Subaru WS2017

LAMOST-Subaru exploration of first stars and merging history of MW

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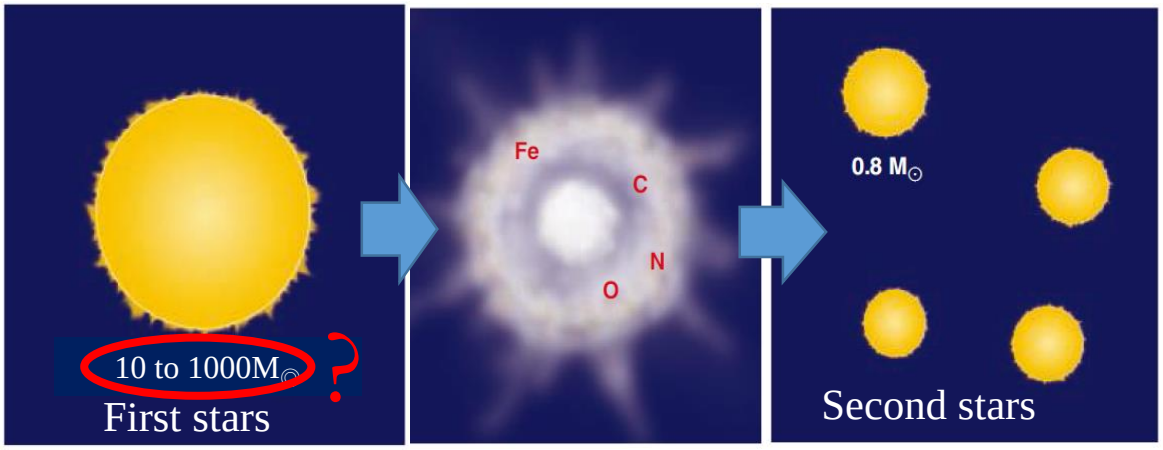
Science driver

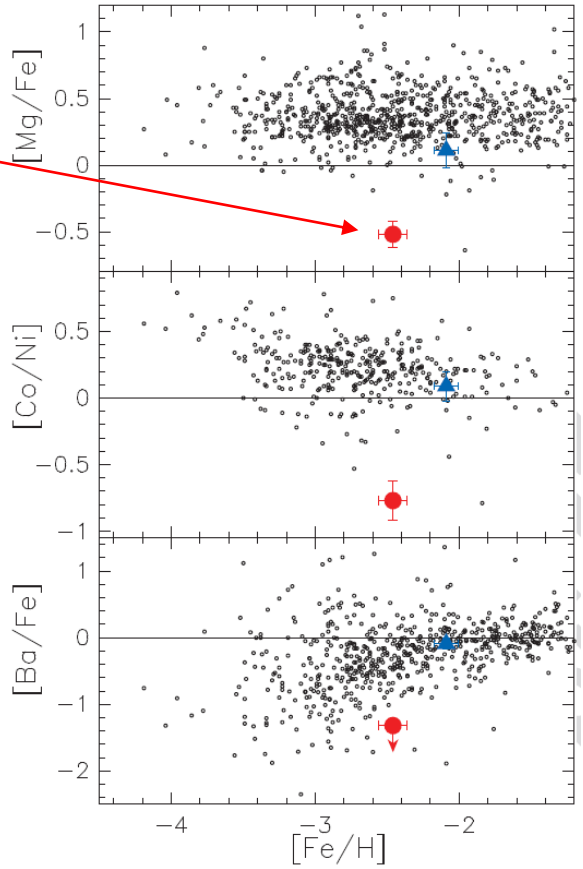
- Galactic stars showing abnormal kinematics and/or chemical compositions, i.e., outlying populations were formed during
  - Enrichment of the early generation of SN
  - Merging history of the halo
  - Particular nucleosynthesis environments
  - …
- Outlying populations constrain the environment and mechanism of their birth and evolution, thus are key to fully understand their progenitors and the history of Galaxy

Metal-poor stars:
relics of first stars



- The chemical compositions of metal-poor stars are fossil records of the nucleosynthesis of single (or a few) process.
- Comparison with chemical evolution models based on statistics of metal-poor stars.

◆ If it's due to limitation of sample, can we find low-mass (< $1M_{\odot}$) first star in the halo or bulge with larger database?

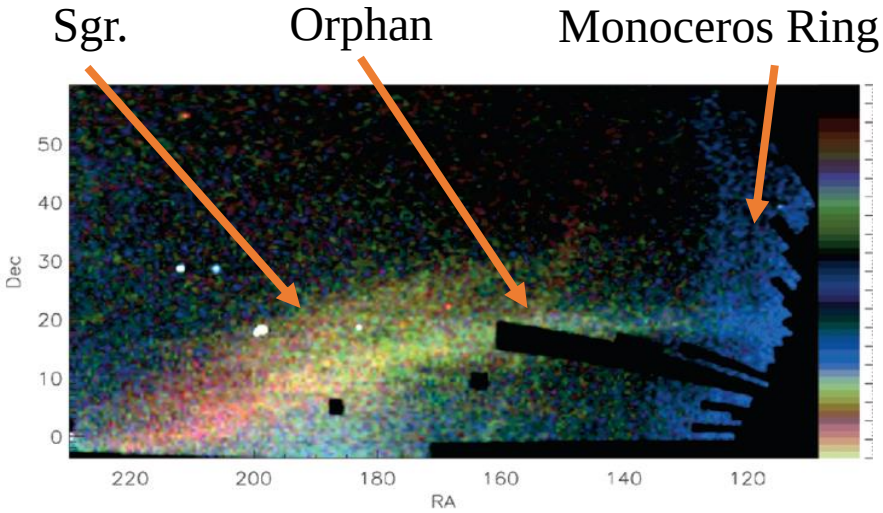


Aoki et al. (2014)

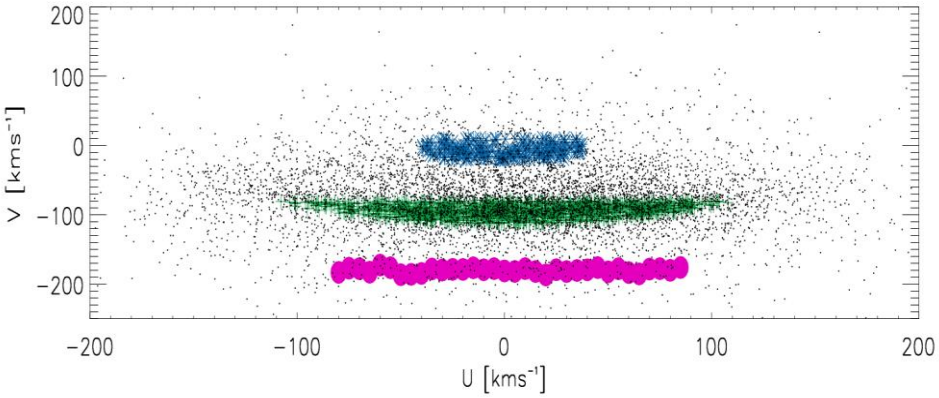
yields of a supernova of a very massive (>$100M_{\odot}$) star

Moving groups in the halo:
Kinematical evidence of MW merging

- Moving groups in the halo: debris of a disrupted satellite



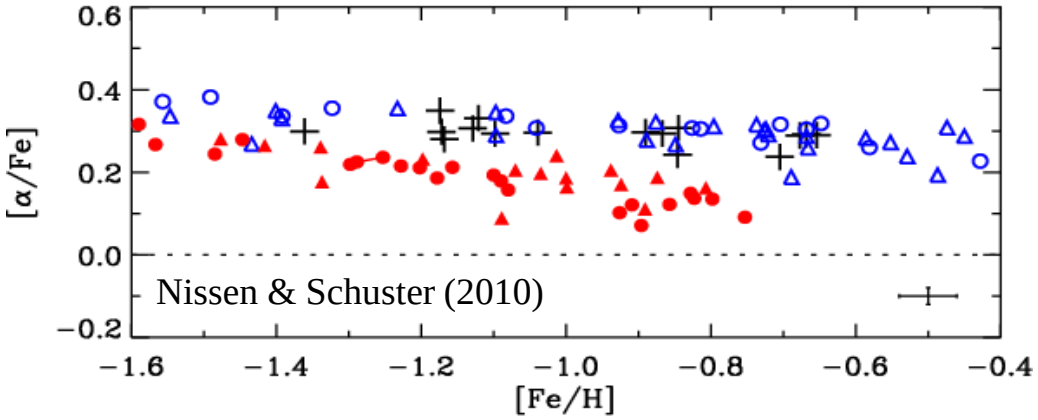
SDSS-DR5 density map

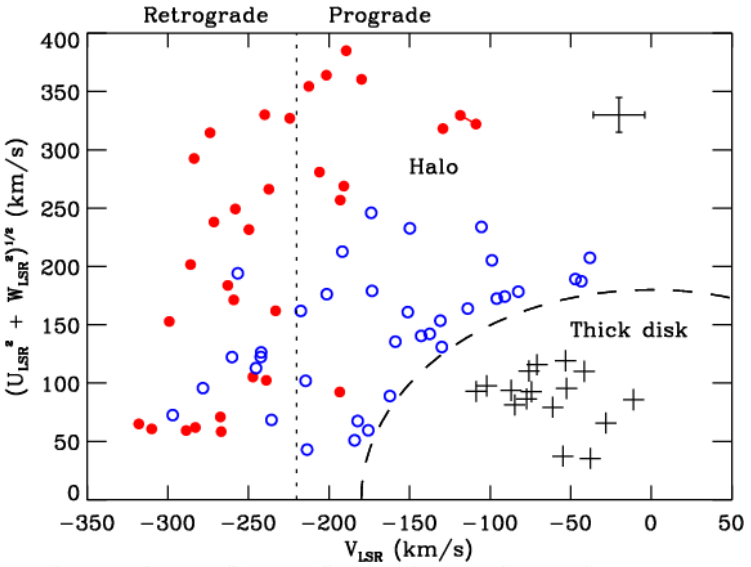


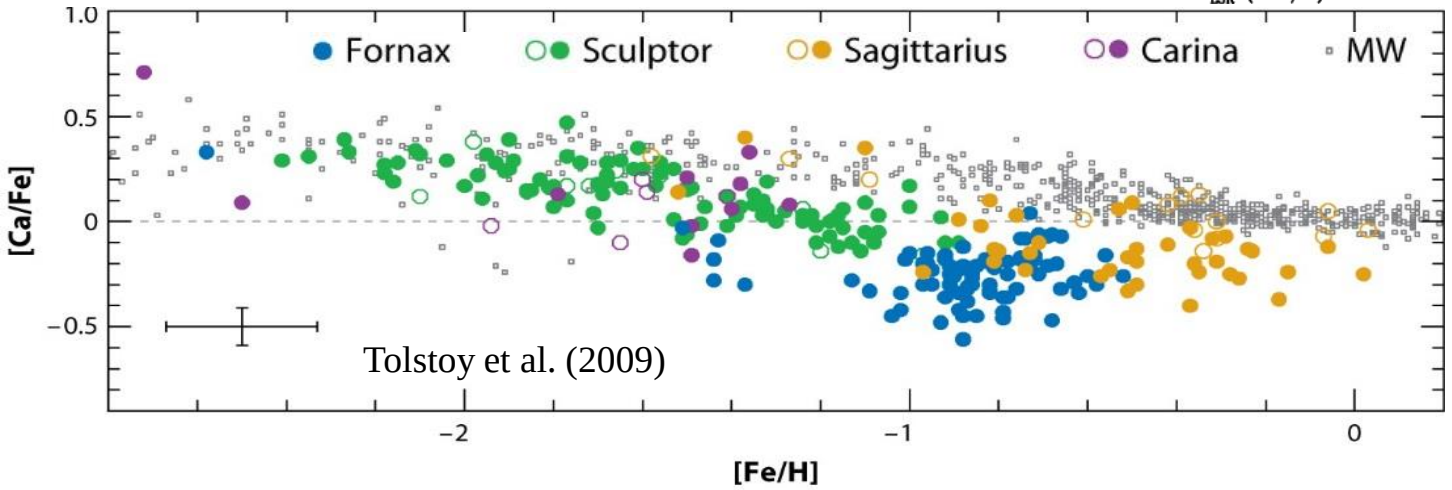
- Less than 30 moving groups have been detected, and very little details are known about the origin: spectroscopy would help to uncover the history

Low-[α/Fe] halo stars:

Chemical evidence of MW merging





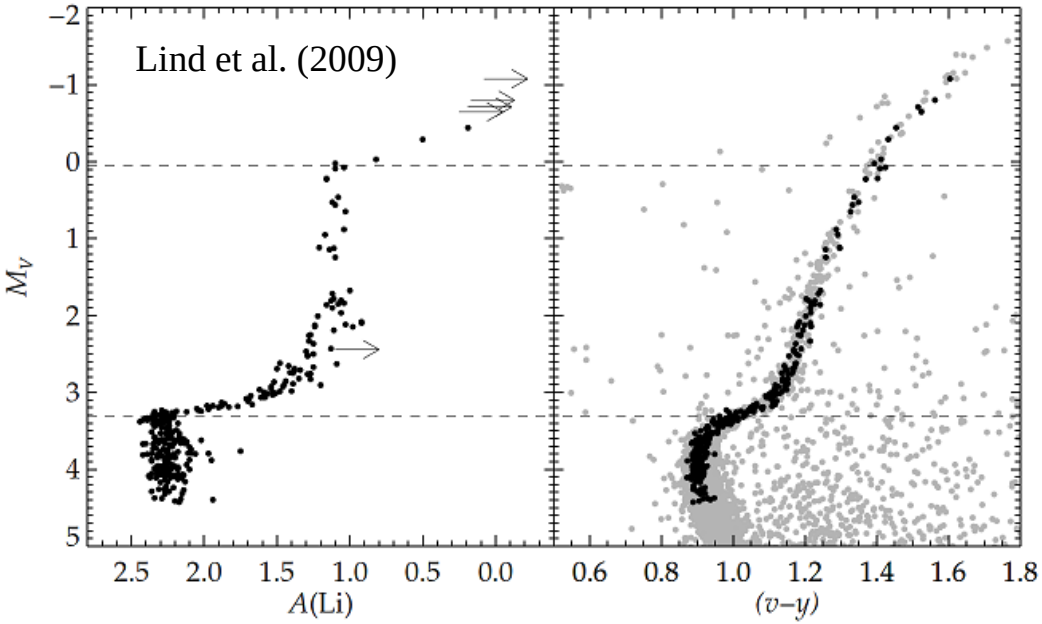


Low-α metal-poor halo stars were originated from dSph galaxies?

Not yet any systematic search

Li-rich giants:
Constrain nucleosynthesis environments

- Mechanism of the production and depletion not yet clear, which may be greatly improved with more accurate surface gravity



- Li-rich candidates in the Kepler filed
  - high-resolution spectra + asteroseismological data
  - the elemental abundance patterns + evolutionary stages
  - constrain the possible scenario(s)

LAMOST spectroscopic survey

LAMOST (The **L**arge Sky **A**rea **M**ulti-**O**bject Fibre **S**pectroscopic **T**elescope)

- Commissioning: 2009.9 - 2011.5
- Pilot survey: 2011.10 - 2012.5
- Regular survey (5 years): 2012.9 –

LAMOST in Xinglong China

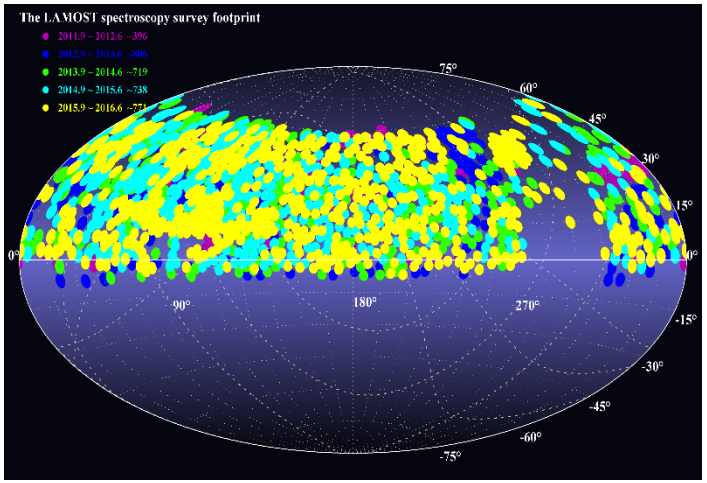
- Combination of large aperture (4m) and wide field (5deg)
- High spectra-obtaining efficiency: 3,400 targets at on exposure
- Direct identification through survey mode

- ~4m
- 4,000 fibers
- R~1800 (2/3 slit)
- r ~17.8

LAMOST data releases (DR4)

DR4 ~ 6,000,000 spectra (sn>10)
AFGK catalogue ~ 4,200,000 stars

> 1.5 million spectra / year



Large survey area (North 7700 deg^2 + South 3500 deg^2)

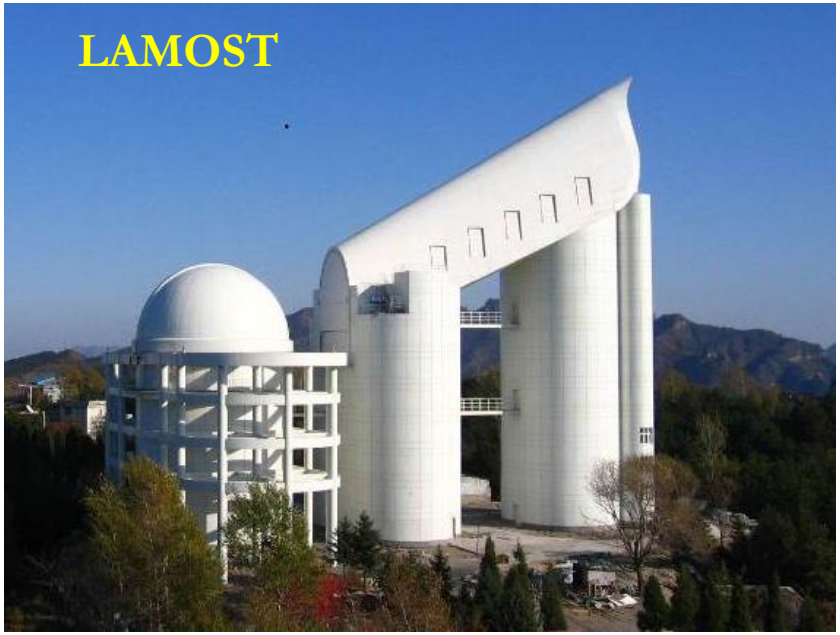
Target selection
Random selection for a given magnitude/temperature range.

suitable for investigating statistics

LAMOST provides an unprecedented opportunity to identify large sample of rare but important outlying populations in large area.

Subaru/HDS follow-up spectroscopy for a large sample of outlying populations found with LAMOST

- High-resolution spectra are demanded to really understand the nature and origin of these peculiar stars
- LAMOST+Subaru joint searching project since 2014

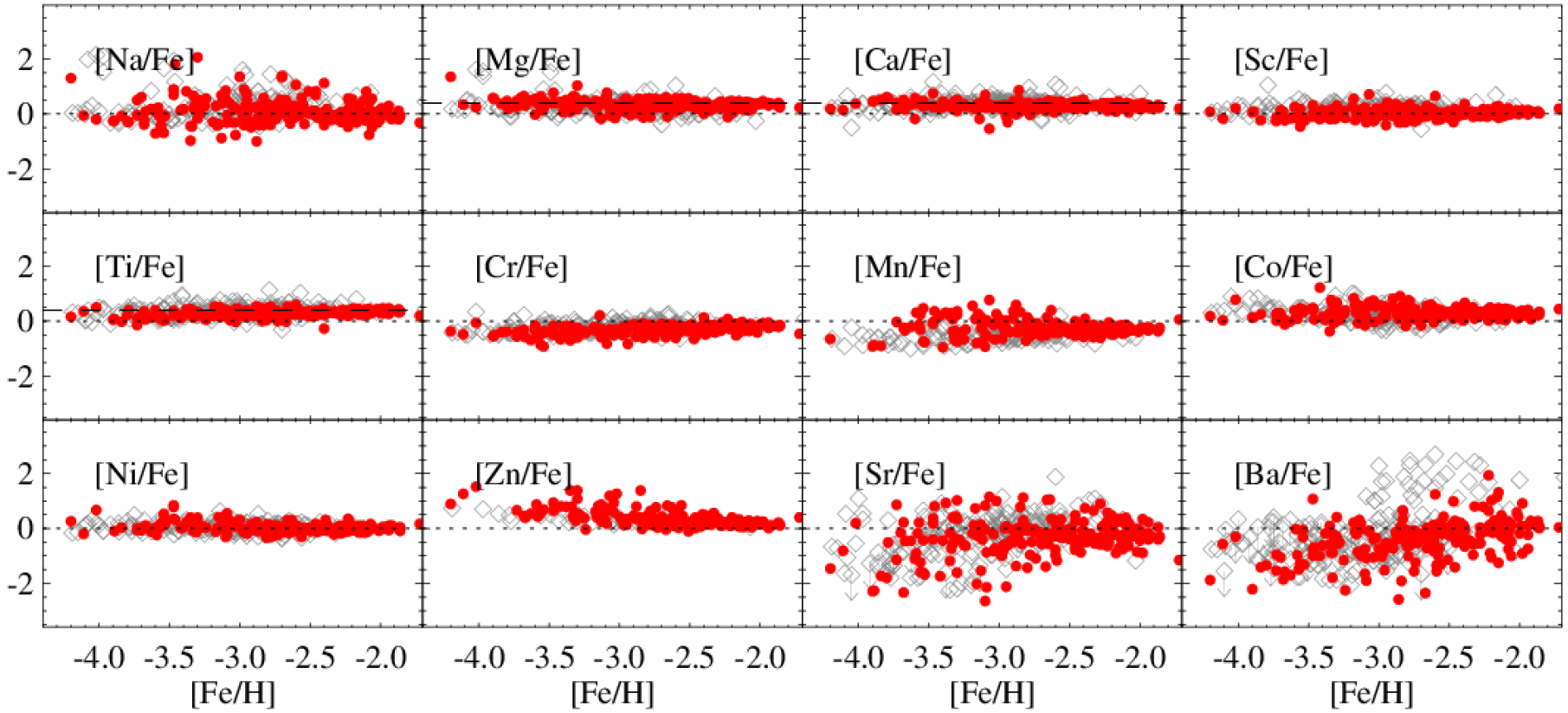


Both telescopes are located in the Northern Hemisphere.

Status of the collaboration

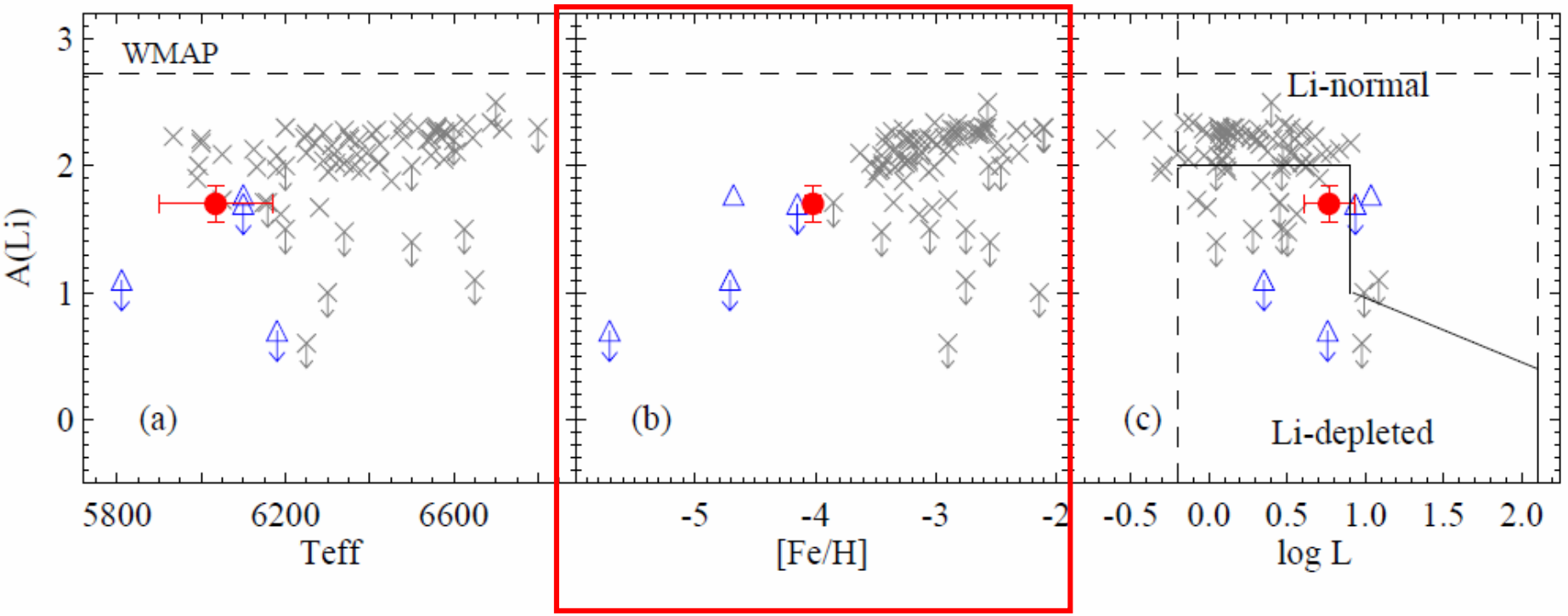
- Subaru open-use normal + service program (2014/2015)
- Subaru open-use intensive program (P.I.: Aoki, 2016-2017)
- CAS-JSPS joint project (P.I.: Zhao & Aoki, 2016-2018)
- Follow-up with Subaru/HDS runs (on-going)
  - Over 250 VMP/EMP stars
  - Over 20 Li-rich giants
  - A dozen moving group member and low-α stars
- Early results and several refereed papers published

Abundances of the large VMP sample
(on-going)



New ultra metal-poor ([Fe/H]<-4.0) stars

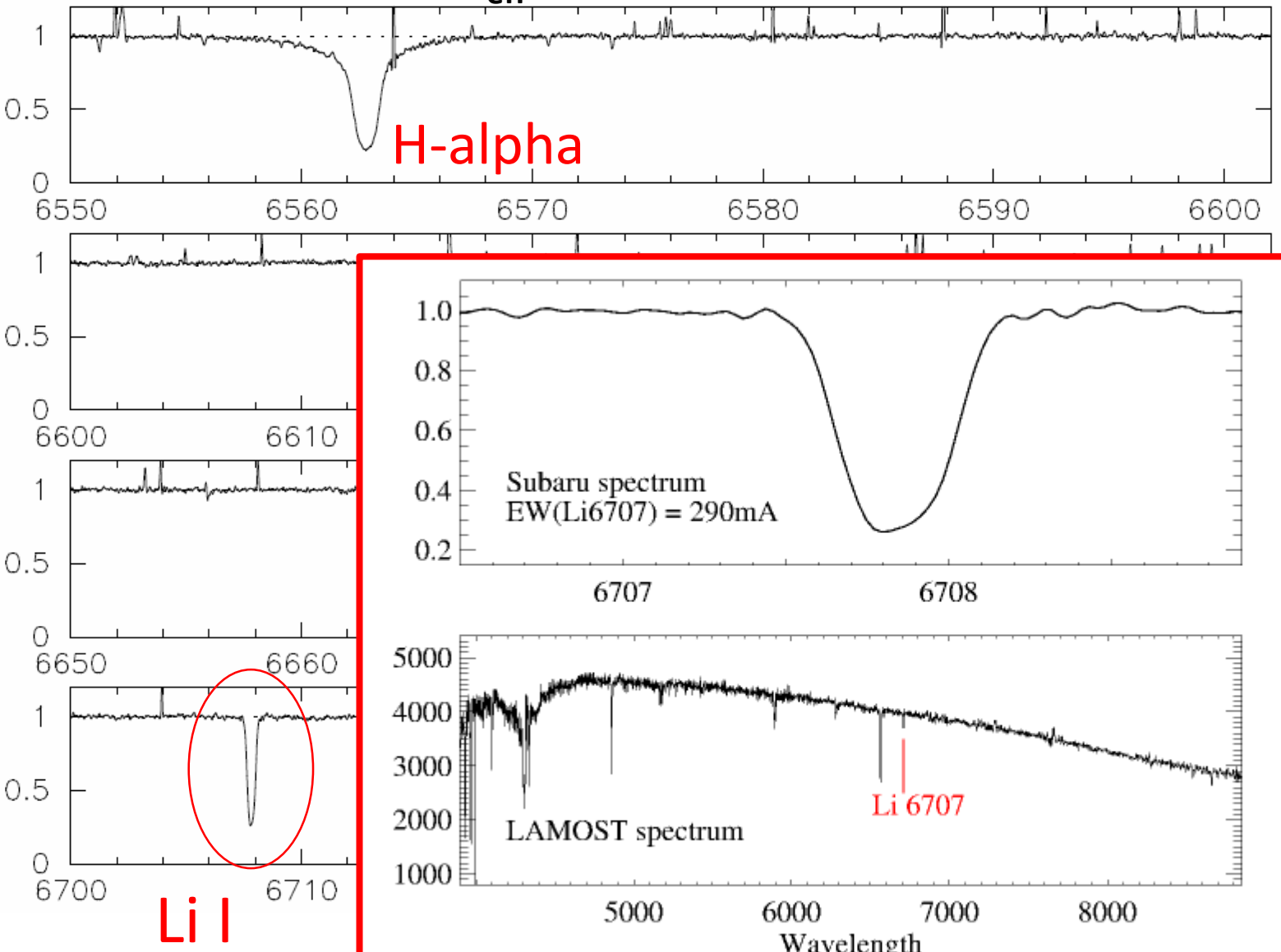
Li, Aoki et al. (2015a)



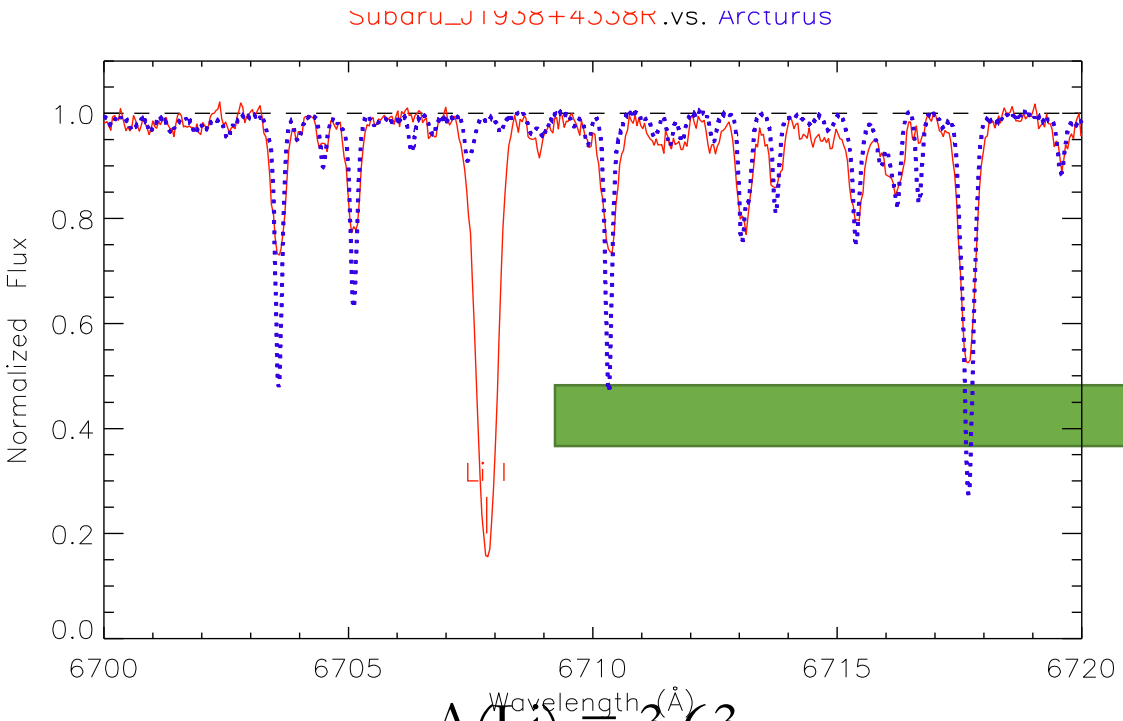
The second example of Li detection in UMP stars

Super Li-rich EMP red giant (in prep.)

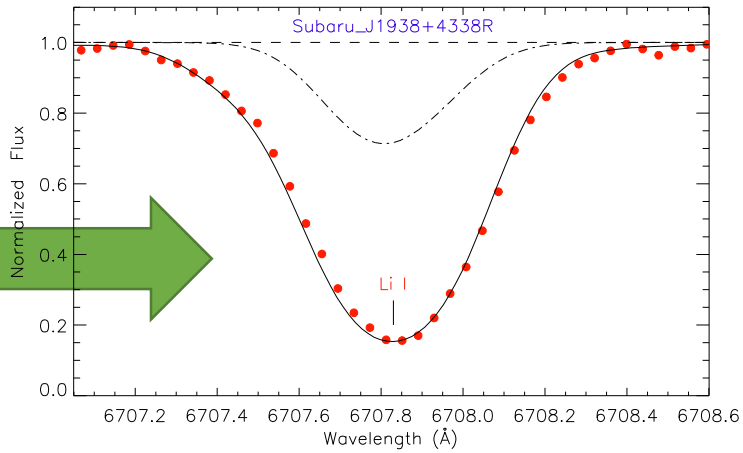
[Fe/H]=-3.3, T_{eff}=5200K, log g=2.2, A(Li)～3.0



Li-rich giants from the Kepler Filed



A(Li) = 3.61



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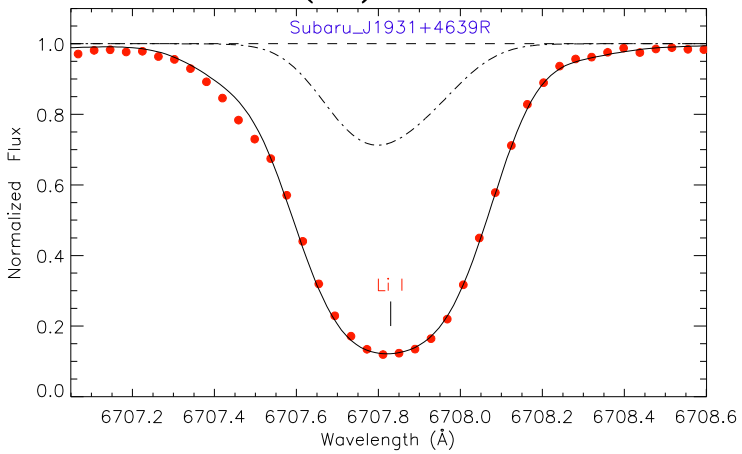
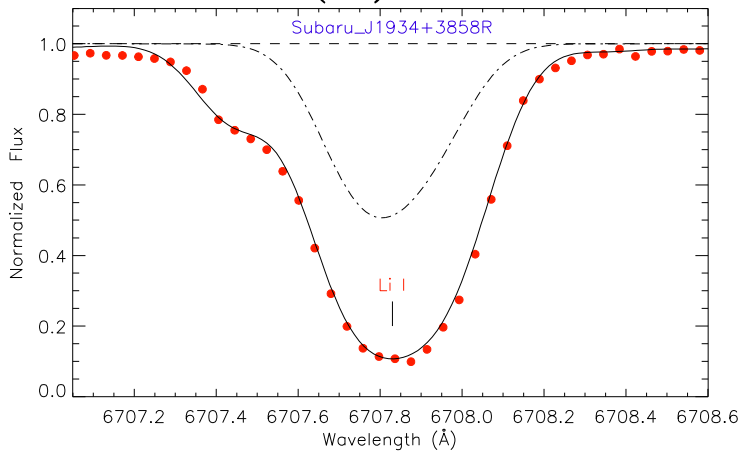


A(Li) = 2.86

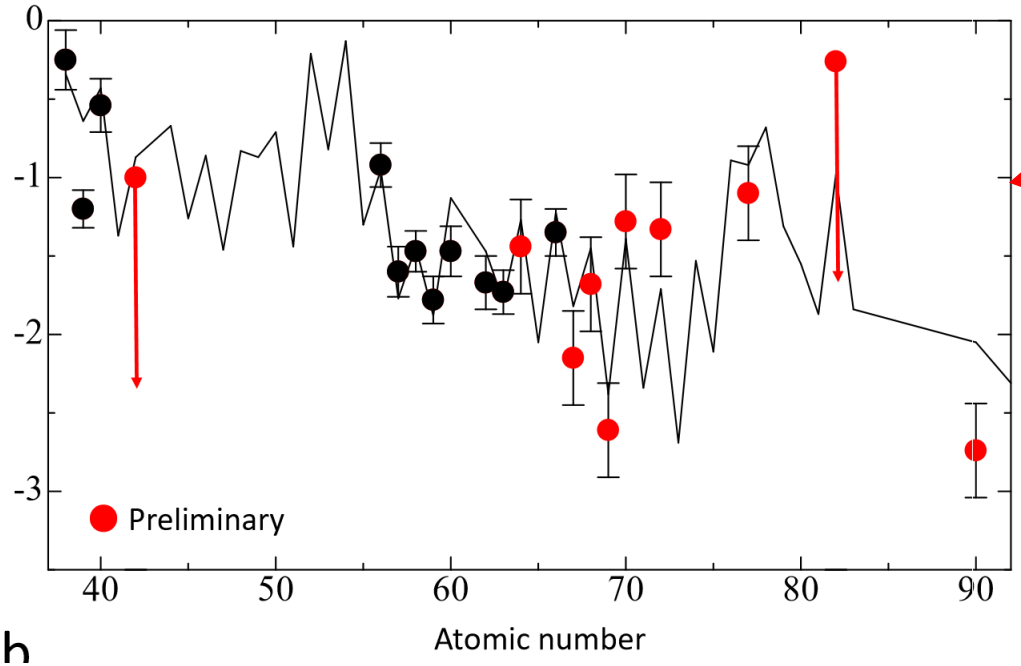


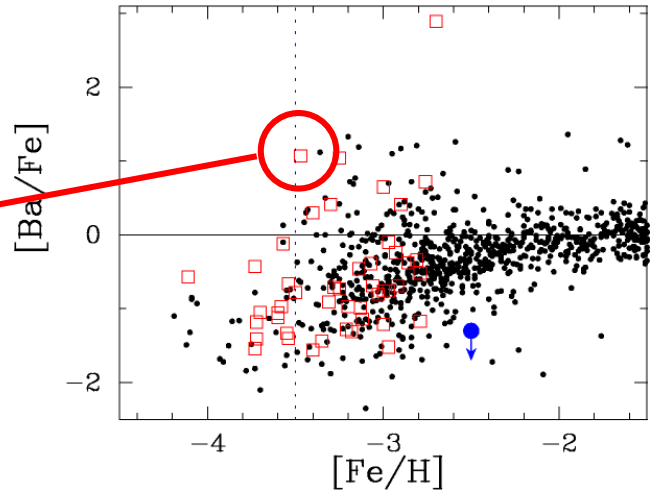
r-rich metal-poor star

New example of an r-process enhanced EMP star (r-II star)

Bright object (g ～ 12)
[Fe/H]=-3.4, [Eu/Fe]=+1.2

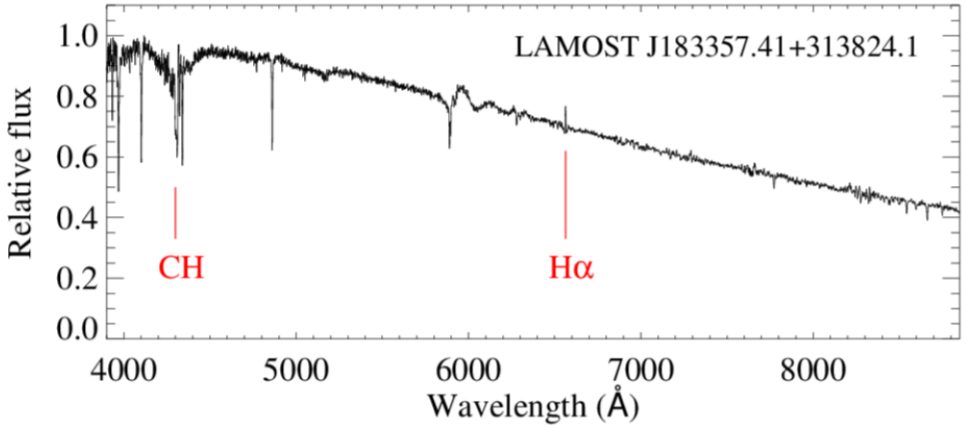
Li, Wako et al. (2015b)





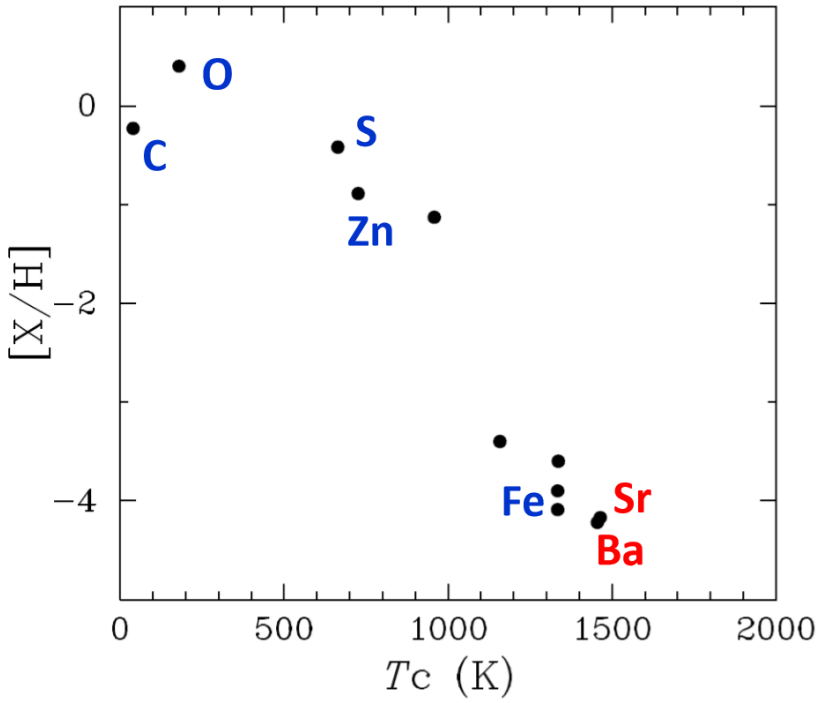
Analysis ongoing

Re-discovery and new-analysis of metal-poor post-AGB star CC Lyr



- New detection of Sr
- No enhancement in neutron-capture elements

Wako et al. (2017)



Future plan

- Homogeneous abundance for about 500 VMP stars
  - **Statistics:** fraction of r-process-enhanced stars, mass distribution of first stars, etc.
- Larger candidate sample after the first five-year of LAMOST regular survey
  - Systematic investigation on low-α halo stars, moving groups, Li-rich giants, etc.
- Combination with Gaia
  - 6D phase for the outlying populations and thus a more complete picture of MW early evolution and formation

Short summary

- Complement each side, resulting in a competitive and efficient team and continued collaborations
- First successful example of LAMOST + Subaru project
- Great chance for young astronomers to reach great instrument and project
- Promote collaborations between Chinese and Japanese astronomers
- Experiences for future collaboration among EAO members, in operating Subaru and TMT, etc.

THANK YOU!

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