The AMBRE Project

Tests of MATISSE on large spectral datasets from the ESO Archive

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Observatoire de la Côte d'Azur





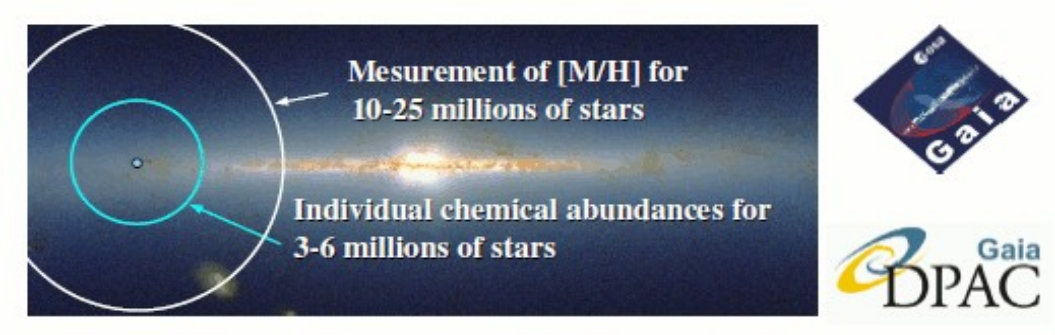


Outline

- Gaia & MATISSE
- The AMBRE Project
- FEROS Archived Spectra
  - Analysis pipeline
  - Reference samples

Gaia & Galactic Archaeology

- Current and future generations of telescope and instruments
- Large datasets over a range of resolutions/wavelengths/signal-to-noise
- Kinematic and chemical signatures





→ **AUTOMATED STELLAR CLASSIFICATION ALGORITHMS**

MATISSE has been selected as one of four codes being tested for the classification of the Gaia RVS spectra

(see A. Recio-Blanco presentation)

MATISSE: *MATrix Inversion for Spectral SynthEsis*

Recio-Blanco, Bijaoui, de Laverny (2006); Bijaoui, Recio-Blanco, de Laverny (2008)

- **Stellar parameters (θ = T_{eff}, *log* g, [M/H], individual chemical abundances) are derived by the projection of an input observed spectrum $O(\lambda)$ on a vector $B_\theta(\lambda)$.**

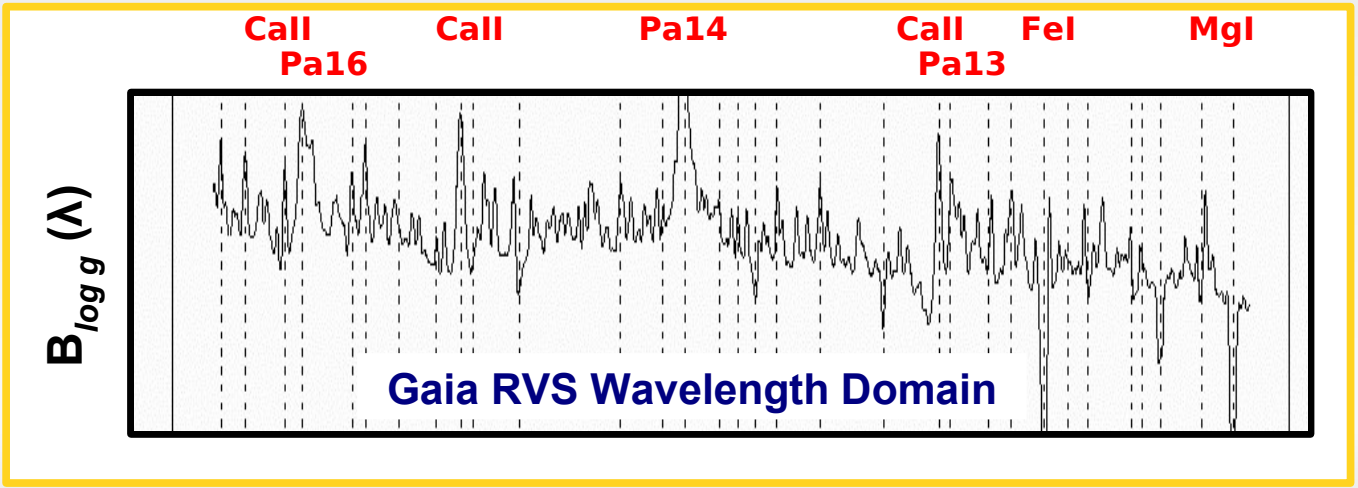
$$\hat{\theta}_i = \sum B_\theta(\lambda) O_i(\lambda)$$

- **The $B_\theta(\lambda)$ vector is an optimal linear combination of theoretical spectra $S(\lambda)$ calculated from a synthetic spectra grid (the learning phase).**

$$B_\theta(\lambda) = \sum \alpha_i S_i(\lambda)$$

Key variations in the observed spectrum occur due to changes in the selected θ.
Hence the $B_\theta(\lambda)$ vector reflects the particular regions that are sensitive to θ.

Indicators of surface gravity eg. $B_{log\ g}(\lambda)$



The AMBRE Project

Archéologie avec Matisse: aBondances dans les aRchives de l'Eso

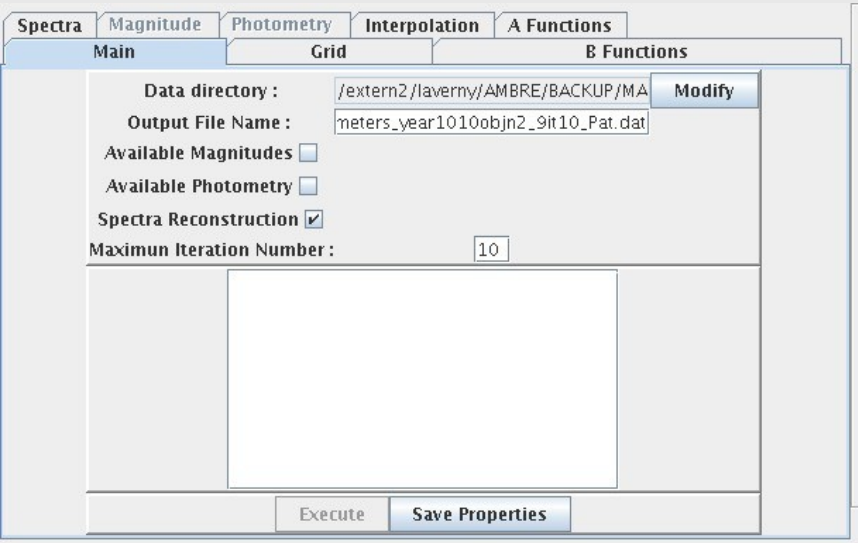
ESO/OCA project: 2009 - 2012

ESO Spectrograph	Resolving Power	Spectral Domain	Approximate No. archived spectra
FEROS	**48,000**	**350nm - 920nm**	**23,000**
HARPS	**115,000**	**378nm - 691nm**	**40,000**
UVES	**40,000 to 110,000**	**300nm - 1100nm**	**35,000**
Flames/GIRAFFE	**5,600 to 46,000**	**370nm - 900nm**	**100,000**
		Total Sample	**198,000**

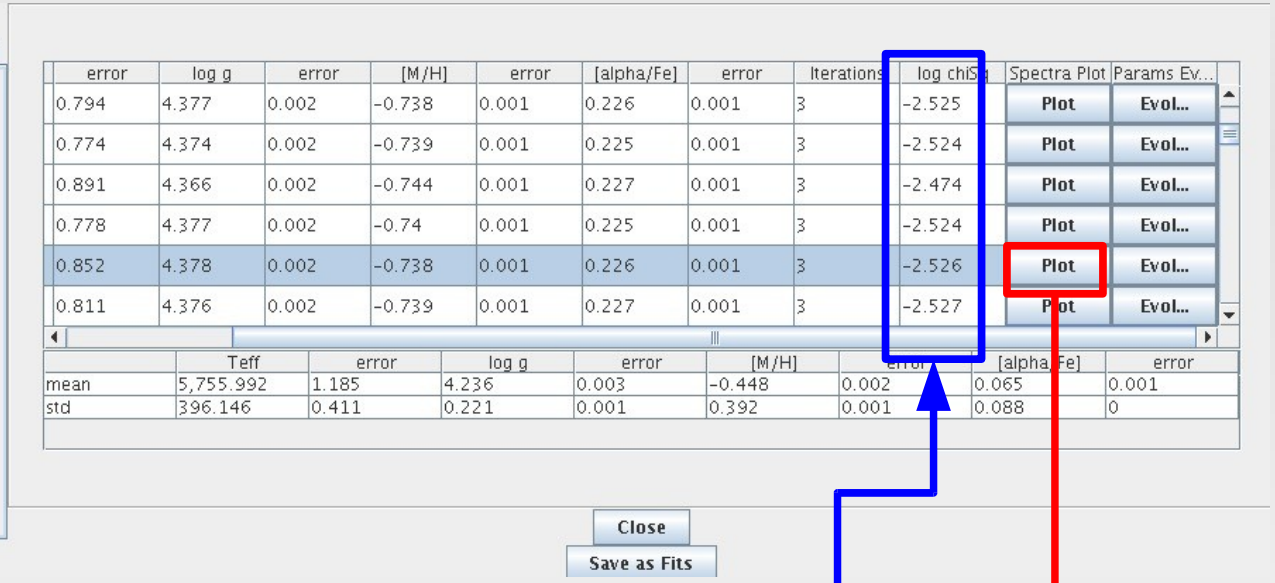
- Objectives 1) to classify the ESO archived spectra → **Virtual Observatory**
  2) to test MATISSE with large sets of real spectra
  3) to create a galactic chemical chart
- This extensive dataset covers a large range of wavelengths and resolutions, **including the wavelength domain and resolutions of Gaia RVS.**
- **Designated as a Sub-Work Package under GSP-spec**

MATISSE: Java Interface

INPUT:



Comparison of Synthetic and Observed Spectra

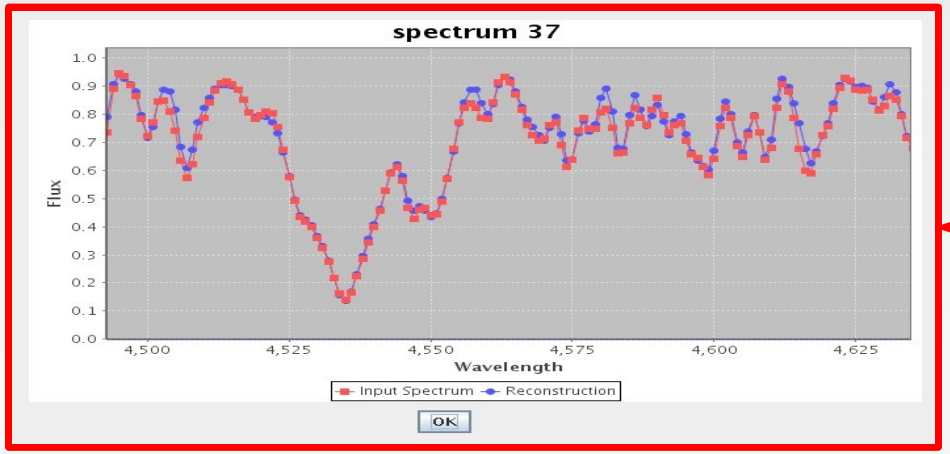


error	log g	error	[M/H]	error	[alpha/Fe]	error	Iterations	log chiSq	Spectra Plot	Params Ev...
0.794	4.377	0.002	-0.738	0.001	0.226	0.001	3	-2.525	Plot	Evol...
0.774	4.374	0.002	-0.739	0.001	0.225	0.001	3	-2.524	Plot	Evol...
0.891	4.366	0.002	-0.744	0.001	0.227	0.001	3	-2.474	Plot	Evol...
0.778	4.377	0.002	-0.74	0.001	0.225	0.001	3	-2.524	Plot	Evol...
0.852	4.378	0.002	-0.738	0.001	0.226	0.001	3	-2.526	Plot	Evol...
0.811	4.376	0.002	-0.739	0.001	0.227	0.001	3	-2.527	Plot	Evol...

	Teff	error	log g	error	[M/H]	error	[alpha/Fe]	error
mean	5,755.992	1.185	4.236	0.003	-0.448	0.002	0.065	0.001
std	396.146	0.411	0.221	0.001	0.392	0.001	0.088	0

Close
Save as Fits

Quality flag

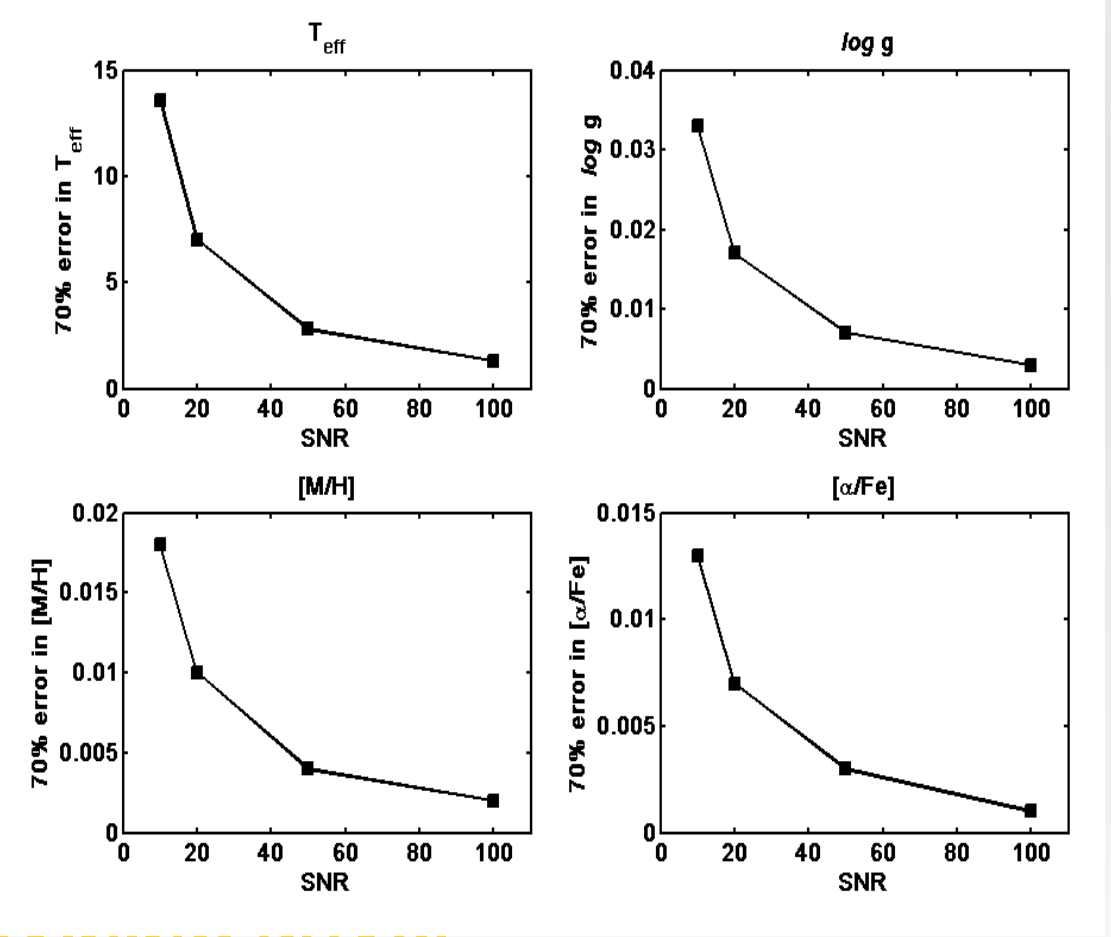


The Grid of Synthetic Spectra

- ~16000 synthetic spectra
- Optical domain: 3000 Å - 12000 Å
- MARCS model atmospheres

  (Gustafsson et al., 2010)
  - T_{eff} : 2500 → 8000 K
  - log g : 0.0 → +5.0 dex
  - [M/H] : -5.0 → +1.0 dex
  - [α/Fe] : -0.4 → +0.8 dex
- Molecular line lists from Bertrand Plez
- Atomic line lists (depends on the analysis grid)

Internal Errors of MATISSE: FEROS GRID



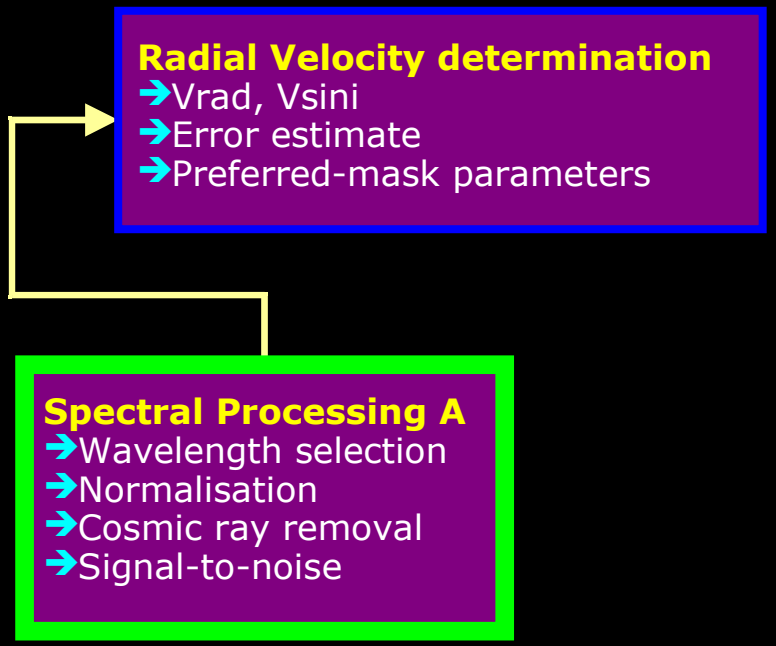
MATISSE TRAINING PHASE

B functions are generated corresponding to each point in the spectral grid

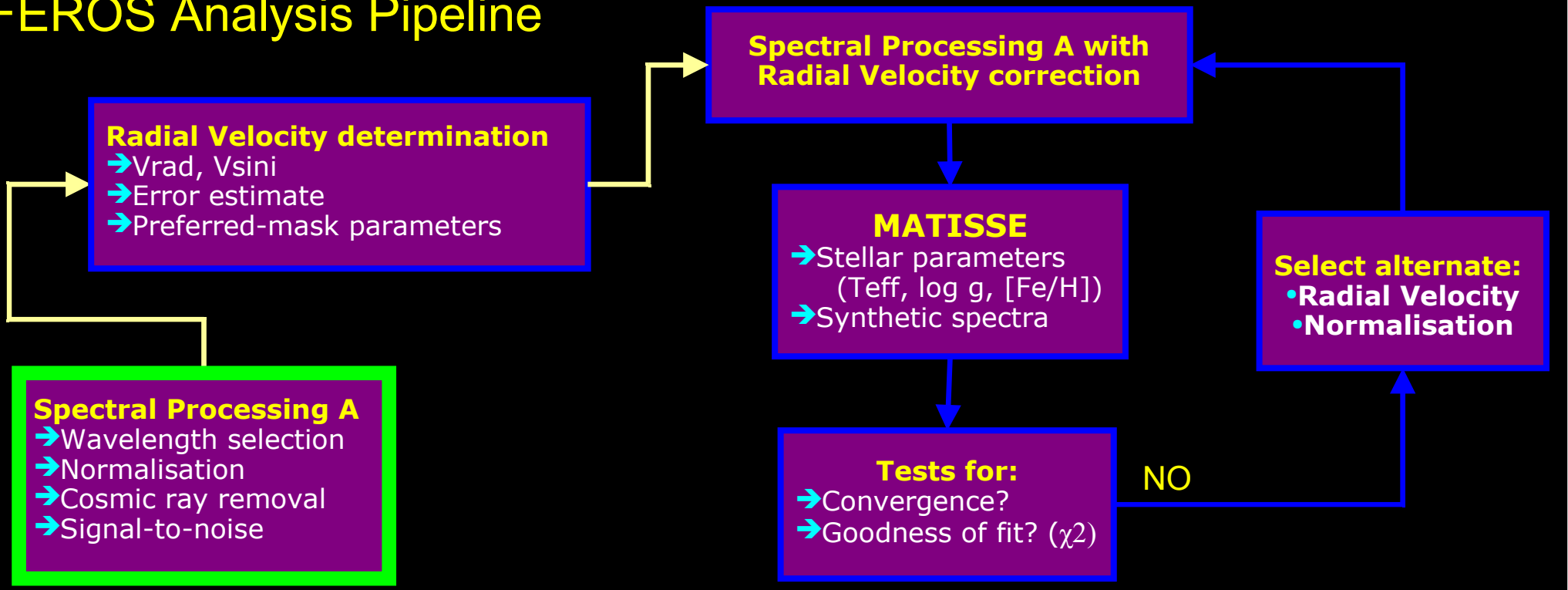
FEROS Analysis Pipeline

Spectral Processing A
- ➔Wavelength selection
- ➔Normalisation
- ➔Cosmic ray removal
- ➔Signal-to-noise

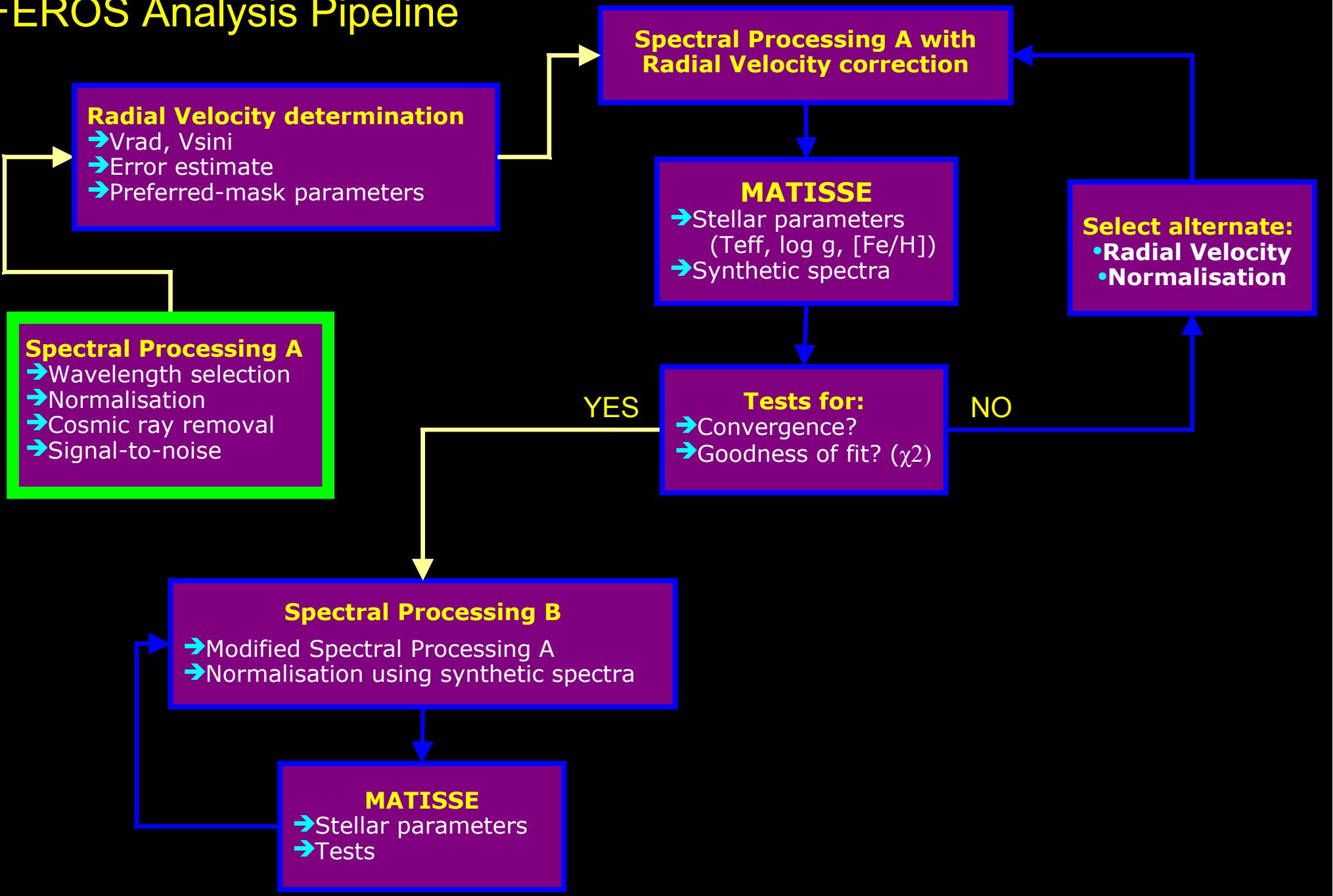
FEROS Analysis Pipeline



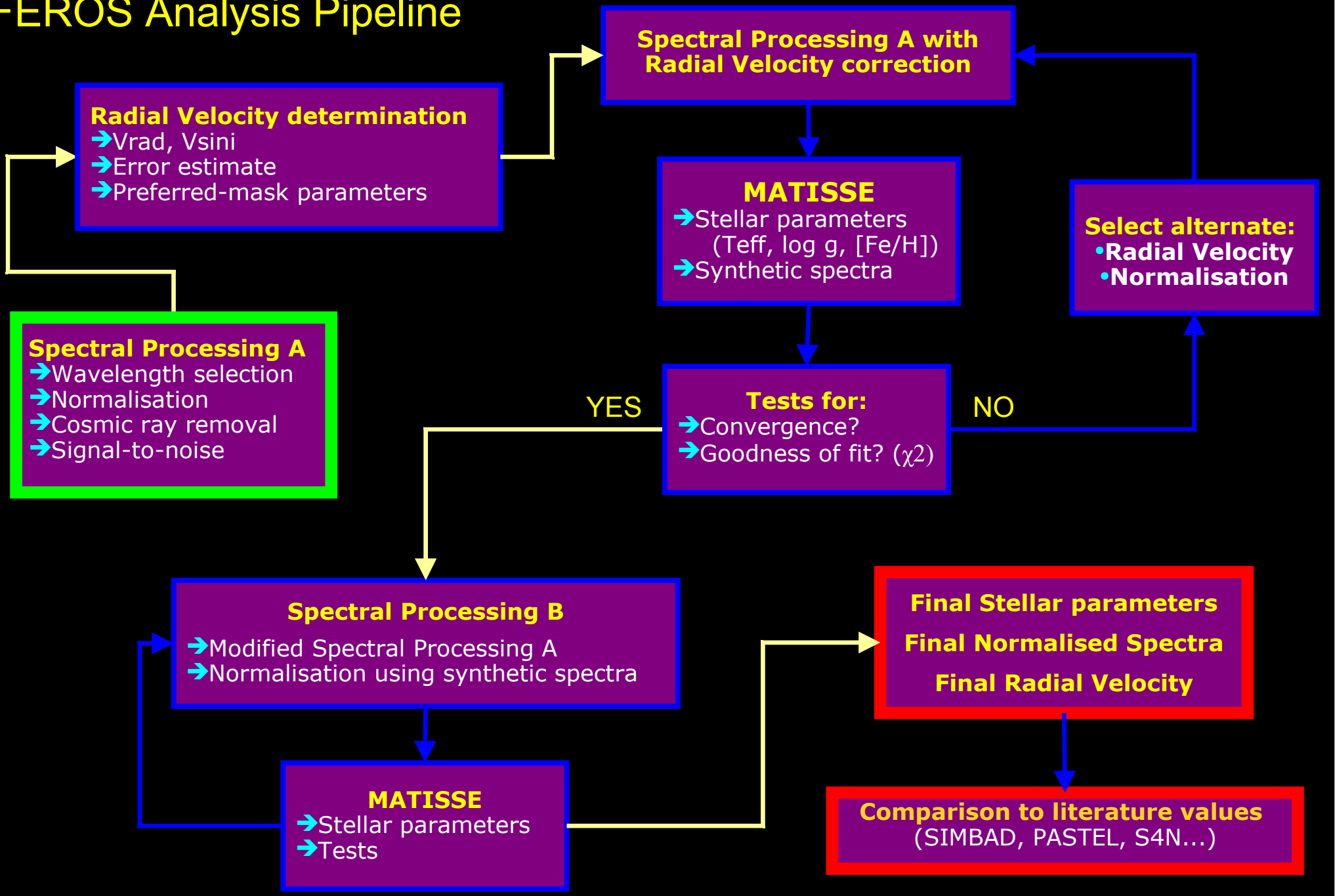
FEROS Analysis Pipeline



FEROS Analysis Pipeline



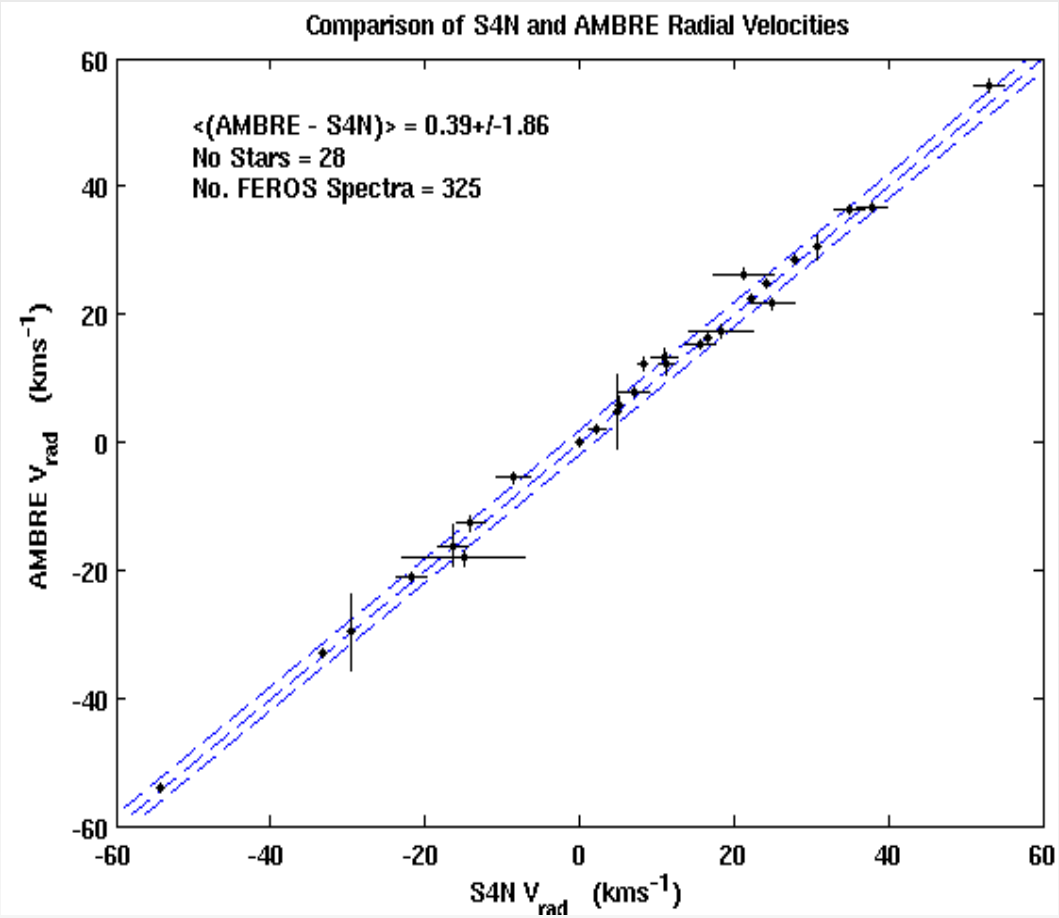
FEROS Analysis Pipeline

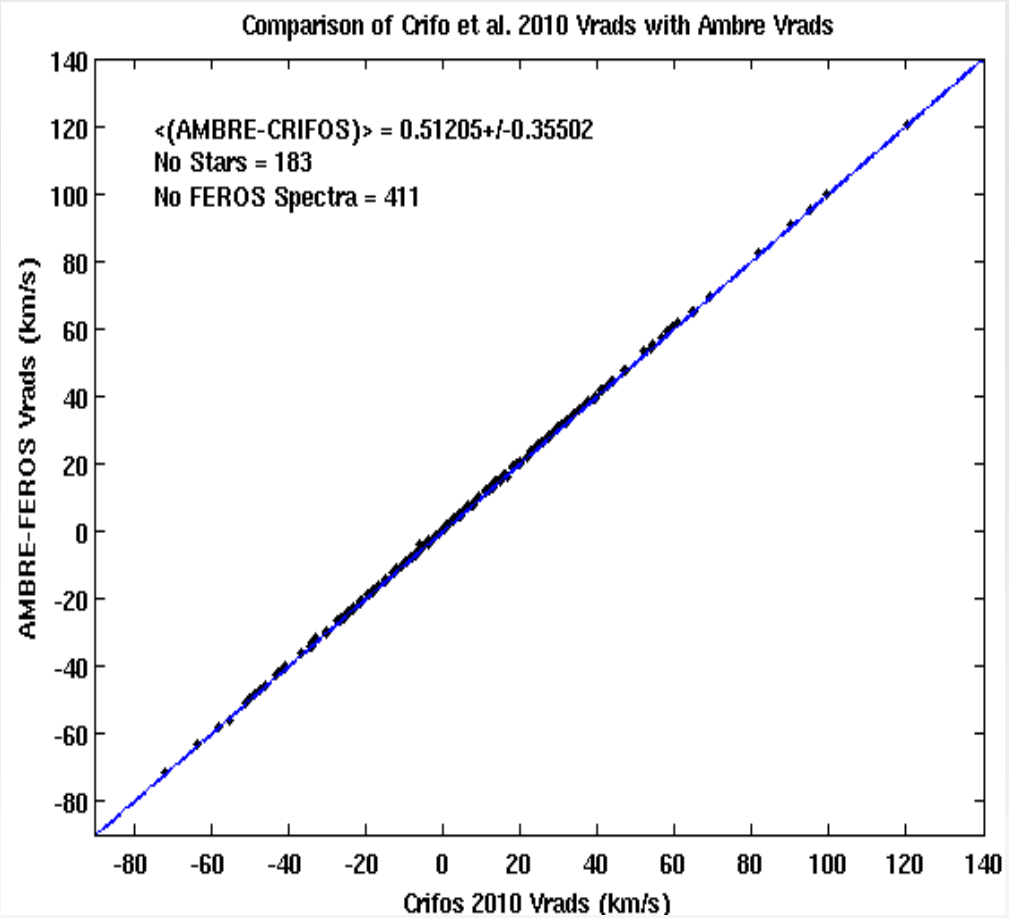


Homogeneous Reference Samples

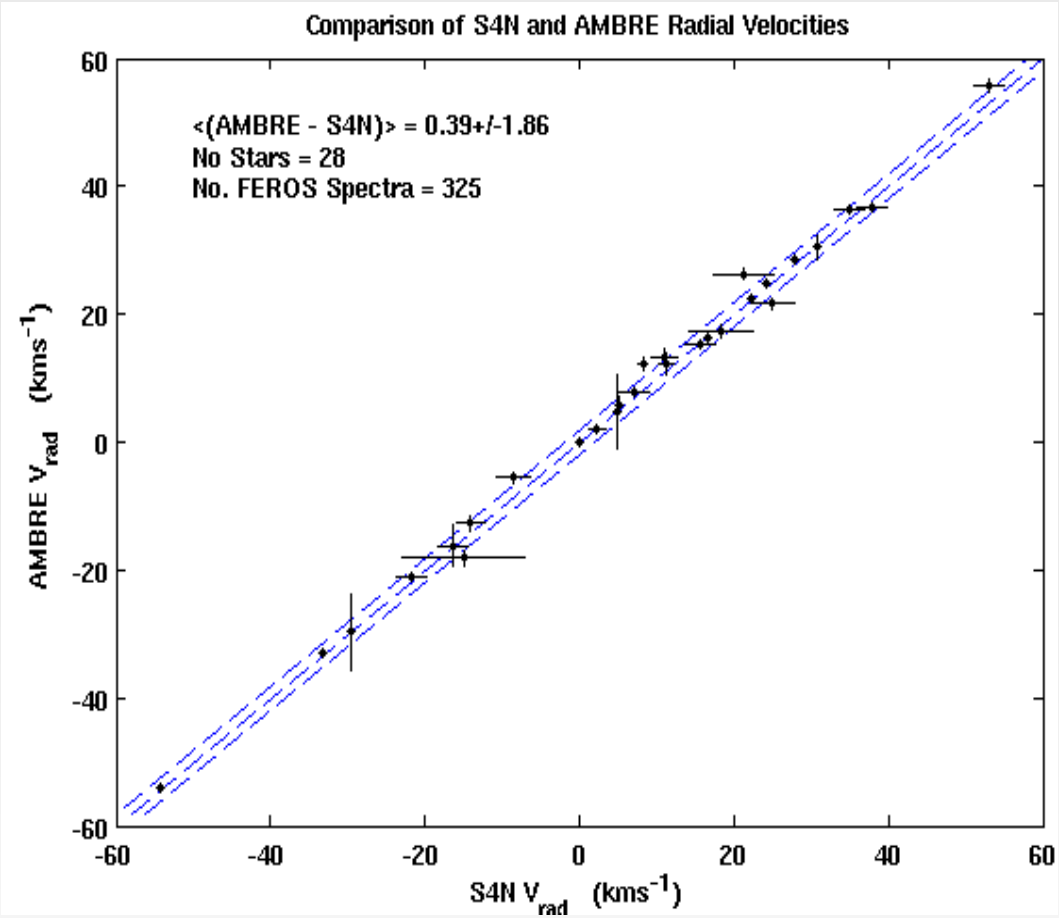
Source	Paper	No. Stars in Feros Sample	No. Feros Spectra
S4N	Allende-Prieto et al 2004 (F & G dwarfs)	30	339
Gaia RVS Standards	Crifos et al (2010)	183	411
PASTEL Soubiran et al (2010)	Fuhrmann 1997, 1998 2000, 2004 2008	44	198
	Gratton 1982, 1989, 1996, 2003	19	104
	Hekker 2007	6	27
	Luck 1983, 1991, 2005, 2006	42	224
	McWilliam 1990	10	43
	Mishenina 1996, 2001, 2003, 2004, 2006, 2008	40	217
	Ramirez 2005, Ramirez 2007	55	226
	Valenti 2005	182	310
	PASTEL Total	126	385

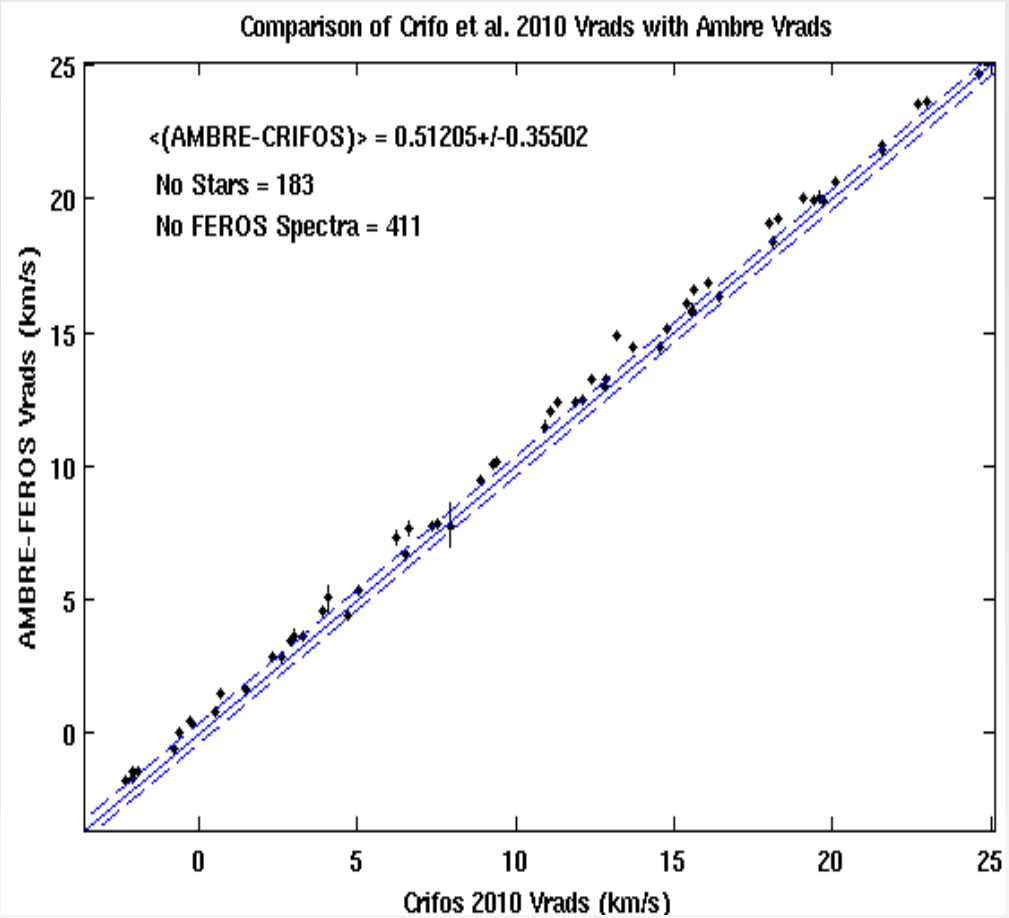
Radial Velocity Comparison



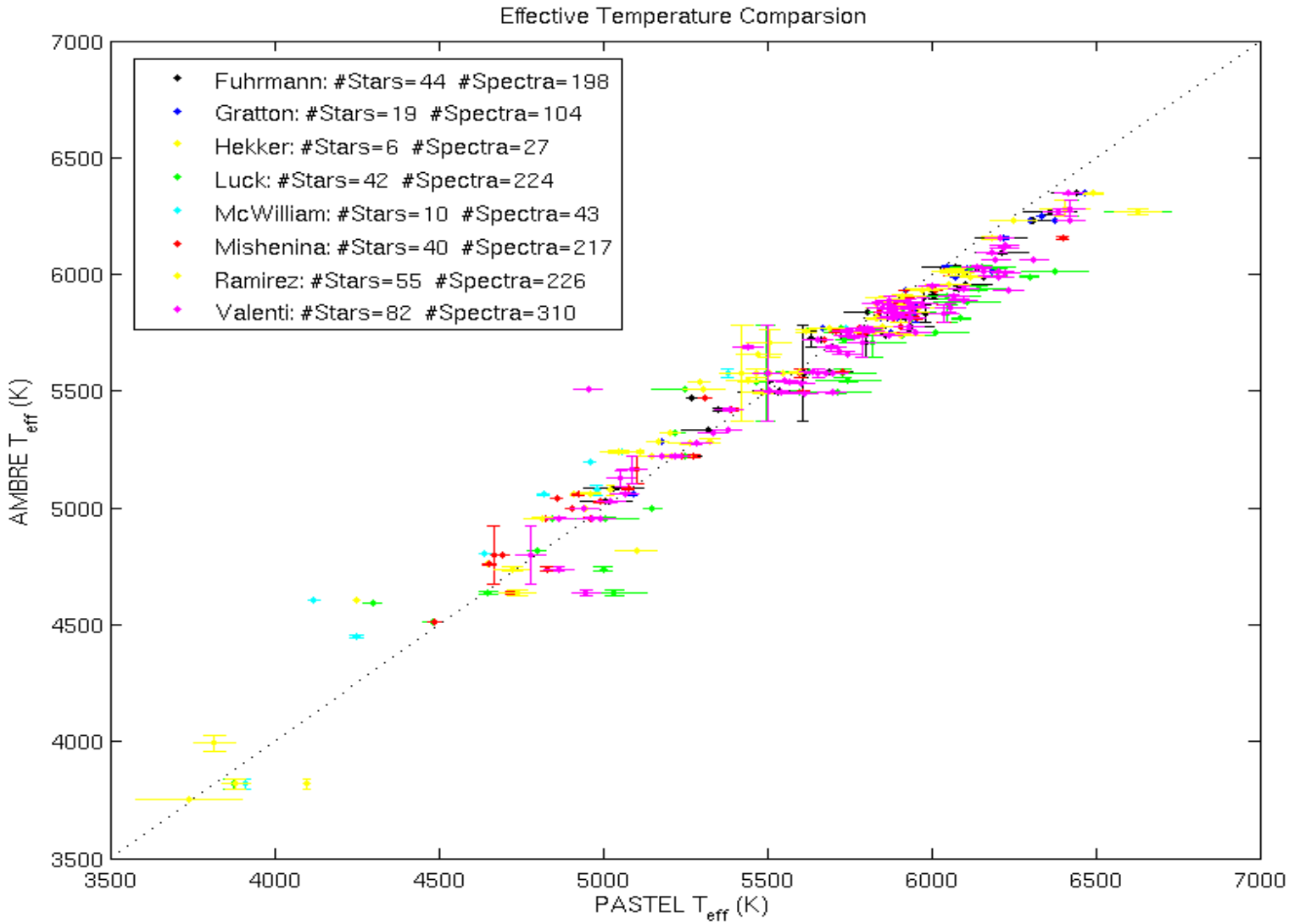


Radial Velocity Comparison

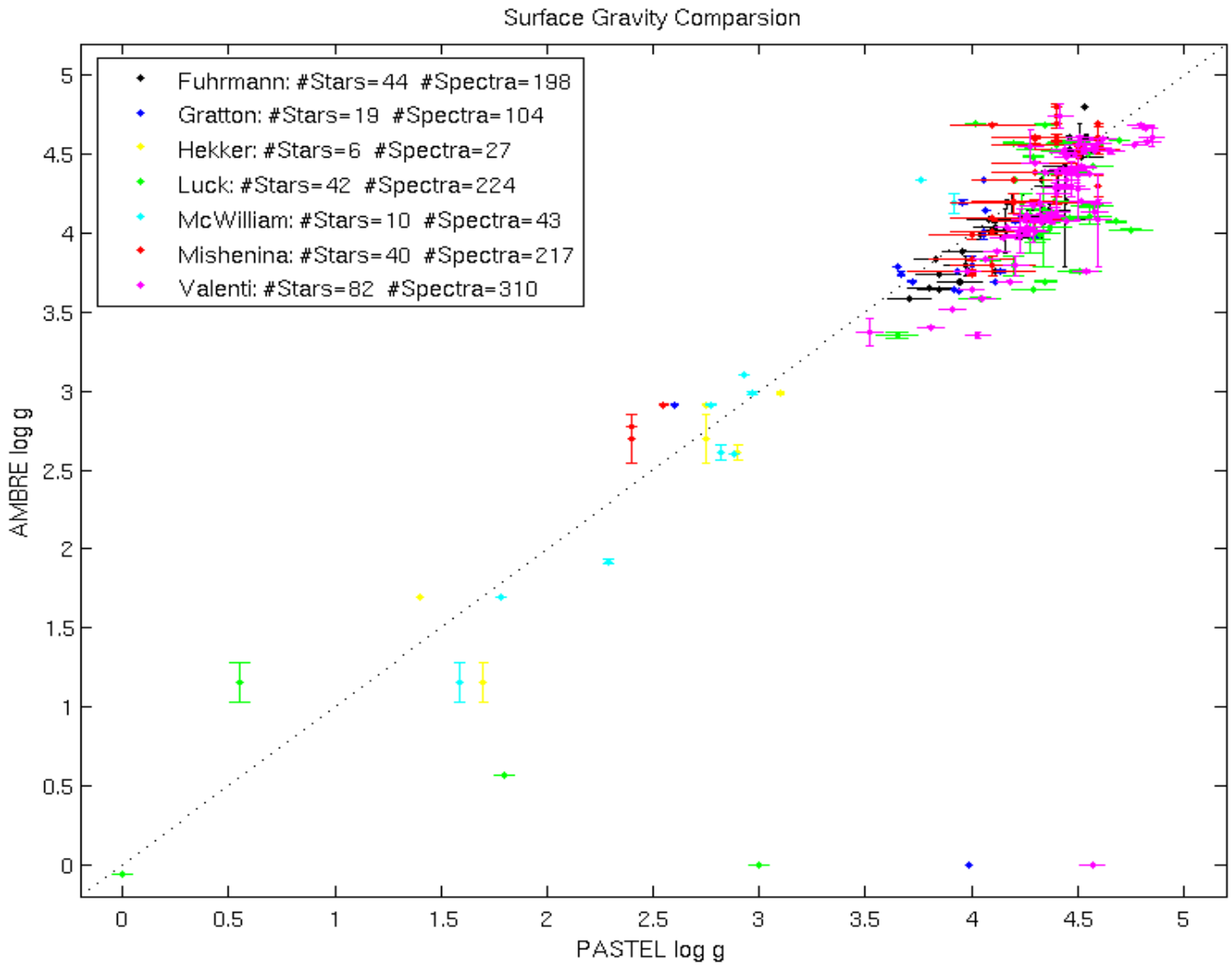




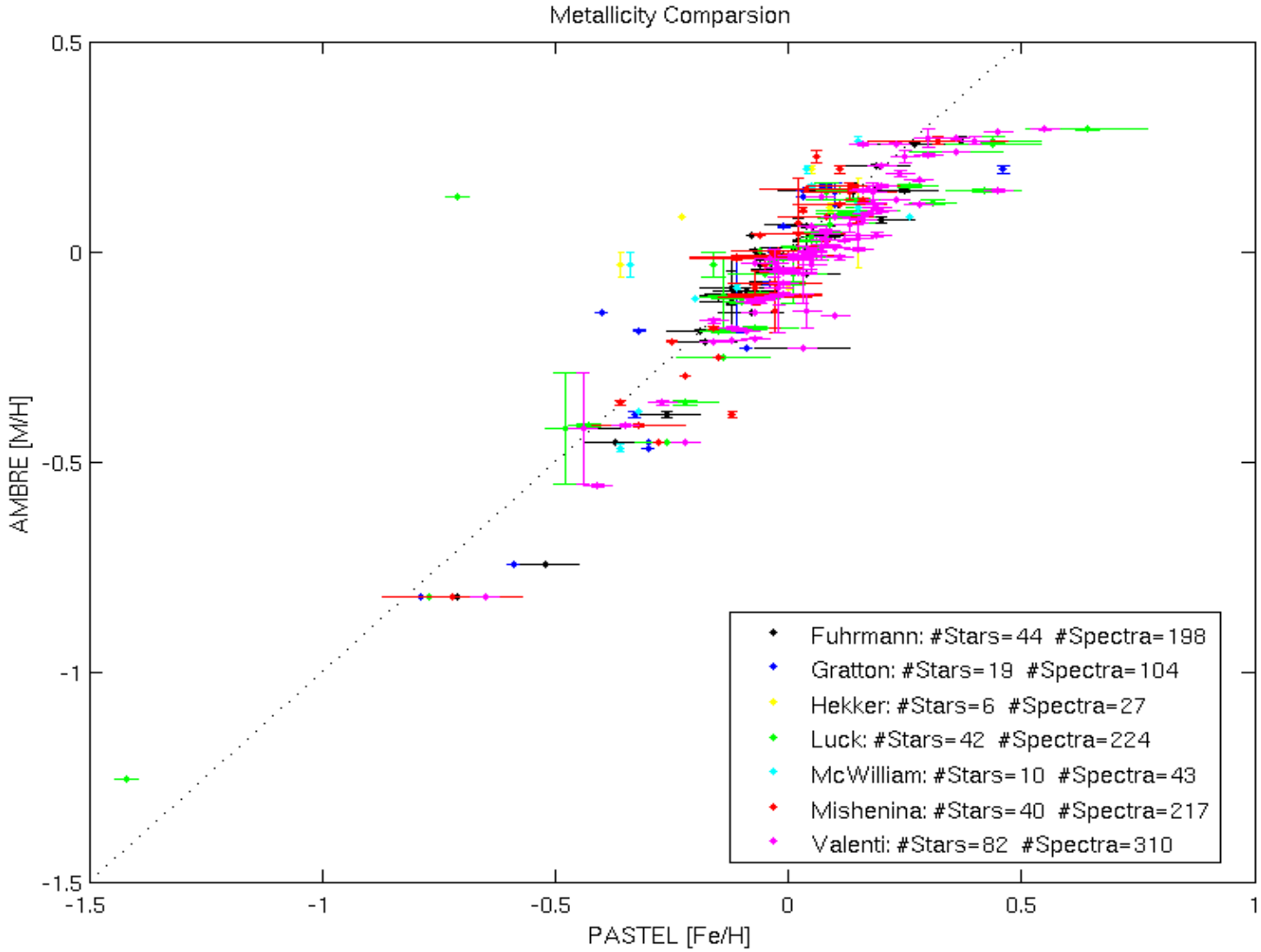
PASTEL Analysis: Effective Temperature



PASTEL Analysis: Surface Gravity



PASTEL Analysis: Metallicity



ESO Archive Chemical Chart: the FEROS Layer

Status of FEROS Analysis

- Final configuration of FEROS analysis is now set
- External error analysis underway → reference samples (PASTEL, S4N...)
- Processing of FEROS sample has begun

First layer of galactic chemical chart

MATISSE will provide Teff, log g, [M/H] and [alpha/Fe]

→ Chemical labeling of FEROS sample

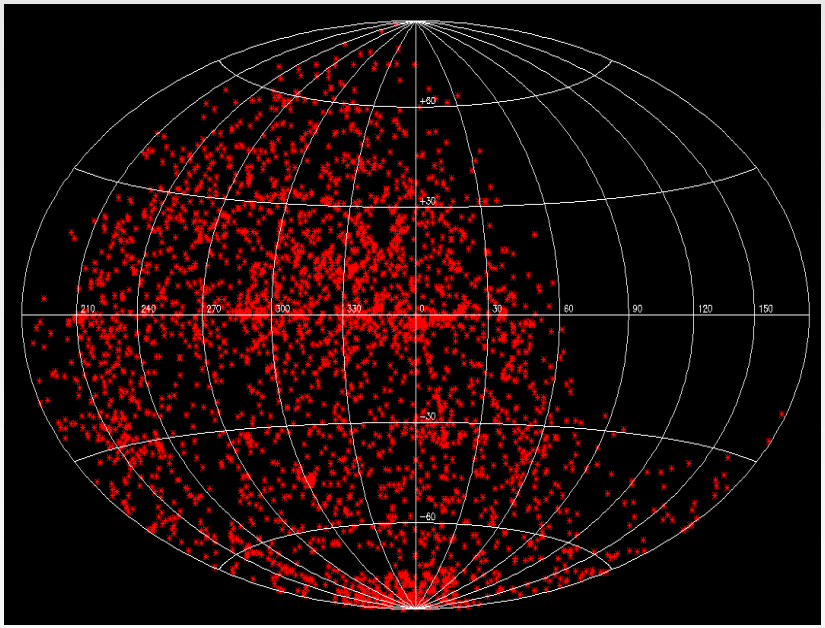
FEROS high resolution spectra will yield light and heavy chemical abundances

Future Layers:

→ UVES,HARPS,FLAMES/GIRAFFE

MATISSE results + kinematic parameters (U,V,W)

FEROS Targets in Galactic Coordinates



Majority of Southern Sky is sampled

The AMBRE Project Summary

Gaia & GSP-spec: Essential Testing of MATISSE

- Gaia RVS wavelengths and resolutions
- Large scale dataset of real stellar spectra
- Extensive error analysis prior to Gaia's launch

Advanced data products for ESO

- Homogeneous determination of stellar parameters for archived spectra
- Key information for each star in the ESO database
- Available to the entire astronomical community → Virtual Observatory

Galactic archaeology

- Creation of a galactic chemical chart
- Selection of specific stellar sample, i.e. halo, thick disk, thin disk...
- Kinematic & chemical analysis of homogeneous samples

Acknowledgements

- Observatoire de la Côte d'Azur
- ESO
- CNES







