Barrel pixel efficiency studies

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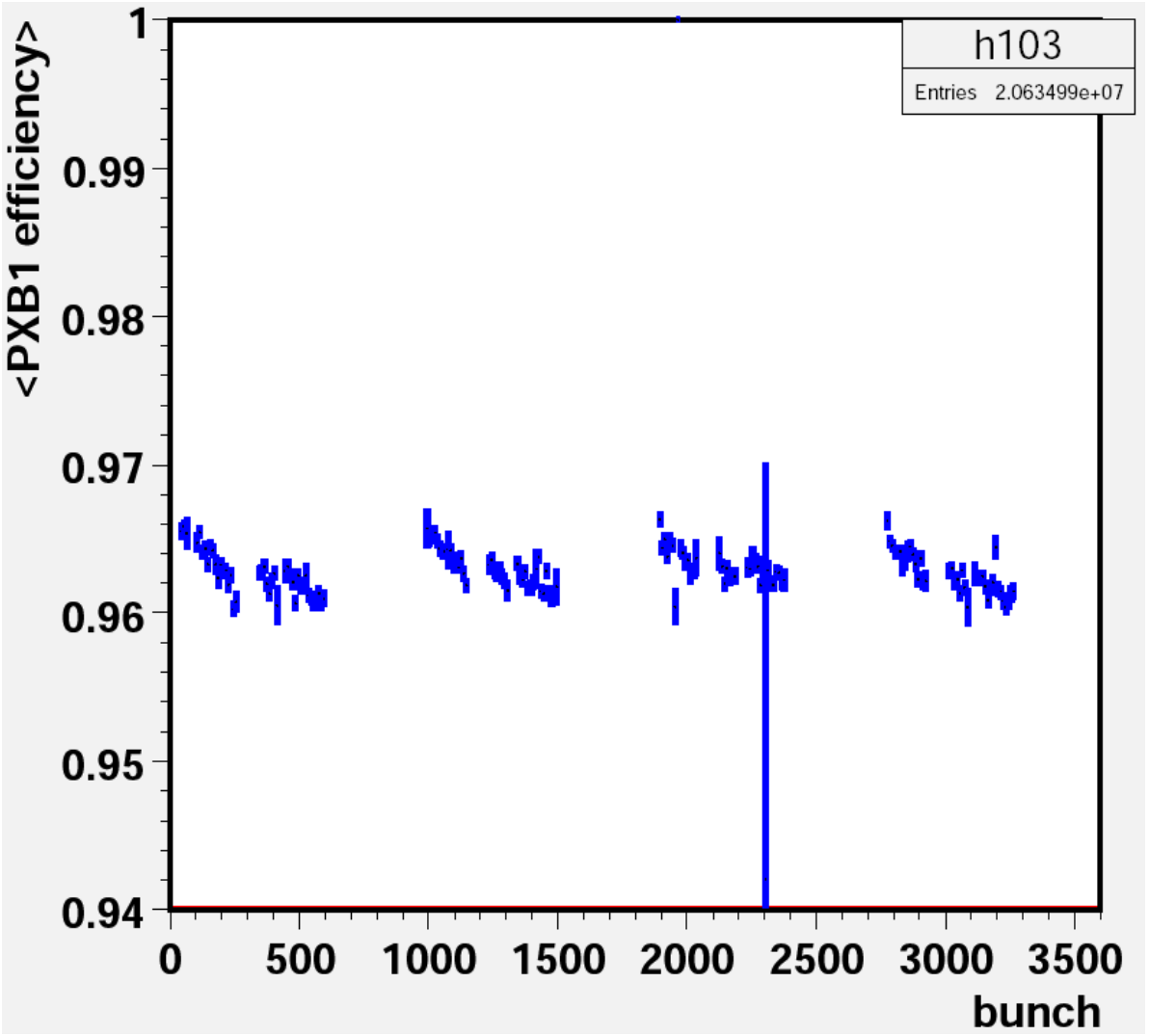
CMS Pixel DPG 19.5.2011



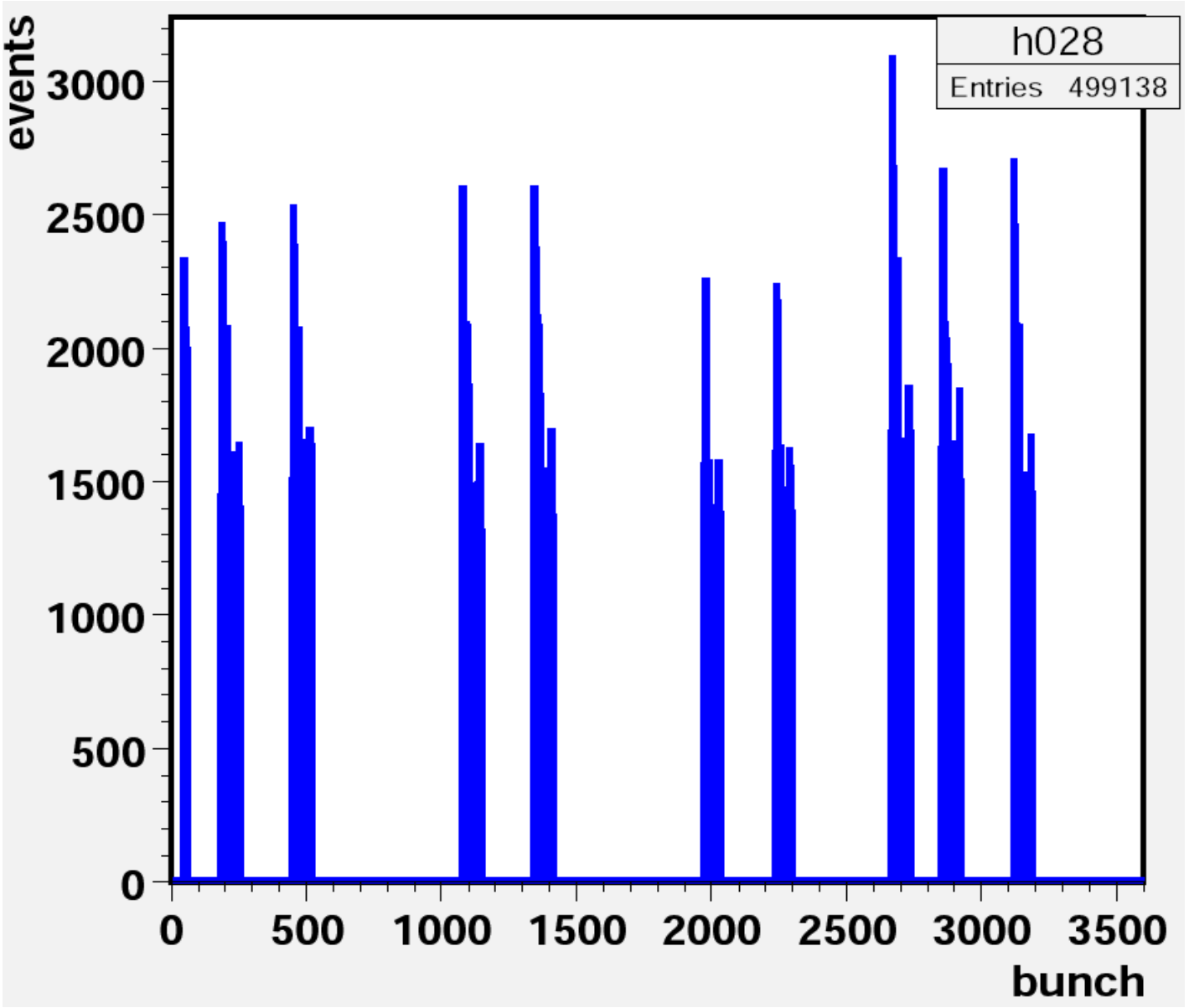
- Efficiency vs
  - bunch pattern
  - z gaps

idea

- The pixel ROC efficiency may be affected by the history of the previous 155 bunch crossings (L1 latency):
  - data losses when Time Stamp or Data buffers are full
- Since April 20, 2011, the LHC was filled with trains of 72 bunches at 50 ns spacing, thus covering 144 clock cycles.
  - The early fills had large gaps between bunch trains, where the ROC could recover all buffers.
- Thus: study the pixel barrel layer 1 efficiency as function of bunch number.
- CMS fill information:

  `https://cmswbm.web.cern.ch/cmswbm/cmsdb/servlet/FillReport`

Bunch pattern fill 1718



LHC:

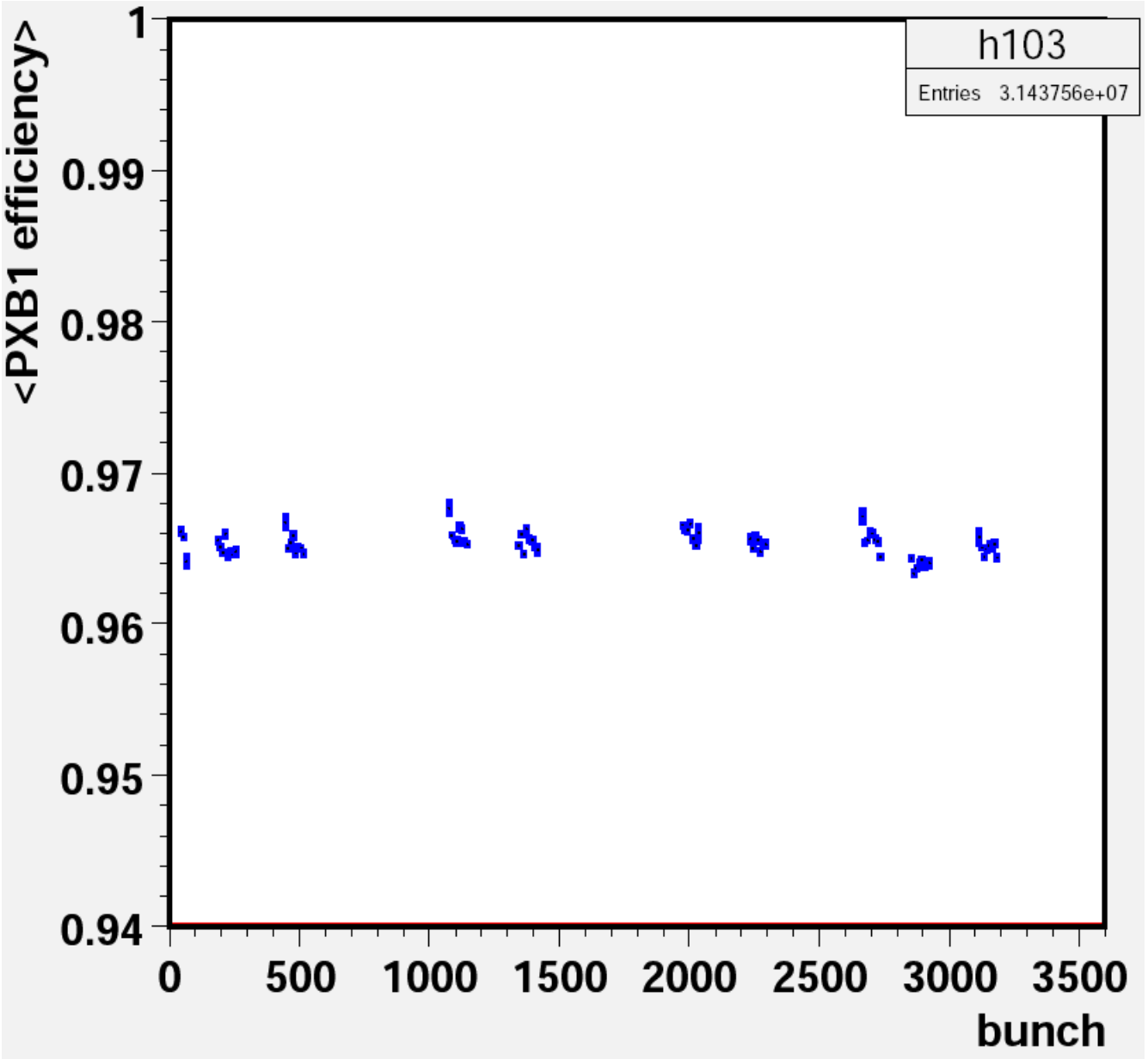
- 26'659 m
- 89 us / turn
- space for 3564 bunches at 25 ns.

Fill 1718:

- 9 trains of 36 bunches at 50 ns plus some extra.
- Mean pile up 5.5 (from the number of primary vertices).

LHC fill 1718 `50ns_336b+1small_322_12_288_36bpi11inj`

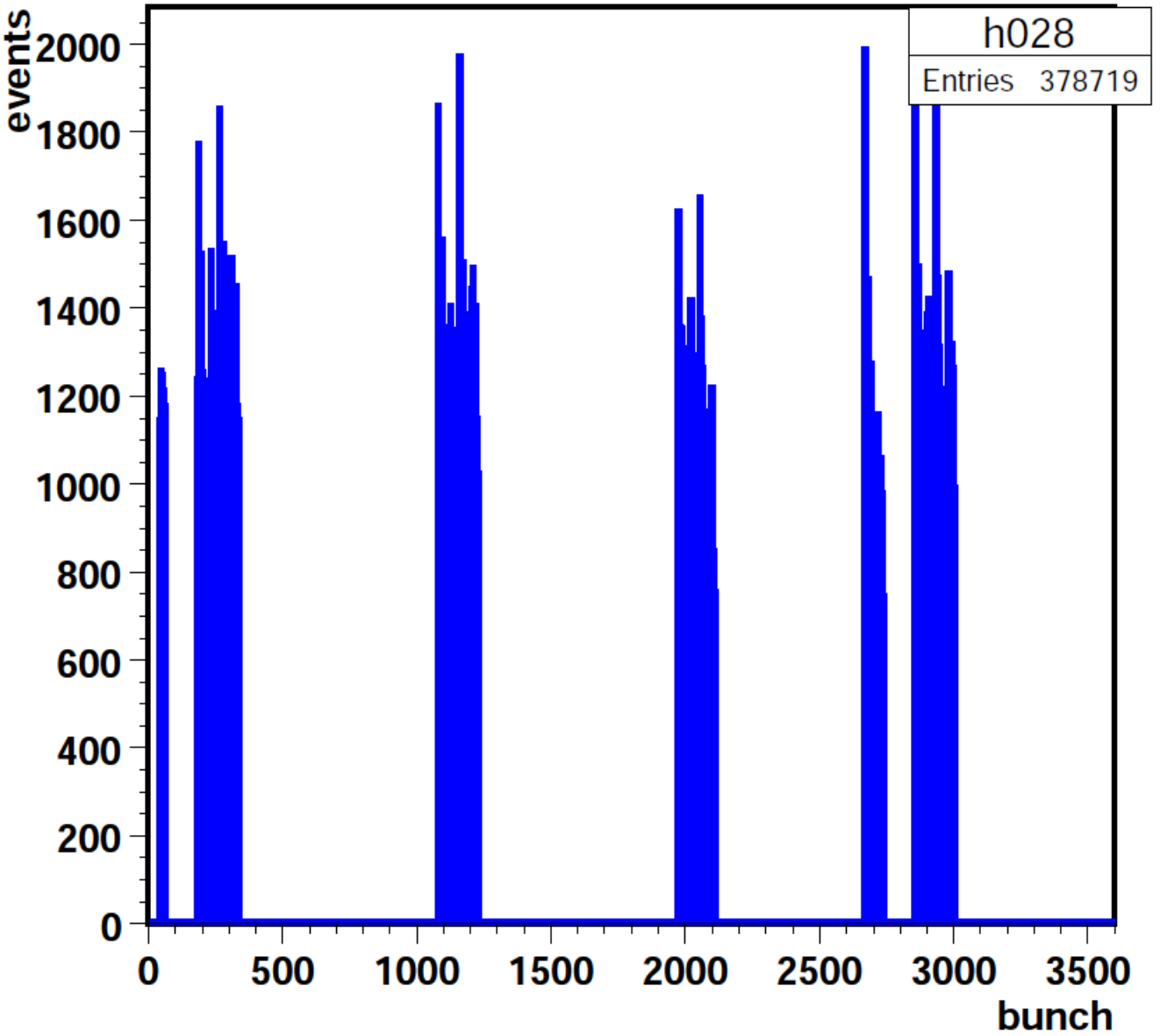
Pixel barrel layer 1 efficiency



LHC fill 1718, jet stream, <PU>=5.2

- Efficiency = (tracks with hit in PXB1) / (tracks through PXB1 – z-gaps)
  - z-gaps taken out
  - dead or bad modules not taken out.
- Jet sample, PromptReco, AOD.
- Mean efficiency 96.5%.
- Degradation within each bunch train: at most -0.2%.
- Bunch trains too short?

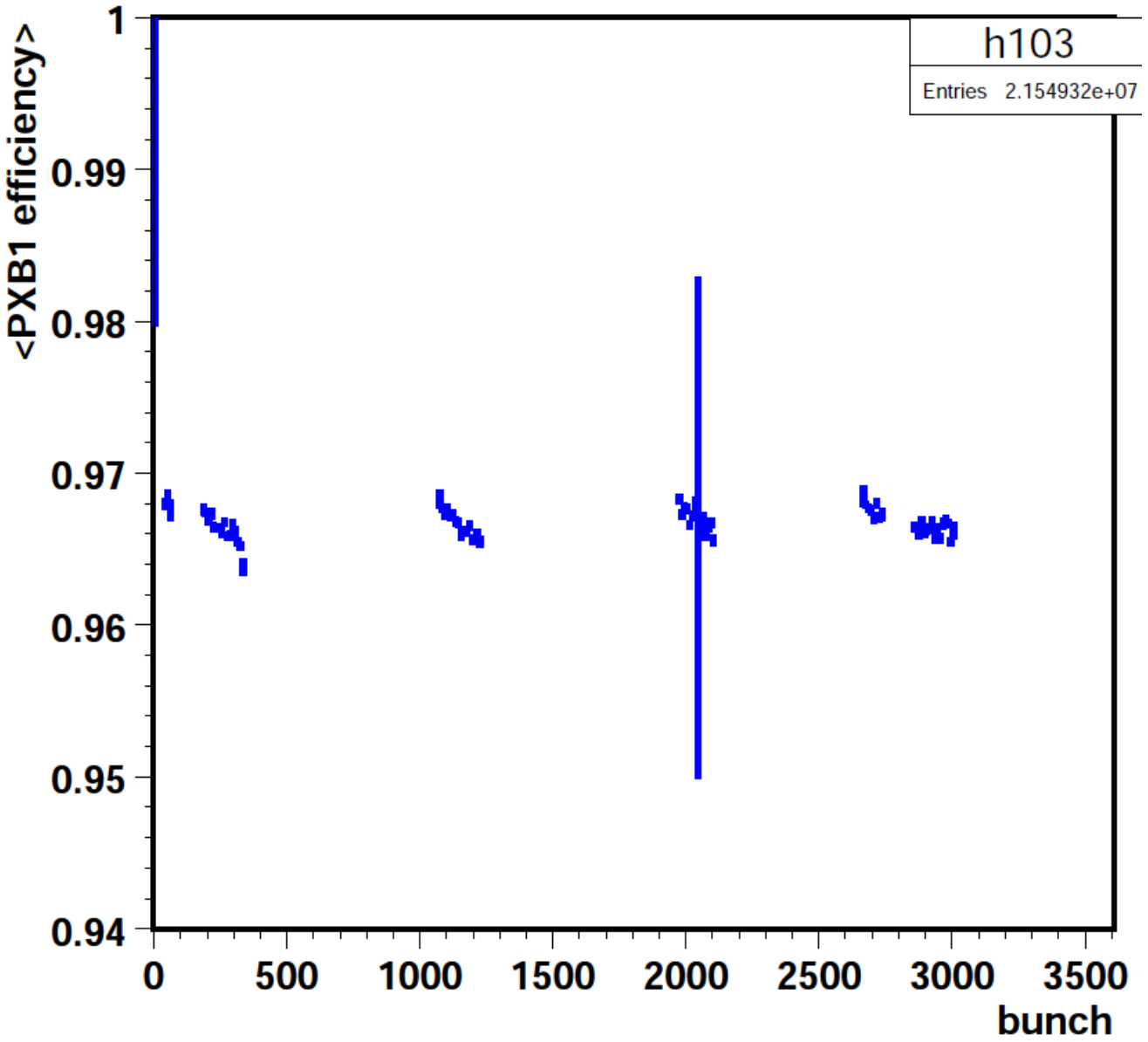
Bunch pattern fill 1727



- LHC:
  - 26'659 m
  - 89 us / turn
  - space for 3564 bunches at 25 ns.
- Fill 1727:
  - 4 trains of 72 bunches plus some extra.
  - Mean pile up 4.6 (from the number of primary vertices).

LHC fill 1727 `50ns_336b+1small_322_14_288_72bpi7inj`

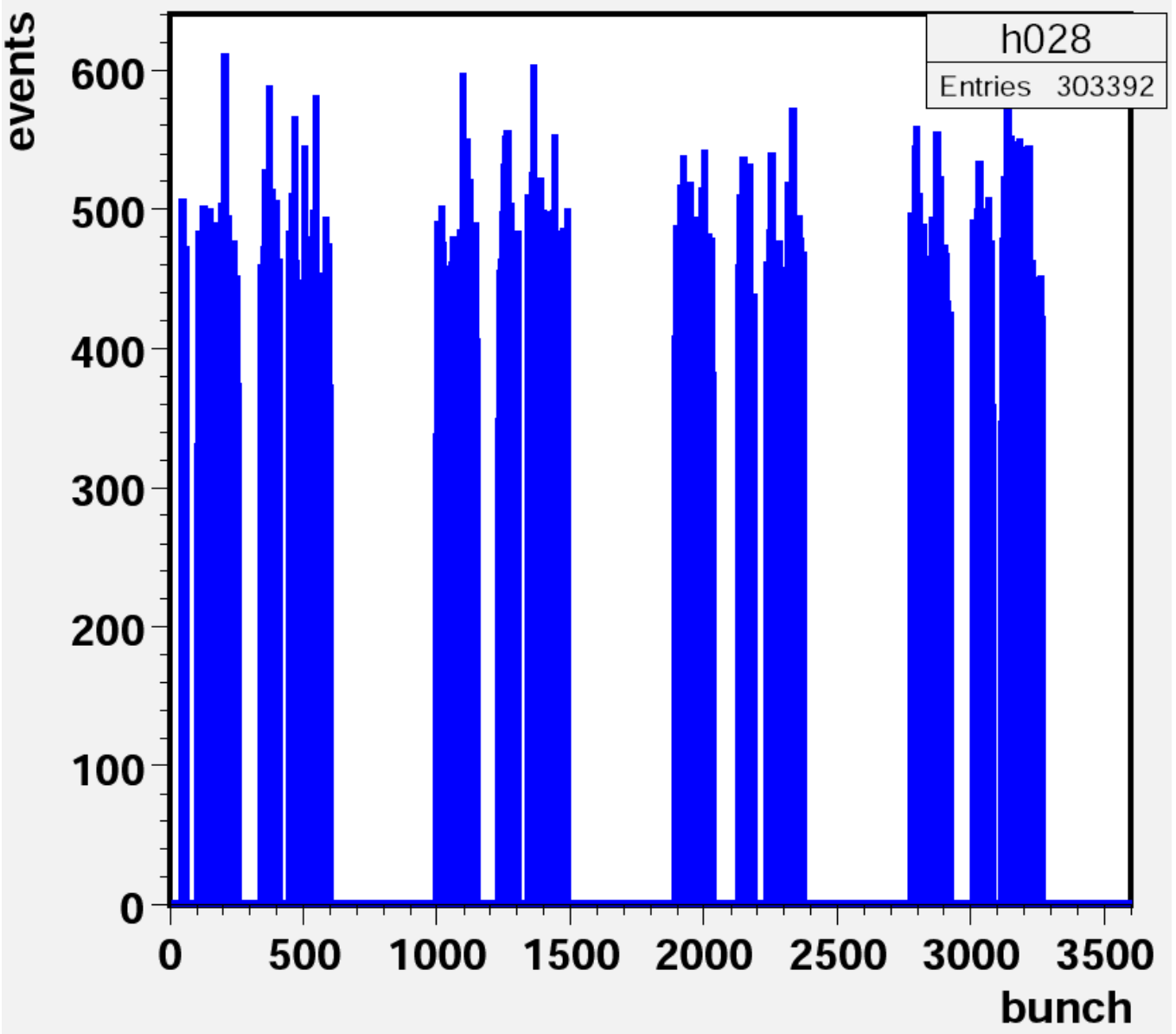
Pixel barrel layer 1 efficiency



LHC fill 1727, jet stream, <PU>=4.6

- Efficiency = (tracks with hit in PXB1) / (tracks through PXB1 – z-gaps)
  - z-gaps taken out
  - dead or bad modules not taken out.
- Jet sample, PromptReco, AOD.
- Top efficiency is close to 97%.
- Degradation within each bunch train: about -0.3%.

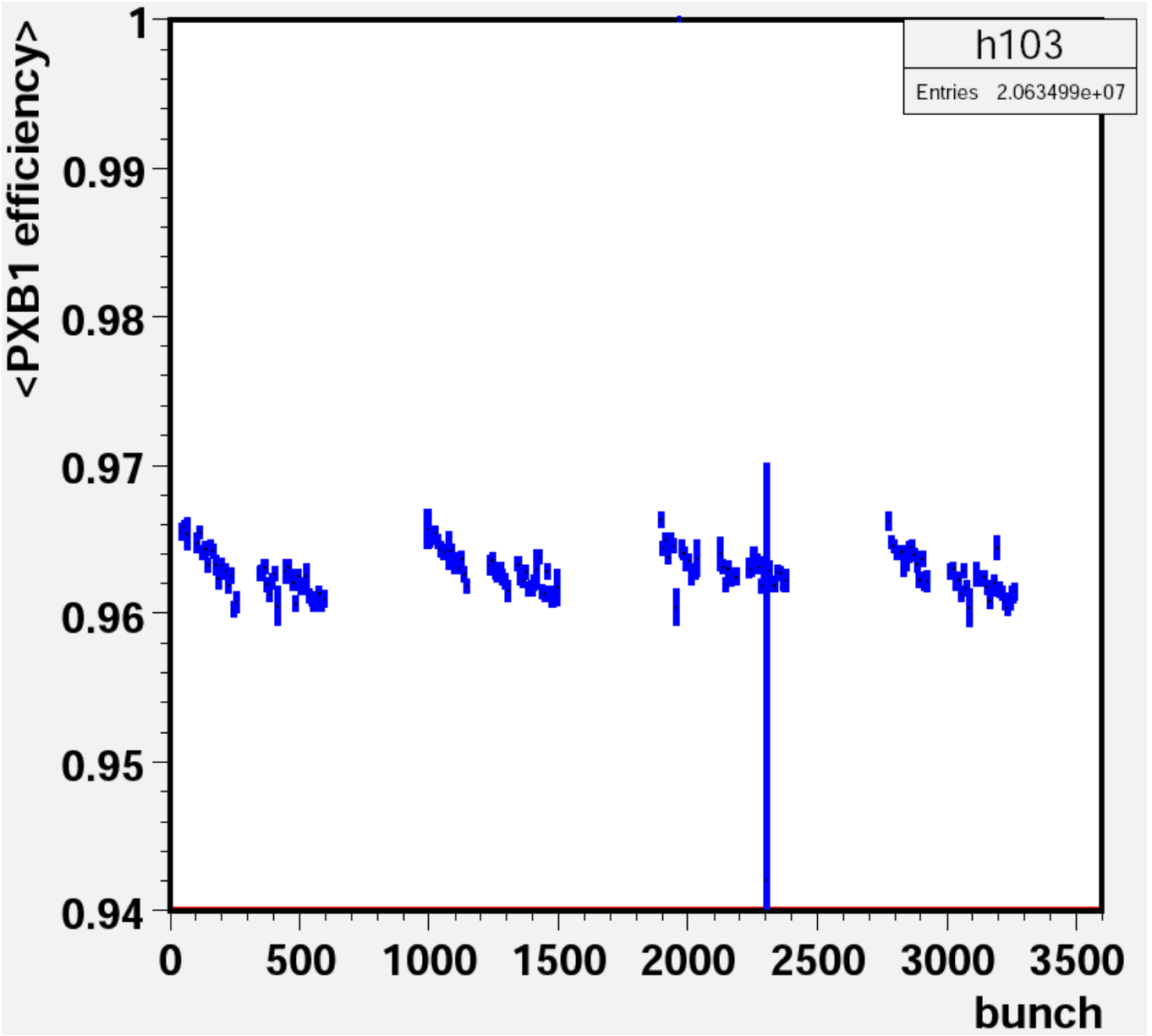
Bunch pattern fill1755



- LHC:
  - 26'659 m
  - 89 us / turn
  - space for 3564 bunches at 25 ns.
- Fill 1755:
  - 8×72 + 4×32 bunches at 50 ns.
  - Average pile up 6.2 (from the number of primary vertices).

LHC fill 1755 `50ns_768b+1small_700_16_756_72bpi15inj_b`

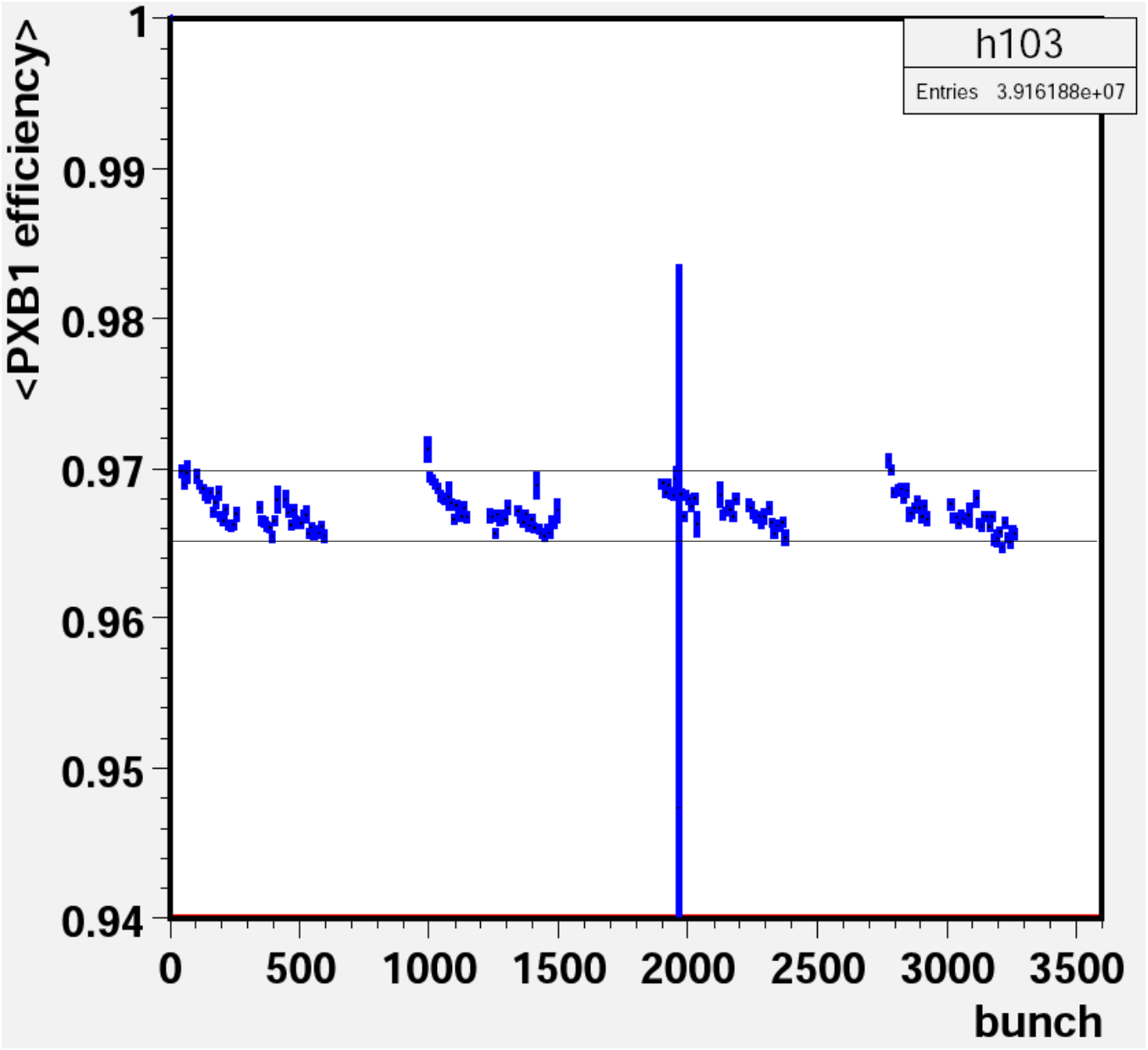
Pixel barrel layer 1 efficiency



LHC fill 1755, jet stream, <PU>=6.2

- Efficiency = (tracks with hit in PXB1) / (tracks through PXB1 – *z*-gaps)
  - *z*-gaps taken out
  - dead or bad modules not taken out.
- Jet sample, PromptReco, AOD.
- Top efficiency is 96.6%.
- Degradation within each bunch train: about -0.6%.

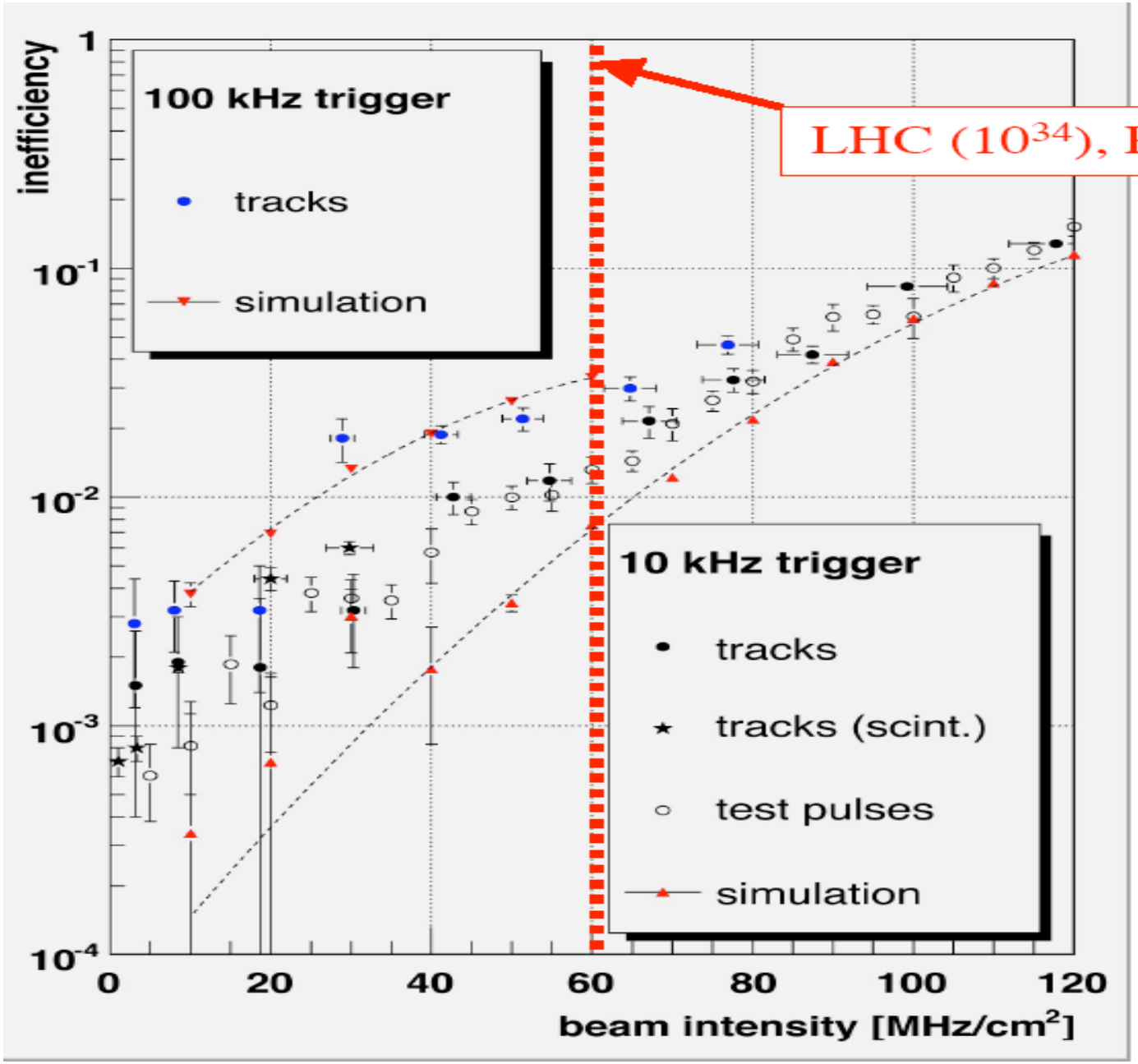
Pixel barrel layer 1 efficiency



LHC fill 1755, DoubleMu, <PU>=6.4

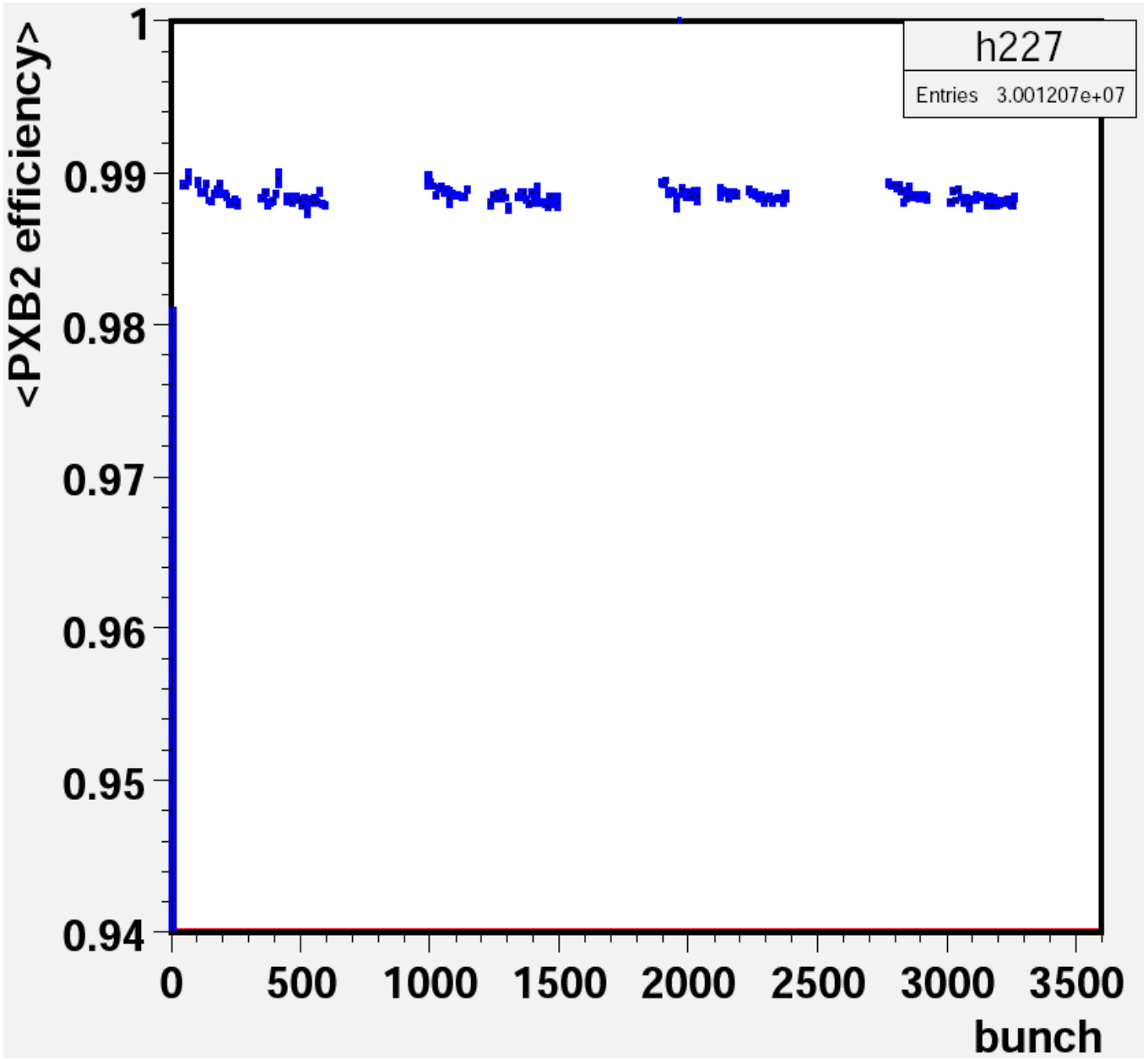
- Efficiency = (tracks with hit in PXB1) / (tracks through PXB1 – *z*-gaps)
  - *z*-gaps taken out
  - dead or bad modules **not taken out**.
- DoubleMu sample, PromptReco, AOD.
- Top efficiency is 97%.
- Degradation within each bunch train: about -0.5%.

Pixel ROC inefficiency



PSI high rate test beam ~2005

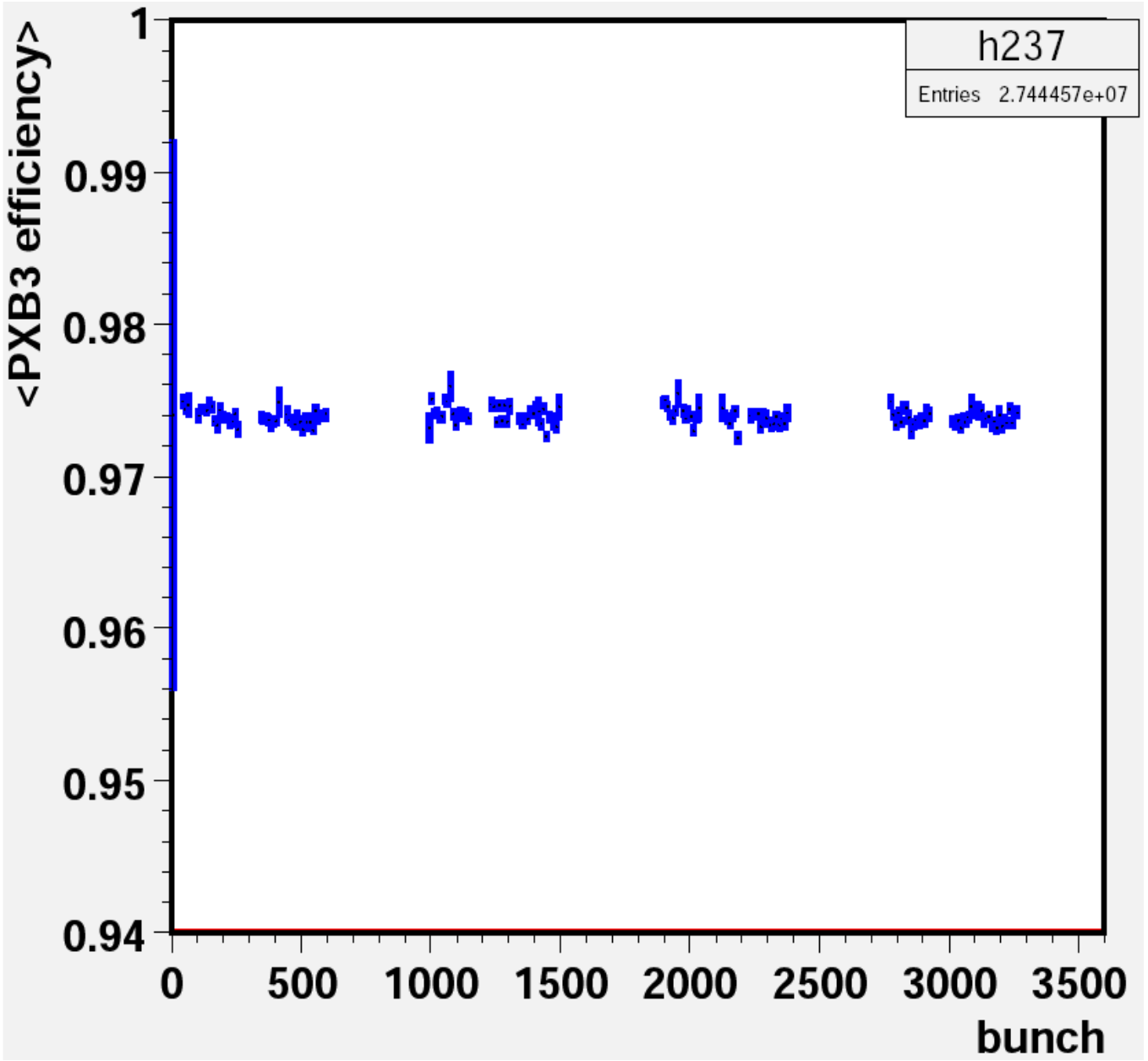
Pixel barrel layer 2 efficiency



LHC fill 1755, DoubleMu, <PU>=6.2

- Efficiency = (tracks with hit in PXB2) / (tracks through PXB2 – z-gaps – dead modules)
  - z-gaps taken out
  - dead or bad modules **are taken out.**
- DoubleMu sample, PromptReco, AOD.
- Top efficiency is 99%.
- Degradation within each bunch train: less than -0.2%.

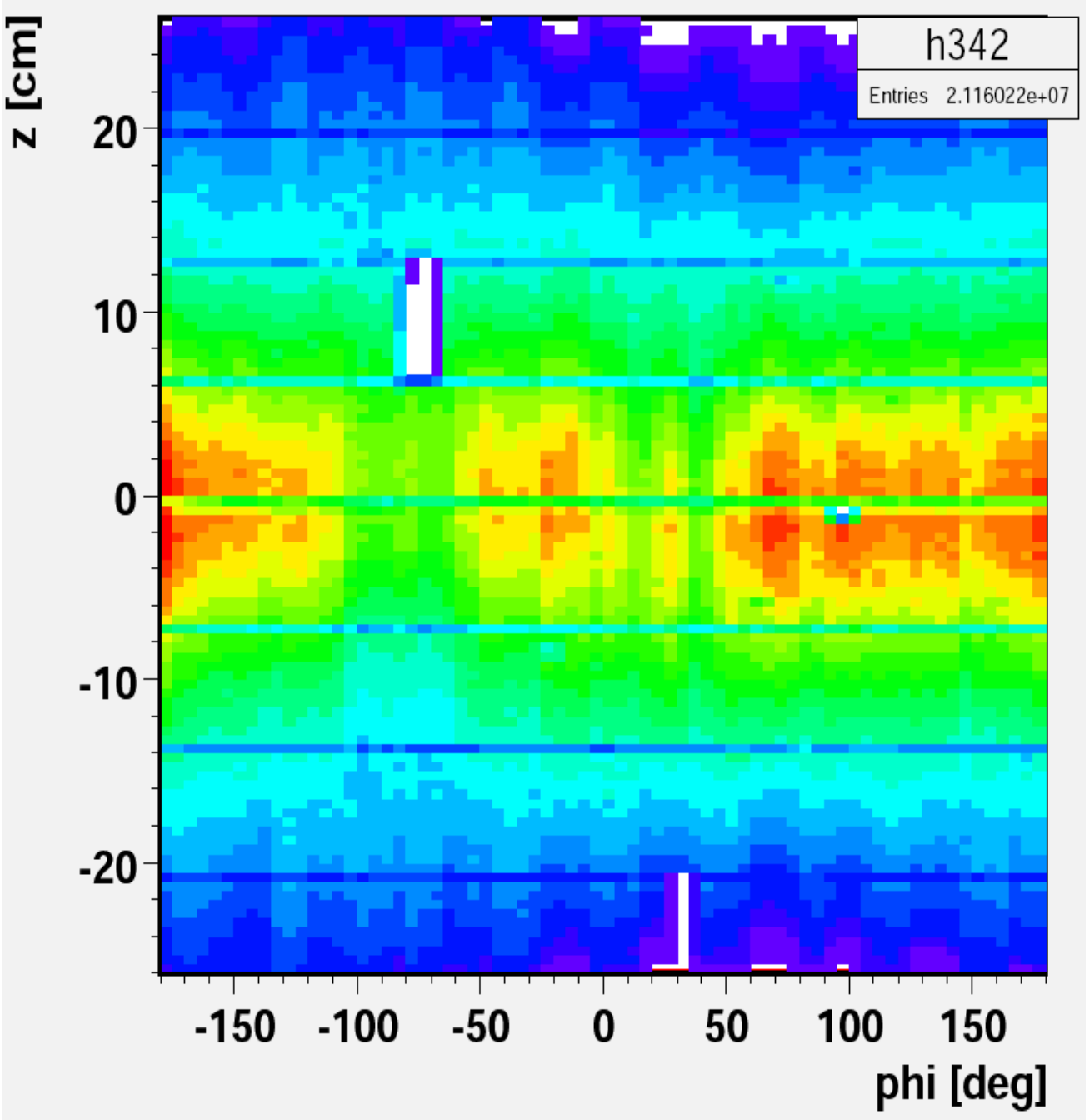
Pixel barrel layer 3 efficiency



LHC fill 1755, jet stream, <PU>=6.2

- Efficiency = (tracks with hit in PXB3) / (tracks through PXB3 – *z*-gaps – dead modules)
  - *z*-gaps taken out
  - known dead or bad modules **are taken out.**
- Mean efficiency is 97.5%.
- Degradation within each bunch train: at most -0.1%.
- Conclusion: effect seen in PXB1 is not caused by track degradation.

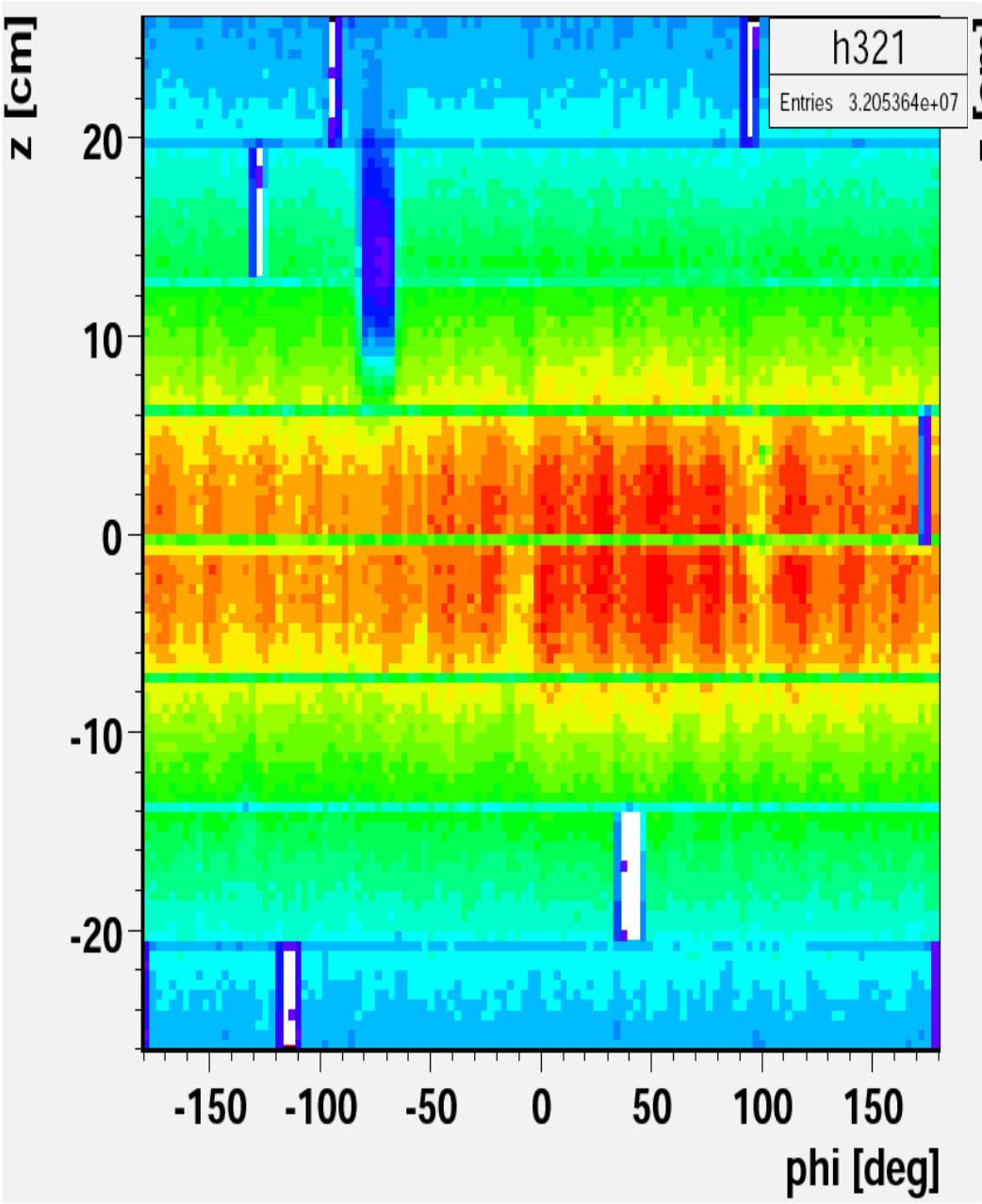
Pixel barrel 1 hits on tracks



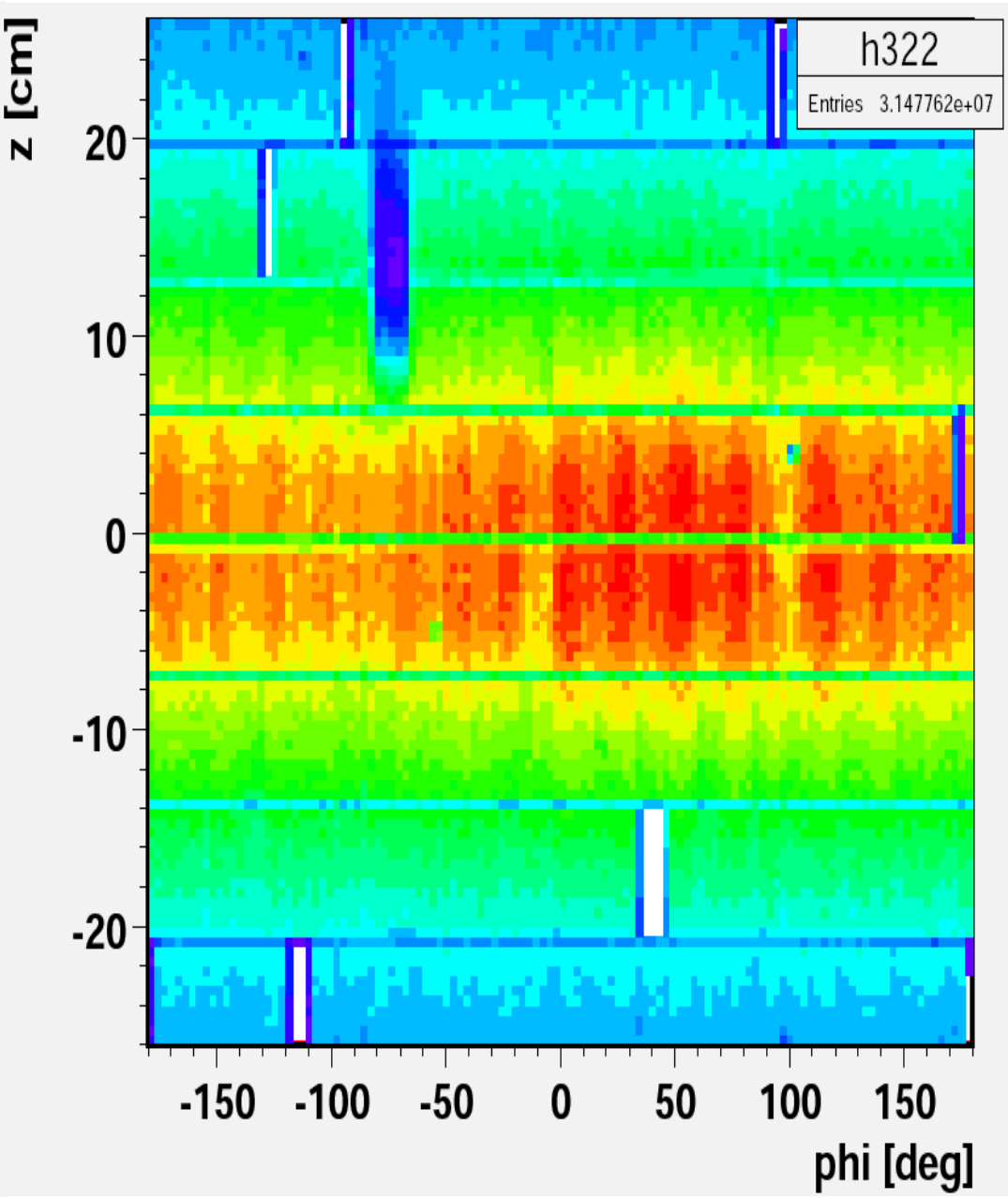
- z-φ map of PXB1 hits on tracks.
- Barrel length = ±26 cm.
- one dead module
- one dead half-module
- 5 gaps between modules in z.

Pixel barrel 2 tracks and hits

tracks with known dead

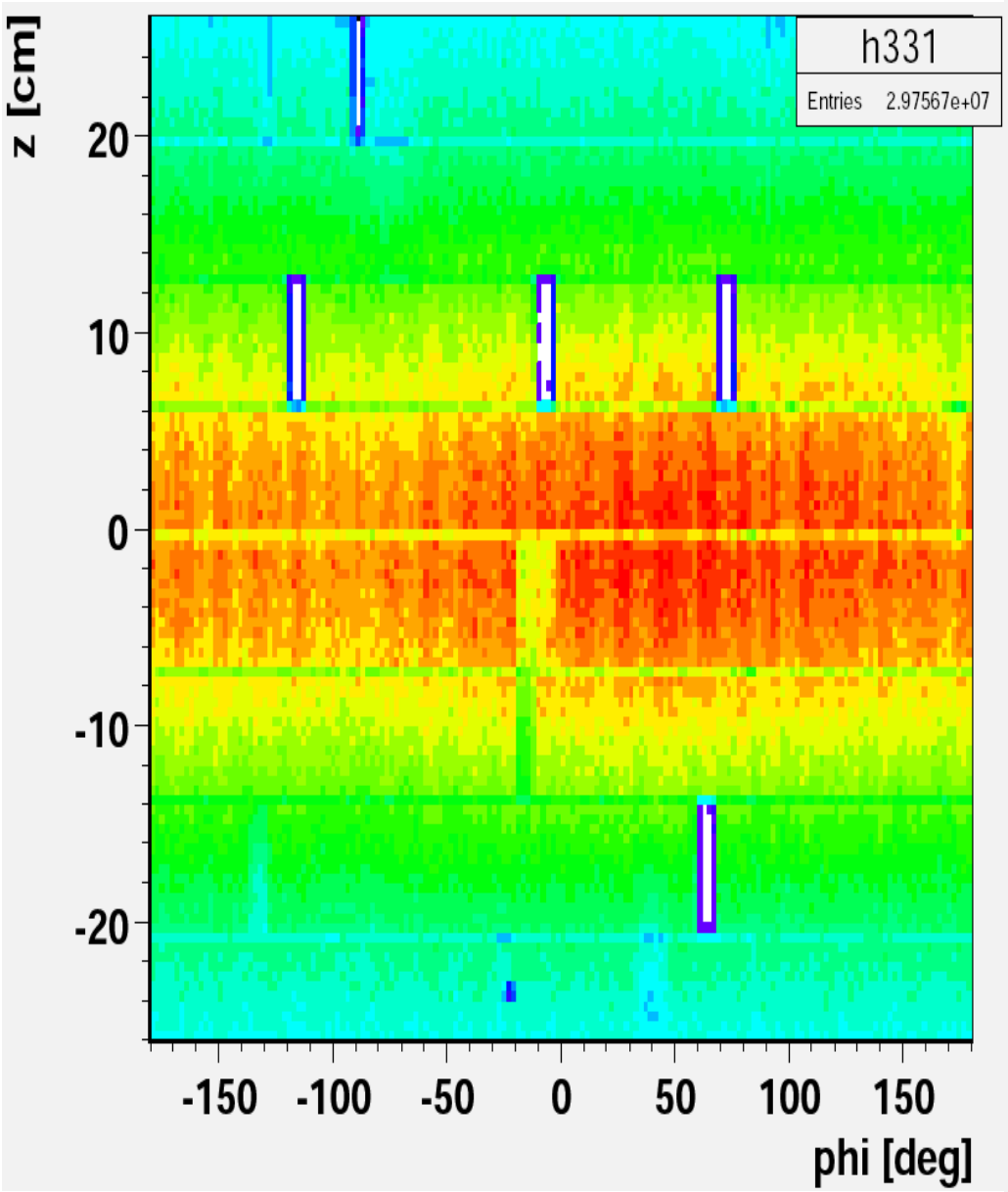


hits with actual dead

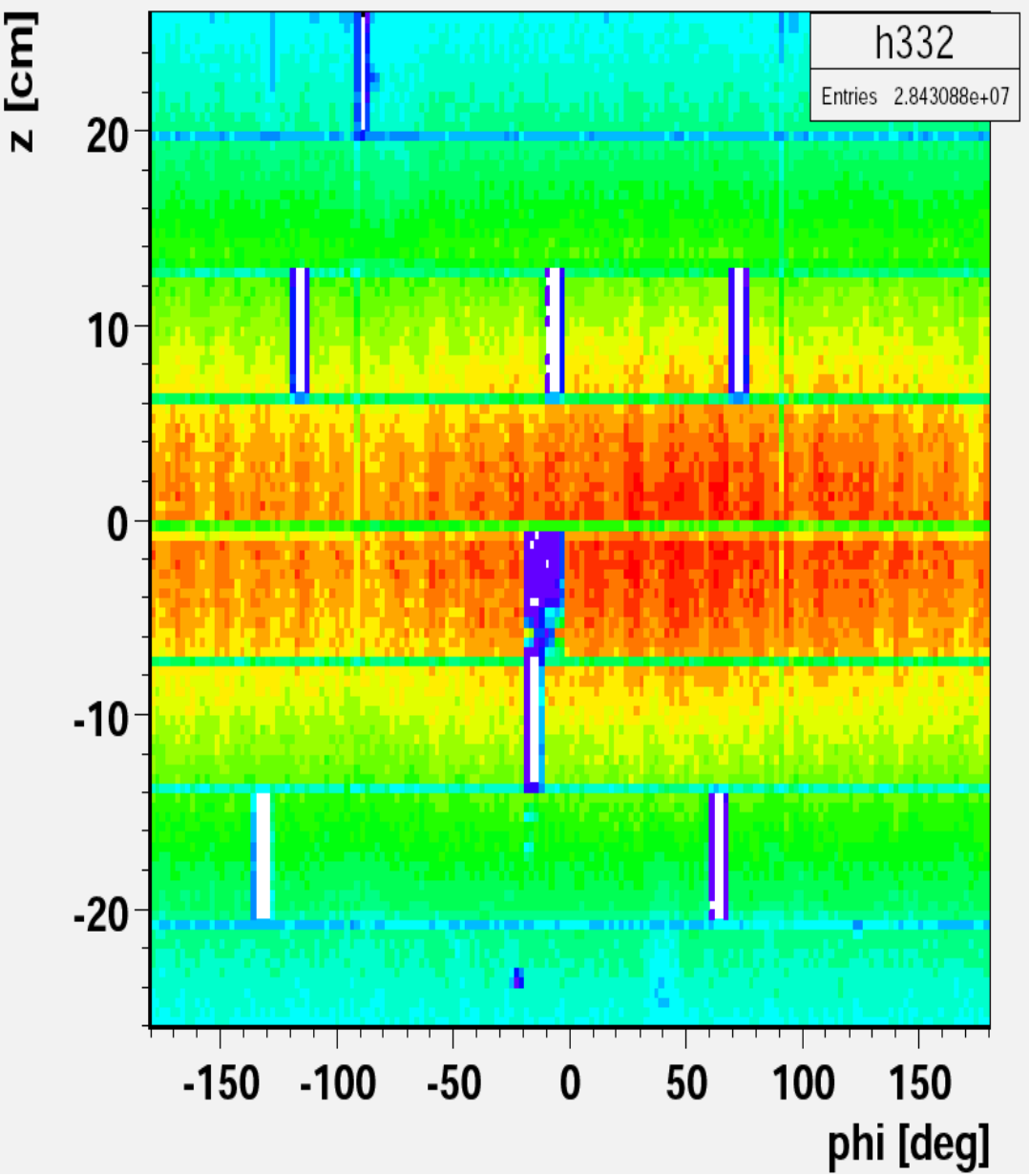


Pixel barrel 3 tracks and hits

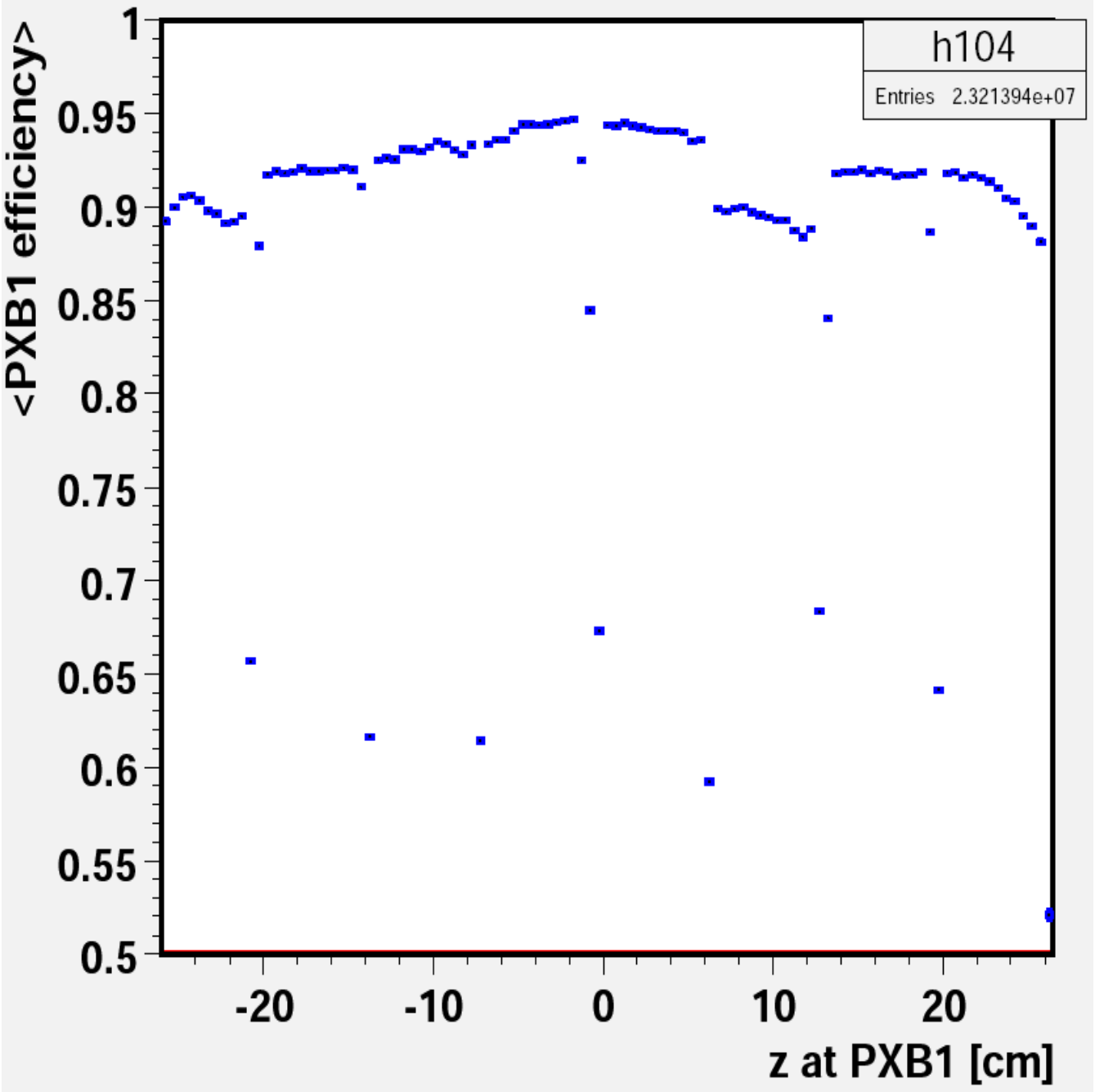
tracks with known dead



hits with actual dead

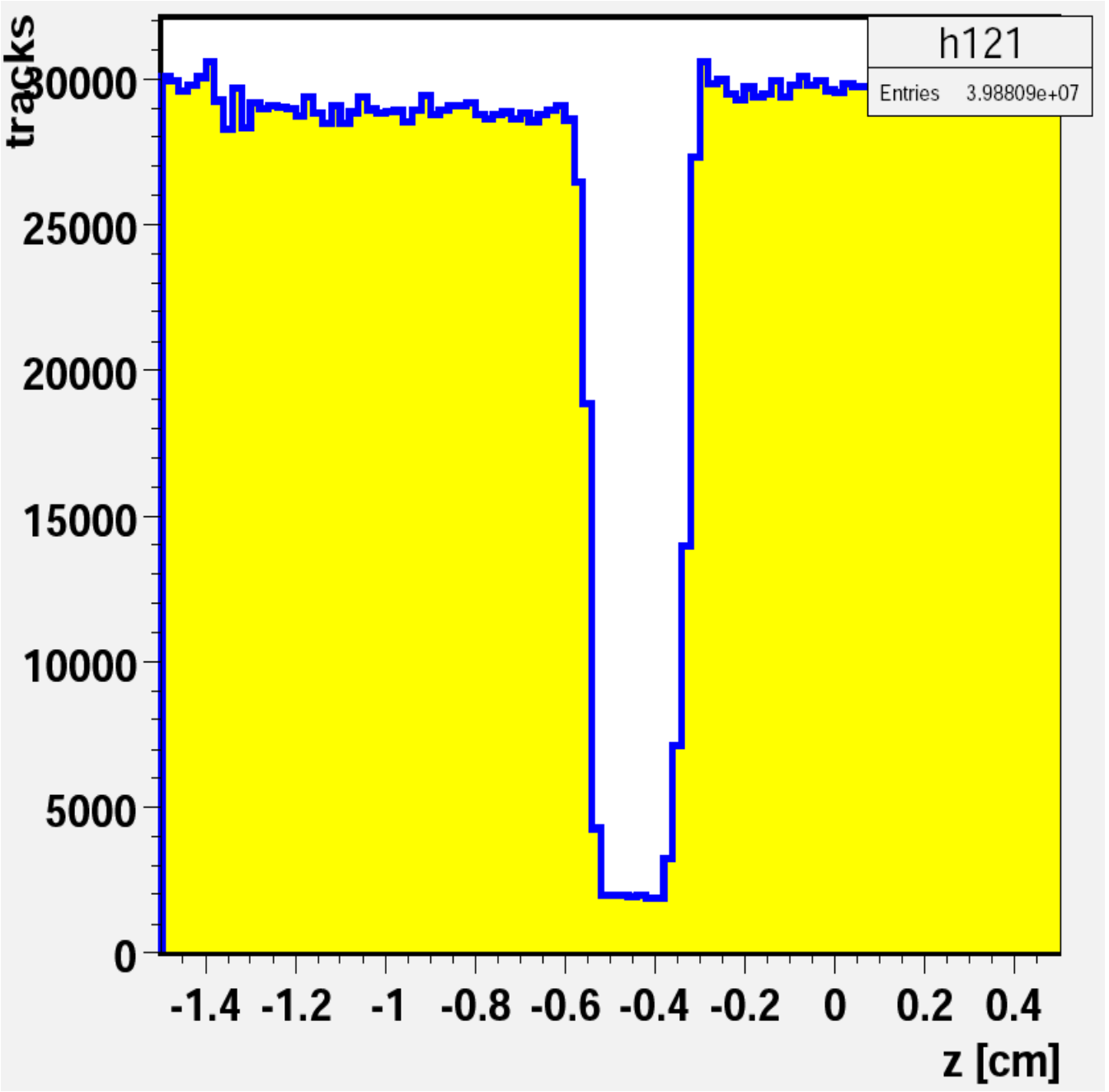


Barrel pixel *z*-gaps



- Efficiency = (tracks with hit in PXB1) / (tracks through PXB1).
- p_t > 0.75 GeV.
- tracker hits > 8.
- Jet sample, PromptReco, AOD.
- 5 gaps between modules in *z*.
- Barrel length = ±26 cm.
- One dead module at *z* = +8 cm (out of 18 in phi).

Barrel pixel z-gap



- Tracks with hits along z.
- Middle gap is not at $z = 0$:
  - Barrel pixel detector not centered?
- width of z-gap is about 2 mm.
- A few tracks with poor z resolution appear to be in the gap...

Summary and status

- Indication of occupancy-induced ROC inefficiency within a bunch train?
  - at the 0.5% level for fill 1755 in barrel pixel layer 1.
  - Layer 2 effect is small,
  - Layer 3 is flat
- New dead modules in layer 3?
- Next: compare to simulation?
- to be followed in future fills
  - Pile up may still increase: larger bunch charge, smaller emittance, smaller beta function in the interaction region.
- z-gaps sharply identified by tracking precision.