Ottica Adattiva Made in Italy: Premiale 2014

LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

Partially founded by T-Rex: Premiale 2011

Elisa Portaluri

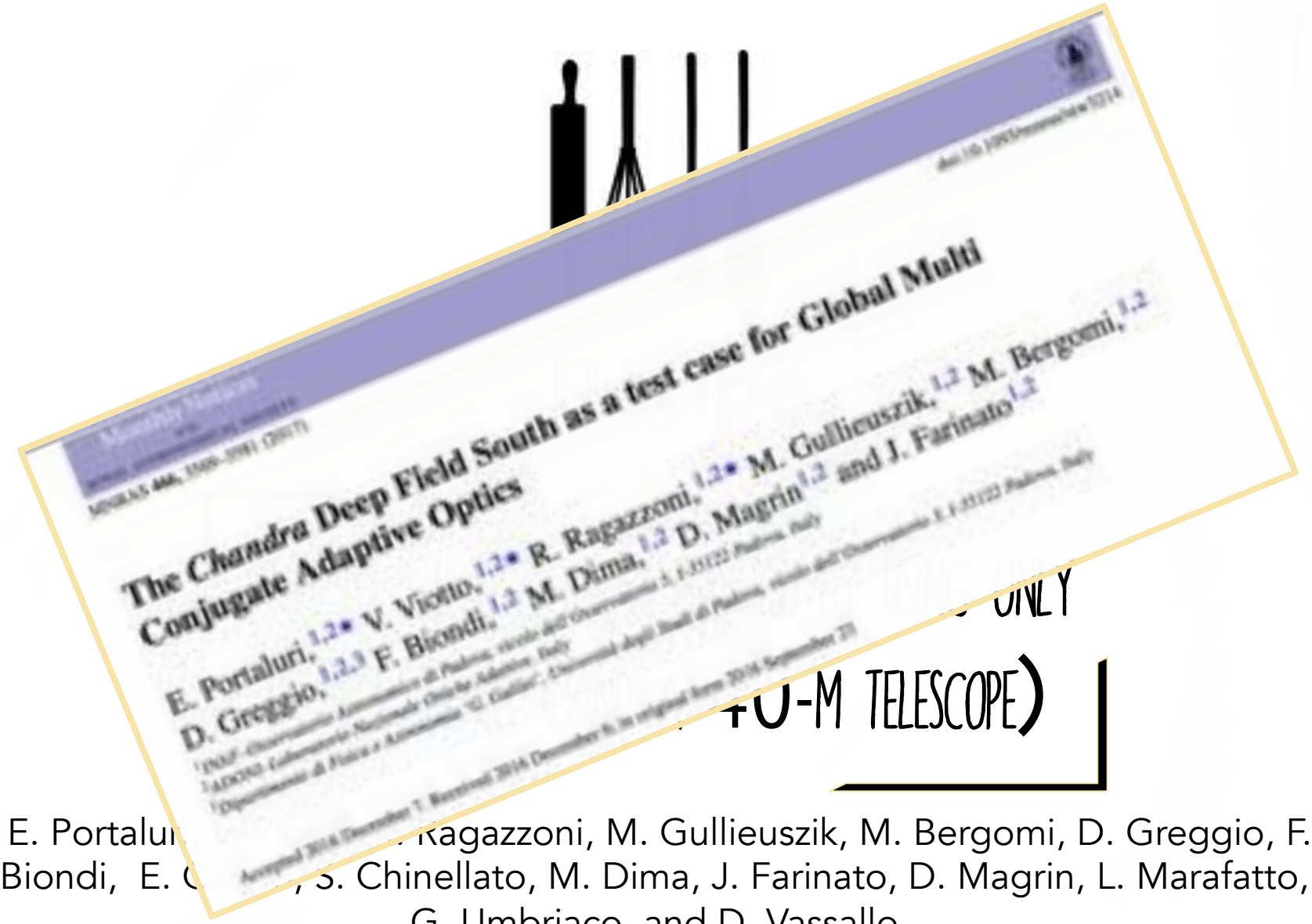
AO4ELT5, 27th June

PROSPECTS OF DEEP FIELD SURVEYS WITH GLOBAL-MCAO ON AN ELT

Recipe

How to study the far universe by using only natural stars (and a 40-m telescope)

E. Portaluri, V. Viotto, R. Ragazzoni, M. Gullieuszik, M. Bergomi, D. Greggio, F. Biondi, E. Carolo, S. Chinellato, M. Dima, J. Farinato, D. Magrin, L. Marafatto, G. Umbriaco, and D. Vassallo



E. Portaluri, R. Ragazzoni, M. Gullieuszik, M. Bergomi, D. Greggio, F. Biondi, E. [illegible], S. Chinellato, M. Dima, J. Farinato, D. Magrin, L. Marafatto, G. Umbriaco, and D. Vassallo

TUTORIAL

THE UNIVERSE CAKE:

1. INGREDIENTS
2. STEPS
3. FILLS AND TOPPING

INGREDIENTS

1) **The far Universe:** ✓

fundamental questions of modern observational cosmology involve expanding the frontiers of knowledge about the formation of the first stars and galaxies at the earliest epochs of the cosmic

INGREDIENTS

1) The far Universe:

Irregulars: (n < 0.5)

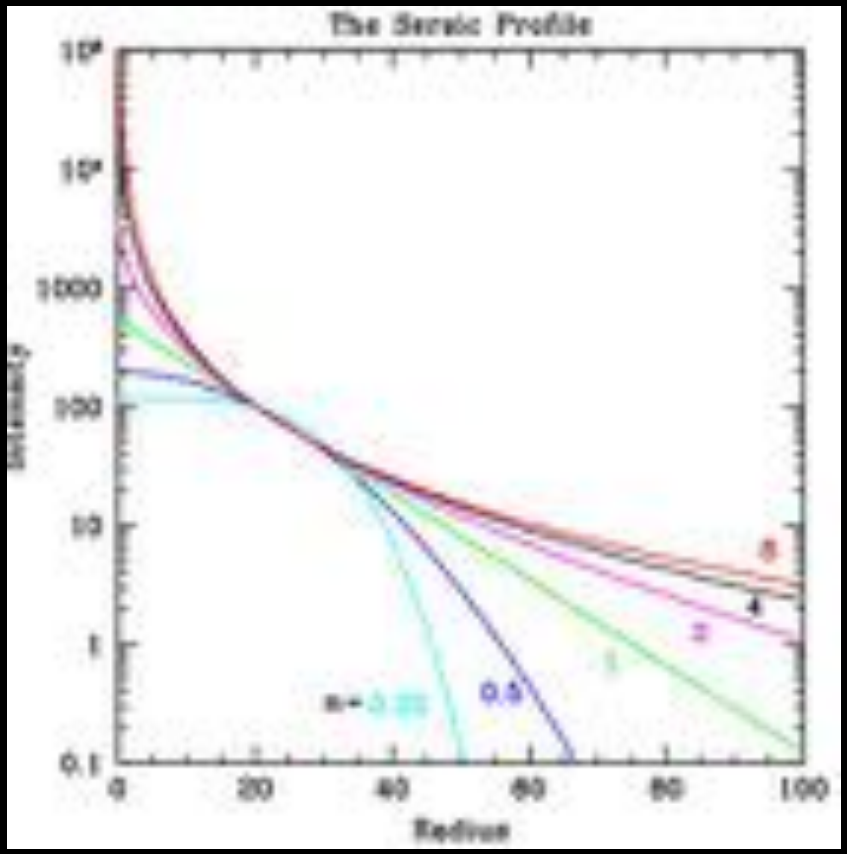
Discs: (0.5 > n > 1.0)

Bulges (n > 2.5)

Central compact component?

(n = 5.0)

n = Sérsic index



INGREDIENTS

1) The far Universe:

Irregulars: (n < 0.5)

Discs: (0.5 > n > 1.0)

Bulges (n > 2.5)

Central compact component?

(n = 5.0)

Galaxies @z~2 have **R_e smaller** than a few Kpc. **Populations gradients** are more prominent in the inner regions.

→Low mass galaxies are much smaller than HST FWHM

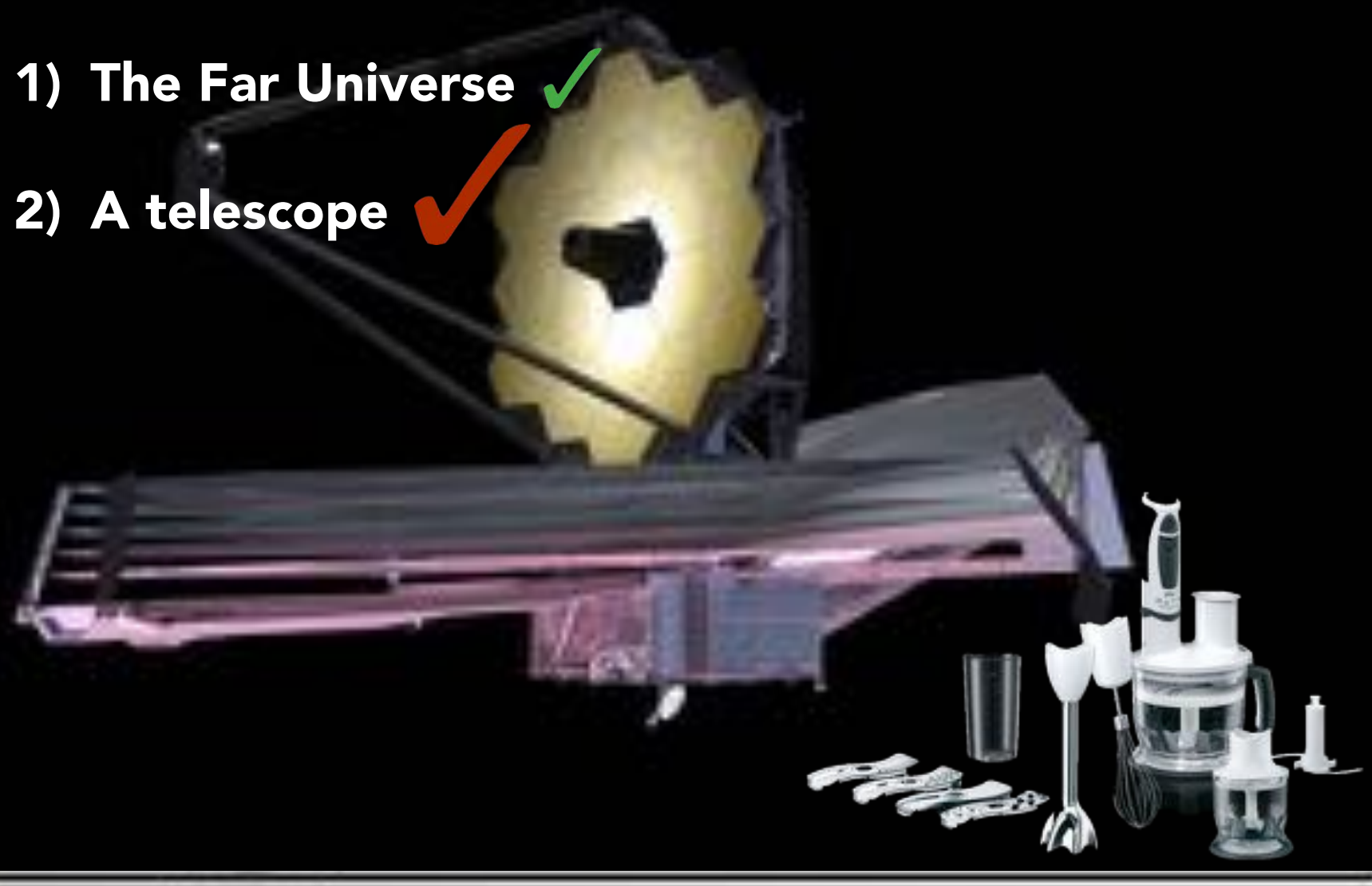
Key questions:

- scaling relations for low mass galaxies at high-z-
- morphological evolution
- transition from early to late-type /star formation quenching
- size evolution (?)
- colour gradients (?)

INGREDIENTS

1) The Far Universe ✓

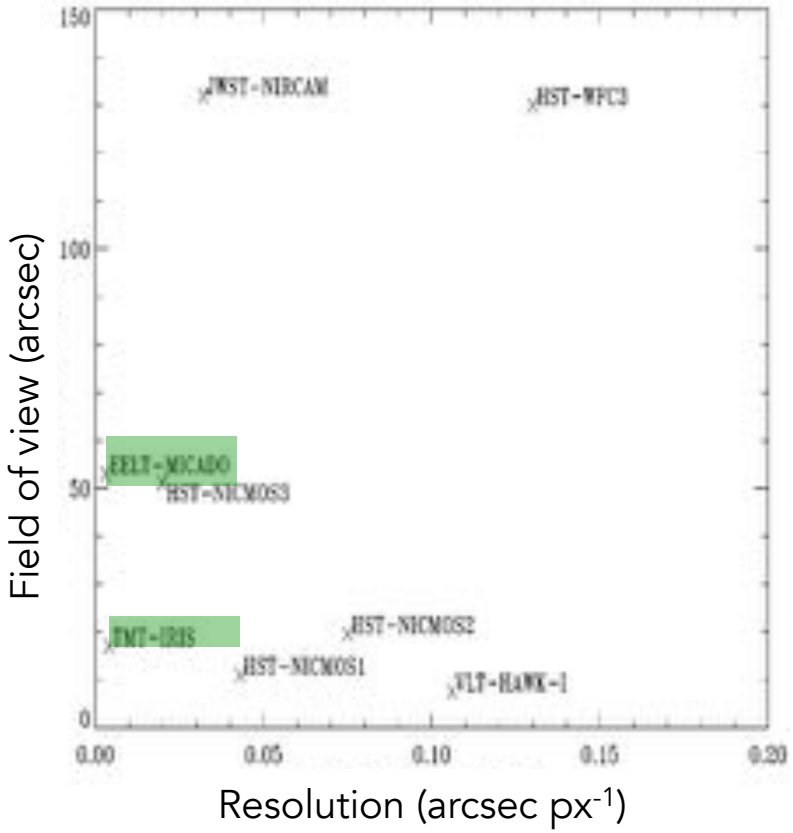
2) A telescope ✓



INGREDIENTS

1) The Far Universe ✓

2) A telescope ✓



INGREDIENTS

1) The Far Universe ✓

2) A telescope: ✓
   - With an adequate AO system

INGREDIENTS

1) The Far Universe ✓

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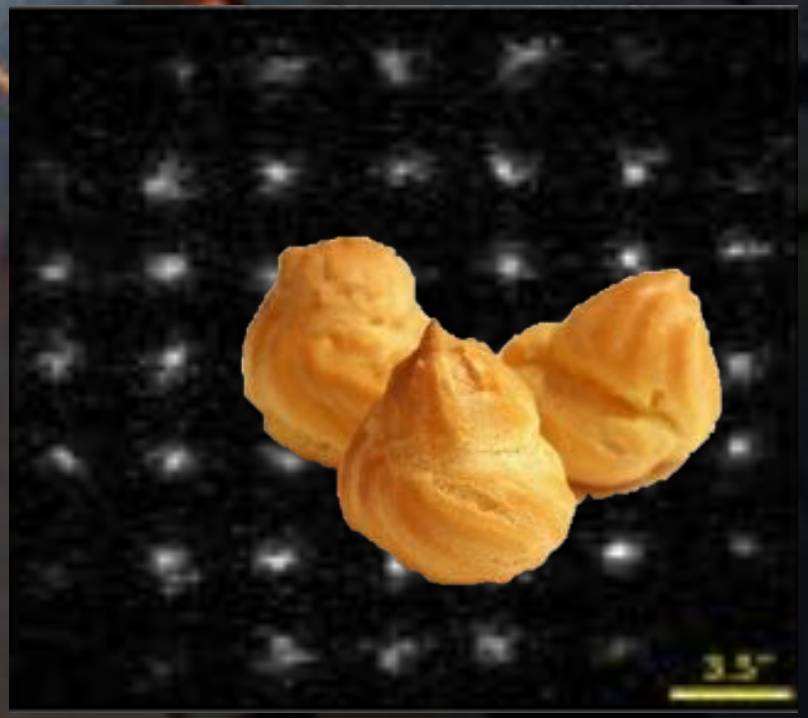
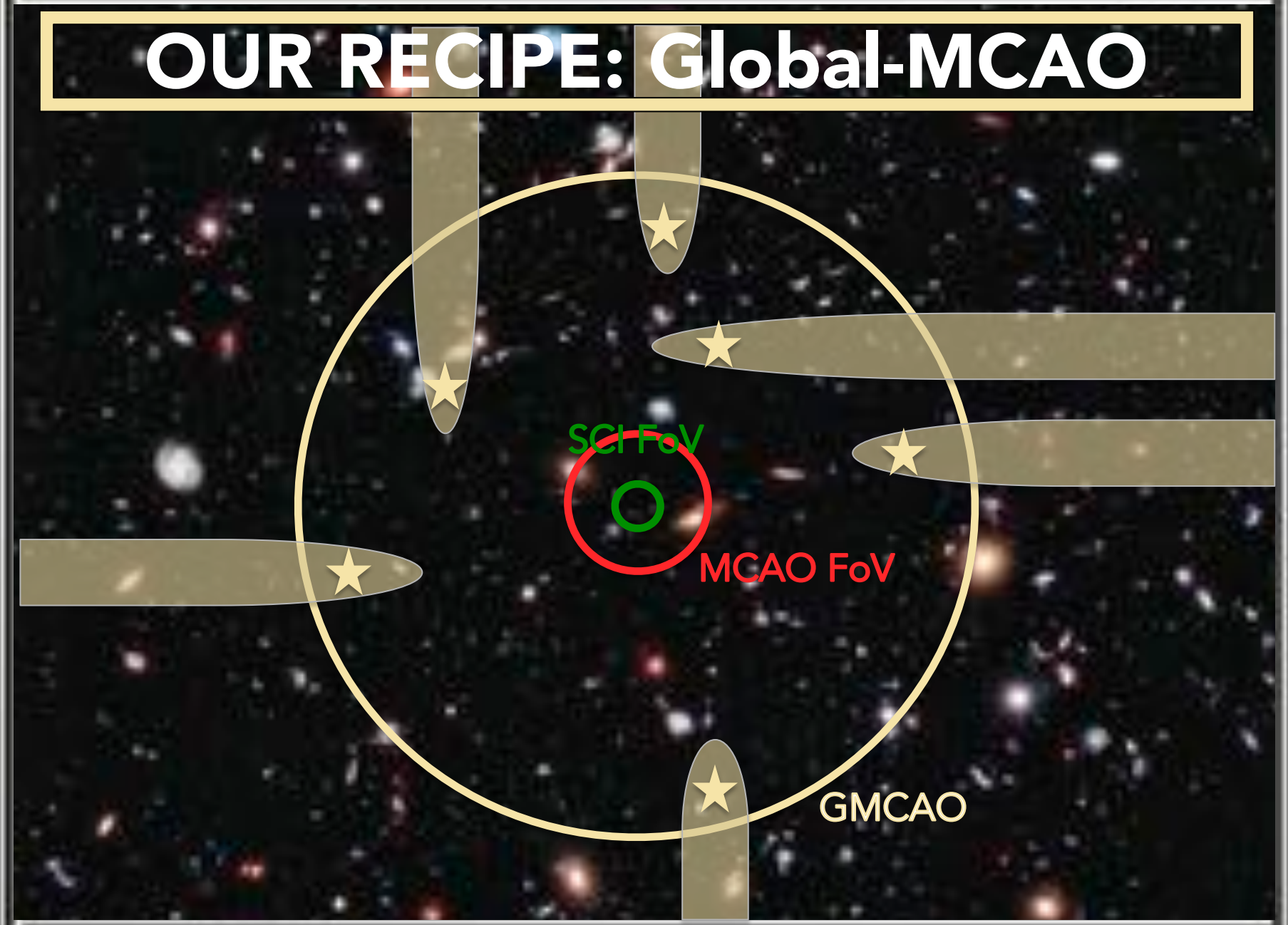


OUR RECIPE: Global-MCAO

- aims to exploit a very wide technical field of view to find AO-suitable Natural Guide Stars

- goal to increase the overall sky coverage and correct a smaller, but adequate scientific FoV.

OUR RECIPE: Global-MCAO

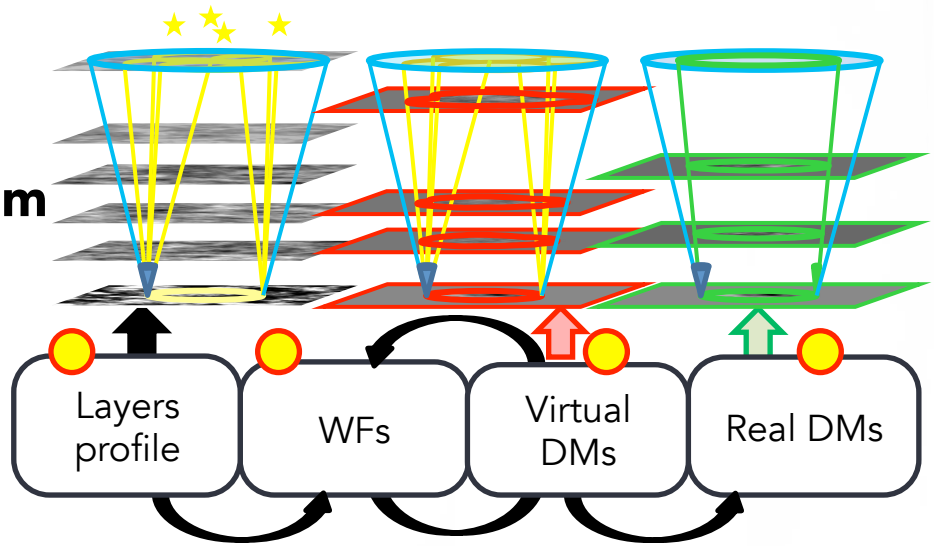


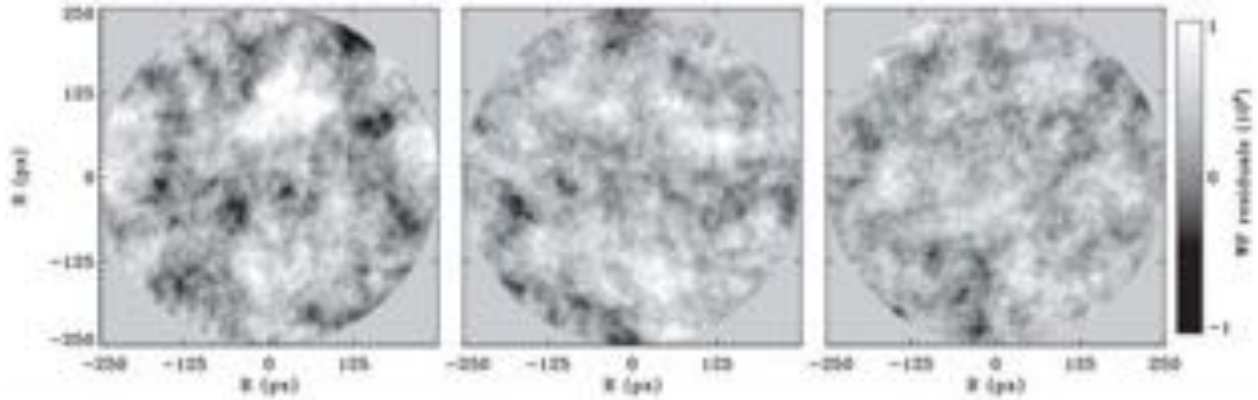
OUR RECIPE: Global-MCAO

1) GIUSTO: GMCAO IDL Unreleased Simulation TOol:

- **40 layers (ESO profile)**
- **h_{max} = 25.2 km @zenit**
- **L_0 = 25 m**
- **r_0 = 0.129 m @30°, 500 nm**

Viotto et al (2015)



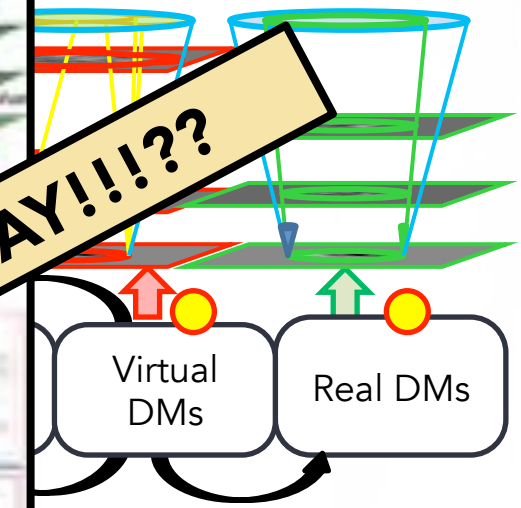


OUR … MCAO

1) GIUST … ation Tool:

- 40 layers
- h_{max} = 25
- L_0 = 25 m
- r_0 = 0.12

Viot…



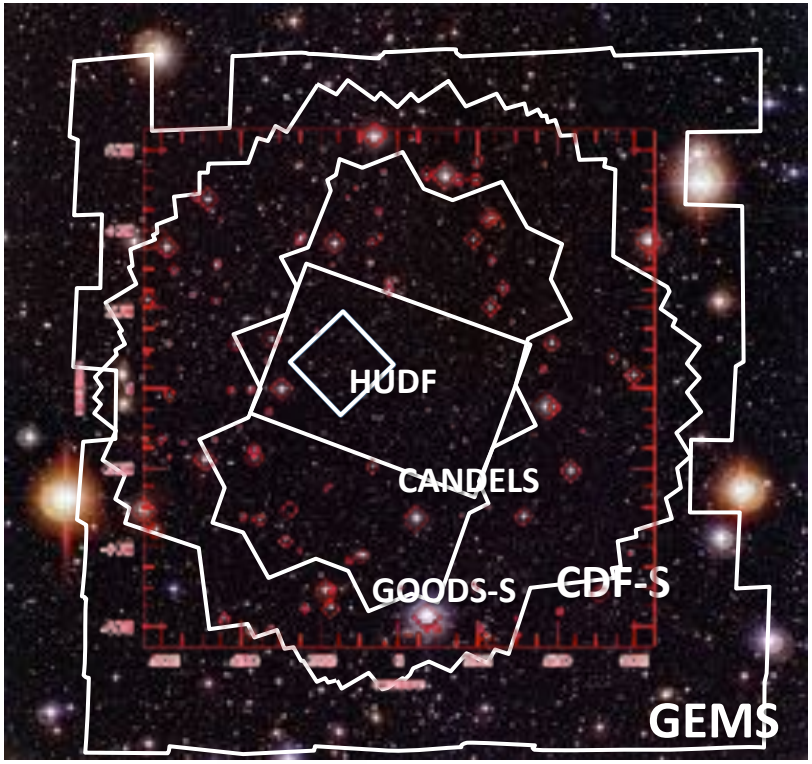
See poster Viotto et al.: YESTERDAY!!!??

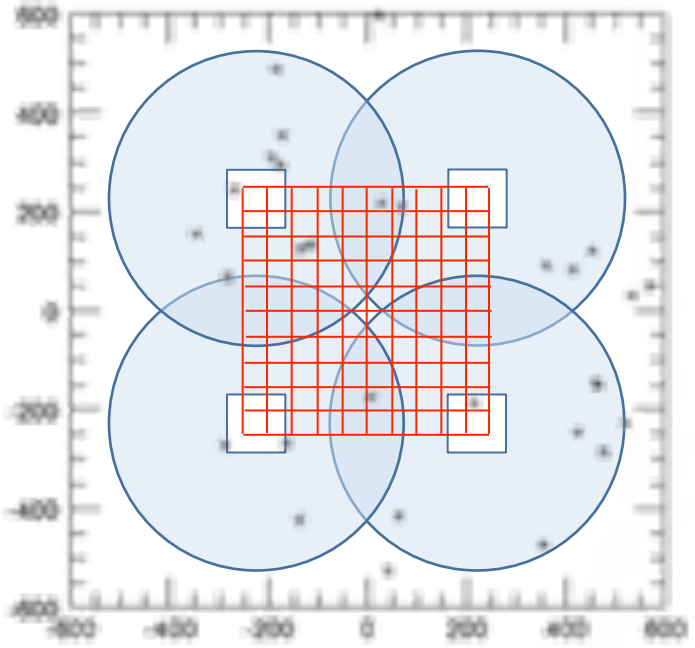
OUR RECIPE: Global-MCAO

GIUSTO: GMCAO IDL Unreleased Simulation TOol:

2) Pointing:

- **Chandra Deep Field South; RA=3h32m28s; DEC=-27°48′30″**
- **Star Catalog: USNO-B, R-band**



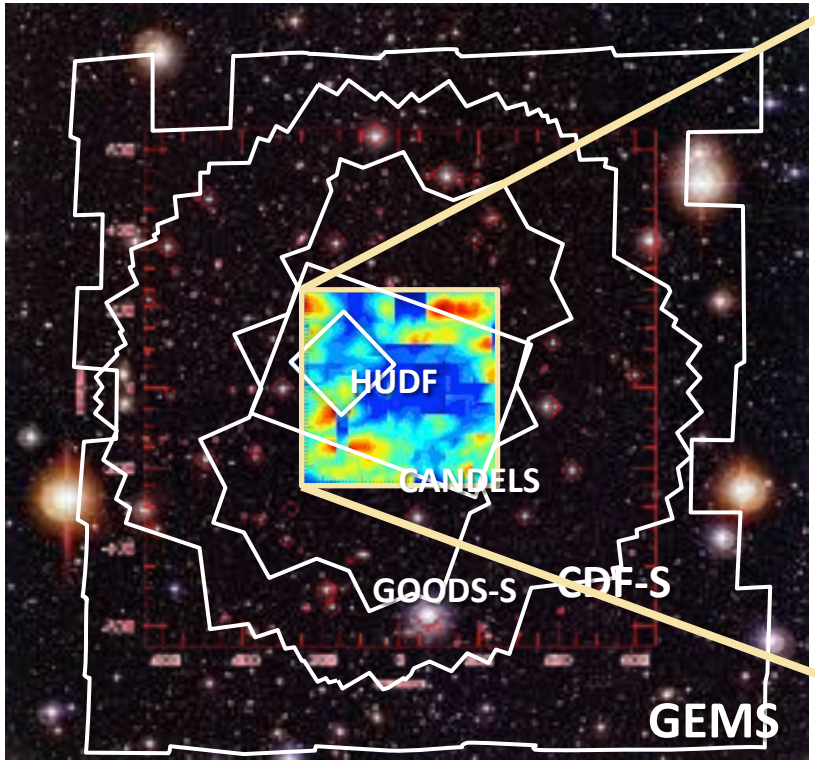


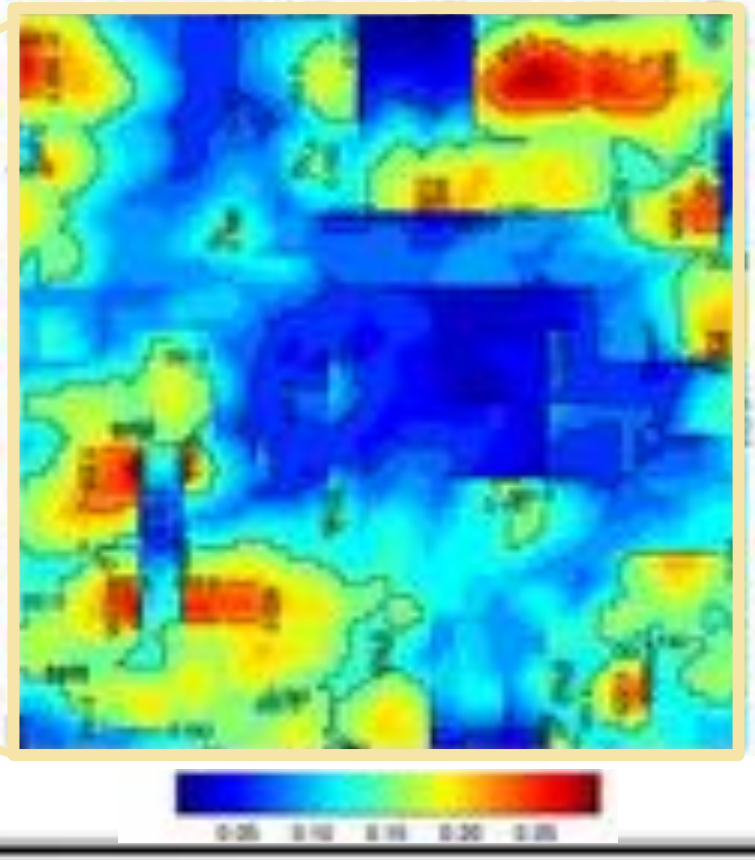
OUR RECIPE: Global-MCAO

GIUSTO: GMCAO IDL Unreleased Simulation TOol:

Pointing

3) K-band Strehl Ratio: 500”x500” star-poor field,<SR>=0.17



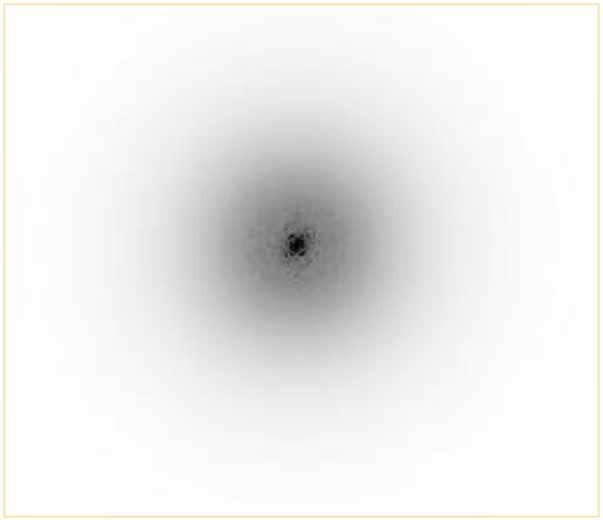


OUR RECIPE: Global-MCAO

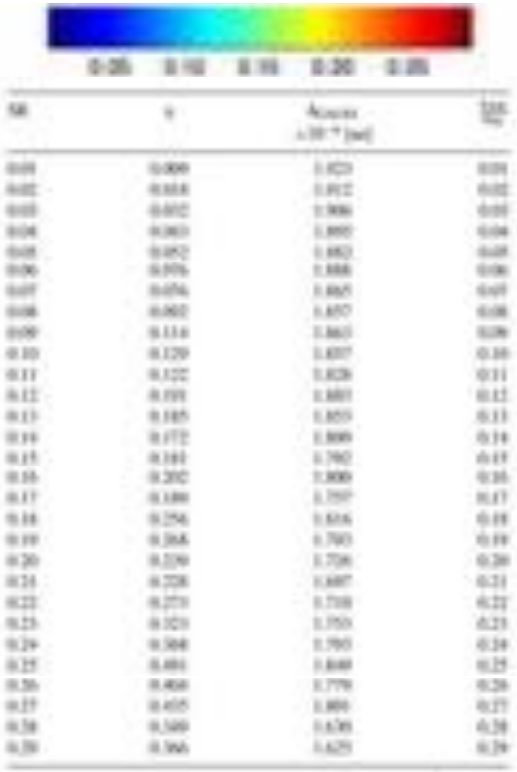
GIUSTO: GMCAO IDL Unreleased Simulation TOol:

Pointing

3) **K-band Strehl Ratio: PSF construction**



$$\begin{cases} PSF_{\mathrm{TOT},i} = \eta \cdot PSF_{\mathrm{wavef},i} + (1-\eta) \cdot PSF_{\mathrm{GAUSS},i}, \\ \frac{h_{\mathrm{TOT},i}}{h_{\mathrm{DL},i}} = SR_i, \end{cases}$$

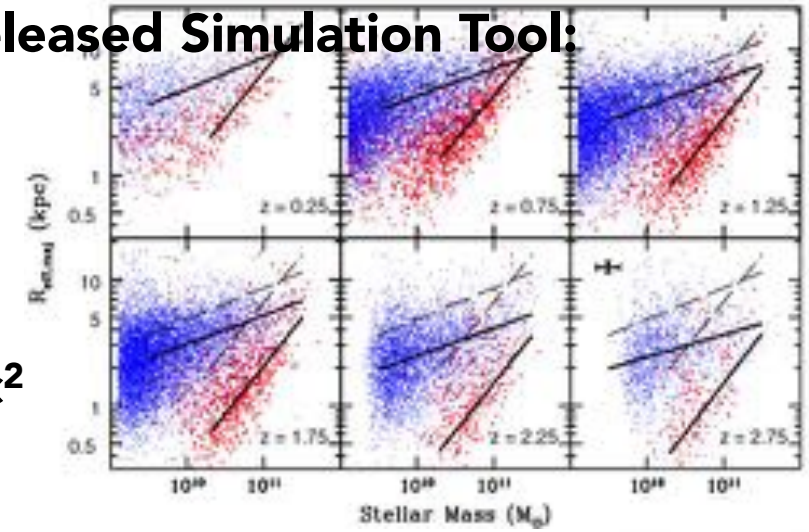


OUR RECIPE: Global-MCAO

GIUSTO: GMCAO IDL Unreleased Simulation Tool:

Pointing

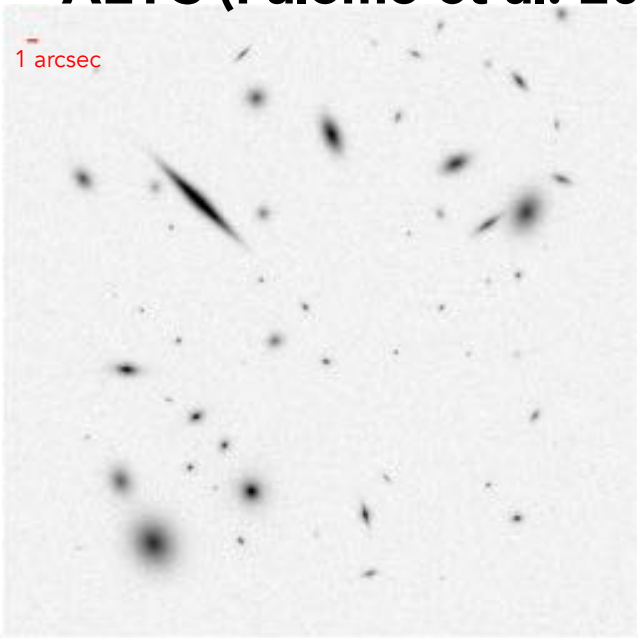
K-band Strehl Ratio



4) Simulation of a deep field:

- 10 x 10 grid of 50 x 50 arcsec²

- AETC (Falomo et al. 2011)

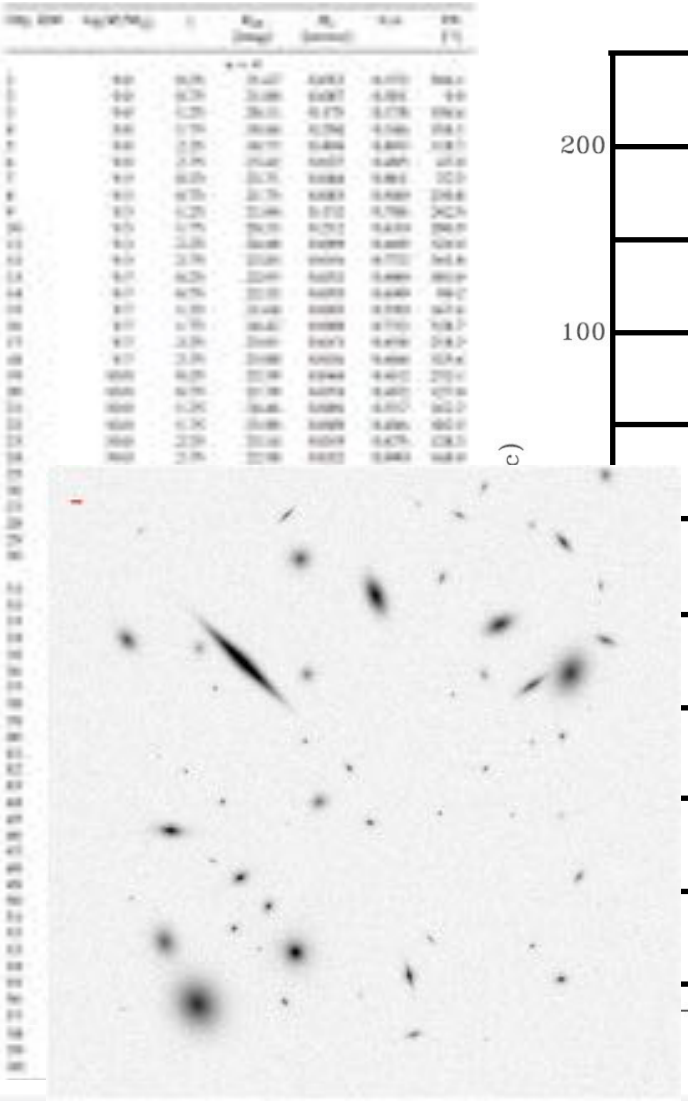


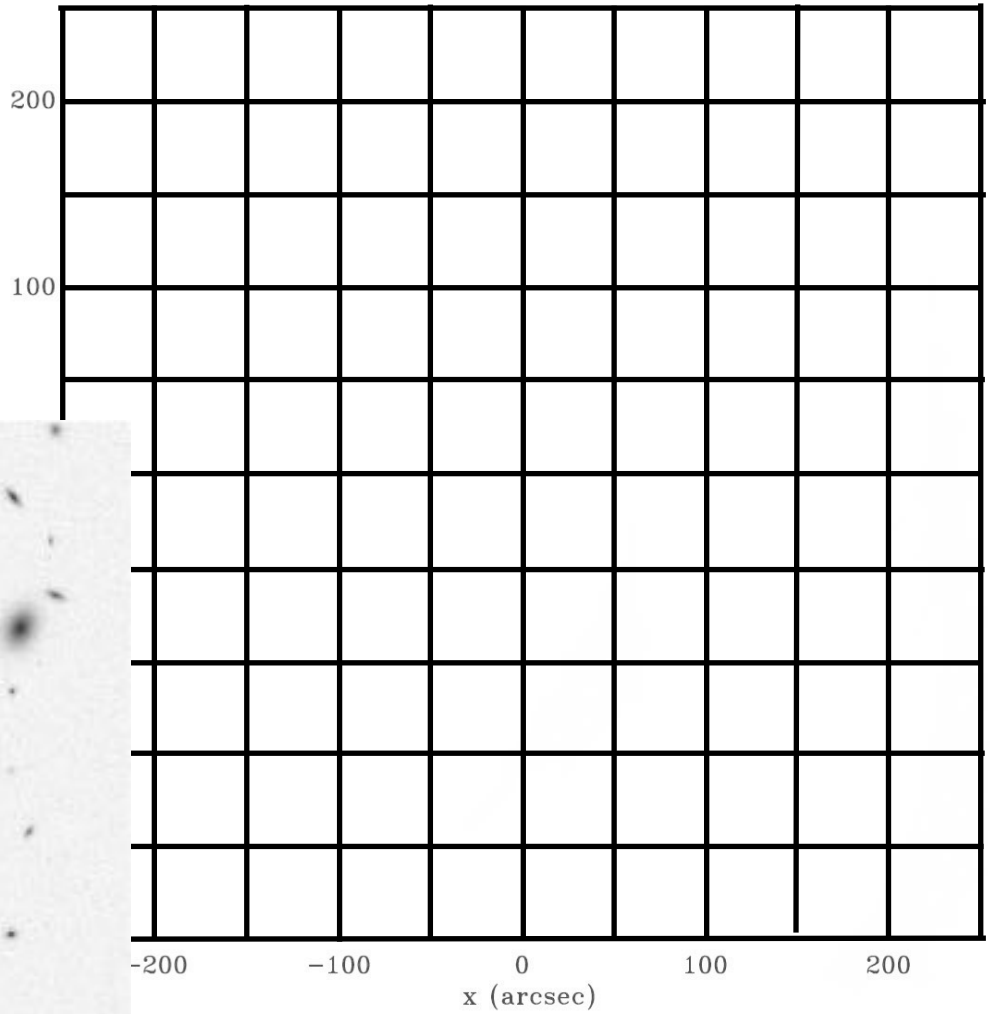
- input parameters
(van der Wel et al. 2014)

$\log (M/M_{\odot}) = 9, 9.3, 9.7, 10, 10.3$

$z = 0.25, 0.75, 1.25, 1.75, 2.25, 2.75$

OUR RECIPE: Global-MCAO

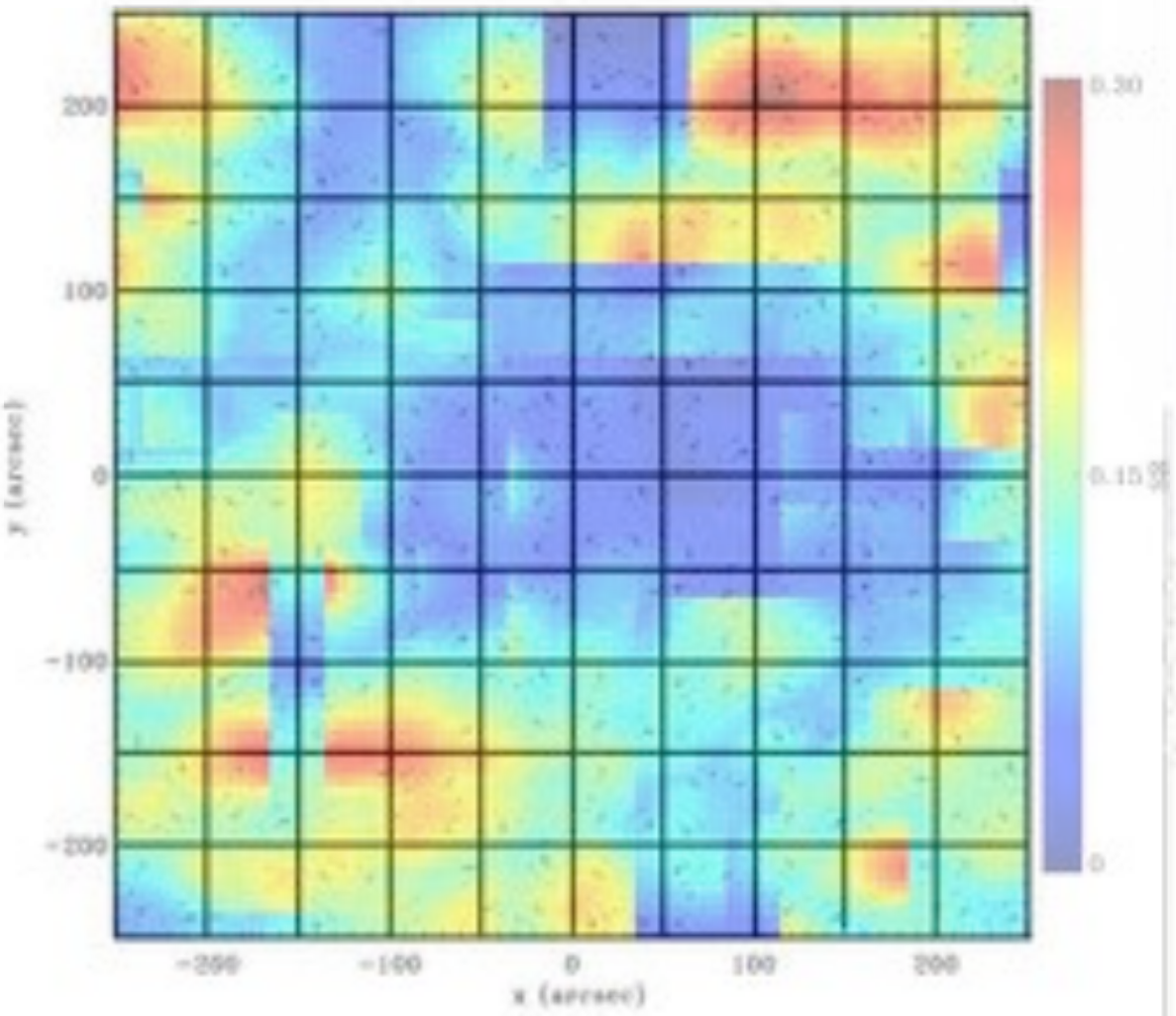




OUR RECIPE: Global-MCAO

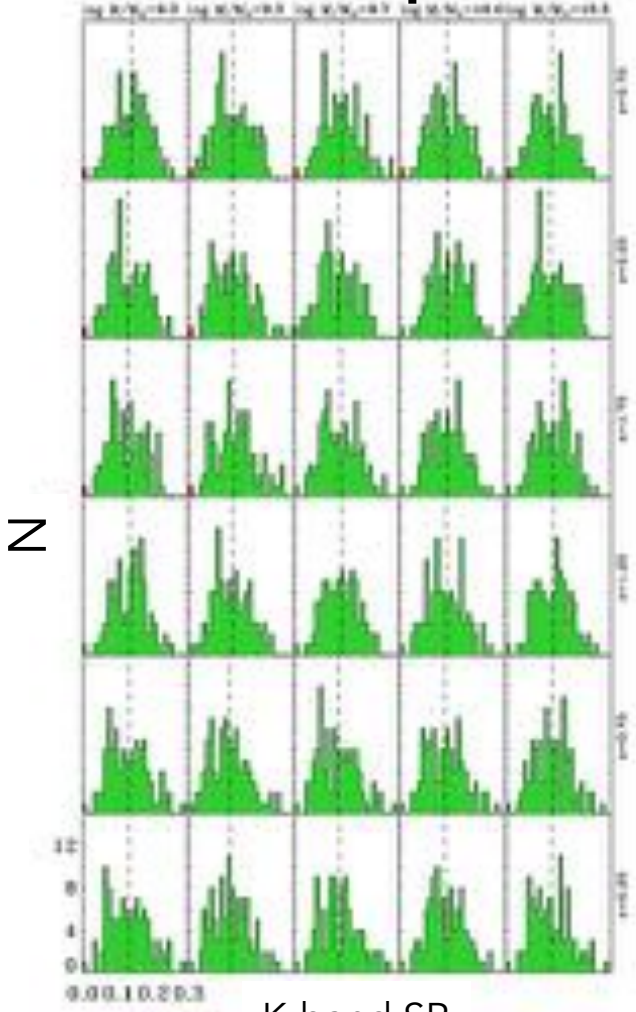
Early types

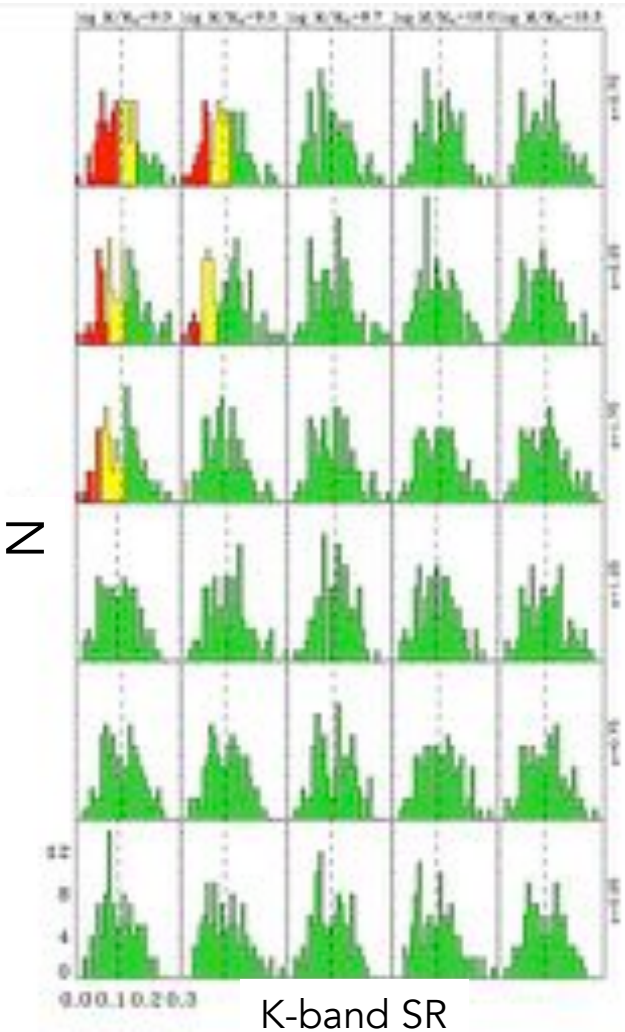
Late types



THE FINAL PRODUCT

1) SExtractor completeness: 99.7% (ETGs) - 89.4% (LTGs)





found

not found

found, 2x2 bin

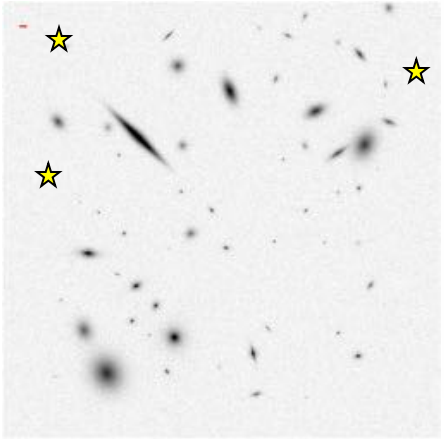
N

Log $M/M_{\odot}$

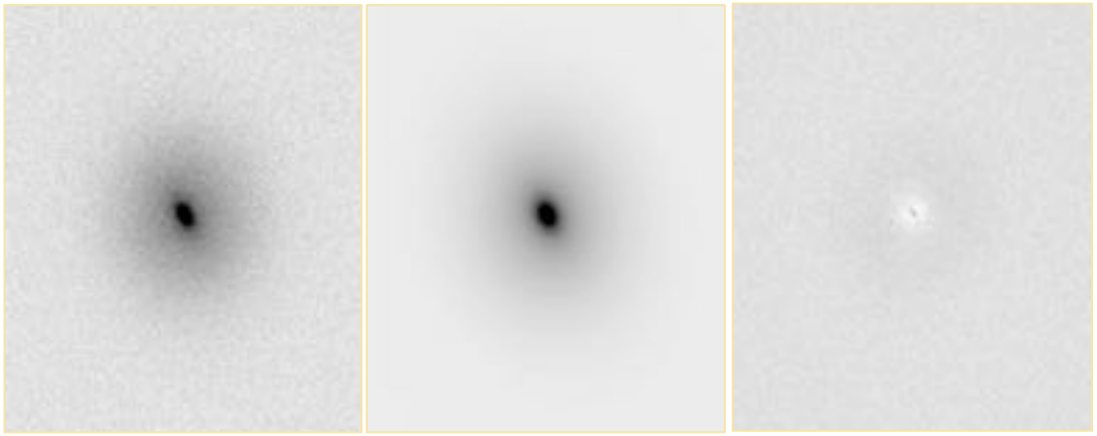
THE FINAL PRODUCT

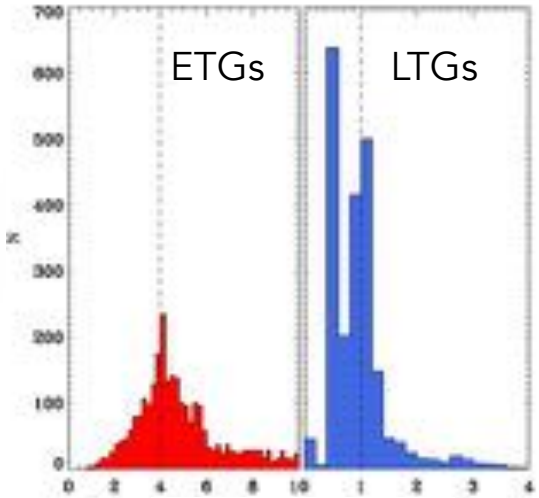
- **SExtractor completeness: 99.7% (ETGs) - 89.4% (LTGs)**

2) **GALFIT: Morphology and Photometry - NO PSF a priori knowledge!**



GALAXY MODEL RESIDUALS





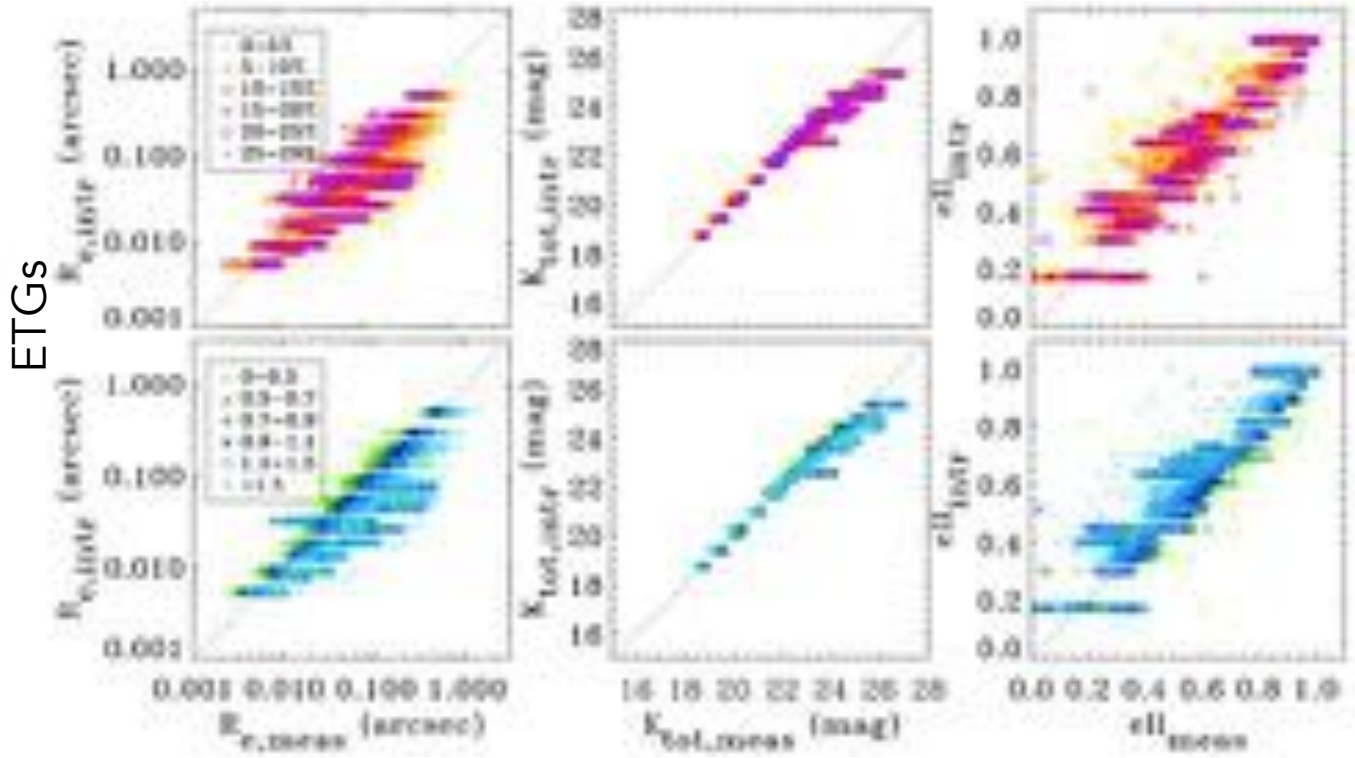
Sérsic index

THE FINAL PRODUCT

SExtractor completeness: 99.7% (ETGs) - 89.4% (LTGs)

GALFIT: Morphology and Photometry

3) Comparison



SR_{model} code

SR_{*}/SR_{model} code

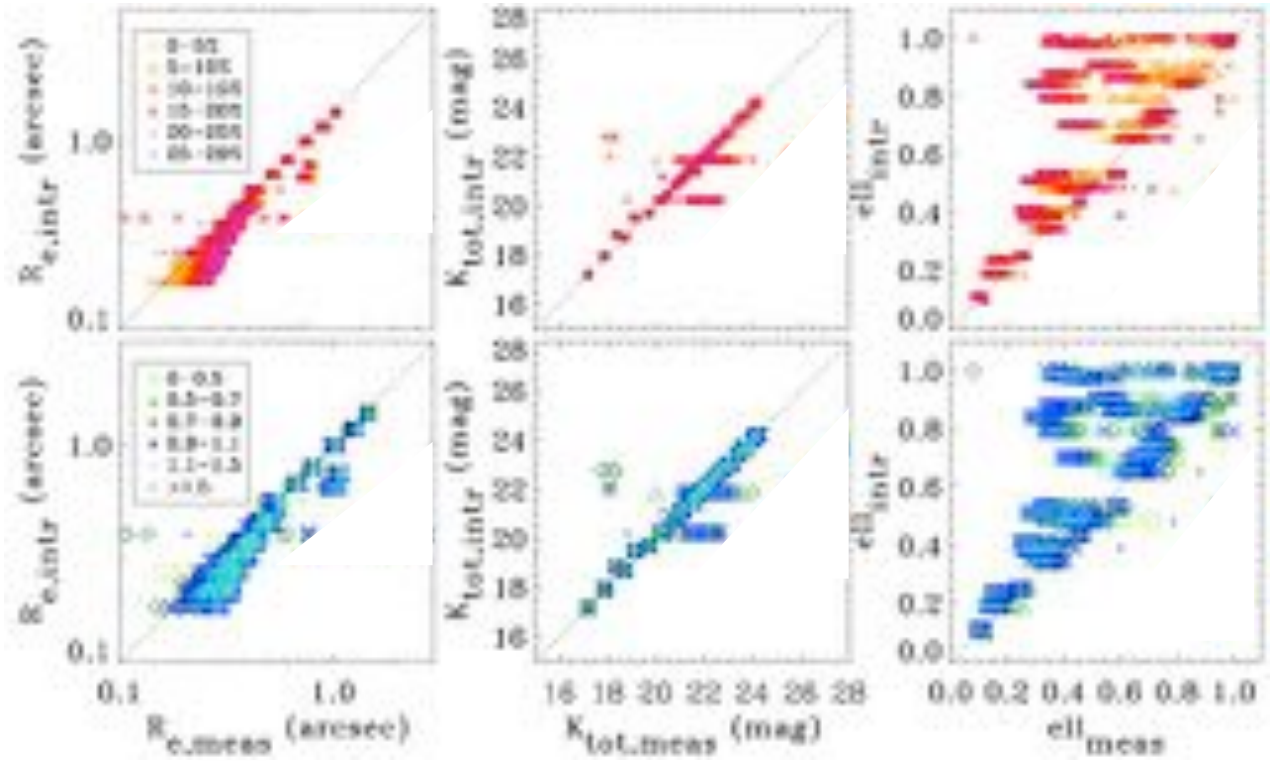
THE FINAL PRODUCT

SExtractor completeness: 99.7% (ETGs) - 89.4% (LTGs)

GALFIT: Morphology and Photometry

3) Comparison

LTGs



SR_{model} code

SR_*/SR_{model} code

A GMCAO-assisted ELT-like telescope can carry out photometric surveys successfully,
recovering the morphology and photometry of sample galaxies adequately

Appetite comes with eating…

CAKE TOPPING

Feasibility (with GMCAO)
of other surveys

CAKE TOPPING

Feasibility (with GMCAO) of other surveys

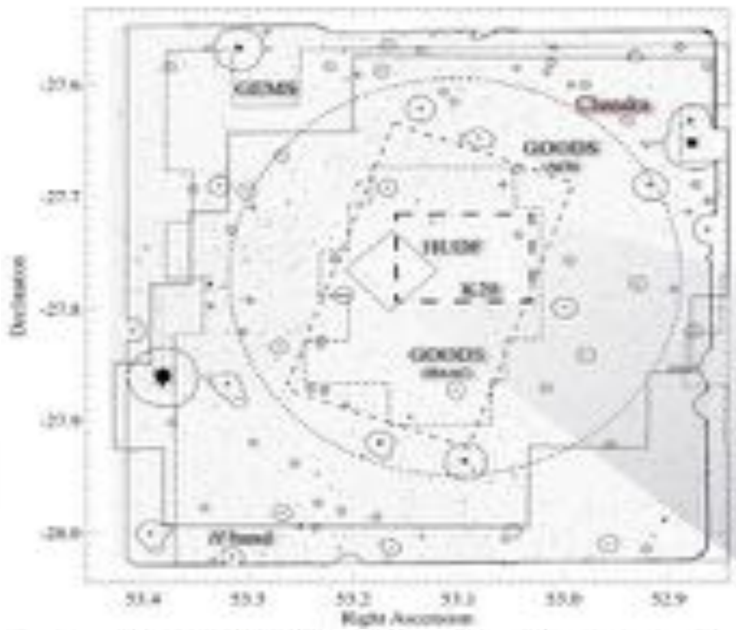


Table 2. Observing capabilities of the ELTs. Column 1: Telescope Name. Column 2: Diameter of the primary mirror. Column 3: Site with coordinates. Column 4: Telescope field of view. Column 5: Resolution. Column 6: Filters

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

Table 1. Observing parameters for most known surveys. Column 1: Name of the survey. Column 2: Right ascension and Column 3: Declination of the central pointing. Column 4: Field of view area. Column 5: Reference.

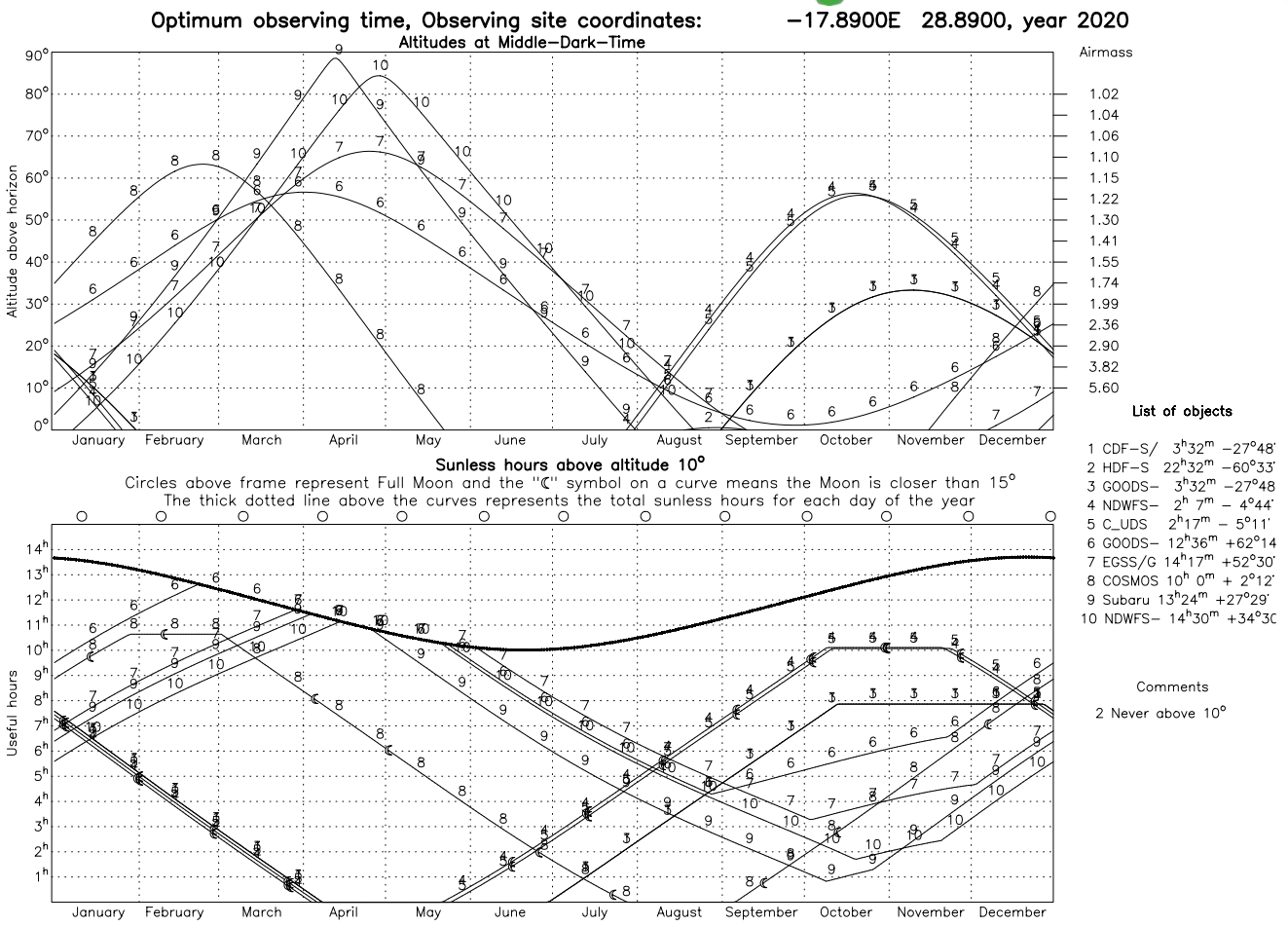
Survey name	RA [°]	DEC [°]	Field of View [′]	Reference
HDF	[illegible]	[illegible]	[illegible]	Williams et al. [illegible]
NDWFS-Bootes	[illegible]	[illegible]	[illegible]	Jannuzi & Dey [illegible]
NDWFS-Cetus	[illegible]	[illegible]	[illegible]	Jannuzi & Dey [illegible]
HDF-S	[illegible]	[illegible]	[illegible]	Williams et al. [illegible]
CDF-S	[illegible]	[illegible]	[illegible]	[illegible]
DLS-1	[illegible]	[illegible]	[illegible]	Wittman et al. (2002)
DLS-2	[illegible]	[illegible]	[illegible]	Wittman et al. (2002)
DLS-3	[illegible]	[illegible]	[illegible]	Wittman et al. (2002)
DLS-4	[illegible]	[illegible]	[illegible]	Wittman et al. (2002)
DLS-5	[illegible]	[illegible]	[illegible]	Wittman et al. (2002)
DLS-6	[illegible]	[illegible]	[illegible]	Wittman et al. (2002)
DLS-7	[illegible]	[illegible]	[illegible]	Wittman et al. (2002)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GEMS	[illegible]	[illegible]	[illegible]	[illegible]
GOODS-N	[illegible]	[illegible]	[illegible]	Giavalisco et al. [illegible]
GOODS-S	[illegible]	[illegible]	[illegible]	Giavalisco et al. [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
COSMOS	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HUDF	[illegible]	[illegible]	[illegible]	[illegible]
CFHTLS-D1	[illegible]	[illegible]	[illegible]	[illegible]
CFHTLS-D2	[illegible]	[illegible]	[illegible]	[illegible]
CFHTLS-D3	[illegible]	[illegible]	[illegible]	[illegible]
CFHTLS-D4	[illegible]	[illegible]	[illegible]	[illegible]
AEGIS	[illegible]	[illegible]	[illegible]	[illegible]
UKIDSS-DXS	[illegible]	[illegible]	[illegible]	Lawrence et al. (2007)
UKIDSS-DXS	[illegible]	[illegible]	[illegible]	Lawrence et al. (2007)
UKIDSS-DXS	[illegible]	[illegible]	[illegible]	Lawrence et al. (2007)
UKIDSS-DXS	[illegible]	[illegible]	[illegible]	Lawrence et al. (2007)
UKIDSS-UD	[illegible]	[illegible]	[illegible]	Lawrence et al. (2007)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C_GOODS-N	[illegible]	[illegible]	[illegible]	Koekemoer et al. (2011)
C_GOODS-S	[illegible]	[illegible]	[illegible]	Koekemoer et al. (2011)
C_COSMOS	[illegible]	[illegible]	[illegible]	Koekemoer et al. (2011)
C_EGS	[illegible]	[illegible]	[illegible]	Koekemoer et al. (2011)
C_UDS	[illegible]	[illegible]	[illegible]	Koekemoer et al. (2011)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XDF	[illegible]	[illegible]	[illegible]	[illegible]

CAKE TOPPING

Feasibility of other surveys:

1) Object visibility (selected dataset)

TMT
La Palma

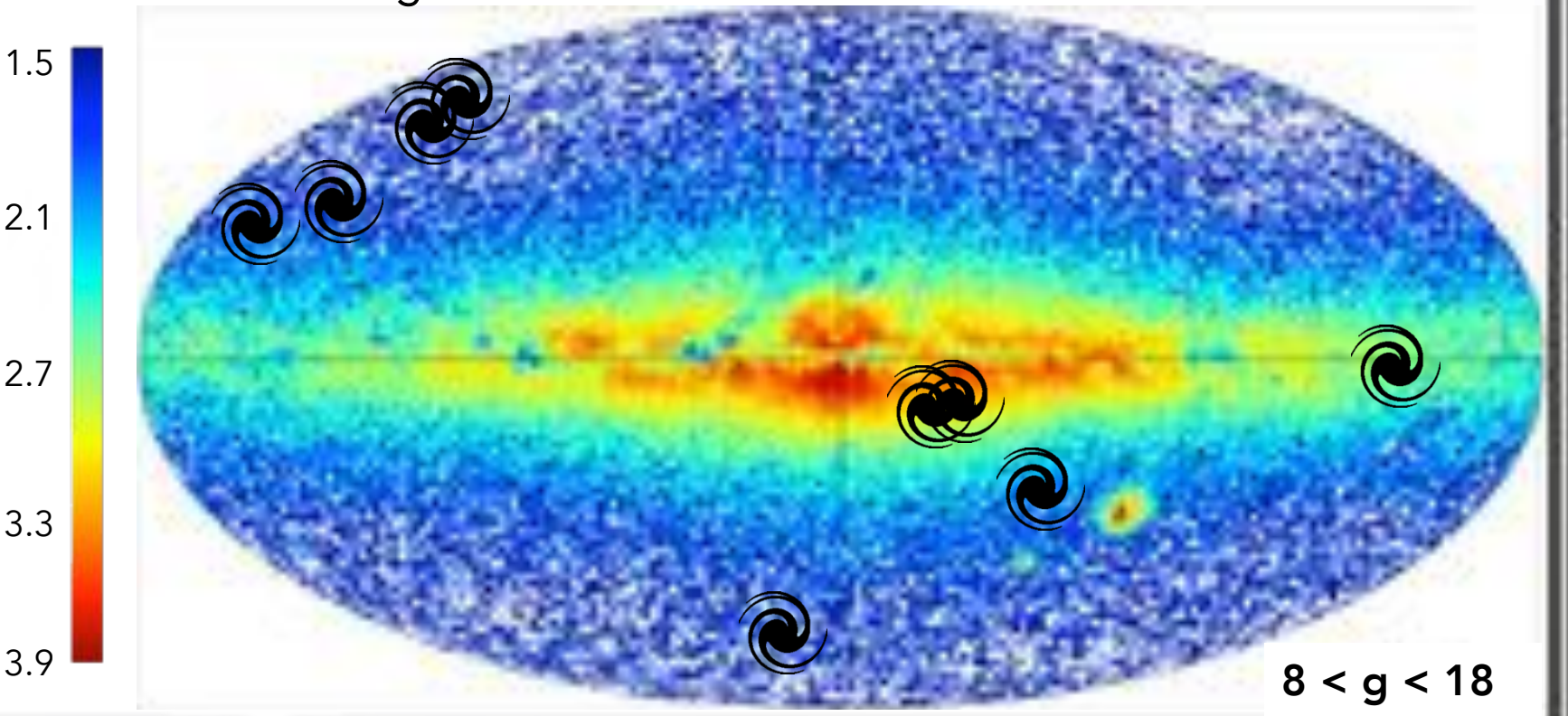


CAKE TOPPING

Feasibility of other surveys:

1) **Object visibility (selected datasets)**
2) **MW stellar density**

Observationally → GAIA (1st release):
Log of number of sources in GMCAO TechFoV



CAKE TOPPING

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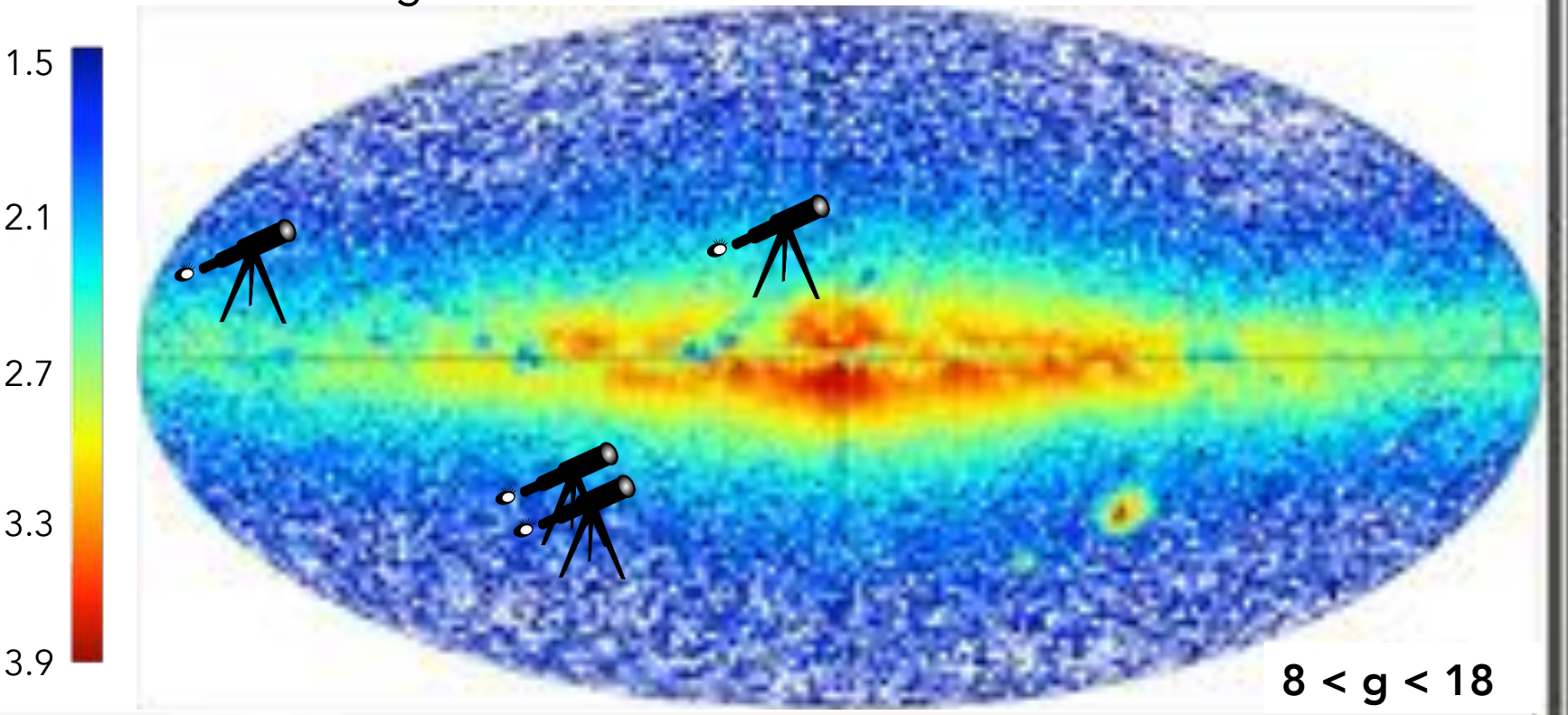
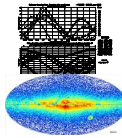


CAKE TOPPING

Feasibility of other surveys:

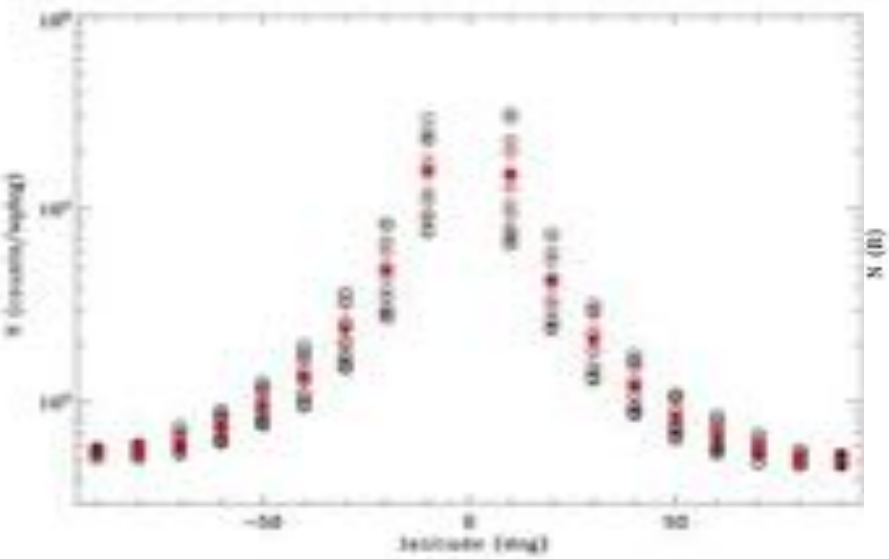


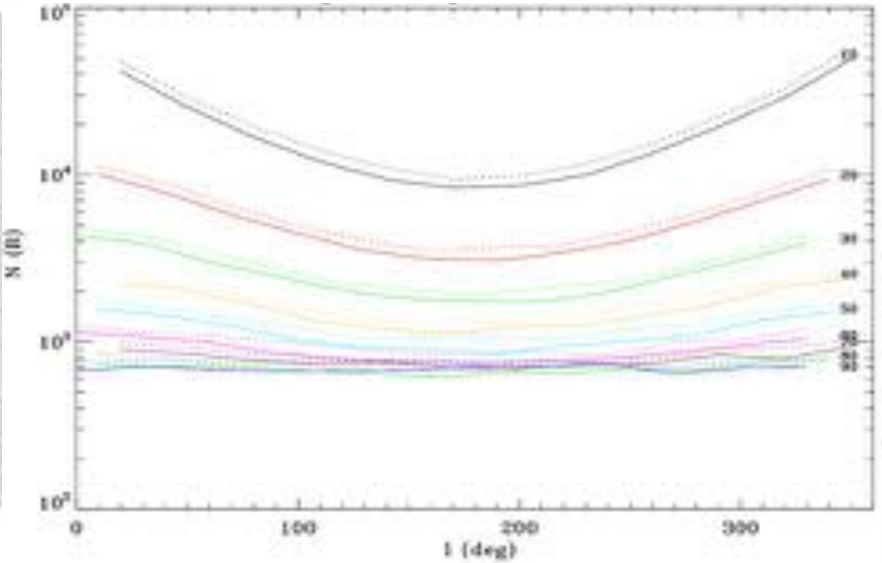
Object visibility (selected dataset)

MW stellar density

Theoretically → TRILEGAL (Girardi+2005) for dependance:

latitude & longitude



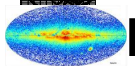


R < 18

CAKE TOPPING

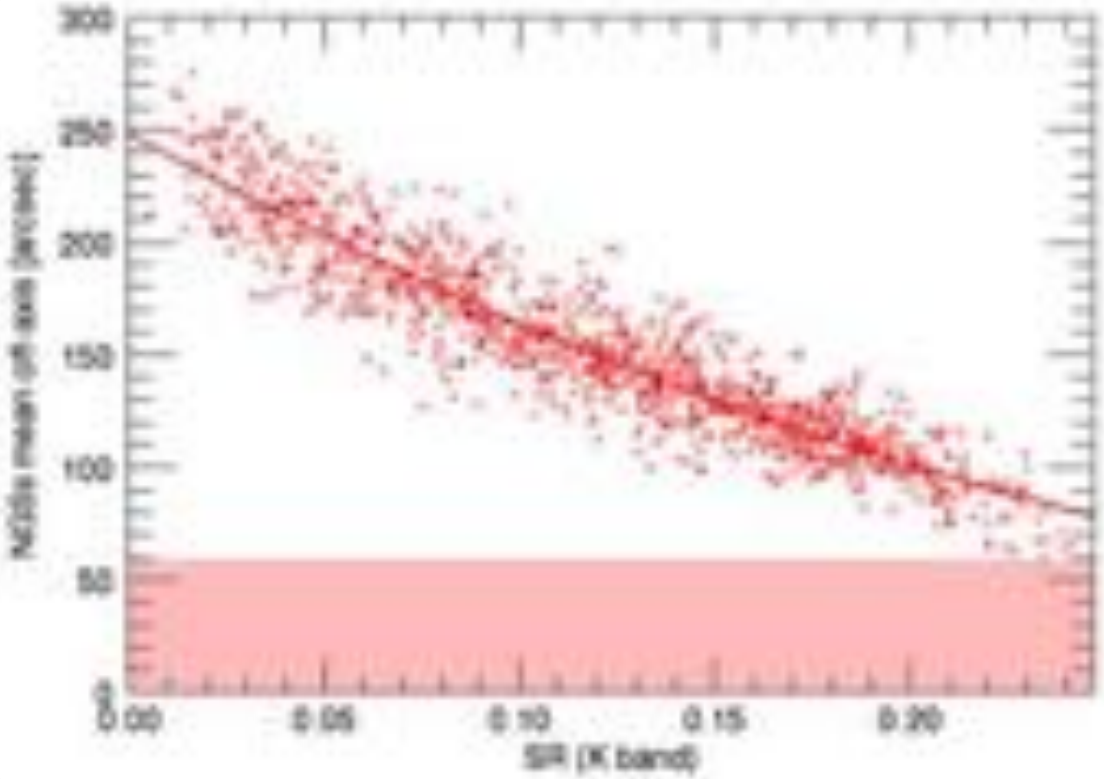
Feasibility of other surveys:

Object visibility (selected dataset)



MW stellar density

3) Asterism mean radius for available NGSs

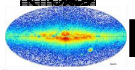


MonteCarlo simulation for statistics

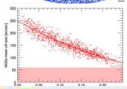
CAKE TOPPING

Feasibility of other surveys:

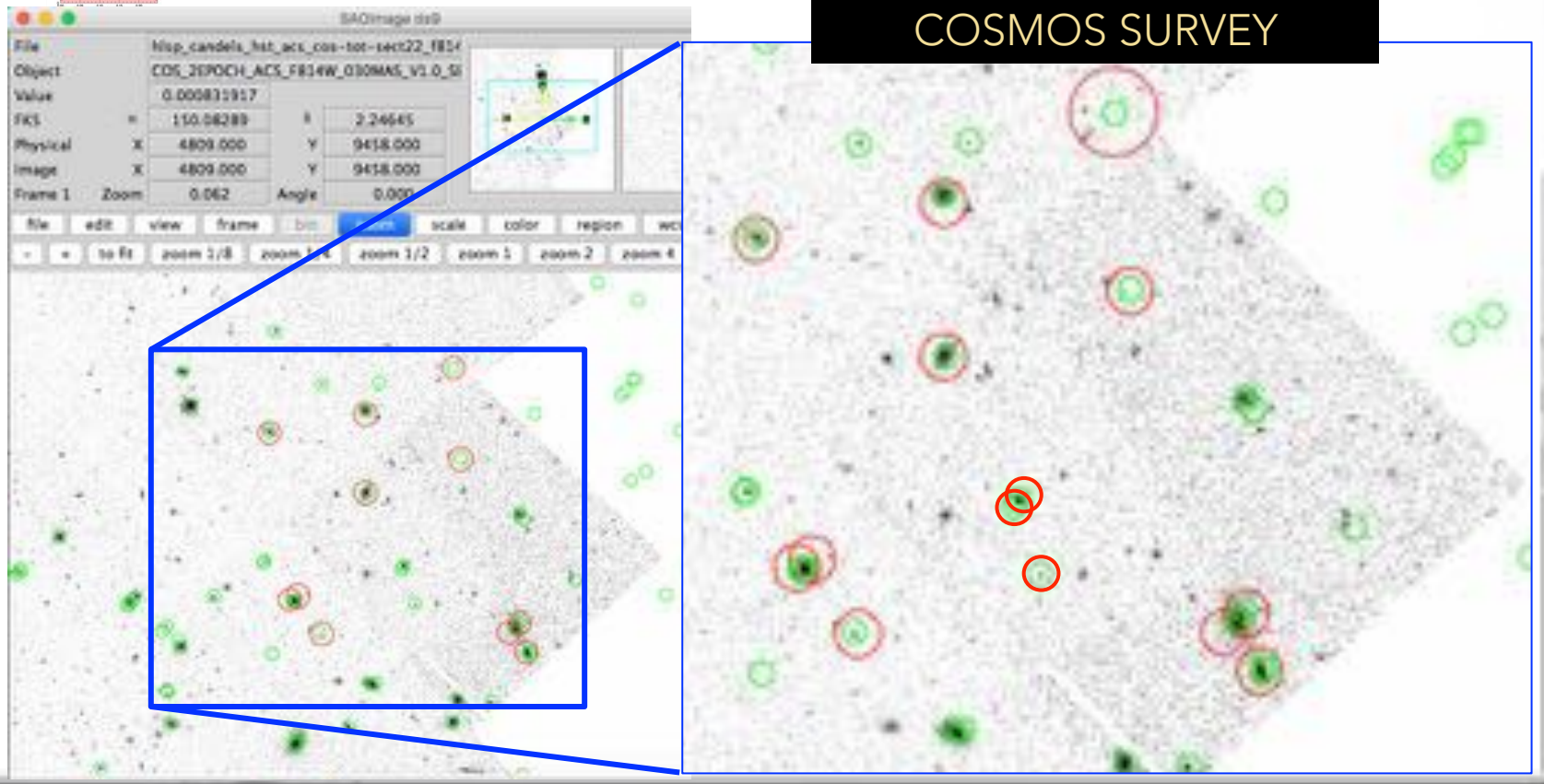
Object visibility (selected dataset)



MW stellar density

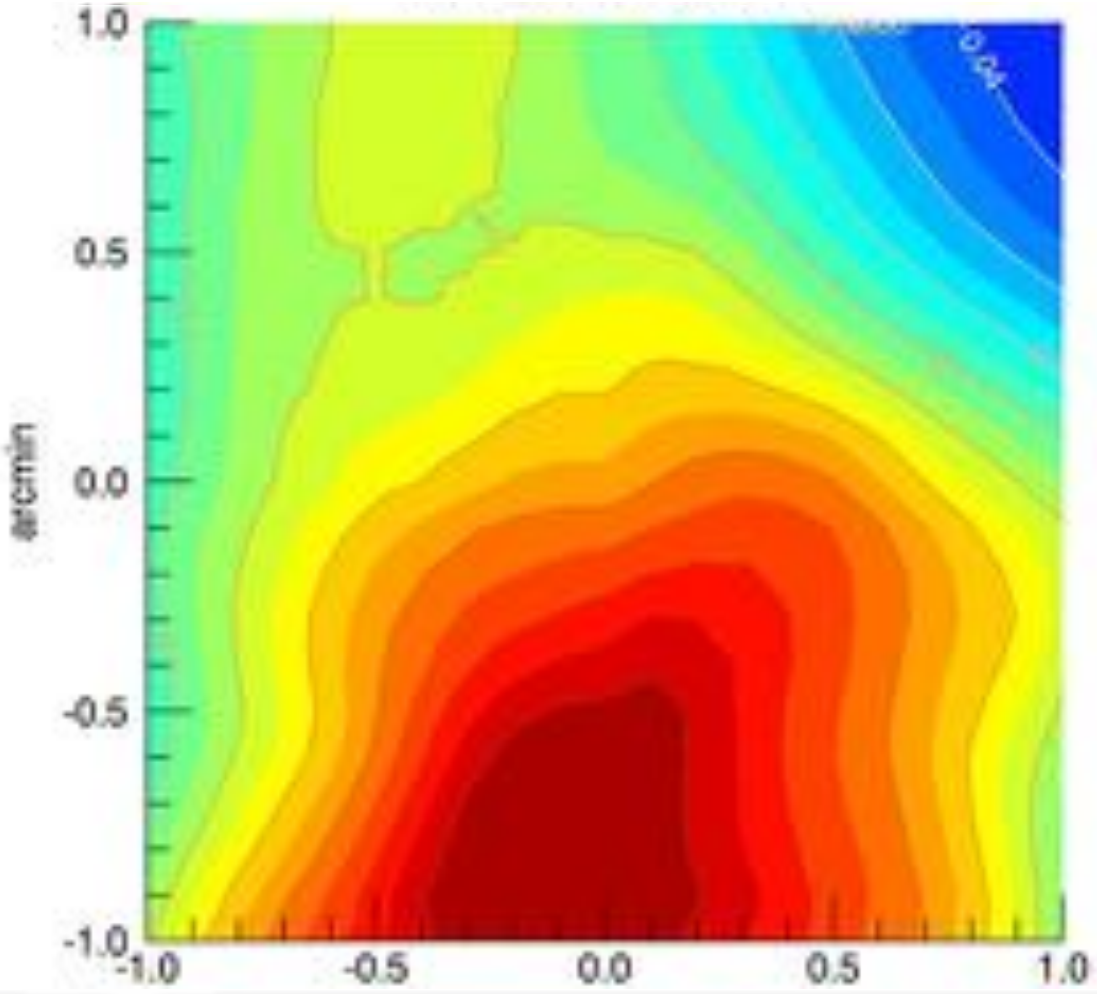


Asterism mean radius for available NGSs



CAKE TOPPING

COSMOS SURVEY: SR preliminary results



WHAT'S NEXT?

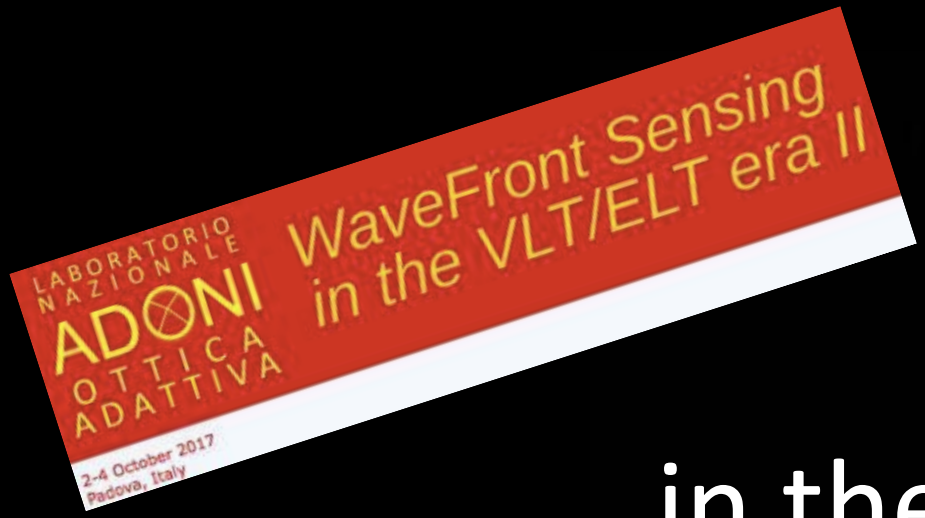
The era of the next generation of giant telescopes requires not only the advent of new technologies but also the development of novel methods, in order to exploit fully the extraordinary potential they are built for.

GMCAO pursues this approach, with the goal of achieving good performance over a field of view of a few arcmin and an increase in sky coverage.

1) **SR maps of other surveys**

2) **Any other science cases where NGSs are preferable to LSGs…**

3) **Other recipes…?**



WFSensing in the VLT/ELT era

When:
2-4 Oct 2017
Where:
Padova (Italy)
Web site:
https://www.ict.inaf.it/indico/event/521/
(or just Google the title…)