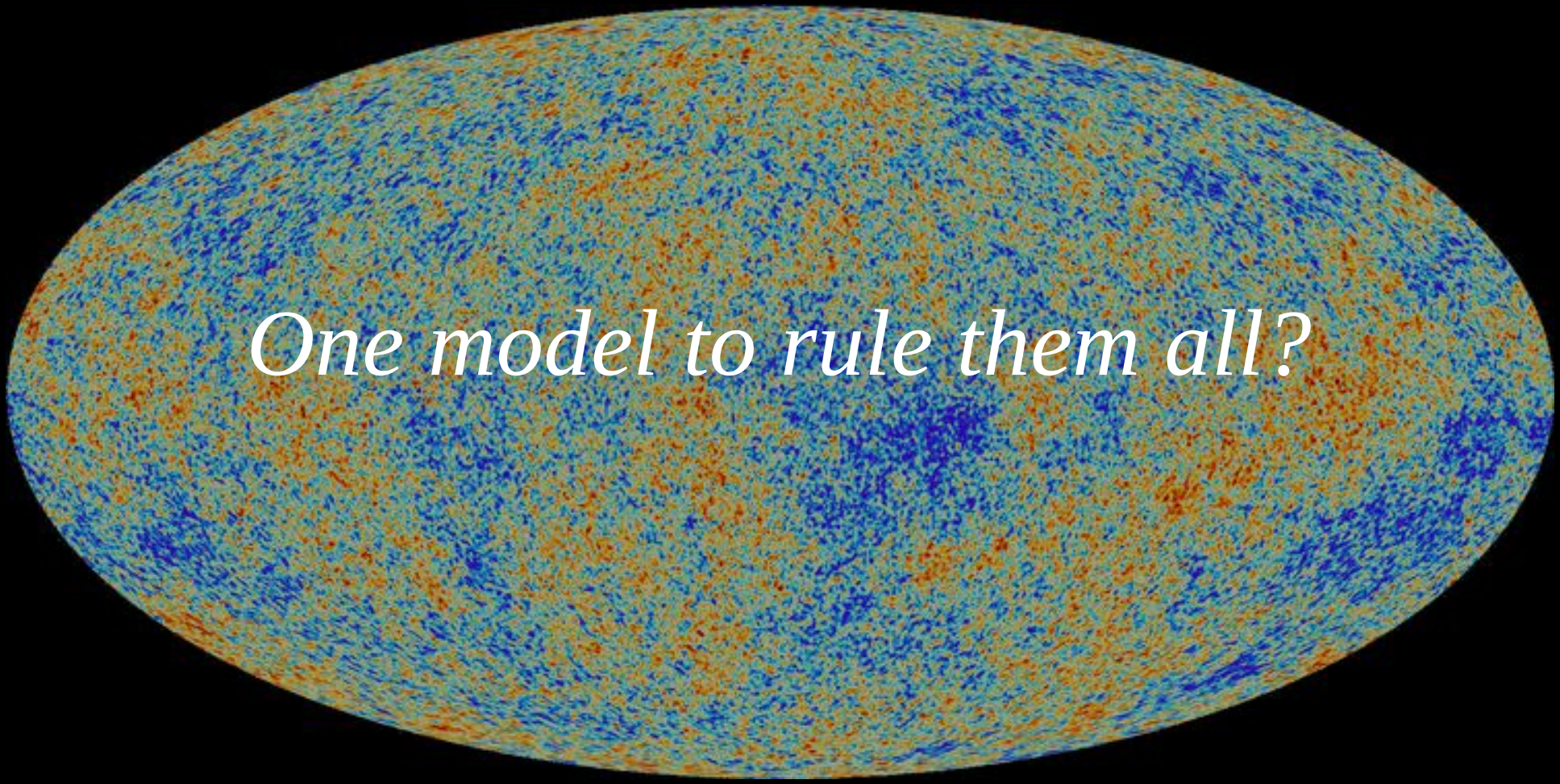
Near-field Cosmology with HSC and PFS

Masayuki Tanaka (NAOJ)


One model to rule them all?

LCDM has a few possible flaws on small scales

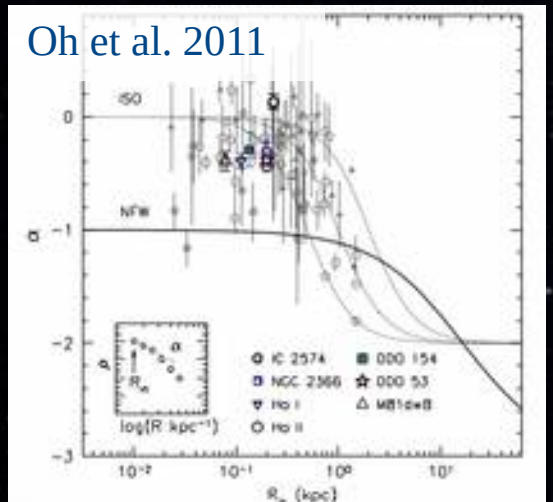
Cusp-Core problem :
the dark matter density profile of LCDM subhalos is too steep

Missing satellite problem:
there are too many LCDM subhalos

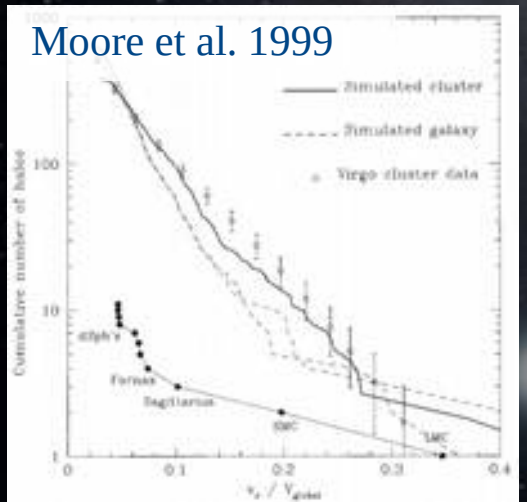
Too-big-to-fail problem:
the most massive subhalos are too concentrated

Satellite-plane problem:
anisotropic distribution and coherent motion of dwarf galaxies around MW + M31 are hard to reproduce

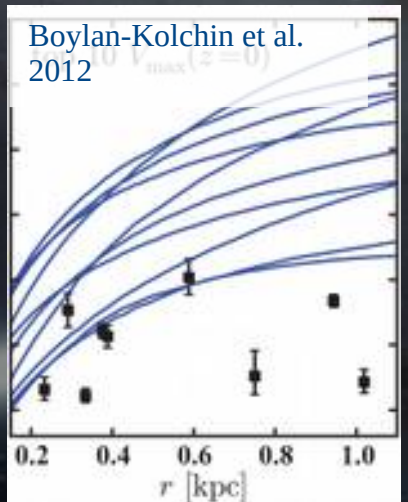
Oh et al. 2011



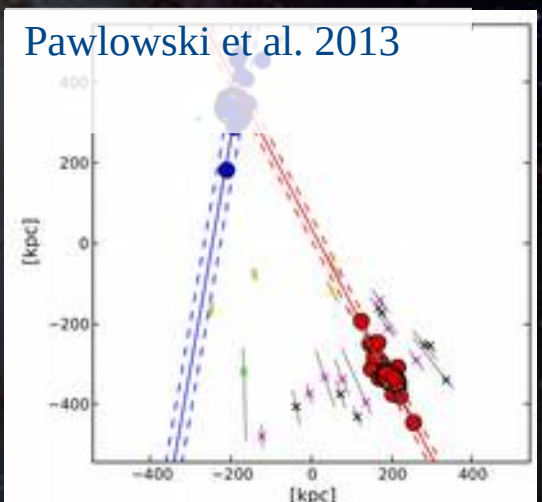
Moore et al. 1999



Boylan-Kolchin et al. 2012

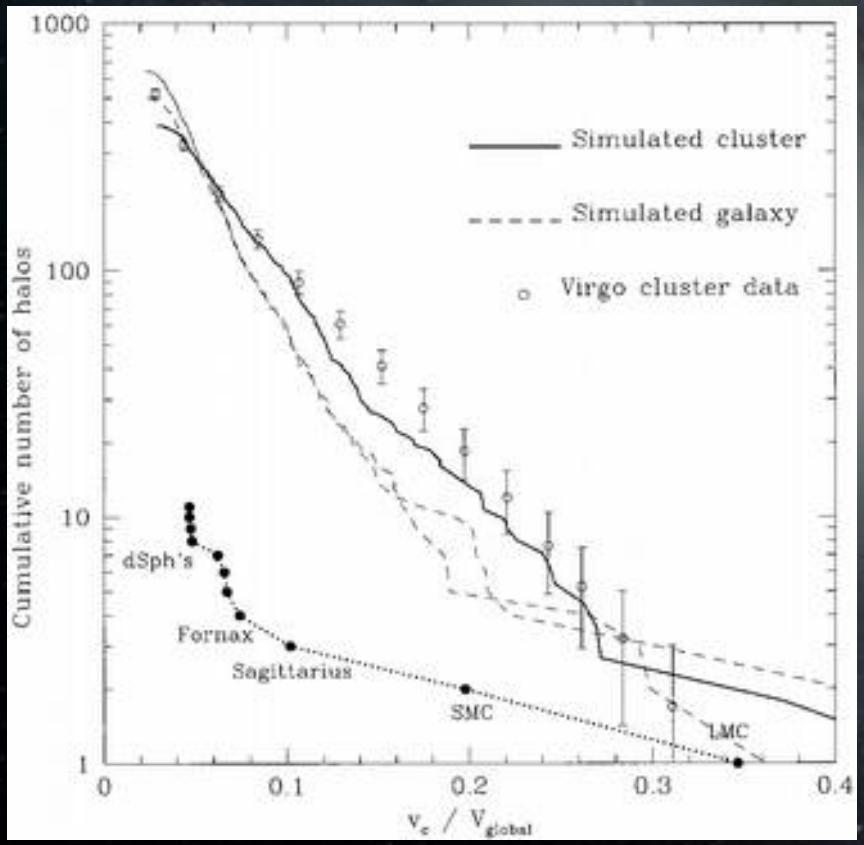


Pawlowski et al. 2013

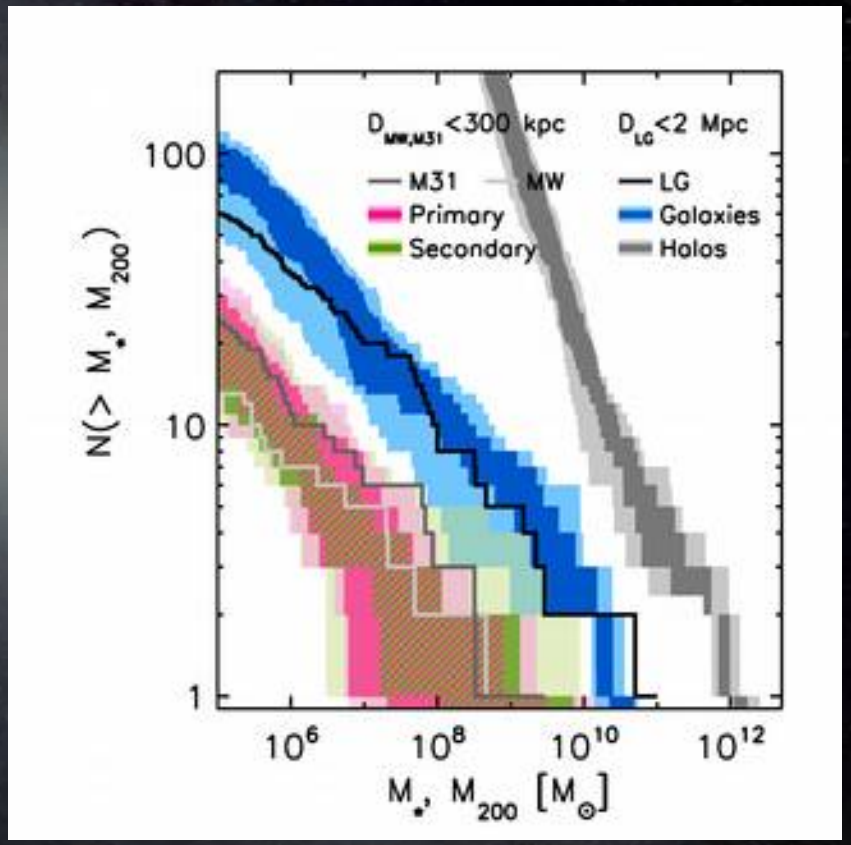


The missing satellite problem

Baryon physics may be a possible solution, but...



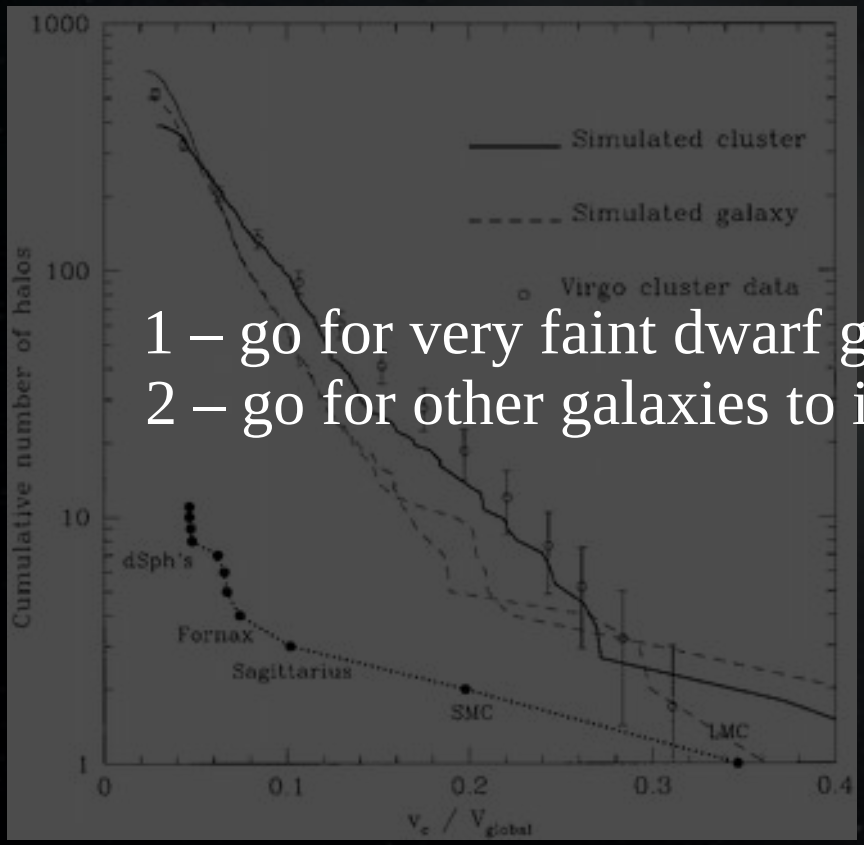
Moore et al. 1999
DM only simulation

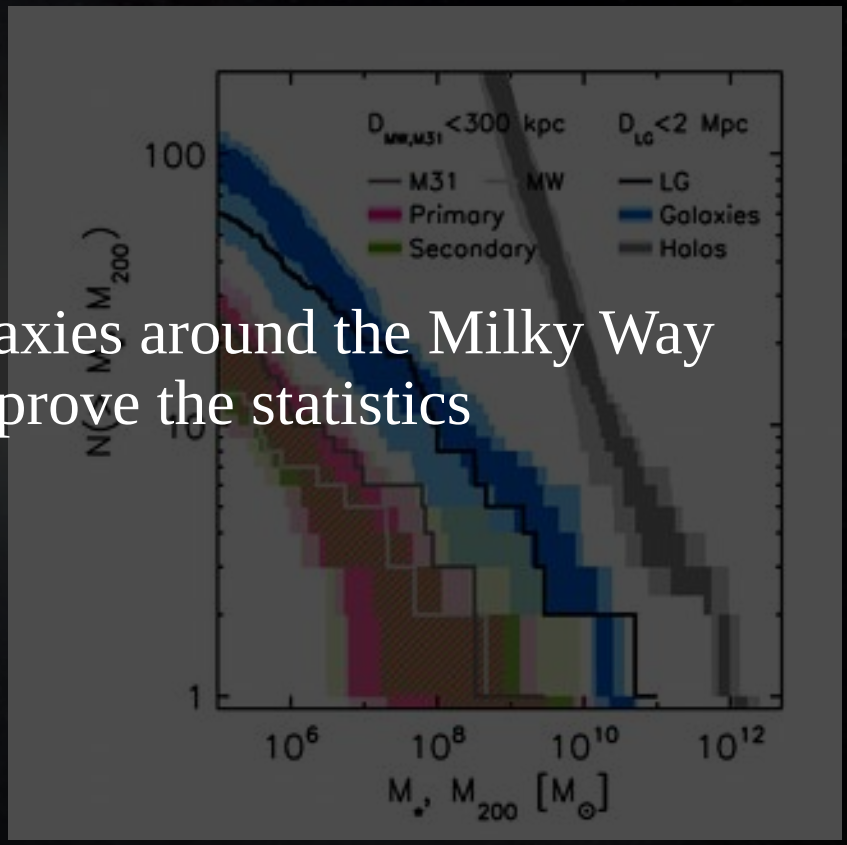


Sawala et al. 2014
DM + Baryon simulation

The missing satellite problem

Baryon physics may be a possible solution, but...





1 – go for very faint dwarf galaxies around the Milky Way
2 – go for other galaxies to improve the statistics

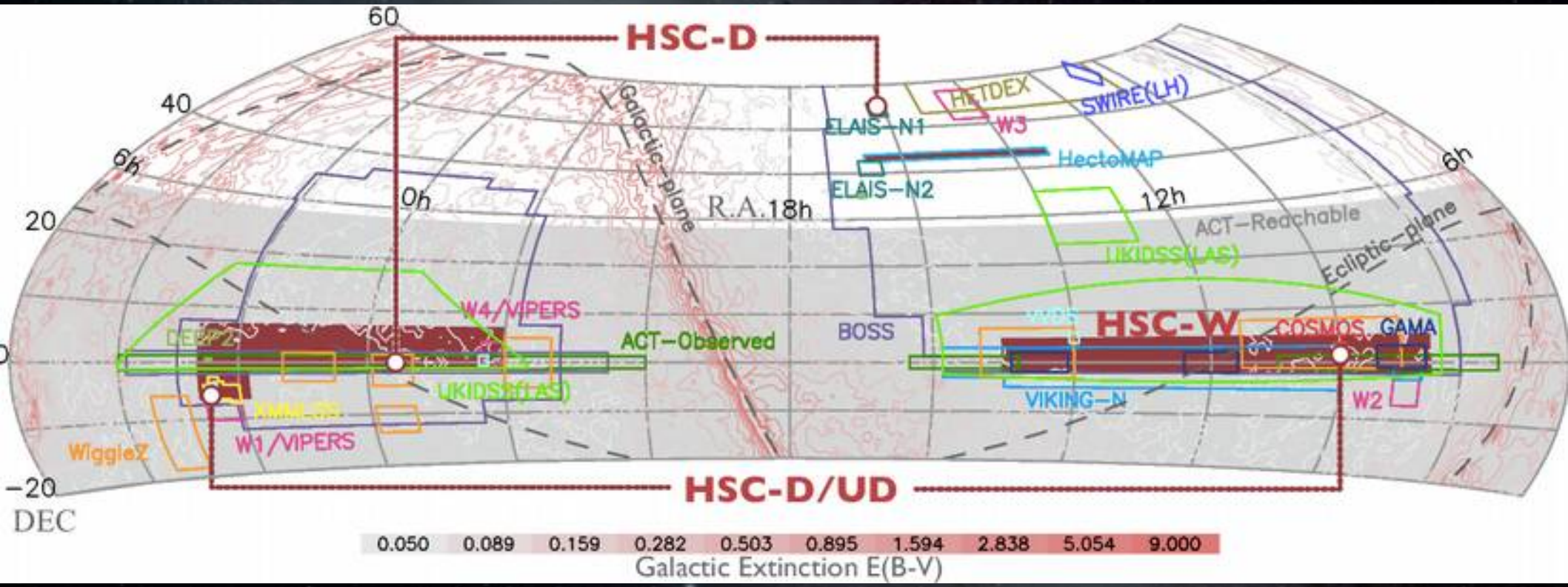
Moore et al. 1999
DM only simulation

Sawala et al. 2014
DM + Baryon simulation

Approach #1

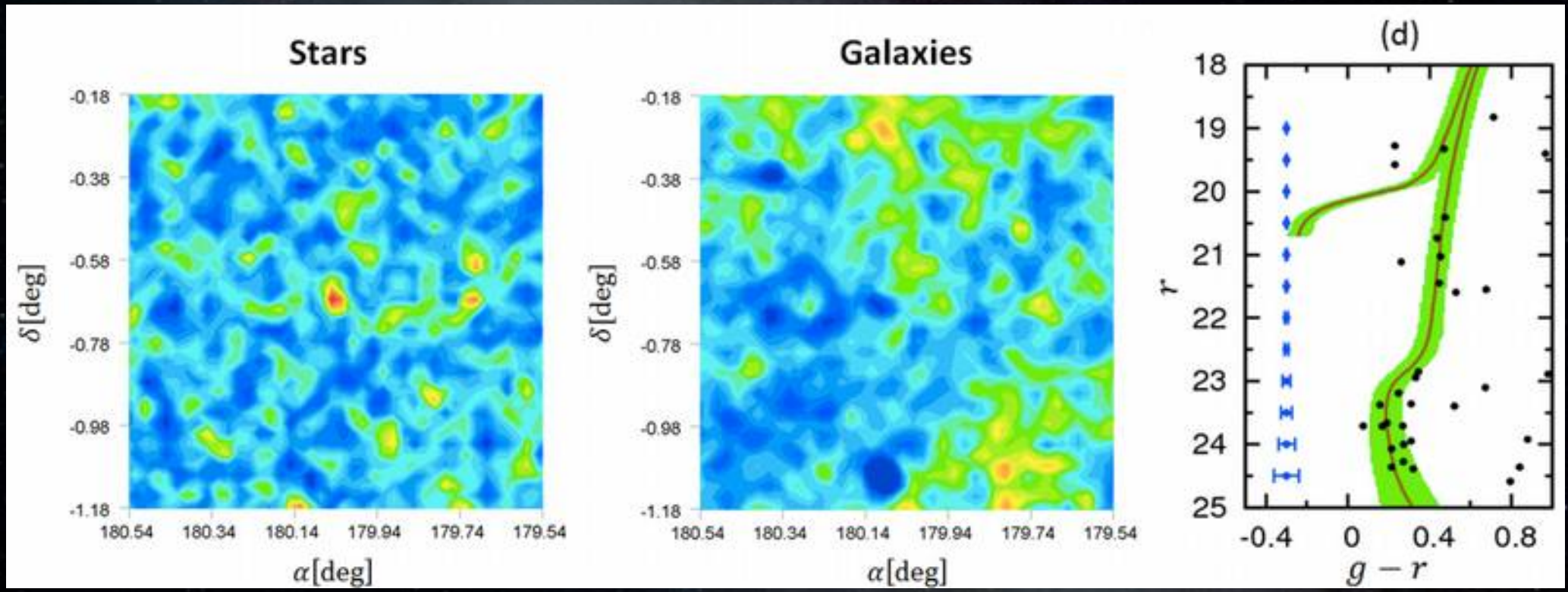
A search for ultra-faint dwarf galaxies around the MW

On-going Subaru Strategic Program with Hyper Suprime-Cam (300 nights)



We aim to cover ~1400sqdeg in 5 filters down to i~26mag.
This is much deeper compared to DES and PanSTARRS.

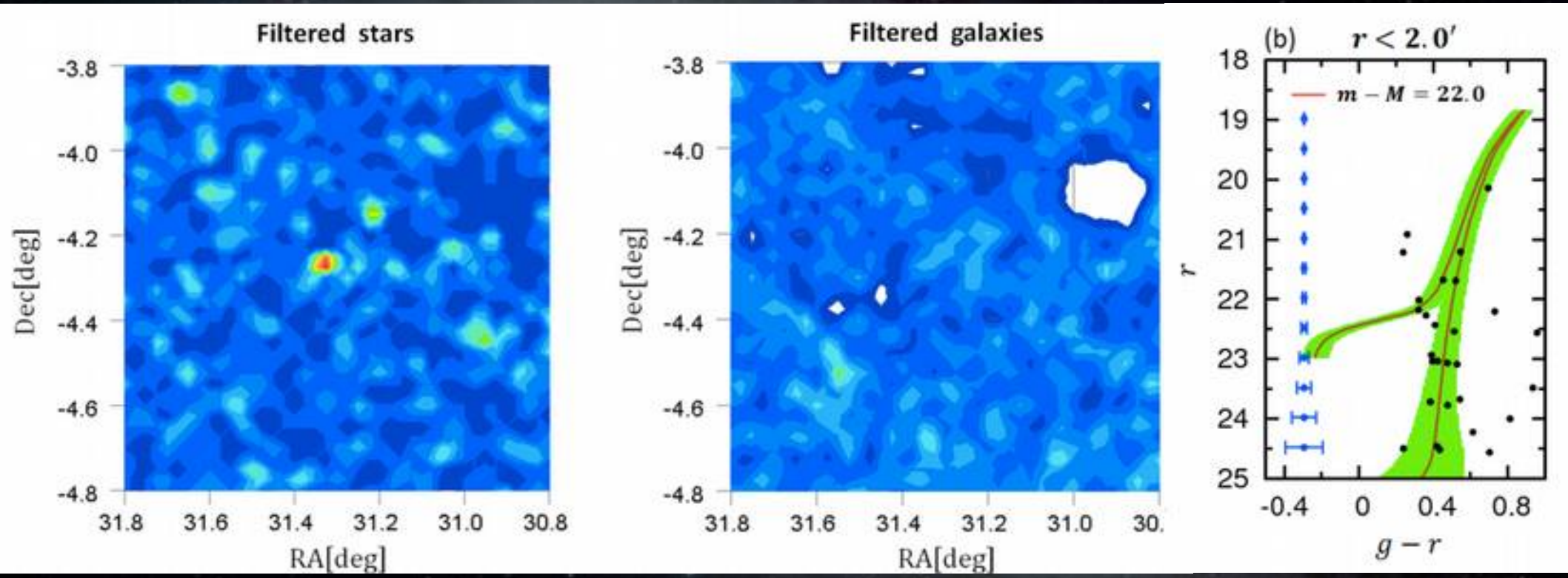
Virgo I



This is a very faint dwarf galaxy located at 90kpc with Mv=-0.3mag

Homma et al. 2016 ApJ

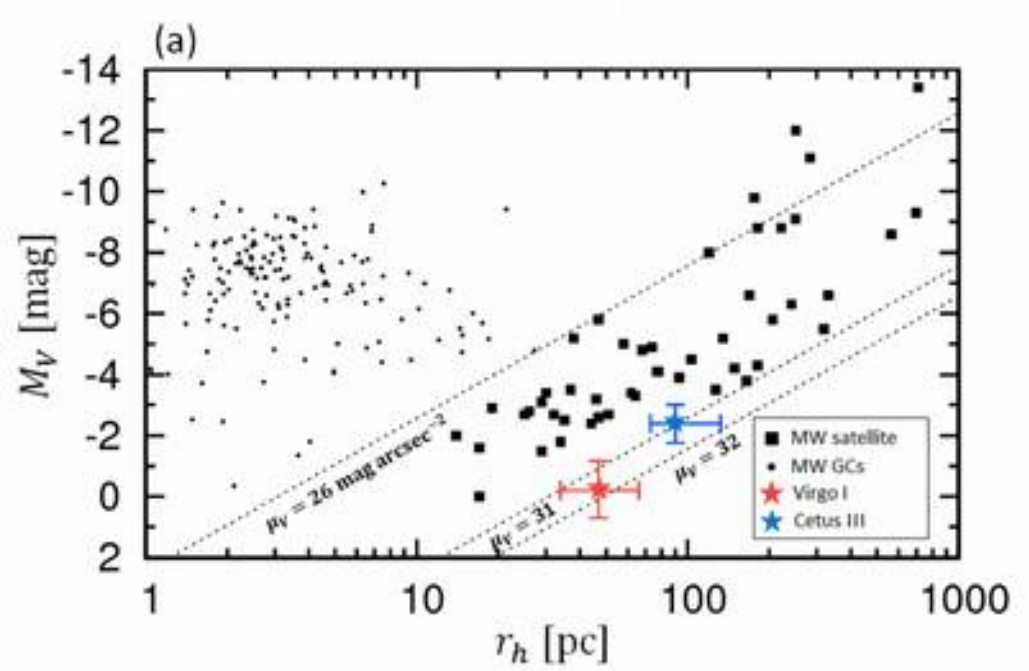
Cetus III

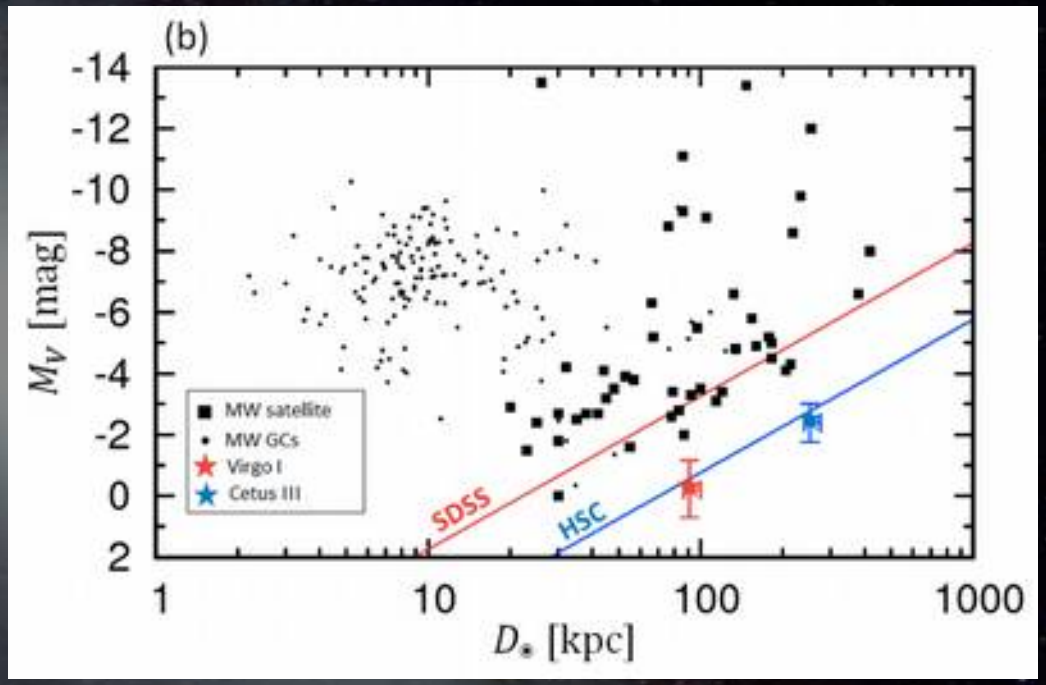


Another one located on the edge of the MW halo at 250kpc.

Homma et al. 2018 ApJ

Virgo I + Cetus III

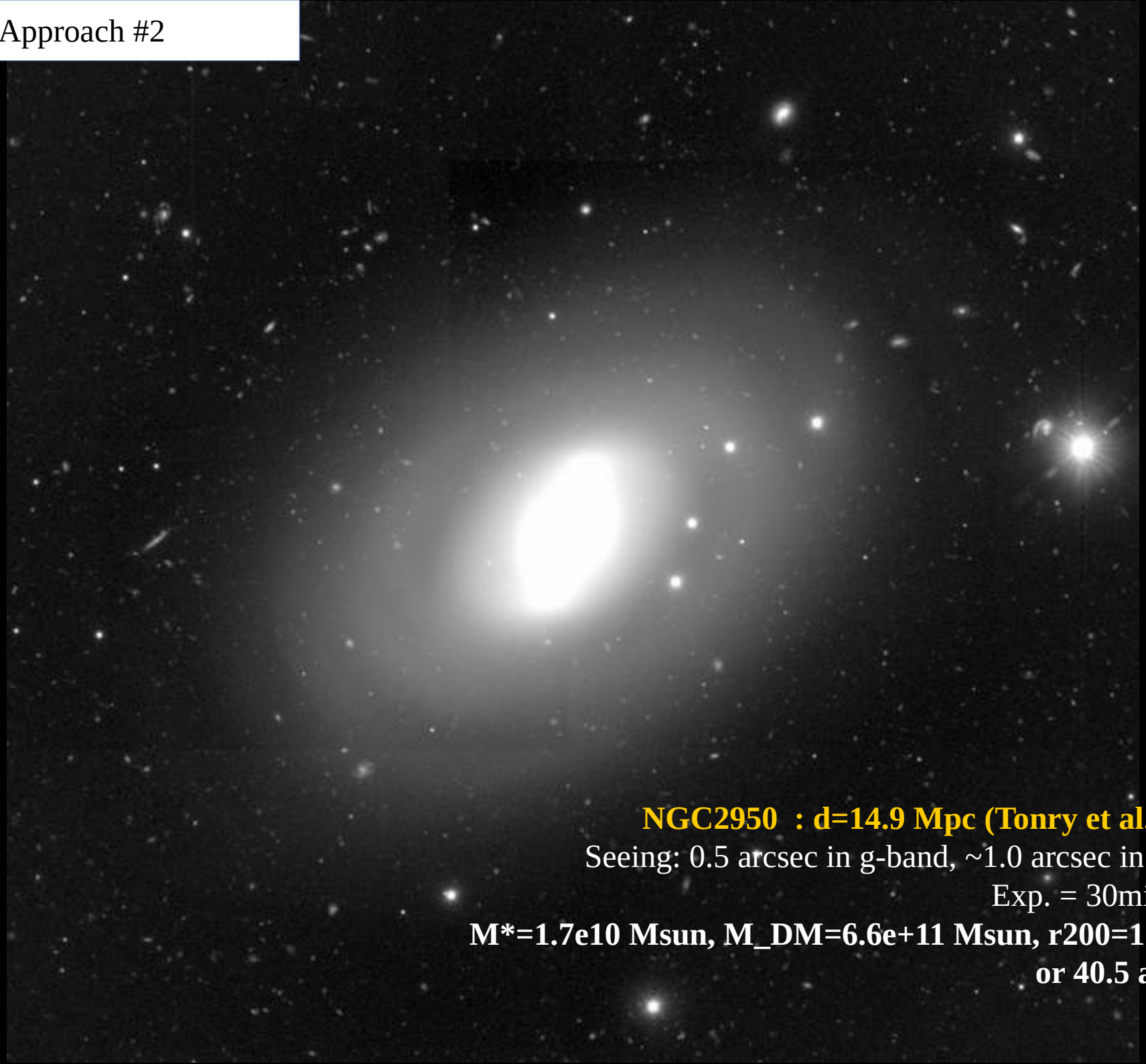




HSC indeed discovers dwarf galaxies beyond the reach of the SDSS.

Homma et al. 2018 ApJ

Approach #2



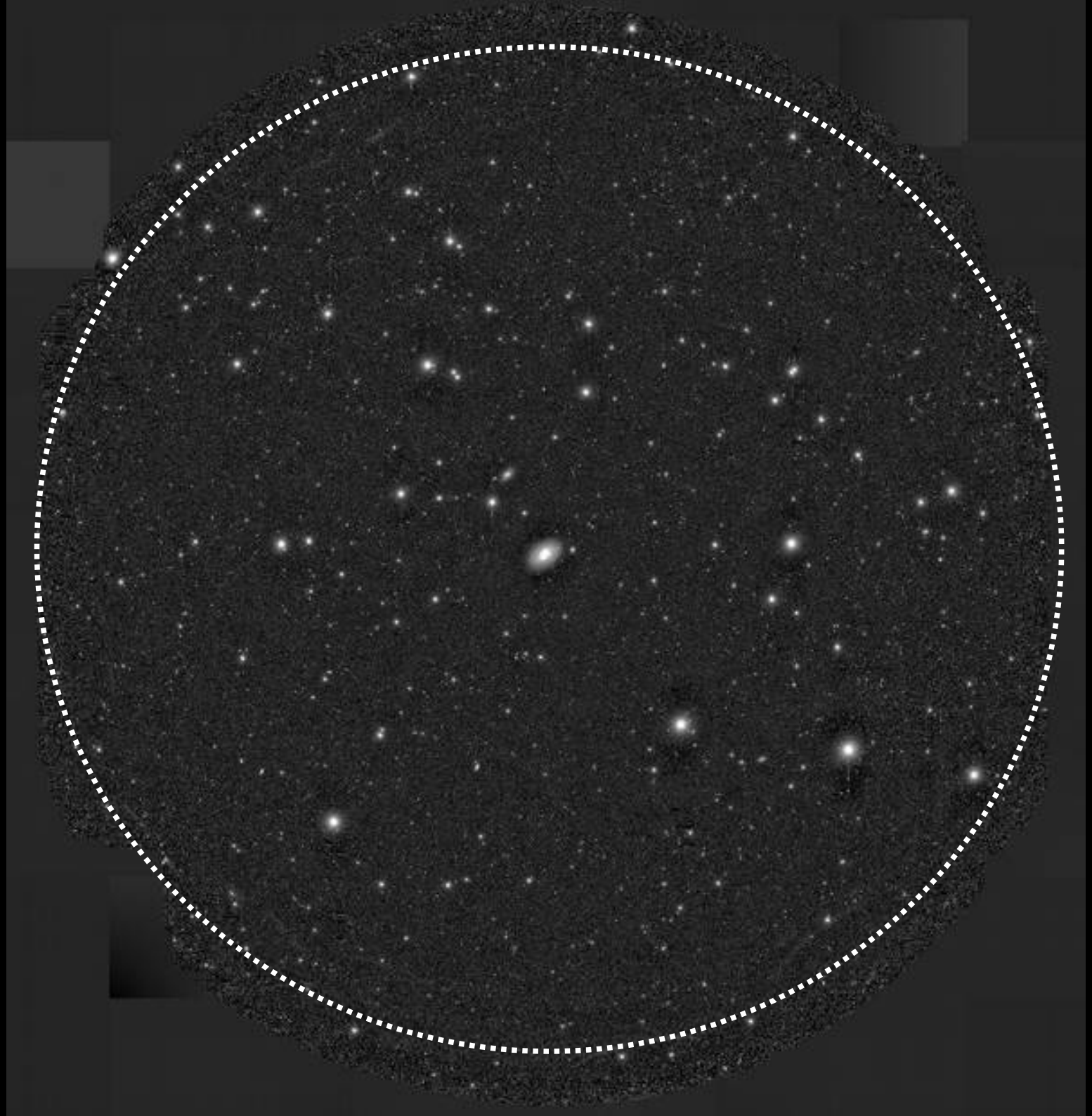
NGC2950 : d=14.9 Mpc (Tonry et al. 2001)

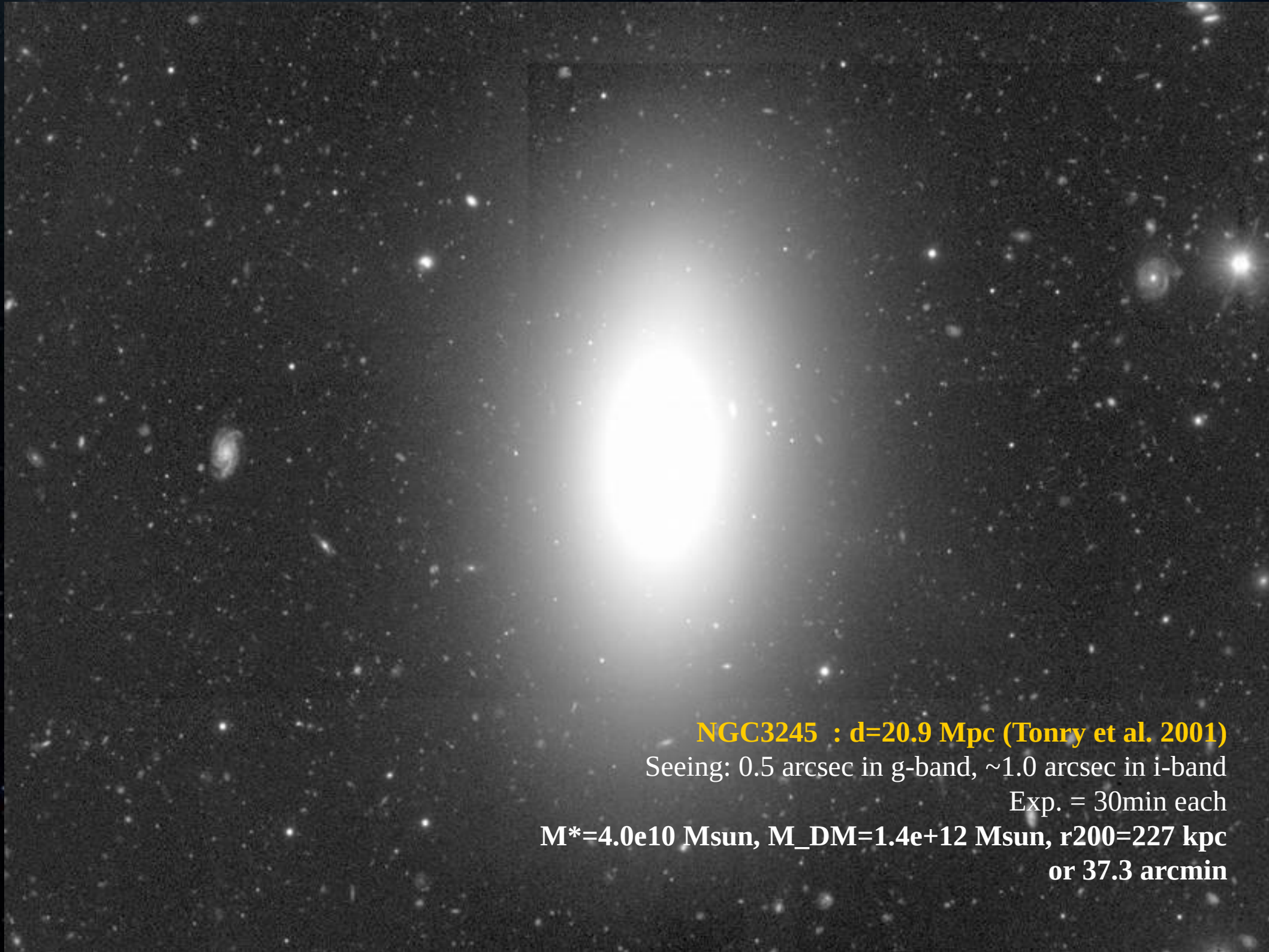
Seeing: 0.5 arcsec in g-band, ~1.0 arcsec in i-band

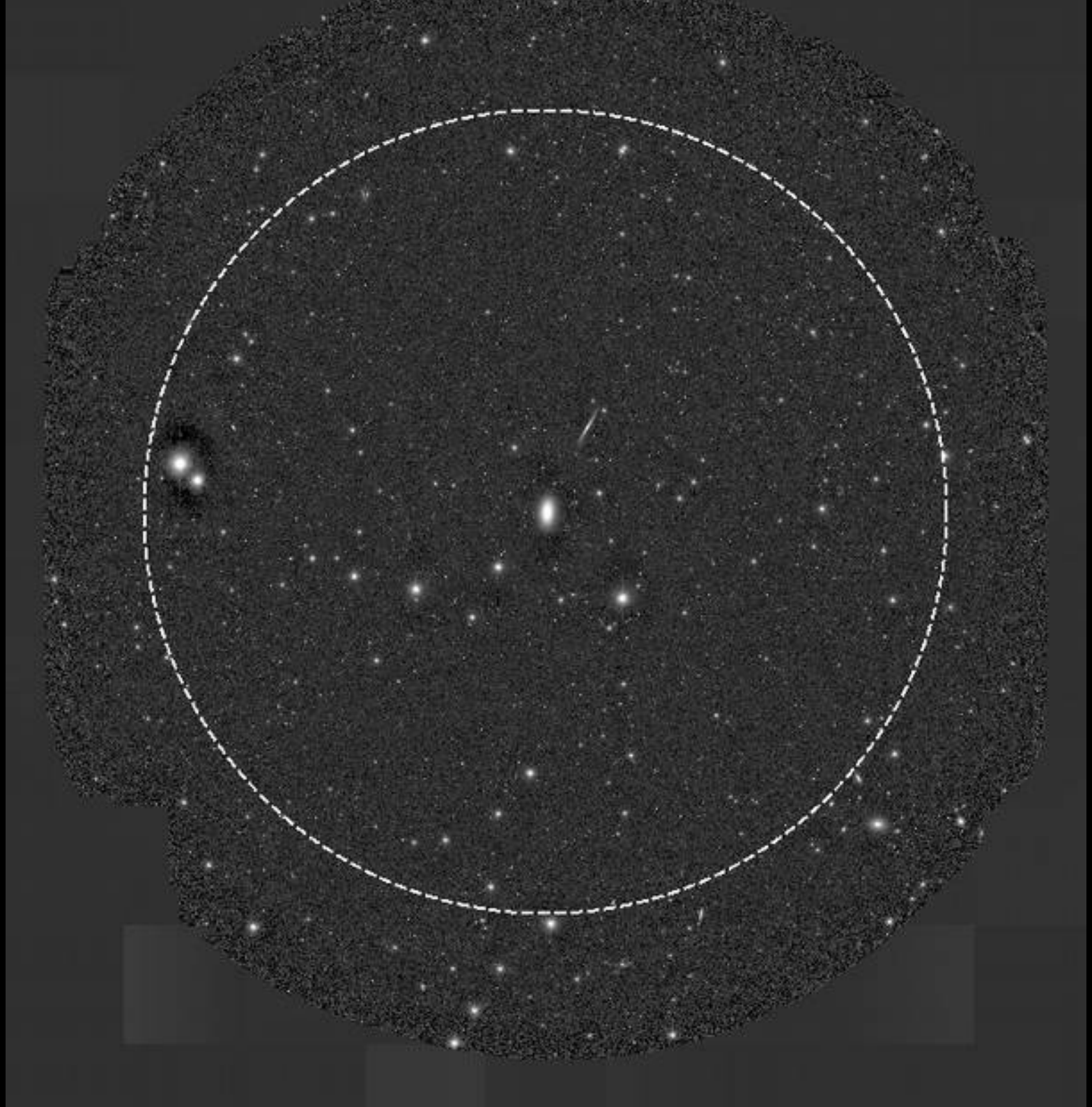
Exp. = 30min each

M*=1.7e10 Msun, M_DM=6.6e+11 Msun, r200=176 kpc

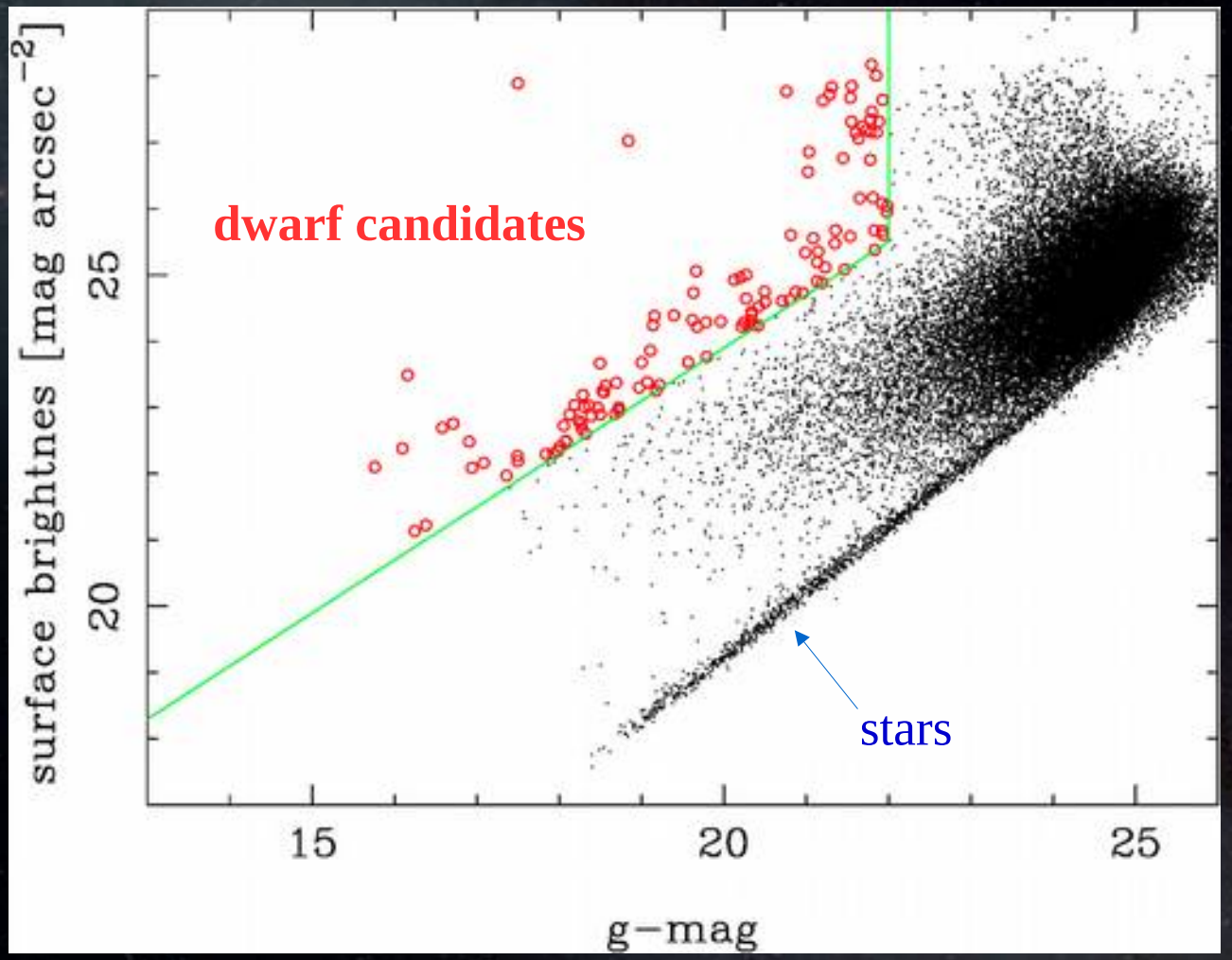
or 40.5 arcmin



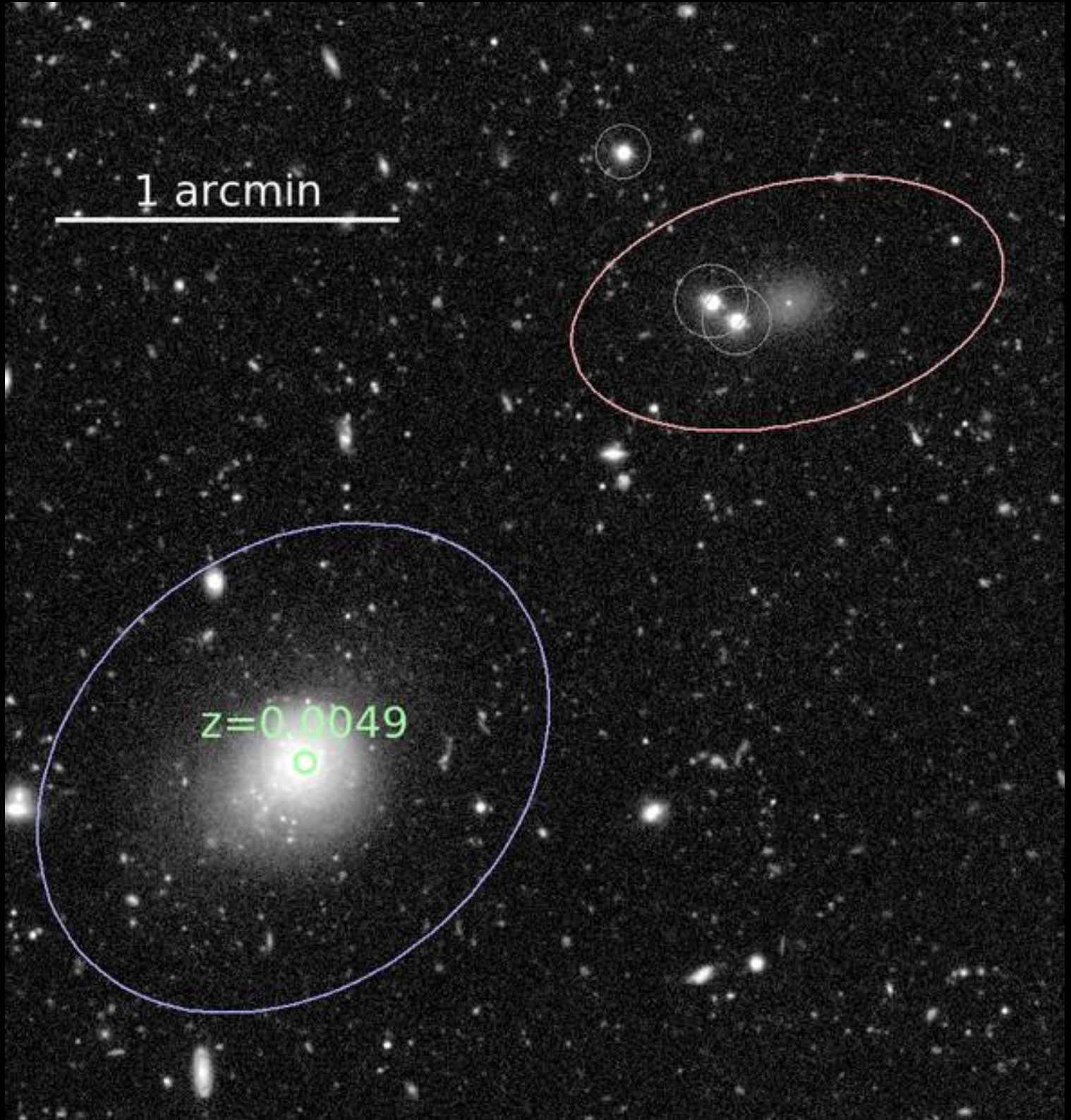

NGC3245 : d=20.9 Mpc (Tonry et al. 2001)
Seeing: 0.5 arcsec in g-band, ~1.0 arcsec in i-band
Exp. = 30min each
M*=4.0e10 Msun, M_DM=1.4e+12 Msun, r200=227 kpc
or 37.3 arcmin



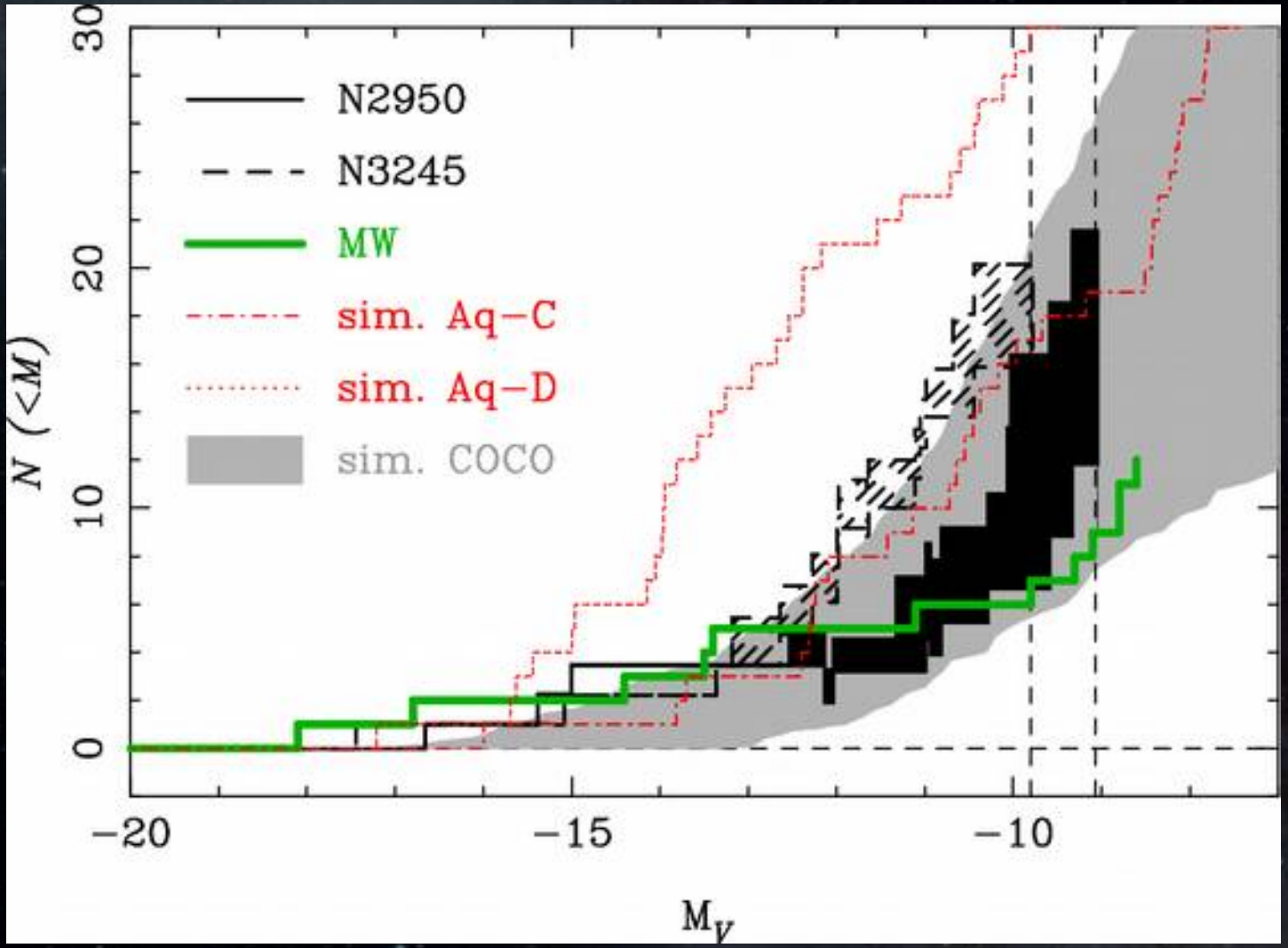
Dwarf galaxy selection



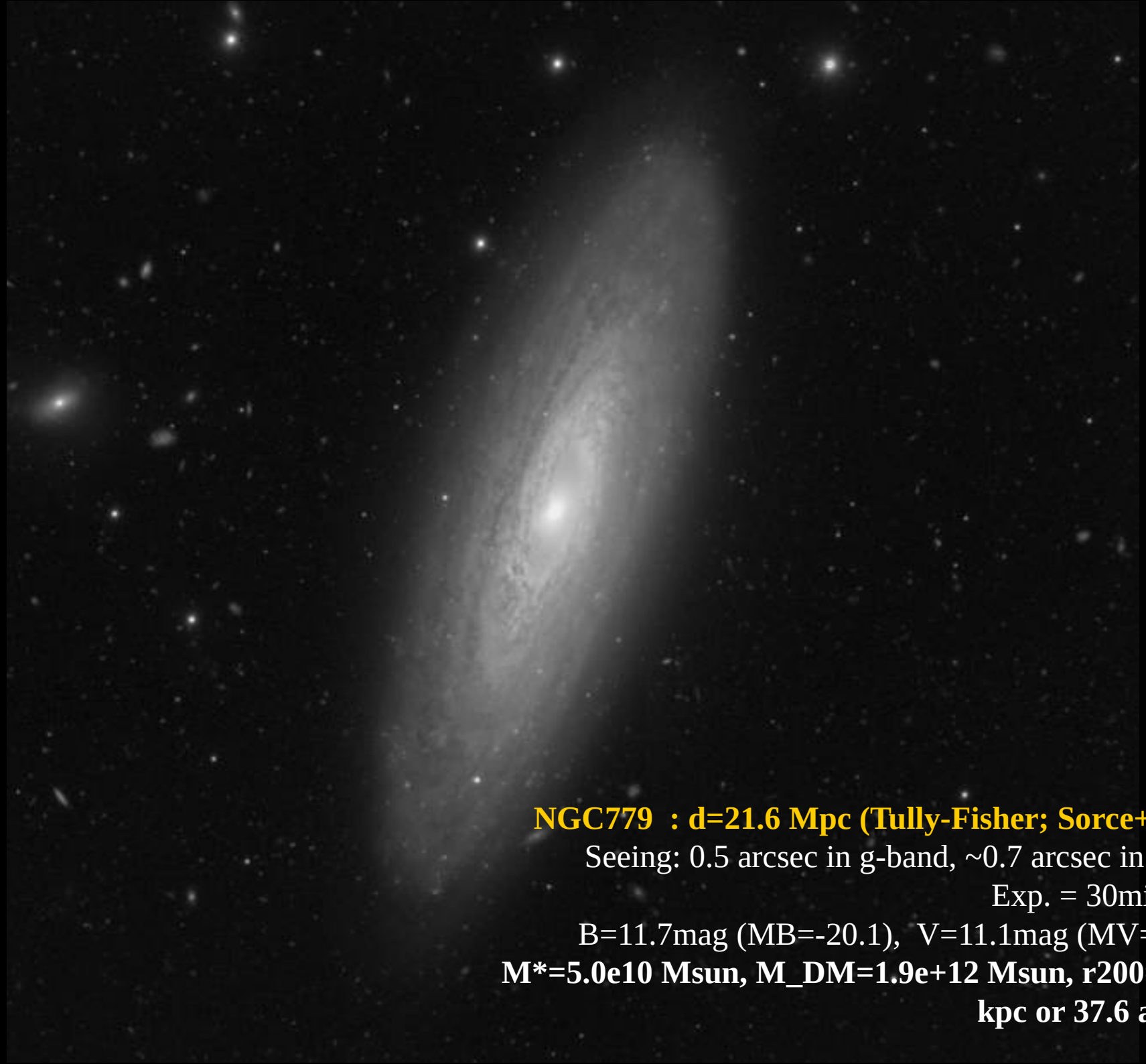
Dwarf candidates (~100 objects per HSC field of view) are visually inspected and junks and other artifacts are removed.


1 arcmin
z=0.0049

Cumulative luminosity function

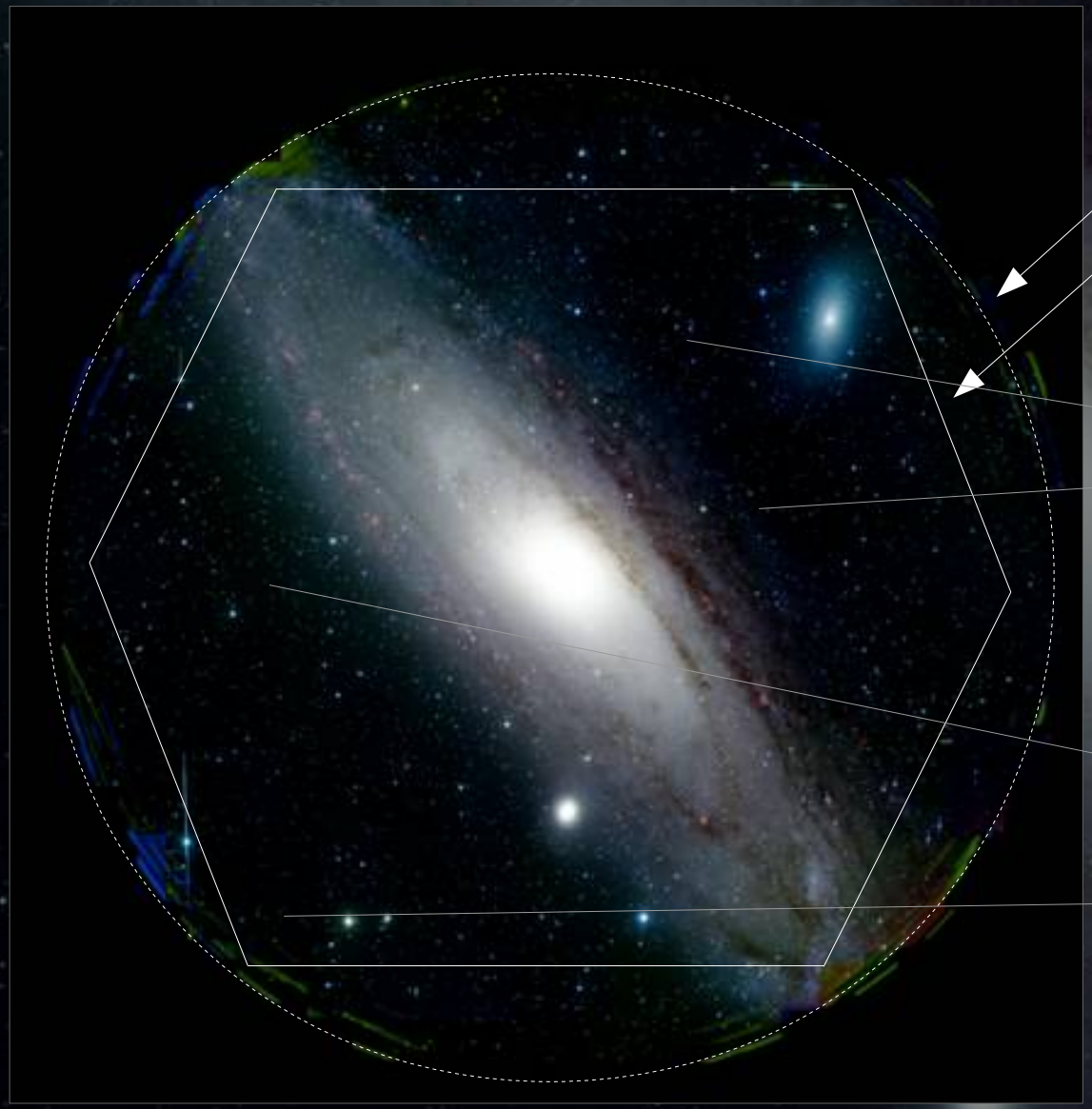


Simulations are from Okamoto (2013, MNRAS, 428, 718) and SAM on Copernicus Complexio (COCO).

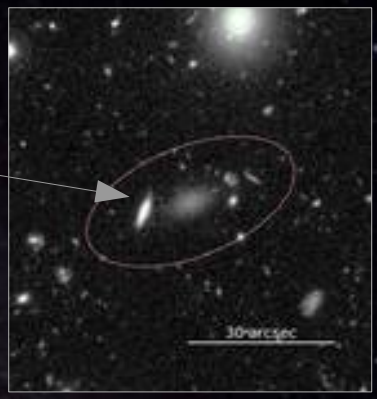


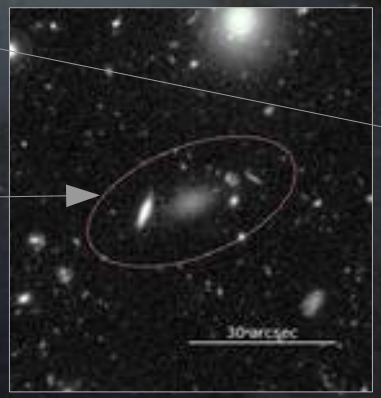
NGC779 : d=21.6 Mpc (Tully-Fisher; Sorce+ 2014)
Seeing: 0.5 arcsec in g-band, ~0.7 arcsec in i-band
Exp. = 30min each
B=11.7mag (MB=-20.1), V=11.1mag (MV=-20.7)
M*=5.0e10 Msun, M_DM=1.9e+12 Msun, r200=248.6 kpc or 37.6 arcmin

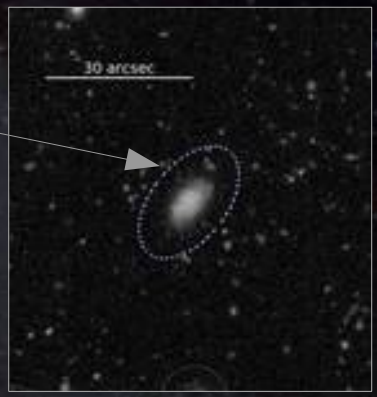
Next steps: spectroscopic follow-up with PFS

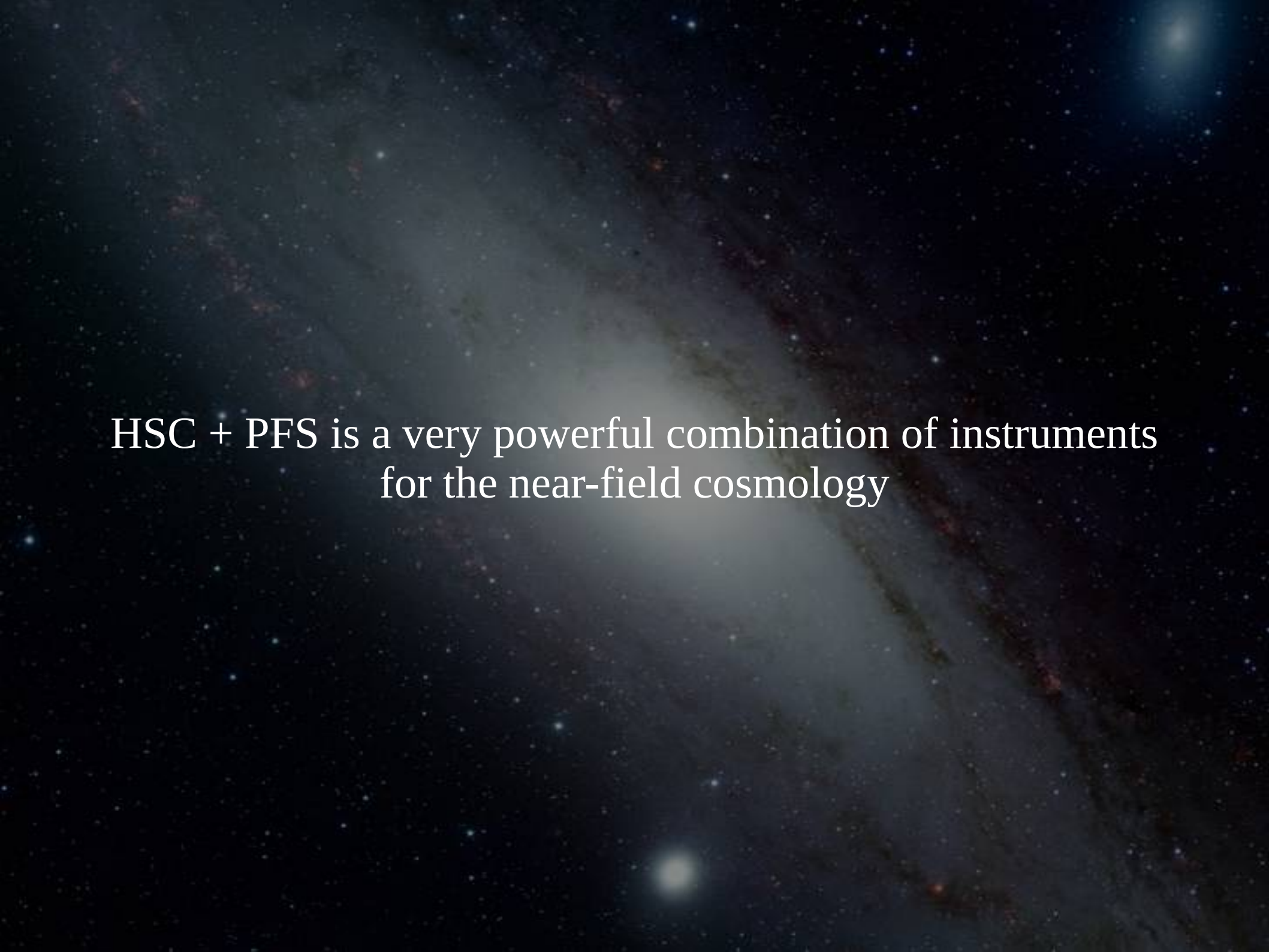


HSC field of view
PFS field of view








HSC + PFS is a very powerful combination of instruments
for the near-field cosmology