

# **MOPED**

## **for Stellar Atmosphere**

### **Parameters from Spectra**

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# Motivation for MOPED

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- For PhD: metallicities of the halo stars from the *Milky Way*
- One standard method: finding in a grid of synthetic spectra the model that fits the best to a given observed spectrum by looking  $\chi^2$  likelihoods.
- Disadvantage: If grid of models or data sample are too large, the method becomes slow
- MOPED: lossless information compression algorithm that enables extremely rapid parameter estimation from a large data set.
- It works for analysis of galaxy spectra (Ben Panter) and therefore should work also for analysis of stellar spectra.

# MOPED Algorithm

- Compression scheme that looks at areas where are particularly sensitive to a given parameter:

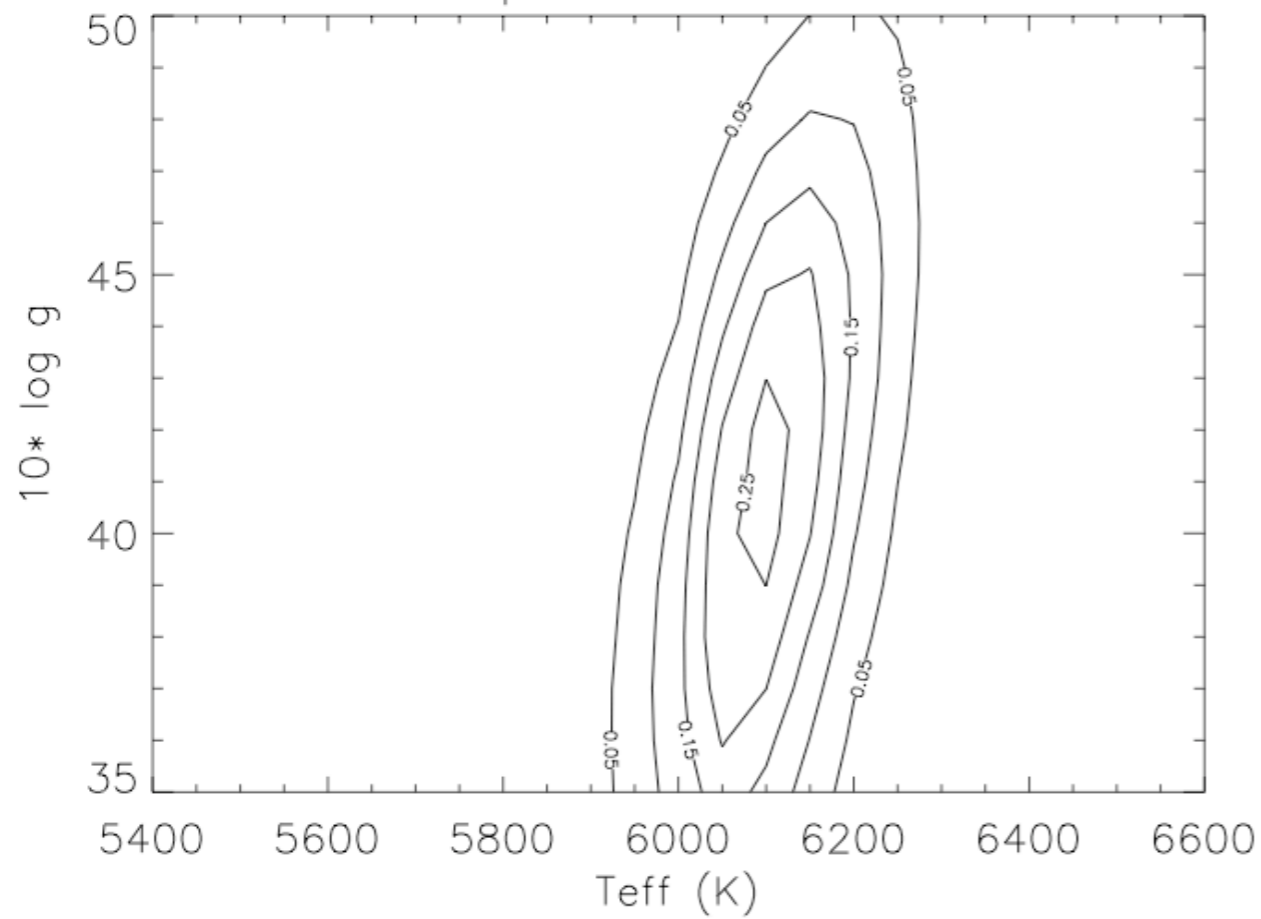
- Definition:  $b_\alpha = \frac{\partial F}{\partial \theta_\alpha}$

- Compression:  $y_\alpha = b_\alpha * X$

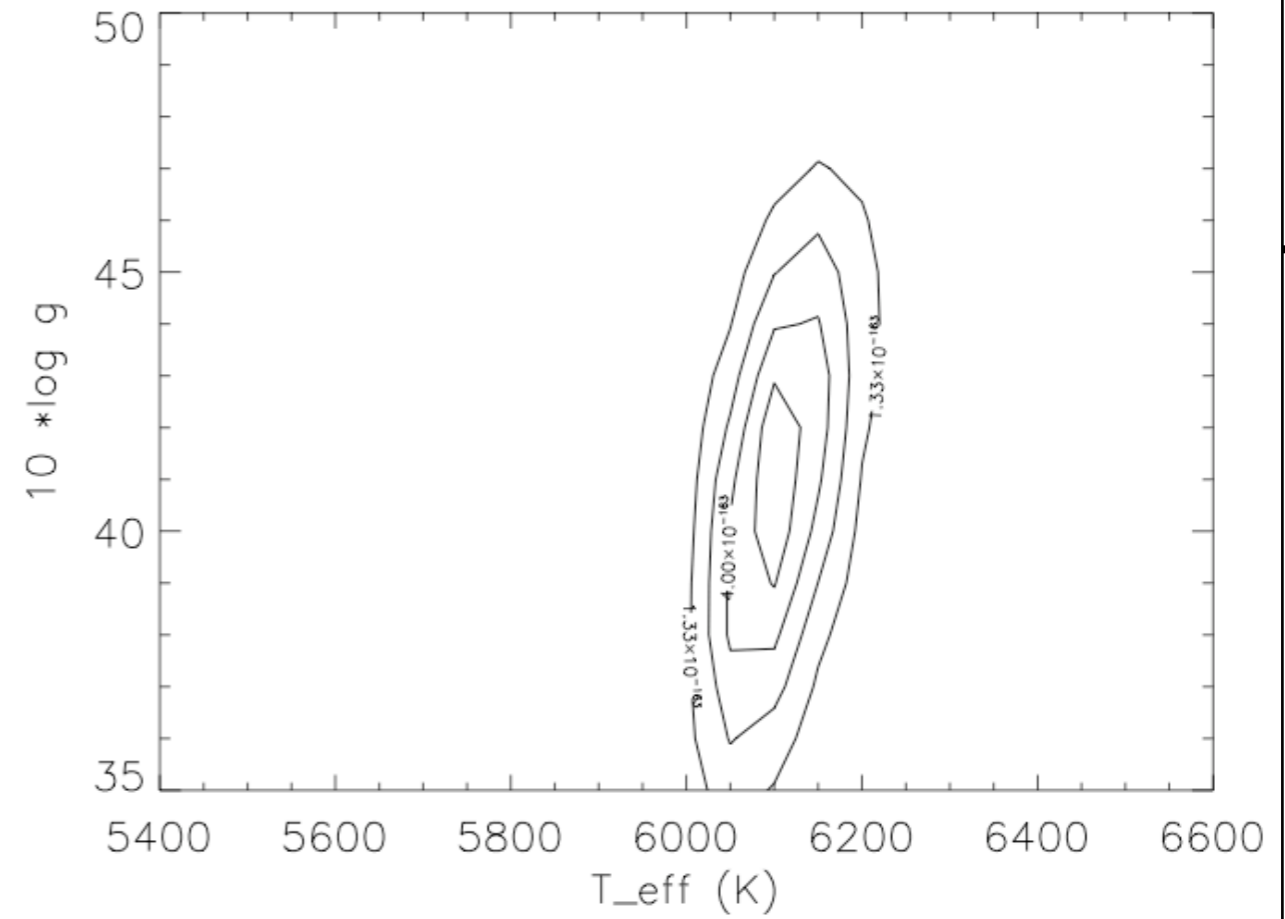
- Goodness of fit:  $\chi_{compressed}^2 \sim \frac{1}{\text{mean}(\sigma^2)} \sum_{\alpha}^{N_{par}} (y_{\alpha,d} - y_{\alpha,m})^2$

- Classical:  $\chi_{reduced}^2 \sim \frac{1}{DoF} \sum_i^{N_{bits}} \frac{(X_{i,m} - X_{i,d})^2}{\sigma^2}$

compressed likelihood



full likelihood



- Goodness of fit:  $\chi_{compressed}^2 \sim \frac{1}{\text{mean}(\sigma^2)} \sum_{\alpha}^{N_{par}} (y_{\alpha,d} - y_{\alpha,m})^2$

- Classical:  $\chi_{reduced}^2 \sim \frac{1}{DoF} \sum_i^{N_{bits}} \frac{(X_{i,m} - X_{i,d})^2}{\sigma^2}$

# Our Analysis

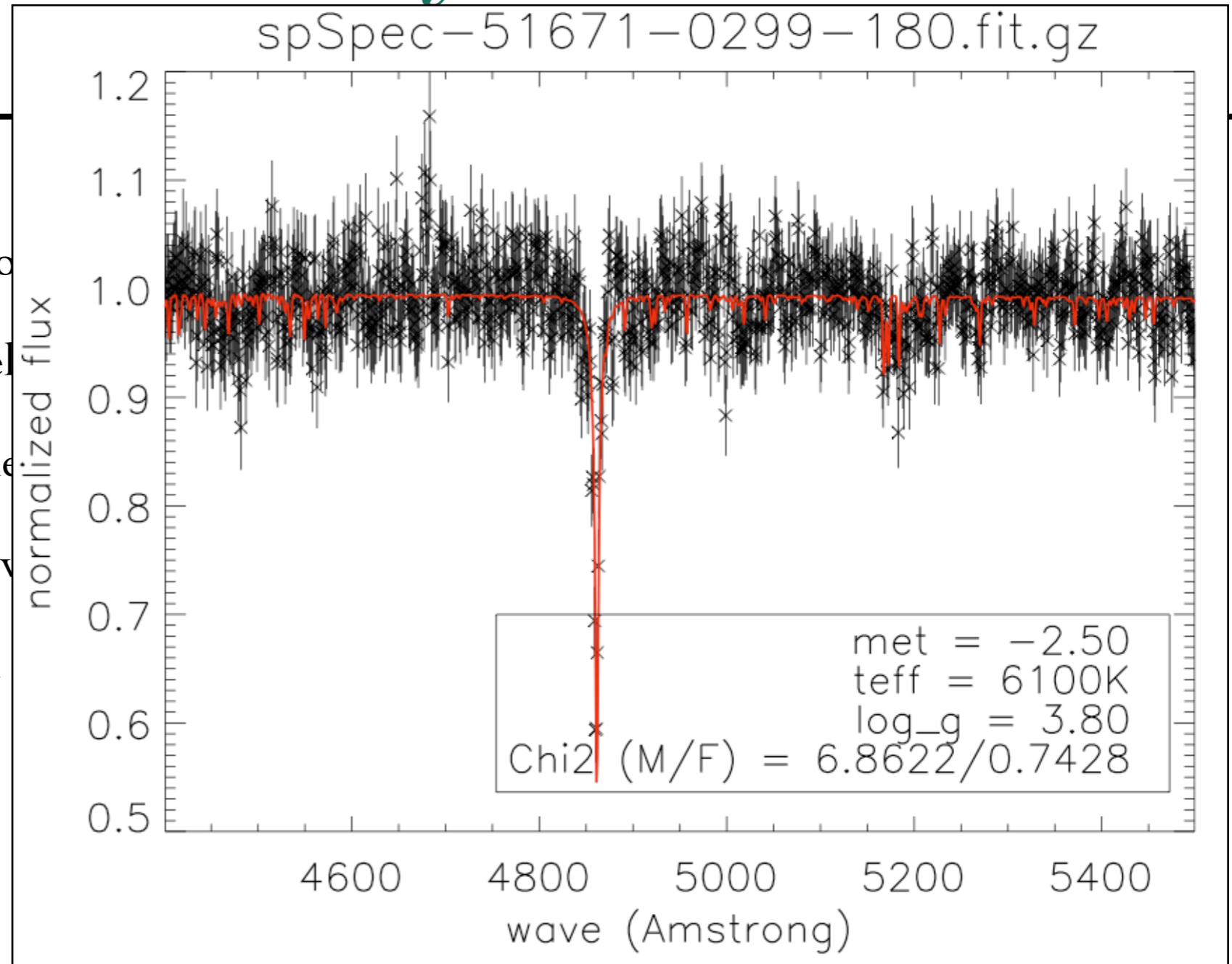
- Use MOPED for estimate metallicity, effective temperature and gravity ( $\log g$ ) of stellar spectra from SDSS ( $R \sim 2000$ )
- Grid of models using:
  - stellar atmosphere models from Castelli and Kurucz
  - synthetic spectra code SPECTRUM from Gray
- 123648 elements with:
  - $[\text{Fe}/\text{H}]$  from -0.5 to -2.5 in steps of 0.1 dex
  - $T_{\text{eff}}$  from 5500 to 6500 K in steps of 50 K
  - $\log g$  from 3.5 to 5 in steps of 0.1 dex

# Our Analysis

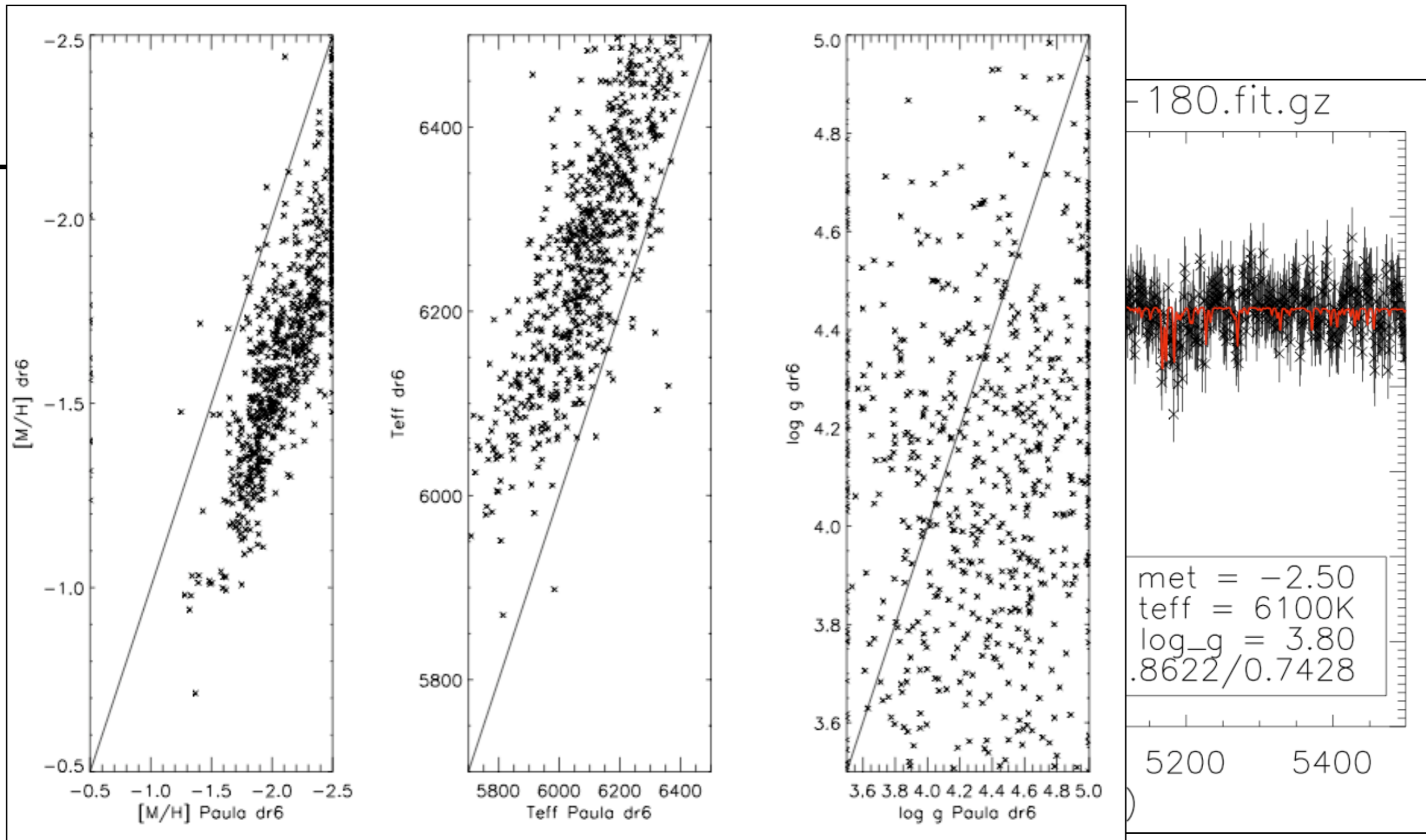
- Corrections:
  - smooth model to SDSS resolution
  - normalize model and data to 1.0
  - interpolate model and data to the same wavelength
  - correct data by velocity
  - select for model and data range of analysis
- Steps:
  - calculate b vectors and y grid
  - calculate y numbers for data and  $\chi^2$
  - search minimum

# Our Analysis

- Corrections:
  - smooth model to
  - normalize model
  - interpolate model
  - correct data by v
  - select for model
- Steps:
  - calculate y grid
  - calculate  $\chi^2$
  - search minimum



→ ~ 0,4 seconds



● search minimum  $\longrightarrow$  ~ 0,4 seconds

# Future Work

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- calculate errors (in prep)
- create definitive grid (broader in metallicity, include  $\alpha$ -enhanced elements as parameter)
- test MOPED with high resolution spectra and run it in SDSS/SEGUE (in prep)
- re-write moped independent of: model, data, wavelength range, parameter

# MOPED for Stars in VO?

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- a VO user could know one parameter of a given star
- a VO user could know many parameters of a sample of stars
- a VO user could use our grid of models/data sample to make his own analysis and then compare with our results
- a VO user could use the MOPED tool in order to analyze his own data sample with his own grid of models.
- would it be possible to add this tool into VO?