# FORNAX DEEP SURVEY: Unveiling the faint stellar halos of the early-type galaxies in the Fornax Cluster

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INAF-Astronomical Observatory of Capodimonte
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on behalf of the **FDS core Team**:

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- new deep survey of the Fornax Cluster to obtain imaging in the u, g, r, i bands at VST

- join project based on INAF & OmegaCam GTO

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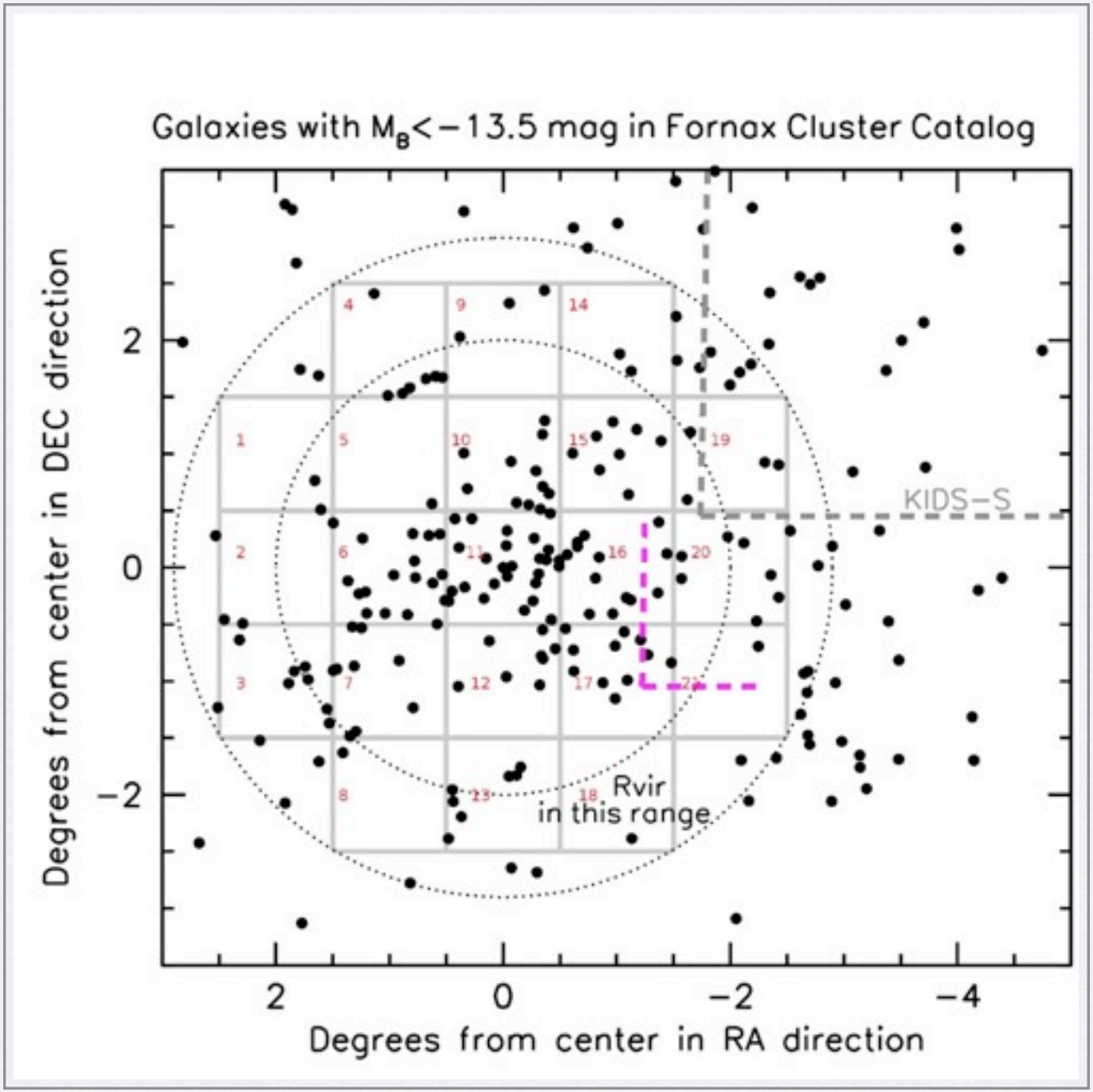
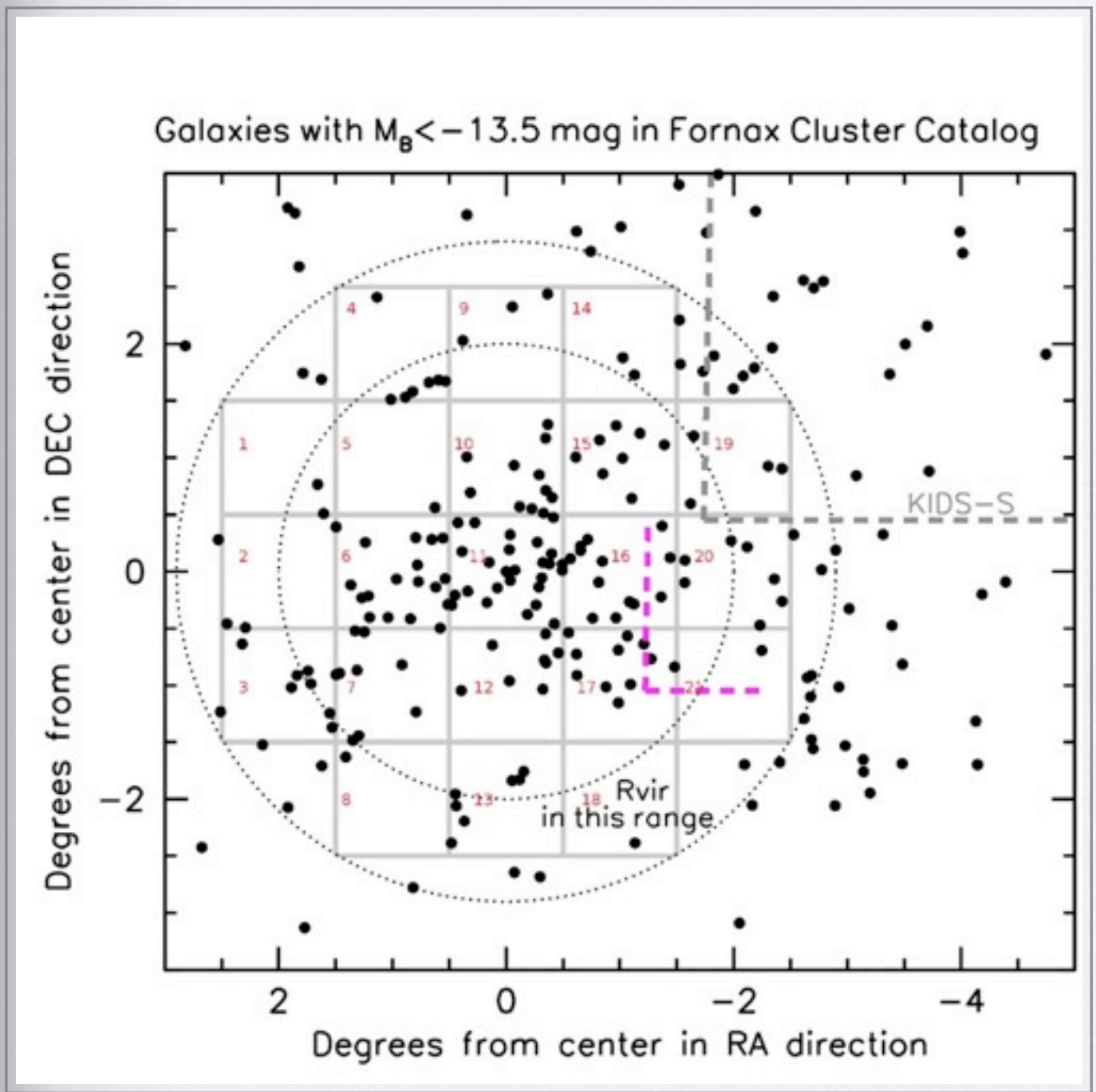
**main scientific aims**

- SB and color profiles out to 8-10 Re
- GCs and compact galaxies
- satellite galaxies
- Long-lived external structures, ICL, connection with the environment

the up-to-date largest mosaic of the Fornax Cluster 5 x 5 degrees that extends up to the virial radius of the cluster



observations were carried out in visitor mode on Nov 2014




**tot exp time for each 1 deg² field:**

17.8 hrs *u* band

12.8 hrs *g* band

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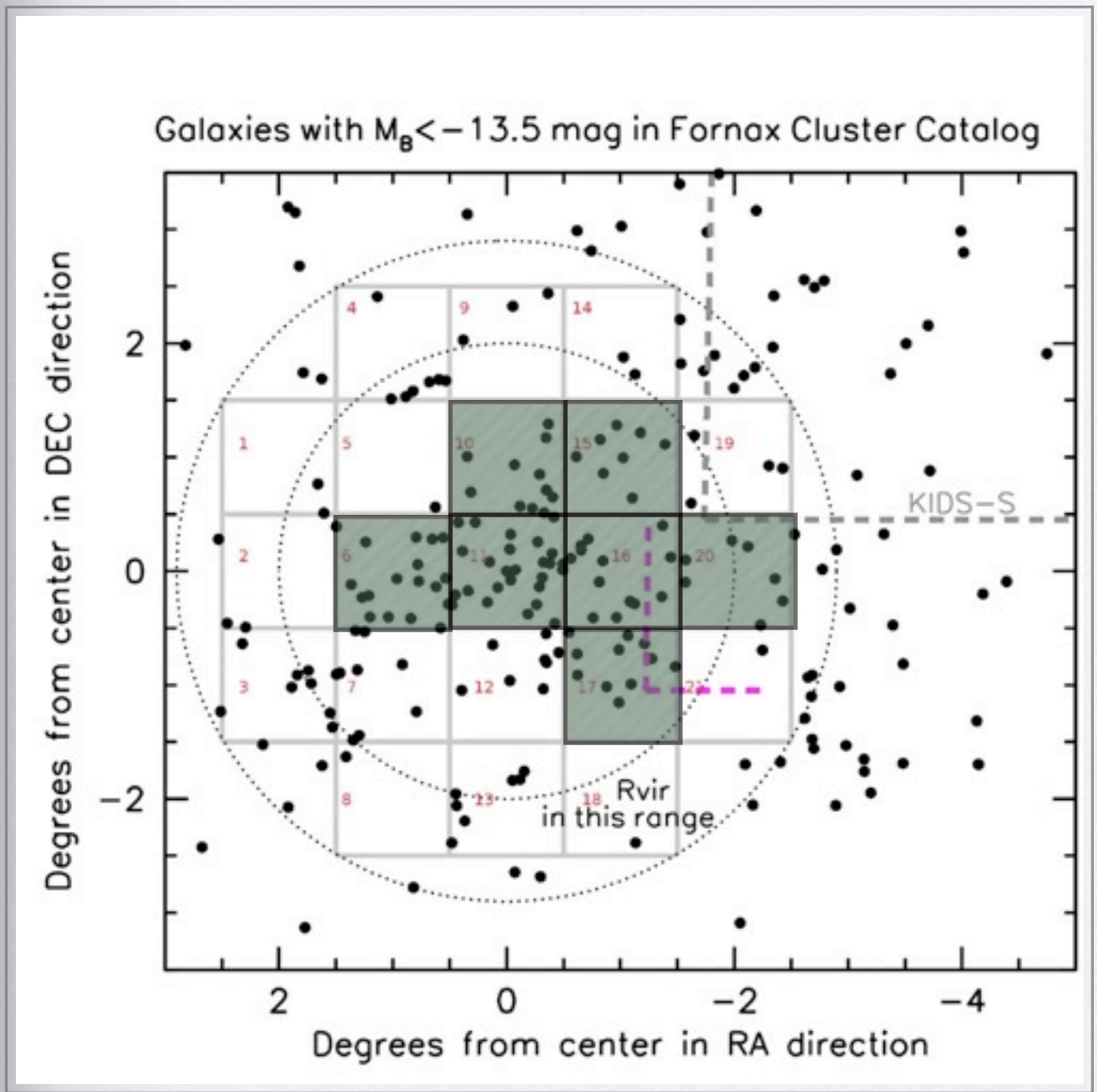


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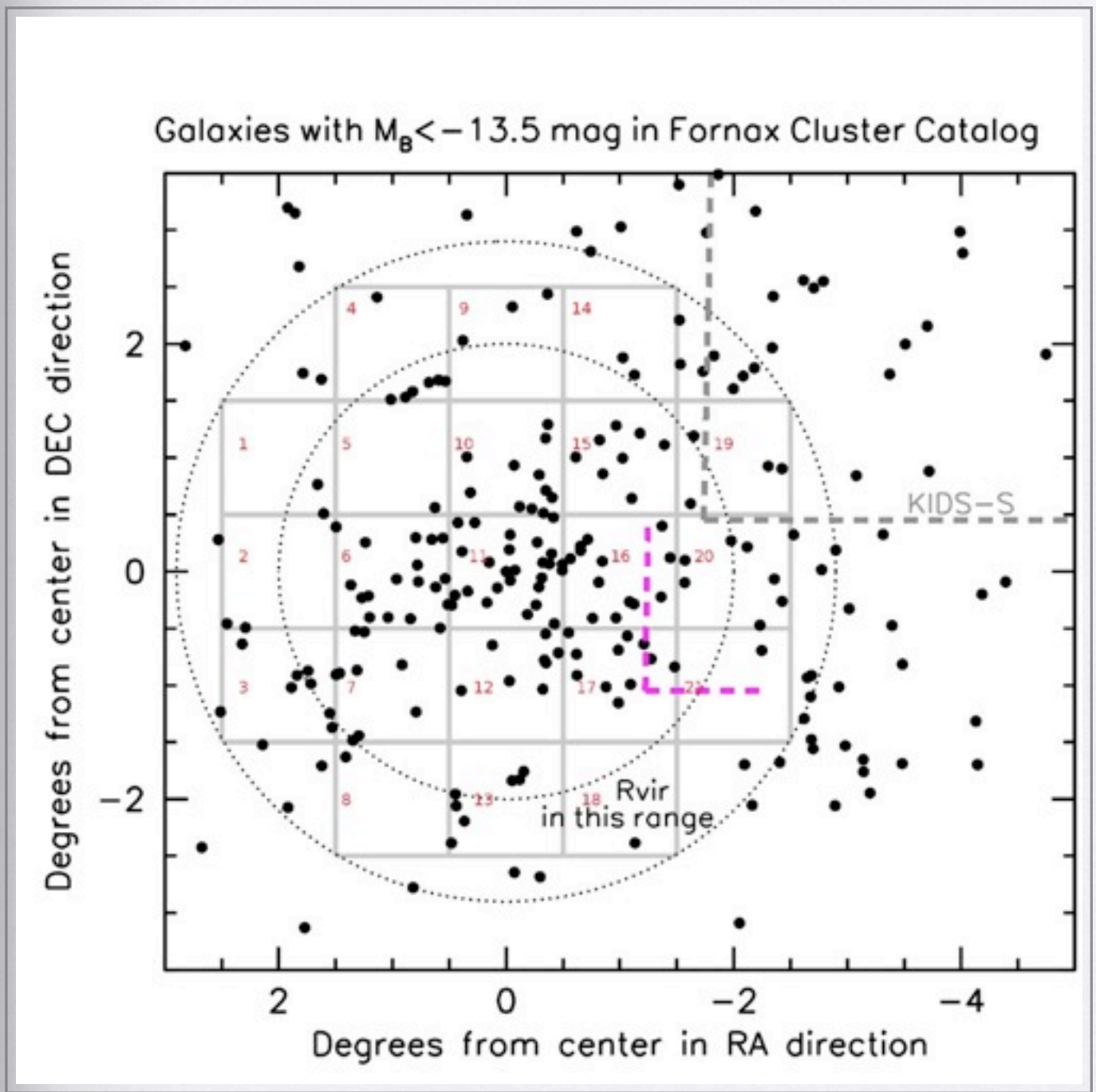


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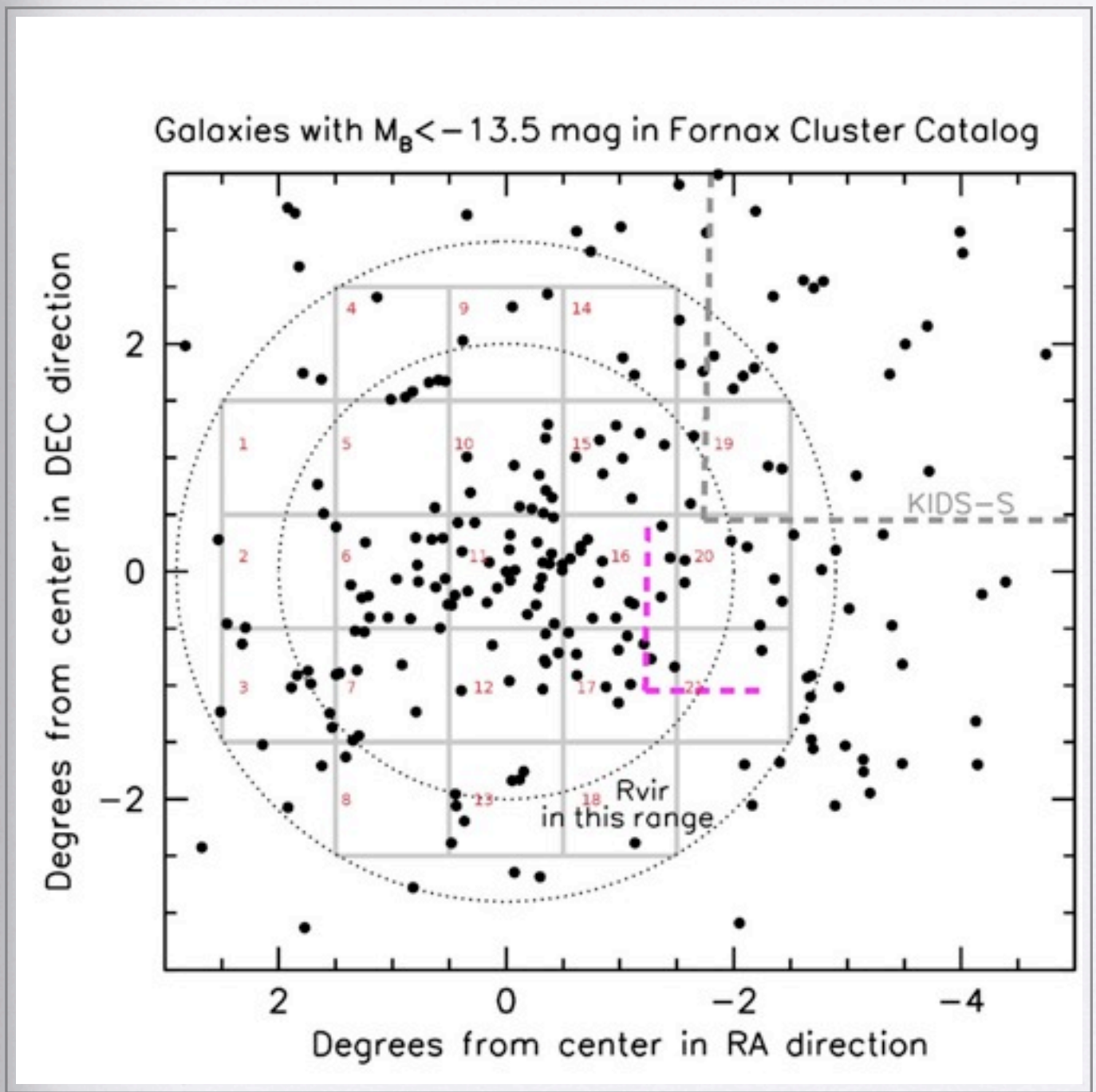


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**ON-OFF observing strategy ~50 exp of 150sec**

**seeing 0.6 - 1.1**

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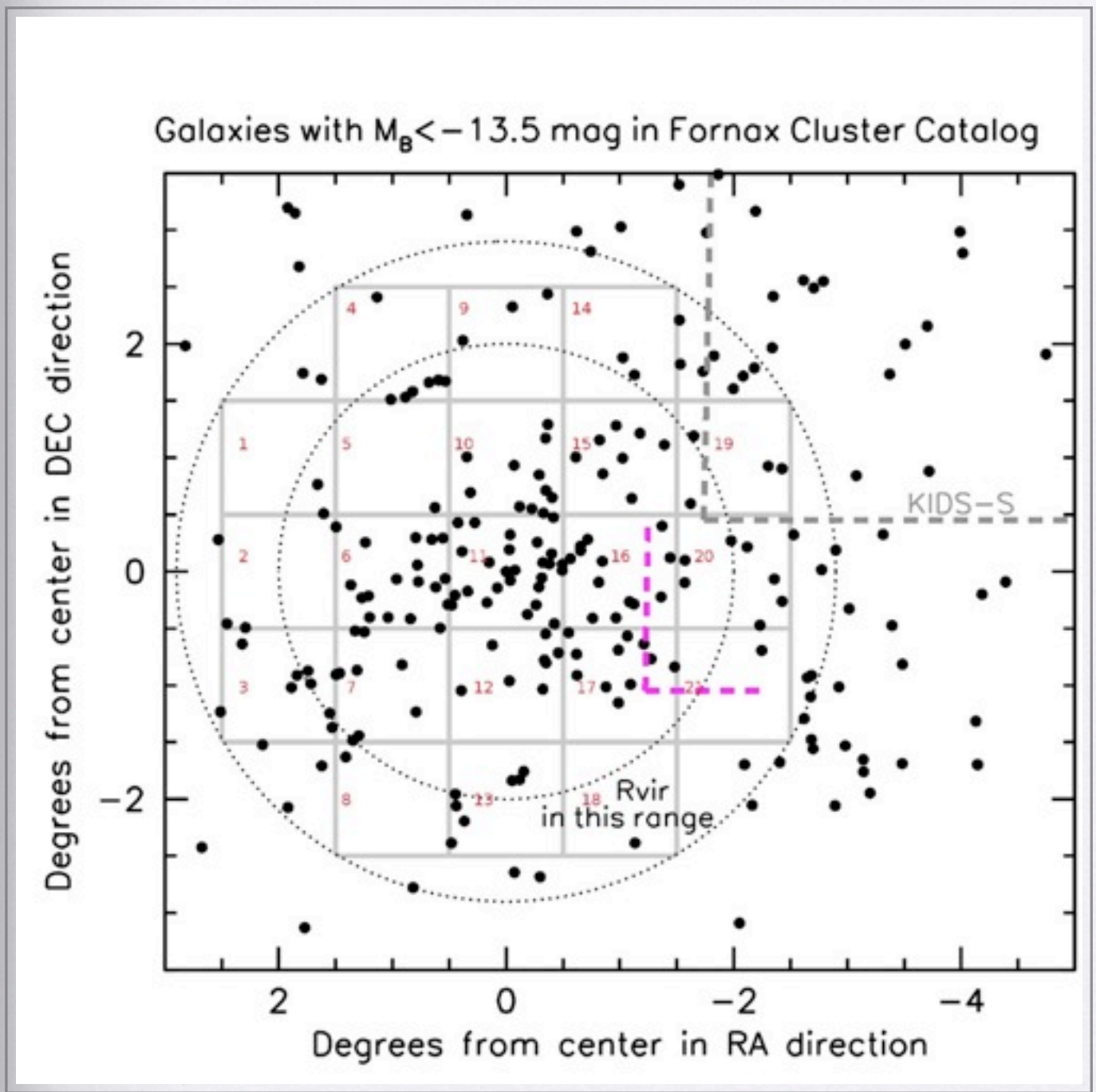


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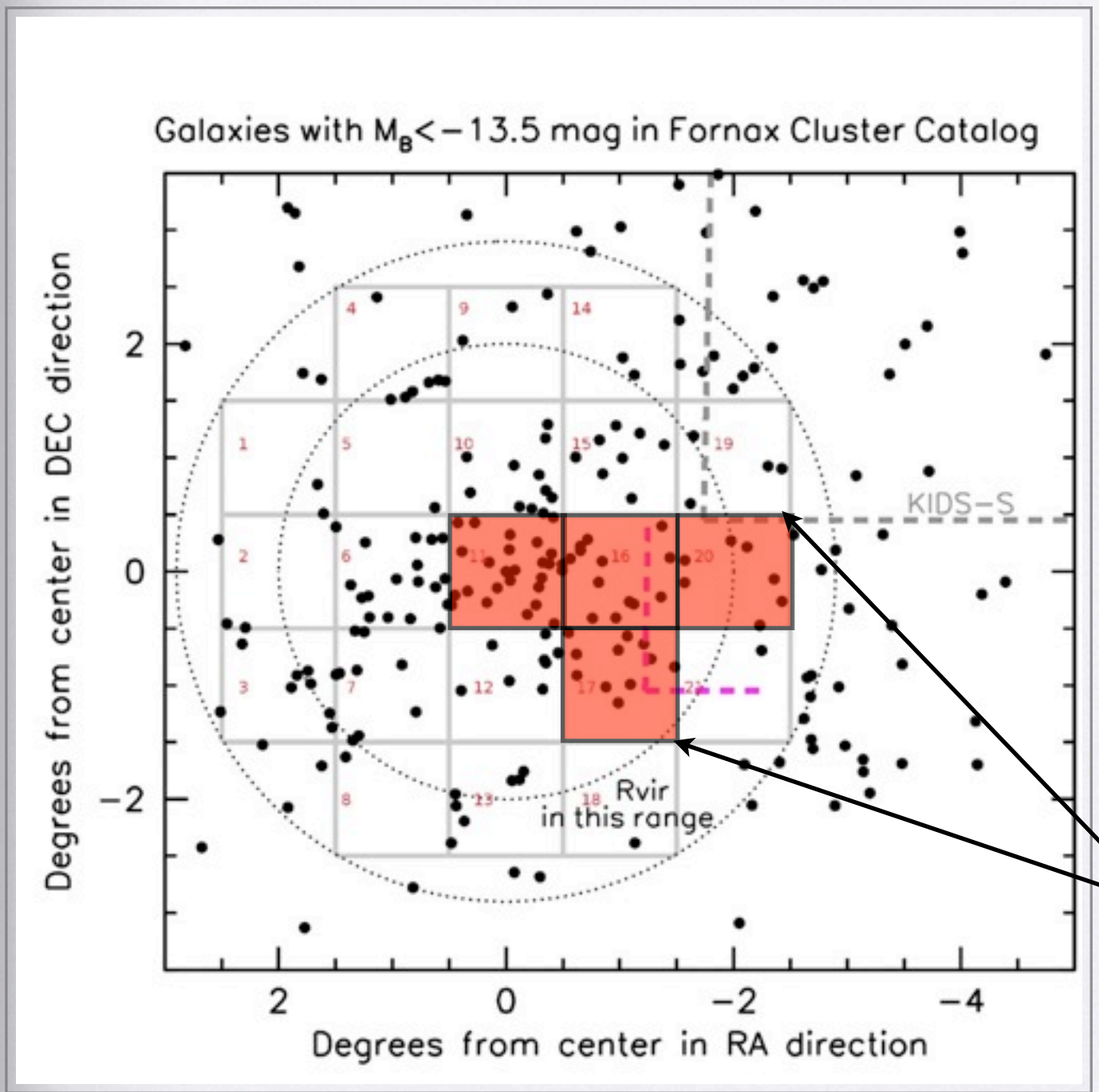


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**ON-OFF observing strategy**
**~50 exp of 150sec**

**seeing 0.6 - 1.1**

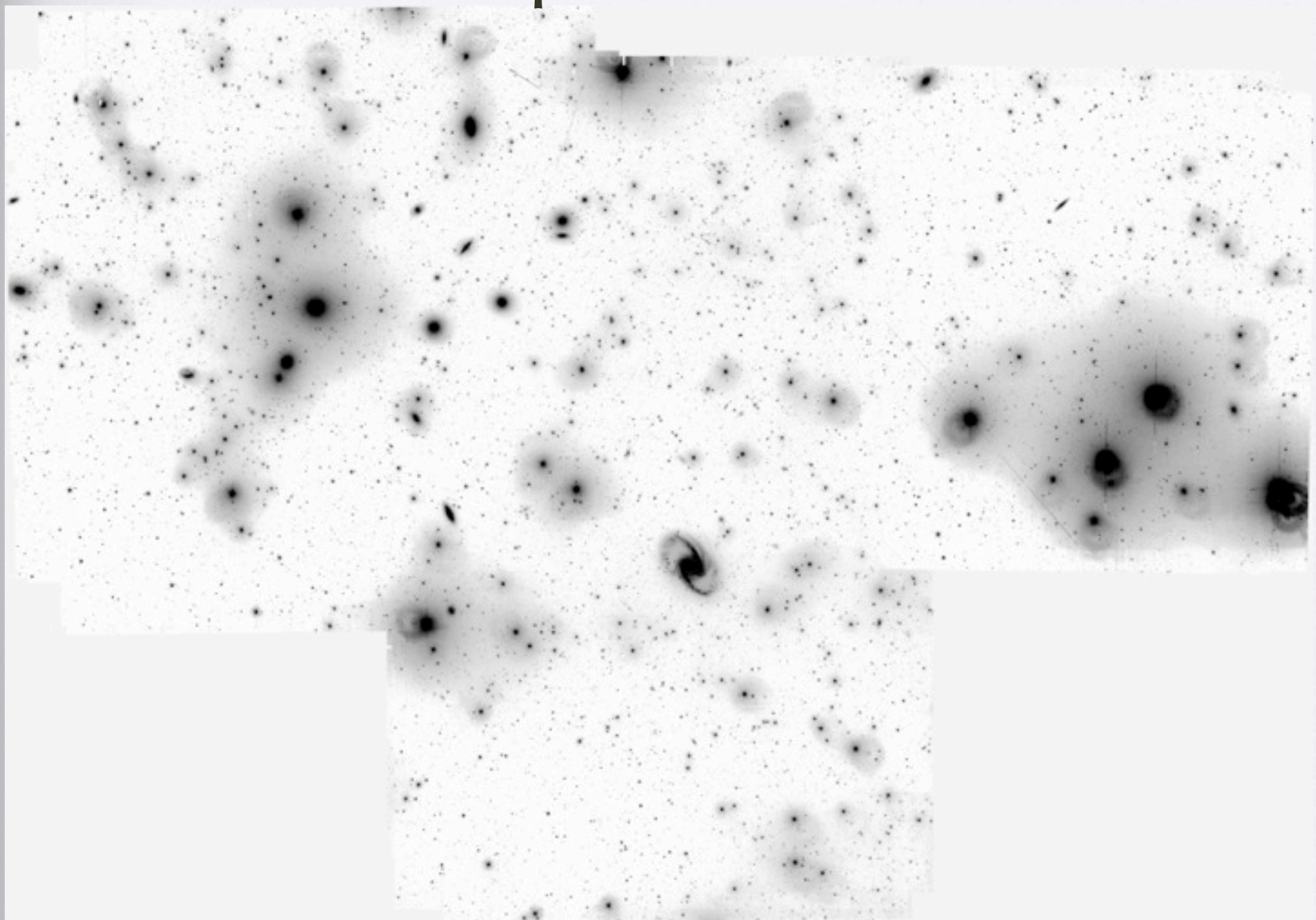
**reduced fields covered area ~3x2 degree²**

# data reduction → VstTube

pipeline developed by
**A.Grado & L. Limatola** at
INAF-OAC Naples

- from raw data to fully calibrated images
- reports on data reduction
- background estimate --> for the ON-OFF strategy an average background image is obtained for each night

# New Deep Fornax mosaic



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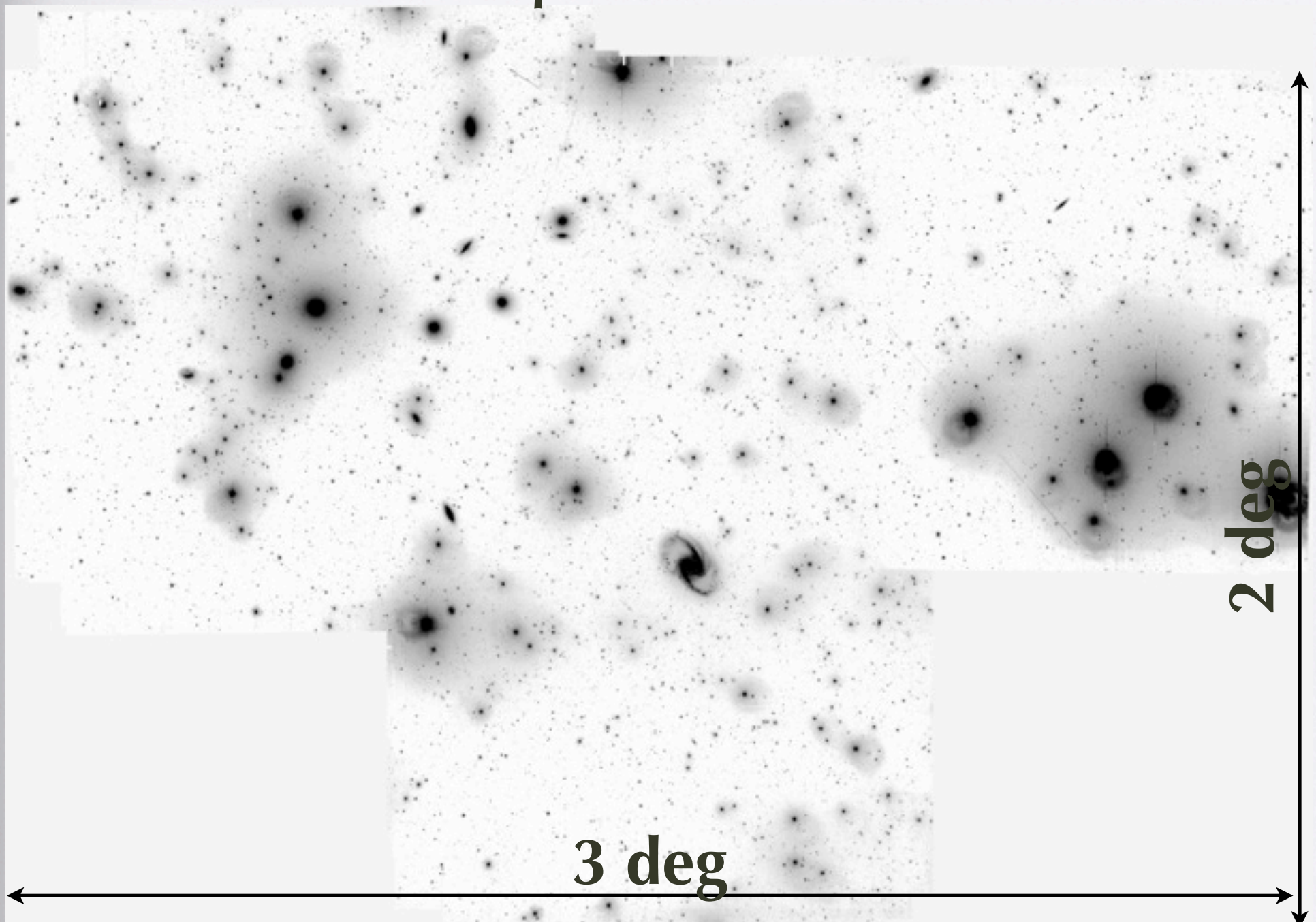

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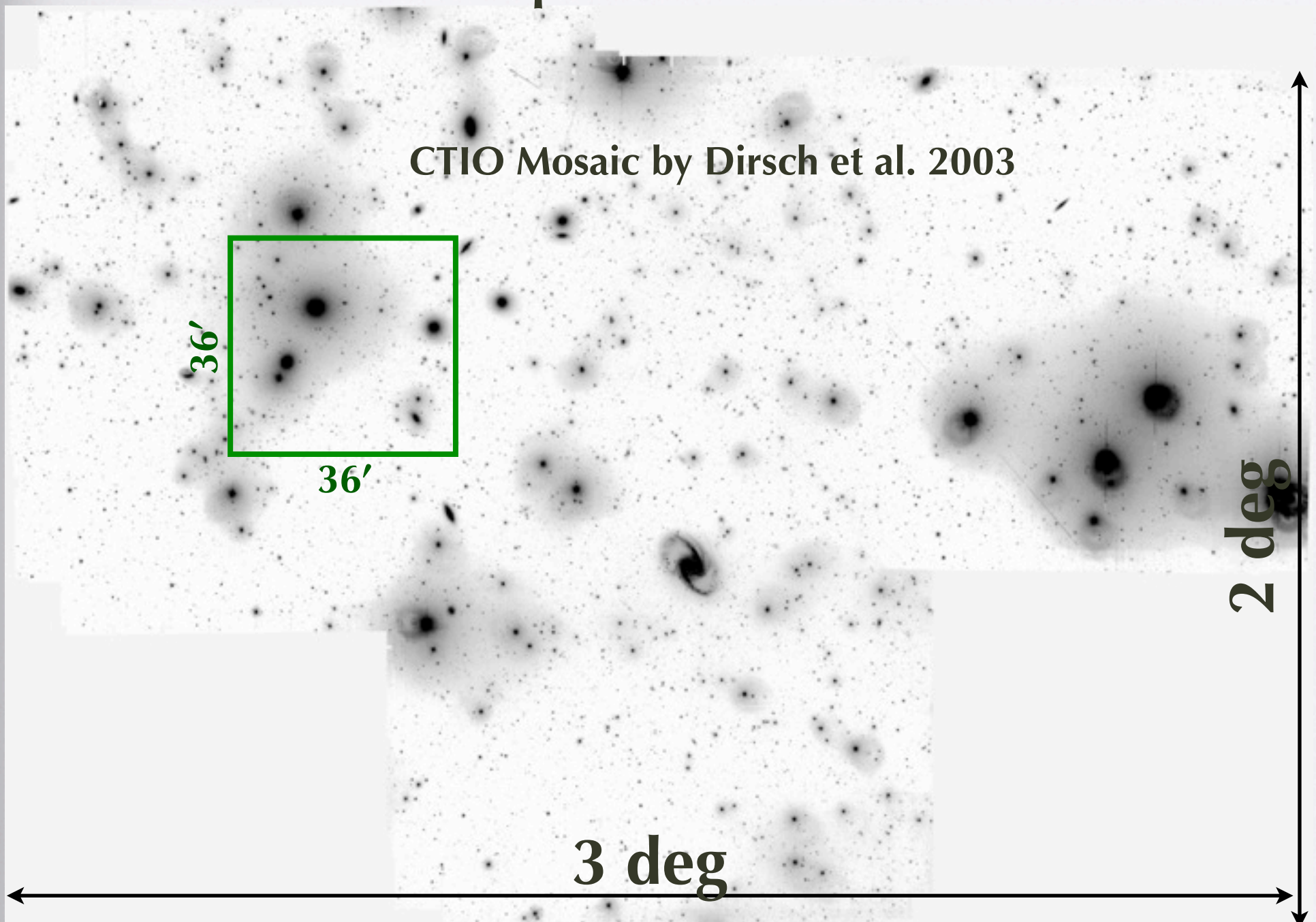

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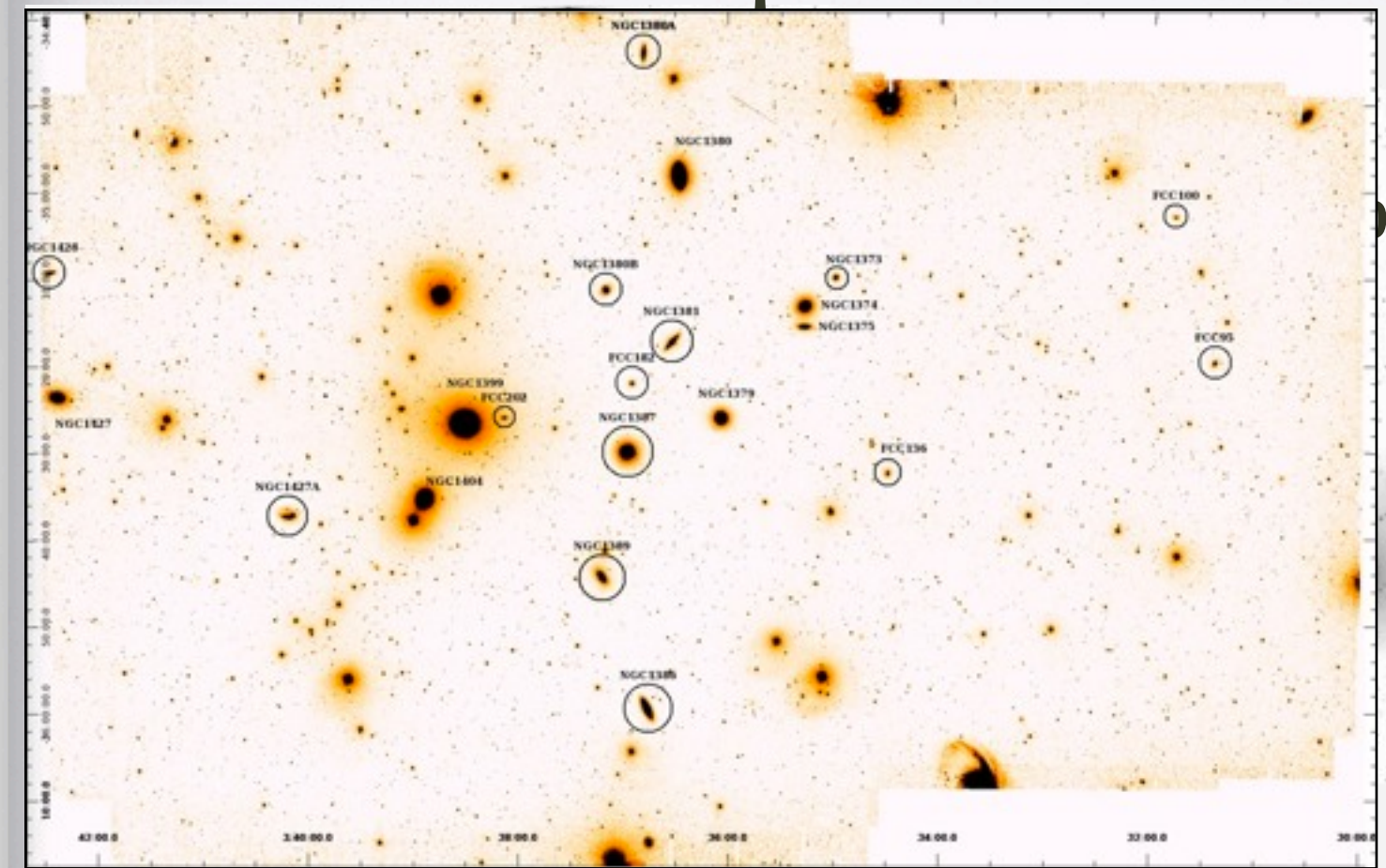


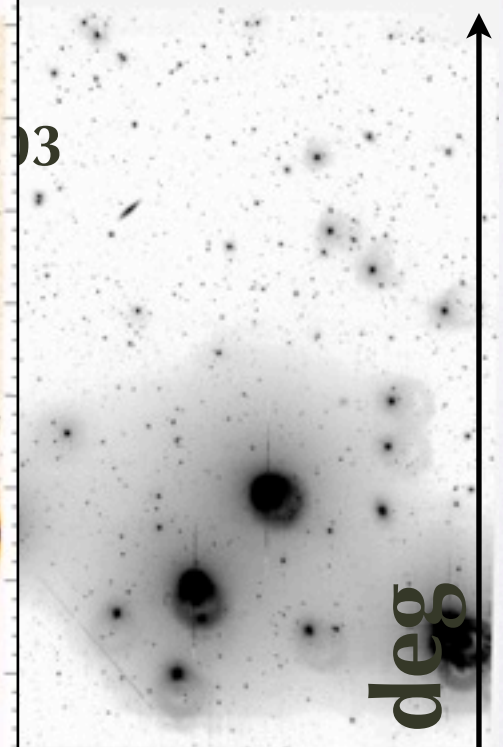

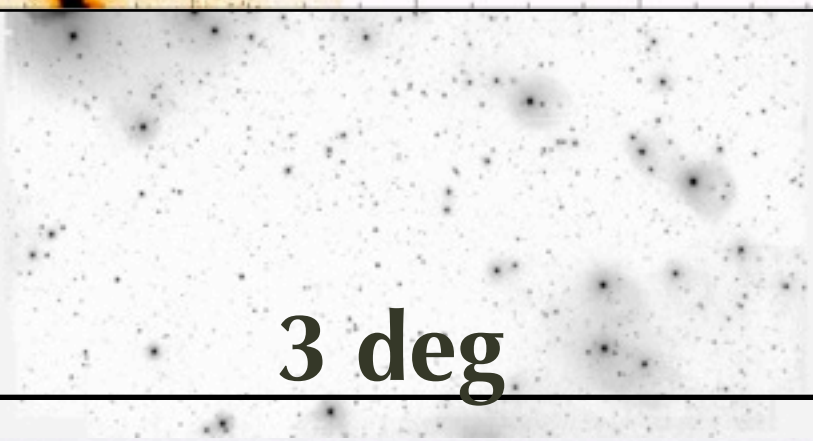

2 deg

3 deg

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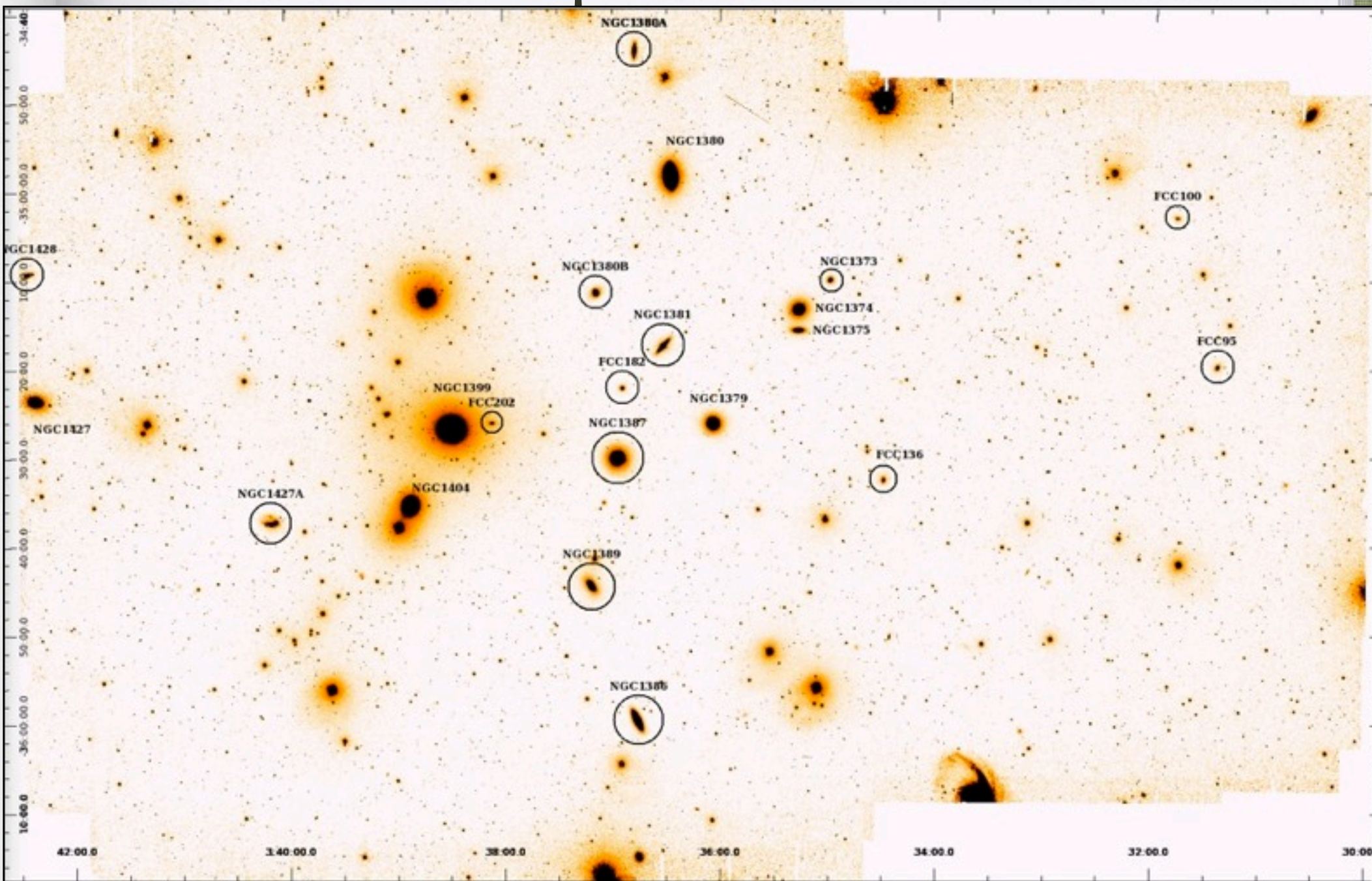
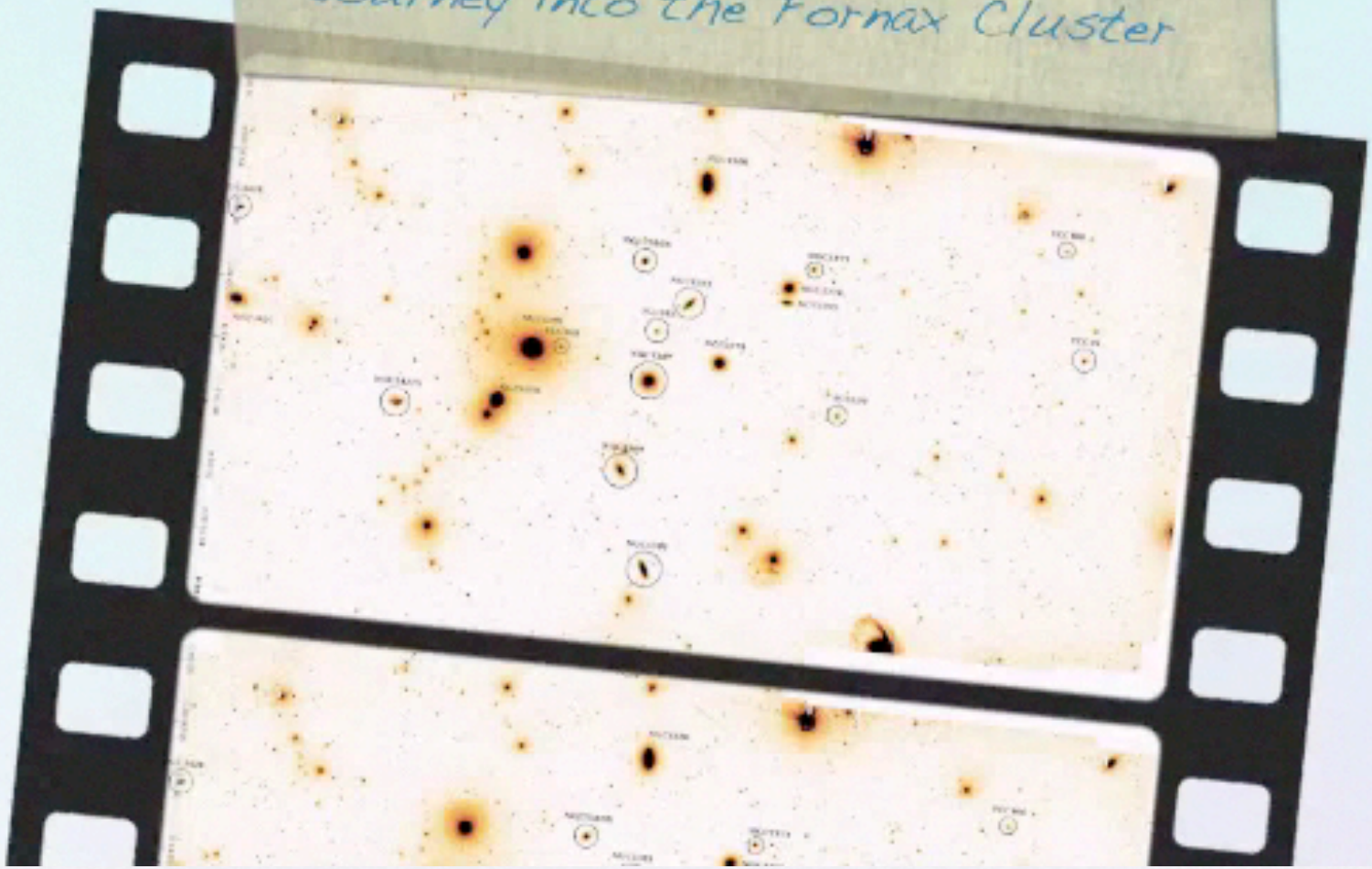


# Journey into the Fornax Cluster



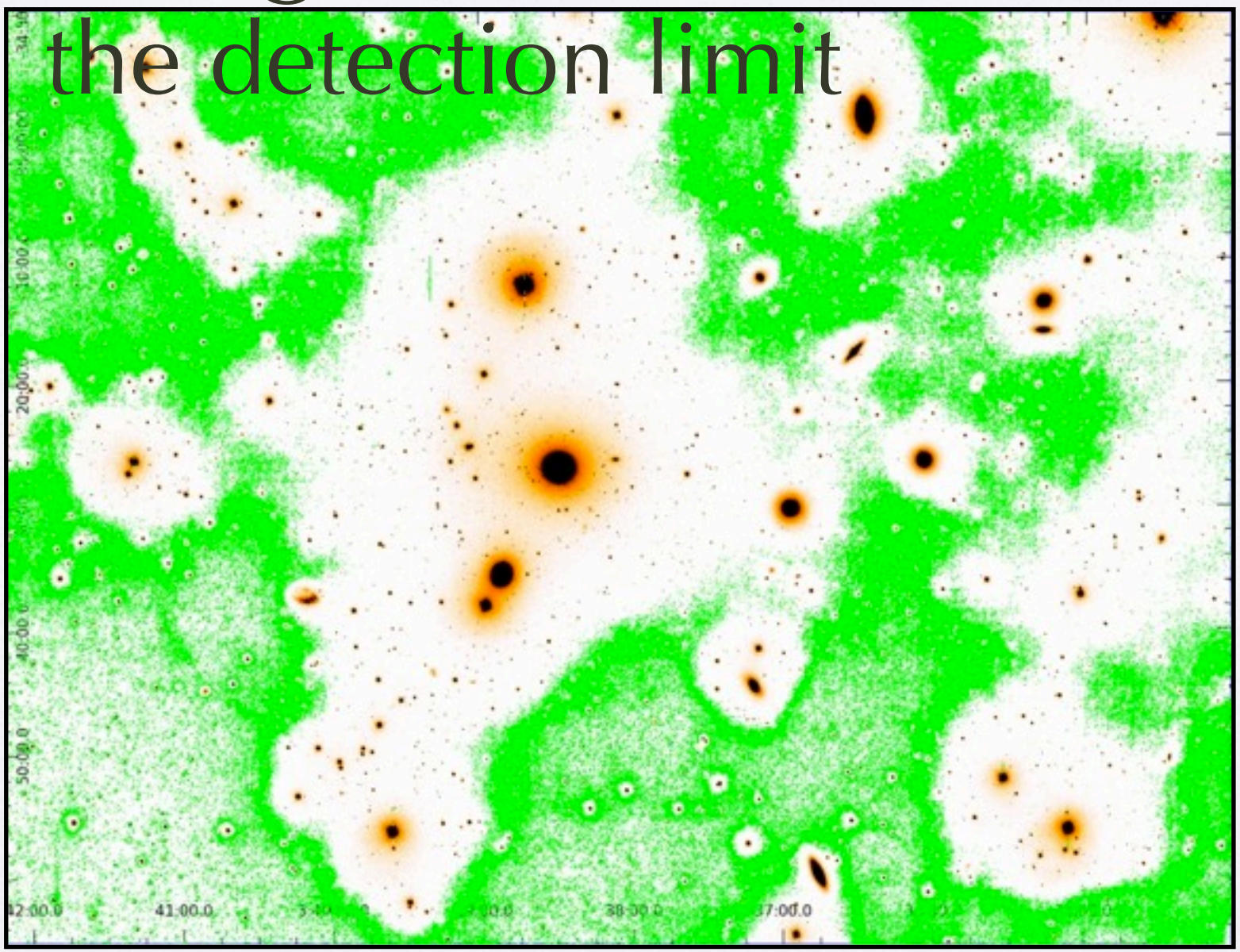
# Surface Photometry: method

- as a first step, every bright sources on all scales (from stars to galaxies and background objects) were accurately masked, thus excluded from the fit

- estimate the outer radius $R_{lim}$ where the galaxy light blends into the sky level

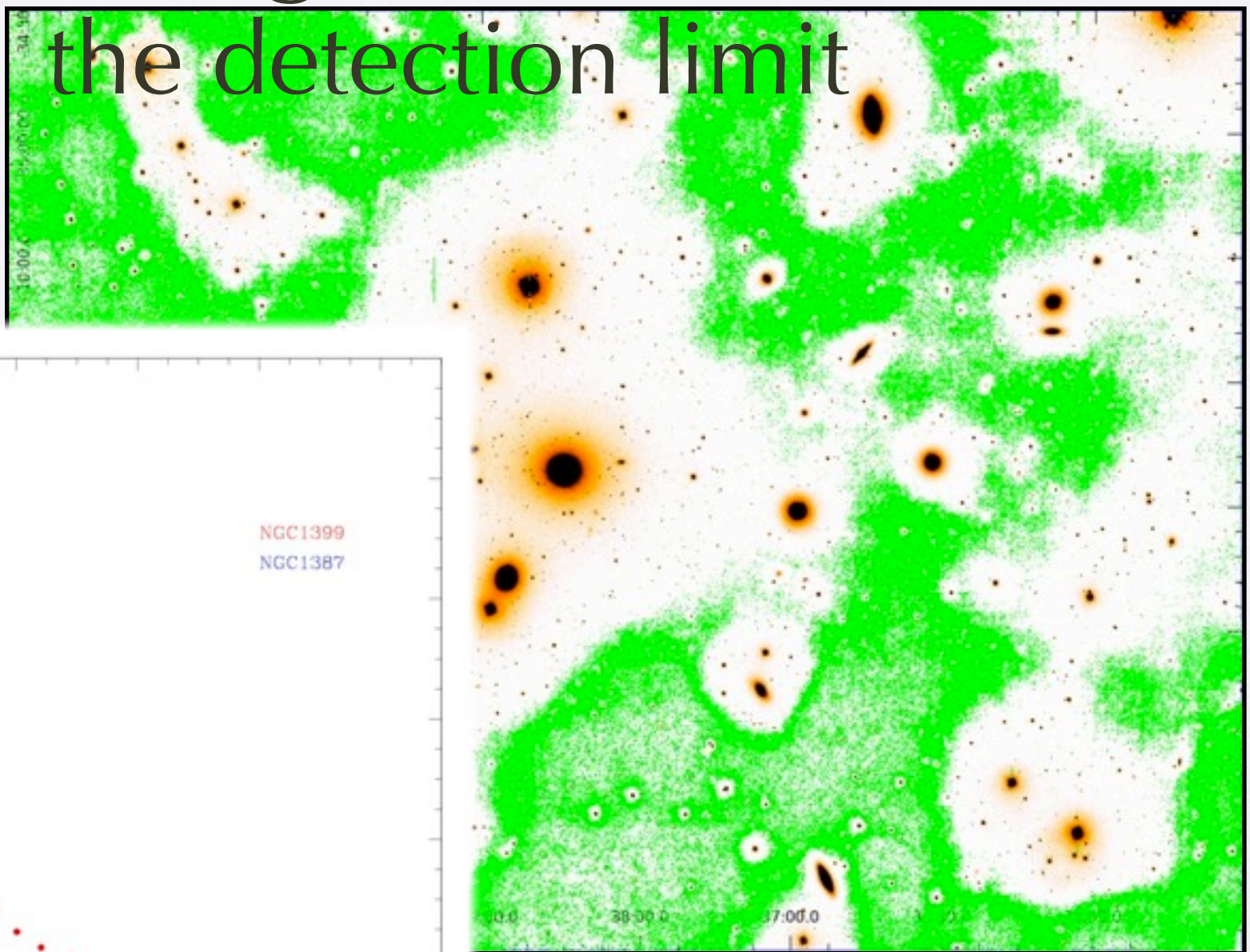
- the **azimuthally averaged SB profiles**, PA and ellipticity profiles, are obtained by the fit of isophotes in elliptical annuli, up to the $R_{lim}$

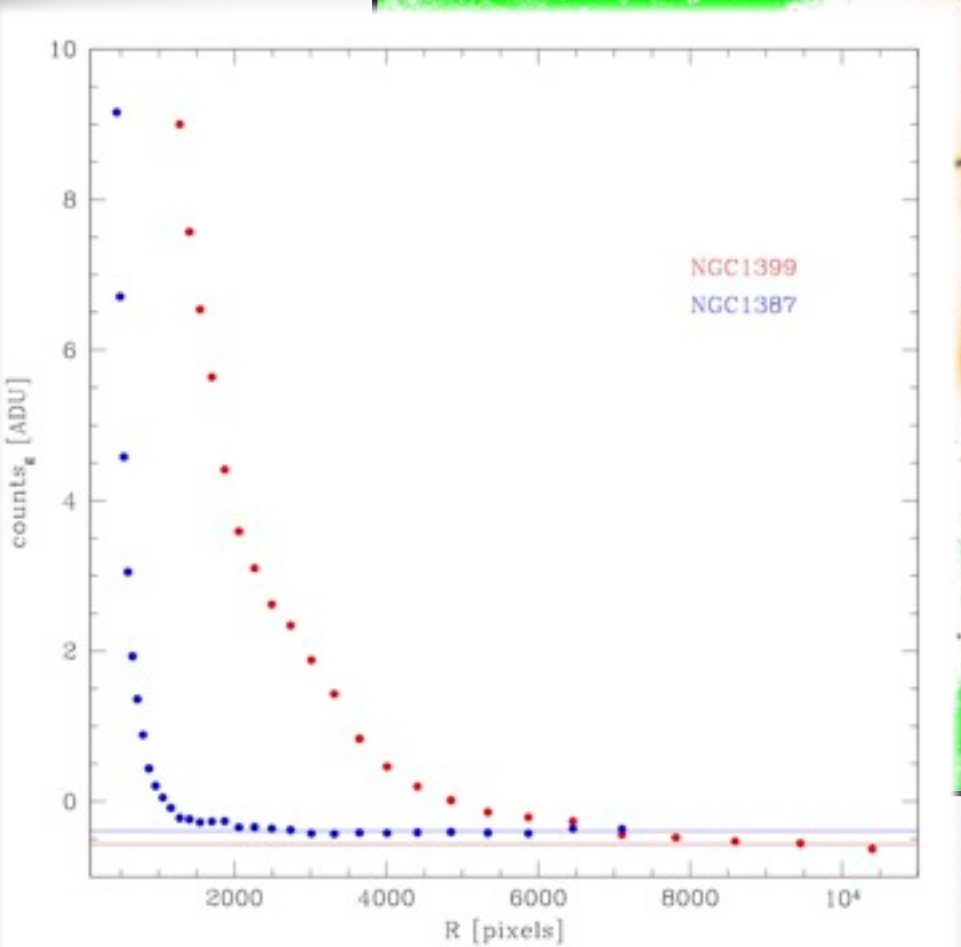
# Where galaxies ends?



# Where galaxies ends?

## the detection limit

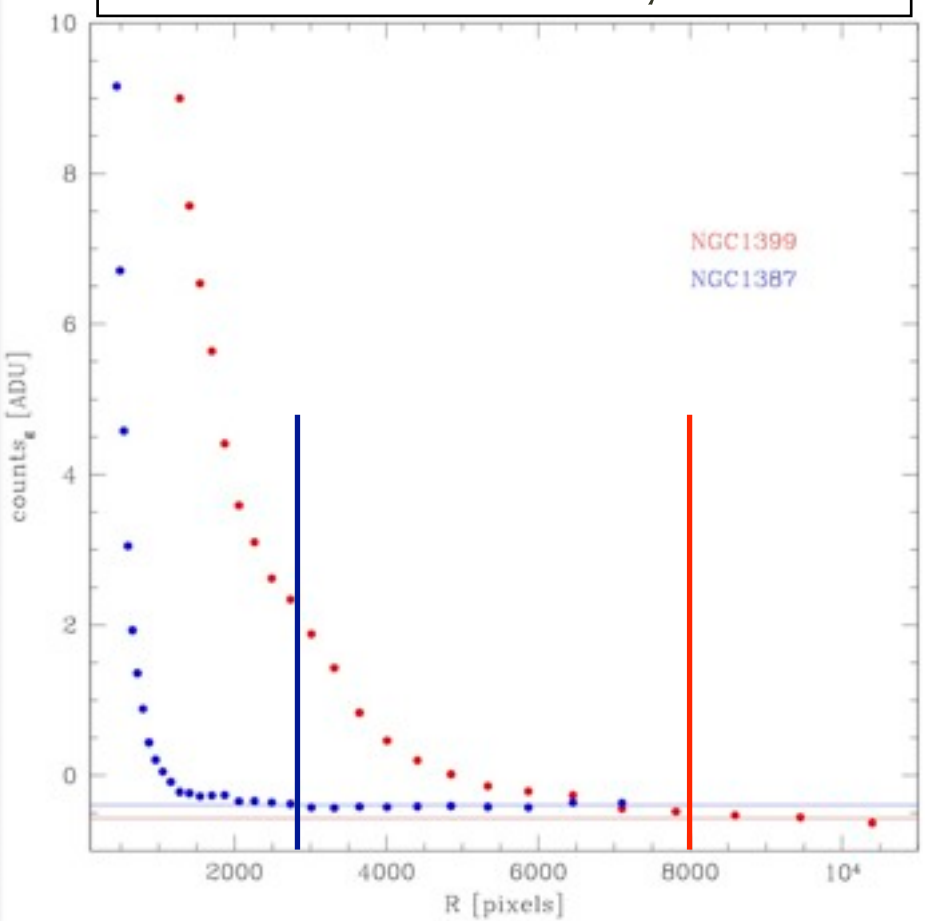


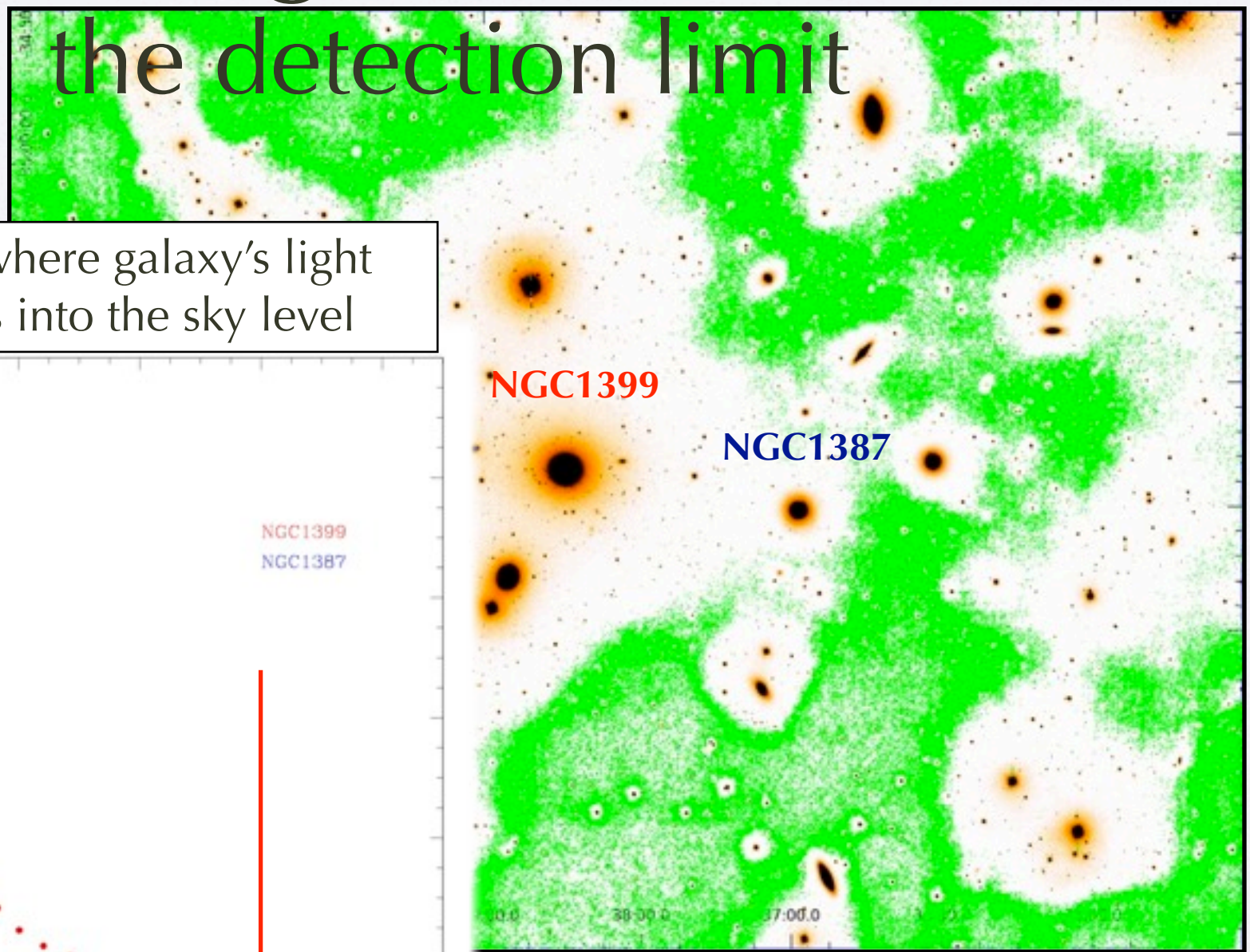


# Where galaxies ends?

## the detection limit

limits where galaxy's light blends into the sky level



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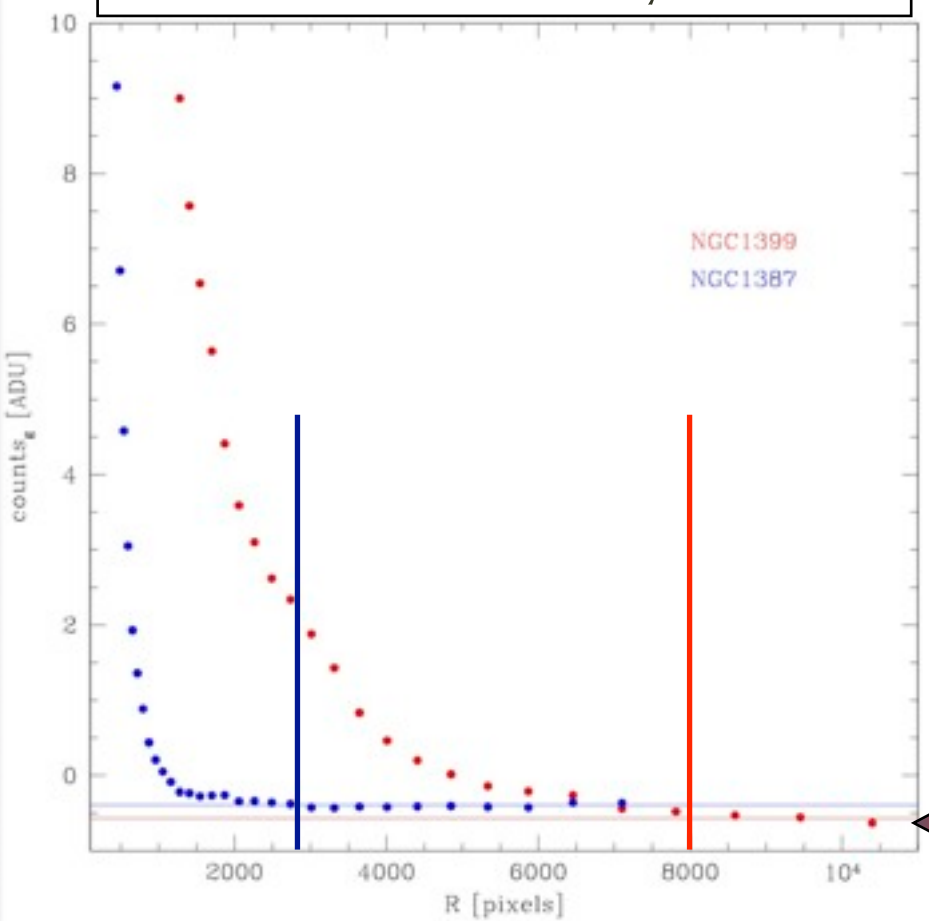
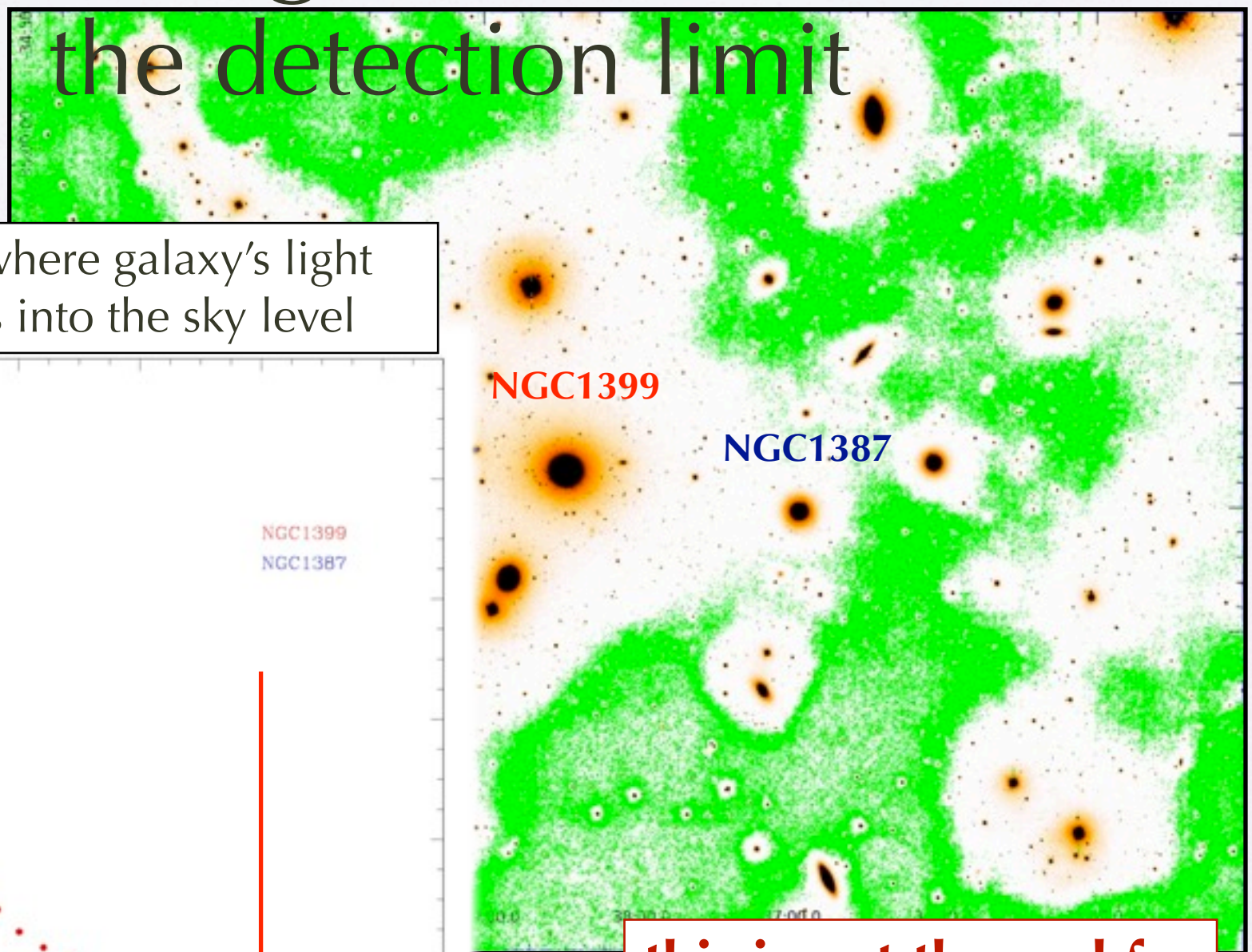
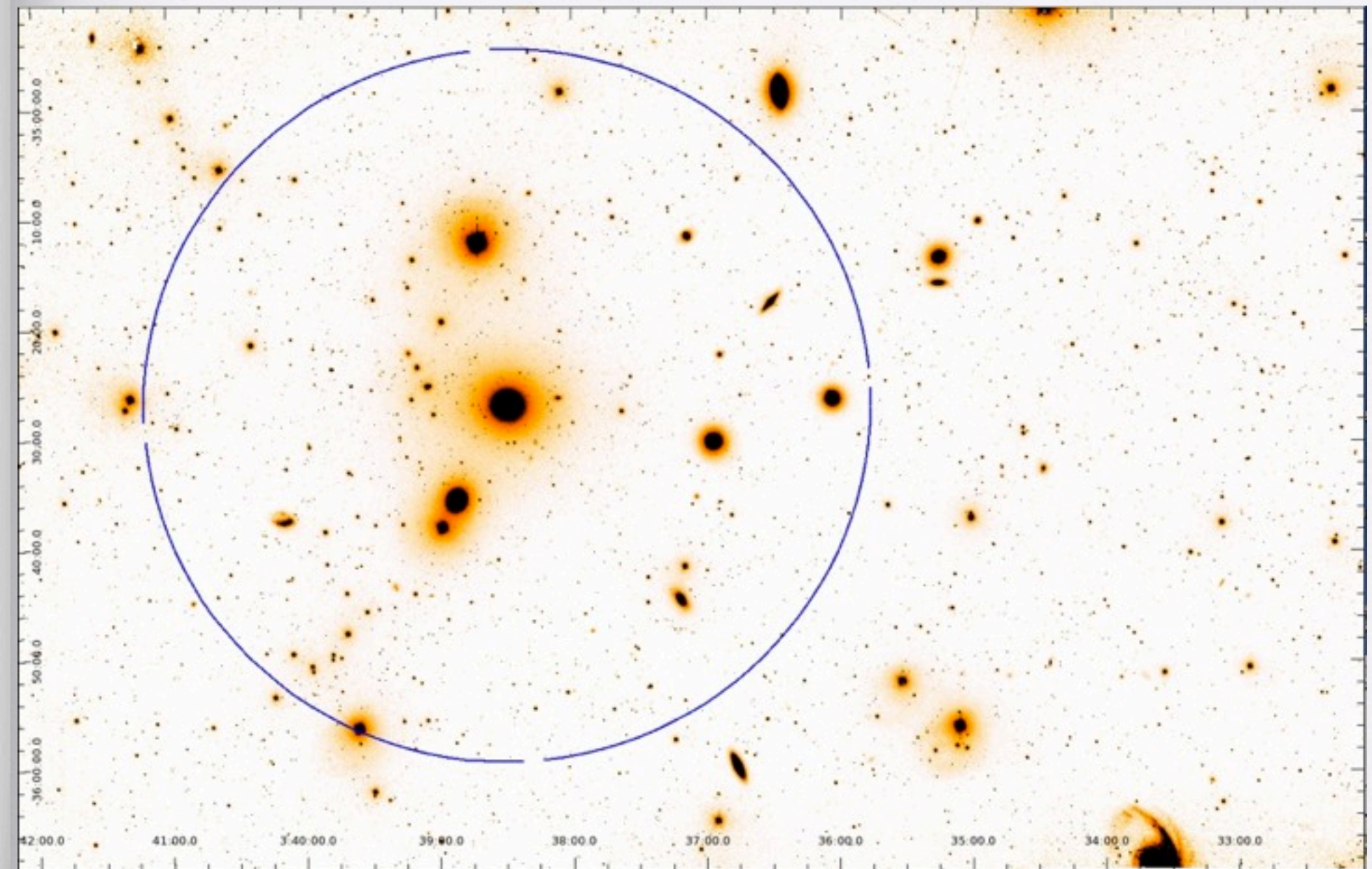



**this is not the end for NGC1399...!!**

# Where galaxies ends?
## the halo "around" NGC1399



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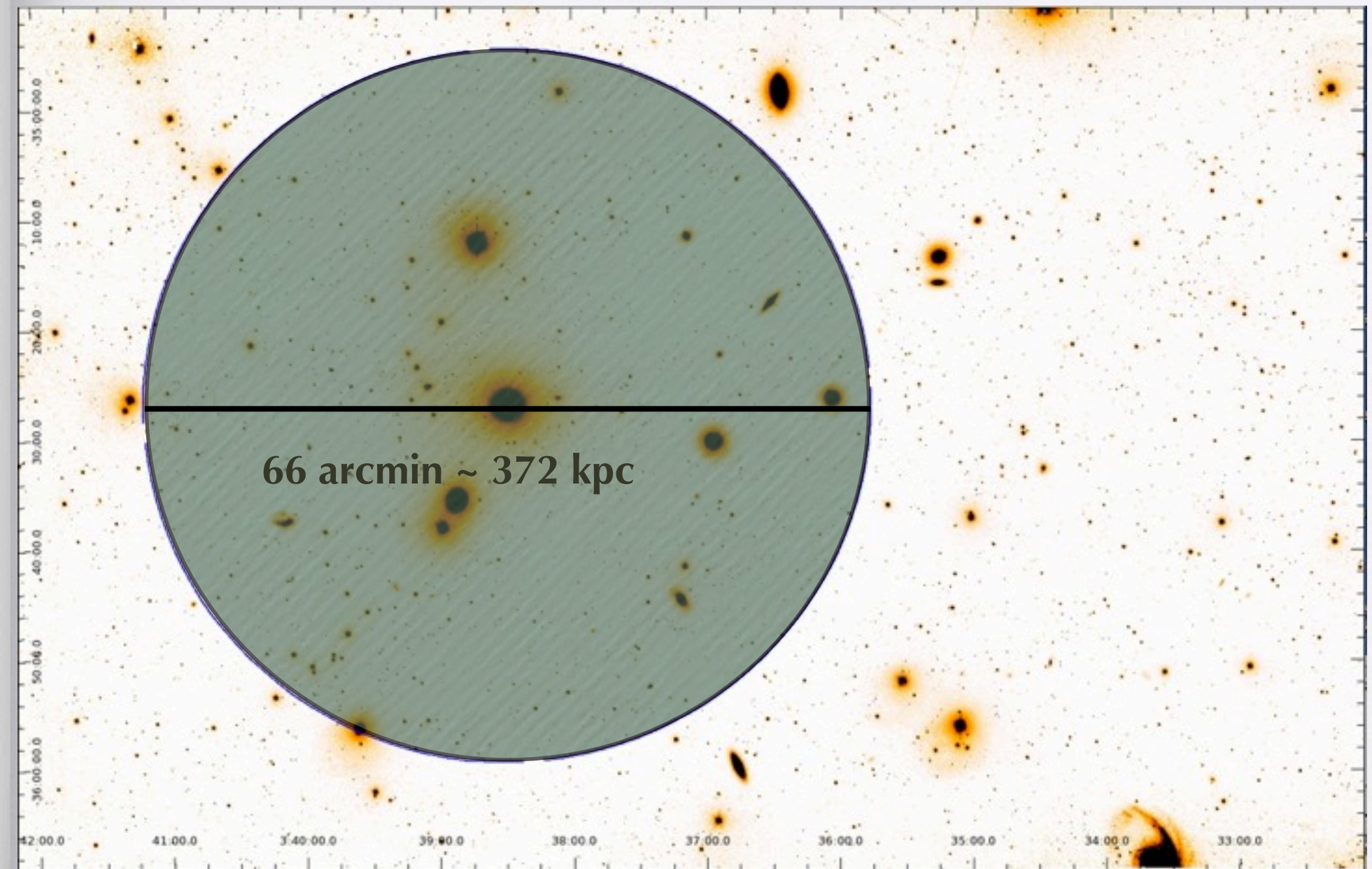
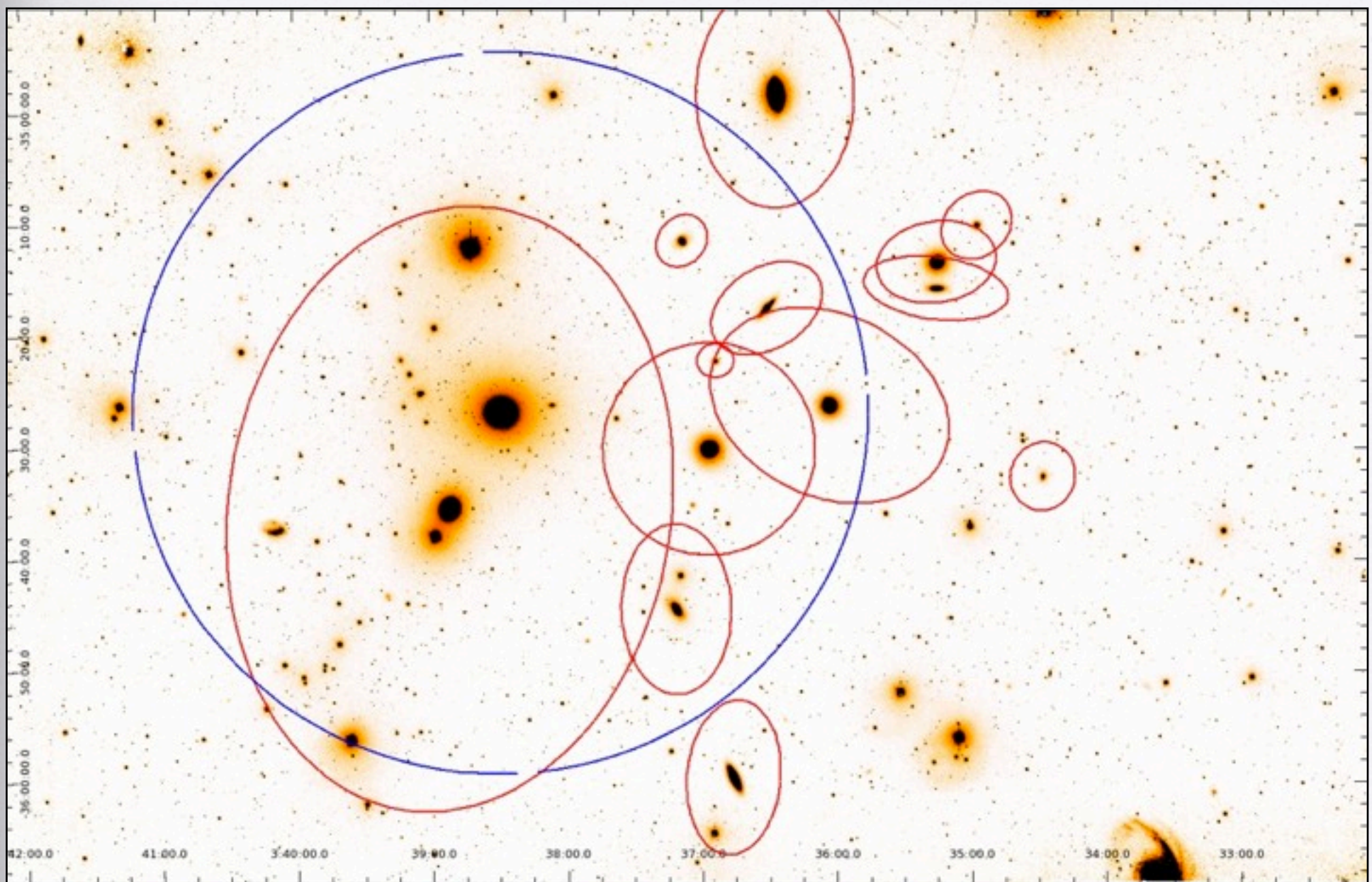


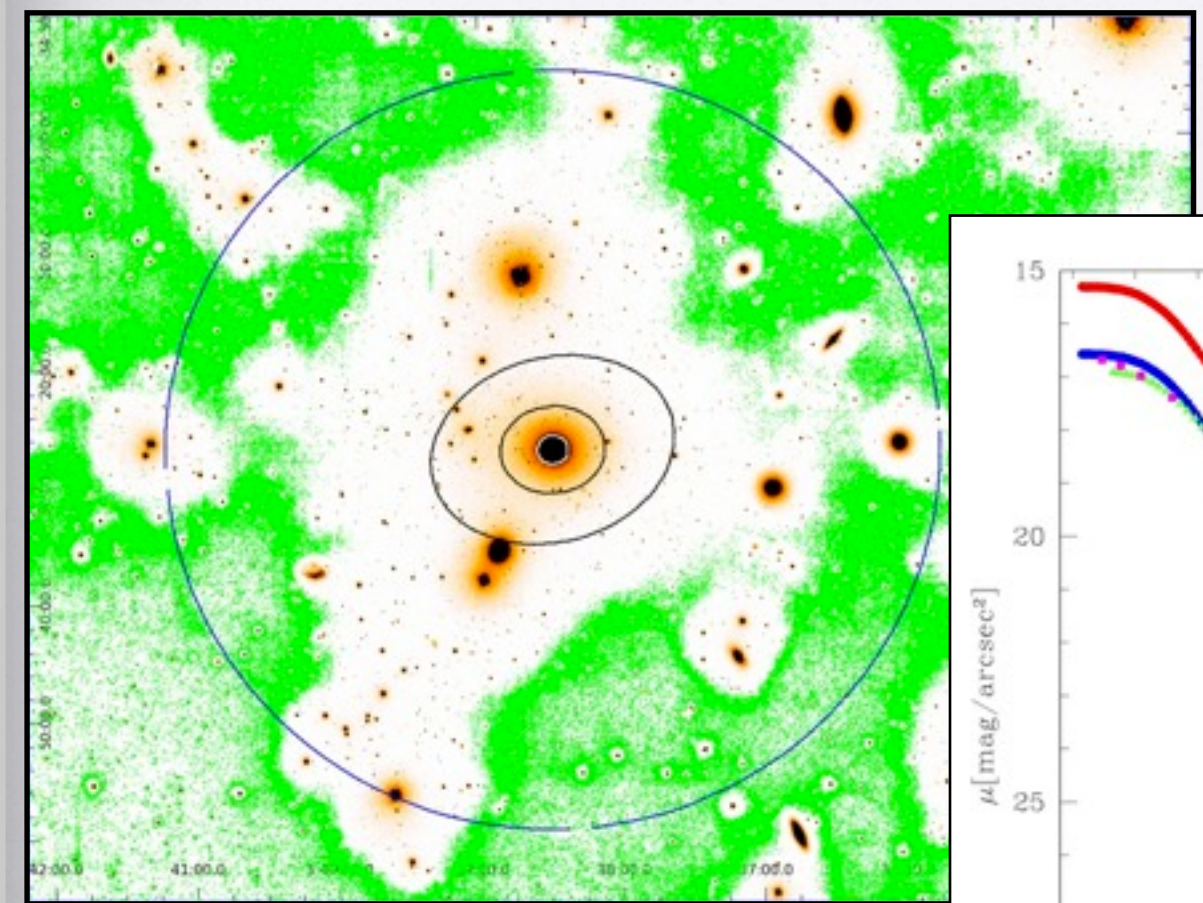
# Where galaxies ends?

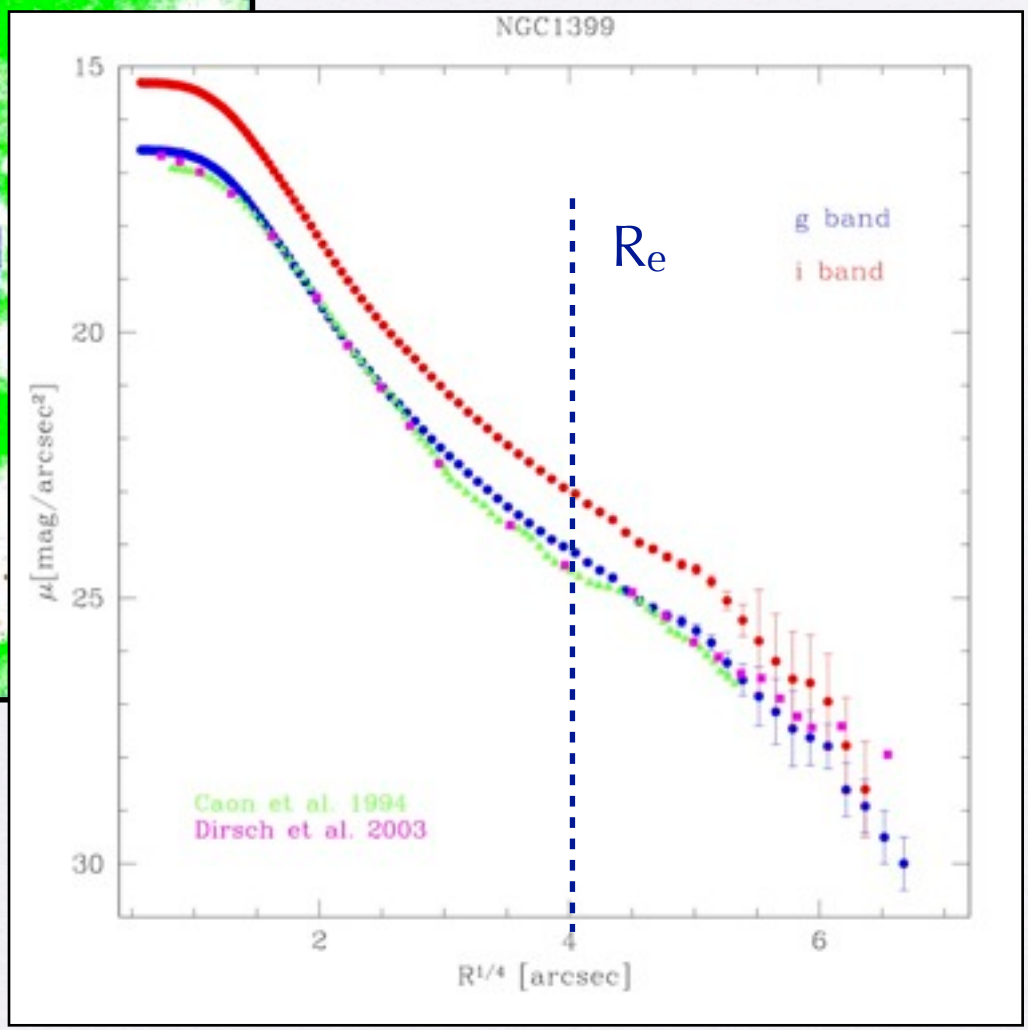
## halos of galaxies in the core of the Fornax cluster



# Light distribution:

## NGC1399





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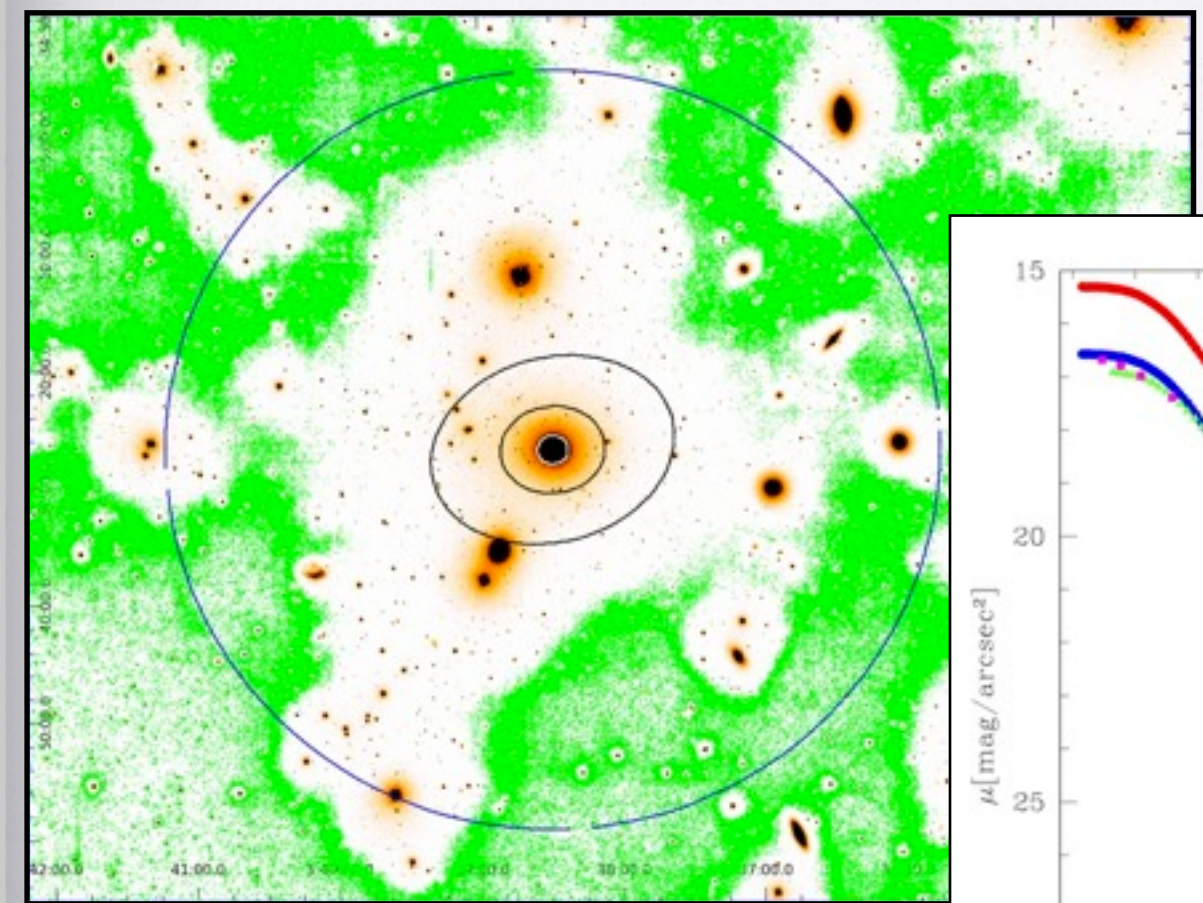

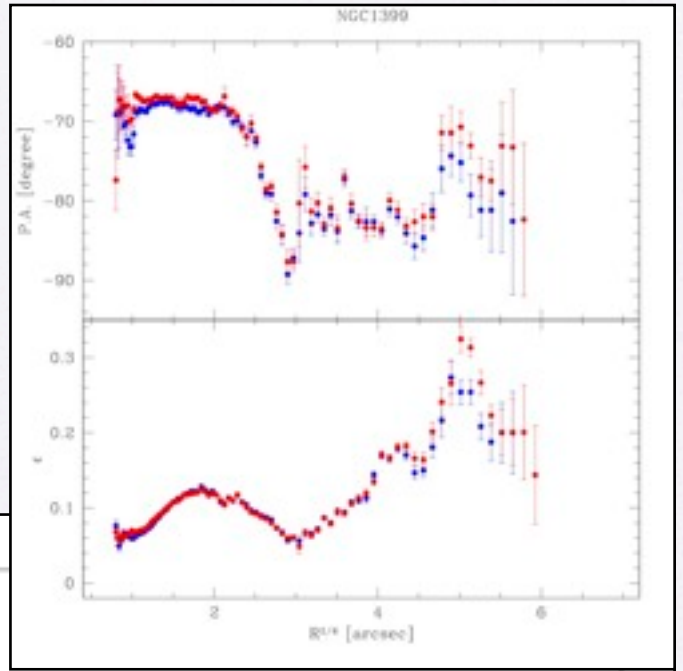


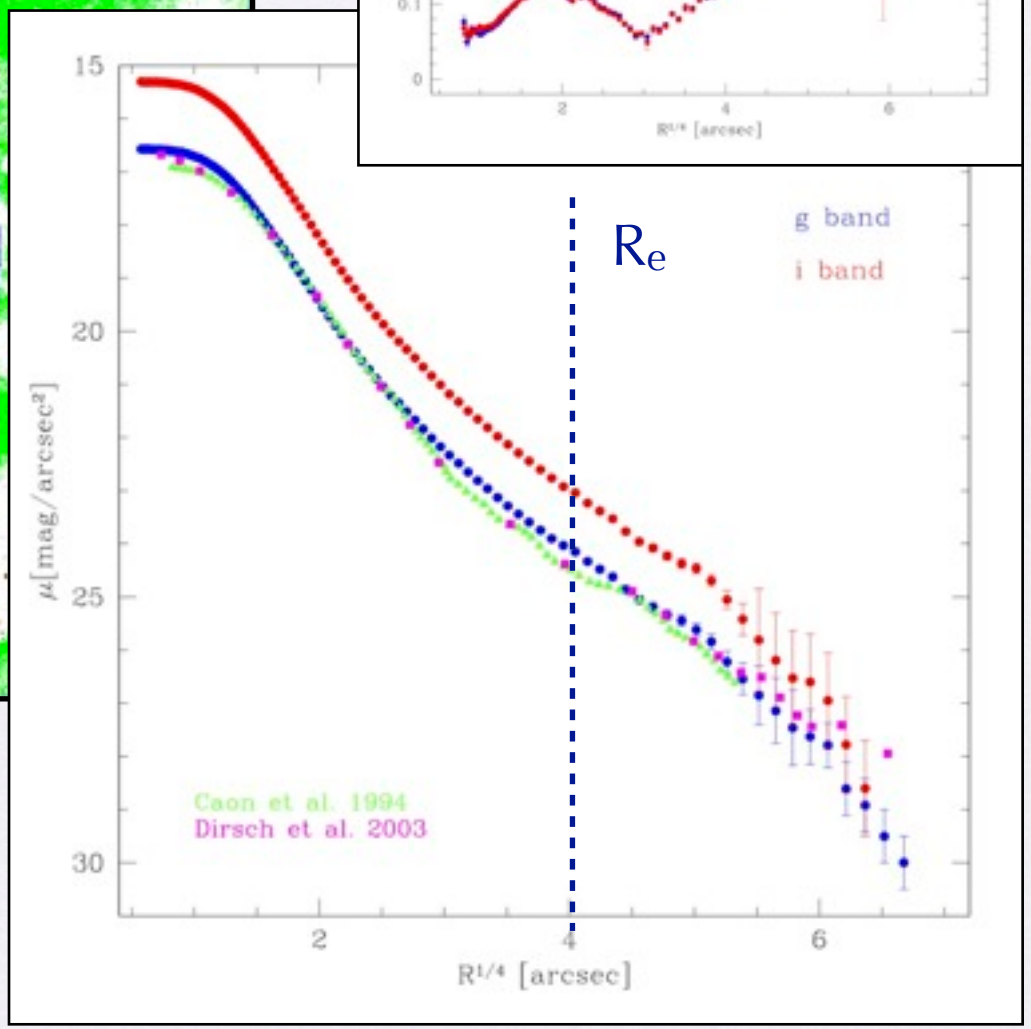

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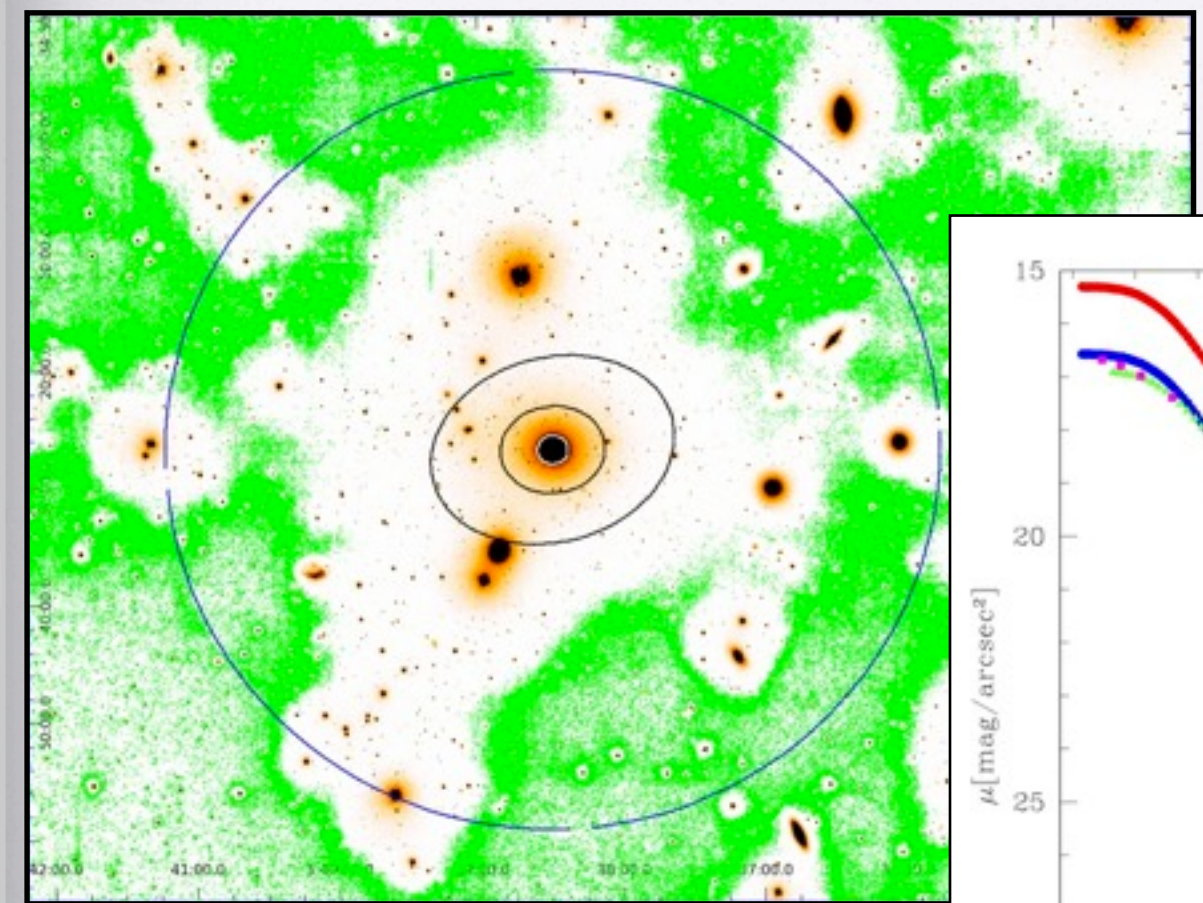

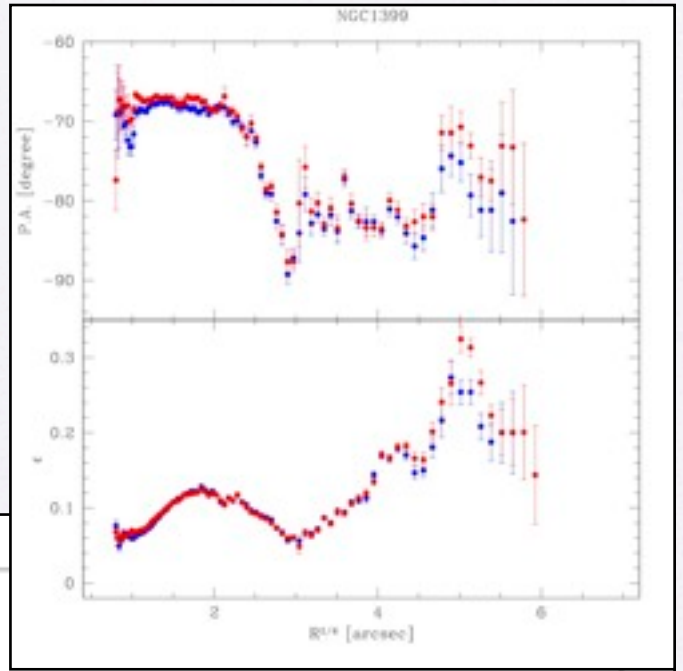


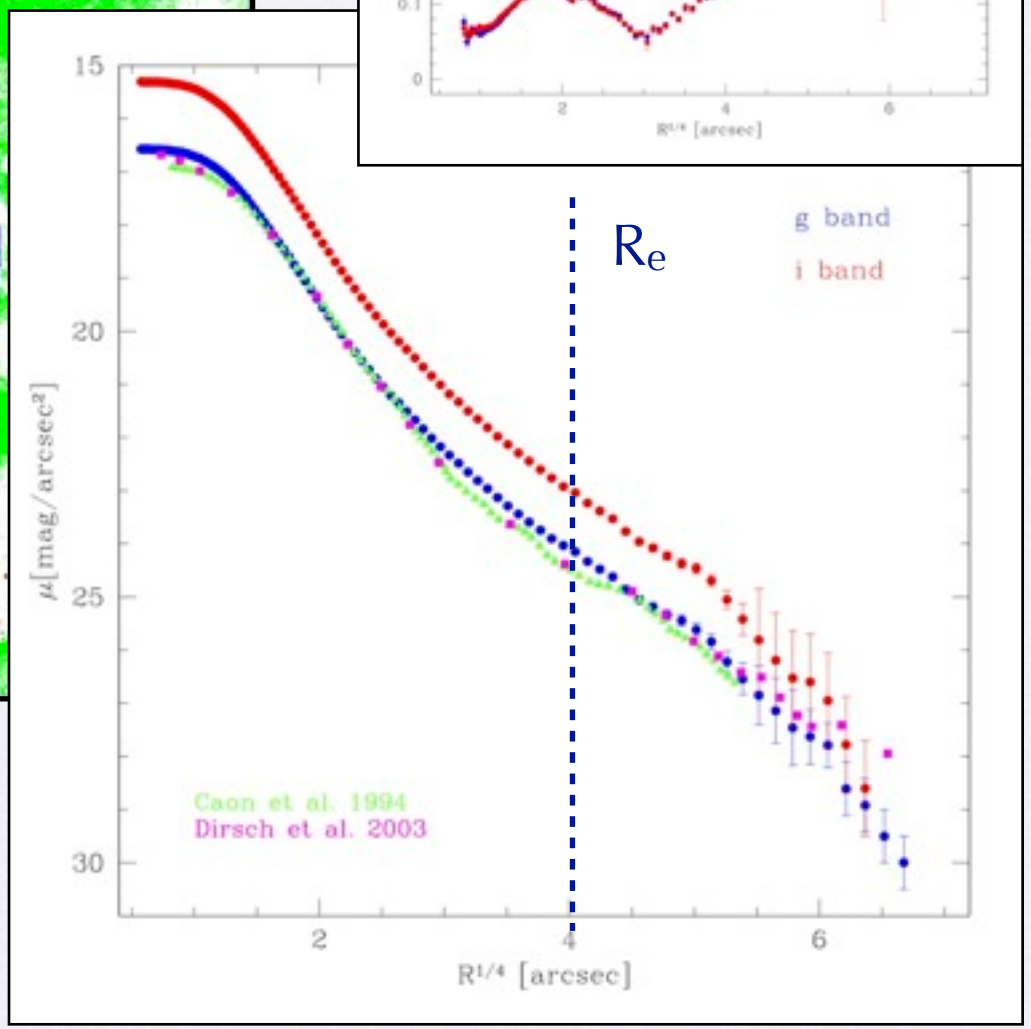


$\mu^{g}_{lim} \sim 30$ mag/arcsec$^2$

$\mu^{i}_{lim} \sim 28.7$ mag/arcsec$^2$

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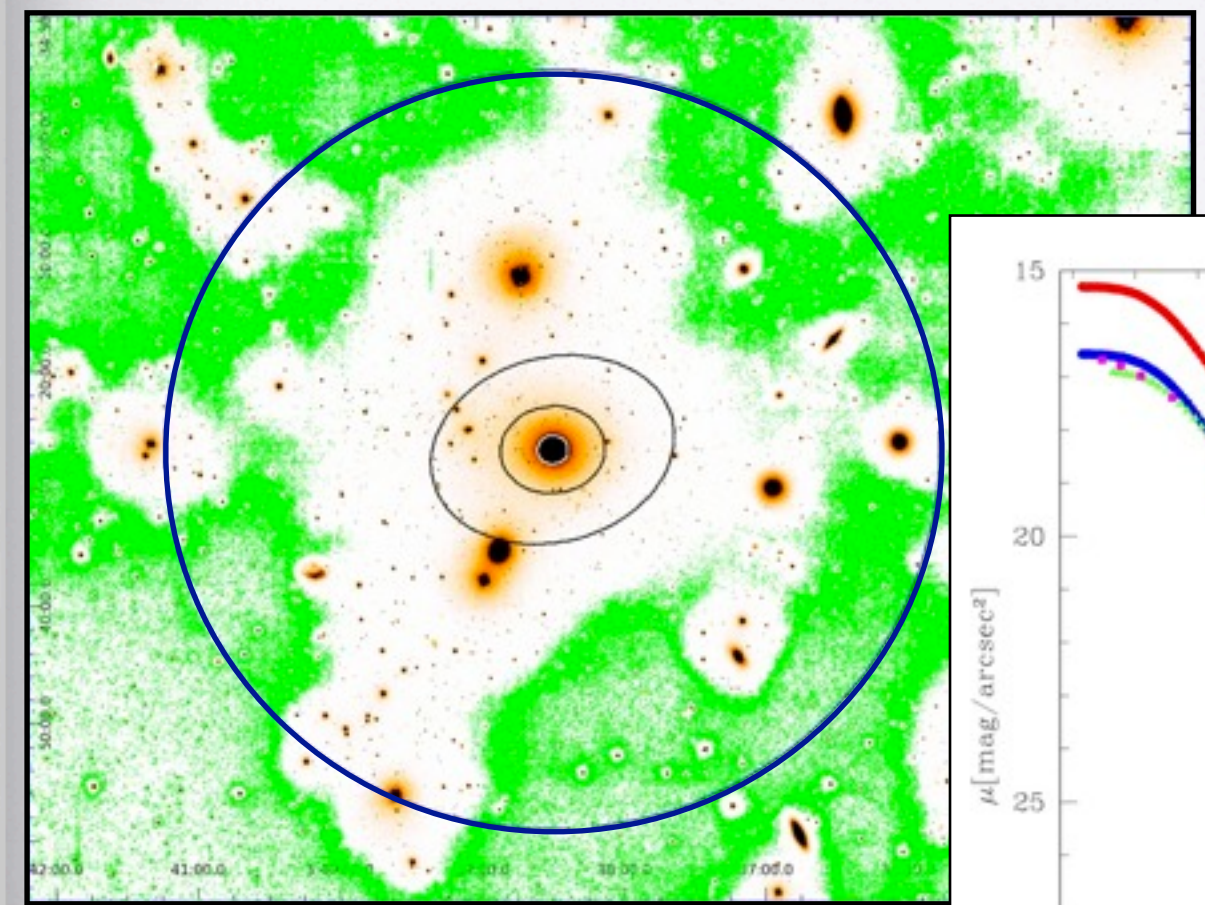

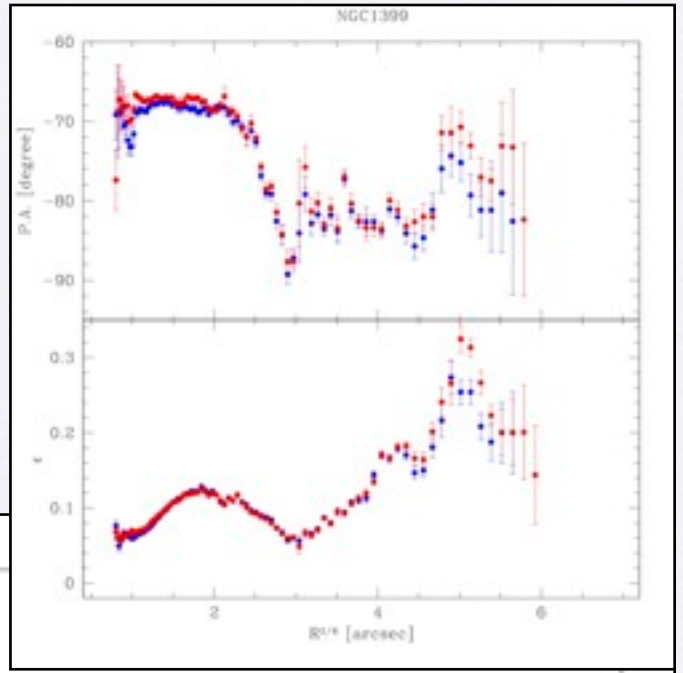


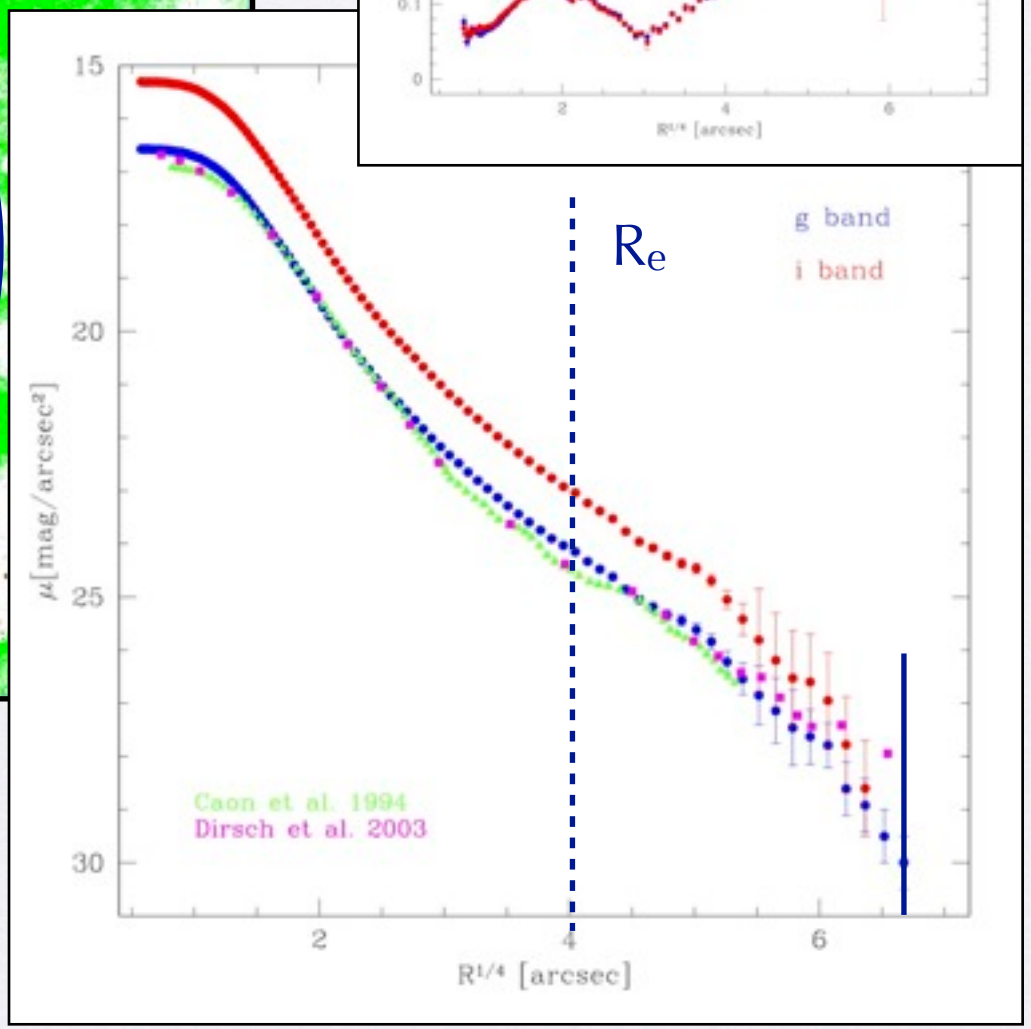


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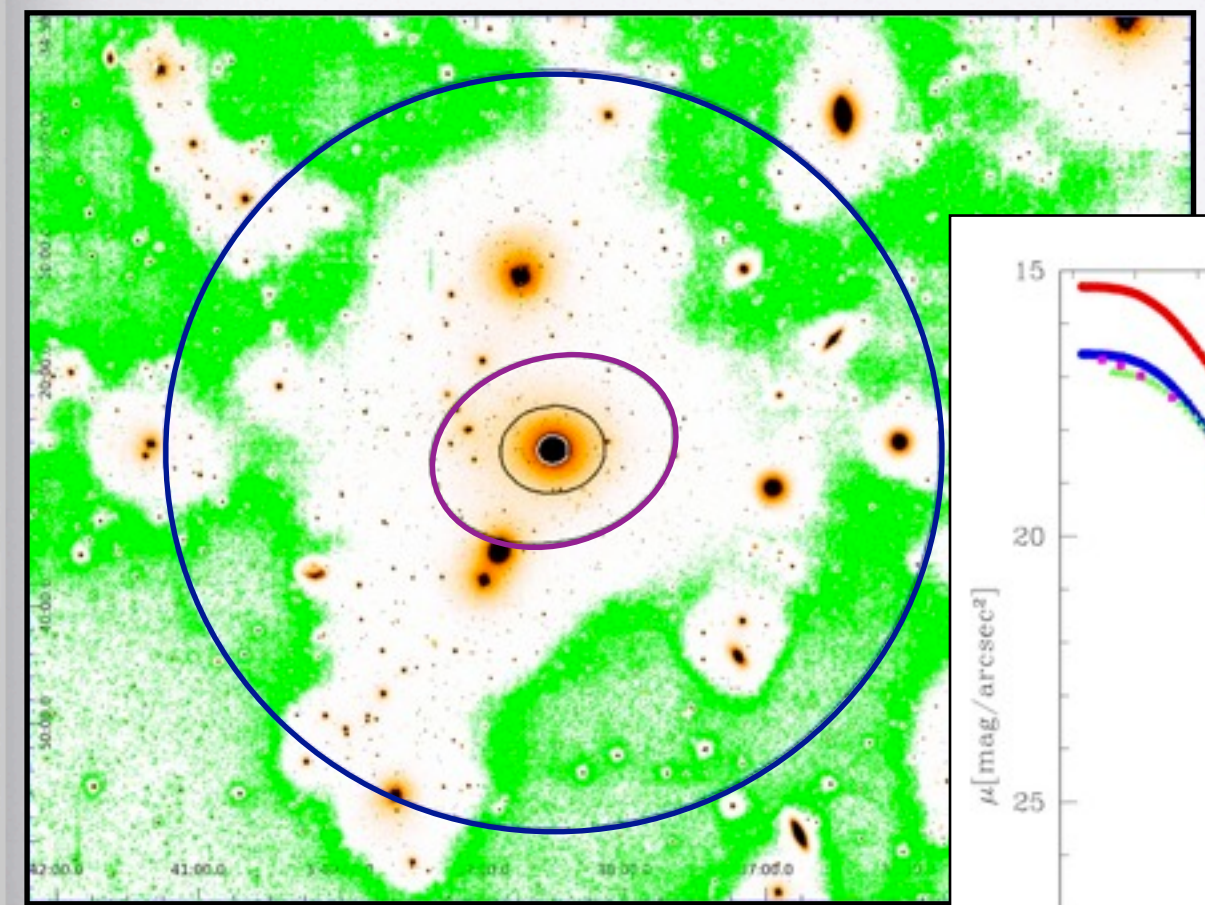

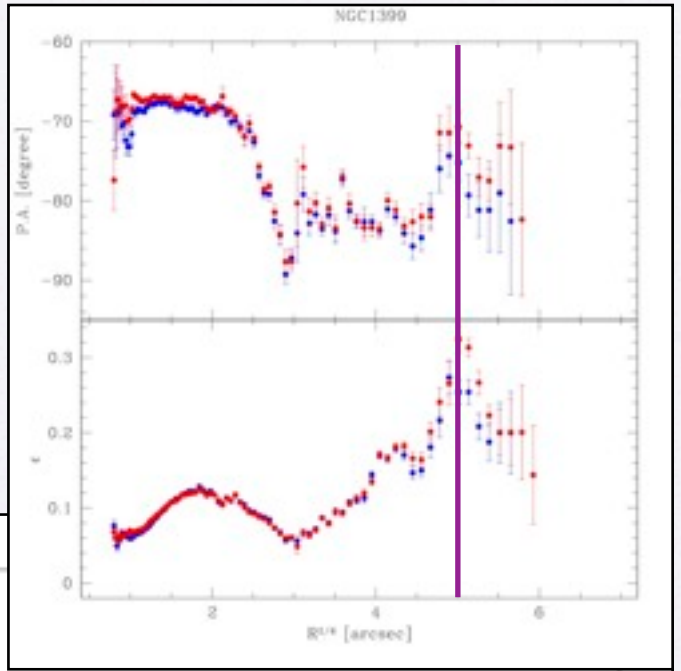


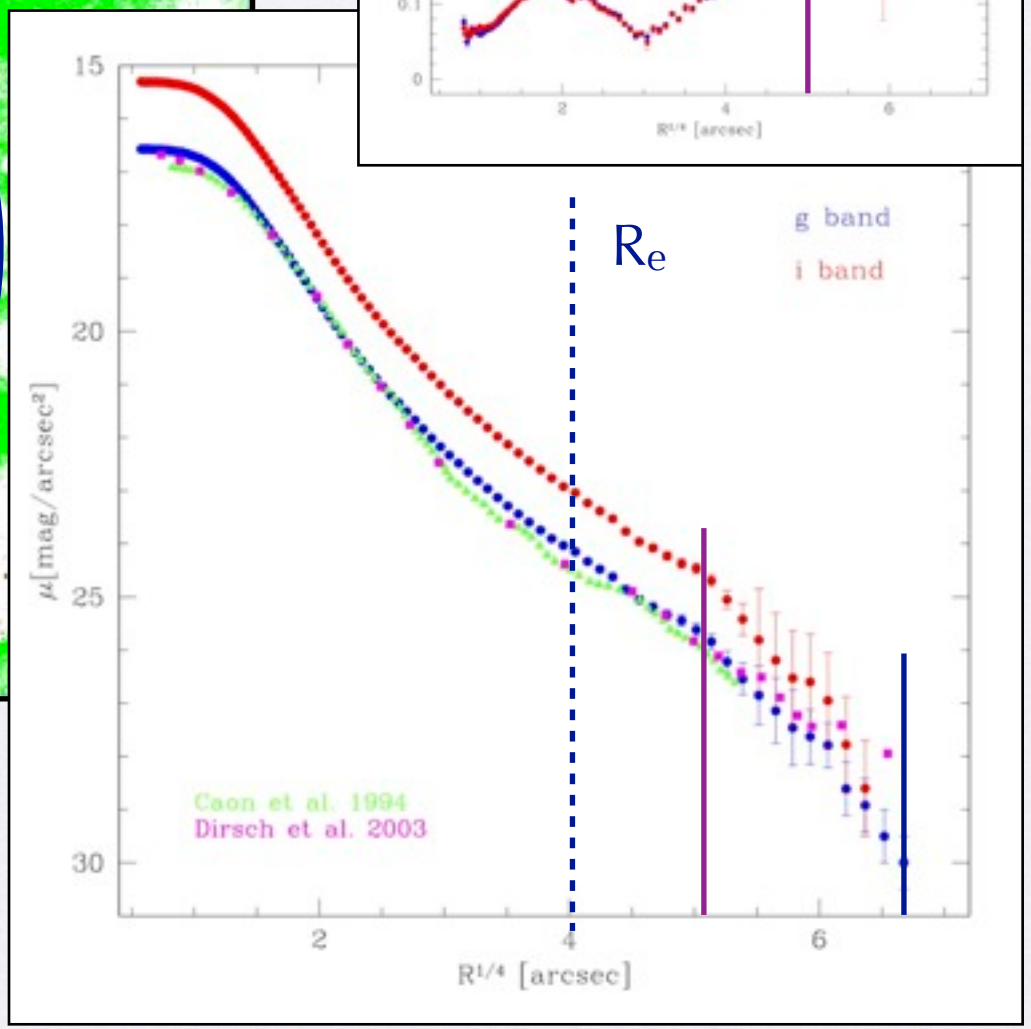


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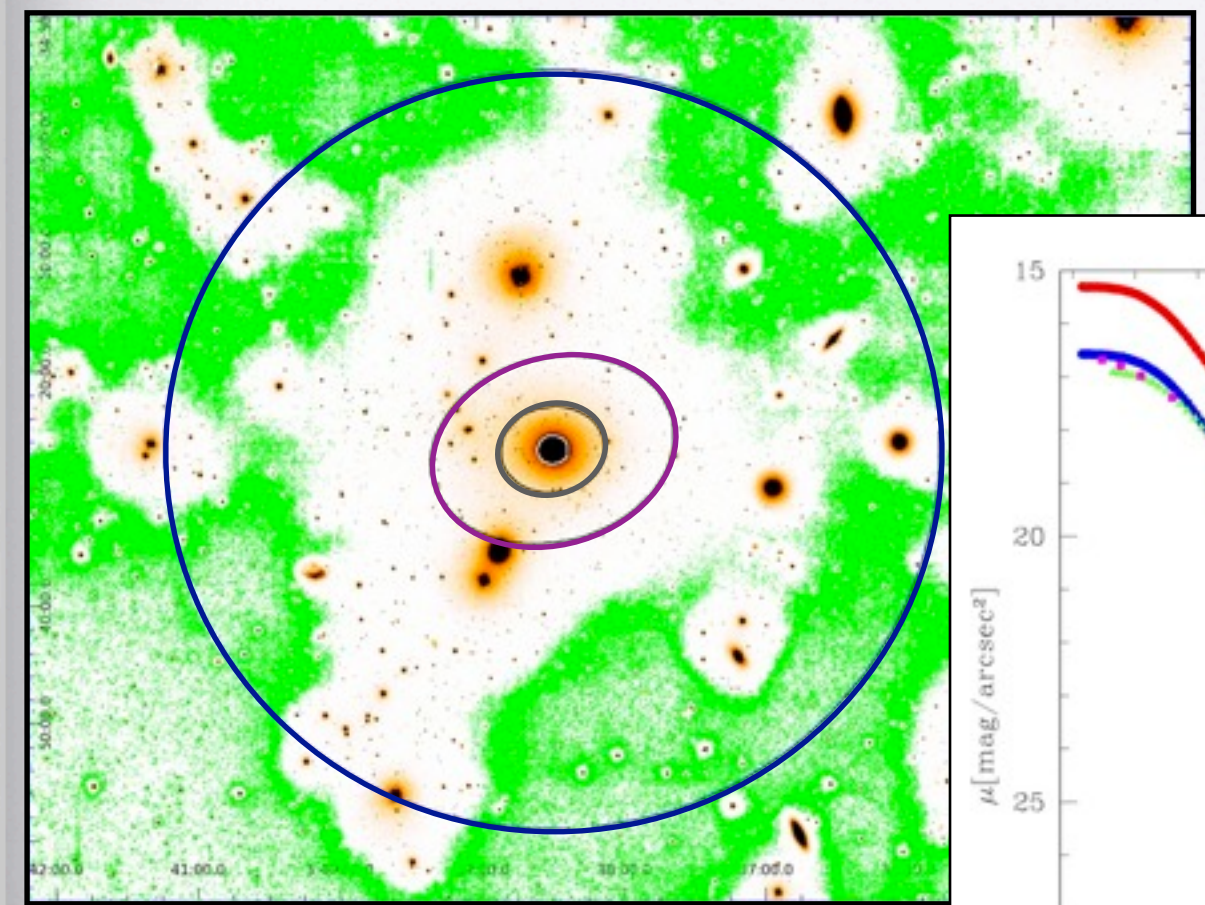

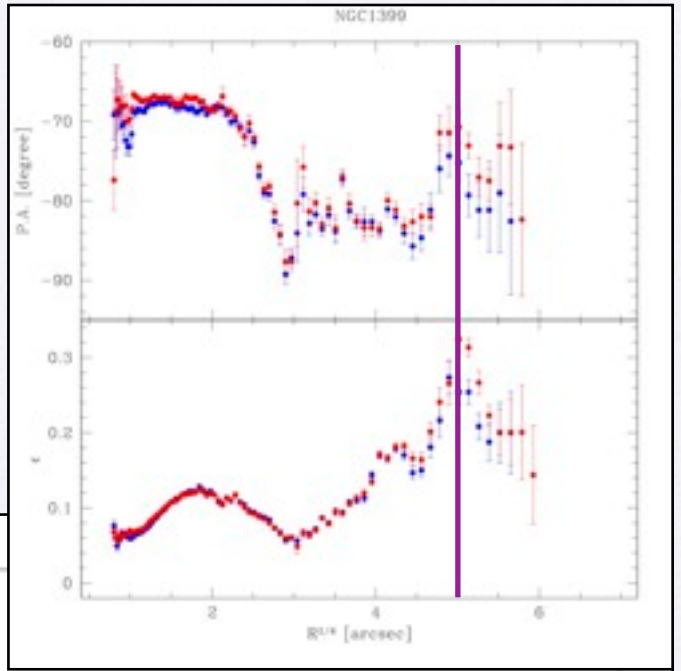


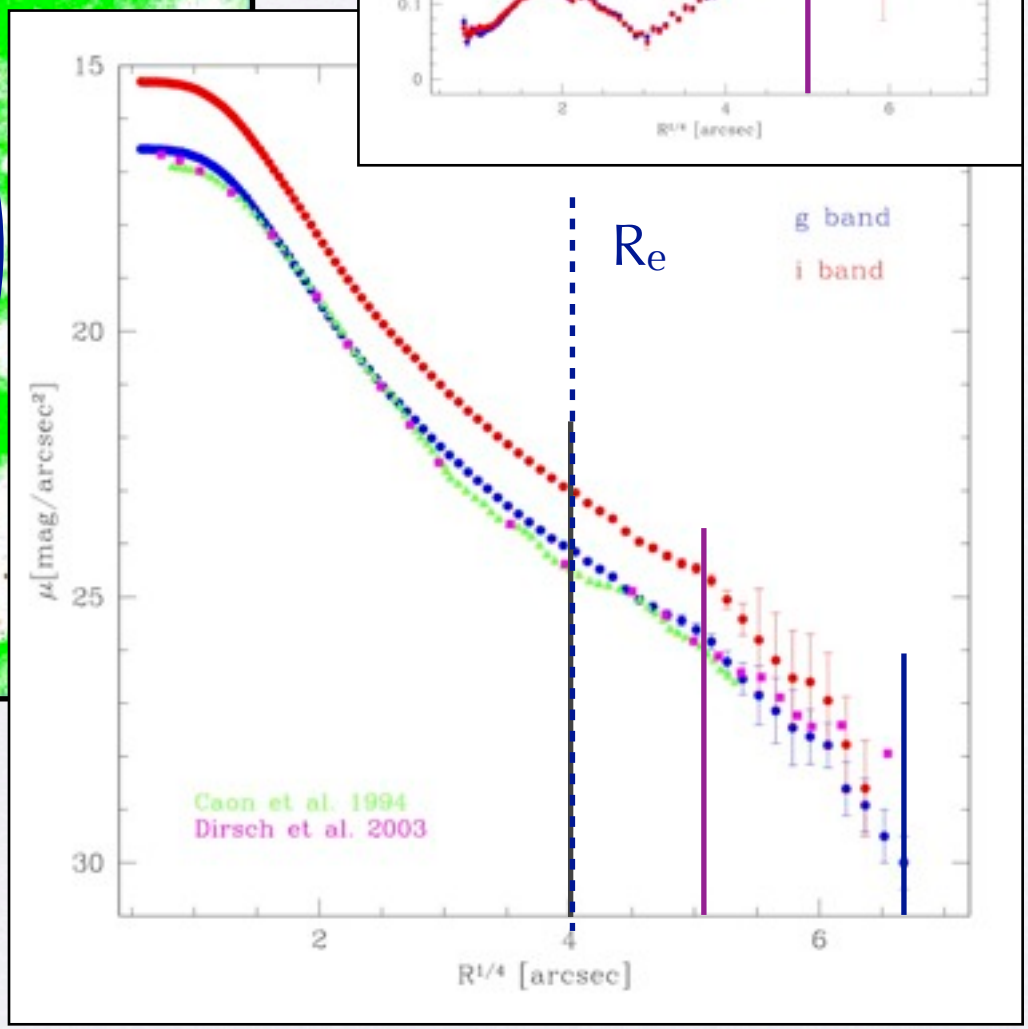


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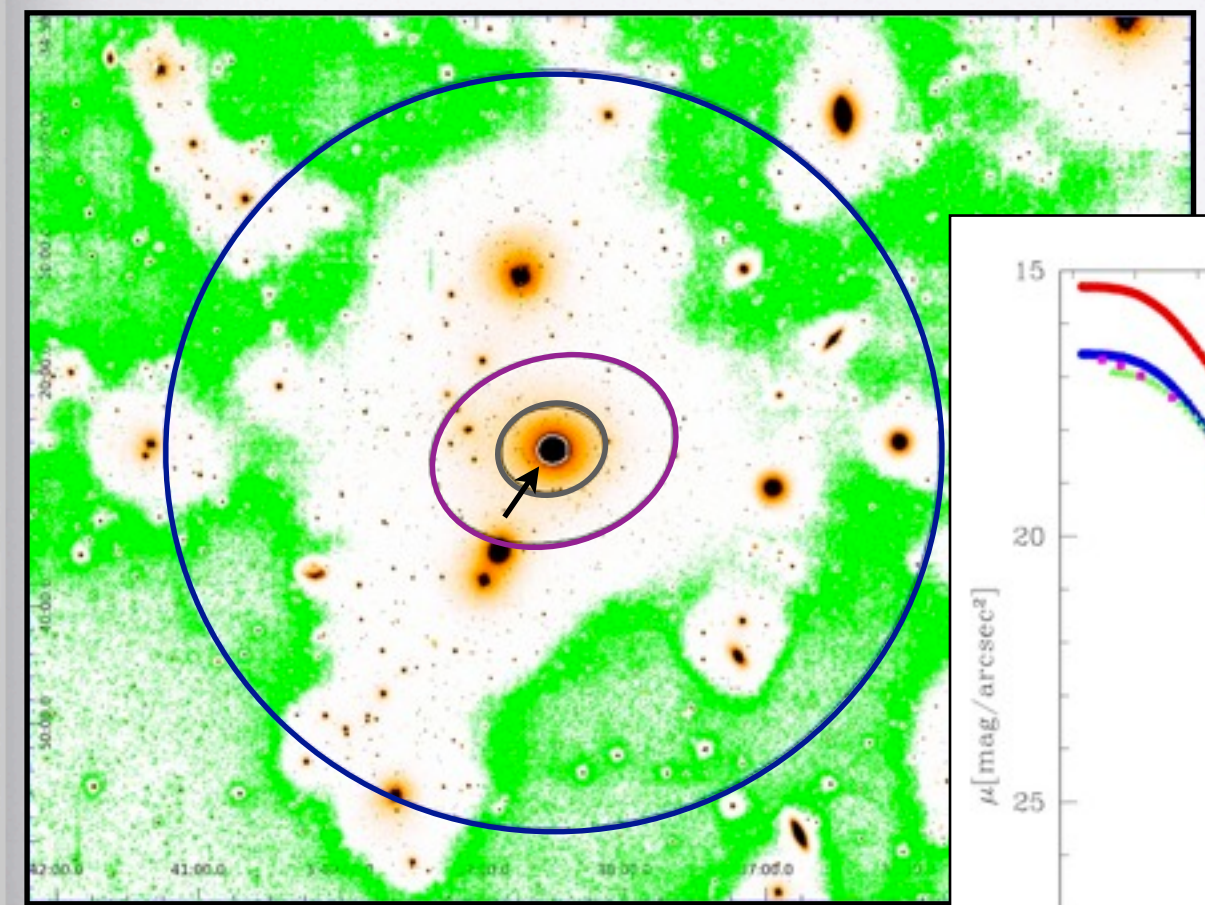

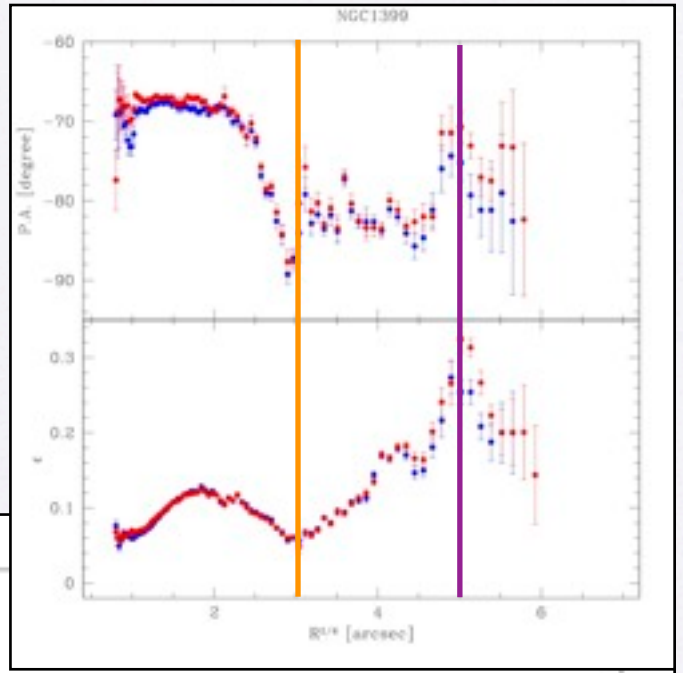


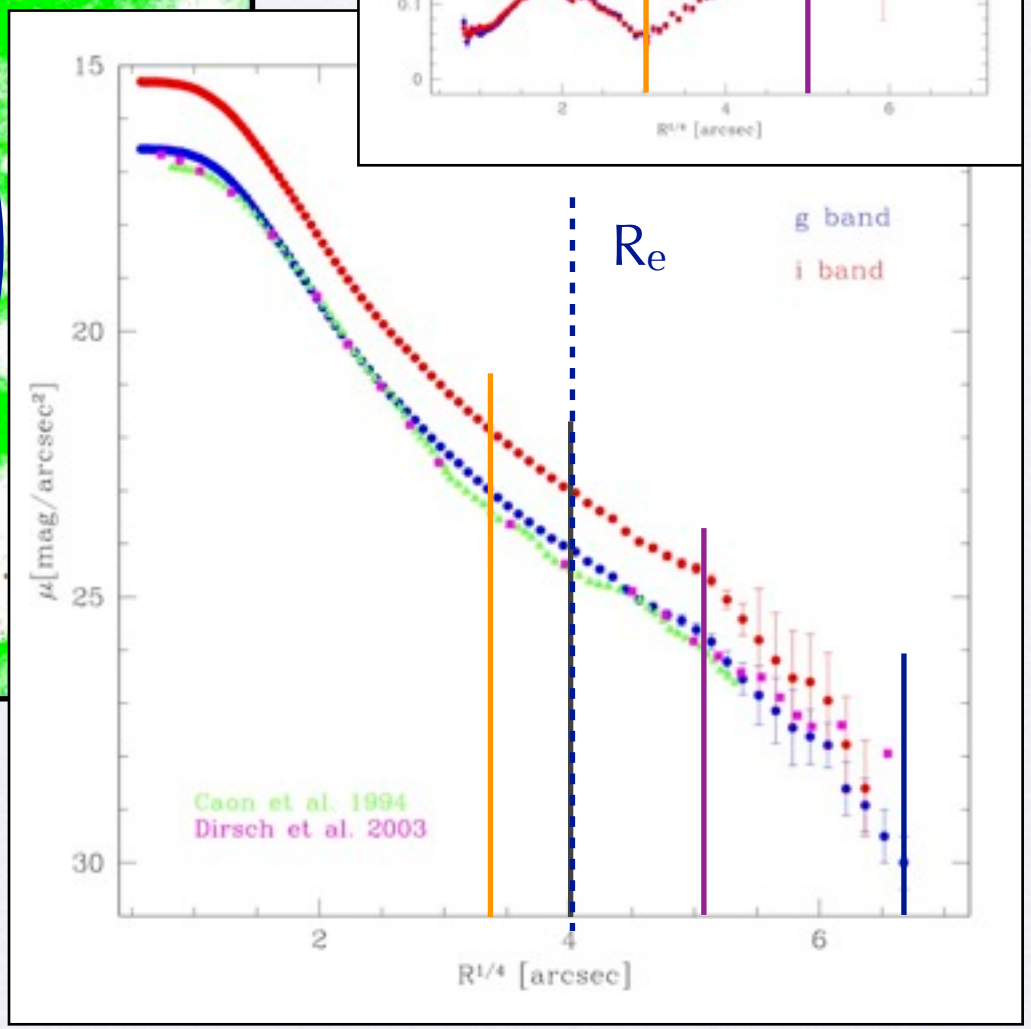


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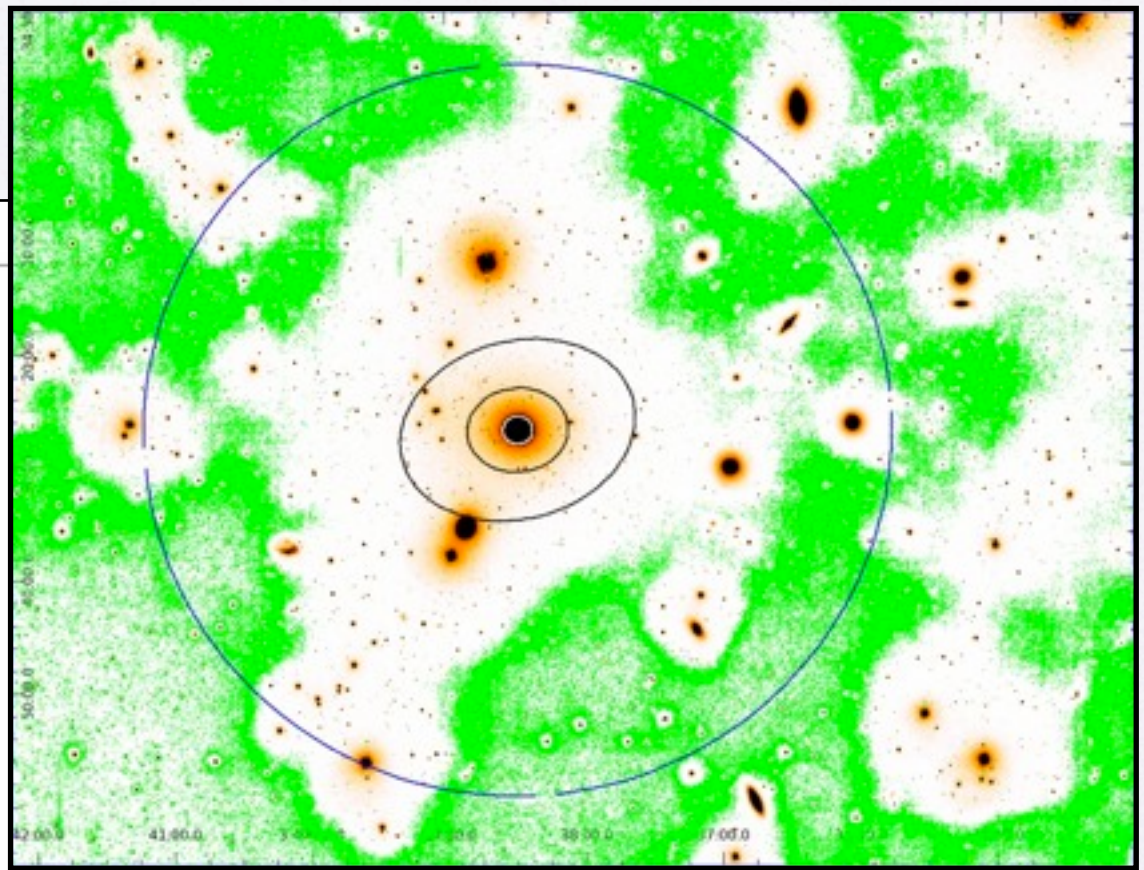

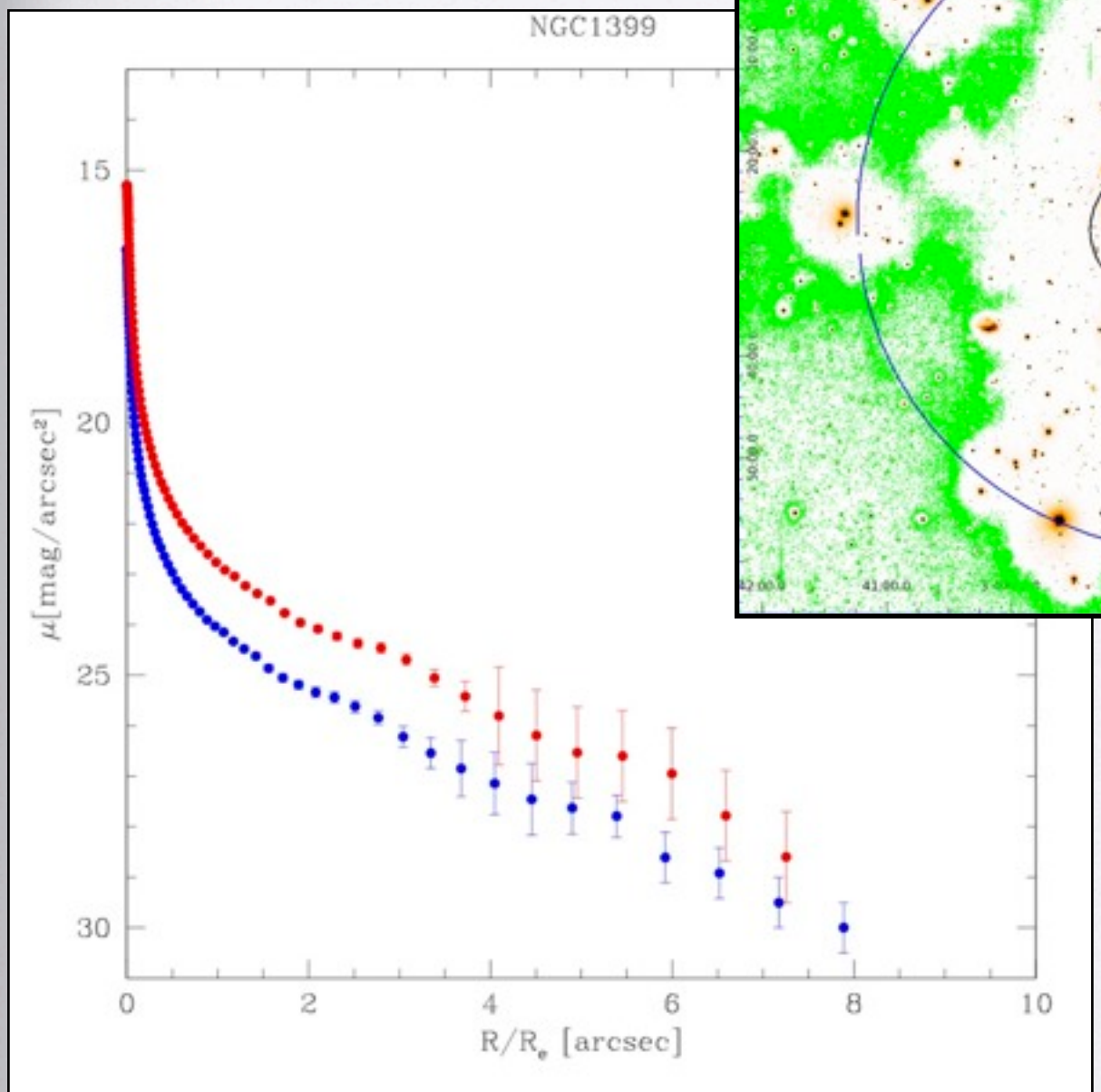

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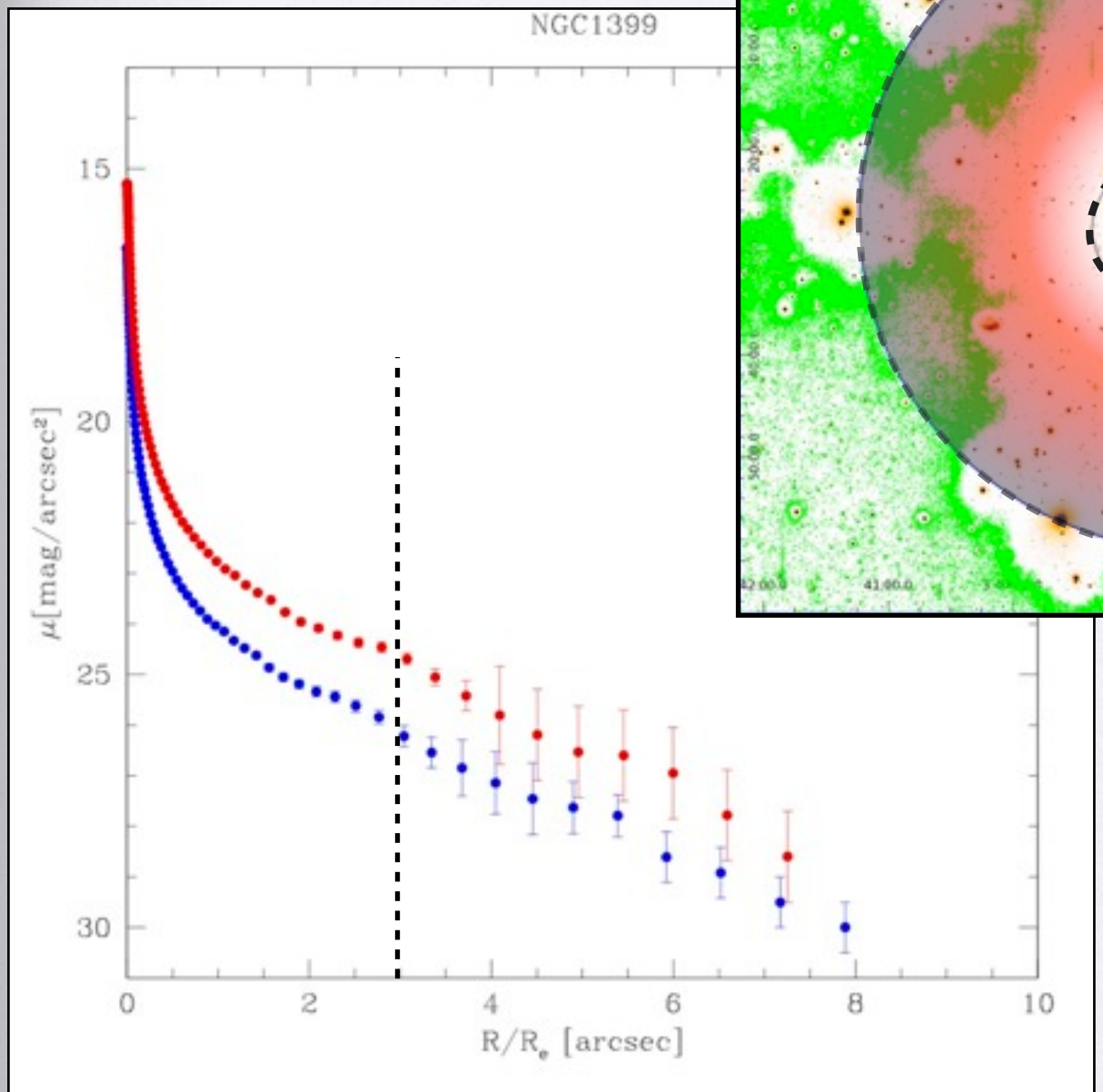


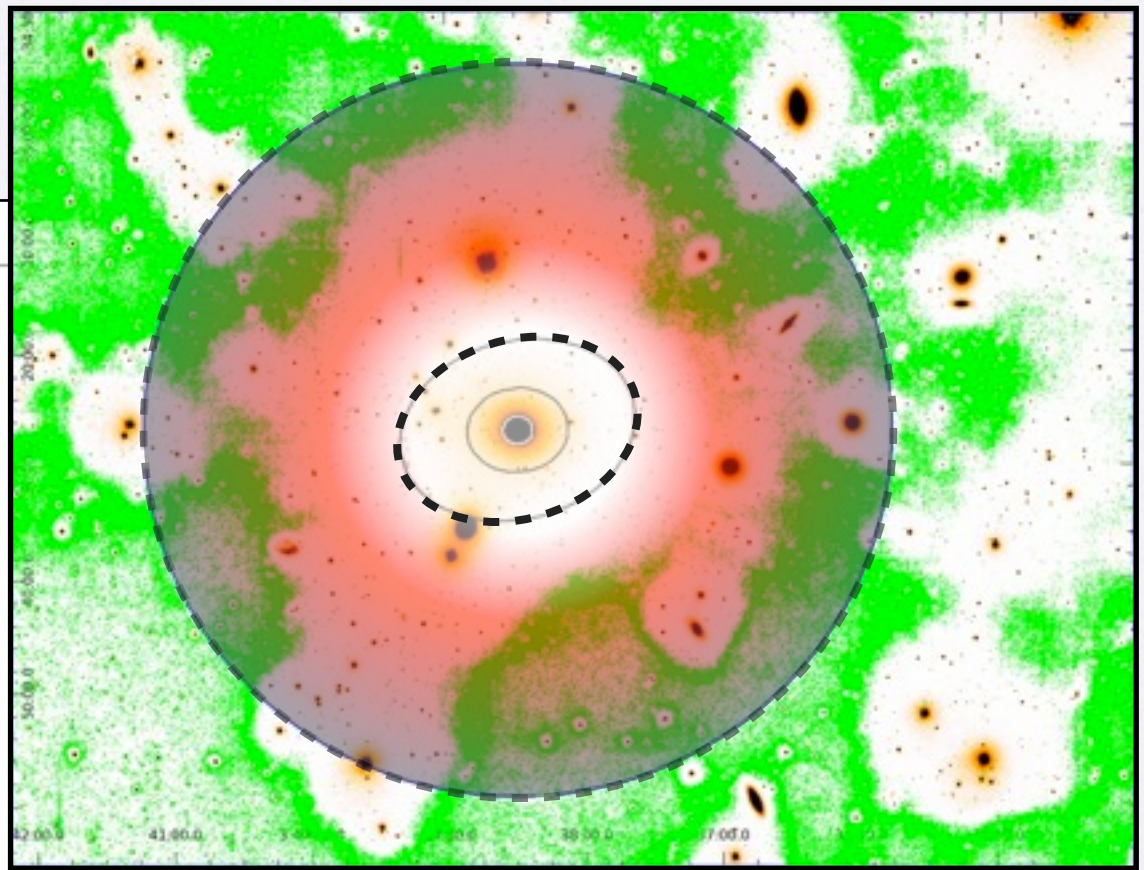

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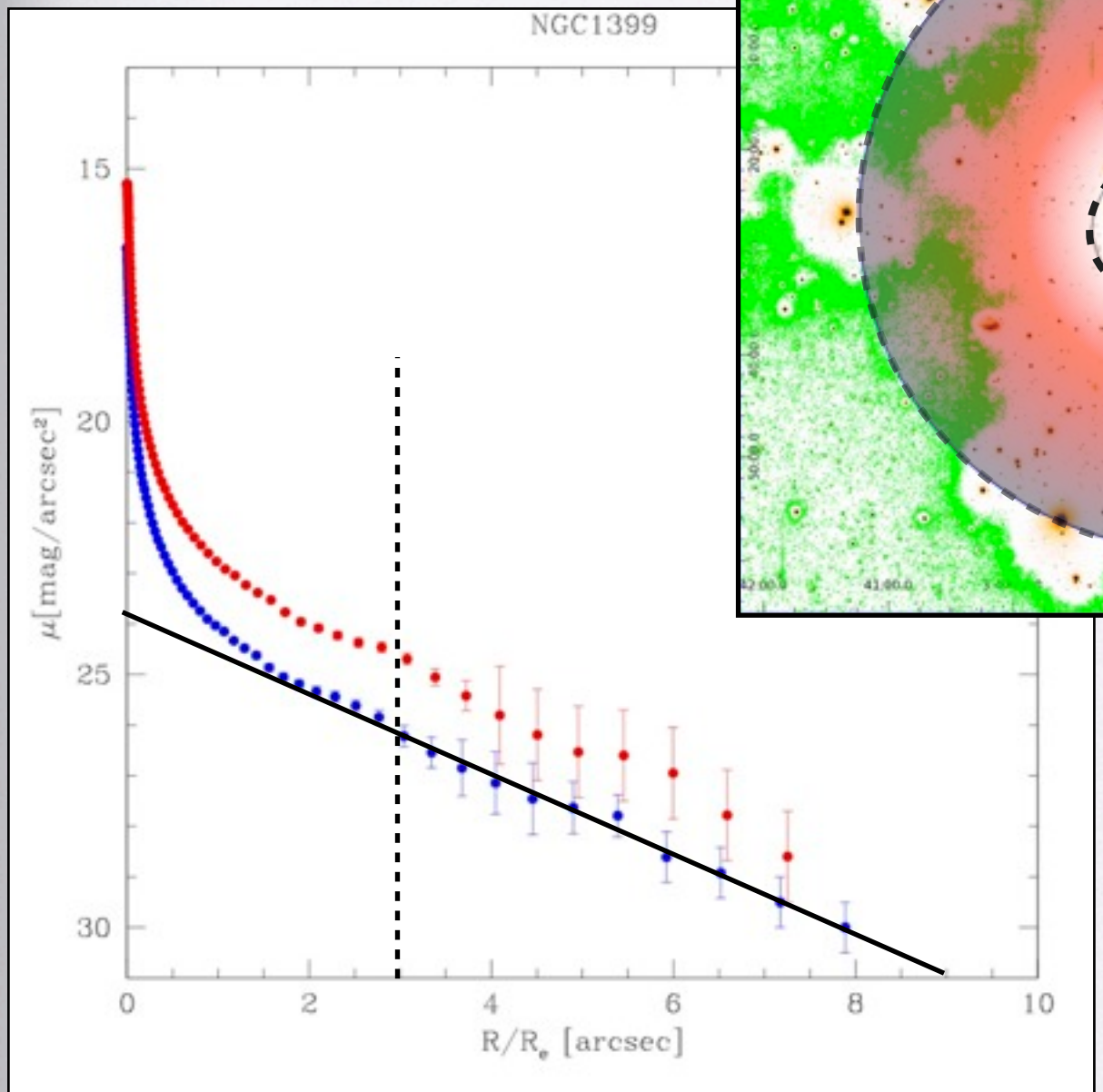
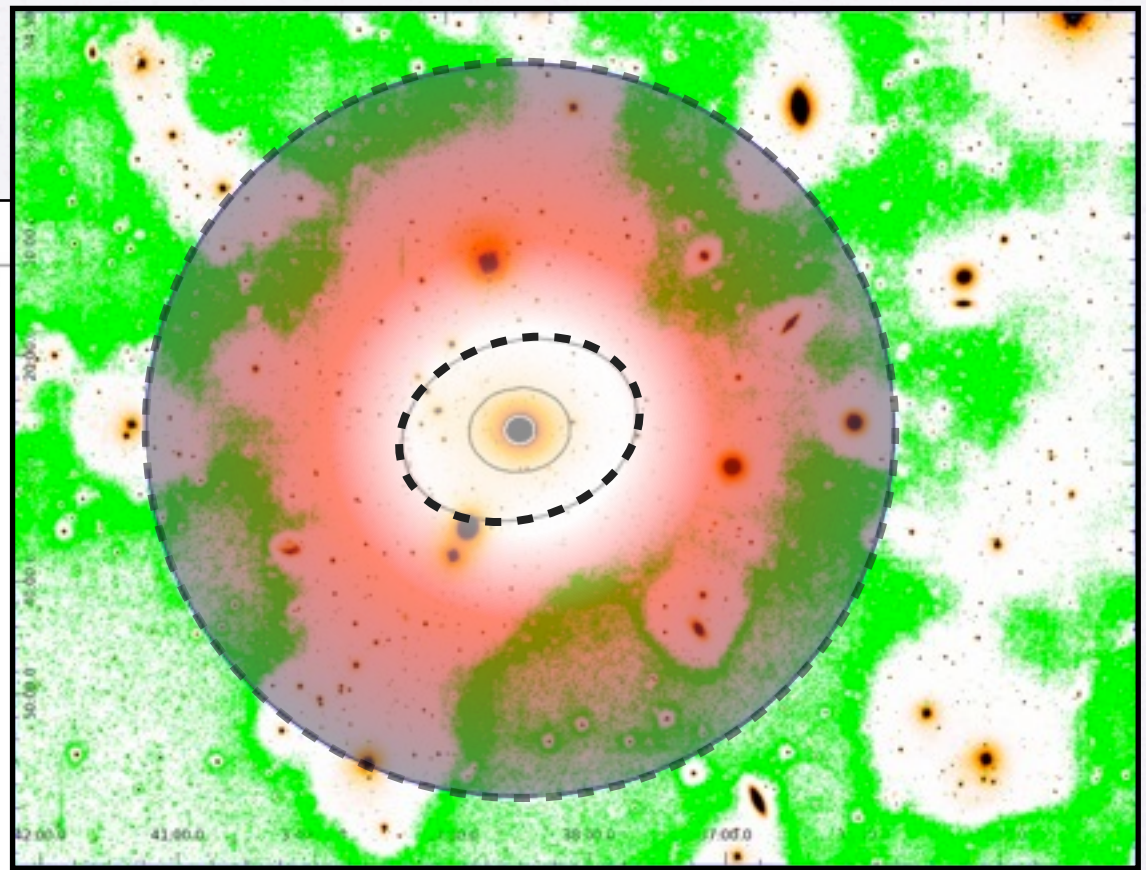


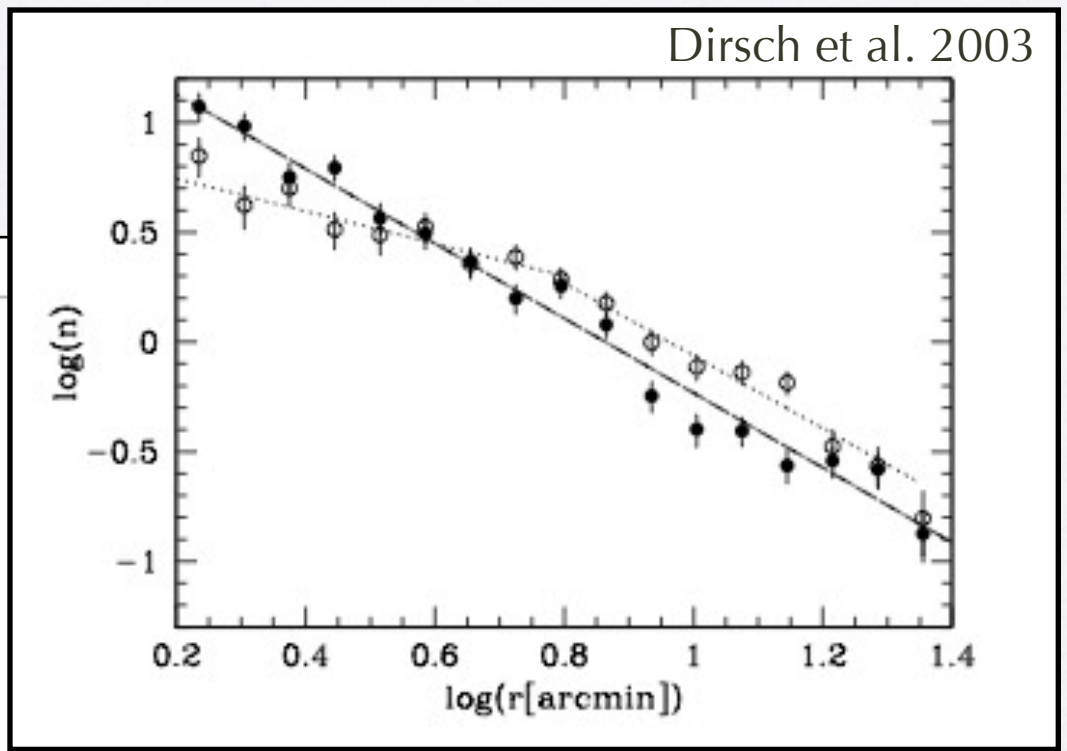



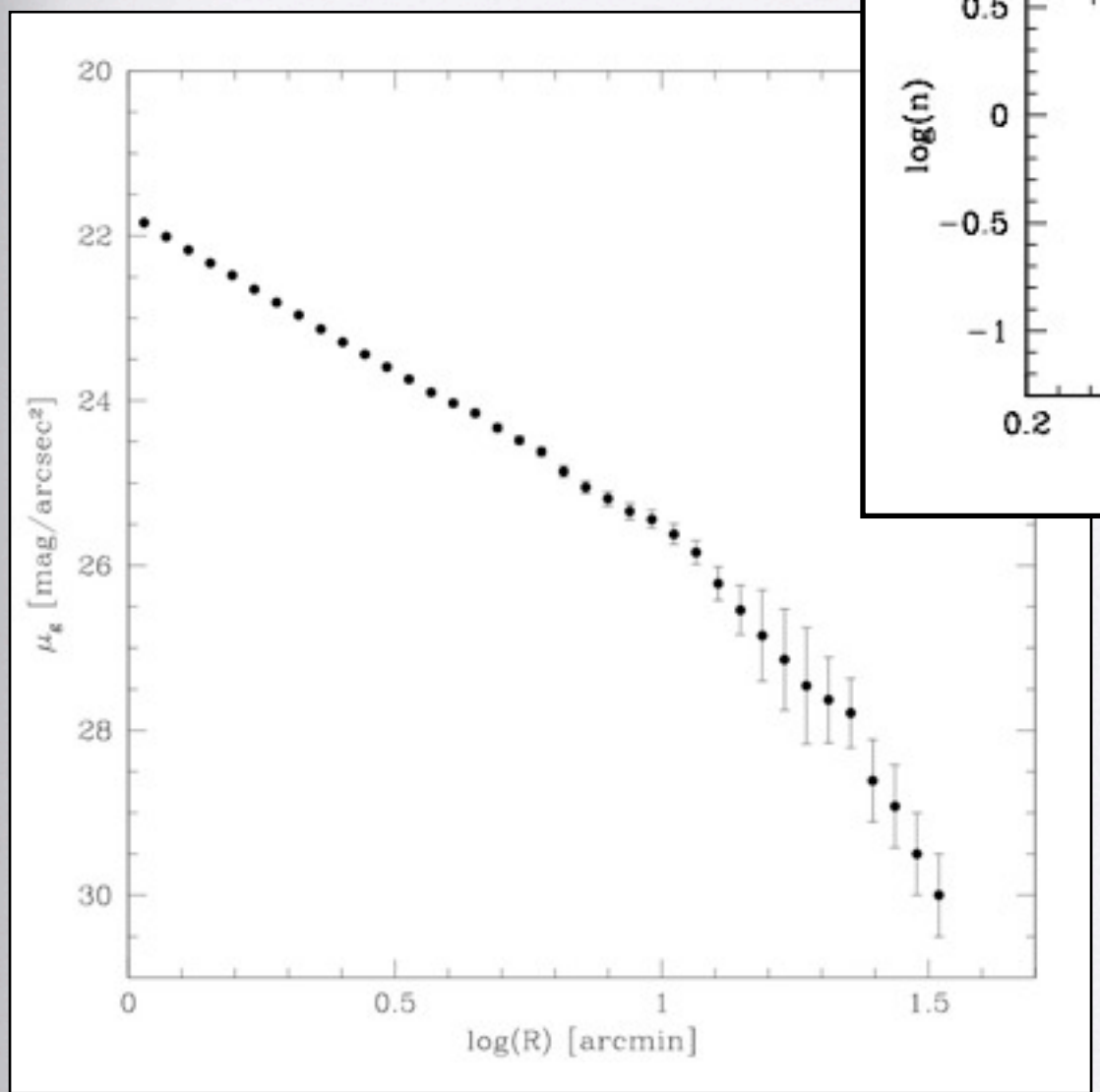
$3\ R_e \leq R \leq 8\ R_e$
**exponential halo** "around"
NGC1399
which contributes to ~**15%**
of the total magnitude

# Light distribution:

## NGC1399

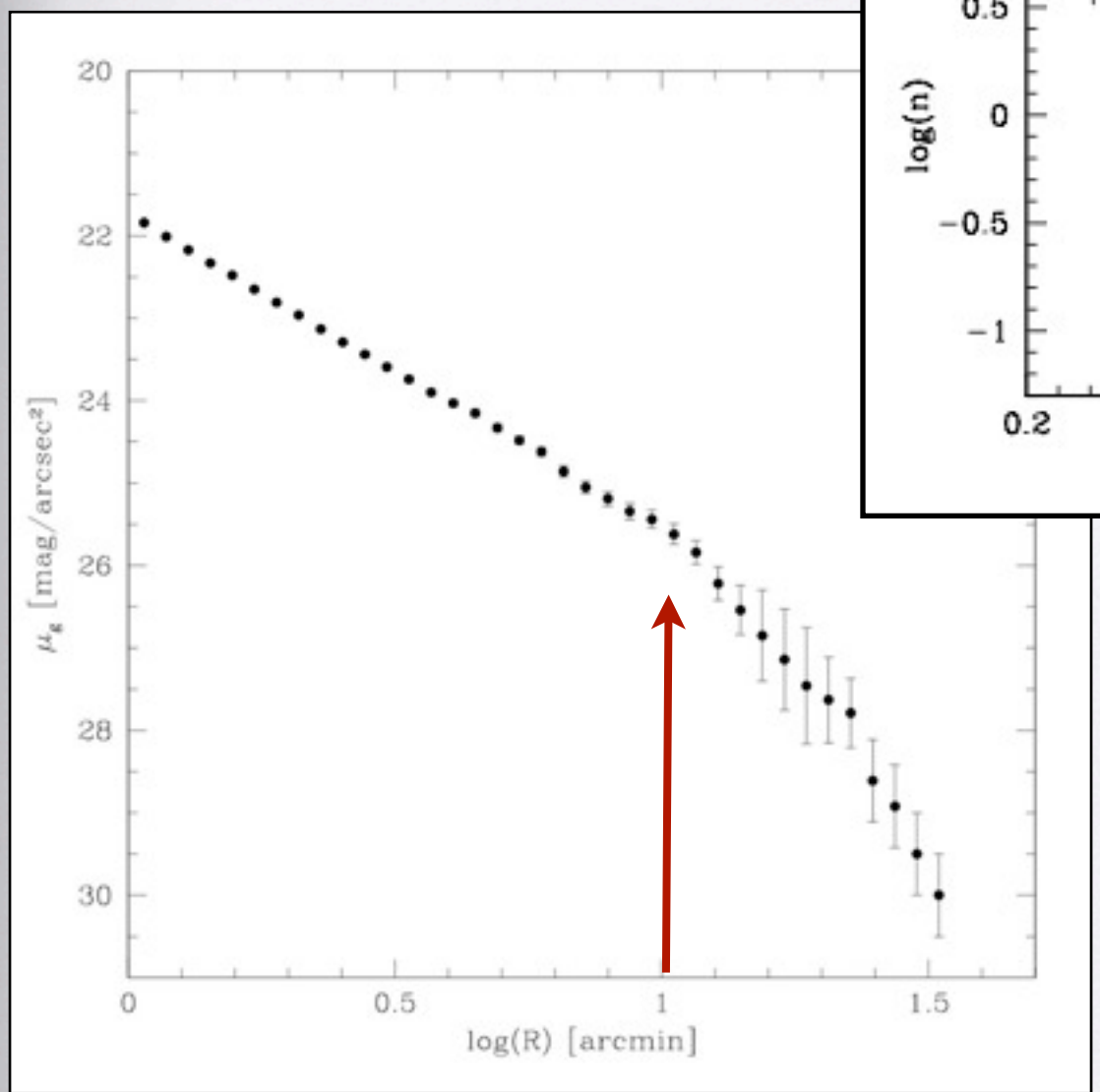
Dirsch et al. 2003

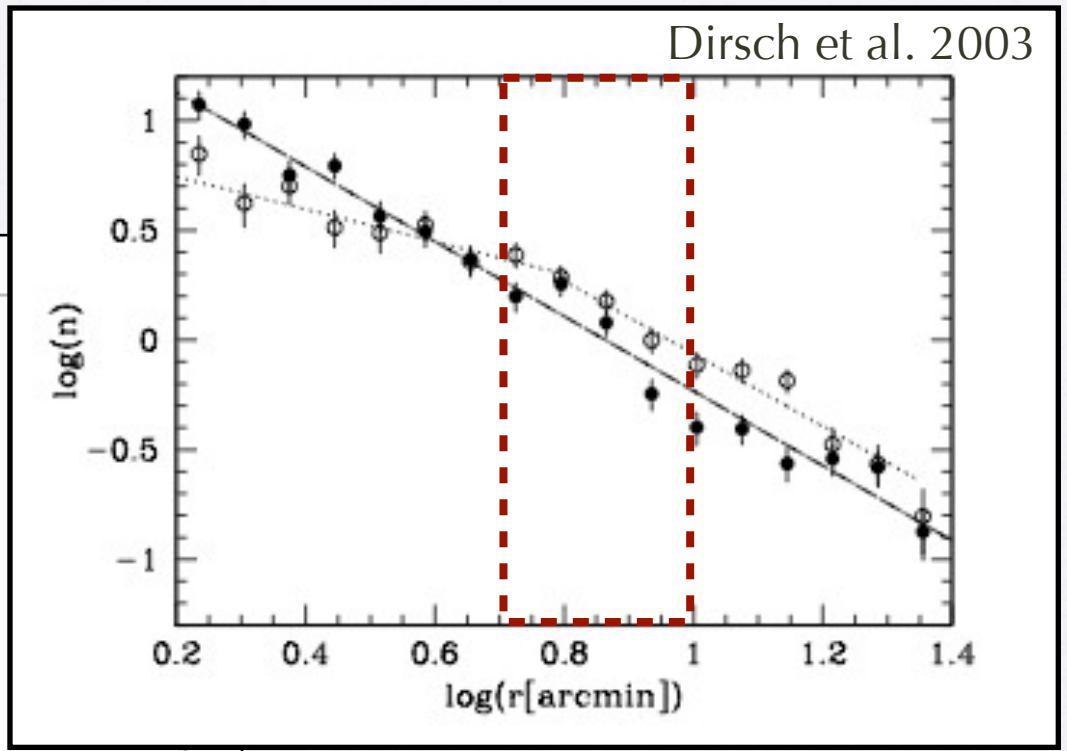


# Light distribution:

## NGC1399

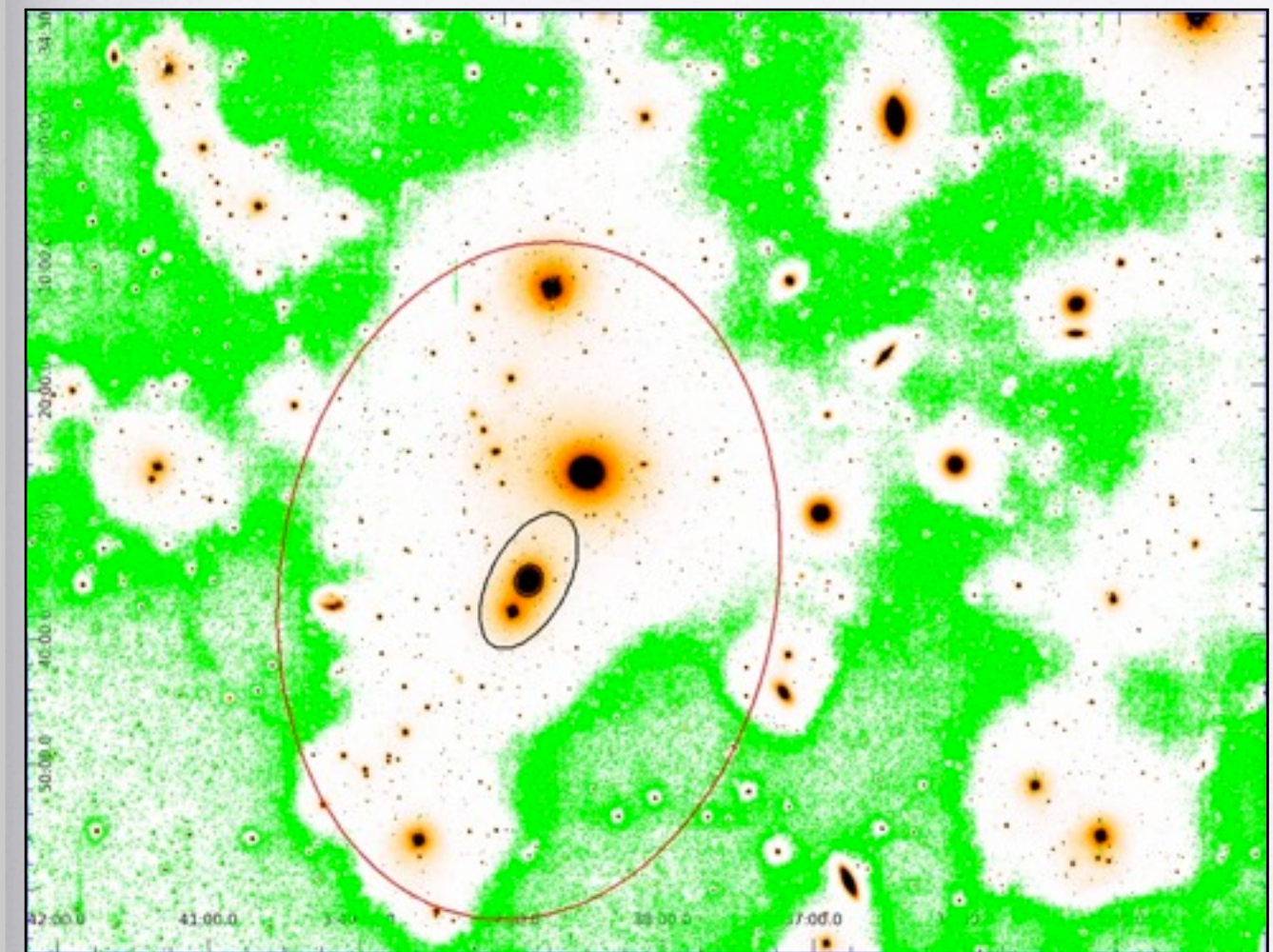



same change of slope also in the radial density profiles of the blue GCs

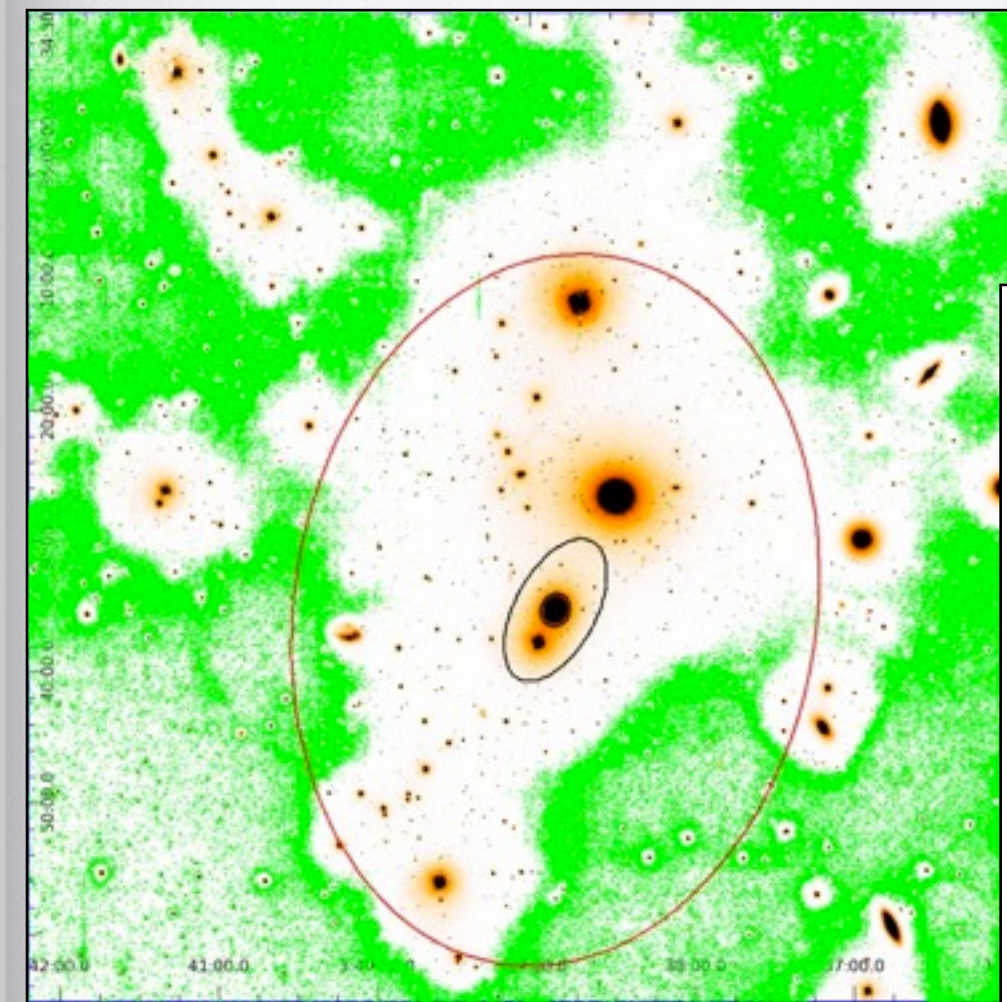
# Light distribution:

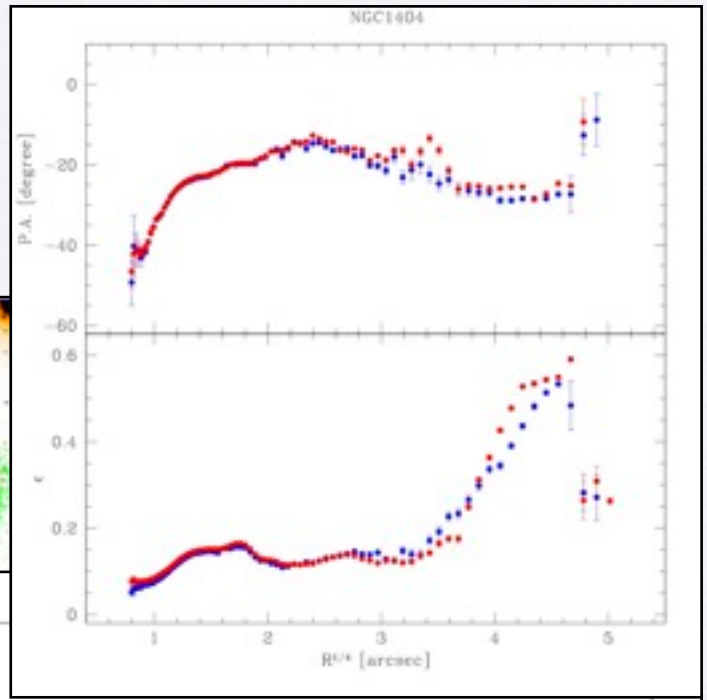
## NGC1404

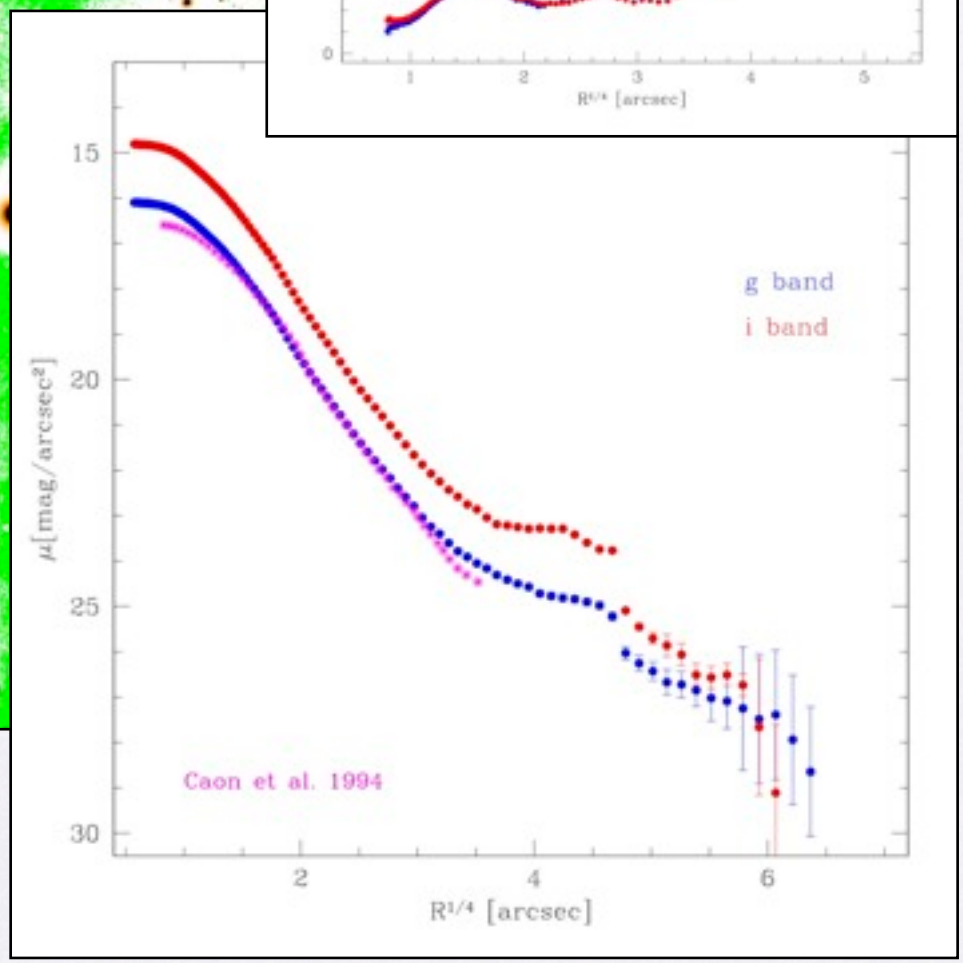


# Light distribution:

## NGC1404

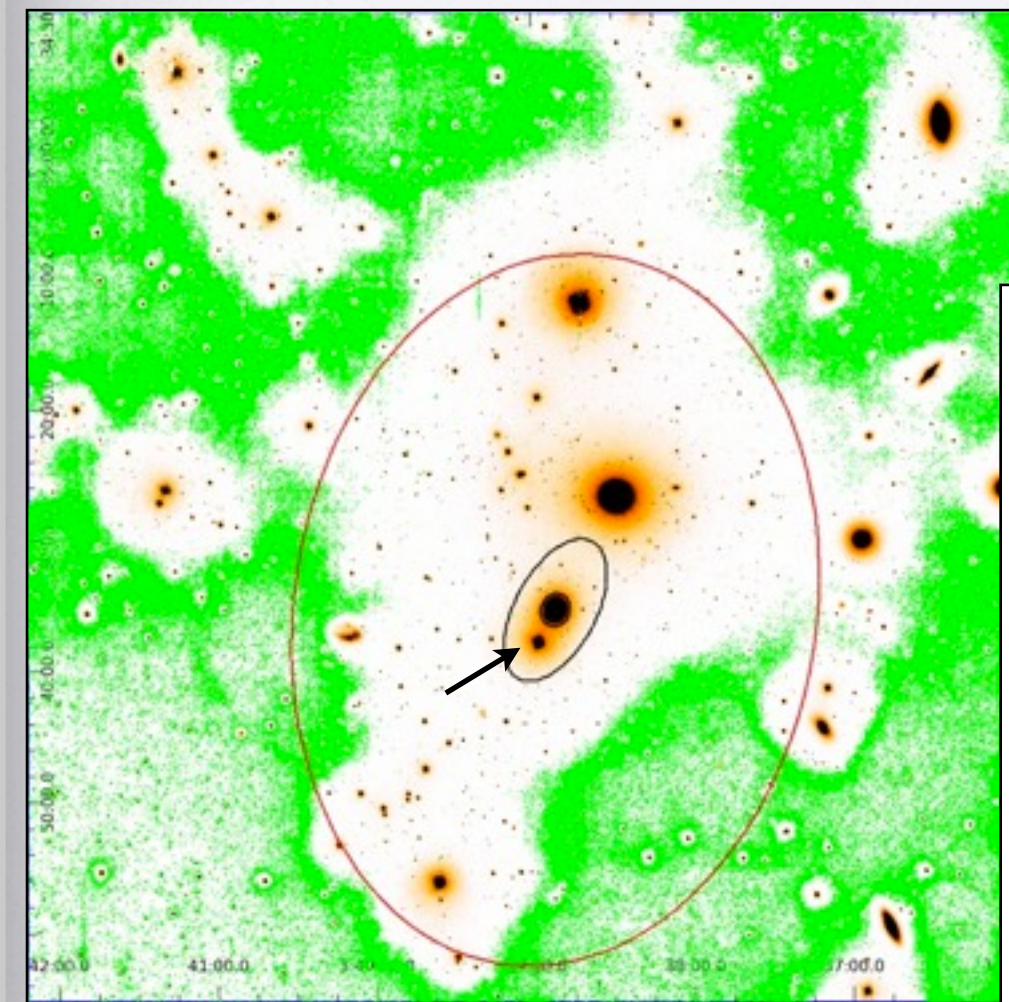


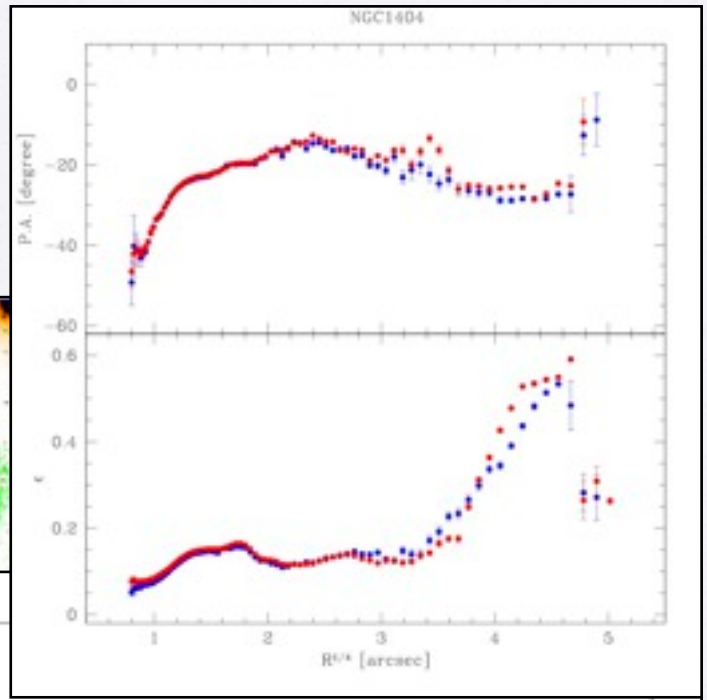


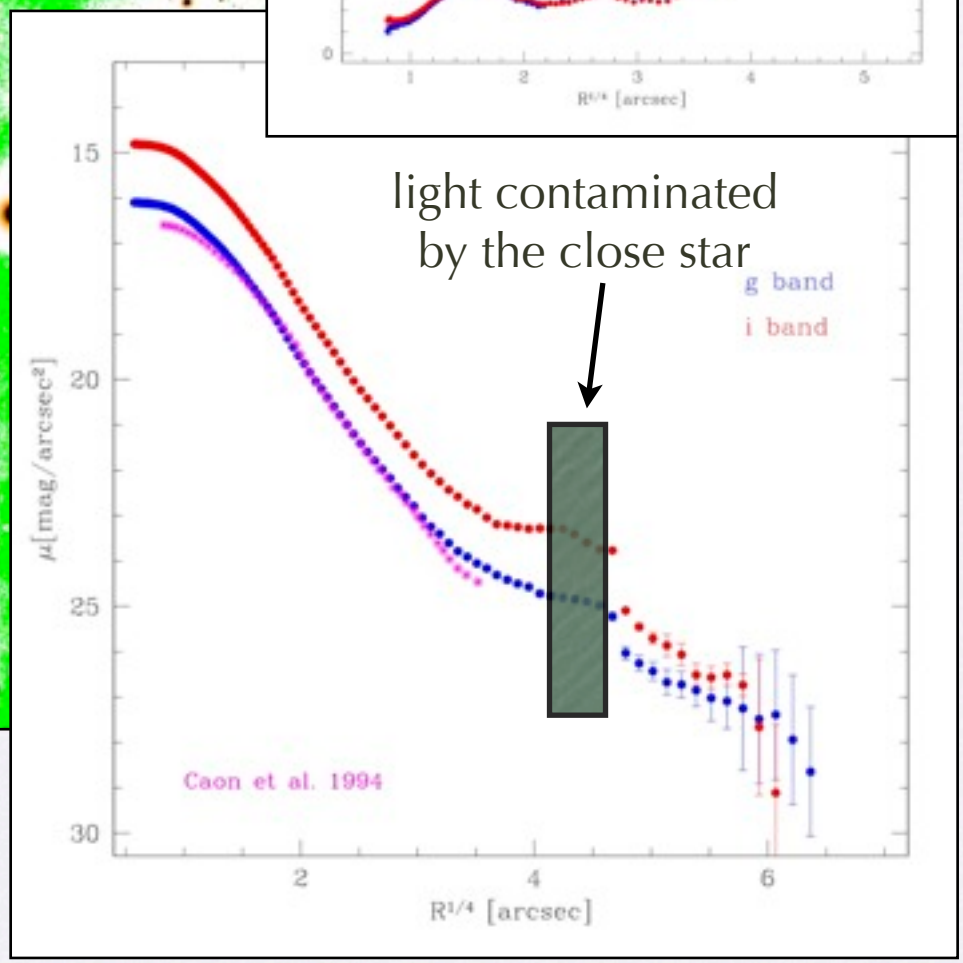



# Light distribution:

## NGC1404

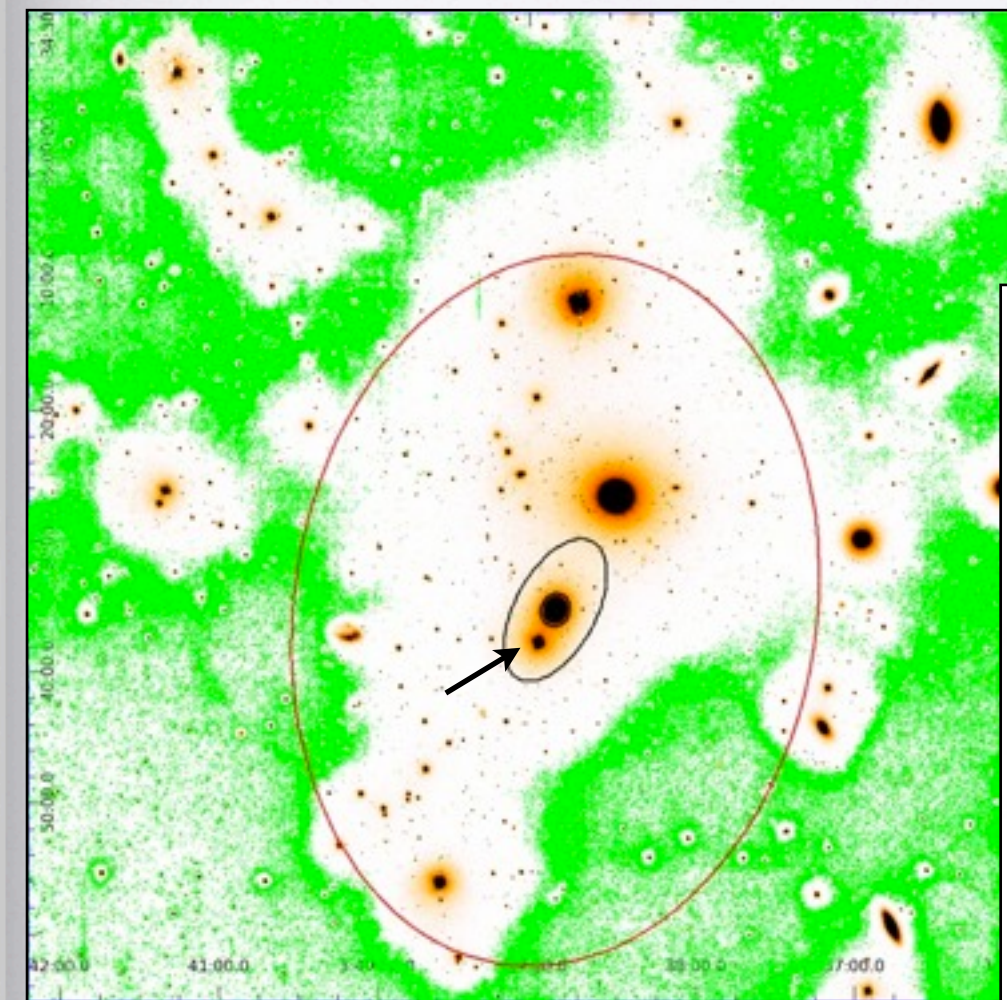


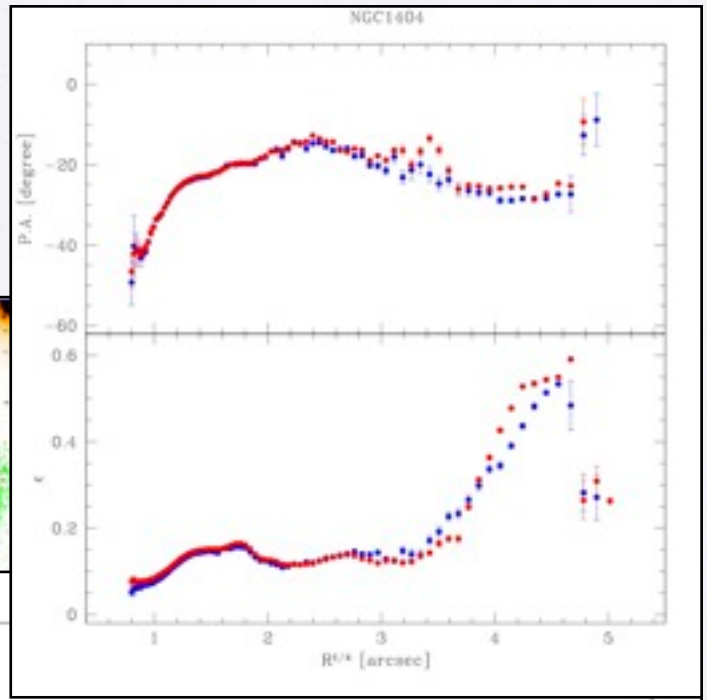


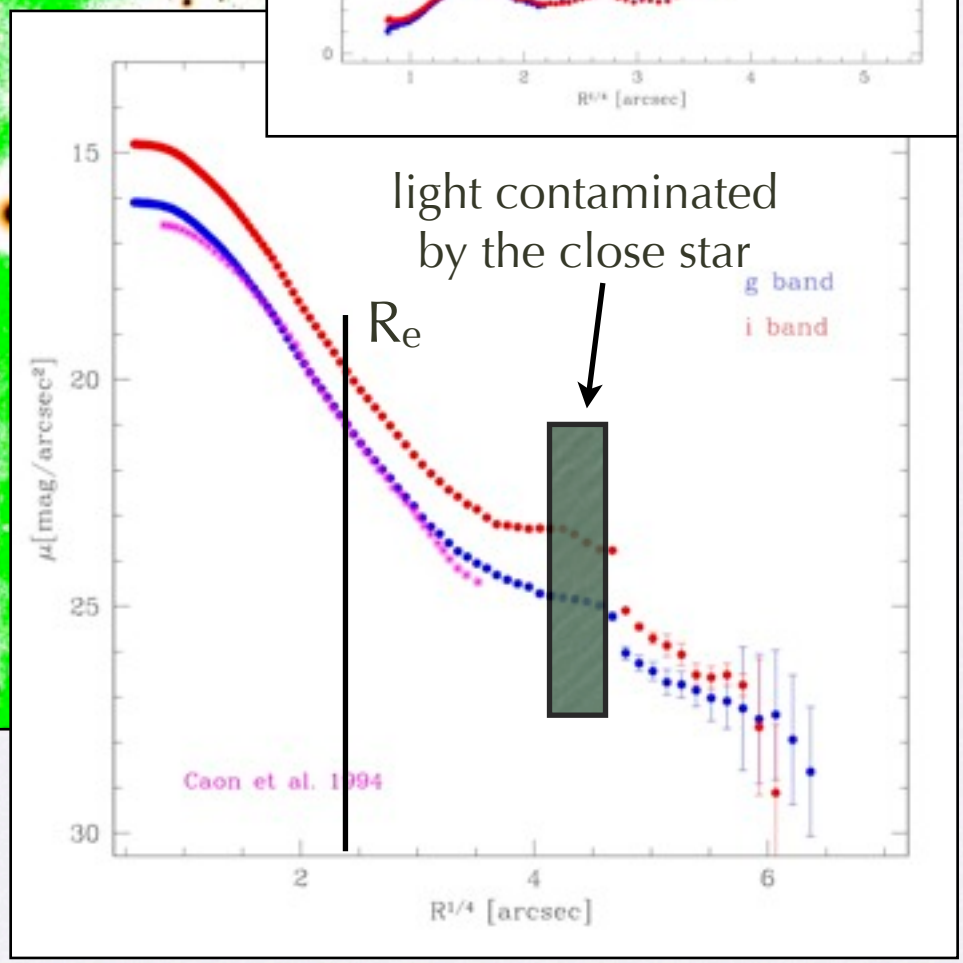



# Light distribution:

## NGC1404

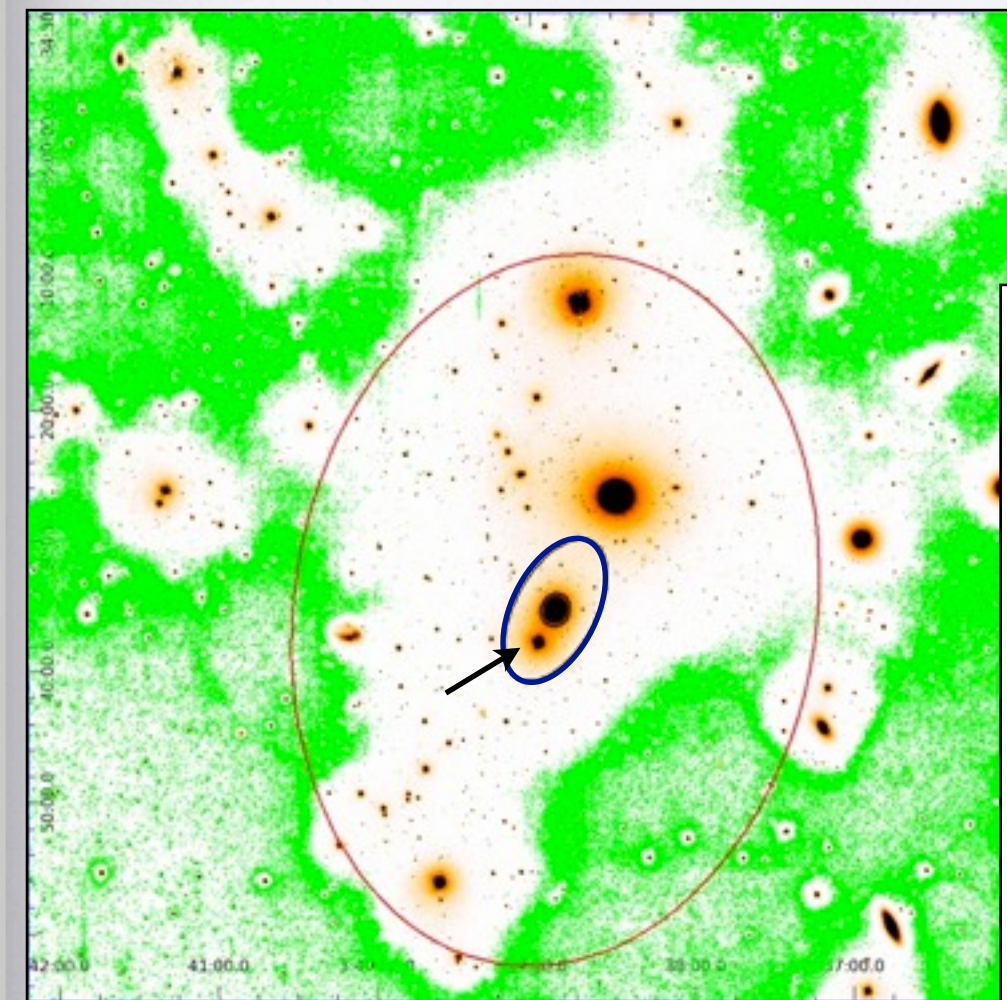


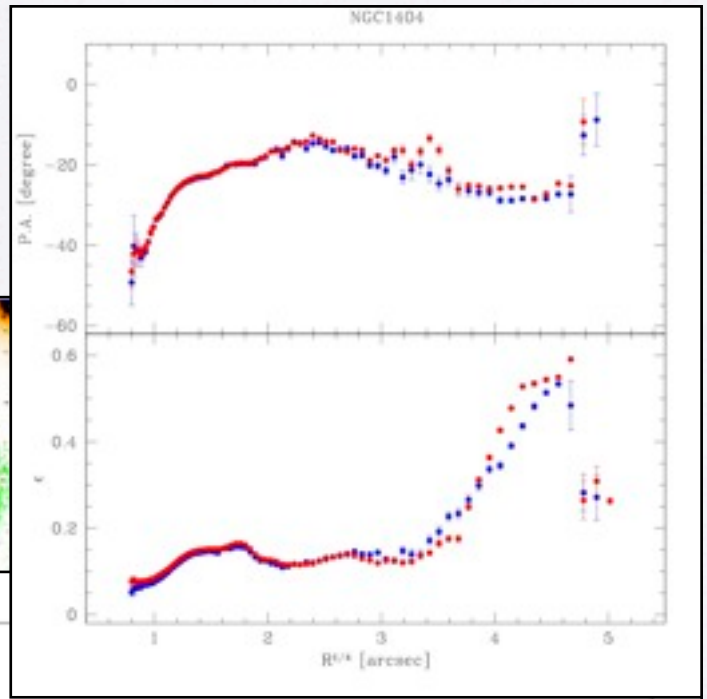


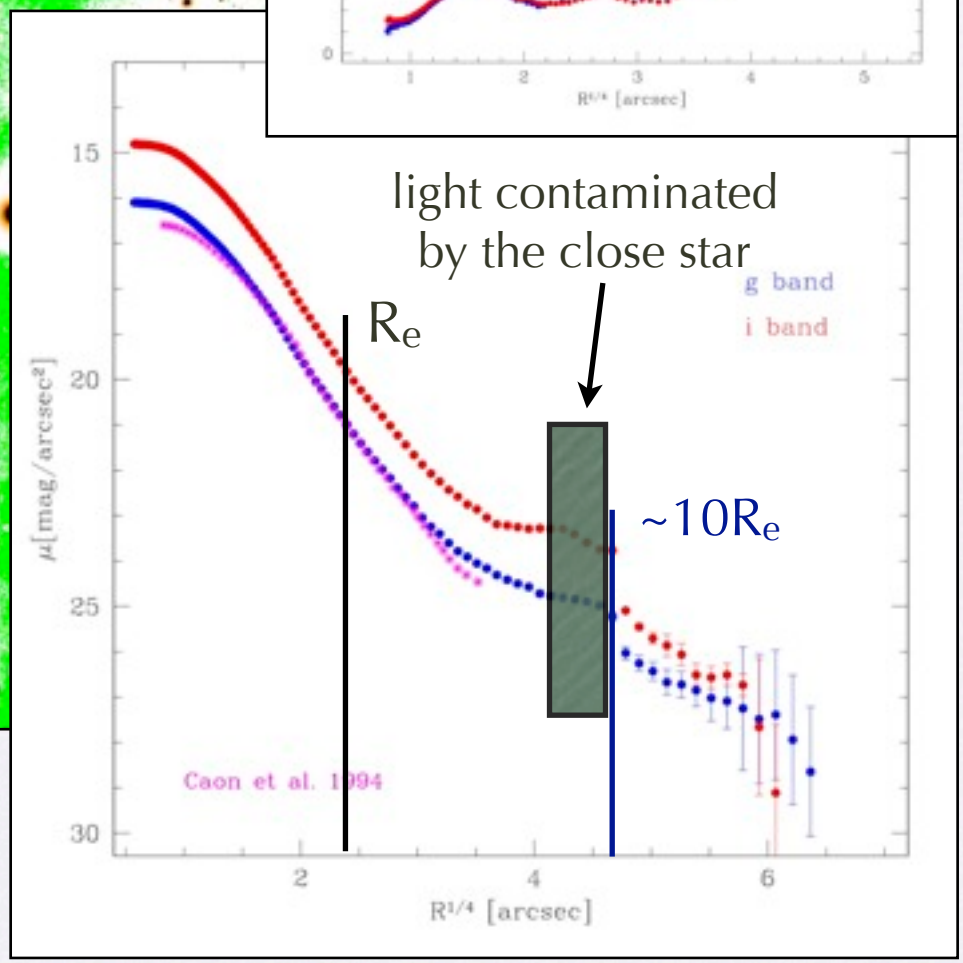



# Light distribution:

## NGC1404

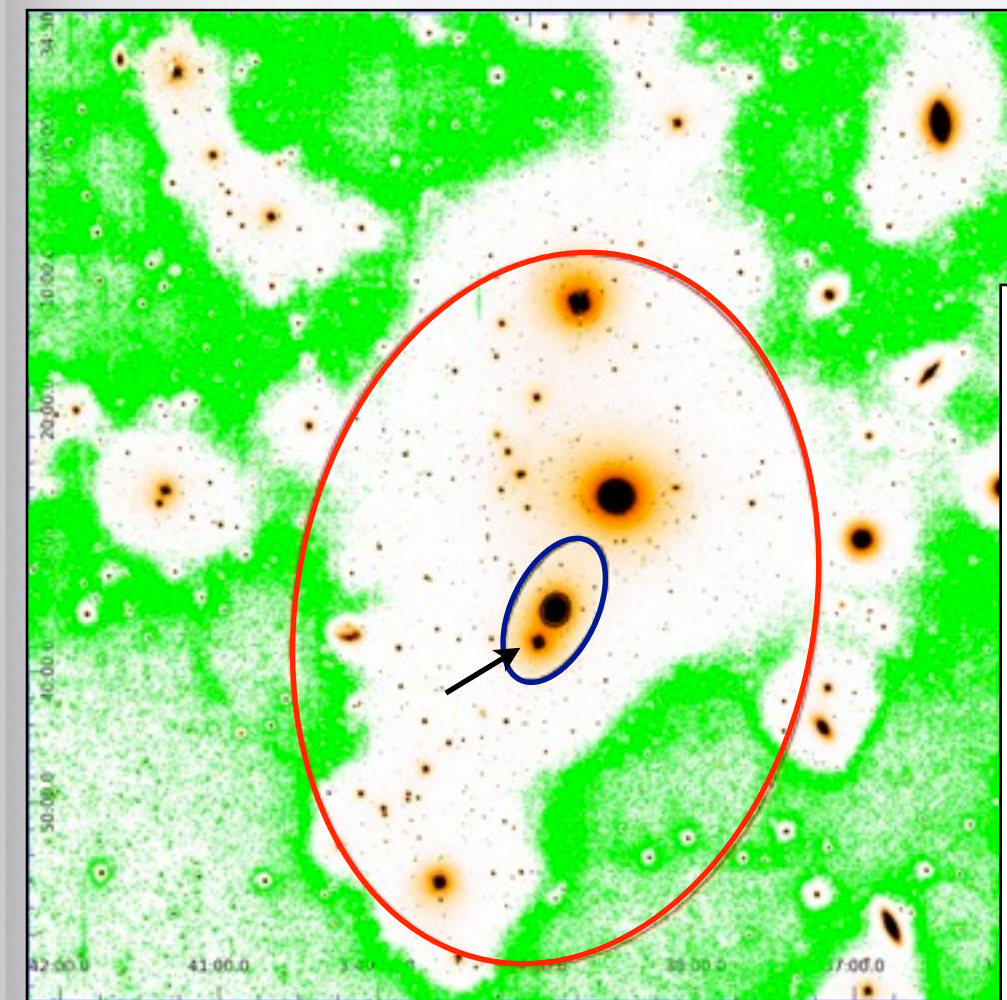


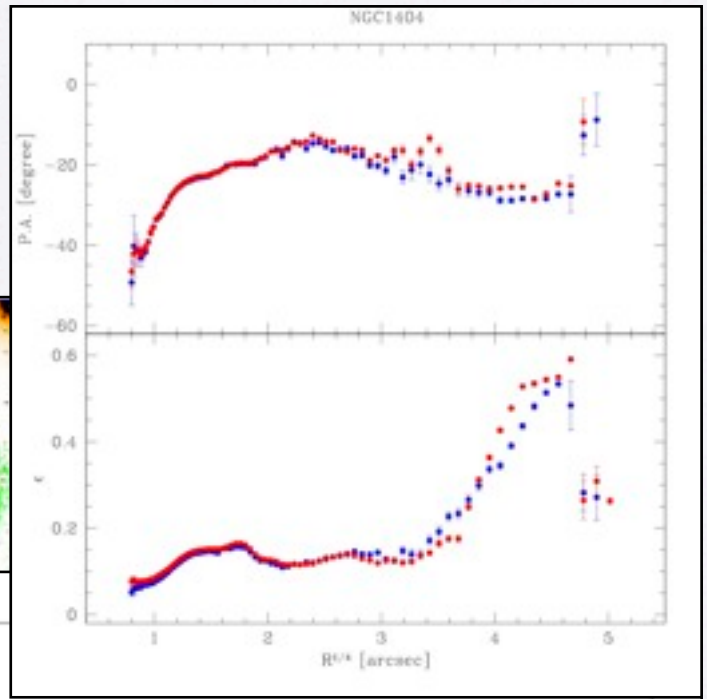


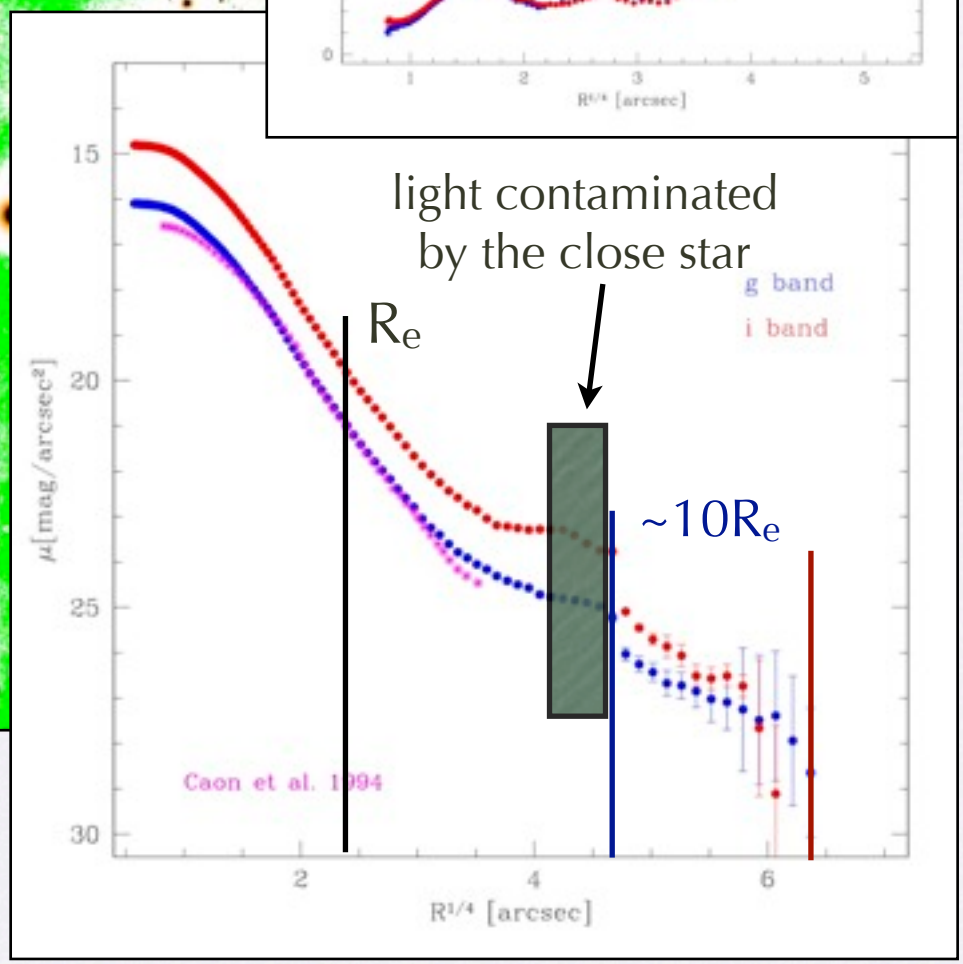



# Light distribution:

## NGC1404

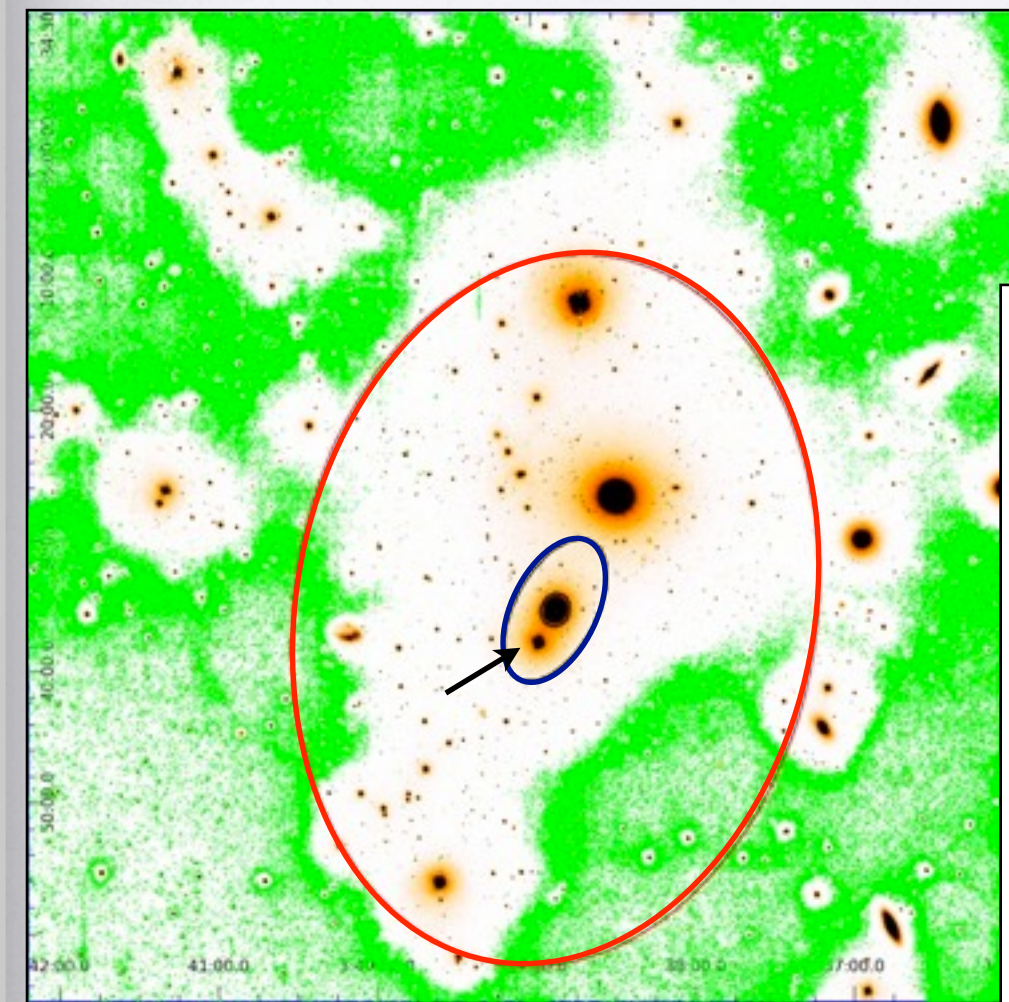


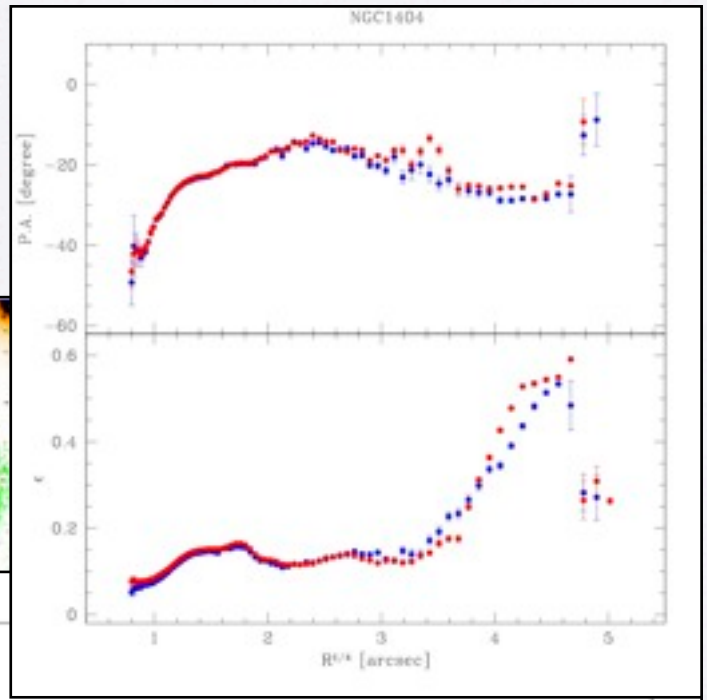


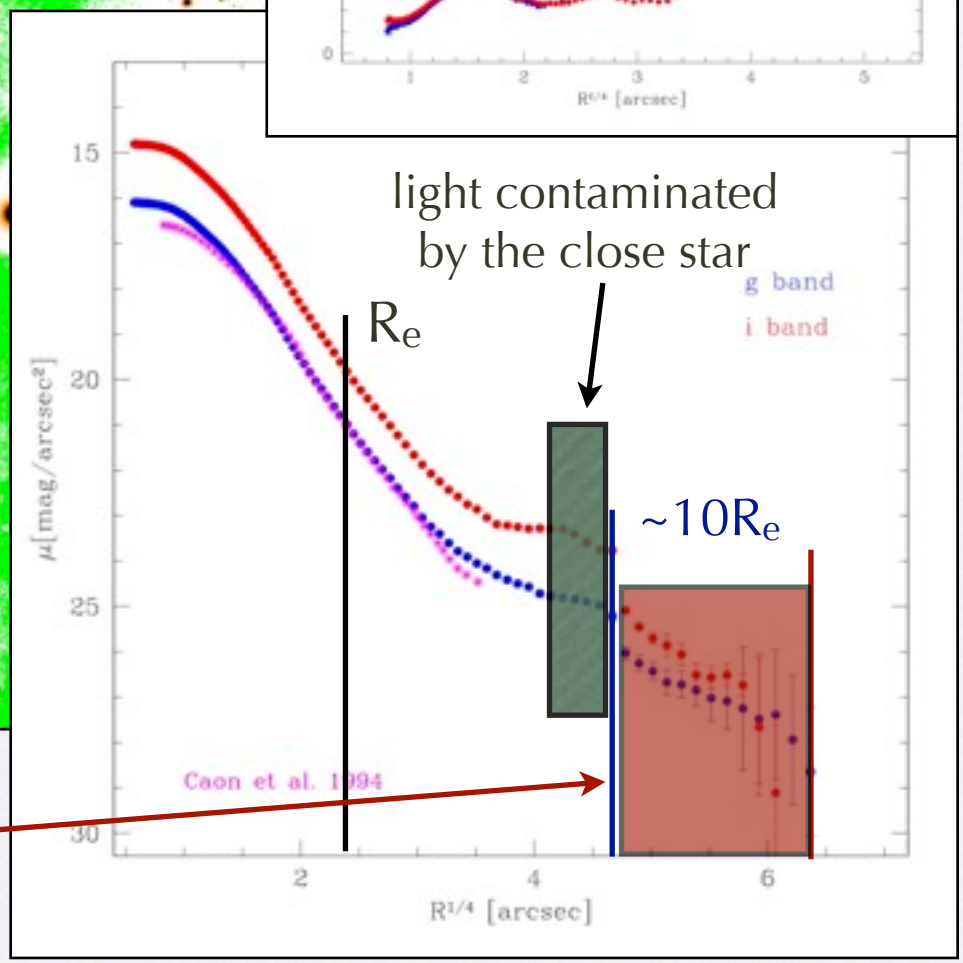



# Light distribution:

## NGC1404



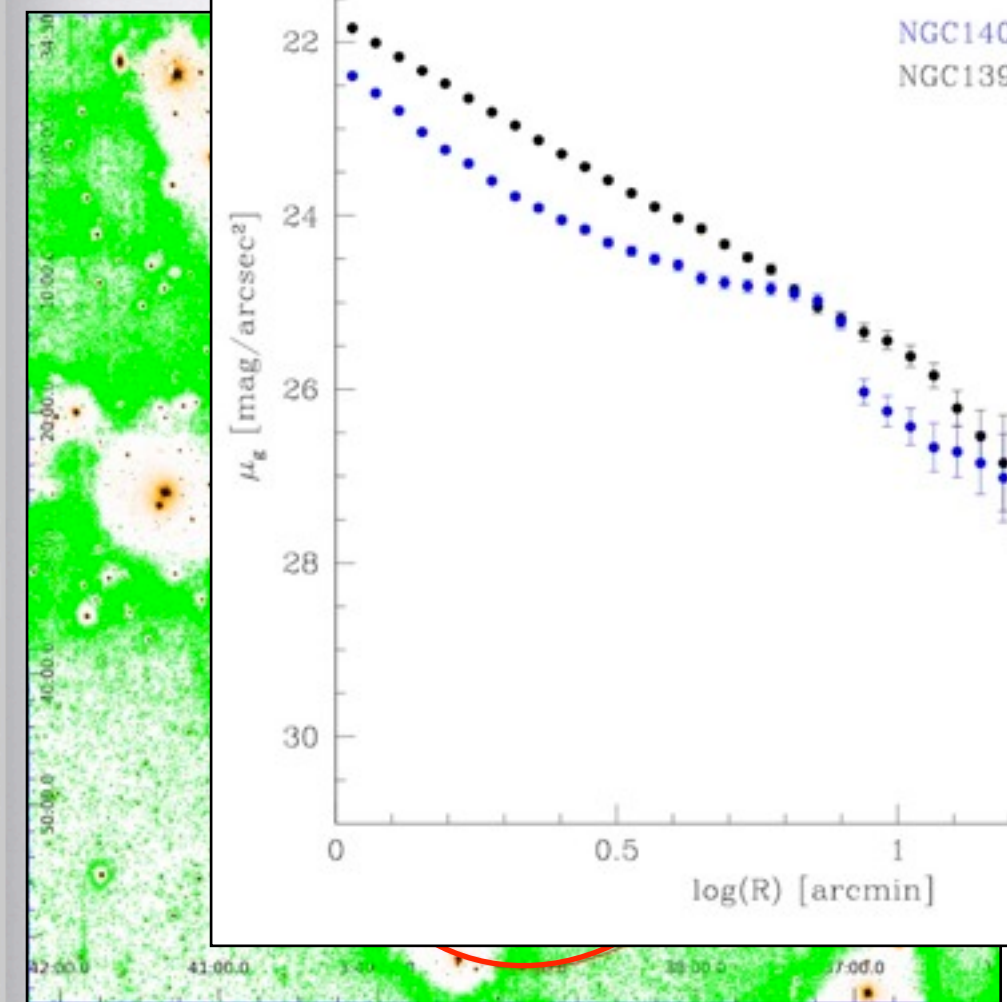


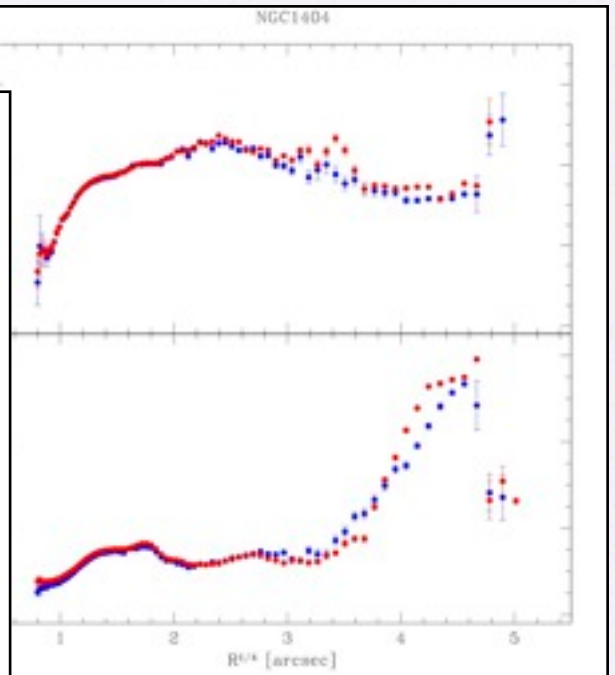

NGC1399 halo?

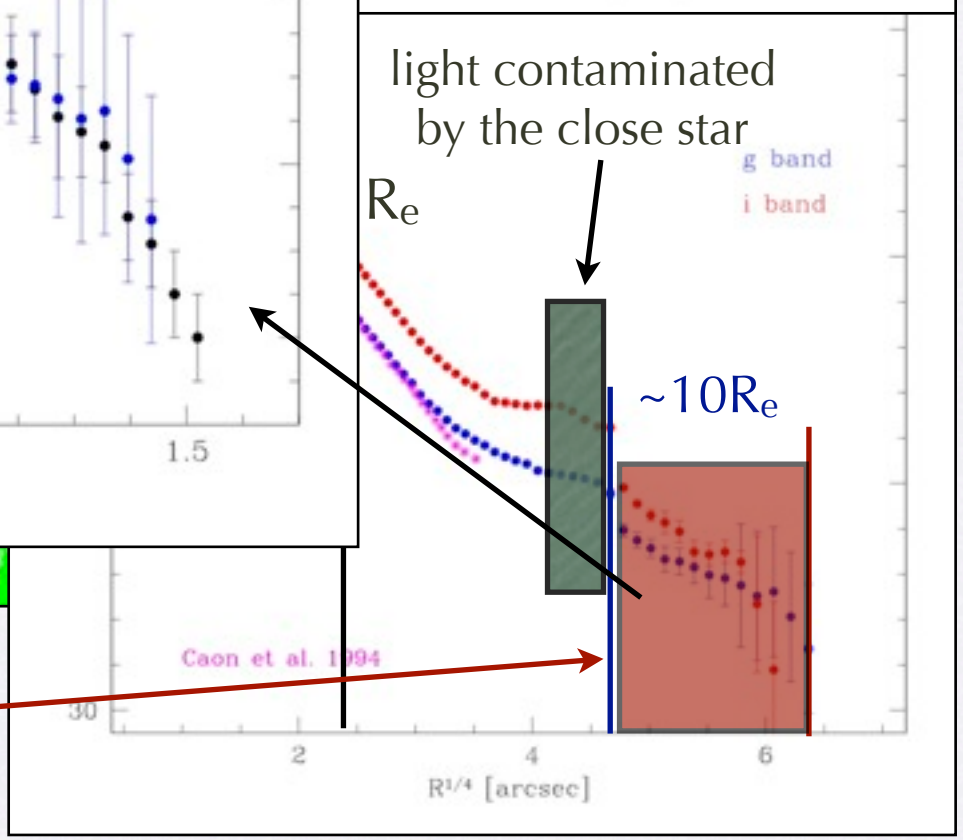
# Light distribution:

## NGC



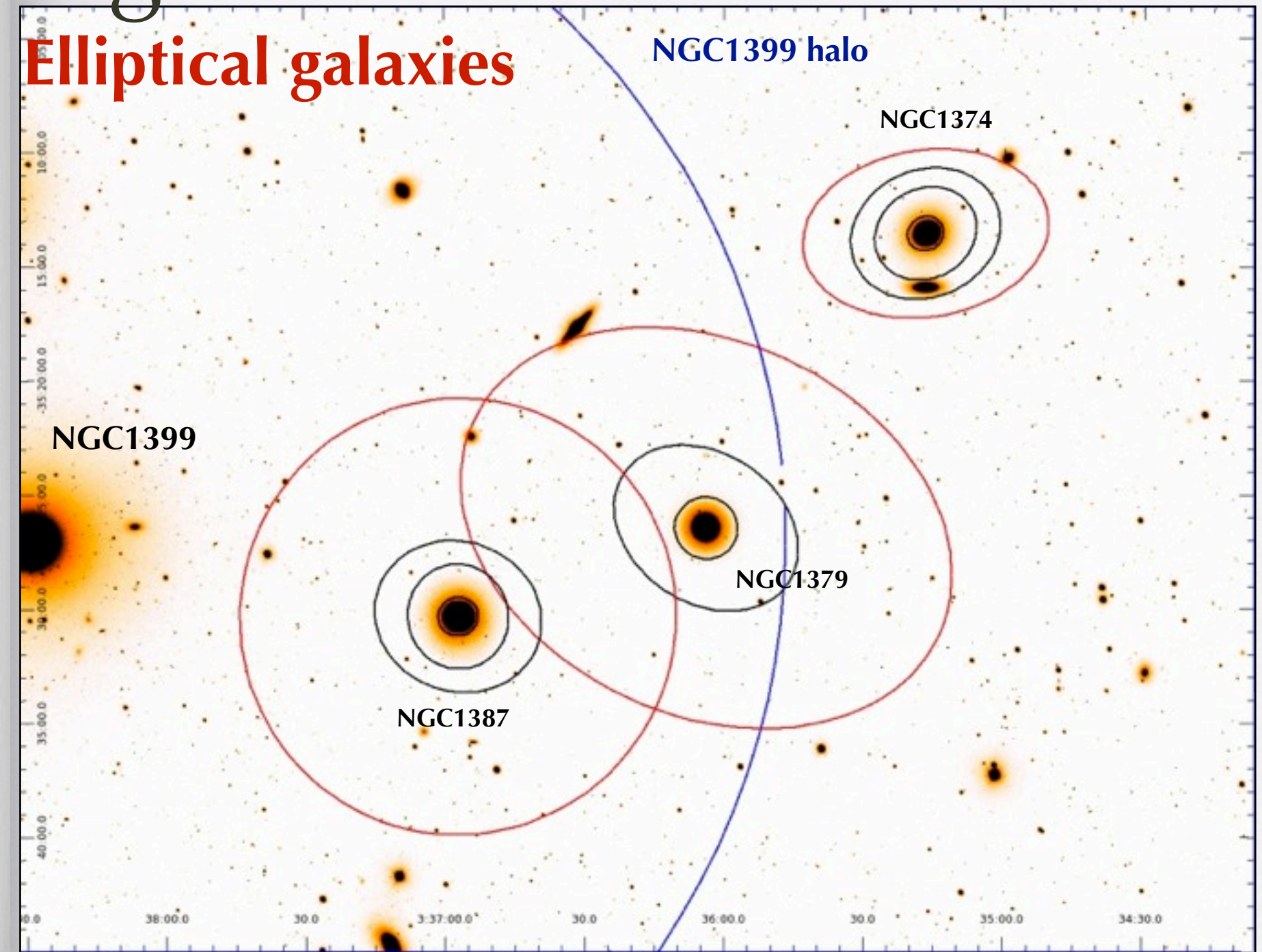


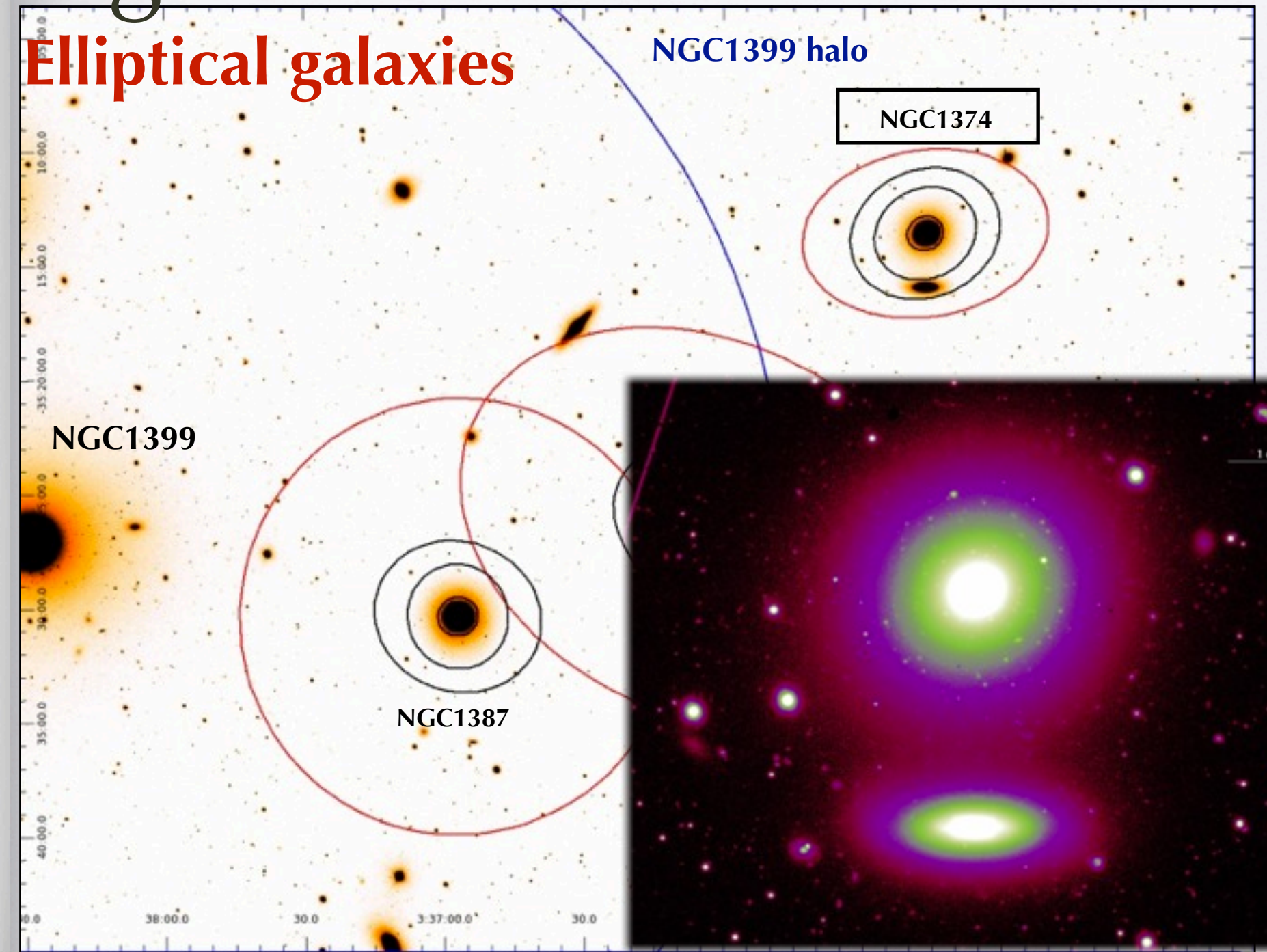




NGC1399 halo?

# Light distribution:

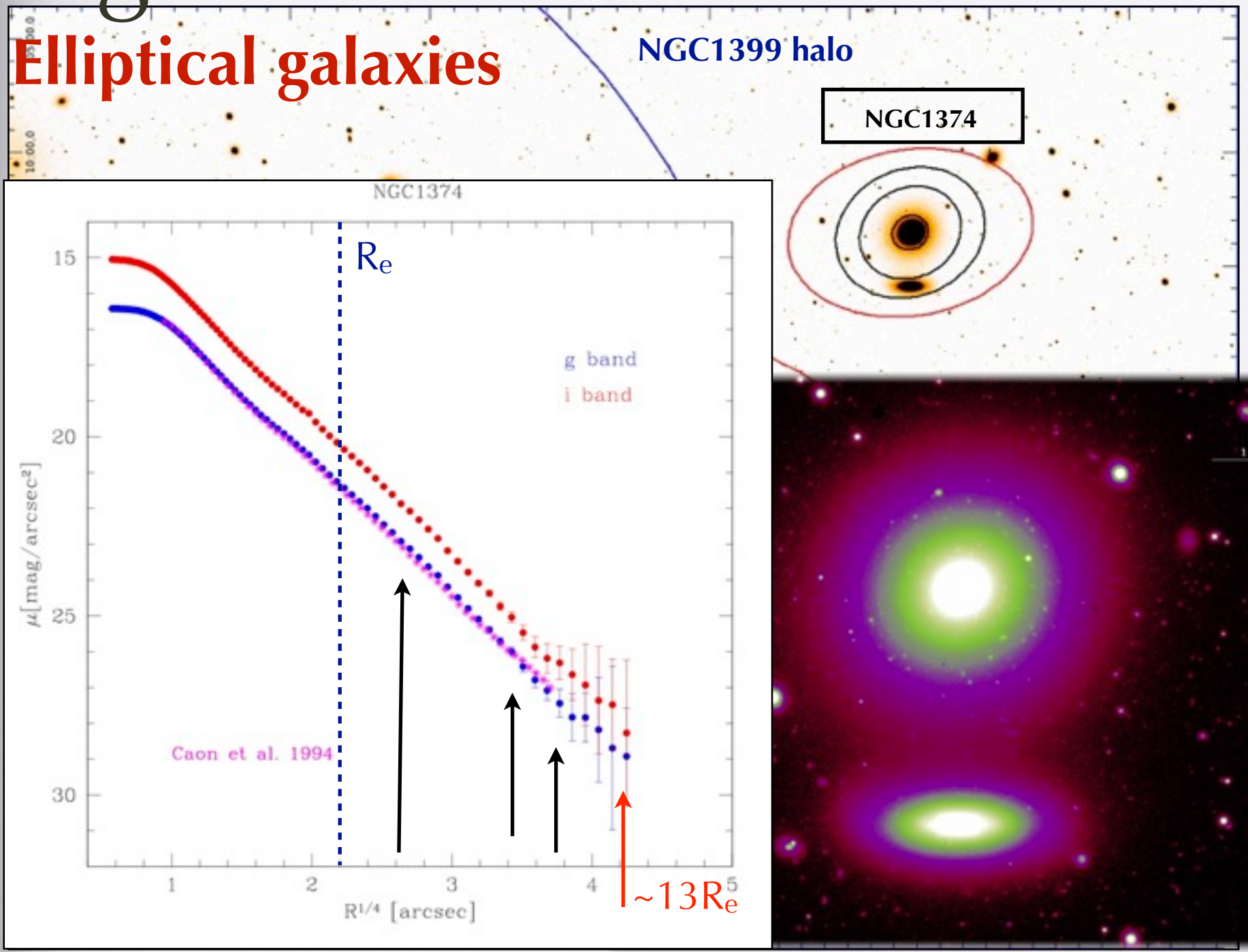


# Light distribution:



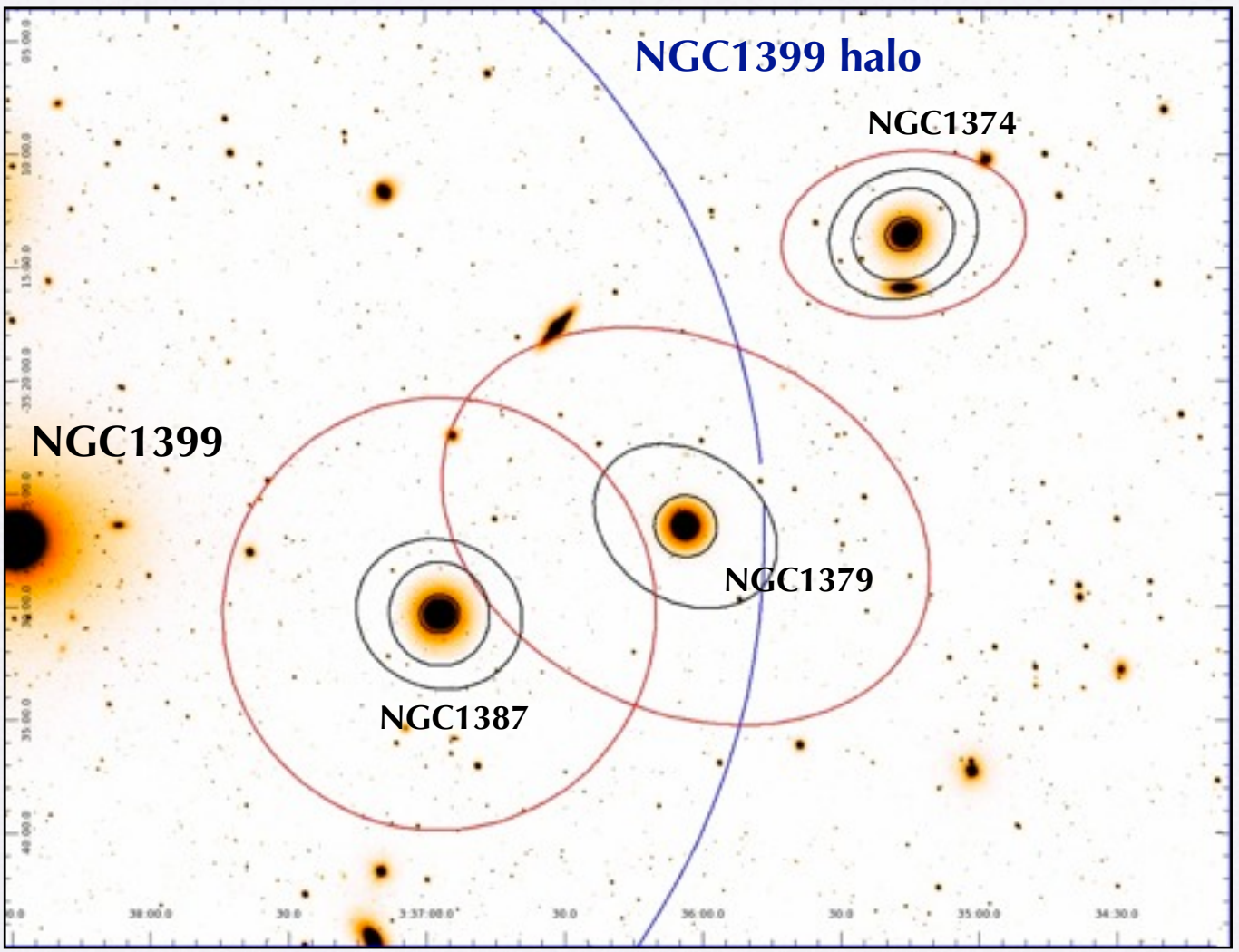
# Light distribution:

## Elliptical galaxies



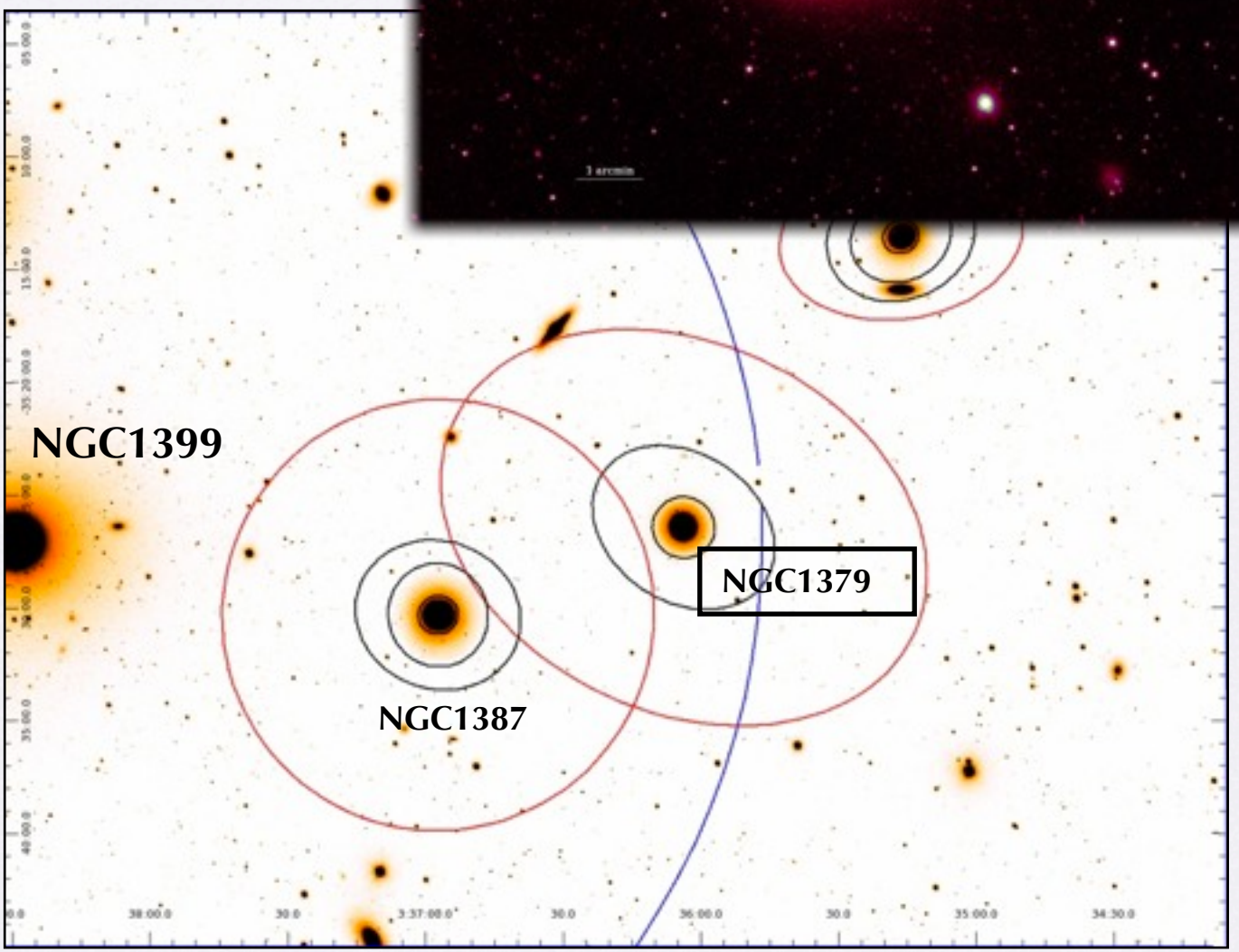
# Light distribution:

## Elliptical galaxies



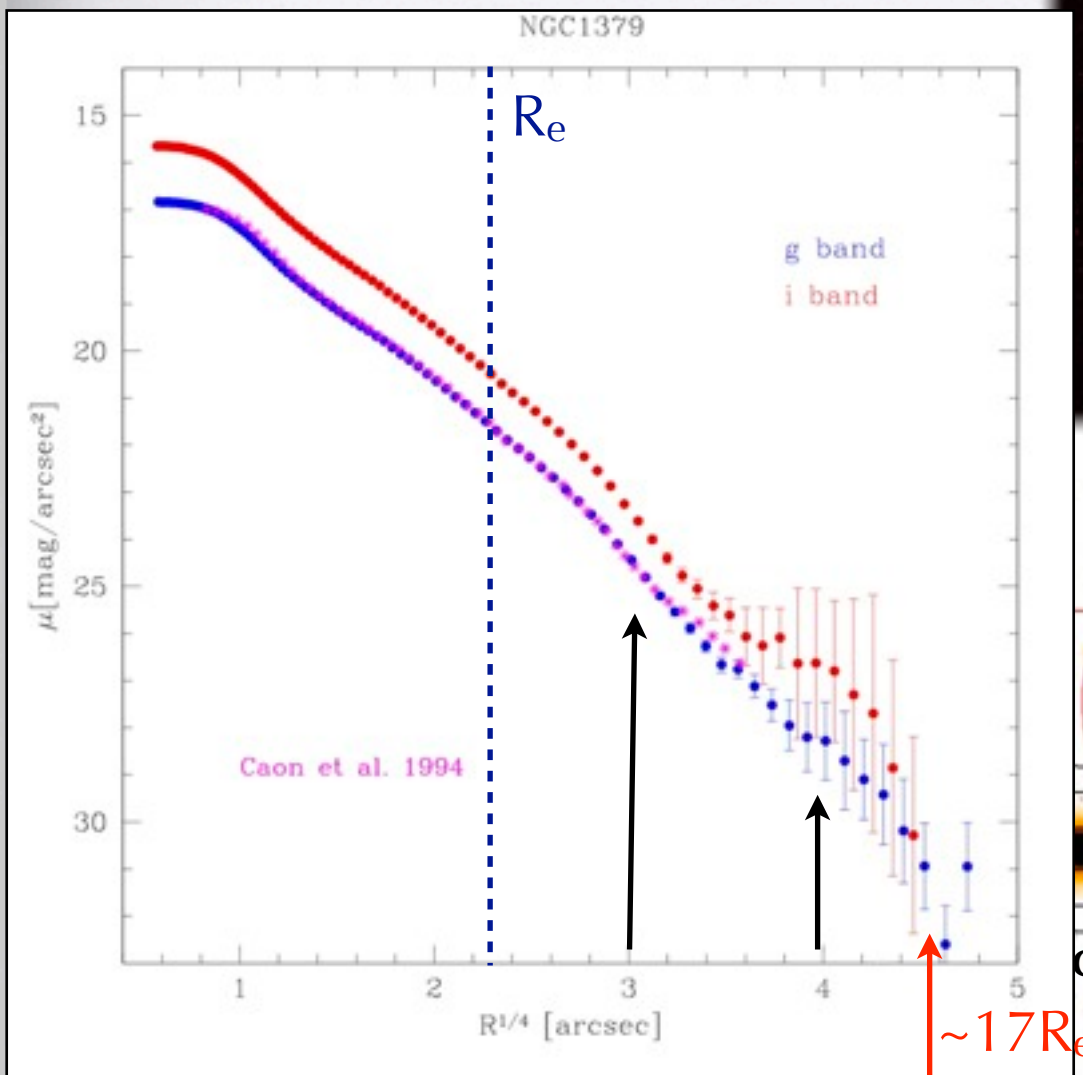
# Light distributio

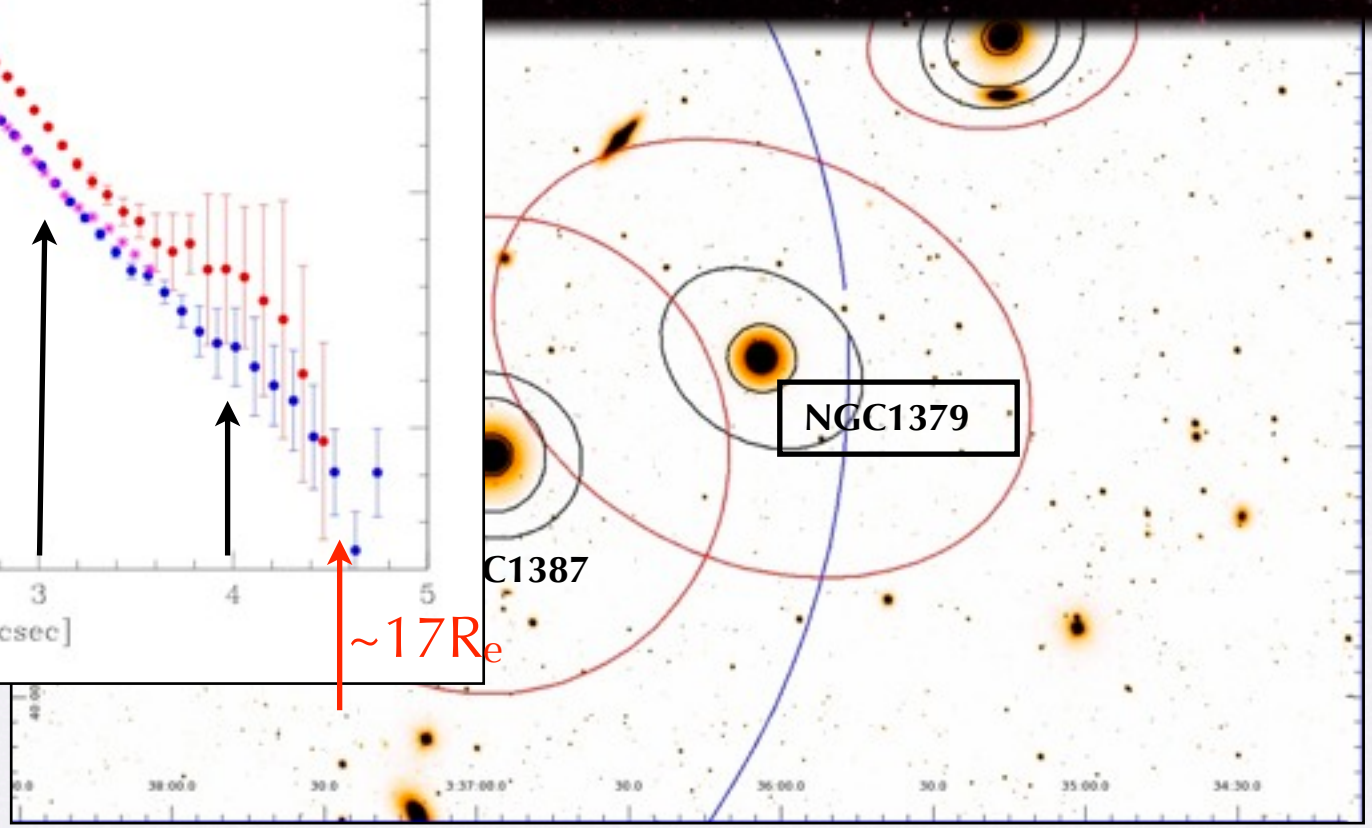
## Elliptical galaxies



# Light distributio

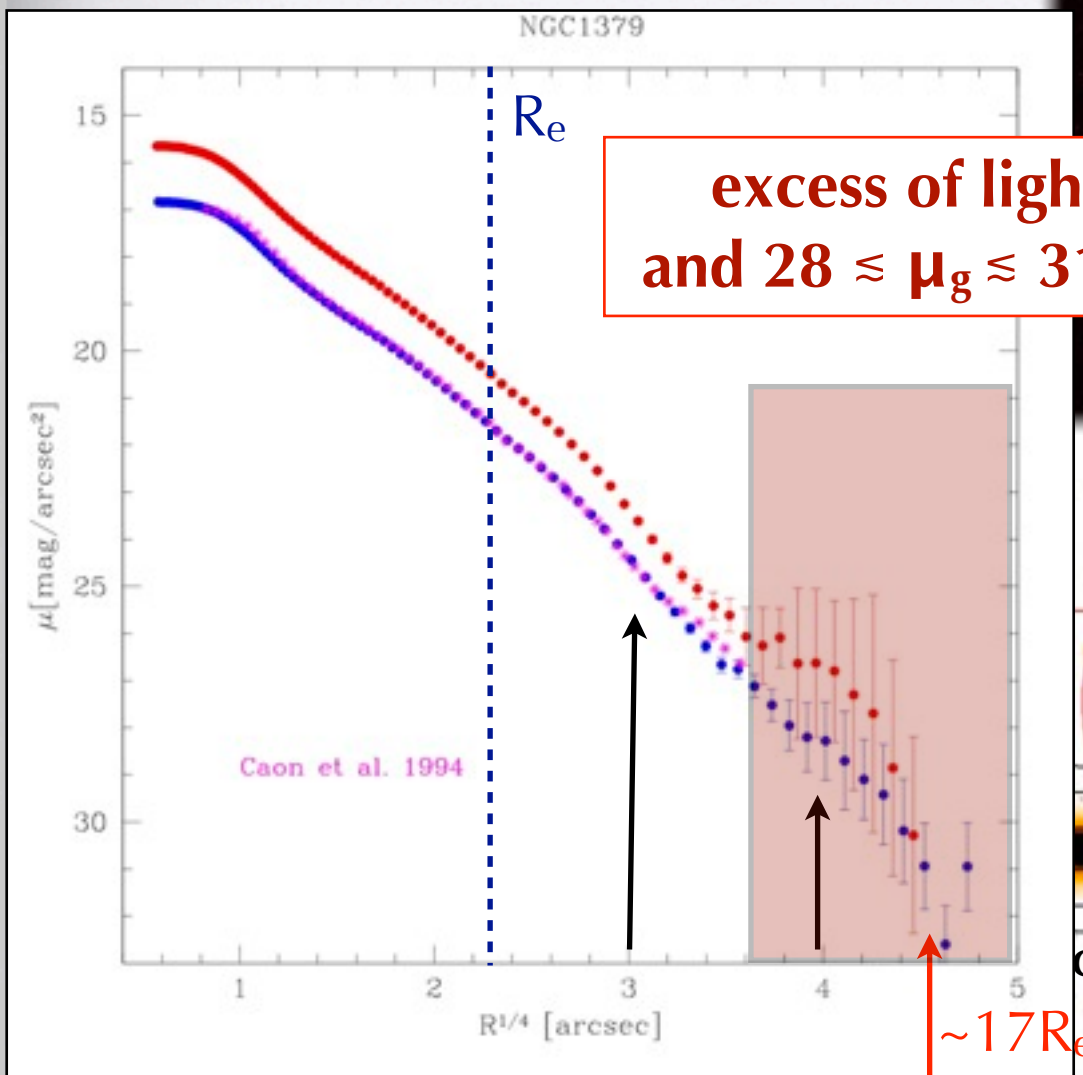
## Elliptical galaxies



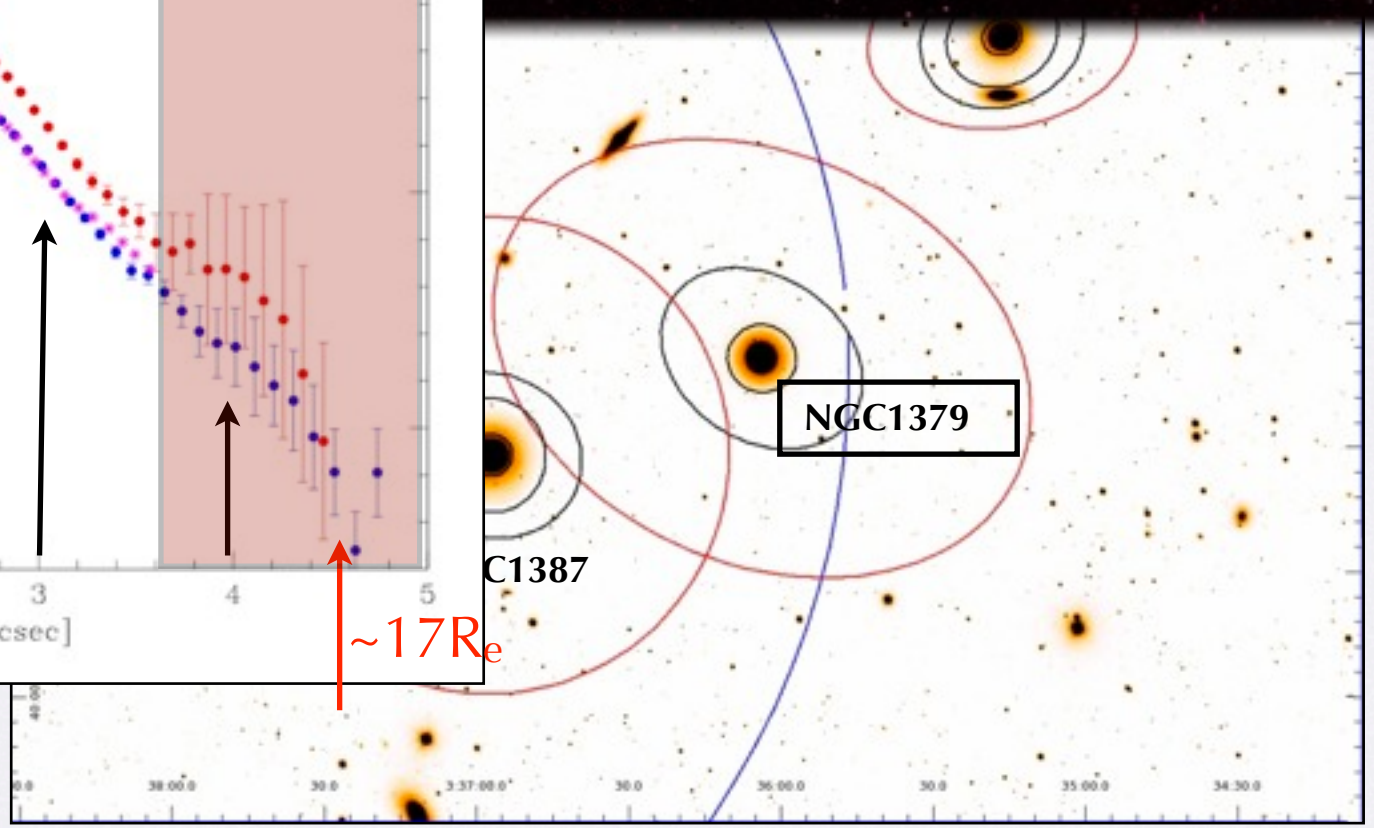



# Light distributio

## Elliptical galaxies

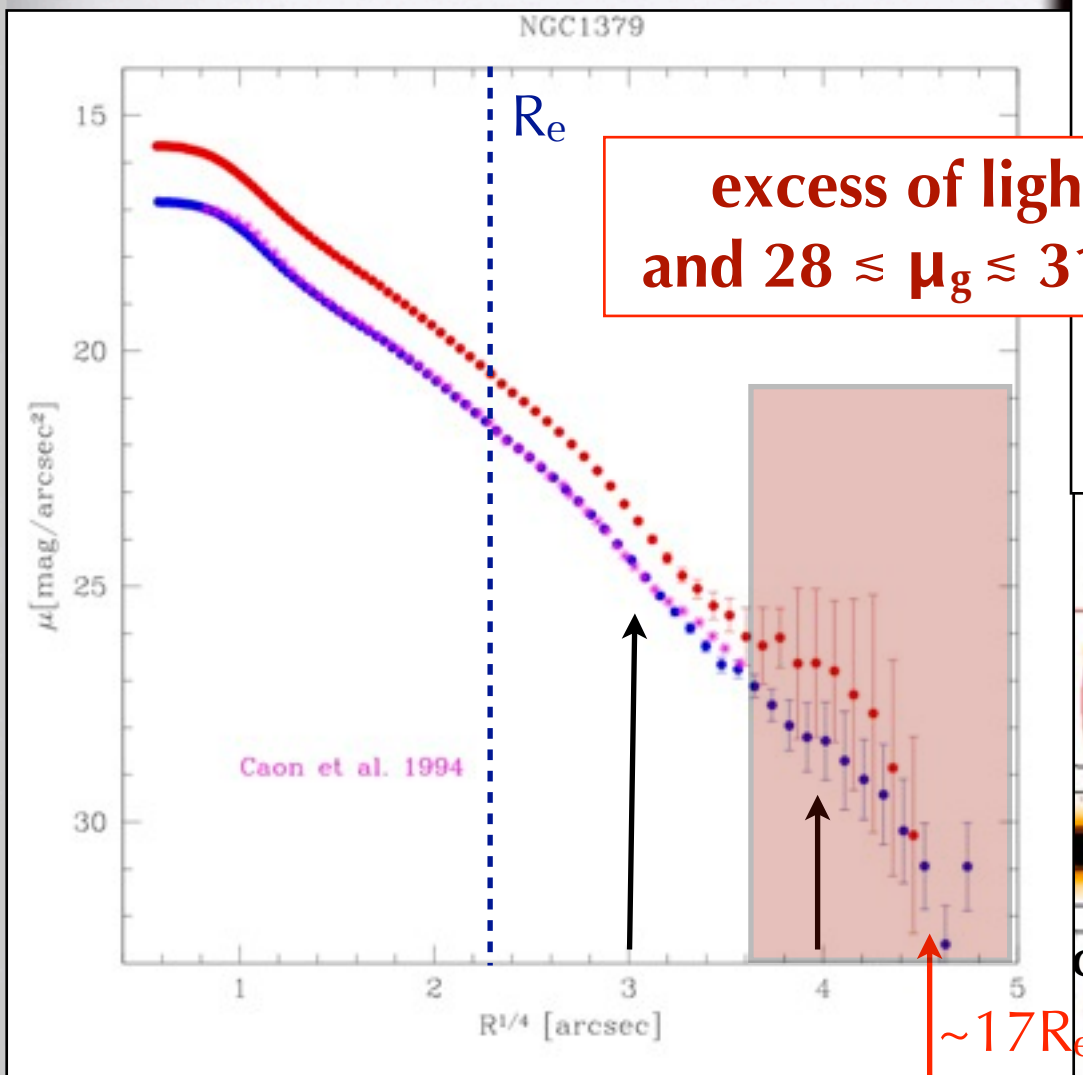


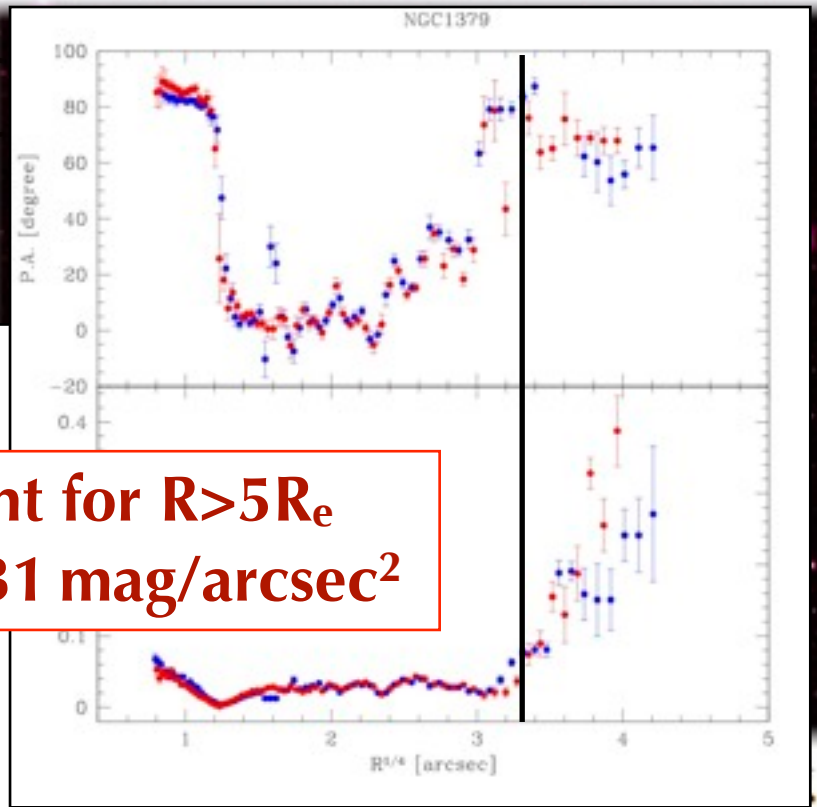

**excess of light for $R>5R_e$ and $28 \lesssim \mu_g \lesssim 31$ mag/arcsec$^2$**



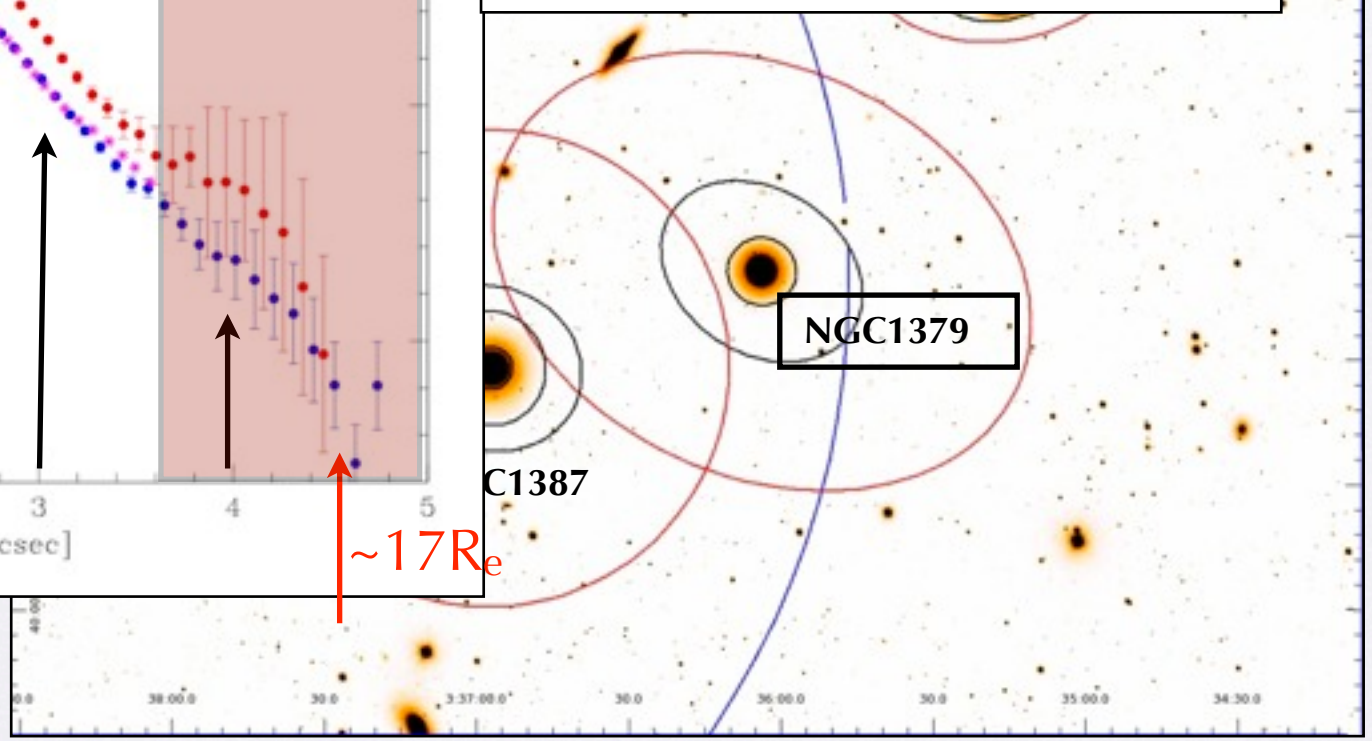
# Light distributio

## Elliptical galaxies



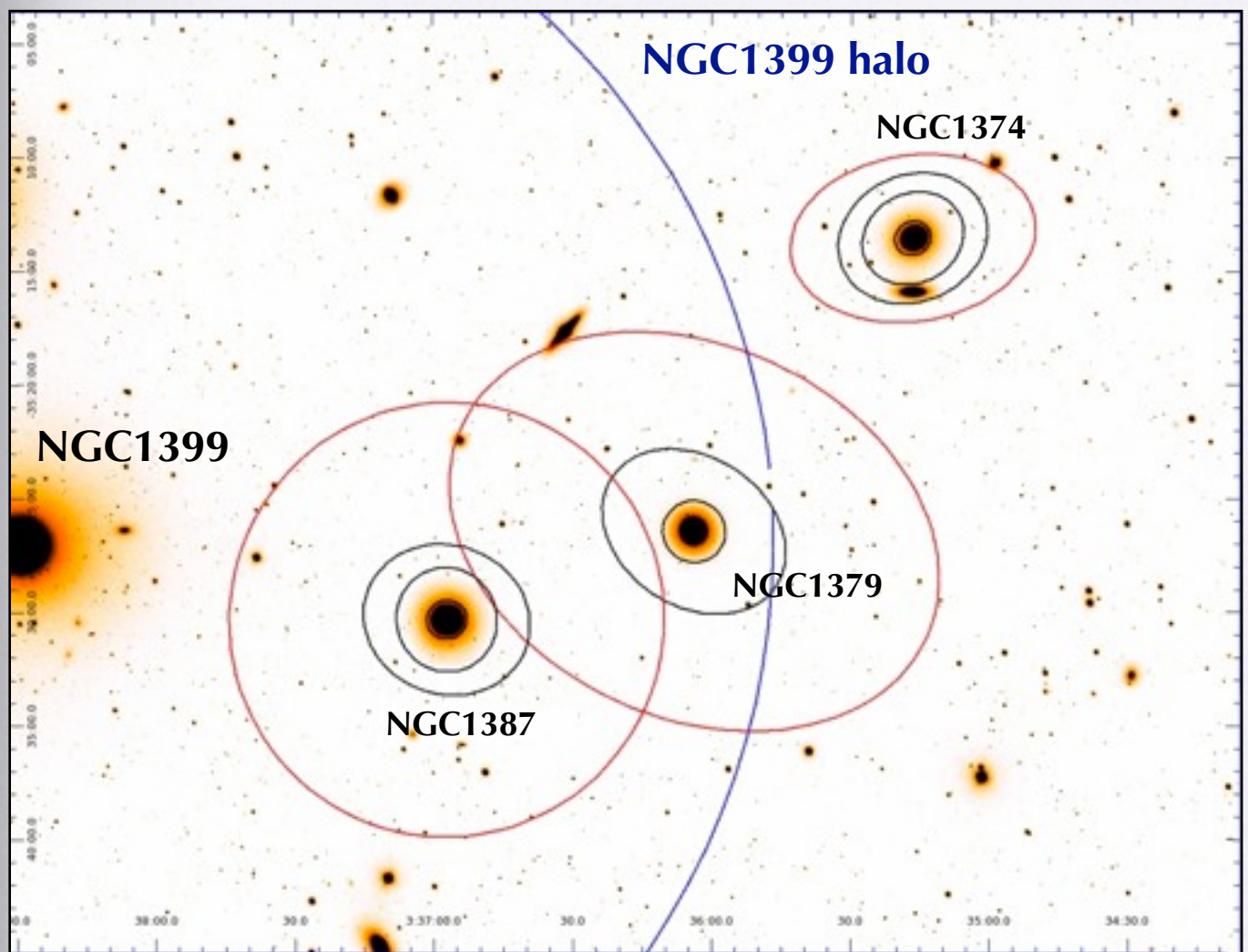




**excess of light for $R>5R_e$ and $28 \lesssim \mu_g \lesssim 31$ mag/arcsec$^2$**

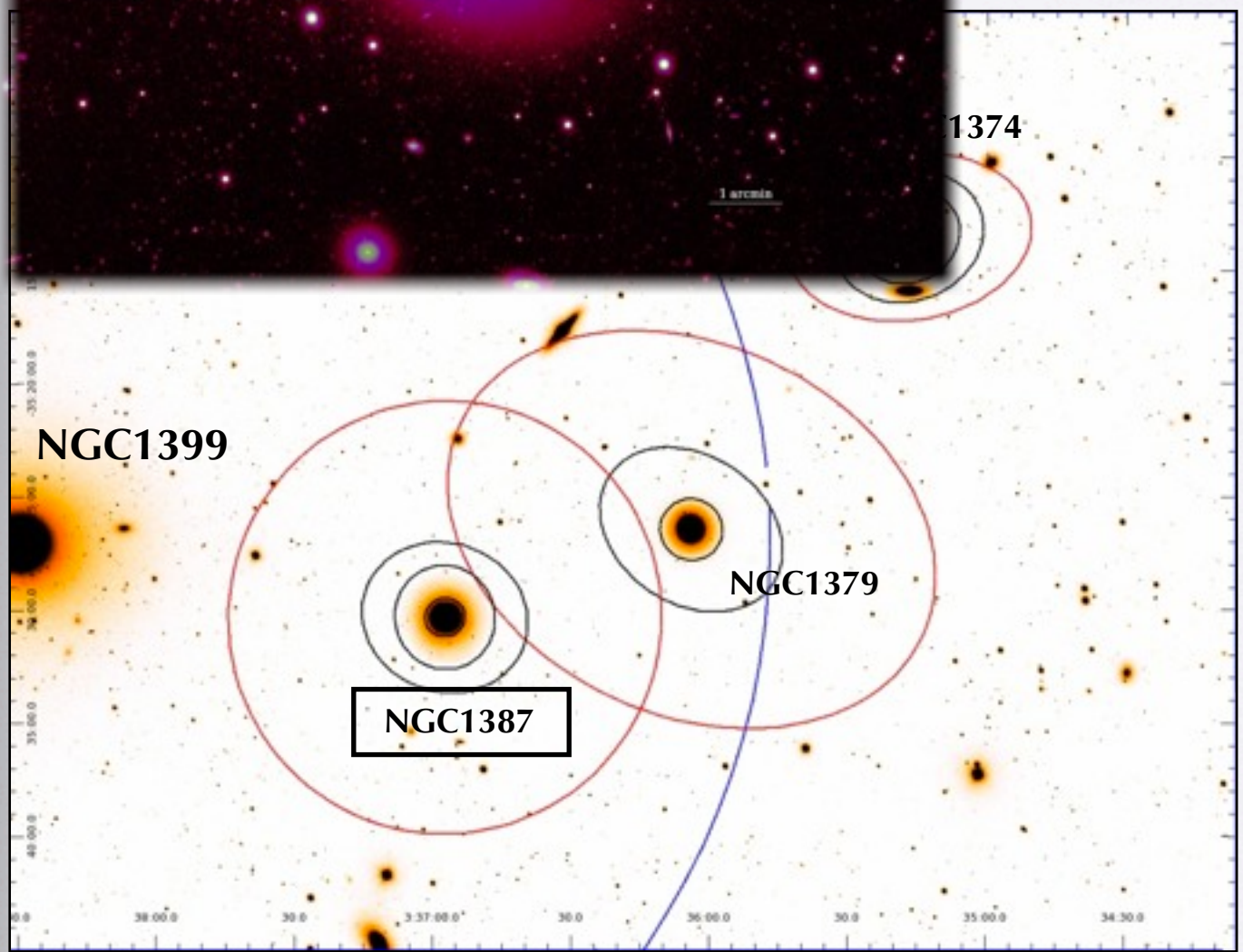


# Light distribution:

## Elliptical galaxies



# on:



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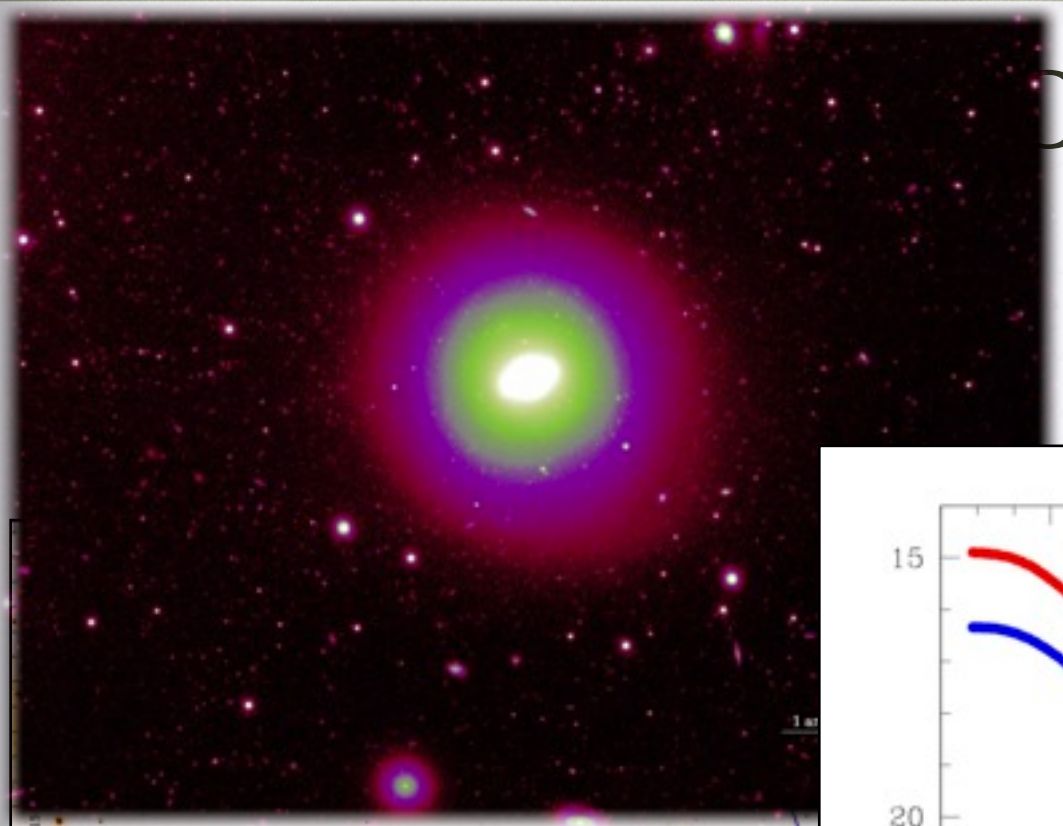
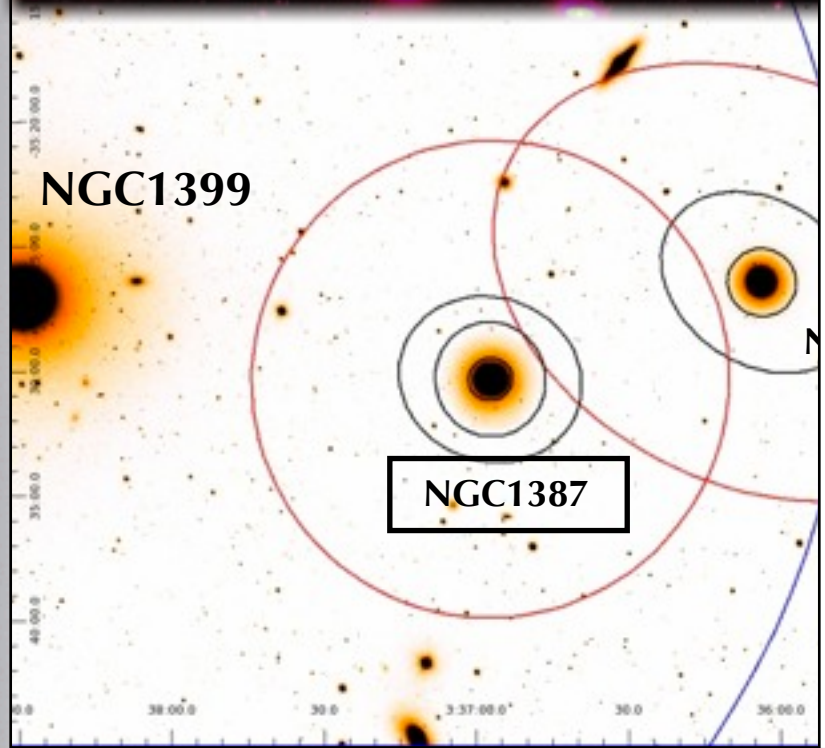
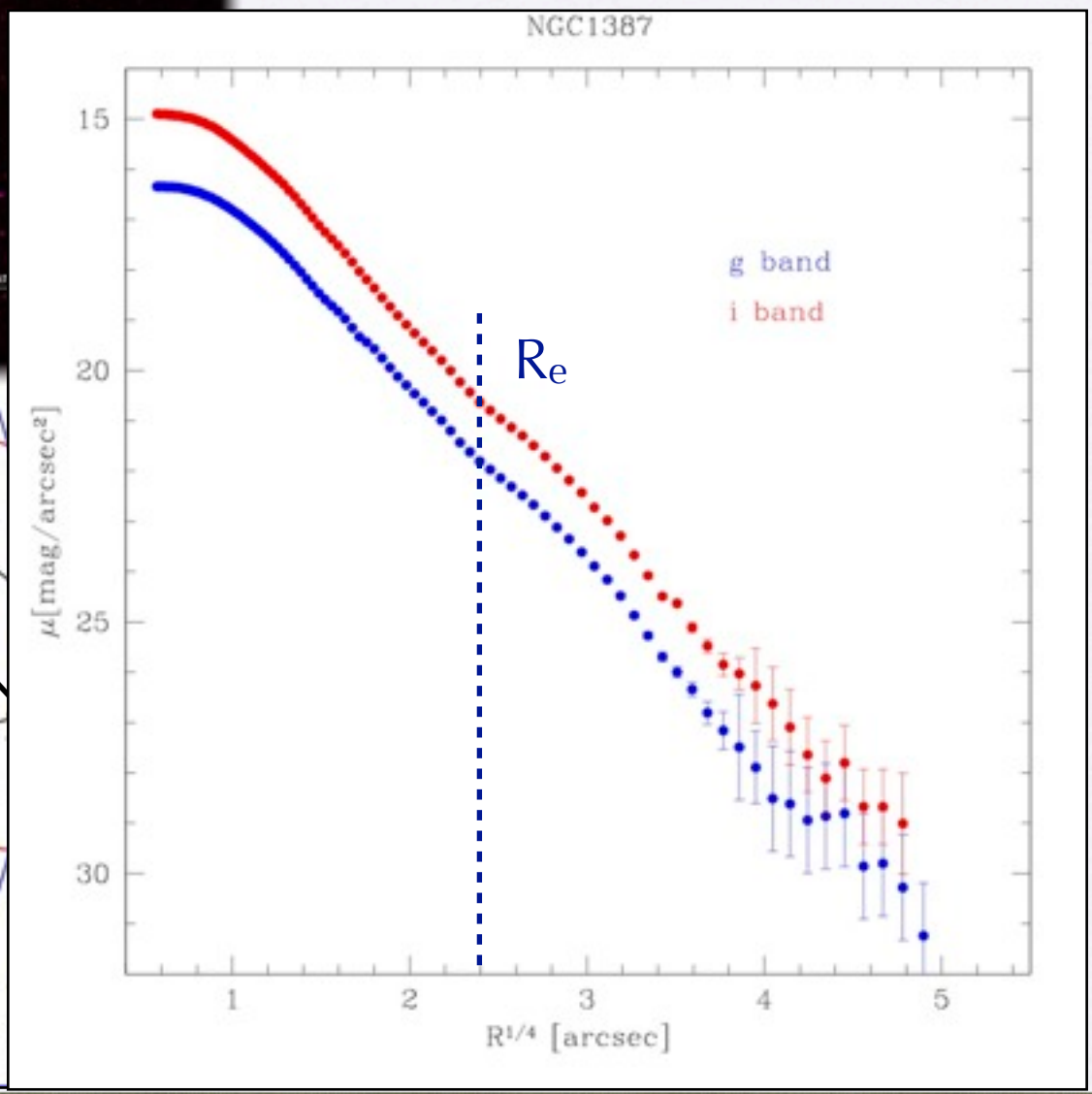
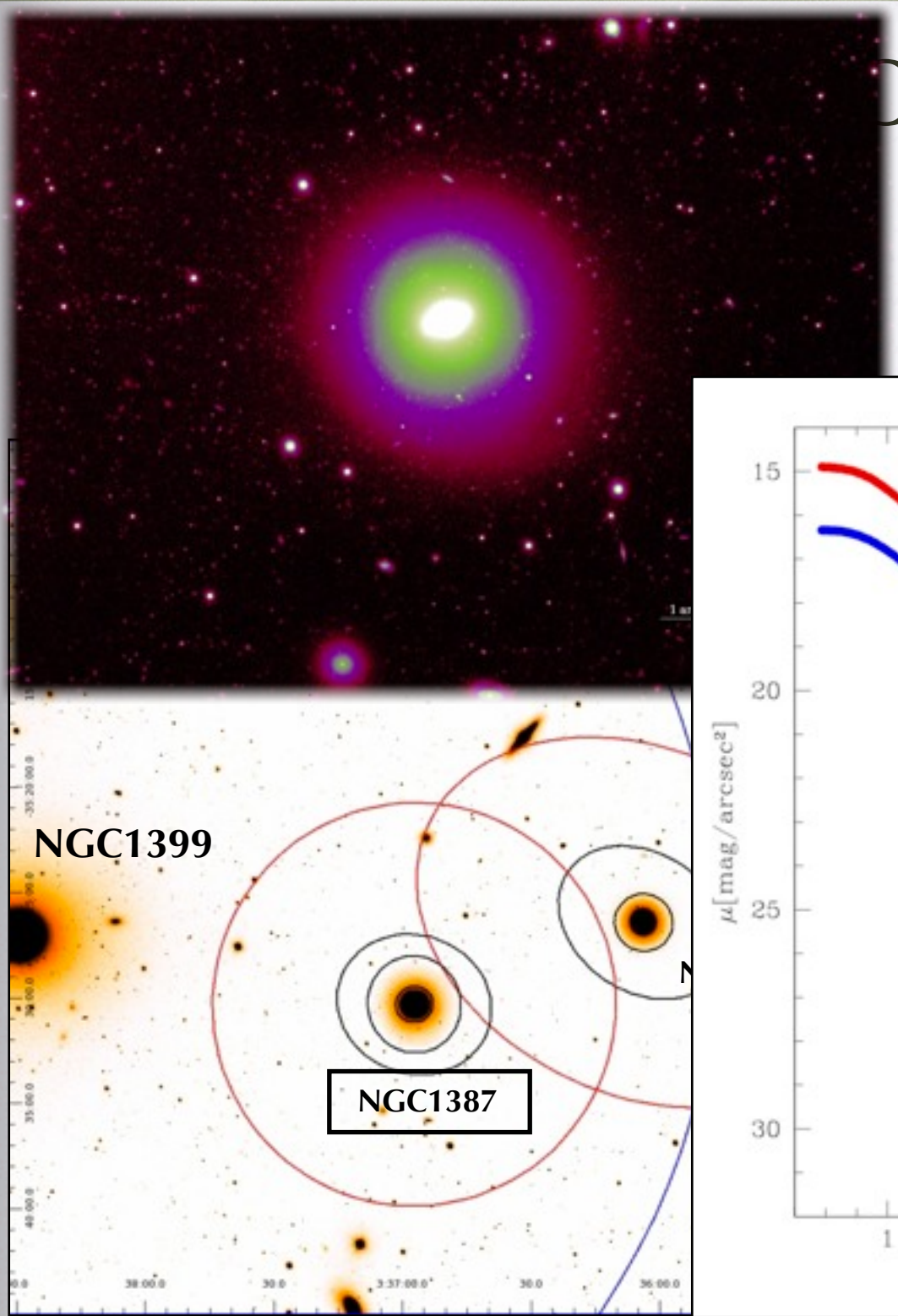
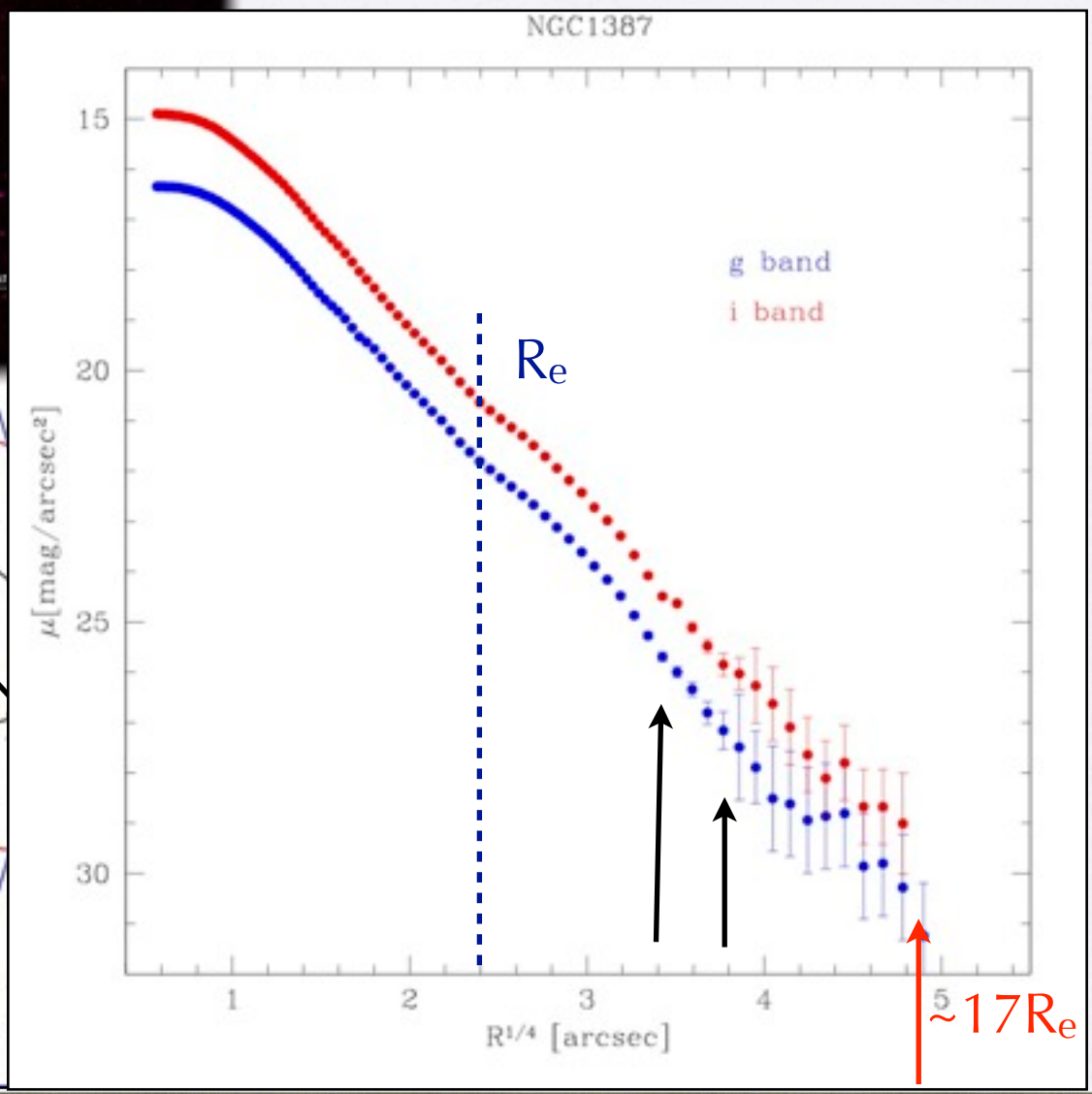



NGC1399
NGC1387

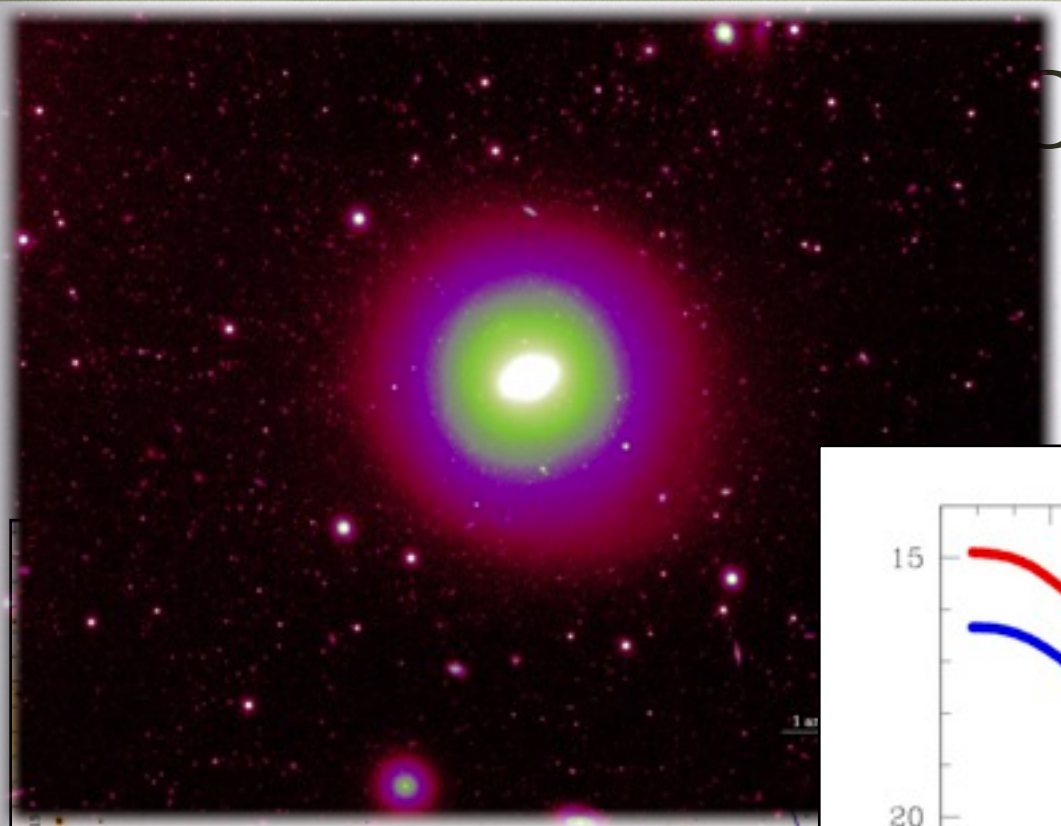

NGC1387
g band
i band
$R_e$
$\mu$[mag/arcsec$^2$]
$R^{1/4}$ [arcsec]
15
20
25
30
1
2
3
4
5

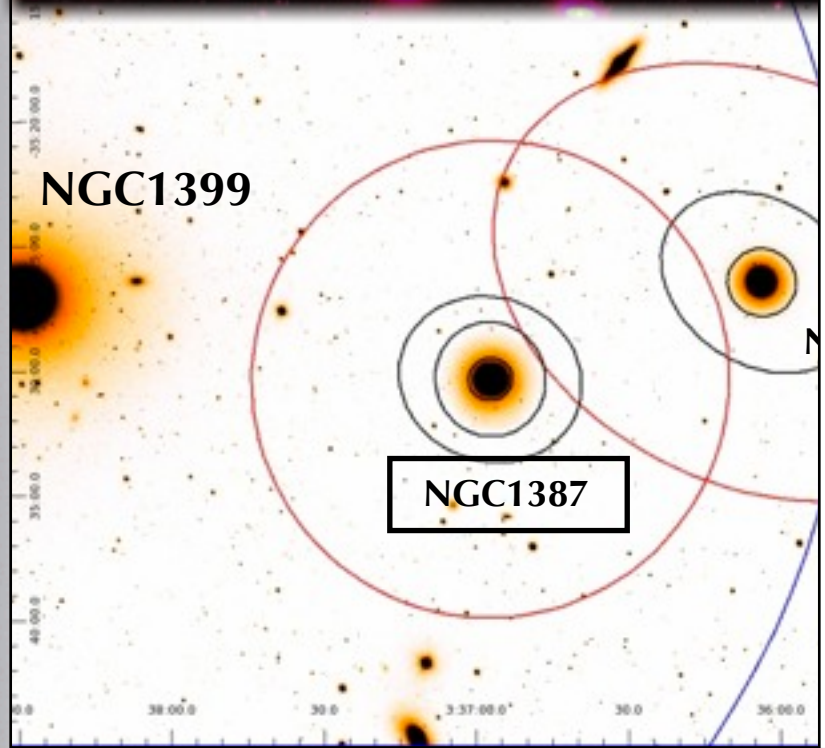
# on:

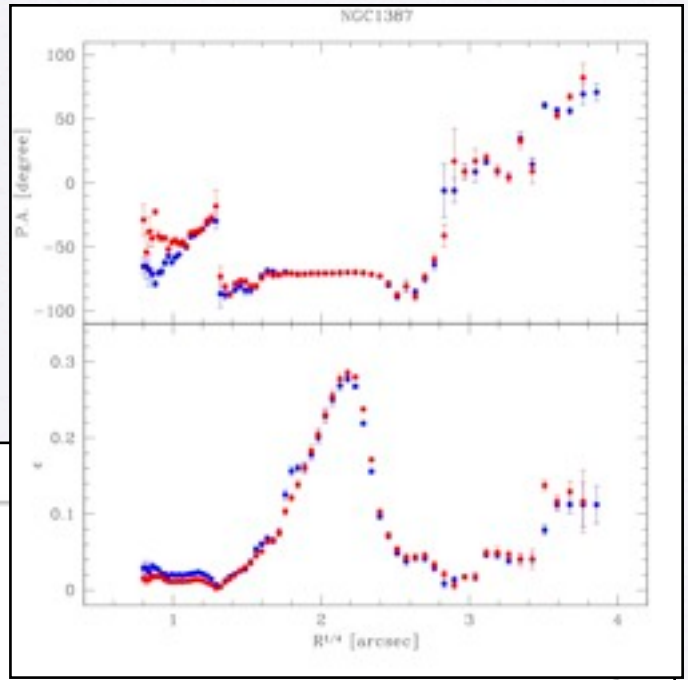

NGC1399
NGC1387

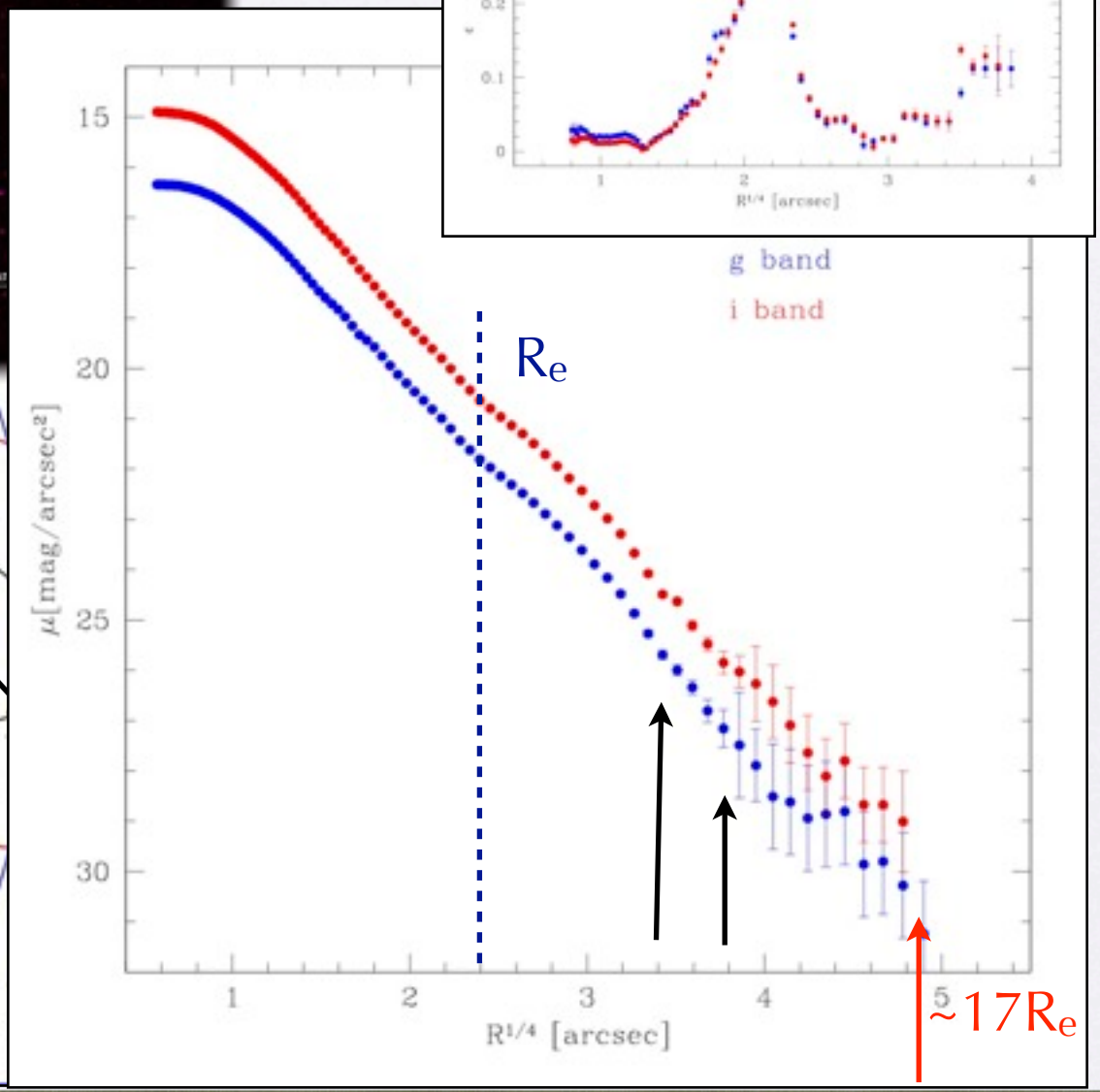

NGC1387
g band
i band
$R_e$
$\mu$[mag/arcsec$^2$]
$R^{1/4}$ [arcsec]
~17$R_e$

# on:

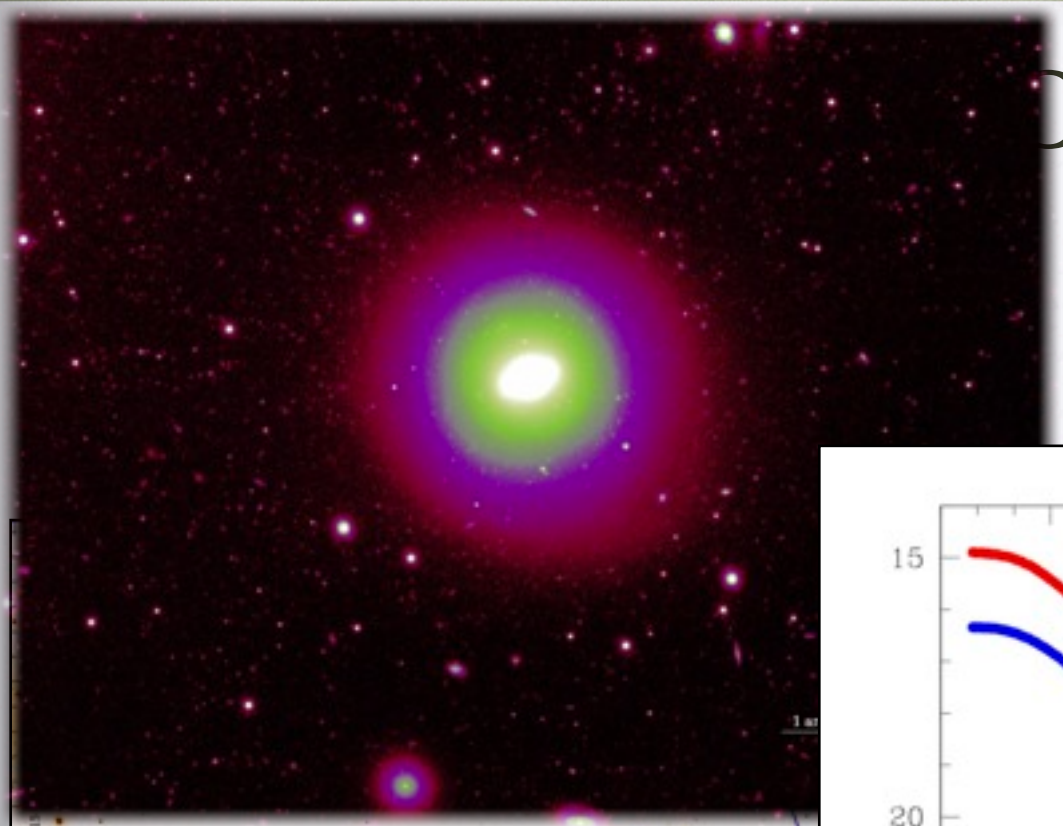


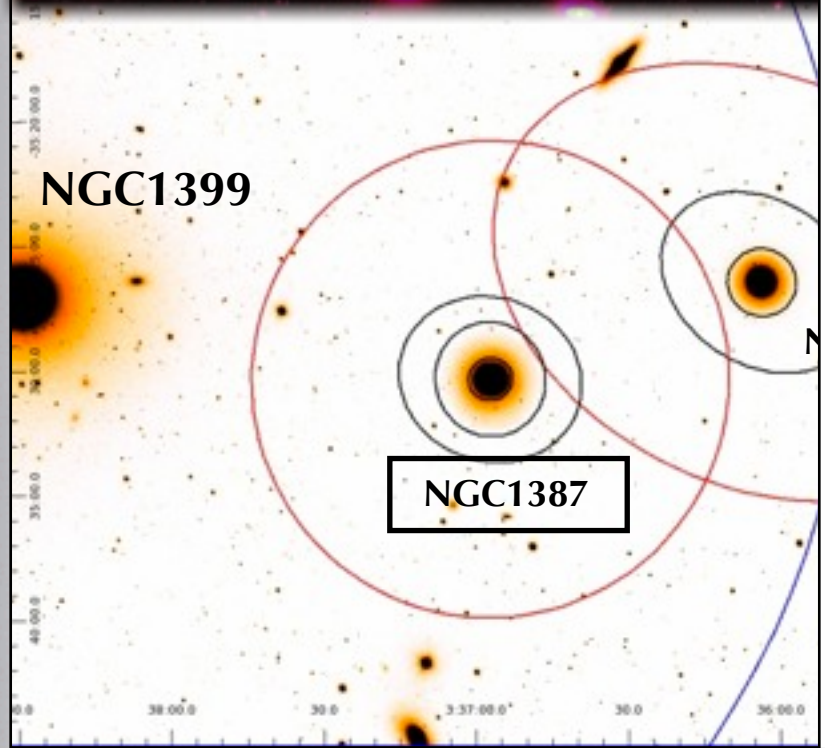

NGC1399
NGC1387

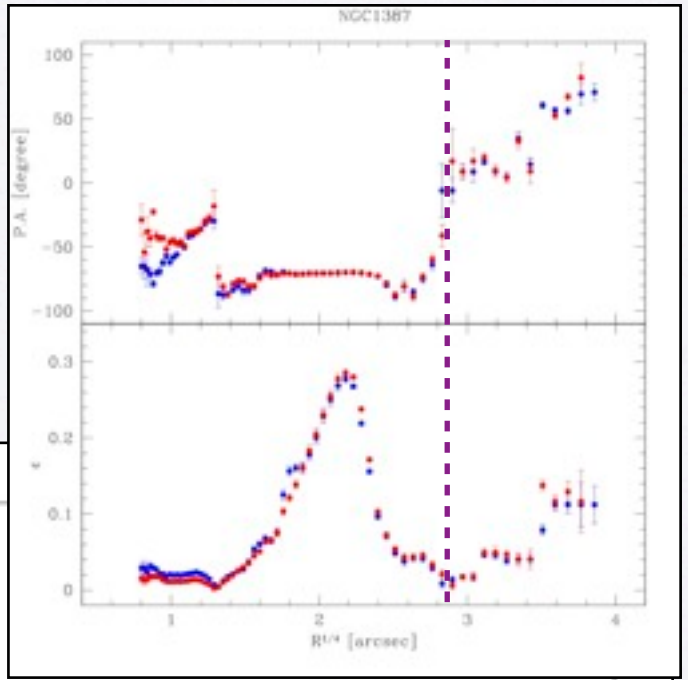

NGC1387
P.A. [degree]
R^1/4 [arcsec]

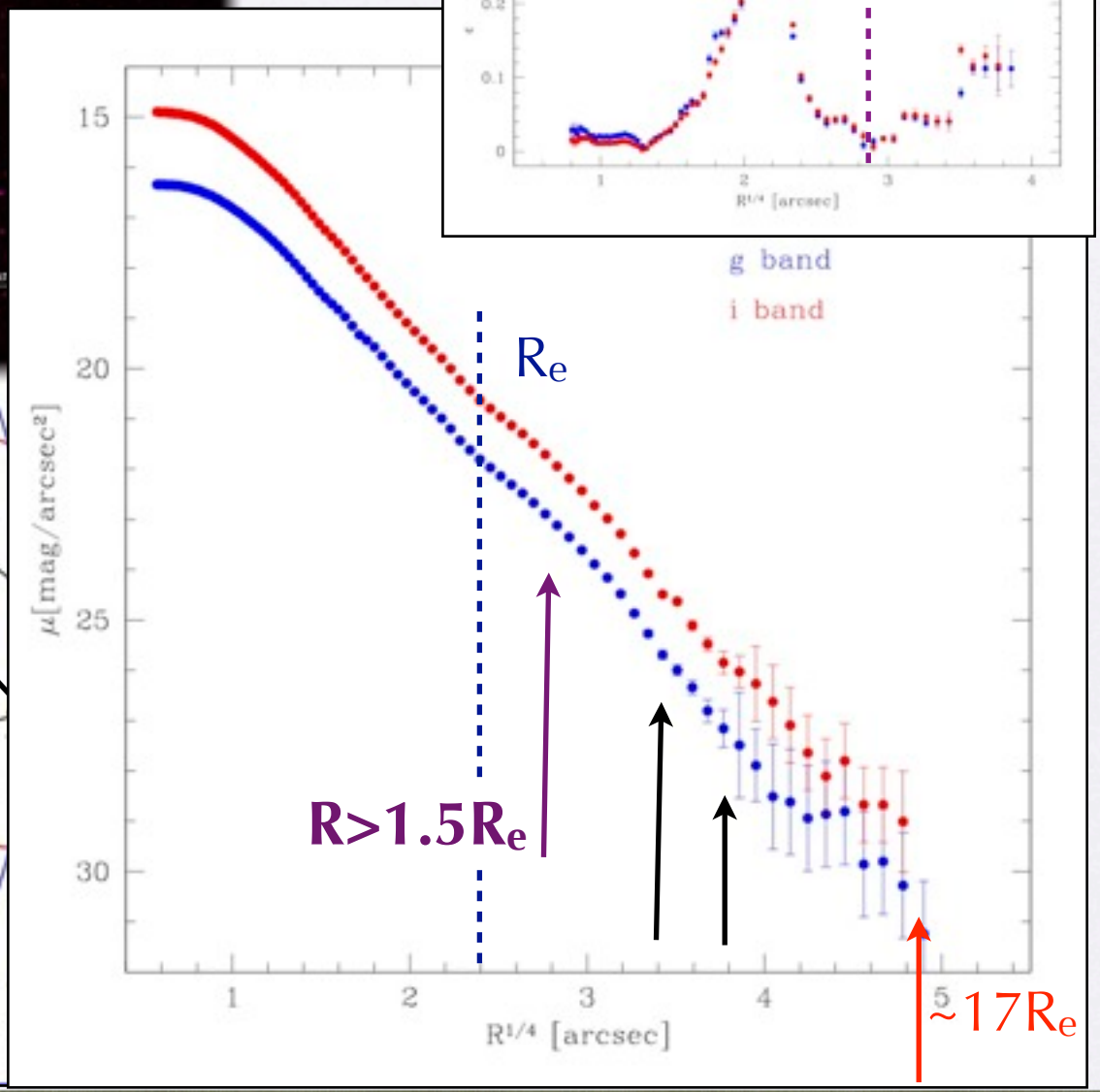

g band
i band
Re
μ[mag/arcsec²]
R^1/4 [arcsec]
~17Re

# on:



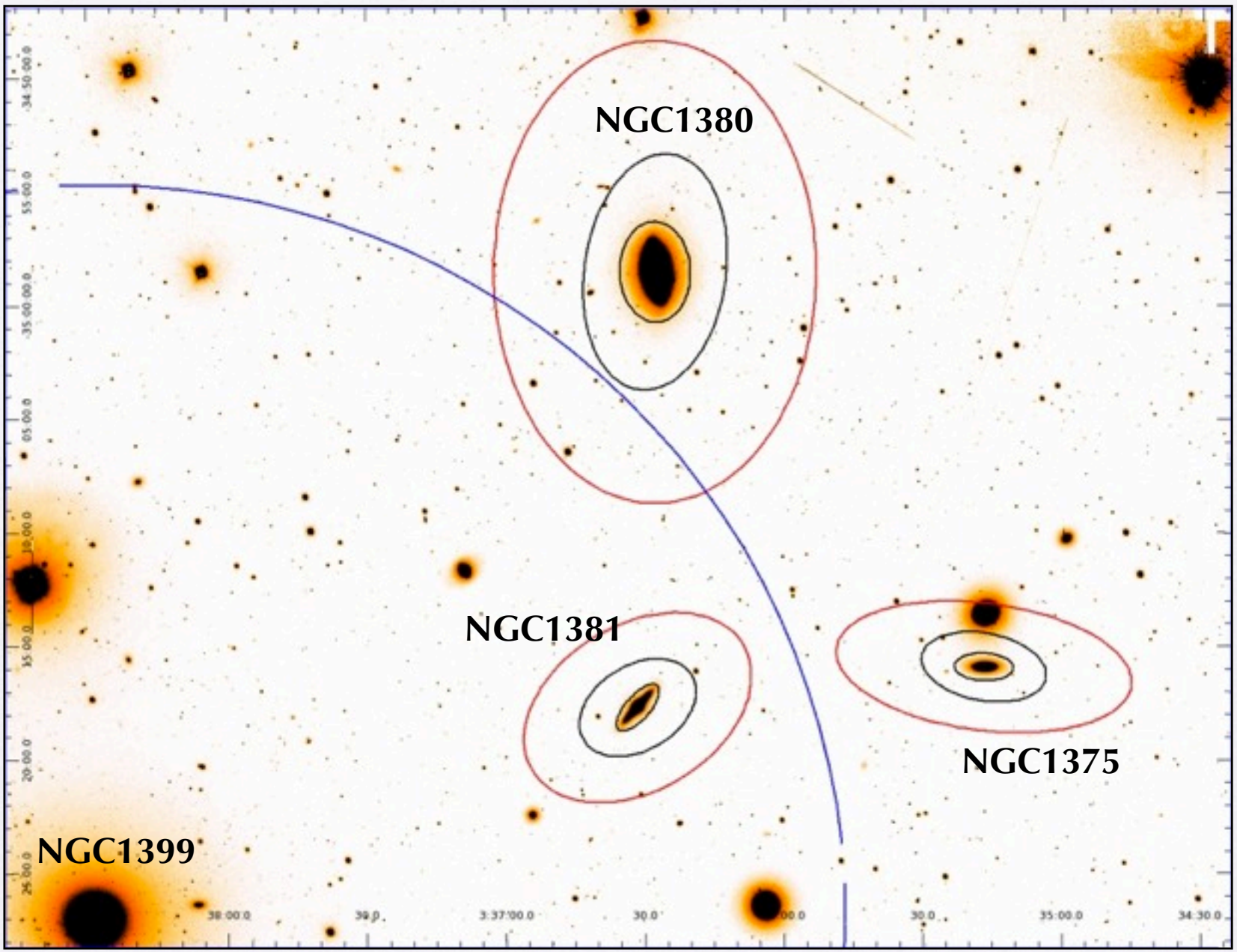

NGC1399
NGC1387


NGC1387
P.A. [degree]
R^1/4 [arcsec]


g band
i band
Re
R>1.5Re
~17Re
μ[mag/arcsec²]
R^1/4 [arcsec]

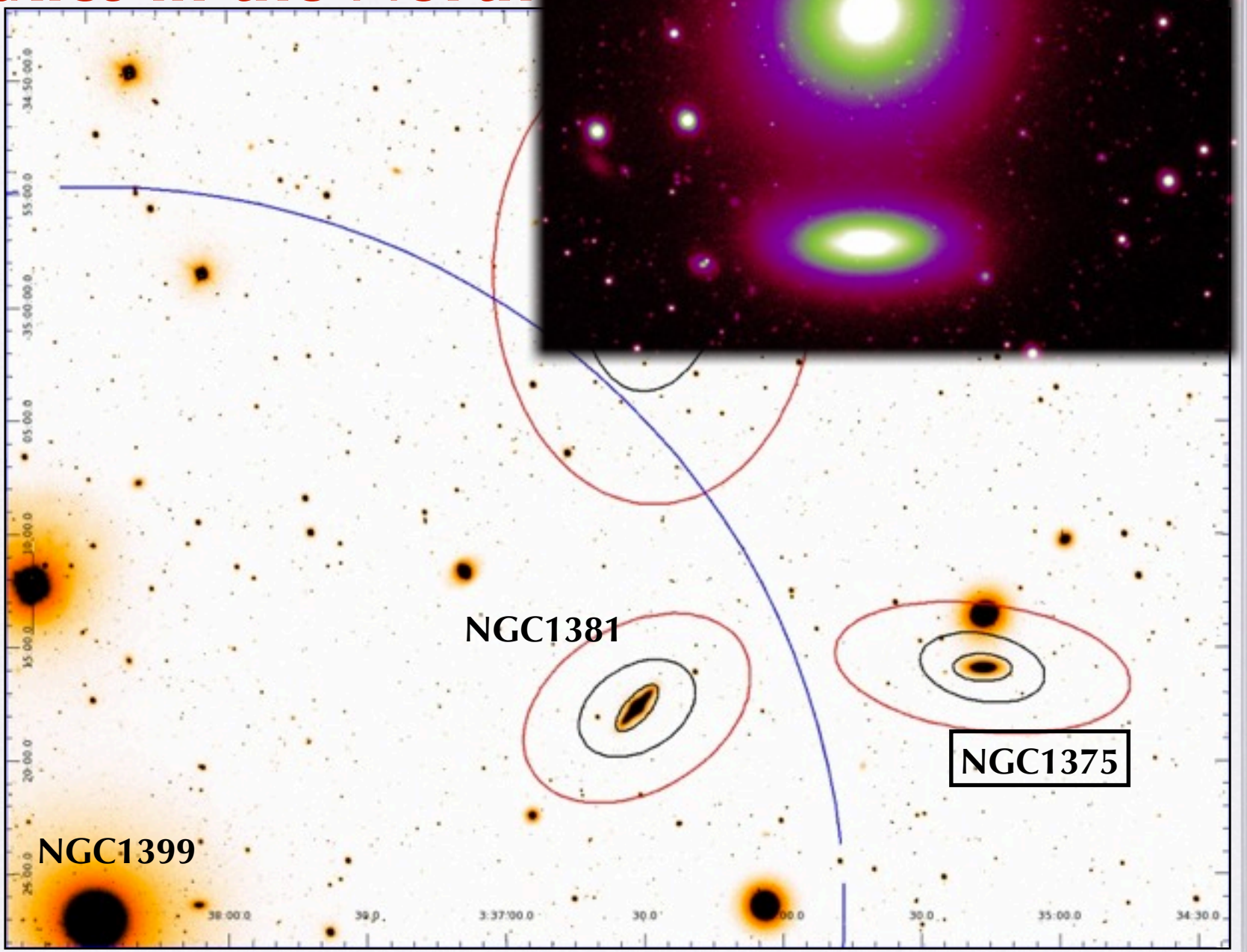
# Light distribution:

## S0 galaxies in the North



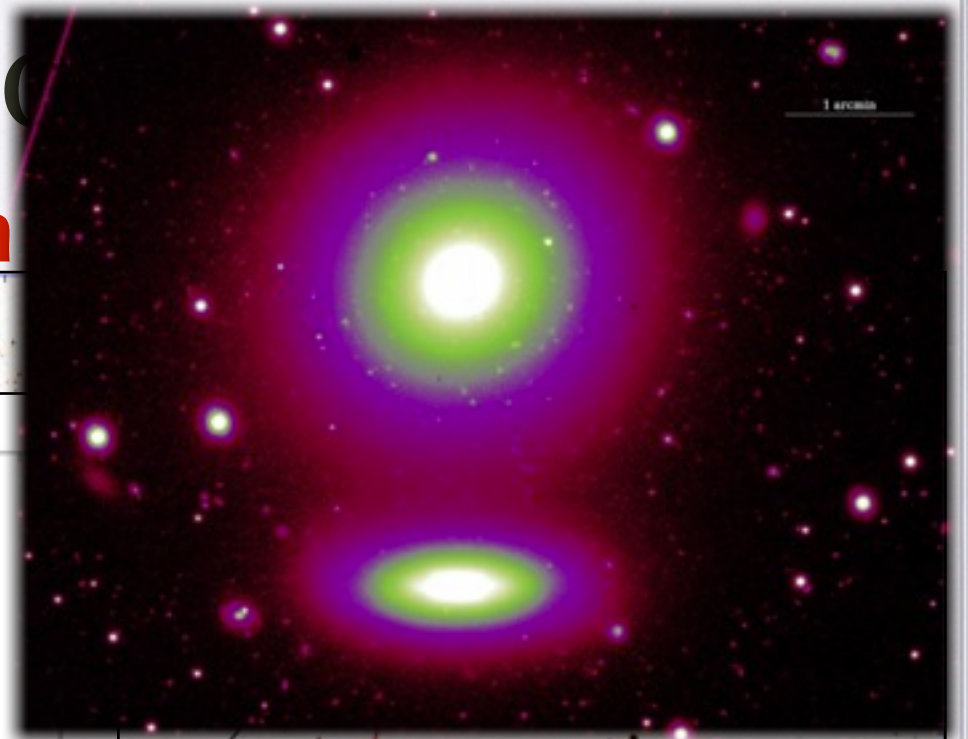
# Light distributi

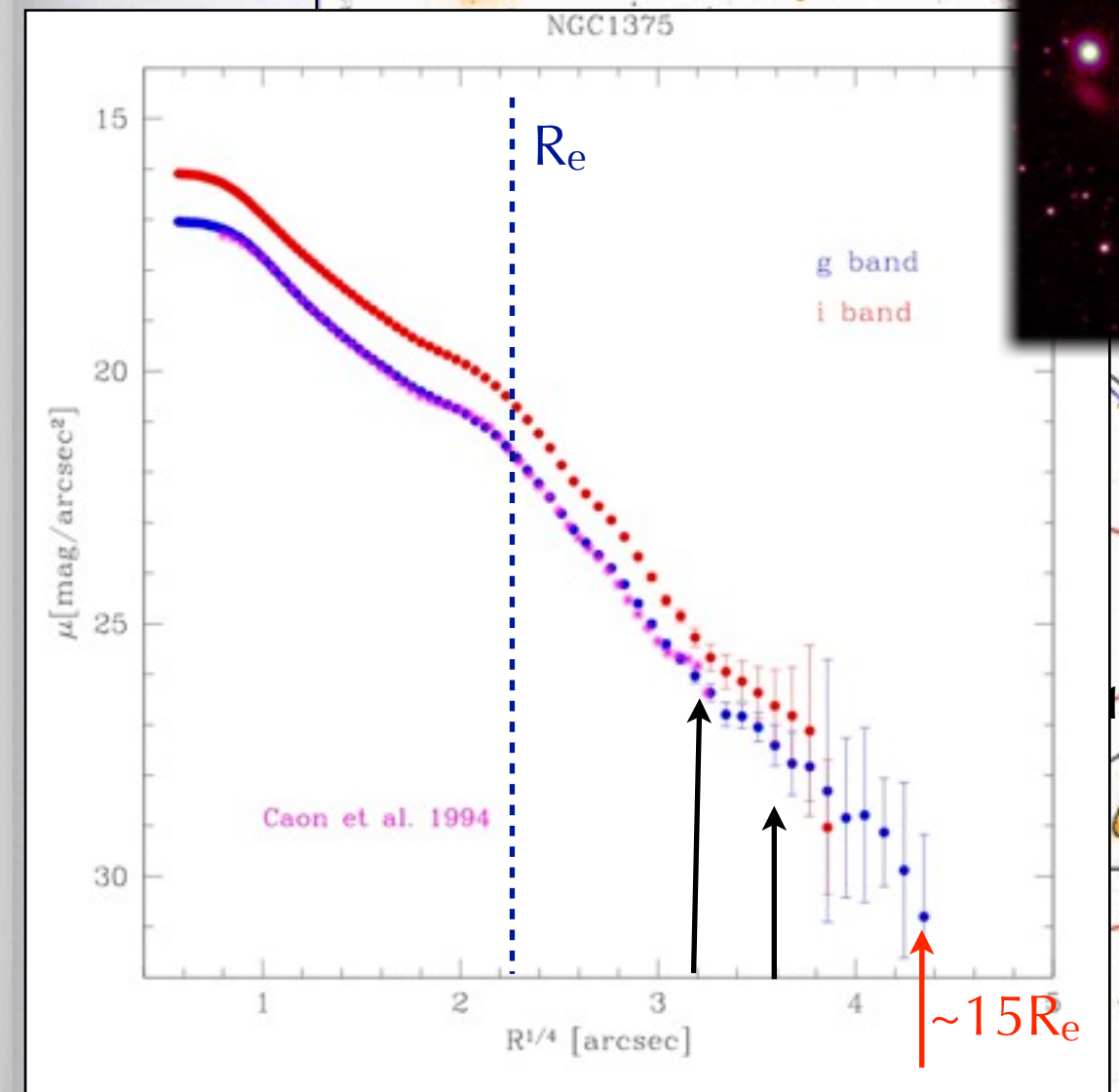
## S0 galaxies in the North

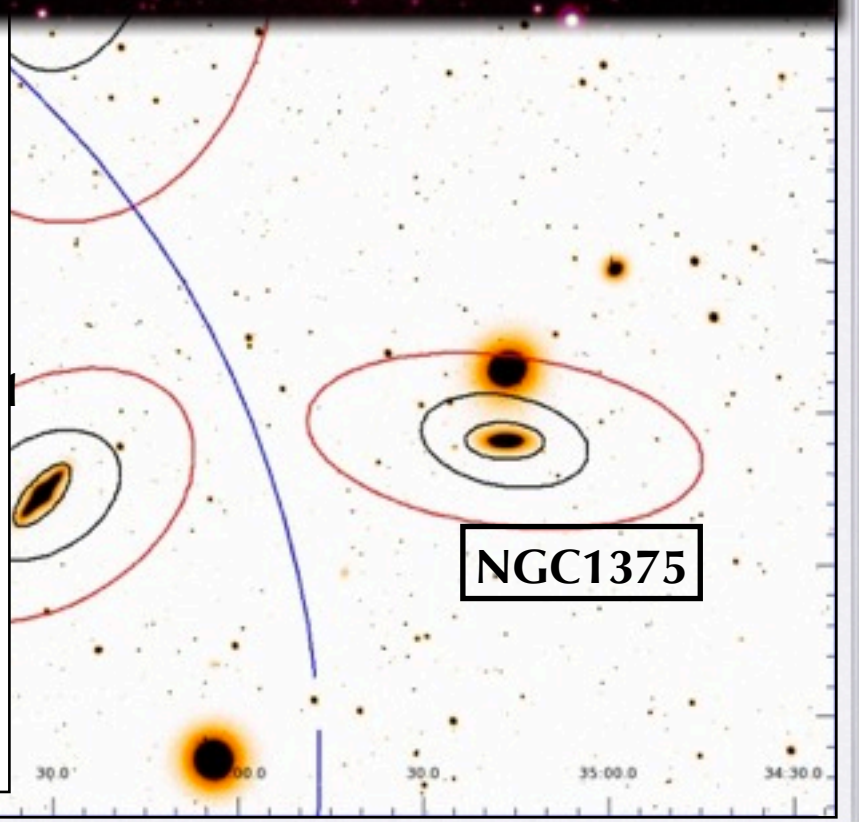


# Light distributi

## S0 galaxies in the North

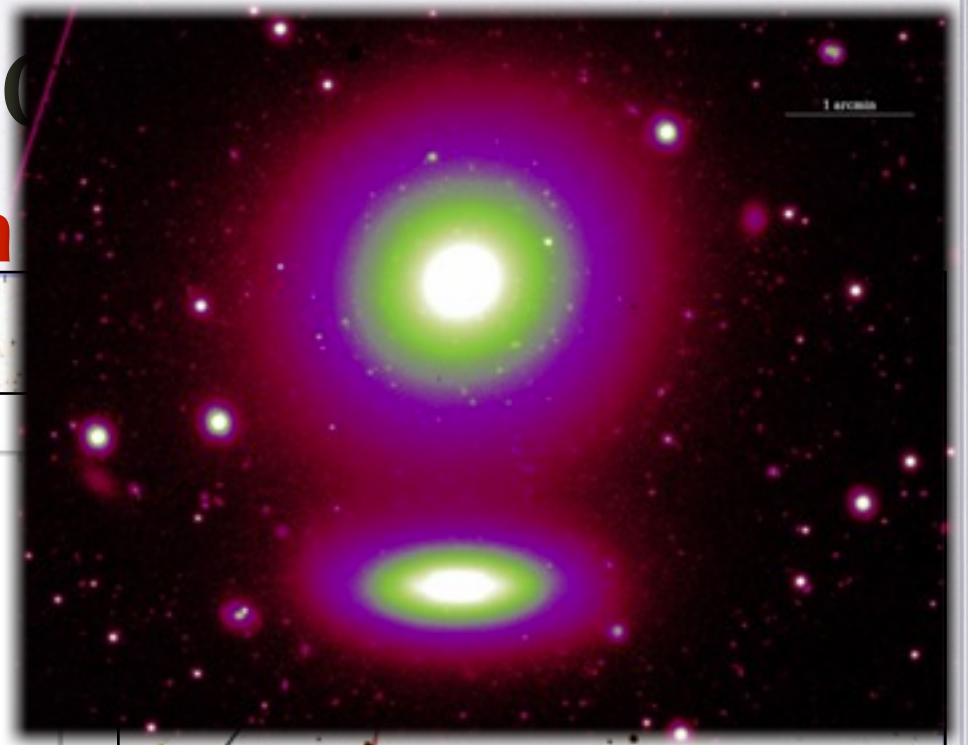


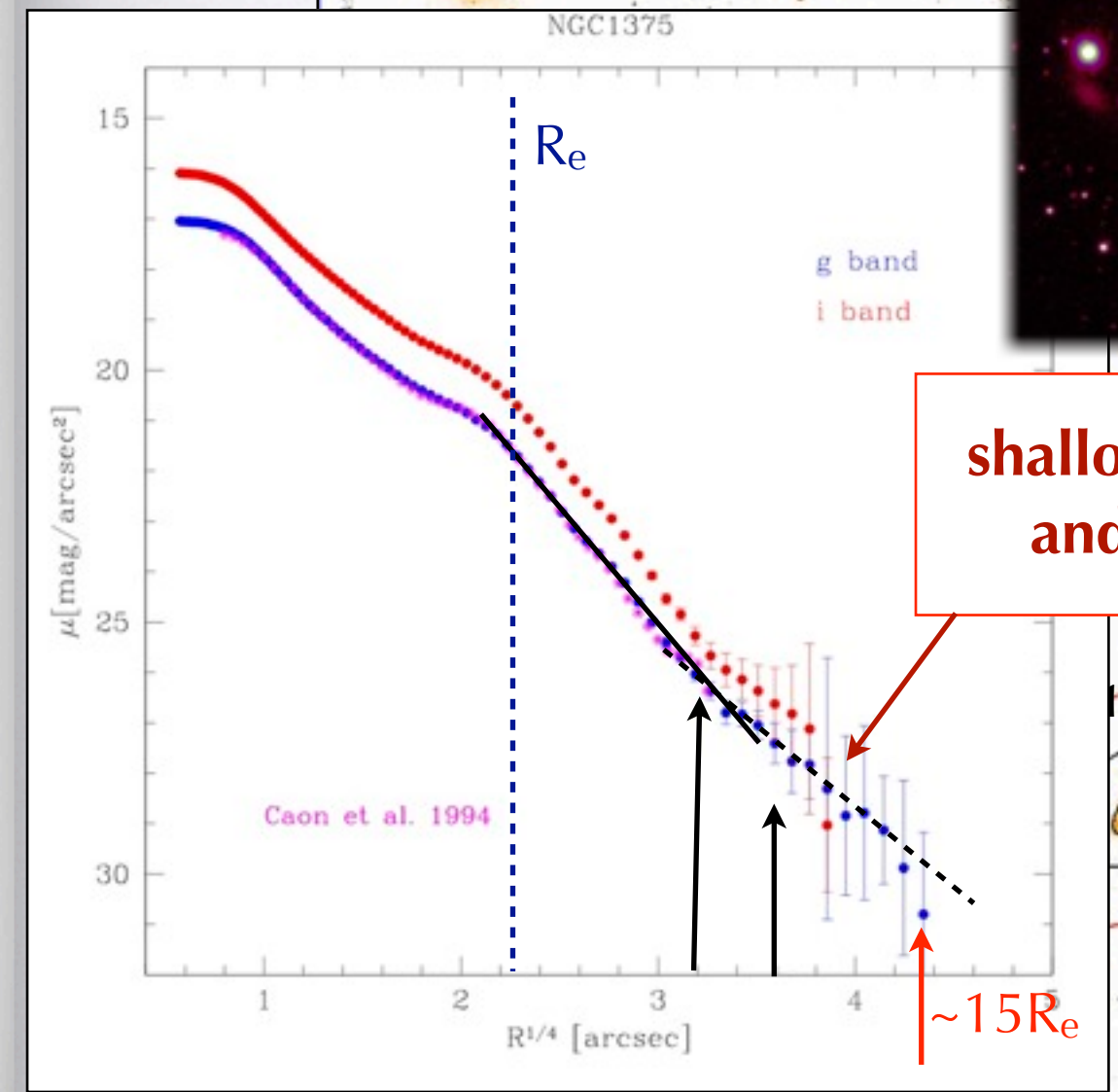


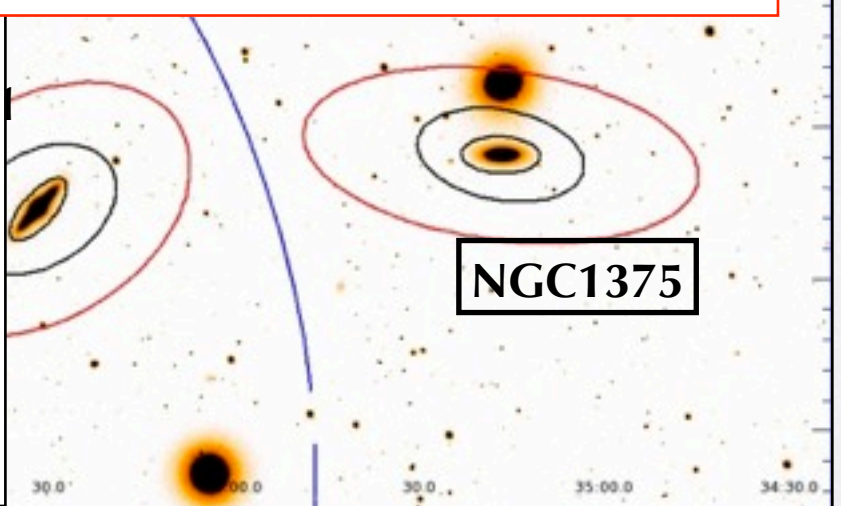
# Light distributi

## S0 galaxies in the North






**shallow light profile for R> 4$R_e$ and 27 ≲ $\mu_g$ ≲ 31 mag/arcsec$^2$**



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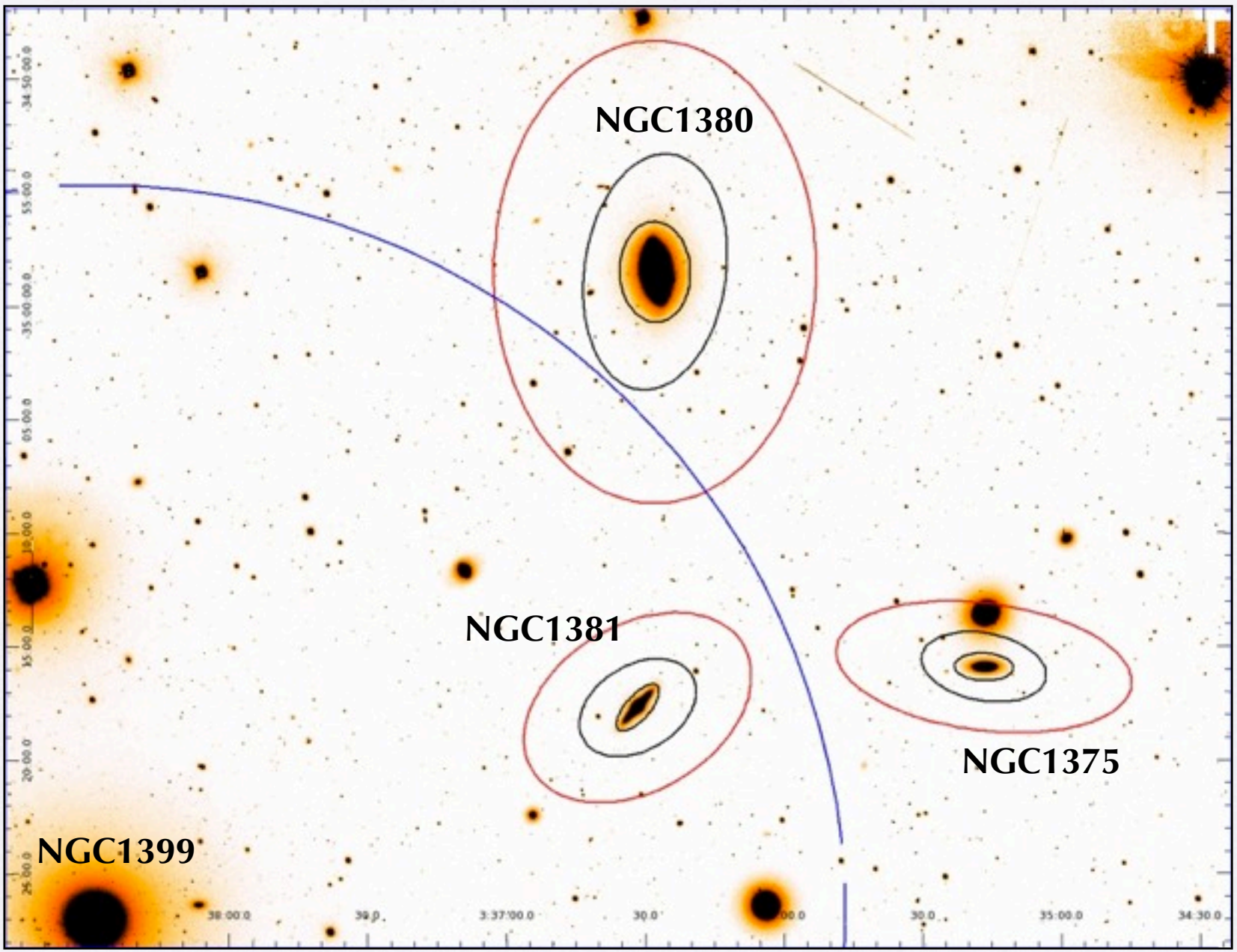
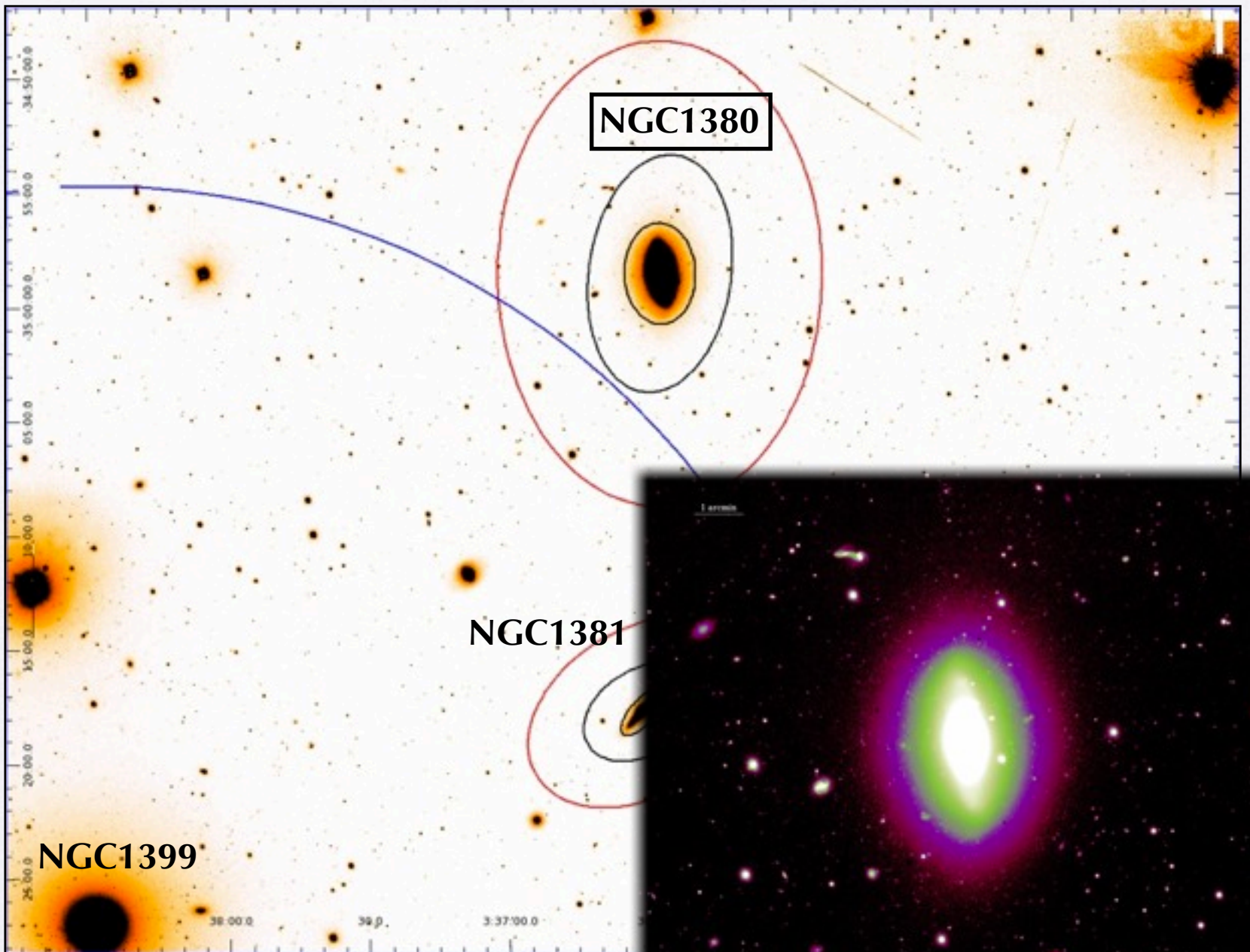
## S0 galaxies in the North



# Light distribution:

## S0 galaxies in the North



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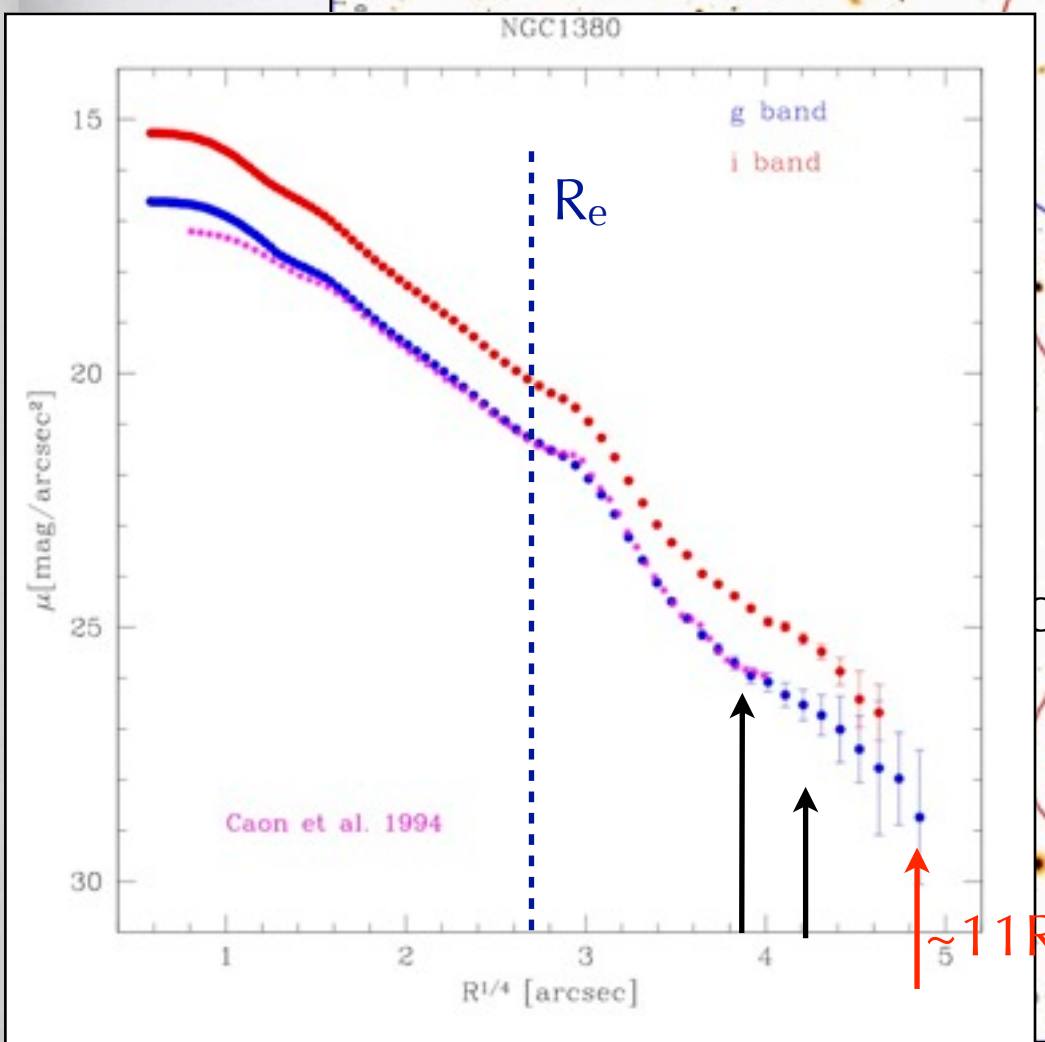
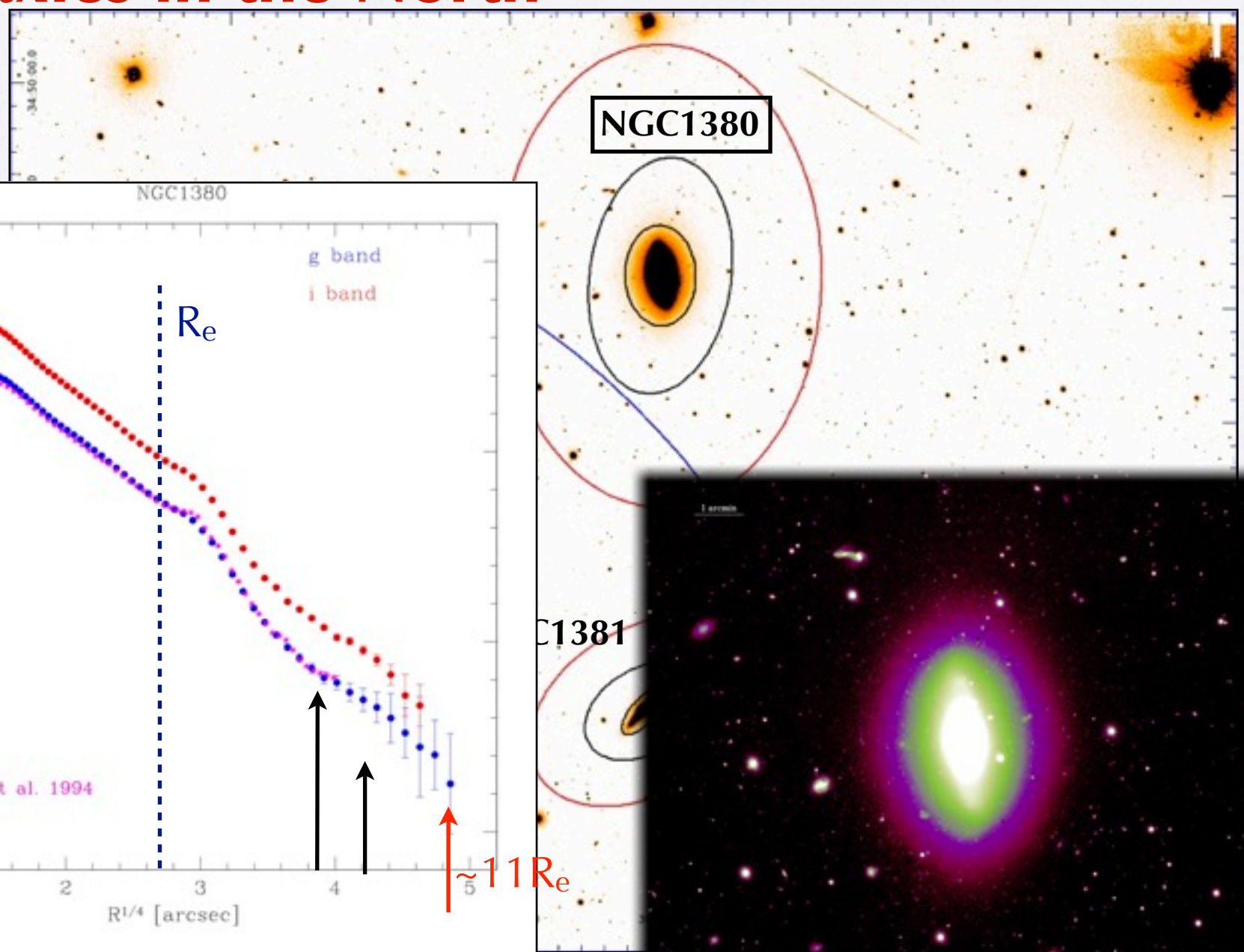
## S0 galaxies in the North



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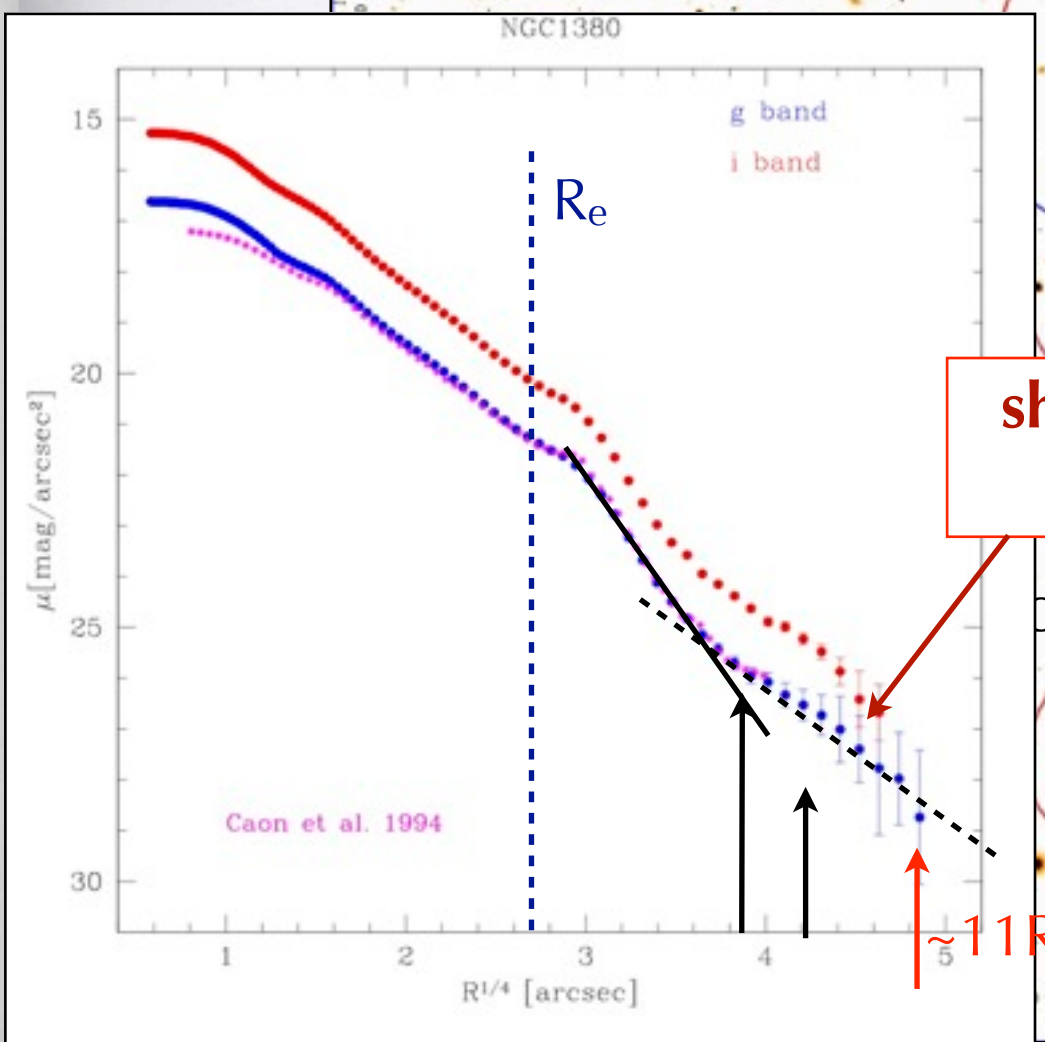
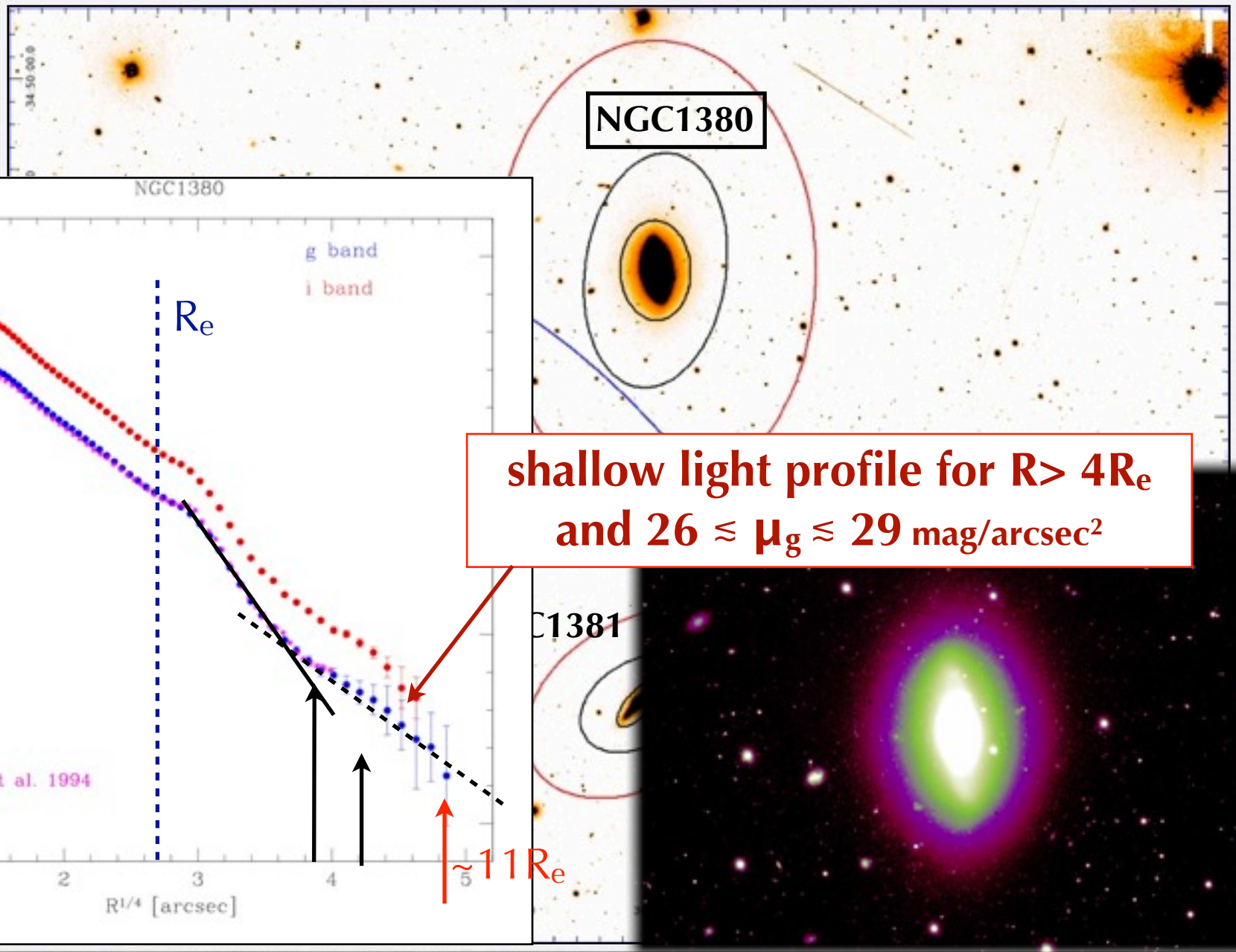
## S0 galaxies in the North




**shallow light profile for R> 4$R_e$ and 26 ≲ $\mu_g$ ≲ 29 mag/arcsec$^2$**

# Light distribution:

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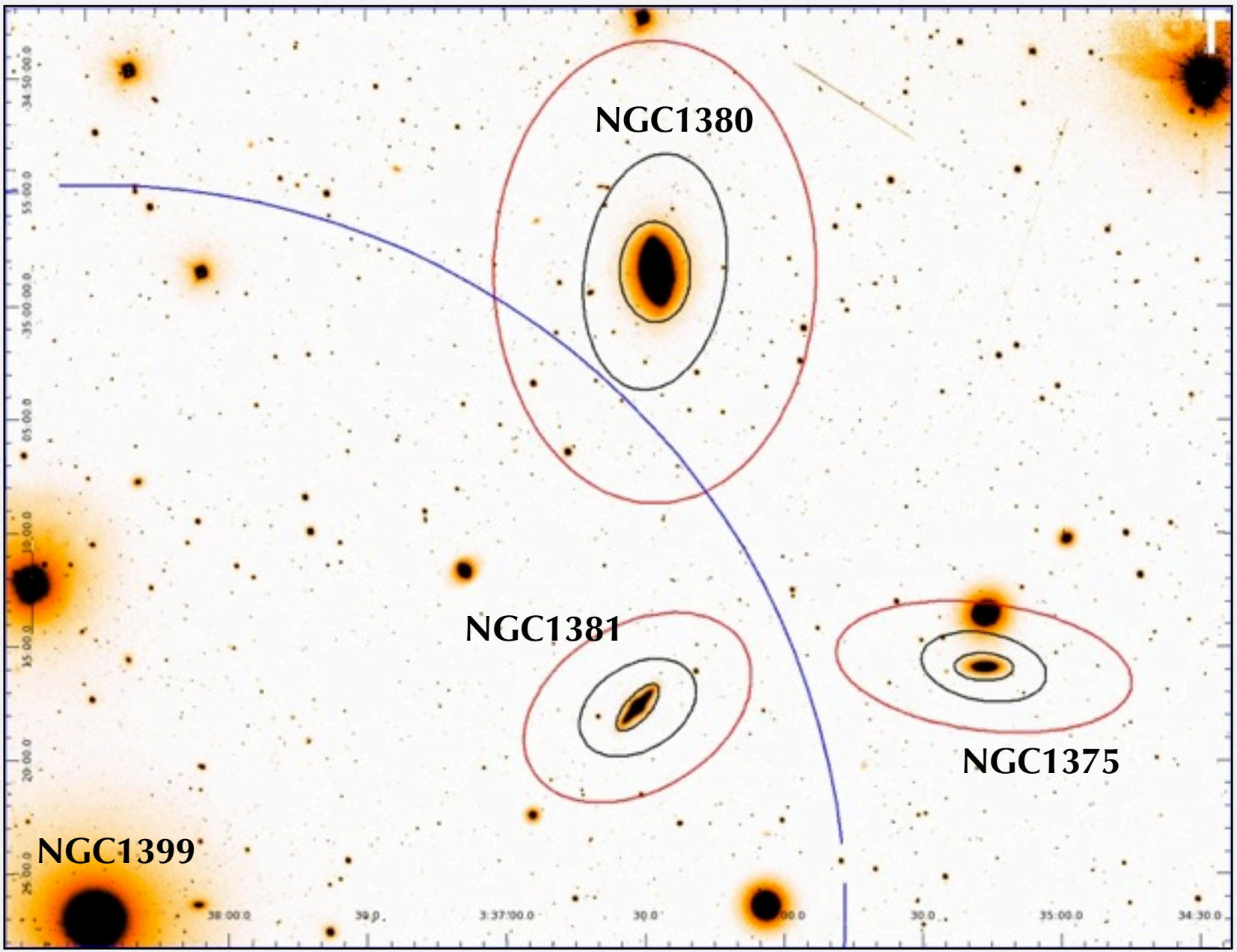

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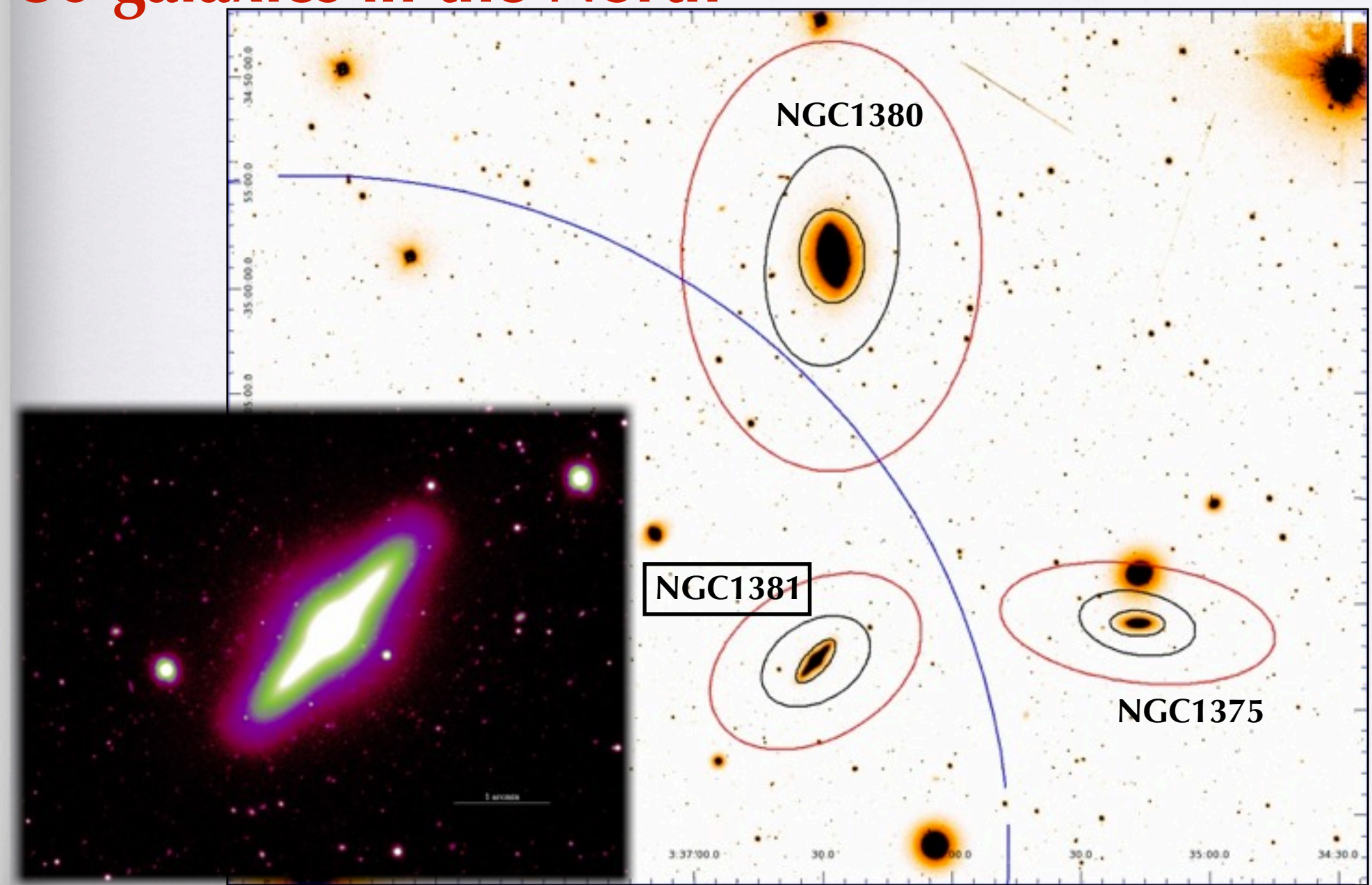
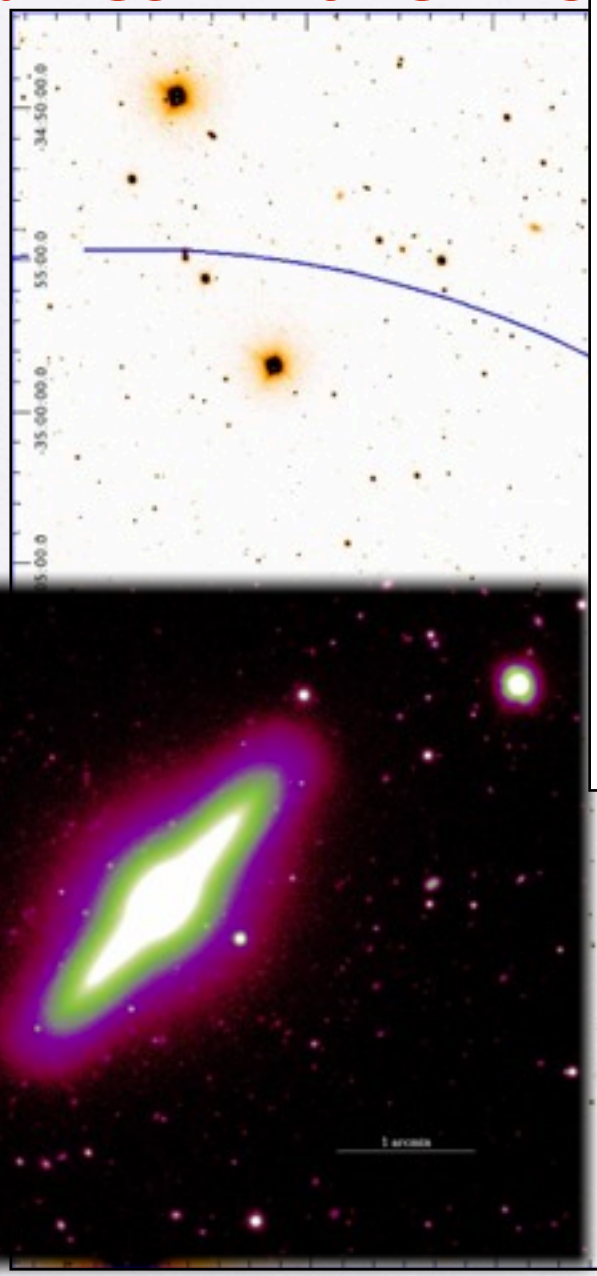
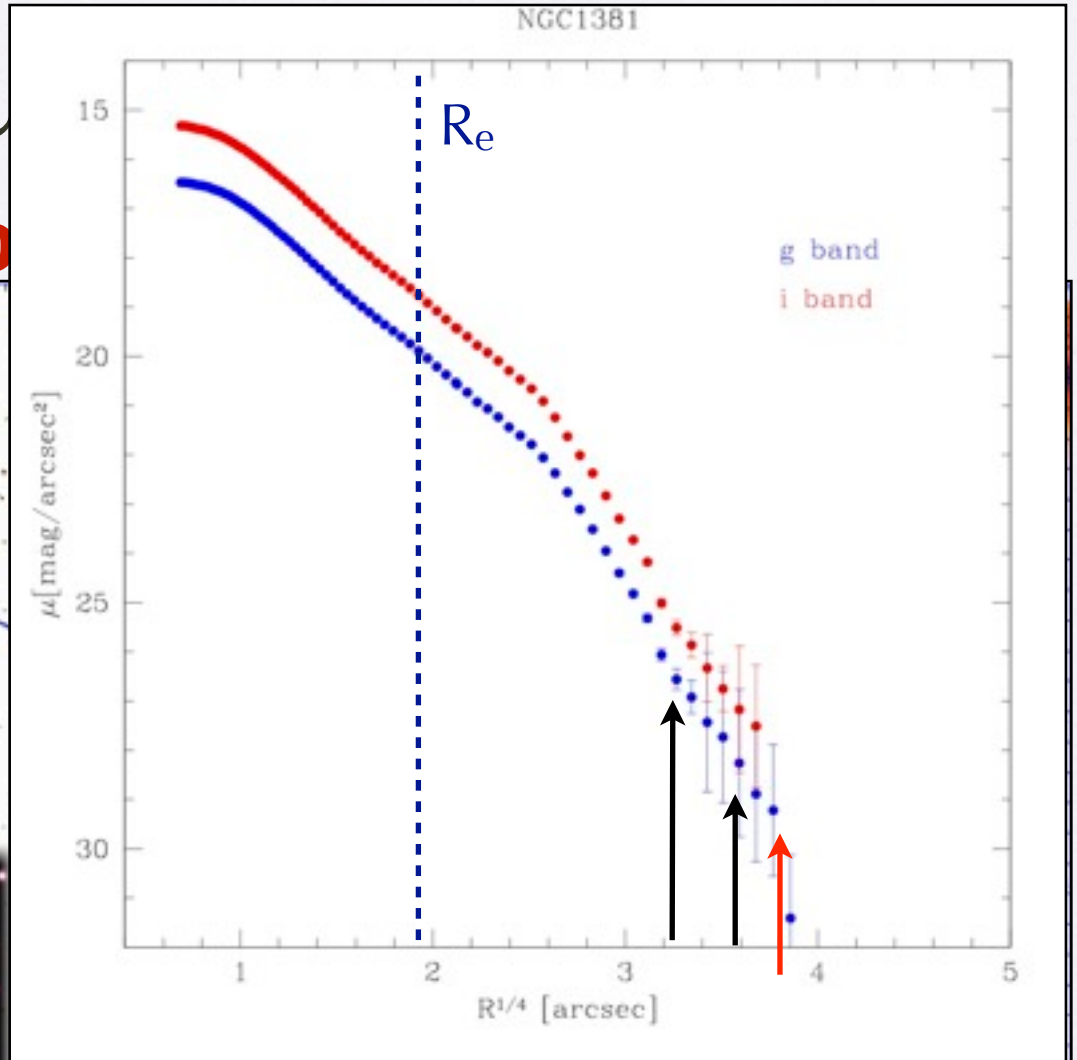


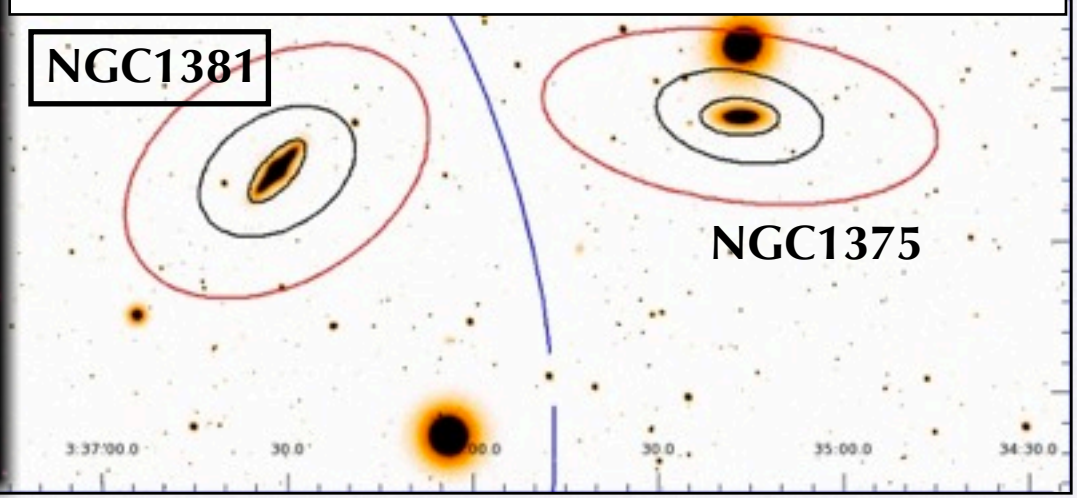
# Light distribu

## S0 galaxies in the No





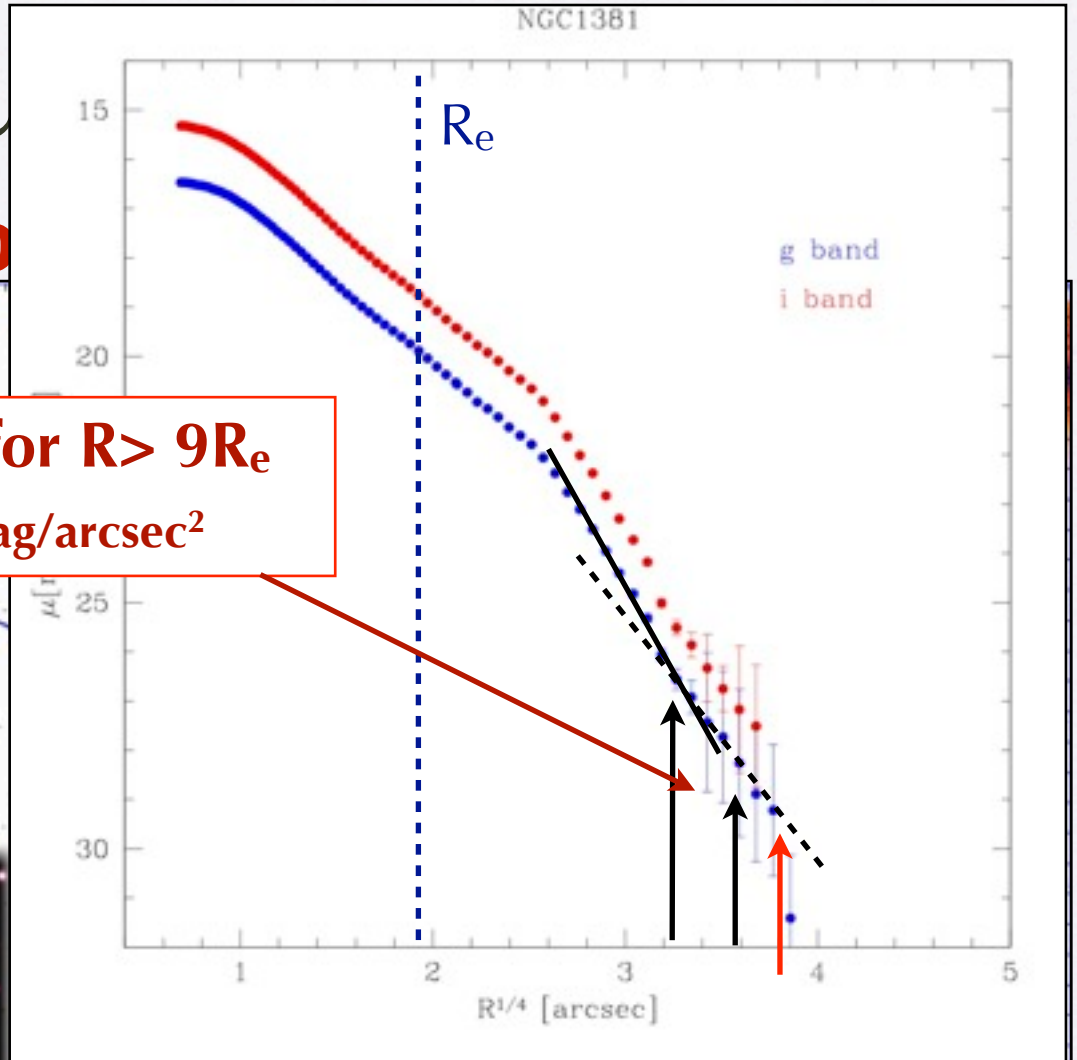


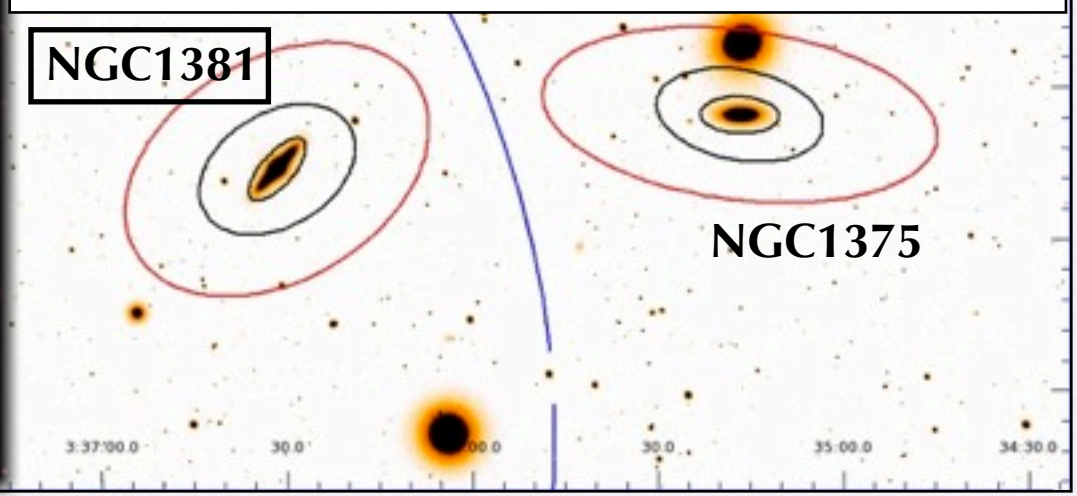



# Light distribu

## S0 galaxies in the No

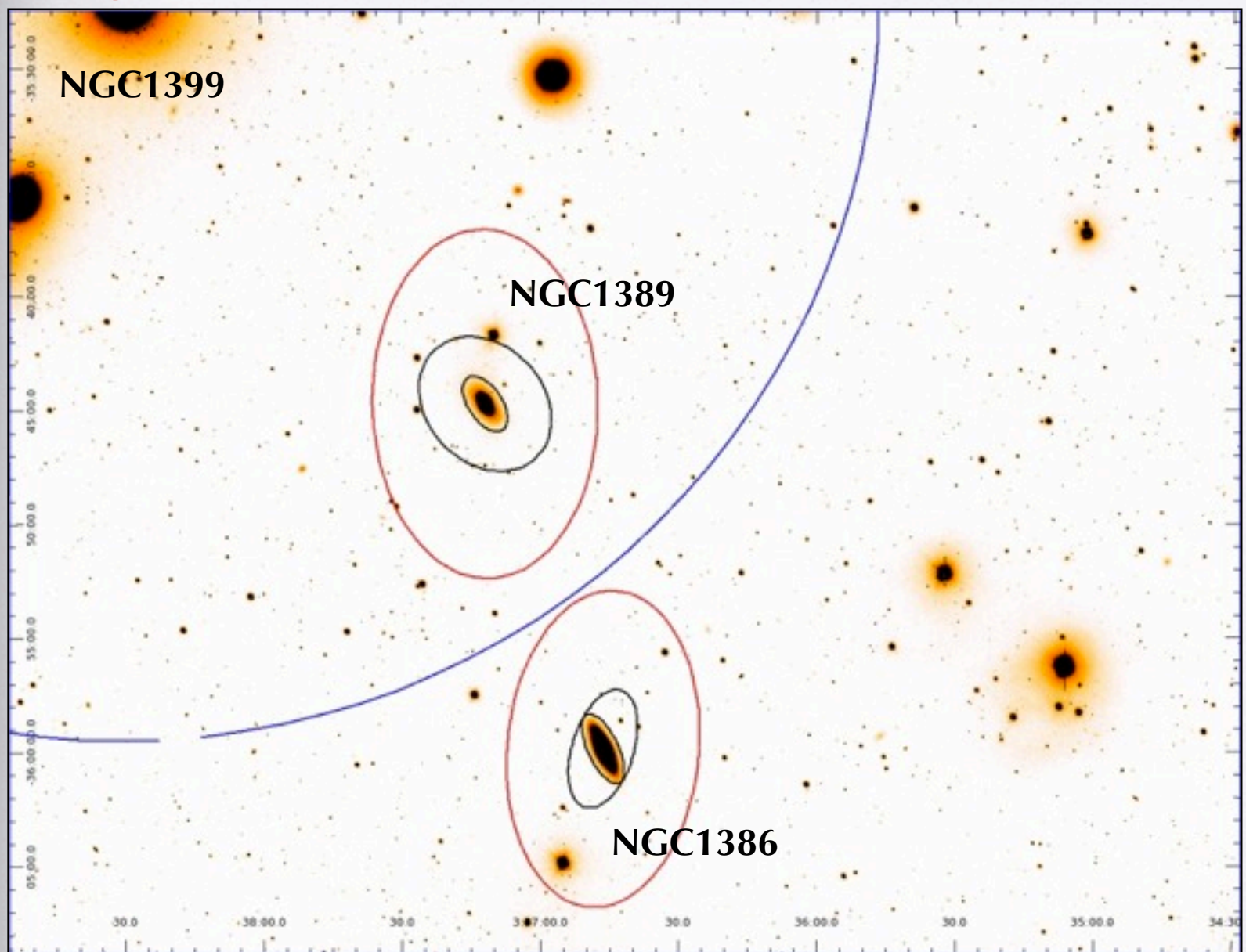
**shallow light profile for R> 9$R_e$**
**and 27 ≲ $\mu_g$ ≲ 29 mag/arcsec$^2$**



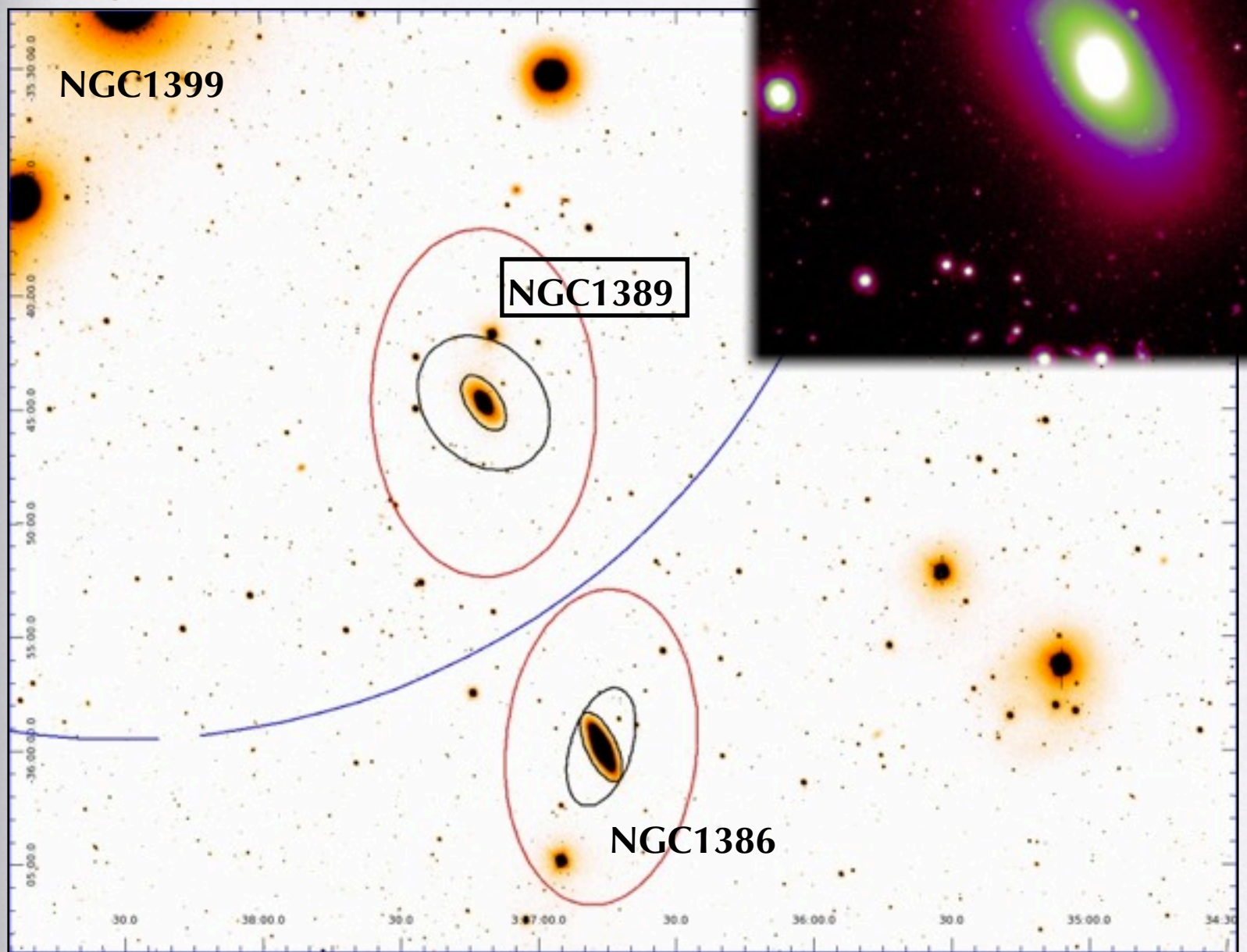
# Light distribution:

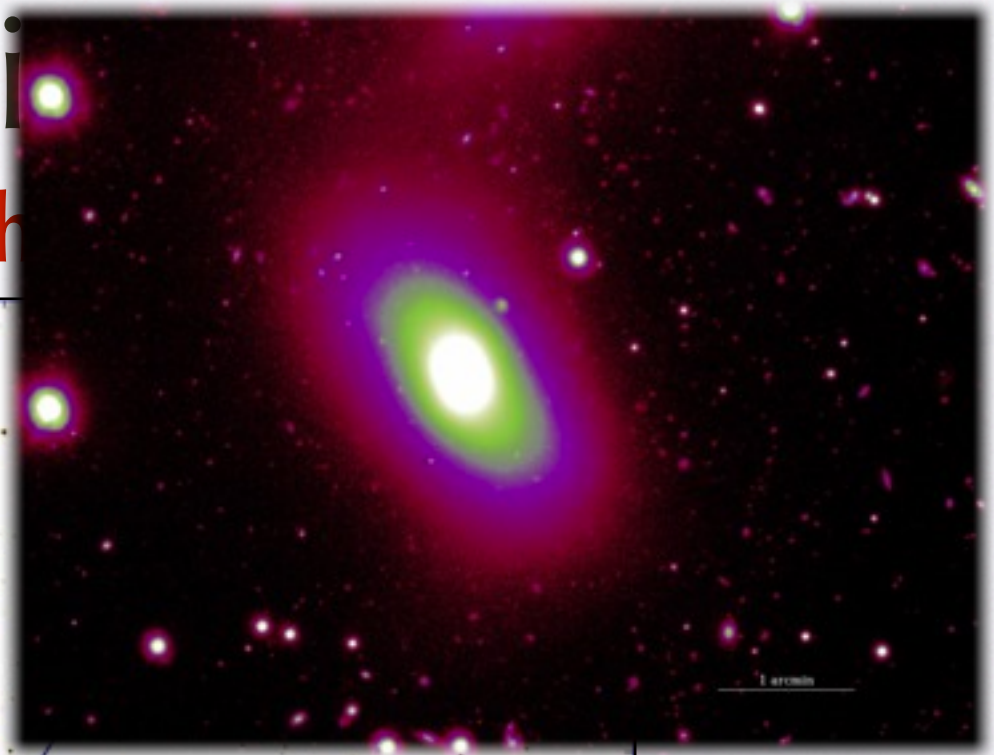
## S0 galaxies in the South



# Light distributi

## S0 galaxies in the South



# Light distributi

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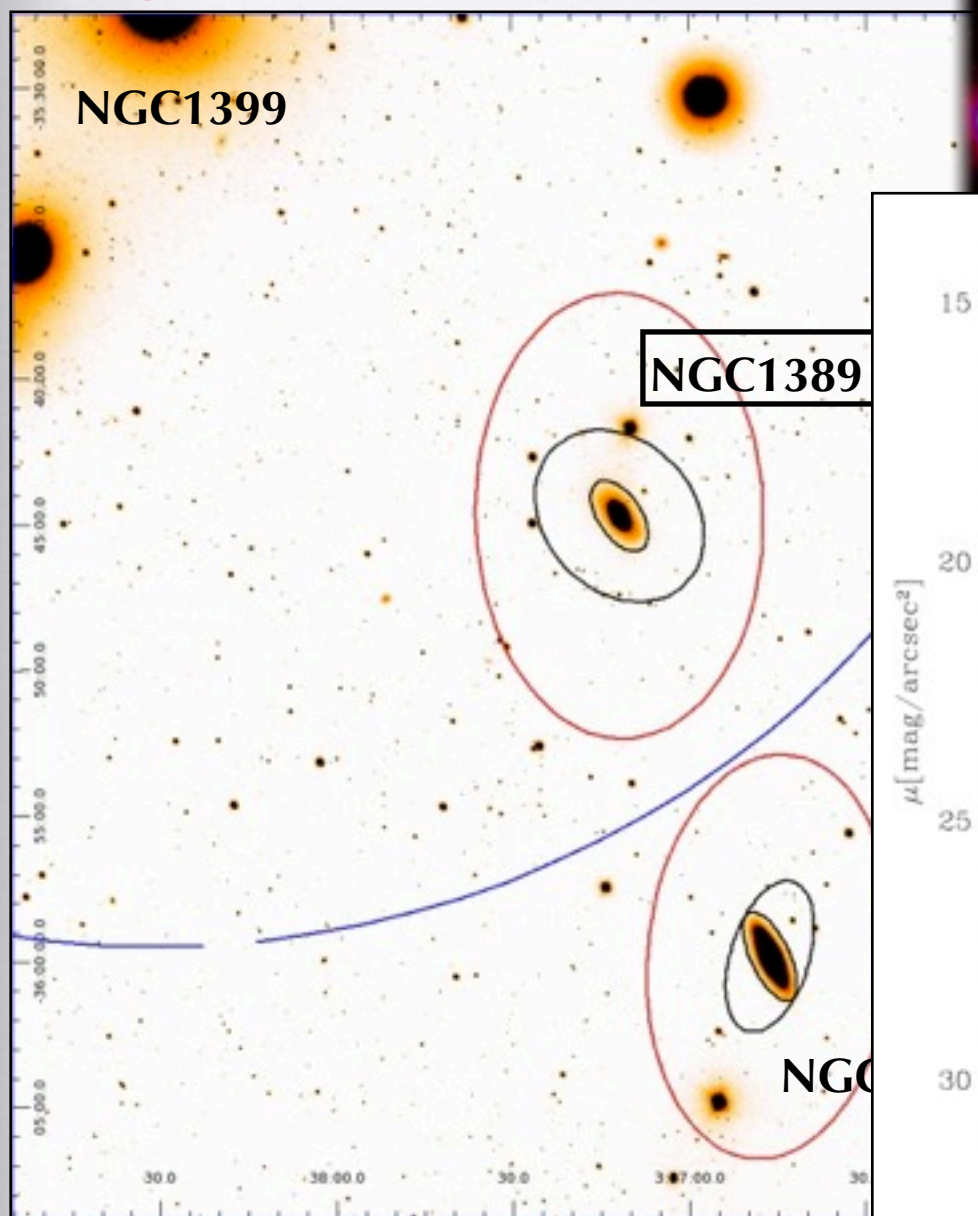


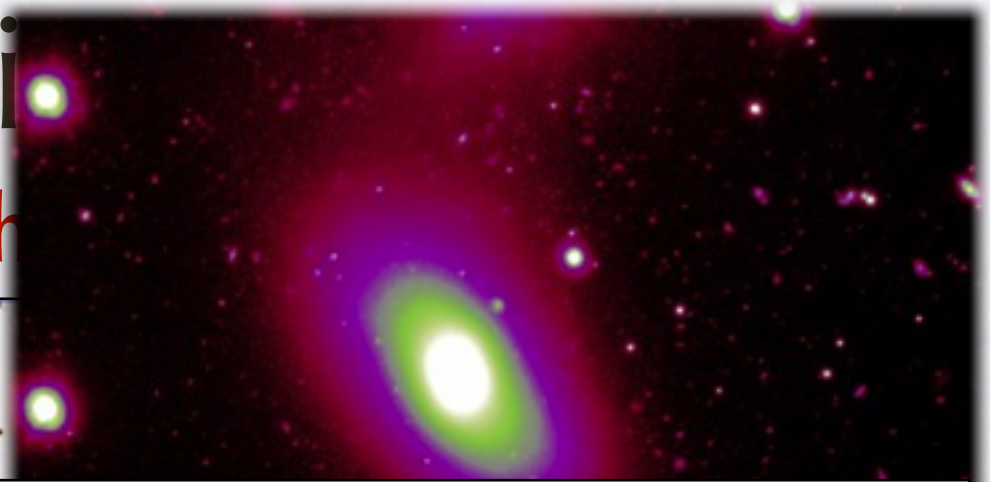

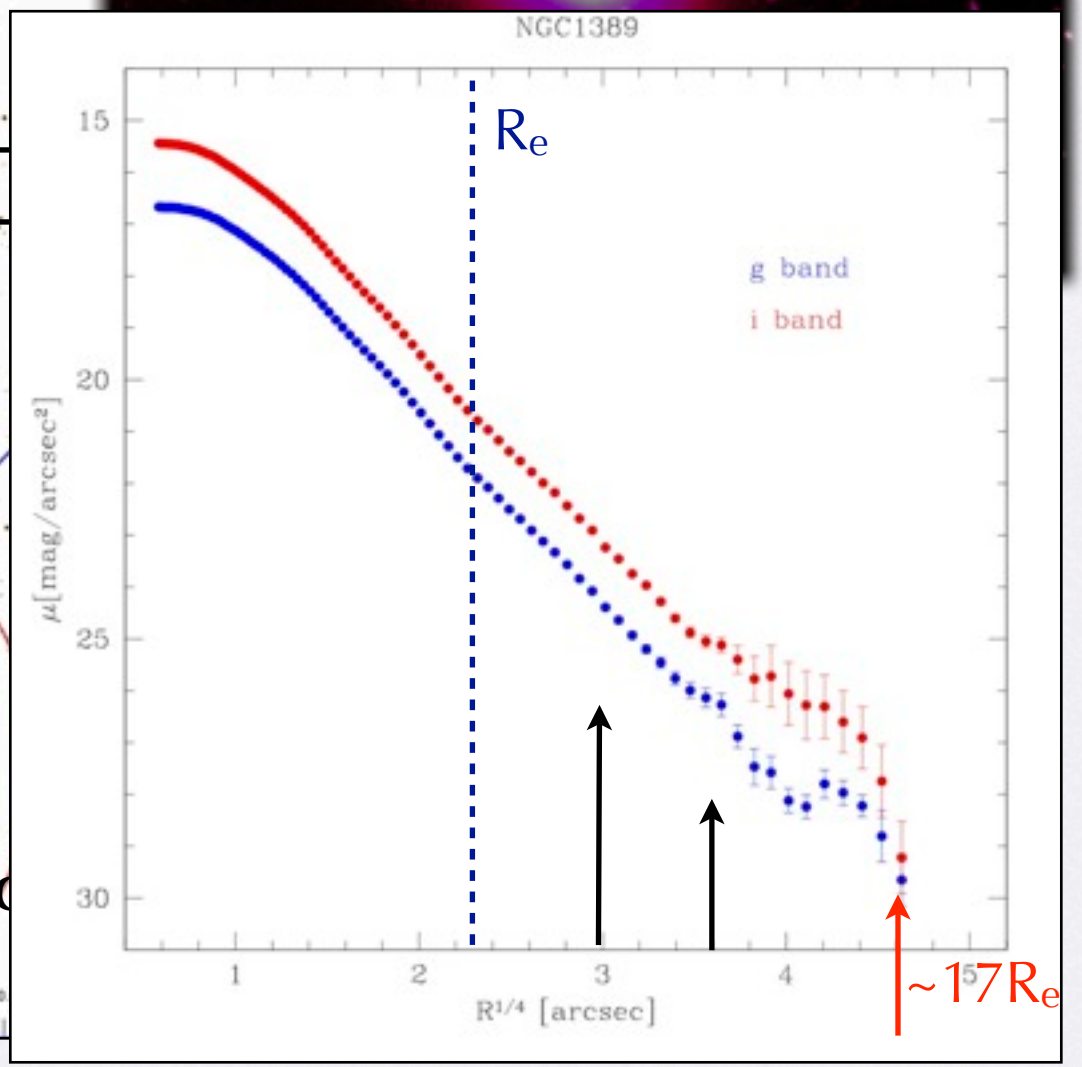

# Light distributi

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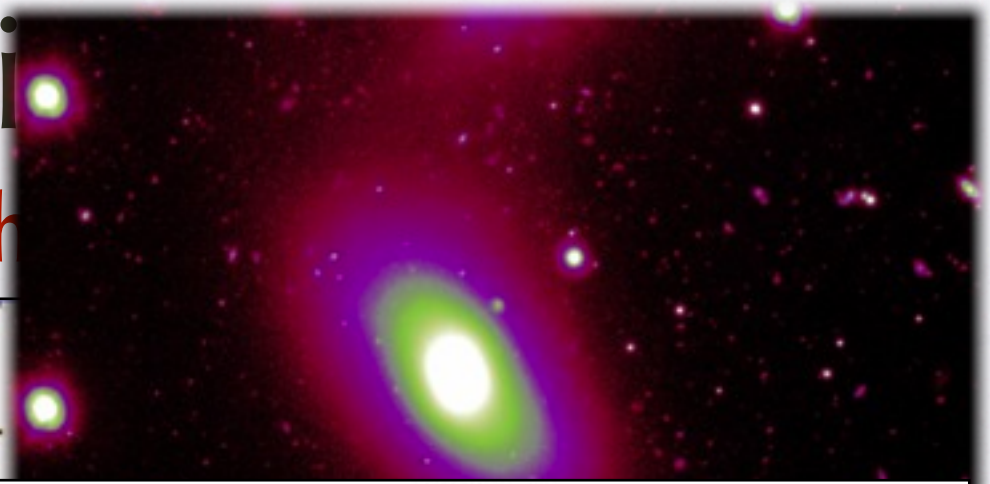
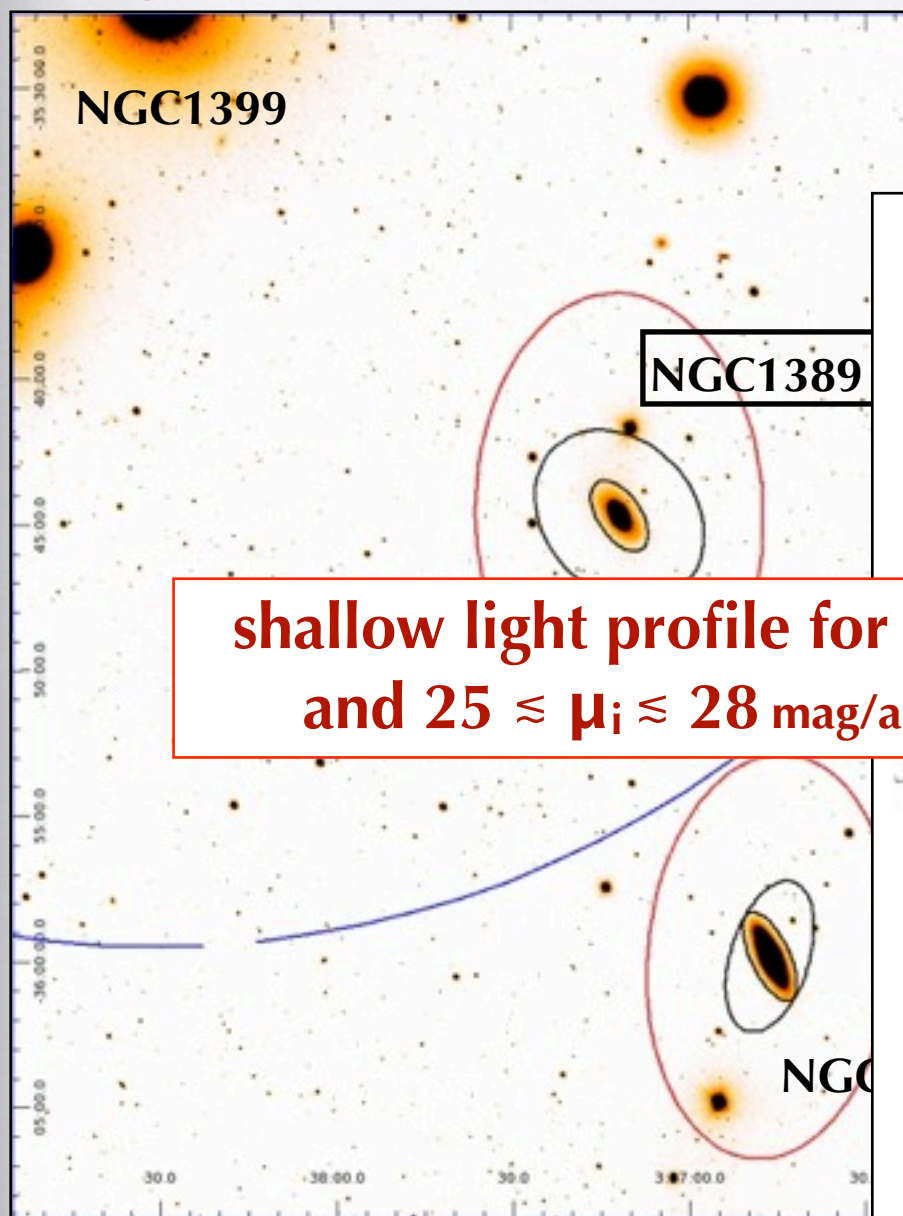
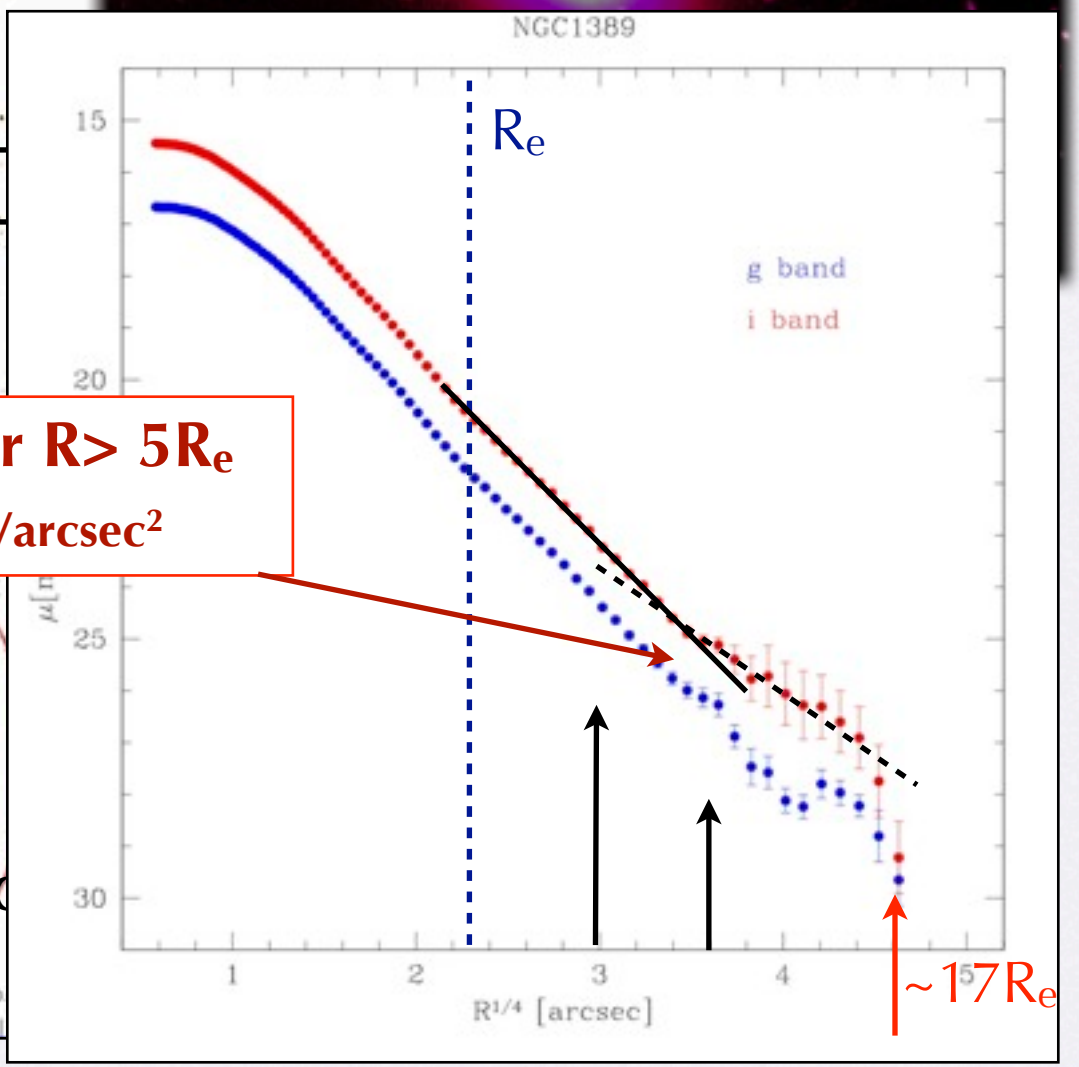





shallow light profile for R> 5$R_e$
and 25 ≲ $\mu_i$ ≲ 28 mag/arcsec$^2$



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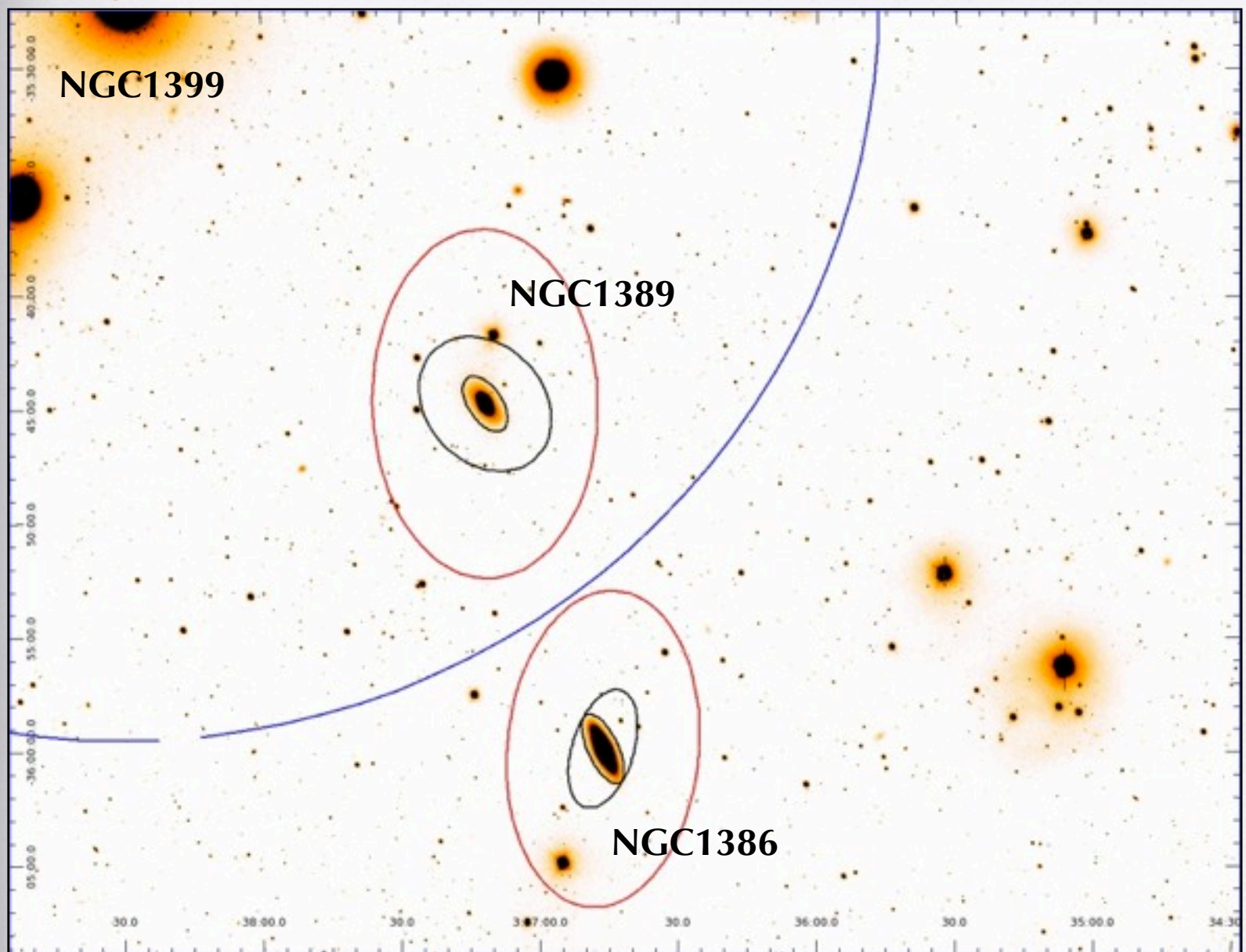
## S0 galaxies in the South



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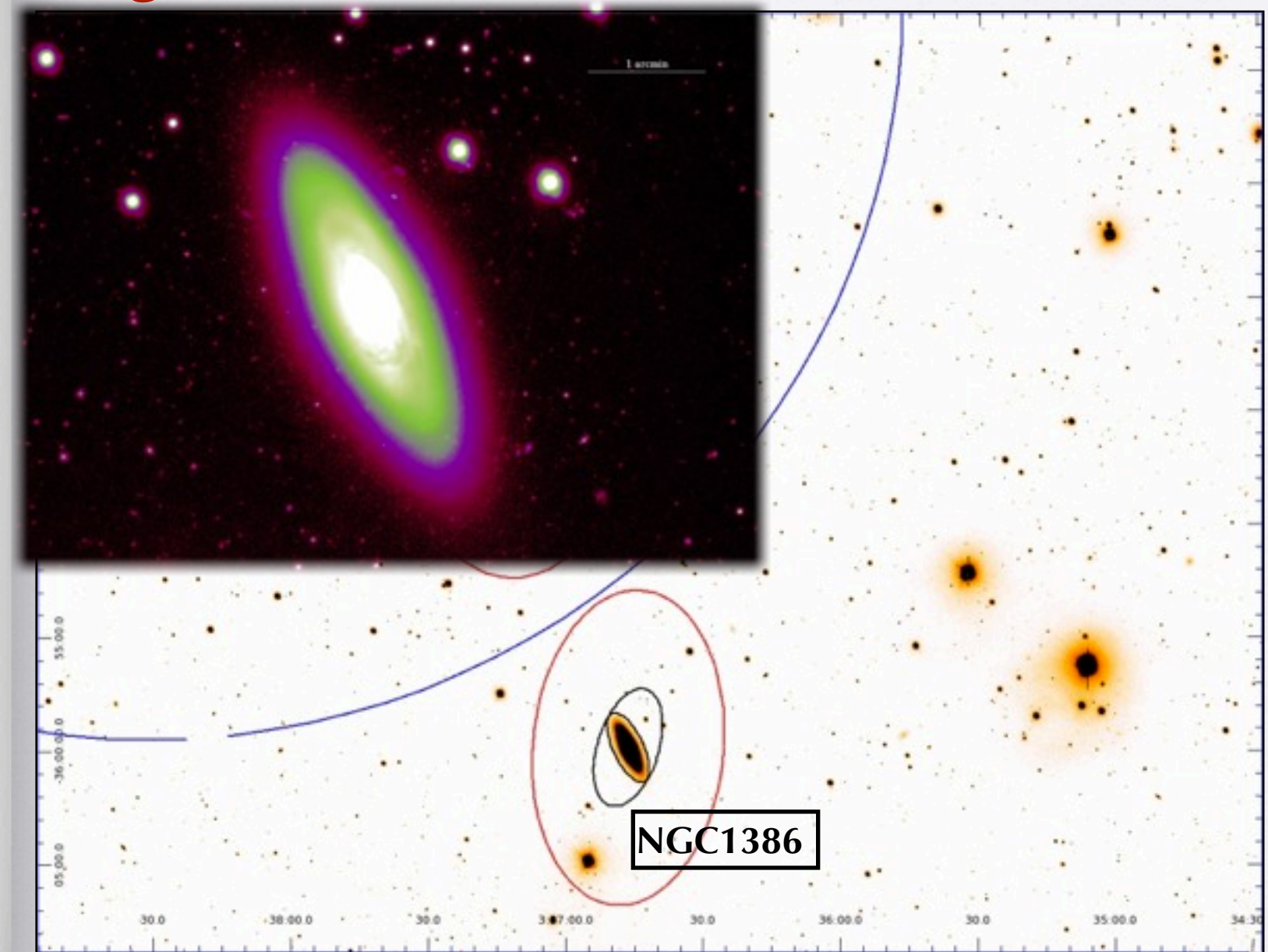
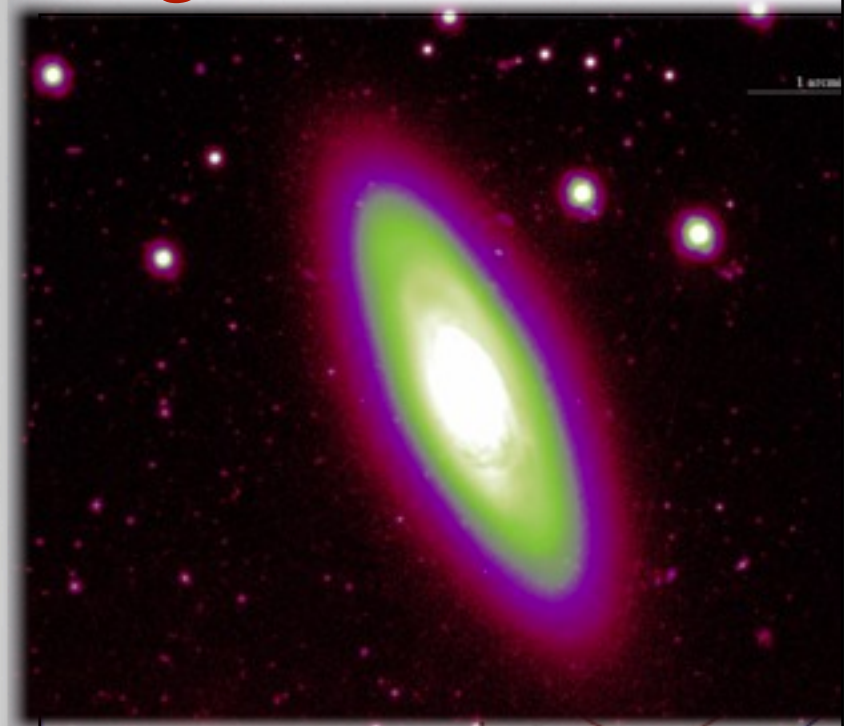
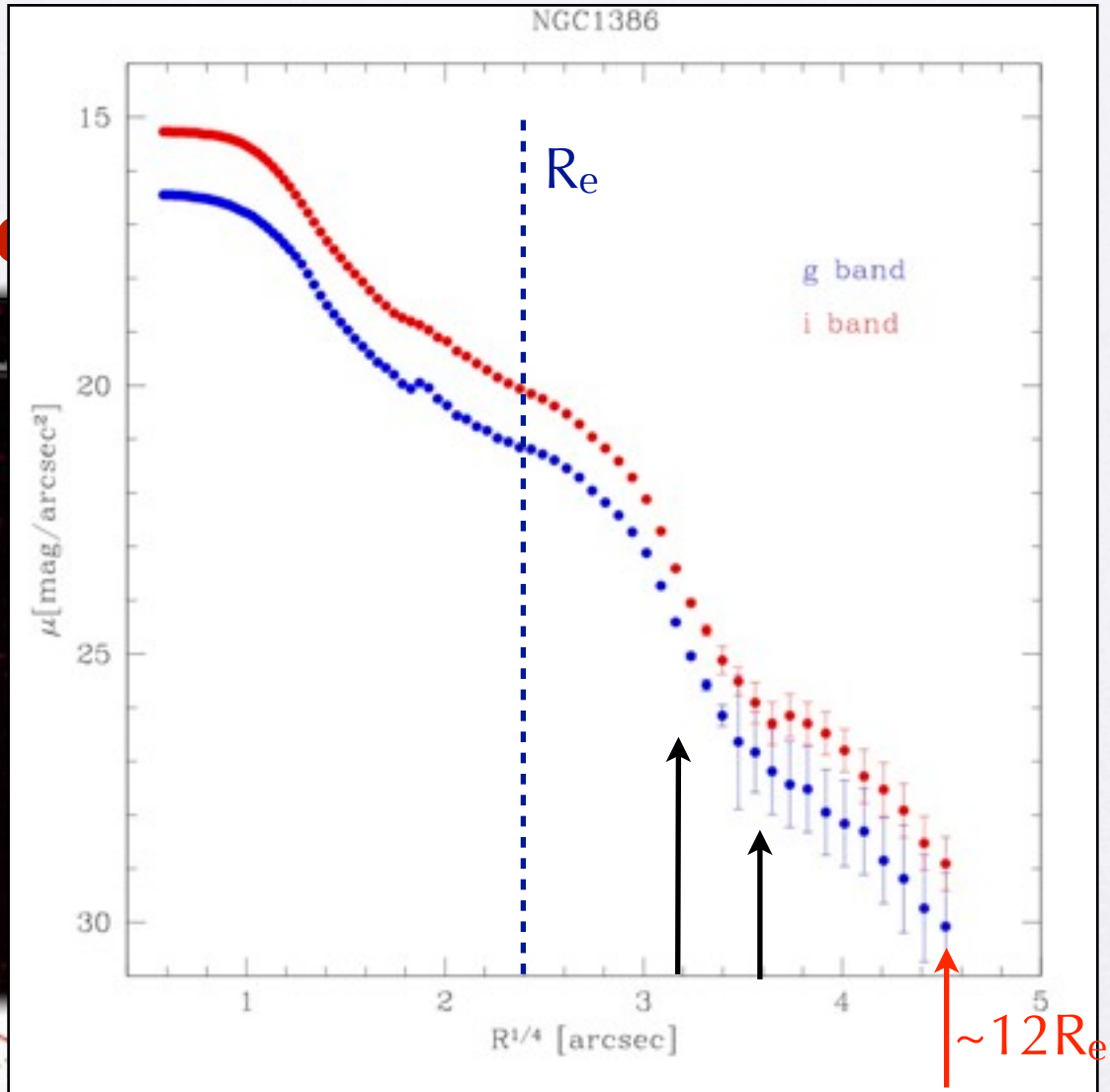
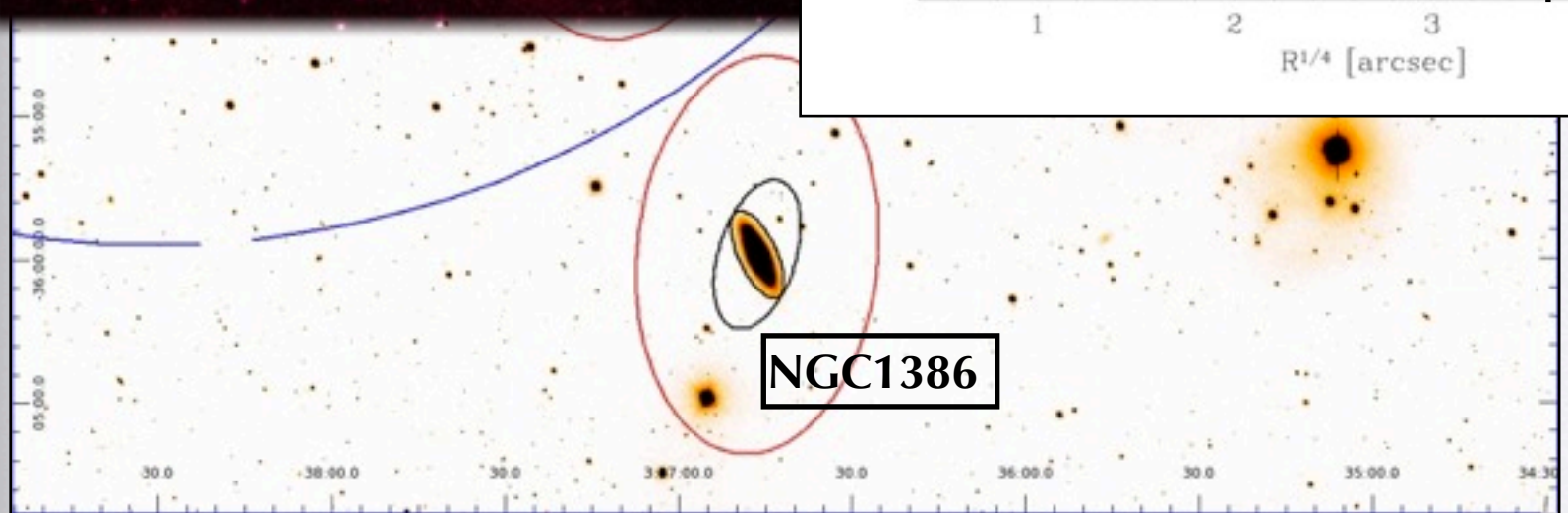


# Light distrib

## S0 galaxies in the S





# Light distrib

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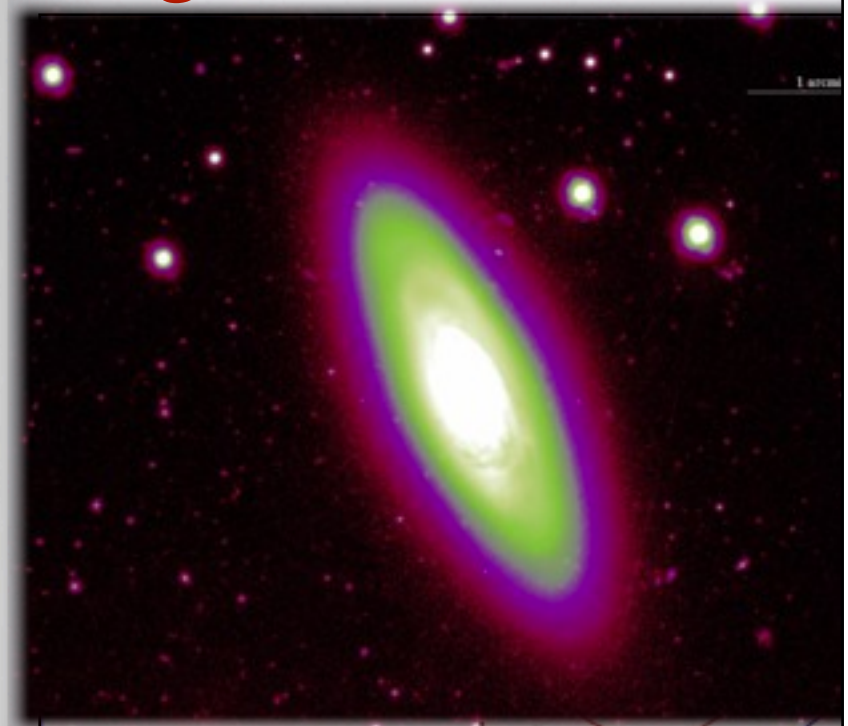

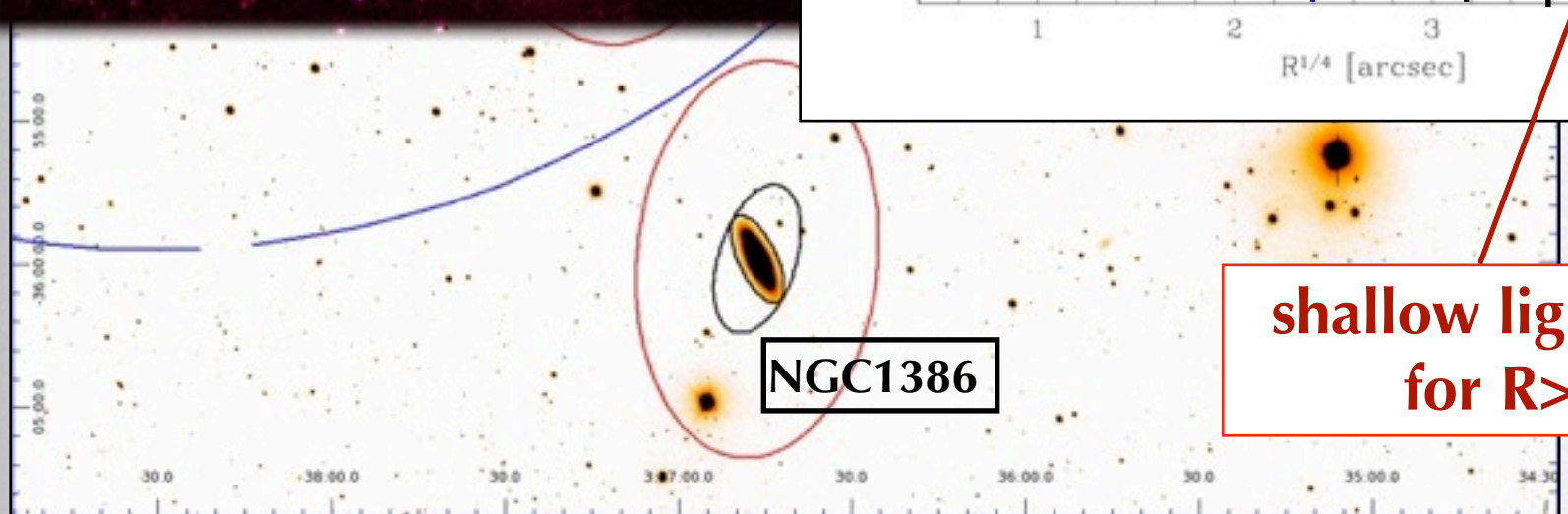


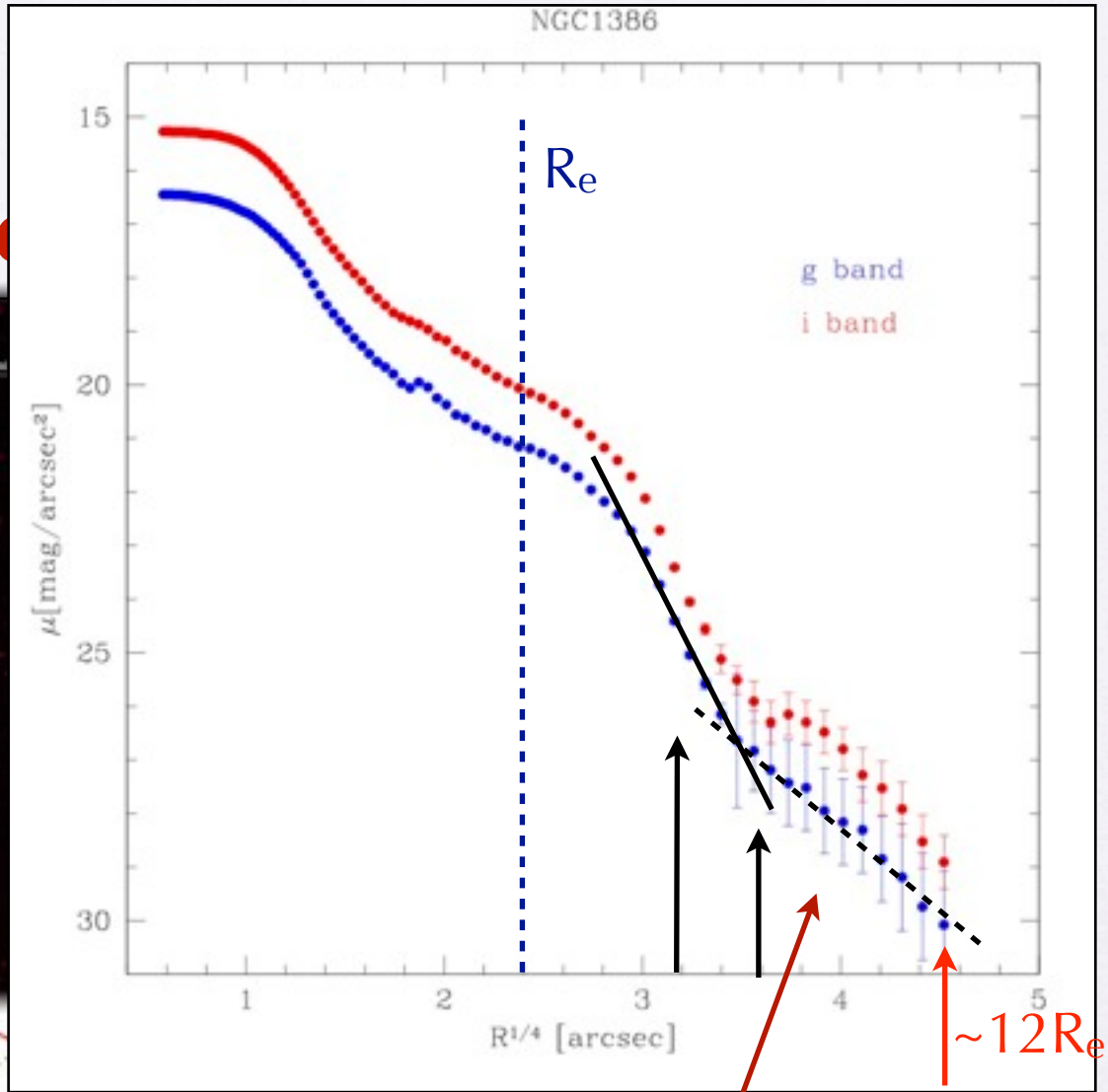


**shallow light profile for R> 4Re**

where the outer excess of light observed in all galaxies comes from?

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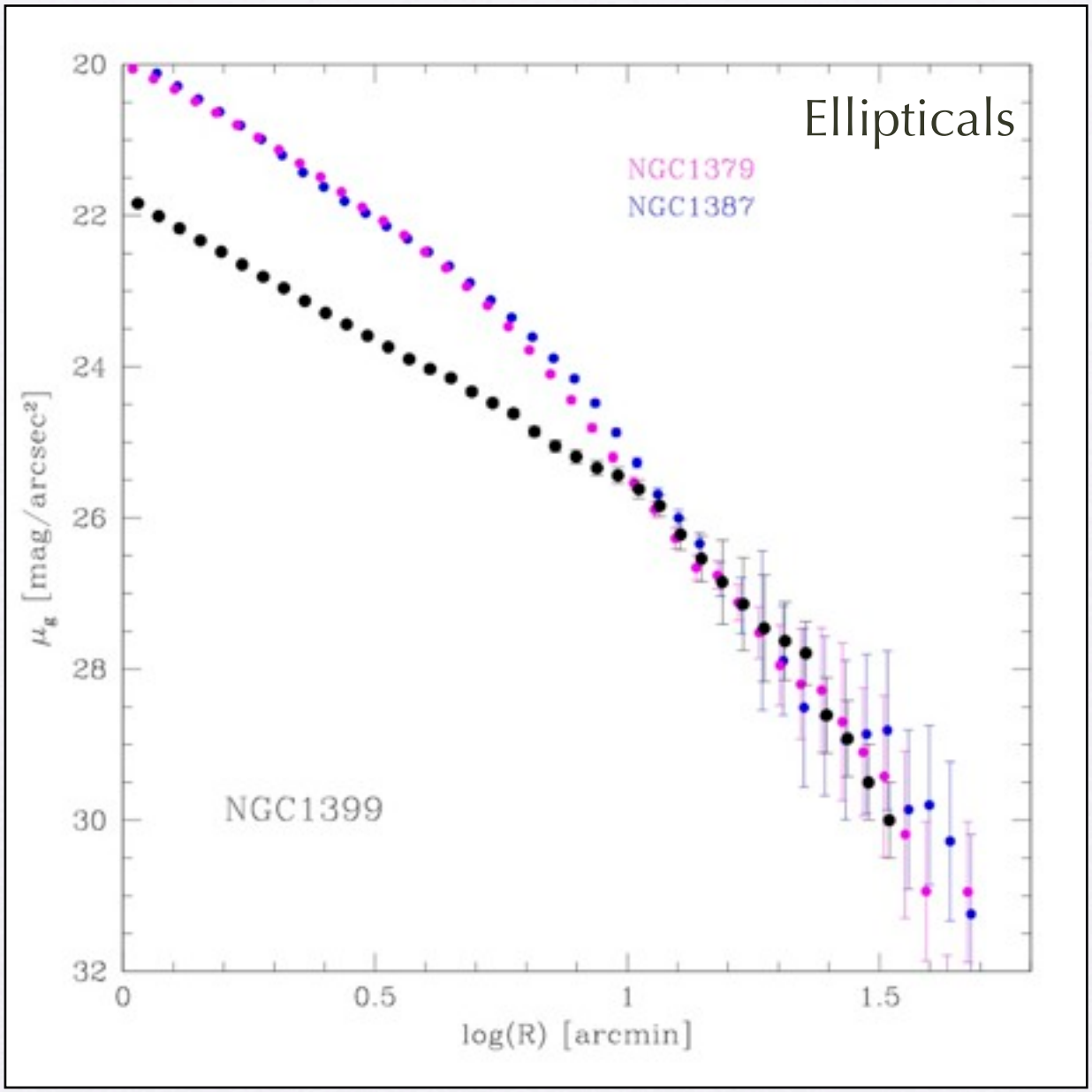

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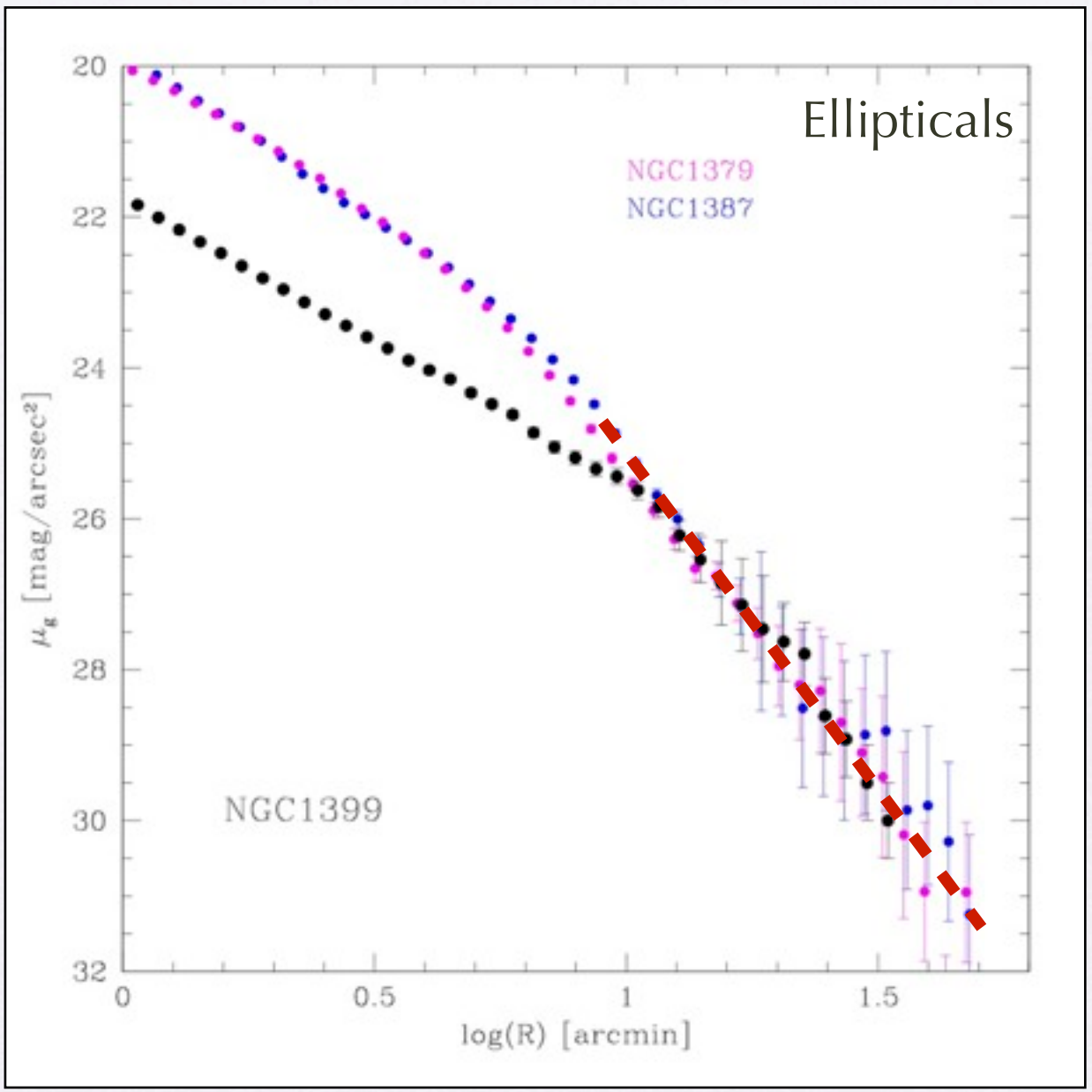

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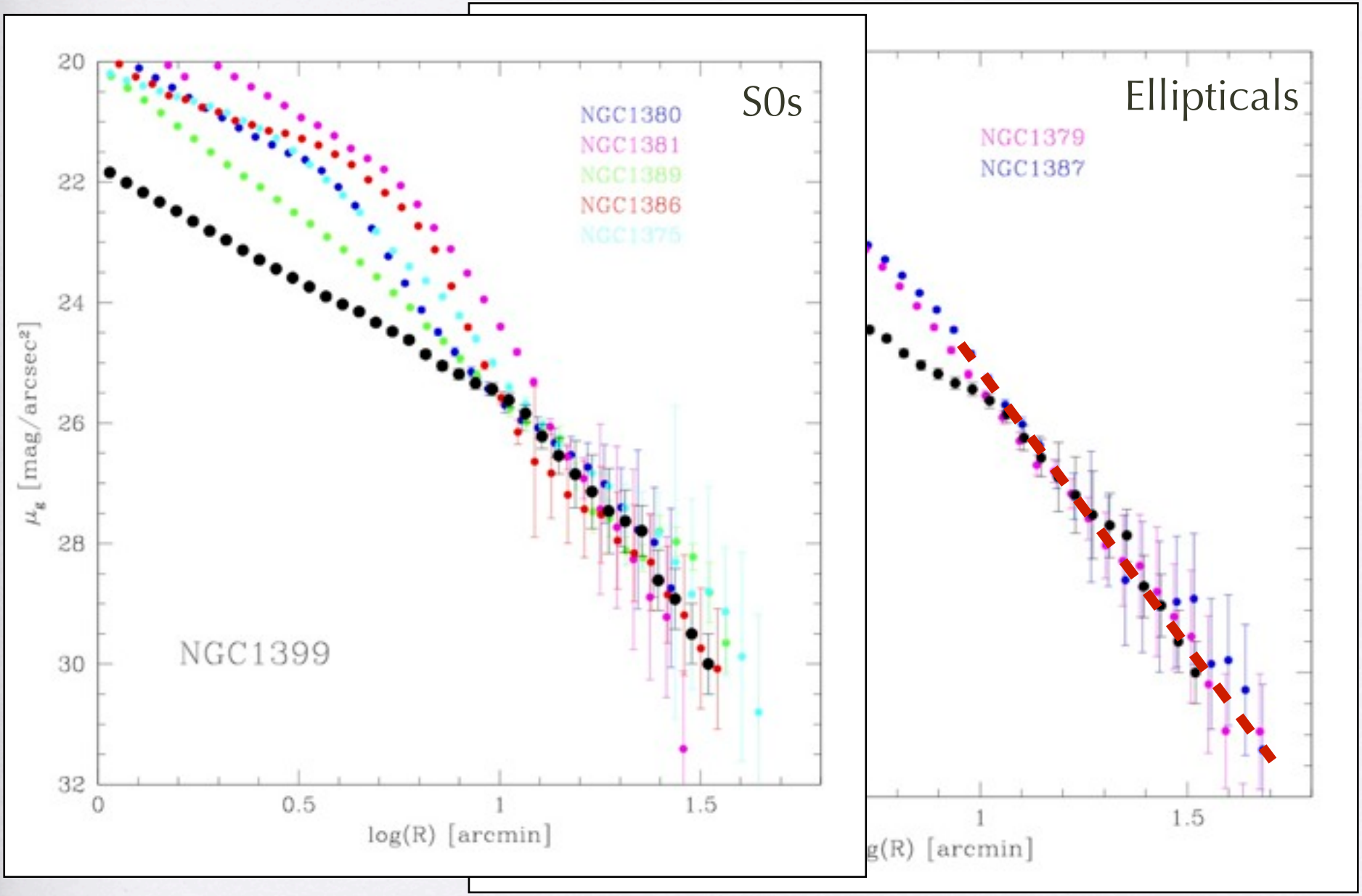

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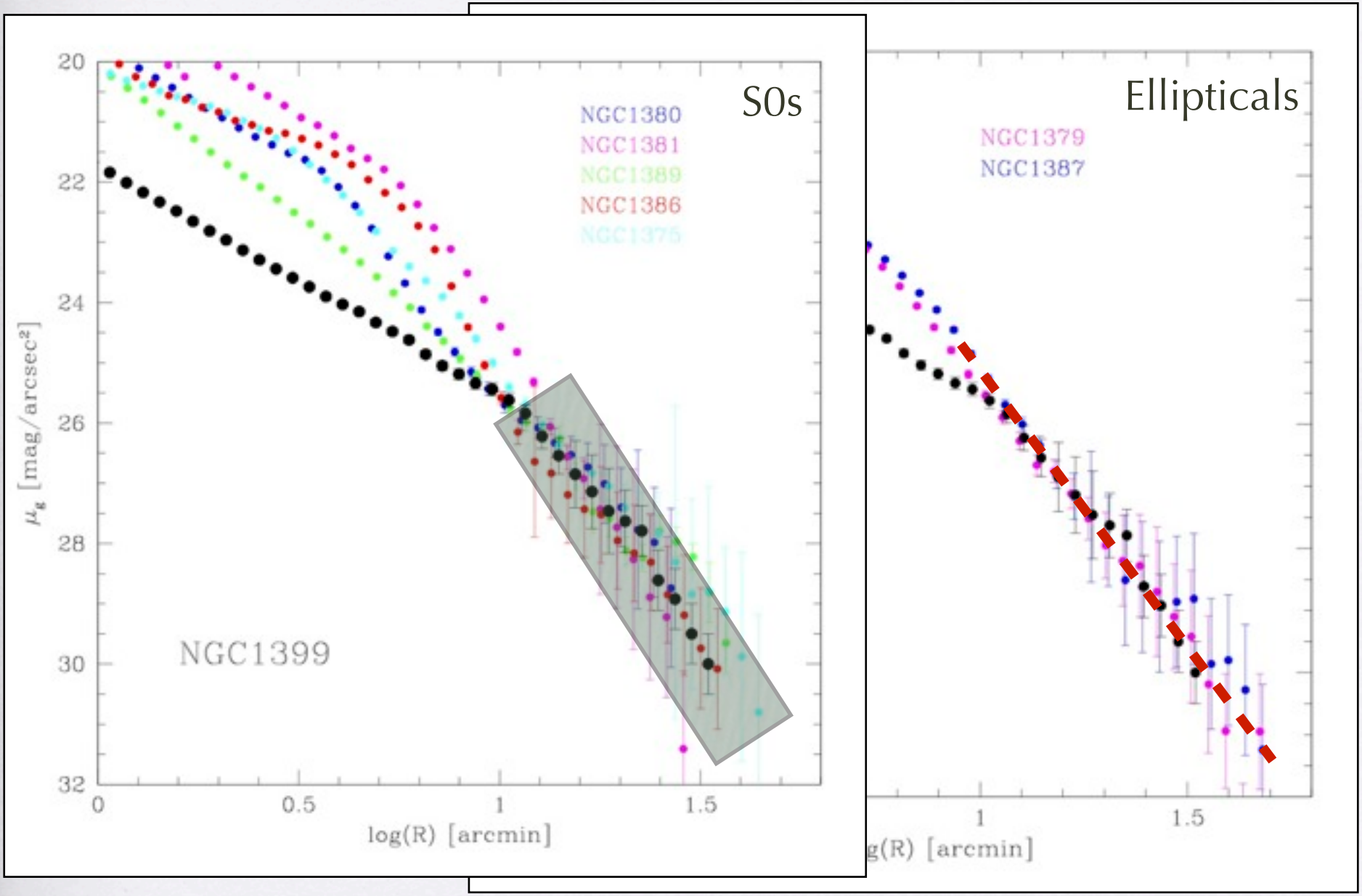
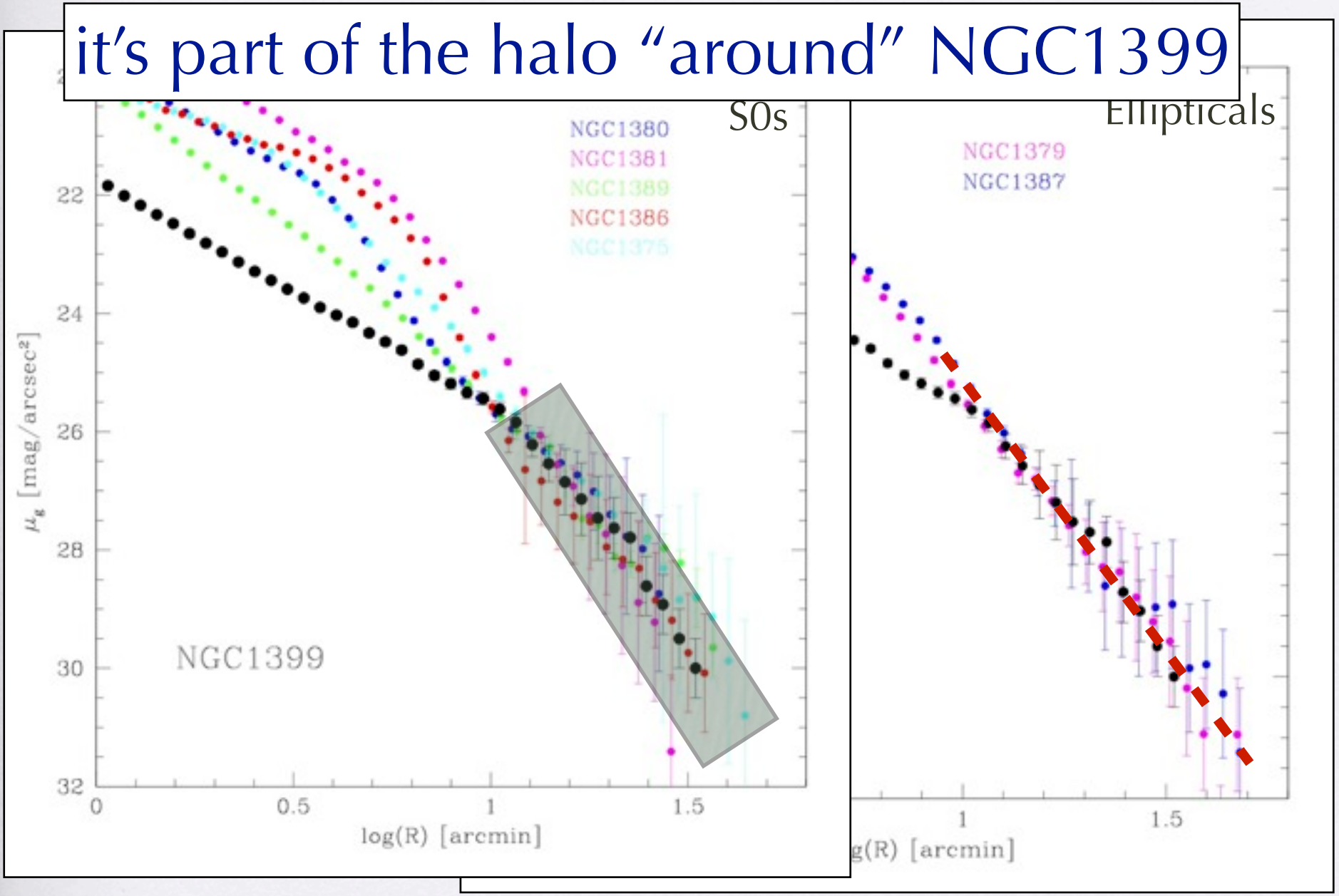


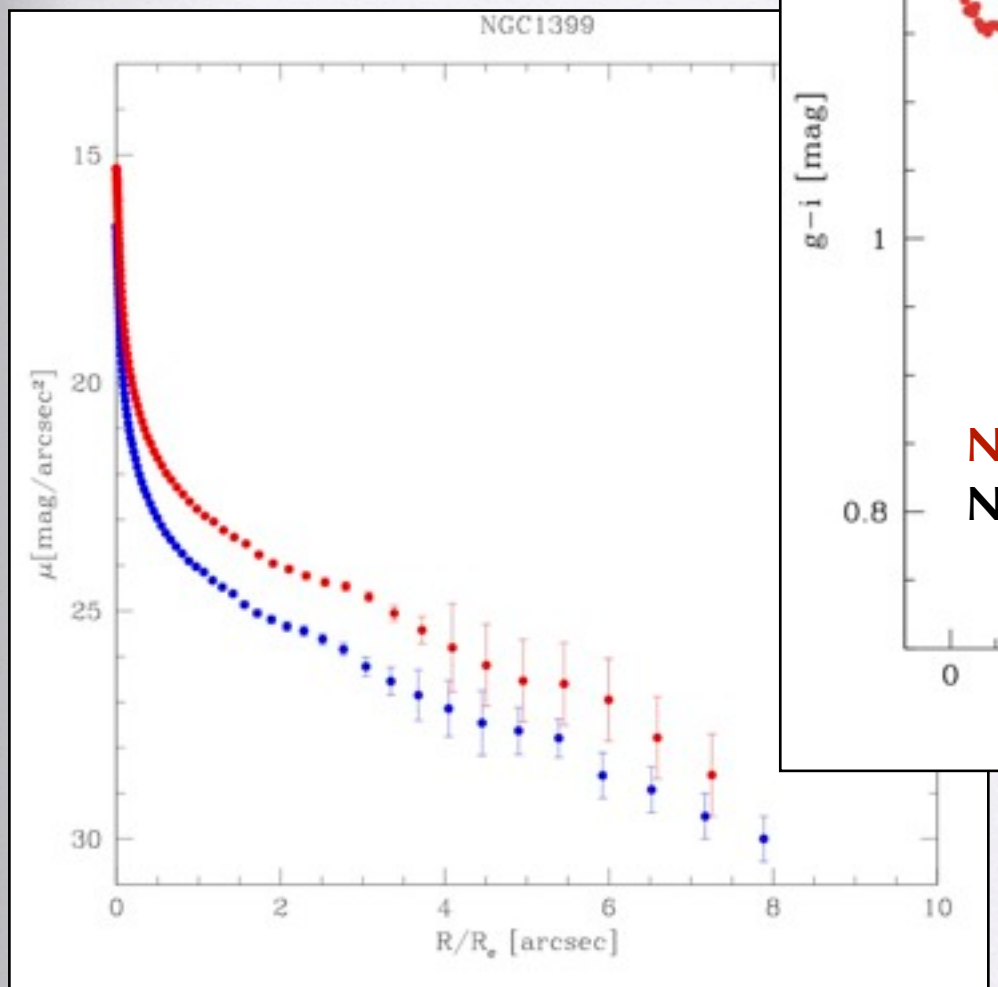
# where the outer excess of light observed in all galaxies comes from?

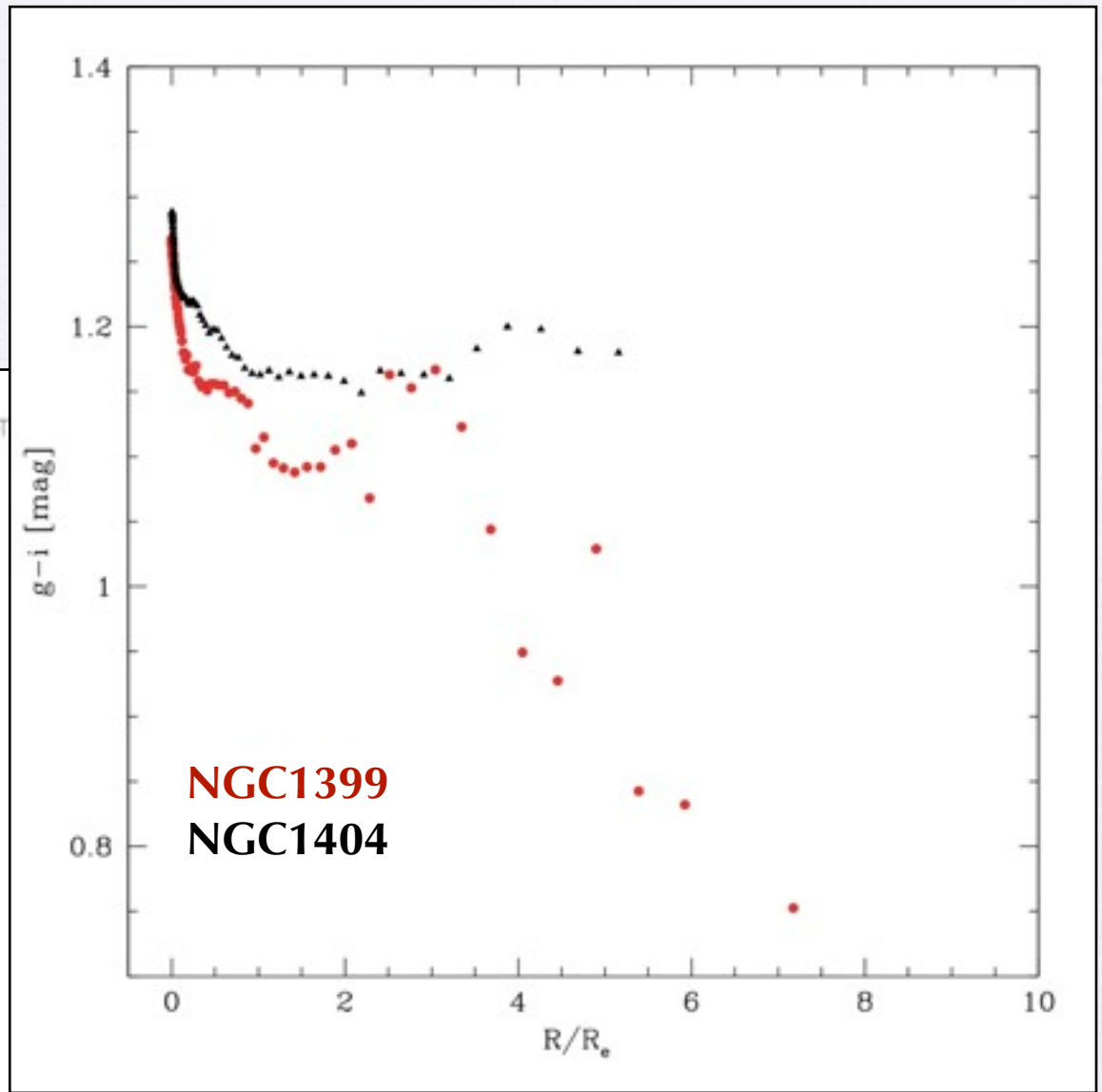
it's part of the halo "around" NGC1399



# color profiles:

## NGC1399



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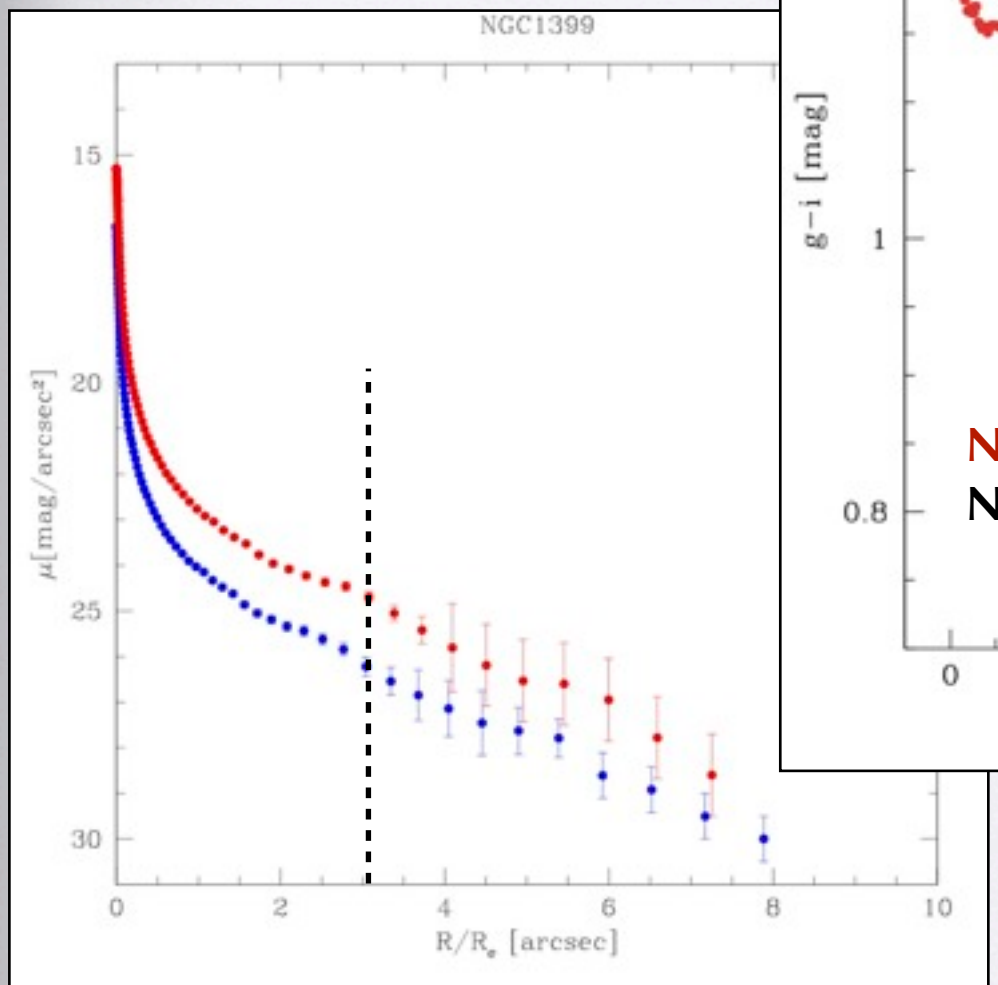
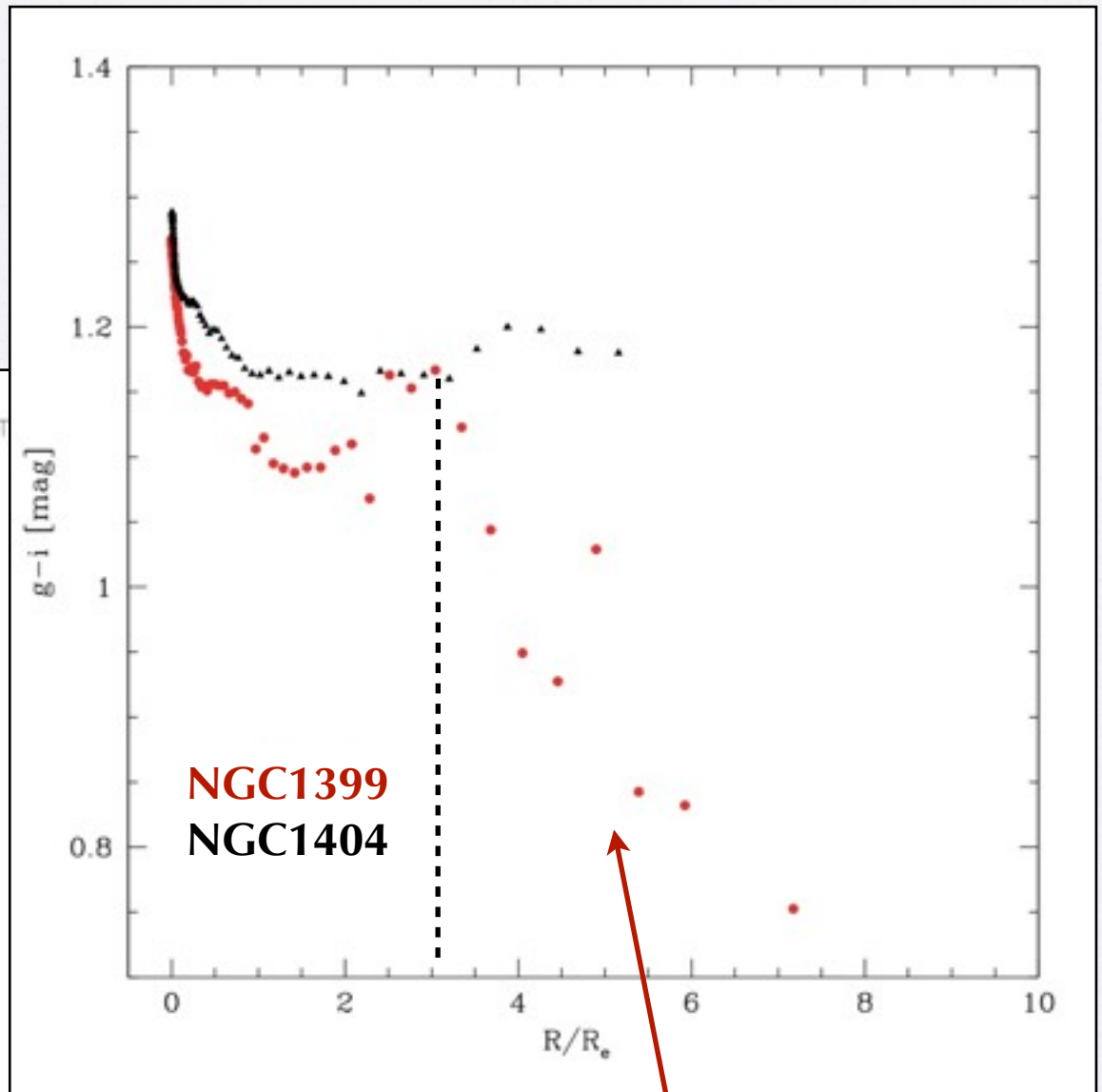
## NGC1399

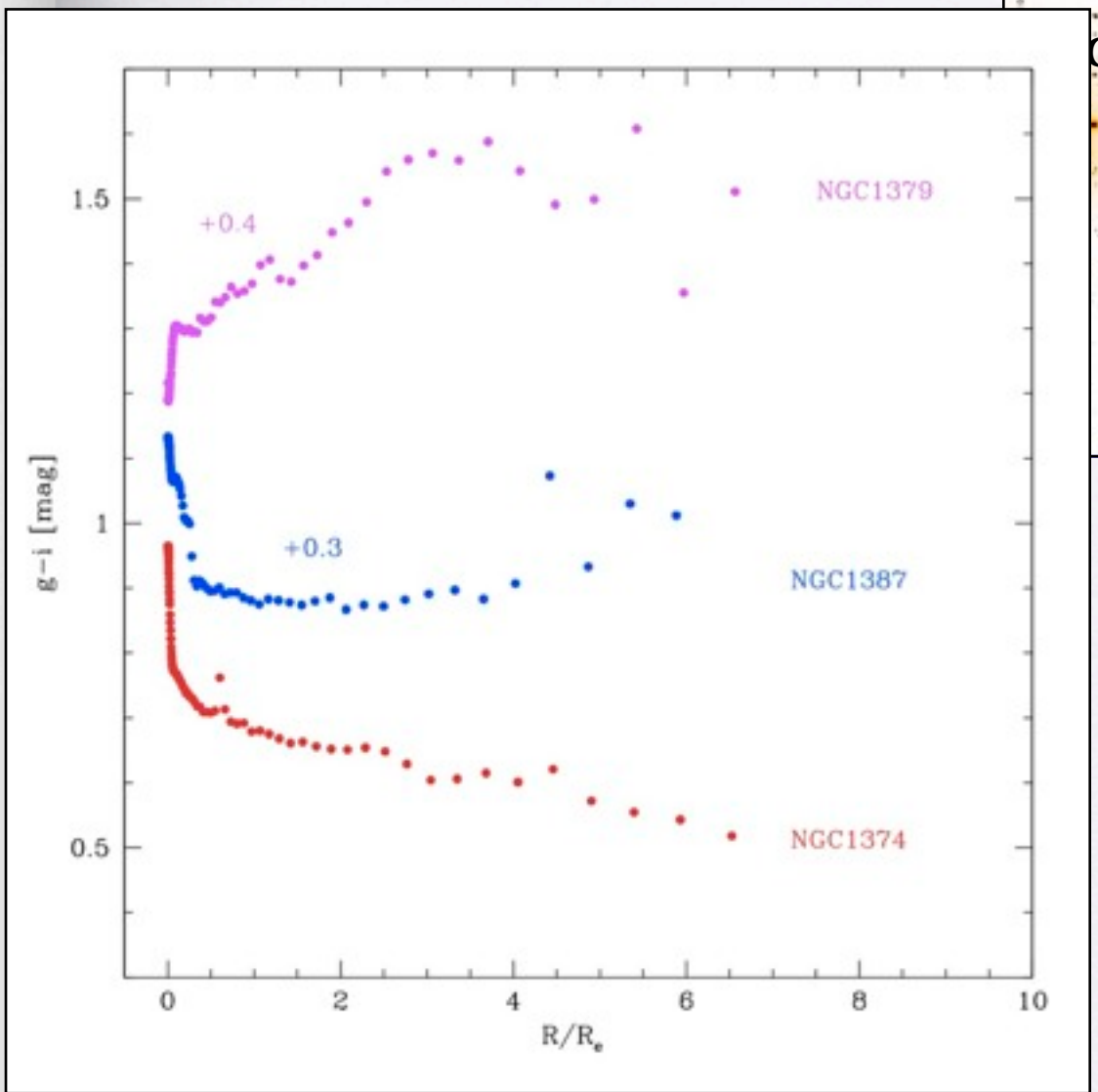


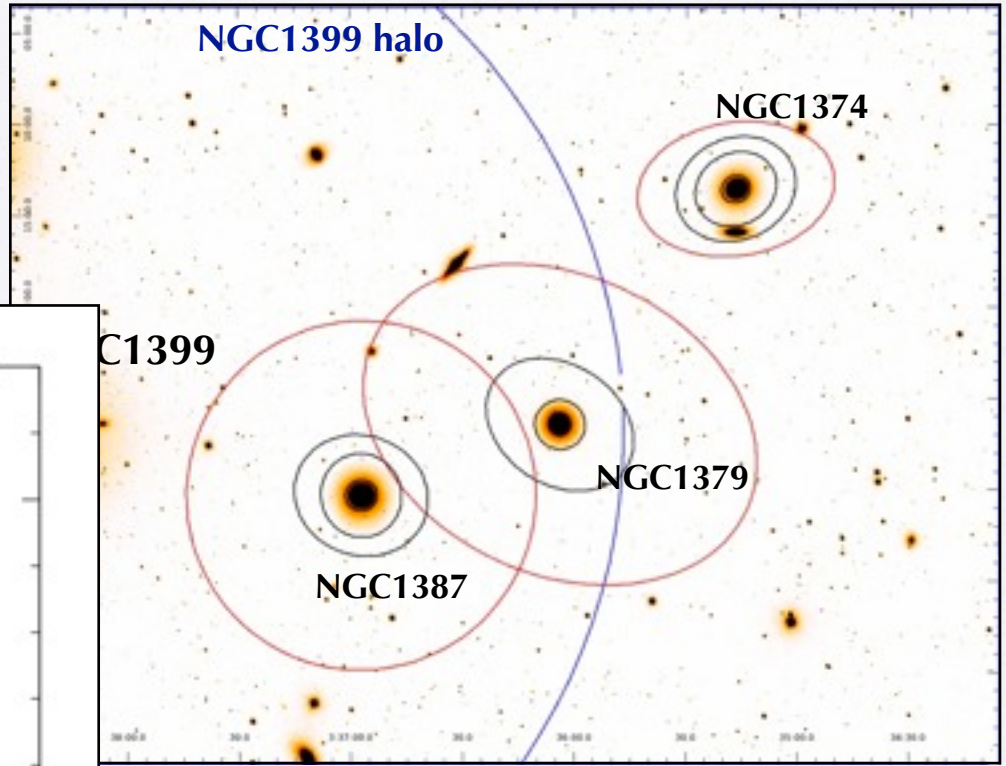




**bluer color for R> 3$R_e$**

# color profiles:

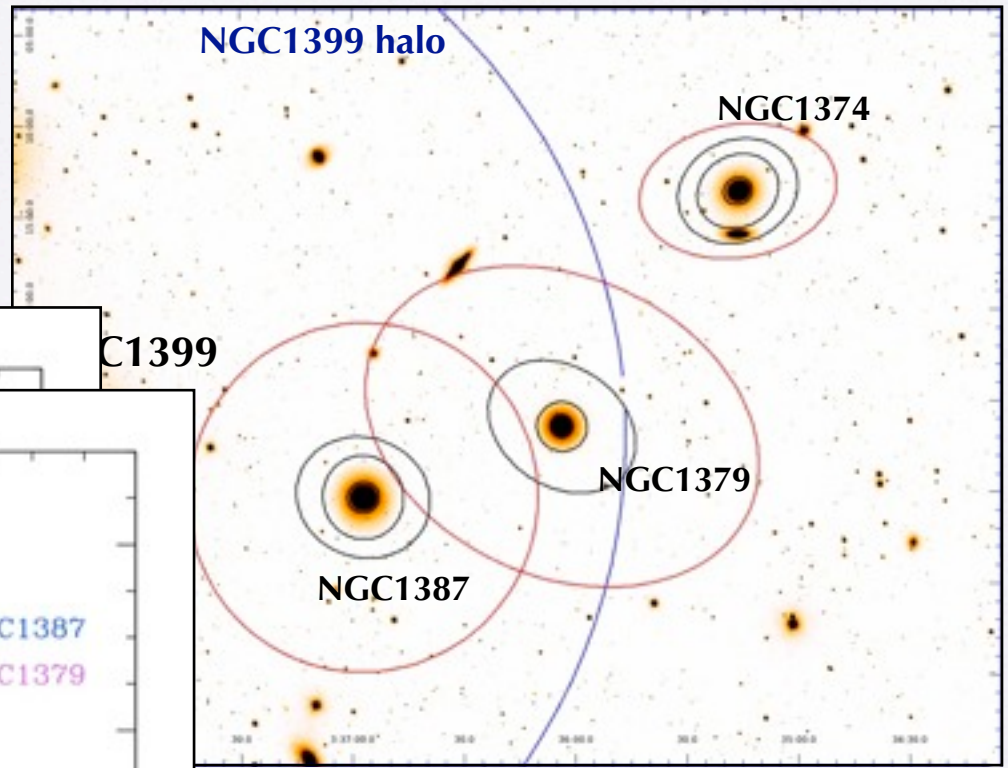
## Elliptical galaxies

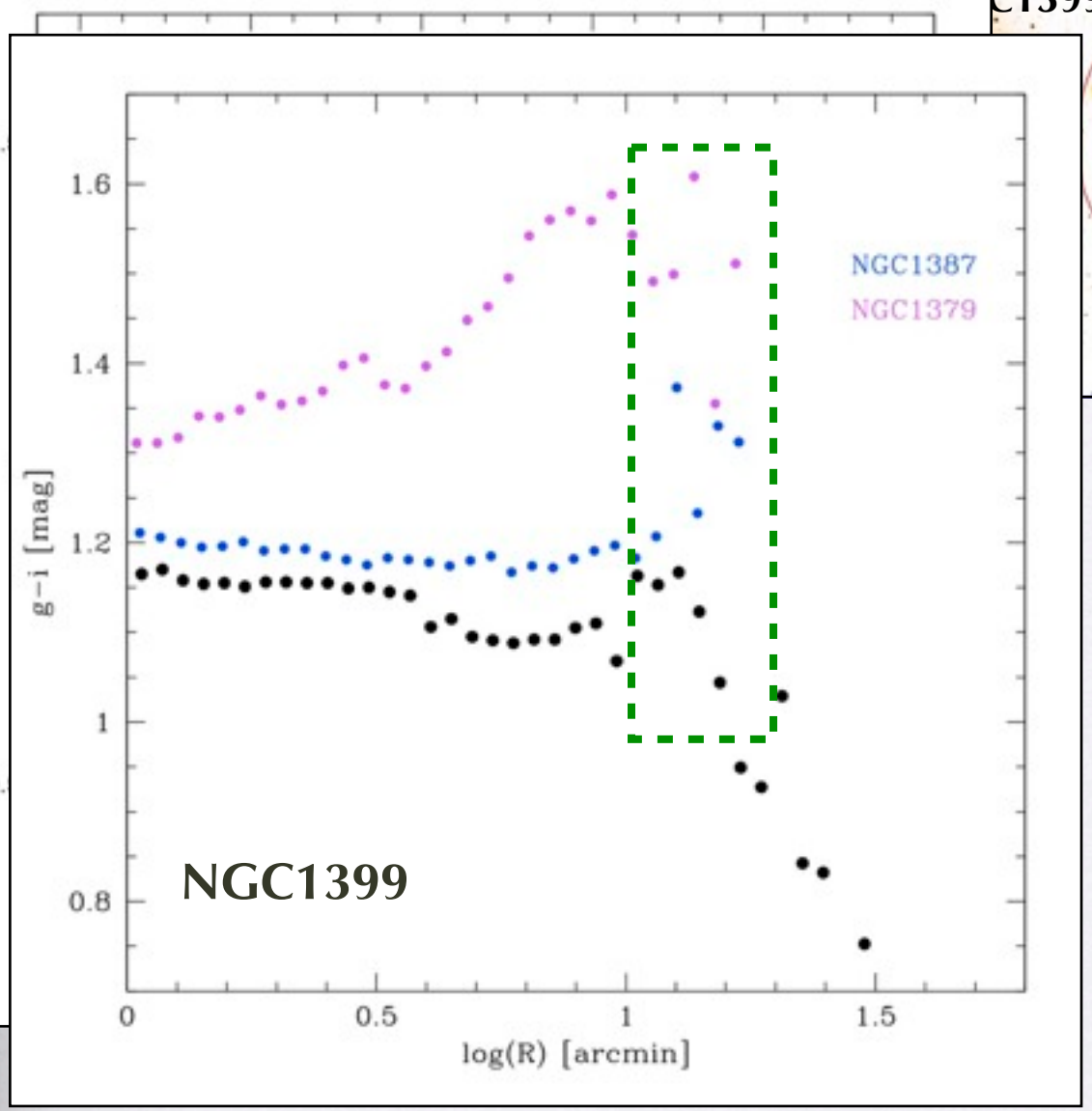


# color profiles:

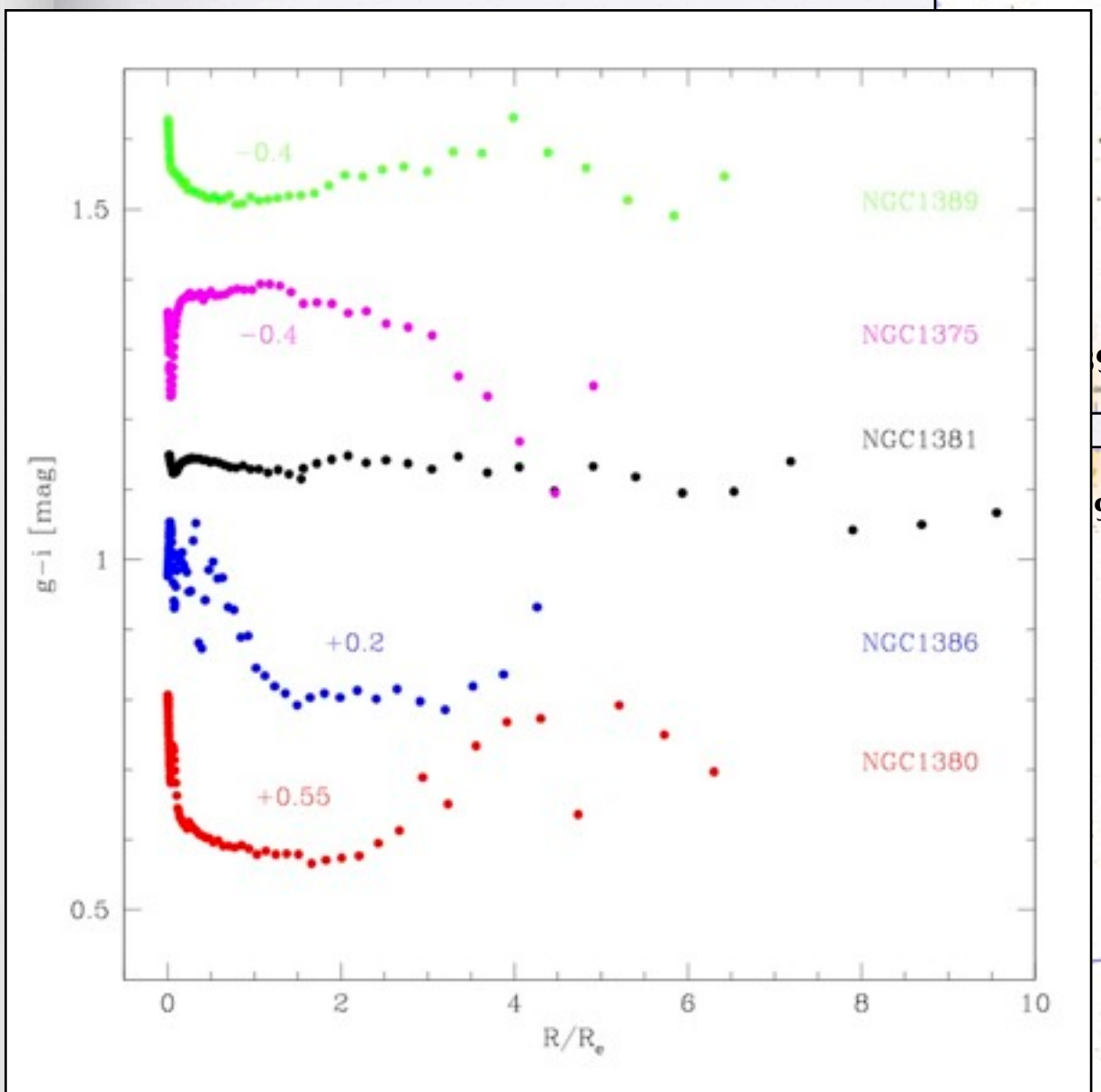
## Elliptical galaxies

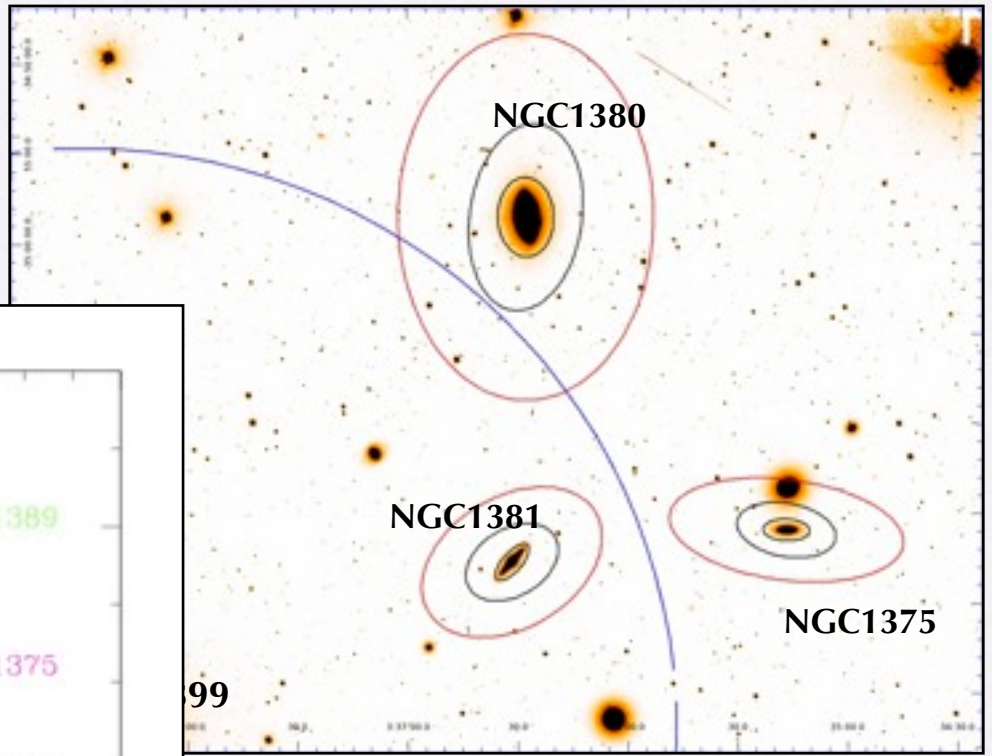


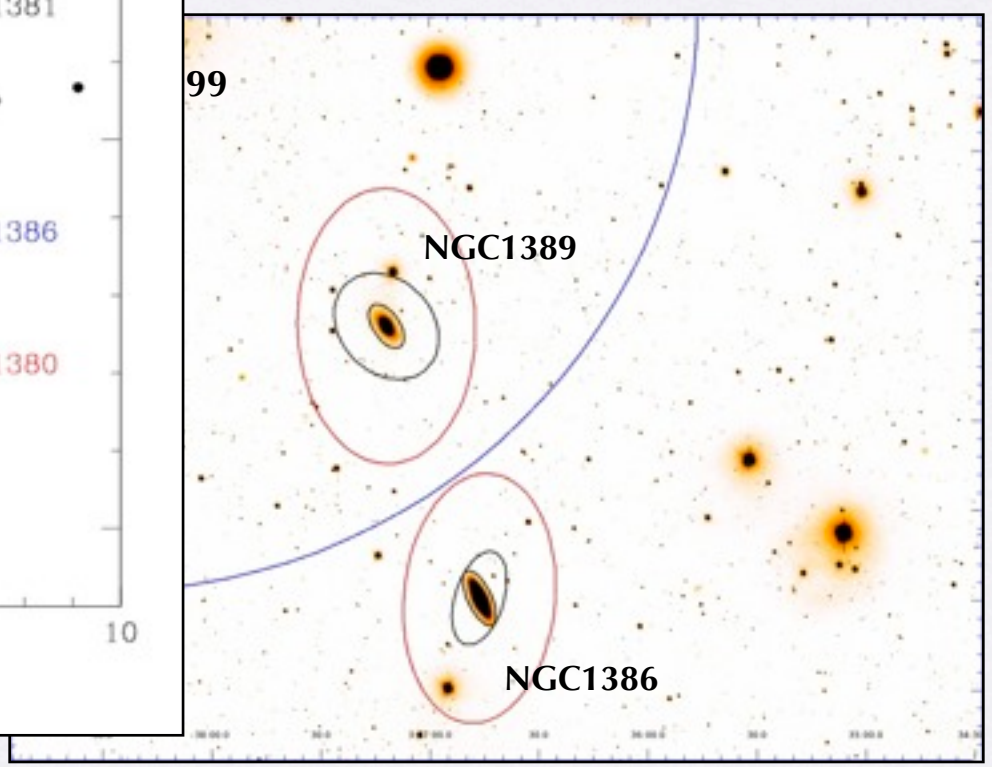



# color profiles:

## S0 galaxies

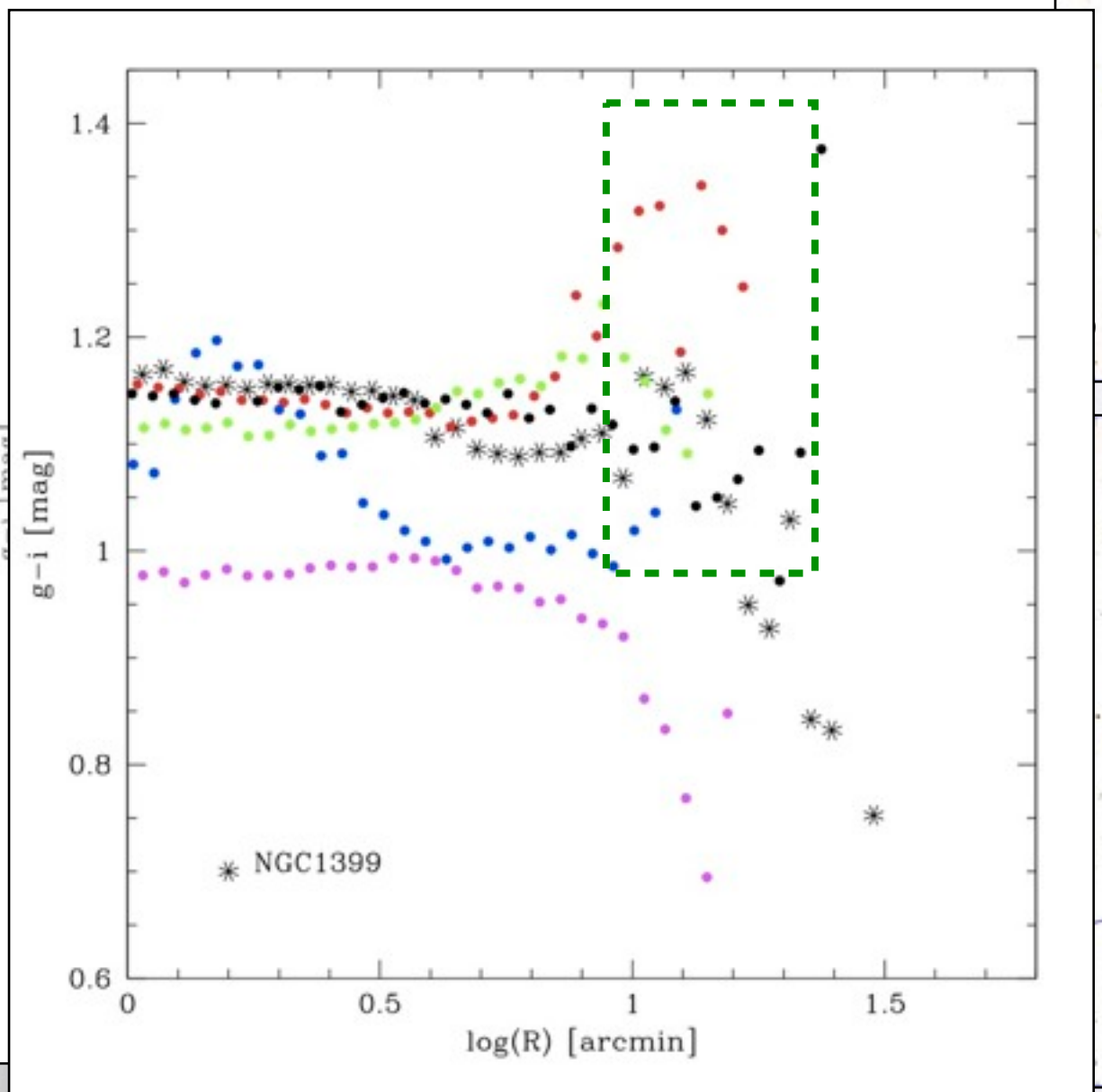


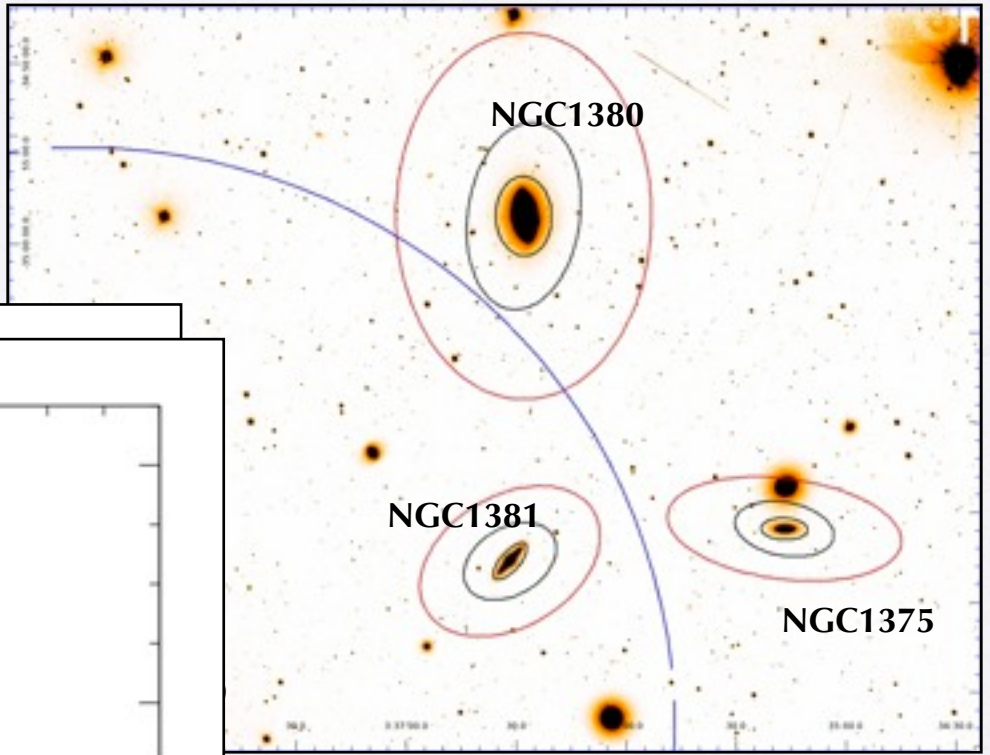



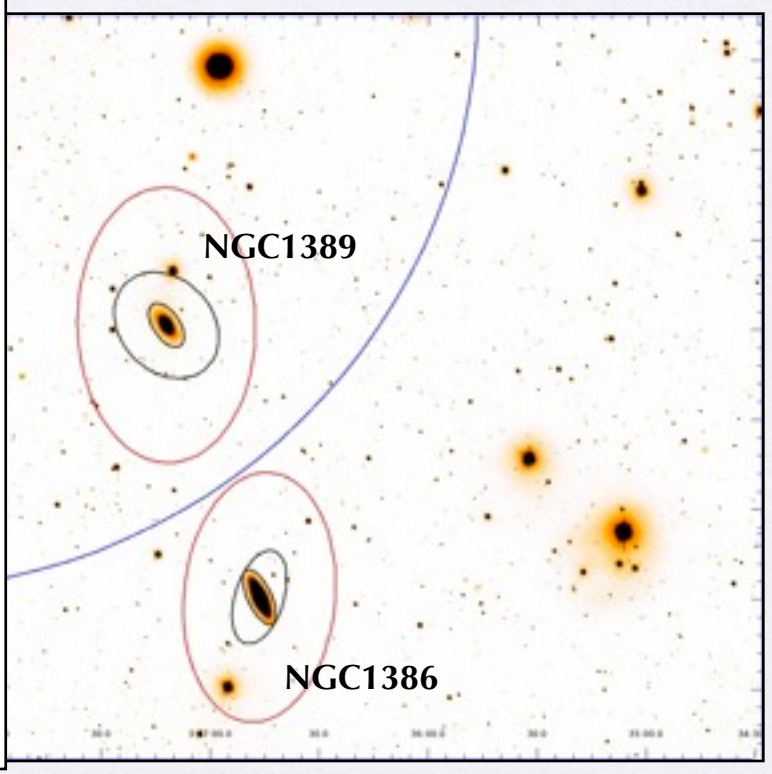



# color profiles:

## S0 galaxies

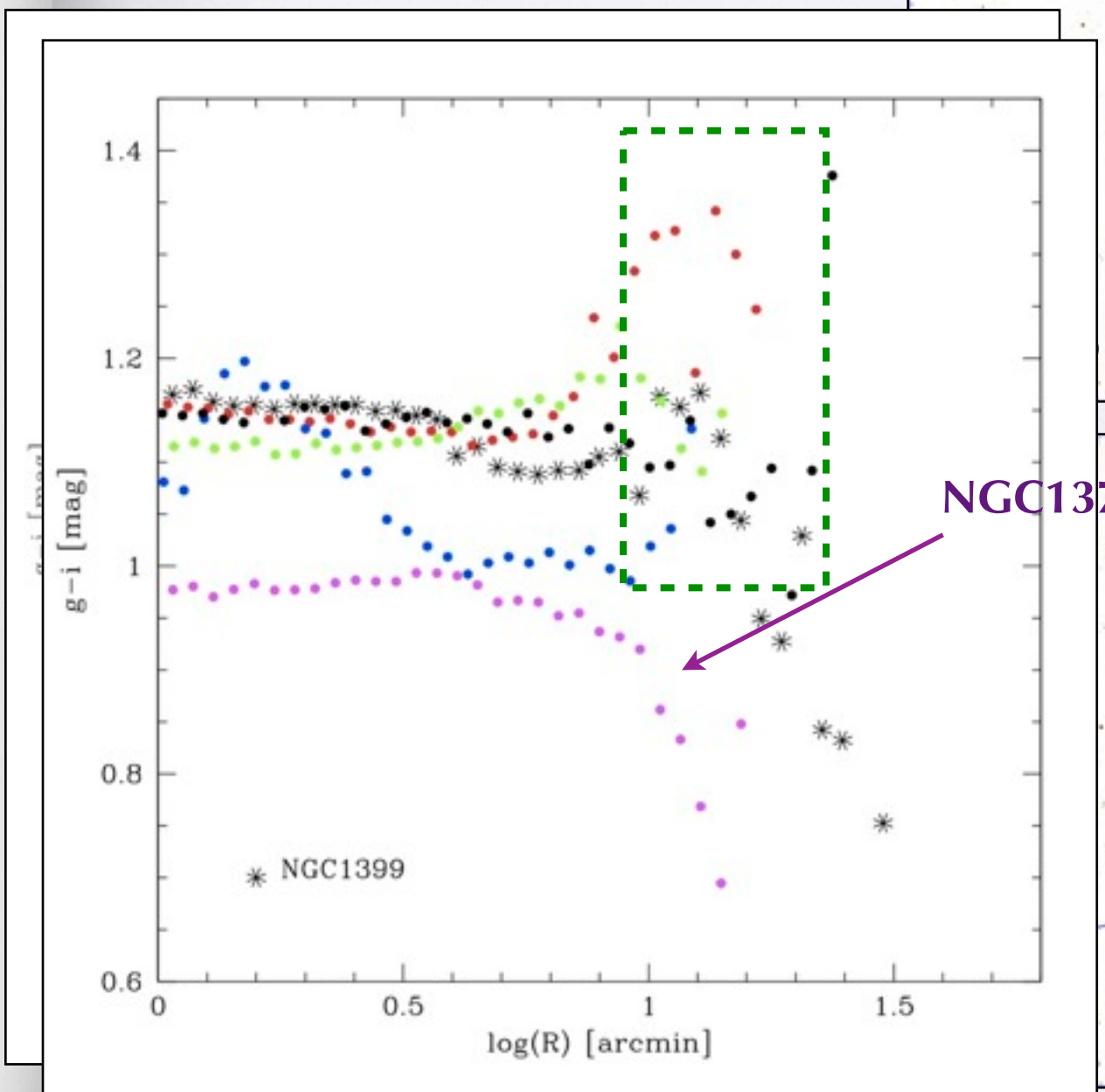


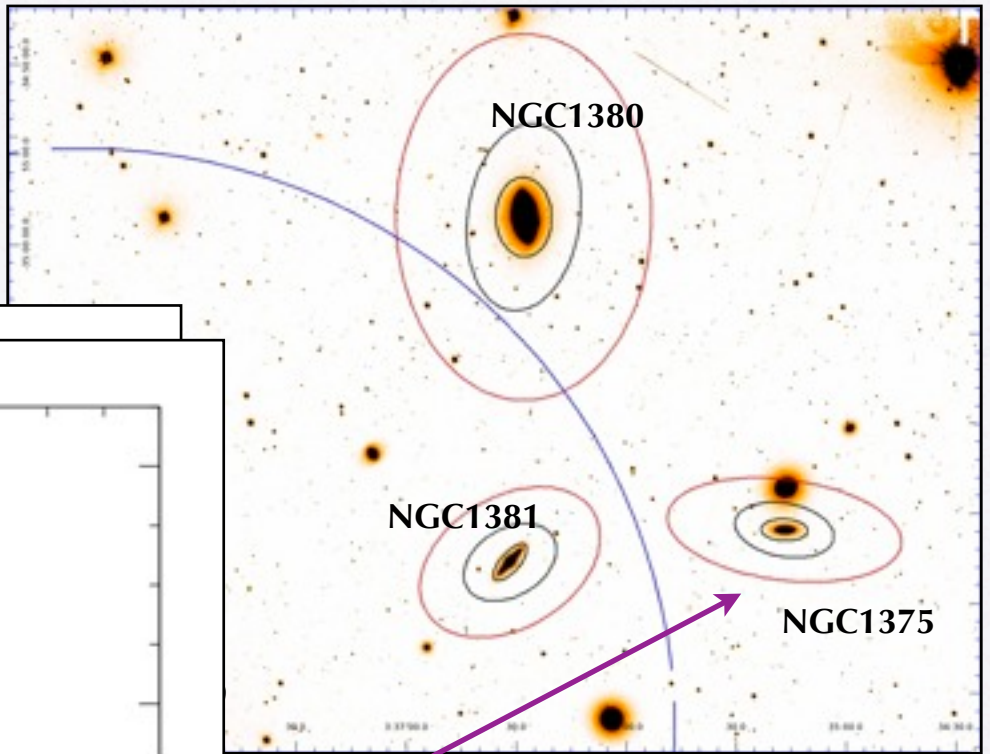



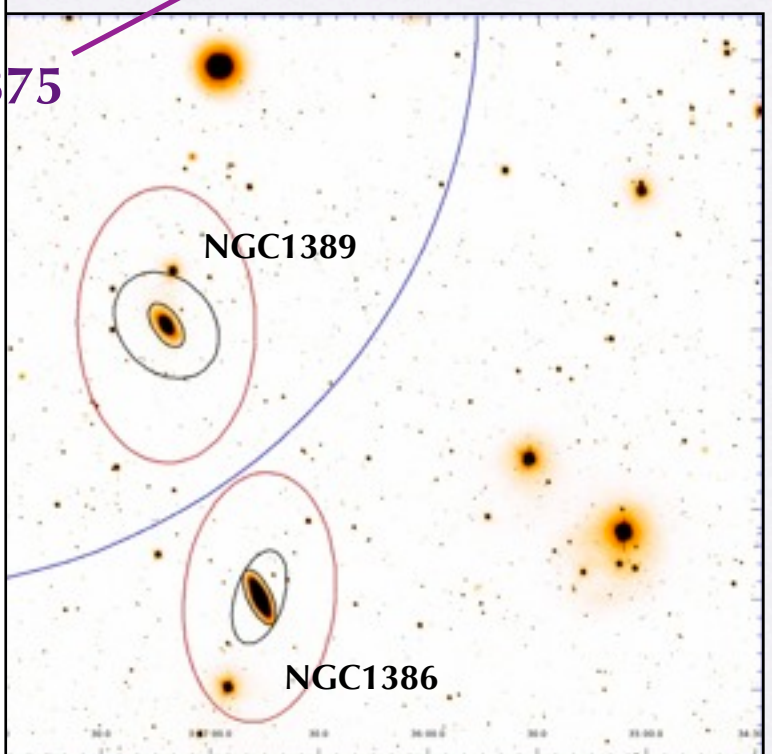
# color profiles:

## S0 galaxies




NGC1375



# Conclusive Remarks

**The large FOV, high efficiency, and spatial resolution of OmegaCAM @ VST allow us**

- to obtain the largest **mosaic of the Fornax Cluster** of ~ **3 x 2 deg$^2$**
- to map the surface brightness of galaxies to an unprecedent galactocentric distance, i.e. **$\mu_g^{lim}$ ~ 28-32 mag/arcsec$^2$** at **R~15 $R_e$** and the **g-i** color profiles up to **6-10 $R_e$**
- to derive the **light profiles** of **NGC1399** up to **~ 150 kpc** from the center, and confirm the **change in the slope** at **R~5$R_e$** and **28 ≲ $\mu_g$ ≲ 31 mag/arcsec$^2$**
- to found that most of **ETGs** "around" NGC1399 show a **change in the slope** of light profile at **4$R_e$ ≲ R ≲ 9$R_e$** and **27 ≲ $\mu_g$ ≲ 31 mag/arcsec$^2$**, and SB matches that of NGC1399 for R≳5$R_e$

# Conclusive Remarks

**The large FOV, high efficiency, and spatial resolution of OmegaCAM @ VST allow us**

these new and very preliminary results are crucial to unveil the structure of the Fornax Cluster

next steps:

- reduce and study the others 2 VST fields on NE side of NGC1399 to go further out from the galaxy center
- study the extended halo "around" NGC1399 (by making 2D model) and compare it with the predictions from simulations

- to derive the **light profiles** of **NGC1399** up to **~ 150 kpc** from the center, and confirm the **change in the slope** at **R~5$R_e$** and **28 ≲ $\mu_g$ ≲ 31 mag/arcsec²**

- to found that most of **ETGs** "around" NGC1399 show a **change in the slope** of light profile at **4$R_e$ ≲ R ≲ 9$R_e$** and **27 ≲ $\mu_g$ ≲ 31 mag/arcsec²**, and SB matches that of NGC1399 for R≳5$R_e$