Sky-subtraction metrics

And how to make skyCorr LSB-compliant

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Motivation

- Preservation of low-surface-brightness flux in LSST images
- Need one version of the coadd to contain this flux
- Typical point of failure for LSB: sky-subtraction
  - Need a sky-subtraction algorithm that preserves LSB flux, which can run at-scale

Quantifying over-subtraction

- For LSB, "sky" means sky: transient telluric emission
  - Galactic cirrus, diffuse starlight, etc. are all LSB science targets
  - (Reflections, ghosts, ghoulies, etc. probably best targeted separately)
- A sky model which includes flux from science targets is not LSB-compliant
- Can test LSB-compliance via source-injection
  - If LSB-compliant, a sky model should be independent of source density, distribution, luminosity, etc.
  - In other words, sky-subtraction should not impact injected models
  - And injected models should not impact derived sky model

Testing strategy

- Examined viability of existing skyCorr task
- This consists three sub-tasks (applied to masked images with calexpBackgrounds restored)
  - bgModel
    - 7024 x 7024 px superpixel model of full focal plane
  - doSky
    - Scale and subtract sky frames
  - bgModel2
    - 256 x 256 px superpixel model of sky-subtracted background
- Isolated impact of each step by running skyCorr with different settings, to see if skyCorr could be LSB-compliant

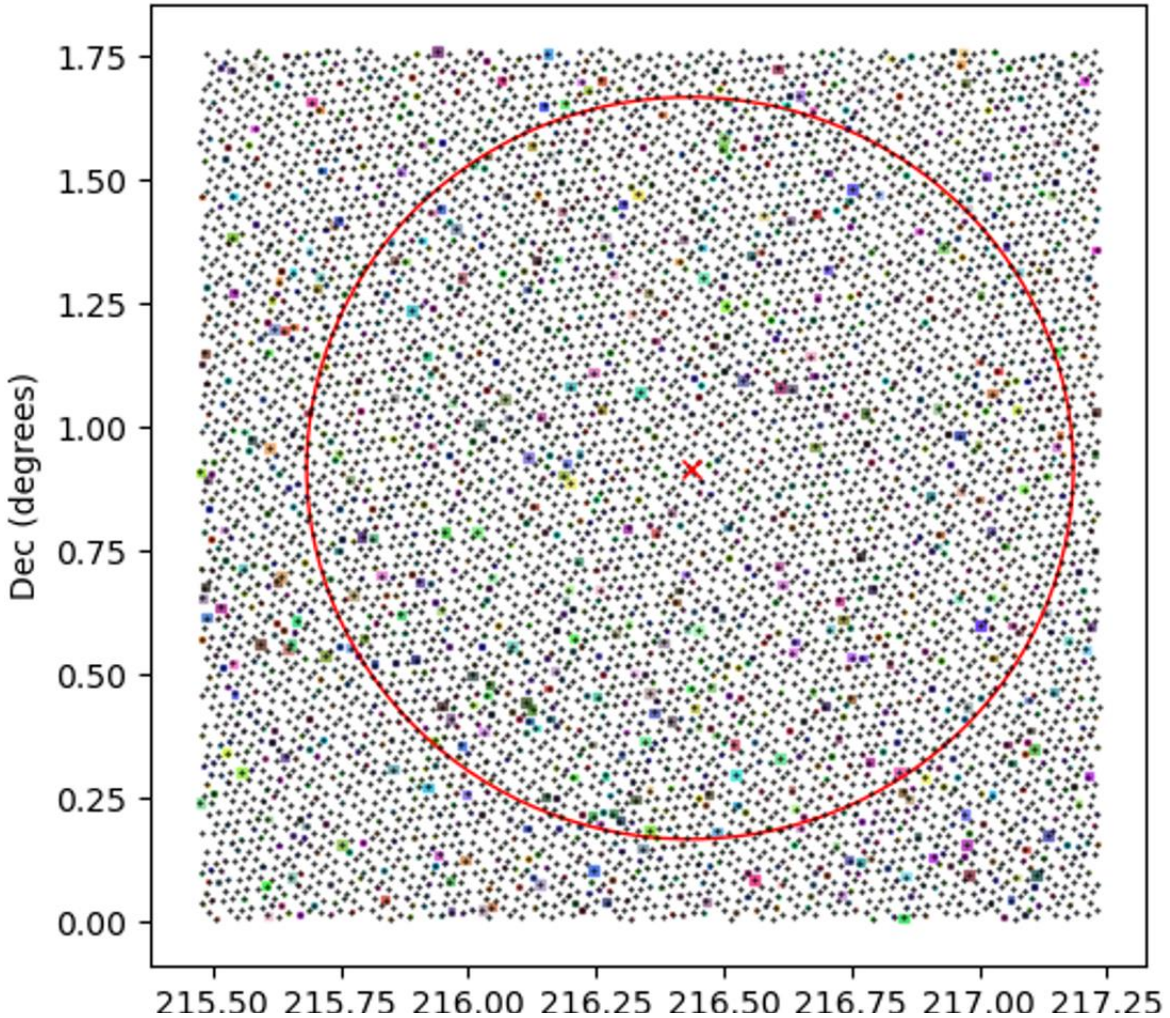
Experimental setup

Name	`skyCorr` tasks	Bin size	Interpolation
bgModel2-1	`bgModel`, `doSky`, `bgModel2`	1.92 (128px)	Akima
default	`bgModel`, `doSky`, `bgModel2`	3.84 (256px)	Akima
bgModel2-2	`bgModel`, `doSky`, `bgModel2`	7.68 (512px)	Akima
bgModel2-3	`bgModel`, `doSky`, `bgModel2`	15.36 (1024px)	Akima
linear	`bgModel`, `doSky`, `bgModel2`	3.84 (256px)	Linear
noBgModel2	`bgModel`, `doSky`	–	–
noDoSky	`bgModel`	–	–
onlyBgModel2	`bgModel`, `bgModel2`	3.84 (256px)	Akima

- Eight tests, primarily varying superpixel ("bin") size in bgModel2
- Also turning off bgModel2, plus miscellaneous tests

Source injection

- Grid of Sérsic models, quasi-randomly distributed (right)
- Injected into single visit (here, 26060, Tract 9615; red circle)
- Run skyCorr (w/specific parameters) on that visit twice:
  - With models injected
  - Without models injected
- Compare impact of skyCorr on models/vice-versa



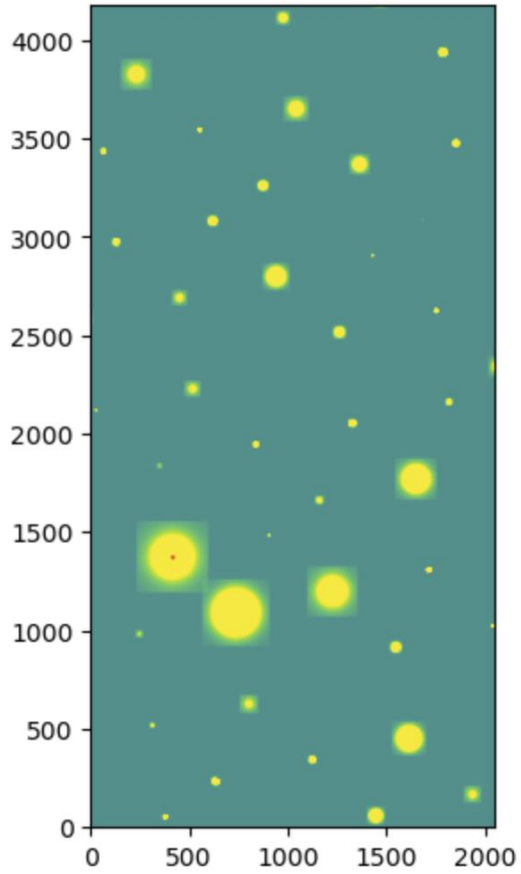
Metric 1: impact of skyCorr on models

- Pre-SS (left panel):
  - injected_calexp – calexp
- Post-SS (right panel):
  - (injected_calexp – injected_skyCorr)

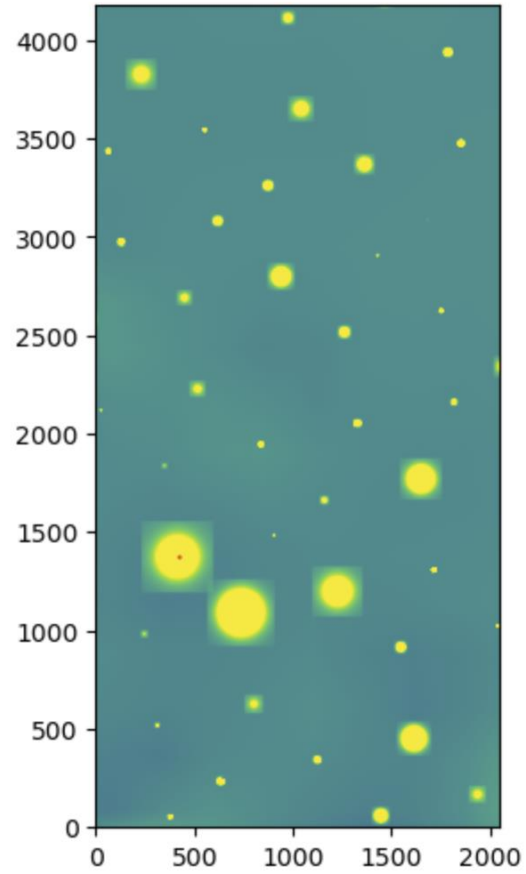
    -

    (calexp – skyCorr)

    = models + ΔskyCorr
- Compare radial surface brightness profiles of all models in both images



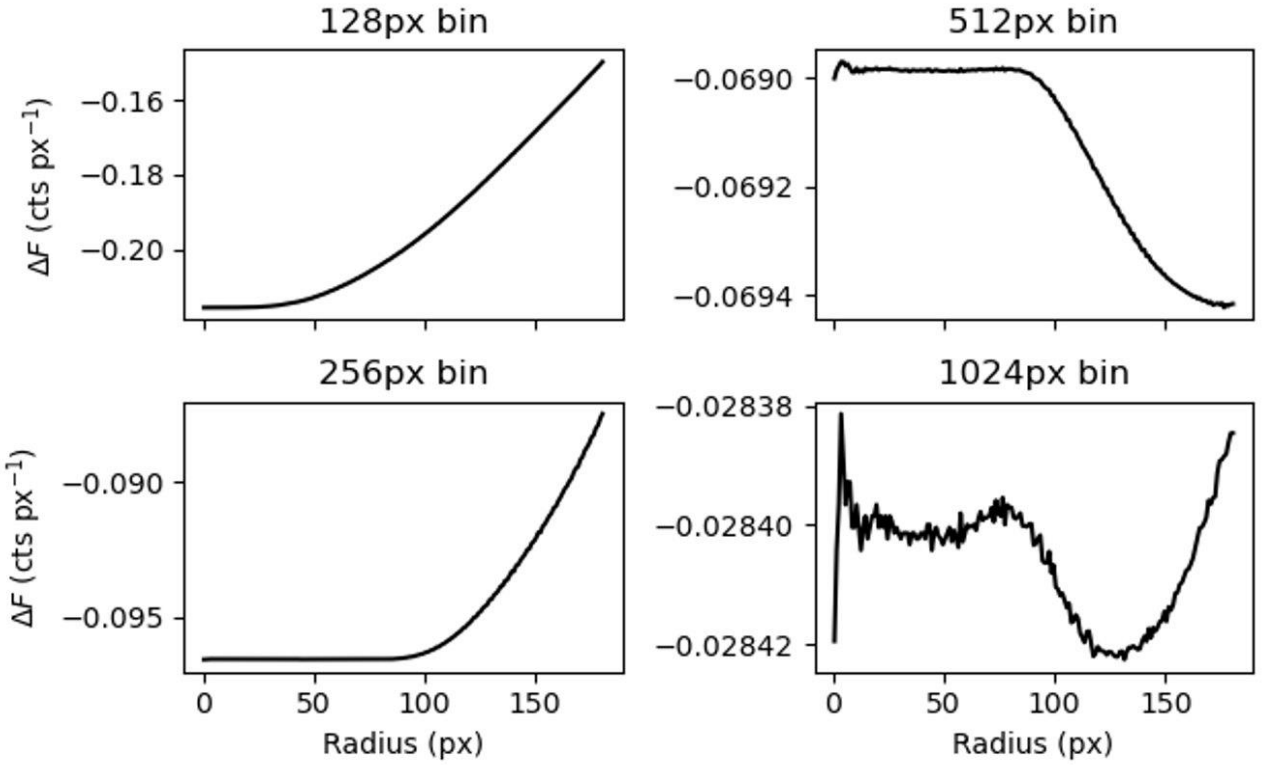
Isolated models



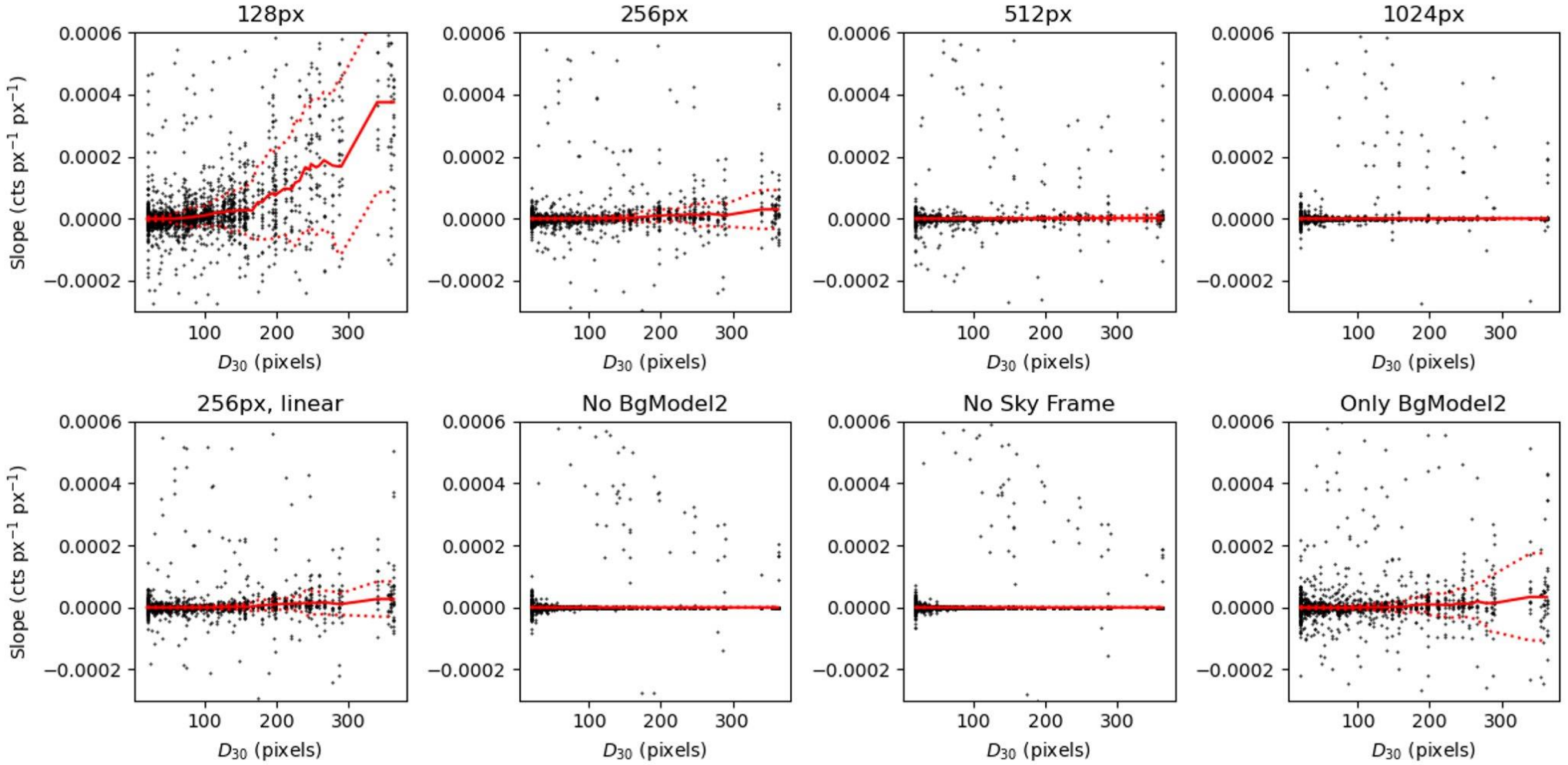
Isolated models + ΔskyCorr

Metric 1 (cont.)

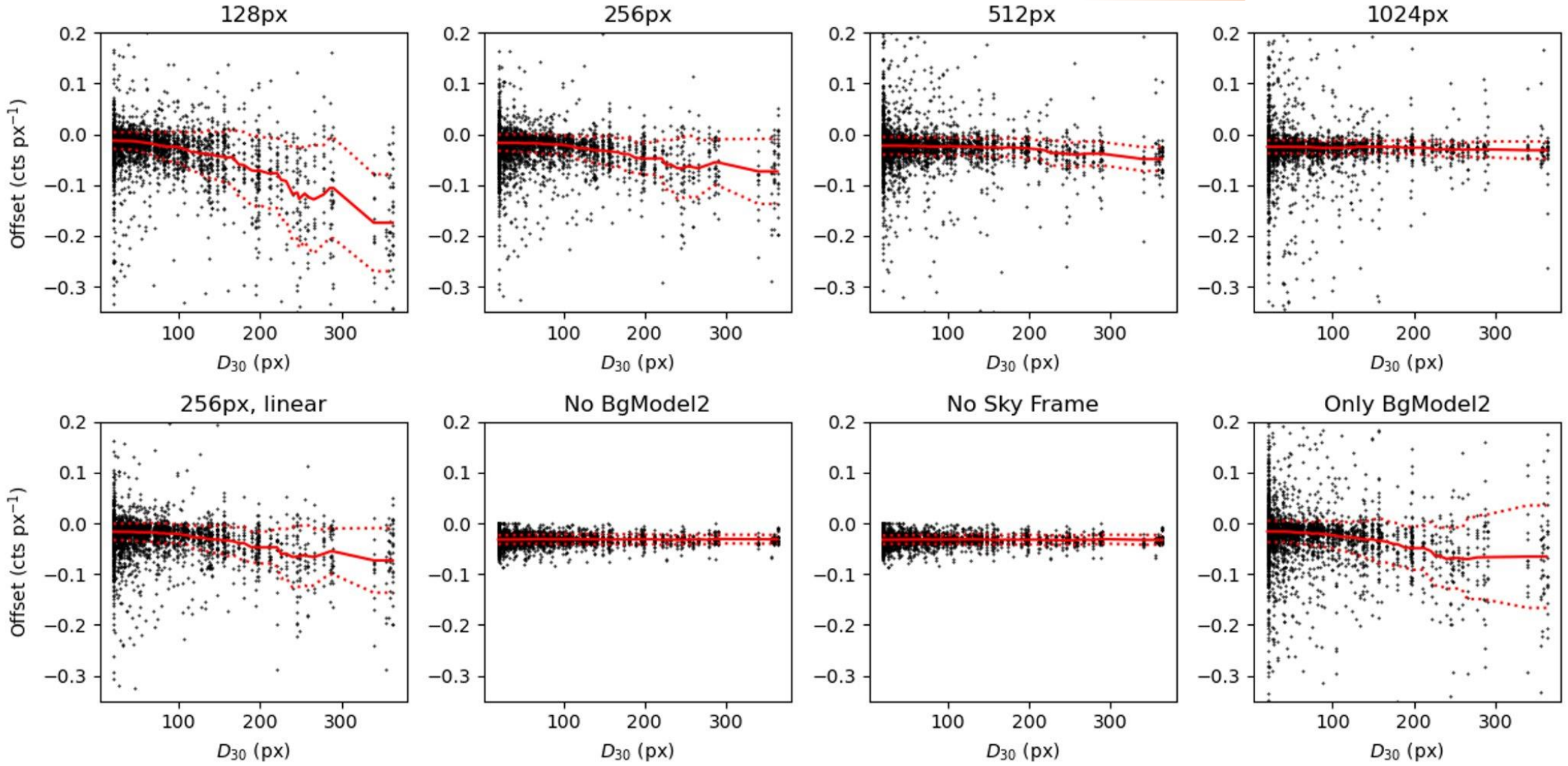
- Right: difference between post-SS and pre-SS surface brightness profile of one model
  - Linear units
- Four bgModel2 bin sizes
  - Small bin, noticeable slope in difference profile
  - Values always < 0
- Two metrics: slope & offset



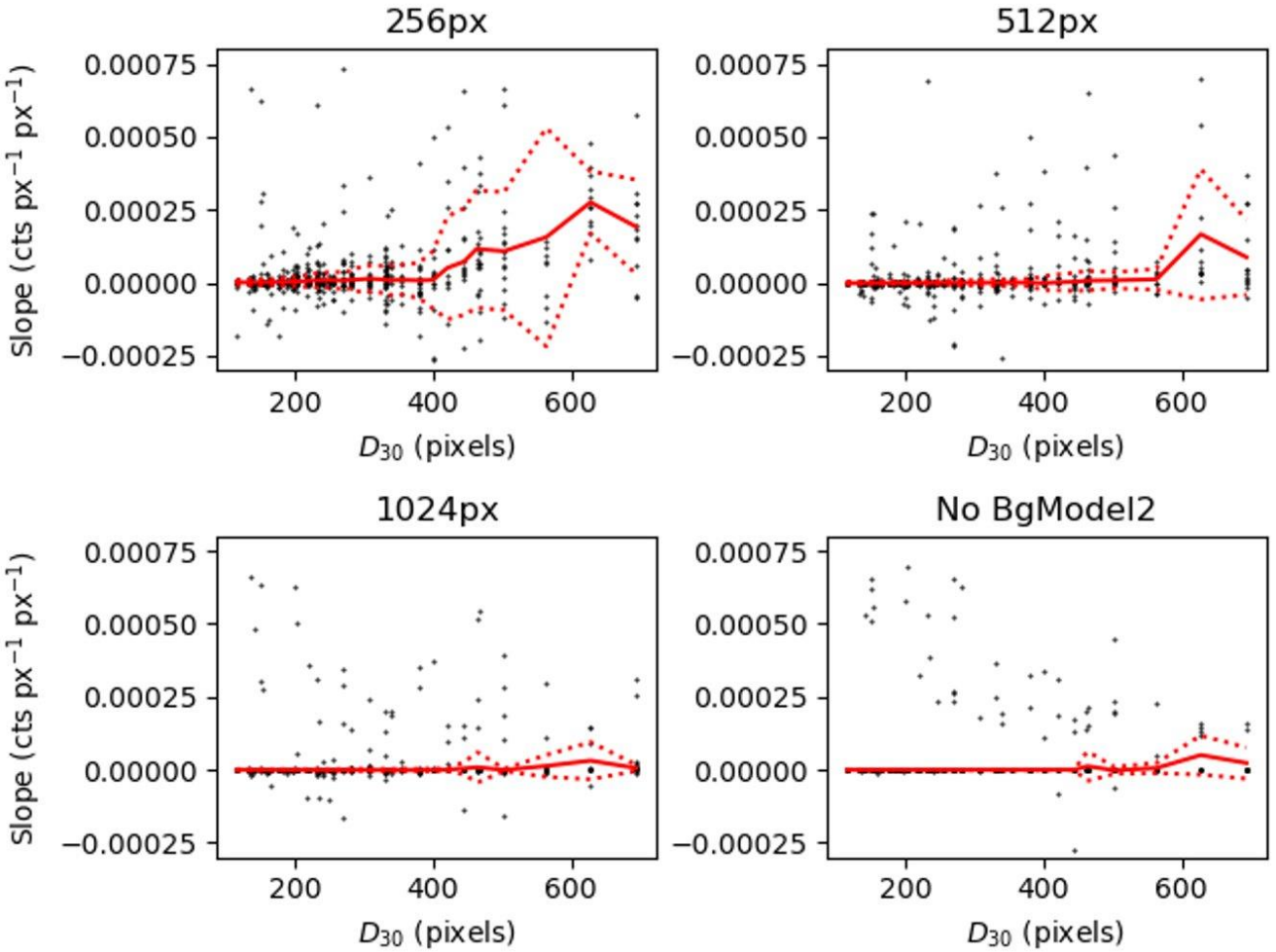
Results: slope (local impact)



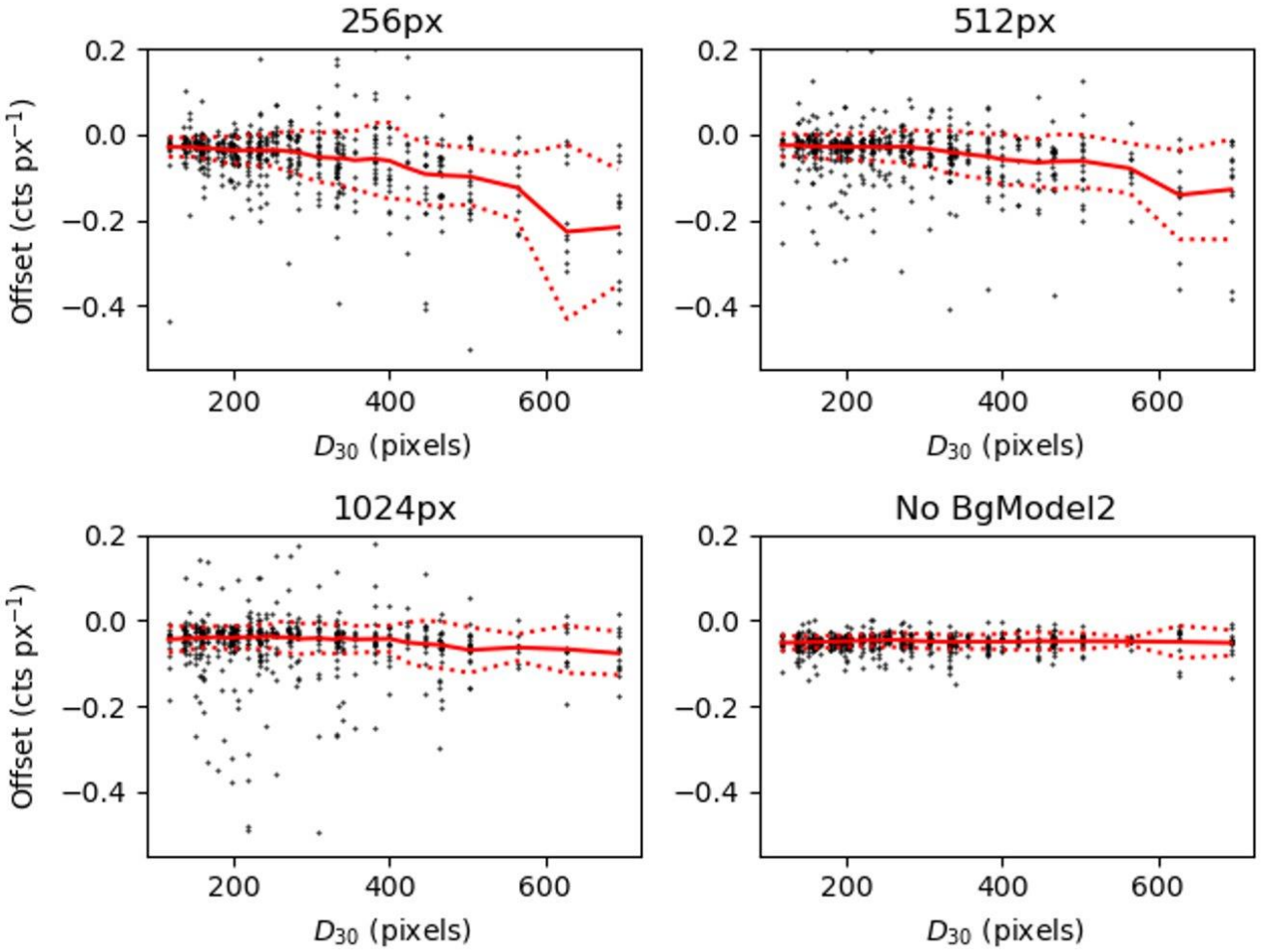
Results: offset (~global impact)



Bigger models (slope)



Bigger models (offset)



Summary of photometry metrics

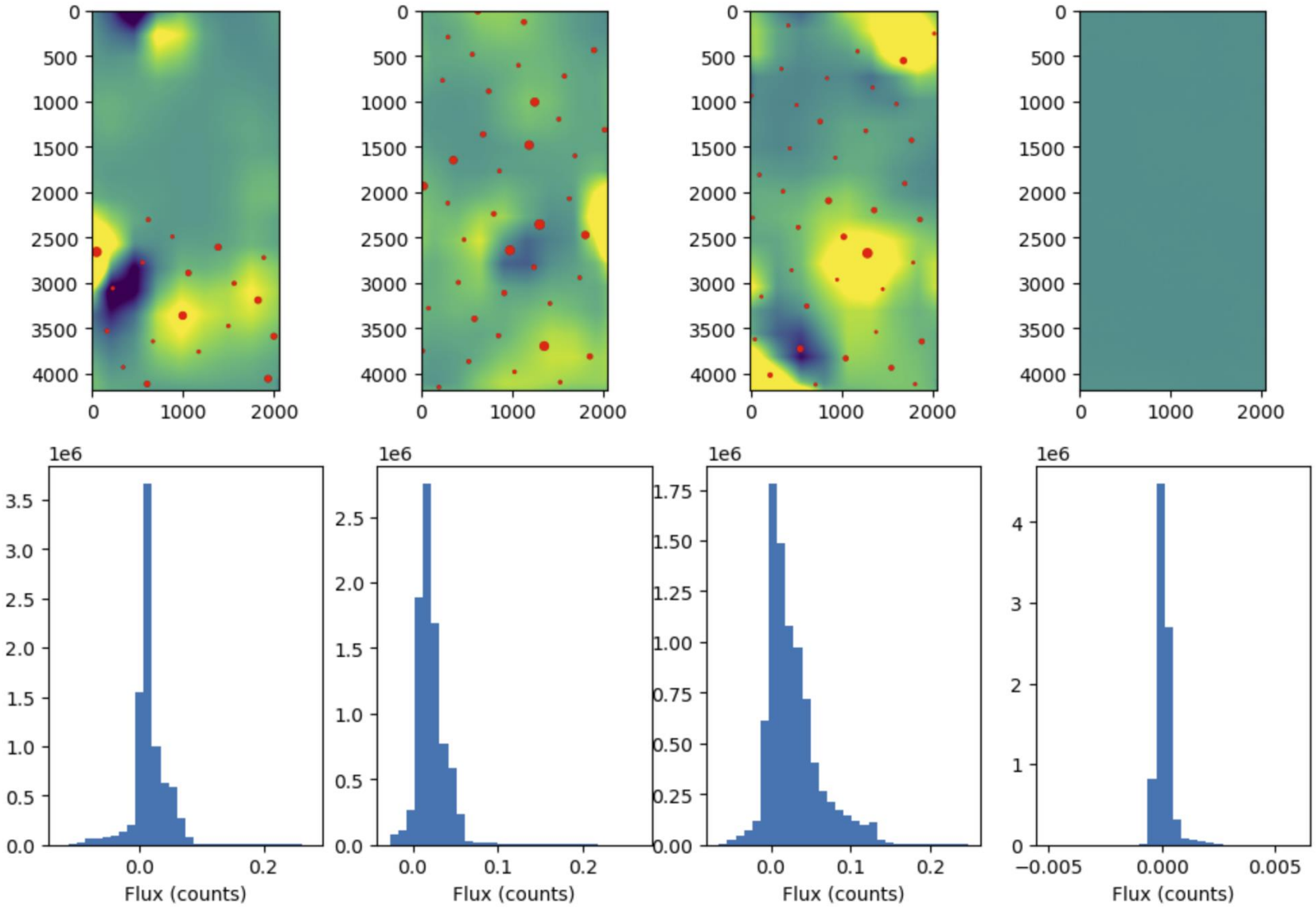
- bgModel2 bin size limits size of objects that will be preserved
  - ICL preservation is a problem: ~arcmin scales even at moderate redshift
- Turning off bgModel2 negates that problem
  - No risk of flux loss (maybe for objects >7000px; untested)
  - Model-to-model scatter also reduces for small models—better for everyone?

- Photometry as a metric is useful, but abysmally slow

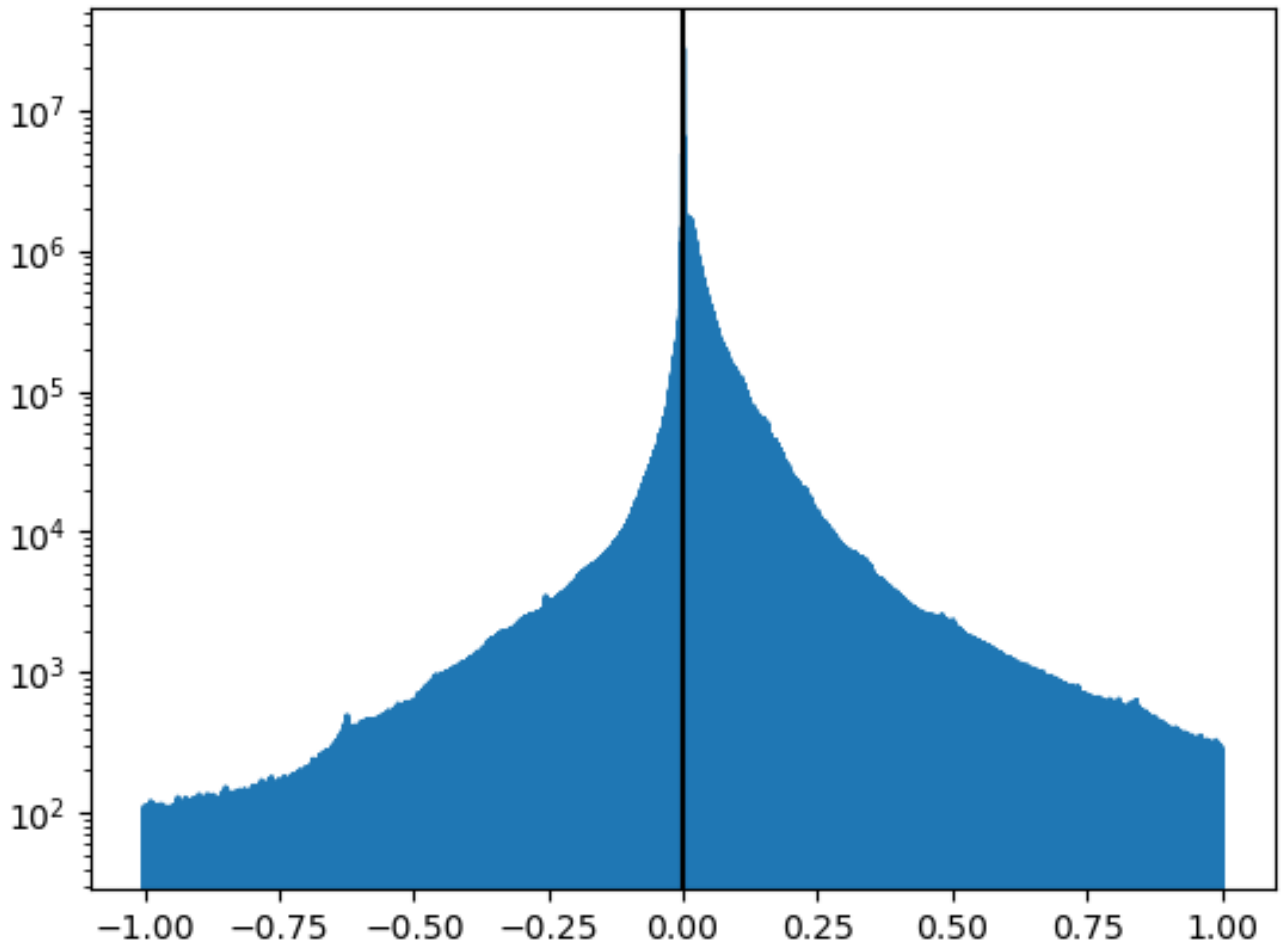
Metric 2: ΔskyCorr

- Inverse of photometry-based metric: impact of models on skyCorr
- Derived as follows:
  - injected_skyCorr – skyCorr = ΔskyCorr
  - If increased source density has no impact (LSB-compliant), distribution of counts in ΔskyCorr should be a narrow peak at 0
  - If there is an impact, distribution will have a measureable width, maybe with a mean offset from 0

Example (4 detectors, visit 1274, tract 9615)



Histogram of full visit (1274)



Lee's trial run as of last Friday, deltaSkyCorrAnalysis in analysis_tools

Summary of ΔskyCorr metric

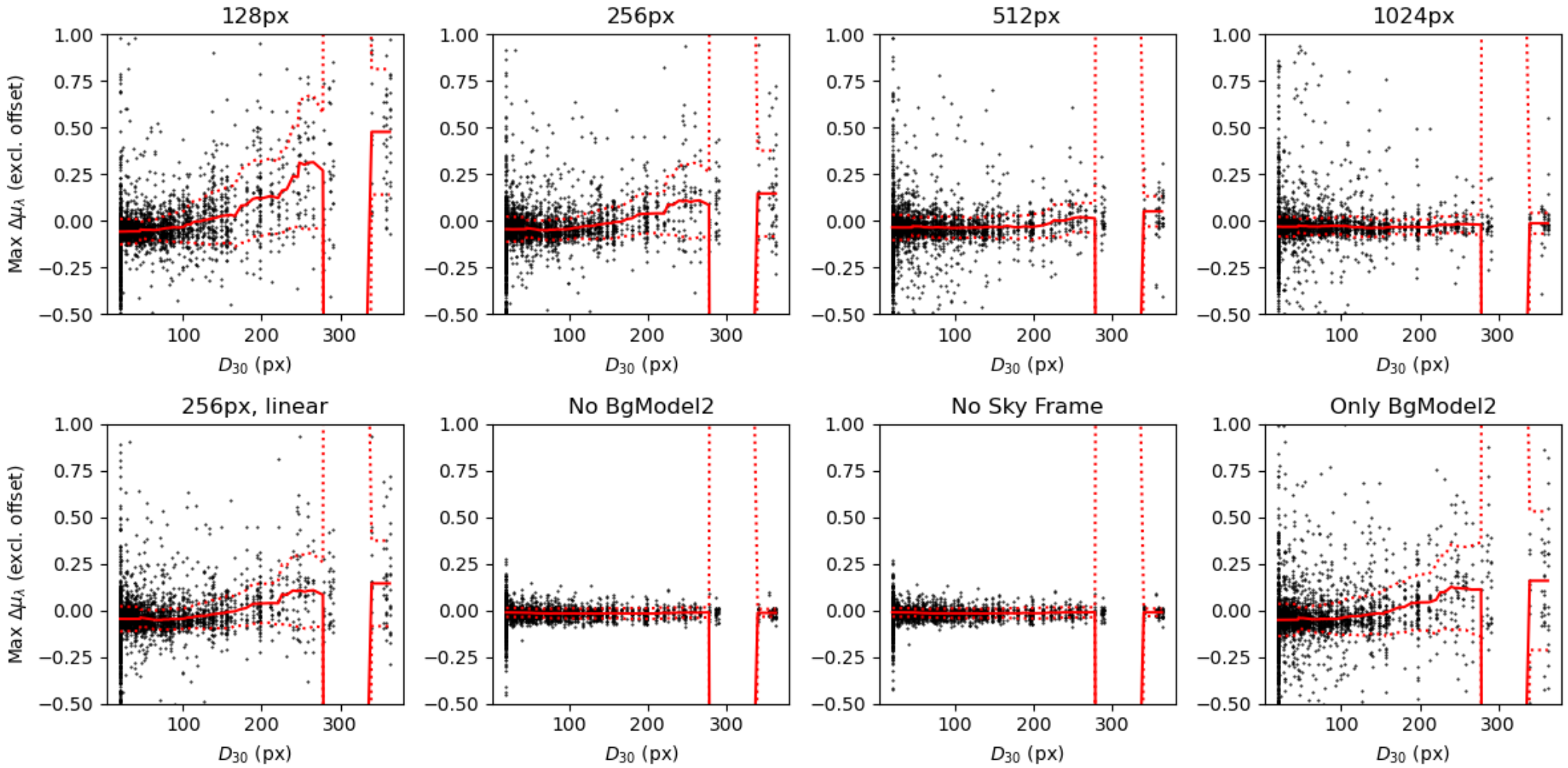
- Condenses photometry metric to a single histogram/handful of numbers
- Much faster to run
  - Load two images per detector
  - Take the difference
  - Compile a histogram
- Not as much granular detail as photometry, but more easily implemented in analysis_tools

- Both present same story: **can approach LSB-compliance by turning off bgModel2 in skyCorr**

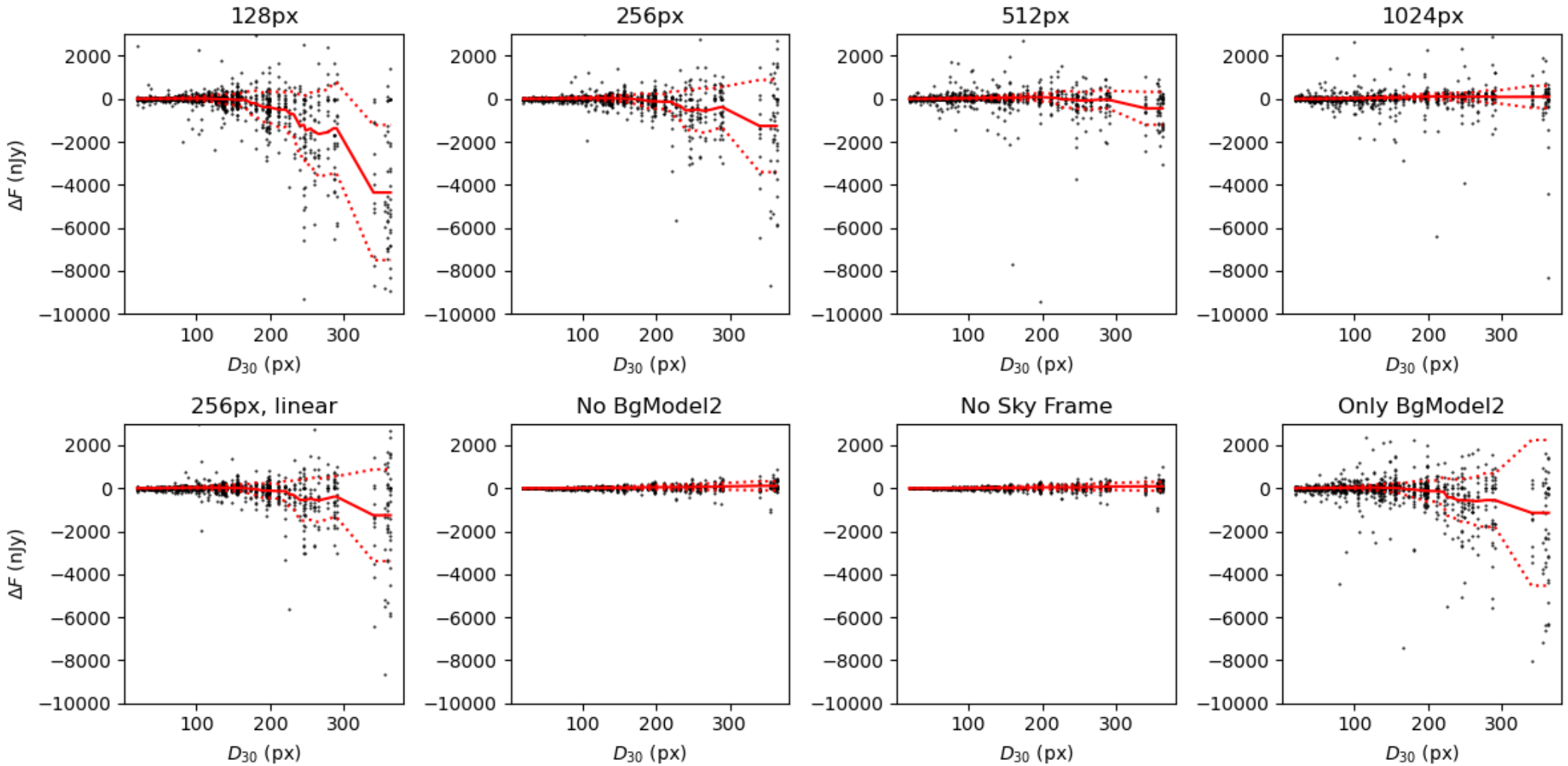
Final point (if time)--catalogues

- Say we have an LSB-compliant deepCoadd. Detection/deblending is still done on deepCoadd_calexp, which lacks LSB flux.
- Catalogues are thus reflective of the deepCoadd_calexp
- What are the logistics of producing catalogues with LSB detections in them? E.g.,
  - How are objectIDs produced and tracked?
  - How expensive to append rows/columns?
  - What if a whole extra catalogue must be created? (Broader implications, e.g. Manda Banerjee's optical/NIR fusion project)

Bonus 1: surface brightness units



Bonus 2: total change in flux (nJy)



Bonus 3: interplay with real sources