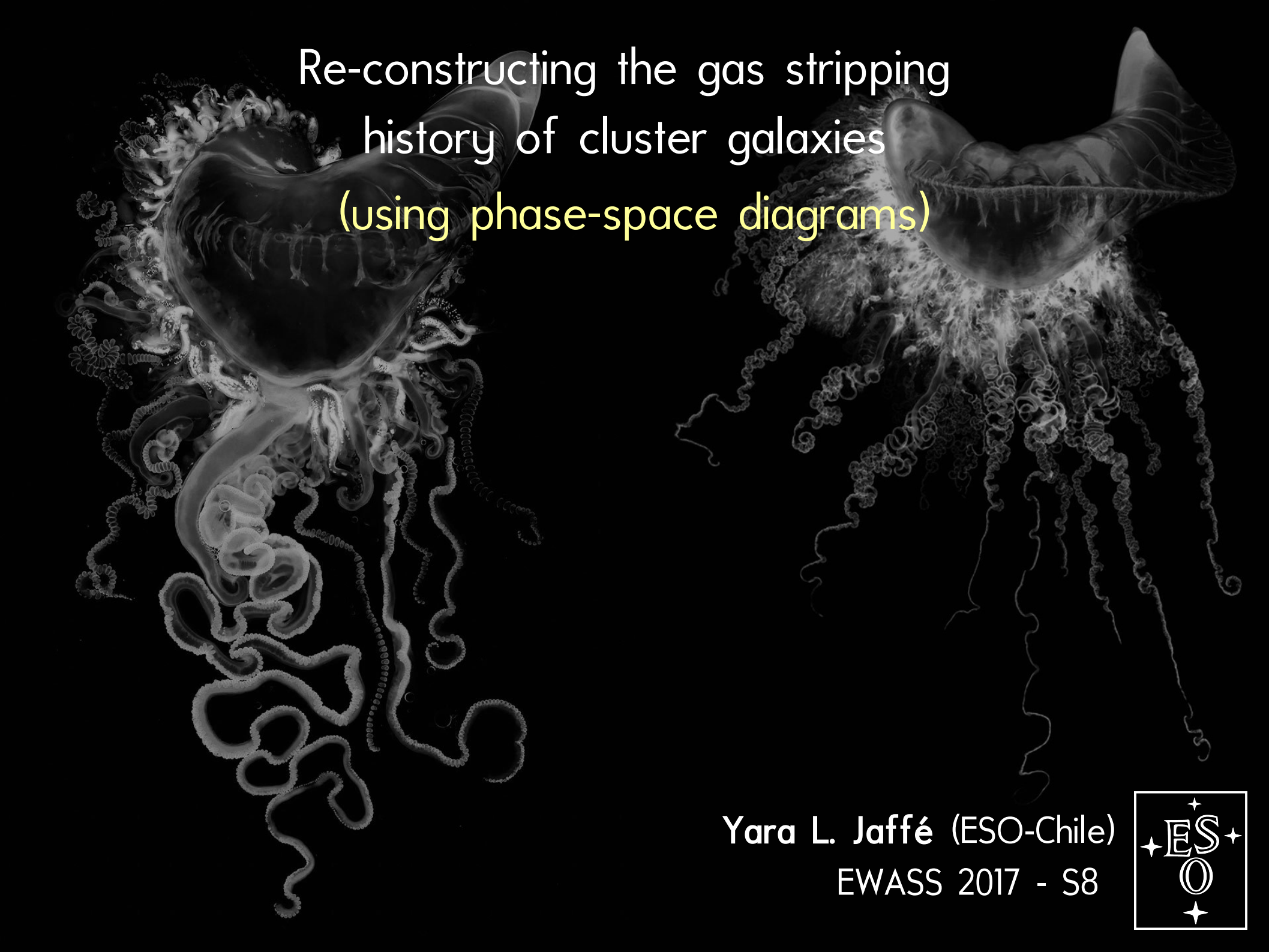
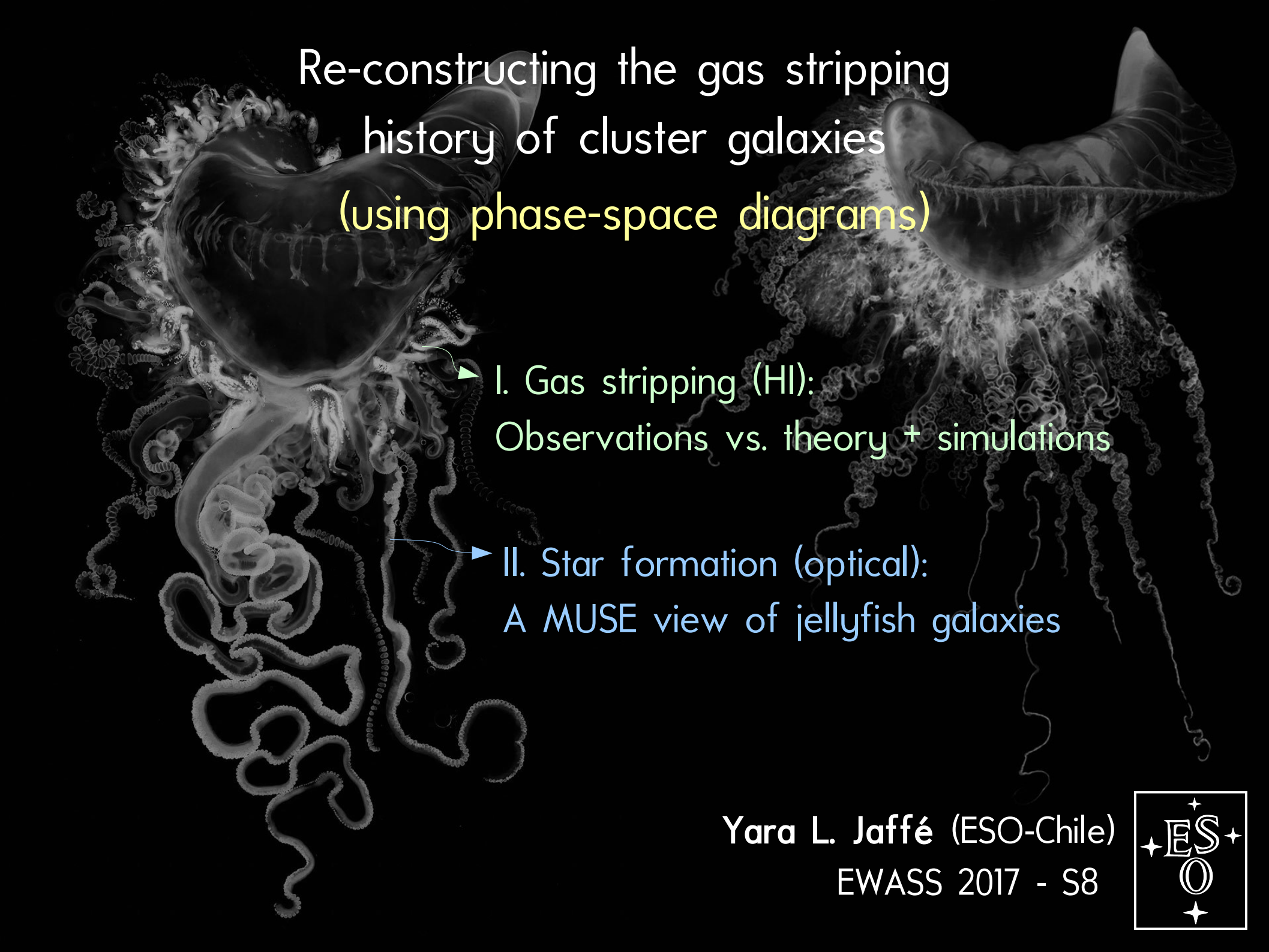


Re-constructing the gas stripping history of cluster galaxies

(using phase-space diagrams)

Yara L. Jaffé (ESO-Chile)

EWASS 2017 - S8



Re-constructing the gas stripping history of cluster galaxies (using phase-space diagrams)

I. Gas stripping (HI):
Observations vs. theory + simulations

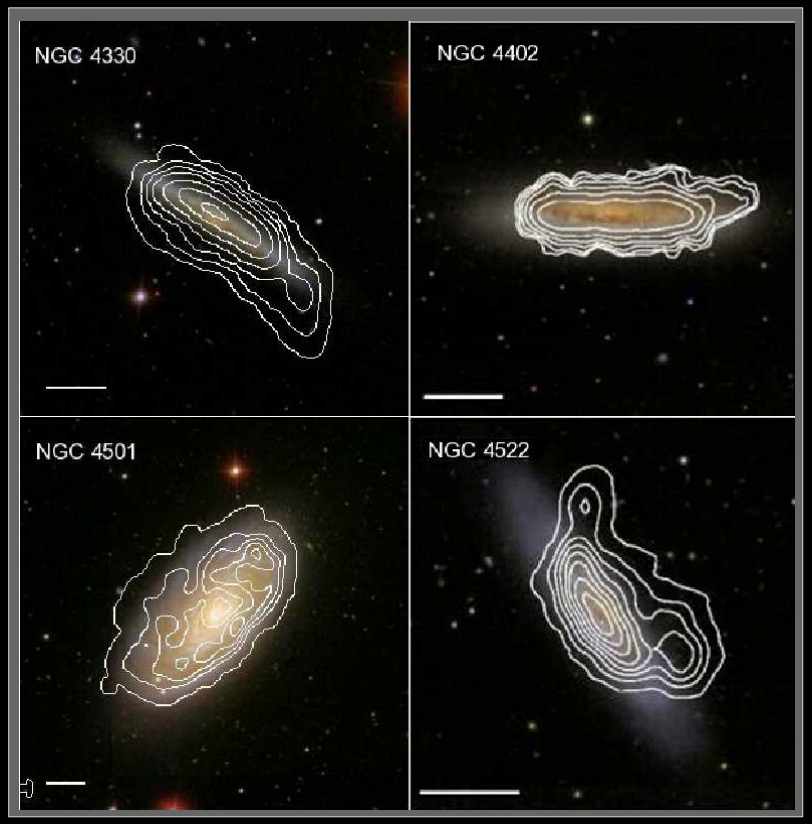
II. Star formation (optical):
A MUSE view of jellyfish galaxies

Yara L. Jaffé (ESO-Chile)
EWASS 2017 - S8

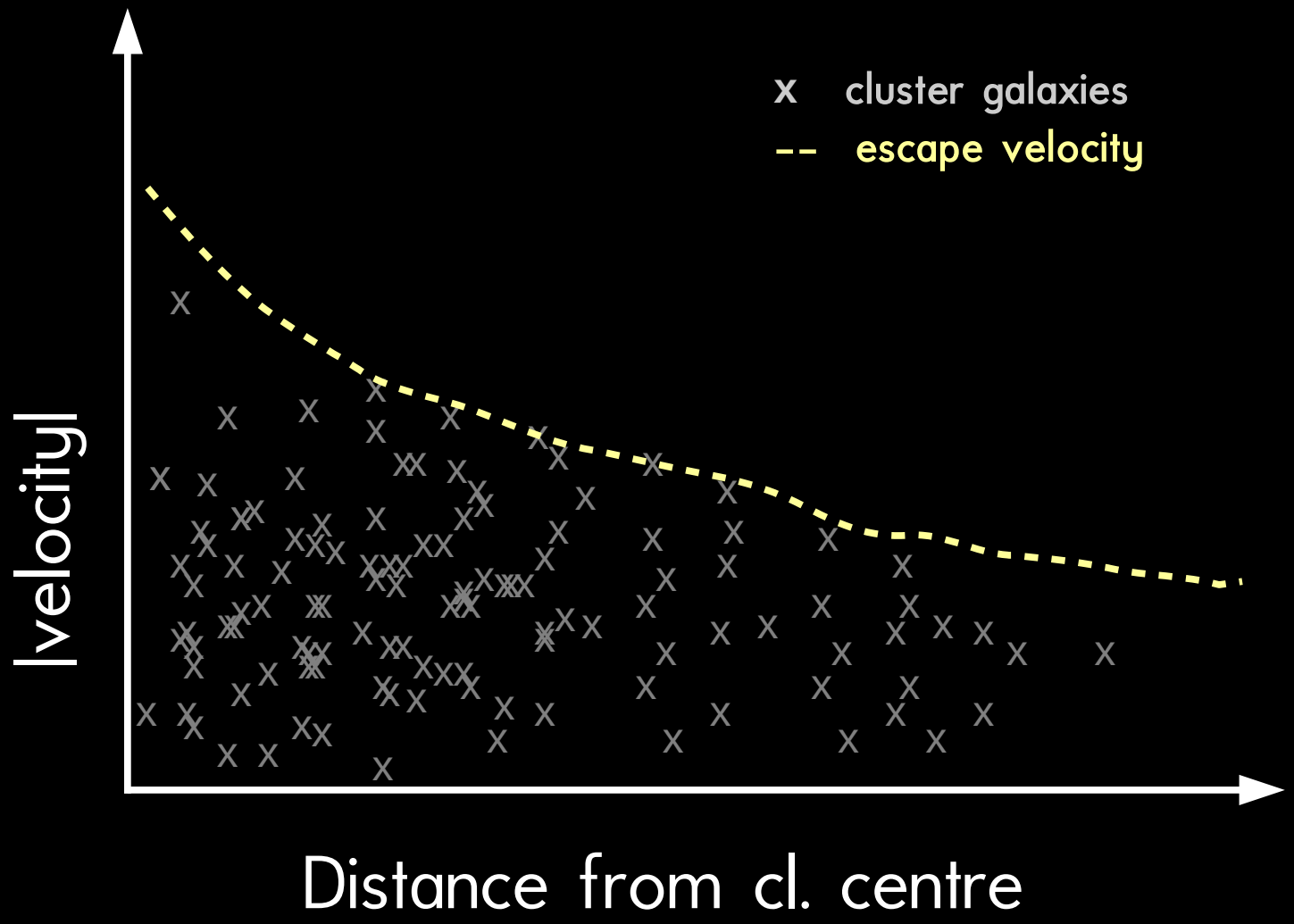
I. Gas stripping of cluster galaxies – An HI view

HI stripping in the Virgo cluster

(VIVA survey: Chung+2009)



The orbits of cluster galaxies in phase-space



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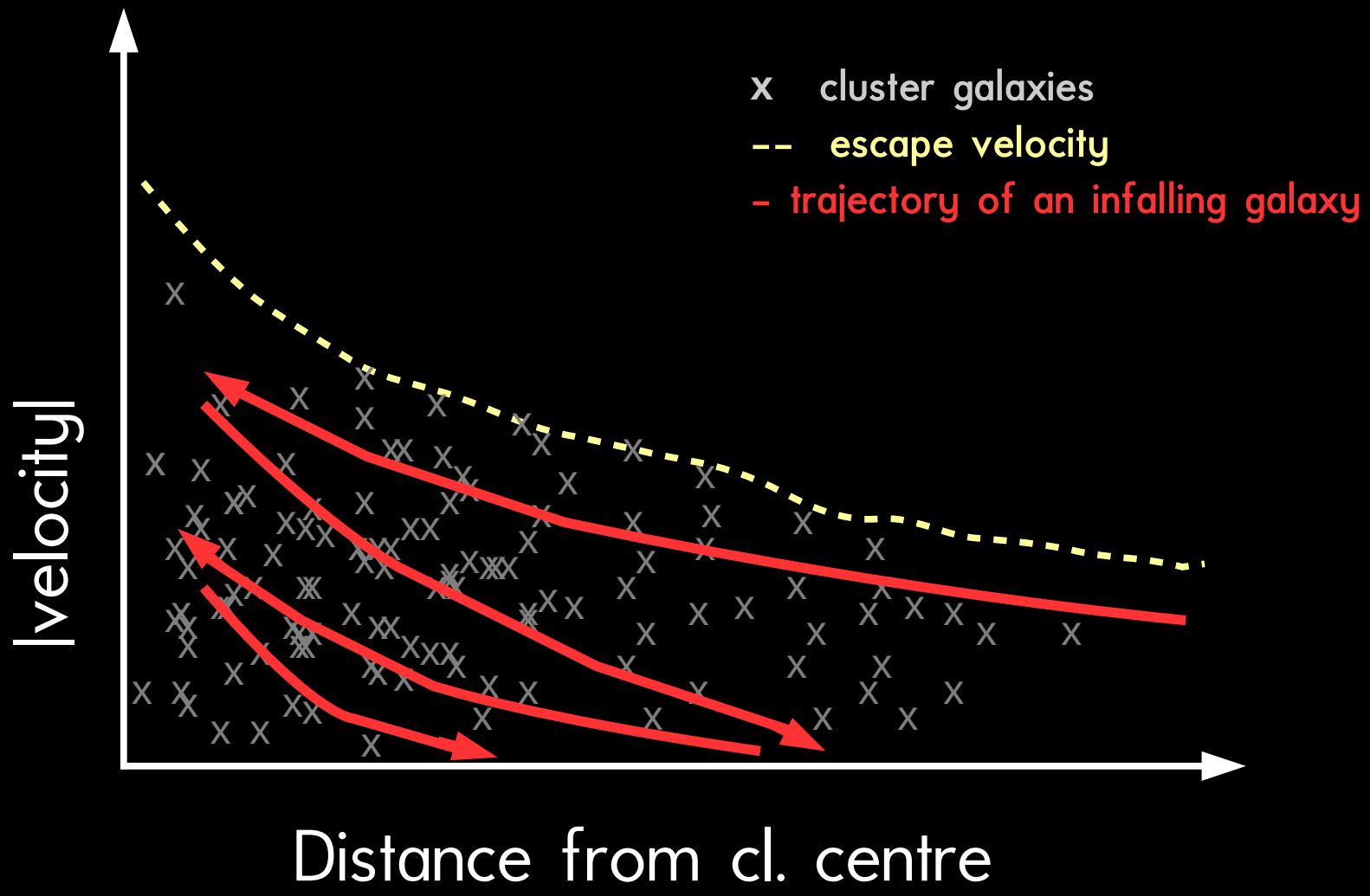
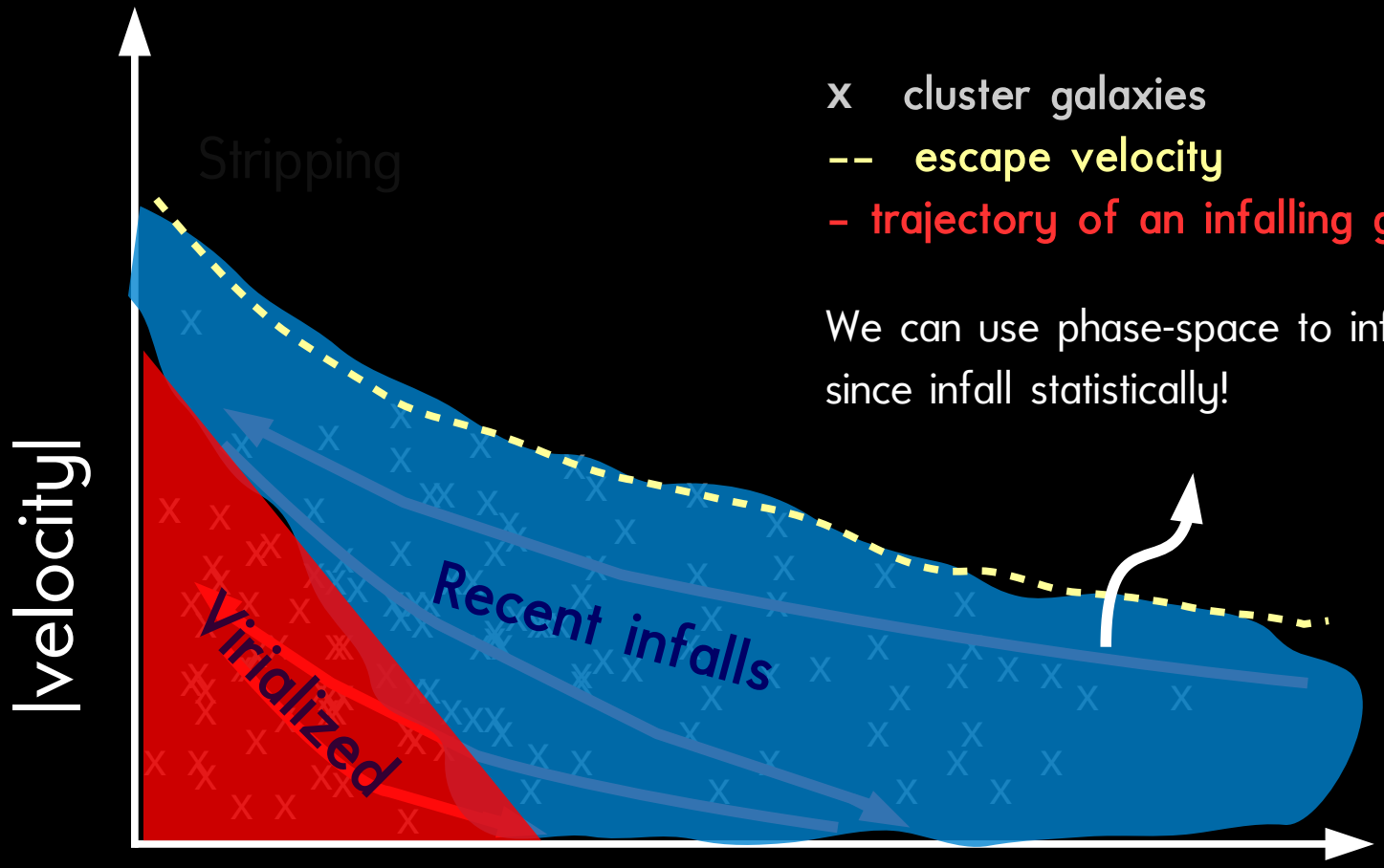
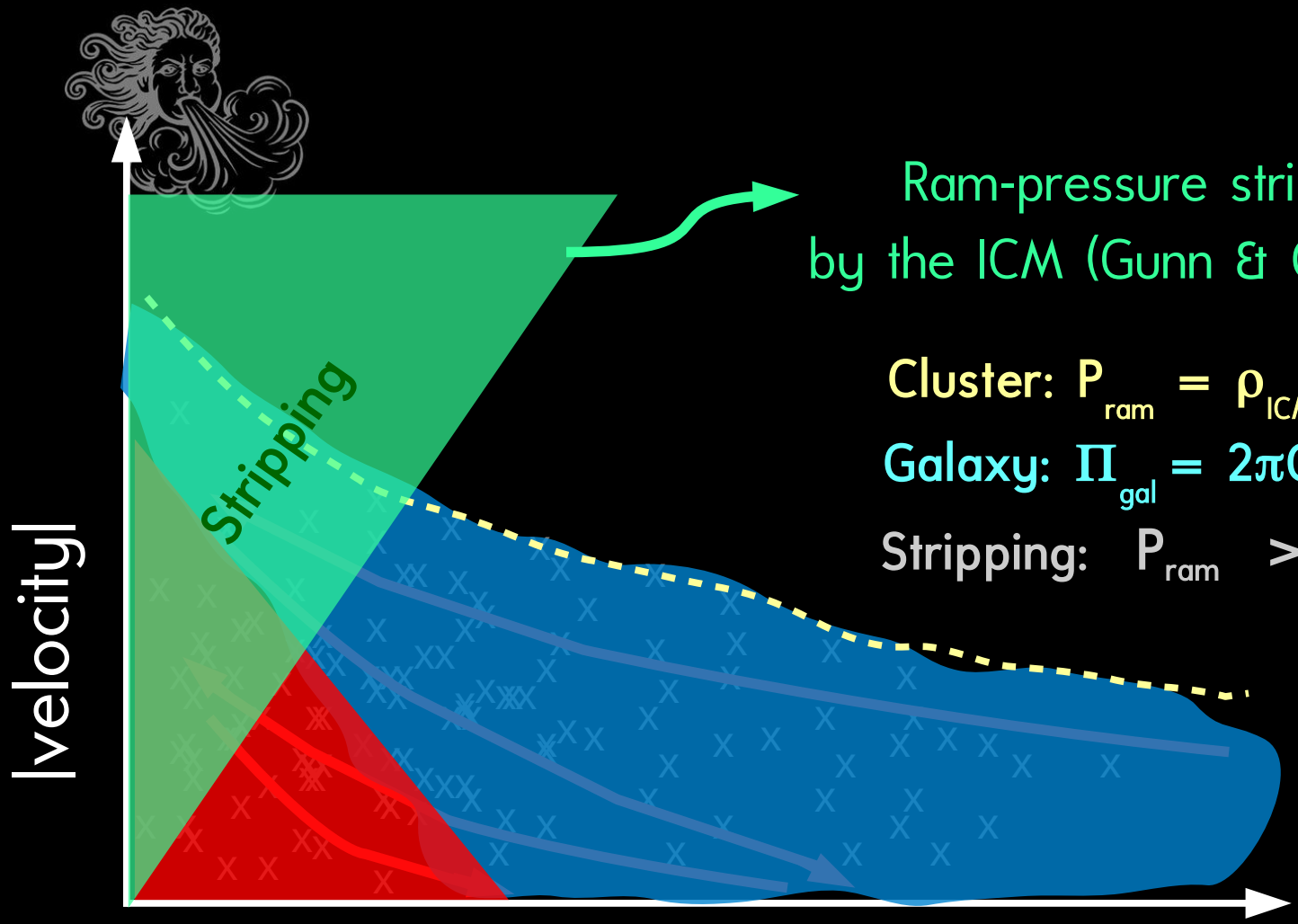


The orbits of cluster galaxies in phase-space



But there are projection effects (see Rhee... Jaffé et al. 2017)

The orbits of cluster galaxies in phase-space



Ram-pressure stripping
by the ICM (Gunn & Gott 1972):

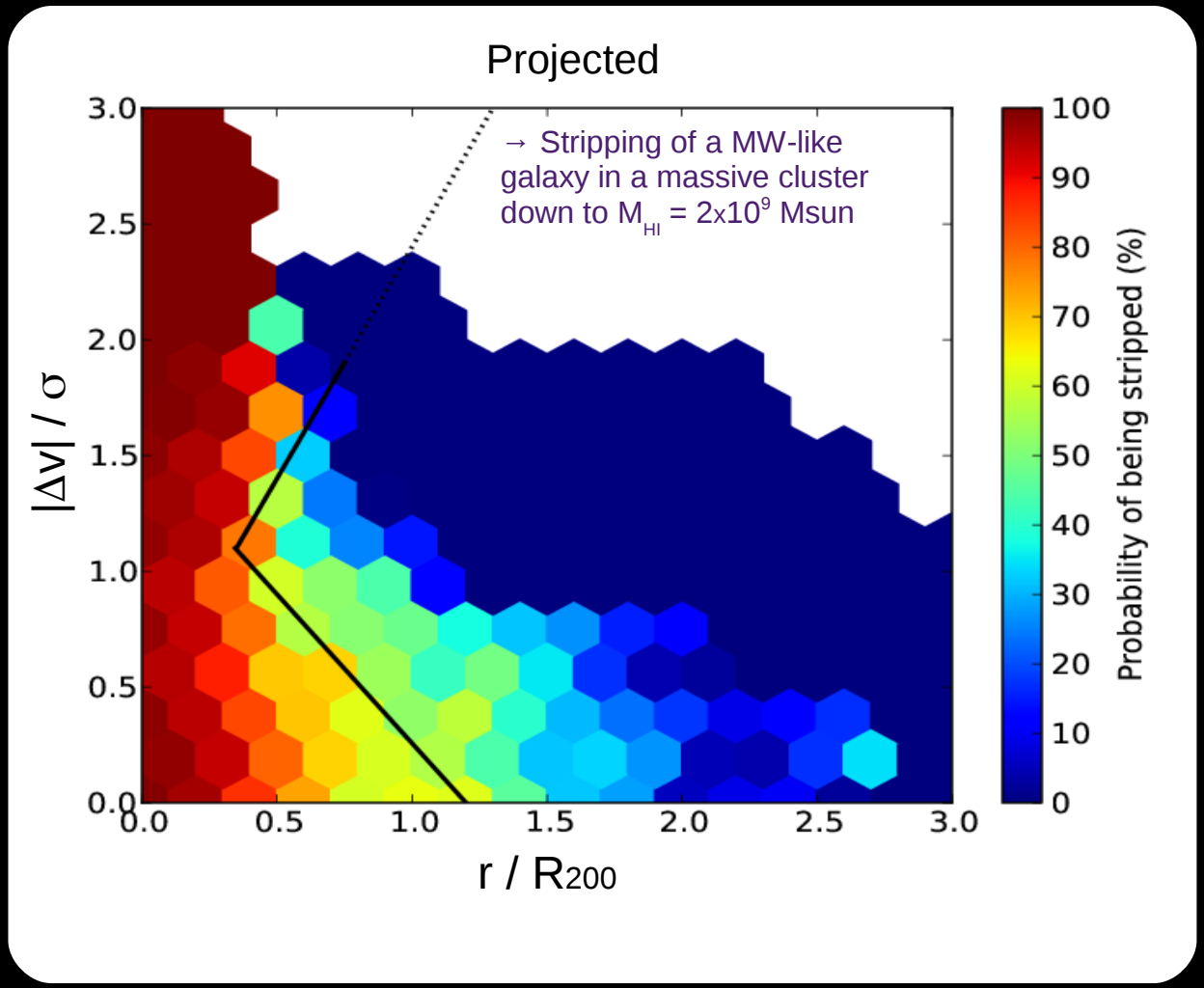
Cluster: $P_{ram} = \rho_{ICM} v_{gal}^2$

Galaxy: $\Pi_{gal} = 2\pi G \Sigma_{gas} \Sigma_{stars}$

Stripping: $P_{ram} > \Pi_{gal}$

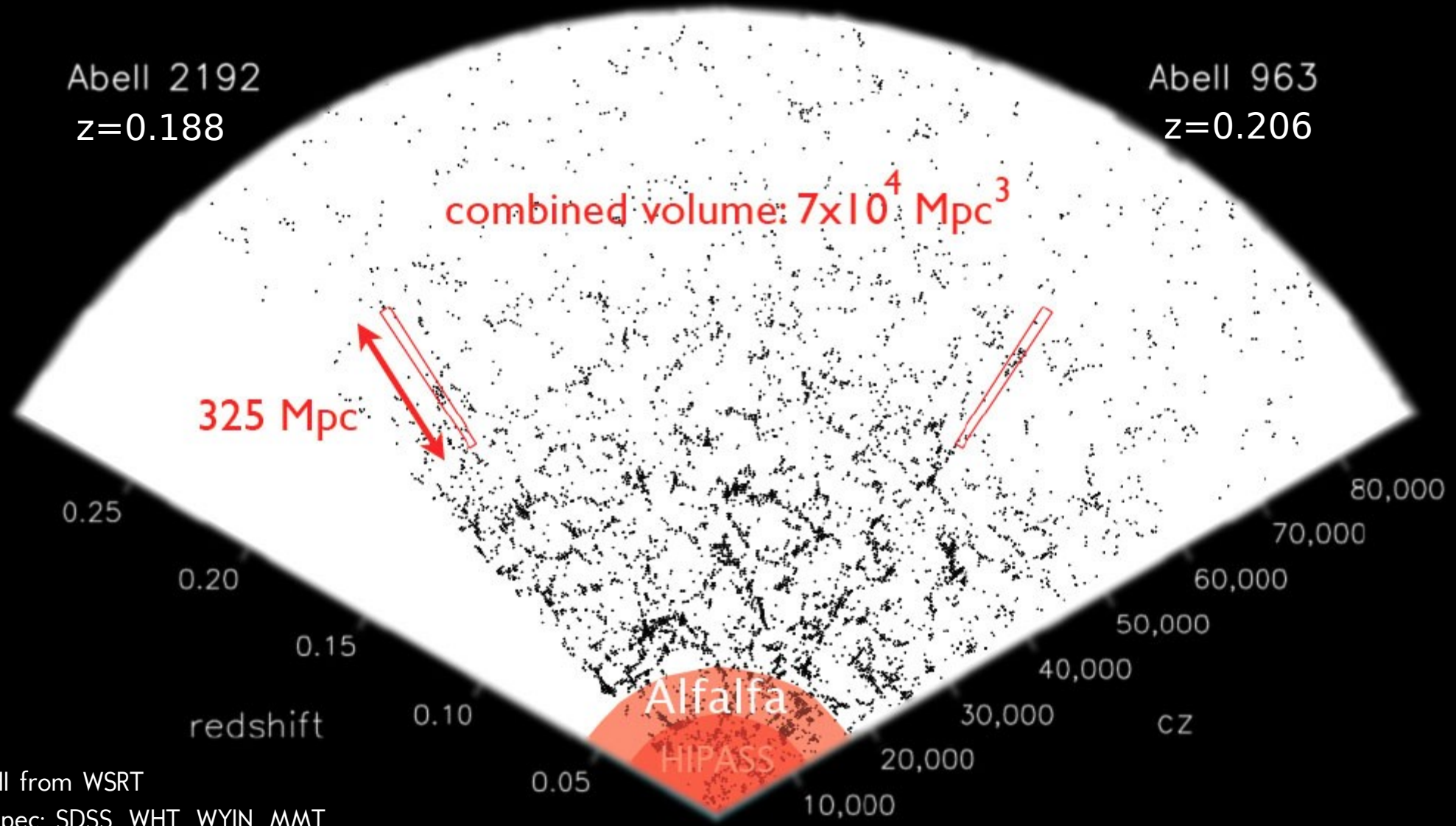
Simulated gas stripping in phase-space

High resolution N-body (dark matter) simulations + analitic RPS (Gunn & Gott)
(Warnick & Knebe 2006; Warnick et al. 2008).



Jaffé, Smith, Candlish et al. (2015)

BUDHIES: Blind Ultra-deep Distant HI Environmental Survey



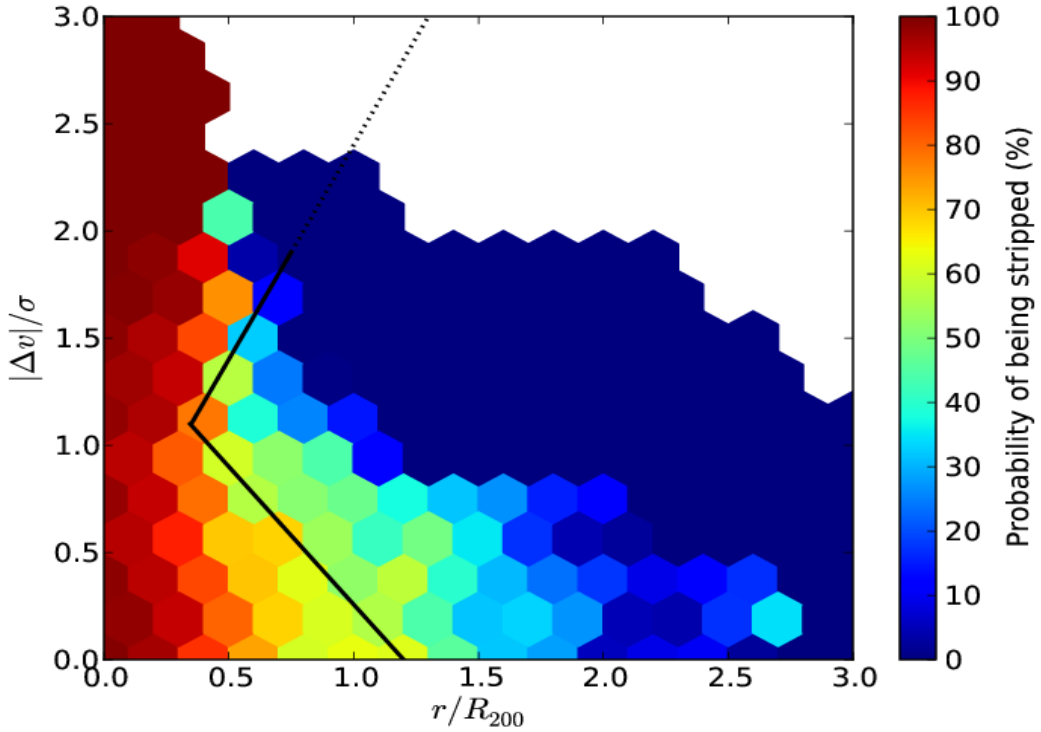
- HI from WSRT
- Spec: SDSS, WHT, WYIN, MMT
- GALEX
- INT B and R
- Spitzer IRAC & MIPS
- Herschel SPIRE & PACS
- UKIRT

A963 part of LoCuSS:

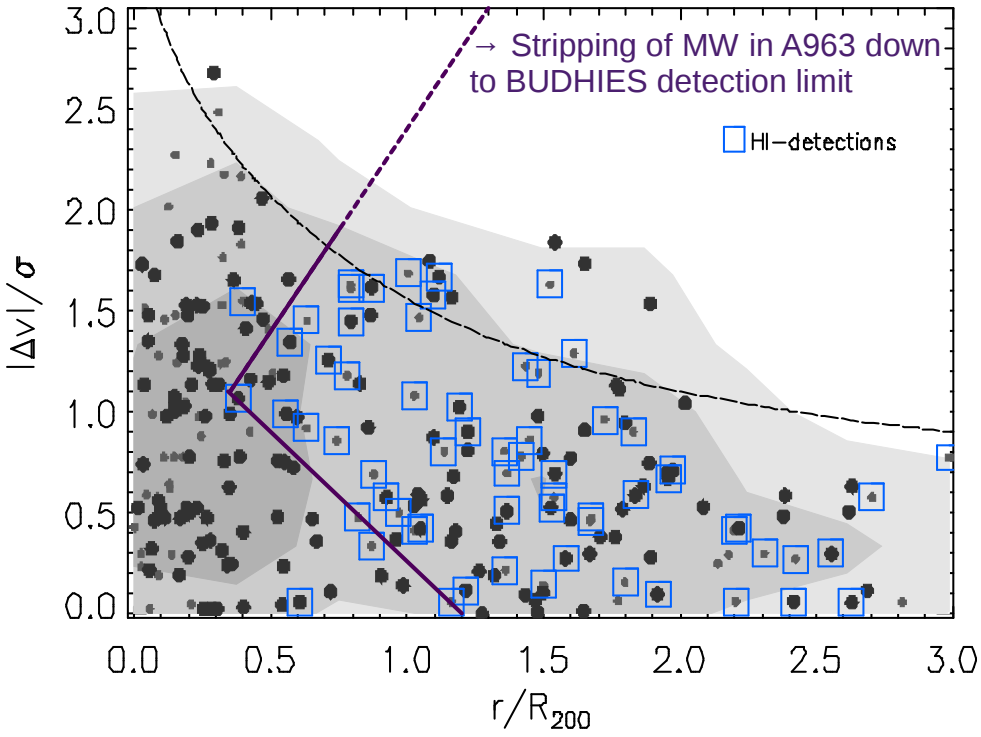
- many more z from MMT spec
- XMM
- Subaru V & I

Gas stripping in projected phase-space

N-body Simulations + analitic RPS



HI Observations of A963 (BUDHIES)



→ Phase-space useful to trace (fast) cluster processes such as gas stripping

→ Galaxies suffer significant gas loss on first infall into the cluster

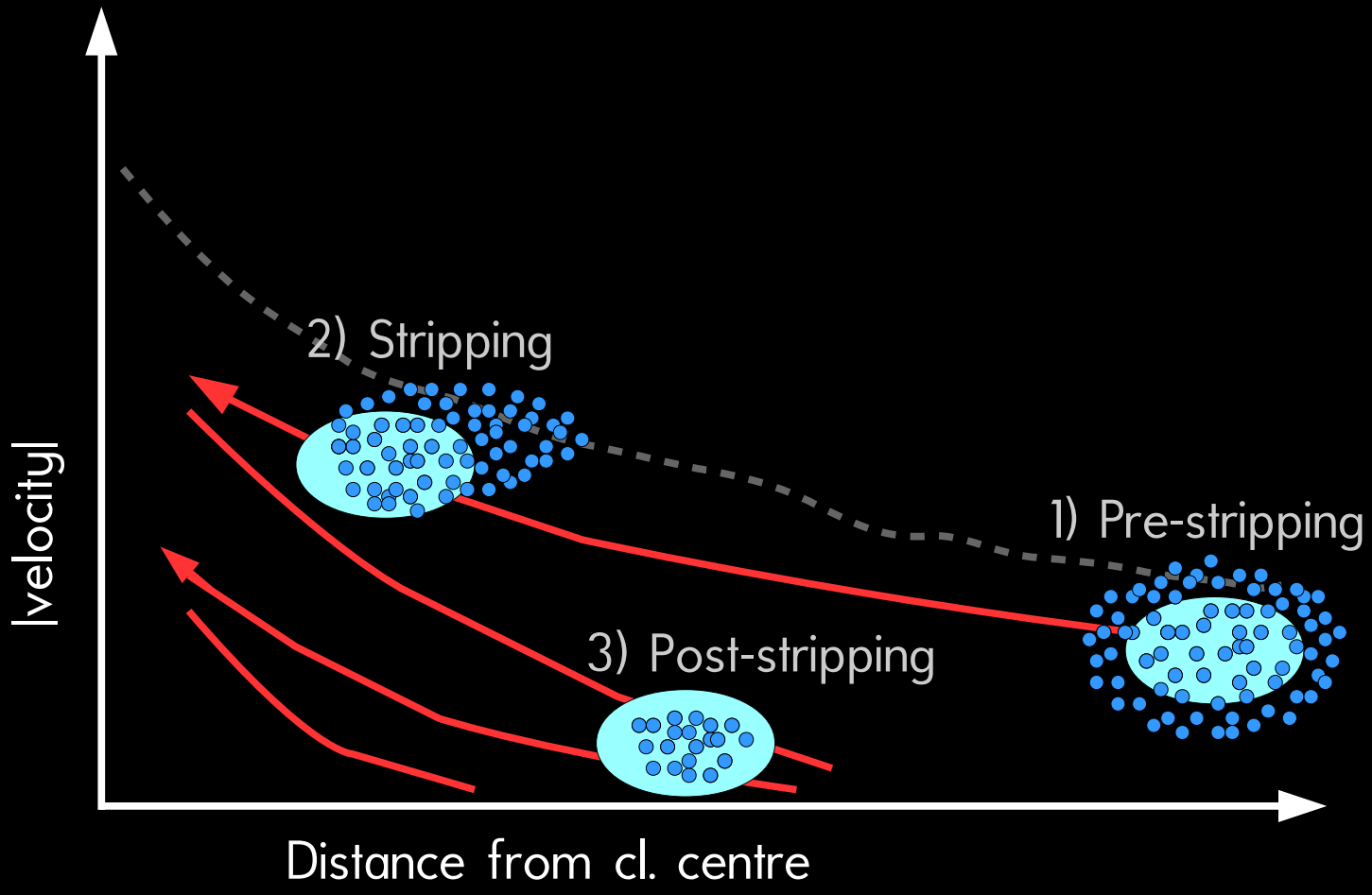
Jaffé, Smith, Candlish et al. (2015)

The stripping sequence:

Combined phase-space with HI morphology

High-resolution HI data of Virgo galaxies from VIVA (Chung+2009)

Yoon, Chung, Smith & Jaffé (2017)



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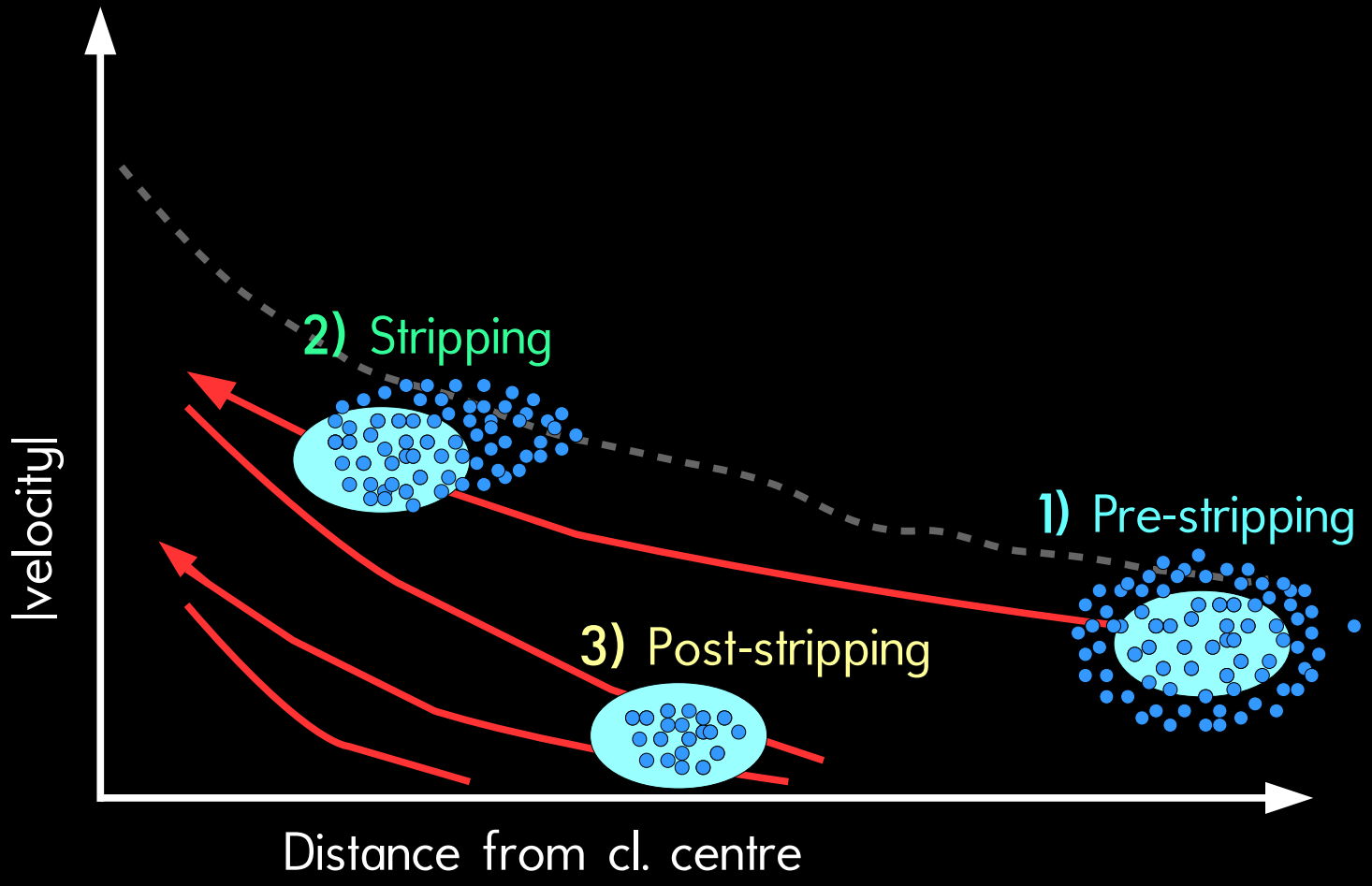
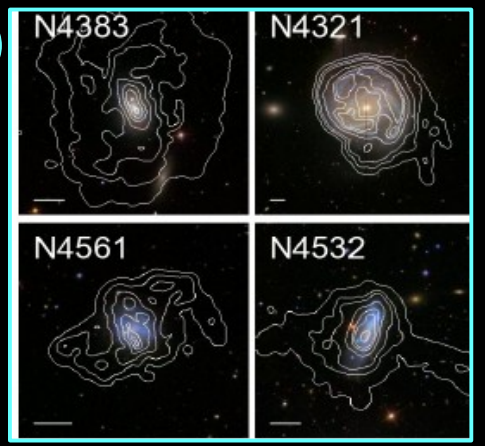


1)



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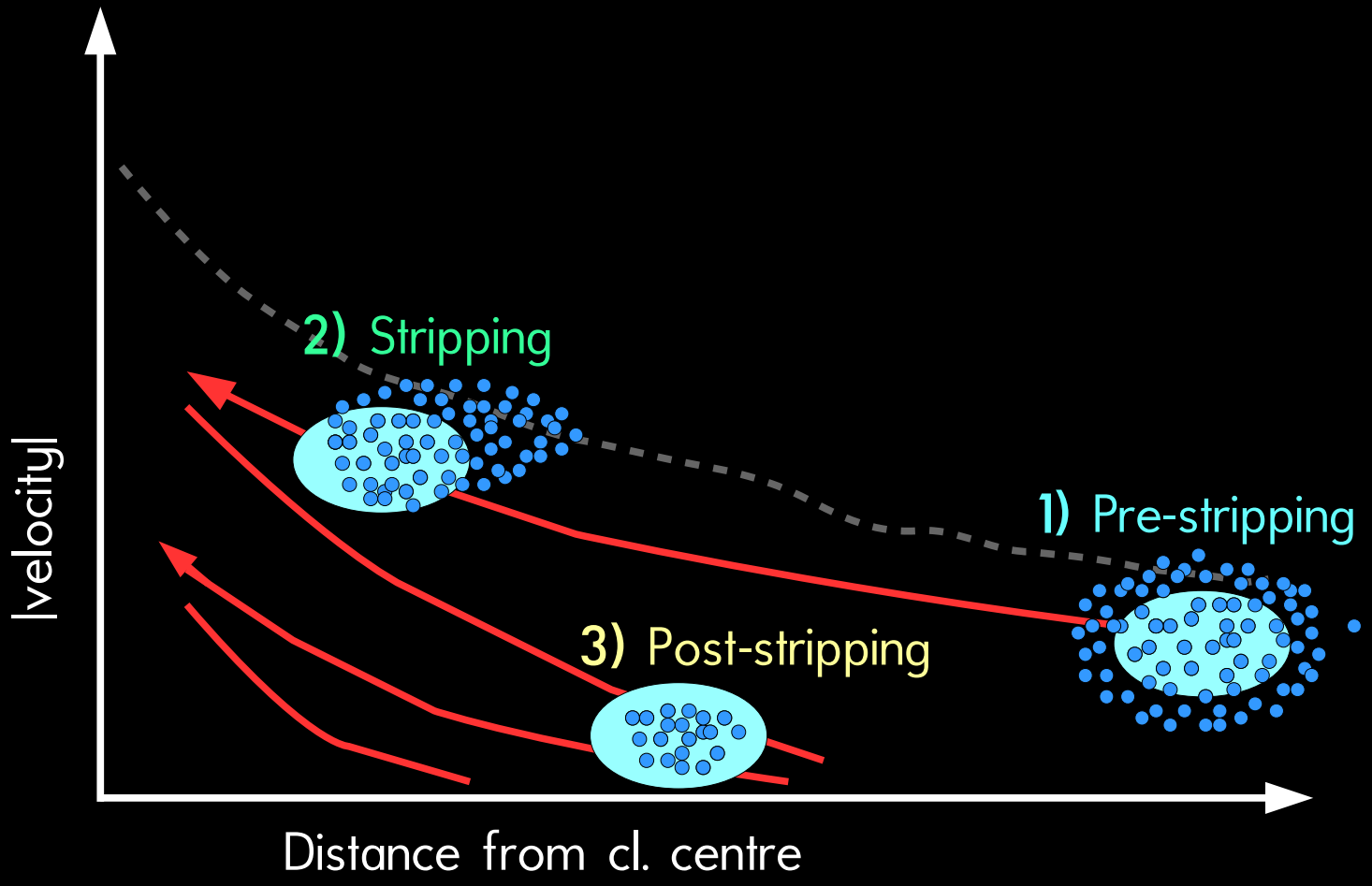
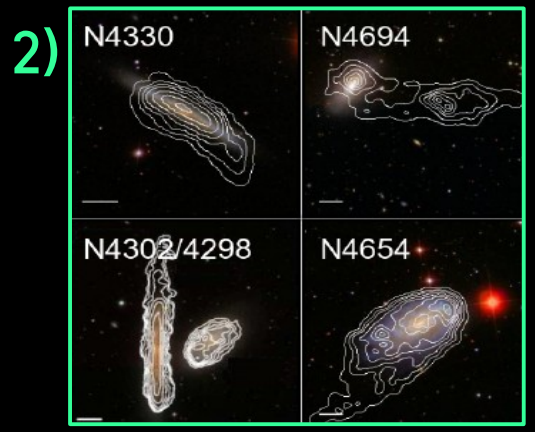
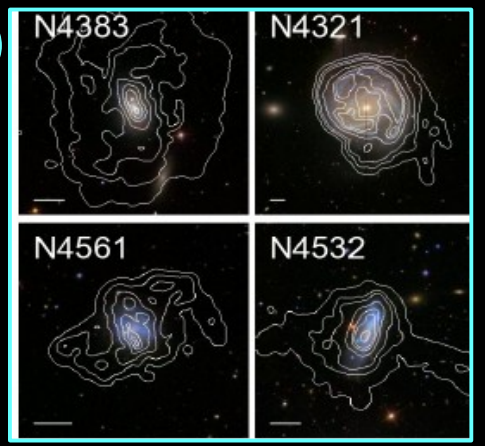
Yoon, Chung, Smith & Jaffé (2017)





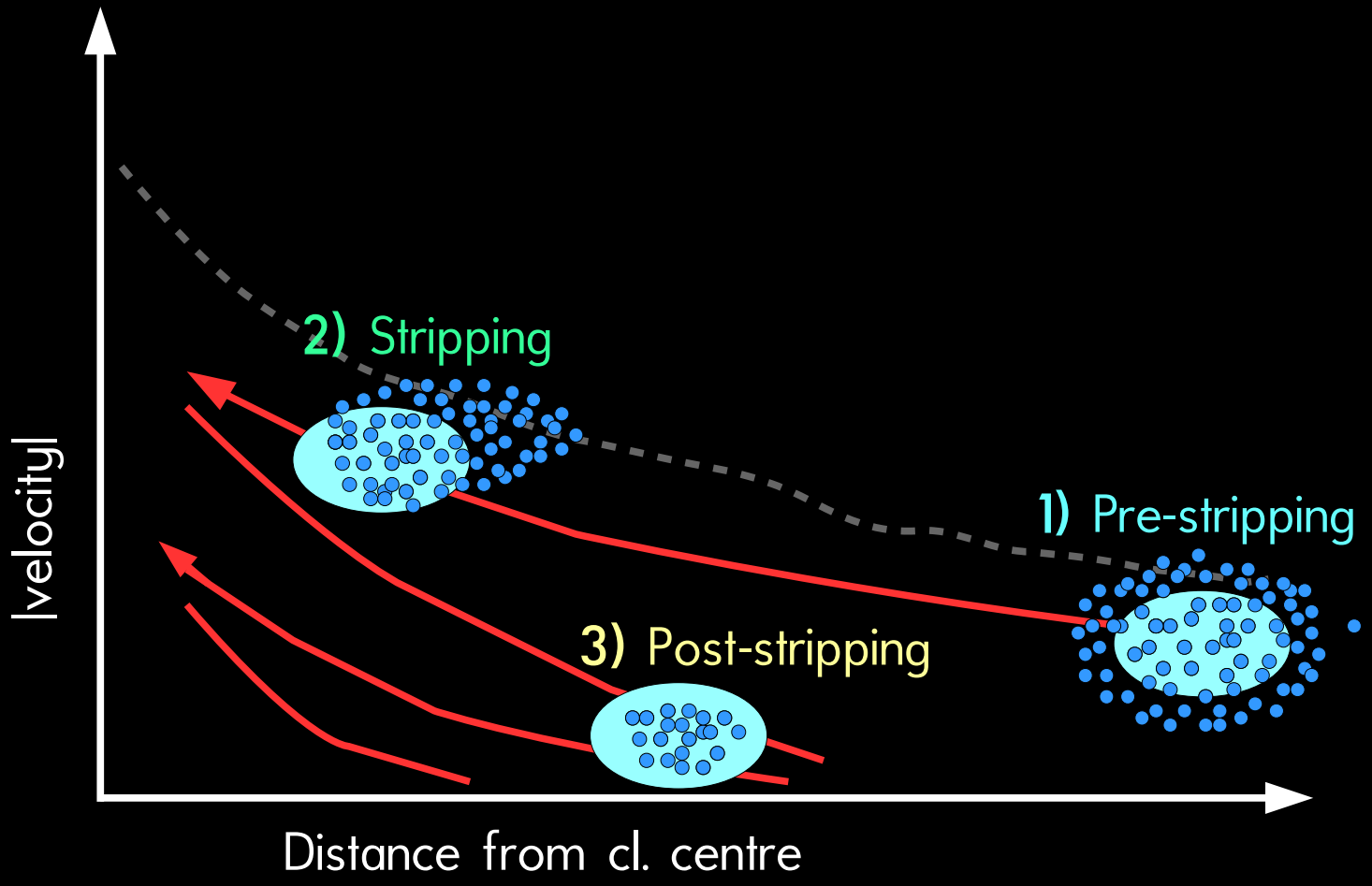


The stripping sequence:

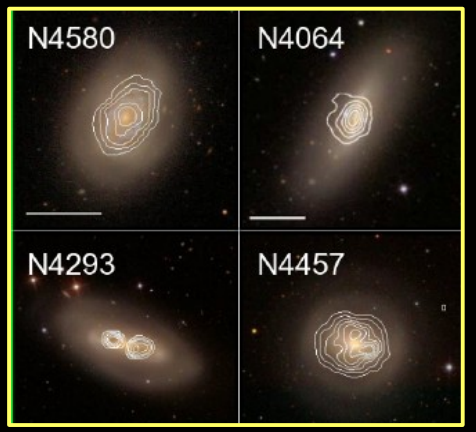
Combined phase-space with HI morphology

High-resolution HI data of Virgo galaxies from VIVA (Chung+2009)

Yoon, Chung, Smith & Jaffé (2017)



3)



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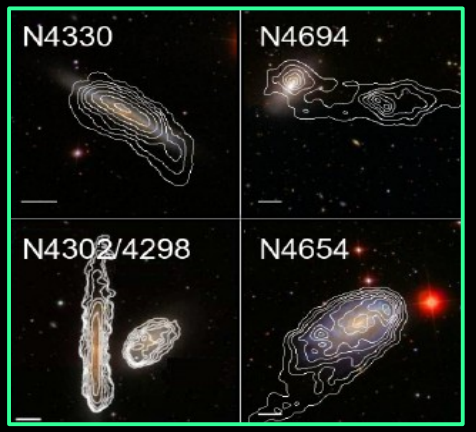
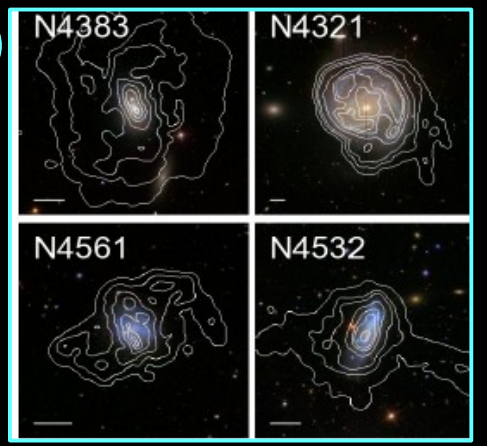
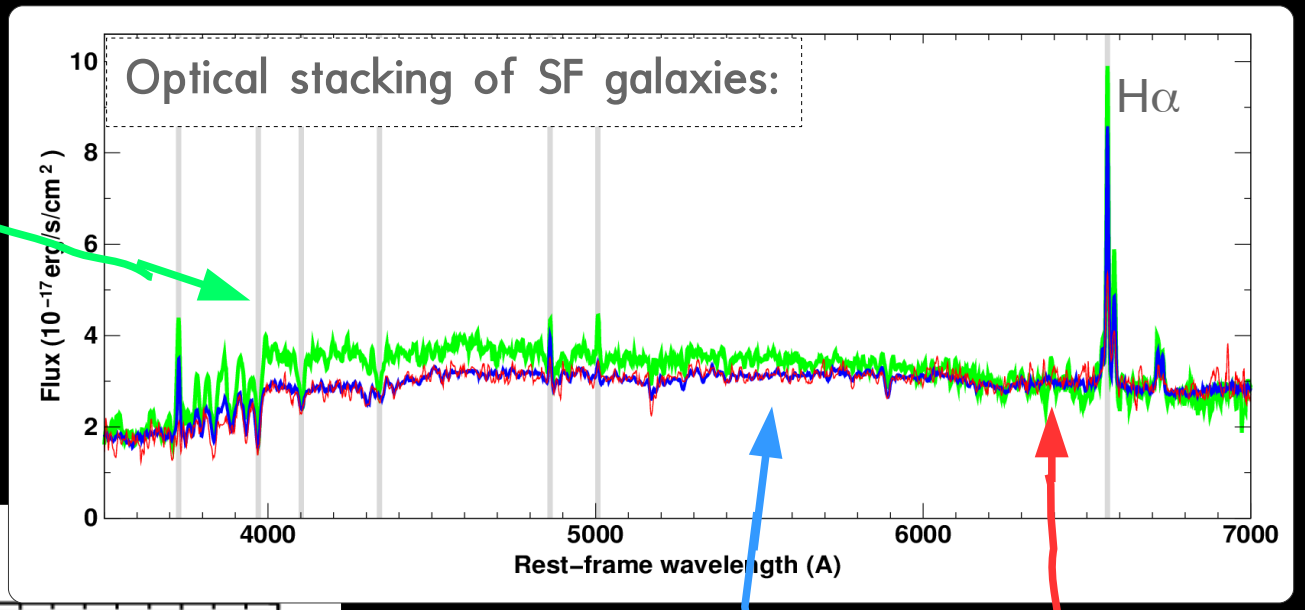


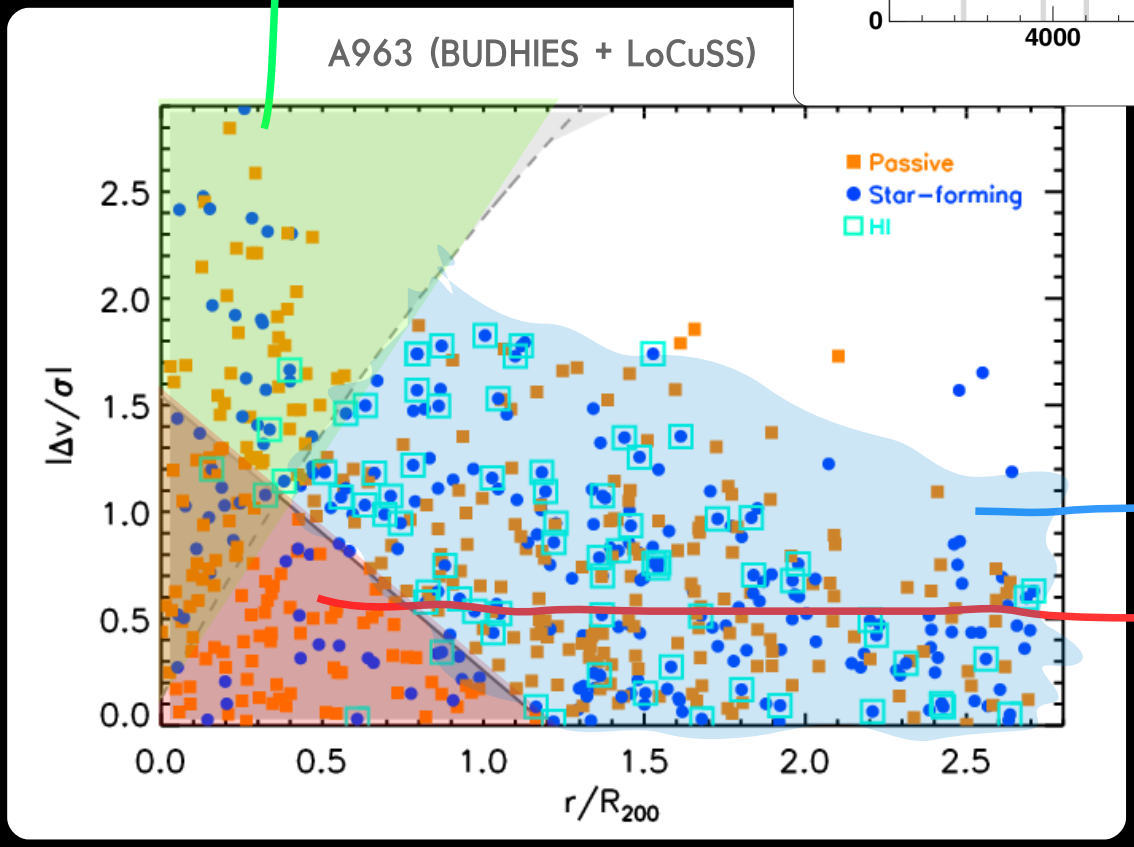
1)



Gas stripping and Star Formation



Ram-pressure stripped galaxies have enhanced SF



Recent infalls

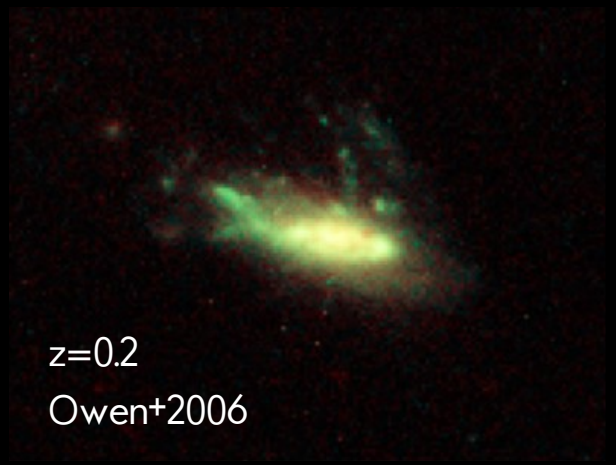
Virialized

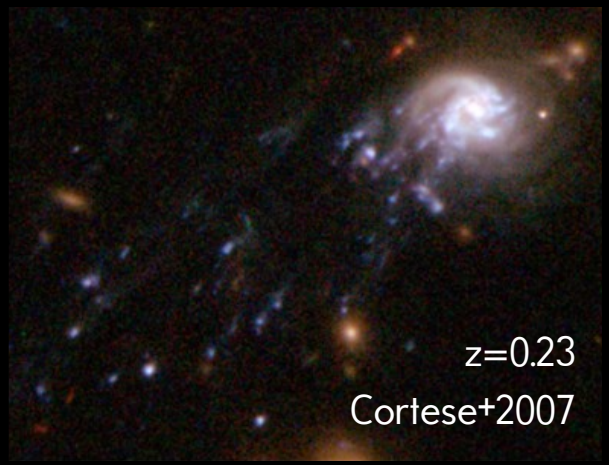
Jaffé, Verheijen, Haines et al. (2016)

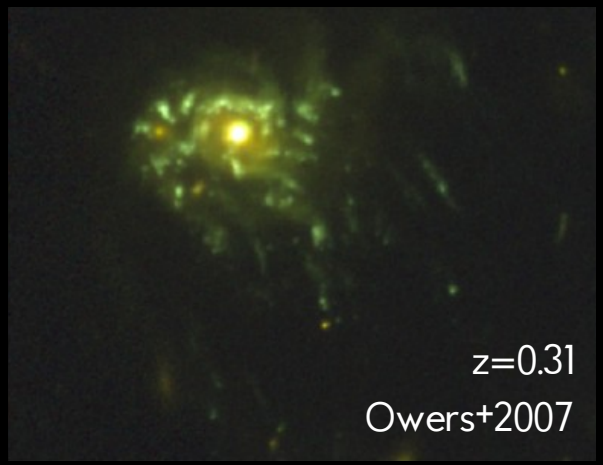
See also Gavazzi & Jaffe 1985; Porter et al. 2008; Mahajan, Raychaudhury & Pimbblet 2012

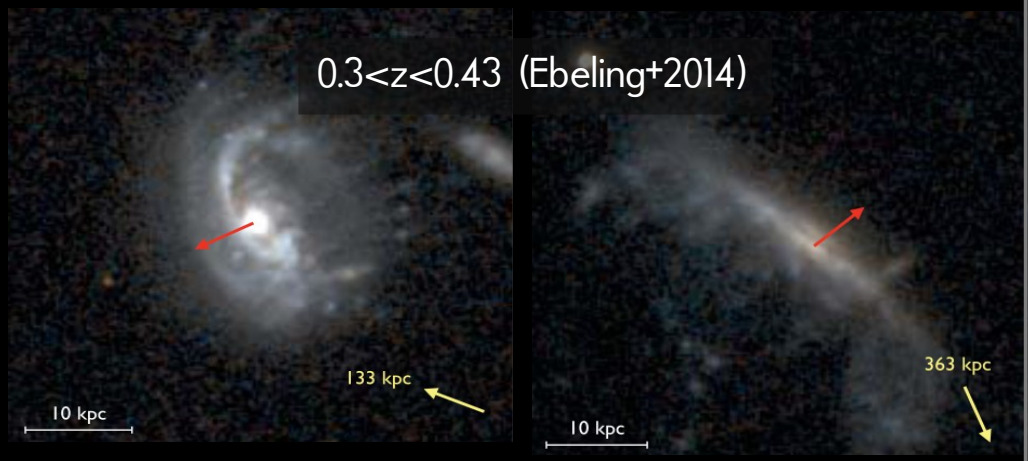
II. Gas stripping of cluster galaxies – Star formation

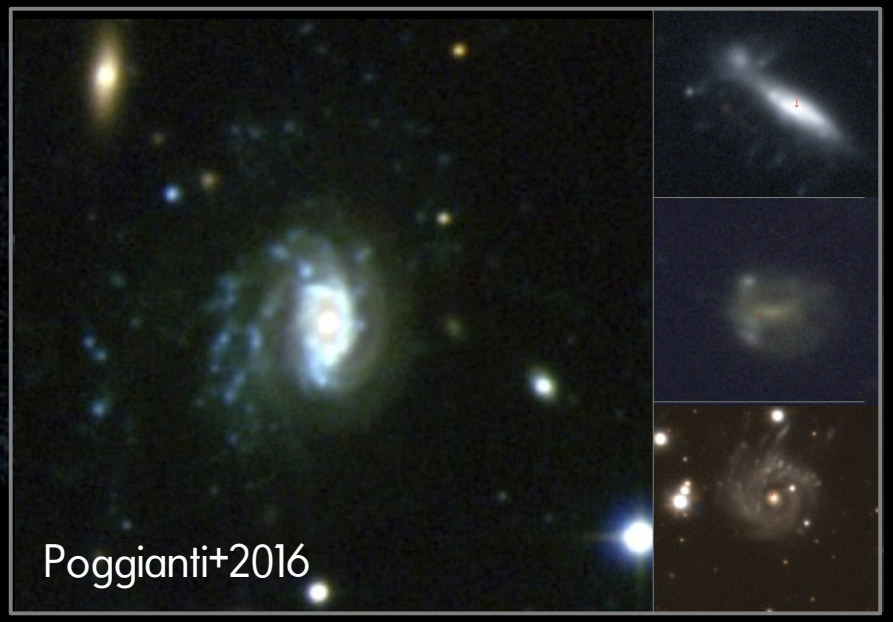
UV/Optical tails make "Jellyfish" galaxies.
Young stars found in the tails and shock front











(see also Yagi+2010, Rawle+2014,
Fumagalli+2014, Fossati+2015, McPartland+2016)

GAs Stripping Phenomena with MUSE (GASP)

120h of MUSE@VLT to study 100 jellyfish galaxies

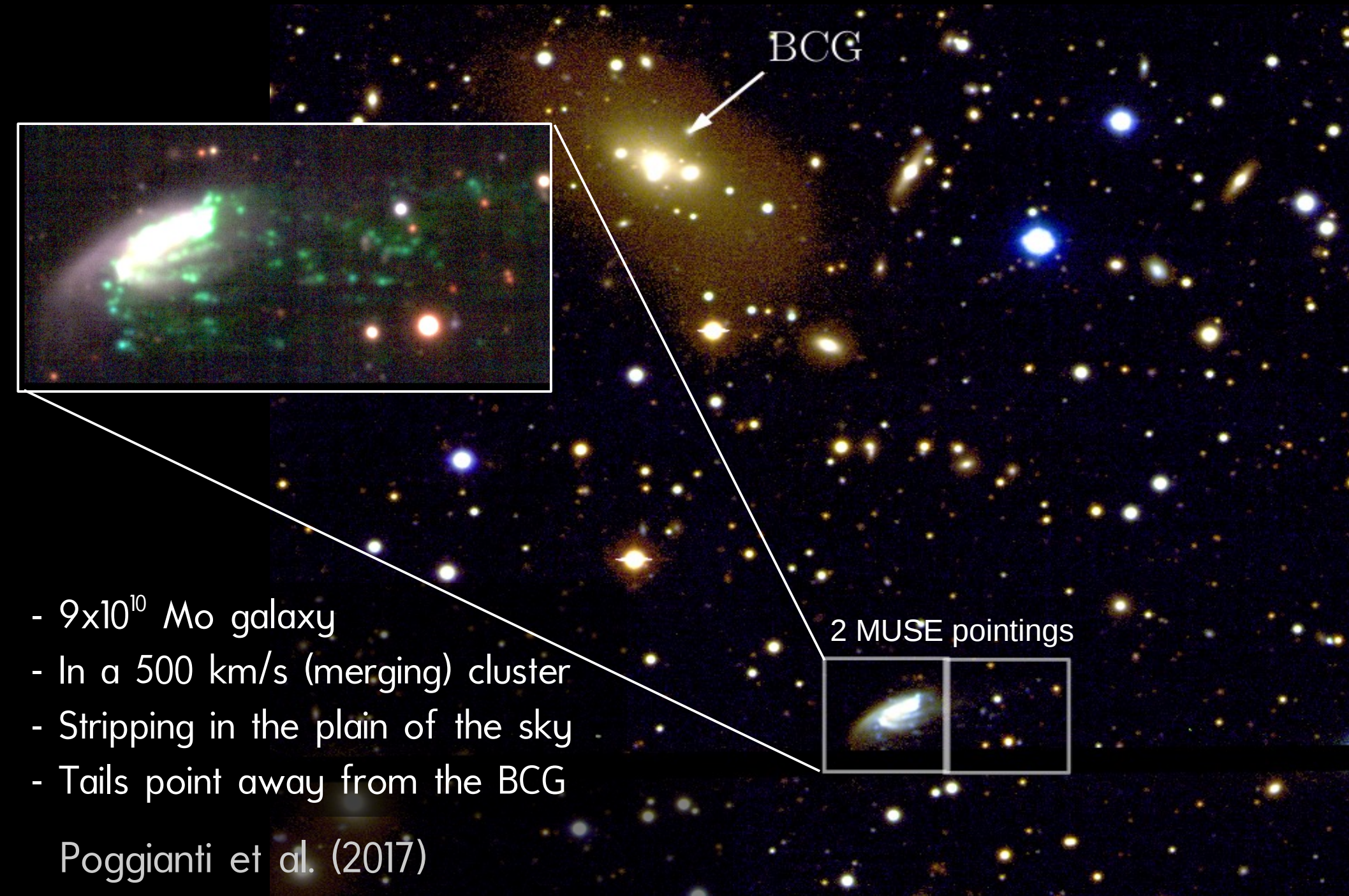
B. Poggianti (PI)
M. Gullieuszik*
A. Moretti*
D. Bettoni
G. Fasano
M. D'Onofrio
B. Vulcani
Y. Jaffé*
C. Bellhouse*
G. Hau
A. Cava
W. J. Couch
J. Fritz
M. Owers
A. Omizzolo
Y-K. Sheen
S. McGee
S. Tonnesen
J. van Gorkom

& many others

*In this room

http://web.oapd.inaf.it/gasp

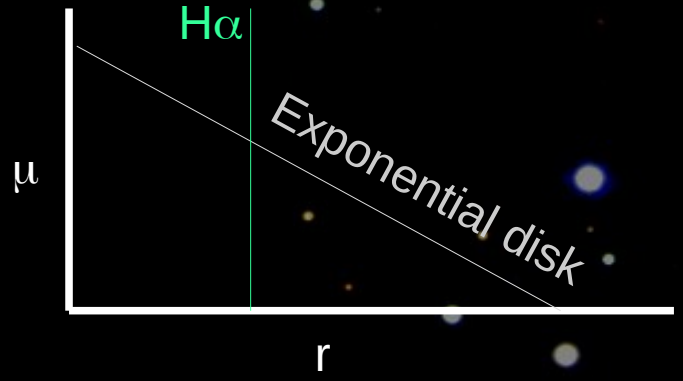
A textbook jellyfish: JO201

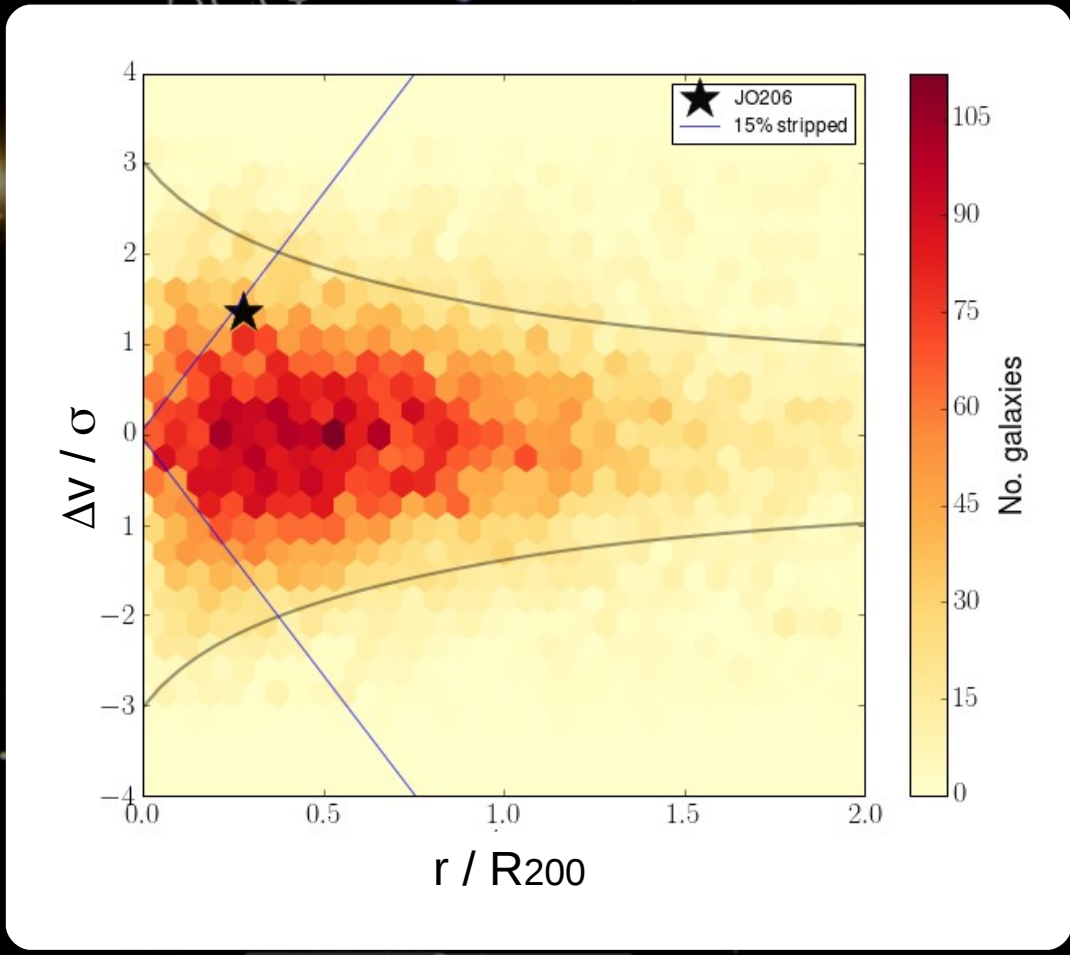


- $9x10^{10}$ Mo galaxy
- In a 500 km/s (merging) cluster
- Stripping in the plain of the sky
- Tails point away from the BCG

Poggianti et al. (2017)

A textbook jellyfish: JO201



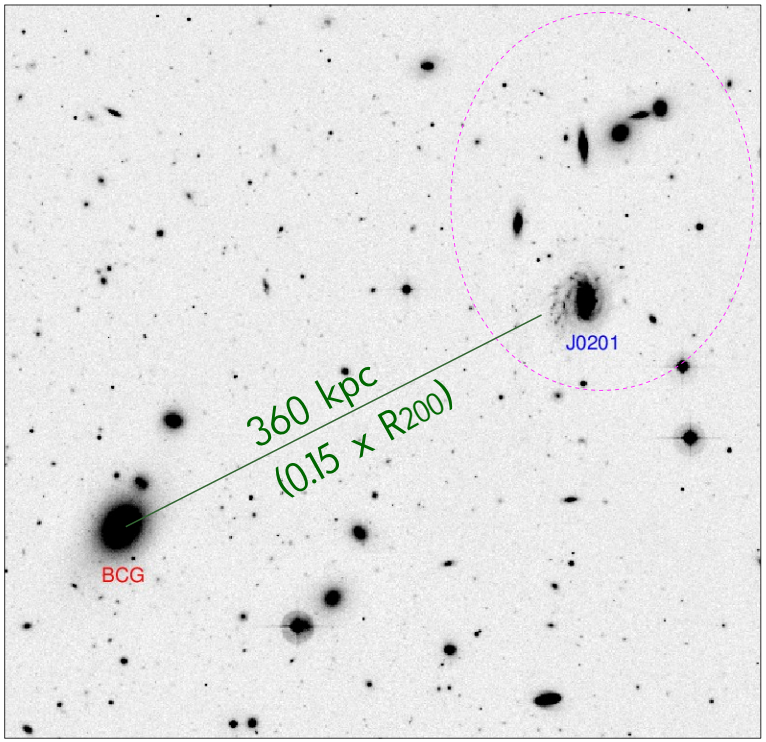


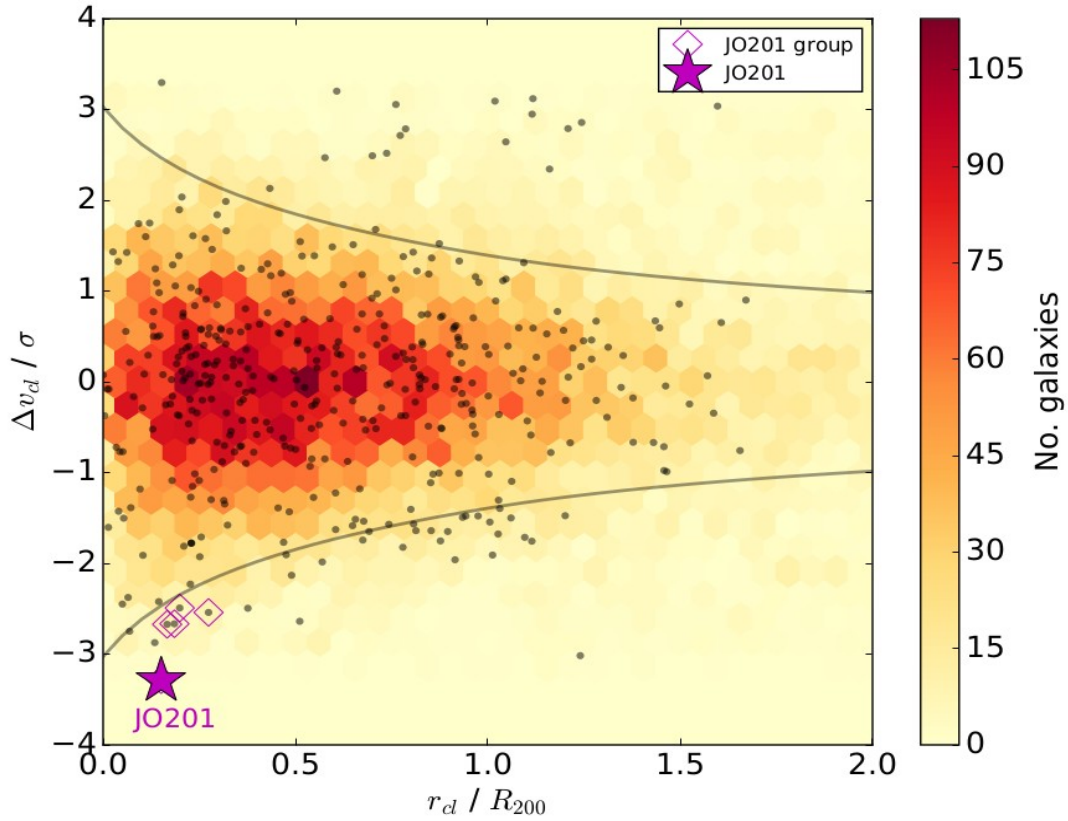
- Phase-space location → 15% stripping if on 1st infall
- Consistent with extent of Hα disk

Poggianti et al. (2017)

An extreme l.o.s. jellyfish: JO201

Environment: A85

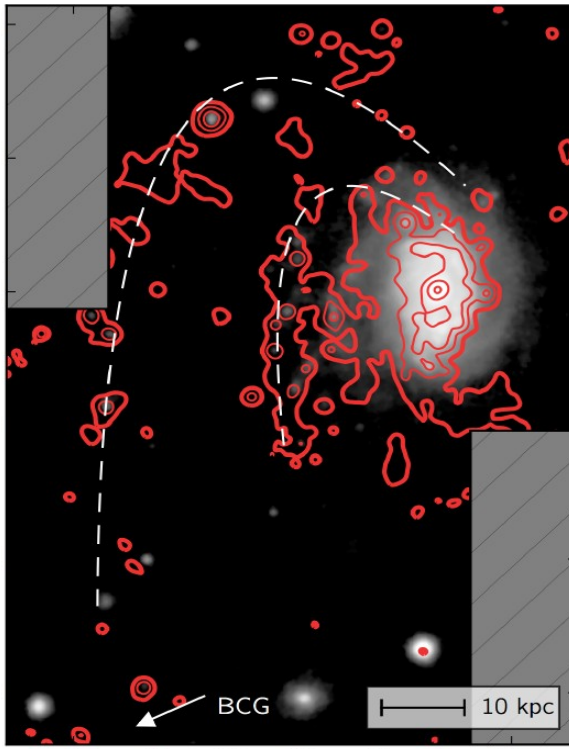




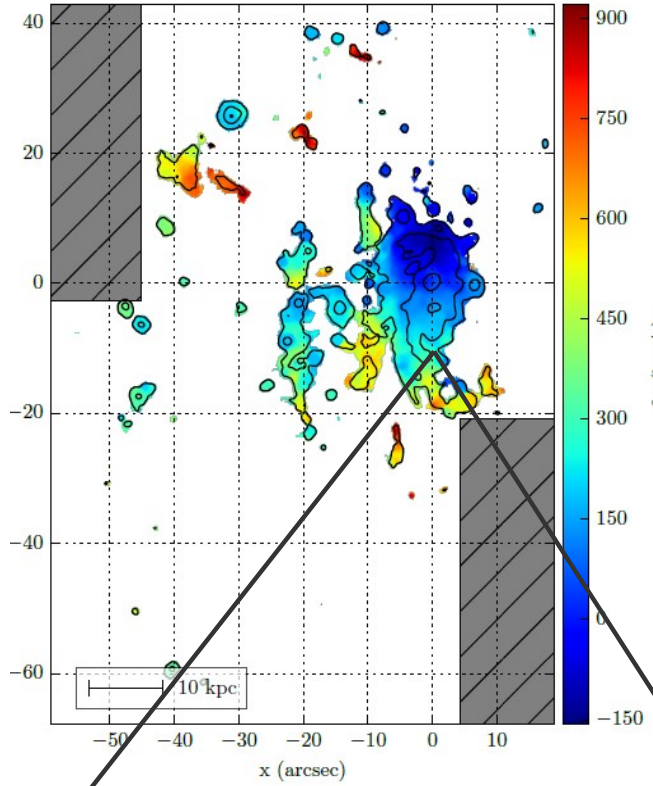
- JO201 is flying though A85 at supersonic speeds along the l.o.s.
- Highly radial orbit
- Falling in within a small group

An extreme l.o.s. jellyfish: JO201

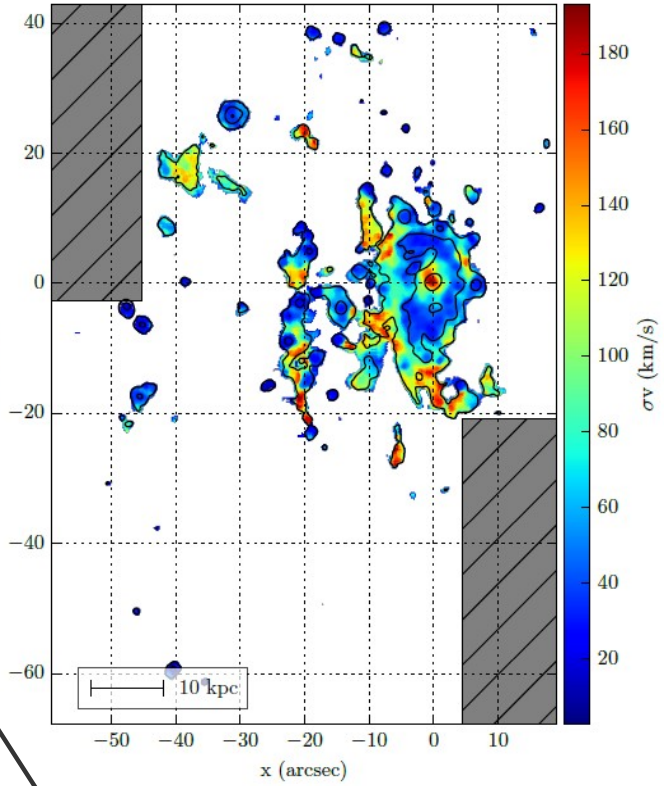
Hα emission

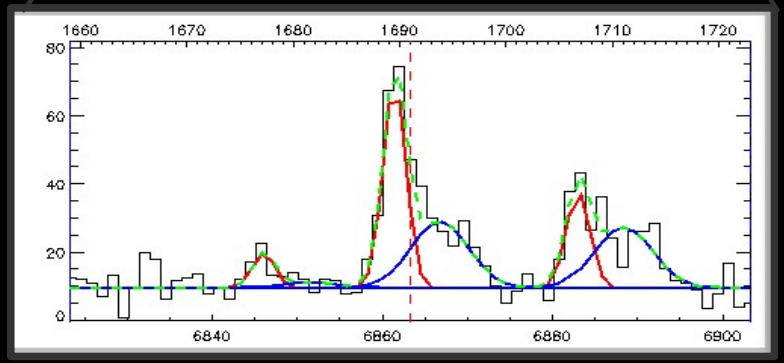


Velocity



Vel. dispersion

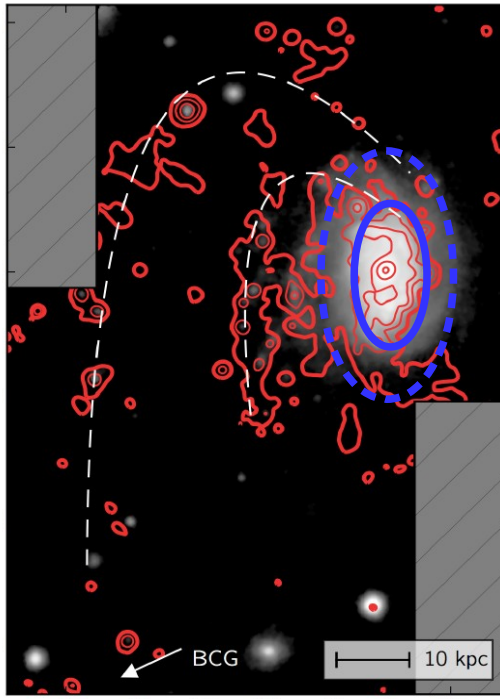


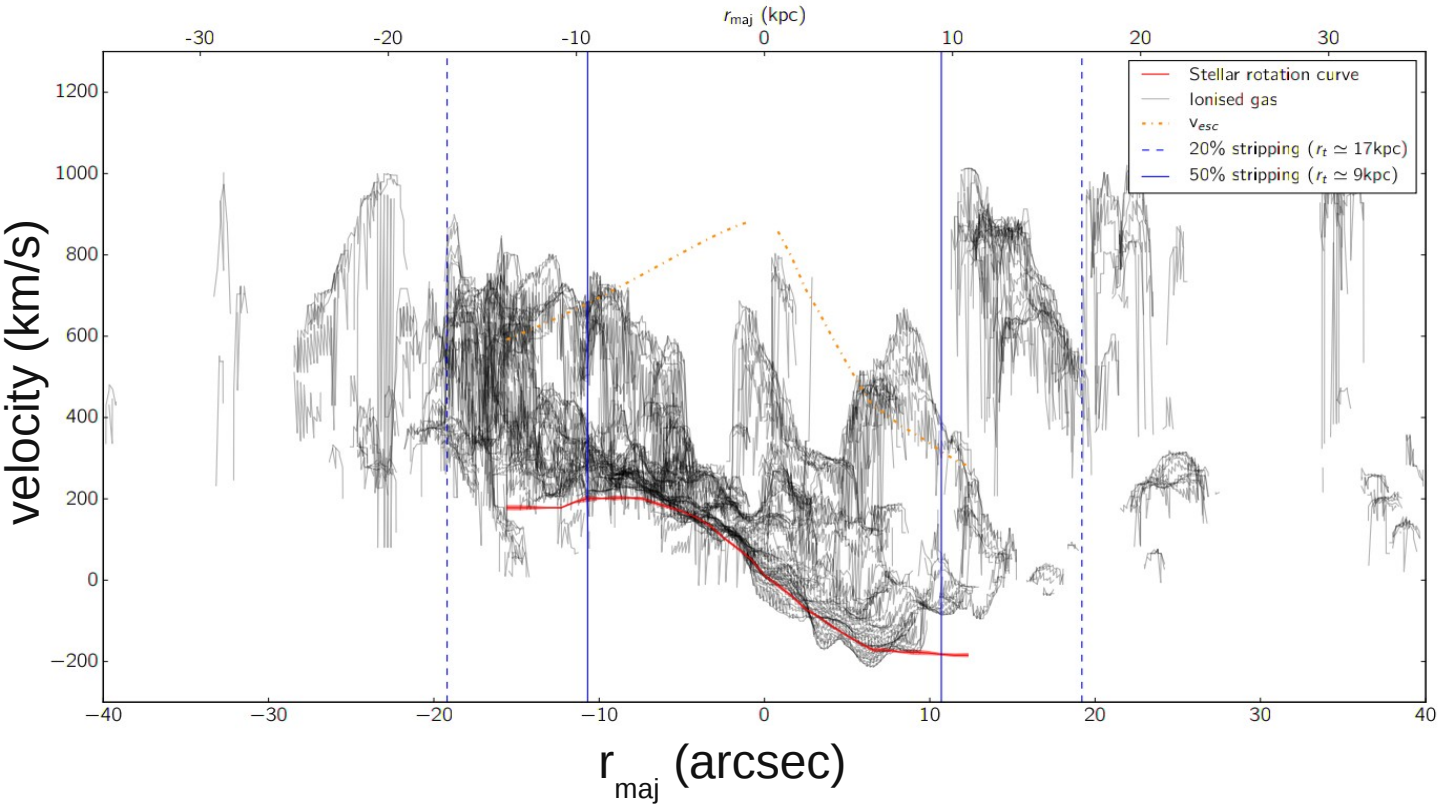


- Extraplanar Ha emission
- Broadened spiral arms
- High velocity gas
- Non-gaussian emission

Callum Bellhouse et al. (2017)

An extreme l.o.s. jellyfish: JO201



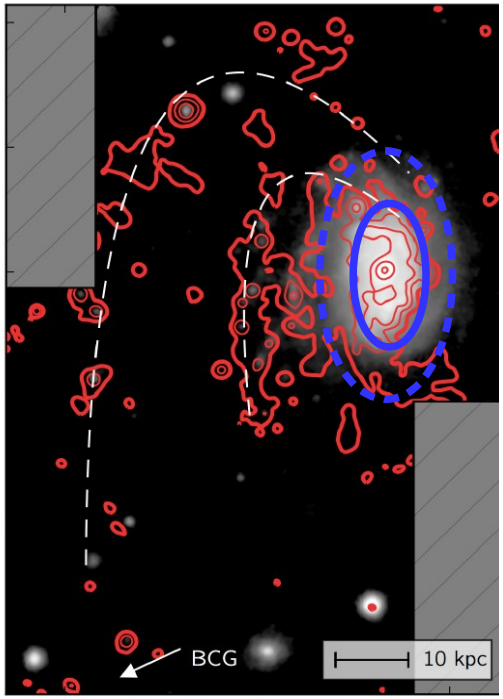


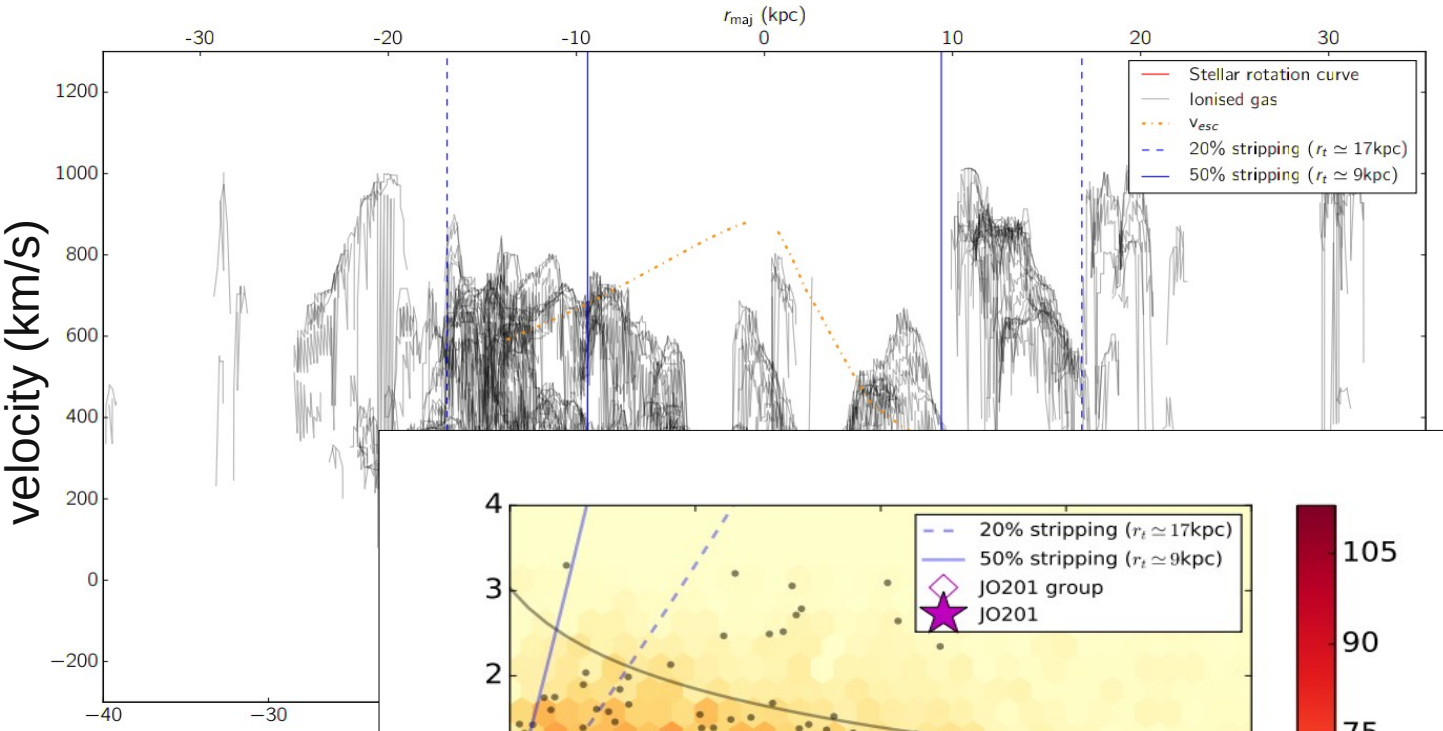
- Stars confined to a smoothly rotating disk.
- Gas redshifted with increasing r → outside-in stripping
- Gas RC consistent with simulations of face-on stripping (Kronberger+2008)

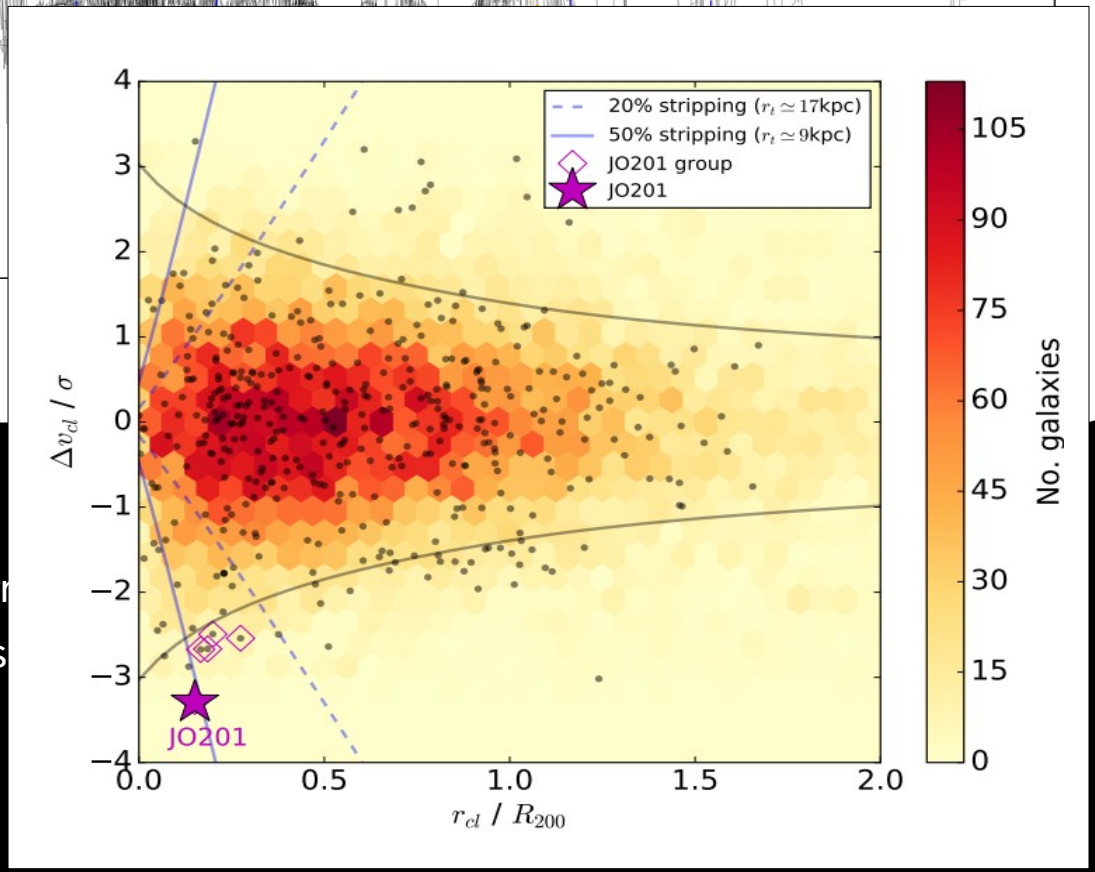
→ **50% of total gas mass is stripped**

Bellhouse, Jaffé et al. (2017)

An extreme l.o.s. jellyfish: JO201







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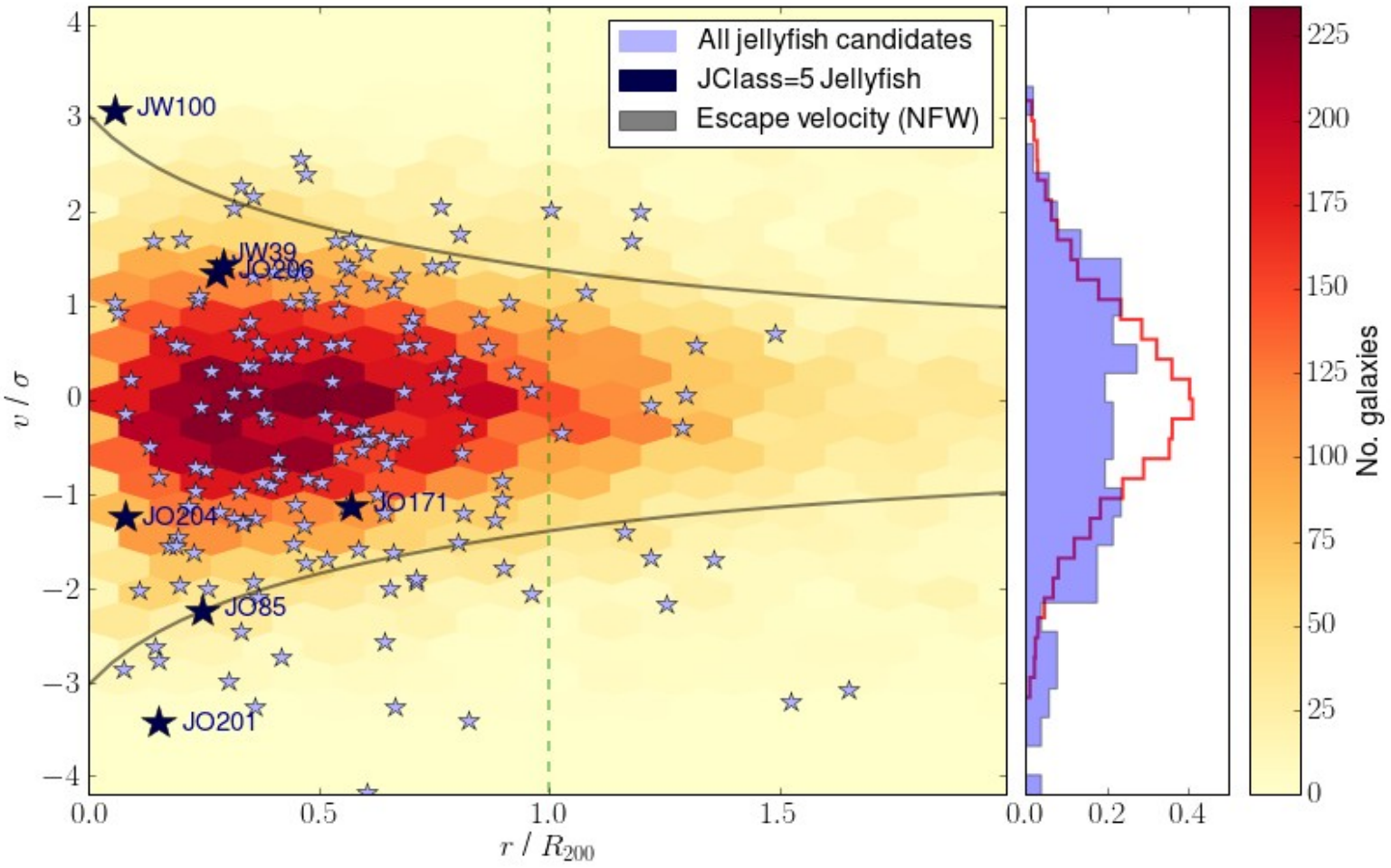
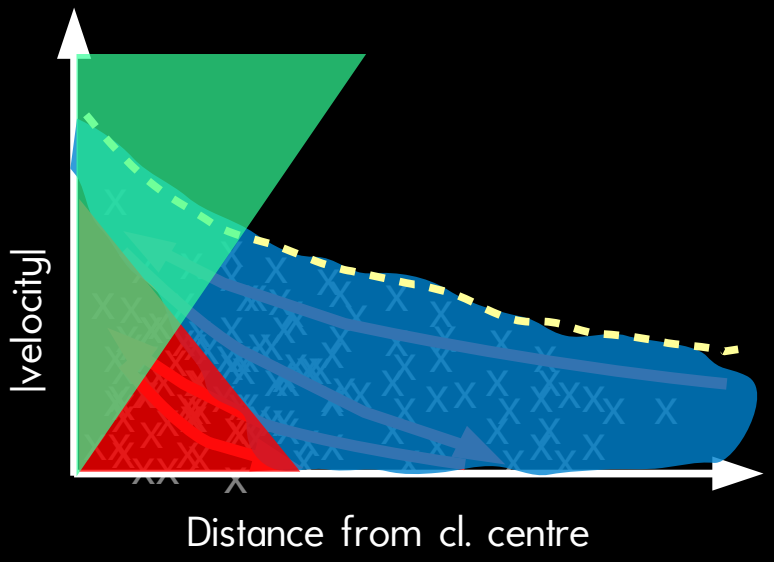
The orbits of cluster jellyfish galaxies



Jaffé, et al. (in prep.)

- On radial orbits and fist passage through the cluster.
- Many of them are in merging clusters like e.g. Shapley supercluster

Conclusions



Phase-space diagrams are useful tools to constrain:

- the orbits of cluster galaxies
- intensity of ram-pressure stripping
- stage of stripping
- total gas mass loss

RPS is very effective at removing gas from galaxies on their 1st cluster passage.

GASP: large MUSE programme

1st systematic jellyfish study of jellyfish galaxies in 3D

> HI, CO, UV, X-ray... on the way!

> web.oapd.inaf.it/gasp

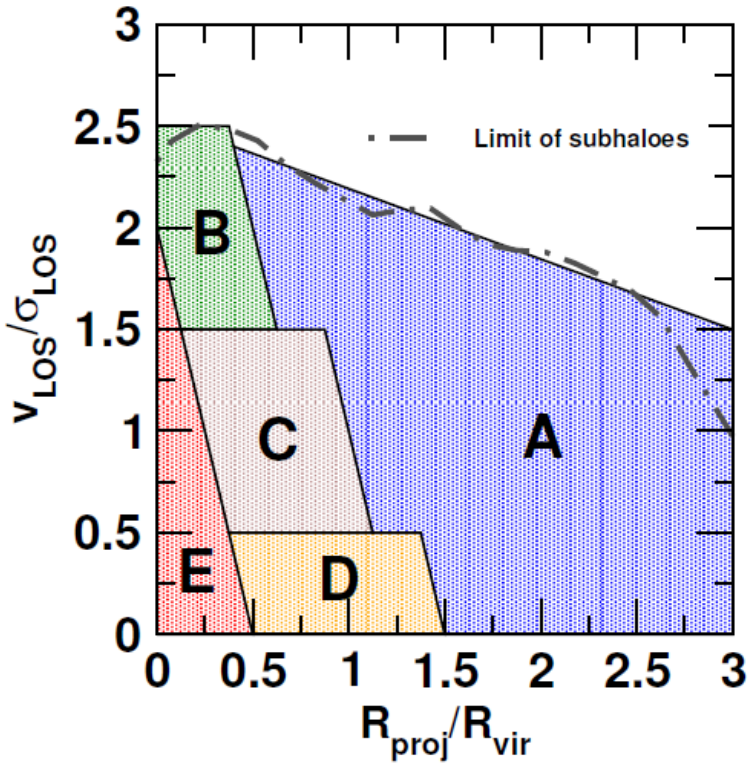
> See talks by A. Moretti & M. Gullieuszik

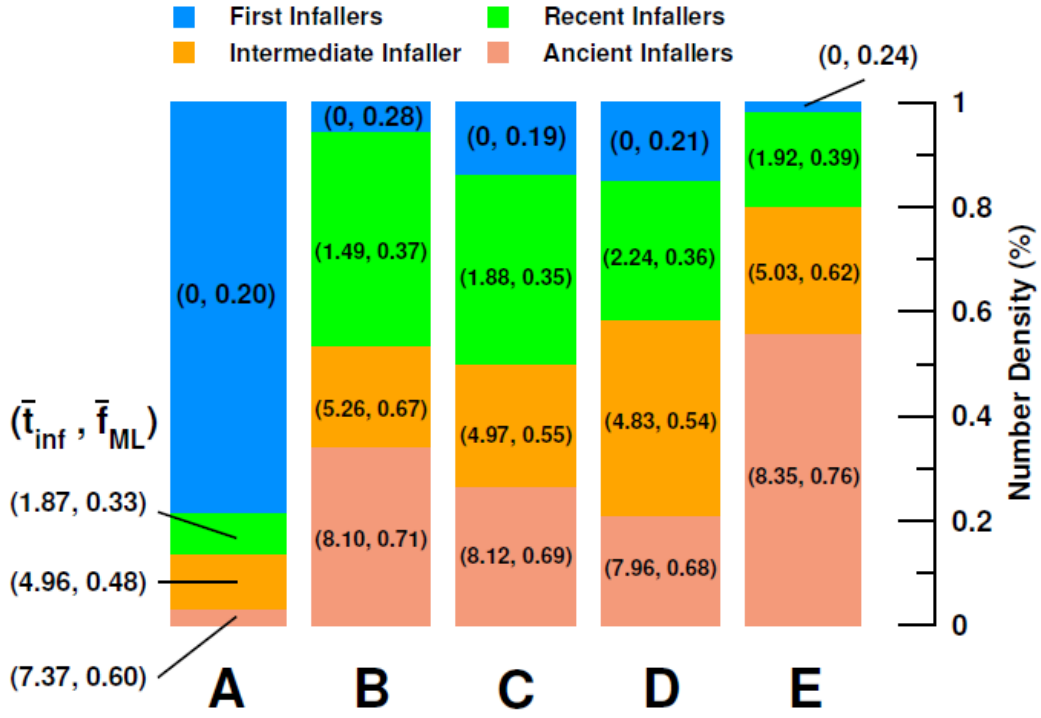
JO204

Gullieuszik+ in prep

The orbits of cluster galaxies in phase-space

Caution: There is quite a bit of mixing of populations in projected phase-space





Rhee, Smith, Choi, Yi, Jaffé, et al. 2017 (see also Oman et al. 2013)