

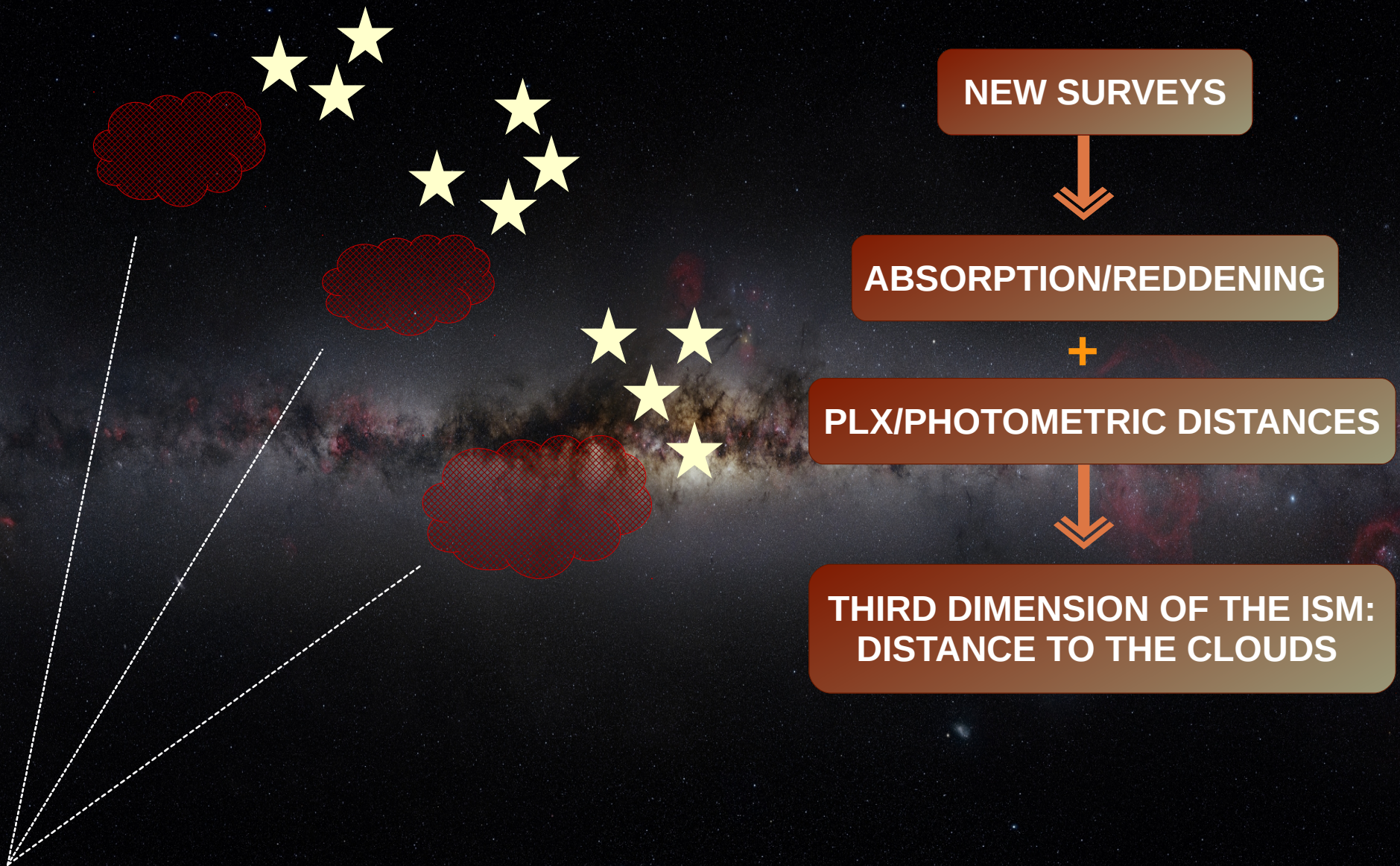
3D Maps of Interstellar Dust in the Local Arm with Gaia, 2MASS and APOGEE-DR14

Laura Ruiz-Dern

R. Lallement, L. Capitanio, C. Danielski, C. Babusiaux,
J.L. Vergely, M. Elyajouri, F. Arenou, N. Leclerc

GEPI, Observatoire de Paris-Meudon

MAPPING THE EXTINCTION



!! Spatial resolution decreases with distance in the radial direction

SIGHTLINE BY SIGHTLINE



- Target stars in a narrow solid angle
 - Assume all targets aligned
- Bayesian technique inversion colour excess
(Tarantola & Valette, 1982; Vergely 2001 to local IS dust)

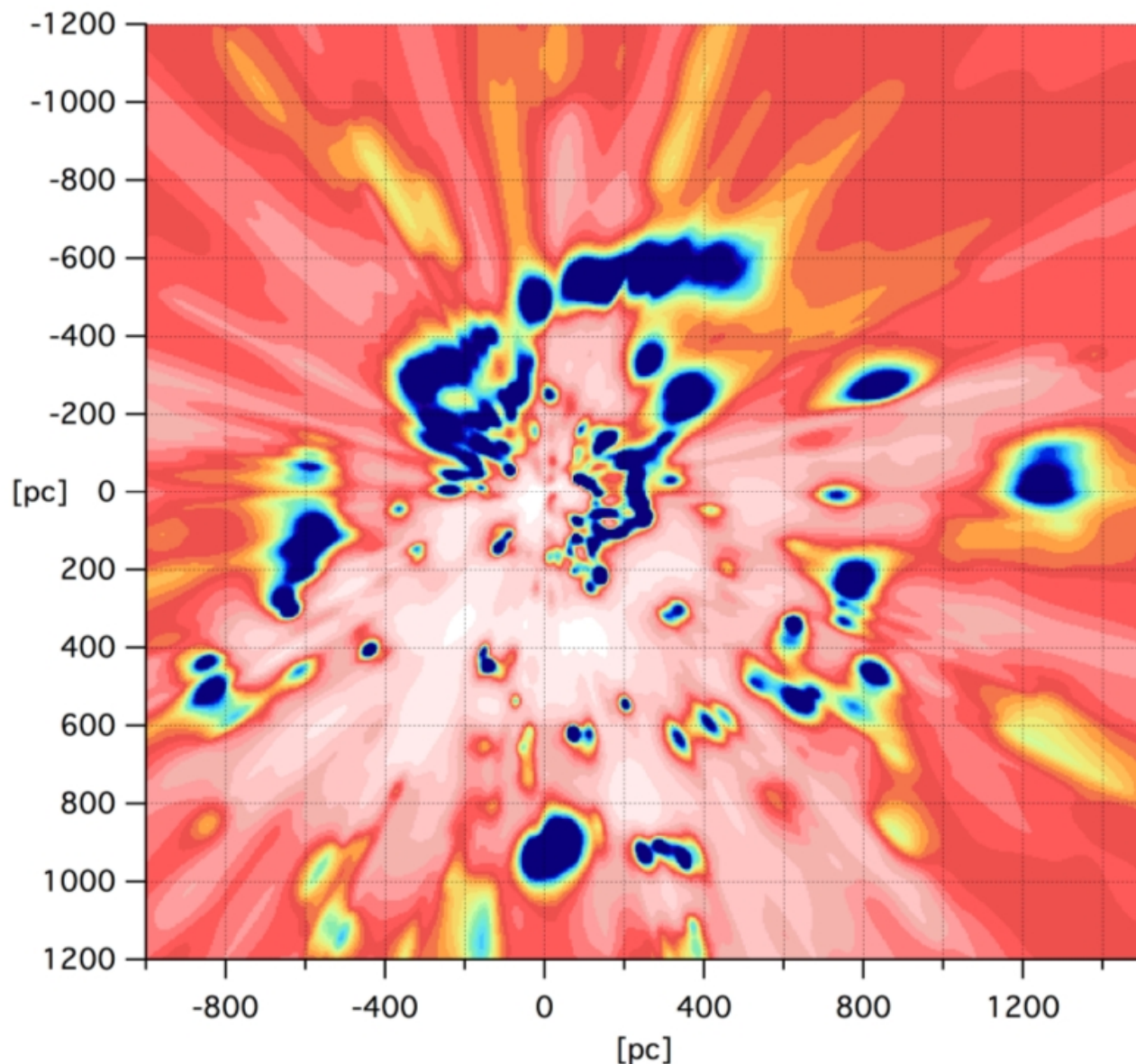
FULL 3D INVERSION



- Link adjacent sightlines**
(i.e. spatial correlations between column densities of IS matter in all directions)
 - E(B-V) column density
- $\rho(P) \rho(P')$: 3D information prior

HIPPARCOS

2.6kpc



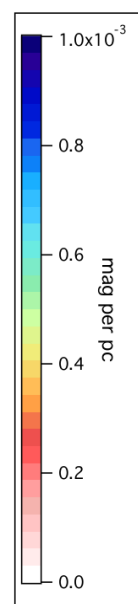
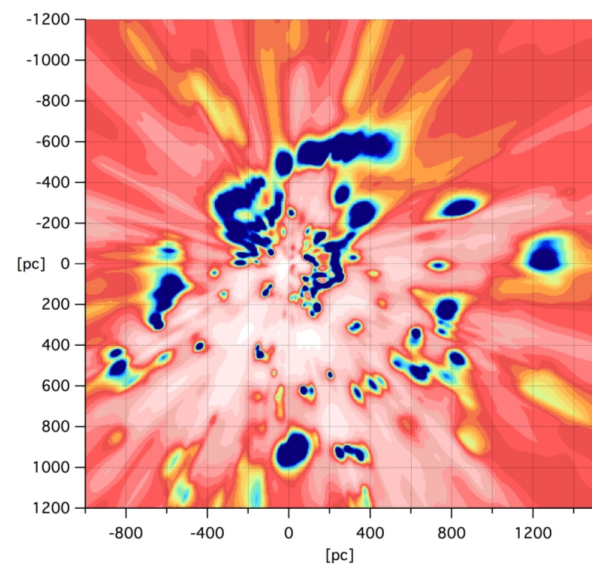
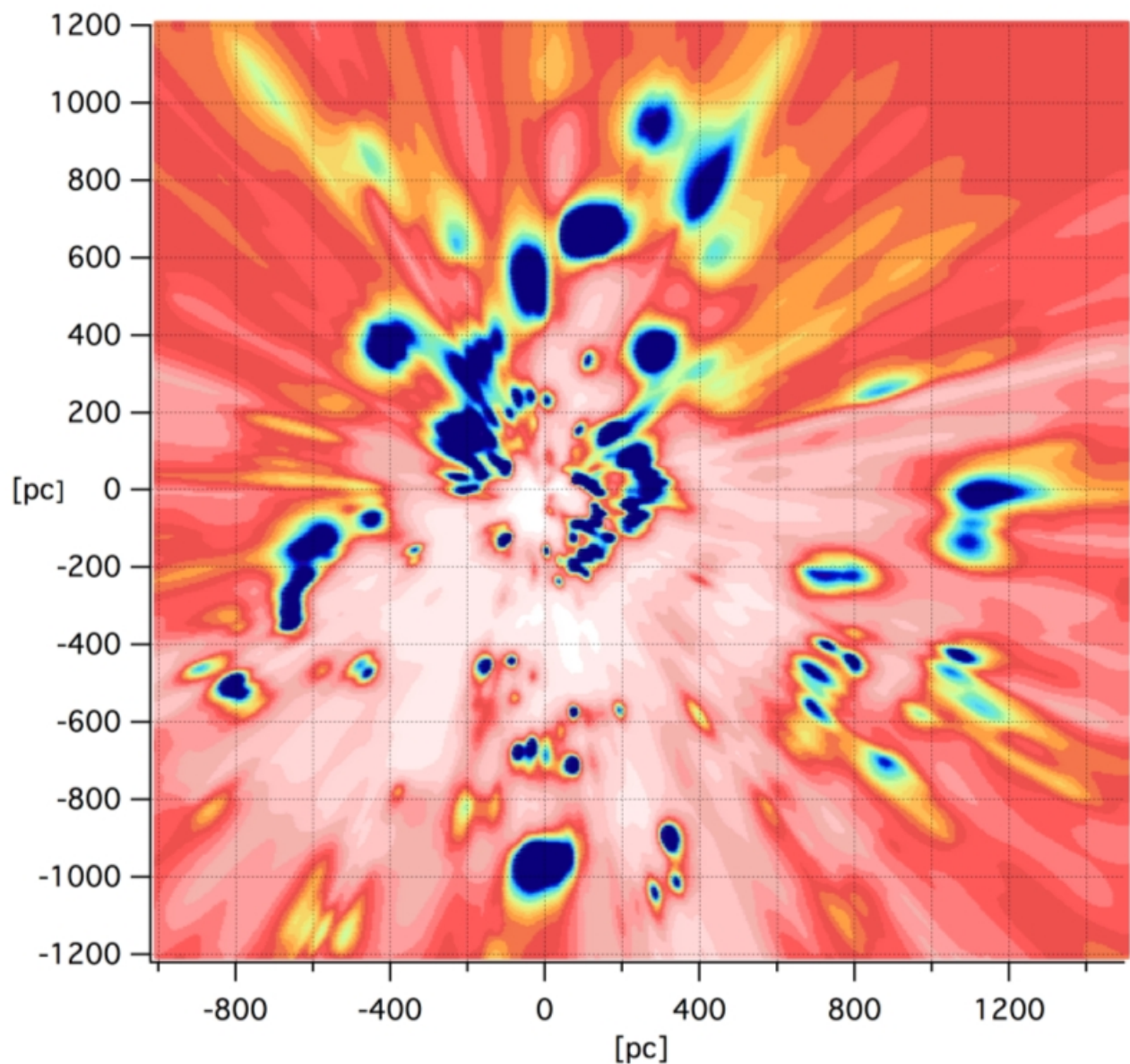
22467 targets

22% Hipparcos distances

78% photometric

Prior
plane-parallel
homogenous
distribution decreasing
exponentially from
the Galactic plane
with a scale height of
200 pc

TGAS DR1

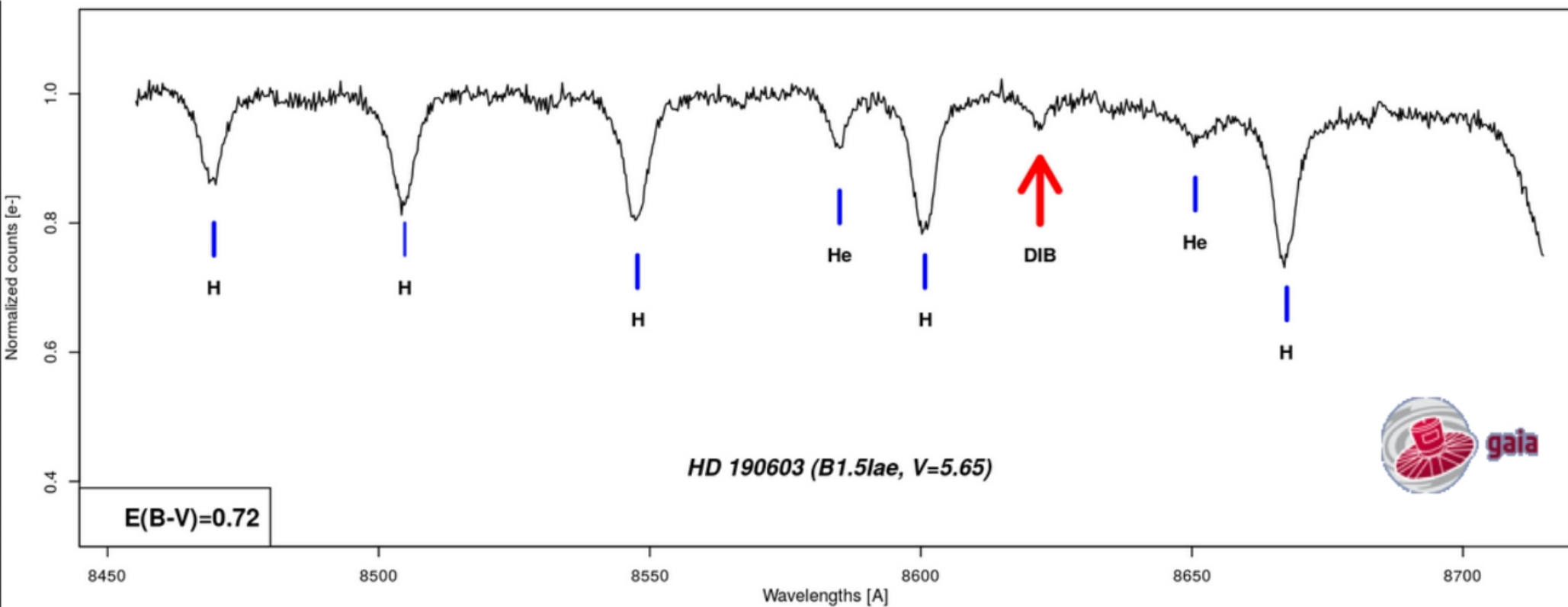


23444 targets

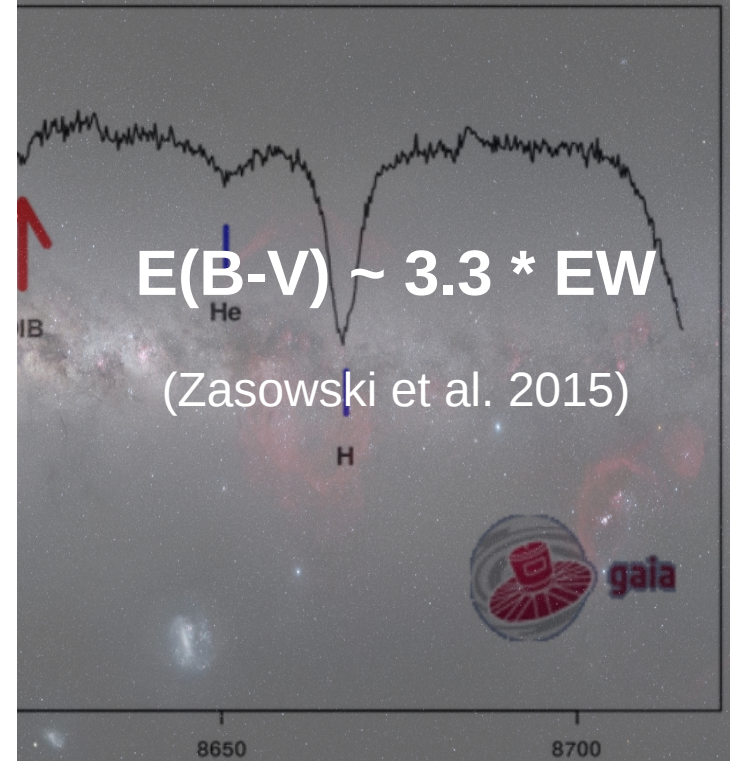
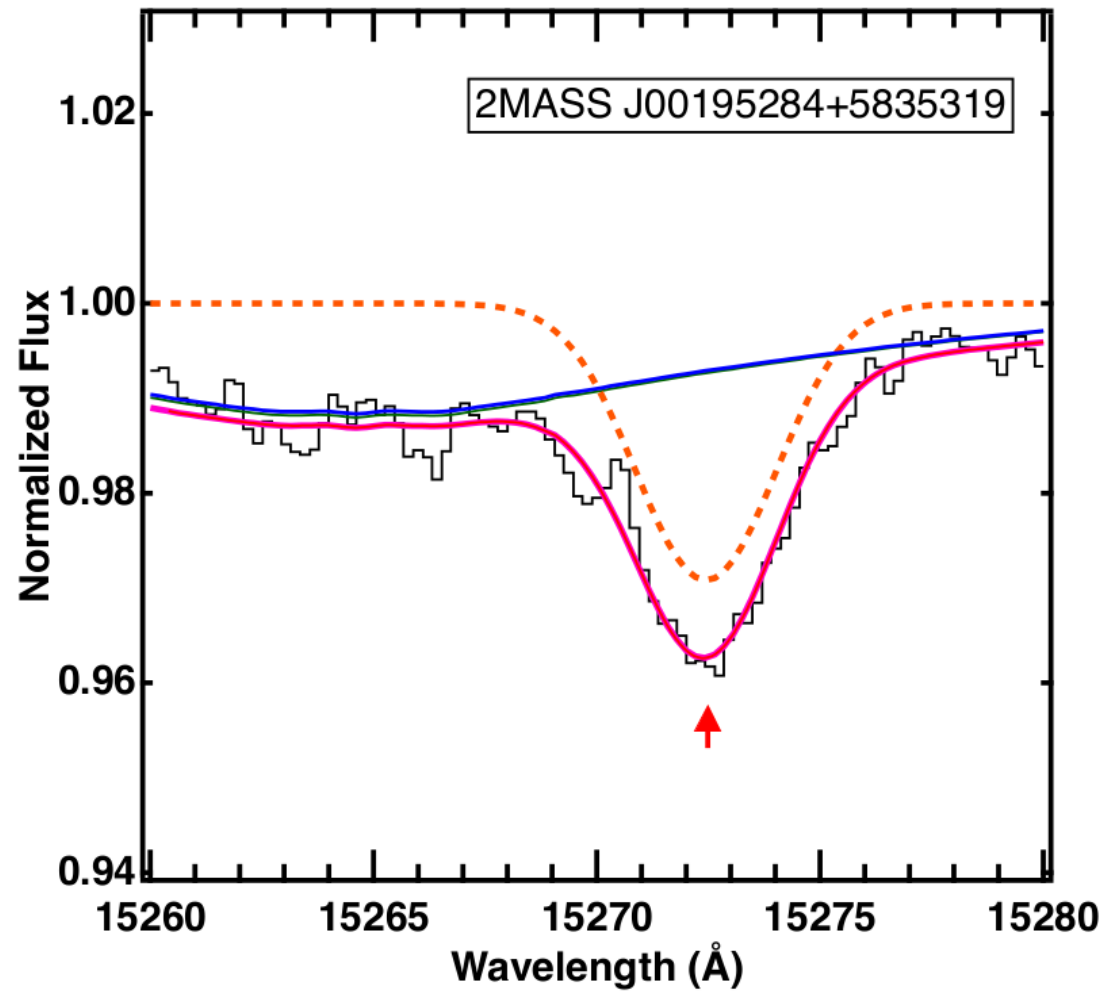
~80% Gaia TGAS
distances

20% photometric

TGAS DR1 + DIB

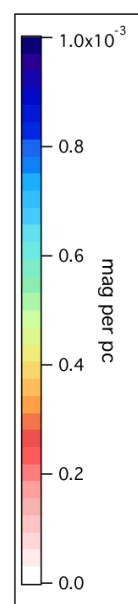
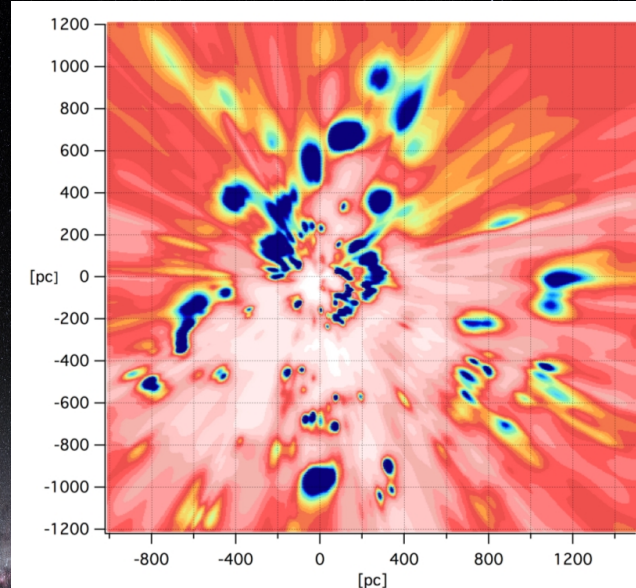
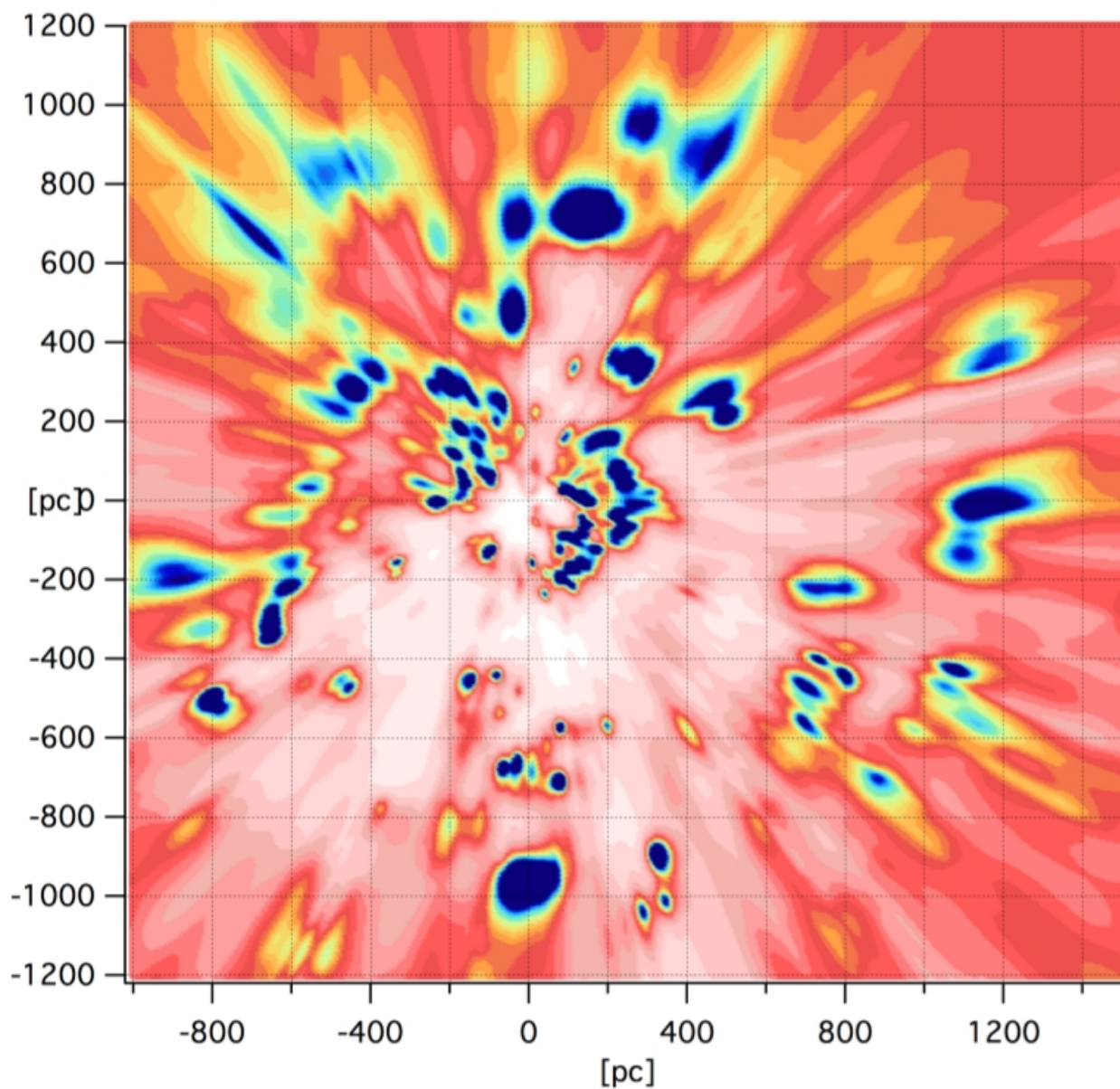


TGAS DR1 + DIB



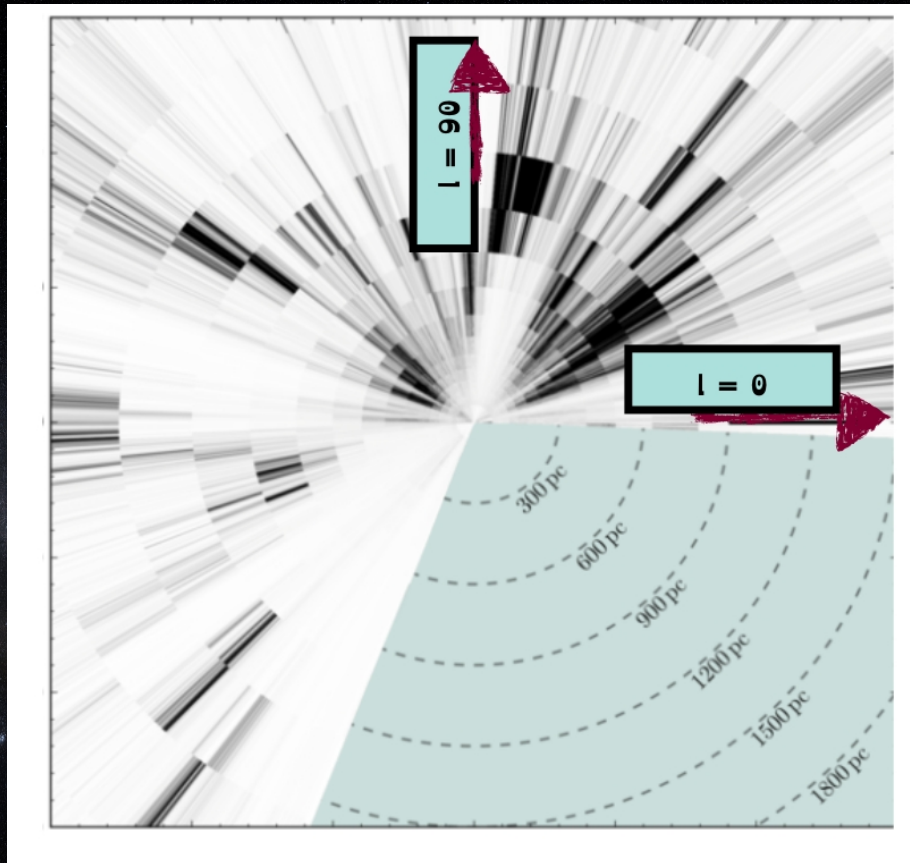
Capitiano et al. 2017

TGAS DR1 + DIB



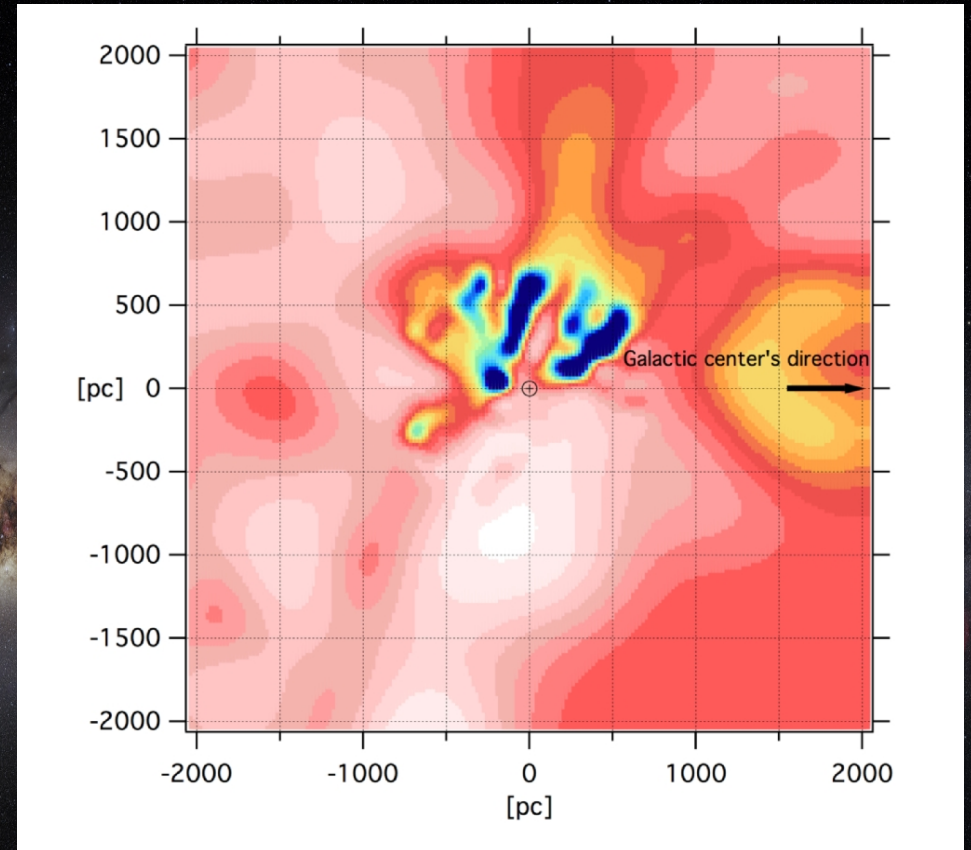
~ 28000 targets
~ 5000 DIB-BASED EXCESS OF COLOUR (SDSS/APOGEE)

TGAS DR1 + DIB + PAN-STARRS



Green et al. 2015

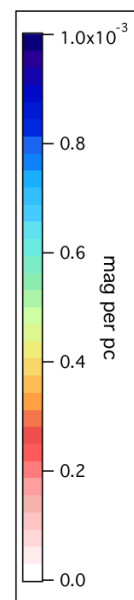
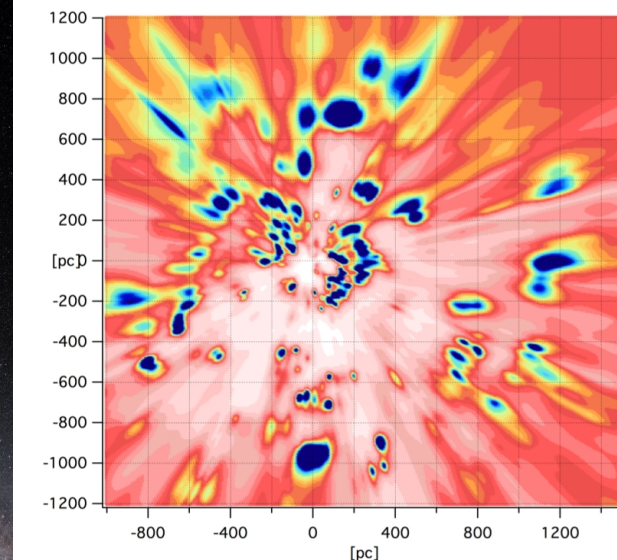
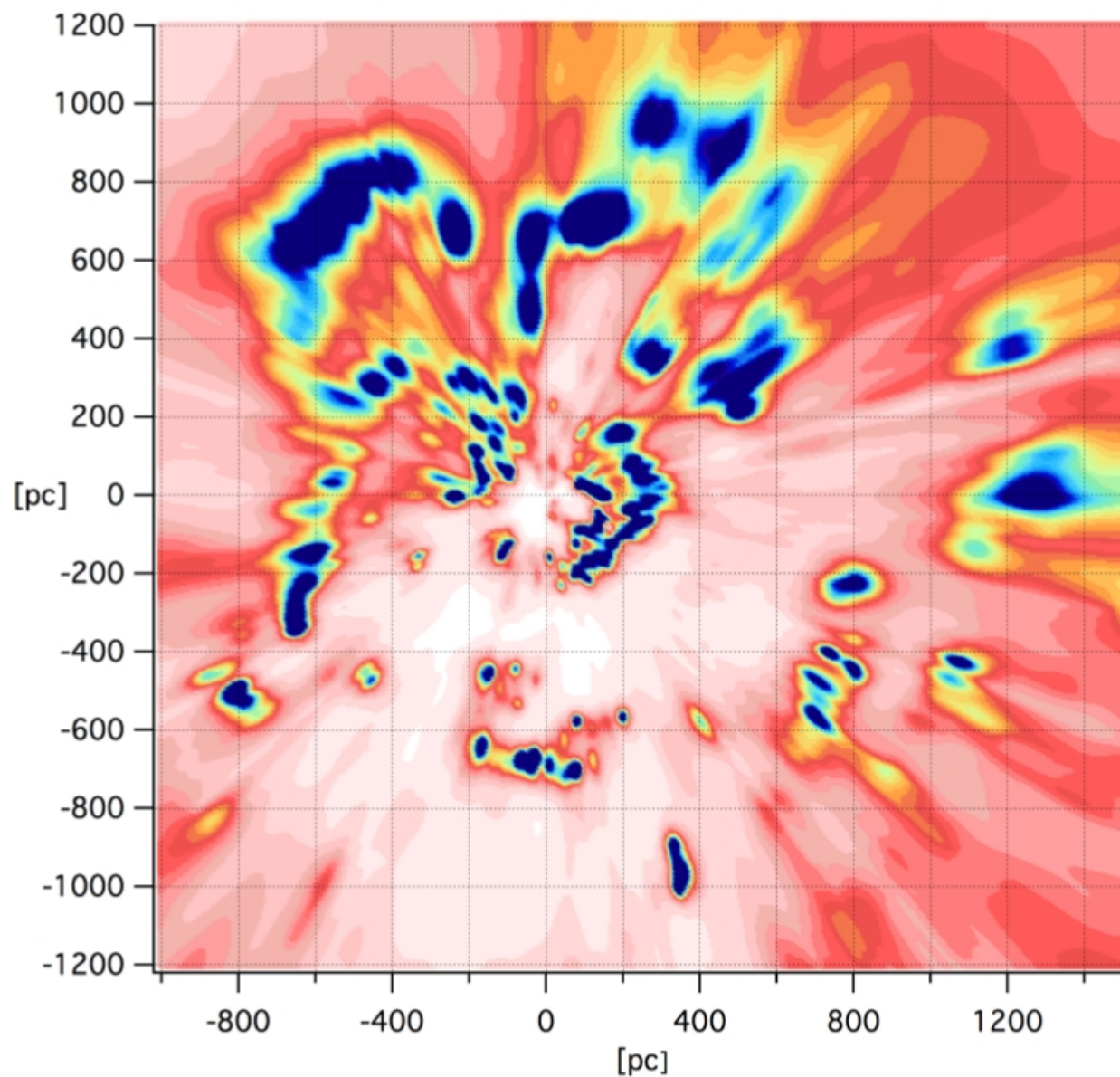
- ✗ Lower distance resolution
- ✗ No local values
- ✗ Only North hemisphere (South hemisphere in preparation)



Courtesy of L. Capitanio

- ✓ Excellent angular resolution ($5'$)
- ✓ Reliable absolute data

TGAS DR1 + DIB + PAN-STARRS

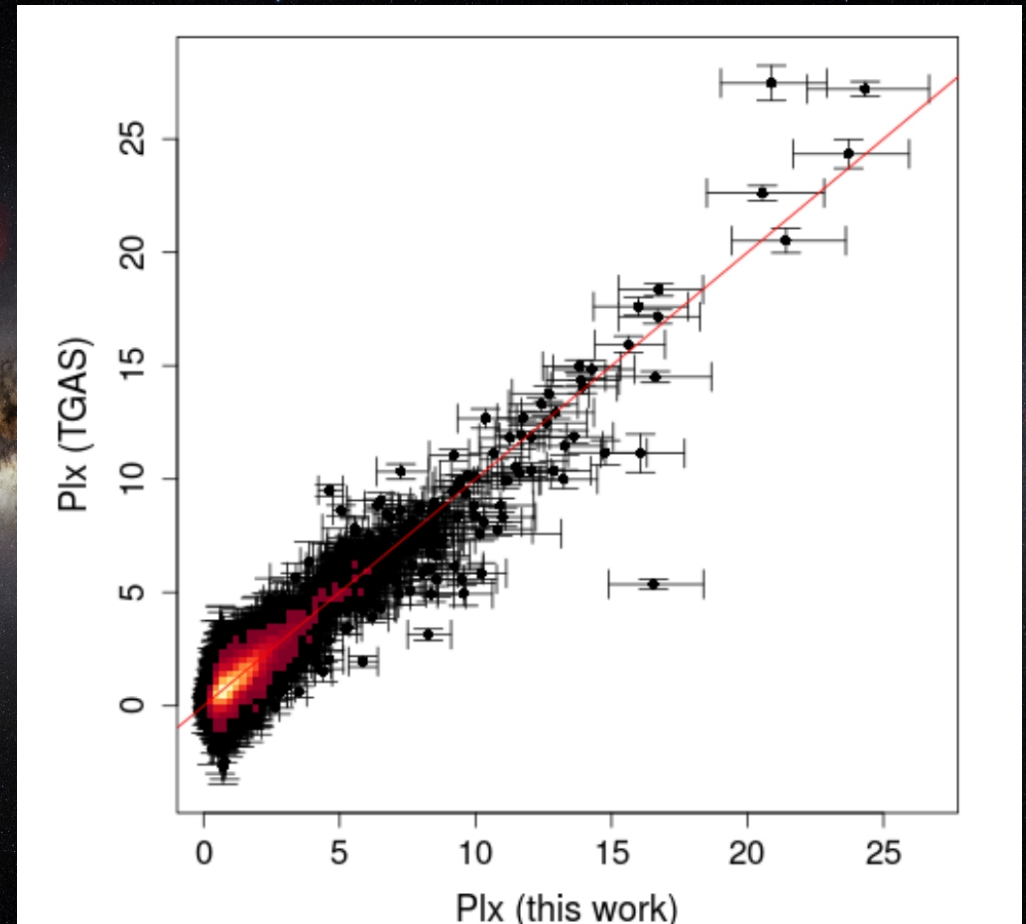


Non-Local ISM
PAN-STARRS map
as prior

TGAS DR1 + DIB + PAN-STARRS + APOGEE DR14 calibration

DISTANCES

- Distance modulus 161683 APOGEE stars – Bayesian method on Padova isochrones
- K_{J-K} magnitude independent of extinction
- IMF of Chabrier 2001
- Flat distribution on age
- $X_{0.99}$ rejection criteria



Lallement et al. 2018

TGAS DR1 + DIB + PAN-STARRS + APOGEE DR14 calibration

EXTINCTION

- APOGEE – 2MASS – Gaia
- $3761 \text{ K} < T_{\text{eff}} + \sigma_{T_{\text{eff}}} < 5288 \text{ K}$
 $-2.3 < [\text{Fe}/\text{H}] < 0.42$
- $\sigma_{G,K,J} < 0.05 \text{ mag}$
- MCMC accounting for errors
- Photometric calibrations Ruiz-Dern et al. 2018 (*updated with APOGEE DR14*)
- k_G calibration of Danielski et al. 2018
- $X_{0.99}$ rejection criteria

TGAS DR1 + DIB + PAN-STARRS + APOGEE DR14 calibration

Gaia RC EMPIRICAL PHOTOMETRIC CALIBRATIONS

Ruiz-Dern et al. 2018

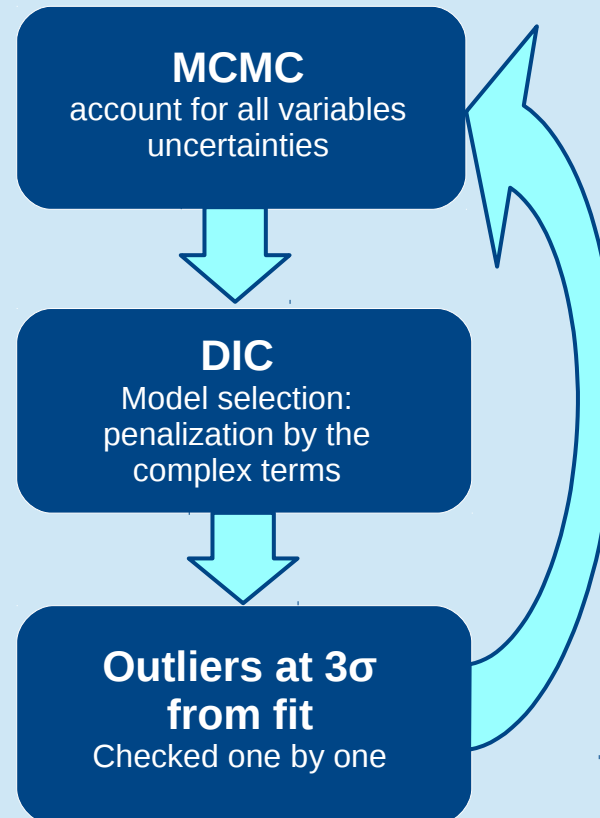
$$\text{Colour} = a_0 + a_1(G-K) + a_2(G-K)^2 + a_3[\text{Fe}/H] + a_4[\text{Fe}/H]^2 + a_5(G-K)[\text{Fe}/H]$$

DATA

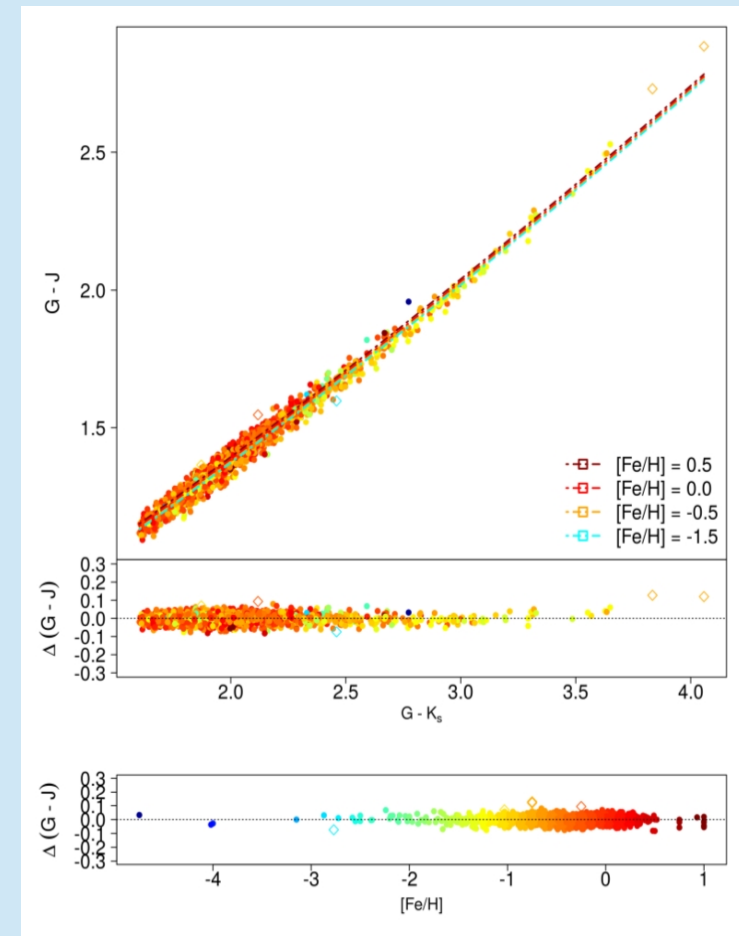
(VizieR)

- Low extinction $E_{B-V} < 0.01$
(3D Capitanio et al. 2017
+ 2D Schlegel 1998)
- Giants (colour & plx)
- $G / B_H V I / B_T V_T /$
 JK_s / gri
- Single stars
- Spectroscopic $[\text{Fe}/H]$
- APOGEE T_{eff}

METHOD



RESULTS



TGAS DR1 + DIB + PAN-STARRS + APOGEE DR14 calibration

Gaia RC EMPIRICAL PHOTOMETRIC CALIBRATION

Ruiz-Dern et al. 2018

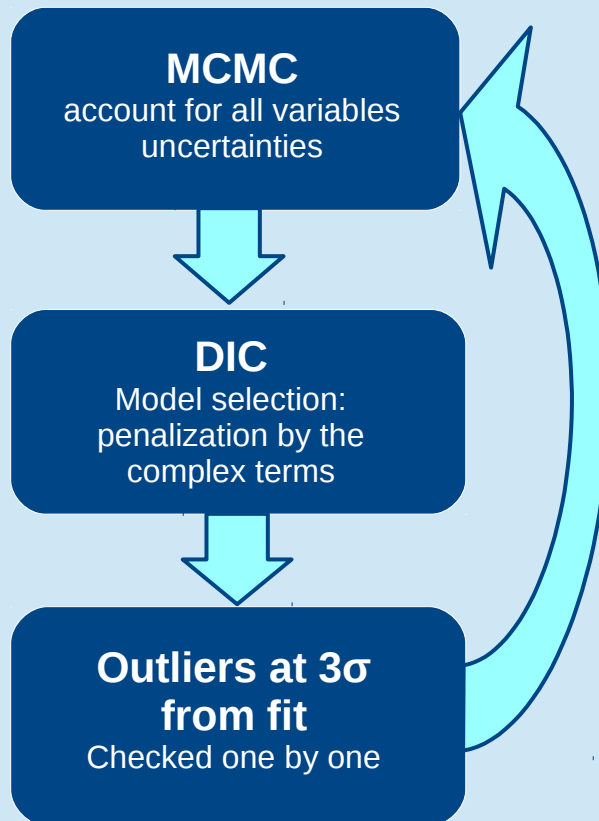
$$\text{Colour} = a_0 + a_1(G-K) + a_2(G-K)^2 + a_3[\text{Fe}/H] + a_4[\text{Fe}/H]^2$$

DATA

(VizieR)

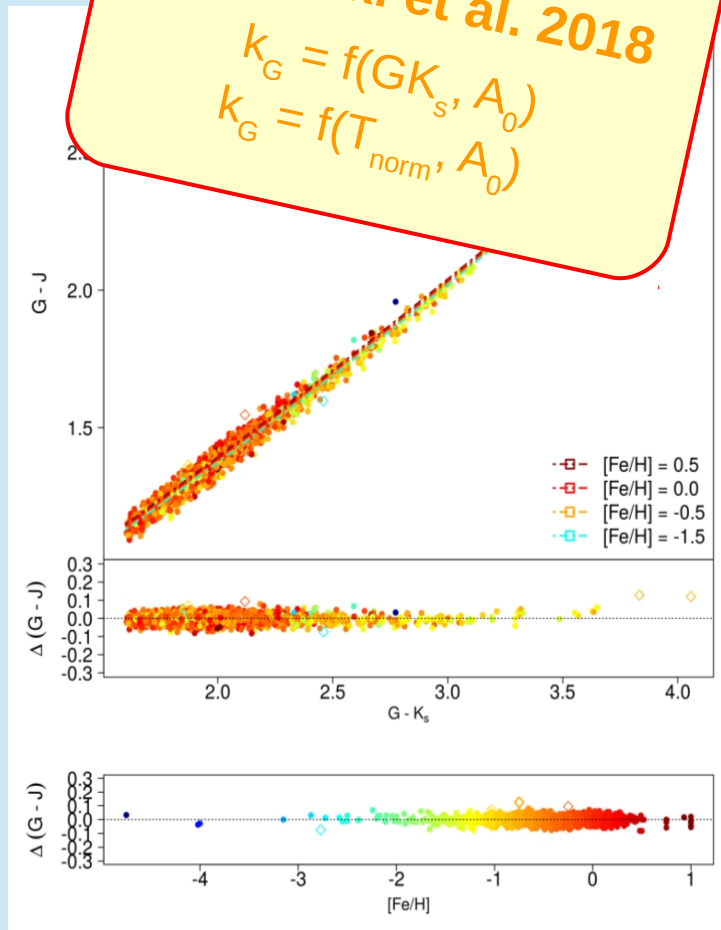
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METHOD



Ruiz-Dern et al. 2018
 $\text{Colour} = f(\text{GK}_s, [\text{Fe}/H])$
 $T_{\text{eff}} = f(\text{GK}_s, [\text{Fe}/H])$

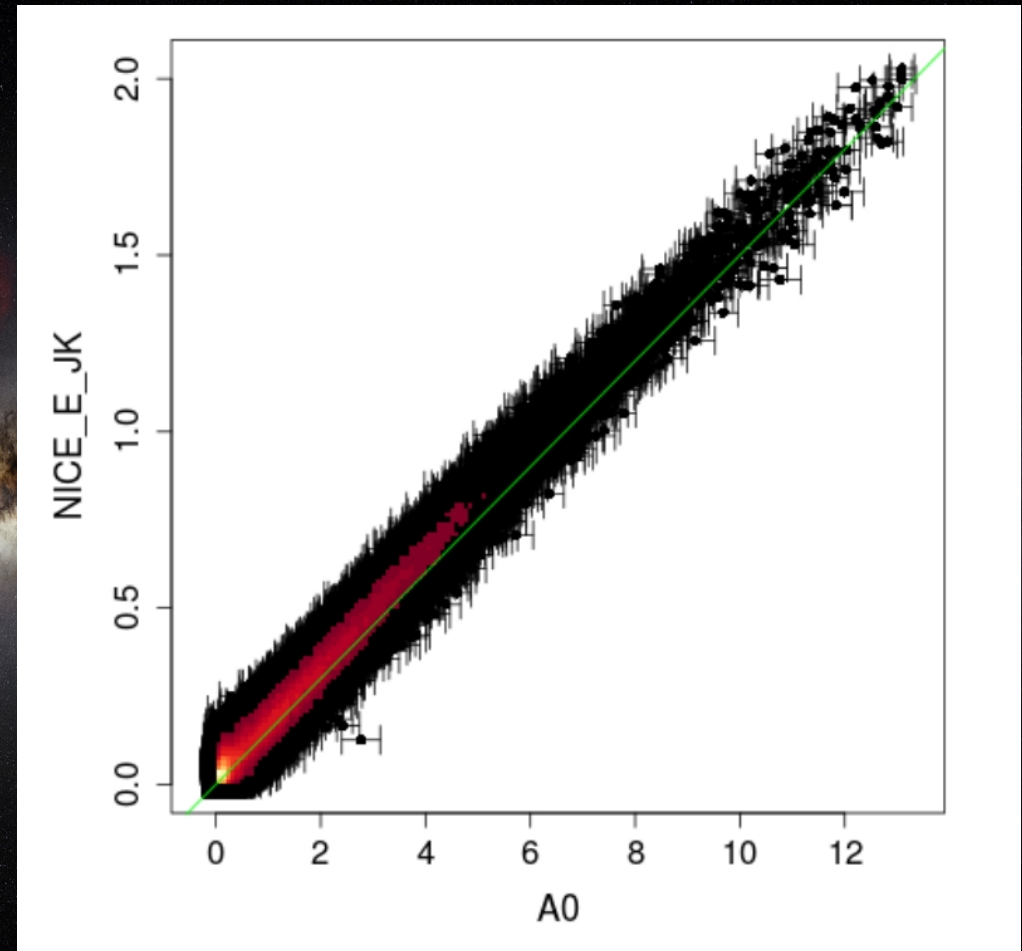
Danielski et al. 2018
 $k_G = f(\text{GK}_s, A_0)$
 $k_G = f(T_{\text{norm}}, A_0)$



TGAS DR1 + DIB + PAN-STARRS + APOGEE DR14 calibration

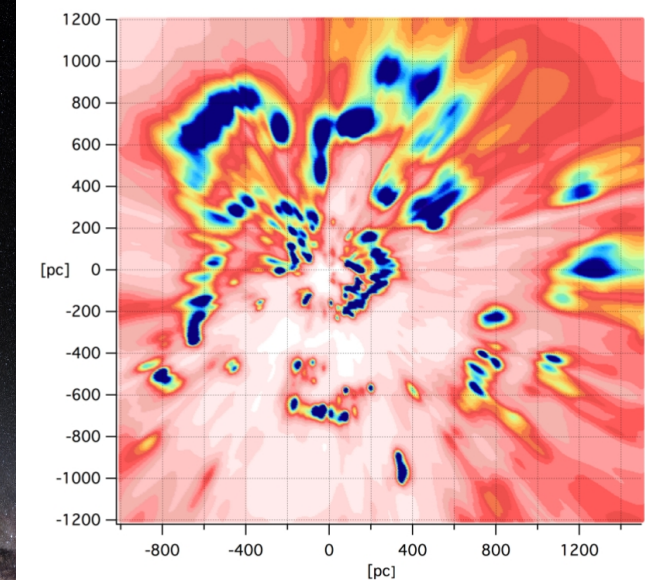
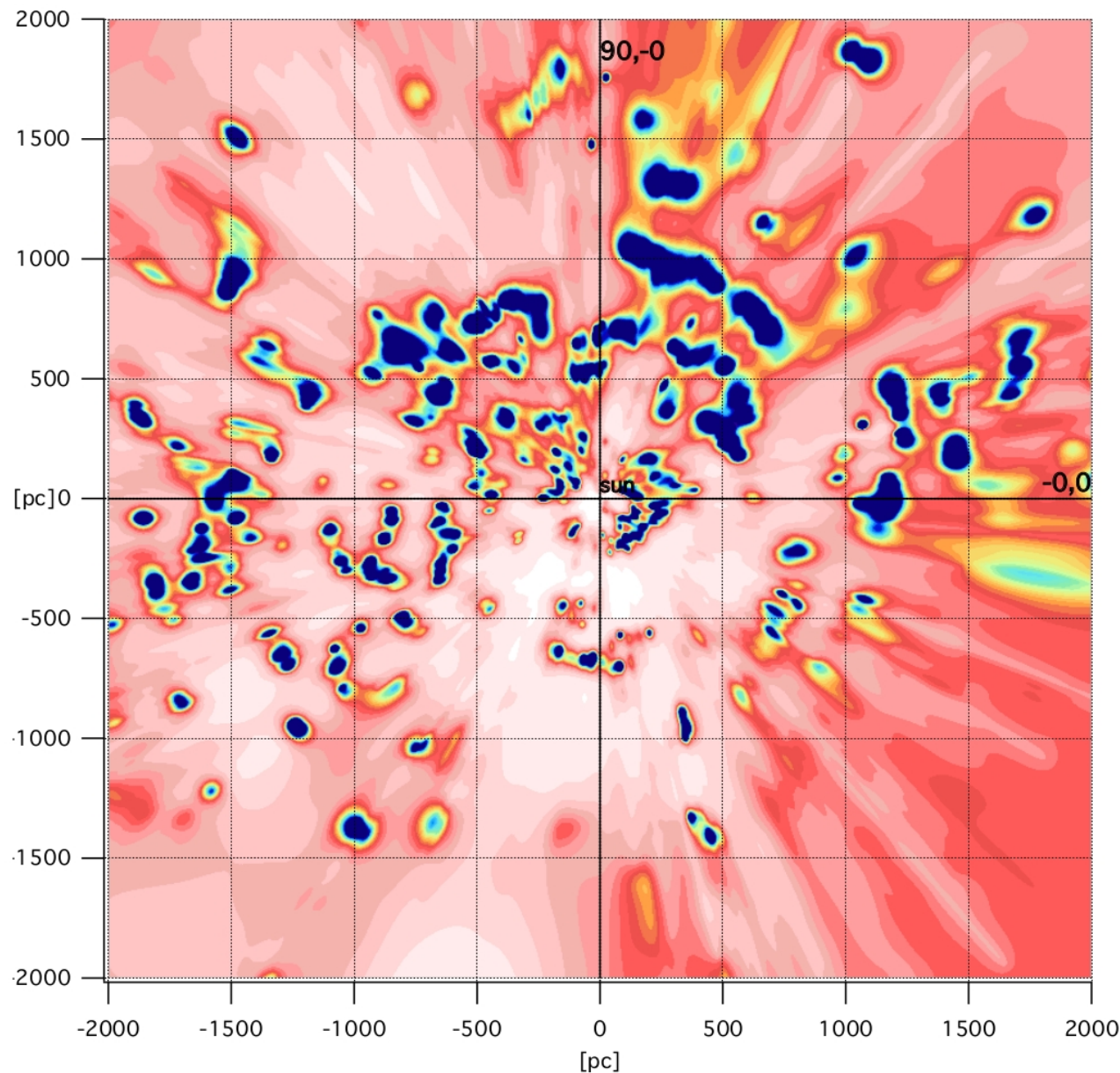
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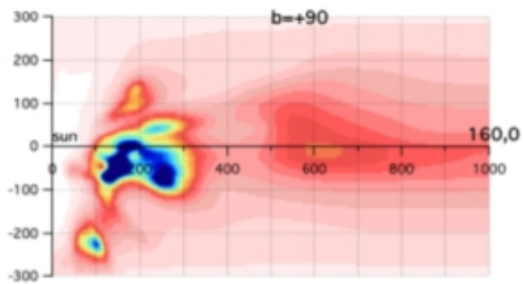
Lallement et al. 2018

TGAS DR1 + DIB + PAN-STARRS + APOGEE DR14 calibration

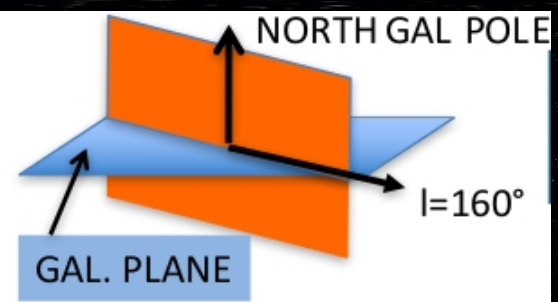


~ 60000 targets

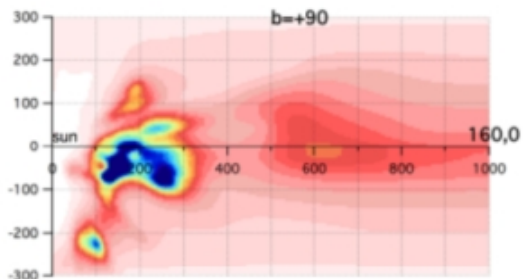
42633 APOGEE
spectrophotometric
distance-extinction



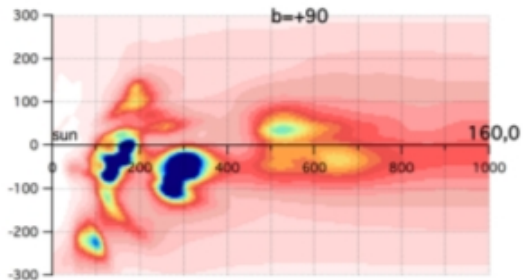
PRE-GAIA



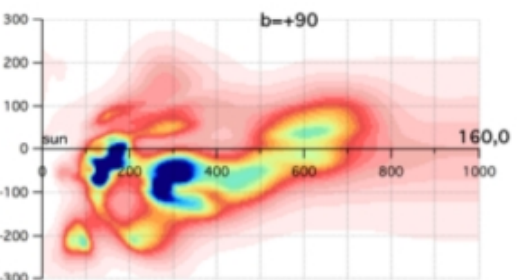
~ 23000



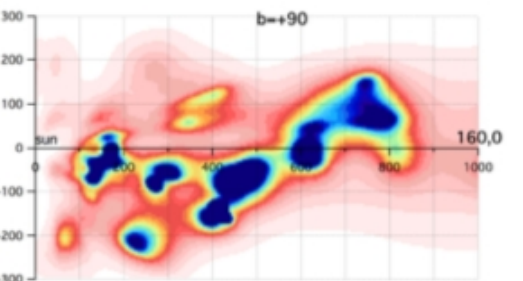
POST-GAIA



DIB APOGEE



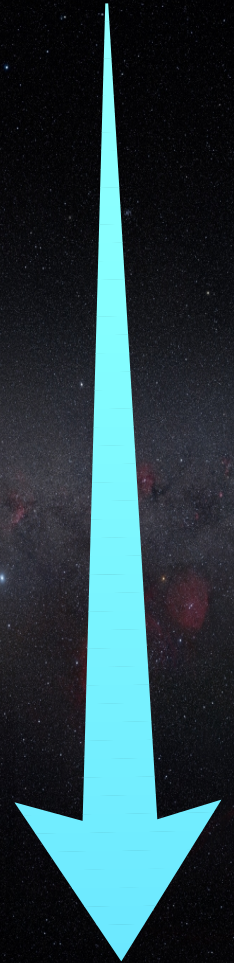
PANSTARRS



APOGEE SPECTROPHOTOM



~ 60000



STILISM

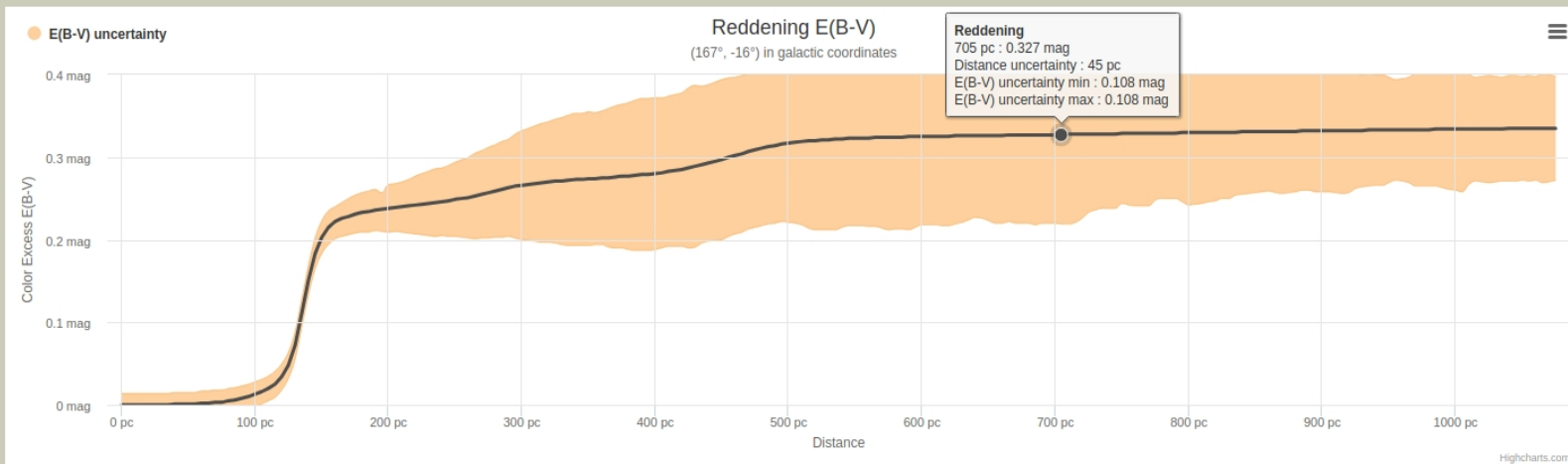
Structuring by Inversion the Local Interstellar Medium

Stilism

Structuring by Inversion the Local Interstellar Medium

Home / Reddening

You can zoom on a region with the mouse



Export data to CSV file

ONLINE TOOL → stilism.obspm.fr

Work in progress & Future

3D Extinction Map

R. Lallement, L. Capitanio

- ✓ Added 20000 Lamost distance-extinction (*Taurus, Perseus*)
- ✓ Integration in GUMS (combined with Marshall et al. 2006)
- ✓ Update with DR2+ (time costs)
- ✓ Include new APOGEE distance-extinction from updated **Photometric Calibrations** (colours, T_{eff} , k_G):

- ✓ Update sample selection with:
 - 3D map Lallement et al. 2018 (to select low extinction stars)
 - Gaia DR2 parallaxes
- ✓ Include new colours (BP, RP)
- ✓ Use for Gaia validation DR3+
- ✓ Asteroseismic distances
- ✓ ...

C. Babusiaux, C. Danielski,
L. Ruiz-Dern

