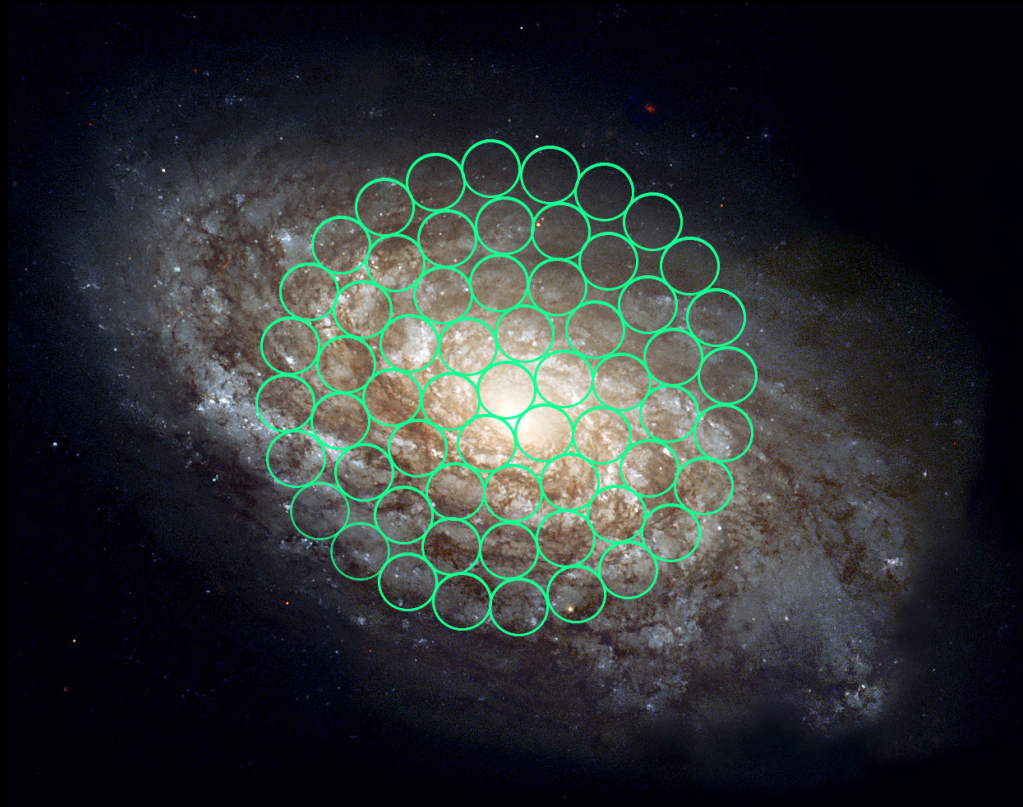
Dissecting discs and bulges with SAMI and Romulus

ICRAR International Centre for Radio Astronomy Research



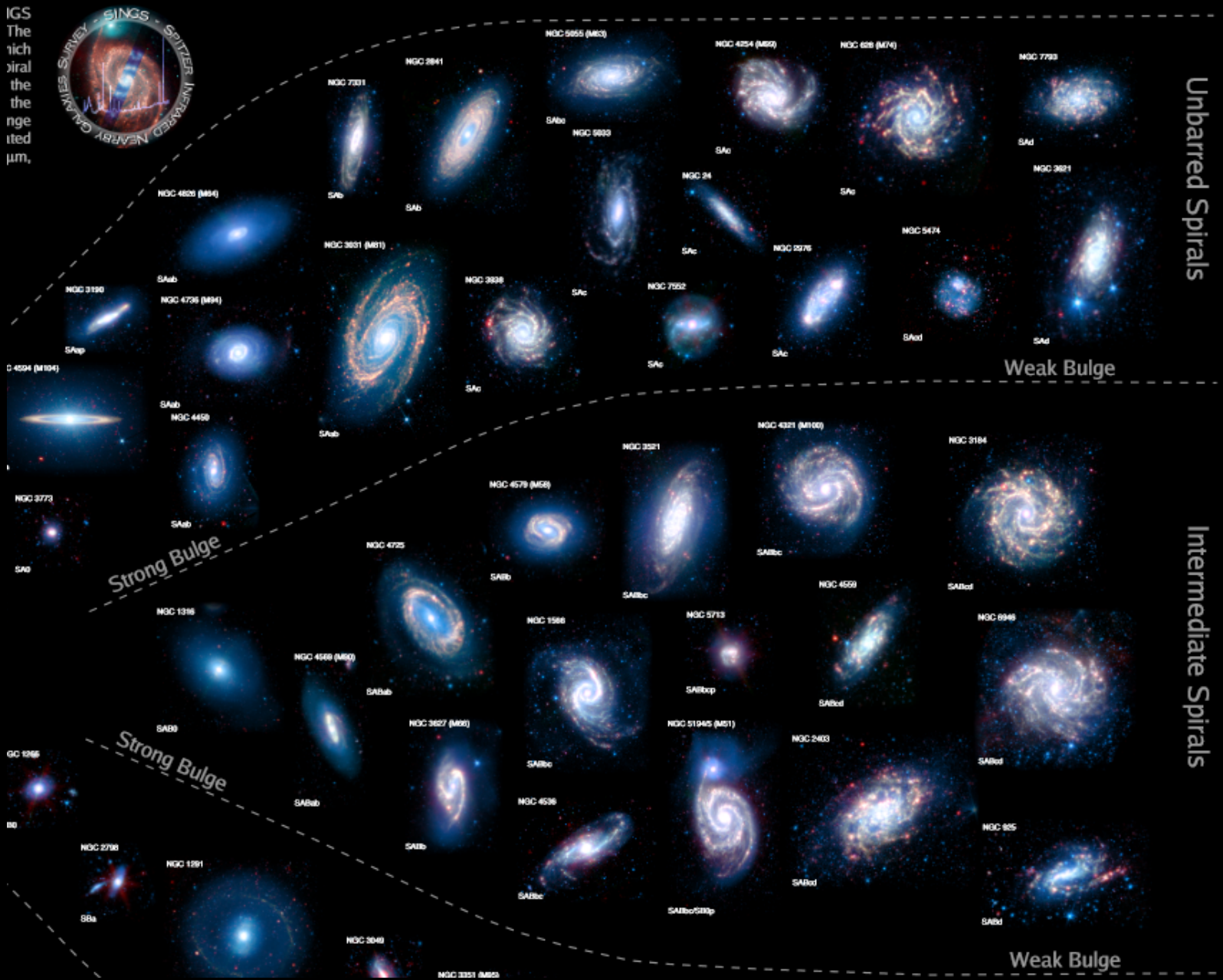
CAASTRO ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

Dan Taranu

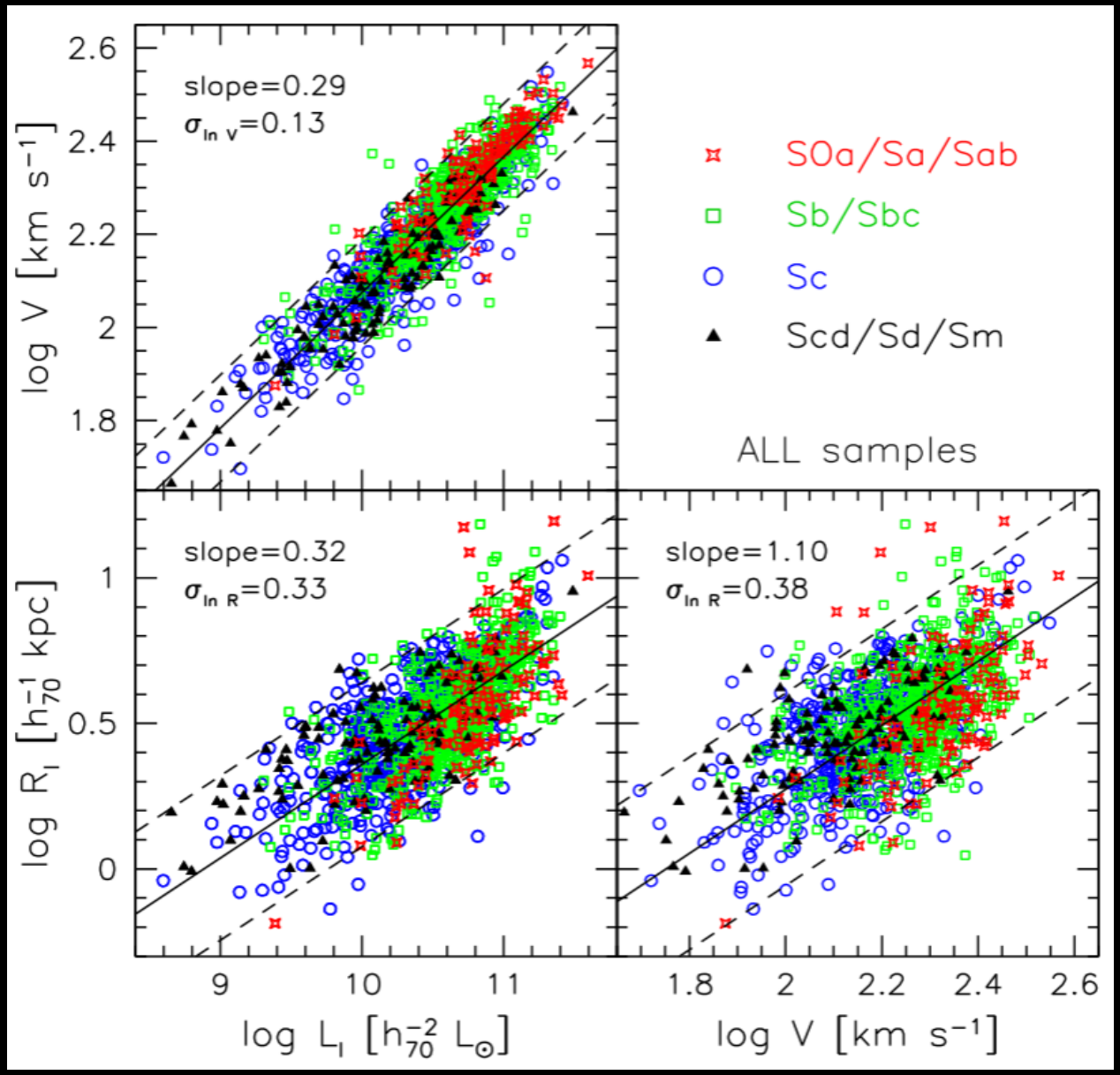
+ SAMI, Romulus

THE UNIVERSITY OF WESTERN AUSTRALIA

Nearby Galaxies Survey (SINGS) Hubble Tuning-Fork



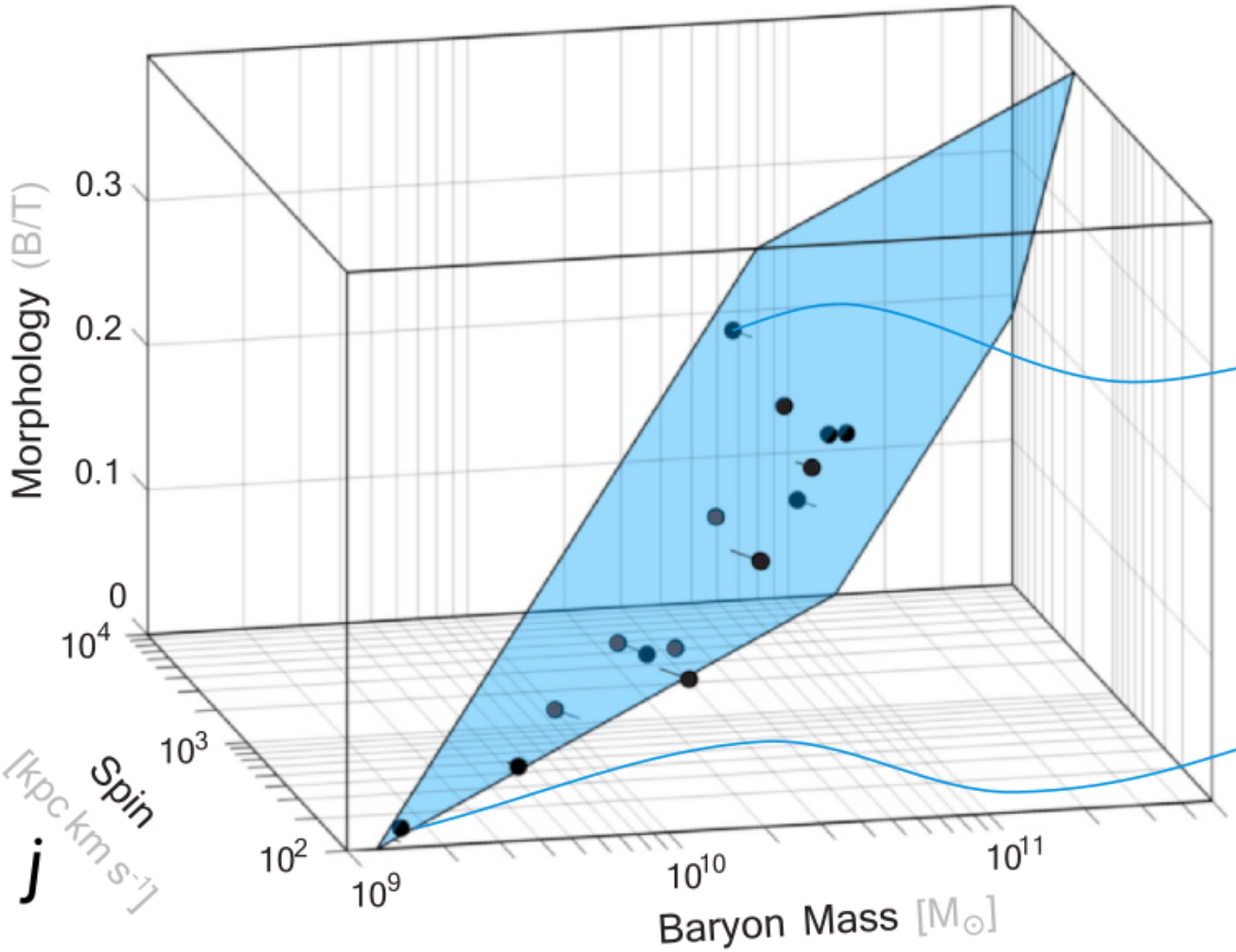
Spiral Galaxy Scaling Relations

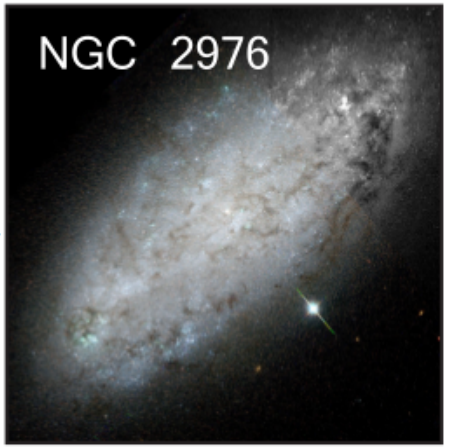


Courteau+07

Mass-Spin-Morphology plane

16 ~M spirals (THINGS) with well measured j (HI, CO, stars)*

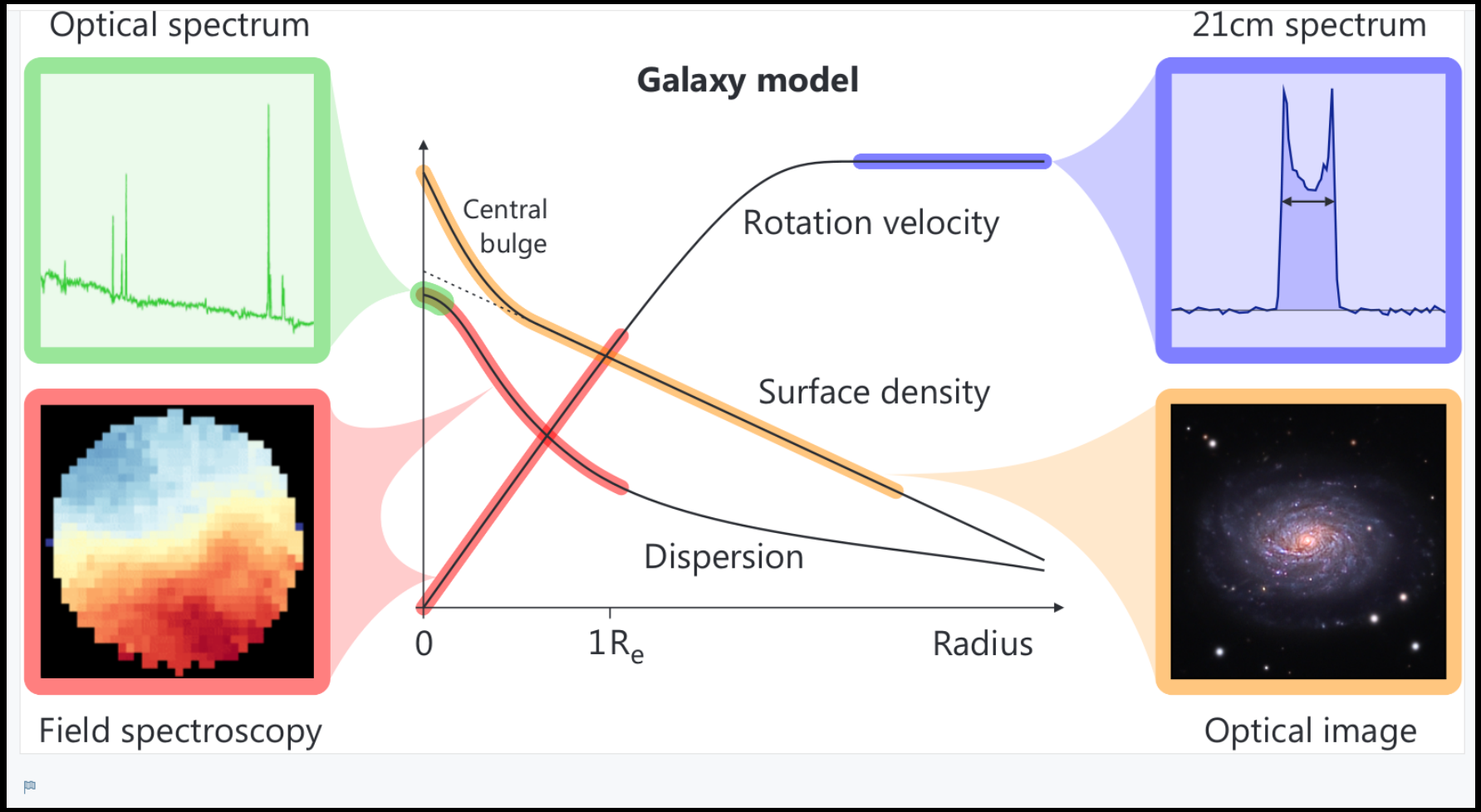




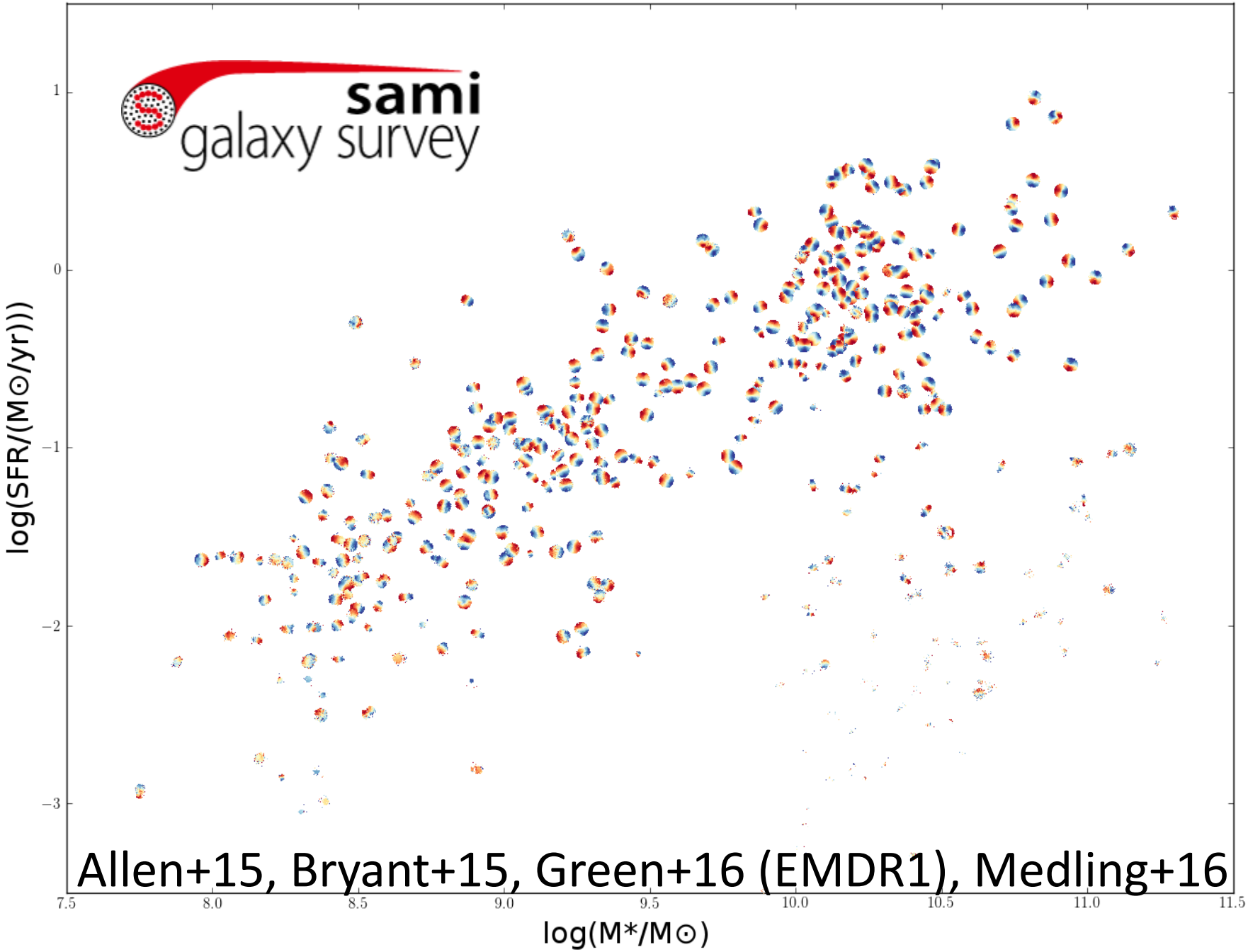
Obreschkow & Glazebrook (2014)

j = specific angular momentum (J/M)

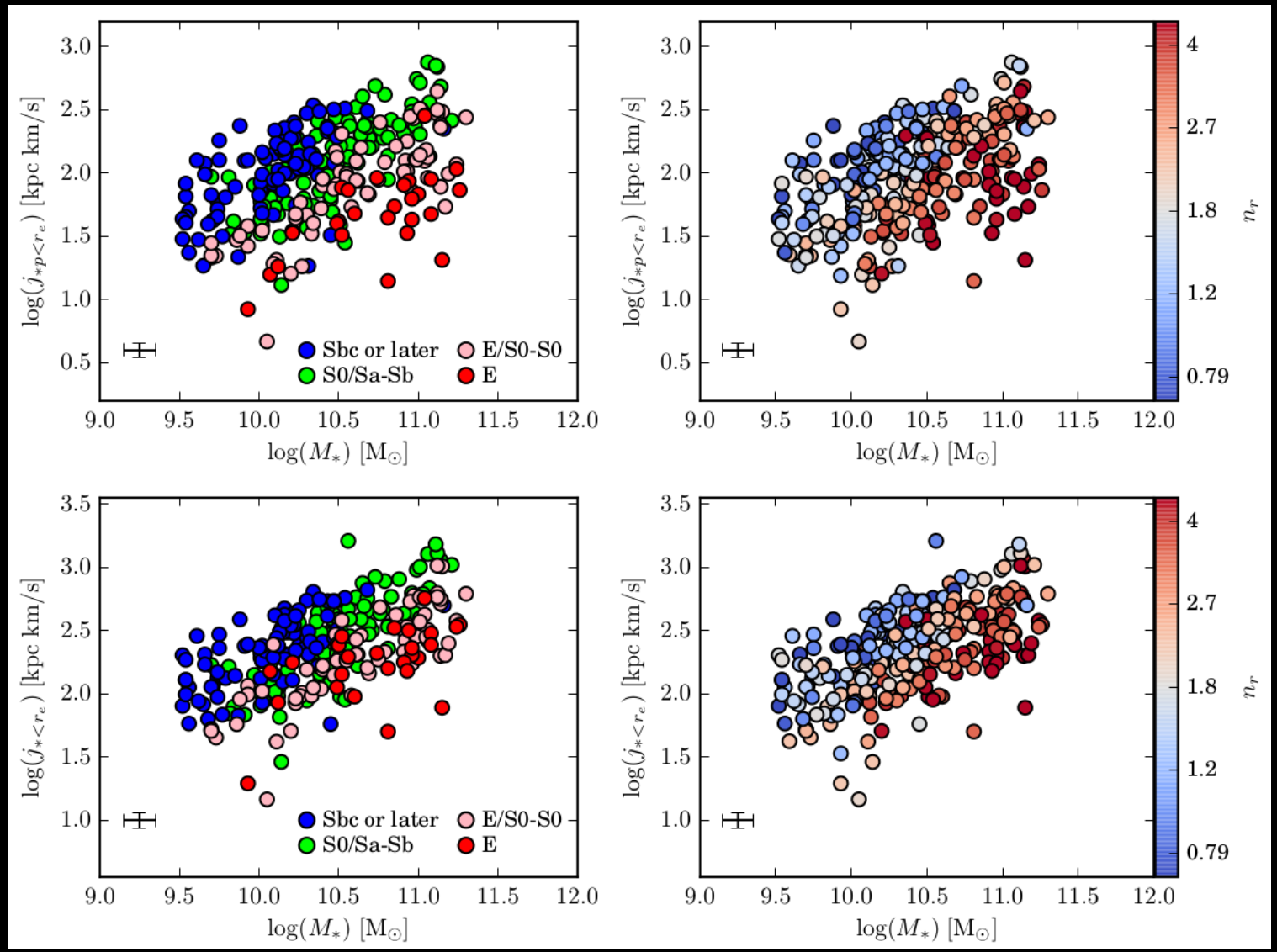
Dissecting Galaxies



From D. Obreschkow

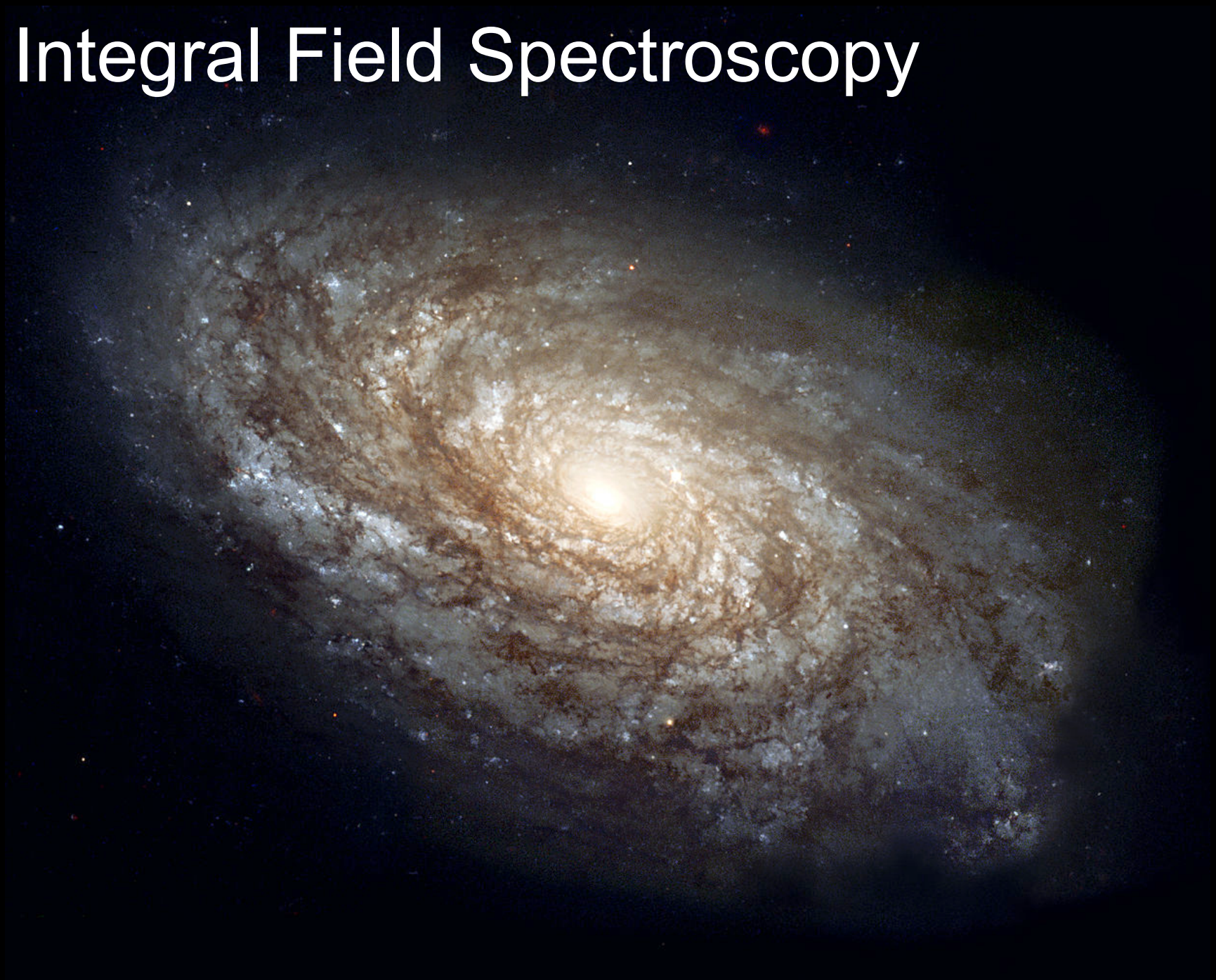

sami
galaxy survey
log(SFR/(M⊙/yr)))
log(M*/M⊙)
1
0
−1
−2
−3
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
Allen+15, Bryant+15, Green+16 (EMDR1), Medling+16

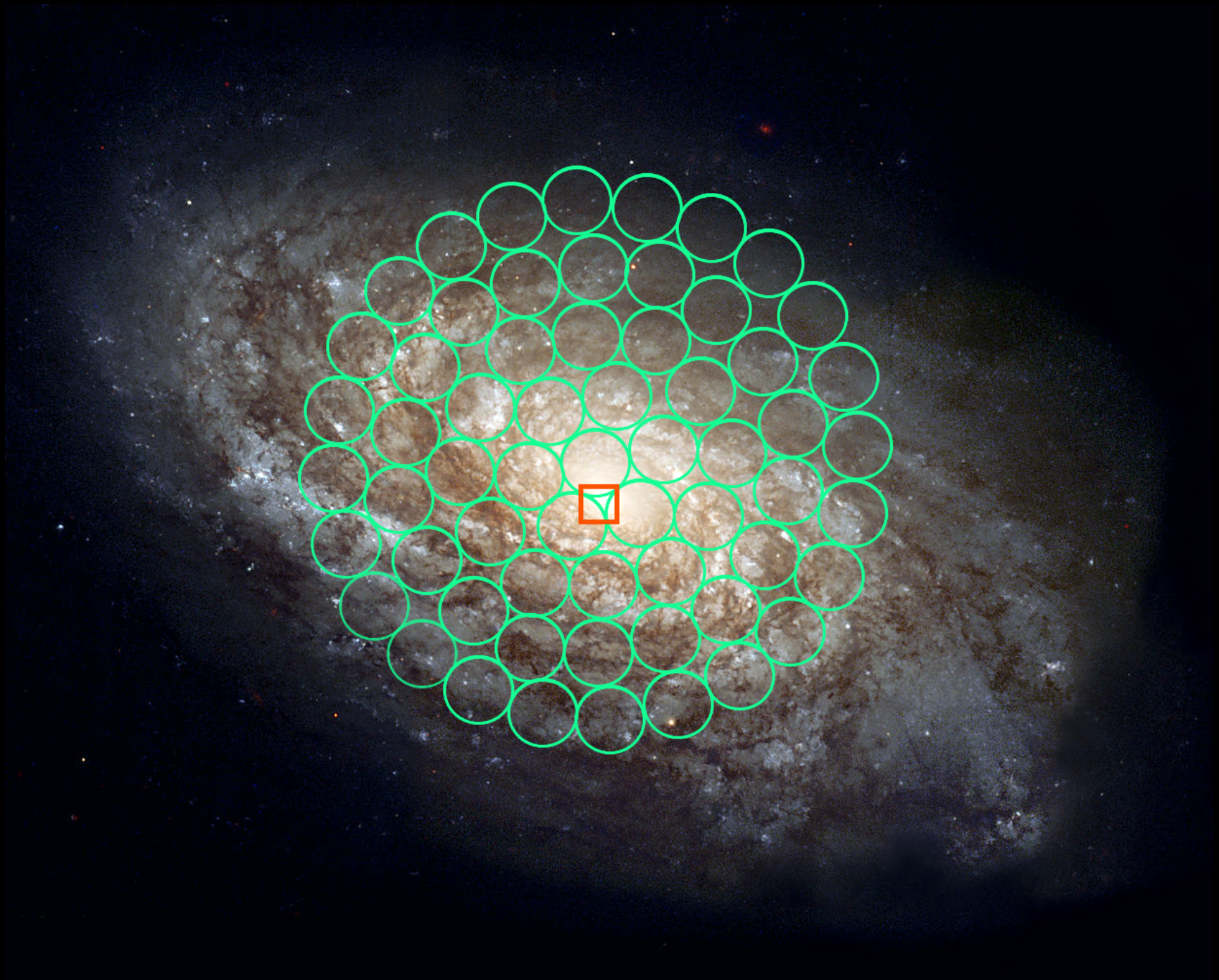
Spiral Galaxy Angular Momentum



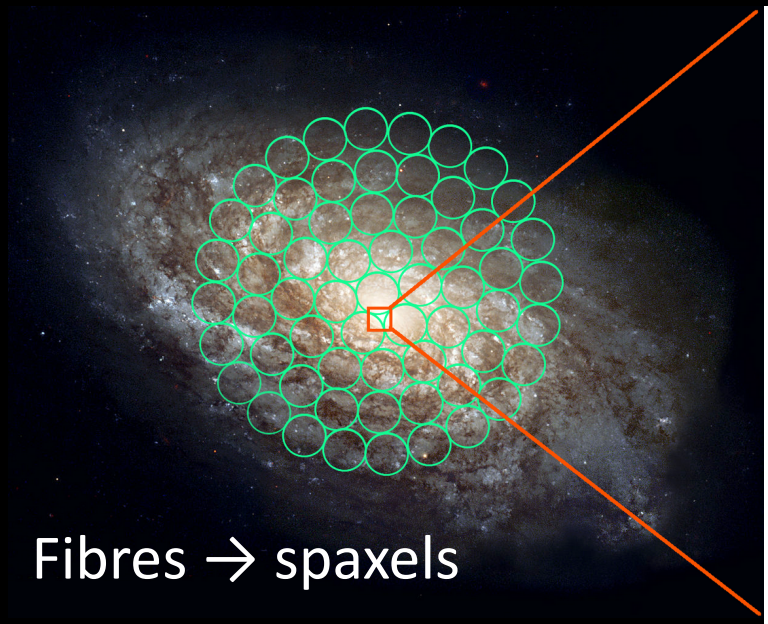
Cortese+16 (submitted)

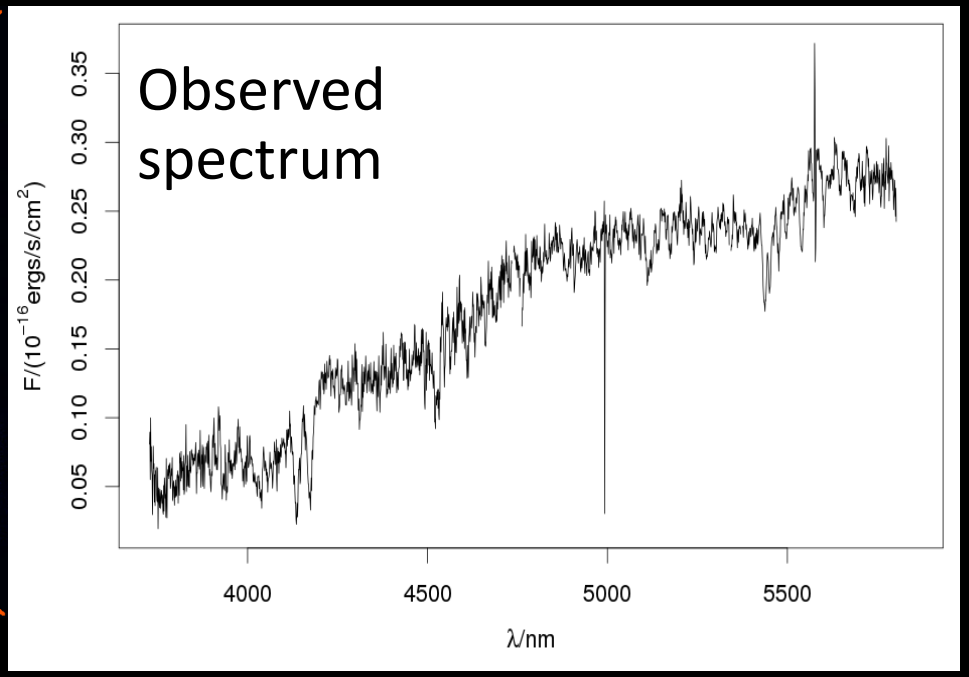
Integral Field Spectroscopy



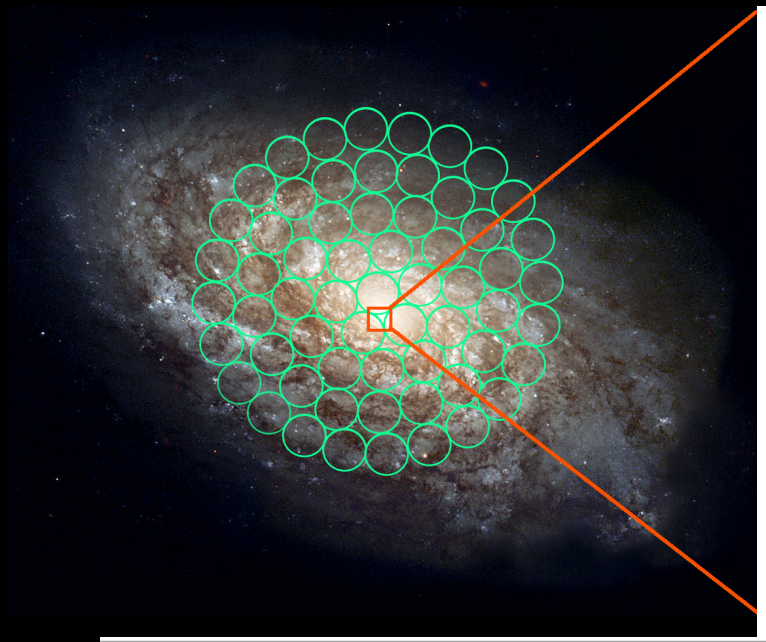


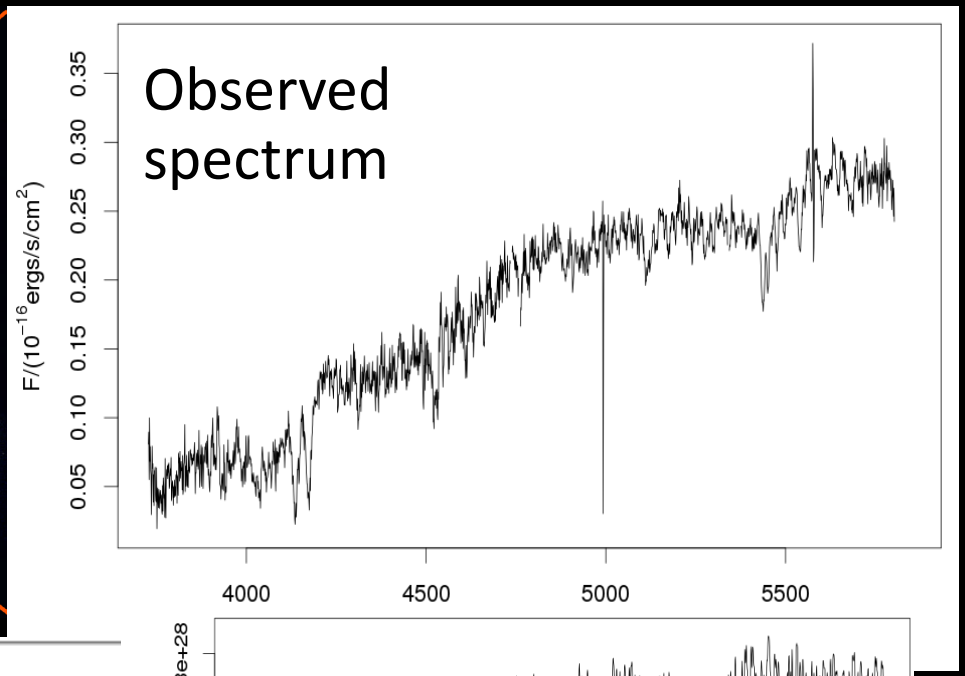
Integral Field Kinematics

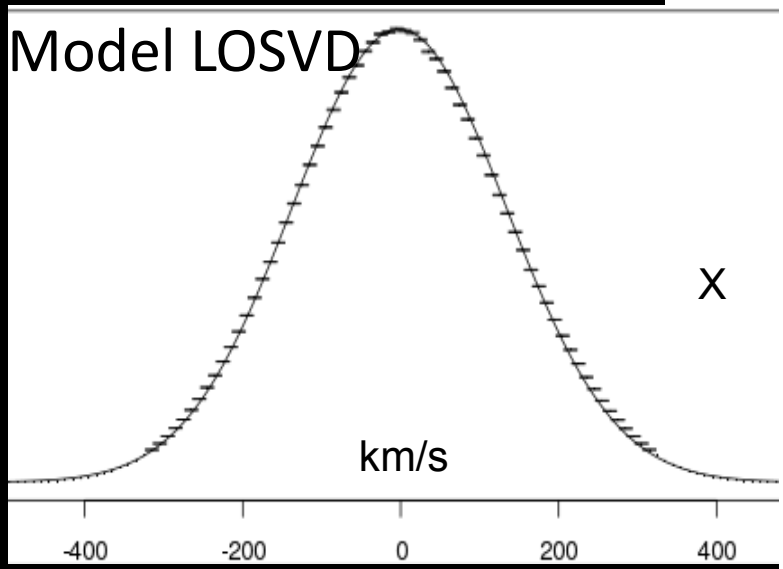




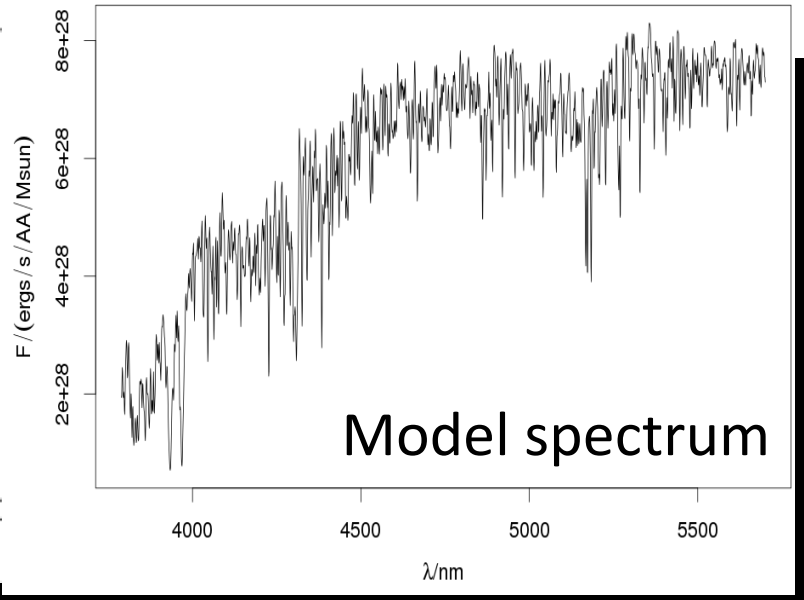
Integral Field Kinematics



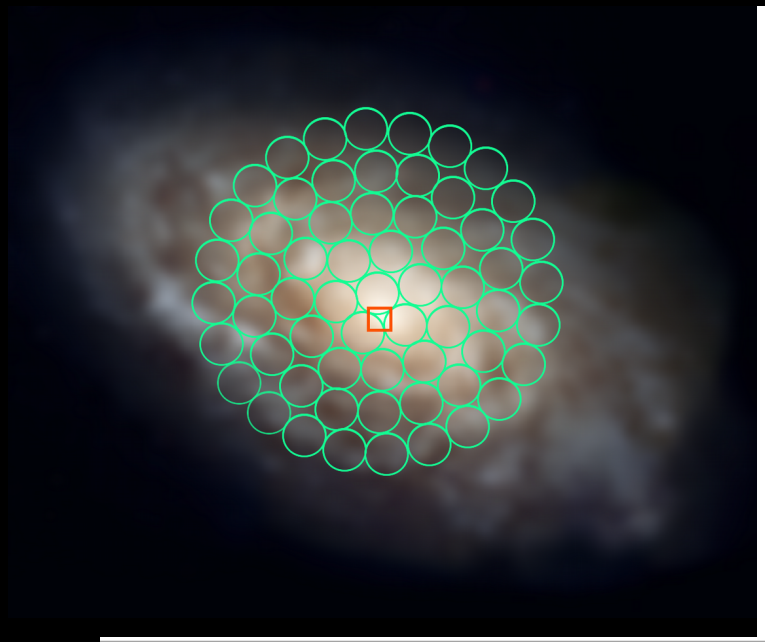


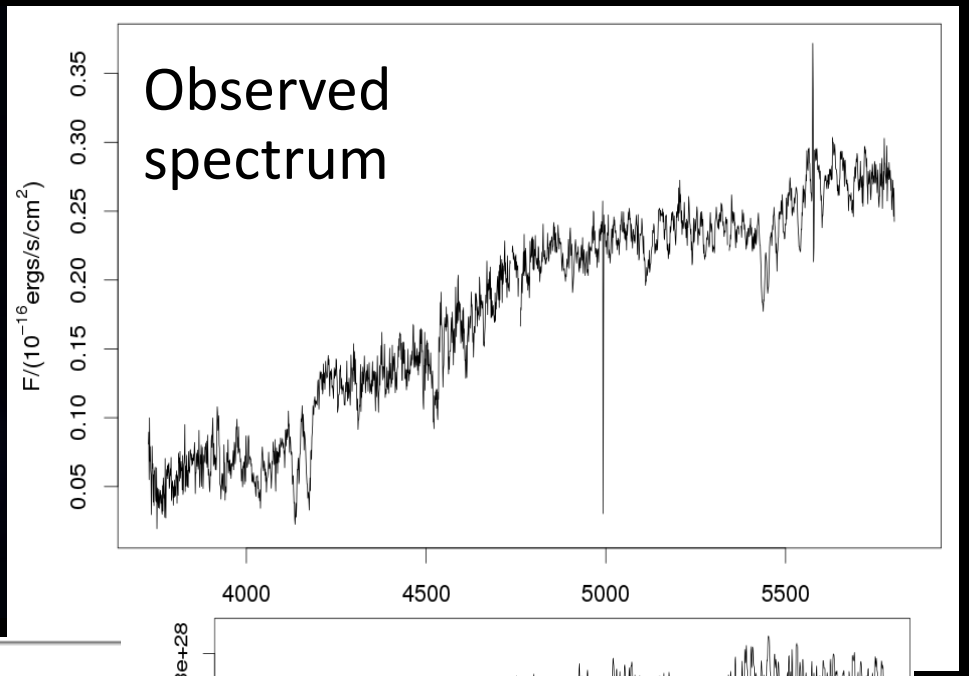


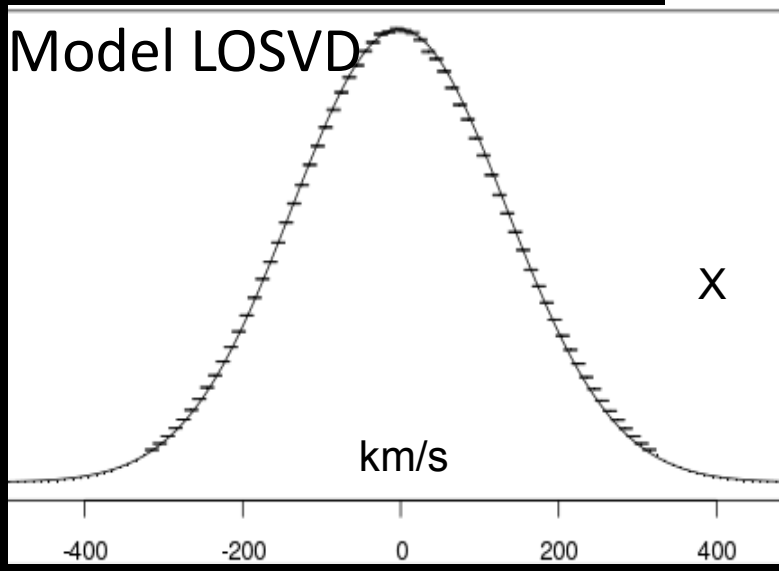
X



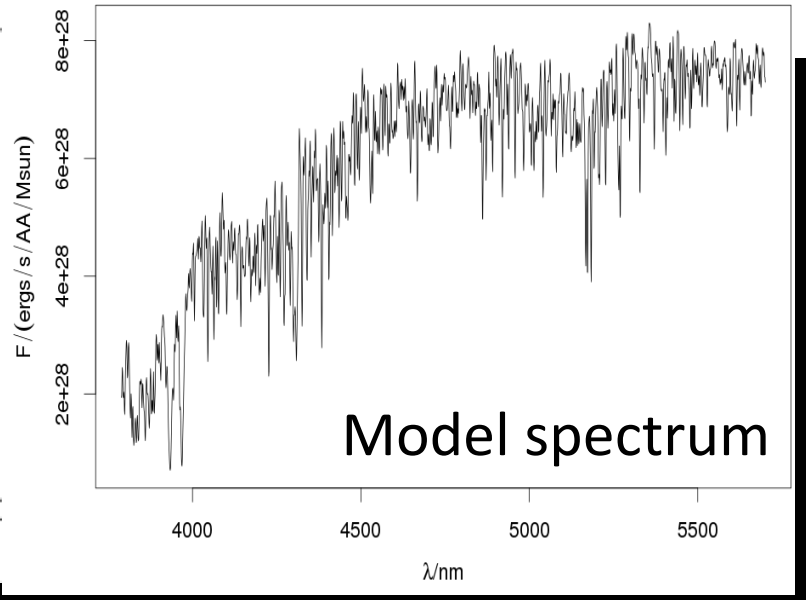
Integral Field Kinematics



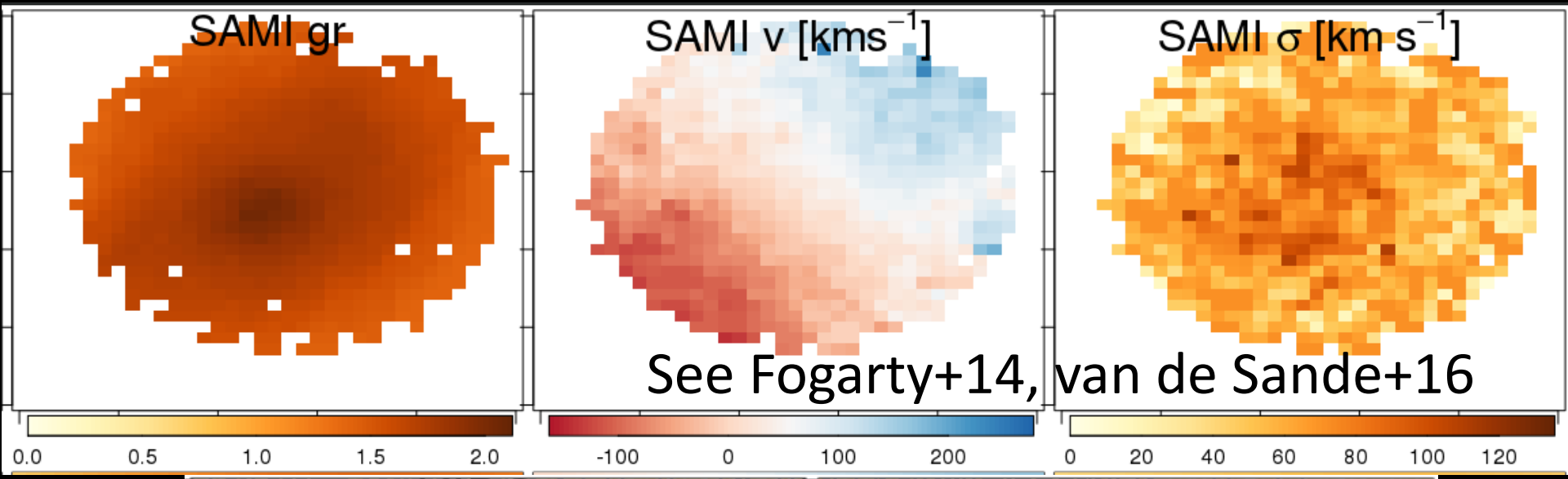




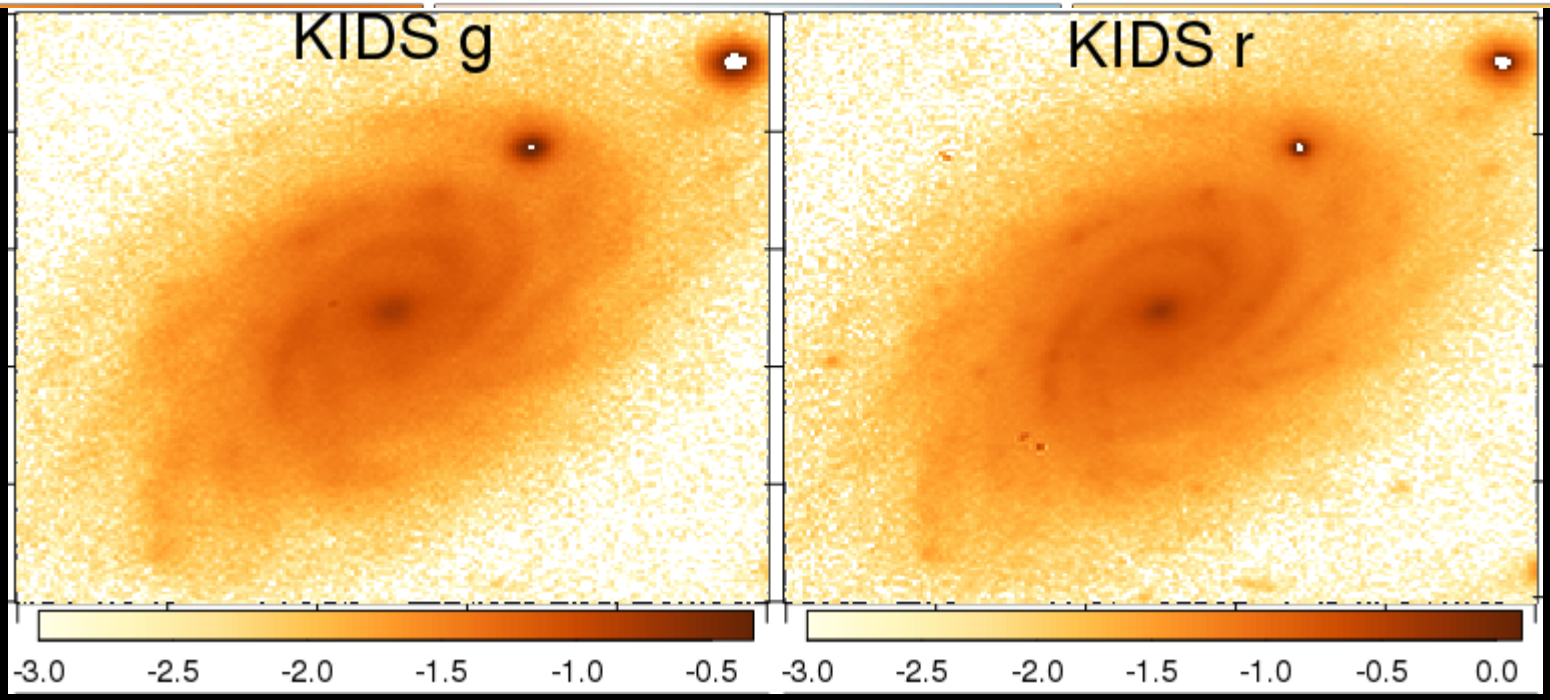
X

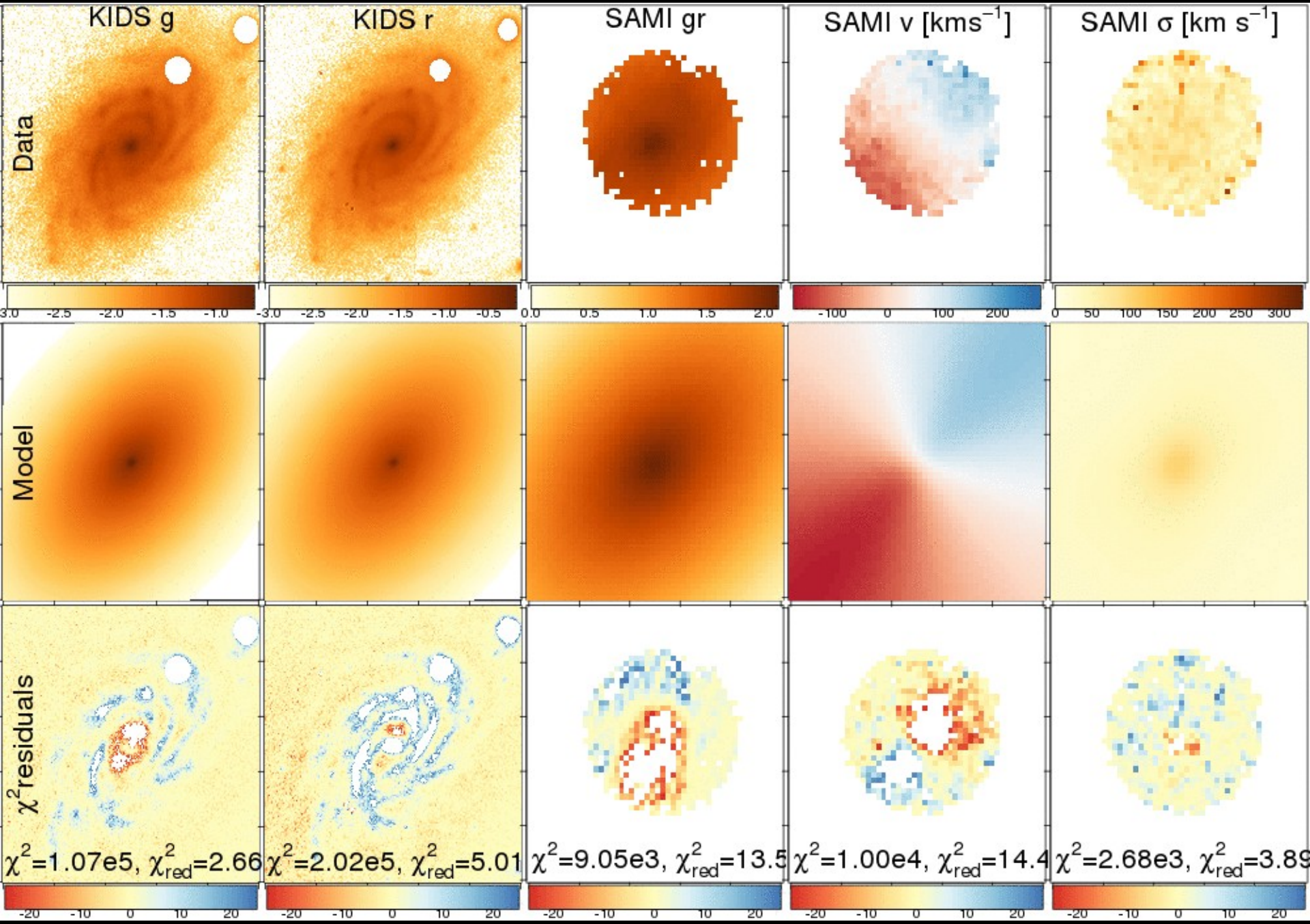


SAMI spectra + KiDS images

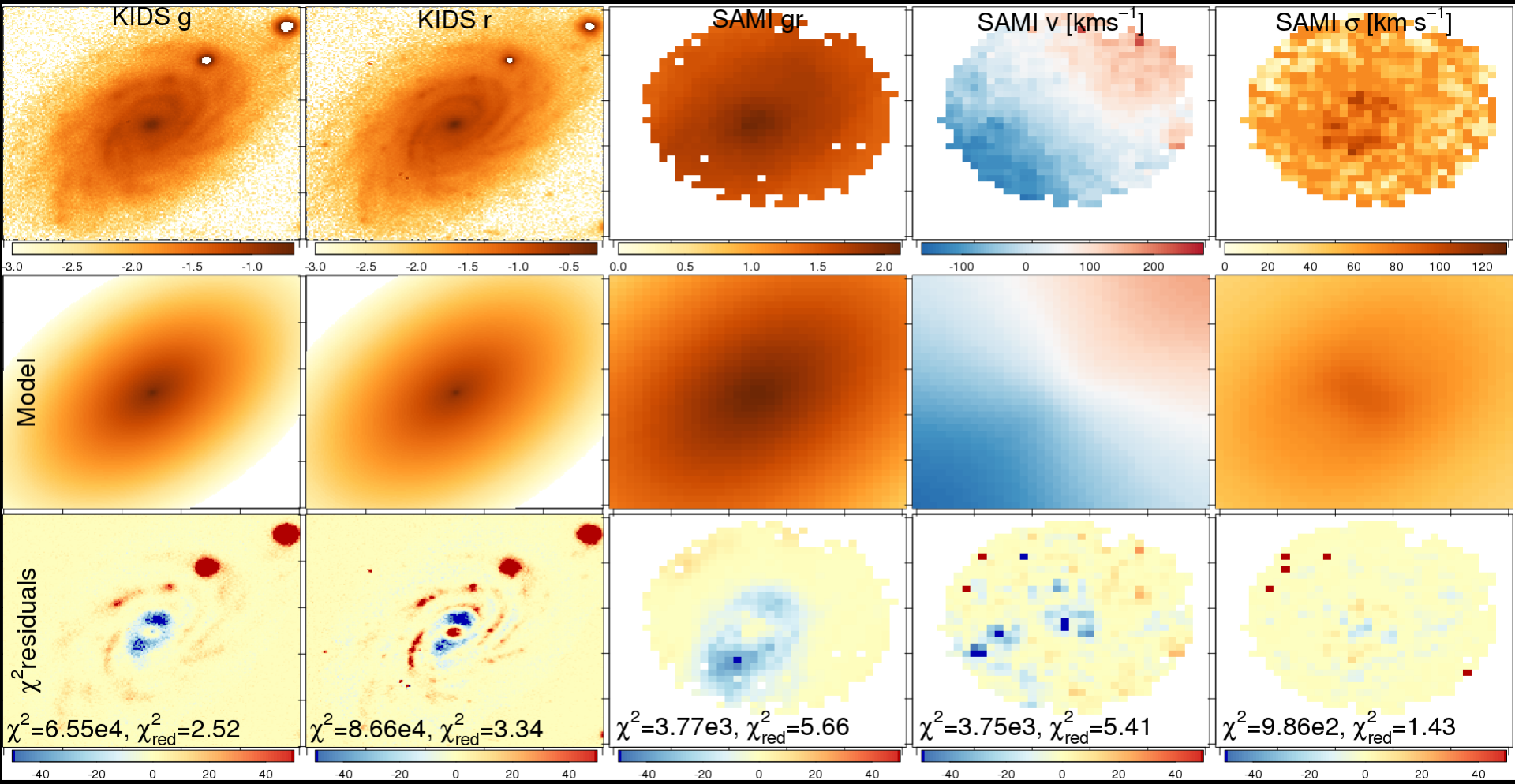


See Fogarty+14, van de Sande+16

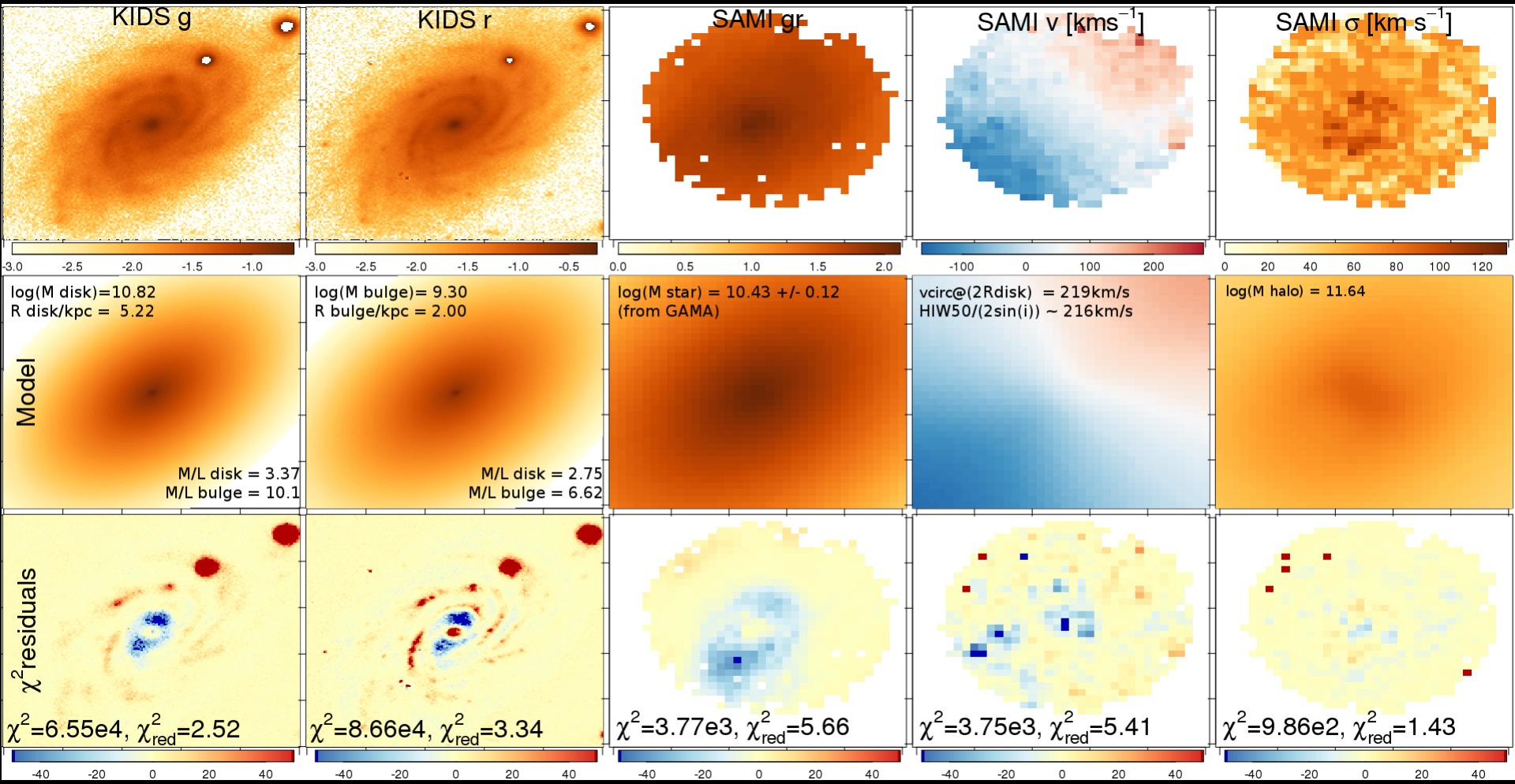



KIDS g
KIDS r
SAMI gr
SAMI v [kms^{-1}]
SAMI σ [km s^{-1}]
Data
Model
χ^2residuals
-3.0 -2.5 -2.0 -1.5 -1.0
-3.0 -2.5 -2.0 -1.5 -1.0 -0.5
0.0 0.5 1.0 1.5 2.0
-100 0 100 200
0 50 100 150 200 250 300
χ^2=1.07e5, χ^2_{red}=2.66
χ^2=2.02e5, χ^2_{red}=5.01
χ^2=9.05e3, χ^2_{red}=13.5
χ^2=1.00e4, χ^2_{red}=14.4
χ^2=2.68e3, χ^2_{red}=3.89
-20 -10 0 10 20

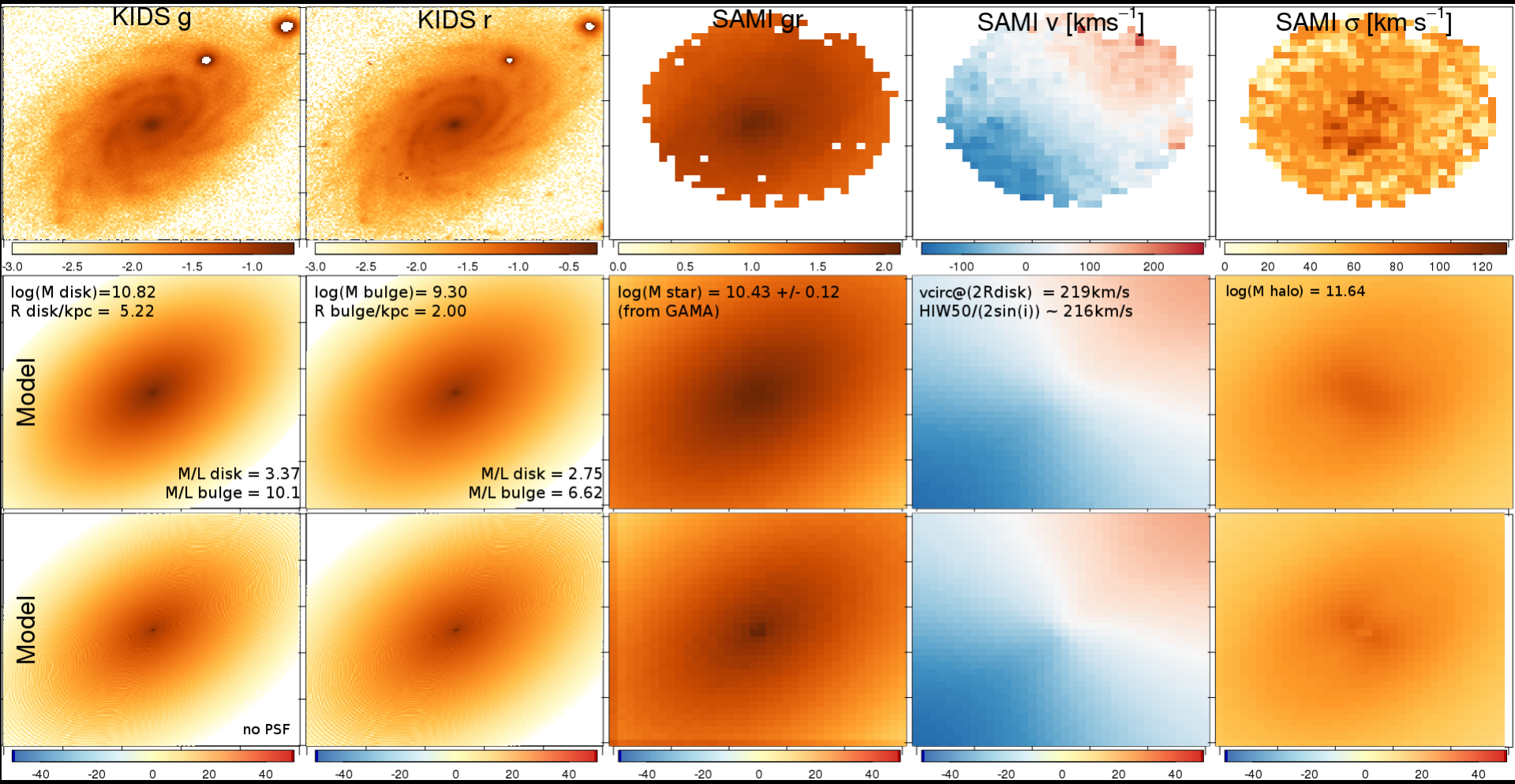
Best fit


KIDS g
KIDS r
SAMI gr
SAMI v [kms^{-1}]
SAMI σ [km s^{-1}]
-3.0 -2.5 -2.0 -1.5 -1.0
-3.0 -2.5 -2.0 -1.5 -1.0 -0.5
0.0 0.5 1.0 1.5 2.0
-100 0 100 200
0 20 40 60 80 100 120
Model
χ^2residuals
χ^2=6.55e4, χ^2_{red}=2.52
χ^2=8.66e4, χ^2_{red}=3.34
χ^2=3.77e3, χ^2_{red}=5.66
χ^2=3.75e3, χ^2_{red}=5.41
χ^2=9.86e2, χ^2_{red}=1.43
-40 -20 0 20 40

Best fit

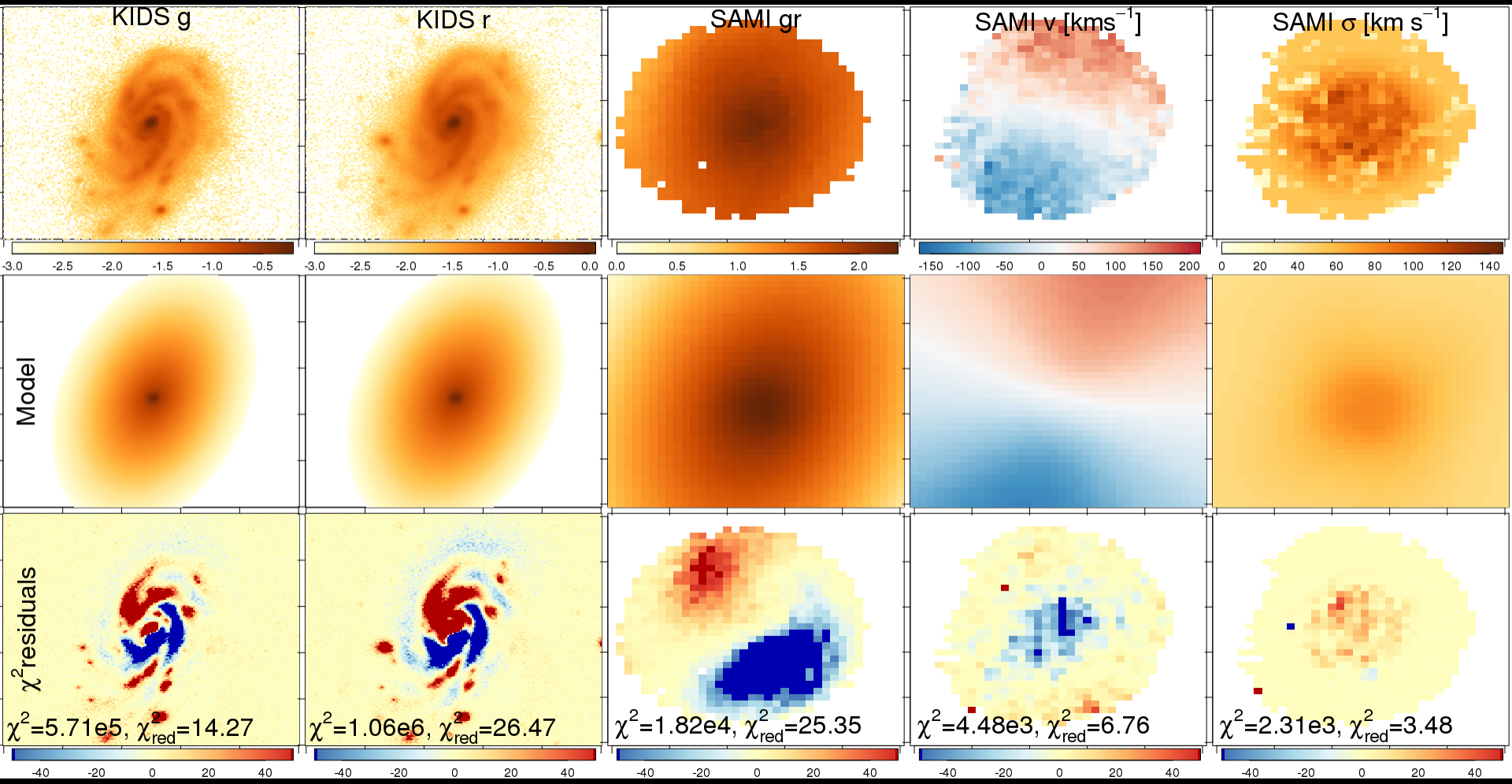

KIDS g
KIDS r
SAMI gr
SAMI v [kms^{-1}]
SAMI σ [km s^{-1}]
-3.0 -2.5 -2.0 -1.5 -1.0
-3.0 -2.5 -2.0 -1.5 -1.0 -0.5
0.0 0.5 1.0 1.5 2.0
-100 0 100 200
0 20 40 60 80 100 120
log(M disk)=10.82
R disk/kpc = 5.22
log(M bulge)= 9.30
R bulge/kpc = 2.00
log(M star) = 10.43 +/- 0.12
(from GAMA)
vcirc@(2Rdisk) = 219km/s
HIW50/(2sin(i)) ~ 216km/s
log(M halo) = 11.64
Model
M/L disk = 3.37
M/L bulge = 10.1
M/L disk = 2.75
M/L bulge = 6.62
χ^{2}residuals
χ^2=6.55e4, χ$^2_{red}$=2.52
χ^2=8.66e4, χ$^2_{red}$=3.34
χ^2=3.77e3, χ$^2_{red}$=5.66
χ^2=3.75e3, χ$^2_{red}$=5.41
χ^2=9.86e2, χ$^2_{red}$=1.43
-40 -20 0 20 40

Best fit


KIDS g
KIDS r
SAMI gr
SAMI v [kms^{-1}]
SAMI σ [km s^{-1}]
-3.0 -2.5 -2.0 -1.5 -1.0
-3.0 -2.5 -2.0 -1.5 -1.0 -0.5
0.0 0.5 1.0 1.5 2.0
-100 0 100 200
0 20 40 60 80 100 120
log(M disk)=10.82
R disk/kpc = 5.22
log(M bulge)= 9.30
R bulge/kpc = 2.00
log(M star) = 10.43 +/- 0.12
(from GAMA)
vcirc@(2Rdisk) = 219km/s
HIW50/(2sin(i)) ~ 216km/s
log(M halo) = 11.64
Model
M/L disk = 3.37
M/L bulge = 10.1
M/L disk = 2.75
M/L bulge = 6.62
Model
no PSF
-40 -20 0 20 40

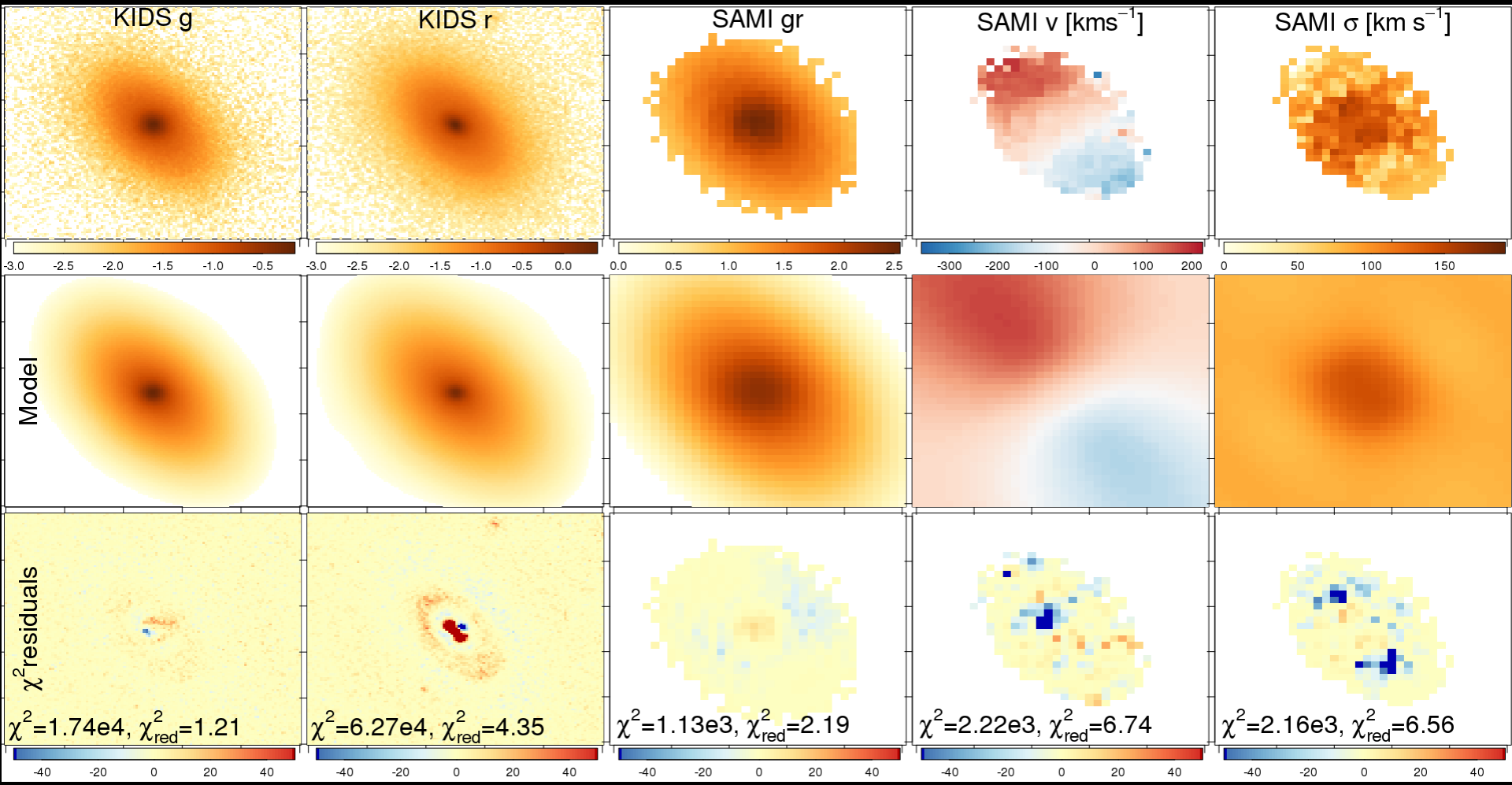
Best fit – strong asymmetries

Forecast: tornados + hail

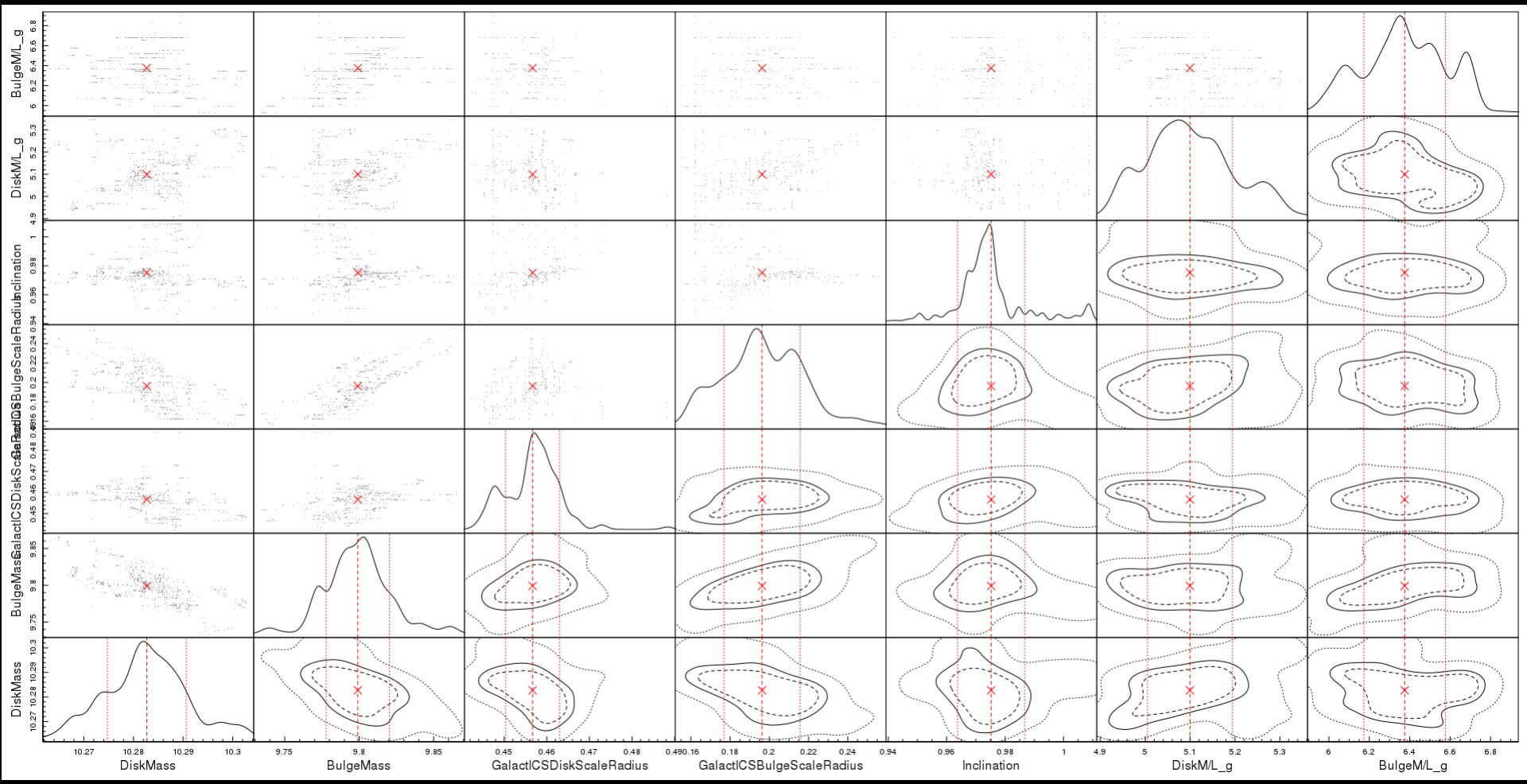


Best fit – weak asymmetries

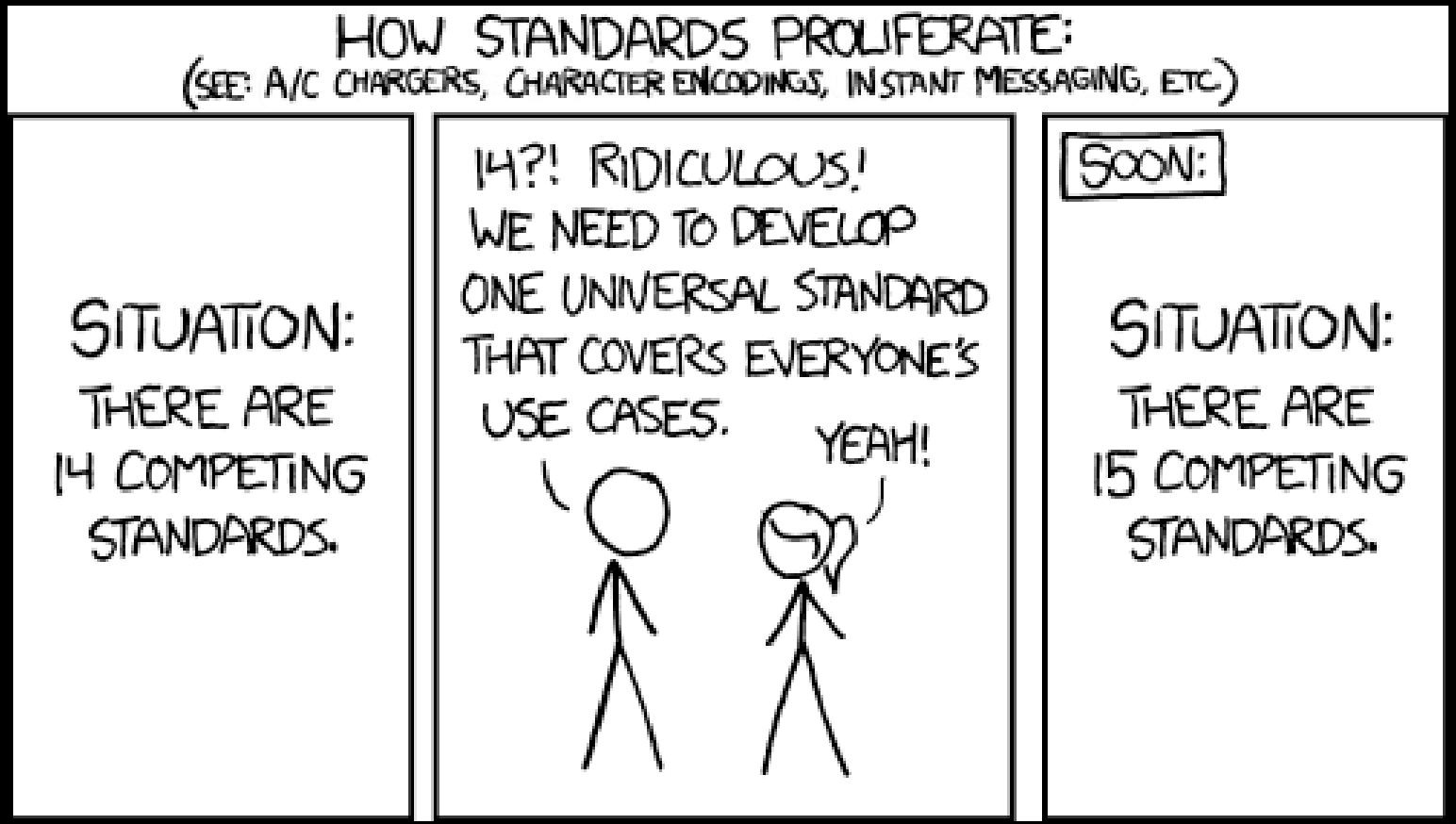
Forecast: sunny :)



MCMC PDF*


DiskMass
BulgeMass
GalactICSDiskScaleRadius
GalactICSBulgeScaleRadius
Inclination
DiskM/L_g
BulgeM/L_g

Why another 2D code?

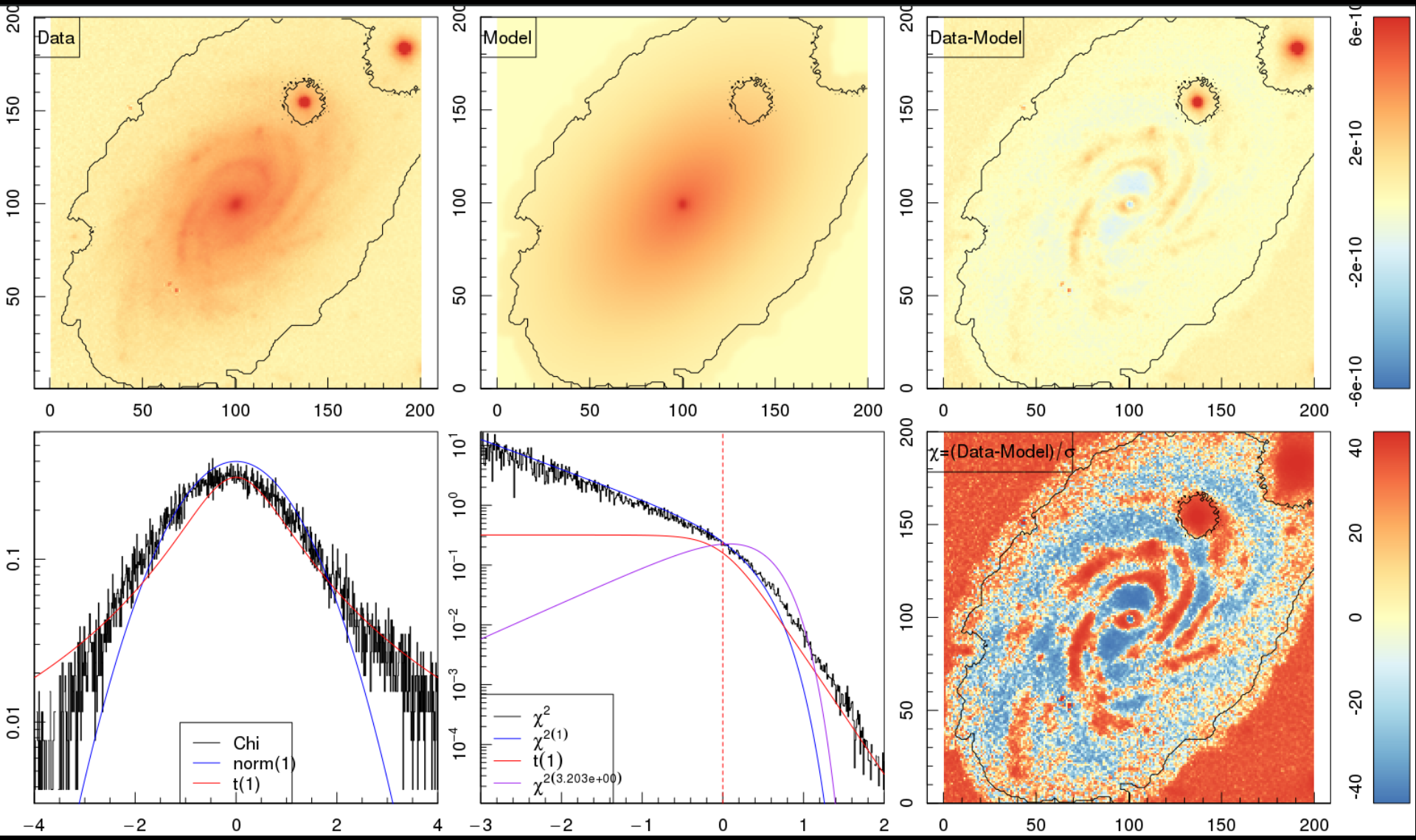


xkcd

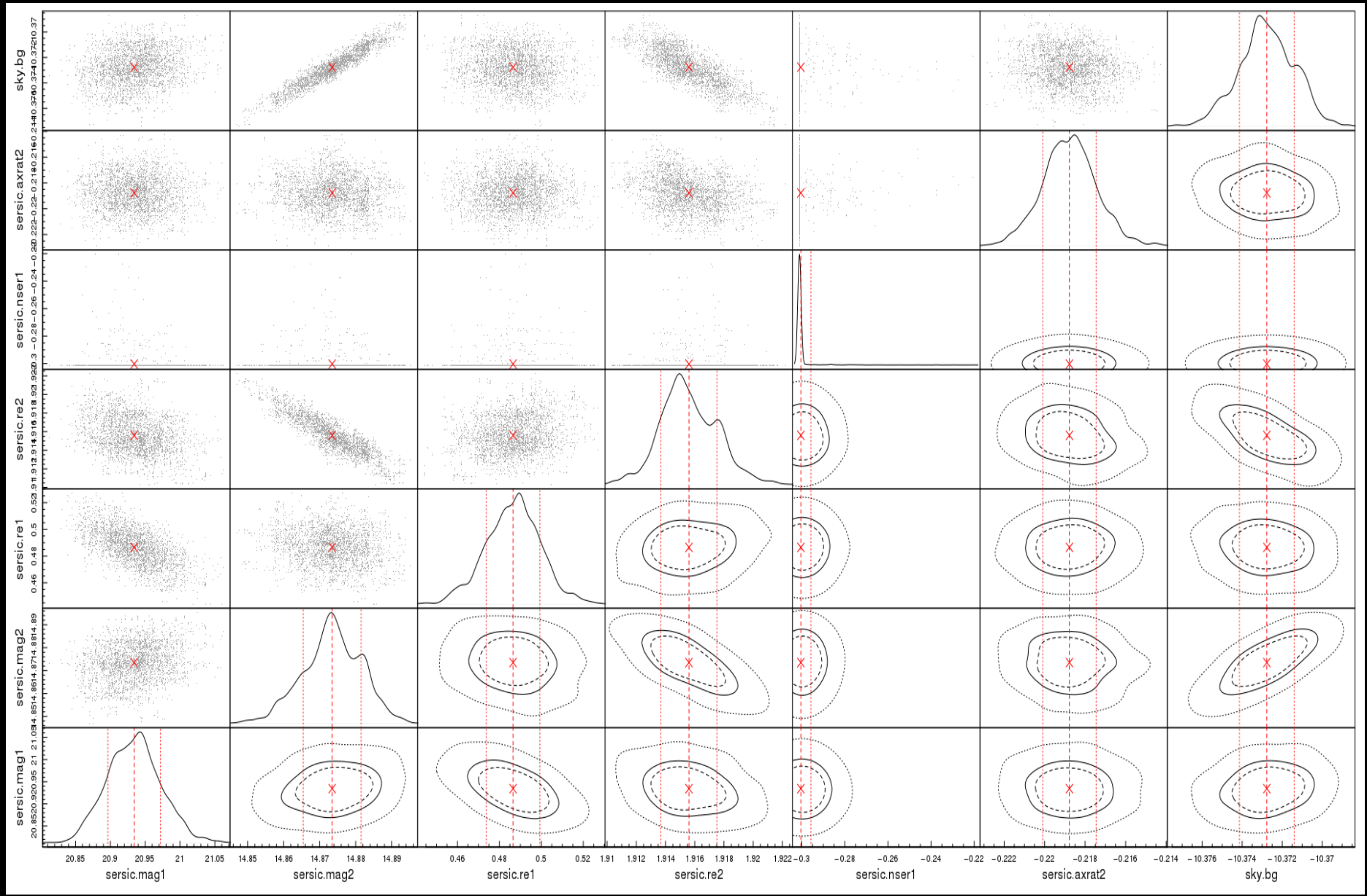
Why another 2D code?

- Popular codes GALFIT, GIM2D closed-source
- Many use poor optimizers (Levenberg-Marquardt)
- Integration inaccurate/slow
- Few use Bayesian (MCMC) methods → errors not robust
-
- I wanted a fast code to:
  - Compare 2D/3D modelling results
  - Test new features quickly
  - Understand origin of tiny uncertainties

ProFit 2D: (github.com/asgr/ProFit)

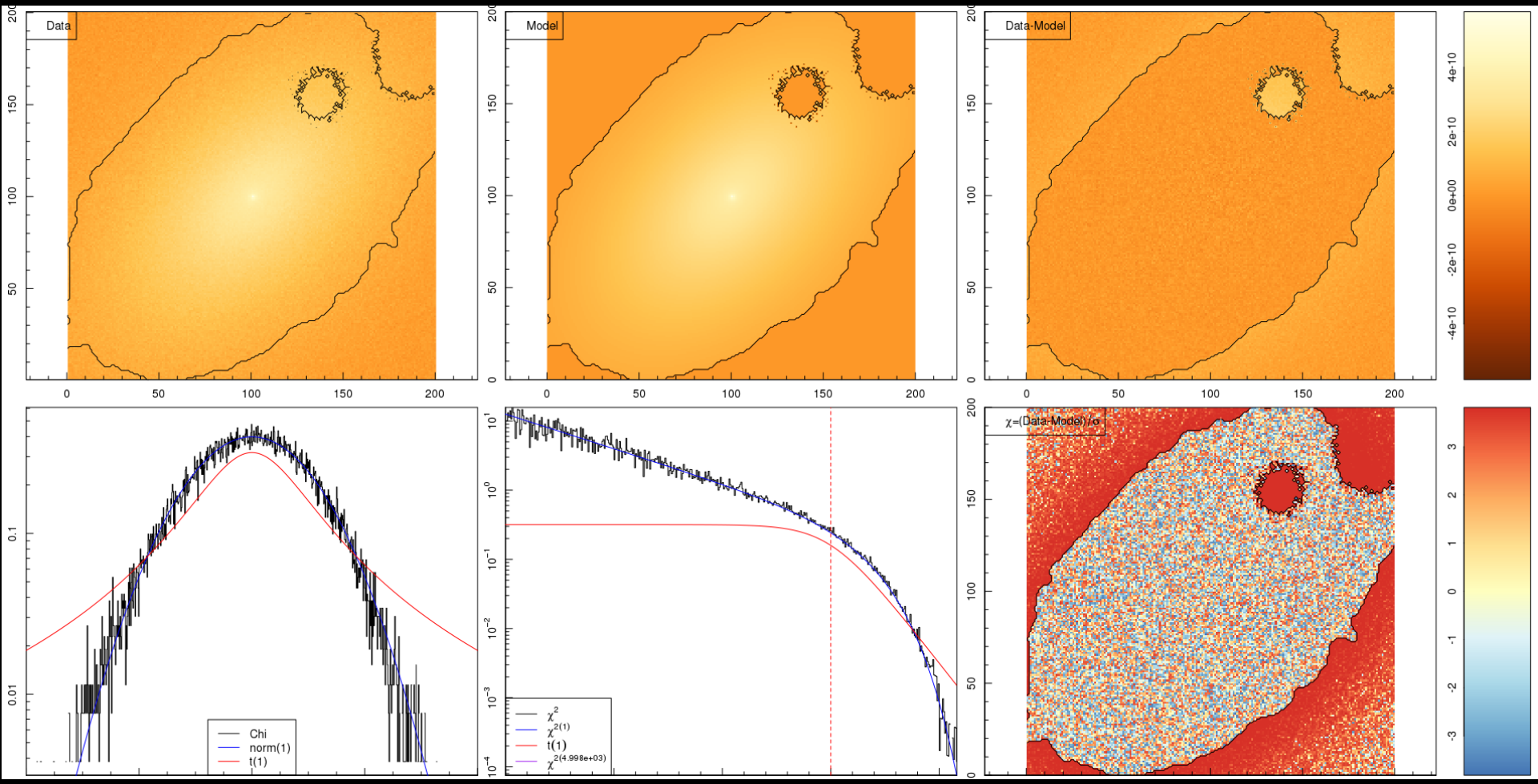


ProFit 2D PDFs

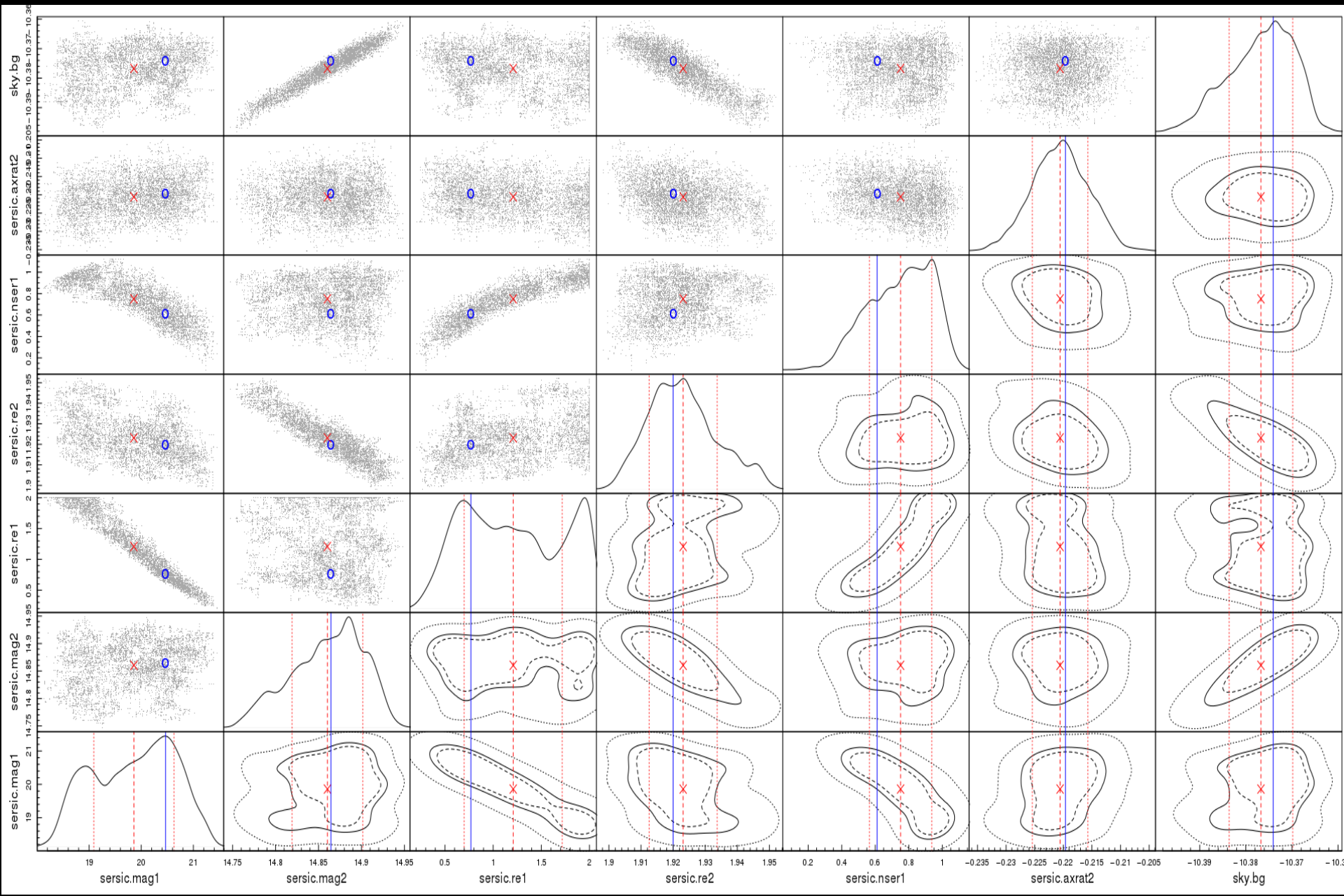


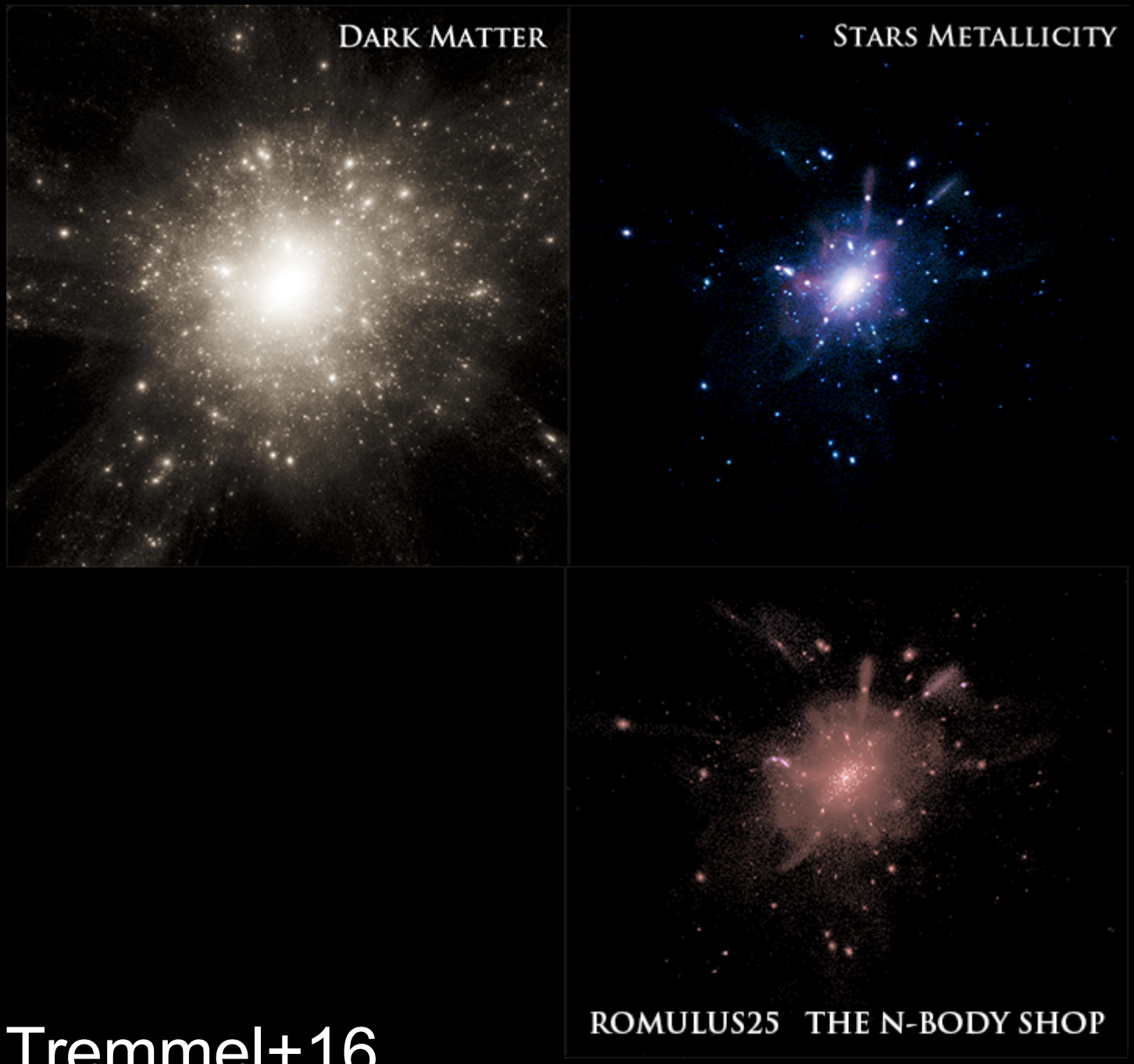
ProFitting from the best fit

Climate, not weather



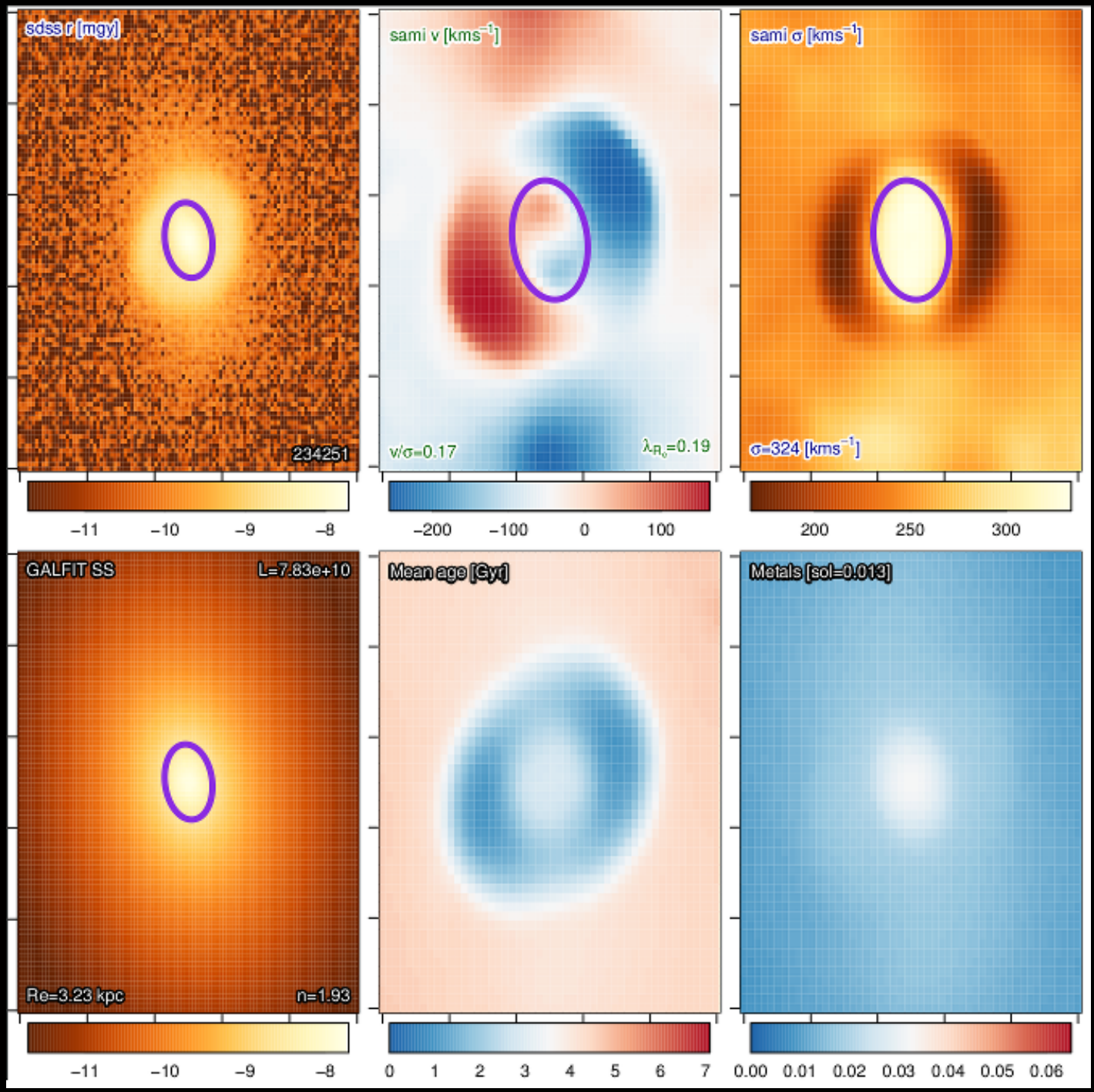
ProFit 2D PDFs – fitting the best fit



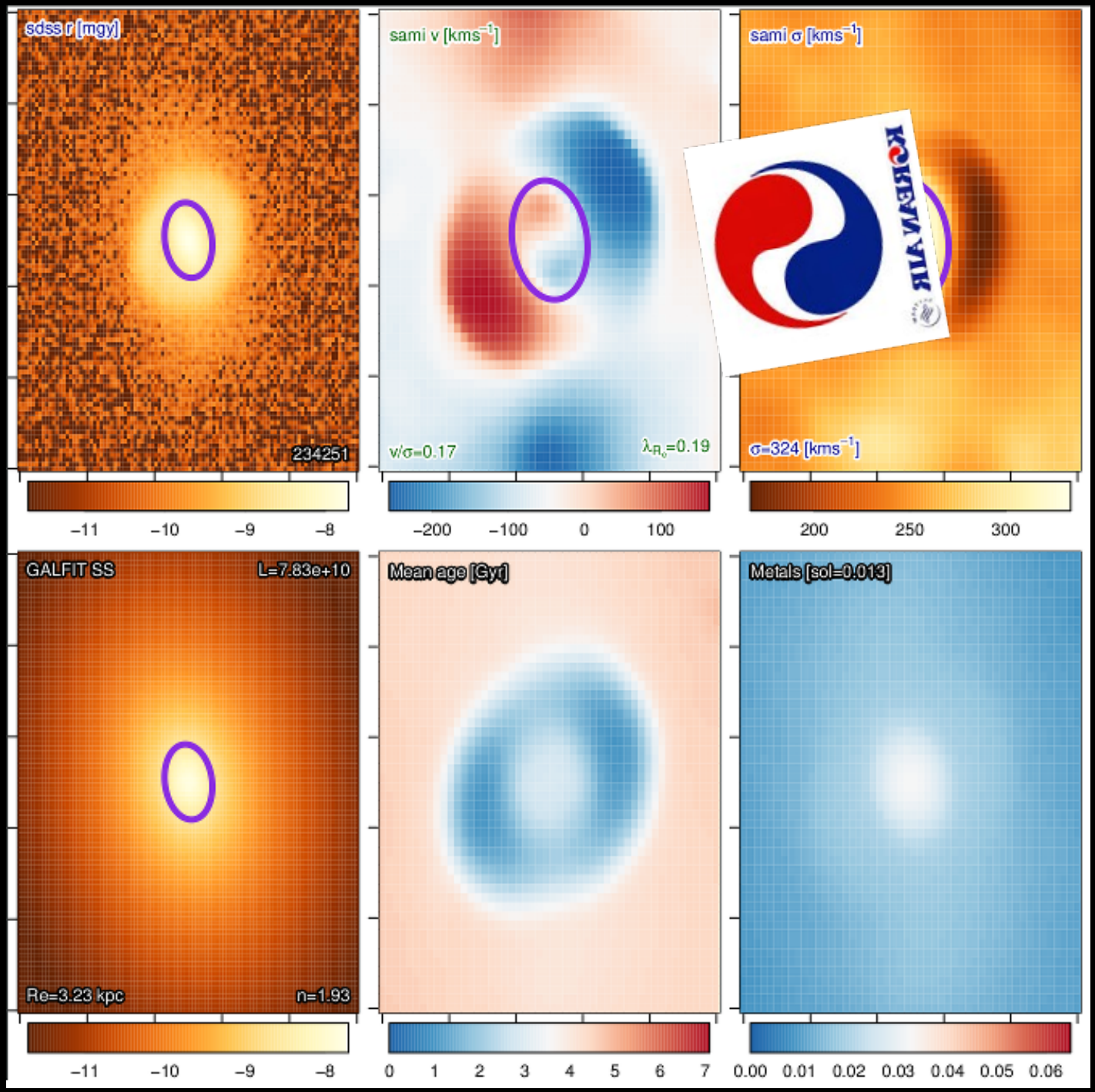


Tremmel+16

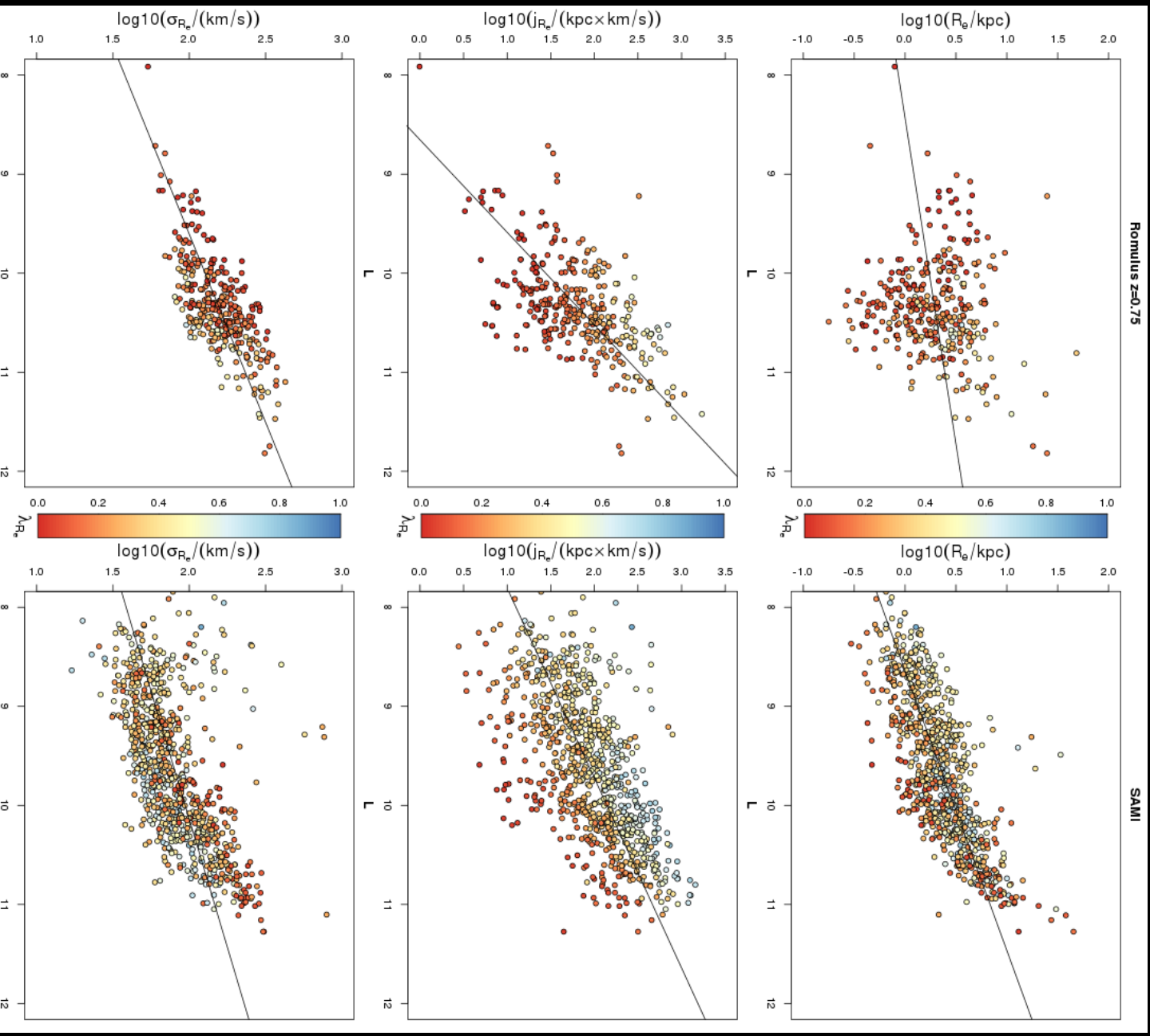
See Tremmel+16 (Romulus)



See Tremmel+16 (Romulus)



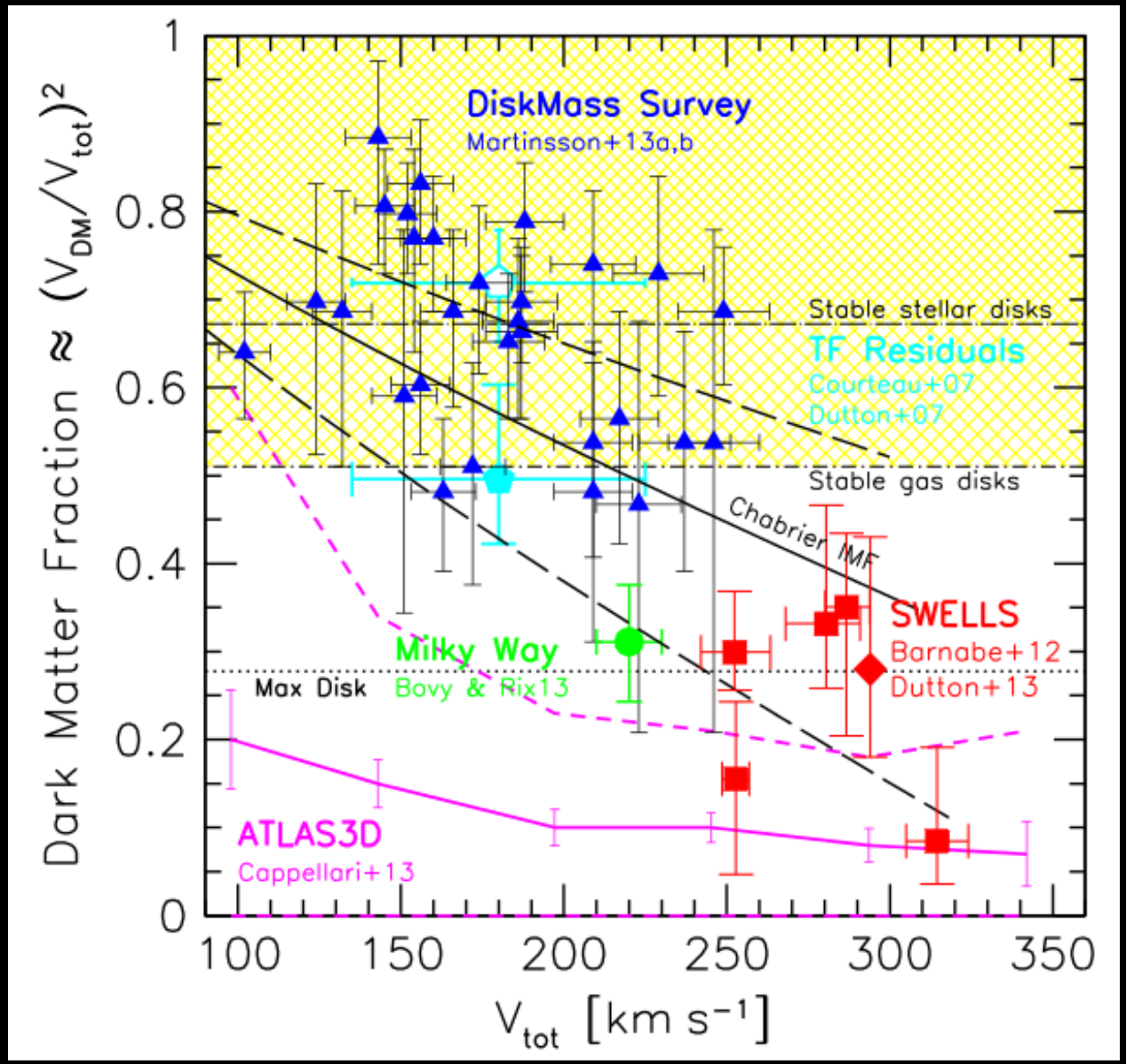
Taranu+16, Romulus@z=0.75, prelim.



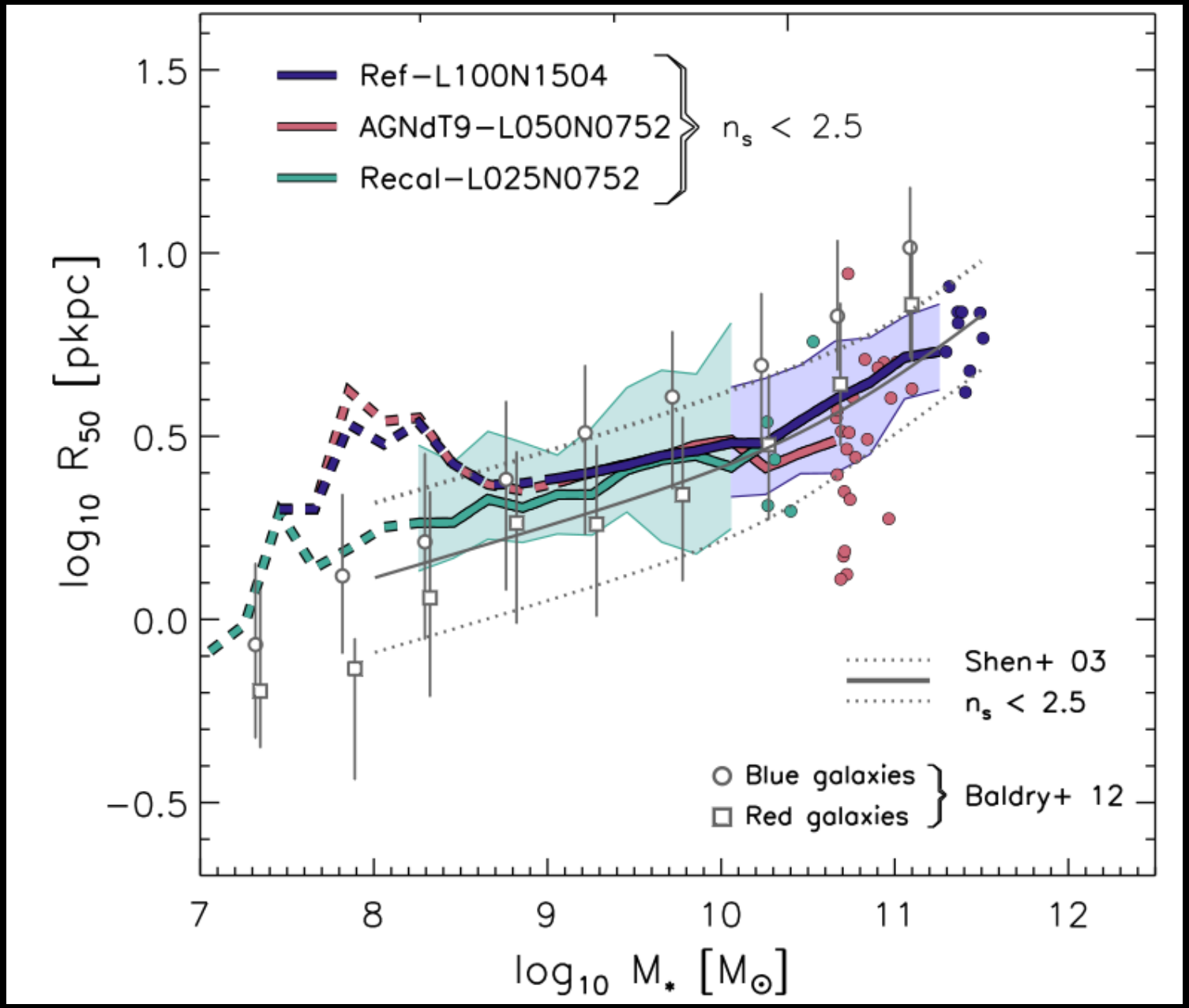
Summary

- Better 3D physical models are coming
  - Robust parameter constraints
- SAMI will have ~5000 galaxy IFU sample
  - Potentially ~100k w/KiDS + central spectra
    - HI with SKA/DINGO
- In 3-5 years, spiral galaxy scaling relations nailed down
  - Possibly constraints on IMF/DM halos
  - Cosmologists might be happy too
- Robust predictions from simulations: cosmological boxes (Romulus), zooms (NIHAO, MUGS2), controlled (TBD)
- 6D bulge/disk decomposition coming?

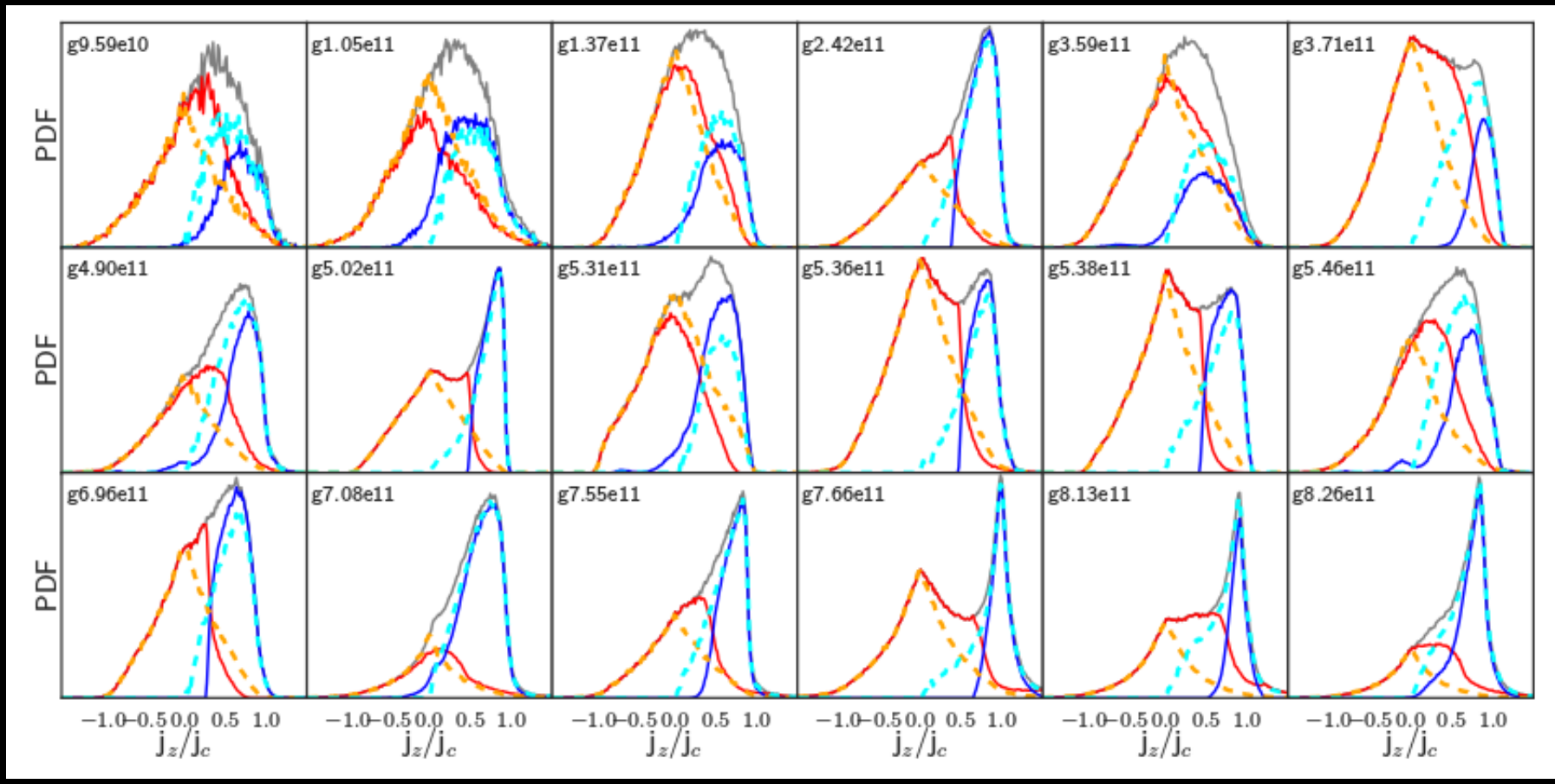
Galaxy Dark Matter Fractions



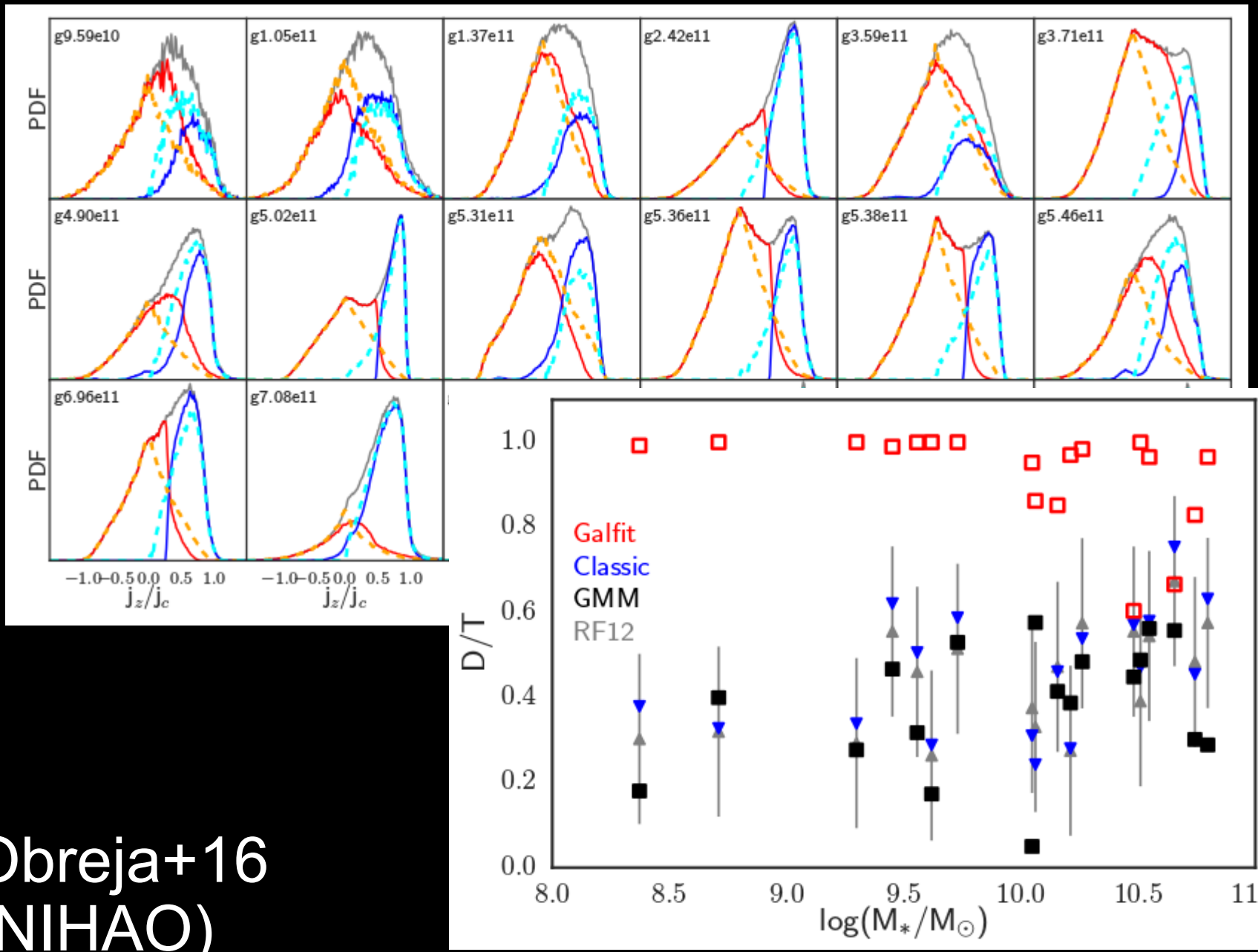
Courteau & Dutton 15



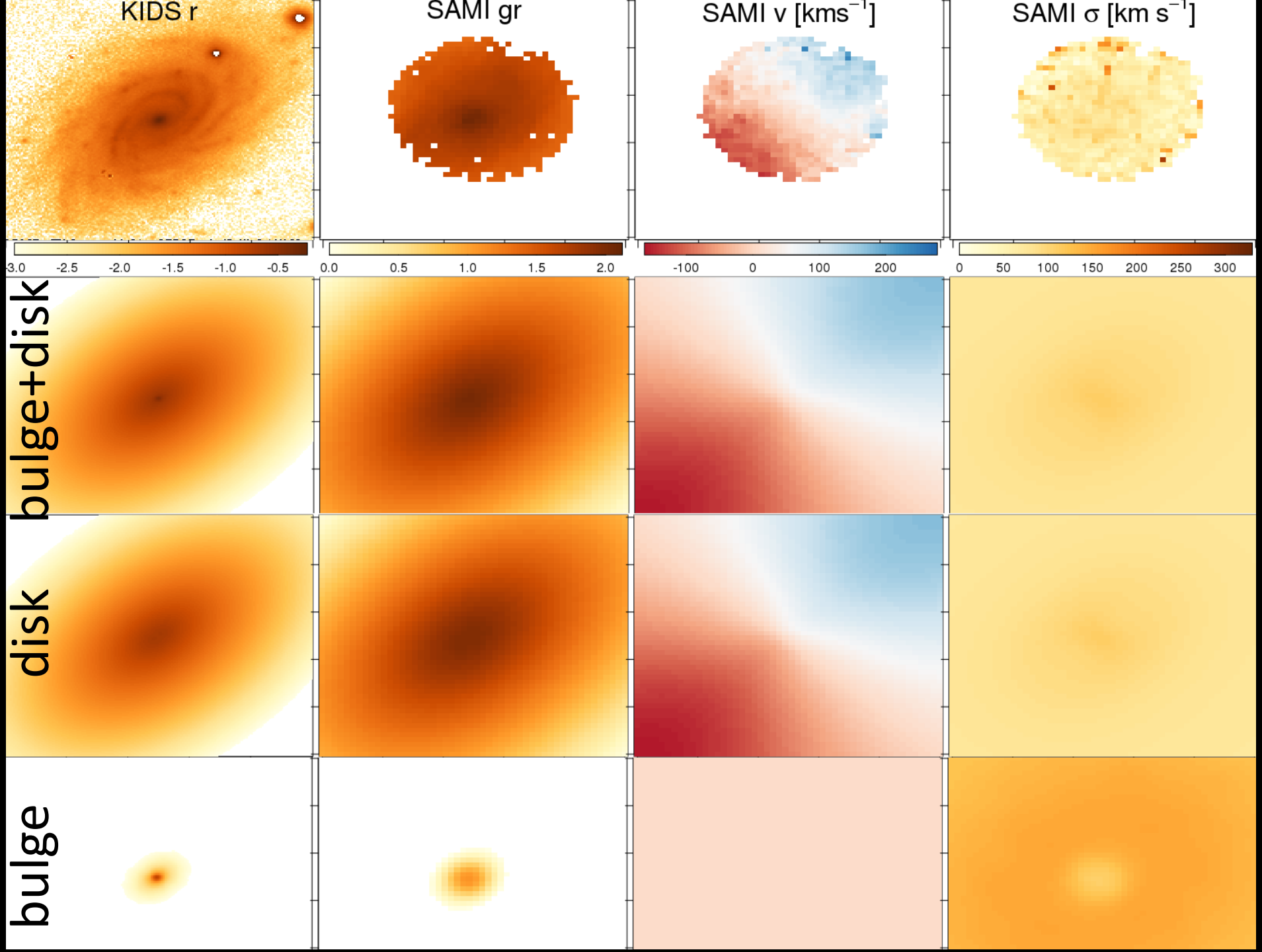
Schaye+15 (EAGLE)



Obreja+16
(NIHAO)



Obreja+16
(NIHAO)


KIDS r
SAMI gr
SAMI v [kms^{-1}]
SAMI σ [km s^{-1}]
-3.0 -2.5 -2.0 -1.5 -1.0 -0.5
0.0 0.5 1.0 1.5 2.0
-100 0 100 200
0 50 100 150 200 250 300
bulge+disk
disk
bulge