# *The CIFIST Legacy*


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***Elisabetta Caffau & Luca Sbordone***

**Cosmological Impact of the FIrst Stars**
**(CIFIST Marie Curie Team)**
**Observatoire de Paris-Meudon (GEPI)**

MARIE CURIE **ACTIONS**

l'Observatoire de Paris


# CIFIST

## Team members:

*Team Leader – Piercarlo Bonifacio*

*Experienced Researcher – Hans-G. Ludwig*

*Researcher – Luca Sbordone*

*Early Stage Researcher – Jonay Gonzalez-Hernandez*

*Early Stage Researcher – Natalie Behara*

*PhD Candidate – Elisabetta Caffau*

## Collaborators:

*GEPI – M. Spite, F. Spite, R. Cayrel, V. Hill, P. François*

*Matthias Steffen (Postdam)*

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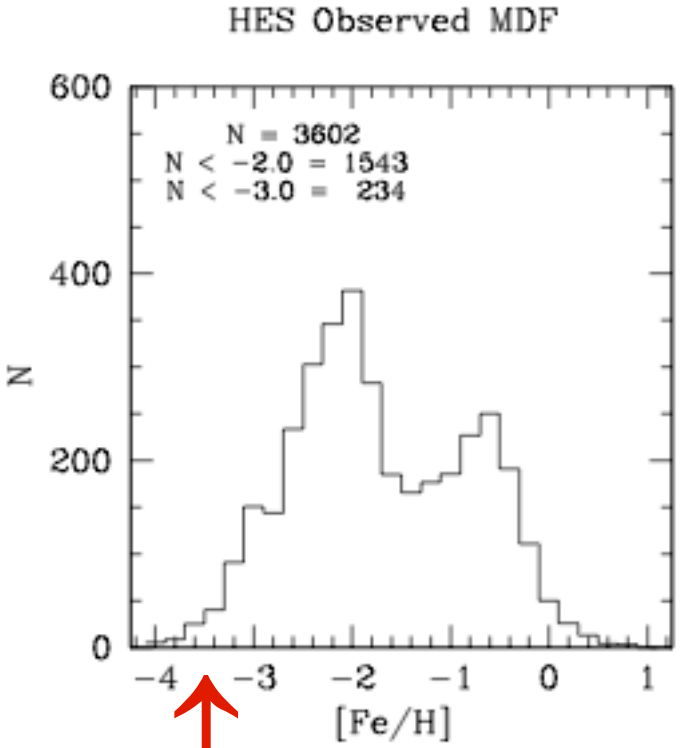
# *CIFIST – **C**osmological **I**mpact of the **FI**rst **ST**ars*


*Main goals:*

*Measure the chemical composition of the lowest metallicity stars, descendants of the First Stars.*




$[X/Y] = \log(X/Y) - \log(X/Y)_{\odot}$

*This implies:*

- *Find the stars (not trivial)*
- *Acquired HR spectra*
- *Interpret the spectra with suitable theory*

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# *CIFIST Activities*


*Activities can be coarsely divided into two branches*

- Observations & analysis of observational data
- Theory of stellar atmospheres, line formation etc..

CIFIST is computing the largest available database of 3D hydrodynamical stellar atmosphere models, as well as compiling a significant database of science-ready, fully reduced spectra of metal-poor stars, typically with very high S/N.

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# *The CIFIST Legacy*


*The CIFIST team began activities in September 2005, and these are due to be completed by September 2009*

*One of our goals is that the CIFIST project must not dissolve into nothing, but leave a "legacy". Something useful for the scientific community which remains after the project, as such is completed. This legacy project is officially supported by the GEPI.*

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# *Data available to the Team*


- First Stars LP legacy
- TNG + SARG spectra EMP dwarfs (5 stars, 1binary)
- VLT+UVES spectra EMP dwarfs, HK/HE (10 stars)
- VLT + UVES spectra EMP dwarfs SDSS (15 stars)
- TNG+SARG spectra low S/N for RV r-rich stars (continue)
- REM VRIK raw photometric data for 274 HK/HE stars
- TNG+SARG MP K dwarfs Mg isotopic ratios
- VLT+UVES MP K dwarfs Mg isotopic ratios
- VLT+Giraffe TO+SG NGC 6397 for Li test
- VLT+CRIRES spectra of MP stars for SI Mult.3
- VLT+UVES High S/N CS22876-32 for $^{6}$Li (to be o
- VLT+UVES spectra of r-I stars (to be obs.)
- OHP1.93m+SOPHIE RV for r-rich EMPS (ongoing)

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# *Observational Dataset*


*CIFIST observations + "First Stars" ESO LP data will cover about 100 objects: high quality, fully reduced spectra.*

*This significant database will be made available to the community for further research, teaching and comparison purposes.*

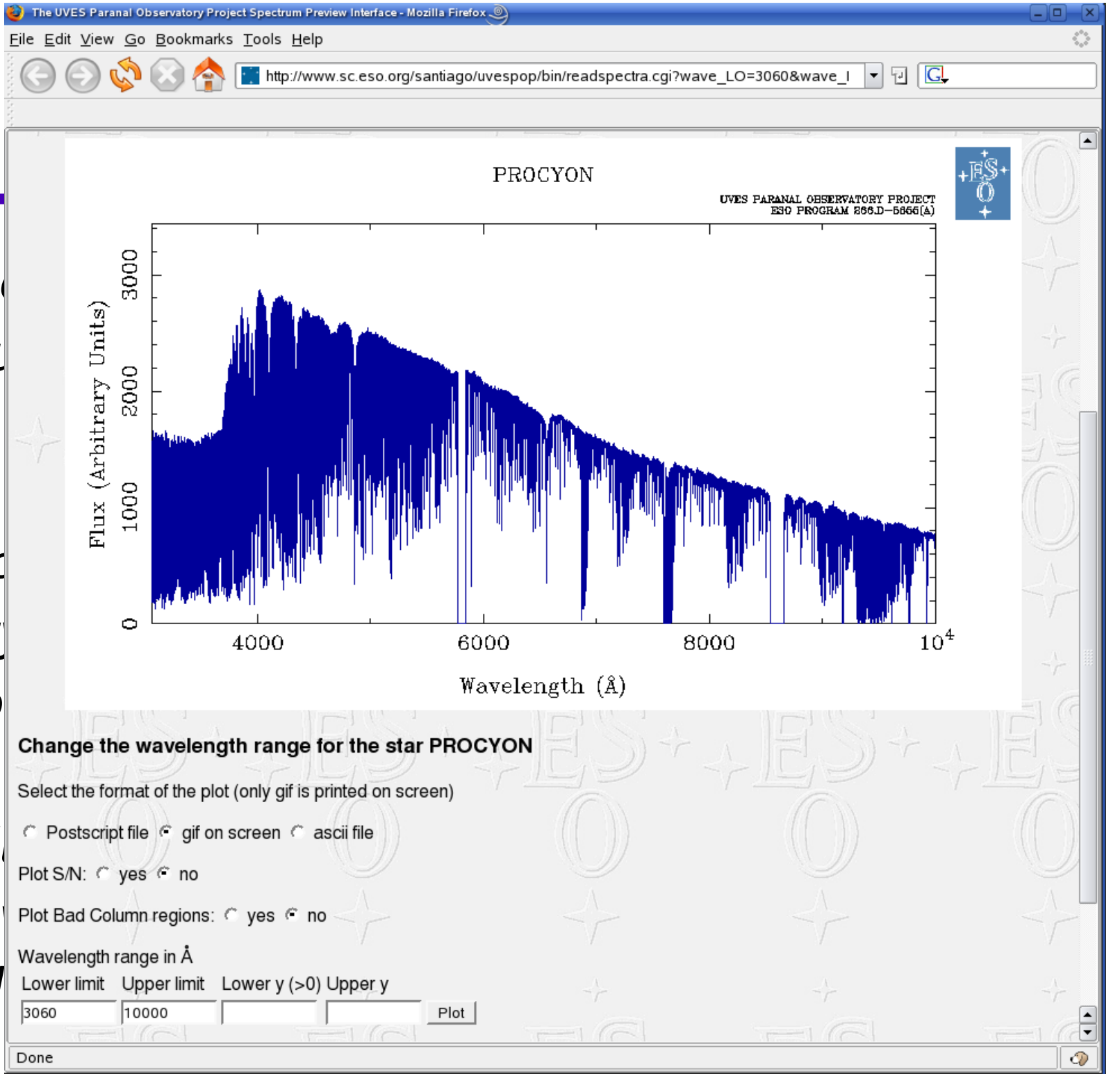
*Archive will be easy to access and search. Links to published work will be provided. VO compatibility is envisioned for the observational database.*

# Observa

*CIFIST obs*
*cover abou*
*spectra.*

*This signific*
*communit*
*compariso*

*Archive wi*
*published*
*envisioned*



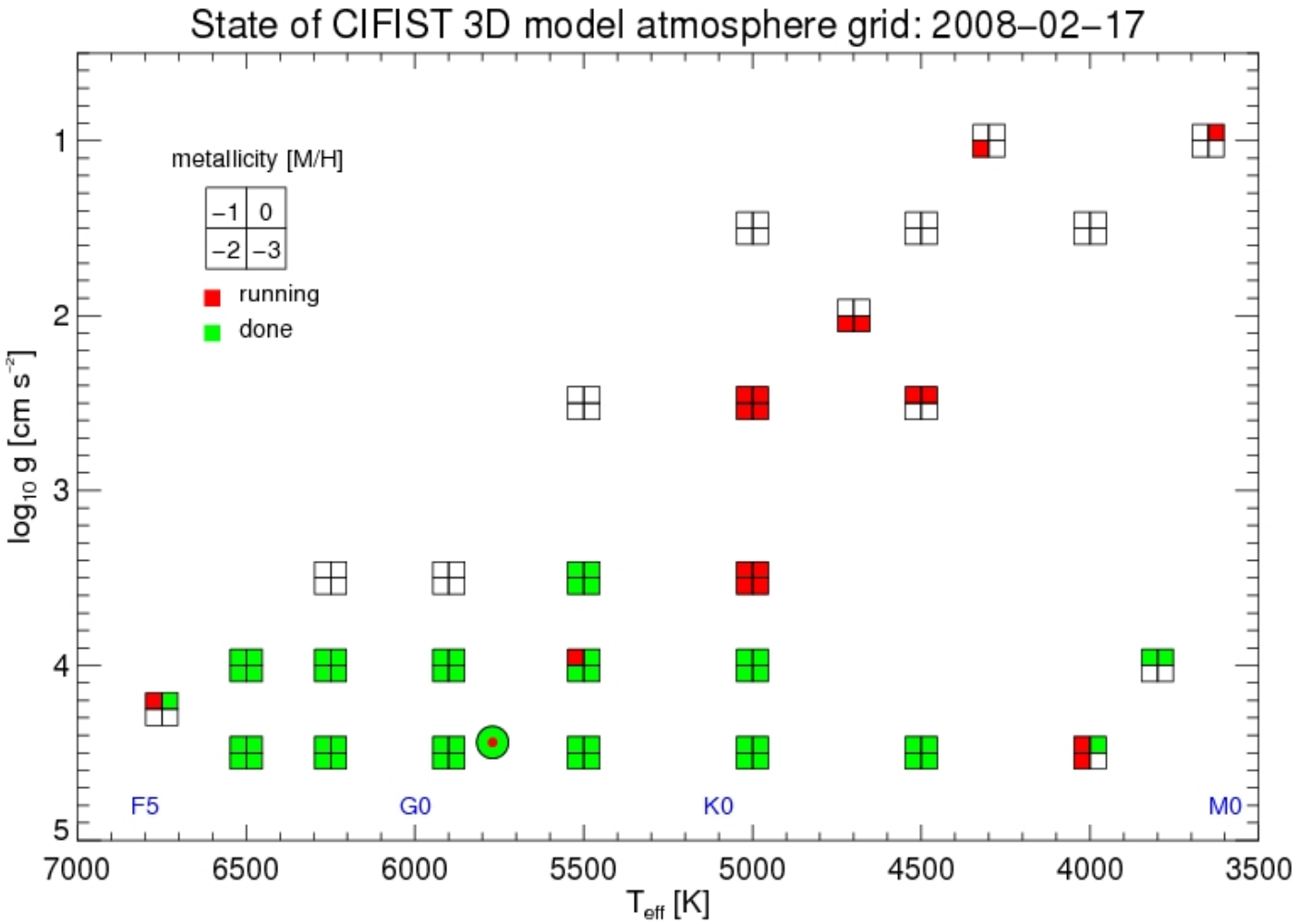
# *3D Model Atmospheres*


*Computed with CO$^5$BOLD, a 3D radiation hydrodynamics code designed to model stellar atmospheres (Freytag et al. 2002).*

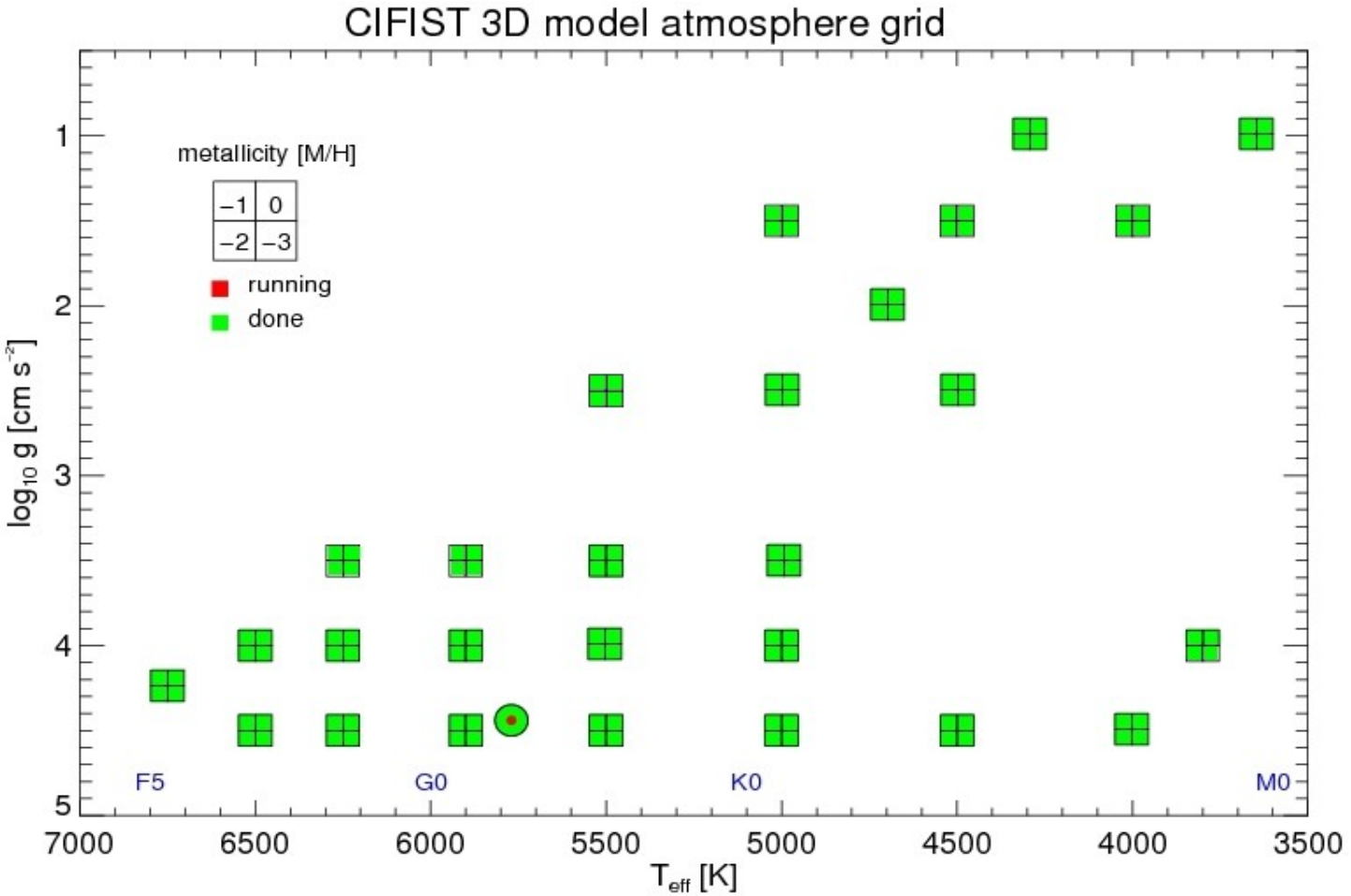
*Gas-dynamical effects can lead to dramatic deviations from radiative equilibrium conditions, especially in metal-poor stellar atmospheres. The aim of 3D models is to represent the detailed interplay of hydrodynamics and radiation.*

*3D models are expensive to compute (CPU time, manpower, hardware) so every model is highly valuable.*


# *Models currently available*



# *Models available at the end of the project*

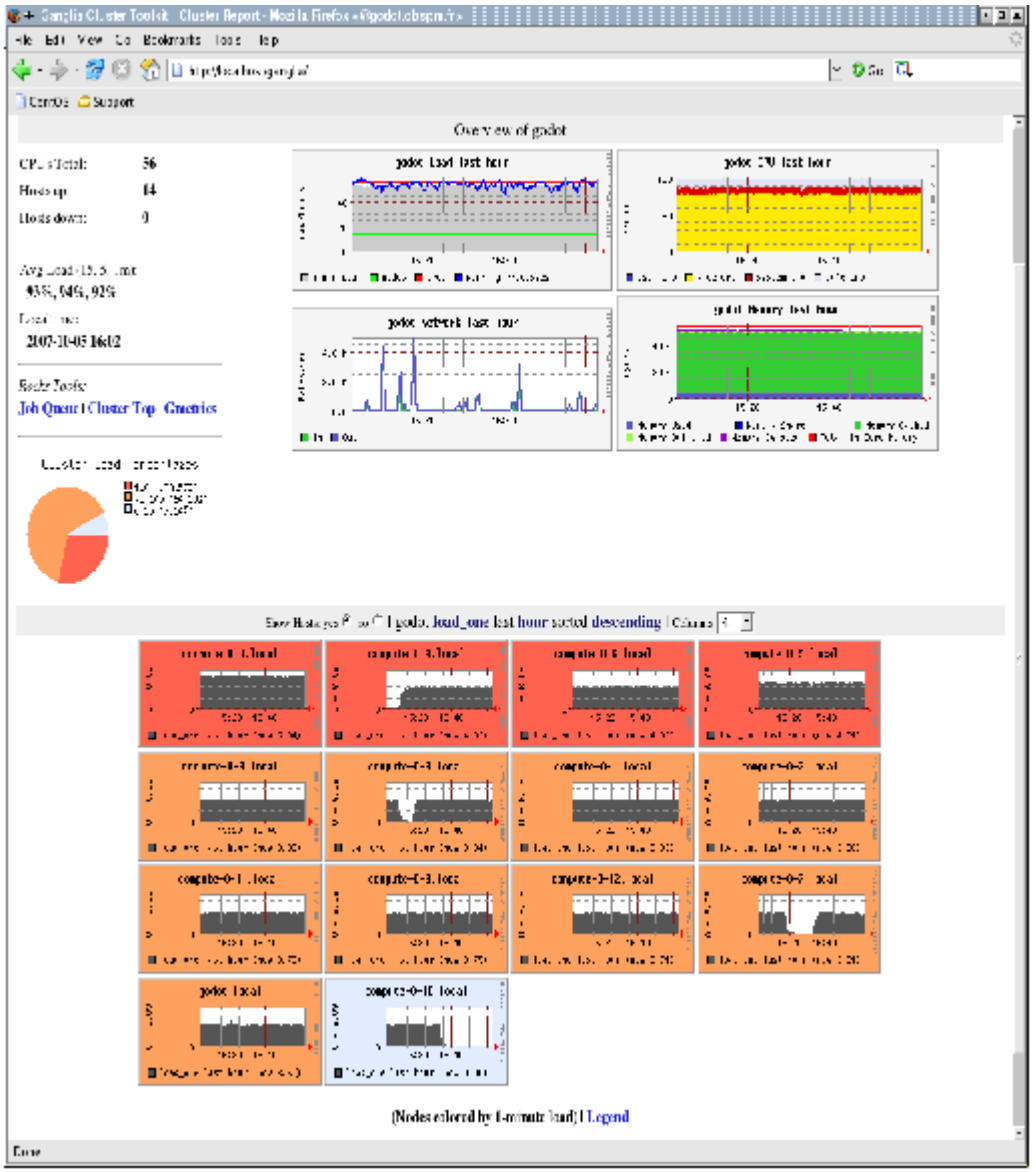


# Compute Cluster GODOT - hardware



- *14 identical PCs, standard ethernet switch (1 Gb/s)*
- *2x dual core AMD Opteron processor 285, 2.6 Ghz, 4 Gb RAM, 120 Gb disk*

# Compute Cluster GODOT - software




- *Rocks Cluster management system*
- *Centos Linux (free Red Hat Enterprise clone)*
- *inter-communication*
- *queuing system, load balancing*
- *job monitoring*
- *software maintenance across cluster nodes*

Untitled Document - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

file:///dp/elcaffau/comomo/comomo_out.html

**Models**

**d3t59g35mm30n01**

**5900.00**

**3.50000**

**godot**

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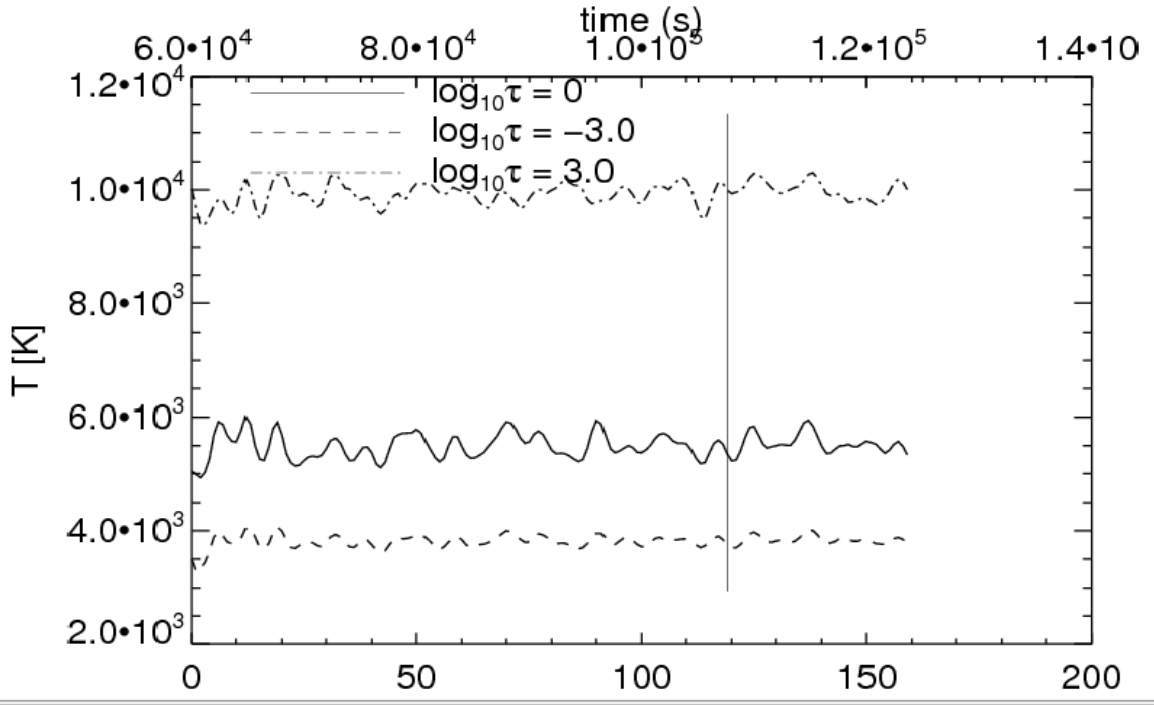
d3t59g35mm00n01
d3t59g35mm10n01
d3t59g35mm20n01
d3t59g35mm30n01
d3t50g25mm10n01
d3t50g25mm20n01
d3t50g25mm30n01
d3t49g20mm20n03
d3t49g20mm30n01
d3t40g45mm10n01
d3t57g44mm20n02
d3t57g44mm10n01
d3t50g35mm00n01
d3t50g35mm10n01
d3t50g35mm20n01
d3t50g35mm30n01
d3t55g40mm10n01
d3t50g25mm00n01
d3t63g35mm20n01

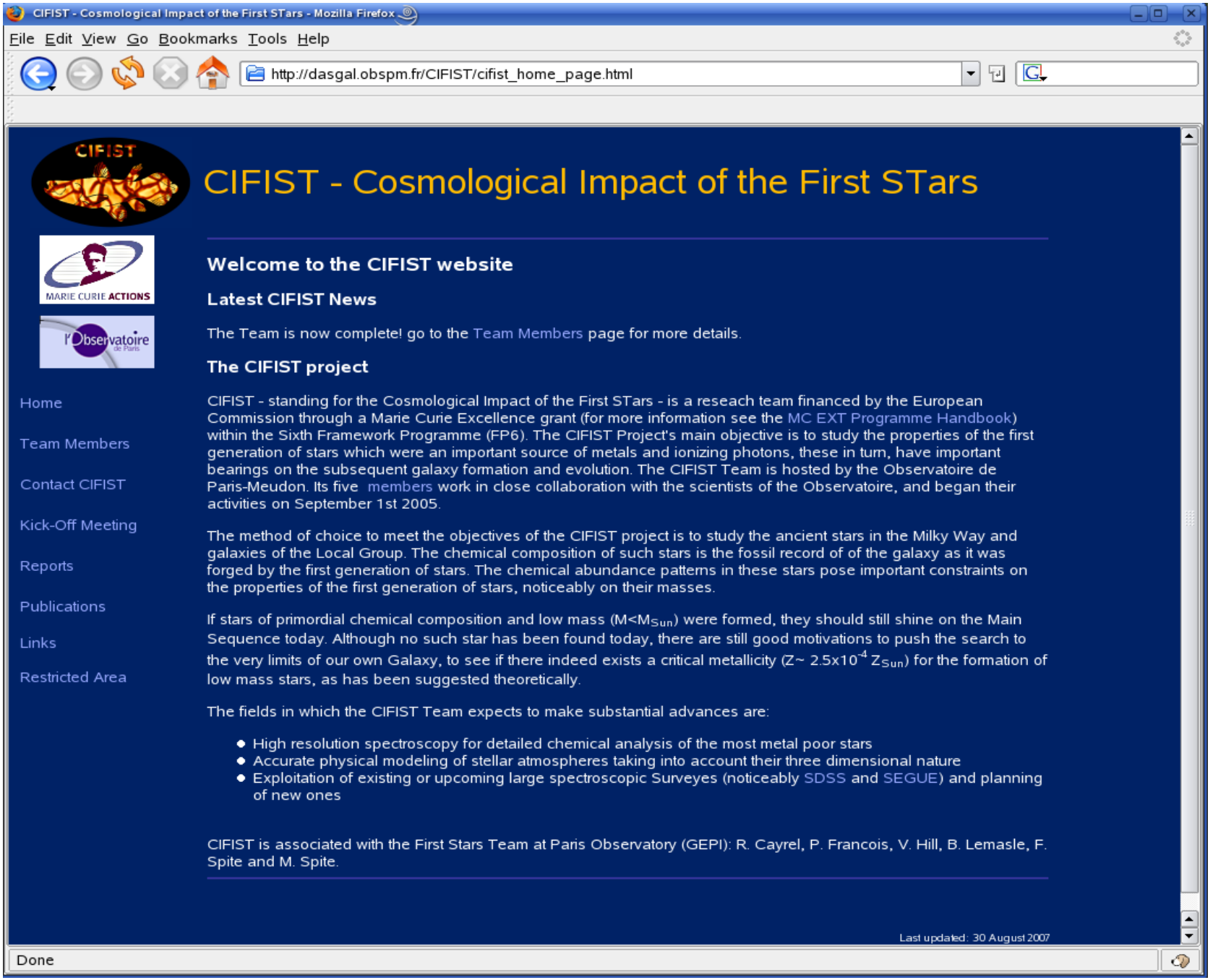
Created *Mon Mar 10 10:16:14 2008 UTC* by CO$^5$BOLD model monitor




Done

- *Allows users to check the availability or status of a 3D model*
- *Semi-automatic update*

# *Main page http://www.galax.obspm.fr/CIFIST/*



# CIFIST - Cosmological Impact of the First STars

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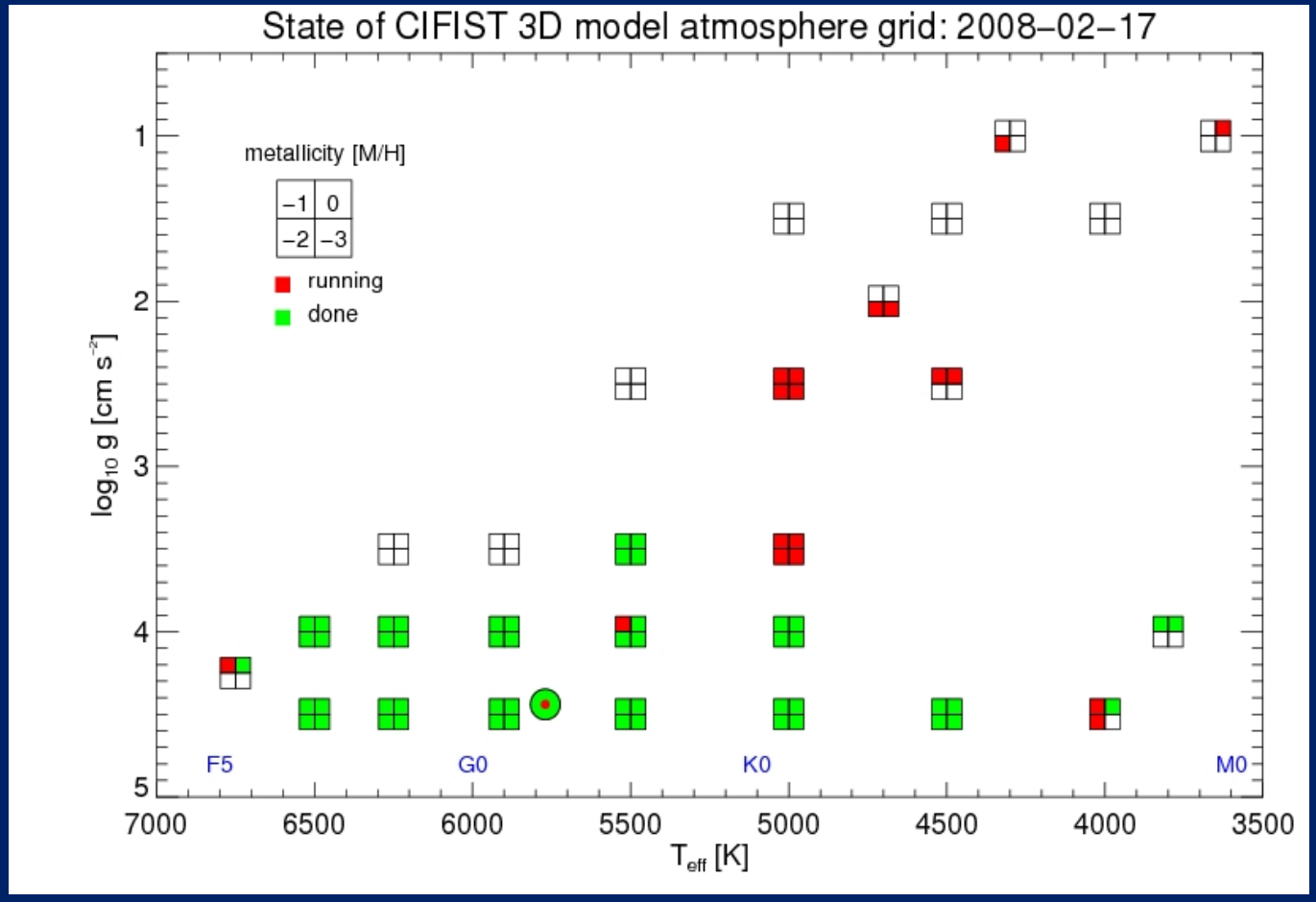
## 3D models status (last database update 2007 10 08 12:33:21)

If it is your first time here see the page instructions!!!

**Model status map** (you can also go directly to the model list)



**Model list**

| Model name | $T_{eff}$ | log g | [Fe/H] | Status | LHD | notes |
|---|---|---|---|---|---|---|
| d3t36g10m00 | 3600 | 1.0 | 00 | SEL | no | 8 snaps |
| d3t38g40mm00 | 3810 | 4.0 | 0.0 | SEL | yes | 20 snaps |
| d3t38g40mm10 | 3790 | 4.0 | -1.0 | SEL | no | 20 snaps |
| d3t38g40mm00 | 3810 | 4.0 | 0.0 | SEL | LHD | 20 snaps |
| d3t40g45mm00 | 3960 | 4.5 | 0.0 | SEL | yes | 20 snaps |
| d3t45g45mm00 | 4510 | 4.5 | 0.0 | SEL | no | 21 snaps |
| d3t45g45mm10 | 4500 | 4.5 | -1.0 | SEL | no | 20 snaps |
| d3t45g45mm20 | 4540 | 4.5 | -2.0 | SEL | no | 20 snaps |
| d3t45g45mm30 | 4520 | 4.5 | -3.0 | SEL | no | 20 snaps |
| d3t50g45mm00 | 4980 | 4.5 | 0.0 | SEL | yes | 20 snaps |
| d3t50g45mm10 | 5060 | 4.5 | 0.0 | SEL | yes | 19 snaps |
| d3t50g45mm20 | 5010 | 4.5 | -2.0 | SEL | no | 20 snaps |
| d3t50g45mm30 | 4990 | 4.5 | -3.0 | SEL | no | 20 snaps |
| d3t50g40mm00 | 4950 | 4.0 | 0.0 | SEL | no | 20 snaps |
| d3t50g40mm10 | 4980 | 4.0 | -1.0 | SEL | no | 20 snaps |
| d3t50g40mm20 | 4960 | 4.0 | -2.0 | SEL | no | 20 snaps |
| d3t50g40mm30 | 4990 | 4.0 | -3.0 | SEL | no | 20 snaps |
| d3t50g35mm00 | 5000 | 3.5 | 0.0 | RUN | – | – |
| d3t50g35mm10 | 5000 | 3.5 | -1.0 | RUN | – | – |
| d3t50g35mm20 | 5000 | 3.5 | -2.0 | RUN | – | – |
| d3t50g35mm30 | 5000 | 3.5 | -3.0 | RUN | – | – |
| d3t50g25mm00 | 5000 | 2.5 | 0.0 | RUN | – | – |
| d3t50g25mm10 | 5000 | 2.5 | -1.0 | RUN | – | – |
| d3t50g25mm20 | 5000 | 2.5 | -2.0 | RUN | – | – |
| d3t50g25mm30 | 5000 | 2.5 | -3.0 | RUN | – | – |
| d3t55g45mm00 | 5490 | 4.5 | 0.0 | SEL | no | 20 snaps |
| d3t55g45mm10 | 5470 | 4.5 | -1.0 | SEL | no | 20 snaps |
| d3t55g45mm20 | 5480 | 4.5 | -2.0 | SEL | no | 20 snaps |
| d3t55g45mm30 | 5490 | 4.5 | -3.0 | SEL | no | 20 snaps |
| d3t55g40mm00 | 5480 | 4.0 | 0.0 | SEL | no | 20 snaps |

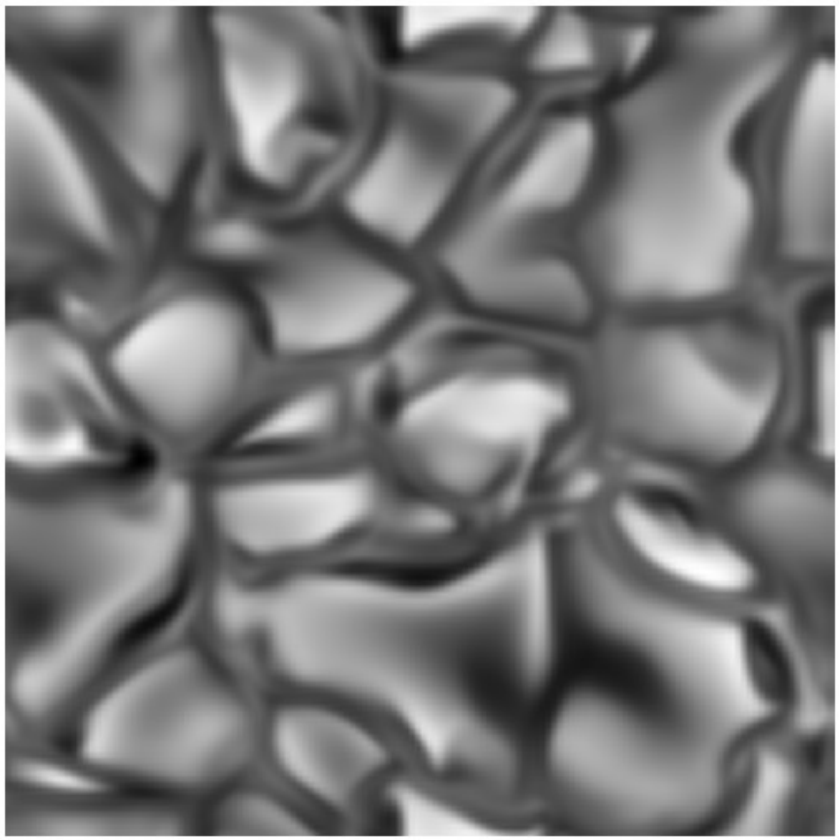

## d3t50g45mm10n03

$T_{eff}$ = 5060 K
Log g = 4.50
[Fe/H] = -1.00
19 snapshots selected
$\Delta$ t = 18.2h
CIFIST abundances

**Plots**
**1D LHD Models**
**Publications**
**Additional Material**

### Full model parameters

Box dimension: 5084.46 x 5084.46 x 2477.64 km
Grid resolution: 140 x 140 x 141
Typical size of granulation pattern: 726 km
Typical lifetime of granulation pattern: 15.1 s
RMS of the constrast: 0.0872575
Numbers of opacity bins used in the radiative transfer: 6



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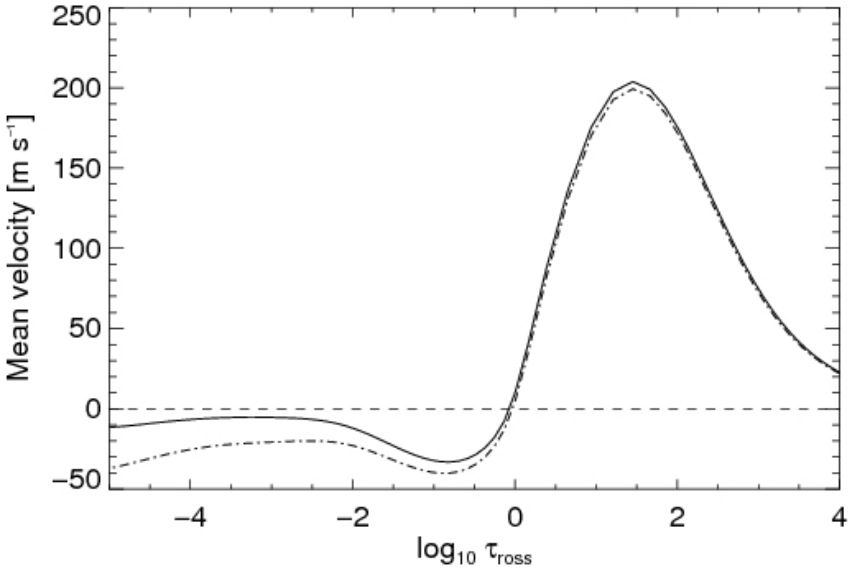
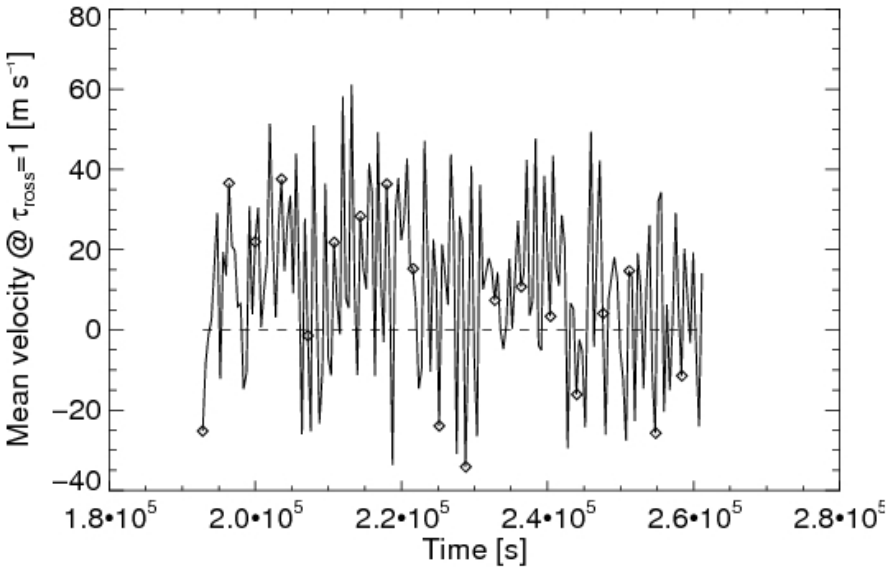
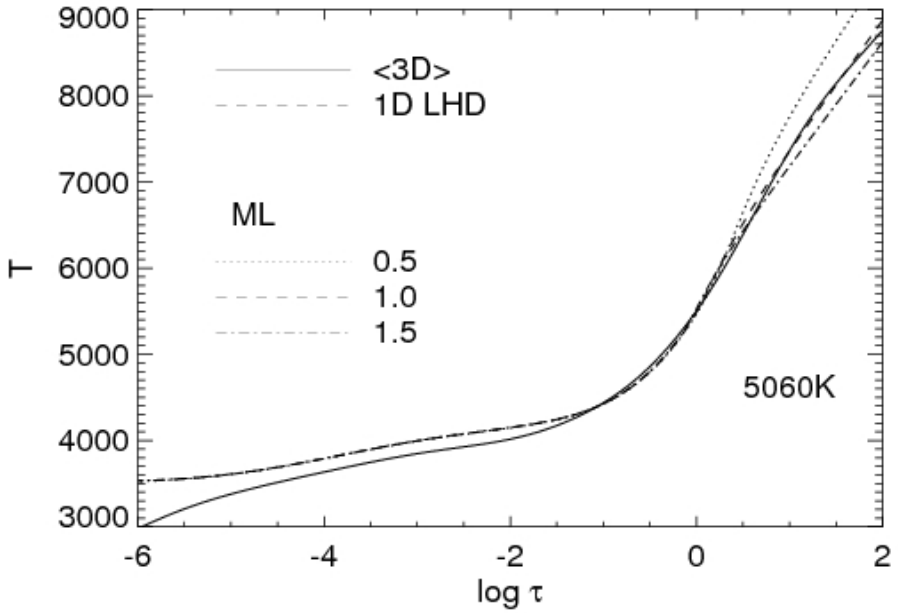
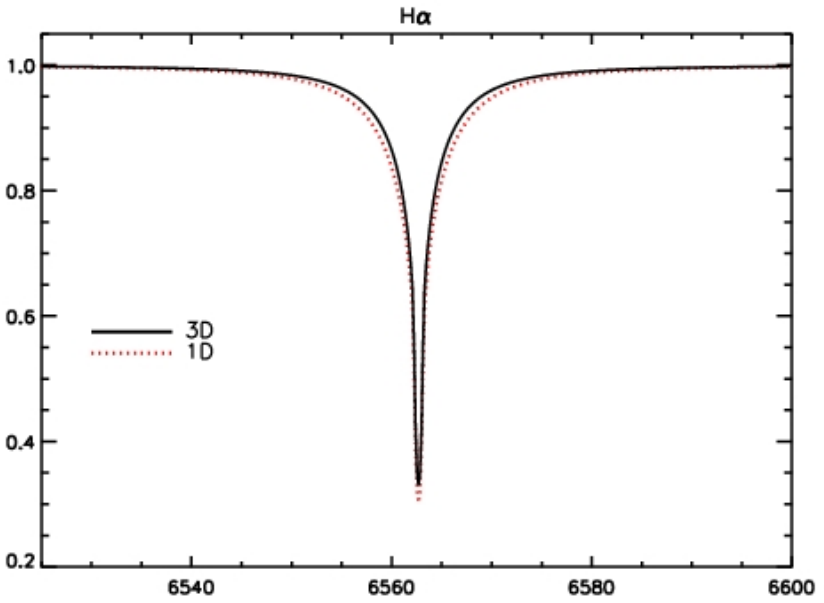
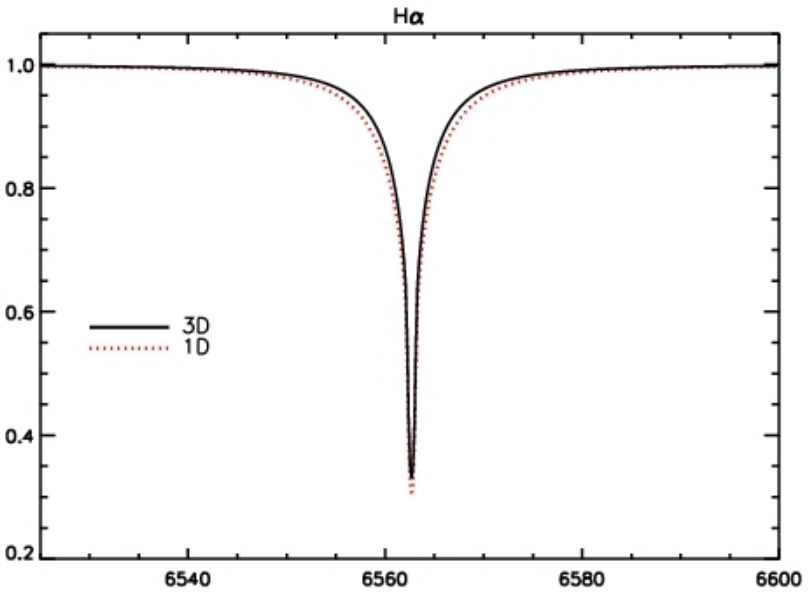
## Plots





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## Associated LHD Models

*Reference 1D LHD models. The parameter α refers to the mixing-length.*

| α = 0.5 | α = 1.0 | α = 1.5 | α = 2.0 |
|---|---|---|---|
| t5060g45mm10 | t5060g45mm10 | t5060g45mm10 | t5060g45mm10 |

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## Related Publications

Caffau, Sbordone, Ludwig, Bonifacio, Steffen, Behara
*The solar photospheric abundance of hafnium and thorium: Results from co5bold 3D model atmospheres*
Astronomy and Astrophysics, 2008, *submitted*

Behara, Ludwig, Bonifacio et al.
*Stellar effective temperatures derived from the analysis of balmer line profiles in 3D metal-poor stars*
2008, *in preparation*