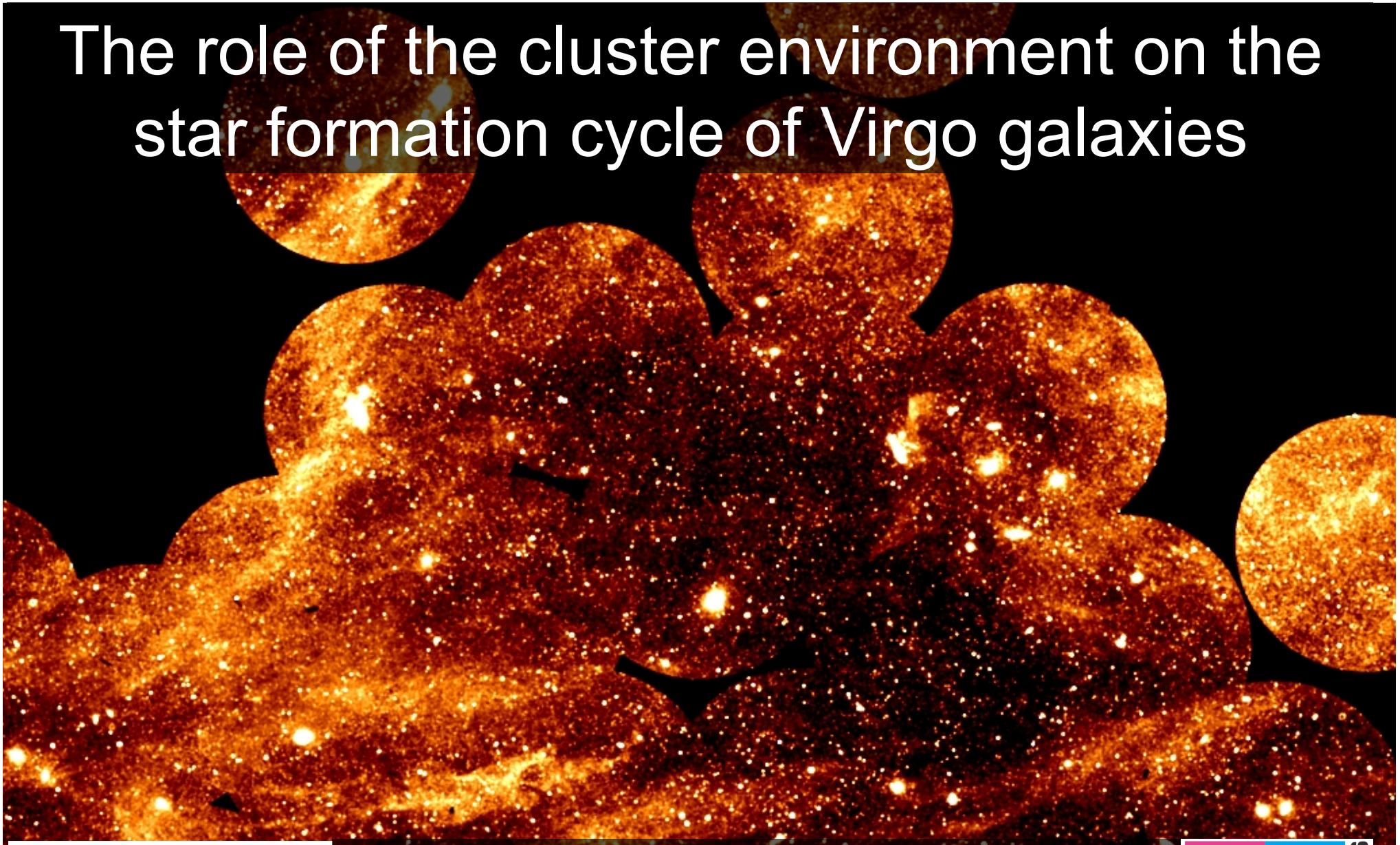
The role of the cluster environment on the star formation cycle of Virgo galaxies



Luca Cortese (ESO)

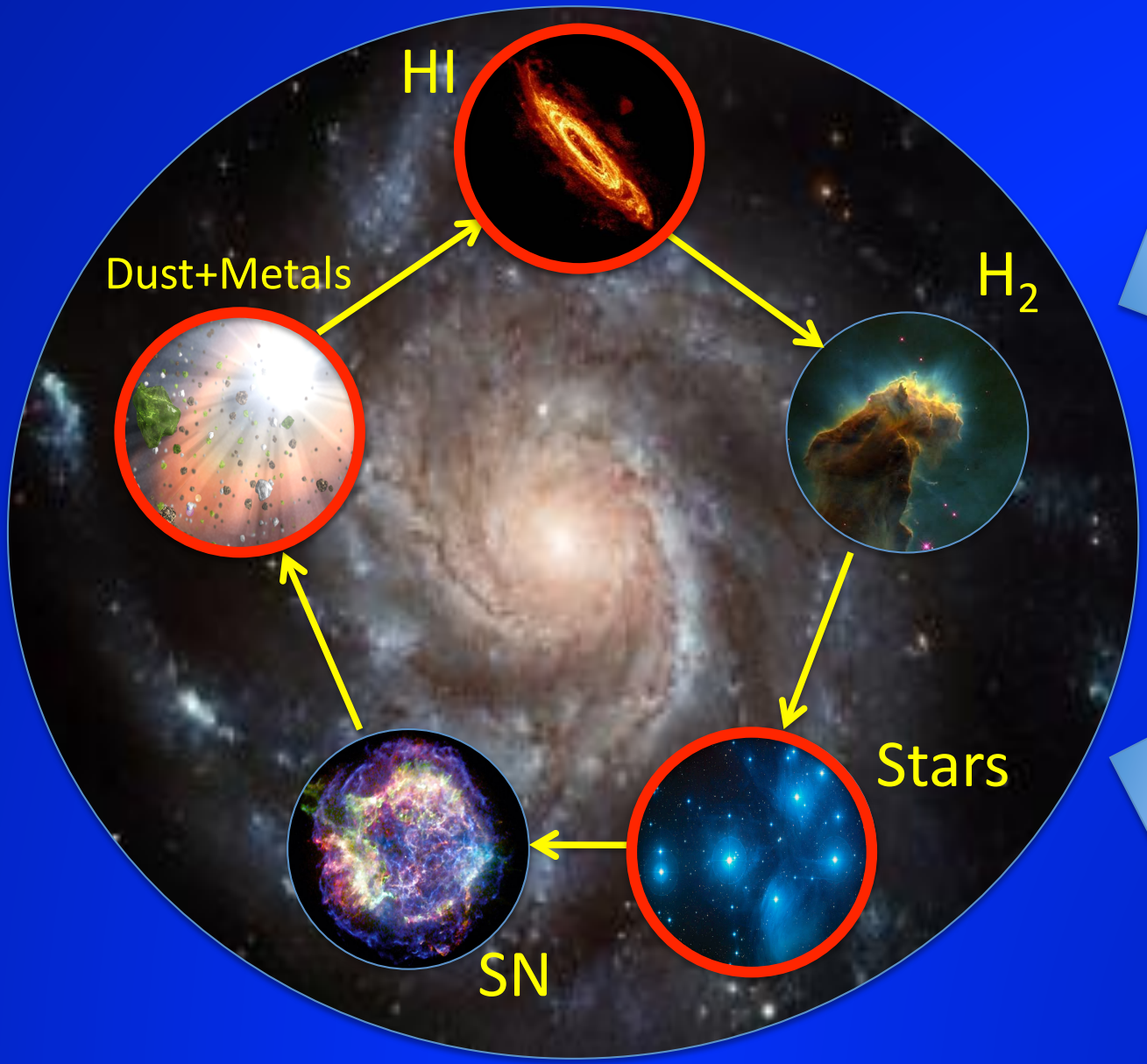
A. Boselli (OAMP), B. Catinella (MPA), T. M. Hughes (Beijing), S. Boissier (OAMP), and the SAG2, HeViCS and GUViCS teams

50 YEARS 1962–2012

ESO

MARIE CURIE ACTIONS

What regulates the evolutionary history of galaxies?



Internal properties

- Mass
- Dynamics
- Nuclear activity
- ....

Environment

- Large-scale str.
- Merging
- Tides
- Stripping
- ....

The Herschel Reference Survey

Boselli, Eales, LC et al. 2010, PASP, 122, 261

322 obj. (62 E/SO, 260 Sp./Irr)

Volume/Stellar Mass limited - From isolated to cluster galaxies

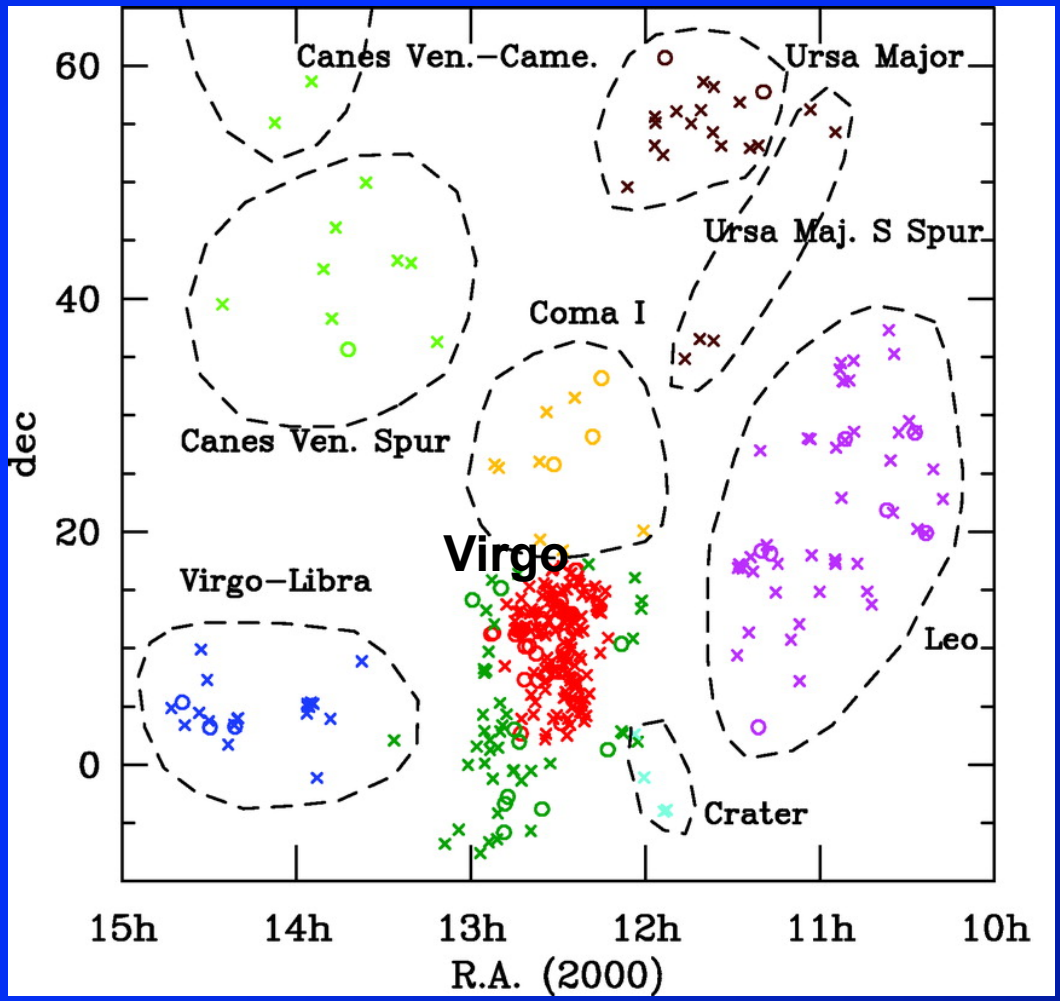
Selection Criteria

- 15<D<25 Mpc
- K<12 for Spirals -- K<8.7 for E/S0
- Gal. lat. > +55° -- A(B) < 0.2 mag

Multi-wavelength

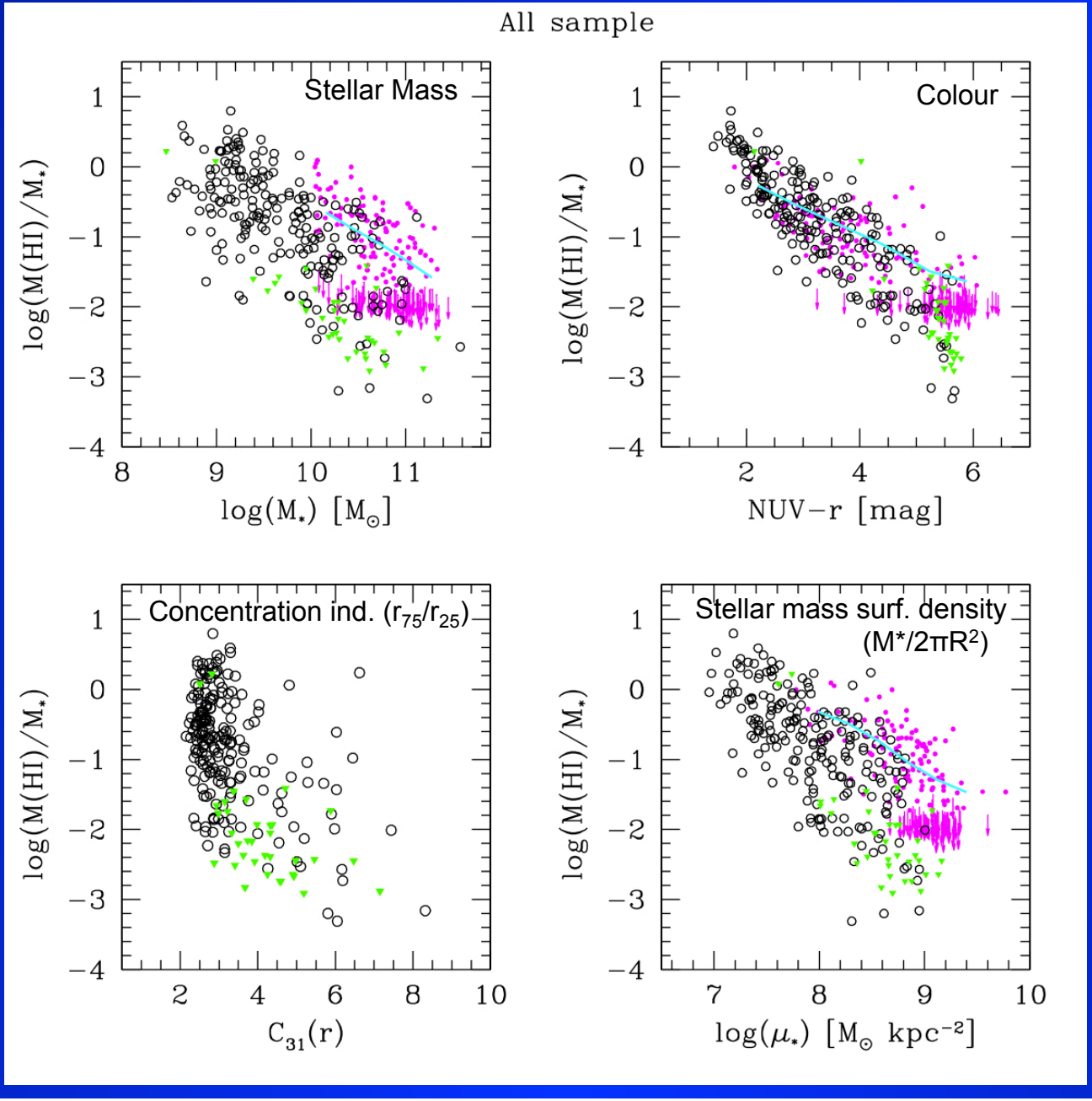
UV GALEX (P.I. Cortese/Boselli)	➔ Unobscured SF
Herschel/PACS (P.I. Cortese/ Davies)	➔ Obscured SF
Herschel/SPIRE (P.I. Boselli/Eales)	➔ Dust masses
12mKittPeak (P.I. Boselli)	➔ H2 properties
Arecibo/VLA/WSRT	➔ HI properties
OHP (P.I. Boselli)	➔ Gas metallicities
SDSS+2Mass	➔ Stellar masses

…and more



HI – Atomic Hydrogen

The HI scaling relations



Black: HRS HI det.
Green: HRS HI non-det.

Magenta: GASS
(Catinella et al. 2010)

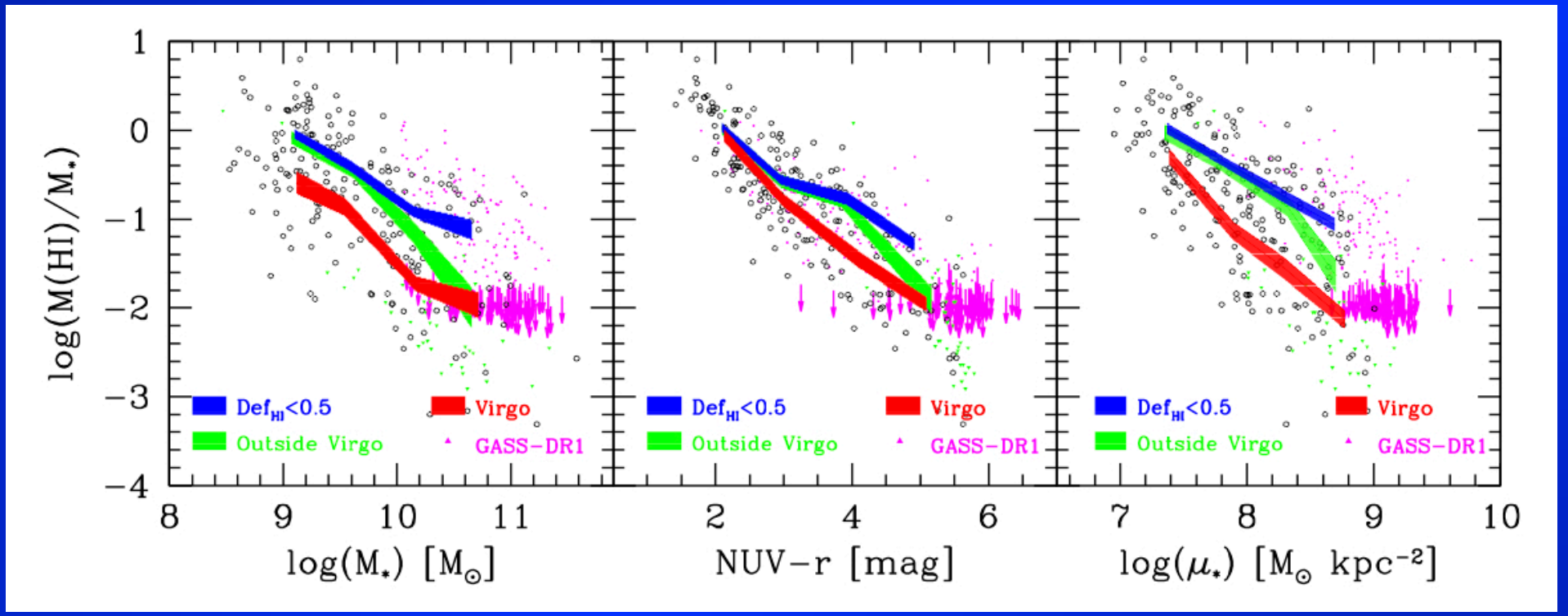
Cyan: ALFALFA stacking
(Fabello et al. 2011)

LC, Catinella, Boissier et al. 2011, MNRAS

The HI scaling relations

Remember Def_{HI} = log<M(HI, D_{opt},Type)> - log MHI_{obs}

(Haynes & Giovanelli 1984)



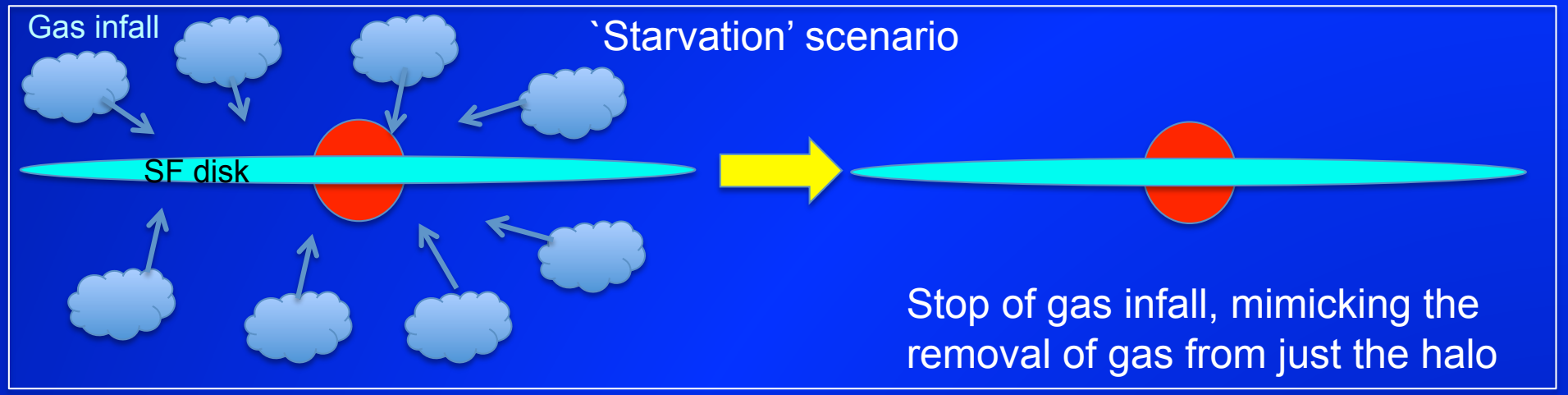
Virgo galaxies show similar scaling relations, but offset towards lower gas content

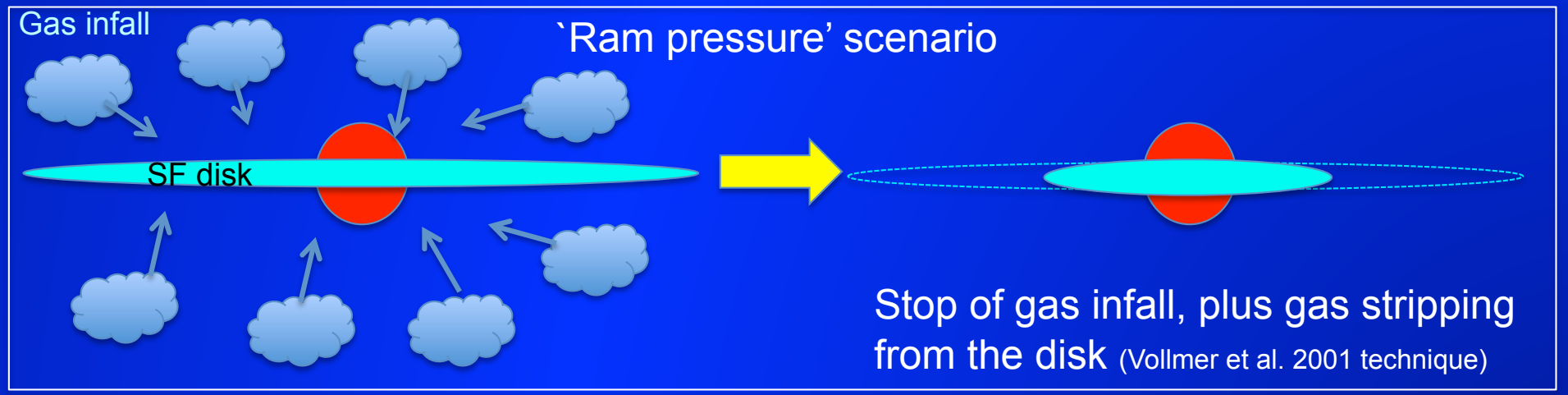
Difference between field and cluster less strong at high stellar masses
(i.e., where early-type systems dominate)

LC, Catinella, Boissier et al. 2011, MNRAS

The HI scaling relations and models

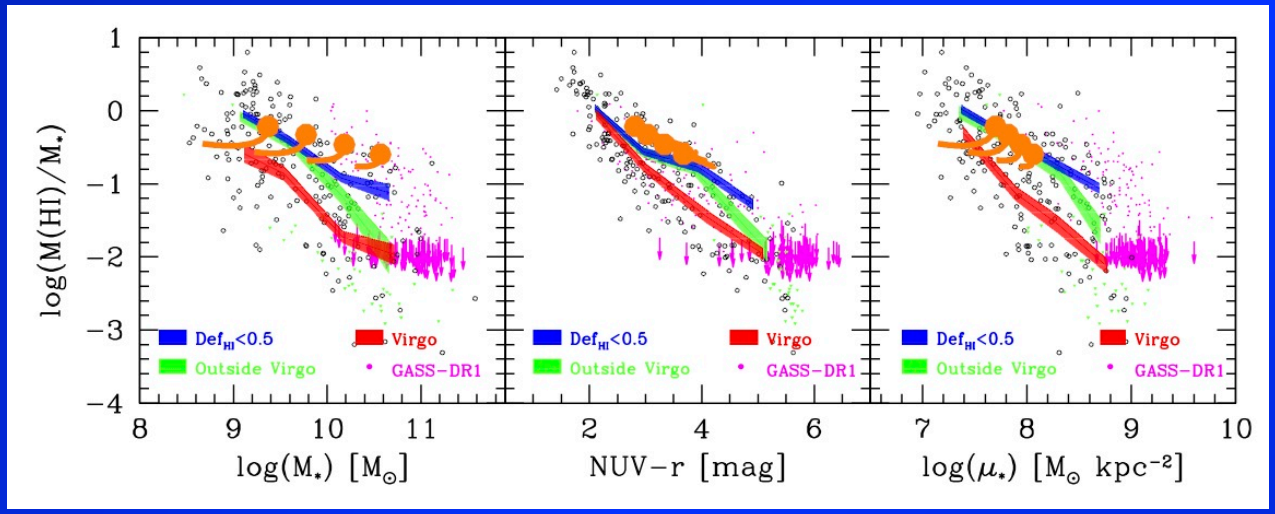
Models of Boissier & Pranzos (2000) – calibrated on pure disk galaxies



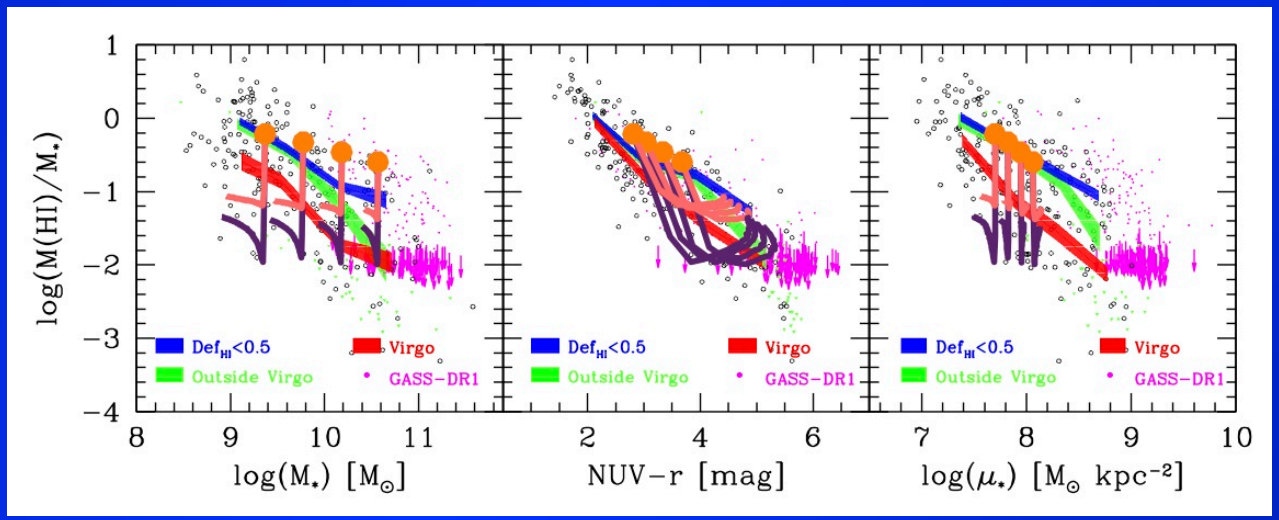


The HI scaling relations and models

Models of Boissier & Pranzos (2000) – calibrated on pure disk galaxies



Starvation



Ram pressure

Ram pressure necessary to explain HI scaling relations in Virgo…

but see Jeff Kenney's talk!

(see also Boselli & Gavazzi 2006, Chung et al. 2007, Vollmer et al. 2009)

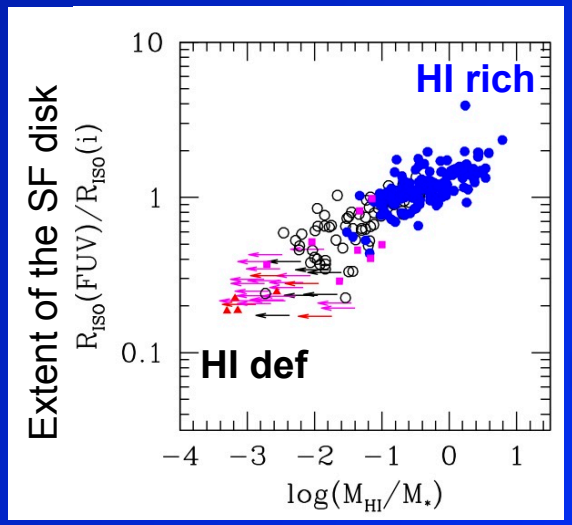
LC, Catinella, Boissier et al. 2011, MNRAS

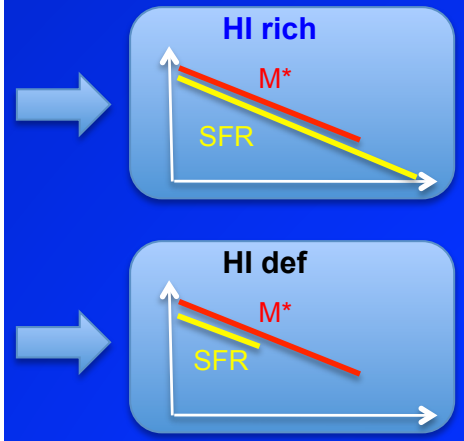
Less HI in cluster galaxies…

what about star formation?

The effect of HI stripping on the star-forming disk

(Remember Koopmann & Kenney 2004)



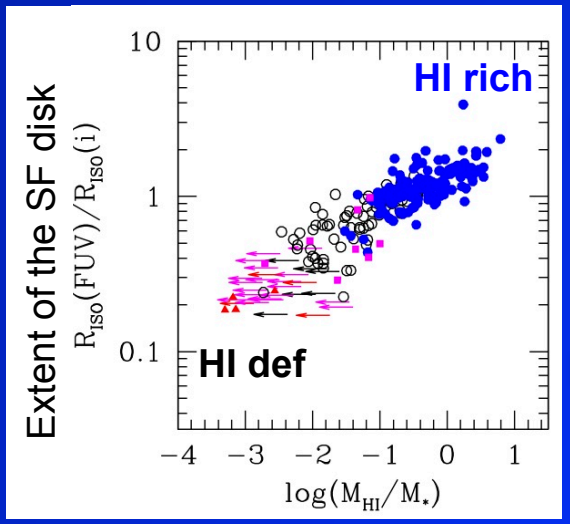


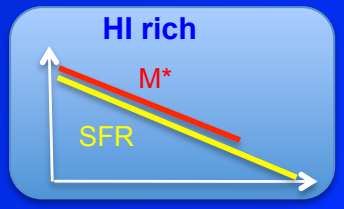
Extent of star-forming disk directly correlated to the HI-gas fraction

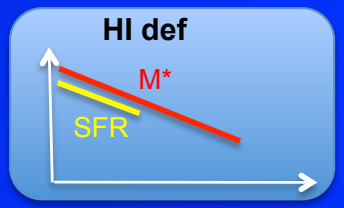
LC, Boissier, Boselli et al., 2012 A&A

The effect of HI stripping on the star-forming disk

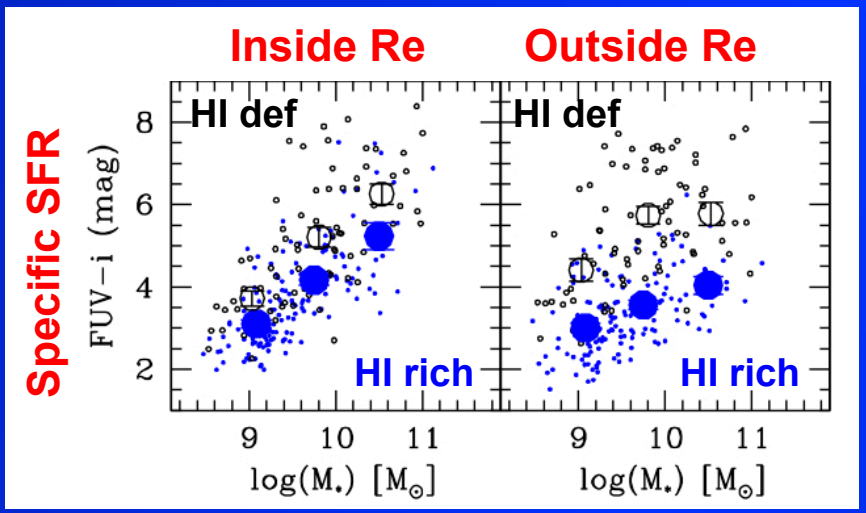
(Remember Koopmann & Kenney 2004)





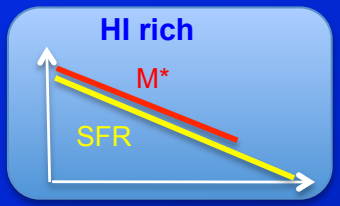


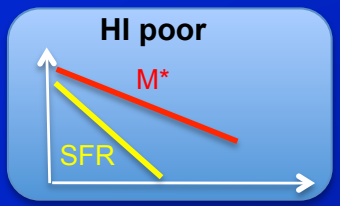
Extent of star-forming disk directly correlated to the HI-gas fraction



In HI-poor systems SF is reduced mainly in the outer parts

The shape of the SF profile also changes!





In HI-def systems star formation is quenched outside-in

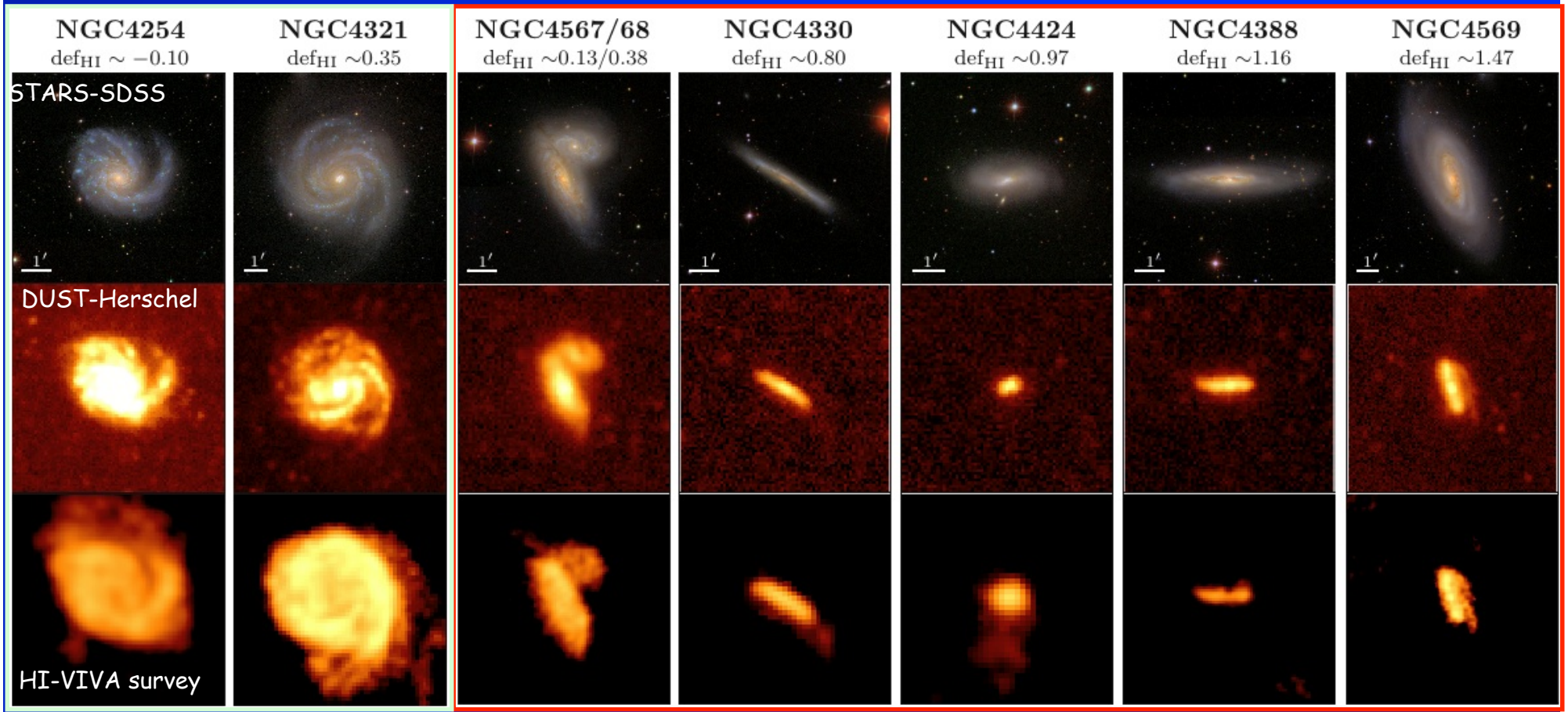
LC, Boissier, Boselli et al., 2012 A&A

HI removed, SF quenched in cluster galaxies…

What about dust?

“Truncated” dust disks in HI-deficient Virgo spirals

HI-rich → HI-poor



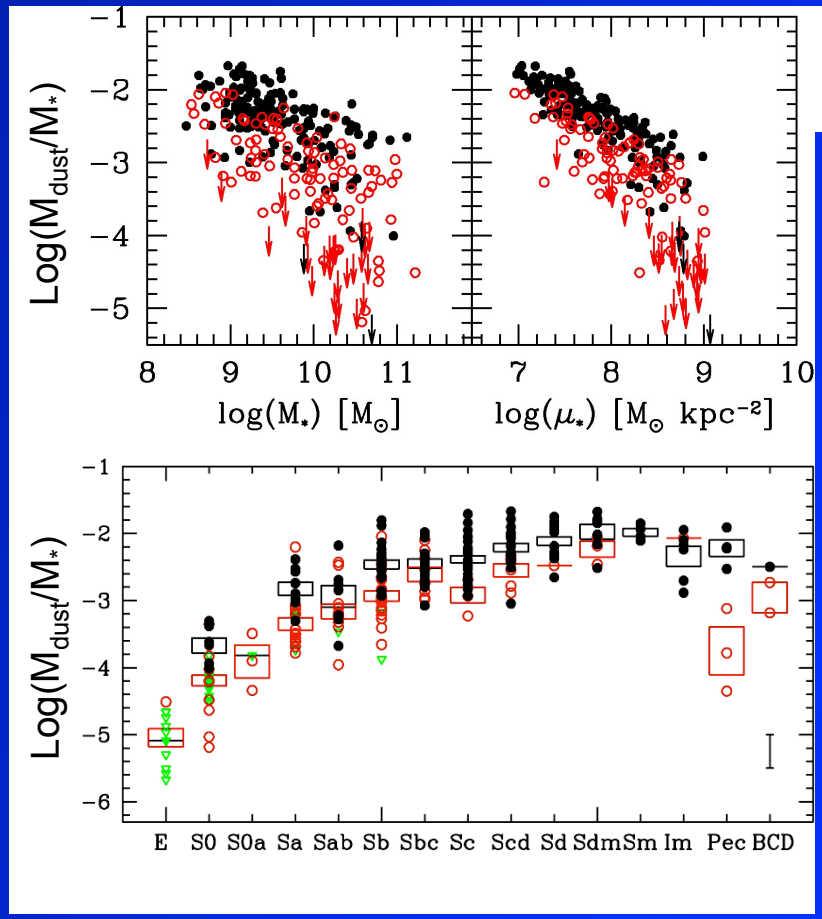
Pohlen, LC, Smith et al. 2010, A&A

LC, Davies, Pohlen et al. 2010, A&A

Gas removal is mainly outside-in: i.e. truncation of the gas and dust disk

Dust scaling relations and environment

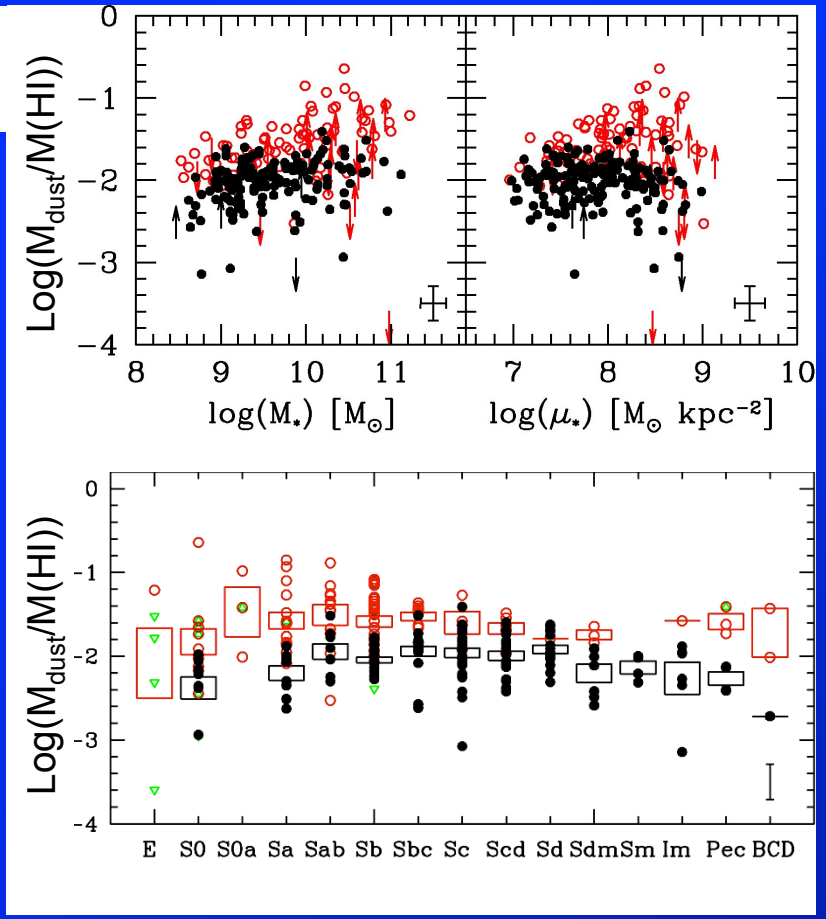
M_{dust}/M_*



Red=HI-def

Black=HI-norm

M_{dust}/M_{HI}



Dust is stripped but….

less than the HI

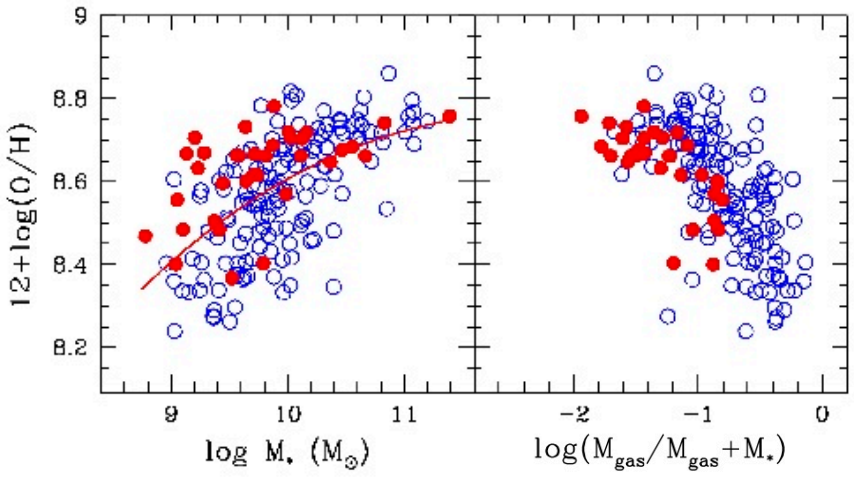
LC, Ciesla, Boselli et al. 2012 A&A

HI and dust removed, SF quenched in cluster galaxies…

at last, what about metals in the ISM?

Gas Metallicity and HI deficiency

Red=HI-def **Blue=HI-norm**



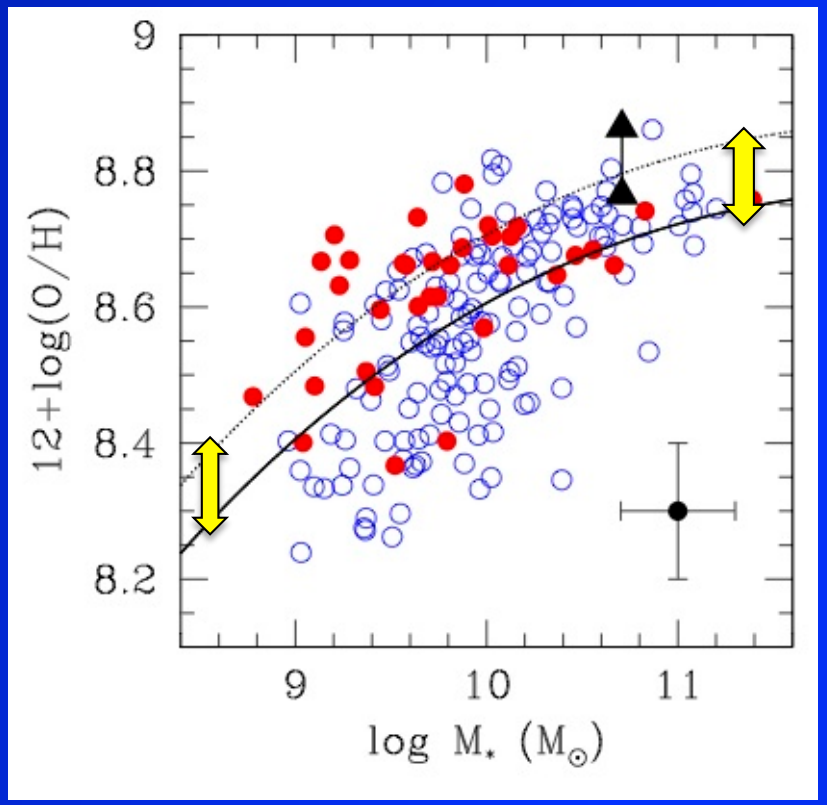
Hughes, LC, Boselli et al. 2012 A&A, submitted

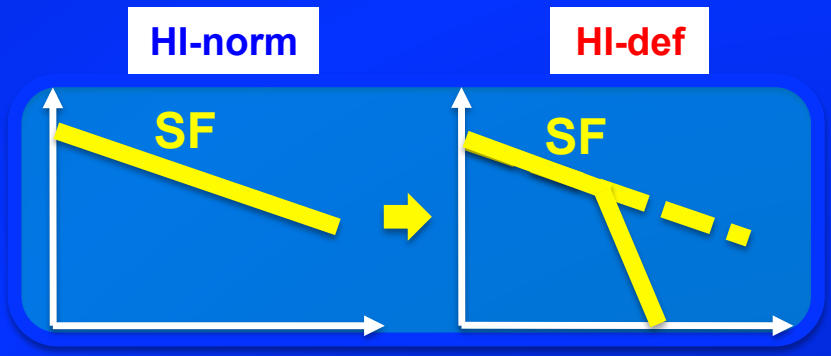
At fixed stellar mass HI-def. galaxies more metal rich

(see Skillmann+1996, Boselli & Gavazzi 2006)

Is this a real effect?

HI def. galaxies ➔ SF disk is truncated ➔ O/H only for the inner parts.





Offset of HI-def galaxies perhaps just an observational bias

Very difficult to use gas metallicities to look for environmental trends

… but see Jorge Iglesias-Paramo's talk…

Hughes, LC, Boselli et al. 2012 A&A, submitted

Summary

- HI

  Virgo galaxies significantly gas poorer than field objects

  RP stripping the main mechanism at work

- Dust

  Scaling relations similar to HI

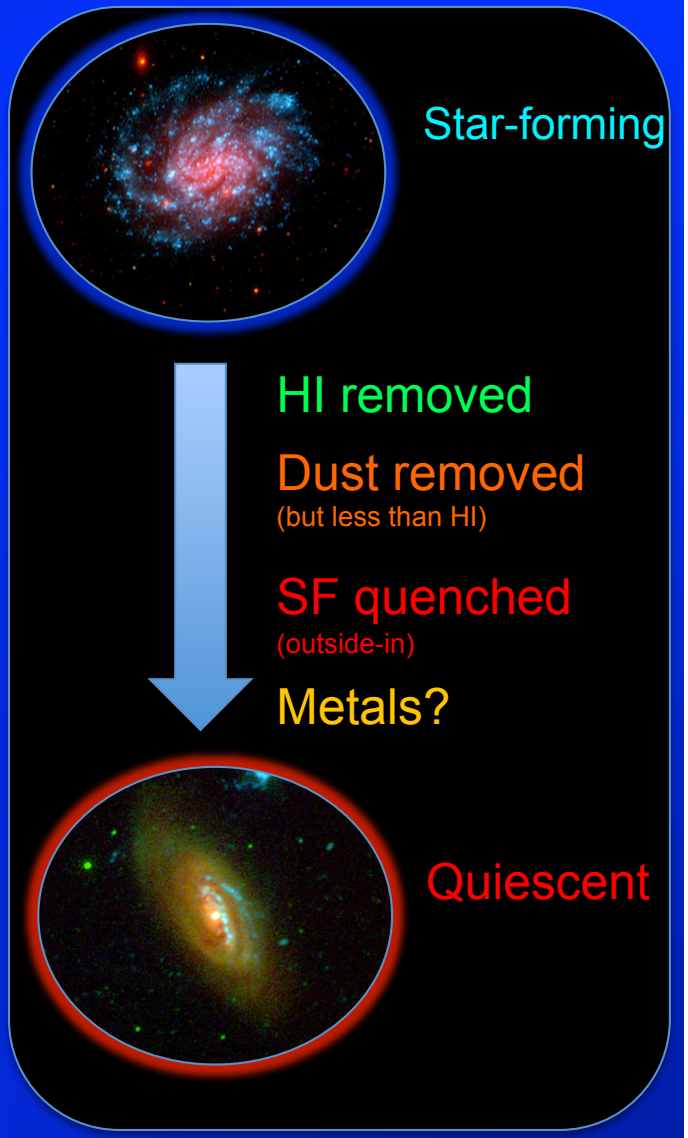
  Dust is stripped but less than HI

- Star formation

  Loss of HI necessary to quench the star formation

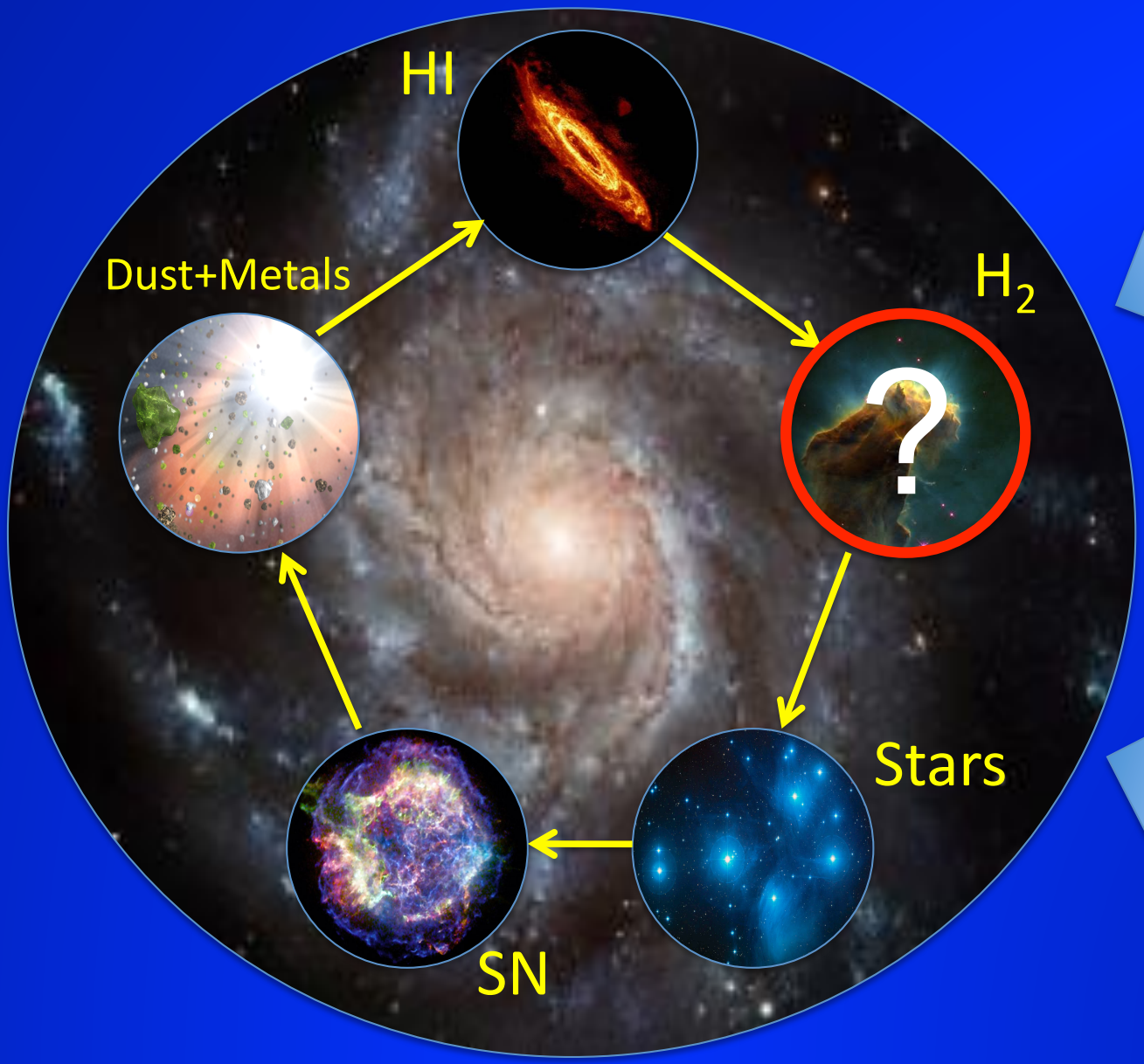
- Metals

  Do integrated metallicities tell anything about environment?



The molecular component is the main missing link

…but remember Christine Wilson's and Ute Lisenfeld's talk



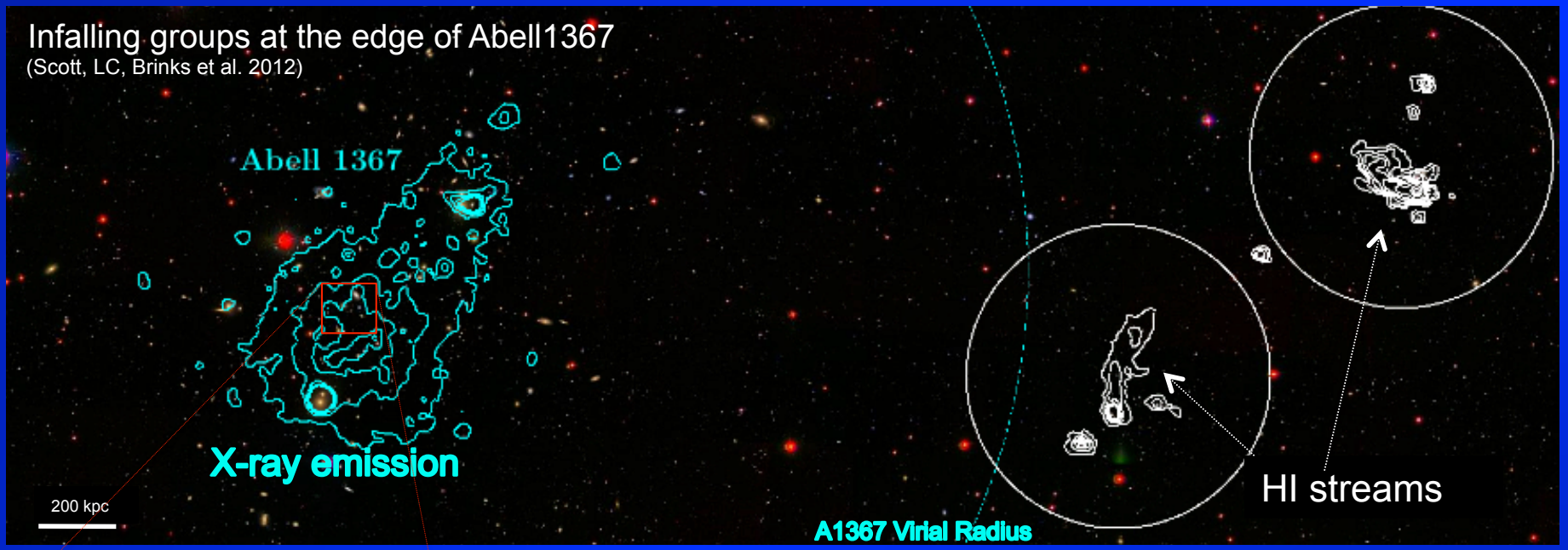
Internal properties

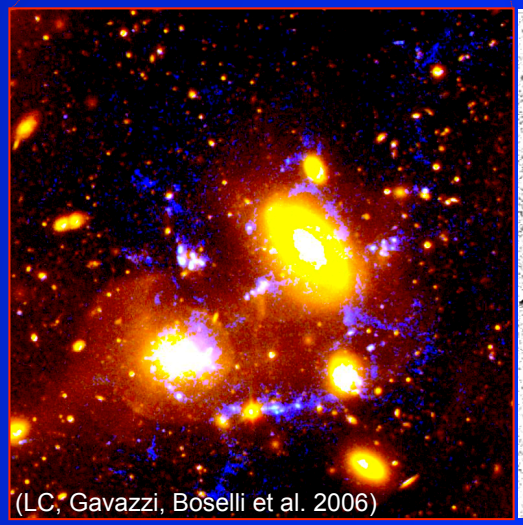
- Mass
- Dynamics
- Nuclear activity
- ….

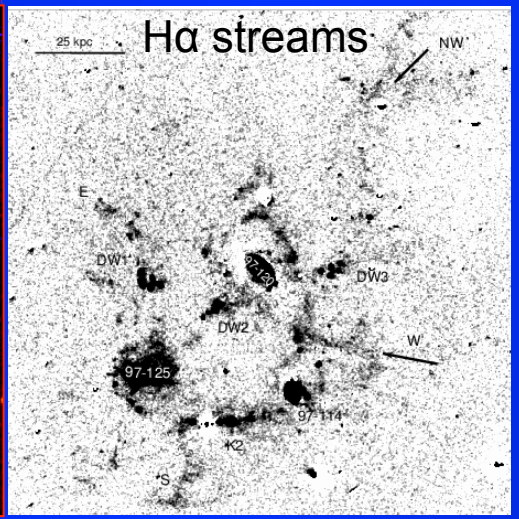
Environment

- Large-scale str.
- Merging
- Tides
- Stripping
- ….

Extend this approach to cluster's infalling regions and groups







HI and Hα streams in groups in the outskirts of nearby clusters.
(but these are NOT HI-def yet!)

SF cycle can be affected before entering the cluster

Thank you!