The VVV-SkZ_pipeline: How to get automatic PSF-fitting photometry from the VVV Survey

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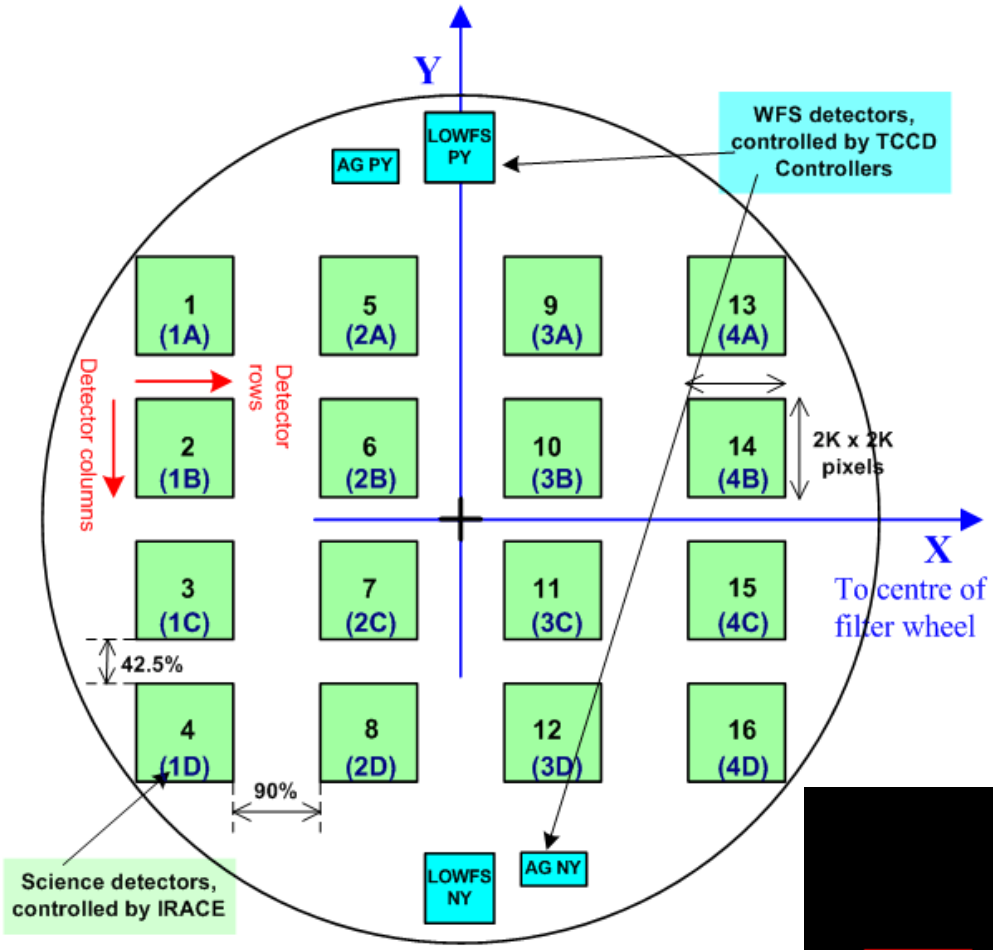
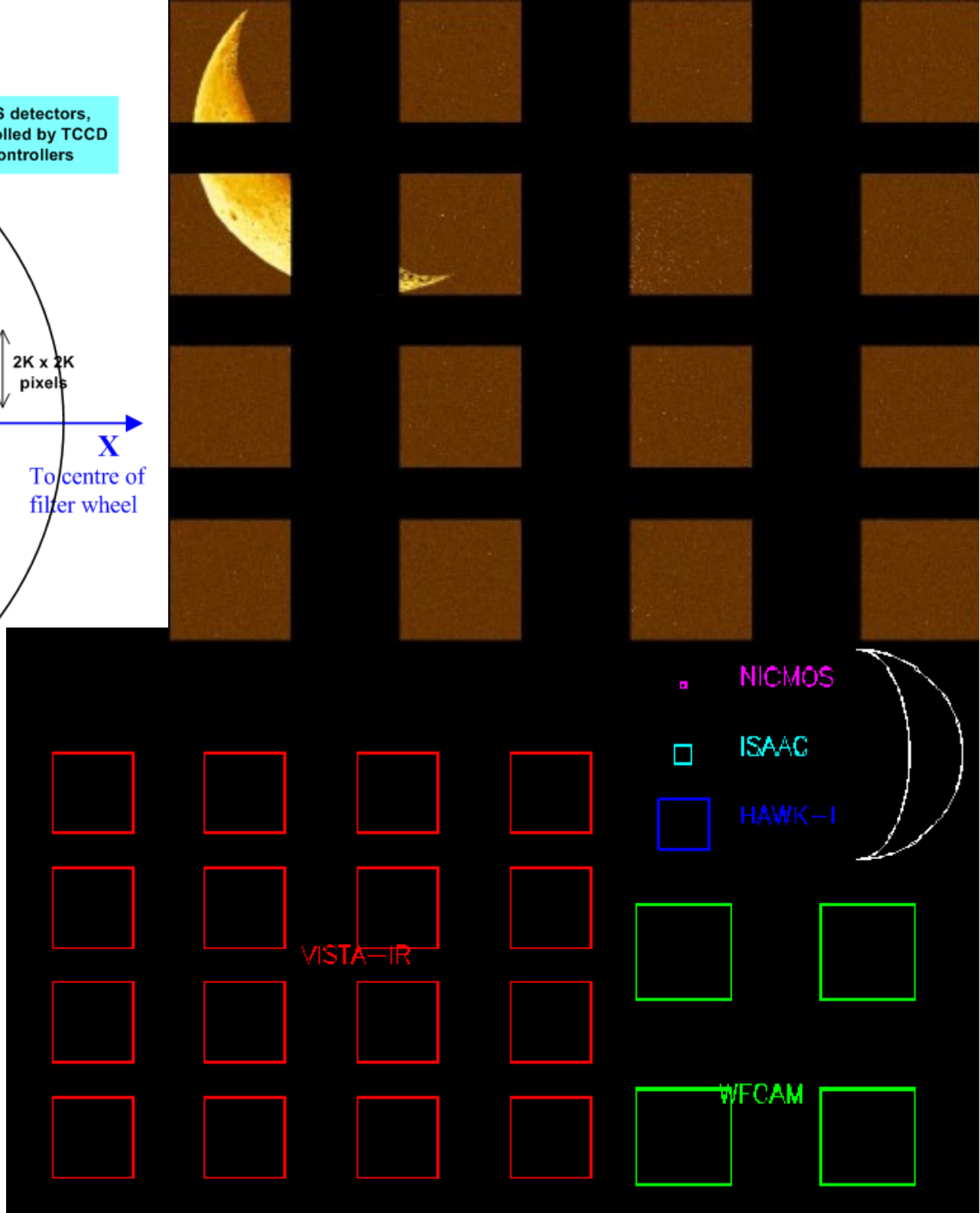
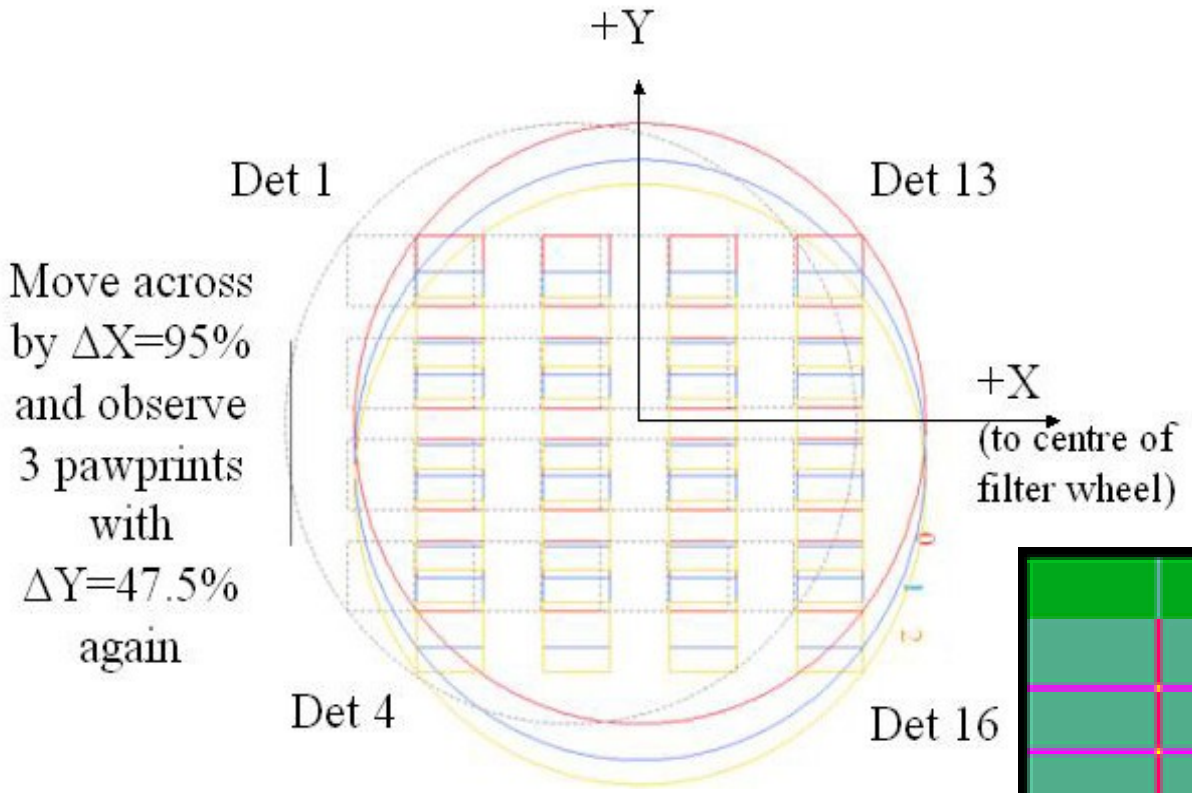

Y
LOWFS PY
AG PY
WFS detectors, controlled by TCCD Controllers
1 (1A)
5 (2A)
9 (3A)
13 (4A)
2 (1B)
6 (2B)
10 (3B)
14 (4B)
2K x 2K pixels
Detector columns
Detector rows
X
To centre of filter wheel
3 (1C)
7 (2C)
11 (3C)
15 (4C)
42.5%
4 (1D)
8 (2D)
12 (3D)
16 (4D)
90%
Science detectors, controlled by IRACE
LOWFS NY
AG NY

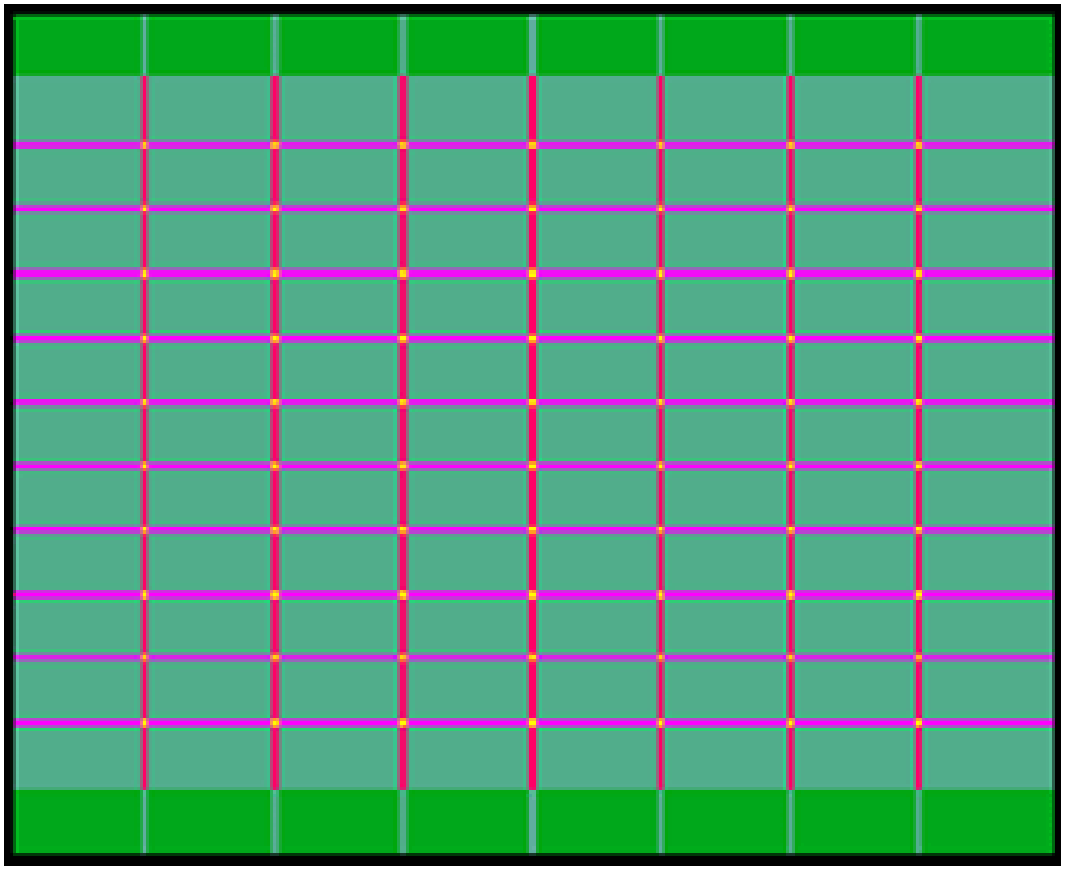

NICMOS
ISAAC
HAWK-I
VISTA-IR
WFCAM

Pawprint

How to get a tile: the sum of 6 pawprints

=96 images





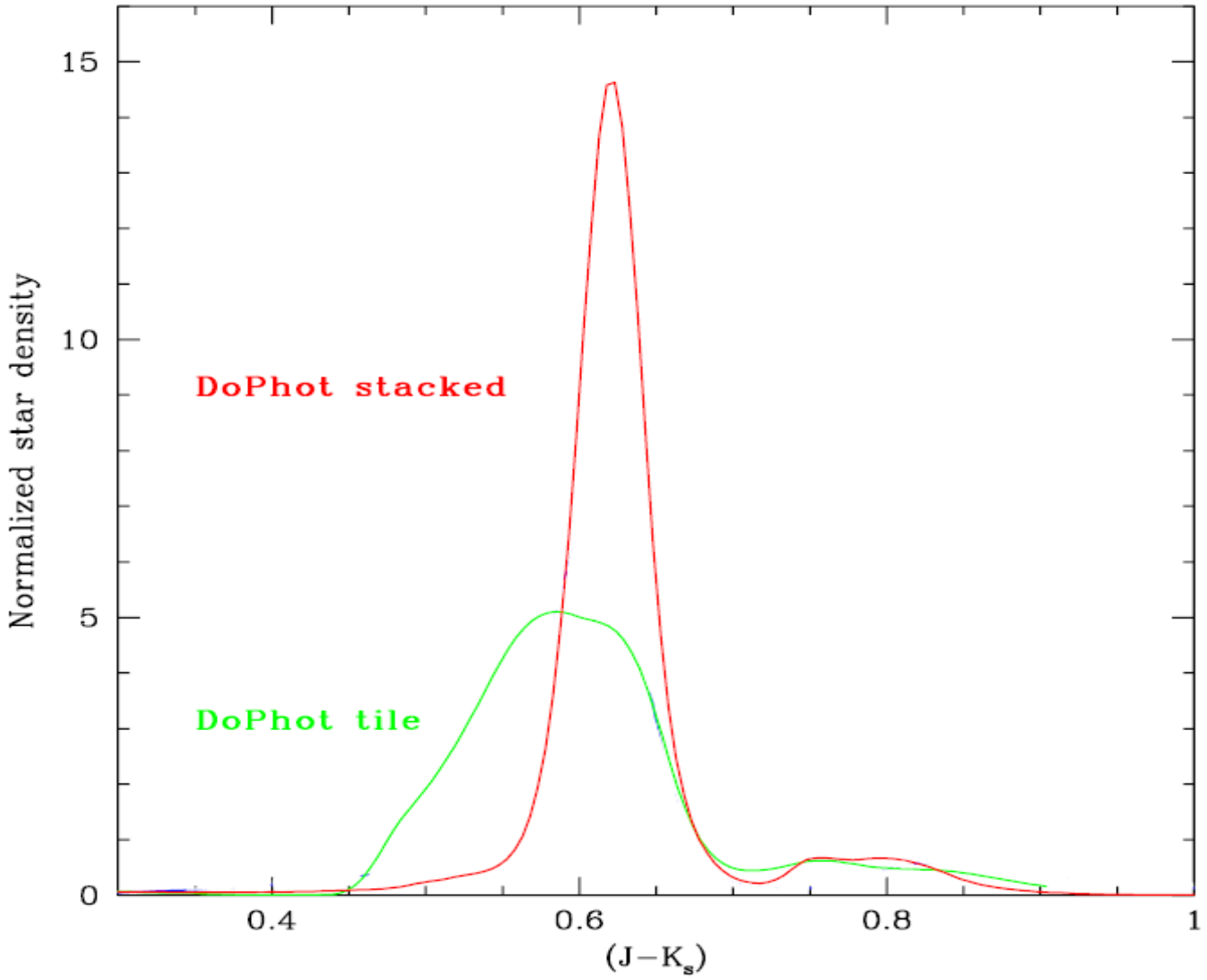
Main characteristics

- Automatic elaboration with minimal interaction
- Accurate calculation of the PSF
- Master list of stars from stacking of several images
- Astrometry from WCS
- Spurious detections cleaning procedure

Main files that you need to prepare

- **Pawprints** in not compressed format (.fits)
- **VVV-SkZ_pipeline.opt** : overall option file of the pipeline
- **VVV-input** : input file where you said for each pawprint how to name the extracted images and which chips you want it to extract
- Catalog of standard stars
- (**login.cl** : the initialization file of IRAF)

Why PSF-fitting photometry on pawprints?

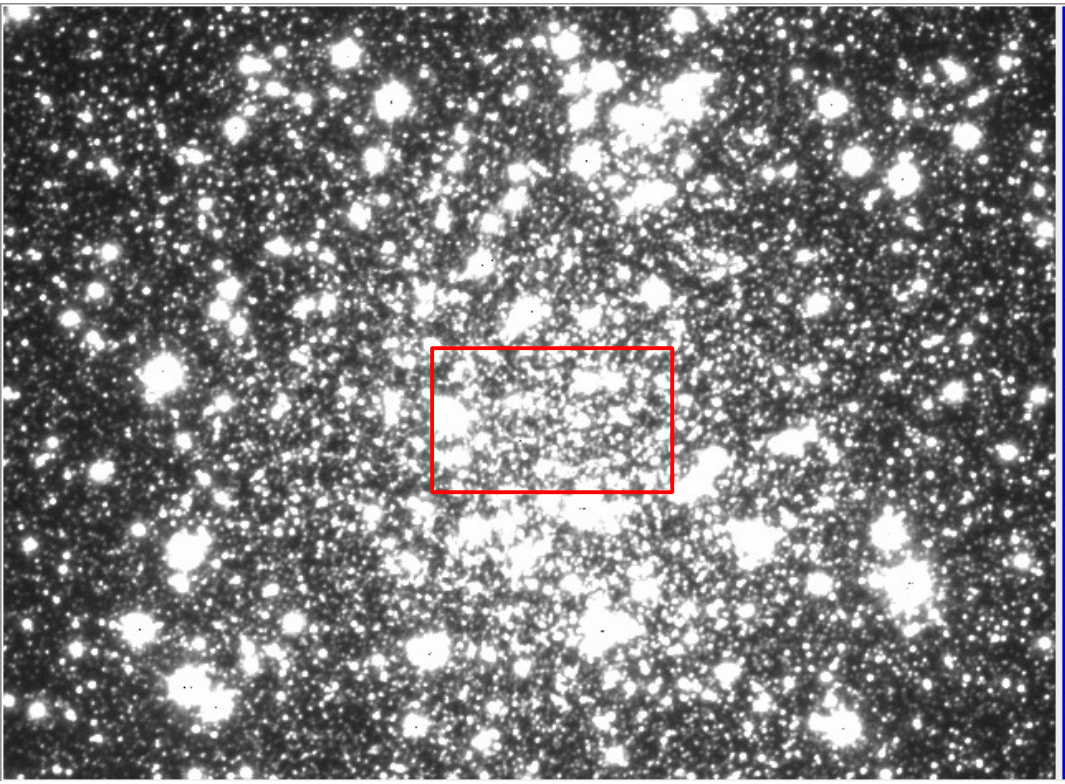


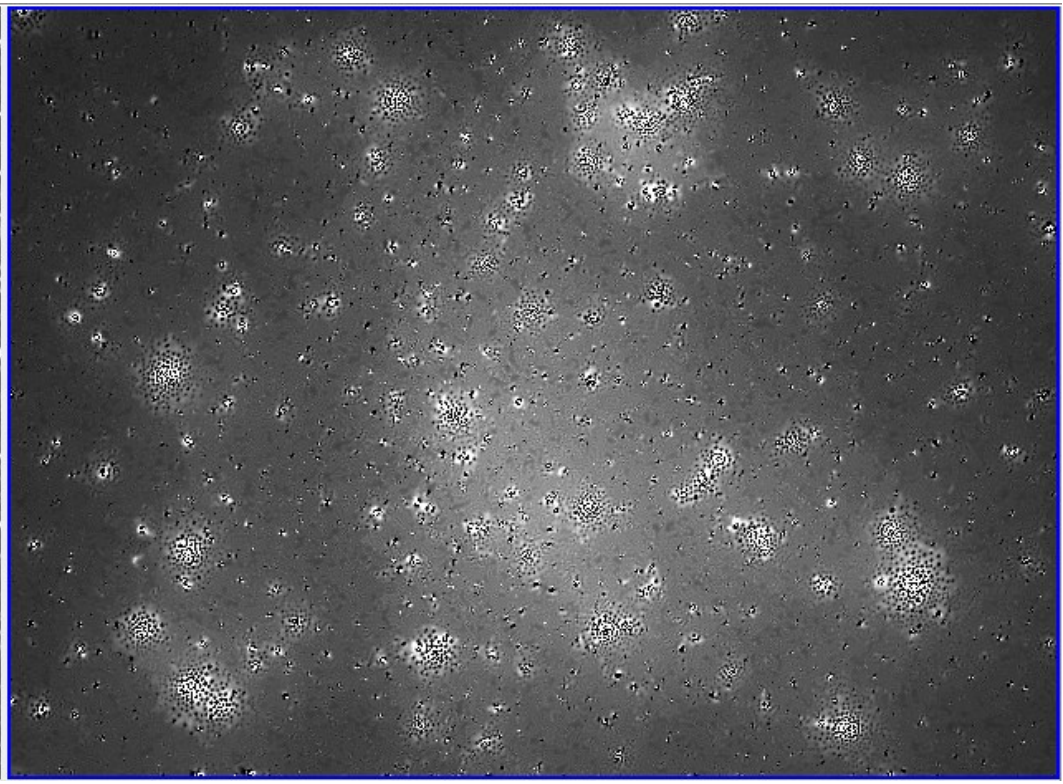
Normalized star densities as a function of color at K=13.5, M22 (Alonso-Garcia 2011)

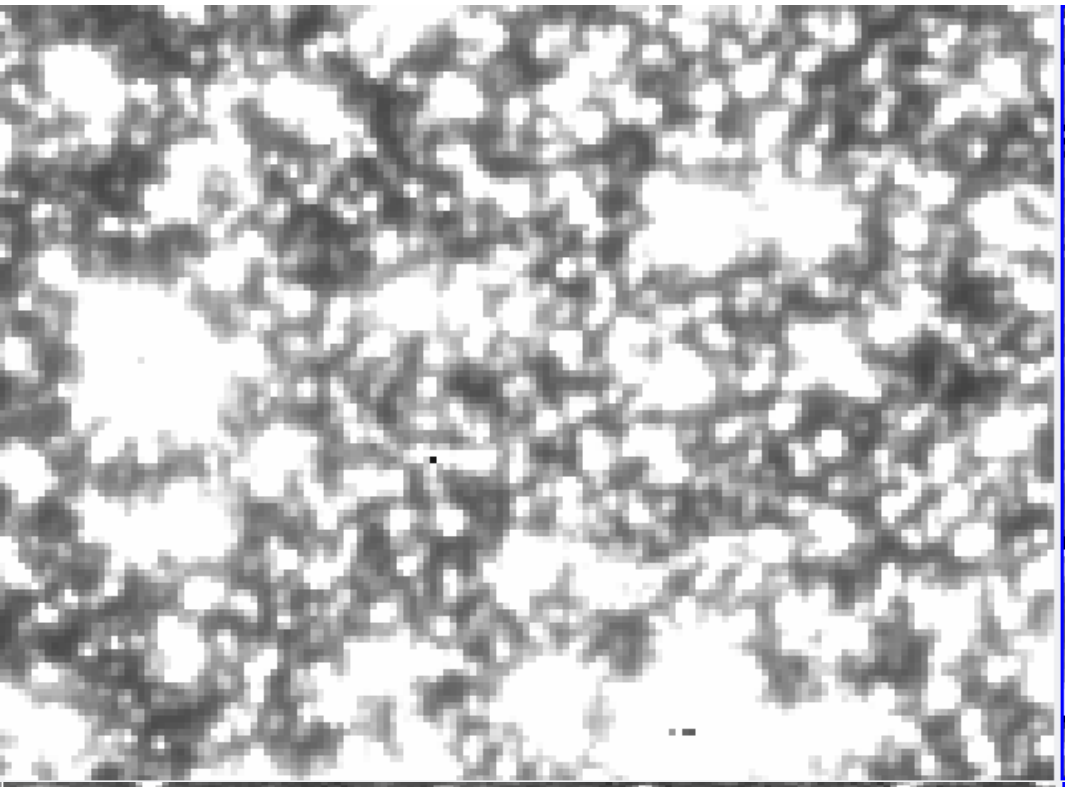
Main structure of the pipeline

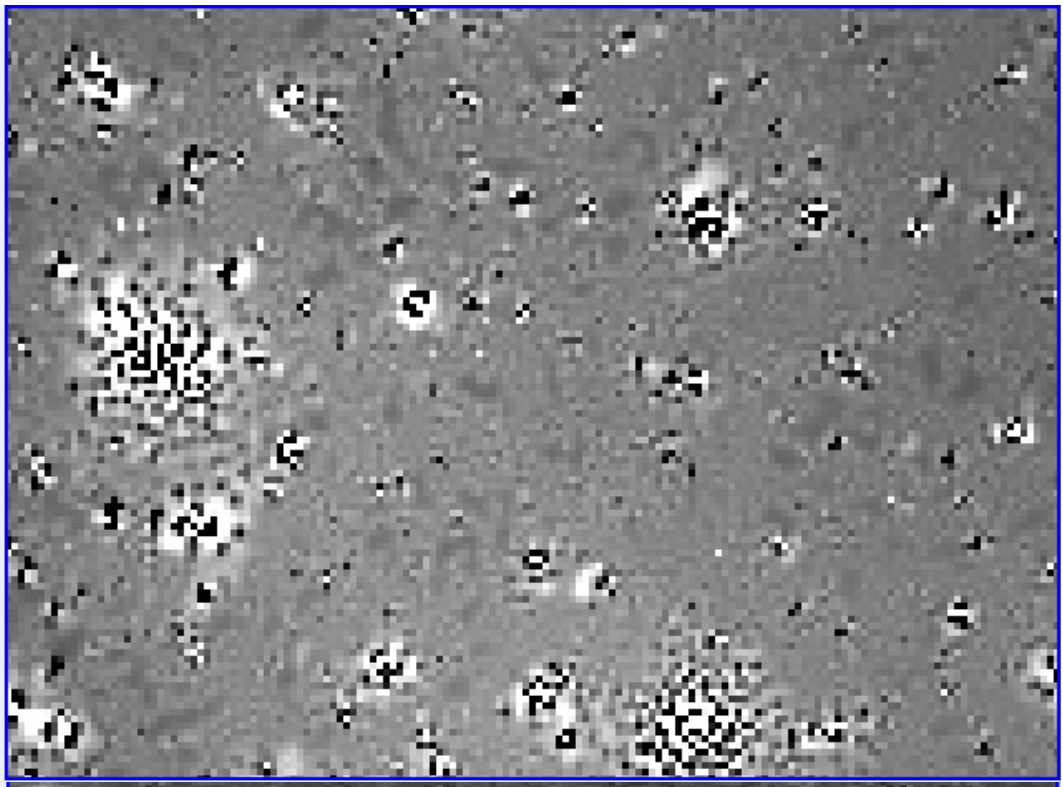
- **VVV-GetImgInfoHdr.pl** : it extracts images from the pawprints and the needed info from the headers;
- **VVV-DpAls4psf.pl** : it calculates the PSF in 5 iteration (VAR from -1 to 2) and produces a preliminary psf-fitting photometry with allstar;
- **VVV-AllframeMntg.pl** : it stacks the images;
- **VVV-DpAlsMnt.pl** : it creates the master list of the sources using the stacked image in 4 iterations;
- **VVV-AllframeLast.pl** : it runs allframe with list of “all” the sources;
- **VVV-MetrCalibMatch.pl** : it uses the WCS to astrometrize, cleans for spurious detections, uses the given catalog to calibrate each image, and then matches all the bands in a single catalog.

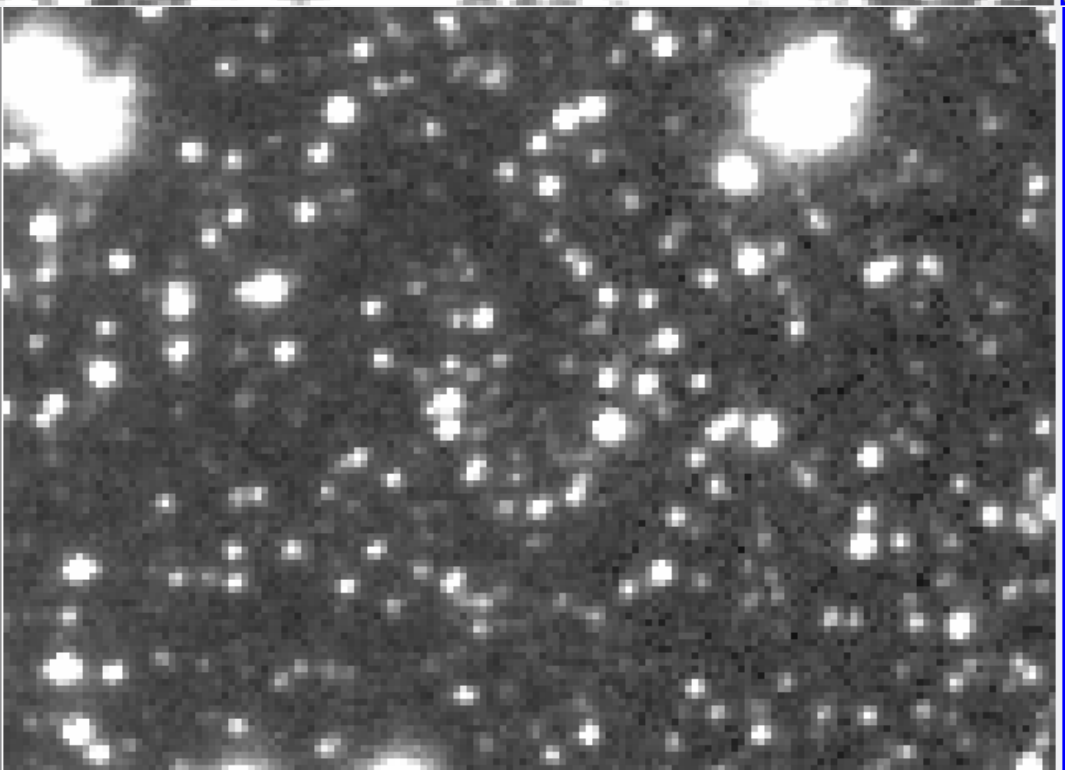
Example of montaged image of the cluster

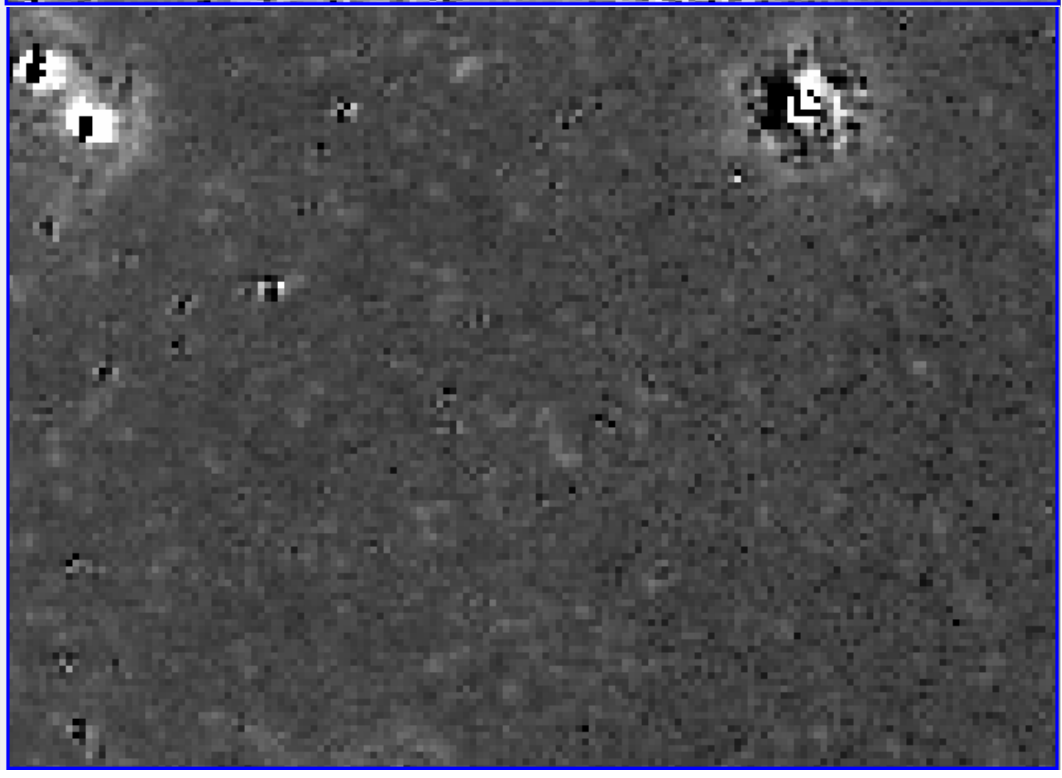


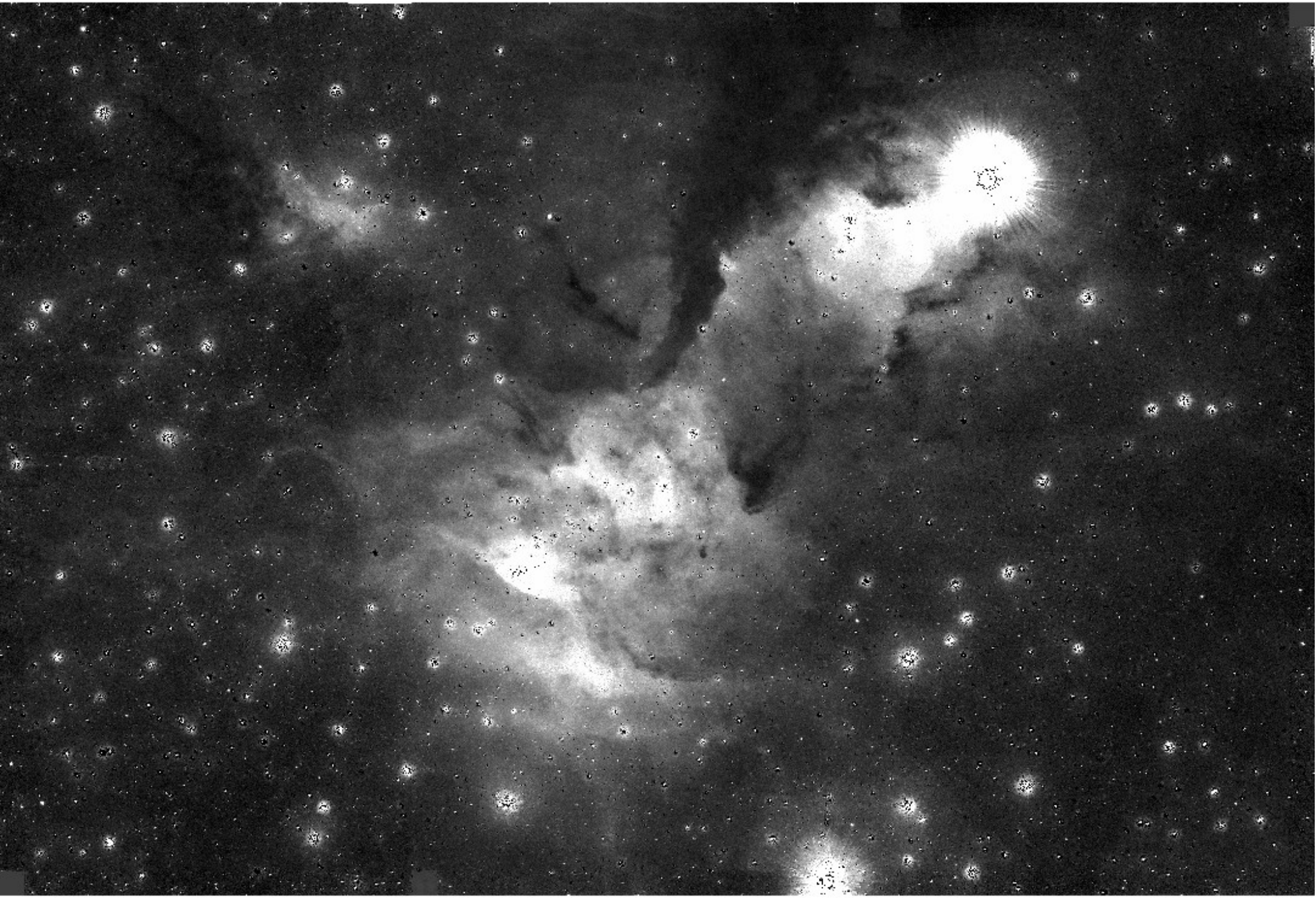


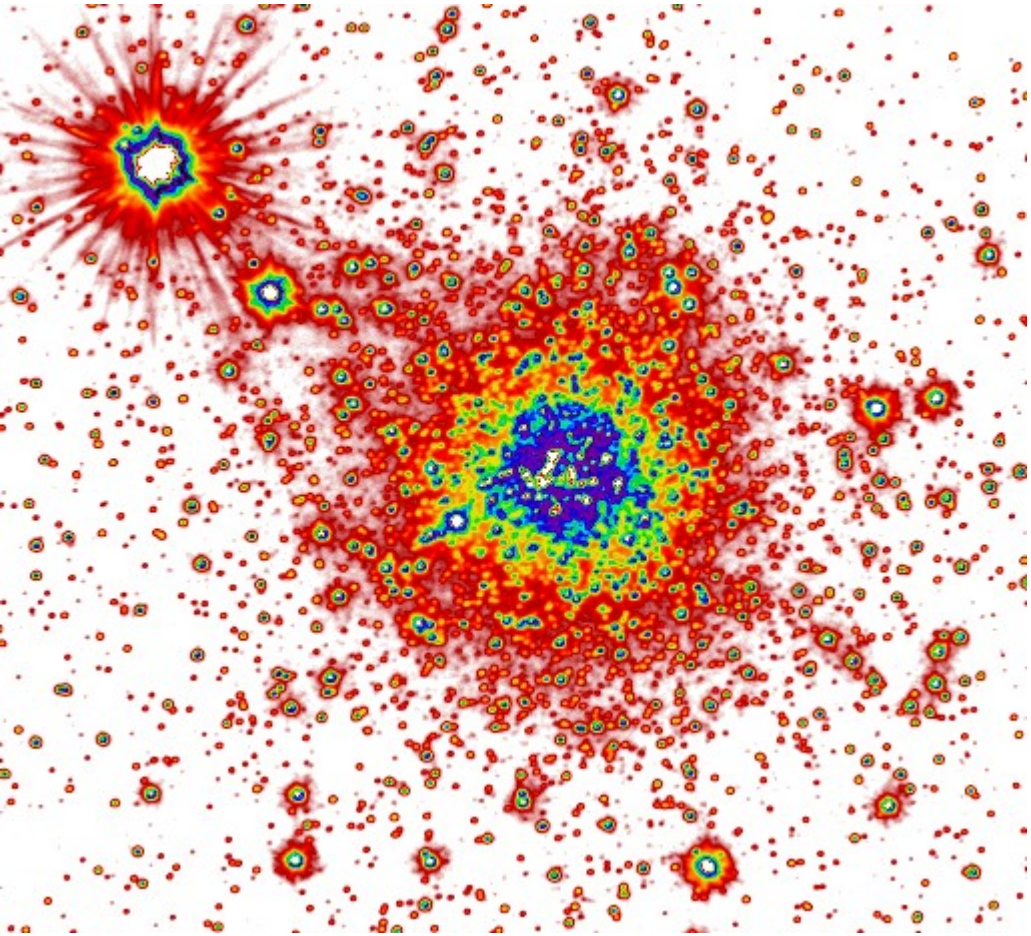






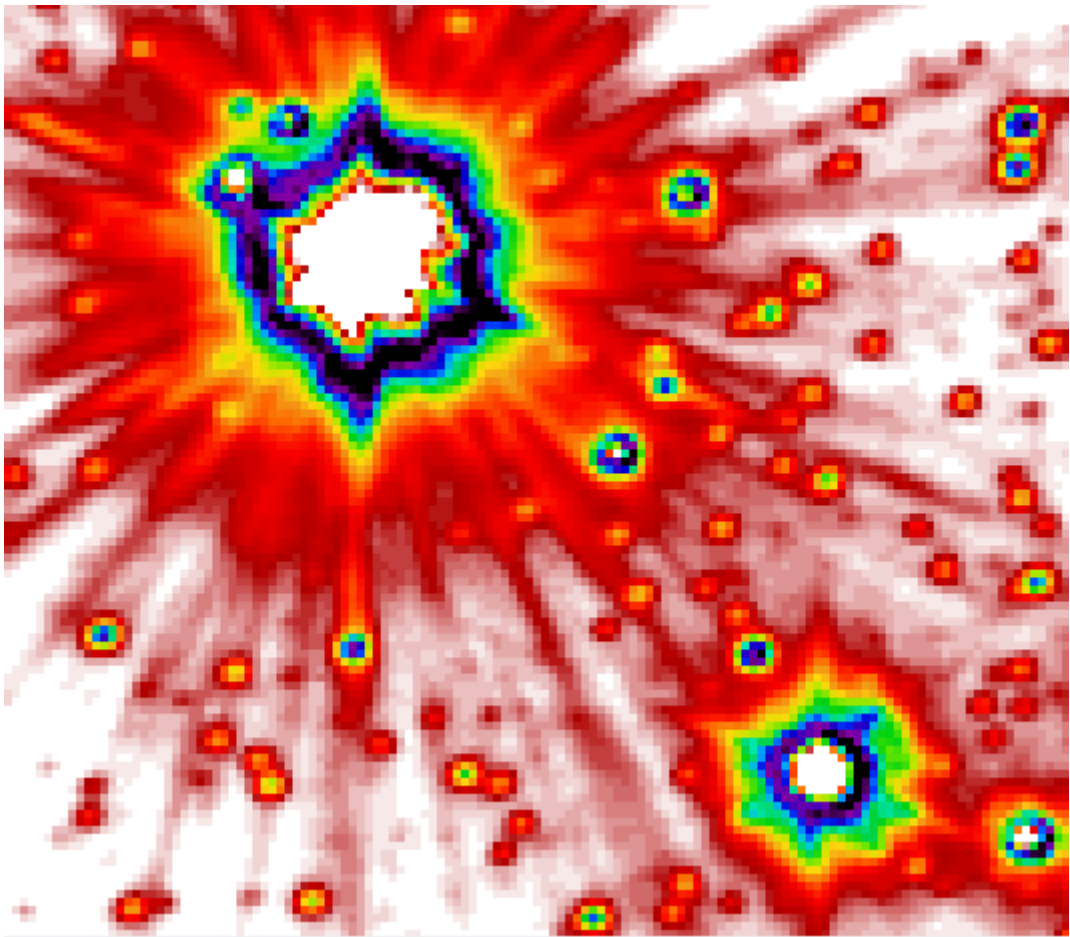






Problems due to IR:

no shatter,
but Fowler sampling



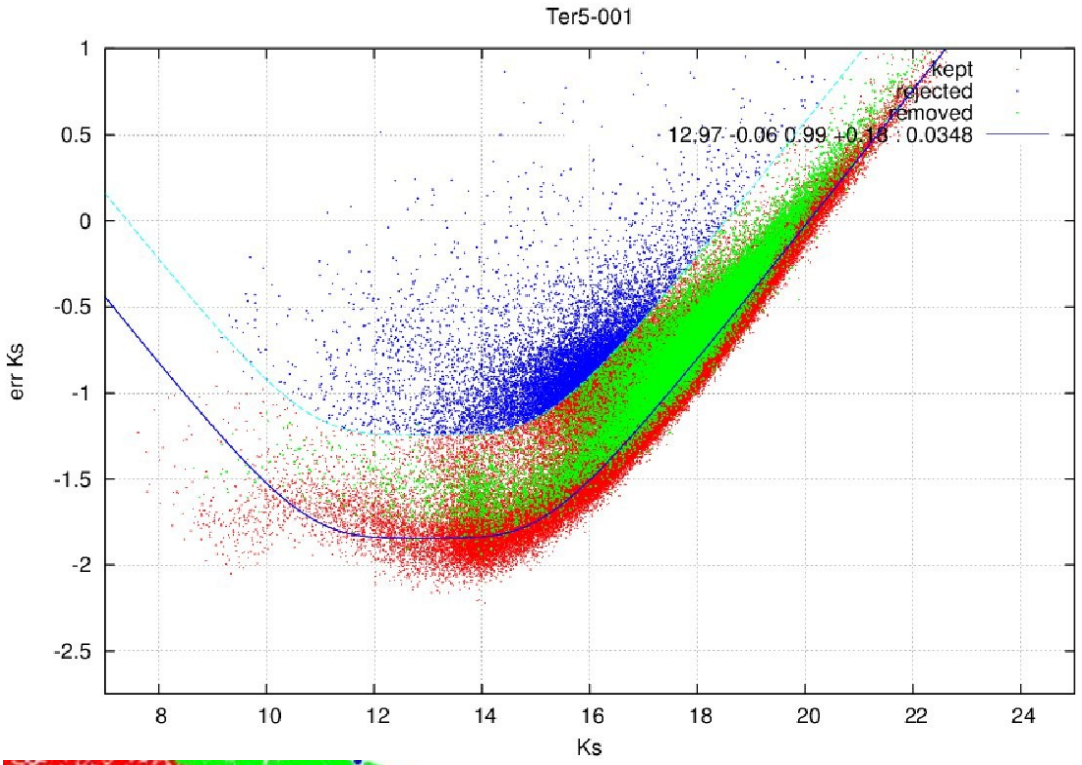
This causes problems with spurious detections, additionally to saturation limits

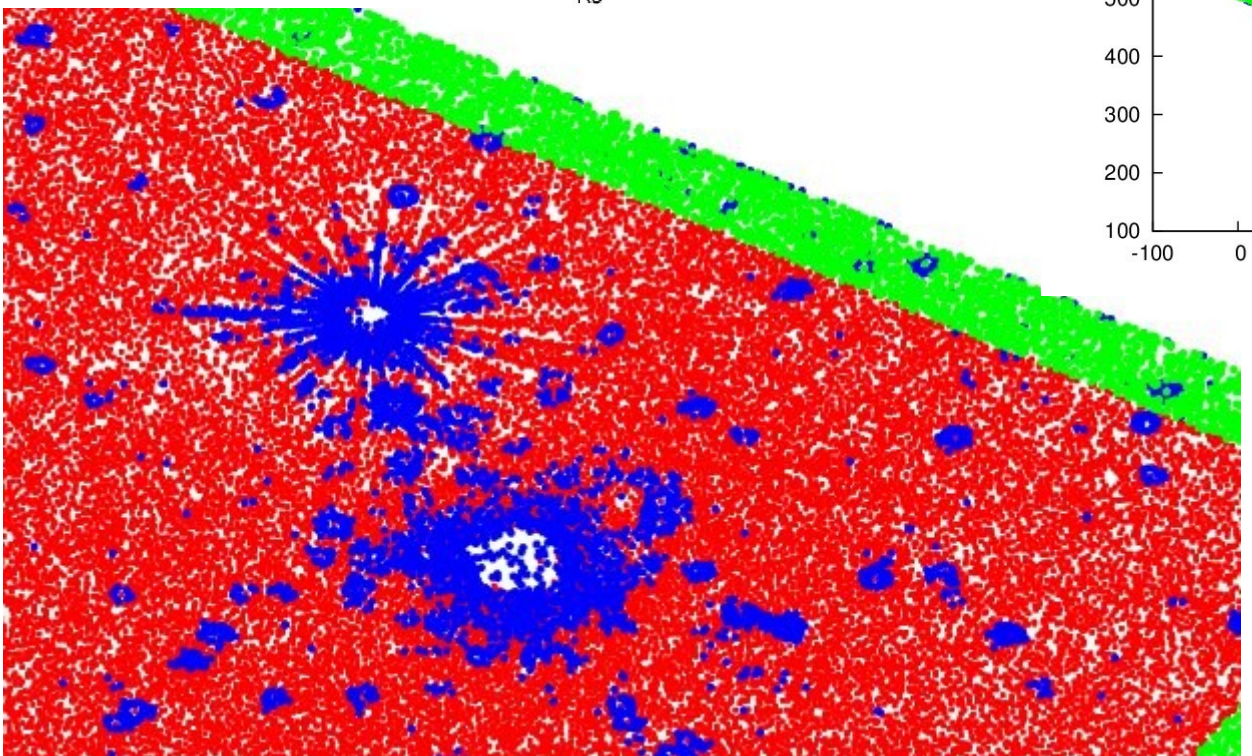
Spurious-detection cleaning procedure in two steps

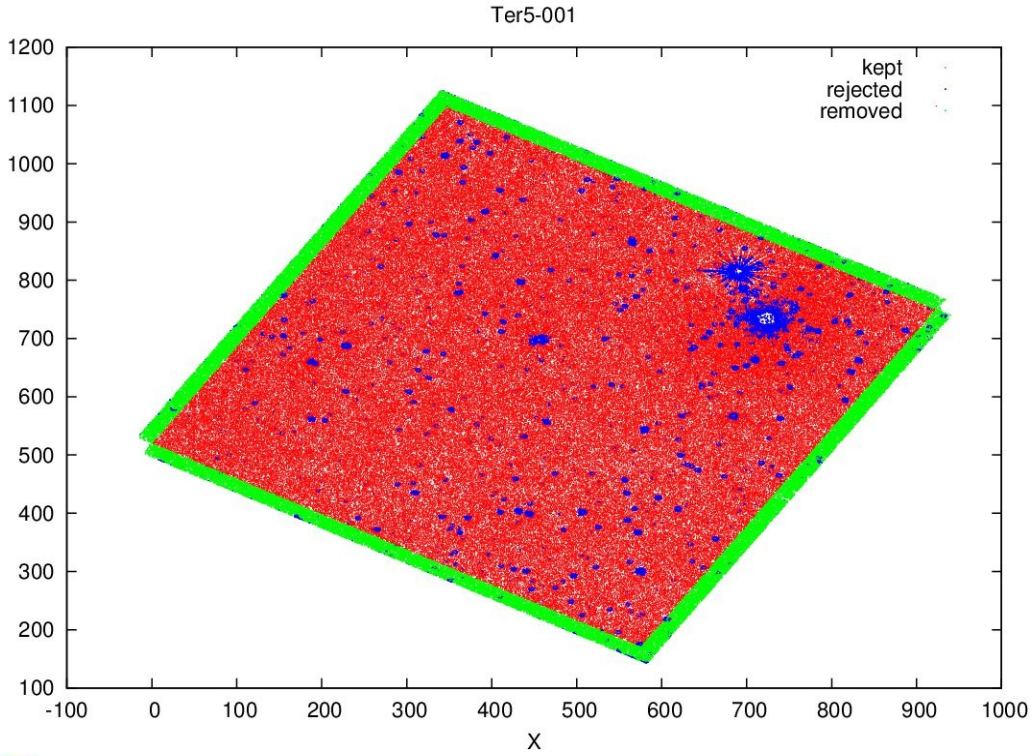
It is composed of two independent processes applied to each ALLFRAME file.

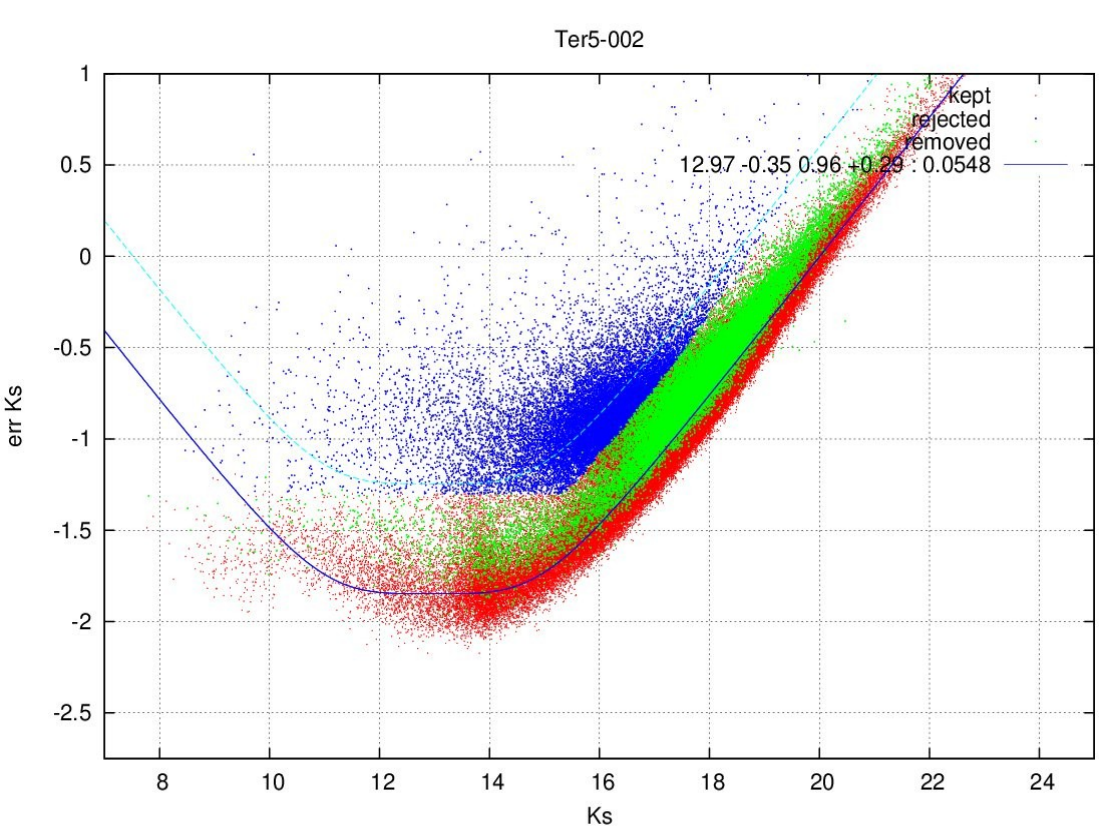
- Sigma-clipping applied to error distribution as function of the magnitude.
- Selection in the error vs magnitude plane based on the clustering around the saturated stars.

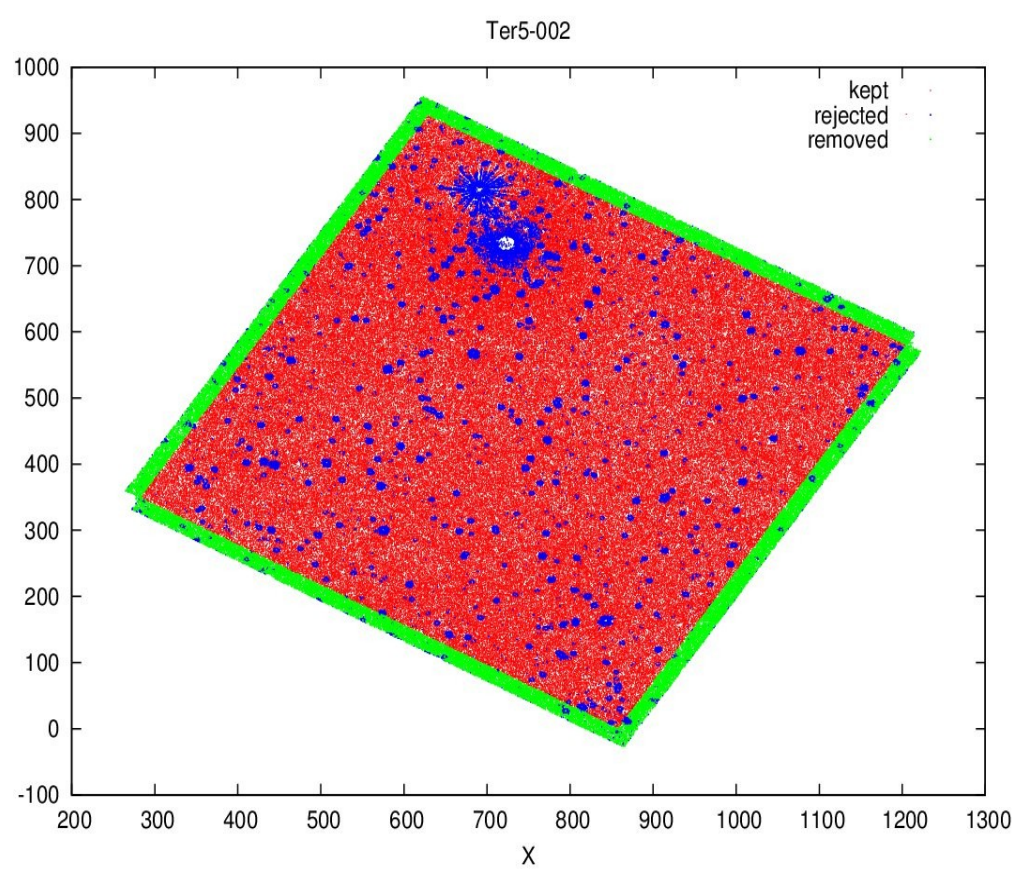
Errors sigma-clipping

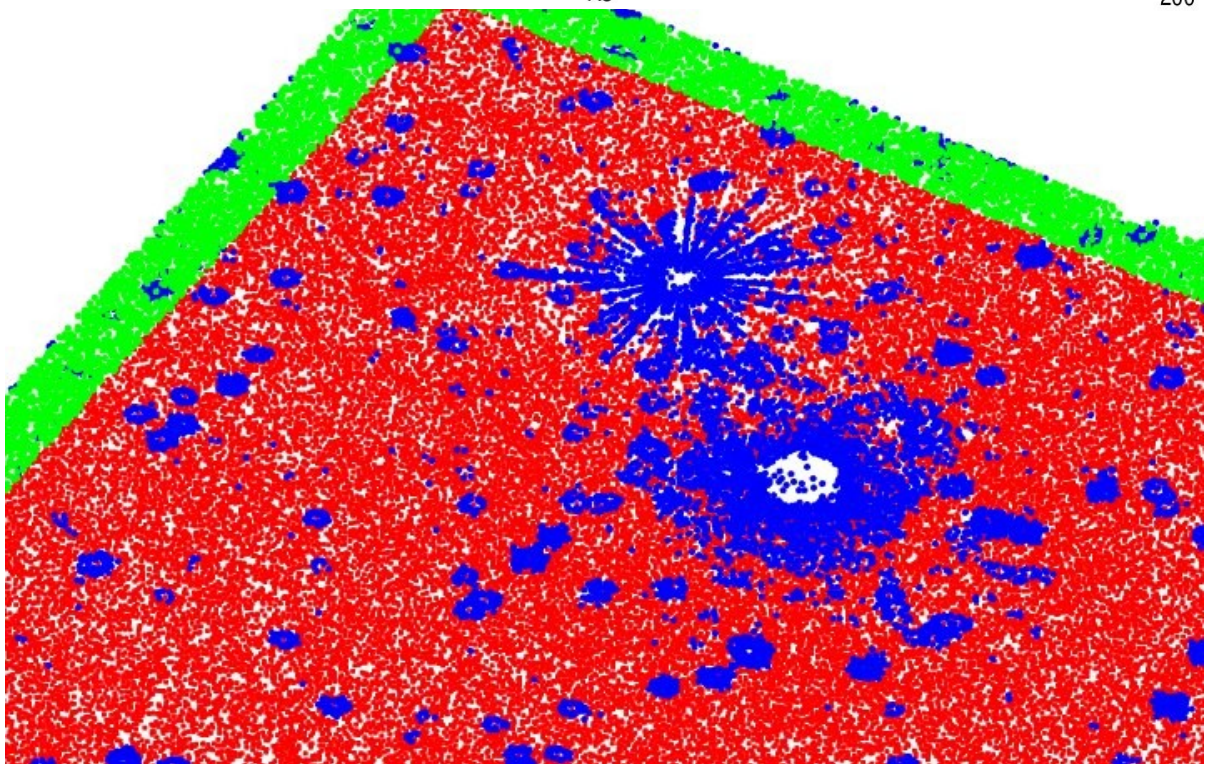


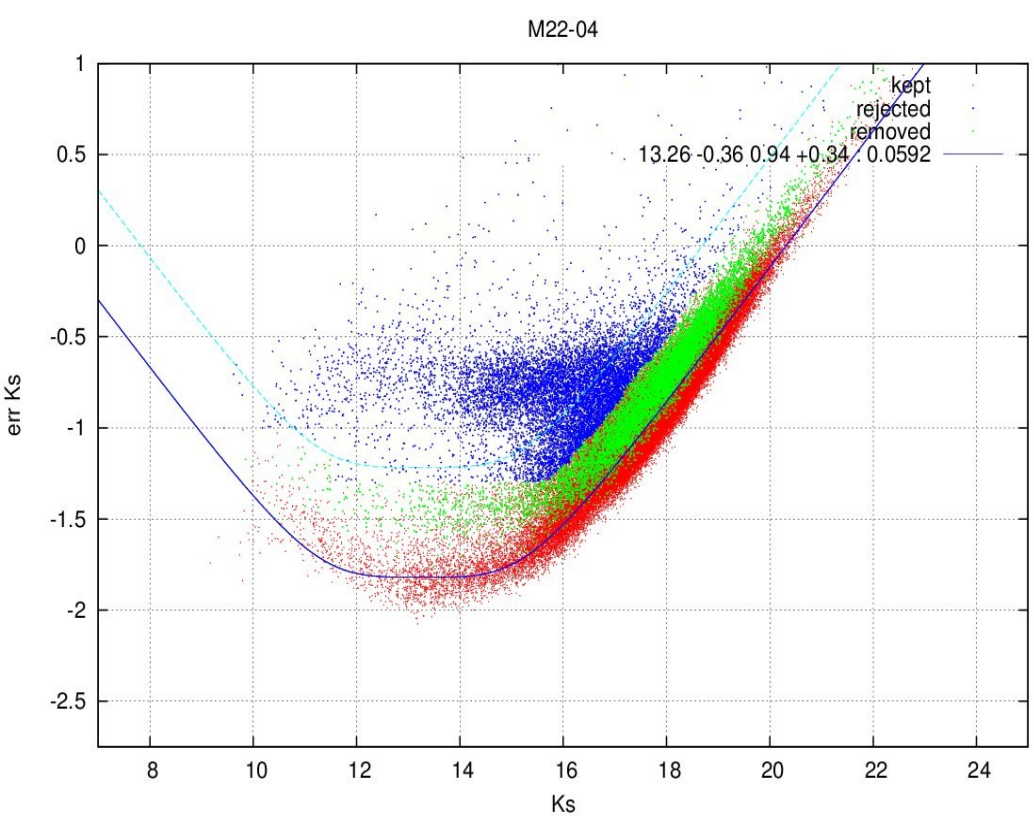


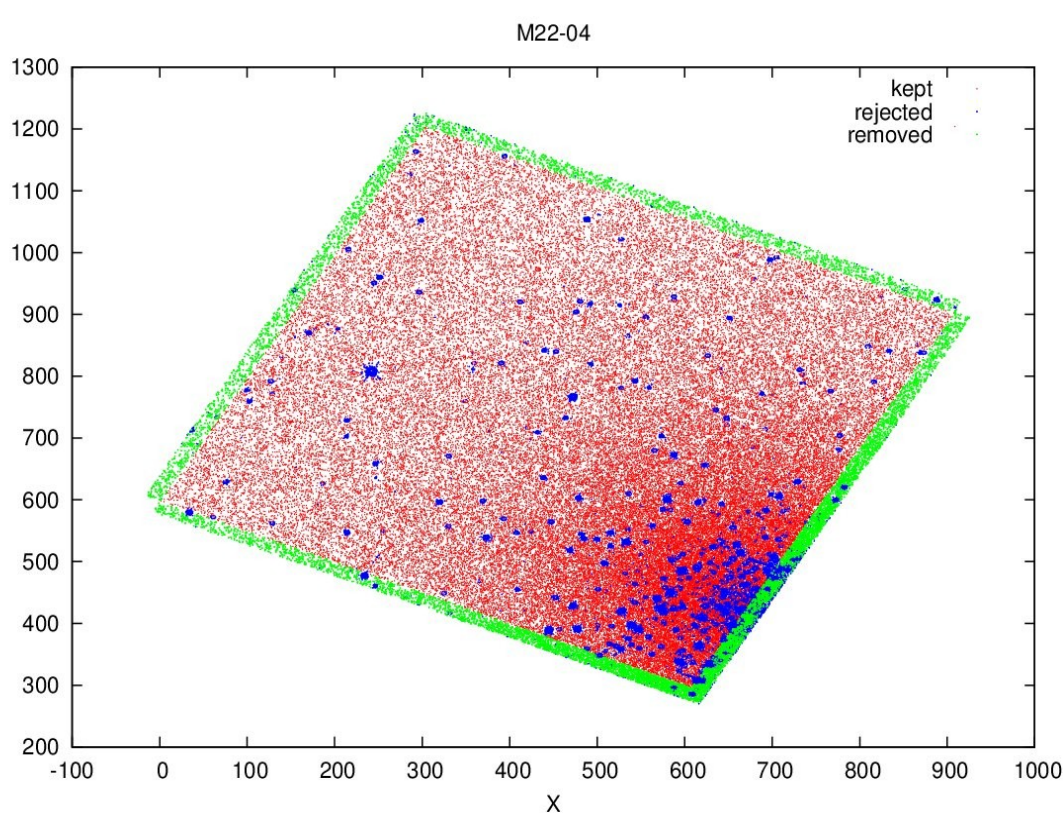


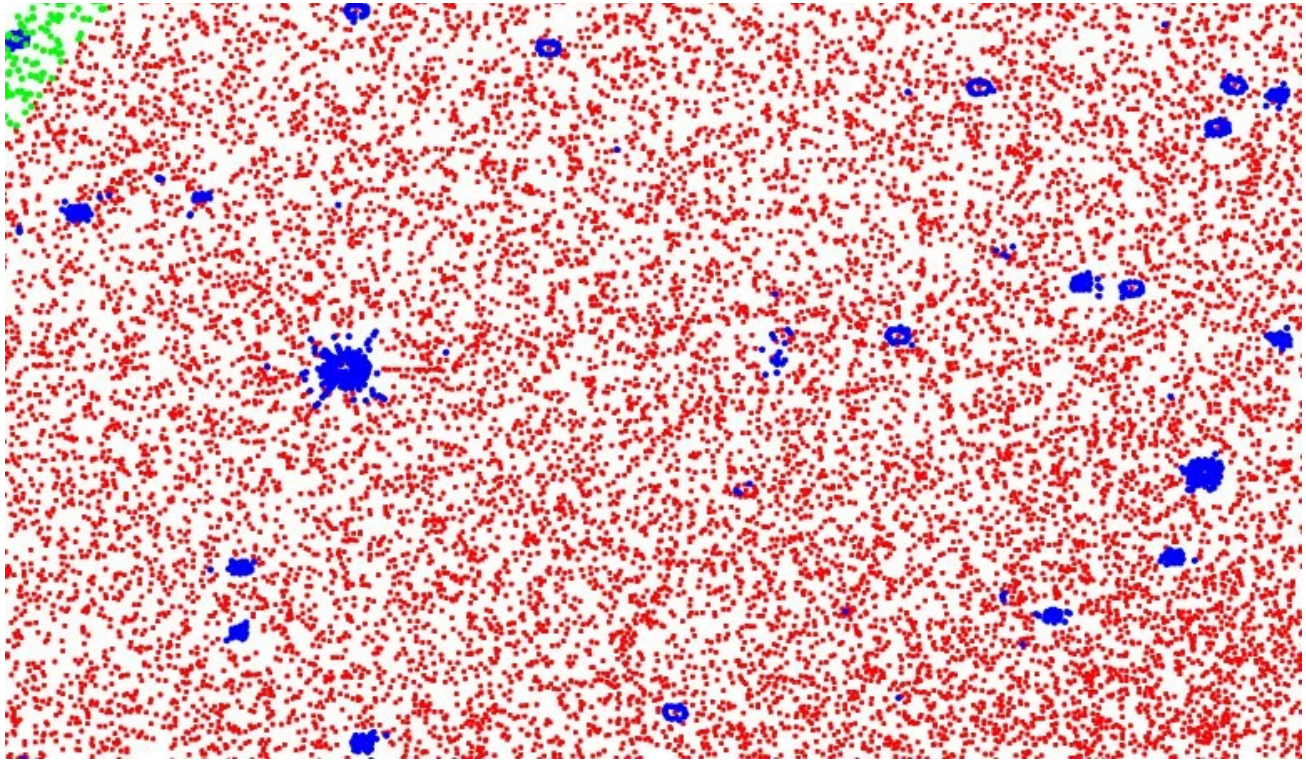

Ter5-002
kept
rejected
removed
12.97 -0.35 0.96 +0.29 : 0.0548
err Ks
Ks


Ter5-002
kept
rejected
removed
X




M22-04
kept
rejected
removed
13.26 -0.36 0.94 +0.34 . 0.0592
err Ks
Ks


M22-04
kept
rejected
removed
X



Calibration: selection

The calibration is designed to use only the stars inside a given magnitude interval and with a maximum supposed contamination from surrounding sources. It was tuned on the 2MASS PSC, anyway any astrometrized catalog can be used, giving the right options.

The least square-fit program assigns a “fudging factor” to the data to weight less the furthest points, instead of a sigma clipping.

Calibration: steps

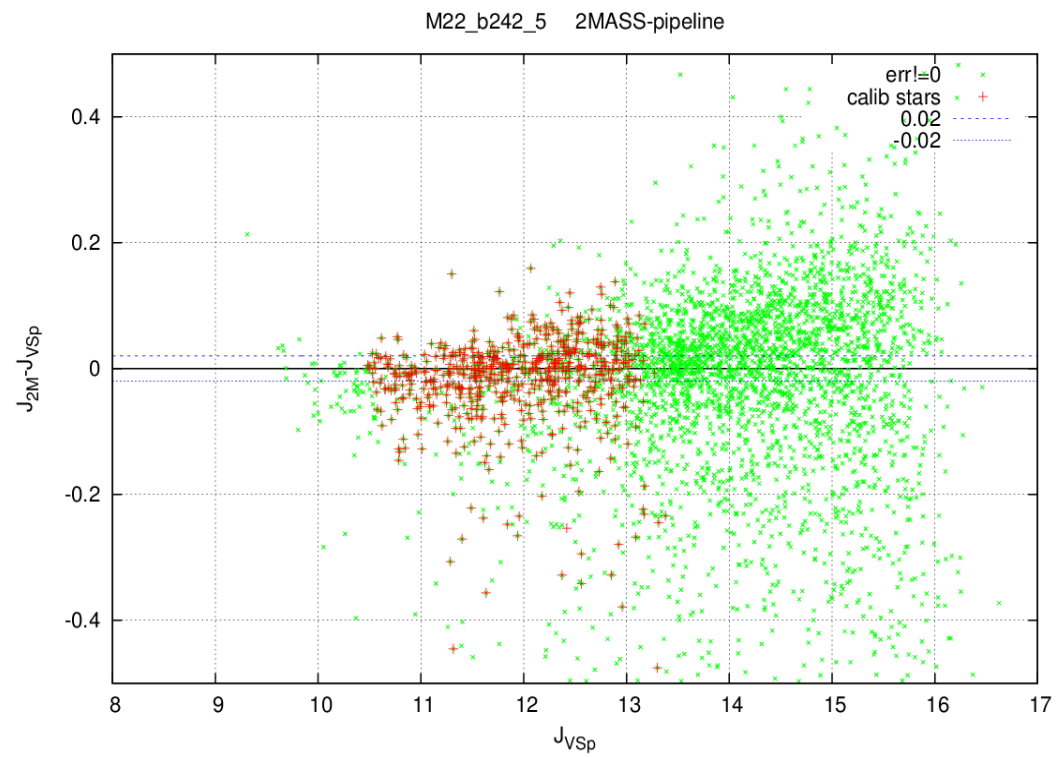
The calibration is operated twice.

1.The first time it is applied to output of allframe and is the classical correction for zero point and color term

$$M_{2\mathrm{MASS}} - m_{VSp} = a_1 (J - Ks)_{2\mathrm{MASS}} + a_0$$

2.The second time it is applied to output of daomaster, after the match of photometries of the same band, and it's just a correction for zero point.

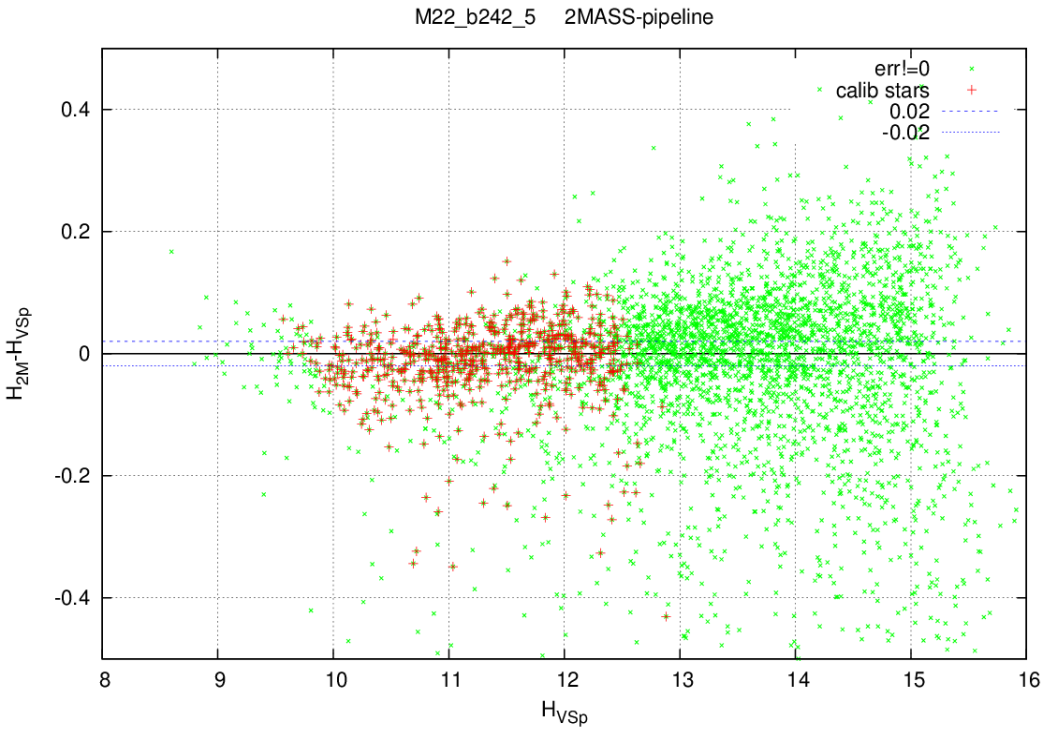
If you need, the calibration of the two steps can be override giving your calibration equations

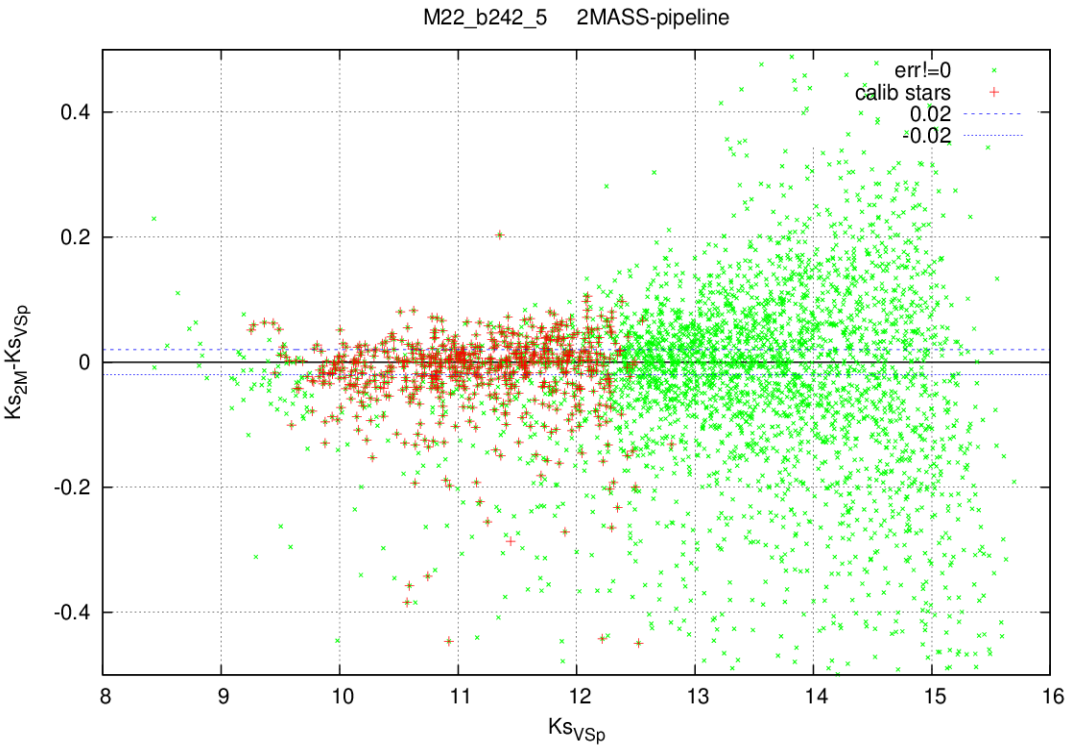


Comparison with 2MASS for M22 (bands)

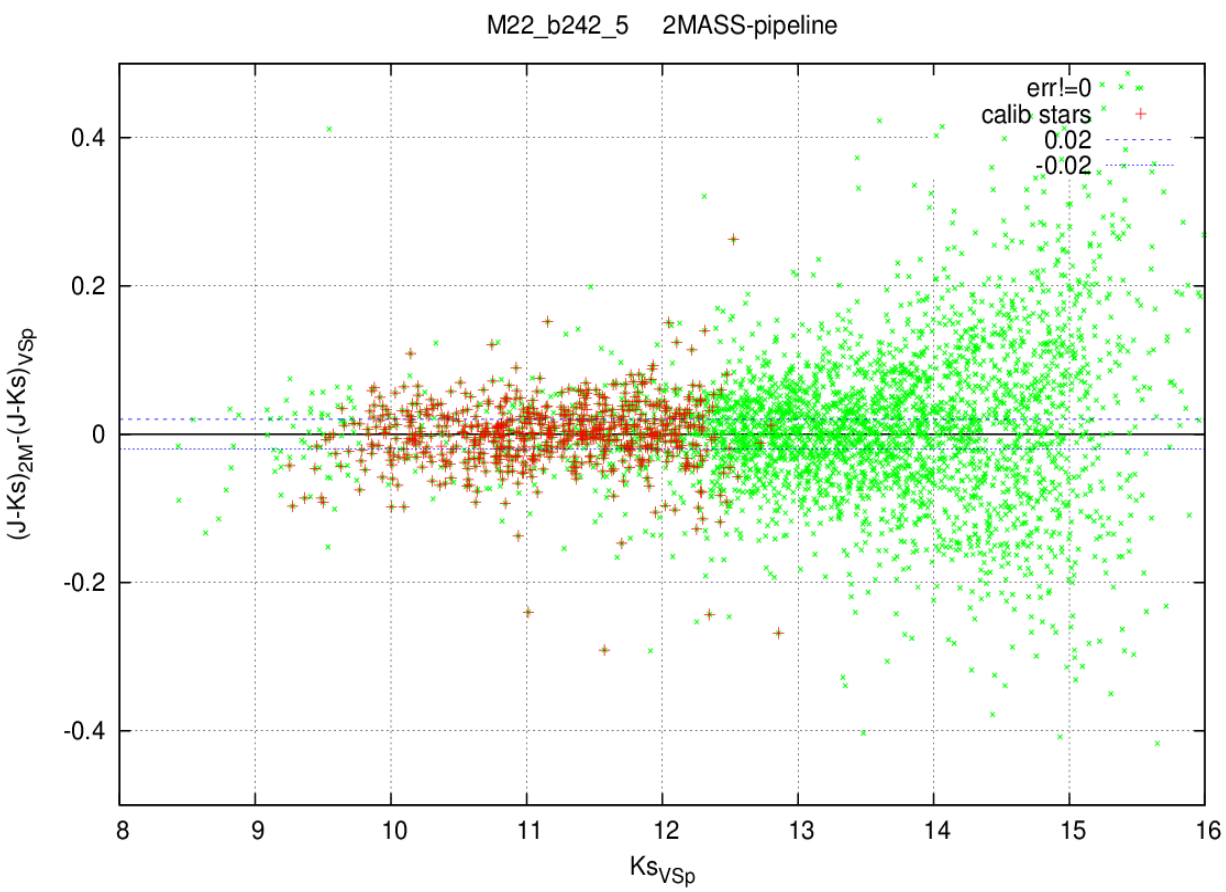
Good agreement down to 13-14, where the known deviation starts

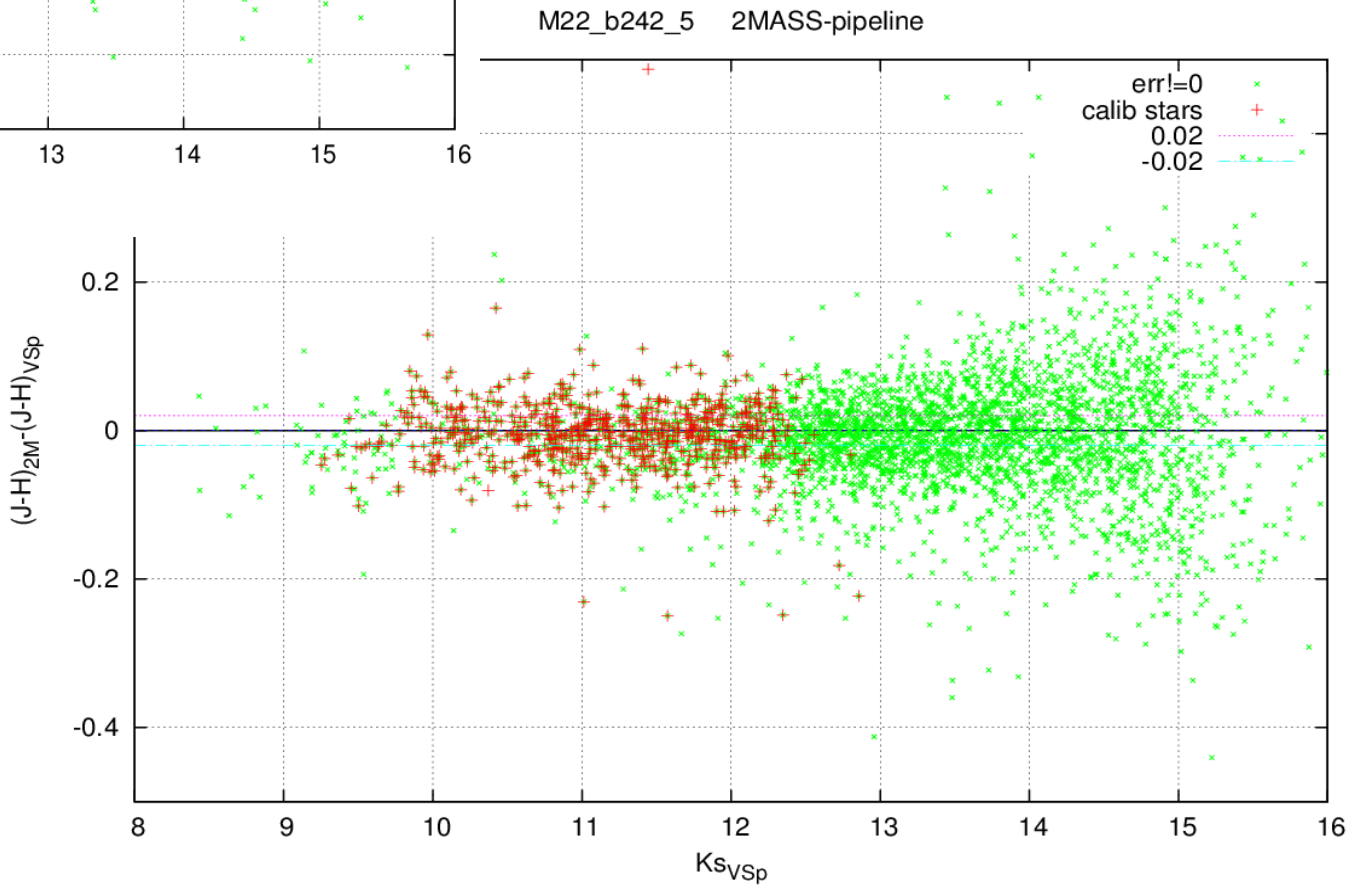
J reliable up to 10.0-10.5
H reliable up to 9.5-10.0
Ks reliable up to 9.5-10.0

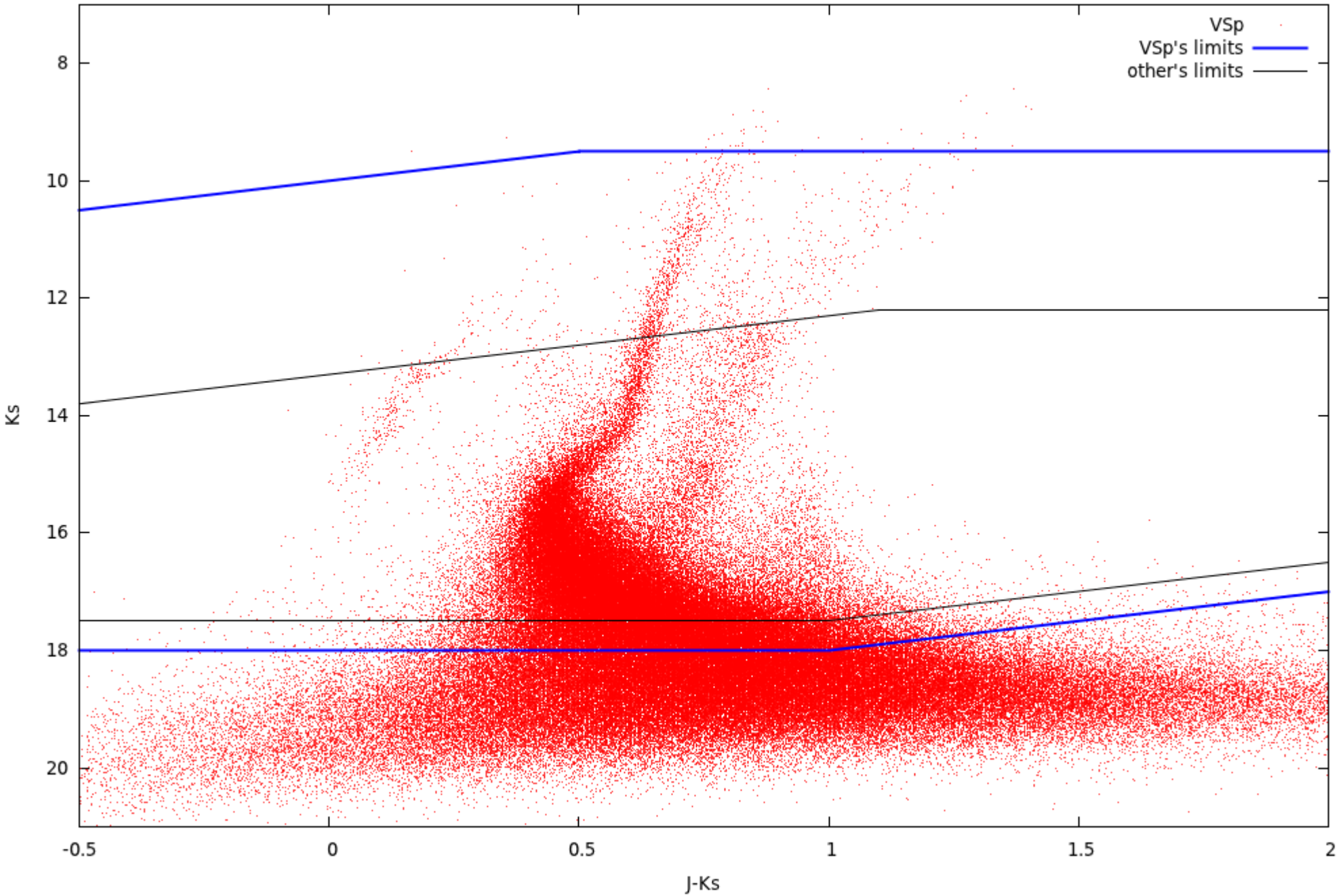




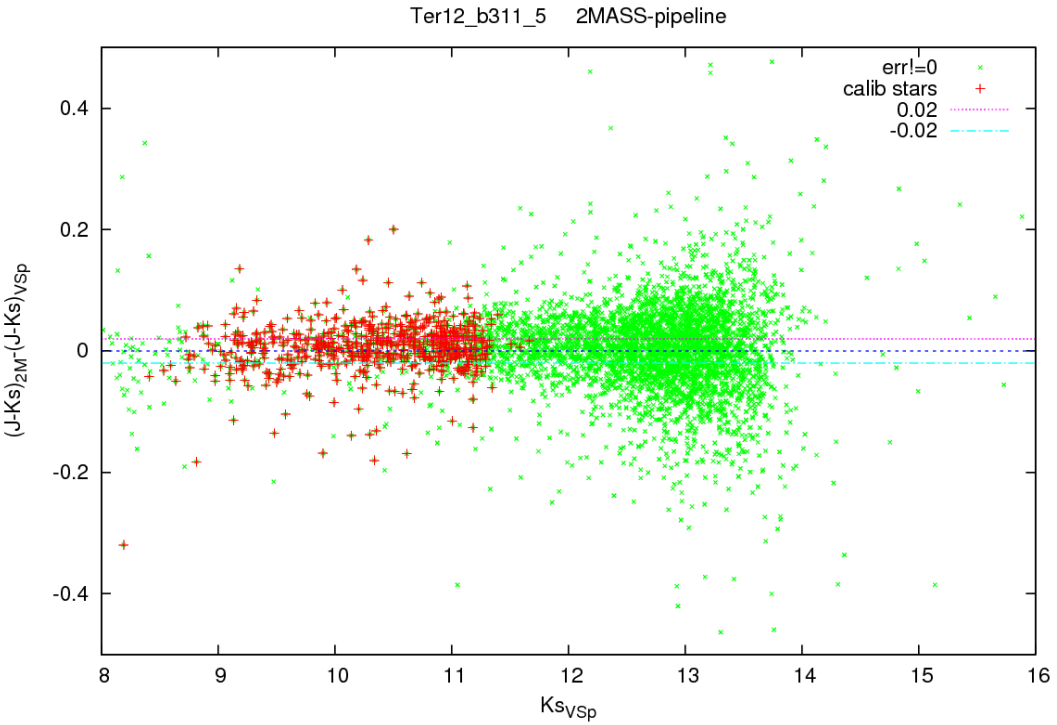
Comparison with 2MASS for M22 (colors)

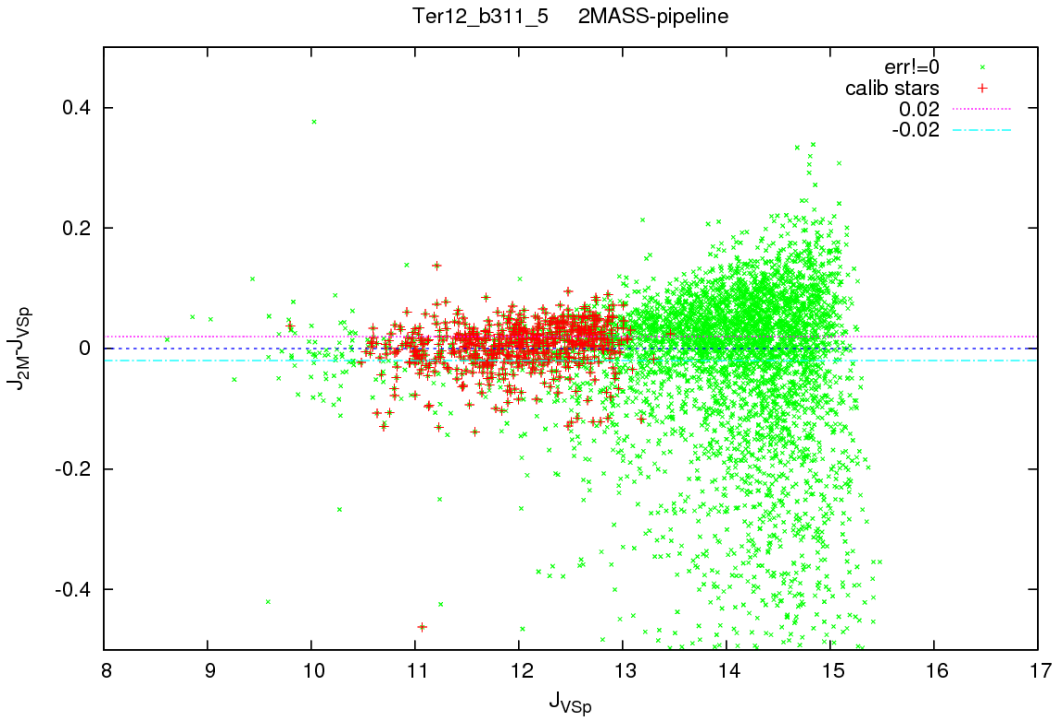


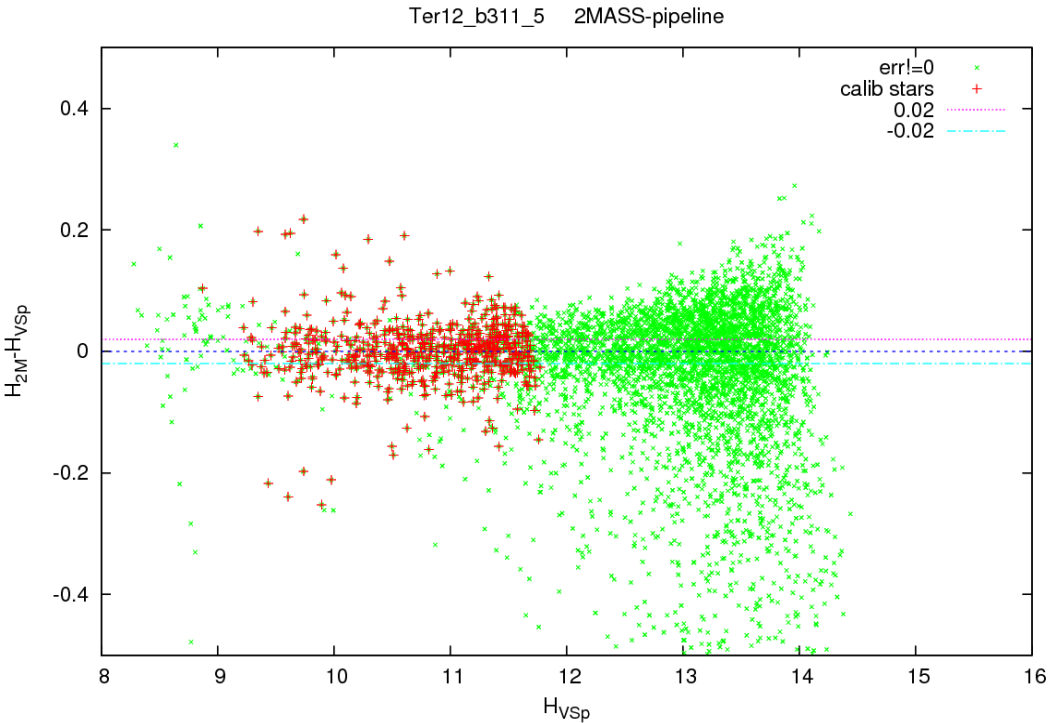


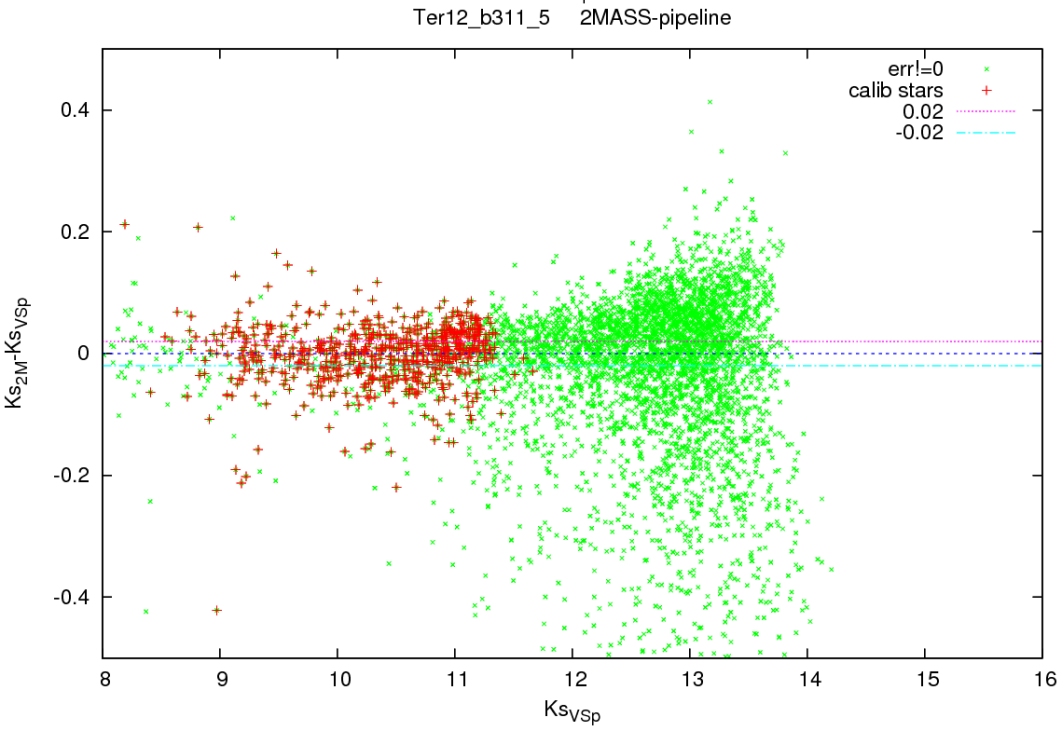

VSp
VSp's limits
other's limits
Ks
J-Ks
8
10
12
14
16
18
20
-0.5
0
0.5
1
1.5
2

Comparison with 2MASS: Terzan 12

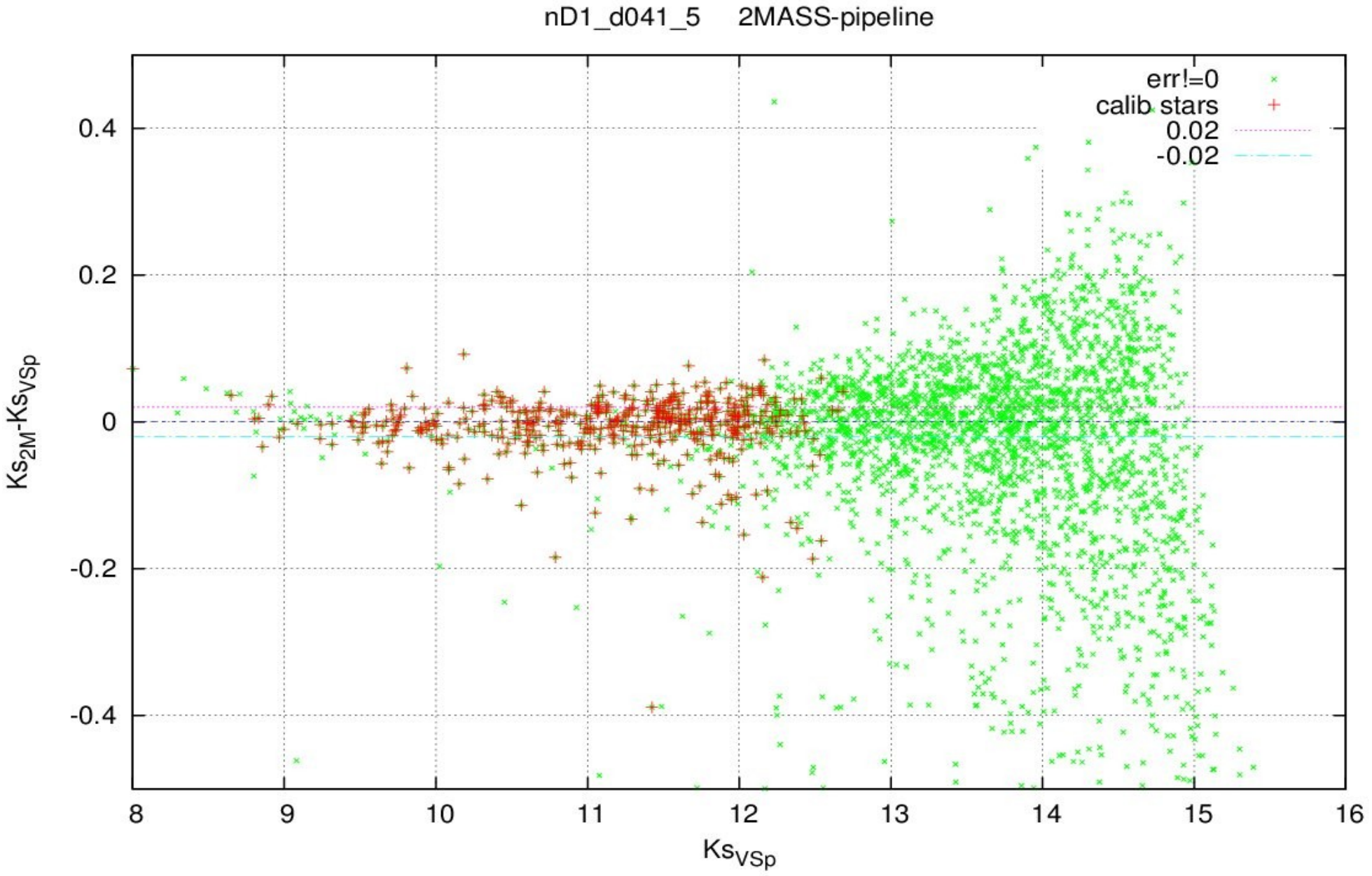




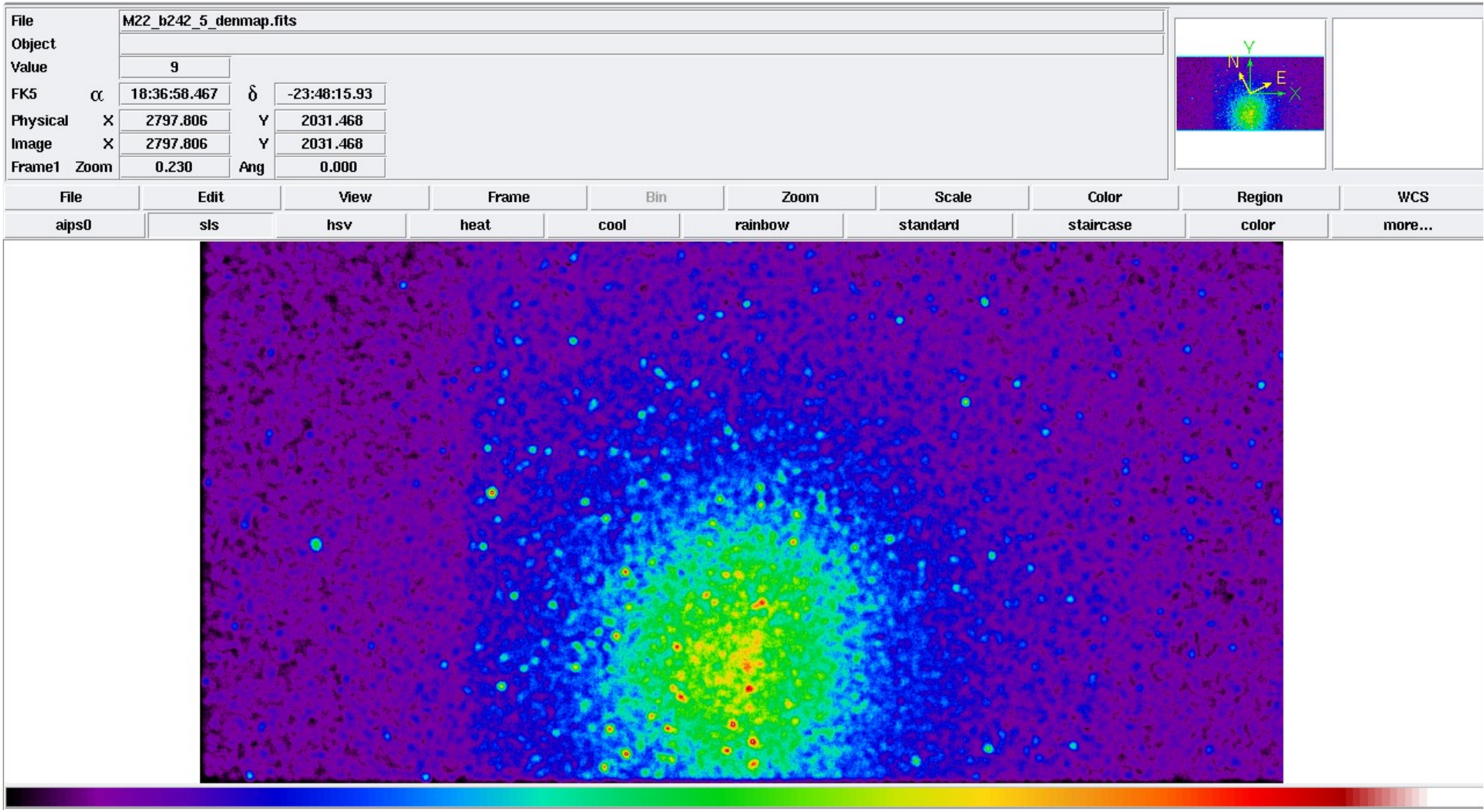


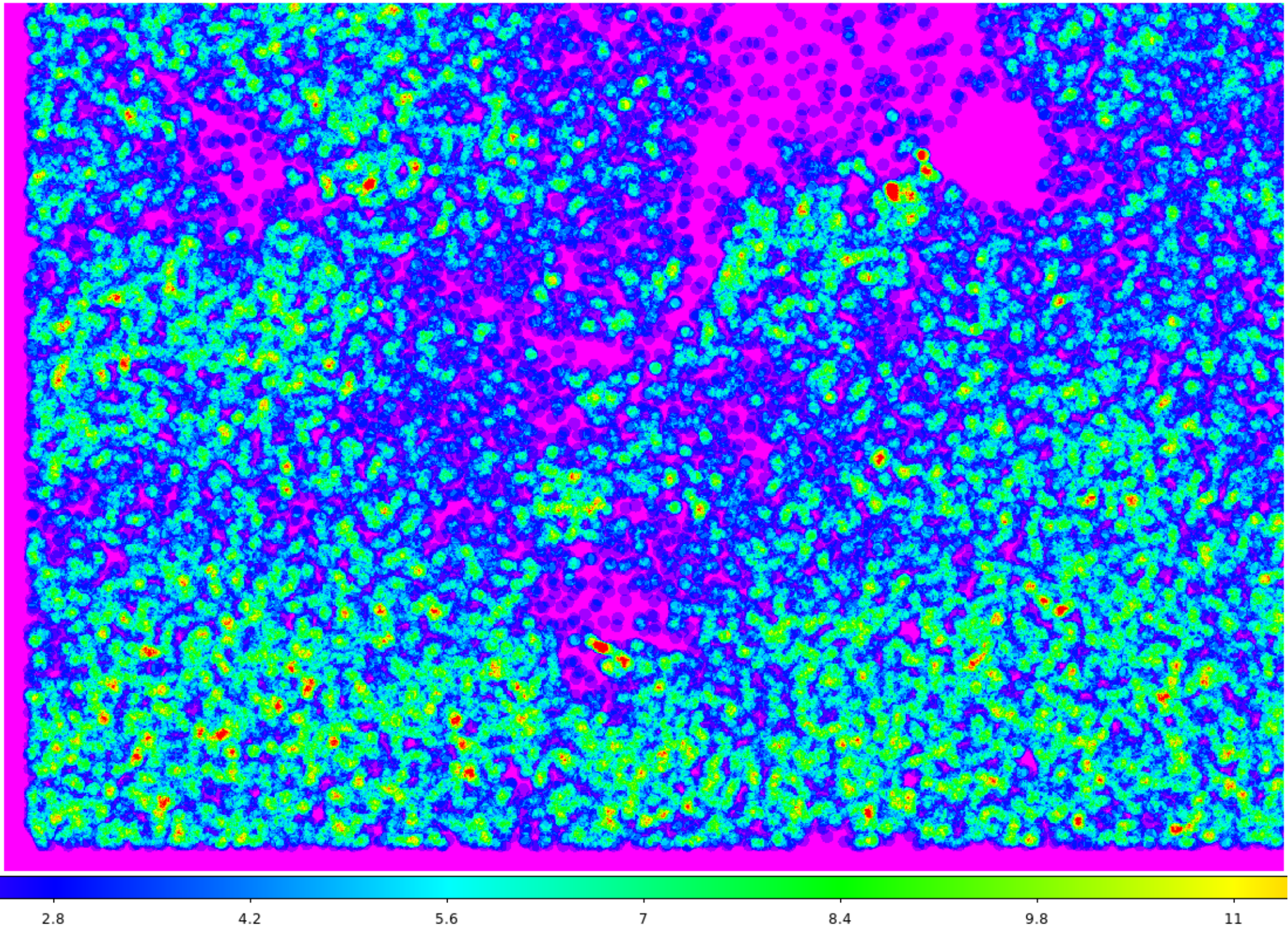


not only in the bulge, but also in the disk



Density map in fits format

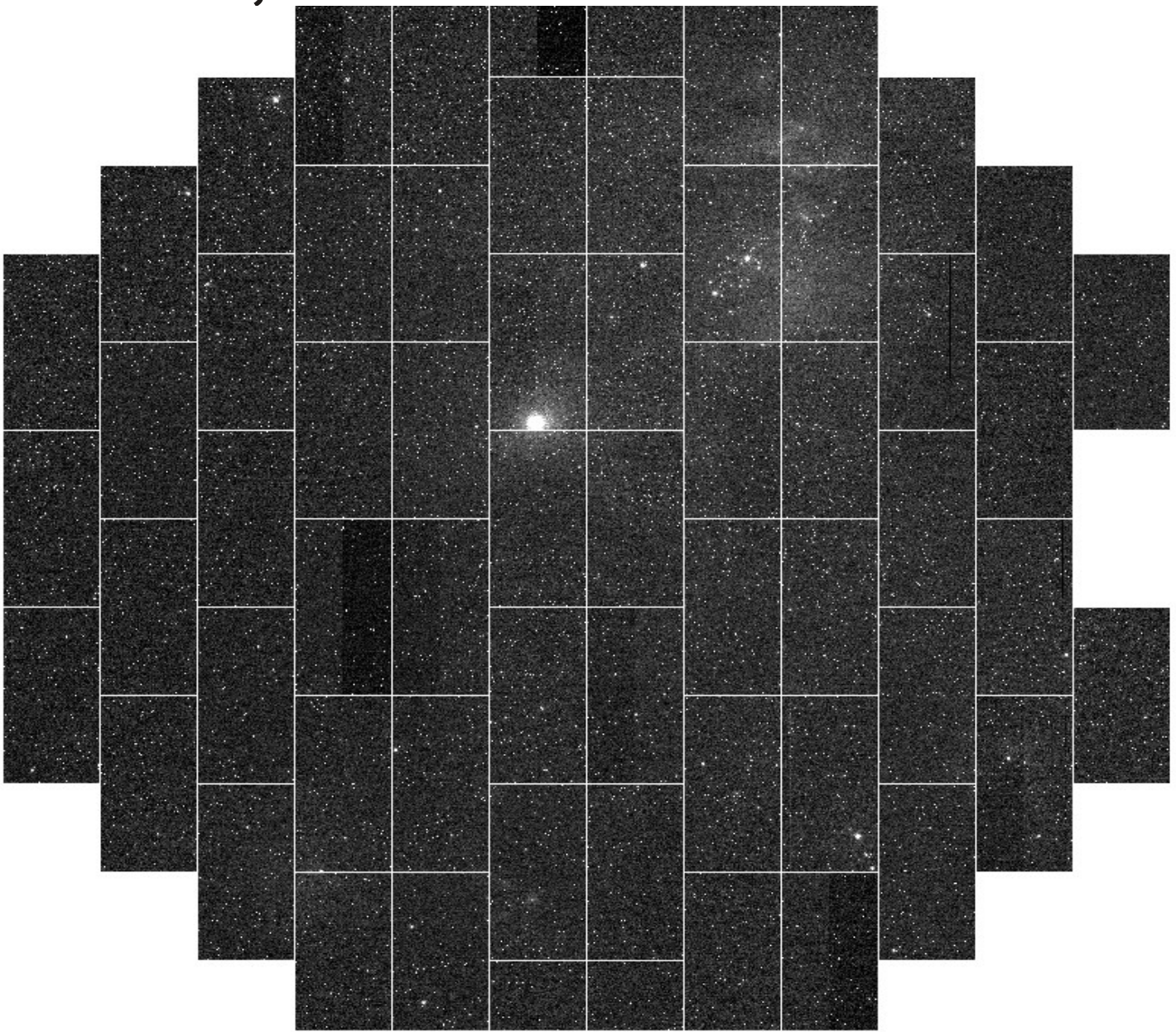



2.8
4.2
5.6
7
8.4
9.8
11

Next improvements for the pipeline

- Artificial stars and completeness test
- Handling variable stars and multi-epochs catalogs
- Improving algorithms
- Improving WCS

Next targets:
VMC, DECam and LSST



Accuracy in position