OS-Atmospheres & Open Cluster MS

Guangzhou – November 24th 2007

Opacity Sampling Model Atmospheres
&
the Main Sequence of Open Clusters

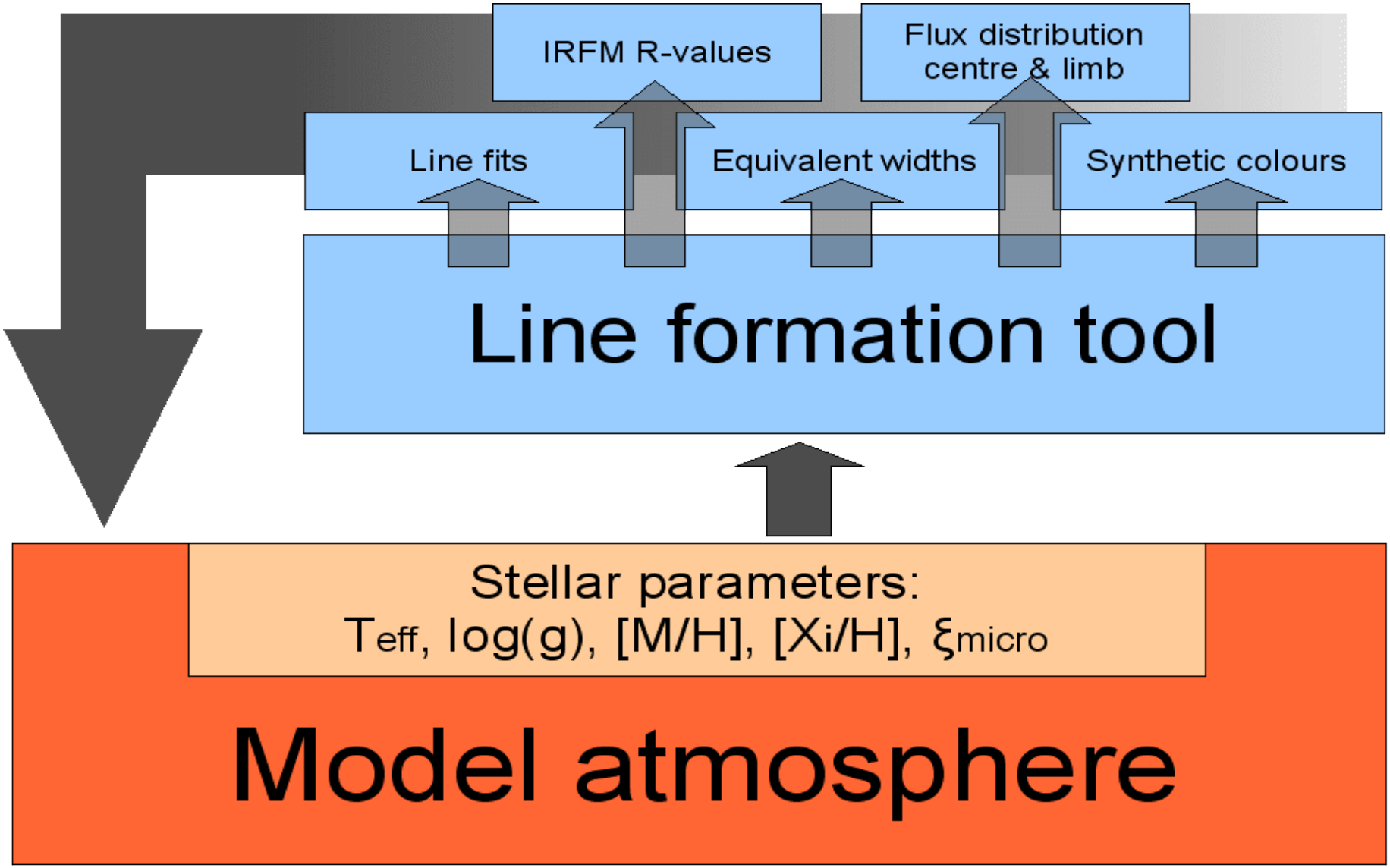
Outline

- Opacity sampling model atmospheres
  - OS versus ODF
  - Solar flux and colors
- *Why* open clusters – *Whic*h open clusters
- Methods of parameter determination
- Chemical homogeneity of the clusters
- Age and distance of Melotte111 & the Pleiades
- An outlook on LAMOST open cluster survey

Model atmospheres – Importance

- Why are model atmospheres so important?
  - Determination of stellar parameters.
    - Color – temperature relations
    - Color – gravity relations
    - IRFM method
    - ... ...
  - Determination of element abundances.
  - Line rations / color ratios in galaxy spectra.
  - Boundary conditions for stellar evolution.
  - Understanding basic physical processes such as convection and radiation transfer.

Model atmospheres – In the center

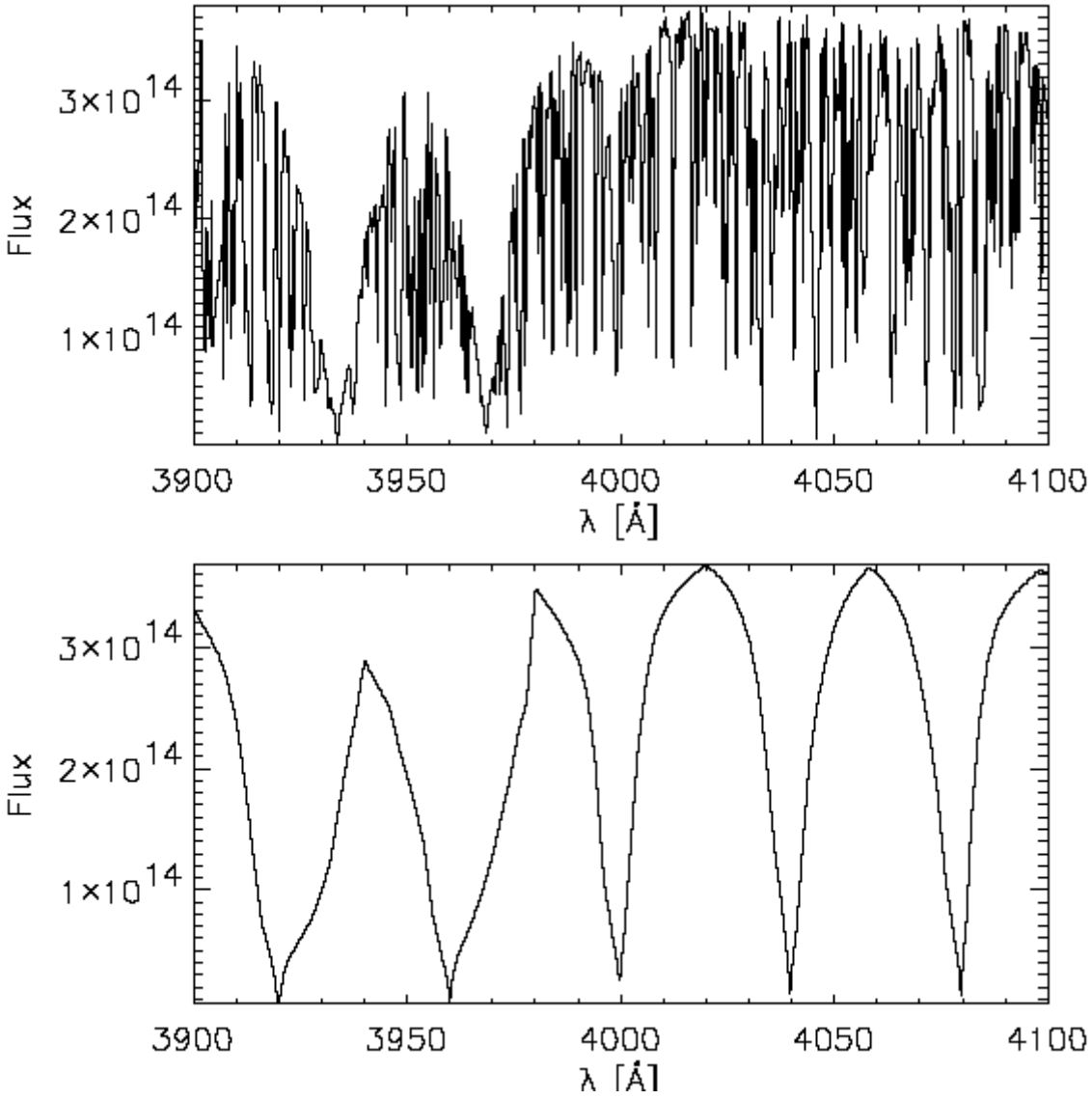


MAFAGS-ODF/OS – Basics

- 1D hydrostatic model
- Plane parallel geometry
- Convection according to Cannuto & Mazitelli
- LTE assumption
- Line opacity can be treated in ODF and OS
- Ionization states I, II and III + diatomic molec.
  → B6 ... A ... F ... G ... K2
  15000K 4800K
- A&A 420, 289-305

MAFAGS – ODF versus OS (1)

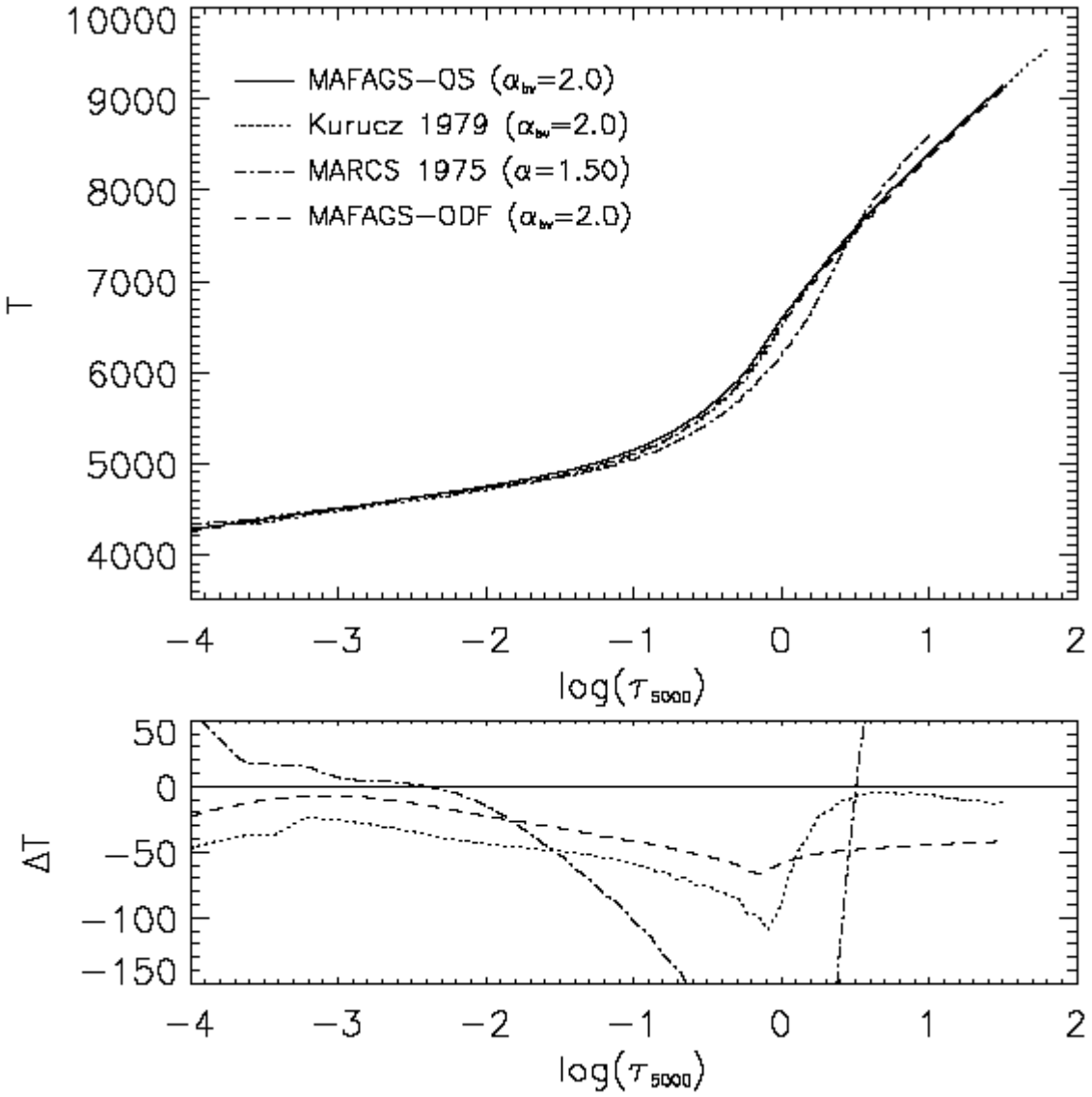
- OS:
  - Each line treated individually (20'000'000)
  - Slow (1min-1hour)
- ODF:
  - Statistic treatment of line opacities
  - Tabulated
  - Fast (1s)



MAFAGS – ODF versus OS (2)

- ODF´s are tabels of 6 dimensions
  - T, P_{gas}, P_e, ξ_{micro}, [Fe/H], [α/H]
  - Interpolation introduces errors
  - Indvidual element abundances (peculiar stars) can not reliably be modeled
    - O, Mg, Si are important electron sources
      → those e^- go into opacity forming species
      (H^-, H_2^-, scatter processes ...)
- OS can be calculated for individual stars
  - Am stars or metal poor stars with α-enhancement

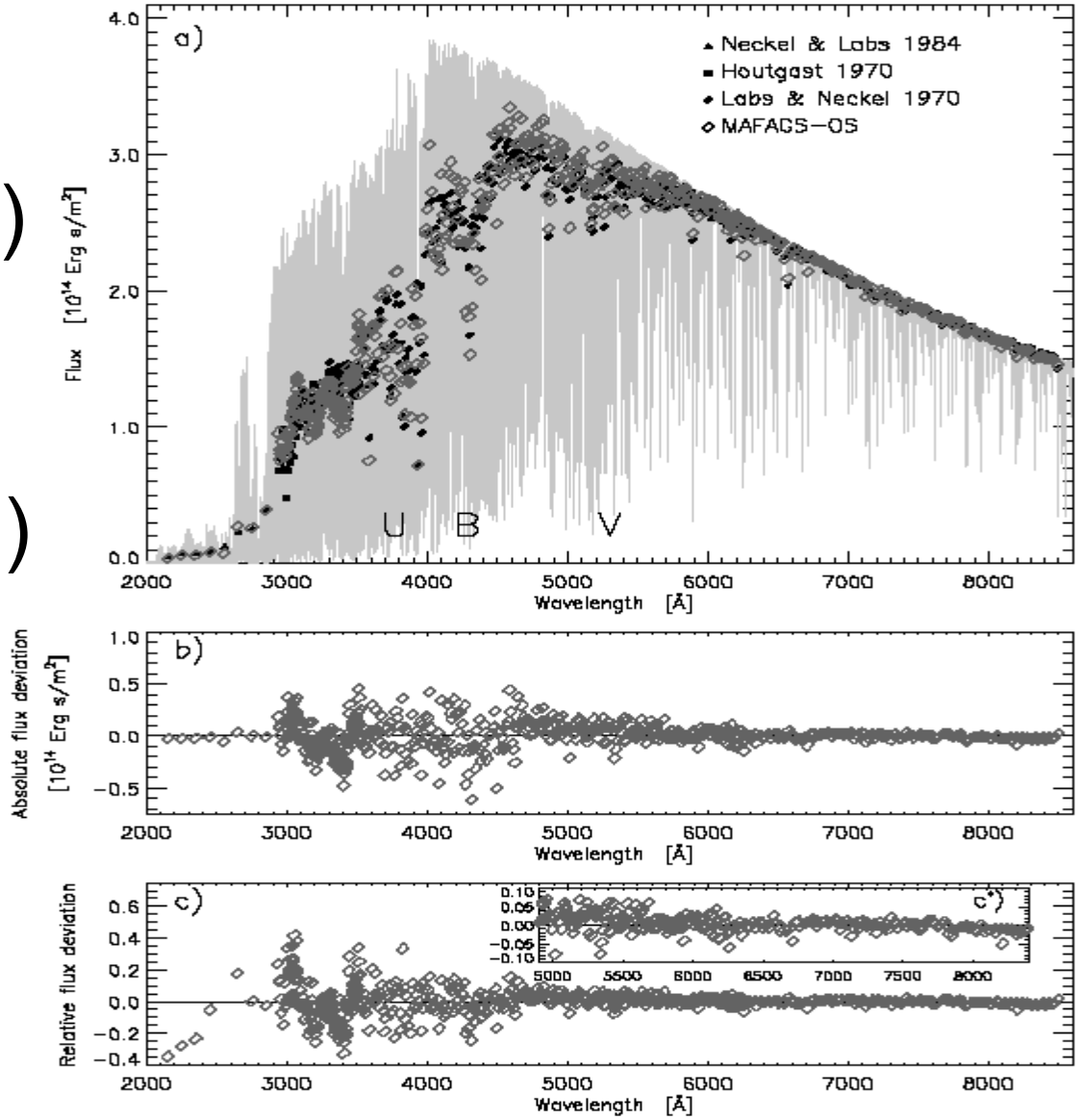
MAFAGS – ODF versus OS (3)



- Solar OS model is ≈50-60K hotter than ODF model!
- This affects:
  - IRFM temperatures
  - Colors (B-V,U-B)
  - Balmer line temp.
  - Element abund.
- Sun is a reference for many methods

MAFAGS-OS – Solar flux & colors

- Flux agrees well.
- $B\text{-}V_{sun}$ = **0.195** (0.02)
  $B\text{-}V_{mafags\text{-}os}$ = 0.19
  $B\text{-}V_{atlas9}$ = 0.08
- $U\text{-}B_{sun}$ = **0.642** (0.02)
  $U\text{-}B_{mafags\text{-}os}$ = 0.64
  $U\text{-}B_{atlas9}$ = 0.59



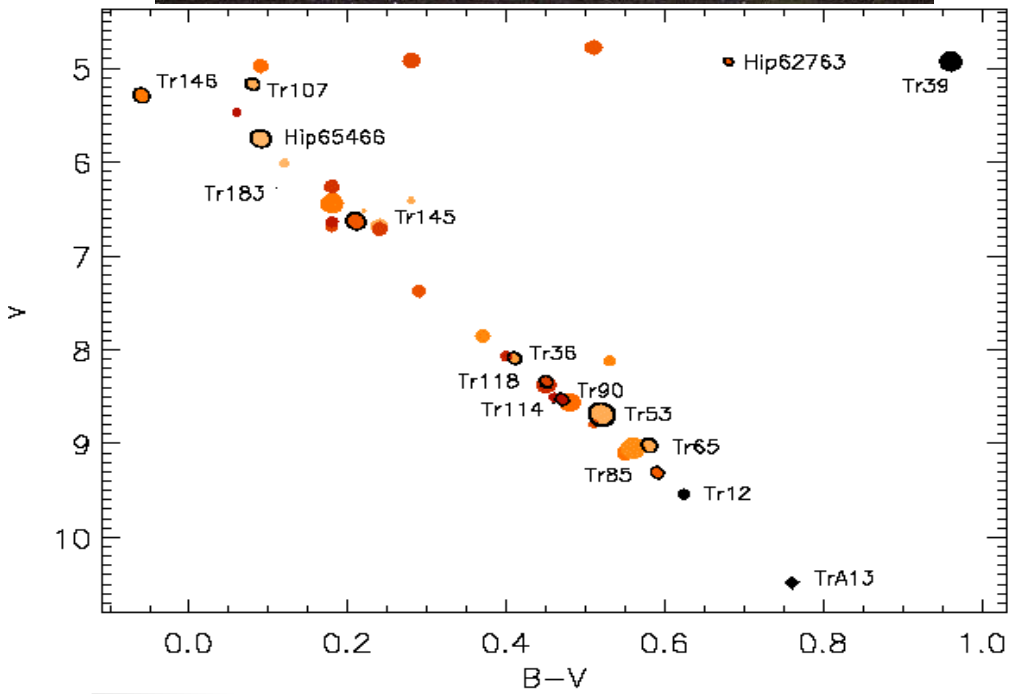
MAFAGS-OS – Summary

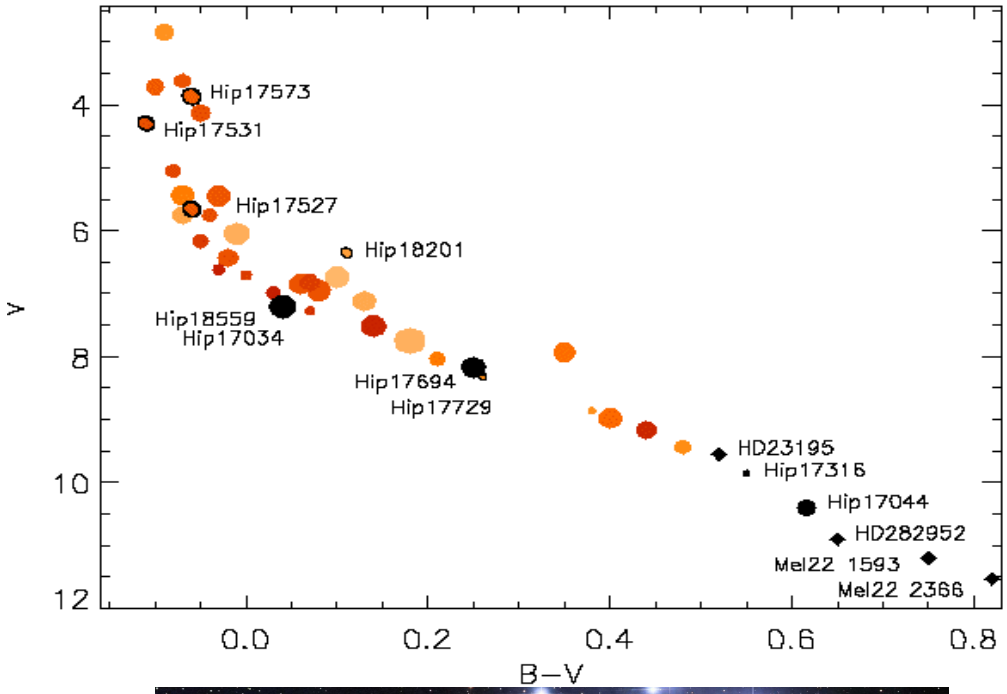
- OS models individual stars instead of using grid interpolation
- OS model calculation takes 0.5-6 hours (ODF model tables only a few seconds)
- Solar flux and colors of the OS model agree well

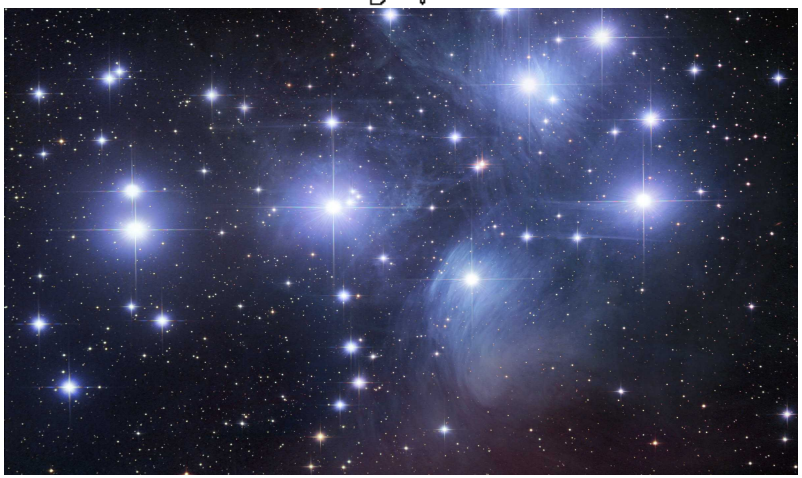
OC main sequence

- A unique laboratory for stellar evolution & model atmosphere testing
  - Stars with “same” age
  - Stars with “same” initial chemical composition
- We need very good parameters
  - Use high resolution high signal to noise spectra
  - Use OS models
  - Use Non-LTE methods
- Only few clusters are near enough and show main sequence up to late B types (He desired)

Melotte 111 and the Pleiades

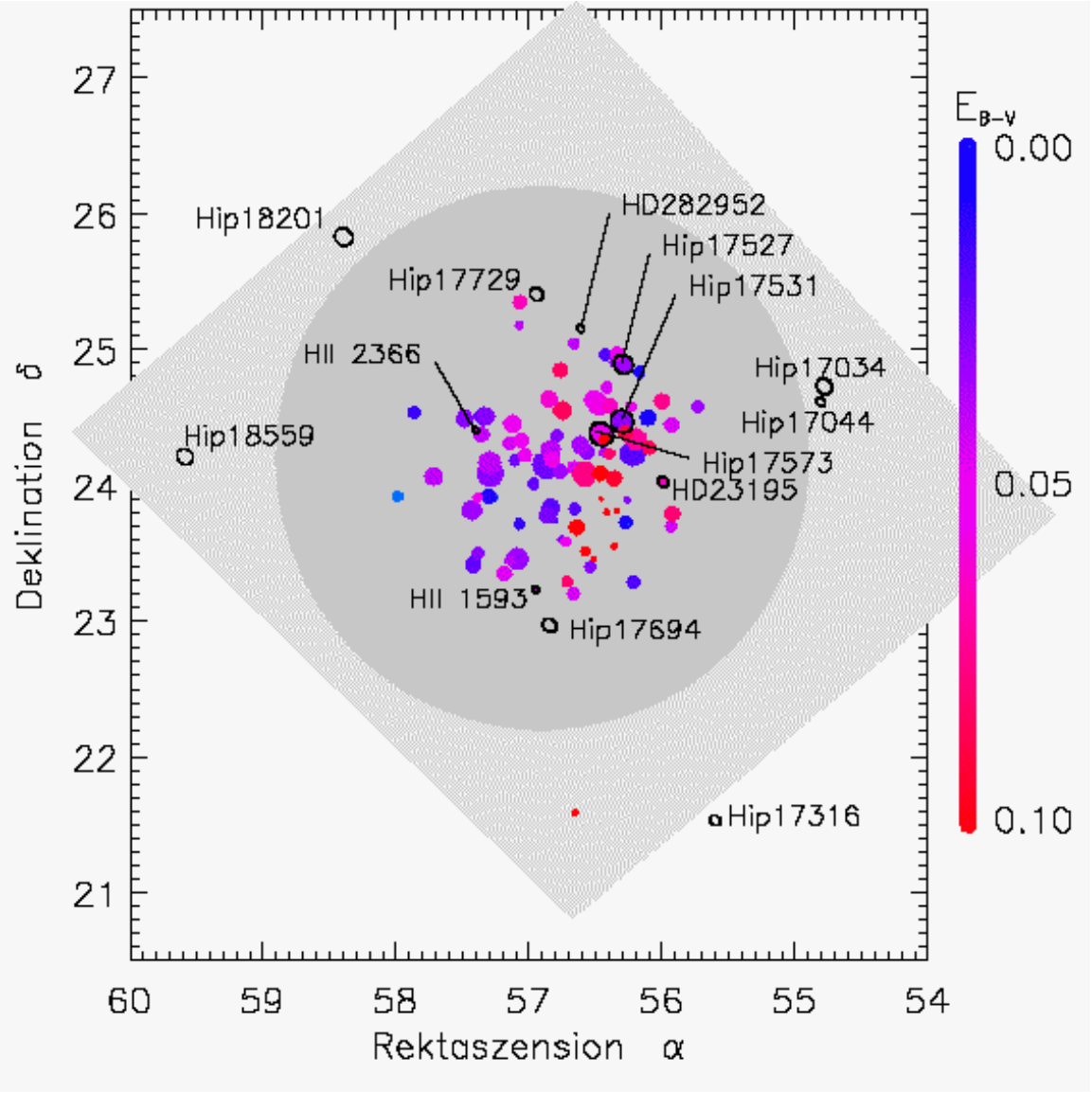






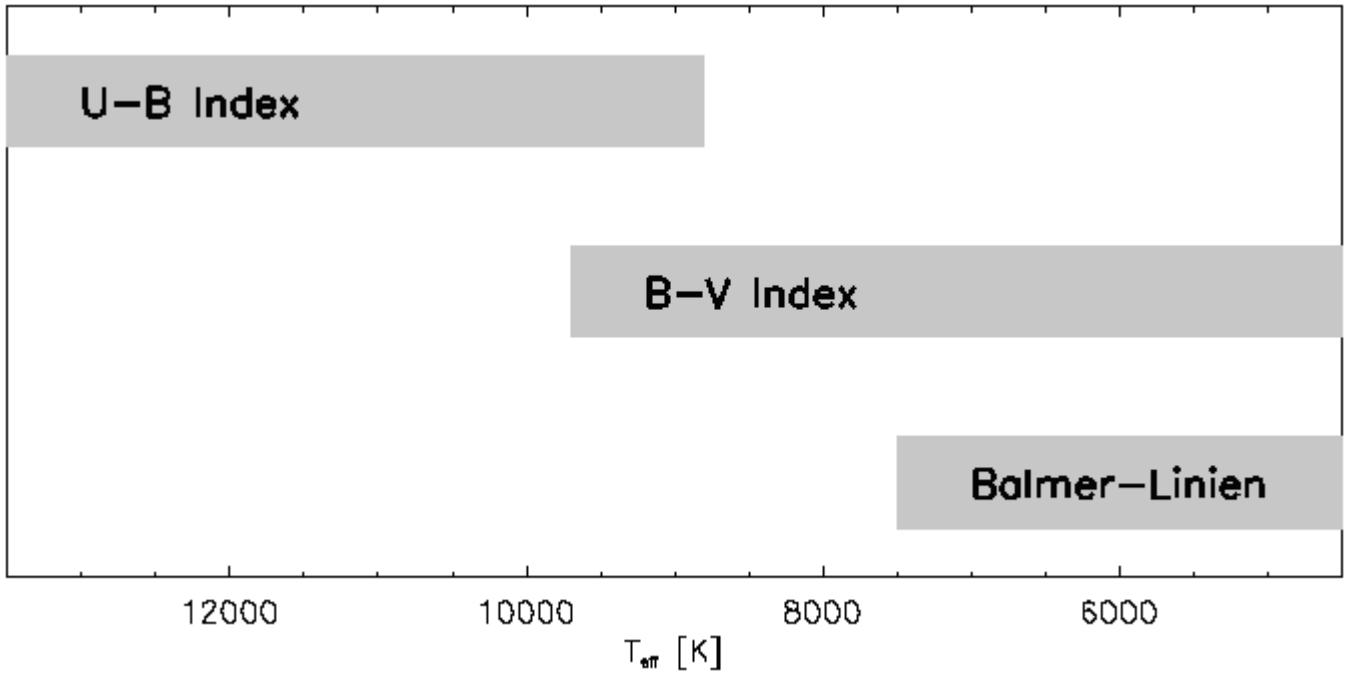
Pleiades - Reddening

- Reddening measurements available
- Reddening very non-uniform
- Any color infor-mation to be treated with care



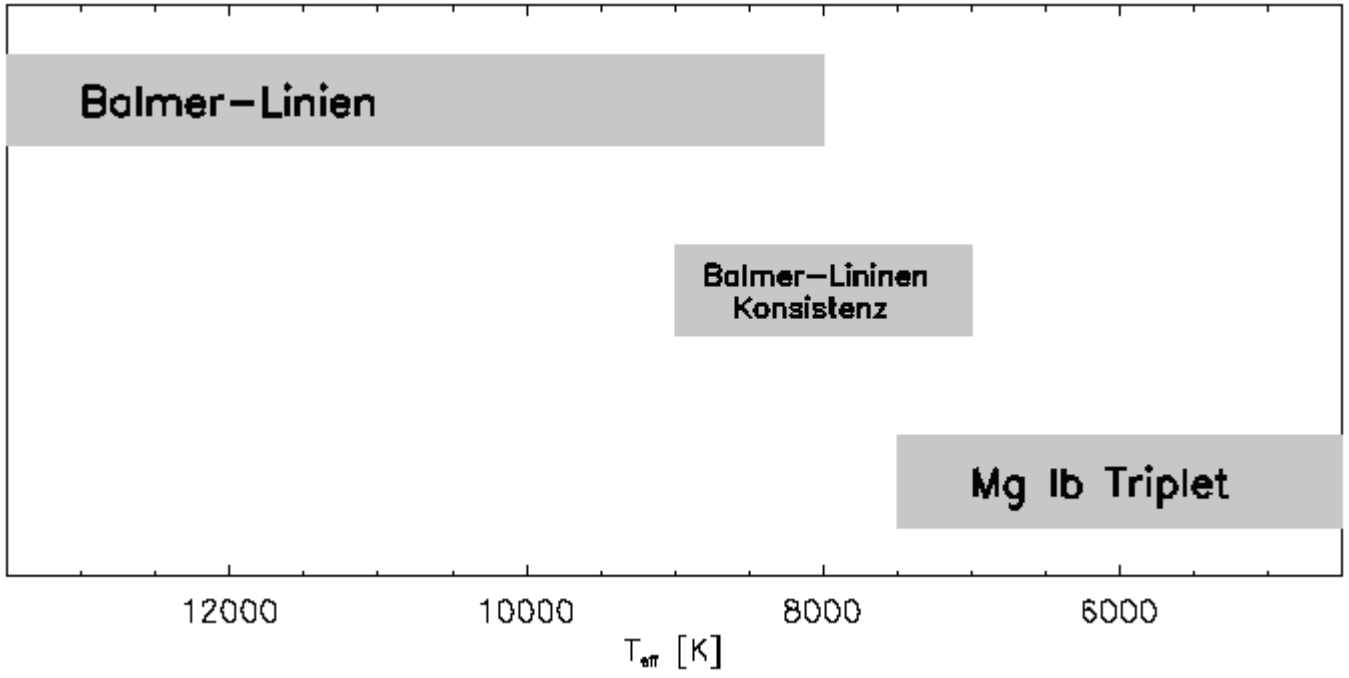
Methods of T_{eff} determination

- Balmer lines between T_{eff} = 4800 and 7500K
- Color indices for higher temperatures
  - Keep in mind reddening!



Methods of log(g) determination

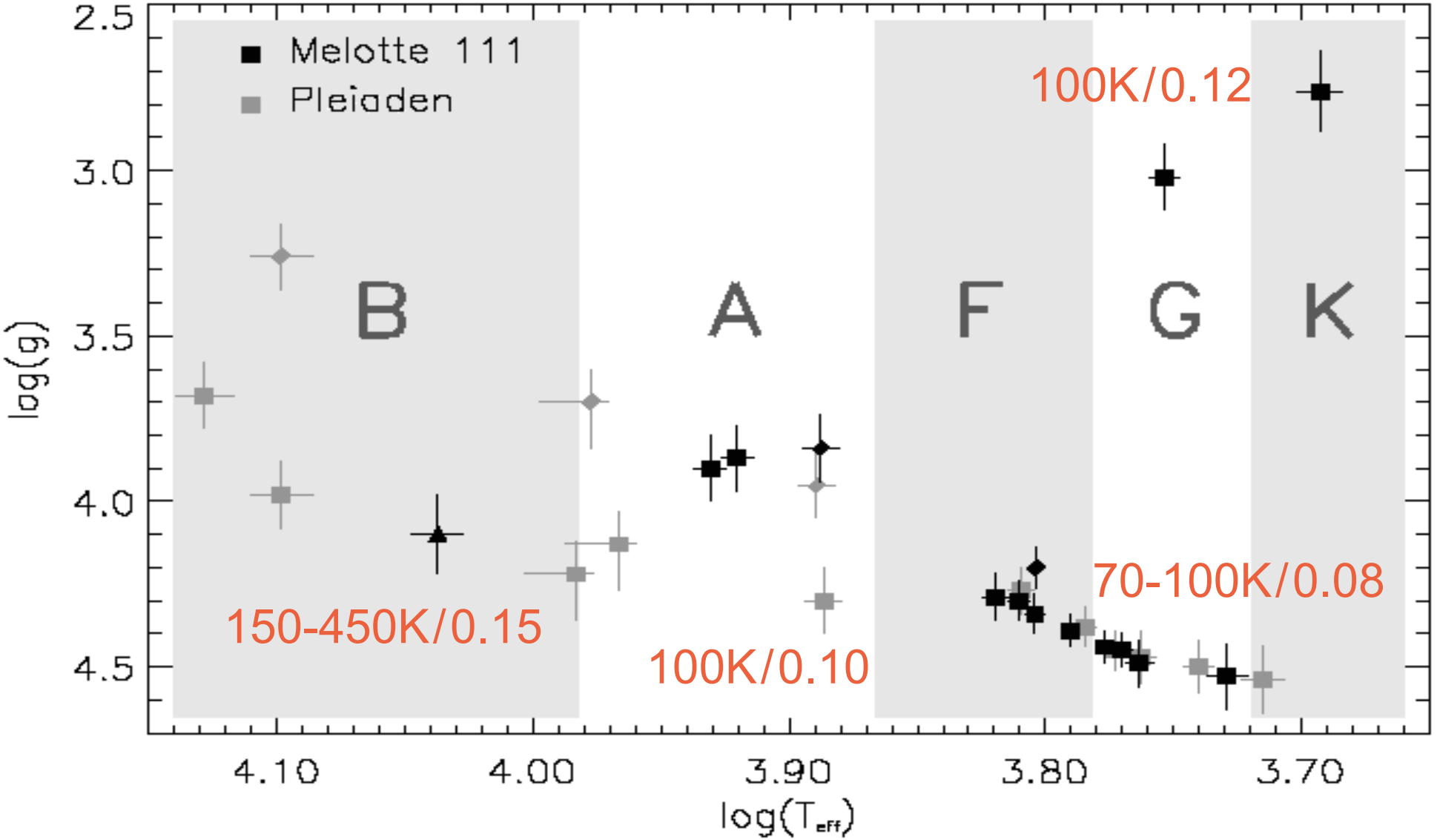
- Wings of broad lines (Mg Ib) for cool stars
- Balmer lines and consistency between Balmer lines for hotter temperatures



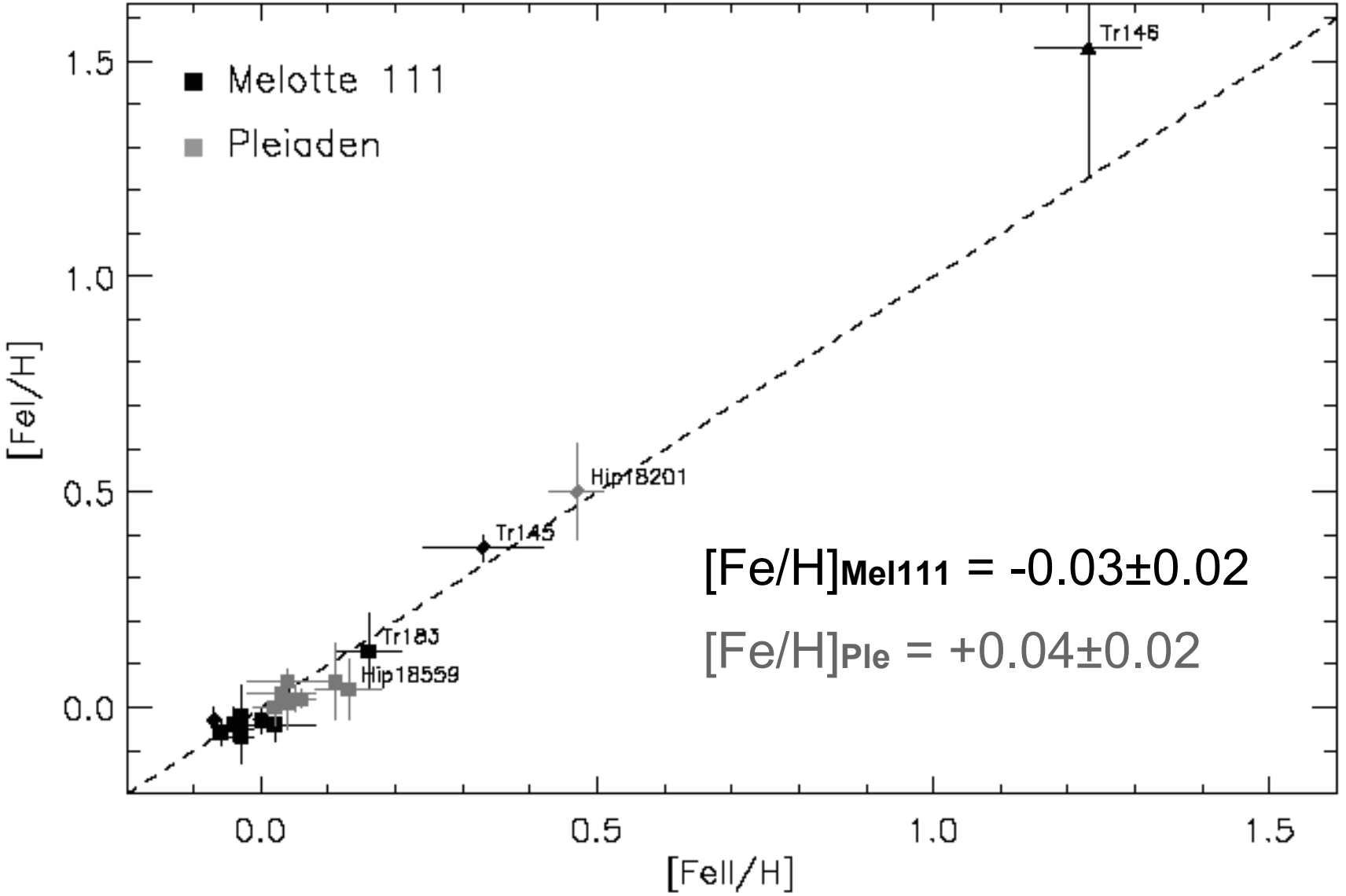
Other parameters

- ξ_{micro} from consistent element abundances of lines of different line-strength
- Element abundances from **LTE** spectrum synthesis and line fitting (no equivalent widths)
- Stellar rotation from line fitting

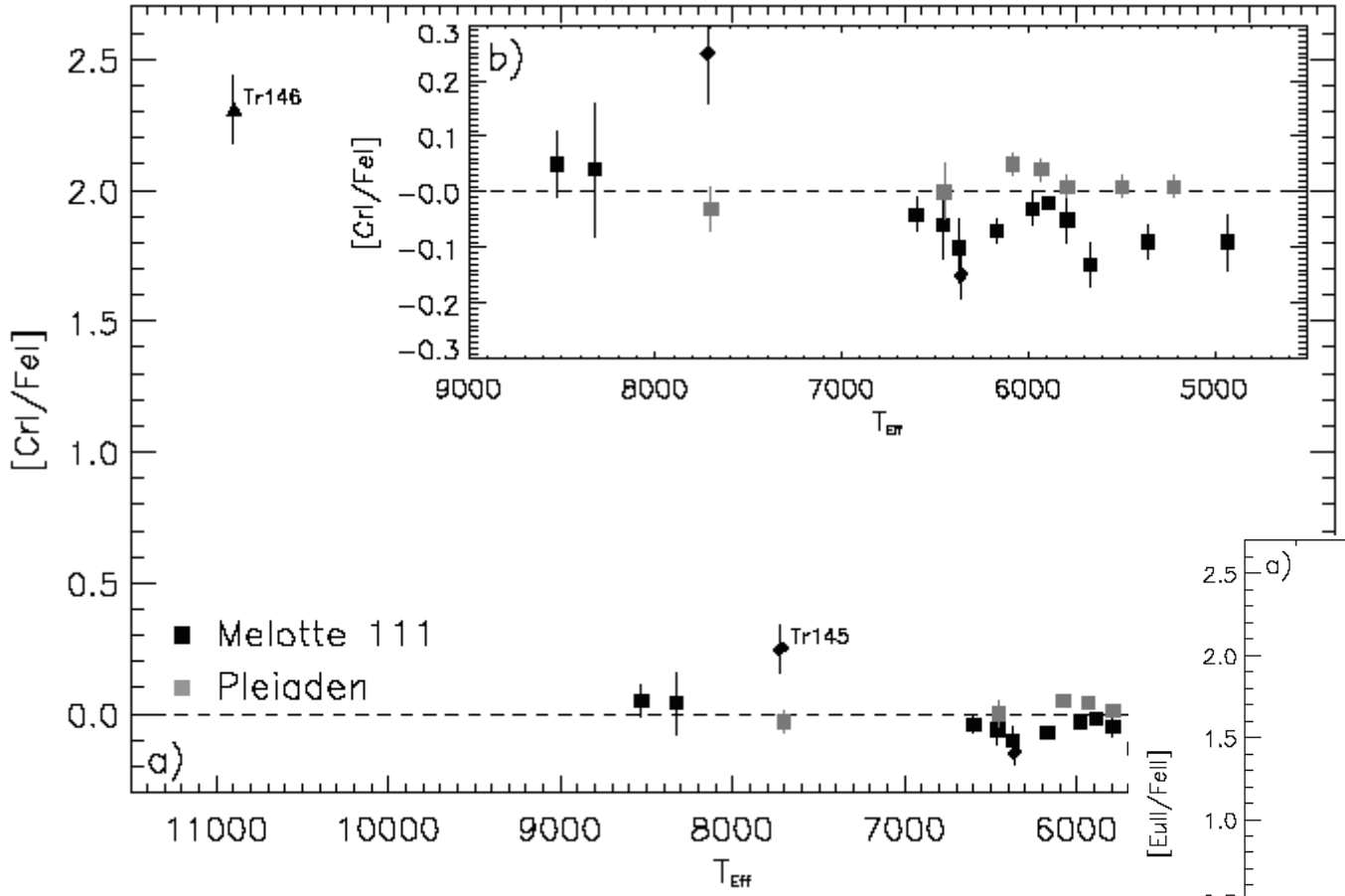
The main sequences – Error bars

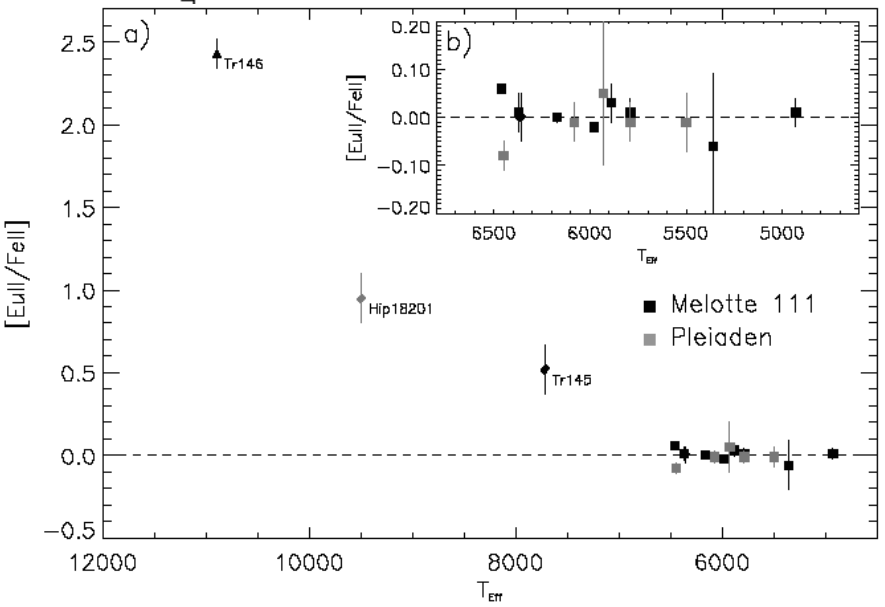


Chemical homogeneity – FeI / FeII



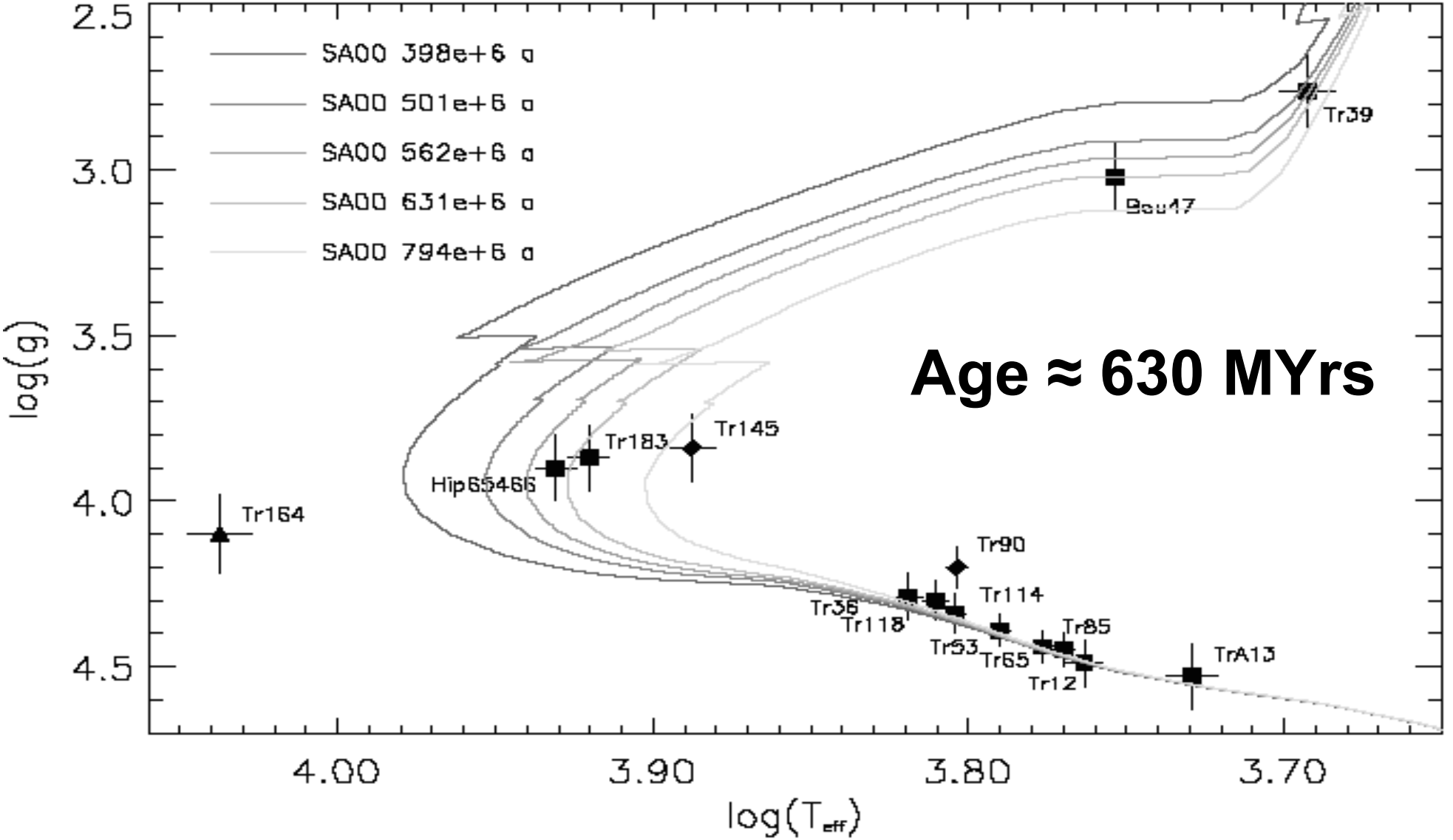
Chemical homogeneity – Tr146



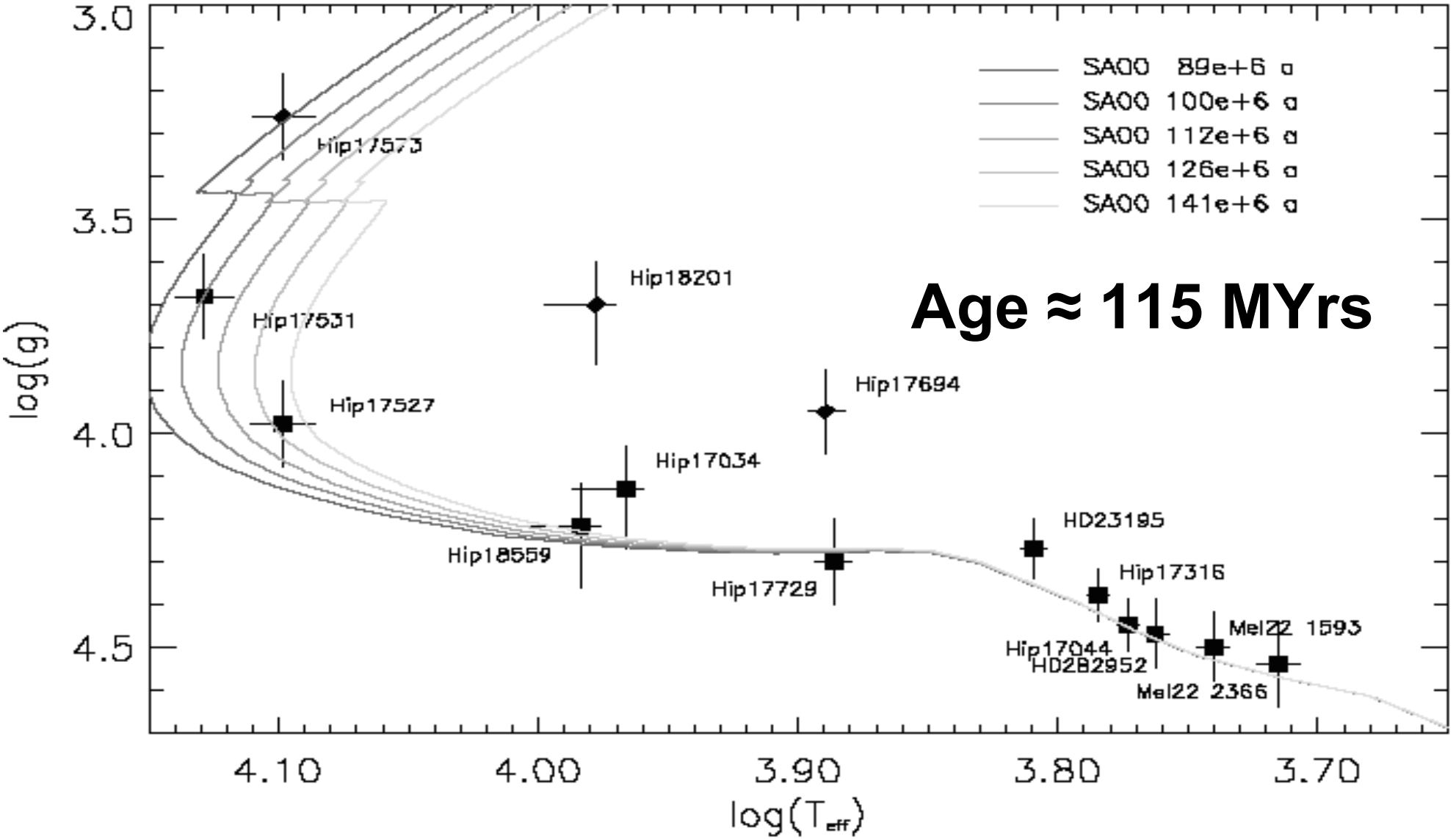


- Tr146 is an Ap star of Cr-Eu type

Age of Melotte 111 – Salasnich 2000

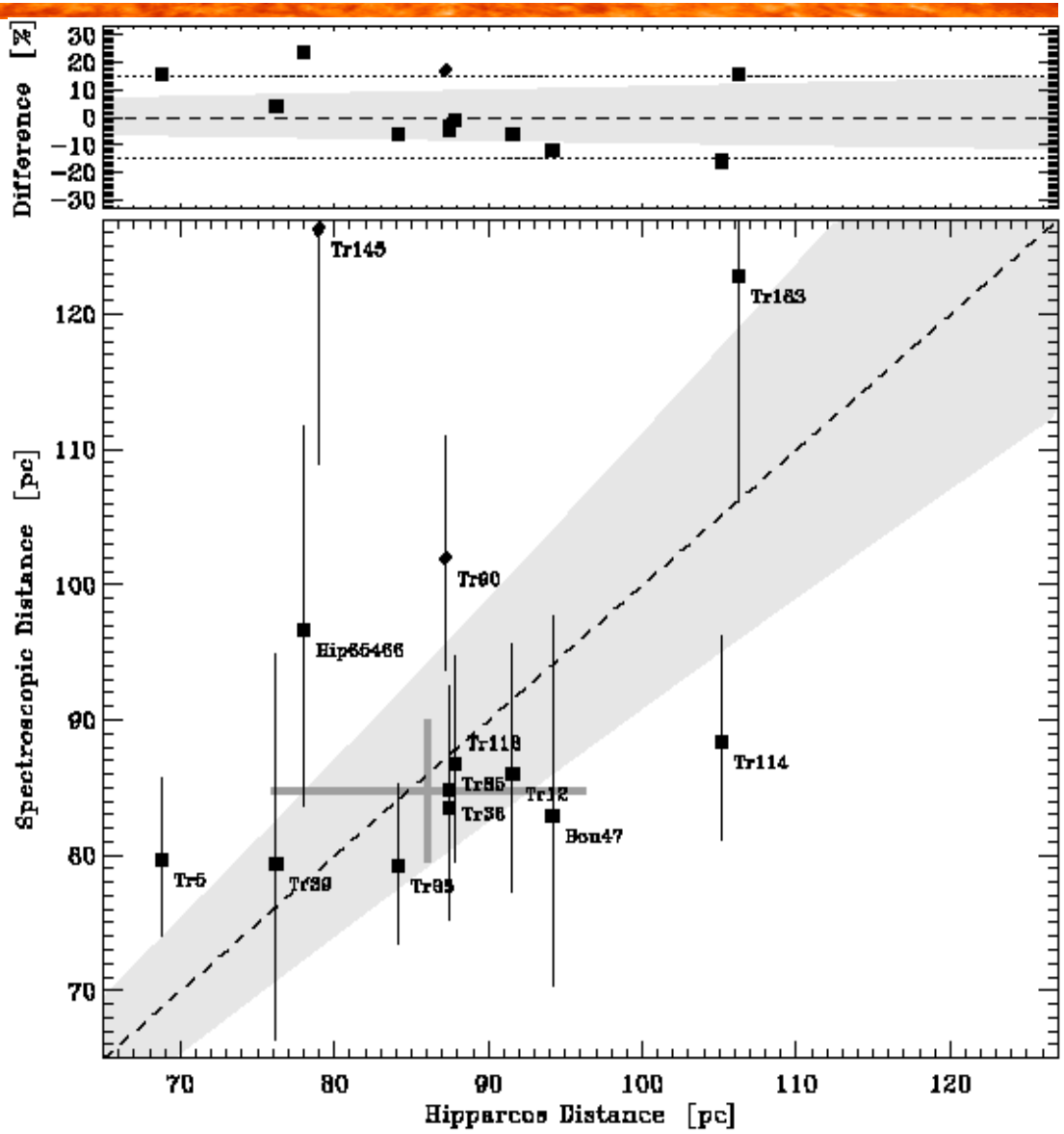


Age of the Pleiades – Salasnich 2000



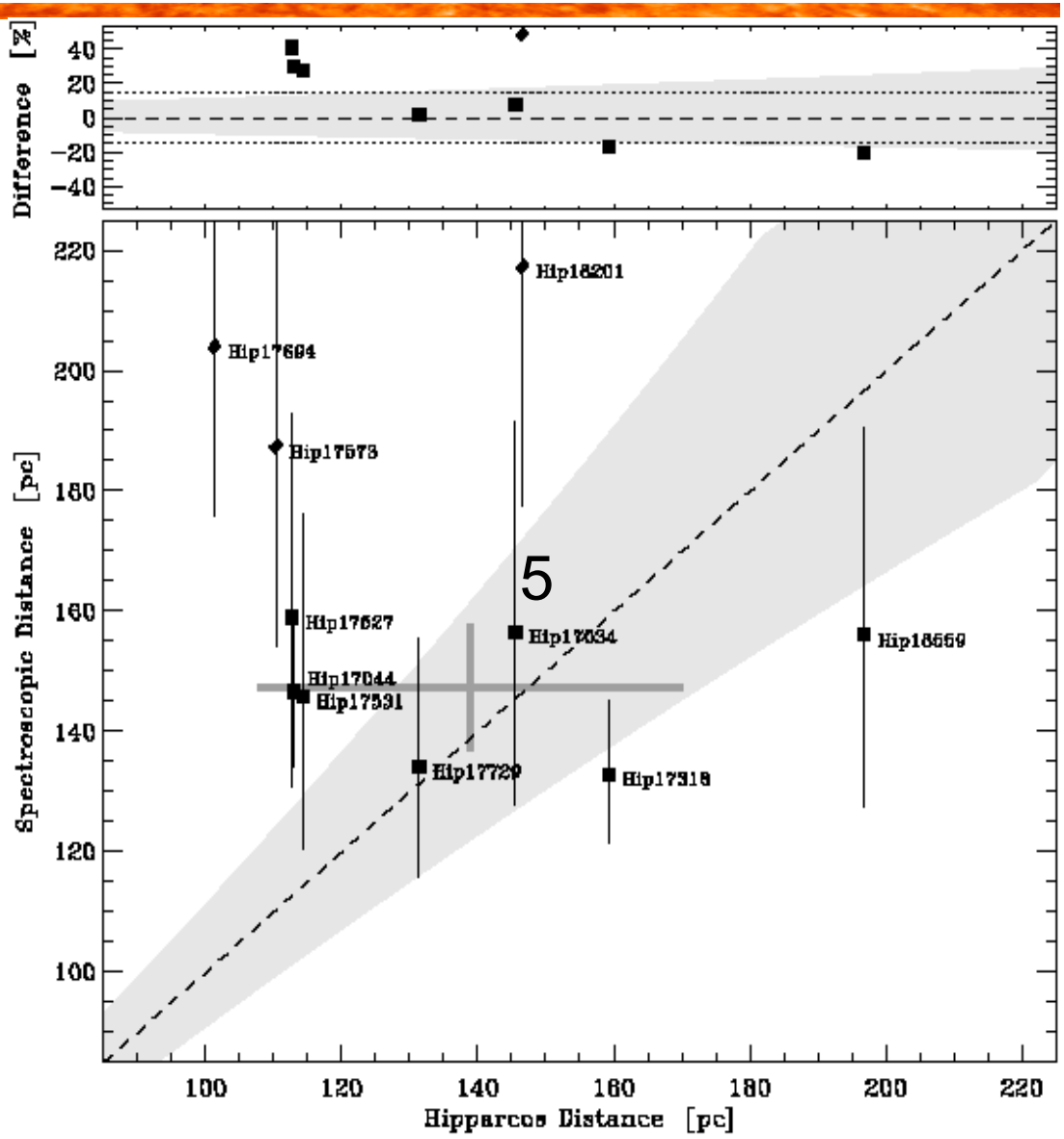
Spectroscopic distances – Mel 111

- Mass, T_{eff}, log(g), BC & V $\longrightarrow$ d_{Sp}
- d_{HIP} = 86.1± 3.1pc
- d_{Sp} = 84.7± 1.7pc
- This can not directly be used as a measurement of the cluster distance



Spectroscopic distances – Pleiades

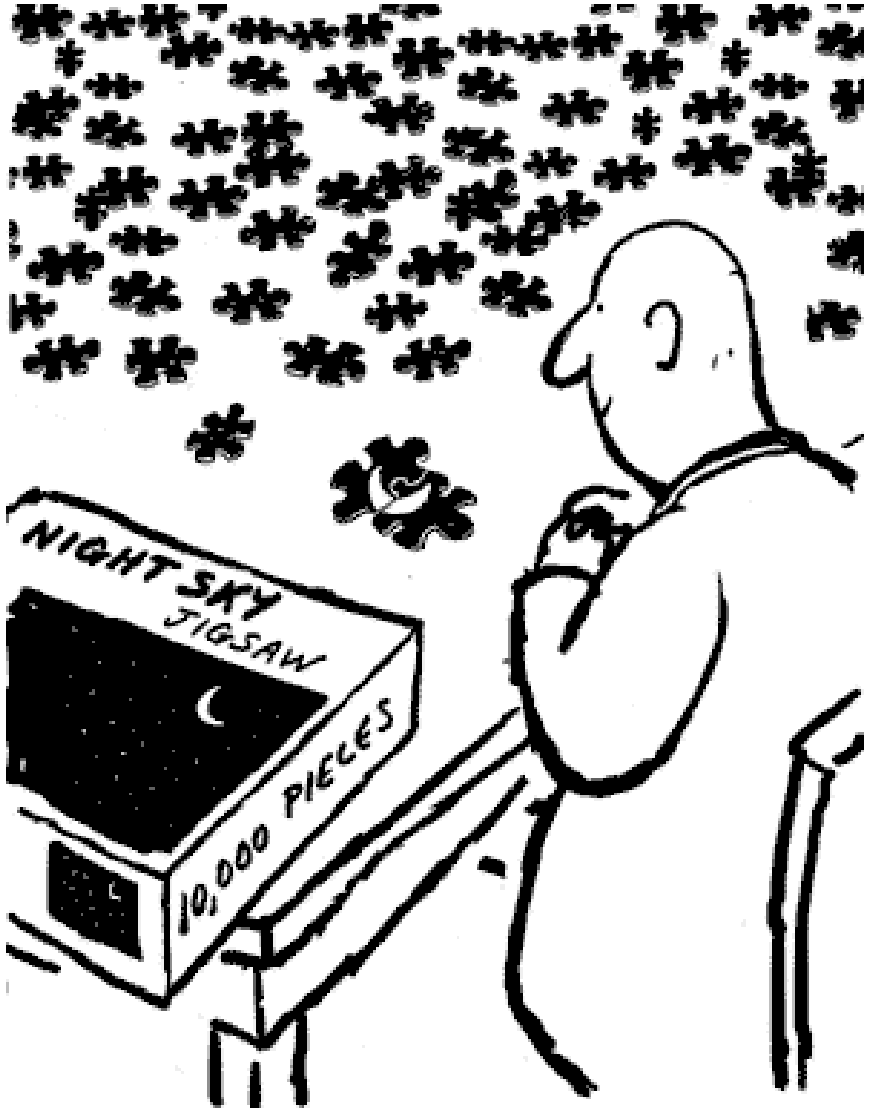
- d_{HIP} = 136.3± 9.3pc
- d_{Sp} = 143.9± 4.1pc



Is there any use for LAMOST?

LAMOST – Open cluster survey LOCS

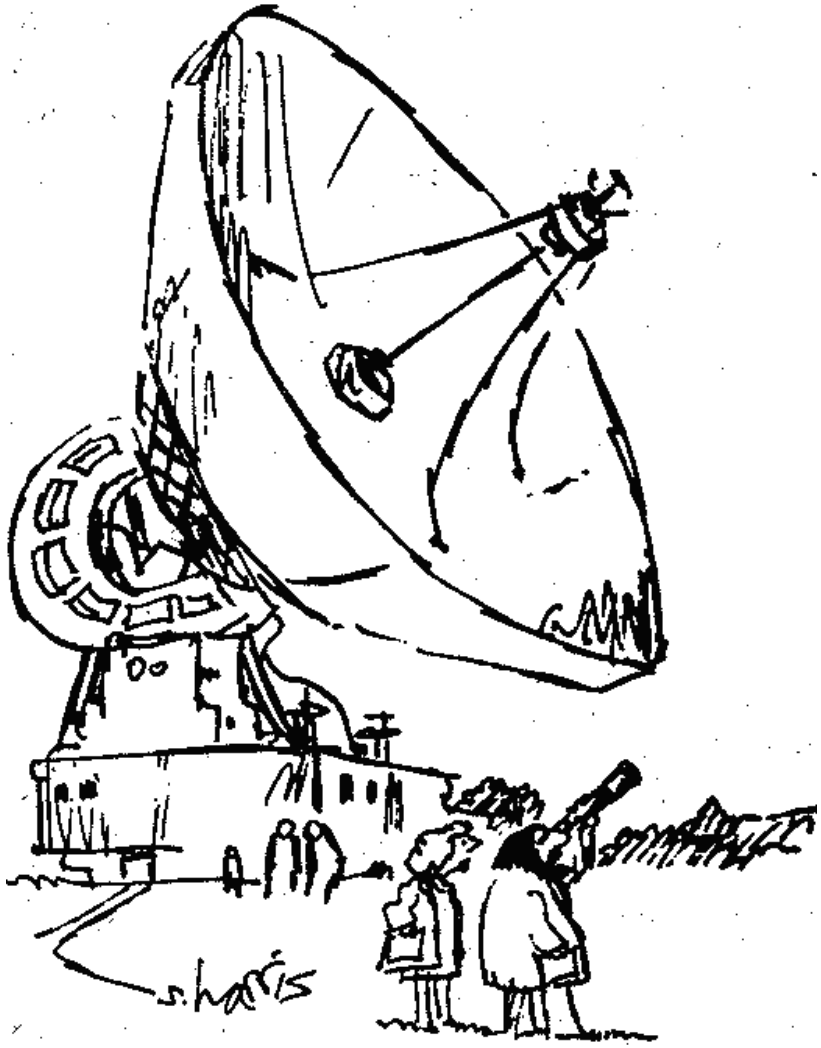
- Low resolving power
- Automatic parameter determination
- Important to know reliability of parameters
- Suggestion:
  - Use parameters from high resolution work as test sample for OC survey



Next steps of our work

- Compare our model atmosphere to others
  - Use the Sun + a small test sample of stars
- Refine our methods of parameter determination

The end: "*Thanks for your dedication!*"



"Just checking."

- The team:
  - Frank Grupp
  - Thomas Gehren
  - TAN Kefeng
- This talk is available online: www.grupp-astro.de