A Study of the Merger of the Galaxy Group HCG 62

Based on X-Ray Observations and SPH Simulations

Dan Hu
hudan_bazhaoyu@sjtu.edu.cn

Supervisor: Haiguang Xu

上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

Outline

- Basic information of galaxy groups and clusters
- Properties of the galaxy group HCG 62
- Main results of X-ray observations and simulations for HCG 62
- Future Prospect

Galaxy Groups and Clusters

- **The largest known gravitationally bound structures in the universe;**

  Typical mass : 10^{13} –10^{15} $M_{\odot}$

  Typical diameter : 1 –10 Mpc

- **Composition :**

  Galaxies (1% - 3%) : 10 – 1000 individual galaxies (poor - massive);

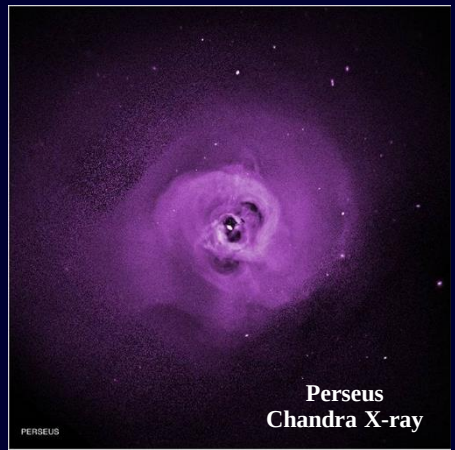
  Dark Matter (75% - 90%) : most massive component but cannot be detected optically;

  Intracluster Medium (ICM, 5% - 15%) : hot gas (10^{7} –10^{8} K) emits X-rays (mostly via bremsstrahlung);

- **Analysis : Optical, Gravitational lensing, X-ray, Radio, S-Z effect ...**

Outstanding Questions :

- ★ **Origin of the multi-phase gas, cooling and heating mechanisms ?**
- ★ **Metal distributions, history of the metal enrichment ?**
- ★ **Dynamic process : shock, turbulence ?**
- ★ **...**



Perseus
Chandra X-ray

Hickson Compact Group 62 (HCG 62)

Main properties:

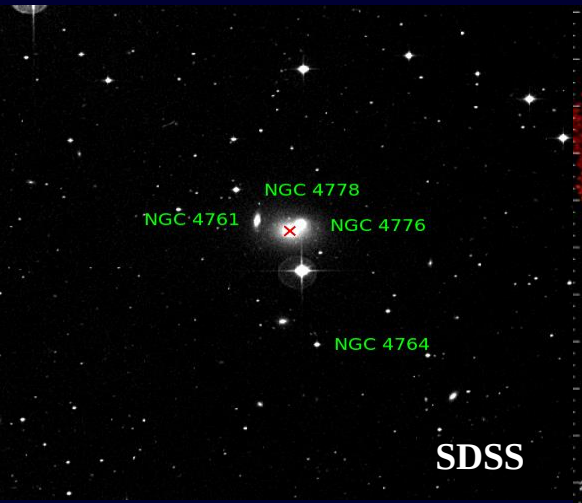
- **Bright, compact ($r_{200} \approx 600$ kpc, $L_x \approx 10^{43}$ ergs s^{-1});**
- **4 bright main member galaxies ($N_{tot} \sim 50$);**
- **Tow cavities, FR I- AGN, weak radio lobes;**
- **Remarkable excess ~36 kpc (X-ray emission & abundance).**

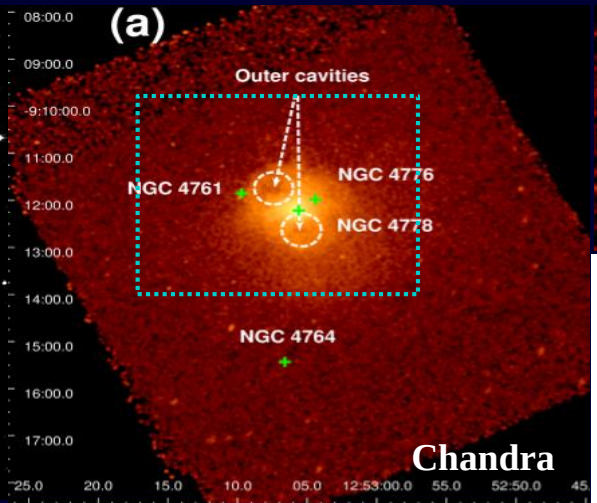
Abundant and complex substructures indicate that this group possibly has experienced some interesting dynamical activities!

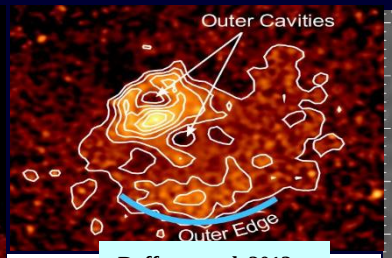
Possible origins of the substructure :

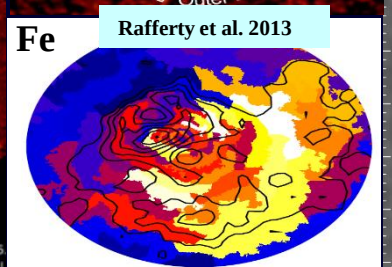
- **AGN jet**
- **Ram-pressure stripping**
- **Merger triggers sloshing**

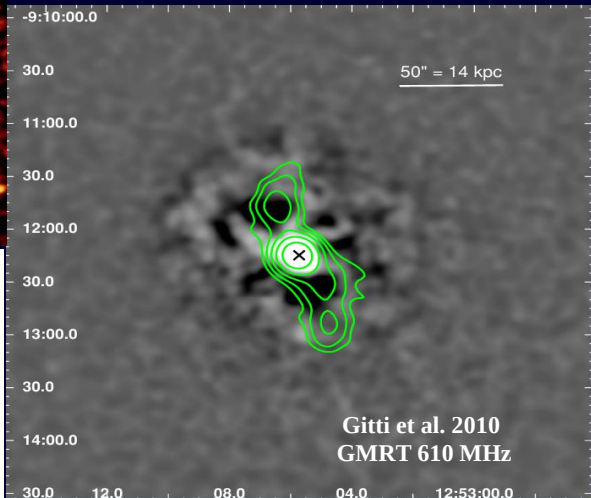
Under debate...





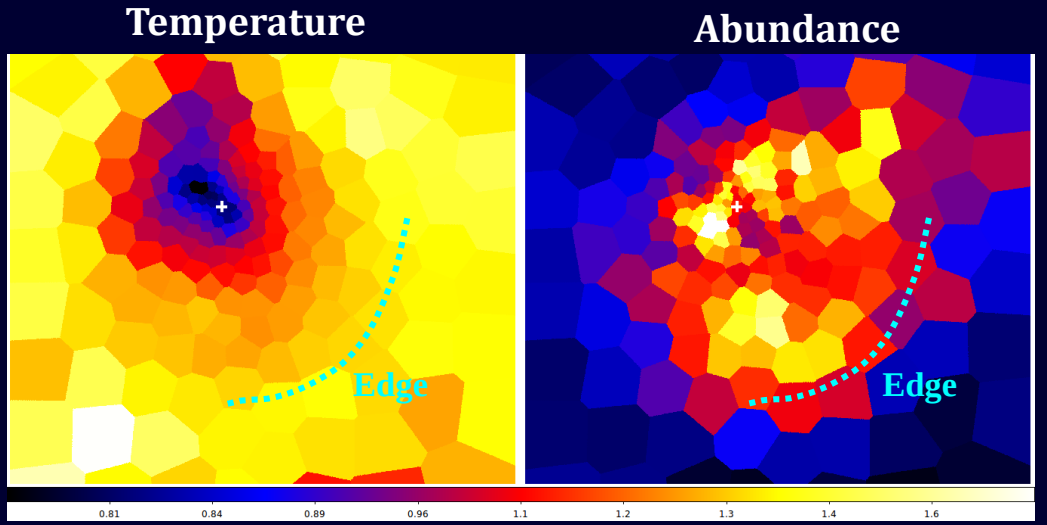


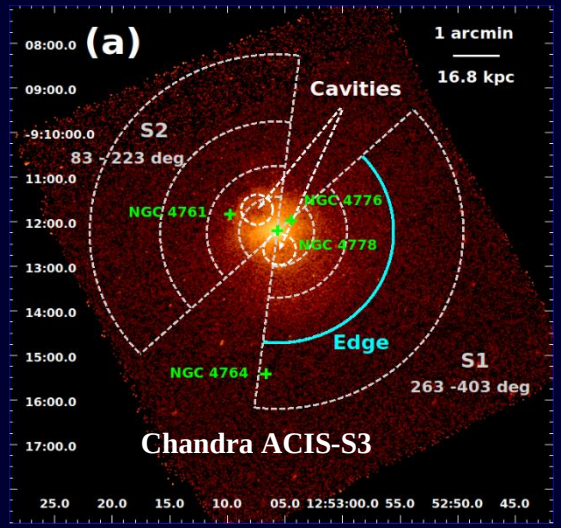


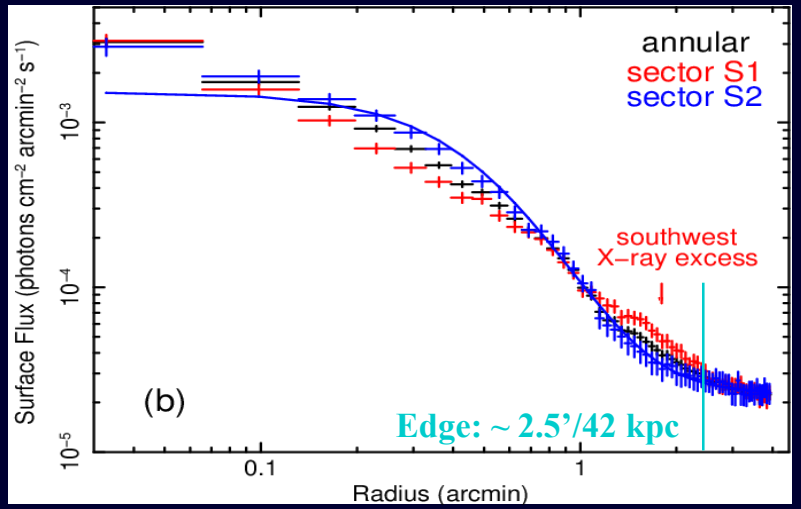


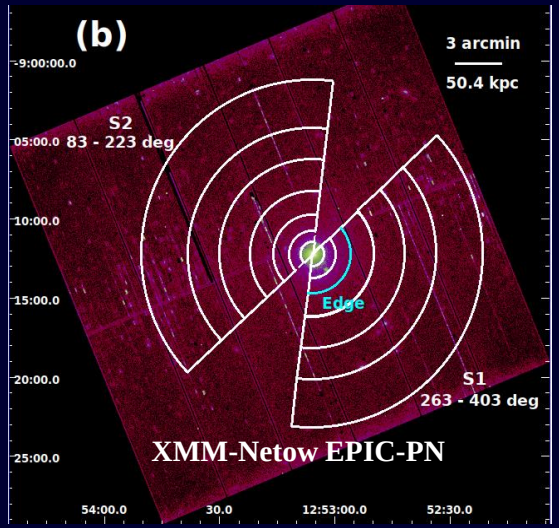
Results Part 1 X-ray Analysis:

- 3*Chandra + 2*XMM-Newton (total ~ 330 ks)
- Pie-region sets
- Crosstalk correction for XMM-Newton
- Direct Spectral Deprojection (Sanders & Fabian 2007)
- Vapec model (O=Ne, Mg=Al, Si, S=Ar=Ca, Fe=Ni)





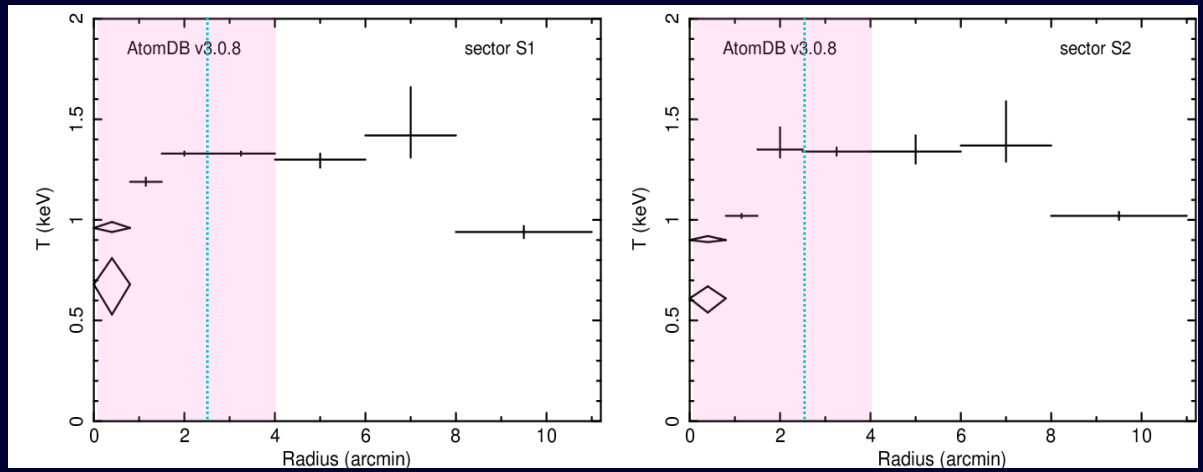


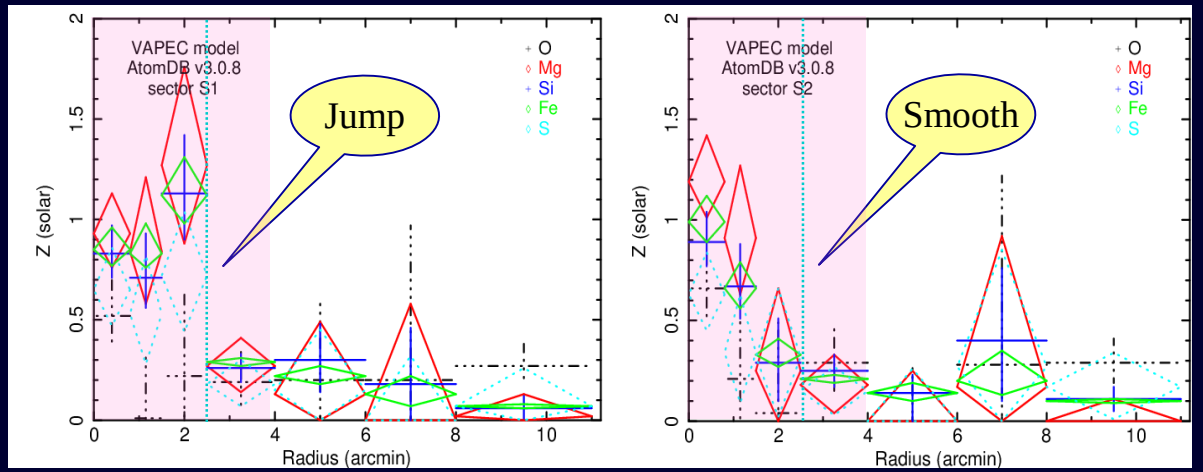


Main results:

- 2T in inner region (< 13 kpc);
  Weak cool component ~ 0.6 keV
- Mg & Si also show high abundances in S1;
  Additional SN II yields
  Merger-induced star formation
- Different abundance patterns (S1 & S2);
  Merger-induced gas sloshing
- Flat abundance distributions in > $0.1r_{200}$;
  Early enrichment theory

Further investigation of the possible recent merger event by simulation.





Part 2 Numerical Simulation:

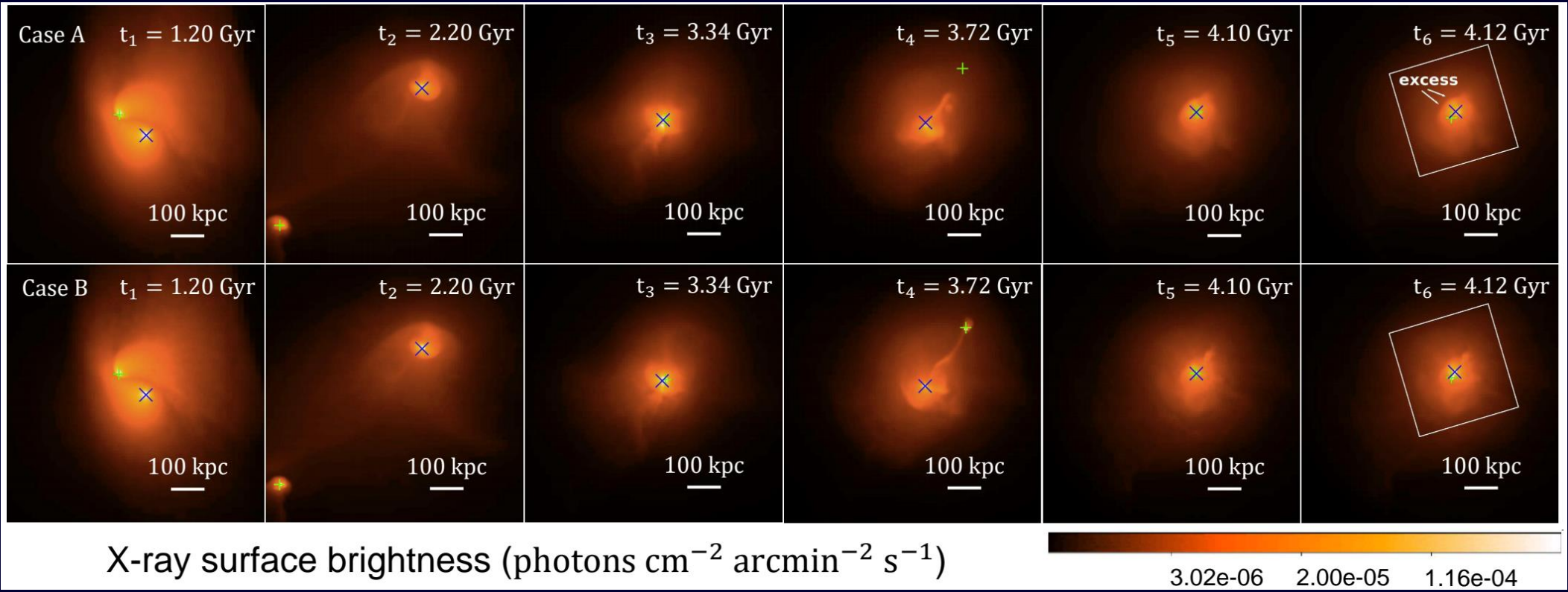
- **Case A : Idealized (gas is assumed to be adiabatic γ = 5/3)**
- **Case B : Case A + gas cooling**

Gadget-3 (Springel 2005)

Mass ratio R_{mass} = 3 : 1

Initial velocity v_{init} = 500 km s^{-1}

Impact parameter P = 300 kpc

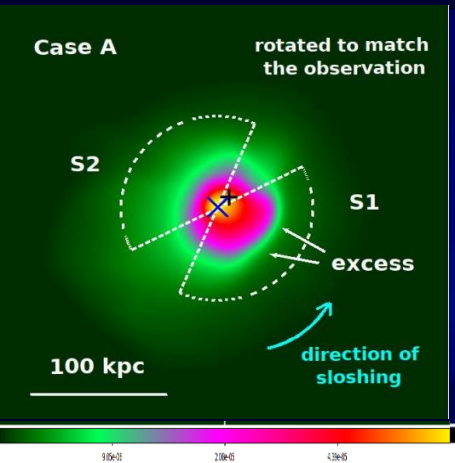


Main results:

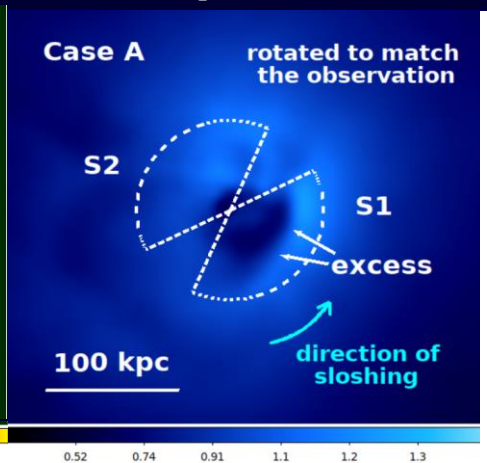
- Similar location and scale of the emission excess, cold front;
  Merger triggers sloshing
- Simulated Mg & Fe profiles match the observed ones, assuming suitable initial profiles;
  Merger triggers SF, accounts for the additional Mg
- Locations of two dark matter centers, roughly consistent with those of two member galaxies.

Conclusion: Merger may be the primary mechanism for the substructure, while we cannot rule out the contributions of AGN activities.

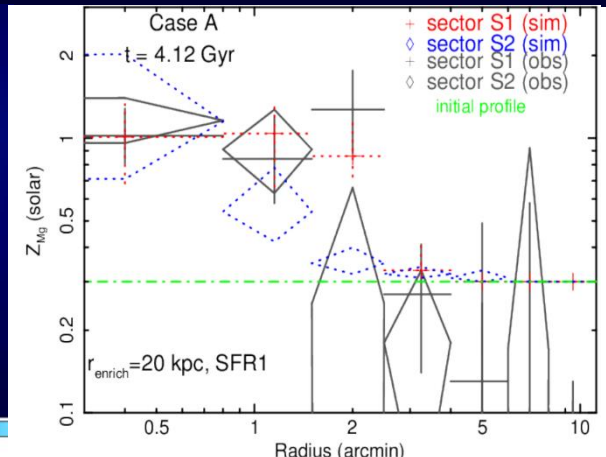
X-ray emission

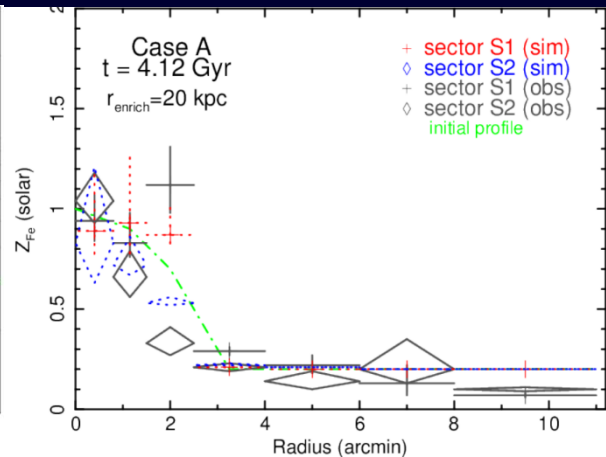


Temperature



Abundance



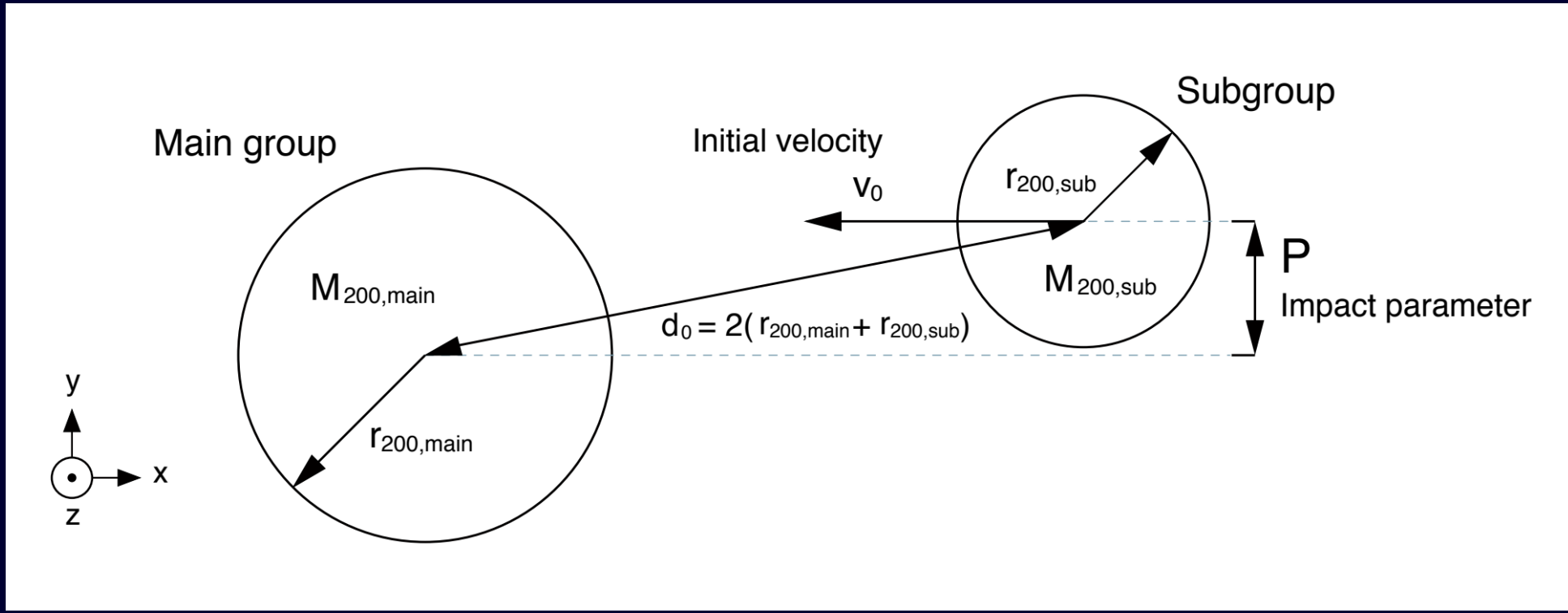


Future Prospect

Future telescopes with low energy band (0.1-0.5 keV) & high energy resolution (~ eV) such as: Athena, XRISM, HUBs …

- **Identify possible non-thermal emission around lobe region → AGN contribution;**
- **Obtain more reliable O profiles → should be same as Mg?**
- **Measure metallicity (O, Mg, Si, S) accurately → constrain the SNe models;**
- **...**

Thanks !


Main group
Subgroup
Initial velocity
v_0
$r_{200,sub}$
$M_{200,main}$
$M_{200,sub}$
$d_0 = 2(r_{200,main} + r_{200,sub})$
P
Impact parameter
$r_{200,main}$
y
x
z