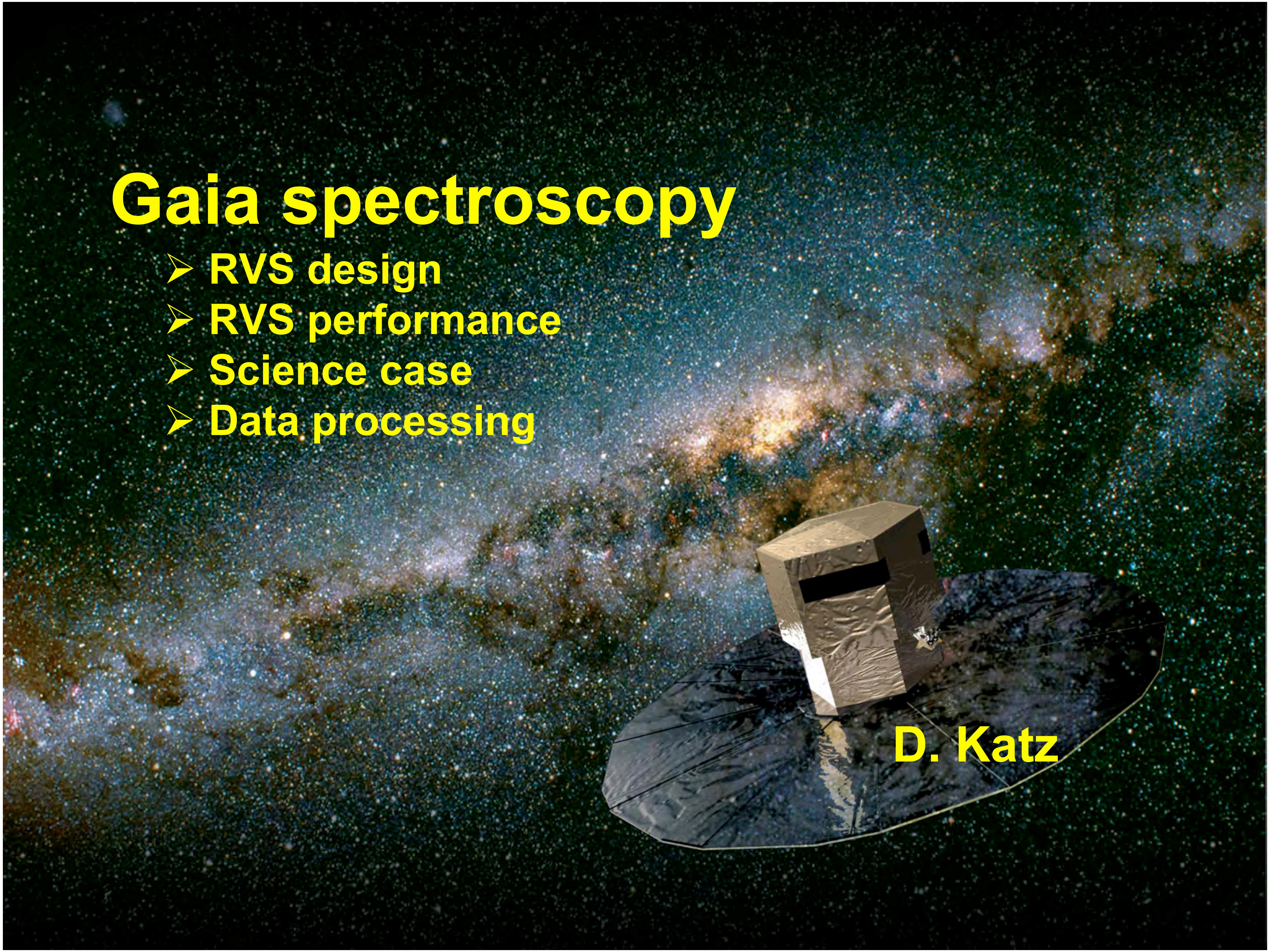


# Gaia spectroscopy

- RVS design
- RVS performance
- Science case
- Data processing

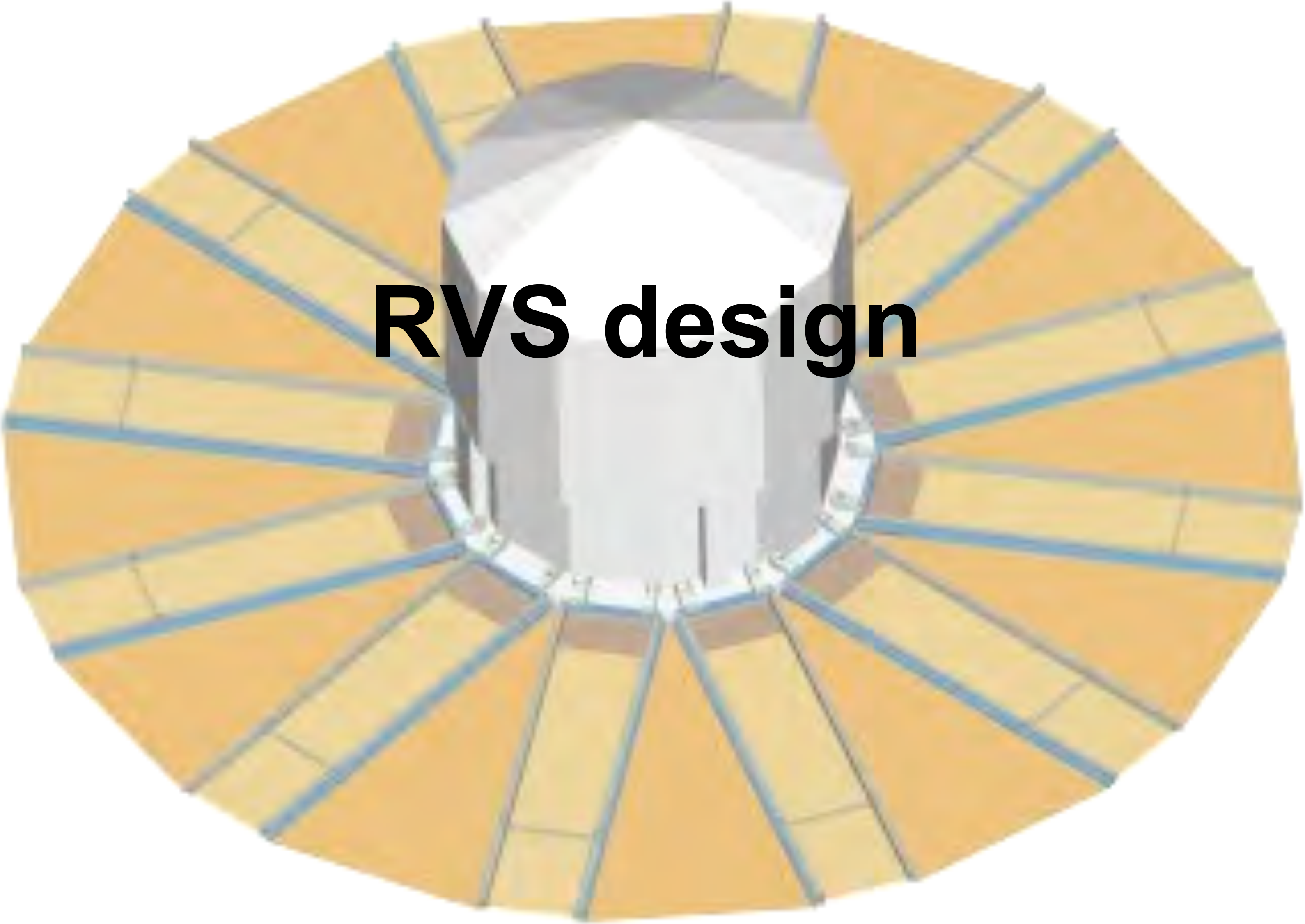
D. Katz


RVS
science case

# RVS science case

- **Radial velocities**
  - 3rd component of velocities: kinematical/dynamical history of the milky way
  - Binary and multiple systems
  - Correct astrometric data from perspective acceleration
- **Atmospheric parameters & abundances**
  - Chemical history of the milky-way
- **Interstellar reddening**
- **Stellar physics**
  - Rotational velocities
  - Variability, mass loss, …

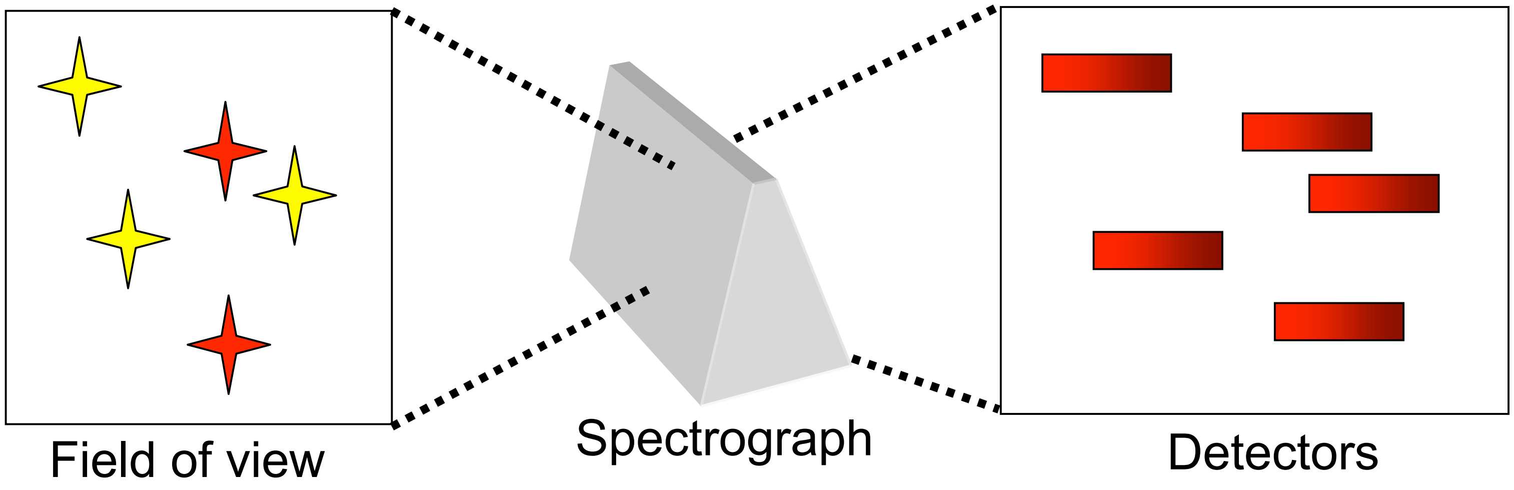
# RVS design



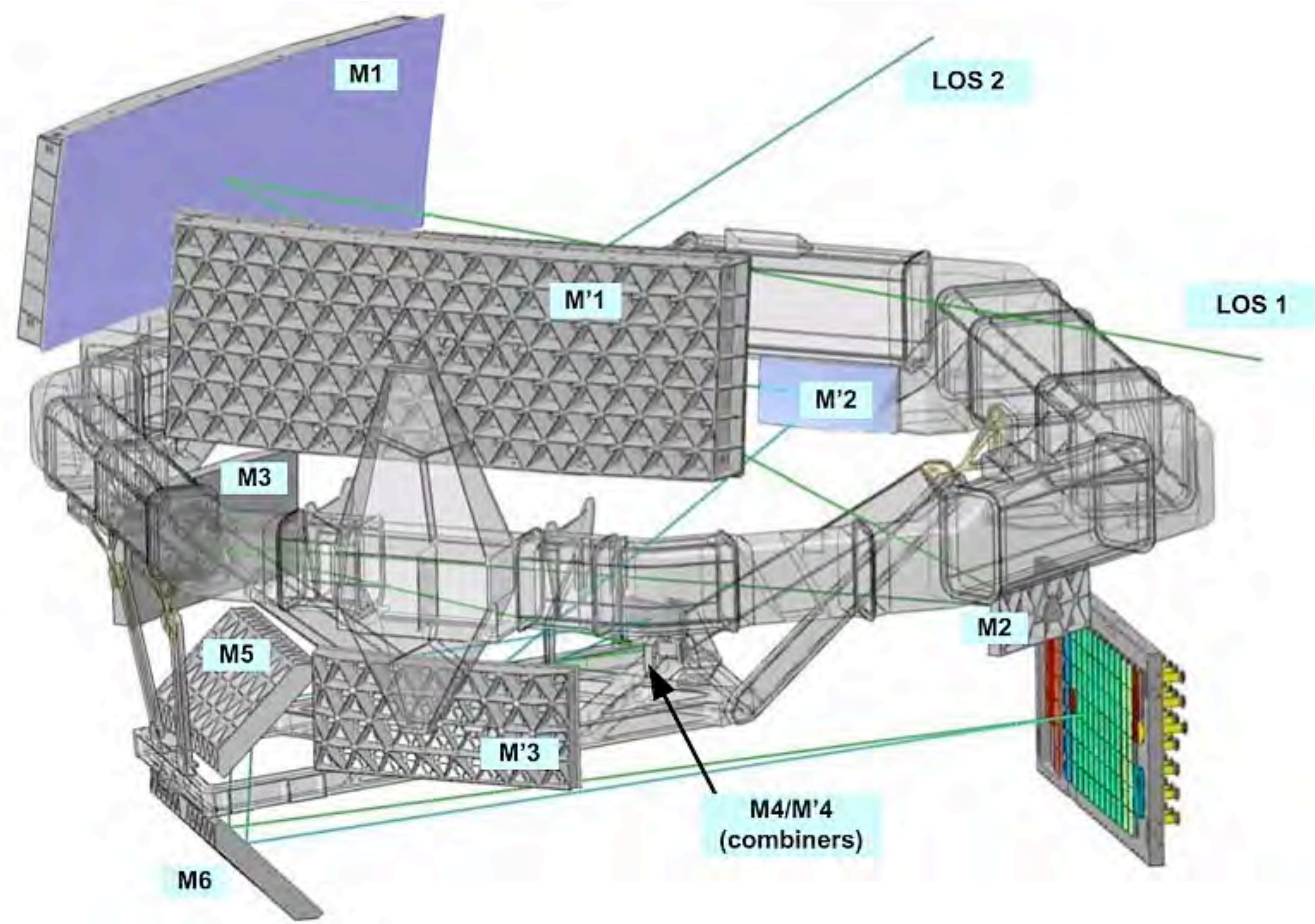
# RVS concept

- Integral field spectrograph
- Operated in Time Delay Integration scan mode
- Multi-epoch scan : **~40 observations** **(SCI-550)**
- Dispersive power : **10 500 < R < 12 500** **(SCI-520)**
- Wavelength range : **[8470 – 8740] A** **(SCI-480)**

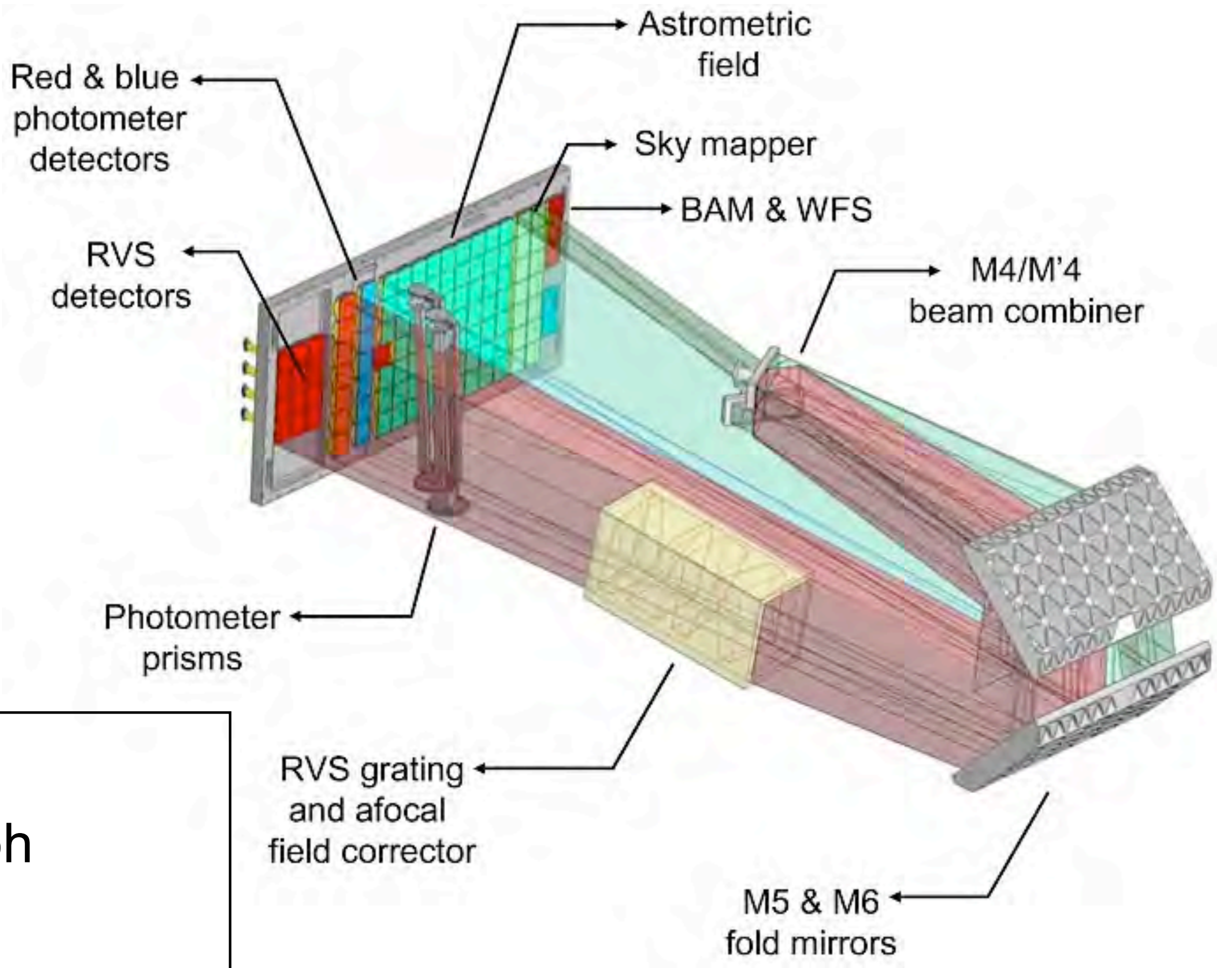
## Mission Requirements Document (MRD)
## GAIA-EST-RD-00553



# The RVS in the Payload



# RVS design

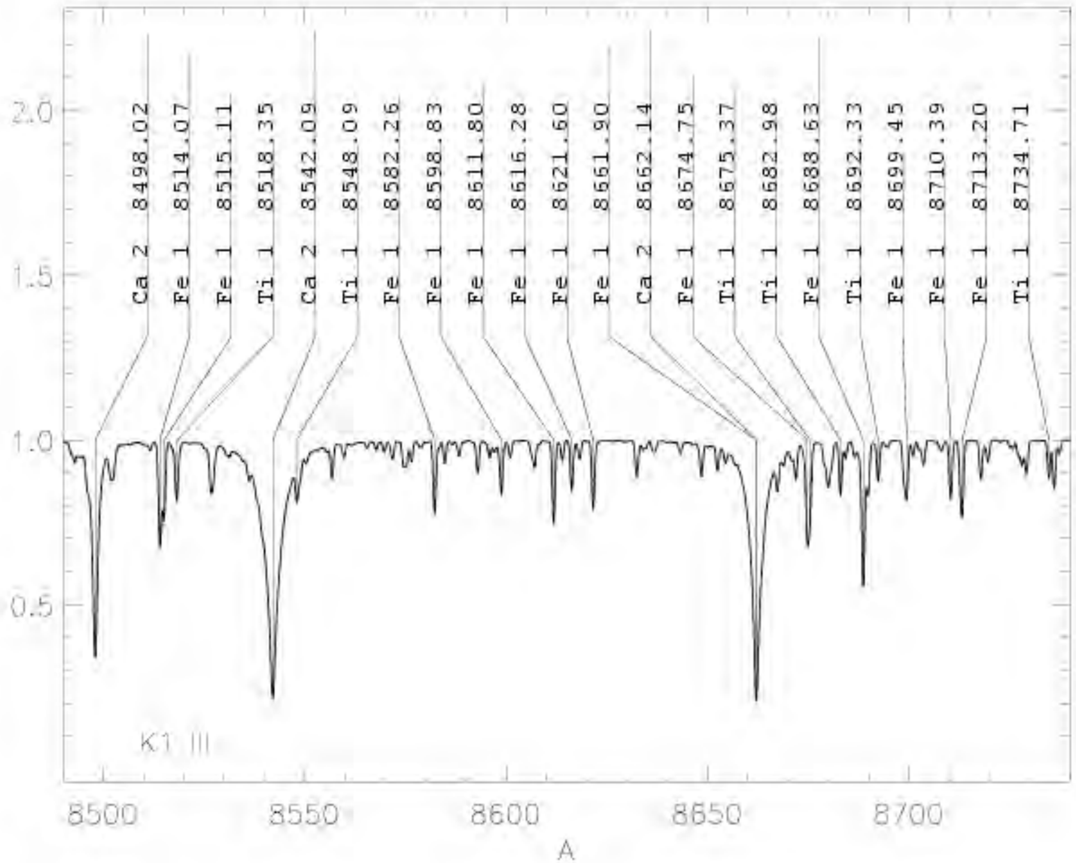


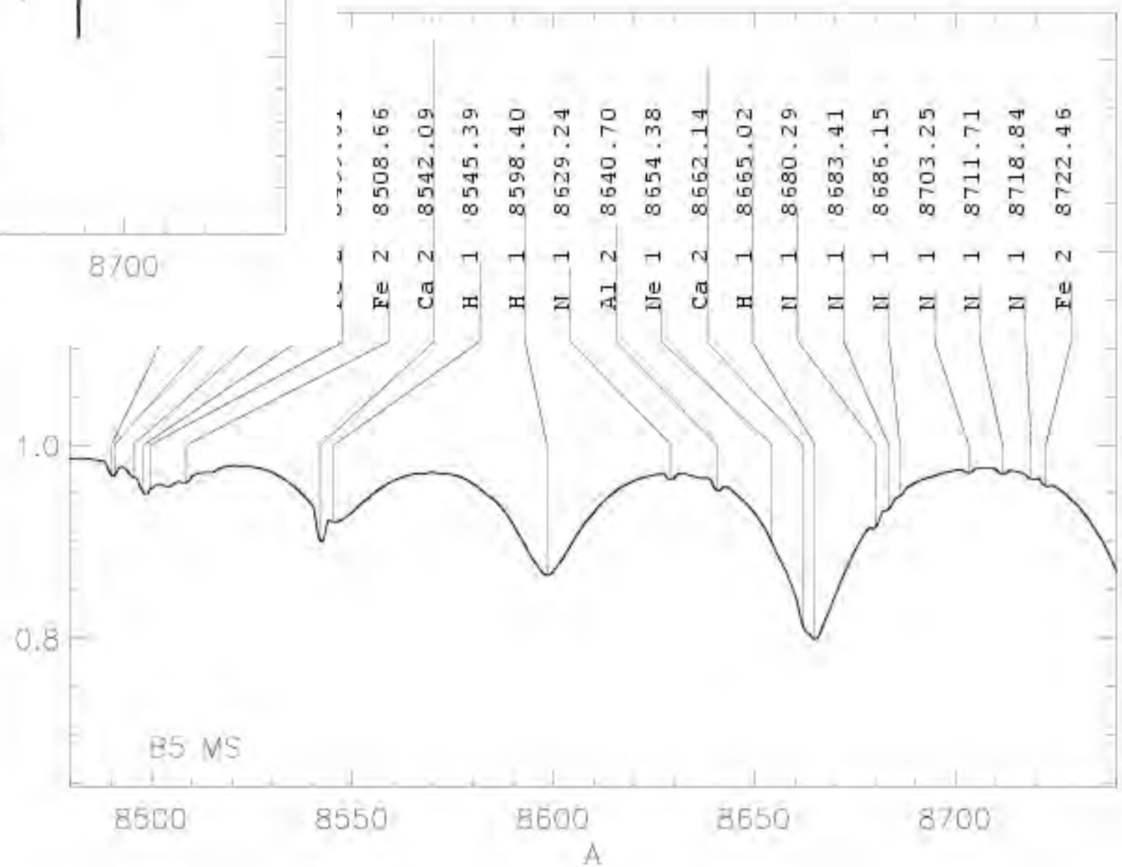

- **RVS instrument**
  - Dioptric spectrograph
  - N FoVs = 2
  - R ~ 11 500
  - λ in [847, 874] nm
  - FoV = 0.22 × 0.39 $deg^2$
  - Expos. = 4.42 s
  - N trans. = 40

# Focal plane

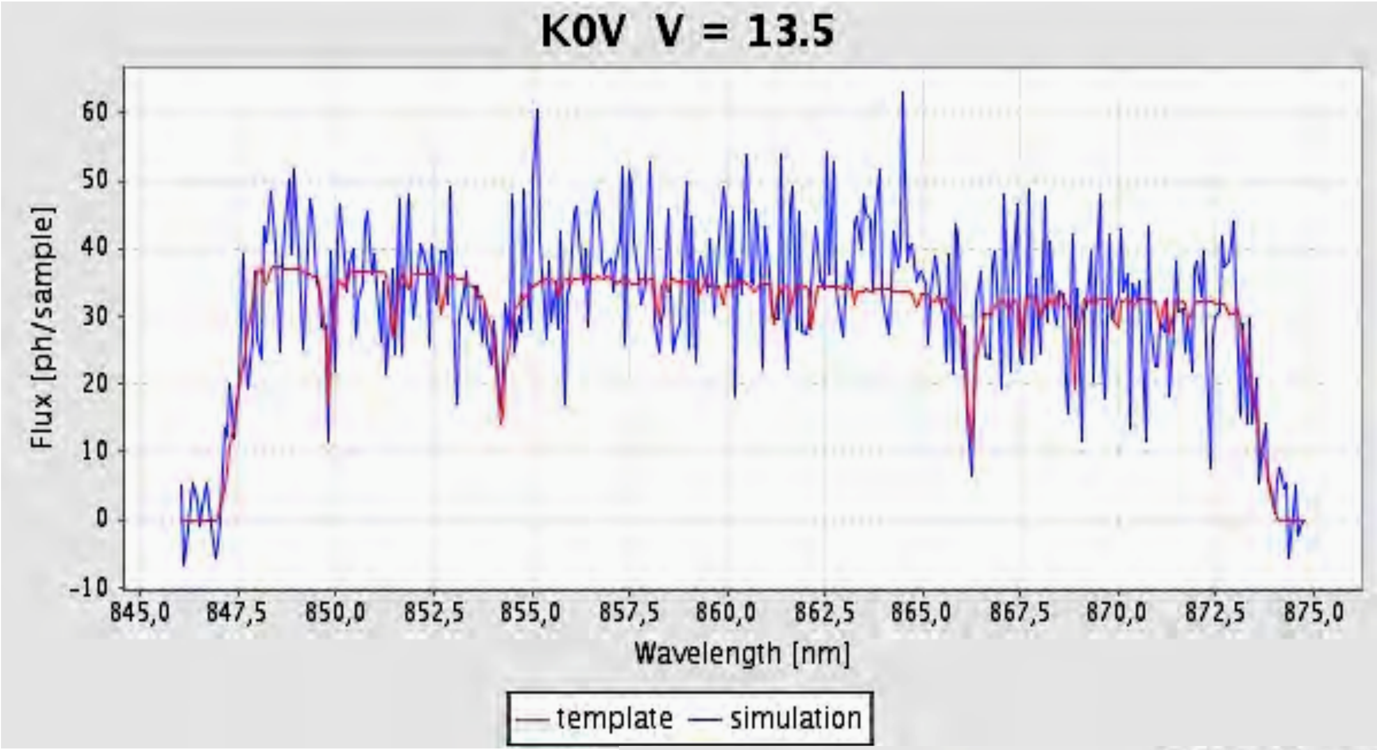

- N CCD = 3 (AL) × 4 (AC)
- CCD type = classical
- CCD = 4500 (AL) × 1966 (AC) pixels
- CCD read in windowed mode – no on-board co-addition

# RVS wavelength range

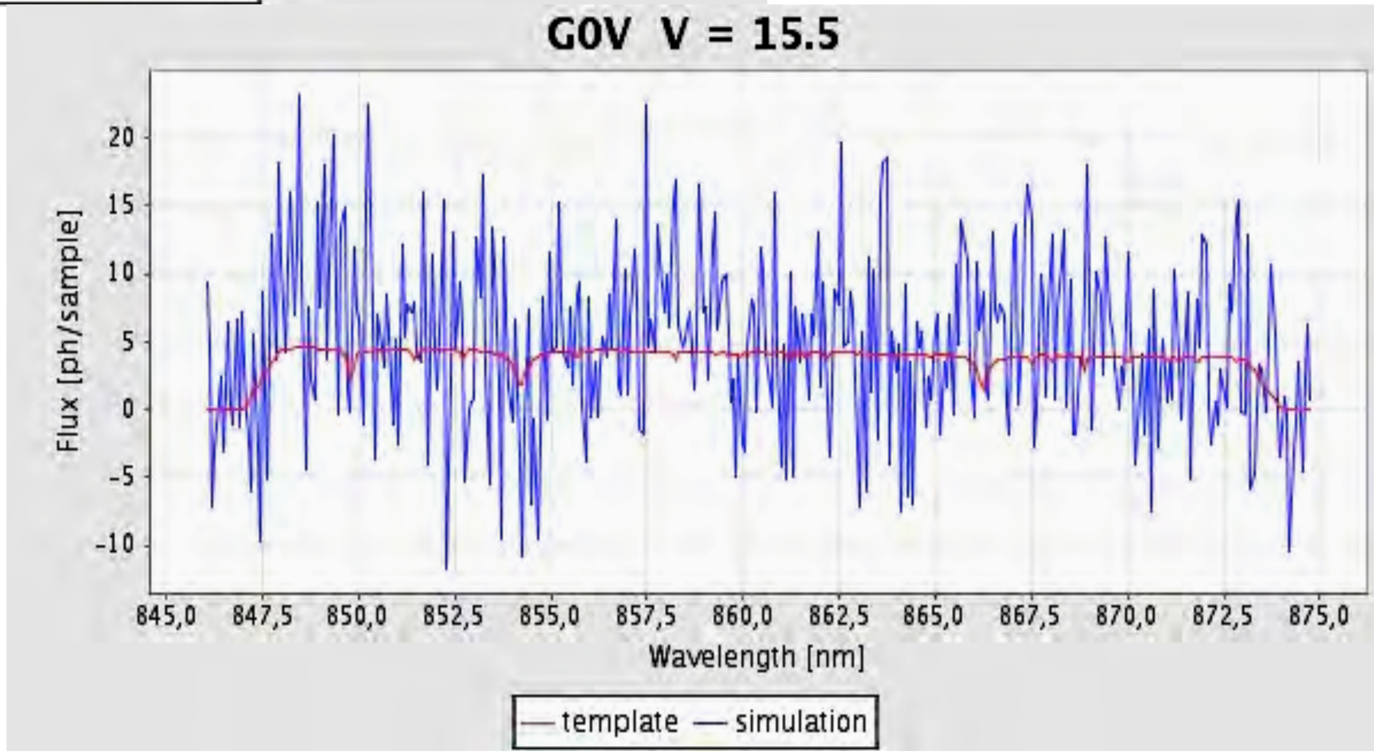


# RVS Spectra



K0V V = 13.5
Flux [ph/sample]
Wavelength [nm]
template
simulation

G0V V = 15.5
Flux [ph/sample]
Wavelength [nm]
template
simulation

# RVS performance

# Radial velocity performance
# Specifications – SCI-620

**End of mission: faint stars**

| | V | Vr (km/s) |
|---|---|---|
| ➢ B1V | 12 | 15 |
| ➢ G2V | 16.5 | 15 |
| ➢ K1IIIMP | 17 | 15 |

**End of mission: bright stars**

| | V | Vr (km/s) |
|---|---|---|
| ➢ B1V | 7 | 1 |
| ➢ G2V | 13 | 1 |
| ➢ K1IIIMP | 13.5 | 1 |

**The specifications are currently met.**

**Main unknown/threat: radiation damages**

# Expected scientific harvest

# Scientific harvest: a few examples

- **Halo streams and merger relics**

| | | |
|---|---|---|
| K2 III | → $\sigma V_r \le 10$ km/s | → ~15 kpc |

- **Milky Way mass & gravitational potential**

| | | |
|---|---|---|
| tip of the RGB | | → ~40 kpc |
| AGB / CH stars | | → ~50 kpc |

- **Spiral arms**

| | | |
|---|---|---|
| B stars | → $\sigma V_r \le 5$ km/s | → ~2 kpc |
| Cepheid | → $\sigma V_r \le 5$ km/s | → ~5-8 kpc |

# Scientific harvest: a few more examples

- **Milky Way chemical history**

  [α/Fe] → $2 \times 10^6$ stars → $V \leq 12$

  G2V → ~250 pc

  K0III → ~1.5 kpc

- **"Extreme" population II stars**

  K III → discriminate [Ca/H] = -4.0 and -3.0

  → ~4-8 kpc

# Scientific harvest: another few more examples

- **Binaries**

  ~500 000 spectroscopic binaries

  ~50 000 eclipsing binaries (~25% SB 2 → masses)

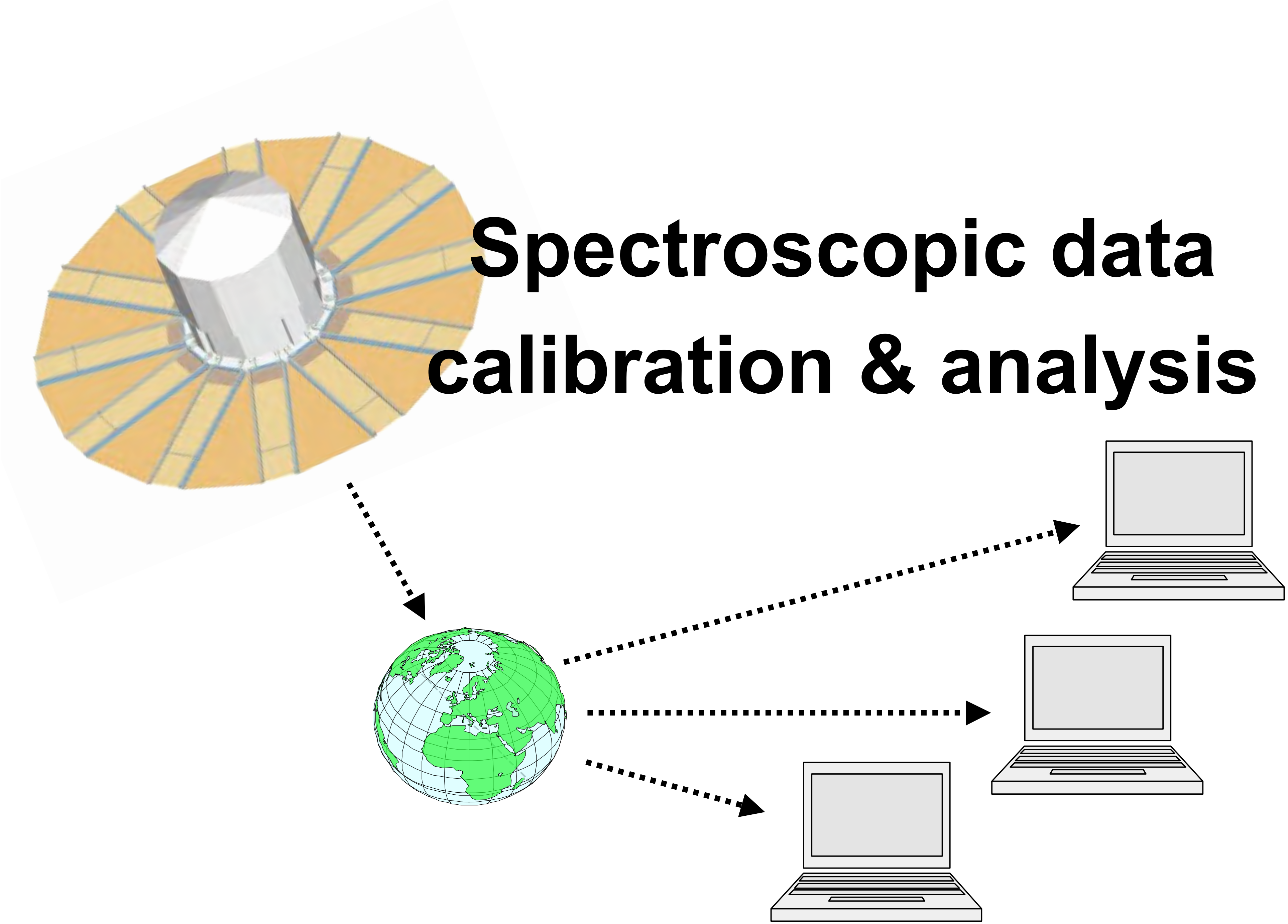
- **Variable stars**

  "Long" period classical Cepheids

  → $\sigma V_r \leq 7$ km/s → ~15-30 kpc

**… and much more in**
**Wilkinson et al., 2005, MNRAS, 359, 1306**

# Spectroscopic data calibration & analysis



# CU6 objectives

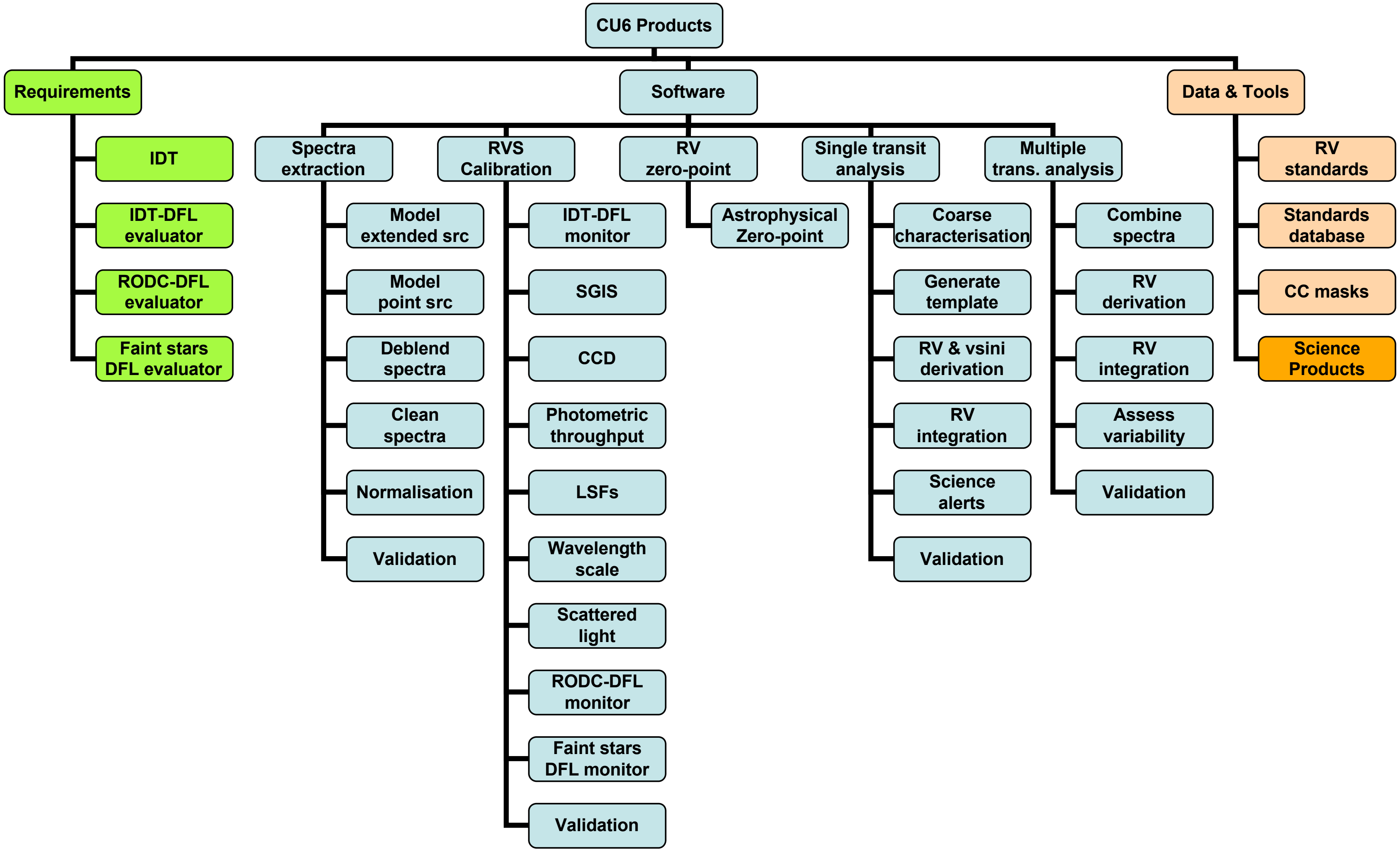
- **CU6 is in charge of the processing of the spectroscopic data provided by the Radial Velocity Spectrometer (RVS)**

- **Main goals**
  - ✓ Extract and clean the RVS spectra
  - ✓ Calibrate the RVS instrument characteristics
  - ✓ Monitor the RVS good-health (under CU3 coordination)
  - ✓ Derive the radial velocities
  - ✓ Derive the rotational velocities
  - ✓ Flag potential multiple and variable sources
  - ✓ Provide cleaned-calibrated-rest-frame spectra

# CU6 group

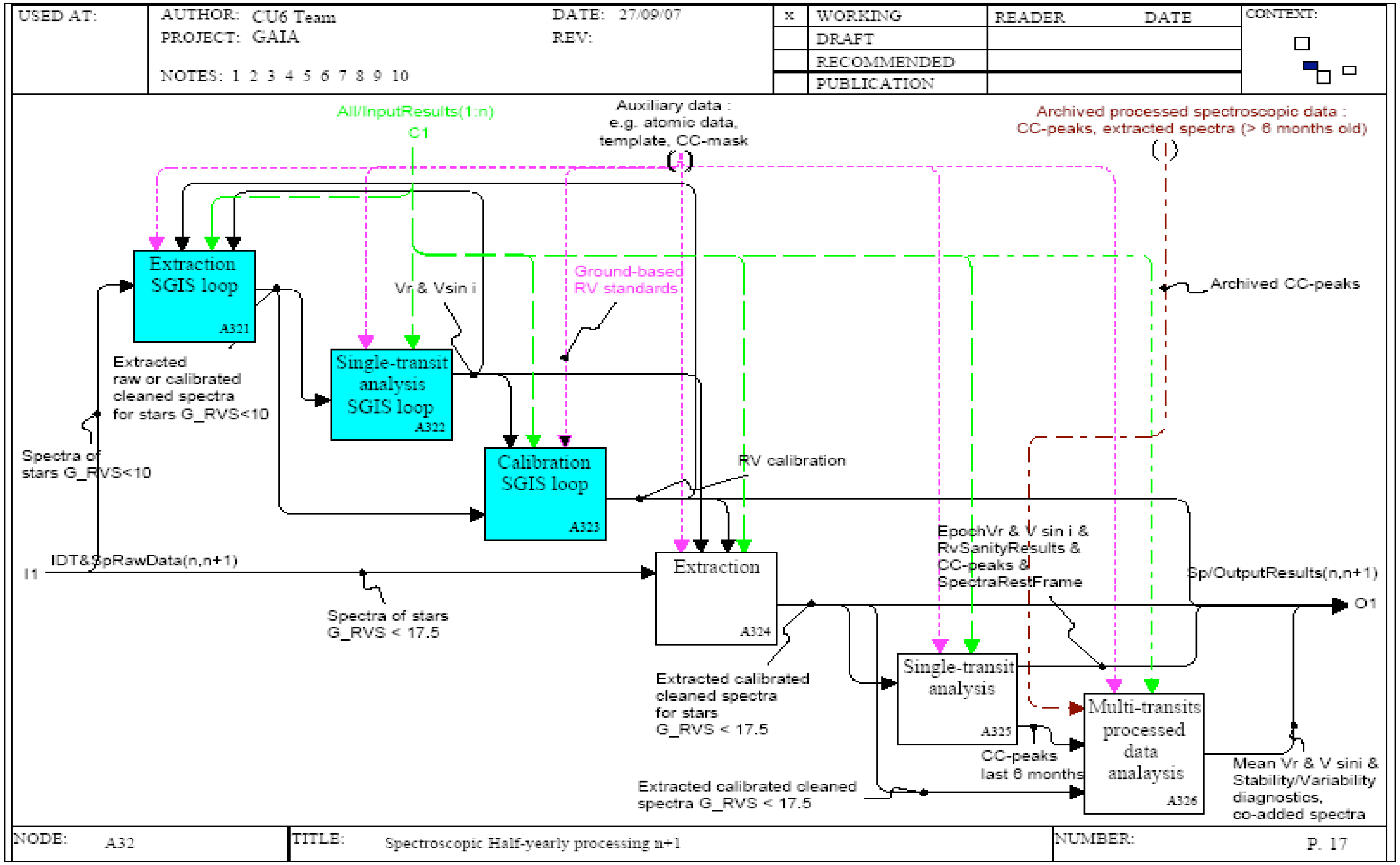
- **Under French responsibility**
  - ✓ Coordinator & Technical coordinator
  - ✓ 5 / 6 members of the steering committee
- **60 members**
  - ✓ 50% French members
- **14 Institutes**
  - ✓ 6 French institutes
- **Spectroscopic processing centre: CNES**

# CU6 tasks




## Software Development Plan (SDP)
## GAIA-C6-PL-OPM-DK-003-03

# Spectroscopic processing




## CU6 Software Requirements Specifications (SRS)

## GAIA-C6-SP-CNES-AJA-001-01

**Thank you for your attention**

**Questions ?**

# Performance: radial velocities (2)
# Crowded fields

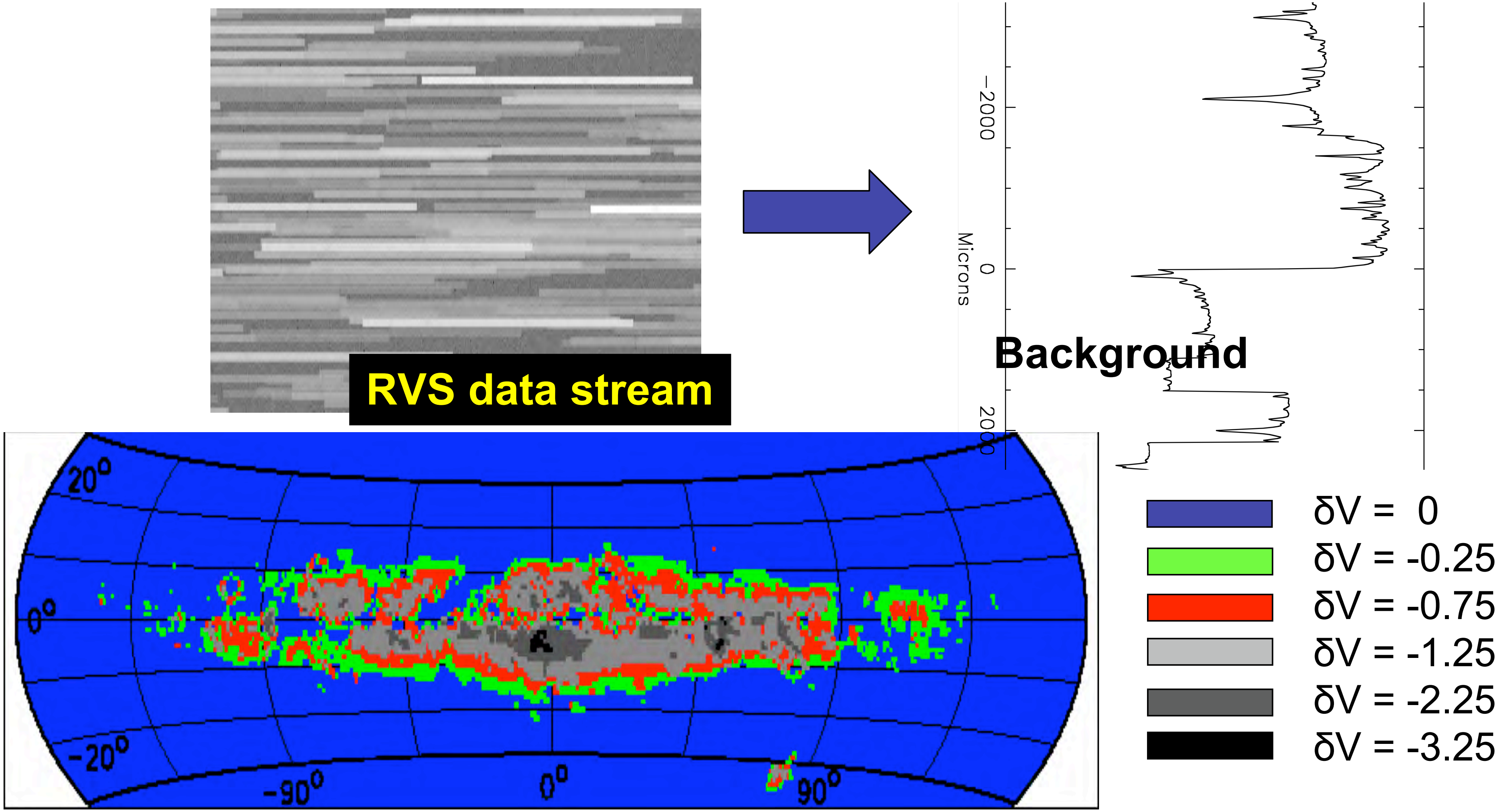


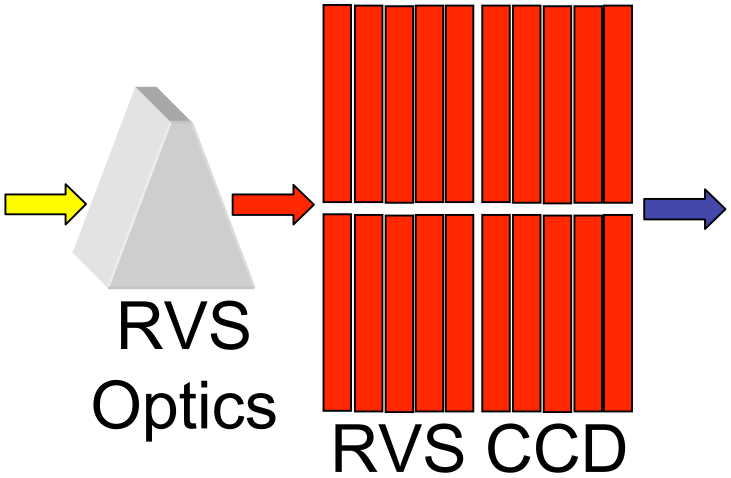

**Figure by courtesy of M. Wilkinson and A. Vallenari based on a study by T. Zwitter (Zwitter, 2003, Monte-Rosa proc., p493)**

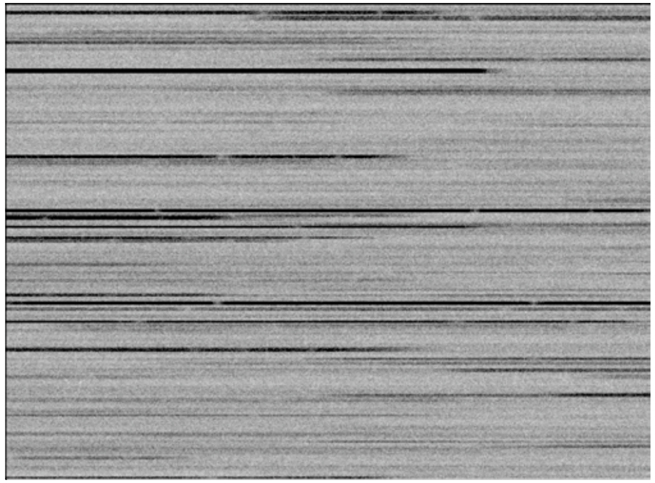
# RVS observations

http://www.mssl.ucl.ac.uk/gaia-rvs/simulator.html

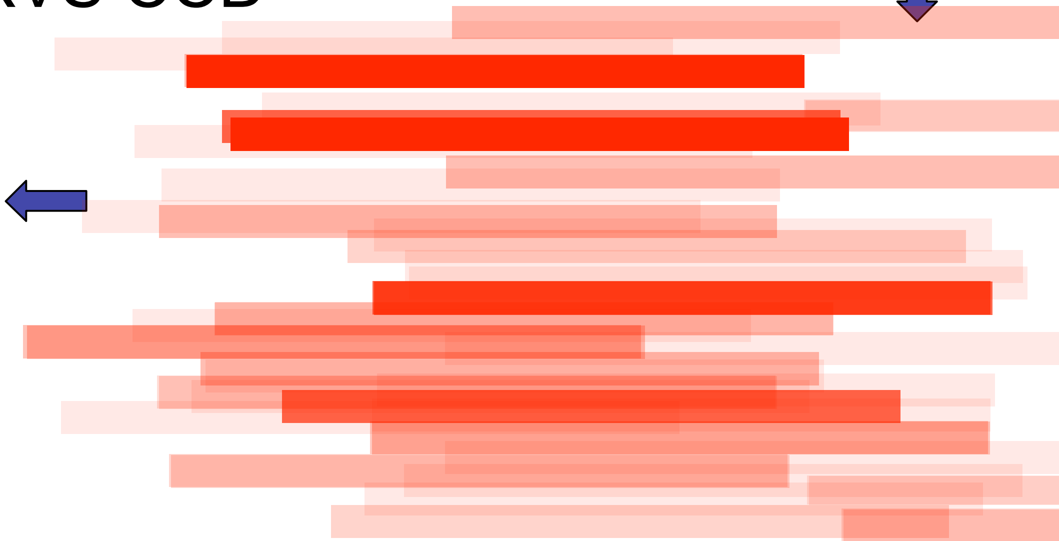
Low/intermediate density fields
High density fields

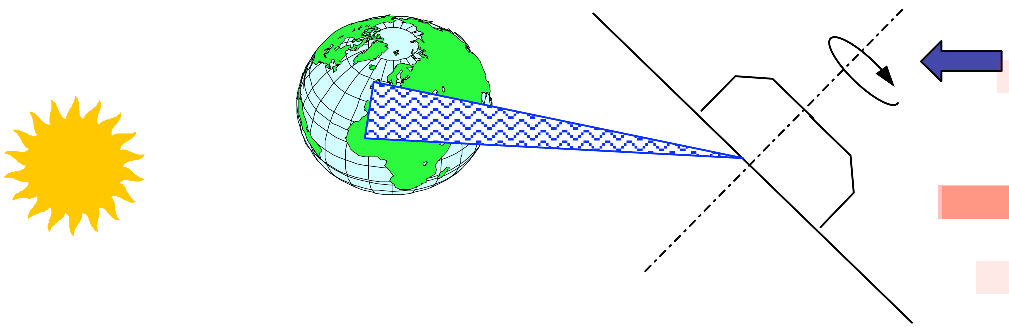
MSSL simulator



With threshold





# Spectroscopic survey

- **Stellar and interstellar parameters**
  - Radial velocities **V≤17-18 ~ 100-150 $10^6$**
  - Rotational velocities **V≤15-16 ~ 25-50 $10^6$**

    **(Gomboc & Katz – session 5)**
  - Atmospheric param. **V≤14-15 ~ 10-25 $10^6$**

    **(Recio-Blanco et al. – session 5)**
  - Abundances **V≤12-13 ~ 2-5 $10^6$**

    **(Recio-Blanco et al. – session 5)**
  - Interstellar reddening **V≤15 from 862 nm DIB**

    **(Vidrih & Zwitter – session 2) (Munari, 1999, Balt. Astr.,8,73)**

- **Diagnostics**
  - Binarity/multiplicity, variability, …

# Data calibration & analysis

- **Very large number of sources** (spectroscopy ~$10^8$ stars, astrometry ~ $10^9$ stars)
- **Large number of epochs** (spectroscopy ~80 epochs/star)
- **Large variety of information** (Astrometry, 15 photometric bands, spectroscopy)
- **Very large variety of objects** (all stages of stellar evolution, peculiar & variable stars, binary & multiple systems, solar system objects, galaxies)

↓

## Very complex analysis

↓

- **Development of new, optimized & fully automated calibration & analysis methods**
- **Constitute libraries of "reference" data**

  (Stellar evolutionary tracks, Atomic & molecular parameters, Synthetic & observed spectra)

# Calibration: Global Iterative Solution

- Continuous scan of the sky during 5 years
- 100 – 150 $\times 10^6$ stars observed
- ~80 epochs per star (on average)
- Optically and mechanically extremely stable

**Global iterative self calibration**

**Iteratively:**

- **Characterize the stars** (e.g. radial velocities)
- **Select a sample of "well behaved" stars**
- **Calibrate the instrument** (e.g. spectral dispersion law)

- Use standard stars to fix the RV zero point