Tests of MATISSE on large spectral datasets from the ESO Archive

Preparing MATISSE for the ESA Gaia Mission

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Automated Stellar Classification & Galactic Archaeology

Outline

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

Galactic Archaeology & Gaia

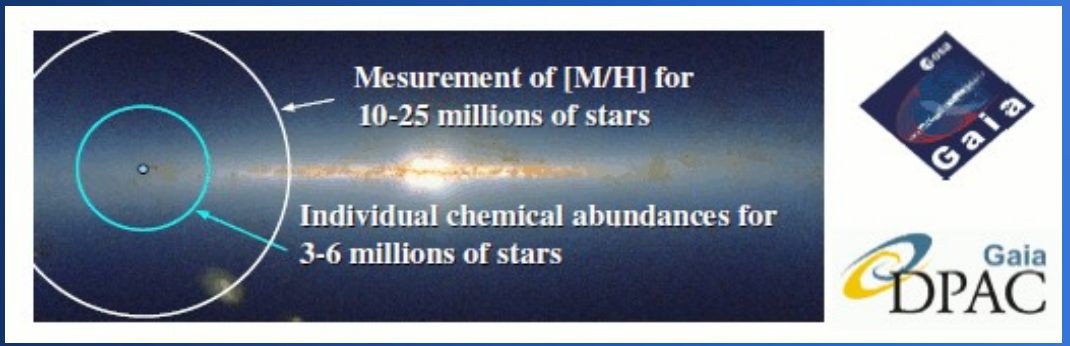
The exploration of large spectral datasets for underlying structures and populations within the Galaxy in order to create a chemical and kinematic chart with which to test theories of galactic formation and evolution

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

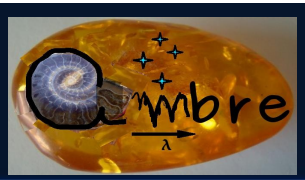
→ AUTOMATED STELLAR CLASSIFICATION ALGORITHMS

Gaia Radial Velocity Spectrometer

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



Gaia Data Processing and Analysis Consortium



Gaia DPAC

Coordination Unit 8

Objective: determination of automated parameters
Data processing centre -> CNES

Generalized Stellar Parametrizer – spectroscopy (GSP-spec)

Objective: automated determination of stellar atmospheric parameters and chemical abundances from the RVS spectra

GSP-spec Sub Work Package (AMBRE)

Objective: testing of MATISSE on large datasets of real spectra in order to identify and resolve potential issues with the analysis of the RVS spectra

Rigorous testing of MATISSE of this type is required in order to ensure its optimum performance in the analysis pipeline that is being compiled at CNES

MATISSE
MATrix Inversion for Spectral SynthEsis

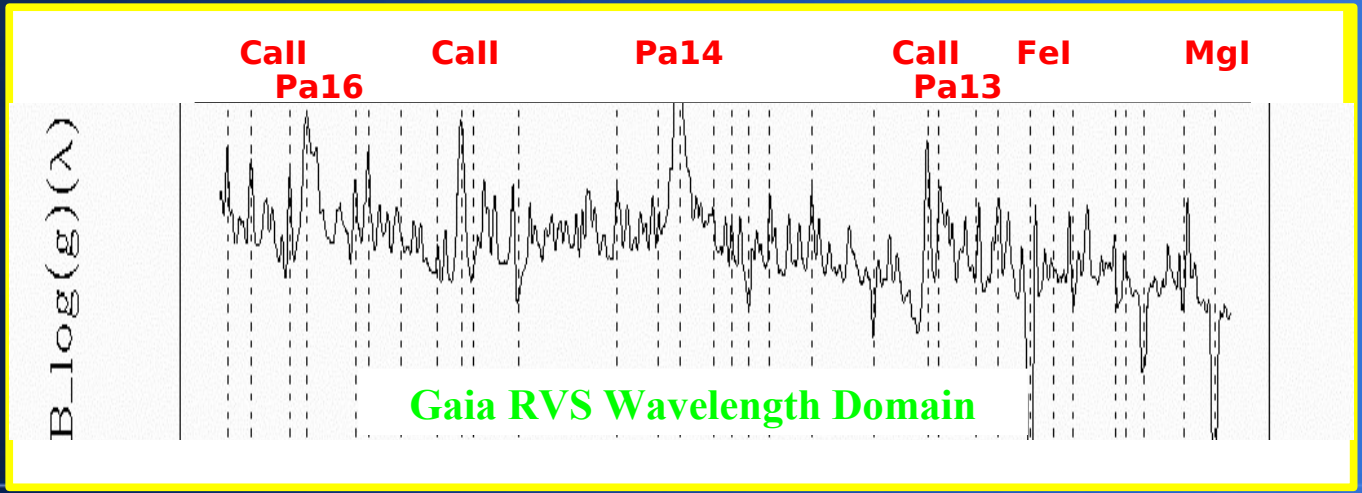
Recio-Blanco, Bijaoui, de Laverny (2006); Bijaoui, Recio-Blanco, de Laverny (2008)

- 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 $B_\theta(\lambda)$.
- 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.

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

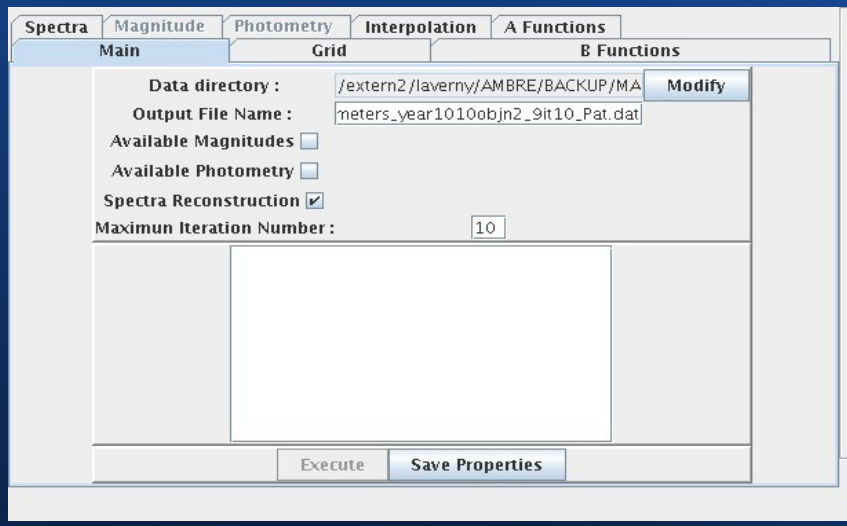
$$\boldsymbol{B}_\theta(\lambda) = \sum_i \alpha_i \boldsymbol{S}_i(\lambda)$$

Example of indicators of surface gravity

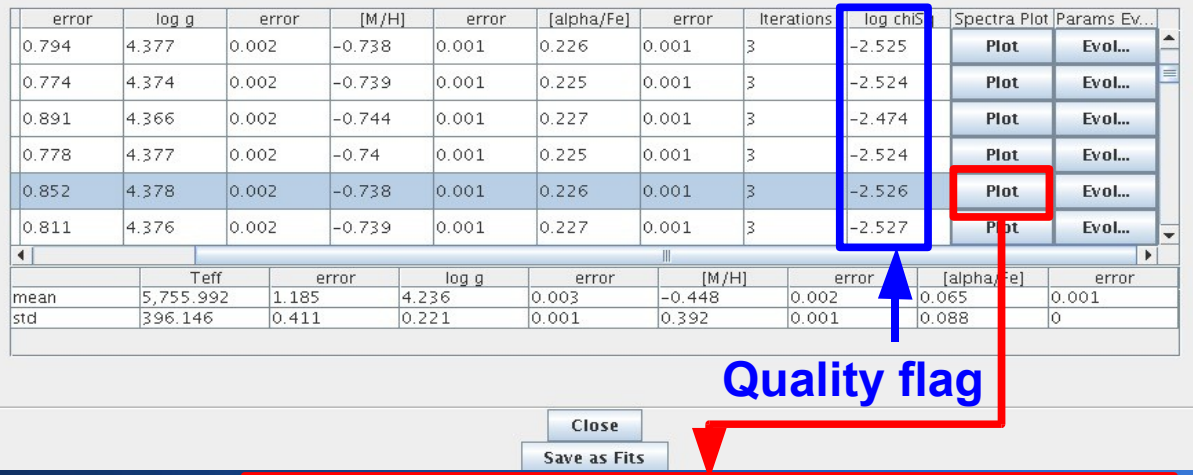


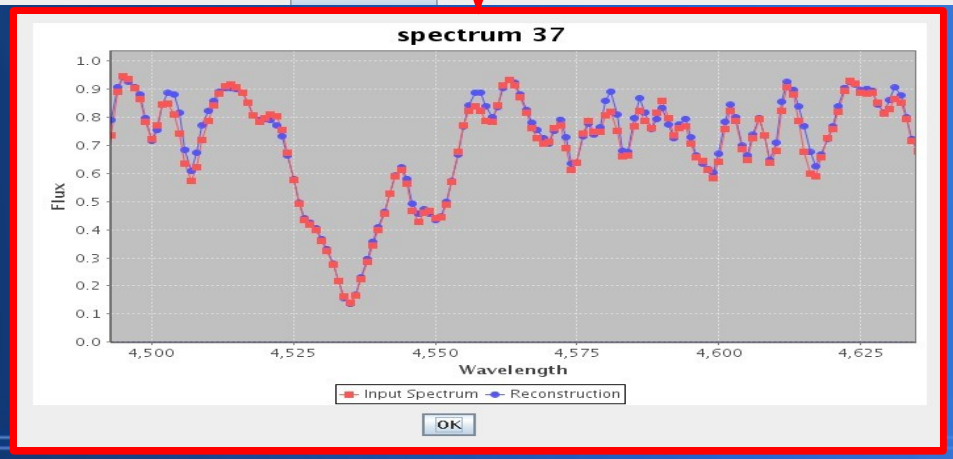
MATISSE: Java Interface

Inputs:



Results: Comparison of Synthetic and Observed Spectra





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.

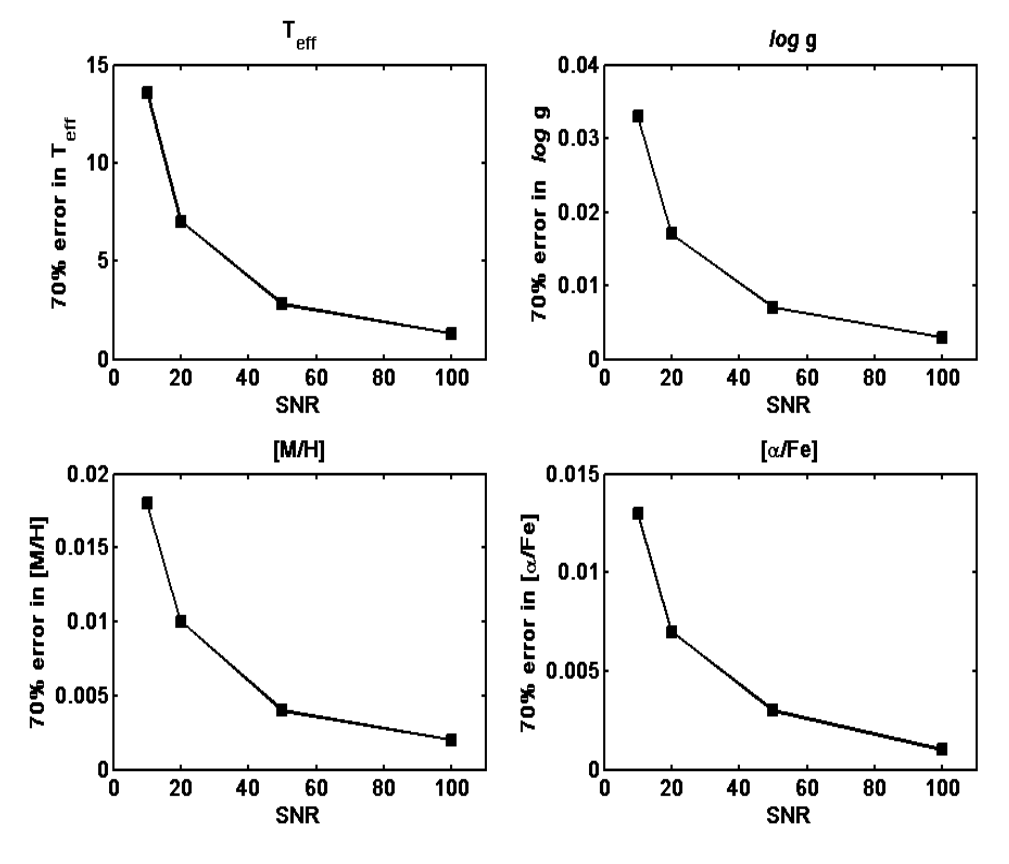
- **This is a unique opportunity to carry out comprehensive testing of MATISSE which is essential to its preparation for the Gaia Mission**

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 K < Teff < 8,000 K
  - 0.5 < log g < 5.0
  - -5 < [M/H] < +1
- Generated B functions corresponding to each point in the spectral grid

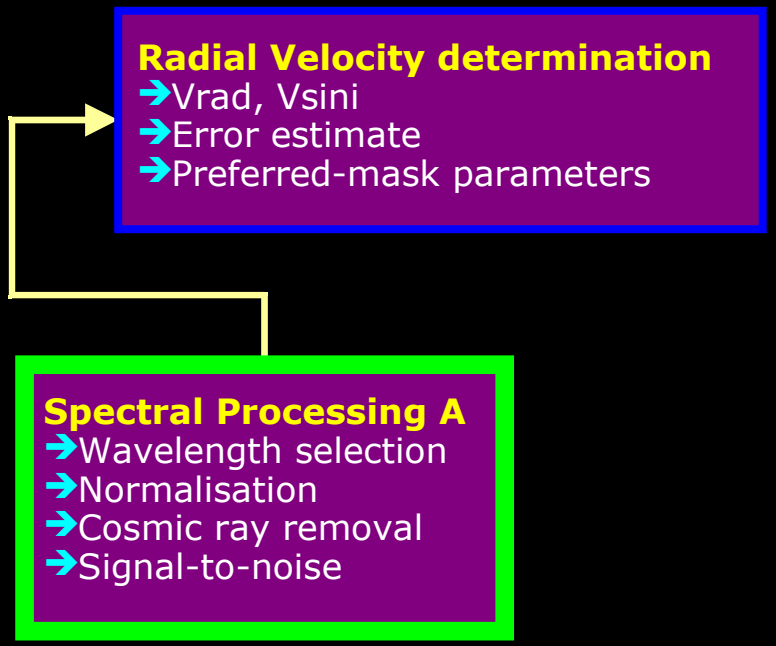
Matisse Internal errors of the FEROS synthetic grid



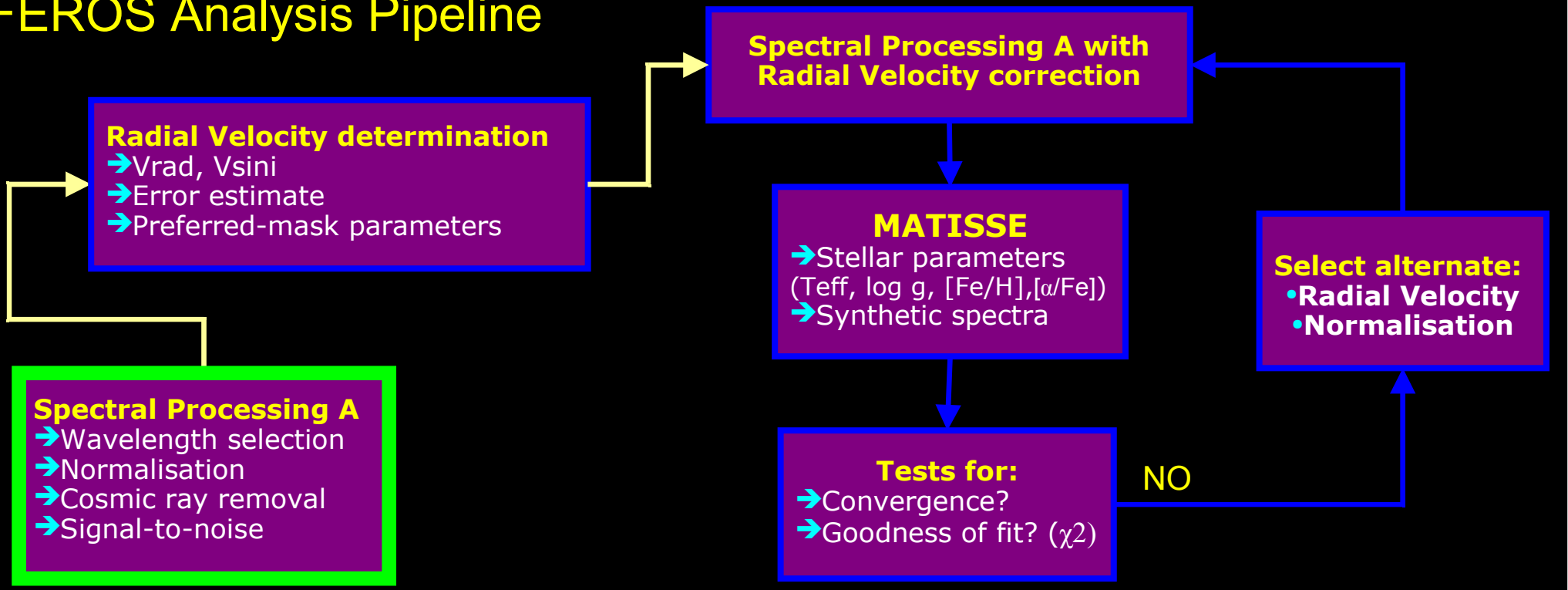
FEROS Analysis Pipeline

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

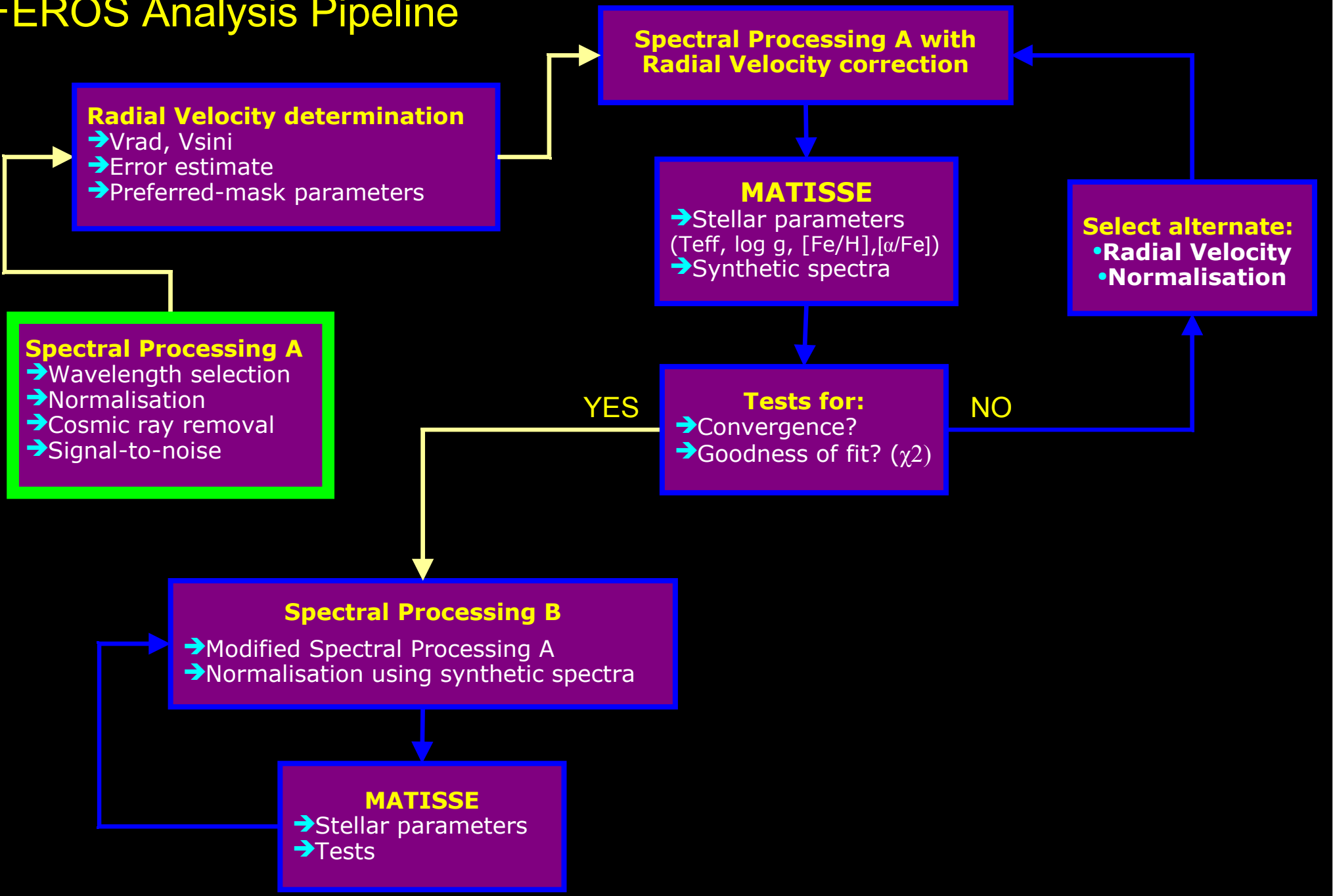
FEROS Analysis Pipeline



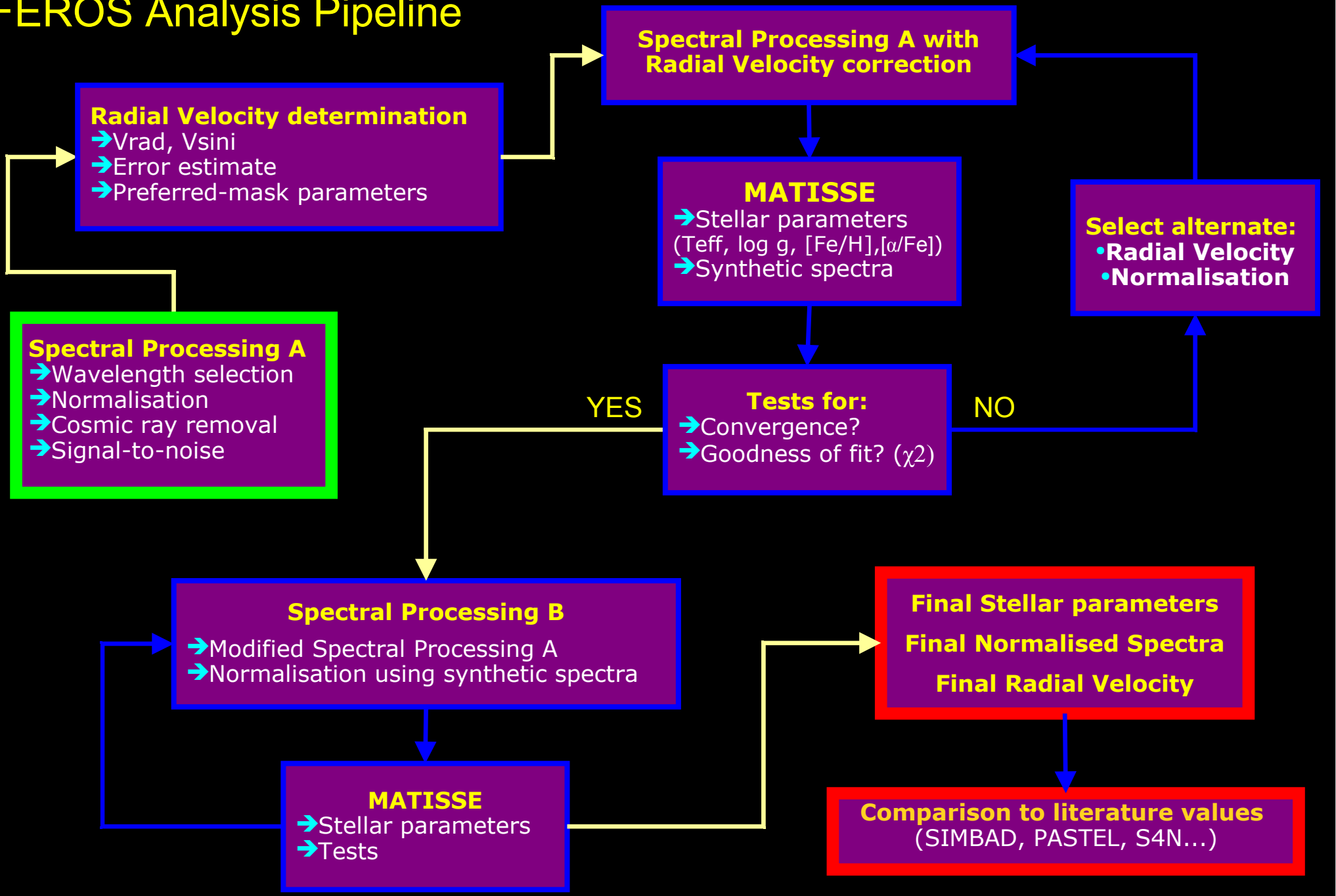
FEROS Analysis Pipeline



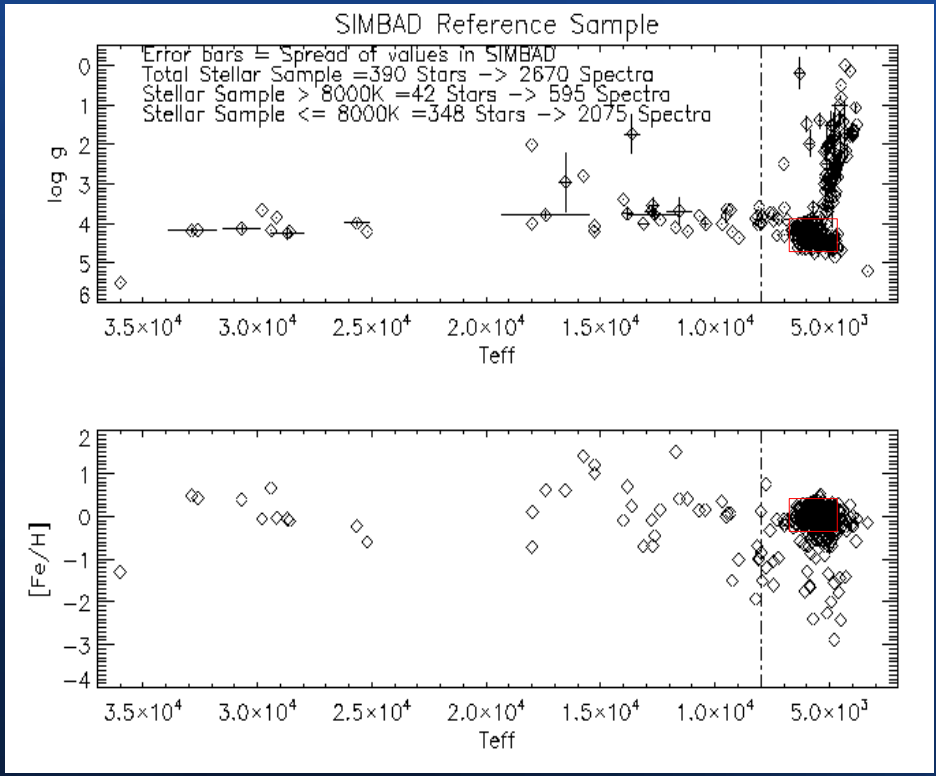
FEROS Analysis Pipeline



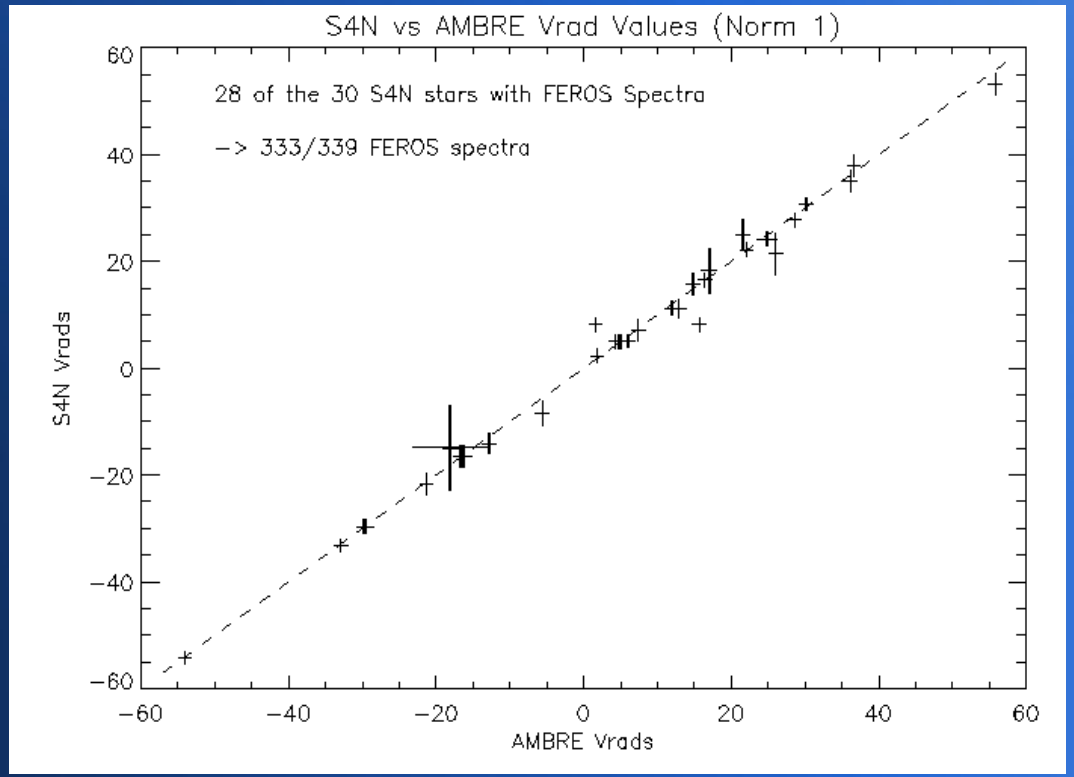
FEROS Analysis Pipeline



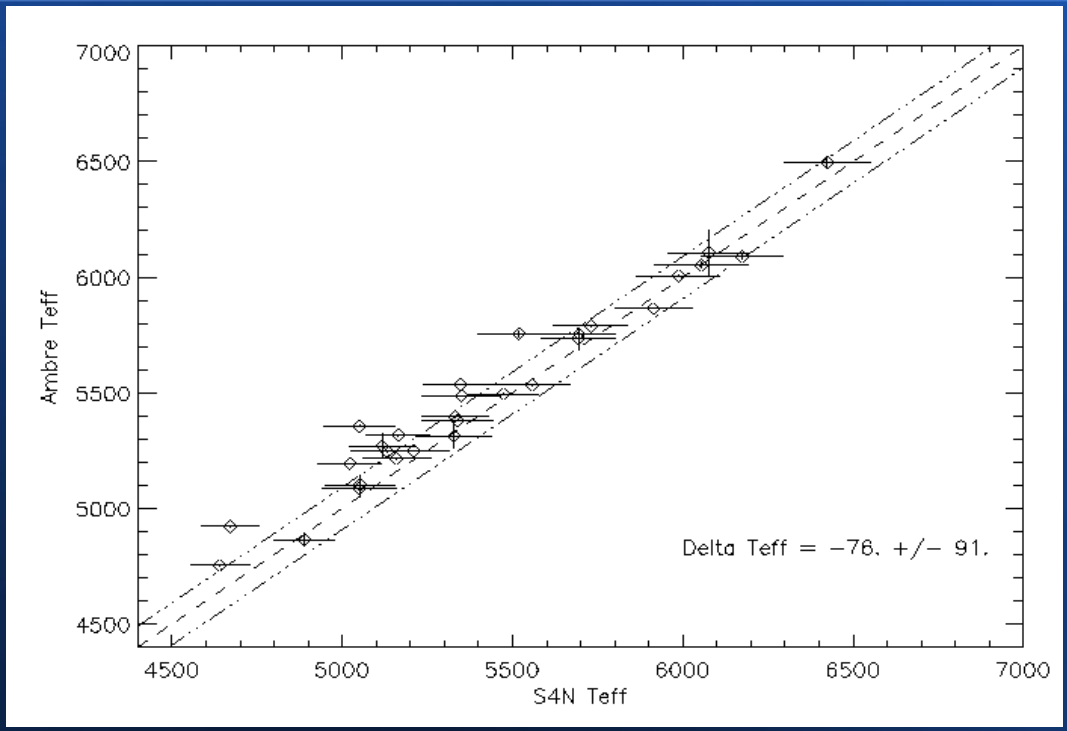
Comparison to Reference Samples

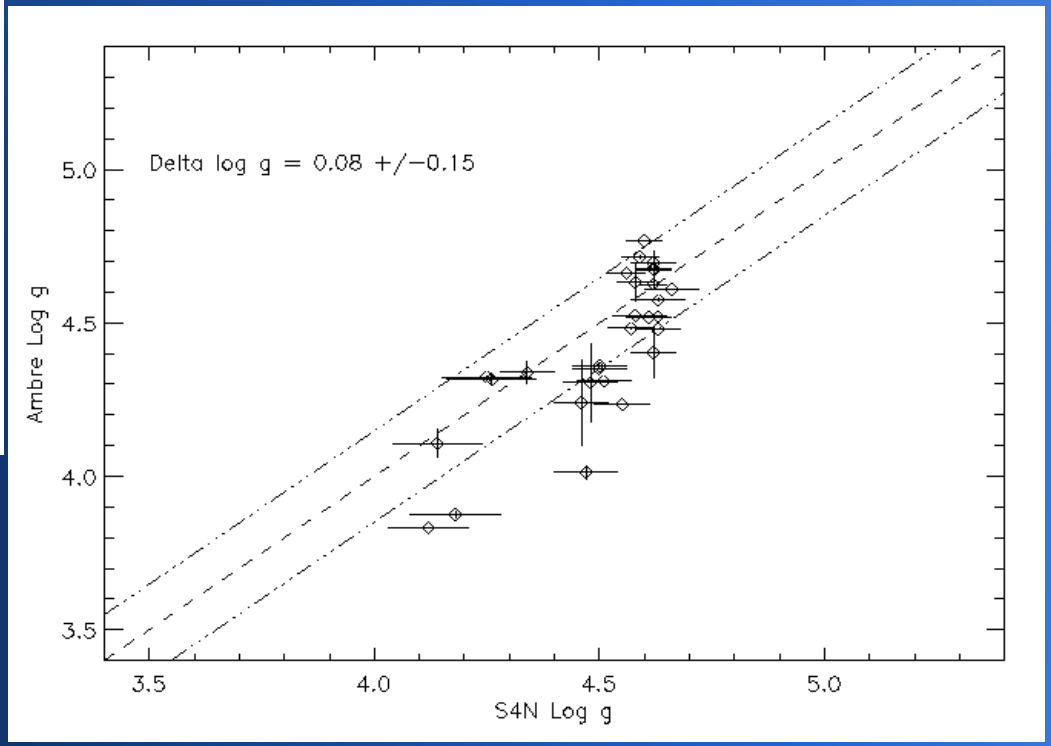


S4N Reference Sample: Allende-Prieto et al. 2004 (F & G dwarfs)

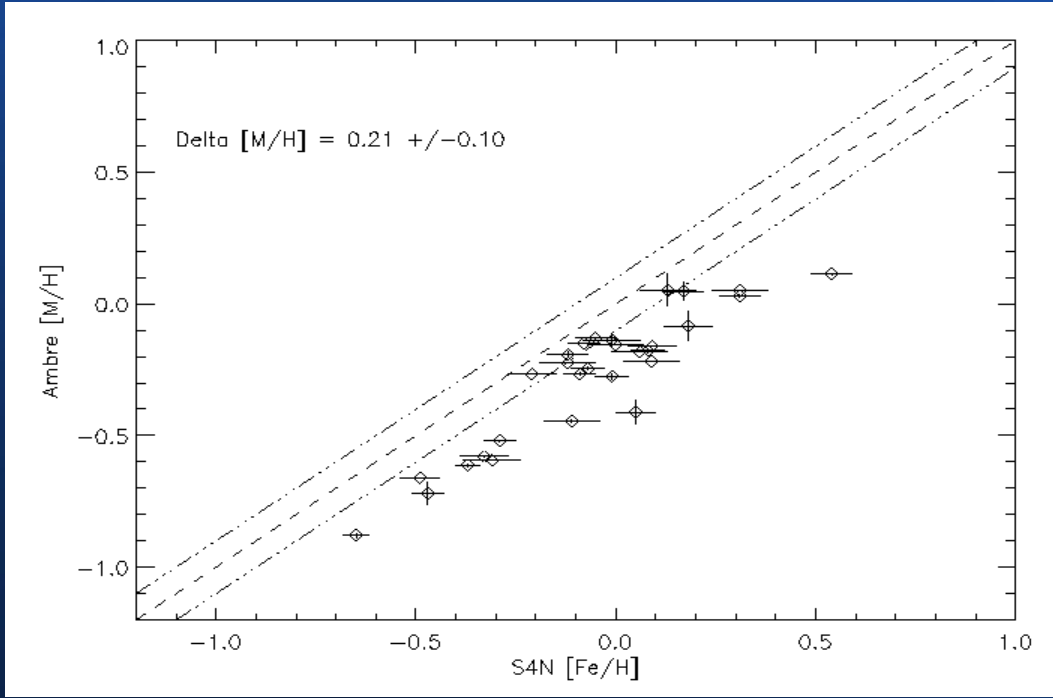


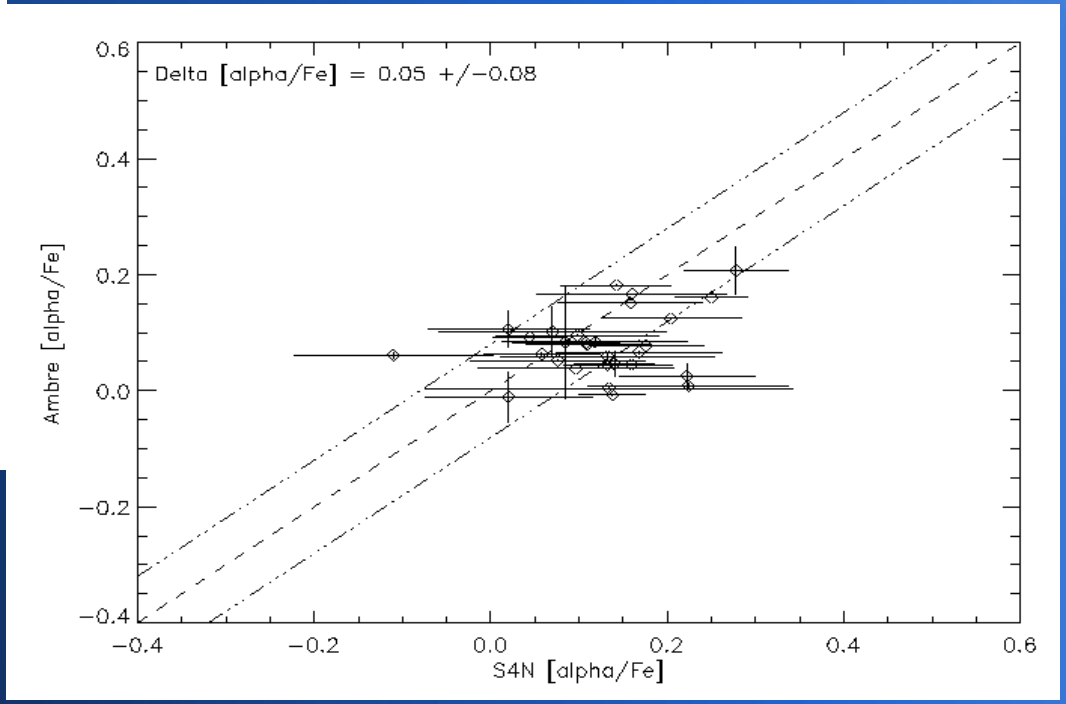
External Error Analysis: T_{eff} & log *g*





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/Fe]

  → Chemical labeling of FEROS sample

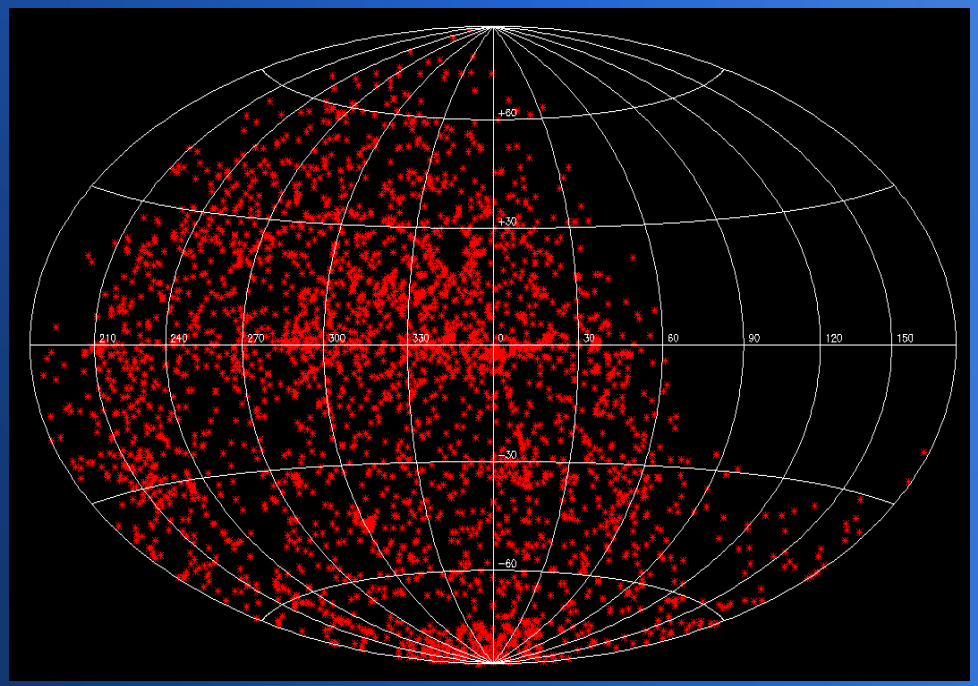
- FEROS high resolution spectra will yield light and heavy chemical abundances

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 ESO, Gaia and Galactic Archaeology

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

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

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 SF2A 2010
- Observatoire de la Côte d'Azur
- ESO
- CNES

FEROS Targets on the Sky