# 3D extinction maps of the MW solar neighbourhood with Gaia GSP-Spec

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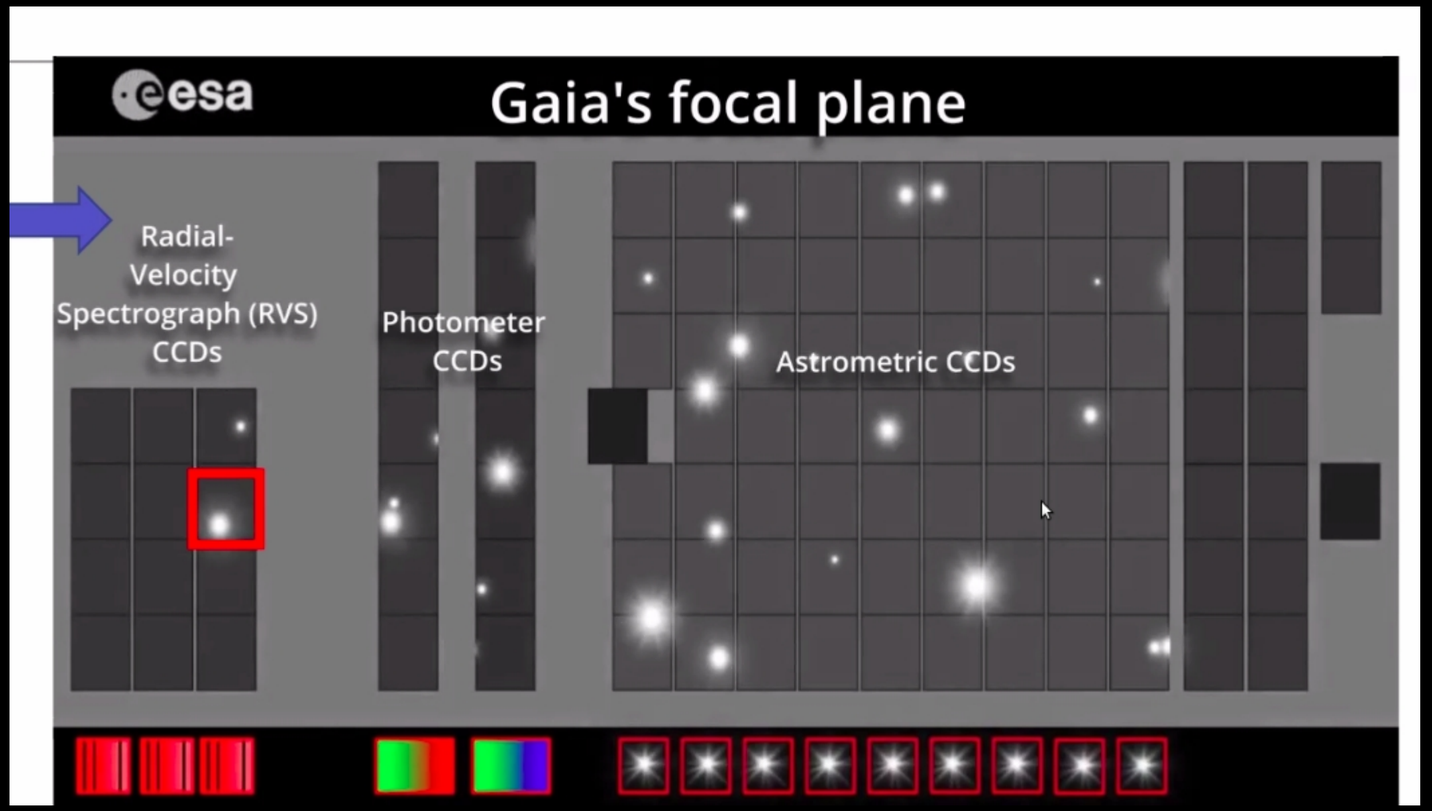
# Gaia

# European Space Agency (ESA) mission

➡ Photometric and astrometric data for : ~2 billions stars (DR3)

➡ Spectroscopic data for : ~33 millions stars (DR3)

Spectral resolution: 11500

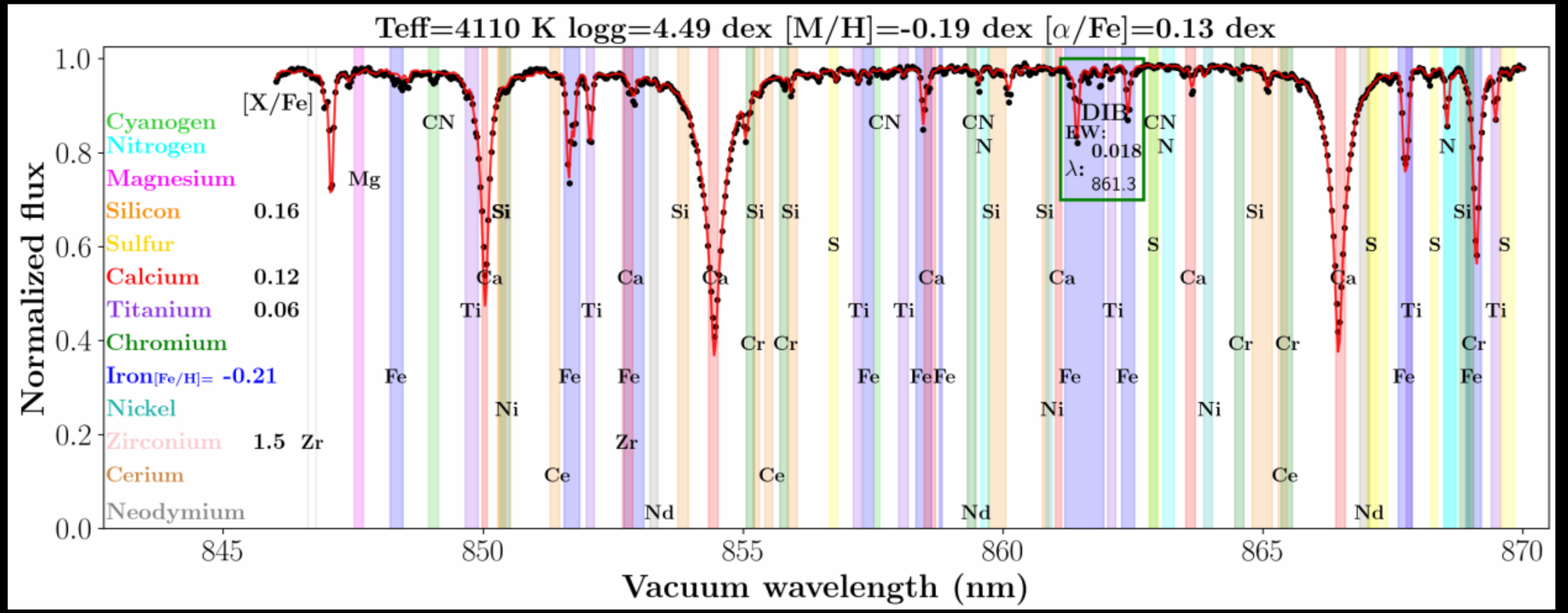



Spectral domain: 845 - 870 nm (NIR) | Visible (Bp/Rp)

Credits : ESA

# Chemical pattern

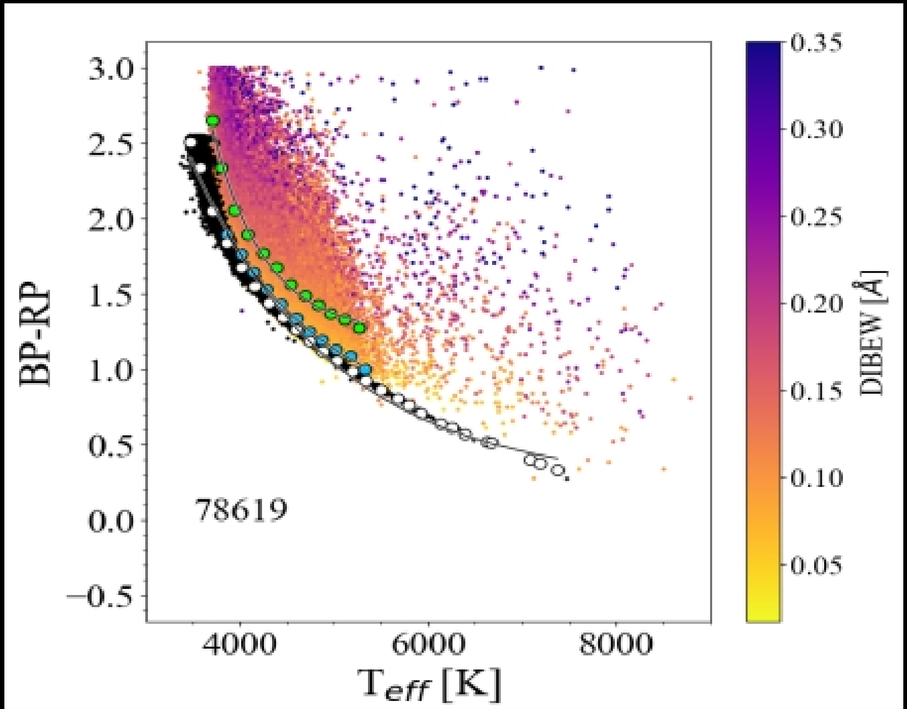
# Gaia spectroscopy with GSP-Spec module




Example of observed spectrum processed by the GSP-Spec workflow (Recio-Blanco+2023)

➡ Estimation of stellar parameters: Teff, surface gravity log(*g*), metallicity and individual abundances for 5.6 millions stars

# Gaia GSP-Spec module




Trend of (BP-RP) colour with GSP-Spec effective temperature for giants (Recio-Blanco+2023)

# Spectral advantages

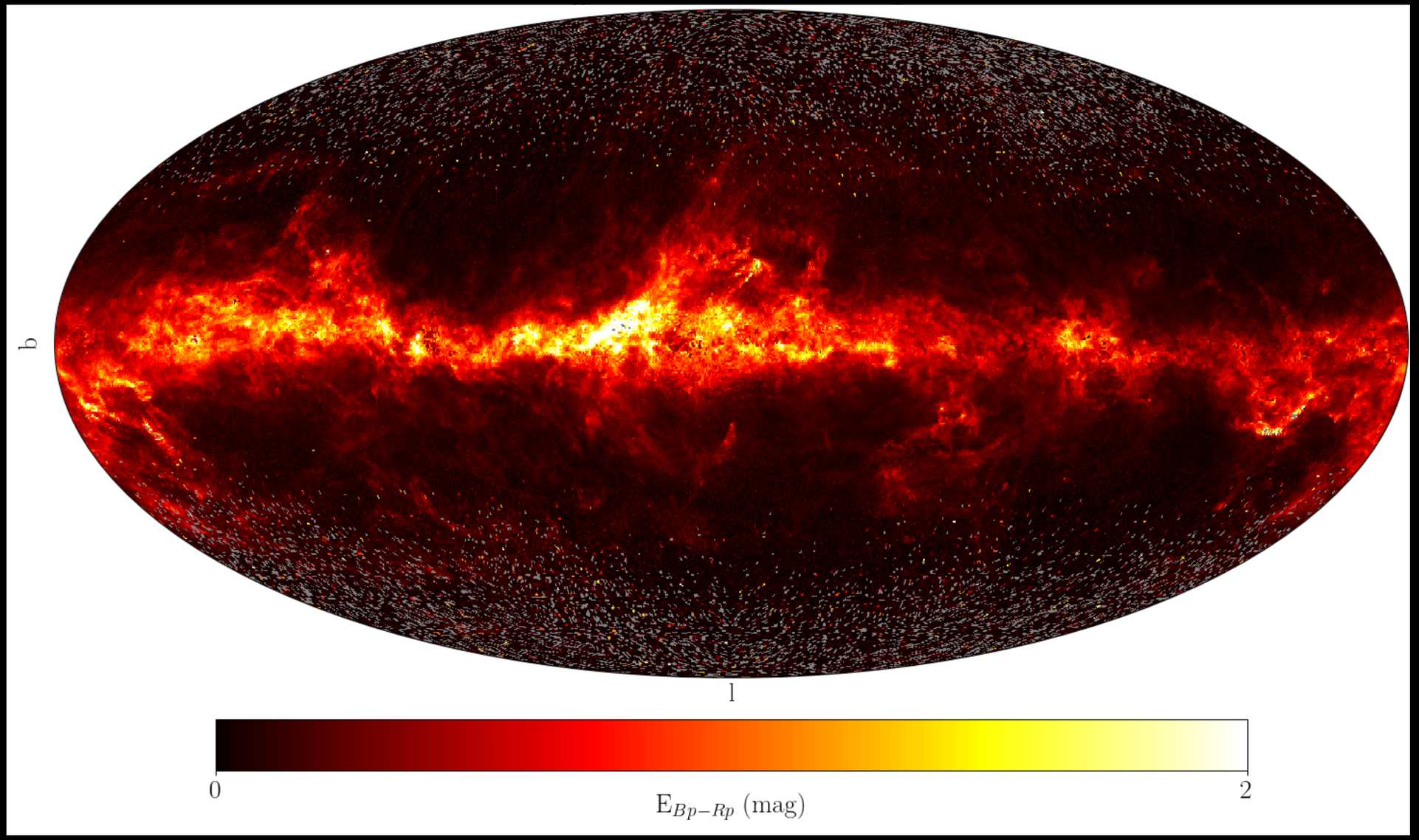
➡ GSP-Spec Teff is <u>unaffected</u> by interstellar extinction

➡ Extinction $E_{(Bp-Rp)}$ difference between :

- Theoretical colour difference based on atmospheric parameters (Teff, log(g), [M/H]) and Teff–colour relation (Casagrande+2021)
- Observed colour (Bp-Rp)

# Interstellar medium seen by Gaia GSP-Spec

## First full 2D extinction map from the GSP-Spec module (5.6 millions stars)




➡ **Detailed all sky extinction map**

*Barbillon et al. 2025b*

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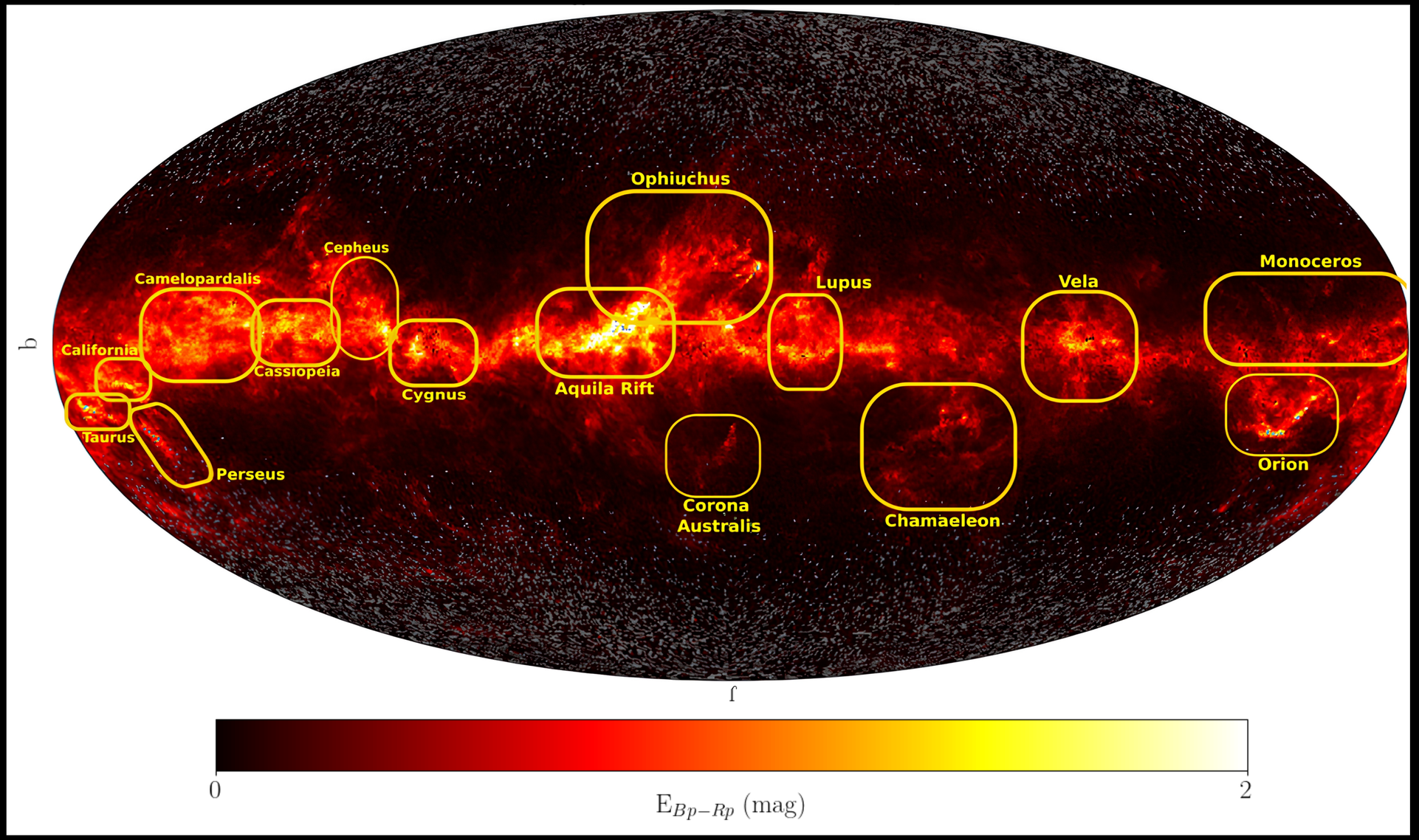


- Detailed all sky extinction map
- Most important structures are retrieved

*Barbillon et al. 2025b*

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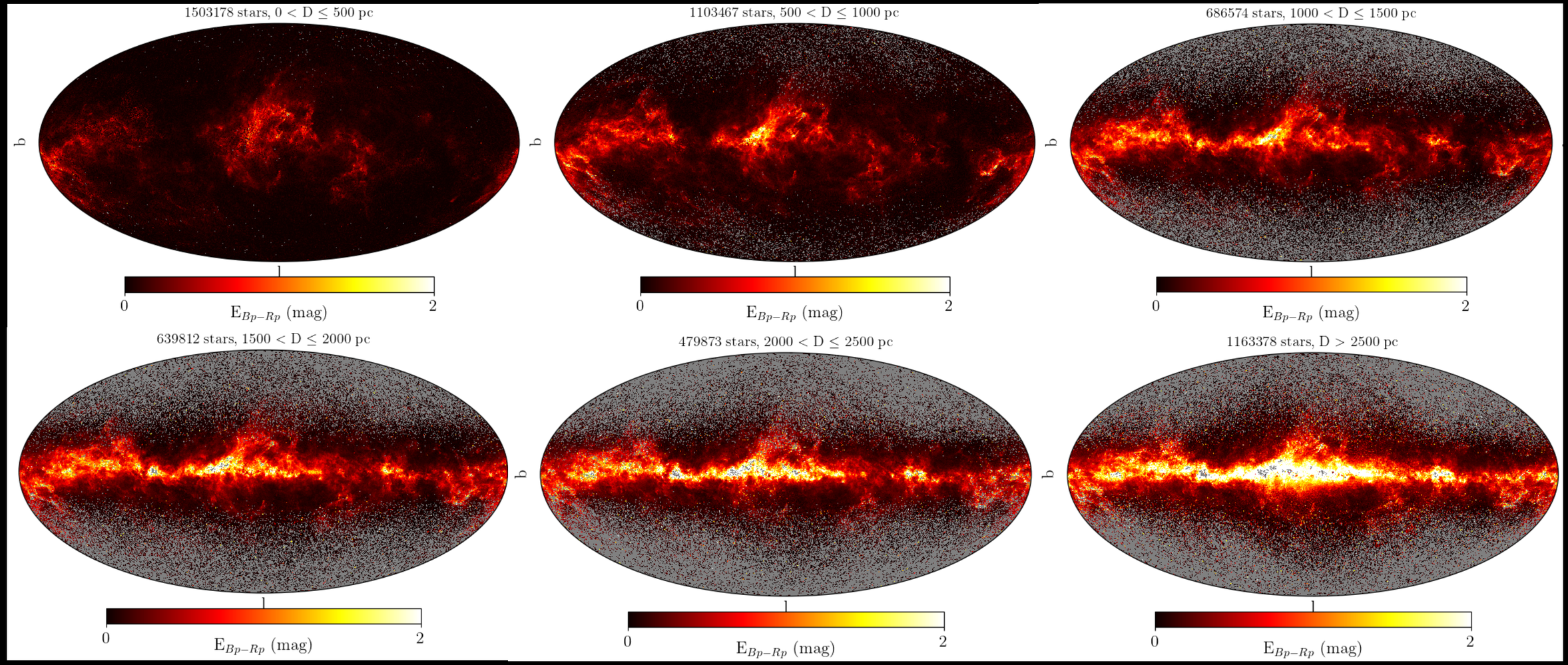
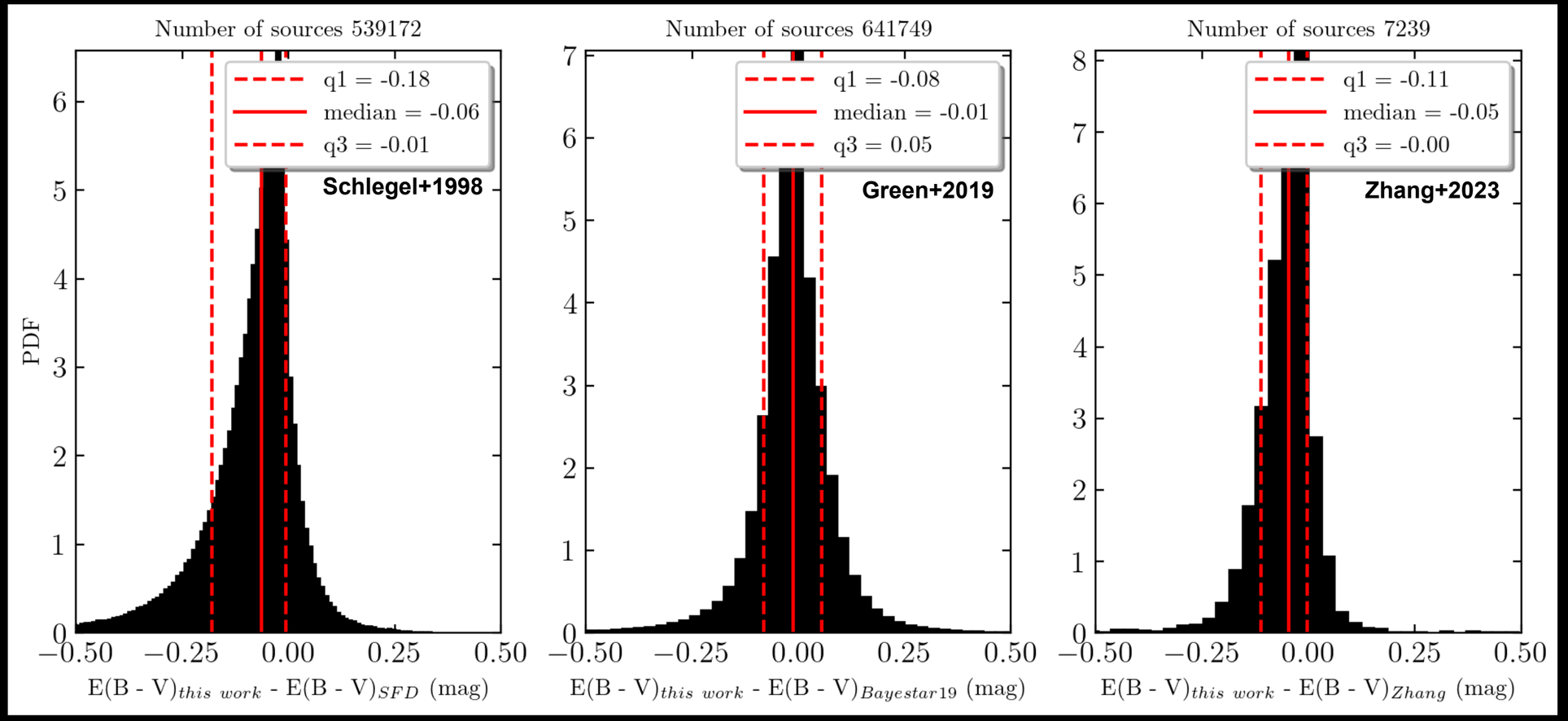



*Barbillon et al. 2025b*

- Gaia astrometry allows to estimate precise stellar distances
- Extinction distribution maps per distances slices

# Comparison to previous works




Comparative histograms between converted E(Bp - Rp) with E(B - V )

➡ Our results show a strong consistency with previous extinction maps based on different methods and surveys

# Quality filters and methodology

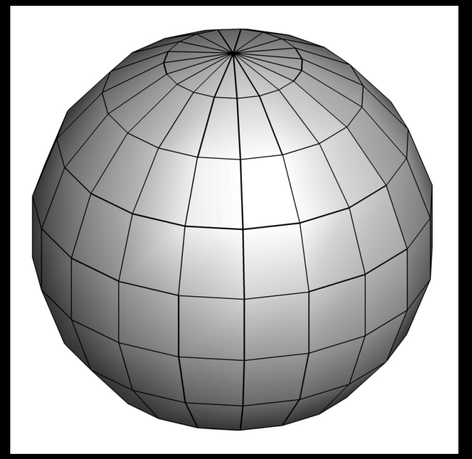
**Quality filters :**

- **High quality extinction flag (de Laverny in prep.)**
- **High quality stellar parameters (Recio-Blanco+2023)**
- **Distance relative error < 10%**
- **Extinction relative error < 10%**
- **Ruwe < 1.4**
- **-0.4 < Z < 0.4 kpc**

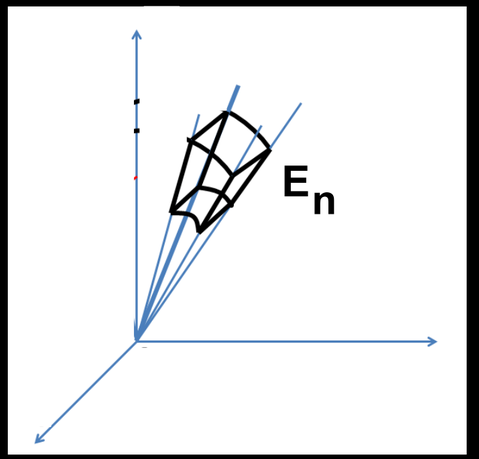
**To build the 3D maps, we computed the differential extinction, ∆E:**

$$\Delta E = E_{n+1} - E_n$$

**$E_n$ and $E_{n+1}$ are the median extinction estimated in each volume.**



**Scheme of the discretisation of the cumulative E(Bp-Rp) in dr, dϕ, dθ**

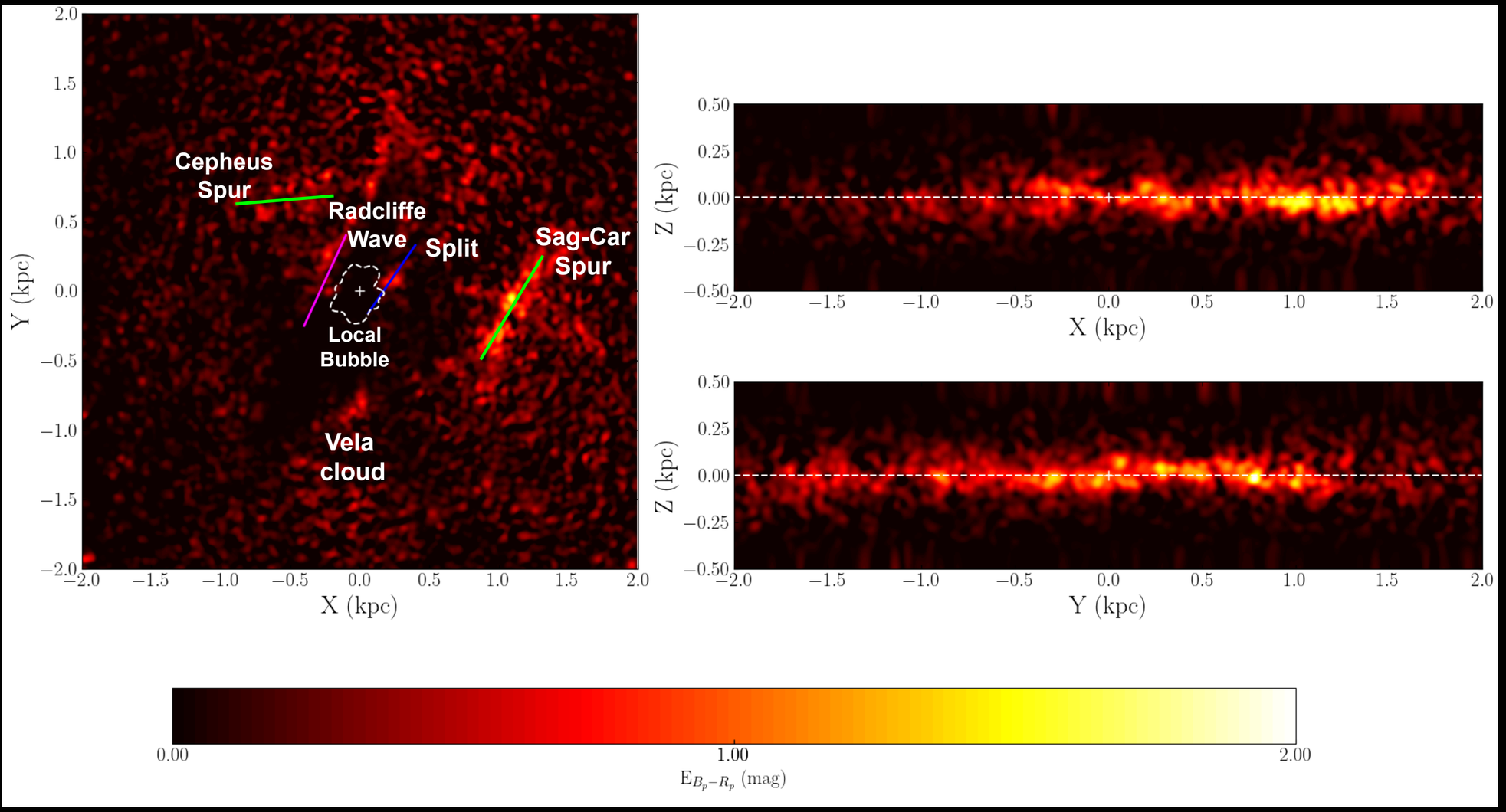



**Example of one volume of median extinction**

# 3D extinction maps

# 2D projected maps of the dust distribution in the Sun vicinity

*Barbillon et al. 2025b*




2D projected maps obtained after accumulated ΔE(Bp-Rp) into the studied projected direction

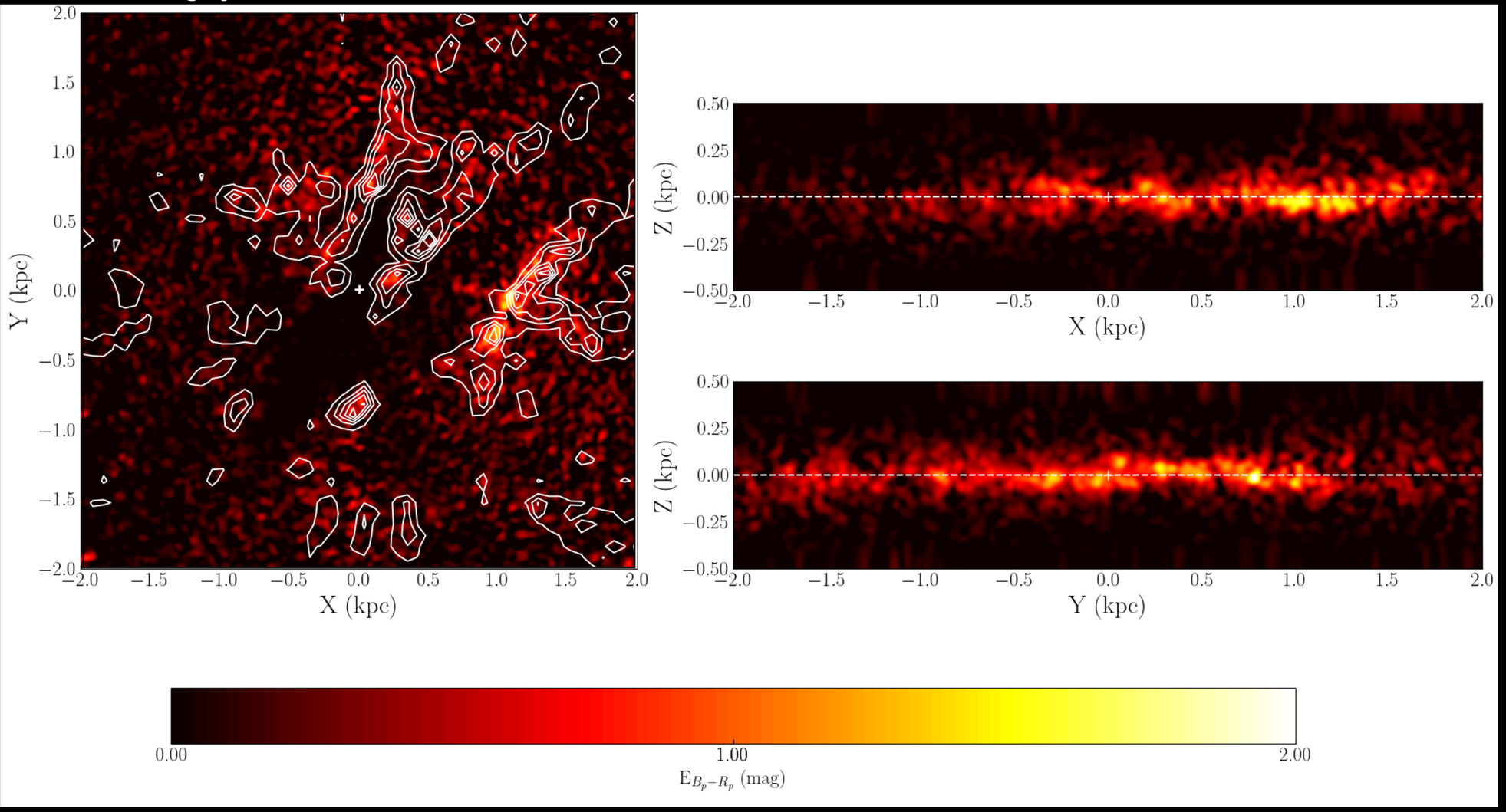
- Clear extinction patterns in 3D
- Presence of the Local Bubble (LB) around the Sun (Pelgrims+2020)
- Known large gaseous structures are observable
- Strong consistency between literature (Zari+2018, Alves+2020, Vergely+2022, Dharmawardena+2024, Edenhofer+2024, etc)
- Wavy pattern of the extinction distribution along the Z-axis (Alves+2020).

# 3D extinction maps

# 2D projected maps of the dust distribution in the Sun vicinity

Vergely+2022 extinction contours

*Barbillon et al. 2025b*

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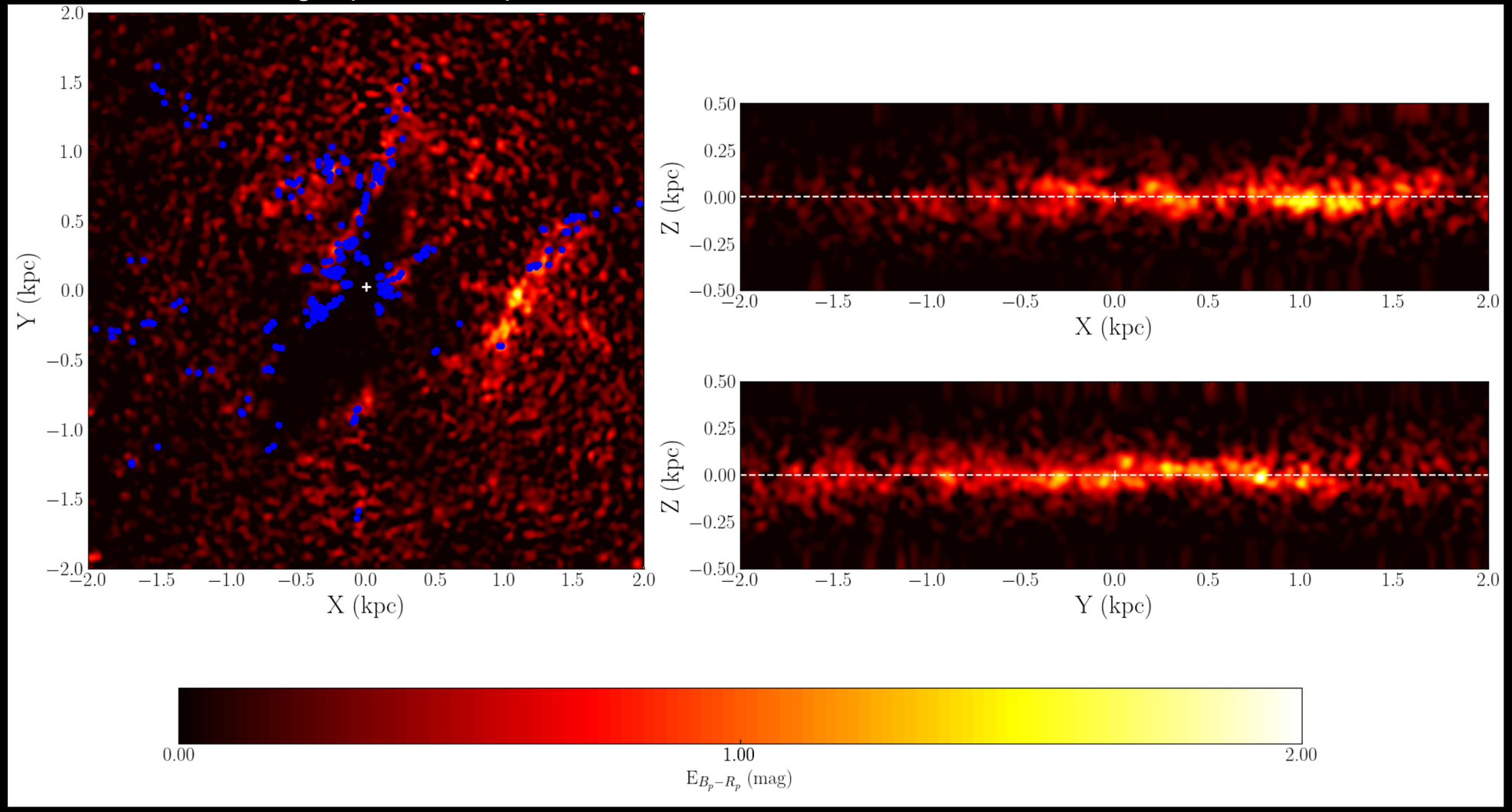
# 3D extinction maps

# 2D projected maps of the dust distribution in the Sun vicinity

Molecular clouds in blue from Star Formation Handbook catalogue (Zucker+2021)

*Barbillon et al. 2025b*



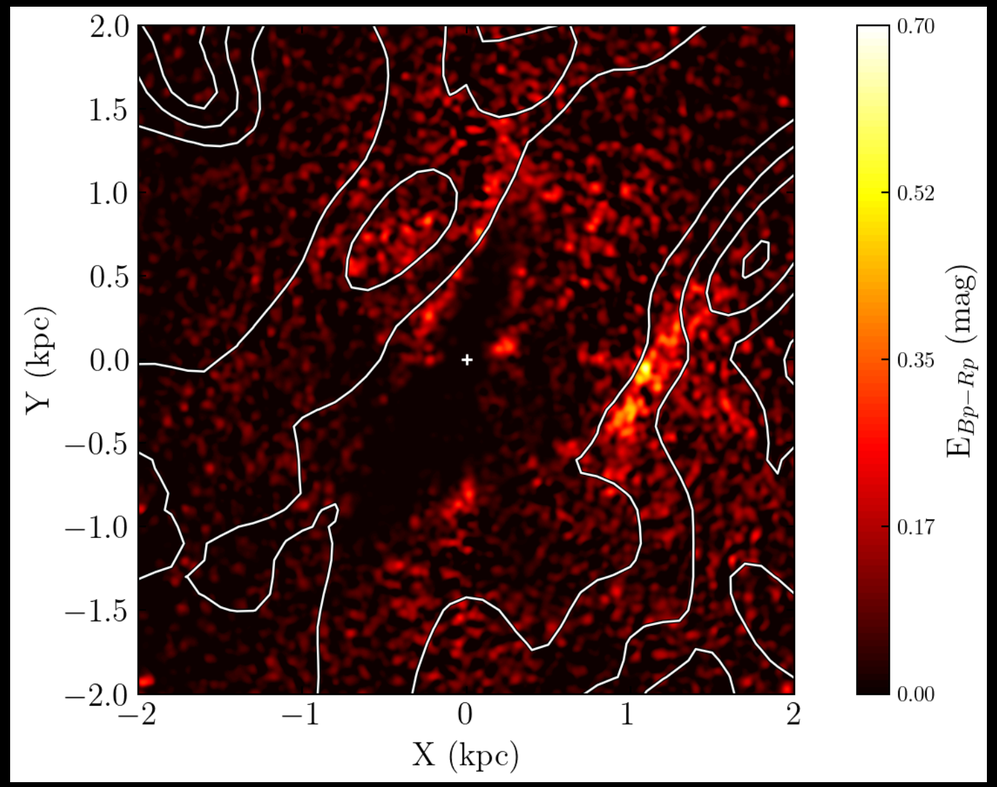

➡ Strong consistency with the distribution of molecular clouds

2D projected maps obtained after accumulated ΔE(Bp-Rp) into the studied projected direction

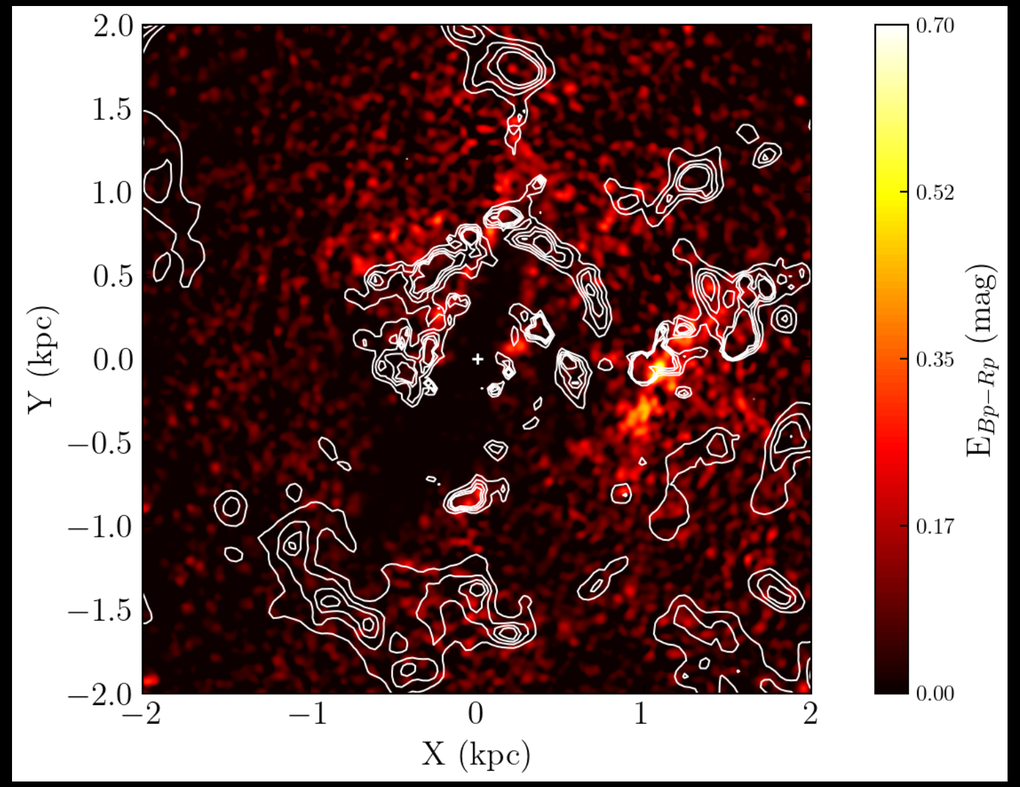
# Extinction as a tracer of spiral arms

## 2D projected maps of the dust distribution in the Sun vicinity

**Overdensity contours of UMS stars (Poggio+2021)**




**Total Hydrogen density distribution (Söding+2025)**



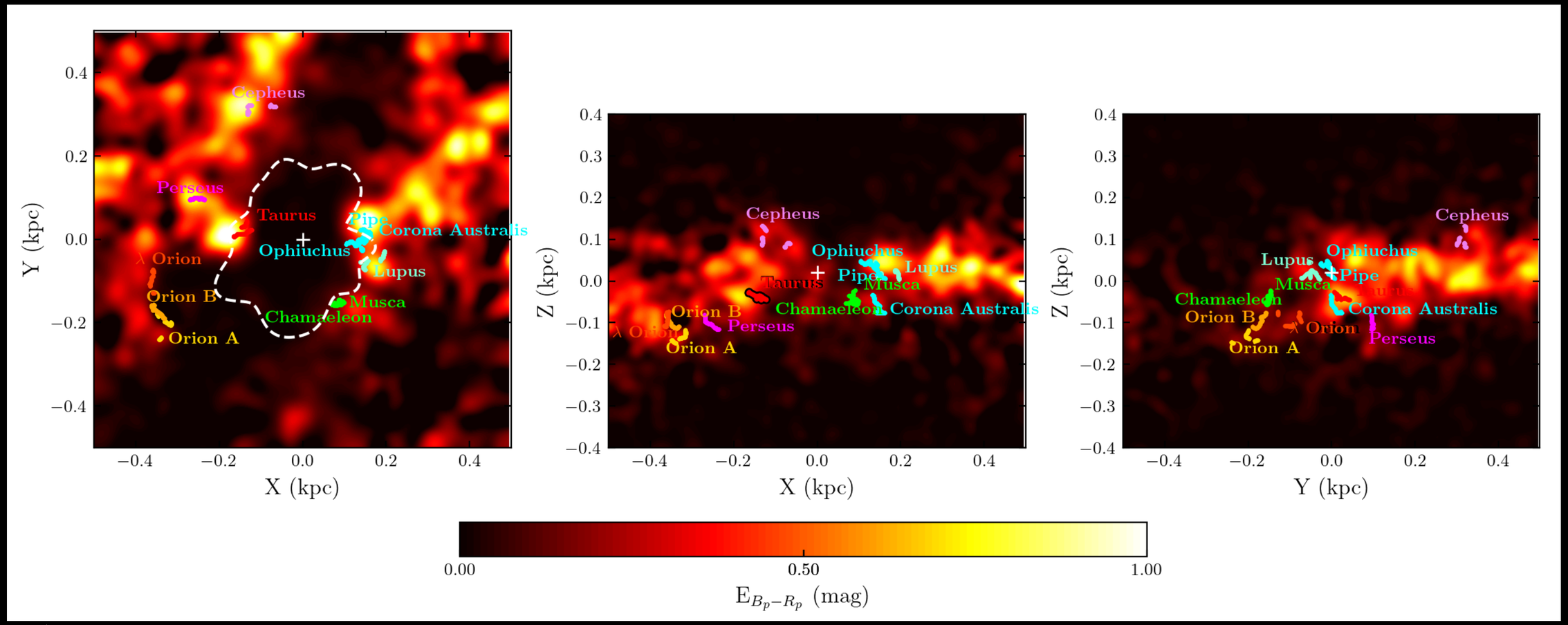

*Barbillon et al. 2025b*

- Dust seems to be preferentially in the edge of arms (Seigar & James 2002; Martínez-García et al. 2009; Silva-Villa & Larsen 2012).
- Evident link between the extinction, the younger stars position and the gas

# 3D extinction maps

# 2D projected maps of the dust distribution in the Local Bubble

LB contours from Pelgrims+2020




*Barbillon et al. 2025b*

- High resolution view of the Local Bubble
- Good agreement with positions of clusters of young star (Zucker+2021, 2022)
- Wavy pattern of the extinction distribution along the YZ plane coherent with the Radcliff Wave structure (Alves+2020).

# Conclusions

- New extinction catalogue of E(Bp-Rp) consistent with published works using different methods and surveys
- Detailed all sky extinction map using homogeneous data from the Gaia space mission
- 3D high resolution view at different scales
- First extinction maps based on spectroscopic temperature <u>unaffected by extinction</u>
- Without any Bayesian methods (no priors, likelihoods…)

# THANK YOU FOR YOUR ATTENTION

# 3D maps of the cumulative number of data