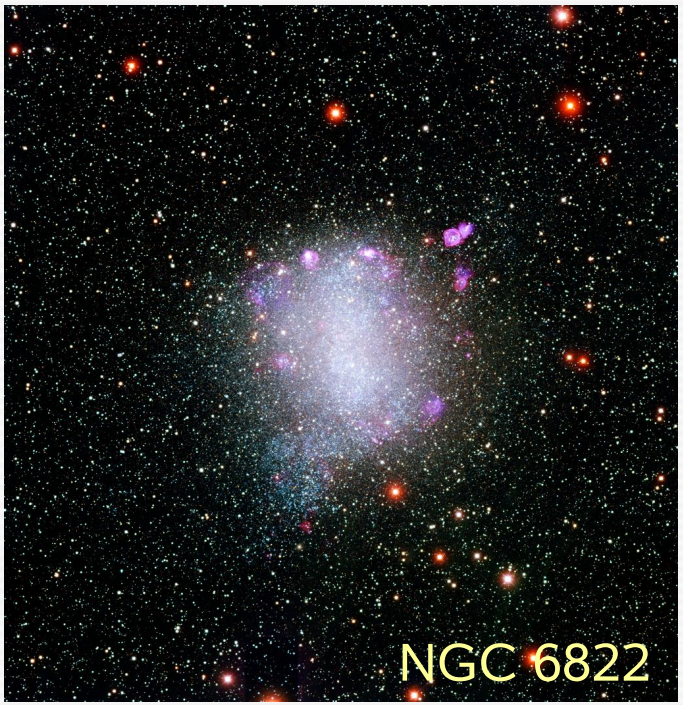
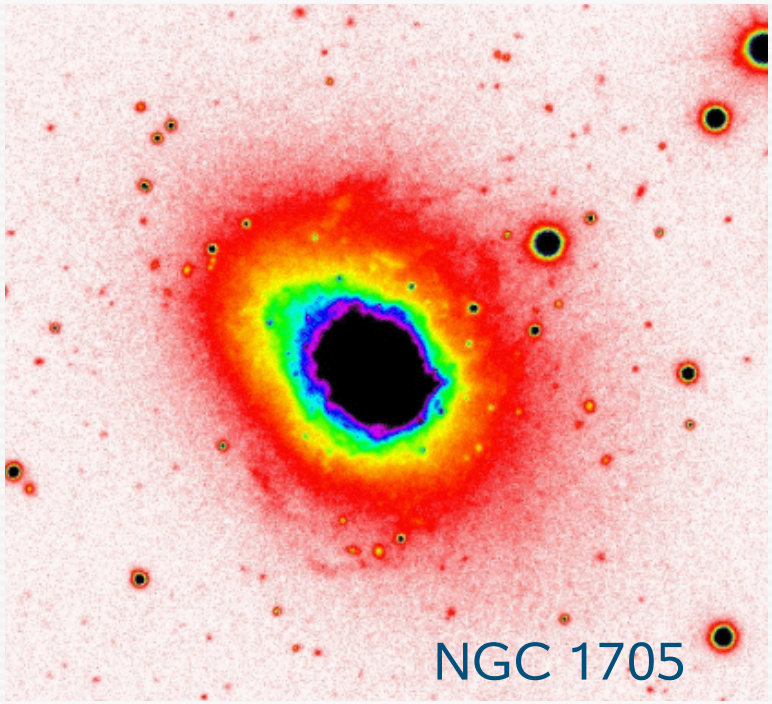
New Insights into Dwarf Galaxy Evolution with LOFAR

P. Papaderos

Star-forming dwarf galaxies in the local Universe



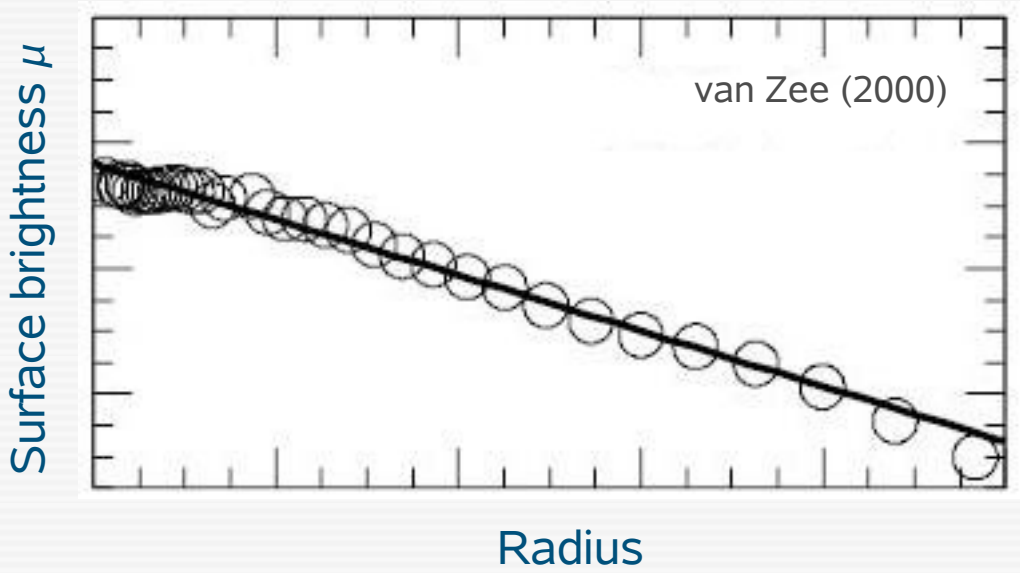
dwarf irregular (dI)



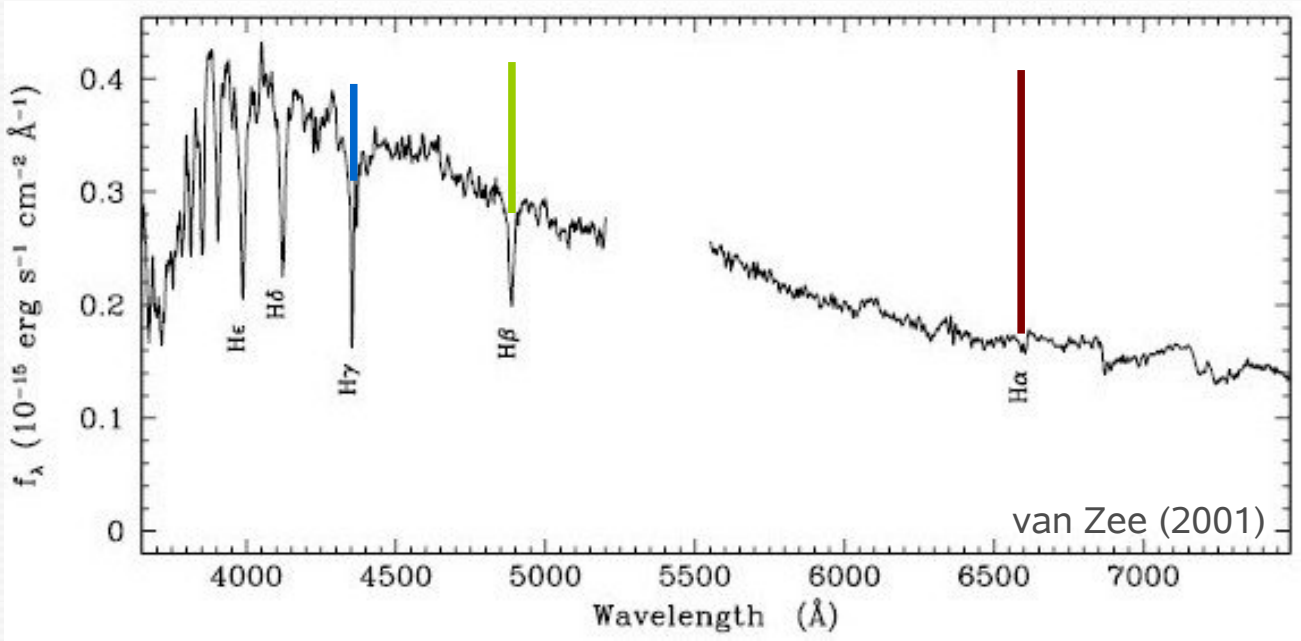
Blue Compact Dwarf (BCD)

- Low mass and luminosity ($10^7 \leq L/L_\odot \leq 10^9$, $M_T \sim 10^8$ ... a few 10^9 $M_\odot$)
- Holmberg radius: 1-6 kpc
- gas-rich: $M_{gas}/M_T(R_{Ho}) = 0.3\text{-}0.8$
- subsolar metallicity; distribution peaking at $12+\log(O/H)=7.9$
- evolved (a few Gyr old) low-surface brightness (LSB) host galaxy in most dIs and BCDs

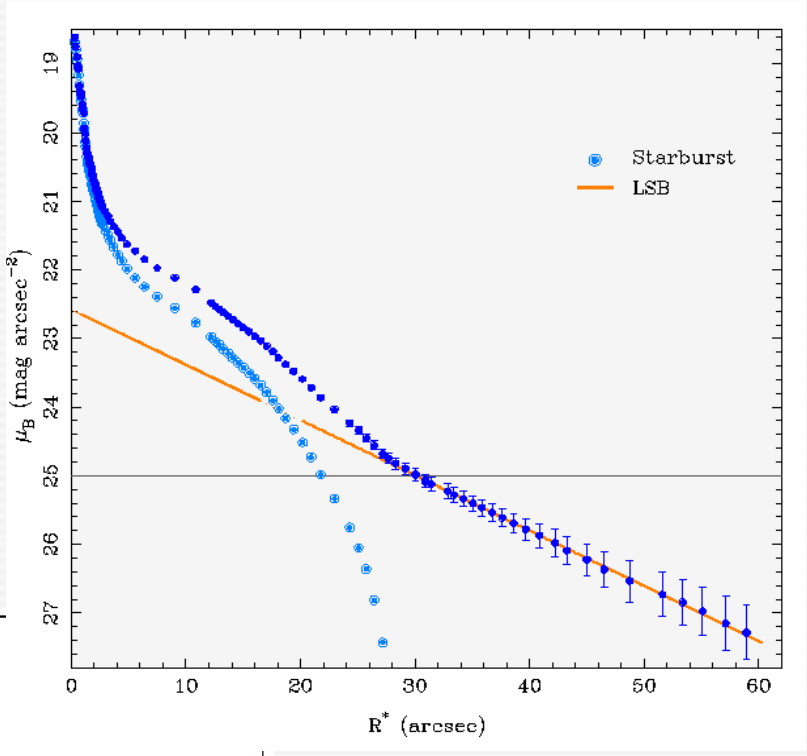
Star-forming dwarf galaxies in the local Universe: **dIs**

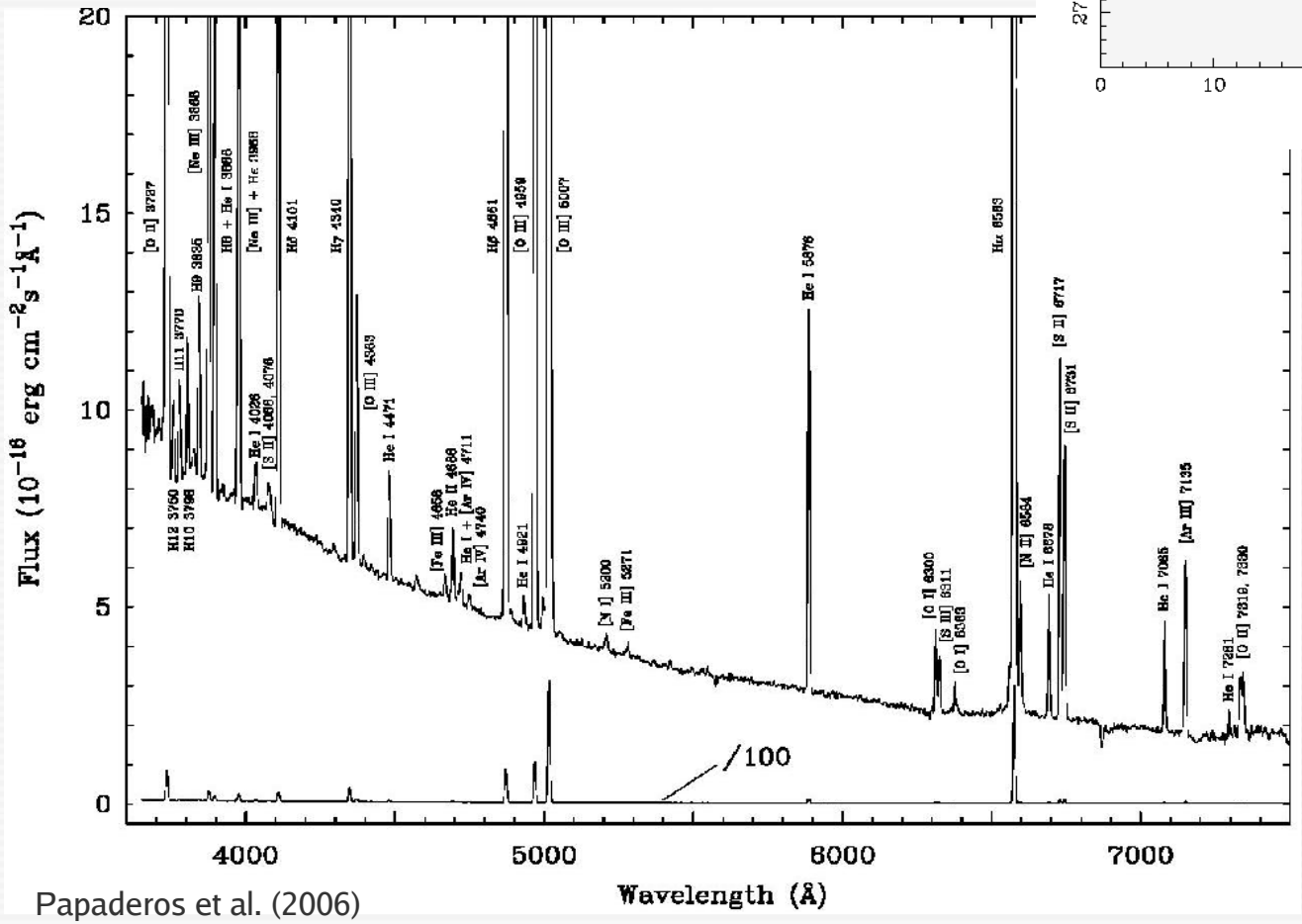


- exponential surface brightness profiles with $\mu_0 \sim 23$ mag arcsec^{-2}
- weak emission lines ontop a rel. blue stellar continuum with broad Balmer absorption lines



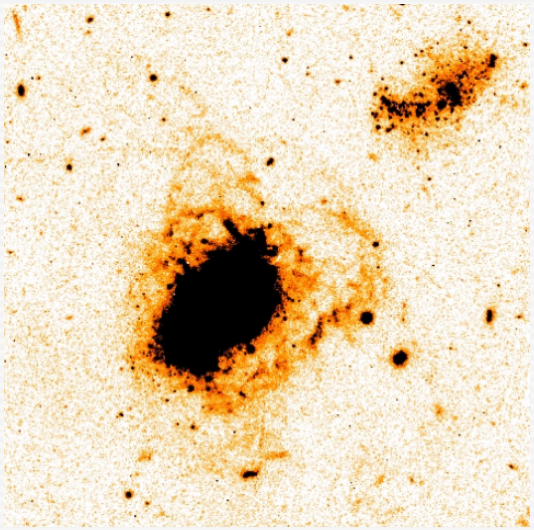
Star-forming dwarf galaxies in the local Universe: **BCDs**



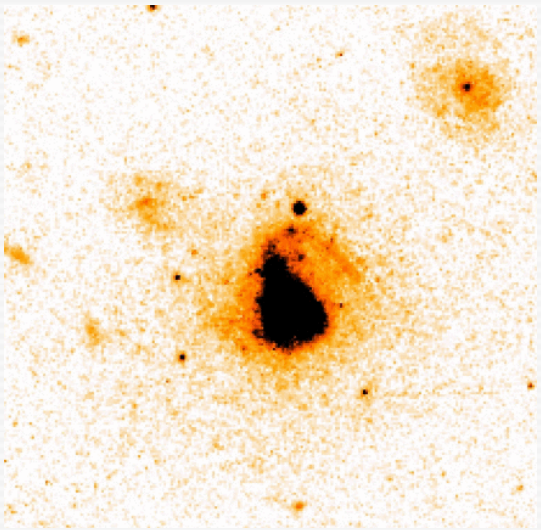


Papaderos et al. (2006)

BCDs are in their vast majority (>95%) old gas-rich dwarfs; young galaxy candidates are extremely rare (~1%)

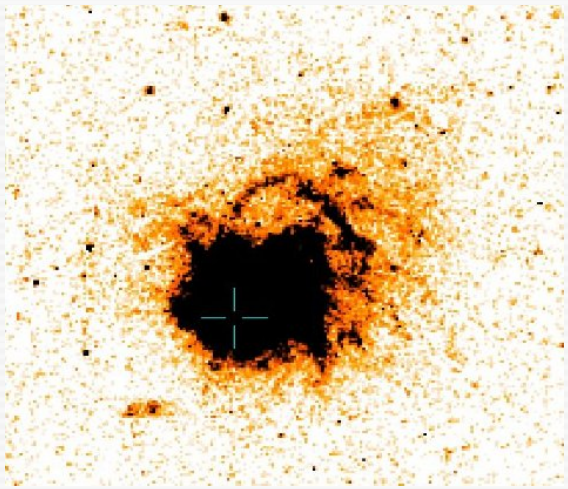


Papaderos et al. (2002)

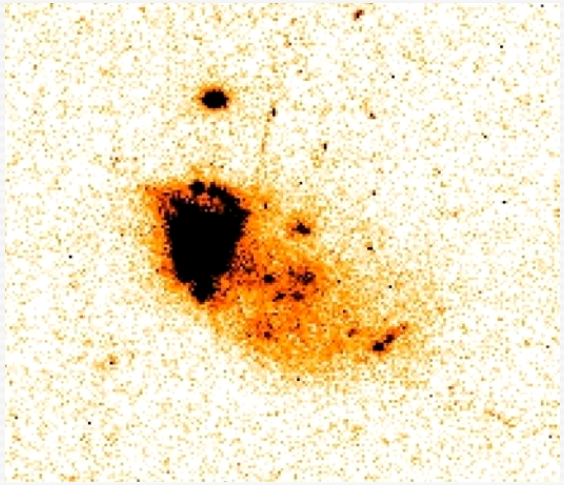


Guseva, Papaderos, Izotov et al. (2004)

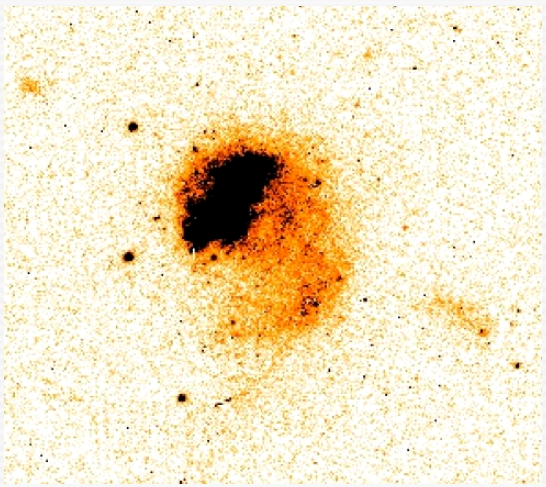
- no evidence for an old host galaxy
- irregular morphology and intense star-forming activity
- extremely metal-deficient ($Z_\odot/60 \leq Z \leq Z_\odot/15$)
- extremely rare (<1% of the BCD-population; until recently only ~15 such systems known)



Thuan et al. (1997),
Papaderos et al. (1998)

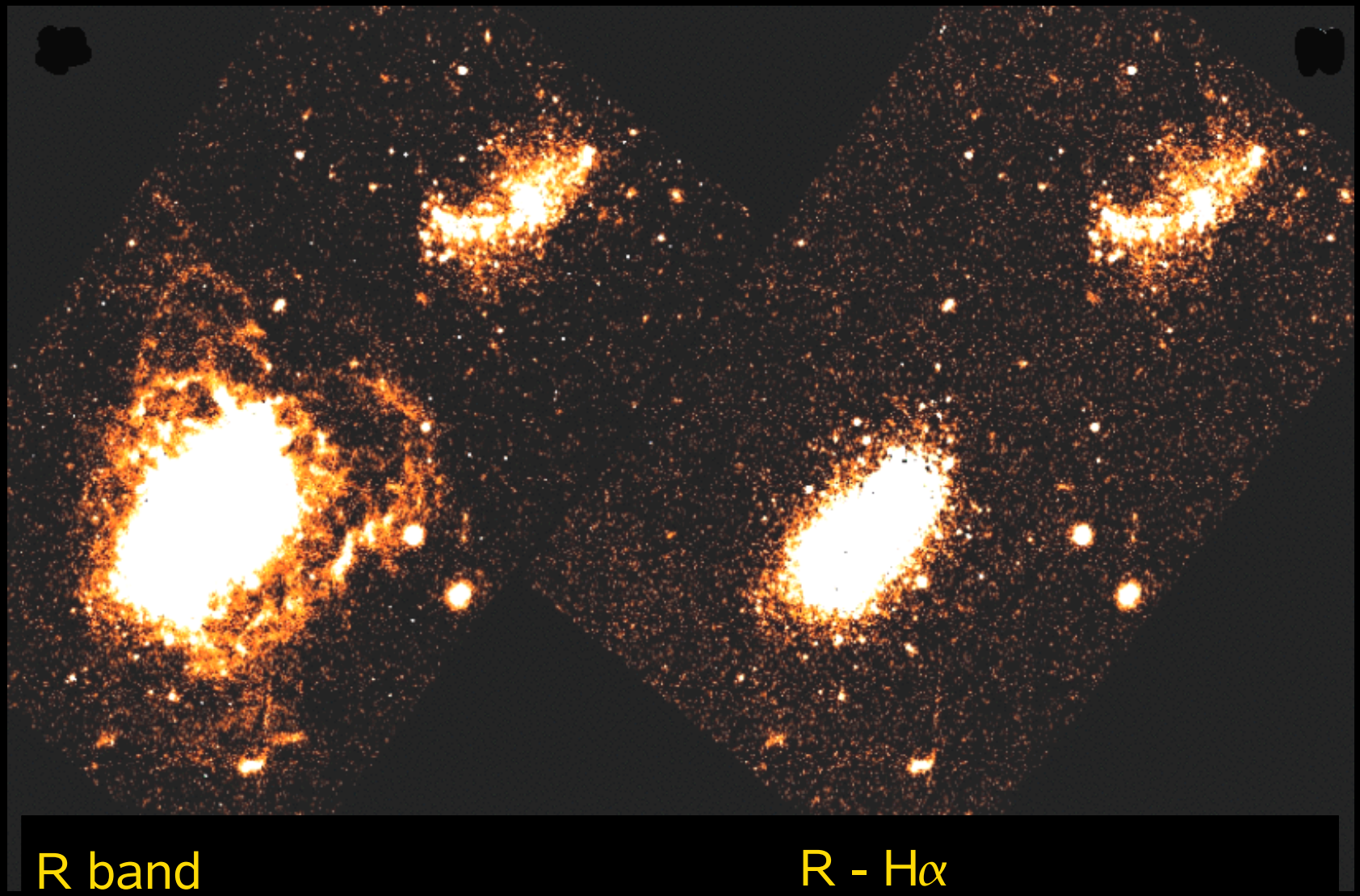


Fricke, Izotov & Papaderos (2001)
Papaderos et al. (2006)



Papaderos et al. (1999,2007)

I Zw 18: a dwarf galaxy forming within an extended ionized gas envelope



Papaderos et al. (2001,2002)

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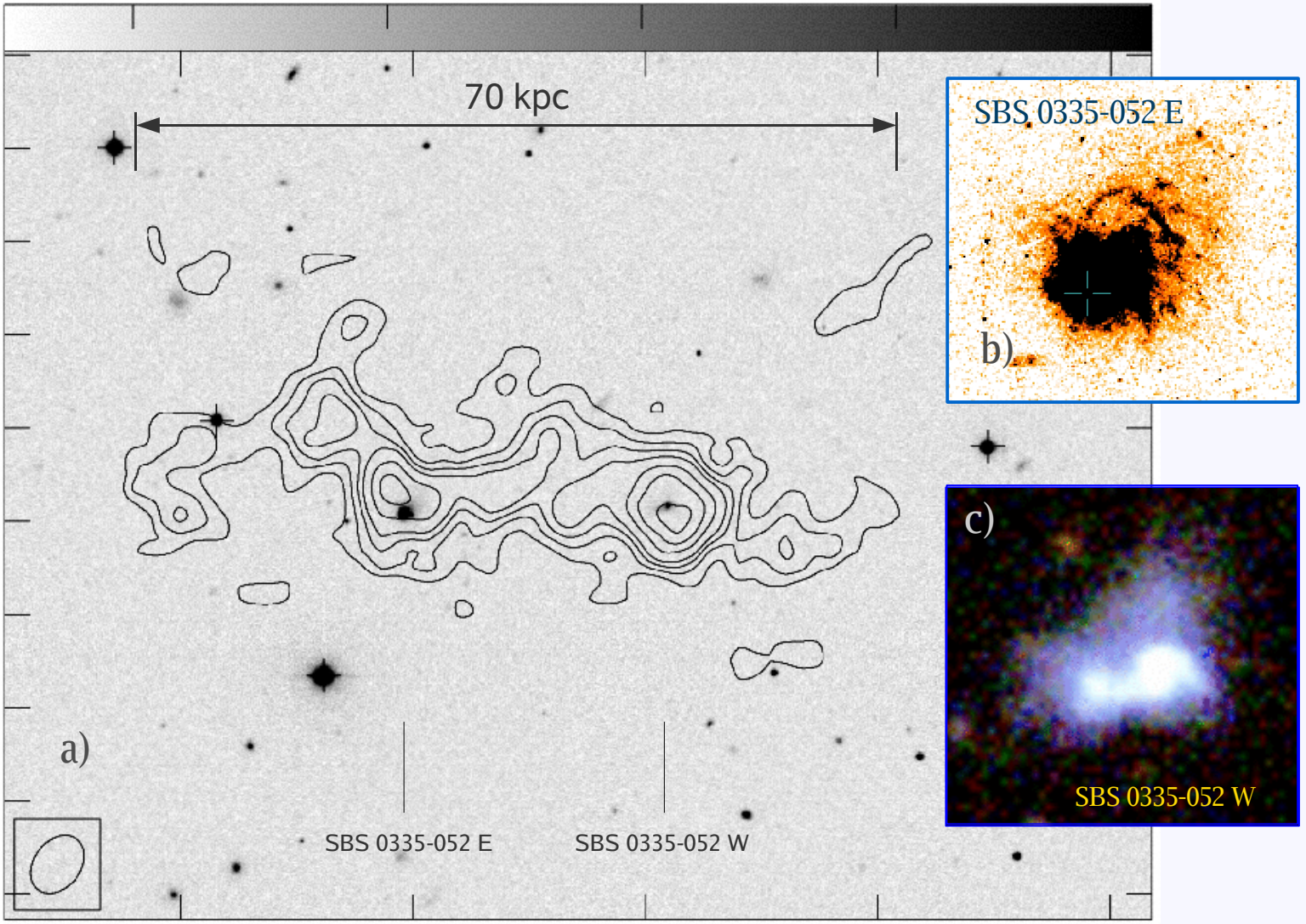
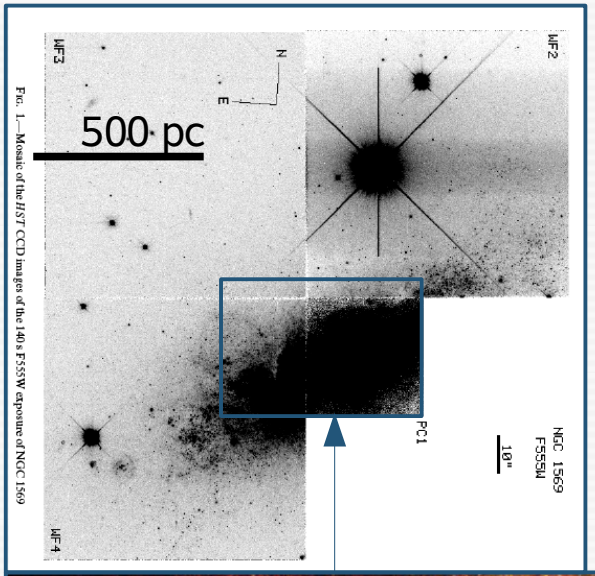


SBS 0335-052: HI cloud with a projected size of 70×20 kpc and a mass of ~10^9 $M_\odot$ (Pustilnik et al. 2001)

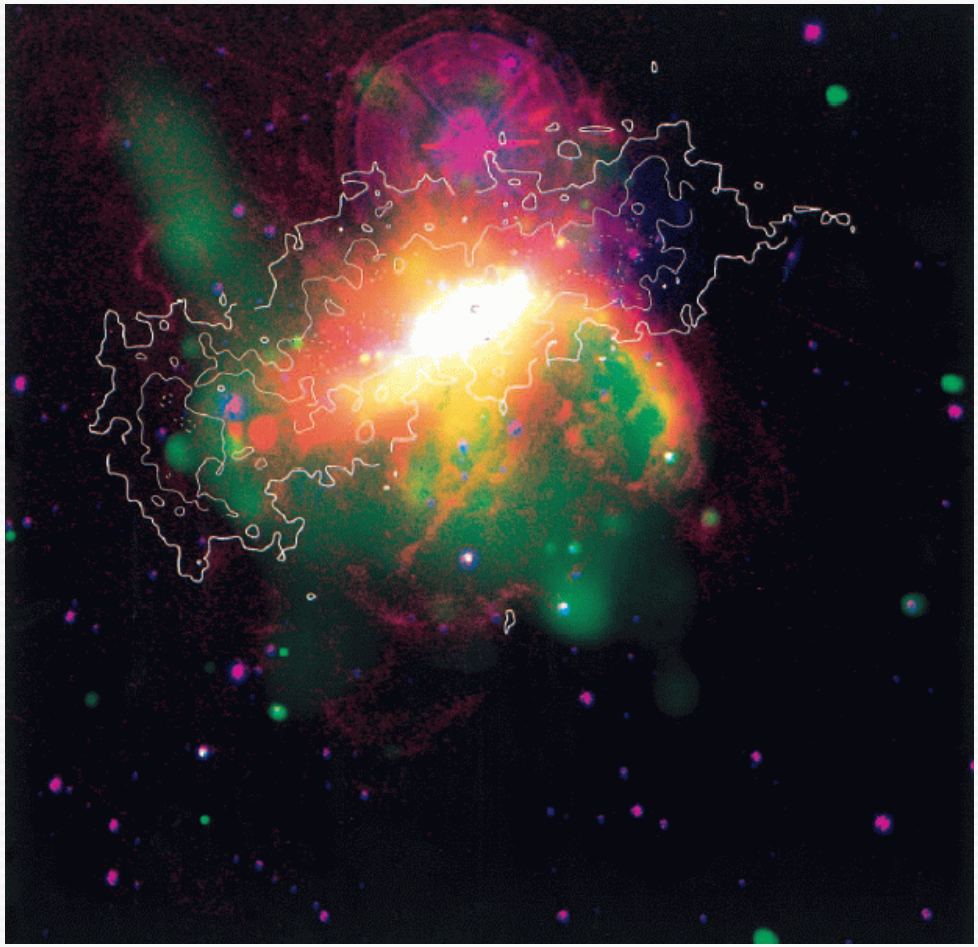
BCDs: starburst-driven mass ejection into halo

NGC 1569



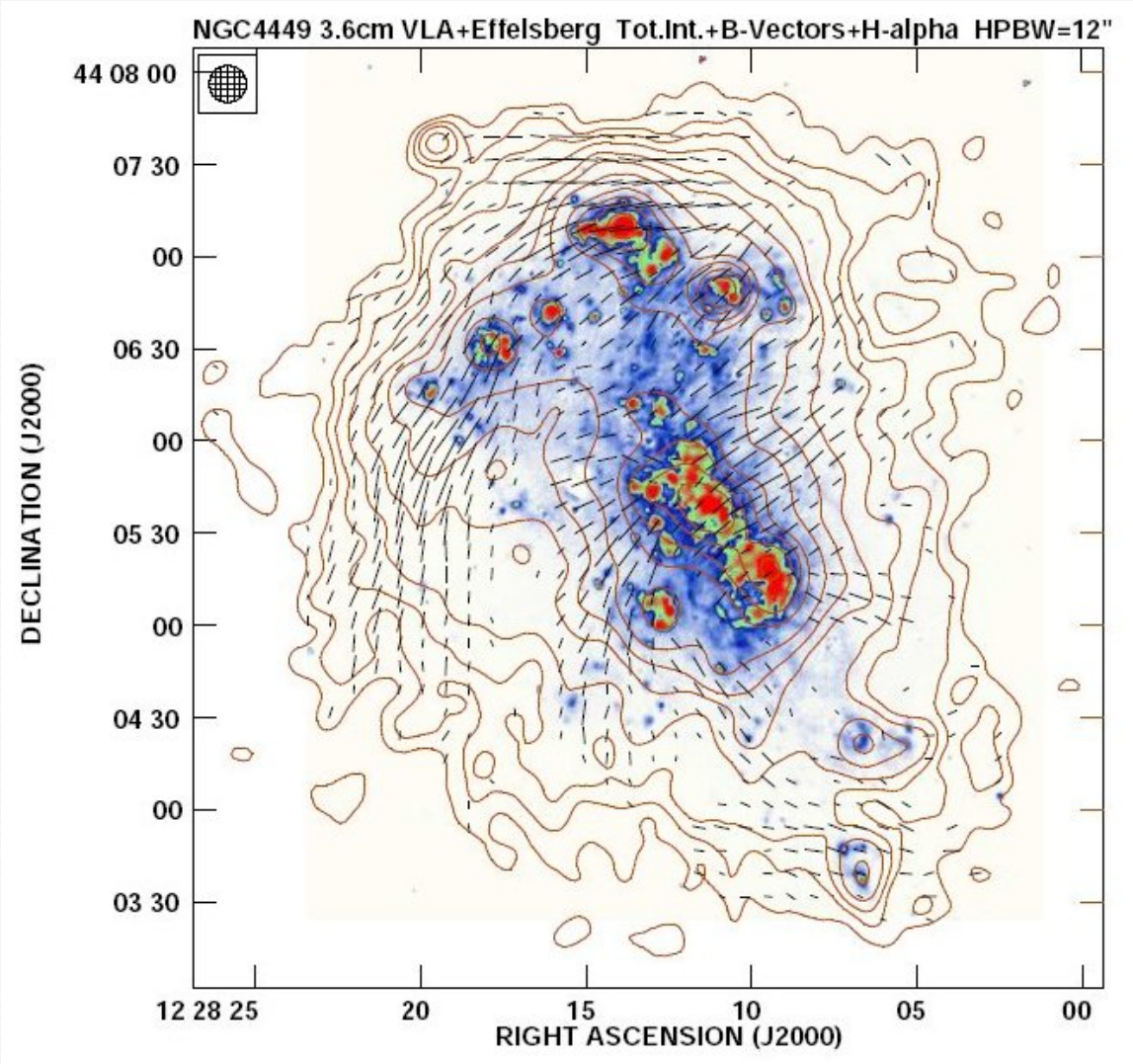
Hunter et al. (2000)

Martin et al. (2001)



HI Hα X-ray

Radio continuum observations and magnetic fields in the halos of dIs/BCDs

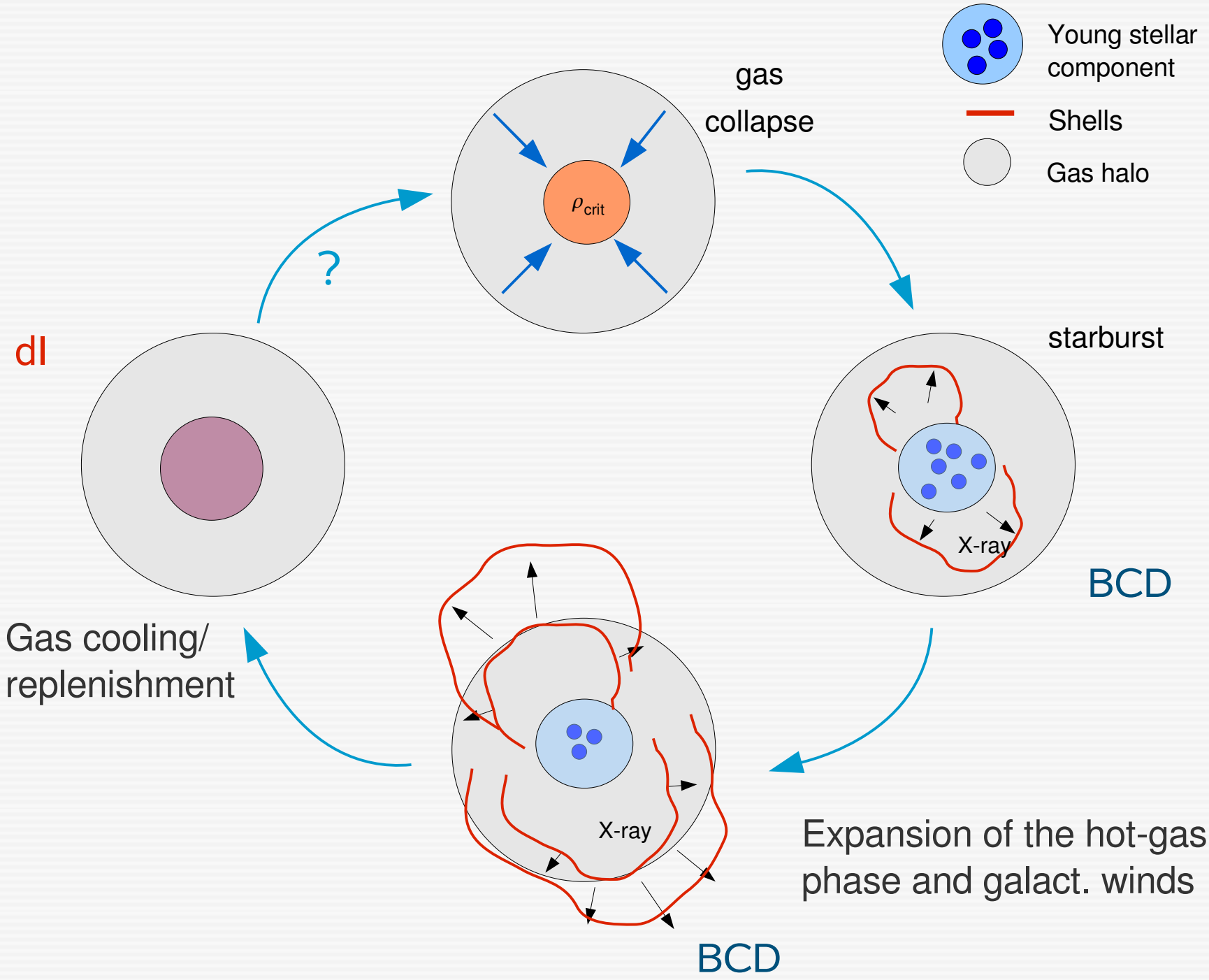


Chyzy et al. (2000)

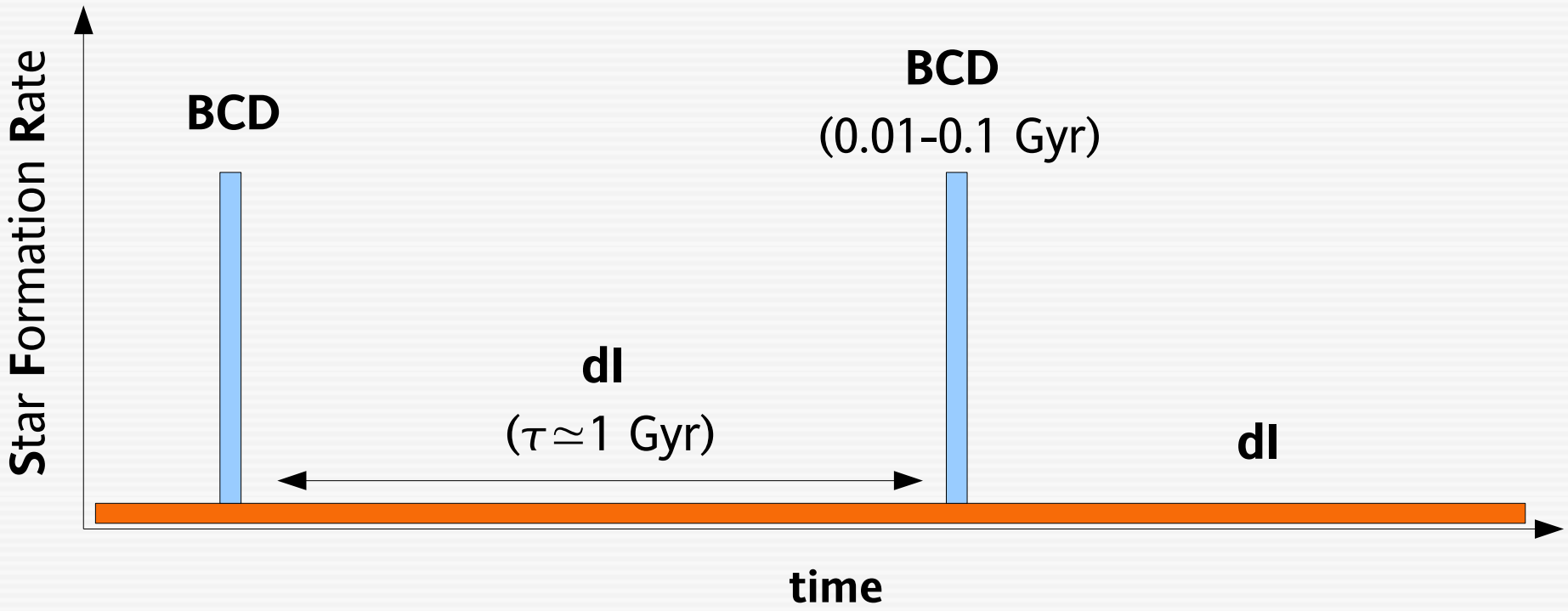
Why are we interested in dwarf galaxies?

- most numerous systems in the Universe
- building blocks of normal galaxies
- Origin and implications of starburst activity in low-mass galaxies ?
- Star formation and feedback processes under chemical conditions similar to those in young galaxies in the early Universe ?
- Evolutionary connections between dIs and BCDs ?

Chronology of a starburst in a dI/BCD



The "standard" dI↔BCD evolutionary scenario

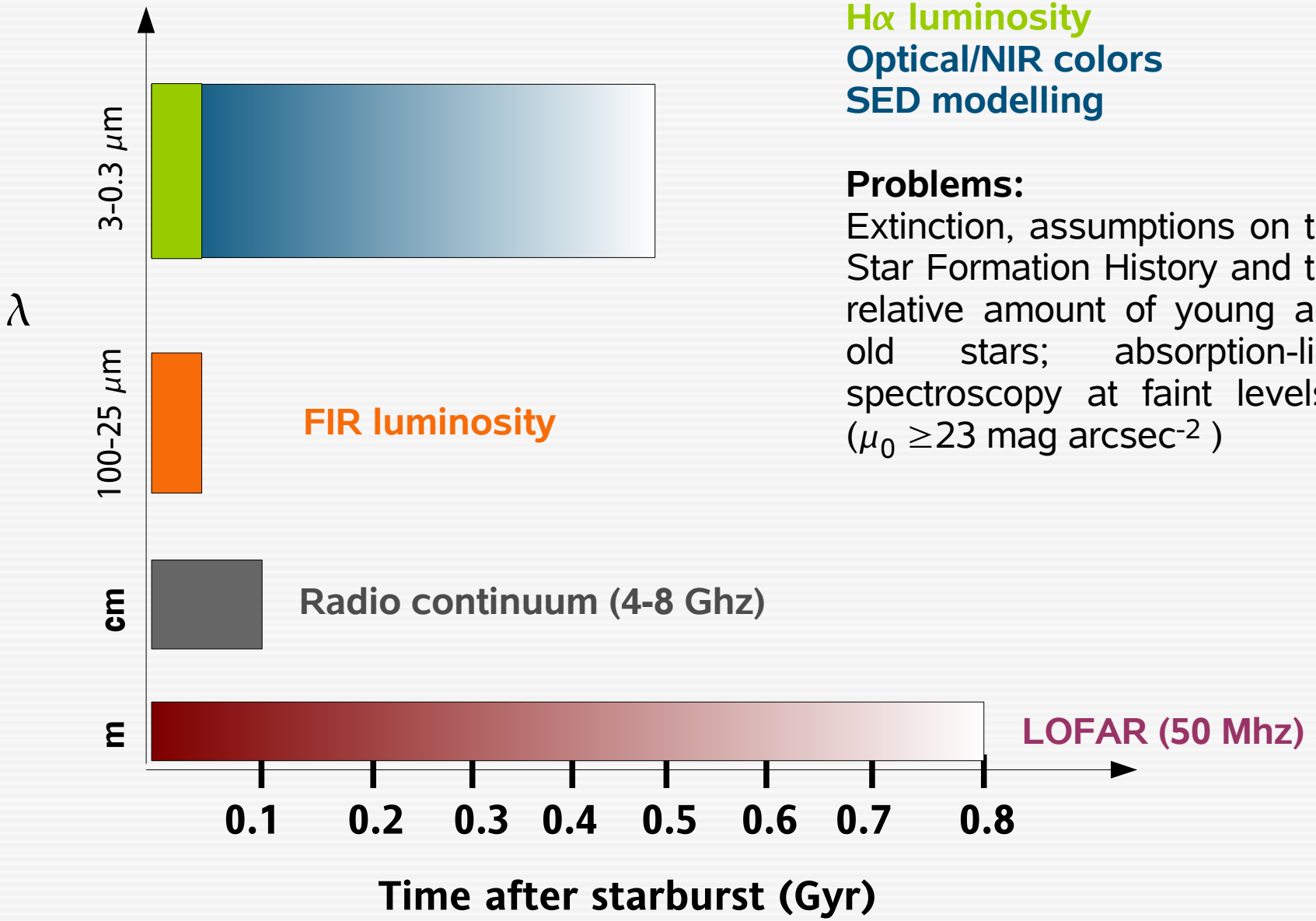


Prediction: BCDs spend more than 90% of their lifetimes in a dormant (dI) phase

→ **N(dIs)/N(BCDs) ~ 10**

Problem: identification of this large population of post-BCD systems

Searching for post-BCDs with LOFAR



Hα luminosity
Optical/NIR colors
SED modelling

Problems:
Extinction, assumptions on the Star Formation History and the relative amount of young and old stars; absorption-line spectroscopy at faint levels ($\mu_0 \geq 23$ mag arcsec^{-2})

LOFAR:
an efficient tool to search for post-starburst galaxies

$$t_{syn} = 1.1 \times 10^9 \text{ yr} \cdot (\nu \text{ / Ghz})^{-0.5} \cdot (B/\mu G)^{-1.5}$$

Lifetime of electrons t_{syn} observed at cm wavelengths is $\sim 10^8$ yr.

At meter wavelengths t_{syn} is $\times$ 5 ... 10 times longer

↓

Radio emission at LOFAR wavelengths memorizes starburst activity (the BCD phase) several 10^8 yr after the termination of the burst

Def. cm/m flux ratio

$$\psi = f_{cm}/f_{m}$$

Case I. post-starburst phase with $0.1 \leq t \leq \tau$ (1 Gyr)

$$\psi \simeq 0$$

Case II. continuous star formation over $t \geq 0.1$ ... several Gyr

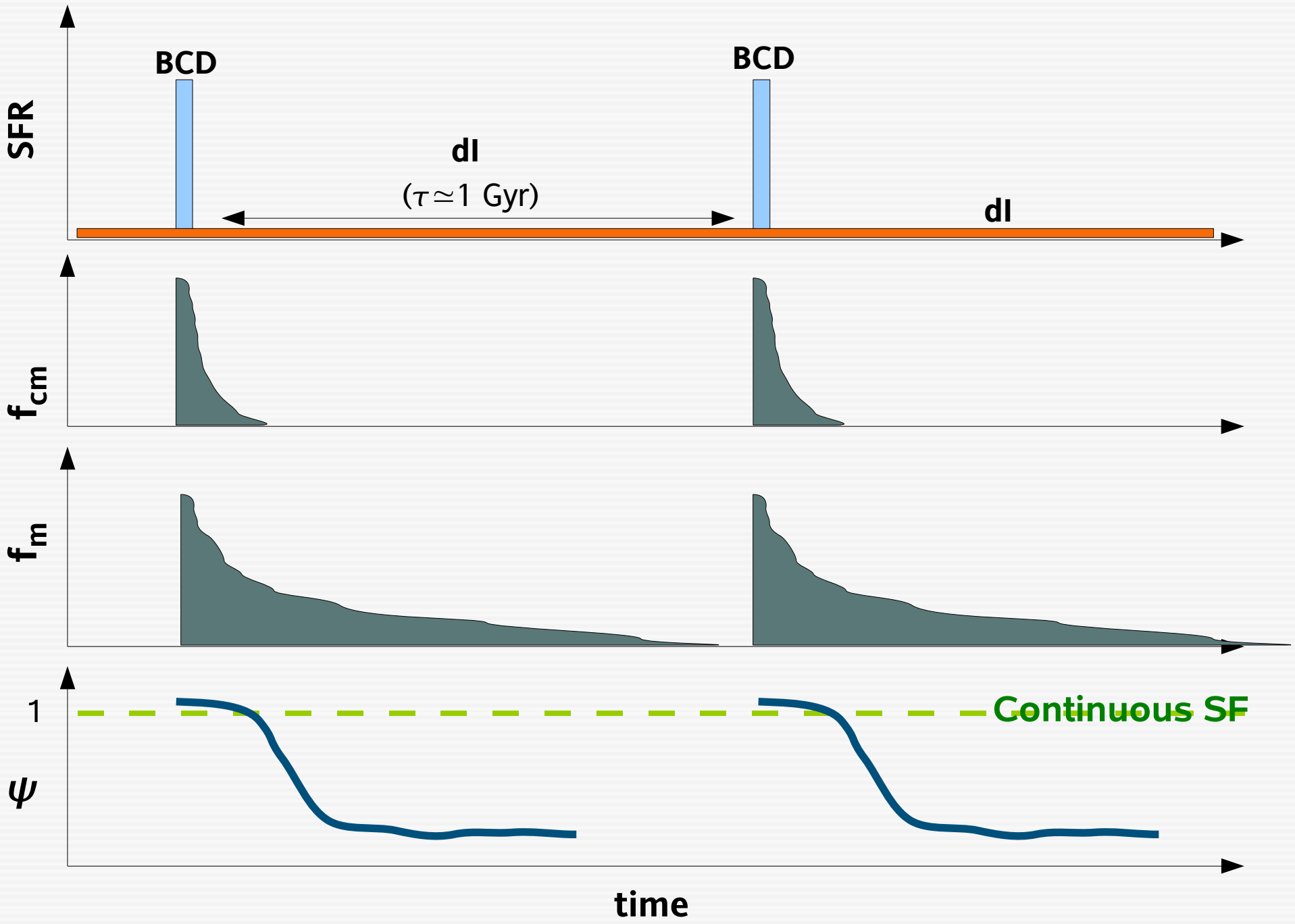
$$\psi \simeq 1$$

If the "standard" dI↔BCD evolutionary scenario is correct then ∃ large population (surface density: 100 deg^{-2}) of nearby ($z<0.2$) dI systems with $\psi \simeq 0$

Summary

LOFAR radio observations at m wavelengths

- will allow us to study the low-frequency halos of star-forming galaxies, illuminated by relativistic particles ejected from starburst regions: a new window to study the nature of low-mass galaxies and the starburst-halo interaction
- will provide a new powerful tool for identifying post-starburst (post-BCD) galaxies, selected by their extended low-frequency radio halos in conjunction with their weak (if any) radio emission at cm wavelengths
- A systematic search for dwarf galaxies with $\psi = f_{cm}/f_m \simeq 0$ will allow us to test whether or not the "standard" dI↔BCD evolutionary scenario for dwarf galaxies is tenable


SFR
BCD
BCD
dI
(τ≃1 Gyr)
dI
f_cm
f_m
1
ψ
Continuous SF
time