PSF estimation in Adaptive Optics images of crowded stellar fields

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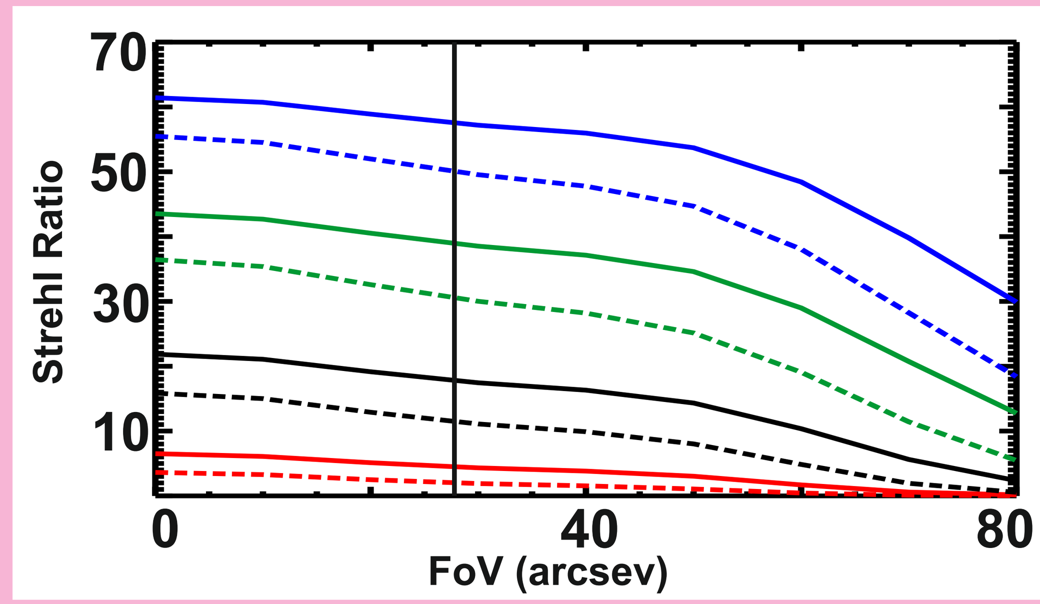
The growing number of available Adaptive Optics (AO) imaging facilities raised the need of significant improvement in the AO Point Spread Function (PSF) modeling. In fact, AO images are characterized by structured PSF with sharp core and extended halo and by a variation across the field of view, mostly evident in single-reference systems. A more uniform correction may be achieved by Multi Conjugate Adaptive Optics (MCAO), a technique based on the use of two or more deformable mirrors and several Guide Stars, demonstrated on sky by MAD on the Very Large Telescope and planned for the future E-ELT. In this context, we explore the problems related to PSF extraction across the Field of View in MCAO images of crowded point-like source fields being applicable to many scientific objects like globular clusters, star forming regions and incipiently resolved galaxies. This study is based on simulated images generated with synthetic PSFs available from the Phase-A study of the E-ELT MCAO system (MAORY) and different crowding conditions. The data have been analyzed with the StarFinder photometry package (Diolaiti et Al, SPIE 2000) employing a numerical PSF extracted directly from the simulated science field. Two different PSFs have been used: an estimation from the images of the brightest stars and the PSF reconstructed by a blind deconvolution of the science field. A comparison of the two PSF estimation methods as a function of crowding is shown.

The instrument: MICADO @ E-ELT

Telescope: the European Extremely Large Telescope, with its 39.3 m aperture diameter

Acquisition Instrument: the MICADO (Davies et Al, SPIE 2010) imaging camera (FoV : 53"x53"; Wavelength range: 0.8 - 2.4μm)

Supplied Adaptive Optics instrument: MAORY (Diolaiti et Al, SPIE 2010), based on Multi-Conjugate Adaptive Optics (MCAO), works in the wavelength range 0.8 - 2.4μm and provides a corrected field corresponding to 120 arcsec on sky.

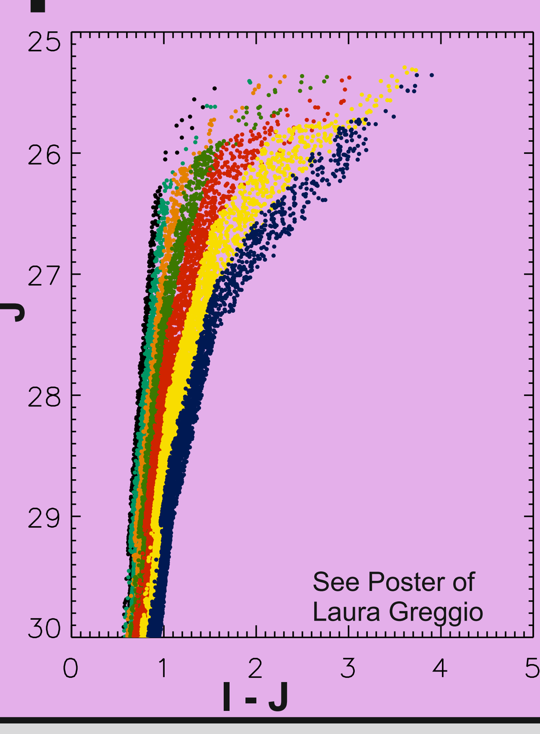


The figure shows the radial profile (from the field center to a radial distance of 80 arcsec) of the strehl Ratio value for the K (blue), H (green), J (black) and I (red) bands and for a seeing value of 0.6" (continuous lines) and 0.8" (dashed lines)

The science case: Resolved stellar population in Virgo Elliptical Galaxies

Synthetic images produced as follows:

- **Old input stellar population** (AGE=10-12 Gyr)
- MAORY PSF (http://www.bo.astro.it/maory)
- T exp: 2 hours
- Advanced Exposure Time Calculator (AETC, Falomo et al 2011) at URL: http://aetc.oapd.inaf.it
- **Different crowding conditions** (surface brightness levels)



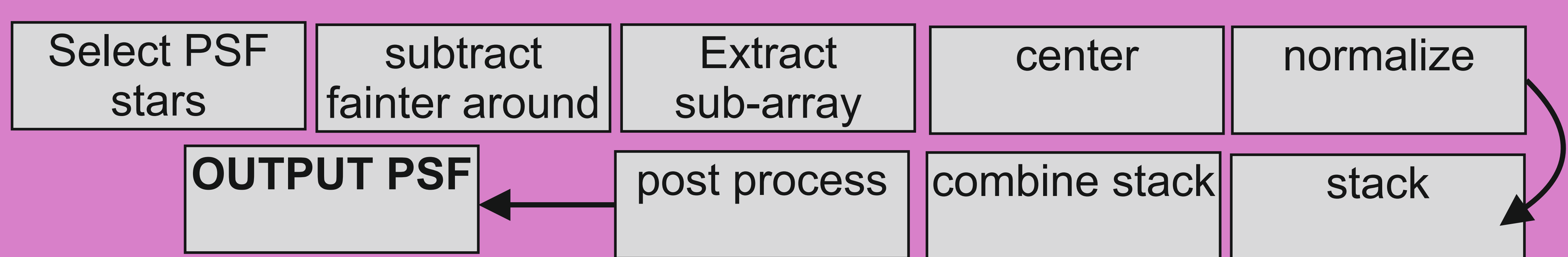
	Distance	FoV	Surface Brightnes	Number of STARS
FIELD 1	0.1 R_E	1.03"	17.3 (I)	124533
FIELD 2	0.25 R_E	1.80"	18.5 (I)	125581
FIELD 3	0.5 R_E	3.01"	19.6 (I)	126128
FIELD 4	1.5 R_E	8.34"	21.8 (I)	125977

Greggio et Al, PASP (2012)

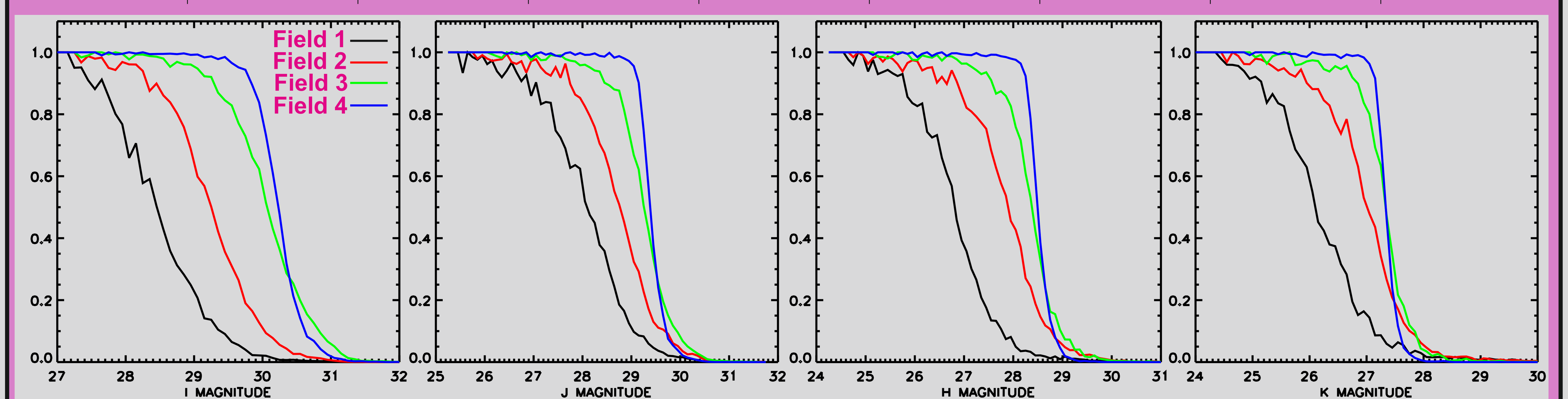
The data reduction: photometry performed with STARFINDER

Input Image (I) → Background (bkg) → Noise (σ) → PSF ESTIMATION → Output: syntetic Image + list of stars + bkg + σ

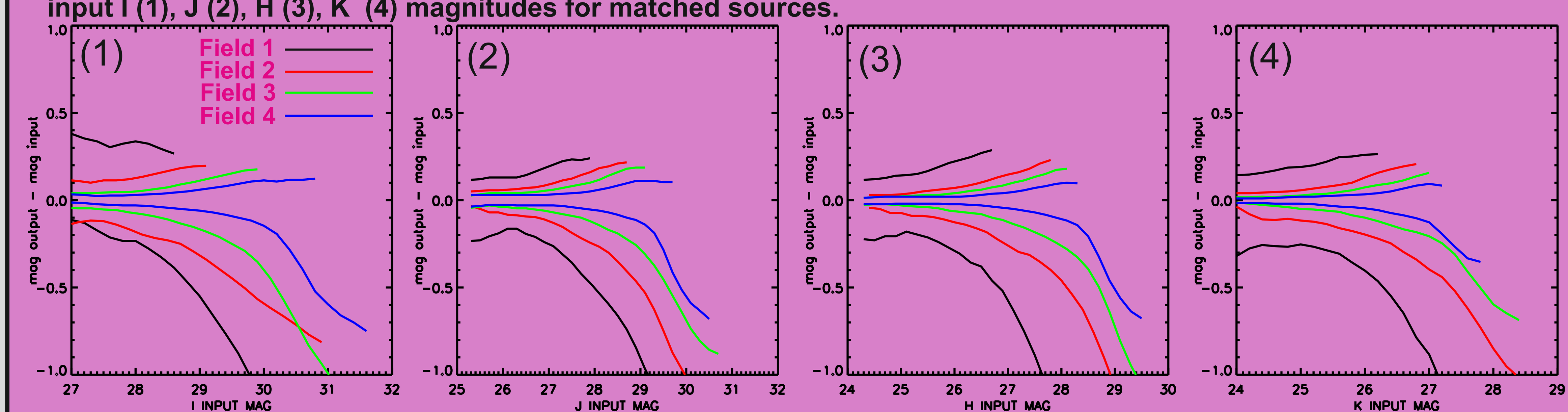
PSF extraction by numerical computation



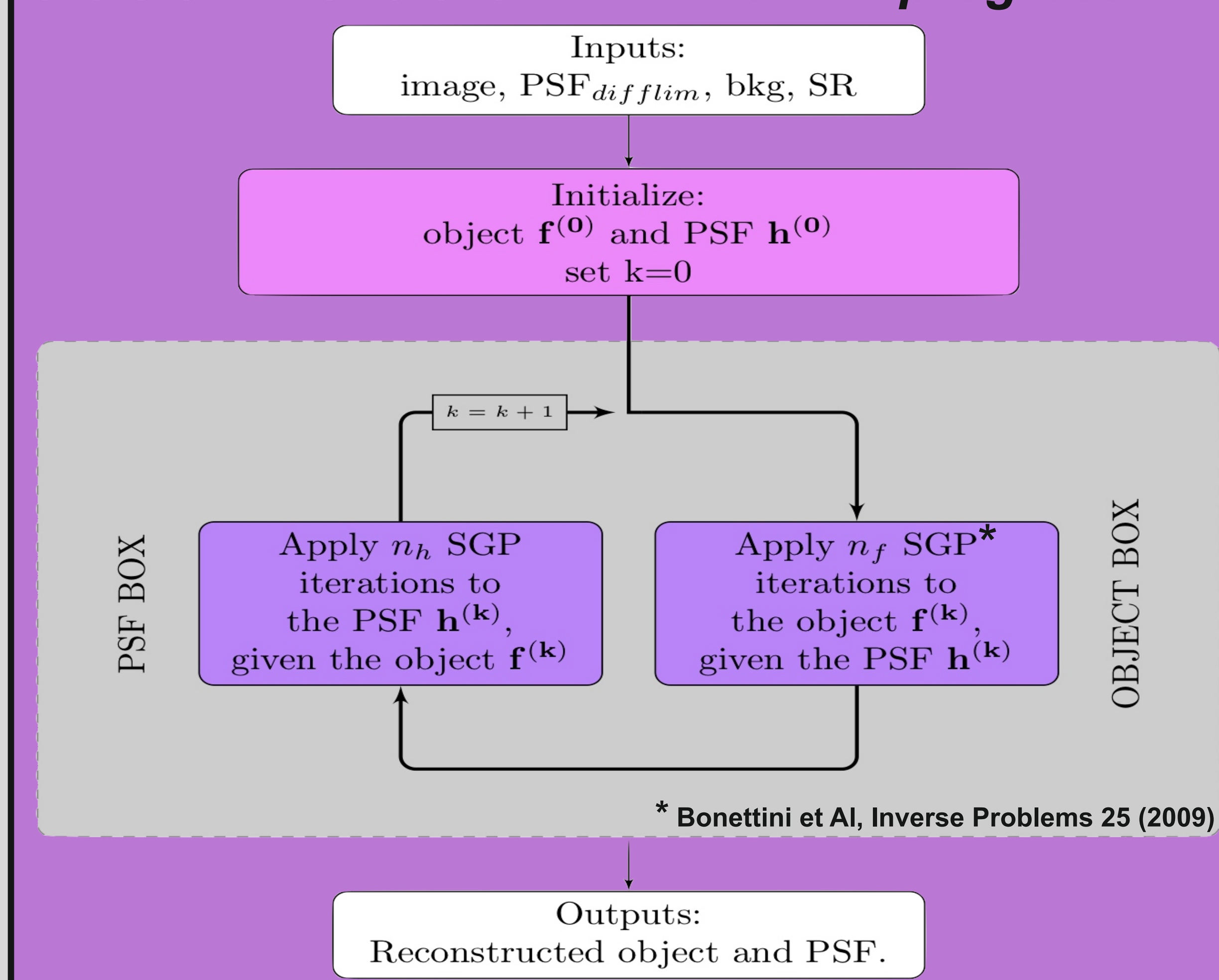
	I BAND		J BAND		H BAND		K BAND	
	matched	false matches	matched	false matches	matched	false matches	matched	false matches
Field 1	3234	1	6915	4	4704	15	3310	15
Field 2	7465	6	11358	44	10335	137	5779	152
Field 3	16276	64	15930	122	13636	237	6661	179
Field 4	16683	57	16462	53	14434	61	6527	34



Top: Completeness functions for the simulated fields for different crowding conditions (color) and different bands
Low: 1σ widths of the error distributions computed separately for positive and negative values as function of the input I (1), J (2), H (3), K (4) magnitudes for matched sources.

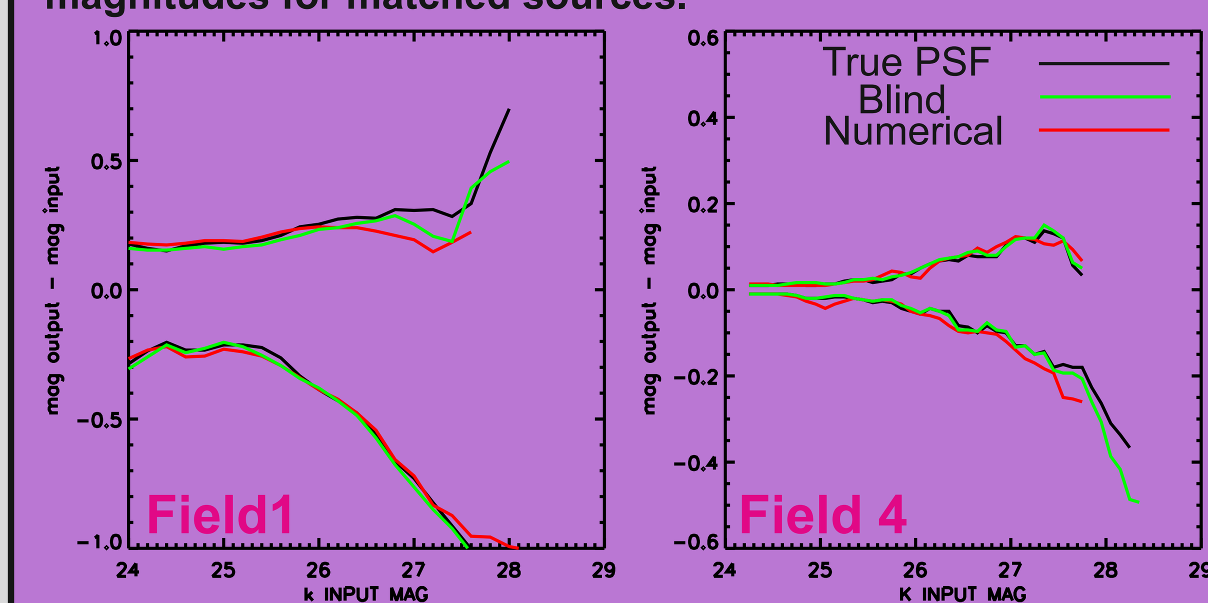


PSF extraction by Blind deconvolution *... work in progress*



Two cases analyzed: **Field1** & **Field 4**

low: 1σ widths of the error distributions computed separately for positive and negative values as function of the input K magnitudes for matched sources.



The usage of a PSF estimated by Blind deconvolution algorithm has the advantage to be independent on the choice of the PSF stars, but it requires a guess of the Strehl Ratio and background.