Environmental imprints in field and cluster dwarf early-types as seen by SAURON

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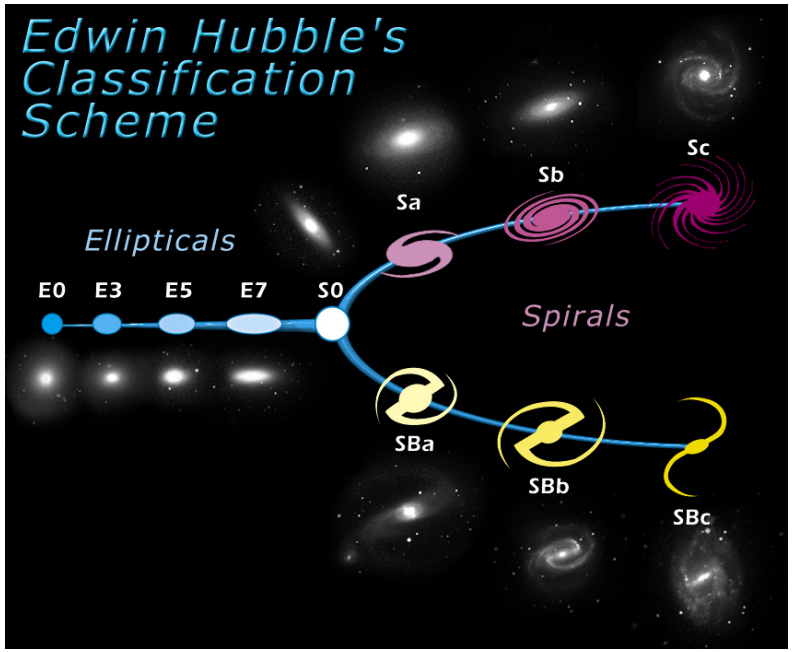
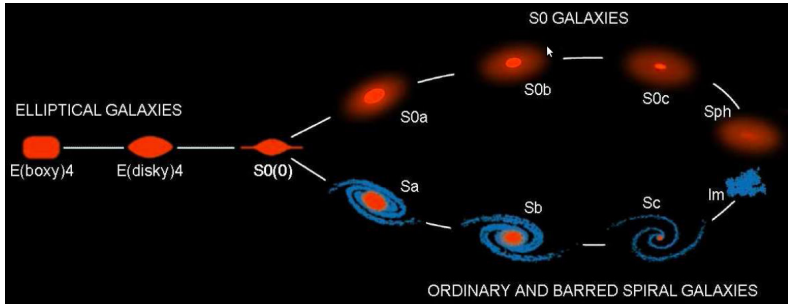
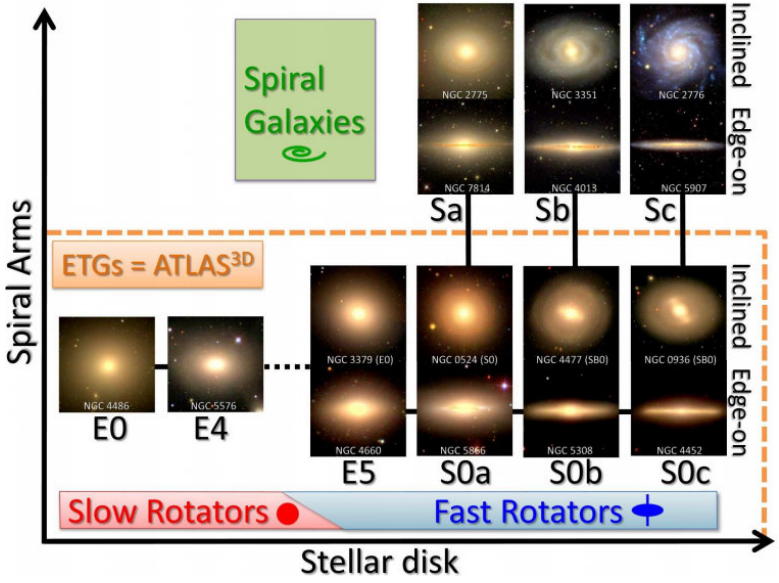
Galaxy classification schemes

From purely morphological classification to systems reflecting true physical properties of galaxies:

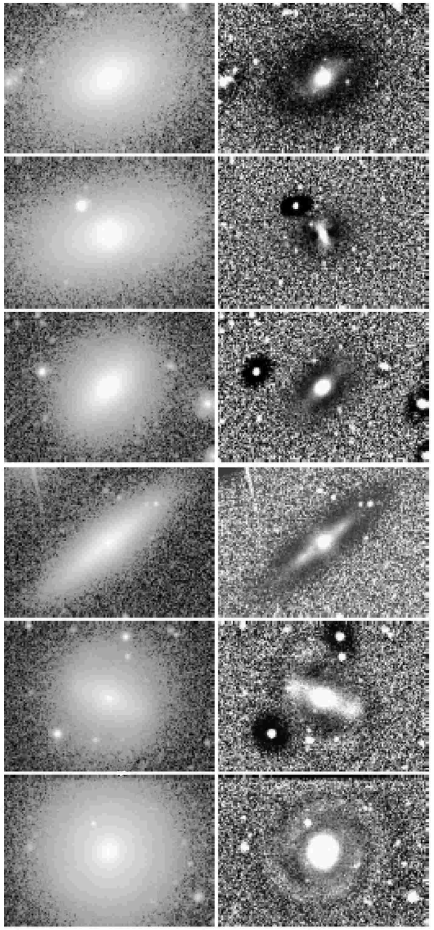






↑ Hubble 1926
Kormendy+ 2012 ↗
Cappellari+ 2013 →

Dwarf early-types: more complex than we used to think



Lisker + 2006

Wealth of substructure:

- spiral arms, bars, disks, lenses, nuclei
- kinematically decoupled cores, rotating & non-rotating
- spread in ages and metallicities

Shallow potential wells (low masses and densities)

- →important testbeds for theories of galaxy formation & evolution

dEs – environmentally transformed late-types?

Galaxy harassment

- high-speed encounters with other galaxies & tidal heating resulting from the interactions with the cluster's potential well
- can remove stellar and (more efficiently) dark mass
- can change morphology
- lowers angular momentum

Ram-pressure stripping

- interactions between galaxies and the intergalactic medium
- quickly removes gas & quenches star formation
- preserves angular momentum

dEs – finding progenitors

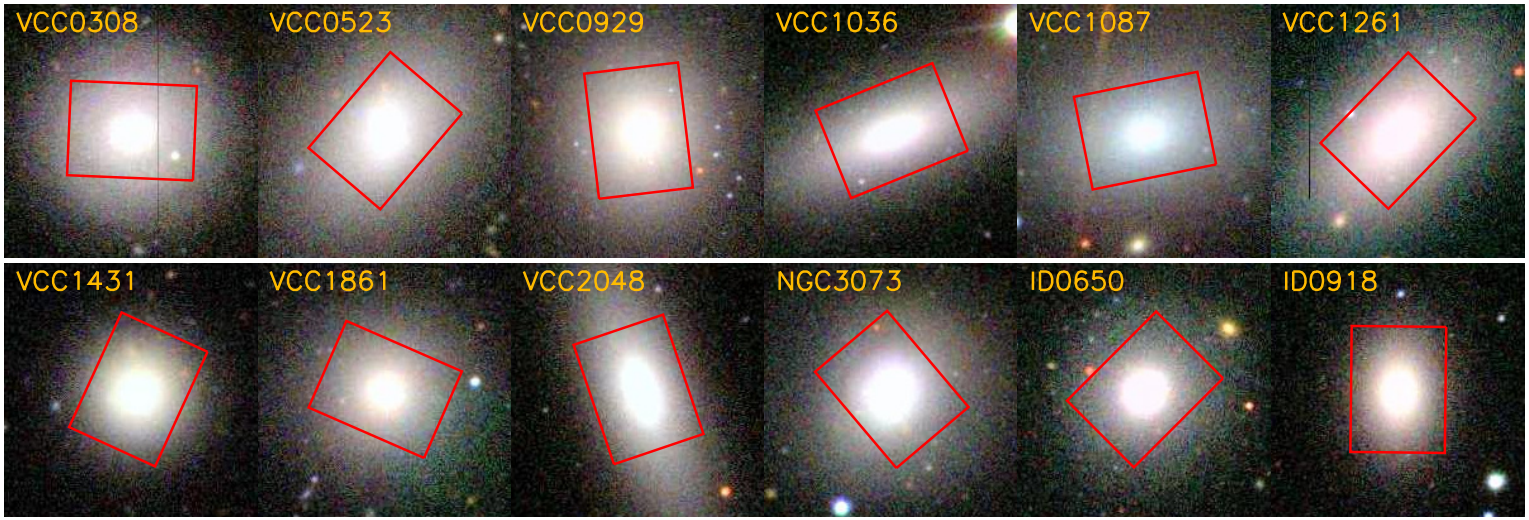
Not a straightforward task:

- observed nearby – *present-day* analogs of dE progenitors
- high-z observations too demanding for these low SB systems
- detailed studies of cluster dEs long hampered by the lack of high-quality data

Recent advances in studies of early-type galaxies

- giant early-types studied in detail in 3D by the SAURON / ATLAS3D teams
- logical next step was to extend this analysis to low-mass systems

Our sample: 12 Virgo and field dEs

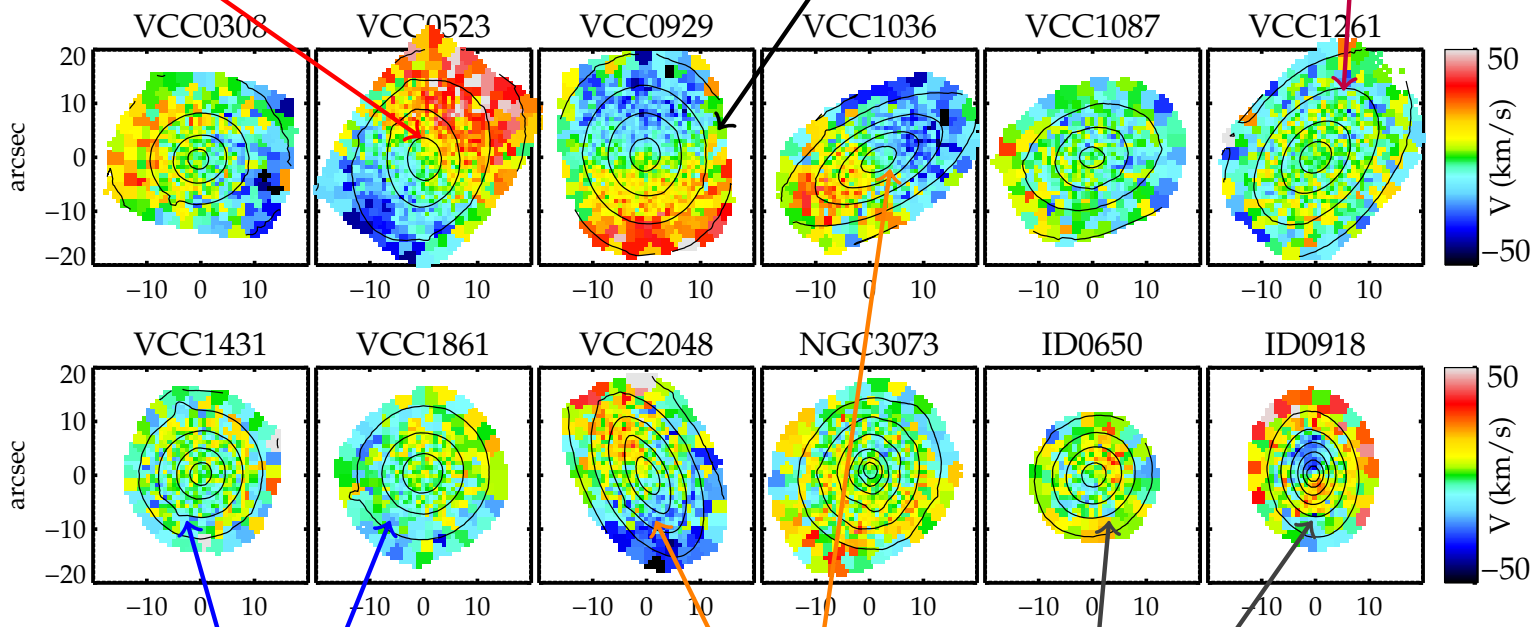


Ryś +2013b

- Virgo Cluster: closest large concentration of dEs
- bright dEs of varying ϵ, level of substructure, local density
- most with long-slit data already available
- covered a range of ϵ and (projected) distances from M87

Stellar velocity maps - diversity everywhere

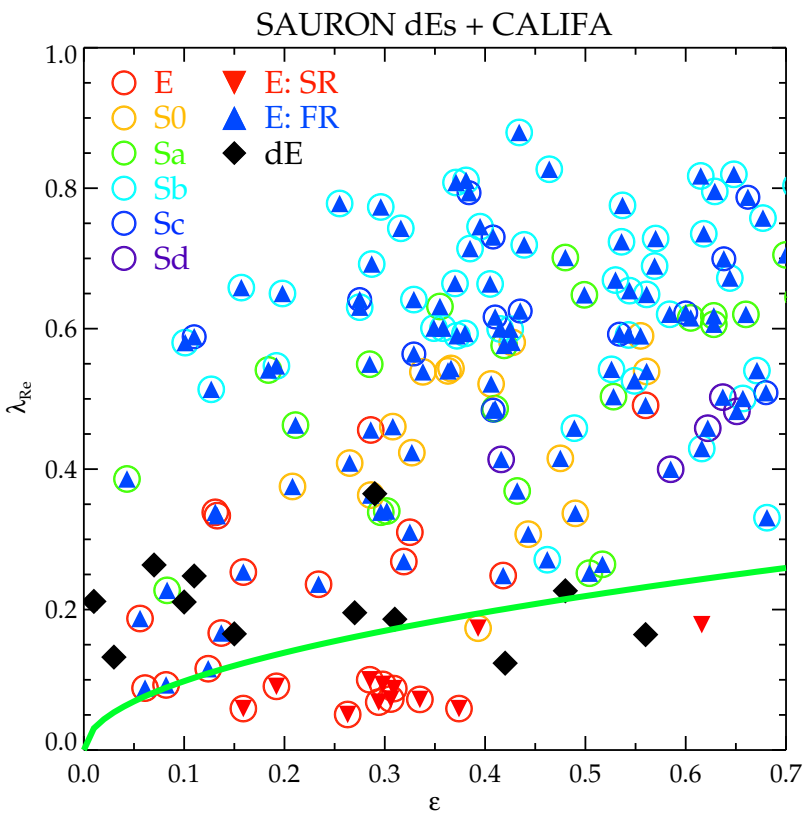
- kinematic twist
- round rotator
- flat non-rotator

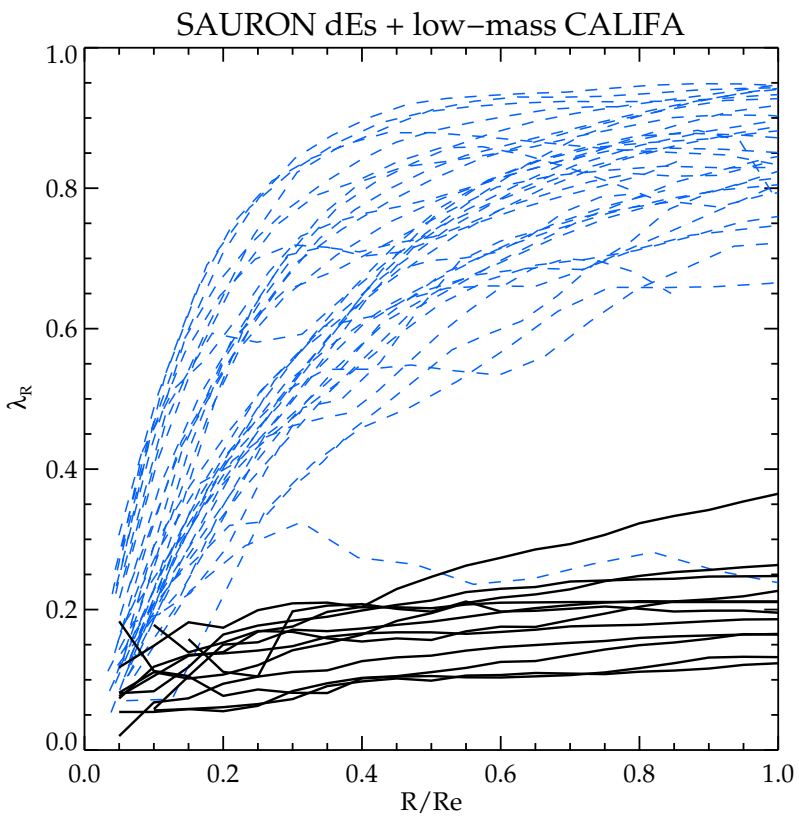


- round non-rotator
- flattened disky rotator
- kinematically decoupled core

(Ryś+ 2013b)

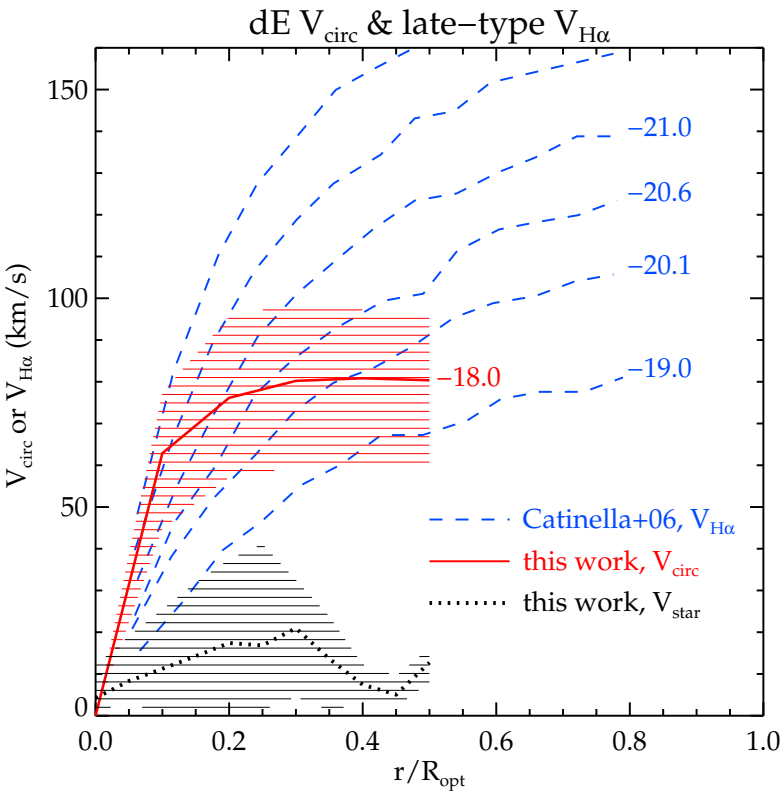
Angular momentum of dEs is much lower than of their presumed late-type progenitors

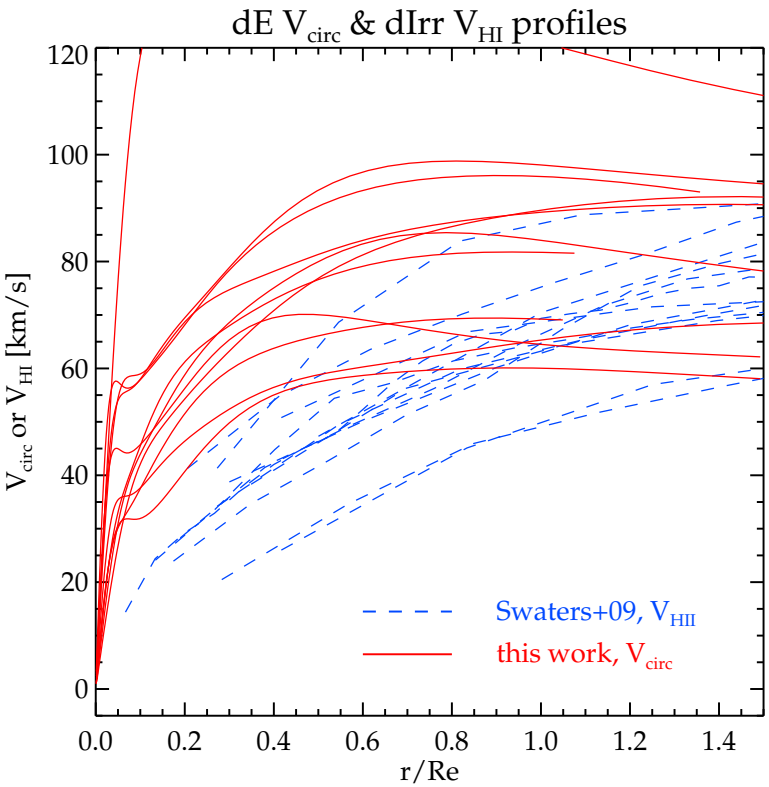




(Ryś+ 2014)

Rotation curves of dEs are much steeper than those of late-type galaxies



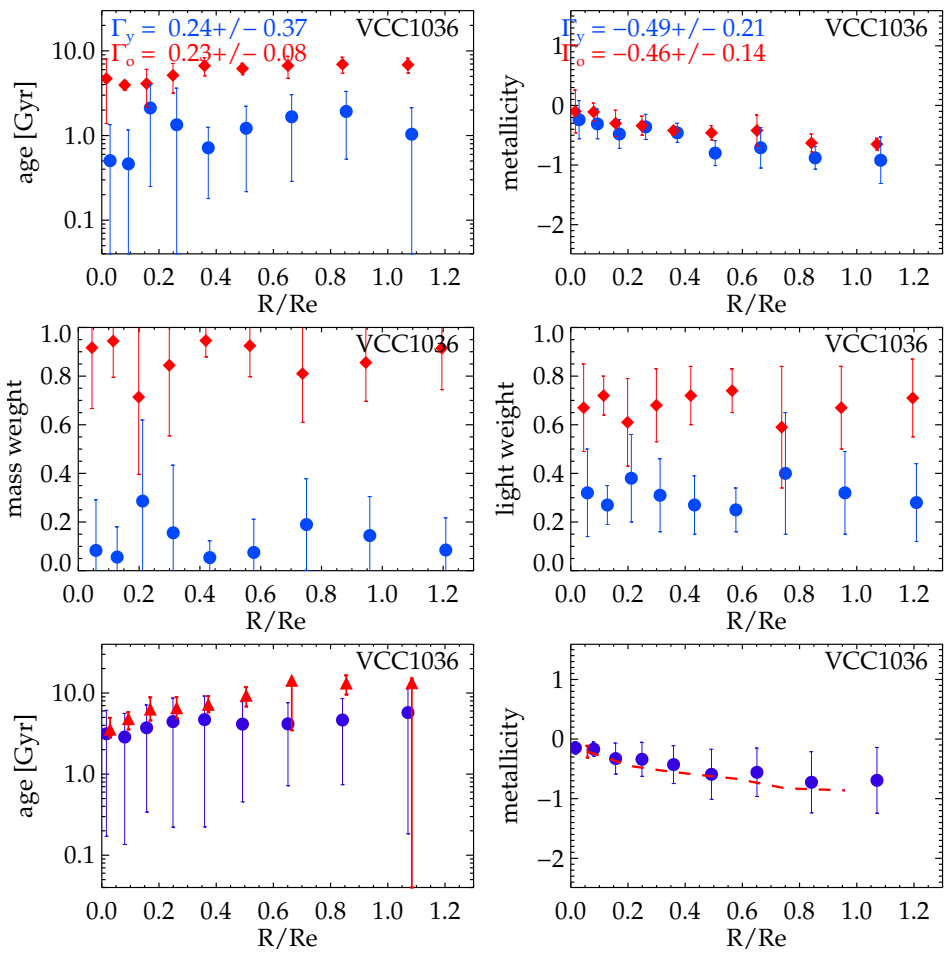


(Ryś+ 2014)

Conclusions (1)

- variety of properties suggests formation/evolution scenario acting stochastically
- dE have lower λ_R and steeper dE V_{circ} profiles than the present-day analogues of their presumed late-type progenitors,
- transformation mechanism needed that is able to lower angular momentum + account for increased stellar concentration,
- <u>transformation due to tidal harassment</u> – unless the dE progenitors were already compact and had lower angular momenta at higher redshifts.

Star formation histories



(Ryś+ 2015)

Ages, Z, mass & light weights of both young and old components:

- old component present in most galaxies
- younger component typically more centrally concentrated than the old one

→ some dwarfs could have contributed to the build-up of massive galaxies' stellar haloes

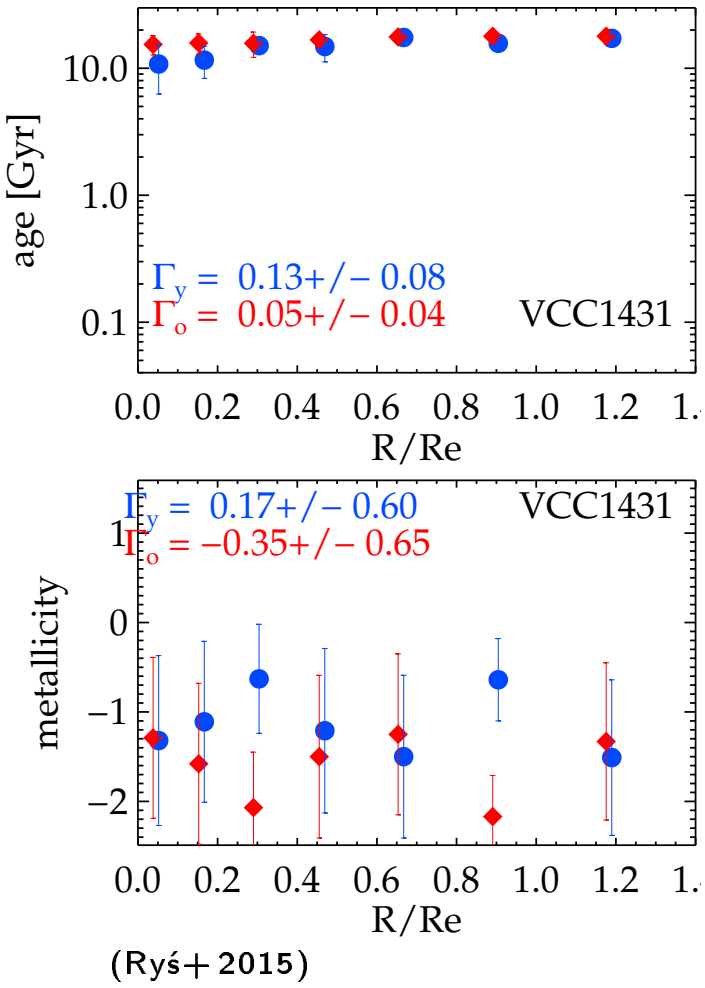
→ secondary burst of SF *or* SF still strong at ∼a few Gyr

VCC 1431 - a genuinely old galaxy?

- no evidence for populations ∼<10 Gyr
- no substructure (Janz+ 2013) → no tell-tale sign of interactions
- centrally located in Virgo
- lowest λ_R and steepest V_{circ} profile

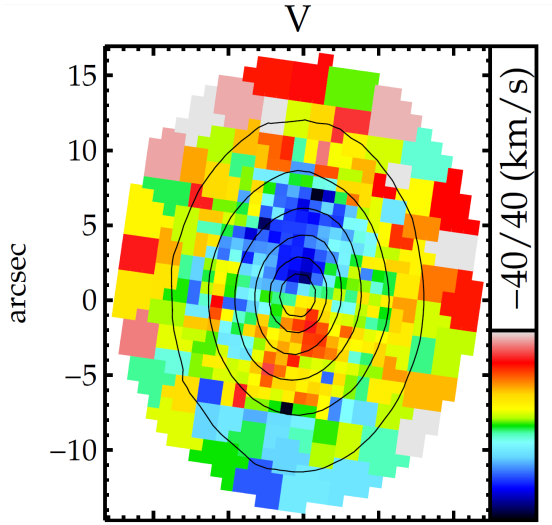
If infallen:

- gas stripped before entering the cluster (in group?) –> SF quenched
- then tidally harrassed –> made more compact & had its λ_R lowered

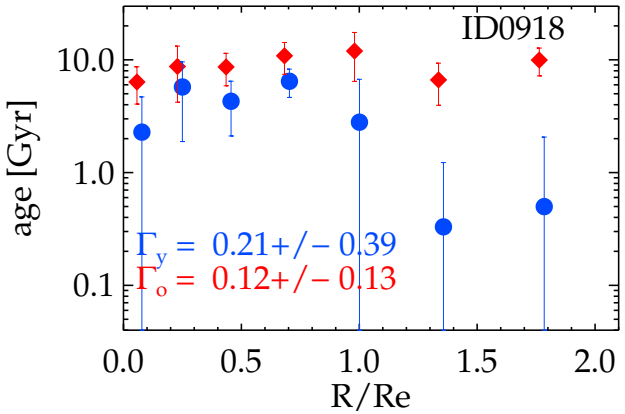


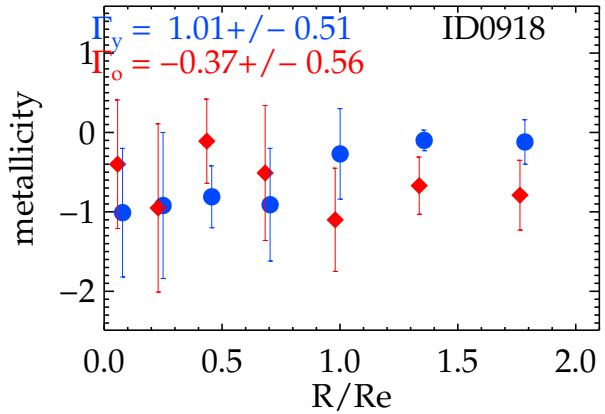
(Ryś+ 2015)

ID 0918 - a merger remnant?



- break in young and old population profiles at KDC radius
- merger, gas lost earlier – no further SF
- isolated location – encounter highly improbable





(Ryś+ 2015)

Conclusions (2)

- we are able to recover 2-SSP SFHs from the limited SAURON λ range thanks to high data quality
- for the majority of objects SF either still strong at a few Gyr of age or secondary SF burst $\sim$at that age
- in agreement with the proposed dE formation scenario where tidal harassment drives the remaining gas inwards and induces a secondary star formation episode.
- we find a candidate "relic" galaxy + an object where kinematic and stellar population properties are correlated (merger remnant?) – illustration of the SFH variety of dEs

Summary

we confirm & add to the variety of dE kinematic and stellar population properties,

we show that dynamical properties of dEs favor the tidal harassment scenario (able to increase compactness, lower angular momentum & DM fraction)

we see that SF activity was still strong a few Gyr ago or that the galaxies experienced a secondary SF burst, compatible with the above scenario

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Future work

Doubled SAURON Virgo sample

- stronger constraints wrt dwarf-giant scaling relations

Expanding the sample to different environments

- cosmic voids
- other nearby clusters (Fornax, Coma)

Making simulations and observations meet:

- looking "through the eye of SAURON" at a new suite of high-resolution simulations od dEs in the Virgo cluster
- $\rightarrow$ come and see my talk @ 12:15 on Thursday (Symposium 2)