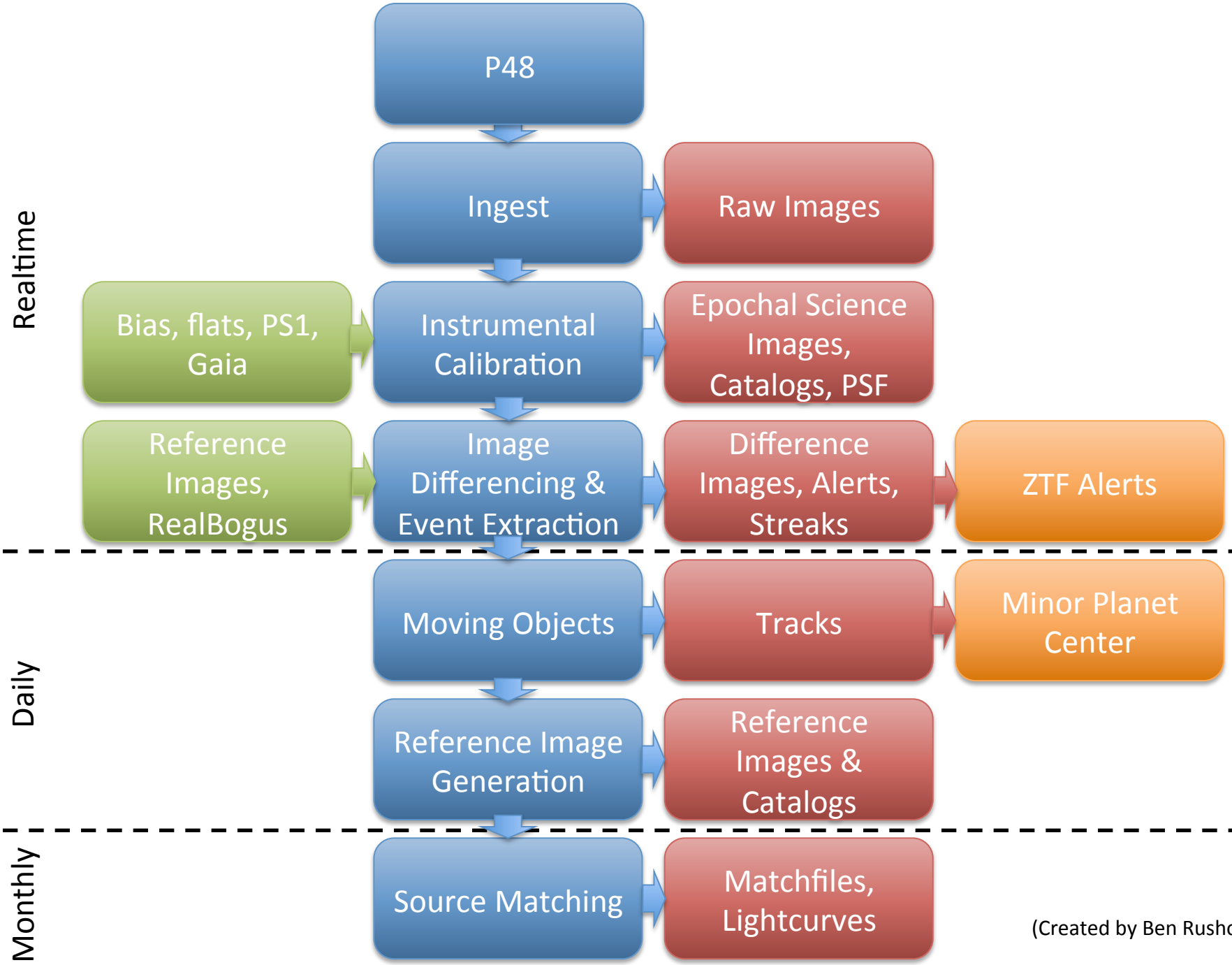
ZWICKY TRANSIENT FACILITY

Reference-Image Coverage

Russ Laher, IPAC Caltech
On behalf of Frank Masci and the ZTF collaboration

Zwicky Transient Facility Team Meeting
AlbaNova University Center
Stockholm, Sweden

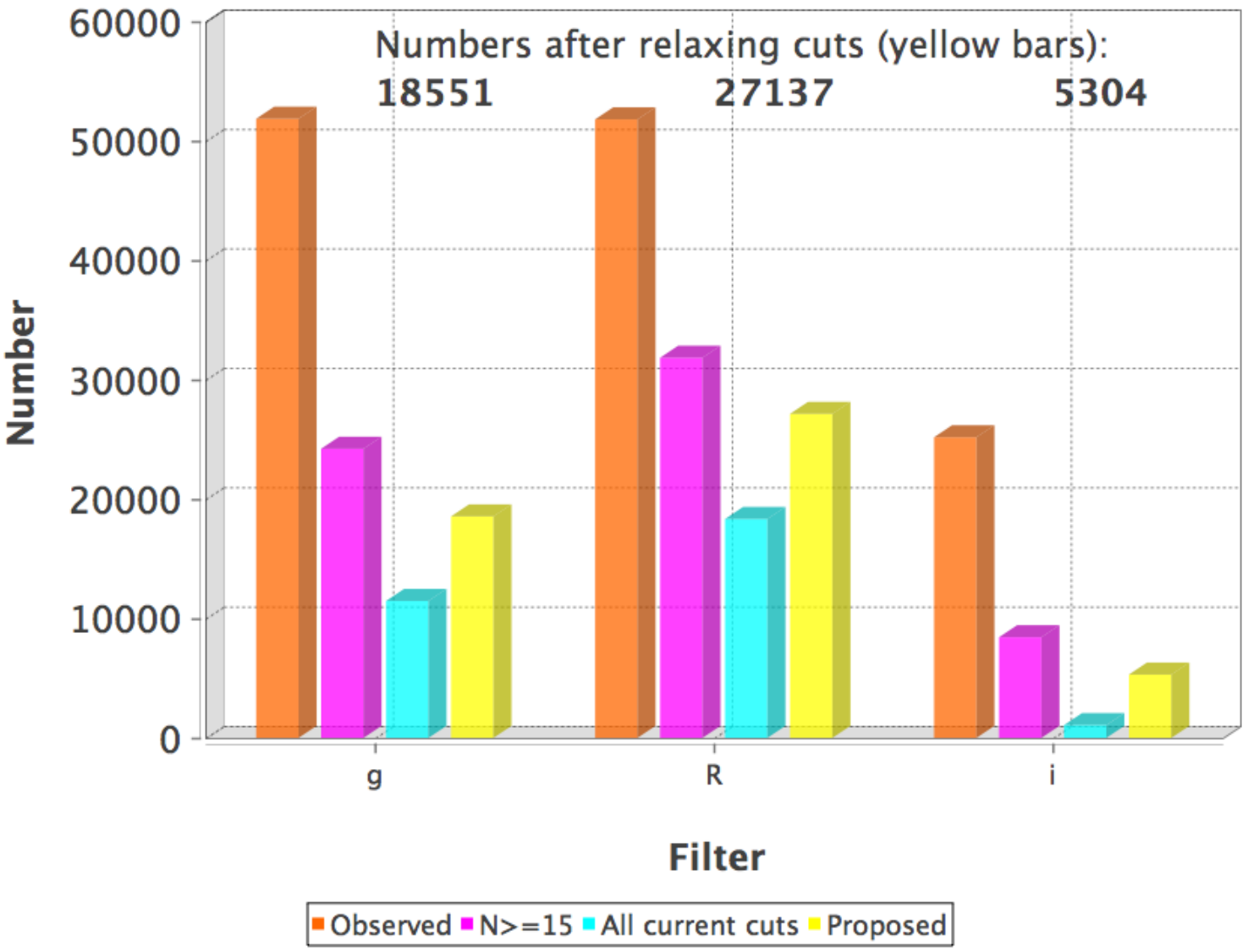
August 6-10, 2018

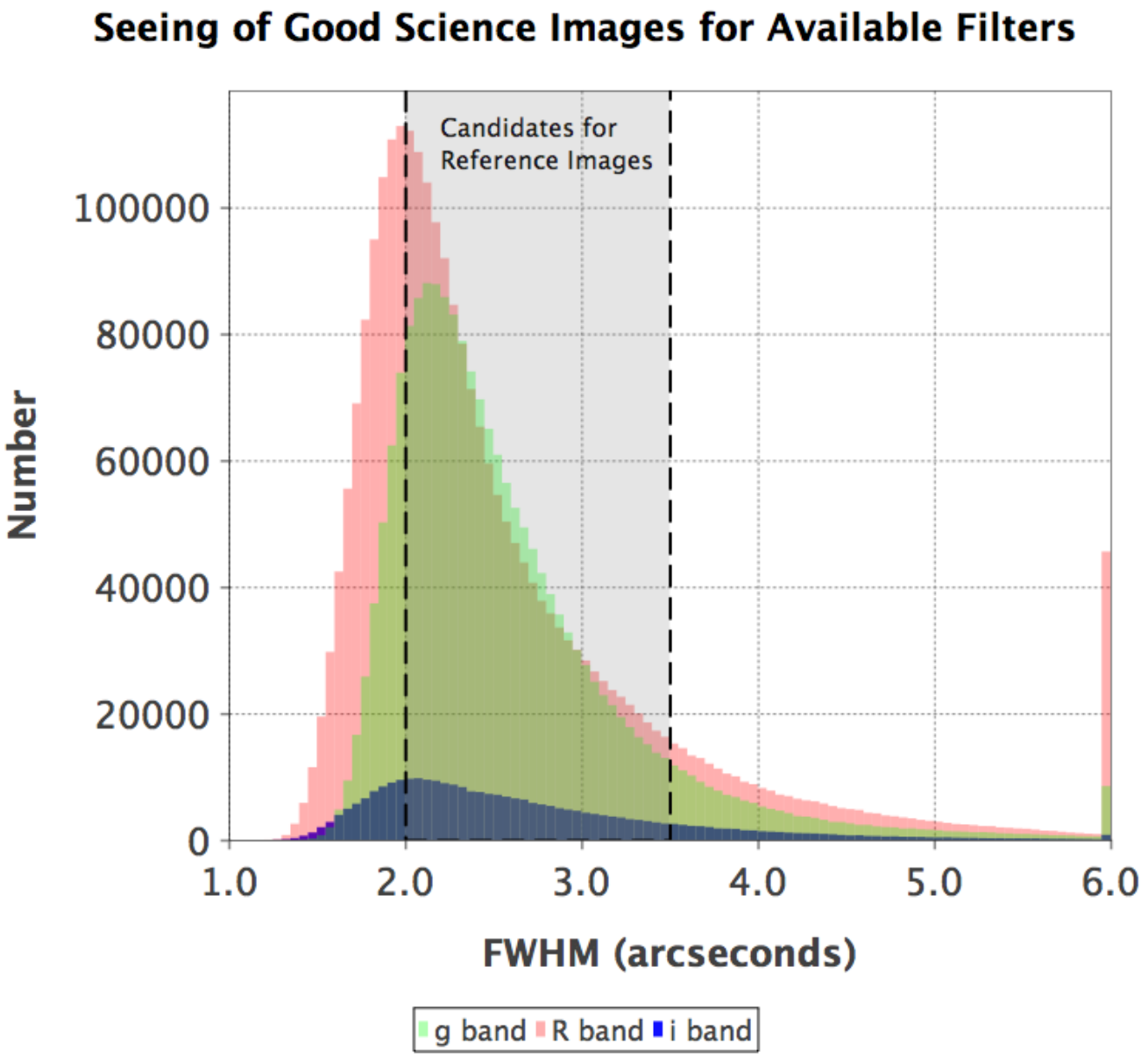

Realtime
Daily
Monthly
P48
Ingest
Raw Images
Bias, flats, PS1, Gaia
Instrumental Calibration
Epochal Science Images, Catalogs, PSF
Reference Images, RealBogus
Image Differencing & Event Extraction
Difference Images, Alerts, Streaks
ZTF Alerts
Moving Objects
Tracks
Minor Planet Center
Reference Image Generation
Reference Images & Catalogs
Source Matching
Matchfiles, Lightcurves
(Created by Ben Rusholme)

Overview

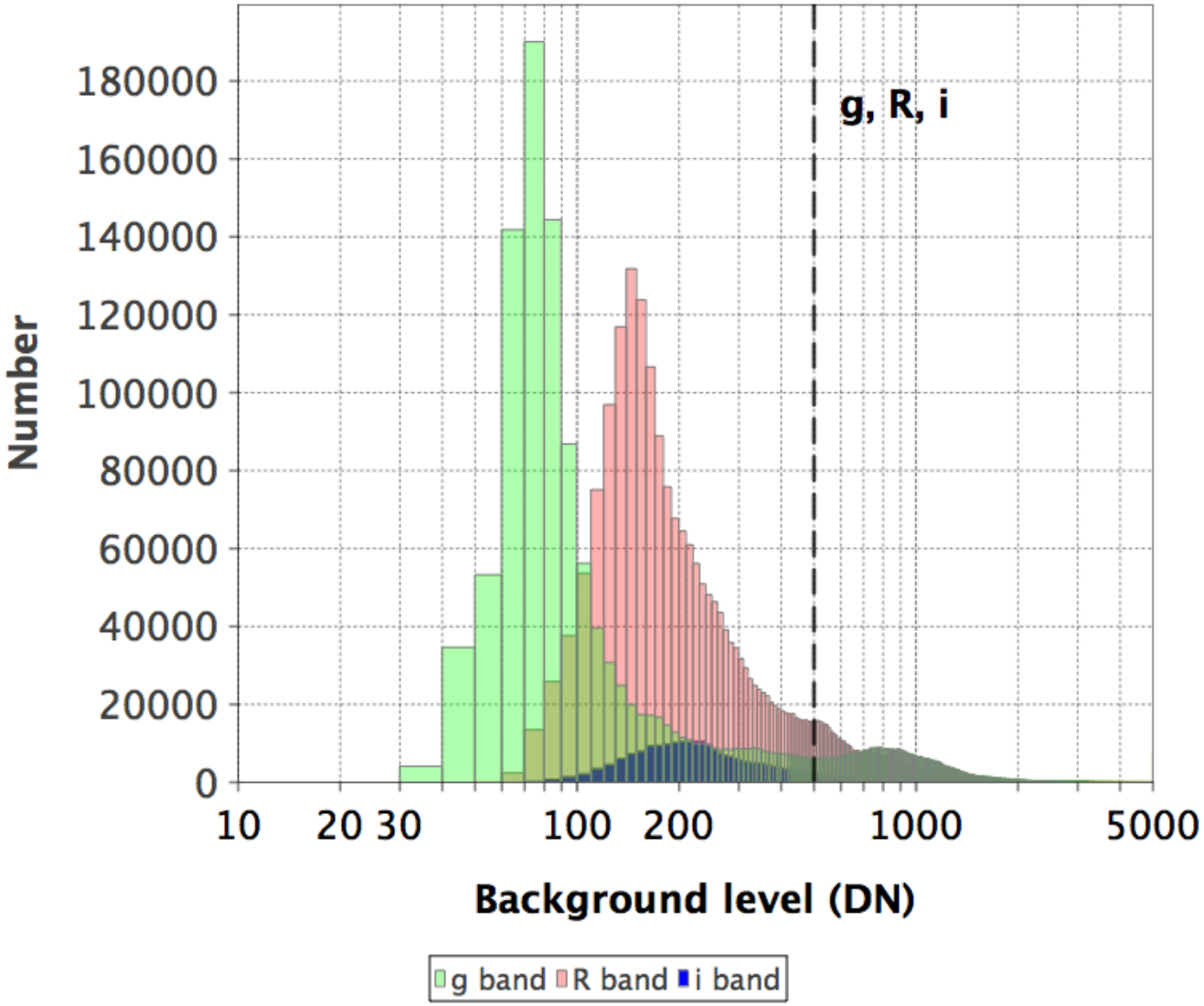
- Issue: Missing reference images
- Current input selection criteria
  - Astrometric
  - Photometric
  - Image quality
- Proposed looser selection criteria
- Current sky coverage

Number of Remaining Fields and CCD Quadrants after applying Selection Criteria

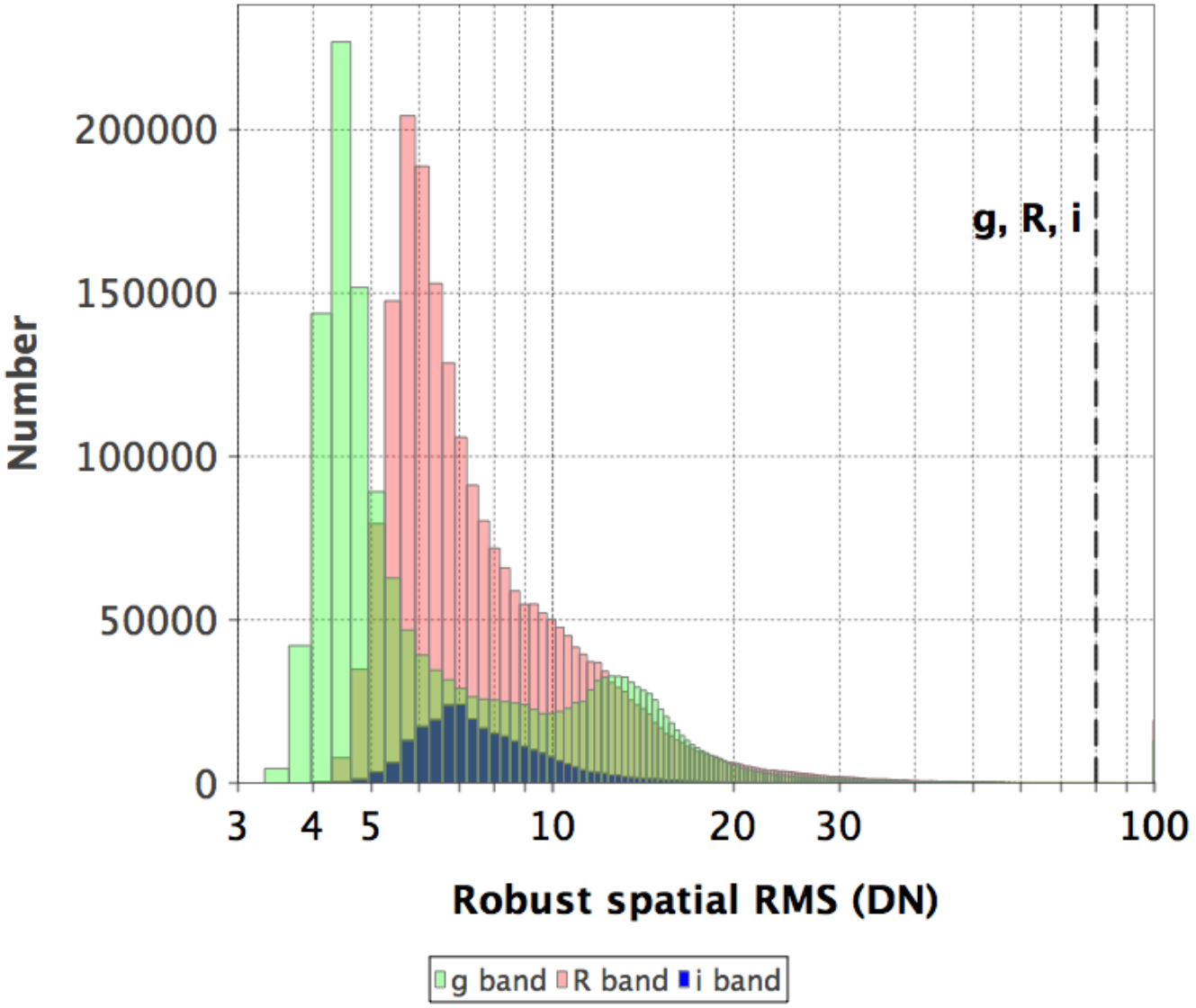


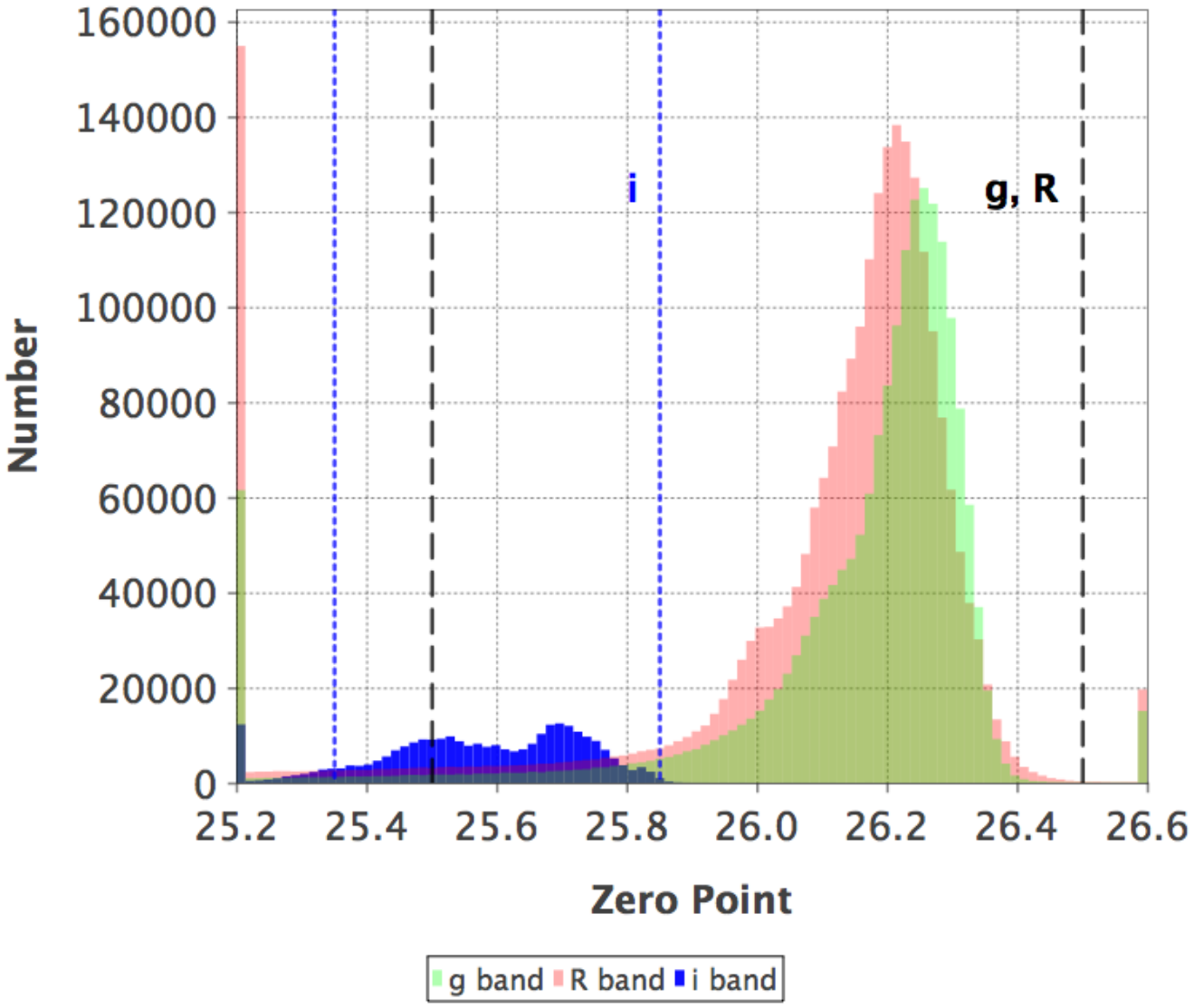

Seeing of Good Science Images for Available Filters
Candidates for
Reference Images
100000
80000
60000
40000
20000
0
Number
1.0
2.0
3.0
4.0
5.0
6.0
FWHM (arcseconds)
g band
R band
i band

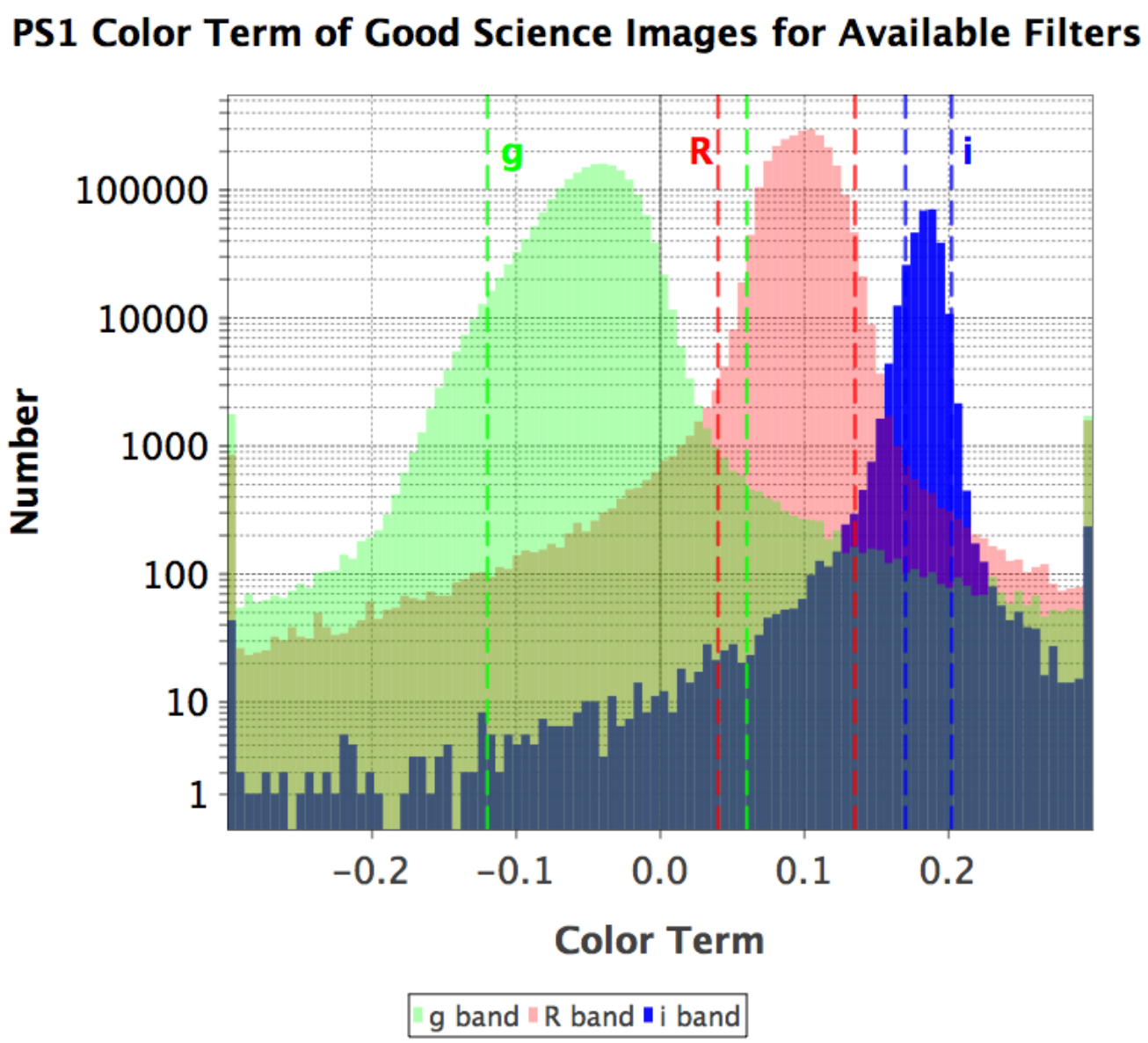
Background Level of Good Science Images for Available Filters



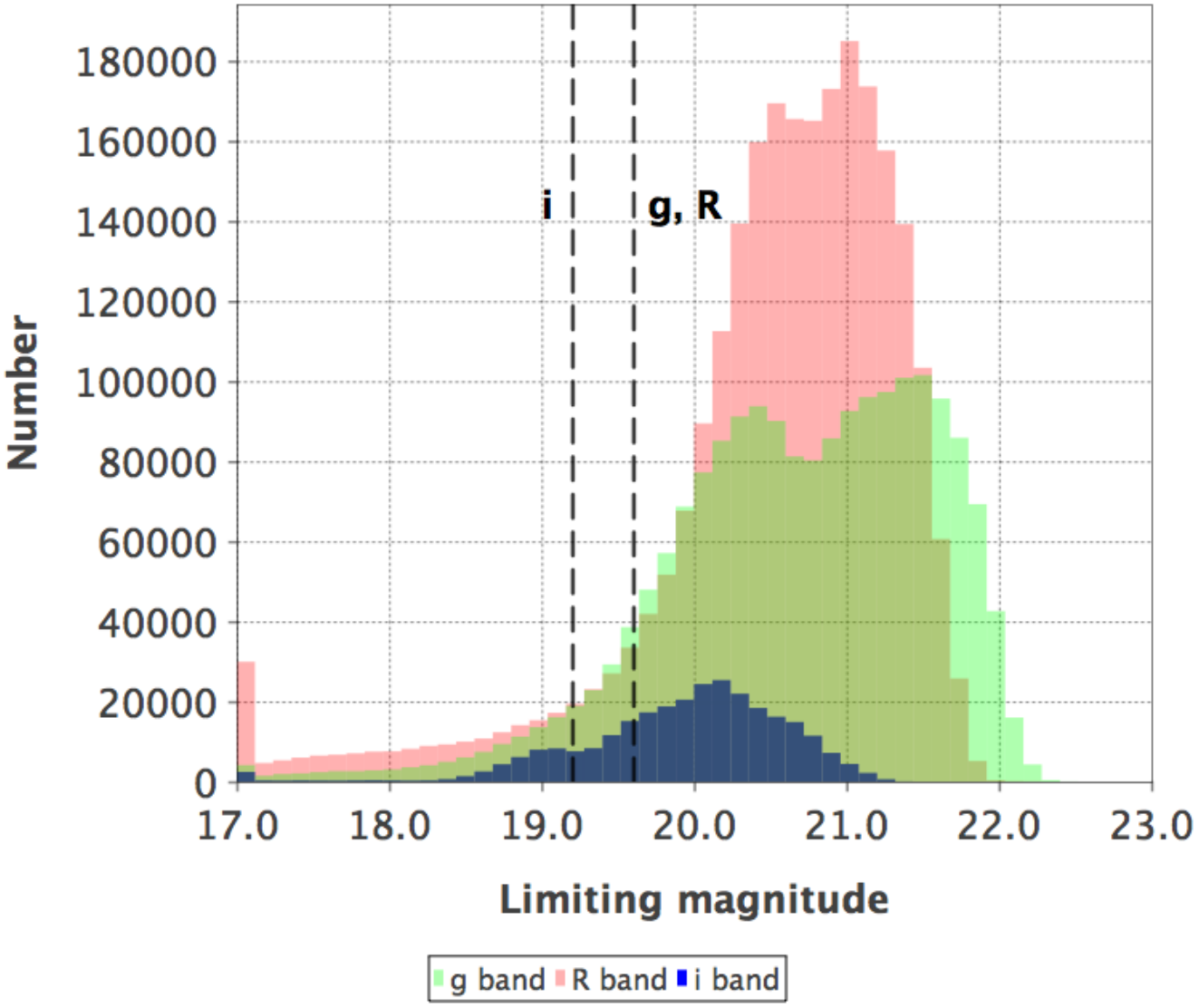
Data Dispersion of Good Science Images for Available Filters




PS1 Zero Point of Good Science Images for Available Filters
160000
140000
120000
100000
80000
60000
40000
20000
0
Number
i
g, R
25.2
25.4
25.6
25.8
26.0
26.2
26.4
26.6
Zero Point
g band
R band
i band


PS1 Color Term of Good Science Images for Available Filters
g
R
i
100000
10000
1000
100
10
1
Number
−0.2
−0.1
0.0
0.1
0.2
Color Term
g band
R band
i band

Limiting Magnitude of Good Science Images for Available Filters

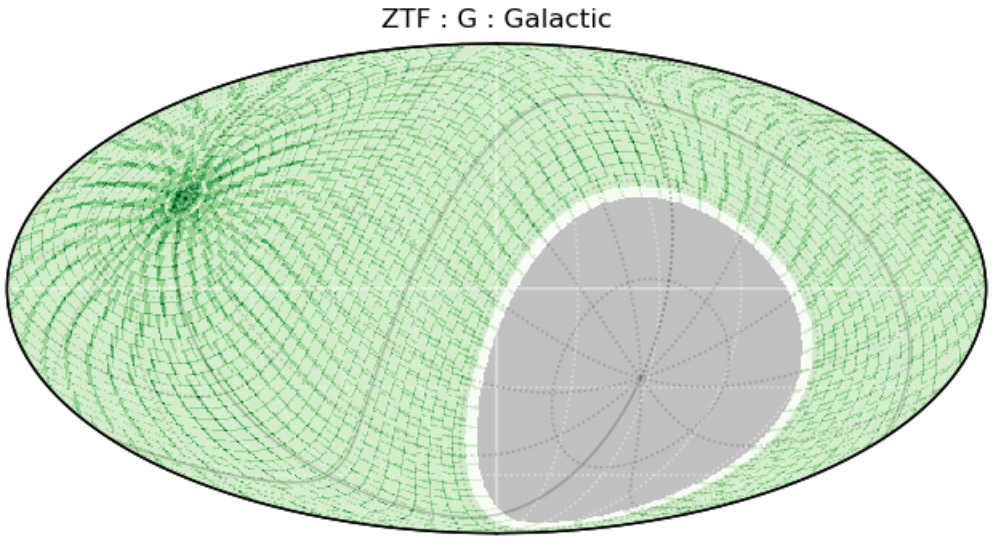


Proposed Loosened Selection Criteria: R-Band

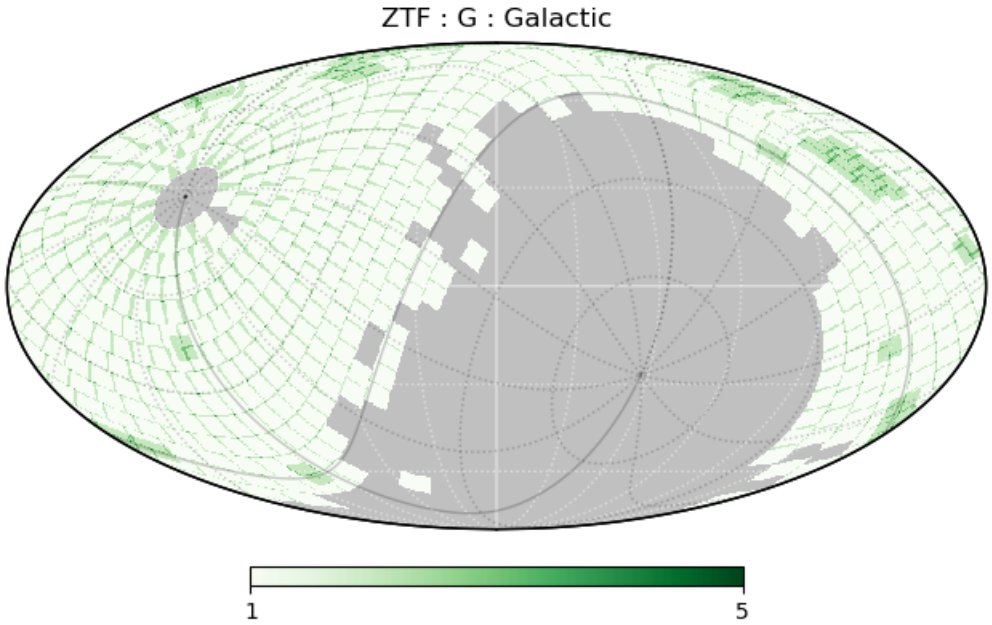
- Observation date >= 2018-02-05 (same)
- 15 <= N_{stack} <= 40
- 1.75 <= FWHM <= 4.5 arcseconds (was 2-3.5)
- 25 <= Zero Point <= 27 (was tighter)
- 0.02 <= Color Term <= 0.15 (was narrower)
- Magnitude limit >= 19 mag (was fainter)
- Global median <= 1000 DN (was 500)
- Robust spatial RMS < 80 DN (same)

Sky Coverage of Ref. Images: g band

Goal:

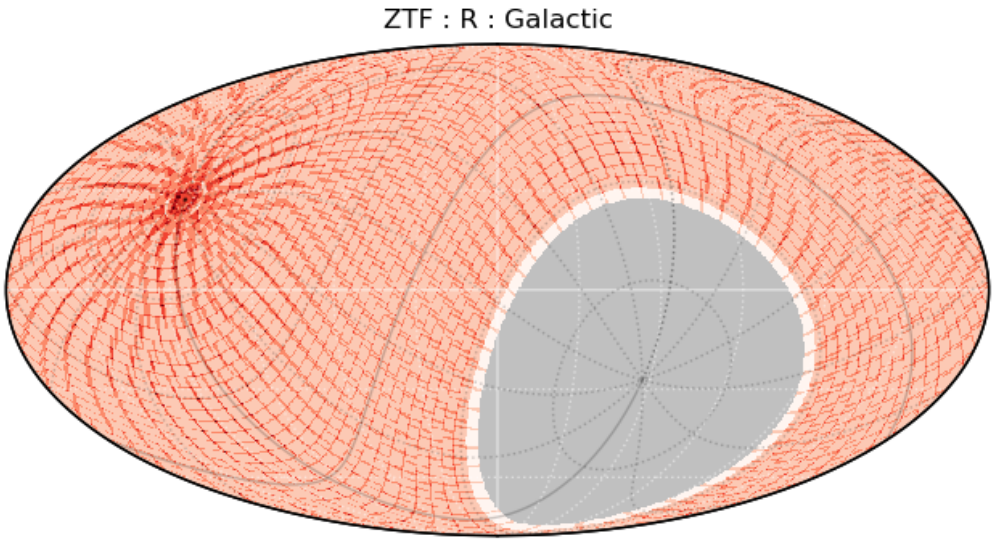


7/30/18

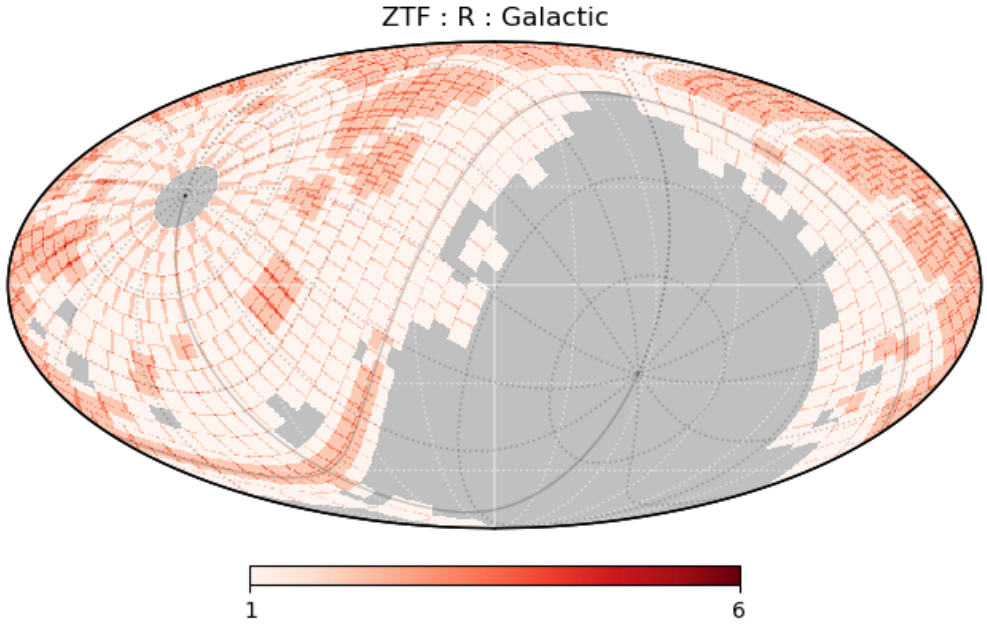


Sky Coverage of Ref. Images: R band

Goal:

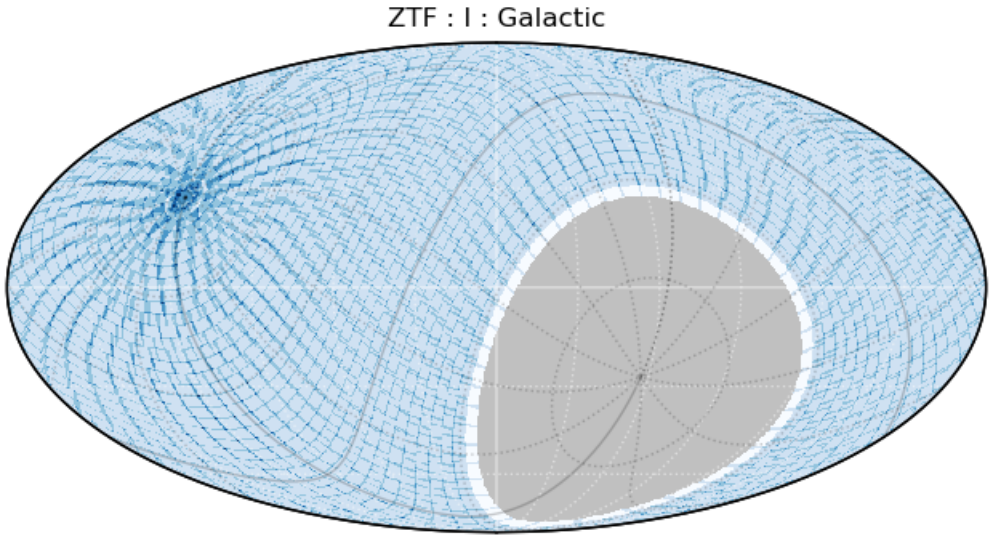


7/30/18

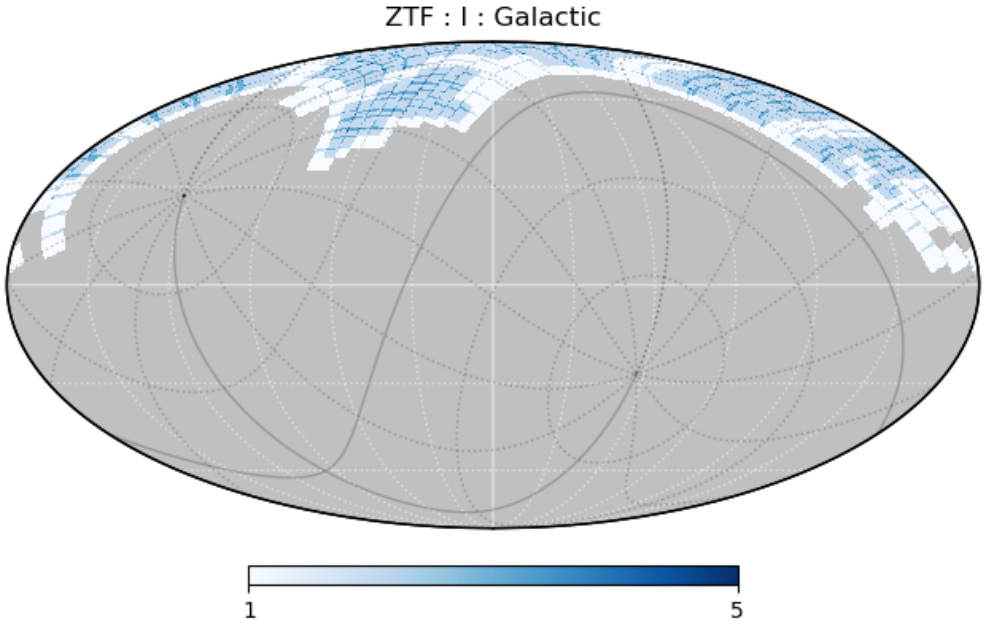


Sky Coverage of Ref. Images: i band

Goal:



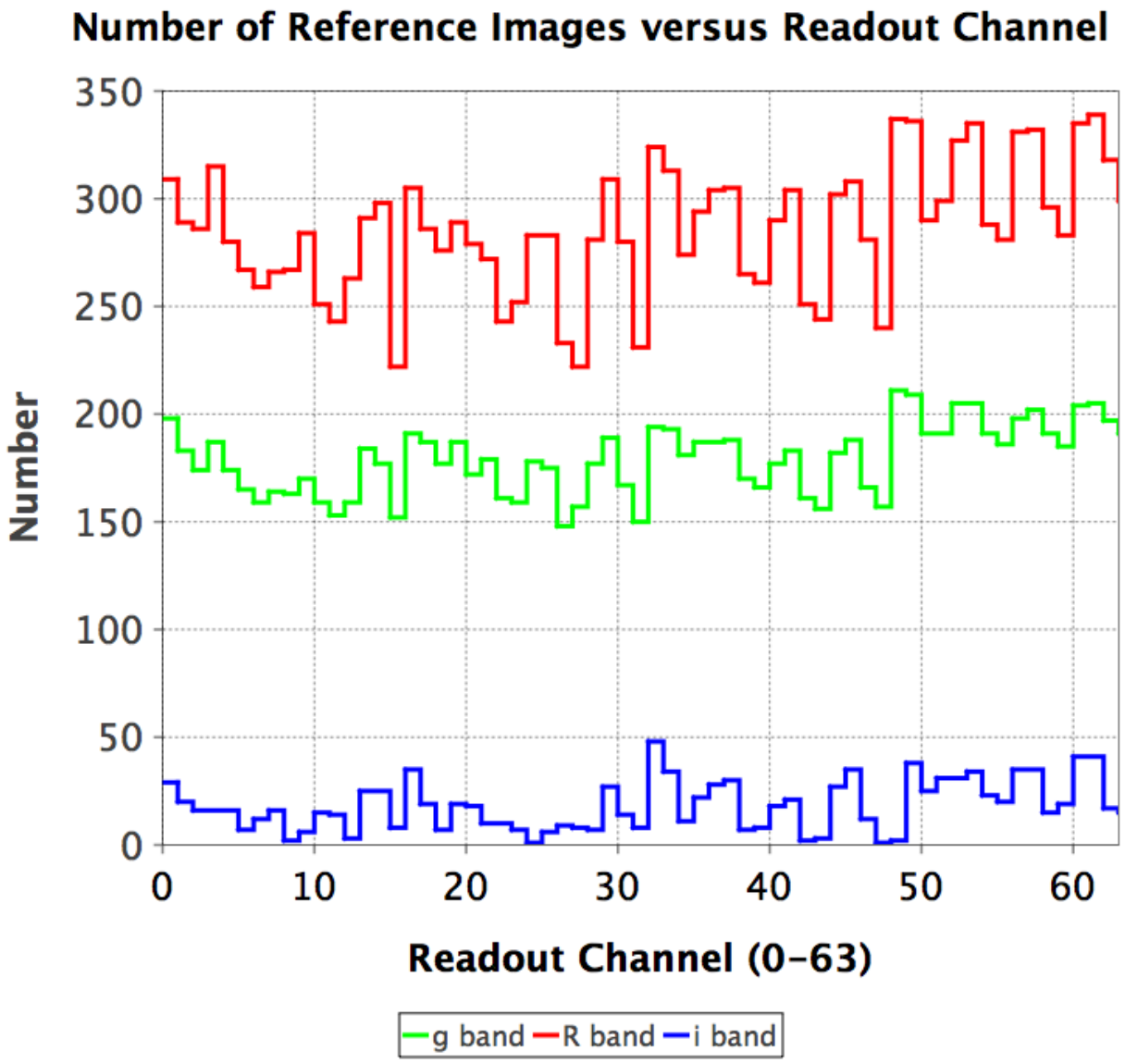
7/30/18

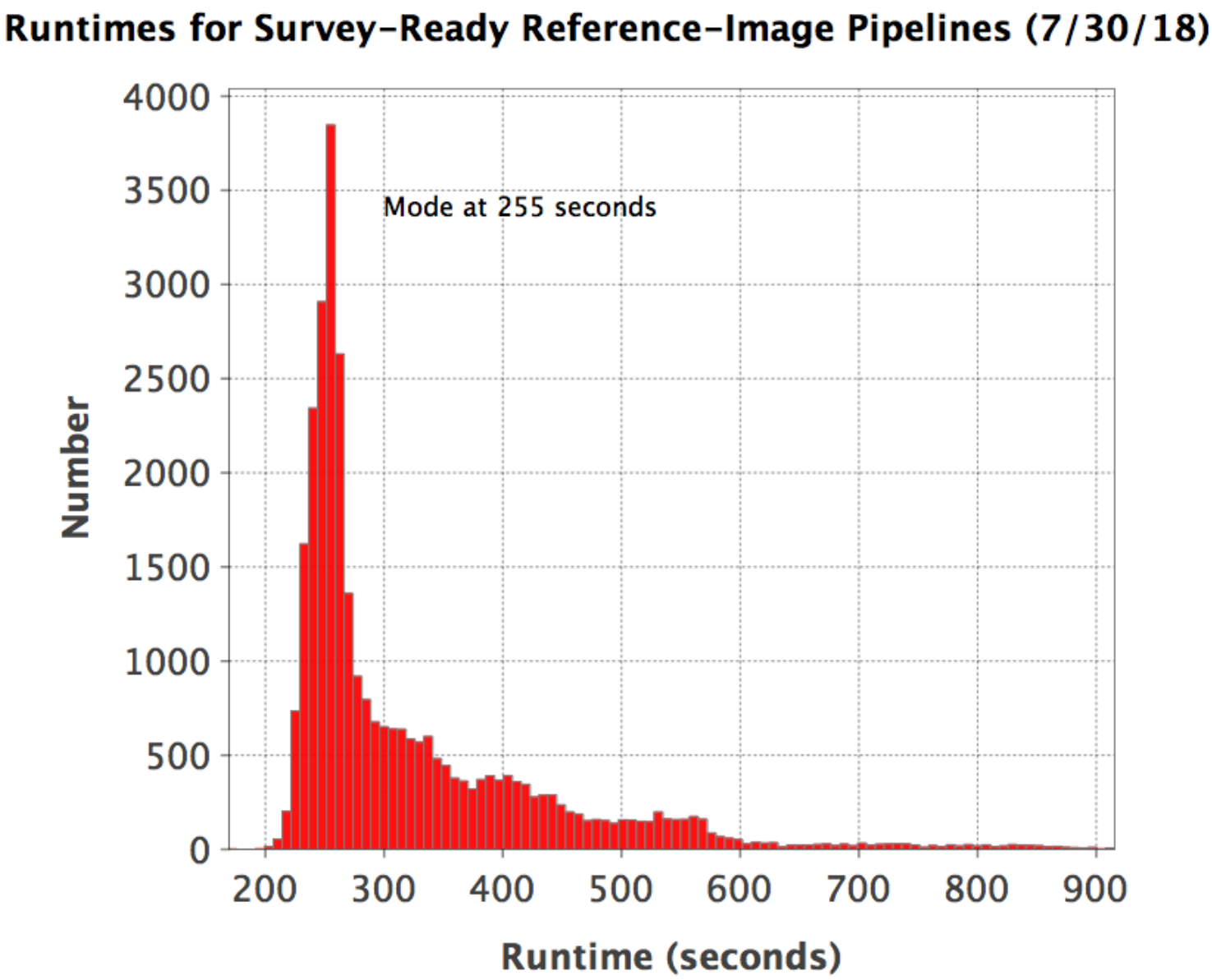


Summary

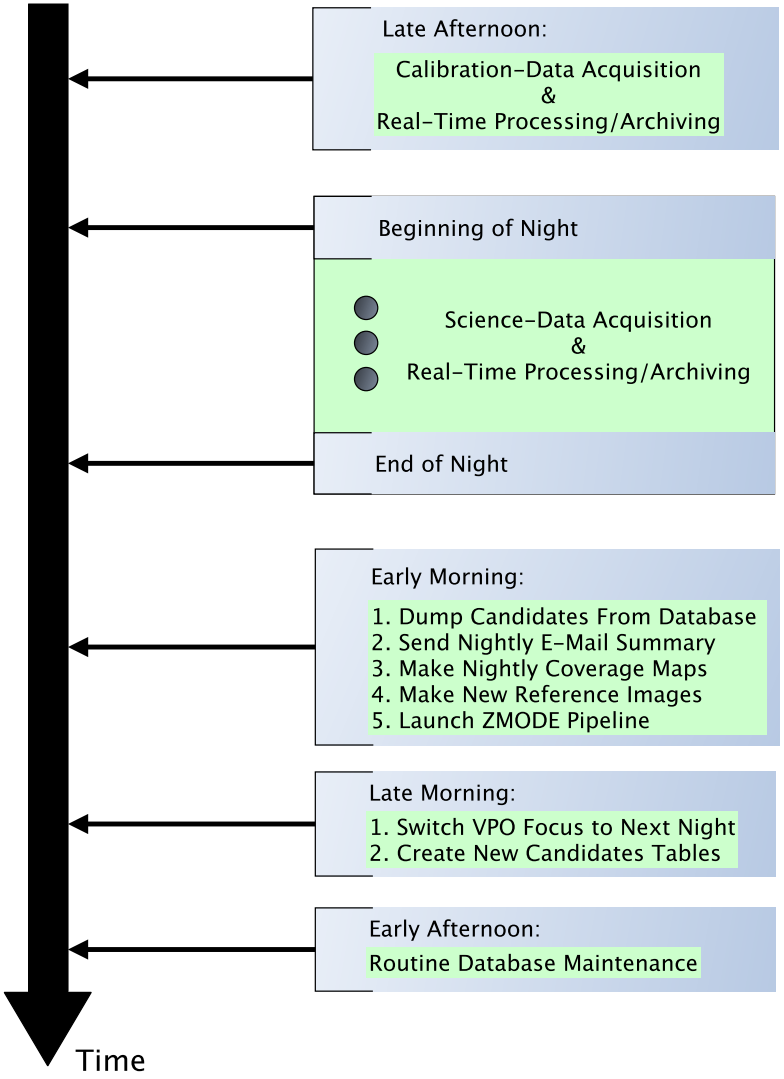
- We have recently realized that the selection criteria for reference-image inputs is too tight, and the sky coverage of the reference images *could be* increased
- We are experimenting with new looser selection criteria for reference-image generation (g, R, and i bands)
- A new set of reference images *could be* generated soon after this meeting (40 images deep), depending on *both* the test results from our experimentation and a policy decision to do so
- This would raise the total number of reference images from ~31K to ~51K field/quadrants (a 65% increase in number for all bands)
- It would require 15-30 hours on 66 machines (4 field/quadrants per machine)
- Also: Need new observations of fields with insufficient coverage!

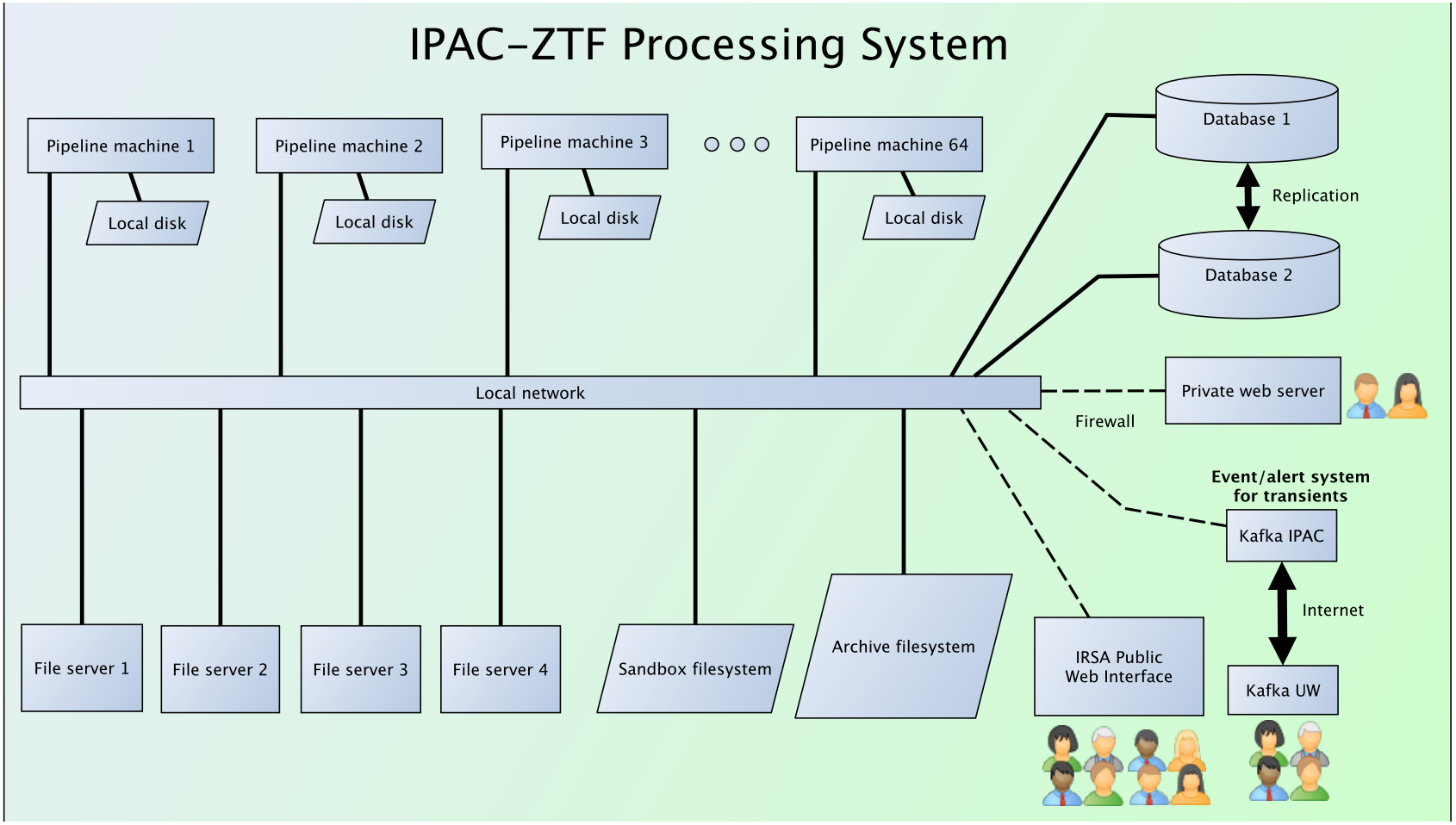
BACKUP


Number of Reference Images versus Readout Channel
Number
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
Readout Channel (0-63)
g band
R band
i band


Runtimes for Survey-Ready Reference-Image Pipelines (7/30/18)
Mode at 255 seconds
Number
Runtime (seconds)
0
500
1000
1500
2000
2500
3000
3500
4000
200
300
400
500
600
700
800
900

A Day in the Life of ZTF
(assuming good-observing weather)




IPAC-ZTF Processing System
Pipeline machine 1
Pipeline machine 2
Pipeline machine 3
Pipeline machine 64
Local disk
Local disk
Local disk
Local disk
Database 1
Replication
Database 2
Local network
Private web server
Firewall
Event/alert system
for transients
Kafka IPAC
Internet
Kafka UW
File server 1
File server 2
File server 3
File server 4
Sandbox filesystem
Archive filesystem
IRSA Public
Web Interface

Method of Estimating Magnitude Limit From Frank Masci

A good semi-empirical estimate of the point-source magnitude limit can be obtained from:

mlim = zp - 2.5 * log10[snr * sigmapix * sqrt(Np)],

where:

zp = photometric zeropoint

snr = desired signal-to-noise limit, e.g., 5.

sigmapix = a _robust_ estimate of the background RMS per pixel (tricky in confused regions and/or with large background gradients but possible if computed over a grid).

Np = the "number of noise pixels" defining the observed PSF, i.e., the "effective footprint" of a point source. For a Gaussian-like profile with FWHM in pixels, Np = 2.226*FWHM^2.

The above assumes that close to mlim you're background dominated (i.e., not source-photon dominated) and that the pixel noise is not significantly correlated.

Processed-Image Infobits

BIT00 = 0 / MEDIAN BACKGROUND LEVEL is > 4000.0 DN
BIT01 = 1 / ROBUST PIXEL NOISE (RMS) is > 100.0 DN
BIT02 = 2 / PERCENT OF SATURATED PIXELS is > 50.0%
BIT03 = 3 / IMAGE SEEING (FWHM) is > 5.0"
BIT04 = 4 / MAGLIM FROM PSF CATALOG UNCERTS is < 17.5 mag
BIT05 = 5 / MAGLIM FROM EMPIRICAL FORMULA is < 17.5 mag
BIT06 = 6 / NUMBER OF PSF CATALOG SOURCES is < 10
BIT07 = 7 / NUMBER OF SEXTRACTOR CAT SOURCES is < 20
BIT08 = 8 / PHOTOMETRIC CALIBRATION NOT POSSIBLE
BIT09 = 9 / NUMBER OF PHOTOMETRIC CALIBRATORS is < 30
BIT10 = 10 / NUMBER OF MATCHES FOR PHOTOMETRIC CAL < 5
BIT11 = 11 / RMS in PHOTCAL RESIDUALS (ZPs) is > 0.2 mag
BIT12 = 12 / ASTROMETRIC CALIBRATION NOT POSSIBLE
BIT13 = 13 / PCT OF REF-CAT MATCHES FOR ASTROM is < 20%
BIT14 = 14 / NUMBER OF MATCHES FOR ASTROM CAL is < 100
BIT15 = 15 / MIN NUM OF IN-GRID MATCHES FOR ASTROM is < 5
BIT16 = 16 / REL-PIXEL SCALE OUT OF RANGE: -0.20% - 2.00%
BIT17 = 17 / PCT CHANGE IN SCAMP CHI-SQUARE is > 0.0%
BIT18 = 18 / CHI-SQUARE FROM SECOND PASS SCAMP is > 30
BIT19 = 19 / MAX IN-GRID MEDIAN ASTROM RESID is > 0.7"
BIT20 = 20 / PSF CREATION (HENCE PSF-FIT PHOT) NOT POSSIBLE
BIT21 = 21 / PCT OF DETECTED MATCHES FOR ASTROM is < 50%

Astrometric Calibration

- Scamp is run twice:
  1. Pattern-matching with assumed prior distortion and allowed 6.5 arcminutes of positional uncertainty
  2. Distortion refinement of 4^{th}-order polynomial with pattern-matching shut off

- Astrometry is declared good when:
  - Chi^2 after second pass is lower than after first pass
  - Chi^2 <= 30 after second pass
  - At least 50% of the SExtractor detections are matched
  - At least 0.2% of the Gaia-catalog sources are matched
  - Minimum number of matches = 100
  - At least 5 matches in each of 9 sub-images
  - Median radial RMS <= 0.7 arcseconds in all 9 sub-images
  - Delta pixel scale in [-0.2%, 2%] range