ASTRON

Netherlands Institute for Radio Astronomy

An HI view of the on-going assembly of early-type galaxies

Paolo Serra

ASTRON is part of the Netherlands Organisation for Scientific Research (NWO)

Outline

- Early-type galaxies and the Atlas^{3D} survey
- Preliminary results on HI in ETGs
- Prospects for the study of HI in ETGs with Apertif
- Conclusions

Early-type galaxies

Early-type galaxies appear as a very homogeneous family:
tight scaling relations, relaxed morphology, strong clustering, old stellar populations, gas-poor (thus passively evolving)

However:

- KDCs, internal discs
- morphological fine structure (shells, ...)
- residual star formation (more recent in the field?) and associated CO
- extended regions with ionised-gas (LINER-like line ratios)
- neutral hydrogen

The Atlas^{3D} survey

A volume-limited multi-wavelength survey of 263 early-type galaxies within ~40 Mpc

Optical integral-field spectroscopy (WHT/SAURON)
Optical imaging (INT+SDSS)
CO (IRAM+CARMA)
HI (WSRT)
archival 2MASS, GALEX, XMM-Newton, Chandra
semi-analytic models
N-body simulations

PIs: Cappellari and Kranjovic (Oxford), Emsellem (ESO), McDermid (Gemini)

Bacon and Bois (Lyon), Blitz and Alatalo (Berkeley), Bournaud (SACLAY), Bureau, Davies and Kochfar (Oxford), de Zeeuw and Kuntschner (ESO), Falcon-Barroso (IAC), Morganti, Oosterloo and Serra (ASTRON), Sarzi (Univ. Hertfordshire), van den Bosch and Weijmans (Leiden), Verdoes Kleijn (Kapteyn), Van de Ven (Institute Advanced Studies) , Young (New Mexico Tech), Naab (Muenchen)

Atlas^{3D} sample selection

M_K <-21.5 (K<11.6 @ $dist_{max}$)

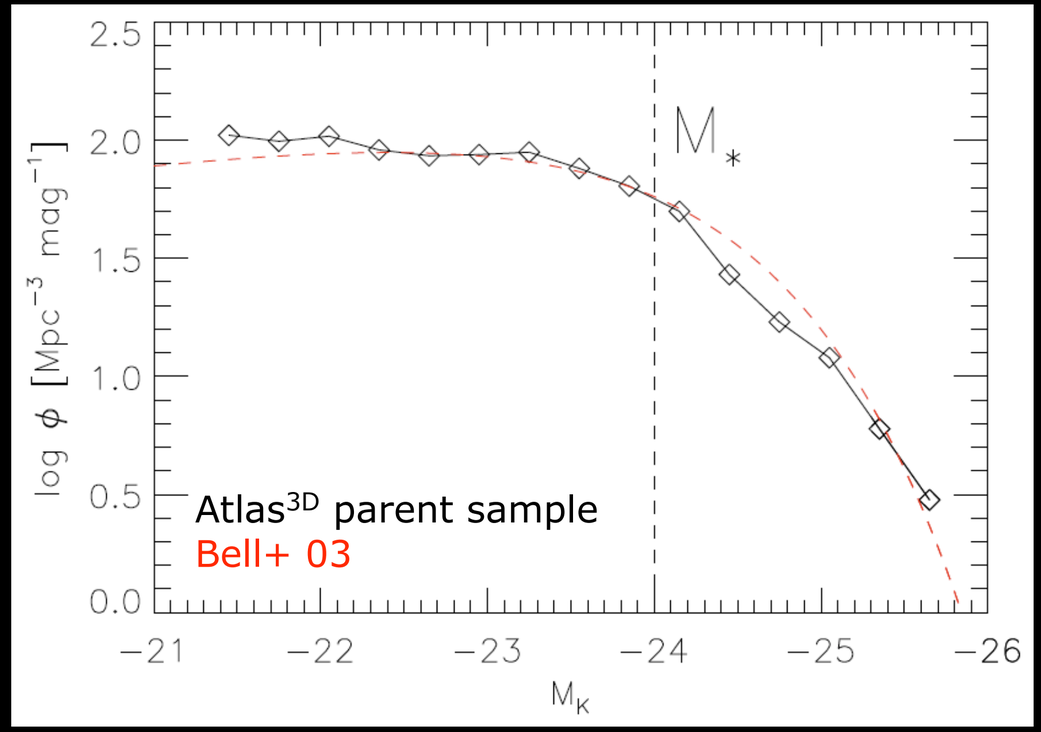
dist<42 Mpc mostly SBF

|δ-29|<35°

|b|>15°

Morphological classification by eye
(82% SDSS, else DSS2-blue)
Main criterion: no spiral arm

263 ETGs (Virgo included)



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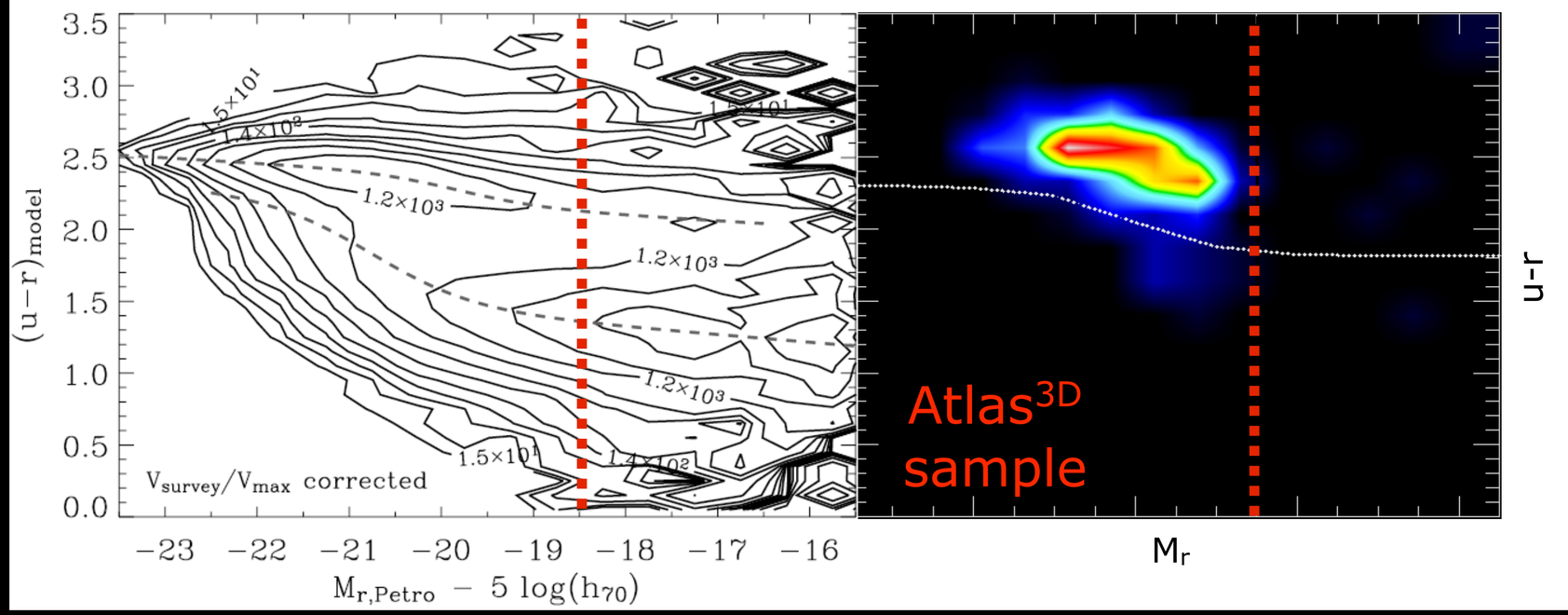
Baldry et al. (2004)



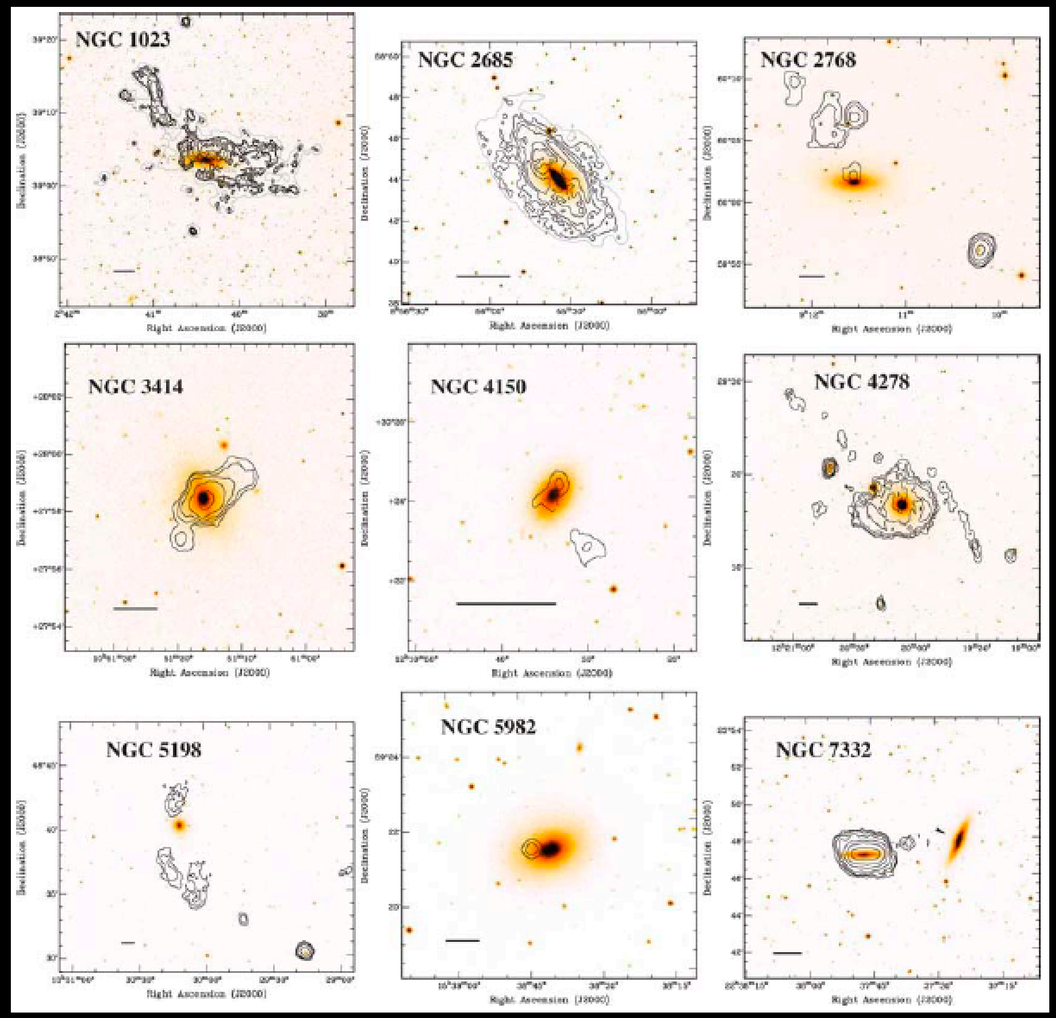
HI in ETGs

Significant fraction of the ISM

Detection rate:
30-70% in the field
~1% in the cluster

$M(HI)=10^{6}$-$10^{10}\ M_{\odot}$
spread over tens of kpc
$n_{HI} < 10^{20}\ cm^{-2}$

(Morganti+ 06, Oosterloo+ 07, Grossi+ 09)



So far, no relation with stellar properties (luminosity, stellar age, kinematics), some relation with other gas phases, BUT poor statistics

WSRT HI survey of the Atlas^{3D} sample (ongoing)

dec>10 deg:

all non-Virgo galaxies => 127 ETGs (full synthesis)

Virgo galaxies detected in Alfalfa (7/44)

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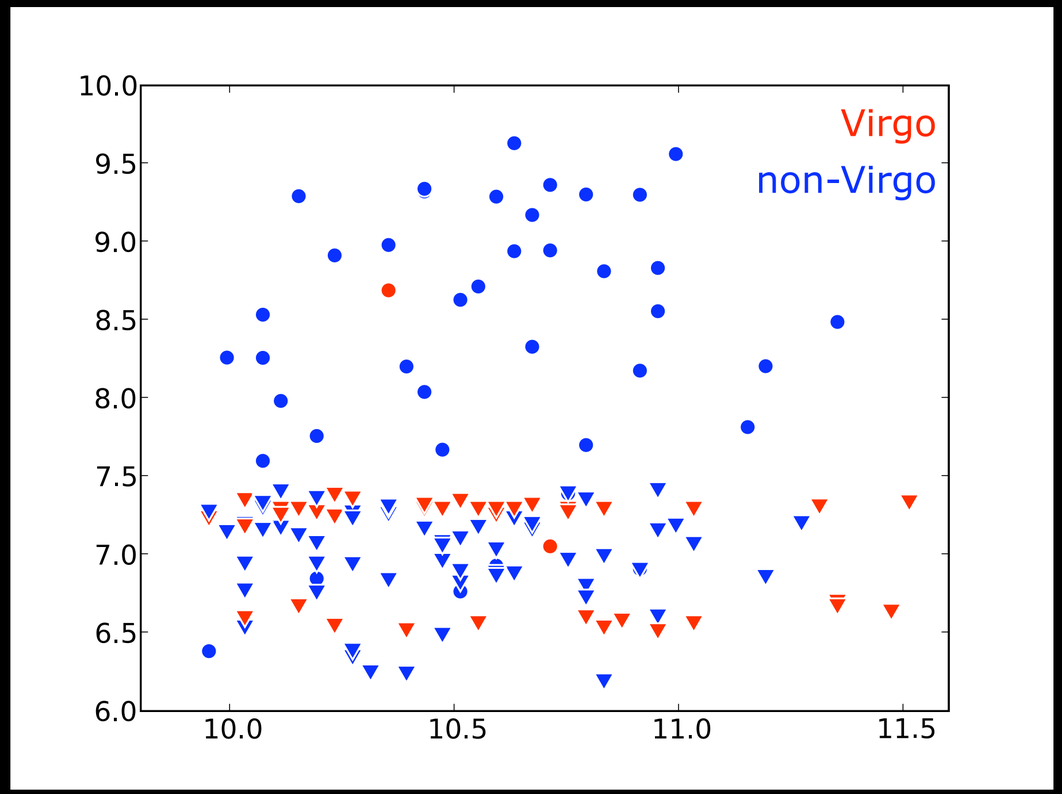

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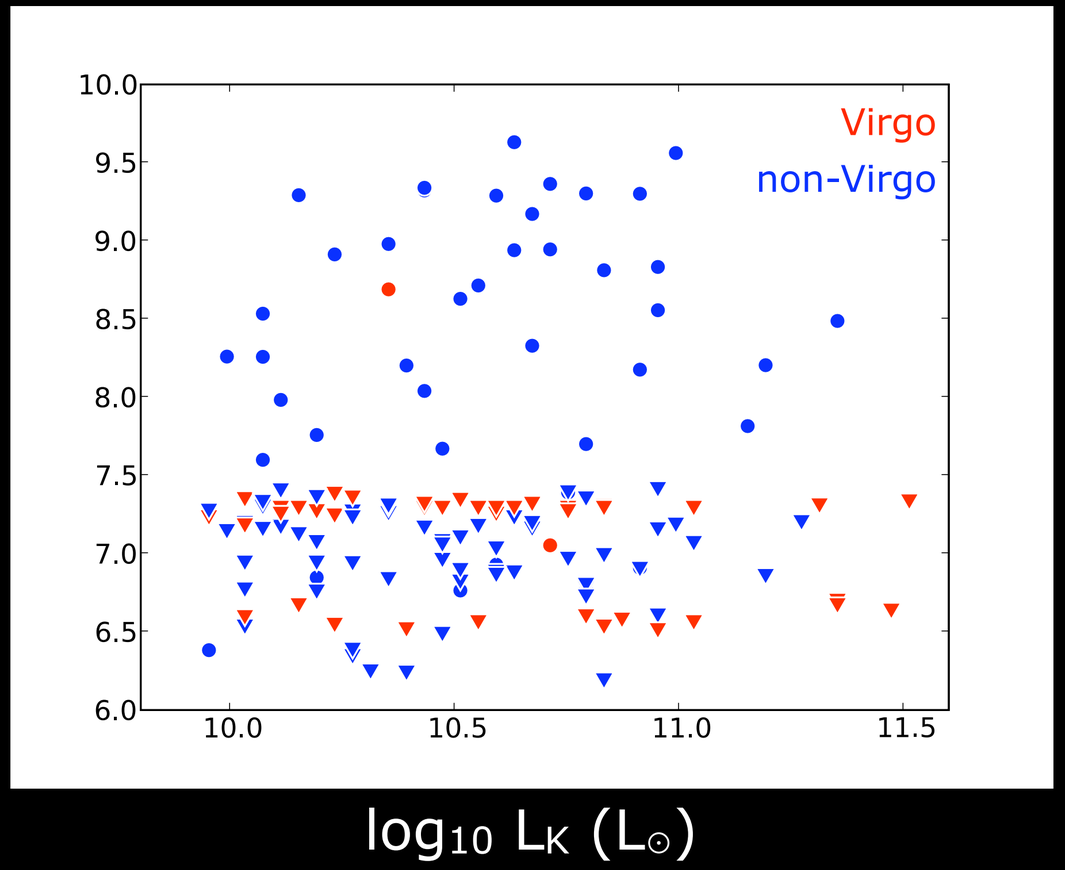

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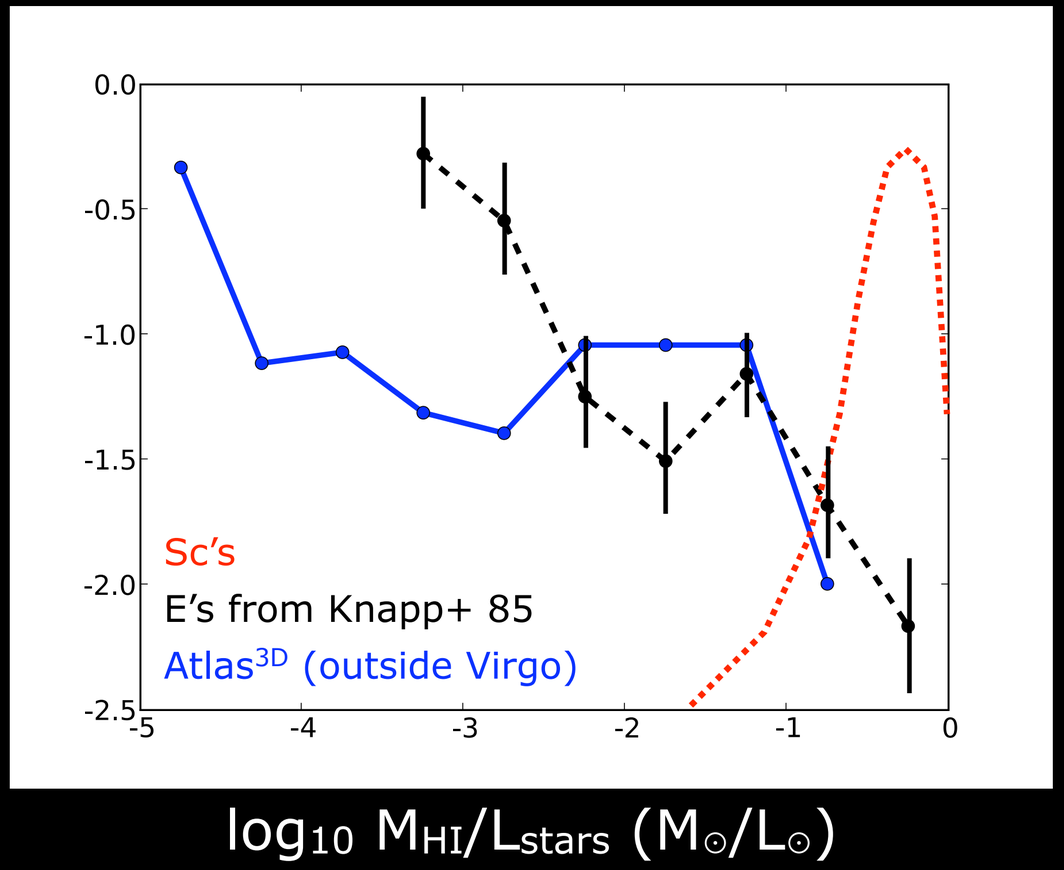

HI external origin?

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HI in ETG's and environment: gas mass

Environment = all galaxies within 1 Mpc, ±300 km/s, and with M_K <-21.5

Isolated galaxies: L_{gal}/L_{env}~1

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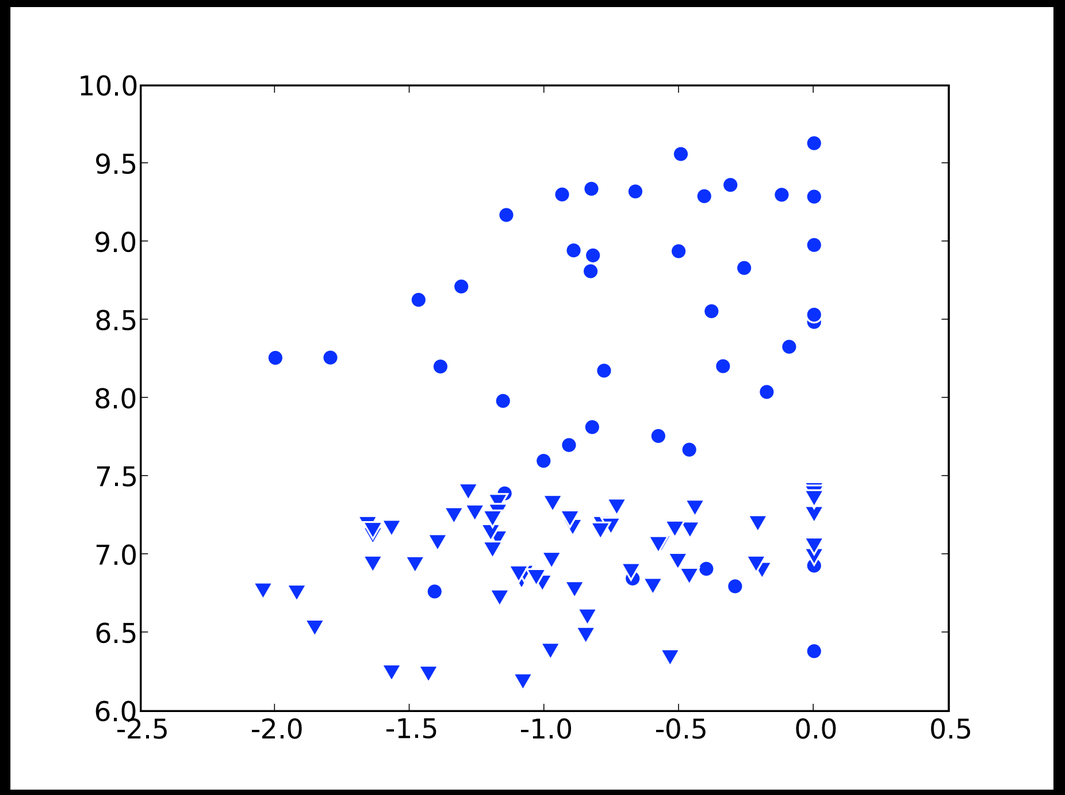

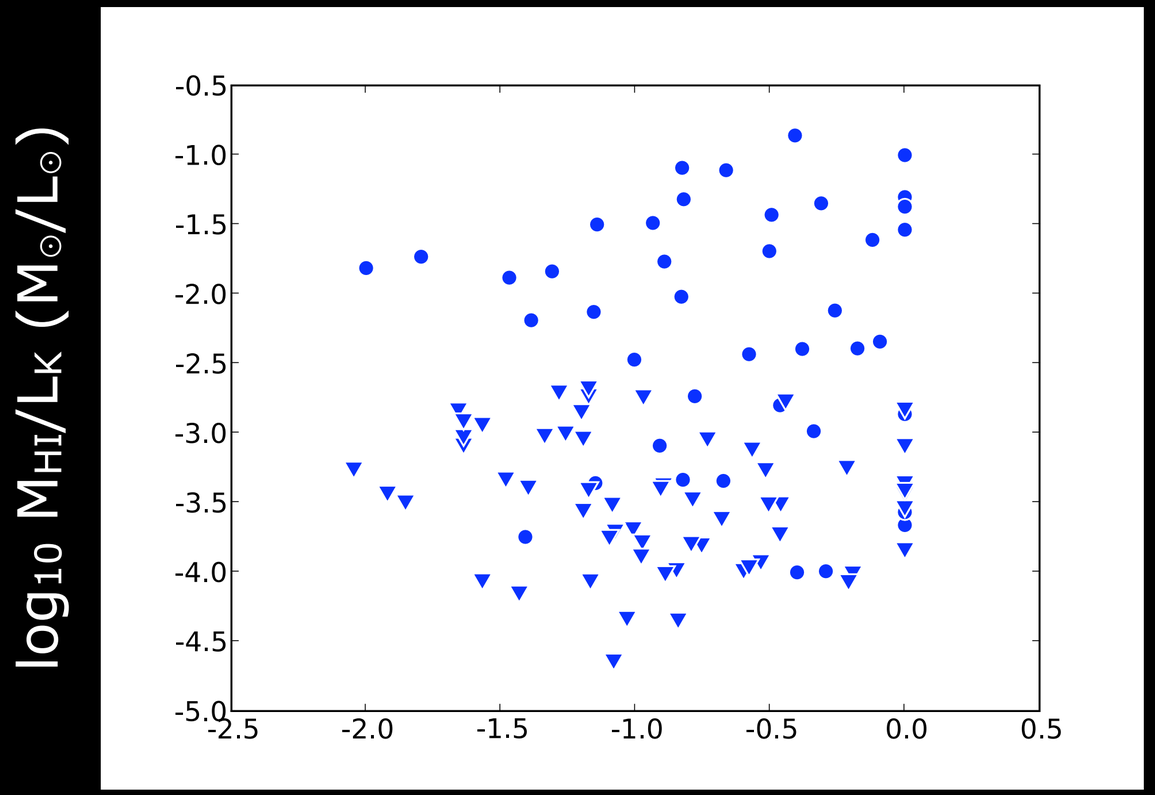

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HI in ETG's and environment: gas morphology

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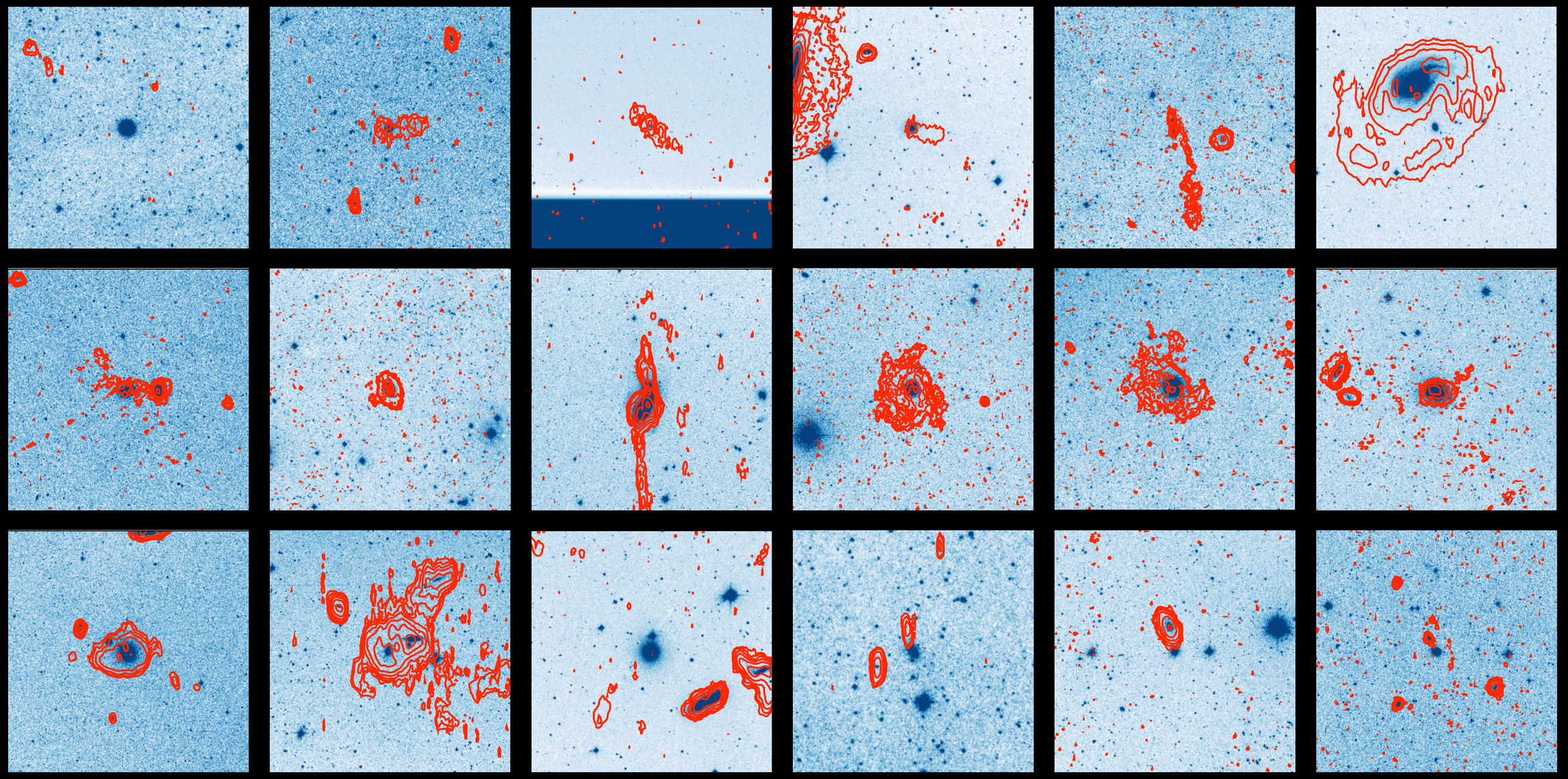
$L_{galaxy}/L_{environment}$

$n_{HI} > 1.5 \times 10^{19}$ cm^{-2}



180 kpc

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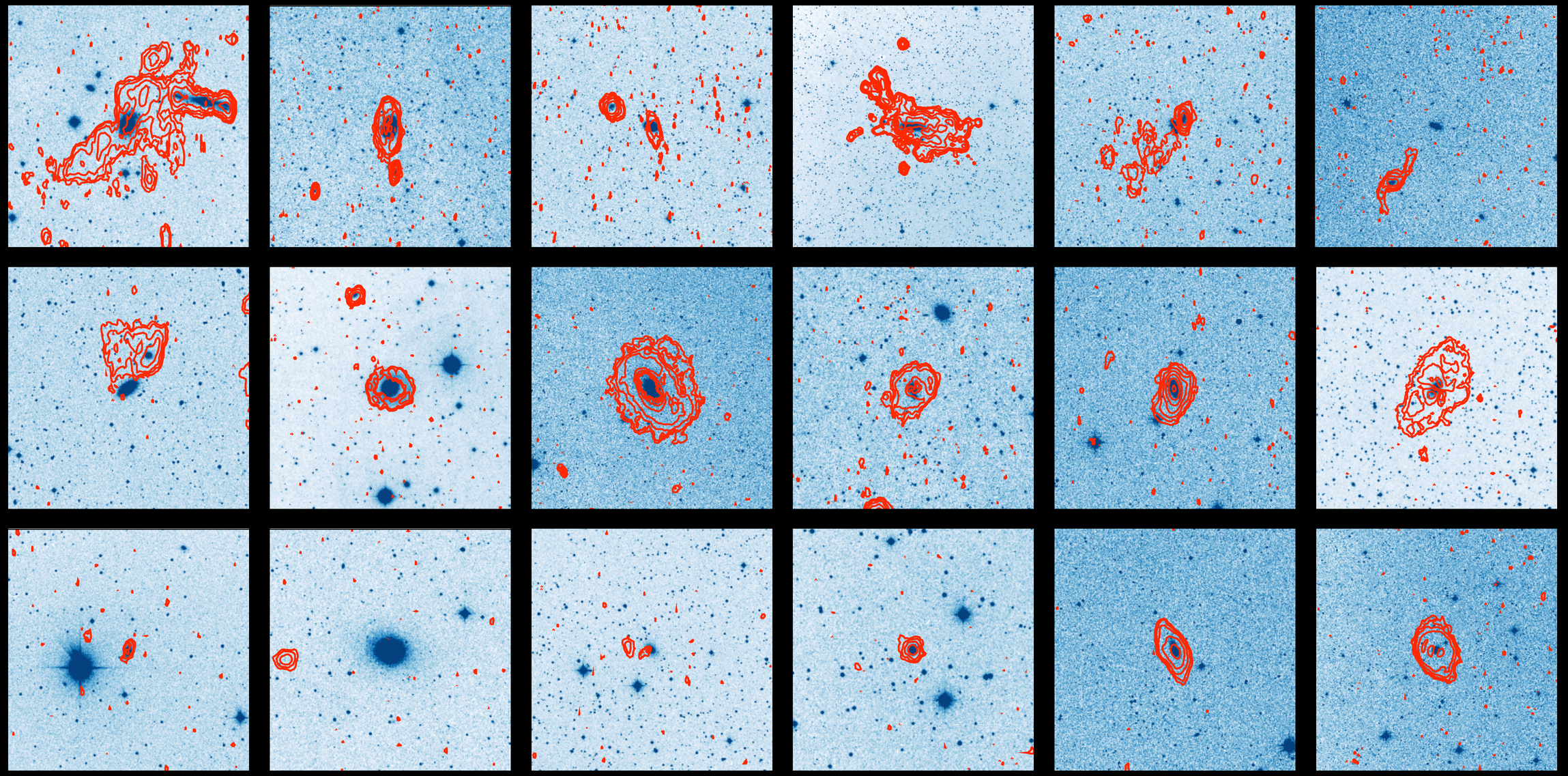

180 kpc

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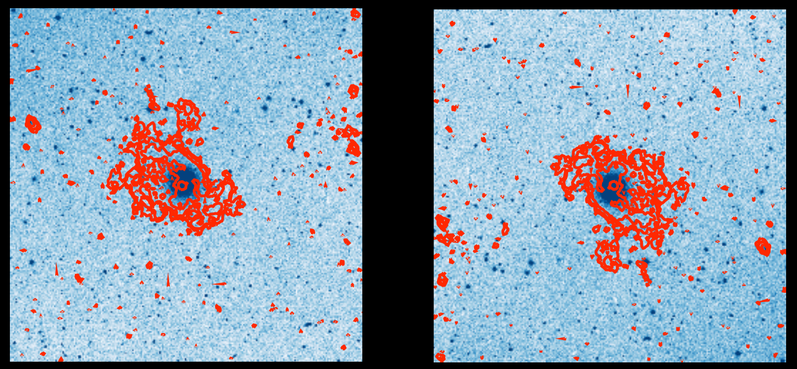
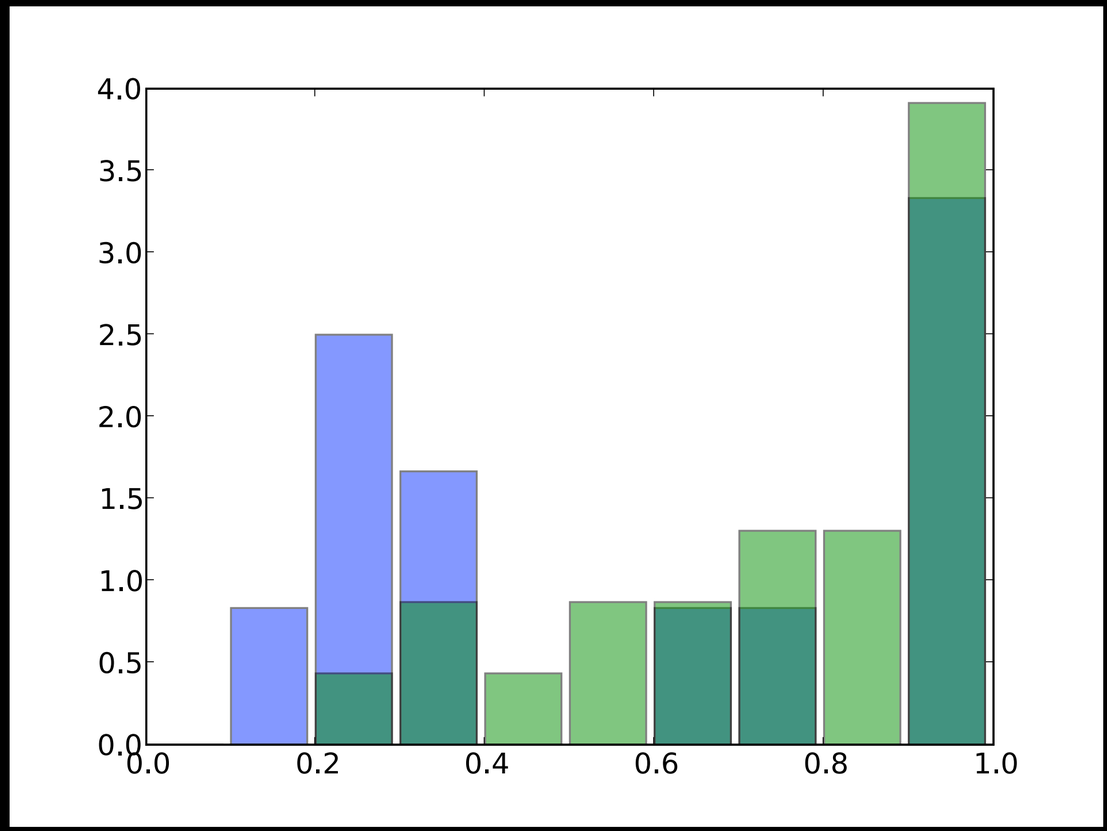
HI asymmetry and environment (preliminary)



$A = 0.5 \times \Sigma |I_0 - I_{180}| / \Sigma I_0$



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The on-going assembly of ETGs

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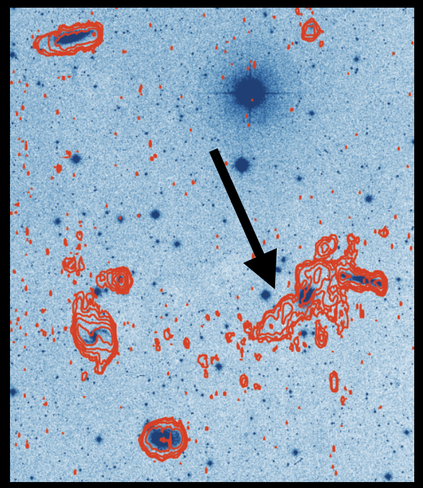
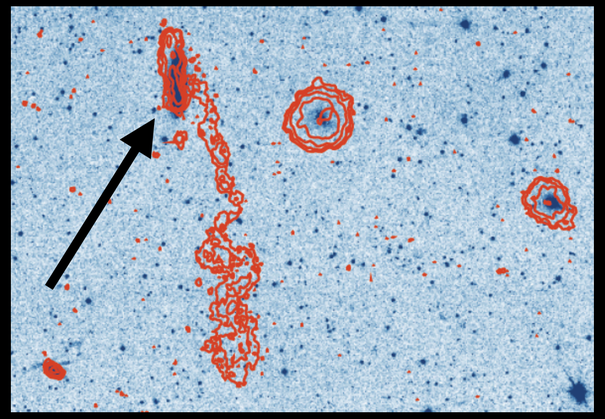
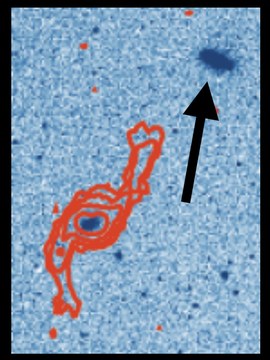
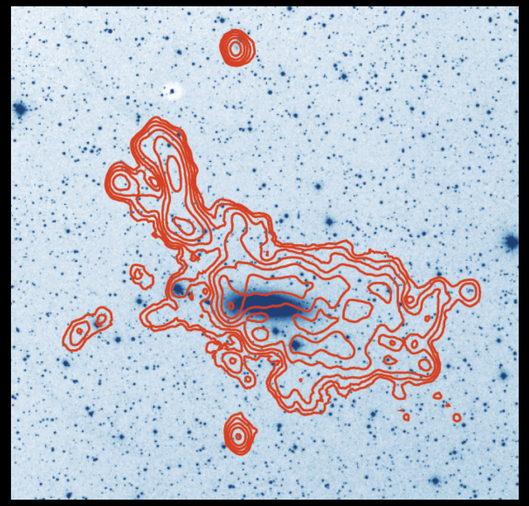
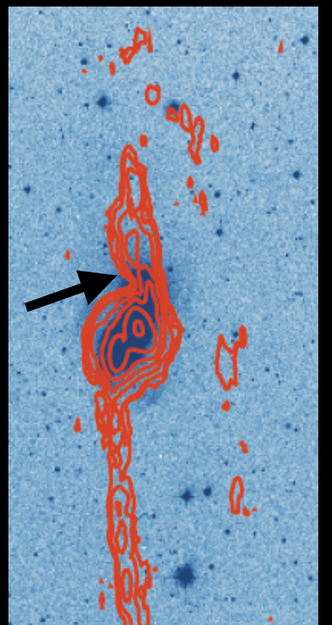
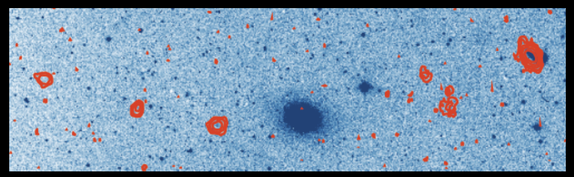
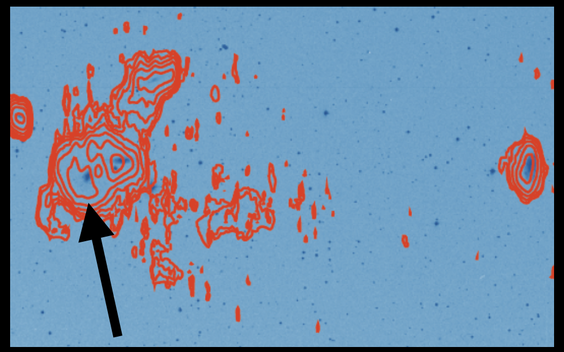
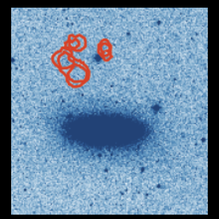
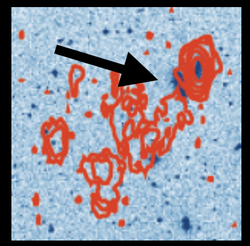
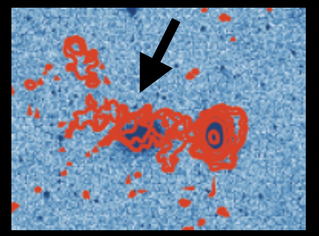
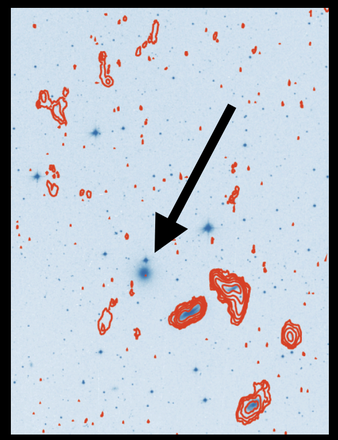
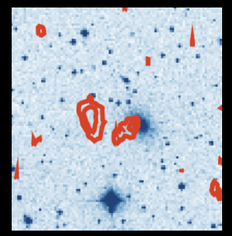
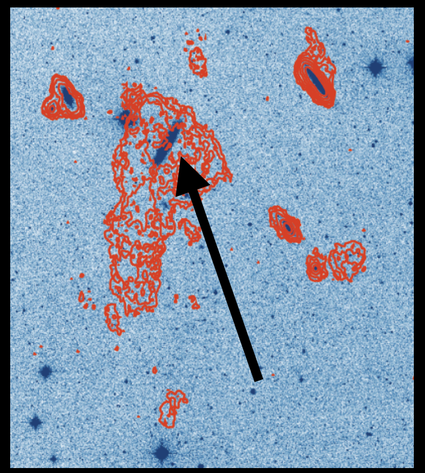
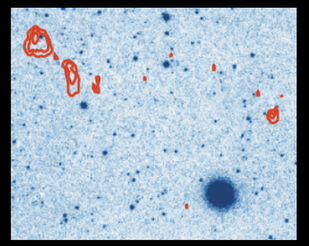
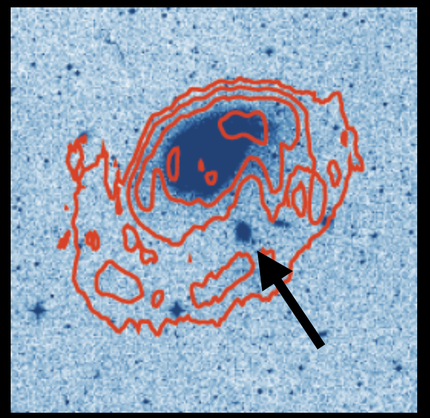
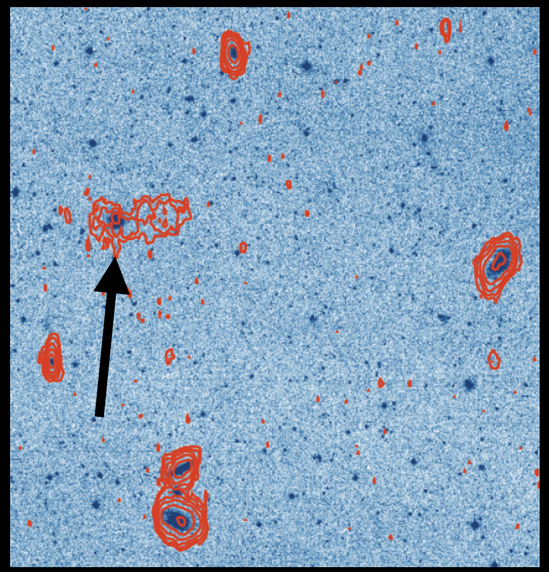
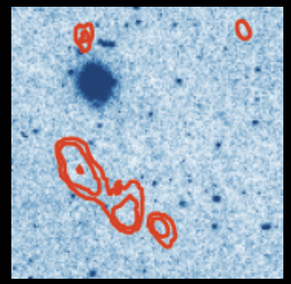
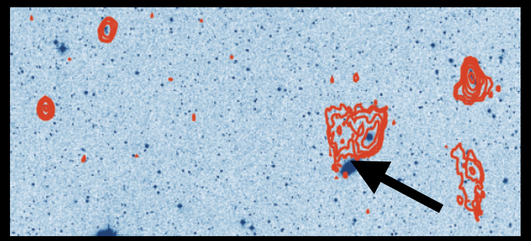

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APERTIF

The current front-end will be replaced by focal plane arrays on the WSRT dishes:

- FOV will increase by a factor ~25
- Instantaneous bandwidth 300 MHz, i.e., z=0-0.3 for HI

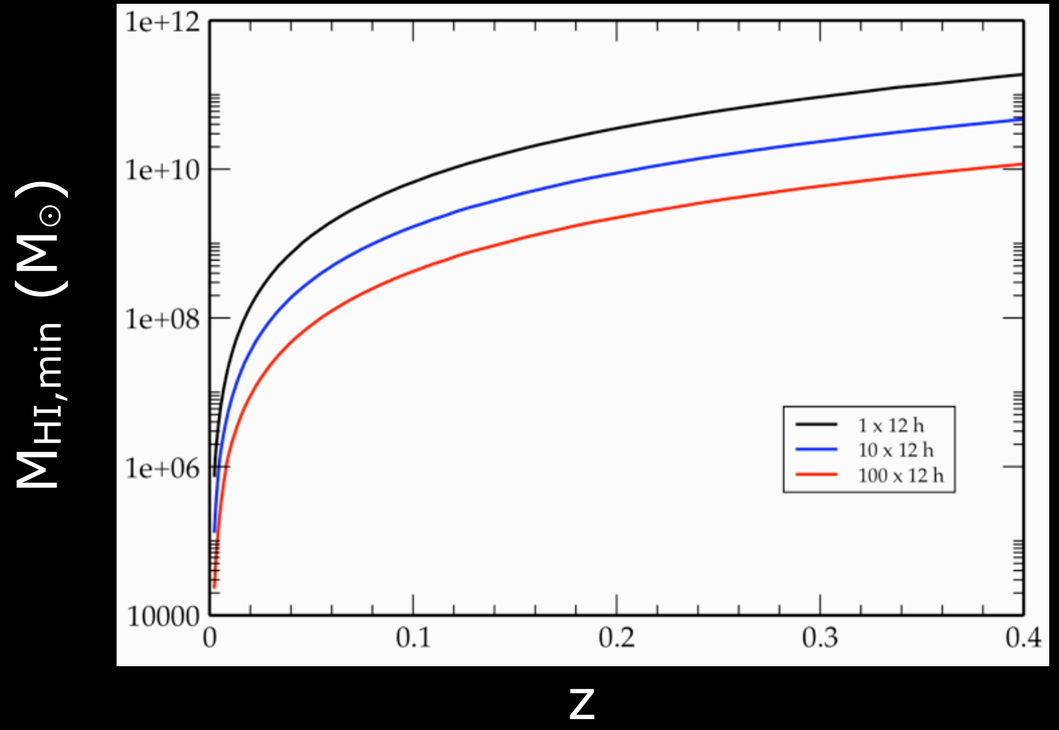
Ideal for ~all-sky surveys out to z~0.3

HI survey of ETGs with Apertif

Atlas^{3D} "surveyed" volume : 7.5 x 10^{-5} Gpc^3

Apertif survey (dec>30°) @ z≤0.1 : 1.2 x 10^{-1} Gpc^3

Factor of >10^3 in volume, but to what depth?



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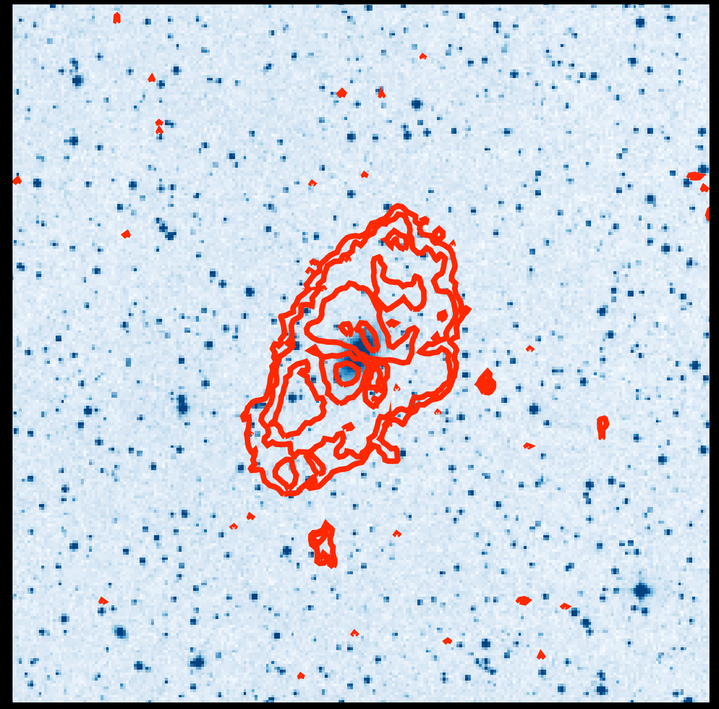
E.g., how will we see NGC 6798 ?



M_{HI} = 2.3 x 10^9 $M_\odot$

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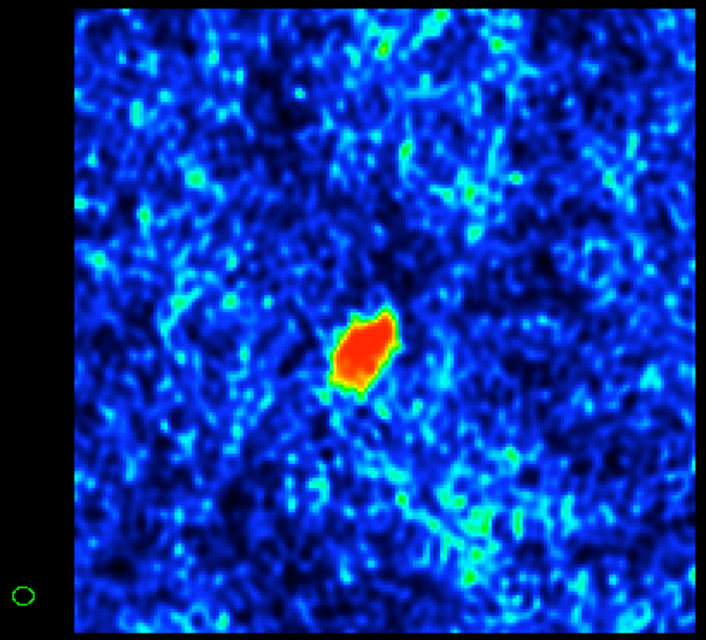
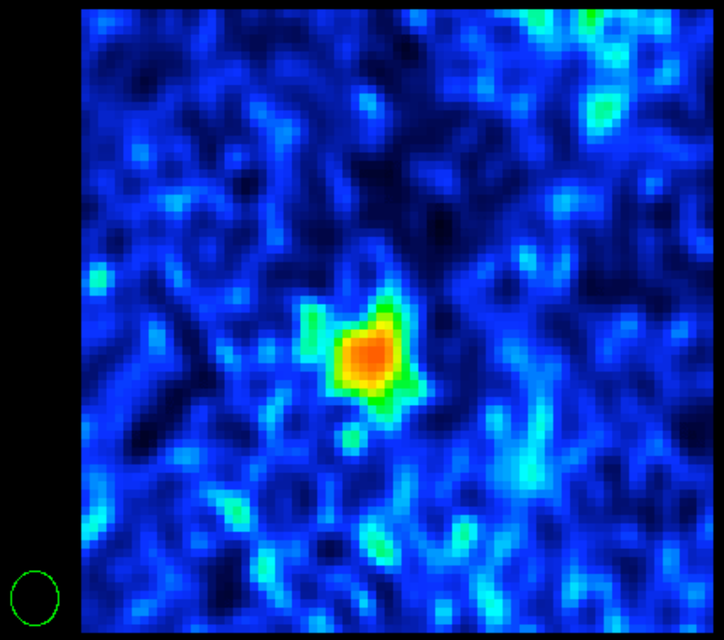
Simulated Apertif observation of NGC 6798

For the full movie, please contact pserra AT astron.nl

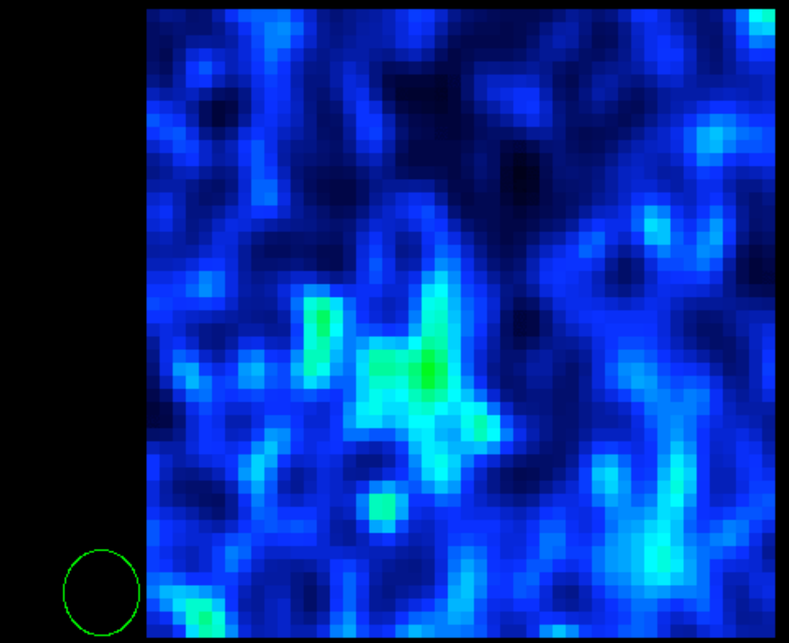
z=0.02



z=0.05



z=0.08



t = 10 x 12 h

beam = 27″ x 23″

$\sigma_{Apertif}$ = 1.4 x σ_{MFFE} ~ 100 μJy/beam @ dv=16 km/s Hanning-smoothed

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Conclusions

Atlas^{3D} survey first results:

- 40% of early-type galaxies outside Virgo contain HI
- flat M_{HI}/L_{stars} function between 10^{-4} and 10^{-1} $M_\odot/L_\odot$

HI and environment of ETGs

- strong dependence of HI mass on environment (Virgo vs. non-Virgo)
- dependence of HI morphology on environment (groups vs. more isolated galaxies)
- high fraction of interacting objects when looking at 21 cm

Apertif and ETGs

- >10^3 x Atlas^{3D} shallow-survey volume @ z≤0.1
- 10 x 12 h integration needed to study ETG properties at z~0.05