狭帯域金属欠乏星探査

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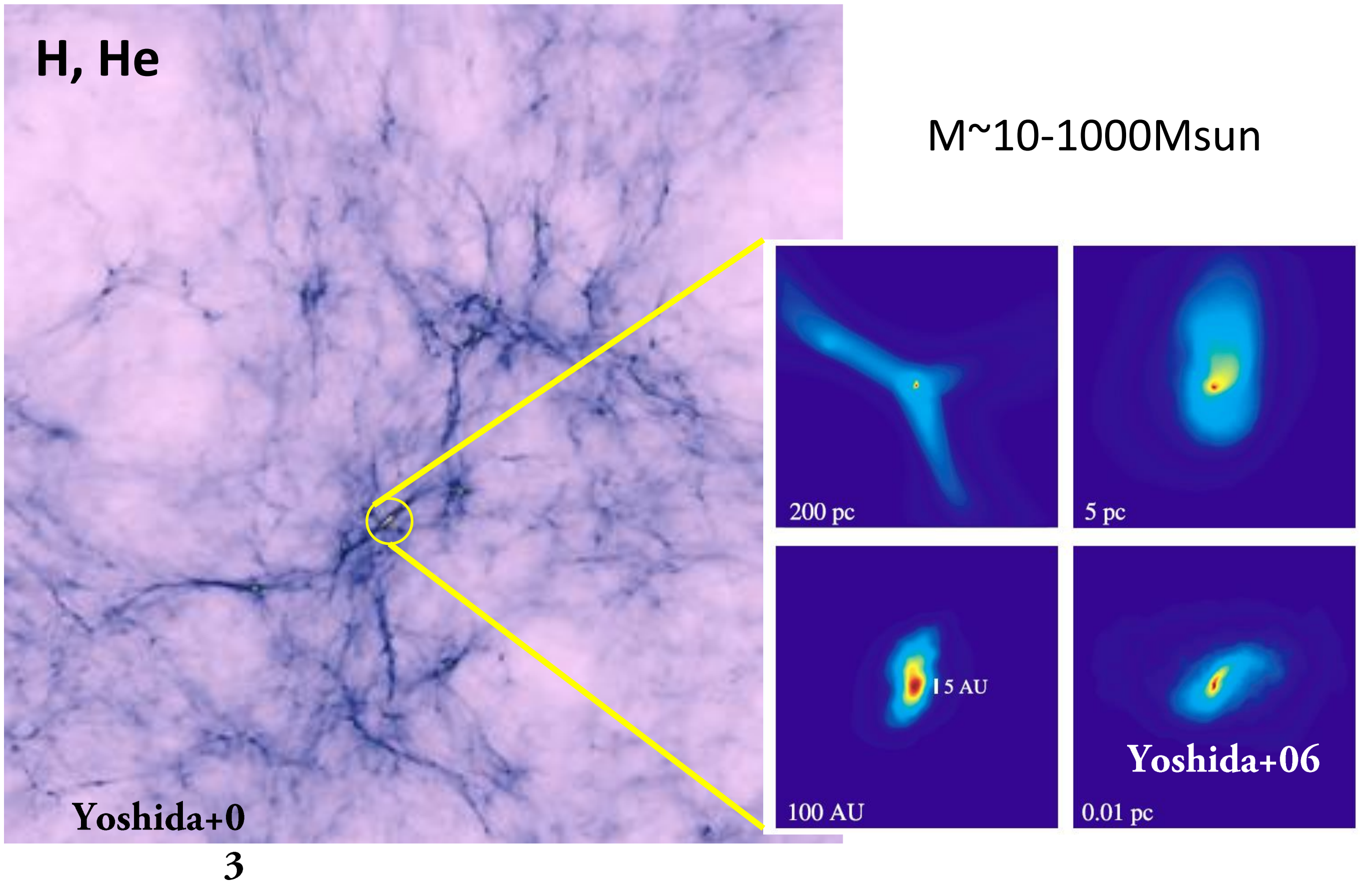
Contents

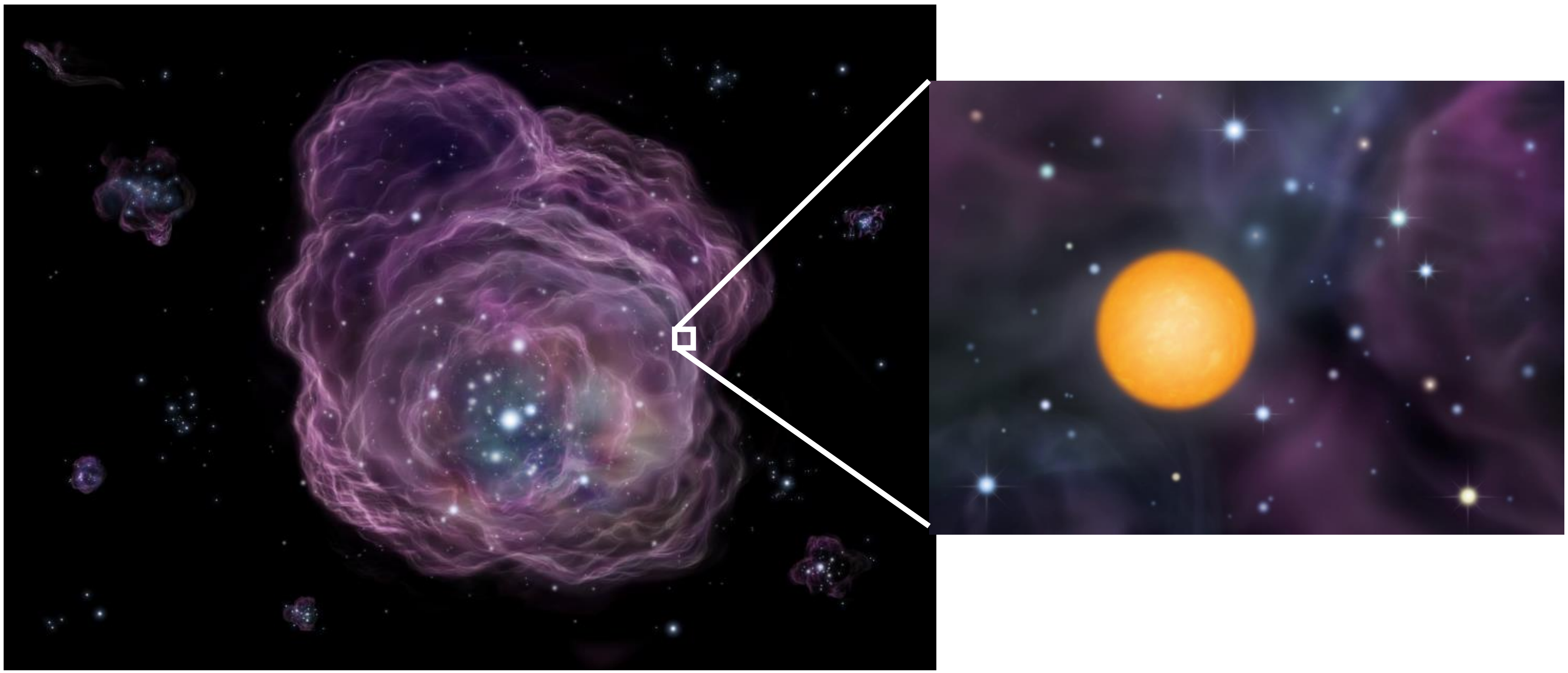
- Metal-poor stars
- 2022年9月と2024年5月の試験観測
- 2025年5月観測

First star formation

M~10-1000Msun

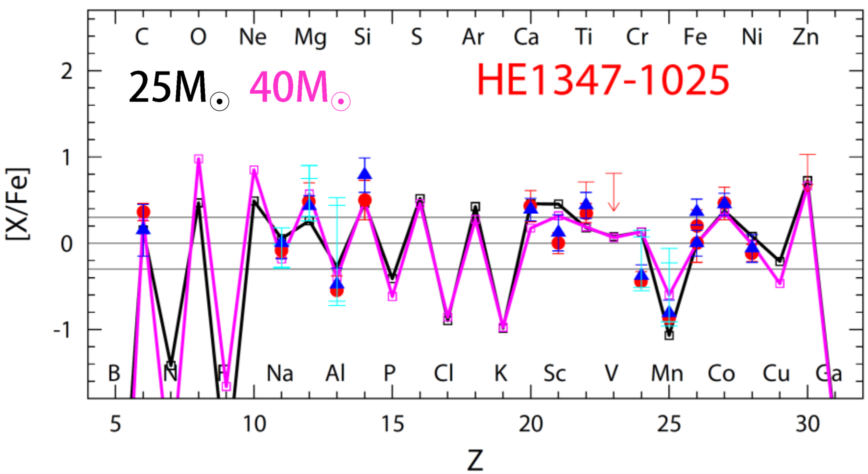


Metal-poor stars formed from the supernova ejecta and the pristine gas



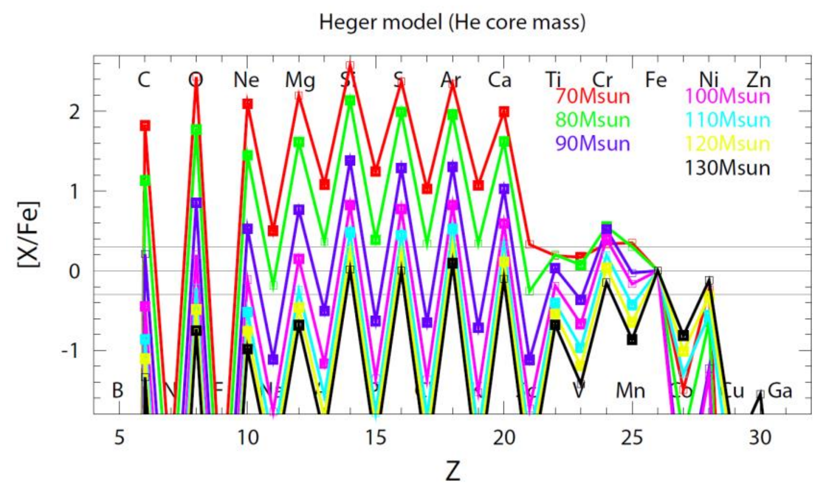
Metal abundances tell us the nature of first stars

- Core-collapse supernova



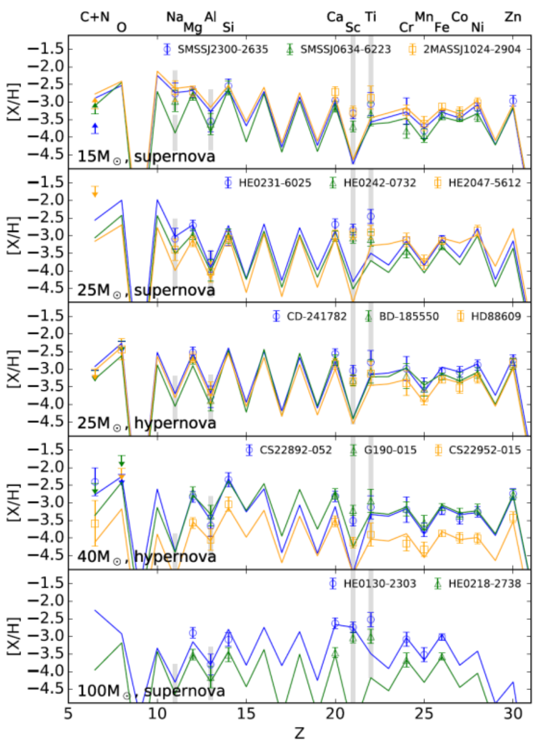
- Mass and mixing: ratios among the elements in the same layer (e.g., C-N-O, Na-Mg-Al)
- Energy: Fe-peak elements
- Explosion geometry: ratios among the elements in the different layer (C-Mg-Fe)

- Pair-instability supernovae

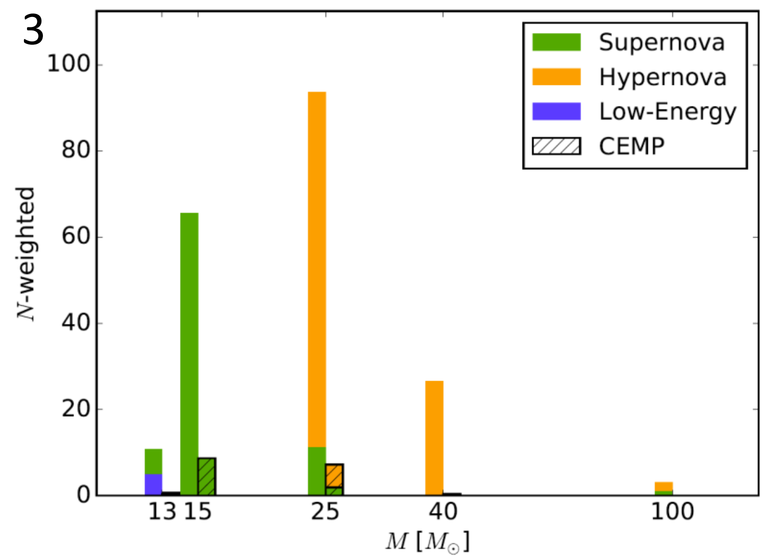


- Strong odd-even effects
- Low [Mg/Si]
- More massive stars result in low [a/Fe]

Mass function of "first stars" (contributing to metal-poor stars, i.e., chemical evolution)



χ^2 fitting of 218 stars with [Fe/H] < -3

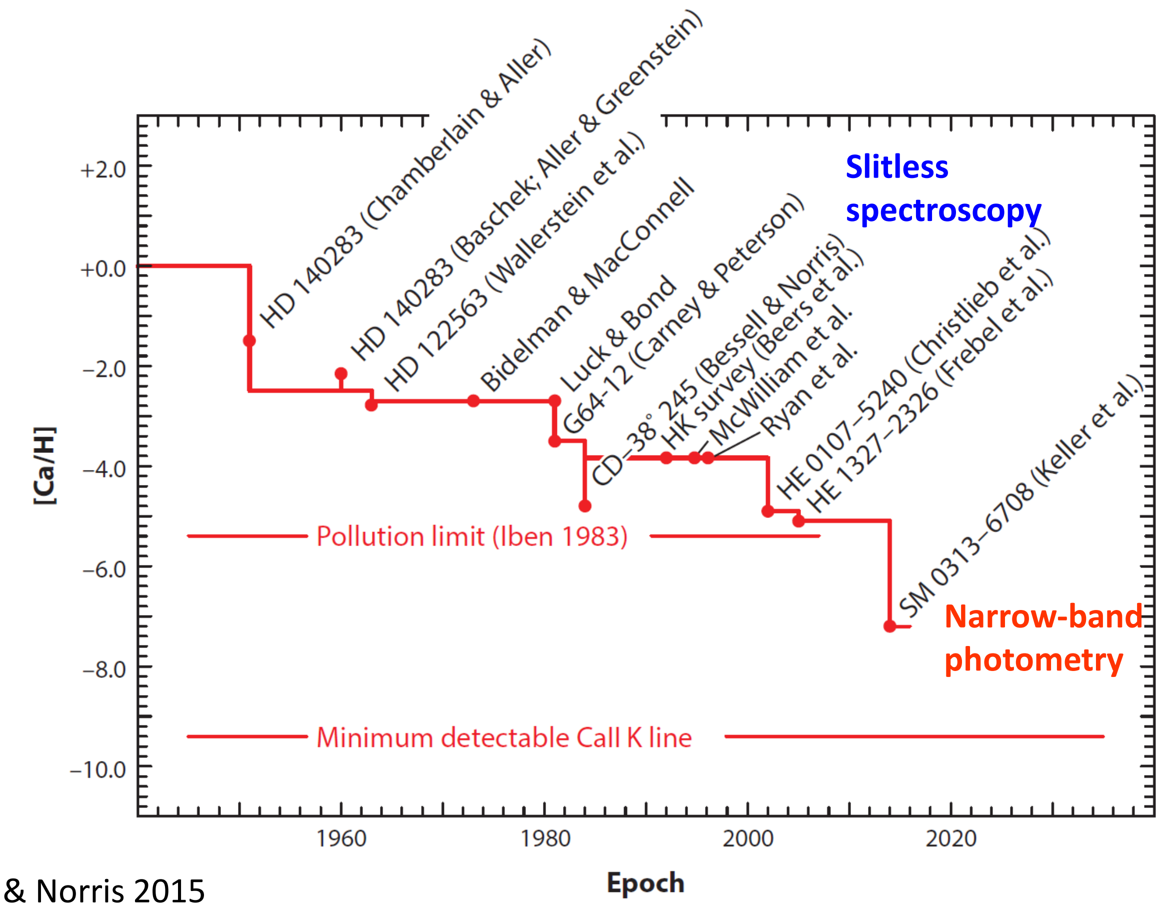


A typical mass of Pop III stars is 25M$_\odot$ and HNe are dominant.

Ishigaki, NT + 18

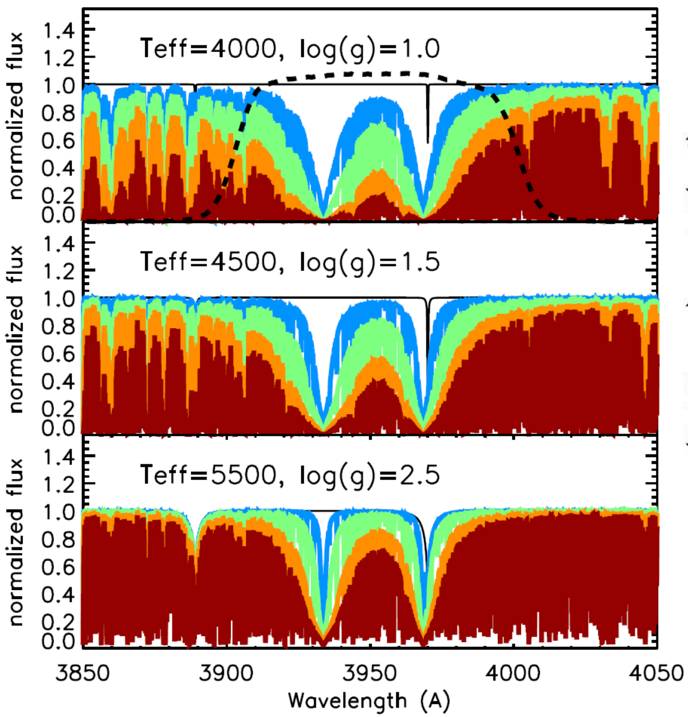
Metal-poor star surveys

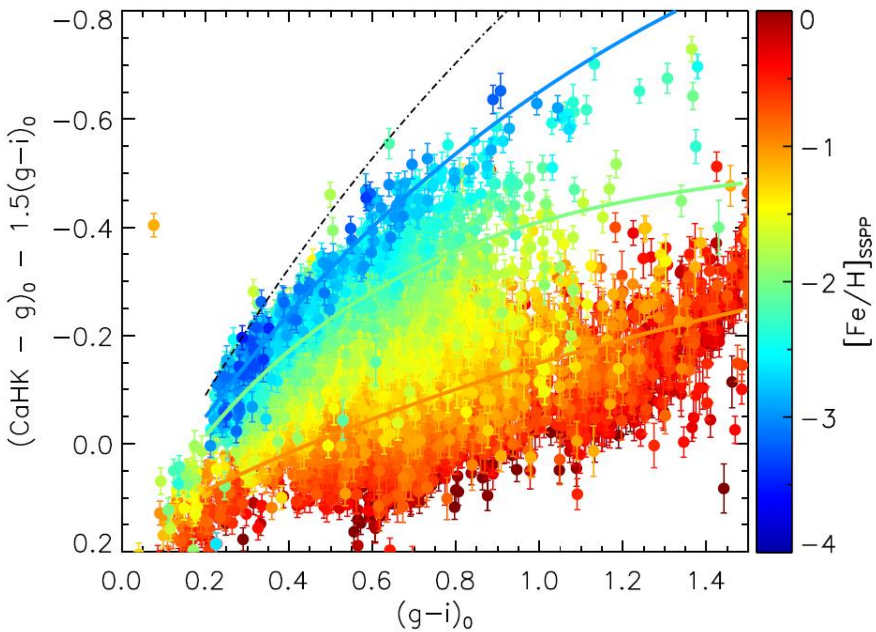
Discoveries of metal-poor stars



Frebel & Norris 2015

Narrow-band survey for metal-poor stars





Starkenburg+17; Da Costa+19

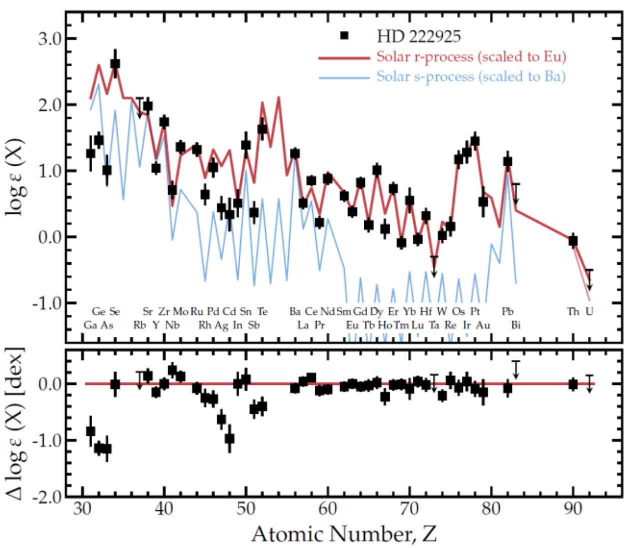
- **Skymapper survey** (Skymapper, 1.3m, Keller+) SkyMapper
- **Pristine survey** (CFHT, 4m, Starkenburg+) PRISTINE

Bright metal-poor star survey with Tomo-e Gozen Camera
(Okada, NT+)

Profits from bright metal-poor stars

- Measurement of rare elements

UV spectroscopy



Roederer+22

- Measurement of low abundance or stringent upper limit

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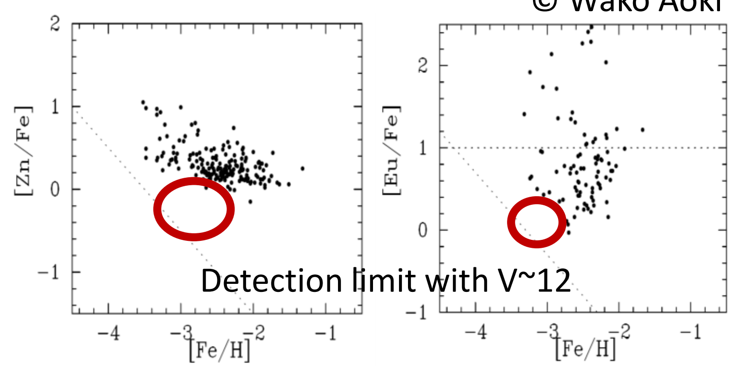
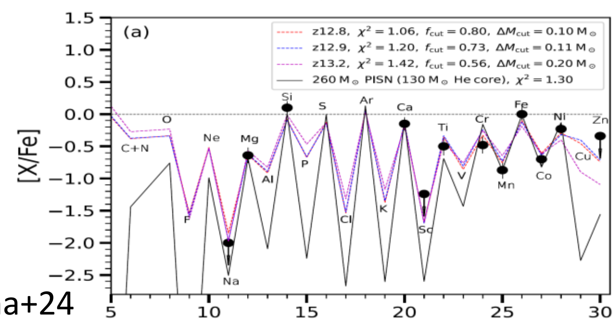
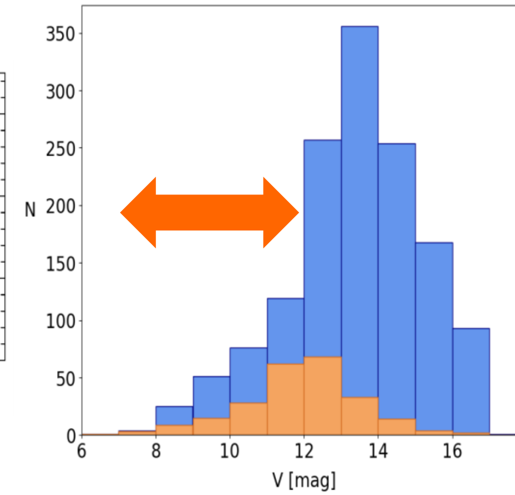


Jeena+24



Magnitude distribution of metal-poor stars with [Fe/H]<-2

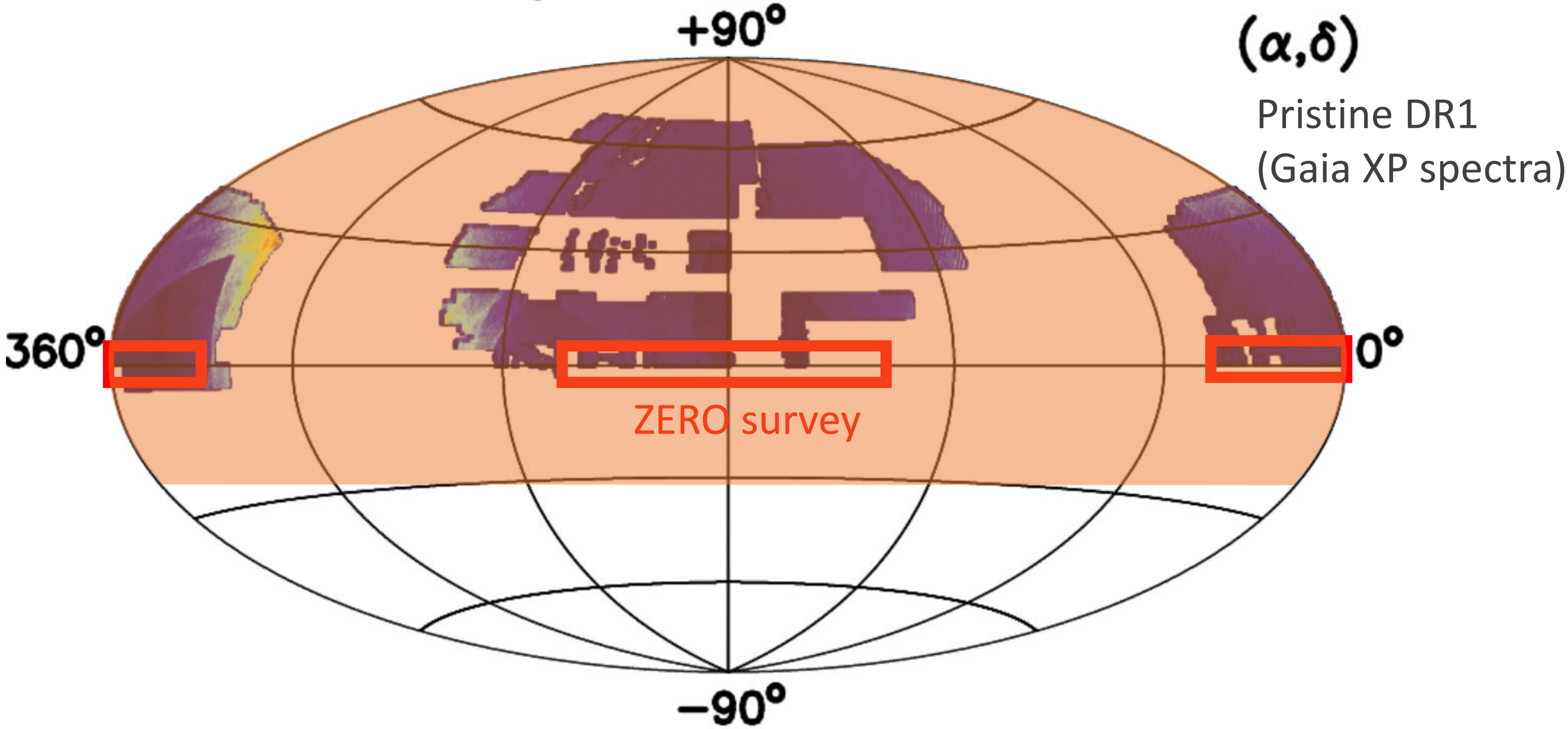


Metal-poor stars
Metal-poor stars with detailed abundance measurements

preliminary

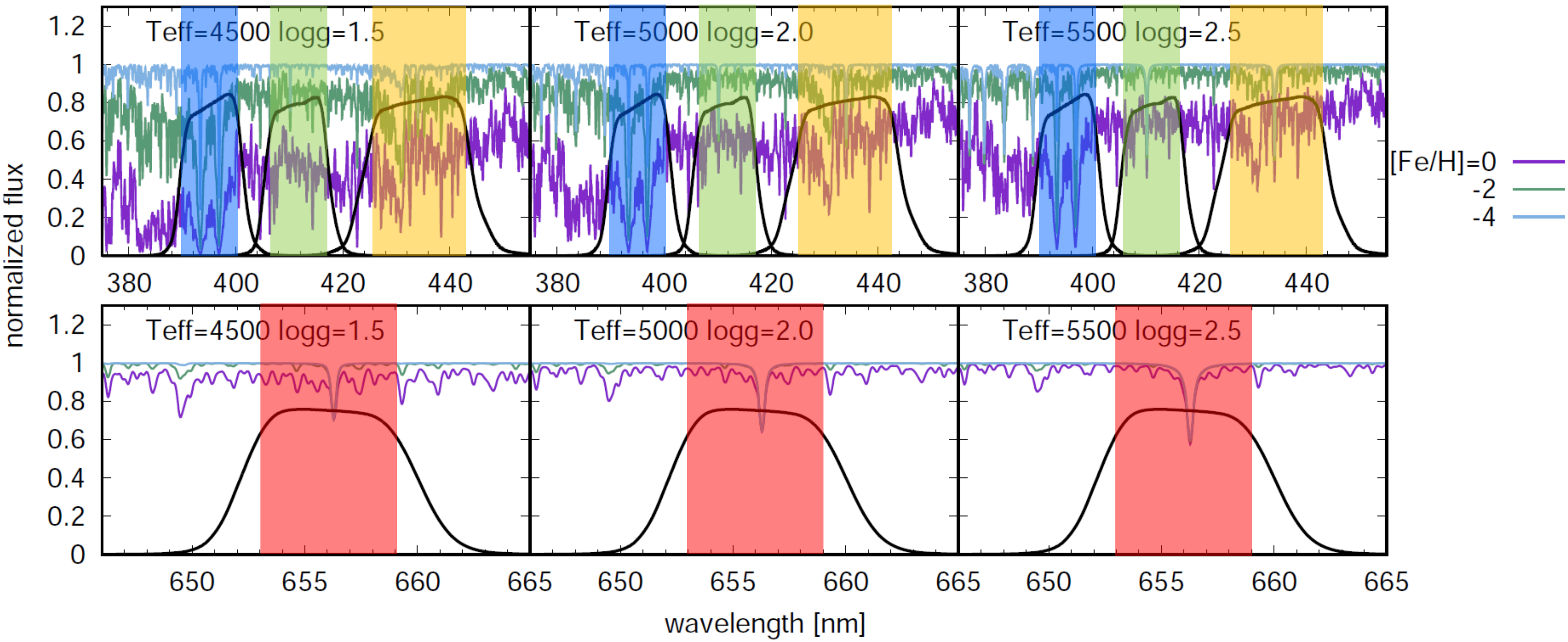
Northern sky survey for bright metal-poor stars

Aims: Precise measurements of rare elements
Understanding of the nature of first stars



Filter selection

NB395 (CaHK), NB411 (ref)
NB433 (CH), NB656 (Ha)



Survey design

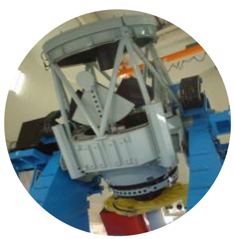
STEP 01

Kiso (1.05 m)

Survey

- Narrow-band photometry with Tomo-e Gozen
- Select bright MP candidates with [Fe/H] < -2

STEP 02



Nayuta (2 m)

Metallicity estimation

- Medium-res. Spectroscopy with MALLS
- R ~ 7500
- Opt. (4900-5300Å)
- Metallicity(Fe) and alpha(Mg) abundance

STEP 03

Seimei (3.8 m)

Abundance determination

- High-res. spectroscopy with GAOES-RV
- R ~ 65000
- Opt. (5160-5930 Å)
- Individual elements (Mg, Ca, Sc, Ti, Cr, Fe, Ni, Ba)

STEP 04

Subaru (8 m)

Detailed abundance determination

- High-res. spectroscopy with HDS
- R > 45000
- Opt. and UV
- Individual elements incl. rare elements

要求夜数（最終）

- Tomo-e : 21 chips (5deg2) x 4 filters
- Dec > -30deg の空 30939deg2 : 6187 pointings (21 chip で)
- target の星 : G<13
- 必要な S/N : >20
- （観測できて astrometry が決まっている画像の中で、transparency, seeing などの variation 込みで）60s 積分で 50%の確率で S/N>20 が G<13 の星に達成
- overhead : ~15s per exposure (with dithering)
- 必要時間：(30s 積分 + 15s overhead) x 2 (60s積分) x 2 (確率50%) x 6187 pointings = 310hr

2025年5月観測

- G<12.5
  - 20s 積分で 50%の確率で G<12.5 に S/N>20 が達成（16%の確率で G<13 にも S/N>20 が達成）
- 春に観測できる RA （全体の約半分)
  - (20s 積分 + 15s overhead) x 2 (確率50%) x 3095 pointings = 60hr
- 4-5月の晴天率は50%程度
  - 4-5月 7-8hr/night -> 10 clear nights -> 20 nights

5s sleep, 0.5s x 6, 2.5s x 8
6.5(+1.5) clear nights
Survey area:
~12,000deg2
4color: 3350deg2

まとめ

- Gaia XP + Tomo-e NB
- 4 filters
  - NB395 (CaHK), NB411 (ref), NB433 (CH), NB656 (Ha)
- 2022, 2024 試験観測 ~8,000 (1130)deg2
- Metallicity estimate with model and ML
- 2025年5月観測 ~12,000 (3350)deg2
  - 6/4- LVK GW observing run
- 将来
  - 津々木システムの使用
  - 秋観測