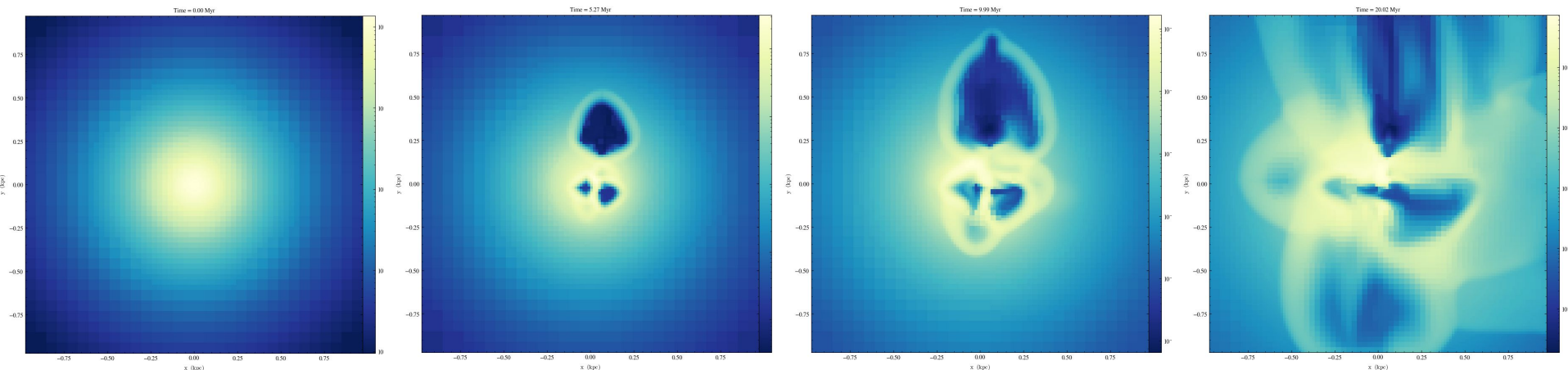


Project 7

Spreading Metals in the ISM



Supervised by Donatella Romano

Group members:
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Alejandra LUGO-ARANDA
Nele STACHLYS
Felix WERSIG

Introduction

- ★ Running simulation shown in [Romano+2019](https://doi.org/10.1051/0004-6361/201935328) (<https://doi.org/10.1051/0004-6361/201935328>) with **lower resolution**
- ★ **RAMSES** adiabatic simulation of an isolated ultrafaint dwarf galaxy: **Boötes I**
- ★ Boxsize is $L=2$ kpc
- ★ Maximum refinement level $\ell=7$ (vs. $\ell=11$, maximum resolution ~ 1 pc)
- ★ Running simulation with two different SN energies: 10^{51} ergs and 10^{52} ergs

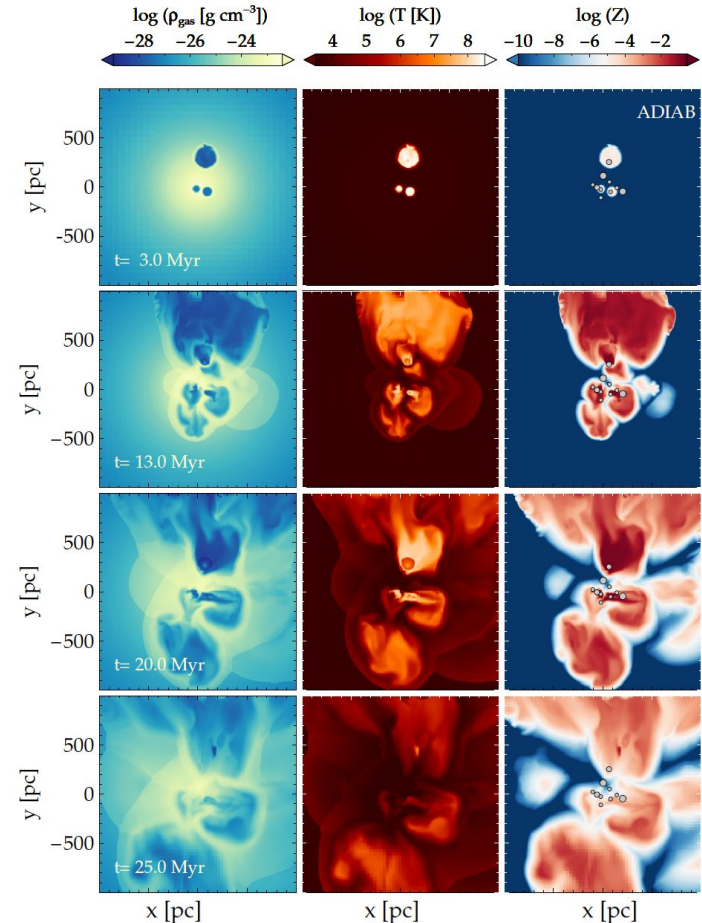
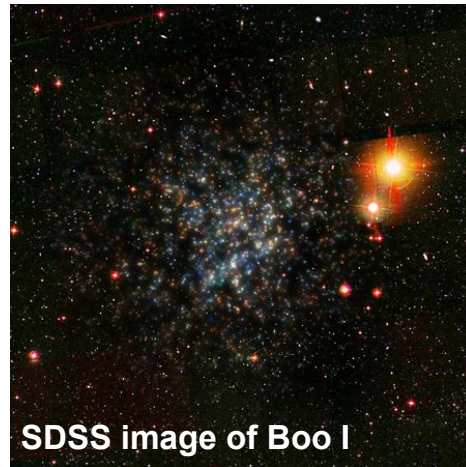
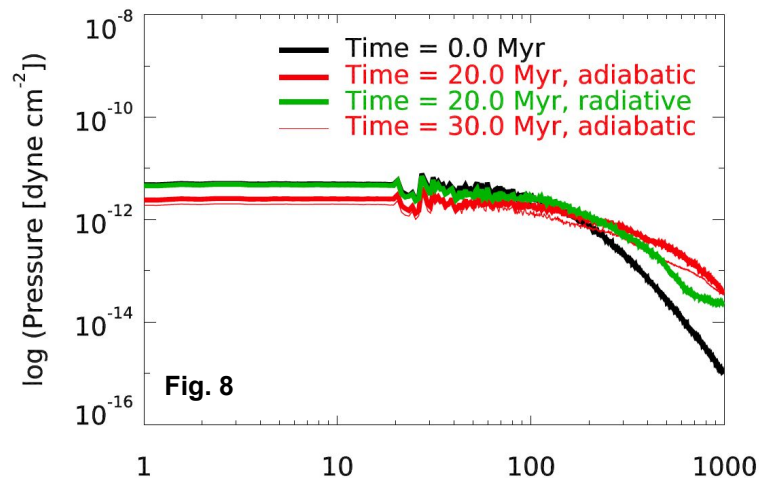
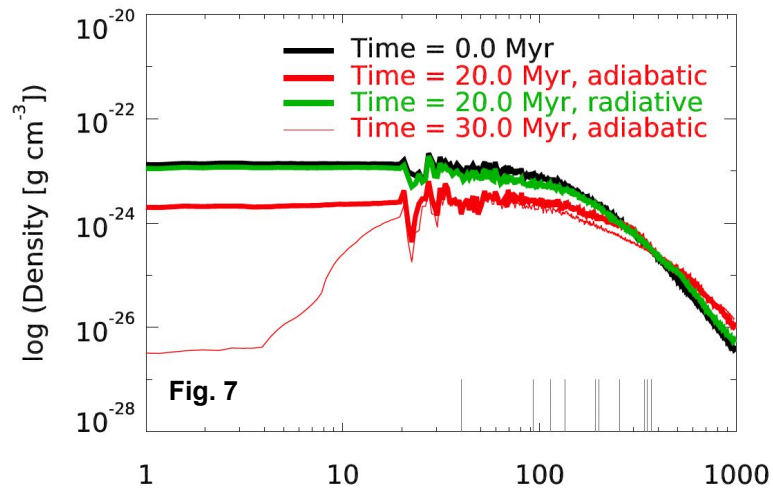


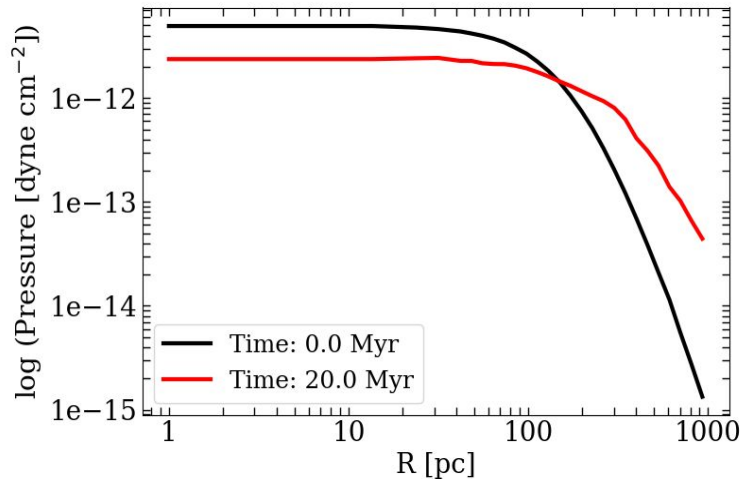
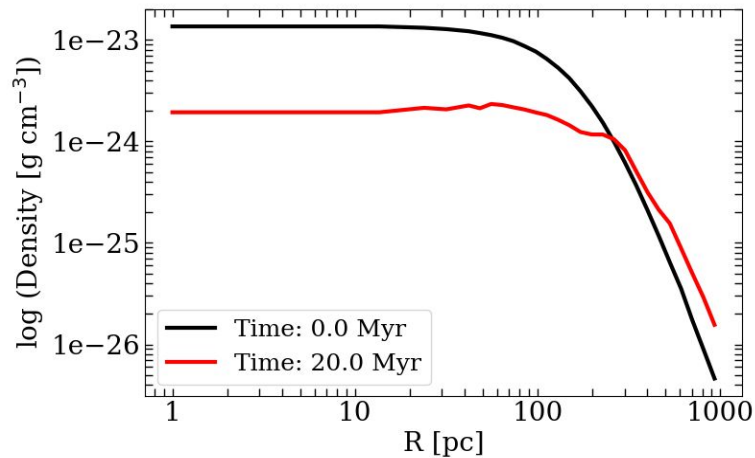
Fig. 1 [Romano+2019](#)

Comparing High and Low-resolution results

Romano+2019

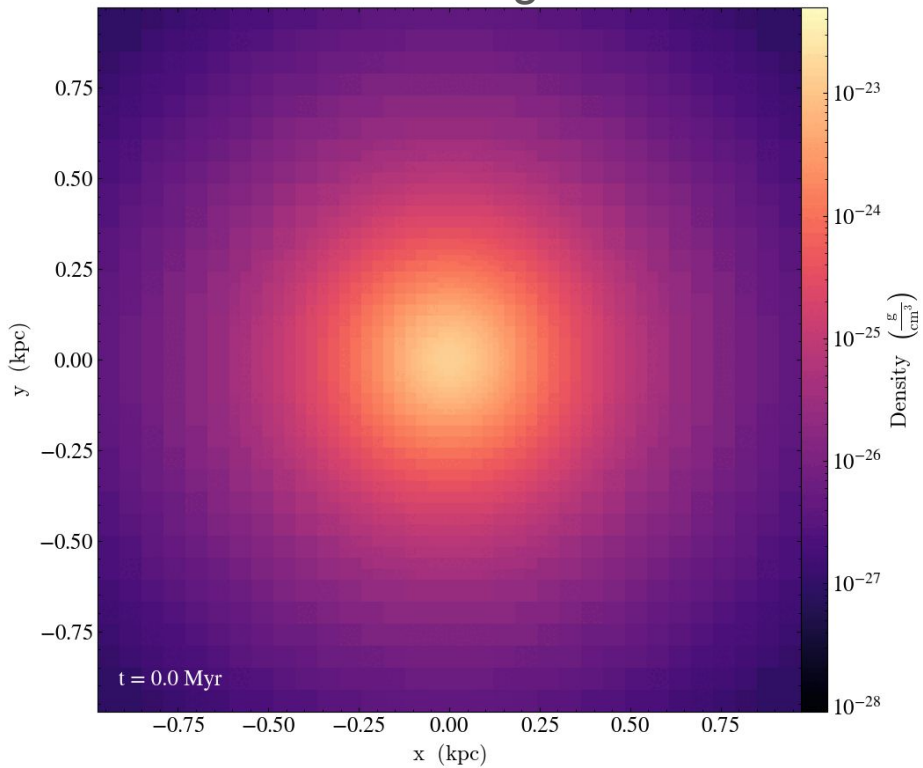


Our results

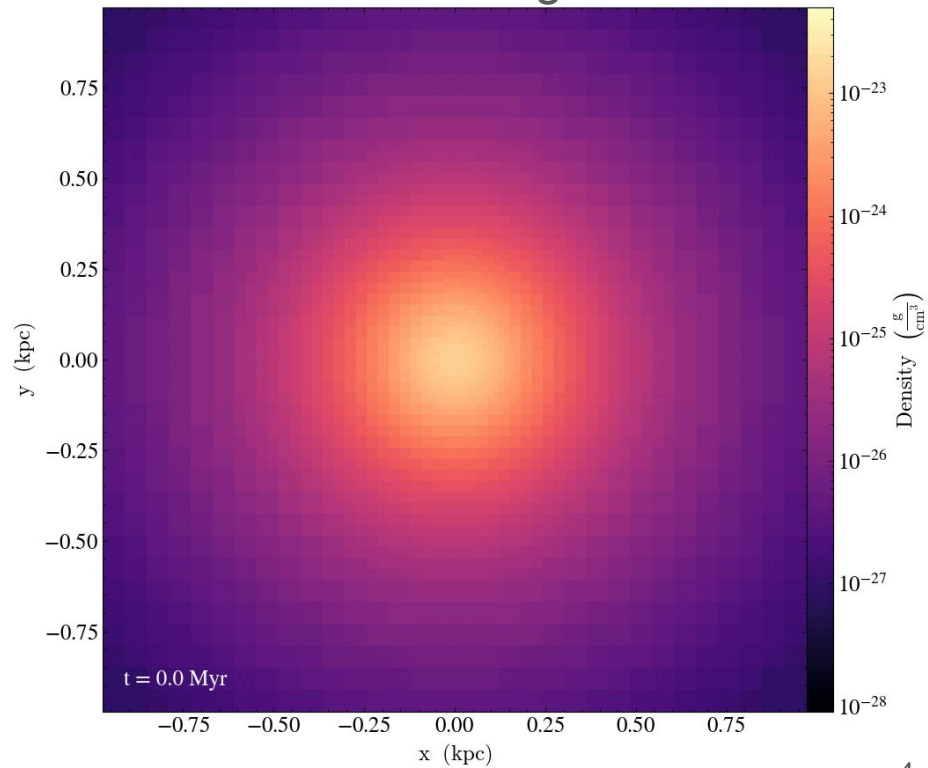


Density movie

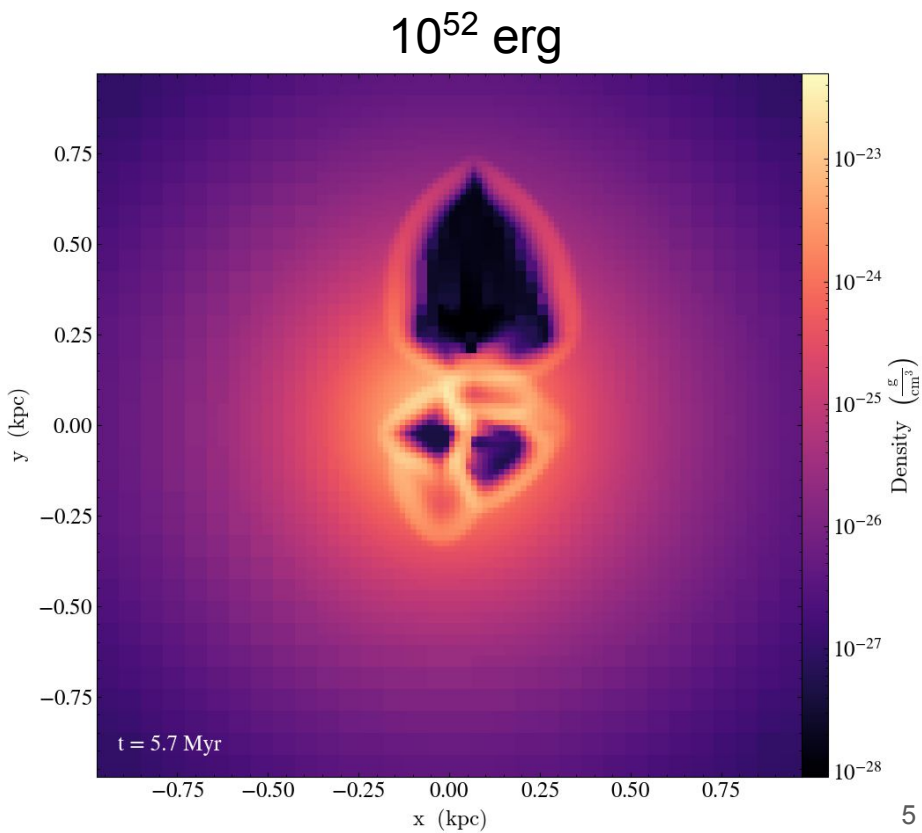
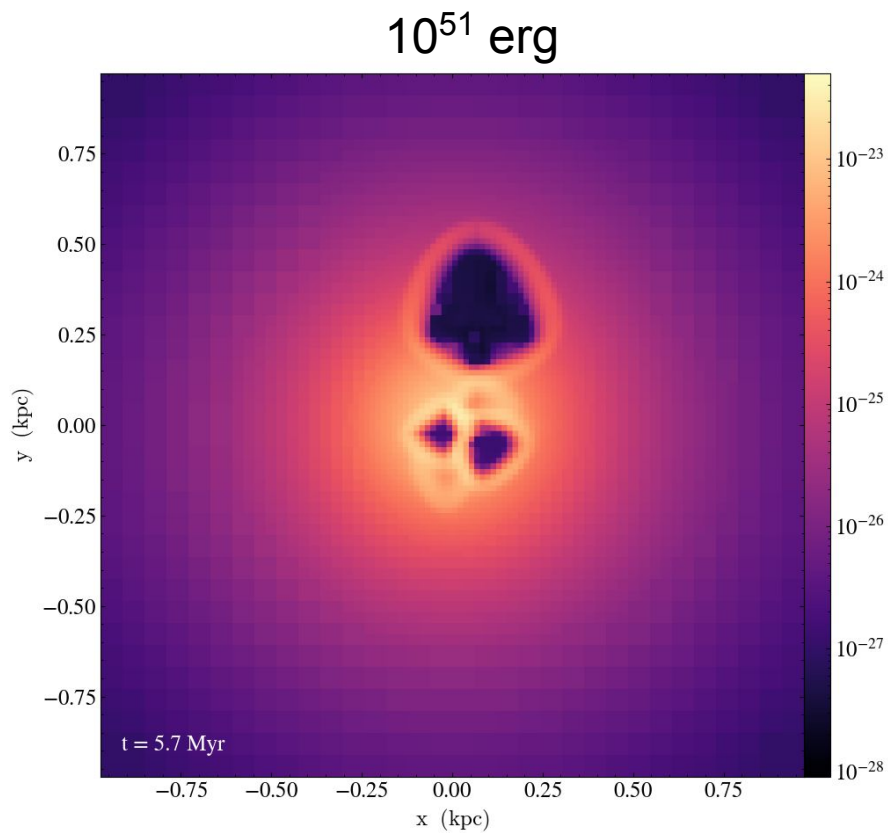
10^{51} erg



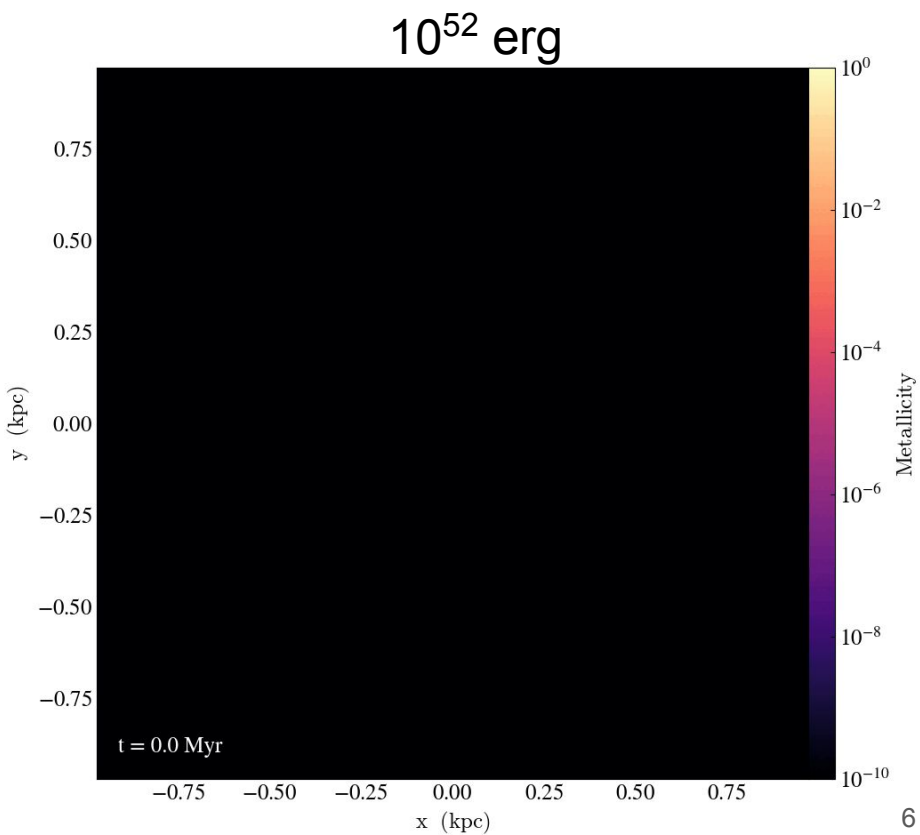
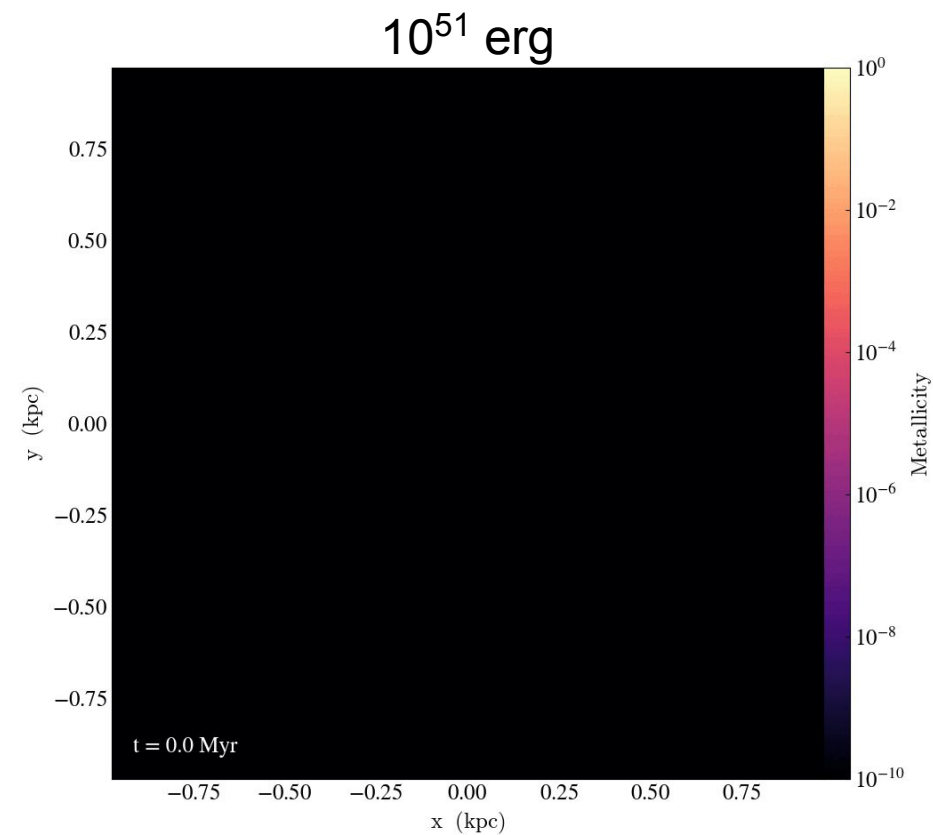
10^{52} erg



Density at 5.7 Myr

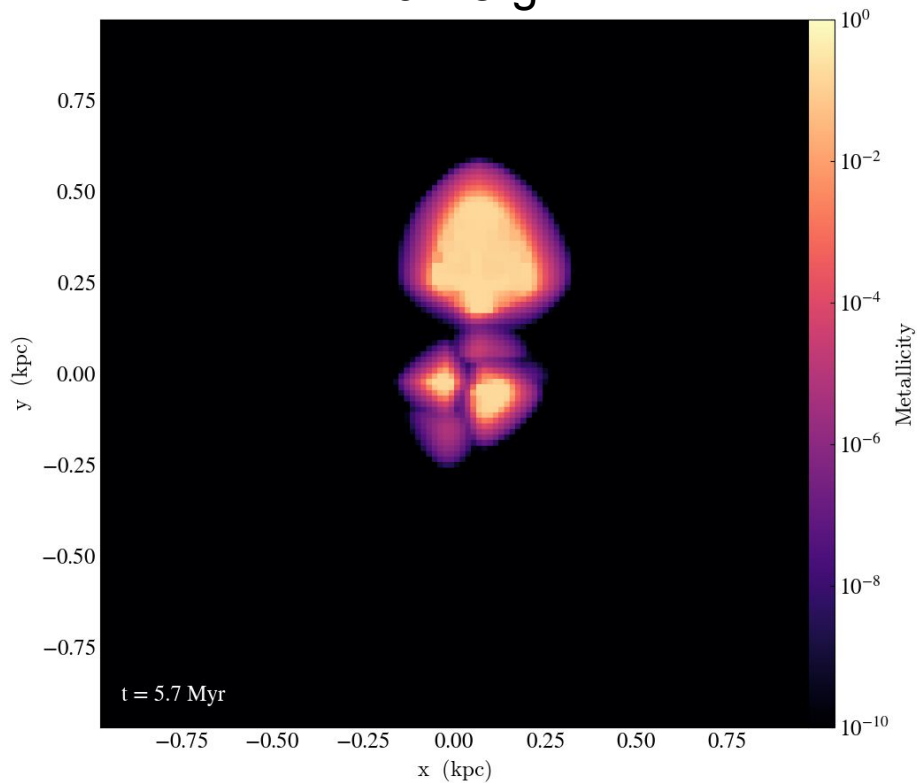


Metallicity movie

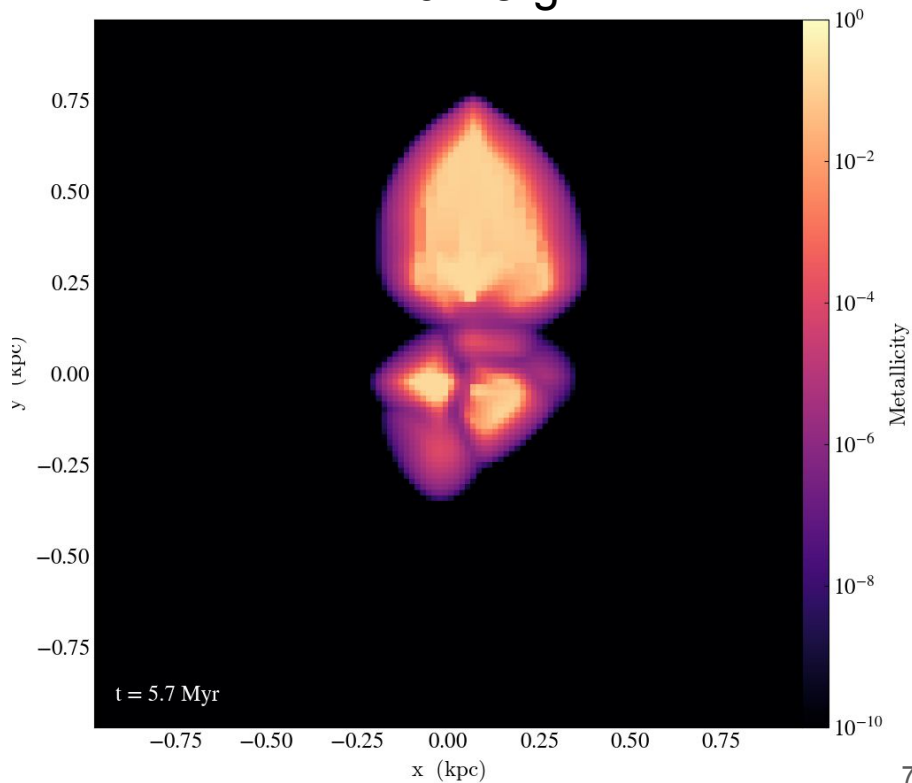


Metallicity at 5.7 Myr

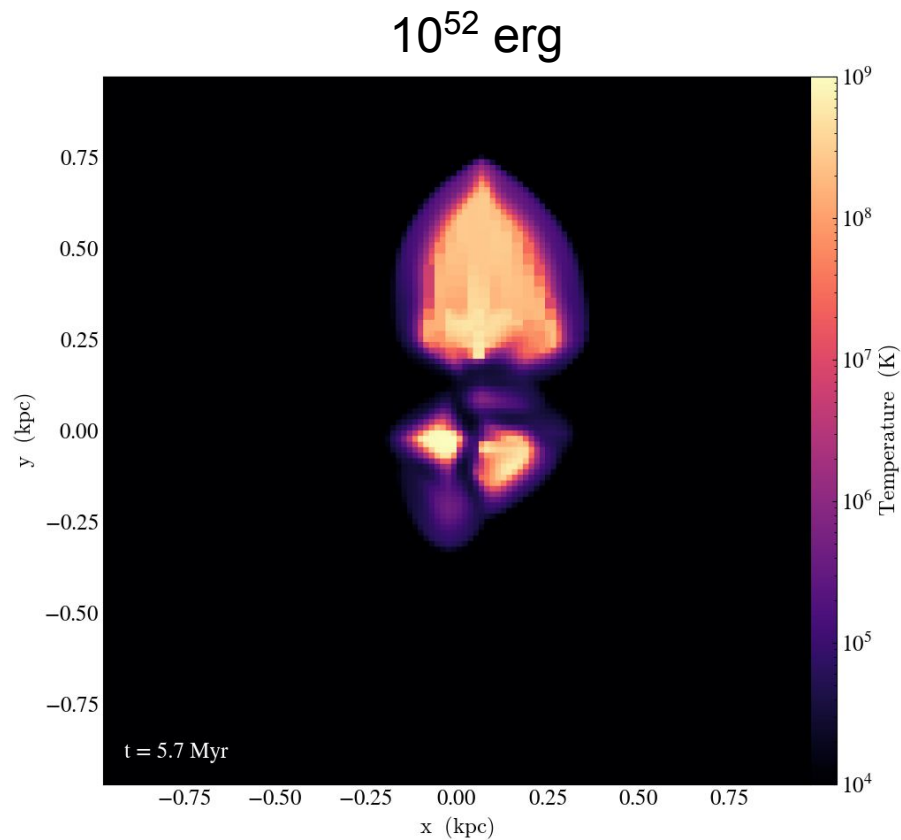
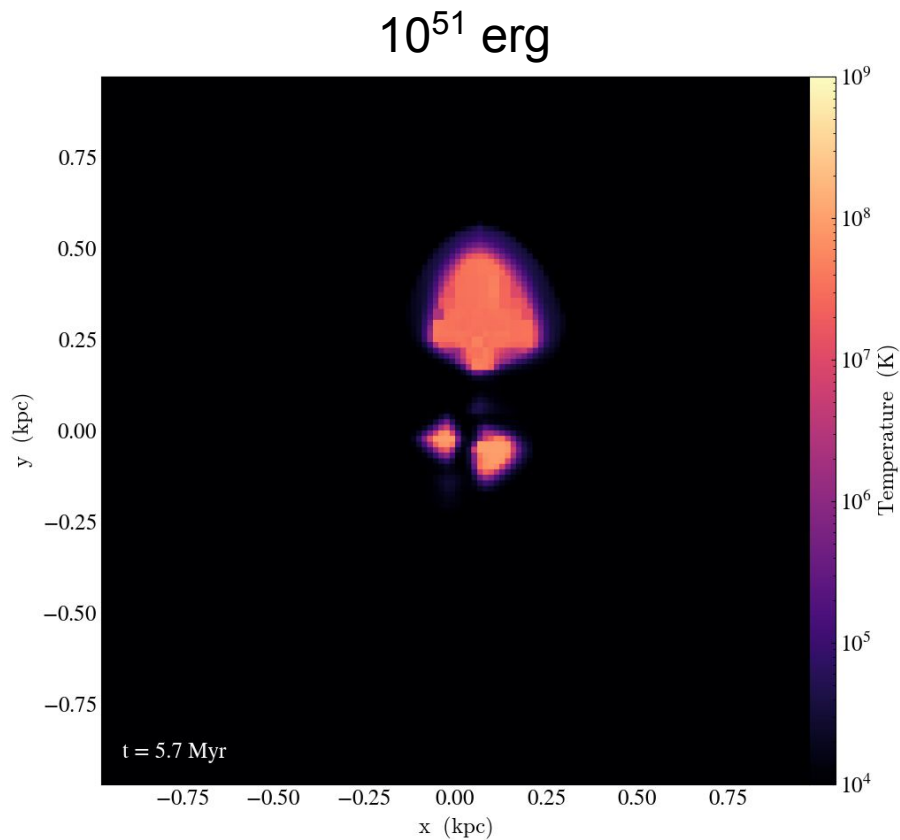
10^{51} erg



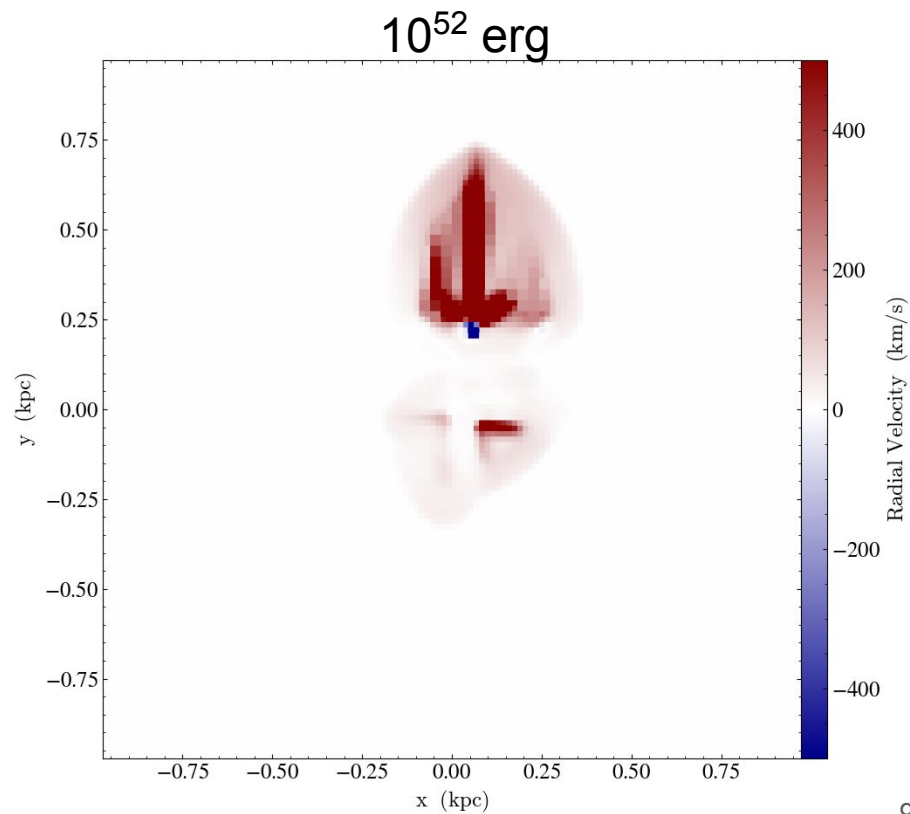
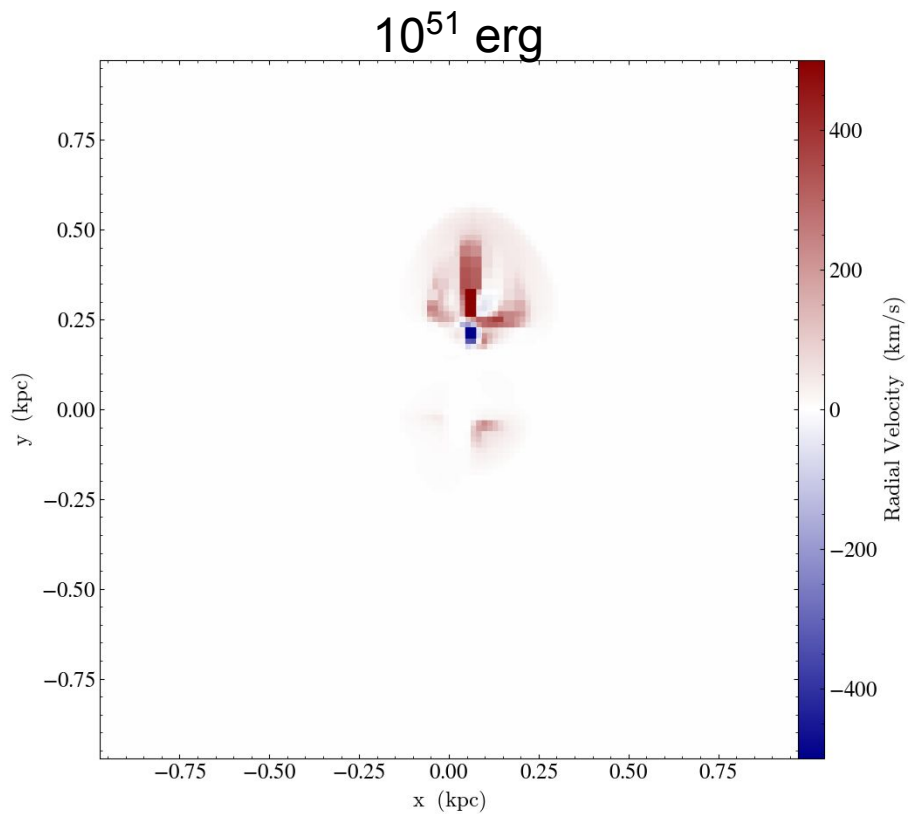
10^{52} erg



Temperature at 5.7 Myr



Radial Velocity at 5.7 Myr



Motivation and simulation set up

Current set up:

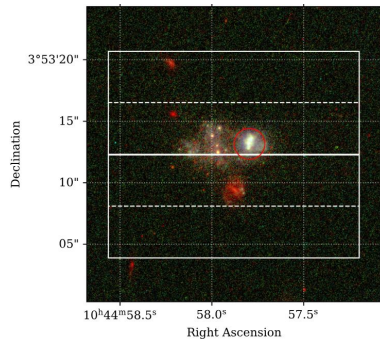
- A non-rotating dwarf galaxy with 10 associations.

New set up:

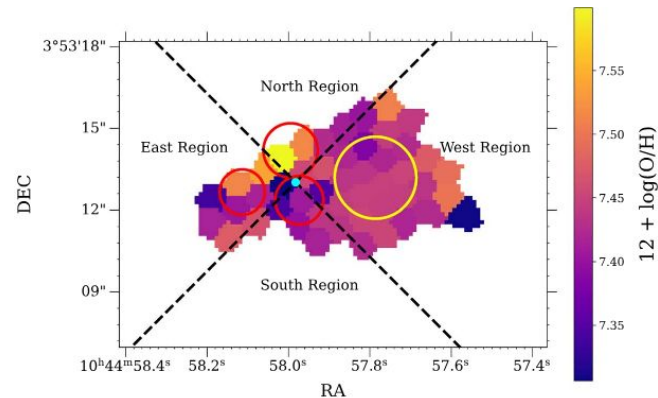
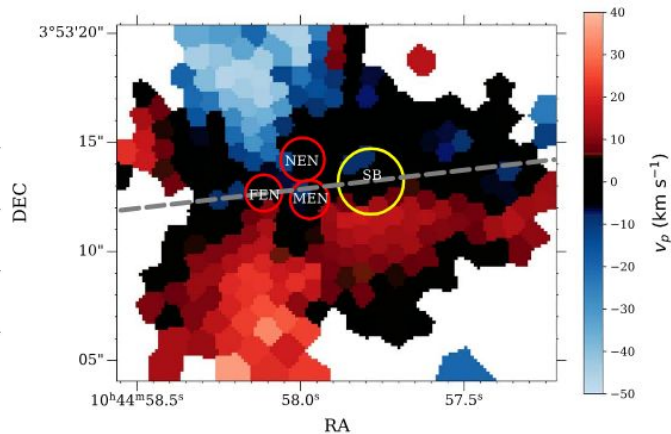
- A rotating galaxy with 2 associations, which are located close to each other and start act with a certain delay (1-20 Myr)

Inspired by

J1044+0353 and **Mrk 71**



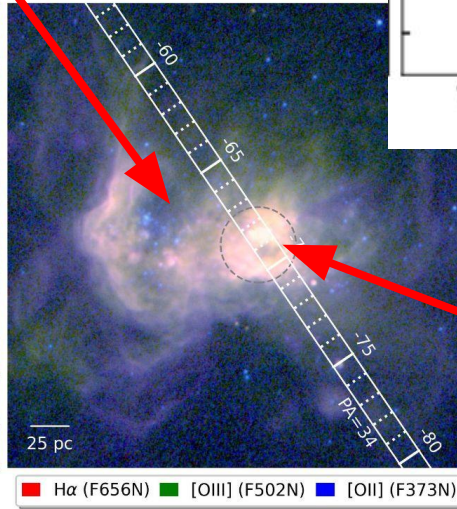
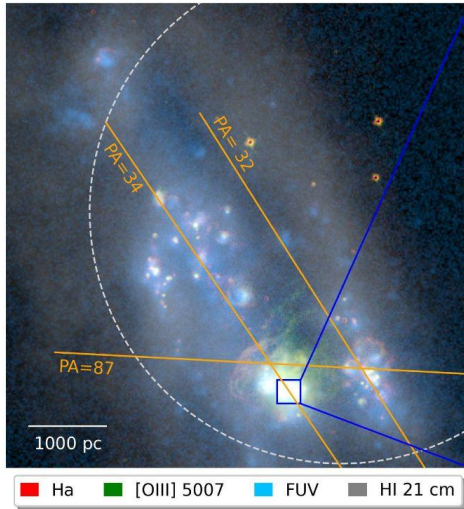
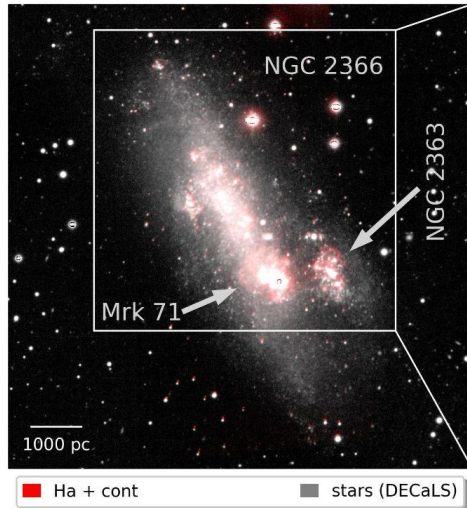
J1044+0353



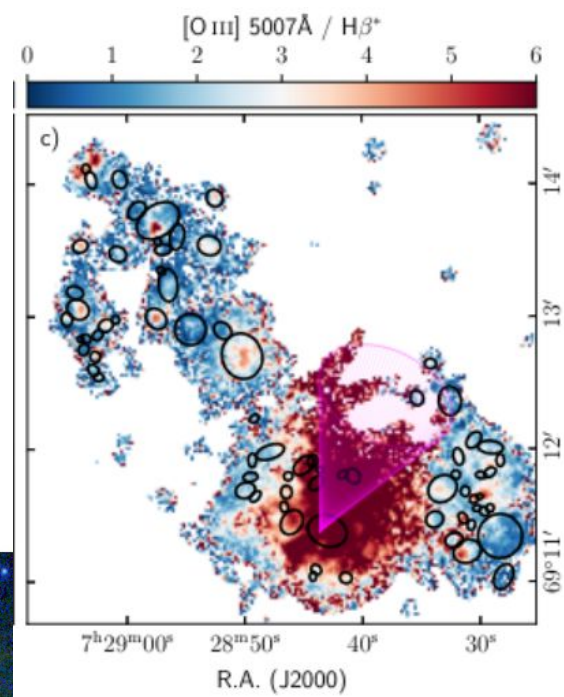
Peng+2023

Motivation and simulation set up

Mrk 71; Yarovova+2025



Cluster 1



Cluster 2

Motivation and simulation set up

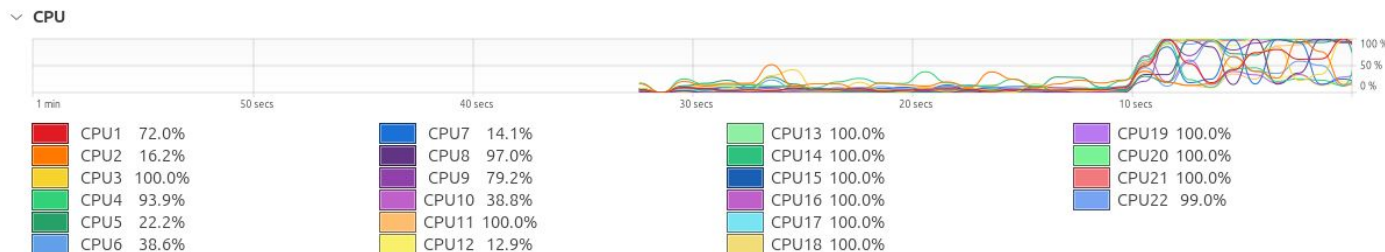
Disc model from
Miyamoto&Nagai 1975:

$$\Phi(R, z) = \frac{GM}{\{R^2 + [a + (z^2 + b^2)^{1/2}]^2\}^{1/2}} \cdot$$

$$\rho(R, z) = \frac{b^2 M}{4\pi} \frac{aR^2 + [a + 3(z^2 + b^2)^{1/2}][a + (z^2 + b^2)^{1/2}]^2}{\{R^2 + [a + (z^2 + b^2)^{1/2}]^2\}^{5/2} (z^2 + b^2)^{3/2}}$$

$$P = \rho(R, z) k_B T / \mu m_H$$

... and a bit of computation with 22 cores:



Some help with fortran from my intelligent friend

fortran

Copy Edit

```
module spherical_integral_module
  implicit none
contains

  function compute_spherical_integral(a, b, R, amcluster) result(total)
    implicit none
    real(8), intent(in) :: a, b, R, amcluster
    real(8) :: total
    integer :: n_rz, n_u

    n_rz = 200 ! Number of rz intervals
    n_u = 100 ! Number of u intervals

    total = 0.5d0 * b**2 * amcluster * simpson_rz(-R, R, n_rz, a, b, R, n_u)
  end function compute_spherical_integral

  ! Integrate over rz using Simpson's rule
  function simpson_rz(a_rz, b_rz, n, a, b, R, nu) result(res)
    implicit none
    integer, intent(in) :: n, nu
    real(8), intent(in) :: a_rz, b_rz, a, b, R
    real(8) :: res, h, rz
    integer :: i

    h = (b_rz - a_rz) / dble(n)
    res = inner_integral(a_rz, a, b, R, nu) + inner_integral(b_rz, a, b, R, nu)
```

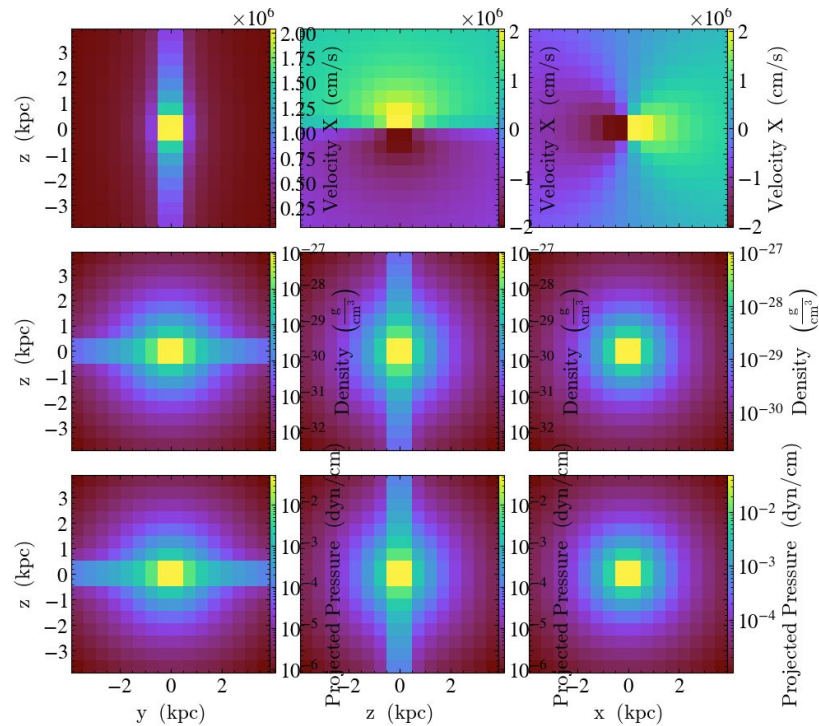
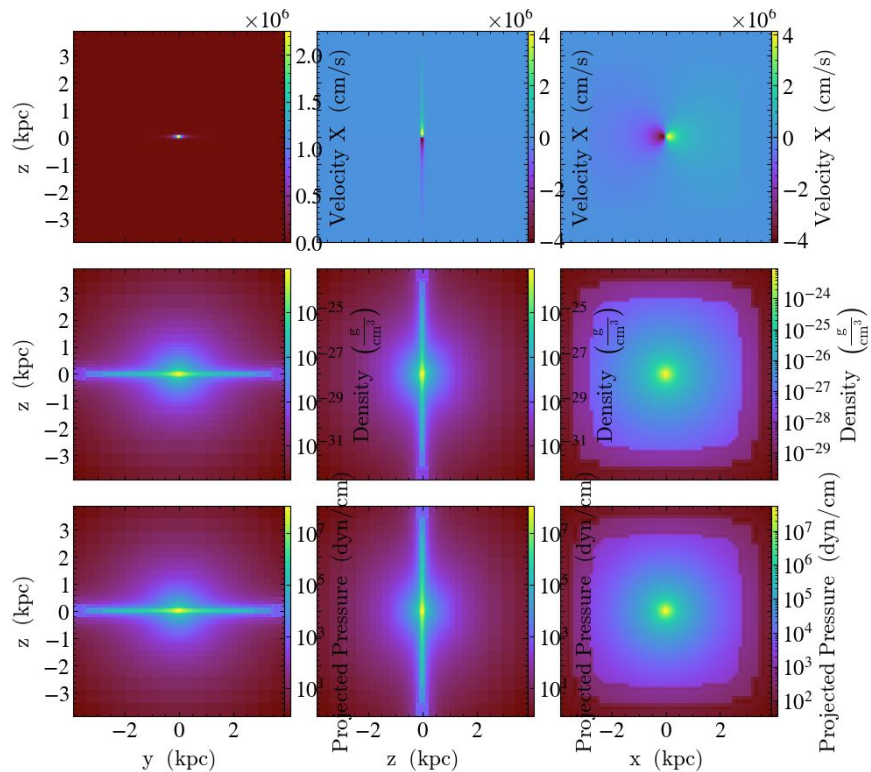
```
! Integrate over rz using Simpson's rule
function simpson_rz(a_rz, b_rz, n, a, b, R, nu) result(res)
  implicit none
  integer, intent(in) :: n, nu
  real(8), intent(in) :: a_rz, b_rz, a, b, R
  real(8) :: res, h, rz
  integer :: i

  h = (b_rz - a_rz) / dble(n)
  res = inner_integral(a_rz, a, b, R, nu) + inner_integral(b_rz, a, b, R, nu)
```

And from responsive people:

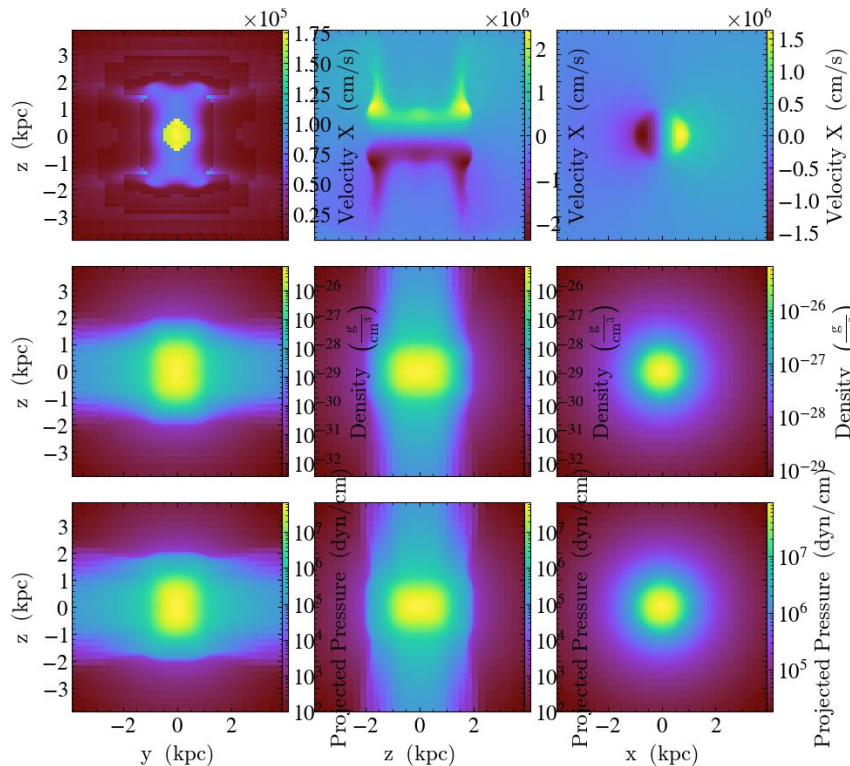


Results: initial conditions

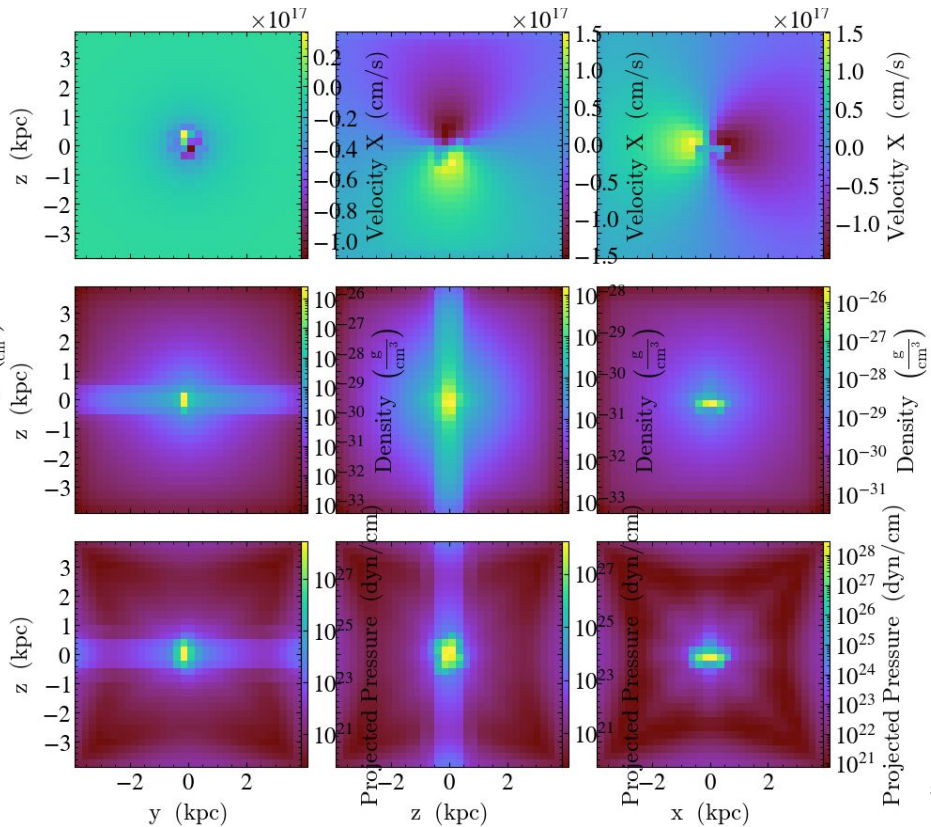


Results: it is not straightforward how to put disc in equilibrium

Some bugs in the code:



Some other bugs in the code:



Thank you for your attention!

Спасибо за внимание!

Vielen Dank für Ihre Aufmerksamkeit!

Gracias por su atención!

