

Tests of MATISSE on large spectral datasets from the ESO Archive

Preparing MATISSE for the ESA Gaia Mission

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Outline

- ▶ Galactic archaeology & Gaia
- ▶ AMBRE & MATISSE
- ▶ Preliminary results for FEROS archived spectra
- ▶ Project objectives



Galactic Archaeology & Gaia

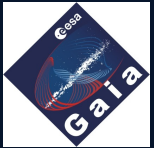
The exploration of large spectral datasets for underlying structures and populations within the Galaxy in order to create a chemical and kinematic chart with which to test theories of galactic formation and evolution

- ▶ 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**

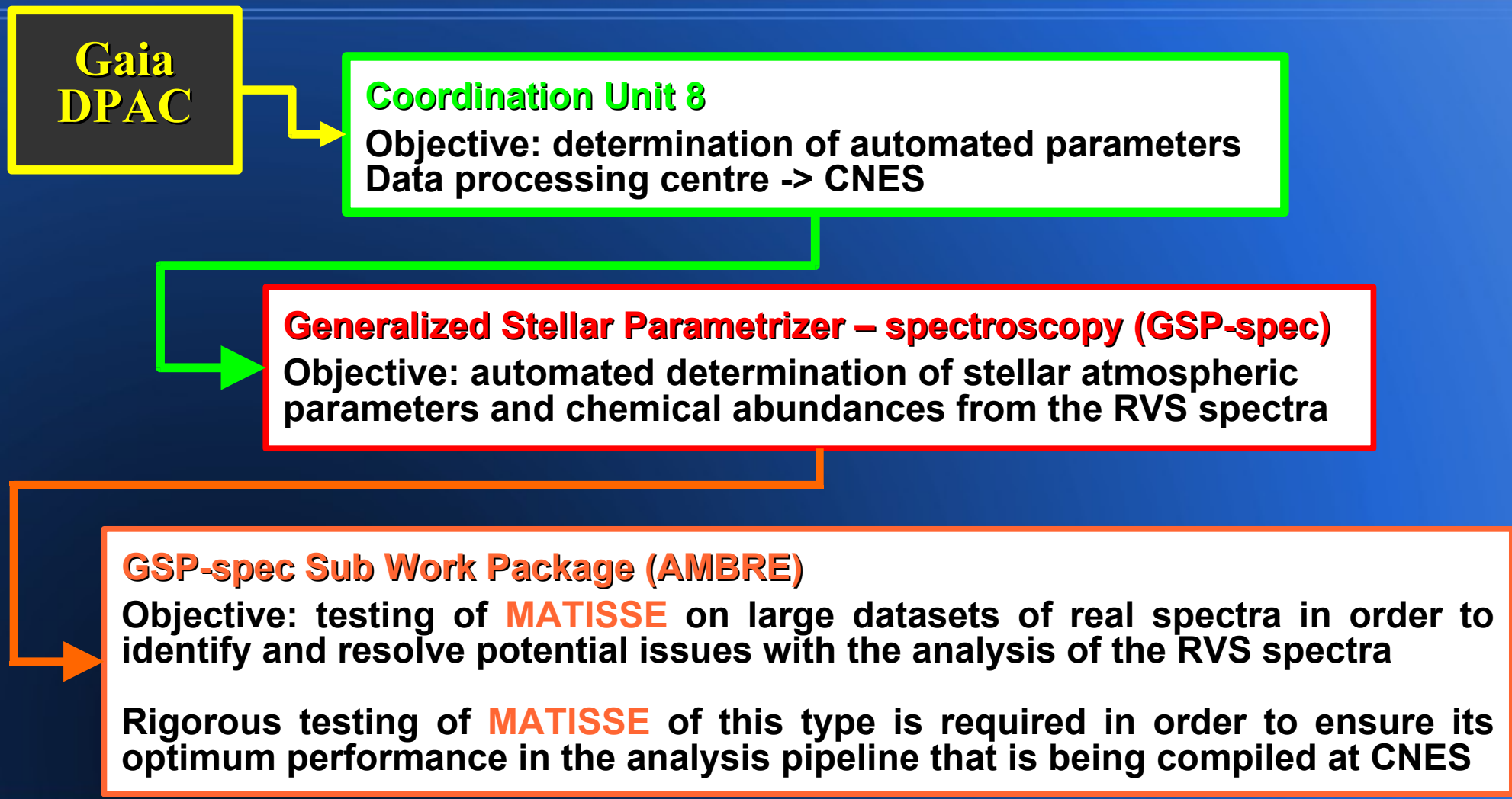
Gaia Radial Velocity Spectrometer

- Wavelength Domain: 847nm to 874nm
- Resolution: $R \sim 11500$ and $R \sim 7000$
- Spectral Features:
 - Ca II IR Triplet, H, Fe, Si, S, Mg, Ti





Gaia Data Processing and Analysis Consortium



MATISSE

MATrix Inversion for Spectral SynthEsis

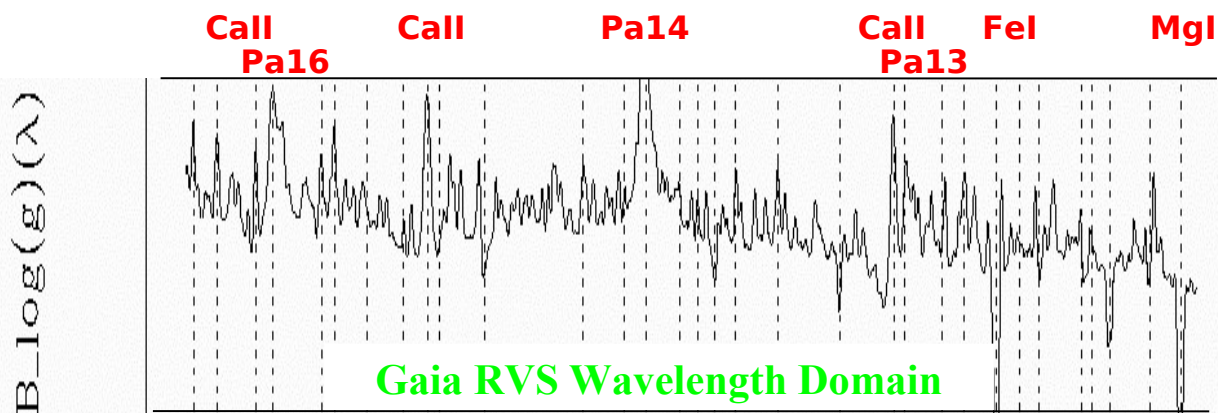
Recio-Blanco, Bijaoui, de Laverny (2006); Bijaoui, Recio-Blanco, de Laverny (2008)

- ▶ Stellar parameters ($\theta = T_{\text{eff}}, \log g, [M/H],$ individual chemical abundances) are derived by the projection of an input observed spectrum $O(\lambda)$ on a vector $B_{\theta}(\lambda)$.
- ▶ The $B_{\theta}(\lambda)$ vector is an optimal linear combination of theoretical spectra $S(\lambda)$ calculated from a synthetic spectra grid (the learning phase).
- ▶ 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 .

Example of indicators of surface gravity

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

$$B_{\theta}(\lambda) = \sum_i \alpha_i S_i(\lambda)$$



MATISSE: Java Interface

Results:

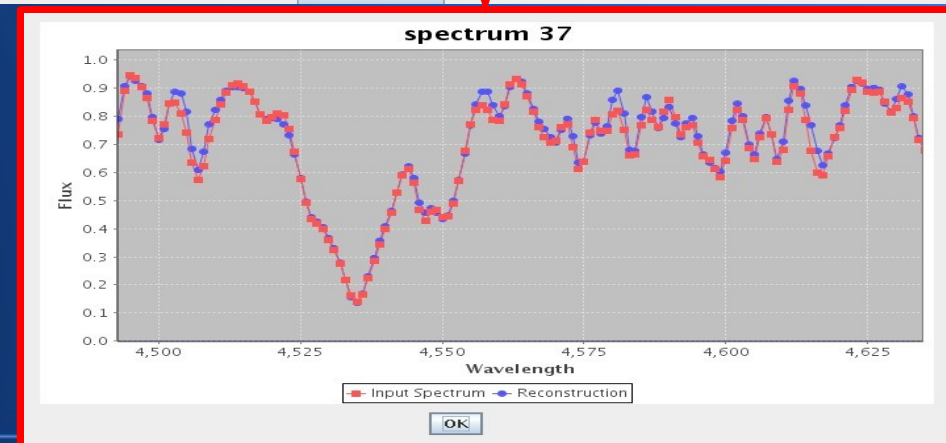
Spectra | Magnitude | Photometry | Interpolation | A Functions
Main | Grid | B Functions

Data directory : /extern2/laverny/AMBRE/BACKUP/MA
 Output File Name : meters_year1010objn2_9it10_Pat.dat
 Available Magnitudes
 Available Photometry
 Spectra Reconstruction
 Maximum Iteration Number :

Comparison of Synthetic and Observed Spectra

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

Quality flag





AMBRE



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

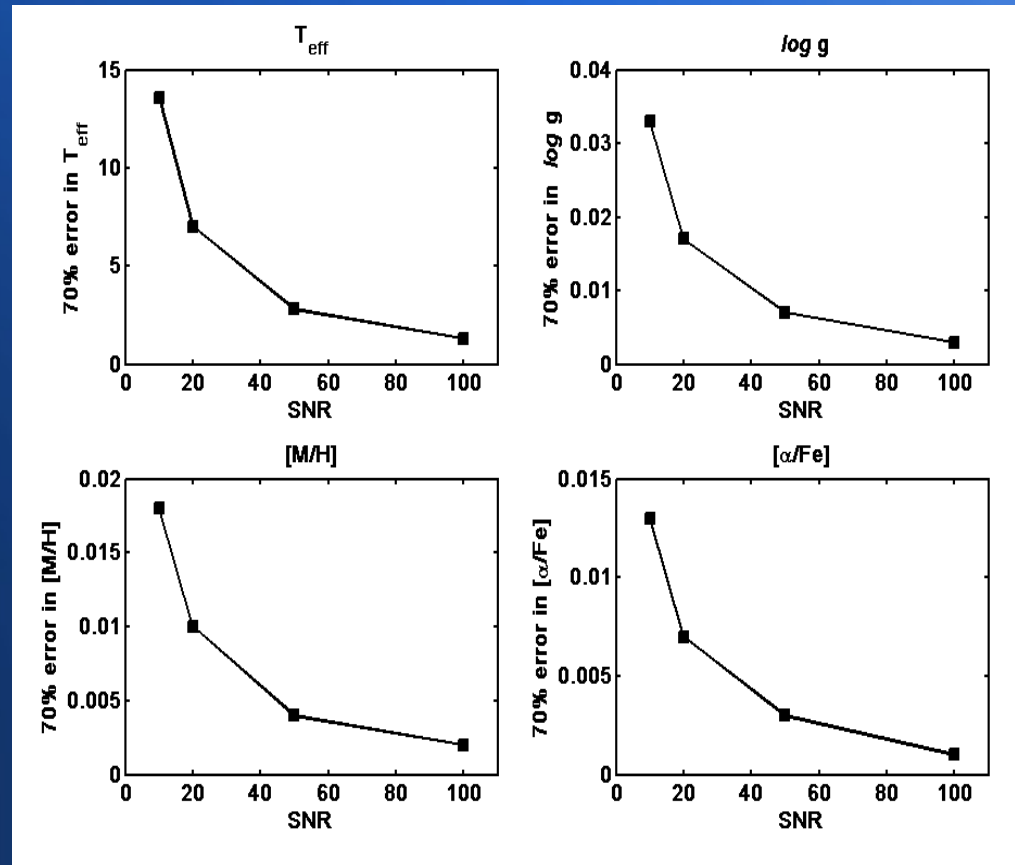
- Objectives
 - 1) to classify the ESO archived spectra → **Virtual Observatory**
 - 2) to test MATISSE with large sets of real spectra
 - 3) to create a galactic chemical chart
- This extensive dataset covers a large range of wavelengths and resolutions, including the wavelength domain and resolutions of Gaia RVS.
- This is a unique opportunity to carry out comprehensive testing of MATISSE which is essential to its preparation for the Gaia Mission

Testing MATISSE on the ESO archive

→ FEROS

- ▶ Sample size ~ 20,000
- ▶ June 2010: 1st data release to ESO
- MATISSE Training Phase**
- Very high resolution synthetic spectra grid
 - MARCS Models $T < 8000$ K
 - Kurucz Models $T > 8000$ K (under construction)
- Entire optical wavelength range
- Current stellar parameters span:
 - $3,000 \text{ K} < T_{\text{eff}} < 8,000 \text{ K}$
 - $0.5 < \log g < 5.0$
 - $-5 < [M/H] < +1$
- Generated B functions corresponding to each point in the spectral grid

Matisse Internal errors of the FEROS synthetic grid

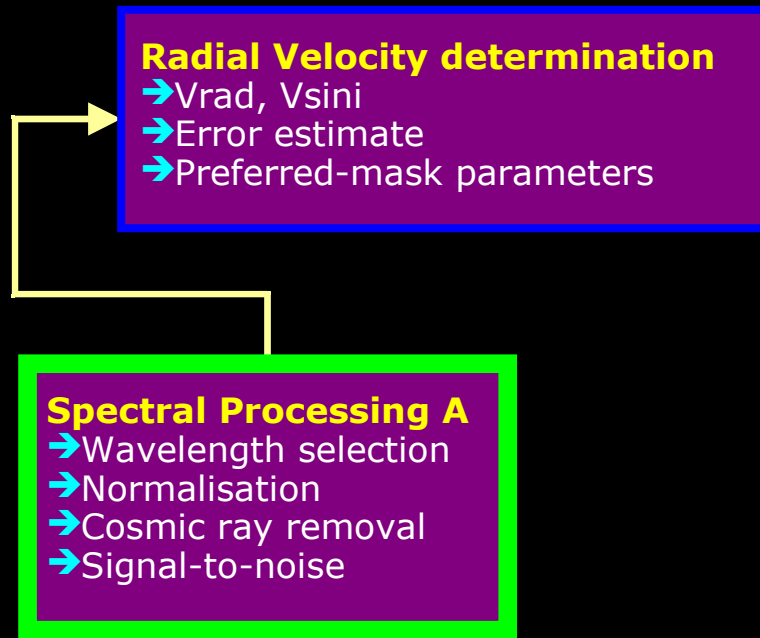


FEROS Analysis Pipeline

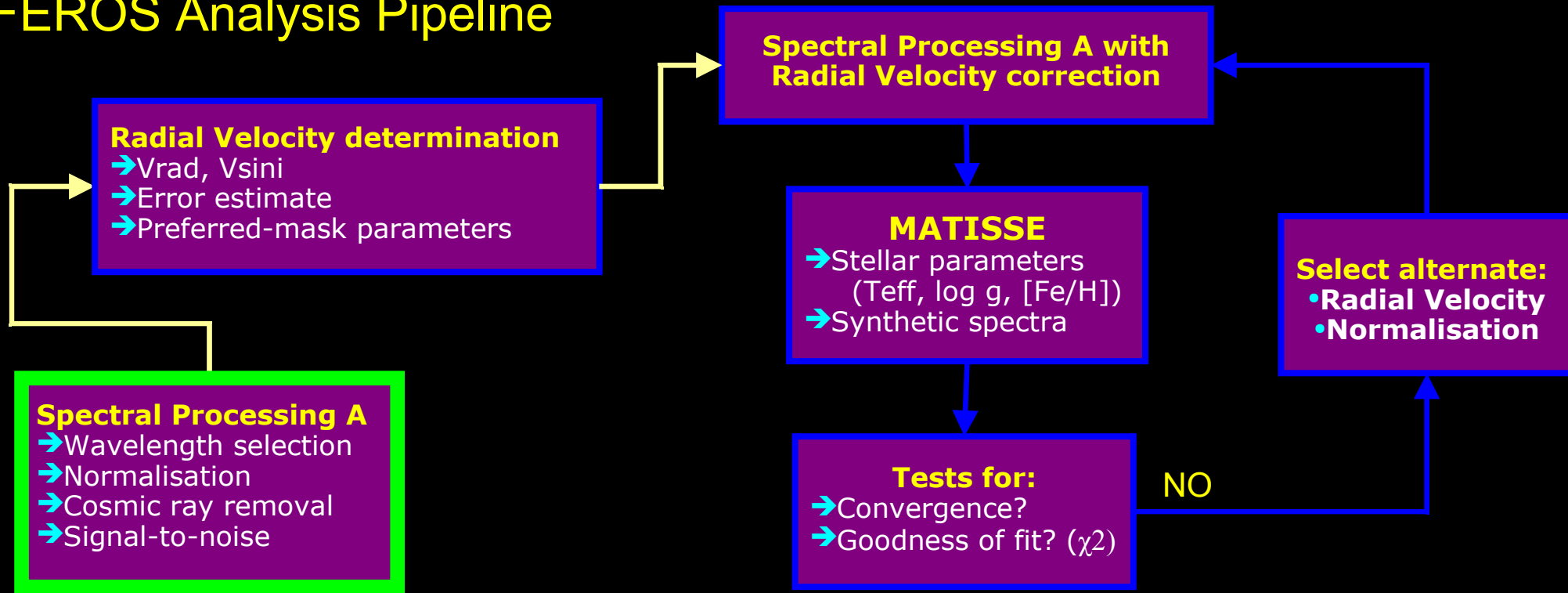
Spectral Processing A

- Wavelength selection
- Normalisation
- Cosmic ray removal
- Signal-to-noise

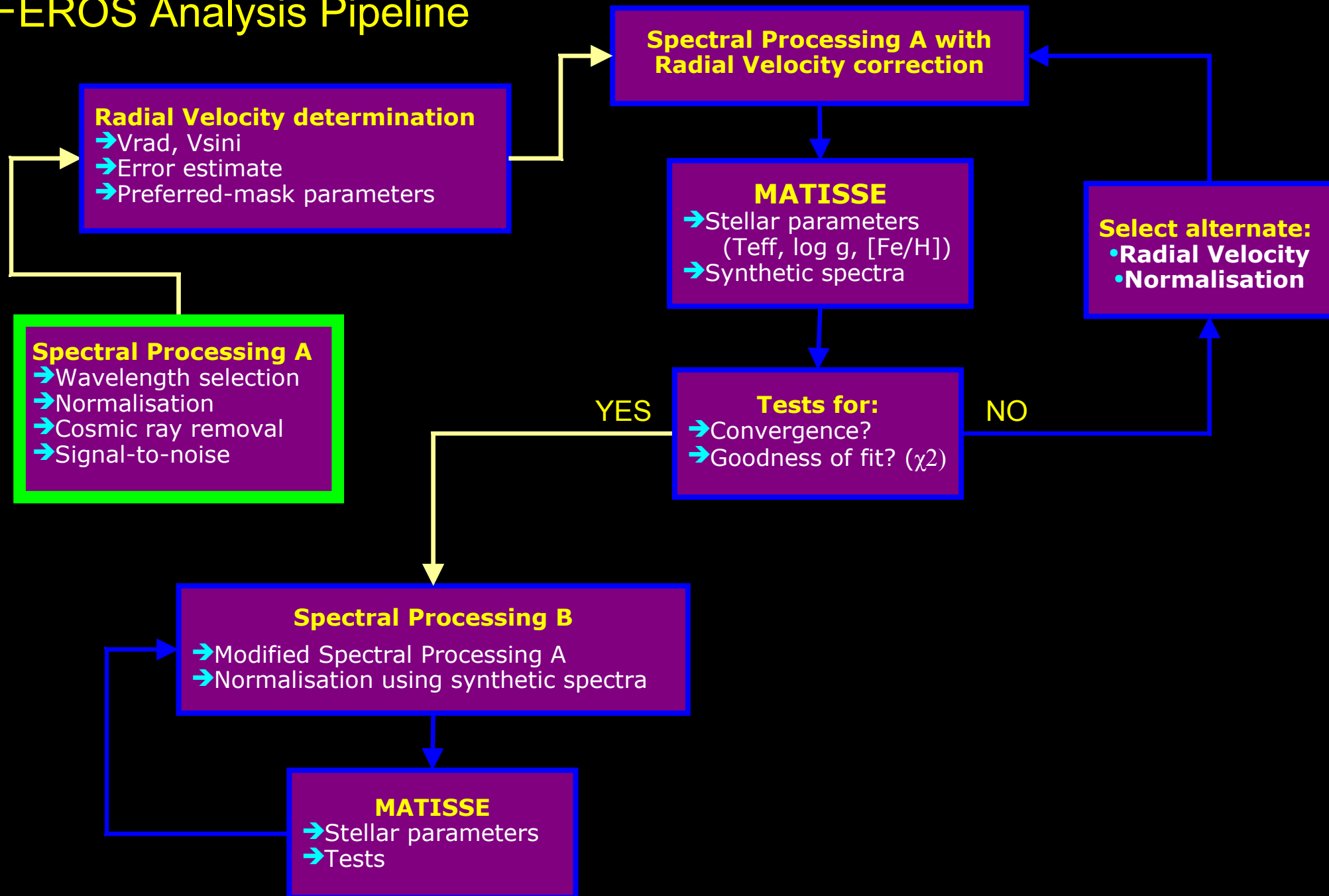
FEROS Analysis Pipeline



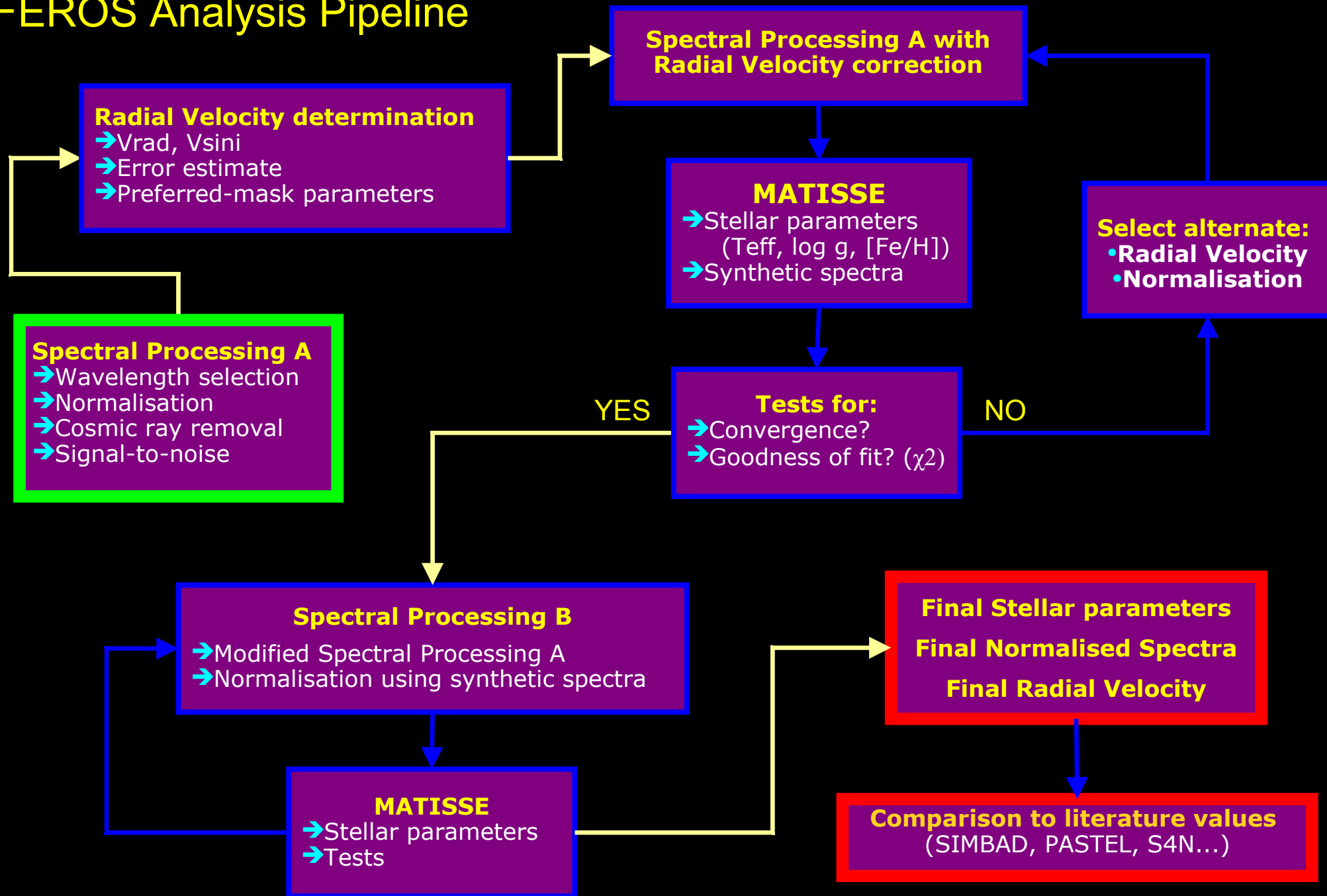
FEROS Analysis Pipeline



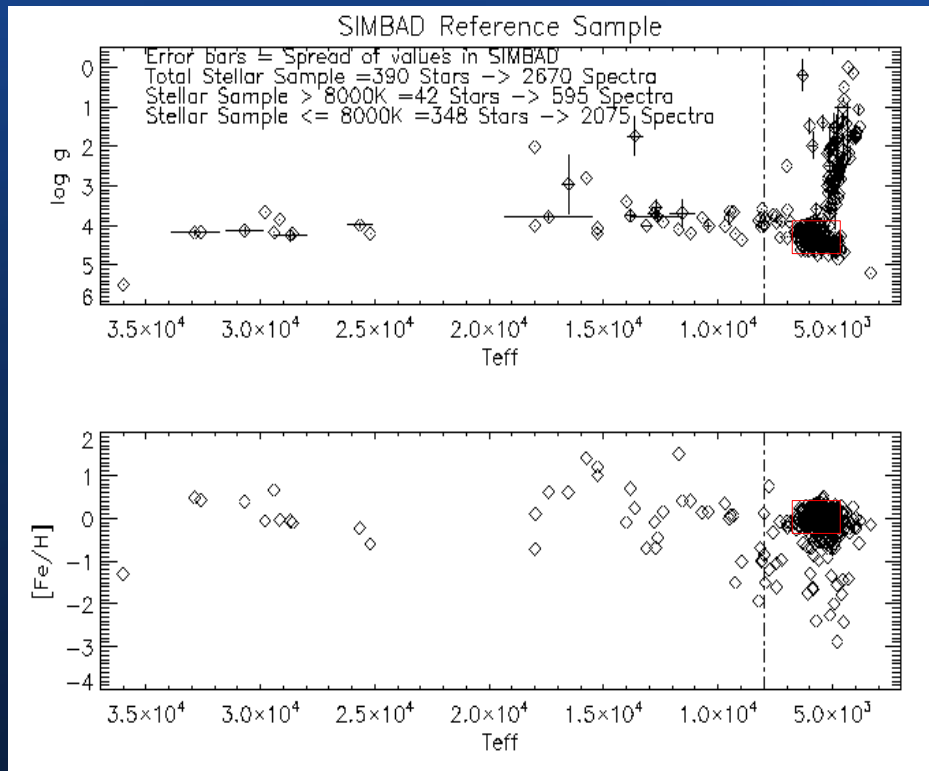
FEROS Analysis Pipeline



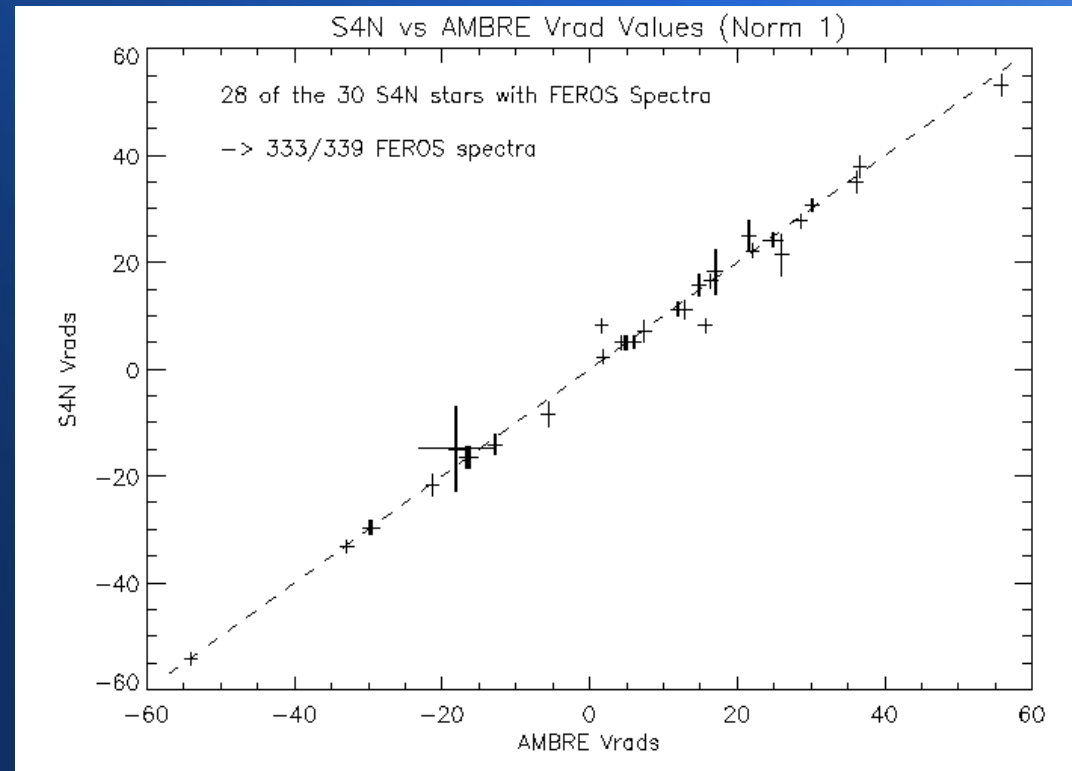
FEROS Analysis Pipeline



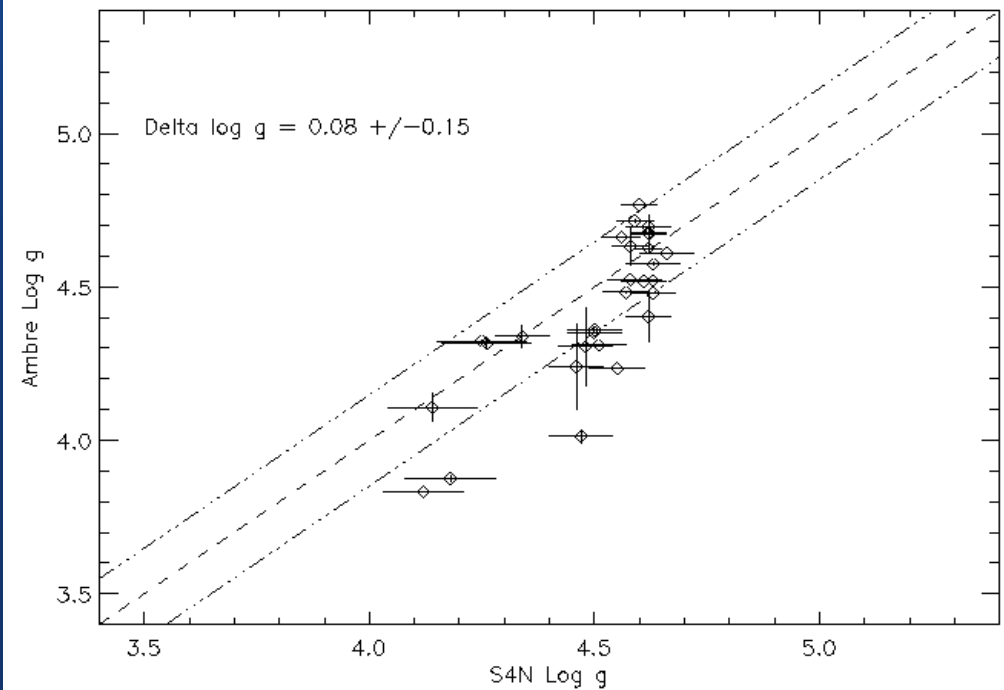
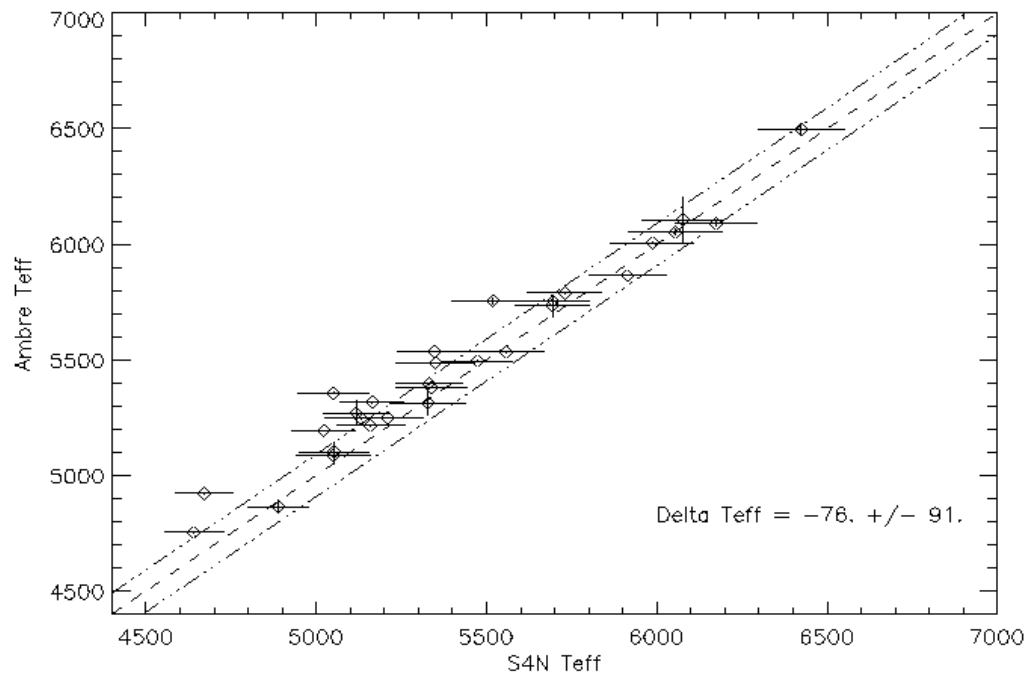
Comparison to Reference Samples



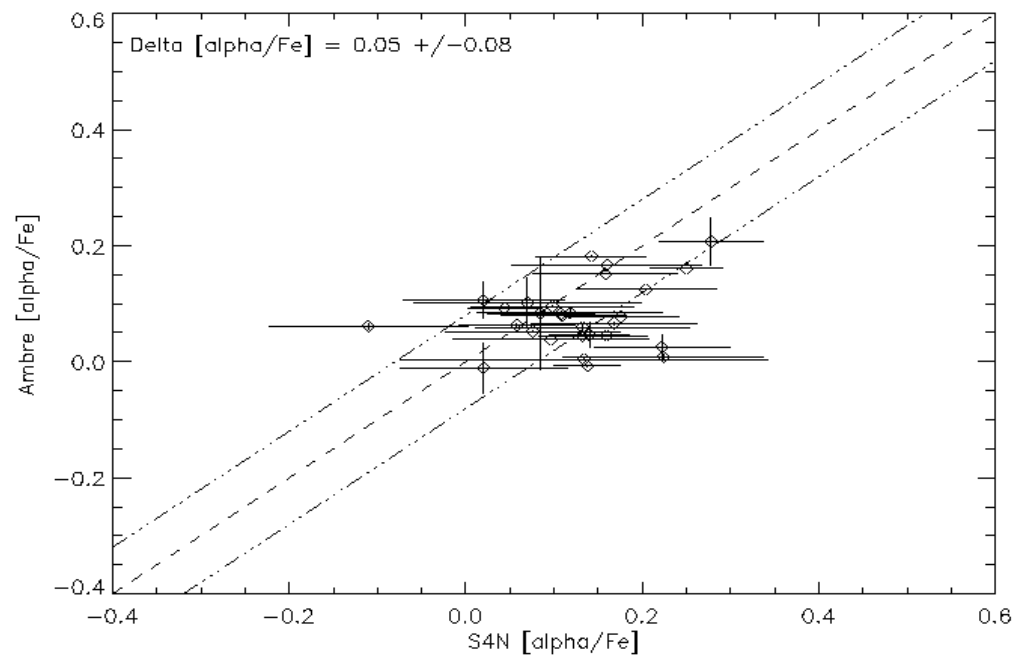
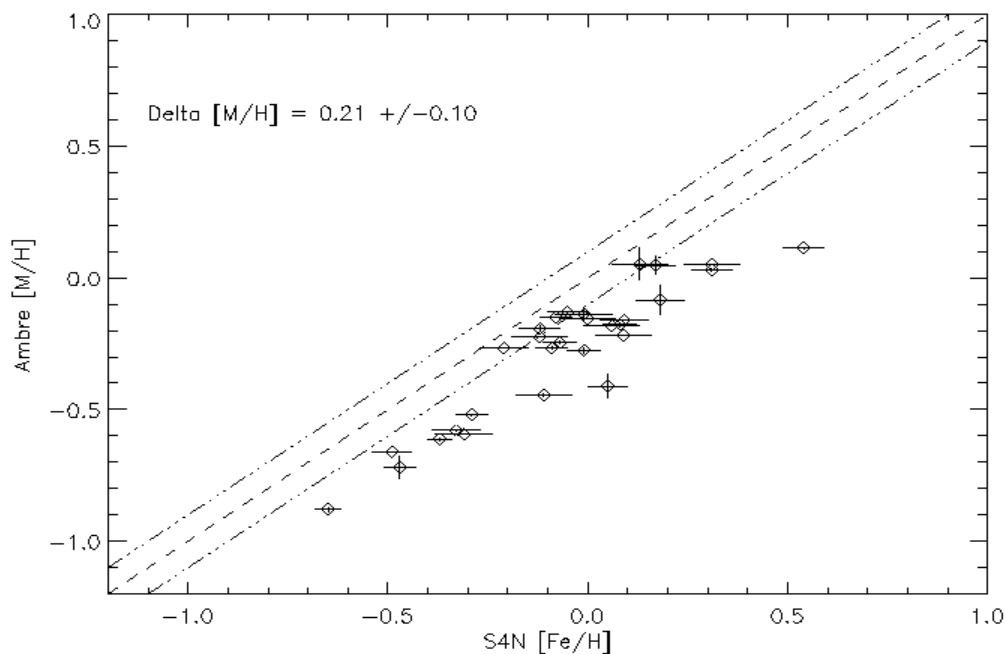
S4N Reference Sample: Allende-Prieto et al. 2004
(F & G dwarfs)



External Error Analysis: T_{eff} & $\log g$



External Error Analysis: [M/H] & [alpha/Fe]



REQUIRED → Comprehensive sample of reference stars across a wide range of parameters

ESO Archive Chemical Chart: the FEROS Layer

First layer of galactic chemical chart

- MATISSE will provide T_{eff} , $\log g$, $[M/H]$ and $[\alpha/\text{Fe}]$

→ Chemical labeling of FEROS sample

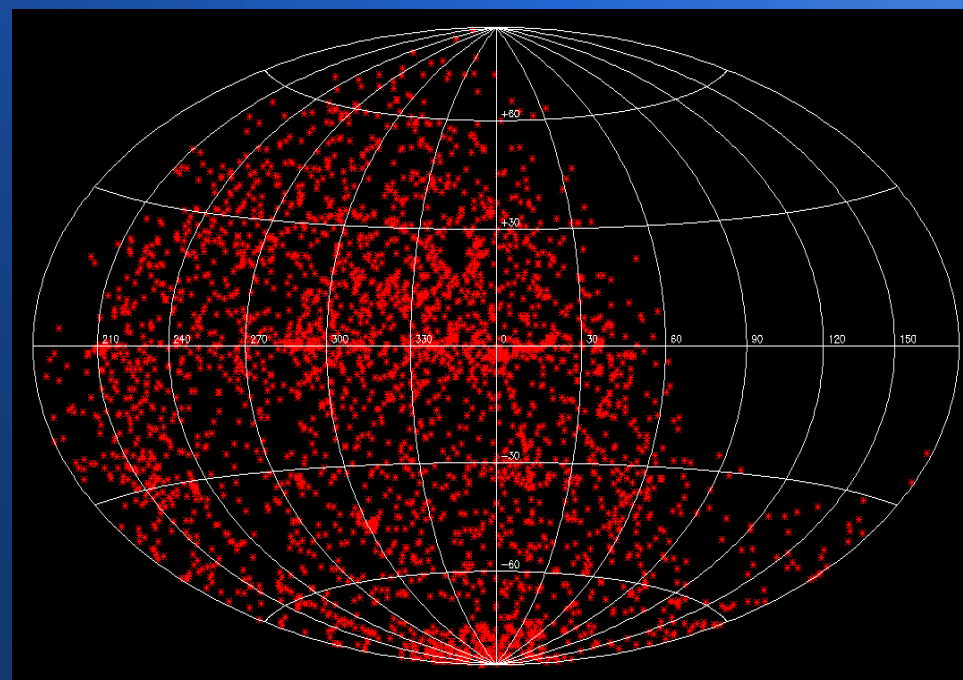
- FEROS high resolution spectra will yield light and heavy chemical abundances

Future Layers:

UVES, HARPS, FLAMES/GIRAFFE

- MATISSE results + kinematic data (U, V, W)

FEROS Targets in Galactic Coordinates



Majority of Southern Sky is sampled

Key Objectives for Gaia, ESO and Galactic Archaeology

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

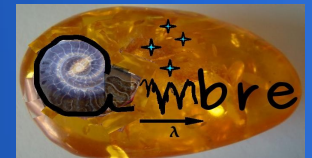
- Homogeneous determination of stellar parameters for archived spectra
- Key information for each star in the ESO database
- Available to the entire astronomical community → Virtual Observatory

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

- SOC & LOC of ELSA 2010
- Observatoire de la Côte d'Azur
- ESO
- CNES



FEROS Targets on the Sky

