Stars, Gas, and the Milky Way: Science for 2nd Gen Instruments

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DSC 2015

Possible with 1st Gen Instruments

- Metal-poor massive stars (WFOS)
- Metallicity dependence of stellar mass loss (WFOS)
- EMP stars (WFOS)
- Field star binary frequency (NFIRAOS)
- Globular clusters at Virgo (WFOS, IRIS)
- M dwarf, WD surveys (WFOS)
- M31 planetary nebulae (WFOS)
- Chemical tagging (WFOS)
- dSph stellar proper motions (IRIS)

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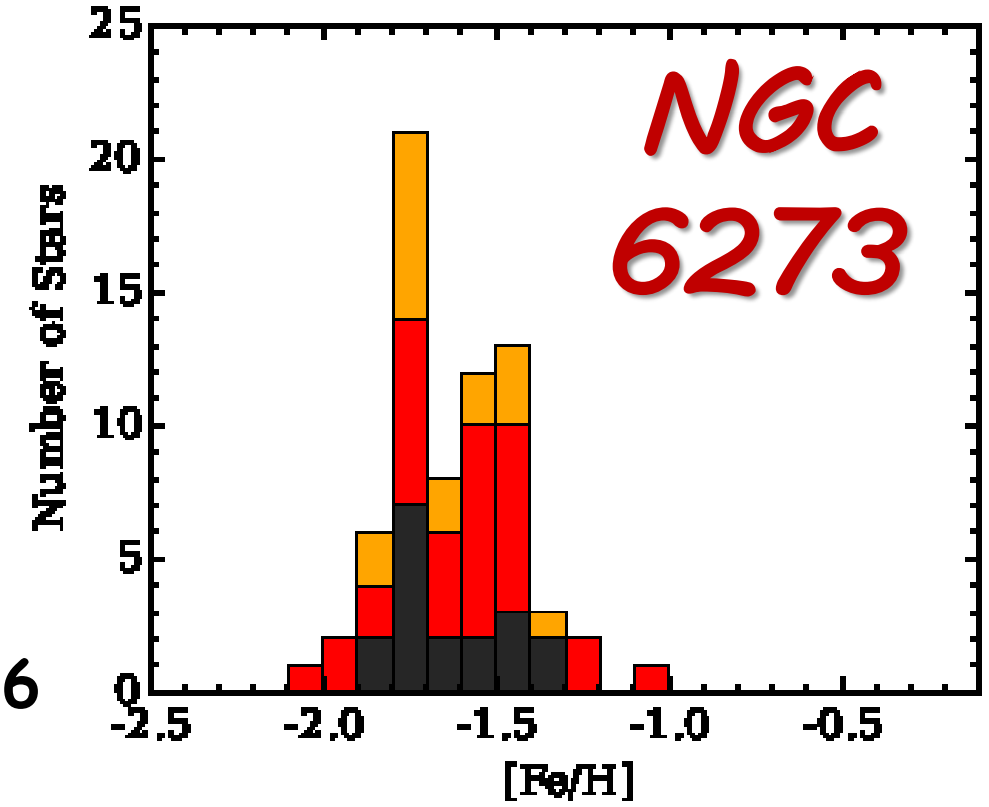
Need 2nd Gen Insts - Mostly HRIS/NIRES

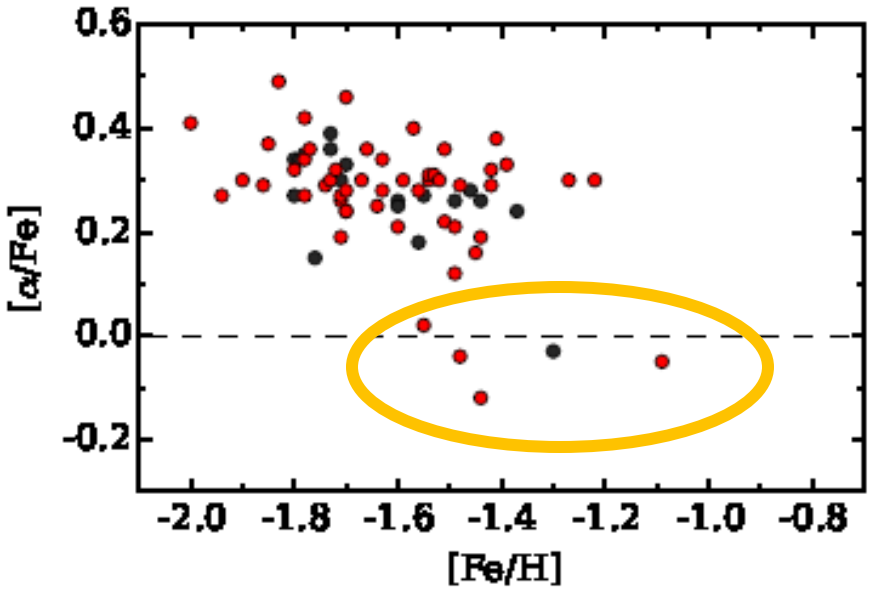
- **Nucleosynthesis & Chemical Enrichment**
  - Globular cluster star spectroscopy @ V=20 mag
    - Multiple populations, Fe-complex clusters
  - EMP stars
  - Other populations
- Rare object spectroscopy (He stars, R CrB stars…)
- Li, Be, r-process (See Sivarani's talk Monday, Aoki today)
- Velocity dispersions of YMCs & local faint dwarf galaxies
- IMBH in clusters (see Mike Rich's talk today)

Multiple Pops in GCs

Another ω Cen?



- **Johnson et al. 2015, 2016**
  - ~3 populations with different [Fe/H]
  - Metal-rich stars centrally concentrated?
  - Metal-rich, α-poor pop
  - Dwarf galaxy nucleus?



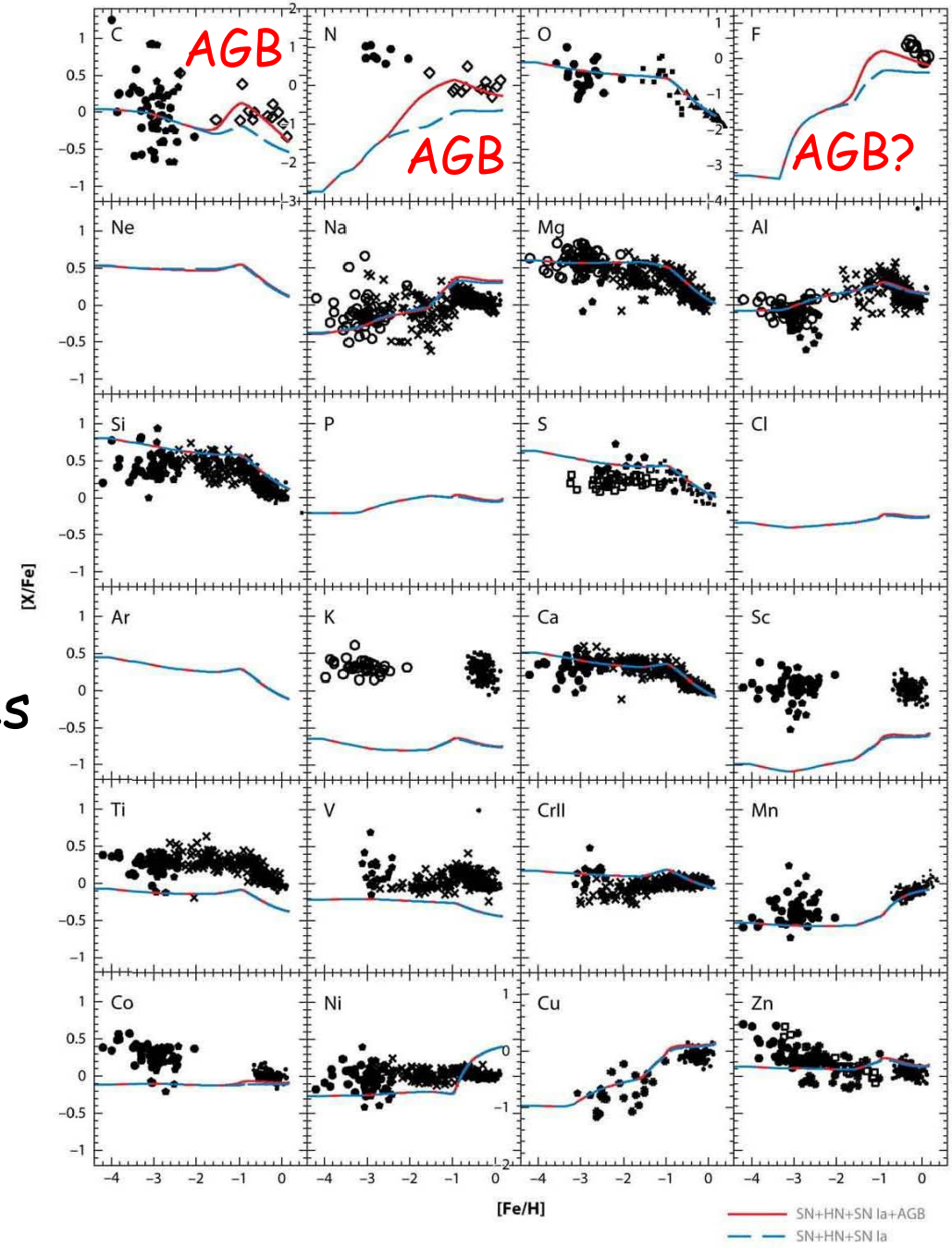
TMT: turn-off and MS stars, HB stars in globular clusters

Abundances
What are the important questions?

Odd elements – NIR
Noble gases – emission lines
(Letizia!)

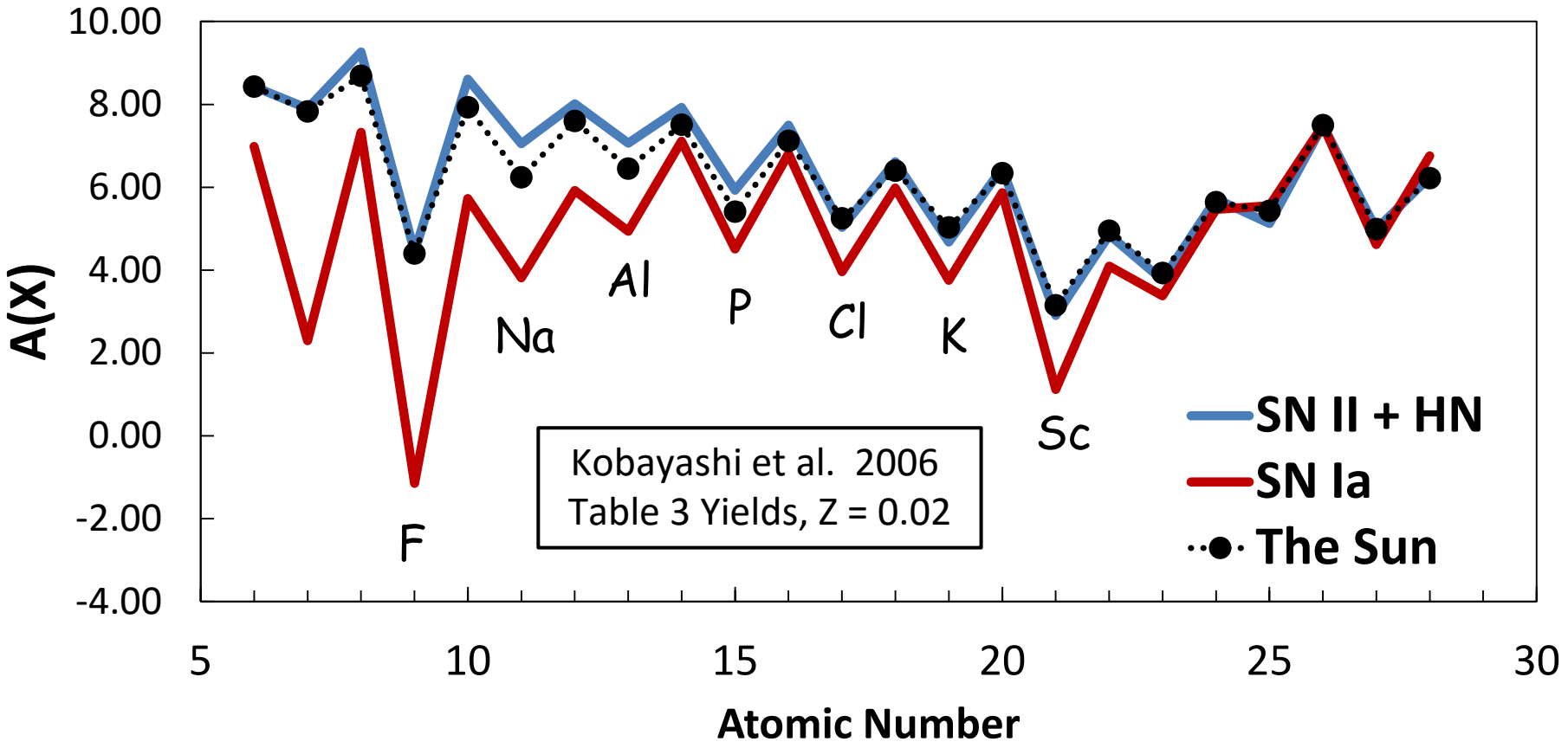
Chemical evolution models from
Nomoto et al. 2013, ARAA
Disk and halo populations

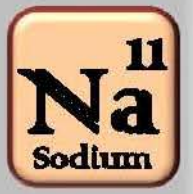
SN + HN + Ia
SN + HN + Ia + AGB

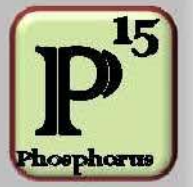


SN Yields and the Sun

- Comparing to yields
  - Heavier alphas fit SN II
  - Light alphas fit less well
  - Odd-even effect matches SN II better



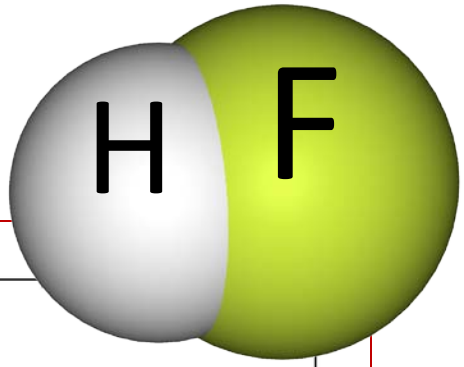




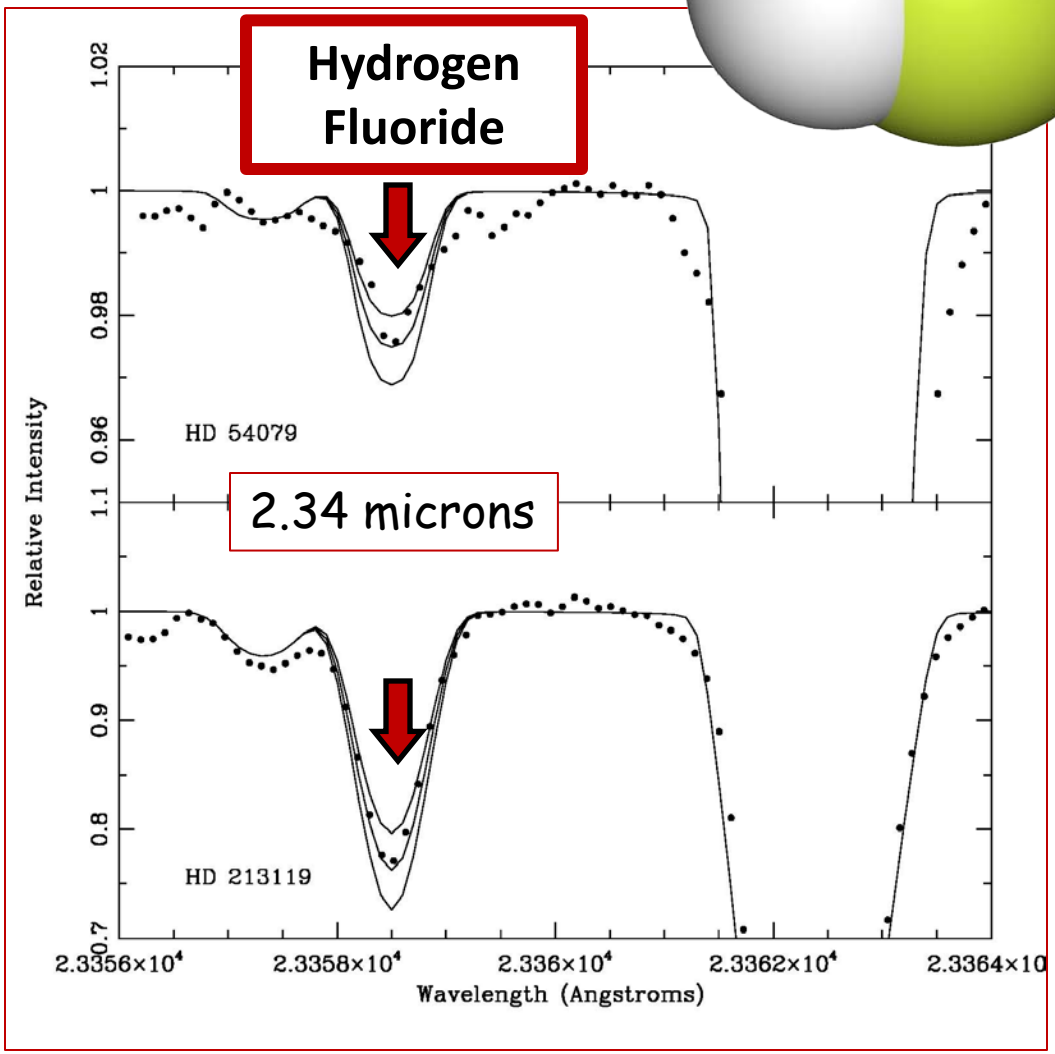
Odds? Why Do We Care?

- Form through odd-ball processes
- Produced in smaller quantities than evens
- Reveal physical conditions during nucleosynthesis
- Constrain sites of nucleosynthesis and chemical evolution models

Fluorine



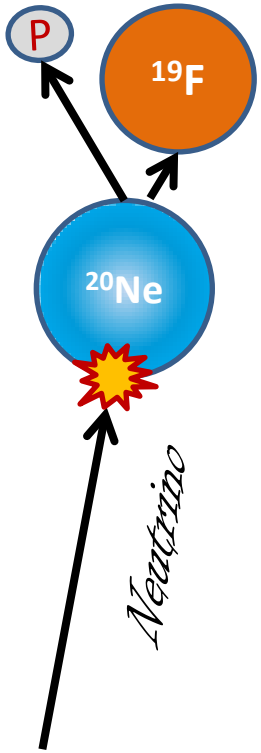
Cool stuff in the infrared!

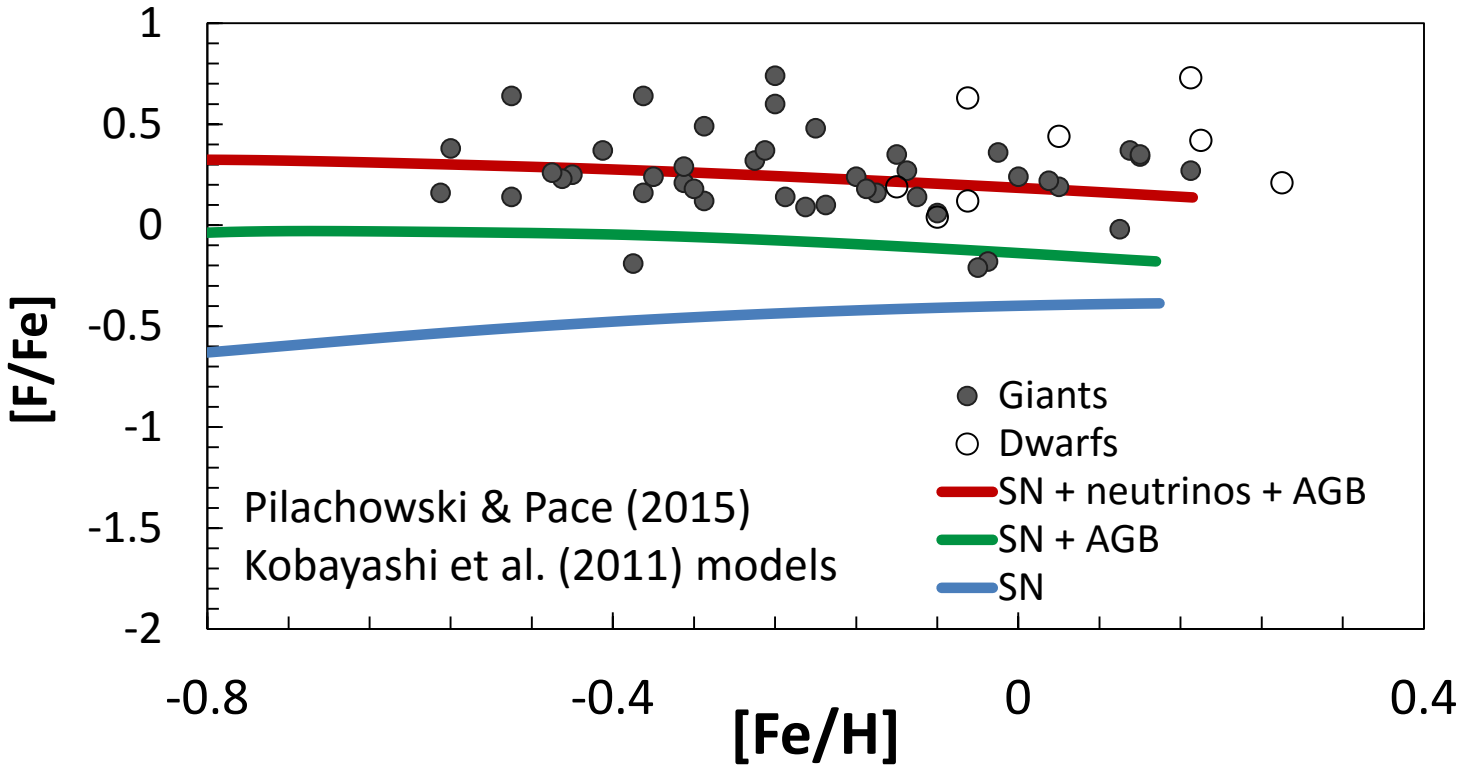


- HF at 2.4 mm
- Phoenix @ Kitt Peak
- TMT: F in GCs, halo, and Bulge

Fluorine & CE Models

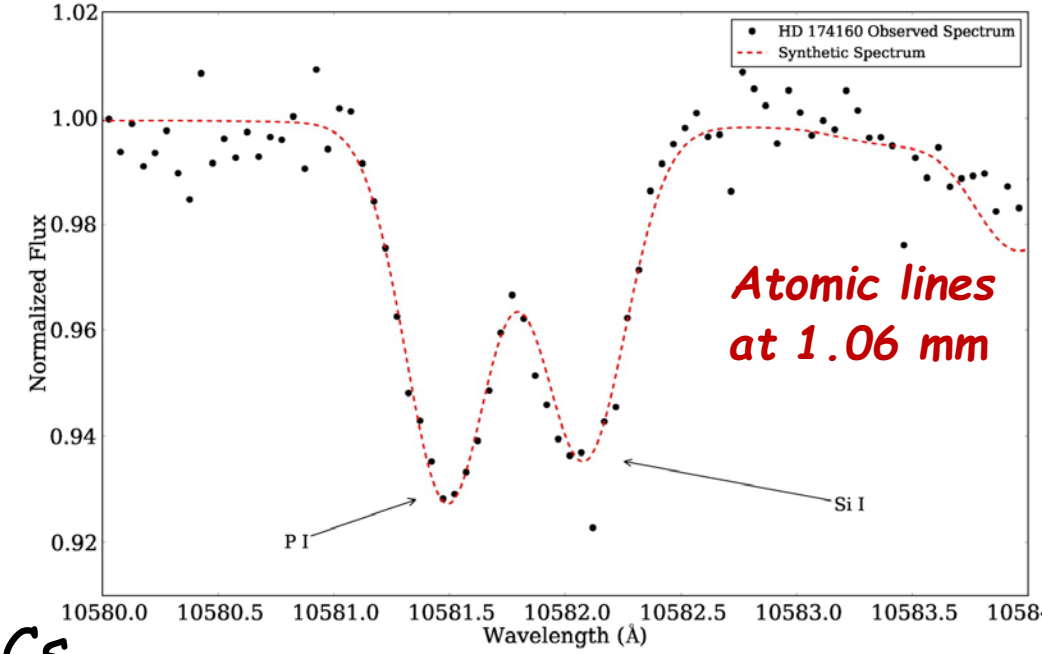
- CCNe +SN Ia + AGB stars **insufficient**
- More fluorine from neutrino spallation
- TMT: fluorine in globular cluster populations

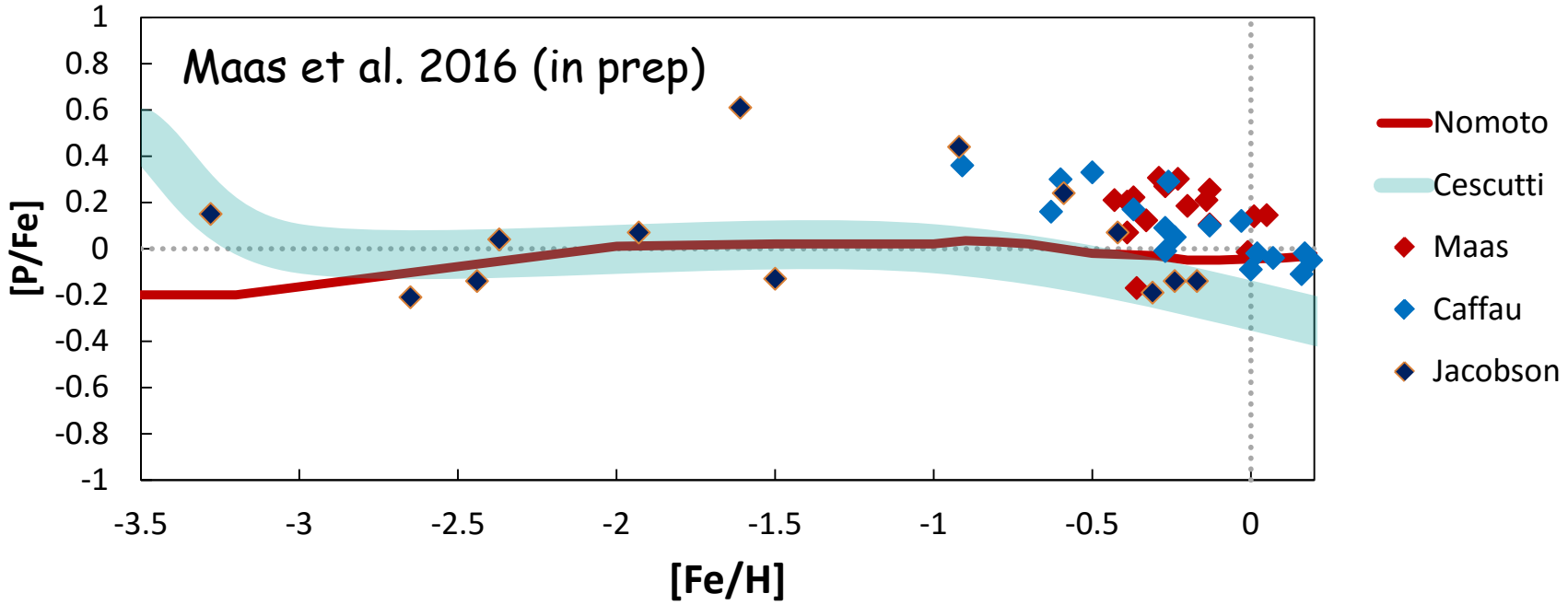




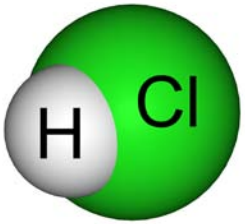
Phosphorus

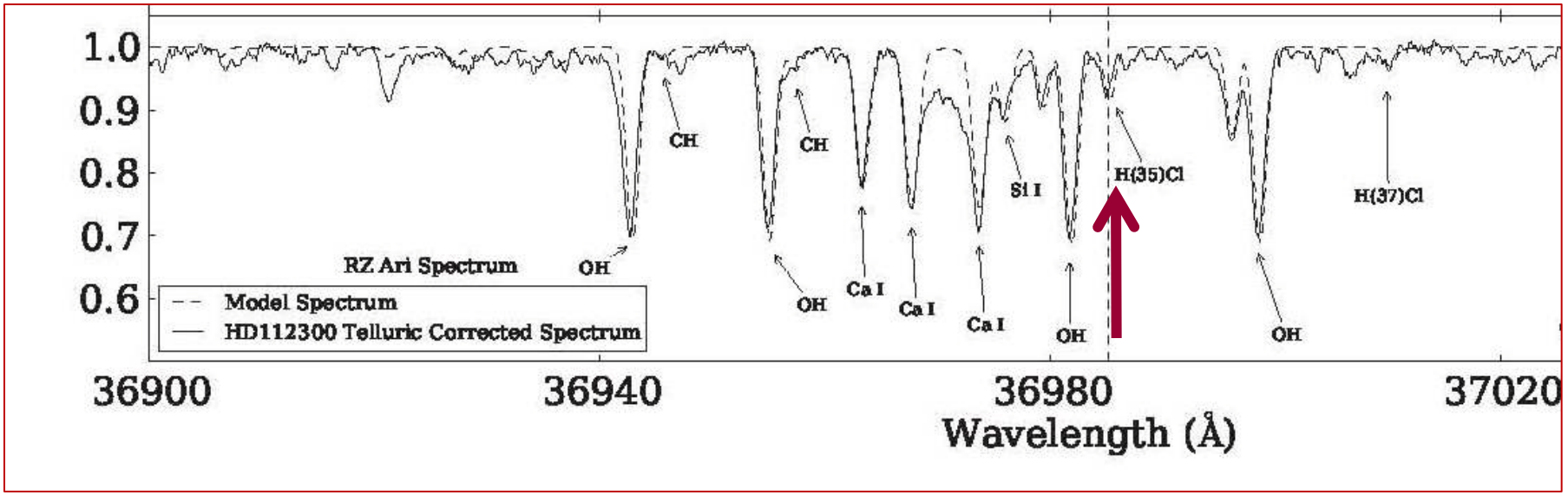
- P mostly from CCNe…
- Not much from SN Ia?
- TMT: P in Bulge, Halo, & GCs



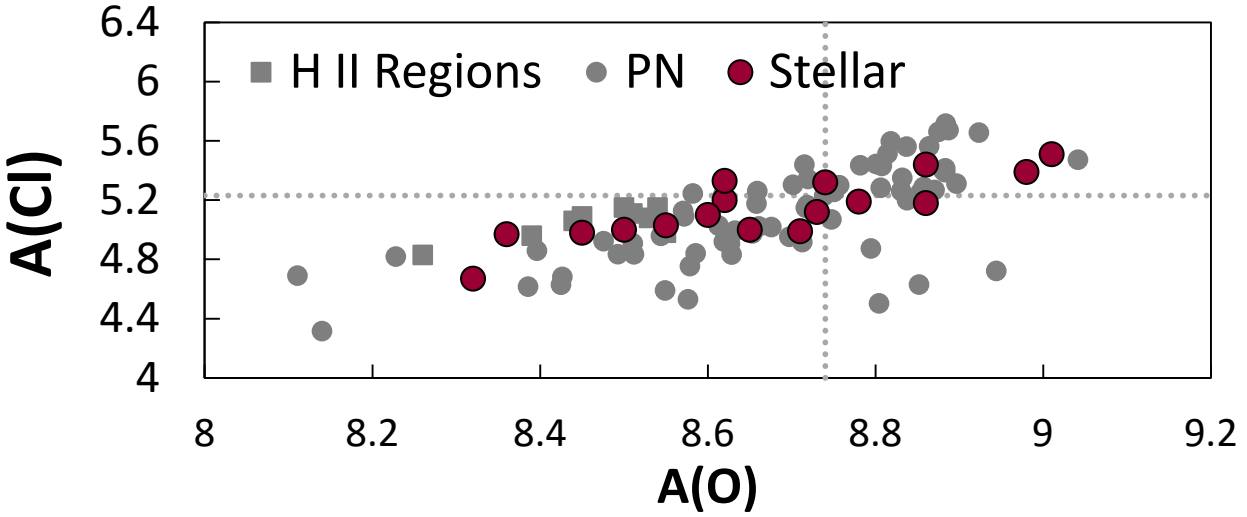


Chlorine



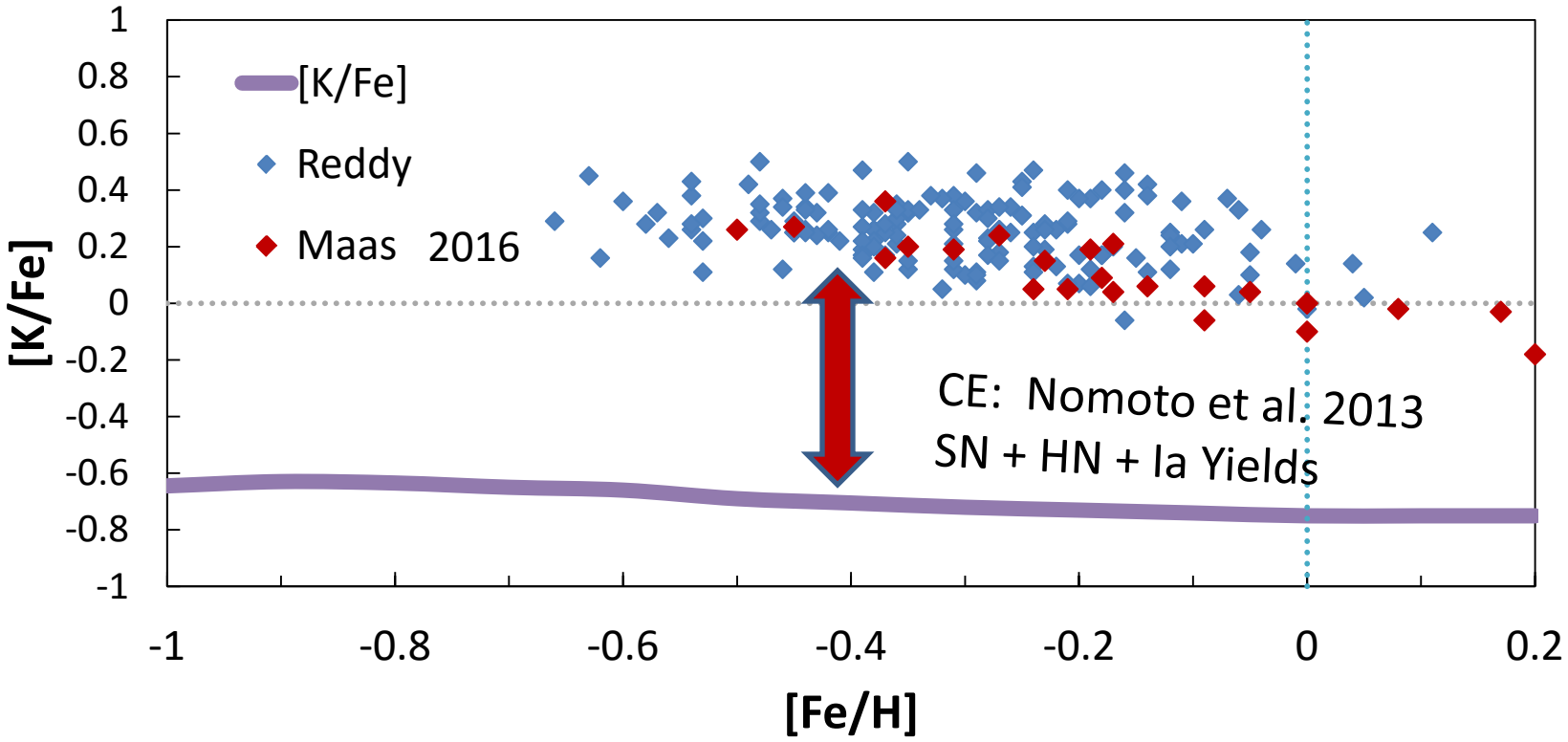


- First stellar abundances for Cl (Maas et al. 2016)
- Cl measured in PN (Delgado-Inglada et al. 2015, Henry et al. 2004) and H II regions (Esteban et al. 2015)
- TM: ClO in the mid-IR?



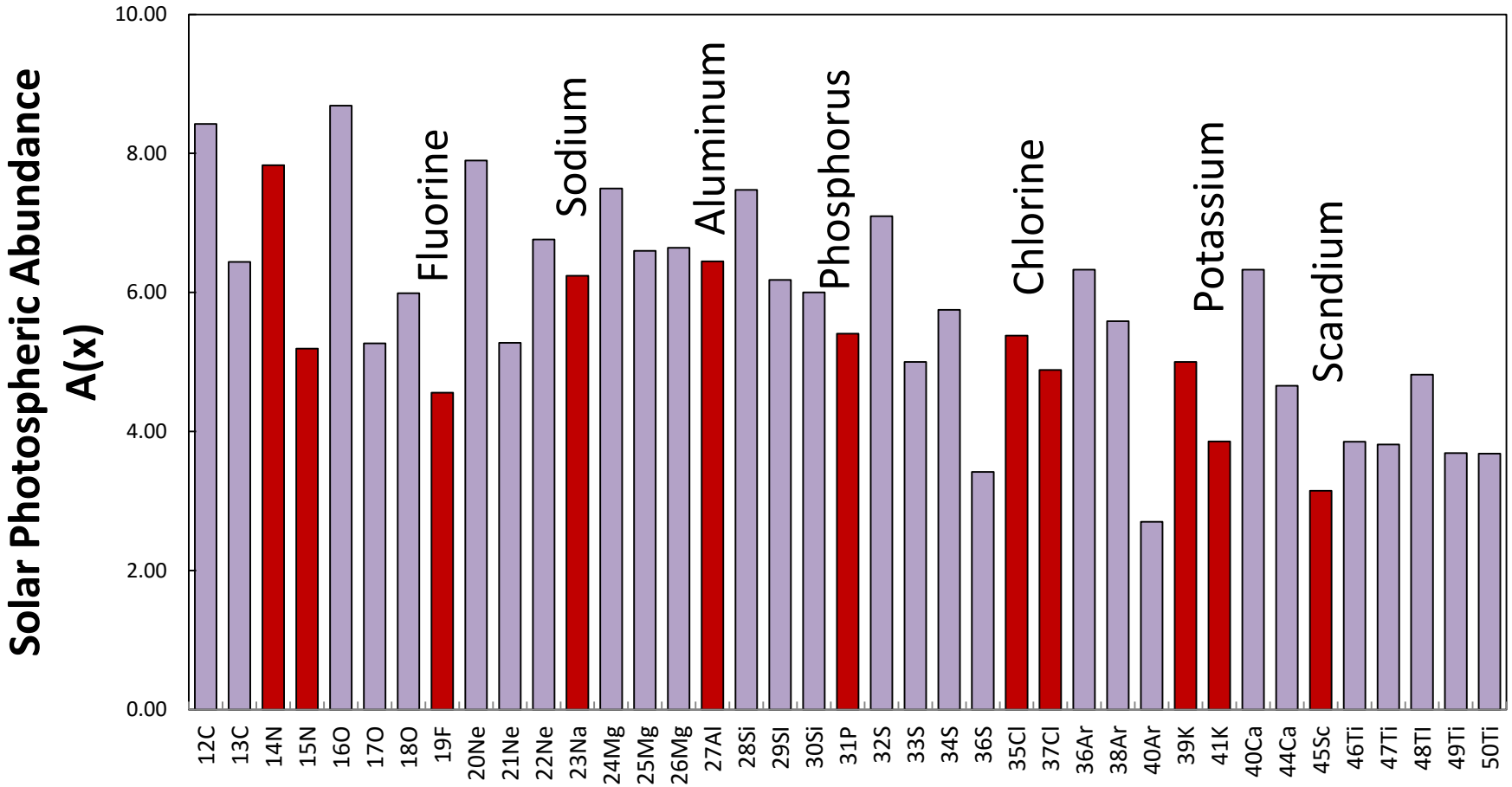
Potassium @ 3·7 μm

- Need additional source (ν process?)
- Decrease in [K/Fe] with [Fe/H] may result from metallicity dependent yields



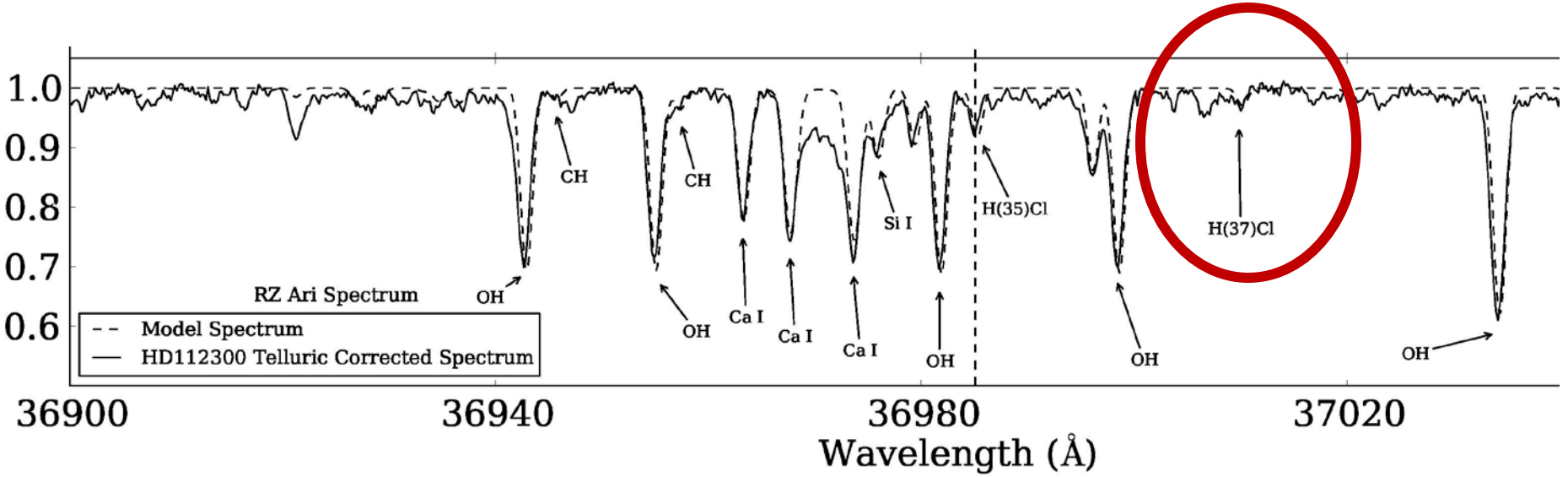
Isotopes

What can we do with the isotopes?



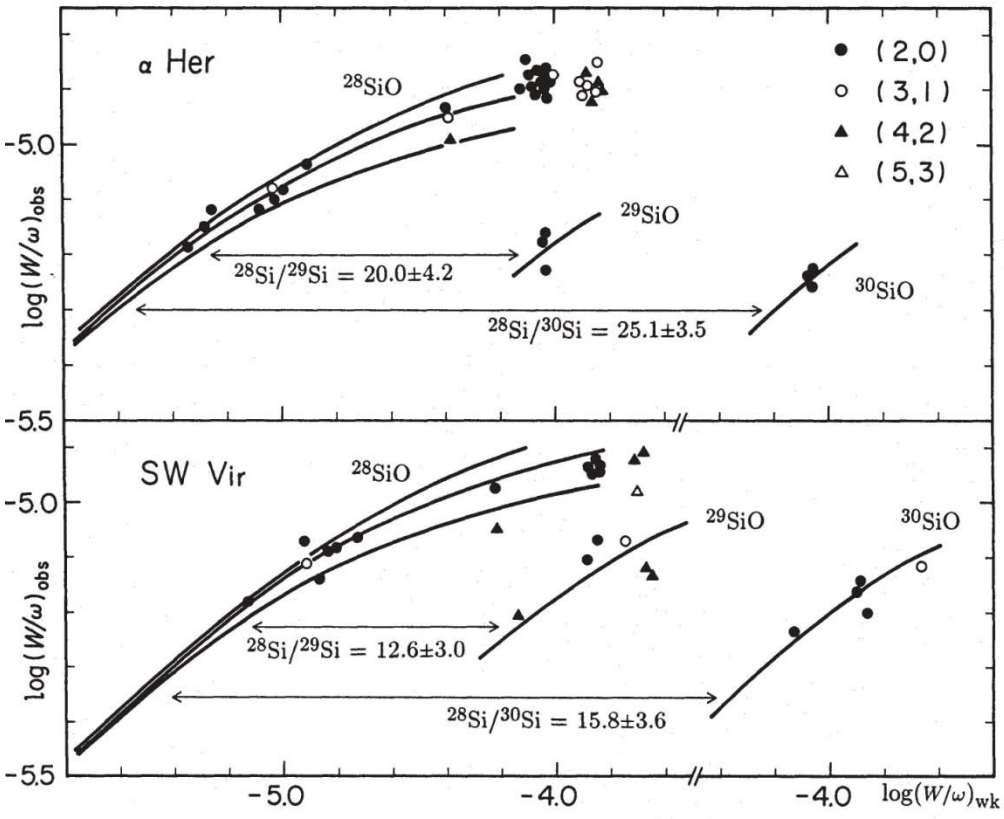
Isotope Ratios: $^{35}Cl/^{37}Cl$

- $^{35}Cl/^{37}Cl$ = 2.2 ± 0.4 measured in RZ Ari
- Solar ratio = 3.1
- Consistent with measurements in the ISM
- CCNe models suggest 1 < $^{35}Cl/^{37}Cl$ < 2.5
- SN Ia models suggest 3.5 < $^{35}Cl/^{37}Cl$ < 5.5

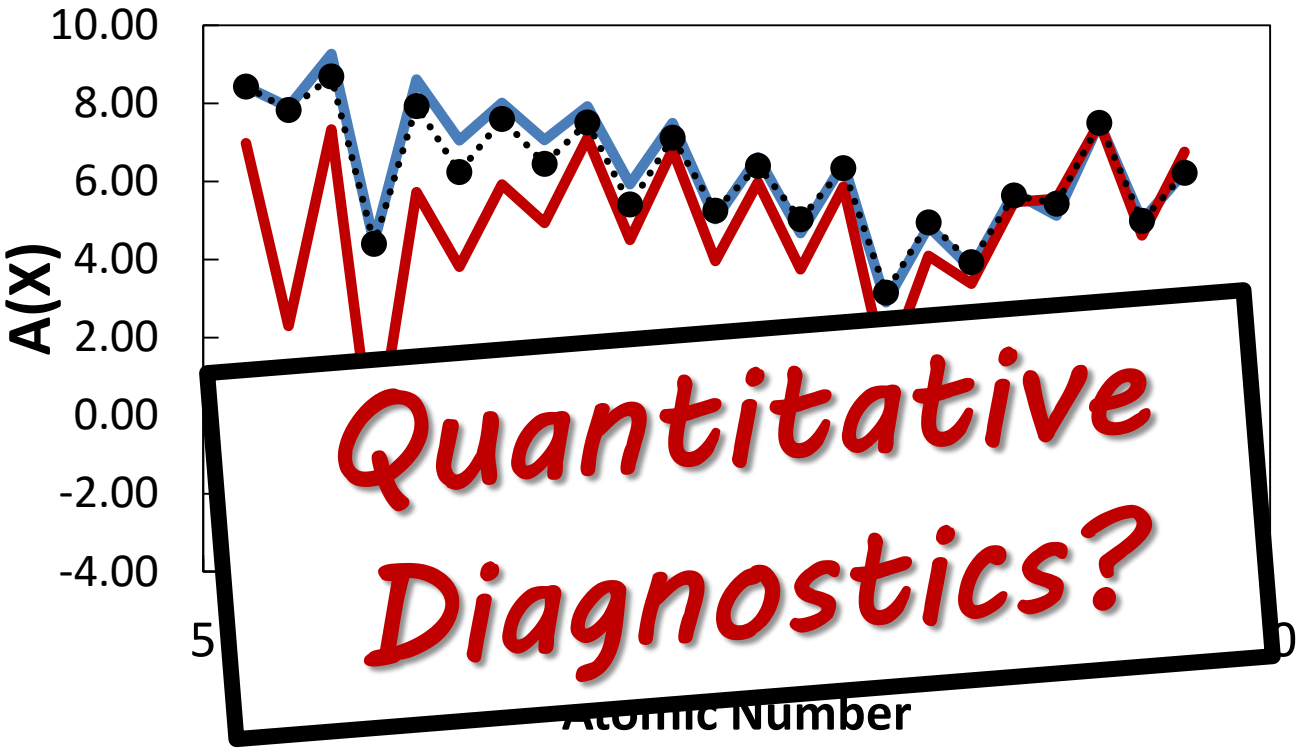


Other Isotopes

- IR and optical high resolution spectroscopy
- Opportunities to constrain specific nucleosynthesis paths and processes
- TMT: GCs, Bulge, Halo



- Mg isotopes from MgH (Melendez & Cohen 2009)
- Silicon isotopes from SiO at 4 m (Tsuji 1994)
- Ti isotopes (Chaves & Lambert 2009)



- Quantifying the CCNe and SN IA contributions in stellar populations
  - Various [Odd/Ca] ratios (F, Na, Sc)
  - [Mg/Si]
  - Amplitude of the [odd/even] effect
  - [alpha/F] ratios