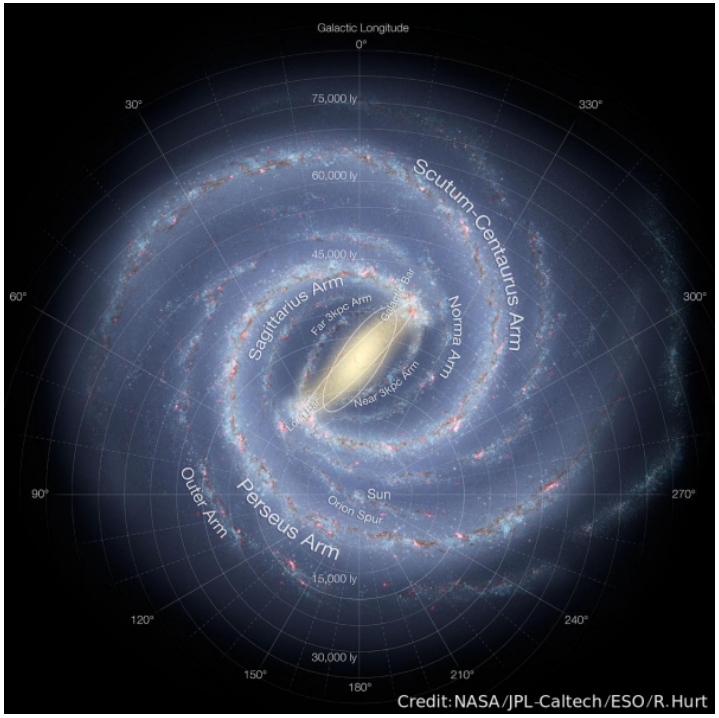
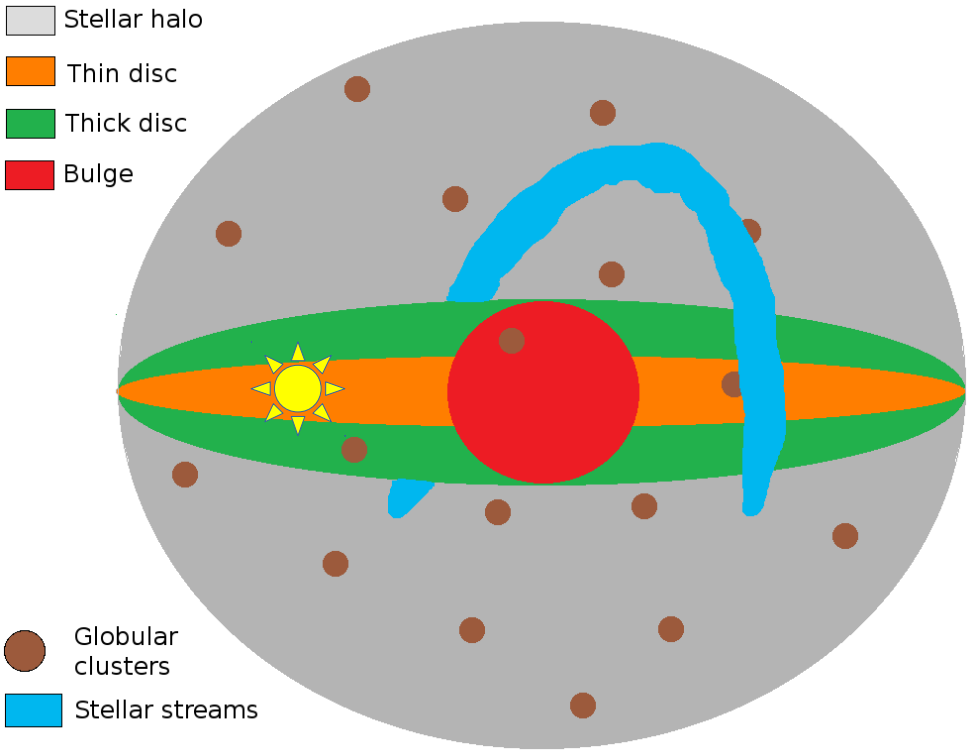
Leibniz-Institut für
Astrophysik Potsdam

Galactic Archeology with RAVE and APOGEE using Convolutional Neural Network

G. Guiglion, G. Matijevic, M. Steinmetz

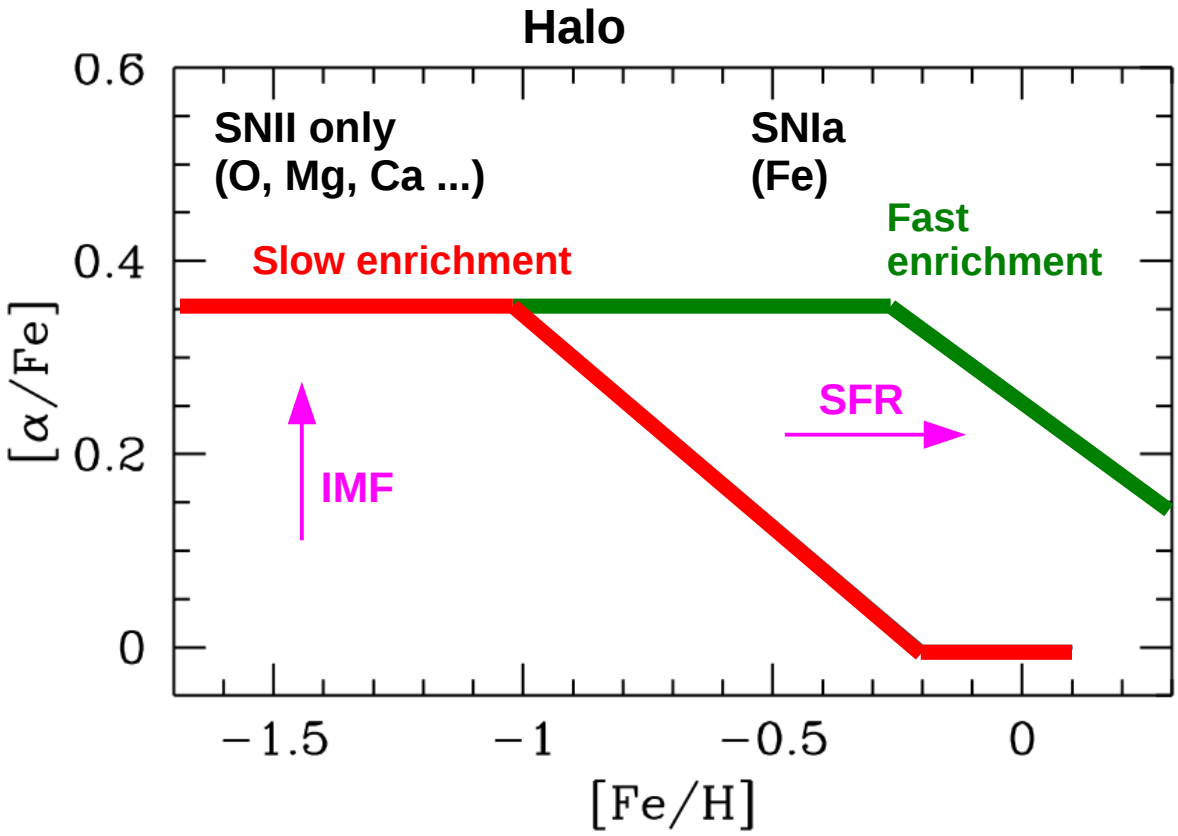
Our Galaxy: the Milky Way

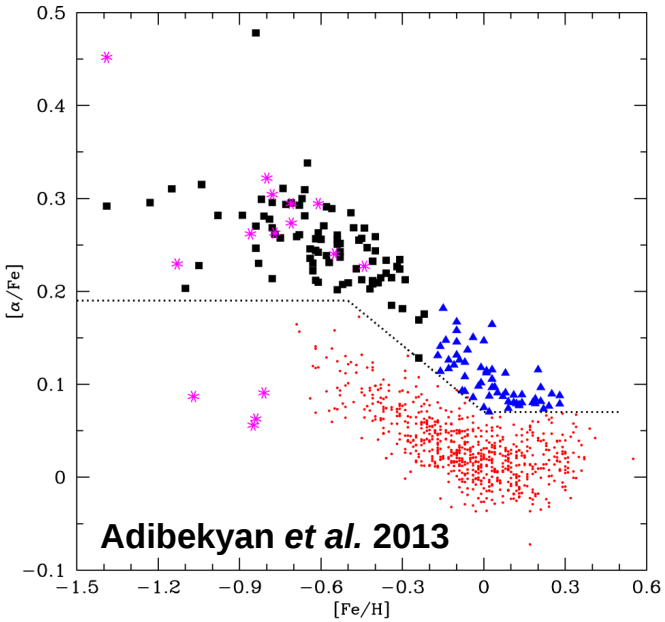




Galactic Archaeology

⇨ **Stars used as fossil records of the interstellar medium**





→ Need
- high statistics
- wide [M/H] coverage
- high quality abundances

CNN in Galactic Archeology

Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

MNRAS **483,** 3255–3277 (2019) doi:10.1093/mnras/sty3217
Advance Access publication 2018 November 28

Deep learning of multi-element abundances from high-resolution spectroscopic data

Henry W. Leung[1★] and Jo Bovy[1,2†]

[1]*Department of Astronomy and Astrophysics, University of Toronto, 50 St. George Street, Toronto, Ontario M5S 3H4, Canada*
[2]*Dunlap Institute for Astronomy and Astrophysics, University of Toronto, 50 St. George Street, Toronto, Ontario M5S 3H4, Canada*

→ **CNN trained on APOGEE data, to evaluate APOGEE data.**

StarNet: A deep learning analysis of infrared stellar spectra

Collin L. Kielty[a], Spencer Bialek[a, b], S. Fabbro[b], K. A. Venn[a], T. O'Briain[a,b], F. Jahandar[a], and S. Monty[a]

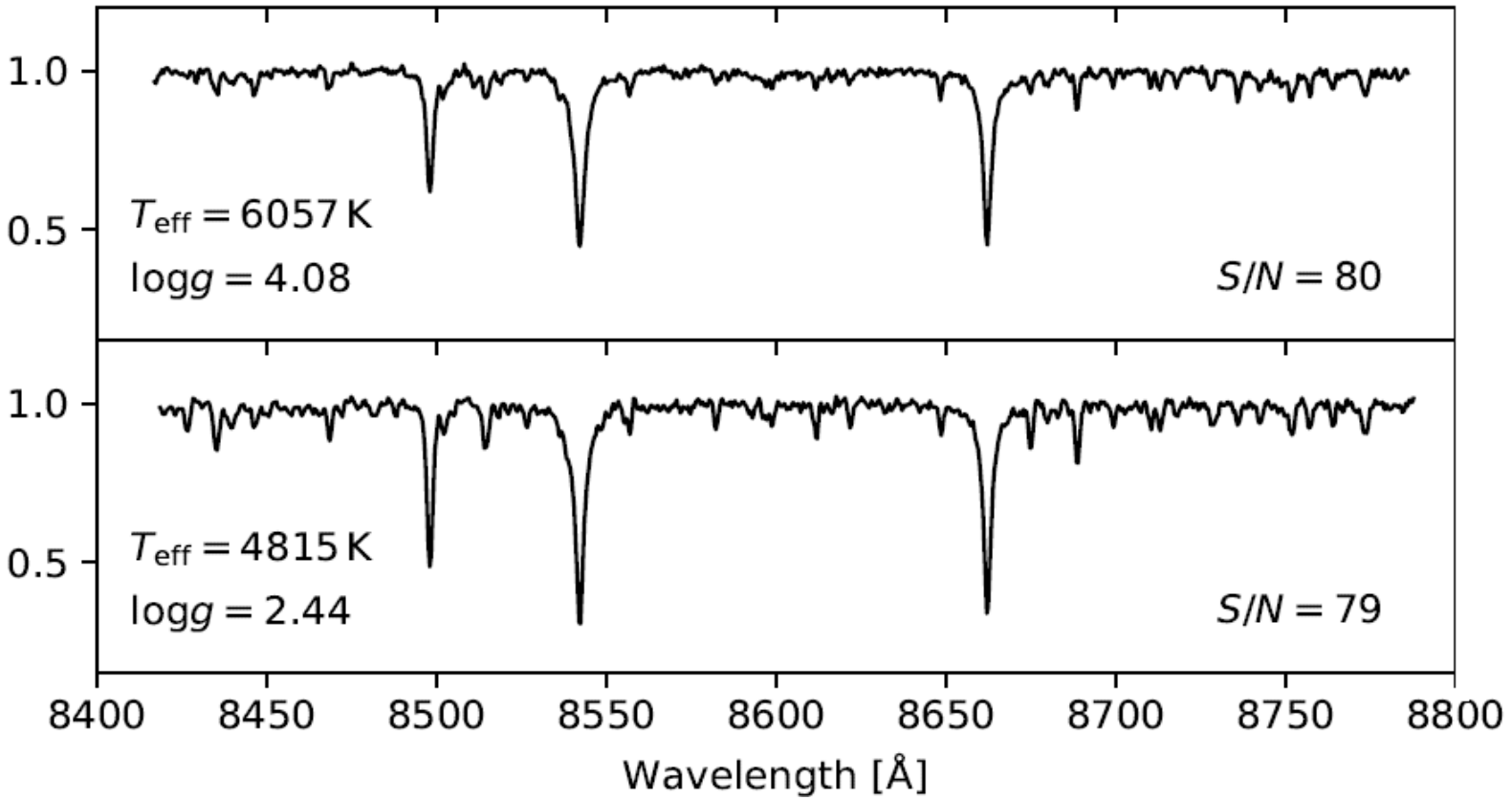
[a]Department of Physics and Astronomy, University of Victoria, Victoria, BC, Canada
[b]National Research Council Herzberg Astronomy & Astrophysics, 4071 West Saanich Road, Victoria, BC, Canada

→ **CNN trained on synth. data, in preparation for GIRMOS data.**

Dafonte et al. 2016, based on synthetic spec, for Gaia-RVS

The RAdial Velocity Experiment (RAVE)

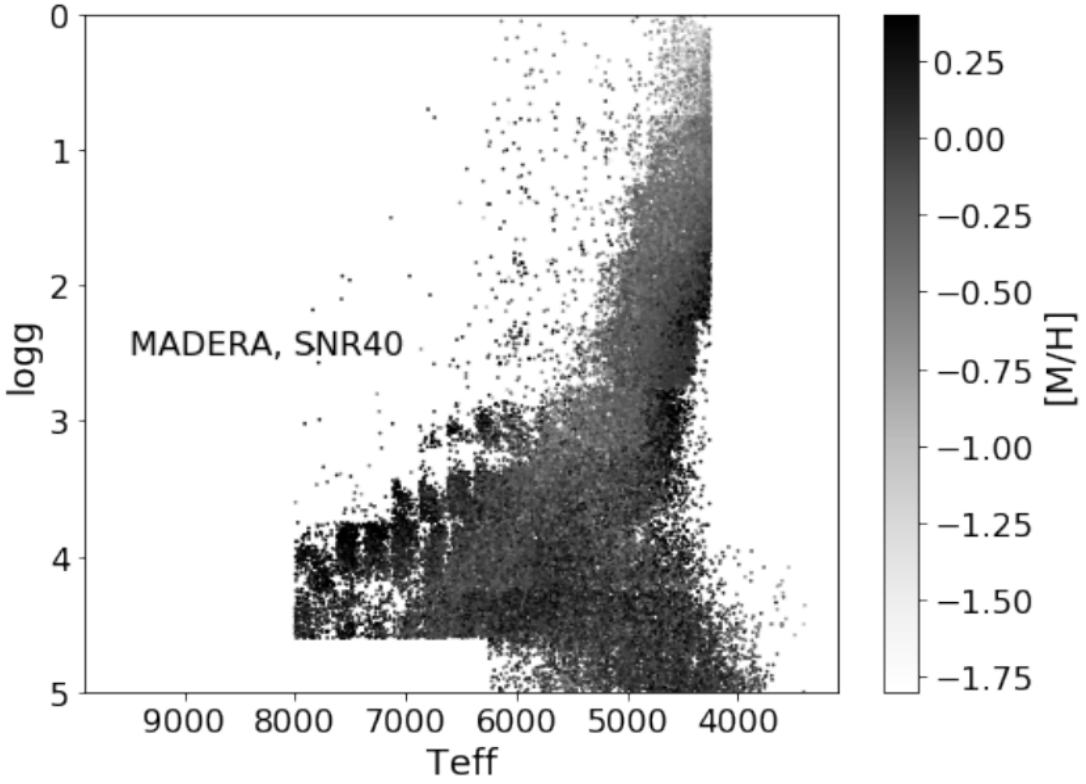
- Multi-object spectrograph (1.2 m UK Schmidt Telescope, AAO)
- 518387 spectra (R~7500)

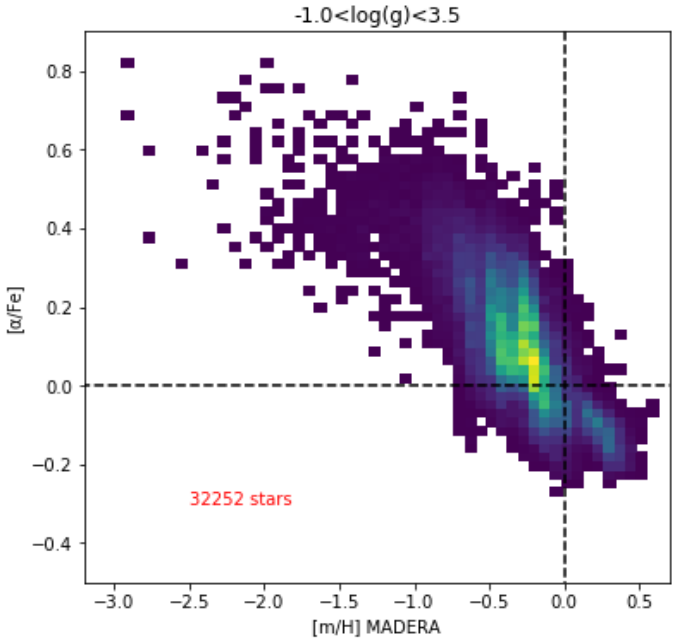


The RAdial Velocity Experiment (RAVE)

DR6 (Steinmetz *et al.* 2019, in prep)

- **V_{rad}, T_{eff}, log(g), [M/H], [alpha/Fe]**
- **Spectral morphological flags, distances with Gaia DR2 priors, etc.**

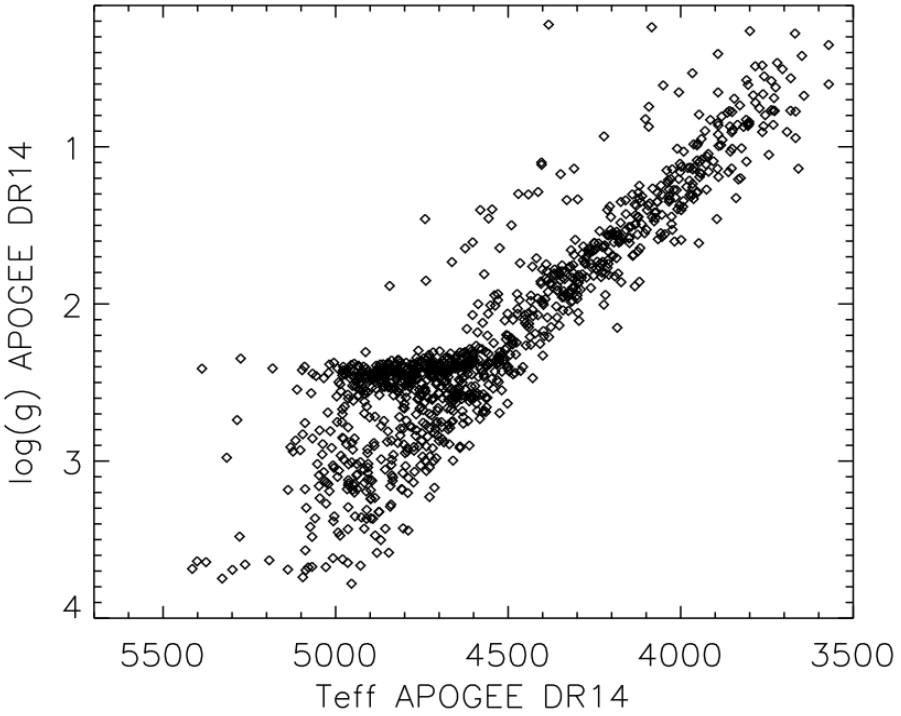


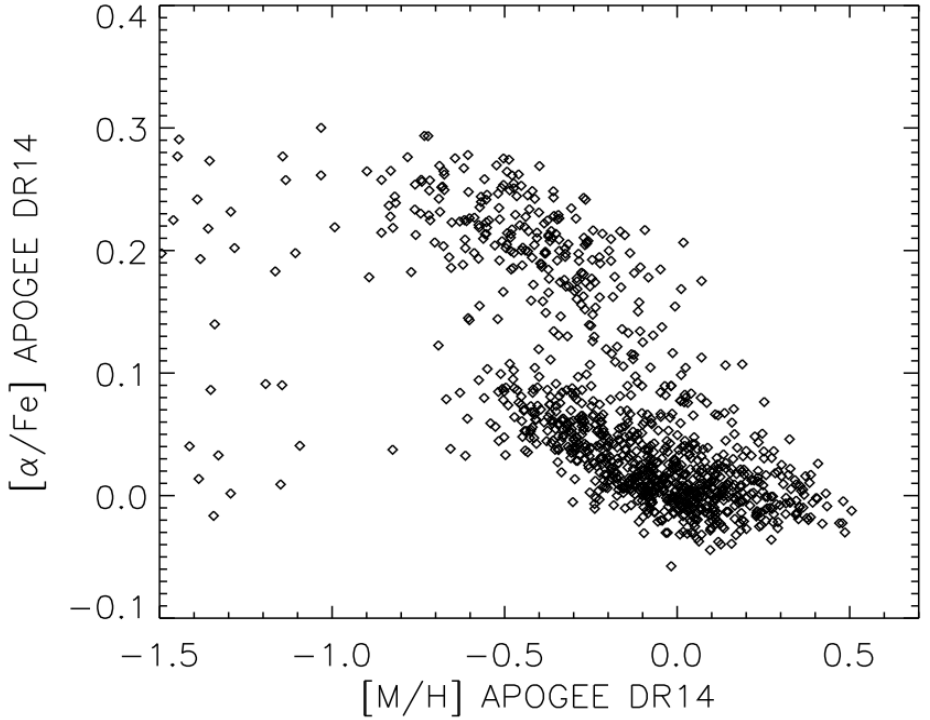


The APOGEE survey

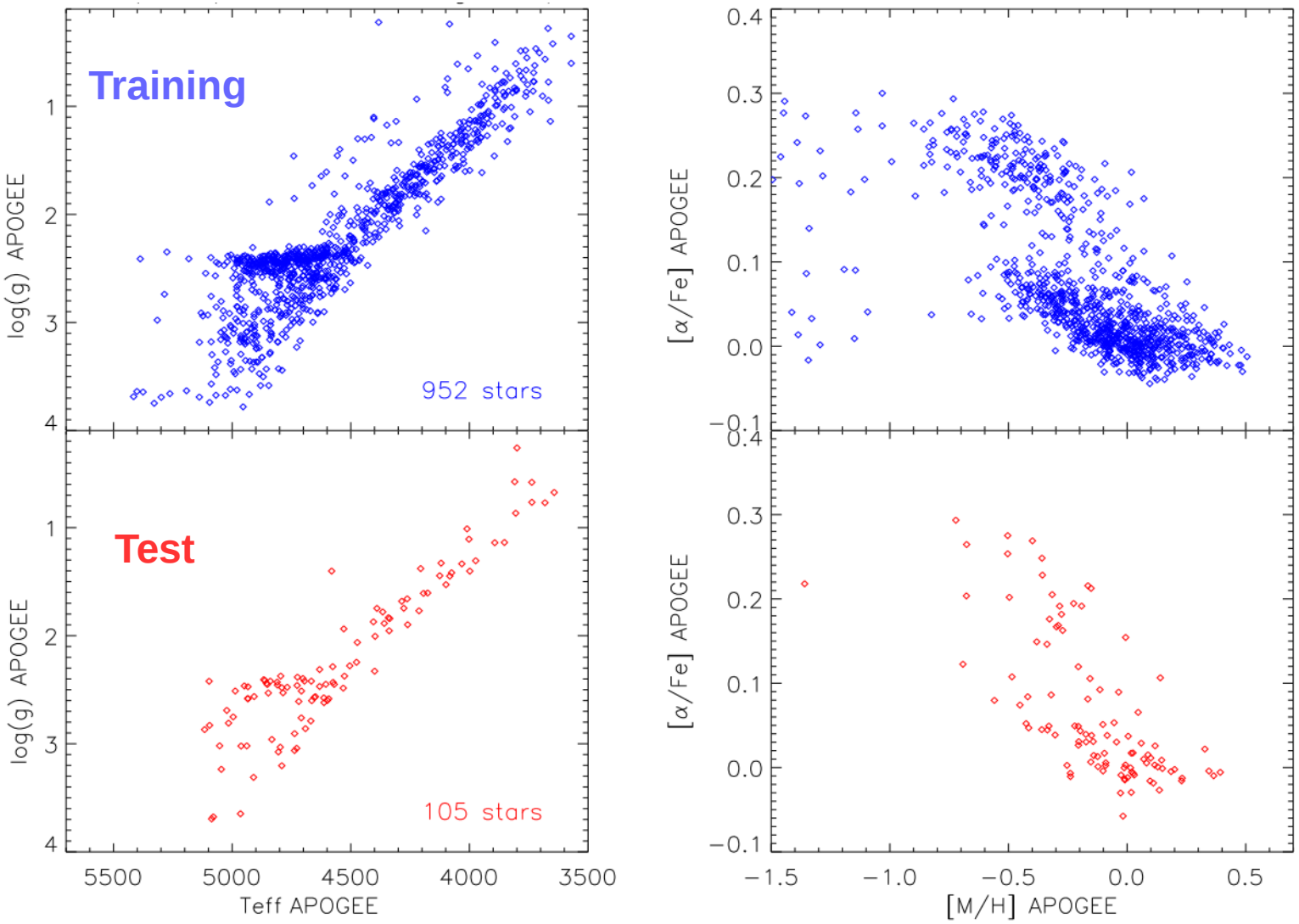
DR14 (Holtzman *et al.* 2018)

- **2.5m Telescope at APO,λ ϵ [1.5-1.7] μm, R~22500, SNR>100**
- **T_{eff}, log(g), [M/H], [alpha/Fe]**
- **1057 stars in common between RAVE DR6 and APOGEE DR14.**





Training and test samples

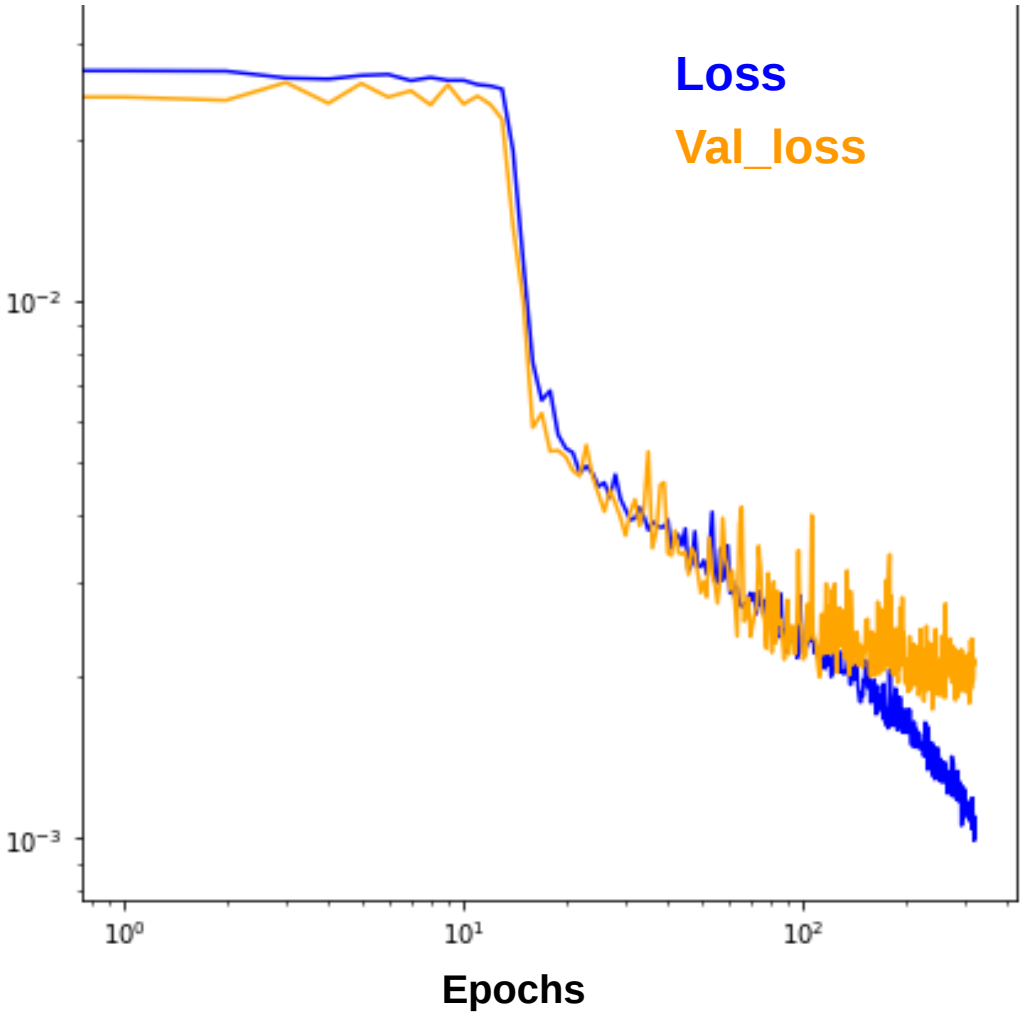


Architecture of the CNN

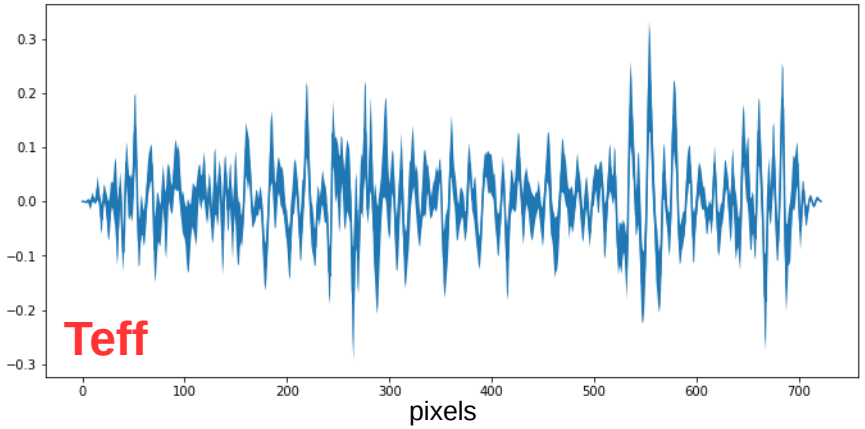
Layer (type)	Output Shape	Param #
input_8 (InputLayer)	(None, 723, 1)	0
convol_1 (Conv1D)	(None, 704, 8)	168
leaky_re_lu_36 (LeakyReLU)	(None, 704, 8)	0
convol_2 (Conv1D)	(None, 685, 4)	644
leaky_re_lu_37 (LeakyReLU)	(None, 685, 4)	0
convol_3 (Conv1D)	(None, 666, 2)	162
leaky_re_lu_38 (LeakyReLU)	(None, 666, 2)	0
dropout_8 (Dropout)	(None, 666, 2)	0
flatten_8 (Flatten)	(None, 1332)	0
dense_1 (Dense)	(None, 32)	42656
leaky_re_lu_39 (LeakyReLU)	(None, 32)	0
dense_2 (Dense)	(None, 16)	528
leaky_re_lu_40 (LeakyReLU)	(None, 16)	0
dense_8 (Dense)	(None, 4)	68

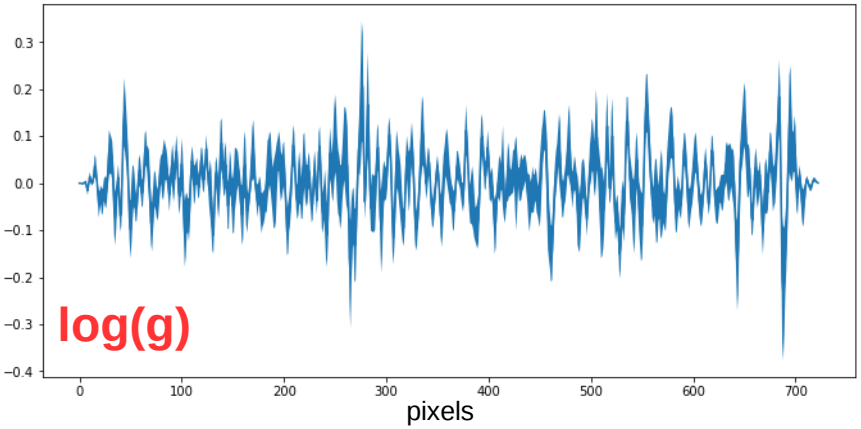
Total params: 44,226
Trainable params: 44,226
Non-trainable params: 0

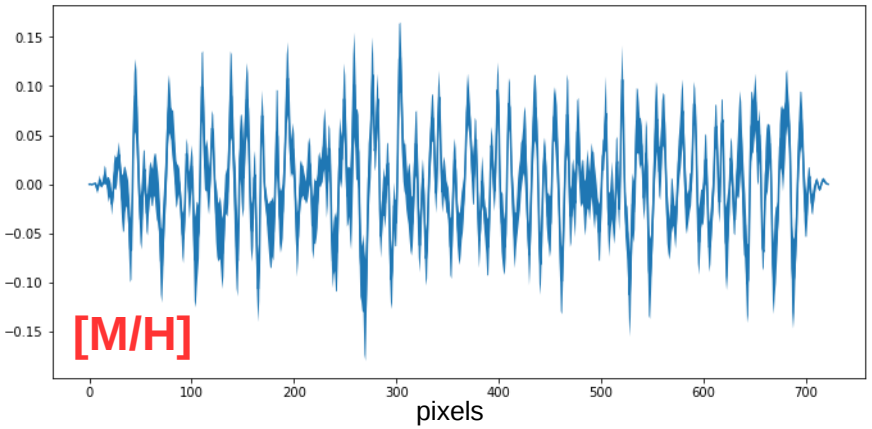
The training phase

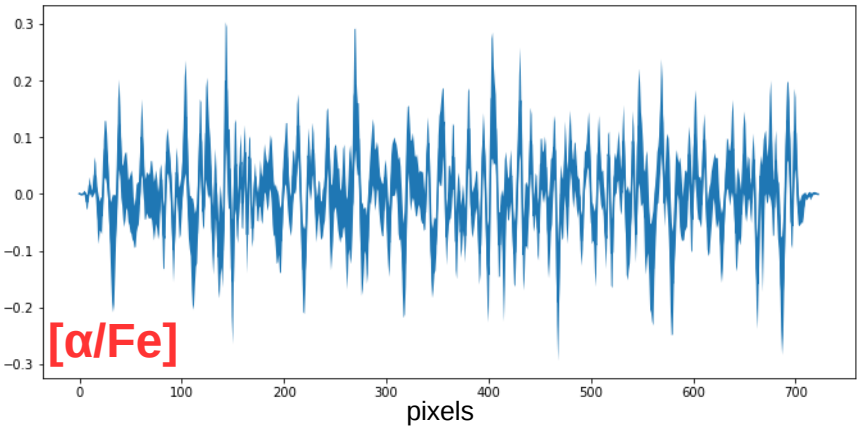


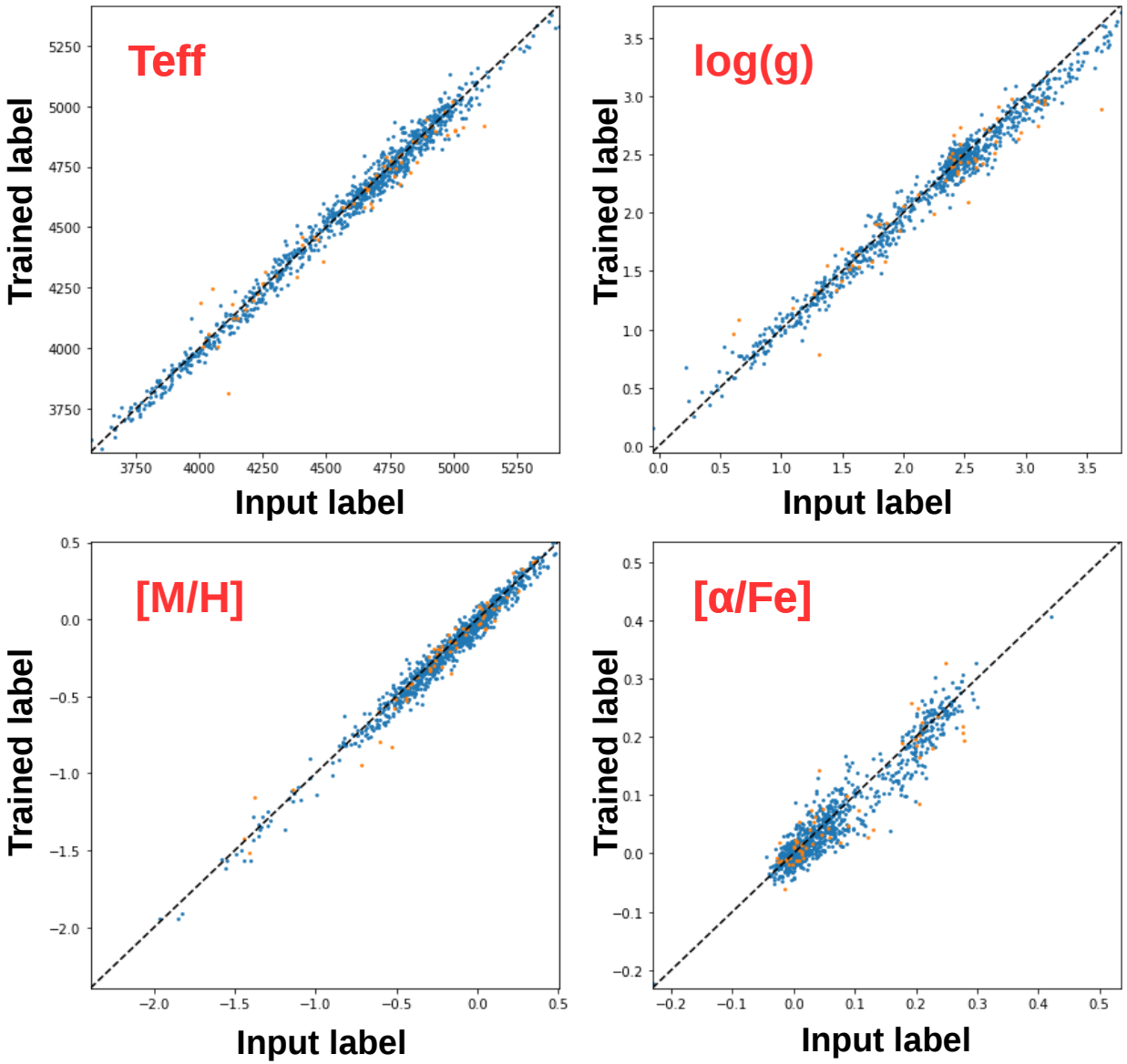
Gradients

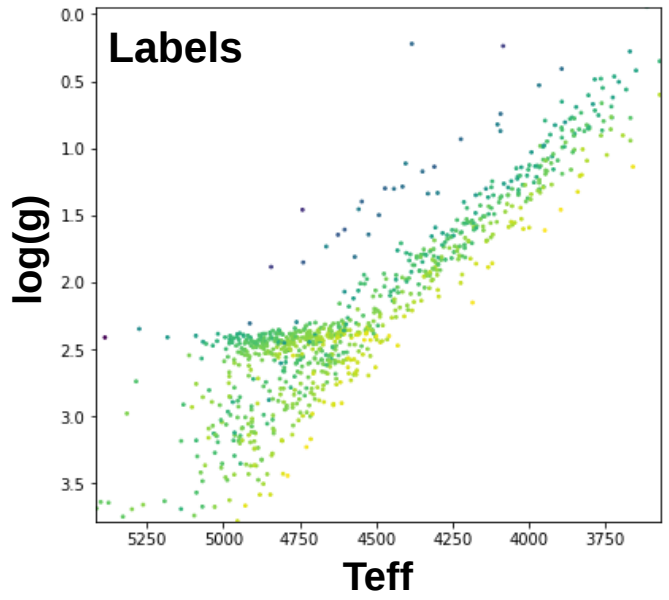


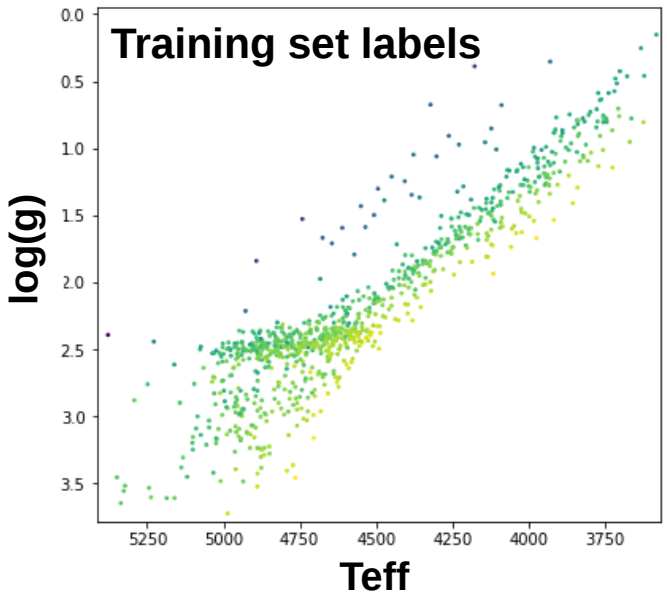


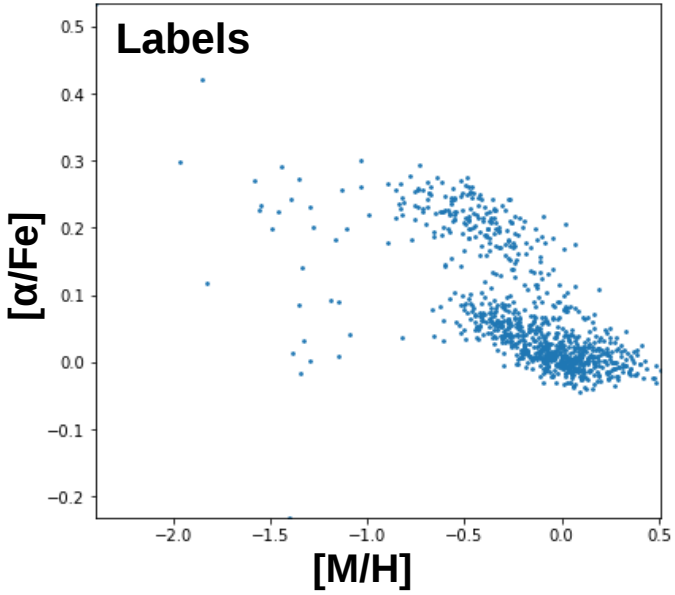


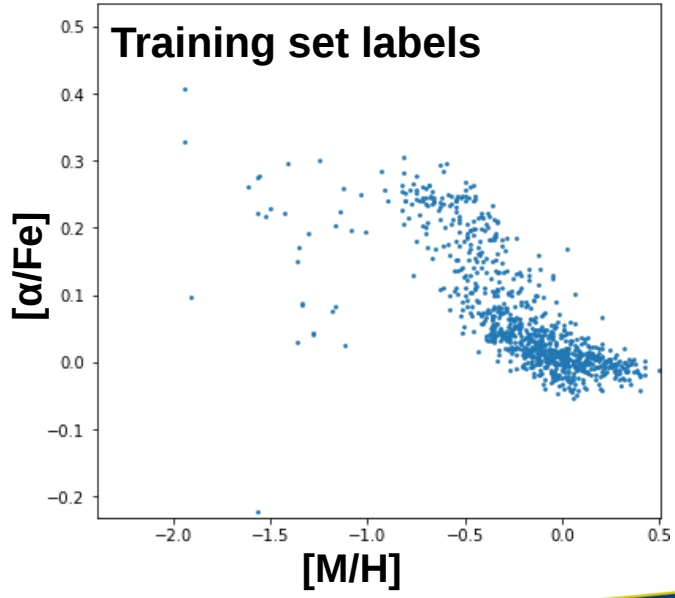


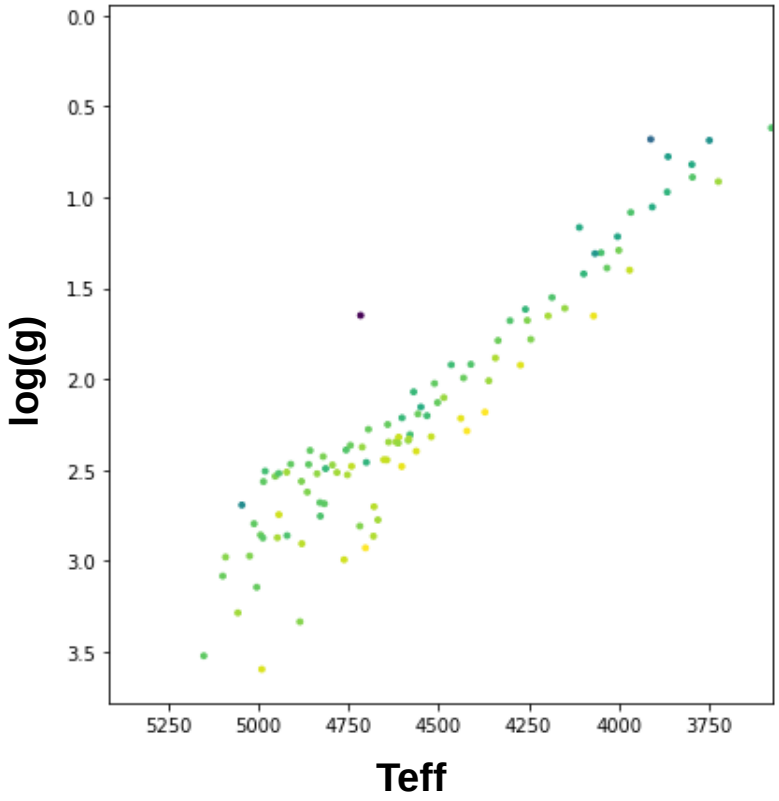

Teff
log(g)
[M/H]
[α/Fe]
Trained label
Input label

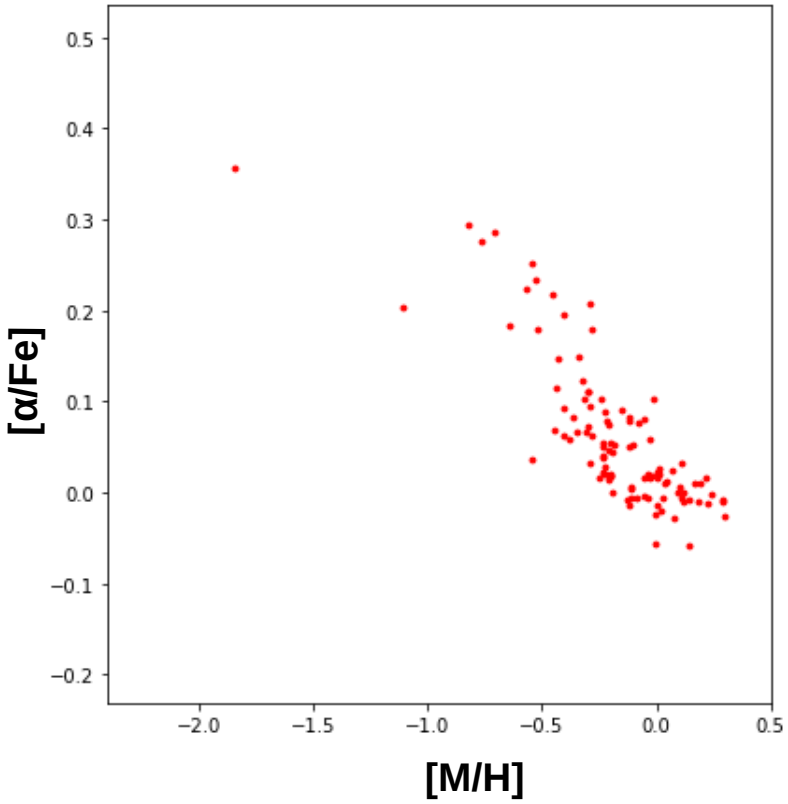

Labels
log(g)
Teff
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
5250
5000
4750
4500
4250
4000
3750


Training set labels
log(g)
Teff
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
5250
5000
4750
4500
4250
4000
3750

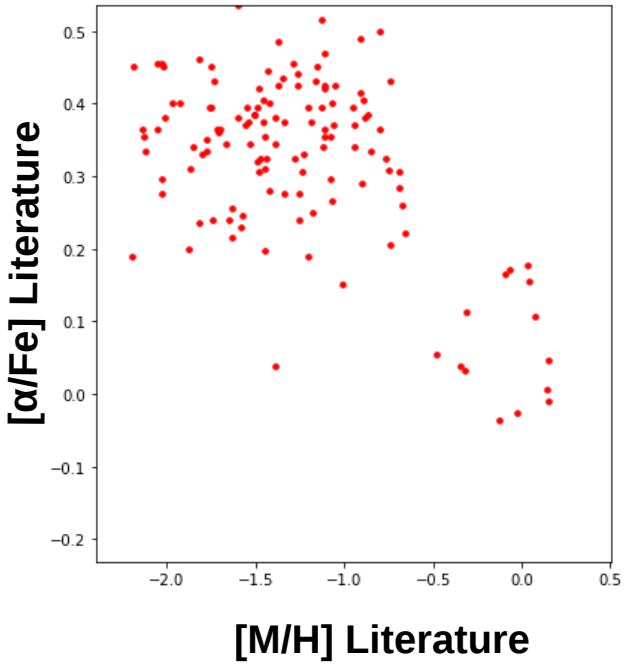

Labels
[α/Fe]
[M/H]
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−2.0
−1.5
−1.0
−0.5
0.0
0.5

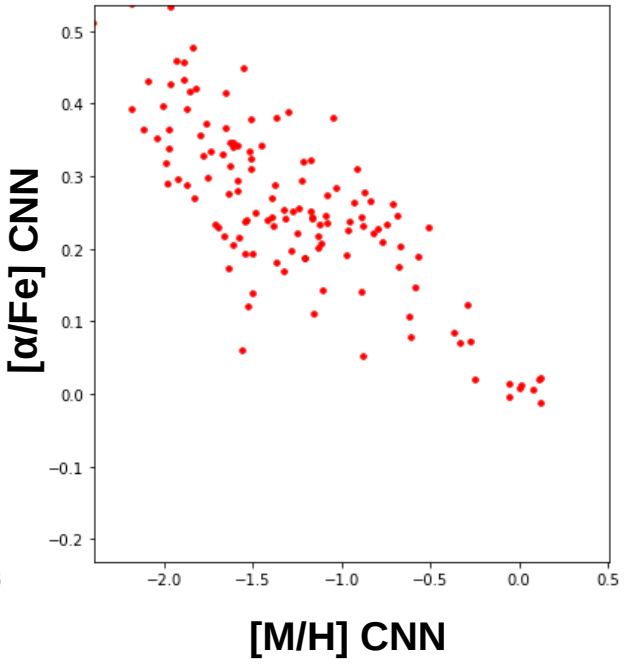

Training set labels
[α/Fe]
[M/H]
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−2.0
−1.5
−1.0
−0.5
0.0
0.5

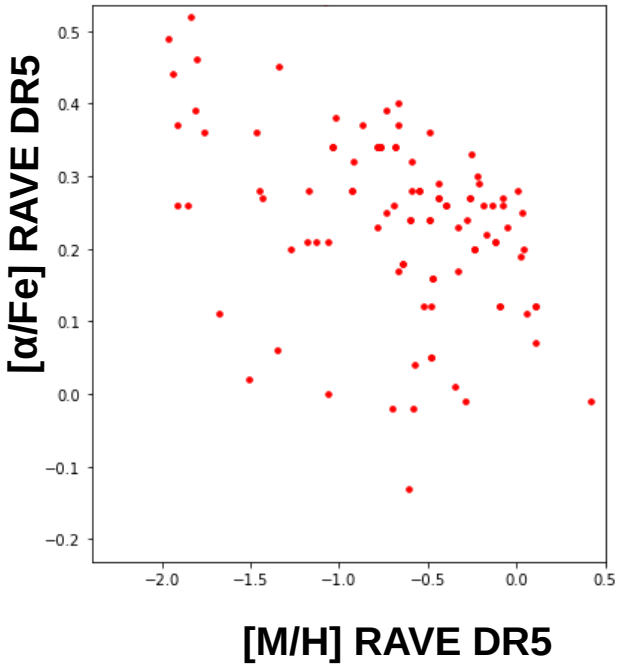

log(g)
Teff
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
5250
5000
4750
4500
4250
4000
3750


[α/Fe]
[M/H]
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−2.0
−1.5
−1.0
−0.5
0.0
0.5

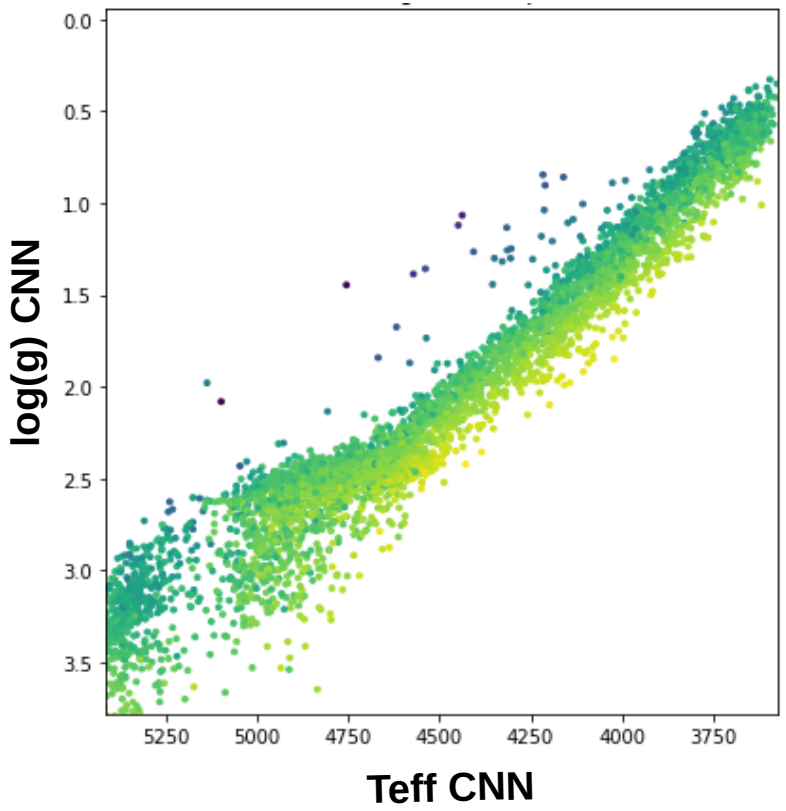
High res sample (~200 stars)

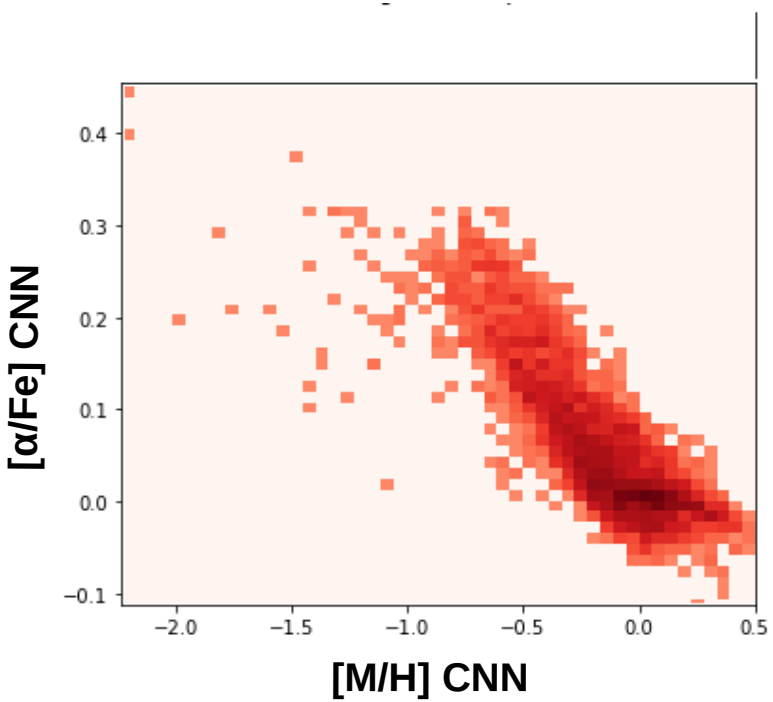






Whole iDR6 sample of 4600 Giants (SNR>80)





Conclusions and Perspectives

- Besides small statistics, efficient training.

- Improvement expected with APOGEE DR16 (more stars in common)

- Full RAVE spectra parametrization

- Individual abundances TBD

- Add extra parameters during training, like parallaxes, photometry, etc.

- Possibility to train with GALAH DR3 soon

Bonus slides

RAVE
RADIAL VELOCITY EXPERIMENT

Labels:
Teff, log(g), [M/H], [α/Fe]
(+ indiv abund).

Training

+ extra Param

Convolutional Neural Network

Evaluation

Improved RAVE Atmospheric parameters, [α/Fe], + indiv abund.