Center for Frontiers in Nuclear Science

Run13 Forward Pions Update

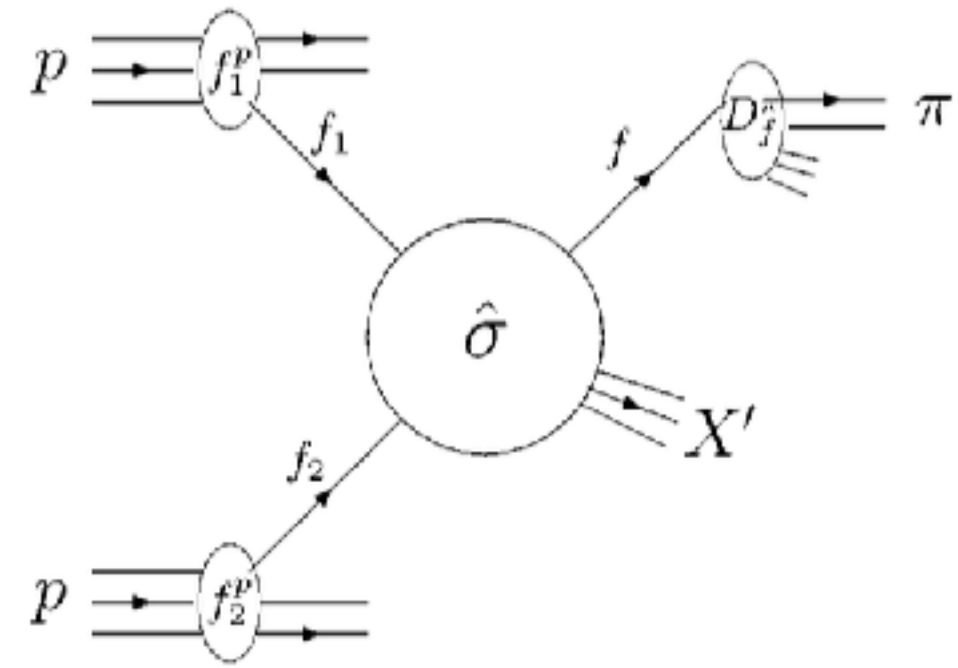
Ross Corliss

July 22, 2020

Stony Brook University

Extracting Polarized PDFs

- Different partonic cross sections have different analyzing powers
- Final states in general correspond to multiple initial states.
- So: extracting polarized PDFs requires measuring multiple final state asymmetries to disentangle.
- TL/DR: Continuing analysis begun by Pedro Montuenga: Measure forward π^0 asymmetry at 500GeV, help constrain ΔG



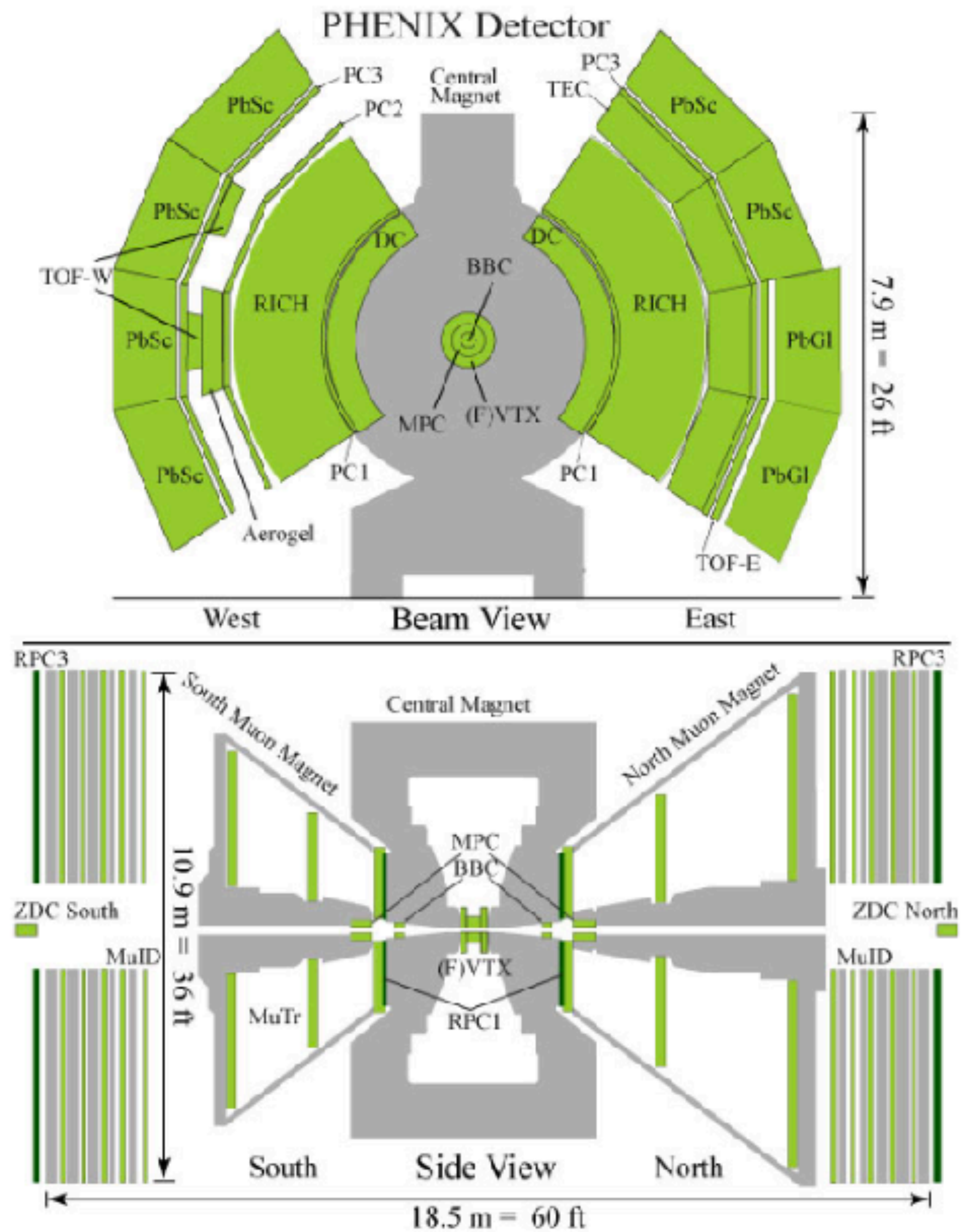
$$A_{LL} = \frac{\sum_{f_1,f_2,f} \Delta f_1 \times \Delta f_2 \times \left[d\hat{\sigma}^{f_1 f_2 \to f X'} \hat{a}_{LL}^{f_1 f_2 \to f X'}\right] \times D_f}{\sum_{f_1,f_2,f} f_1 \times f_2 \times [d\hat{\sigma}^{f_1 f_2 \to f X'}] \times D_f}$$

$$\hat{a}_{LL}^{f_1 f_2 \to f X'} = d\Delta\hat{\sigma}^{f_1 f_2 \to f X'} / d\hat{\sigma}^{f_1 f_2 \to f X'}$$

$$A_{LL} = \frac{(\sigma_{++} + \sigma_{--}) - (\sigma_{+-} + \sigma_{-+})}{(\sigma_{++} + \sigma_{--}) + (\sigma_{+-} + \sigma_{-+})}$$

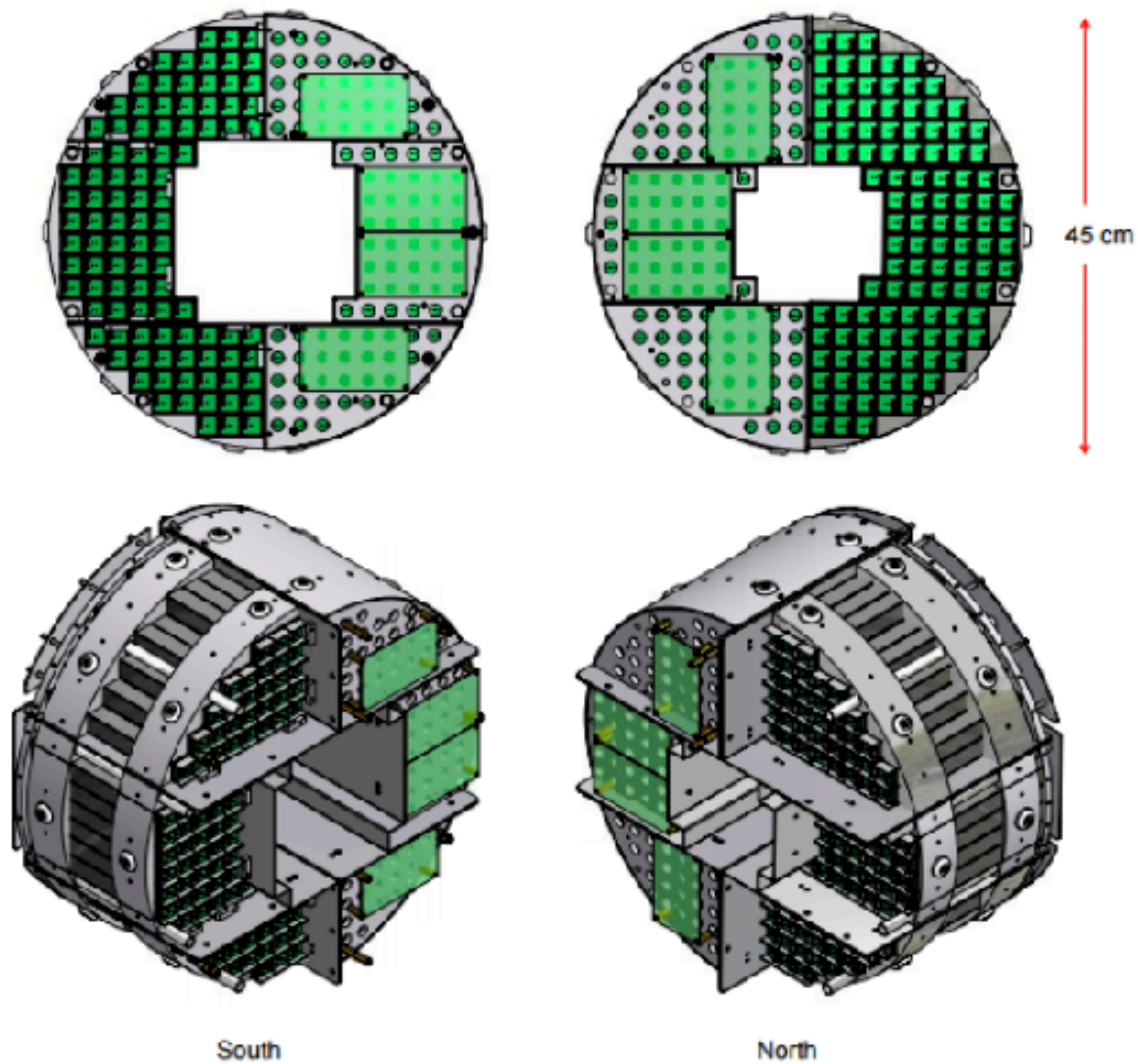
PHENIX

- ZDC and BBC for luminosity monitoring
- Muon Piston Calorimeters (MPC) for π^0 reconstruction



Muon Piston Calorimeter

- 2.2x2.2x18cm $PbWO_4$ crystals
- Moliere radius ~2.0cm
- $3.1<\eta<3.9$ (N)
- $-3.1>\eta>-3.7$ (S)



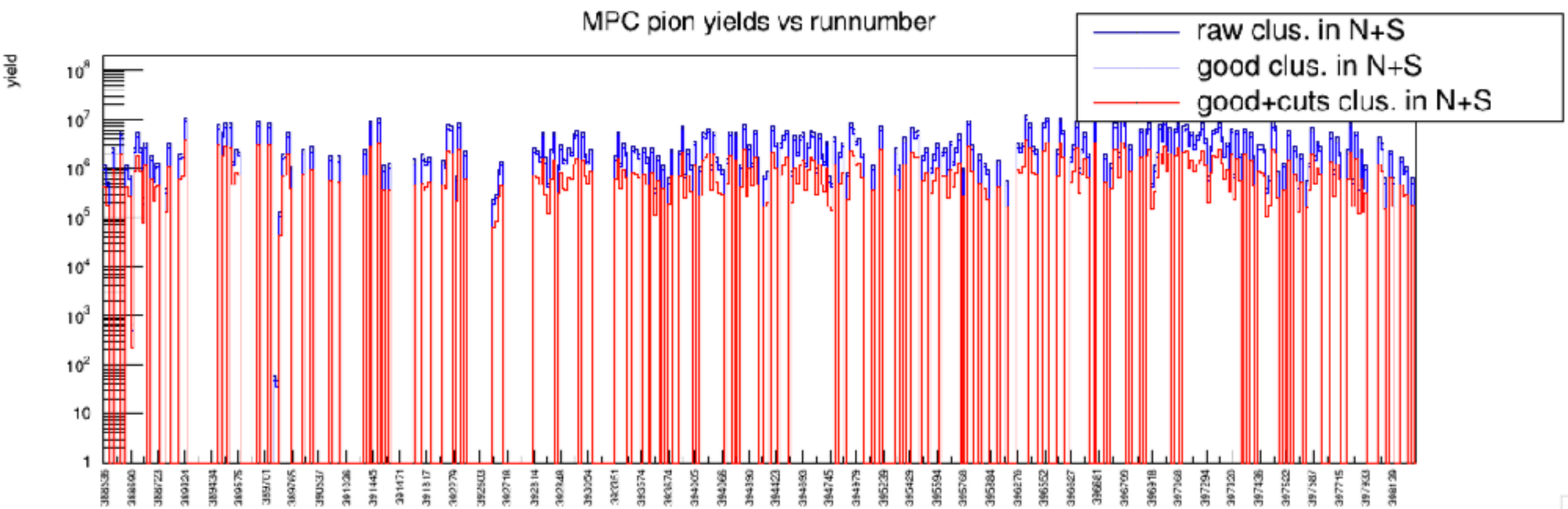
π^0 Cuts

- Not "Good" cluster if:

  !isCrystal -- cluster core has an invalid fee. Never happens.
  isWarn -- cluster core is in the warm-tower map
  !(11cm<r<19cm) -- cluster may not be fully contained
  pt<1.0 -- cluster pt below our lowest ptbin

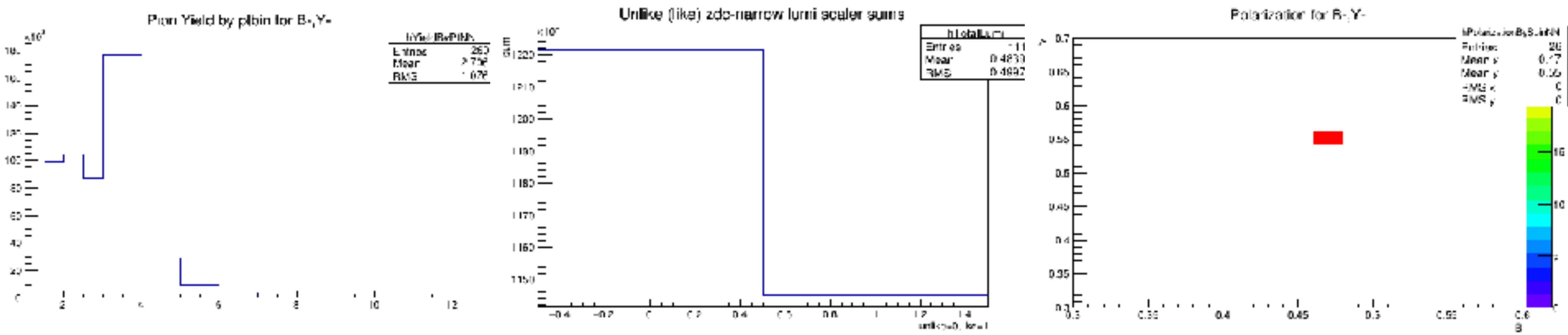
- Cluster fails pion cuts if:

  mult<3 -- cluster has fewer than 3 towers
  disp<5e-4 -- cluster energy is extremely concentrated
  chi2core>30 -- pulse shape does not look like EM shower



Asymmetry Calculation

- From pion yields, (and spin database for polarization and scalers) generate asymmetries per-run:

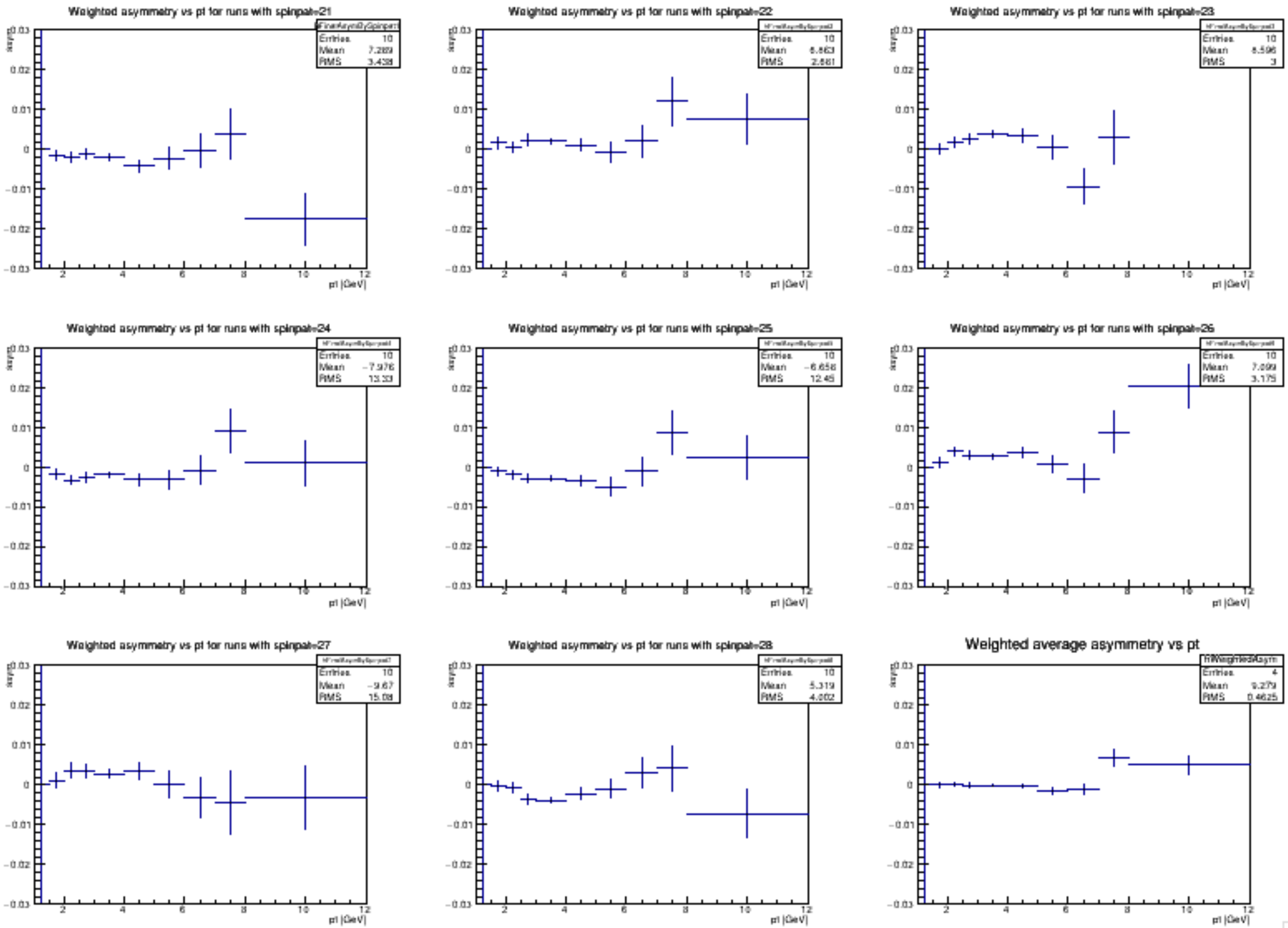


$$A_{\mathrm{LL}}^{\mathrm{cluster}} = \frac{1}{P_{\mathrm{b}} P_{\mathrm{y}}} \frac{N_{\mathrm{cluster}}^{++} - R N_{\mathrm{cluster}}^{+-}}{N_{\mathrm{cluster}}^{++} + R N_{\mathrm{cluster}}^{+-}}$$

- From per-run A_{LL}, generated final, error-weighted average:

$$A_{\mathrm{LL}}^{\mathrm{ave}} = \Sigma \frac{A_{\mathrm{LL}}^{i}}{(\sigma_{A_{\mathrm{LL}}}^{i})^2}$$

Asymmetry by spinpattern



using zdc narrow for luminosity

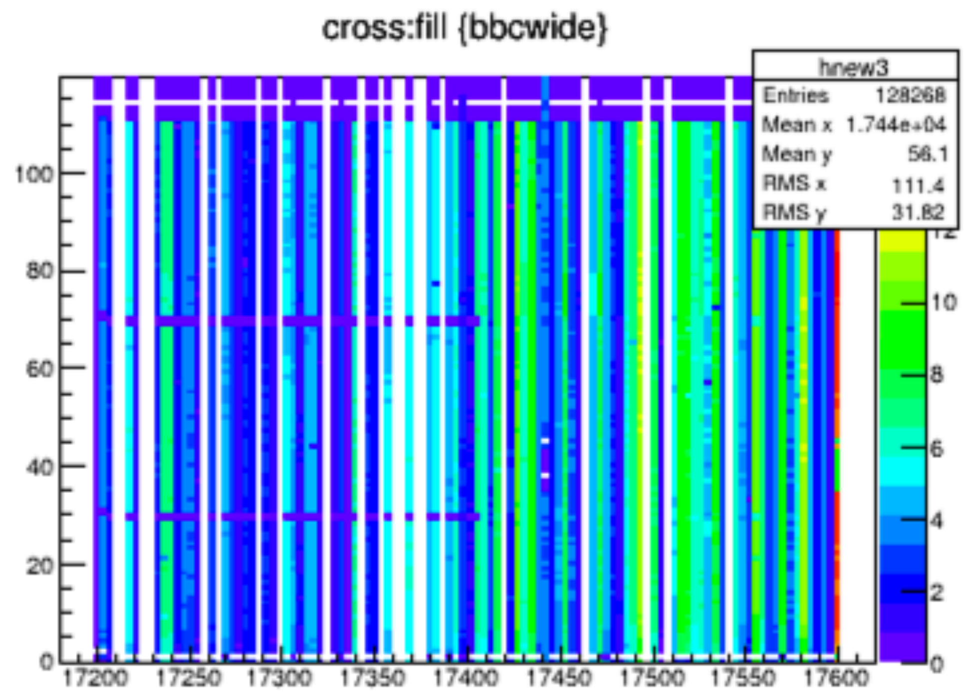
Old Bunch and Run Cuts

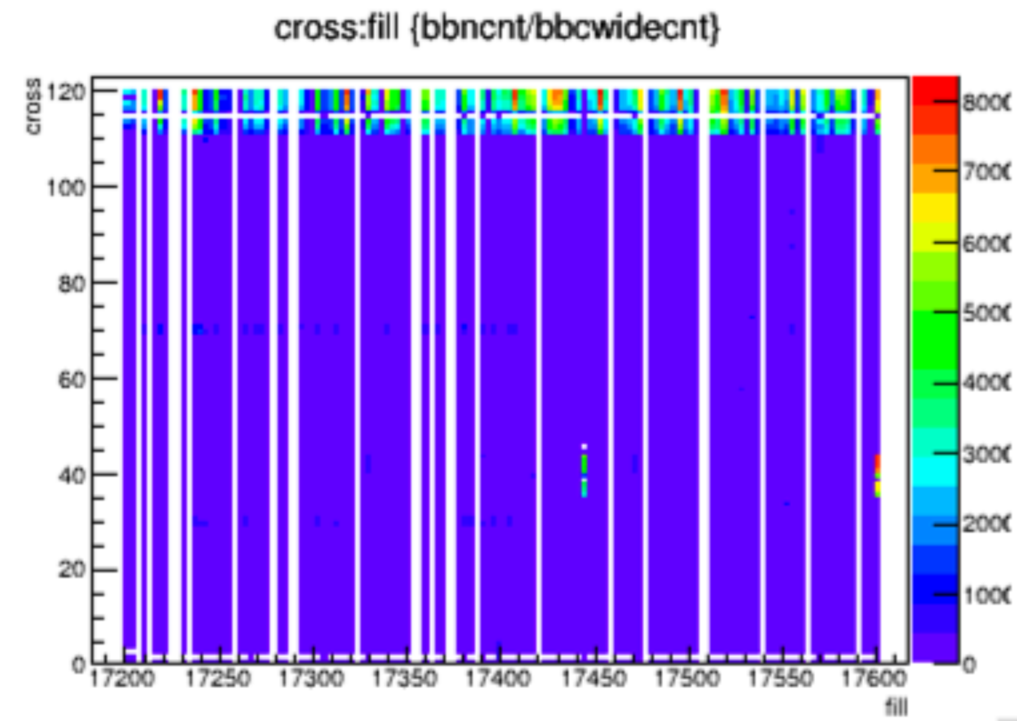
- Working to reproduce series of cuts for relative lumi QA:
  1. remove bunches that were live for fewer than 1e6 clock pulses (this cuts short runs, and is similar to Pedro's GL1 to starscaler cut)
  2. remove bunches where livetimes were below 70% (similar to Pedro's run-by-run cut on same)
  3. remove bunches where singles-to-doubles are too far from the main line (similar to Pedro's cut on fills where that ratio is not linear vs rate)
  4. *remove runs where 20 or more xings were cut for reasons from the previous (not all bunch xing cuts listed here)*
  5. *remove runs where the bunch shuffling RMS was above 1.0*

Revised Bunch and Run Cuts

- Finalizing run QA (tracks Pedro's with a few additional items). Cuts divided by concept:
  A. crossing cuts: Remove bunches or runs where data from certain bunches alone implicates the bunch or the entire run.
  B. coin scaler cuts: remove bunches and runs where behavior of scalers compared to each other suggest something is unreliable.
  C. singles scaler cuts: remove bunches where singles behavior deviates from the other bunches in that run
  D. livetime cuts: cut any remaining busy bunches.
  E. tatters cuts: remove runs that have lost more than 20 bunches (and a cut on run outliers that is in this group for historical reasons)

Crossing-Based Cuts



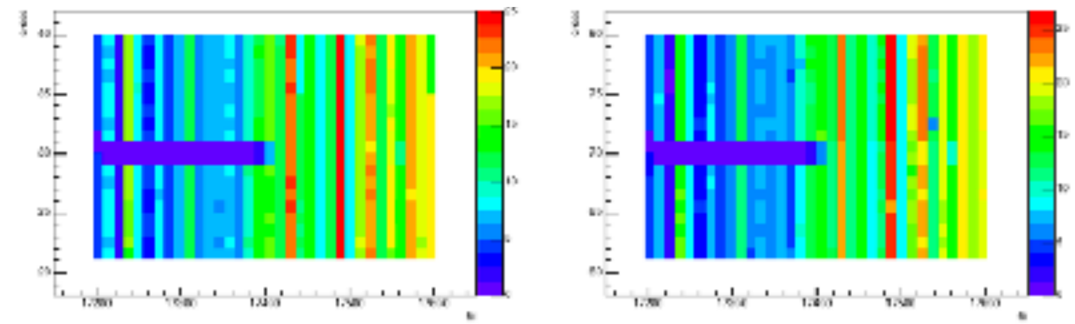


- Half-empty bunches near 30 and 70
- Abort gap at 111-120
- Dead crossing near zero shifts in early fills

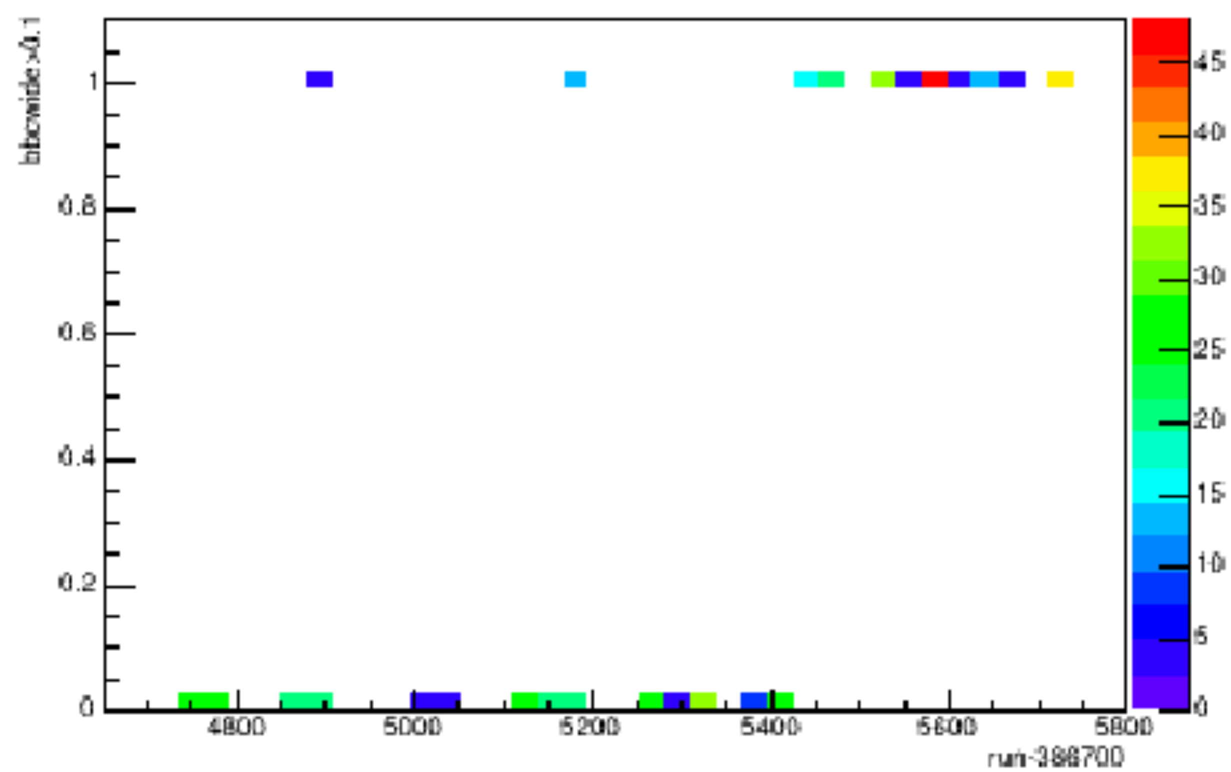
Crossing-Based Cuts

- Half-empty bunches near 30 and 70 turn normal about halfway through the fills. Remove by requiring bunch_bbcwide>0.05 (this also takes care of most of the abort gap)

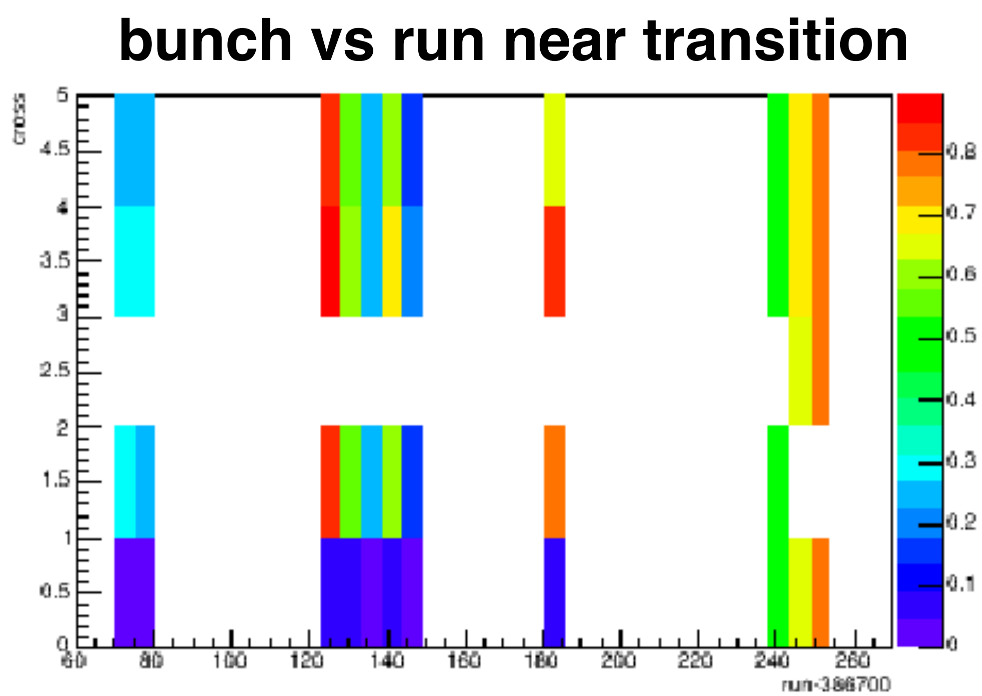
bunch vs fill near 30 and 70

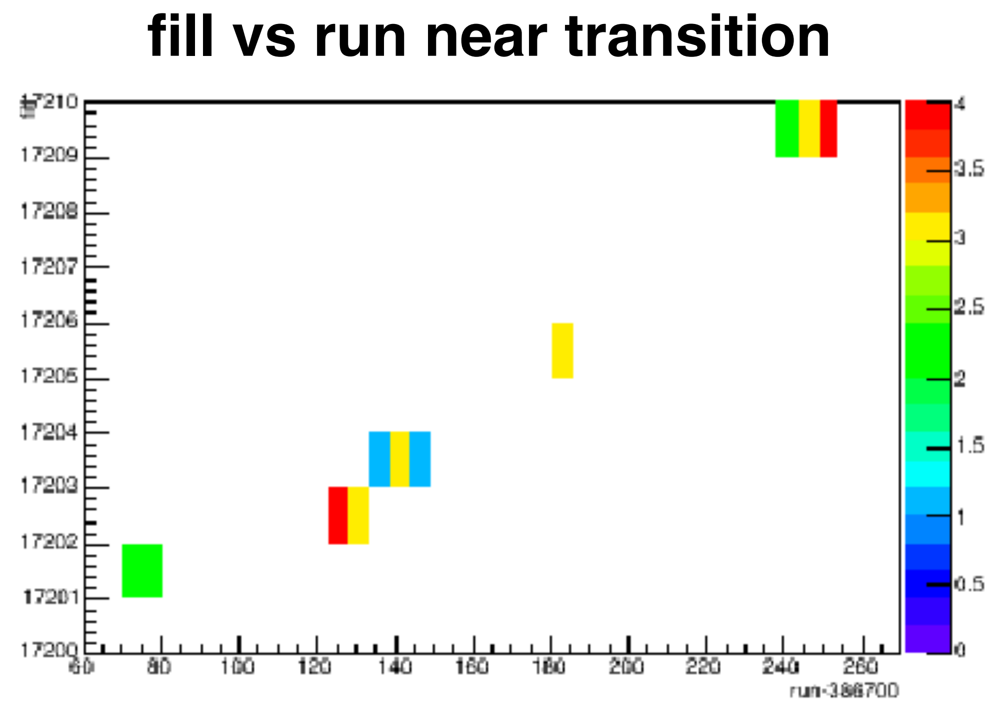


(bbc>0.1) vs run for empty bunches near transition



Crossing-Based Cuts





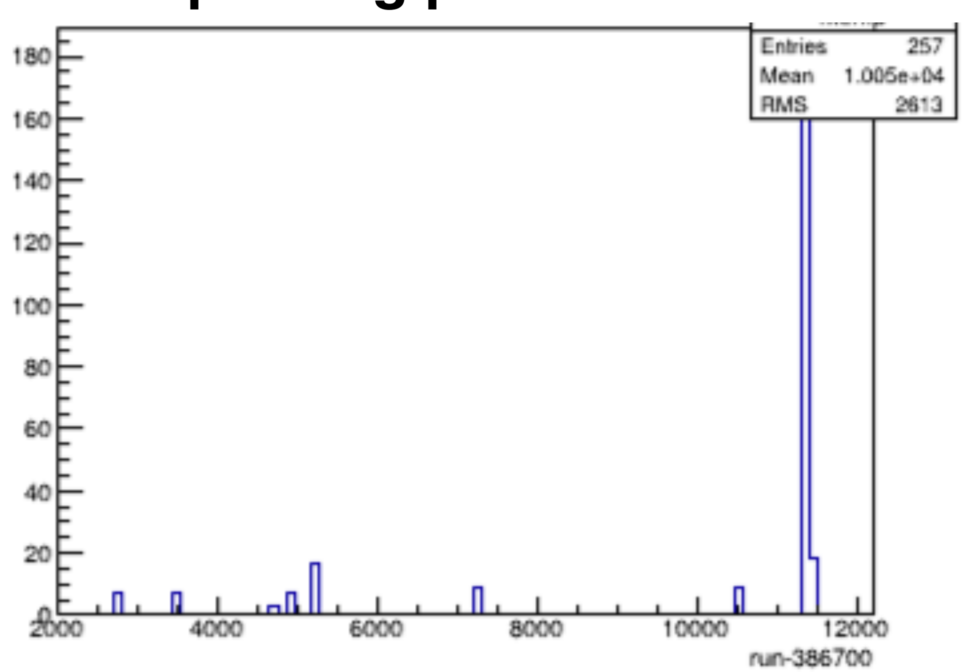
- Empty bunch jumps from crossing 2 to crossing 1 in fill 17209. Remove by requiring fill>17209 (could recover?)

Crossing-Based Cuts

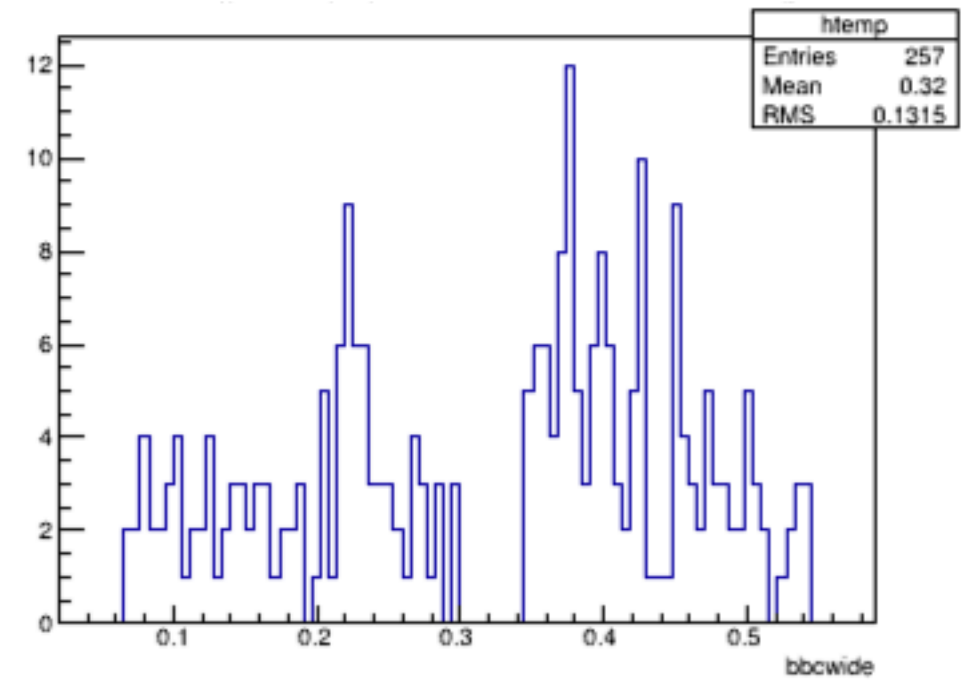
- bbcwide cut removes most of the abort gap (and some other bunches here and there). Remaining abort gap entries suggest high backgrounds throughout run. Remove by explicit veto runlist (33).

Crossing-Based Cuts

number of abort gap bunches passing previous cuts

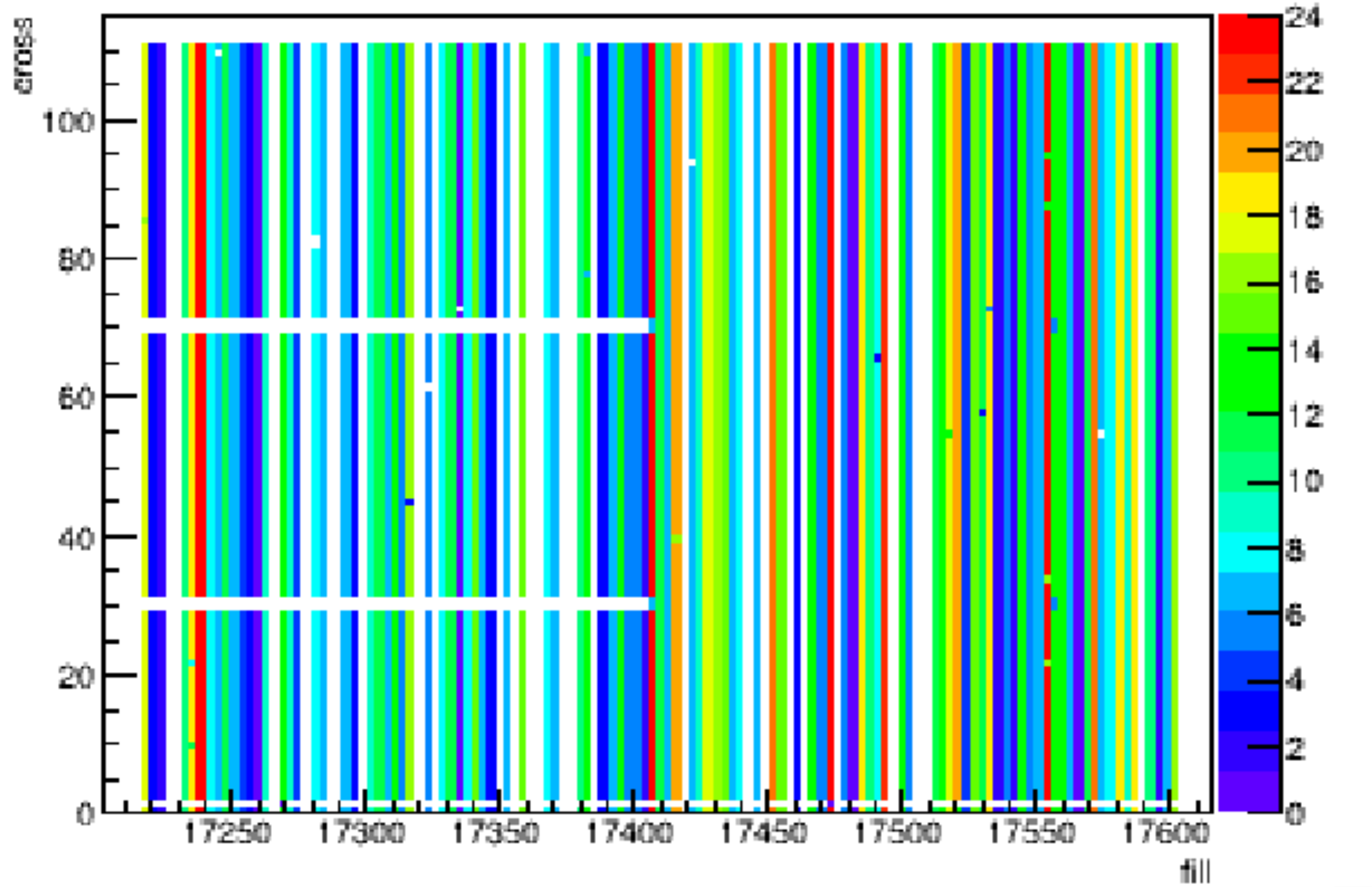


abort gap bbcwide spectrum



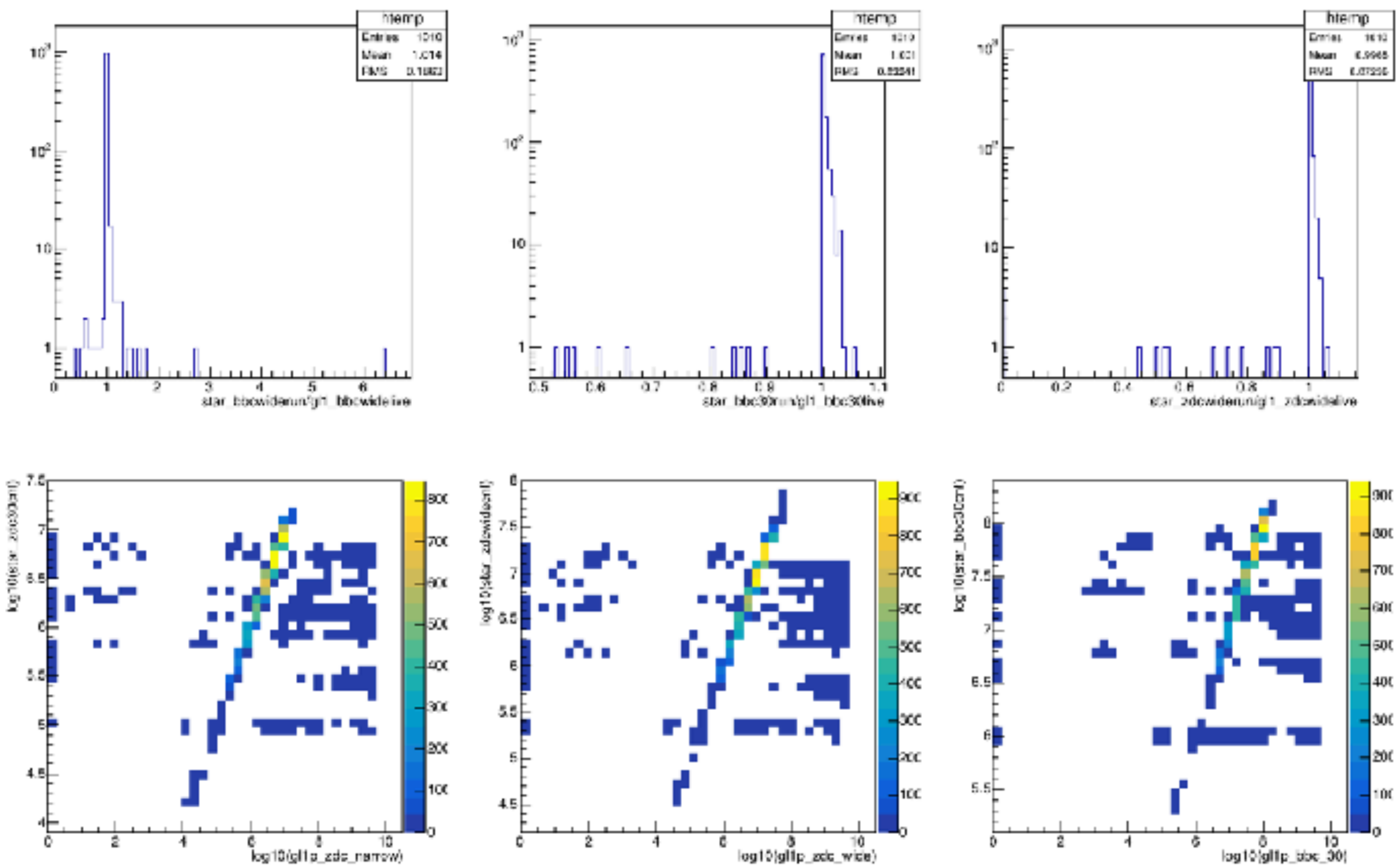
- bbcwide cut removes most of the abort gap (and some other bunches here and there). Remaining abort gap entries suggest high backgrounds throughout run. Remove by explicit veto runlist (33).

After Crossing-Based Cuts



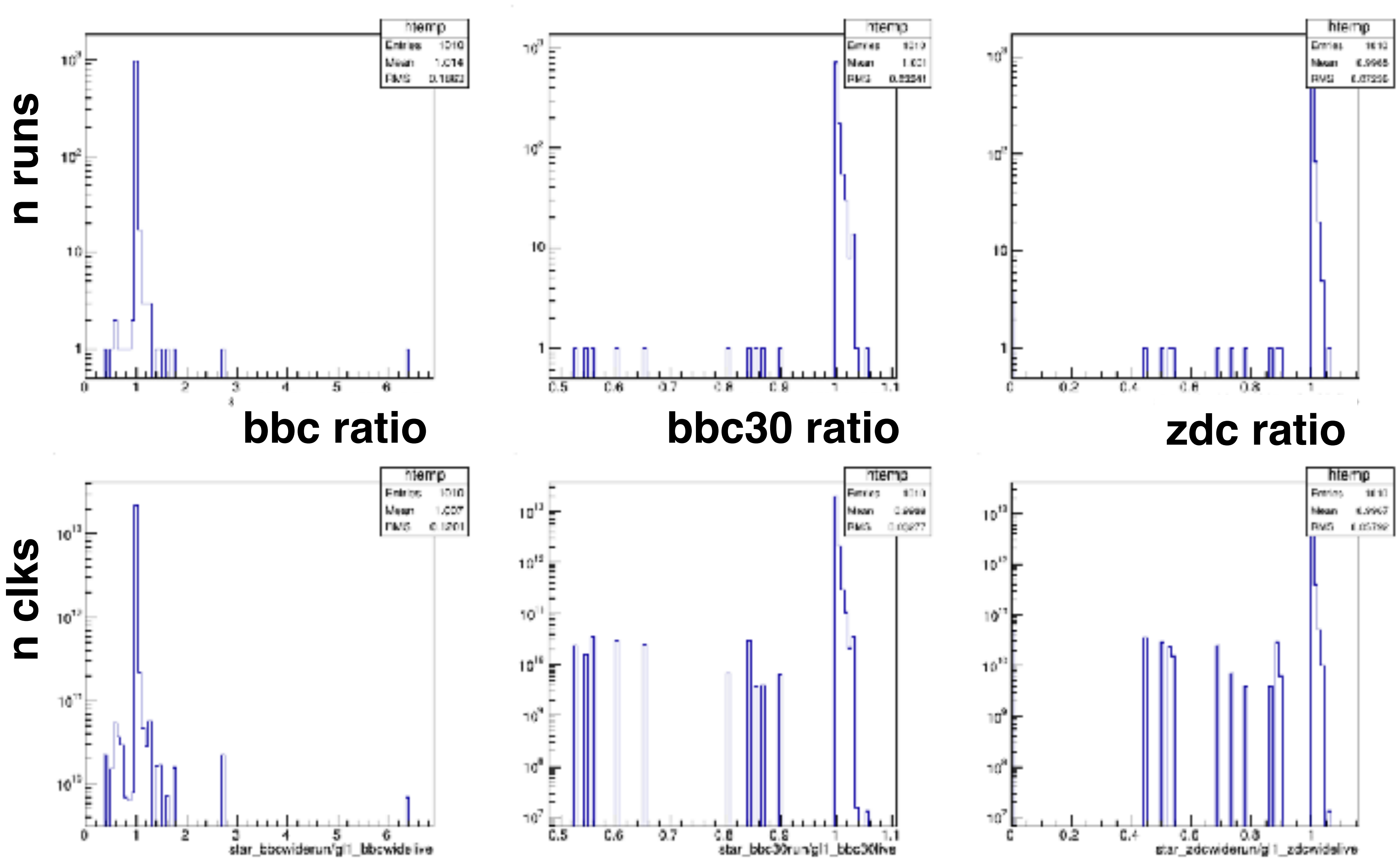
- removed bunches with:
  - xing==1, xing>110, bbcwide<0.05
- remove runs with:
  - fill<17211, fill==17443, run in loud abort gap runlist

Coincidence Scaler Cuts



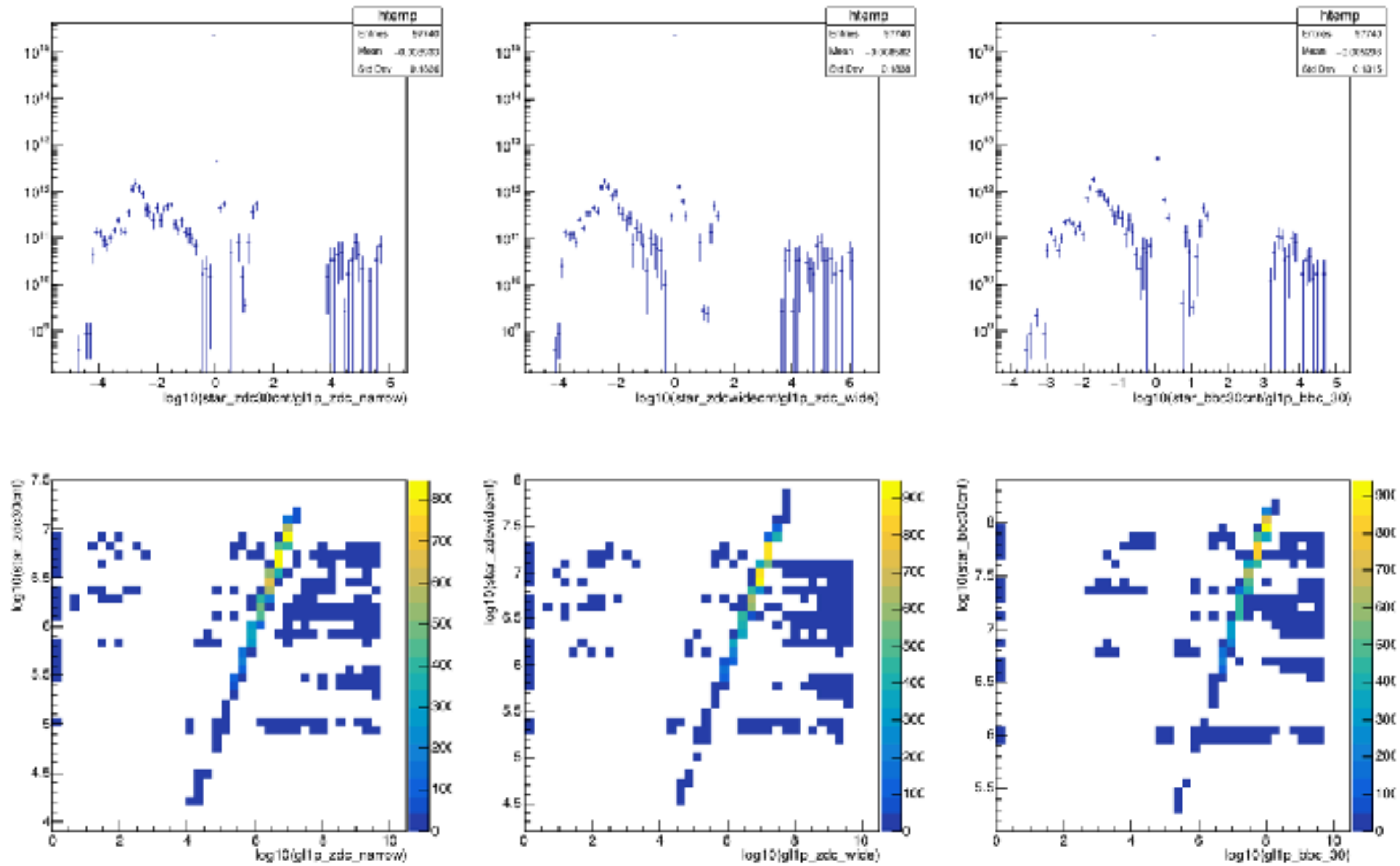
- Run-by-run comparisons of star scalers to gl1 scalers shows some variation
- As does bunch-by-bunch comparison to available gl1p scalers.

Coincidence Scaler Cuts



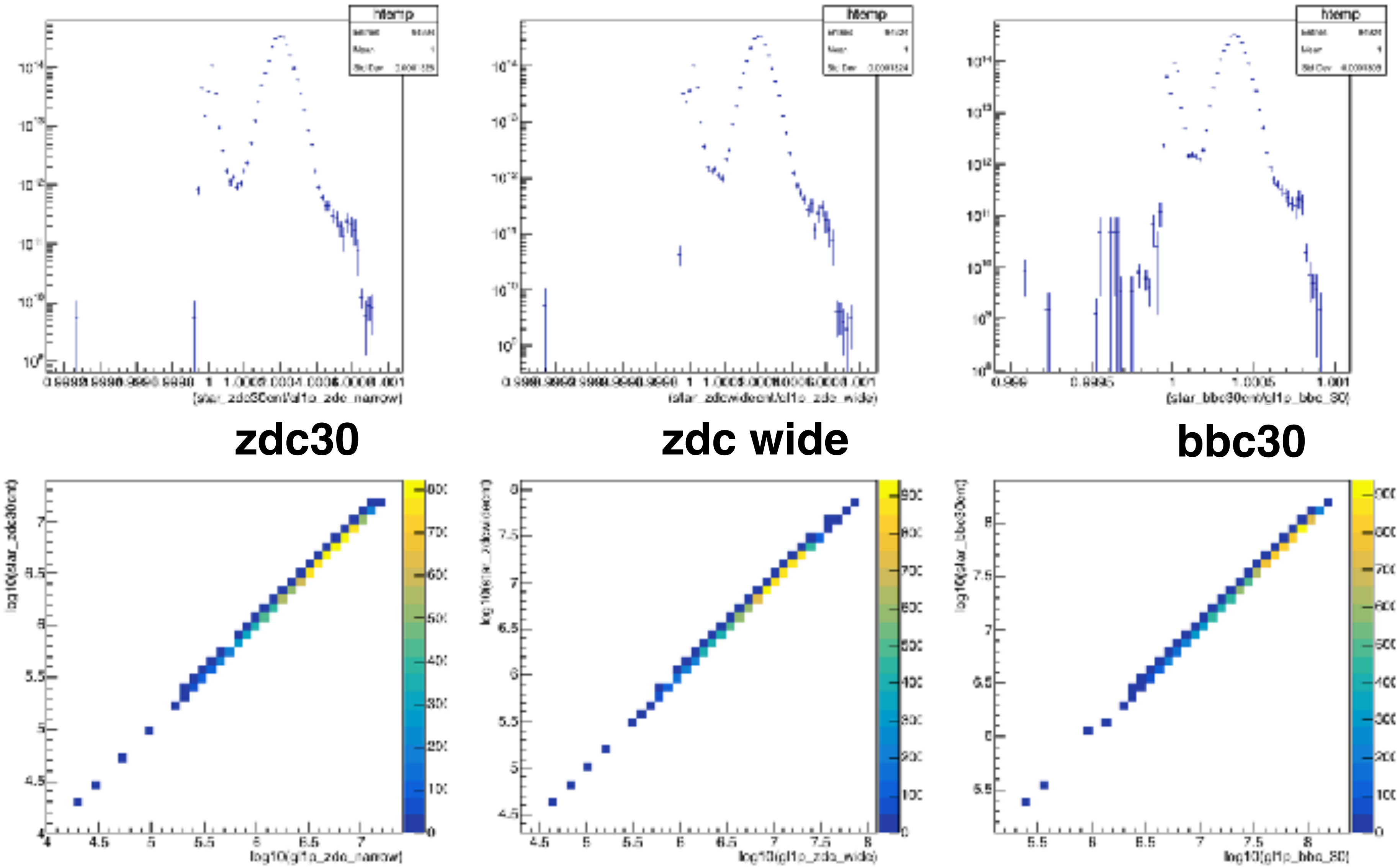
- Remove gl1 to starscaler sums by requiring the ratio between 0.99 and 1.015
- Small fraction of total number of clks.

Coincidence Scaler Cuts



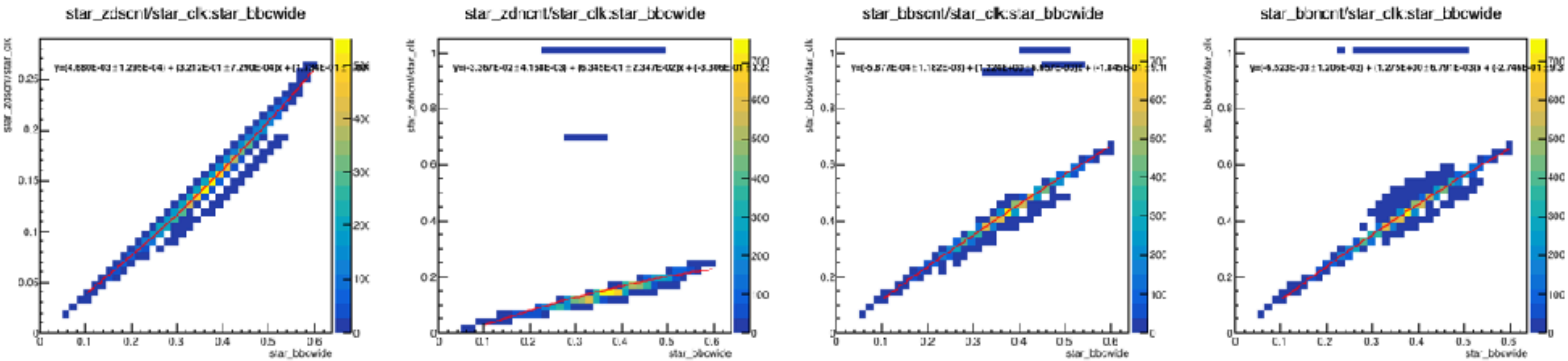
- Apply similar cut on ratio of star scaler to gl1p scalers: star/gl1=1.0±0.001
- very narrow peak with little noise nearby

After Coincidence Scaler Cuts



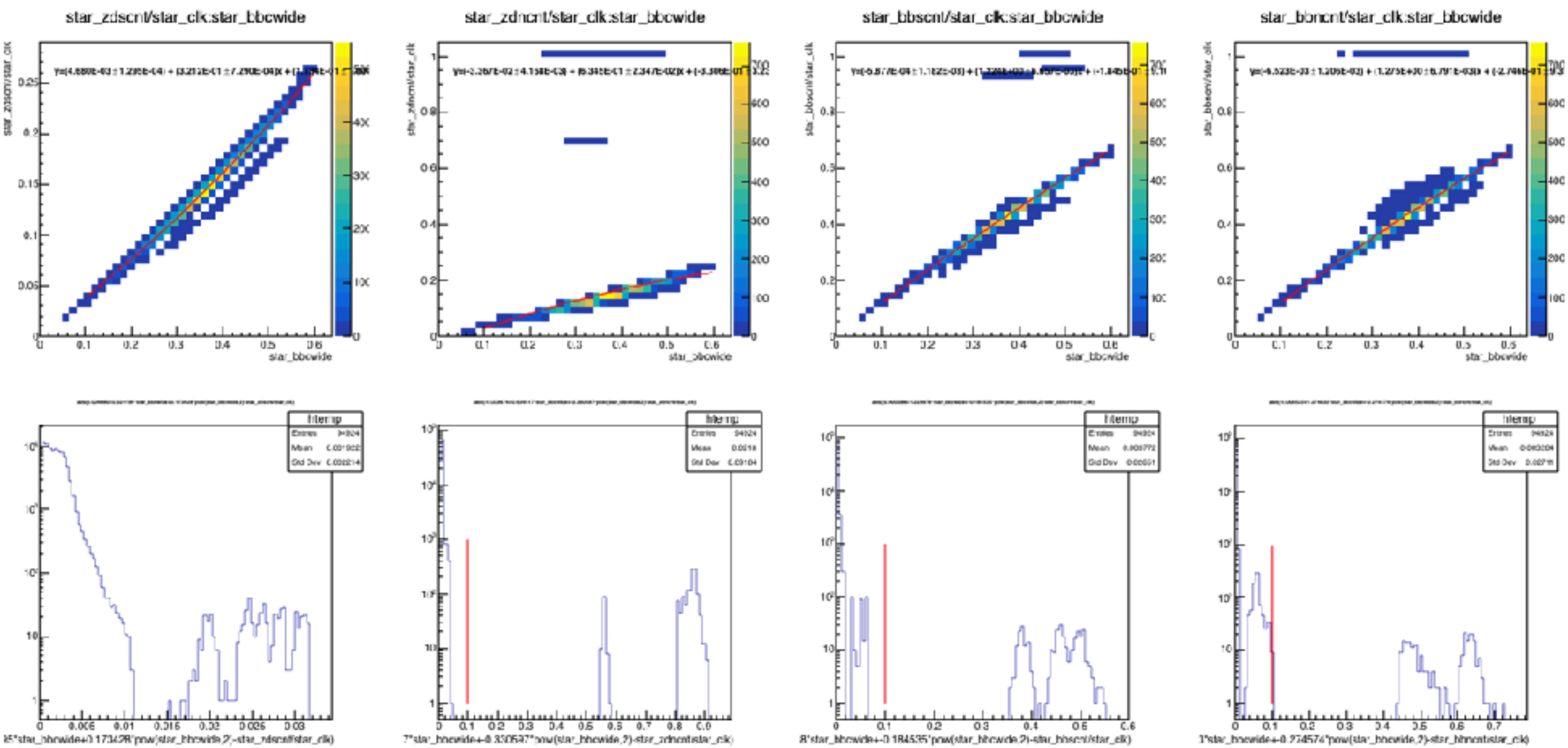
- removed bunches with:
  - abs(star/gl1p-1)>0.001
- remove runs with:
  - star/gl1>1.015, star/gl1<0.99

Singles Scaler Cuts



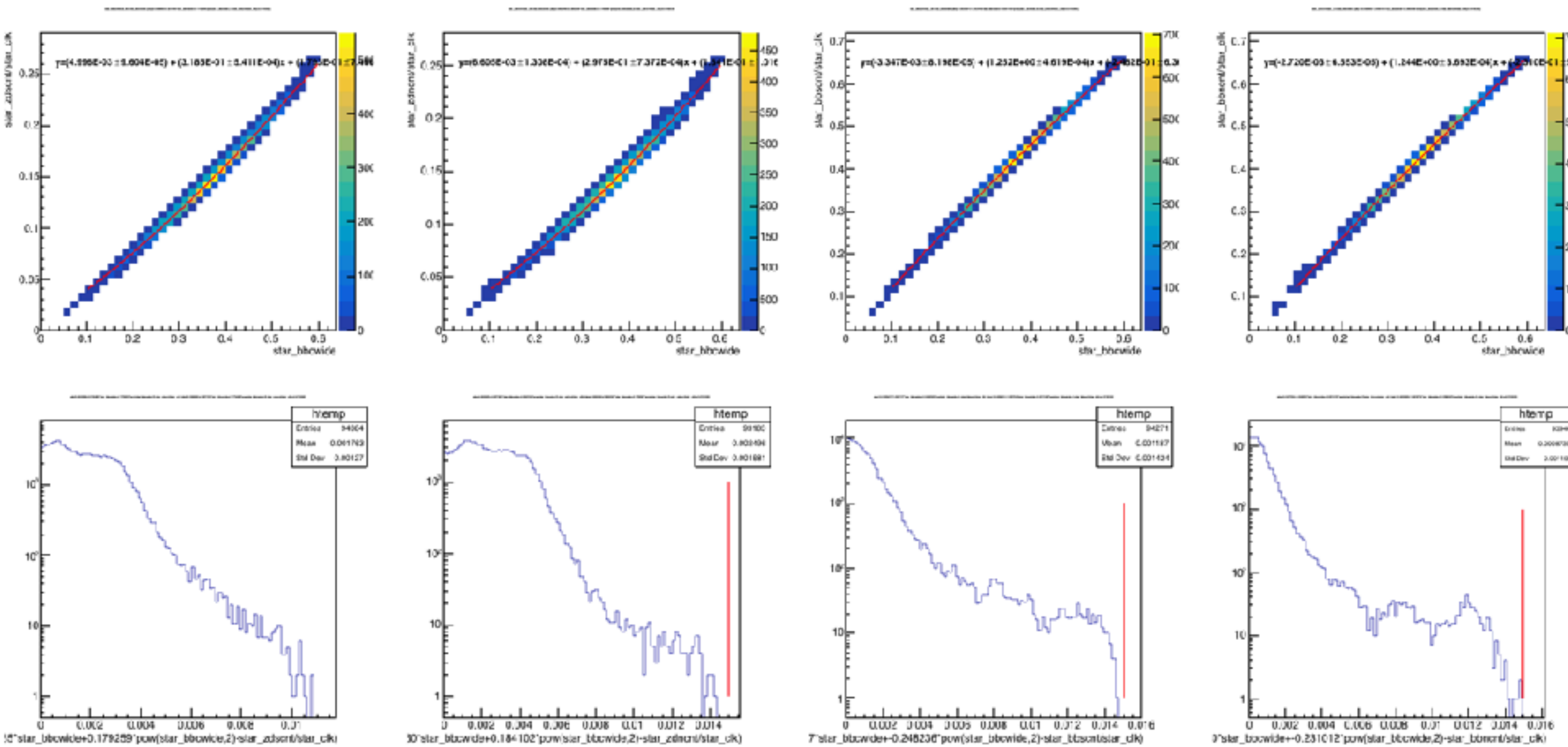
- Subtler outliers in singles identified by rate far from the trend line (both quiet and noisy) suggest monitor may not be reliable there

Singles Scaler Cuts



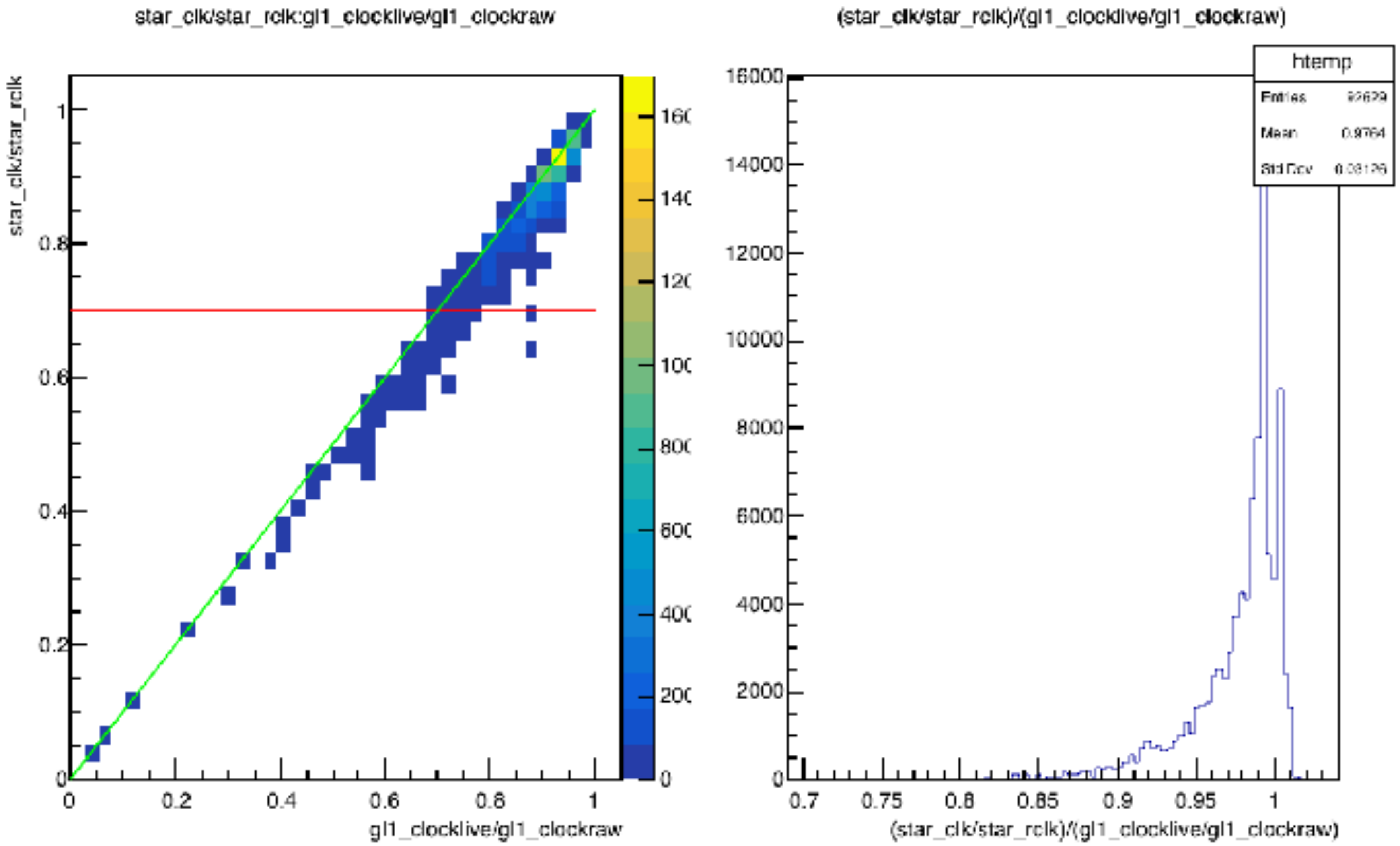
- Fit with 2nd order polynomial. First pass remove outliers abs(star_singlerate-trendline(bbcrate))>0.1

After Singles Scaler Cuts



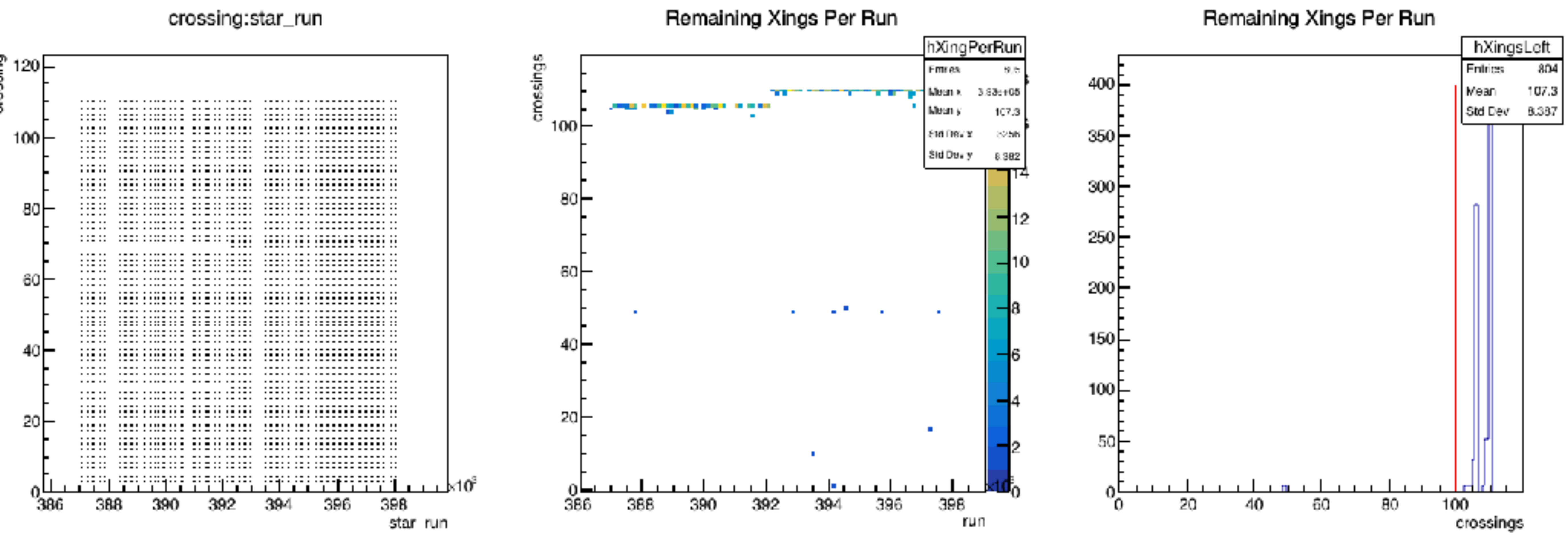
- Stable at 3rd pass. Remove outliers abs(star_singlerate-trendline(bbcrate))>0.015

Singles Scaler Cuts



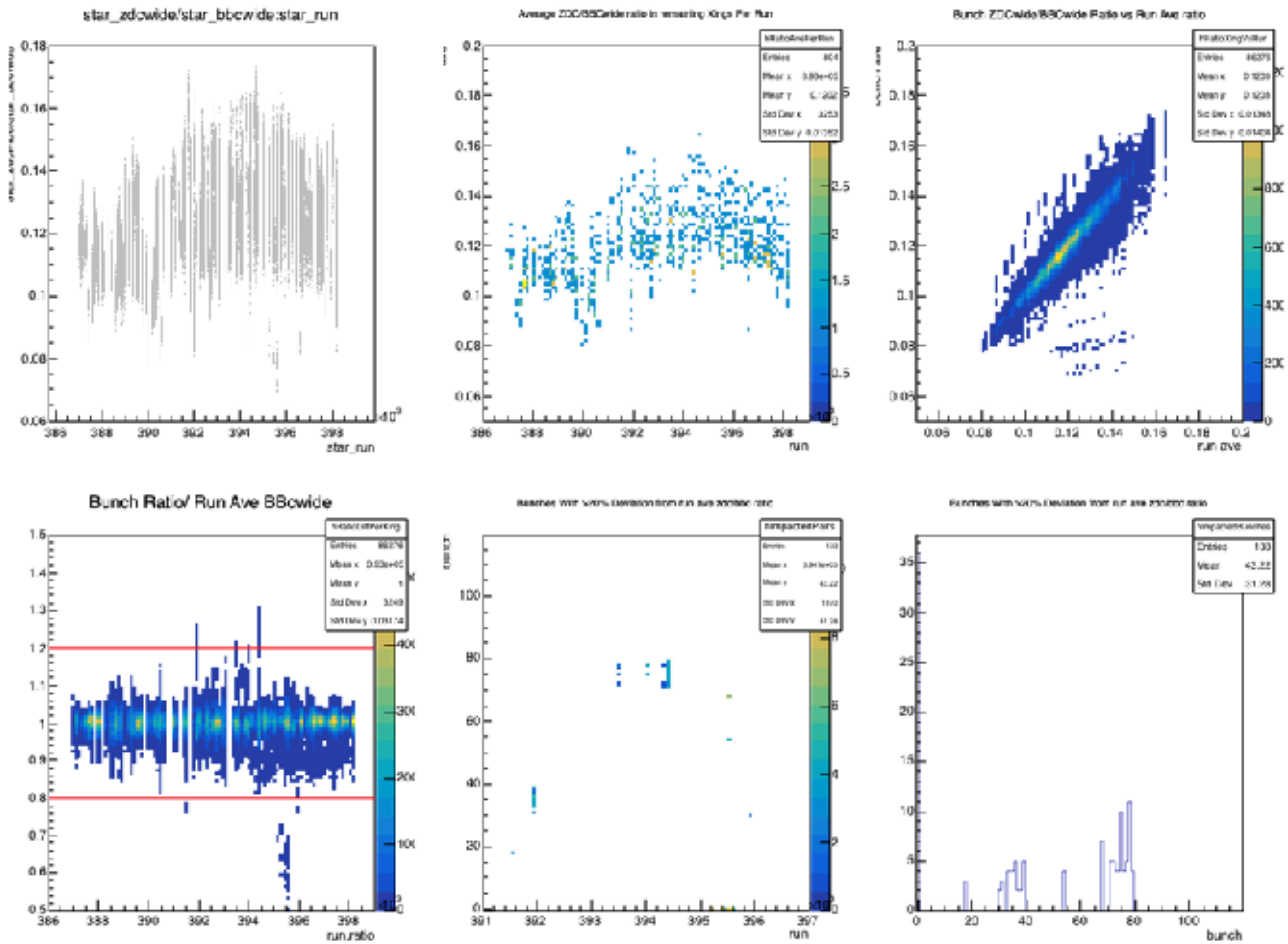
- Remove runs with significant deadtime in star scalers (require star_livetime>0.70)

Tatters Cuts



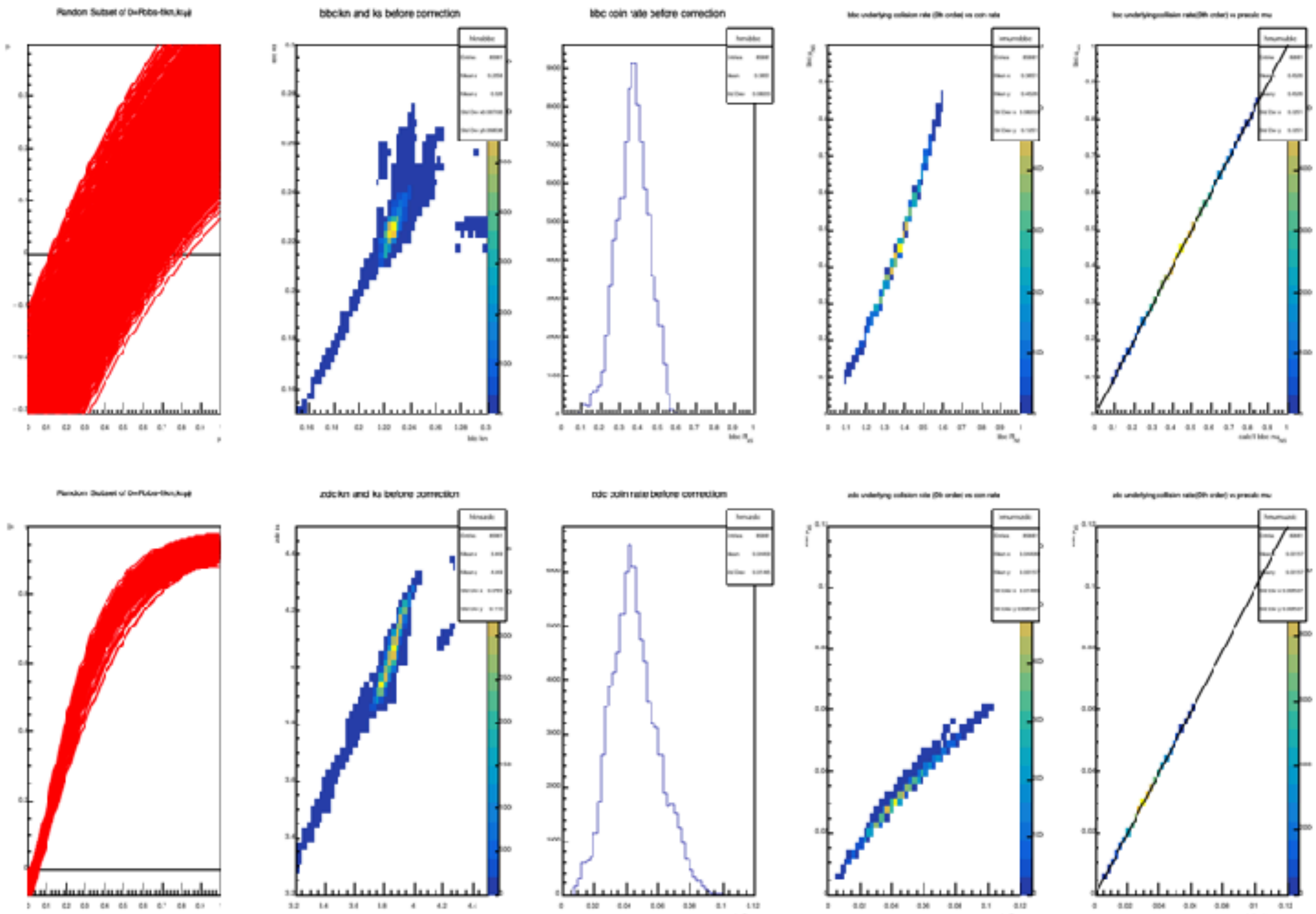
- A few runs are hard-hit by these cuts. They likely have issues, so just remove them. (require n_bunches>100) (10 runs lost)

One more Coin cut



- Compare the zdc/bbc ratio per bunch to the run average, remove outliers. (require abs(ratio/ave-1)<0.2) (~140 crossings)

Rate correction



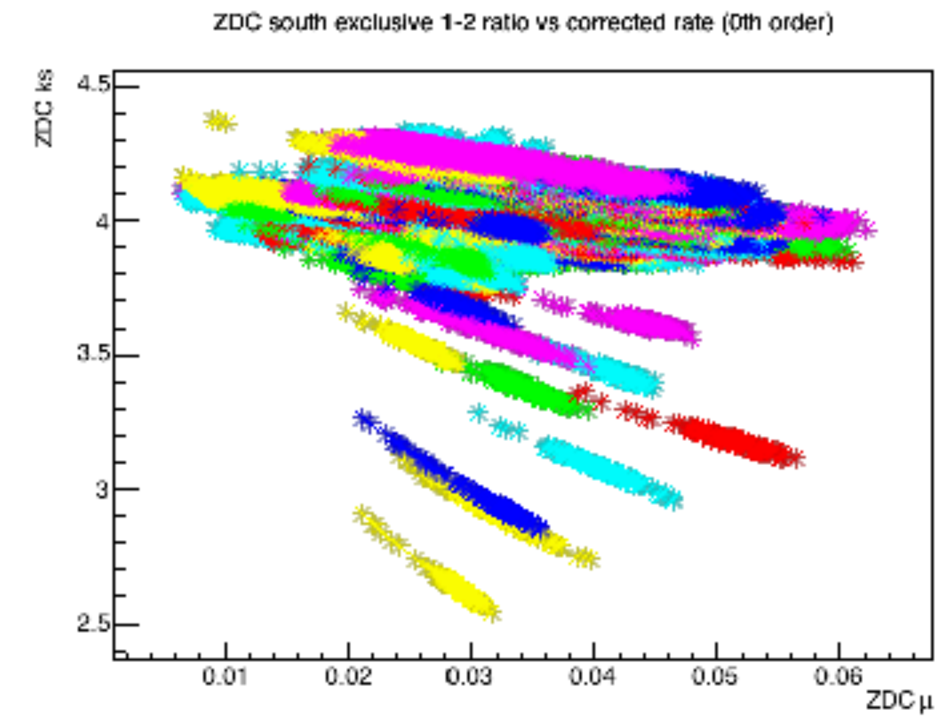
- Performed rate correction per lumi paper -- two different methods, same result.

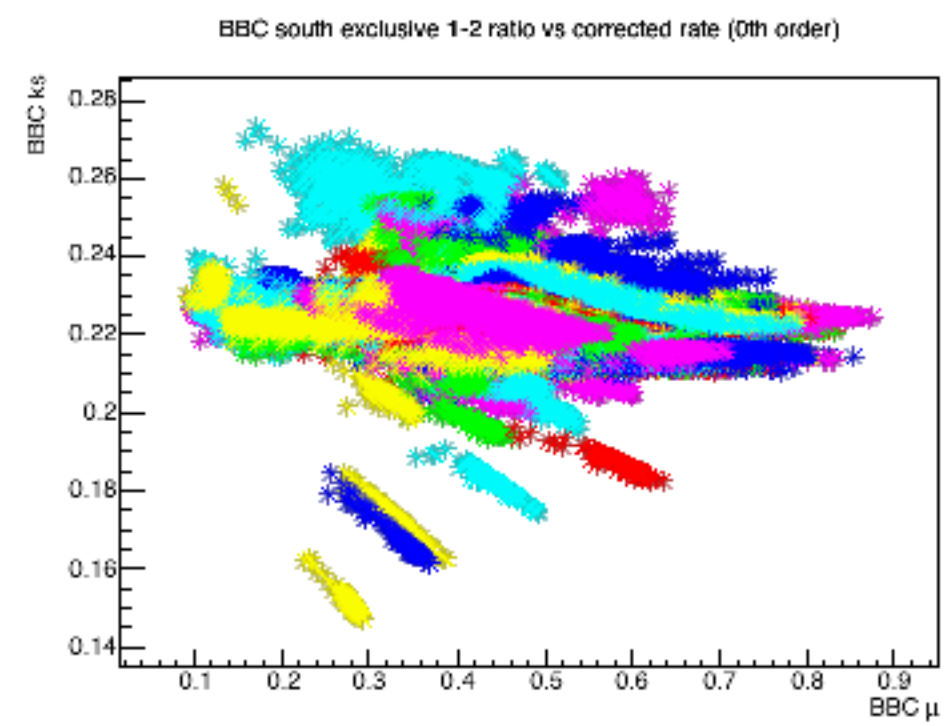
Nonlinearity Correction

- You probably know this, but rate correction only holds if kn is the constant representing the ratio of fundamental probabilities between singles and doubles.

$$\text{Let's assume}\mu_{N,meas} = \epsilon_N(1 + A\mu)\mu$$
$$hence\mu_{N,meas} = \epsilon_N/\epsilon_{NS}(1 + A\mu)\mu_{NS}$$
$$\text{since we can insist that one of them is constant,}$$
$$\text{and move the dependence into theother.}$$
$$\text{then } k_{N,meas} = epsilon_N/\epsilon_{NS}(1 + A\mu) - 1$$
$$k_{N,meas} = epsilon_N/\epsilon_{NS}(1 + A\mu) - \epsilon_{NS}/\epsilon_{NS}$$
$$k_{N,meas} = (epsilon_N(1 + A\mu) - \epsilon_{NS})/\epsilon_{NS}$$
$$k_{N,meas} = k_{N,true} + A\mu/\epsilon_{NS}$$
$$\text{and without loss of generality}$$
$$k_{N,meas} = k_{N,true} + B\mu_{NS}$$

- Try to fit this fill-by-fill to iteratively extract the residual rate dependence to get better estimates of true kn,ks and hence true bunch lumi

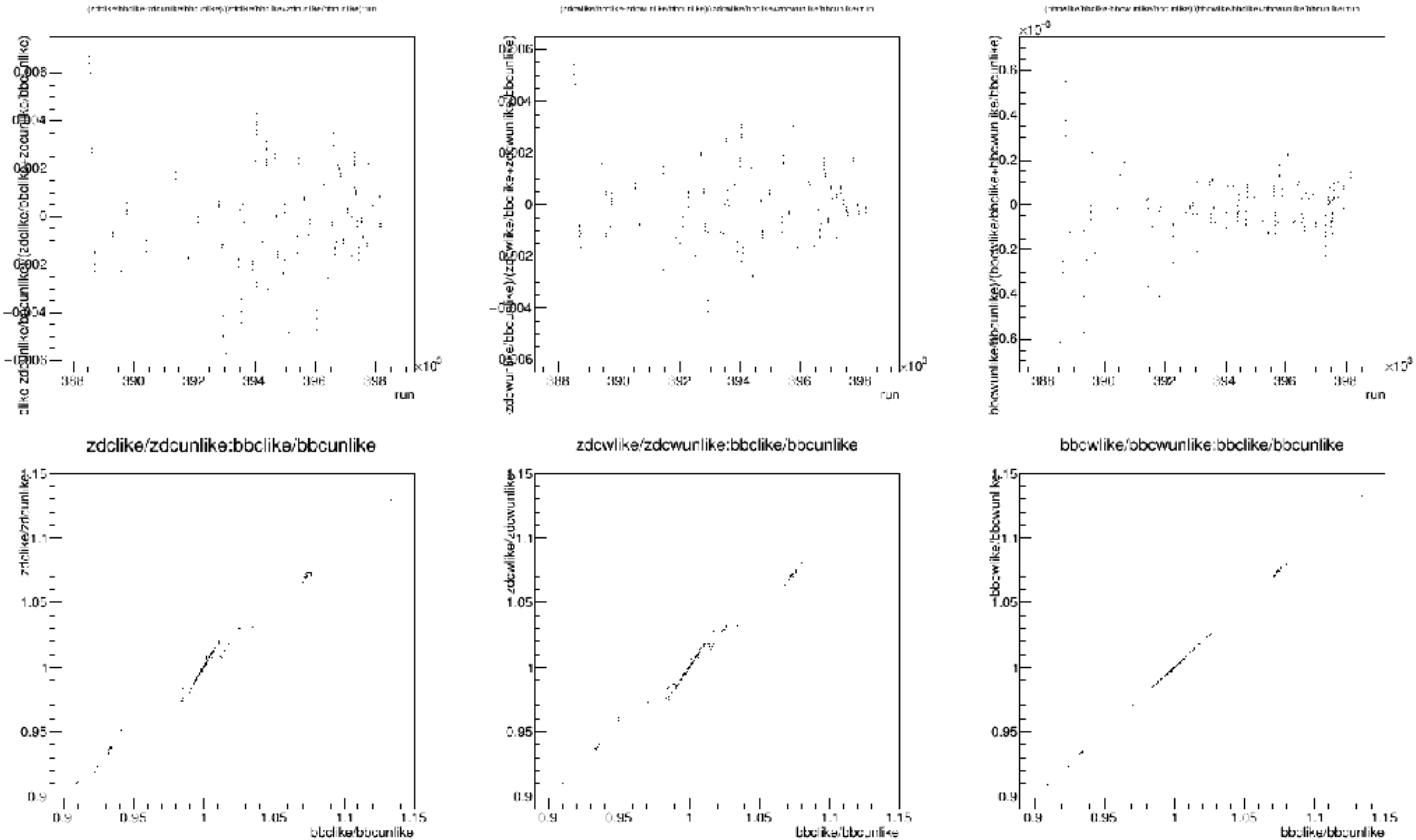




Status

- Dug deep into scaler behaviors
- Applied rate and first-pass noise corrections to remaining bunches (currently not converging right)
- Working on the bunch-shuffling analysis with these cuts.

Lumi Asyms vs Run



MPC Cluster Data

- Expected to be predominantly π^0.
- Cluster pulse shape analysis to distinguish photons from two non-photonic signal types.

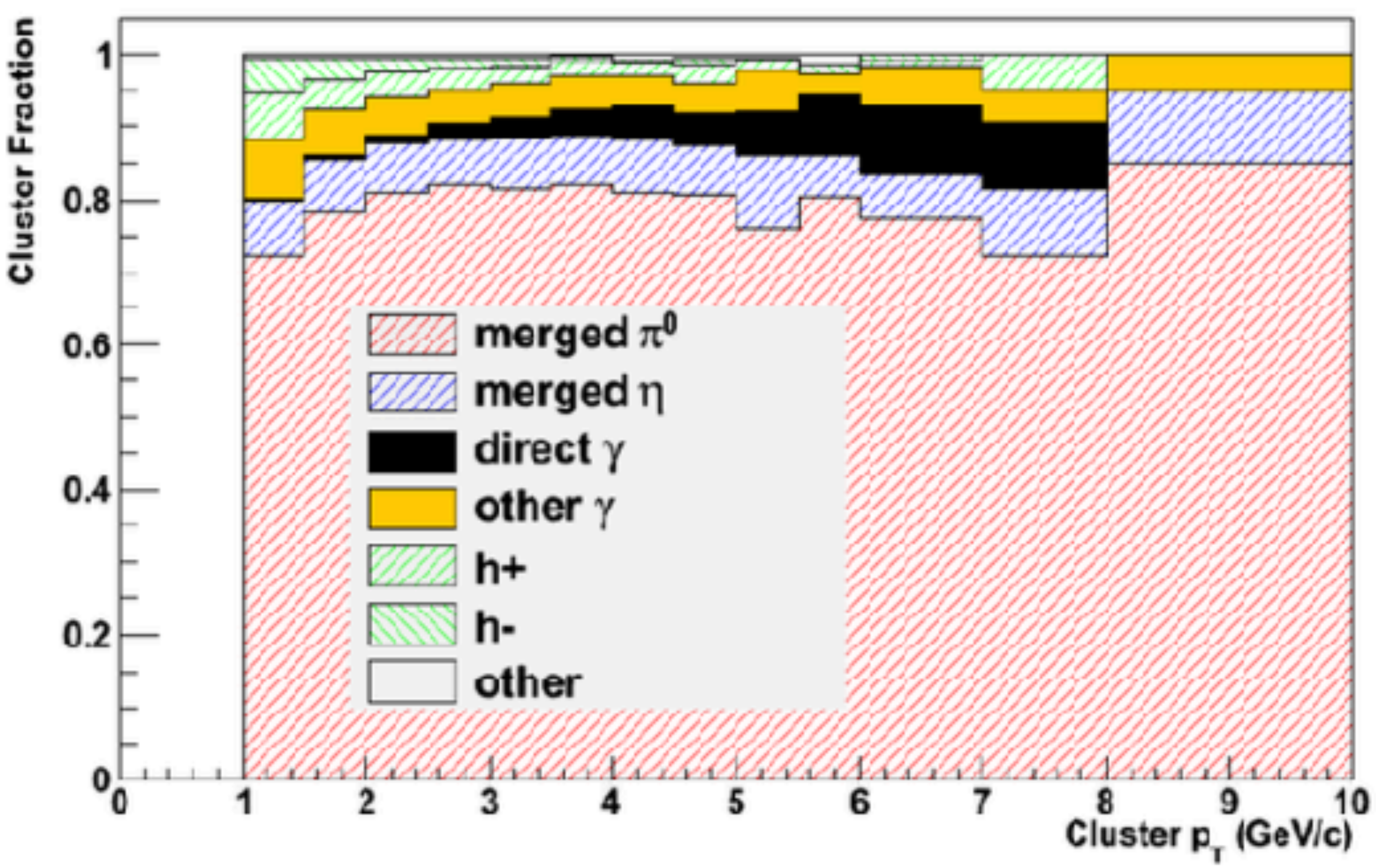
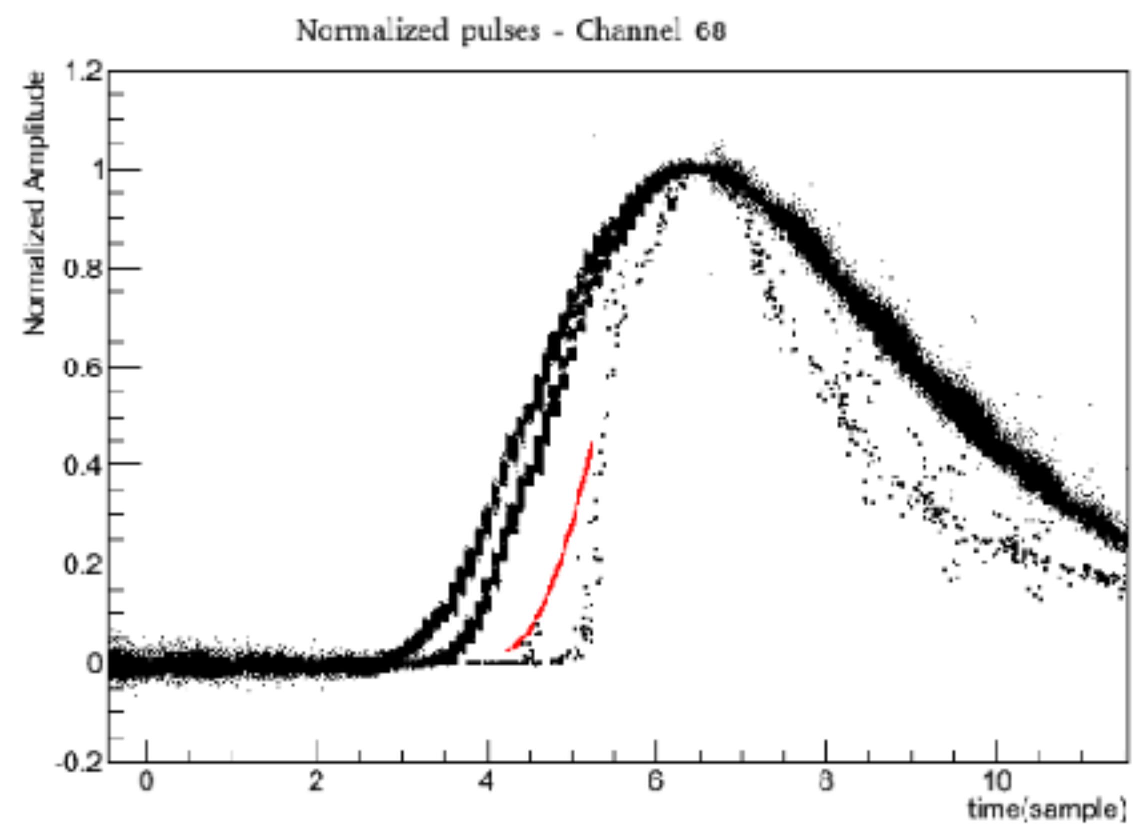


Figure 8.1: Cluster decomposition from PYTHIA and GEANT at $\sqrt{s} = 500$ GeV [54].



Bootstrapping

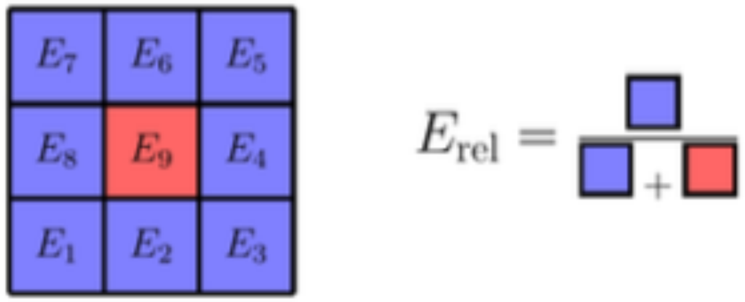


Figure 5.5: Ratio E8/E9.

Pulse type	Energy Range	E8/E9 range
Photons	$\geq$ 50 ADC	$\geq$ 0.05
NP1	$\geq$ 300	$\leq$ 0.05
NP2	$\geq$ 300	$\leq$ 0.05

Table 5.1: Initial set of cuts for each pulse type.

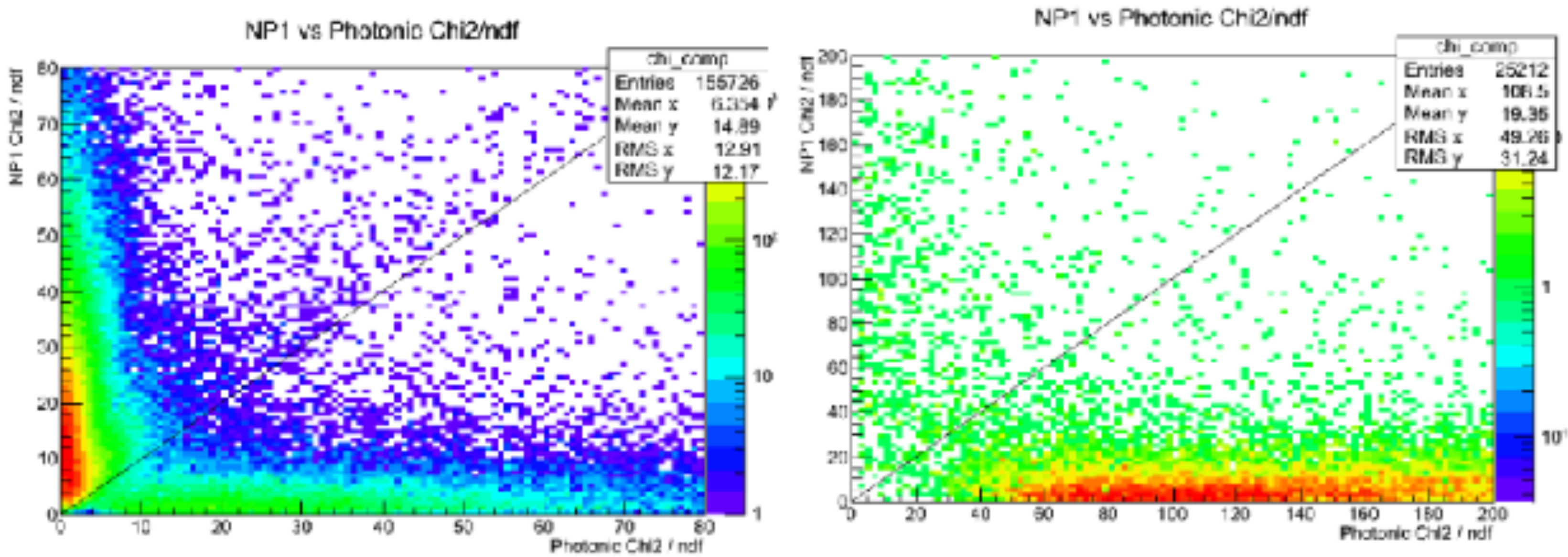
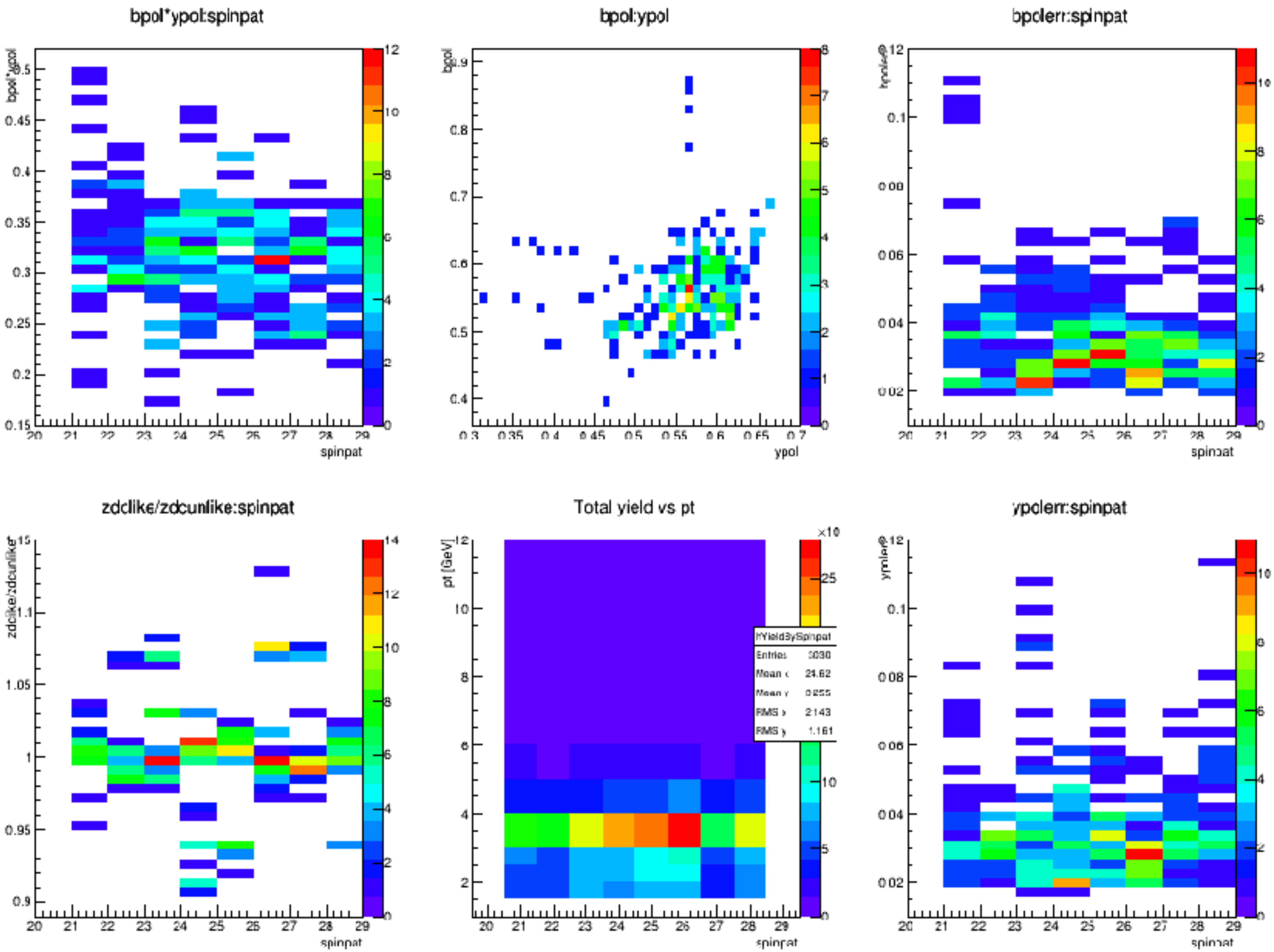


Figure 5.7: Left shows the result of χ^2/dof when fitting pulses in the photon sample to both the photon and the NP1 shape. Right shows the same plot for pulses in the NP1 sample. In both of these plots we see that; despite most of the pulses have a good fit value when fitting to their intended pulse shape, a fraction of them also have good values when fitting them to the opposite shape.

- From initial cuts, remove events from each category if they have low chi2 when fitting using the template of the other set.
- Iterate this procedure to refine the template. Use chi2 as a discriminate between samples.

Polarization Checks



Luminosity Asym Cross-checks

zdc narrow | zdc wide | bbc nocut

Asym

vs bbc_vtx rel

/ bbc_vtx rel