# Gaia spectroscopy overview and synergy with ground-based surveys

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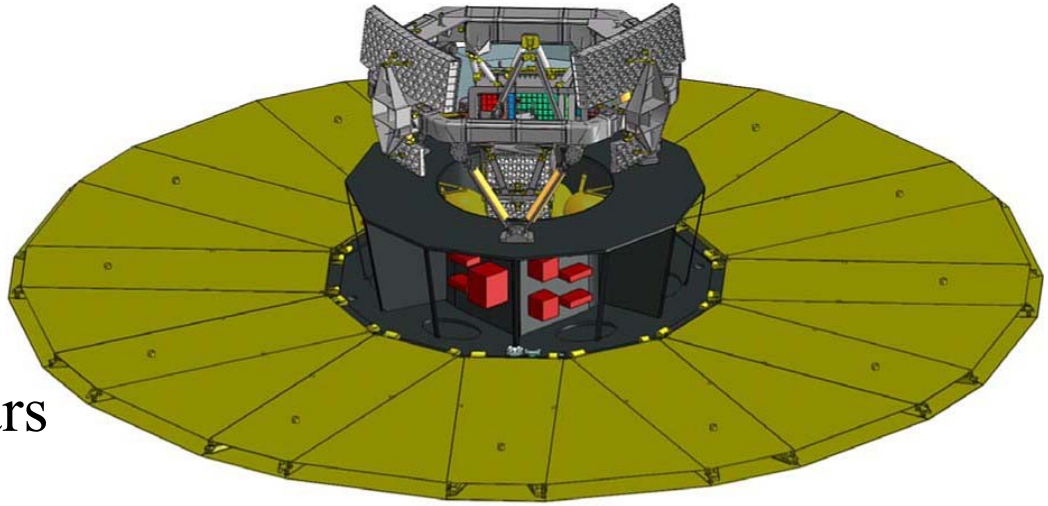
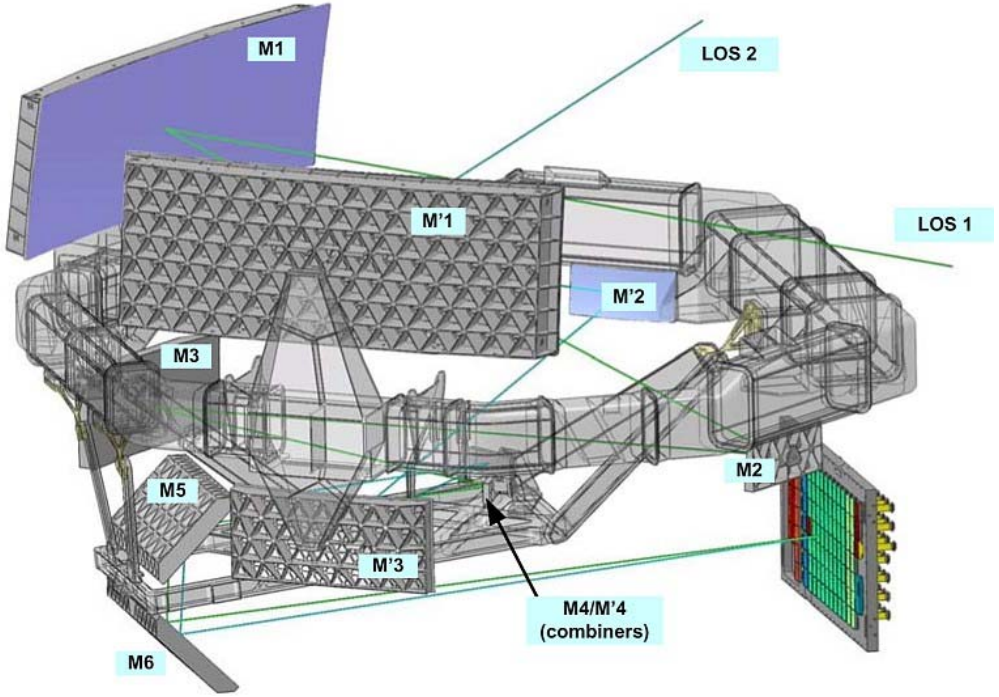
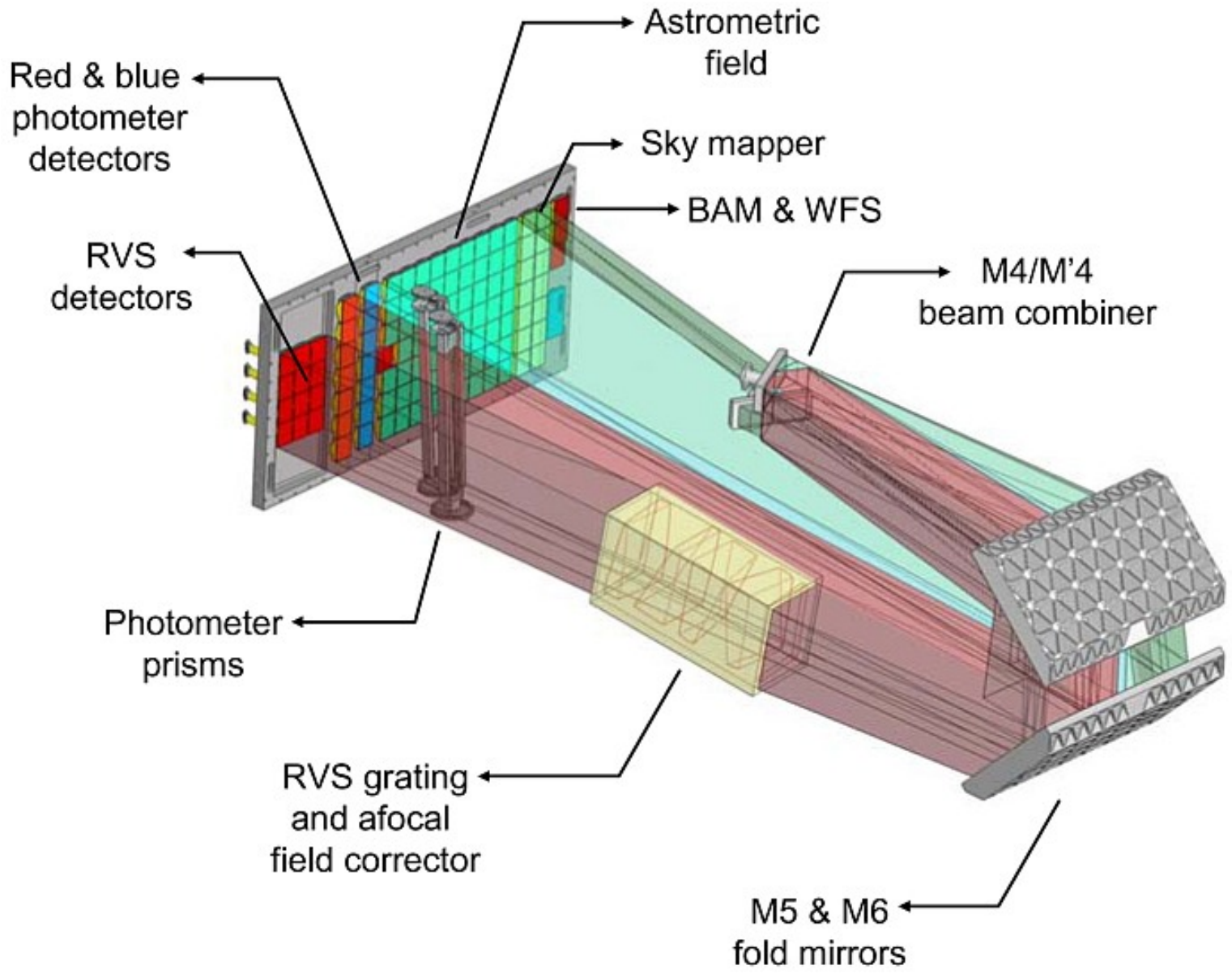
# Gaia mission

- ESA Cornerstone
- Launch **March 2012**
- Mission duration: 5 + 1 years
- 2 lines of sight
- 1 focal plane
- 3 instruments:
  - ✓ Astrometric instrument
  - ✓ Spectro-photometer
  - ✓ Spectrograph: RVS



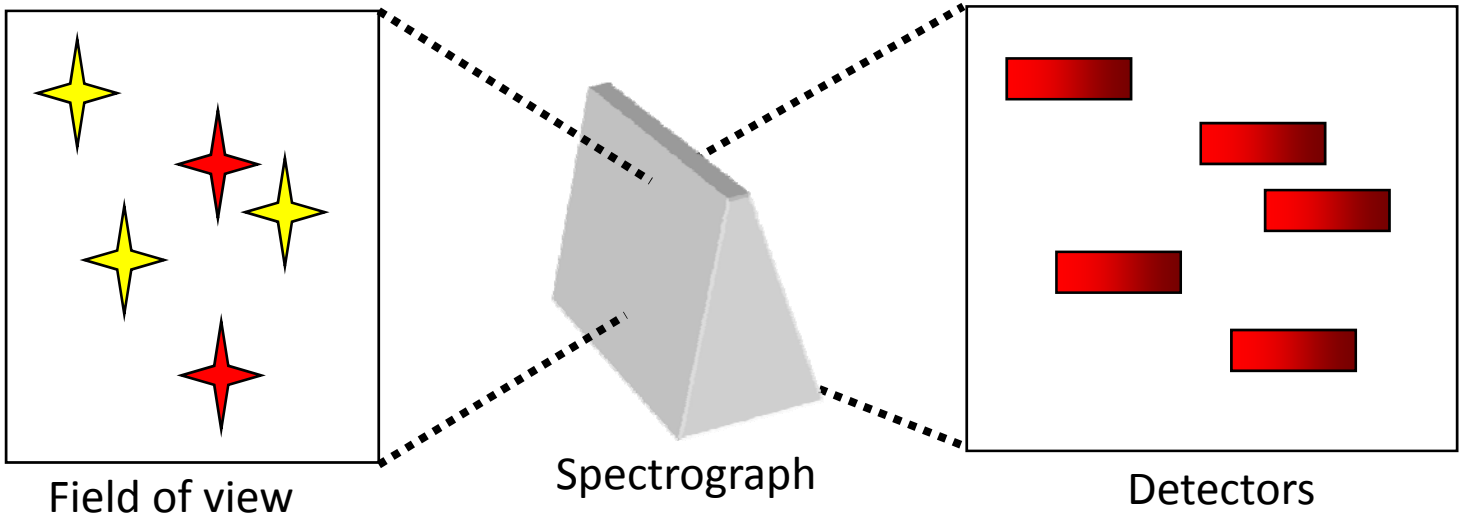


# The Gaia payload

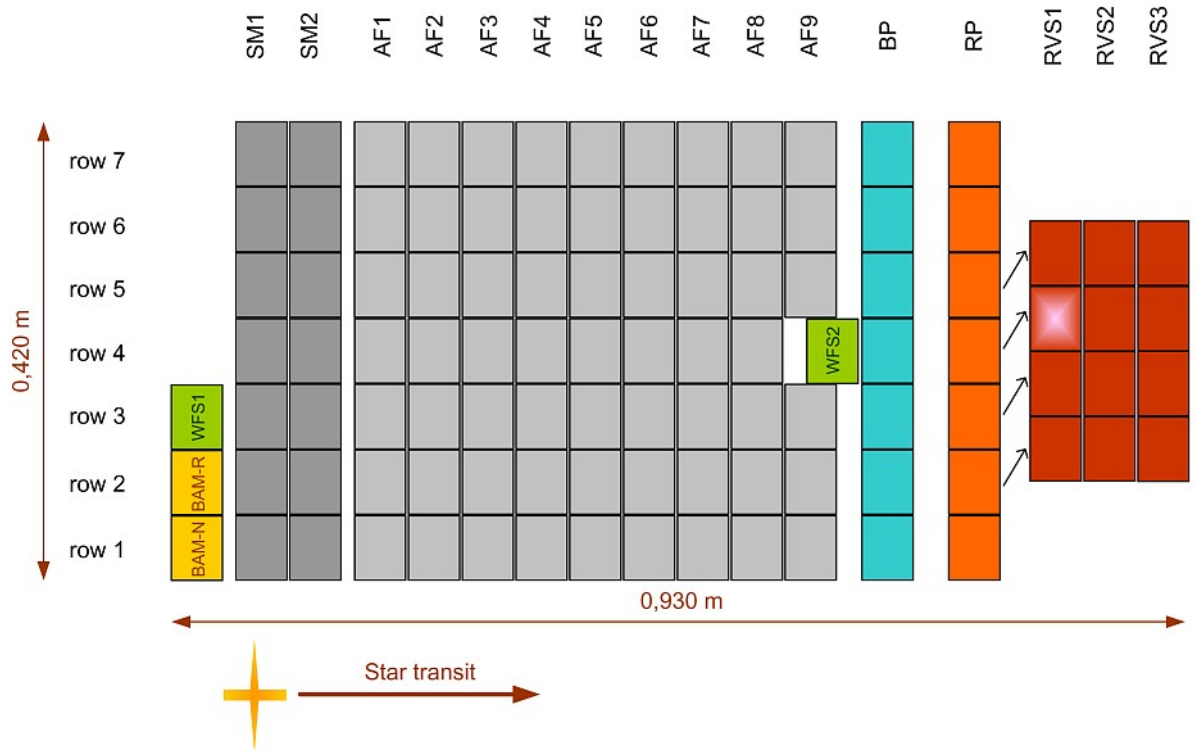


# RVS concept

- Integral field spectrograph
- Operated in Time Delay Integration scan mode
- Multi-epoch scan : **~40 observations** (on average)
- Dispersive power : **R = λ / Δλ = 11 500**
- Wavelength range : **[8470 – 8740] A**



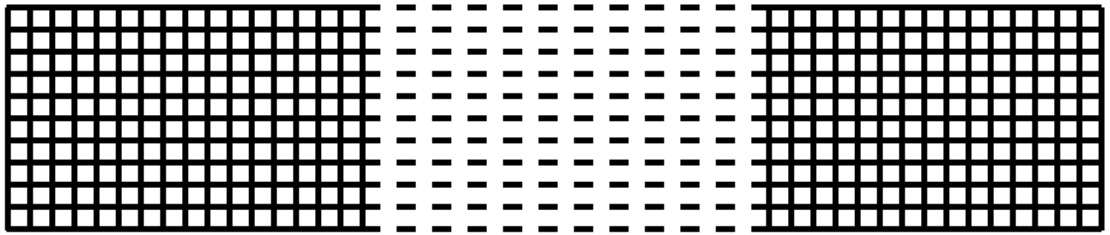
# The Radial Velocity Spectrometer




- 12 CCDs : 4500 (AL) × 1966 (AC) pixels per CCD
- FoV : $0.22 \times 0.39$ deg$^2$
- Exposure : 4.42 s per CCD
- 120 spectra per star over 5 years (on average). The faintests need to be combined for analysis.

# Windowing and Sampling

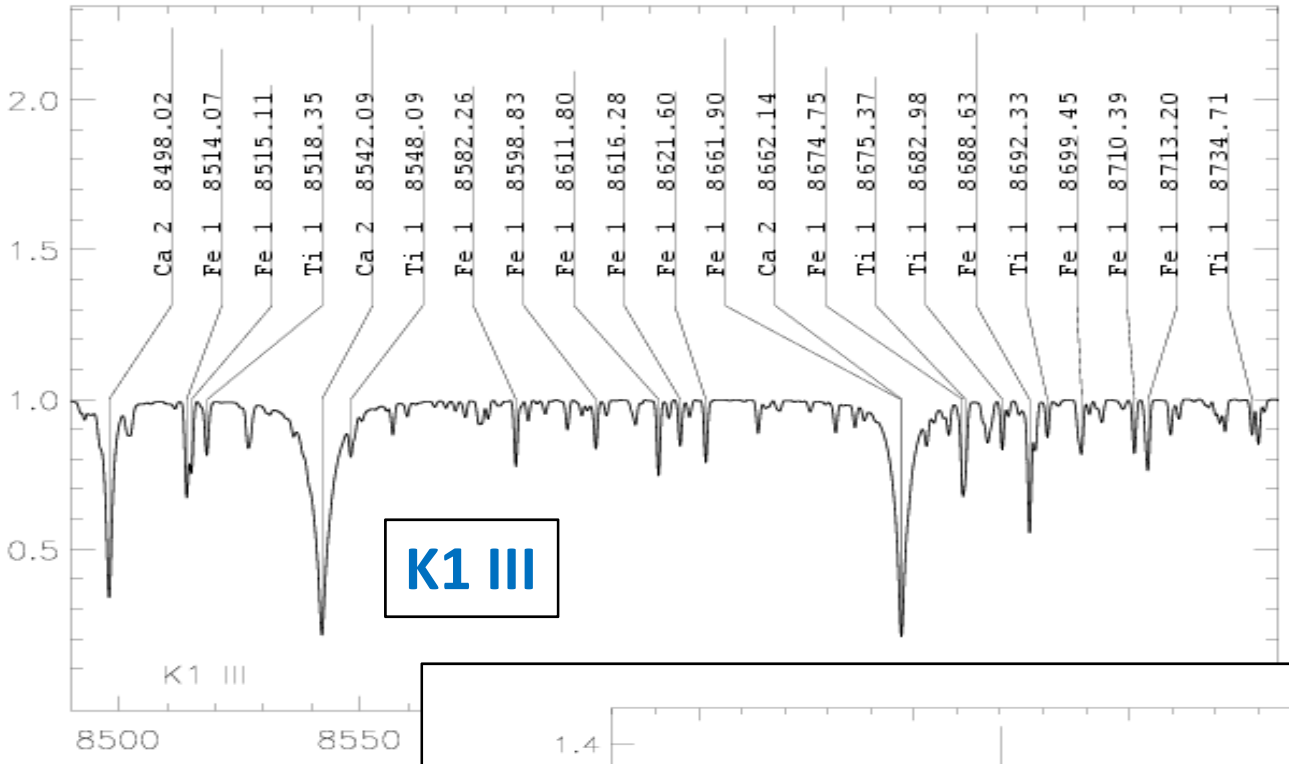
- **3 Sampling schemes**
  - ✓ $5 \leq G\_RVS \leq 7$
  - ✓ Calibration faint stars
  - ✓ 1260 × 10 samples (1 × 1)
  - ✓ 0.26 A/sample

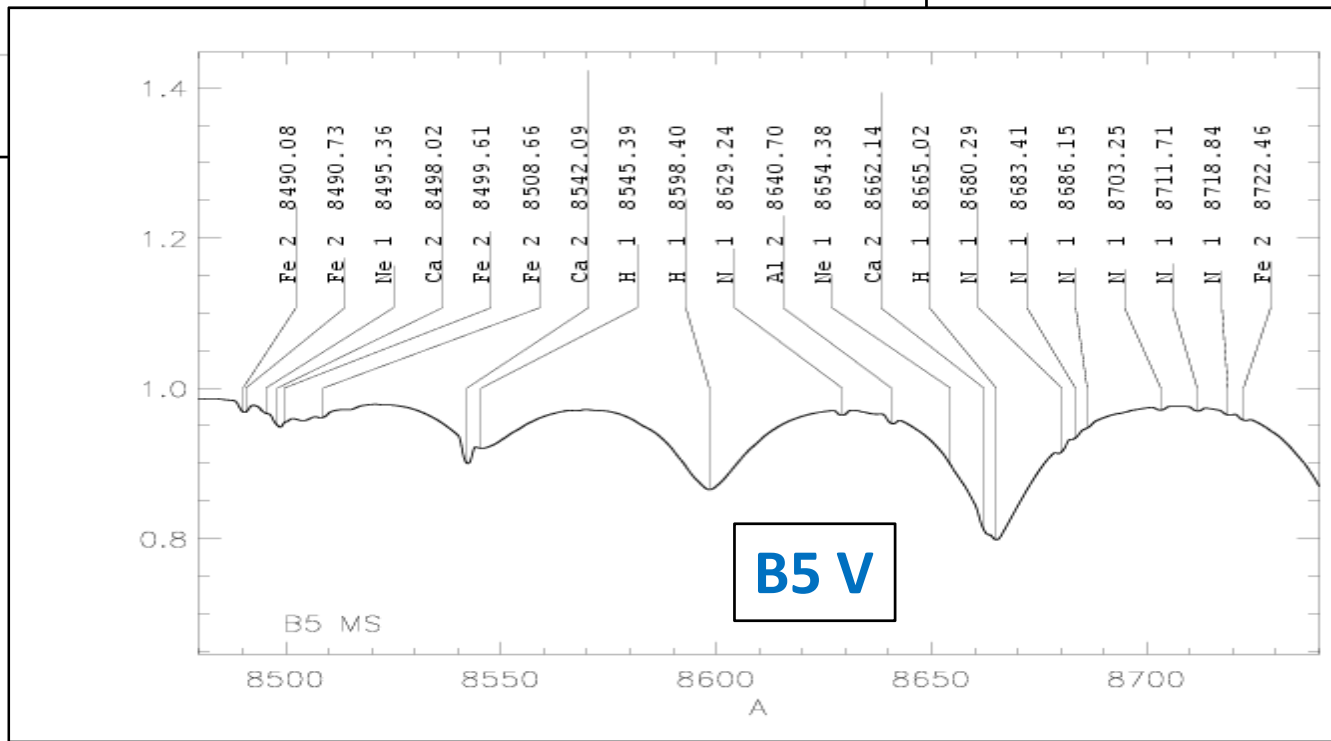


  - ✓ $7 \leq G\_RVS \leq 10$
  - ✓ 1260 × 1 samples (1 × 10)
  - ✓ 0.26 A/sample

  - ✓ $10 \leq G\_RVS \leq 17$
  - ✓ 420 × 1 samples (3 × 10)
  - ✓ 0.78 A/sample

  - ✓ Number of available windows allows to observe a maximum of 36 000 stars per square degree (i.e. 36 000 brightest stars per square degree)
  - ✓ Baade's window Vlim ~ 13-14


Ca 2 8498.02
Fe 1 8514.07
Fe 1 8515.11
Ti 1 8518.35
Ca 2 8542.09
Ti 1 8548.09
Fe 1 8582.26
Fe 1 8598.83
Fe 1 8611.80
Fe 1 8616.28
Fe 1 8621.60
Fe 1 8661.90
Ca 2 8662.14
Fe 1 8674.75
Ti 1 8675.37
Ti 1 8682.98
Fe 1 8688.63
Ti 1 8692.33
Fe 1 8699.45
Fe 1 8710.39
Fe 1 8713.20
Ti 1 8734.71
2.0
1.5
1.0
0.5
K1 III
8500
8550
K1 III


Fe 2 8490.08
Fe 2 8490.73
Ne 1 8495.36
Ca 2 8498.02
Fe 2 8499.61
Fe 2 8508.66
Ca 2 8542.09
H 1 8545.39
H 1 8598.40
N 1 8629.24
Al 2 8640.70
Ne 1 8654.38
Ca 2 8662.14
H 1 8665.02
N 1 8680.29
N 1 8683.41
N 1 8686.15
N 1 8703.25
N 1 8711.71
N 1 8718.84
Fe 2 8722.46
1.4
1.2
1.0
0.8
B5 MS
8500
8550
8600
8650
8700
A

**K1 III**

**B5 V**

# Vr specifications & S/N performance

## End of mission specifications

| | V | Vr km/s |
|---|---|---|
| B1V | 7 | 1 |
| B1V | 12 | 15 |
| | | |
| G2V | 13 | 1 |
| G2V | 16.5 | 15 |
| | | |
| K1 III MP | 13.5 | 1 |
| K1 III MP | 17 | 15 |

## G2 V

| V | S/N / transit | S/N / mission |
|---|---|---|
| 6 | 150 | 1000 |
| 10 | 20 | 150 |
| 12 | 8 | 50 |
| 14 | 2 | 10 |
| 16 | | 2 |

# Spectroscopic survey

- **Stellar and interstellar parameters**
  - Radial velocities — **V ≤ 17** — **~ 150 $10^6$**
  - Rotational velocities — **V ≤ 13** — **~ 5 $10^6$**
  - Atmospheric param. — **V ≤ 13** — **~ 5 $10^6$**

    **much fainter with spectro-photometer**
  - Abundances — **V ≤ 12** — **~ 2 $10^6$**
  - Interstellar reddening — **V ≤ 13** — **from 862 nm DIB**

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

# Scientific harvest

- **Halo streams and merger relics:** $\sigma Vr \leq 10$ km/s  K2 III ~ 20 kpc
- **MW mass/gravitational potential:** RGB tip ~50 kpc  AGB/CH stars ~60 kpc
- **Spiral arms:** $\sigma Vr \leq 5$ km/s  B stars ~ 2.5 kpc  Cepheid ~ 6-10 kpc
- **Chemical history:** [α/Fe]  $V \leq 12$  G2V ~250 pc  K0III ~1.5 kpc
- **"Extreme" pop. II stars:** K III: discriminate [Ca/H] = -4.0/-3.0  ~ 5-7 kpc
- **Binaries:** ~$10^6$ spectroscopic  ~$10^5$ eclipsing (~25% SB 2 → masses)
- **Variable stars:** "Long" period classical Cepheids: $\sigma Vr \leq 7$ km/s  ~20-40 kpc

**Wilkinson, Vallenari, Turon, Munari, Katz et al., 2005, MNRAS, 359, 1306**

# Synergy with ground-based surveys: Galactic kinematic & dynamic

## ➢ Improved precision/accuracy

- ✓ Vr = 1 (a few) km/s for 12-13 < V < 16-17 Disk studies
  - **Hermes: V < 14-15 (1.2 millions stars)**
  - **SEGUE (240 000) – LAMOST (2.5 millions)**

## ➢ Expend sample

- ✓ Vr < 10-15 km/s for V > 16 Halo, streams, mass, potential
  - **LAMOST: 17 < g < 20 (2.5 millions stars)**
- ✓ Observations in high stellar density areas
  - **Winered: bulge (1 million stars)**
  - **Apogee: disk/bulge (100 000 stars)**
  - **RAVE (several fields in the Galactic plane)**

## ➢ Future survey?

- ✓ 1 billion Vr survey: 13 < V < 20

# Synergy with ground-based surveys: Galactic chemistry

## ➢ Improved precision/accuracy

- ✓ Higher resolving power R > 30 000 - 40 000
  - **Winered (R=100 000) – Hermes (R=30 000) – Apogee (R=20 000)**
- ✓ Larger/different wavelength range (and R > 10 000)
  - **See below**

## ➢ Additional chemical species

- ✓ Larger/different wavelength range (and R > 10 000)
  - **Winered 0.9 – 1.35 µm – Apogee 1.52 – 1.69 µm – Hermes 370 - 950 nm**

## ➢ Expend sample

- ✓ Abundances V > 12
  - **Hermes (V<14-15) – Apogee (H<13.5) – Winered (?)**
- ✓ Observations in high stellar densities areas
  - **Winered (bulge) – Apogee (disk/bulge)**

## ➢ Future surveys?

- ✓ Multi-object R = 40 000 “Large wavelength range” (Hermes-like)