P6

Oxygen Abundance of Very Metal-Poor Stars using Subaru/IRD Spectra

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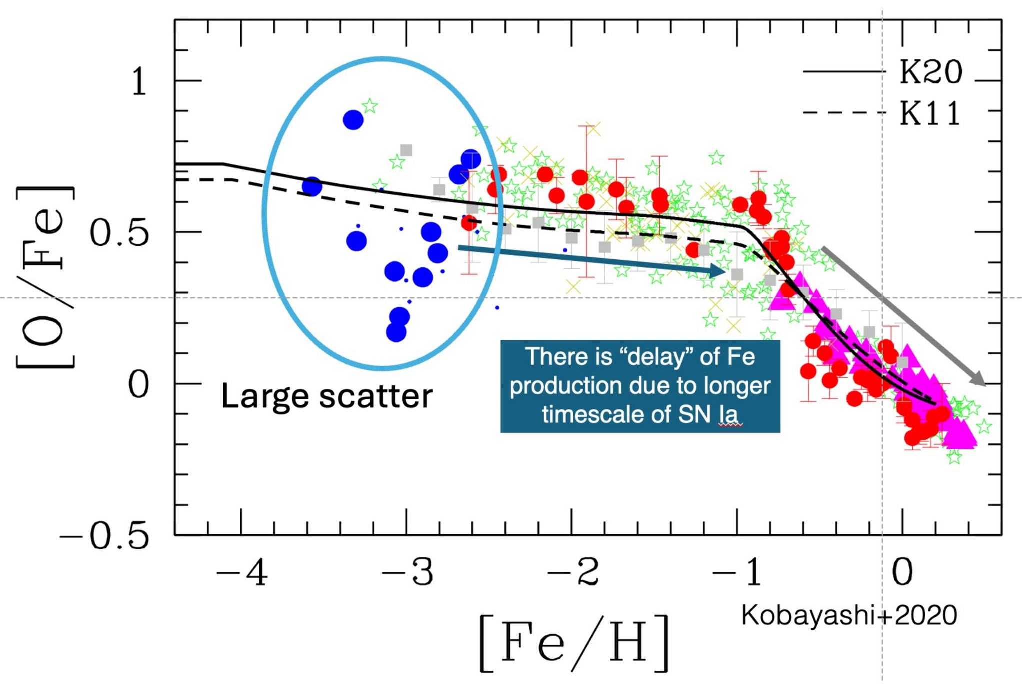
Aims of project

1. Derive oxygen abundance for large sample of Very Metal-Poor (VMP) and Extremely Metal-Poor (EMP) stars (-4 < [Fe/H] <-1.5) from OH first overtone rotational-vibrational lines using `SUBARU/IRD` *H*-band spectra.
2. Investigate how reliable the OH lines as oxygen diagnostics by checking the sensitivity of input parameters to derived abundance, compare derived abundance to another reliable oxygen tracer (e. g., [OI] λ6300Å), and perform the NLTE correction if possible.

Why oxygen and OH lines?

- ✓ Oxygen is 3rd most abundant element in universe and **most abundant** element that was not produced by Big Bang Nucleosynthesis.
- ✓ Product of 3α and α-capture reaction and **most of it ejected through SN II/HN**.
- ✓ Oxygen overabundance trends in lower metallicity → **constraint SN II/HN and SN Ia rate in the early universe**.



- ✓ Large scatter [O/Fe] measured in lower metallicity region.
- ✓ Observational constraint : **absence of reliable oxygen diagnostic line for VMP/EMP sample** (most reliable, one [OI] optical line is very weak).
- ✓ **Importance of OH lines (2x stronger** (Dobrovolskas+2015) **and plentier than [OI]) in extremely low metallicity region.**

Observational Data

- **44 sample stars** of 2022 **`Subaru/IRD` observations** (`S22A-068`, `S22B-114`, PI: Wako Aoki, *YJH* band, 0.97-1.75 μm, R~70,000).
- Query **equivalent width Fe opt. data** from literature **(check code consistency)**

Sample Selection

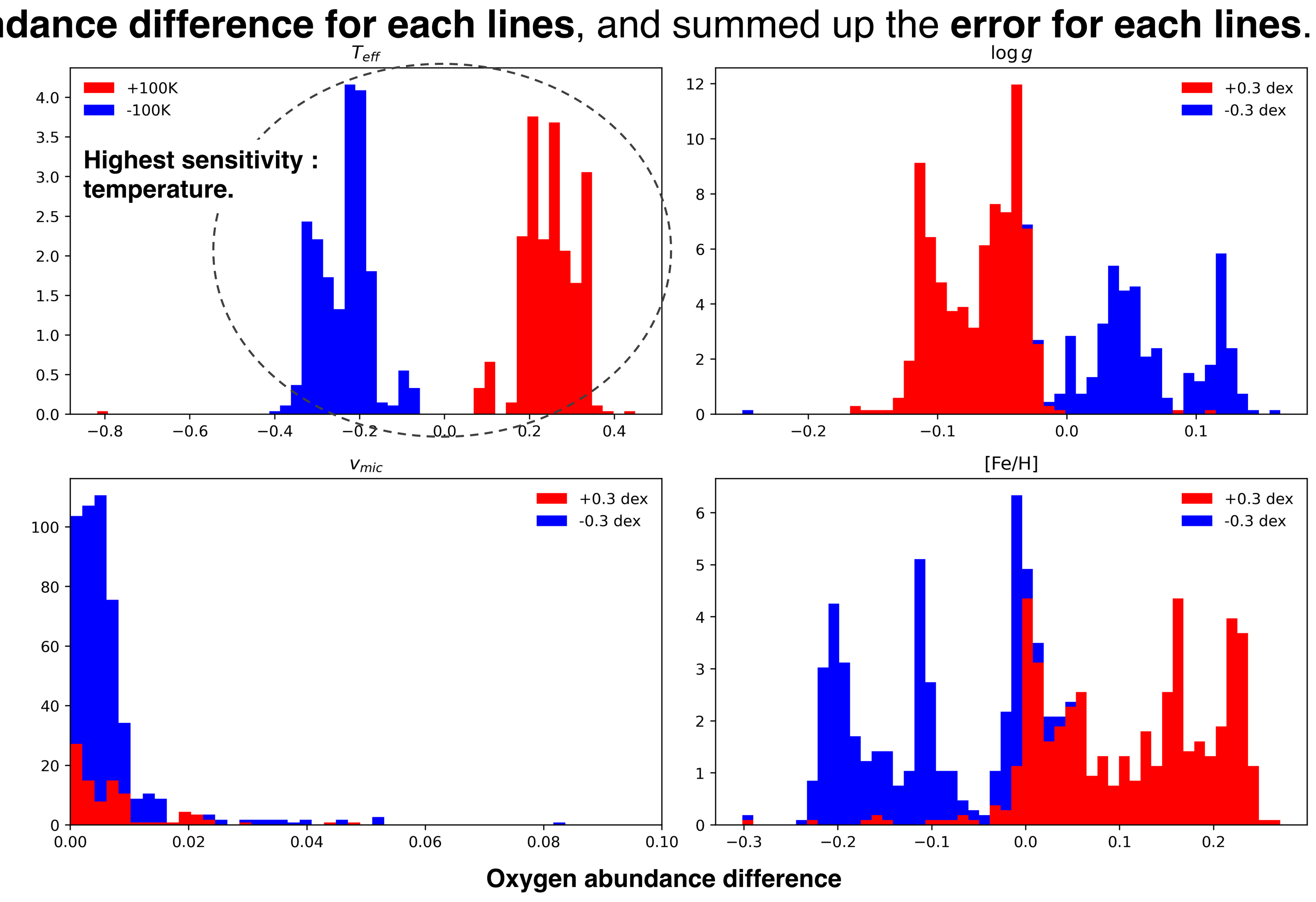
- **Wavelength correction** by cross-correlation with synthetic *YJH* spectra with literature stellar parameters (T_{eff}, log g, [Fe/H], and v_{mic}).
- **OH lines detection** with updated OH line data (Brooke+2016) and `iSpec` (Blanco-Cuaresma+2014), followed by visual inspection and continuum level adjustment.
- **Selected 30 stars with >1 detected OH line.**

Abundance Derivation & Adjustments

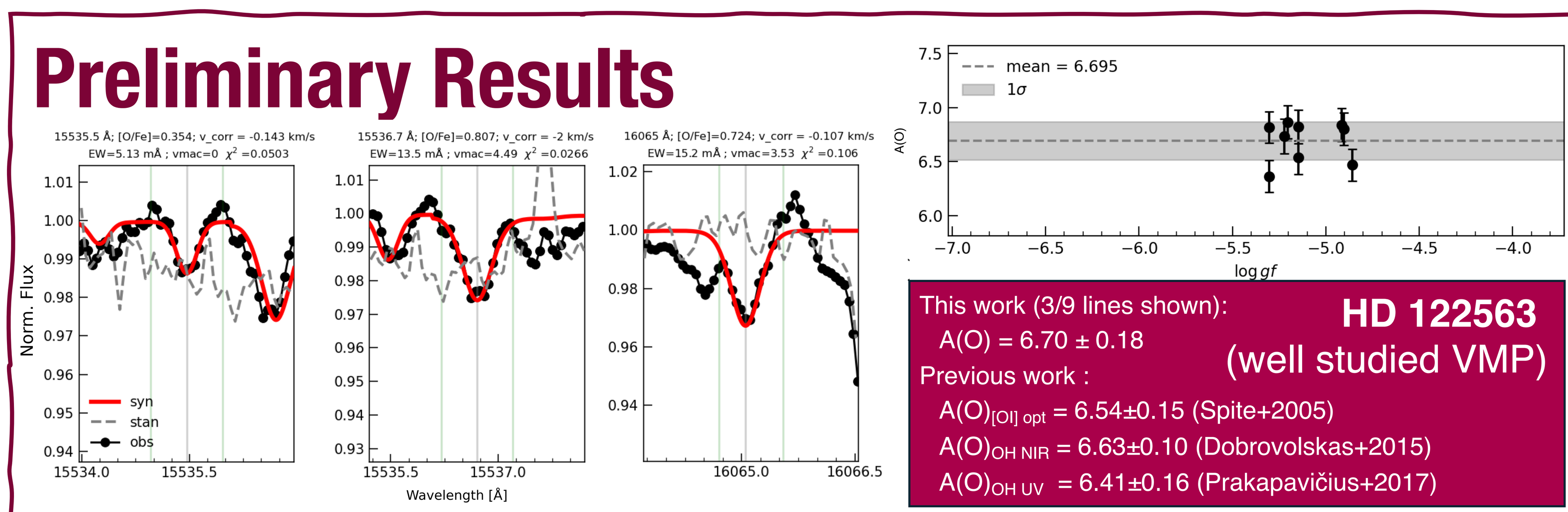
- **`TurbospectrumNLTE & TSFitPy`** (Gerber+2023). MARCS model atmosphere (**spherical** model for giants and **plan-parallel** model for dwarfs). `APOGEE DR17` atomics and molecular linelist (Smith+2021).
- LTE and $v \sin i \sim 0$ km/s assumption. $A_{\odot}(O)$ = 8.77±0.05 (Magg+2022).
- Spectral syntesis fitting for oxygen, and equivalent width method for iron abundance.
- **Adjustments :** (1) Set input **log g = 0.5 and [Fe/H] = -3** for sample with log g < 0.5 and [Fe/H] < -3. (2) Set input **[C/Fe] to CH band abundance** from literature (derived O abundance **difference up to -0.2 dex** for sample with lower [C/Fe]).

Sensitivity Analysis

Change the input parameters : temperature (±100K), surface gravity (± 0.3 dex), microturbulence velocity (± 0.3 km/s), and metallicity (± 0.3 dex). Calculate the derived **abundance difference for each lines**, and summed up the **error for each lines**.



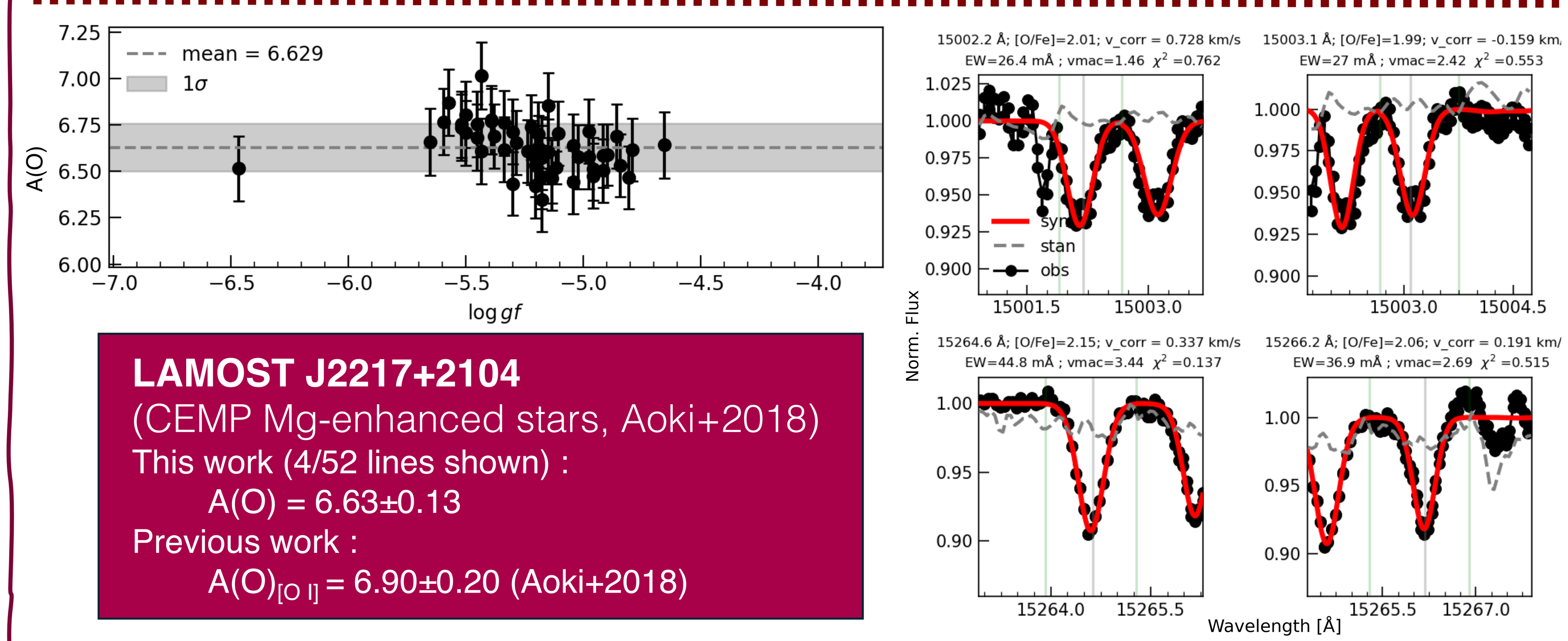
Preliminary Results



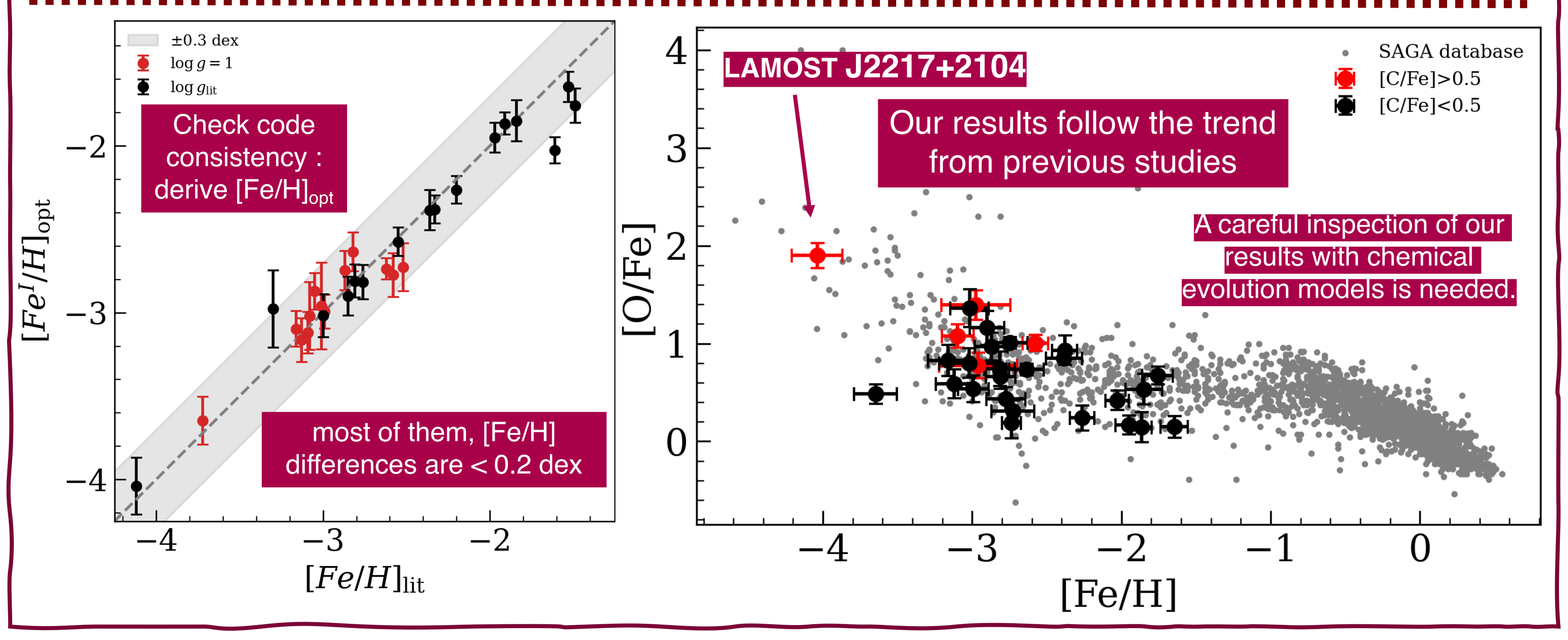
This work (3/9 lines shown):
A(O) = 6.70 ± 0.18

HD 122563 (well studied VMP)

Previous work :
$A(O)_{[OI]\ opt}$ = 6.54±0.15 (Spite+2005)
$A(O)_{OH\ NIR}$ = 6.63±0.10 (Dobrovolskas+2015)
$A(O)_{OH\ UV}$ = 6.41±0.16 (Prakapavičius+2017)

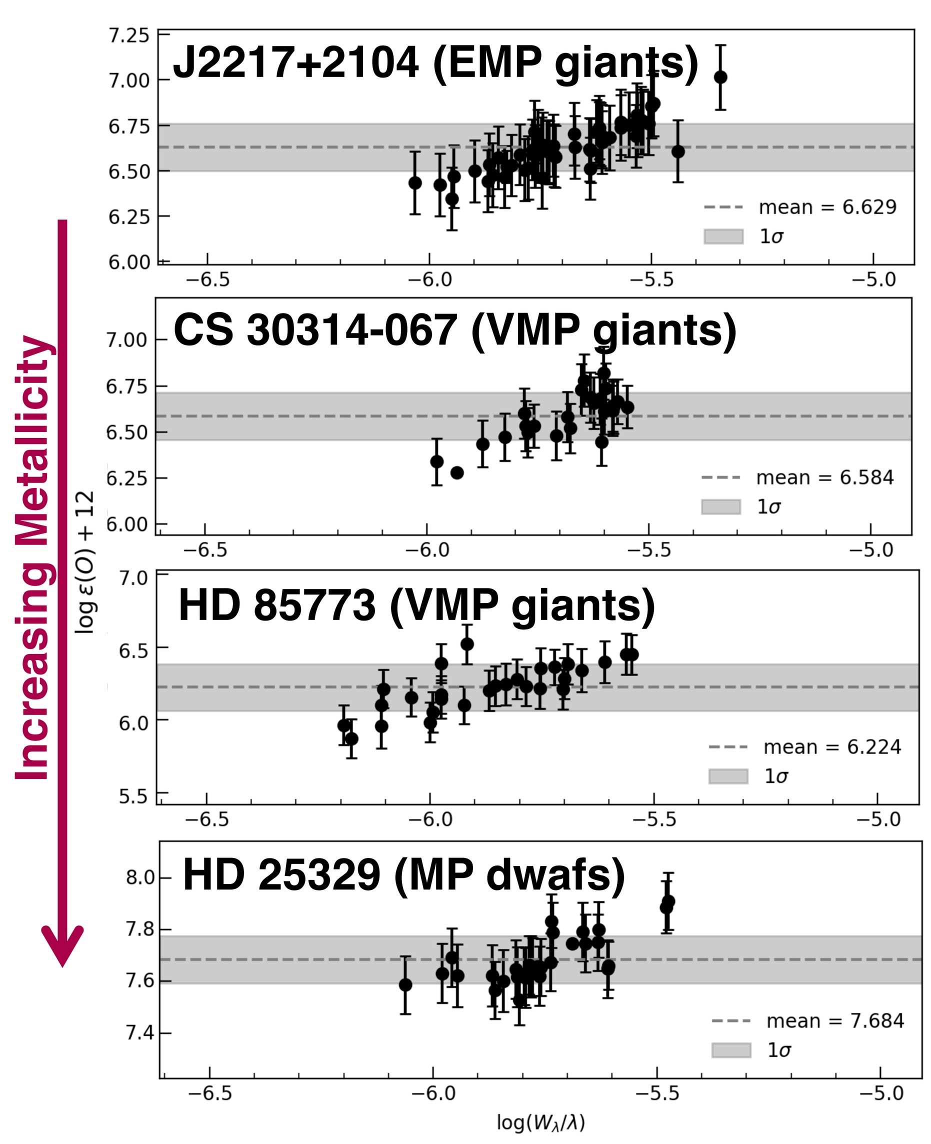


LAMOST J2217+2104
(CEMP Mg-enhanced stars, Aoki+2018)
This work (4/52 lines shown) :
A(O) = 6.63±0.13
Previous work :
$A(O)_{[O\ I]}$ = 6.90±0.20 (Aoki+2018)



Concern

- **Higher oxygen abundance** were derived from **stronger lines**.
- 3D atmosphere model seems **improve the results**, but the trends still noticeable (Dobrovolskas+2015).
- No conclusive reason from previous study.
- The abundance of 1D lines can **differ** from 3D lines by up to **0.3 dex**.
- OH lines form slightly higher in the atmosphere and have **a larger temperature distribution** compared to [O I] line formation (Dobrovolskas+2015)



Summary & Next Steps

- Our preliminary results have derived oxygen abundance from 30 sample stars using Subaru/IRD spectra.
- In general, our preliminary results of the sample's O abundance follow the well-known galactic chemical evolution model (as seen from [O/Fe] vs [Fe/H]).
- There is more work to be done to verify the results by comparing with optical/UV oxygen abundance, and also investigating the NLTE and 3D effects on the derived abundance.