A new software for astrometry and photometry in the AO era

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In collaboration with
Eline Tolstoy (Kapteyn-Groningen)
Davide Massari (INAF-Bologna)
...et al.

AO2020 - Roma - 18/02/20

Motivation: why do we need a new software?

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We need *high-precision astro/photo-metric measurements*, but…

- PSFs are becoming complex, difficult to be described analytically
- PSFs varies across the an image in a way that it is difficult to predict a priori
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The community is aware of these issues:

Laura Schreiber's talk

Davide Massari's talk

Carmelo Arcidiacono's talk

Andrea Grazian's talk

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A possible solution

A software that

A. extract purely ***numerical*** PSFs in different regions of the image
B. use these PSFs to extract position and magnitude of all sources
C. iterates A and B to improve on PSF models, astrometry and photometry

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SUPERSTAR

SUPERSTAR FLOW CHART

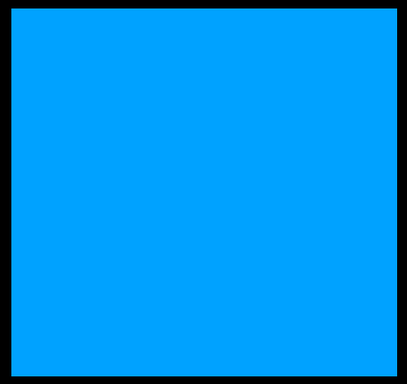
Original image

-

Model image

=

Residual image



SUPERSTAR FLOW CHART

1 - SKY

Background and noise map
via ‘running window’ method

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Look for candidate stars in the residual image
S/N based
First estimate of position and fluxes
Flag “isolated” stars

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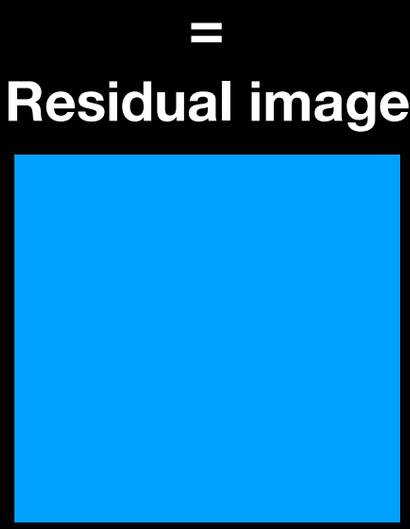

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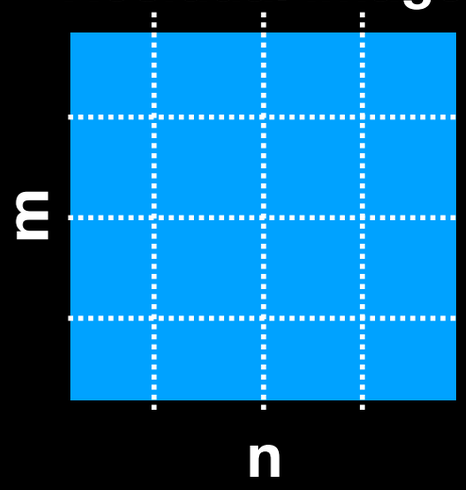

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based on Anderson & King 2000,2006
stacking isolated, high S/N stars on a *fine* grid
multi-kernel smoothing
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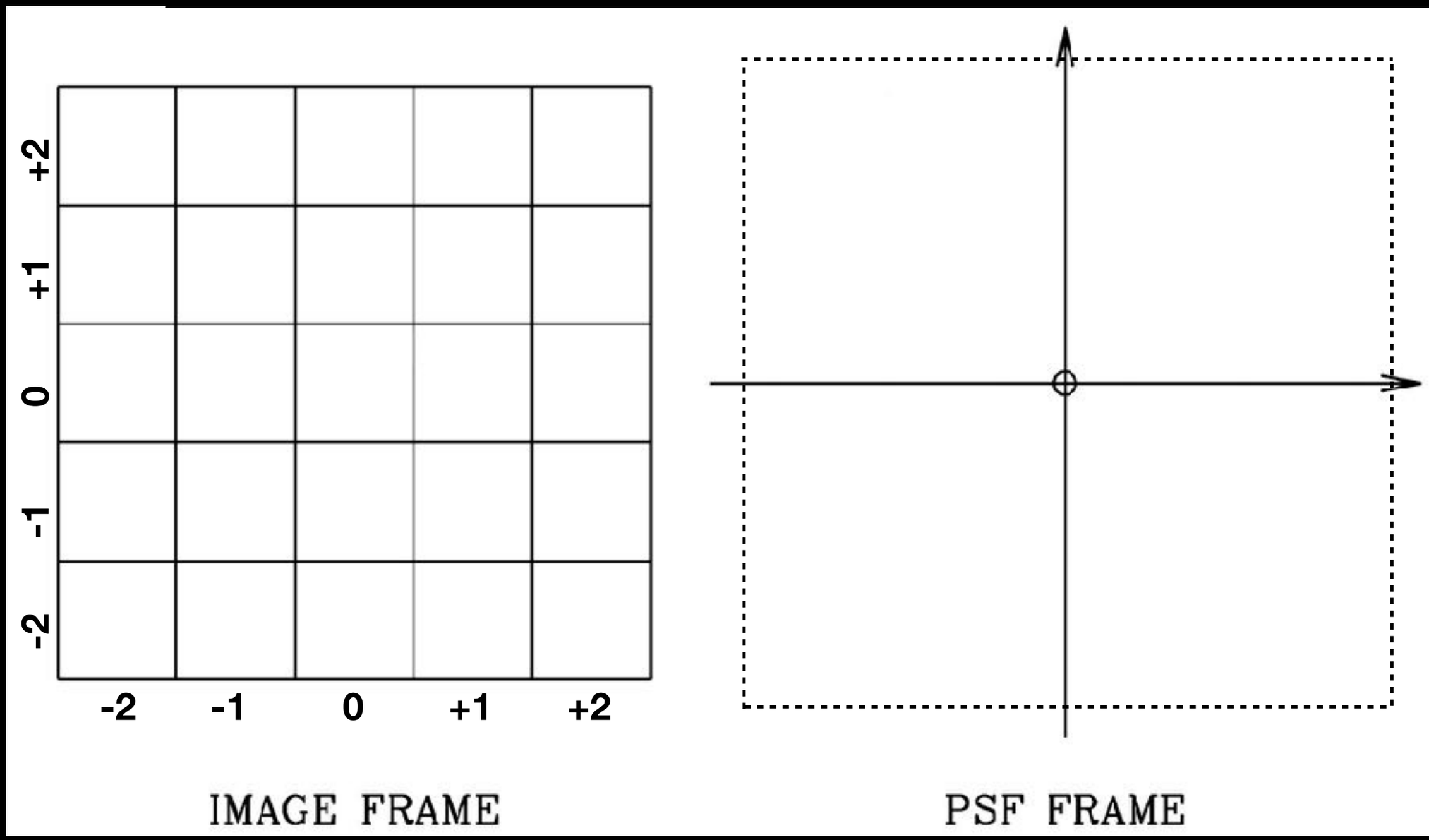
ePSF NUMERICAL MODELLING



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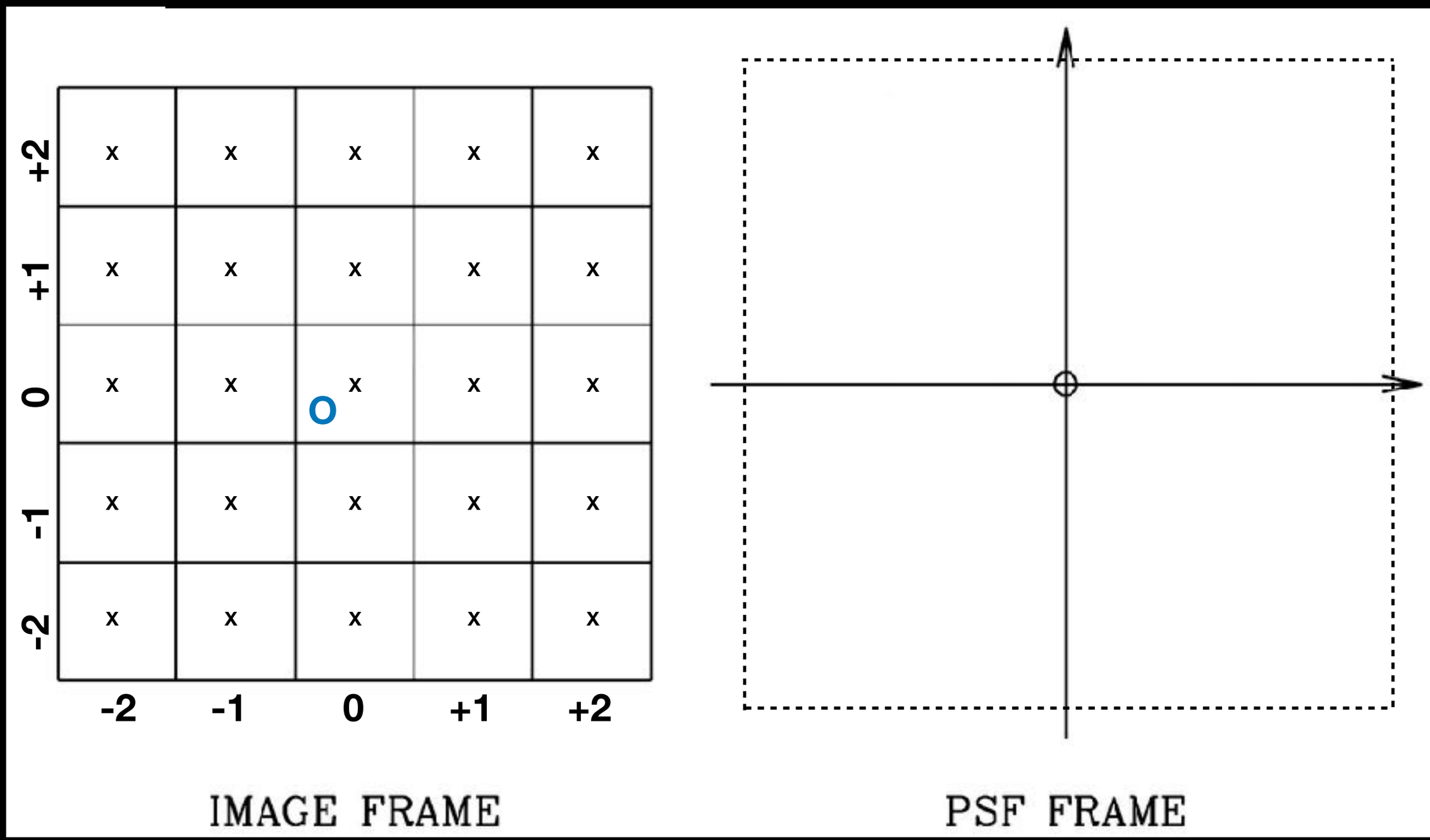

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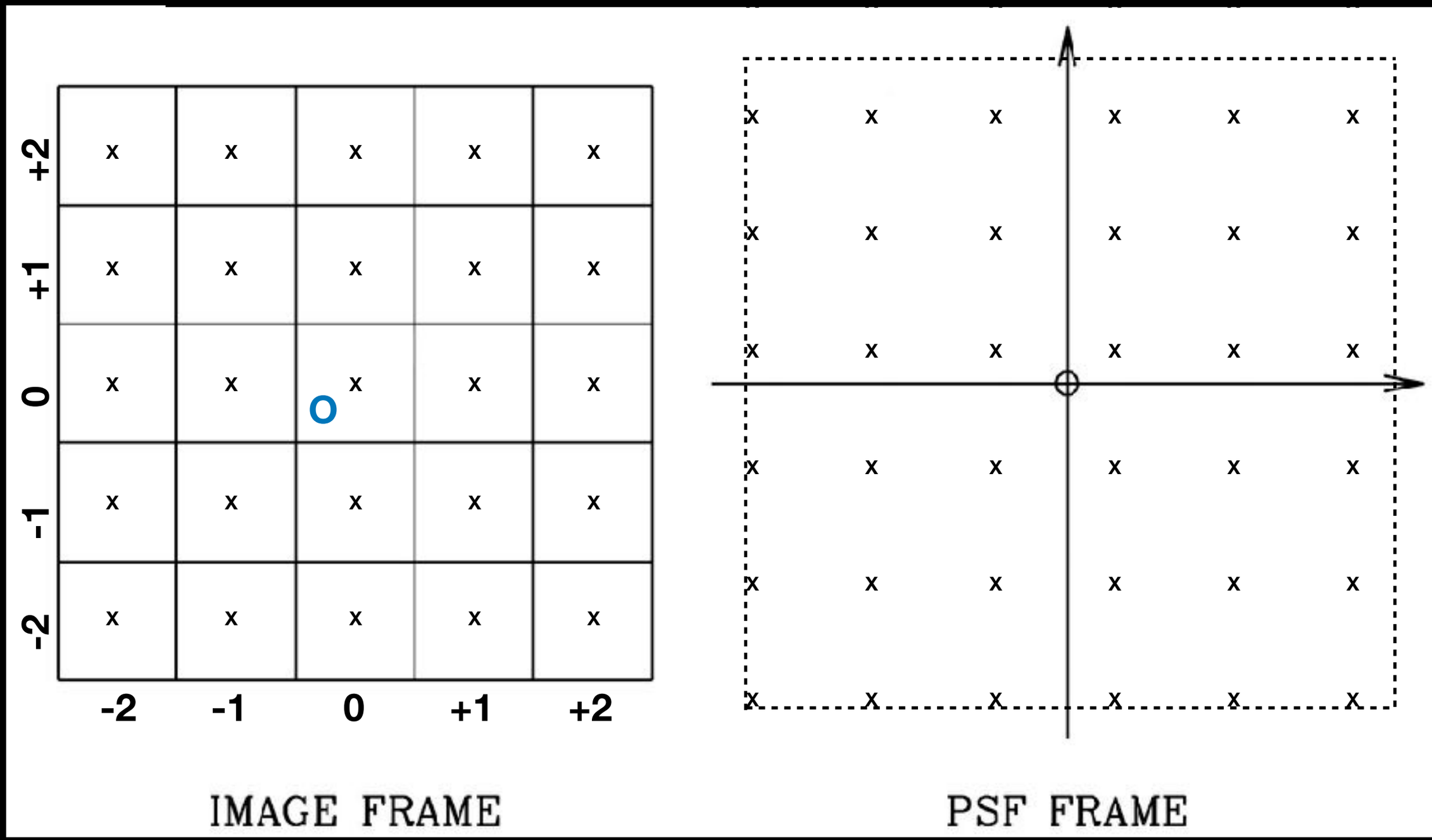

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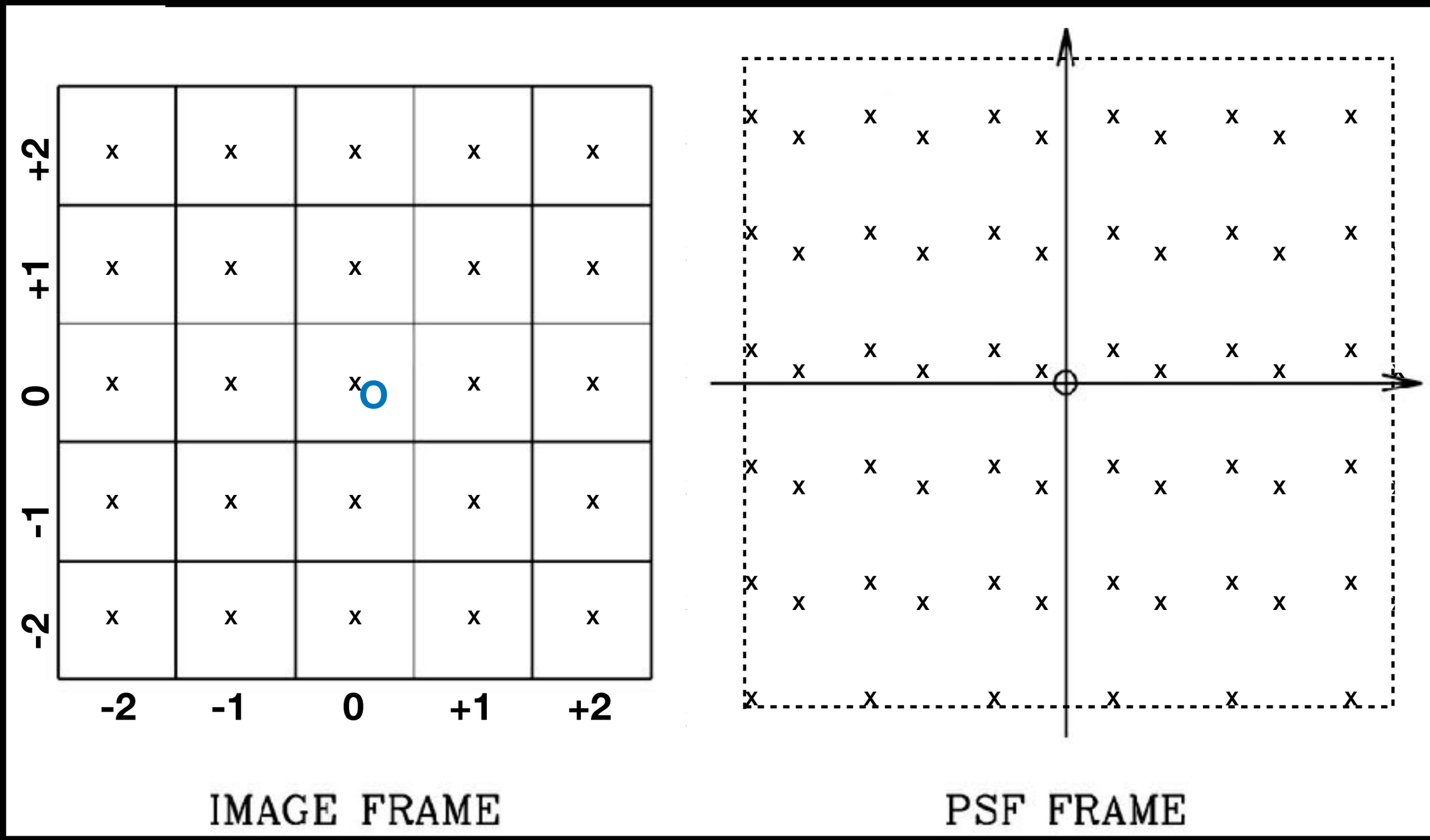

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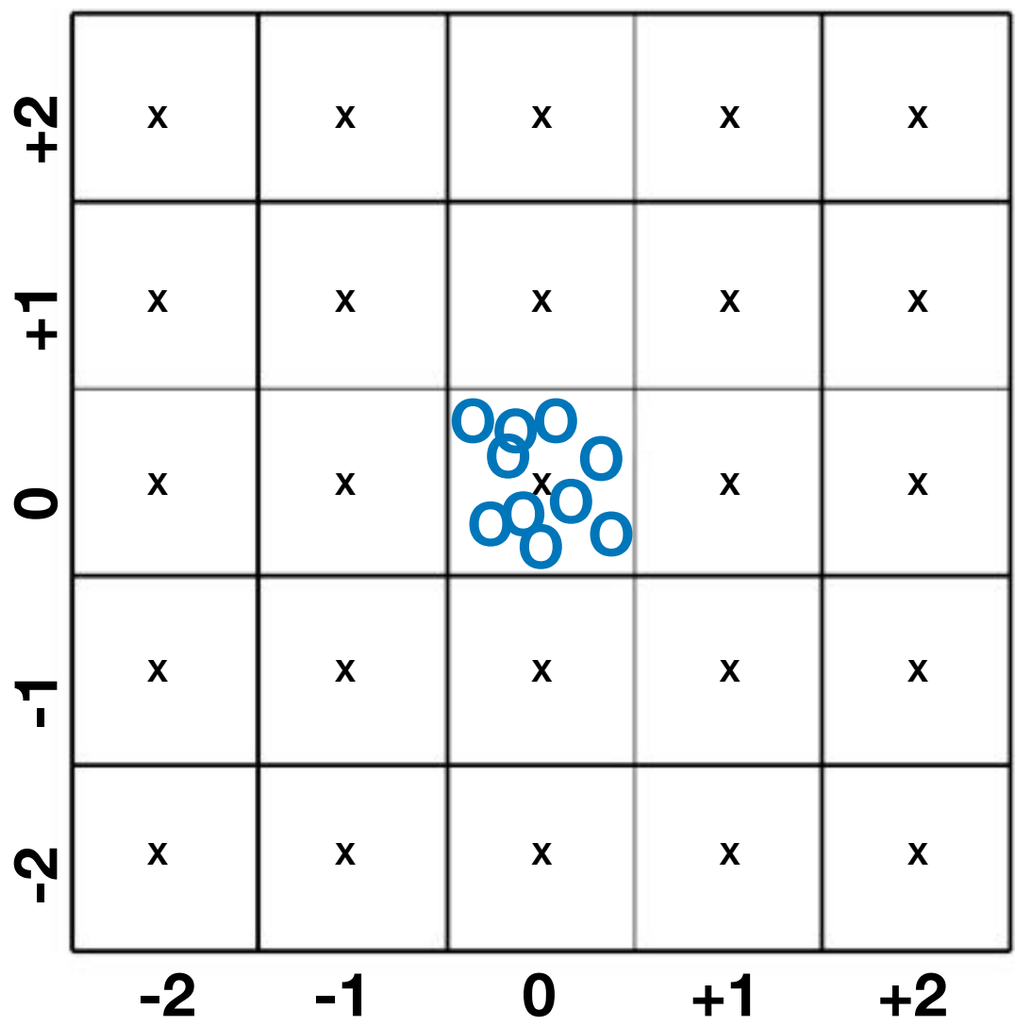
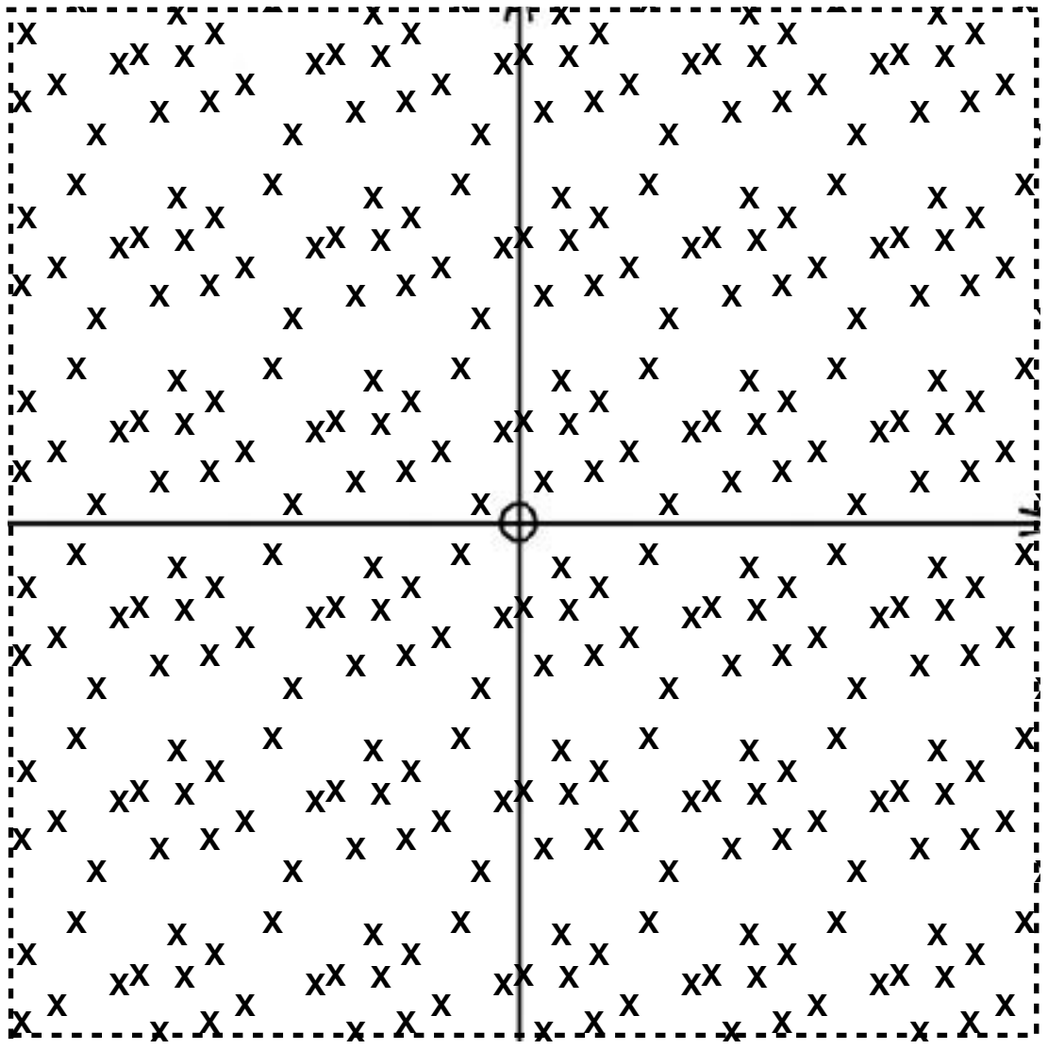


IMAGE FRAME



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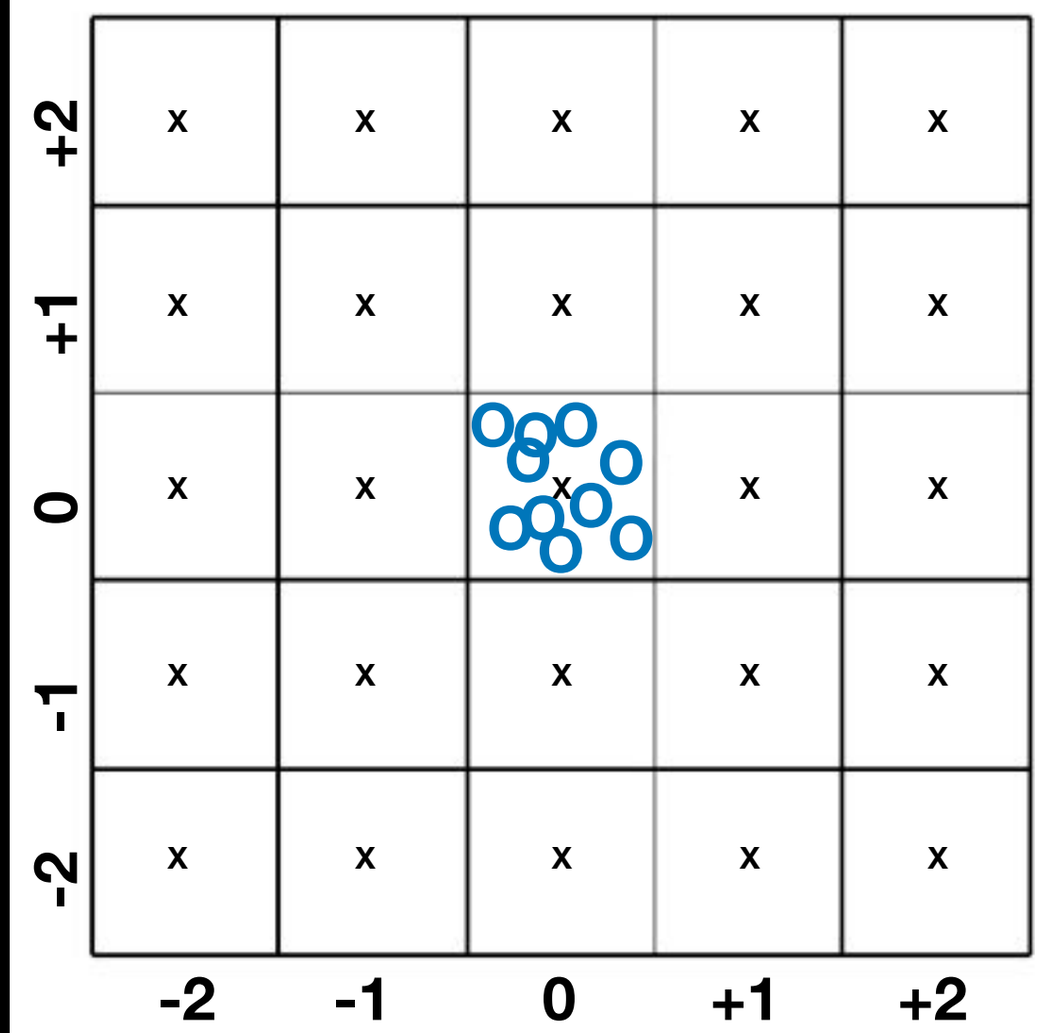

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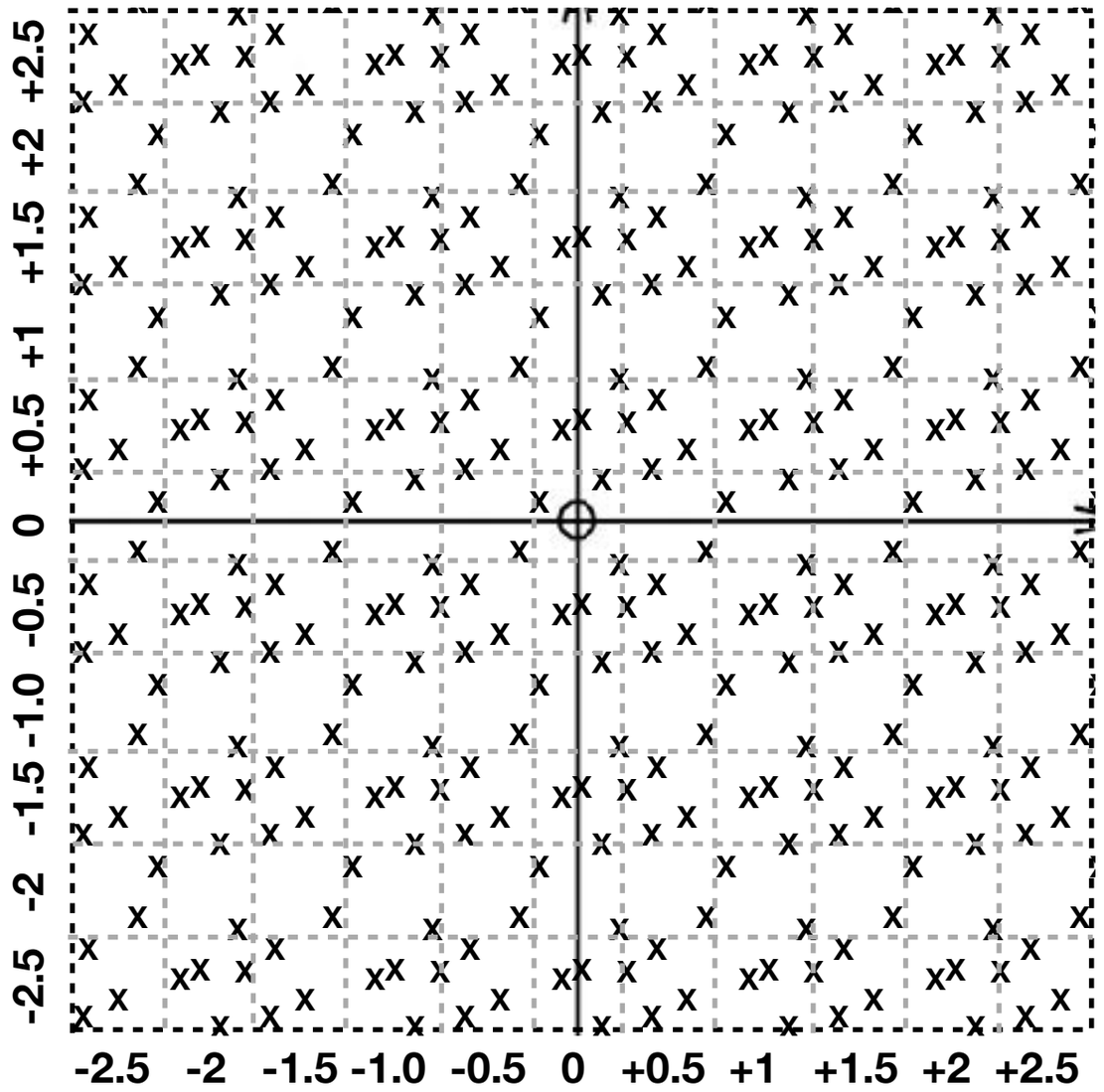

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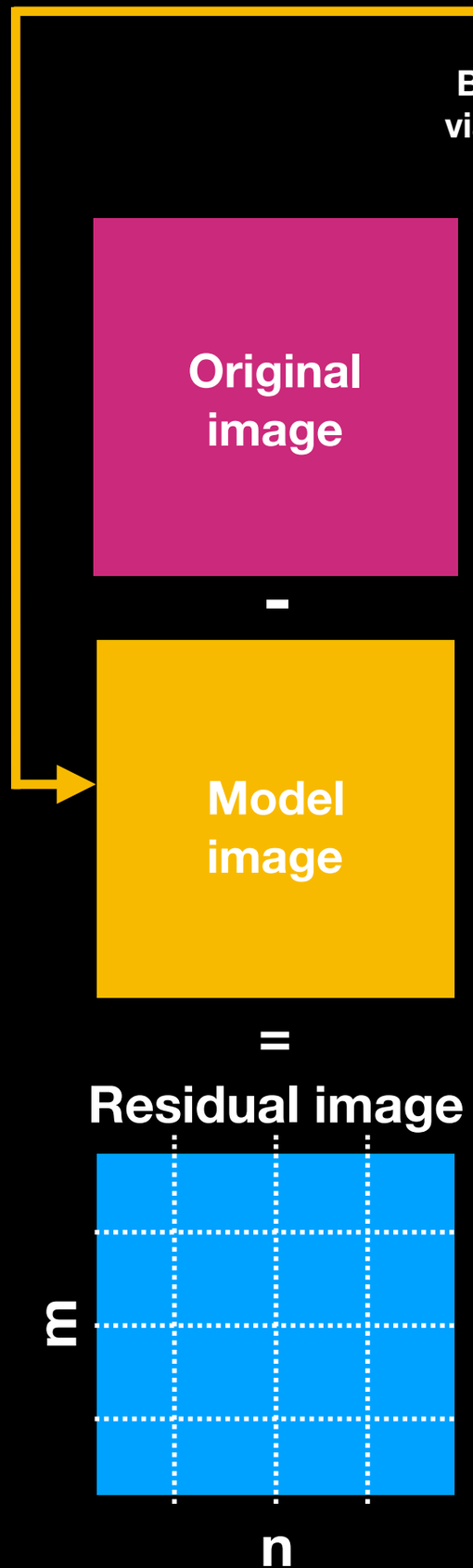

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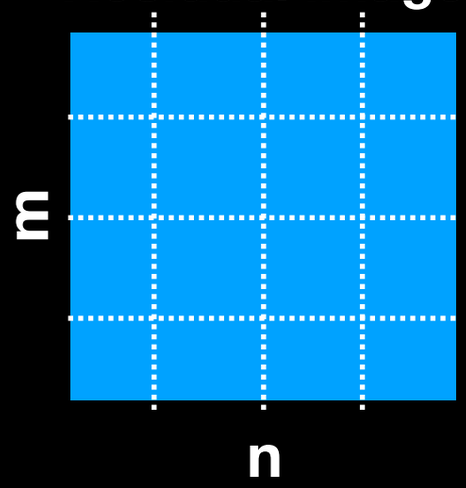

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correlation coefficient (StarFinder)
least-square fitting (single or multiple stars)
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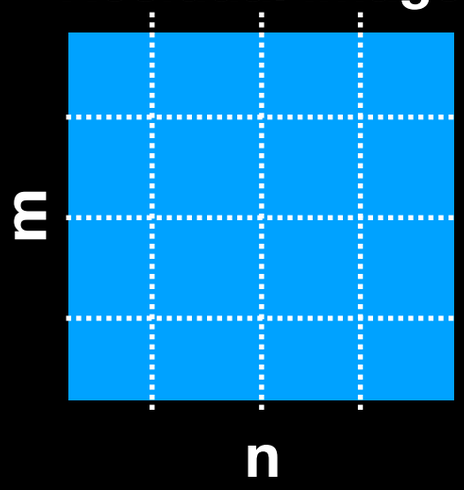

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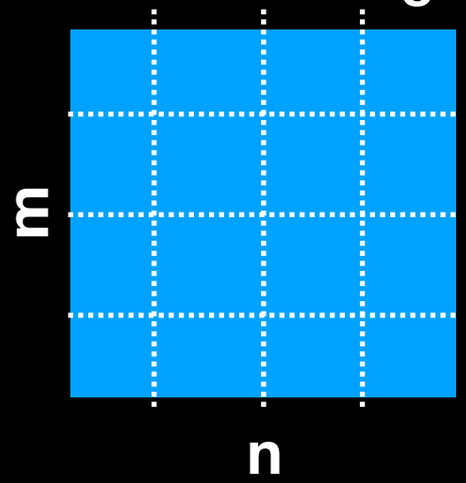

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cycle

SUPERSTAR OUTPUTS

catalogues

- initial estimates for (x,y,mag)
- final (x,y,mag) and corr.coefficients

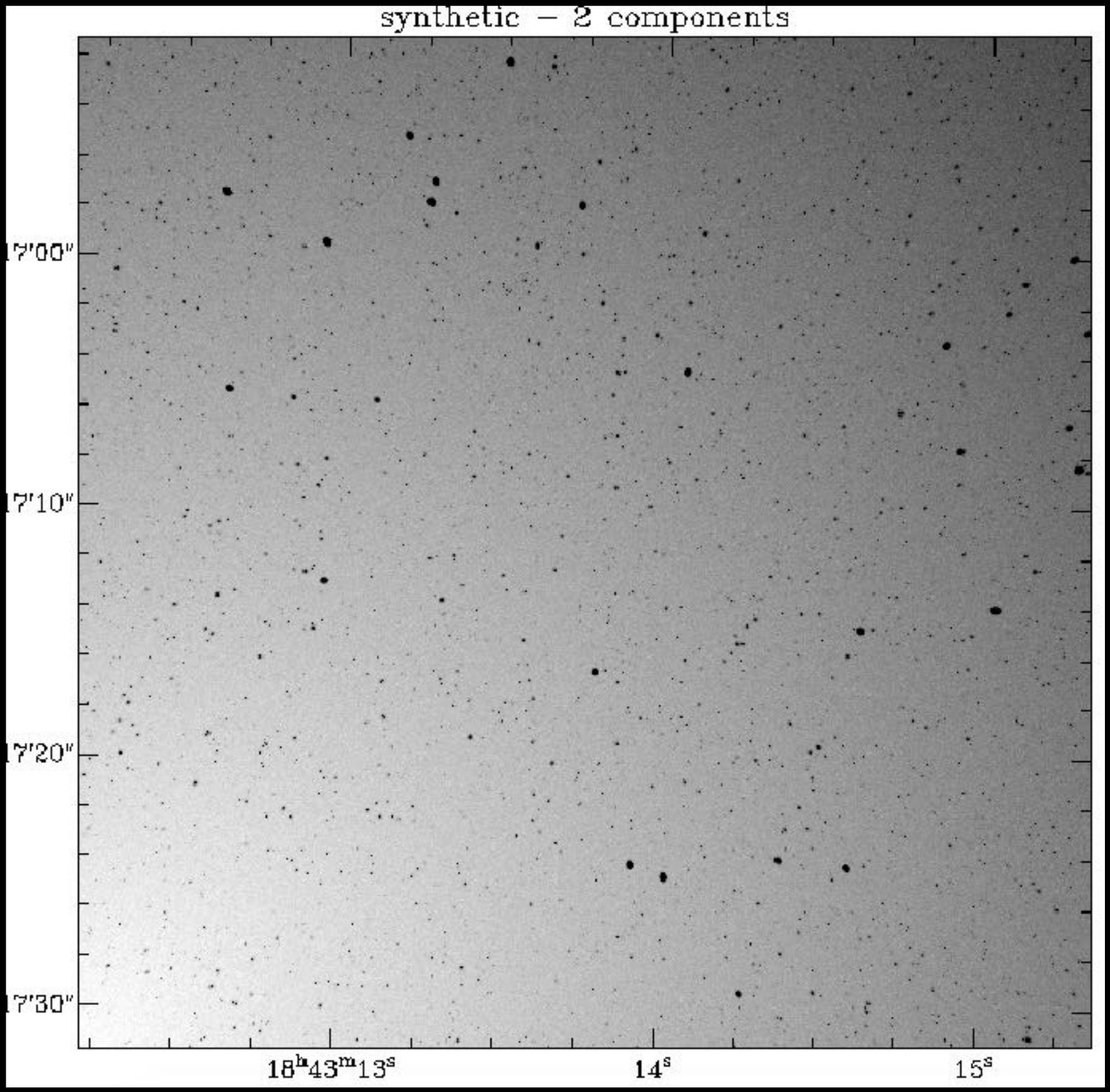
images (fits format)

- residuals (data-model)
- modelled sky background
- modelled sky noise
- initial (x,y) of all sources (1-0 map)
- final (x,y) of all sources (1-0 map)
- (x,y) of surces used to extract ePSF (1-0)

datacube (fits format)

- ePSF in the various regions

SUPERSTAR vs DAOPHOT: synthetic images



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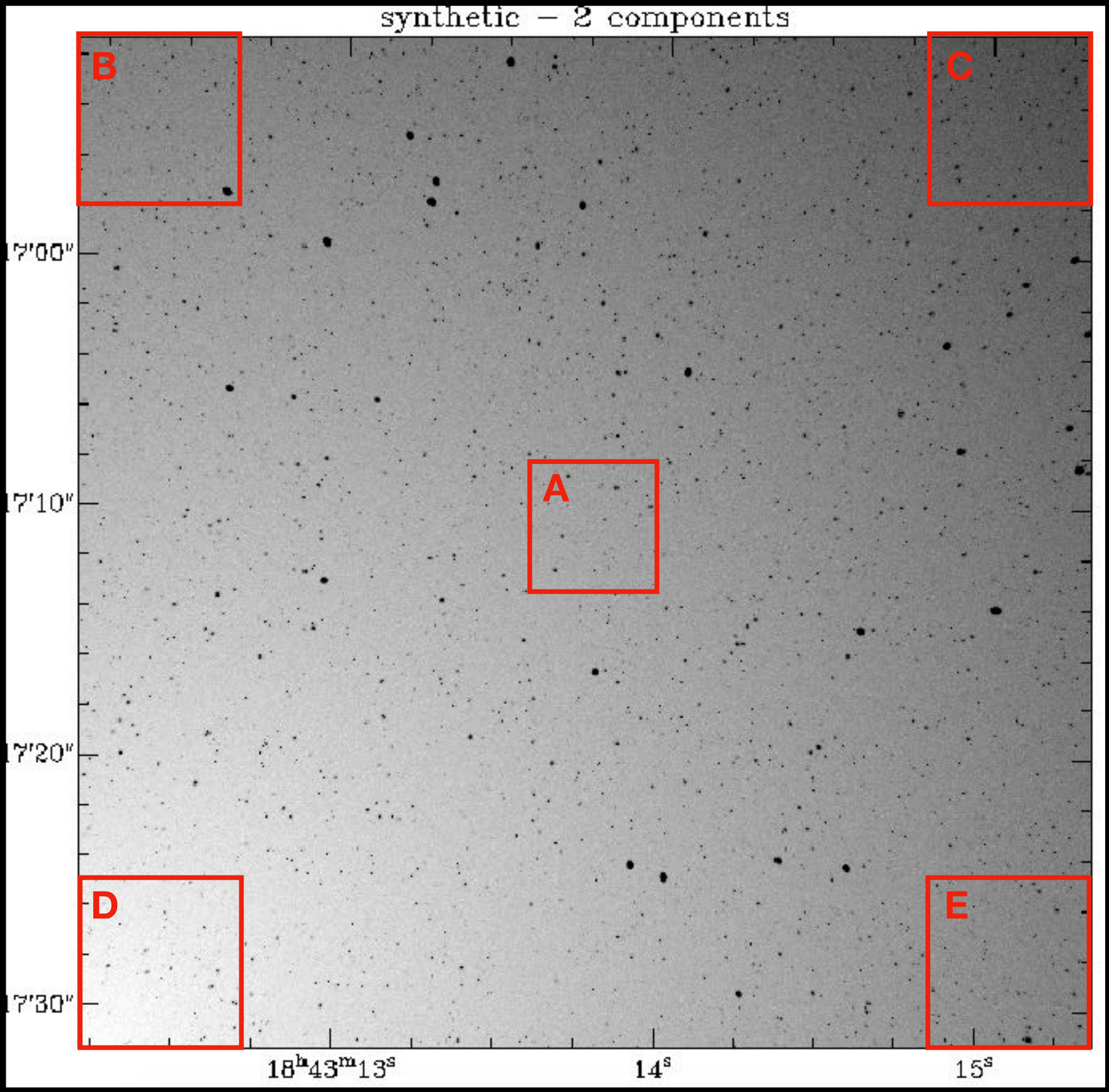

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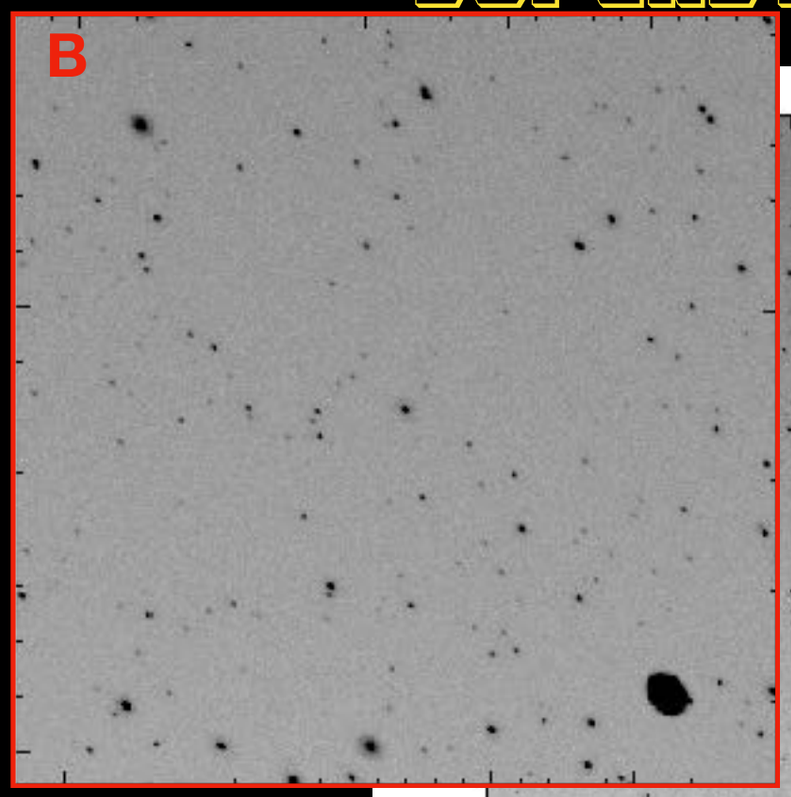
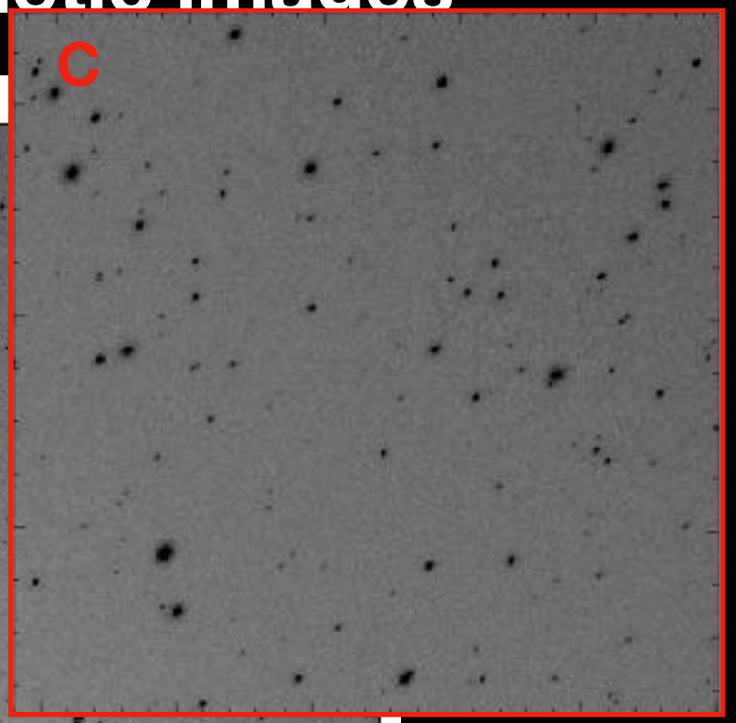
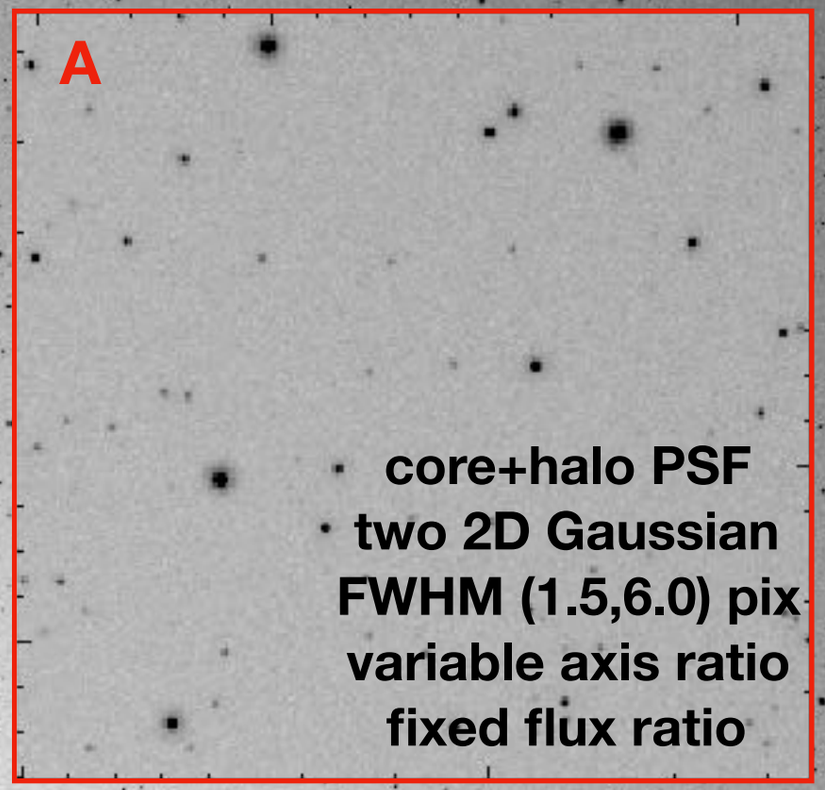


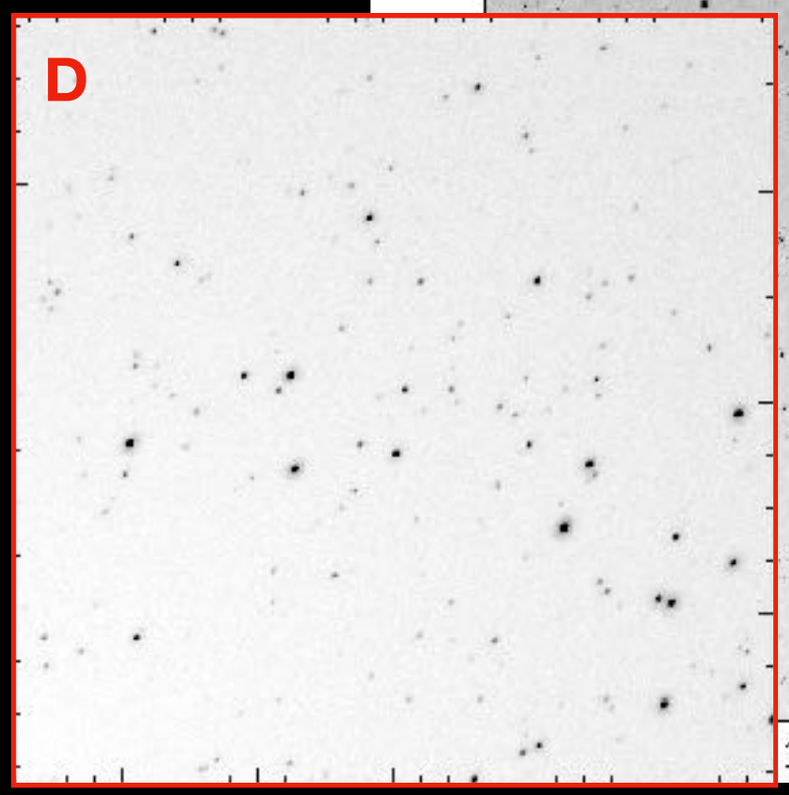


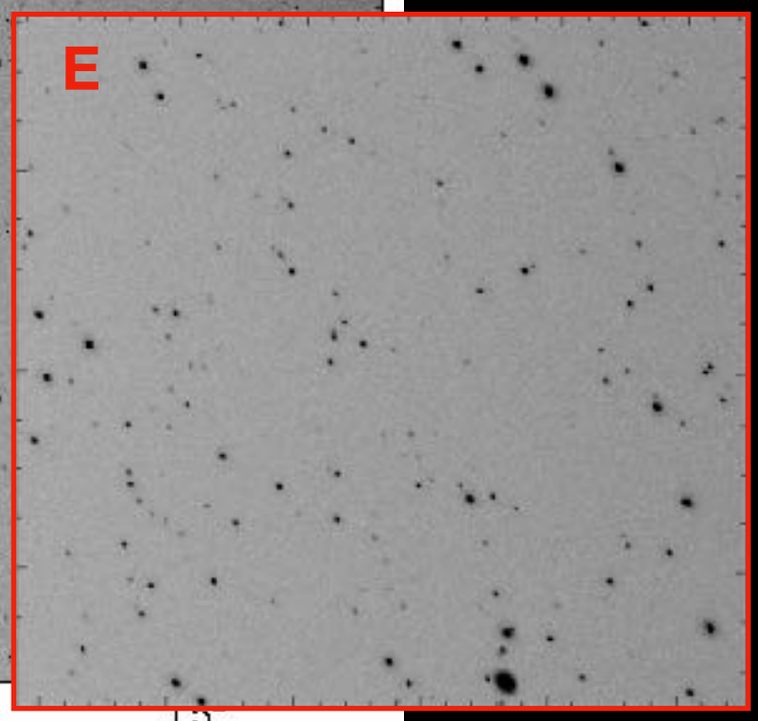
synthetic – 2 components



core+halo PSF
two 2D Gaussian
FWHM (1.5,6.0) pix
variable axis ratio
fixed flux ratio

17'10"





$18^h43^m13^s$ 14^s 15

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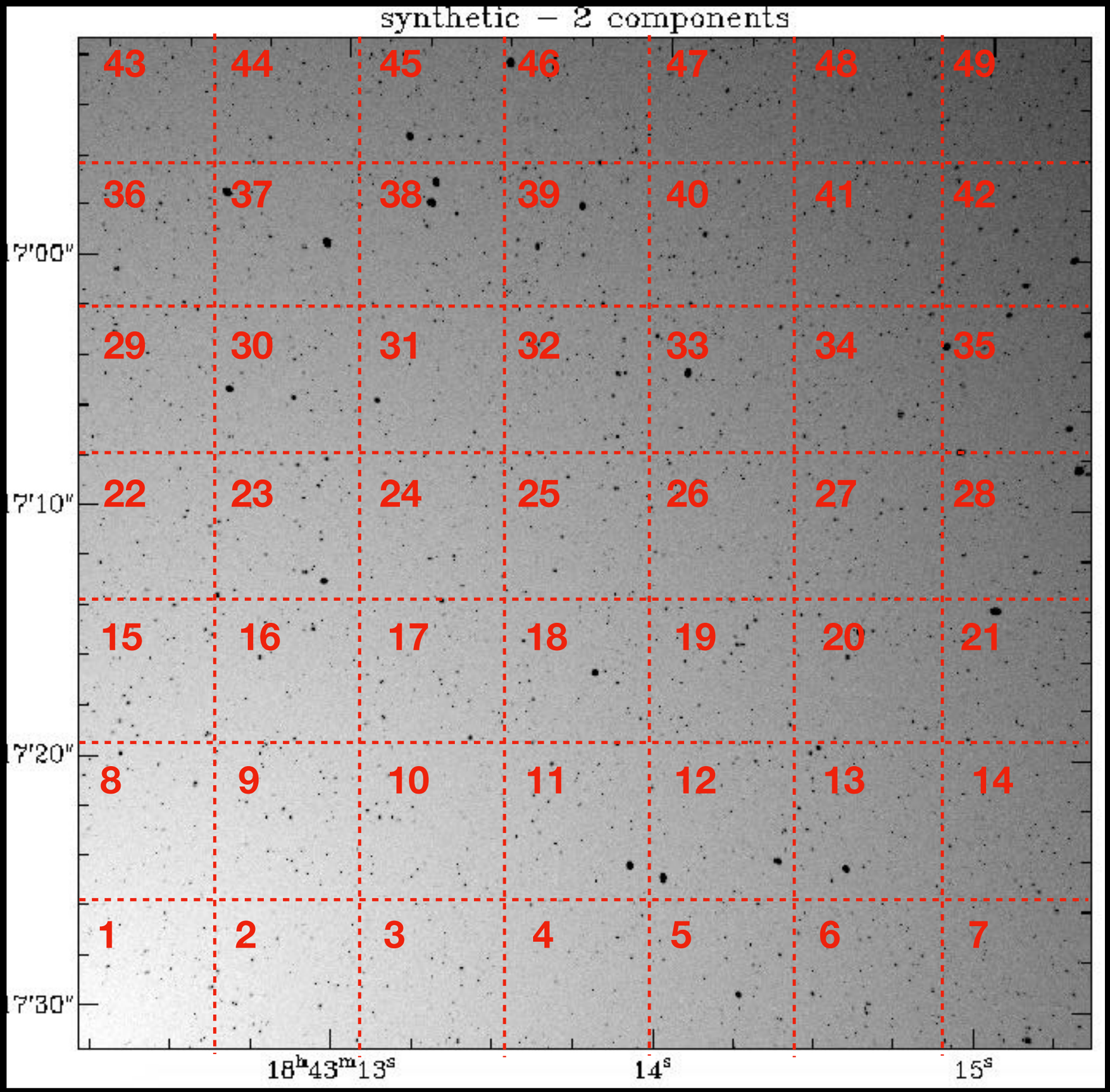

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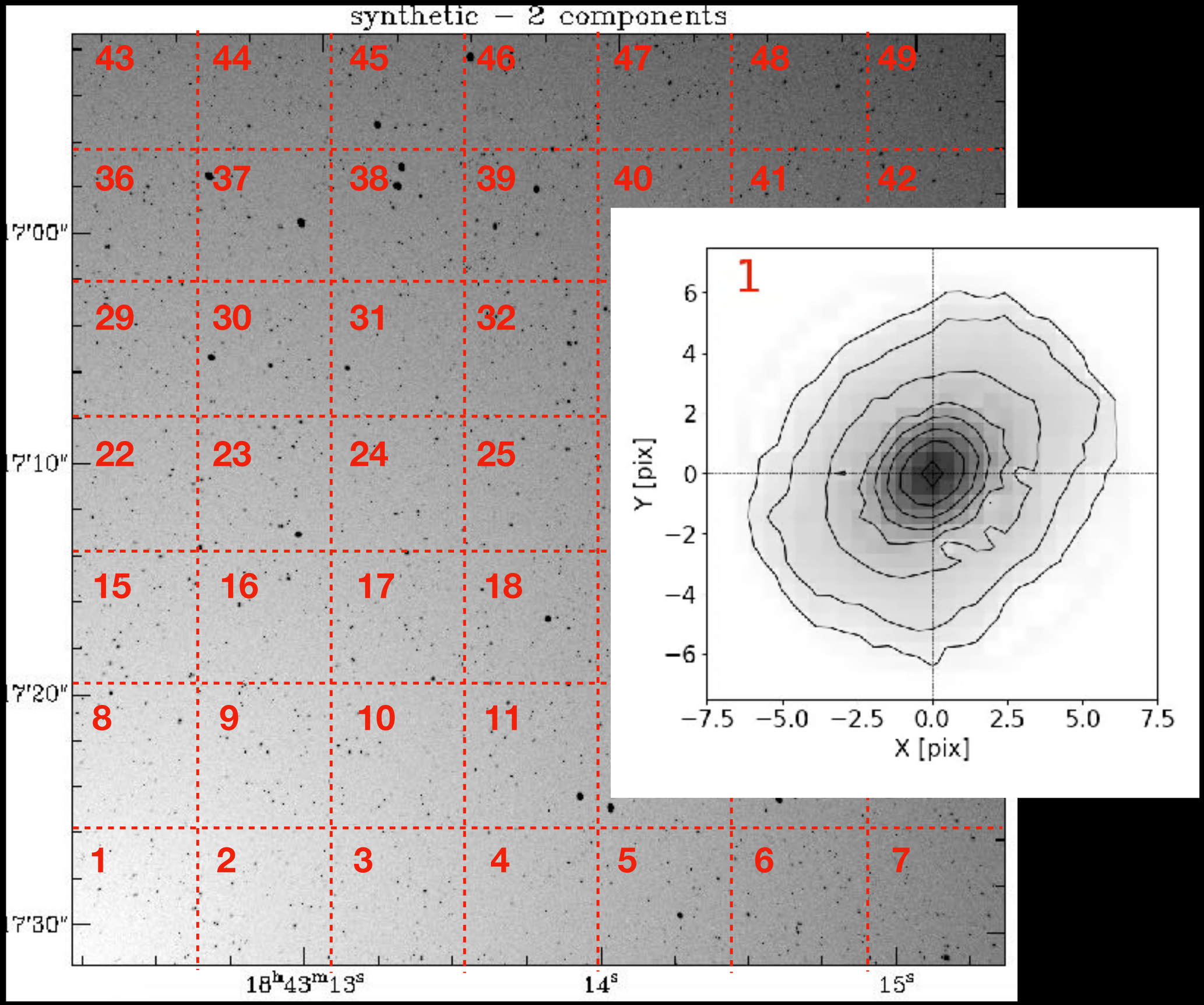

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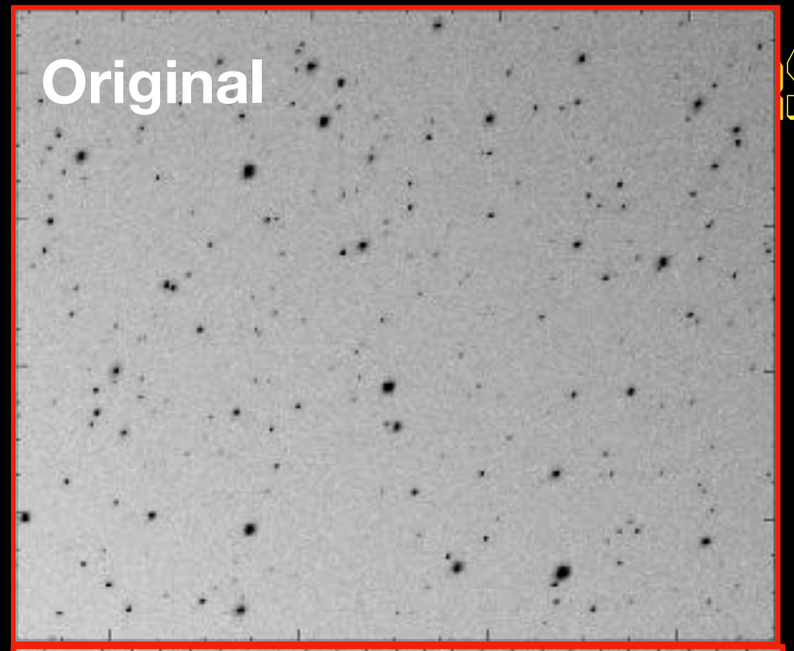

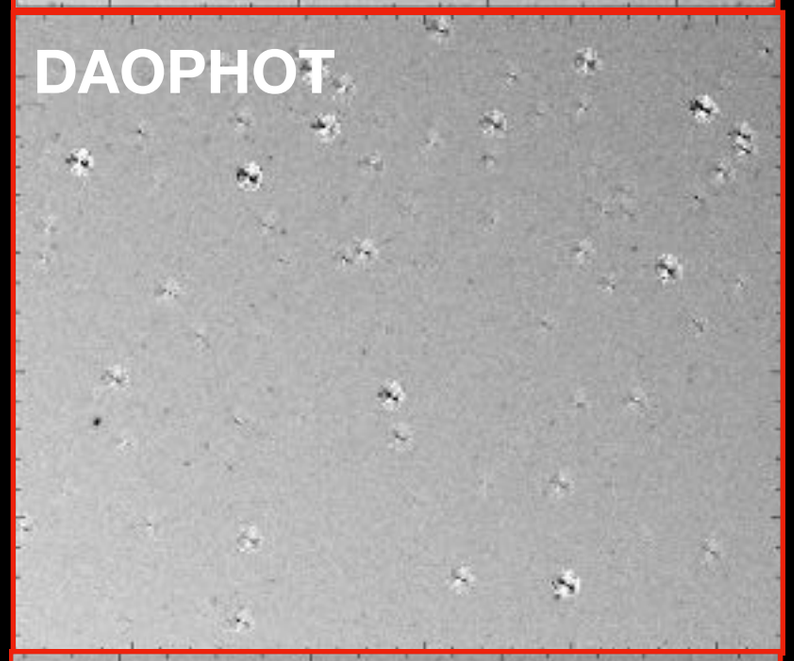

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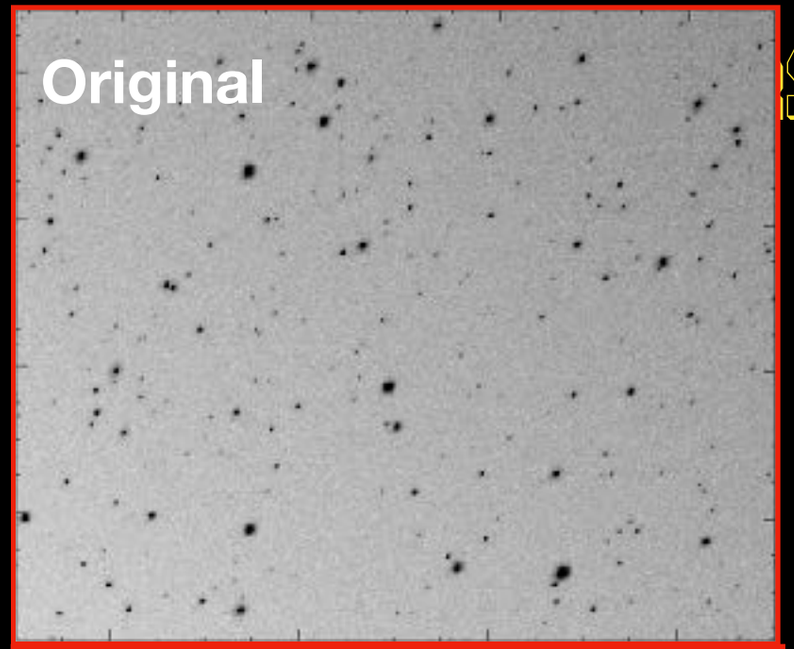
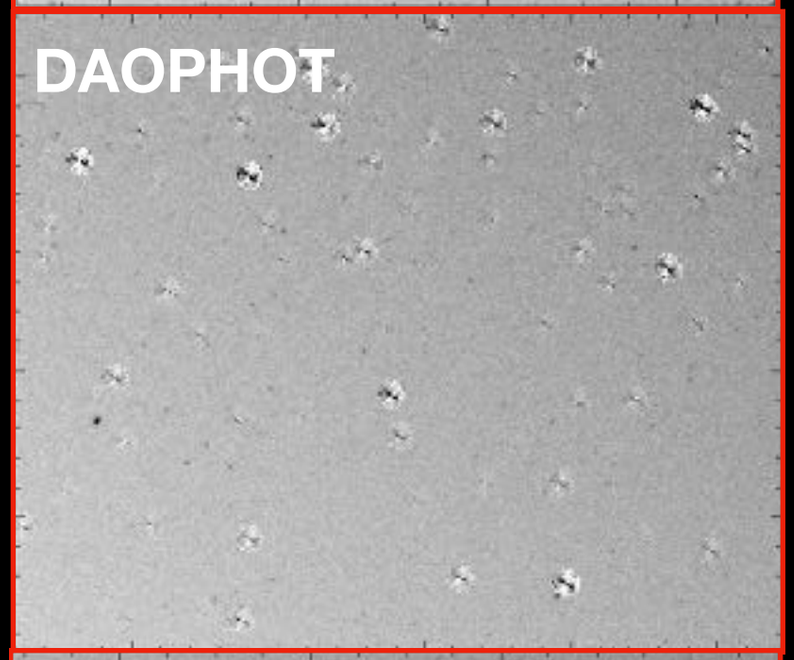
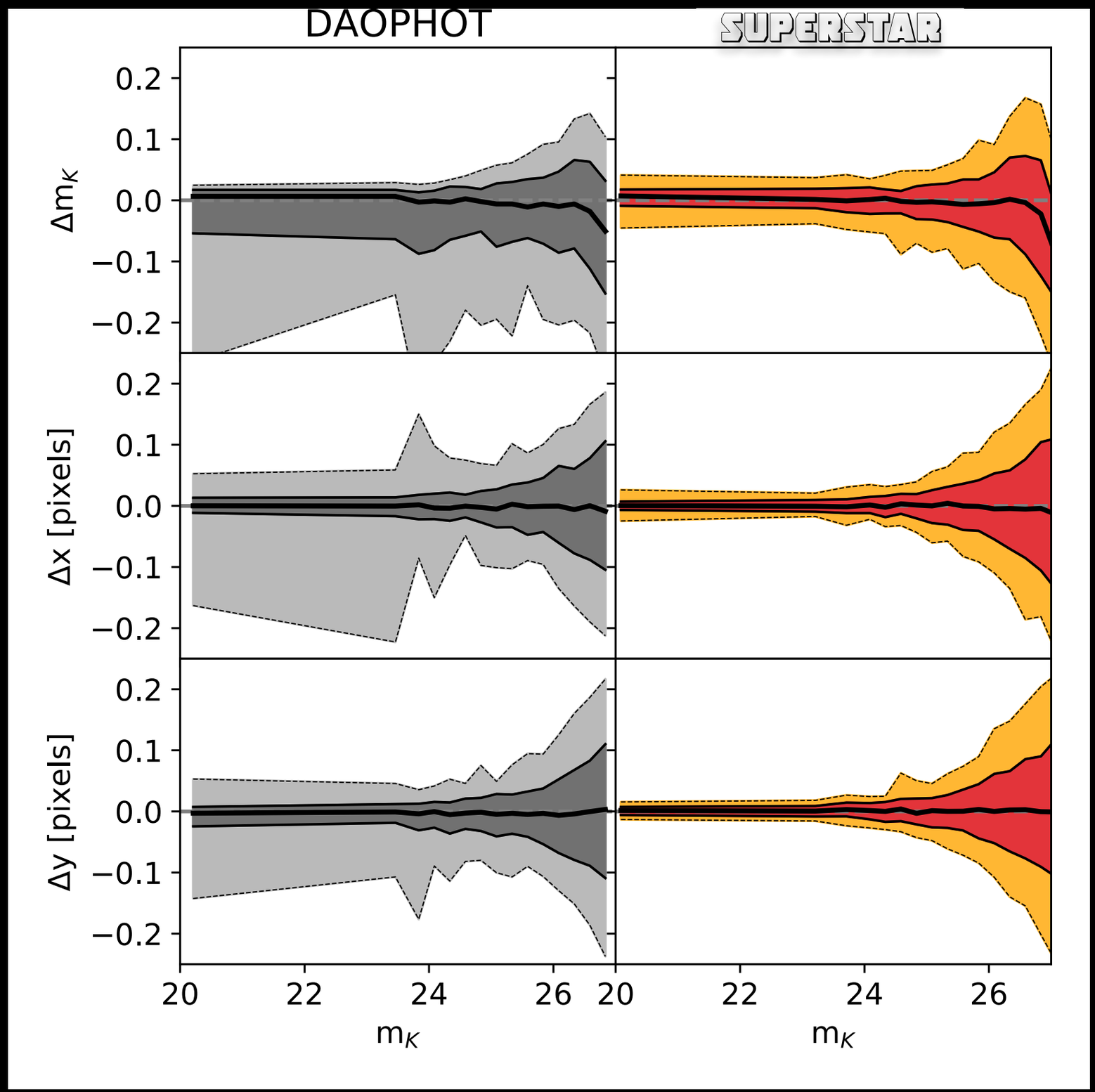
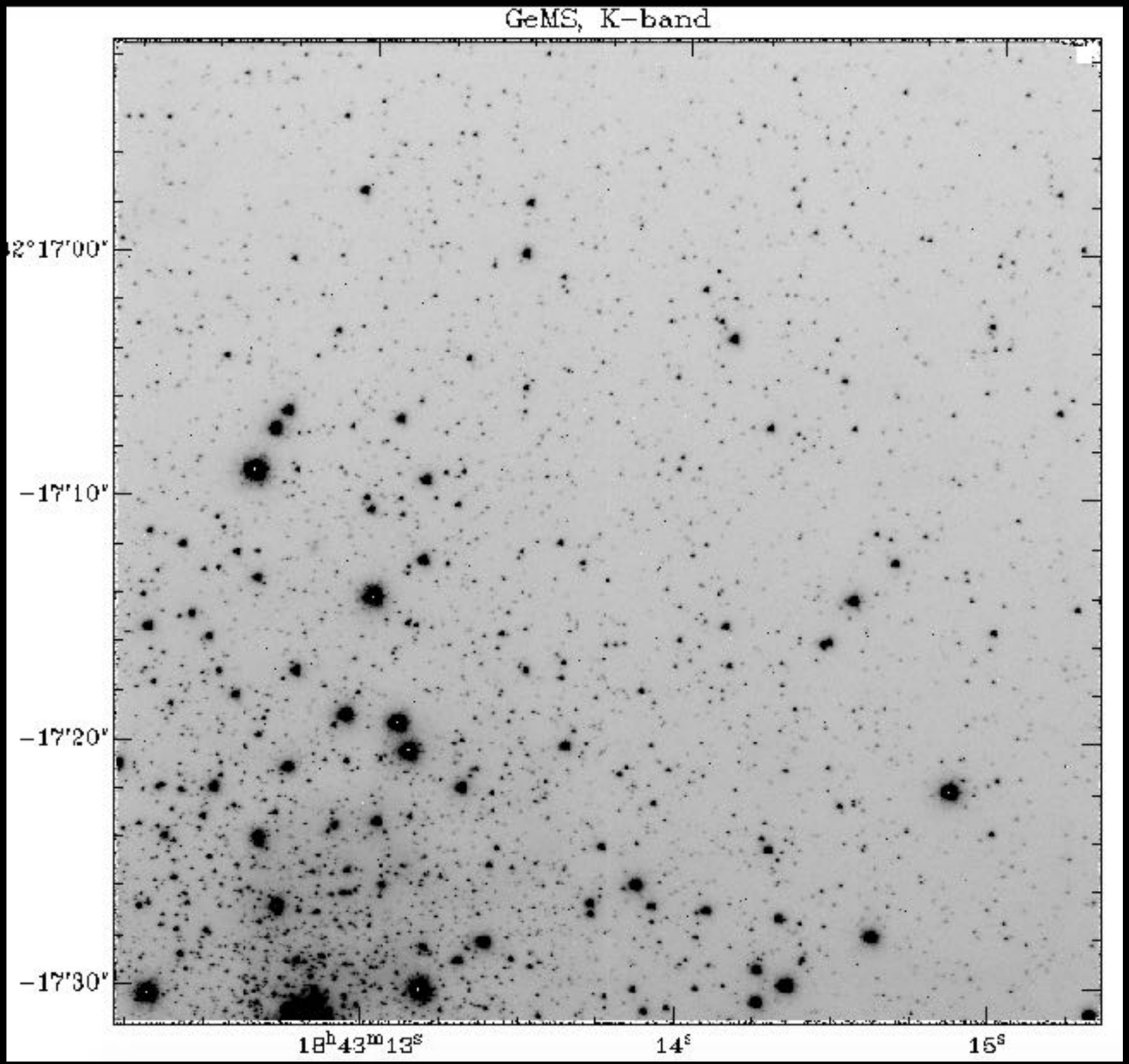






SUPERSTAR on GeMS data (NGC 6681)



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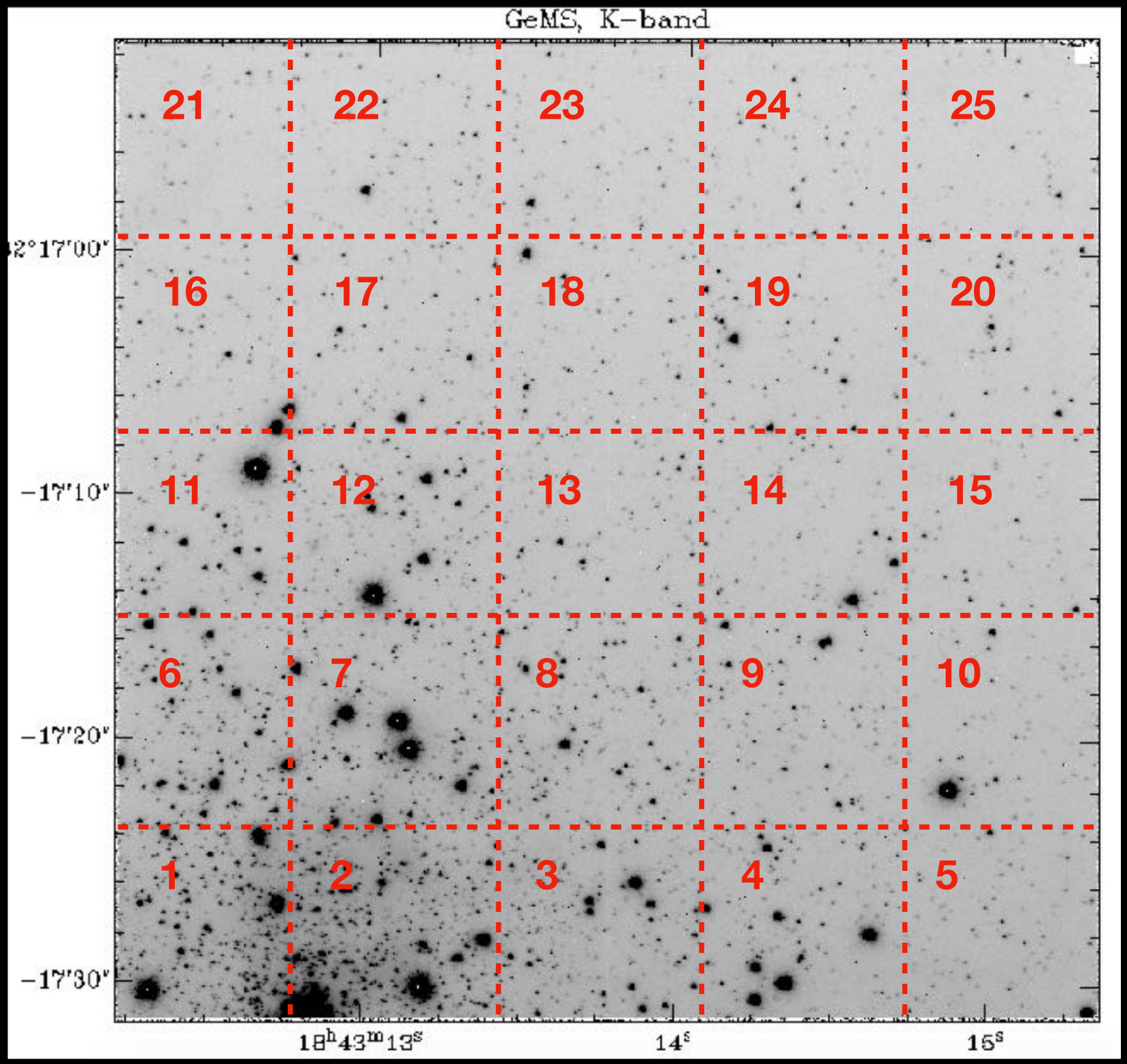

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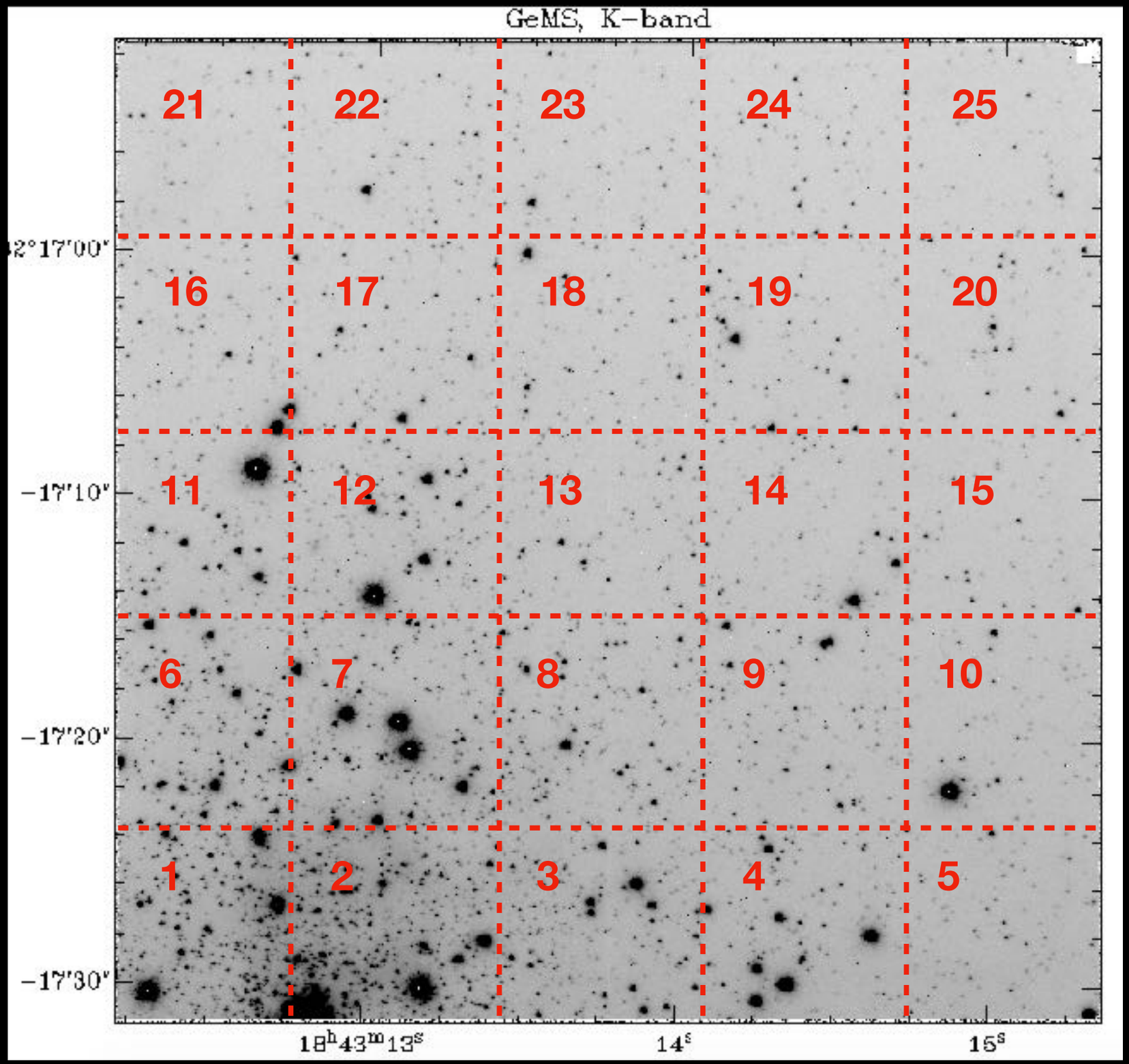

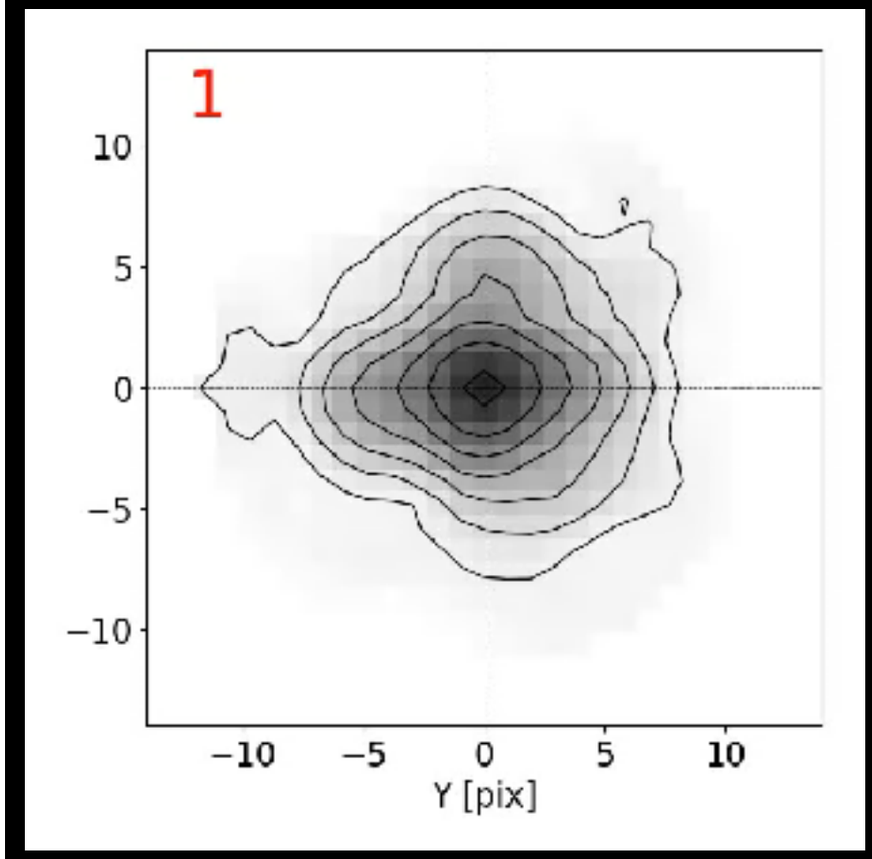

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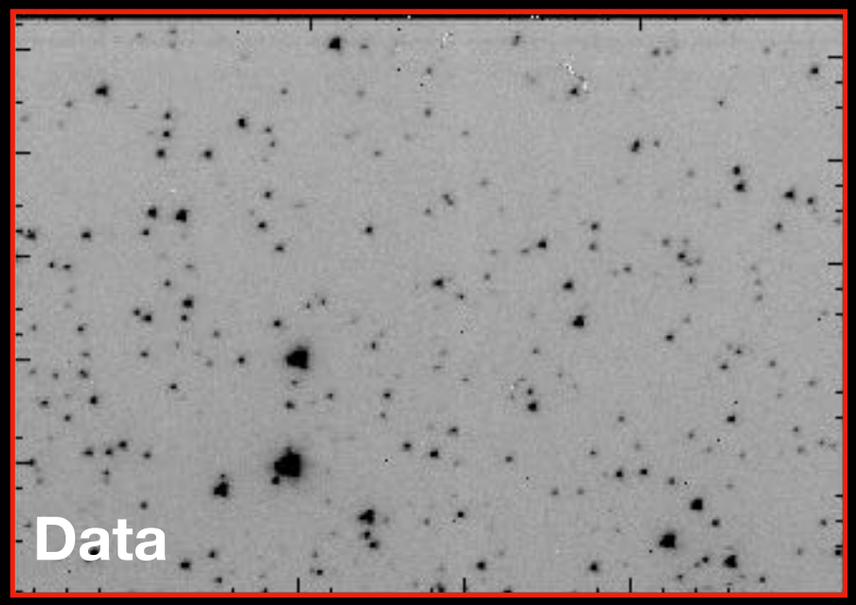

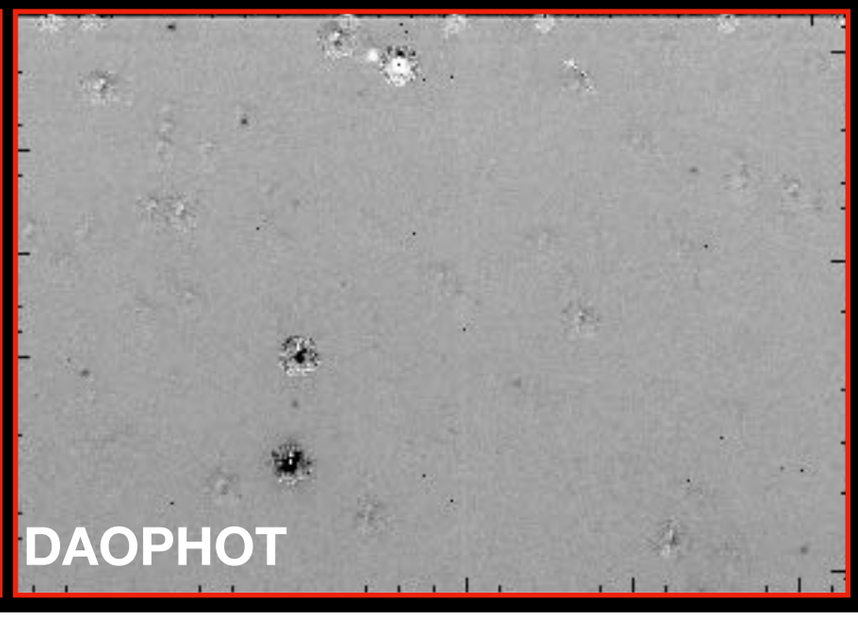

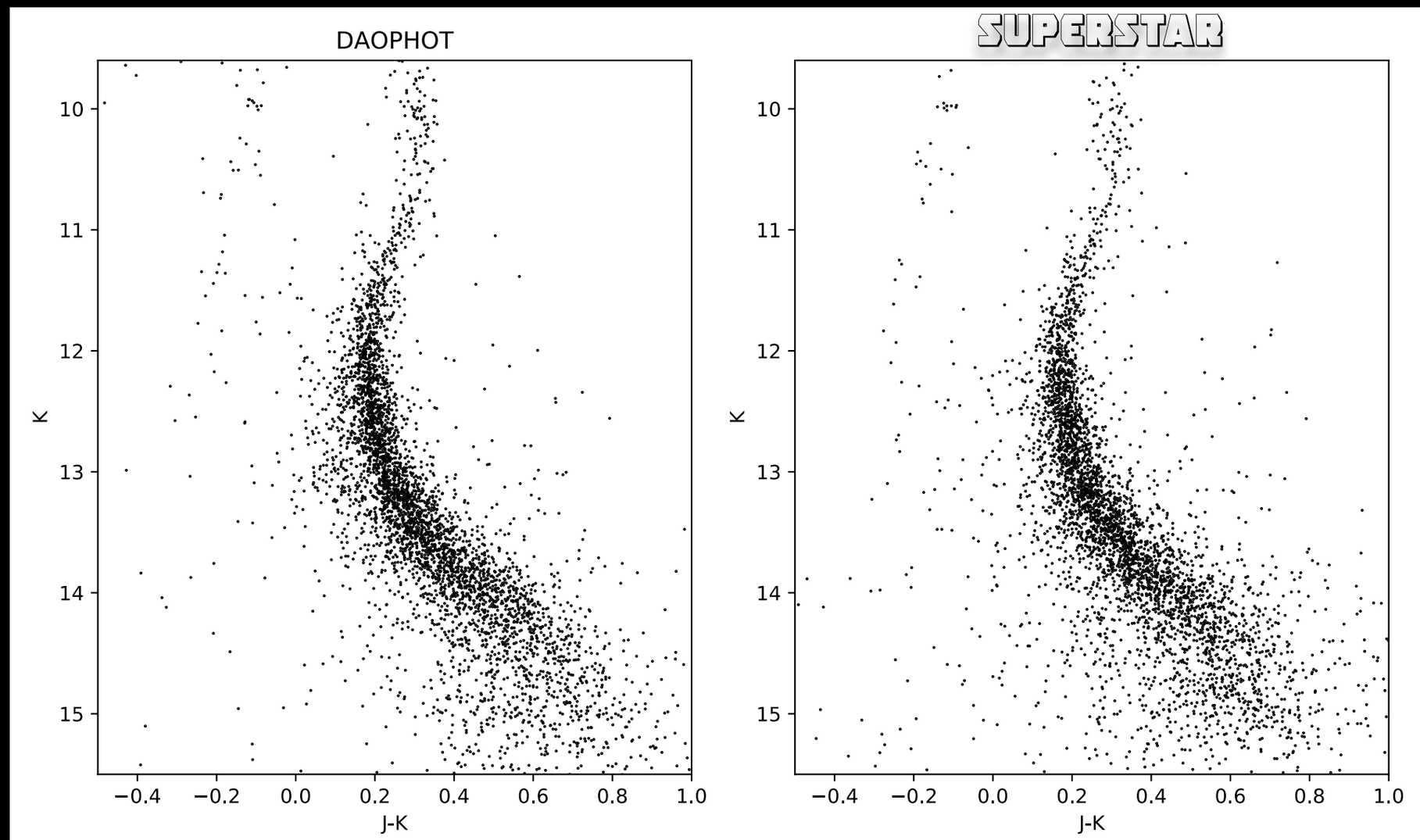

Synergy with PSF-reconstruction

SUPERSTAR takes as an input external PSFs (cubes) in fits format

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direct approach → SS as a fitting machine (e.g. to validate PSFr)

hybrid approaches → reconstructed PSF as a first guess for SS

→ compact PSF core modelled by SS on the image

→ extended PSF halo from PSF-reconstruction

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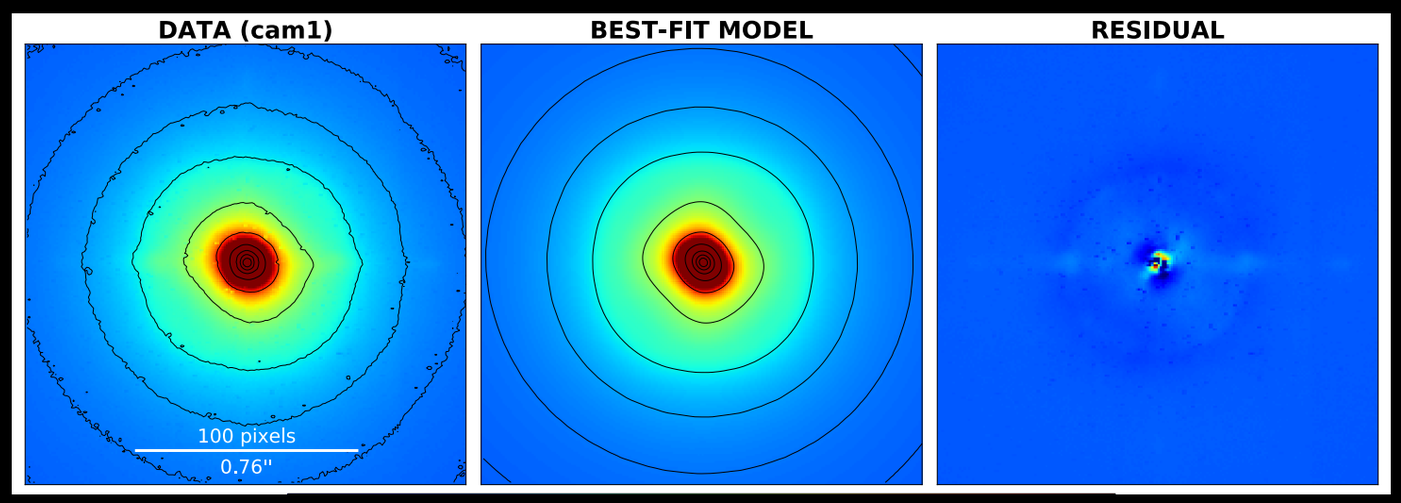
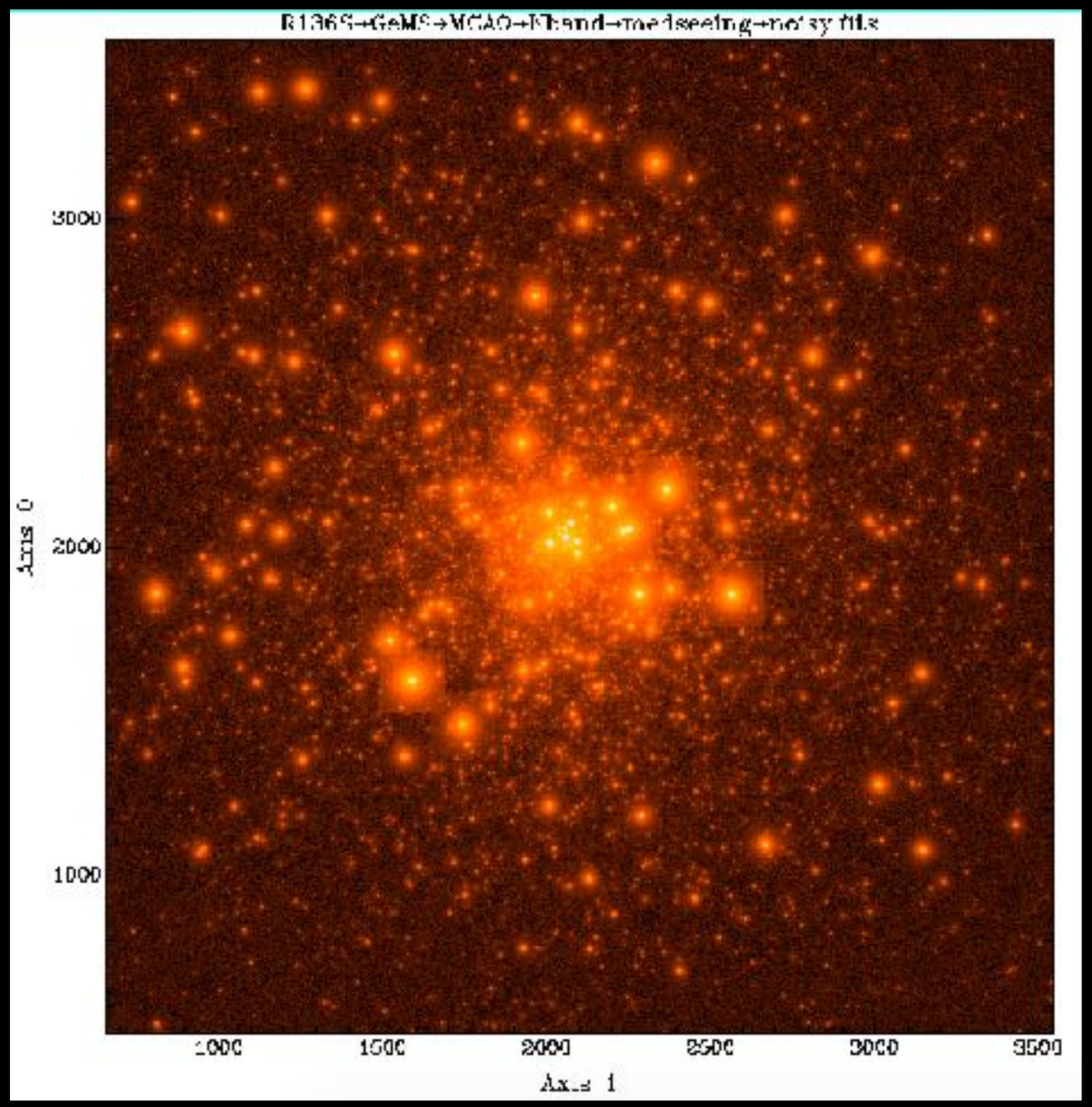


See talk by Davide Massari

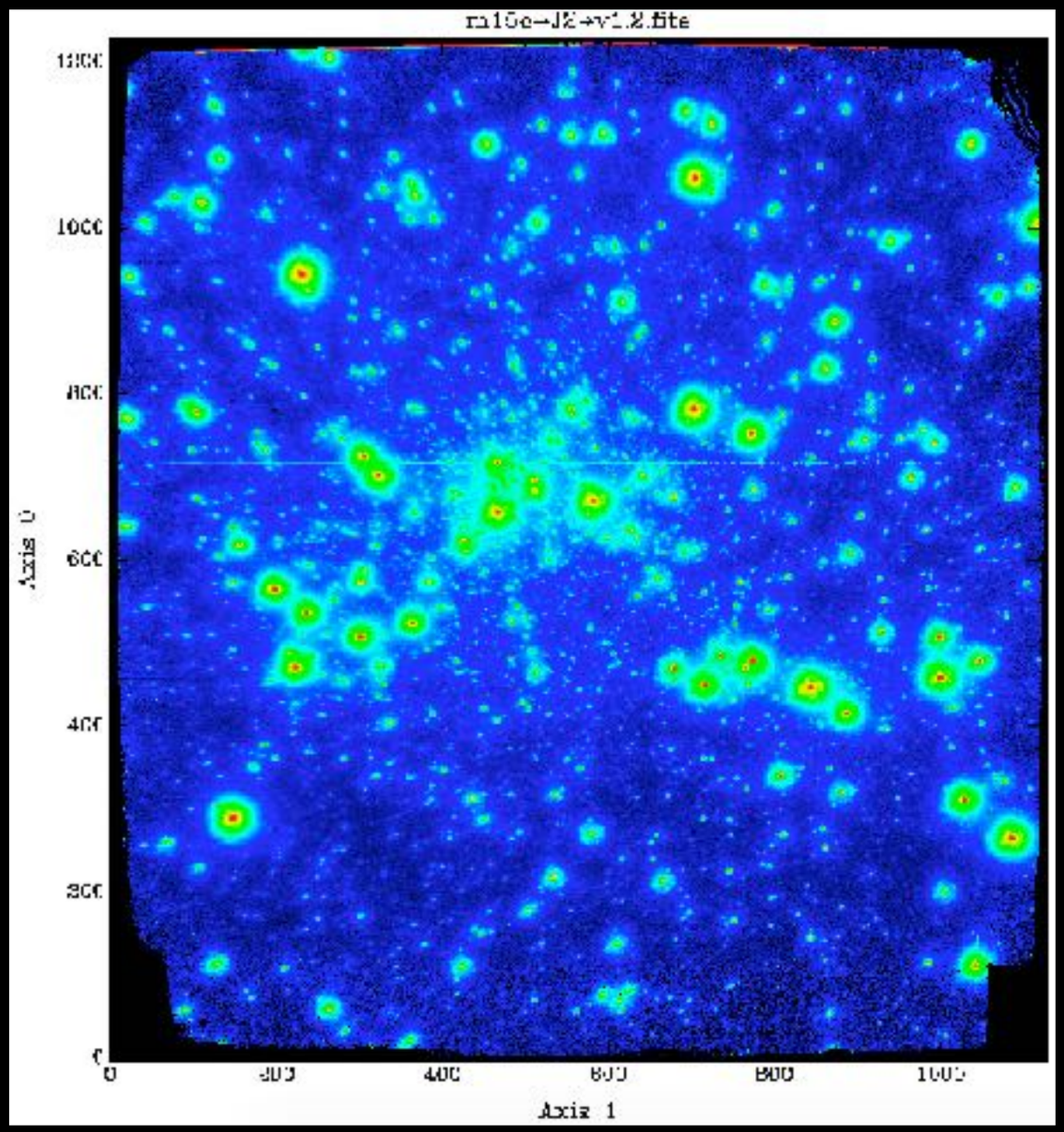
Work in progress

SUPERSTAR on simulations



core of a GC with GeMS
H,J,K, different seeing and exp.time
(collaboration INAF/LAM)

SUPERSTAR on real data



core of M15 with PISCES@LBT
(with C. Arcidiacono)