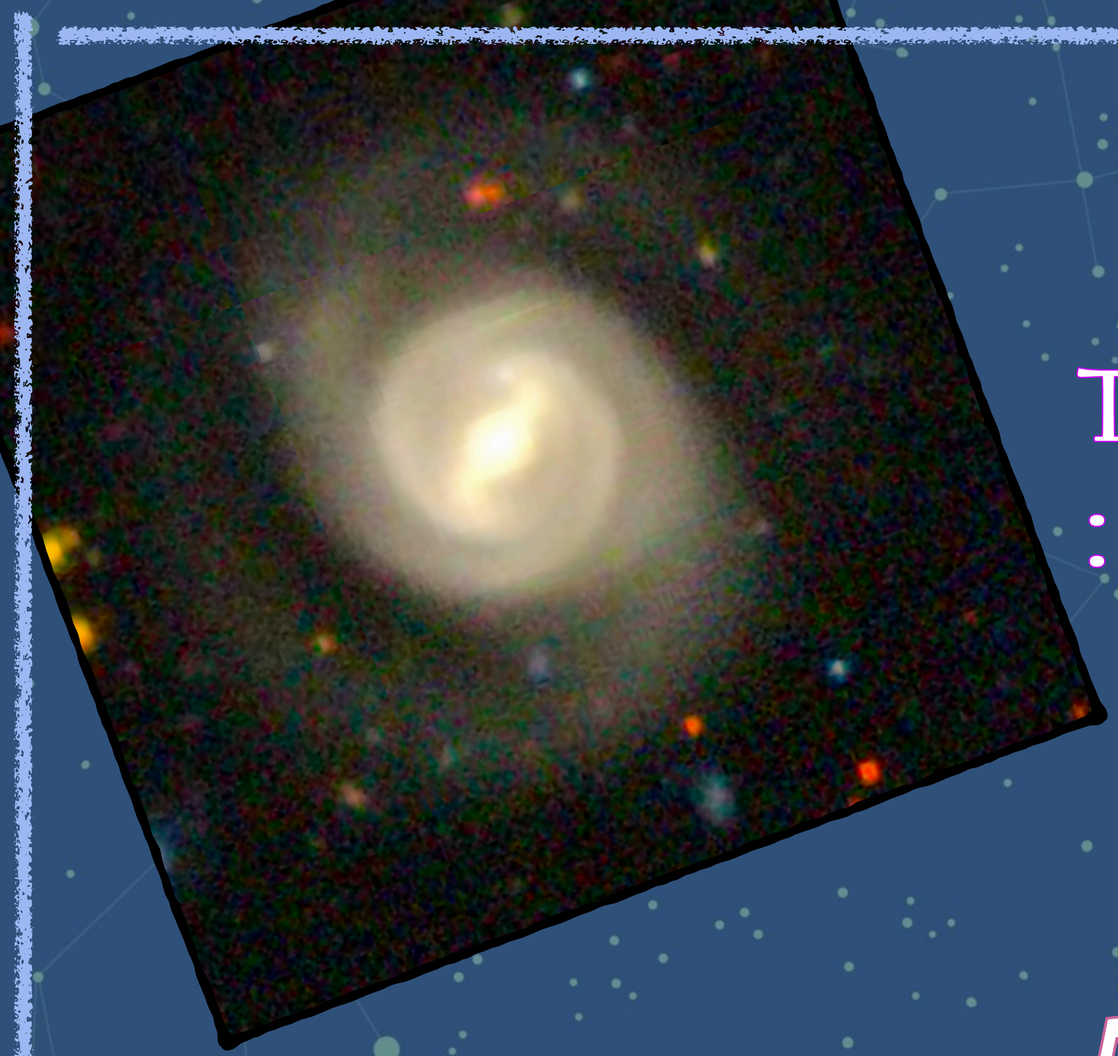
09 Feb 2021



The SAMI galaxy survey : stellar populations of passive spiral galaxies in different environments

Mina Pak (KASI)

Motivation

Gas deficient, anemic spirals

A NEW CLASSIFICATION SYSTEM FOR GALAXIES*

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Received 1975 October 6

ABSTRACT

1) A new galaxy classification system is proposed in which normal spirals and lenticulars form parallel sequences within which "early" and "late" systems are distinguished by means of their disk-to-bulge ratios.

2) A sequence of "anemic spirals," which occur most frequently in rich clusters, is found to have characteristics that are intermediate between those of vigorous gas-rich normal spirals and gas-poor systems of type S0.

3) The differences between normal spirals (Sa-Sb-Sc), anemic spirals (Aa–Ab–Ac), and lenticulars (S0a–S0b–S0c) are tentatively interpreted in terms of the influence of environment on the evolution of flattened galaxies.

Members of the U of T astronomy department in 1962 with the David Dunlap Observatory in the background: from left to right, S. Van den Bergh, Helen Hogg, D.A. MacRae, Ruth Northcott, J.D. Fernie and J.F. Head (director).

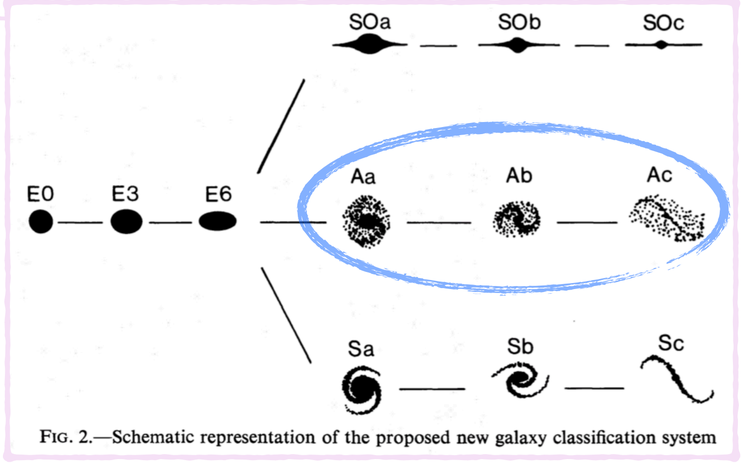
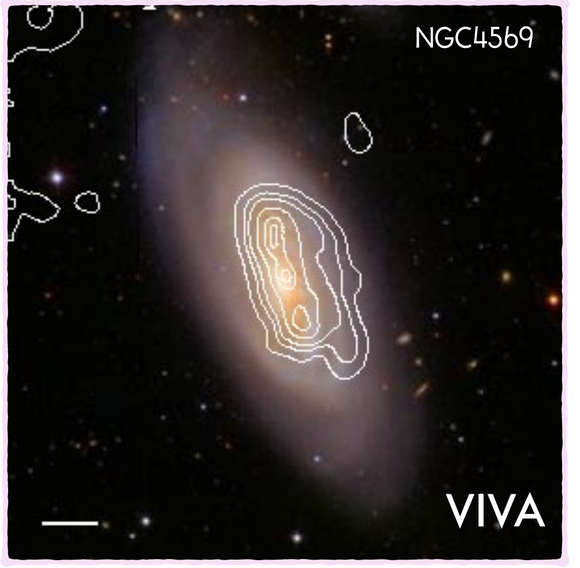


FIG. 2.—Schematic representation of the proposed new galaxy classification system

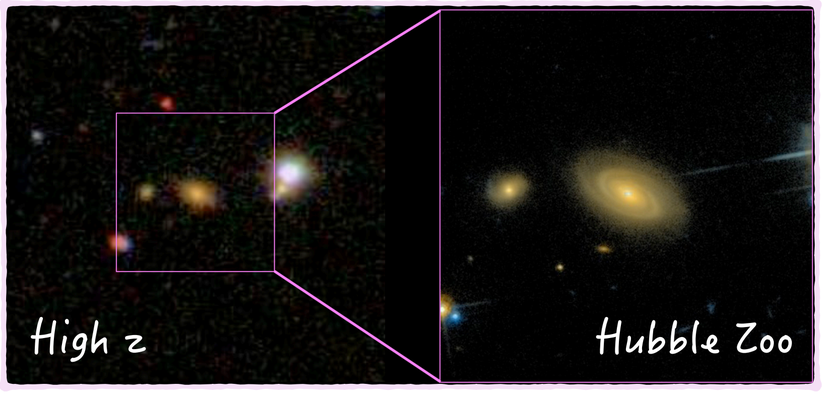


Motivation

Passive spiral galaxy

DECaLs

- Spiral structure
- Red in optical wavelength
- No/weak star formation
- Old in the center (Fraser-Mckelvie+18), intermediate ages overall (Pak+19)
- Higher bar fraction (Masters+11; ~76% in Fraser-Mckelvie+18; ~80% in Pak+19;)
- Low- and high-z (Moran+06)
- In the intermediate density environments (Goto+03; Masters+10), also in isolation (Fraser-Mckelvie+18)



Masters's talk

Motivation

Formation scenarios for S0 galaxies

1) Faded spirals

Through secular processes and/or environmental effects
(van den Bergh+09, Laurikainen+10, Williams+10, Bekki & Couch 11, Aguerri+12, Cheung+13, Rizzo+17 etc.)

→ Bulgeless/Disk-like (pseudo) bulges (rotation supported)

2) Major mergers/Gas accretion (high-z)

(Spitzer & Baade 51, Querejeta+15, Falcón-Barroso+17, Tapia+17, Méndez-Abreu+18, Diaz +18)

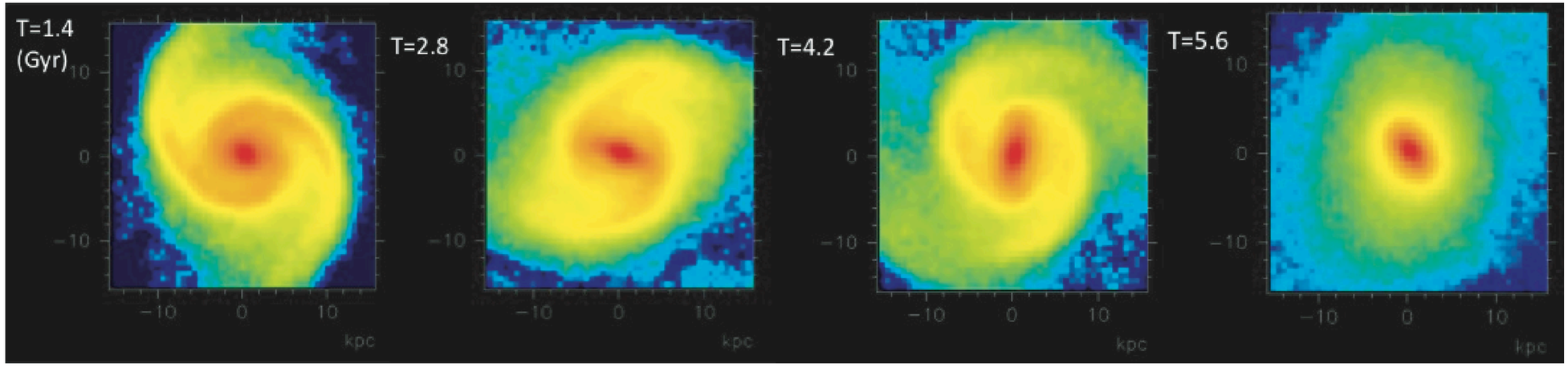
→ Classical bulges (pressure supperted)

Motivation

Spiral → (Passive spiral) → S0?

- In observations..
  The continuity between spirals and lenticulars in many parameter spaces
  eg. Structures (B/T; Laurikainen+10) and Kinematics (spin; Bellstedt+17, angular momentum; Rizzo+18)

- In simulations..

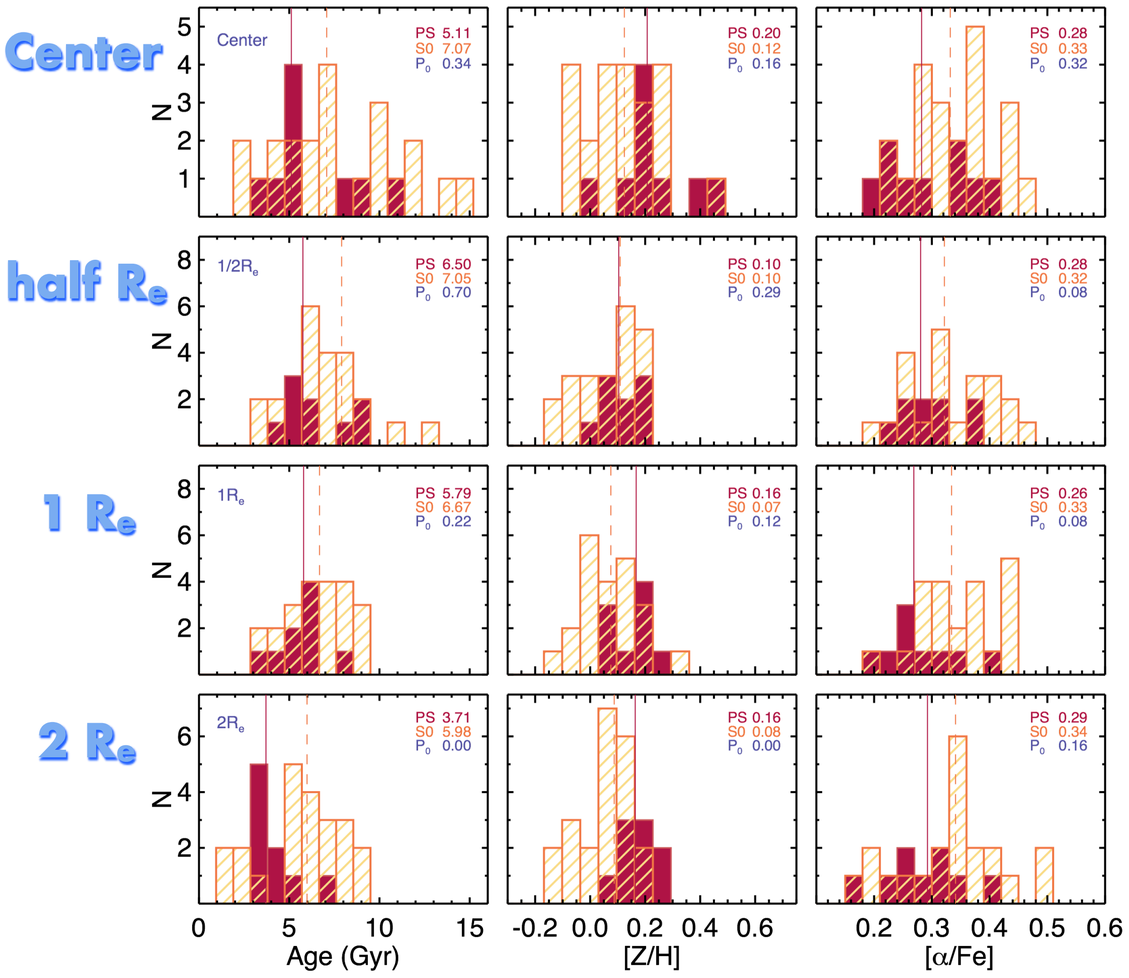


Bekki & Couch+11

Motivation

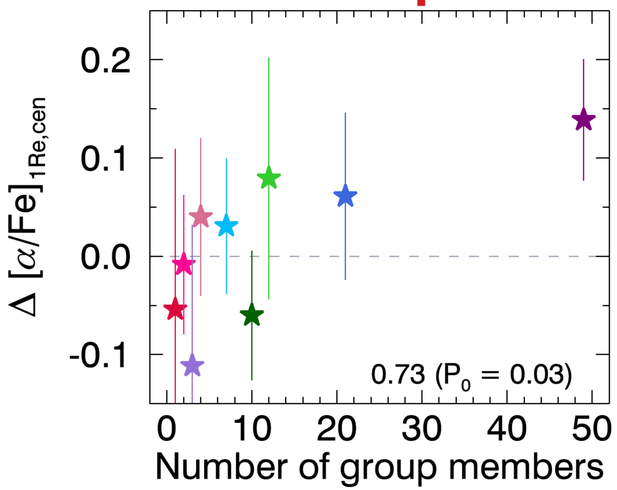
Stellar populations of nine passive spirals in CALIFA survey

Passive spirals + S0s



- Quenched recently (~5 Gyrs) w/o destroying spiral structure
- Passive spirals are under a bias towards younger, higher [Z/H], lower [α/Fe].
- Hint of environmental quenching

Passive spirals



Δ = 1Re - center

Pak+19

SAMI Galaxy Sruvey

- ~3200 galaxies
- A redshift range $0.004 < z < 0.16$
- All morphological types
- A large stellar mass range $7.5 < \log(M_\star/M_\odot) < 11.6$
- A wide range of environments
- A 1-degree-diameter field of view

The SAMI Galaxy Survey: the third and final data release

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Croom, Scott M.; Owers, Matt S.; Scott, Nicholas; Poetrodjojo, Henry; Groves, Brent; van de Sande, Jesse; Barone, Tania M.; Cortese, Luca; D'Eugenio, Francesco; Bland-Hawthorn, Joss; Bryant, Julia; Oh, Sree; Brough, Sarah; Agostino, James; Casura, Sarah; Catinella, Barbara; Colless, Matthew; Cecil, Gerald; Davies, Roger L.; Drinkwater, Michael J. Driver, Simon P.; Ferreras, Ignacio; Foster, Caroline; Fraser-McKelvie, Amelia; Lawrence, Jon; Leslie, Sarah K.; Liske, Jochen; López-Sánchez, Ángel R.; Lorente, Nuria P. F.; McElroy, Rebecca; Medling, Anne M.; Obreschkow, Danail; Richards, Samuel N.; Sharp, Rob; Sweet, Sarah M.; Taranu, Dan S.; Taylor, Edward N.; Tescari, Edoardo; Thomas, Adam D.; Tocknell, James; Vaughan, Sam P.

SAMI targets in the GAMA fields

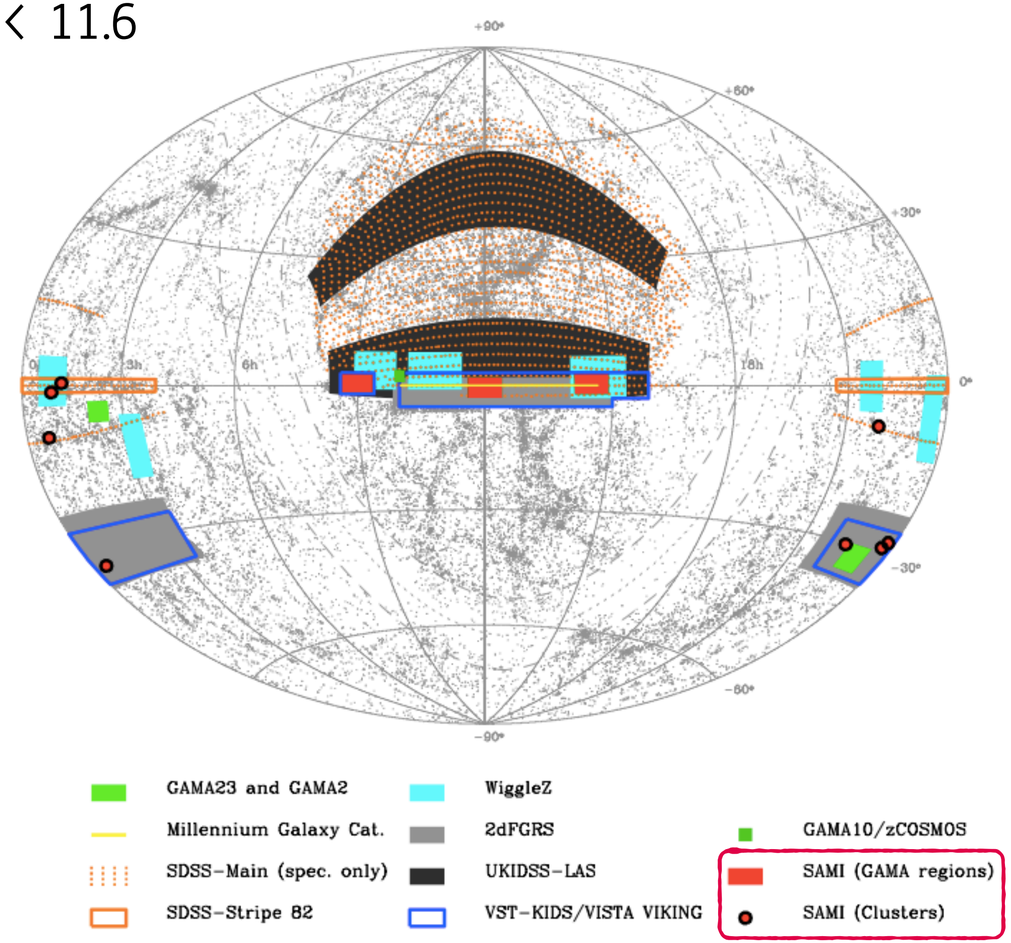
The main sample of galaxies targeted by SAMI are in areas surveyed by the GAMA project. In particular the GAMA-I G09, G12 and G15 areas which are:

Field	RA range	Dec range
G09	129.0 to 141.0	−1 to +3
G12	174.0 to 186.0	−2 to +2
G15	211.5 to 223.5	−2 to +2

SAMI cluster targets

The GAMA regions do not contain any massive clusters at z<0.1, so we are separately targeting galaxies in 8 specific clusters. The clusters to be targeted are listed below.

Cluster	RA	DEC	z
EDCC0442	6.381	-33.047	0.0494
Abell0085	10.460	-9.303	0.0556
Abell0119	14.067	-1.255	0.0442
Abell0168	18.740	0.431	0.0448
Abell2399	329.389	-7.794	0.0582
Abell3880	336.977	-30.575	0.0579
APMCC0917	355.398	-29.236	0.0509
Abell4038	356.895	-28.125	0.0297

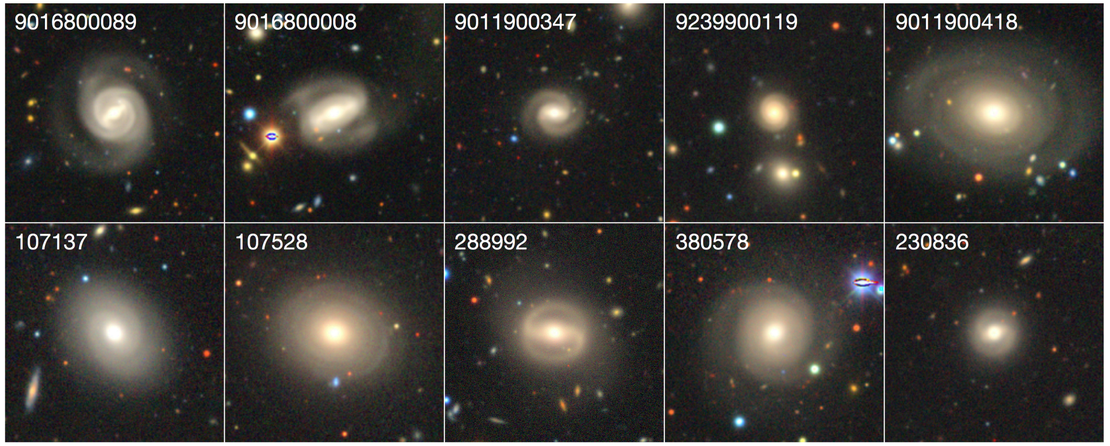


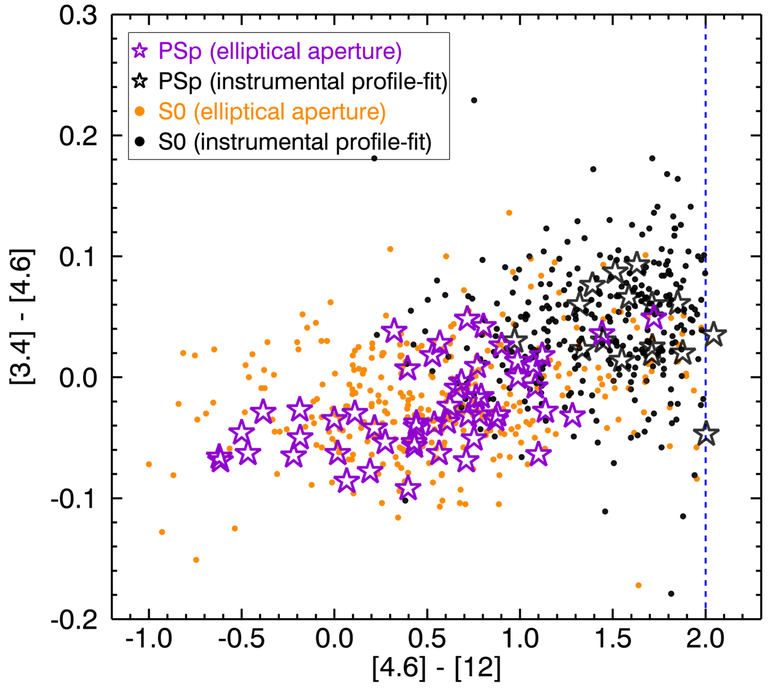
Passive spiral selection

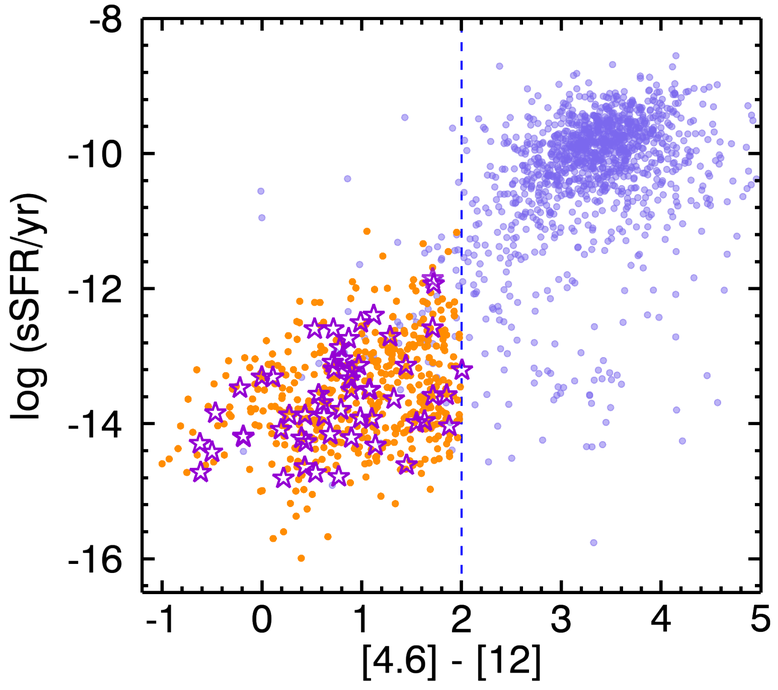
52 cluster & 18 field/group passive spirals

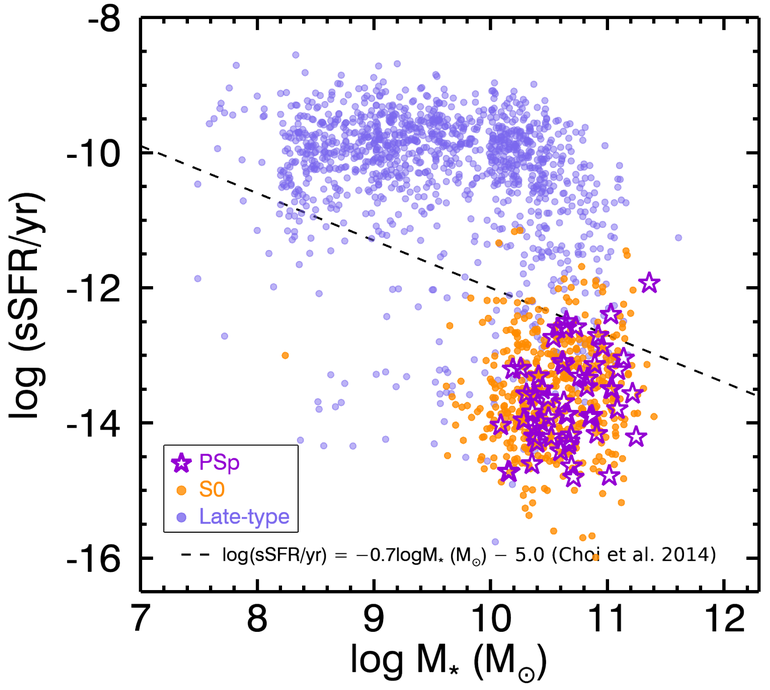
- Selection criteria
  - eyeball: spirals with red in optical wavelengths
  - IR colors

Some examples of PSp in clusters (top) and field/groups (bottom)









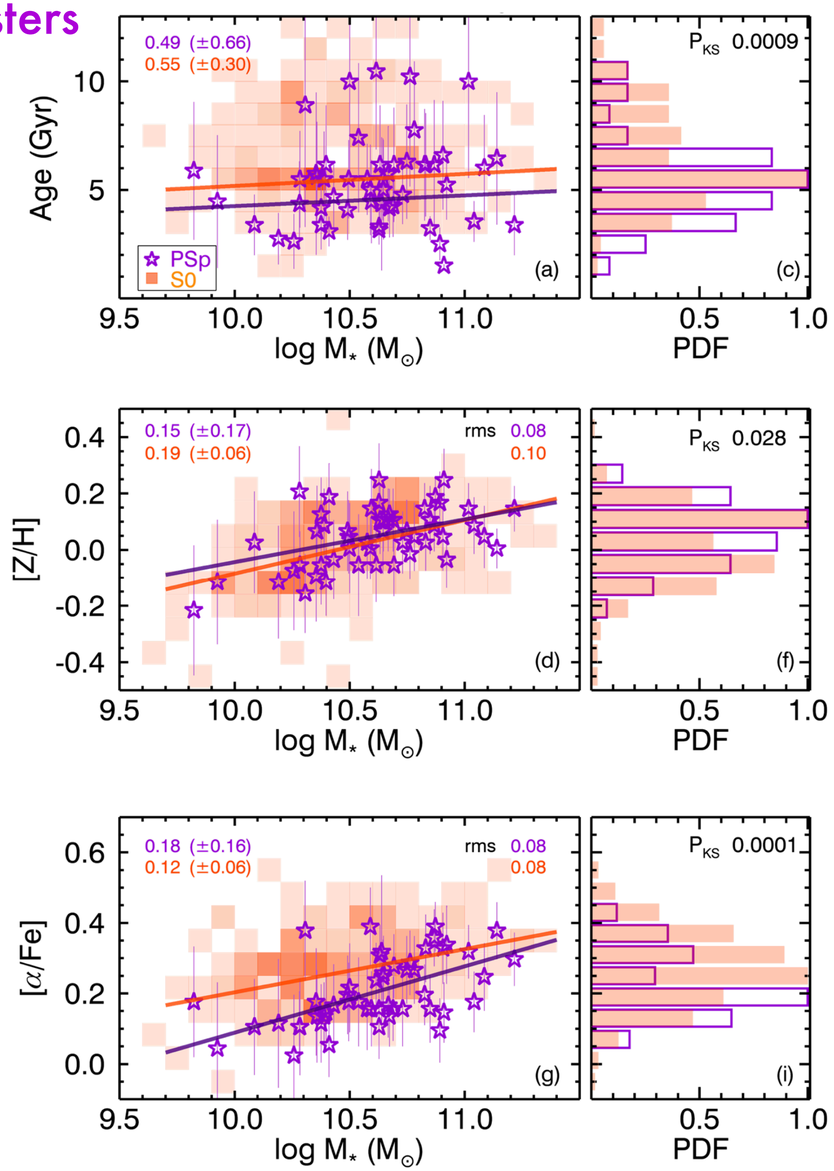
Results

PSp vs. S0s & Cluster vs. Field/group environments

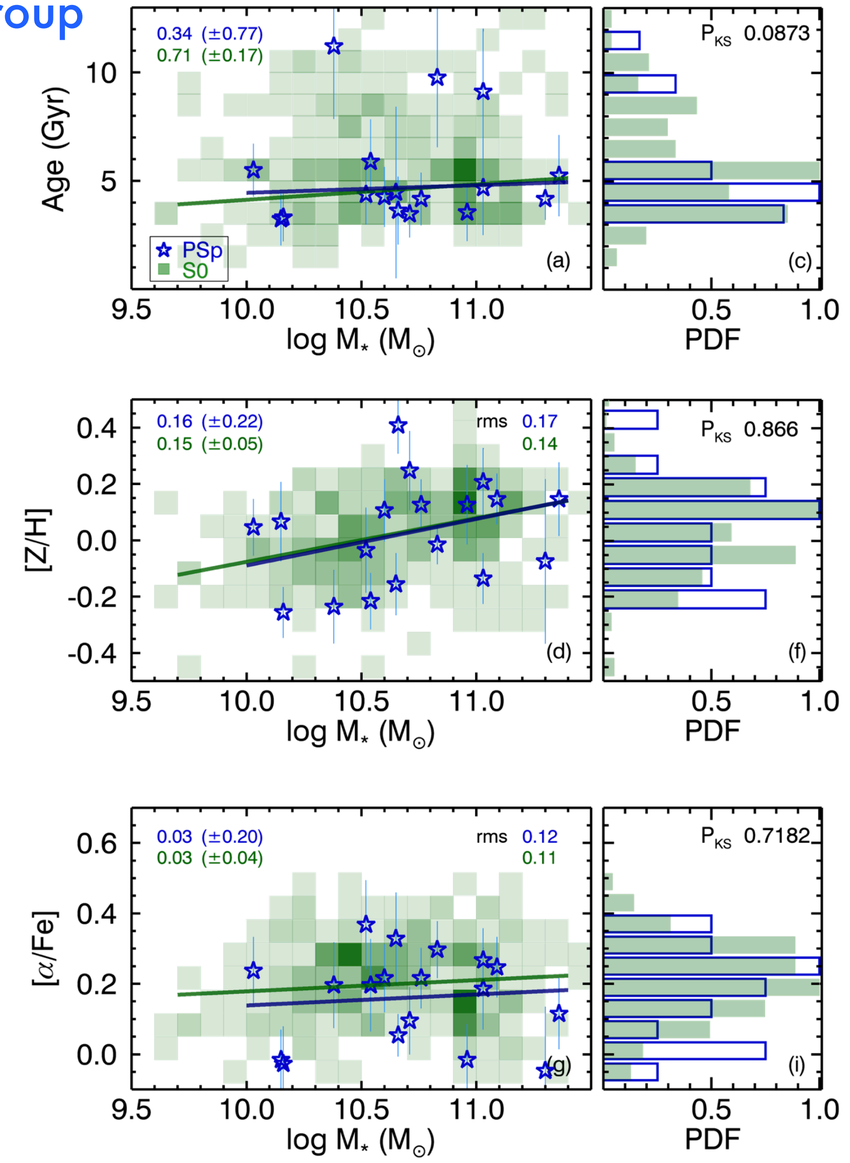
< 1Re

★ PSp
■ S0

Clusters

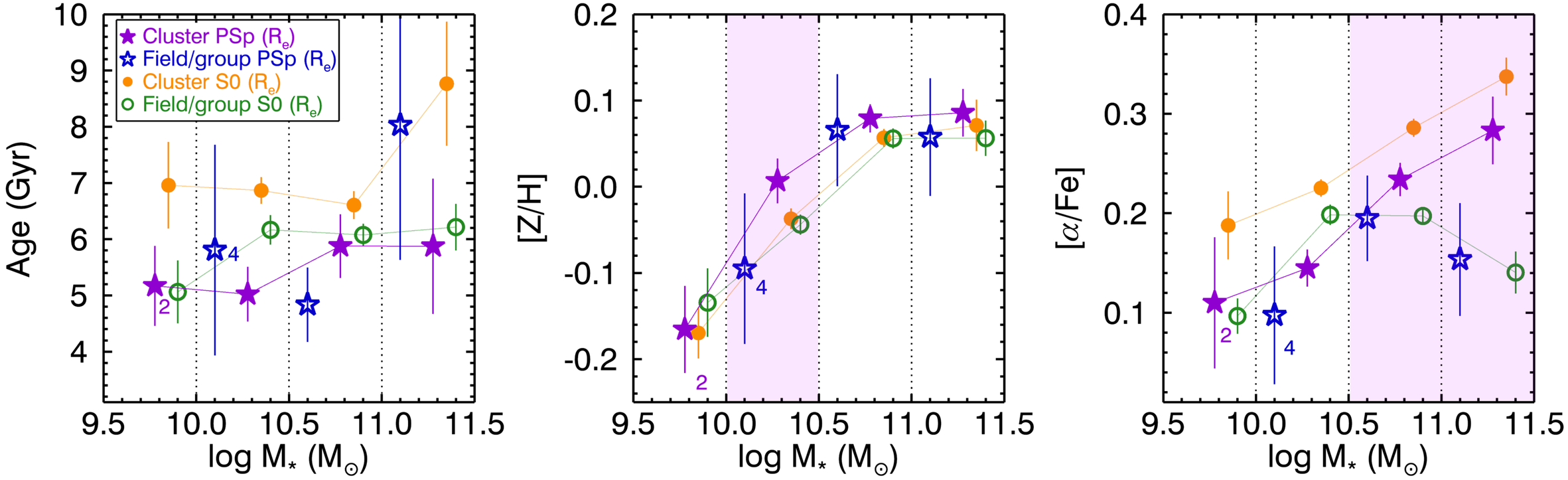


Field/group



Results

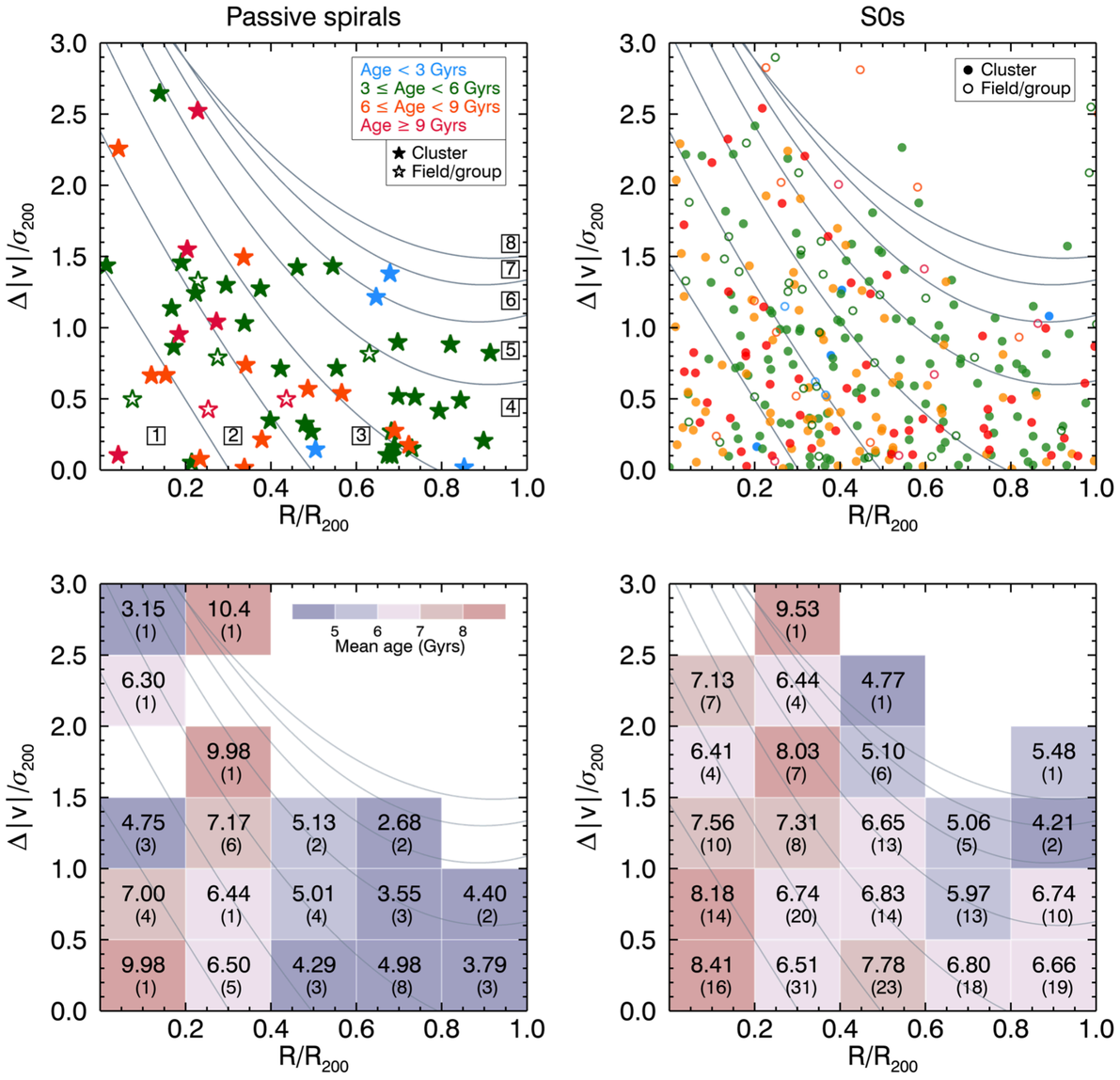
Mean stellar populations for all subdivisions in each mass bin



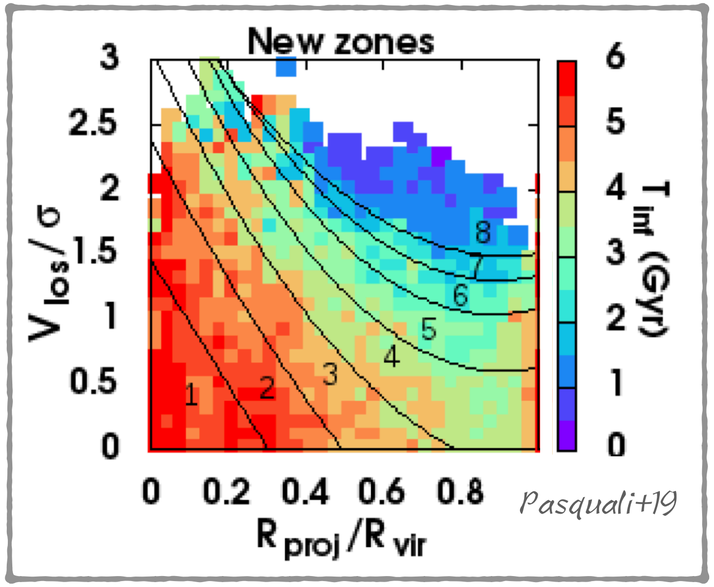
- Passive spirals tend to be younger than S0s at the fixed stellar masses in cluster.
- Cluster passive spirals tend to be more metal-rich than S0s (log ($M_\star/M_\odot$) ≳ 10.0).
- [α/Fe] flattens and/or bends over at log ($M_\star/M_\odot$) ≳ 10.5 for the field/group passive spirals and S0s.

Results

Age in phase-space

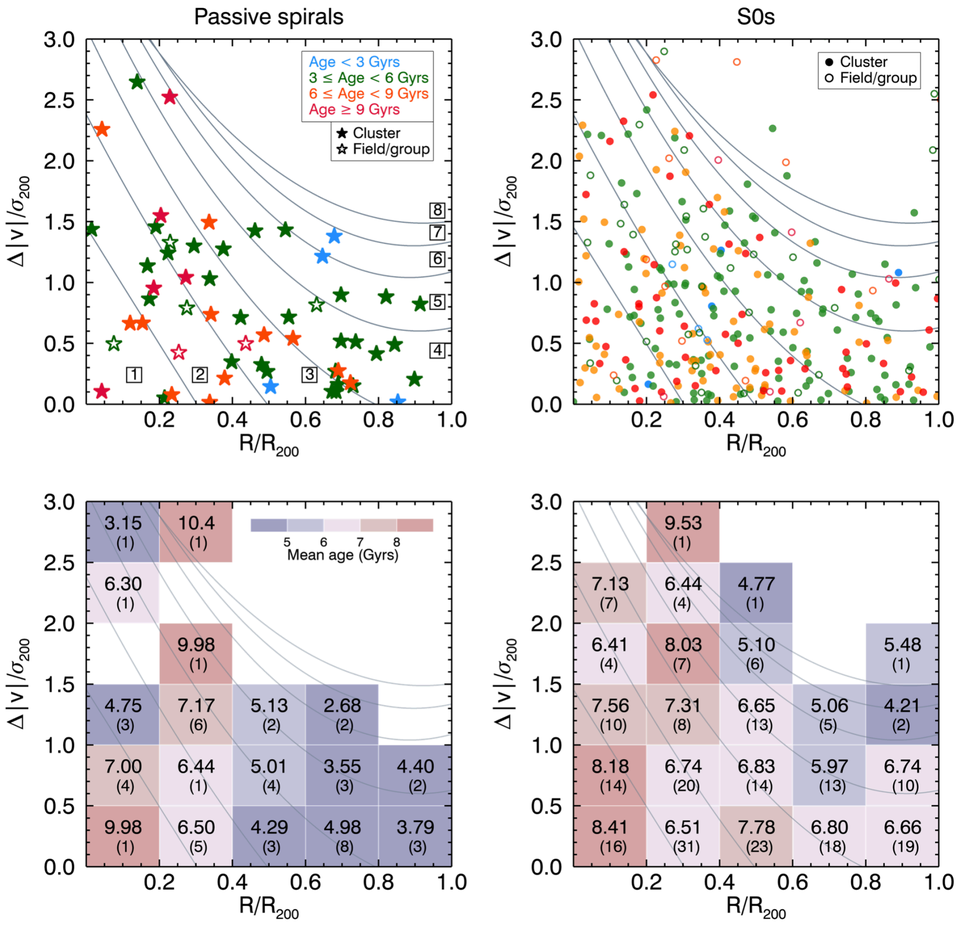


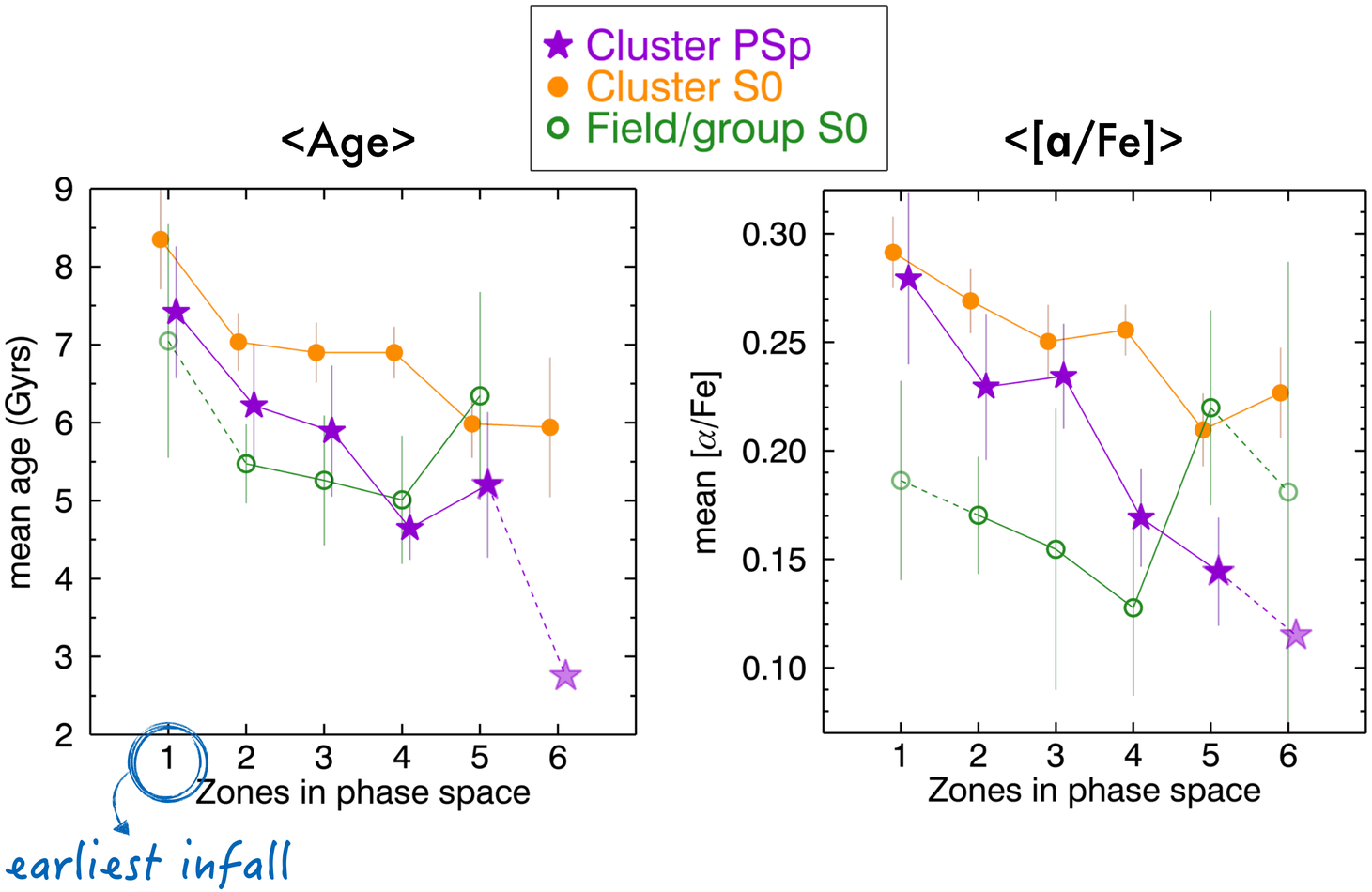
- curves in phase-space from Pasquali+19, which grade the average infall time (= time elapsed since the first infall) of the galaxies



Results

Age and [α/Fe] with zones





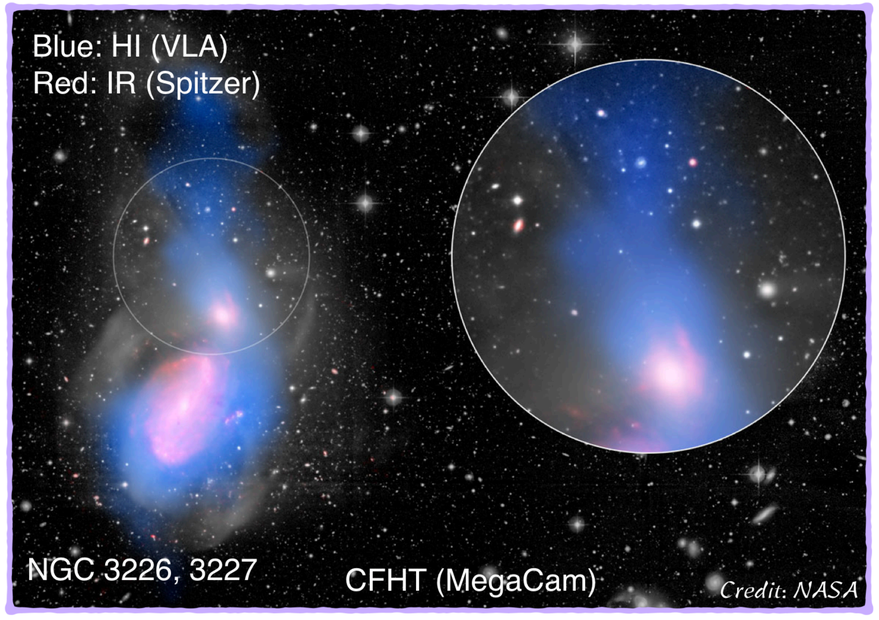
Conclusions

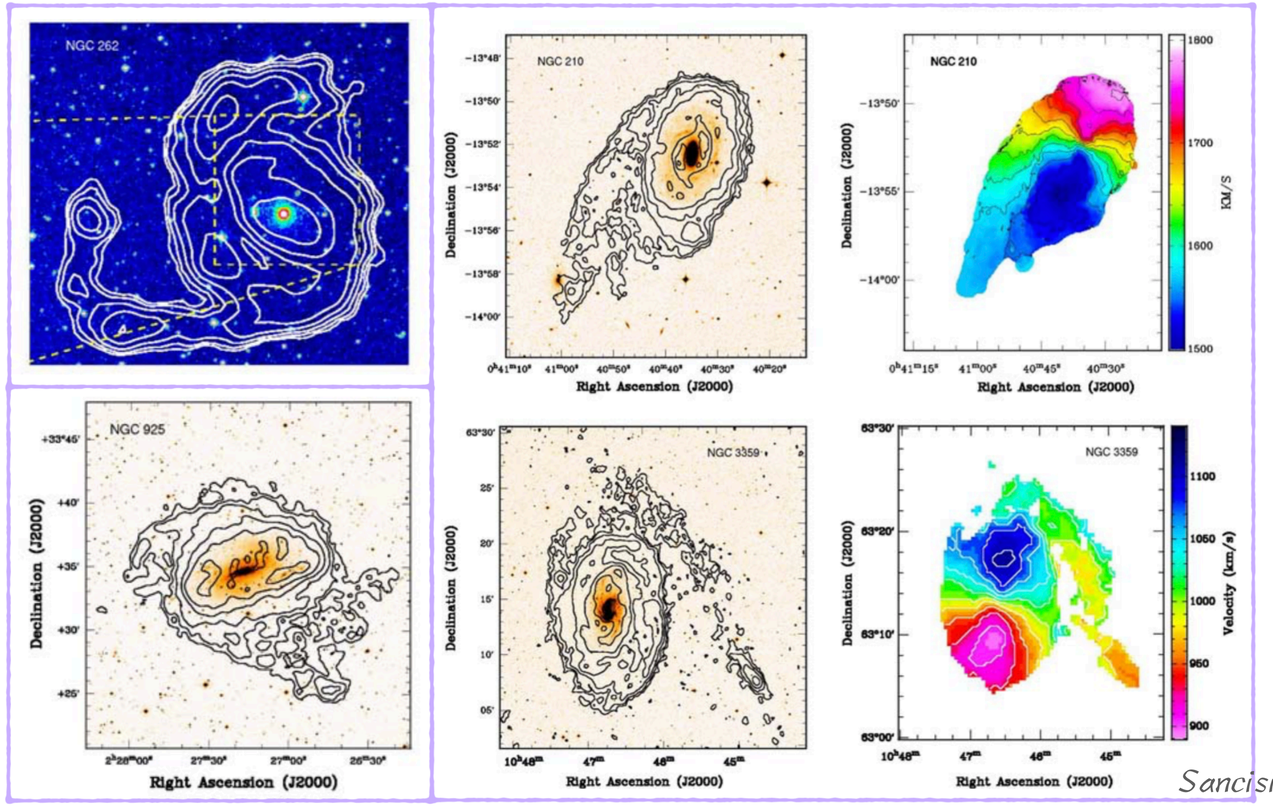
- Passive spiral galaxies may have different formation histories depending on their environments.

- Spiral to S0 transformation is probably caused by multiple mechanisms.

  In low density environment,

  1) cold gas accretion
  2) gas fuel by wet minor merging





Sancisi+08

Conclusions

- Spiral to S0 transformation is probably caused by multiple mechanisms.

  In cluster environment,

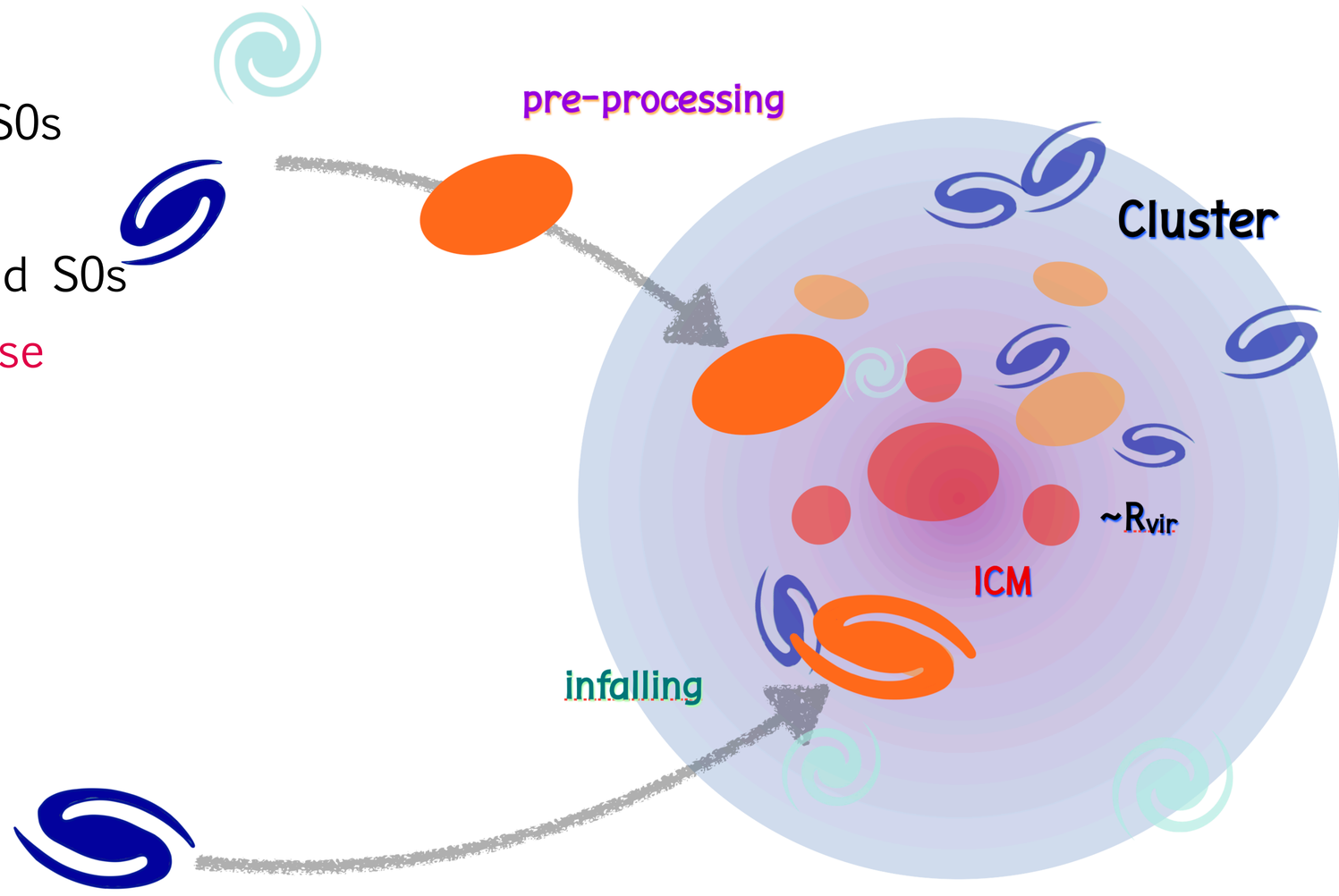
  1) merging at early epoch

     → older & more α-enhanced S0s

  2) interaction with clusters

     → younger & lower α-enhanced S0s

     through passive spiral phase



Take-home message

Passive Spirals could be one of the channels transforming from spirals to S0s.

- ✪ Suggesting observational constraint in timescales between SF quenching and morphological transformation (~5 Gyrs)
- ✪ Passive spiral galaxies also may have different formation histories depending on their environments.