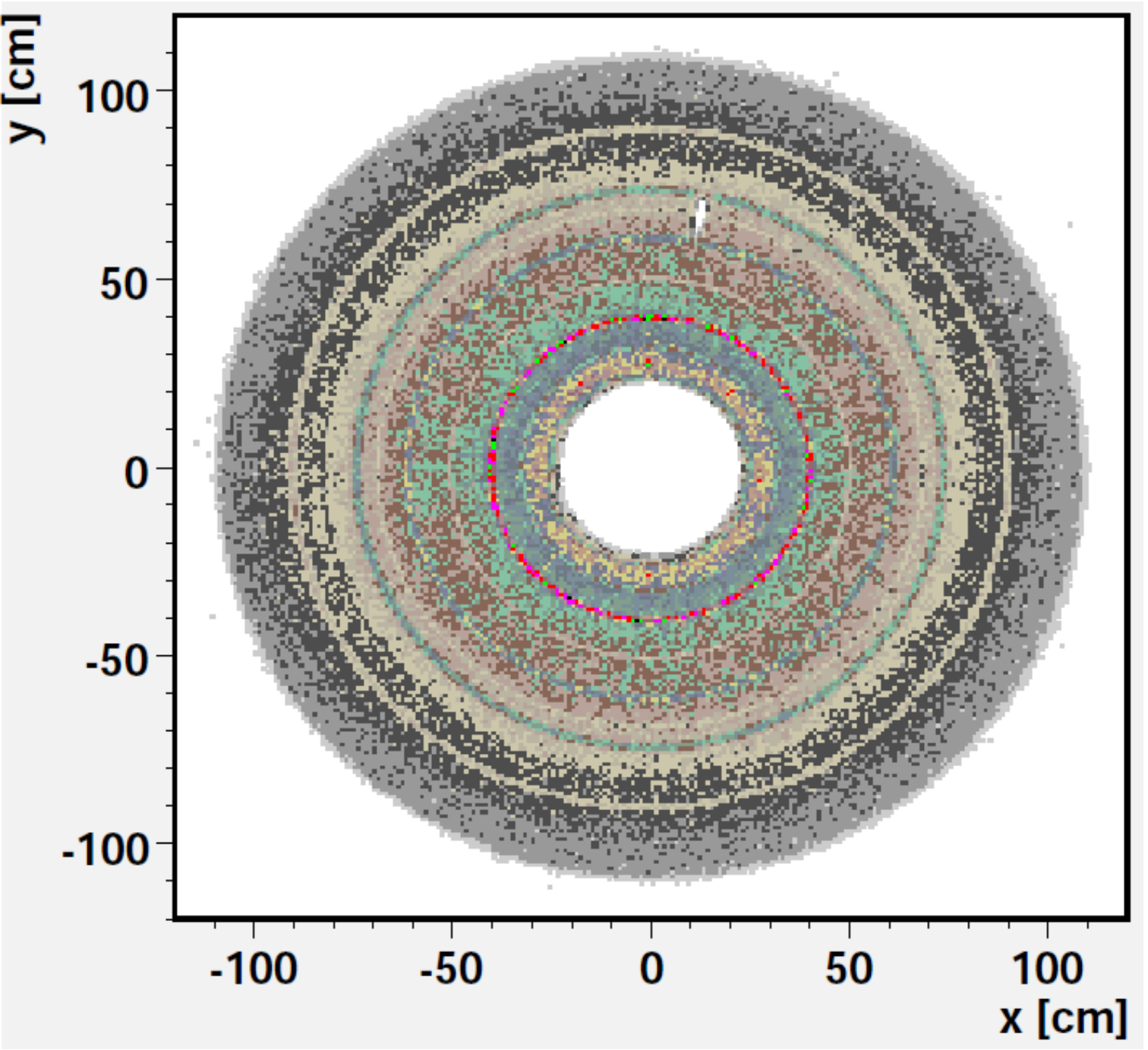
- **TEC1: 96.5%**
- **stable.**

TEC-2 in Oct 2010



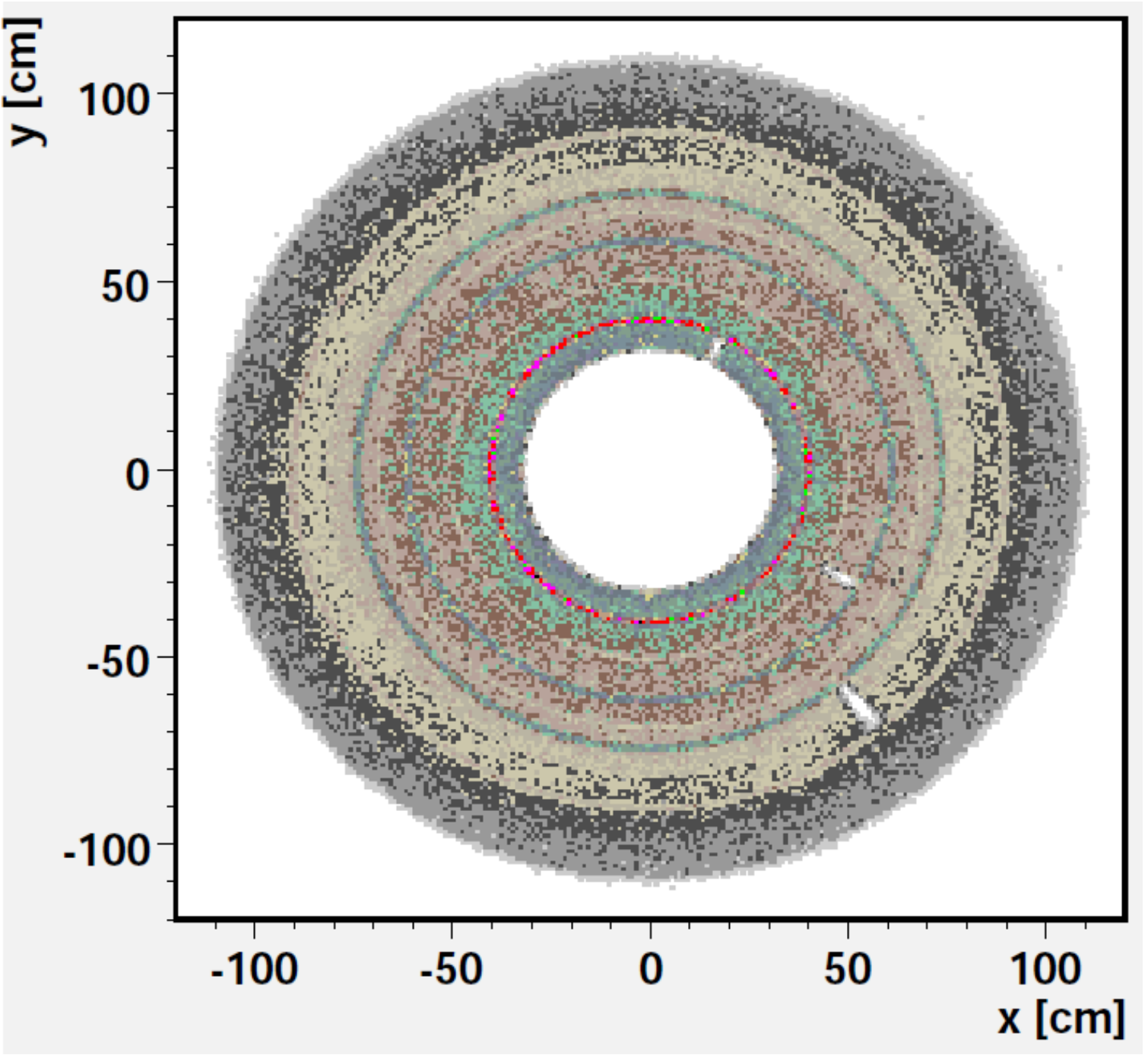
- **TEC2: 97.5%**
- **stable.**

TEC-3 in Oct 2010



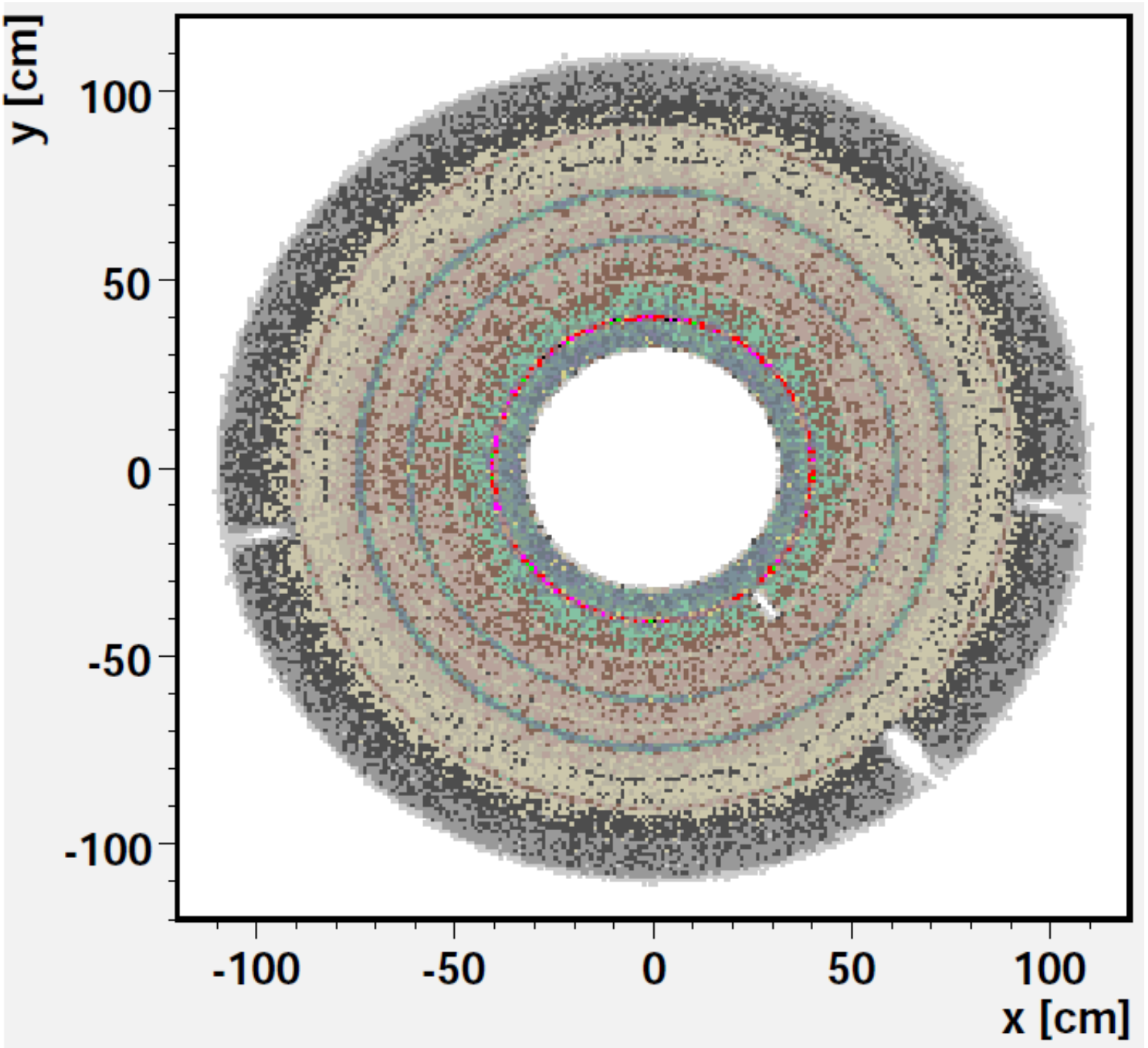
- **TEC3: 98.5%**
- **1% step up.**

TEC-4 in Oct 2010



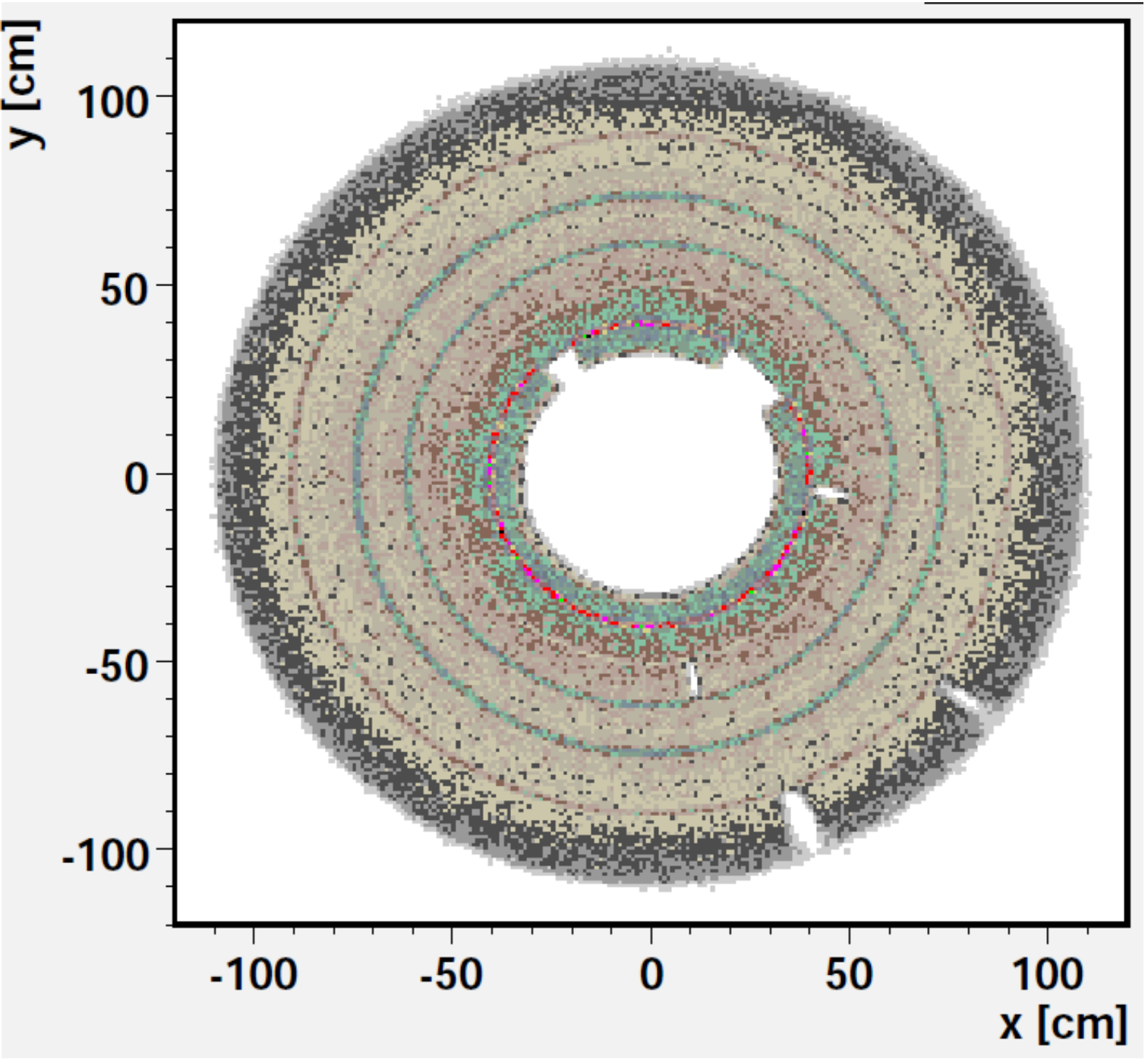
- **TEC4: 97.5%**
- **stable.**

TEC-5 in Oct 2010



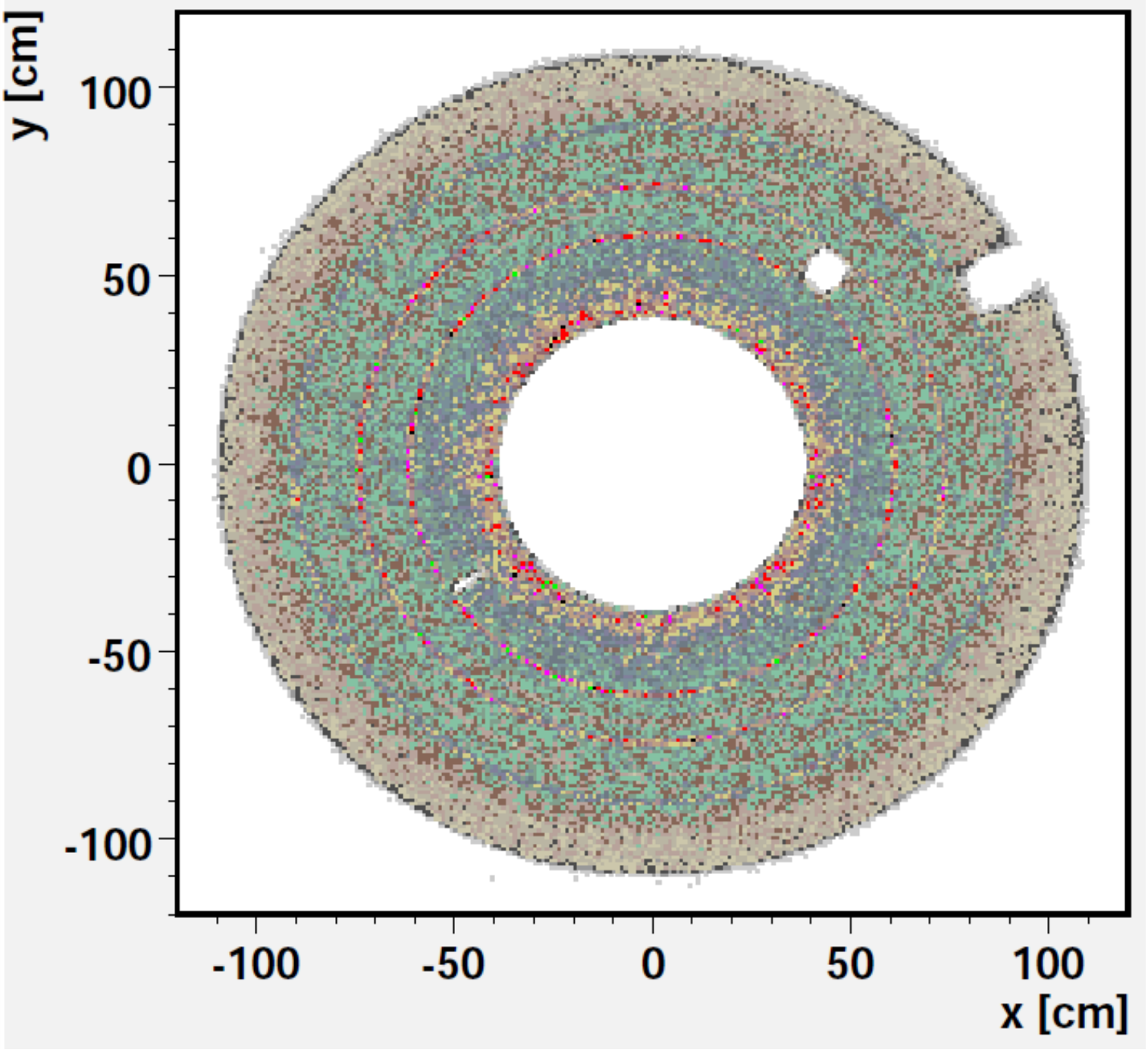
- **TEC5: 98%**
- **stable.**

TEC-6 in Oct 2010



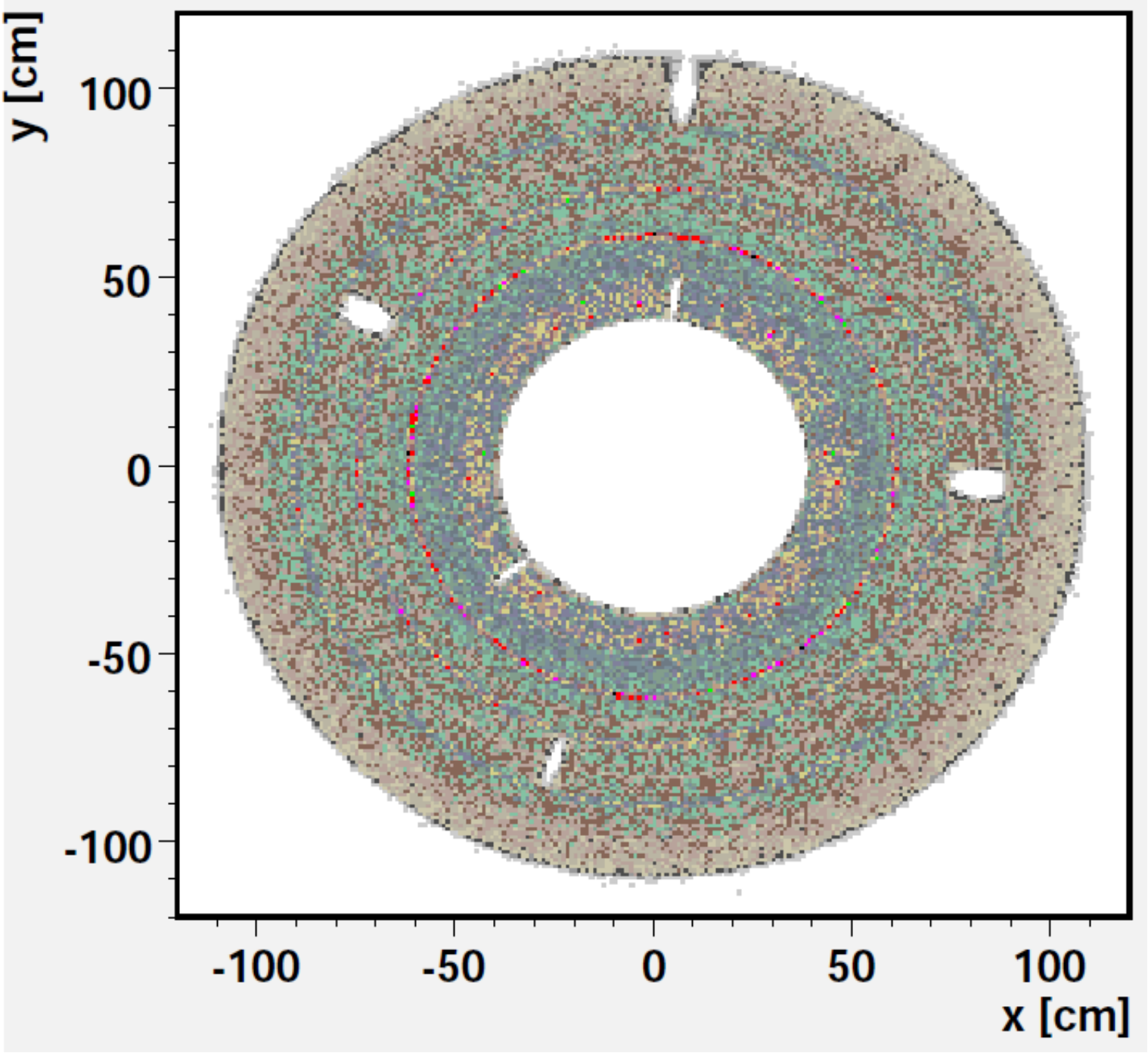
- **TEC6: 97.5%**
- **stable.**

TEC-7 in Oct 2010

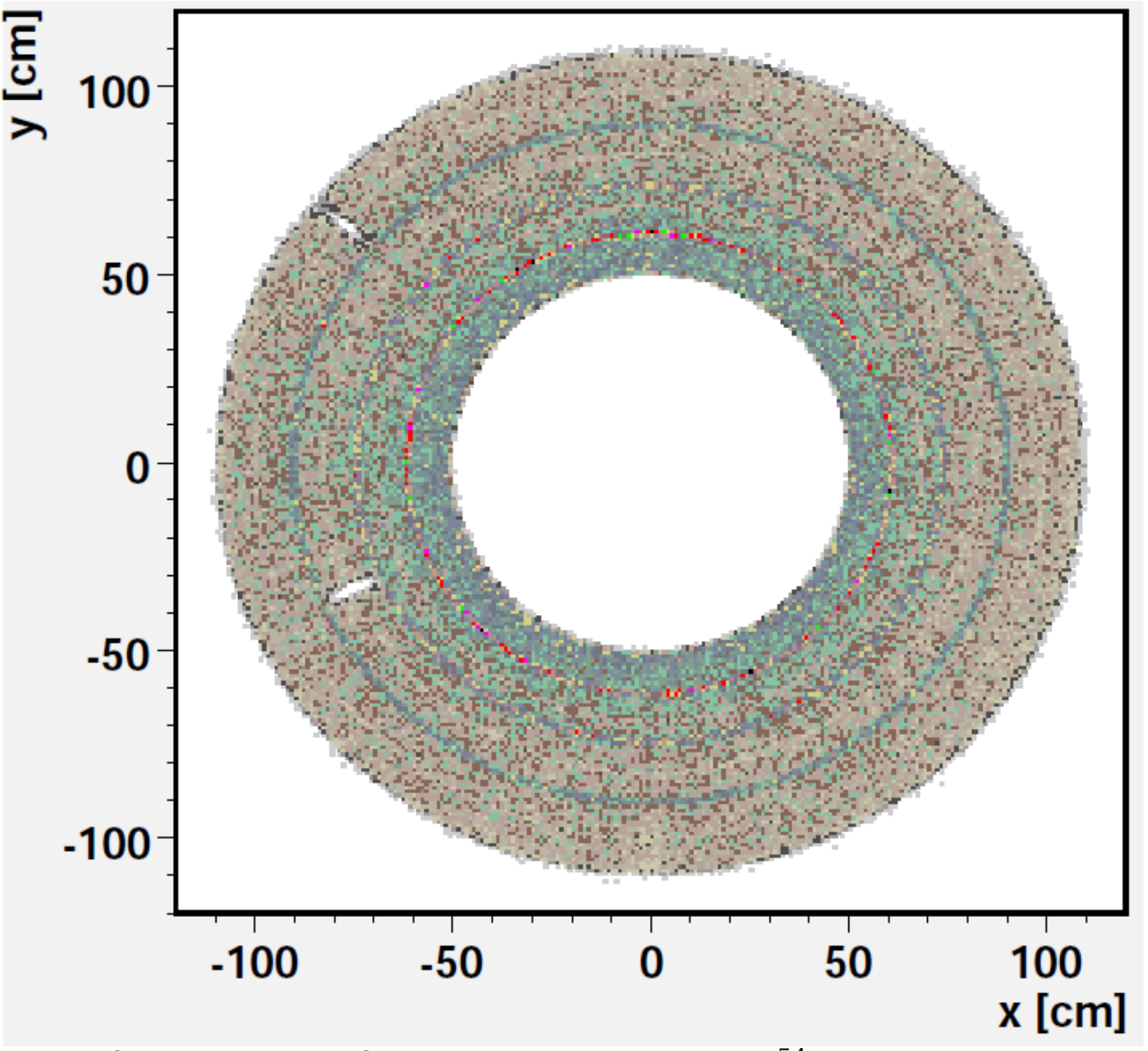


- **TEC7: 97%**
- **stable.**

TEC-8 in Oct 2010



TEC-9 in Oct 2010



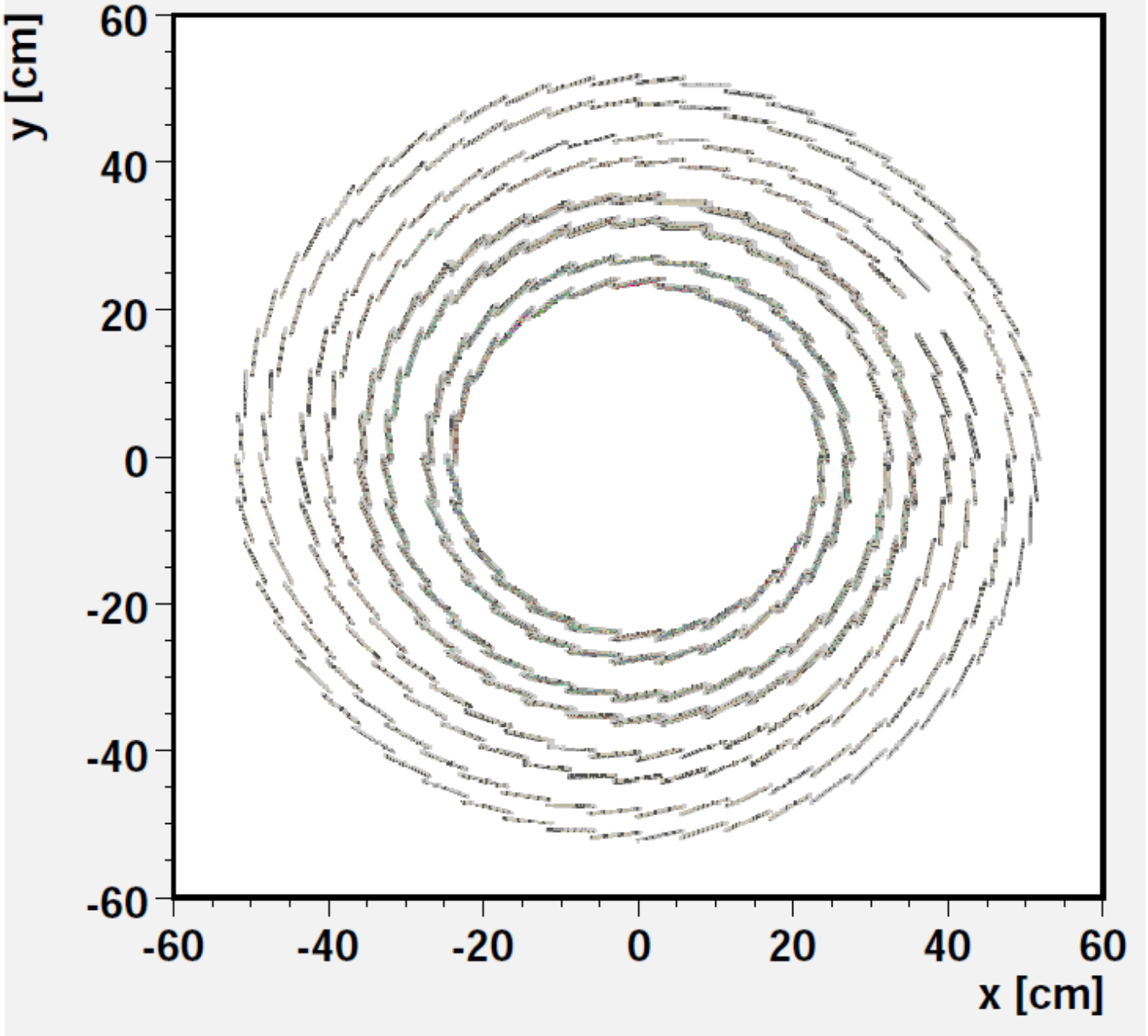
Summary

- Detailed hit maps are possible on RECO data
  - Pixel detector monitoring at the ROC level is possible (12288 in the barrel).
  - Can we zoom into the pixel level (51M)?
- Efficiency monitoring is possible with hits on tracks using AOD.
  - (except for the first pixel and last strip layer).
  - PXB was stable in autumn 2010
  - one PXD lost one octant
  - some variations in TIB1,2,3
  - TID, TOB, and TEC were stable in autumn 2010
- Next:
  - dead modules included in MC?
  - monitor PXB at high pile-up and occupancy.

Tracker segmentation

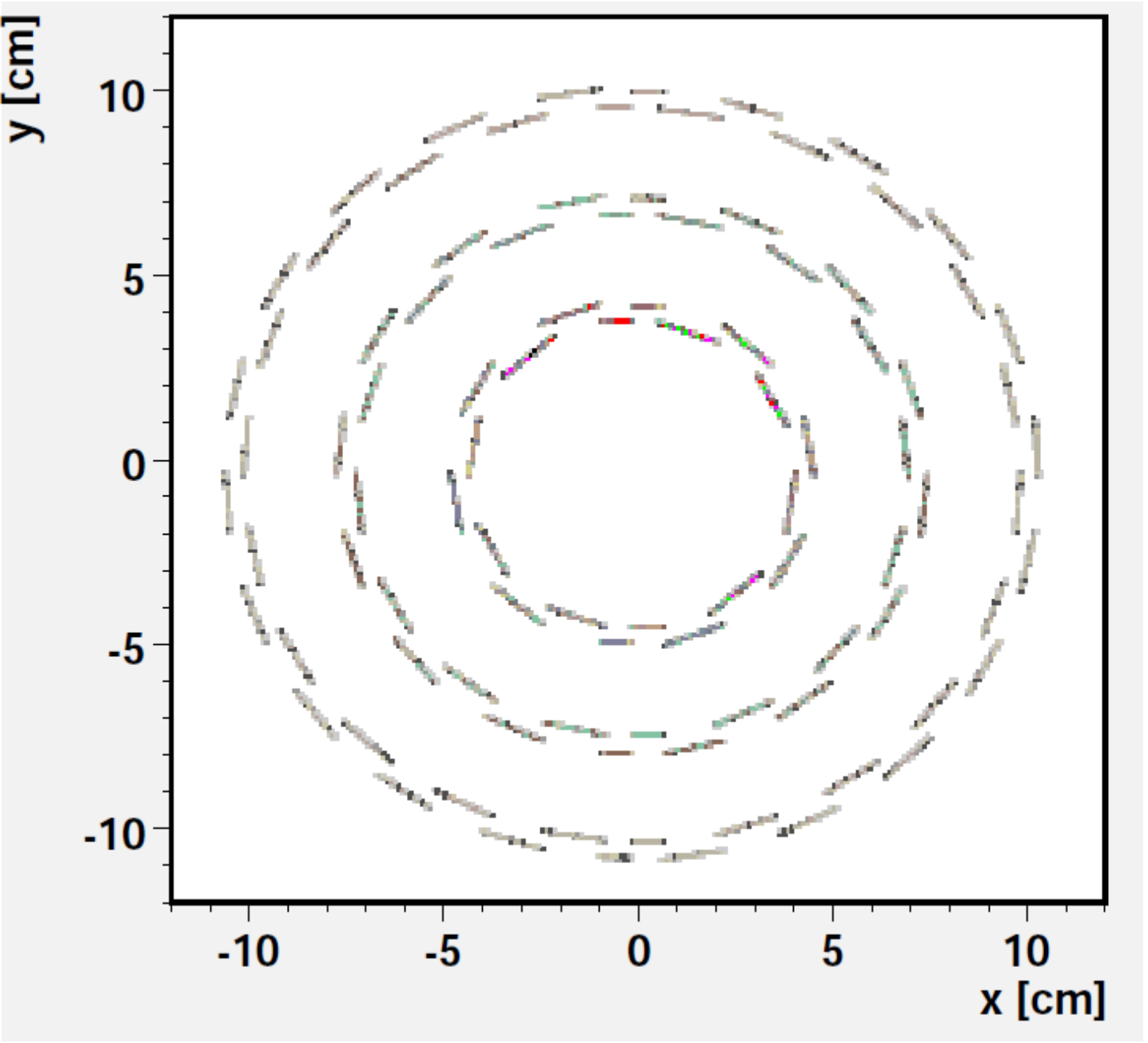
- Pixel Barrel PXB:
  - Layers in R
  - Ladders in phi
  - Modules in z
- Pixel endcap disks PXD:
  - Disks in z
  - Blades in phi
  - Panels ?
  - Modules in R
- Tracker inner barrel TIB:
  - Layers in R
  - Strings in phi
  - Modules in z
- Tracker inner disks TID:
  - Disks in z
  - Rings in R
  - Modules in phi
- Tracker outer barrel TOB:
  - Layers in R
  - Rods in phi
  - Modules in z
- Tracker endcaps TEC:
  - Wheels in z
  - Rings in R
  - Petals in phi
  - Modules in ?

TIB in Oct 2010



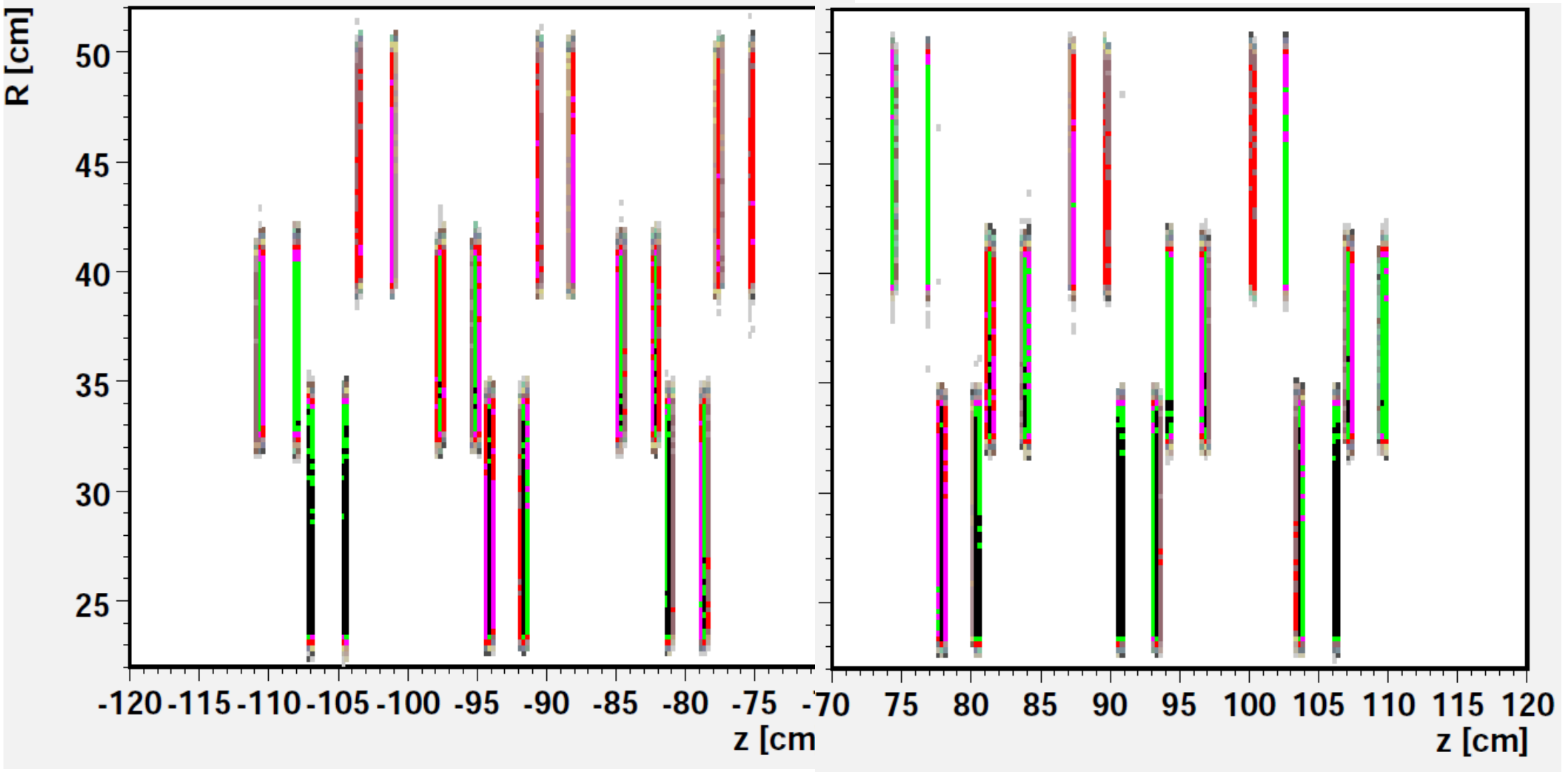
- Each layer has complete ϕ coverage.
  - except for a hole in TIB3.
- Sensor tilt direction compensates Lorentz angle of drifting electrons in the solenoid field:
  - Reversing the B field direction would deteriorate the hit resolution in the TIB...

PXB in Oct 2010



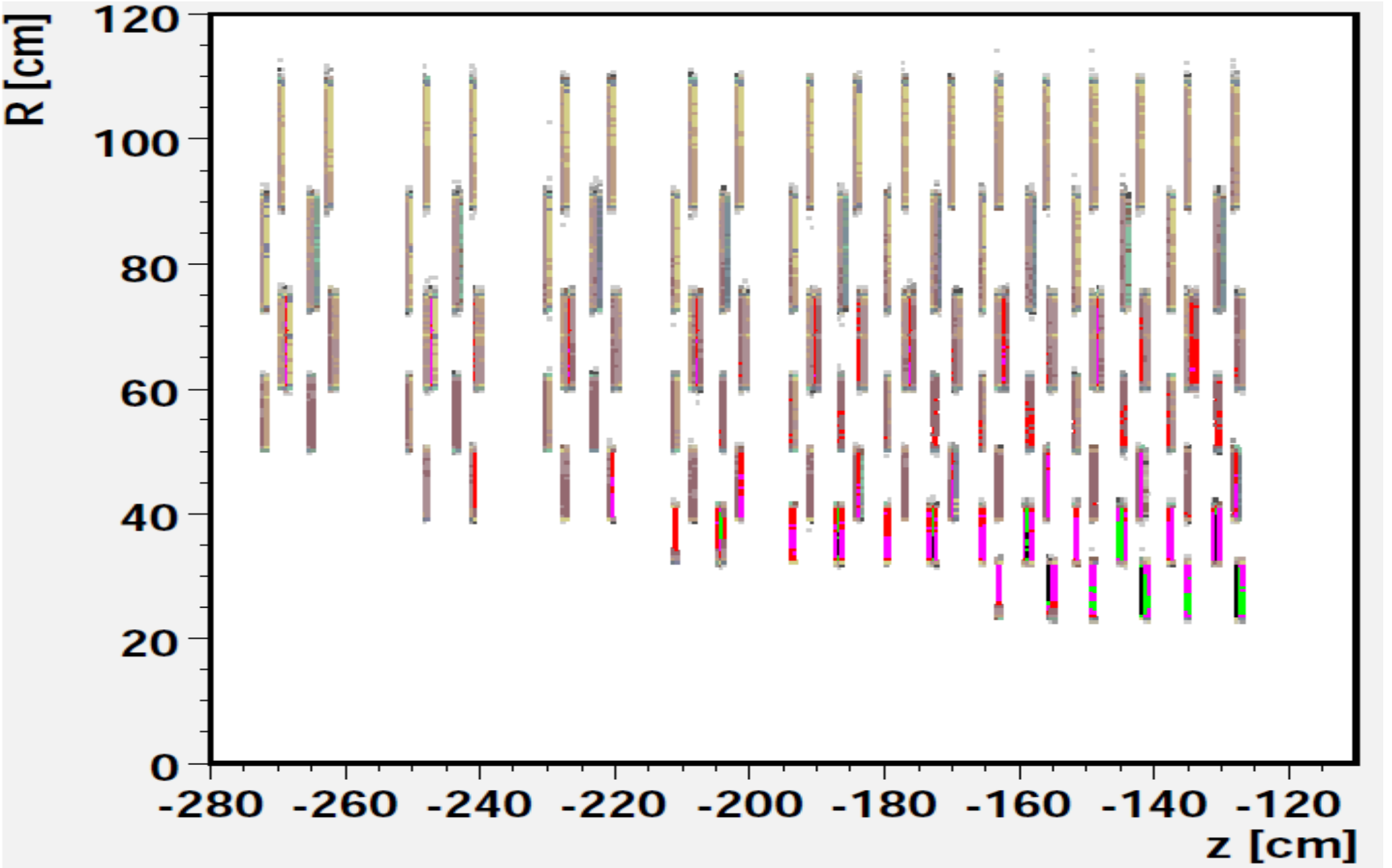
- Each layer has complete ϕ coverage.
  - Each ladder has 8 modules in z.
  - No loss of a complete ladder.
- Note the half-modules at the vertical split between left and right half-shells needed for insertion.
- The beam pipe is at R = 2.9 cm.

TID



neighboring ϕ sectors are staggered in *z*.

TEC-



TEC+