



Bootstrapping Photometric Calibrations

Eli Rykoff
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U.S. DEPARTMENT OF
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How To Do Initial Photometric Calibration?

- We have plans for self-calibration for full DRP releases
- Later years we can use previous release as a dense network of reference stars (in the LSST system!)
- What do we do during first light/commissioning for photometric calibration during image processing?
 - We need to know on day 1 what the zero-point is ...
 - And compare this to what is expected.

How well do we need to know it?

- We do *not* need 5 mmag precision for initial photometric calibration
 - We would not get this from 1 zp per detector anyway.
 - Q: how much can residuals vary over detector?
- Is 5% good enough? 2%? 1%?
 - On day 1, I'm confident 5% is just fine.
 - On day n-1, we will want better.
 - At the end of commissioning, we should be able to use previous calibrated stars as a reference; this is roughly equivalent to what we will do after first year of observations.

What will we be calibrating?

- Commissioning observing strategy has not been finalized
- Comcam first
- Followed by LSSTCam
 - If LSSTCam is comcom+6 months, these will necessarily be different fields
- Include something like 3 fields with mini-surveys to LSST 20-year depth
 - DDF field
 - Ecliptic field
 - Dense stellar field?
- Which fields chosen will depend on commissioning season
 - COSMOS if possible
 - Other observations will be in the southern sky
 - Observations in ugrizy

Key Questions

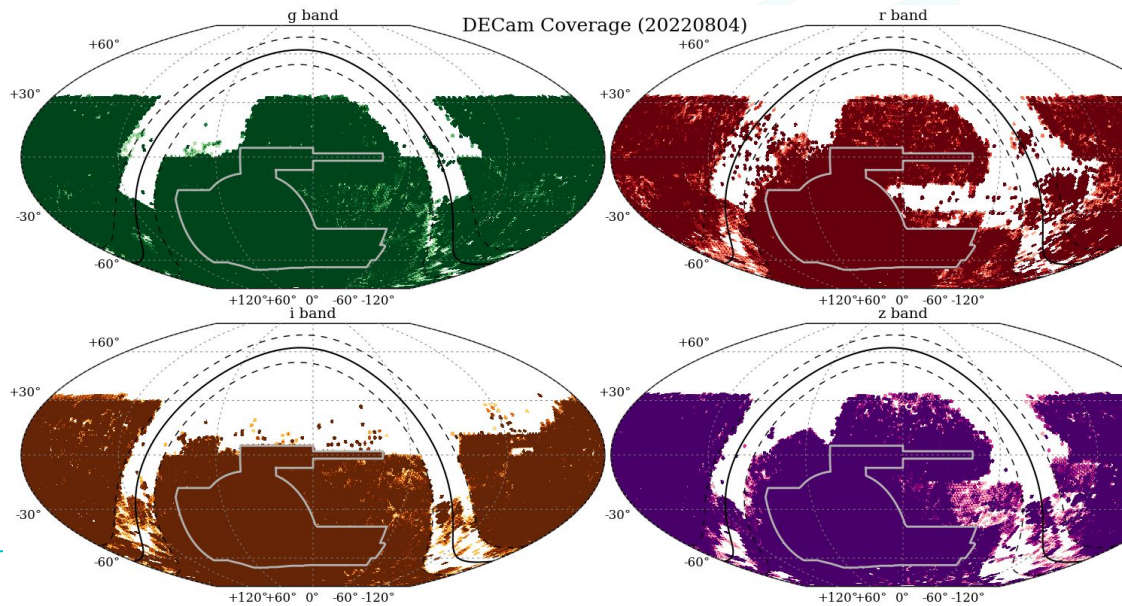
- Open the shutter for the first time ... what is the zero-point?
 - The bootstrap problem
- What are the best zero-points during commissioning?
 - This should be handled by standard DRP processing including fgcmcal global calibration.
 - Reference stars not required for relative calibration, something required for absolute calibration.
- How to validate/verify our photometry
 - Repeatability can be done internally
 - Compare to some external refs to evaluate uniformity and absolute calibration (Gaia likely; see next slides)

Reference Catalog Options

- Pan-STARRs 1 (PS1)
 - We use this currently for HSC
 - Good density of stars
 - Decent enough uniformity
 - Covers grizy (though y is a bit dicey)
 - Only down to -30 degrees declination
- DES
 - 2mmag uniformity over grizy, dense network of reference stars
 - Covers only a portion of the southern sky

Reference Catalog Options

- DELVE survey (Drlica-Wagner et al, <https://arxiv.org/abs/2203.16565>)
 - DECam heterogeneous observations
 - Observations in griz
 - All the way to +30 degrees declination
- Even if we don't use DELVE, they have extensive experience with refcats over the south



Reference Catalog Options

- SkyMapper
 - Covers the region south of PS1
 - 1% calibration shift between SkyMapper and PS1
 - DELVE will have this all figured out soon

Reference Catalog Options

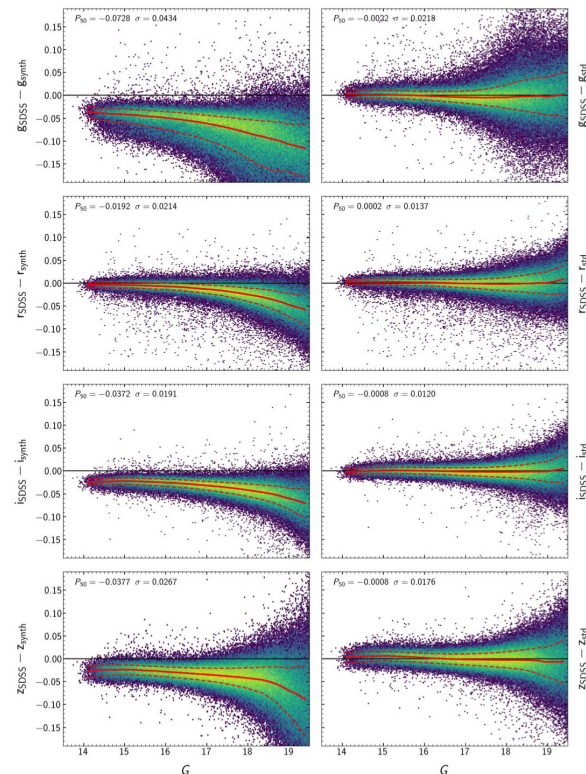
- What about u?
 - We don't have a lot of u-band survey observations, unfortunately
 - Could rely on color terms from g, r, i
 - Transformation will be metallicity/position dependent
 - How well do we need to know u for initial bootstrapped calibrations?
 - Note that final requirement is 20 mmag uniformity in u, 10 mmag for colors including u.

One more option...

- Gaia DR3 (Motegriffo et al. 2022, “The Galaxy in your preferred colours.”)
- Gaia has low resolution spectrophotometry (“XP spectra”) from the BP/RP channels
 - 220 million stars around the sky
 - Majority are $G < 17.65$, some going fainter
 - Wavelength coverage 330 nm to 1050 nm
- Software provided to convert to different surveys
 - <https://gaia-dpci.github.io/GaiaXPy-website/>
 - Includes transformations to broadband systems including PS1, DECam, etc.

Some Gaia XP Spectra Caveats

- Left panel: comparison of (raw) synthetic SDSS griz to real SDSS griz
 - Absolute offsets at bright end
 - Significant background issues causing curvature to the faint end
- “Standardisation” of synthetic magnitudes
 - Empirical (global) fix to background and offsets
 - Is not “true” spectrophotometry
- Uncorrected values are good to $\sim 5\%$ at $G < 17.5$



Gaia questions

- Is the density high enough?
 - This is easier than HSC because LSST survey has much shorter exposures and much brighter saturation magnitude
 - Looking at DC2 imsim data, we will have ~10-20 stars per detector (but as few as 2-3 in a quick scan with simple selections)
 - Plenty per visit, if not per detector per visit.
 - Science Pipelines is not currently set up to do per-visit initial zps, do we need to?
- Can we use (e.g.) synthetic DECam fluxes from XP spectra, and add our own synthetic color terms?
- Certainly this will be great for validation of uniformity after a suitable standardization procedure.

- Bullets

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