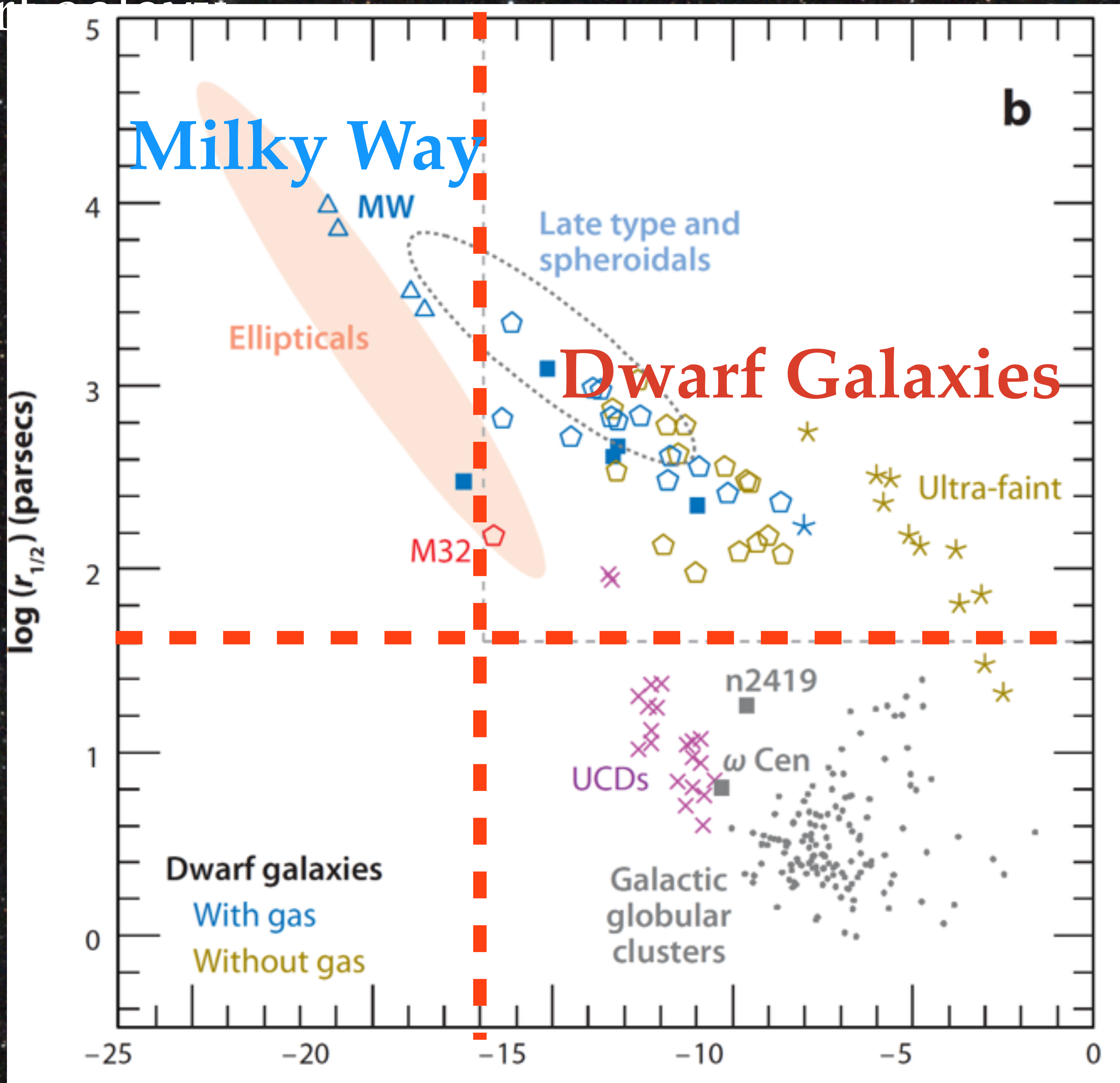
11th Russbach School on Nuclear Astrophysics

Chemo-Dynamical evolution of dwarf spheroidal galaxies

Yutaka Hirai
(The University of Tokyo, NAOJ)
Jun Hidaka (NAOJ), Takayuki R. Saitoh (Titech),
Michiko Fujii(NAOJ), Shota Shibagaki (UTokyo),
Grant J. Mathews (U. Notre Dome),
and Toshitaka Kajino (NAOJ, UTokyo)

Dwarf Galaxies

Leo II dwarf



Tolstoy et al. 2009

Galaxy Formation

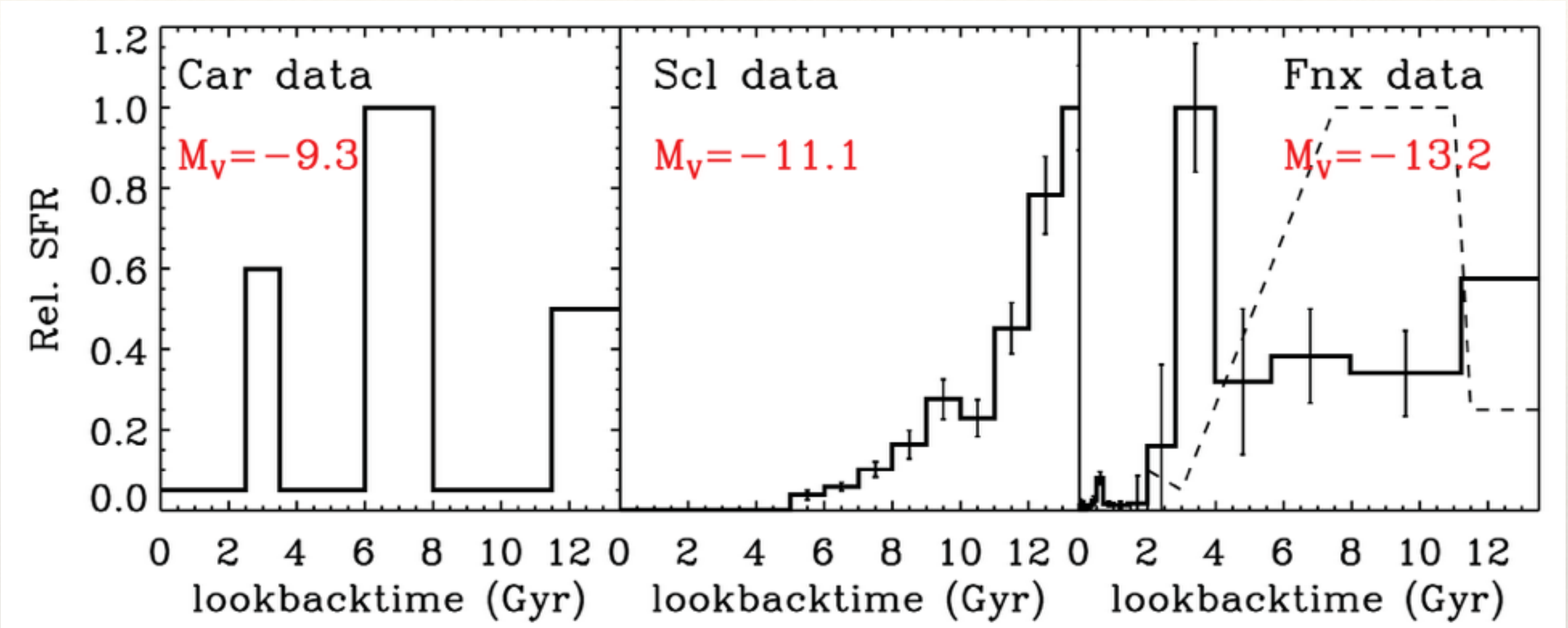
Dwarf Galaxies might be building blocks of the Milky Way

We can observe each star in nearby dwarf galaxies to estimate star formation histories and metallcity.

Dwarf galaxies are useful tool to study galaxy formation and evolution

Observation

Star Formation Histories of dwarf galaxies

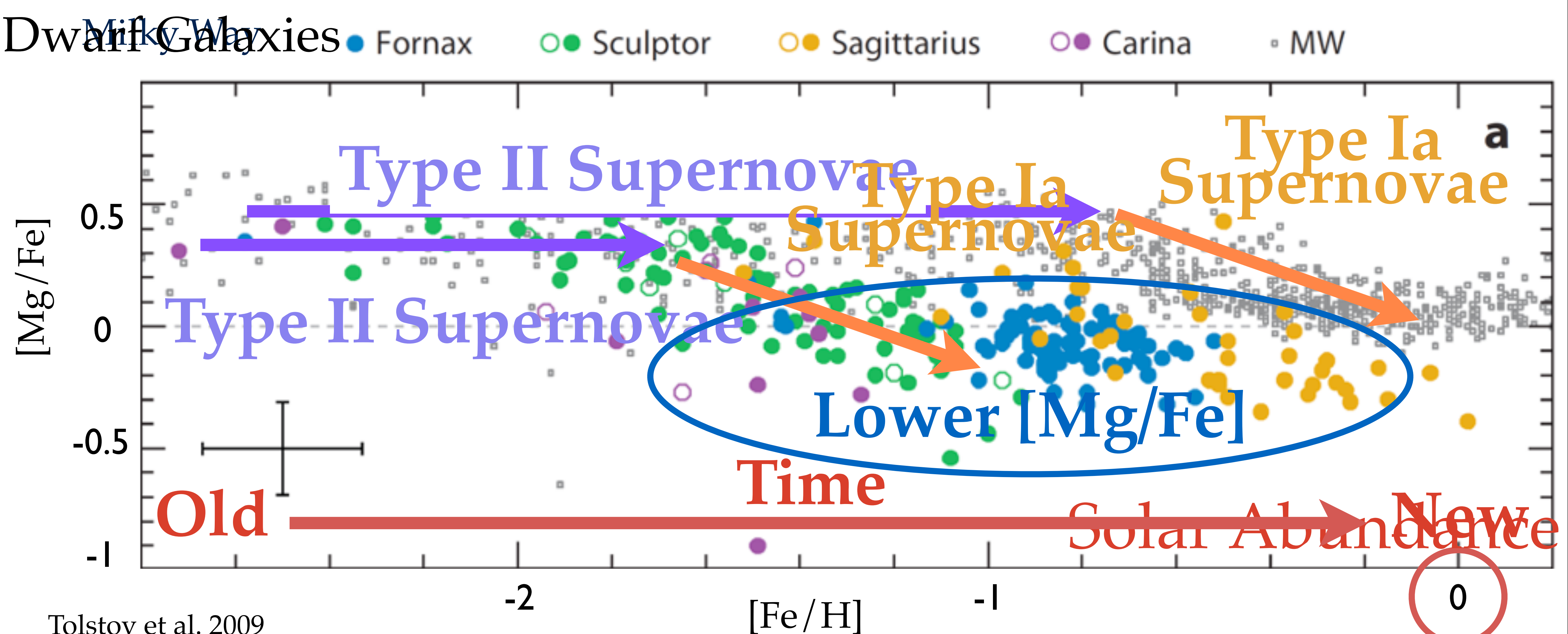


Starkenburg et al. 2013

Each dwarf galaxies might experience different evolution.

Star formation histories affect the chemical abundance pattern of galaxies

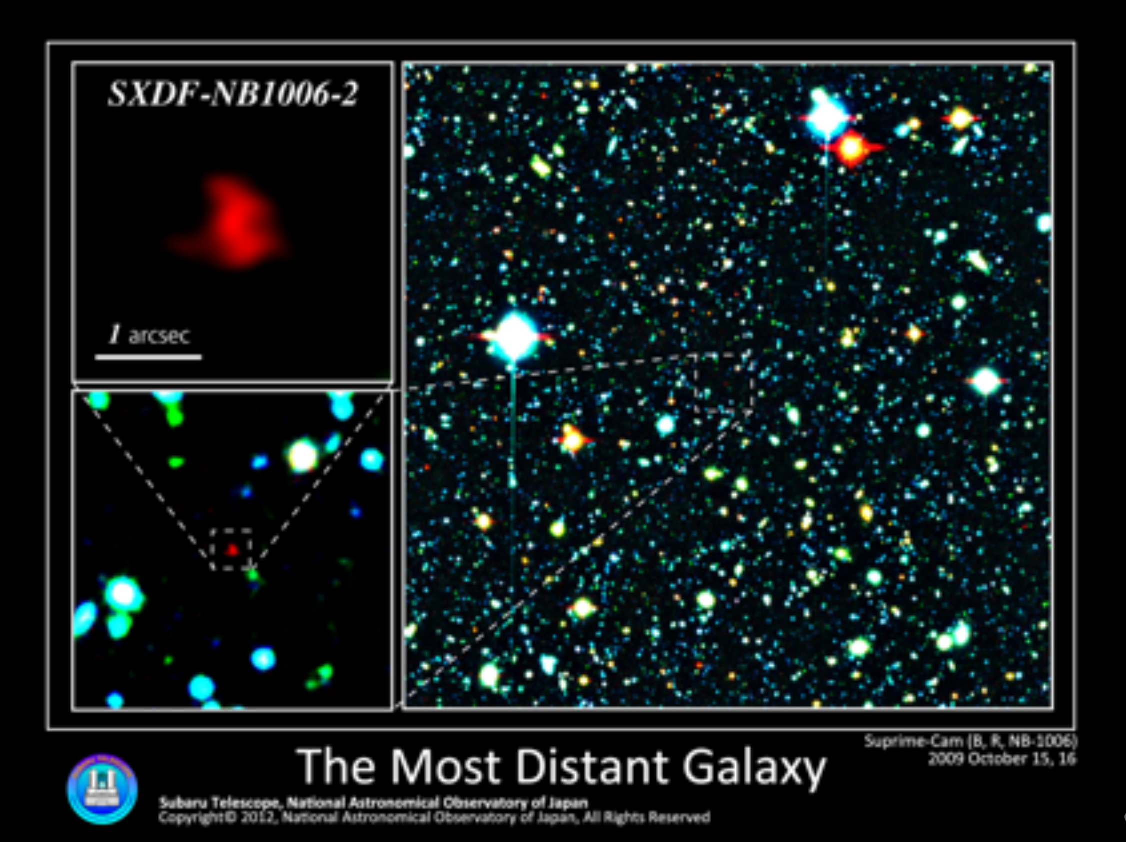
Elemental Abundance Pattern of dwarf galaxies



Tolstoy et al. 2009

$$[\mathrm{Fe/H}] = \log_{10}\left(\frac{N_{\mathrm{Fe}}}{N_{\mathrm{H}}}\right)_{\mathrm{star}} - \log_{10}\left(\frac{N_{\mathrm{Fe}}}{N_{\mathrm{H}}}\right)_{\mathrm{sun}}$$

Systematically different chemical abundance pattern from Milky Way



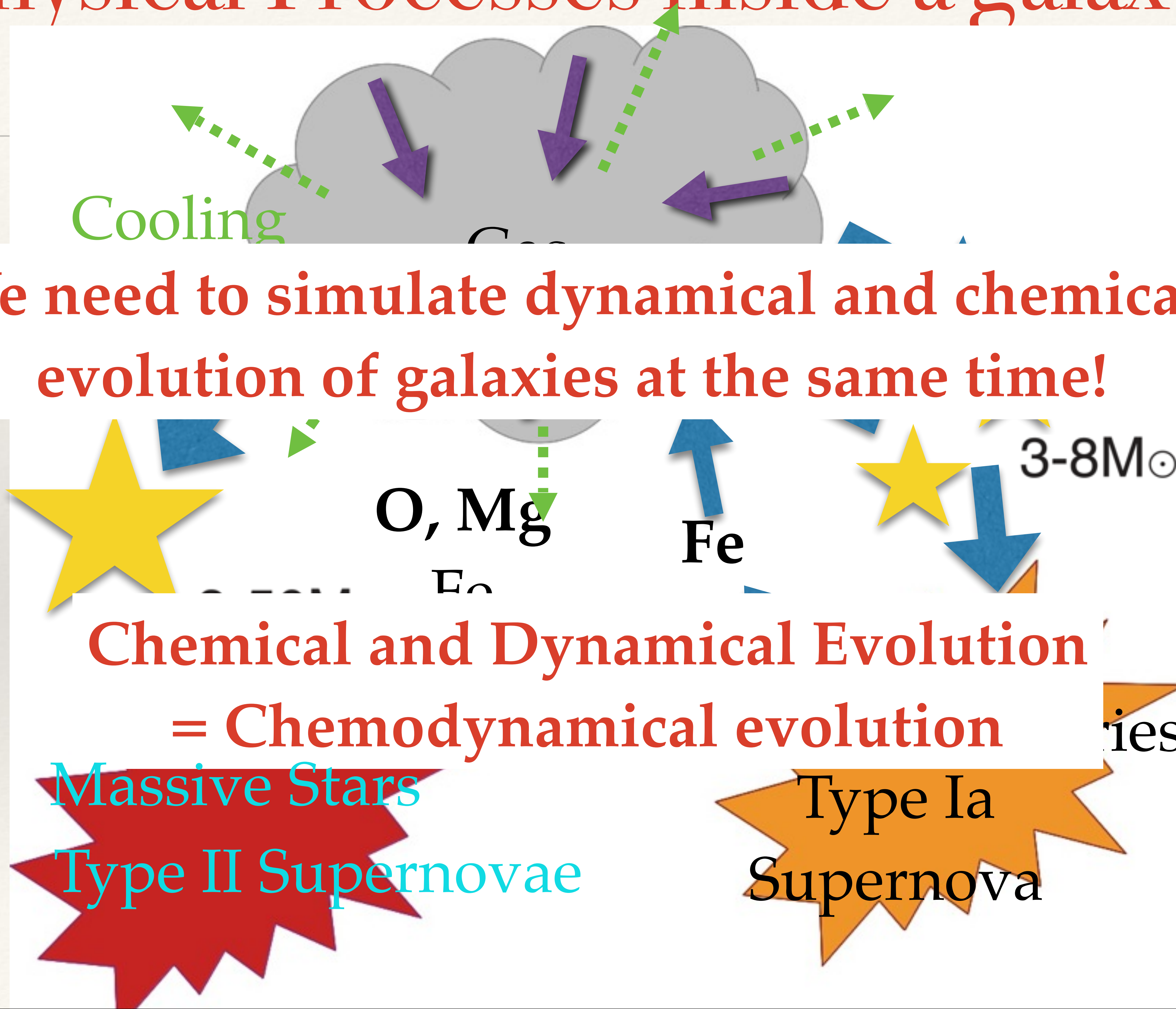
Present dwarf galaxies and building blocks of the Milky Way are different?

?

We need detailed simulation of dwarf galaxy evolution

Physical Processes inside a galaxy

We need to simulate dynamical and chemical evolution of galaxies at the same time!



Chemical and Dynamical Evolution
= Chemodynamical evolution

Our Ultimate Goal

to reveal the chemo-dynamical evolution of dwarf galaxies in order to construct a comprehensive picture of the formation and evolution of the Milky Way in terms of the origin and evolution of atomic elements!

Today's goal

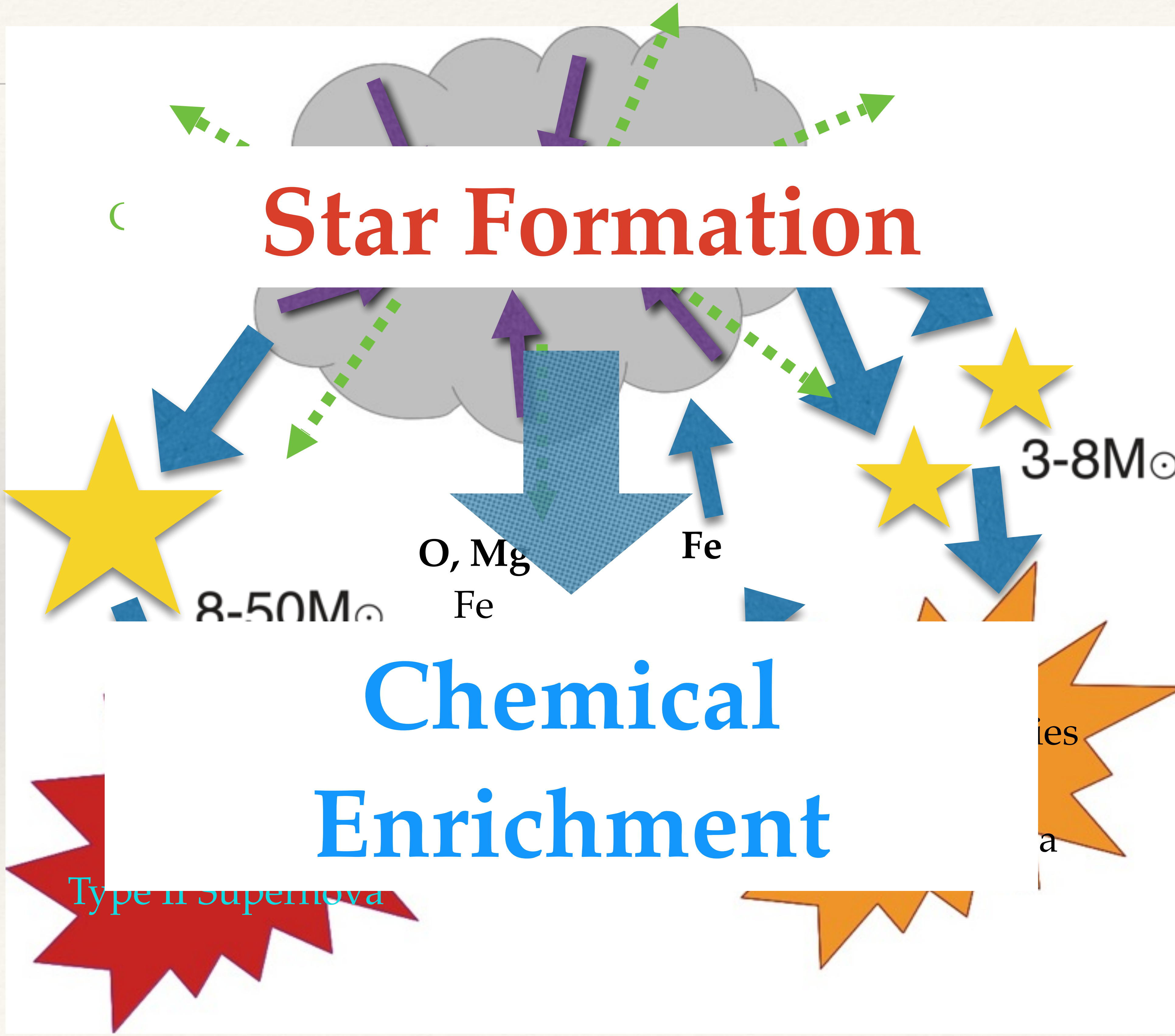
- to construct a "**chemo-dynamical evolution code**"
- to find important physics on **star formation histories**

Next Goal

- to implement "supernova nucleosynthesis yields" which we are calculating in our Tokyo Group into the present chemo-dynamical code

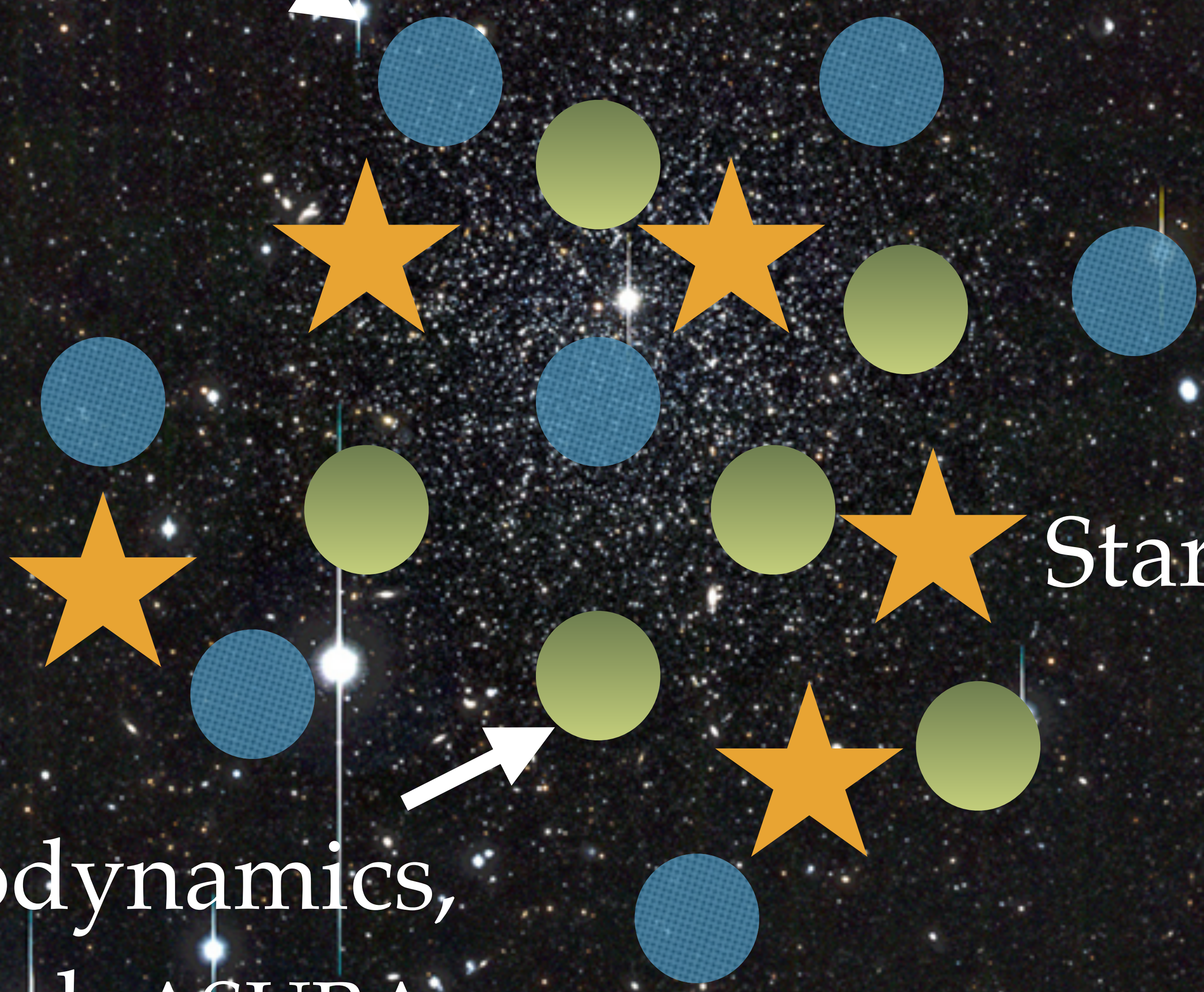
- to study the "chemical evolution" and "dynamical evolution" of dwarf spheroidal galaxies simultaneously as building blocks of understanding the Milky Way

Importance of star formation for chemical enrichment inside a galaxy



Chemo-Dynamical Evolution Code

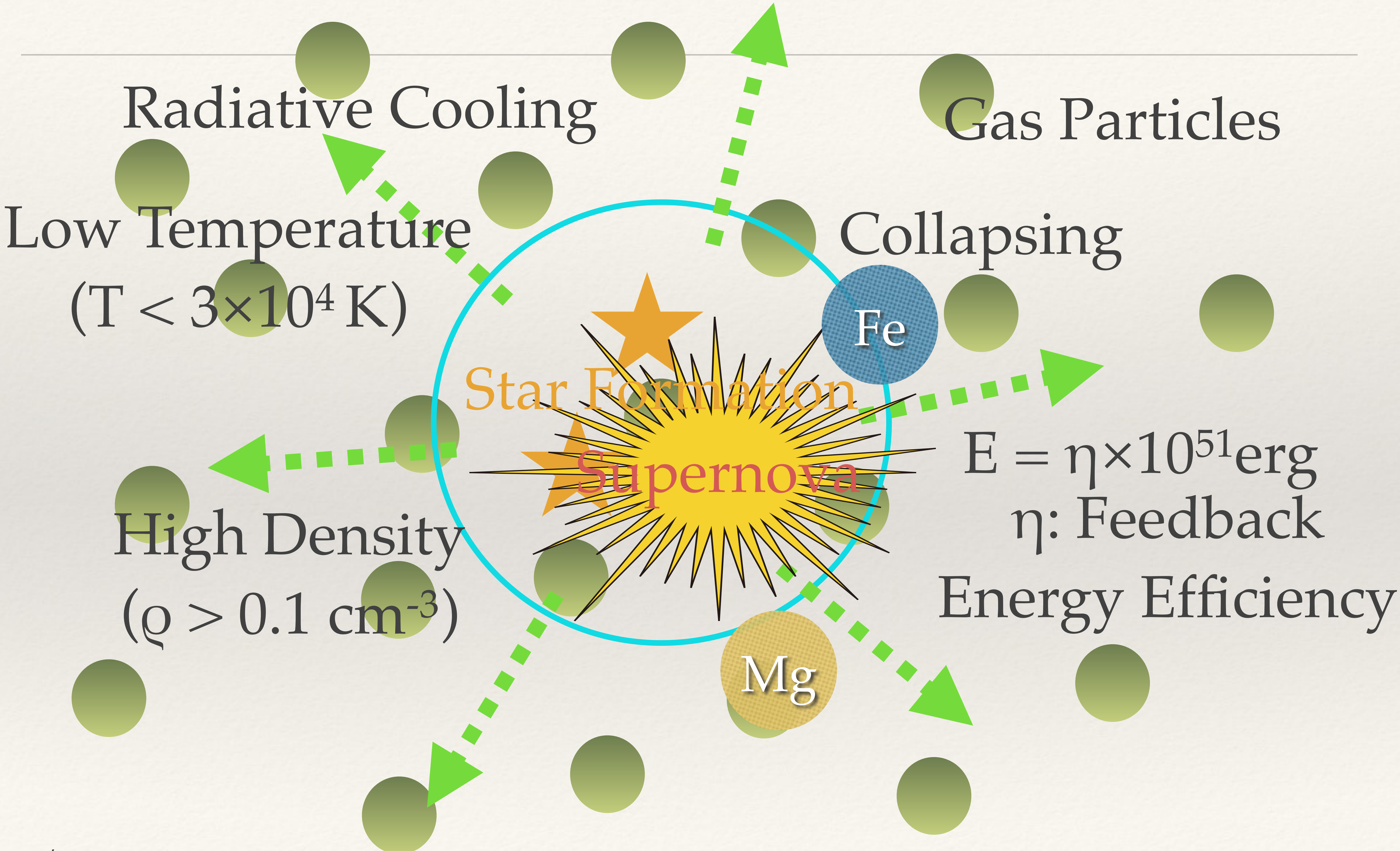
Dark Matter (Gravity, Tree method)



Star (Feedback)

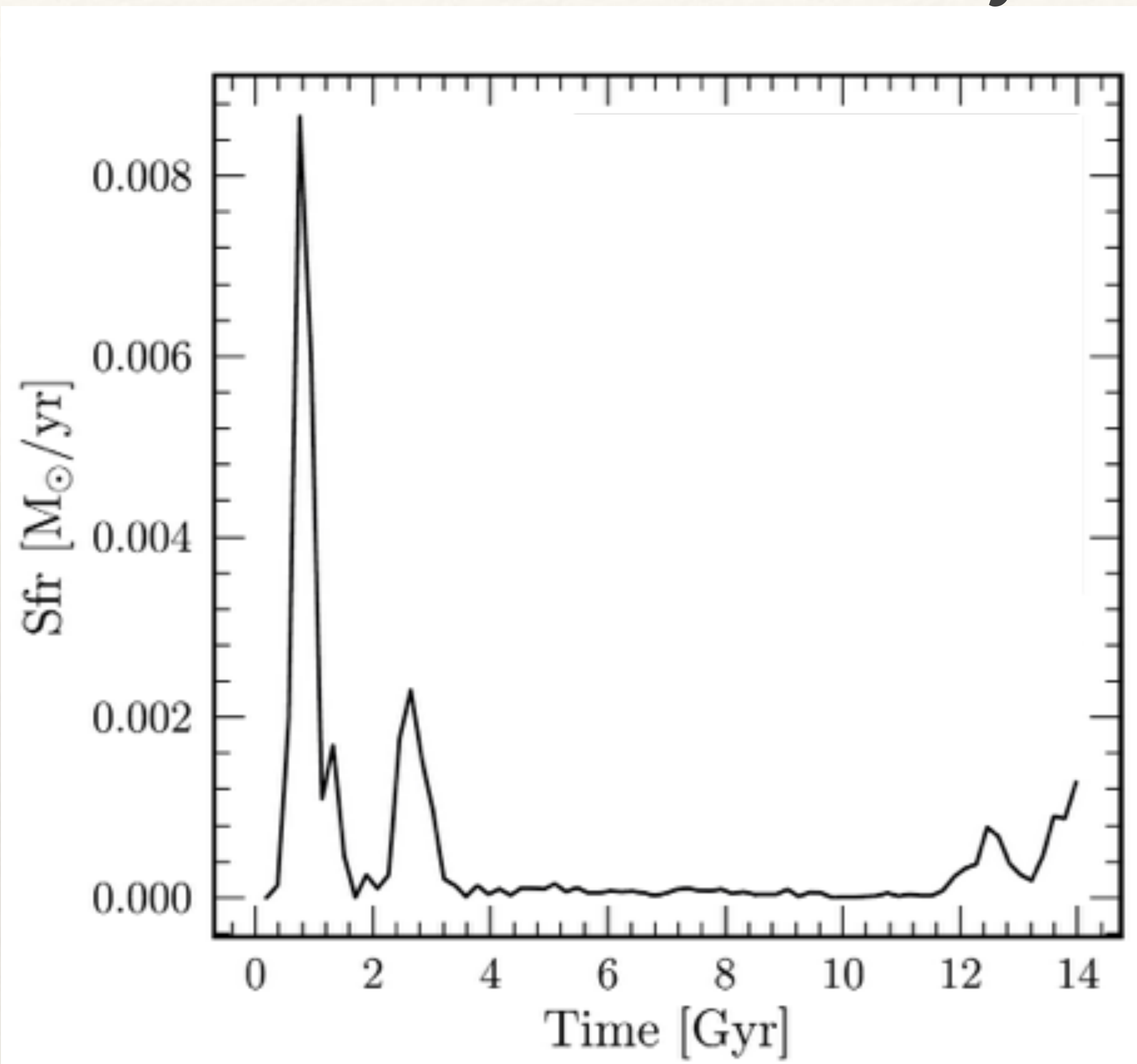
Gas (Hydrodynamics, SPH method, ASURA (Saitoh & Makino, 2013))

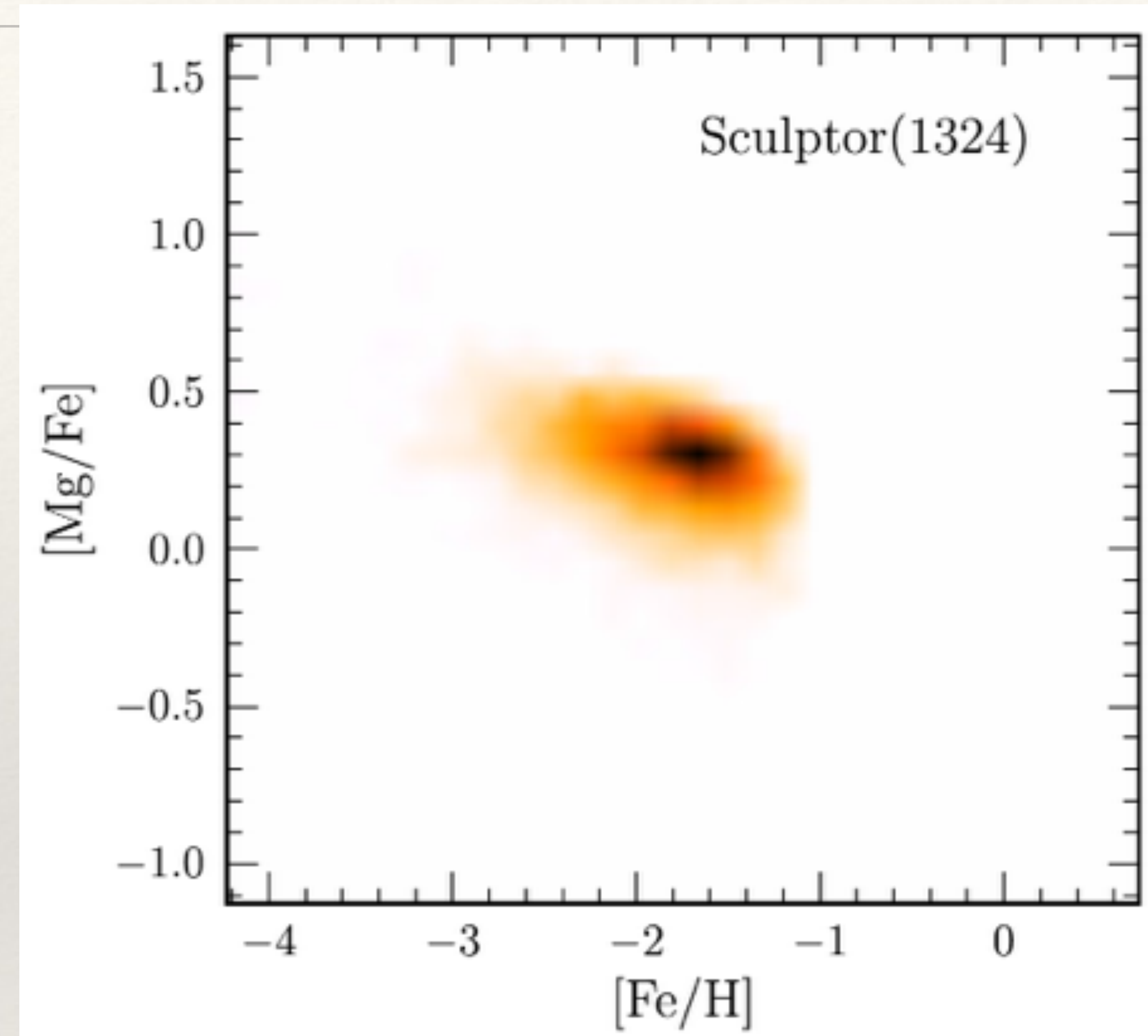
Star Formation Law and Supernova Feedback



Past Studies (Revaz & Jablonka 2012)

Star Formation History Chemical Abundance Pattern





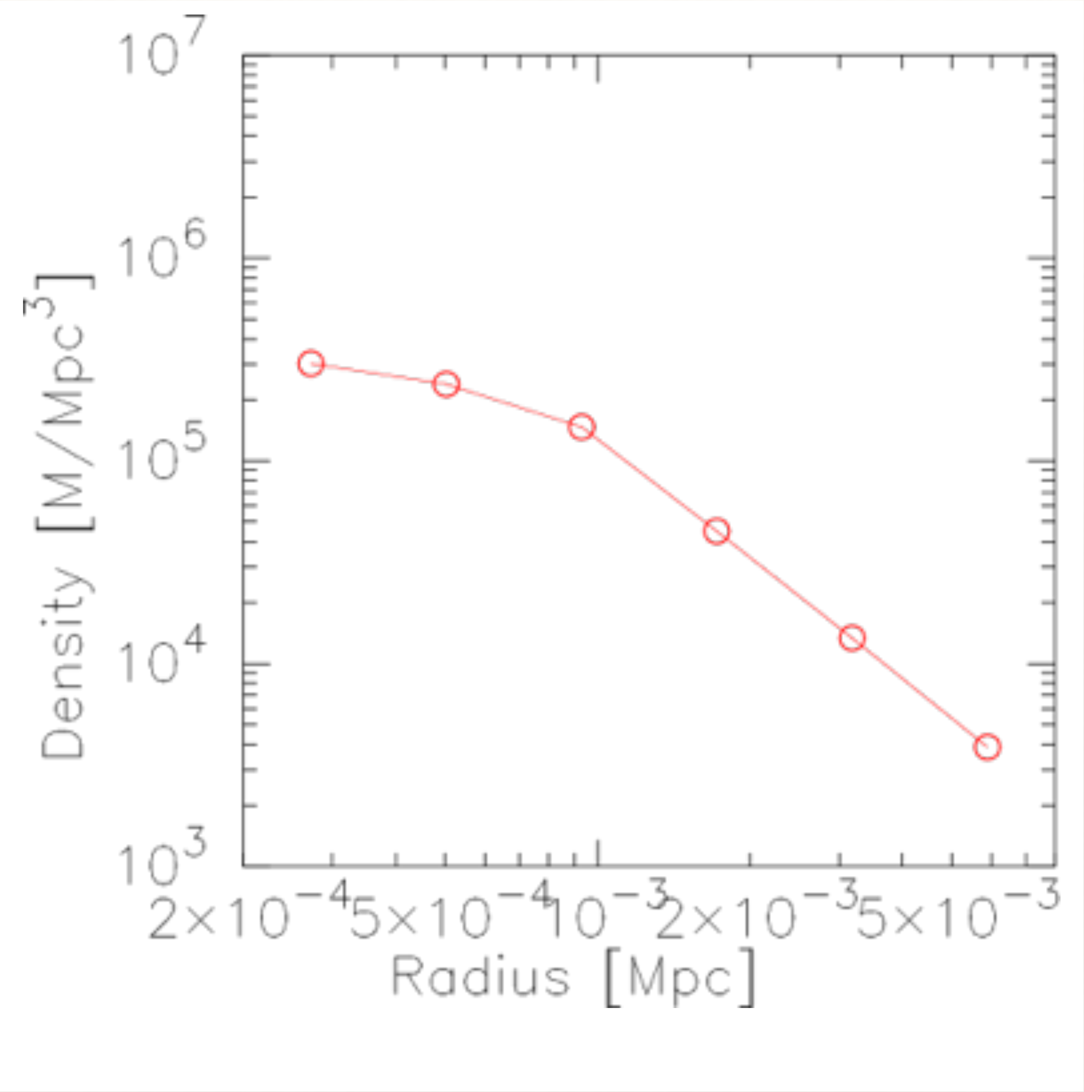
Successfully reproduce star formation histories and chemical abundance patterns

But… they reduce the energy of the supernova explosion (10^{49} erg)

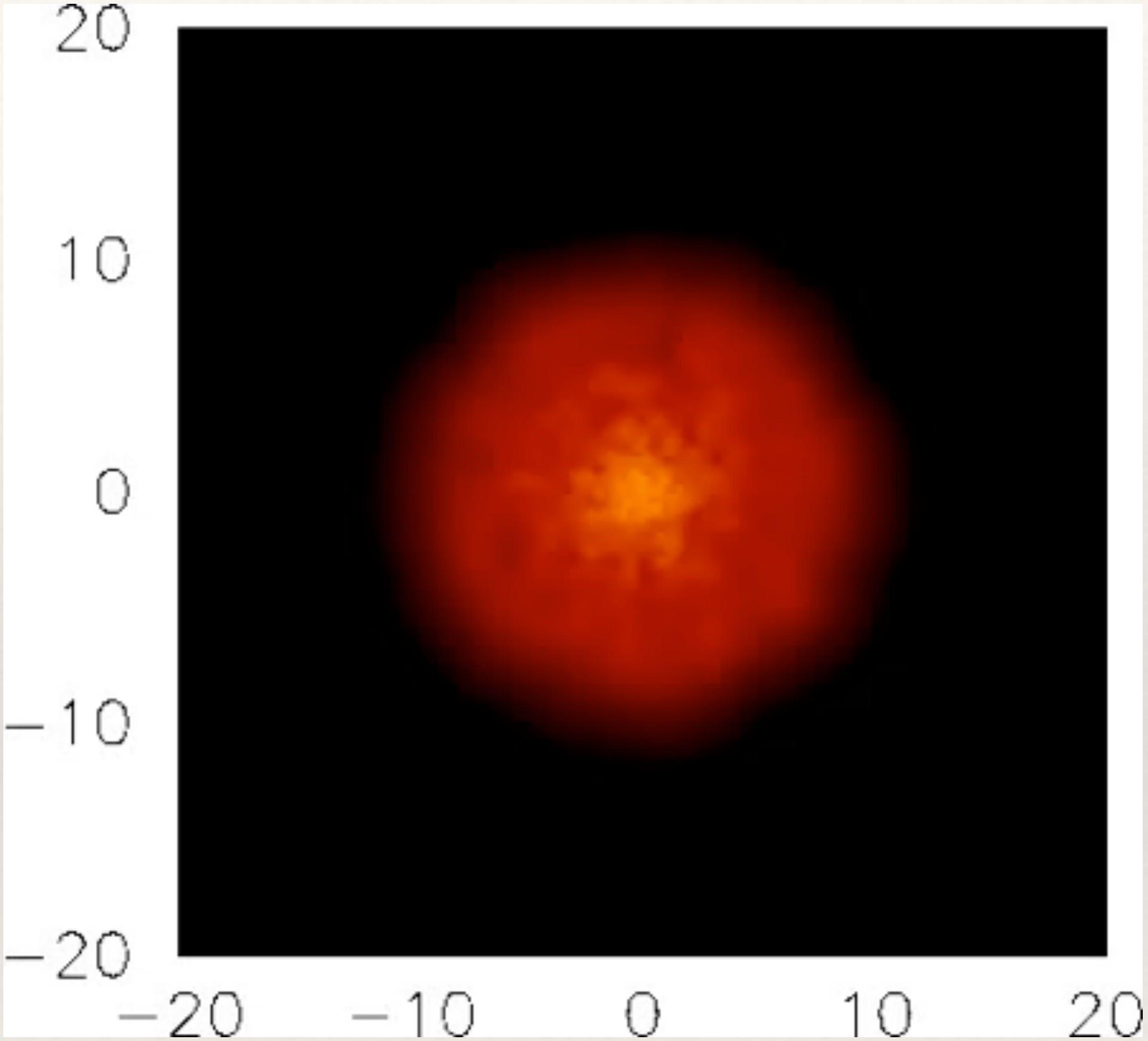
Initial Condition

Density Profile: pseudo-isothermal profile

Radial Density Profile



Density Distribution

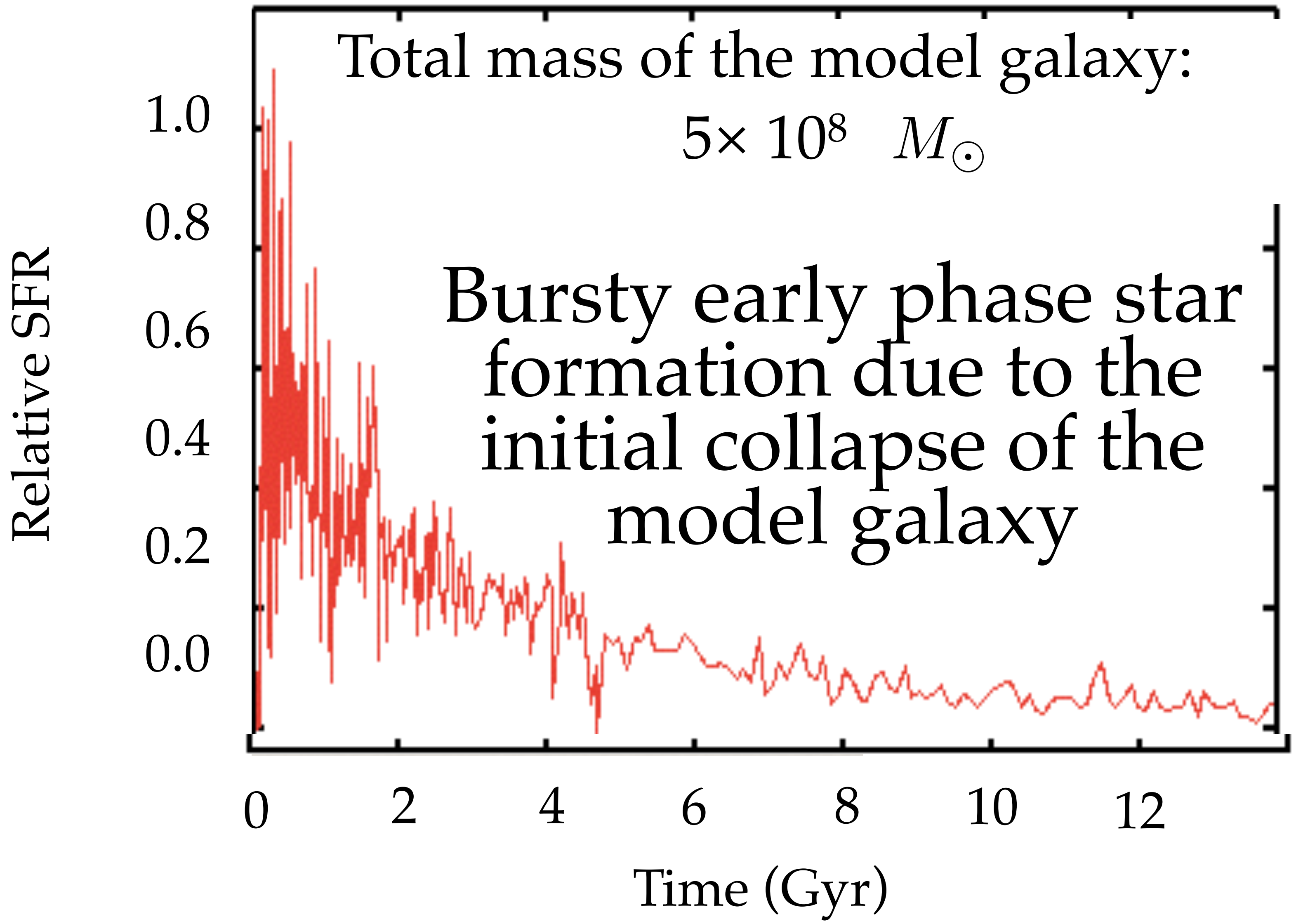


Total Number of Particles: 2^{16}

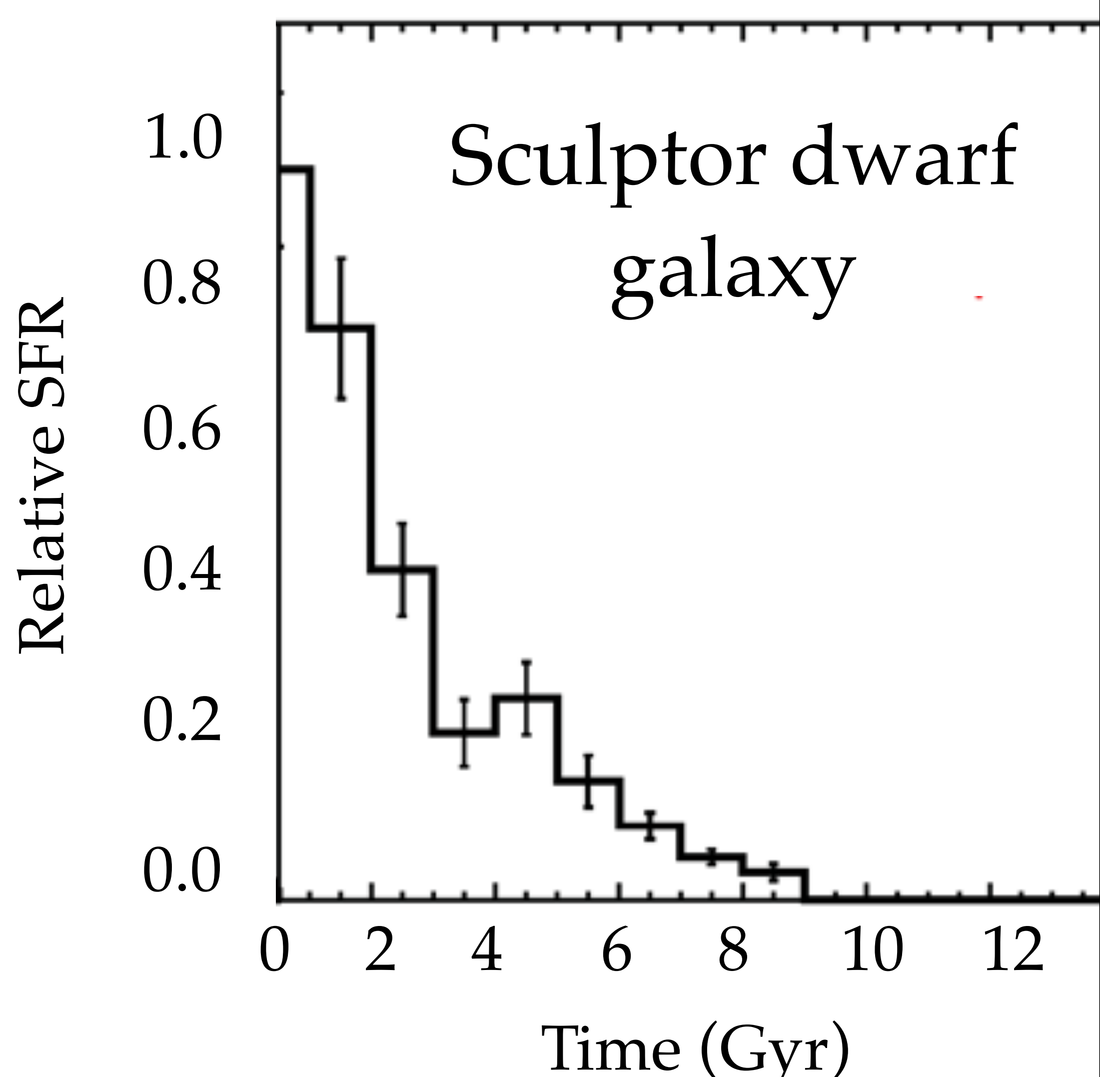
Mass of One Gas Particle: $10^3\,M_\odot$

Star Formation Histories

Simulation

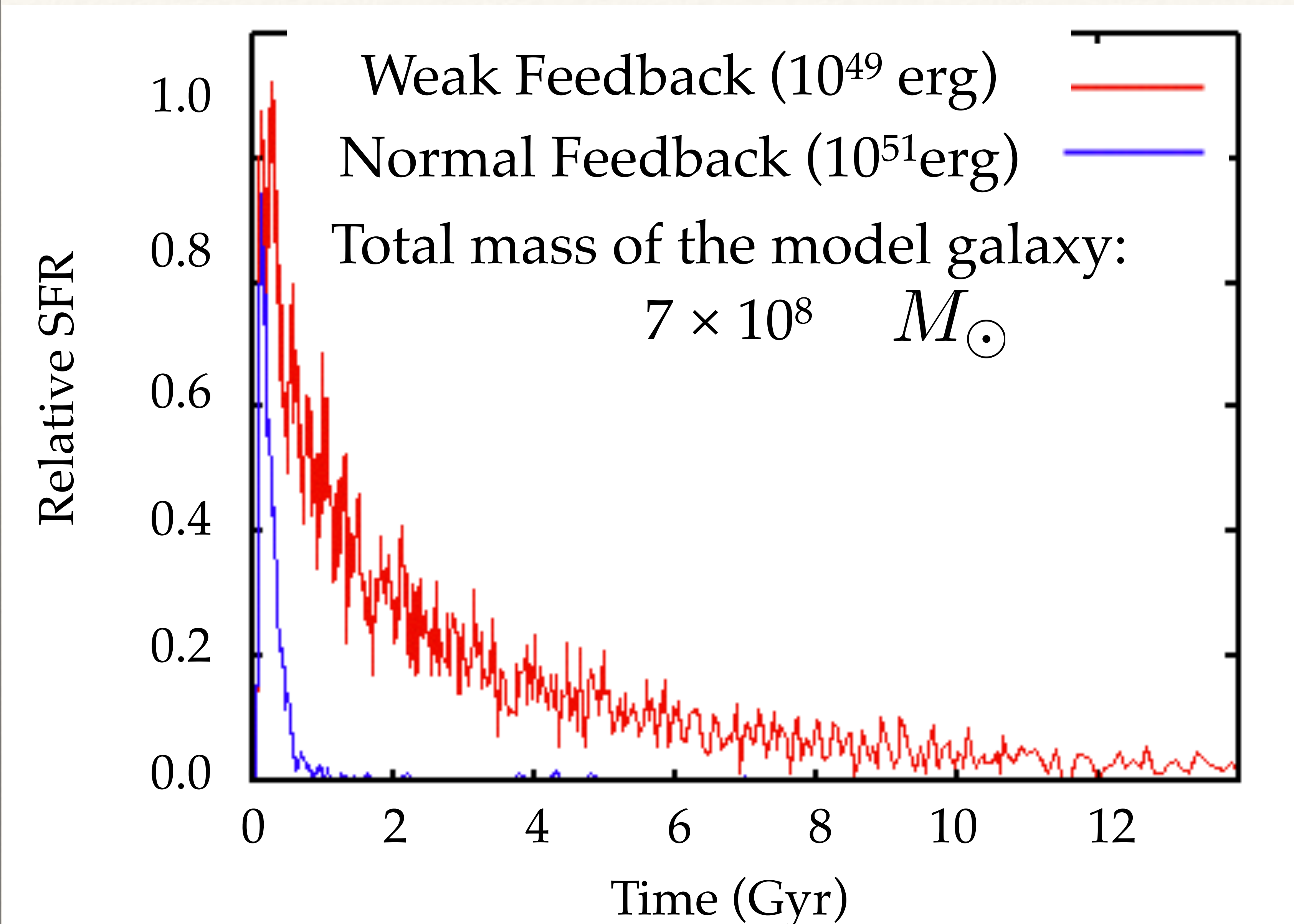


Observation



Sculptor dwarf galaxy seems to evolve isolated

Importance of supernova feedback



- Supernova feedback strongly affects the star formation rate
- Strong feedback blew away the gas inside the galaxy
- Chemical abundance pattern may be affected by supernova feedback

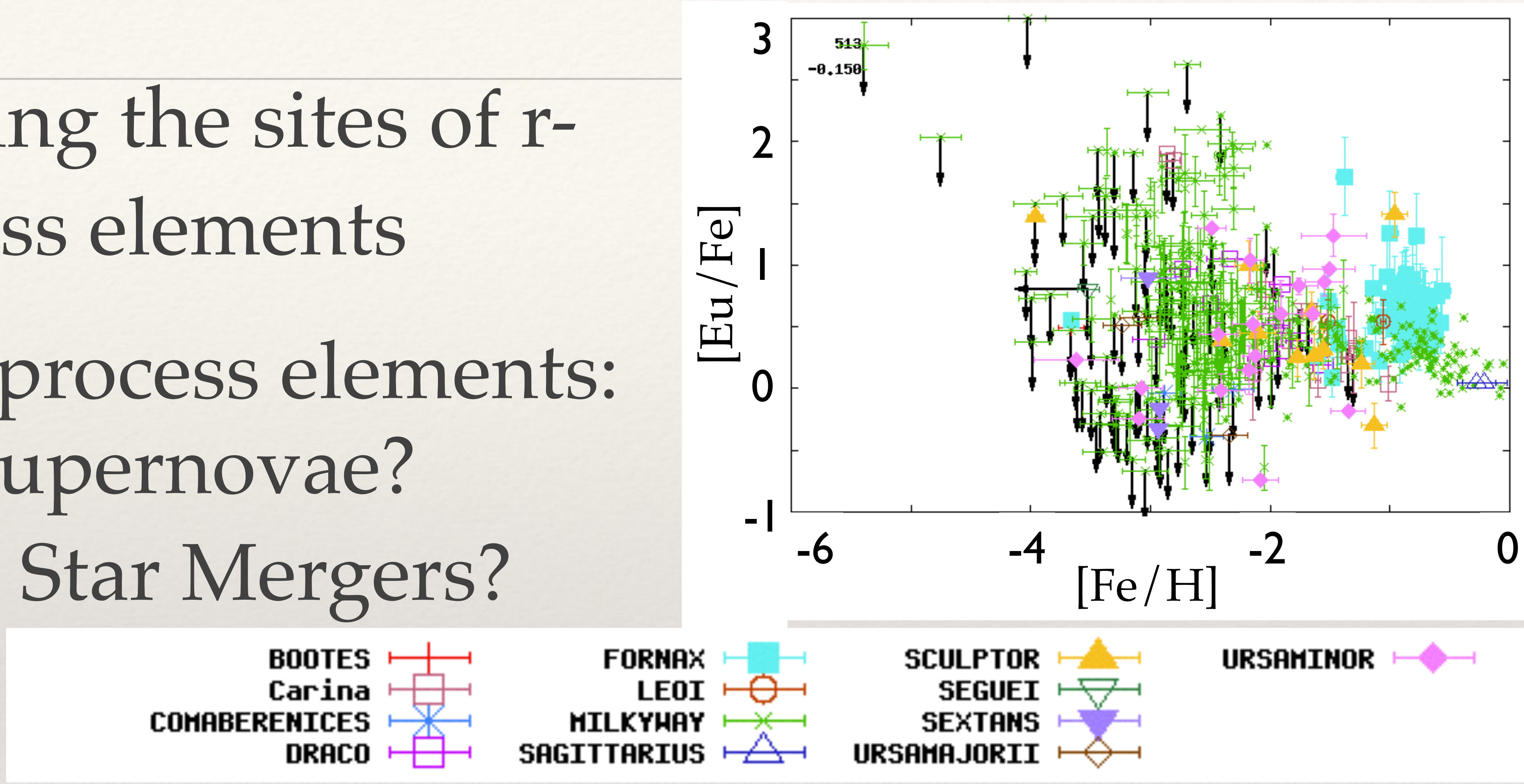
For near future

We need to check more massive galaxy and effects of merger with feedback

Next Prospects

Constraining the sites of r-process elements

Origin of r-process elements:
Type II supernovae?
Neutron Star Mergers?



SAGA databese (Suda et al. 2008)

The answer might be in chemodynamical simulation of dwarf galaxies!

Summary

- Dwarf spheroidal galaxies is useful tool to study galaxy formation and evolution.
- We constructed chemical and dynamical evolution code.
- Supernova feedback is an important process to derive star formation histories.
- We will include chemical feedback such as r-process elements to deeply study evolution of dwarf galaxies and origin of elements