Morphology and Size Evolution of Massive and Compact Galaxies from z=8 to z=1

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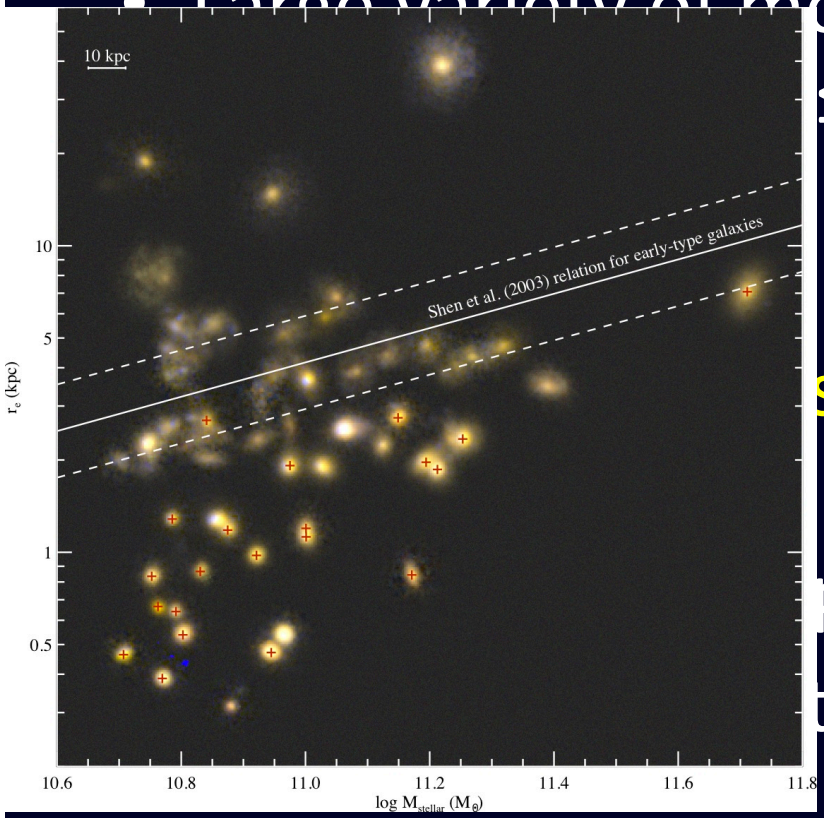
Reinhard Genzel, Joel Primack, Anatoly Klypin

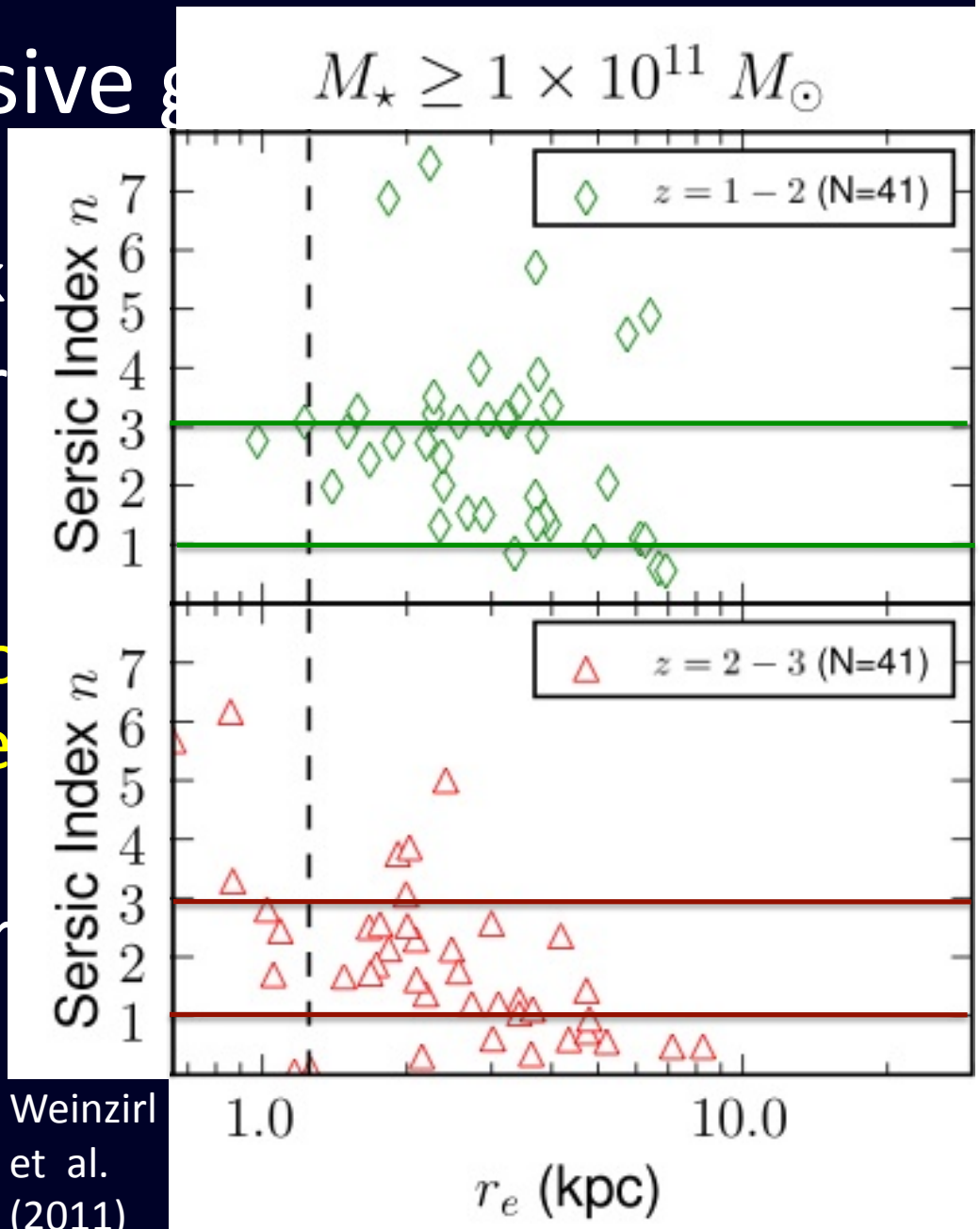
CLUES meeting, 2012

Structure of massive g

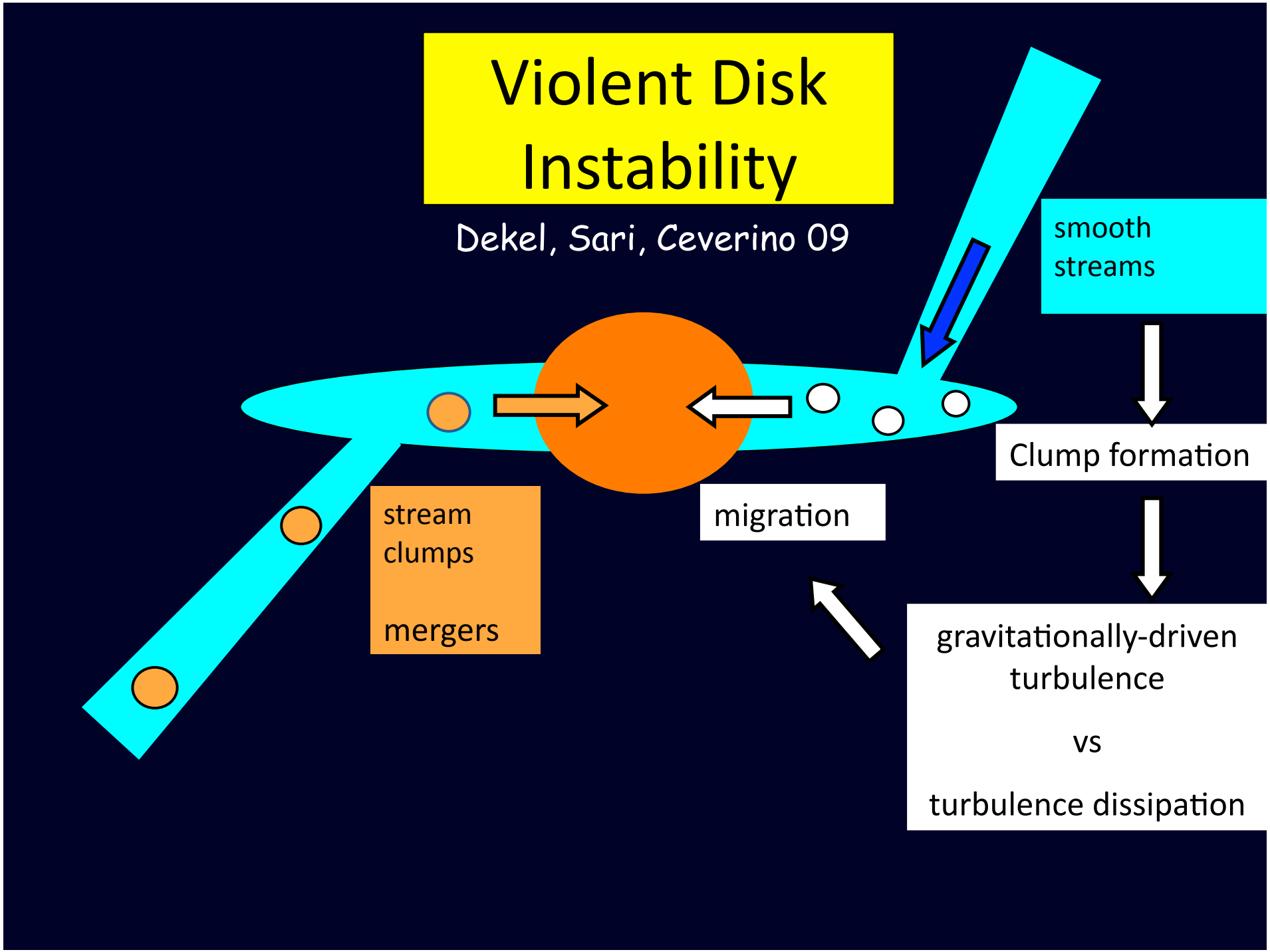
- Compact (Re < 2-3 k
- Large variety of mor



Szomoru, Franx, van Dokkum 2011

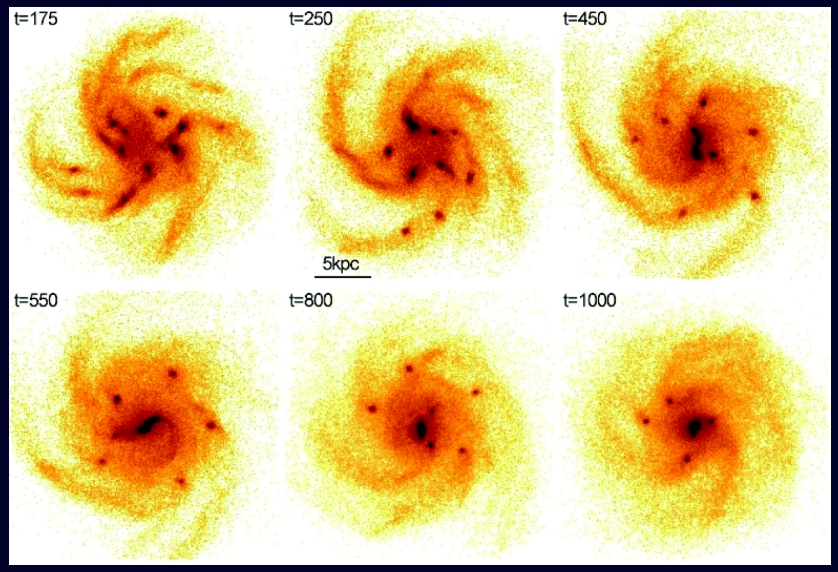


Weinzirl et al. (2011)

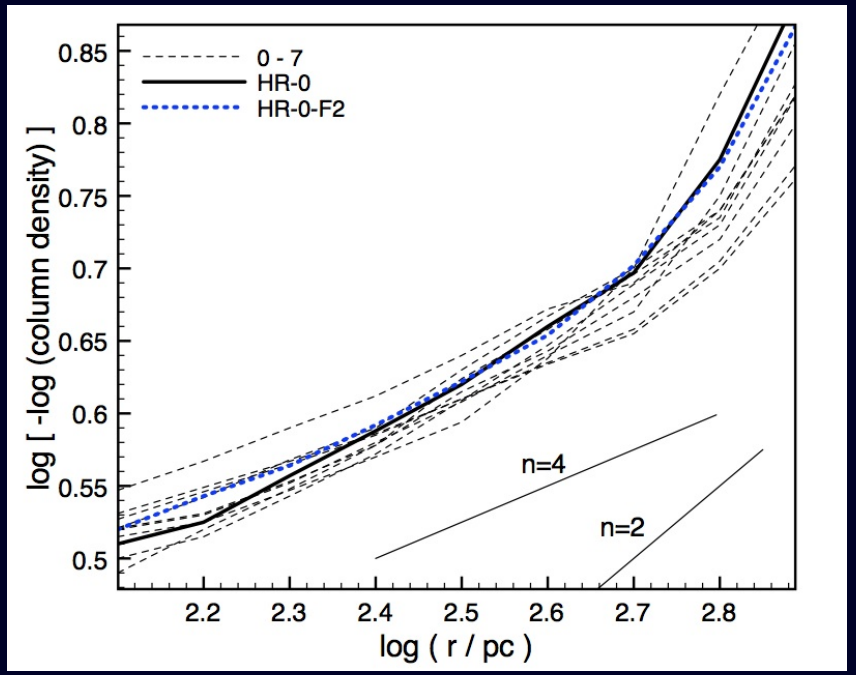

Violent Disk Instability
Dekel, Sari, Ceverino 09
smooth streams
Clump formation
gravitationally-driven turbulence
vs
turbulence dissipation
migration
stream clumps
mergers

VDI makes classical spheroids (n=3-4.5)

Gravitationally unstable isolated discs



Normalized surface density profile: log(-log Σ)



Elmegreen, Bournaud, Elmegreen(2008)

Galaxy formation simulations done with ART

- AMR code: HYDRO-ART (Kravtsov et al 1997, Kravtsov 2003)
- Gas Cooling, Star Formation, Stellar Feedback (Ceverino & Klypin 2009; Ceverino, Dekel and Bournaud 2010)
  - Cooling below 10^4 K (minimum temperature of 300 K).
  - Thermal feedback + runaway stars.
  - Things that we are NOT doing (although it is tempting): Shutdown cooling, shutdown of hydrodynamical forces.
- Sample of **13** halos with a virial mass between 10^{12} -10^{13} $M_\odot$ h^{-1} at z=1
- Maximum resolution of 30-70 pc

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.1

85

5

2
ensity
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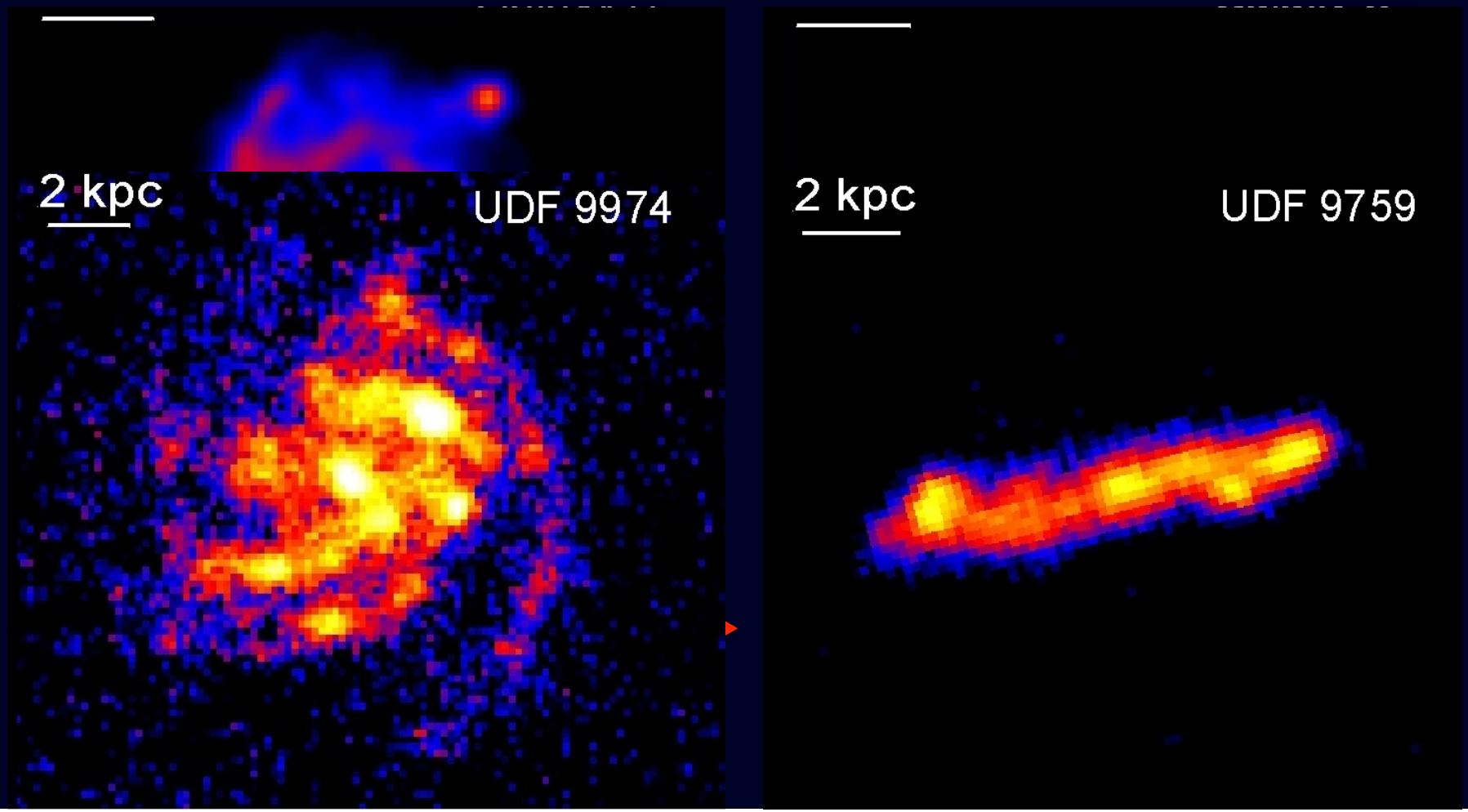
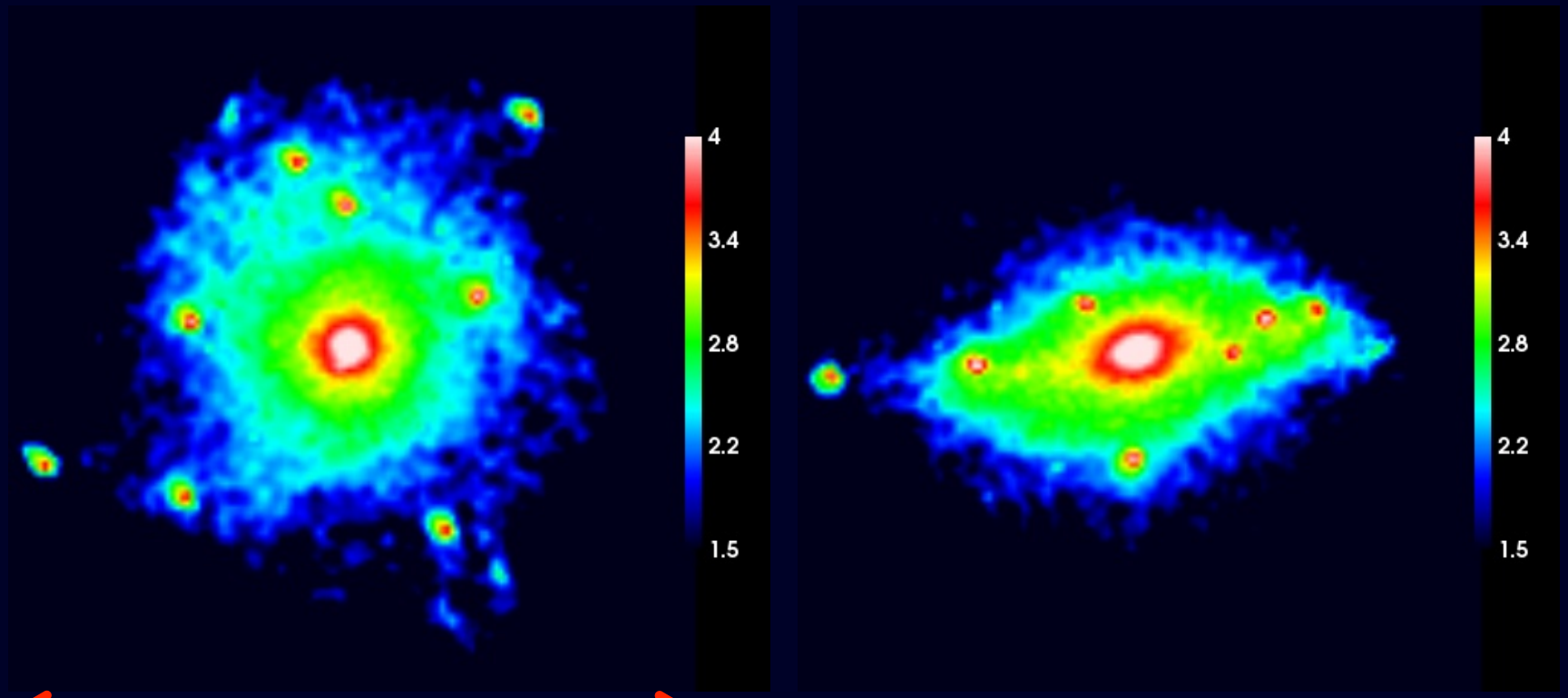
Young stellar disc

Ceverino, Dekel & Bournaud 2010



A Massive Bulge

Stellar Surface Density

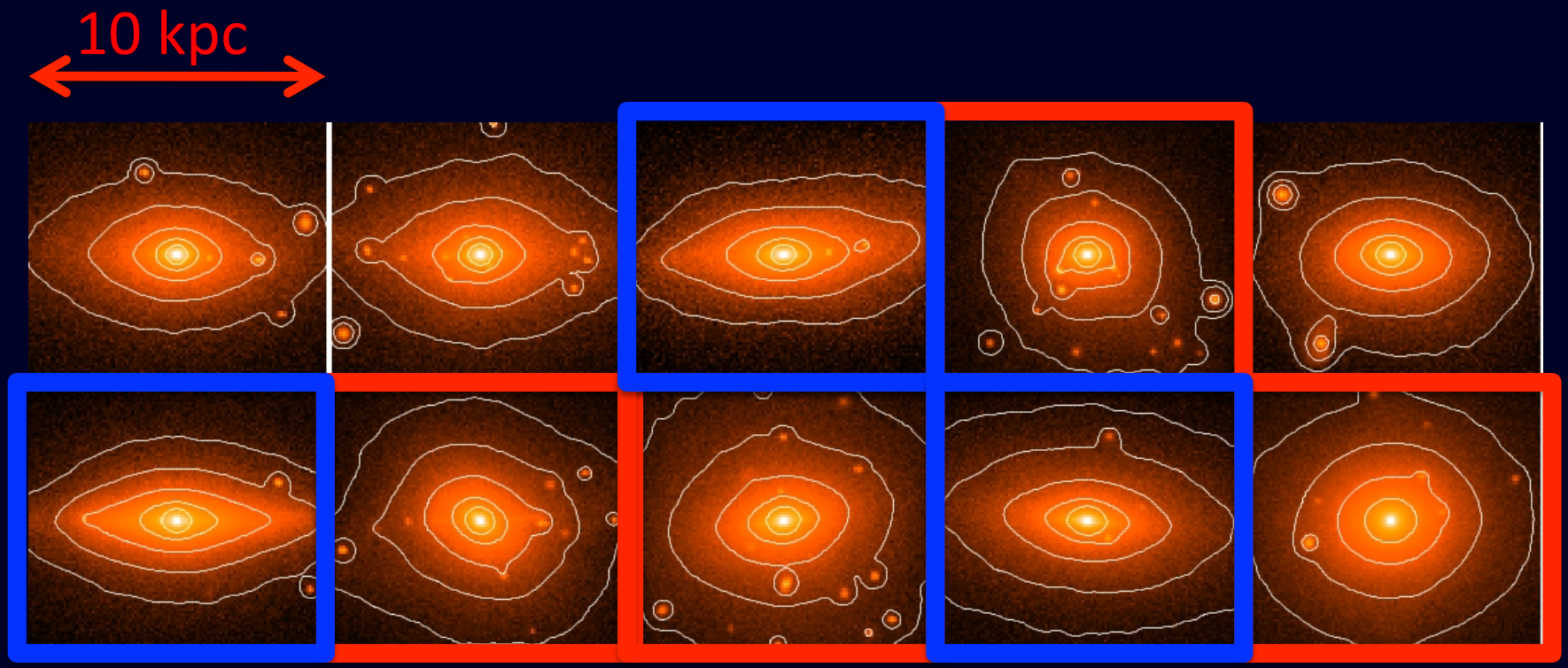


10 kpc

Face-on view

Edge-on view

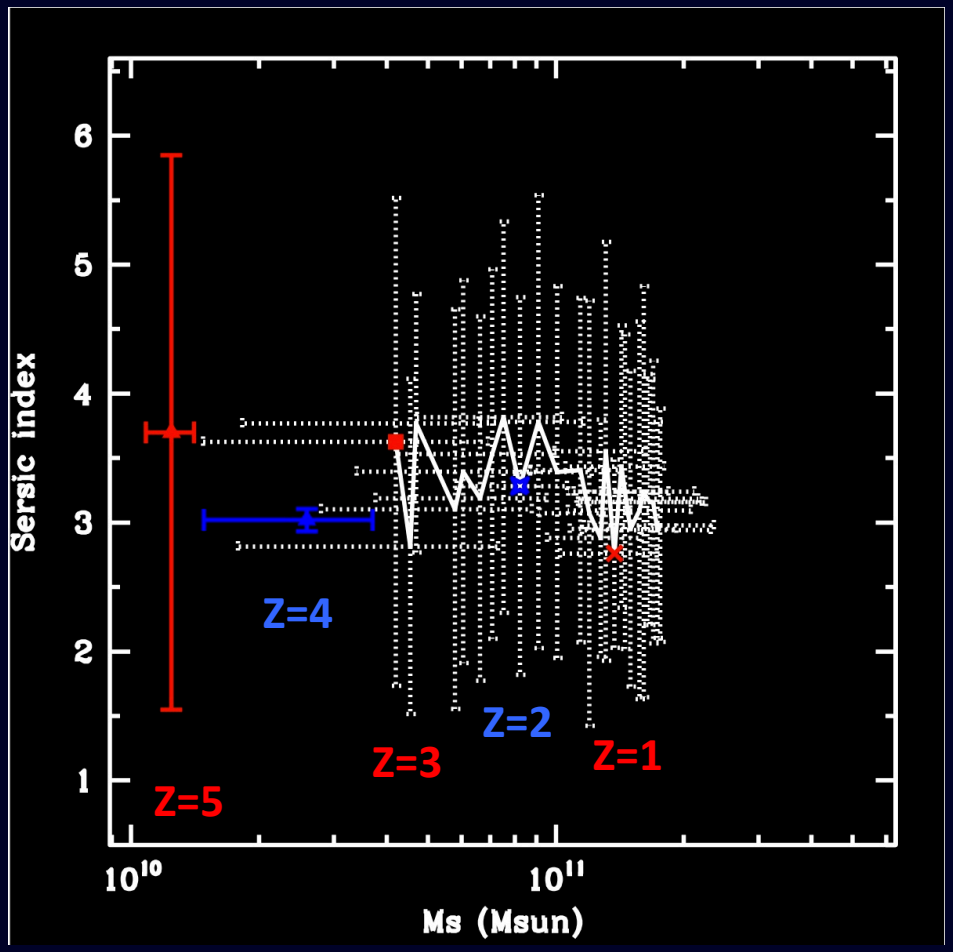
The sample at z=1



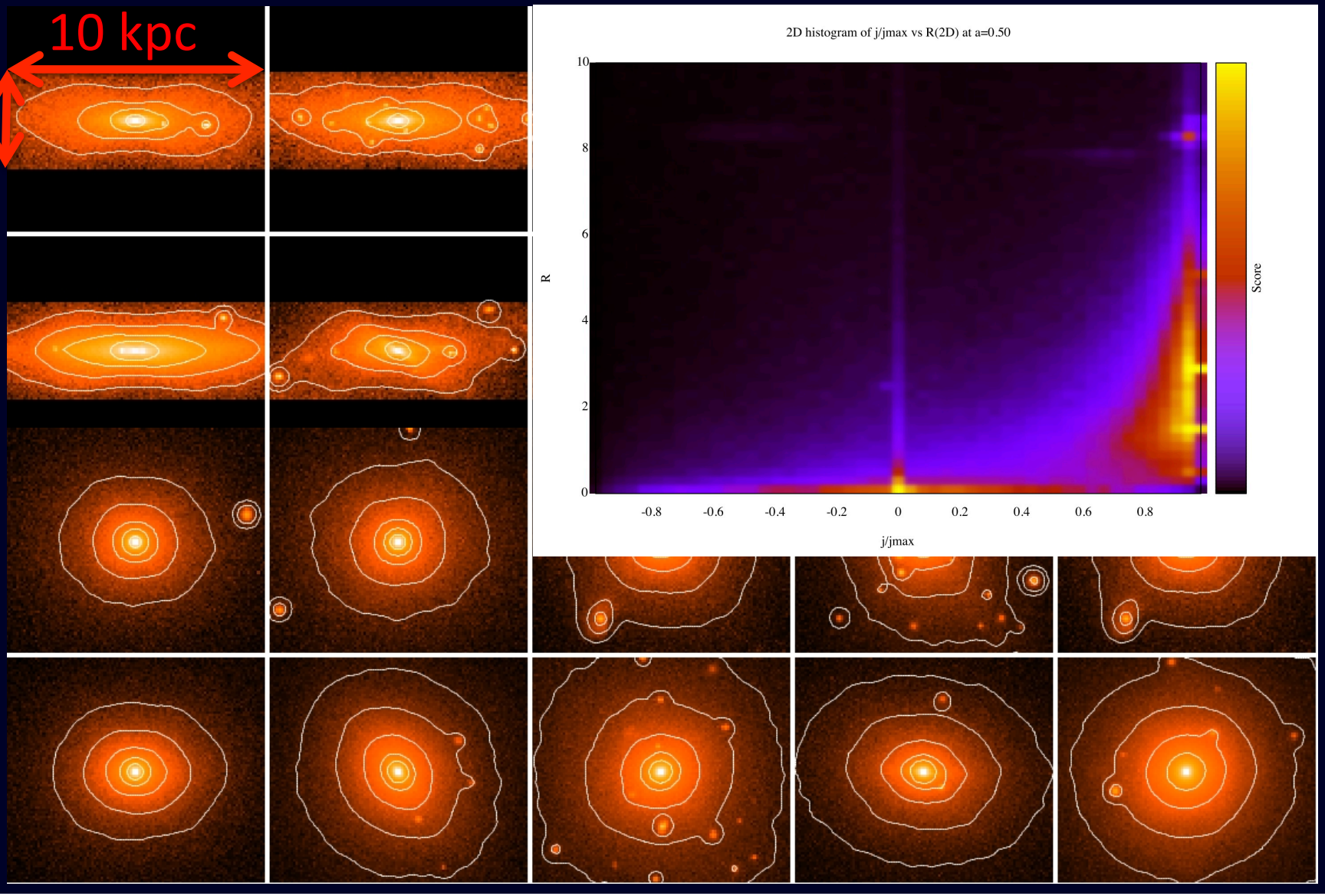
A large variety of shapes: from round to disky spheroids

Sersic fitting to stellar surface density

- <n>=3.3 ± 1.4
- Large spread of shapes: from n≈5 to n≈2
- Not a single case of pure exponential profiles (n=1)

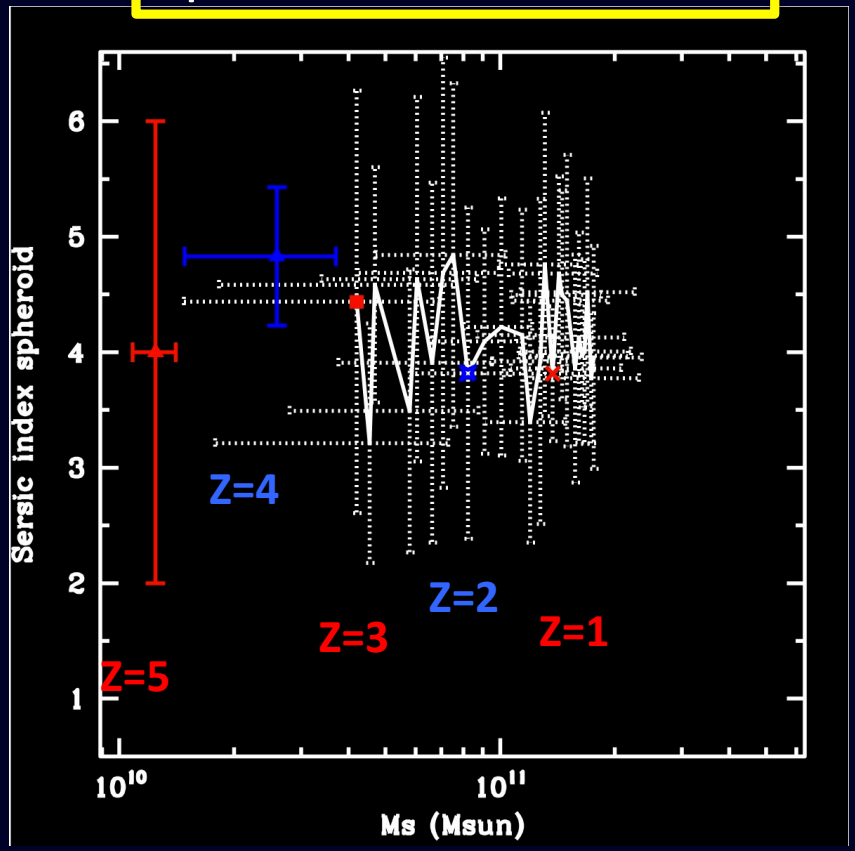


Spheroid and disk components



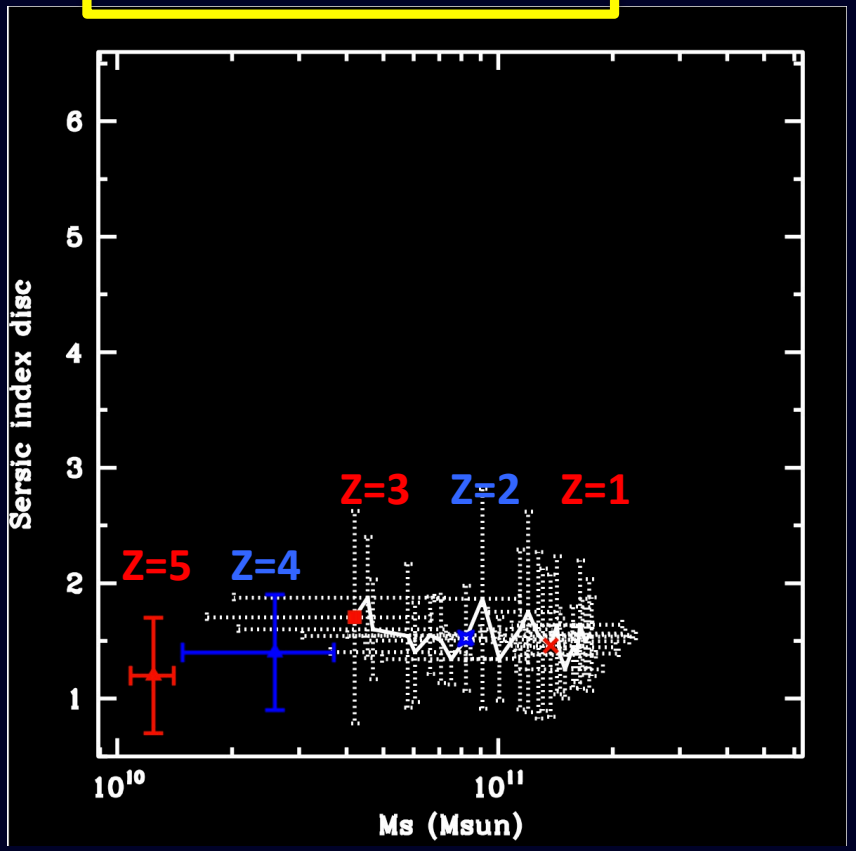
Sersic fitting for different components

Spheroid: <n>=4.3 ±1.4



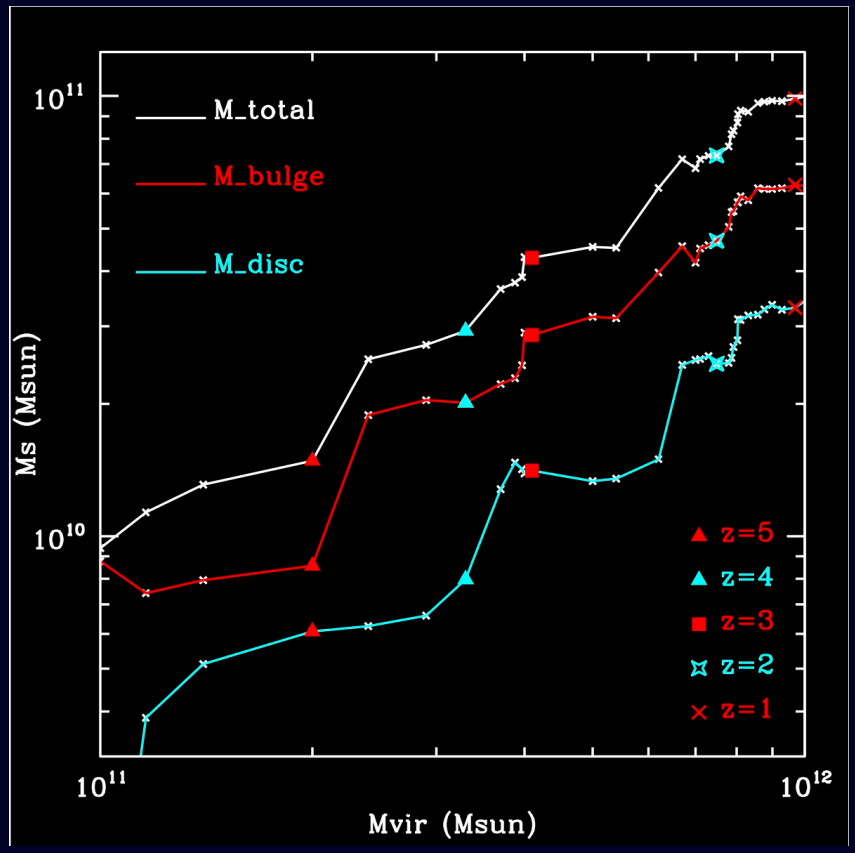
Classical bulge

Disc: <n>=1.5 ± 0.6



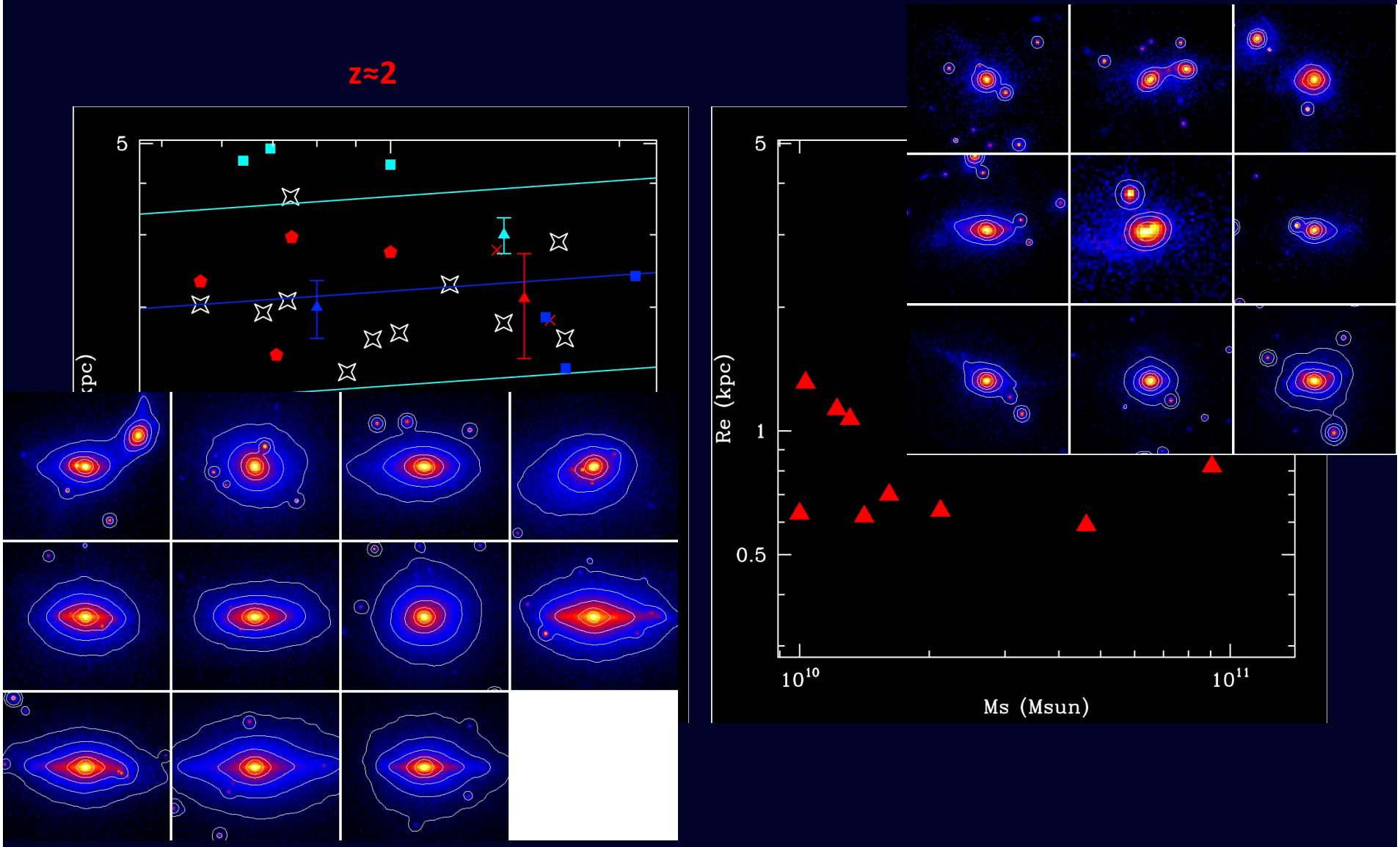
Exponential disc

Continuous bulge and disc growth



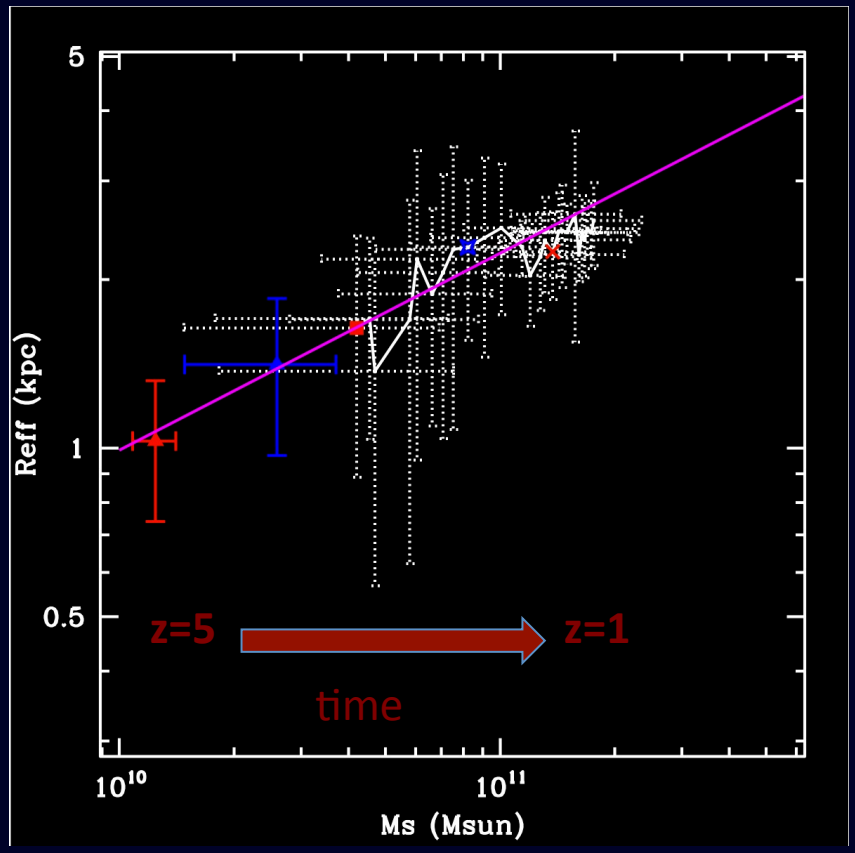
- Continuous disc growth fuels by gas accretion
- Continuous bulge growth due to VDI
- Major mergers only produces discrete and rare jumps in the stellar growth.
- $M_s/M_{vir} \approx 0.5\ \Omega_b/\Omega_m$

Mass-size relation

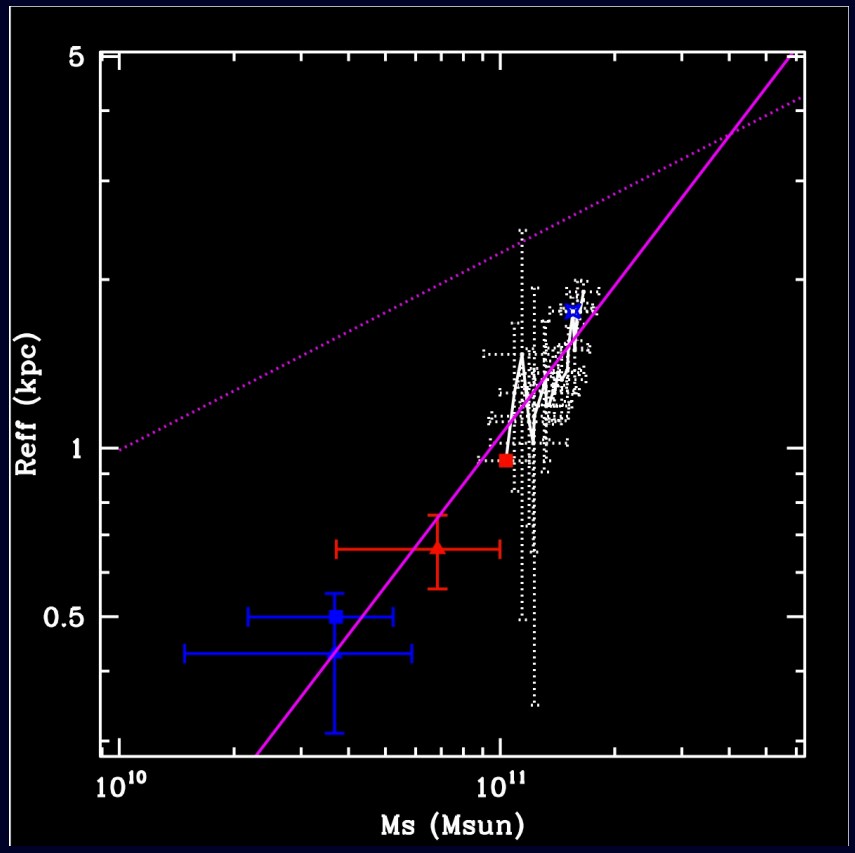


Mass-Size Evolution

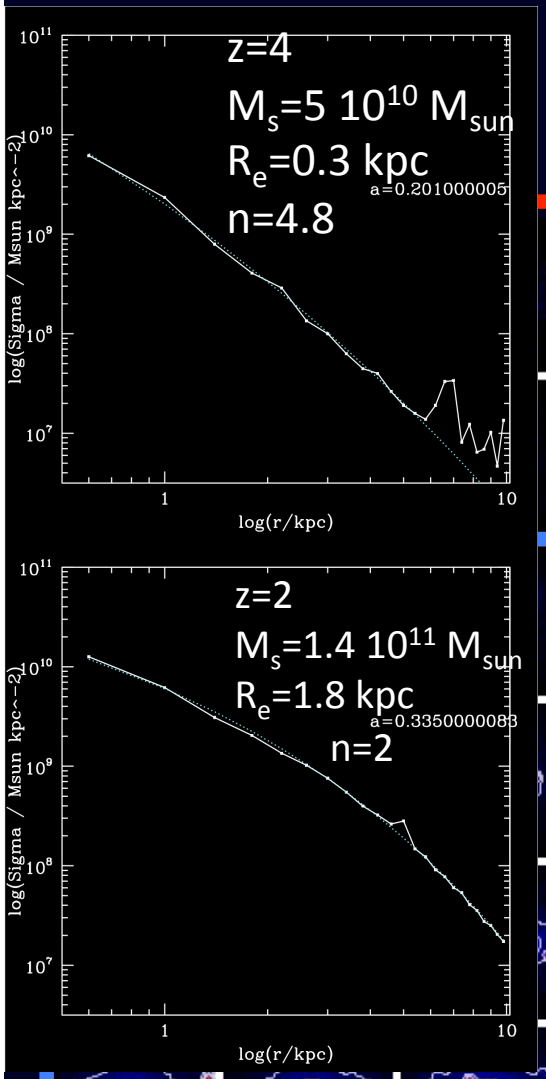
$M_{v,final} \approx 2\ 10^{12}\ M_{sun}$ at z=1



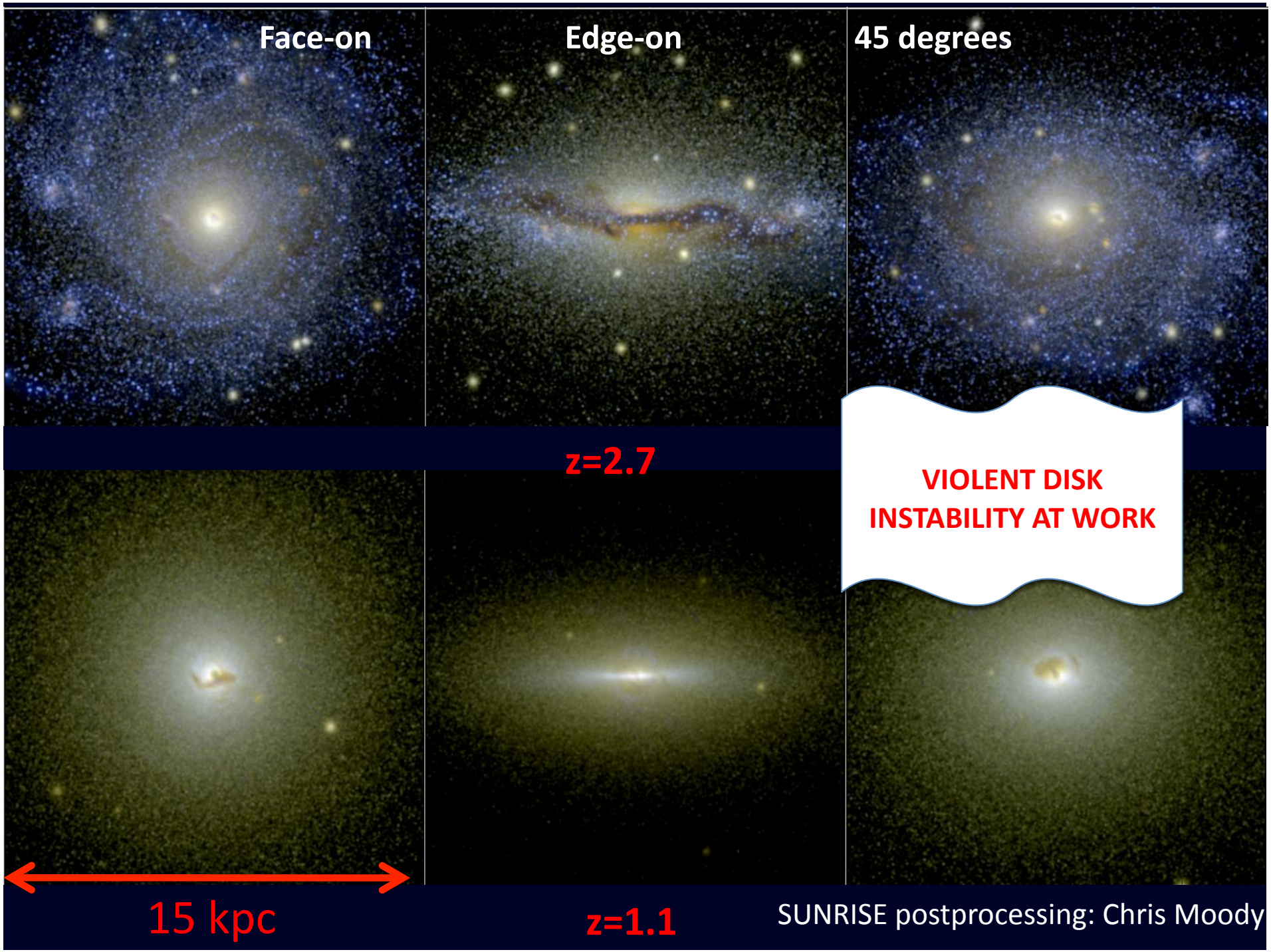
$M_{v,final} \approx 5\text{-}6\ 10^{12}\ M_{sun}$ at z=1



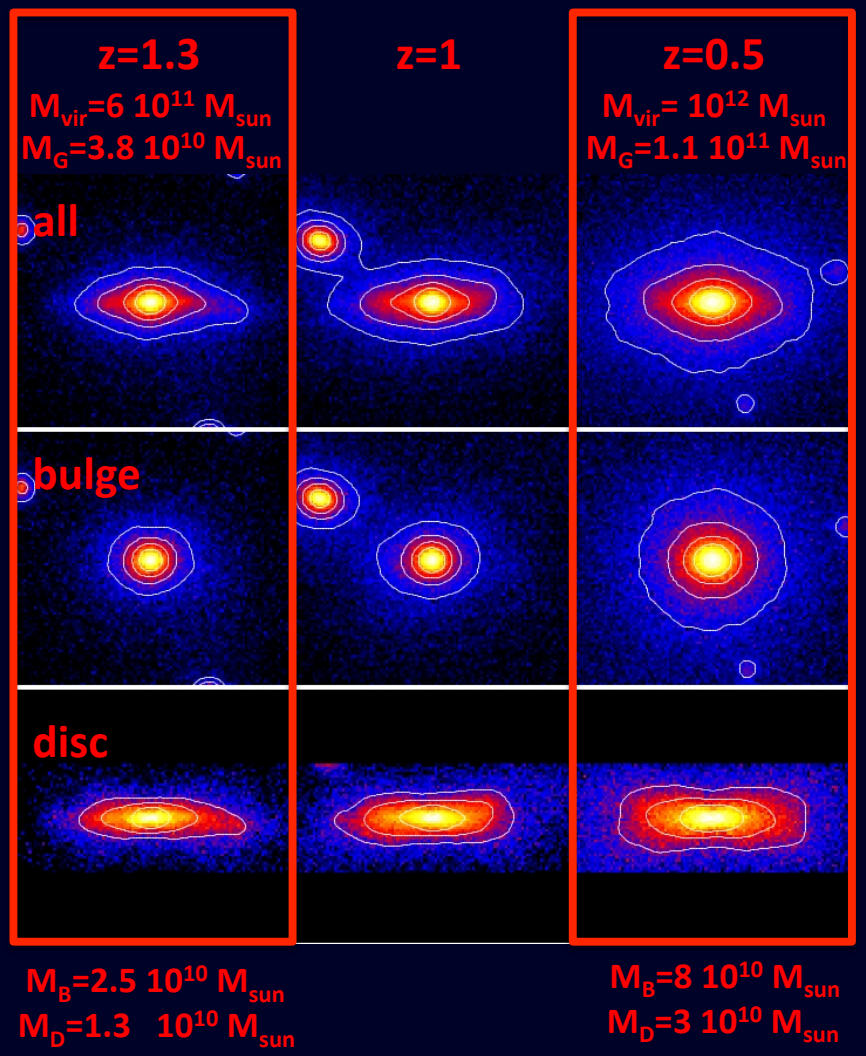
One example:



- Period of frequent wet major mergers
- Period of strong gas accretion, disc growth and disk instabilities (VDI)


Face-on
Edge-on
45 degrees
z=2.7
VIOLENT DISK
INSTABILITY AT WORK
15 kpc
z=1.1
SUNRISE postprocessing: Chris Moody

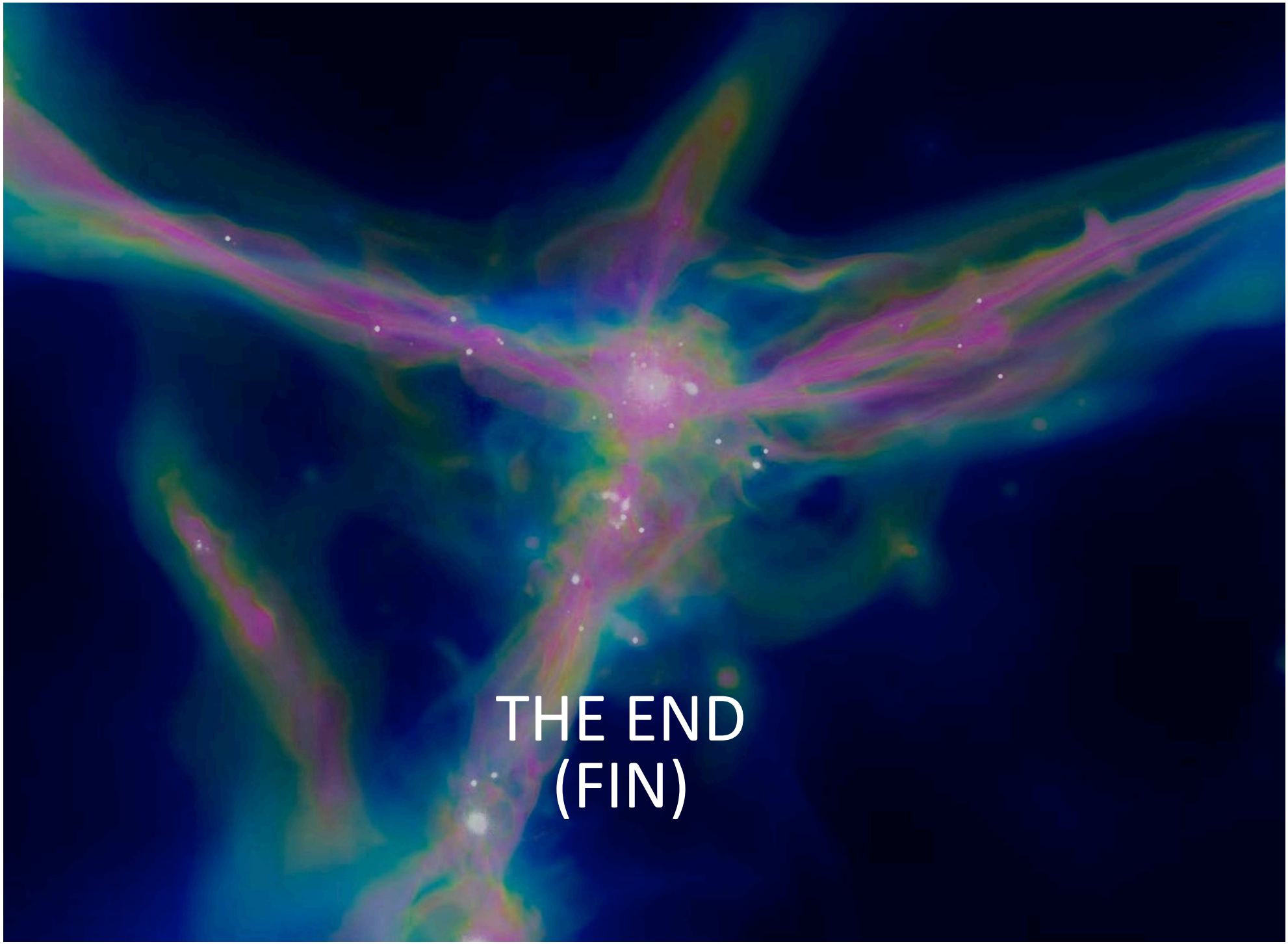
ABOUT CLUES



- LG_2Mpc_2048 run
- WMAP 5
- Δ=170 pc at z=1
- Last major merger at z≈1
- $M_G/M_{vir} \approx 0.4\text{-}0.6\ \Omega_b/\Omega_m$
- 4096^3 running at SuperMIC

Conclusions

- Final products of violent disk instability (VDI) are compact (R_e=2-4 kpc), classical (2<n_{sersic}<5), spheroids or S0s with D/T<0.4
- Disc and bulge grow and evolve together mostly by smooth gas accretion and VDI
- The effective radius of typical, $M_s=10^{11}$ M_{sun}, galaxies at z=1 has grown by a factor 2.5 between z=4 and z=1.
- More rare and massive galaxies evolve faster due to an early phase of frequent wet mergers (z>4) plus a second, more extended phase of disc and bulge growth by VDI.


THE END
(FIN)