中国科学院国家天文台
NATIONAL ASTRONOMICAL OBSERVATORIES, CAS

Uncovering the Origin of Galactic Ancient Accretion Relics

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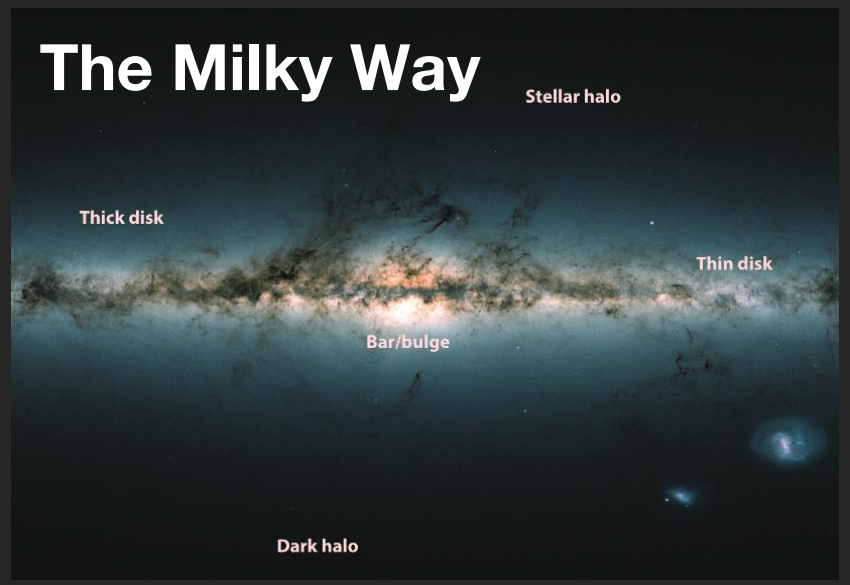
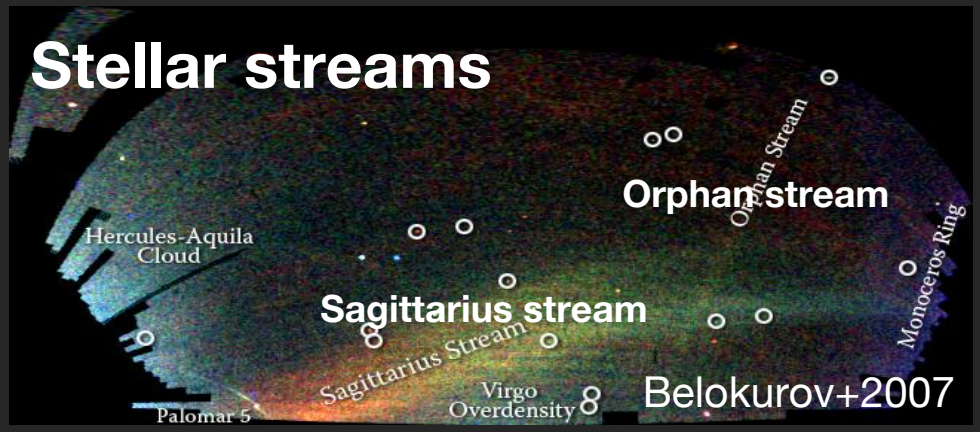
Tracing the Galactic early assembly history

Assembly time

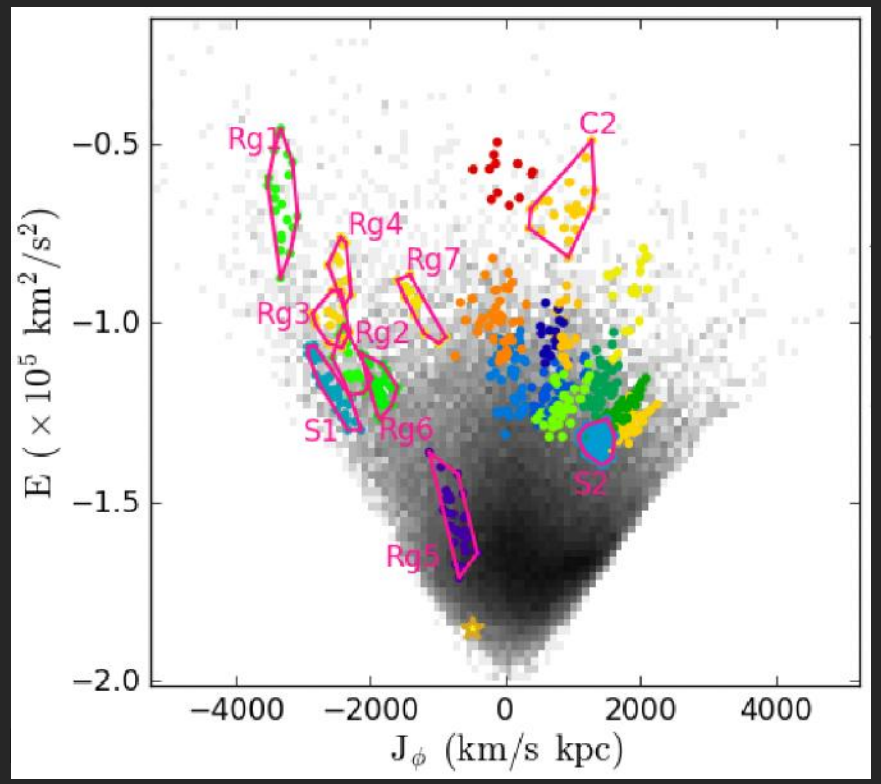
Hierarchical merging

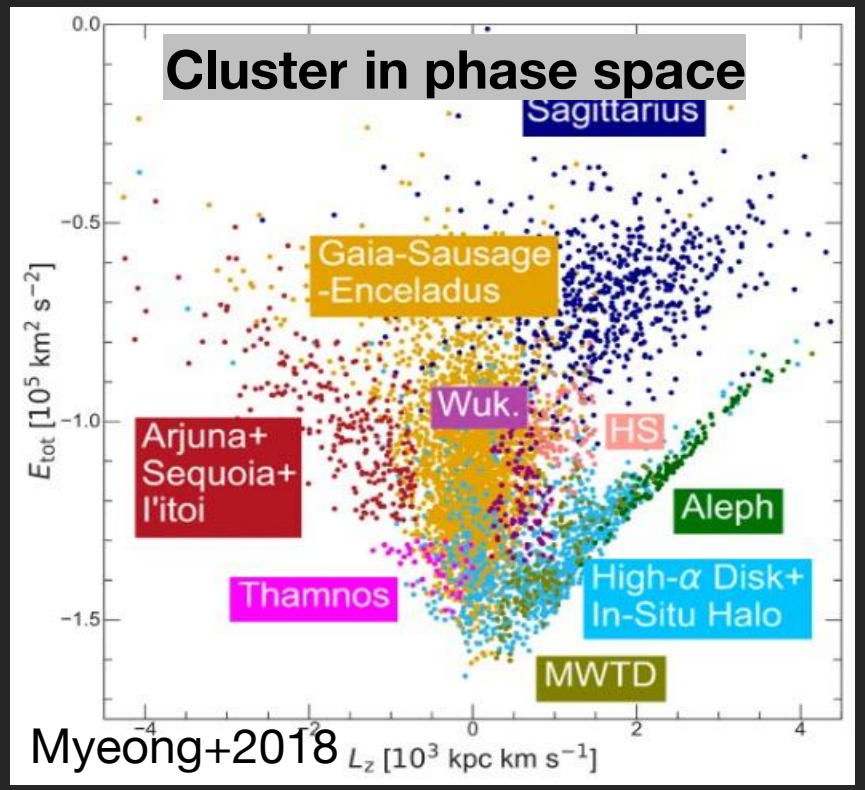




Overdensity in coordinate space

dynamical information—progenitor system

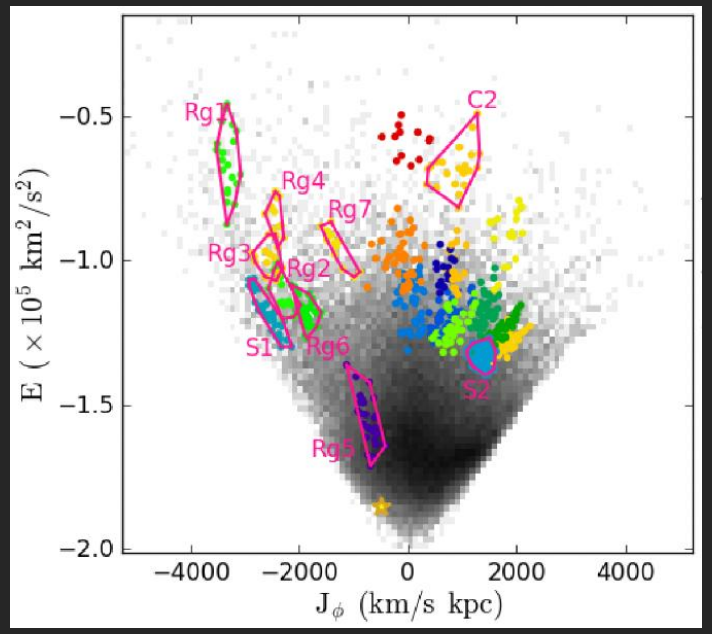




Myeong+2018

dynamical information ⟶ distinguish origin of stars

Chemodynamical analysis of accretion relics



distinguish origin of stars

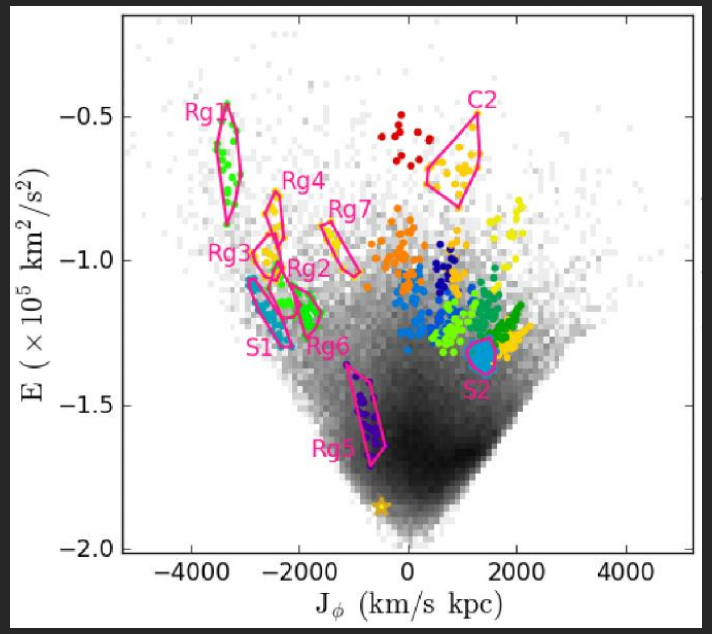
→ progenitor system

Mass?

Nucleosynthesis events?

Accretion history?

Chemodynamical analysis of accretion relics



→ **progenitor system**

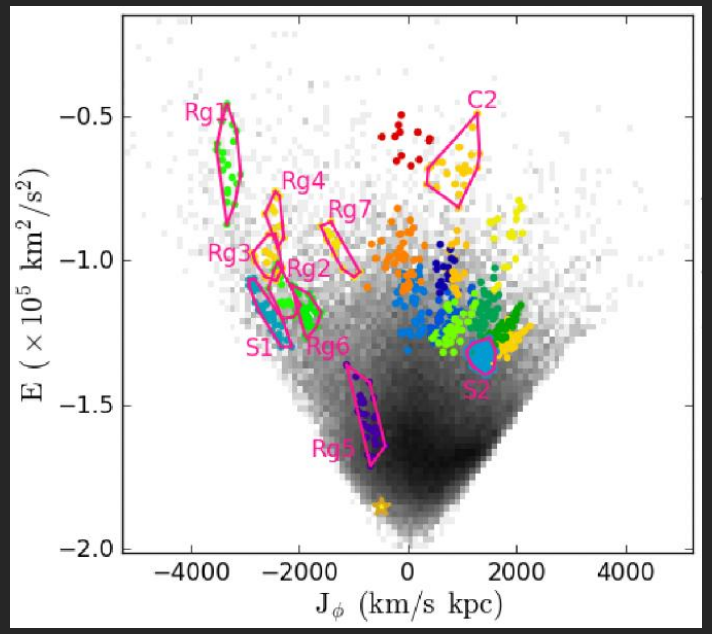
Mass? — MDF (metallicity distribution function)

Nucleosynthesis events? — CCSN, Type Ia, NSM, AGB

Accretion history? — ages

explore properties of progenitor system

Chemodynamical analysis of accretion relics



→ **progenitor system**

Mass? — Fe abundance

Nucleosynthesis events? — Mg, Fe, Eu, Ba abundance

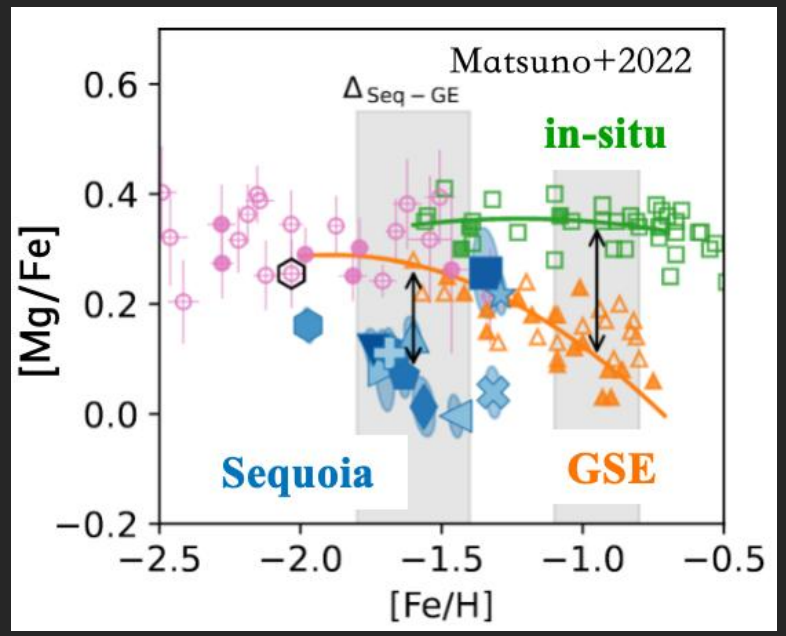
Accretion history? — Th abundance

Chemical abundance provide the key information to uncover the accretion history of the Milky way

Chemical evolution

Fe: Type Ia

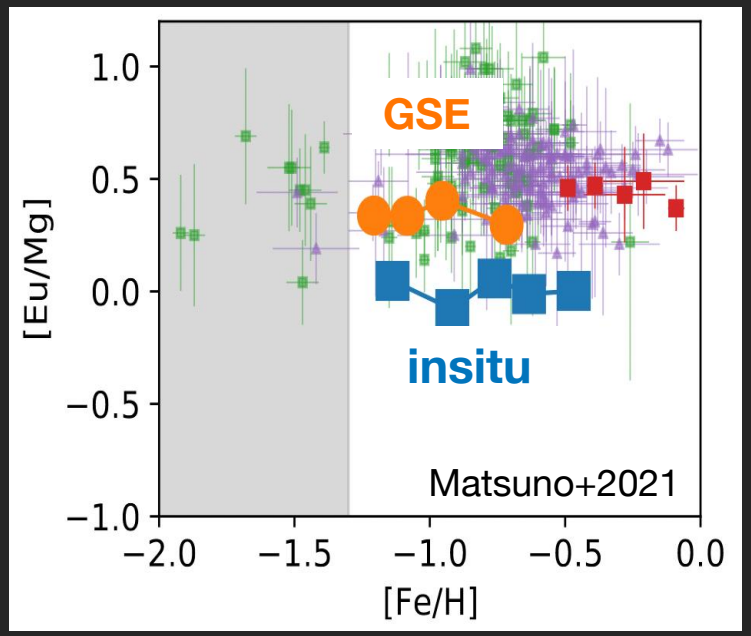
Mg: Type II



Star formation efficiency

Mg: Type II

Eu: Type II + NSM

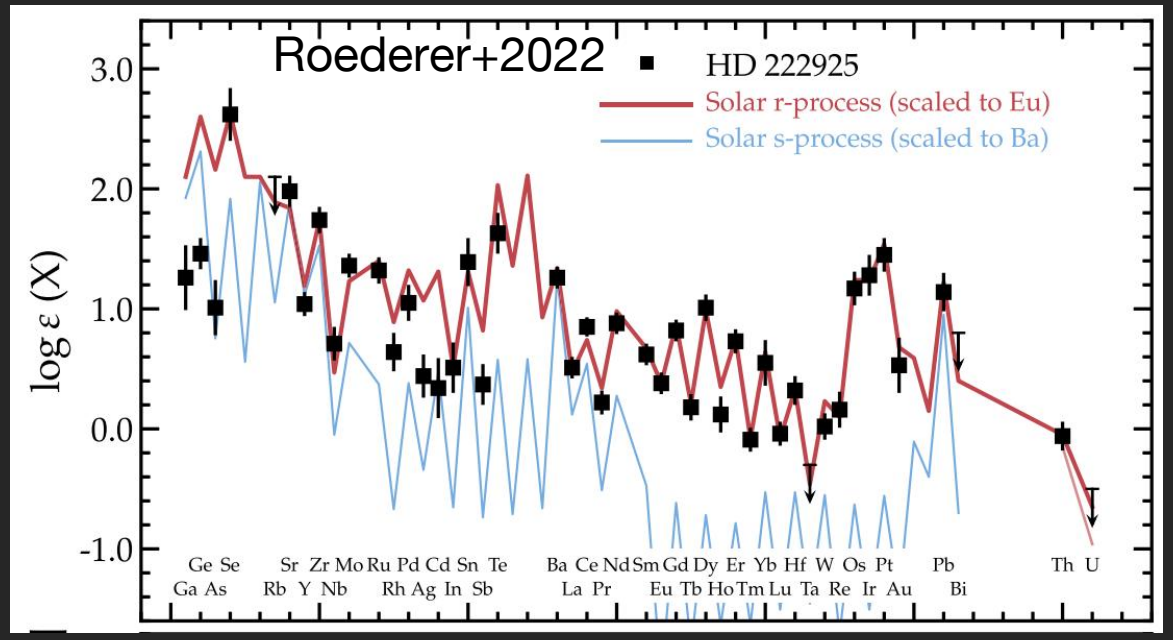


Time-delay source contribution

Chemical abundance provide the key information to uncover the accretion history of the Milky way

pattern that r-process nucleosynthesis produces

Dwarf galaxy: simple chemical evolution history

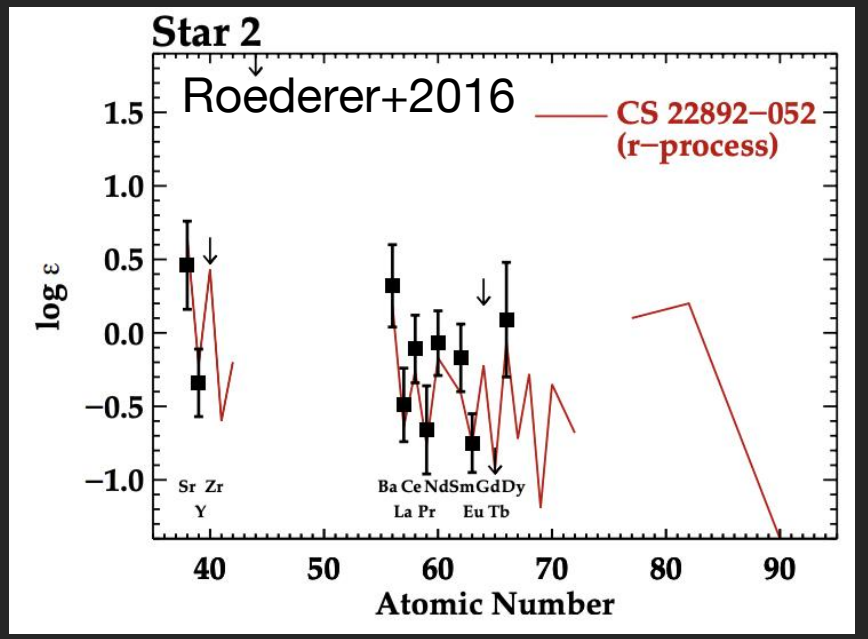


insitu (nearby and bright)

[Eu/Fe] = 1.32 — full pattern

↙

represent element produce by r-process



dwarf galaxies (distant and faint**)**

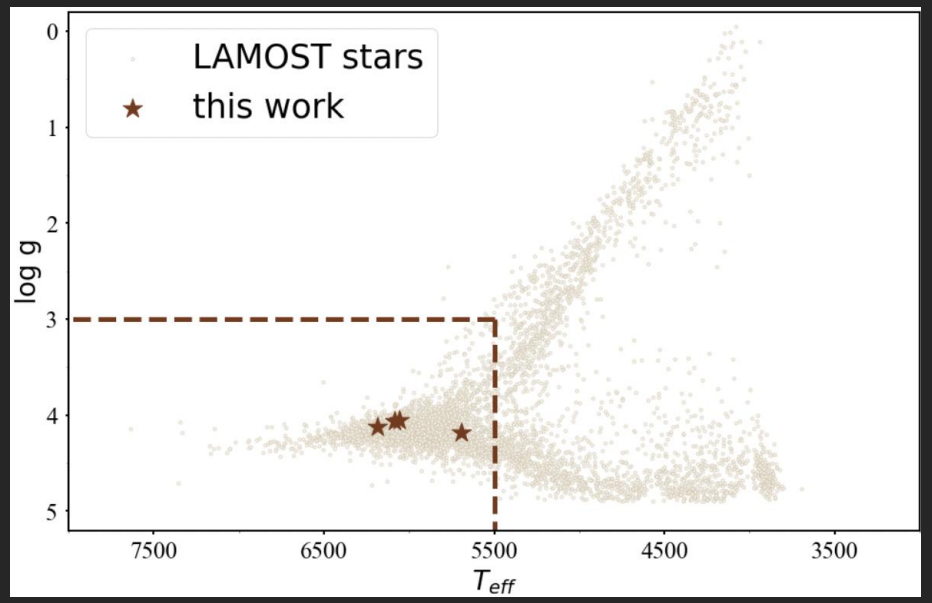
[Eu/Fe] = 1.68

Advantage of Substructure

- **Member stars are nearby**
  - **obtain the high-resolution spectra**
  - **measure the elemental abundance to get full pattern**
- **Correspond to accreted dwarf galaxies**
  - **born in dwarf galaxy that were disrupted and accreted by the MW**

Main sequence turn-off (MSTO) star

Previous studies: Giants as tracers



Advantage of MSTO:

- **Represent stage before the first dredge-up**
- **Provide relatively accurate age can restrict the accretion events**
- **Bright enough to obtain their high-resolution spectra**

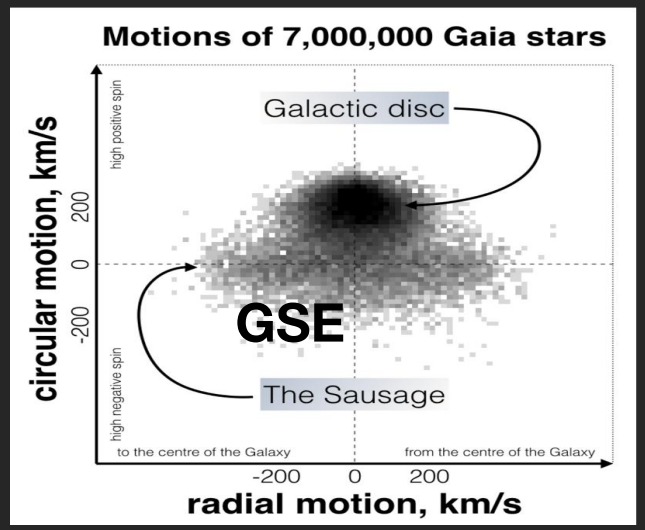
Systematic chemodynamical analysis for MSTO stars

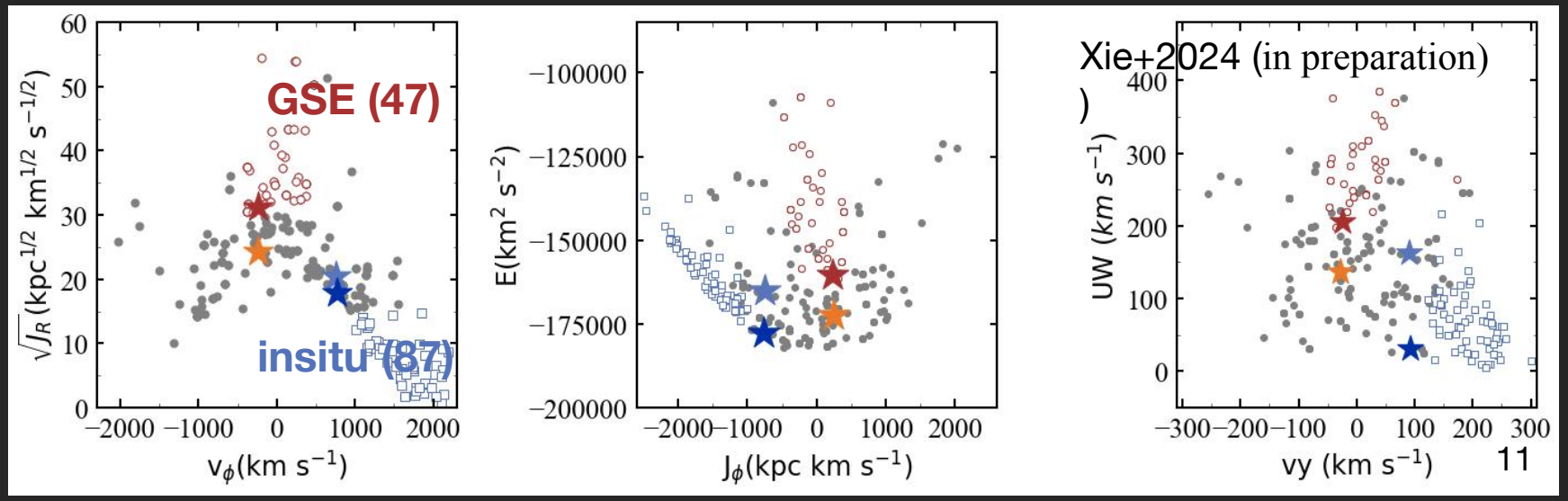
Sample: MSTO stars with elemental abundance from SAGA and CFHT observations

Dynamical analysis
- Agama
- McMillan potential

+

Chemical analysis
- TAME (equivalency width)
- MOOG (elemental abundances)





Xie+2024 (in preparation)
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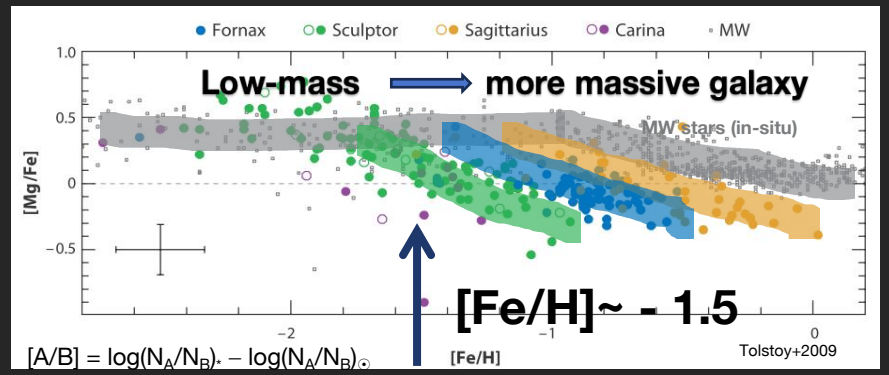
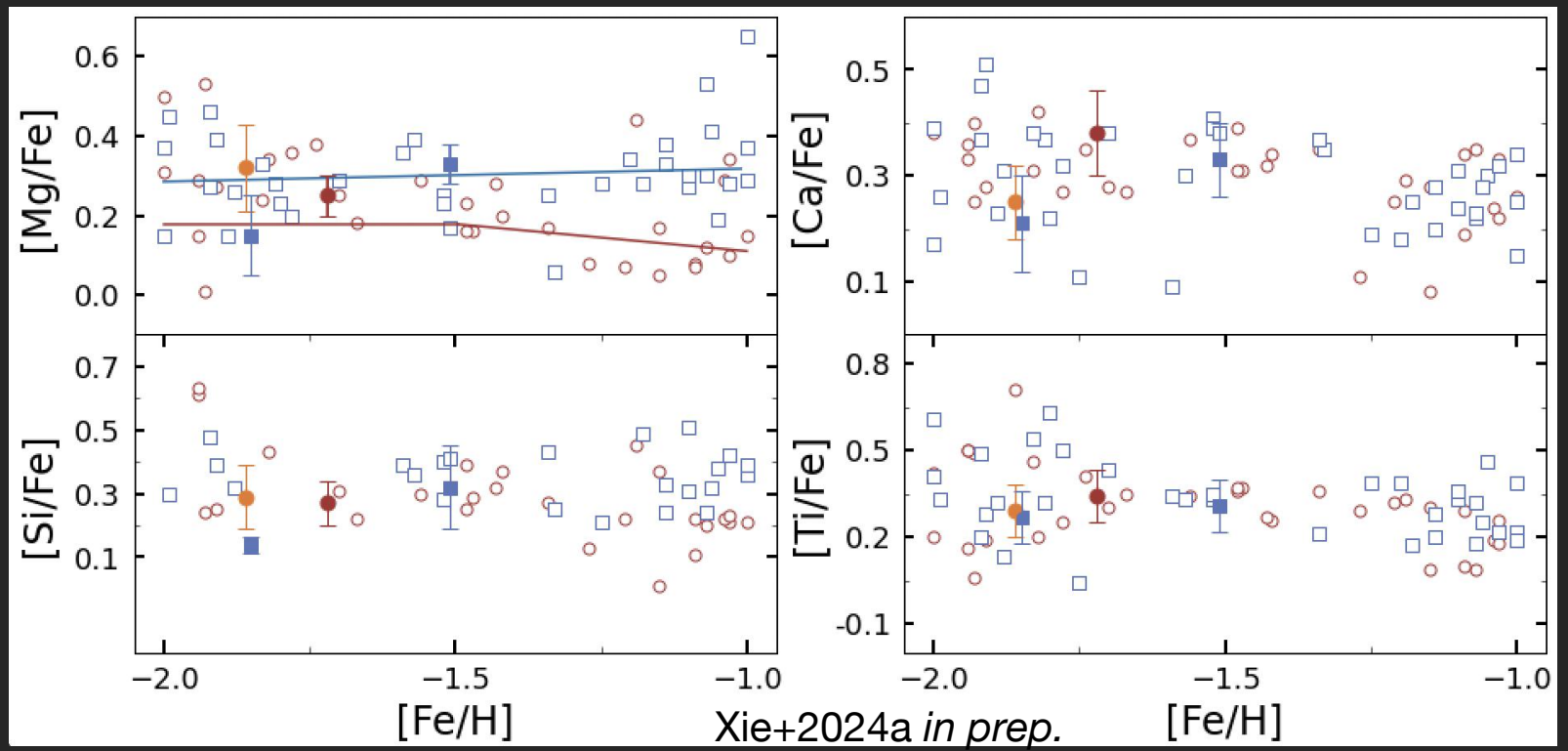
GSE: chemical properties--alpha elements

Alpha-knee at [Fe/H] ~ -1.5:

- **onset of Type Ia supernovae**
- **consistent with previous work**
- **less massive than the MW**

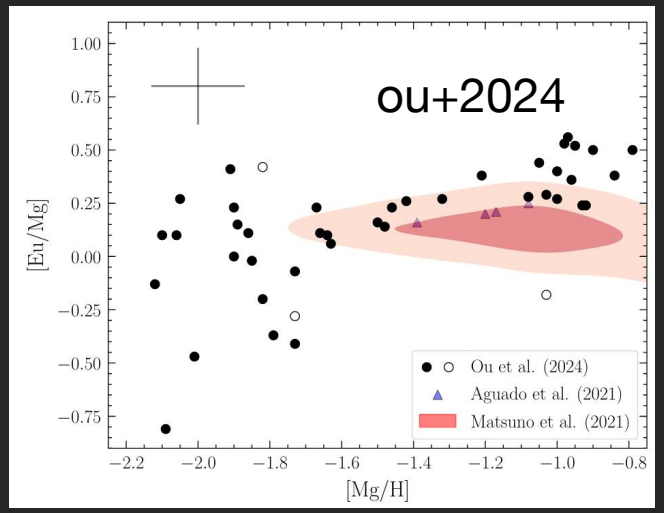


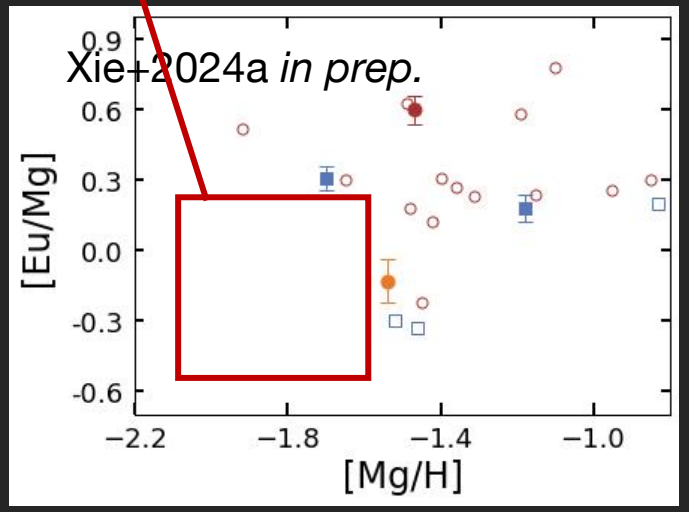


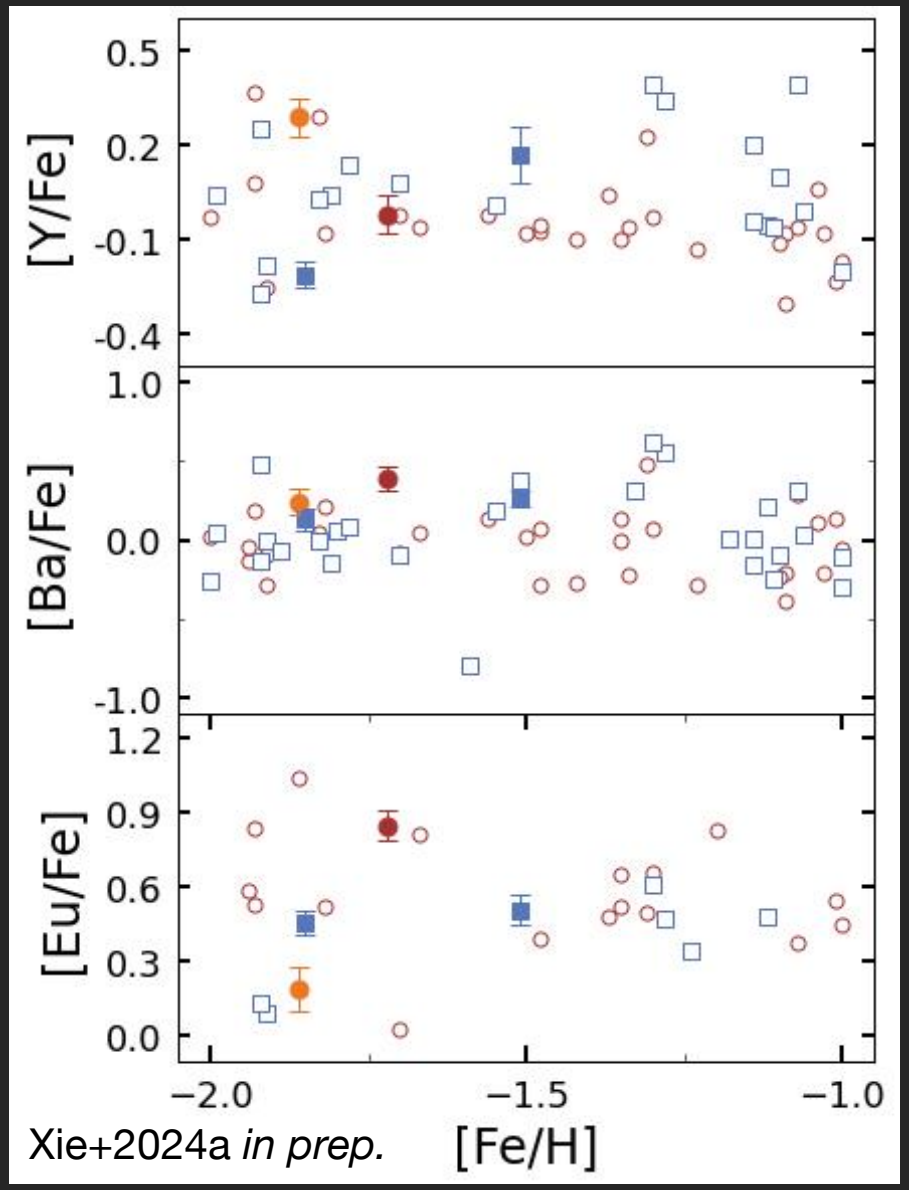
GSE: chemical properties--heavy elements

- Similar to insitu component
- evidence of time-delay source in GSE

  lack of very metal-poor star



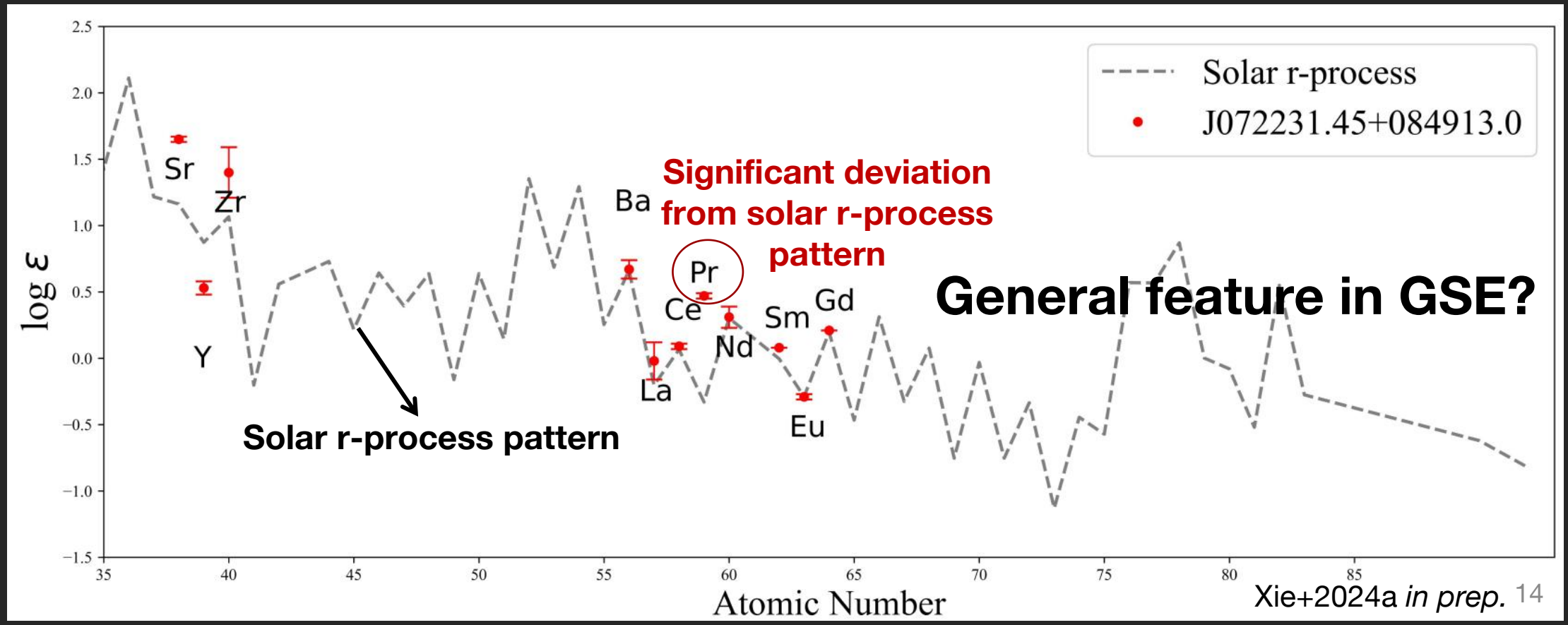




GSE: r-process pattern

Pilot project with CFHT: follow-up studies of an r-process enhanced star

J0722: T_{eff} = 6133 K, logg = 3.69, [Fe/H] = -1.8, Eu/Fe = 0.88



General agreement with solar r-process except for praseodymium

Summary

- Systematic chemodynamical analysis for MSTO stars

- GSE — alpha knee:
  - ✓ alpha knee in [Fe/H] ~ -1.5
  - ✓ less massive than the MW

- GSE — heavy element:
  - ✓ Large scatter, similar to galactic field stars
  - ✓ Provides valuable comparison of the r-process pattern ex/in-situ