Simulations of crowded stellar fields

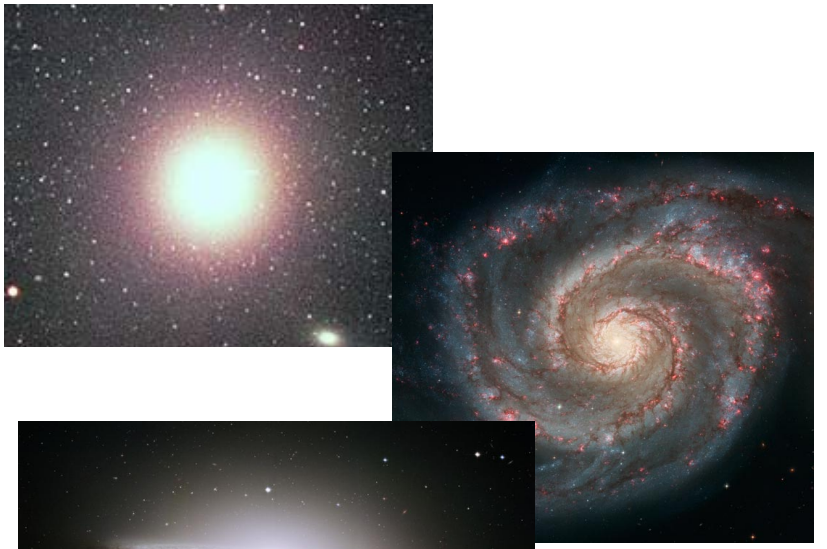
Joe Liske

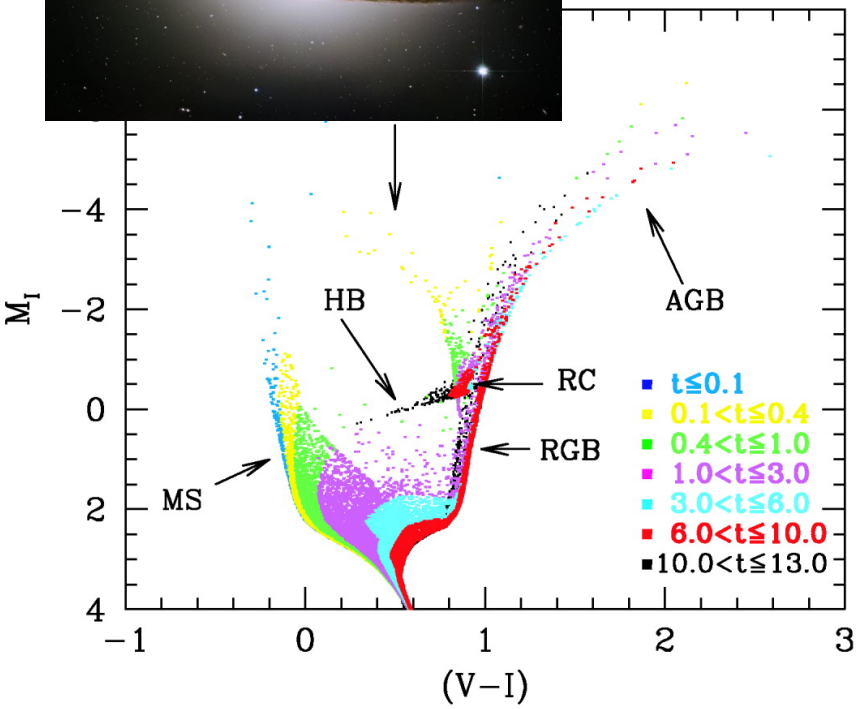
Resolved stellar populations

- To understand the formation of various types of galaxies we have to investigate the properties of their stellar components.

- Disentangling a galaxy's various stellar populations gives insight into its star formation history and thereby indicates the major events in its life: formation and major mergers.

- We'd like to be able to do this at the distance of Virgo to study the nearest giant ellipticals.

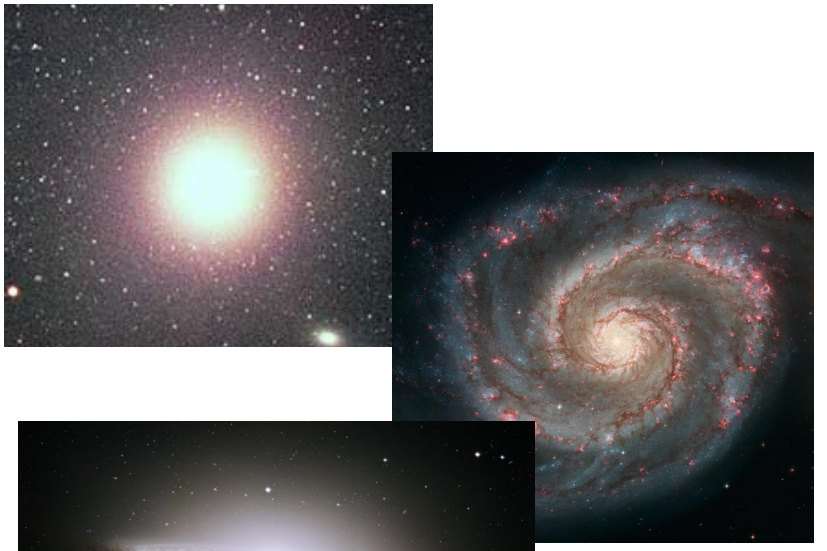


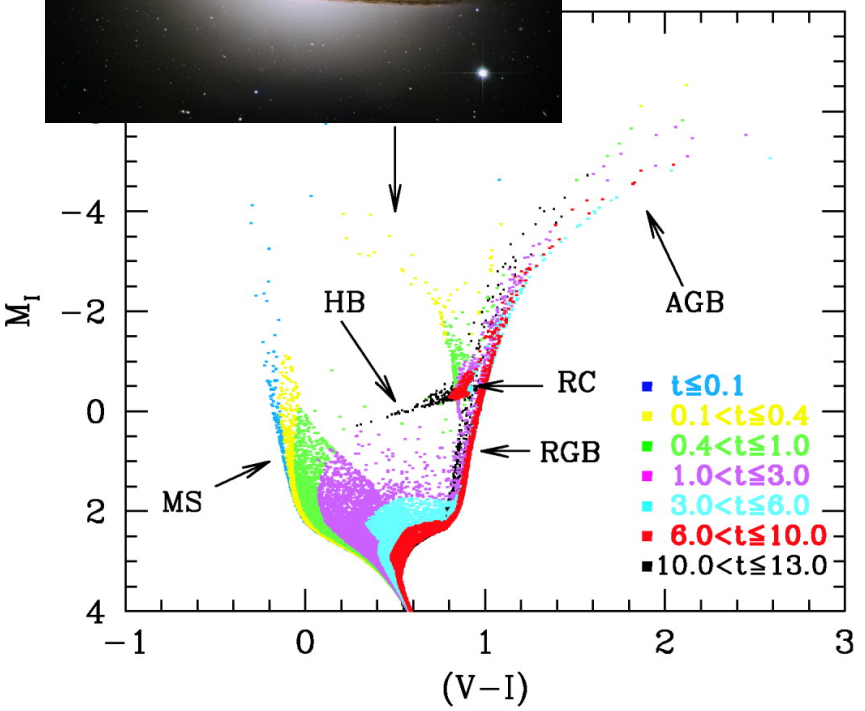


Resolved stellar populations

Some questions to the DRM:

- At the distance of Virgo, how far down the luminosity function will we be able to probe?
- What limits the above?
- Which are the best wavelengths to use?
- What is the trade-off between field size and quality of AO correction?
- How sensitive are any results to variations of the scientific and technical input data (SFH, IMF, PSFs, etc)?





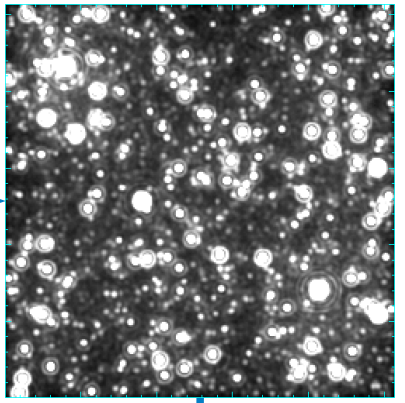
Simulation 'pipeline'

Stellar population

Monte Carlo

Catalogue

Observational parameters: telescope, PSF sims, etc.

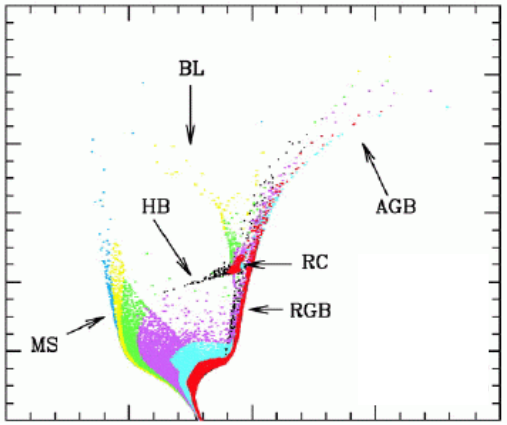


SFH

IMF

Yonsei-Yale isochrones (Yi et al. 2003)

Measured CMD



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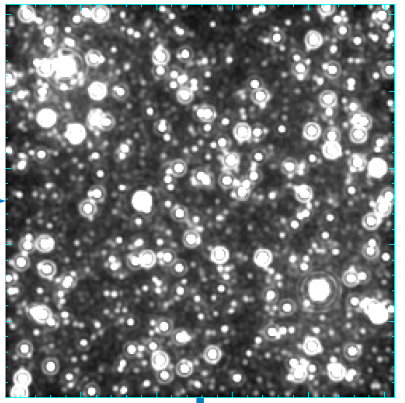
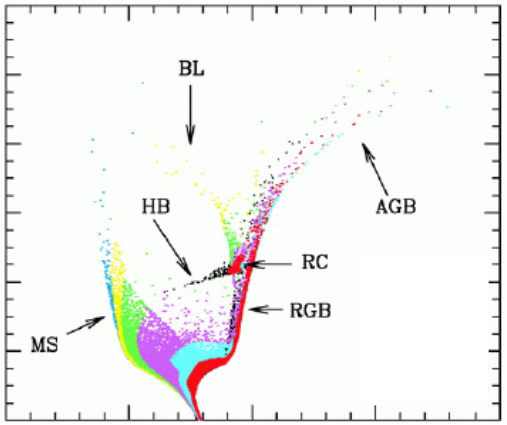


SFH

IMF

BASTI isochrones (Pietrinferni et al. 2004)

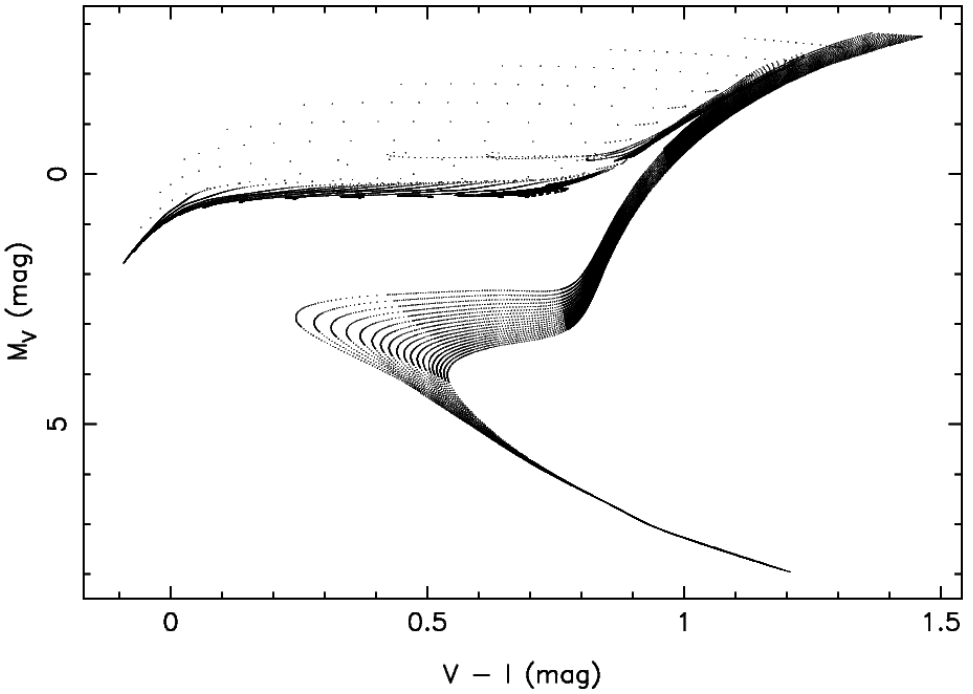
Measured CMD



Catalogue

Making a stellar population

- Choose model / set of isochrones:
  - Scaled solar / alpha-enhanced
  - Canonical / non-canonical
  - Chemical composition
- Specify IMF
- Specify SFH



➔ Stellar population with relative weights between different types of stars

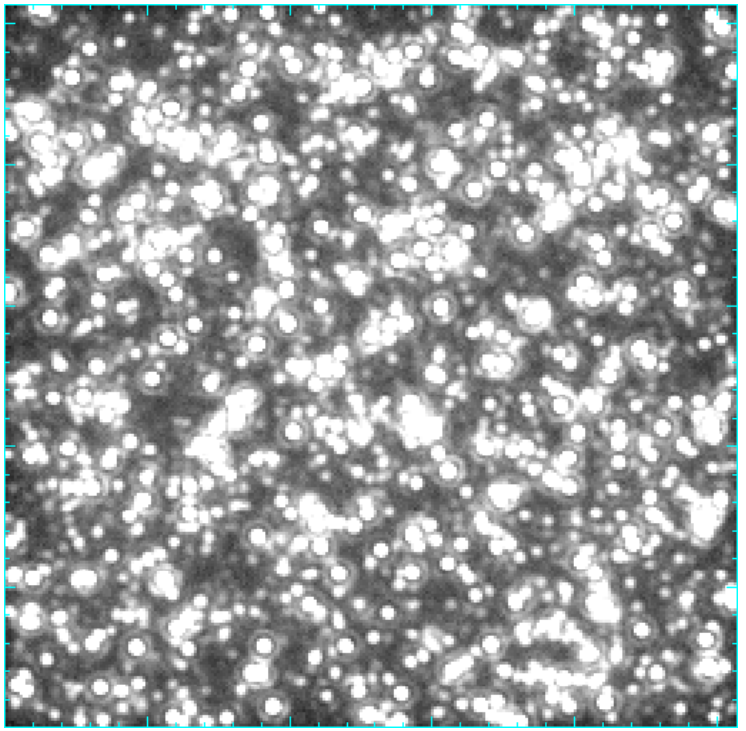
- Limitations:
  - No interpolation between isochrones, i.e. stuck with ages at which isochrones have been computed.
  - What about binarity?

Making an object catalogue

- Specify distance modulus
- Surface brightness
- Size of field of view
- Populate CMD randomly according to weights from stellar population
- Distribute randomly on sky according to a given spatial distribution

Making an image

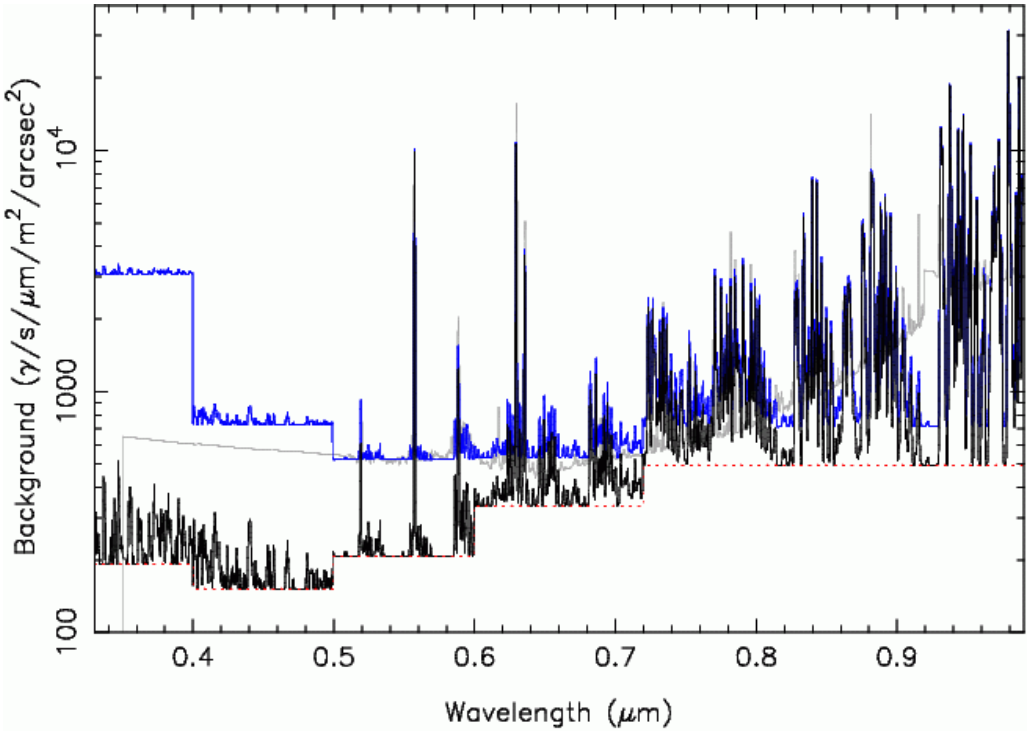
- Technical and observation parameters: background, atmospheric throughput, telescope size, telescope throughput, instrument throughput, pixel size, detector noise, AO correction, etc.
- Using IRAF/mkobjects to create images
- Limitations:
  - Slow
  - Can't vary PSF smoothly as a function of position in the field of view
  - Interpolation ok?

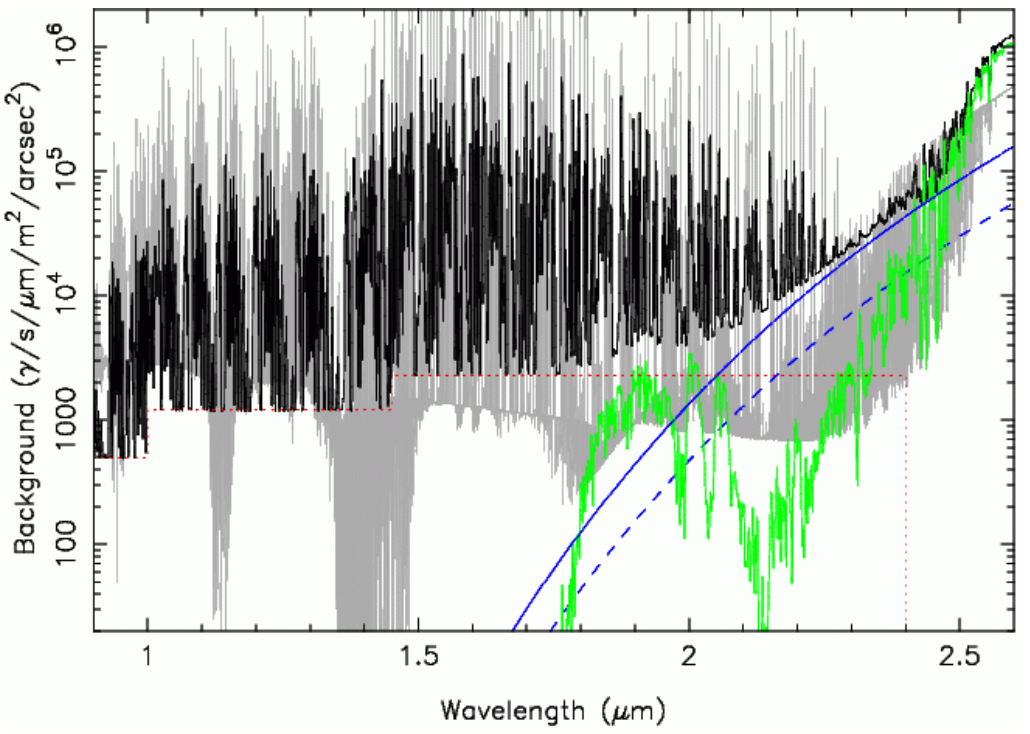


Background model

Limitations:

- Model for sky brightness due to moon
- Variability of OH lines

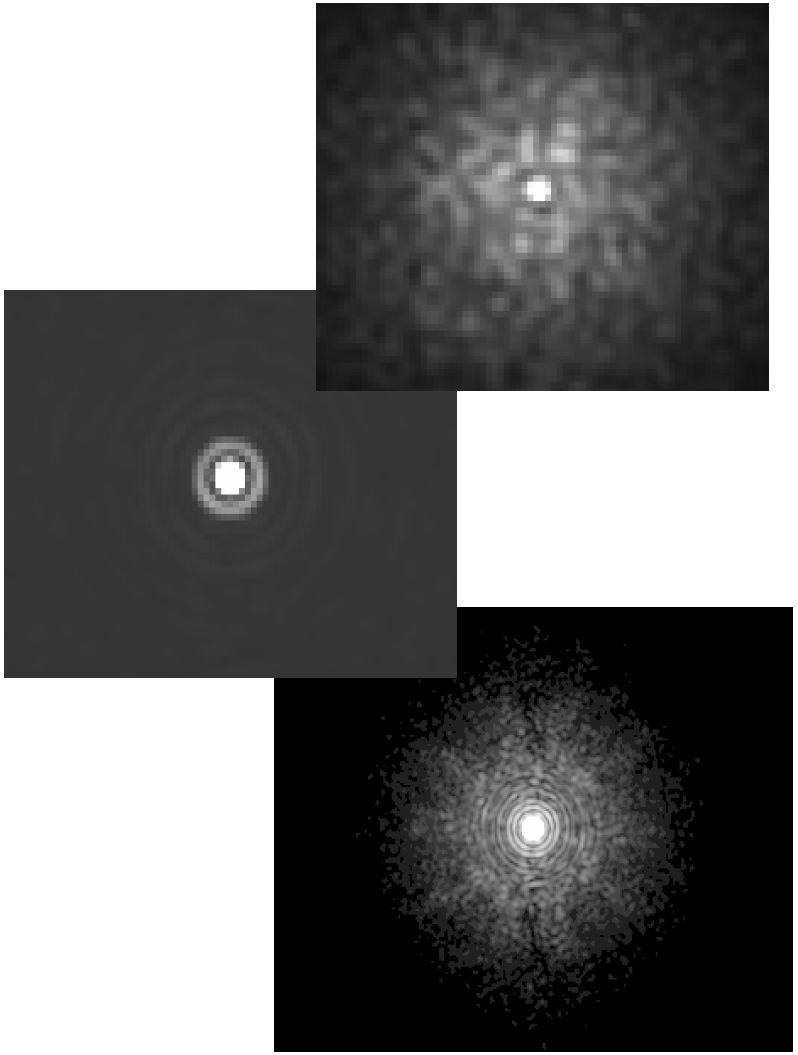




PSFs

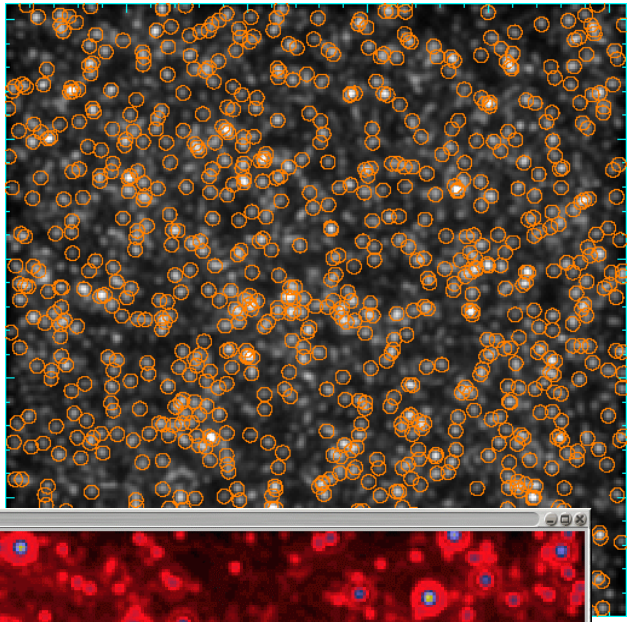
Difficulties:

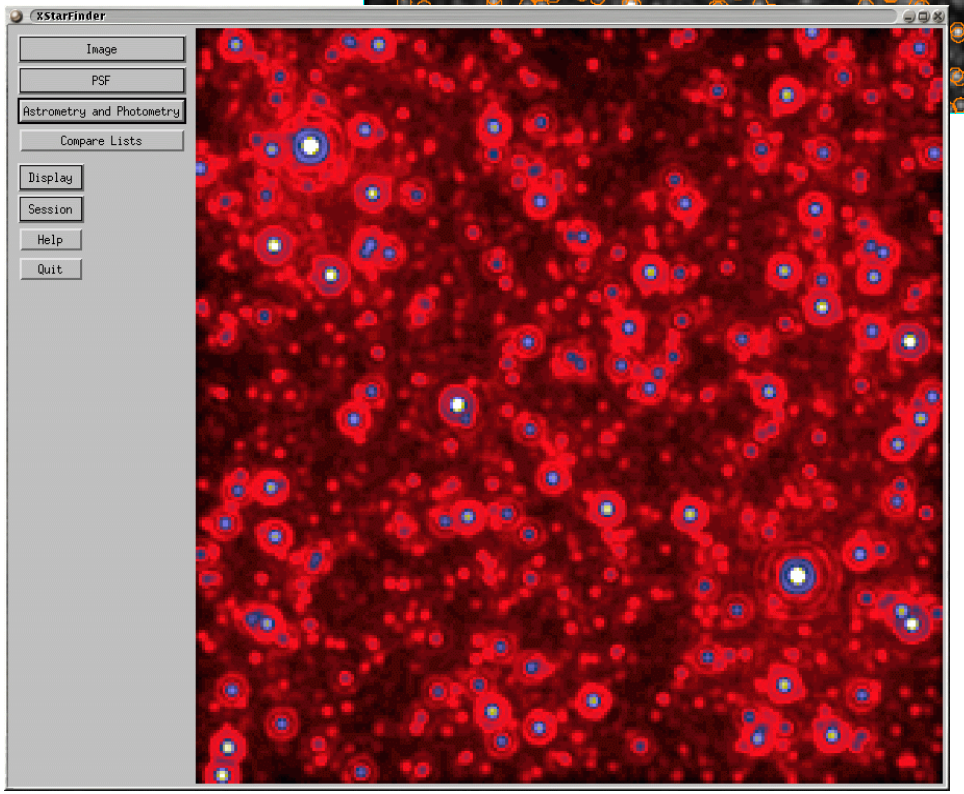
- Sampling the diffraction limit while covering the size of the halo requires a huge amount of pixels. Here: 4k x 4k.
- Need some scheme to 'compress' them.
- Variable contrast between central pixel and edge of PSF as a function of wavelength.
- Speckles.

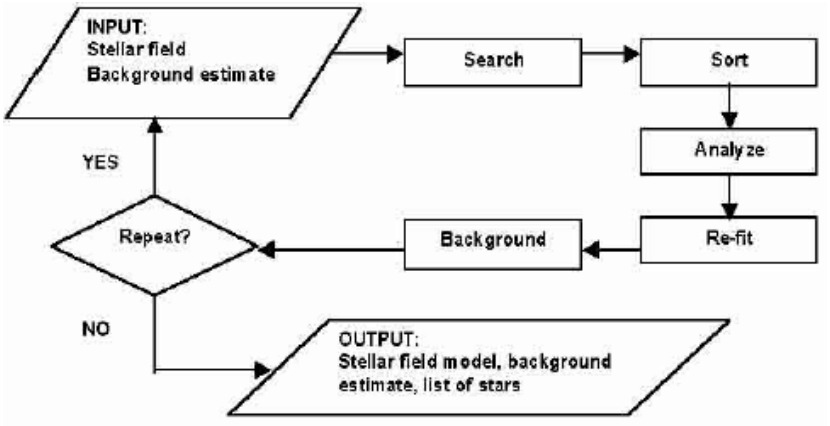


Extraction of a catalogue

- Many tools to perform photometry.
- PSF photometry *required*?
- Need to do it automatically.
- StarFinder (Diolaiti et al. 2000):
  - Interactive
  - Determines PSF from image
  - Iterative procedure

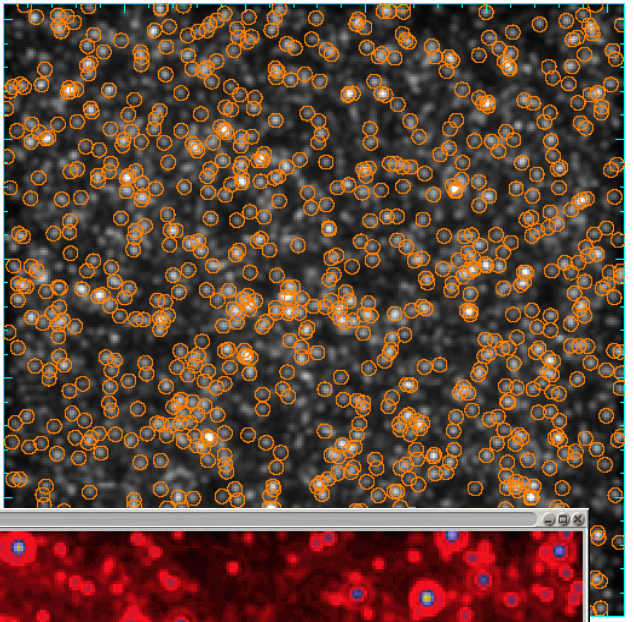


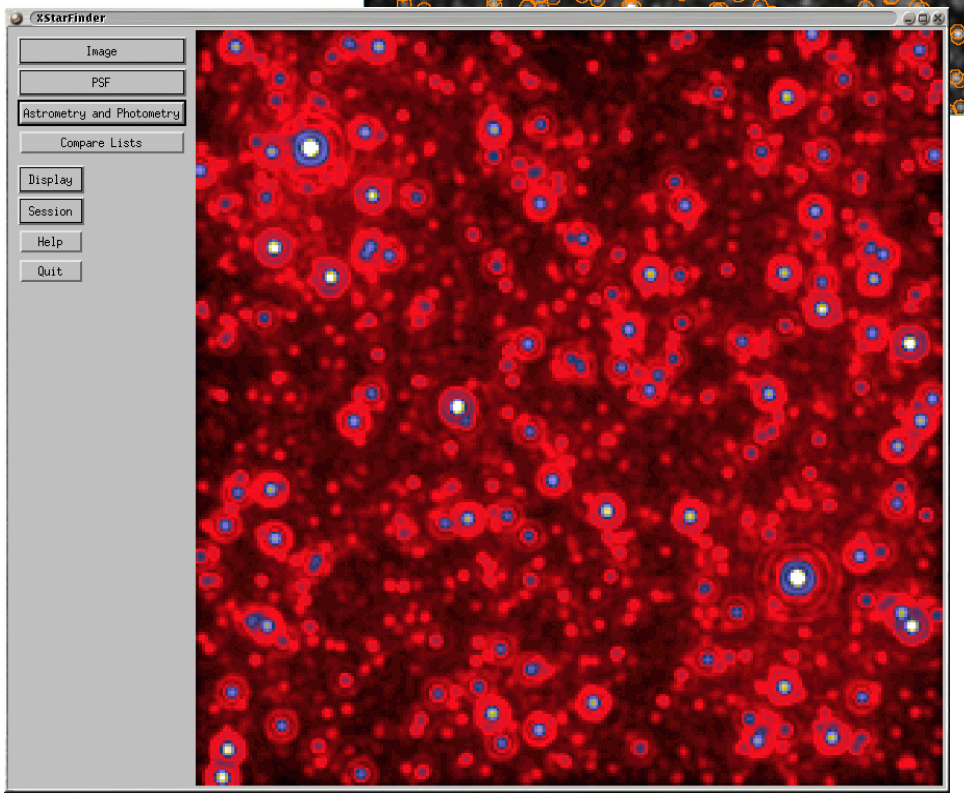




Extraction of a catalogue

- Created a non-interactive version of StarFinder for use in pipeline.
- Main limitations:
  - No automation of the determination of the PSF from the image. Feed StarFinder the true PSF instead.
  - Cannot handle varying PSF as a function of position in the FoV, or star colour.
  - Cannot handle joint detection in multiple images.



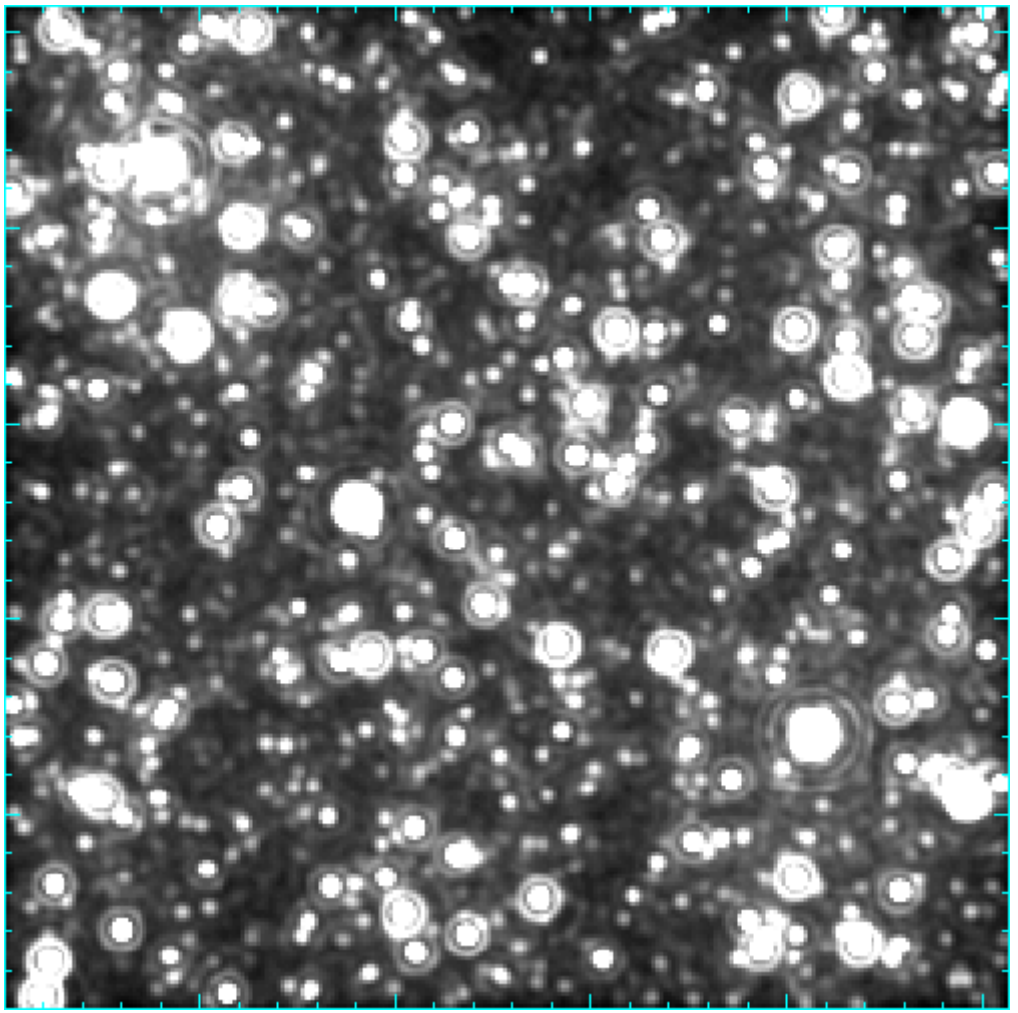


Example

K-band

10 h integration

0.9 x 0.9 arcsec^2



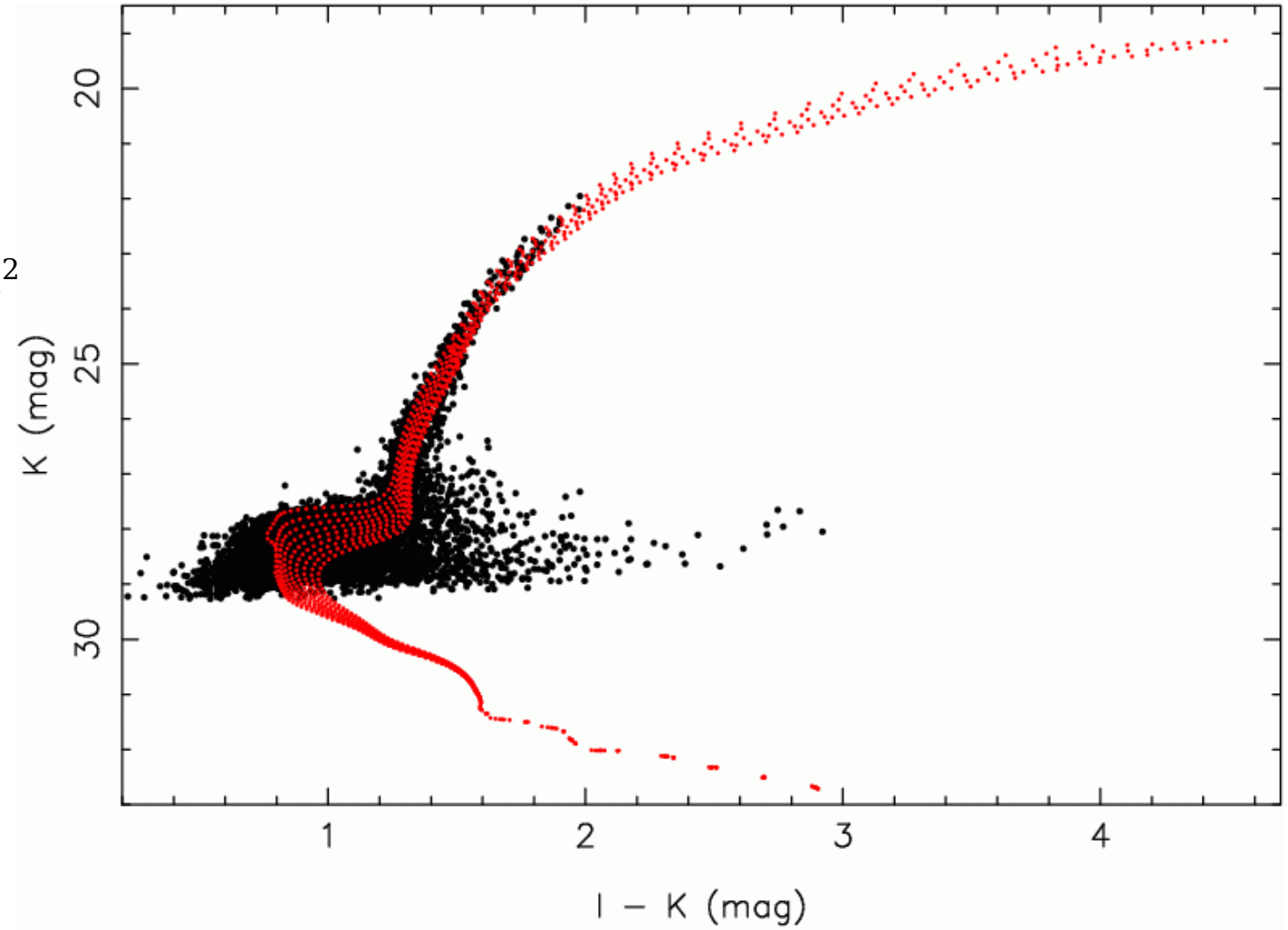
Effect of crowding

DM = 26 mag

$\langle \mu_V \rangle$ = 22 mag/arcsec^2

t_{exp} = 100 h

FoV = 3.6 x 3.6
= 13 arcsec^2



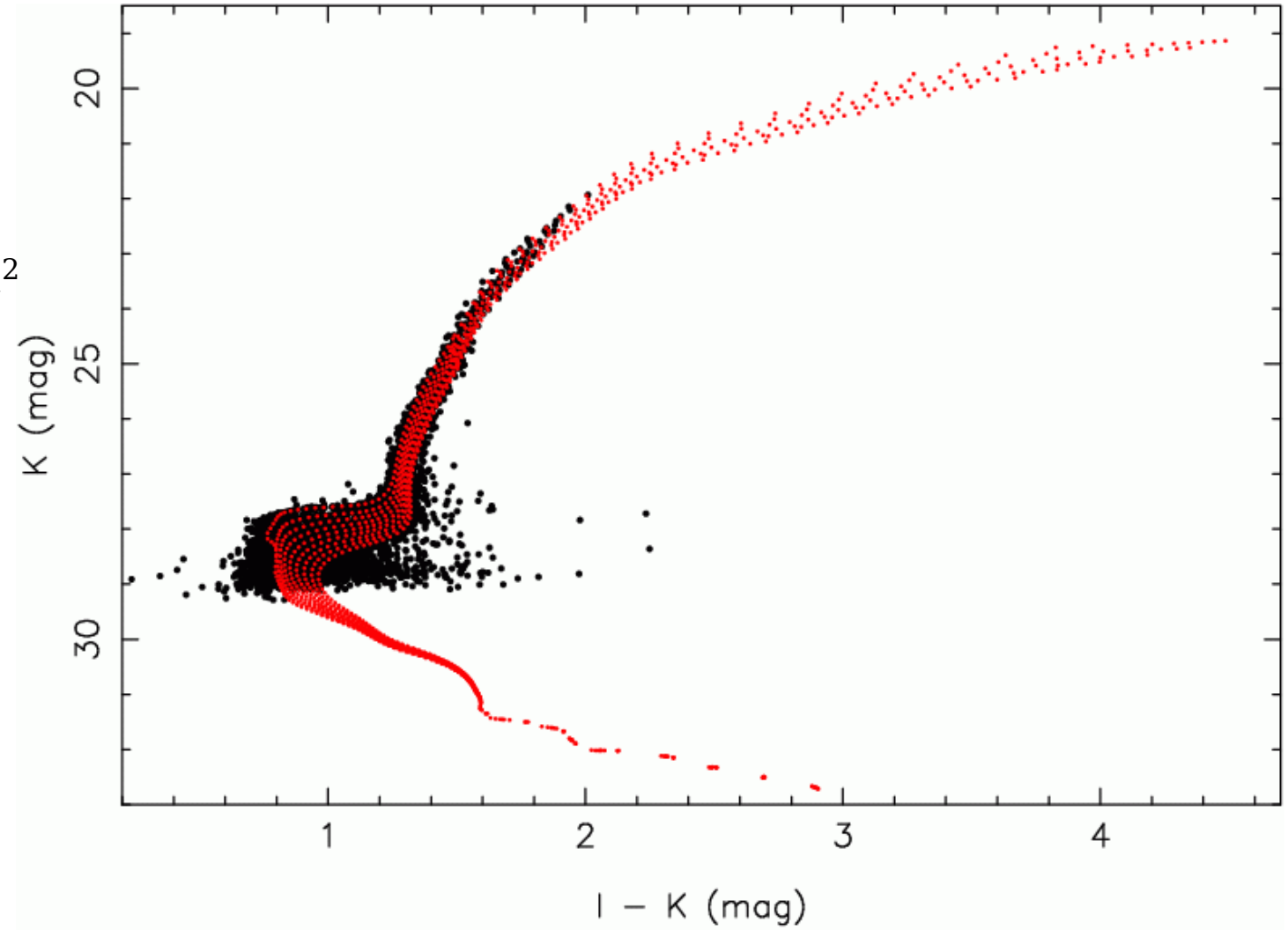
Effect of crowding

DM = 26 mag

$\langle \mu_V \rangle$ = 24 mag/arcsec^2

t_{exp} = 100 h

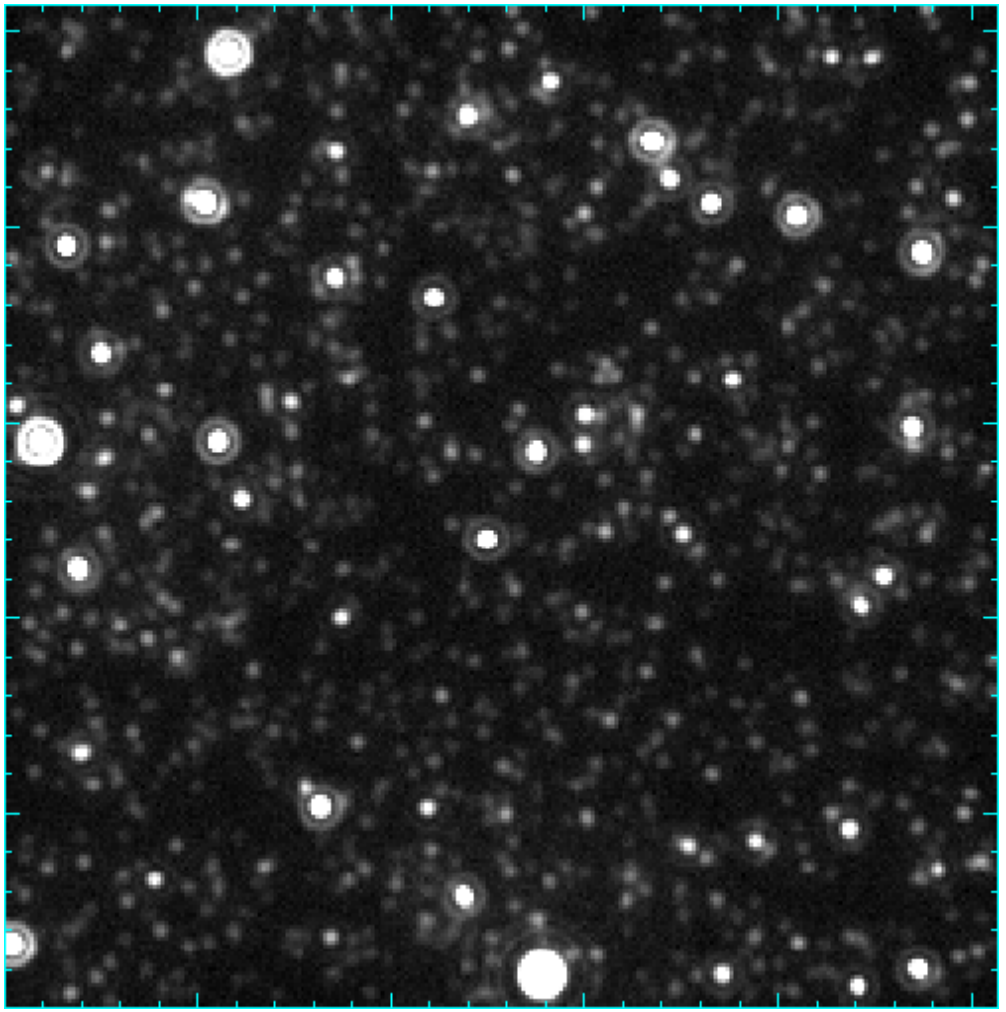
FoV = 9.1 x 9.1
= 82 arcsec^2



Effect of crowding

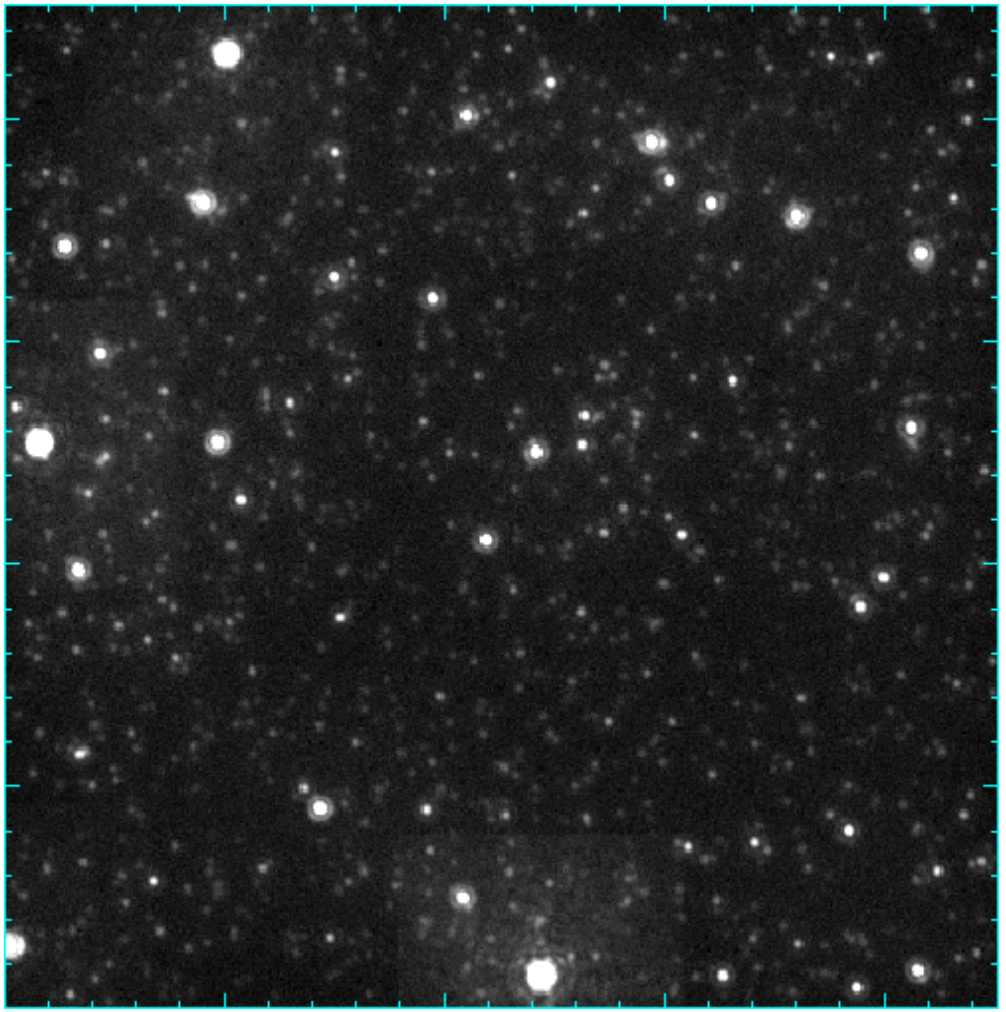
Original

K-band



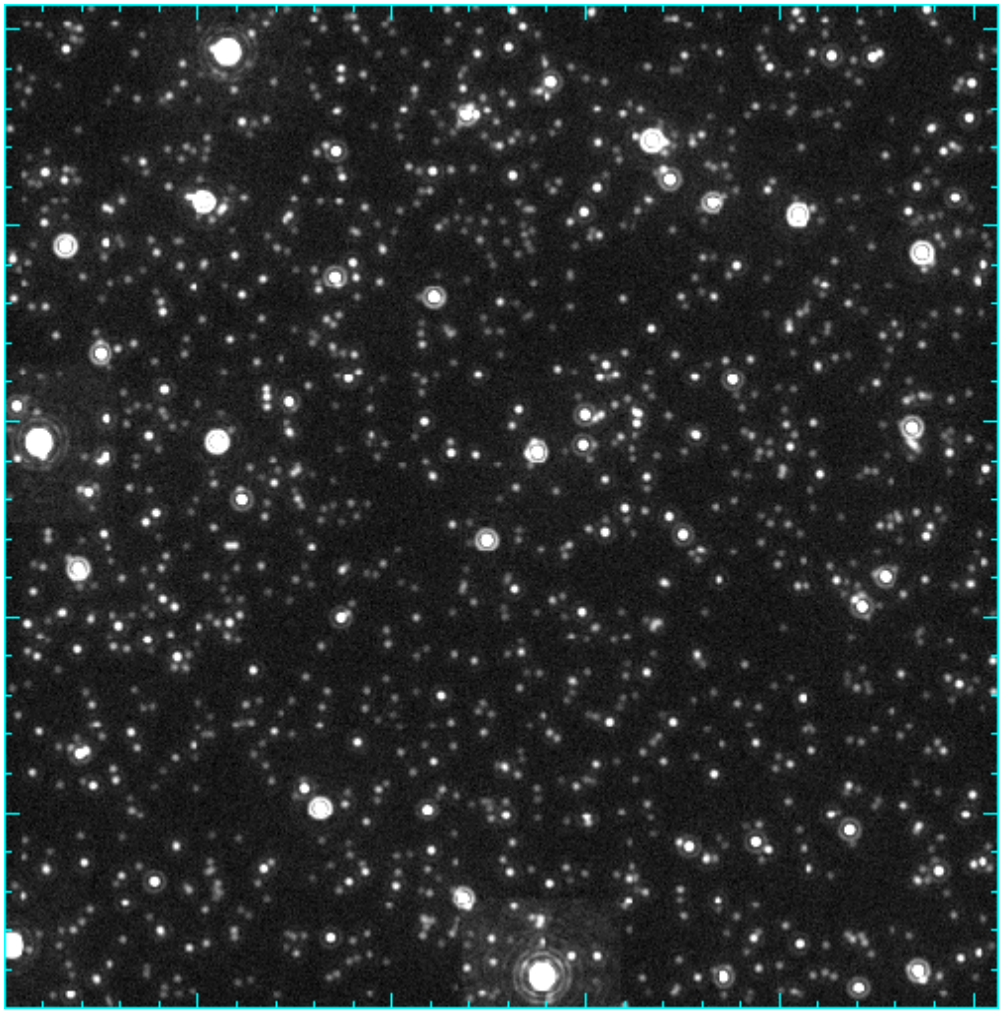
Effect of crowding

J-band PSF



Effect of crowding

PSF scale / 2



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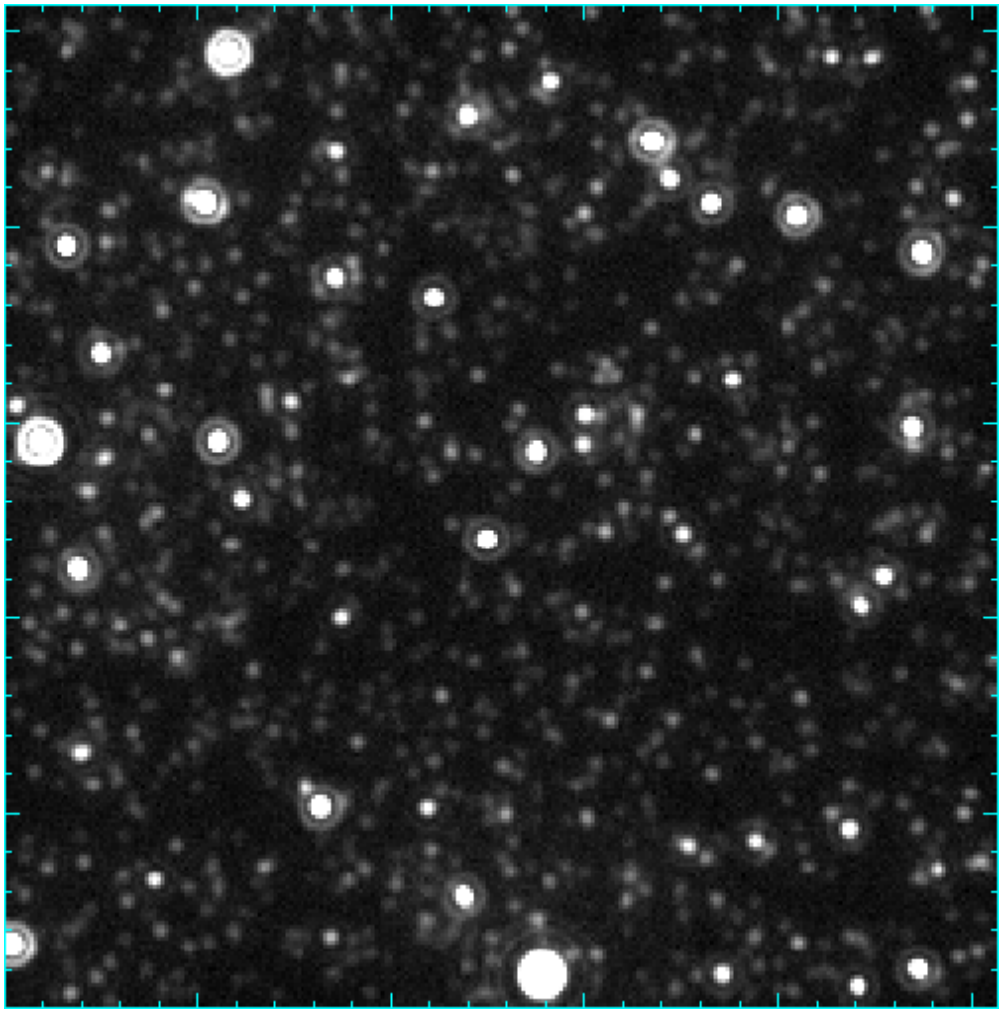

Effect of crowding

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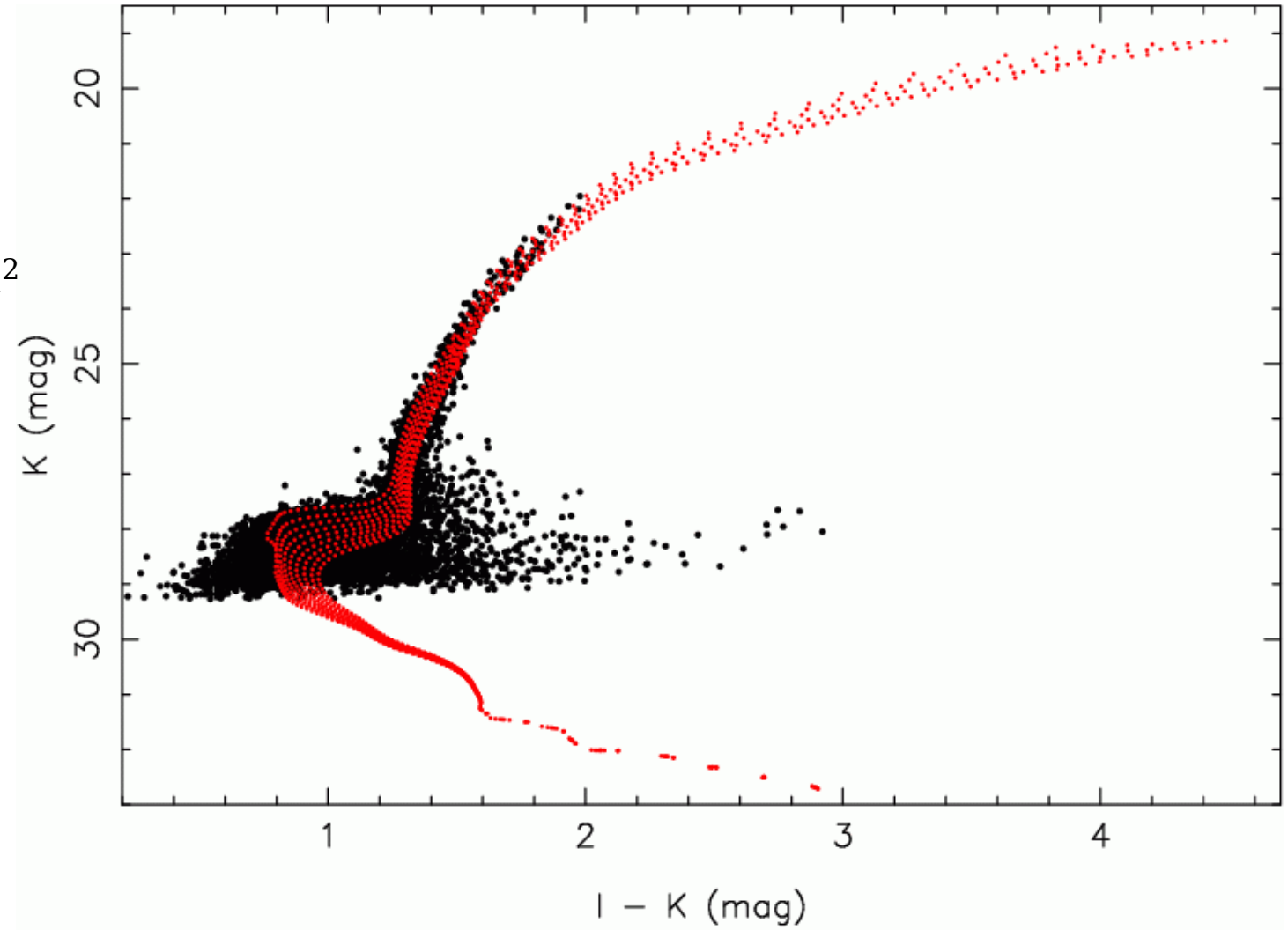
FoV = 3.6 x 3.6
= 13 arcsec^2

Original K-band



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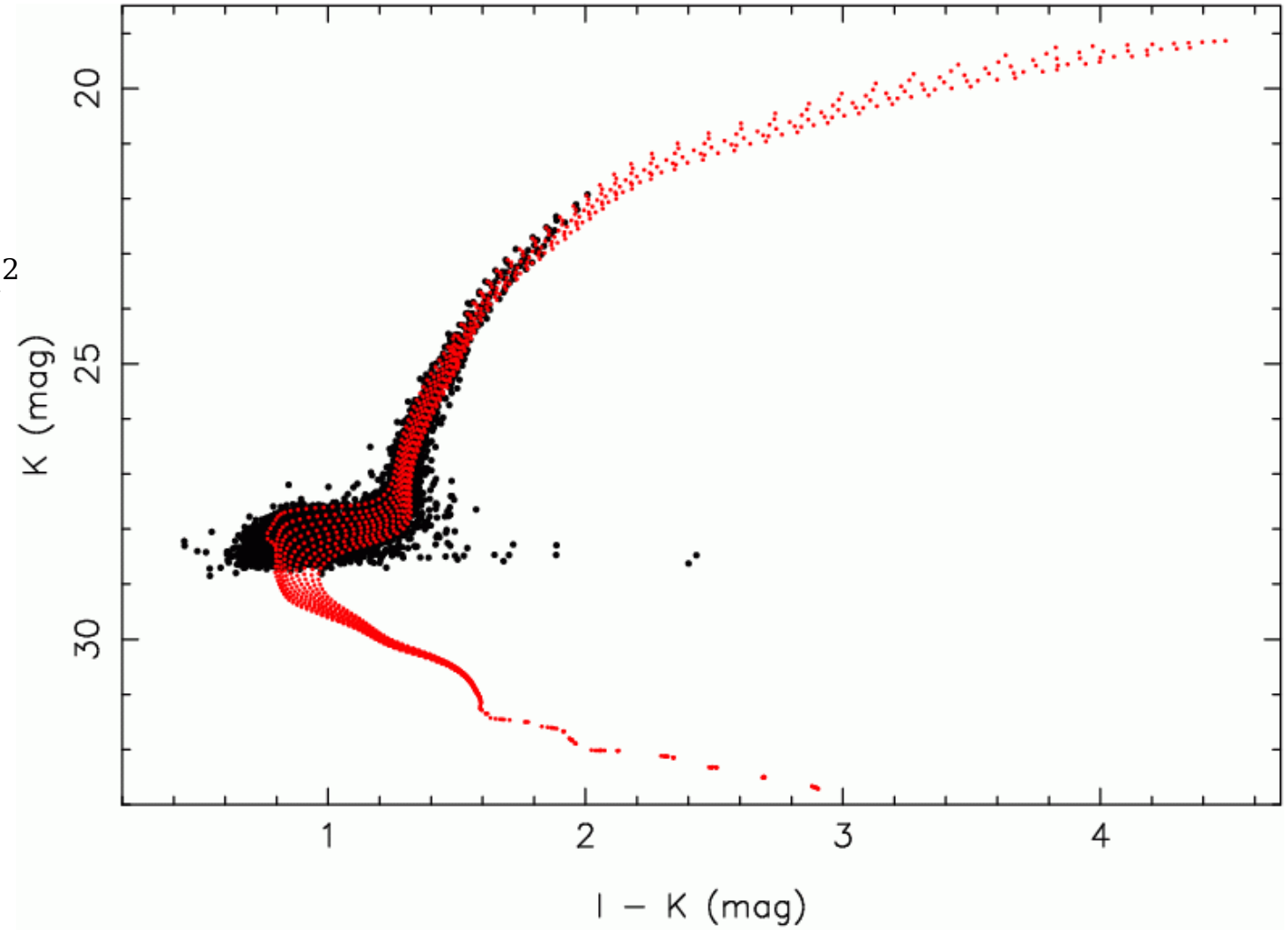
PSF --> J-band PSF



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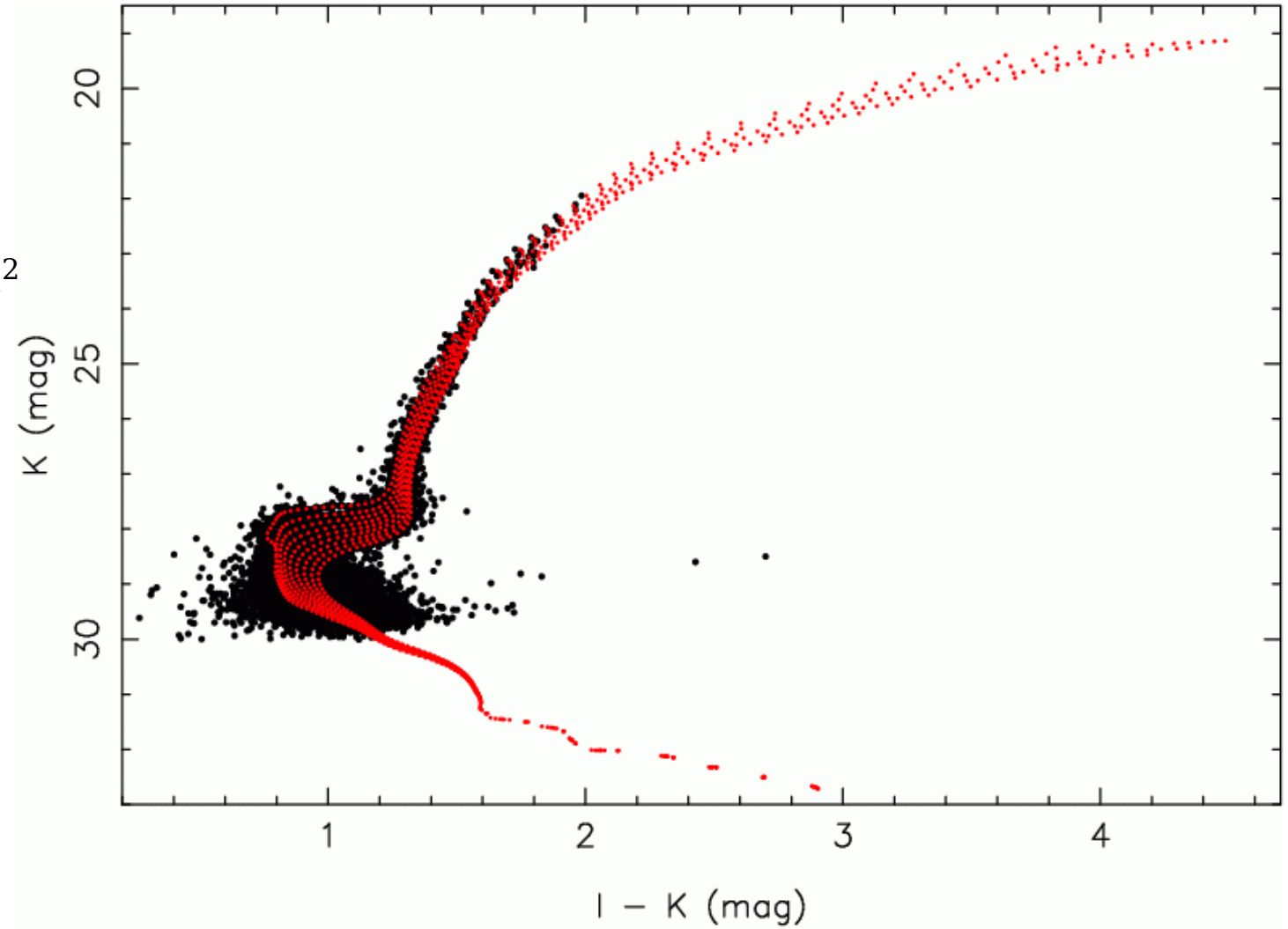

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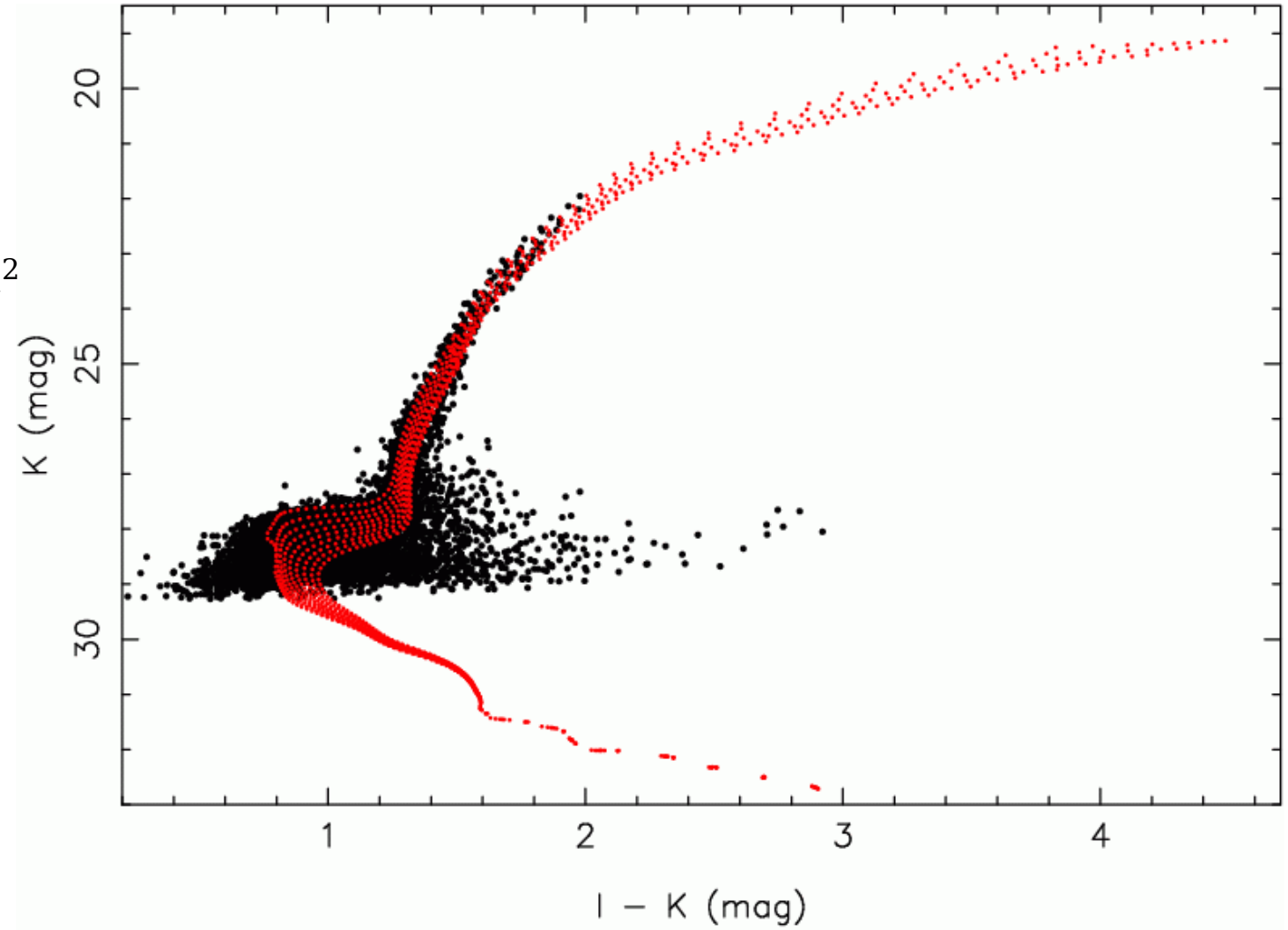

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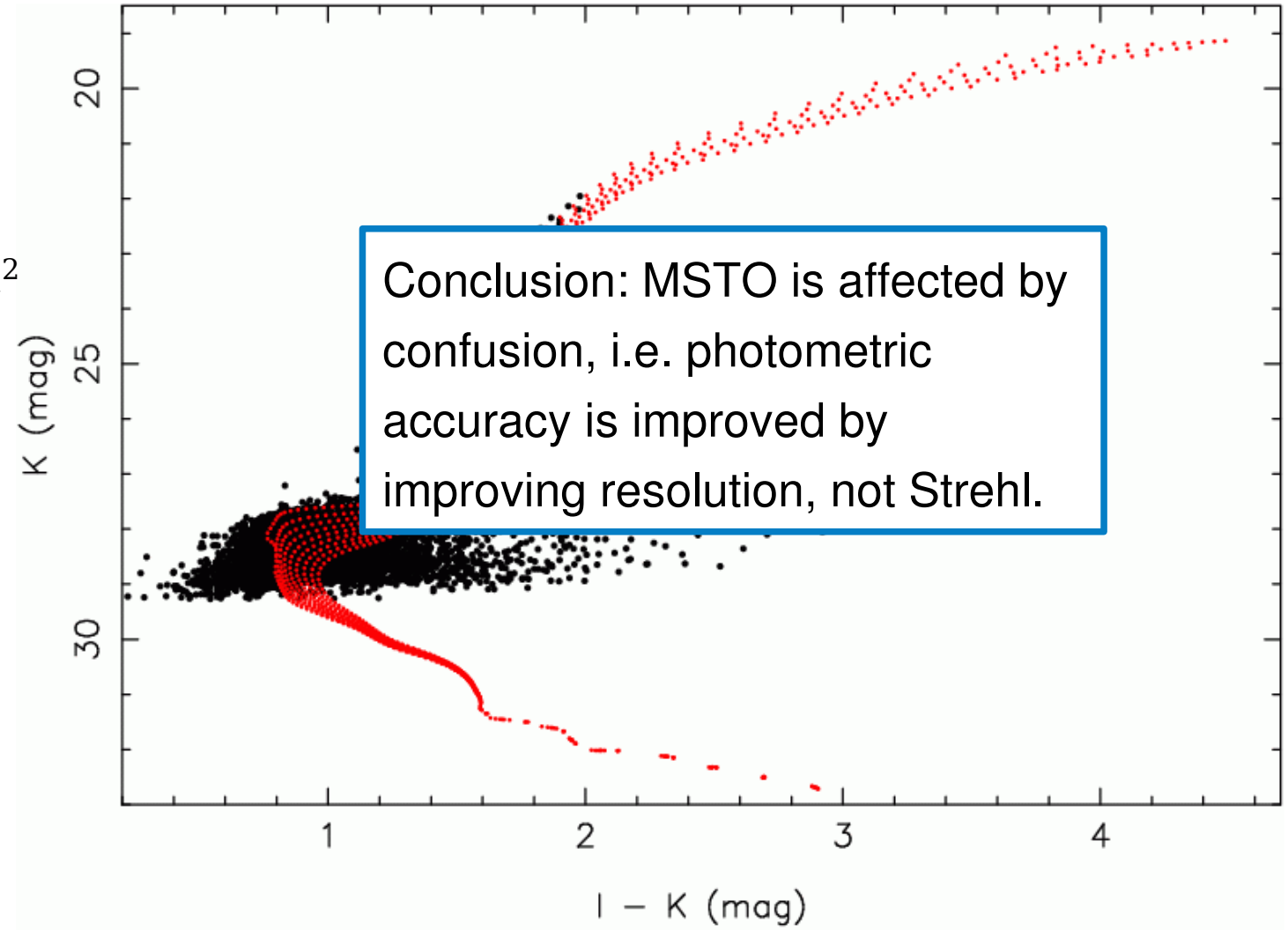

Conclusion: MSTO is affected by confusion, i.e. photometric accuracy is improved by improving resolution, not Strehl.

Required improvements

- Interpolation between isochrones
- How to deal with massive PSFs in image generation?
- How to include anisoplanatism?
- How to include joint detection of sources in multiple images?
- How to 'simulate' imperfect PSF estimation?