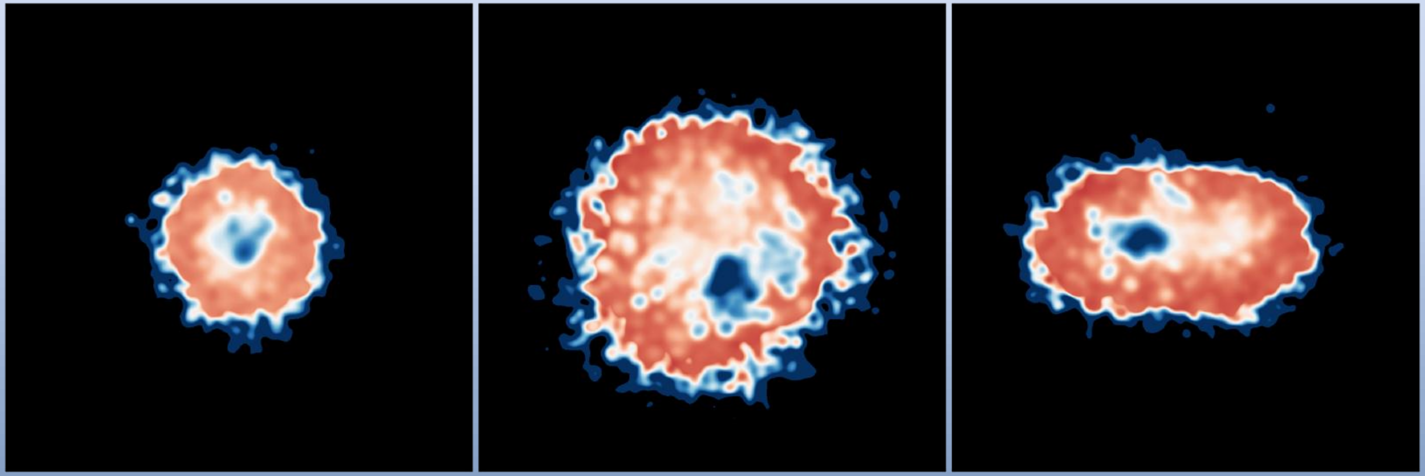
Starbursts in simulated dwarf galaxies triggered by gaseous infall

$B - I$



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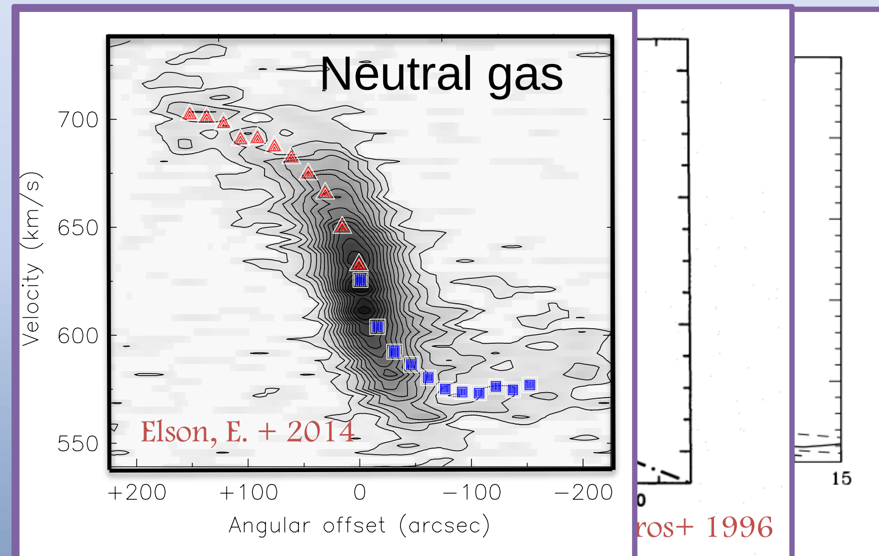
From Galactic to Extragalactic Star Formation – Marseille
12 September 2014

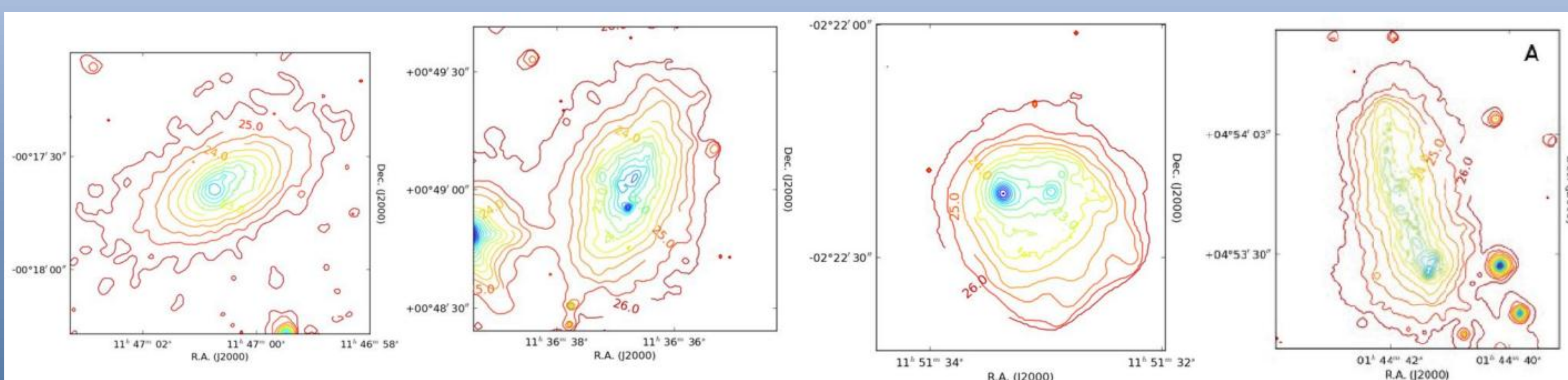
Observations: Blue Compact Dwarfs

- Definition (Gil de Paz+ 2003, Tolstoy+ 2009)
  - Dwarfs
    - $M_V > -17$ mag
  - Blue
    - $\mu_{B,\,peak} - \mu_{R,\,peak} < 1$
- Special properties
  - Compact
    - HI concentration (e.g. Taylor + 1994)
    - Old stars (e.g. Papaderos + 1996)
    - Dark matter (From steep rotation curves) (e.g. van Zee+ 2001)
  - High Star Formation Rates (> 10 higher)
  - Low metallicity (e.g. Terlevich+ 1991)
  - Different morphologies (Loose & Thuan 1986)



Morphologies

- i0 – galaxies forming their first stars
- nE – nuclear starburst in an elliptical host galaxy
- iE – irregular starburst in an elliptical host
- iI – irregular starburst in an irregular host
  - iI,C – cometary shape
  - iI,M – signs of merging



Micheva et al. 2013a,b

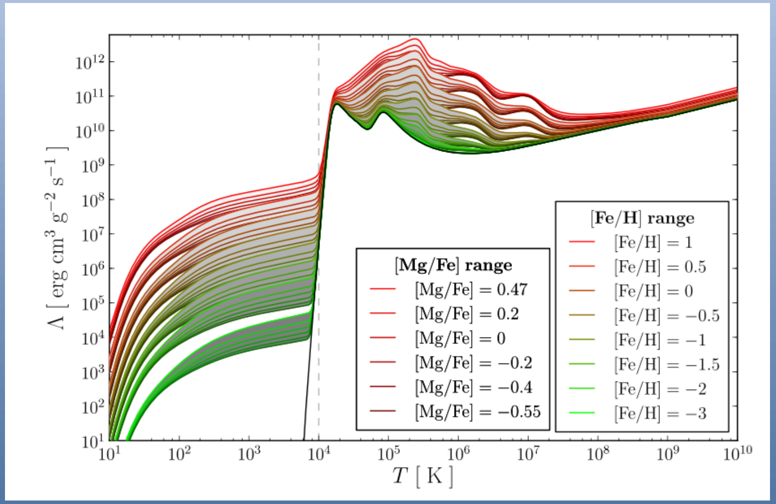
Triggering mechanisms

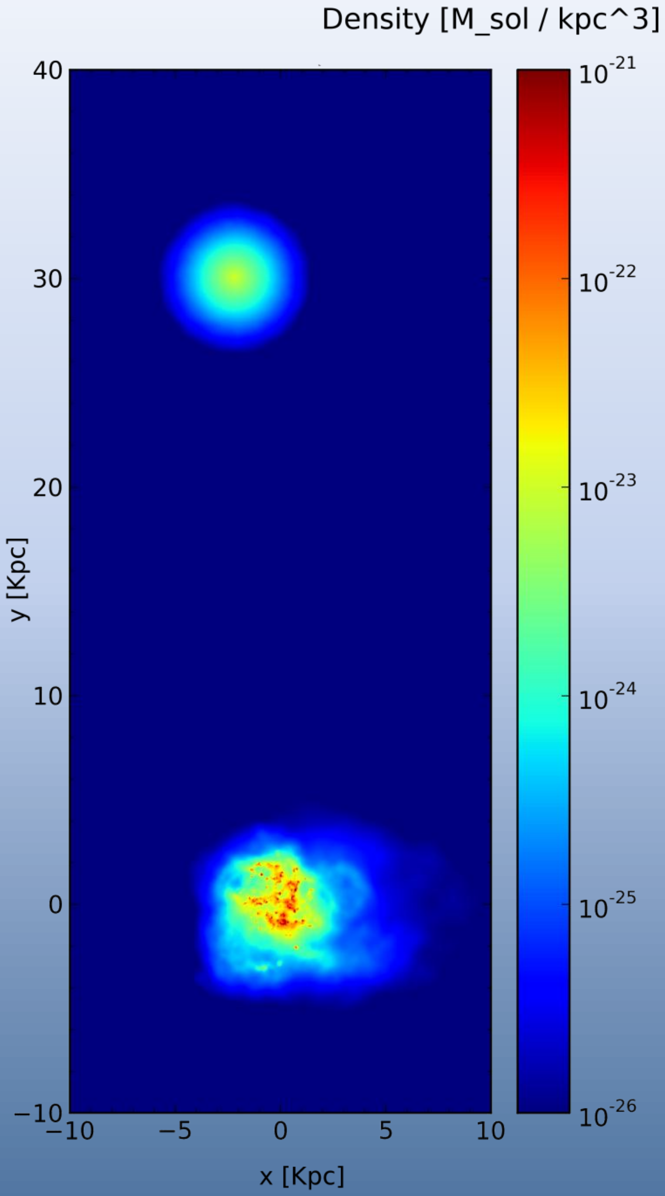
- Internal triggering
  - Torques of massive star forming clumps (Hunter & Elmegreen 2012)
  - Triaxial DM haloes (Bekki & Freeman 2002)
  - DM bars (Hunter & Elmegreen 2004)
- External triggering (Lelli+ 2014)
  - Tidal interaction (e.g. Brinks & Klein 1988)
  - Dwarf-dwarf merger (e.g. Östlin+ 2001, Bekki 2008)
  - Gas infall (e.g. Gordon & Gottesman 1981)

Simulations

- Gadget-2 (Springel 2005), extended (Valcke+ 2008, Schroyen+ 2011,2013, Cloet-Osselaer+ 2012,2014) with
  - Star formation (High density treshold)
  - Stellar feedback (SN Ia and II and stellar winds)
  - Chemical enrichment
  - Metallicity (Fe and Mg) dependent radiative cooling (De Rijcke+ 2013)
- Isolated dwarf galaxies
  - $m_{DM} \approx 1.25 \cdot 10^4\ M_\odot$
  - $m_* \approx m_{gas} \approx 2.5 \cdot 10^3\ M_\odot$
  - Gravitational softening = 30 pc

→ -15 mag $\lesssim M_B \lesssim -12$ mag





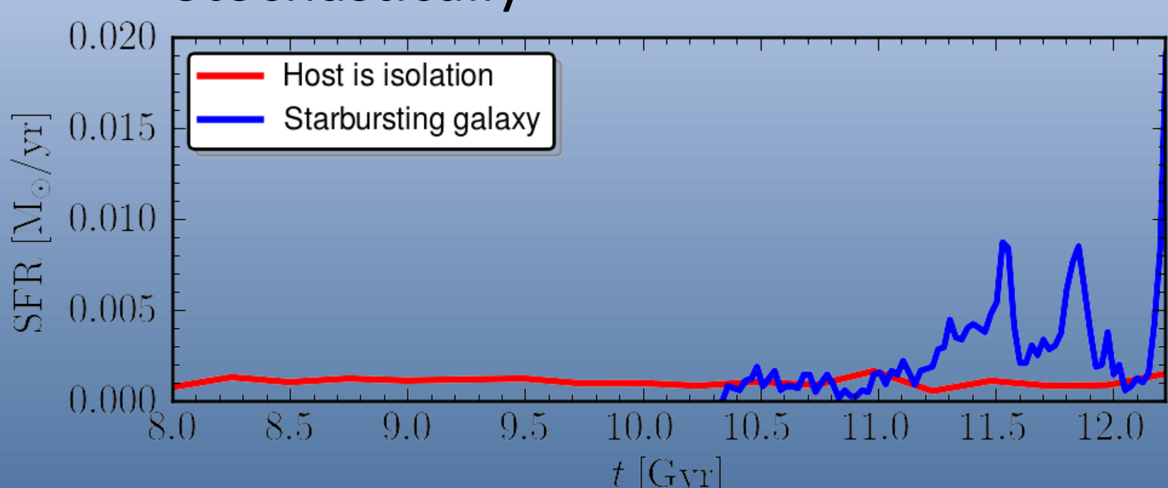
Approach

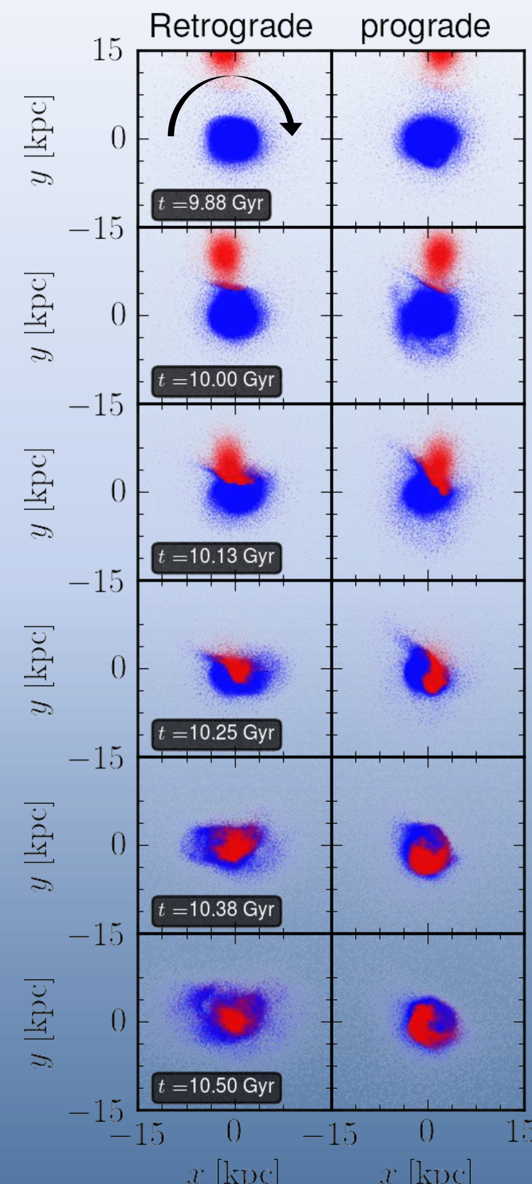
- Simulate dwarf in isolation (starting at $z = 4.3$)
- Gas cloud at $z \approx 0$
  - Inspired by HI clouds around BCDs and HVC around Milky Way
  - $M \lesssim 10^7\ M_\odot$
  - Zero-metallicity
  - $1/r$ density profile
  - $v \approx$ Escape velocity
- Variables
  - Orbits
  - Size
  - Mass

General results

SFR can go up with a factor of ~ 15,
but it needs special conditions:

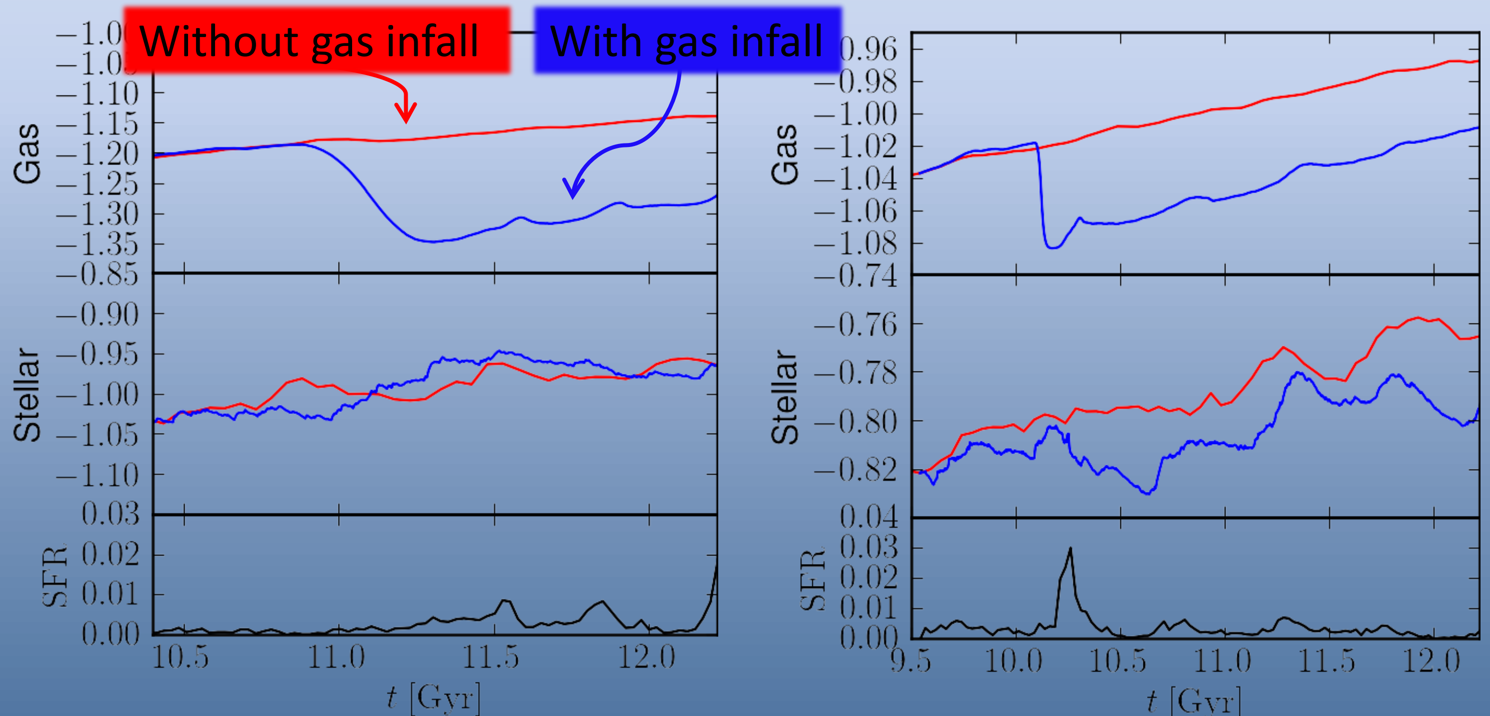
- $M_{gas\ cloud}/M_{gal}$ must be big enough
- Retrograde orbits are favourable. Prograde orbits do not produce a burst
- Stochastically





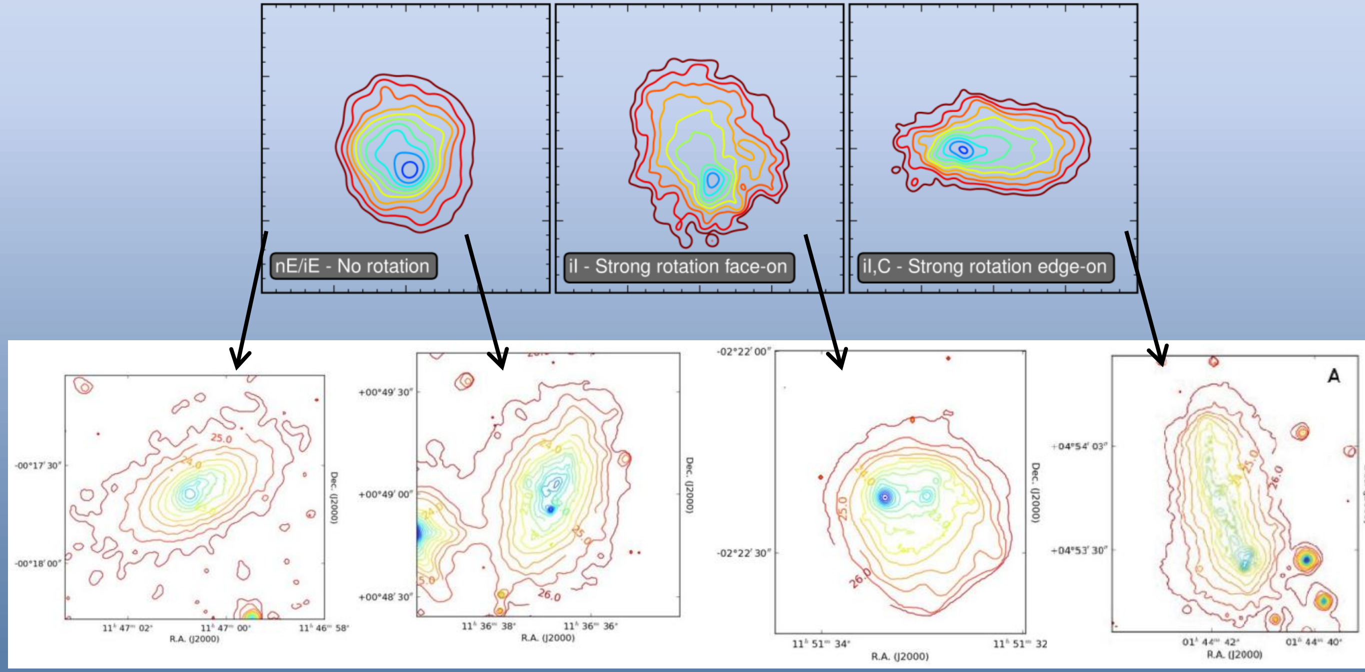
Metallicity

- Gas metallicity drops
- Stellar metallicity can increase or decrease

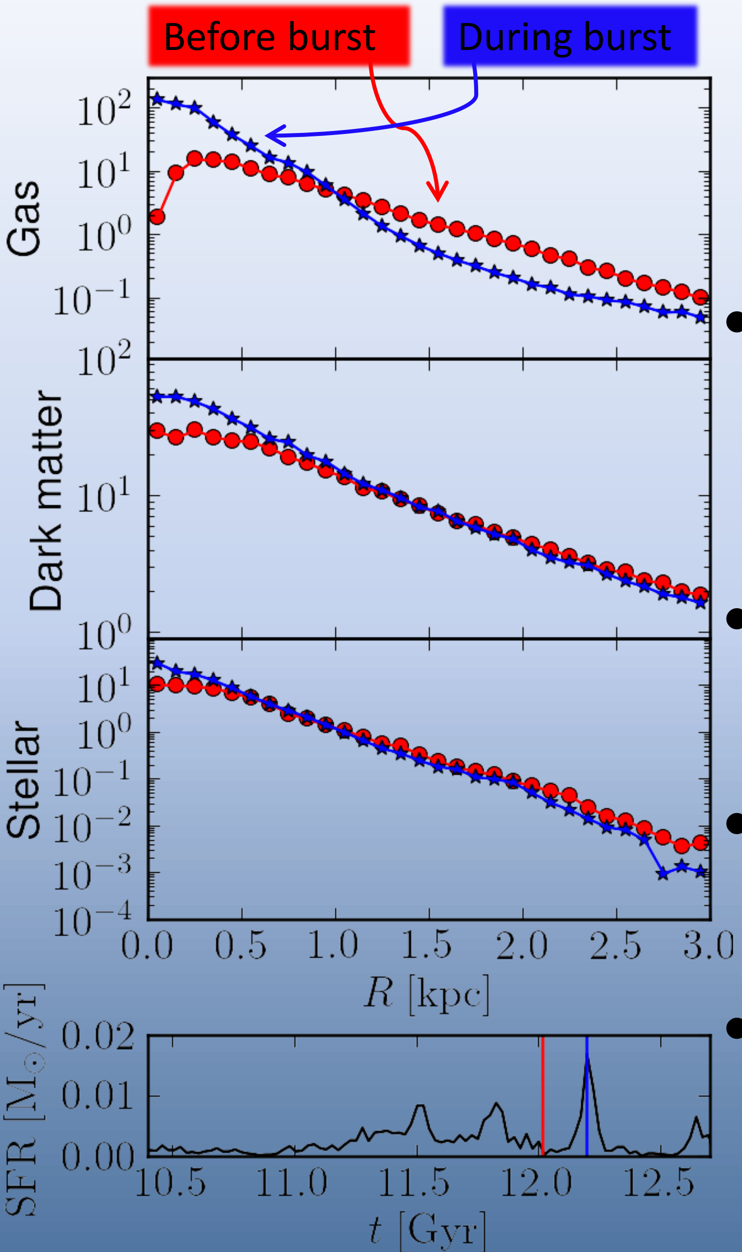


Possible explanations of different subclasses

- Non-rotating host → nE or iE BCD
- Feedback can induce further star formation → evolution from nE to iE
- Rotating host → iI
- iI viewed edge-on can have cometary shape → iI,C



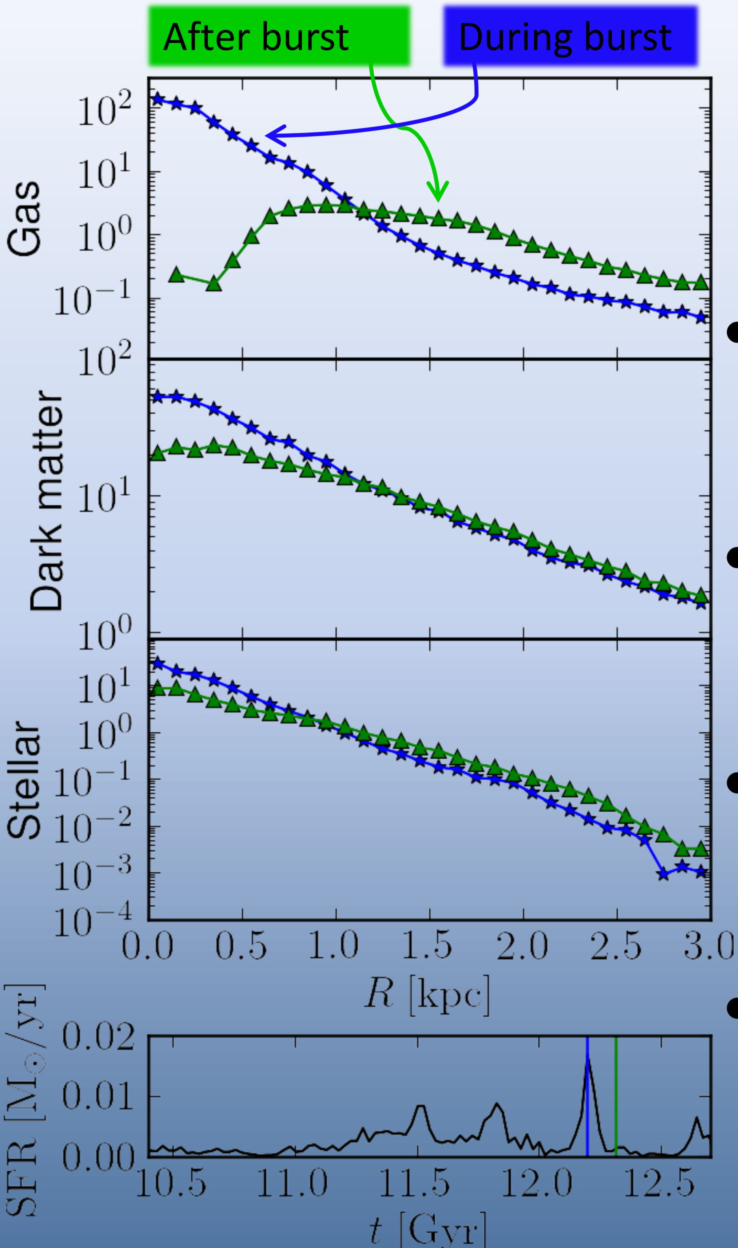
Micheva+ 2013a,b



Density profiles

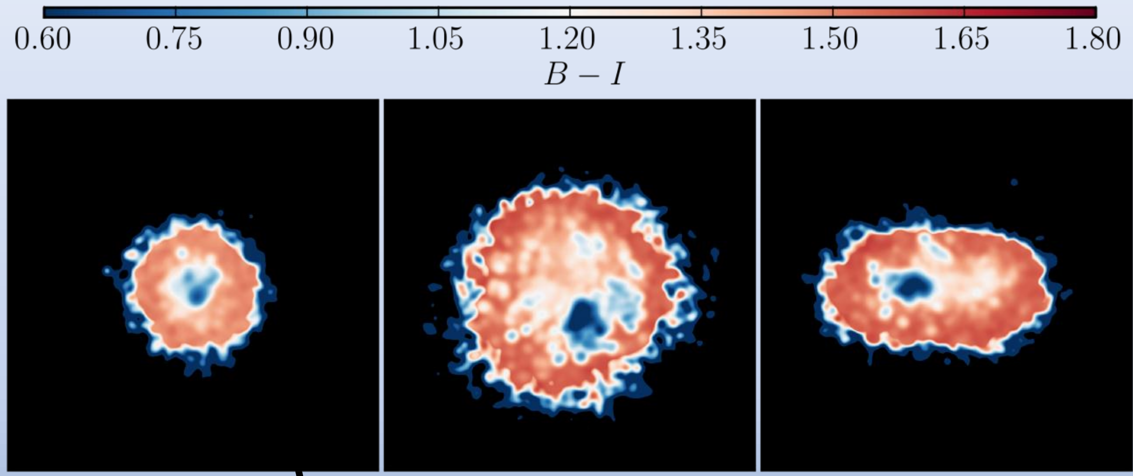
- During burst: large gas concentration that fuels the burst
- Gravitational potential deepens
- Dark matter and stellar concentration increase as well
- In agreement with observations

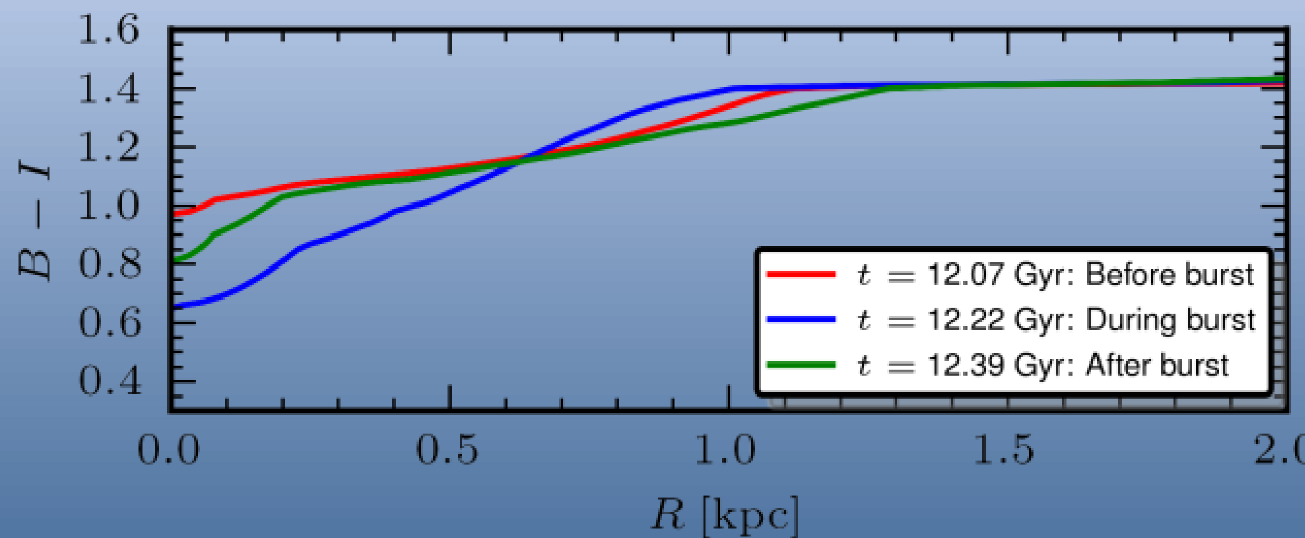
Density profiles



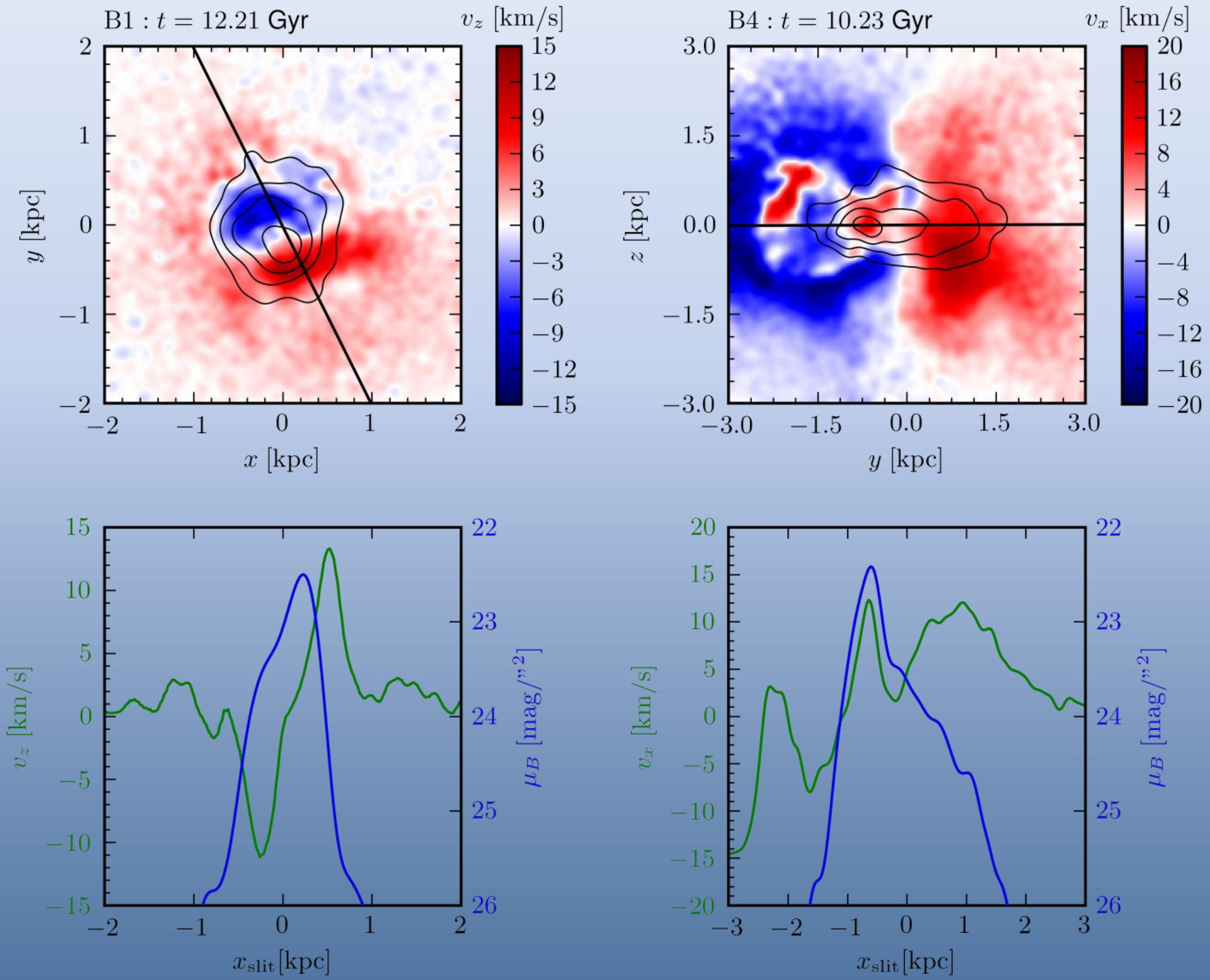
- After burst: gas is rapidly removed by SN feedback
- Shallower gravitational potential
- Dark matter and stars migrate outwards
- Postburst dwarfs are more diffuse

Colour

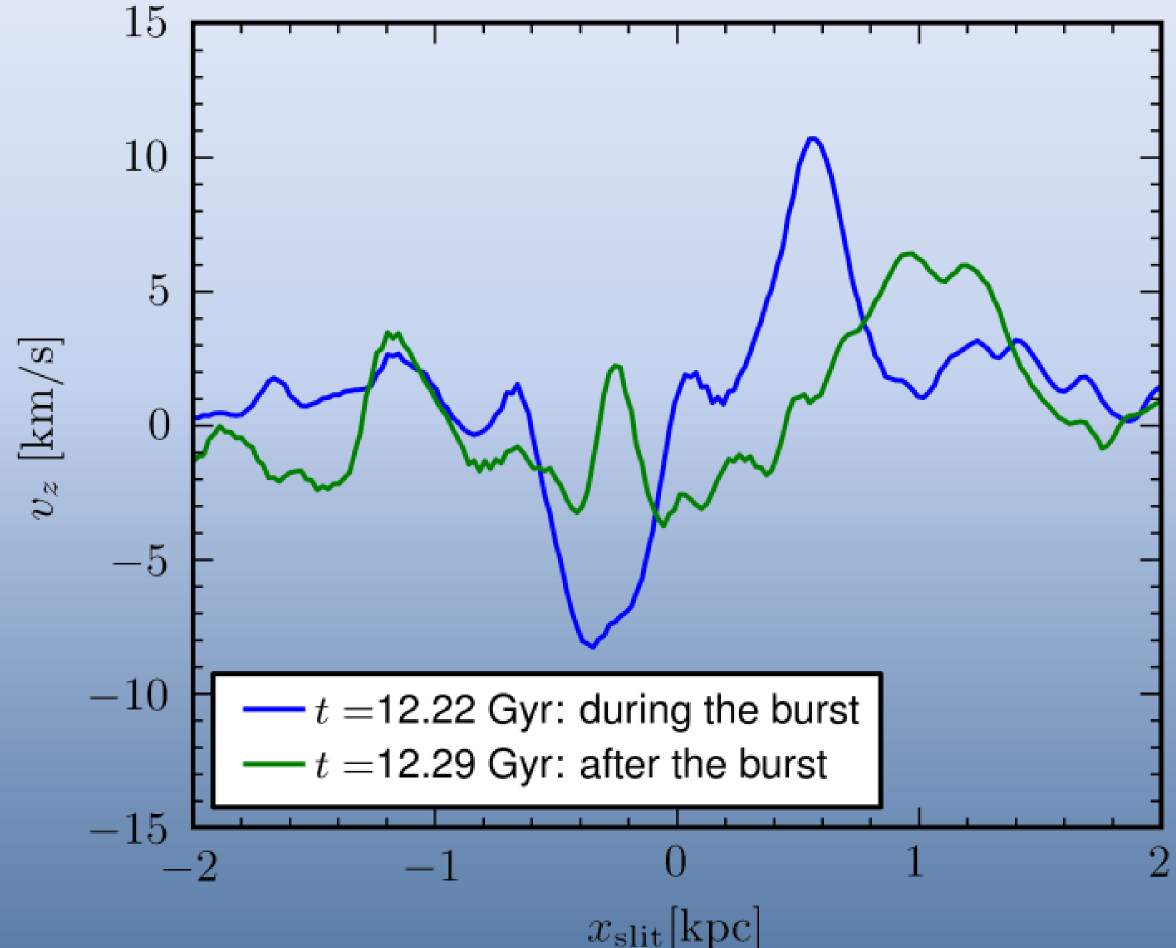

0.60
0.75
0.90
1.05
1.20
1.35
1.50
1.65
1.80
$B - I$


$B - I$
R [kpc]
0.0
0.5
1.0
1.5
2.0
0.4
0.6
0.8
1.0
1.2
1.4
1.6
t = 12.07 Gyr: Before burst
t = 12.22 Gyr: During burst
t = 12.39 Gyr: After burst

Rotation curves



Rotation curves



Summary

- Gaseous infall can trigger a starburst in dwarfs
- The orbit of the infalling gas is important
- The gas metallicity drops, but the stellar metallicity depends of the density of the infalling gas cloud
- The expected morphologies are all reproduced
- During the burst, the gas, stars and DM become more centrally concentrated
- Steep rotation curves are reproduced
- Postburst dwarf galaxies are again more extended and have flatter rotation curves

Verbeke+ 2014 (MNRAS)