Study of thermonuclear explosions of white dwarfs

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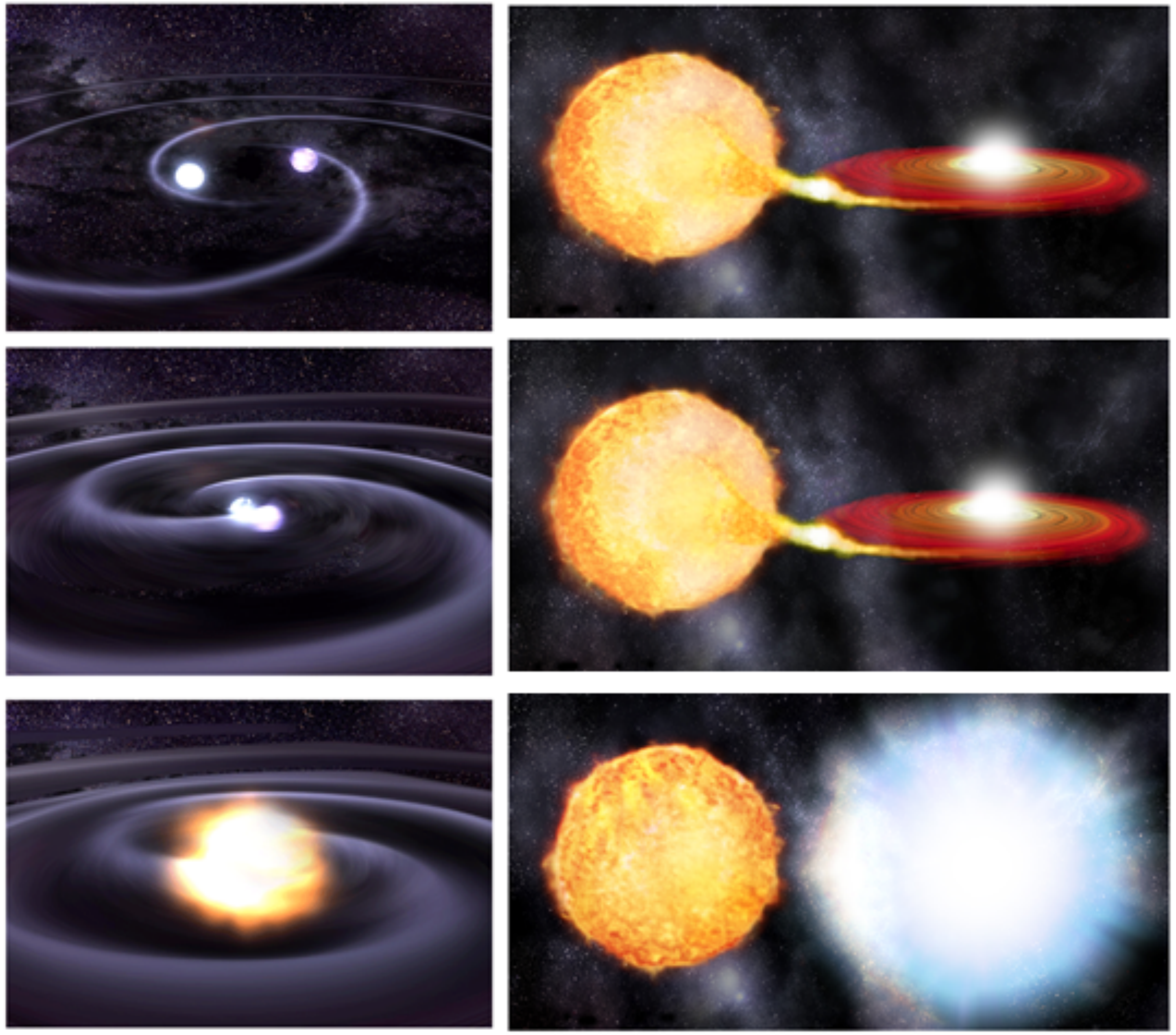
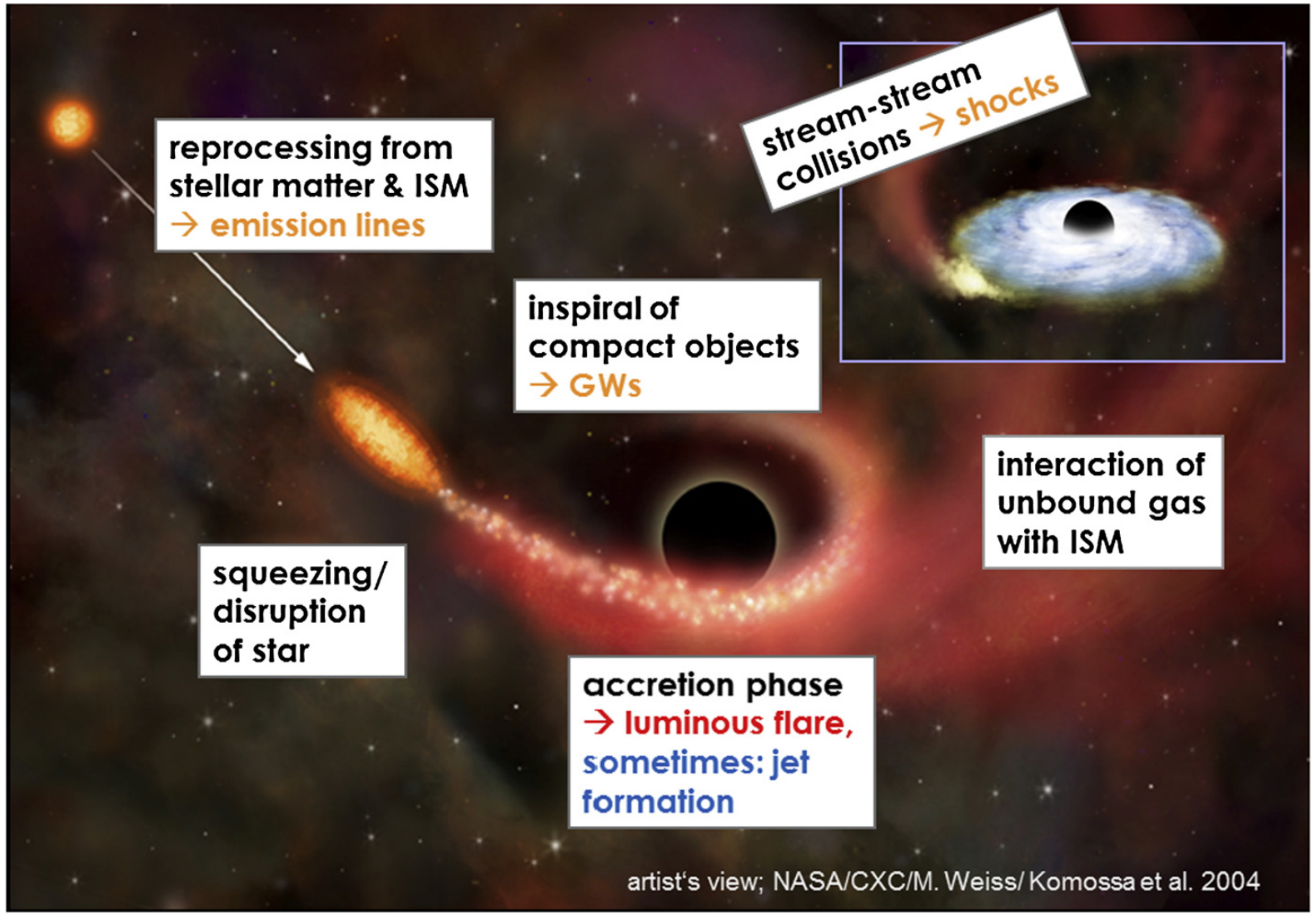
White dwarf (WD) explosion

Type Ia supernovae

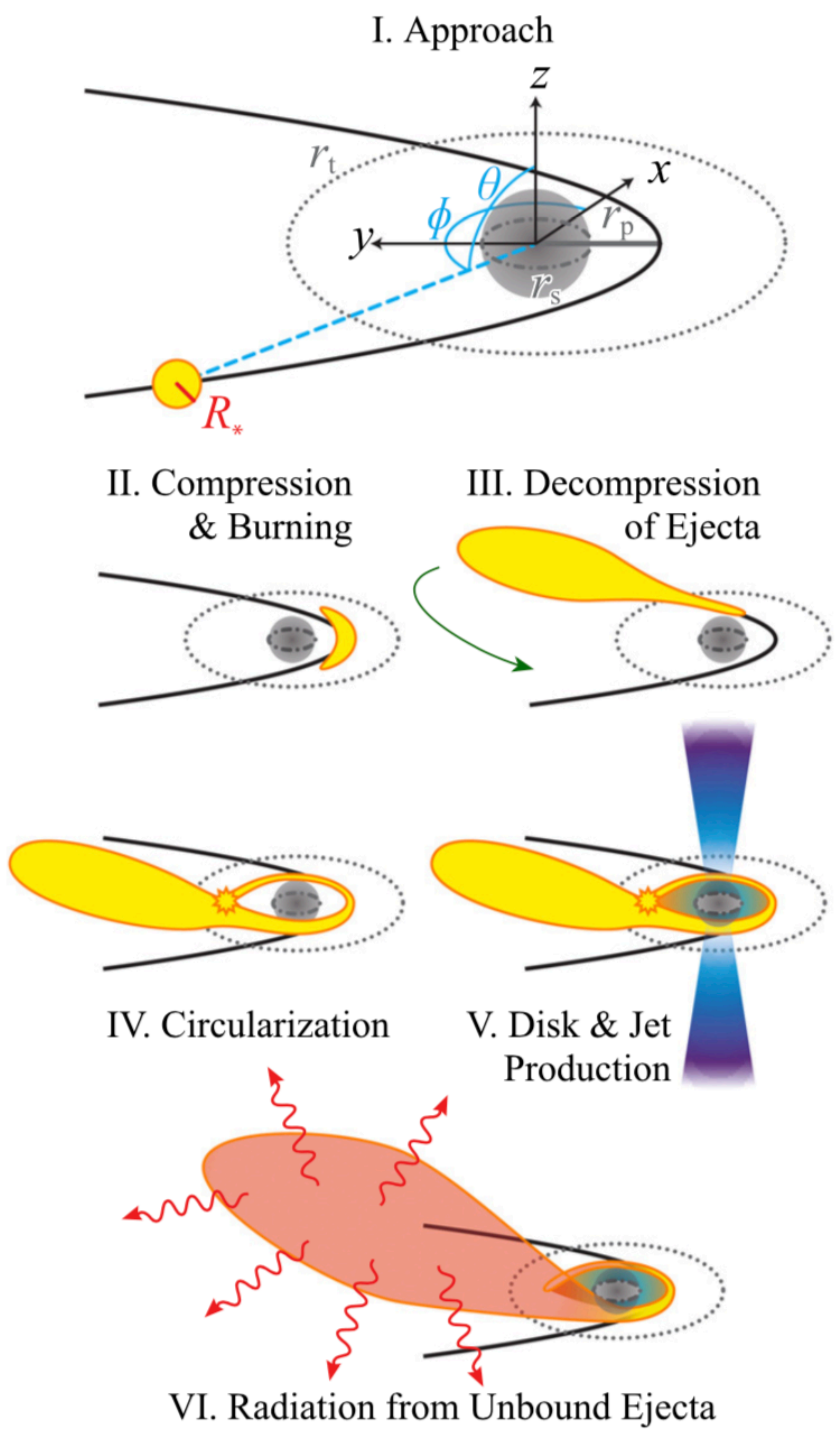


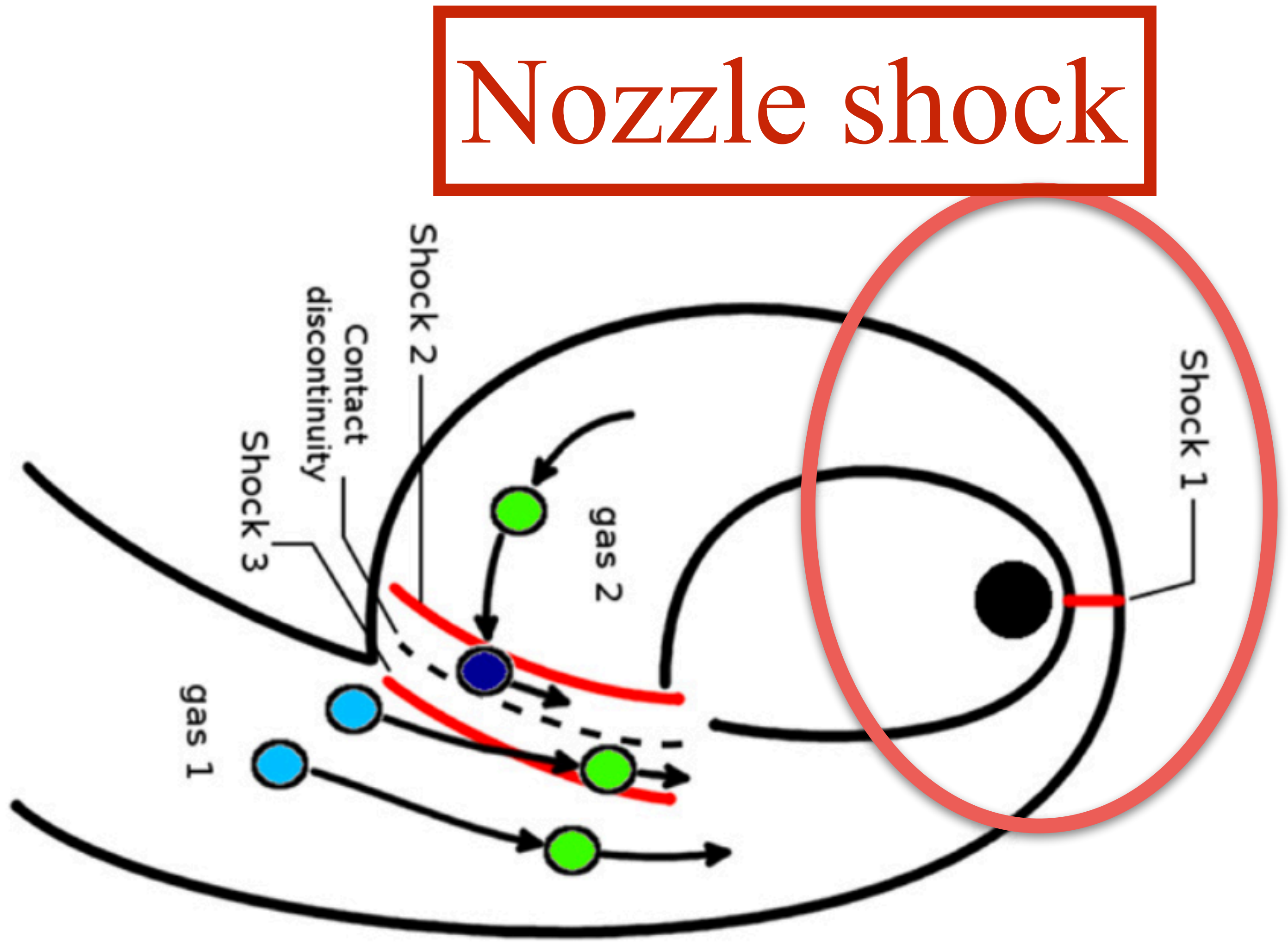
WD Tidal disruption event (TDE)



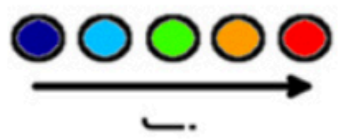
Shock heating

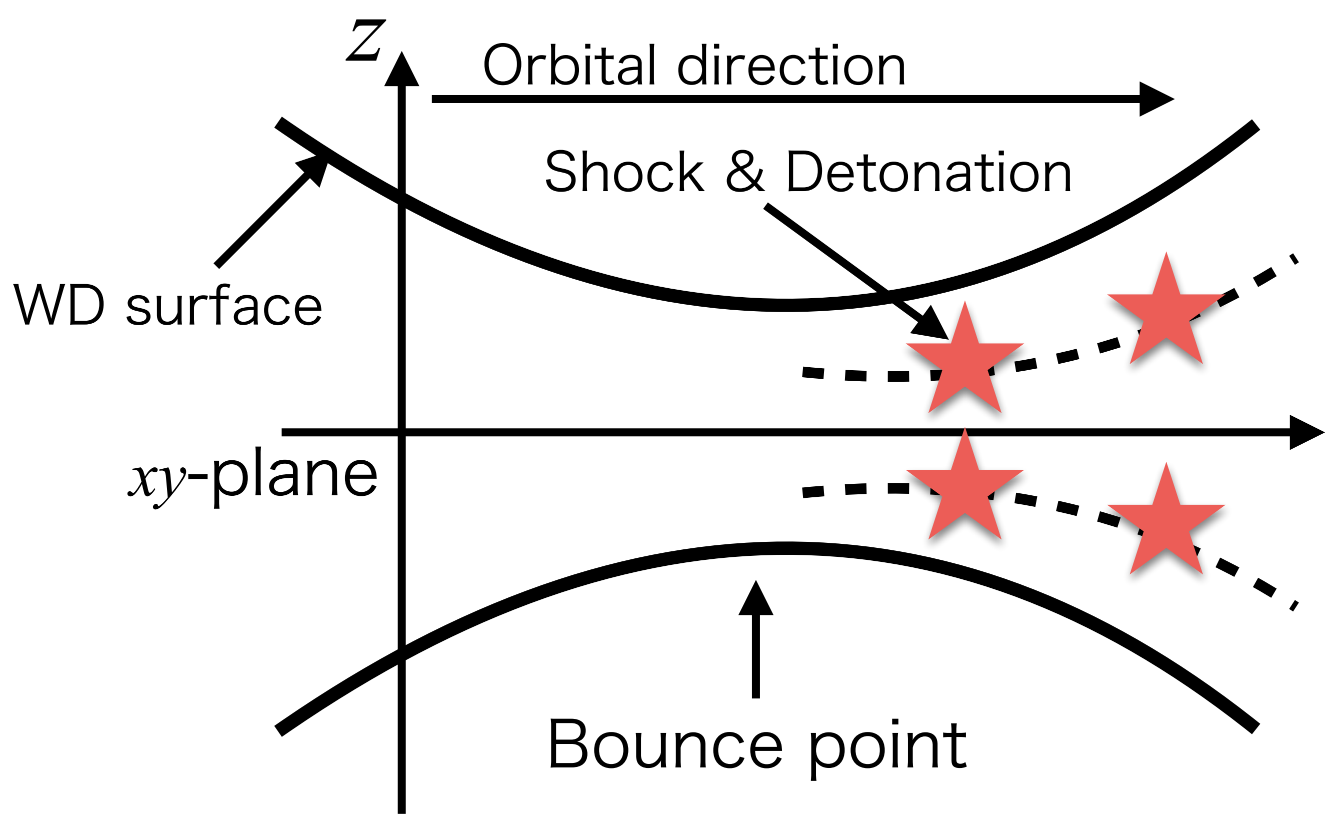
- Thermonuclear explosion requires shock heating.
- The first shock heating occurs by nozzle shock.





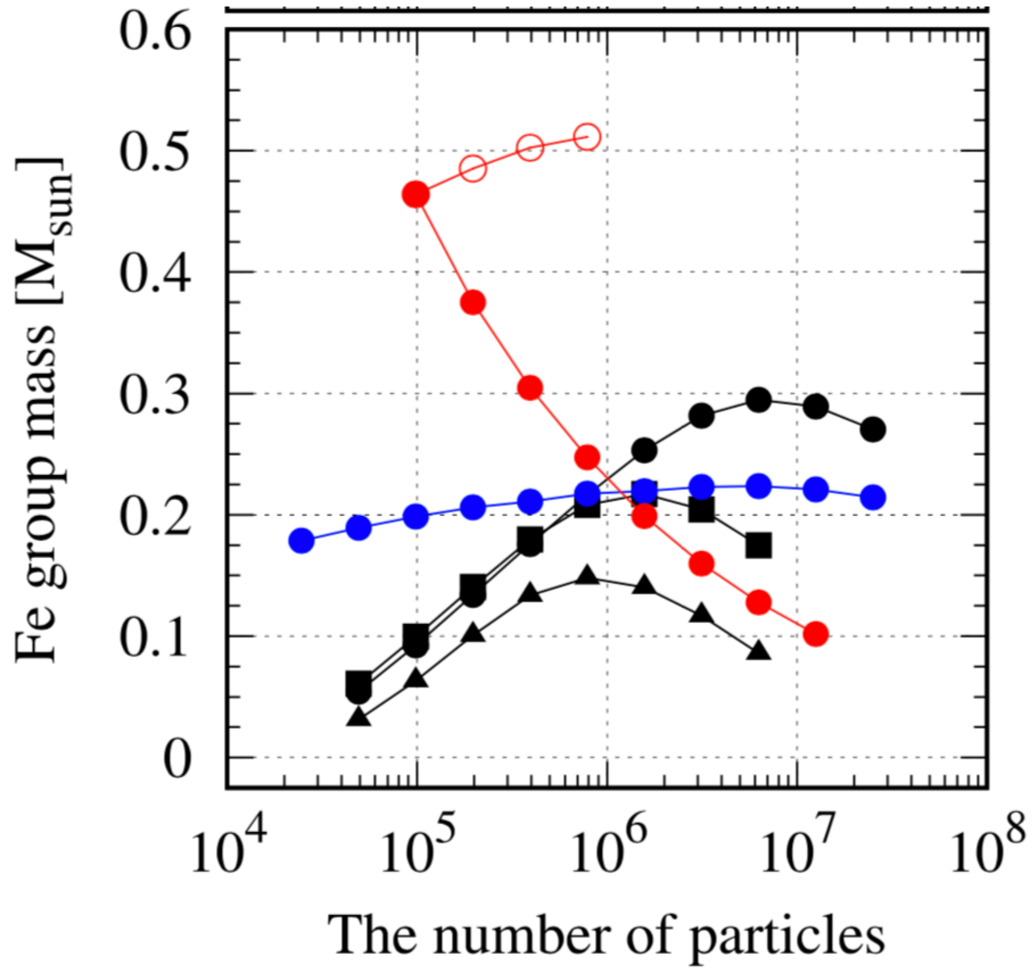
Shiokawa et al. (2015)

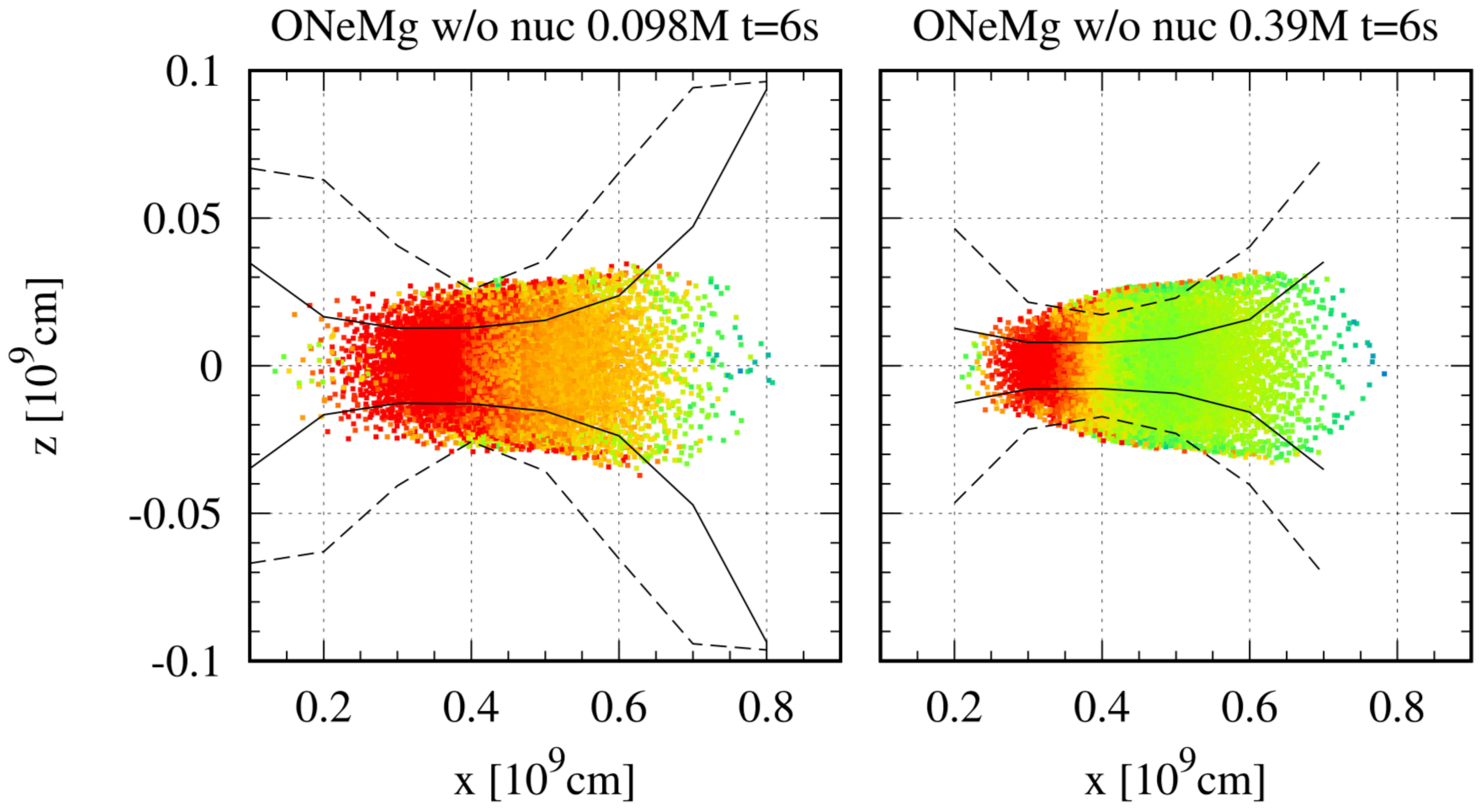




3D simulation

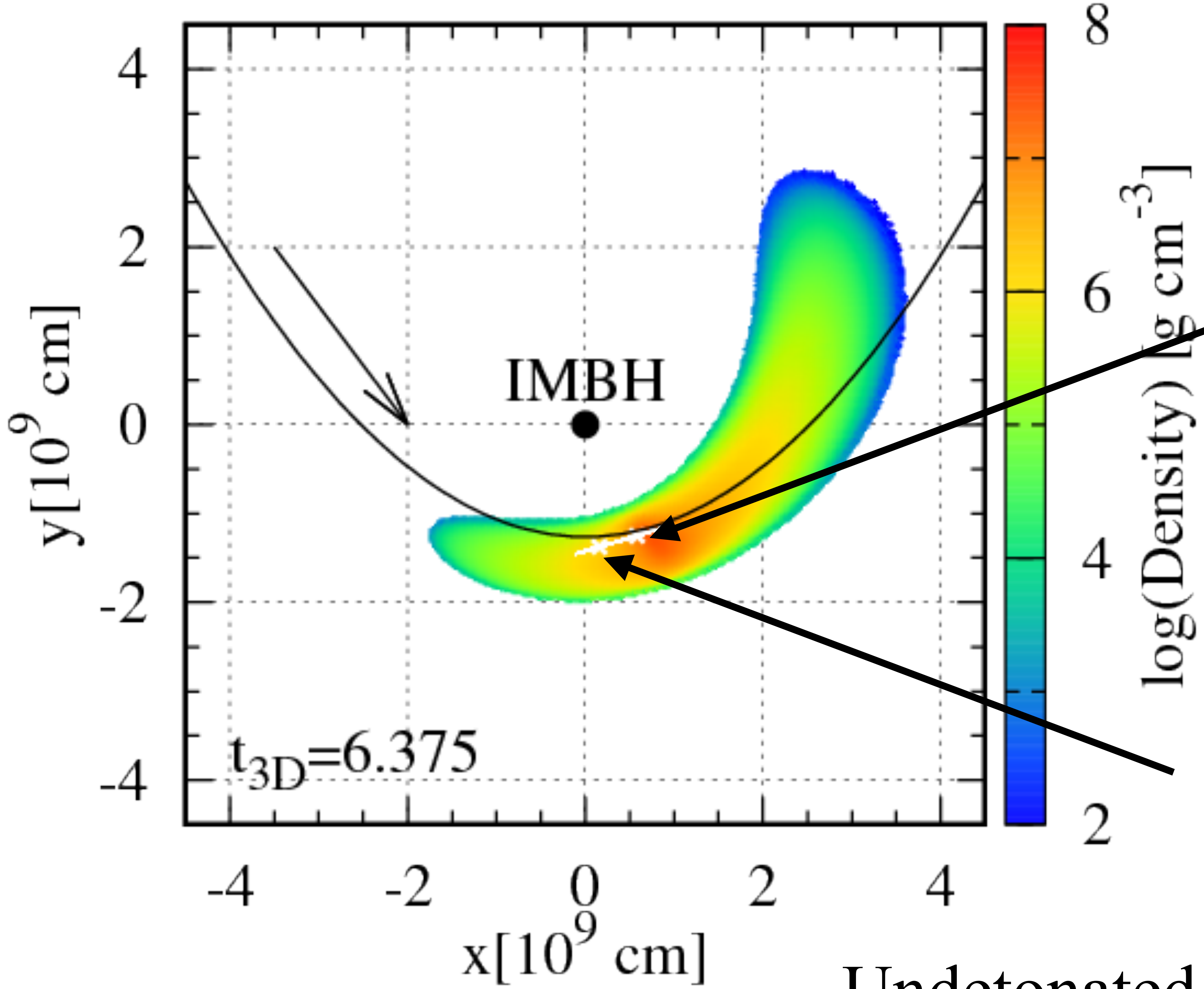
- 3D (SPH) simulation fails to capture nozzle shock.
- The scale height around the nozzle becomes smaller than the resolution size.



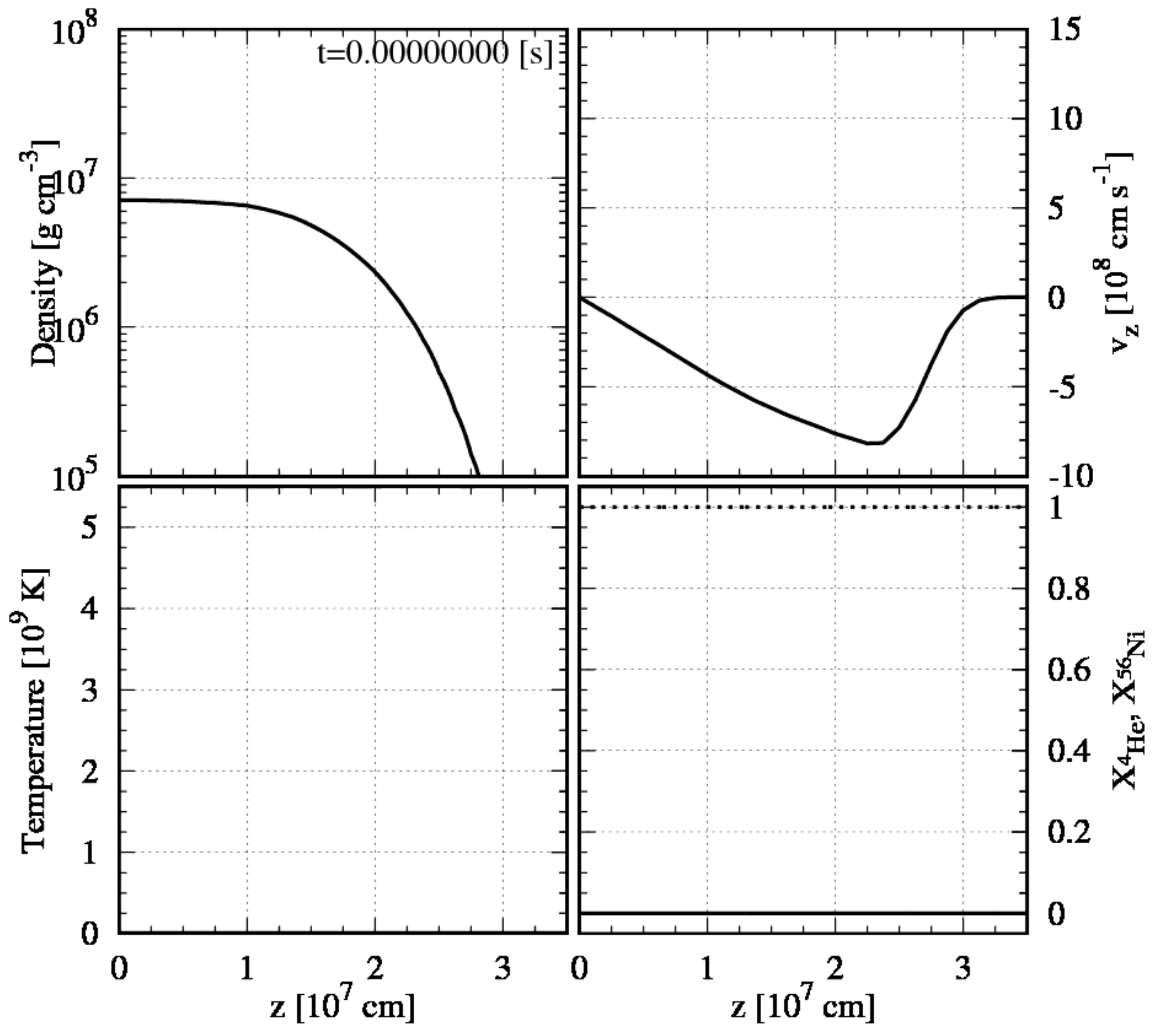


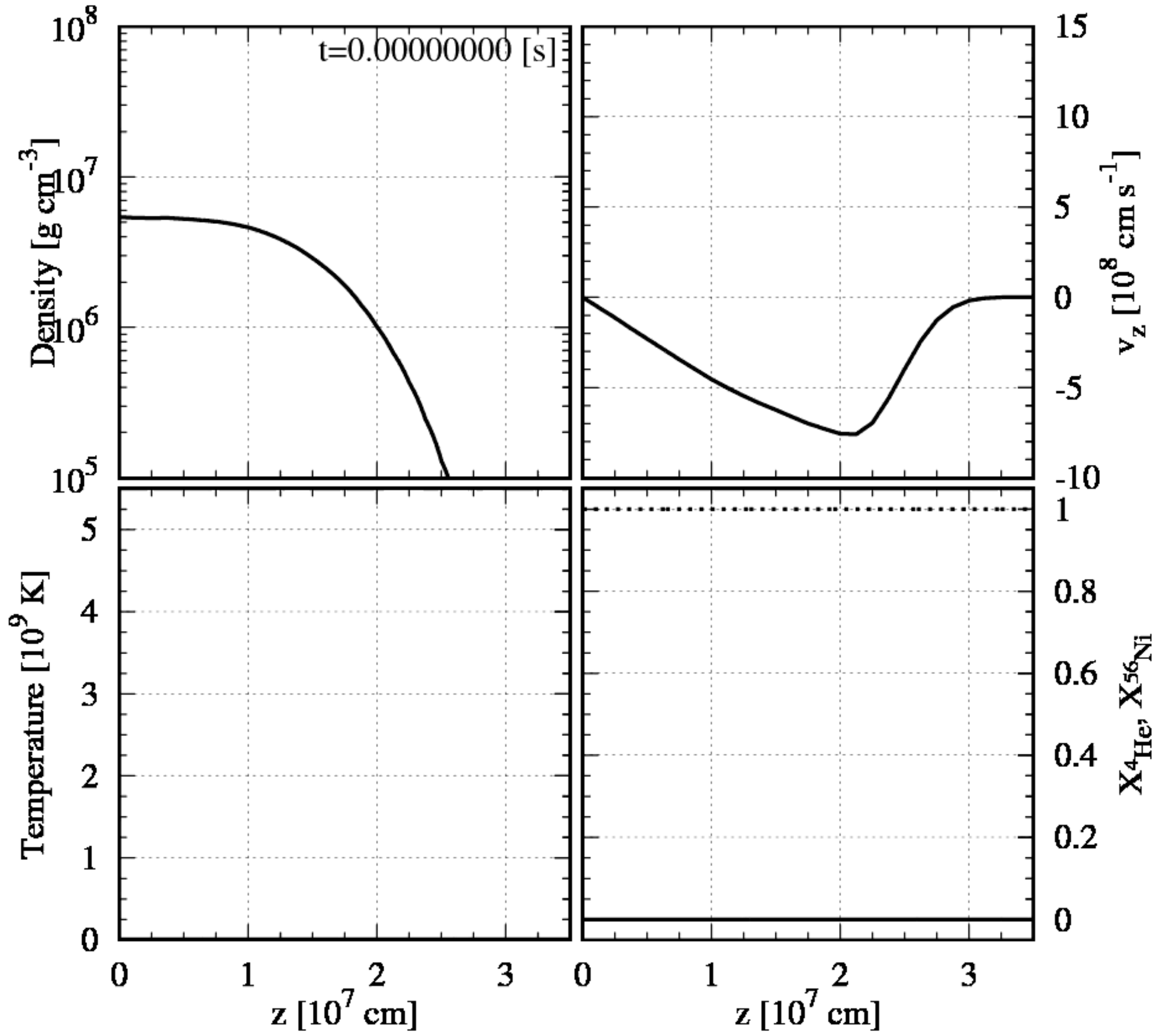
Tanikawa et al. (2017, ApJ, 839, 81)

Previous work (1D simulation)



Successfully detonated





Undetonated

Tanikawa (2018, ApJ, 858, 26; 2018, MNRAS, 475, 67)

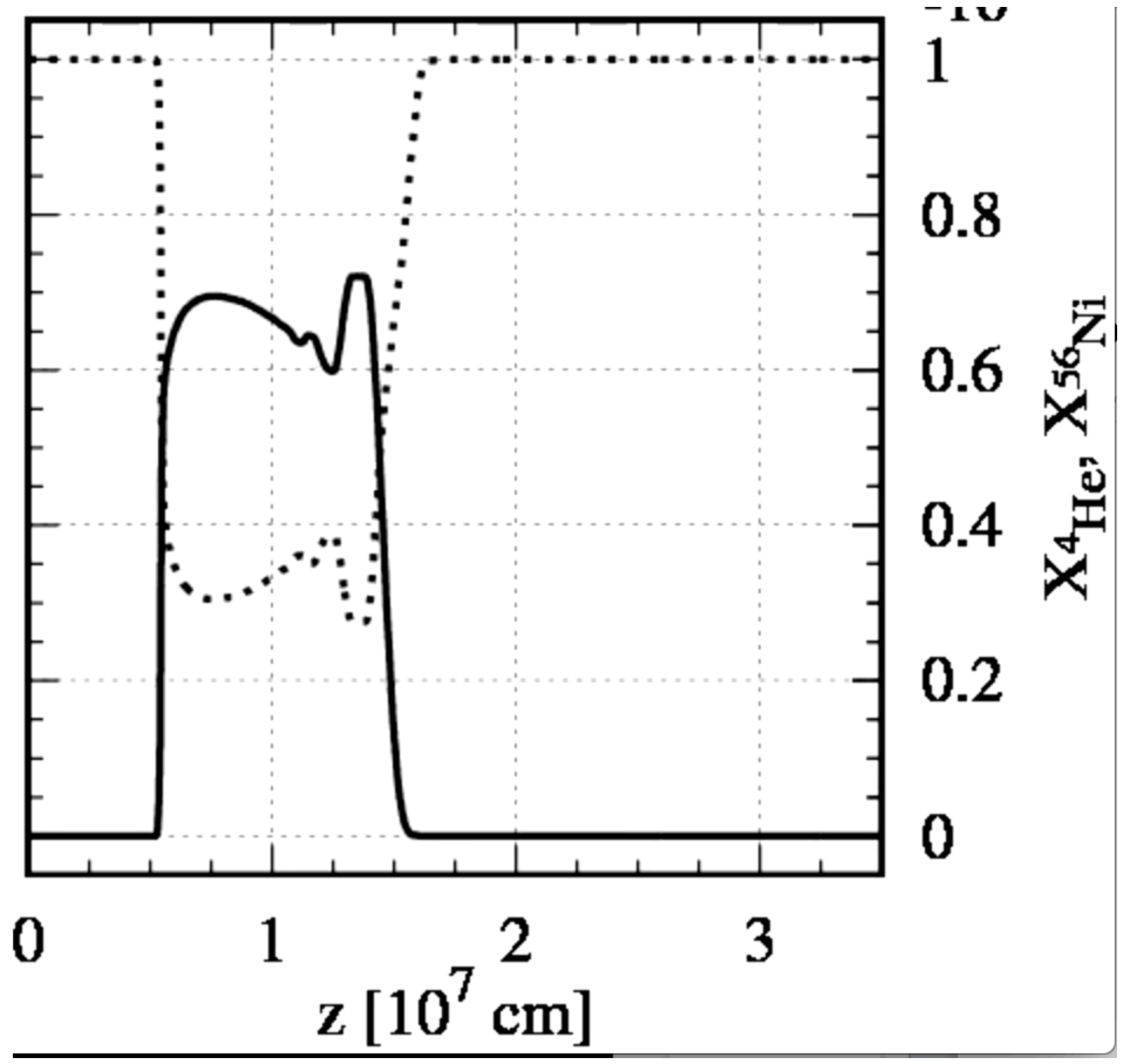
Results

IMBH
t_{3D}=6.375
x[10^9 cm]
y[10^9 cm]
log(Density) [g cm^{-3}]
log(ρ)
log(T)
$v_s/10^9$
$v_z/10^9$
log(X_{He})
log(X_{Ca})
log($X_{^{44}Ti}+X_{^{48}Cr}+X_{^{52}Fe}$)
log(X_{56})
z [10^8 cm]
s [10^8 cm]

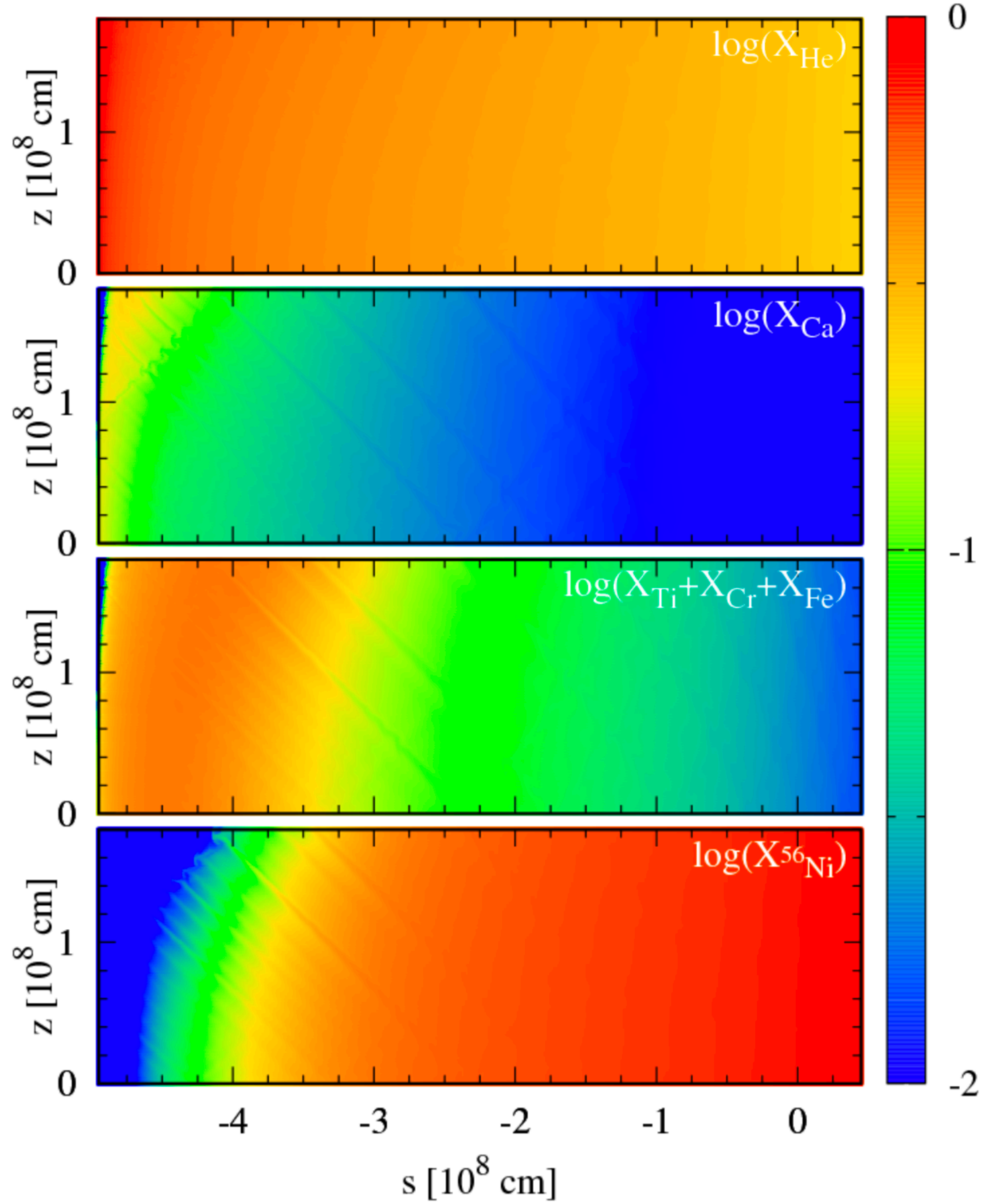
Detonation

- Detonation continues to the trailing part.
- The previous 1D simulation can produce only ^{56}Ni.
  - The 2D simulation can yield not only ^{56}Ni, but also lighter elements, such as Ca, Ti, Cr, and Fe.
  - This results are helpful to identify He WD TDEs.

1D case



2D case



MHD simulation in the Galactic center (GC) region

(Magnetohydrodynamics)

(Kakiuchi et al. in prep.)

Aim: Clarification of Magnetic activity
in the GC region (R~100pc)

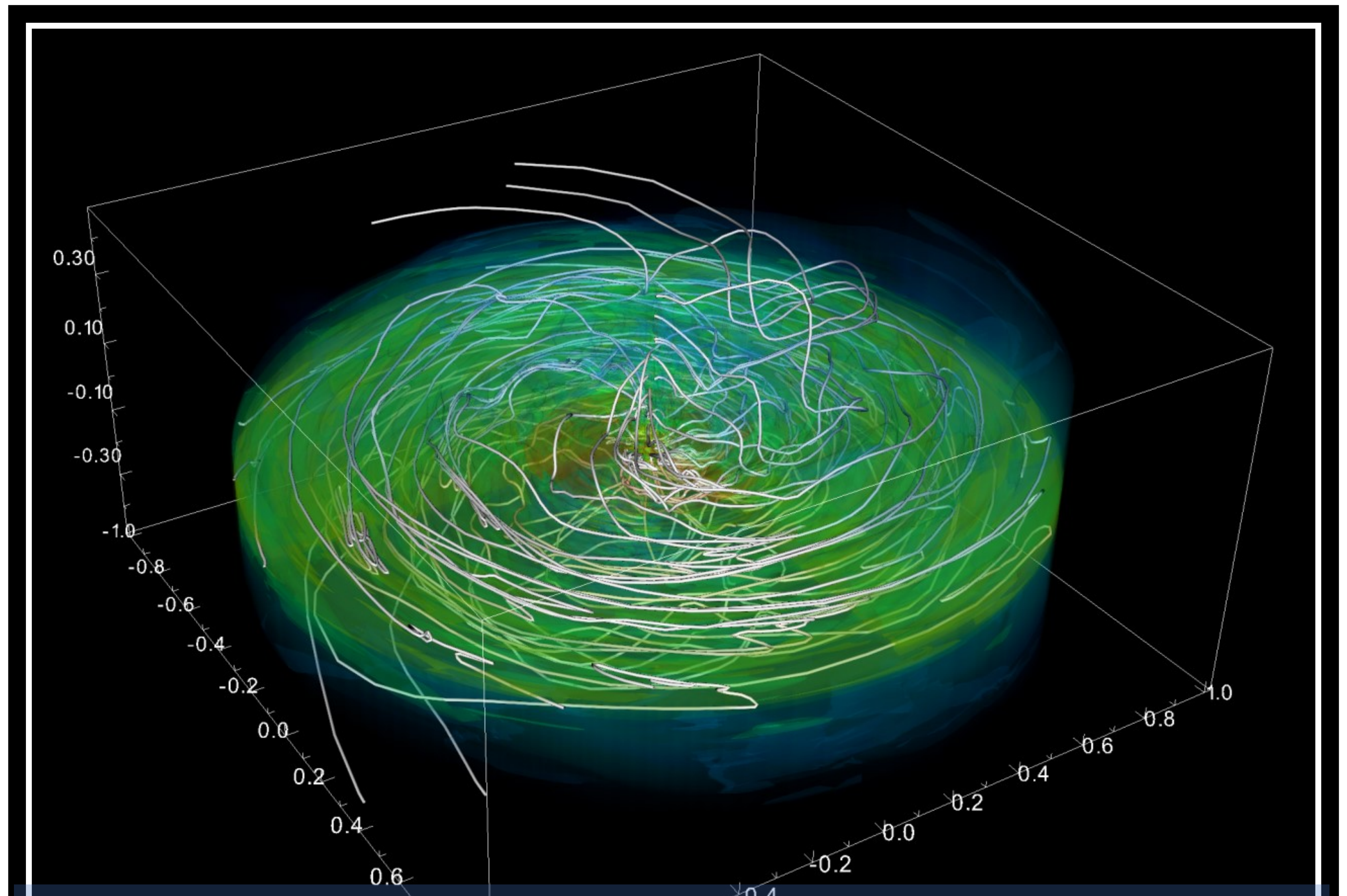
Observations of the magnetic field

- ✓ ~0.05-0.1mG (in average)
- ✓ ~1.0 mG (at local dark cloud)

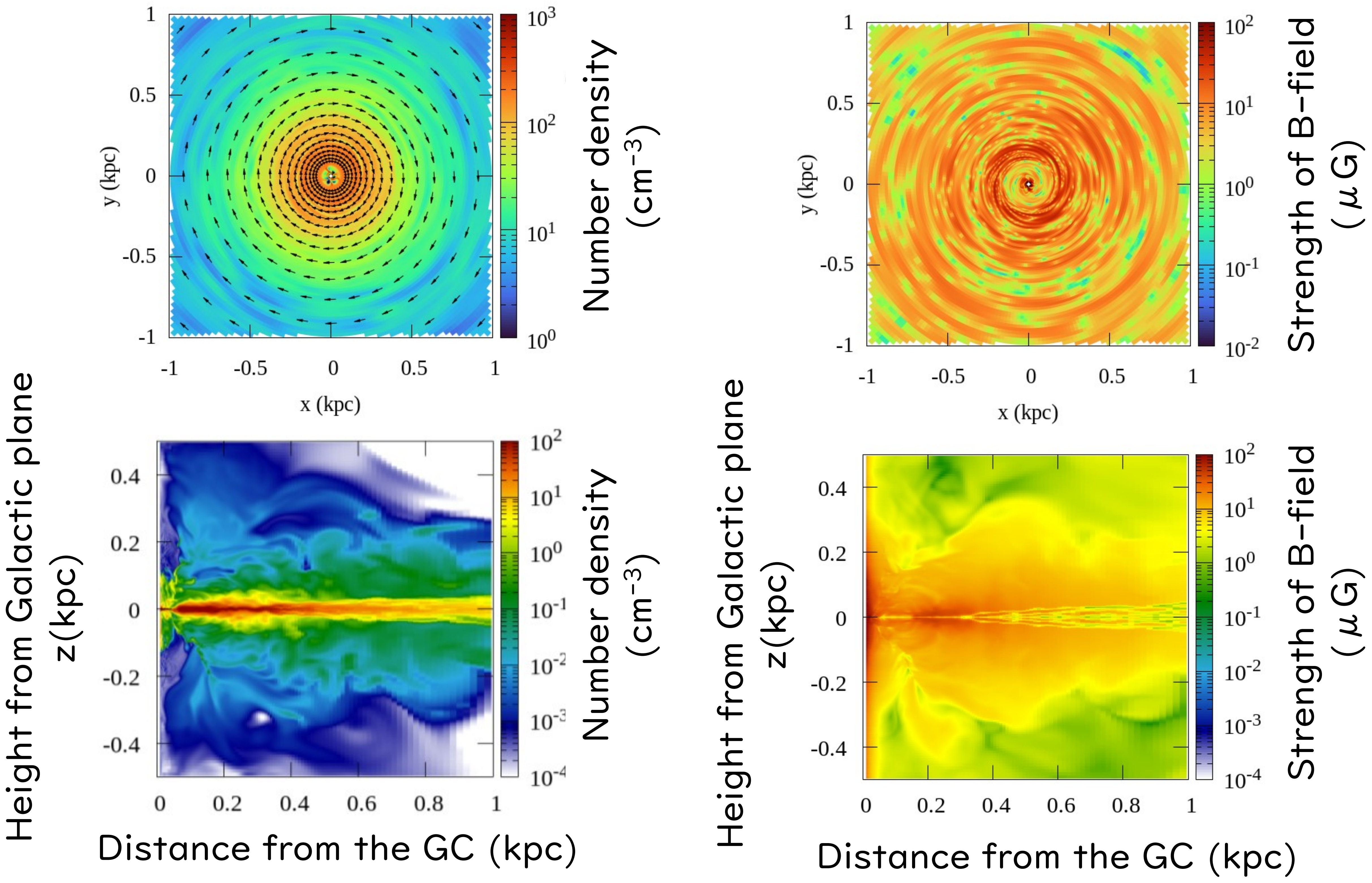
Magnetic energy ~ Thermal energy

Development of this numerical code, one of the few examples in the world

Global 3D-MHD simulation
+ Radiative cooling & heating



Reproduction of the environment of the magnetic field roughly consistent with observations



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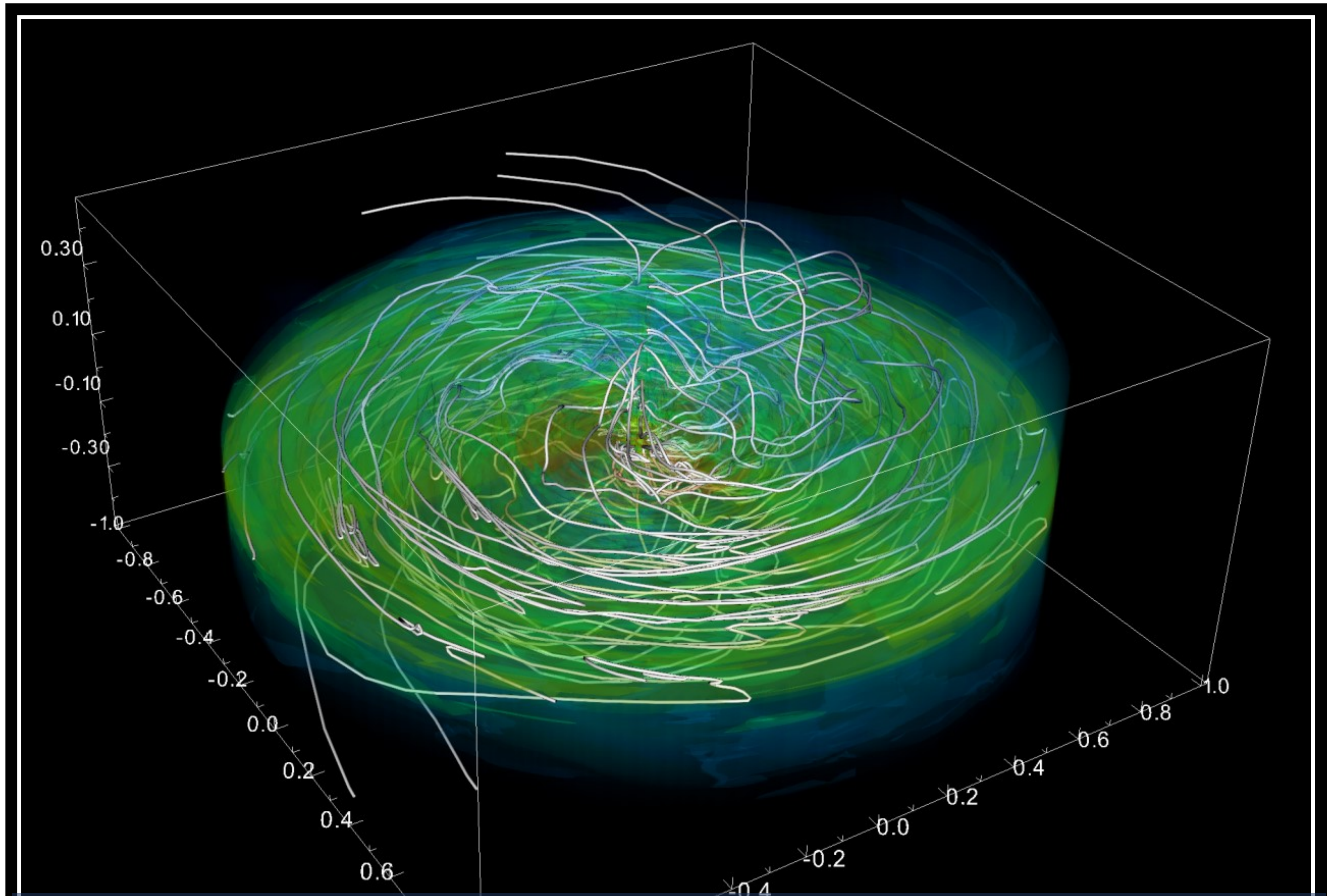
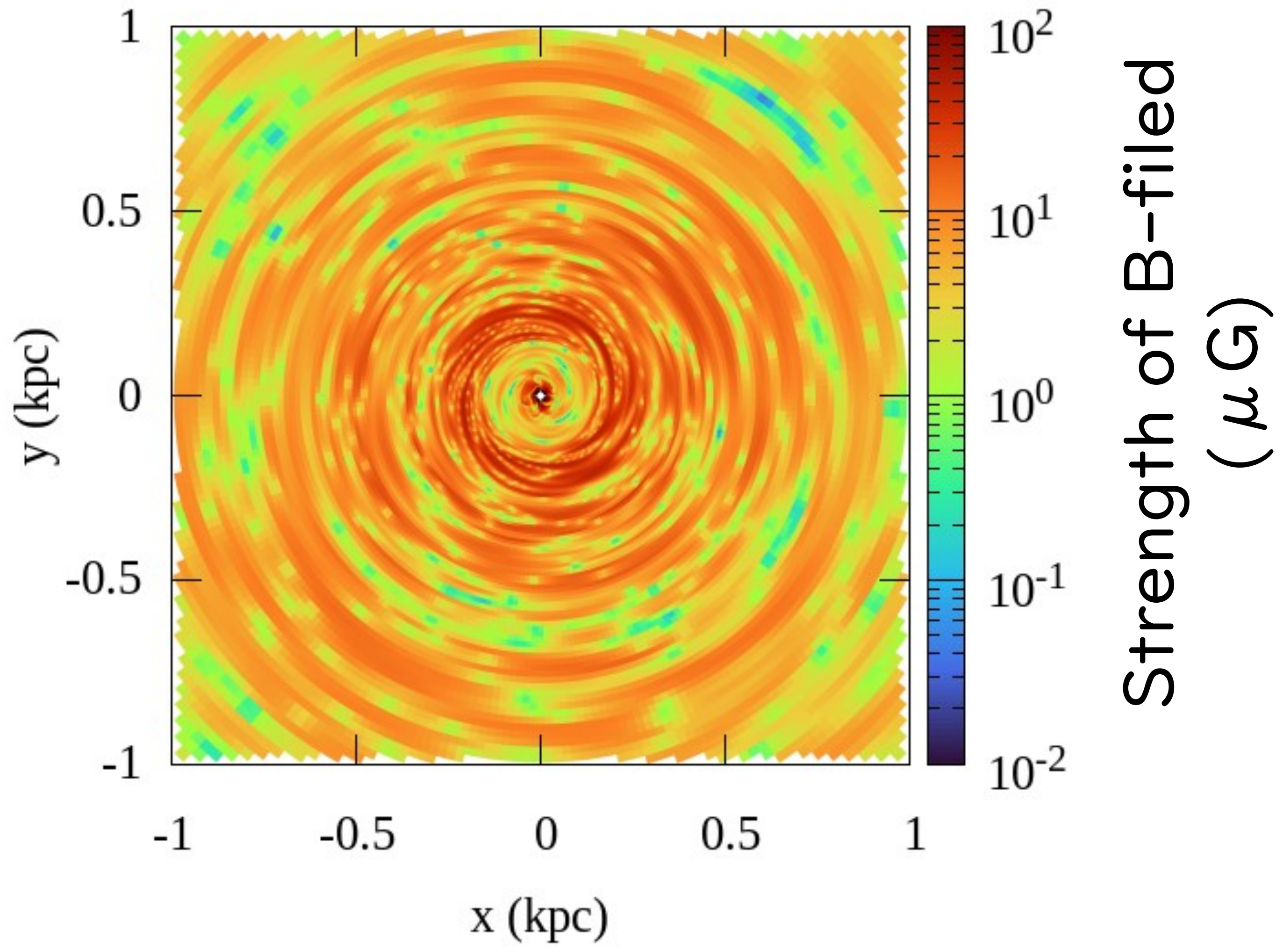
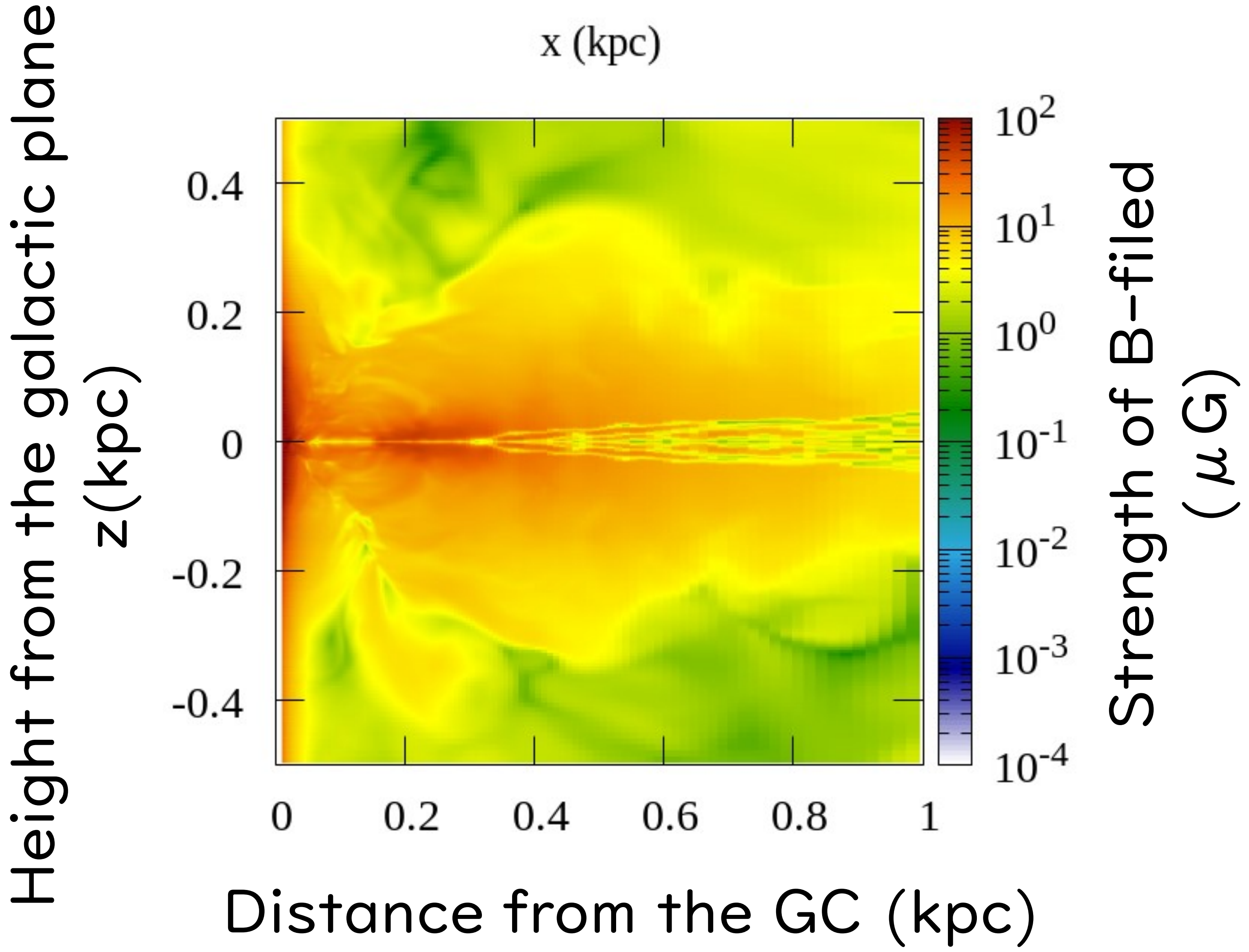


Reproduction of the environment of the magnetic field roughly consistent with observations





Summary

- We performed 2D simulation of a He WD TDE.
- The detonation continues to the trailing part.
- The simulation can follow synthesis of Ca, Ti, Cr, and Fe lighter than ^{56}Ni.
- We also performed magnetohydrodynamics simulation of the Galactic center.
- The simulation can reproduce the magnetic field consistently with observations.