200 JAAR
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Multi-wavelength extragalactic astronomy at UGent

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EXTRA
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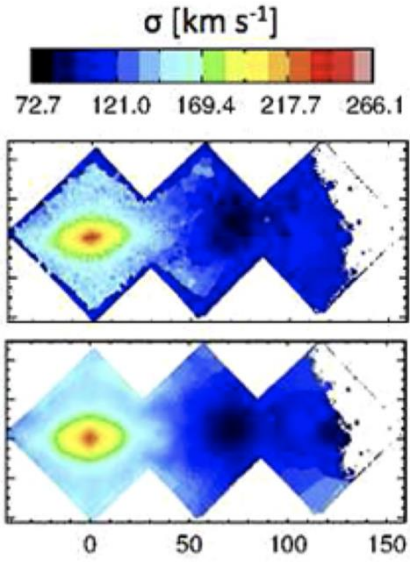
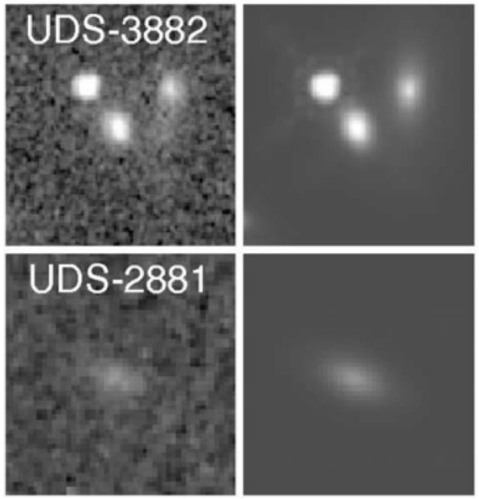
PÈRES TRAPPISTES
BLANCHE DE BRUXELLES

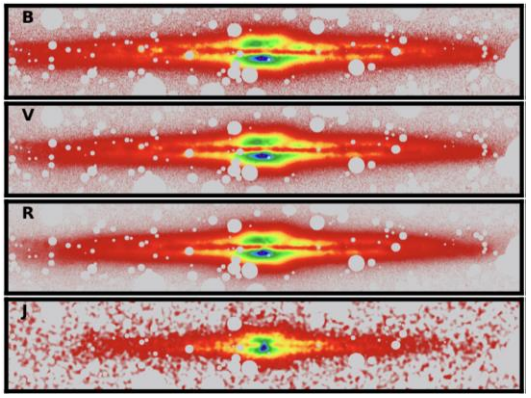
Extragalactic research at UGent



Galaxy kinematics and dynamics



Intermediate and high-z galaxies



Interstellar dust in galaxies

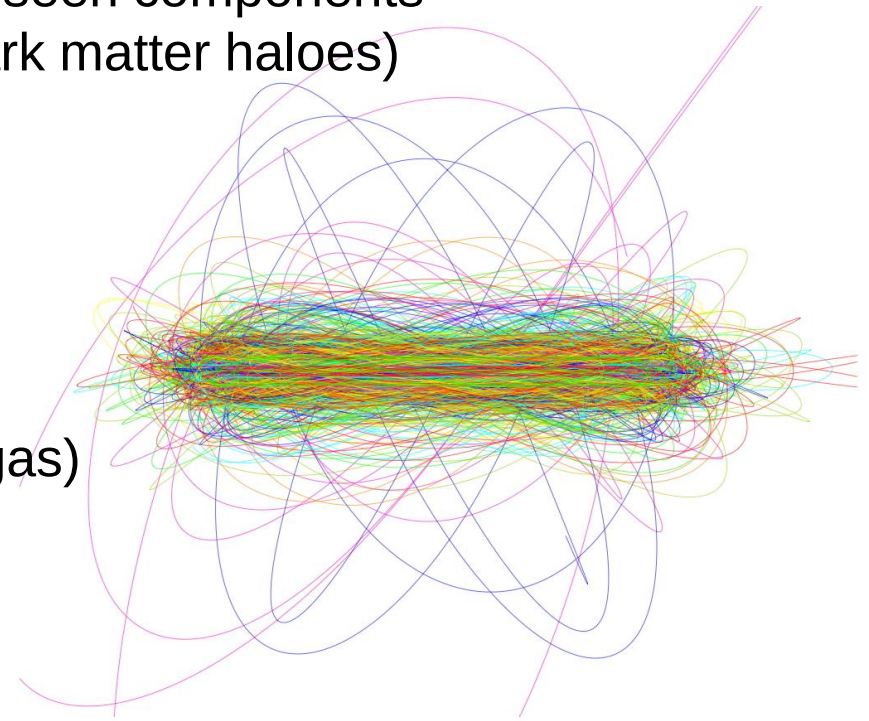
Galaxy kinematics and dynamics

General goals

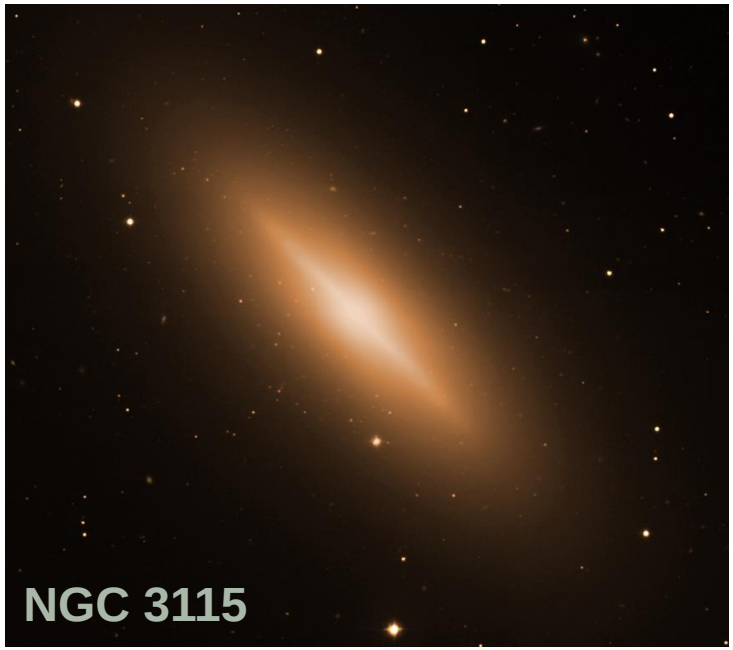
- determine the structure and internal motions of gas/stars within galaxies
- constrain the formation/evolution scenarios
- search for and characterize unseen components (supermassive black holes, dark matter haloes)

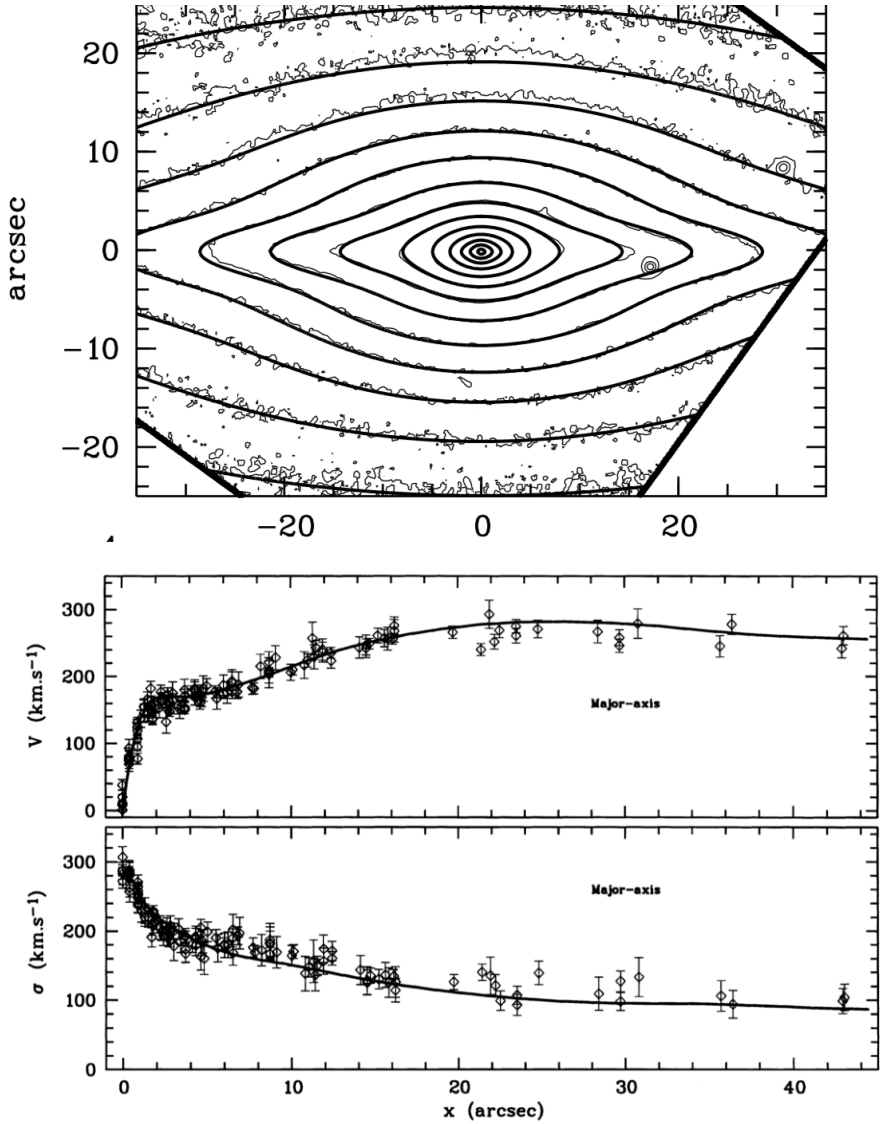
What is needed ?

- optical/NIR imaging
- medium-resolution optical spectroscopy (stars)
- Halpha/HI/CO spectroscopy (gas)



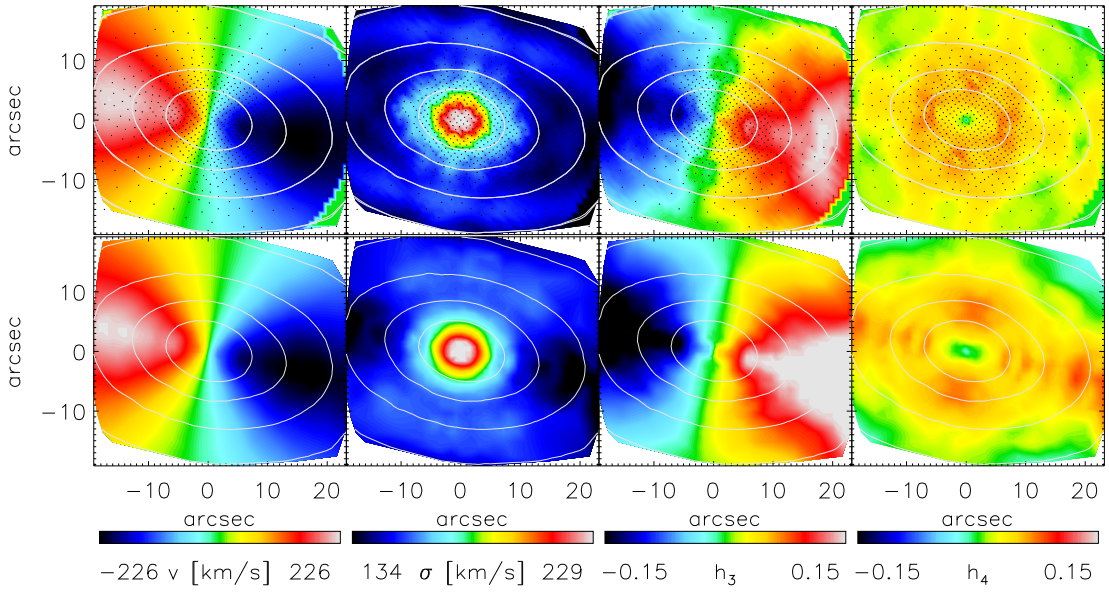
Early-type galaxy stellar dynamics

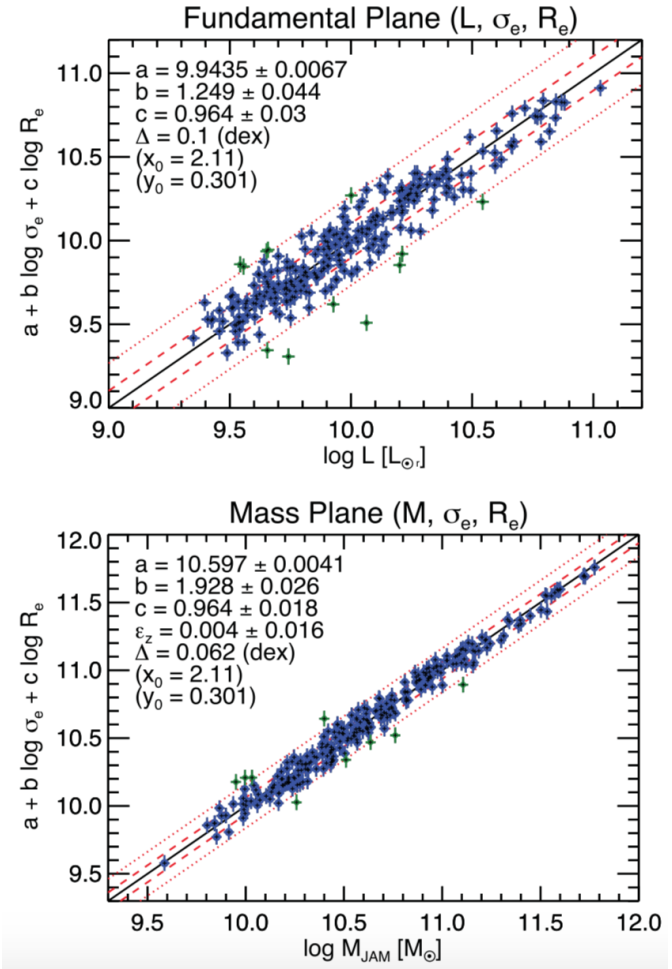




Emsellem et al. 2002

Current state of the art

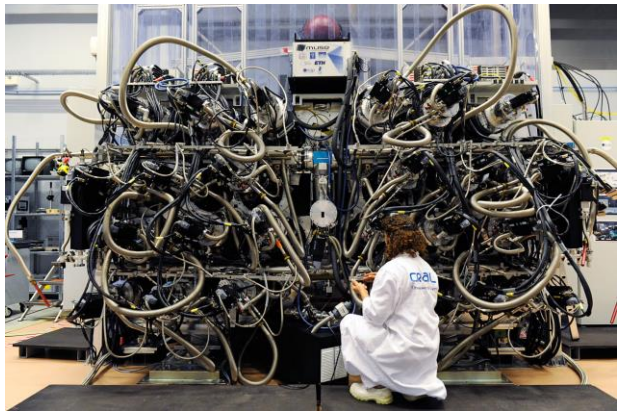




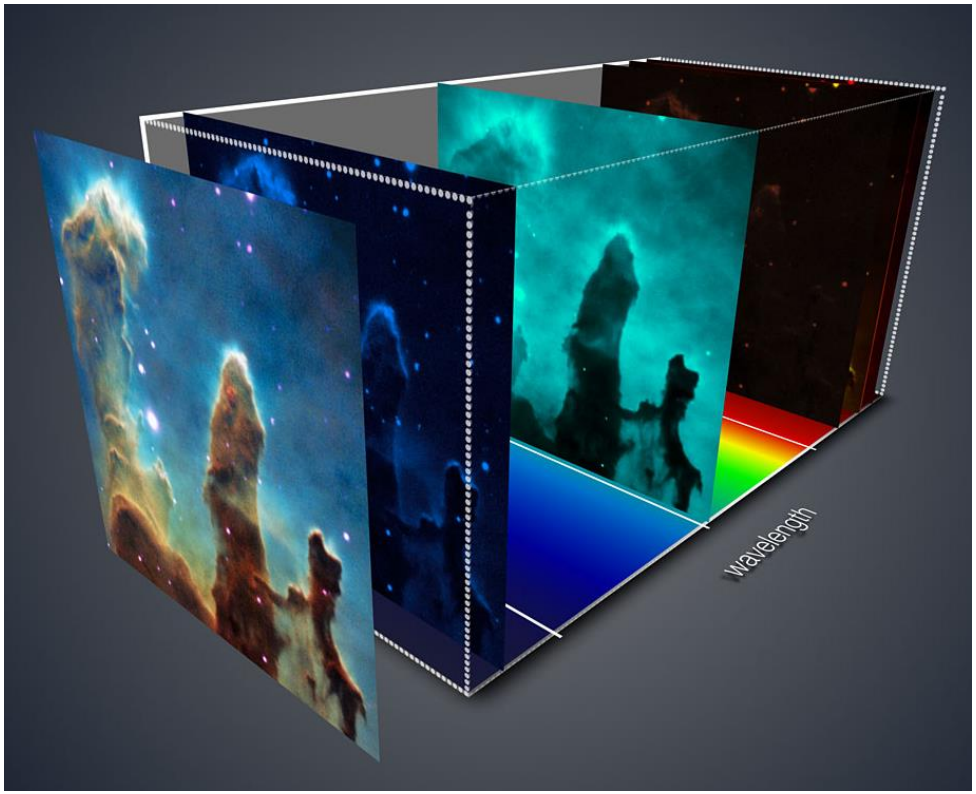
Current state of the art: Schwarzschild models fitted to integral-field kinematics !

Cappellari et al. 2013, Sarzi et al. 2018…

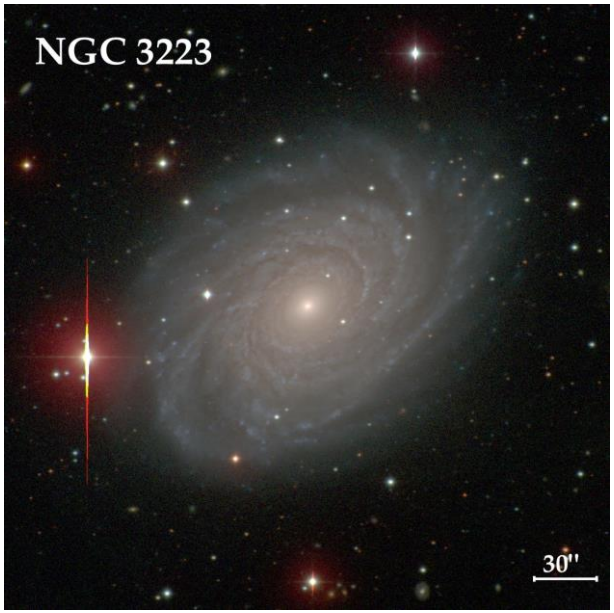
The next stage: MUSE…



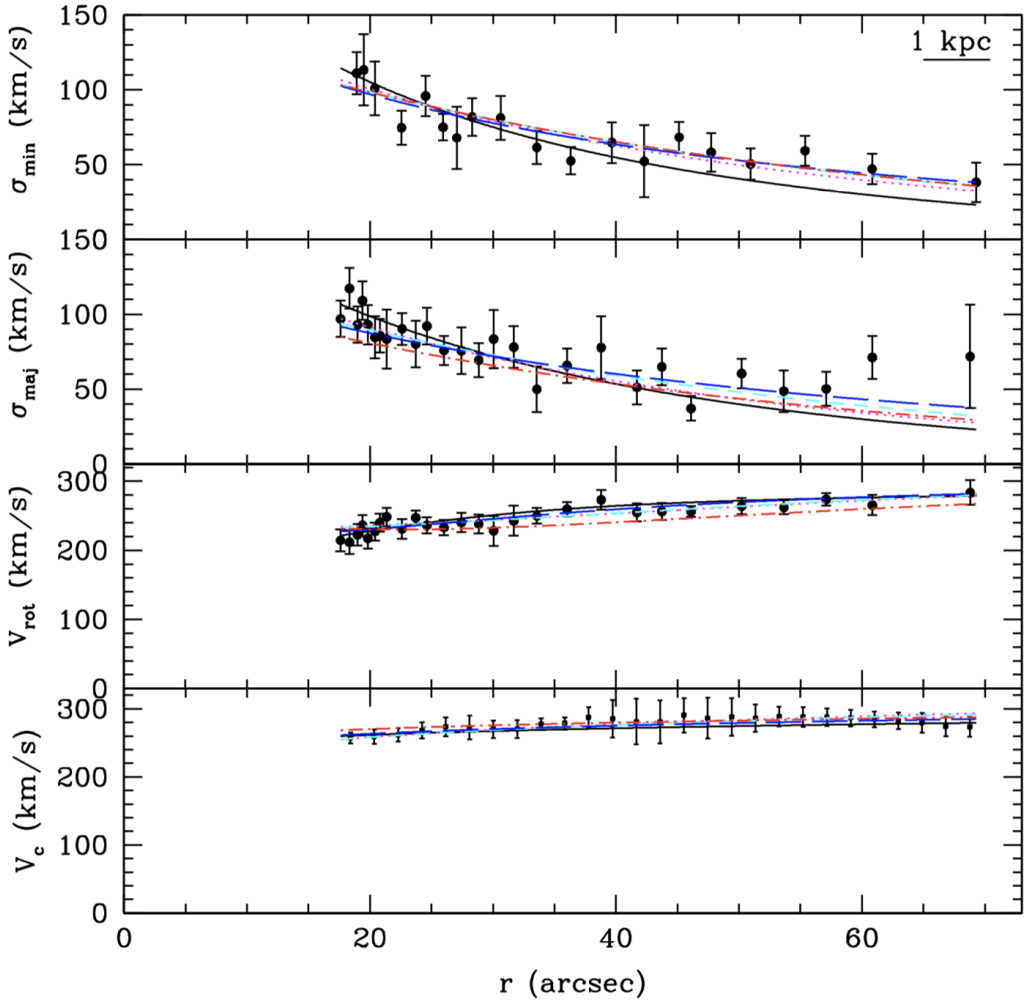
muse
multi unit spectroscopic explorer



Spiral galaxy stellar dynamics

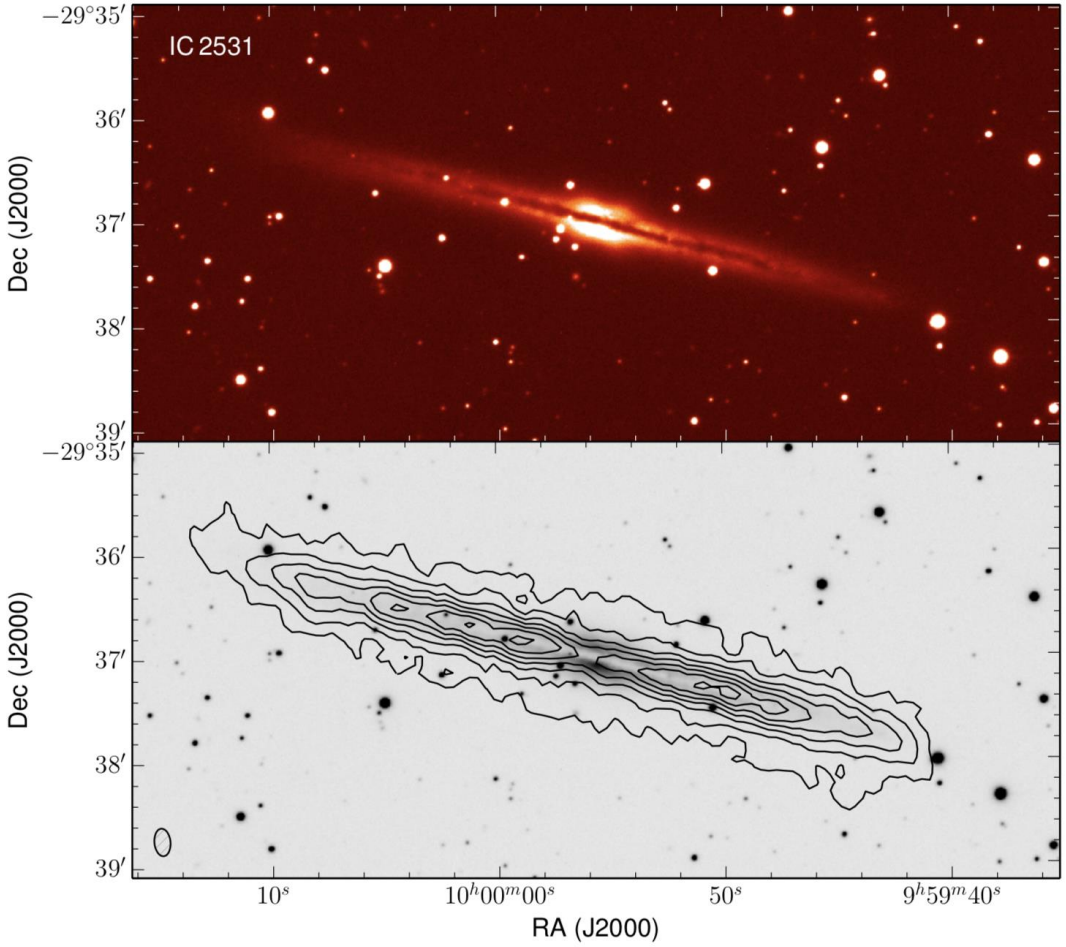


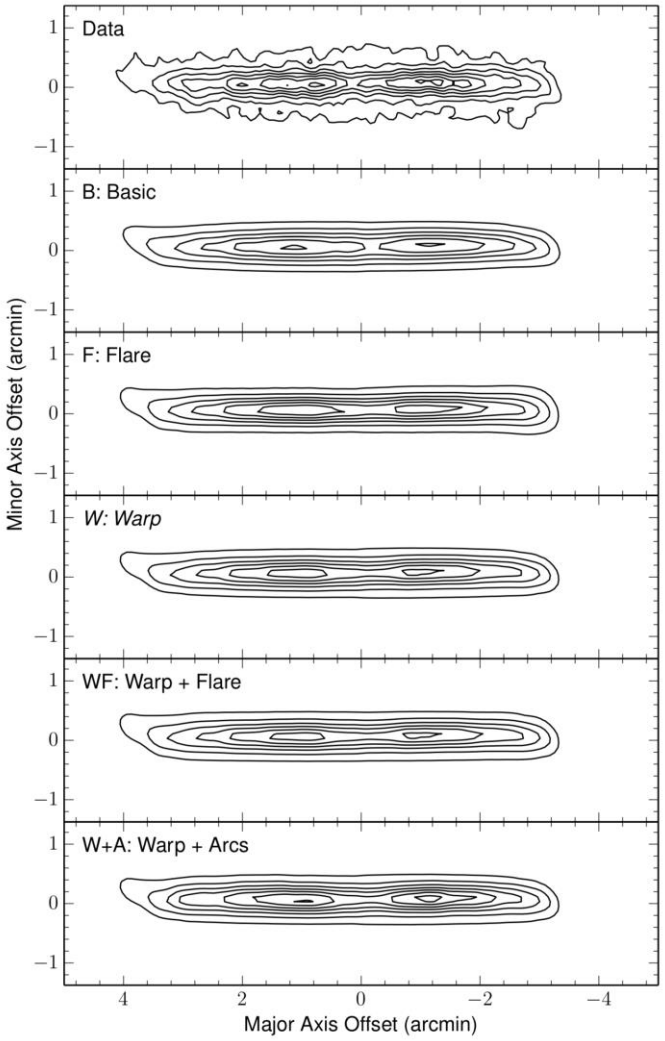
stellar disks are faint, and have low stellar velocity dispersions. 8m class telescopes are necessary…



Gentile et al. 2015

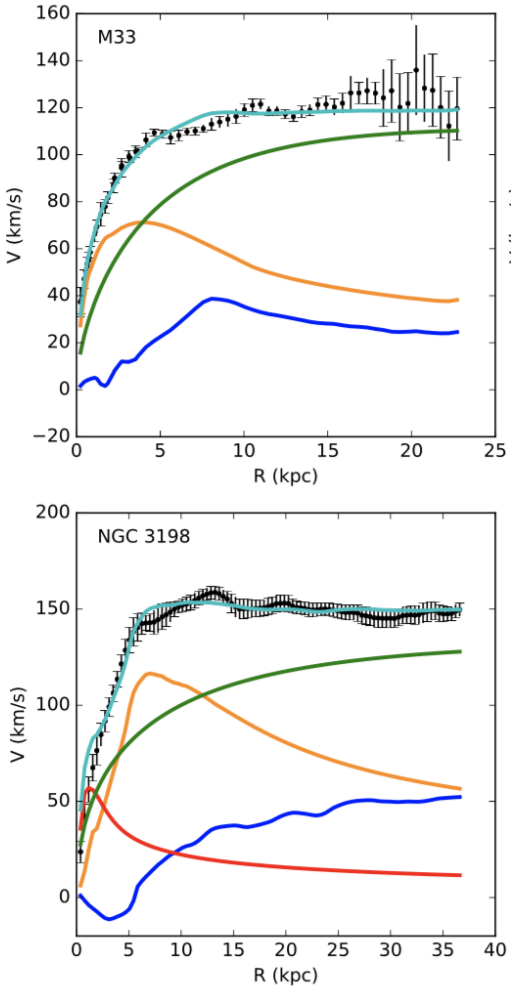
Spiral galaxy gas dynamics

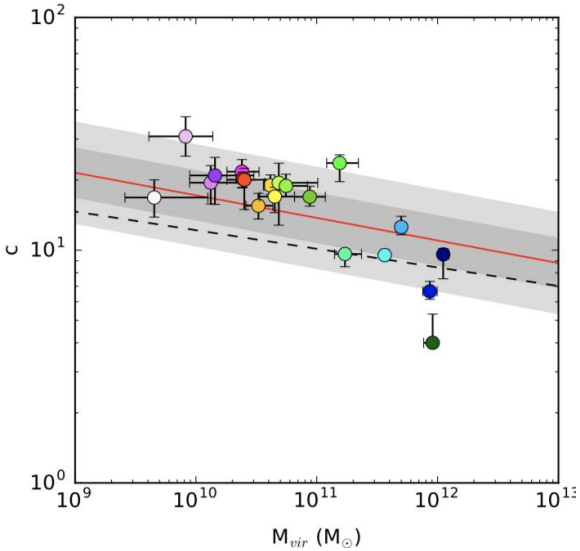


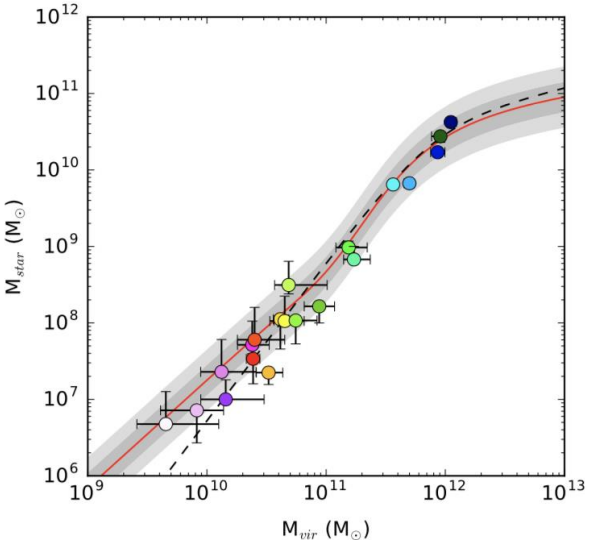


Allaert et al. 2015

Spiral galaxy gas dynamics



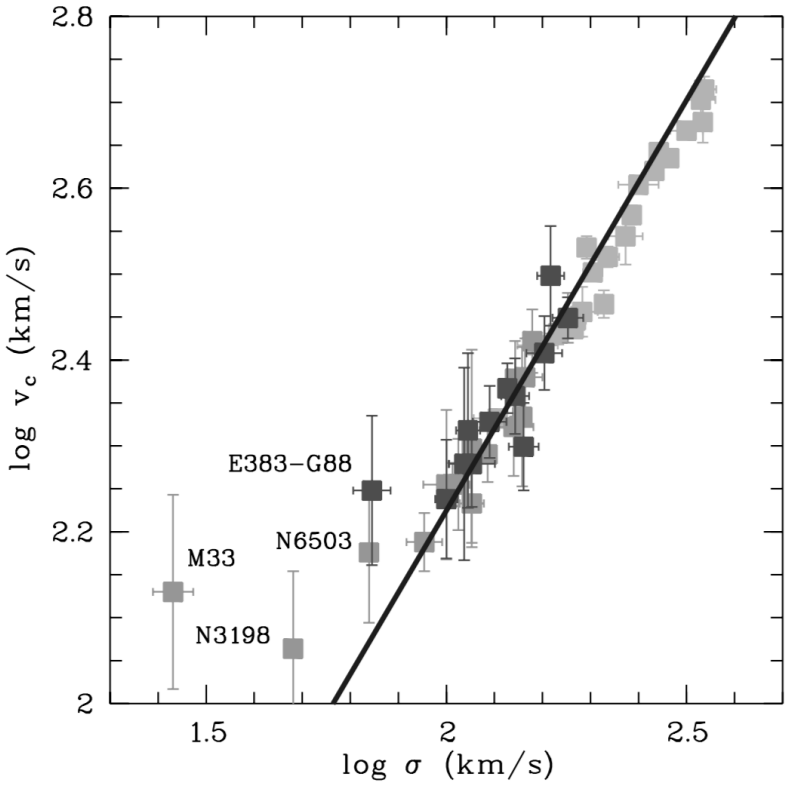


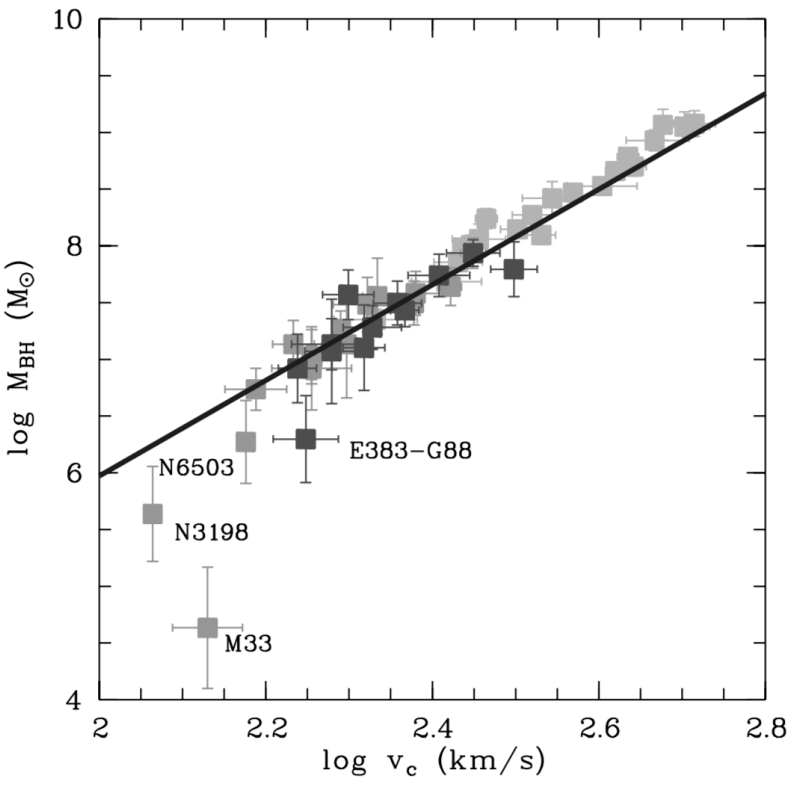


Mass modelling of spiral galaxy HI rotation curves yields dark matter haloes with properties that are in agreement with ΛCDM halo models that include baryon-induced core formation.

Allaert et al. 2017

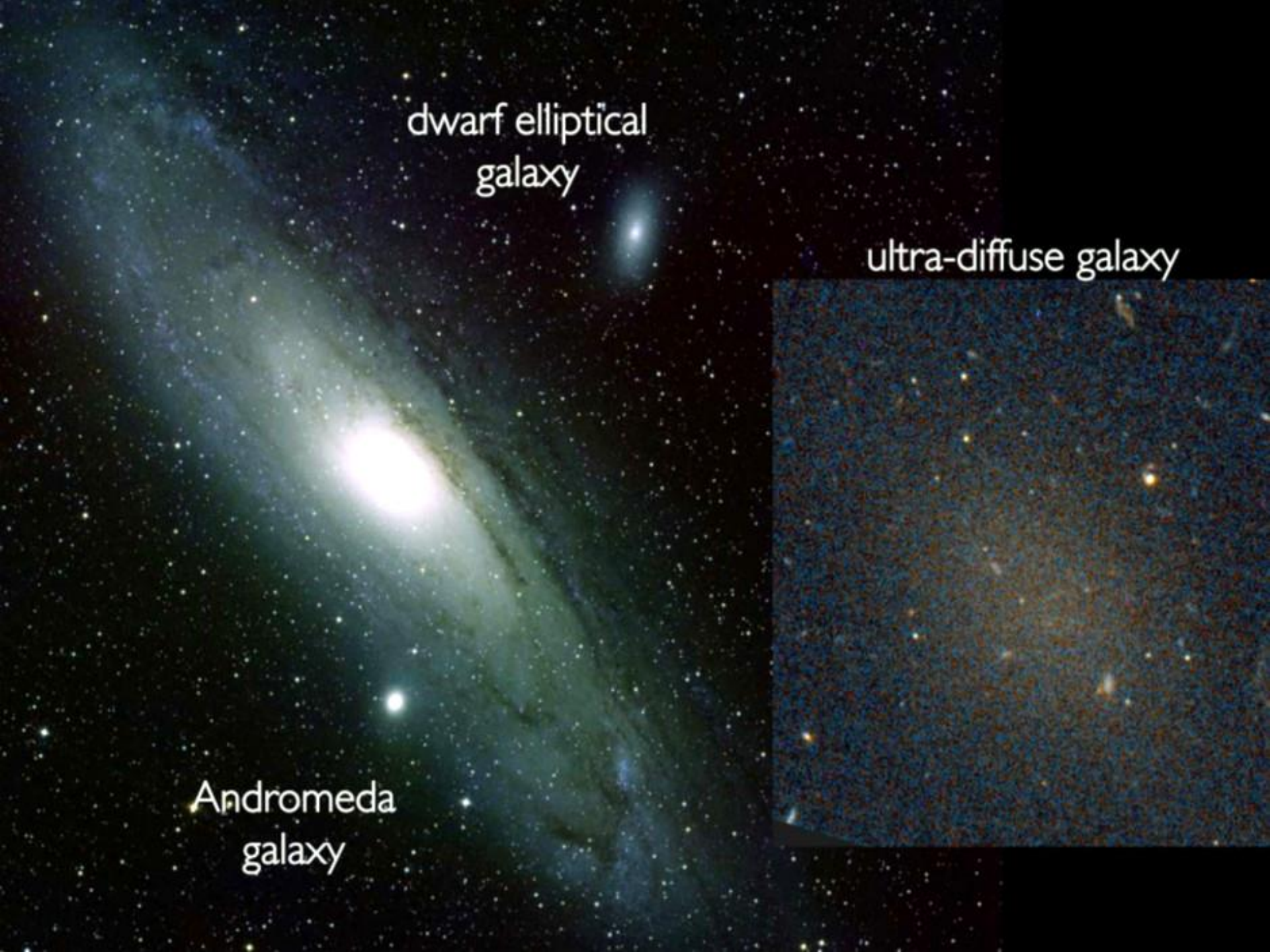
Black holes and dark matter



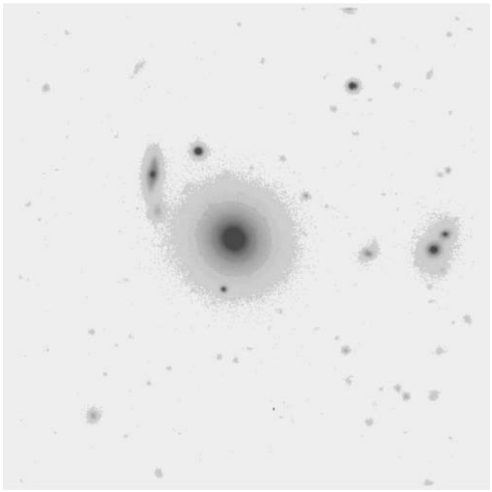


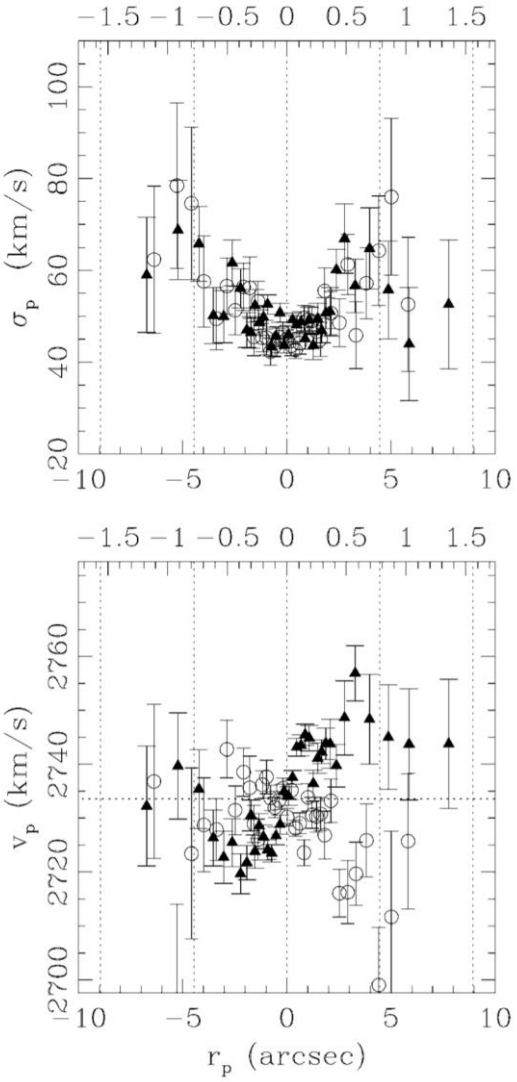
Strong correlation between velocity dispersion and rotation velocity in spiral galaxies. Indicative of a correlation between black holes and dark matter haloes ?

Ferrarese et al. 2002; Baes et al. 2003; Buyle et al. 2006

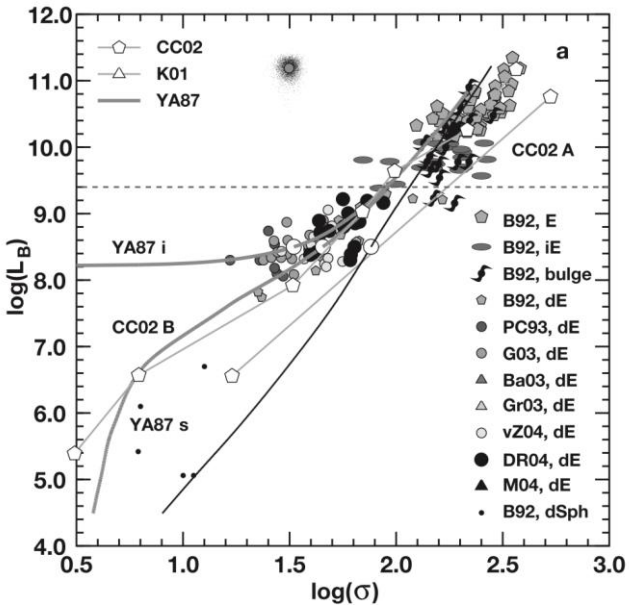

dwarf elliptical
galaxy
ultra-diffuse galaxy
Andromeda
galaxy

Dwarf galaxy stellar dynamics



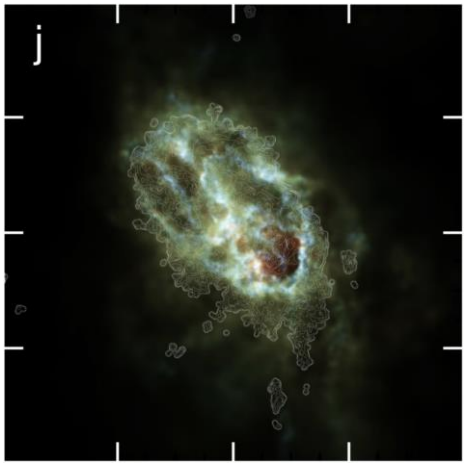


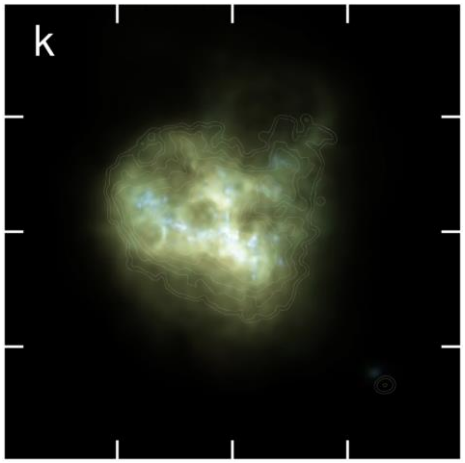
Dwarf galaxies require high spatial resolution, high spectral resolution and a large light gathering power…

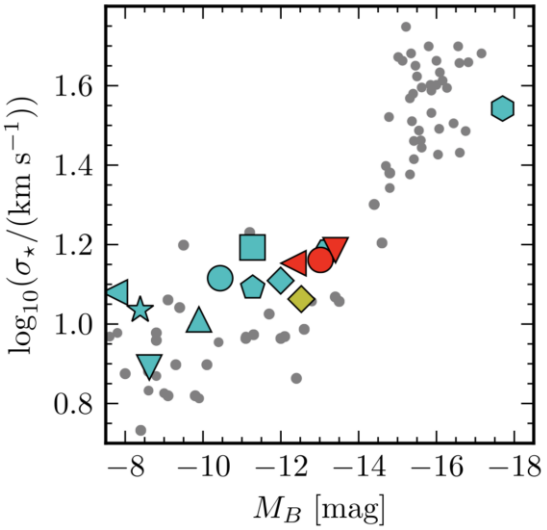


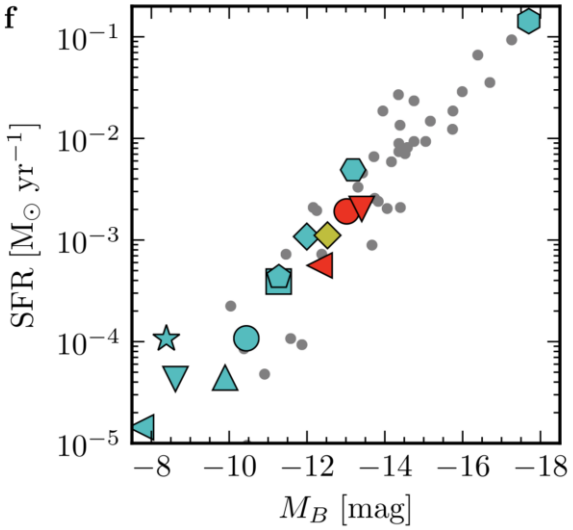
De Rijcke et al. 2001, 2005

Dwarf galaxy simulations



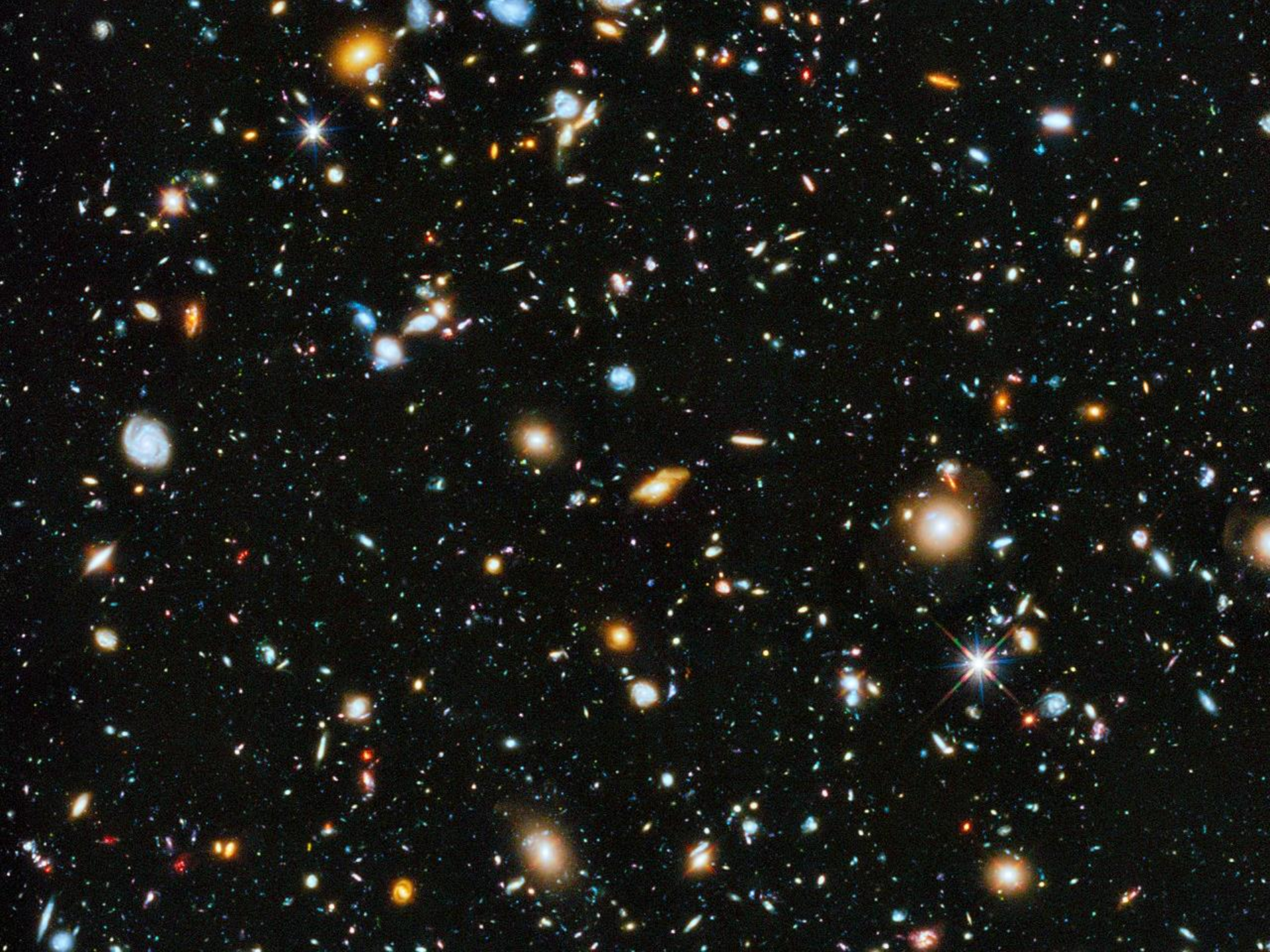




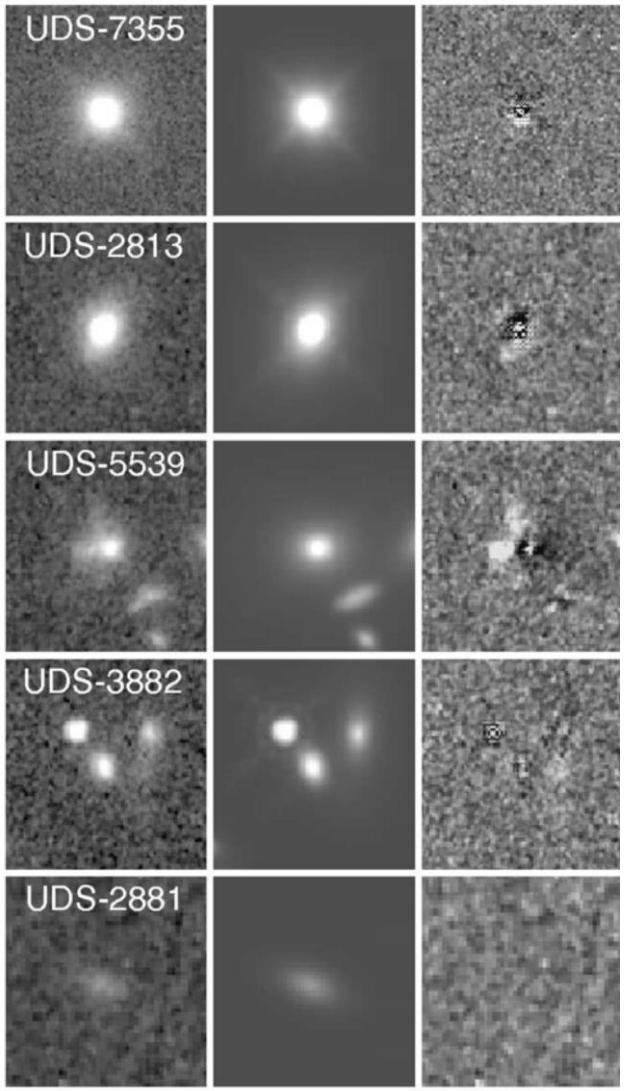


SUNDIAL
H2020 Innovative Training Network

Vandenbroucke et al. 2015; Verbeke et al. 2015



Observational galaxy evolution



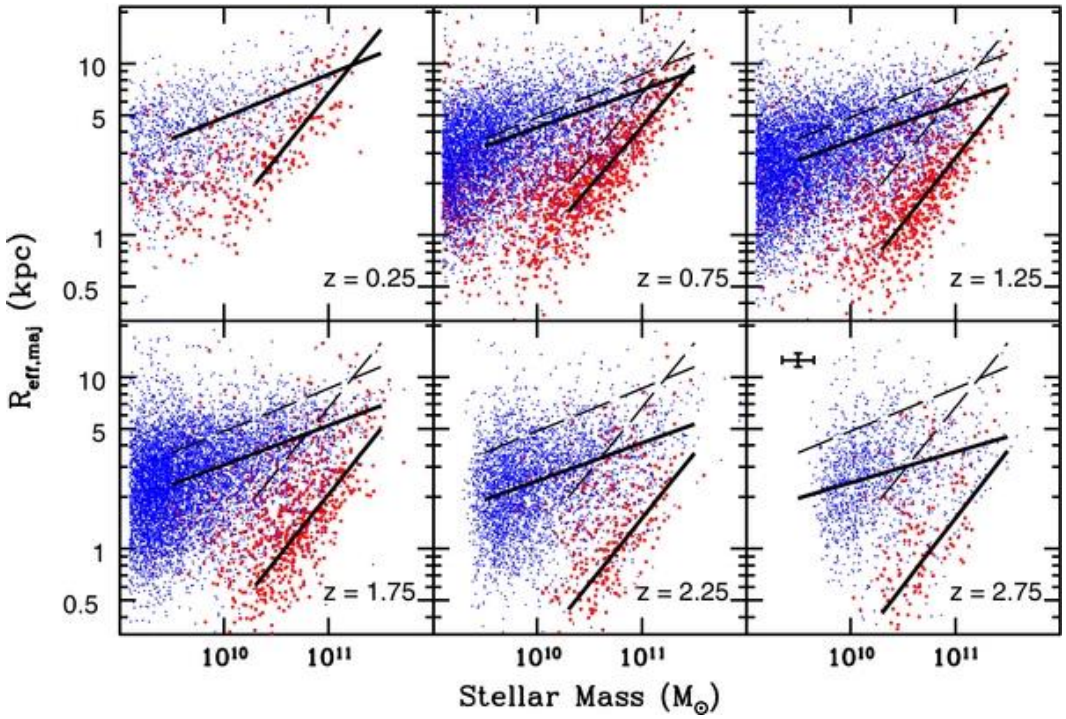
Deep surveys of the extragalactic sky allow to directly map the evolution of galaxy properties or scaling relations with cosmic time.

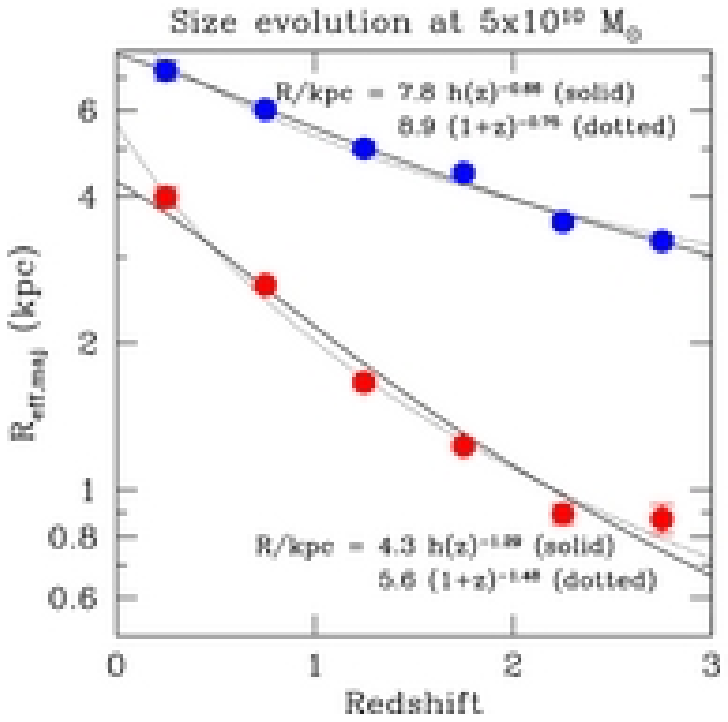
Strong and immediate constraints on galaxy formation/evolution models.

What is needed ?

- multi-band optical/NIR imaging
- spectroscopy
- …

Galaxy size evolution



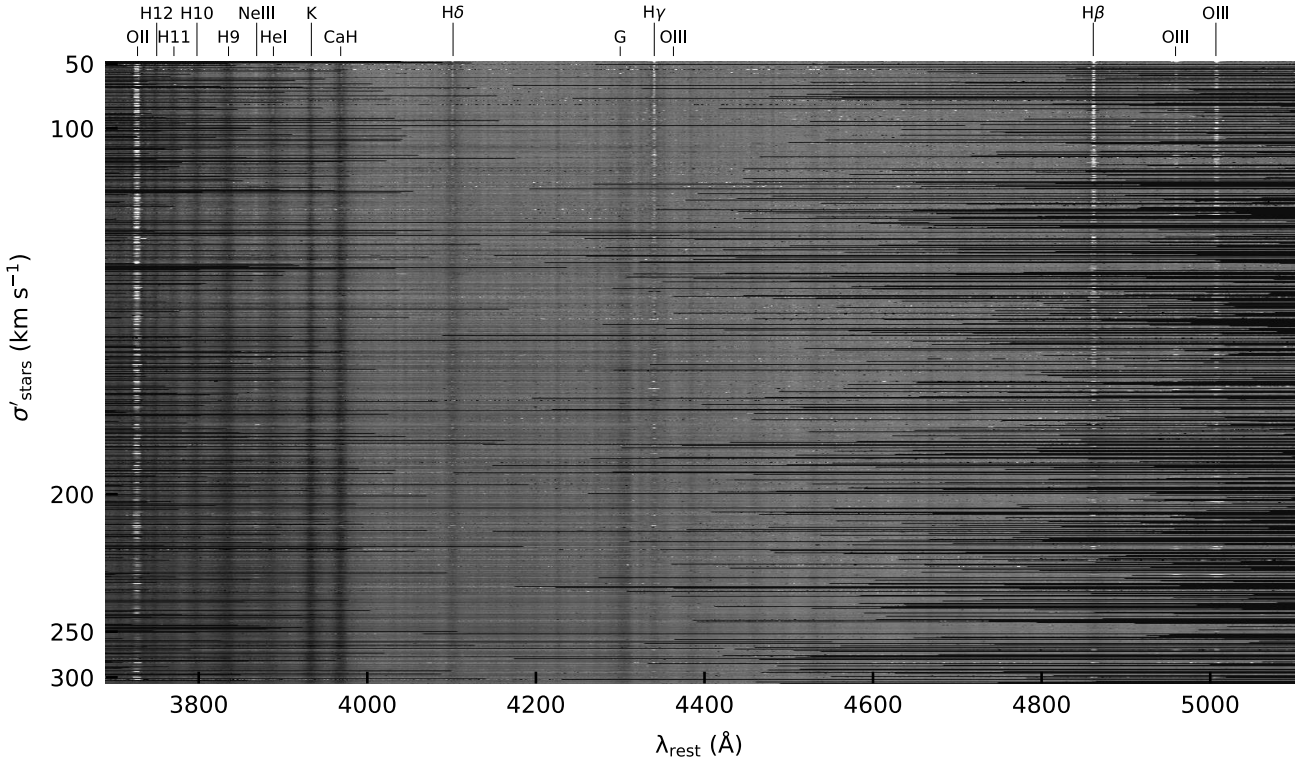


Fast size evolution for early-type galaxies, moderate evolution for star-forming galaxies over the redshift range $0 < z < 3$.

van der Wel et al. 2012, 2014

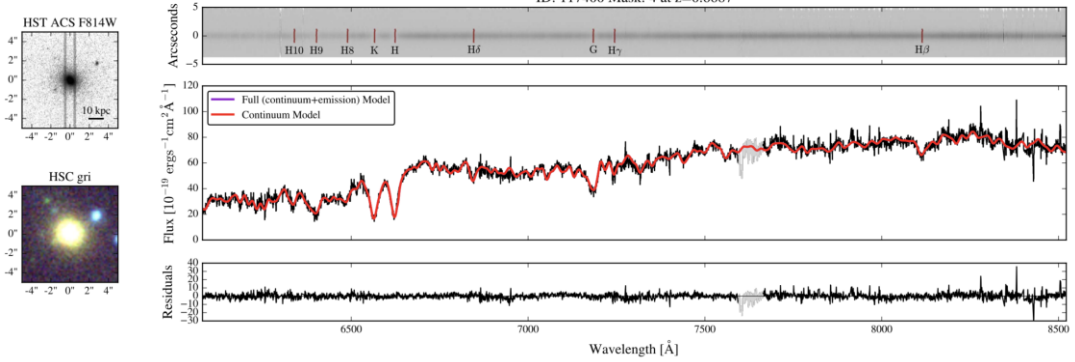
Galaxy dynamics evolution

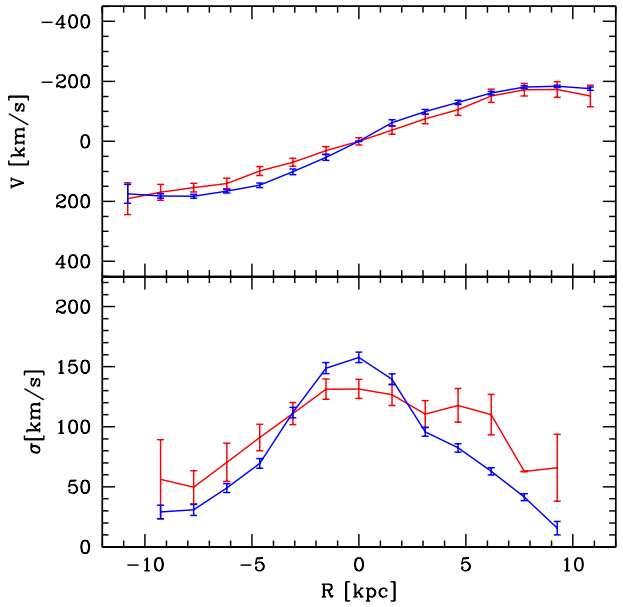
ESO Public Survey: deep optical spectroscopy of several thousands of z ~ 0.8 galaxies. Typically ~20h VLT time per pointing !

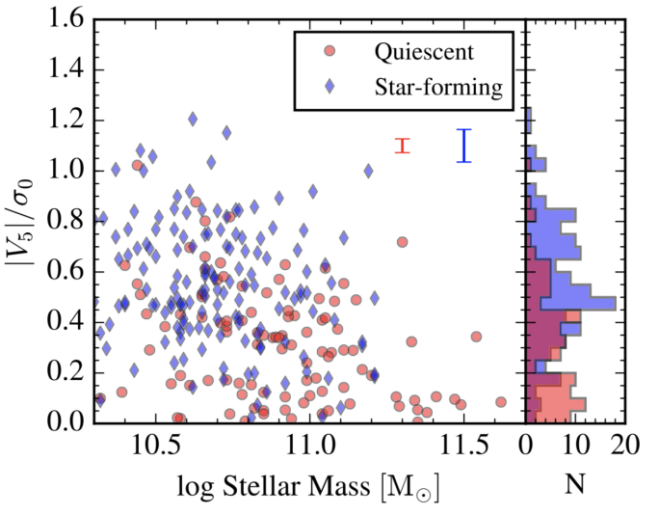


van der Wel et al. 2016; Straatman et al. 2018

Evolution of galaxy dynamics



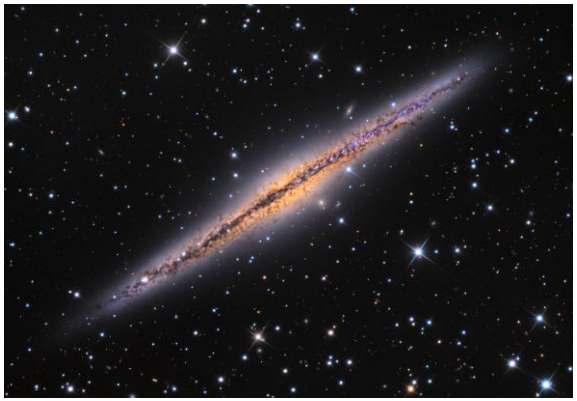


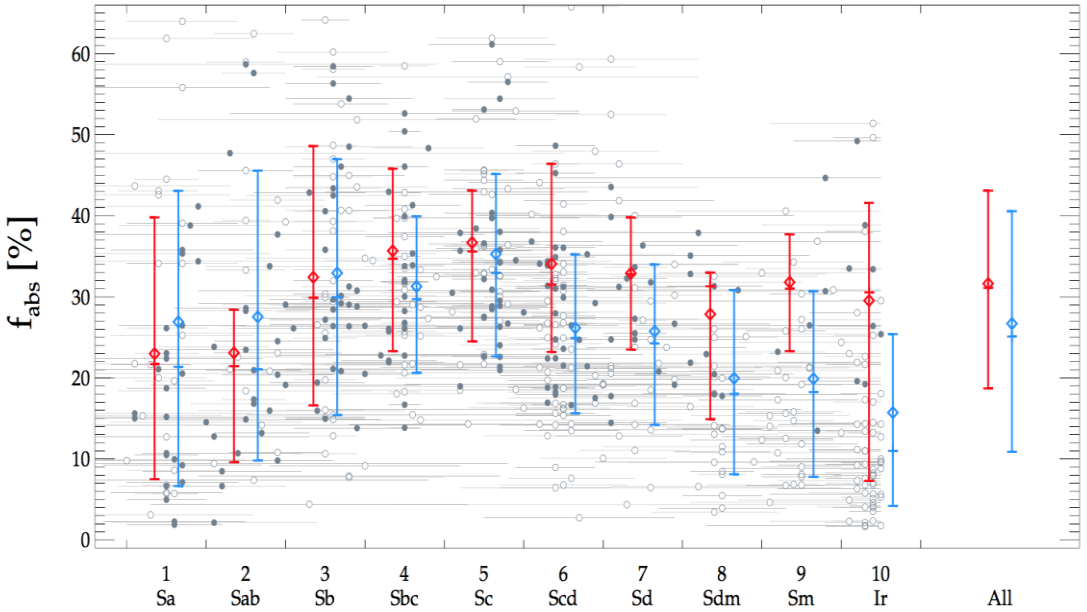


z=1 quiescent galaxies have more rotational support than local counterparts. Quiescent galaxies lose angular momentum (due to merging?)

Bezanson et al. 2018

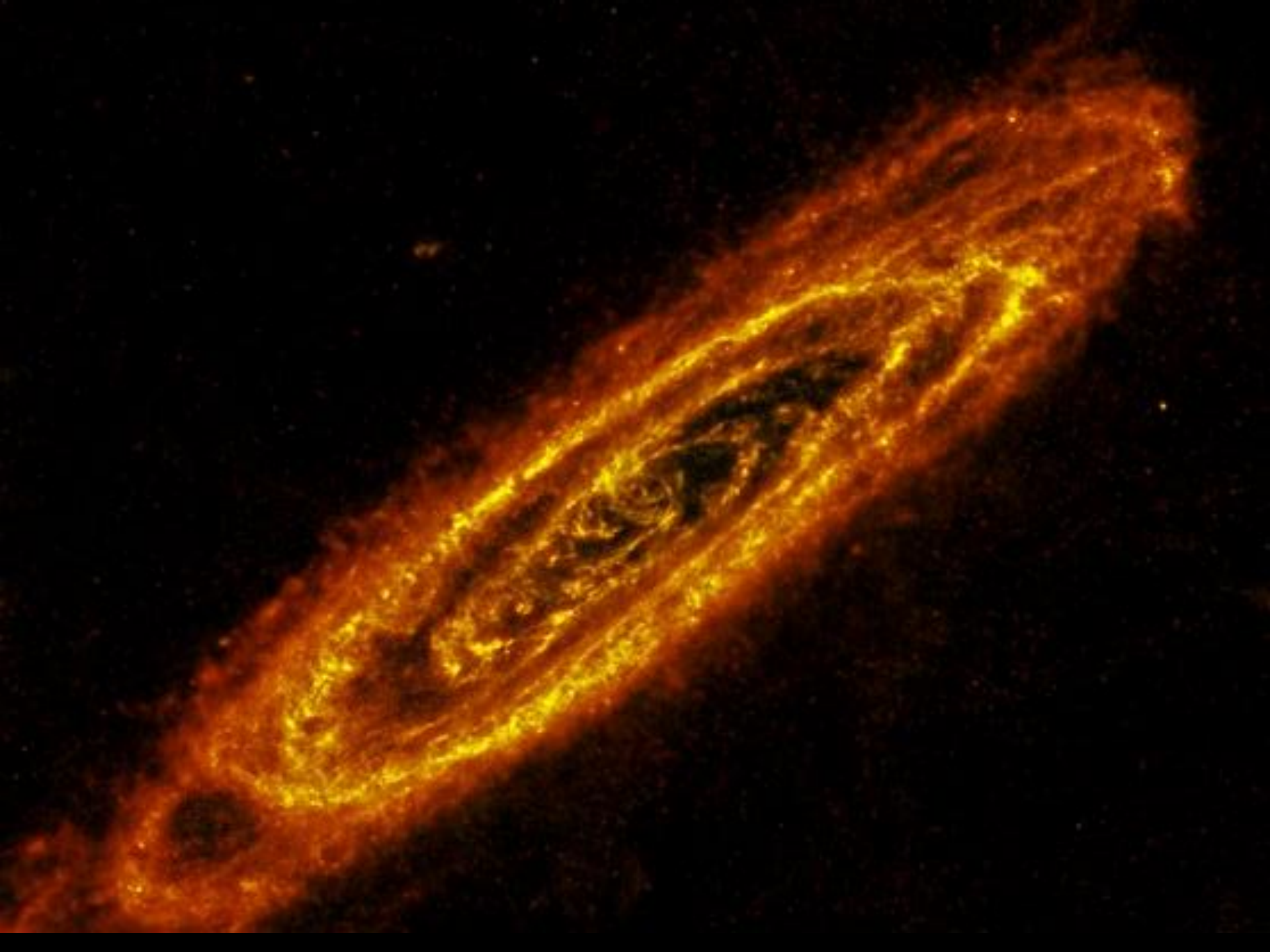
Interstellar dust



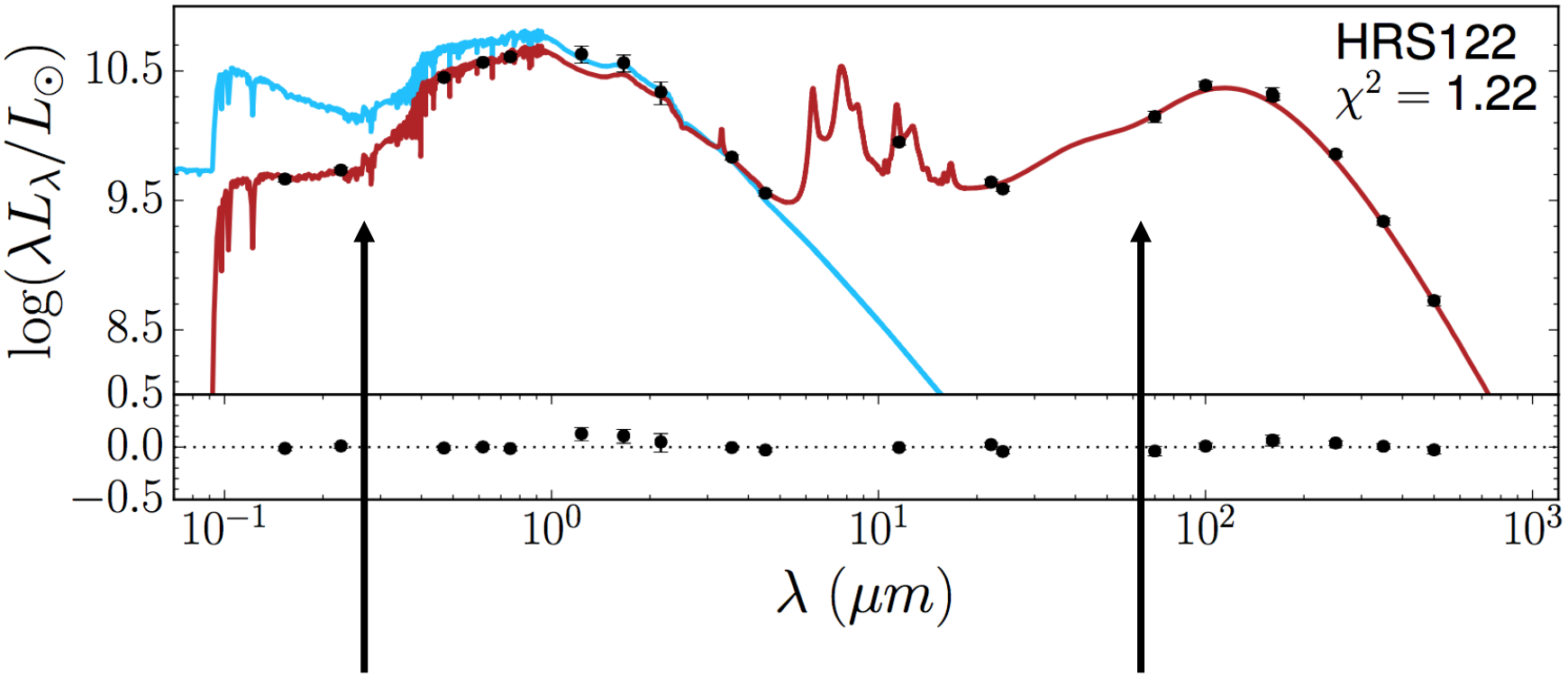


Dust absorbs 30 – 50% of all the starlight in a typical galaxy, and converts it to thermal infrared radiation.

Bianchi et al. 2018

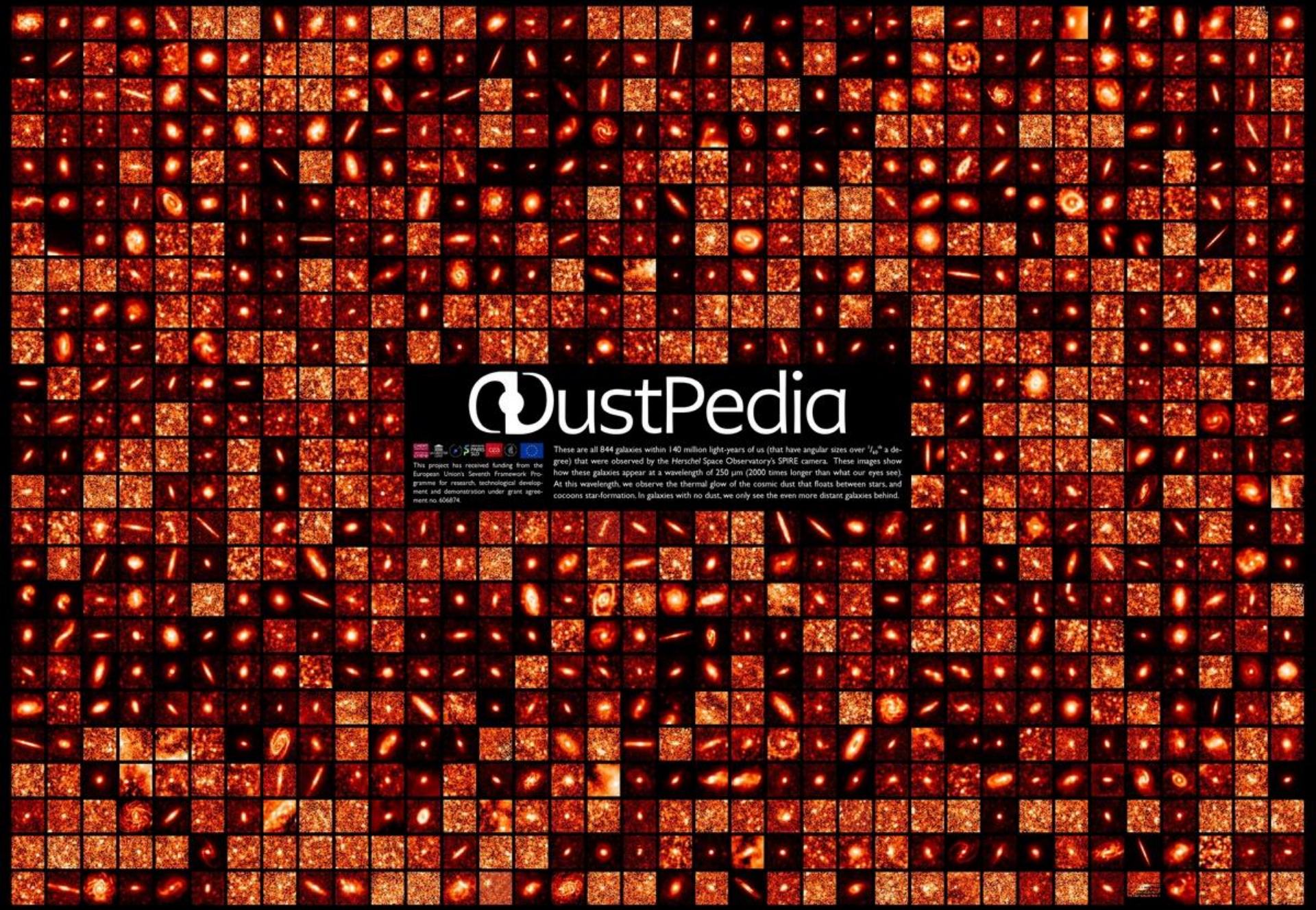


Galaxy SEDs with and without dust



UV / optical:
stellar emission seriously attenuated by dust

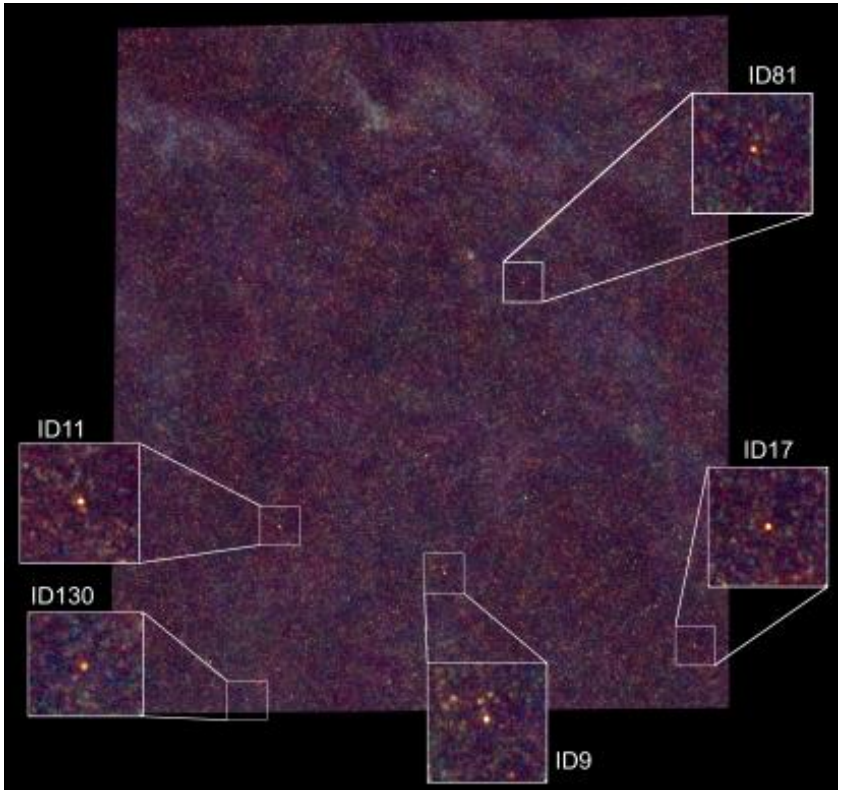
MIR / FIR / submm
emission completely dominated by dust emission

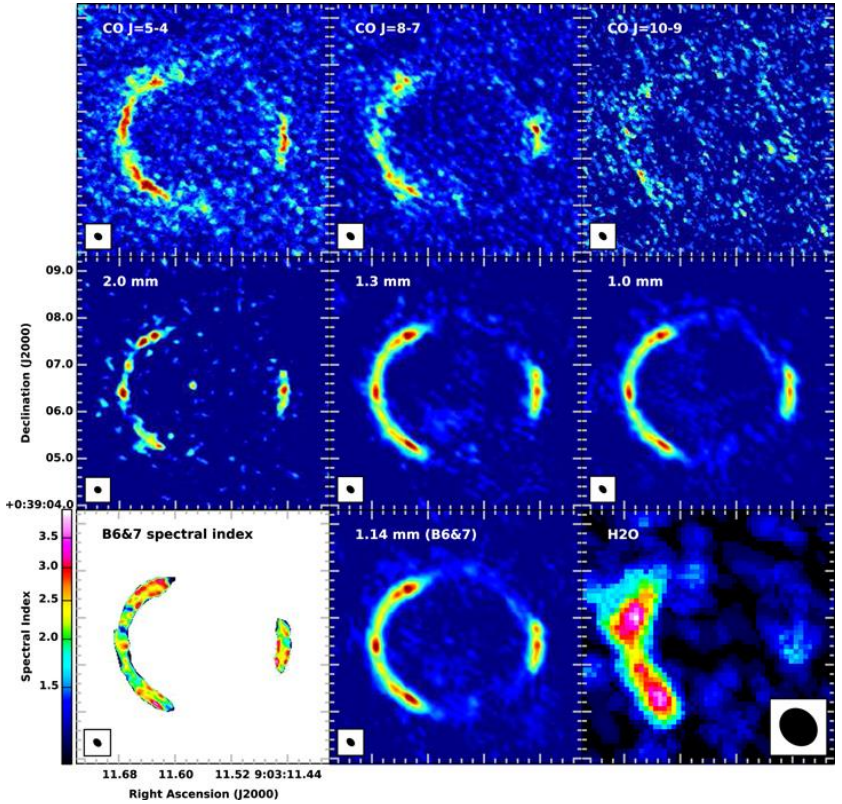


This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 606874

These are all 844 galaxies within 140 million light-years of us (that have angular sizes over $^{1}/_{10}^{th}$ a degree) that were observed by the *Herschel* Space Observatory's SPIRE camera. These images show how these galaxies appear at a wavelength of 250 μm (2000 times longer than what our eyes see). At this wavelength, we observe the thermal glow of the cosmic dust that floats between stars, and cocoons star-formation. In galaxies with no dust, we only see the even more distant galaxies behind.

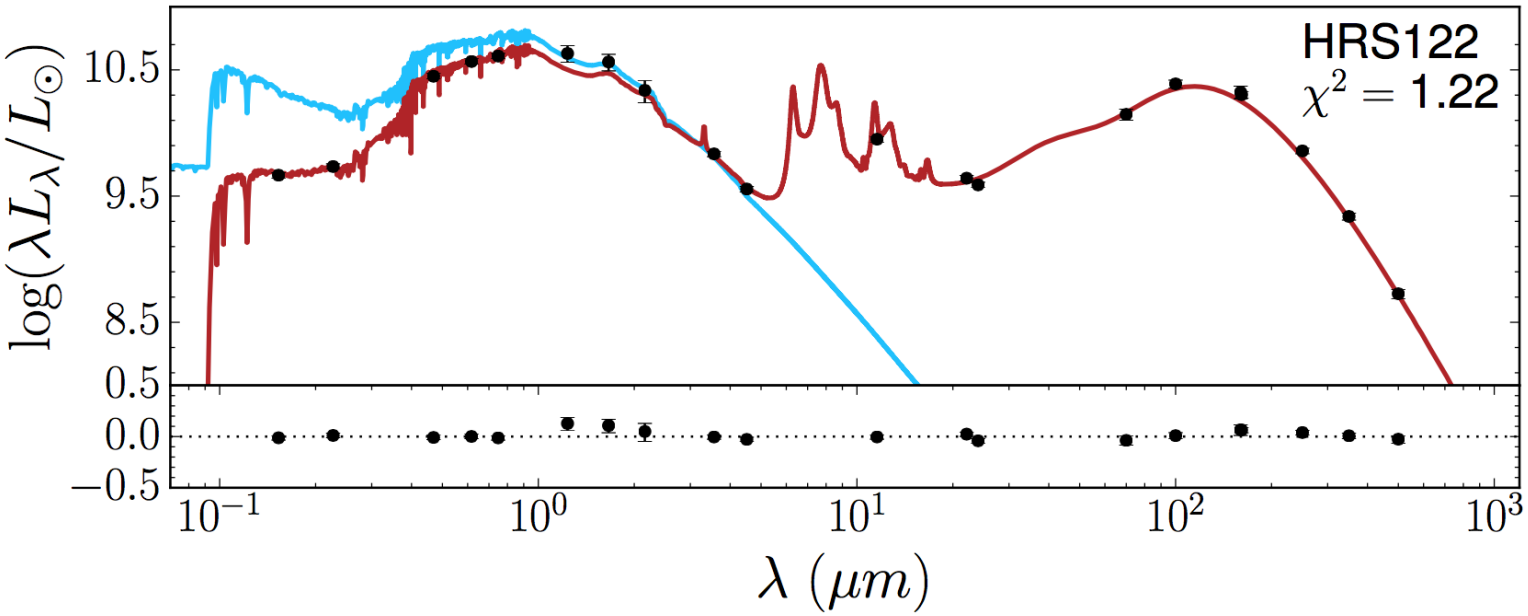
High-redshift submm galaxies





ALMA observations of lensed high-redshift submm galaxy

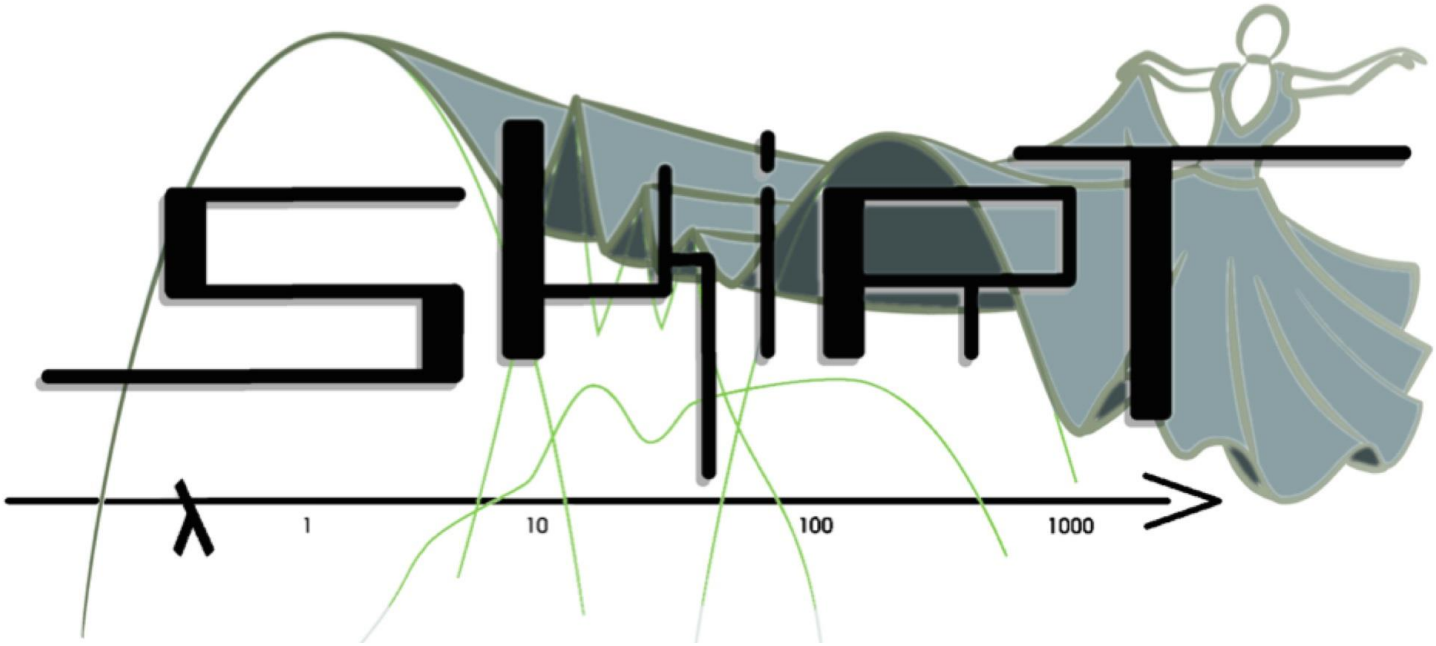
Galaxy SEDs with and without dust



It should be possible to also obtain information on the dust in galaxies by carefully studying the UV-optical regime…

Important to get it right:

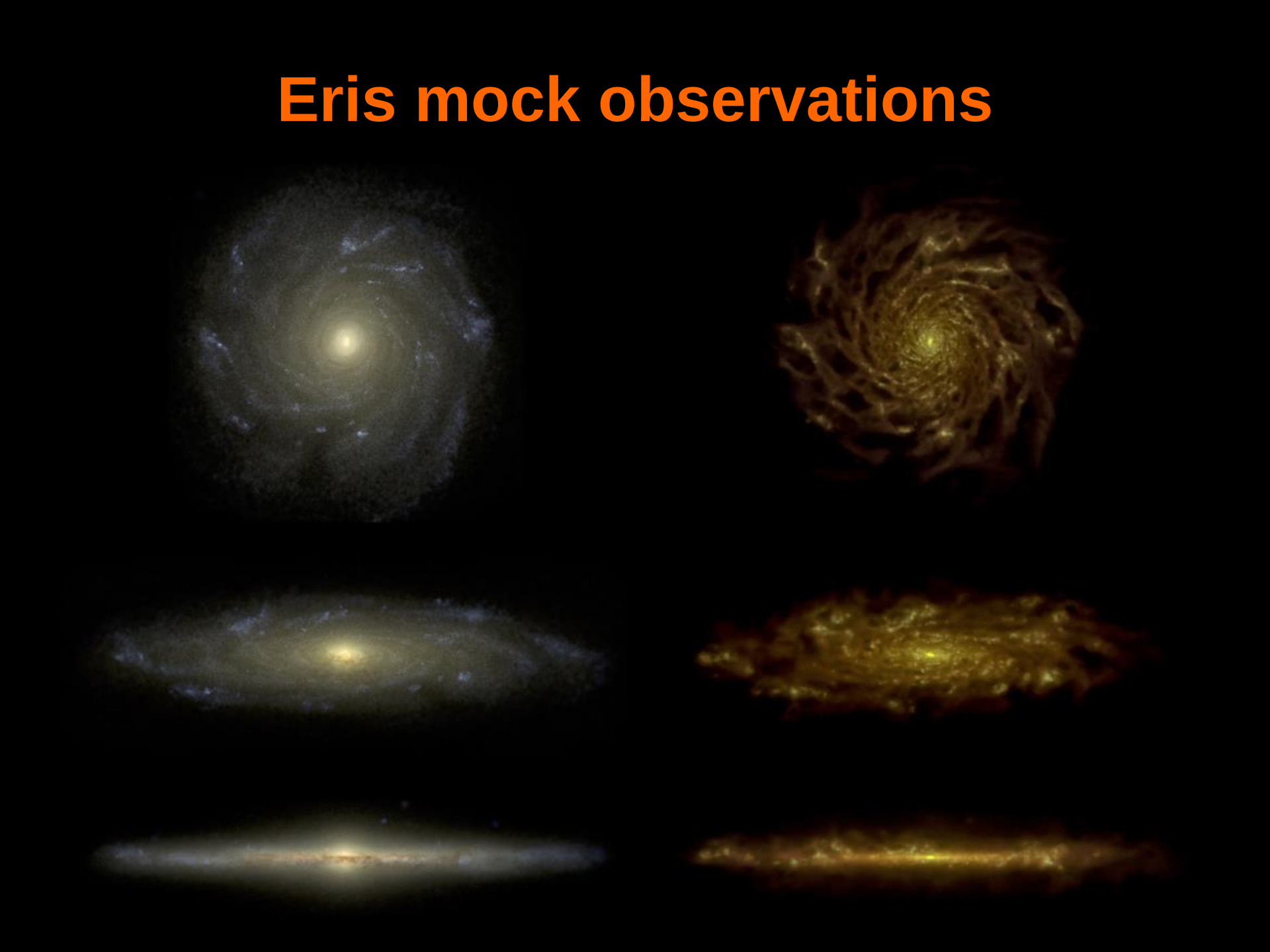
- realistic star-dust geometry
- absorption and multiple anisotropic scattering, thermal dust emission



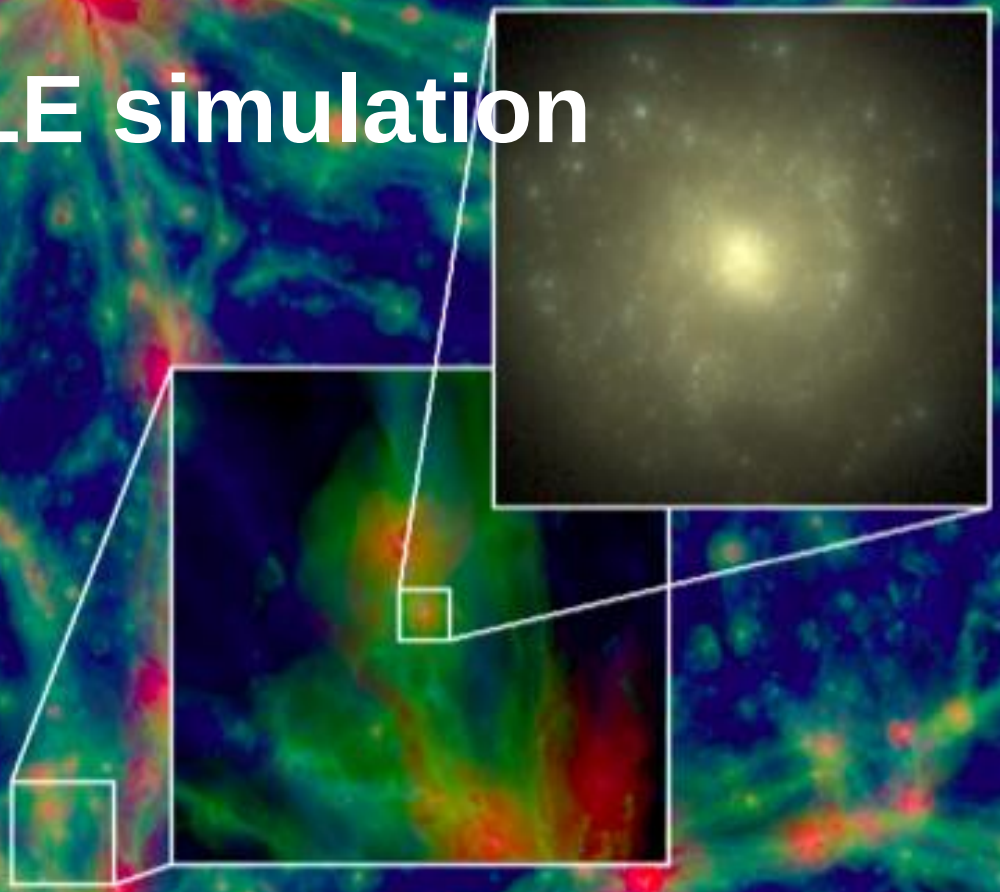
www.skirt.ugent.be

Baes et al. 2003, 2011; Camps & Baes 2015

Eris mock observations



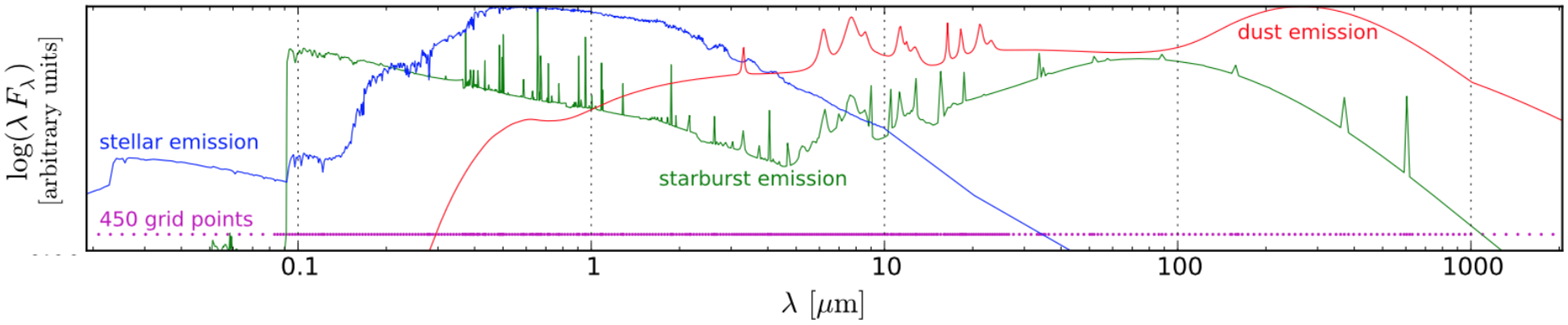
The EAGLE simulation

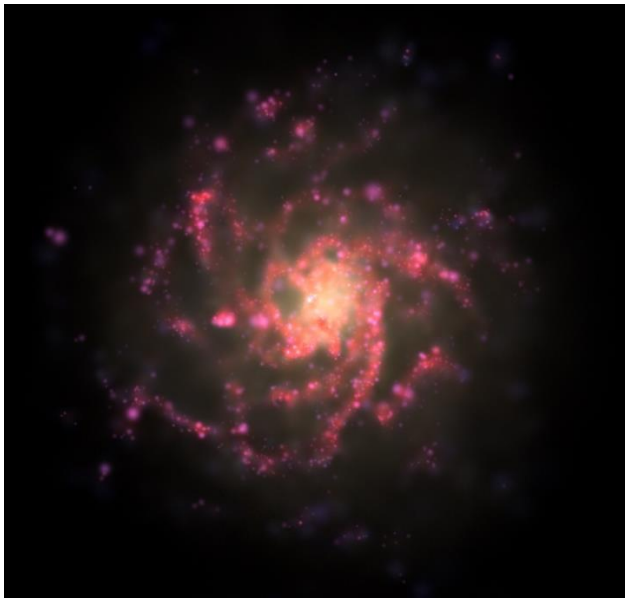


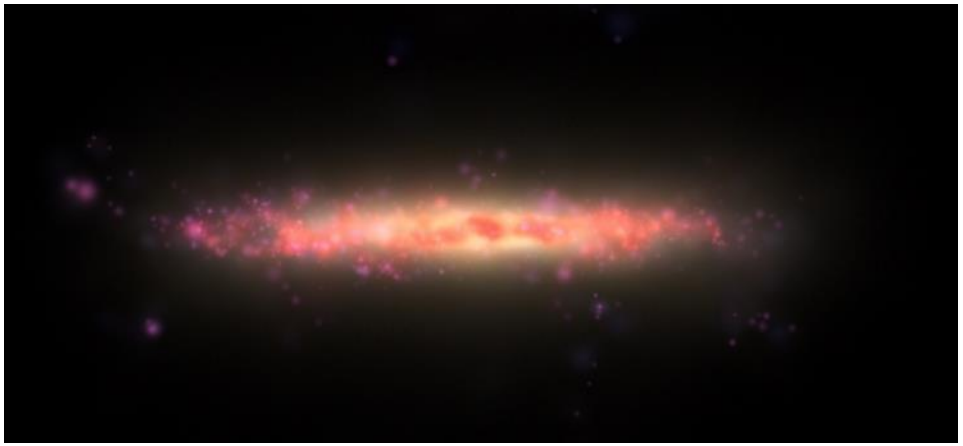
- suite of N-Body/SPH simulations
- full cosmological context (ΛCDM)
- box size from 25 to 100 Mpc
- up to 3 billion particles

Schaye et al. 2015

EAGLE: panchromatic mock SEDs

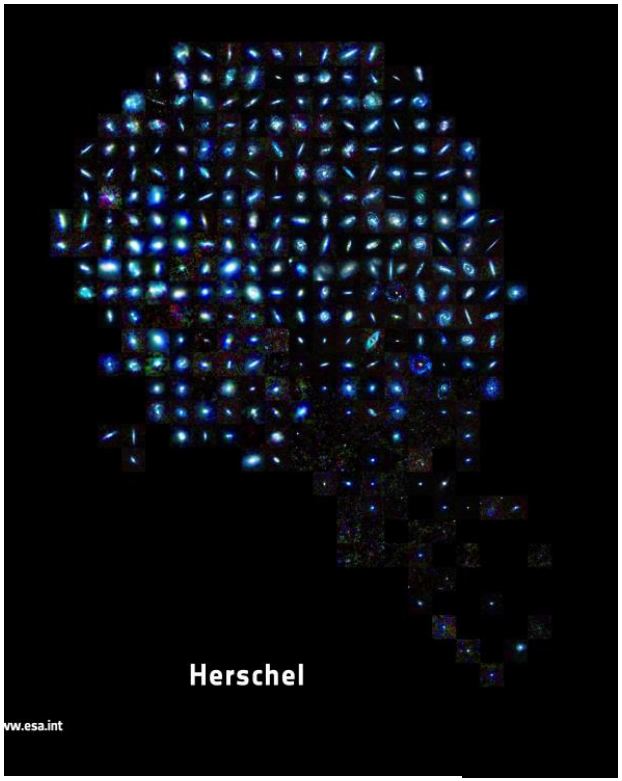


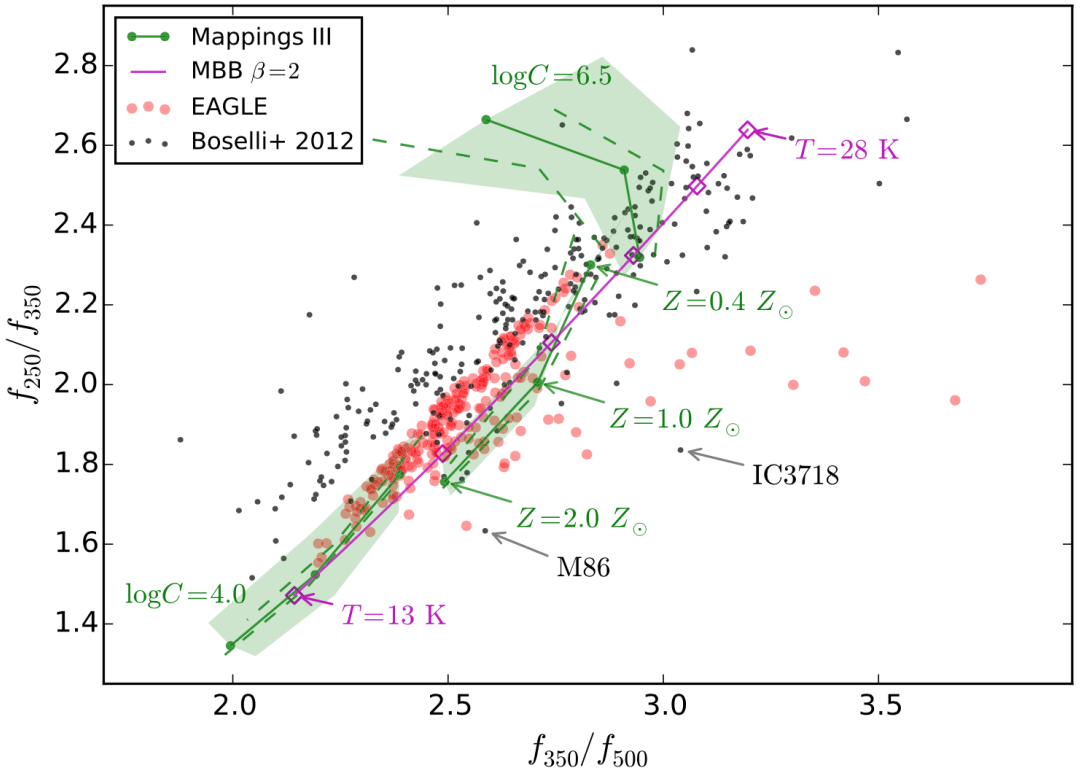




Camps et al. 2016, 2018

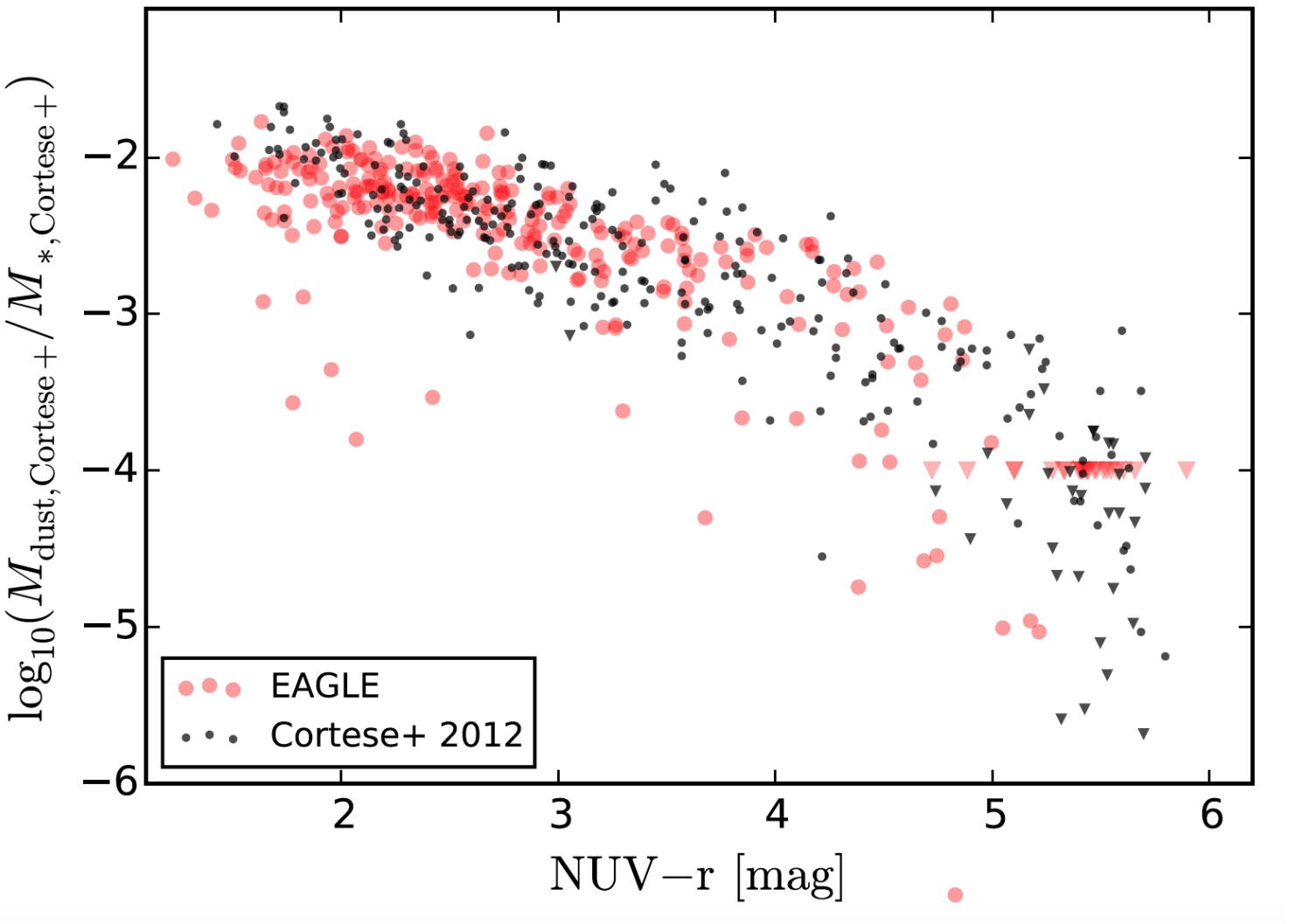
EAGLE: submm colors





Camps et al. 2016, 2018; Trayford et al. 2017

EAGLE: dust scaling relations

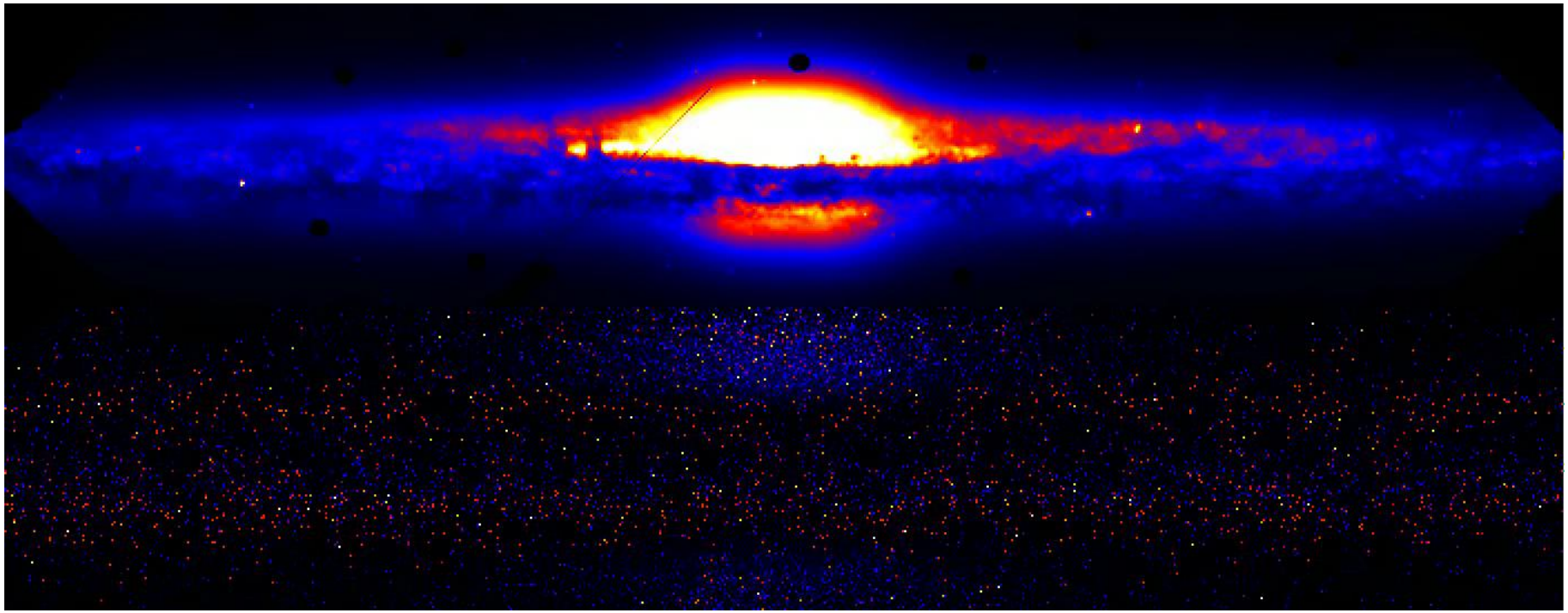


Camps et al. 2016, 2018; Trayford et al. 2017

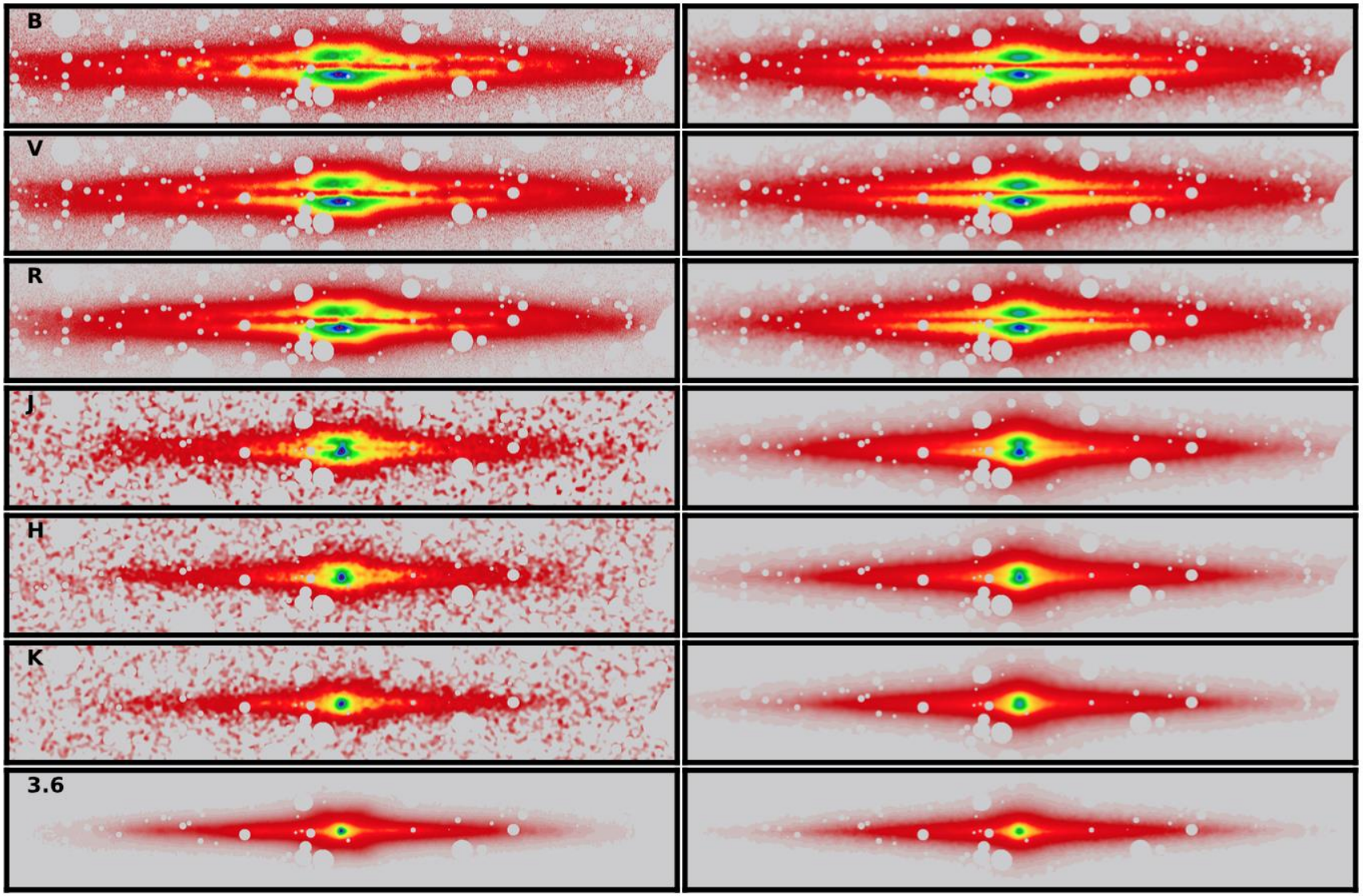
Edge-on spiral galaxies

Forward radiative transfer is now so efficient that we can use RT simulations in actual modelling/fitting.

Our approach: FitSKIRT (SKIRT radiative transfer + genetic algorithms)



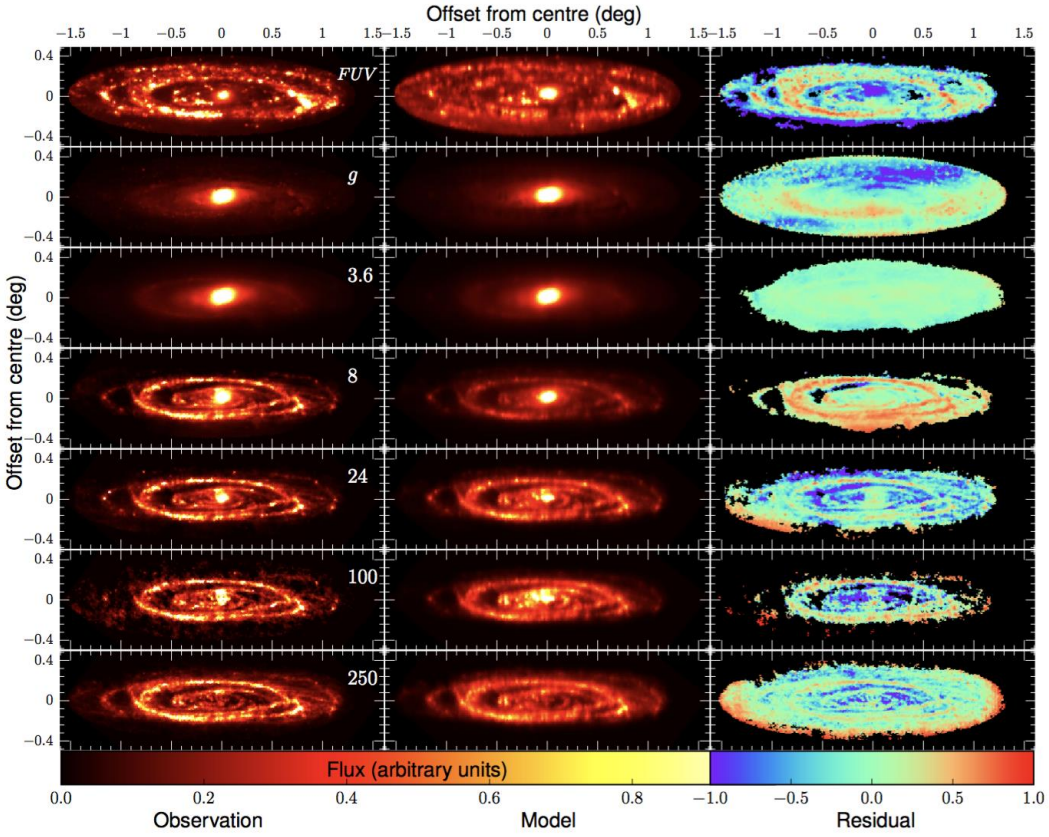
De Geyter et al. 2013, 2014

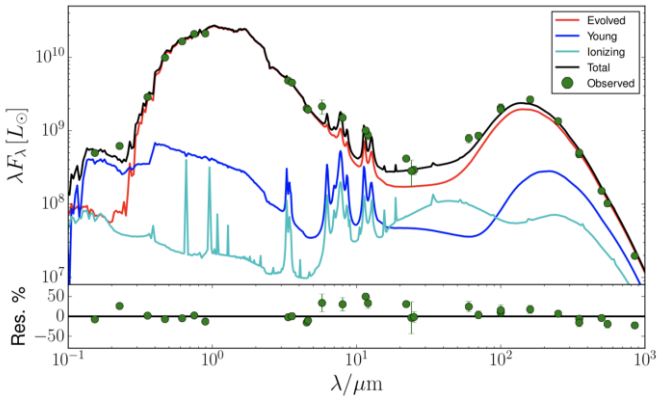


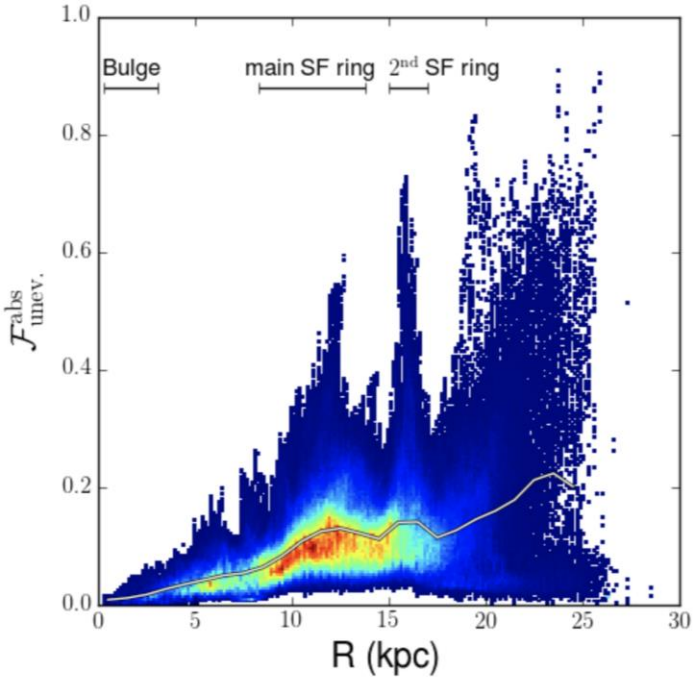
Additional deep UV, U-band and NIR images would always be welcome….

Baes et al. 2010; De Geyter et al. 2013, 2014; Mosenkov et al. 2016, 2018

Inclined/face-on spiral galaxies



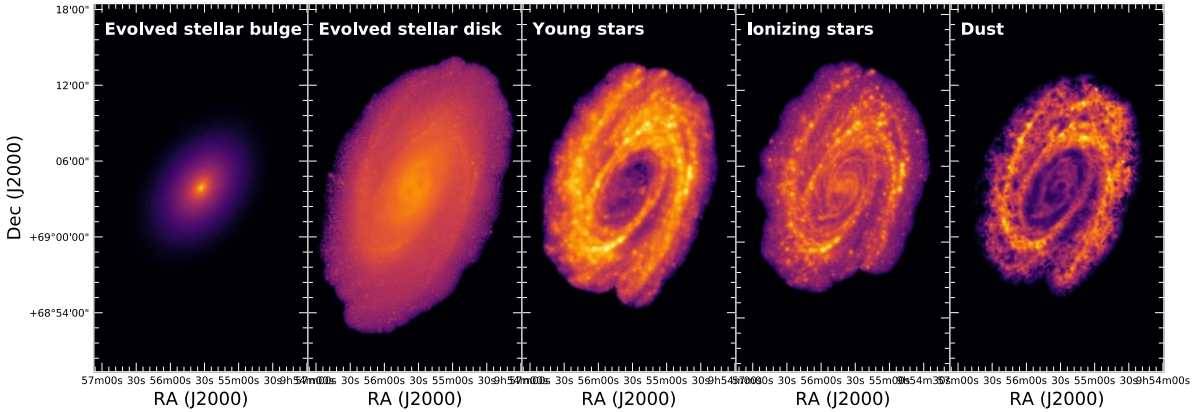




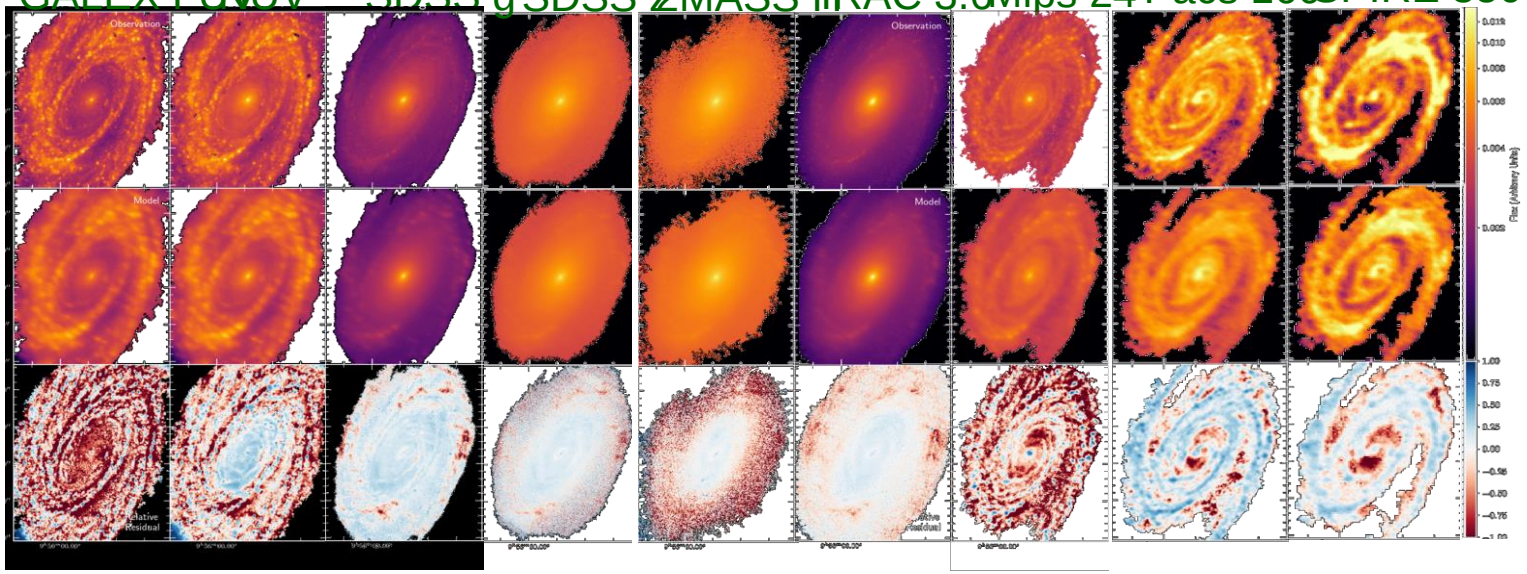
The bulge stars are the strongest heating agent for dust in Andromeda.

Viaene et al. 2014, 2017

Inclined/face-on spiral galaxies

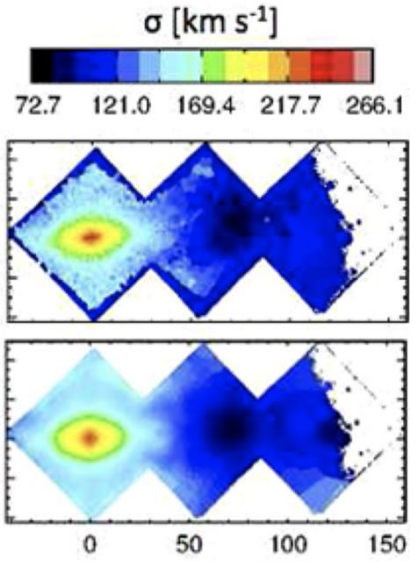


GALEX FUV NUV SDSS g SDSS z 2MASS H IRAC 3.6 Mips 24 Pacs 160 SPIRE 350

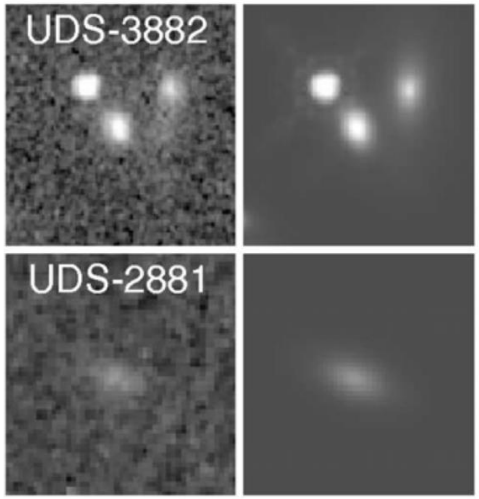


Verstocken et al. 2018

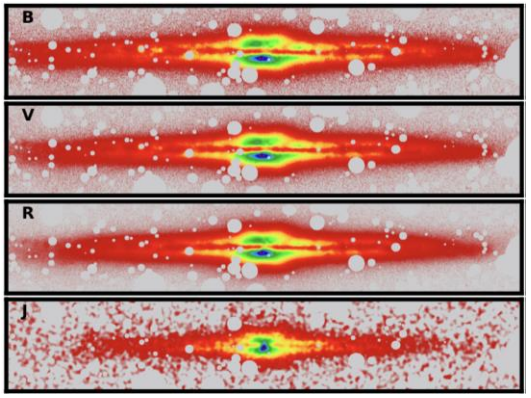
Extragalactic research at UGent



Galaxy kinematics and dynamics



Intermediate and high-z galaxies



Interstellar dust in galaxies

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Multi-wavelength extragalactic astronomy at UGent

Maarten Baes

Sterrenkundig Observatorium, Ghent University