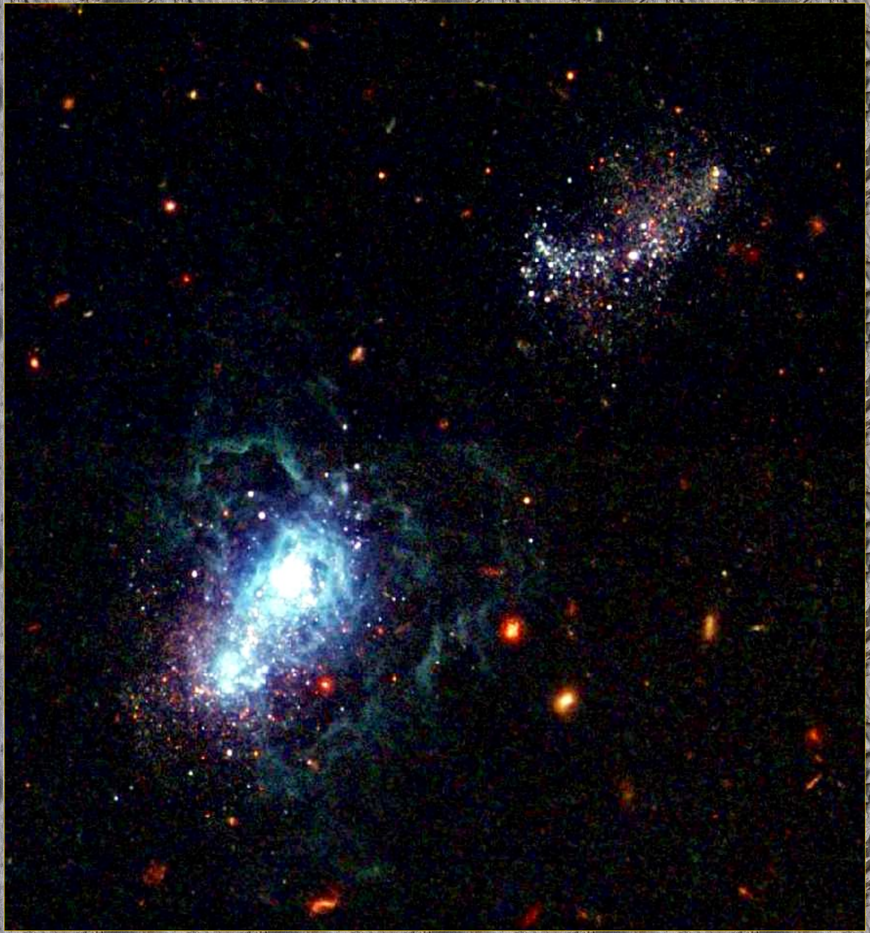

Extremely Metal-Poor Blue Compact Dwarf Galaxies

(some) Challenges and Perspectives

Polychronis Papaderos
Centro de Astrofísica da Universidade do Porto

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Centro de Astrofísica da Universidade do Porto

Outline

Extremely Metal-Poor Blue Compact Dwarf Galaxies **(XBCDs)** ≡

BCDs with a gas-phase metallicity 12+log(O/H)≤7.6

- General Properties
  - Statistics & spatial distribution
  - Morphology
  - Evolutionary status
- Why to study XBCDs?
- Clues to the formation process of XBCDs
- Extended ionized gas emission in XBCDs
- Prospects of IFU spectroscopy with 10m-class telescopes?
- Summary

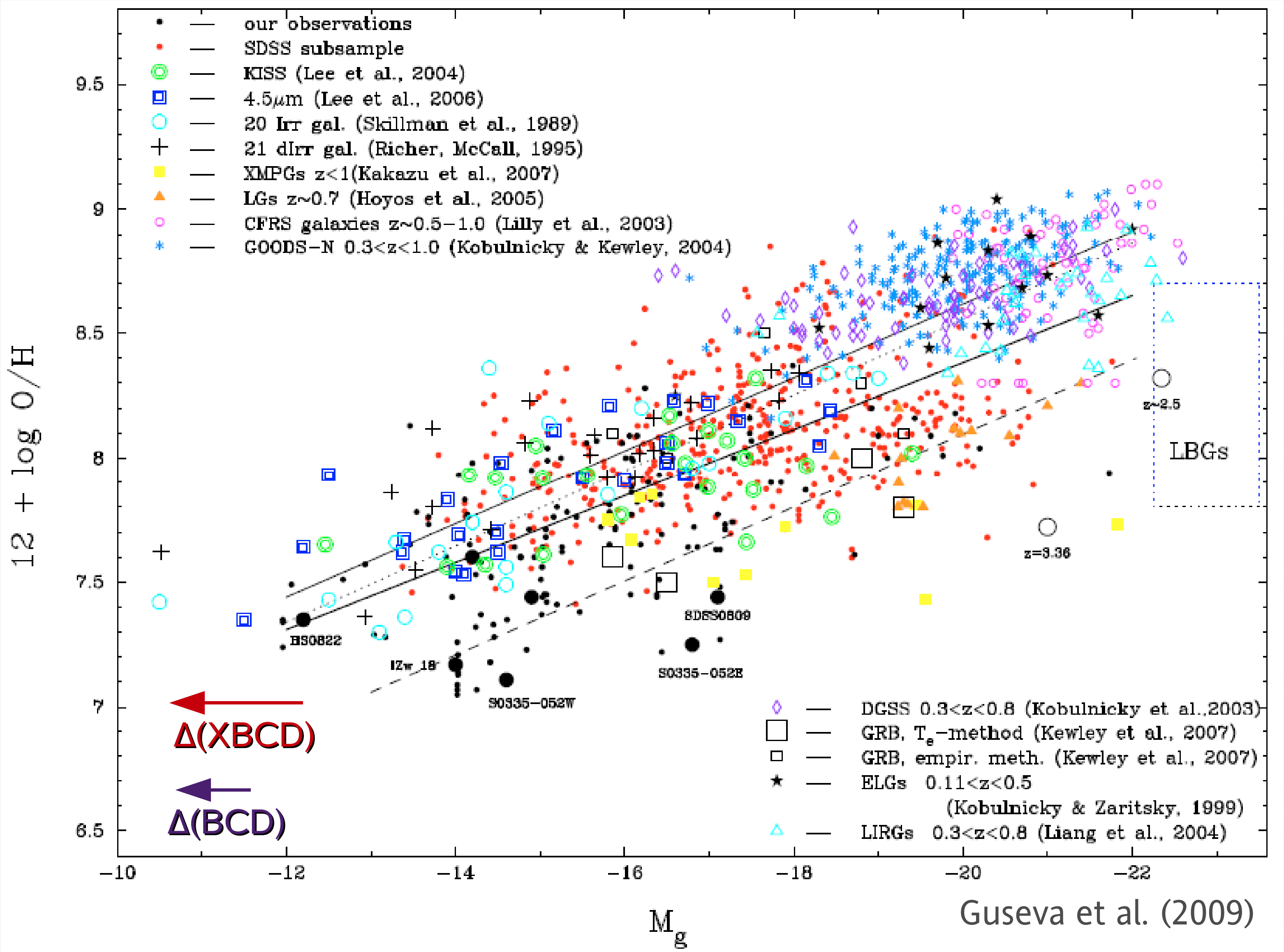
Statistics & Spatial Distribution

2000: about 15 XBCDs identified (mainly from Tololo and SBS)

2010: ~50 XBCDs discovered in the nearby Universe (mainly from the SDSS), nearly 100 BCDs with a slightly higher oxygen abundance of $12+\log(O/H)\leq 7.7$

Spatial distribution: mostly in low-density environments, however several XBCDs in interaction with an intrinsically faint companion

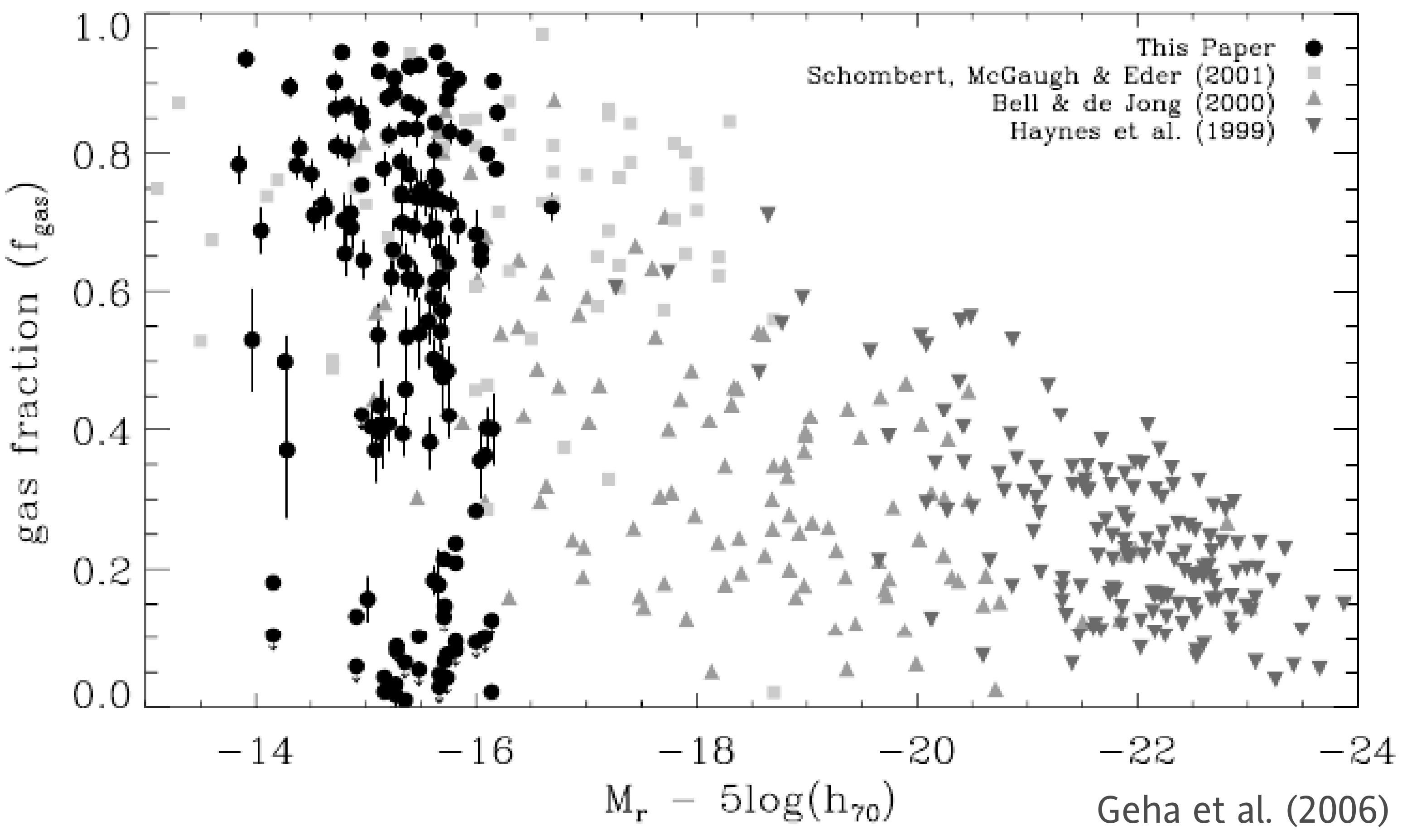
Luminosity-metallicity relation



- Estimated fading after the termination of the starburst (BCDs ~0.75 B mag, XBCDs ~1-2 B mag)

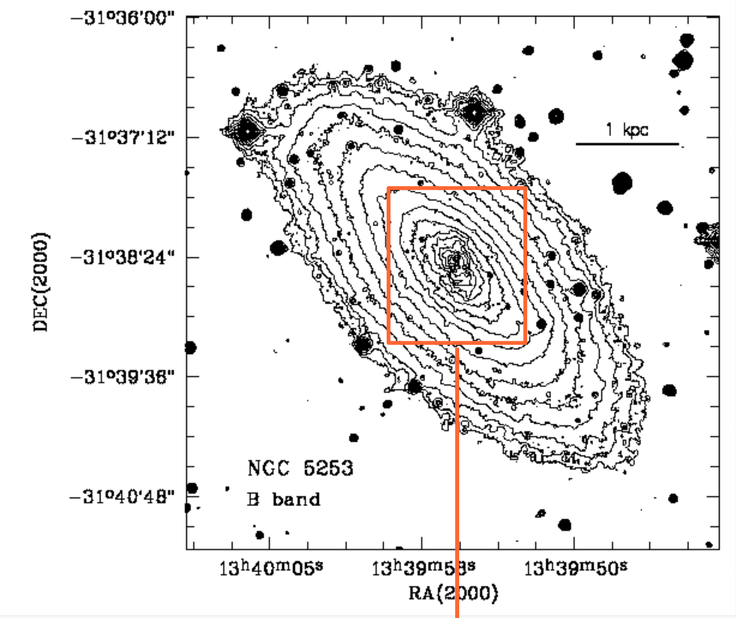
HI content

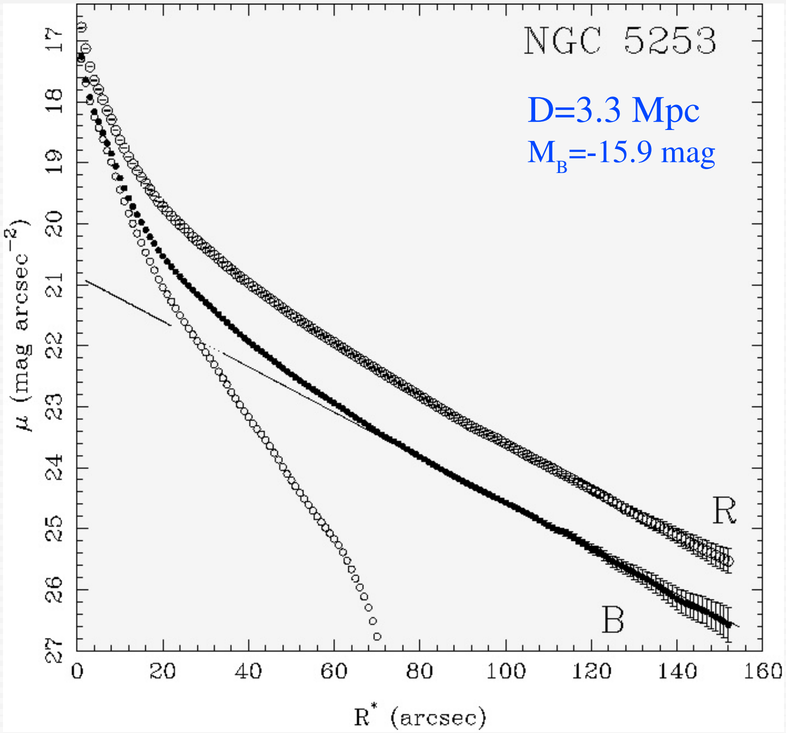
M(HI+He)/M(⋆+gas) > 0.9



Geha et al. (2006)

Morphology of evolved BCDs (NGC 5253)

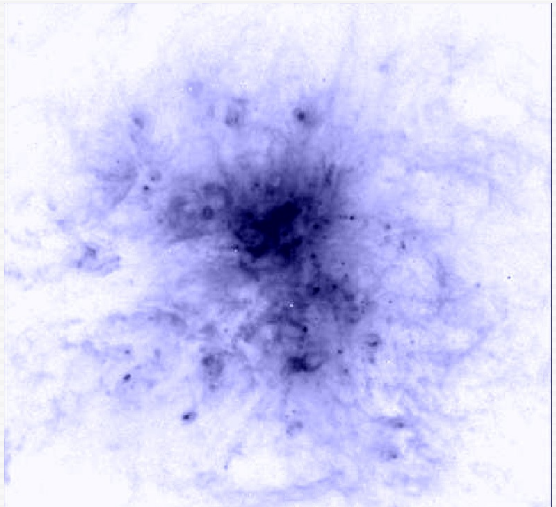




surface brightness μ (mag arcsec^{-2})

photometric radius R* (arcsec)

NGC 5253

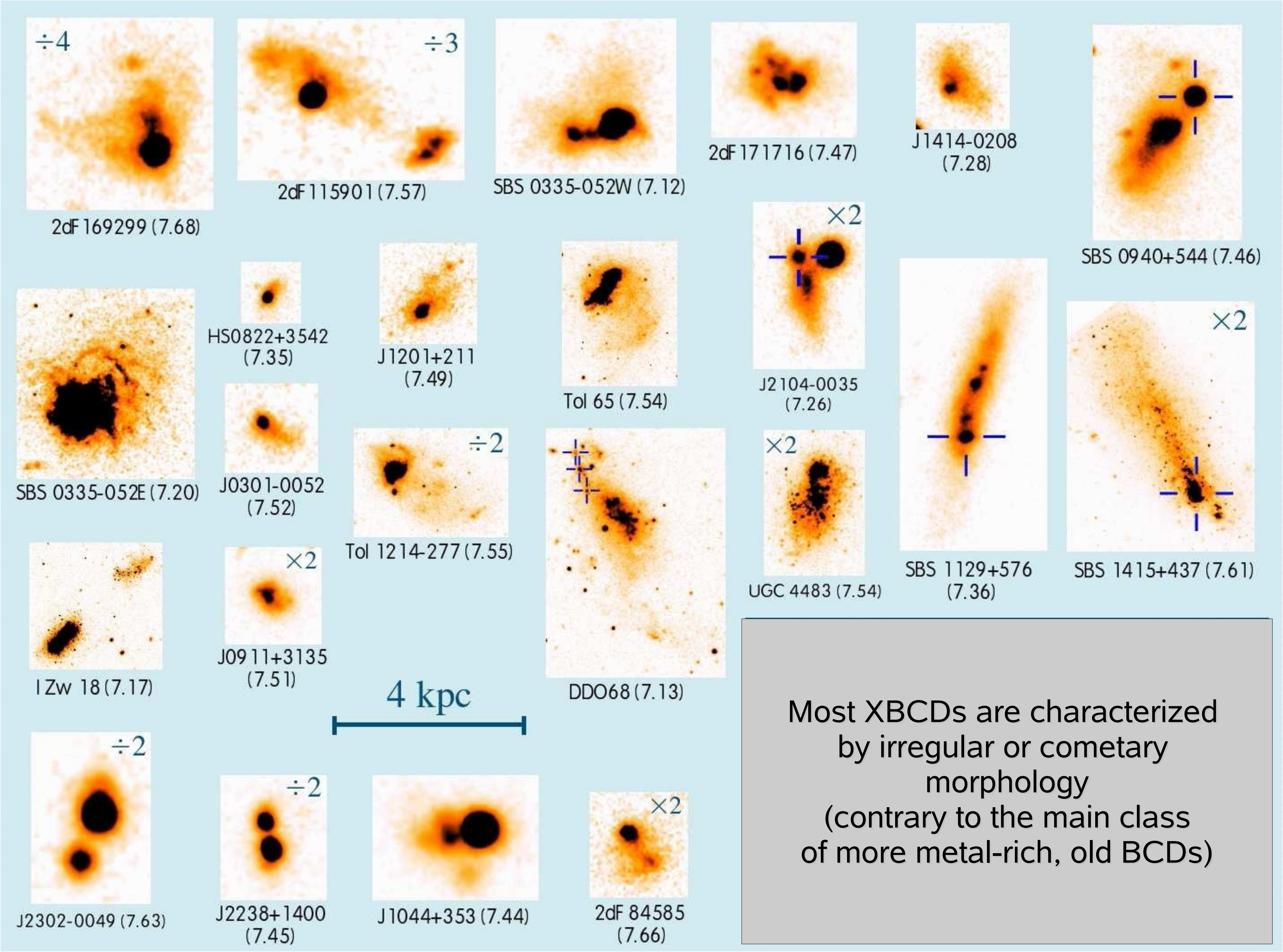


HST WFPC2, Calzetti et al. (1999)

Color gradients (up to 2 mag/kpc) and constant, red (B-R=1.0, V-I=0.9 mag) colors in the host galaxy.

→ Old (>6 Gyr) stellar population.

Morphology of XBCDs



Most XBCDs are characterized by irregular or cometary morphology (contrary to the main class of more metal-rich, old BCDs)

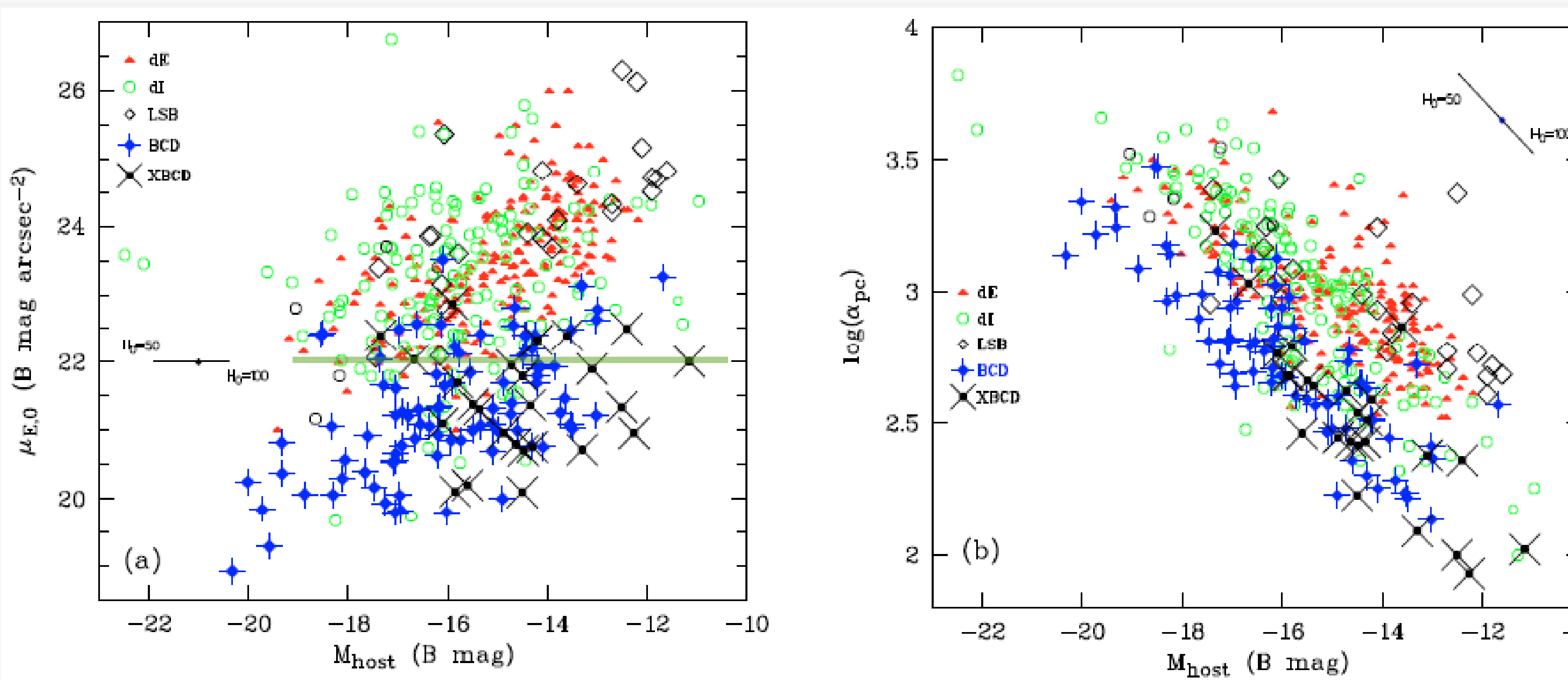
Papaderos et al. (2008)

Evolutionary status

- ~10 XBCDs studied in some detail with surface photometry and evolutionary synthesis models
  - ∃ stellar host galaxy with a Holmberg diameter of few 100 pc → XBCDs are not forming their first stellar generation
  - However – *contrary to normal BCDs* - the colors of the host galaxy (*in regions with weak nebular emission, or after subtraction of nebular emission*) are very blue **(V-I=0.1 … 0.5 mag)**
  - for standard SFHs (exp. SFR with an e-folding time of 1-3 Gyr) such colors imply that ½ of the stellar mass has formed during the last 0.5 – 4 Gyrs
- → several XBCDs are **cosmologically young** objects

Structural properties of the host galaxy of XBCDs

- Similar to BCDs, dIs and dEs the host galaxy of XBCDs shows an exponential profile
- XBCDs and BCDs occupy roughly the same parameter space with respect to the
  - central surface brightness $\mu_{E,0}$ vs. abolute magnitude M_{host}
  - exp. scale length α_{pc} vs. M_{host}
- → XBCDs and BCDs form a common evolutionary sequence



Papaderos et al. (2008)

Why to study XBCDs?

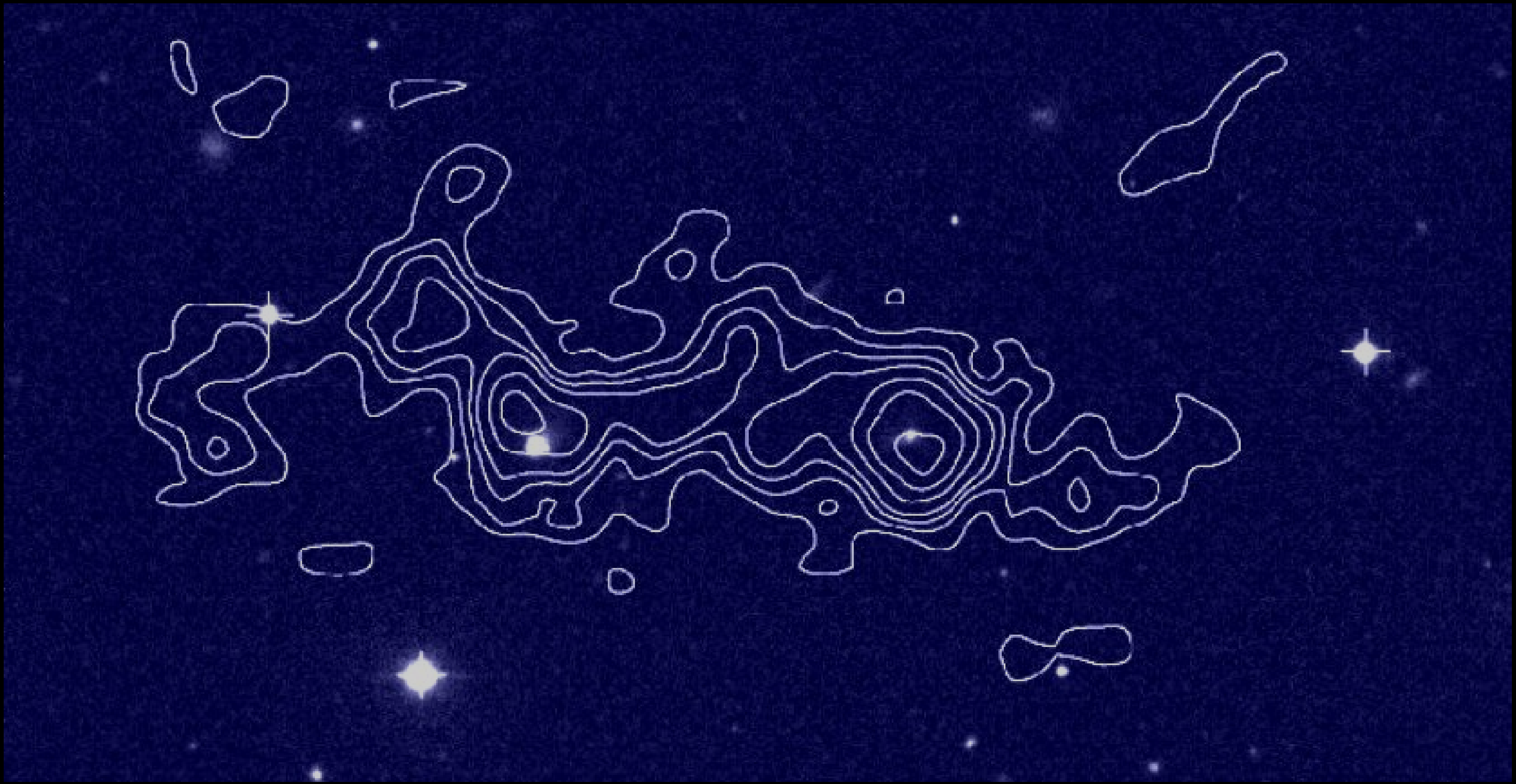
Star formation and feedback processes under chemical conditions similar to those in high-redshift protogalaxies

- gas collapse characteristics and star formation
- properties of massive low-metallicity stars
- cooling efficiency of the hot, X-ray emitting plasma

Dynamical build-up and early chemical and spectrophotometric evolution of low-mass galaxies

- dynamical processes (e.g. monolithic collapse, inside-out, propagation)
- observational constraints to numerical simulations of dwarf galaxy formation

The pair of XBCDs SBS 0335-052 E&W



Pustilnik et al. (2001)

SBS 0335-052: HI cloud with a projected size of 70×20 kpc; mass of ~10^9 $M_\odot$

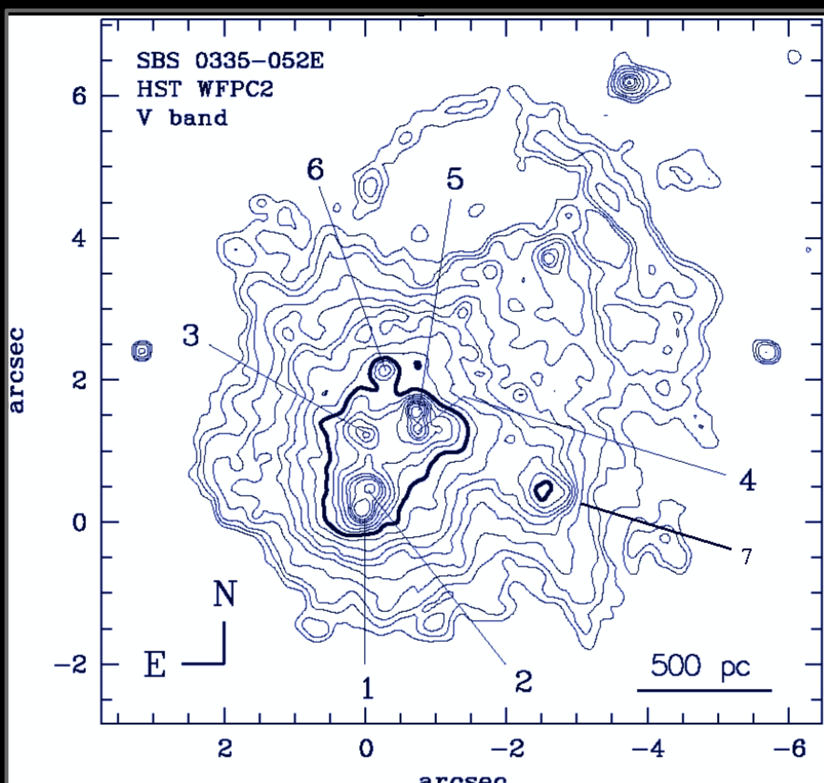
SBS 0335-052: formation

- Study of the V-I color and spatial distribution of stellar clusters using HST data

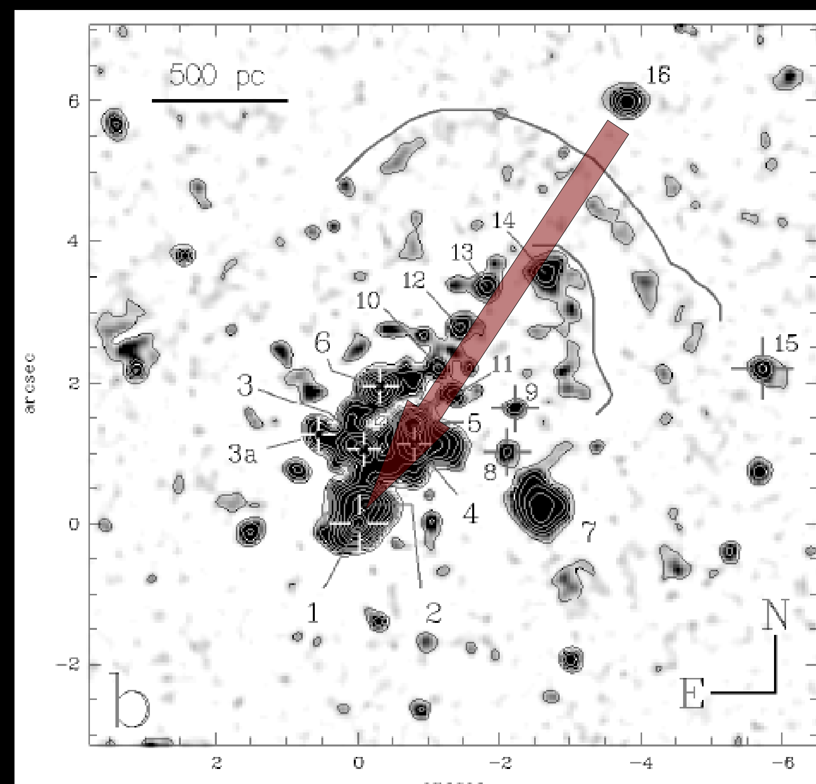
→

- galaxy is forming in a propagating mode from northwest to southeast with a mean velocity of ~20 km/s.

Papaderos et al. (1998)



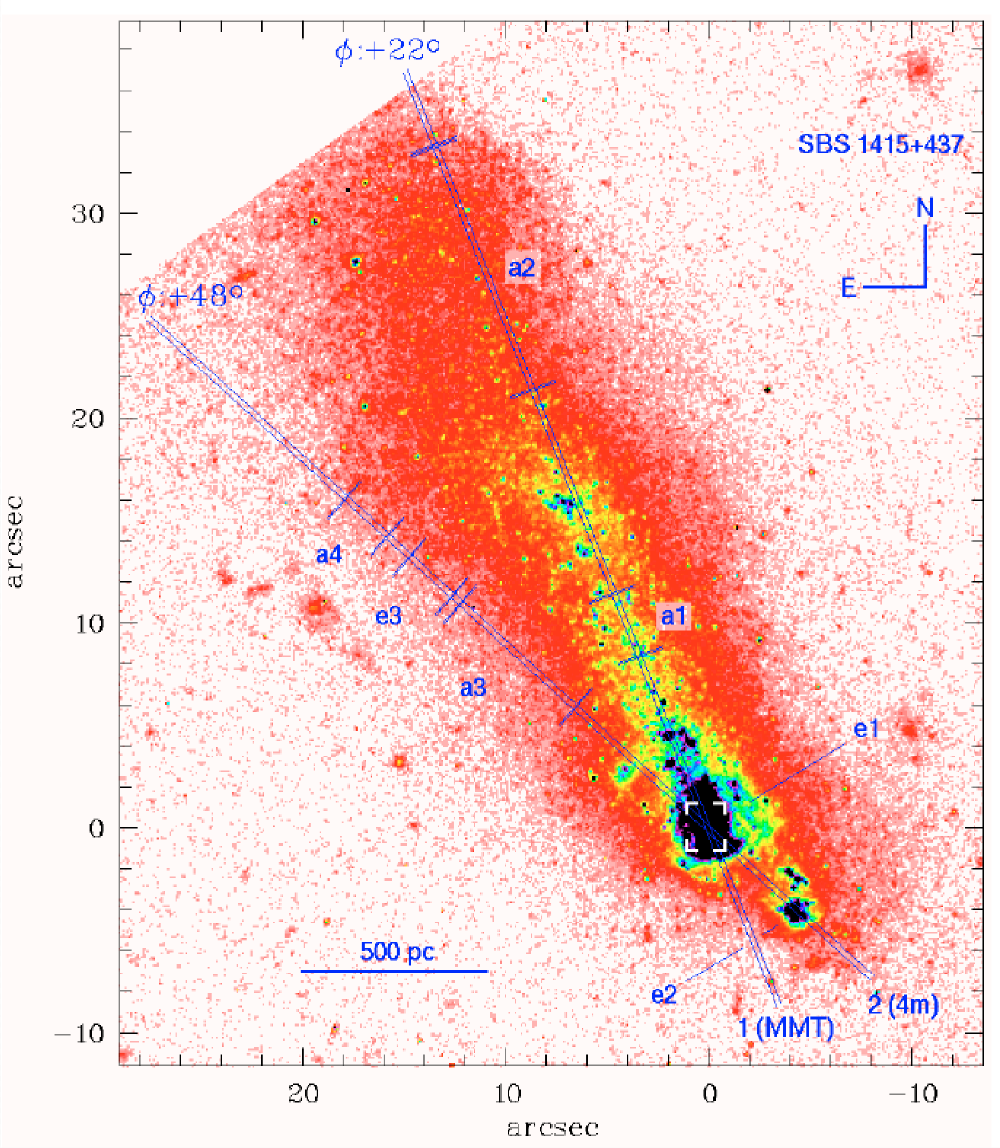
HST/WFPC2, V band



HST/WFPC2, I band, unsharp masked

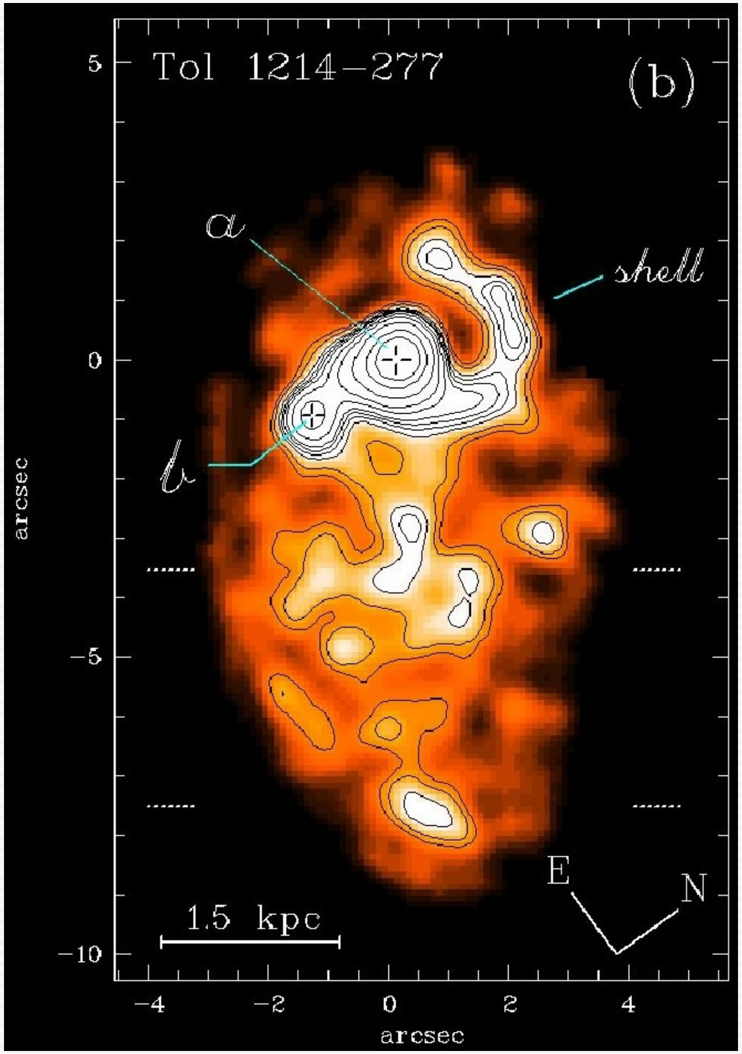
… other examples of cometary XBCDs, possibly forming through SF propagation

SBS 1415+437



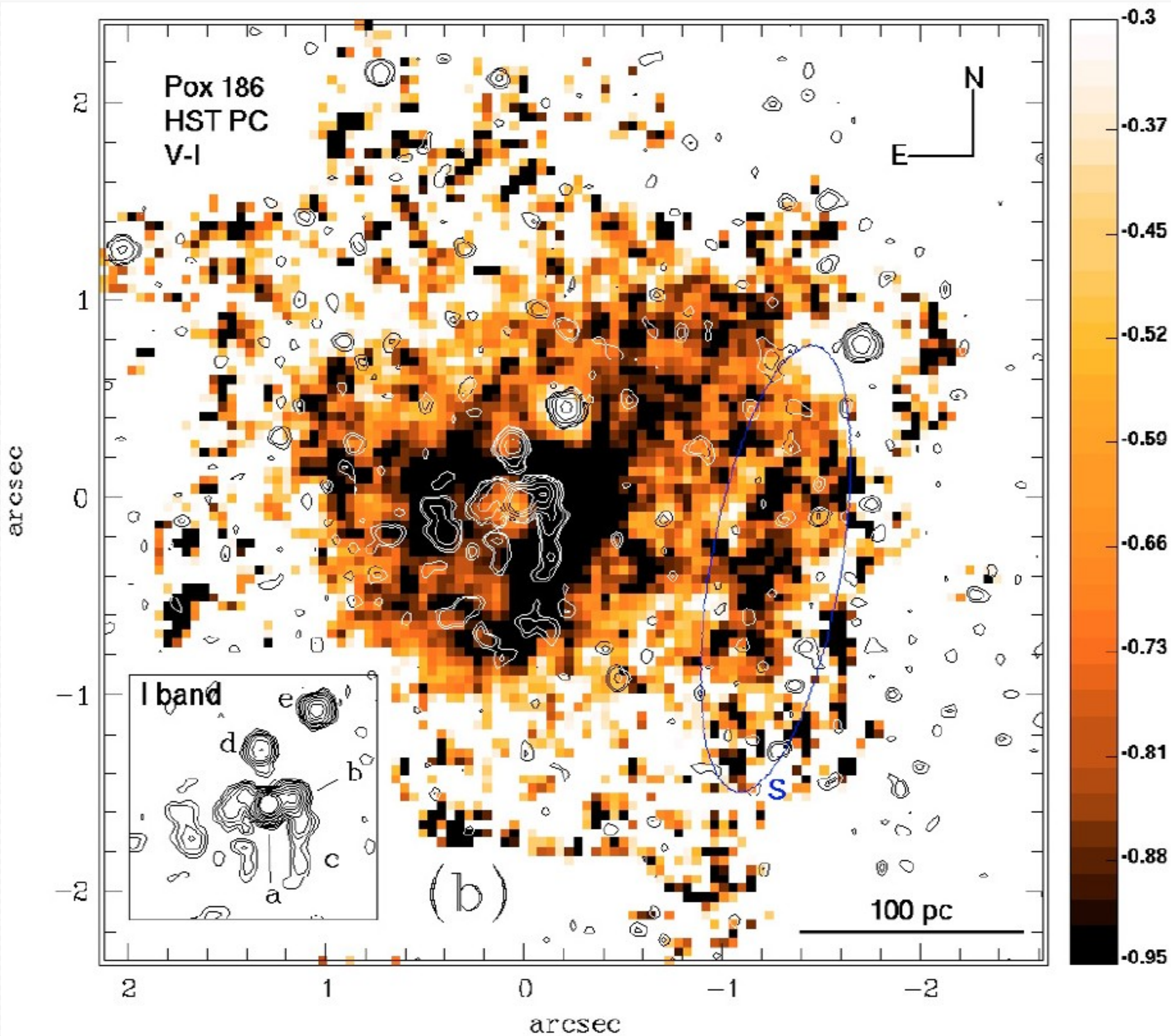
Guseva et al. (2003)

Tol 1214-277



Fricke et al. (2001)

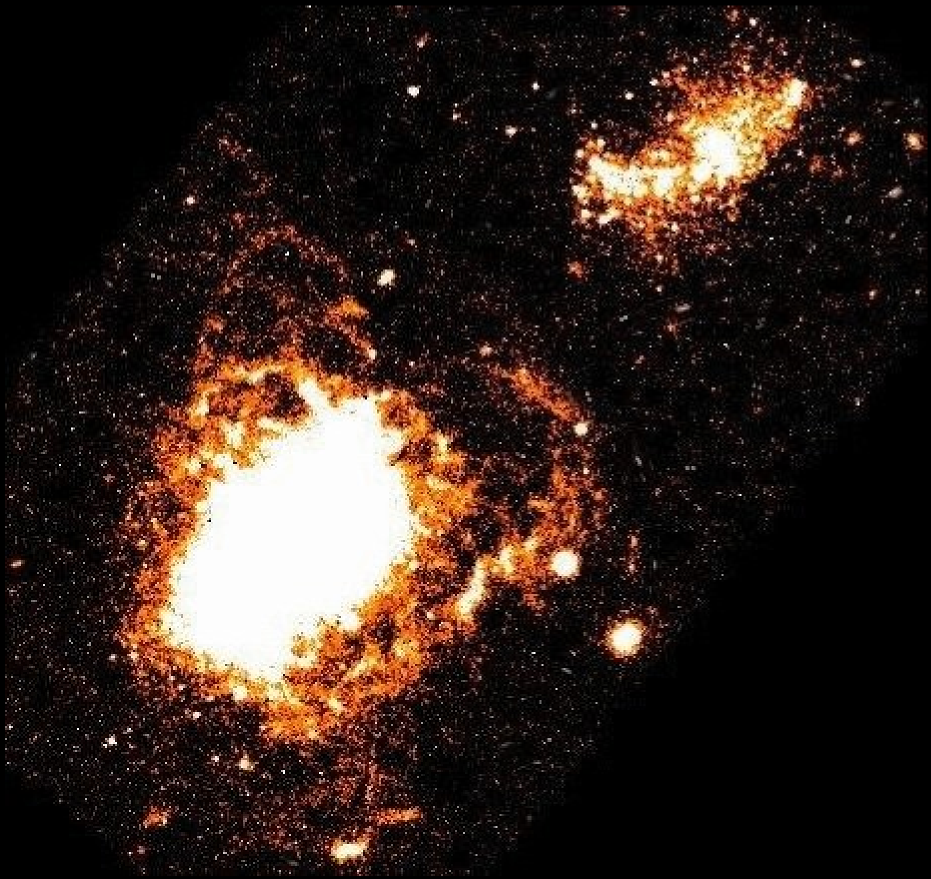
Ionized gas emission in XBCDs

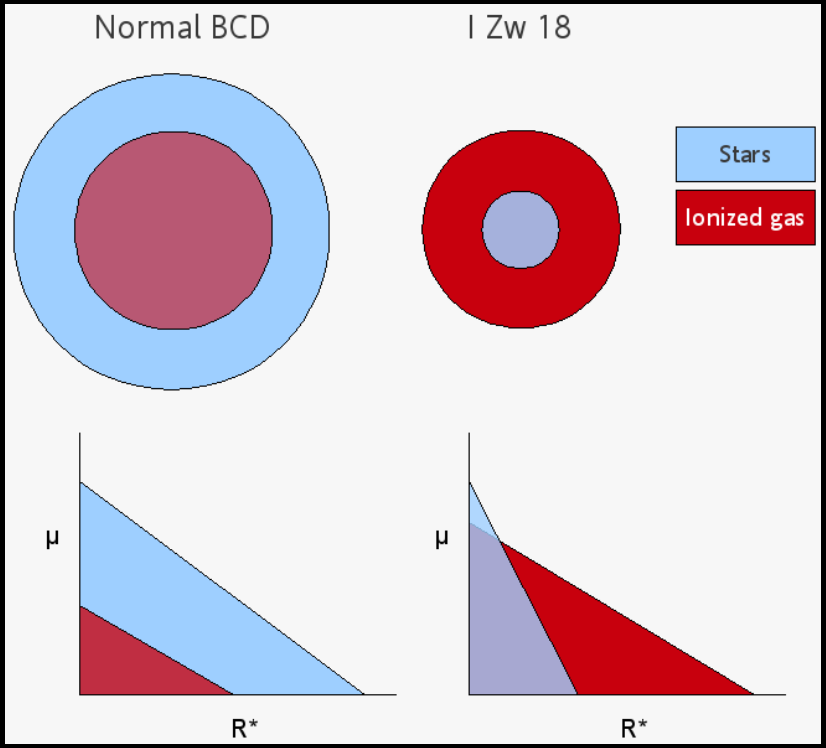


Guseva et al. (2004)

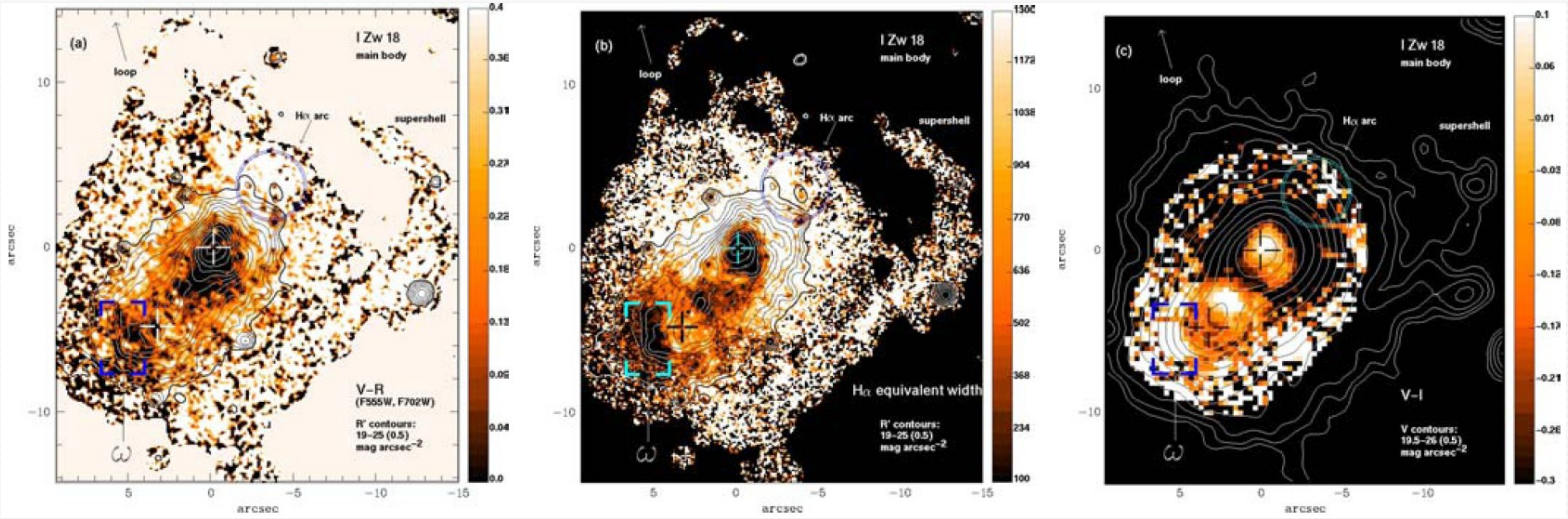
- Several XBCDs show intense nebular emission (EW > 1000 Å), 0.1-1 kpc away from their SF regions
- Typical signatures:
  very blue (-0.5 .. -1 mag) V-I and R-I and
  moderately red (0.4 … 0.6) B-R and V-R colors
- Corrections for ionized gas emission are necessary for age-dating of stellar populations using colors and/or color magnitude diagrams

I Zw 18: a dwarf galaxy surrounded by an extended ionized gas halo





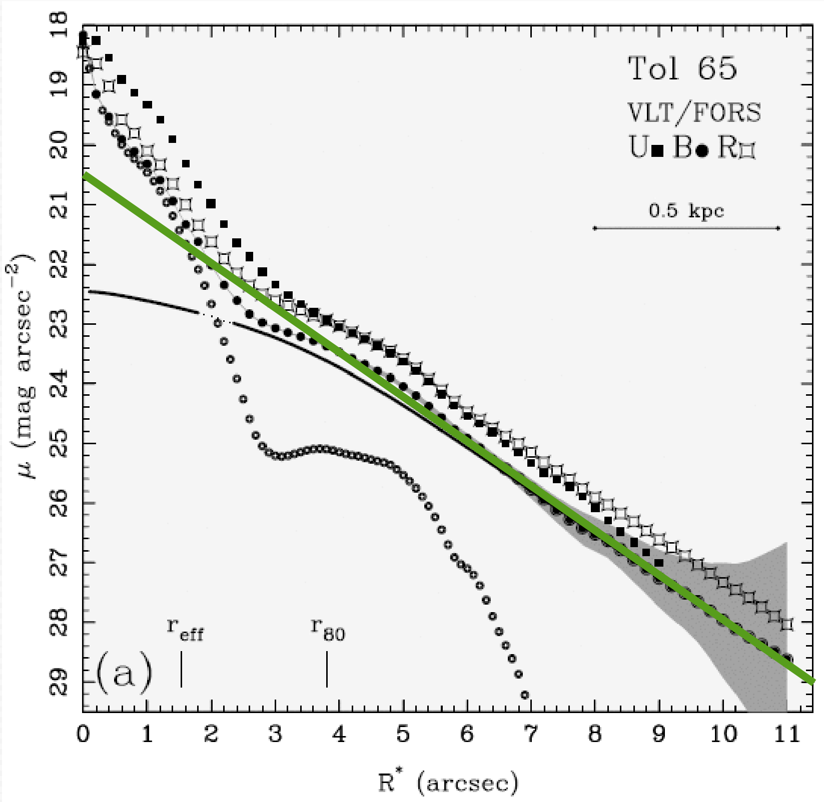
I Zw 18: a dwarf galaxy surrounded by an extended ionized gas halo

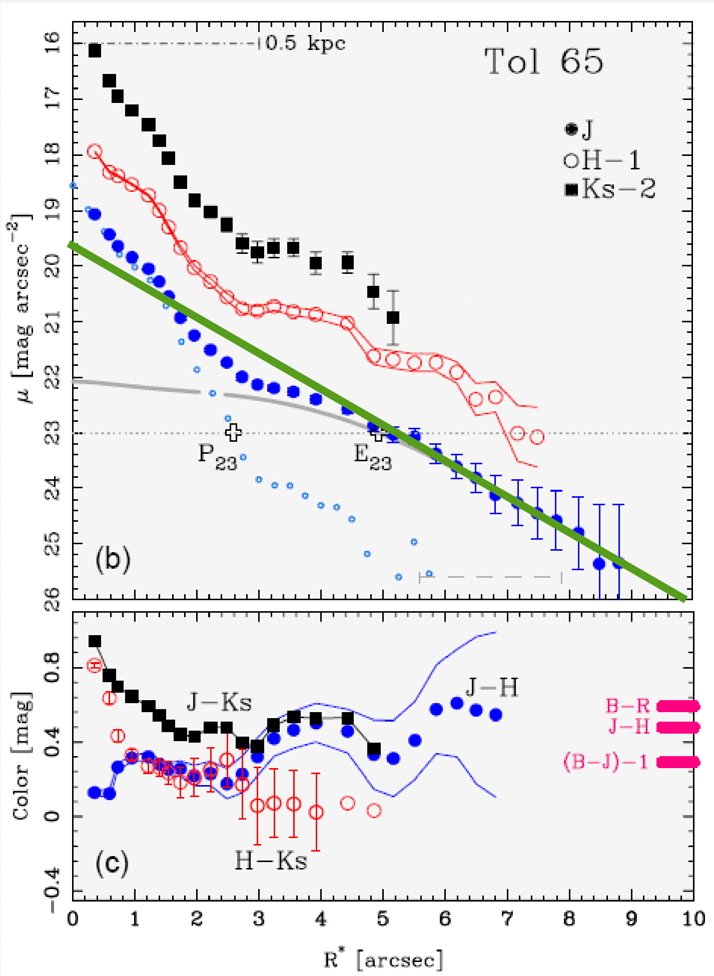


Papaderos et al. (2002)

XBCDs: Intensity distribution of the host galaxy in its **central** part ?

Papaderos et al. (1999)





Noeske et al. (2003)

$$I(R^*) \equiv I_{\rm exp} = I_0 \exp\left(-\frac{R^*}{\alpha}\right)$$

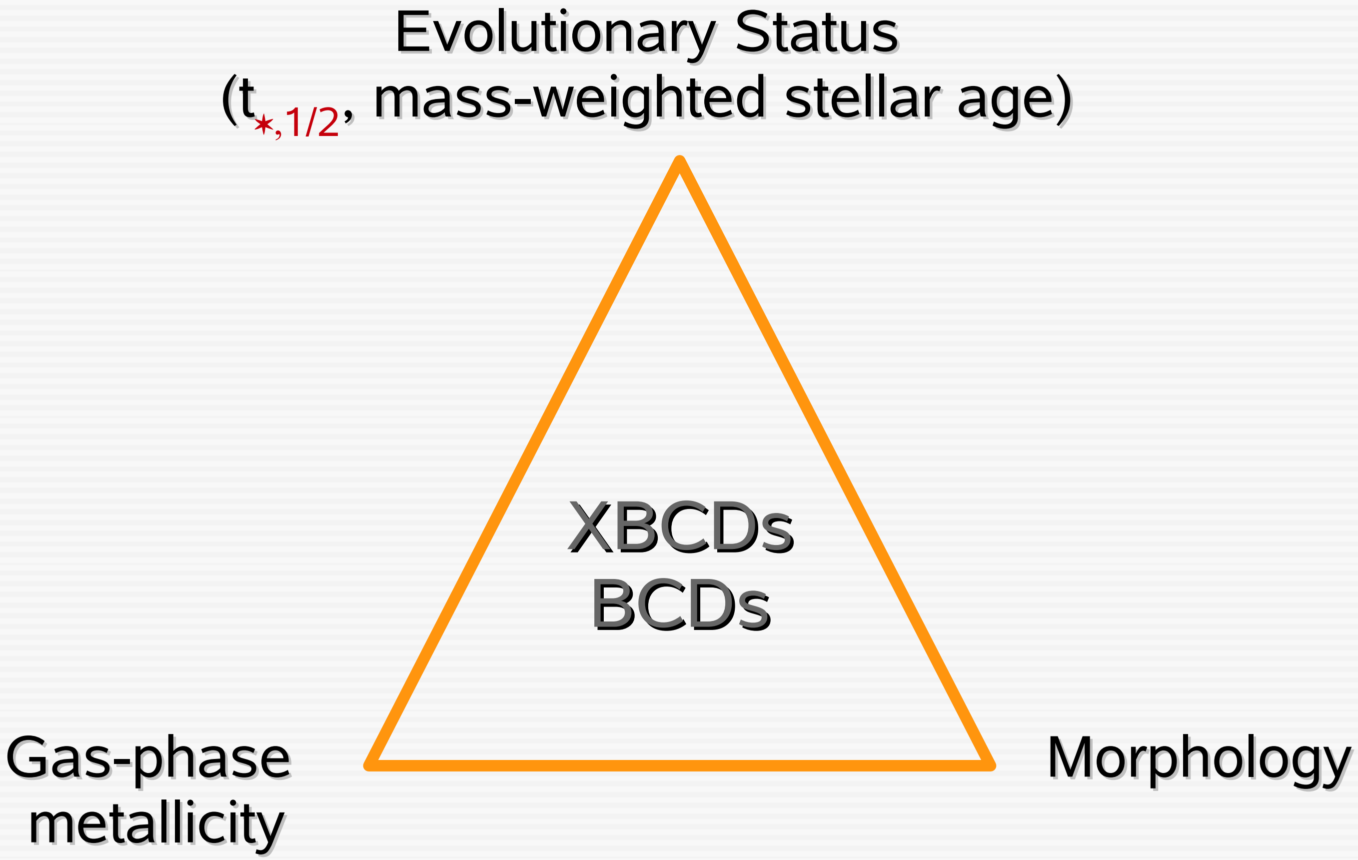
$$I(R^*) = I_{\rm exp} \cdot \left[1 - \epsilon_1 \exp(-P_3(R^*))\right]$$

with $P_3(\epsilon_1,\epsilon_2)$

ϵ_1: central depression $\Delta I/I_0$

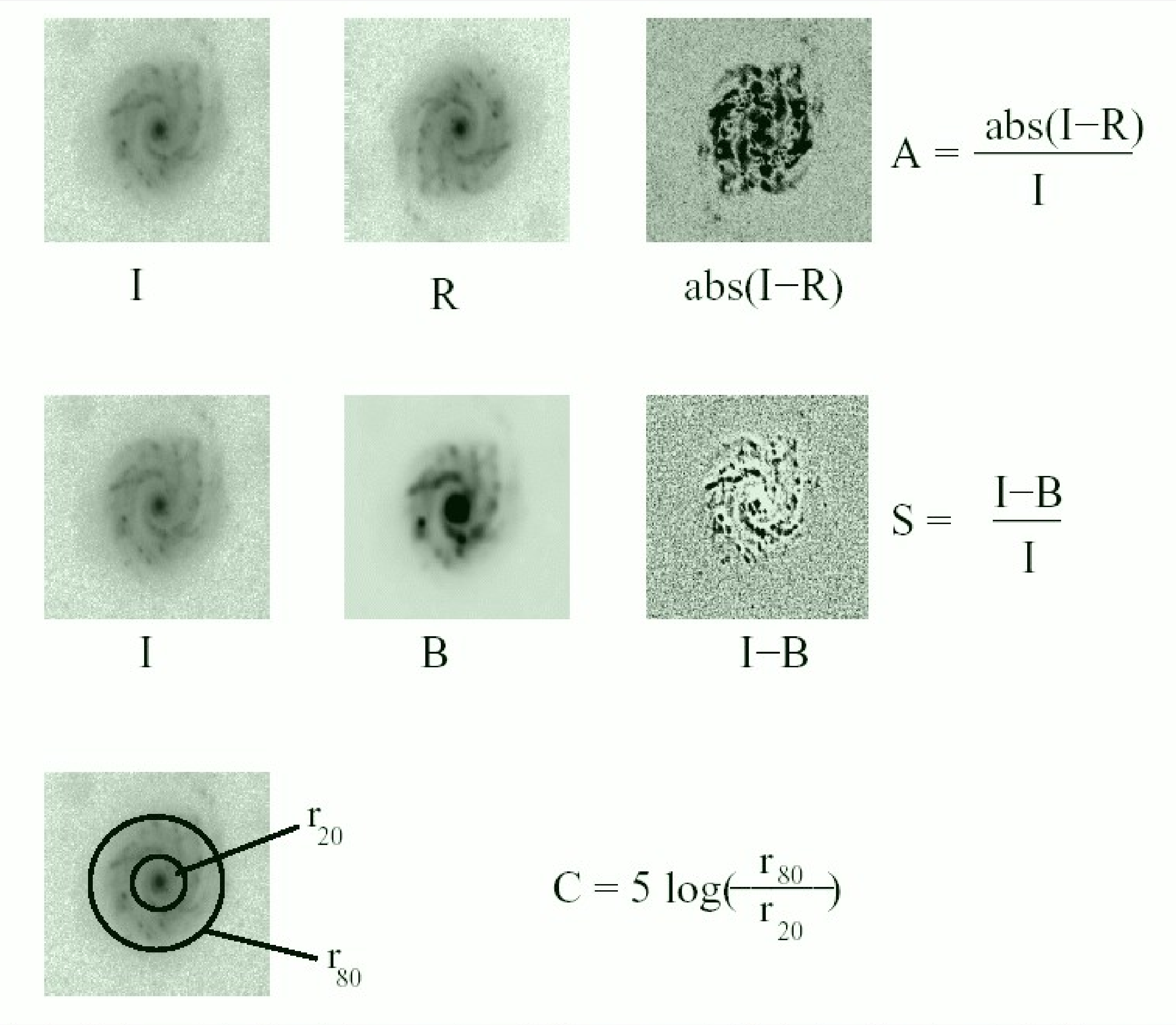
ϵ_2: core radius in α (exp. scale length)

modified exp. fitting law
(Papaderos et al. 1996)



+ mass & environment

Quantive galaxy morphology indicators for XBCDs (and other dwarf galaxies)

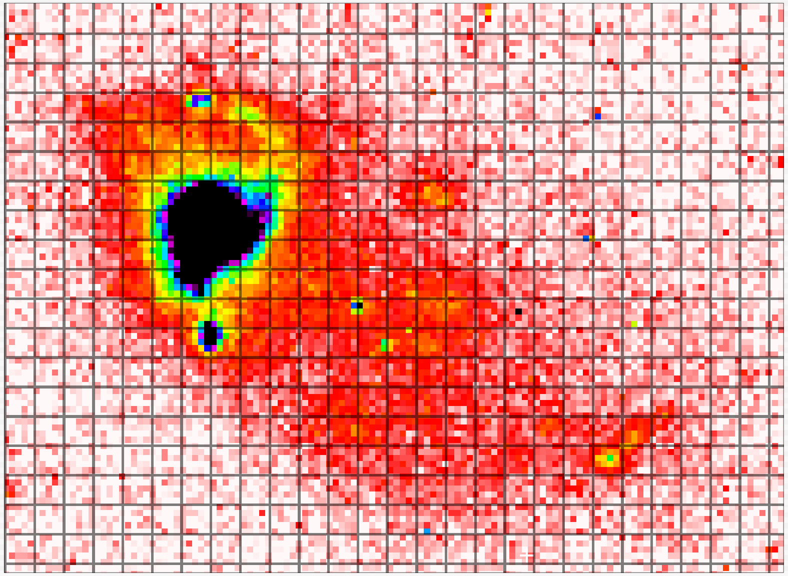


Abraham et al. (1996), Concelice (2003)

- Gini coefficient (Lotz et al. 2004), Sersic coefficient, … (?)
- Dependence of QGMIs on surface brightness limit

IFU spectroscopic studies of XBCDs

- only one XBCD has been studied with IFU spectroscopy (SBS 0335-052E, Izotov et al. 2006).
- IFU spectroscopy: **i)** the origin and locus of the hard ionizing field, **ii)** chemical abundance patterns (incl. N/O), **iii)** the properties and spatial distribution of WR stellar populations in low-metallicity SF environments, **iv)** ionized gas kinematics.
- 2D modelling & subtraction of ionized gas emission in order to study the underlying stellar component



- and permit spatially resolved studies of the star formation history, thus the formation process of XBCDs (*star-formation propagation, diffusion of newly former stars, inside-out formation*). For R>15000 also stellar kinematics (at least in their central part).

Summary

- The number of XBCDs ($7.0 \leq 12+\log(O/H) \leq 7.6$) has dramatically increased in the last decade (~60 XBCDs currently known). Very few XBCDs have been studied in detail so far.

- All XBCDs studied have a stellar host galaxy, i.e. none of these systems forms its first stellar generation.

- However, XBCDs are cosmologically young ($M_{\star,\mathrm{old}}/M_{\star,\mathrm{0.5\text{-}4\ Gyr}} \leqslant ½$).
$\rightarrow$ Studies of XBCDs may yield important insights into the main processes driving dwarf galaxy formation.

- IFU spectroscopic studies will permit a major step forward in our understanding of XBCD/BCD evolution.