Theoretical data in the VO

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Madrid, 13-17 Septiembre 2010

What is the VO?

- An international effort in astrophysics for:
  - **Standardization**
    - common data formats (VOTable, Data Models,...)
      (how the data are represented, written...)
  - **Interoperability**
    - common protocols (SIAP, SSAP, TSAP...)
      (how to make questions and how to answer them)

Theoretical Models in VO

- Final aim: Full interoperability between observational and theoretical data.
- Efficiency
  - easier and faster to **compare models** with observations and with other models.
  - easier characterization
- Visibility
  - More people will have an **easier access** to the models.
  - The models will, eventually, be **more used** and referenced.

A case study: Kurucz and Nextgen models

The Astronomical Journal, 128:829–841, 2004 August

ATLAS VERSUS NEXTGEN MODEL ATMOSPHERES: A COMBINED ANALYSIS OF SYNTHETIC SPECTRAL ENERGY DISTRIBUTIONS

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[2] See http://kurucz.harvard.edu.
[3] See ftp://calvin.physast.uga.edu/pub/ and http://dilbert.physast.uga.edu/~yeti. Note that the libraries of dwarf and giant stars available at these sites have lower $T_{\rm eff}$ limits than the published ones.

Obtaining Kurucz models

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This is a combined Web/outgoing-FTP site, KURUCZ.HARVARD.EDU or CFAKU5.CFA.HARVARD.EDU. It provides up-to-date public access to my data and programs. These are the same programs and files that I use in my research. Many bugs and problems have been corrected but there are still many more errors remaining to be found. Programs and data that I would not use myself because they are still under development are not on this computer. Many of the files are large and are also available on CDs or DVDs, and I am willing to write DVDs on demand. Some files taken from Kurucz CD-ROMs 1-26 are given for historical checks although many have been replaced by new versions. Binary versions will eventually be replaced by (much larger) ASCII versions. I am willing to rewrite them in ASCII on demand. Neither the programs nor data are "black boxes". You should not be using them if you do not have some understanding of the physics and of the programming in the source code.

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Obtaining Kurucz models

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Logical name
GRIDM01
GRIDM02
GRIDM03
GRIDM05
GRIDM05ODFNEW
GRIDM05AODFNEW
GRIDM05NOVER
GRIDM10
GRIDM10ANOVER
GRIDM10AODFNEW
GRIDM10HE50
GRIDM10NOVER
GRIDM10ODFNEW
GRIDM15
GRIDM15NOVER
GRIDM15ODFNEW
GRIDM15ANOVER
GRIDM15AODFNEW
GRIDM20
GRIDM20NOVER
GRIDM20ODFNEW
GRIDM20ANOVER
GRIDM20AODFNEW
GRIDM25
GRIDM25NOVER
GRIDM25ODFNEW
GRIDM25ANOVER
GRIDM25AODFNEW
GRIDM30
GRIDM35
GRIDM40

ddop00k2.red13	13-Aug-2009 11:40	623K
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fp00k0.pck19	13-Aug-2009 11:40	11M
fp00k1.pck	13-Aug-2009 11:40	12M
fp00k1.pck19	13-Aug-2009 11:40	11M
fp00k2.pck	13-Aug-2009 11:40	9.8M
fp00k2.pck13	13-Aug-2009 11:40	9.7M
fp00k2.pck19	13-Aug-2009 11:40	11M
fp00k4.pck	13-Aug-2009 11:40	11M
fp00k4.pck19	13-Aug-2009 11:40	11M
fp00k8.pck	13-Aug-2009 11:40	11M
fp00k8.pck19	13-Aug-2009 11:40	11M
fsun.pck13	13-Aug-2009 11:40	37K
fsun.pck19	13-Aug-2009 11:40	37K

Obtaining Nextgen models

[1] Available via anonymous FTP from ftp://calvin.physast.uga.edu/pub/NextGen or via the WWW URL http://dilbert.physast.uga.edu/~yeti.

Kurucz: data characterization

```
SDSC GRID  [+0.0]  VTURB 2.0 KM/S   L/H 1.25
      PROGRAM READFLUX
C     SAMPLE PROGRAM READS THIS FILE ON UNIT 1
      DIMENSION Hnu(1221),HnuCONT(1221),WAVE(1221)
      CHARACTER*80 TITLE
      DO 11 ISKIP=1,22
   11 READ(1,1)
C     wavelength in nm
      READ(1,1)WAVE
    1 FORMAT(10F10.2)
      DO 8 MODEL=1,500
C     ergs/cm**2/s/hz/ster
      READ(1,2,END=9)TITLE
    2 FORMAT(A80)
      PRINT 3,MODEL,TITLE
    3 FORMAT(I5,1X,A80)
      READ(1,4)Hnu
      READ(1,4)HnuCONT
    4 FORMAT(8E10.4)
    8 CONTINUE
    9 CALL EXIT
      END
      9.09      9.35      9.61      9.77      9.96     10.20     10.38     10.56
     10.77     11.04     11.40     11.78     12.13     12.48     12.71     12.84
     13.05     13.24     13.39     13.66     13.98     14.33     14.72     15.10
     15.52     15.88     16.20     16.60     17.03     17.34     17.68     18.02
     18.17     18.61     19.10     19.39     19.84     20.18     20.50     21.05
     21.62     21.98     22.30     22.68     23.00     23.40     24.00     24.65
```

Theoretical models in the VO?

Same problems as the observational data.

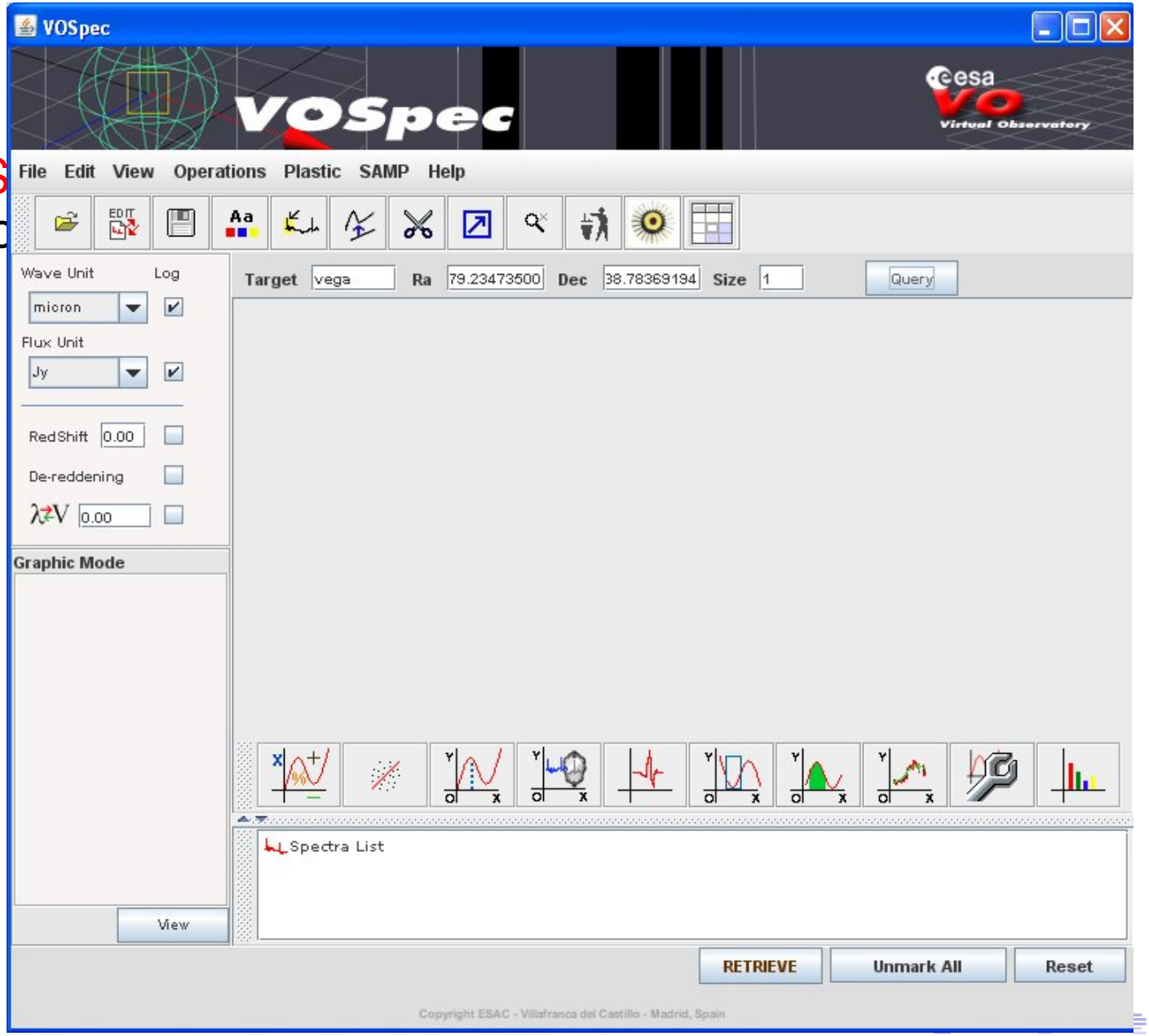
- Where are they? → Registries
- Data format (ASCII, FITS, ...) → VOTables
- Data characterisation → Data Models
- Data Access
  - VO protocols (ConeSearch, SIAP, SSAP, ...) are built around coordinates
    - http://.../ssap.jsp?POS=336.5228,-48.43854&SIZE=0.2
    - NOT VALID FOR THEORETICAL OBJECTS
  - A theoretical model is defined by a set of parameters and the allowed values for each of them.
  - Those parameters and values are not the same for different models.

Theoretical spectra in the VO.

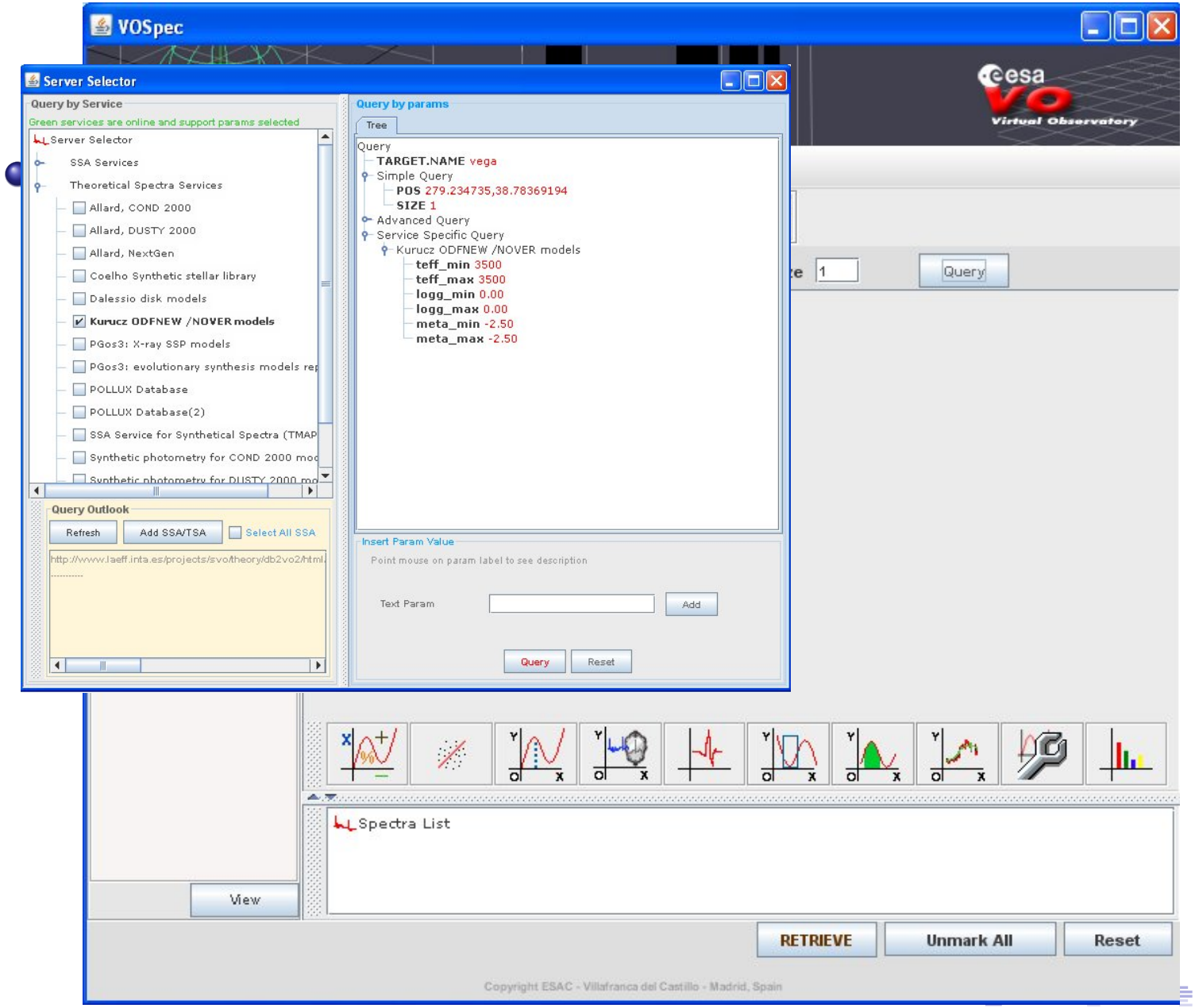
- SSAP/TSAP: Protocol to access theoretical spectra jointly developed by SVO & ESAVO.
  - Dialog Server-Application

Theoretical spectra in the VO.

- S
  jc

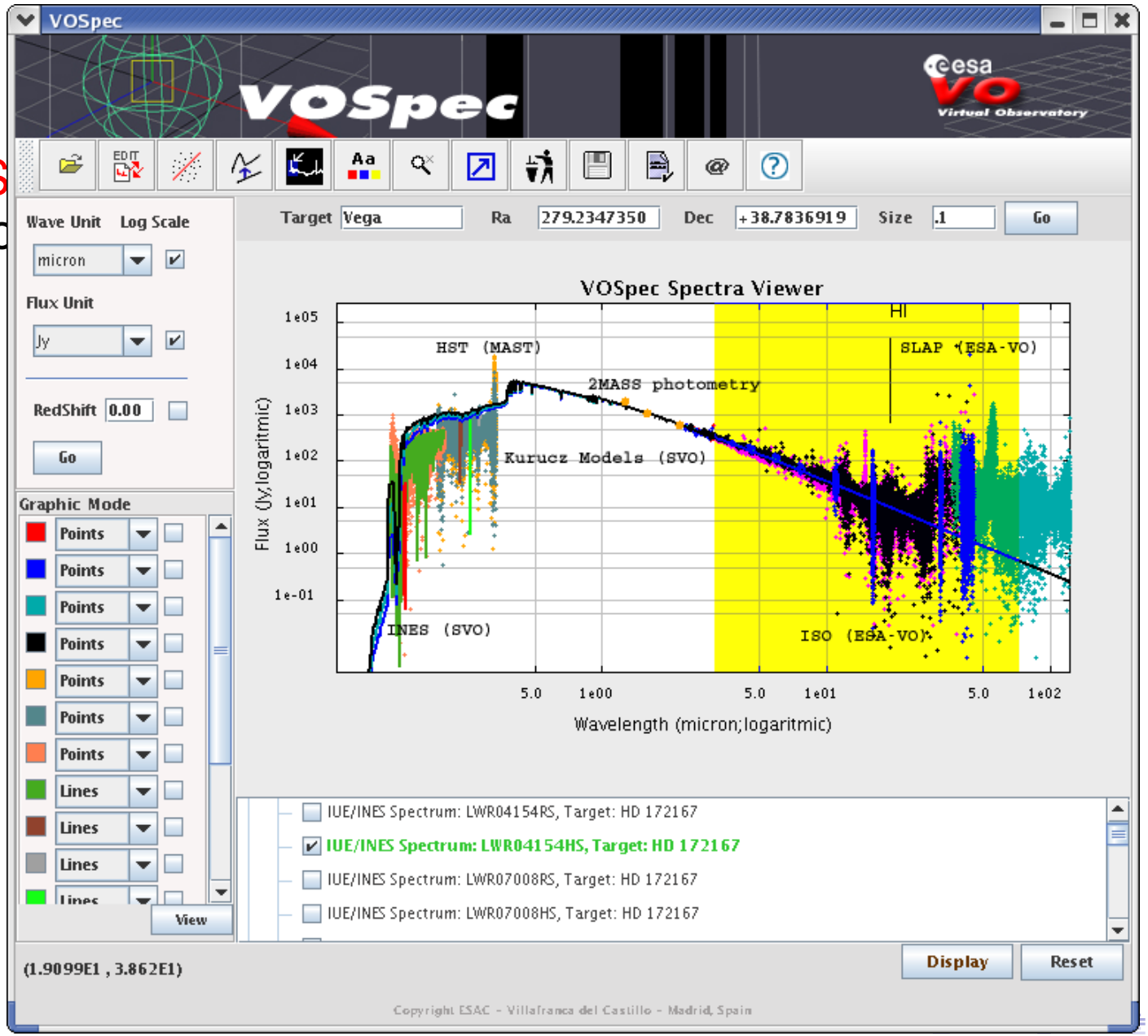


Theoretical spectra in the VO.

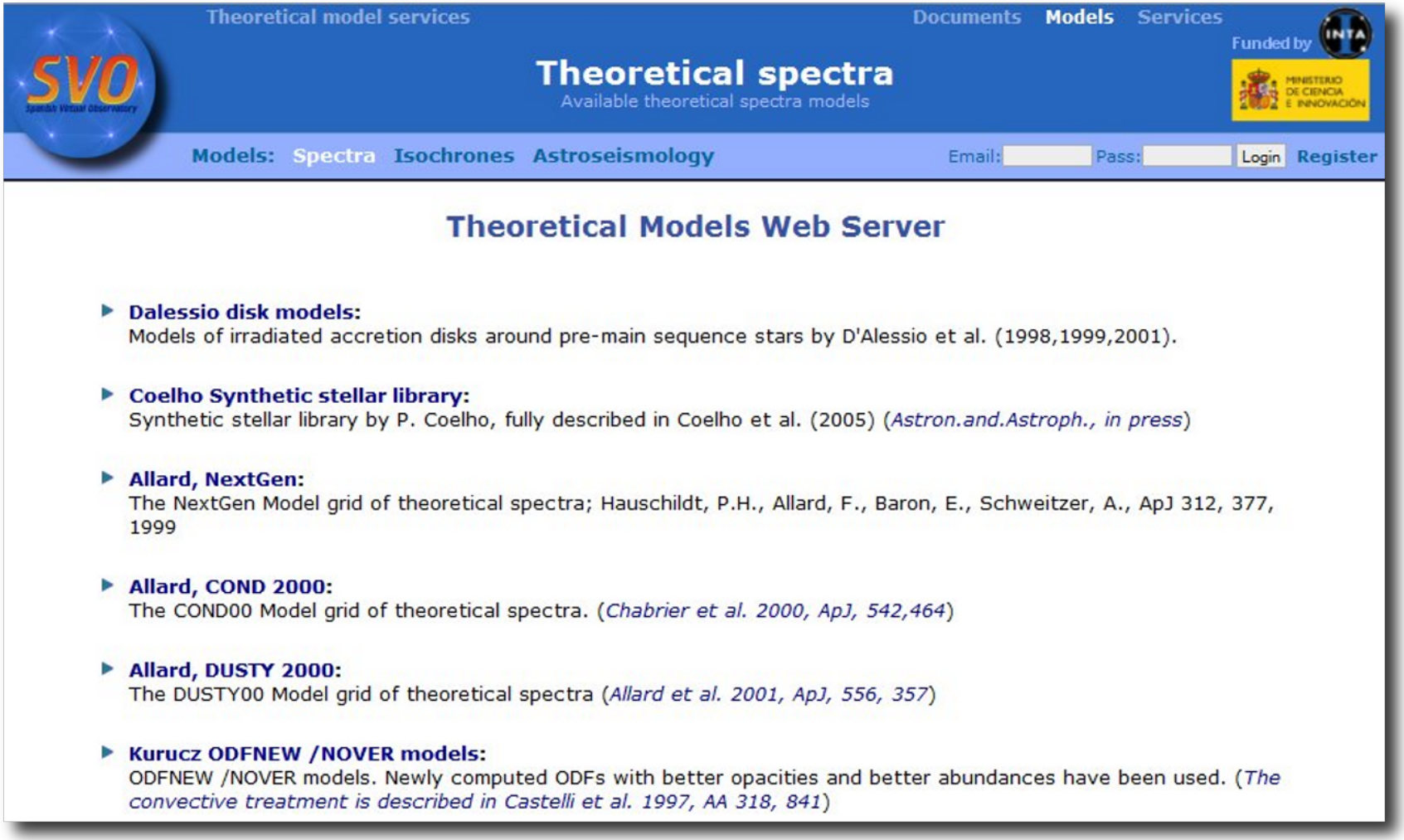


Theoretical spectra in the VO.

- S
  jo



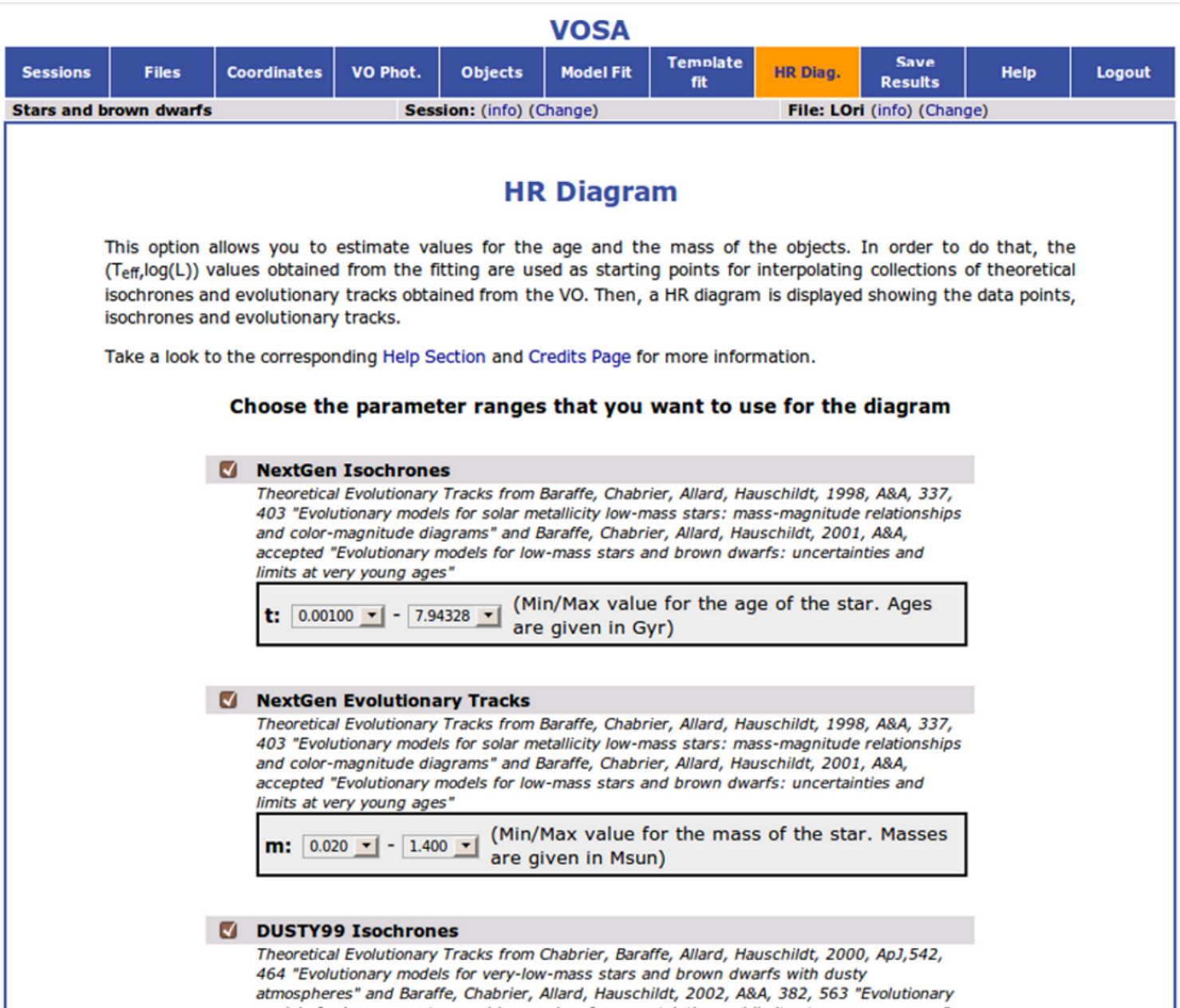
Theoretical spectra in the VO.



S3: a more general approach for theoretical data.

- Servers for isochrones and evolutionary tracks.
  - NextGen, COND, DUSTY, Siess (SVO)
  - BaSTI (IVO)

S3: a more general approach for theoretical data.



S3: a more general approach for theoretical data.

VOSA

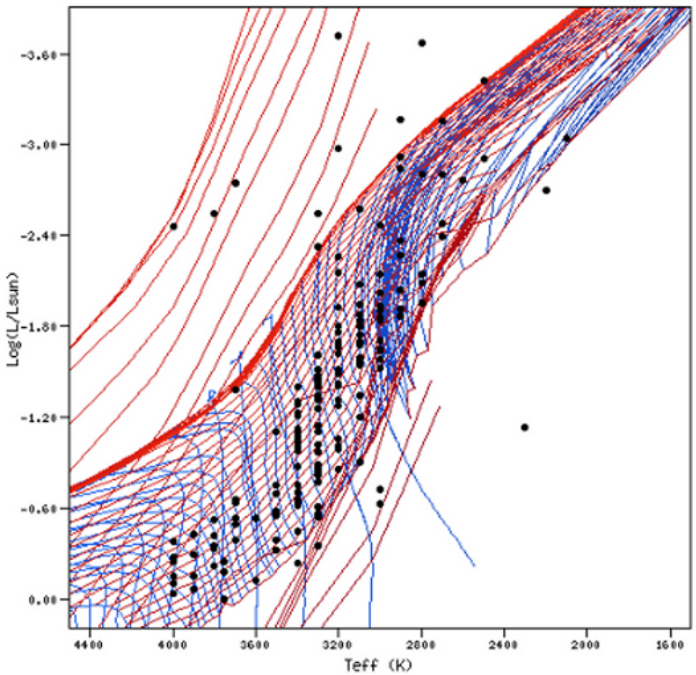
Sessions | Files | Coordinates | VO Phot. | Objects | Model Fit | Template fit | HR Diag. | Save Results | Help | Logout

Stars and brown dwarfs — **Session:** (info) (Change) — **File: LOri** (info) (Change)

HR Diagram

Objects

Object	Model	T_{eff}	LogL	Age		Mass	
LOri001	COND00	4000	-0.0297	---	[4]	---	[4]
LOri002	siess	3750	-0.0008	0.0010		0.4998	
LOri003	siess	4000	-0.1033	0.0019		0.7000	
LOri004	COND00	3600	-0.1223	---	[4]	---	[4]
LOri005	COND00	3900	-0.0638	---	[4]	---	[4]
LOri006	siess	4000	-0.1505	0.0020		0.7000	
LOri007	COND00	3800	-0.2146	---	[4]	---	[4]
LOri008	NextGen	3900	-0.1497	0.0037		1.0382	
LOri009	COND00	4000	-0.2490	---	[4]	---	[4]
LOri010	COND00	4000	-0.2713	---	[4]	---	[4]
LOri011	siess	3750	-0.1763	0.0010		0.4994	
LOri012	siess	3750	-0.2451	0.0012		0.4994	
LOri013	COND00	3400	-0.2337	---	[4]	---	[4]
LOri014	COND00	3900	-0.2919	---	[4]	---	[4]
LOri015	COND00	4000	-0.2673	---	[4]	---	[4]
LOri016	siess	3500	-0.3251	0.0010		0.3694	
LOri017	NextGen	4000	-0.3789	0.0097		1.0000	
LOri018	NextGen	3800	-0.3340	0.0049		0.8877	
LOri019	NextGen	3800	-0.3462	0.0050		0.8836	[1]
LOri020	COND00	3300	-0.3493	---	[4]	---	[4]
LOri021	DUSTY00	3800	-0.4148	---	[4]	---	[4]
LOri022	DUSTY00	3700	-0.3894	---	[4]	---	[4]
LOri023	NextGen	3800	-0.4205	0.0063		0.8505	
LOri024	COND00	3900	-0.4213	---	[4]	---	[4]
LOri025	NextGen	4000	-0.3813	0.0098		1.0000	
LOri026	NextGen	3500	-0.3870	0.0017		0.5090	
LOri027	COND00	3700	-0.4920	---	[4]	---	[4]
LOri028	COND00	3300	-0.5599	---	[4]	---	[4]
LOri029	NextGen	3400	-0.4406	0.0013		0.4271	
LOri030	NextGen	3800	-0.5177	0.0080		0.8177	
LOri031	COND00	3600	-0.5291	---	[4]	---	[4]



S3: a more general approach for theoretical data.

- Synthetic photometry for different models:
  - NextGen, COND, DUSTY, Kurucz...

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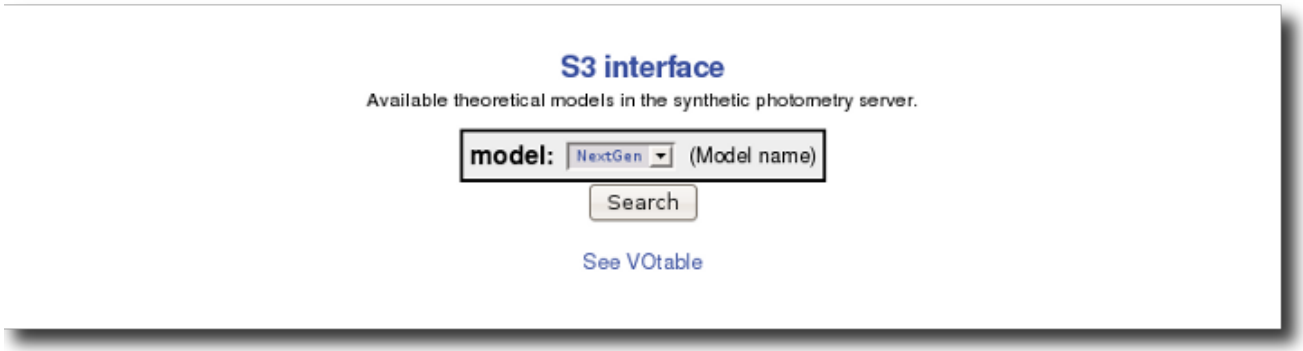

S3: a more general approach for theoretical data.

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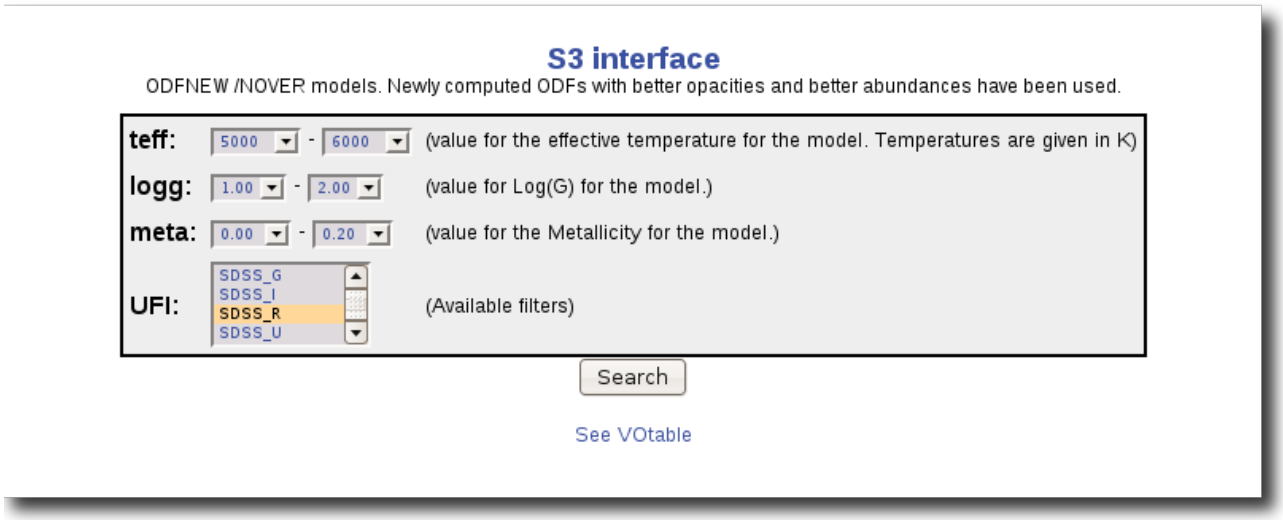


S3: a more general approach for theoretical data.

- Synthetic photometry for different models:
  - NextGen, COND, DUSTY, Kurucz...

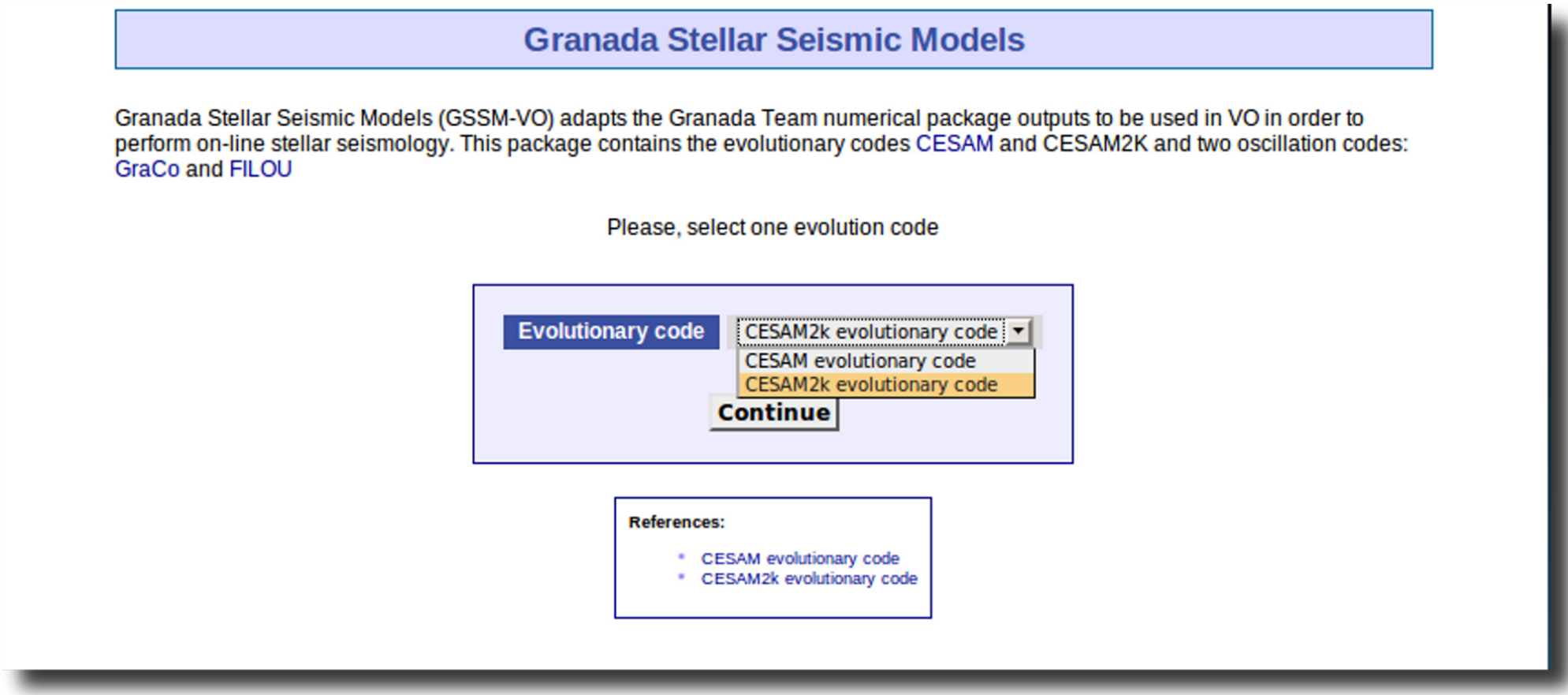
S3 interface

Synthetic photometry for Kurucz ODFNEW /NOVER models. Newly computed ODFs with better opacities and better abundances have been used.

teff	logg	meta	UFI	phot
5000	1.00	0.00	SDSS_R	1.39734087217e-13
5000	1.50	0.00	SDSS_R	1.38714034883e-13
5000	2.00	0.00	SDSS_R	1.37719326443e-13
5250	1.00	0.00	SDSS_R	1.7696765093e-13
5250	1.50	0.00	SDSS_R	1.75586497773e-13
5250	2.00	0.00	SDSS_R	1.74290347396e-13
5500	1.00	0.00	SDSS_R	2.19029620013e-13
5500	1.50	0.00	SDSS_R	2.17163839636e-13
5500	2.00	0.00	SDSS_R	2.15413488457e-13
5750	1.00	0.00	SDSS_R	2.66023807988e-13
5750	1.50	0.00	SDSS_R	2.63624783206e-13
5750	2.00	0.00	SDSS_R	2.61345124187e-13
6000	1.00	0.00	SDSS_R	3.17930670692e-13
6000	1.50	0.00	SDSS_R	3.15149711273e-13
6000	2.00	0.00	SDSS_R	3.1237641431e-13

See VOtable

S3: asteroseismology



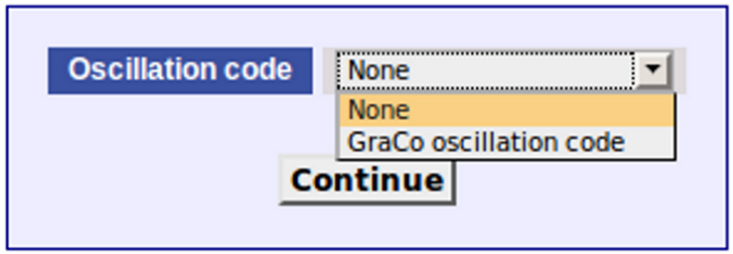
S3: asteroseismology

Granada Stellar Seismic Models

Granada Stellar Seismic Models (GSSM-VO) adapts the Granada Team numerical package outputs to be used in VO in order to perform on-line stellar seismology. This package contains the evolutionary codes CESAM and CESAM2K and two oscillation codes: GraCo and FILOU

CESAM2k evolutionary code

Please, select an oscillation code or 'None' if you only want to access the structure information



References:

- CESAM2k evolutionary code
- GraCo oscillation code

S3: asteroseismology

- Please, select a range for each parameter that you want to use in the search and then click the "Search" button to retrieve a list of the availa files.
- Take into account that some combinations of values could correspond to no result.

Structure search parameters

(?)	T_{eff}	4000	5000	(K)
(?)	Lum			(Lsun)
(?)	Log(g)			
(?)	Density			(g/cm3)
(?)	Age			(Myr)
(?)	[Fe/H]			
(?)	Z			
(?)	Hcent			
(?)	R•			(Rsun)
(?)	Mass			(Msun)
(?)	Vrot			cm/s
(?)	Wrot			rad/s
(?)	Trot			sec
(?)	α_{MLT}			
(?)	Over.			

Sismology search parameters

(?)	F0			(muHz)
(?)	F1			(muHz)
(?)	F0/F1			
(?)	Δ(v)	20	25	(muHz)
(?)	δ(v)			(muHz)
(?)	[v]			(muHz)
(?)	[l]			
(?)	[n]			
(?)	Sta.	all modes		
(?)	v_{Sta}			(muHz)

Search Reset

References:

- CESAM2k evolutionary code
- GraCo oscillation code

S3: asteroseismology

Granada Stellar Seismic Models

Granada Stellar Seismic Models (GSSM-VO) adapts the Granada Team numerical package outputs to be used in VO in order to perform on-line stellar seismology. This package contains the evolutionary codes CESAM and CESAM2K and two oscillation codes: GraCo and FILOU

CESAM2k evolutionary code

1939 results have been found for your search criteria.

Summary table

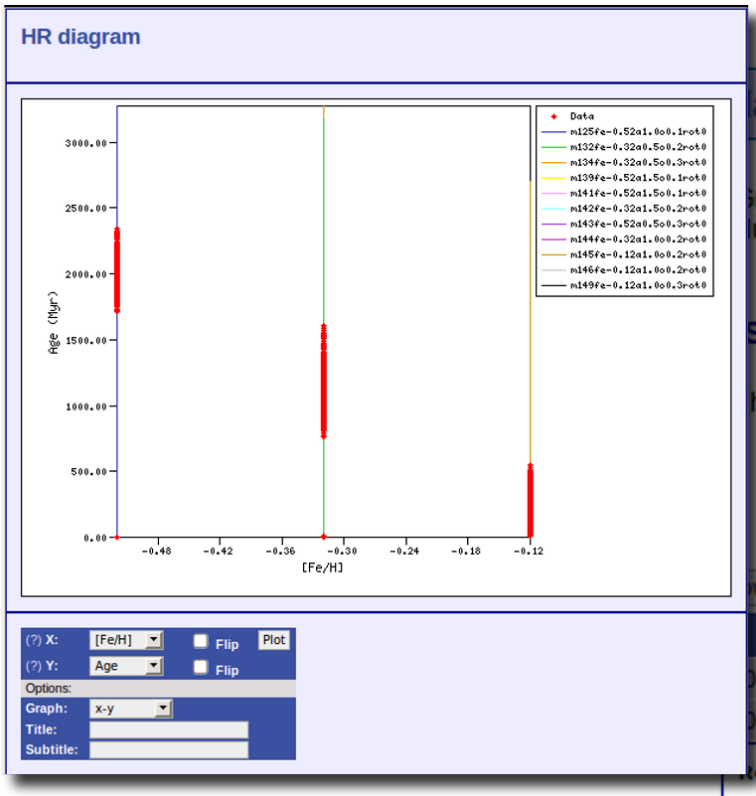
Show Results | HR diag | New Search

	T_{eff}	Lum	Log(g)	Density	Age	[Fe/H]	Z	Hcent	R.	Mass	Vrot	Wrot	Trot	α_{MLT}	Over.
Min	7355.0000	4.5114	4.2506	0.6605	0	-0.5200	0.0055	0.7221	1.2901	1.2502	0	0	0	0.5000	0.1000
Max	7504.9000	5.3293	4.3585	0.9057	2345.9000	-0.1200	0.0134	0.7473	1.3899	1.4902				1.5000	0.3000

References:

- CESAM2k evolutionary code

S3: asteroseismology



a Stellar Seismic Models

ranada Team numerical package outputs to be used in VO in order to perform
utionary codes CESAM and CESAM2K and two oscillation codes: GraCo and FILOU

SAM2k evolutionary code

have been found for your search criteria.

Summary table

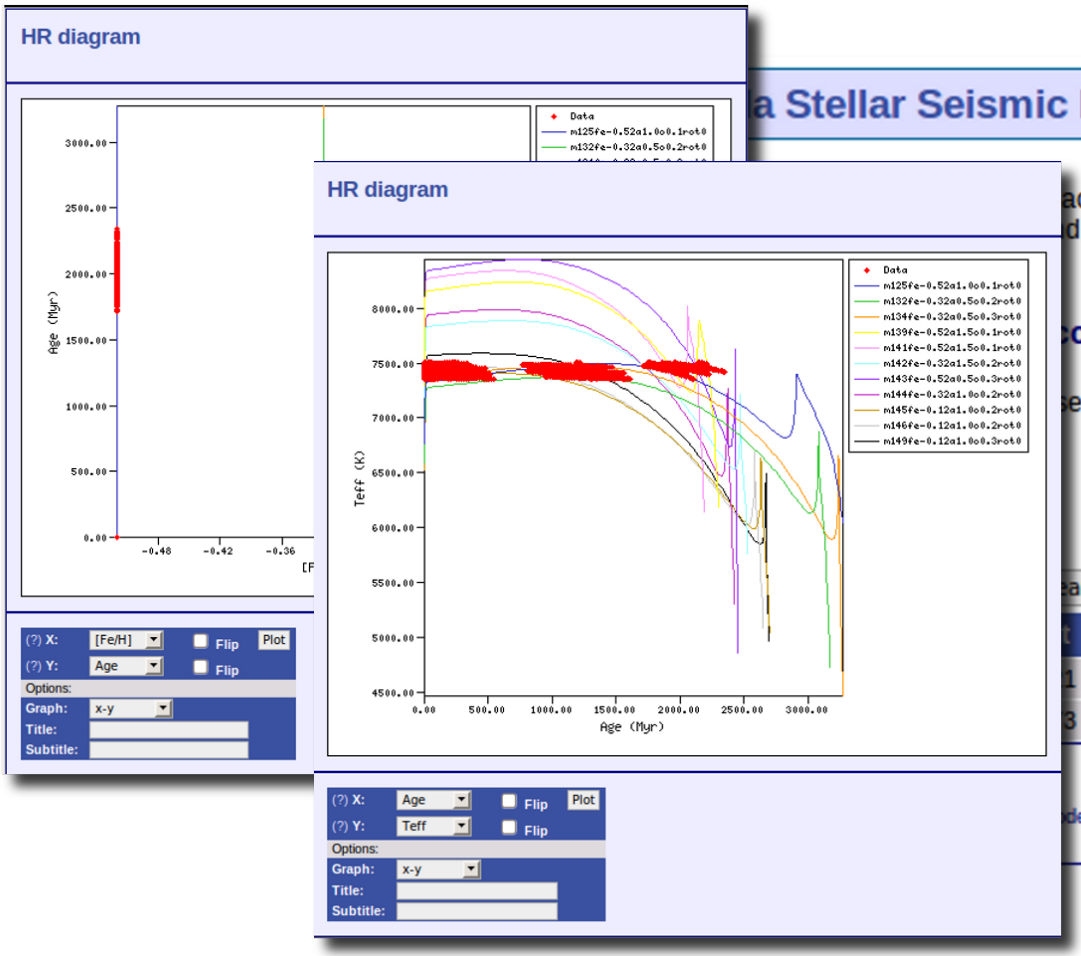
w Results | HR diag | New Search

	[Fe/H]	Z	Hcent	R•	Mass	Vrot	Wrot	Trot	α_{MLT}	Over.
)	-0.5200	0.0055	0.7221	1.2901	1.2502	0	0	0	0.5000	0.1000
)	-0.1200	0.0134	0.7473	1.3899	1.4902				1.5000	0.3000

eferences:

- CESAM2k evolutionary code

S3: asteroseismology



a Stellar Seismic Models

ackage outputs to be used in VO in order to perform
d CESAM2K and two oscillation codes: GraCo and FILOU

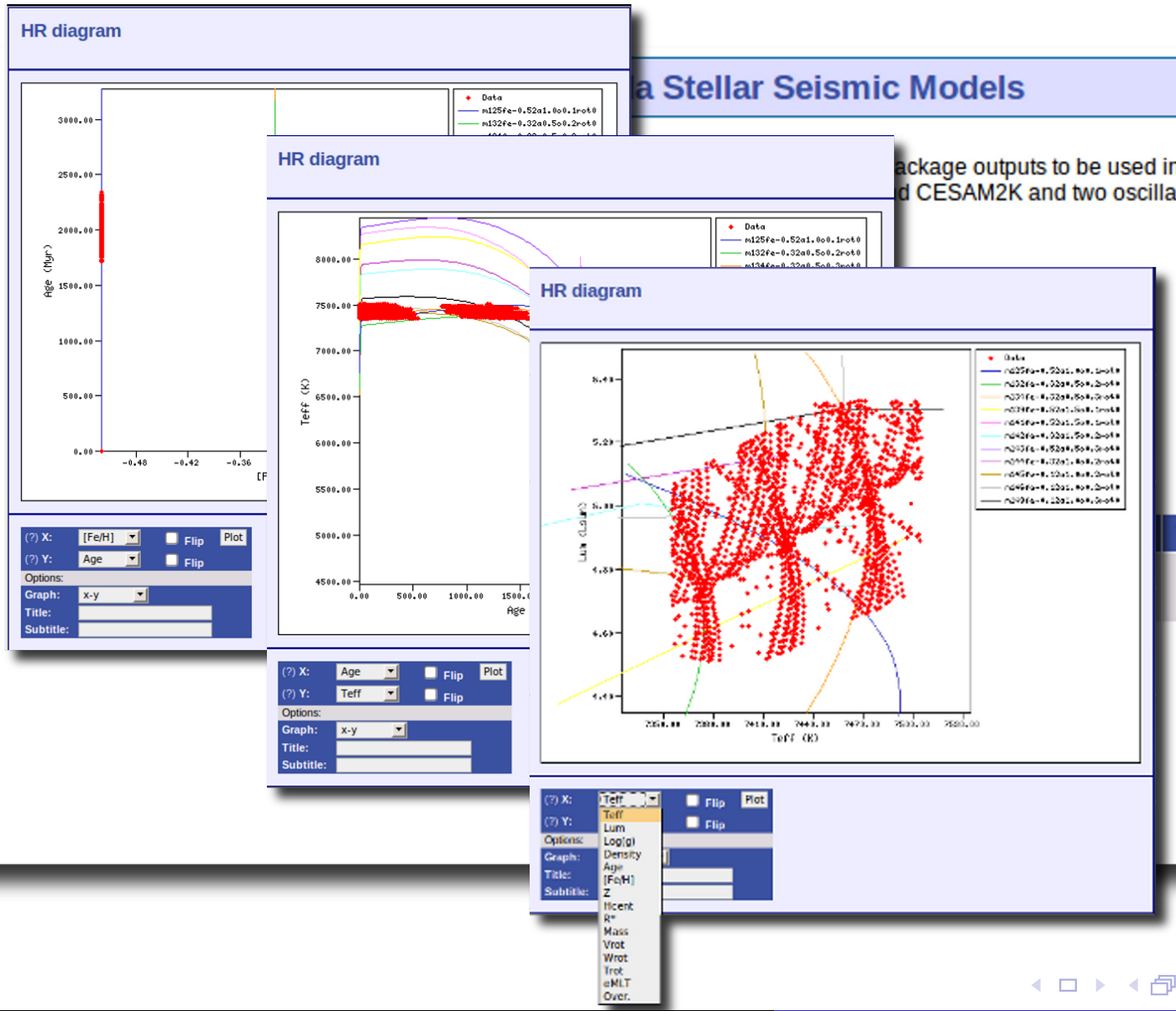
ode

earch criteria.

earch

	R.	Mass	Vrot	Wrot	Trot	α_{MLT}	Over.
1	1.2901	1.2502	0	0	0	0.5000	0.1000
3	1.3899	1.4902				1.5000	0.3000

S3: asteroseismology



a Stellar Seismic Models

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d CESAM2K and two oscillation codes: GraCo and FILOU

Wrot	Trot	α_{MLT}	Over.
0	0	0.5000	0.1000
		1.5000	0.3000

S3: asteroseismology

Results table

Summary | New Search | Restart

Values common to all shown results

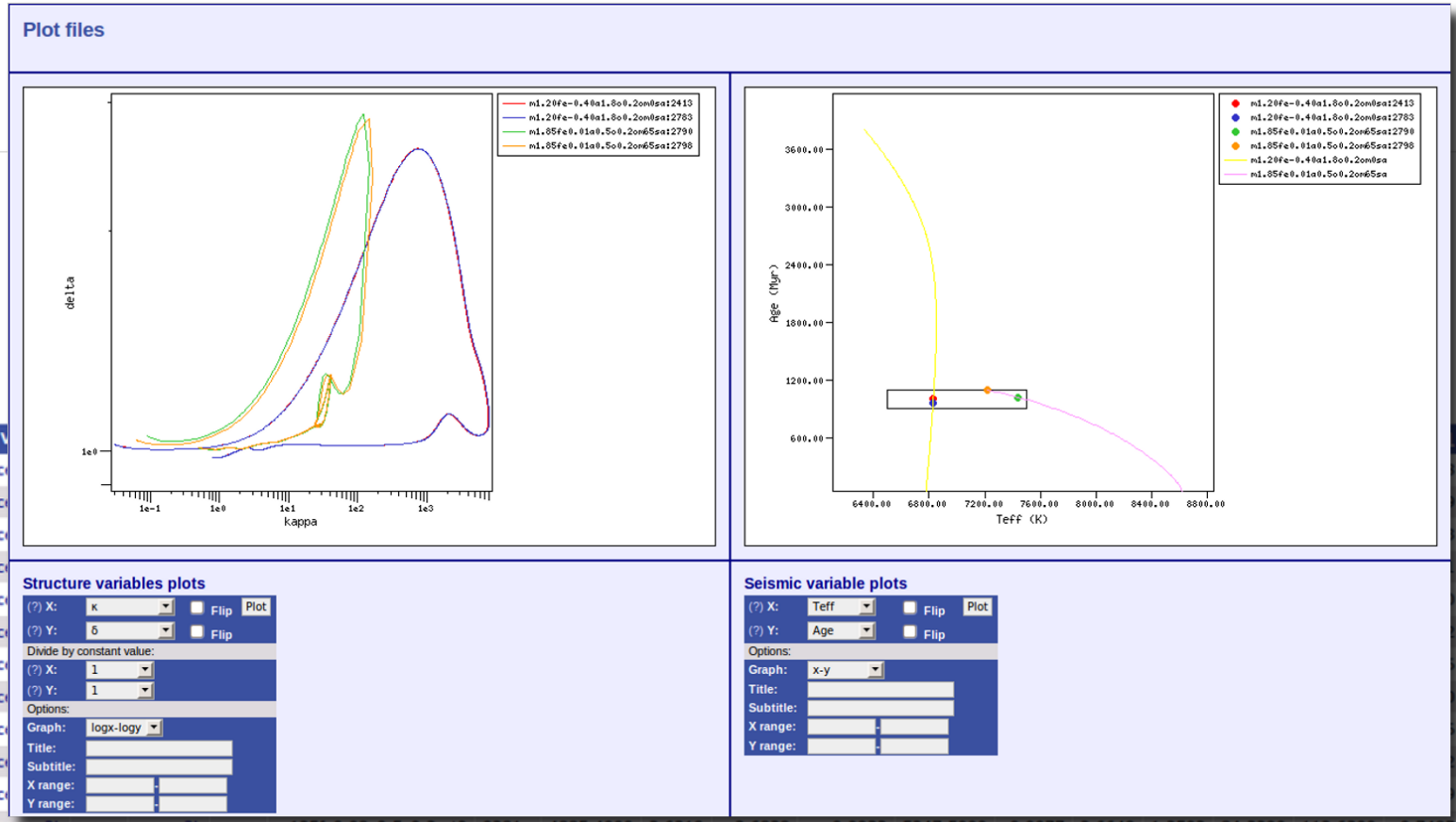
[Fe/H]	Z	Vrot	Wrot	Trot	α_{MLT}	Over.
0.0800	0.0206	0	0	0	0.5000	0.3000

Page: 1 2 3 4 Next Results

Mark All | Unmark All | Retrieve | Plot

Plot	VOT	Txt	VOT		Txt		Track	Fileid	T_{eff}	Lum	Log(g)	Density	Age	Hcent	R*	Mass	F0	F1	F0/F1	Δ(v)	δ(v)
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0292	4986.7000	3.8788	3.6908	0.0955	5261.3000	0.0033	2.6433	1.2502	87.3310	115.2400	0.7578	22.4010	-37.1810
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0291	4957.1000	3.8078	3.6885	0.0948	5258.6000	0.0042	2.6503	1.2502	86.4820	114.4000	0.7559	22.4240	-36.1970
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0290	4937.7000	3.7608	3.6871	0.0943	5256.4000	0.0049	2.6546	1.2502	85.9140	113.9000	0.7543	22.0370	-36.9380
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0289	4924.1000	3.7276	3.6862	0.0940	5254.6000	0.0055	2.6575	1.2502	85.5050	113.5400	0.7531	22.6830	-35.8050
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0288	4914.2000	3.7033	3.6855	0.0938	5253.0000	0.0060	2.6595	1.2502	85.2120	113.3100	0.7520	23.4070	-34.5530
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0287	4906.7000	3.6849	3.6850	0.0936	5251.8000	0.0064	2.6610	1.2502	84.9840	113.1300	0.7512	22.8640	-35.5080
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0286	4901.0000	3.6708	3.6847	0.0935	5250.7000	0.0067	2.6622	1.2502	84.7990	112.9800	0.7506	23.0220	-35.3060
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0285	4896.4000	3.6597	3.6843	0.0934	5249.8000	0.0070	2.6631	1.2502	84.6550	112.8700	0.7500	23.2040	-35.1530
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0284	4892.7000	3.6509	3.6841	0.0933	5249.0000	0.0072	2.6639	1.2502	84.5410	112.7800	0.7496	23.4410	-35.0020
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0283	4889.7000	3.6435	3.6839	0.0933	5248.4000	0.0074	2.6644	1.2502	84.4550	112.7300	0.7492	23.2930	-34.9090
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0282	4887.3000	3.6372	3.6838	0.0932	5247.9000	0.0076	2.6648	1.2502	84.3850	112.6800	0.7489	23.2950	-34.8380
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0281	4885.4000	3.6319	3.6838	0.0932	5247.5000	0.0077	2.6649	1.2502	84.3290	112.6300	0.7487	22.8750	-34.7850
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0280	4883.9000	3.6275	3.6837	0.0932	5247.1000	0.0078	2.6650	1.2502	84.2900	112.6100	0.7485	23.1260	-33.0690
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0279	4882.7000	3.6240	3.6837	0.0932	5246.8000	0.0079	2.6650	1.2502	84.2700	112.6200	0.7483	23.3500	-32.7900
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0278	4881.8000	3.6213	3.6837	0.0932	5246.6000	0.0080	2.6650	1.2502	84.2440	112.5900	0.7482	23.4390	-33.0420
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0277	4881.1000	3.6193	3.6837	0.0932	5246.4000	0.0080	2.6650	1.2502	84.2330	112.6000	0.7481	23.1310	-33.0610
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0276	4880.6000	3.6179	3.6837	0.0932	5246.2000	0.0081	2.6650	1.2502	84.2140	112.5800	0.7481	22.9590	-32.8680
☐	☐	☐	cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0275	4880.3000	3.6171	3.6837	0.0932	5246.1000	0.0081	2.6651	1.2502	84.2040	112.5700	0.7480	23.6950	-32.6260

S3: asteroseismology



Plot	VOT	Txt																	Δ(ν)	δ(ν)
																			22.4010	-37.1810
																			22.4240	-36.1970
																			22.0370	-36.9380
																			22.6830	-35.8050
																			23.4070	-34.5530
																			22.8640	-35.5080
																			23.0220	-35.3060
																			23.2040	-35.1530
																			23.4410	-35.0020
																			23.2930	-34.9090
																			23.2950	-34.8380
			cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0281	4885.4000	3.6319	3.6838	0.0932	5247.5000	0.0077	2.6649	1.2502	84.3290	112.6300	0.7487	22.8750	-34.7850
			cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0280	4883.9000	3.6275	3.6837	0.0932	5247.1000	0.0078	2.6650	1.2502	84.2900	112.6100	0.7485	23.1260	-33.0690
			cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0279	4882.7000	3.6240	3.6837	0.0932	5246.8000	0.0079	2.6650	1.2502	84.2700	112.6200	0.7483	23.3500	-32.7900
			cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0278	4881.8000	3.6213	3.6837	0.0932	5246.6000	0.0080	2.6650	1.2502	84.2440	112.5900	0.7482	23.4390	-33.0420
			cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0277	4881.1000	3.6193	3.6837	0.0932	5246.4000	0.0080	2.6650	1.2502	84.2330	112.6000	0.7481	23.1310	-33.0610
			cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0276	4880.6000	3.6179	3.6837	0.0932	5246.2000	0.0081	2.6650	1.2502	84.2140	112.5800	0.7481	22.9590	-32.8680
			cesam2k	graco	cesam2k	graco	m125fe0.08a0.5o0.3rot0	0275	4880.3000	3.6171	3.6837	0.0932	5246.1000	0.0081	2.6651	1.2502	84.2040	112.5700	0.7480	23.6950	-32.6260

THANK YOU!