Deep observations with an ELT in the Global-MCAO perspective

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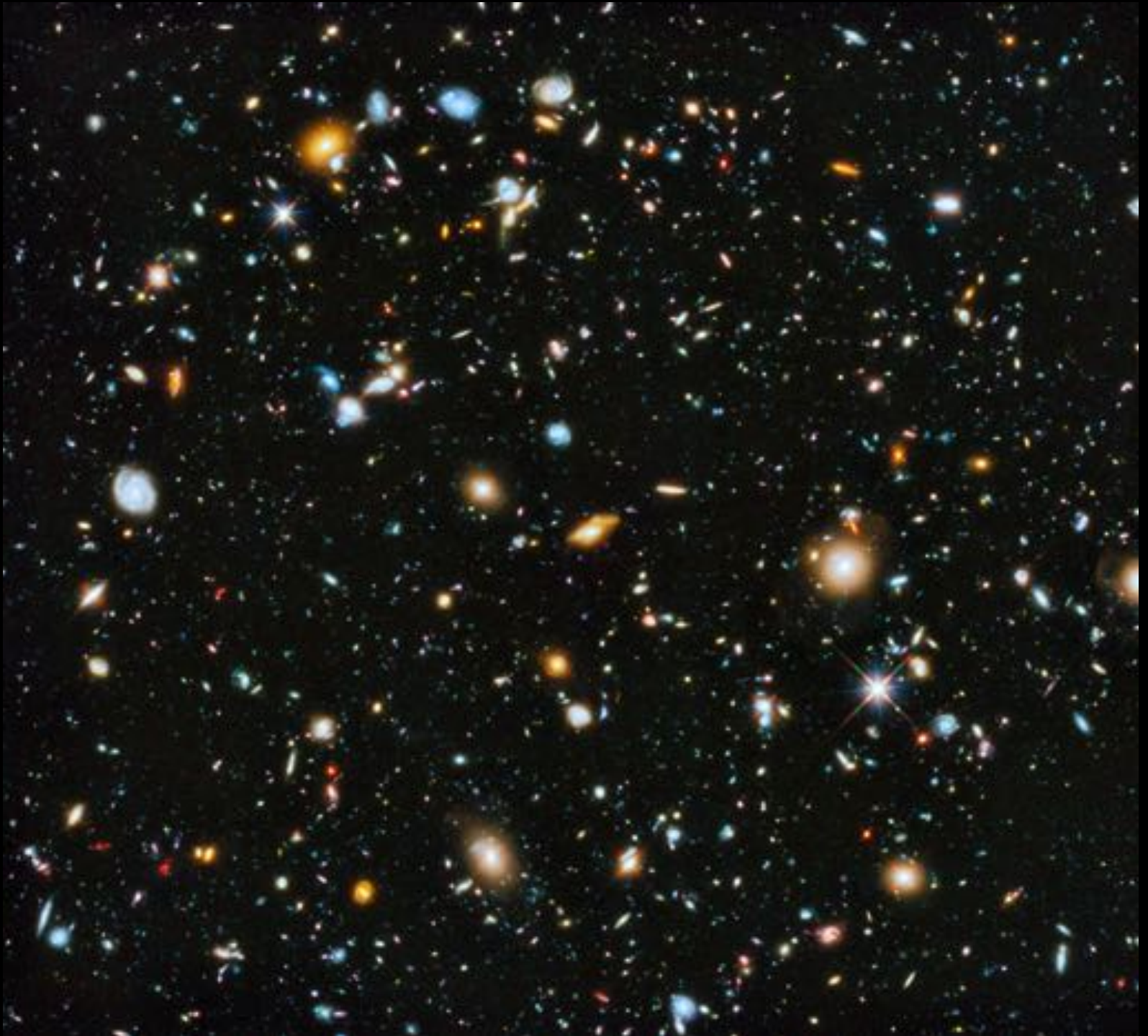
INAF

LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

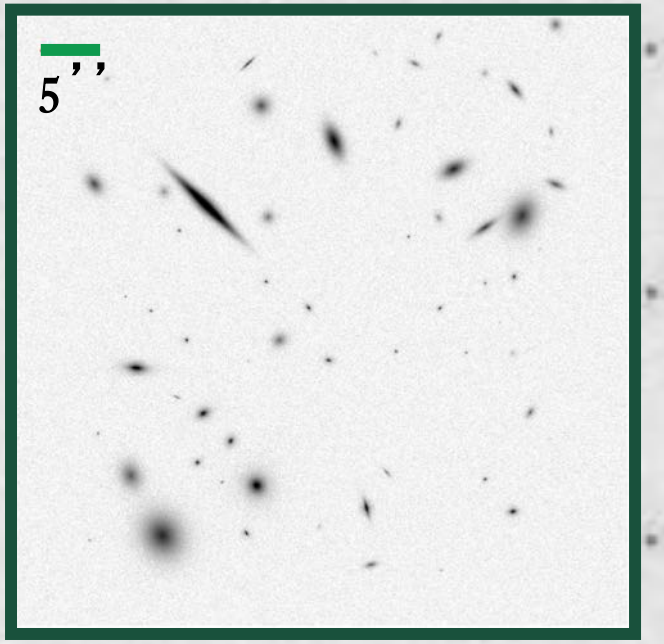
Wavefront sensing and control in the VLT/ELT era, 3rd edition



Deep Universe :

- big collaborations, multiple facilities and shared knowledge.
- ELTs will have a key role because of their angular resolution and their capability in collecting the light of faint sources.
- Test-bench for the Global-Multi Conjugate Adaptive Optics (GMCAO) approach.

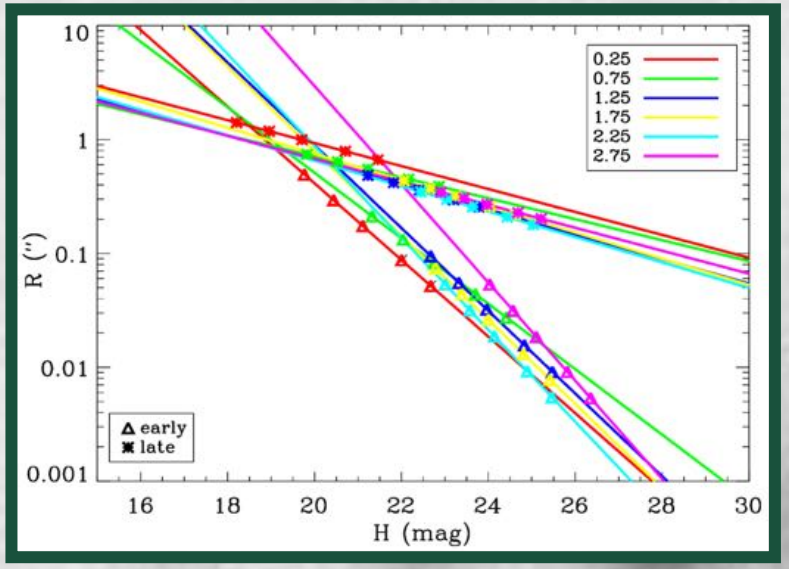
THE AIM OF THE STUDY: GMCAO WORKS!!



Mock K-band image of one portion of the Chandra-GMCAO deep field having 60 high-redshift galaxies. The FoV is 50x50 arcsec². The green dash is 5 arcsec wide.

OUR SAMPLE:

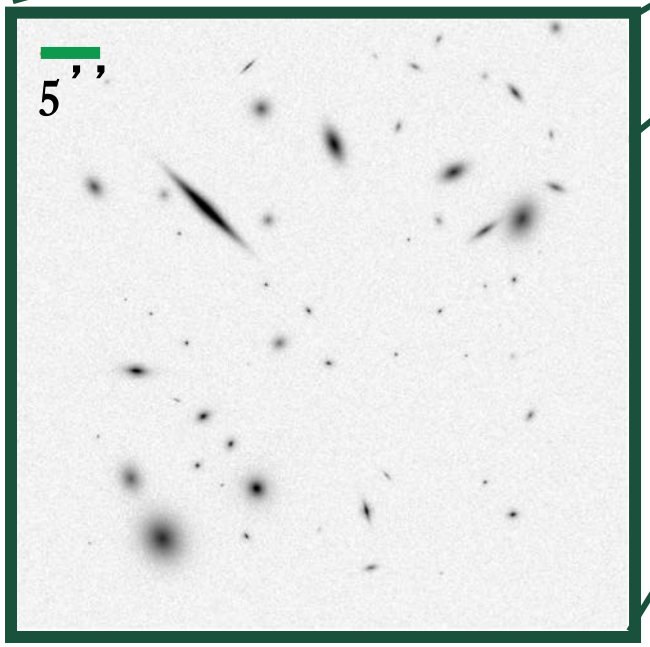
- 60 (30 early- and 30 late-) galaxies
- Sérsic models
- random inclinations and PA
- z = 0.25, 0.75, 1.25, 1.75, 2.25, 2.75
- log(M/M⊙) = 9, 9.3, 9.7, 10, 10.3,
- Re, M, H relations



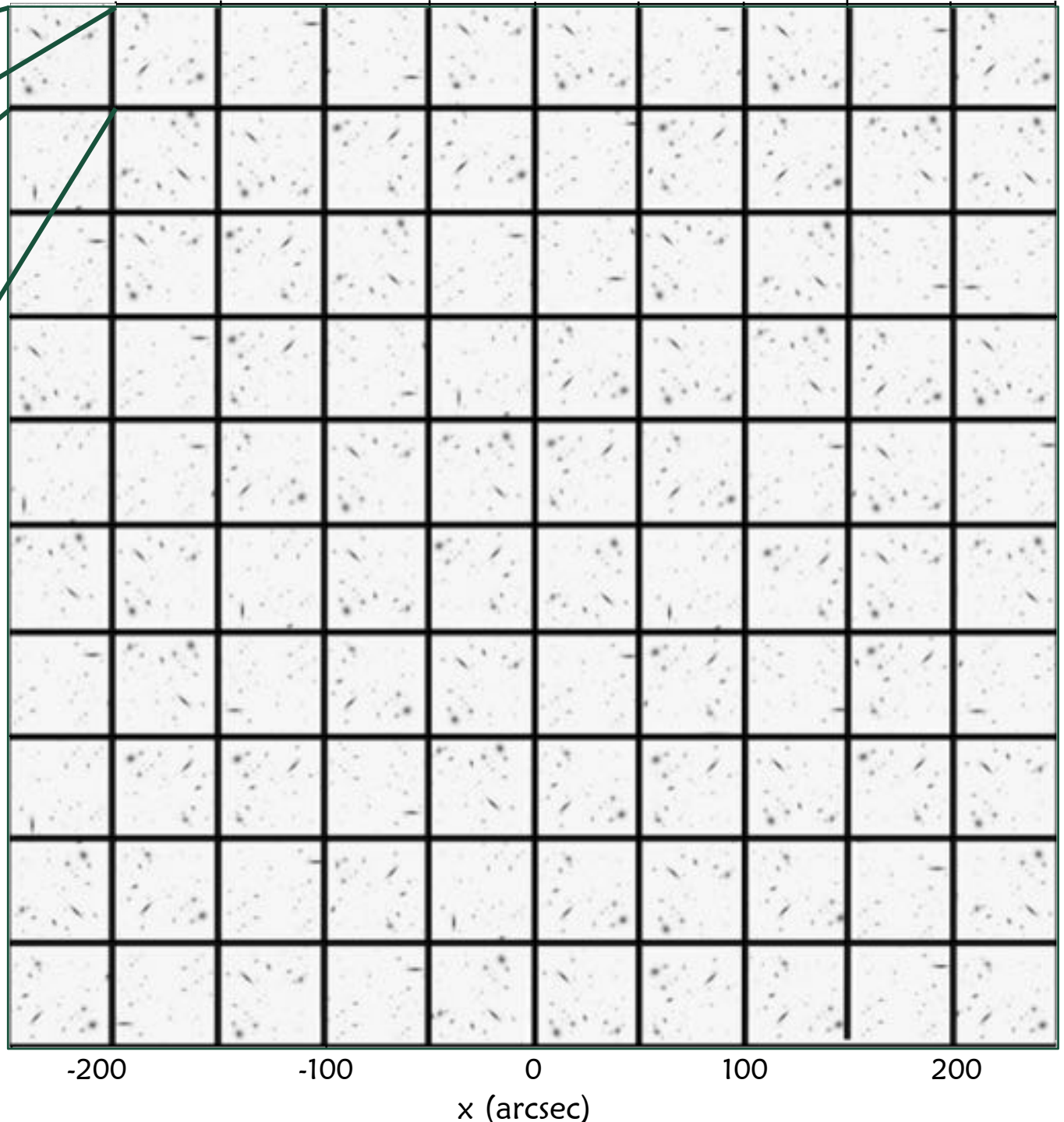
Portaluri et al., 2017, MNRAS, 466, 3569).

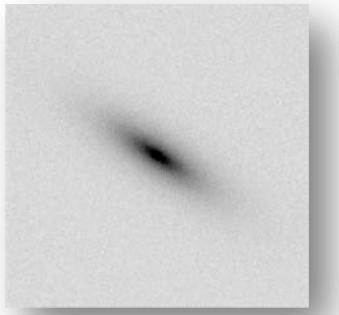
6000 high-redshift galaxies

500x500 aresec²



THE MOCK CHANDRA DEEP FIELD SOUTH





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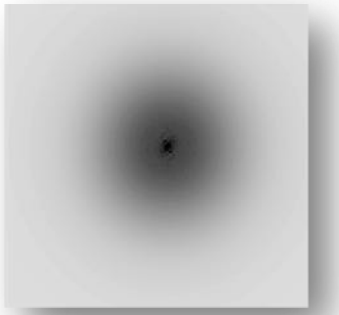

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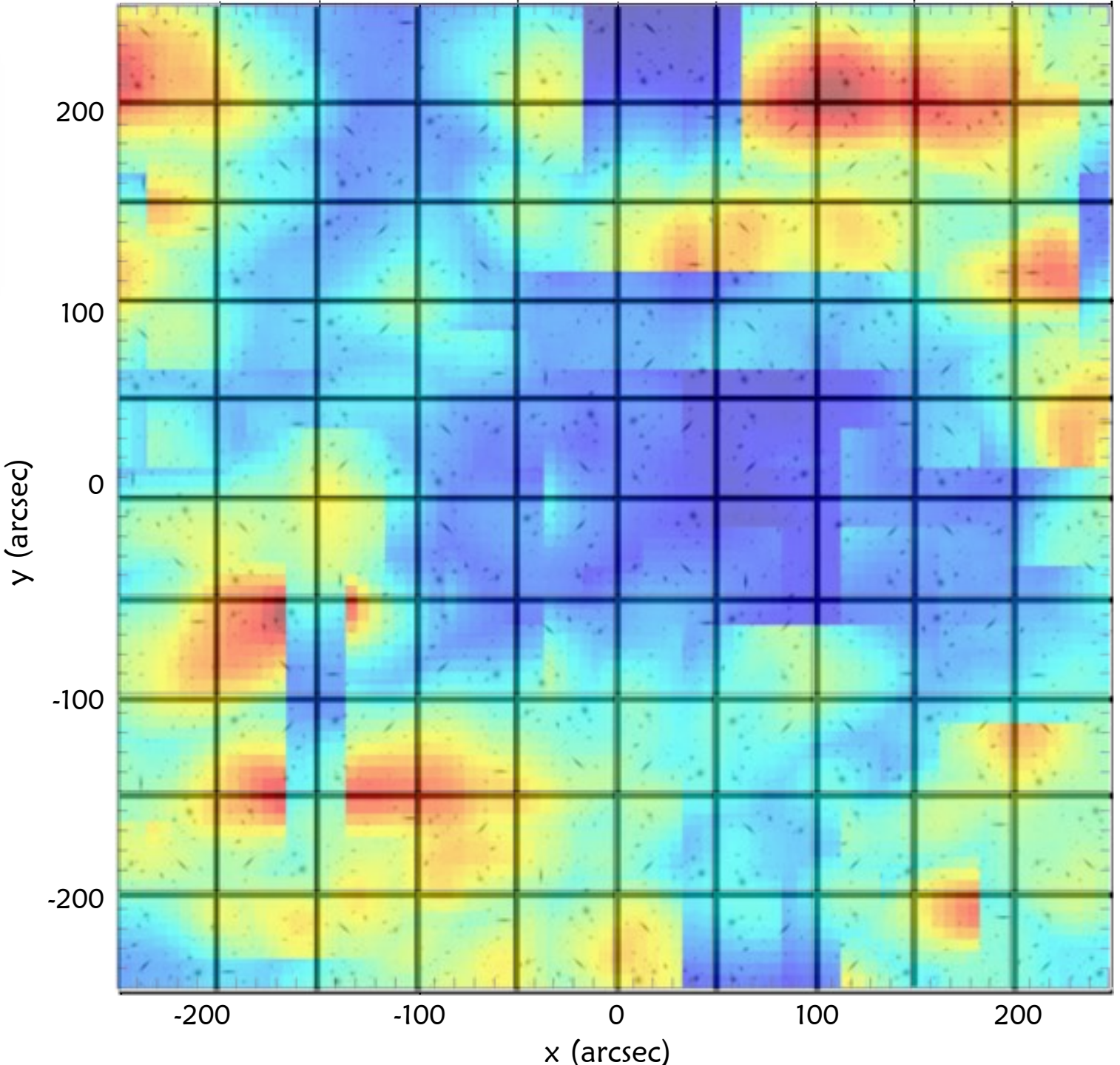
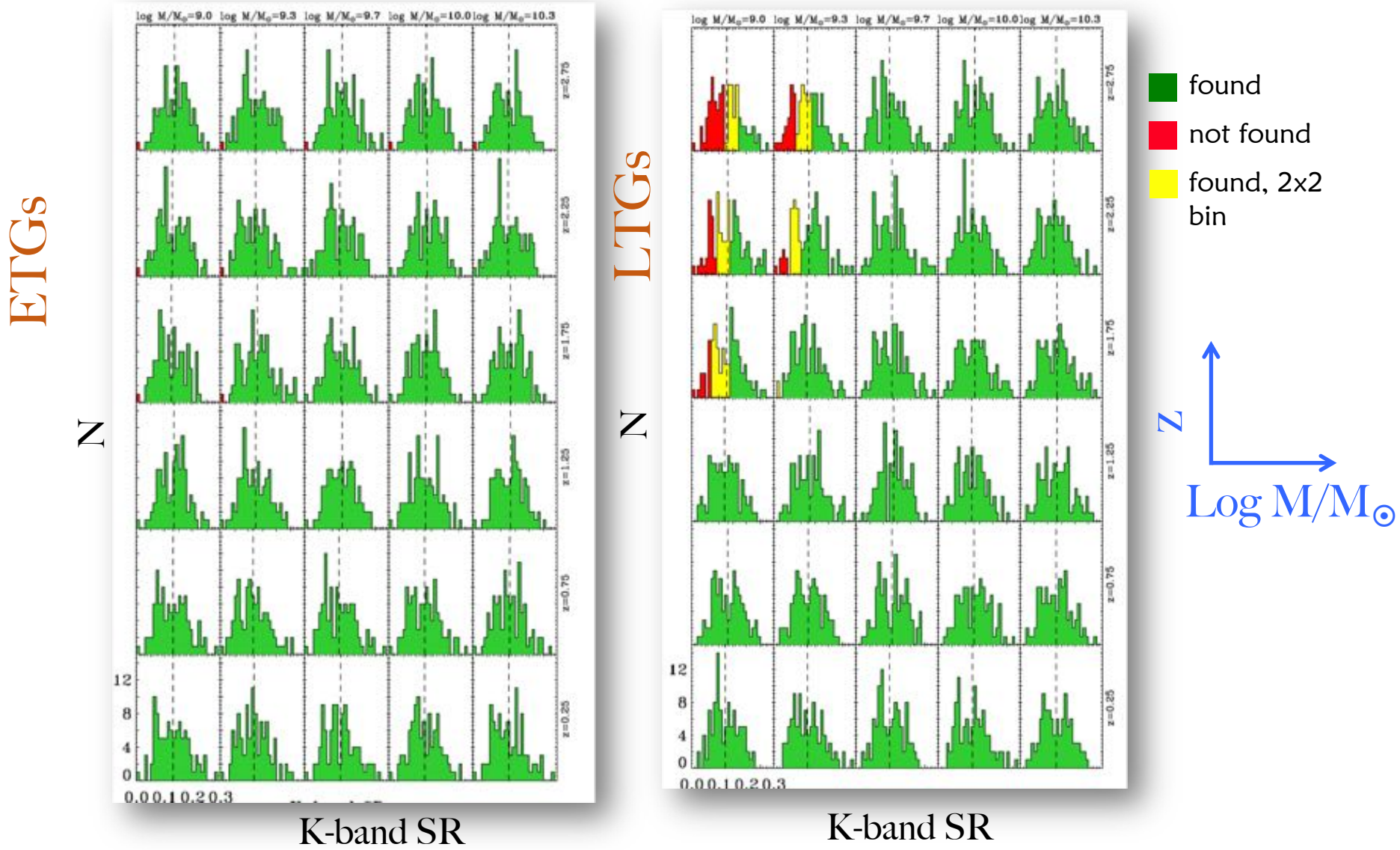
THE MOCK CHANDRA DEEP FIELD SOUTH



DATA ANALYSIS

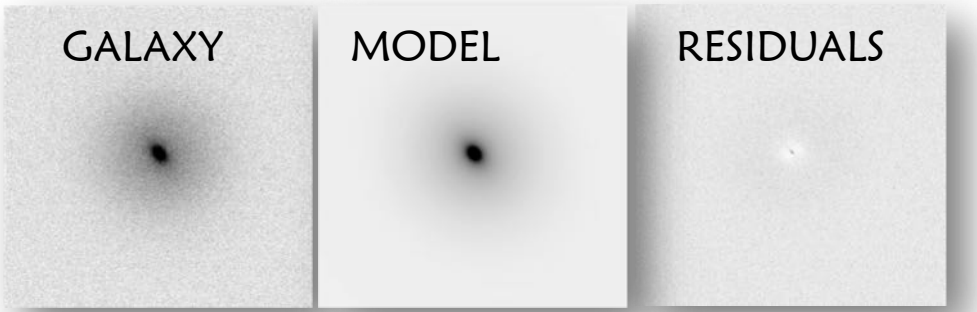
SExtractor completeness (2σ threshold level): 99.7% (ETGs) - 89.4% (LTGs)

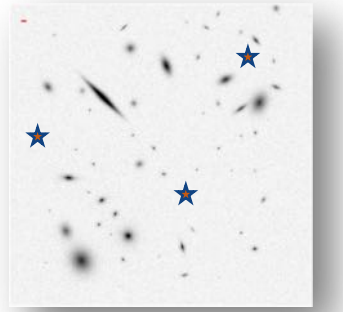


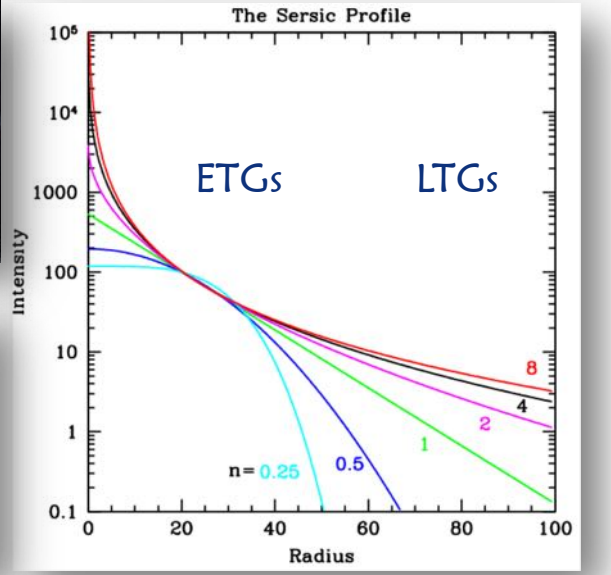
DATA ANALYSIS

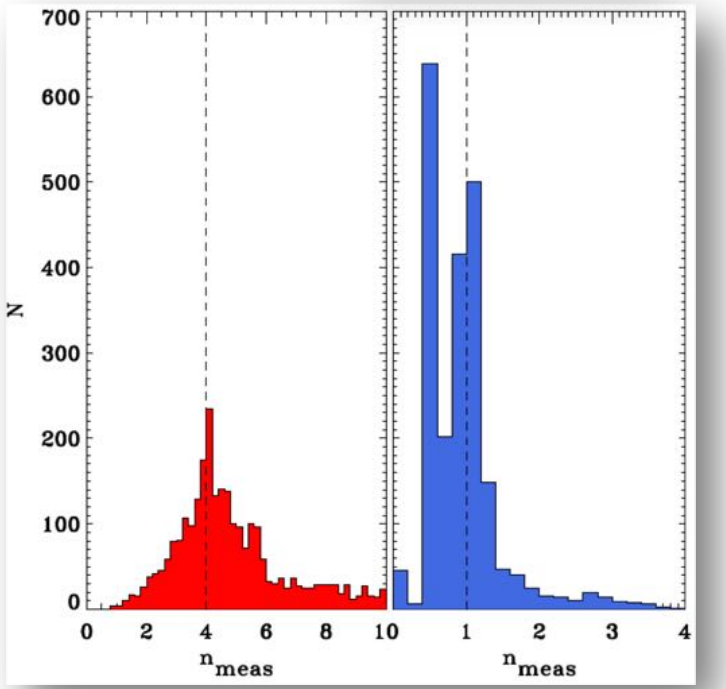
GALFIT: Morphology and Photometry

NO PSF a priori knowledge









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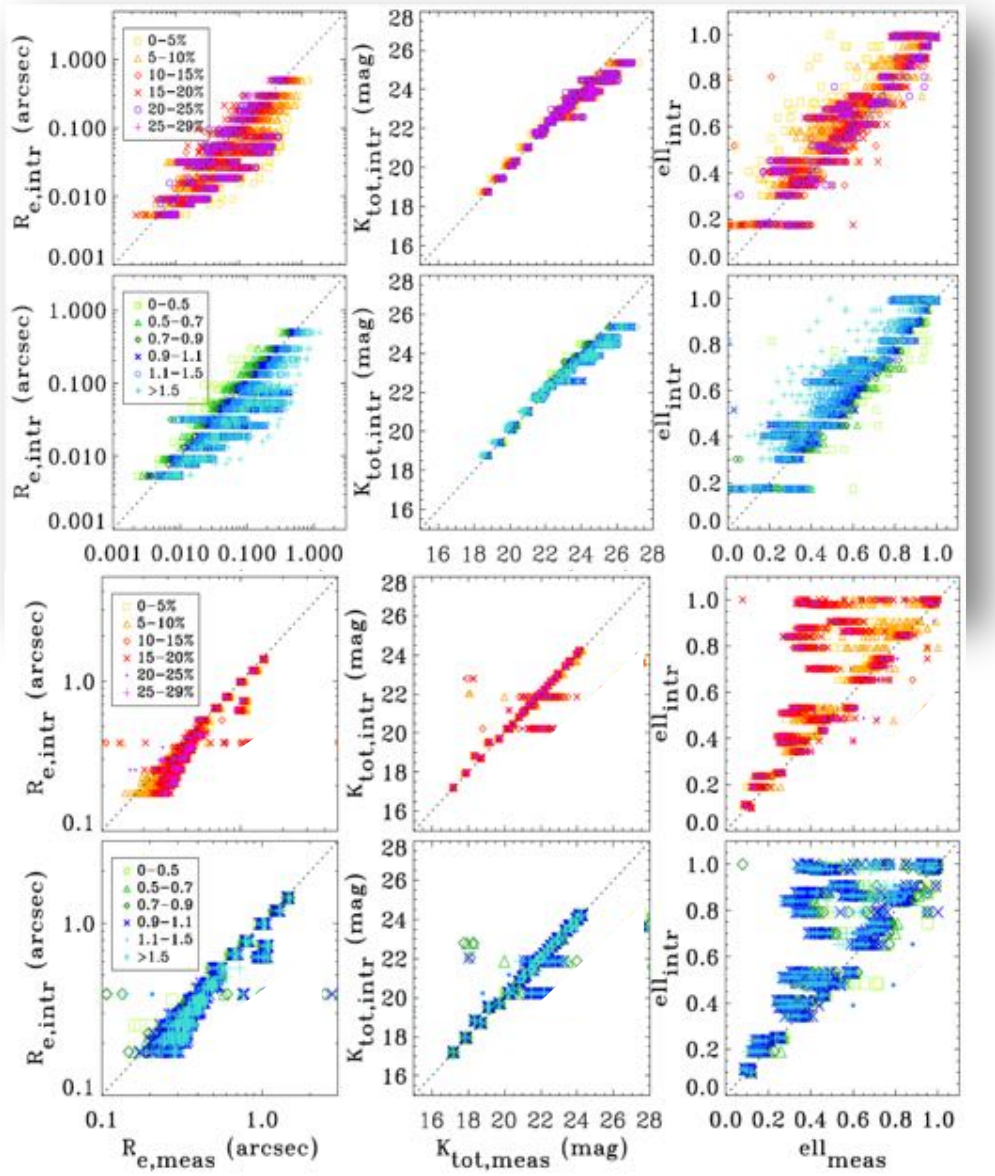
DATA ANALYSIS

ETGs

LTGs



Comparison between inputs and recovered parameters

SR_{model} code

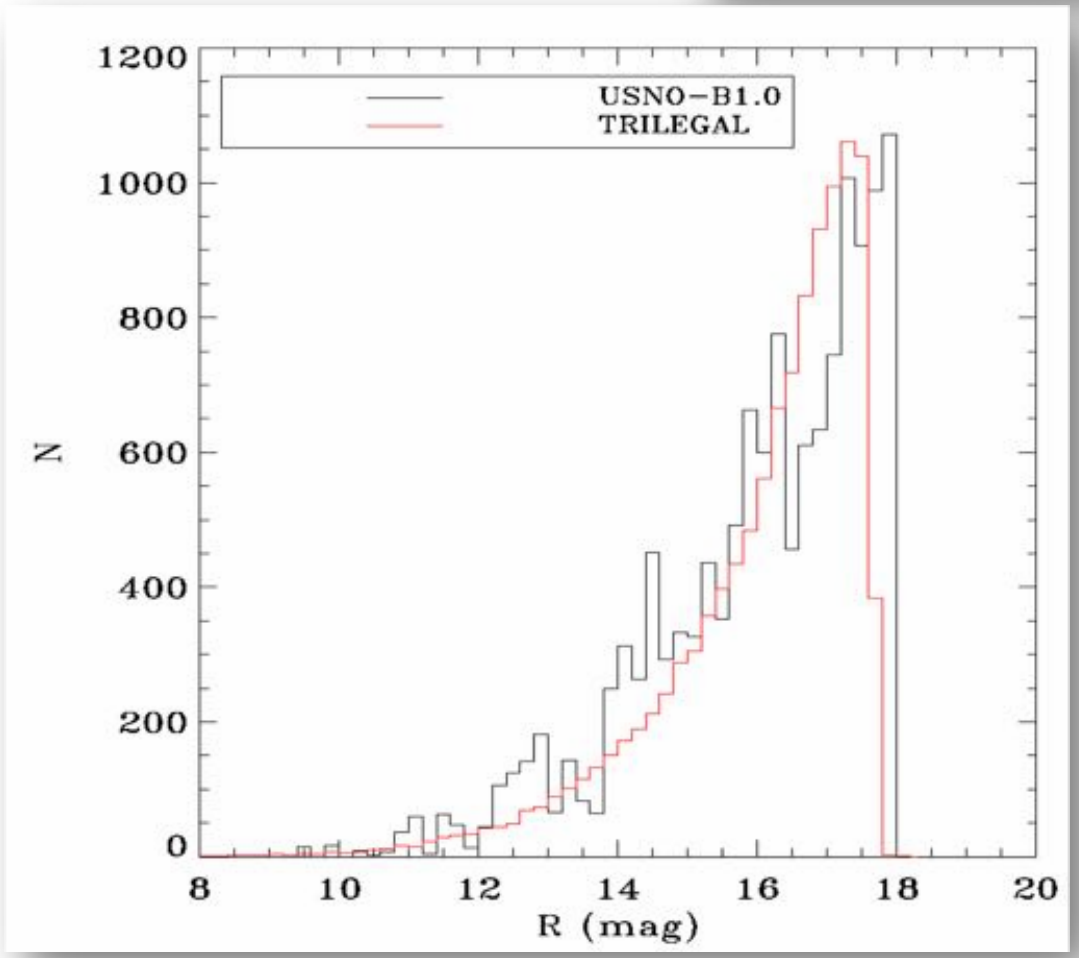
SR_*/SR_{model} code

→ Results show a higher correlation of the retrieved parameter accuracy with the SR_*/SR_{model} than with the absolute SR_{model}

FEASIBILITY OF OTHER SURVEYS

Object visibility (selected datasets)

Telescope	Diameter [m]	Site [°]	Field of View	Resolution [mas]	Filters
E-ELT (MICADO)	39	Cerro Amazones (-70.19,-24.59)	53 ″× 53 ″ 16 ″× 16 ″	4 1.5	I,z,Y,J,H,K
GMT (GMTIFS)	7×8.4	Las Campanas (-70.69,-29.02)	20.4″× 20.4″	5	J,H,K
TMT (IRIS)	30	Mauna Kea (-155.47,19.82) La Palma (-17.89,28.89)	34 ″× 34 ″	4	J,H,K

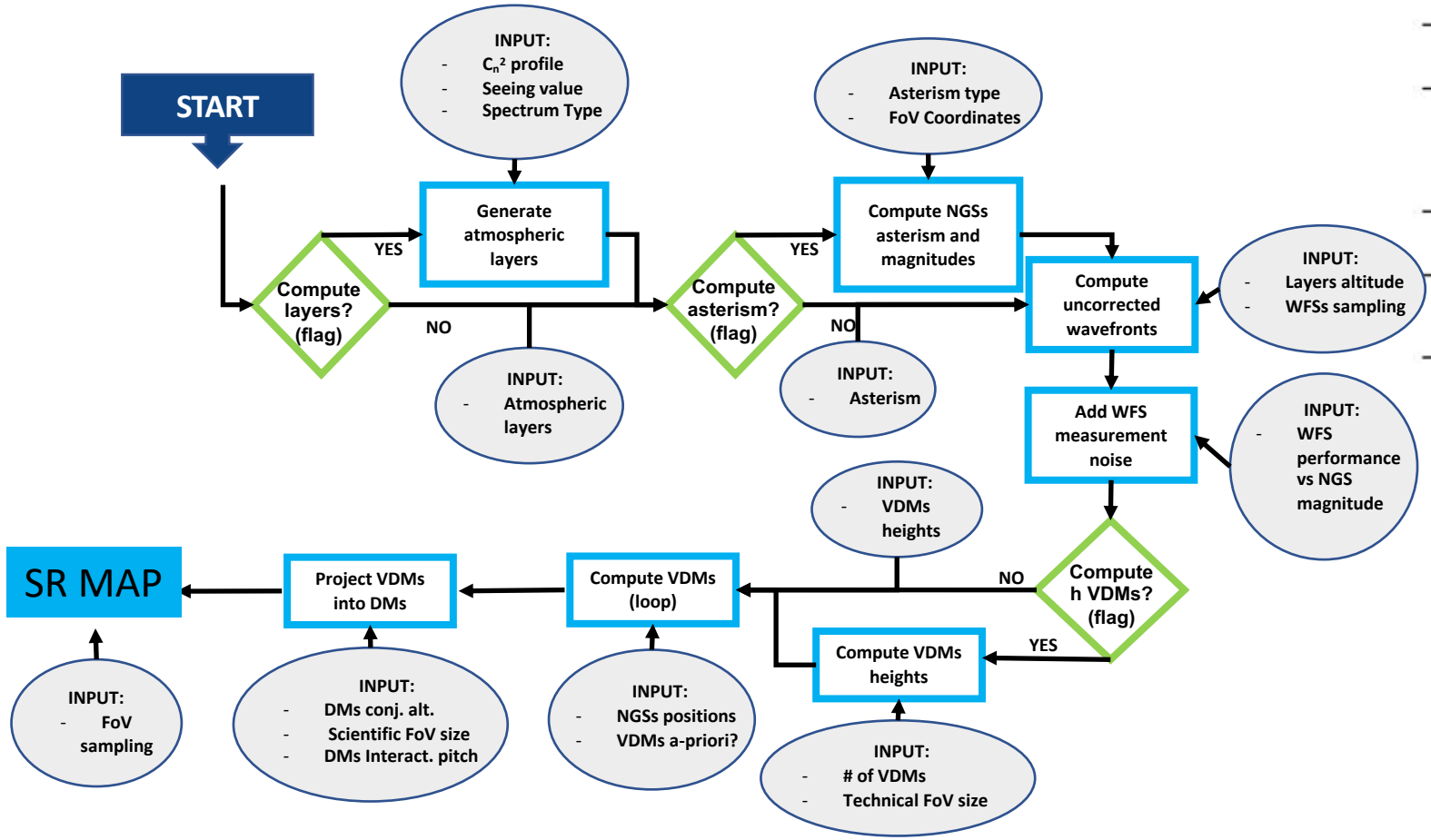


Histogram of the NGS K-band magnitudes for the 22 GMCAO surveys.
The red distribution represents the values we found using TRILEGAL while the black one refers to USNO-B1 catalog.

Survey name	RA [°]	DEC [°]	Field of View [′]	Reference
HDF	189.2042	62.2161	5	Williams et al. (1996)
NDWFS-Bootes	217.500	34.5000	32400	Jannuzi & Dey (1999)
NDWFS-Cetus	31.8708	-4.7356	33116	Jannuzi & Dey(1999)
HDF-S	338.2458	-60.5508	5.3	Williams et al. (2000)
CDF-S	53.1167	-27.8083	396	Giacconi et al. (2001)
DLS-1	13.3542	12.5653	14400	Wittman et al. (2002)
DLS-2	139.5000	30.0000	14400	Wittman et al. (2002)
DLS-3	80.0000	-49.0000	14400	Wittman et al. (2002)
DLS-4	163.0000	-5.0000	14400	Wittman et al. (2002)
DLS-5	208.7500	-10.0000	14400	Wittman et al. (2002)
DLS-6	32.5000	-4.5000	14400	Wittman et al. (2002)
DLS-7	218.0000	34.2800	14400	Wittman et al. (2002)
EGSS	214.2500	52.5000	700	Davis et al. (2003)
GEMS	53.1042	-27.8139	800	Rix et al. (2004)
GOODS-N	189.2292	62.2375	160	Giavalisco et al. (2004)
GOODS-S	53.1250	-27.8056	160	Giavalisco et al. (2004)
SubaruDF	201.1625	27.4906	918	Kashikawa et al. (2004)
COSMOS	150.1167	2.2058	7200	Scoville et al. (2004)
GSS	214.4042	52.4828	127	Vogt et al. (2005)
HUDF	53.1625	-27.7914	11	Beckwith et al. (2006)
CFGTLS-D1	36.4958	-4.4944	3600	Culliandre et al. (2006)
CFGTLS-D2	150.1167	2.2083	3600	Culliandre et al. (2006)
CFGTLS-D3	214.8625	52.6822	3600	Culliandre et al. (2006)
CFGTLS-D4	333.8792	-17.7320	3600	Culliandre et al. (2006)
AEGIS	214.2500	52.5000	700	Davis et al. (2007)
UKIDSS-DXS1	36.2500	-4.5000	126000	Lawrence et al. (2007)
UKIDSS-DXS2	164.2500	57.6667	126000	Lawrence et al. (2007)
UKIDSS-DXS3	242.5	54.0000	126000	Lawrence et al. (2007)
UKIDSS-DXS4	334.2500	0.3333	126000	Lawrence et al. (2007)
UKIDSS-UD	36.2500	-4.5000	2772	Lawrence et al. (2007)
HUDF9	53.1625	-27.7914	4.7	Bouwens et al. (2011)
C_GOODS-N	189.2286	62.2385	918	Koekemoer et al. (2011)
C_GOODS-S	53.1228	-27.8050	1122	Koekemoer et al. (2011)
C_COSMOS	150.1163	2.2010	14400	Koekemoer et al. (2011)
C_EGS	214.8250	52.8250	7200	Koekemoer et al. (2011)
C_UDS	34.4062	-5.2000	7200	Koekemoer et al. (2011)
UDF12	53.1625	-27.7914	5	Koekemoer et al. (2013)
XDF	53.1583	-27.7833	10.9	Illingworth et al. (2013)

THE METHOD

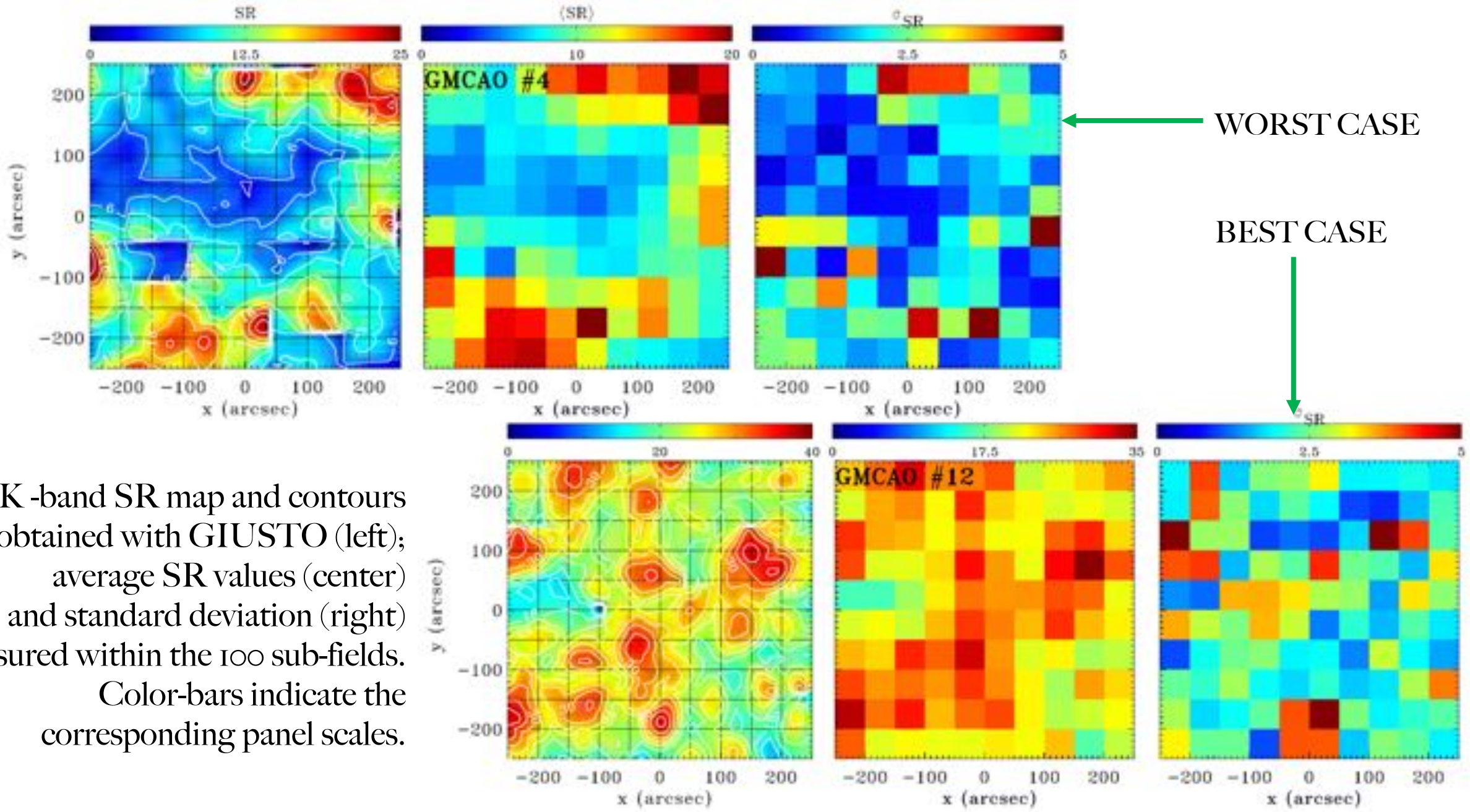
We run GIUSTO, an IDL tomographic simulation tool to obtain the SR over a given FoV.



Main inputs used for GIUSTO:
Parameter; Corresponding value; Unit of measure.

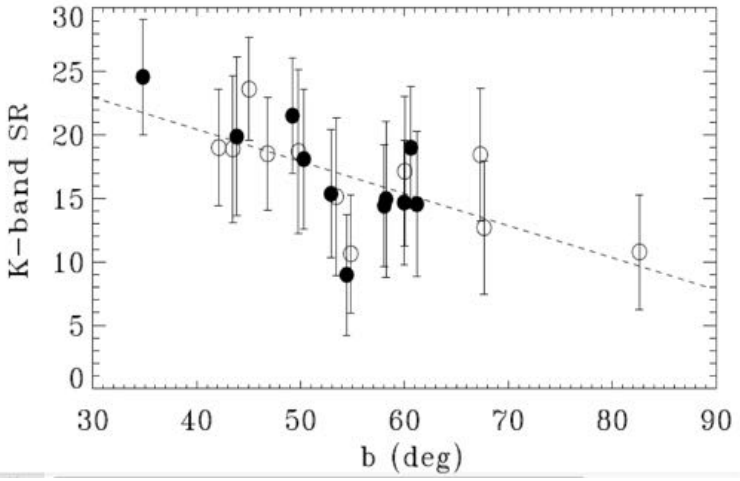
Reference stars		
Number of NGSs	6	
Position/Magnitude NGSs	USNO-B1 catalog	
Limit magnitude	R,18	mag
Tomography		
Screen scale	0.1	[m/pixel]
Number of VDMs	6	
System		
Sensing wavelength	0.5	[μm]
Scientific wavelength	2.2	[μm]
Entrance pupil diameter	39	[m]
Probes proximity (min)	10	[arcsec]
Technical FoV	600	[arcsec]
Rejected FoV	120	[arcsec]
Scientific FoV	120	[arcsec]
Number of fields	100	
Number of DMs	3	
DMs conjugated altitudes	0,4000,12700	[m]
Atmosphere		
Atmospheric profile	35	[layers]
Fried Radius	0.14	[m]
L_0 max	25	[m]
l_0 min	0.001	[m]
Atmospheric spectrum	von Karman	

THE METHOD



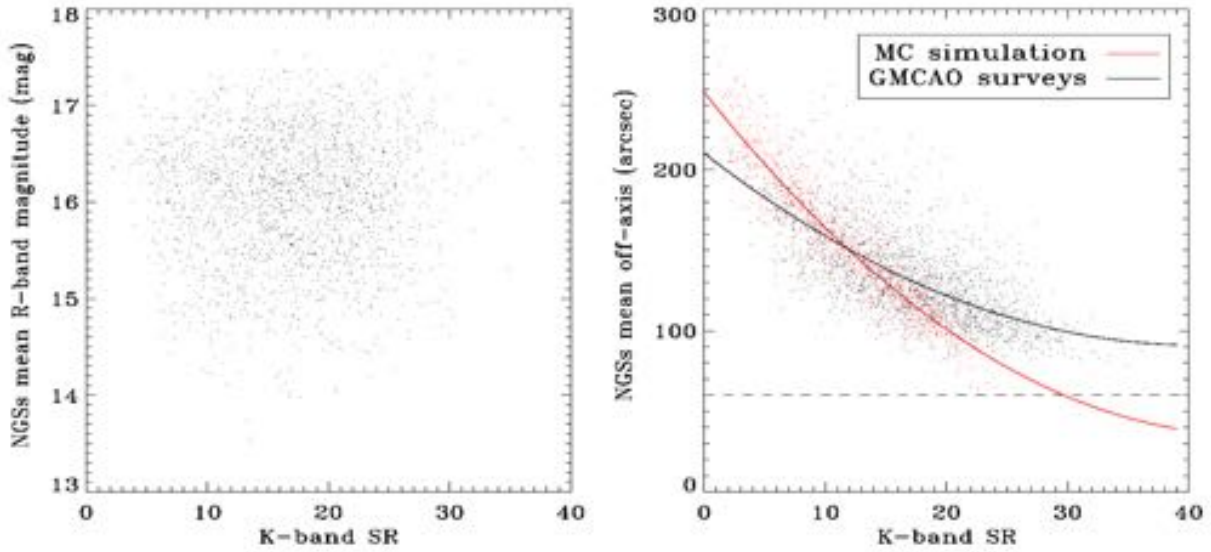
K -band SR map and contours obtained with GIUSTO (left); average SR values (center) and standard deviation (right) measured within the 100 sub-fields. Color-bars indicate the corresponding panel scales.

STATISTICS



Mean K-band SR as a function of the galactic latitudes of the GMCAO surveys.
Filled circles represent points with negative values of galactic latitude, while open circles are for positive values.
The error bars represent 1σ value.

NGS K -band magnitude (left) and radial distance from the center (right) as a function of the field SR for all the 22 GMCAO surveys..



The red points were obtained with a Monte Carlo simulation using a 40-layers profile atmosphere.
The solid lines represent the best-fit,
while the dashed one shows the lower limit for finding NGSs in the technical field

CONCLUSIONS

The SR averaged value is 16.8 ± 2.3, consistent with our previous work.

The SRs correlate linearly with the latitude as expected because of the availability of stars.

The best performance are obtained with stars that are relatively close to the Scientific FoV: stellar magnitudes of NGSs do no impact the performance, while mean off-axis position of NGSs plays a key role.

Now the performance that can be obtained with the GMCAO method has a robust statistical confirmation: it can be applied to the next-generation of ELTs to carry out a deep observations obtaining good data to process in order to shed light in the puzzle of formation and evolution of galaxies.

THANKS

Elisa Portaluri – INAF: Osservatorio Astronomico di Padova