



Ottica Adattiva Made
in Italy: Premiale 2014

LABORATORIO
NAZIONALE
ADONI
OTTICA
ADATTIVA



Elisa Portaluri
AO4ELT5, 27th June

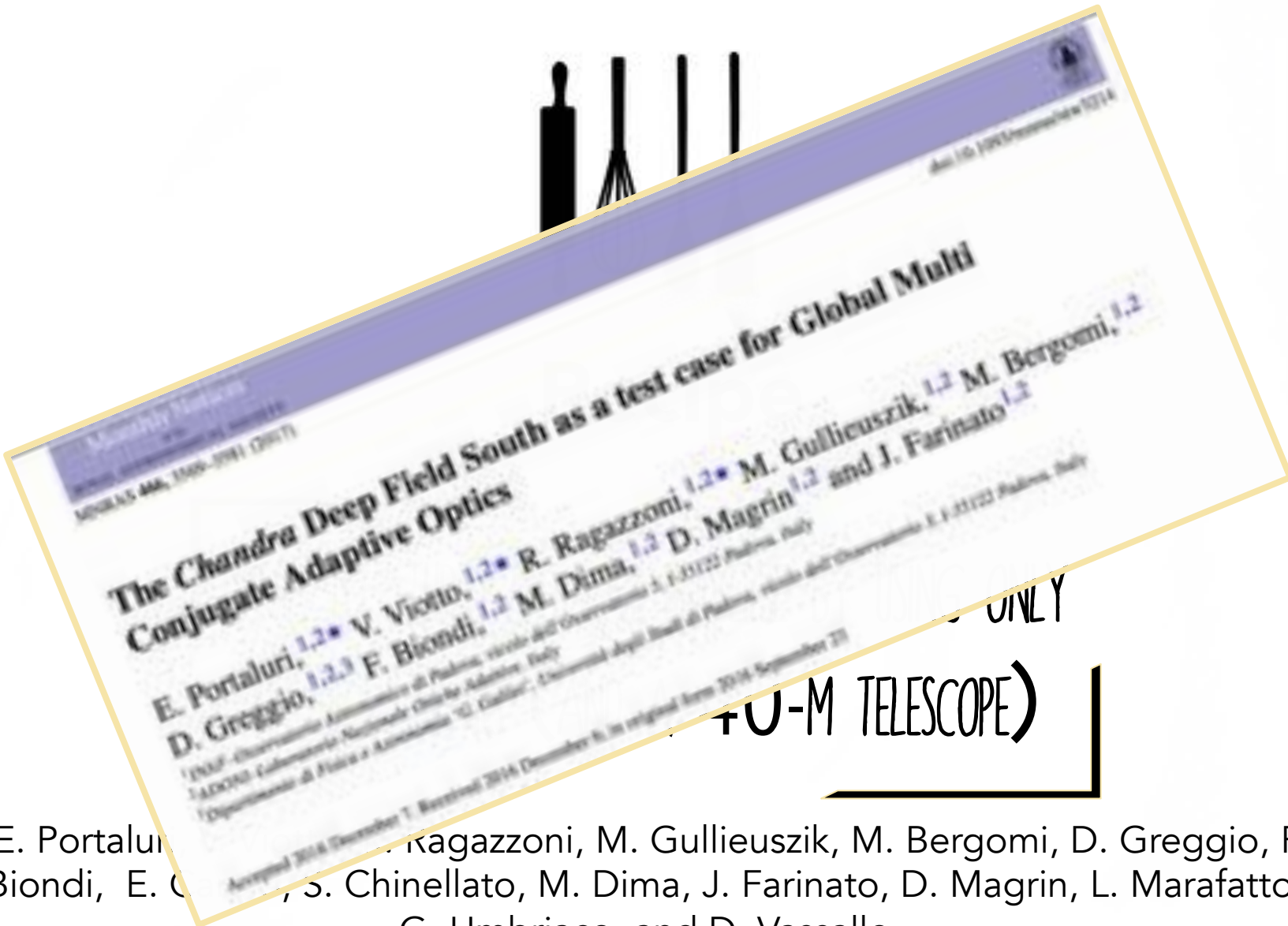
PROSPECTS OF DEEP FIELD SURVEYS WITH
GLOBAL-MCAO ON AN ELT



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



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ONLY
(U-M TELESCOPE)

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: ✓

n = Sérsic index



Irregulars: ($n < 0.5$)



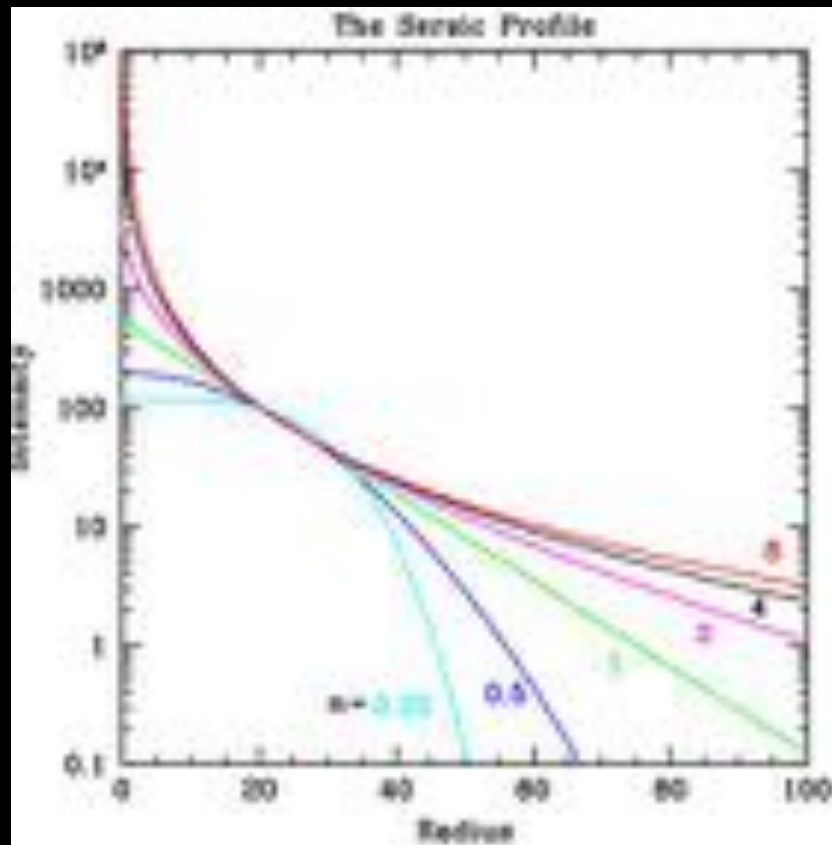
Discs: ($0.5 > n > 1.0$)



Bulges ($n > 2.5$)



Central compact component?
($n = 5.0$)



INGREDIENTS

1) The far Universe:



Irregulars: ($n < 0.5$)

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



Discs: ($0.5 > n > 1.0$)

→ Low mass galaxies are much smaller than HST FWHM



Bulges ($n > 2.5$)

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 (?)



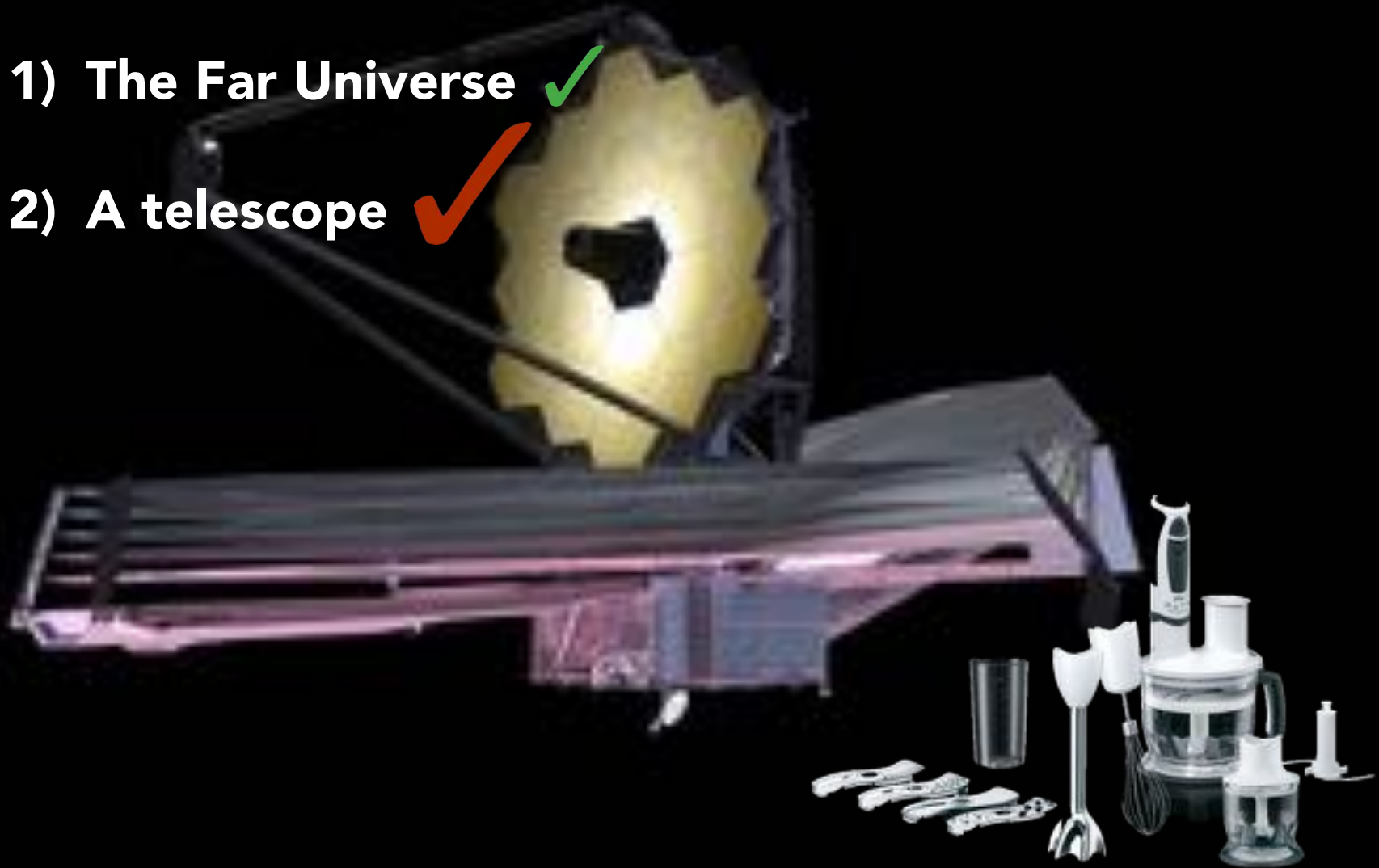
Central compact component?

($n = 5.0$)

INGREDIENTS

1) The Far Universe ✓

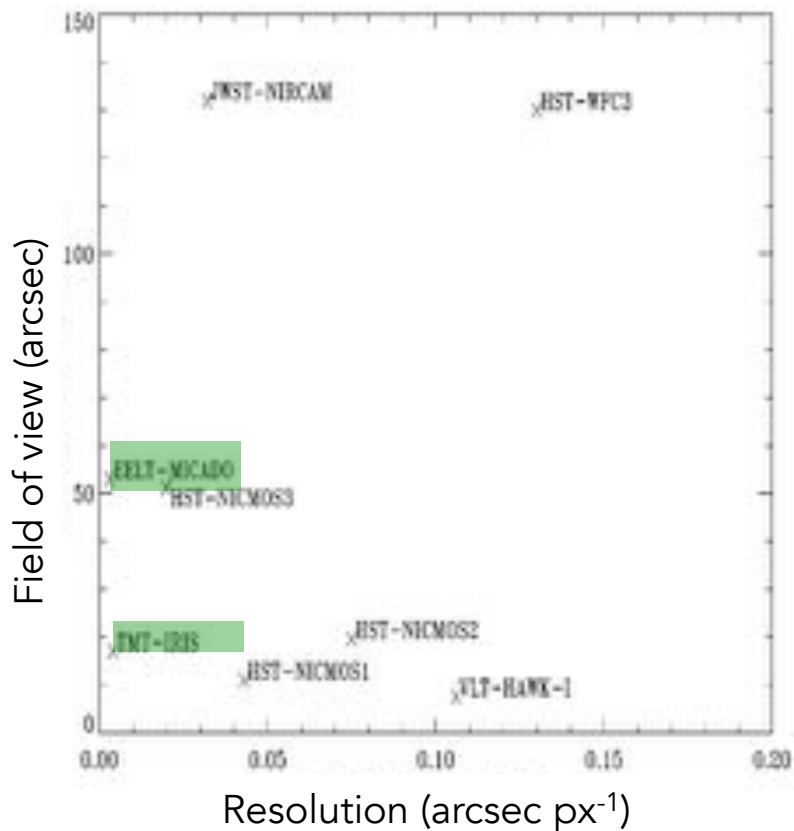
2) A telescope ✓



INGREDIENTS

1) The Far Universe ✓

2) A telescope ✓



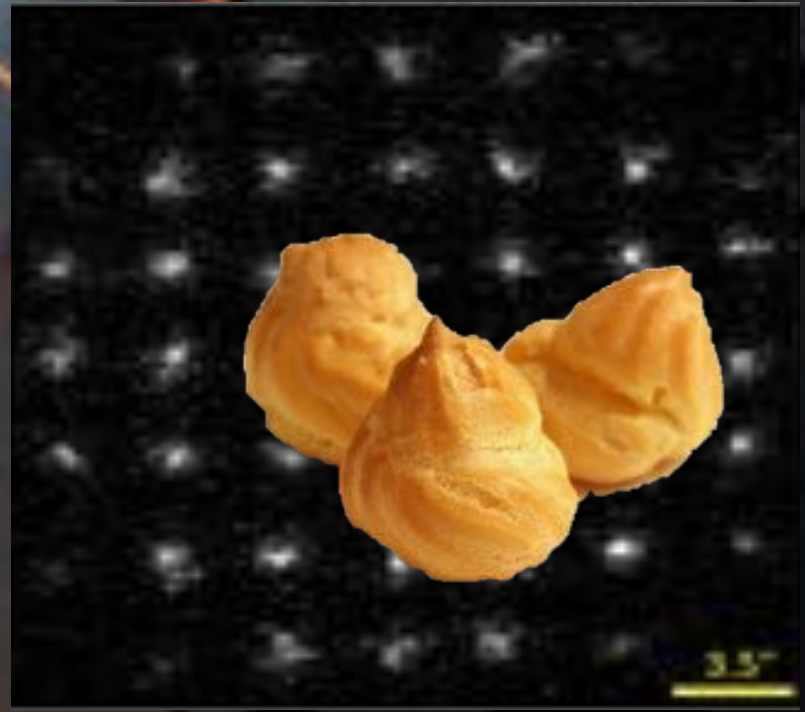
INGREDIENTS

- 1) The Far Universe ✓
- 2) A telescope: ✓
 - With an adequate AO system



INGREDIENTS

- 1) The Far Universe ✓
- 2) A telescope: ✓
 - With an adequate AO system

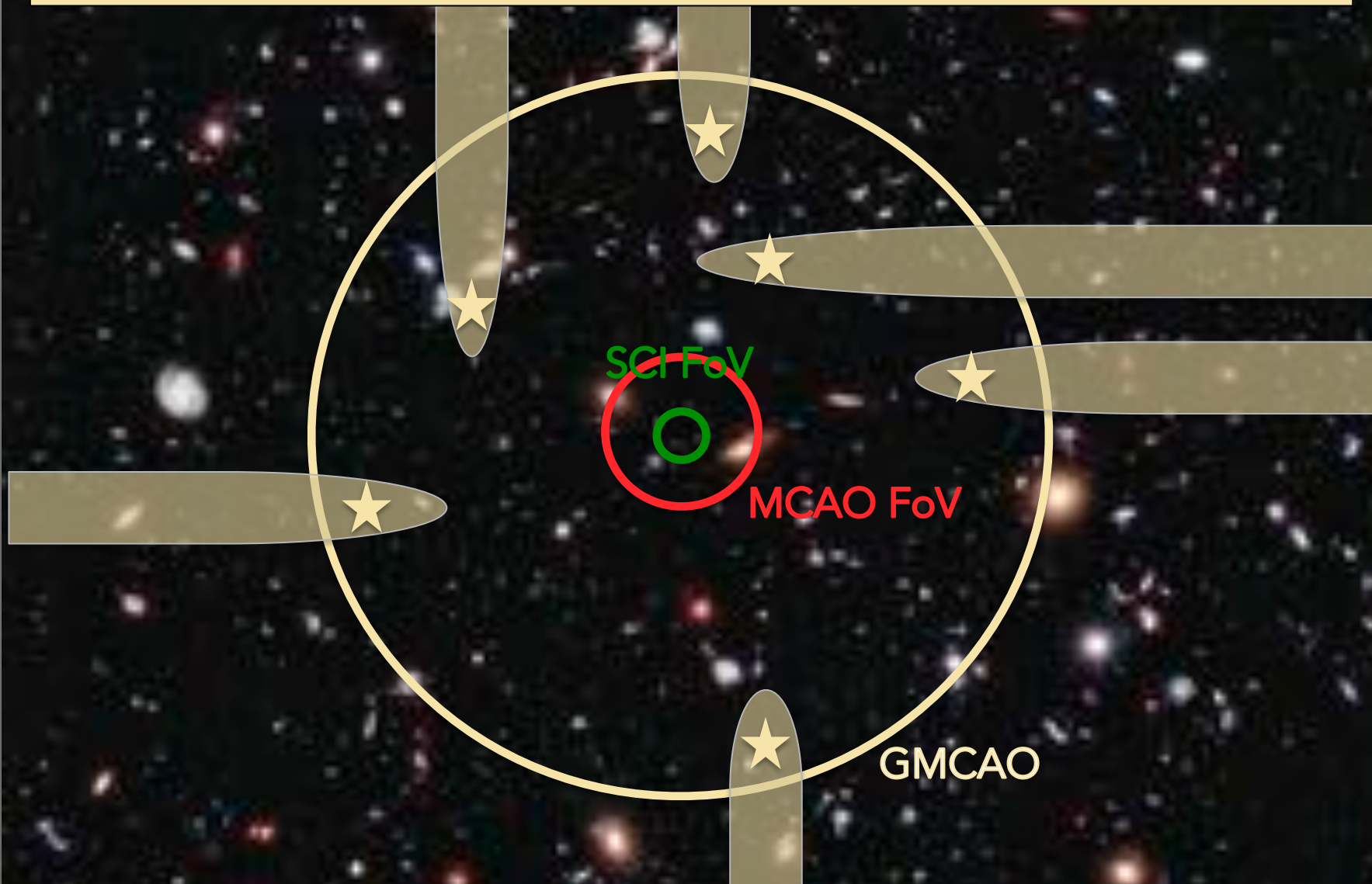


OUR RECIPE: Global-MCAO

- 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

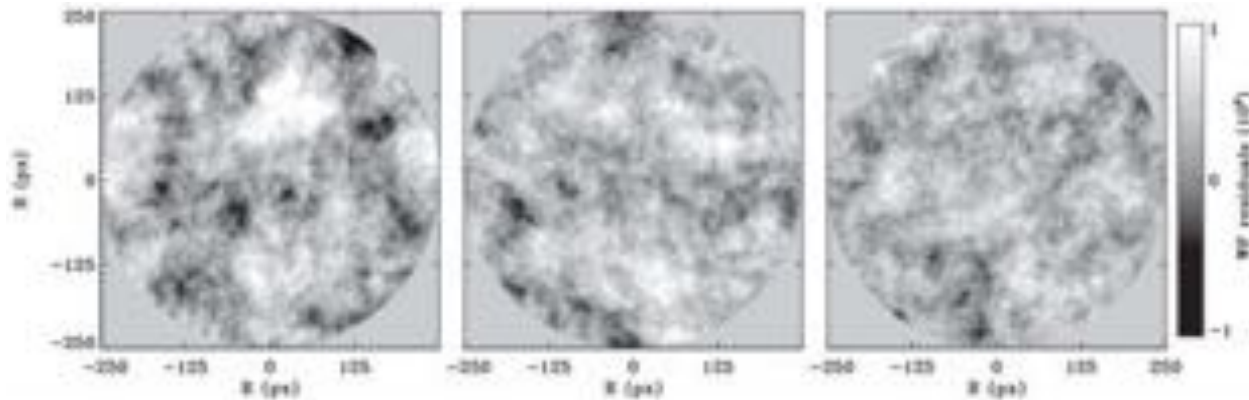
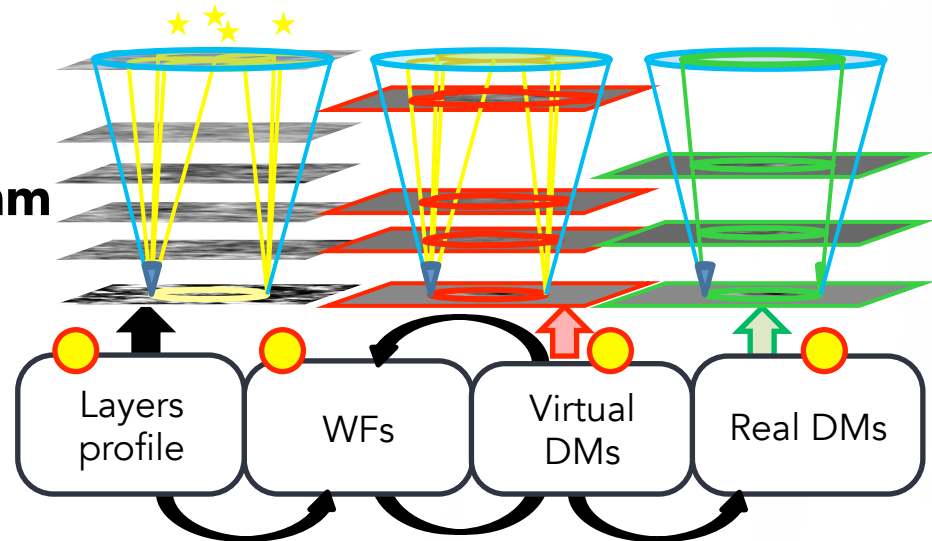


OUR RECIPE: Global-MCAO

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)

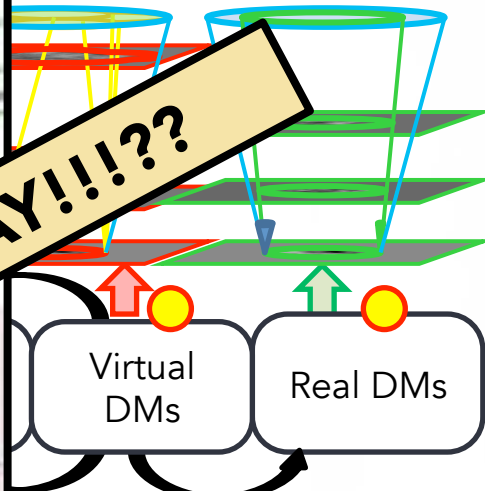


OUR

GMCAO simulation tool development

MCAO

Simulation Tool:



1) GIUSTI

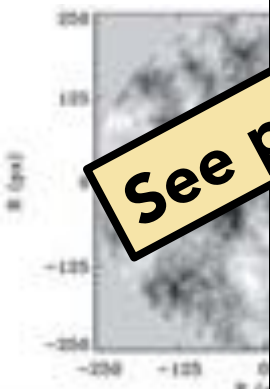
- 40 layers
- $h_{\max} = 25$
- $L_0 = 25$
- $r_0 = 0.12$

The poster contains several sections:

- GMCAO technique:** Shows a 4x4 grid of images representing different simulation stages.
- Simulation tool scheme:** A flowchart showing the process from input to output, including steps like 'Simulation', 'Control', 'Data', and 'Analysis'.
- Simulation Flow:** A detailed flowchart of the simulation process, including 'Input parameters', 'Simulation', 'Data processing', and 'Output'.
- Simulation results:** A 2D plot showing the results of the simulation, with axes labeled 'x (arcsec)' and 'y (arcsec)'.
- FoV Analysis (e.g. CDF5):** A plot showing the cumulative distribution function (CDF) of the field of view (FoV) analysis.

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

Viotto



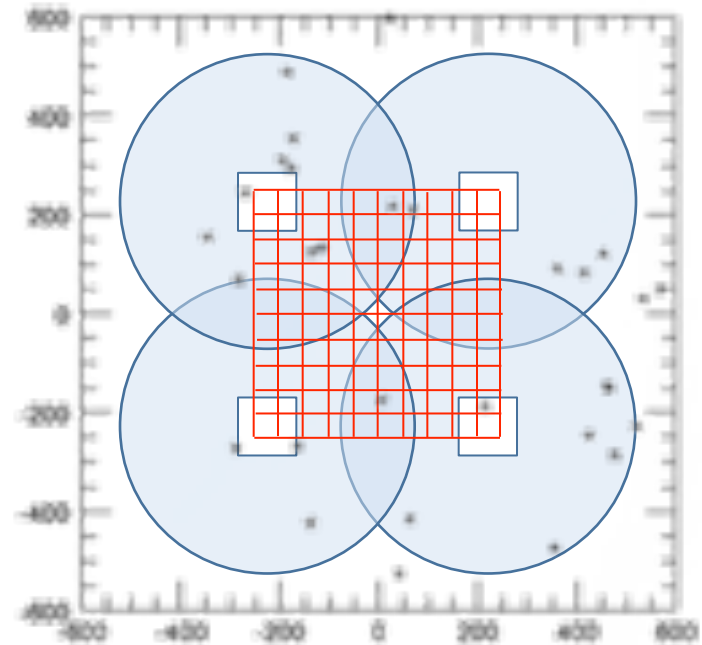
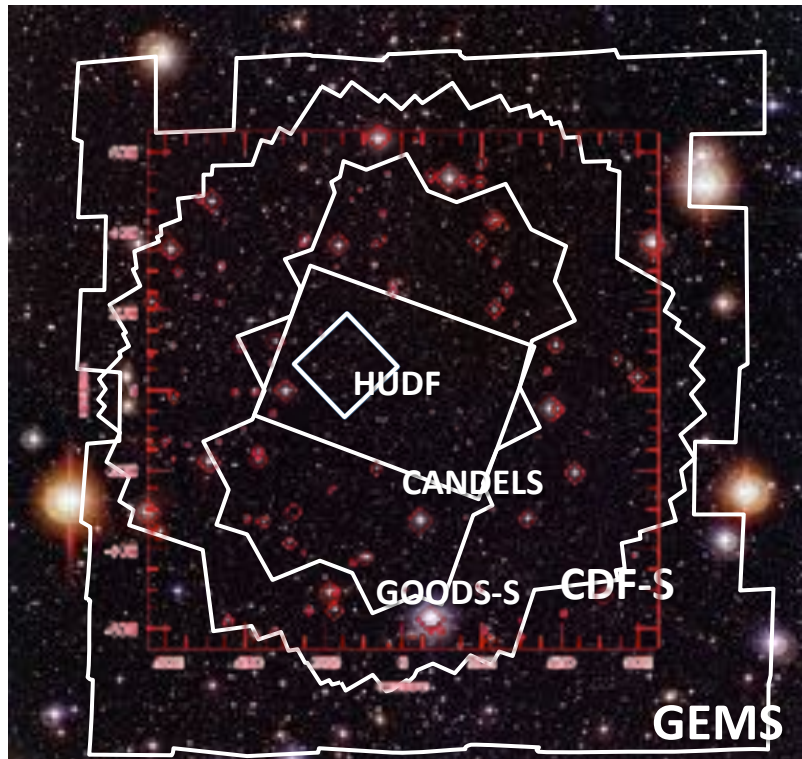
WF residuals (10⁴)

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



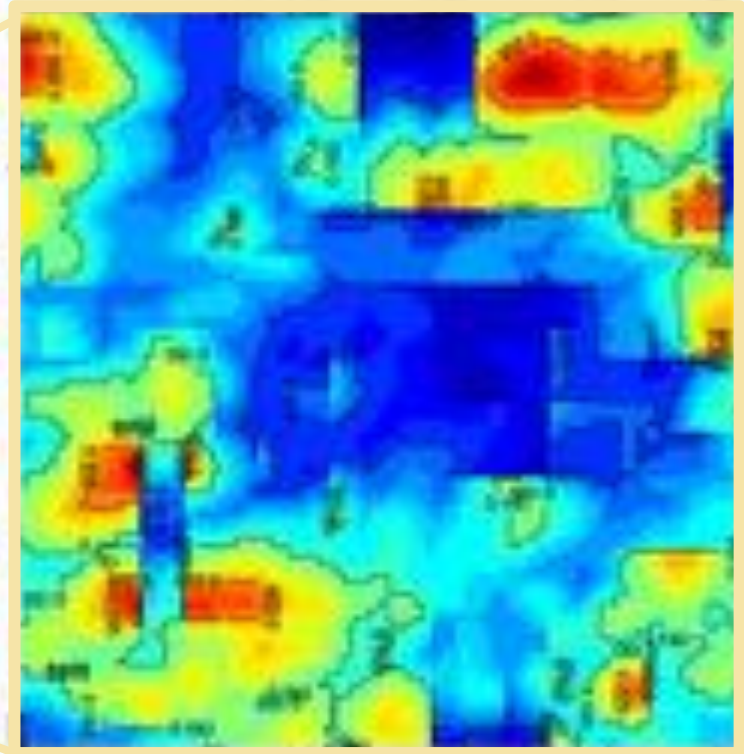
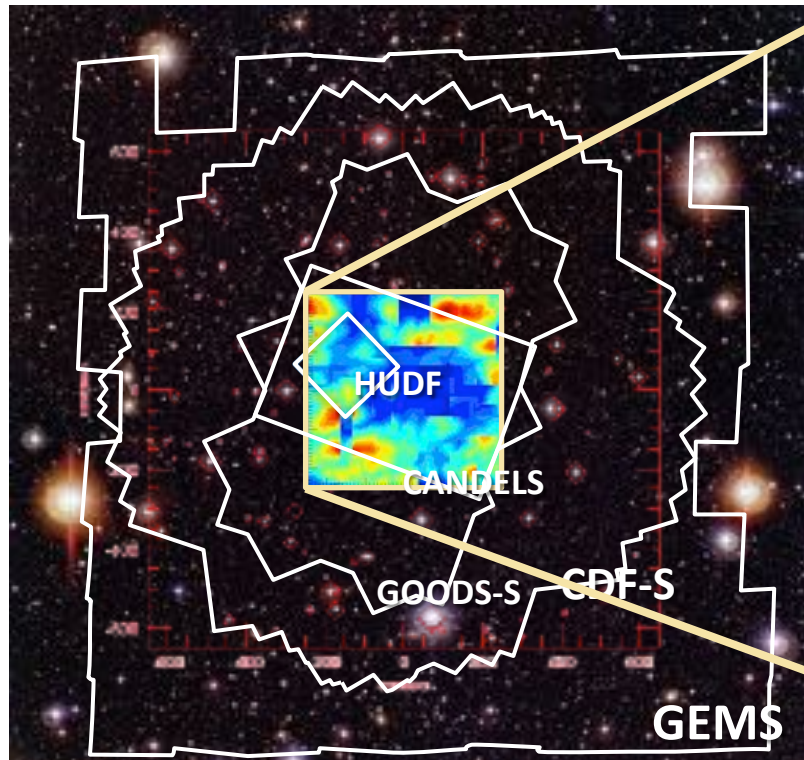
OUR RECIPE: Global-MCAO



GIUSTO: GMCAO IDL Unreleased Simulation Tool:

Pointing

3) K-band Strehl Ratio: 500"x500" star-poor field, $\langle SR \rangle = 0.17$



OUR RECIPE: Global-MCAO

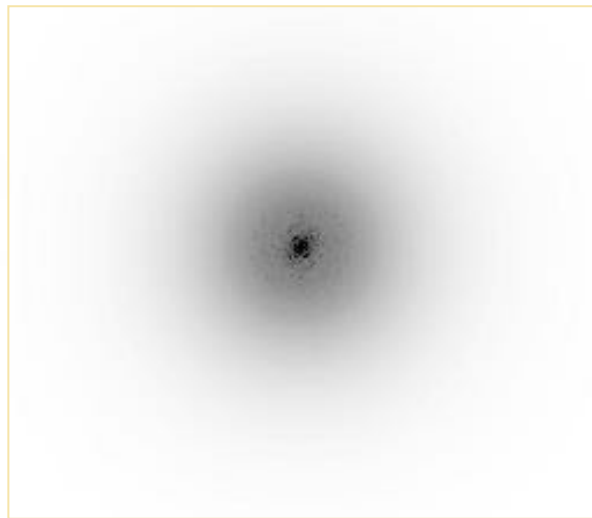


GIUSTO: GMCAO IDL Unreleased Simulation TOol:

Pointing

3)

K-band Strehl Ratio: PSF construction



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



SR	η	Radius x 10 ⁻⁴ [arc]	SR
0.09	0.000	1.620	0.09
0.02	0.008	1.612	0.02
0.03	0.010	1.606	0.03
0.04	0.013	1.600	0.04
0.05	0.017	1.592	0.05
0.06	0.021	1.586	0.06
0.07	0.026	1.580	0.07
0.08	0.030	1.570	0.08
0.09	0.034	1.560	0.09
0.10	0.039	1.550	0.10
0.11	0.042	1.528	0.11
0.12	0.045	1.500	0.12
0.13	0.048	1.470	0.13
0.14	0.052	1.440	0.14
0.15	0.055	1.400	0.15
0.16	0.058	1.360	0.16
0.17	0.061	1.320	0.17
0.18	0.064	1.280	0.18
0.19	0.067	1.240	0.19
0.20	0.070	1.200	0.20
0.21	0.073	1.160	0.21
0.22	0.075	1.120	0.22
0.23	0.078	1.080	0.23
0.24	0.080	1.040	0.24
0.25	0.082	1.000	0.25
0.26	0.084	0.970	0.26
0.27	0.085	0.940	0.27
0.28	0.086	0.910	0.28
0.29	0.087	0.880	0.29

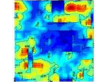
OUR RECIPE: Global-MCAO



GIUSTO: GMCAO IDL Unreleased Simulation Tool:



Pointing

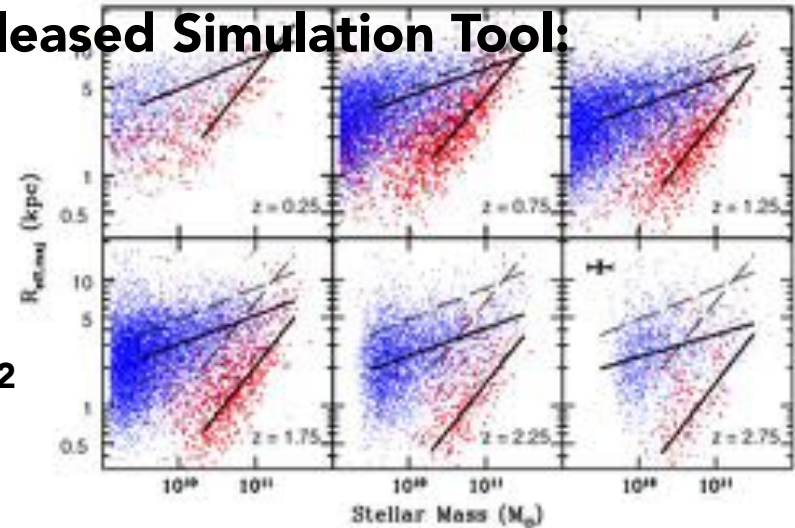
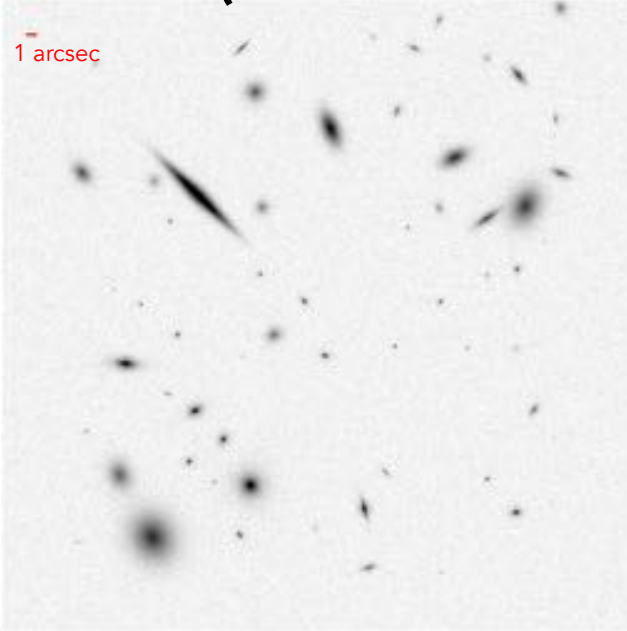


K-band Strehl Ratio

4) Simulation of a deep field:

- 10 x 10 grid of 50 x 50 arcsec²
- AETC (Falomo et al. 2011)

1 arcsec



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

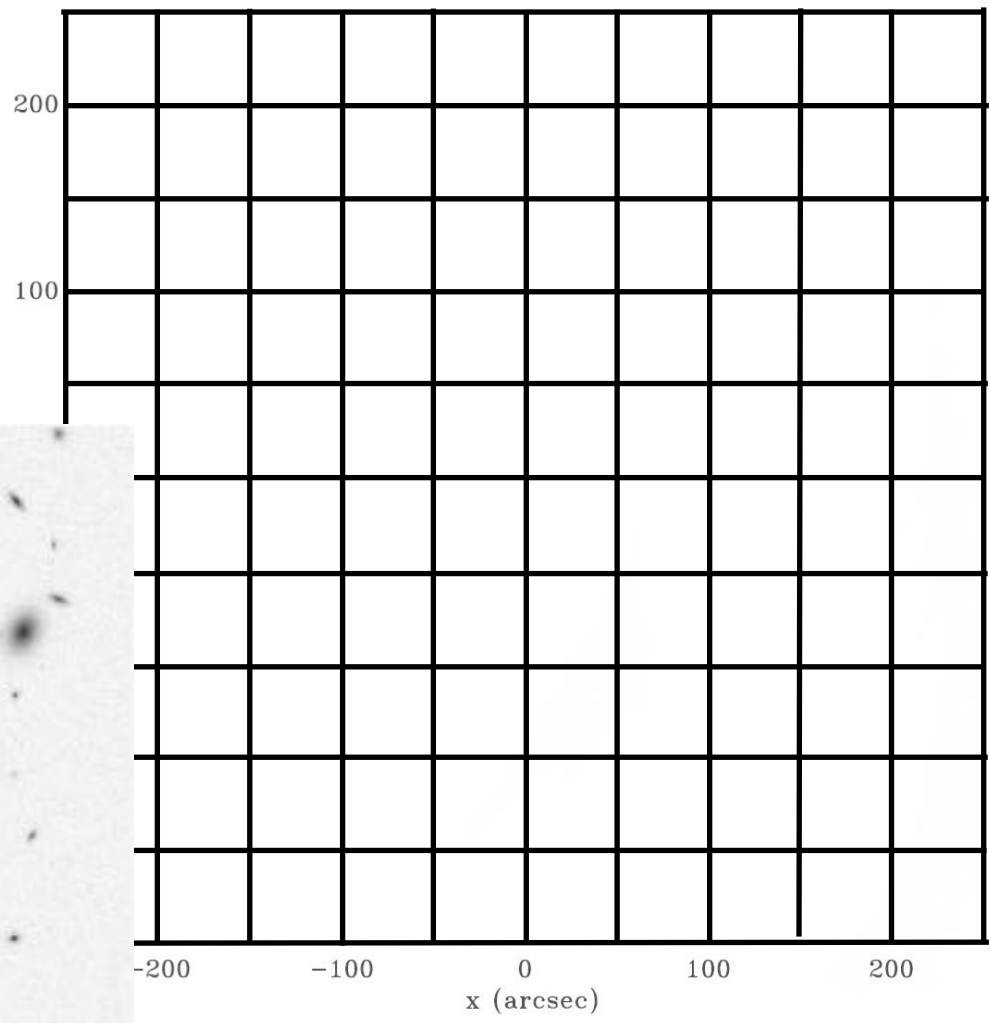
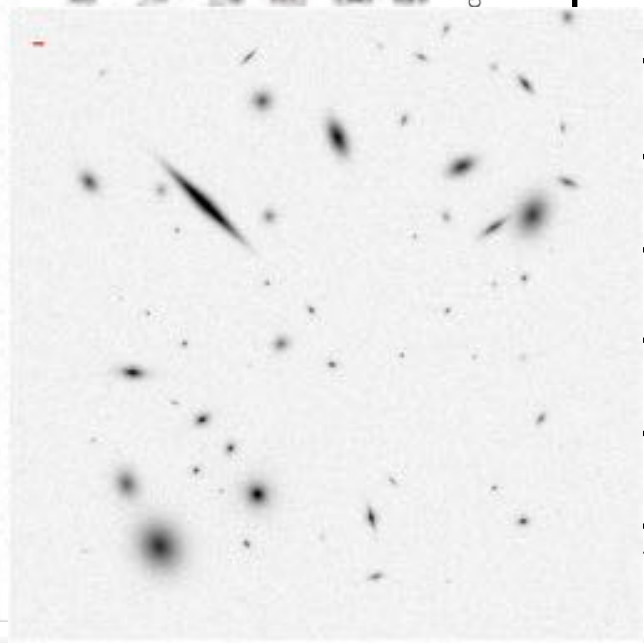
$$\log (M/M_{\odot}) = 9, 9.3, 9.7, 10, 10.3$$

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

OUR RECIPE: Global-MCAO

Obs. ID	Ag (WFS)	z	R ₀ (Ang)	R ₁ (Ang)	R ₂ (Ang)	R ₃ (Ang)	R ₄ (Ang)	R ₅ (Ang)
00	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
01	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
02	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
03	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
04	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
05	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
06	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
07	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
08	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
09	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
10	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
11	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
12	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
13	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
14	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
15	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
16	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
17	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
18	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
19	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
20	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
21	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
22	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
23	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
24	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
25	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
26	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
27	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
28	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
29	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
30	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
31	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
32	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
33	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
34	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
35	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
36	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
37	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
38	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
39	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
40	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
41	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
42	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
43	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
44	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
45	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
46	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
47	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
48	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
49	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27
50	6.75	0.27	0.27	0.27	0.27	0.27	0.27	0.27

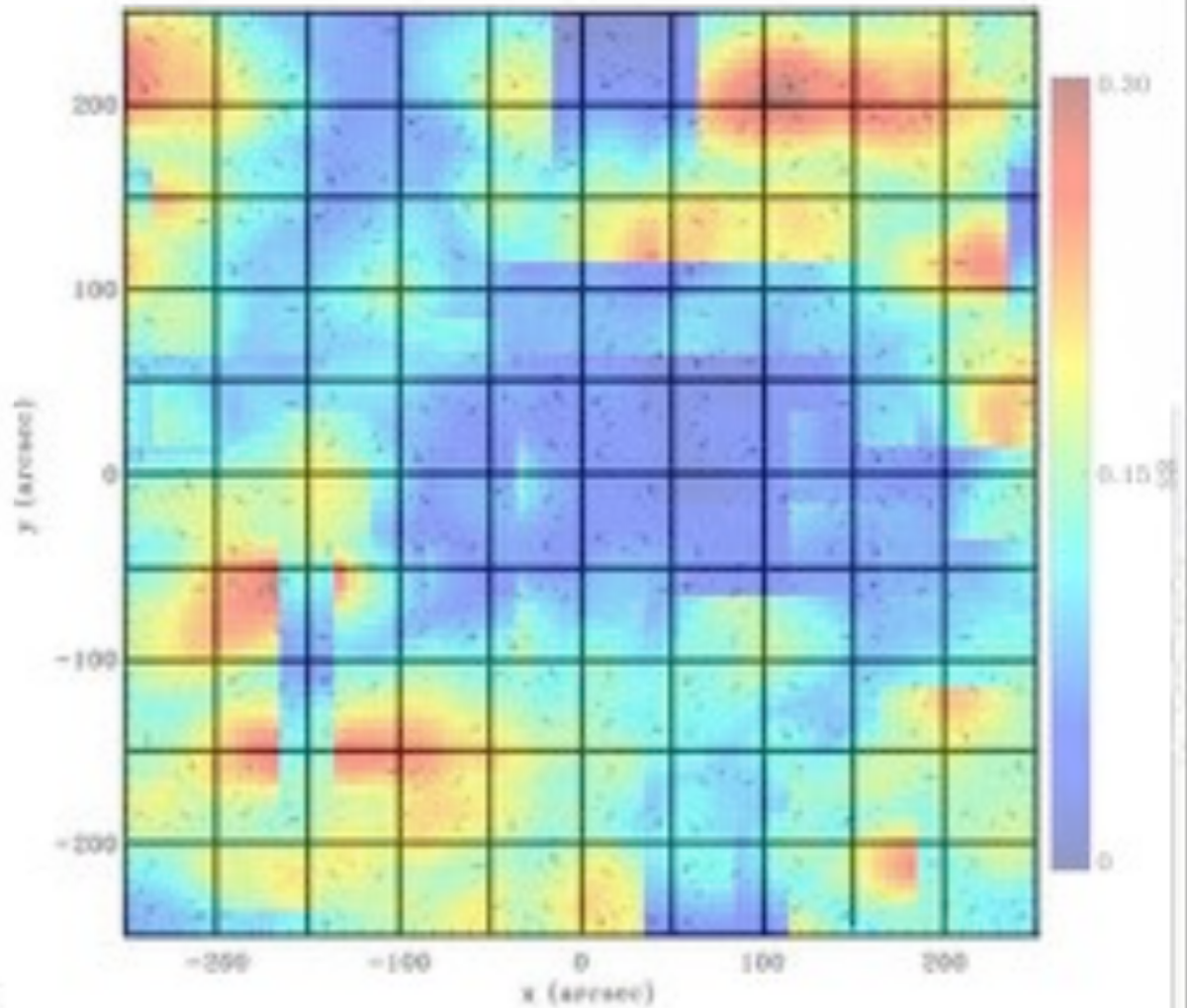
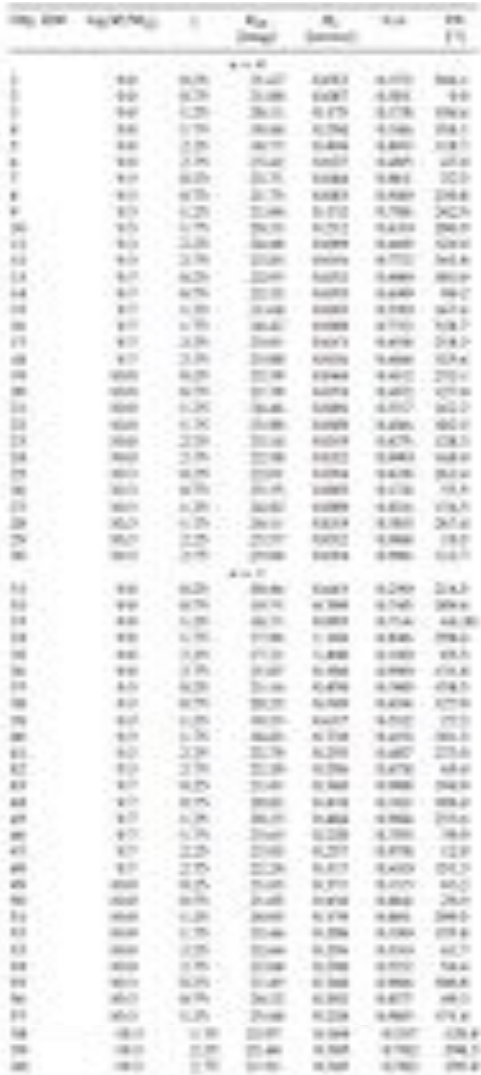
c)



OUR RECIPE: Global-MCAO

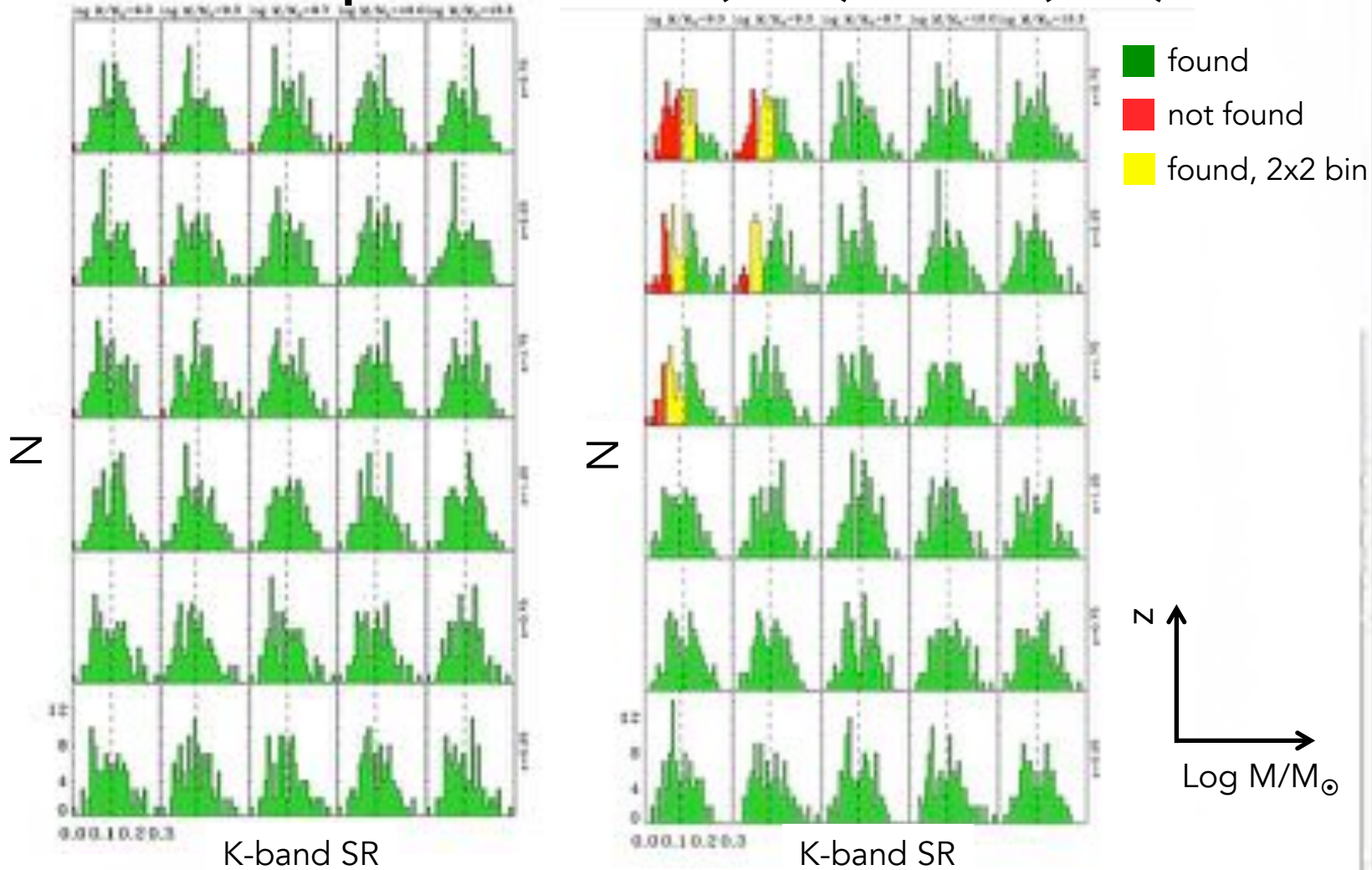
Early types

Late types



THE FINAL PRODUCT

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

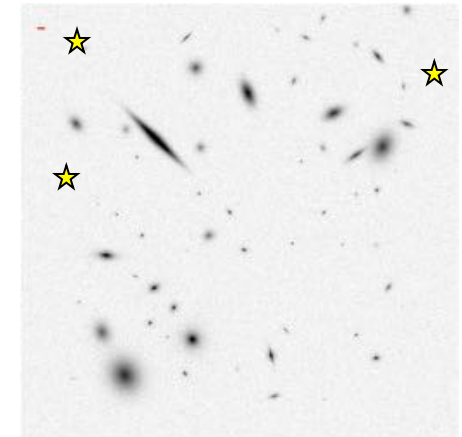


THE FINAL PRODUCT



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

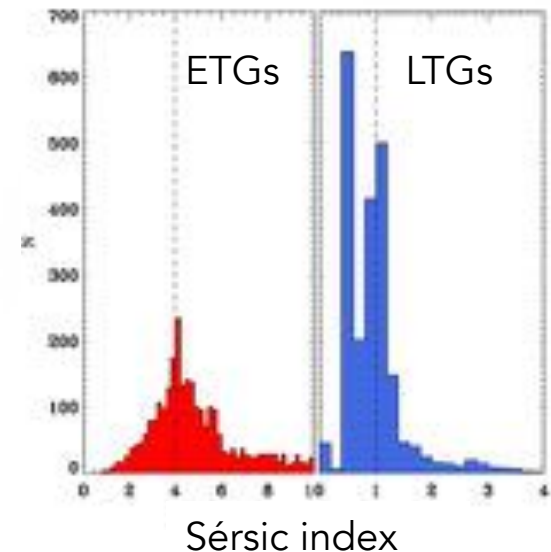
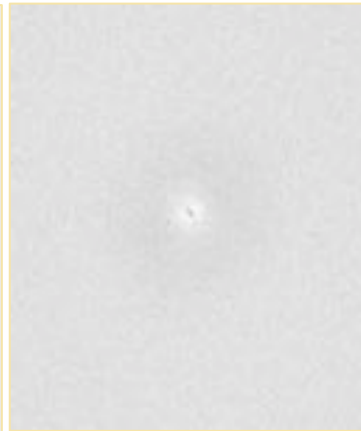
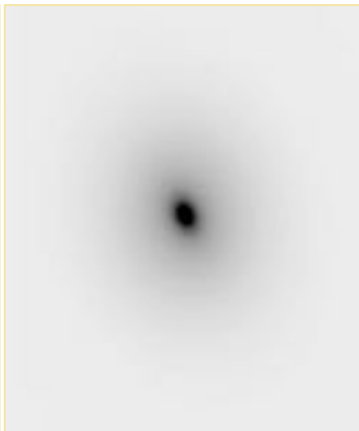
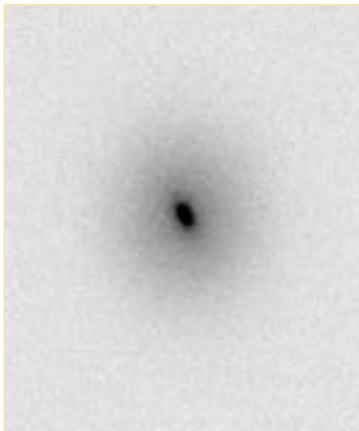
**2) GALFIT: Morphology and Photometry -
NO PSF a priori knowledge!**



GALAXY

MODEL

RESIDUALS



THE FINAL PRODUCT

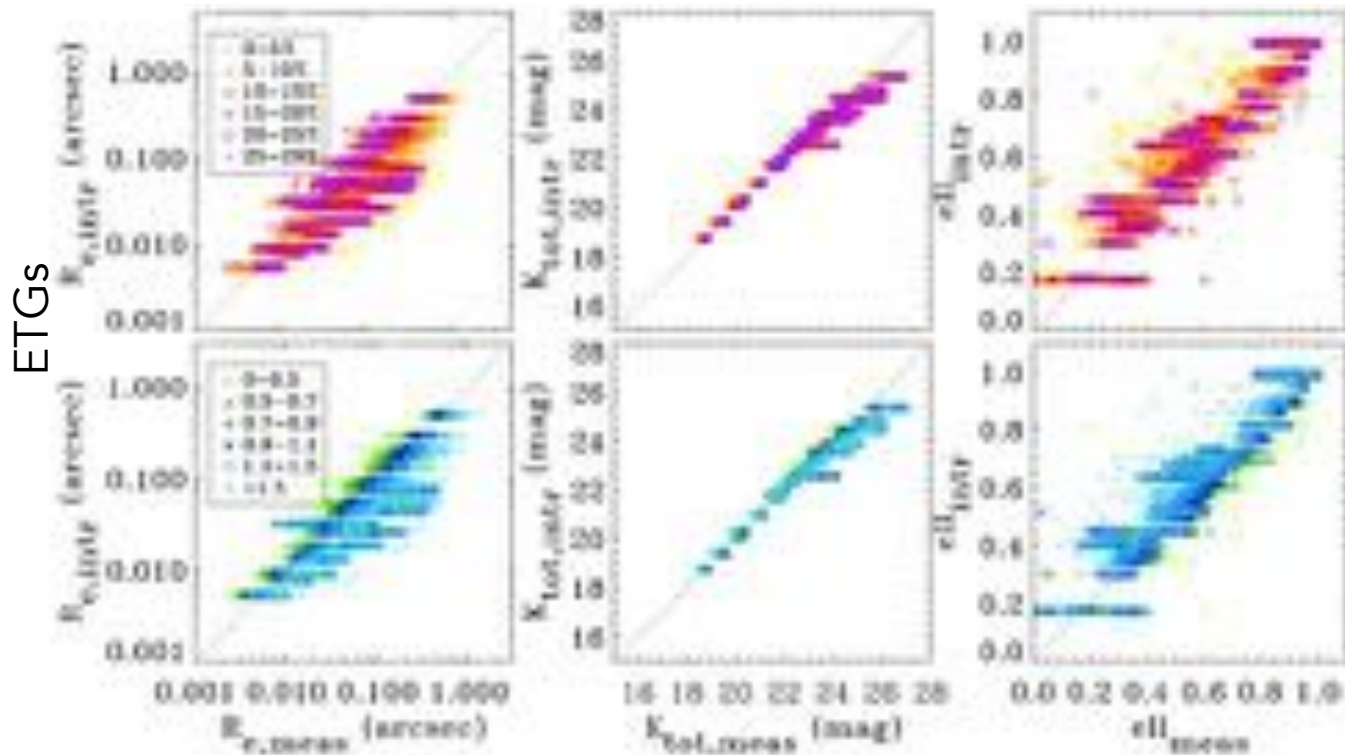


SExtractor completeness: 99.7% (ETGs) - 89.4% (LTGs)



GALFIT: Morphology and Photometry

3) Comparison



SR_{model} code

SR^*/SR_{model} code

THE FINAL PRODUCT



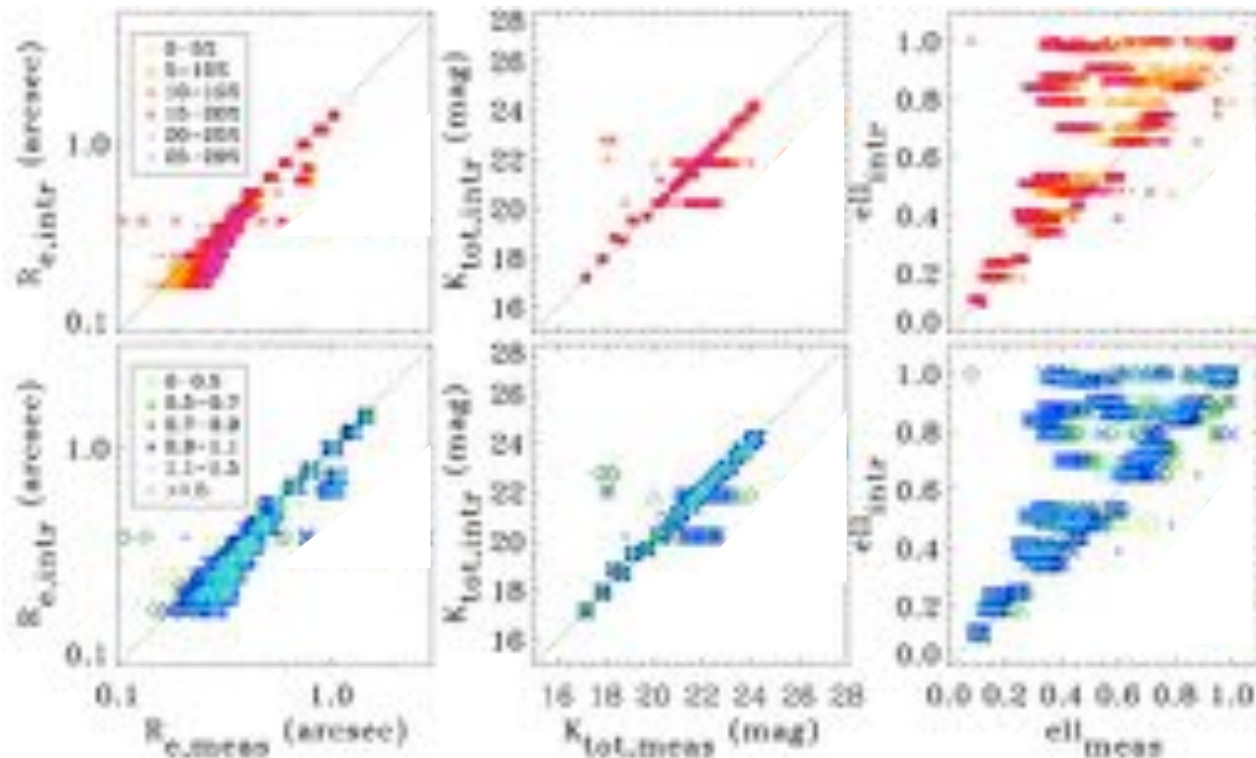
SExtractor completeness: 99.7% (ETGs) - 89.4% (LTGs)



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

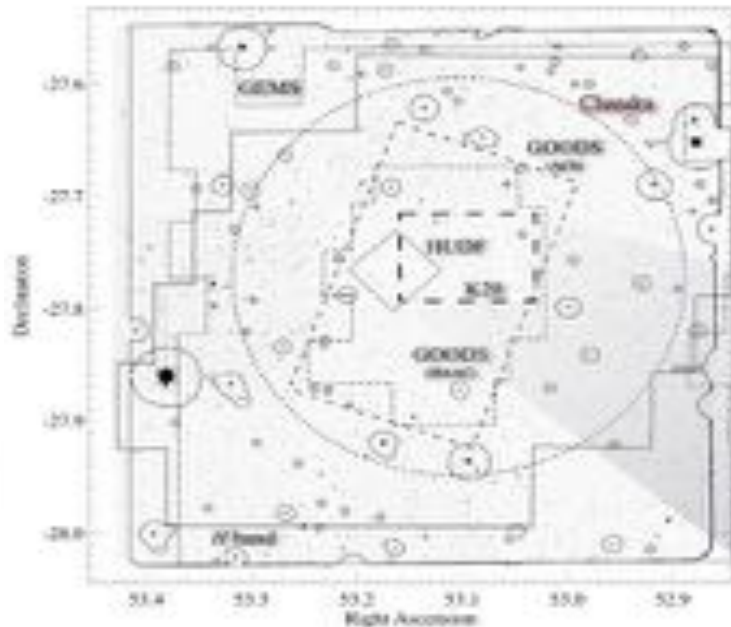


Table 1. Observing parameters for most laser surveys. Column 1: Name of the survey. Column 2: Right ascension and Column 3: Declination of the central pointing. Column 4: Field of view size. Column 5: Resolution.

Survey name	RA [°]	DEC [°]	Field-of-View [']	Resolution
GLS	199.3443	27.7307	5	Williams et al. (1999)
NIRV (V. Iaconis)	111.000	24.000	1000	Iaconis & Jay (1999)
NIRV (S. Casas)	11.0700	-4.1500	20.14	Iaconis & Jay (1999)
GLS-A	109.3440	27.7300	5.3	Williams et al. (1999)
GLS-B	11.1807	-27.8862	50	Cheriton et al. (2001)
GLS-1	11.3121	-27.8871	100	Williams et al. (2002)
GLS-2	119.3000	20.0000	1000	Williams et al. (2002)
GLS-3	10.0000	-20.0000	1000	Williams et al. (2002)
GLS-4	103.0000	-5.0000	1000	Williams et al. (2002)
GLS-5	208.7100	-19.0000	1000	Williams et al. (2002)
GLS-6	11.0000	-4.5000	1000	Williams et al. (2002)
GLS-7	214.0000	34.2000	1000	Williams et al. (2002)
GLS8	214.3100	33.2000	70	Doris et al. (2002)
GLS9	11.1942	-27.8120	60	Wu et al. (2003)
GLS10-A	109.3200	27.7375	10	Cheriton et al. (2004)
GLS10-B	11.1200	-27.8950	10	Cheriton et al. (2004)
GLS11-A	107.7425	27.8900	10	Kochanek et al. (2004)
GLS11-B	107.7307	2.8950	120	Scotti et al. (2004)
GLS12	114.4943	10.4020	11	Wu et al. (2004)
GLS13	11.7471	-27.7914	11	Jackson et al. (2004)
GLS14-A	10.4900	-4.4900	100	Cheriton et al. (2004)
GLS14-B	107.7307	2.8950	100	Cheriton et al. (2004)
GLS14-C	114.4943	10.4020	100	Cheriton et al. (2004)
GLS14-D	107.7307	-27.7920	100	Cheriton et al. (2004)
GLS15	111.0000	24.0000	100	Faria et al. (2005)
GLS16A (S. Iaconis)	10.000	-4.000	10000	Iaconis et al. (2007)
GLS16B (S. Iaconis)	204.200	27.600	12000	Iaconis et al. (2007)
GLS16C (S. Iaconis)	142.5	34.000	12000	Iaconis et al. (2007)
GLS16D (S. Iaconis)	204.200	3.222	12000	Iaconis et al. (2007)
GLS16E (S. Iaconis)	10.200	-4.200	2171	Iaconis et al. (2007)
GLS17	11.1421	-27.7914	47	Williams et al. (2011)
GLS18A-S	109.3200	27.7300	50	Kochanek et al. (2011)
GLS18B-S	11.1200	-27.8950	117	Kochanek et al. (2011)
GLS18C-S	107.7303	2.8950	1000	Kochanek et al. (2011)
GLS19	214.310	33.200	700	Kochanek et al. (2011)
GLS20	11.490	-5.200	700	Kochanek et al. (2011)
GLS21	11.405	-27.7914	4	Kochanek et al. (2011)
GLS22	11.194	-27.791	10	Williams et al. (2011)

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 Amalago (-70.19,-24.59)	53" × 53" 16" × 16"	4 1.5	I, 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	Mama Kea (-155.47,19.82) La Palma (-17.89,28.89)	34" × 34"	4	J, H, K

CAKE TOPPING

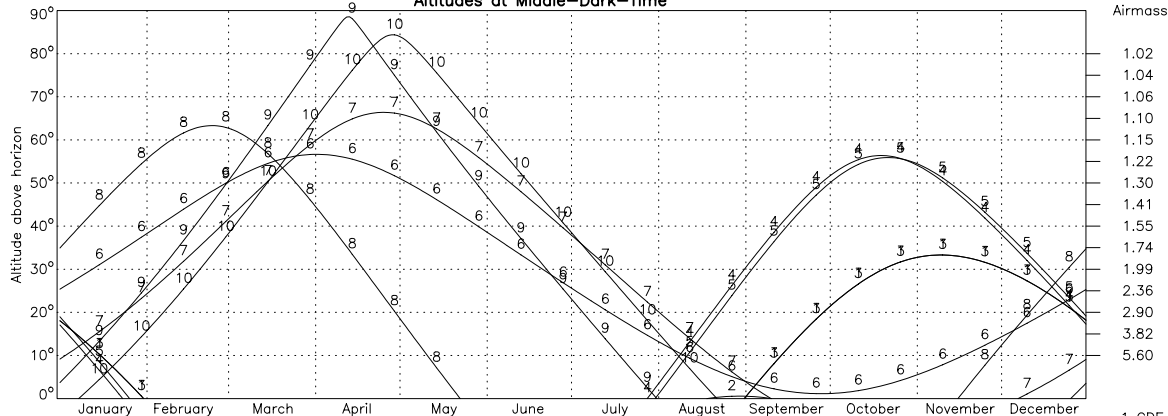
Feasibility of other surveys:

1) Object visibility (selected dataset)



Optimum observing time, Observing site coordinates:
Altitudes at Middle-Dark-Time

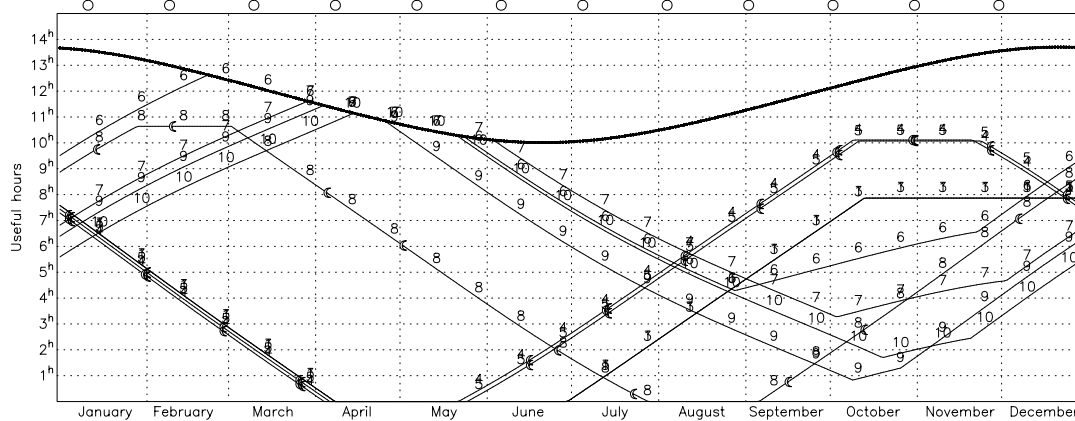
-17.8900E 28.8900, year 2020



List of objects

- 1 CDF-S/ 3^h32^m -27°48'
- 2 HDF-S 22^h32^m -60°33'
- 3 GOODS- 3^h32^m -27°48'
- 4 NDWFS- 2^h 7^m - 4°44'
- 5 C_UDS 2^h17^m - 5°11'
- 6 GOODS- 12^h36^m +62°14'
- 7 EGSS/G 14^h17^m +52°30'
- 8 COSMOS 10^h 0^m + 2°12'
- 9 Subaru 13^h24^m +27°29'
- 10 NDWFS- 14^h30^m +34°30'

Circles above frame represent Full Moon and the "C" symbol on a curve means the Moon is closer than 15°
The thick dotted line above the curves represents the total sunless hours for each day of the year



Comments

- 2 Never above 10°

TMT
La Palma

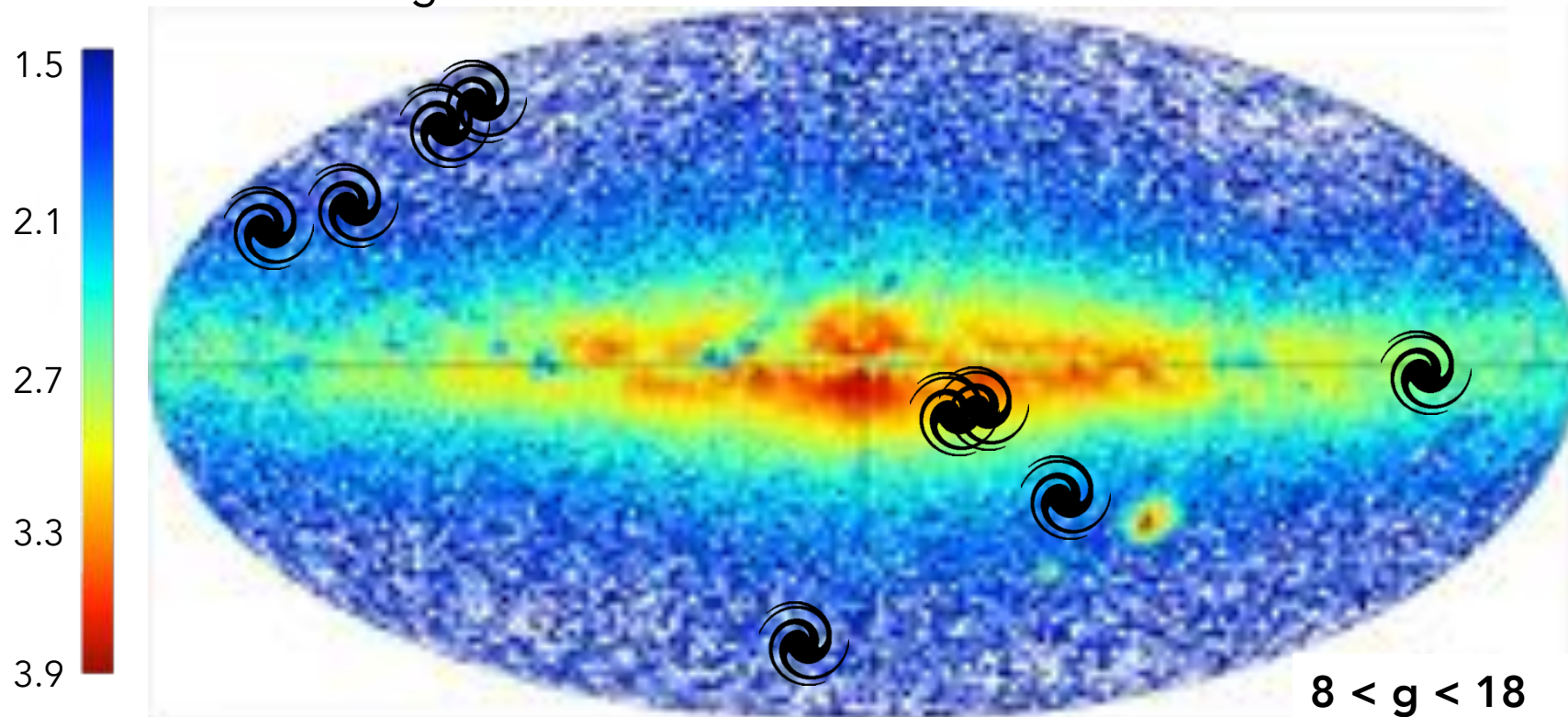
CAKE TOPPING

Feasibility of other surveys:

 **Object visibility (selected datasets)**

2) MW stellar density

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



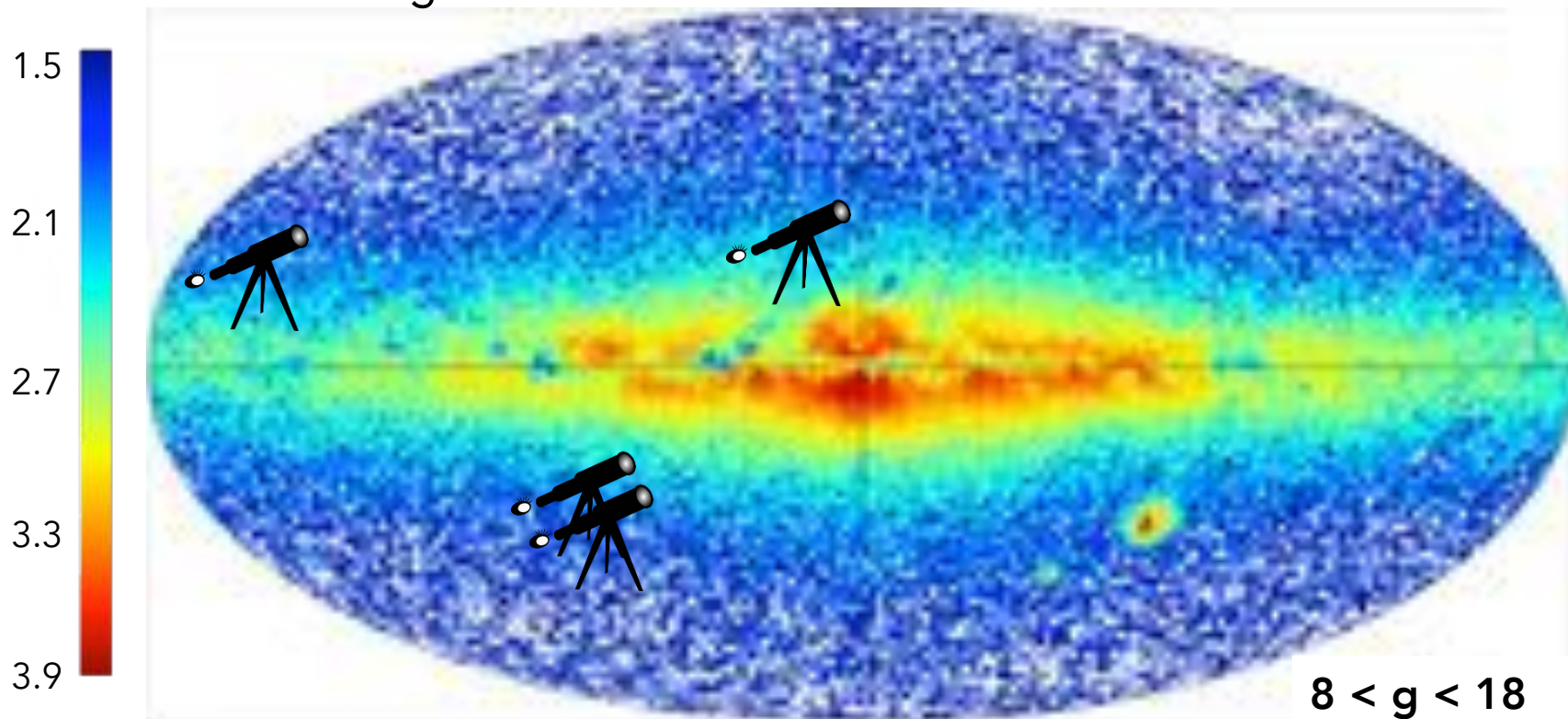
CAKE TOPPING

Feasibility of other surveys:

 Object visibility (selected datasets)

2) MW stellar density

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

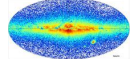


CAKE TOPPING

Feasibility of other surveys:

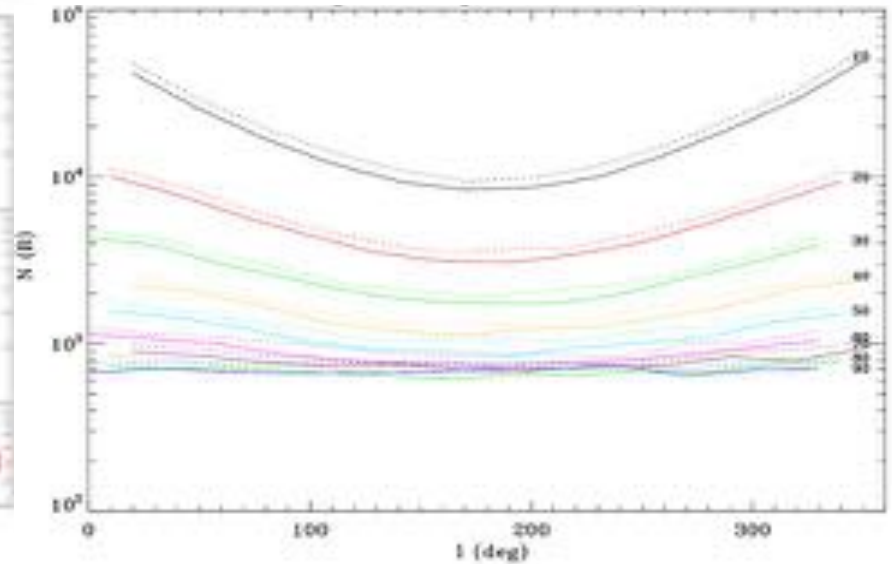
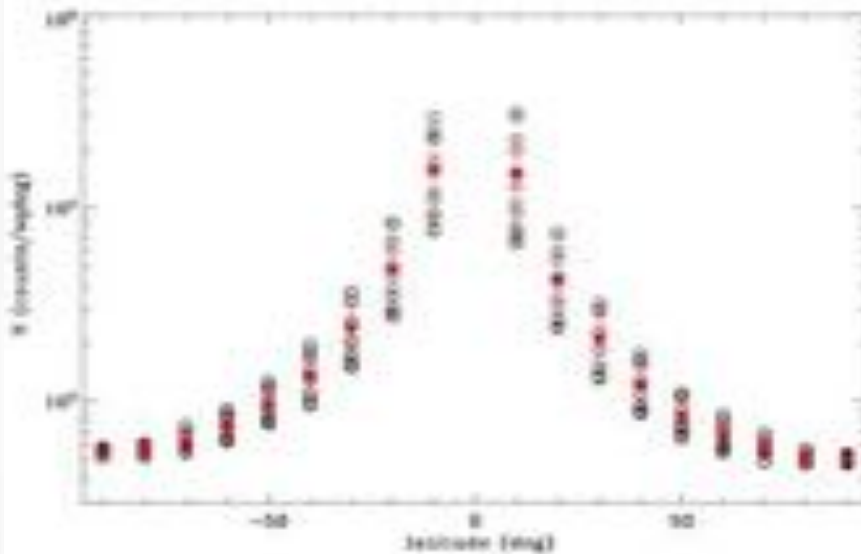


Object visibility (selected dataset)



MW stellar density

Theoretically → TRILEGAL (Girardi+2005) for dependence:
latitude & longitude



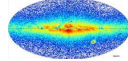
R < 18

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Feasibility of other surveys:

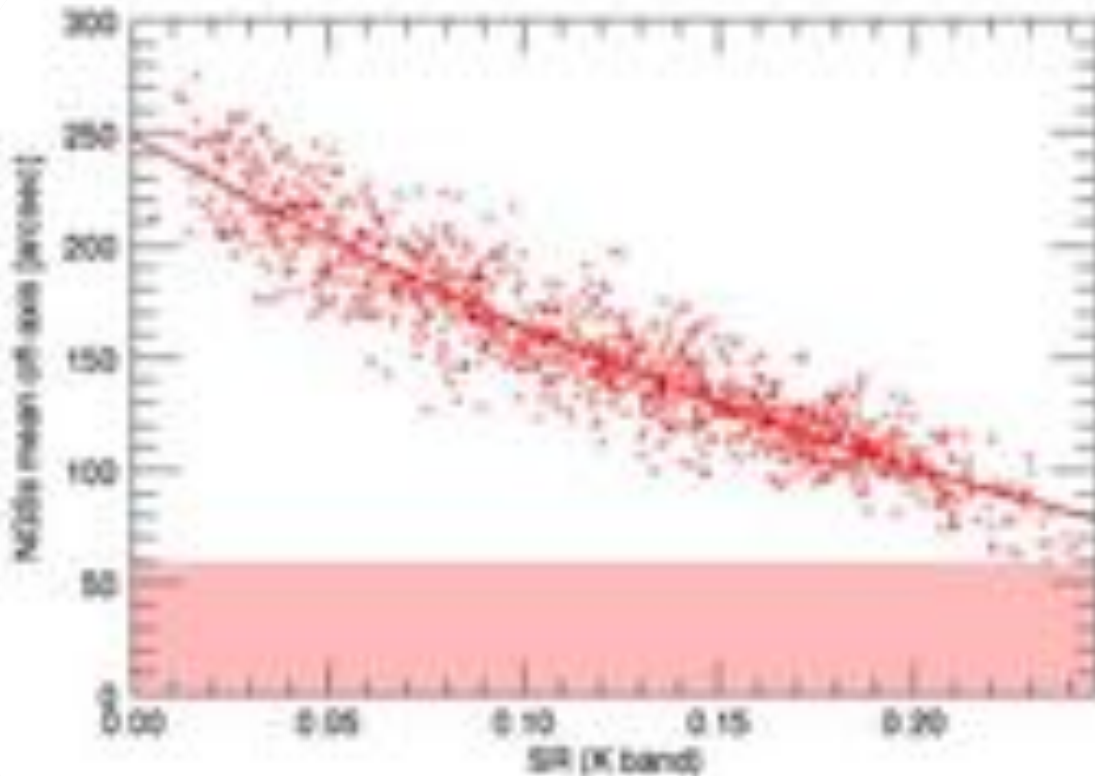


Object visibility (selected dataset)



MW stellar density

3) Asterism mean radius for available NGSs



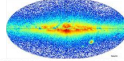
MonteCarlo simulation for statistics

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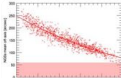
Feasibility of other surveys:



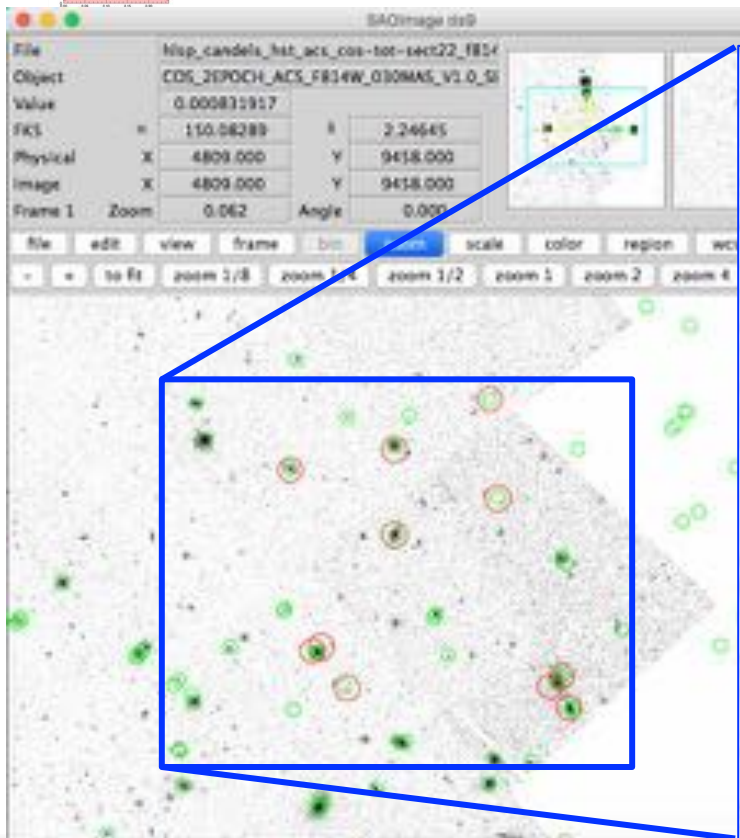
Object visibility (selected dataset)



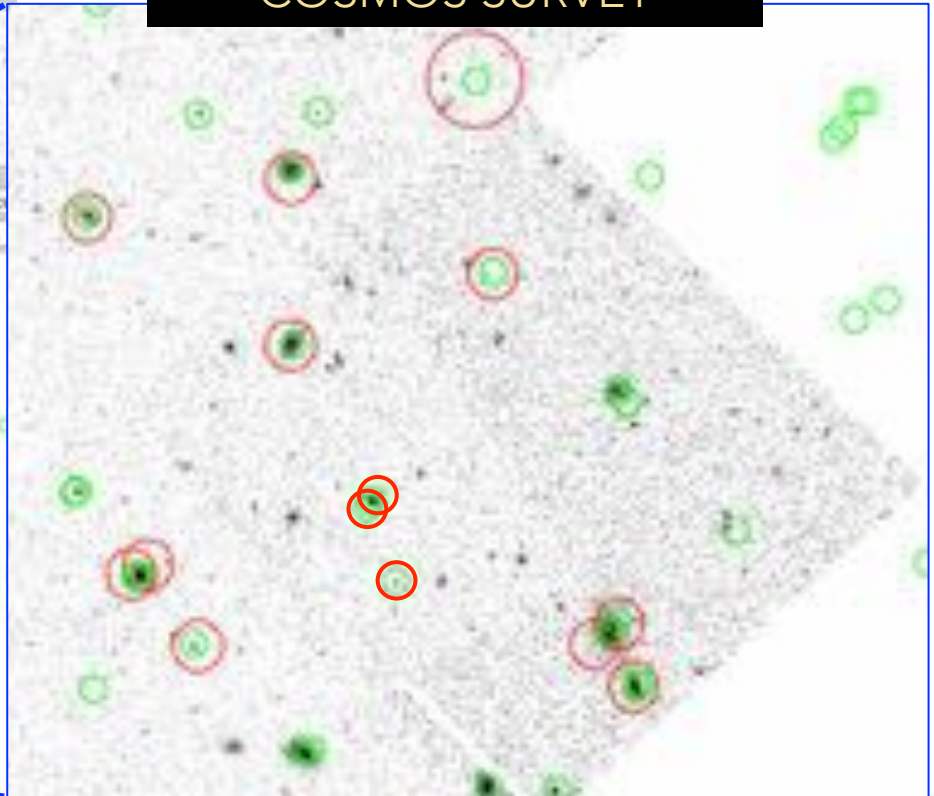
MW stellar density



Asterism mean radius for available NGSs

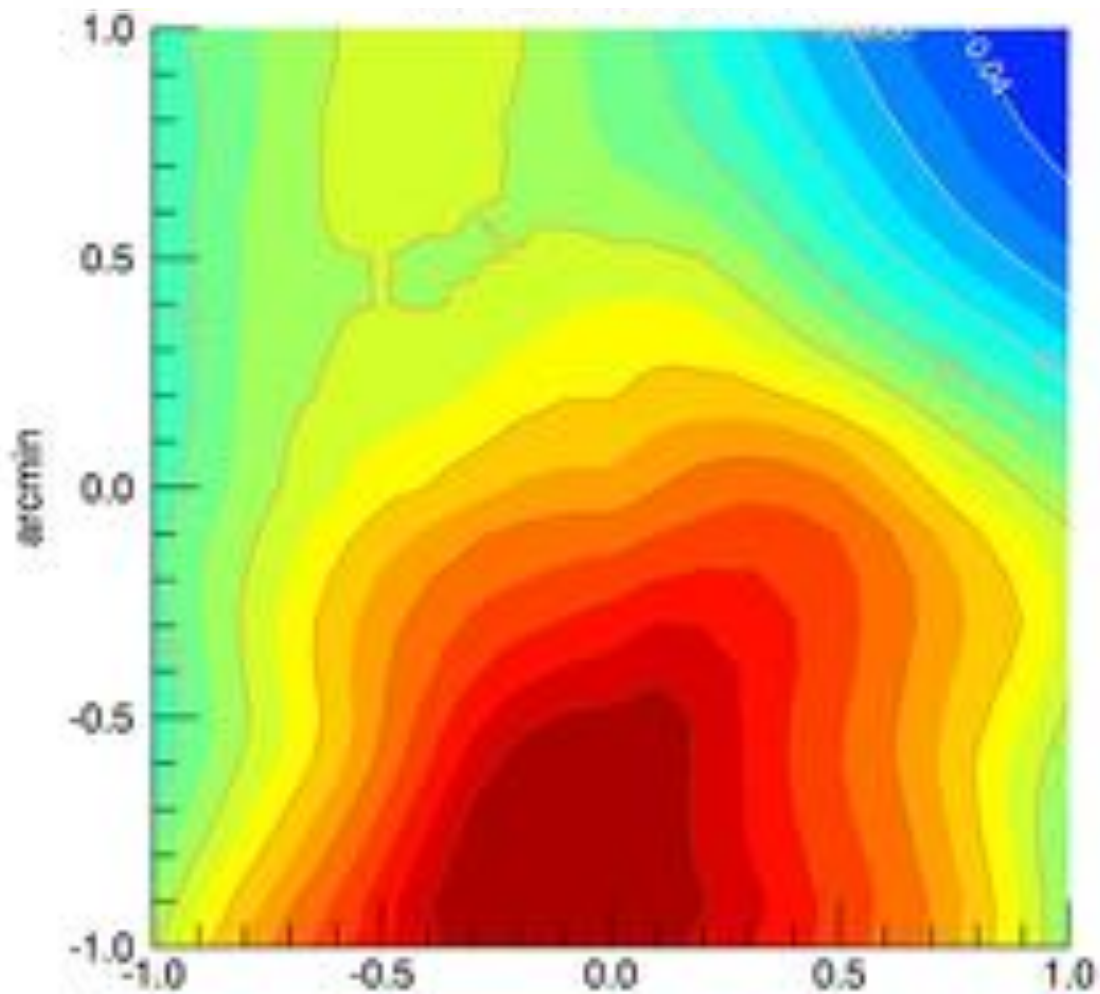


COSMOS SURVEY



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...?**



ensing
in the
era



When:

2-4 Oct 2017

Where:

Padova (Italy)

Web site:

<https://www.ict.inaf.it/indico/event/521/>

(or just Google the title...)