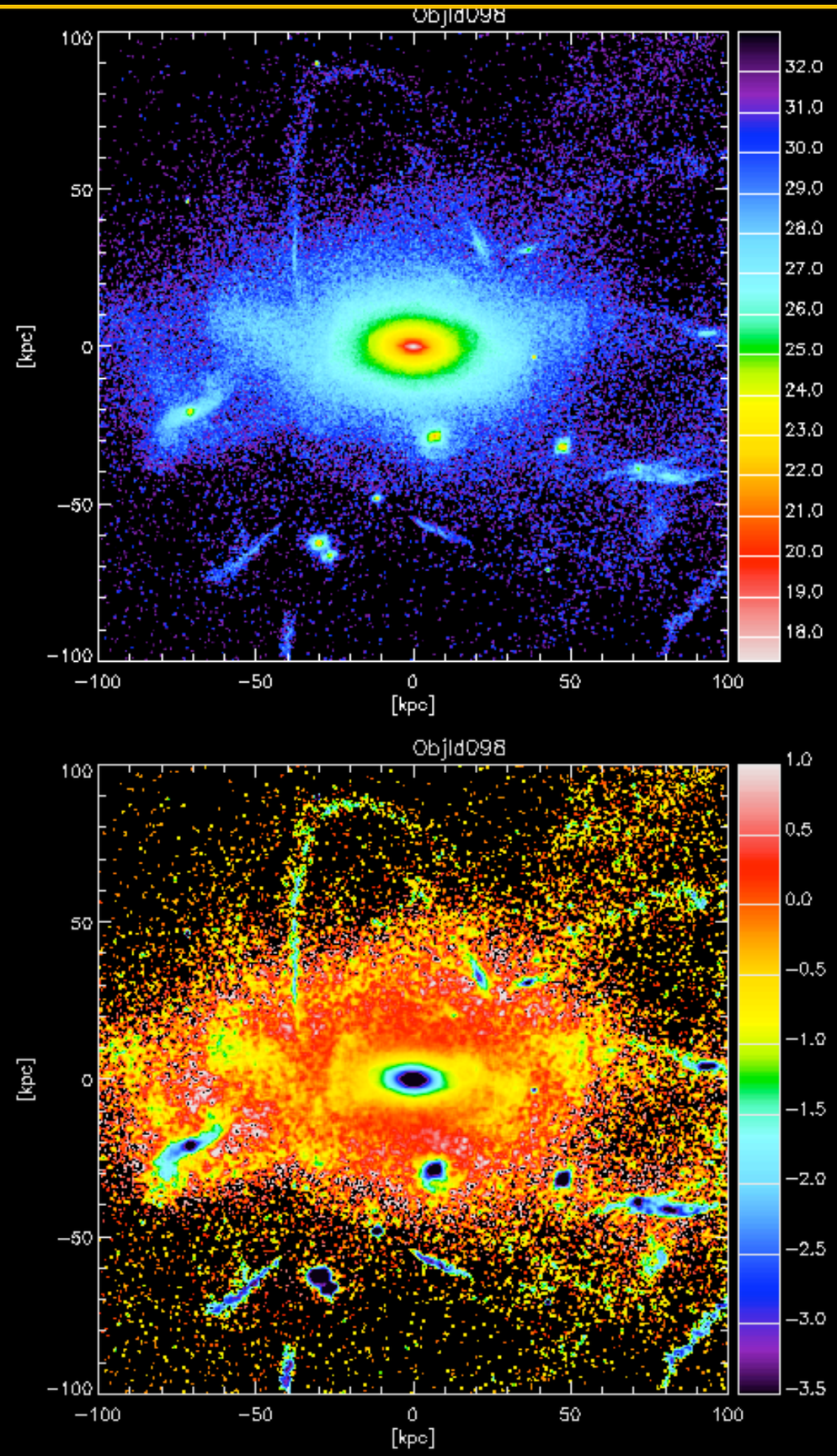
LSB science in the nearby Universe with the NSLS

Pierre-Alain Duc

NSLS workshop, Paris, June 2014

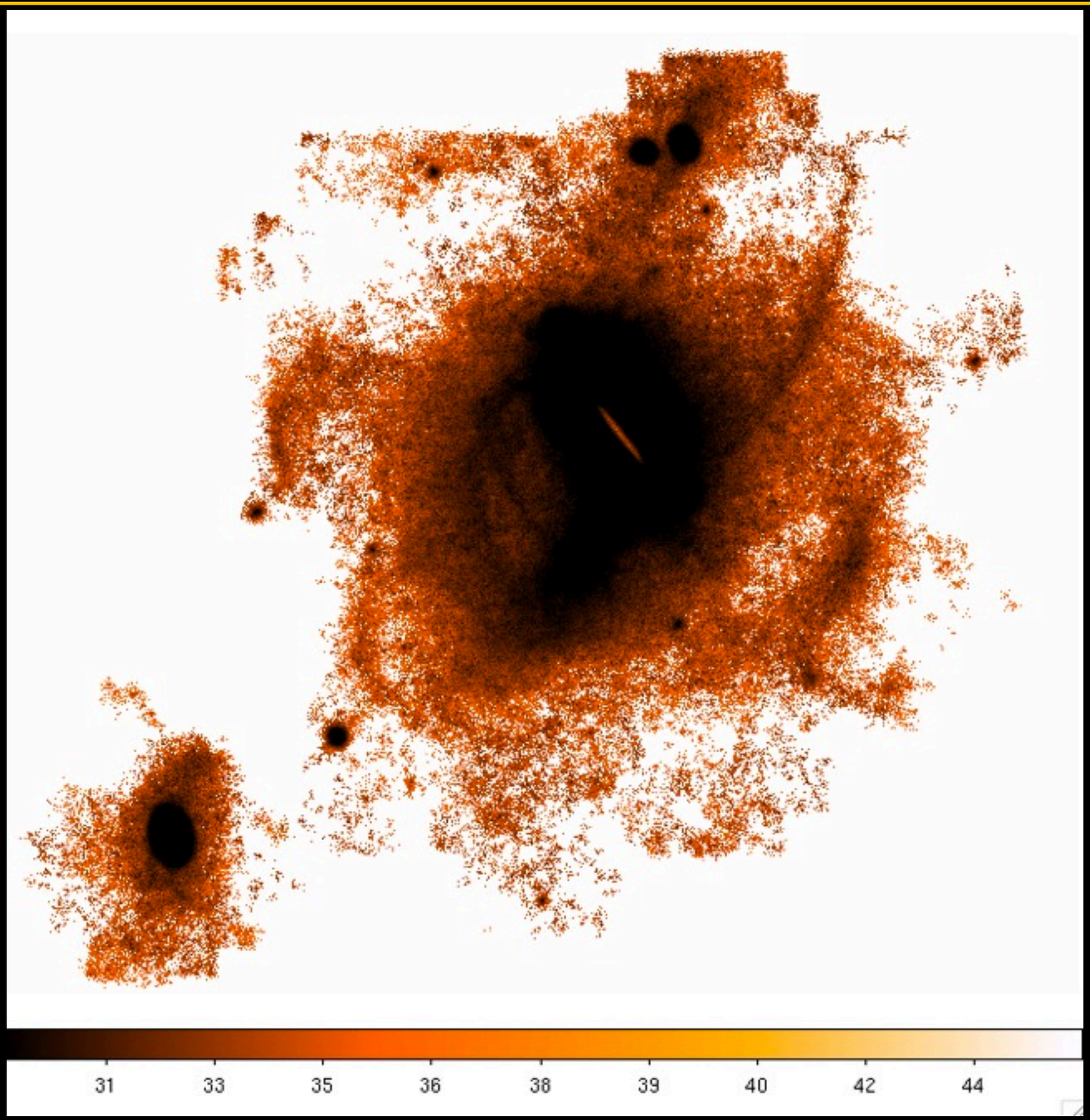
Galactic archeology



Prime science motivation: reconstructing the mass assembly of galaxies from the census of collisional debris in nearby galaxies

Michel-Dansac et al., in prep

Detections of LSB structures with stellar counts



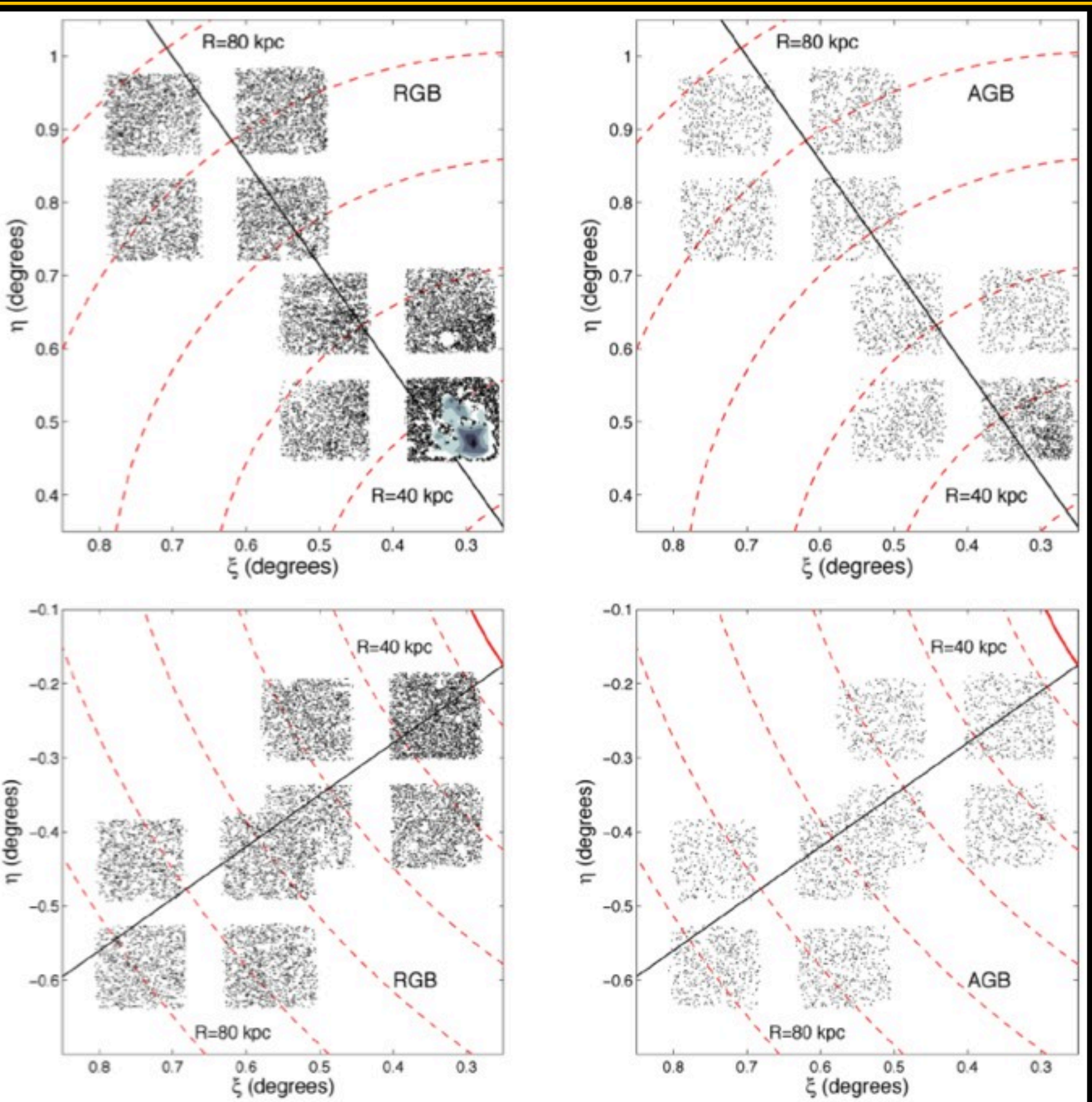
- Resolved star counts allow to detect streams as faint as 33 mag.arcsec-2

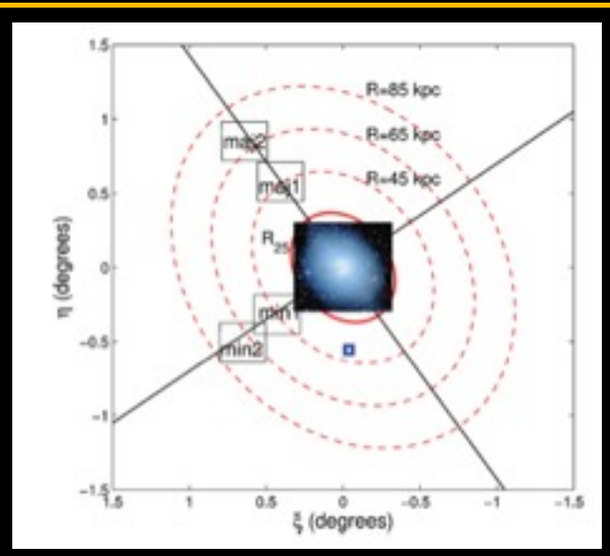
- Method working for galaxies resolved in stars: basically, within a few Mpc (Local and very nearby Groups)

- Centaurus A (D=3.8 Mpc) as seen by VLT/VIMOS (Crnojevic, Ferguson et al., 2013)

M31 by PAndAS

Detections of LSB structures with stellar counts



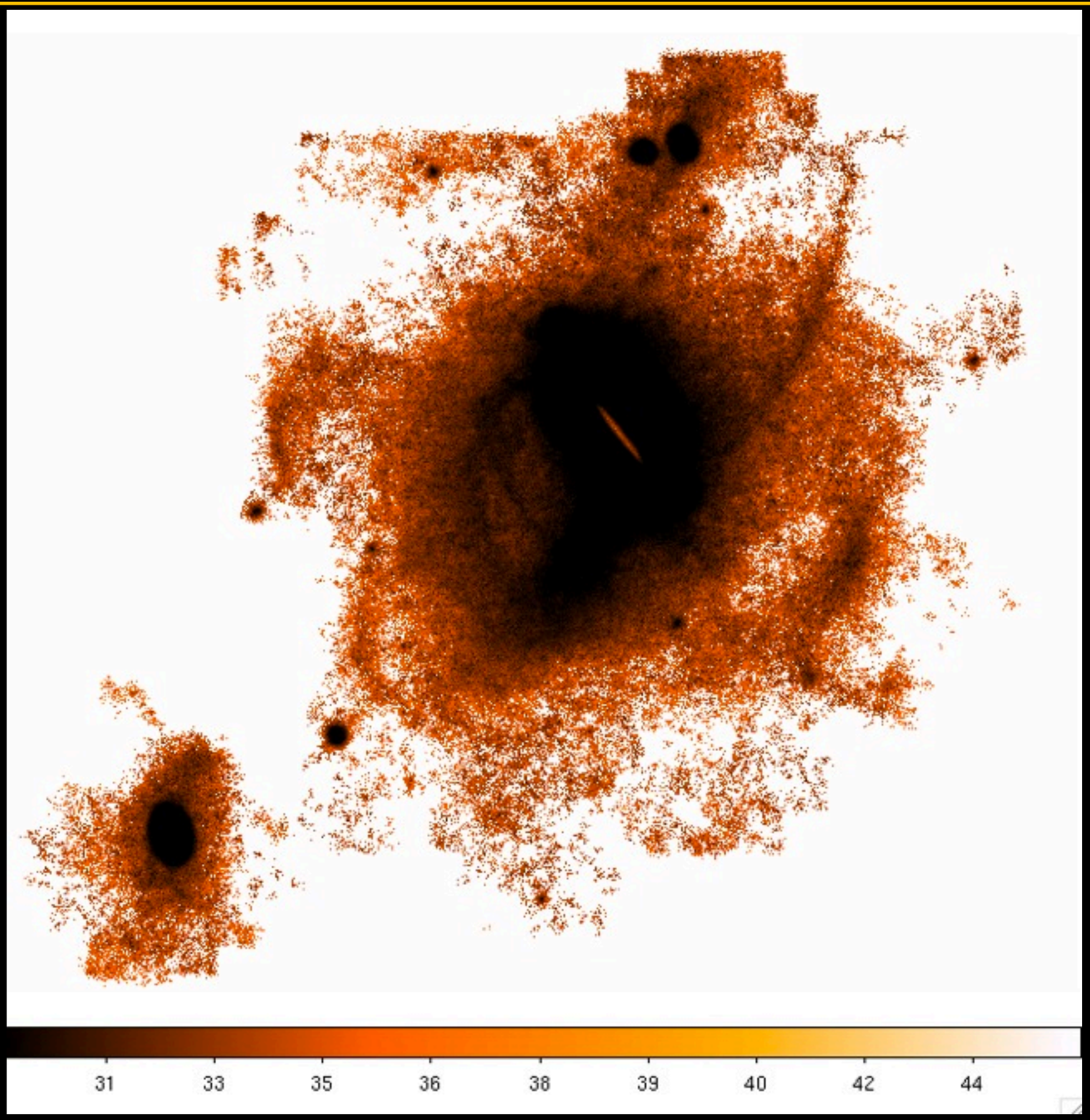


- Centaurus A (D=3.8 Mpc) as seen by VLT/VIMOS (Crnojevic, Ferguson et al., 2013)

- Resolved stars counts mapping the large-scale spatial distribution of old RGB stars and intermediate-age AGB stars

- Method allows to study the outerhalo, but no so much the fine structures around it

Galactic archeology



• Prospects of galaxy archeology beyond the nearby groups

• in the far future: ELT (but lack of field of view)
~~Space missions~~

=> Using unresolved, diffuse, light

Detections of LSB structures with diffuse light

- With «amateur» telescope (Blackbird), long exposures in a dark site

Extensive surveys time consuming

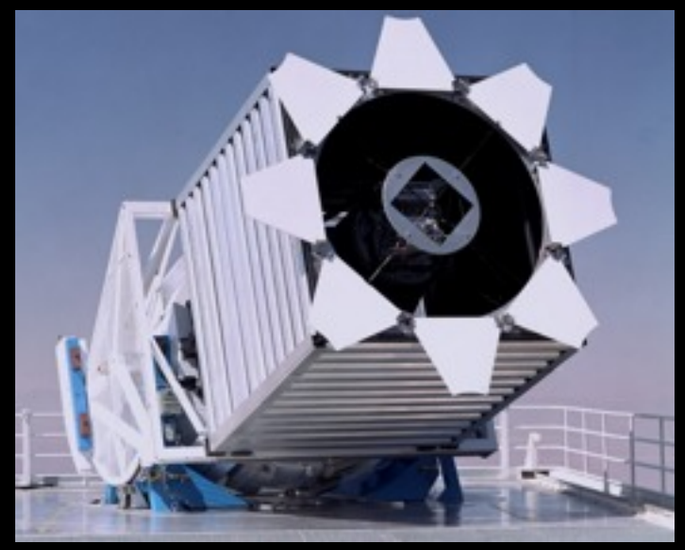
- Achieved surface brightness limit uncertain (follow-up photometric calibrations required)

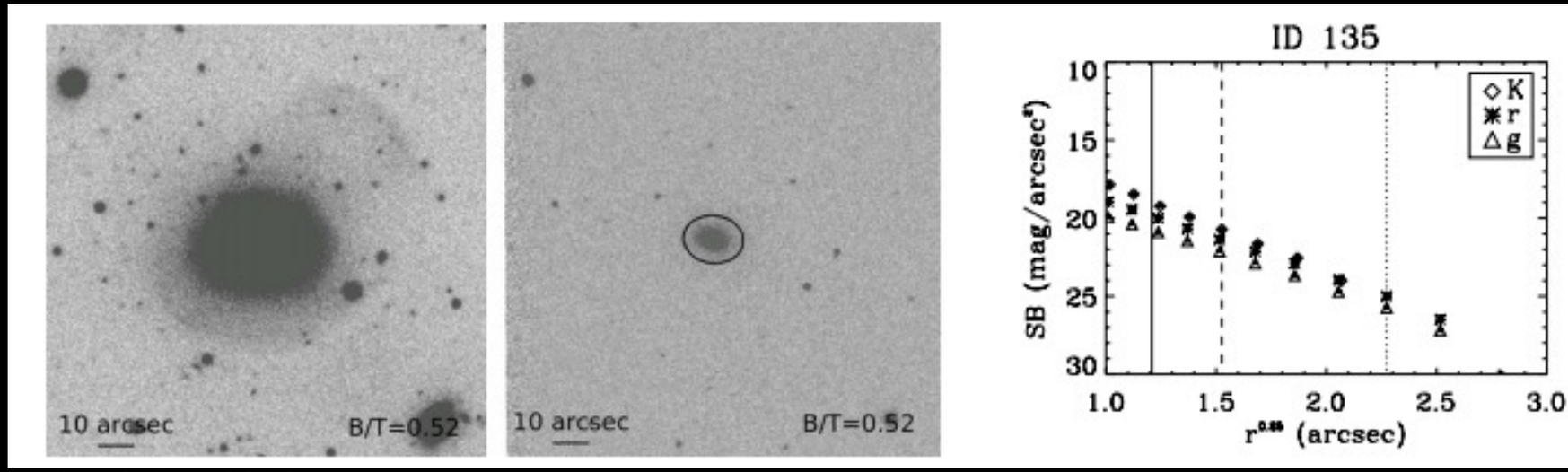
© NGC 5907: Martinez-Delgado et al.

Detections of LSB structures with diffuse light

Jiang, Huang & Gu, 2011

- With 2.5m Sloan telescope: calibration field stripe 82
(co-addition of 50 SDSS single scans, gain of 2 mag, reaching 28 mag.arcsec-2)





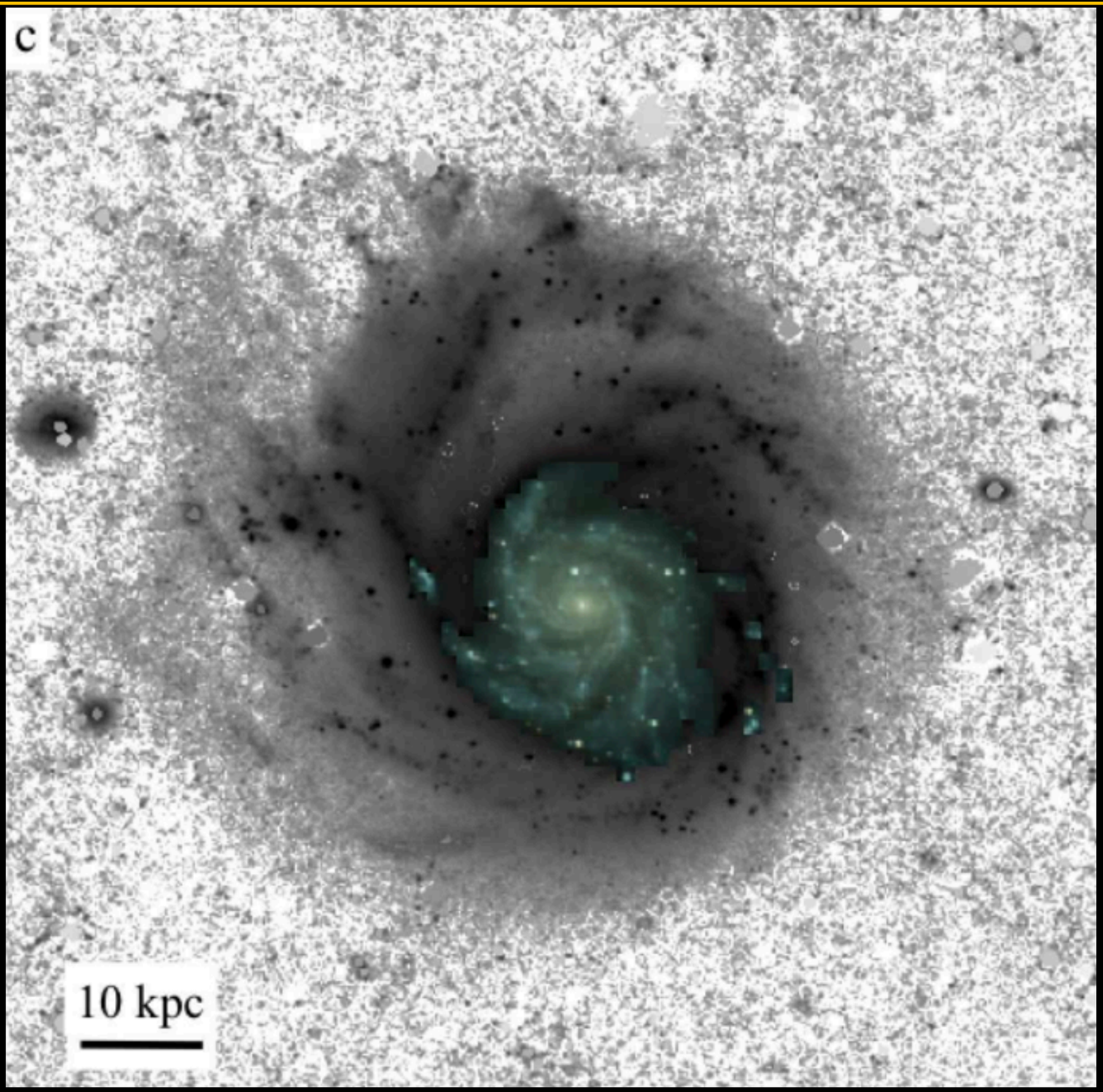
Kim & Im, 2013

Detections of LSB structures with diffuse light

Mihos et al., 2005

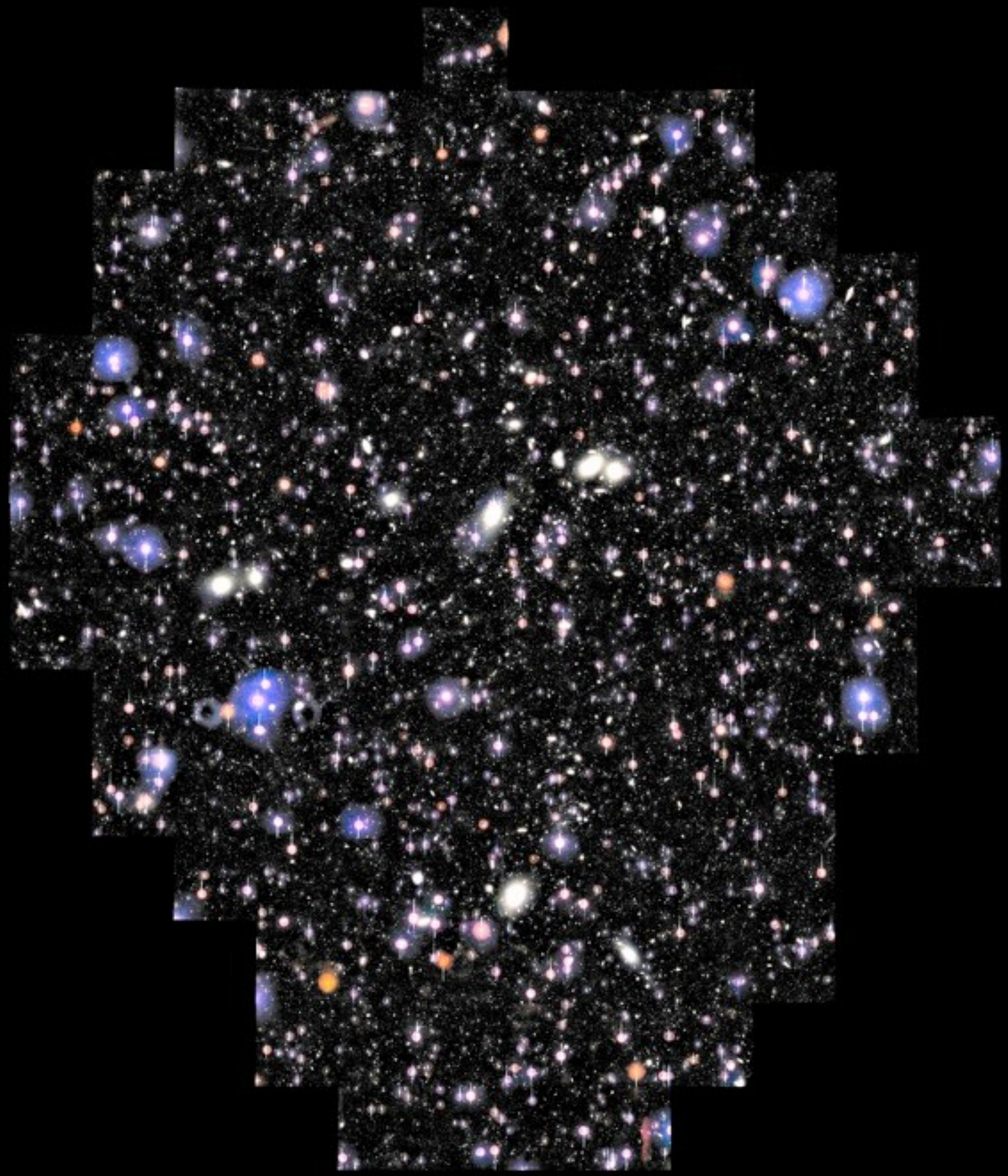
- With Burrell Schmidt telescope, with optimized camera and CCD telescope
- Reaching 29 mag.arcsec-2 on several fields in the Virgo Cluster
- Gain of large field of view cameras
- Aim: detection of intracluster light

Detections of LSB structures with diffuse light



- And the winner is...

© M101 by van Dokkum et al., 2014, and the DragonFly Photo array



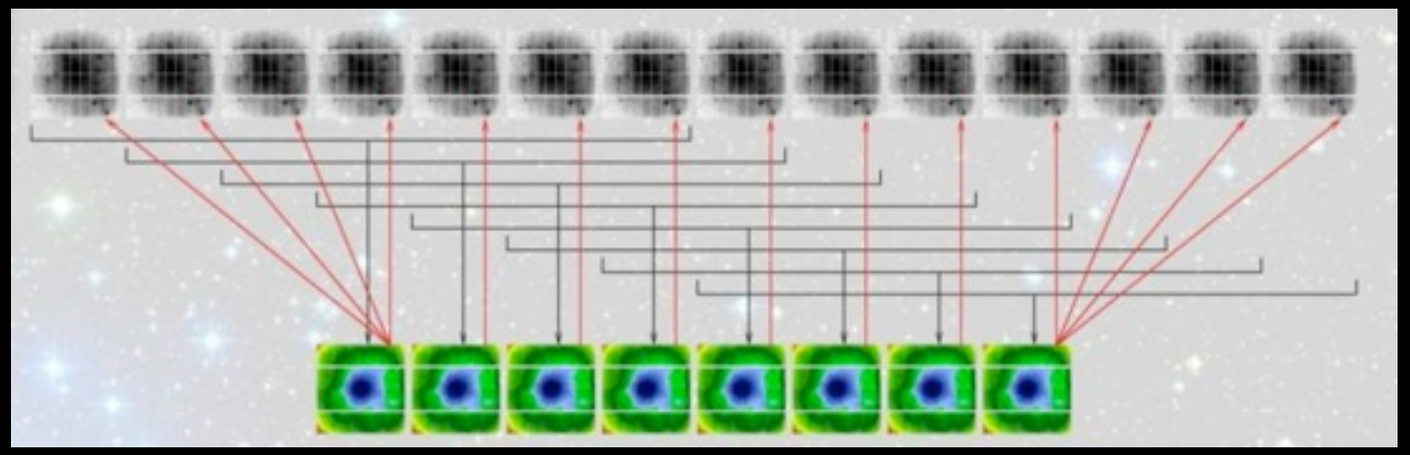
Ferrarese et al, 2012

- 104 square degree
- 4 bands (u,g,i,z + r)

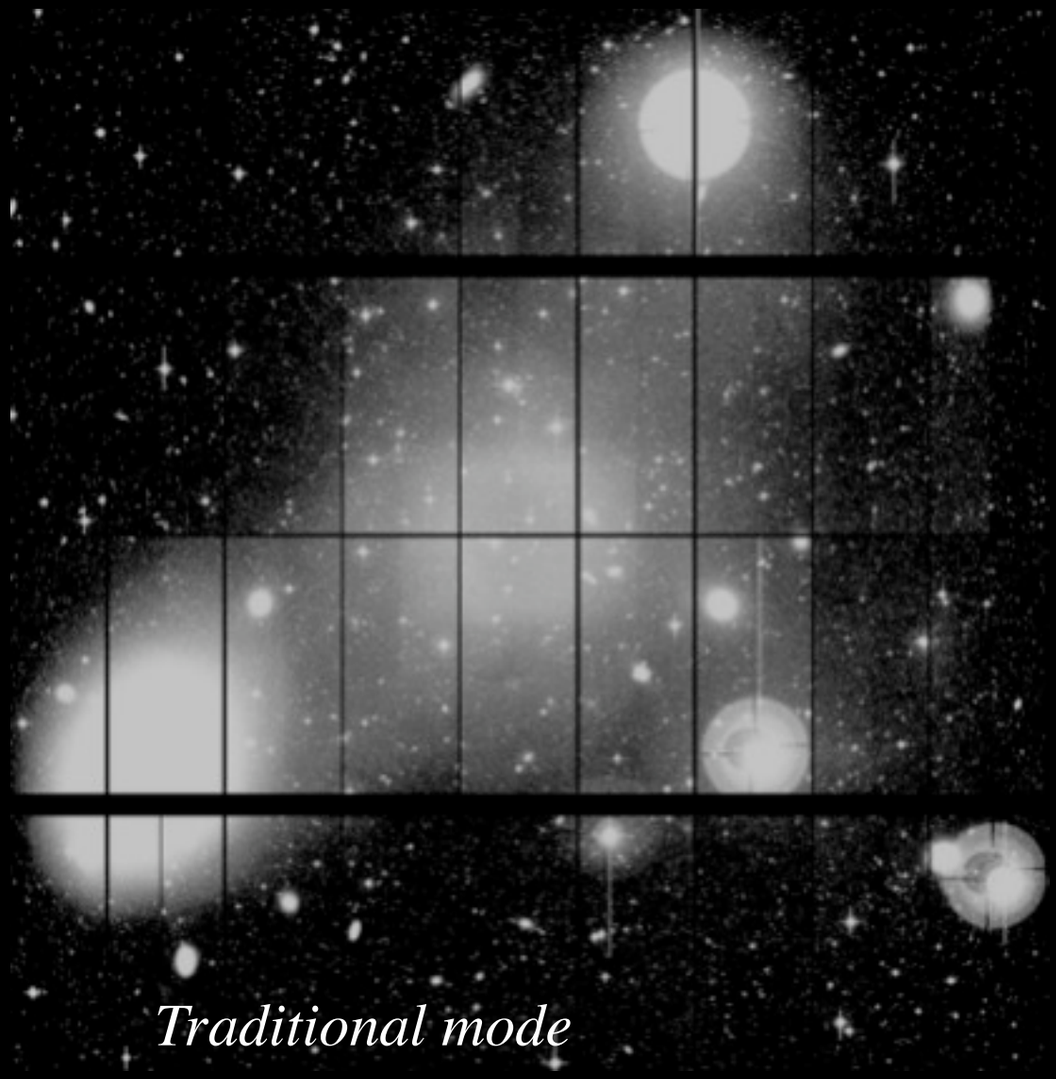
- *g*~25.7 AB mag
- SB (g)< 29 mag/arcsec2
- Image quality: 0.6-0.8”

u=6400 s
g=3200 s
r=1600 s
i=2050 s
z=4400 s

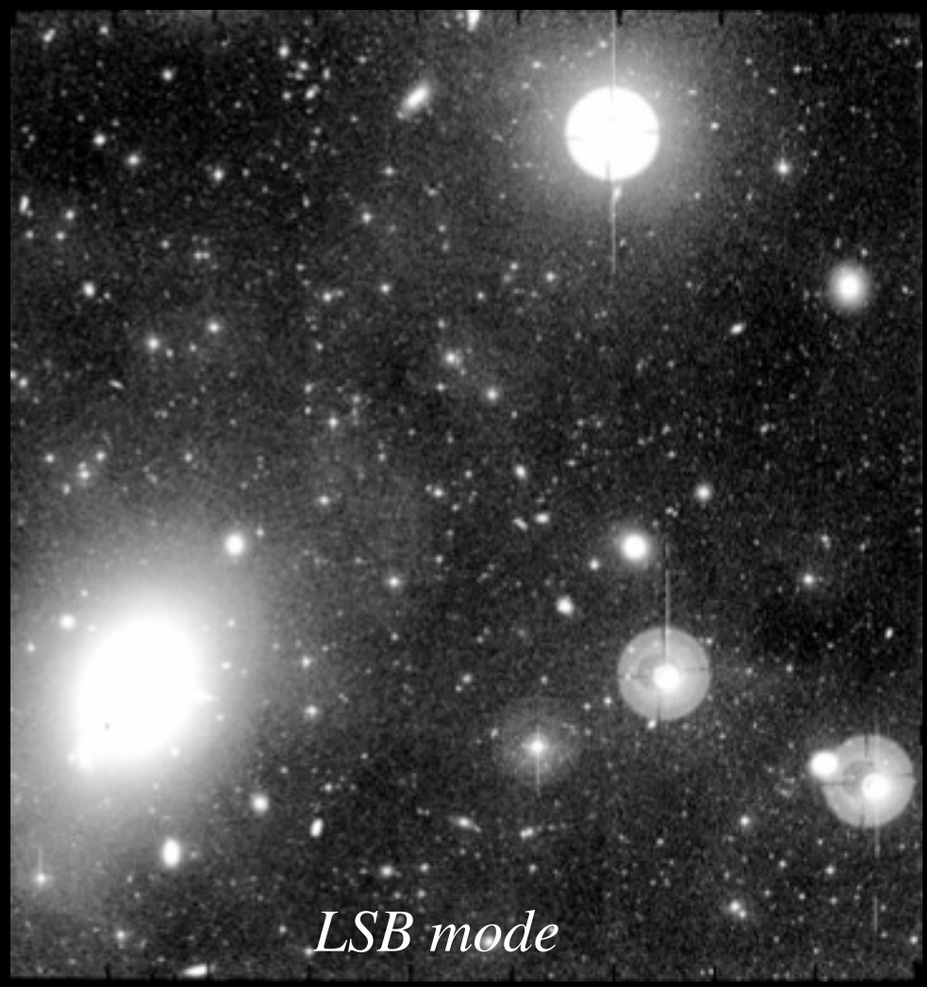
A specific observing strategy



- scattered light removed by an ad-hoc observing strategy and pipeline (Elixir-LSB)



Traditional mode



LSB mode

A volume-limited sample of 260 massive ETGs with D < 42 Mpc

- Observed with the large field of view camera MegaCam, as part of NGVS for the Virgo ETGs, and MATLAS for the other ones
- With specific observing strategy (large offsets, sky subtraction) and data reduction technique (Elixir-LSB) to optimize the detection of low surface brightness features
- Requirements: dark conditions .... but not necessarily a good seeing

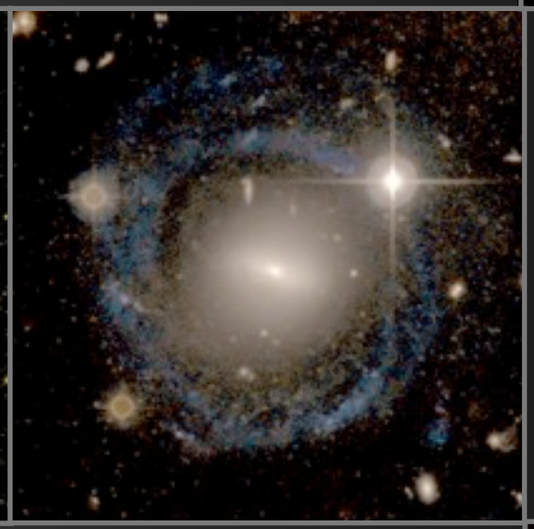
The Hubble diagram as seen with SDSS-like observations

©SDSS

- blue star-forming spirals

- read and dead ellipticals

The Hubble diagram as seen with LSB mode of MegaCam



- spirals with a red halo

- ellipticals with star-forming disks

©SDSS

Massive galaxies as seen with the SDSS

Relaxed, with only weak signs of tidal perturbations

©Duc/MATLAS/NGVS

Massive galaxies as seen with LSB mode of MegaCam

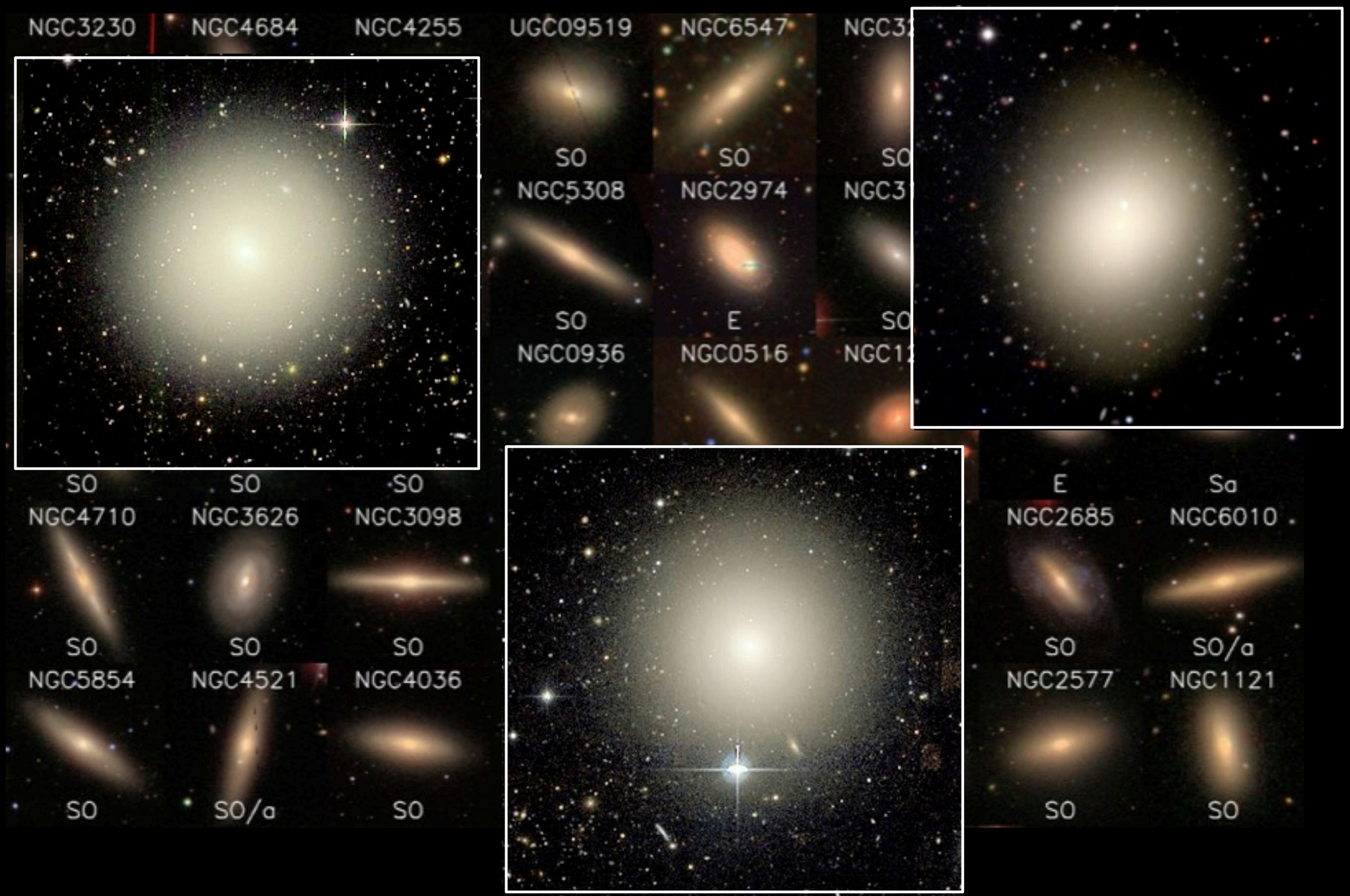
http://irfu.cea.fr/Projets/matlas

Paudel et al., 2013

Duc et al., 2011

Same galaxies show a (recent) complex mass accretion history

Fully relaxed, unperturbed, boring ETGs, even at MegaCam depth



• Not all massive ETGs/ spirals show tidal features (contrary to simulations?)

Assembled earlier? In different environments? By different processes?

• Need for a statistical analysis over a large number of galaxies

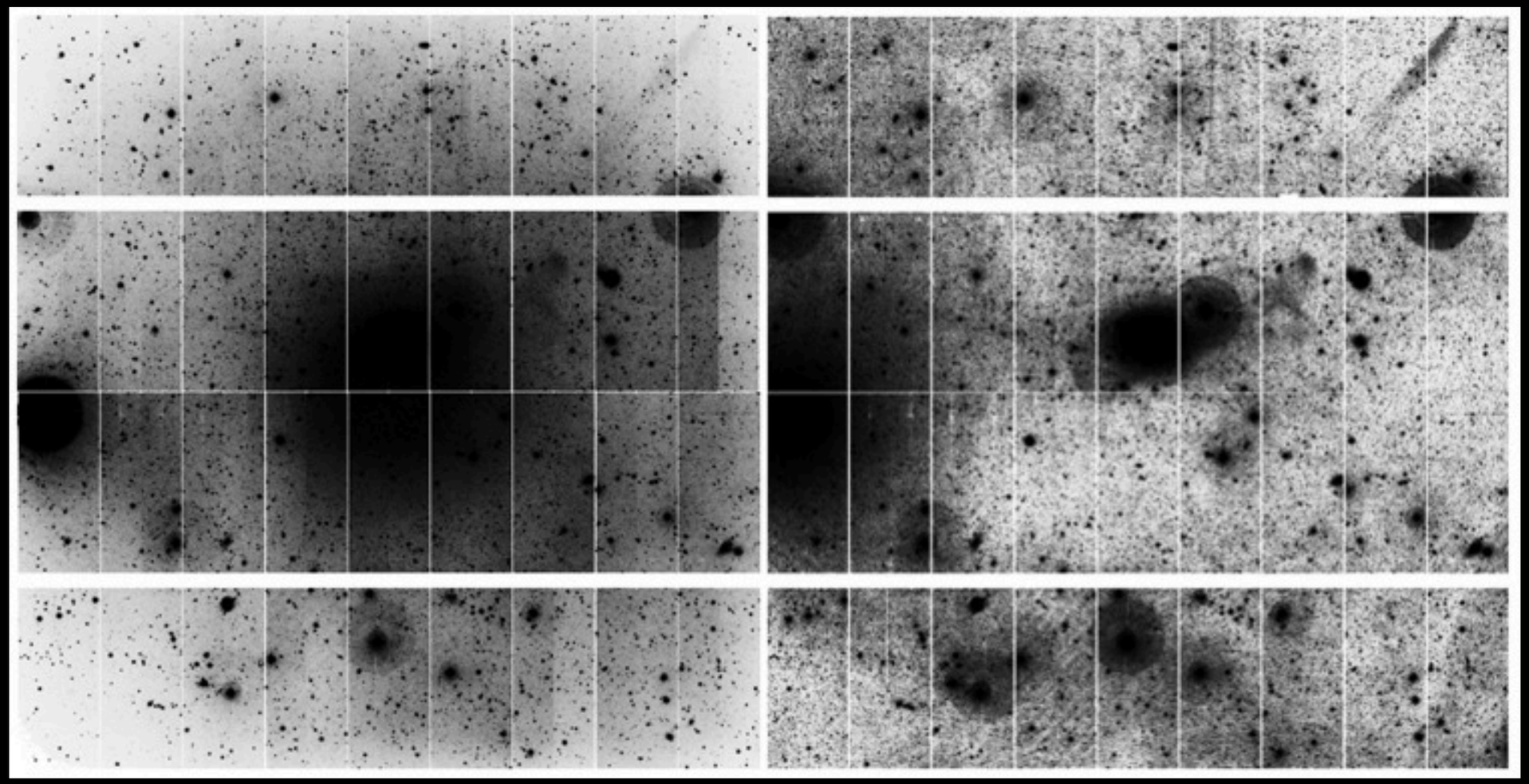
• Could be the aim of a large survey like NSLS

- Is the observing survey strategy ad hoc for LSB science?

YES !

Contrary to CFHTLS and its dithering strategy optimized for distant galaxies, the NSLS will adopt a NGVS-type strategy with large offsets, allowing the removal of the sky background

- Is the exposure time long enough to detect LSB features?



Individual (background subtracted) image NGC 5557: 300 sec in g
28 mag/arcsec^2 features detected

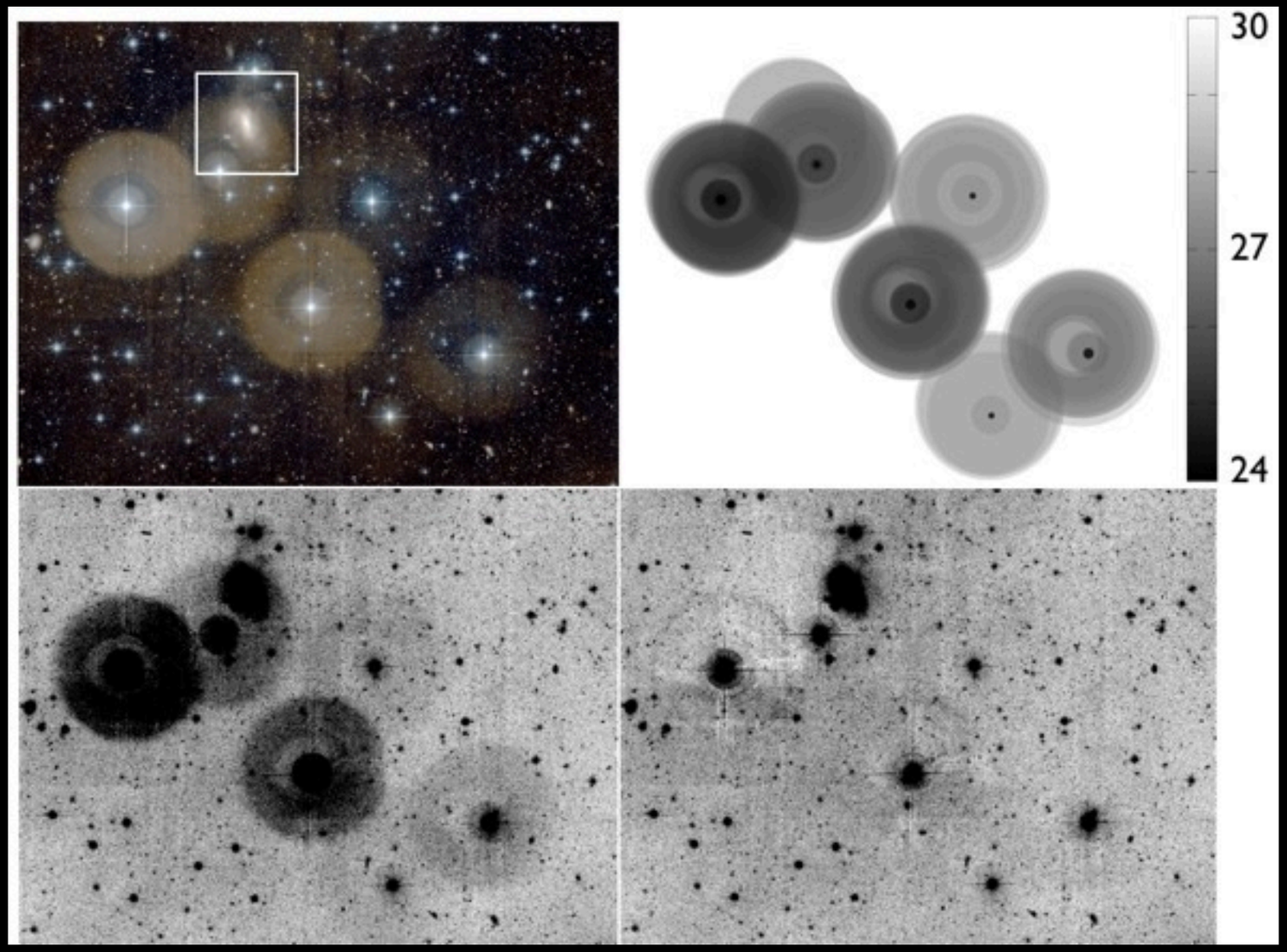
Likely !

When 3 passages are done

NSLS: 3x120 s

The limiting surface brightness not only set by photon noise statistics, but by background variations

- What will be the limitations of the LSB science?



The large reflection halos of MegaCam

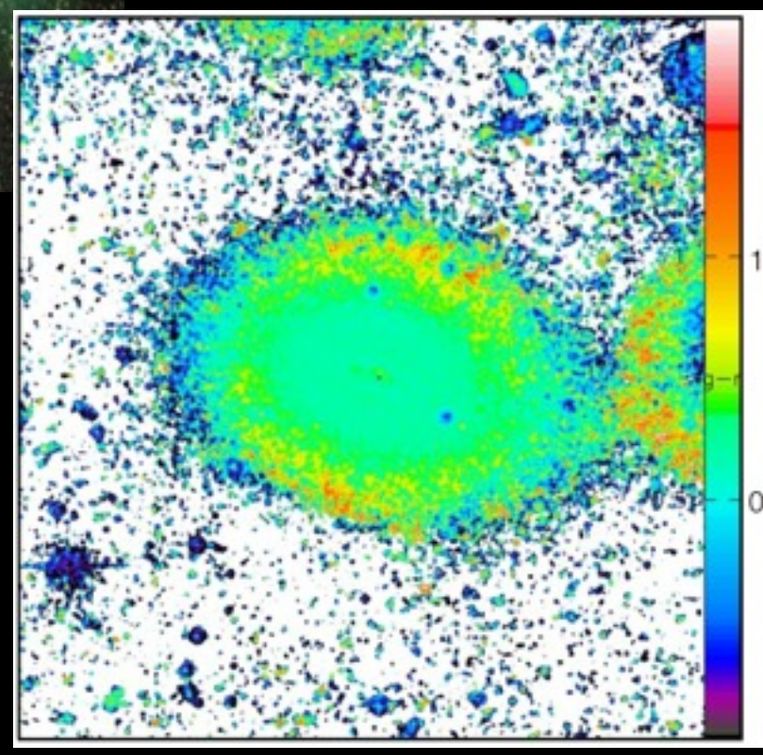
Will not be removed (camera unchanged)

Extended halos around bright stars in MATLAS

Hope: automatic modeling of internal reflections (N. Regnault in prep.)

- What will be the limitations of the LSB science?

The large reflection halos of MegaCam



Halos generated by the bright nucleus of each galaxy

Hope: subtraction of this halo will allow the study of stellar populations
at large radii (beyond 5 Re)

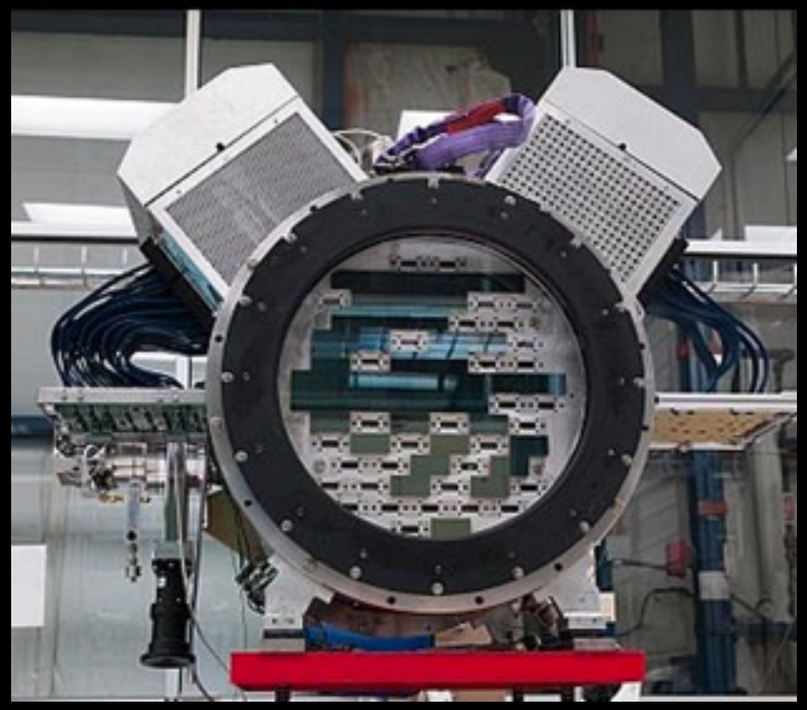
- What will be the limitations of the LSB science?

The scattered optical emission of Galactic cirrus

Planck (857 GHz) *MegaCam, g+r* *MegaCam, g SB map*

The Bad: emission shows up above 26 mag/arcsec^2. A significant fraction of the images contaminated
The good: allows a study of the dust distribution in the Galaxy at unprecedented spatial resolution (300 times better than Planck!)

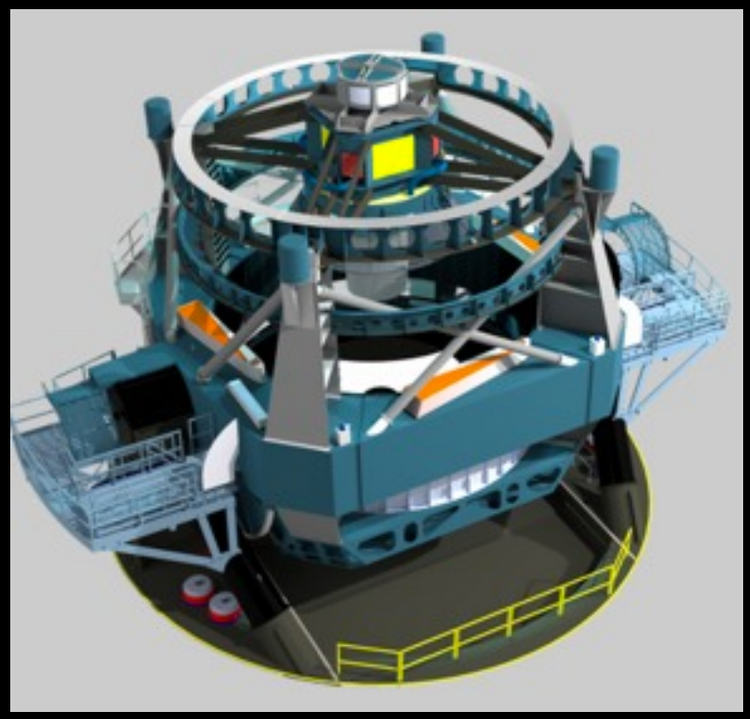
- What is the competition?



LSST
(southern
hemisphere)

Surveys with LSB-compatible observing strategy

DES
(southern
hemisphere)



=> None in the northern hemisphere

The LSB universe with the NSLS