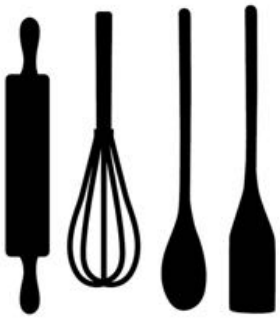
LABORATORIO NAZIONALE
ADONI
OTTICA ADATTIVA

ELISA PORTALURI

ADONI, 10-12 Aprile 2017

HOW TO STUDY THE FAR UNIVERSE BY USING ONLY THE STARS (AND A 40-M TELESCOPE)

MNRAS, 2017, 466, 3569



Recipe

HOW TO STUDY THE FAR UNIVERSE BY USING ONLY THE STARS (AND A 40-M TELESCOPE)

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

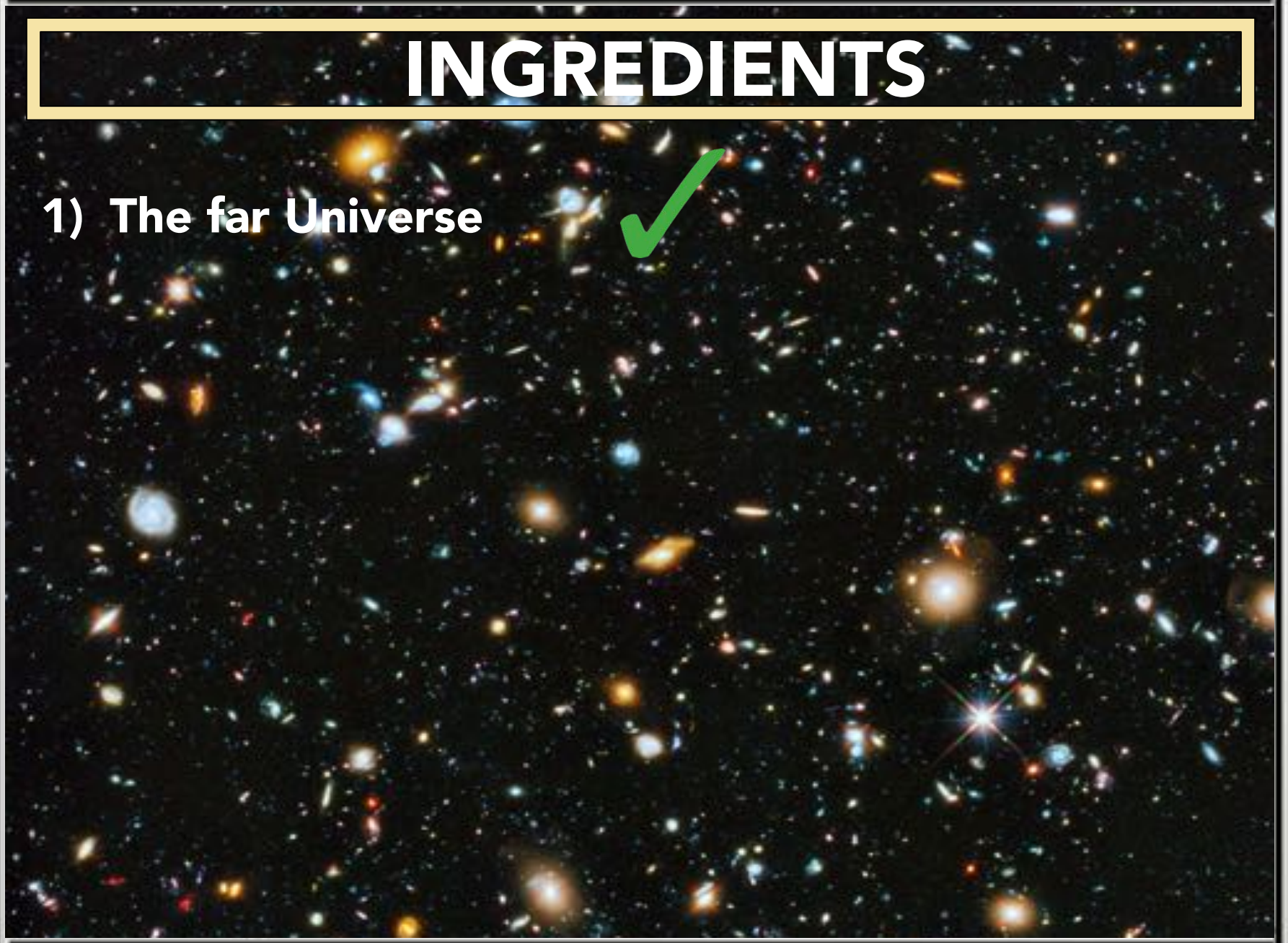
TUTORIAL

THE UNIVERSE CAKE:

1. INGREDIENTS
2. STEPS
3. FILLS

INGREDIENTS

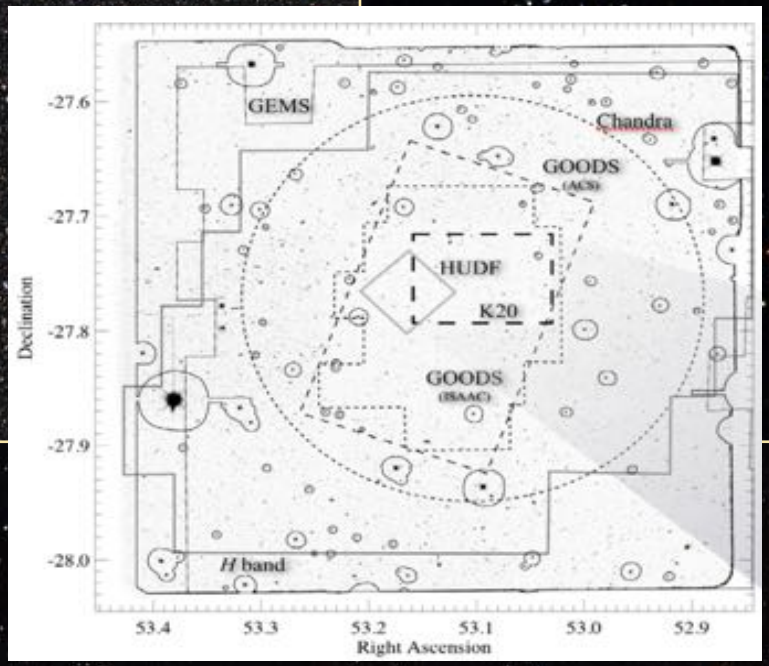
1) The far Universe ✓



INGREDIENTS

1) The far Universe ✓

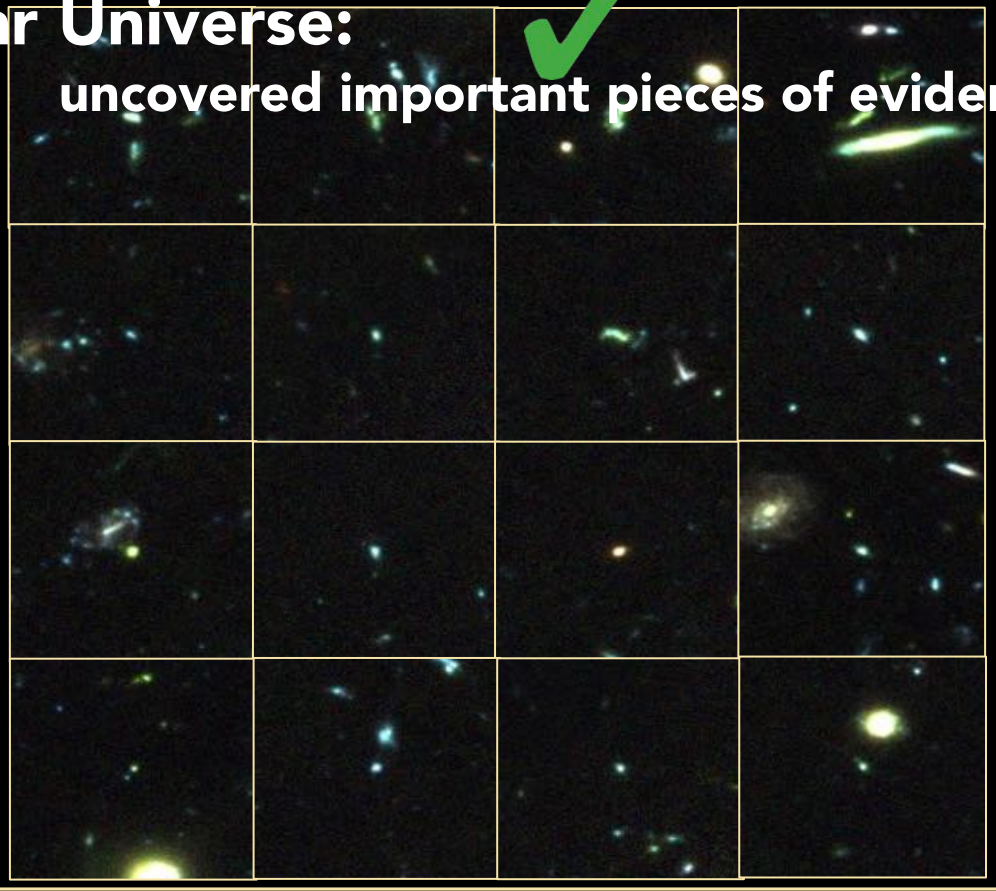
numerous surveys



INGREDIENTS

1) The far Universe:

uncovered important pieces of evidence



Irregulars: (n < 0.5)

Discs: (0.5 > n > 1.0)

Bulges (n > 2.5)

Central compact component?

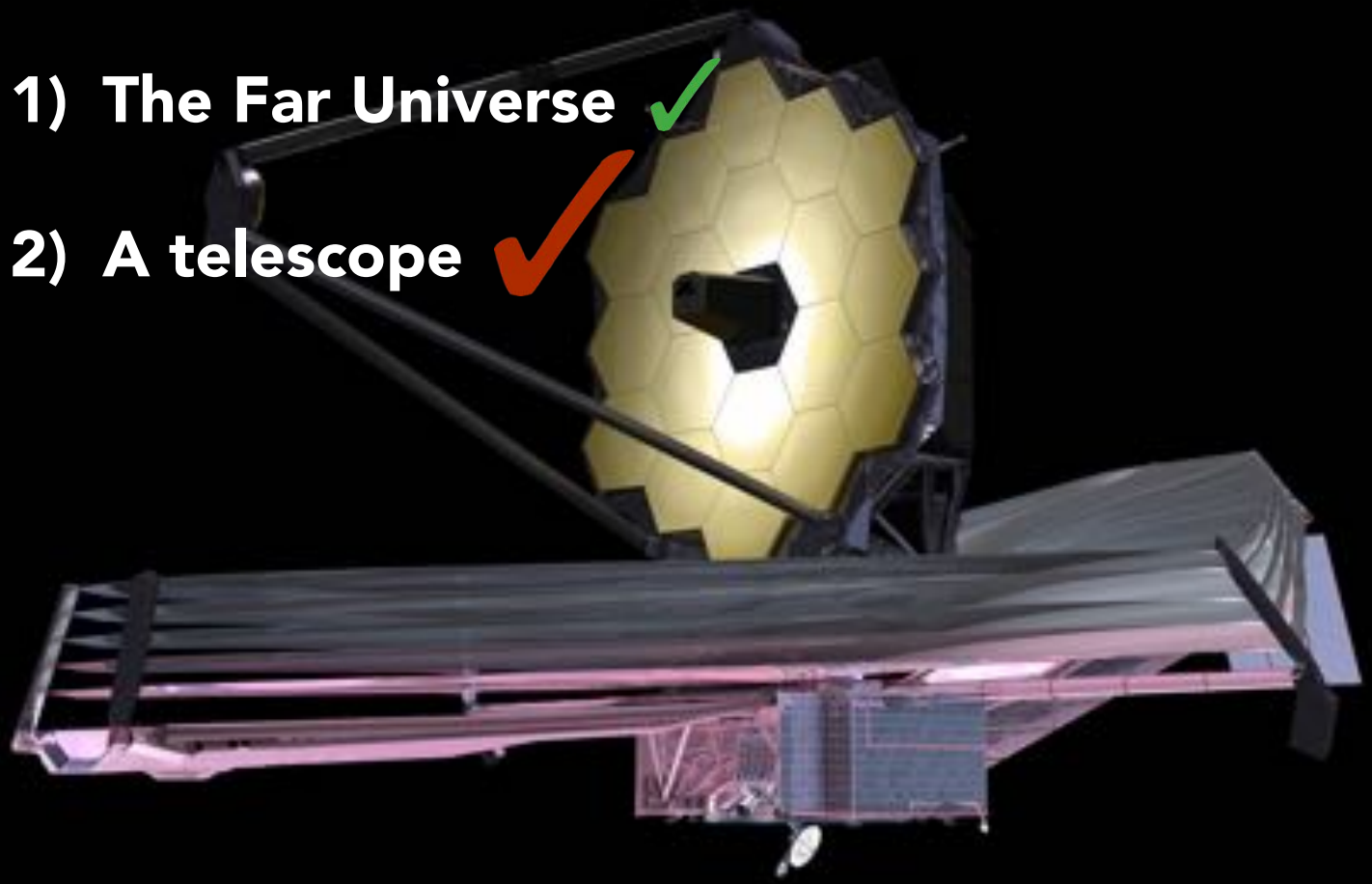
(n = 5.0)

Smaller - Regulars – Irregulars - Merging - Spheroids? - Discs? - No Hubble Seq.? - No λ-dependence

INGREDIENTS

1) The Far Universe ✓

2) A telescope ✓



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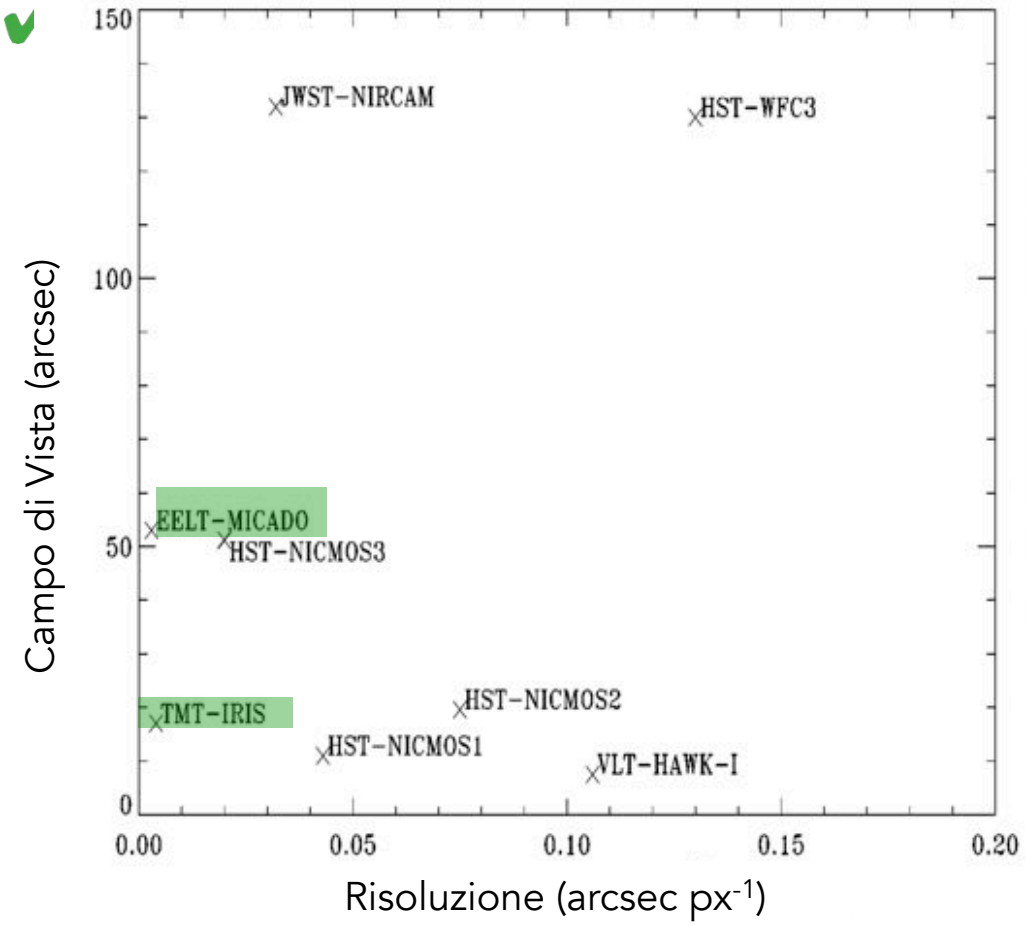
1) The Far Universe ✔

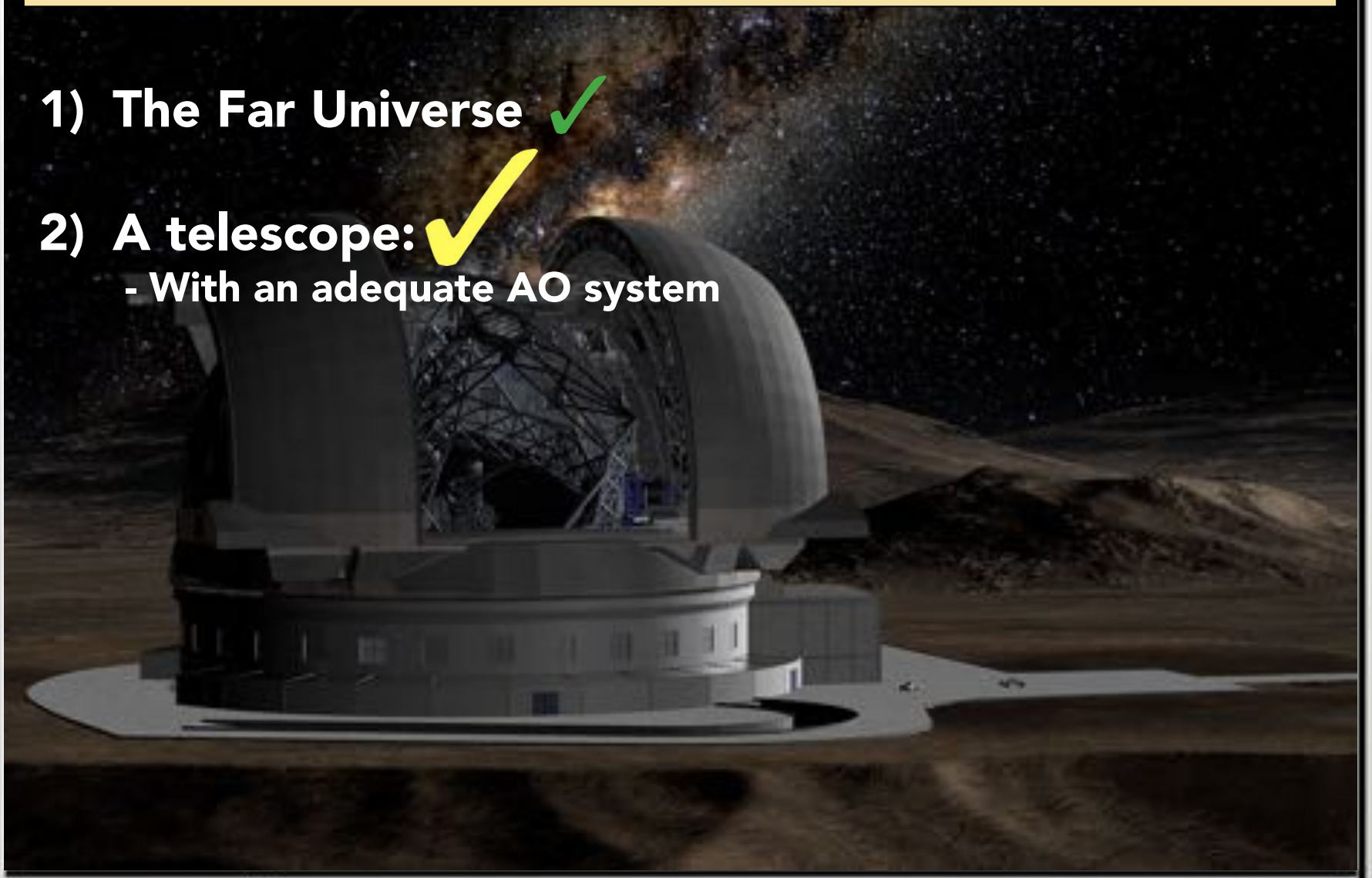
2) A telescope ✔



INGREDIENTS

1) The Far Universe ✓

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



INGREDIENTS

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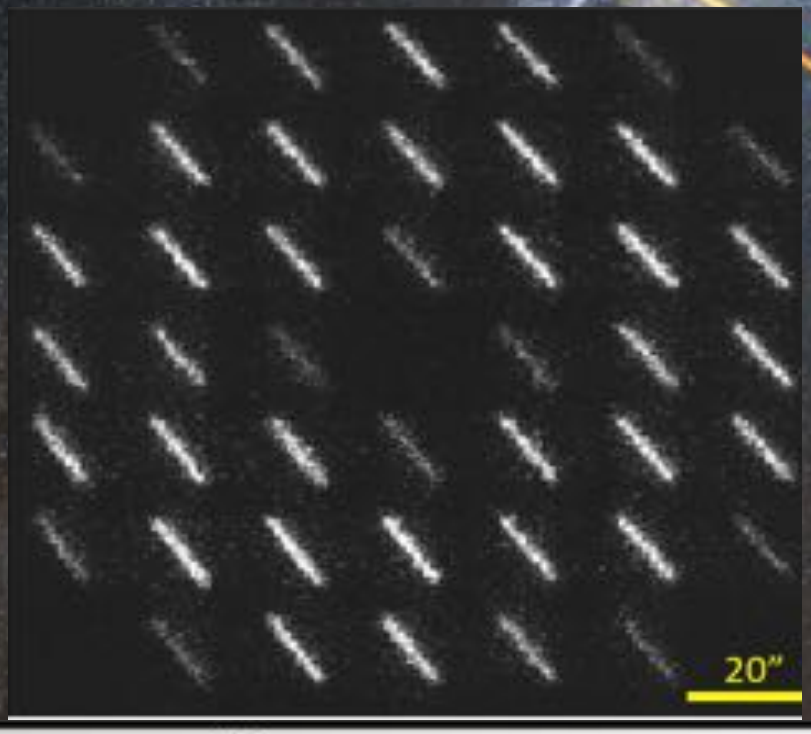
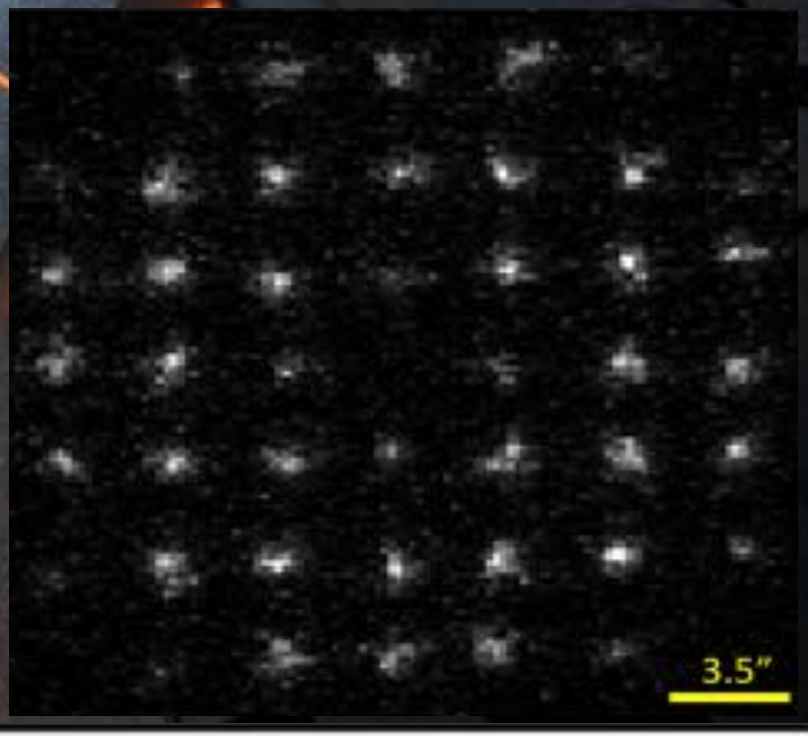
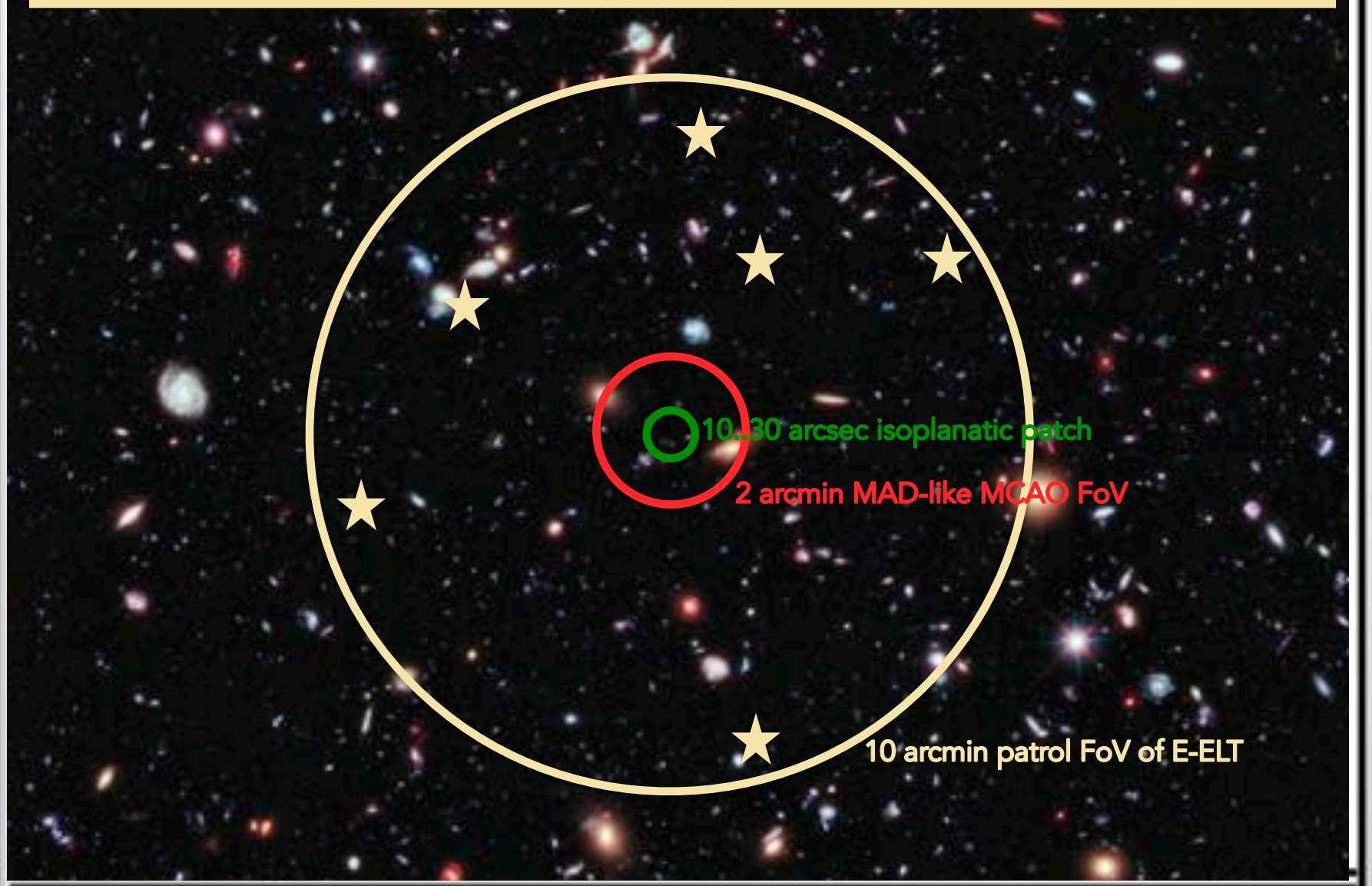




OUR RECIPE: Global-MCAO

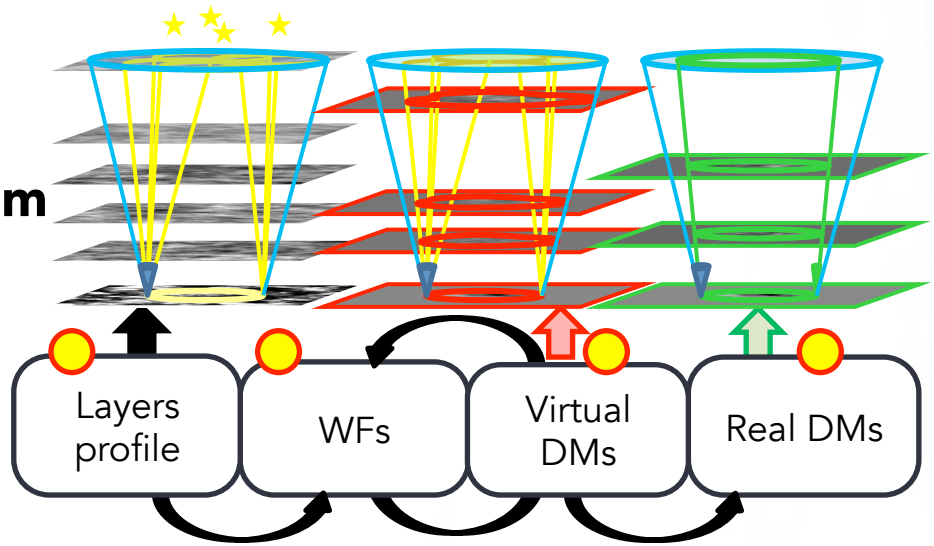


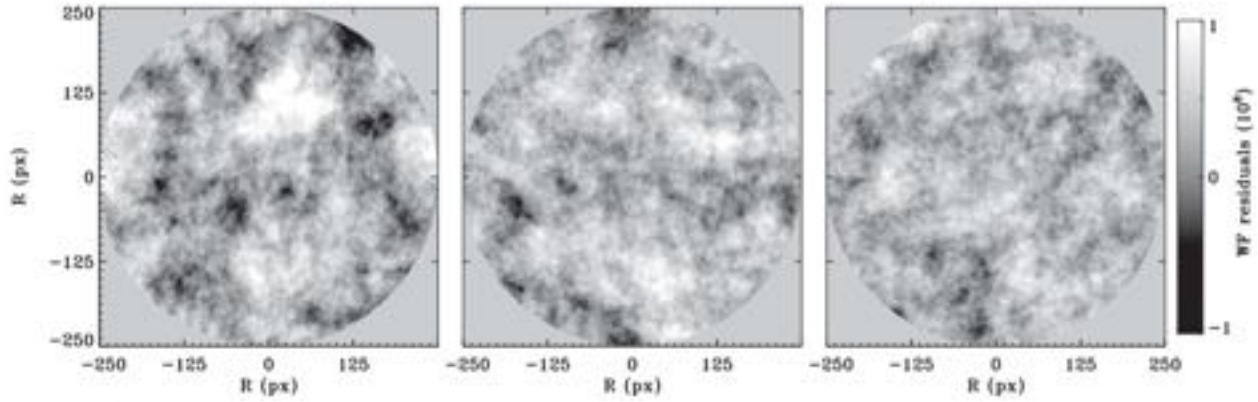
OUR RECIPE: Global-MCAO

1) Atmospheric 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)



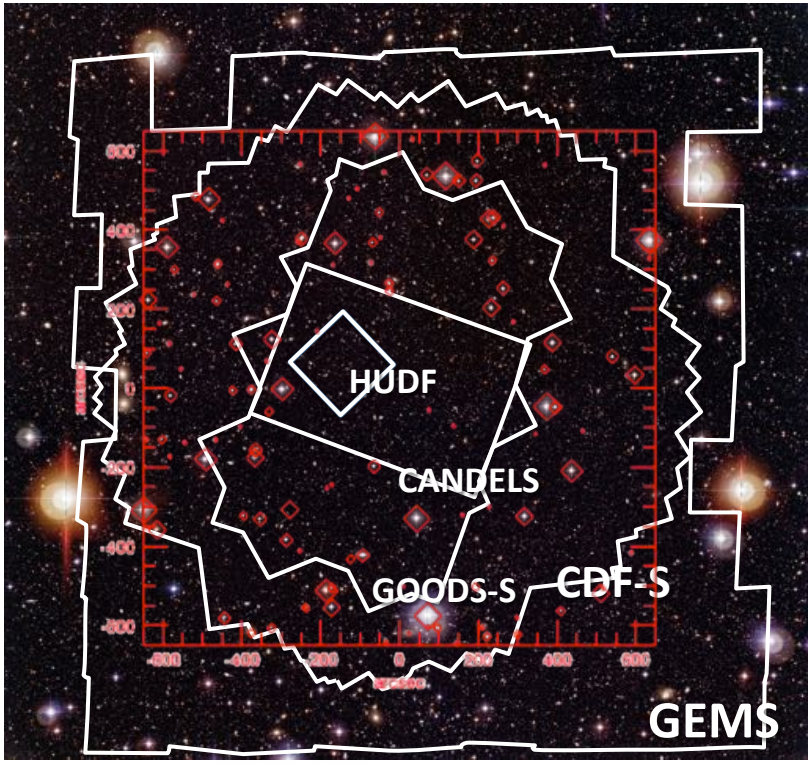


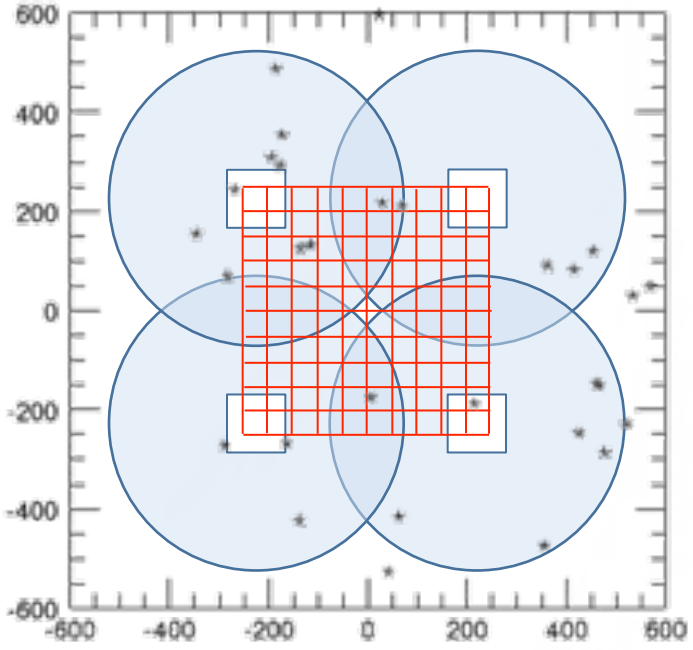
OUR RECIPE: Global-MCAO

Atmospheric Simulation Tool

2) Pointing:

- **Chandra Deep Field South; RA=3:32:28; DEC=-27:48:30**
- **Star Catalog: USNO-B, R-band**



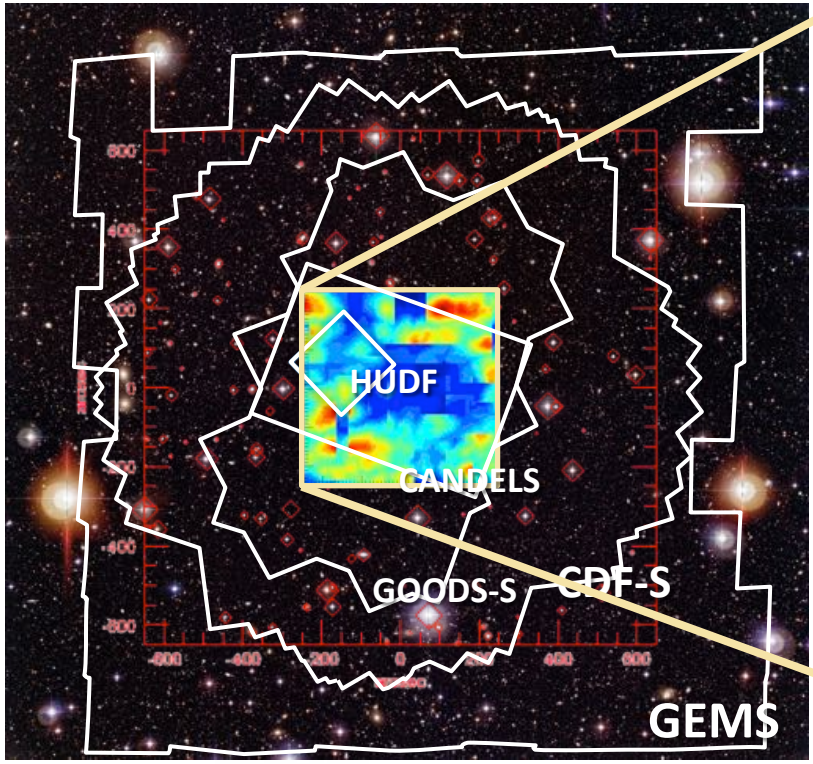


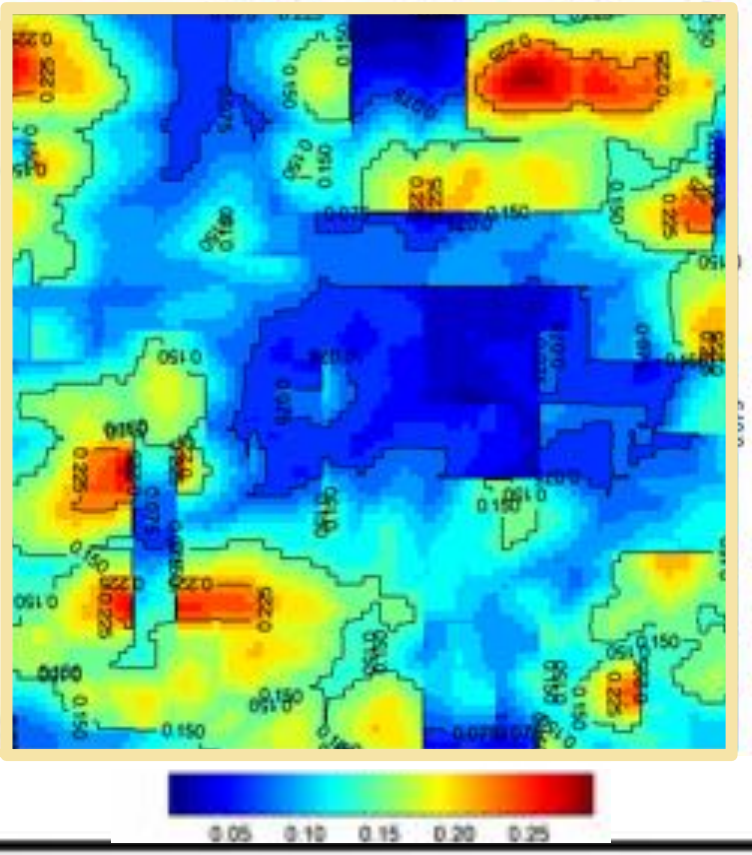
OUR RECIPE: Global-MCAO

Atmospheric Simulation Tool

Pointing

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



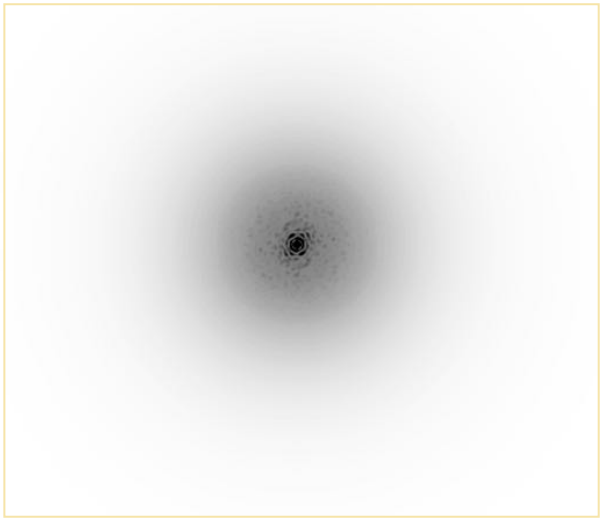


OUR RECIPE: Global-MCAO

Atmospheric Simulation Tool

Pointing

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



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

SR	η	h_{GAUSS} $\times 10^{-6}$ [as]	$\frac{h_{\mathrm{TOT}}}{h_{\mathrm{DL}}}$
0.01	0.009	1.923	0.01
0.02	0.018	1.912	0.02
0.03	0.032	1.906	0.03
0.04	0.043	1.895	0.04
0.05	0.052	1.882	0.05
0.06	0.076	1.888	0.06
0.07	0.076	1.865	0.07
0.08	0.092	1.857	0.08
0.09	0.114	1.863	0.09
0.10	0.129	1.857	0.10
0.11	0.122	1.828	0.11
0.12	0.191	1.883	0.12
0.13	0.185	1.853	0.13
0.14	0.172	1.809	0.14
0.15	0.181	1.792	0.15
0.16	0.202	1.800	0.16
0.17	0.189	1.757	0.17
0.18	0.256	1.816	0.18
0.19	0.268	1.793	0.19
0.20	0.239	1.726	0.20
0.21	0.228	1.697	0.21
0.22	0.273	1.710	0.22
0.23	0.323	1.753	0.23
0.24	0.368	1.793	0.24
0.25	0.491	1.849	0.25
0.26	0.404	1.779	0.26
0.27	0.435	1.801	0.27
0.28	0.349	1.630	0.28
0.29	0.366	1.625	0.29

OUR RECIPE: Global-MCAO

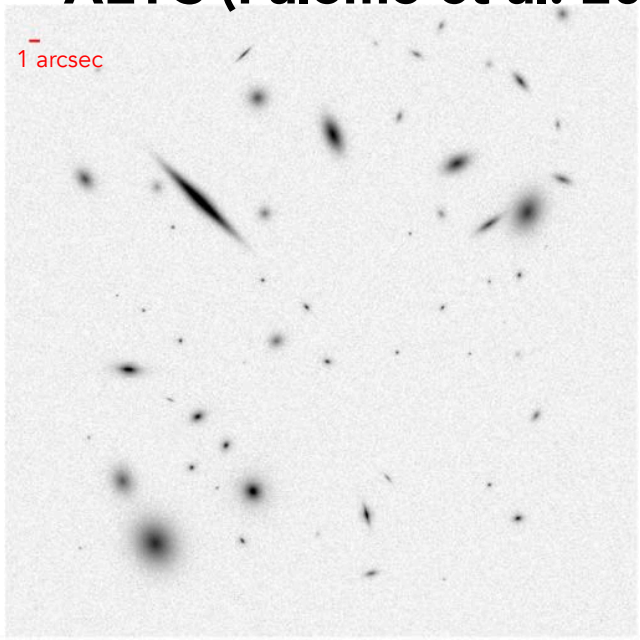
Atmospheric Simulation Tool

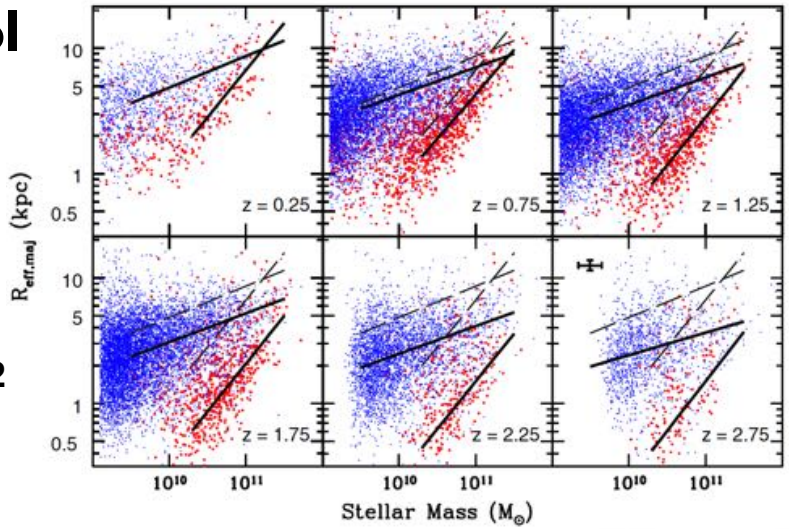
Pointing

K-band Strehl Ratio

4) Simulation of a deep field:

- 10 x 10 grid of 50 x 50 arcsec^2
- AETC (Falomo et al. 2011)





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

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

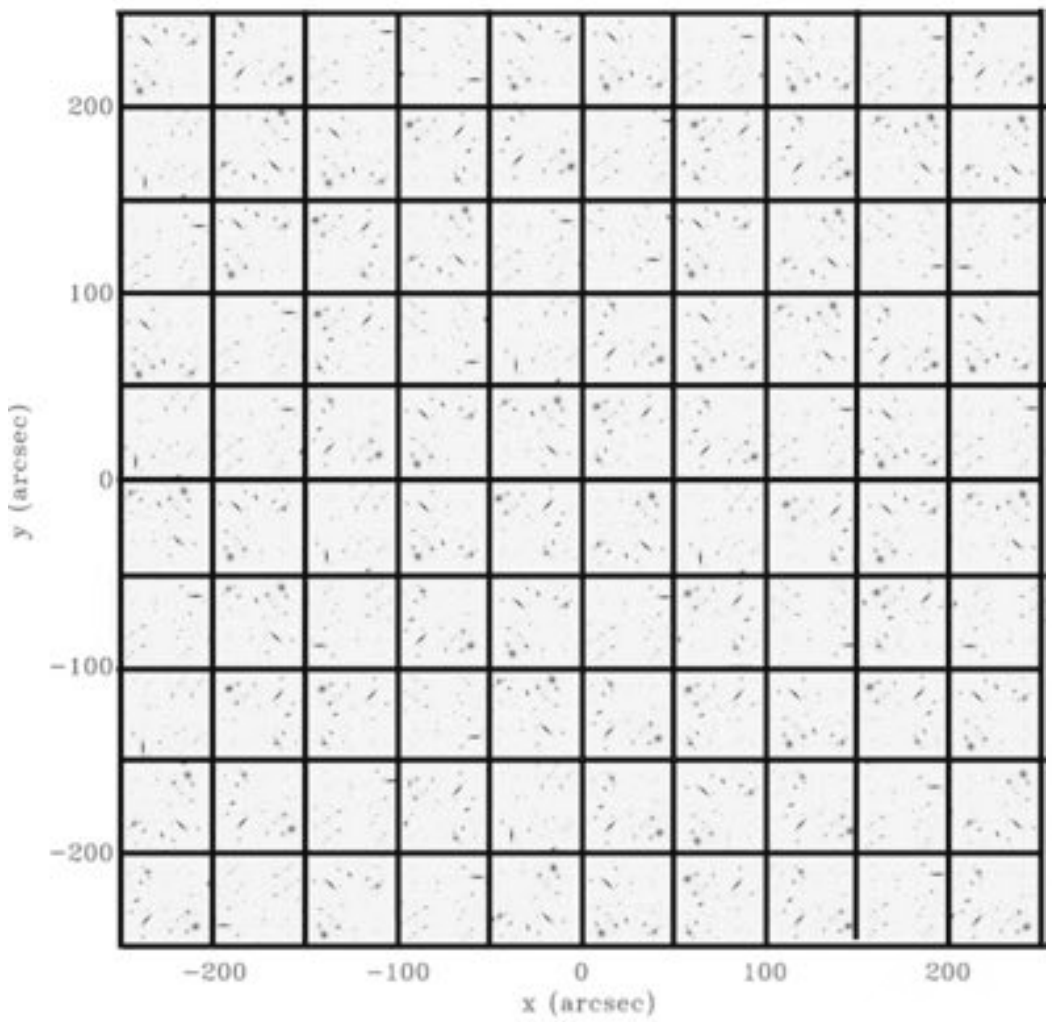
$z = 0.25, 0.75, 1.25, 1.75, 2.25, 2.75$

OUR RECIPE: Global-MCAO

Early types

Late types

Obj. ID#	$\log M/M_\odot$	z	K_{tot} [mag]	R_e [arcsec]	b/a	PA [°]
			$n = 4$			
1	9.0	0.25	21.67	0.052	0.372	304.1
2	9.0	0.75	21.00	0.087	0.581	9.9
3	9.0	1.25	20.11	0.175	0.178	104.6
4	9.0	1.75	19.44	0.294	0.346	354.1
5	9.0	2.25	18.77	0.494	0.893	118.7
6	9.0	2.75	23.42	0.027	0.495	47.0
7	9.3	0.25	22.71	0.044	0.861	52.5
8	9.3	0.75	21.75	0.083	0.949	230.8
9	9.3	1.25	21.04	0.132	0.706	242.9
10	9.3	1.75	20.33	0.212	0.610	206.9
11	9.3	2.25	24.48	0.009	0.449	324.9
12	9.3	2.75	23.83	0.016	0.772	341.8
13	9.7	0.25	22.97	0.032	0.900	303.0
14	9.7	0.75	22.32	0.055	0.699	99.2
15	9.7	1.25	21.68	0.095	0.550	167.6
16	9.7	1.75	24.42	0.008	0.732	328.7
17	9.7	2.25	23.81	0.013	0.654	218.3
18	9.7	2.75	23.00	0.026	0.404	325.6
19	10.0	0.25	22.39	0.044	0.412	232.1
20	10.0	0.75	21.78	0.074	0.452	127.0
21	10.0	1.25	24.46	0.006	0.517	162.2
22	10.0	1.75	23.90	0.009	0.696	302.5
23	10.0	2.25	23.14	0.019	0.675	128.3
24	10.0	2.75	22.58	0.032	0.990	168.9
25	10.3	0.25	22.01	0.054	0.638	262.4
26	10.3	0.75	25.35	0.005	0.174	33.5
27	10.3	1.25	24.82	0.009	0.816	174.5
28	10.3	1.75	24.11	0.019	0.303	267.4
29	10.3	2.25	23.57	0.032	0.988	19.5
30	10.3	2.75	23.04	0.054	0.996	112.7
			$n = 1$			
31	9.0	0.25	20.46	0.663	0.250	214.5
32	9.0	0.75	19.71	0.789	0.745	289.6
33	9.0	1.25	18.71	0.995	0.714	64.20
34	9.0	1.75	17.96	1.184	0.846	298.6
35	9.0	2.25	17.21	1.408	0.100	85.5
36	9.0	2.75	21.87	0.388	0.990	131.8
37	9.3	0.25	21.16	0.450	0.389	158.5
38	9.3	0.75	20.23	0.549	0.654	127.0
39	9.3	1.25	19.53	0.637	0.532	27.2
40	9.3	1.75	18.83	0.739	0.435	291.5
41	9.3	2.25	22.79	0.255	0.487	273.9
42	9.3	2.75	22.20	0.296	0.478	69.4
43	9.7	0.25	21.41	0.360	0.988	194.8
44	9.7	0.75	20.82	0.418	0.343	309.4
45	9.7	1.25	20.23	0.484	0.984	233.6
46	9.7	1.75	23.63	0.220	0.793	39.9
47	9.7	2.25	23.03	0.257	0.978	12.0
48	9.7	2.75	22.24	0.317	0.410	151.3
49	10.0	0.25	21.65	0.371	0.113	43.2
50	10.0	0.75	21.05	0.434	0.864	29.5
51	10.0	1.25	24.03	0.179	0.841	299.5
52	10.0	1.75	23.44	0.208	0.190	155.8
53	10.0	2.25	22.64	0.256	0.510	62.7
54	10.0	2.75	22.04	0.298	0.532	54.4
55	10.3	0.25	21.45	0.348	0.906	300.8
56	10.3	0.75	24.22	0.202	0.877	49.3
57	10.3	1.25	23.68	0.228	0.985	171.4
58	10.3	1.75	22.97	0.269	0.237	129.8
59	10.3	2.25	22.44	0.305	0.702	298.3
60	10.3	2.75	21.91	0.345	0.382	195.0



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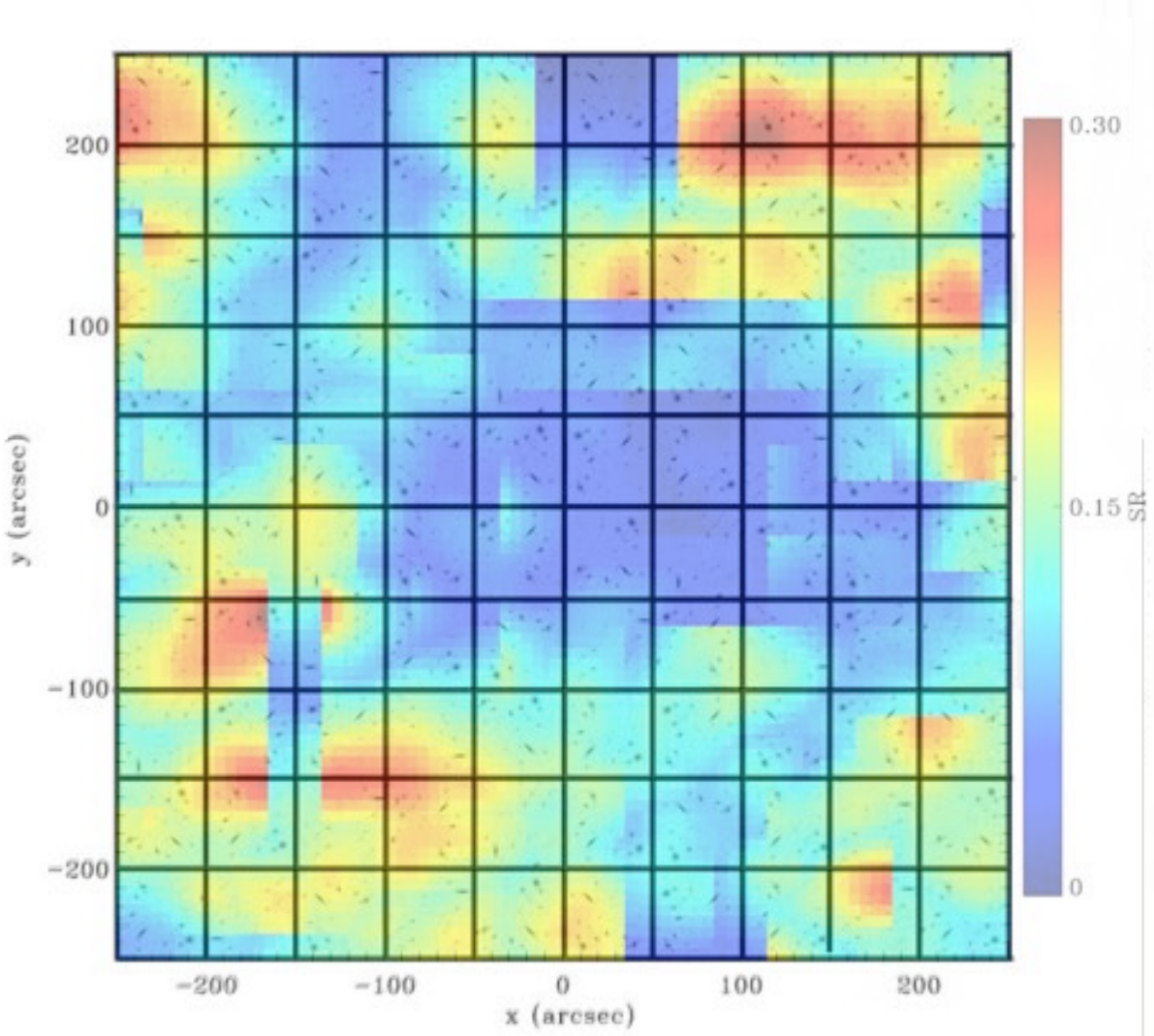
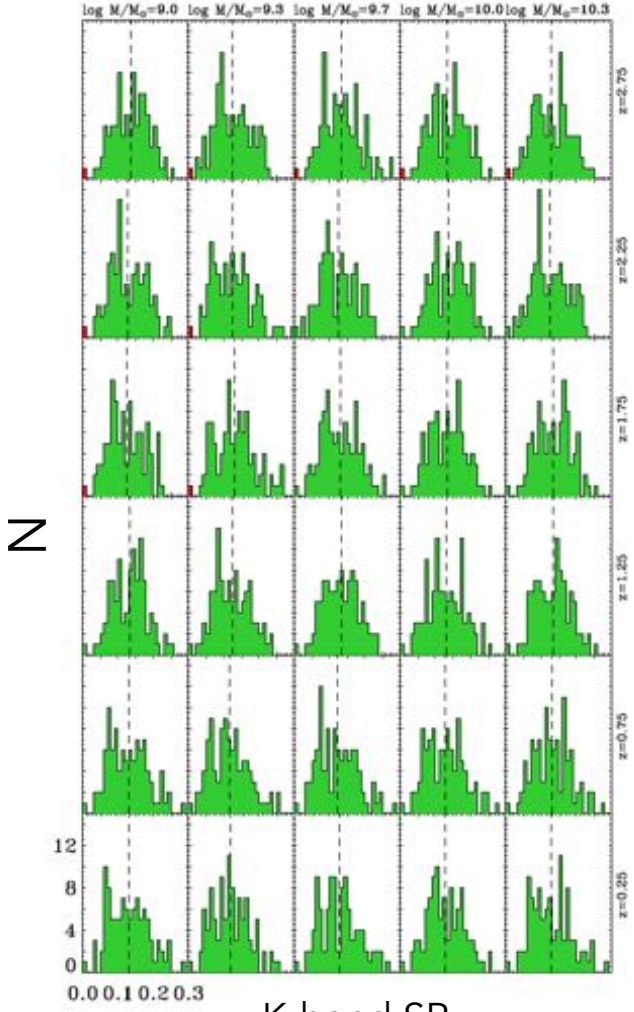
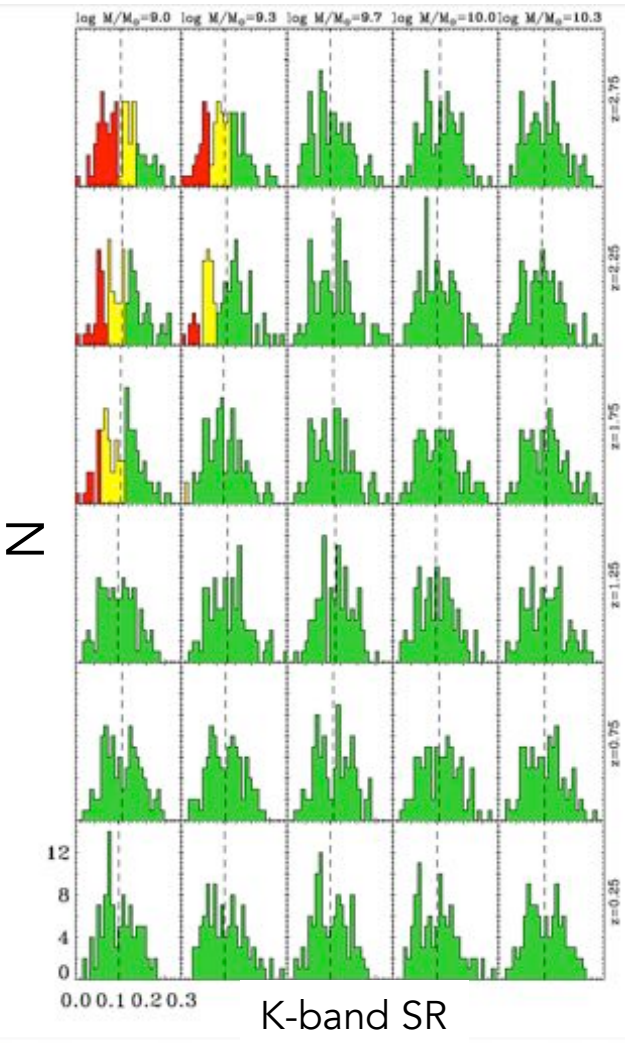


THE FINAL PRODUCT

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

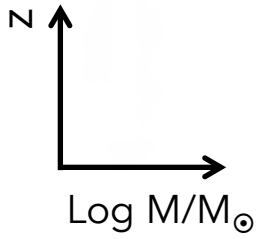




found

not found

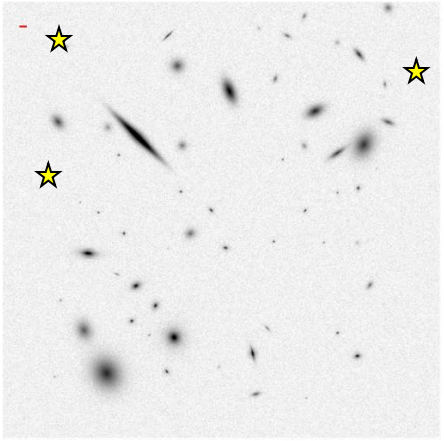
found, 2x2 bin



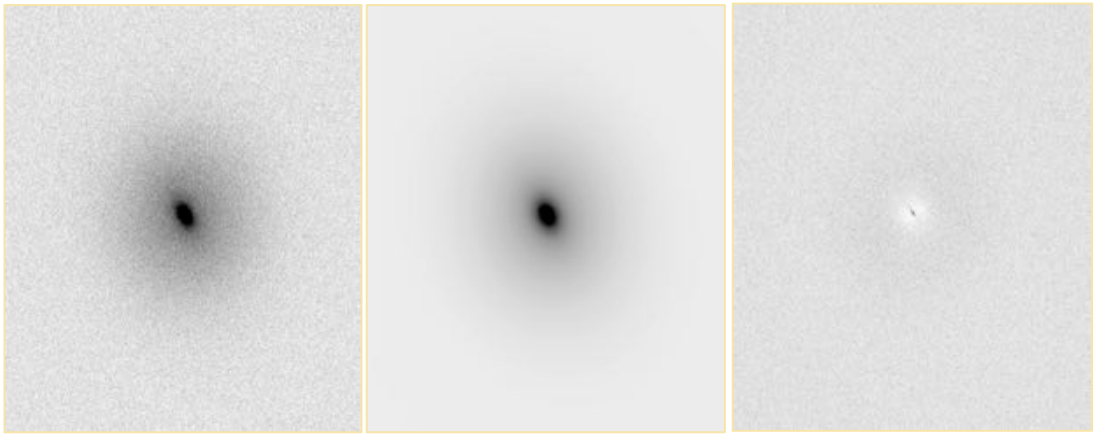
THE FINAL PRODUCT

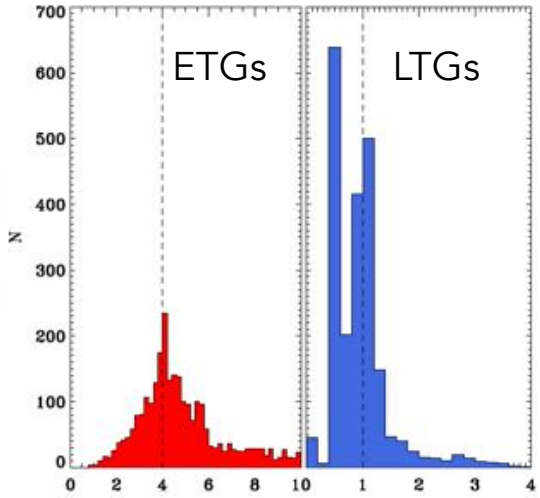
- **SExtractor completeness: 99.7% (ETGs) - 89.4% (LTGs)**

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



GALAXY MODEL RESIDUALS



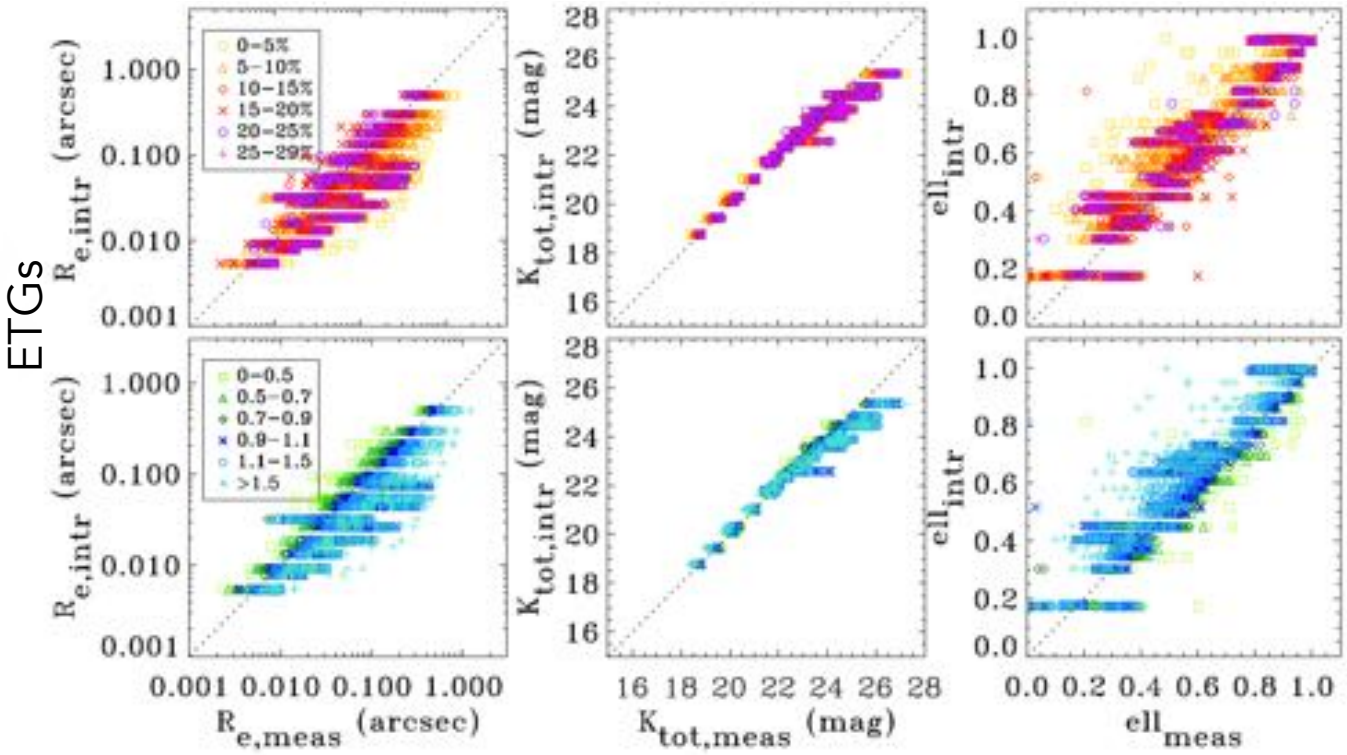


THE FINAL PRODUCT

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

GALFIT: Morphology and Photometry

3) Comparison



SR_{model} code

SR_*/SR_{model} code

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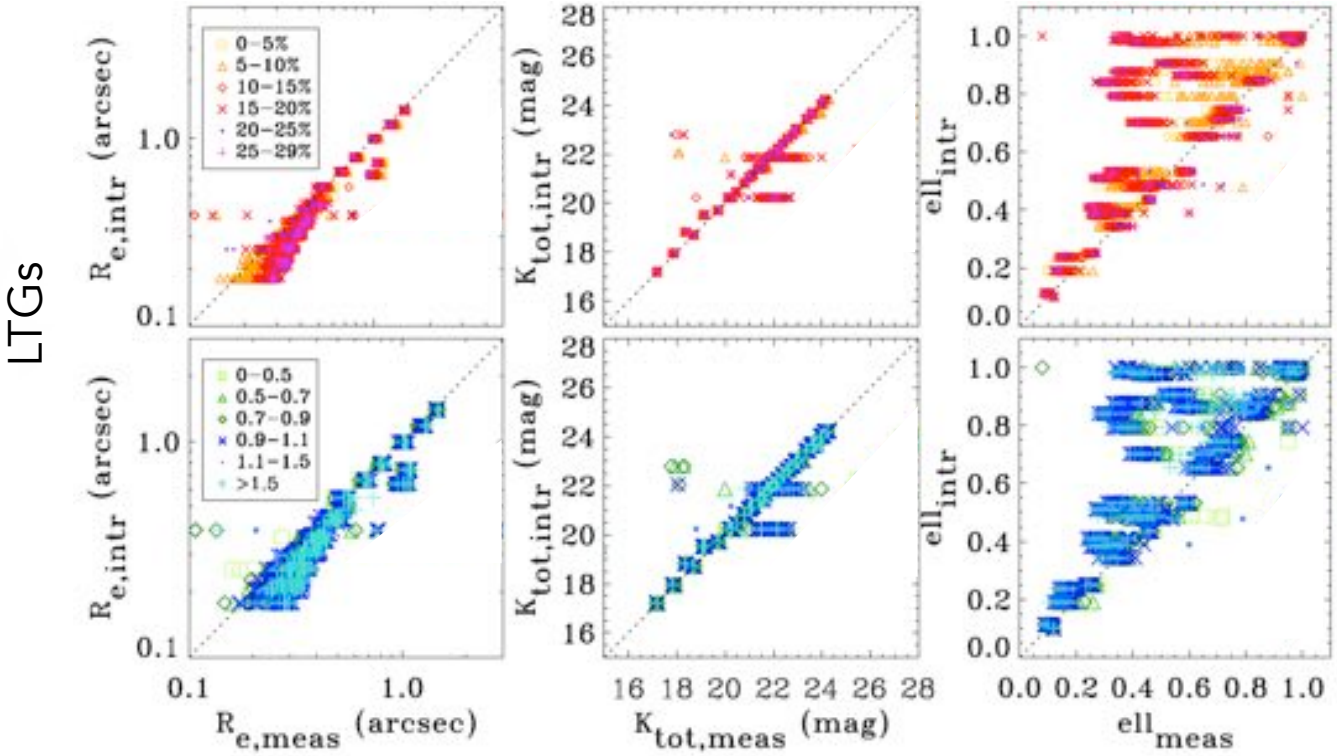


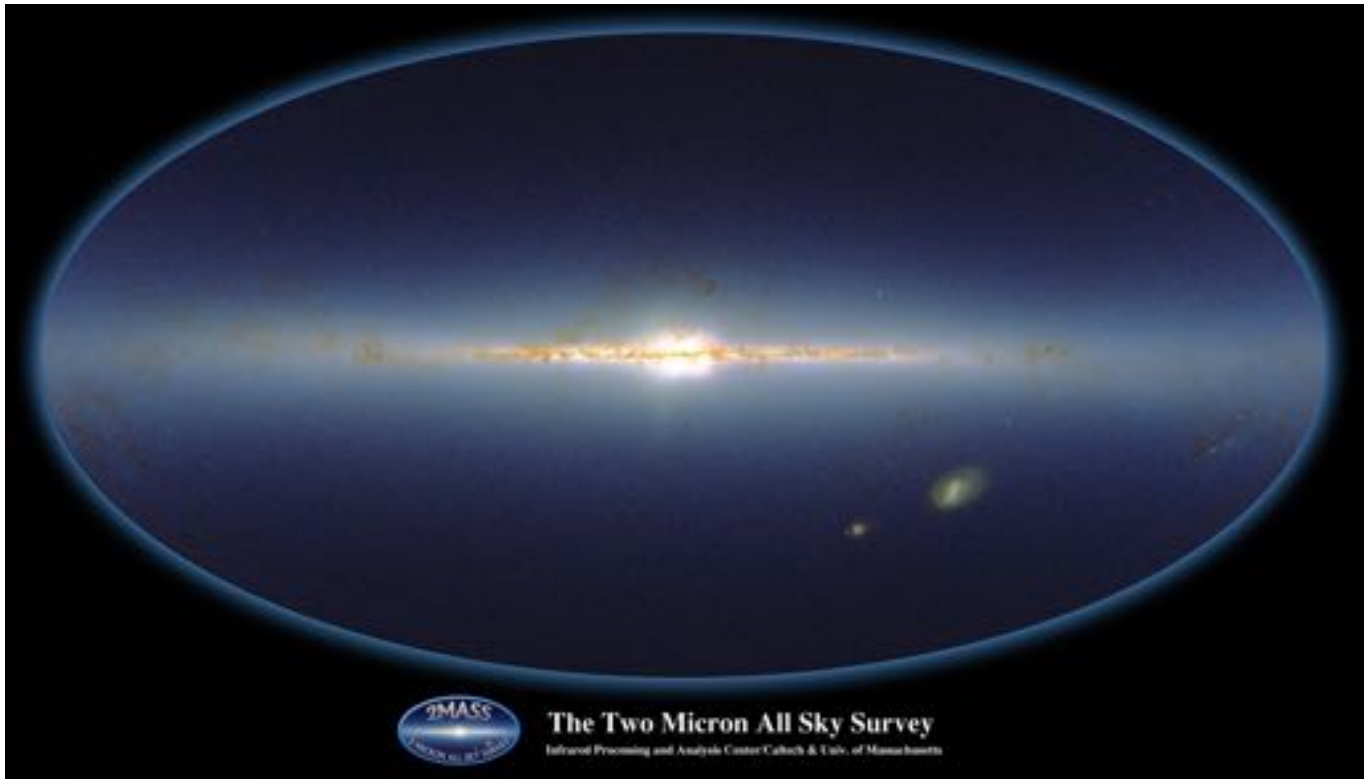
SR_{model} code

SR_*/SR_{model} code

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

WHAT'S NEXT?

1) Feasibility (with GMCAO) of other surveys



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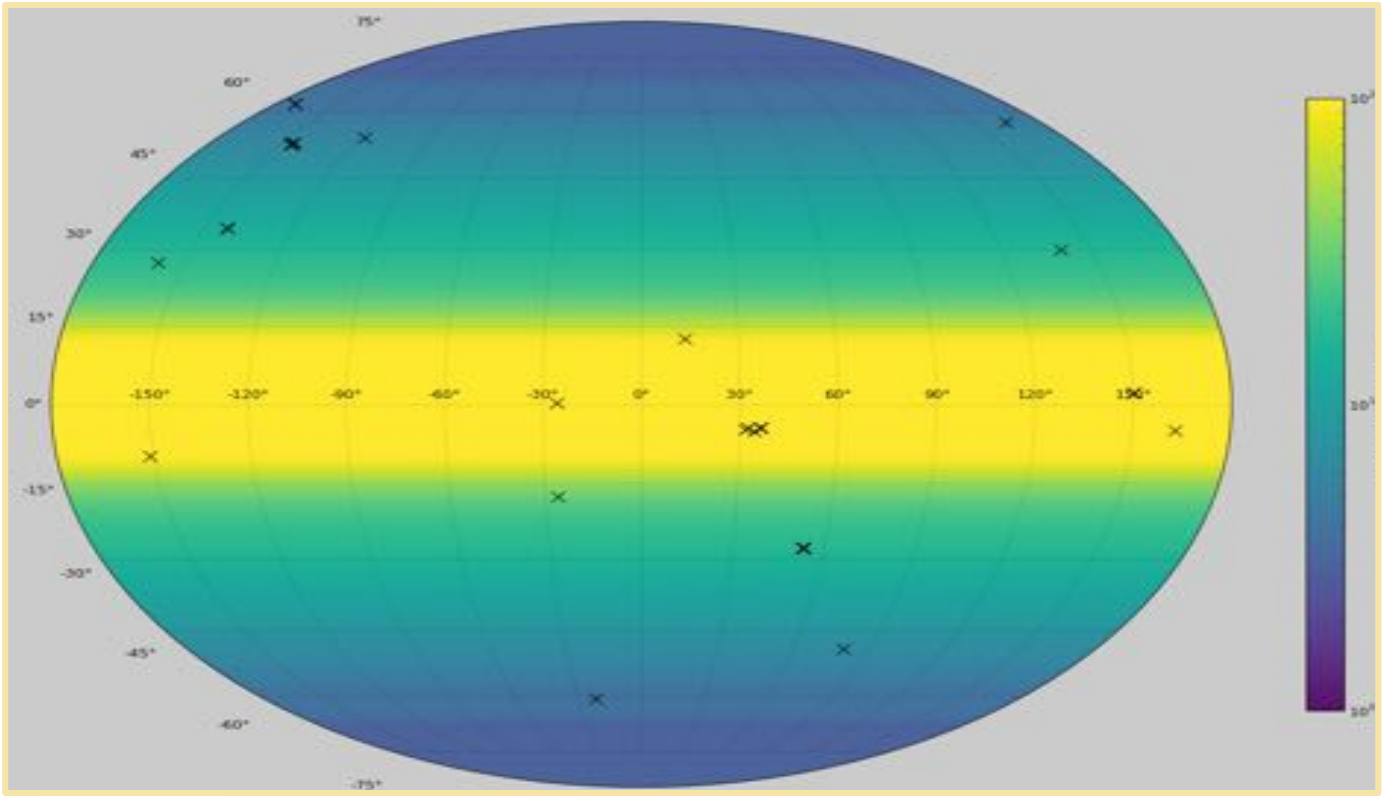

A GMCAO-assisted telescope can carry out photometric surveys successfully, recovering the morphology and photometry of sample galaxies adequately

WHAT'S NEXT?

1) **Feasibility (with GMCAO) of other surveys**

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

3) **Other recipes..**

Enjoy the cake