Data Processing for the WTS

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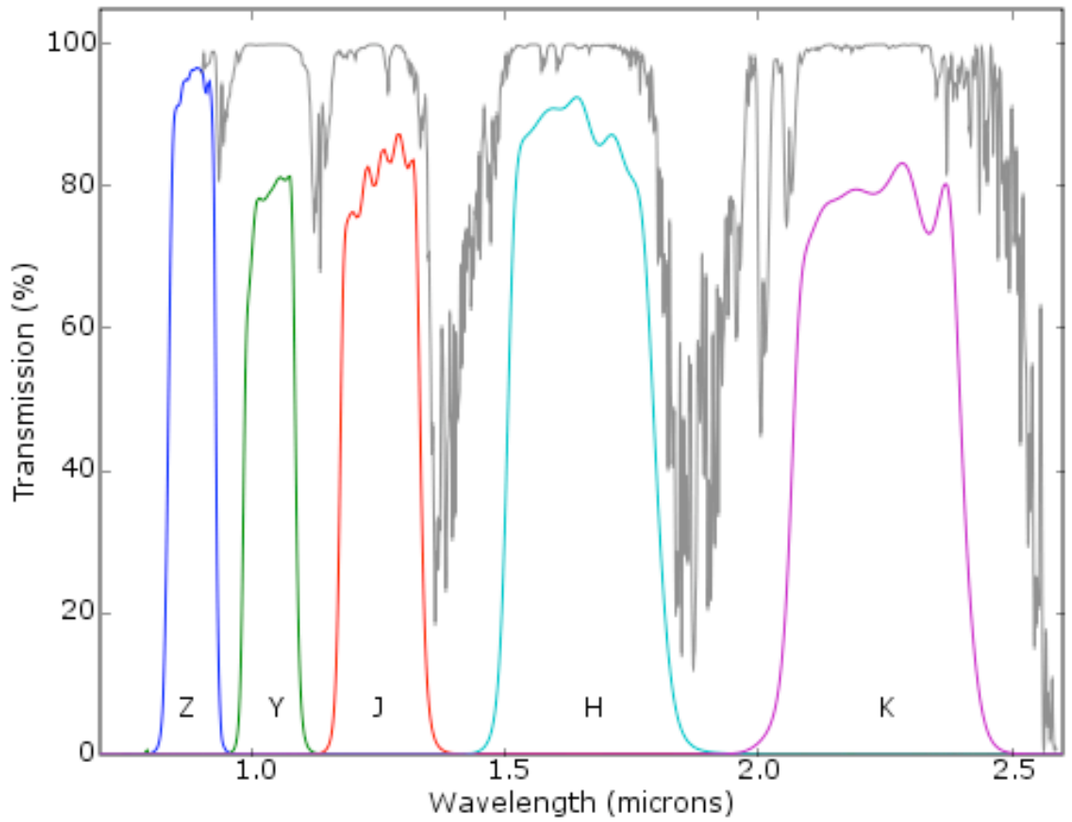
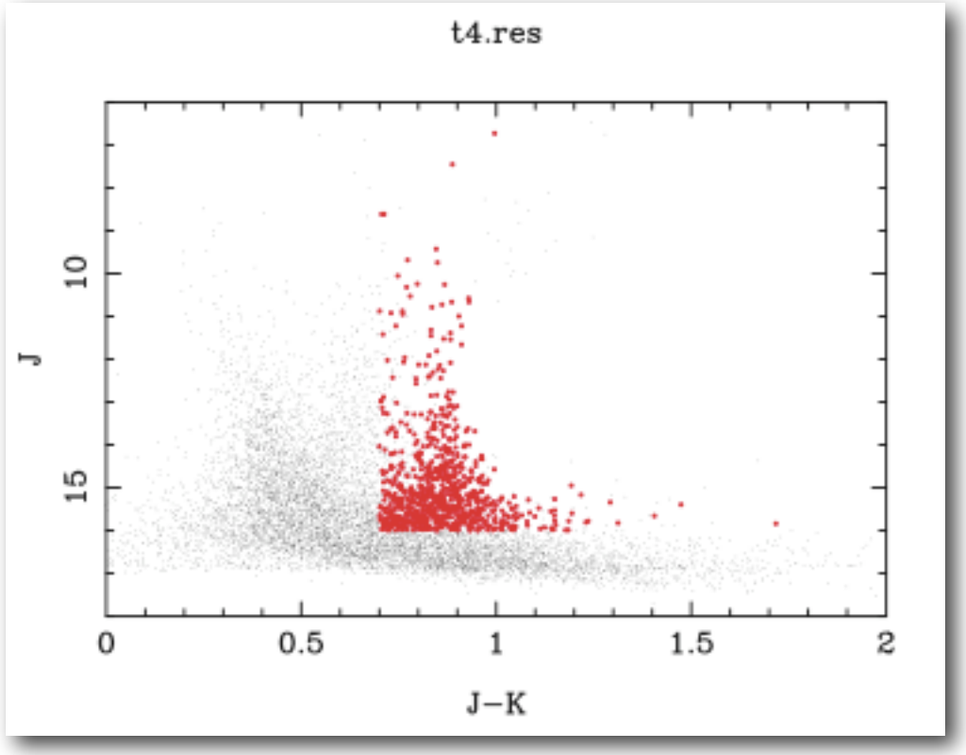
UKIRT+WFCAM

- Queue scheduled
- Now mounted 100% of the year
- We answered a call for campaign proposals released in Apr 2006
- We were awarded a total of 200 nights (2000 hours) with seeing>1.2 arcecs. 80 nights from 07B-09B
- Observations started summer 2007
- Extension proposal required for continuation beyond 09B



WTS Target Fields

- We tried to select fields that:
  - maximized stellar density
  - avoided overcrowding
  - minimized giant contamination
  - kept reddening to an acceptable level (<0.1)
  - will pass within ~15 of degs of zenith
- Survey strategy should:
  - maximize areal coverage , while
  - maintaining sufficient cadence (<15 mins)

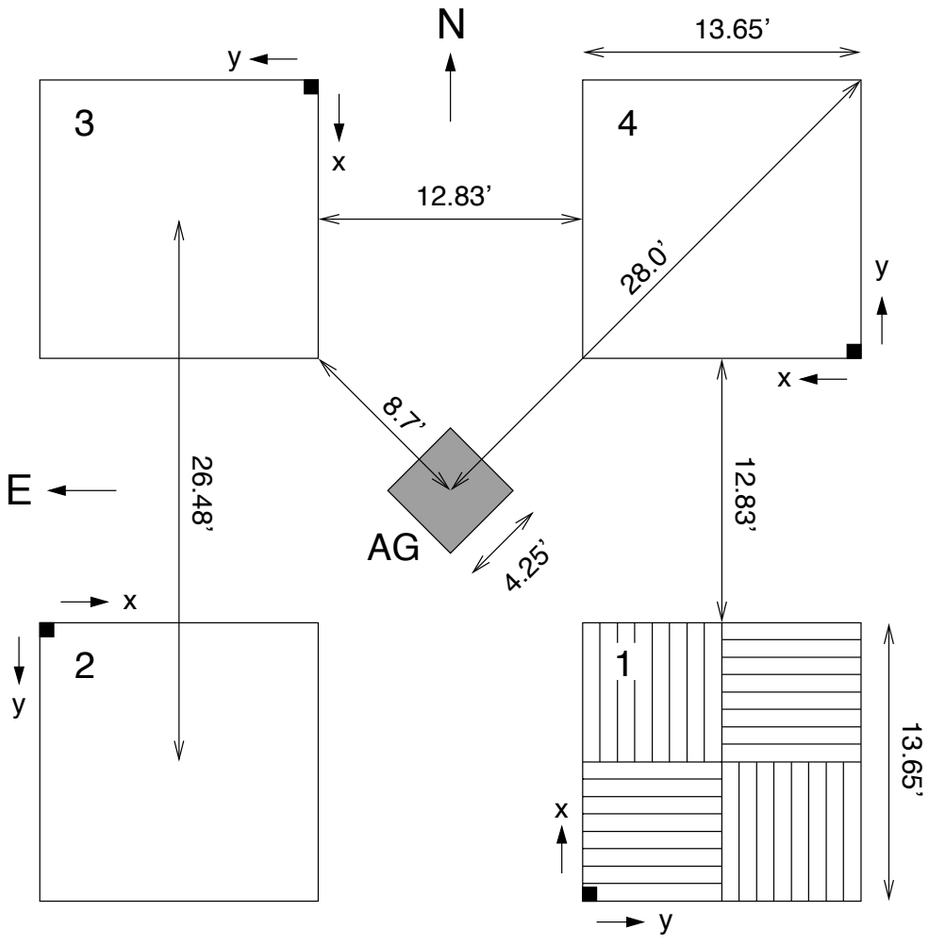


Around b=20, from 2MASS, expect:

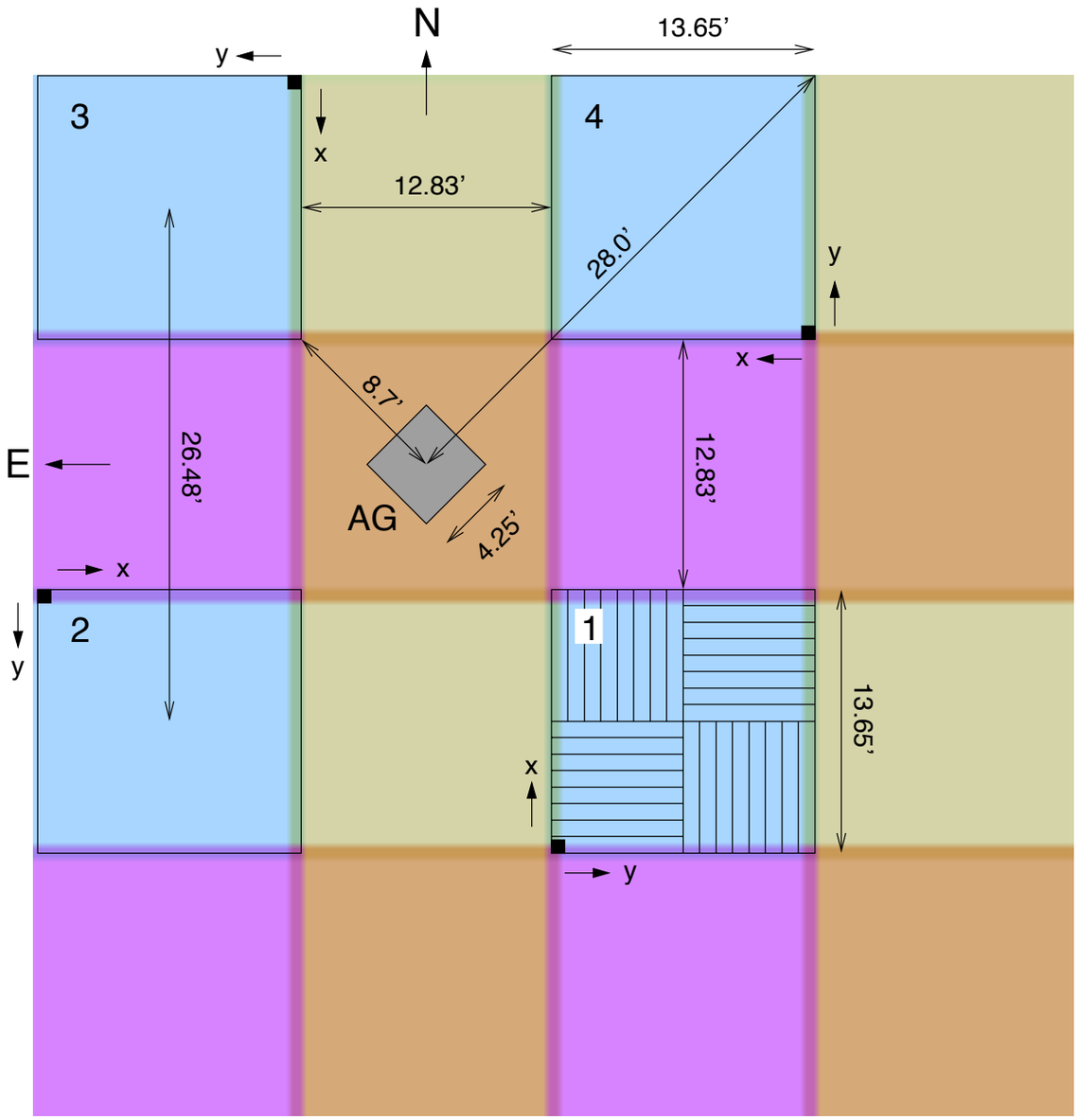
- ~200 dM stars to J=16/pawprint
- ~800/tile
- ~6400 in 4 fields

Pawprints, Tiles, Fields

Pawprints, Tiles, Fields



Pawprints, Tiles, Fields



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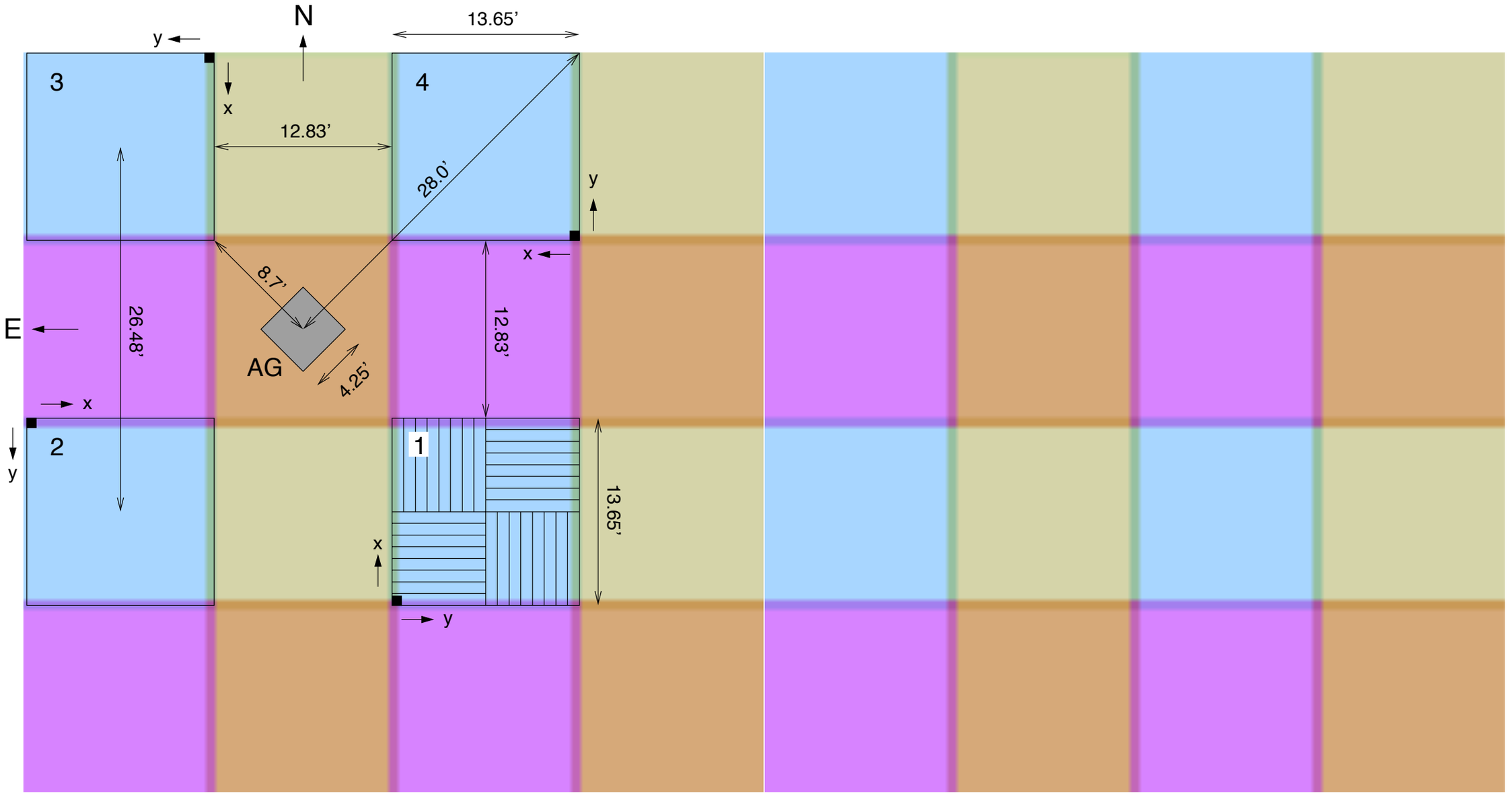

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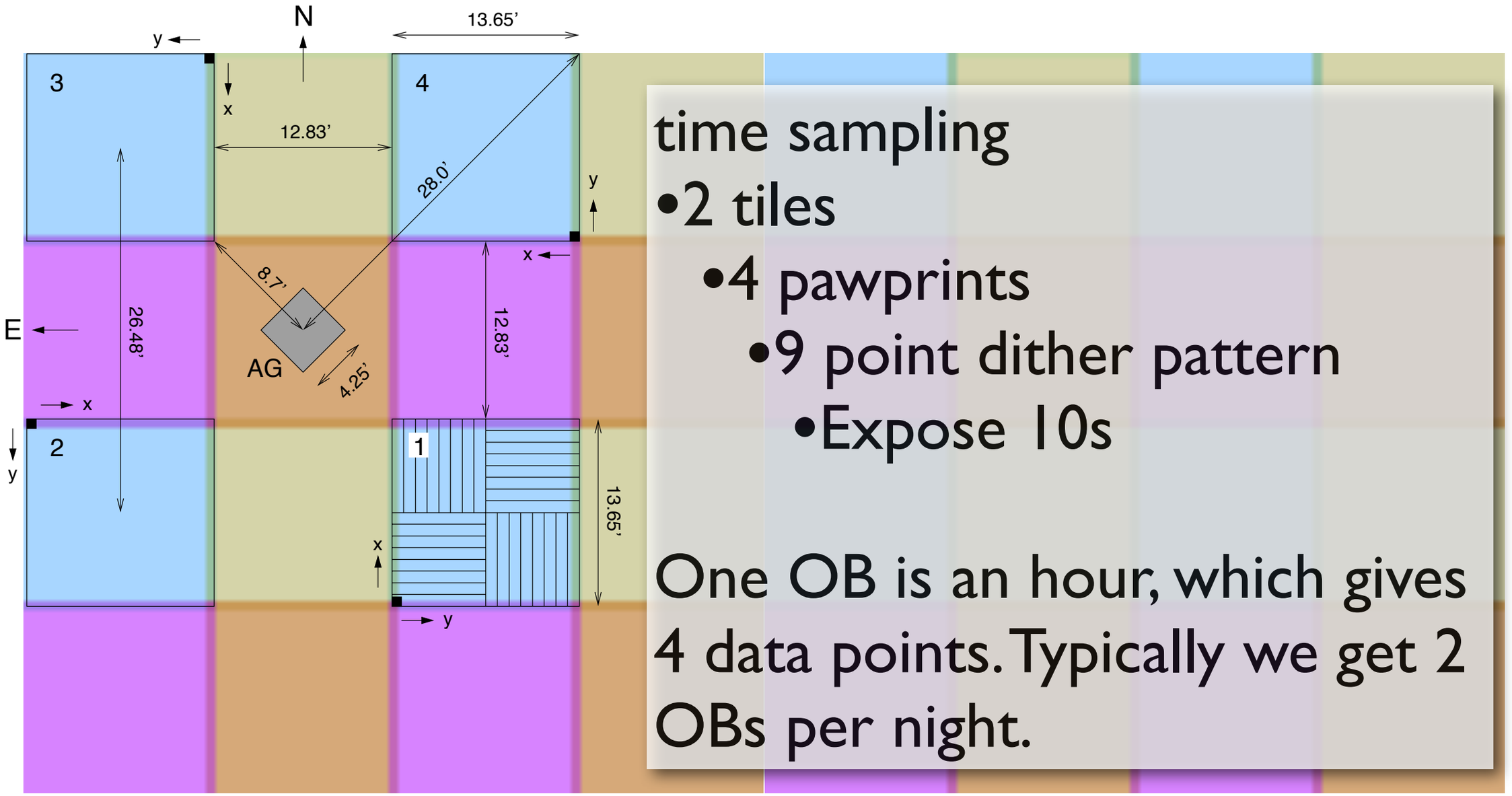
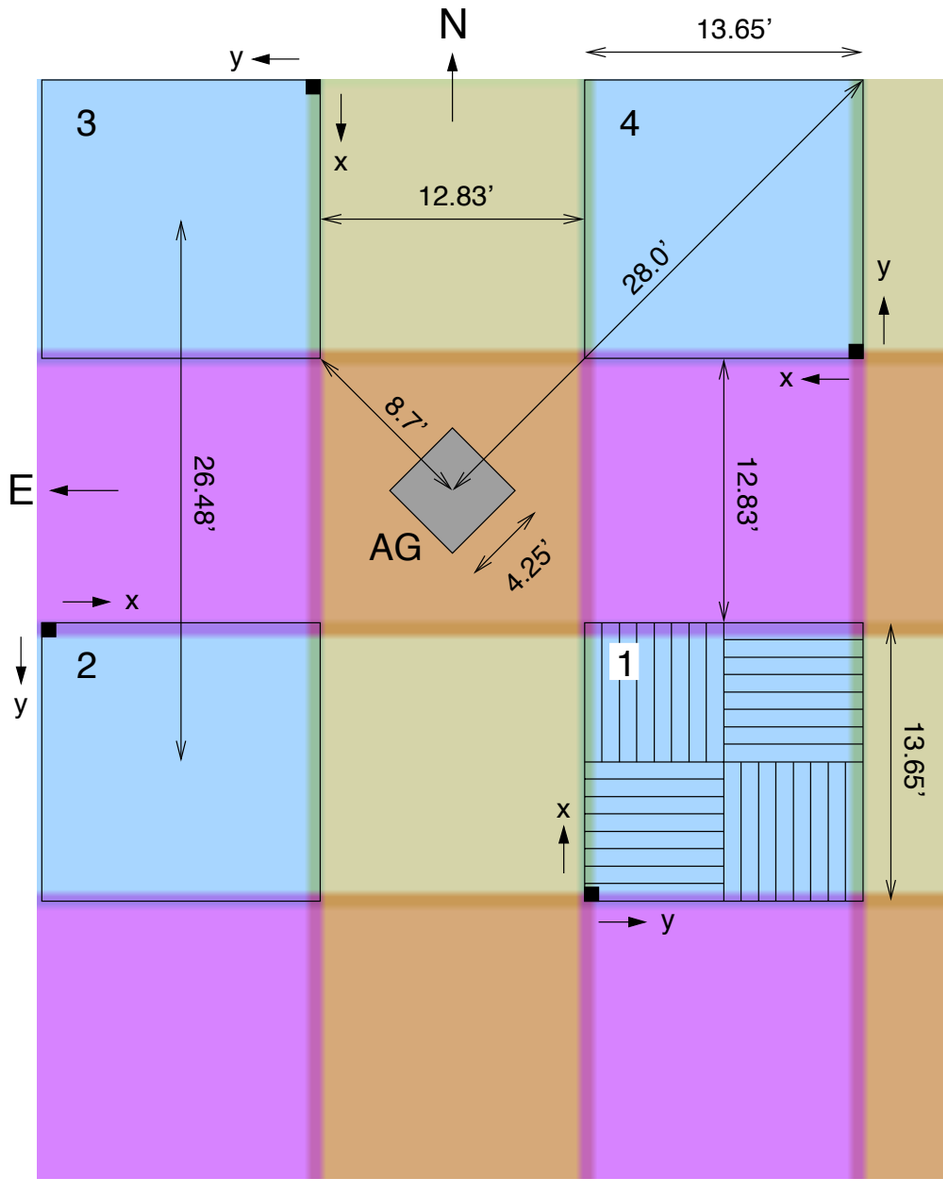


time sampling

- 2 tiles
  - 4 pawprints
    - 9 point dither pattern
      - Expose 10s

One OB is an hour, which gives 4 data points. Typically we get 2 OBs per night.

Pawprints, Tiles, Fields

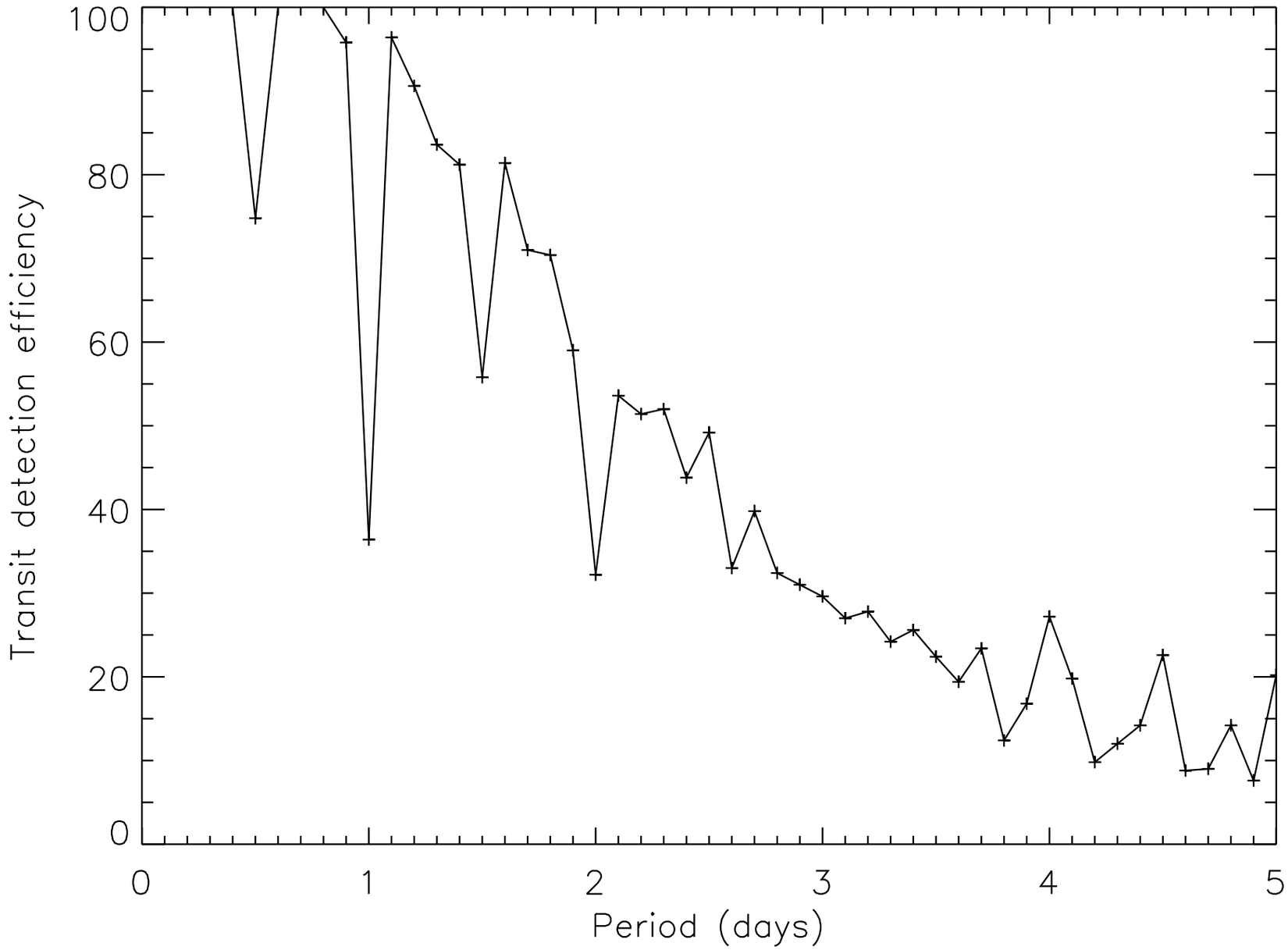


time sampling

- 2 tiles — 16m
  - 4 pawprints — 360s
    - 9 point dither pattern — 90s
      - Expose 10s — 10s

One OB is an hour, which gives 4 data points. Typically we get 2 OBs per night.

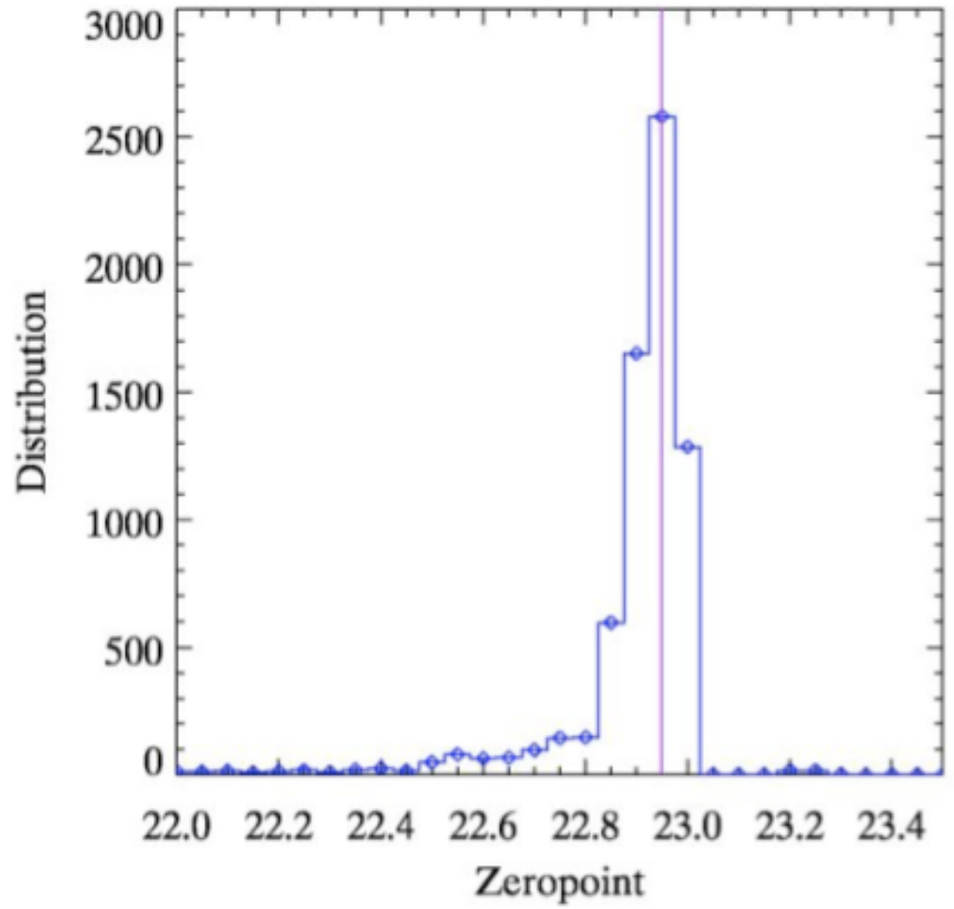
WTS Survey Sensitivity

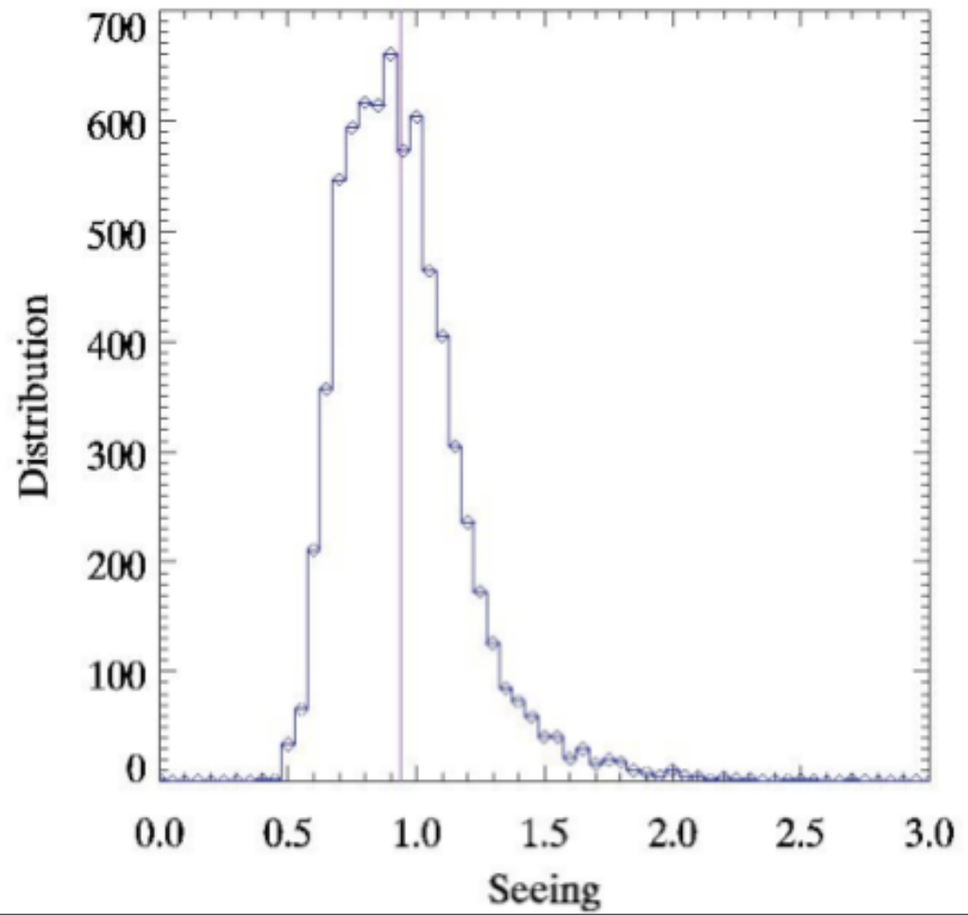


The **simulated** efficiency of the WTS transit detection for 200 hrs on each region. A confirmed transit detection requires that at least 4 separate transits are measured, and a total in-transit signal-to-noise of at least 10 is obtained.

Data Quality

Field	Number of stacked images per field
03.60 +39.12	127
03.60 +39.34	125
03.62 +39.12	127
03.62 +39.34	125
03.68 +39.12	126
03.68 +39.34	124
03.70 +39.12	124
03.70 +39.34	124
07.05 +12.83	105
07.05 +13.05	105
07.06 +12.83	105
07.06 +13.05	103
07.11 +12.83	103
07.11 +13.05	103
07.12 +12.83	104
07.12 +13.05	104
17.21 +03.63	180
17.21 +03.85	178
17.22 +03.63	182
17.22 +03.85	179
17.26 +03.63	178
17.26 +03.85	178
17.28 +03.63	177
17.28 +03.85	177
19.53 +36.38	476
19.53 +36.60	480
19.55 +36.38	476
19.55 +36.60	471
19.60 +36.38	472
19.60 +36.60	471
19.62 +36.38	470
19.62 +36.60	468





Processing steps

prepare - ingest, check, MEF, check, index, select, preview, process

linearity - dome sequences, non-linearity < 1%

dedark - combine darks, illumination-dependent reset anomaly

flatfield - weekly/monthly twilight flats, stable, internal gain corr

curtain - +/-5 ADUs, ~ 4-quadrant symmetry, bilinear removal

skysub - group master skys by time and MSB if possible

combine - interleaves, compute shifts and stack dithers

catalog - detect and parameterise objects

classify - morphological classification

astrom - astrometric calibration per detector

photom - photometric calibration per pointing

check - examine QC, reject bad products, random inspection

Processing: locating the apertures

- the error in the photometry due to aperture placement goes as:

  $\delta F/F \approx 0.119\Delta^2/\sigma^2 \approx$ mmag

  (where Δ is the error in the position of the aperture and σ the s:n of the source, typically $\Delta \approx 0.1\sigma$)

- default placement using source centroid adds mmag jitter, plus additional blending issues.

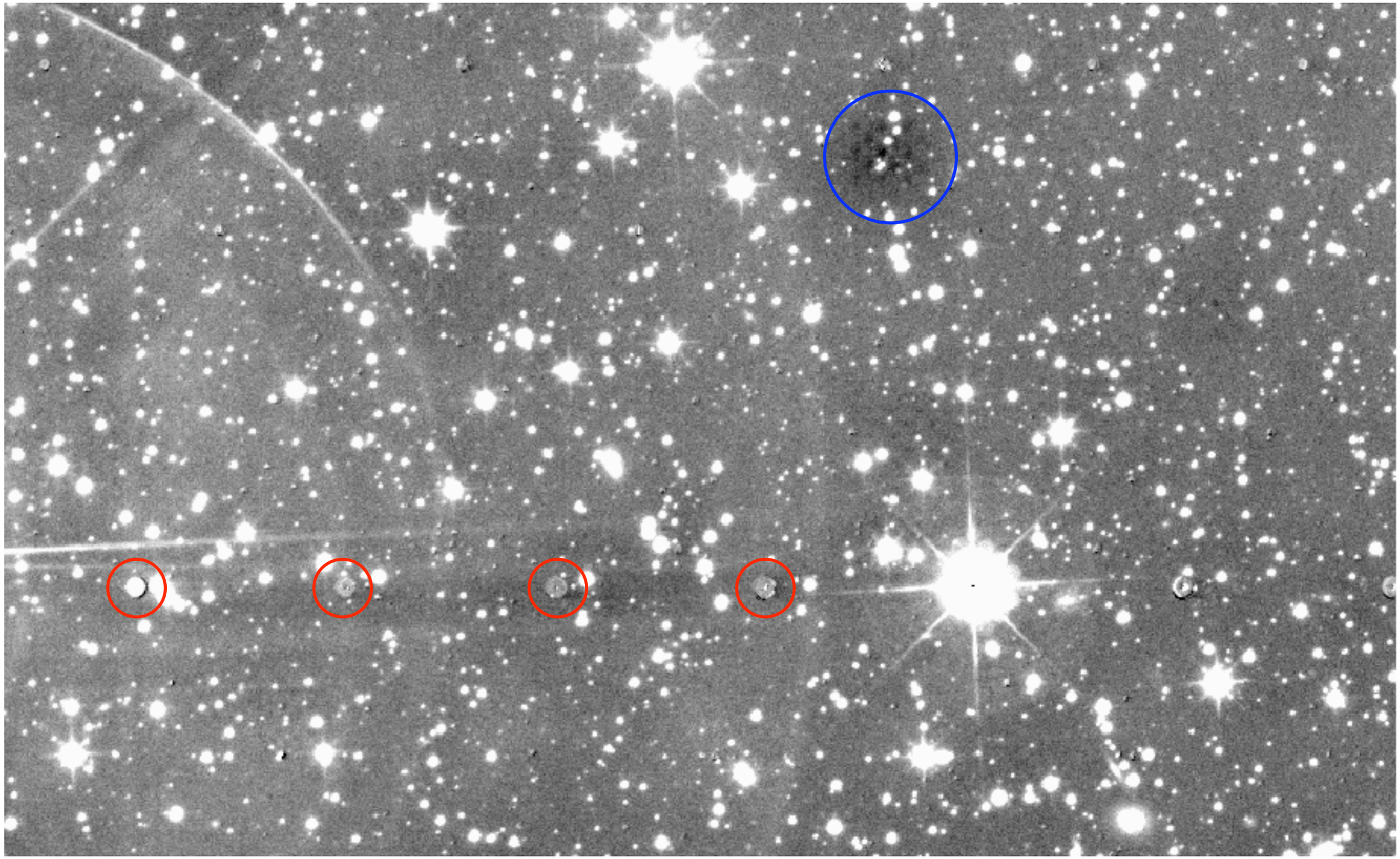
- instead we measure the relative positions of the sources in a *master* frame, and compute the transformation to each separate observed field.

- more important in undersampled data.

Processing: Forming the Master

- We stack around 20 of the best seeing frames to form a master image (per pawprint)
- We then generate a master catalogue
- And revise the astrometry and photometry
- This catalogue provides the source list for lightcurve generation
- Aperture photometry is measured for each source in each image

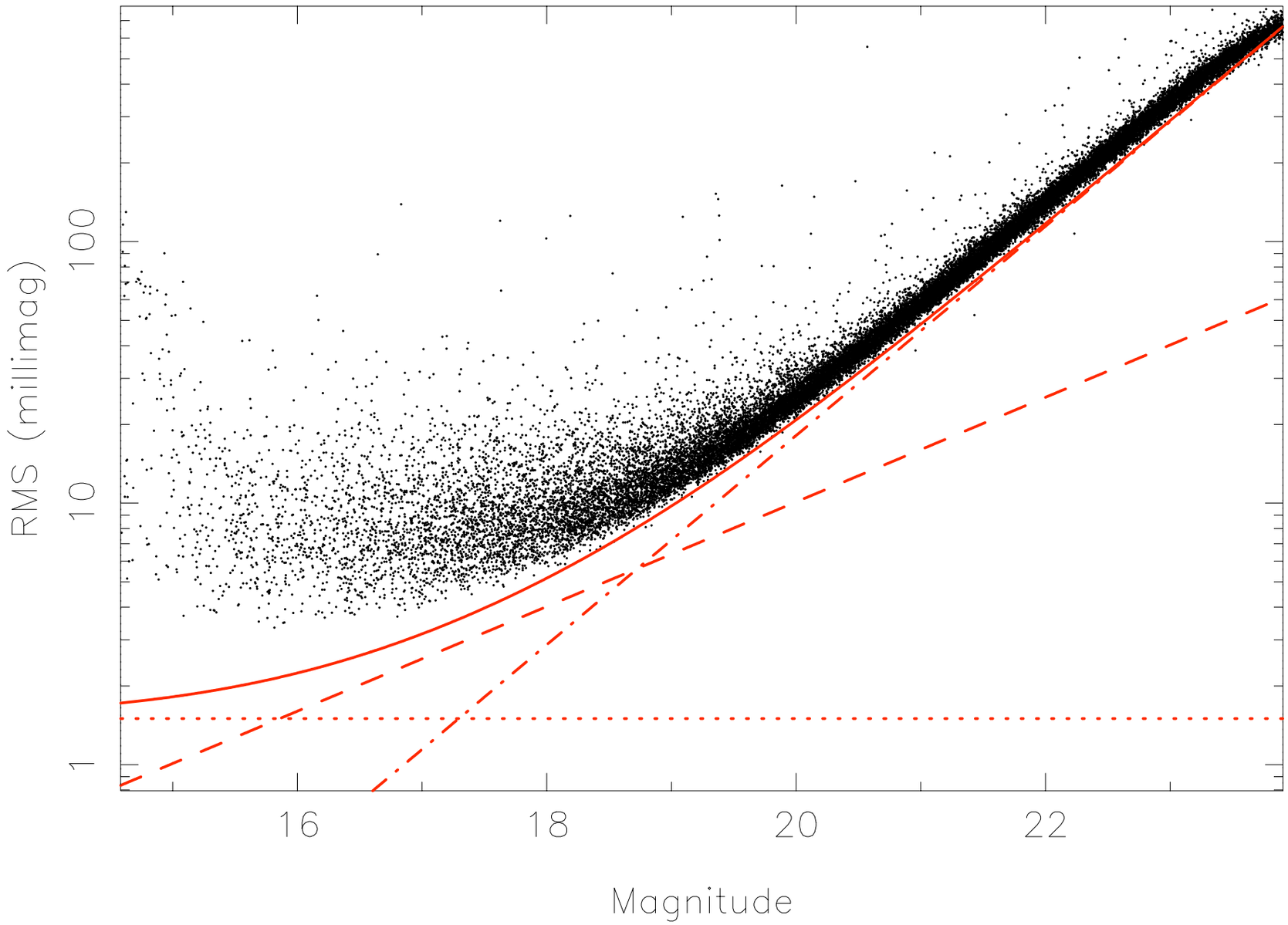
Processing: Features



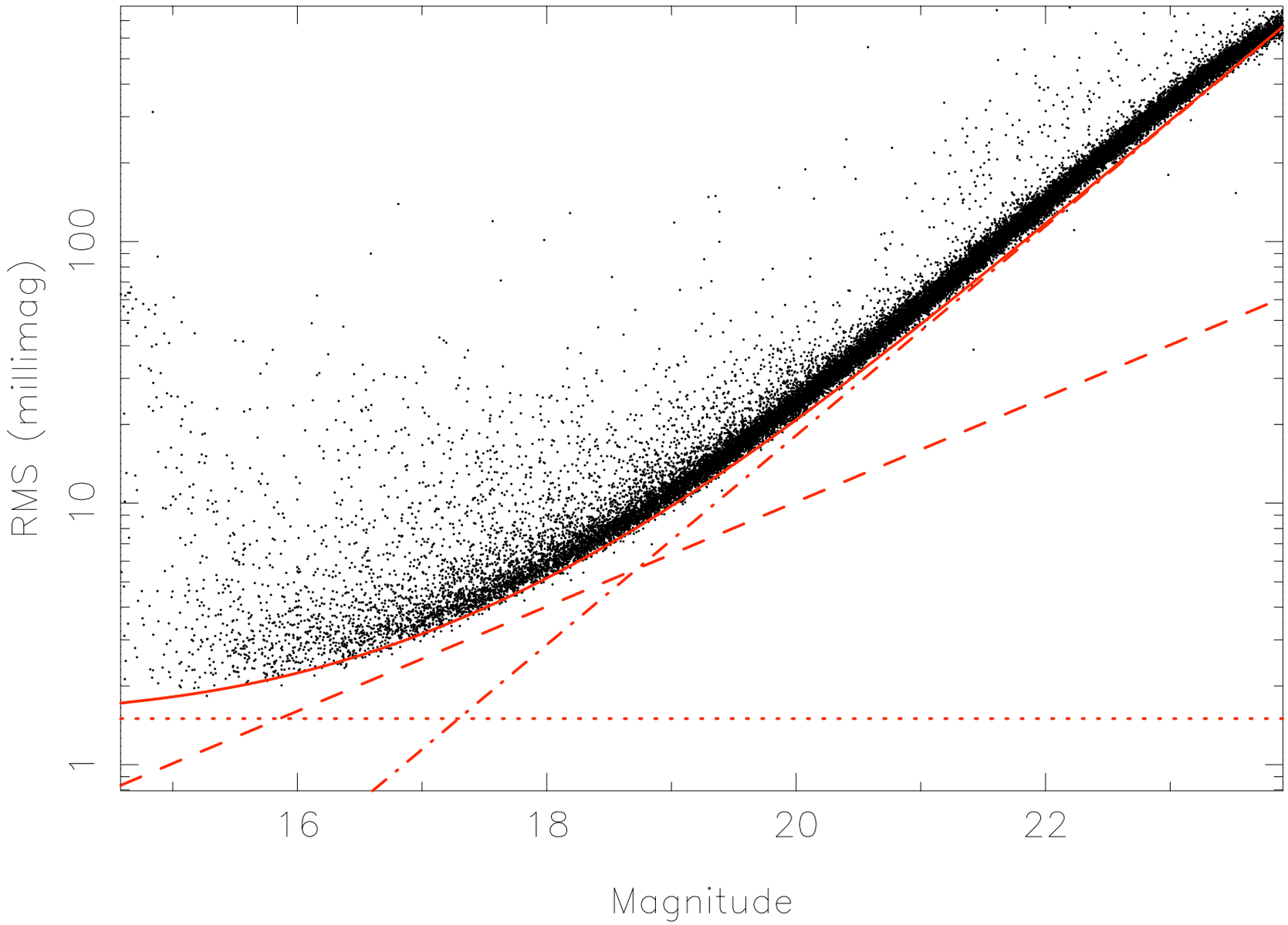
Photometry: size of the apertures

- Optimum signal-to-noise is achieved using the rule of thumb: that the aperture radius should match the stellar FWHM
- Complicated by:
  - if the aperture is too big, blending becomes an issue
  - bright stars can afford bigger apertures
- Best of both worlds solution is to use a variable aperture
- Modification is to use the aperture which minimises the rms on a per-source basis.

aperture: fixed



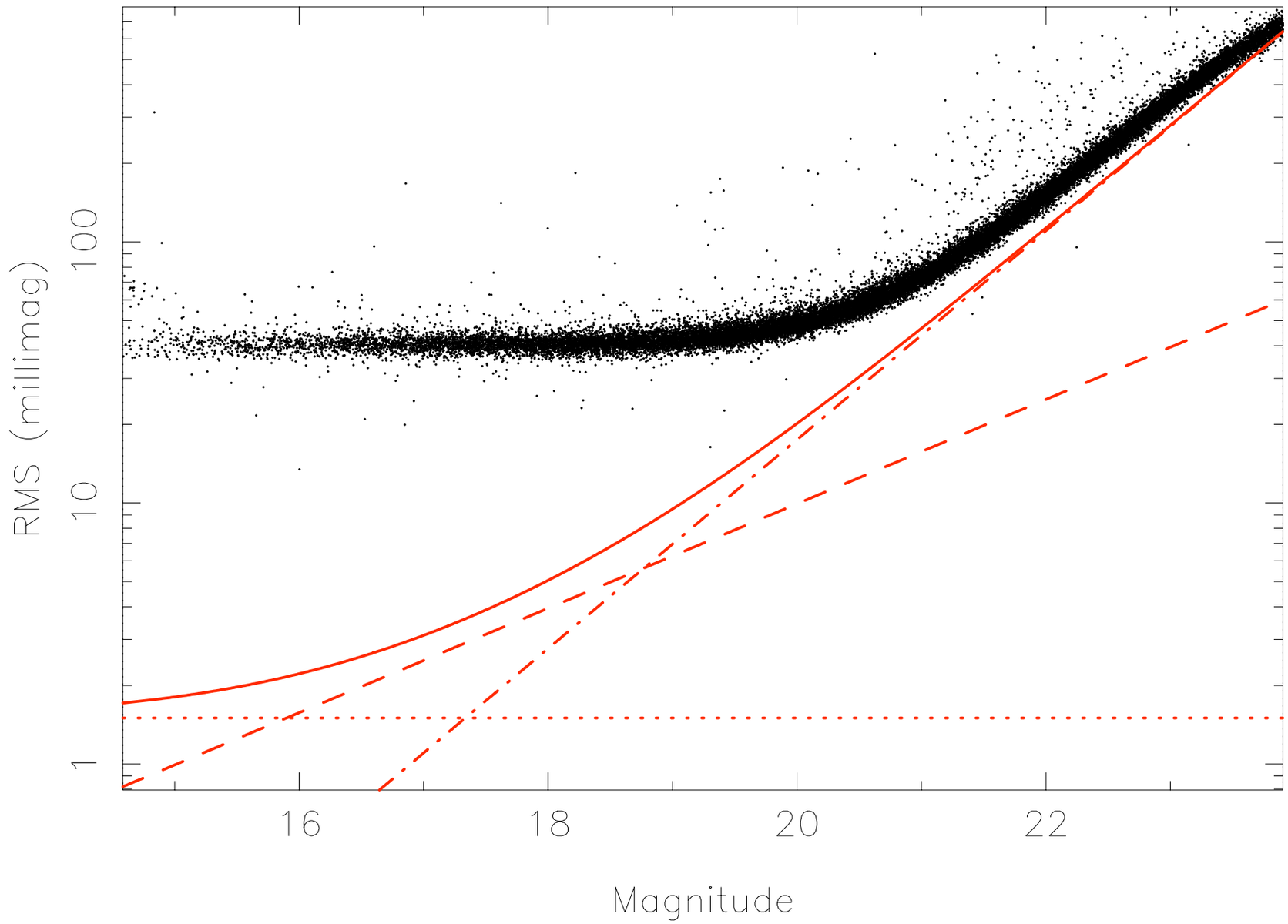
aperture: variable



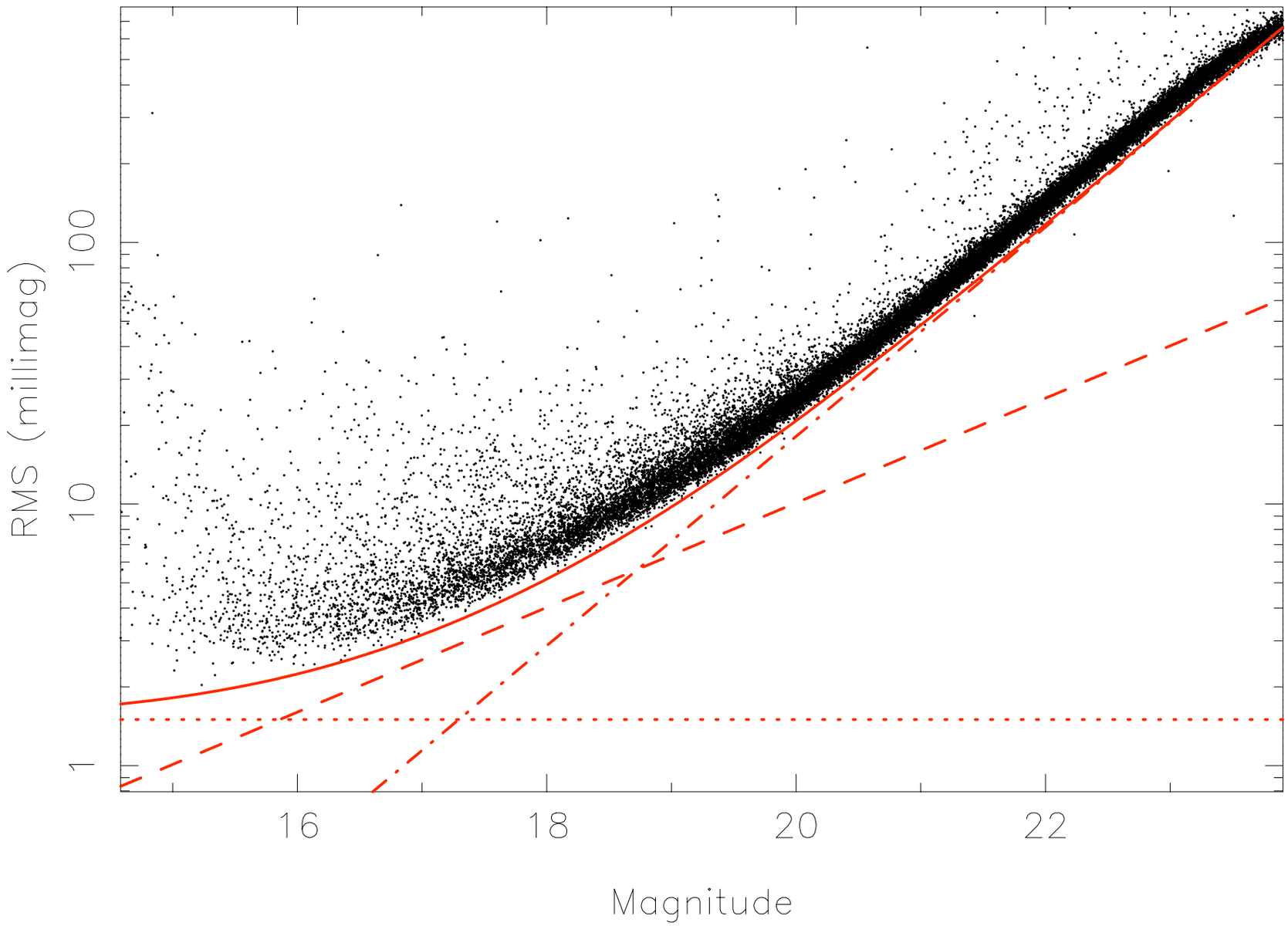
Processing: Making the lightcurves

- The flux for a star in each frame needs to be normalized to account for variable extinction, instrument throughput and so on.
  - simple case - use the median flux for selected stars as a linear offset
  - modified to allow for a quadractic fit to the spatially resolved median flux (plenty stars)
  - thus allow for differential extinction, varying pixel scale, intra-pixel sensitivity etc...

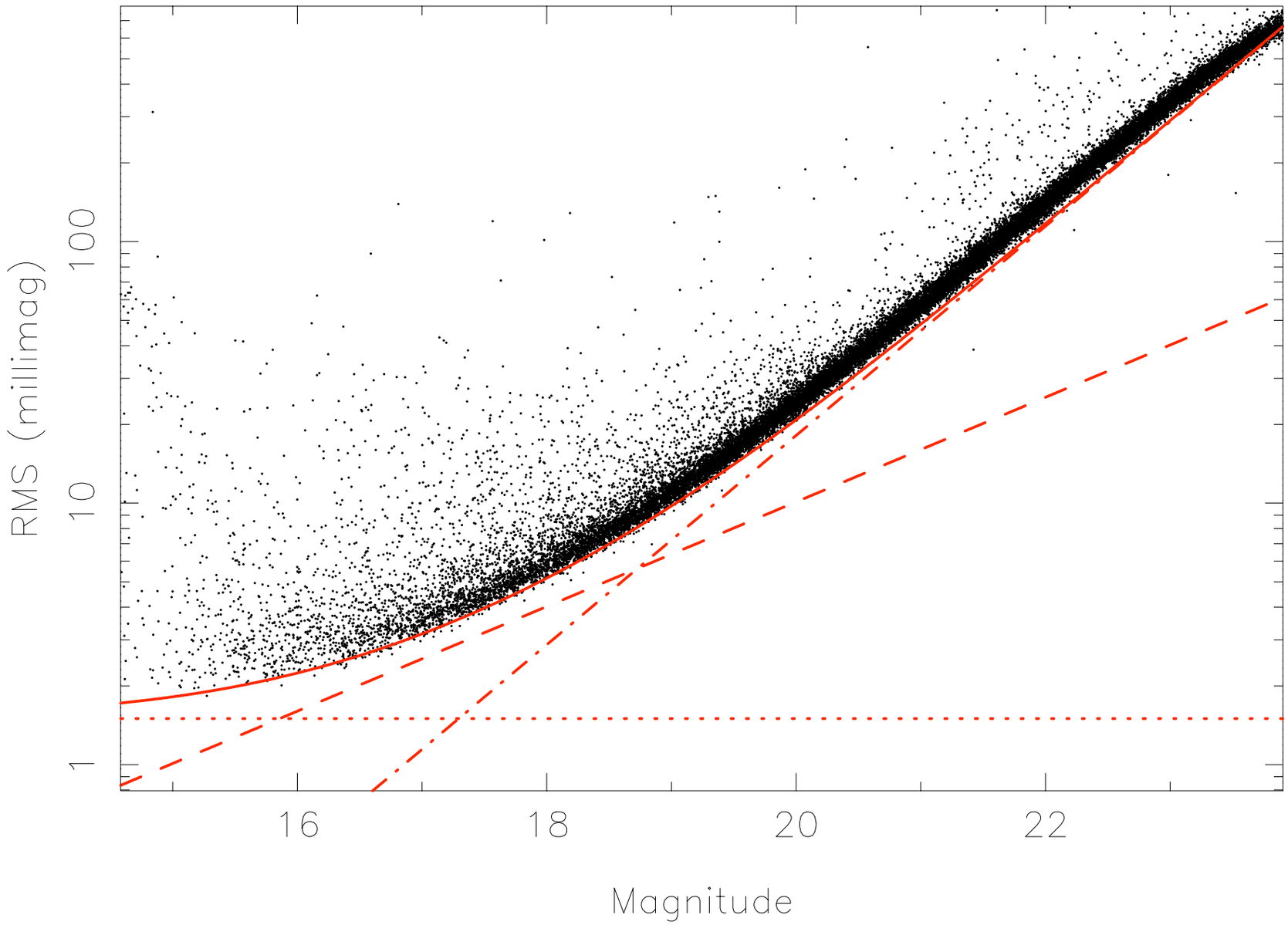
frame correction: none



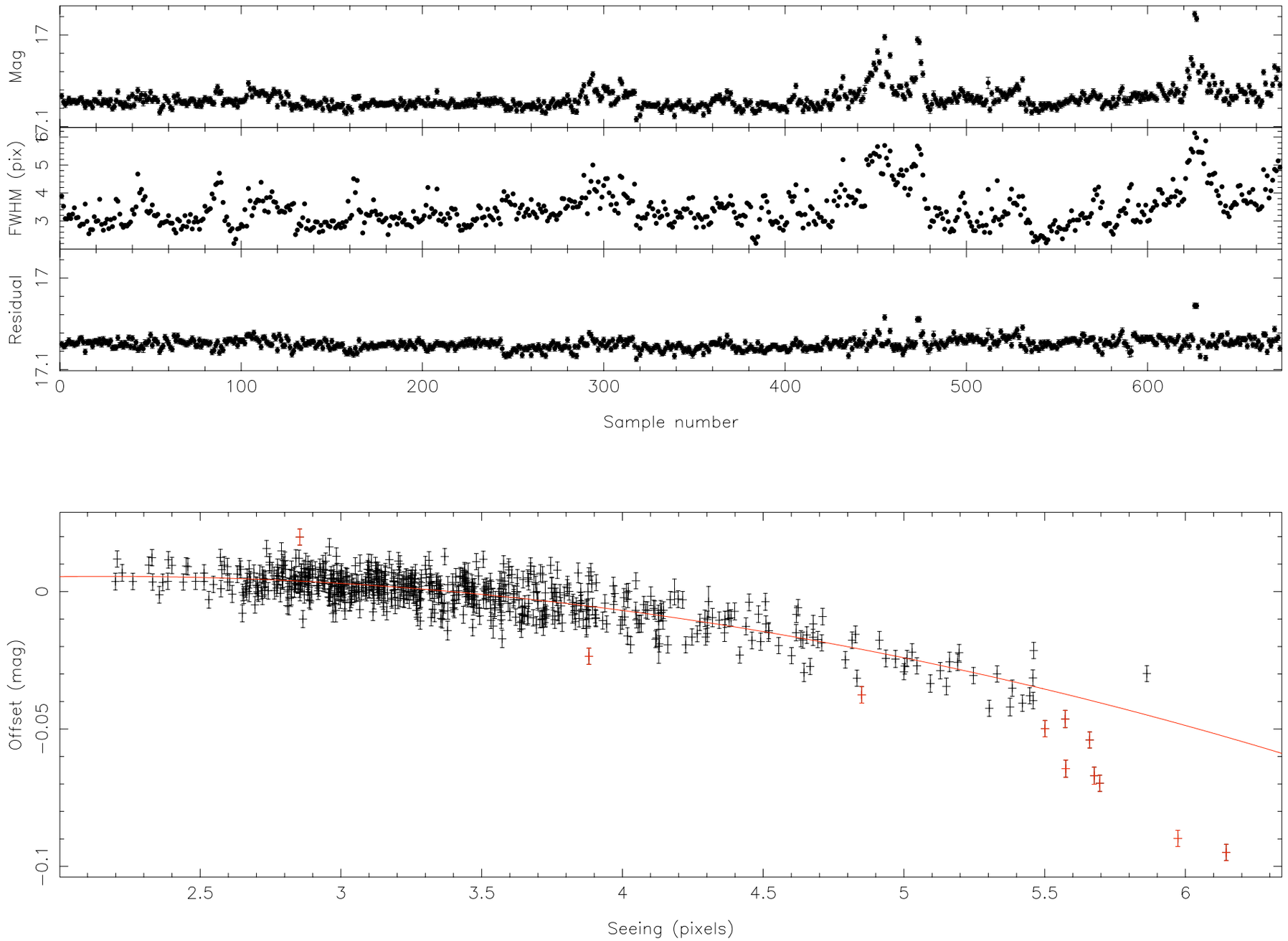
frame correction: constant



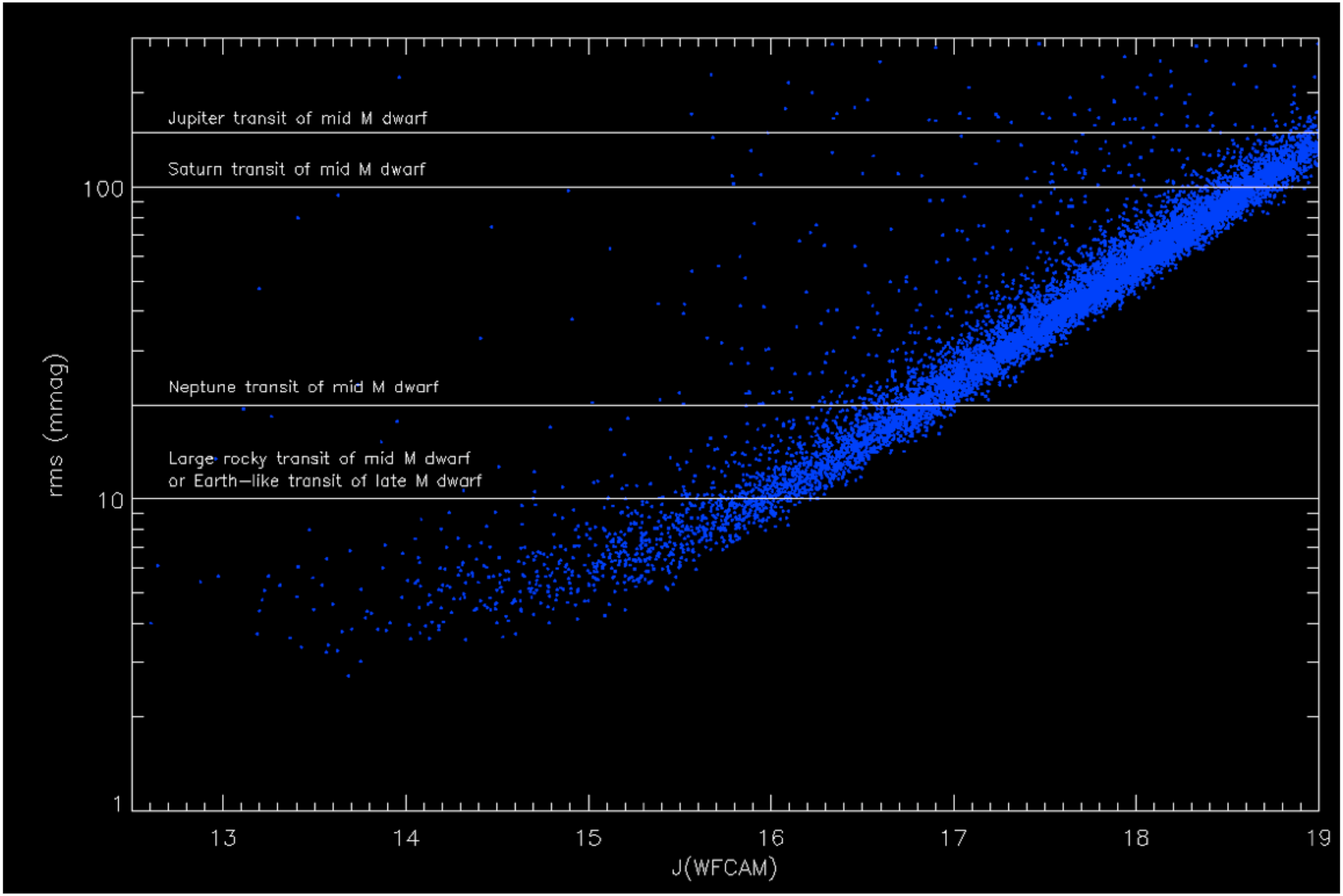
frame correction: quadratic



Processing: seeing correction



WTS rms


Jupiter transit of mid M dwarf
Saturn transit of mid M dwarf
Neptune transit of mid M dwarf
Large rocky transit of mid M dwarf
or Earth–like transit of late M dwarf
100
10
1
rms (mmag)
13
14
15
16
17
18
19
J(WFCAM)

Proposal for extension of the WTS

1. False alarm rate - both international reviewers were concerned that the false alarm rate in this type of imaging survey would be prohibitive. The Board accepts this as a risk for the period to 2009, but expects to see hard evidence that the false positive rate is under control should the team propose an extension of the project.

2. Number of predicted transits - the Board recognise that there is a risk that no transits will be found. Before considering extending the WTS the Board will need observational evidence that the claimed sensitivity has been reached.

3. Additional time domain science goals - while not the primary goal of the WTS, including some indication of the additional science areas that can be addressed with the data would be helpful.

due late 2009, currently reports sent every 6 months