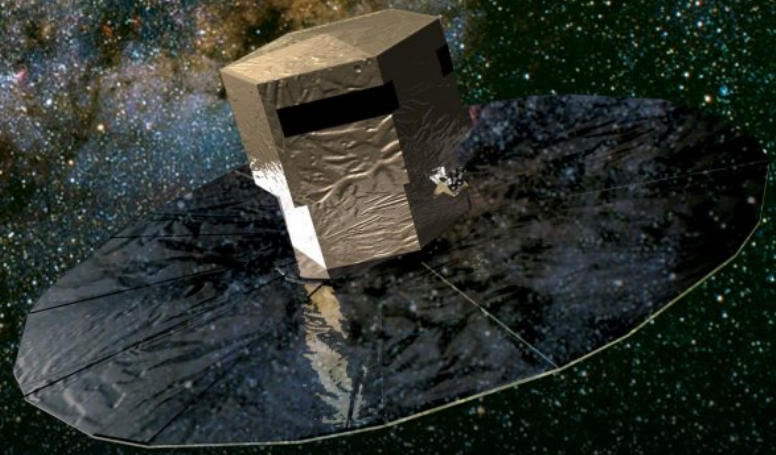
Three-dimensional (3D) reconstruction of the Galactic Interstellar Medium



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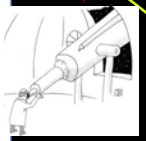
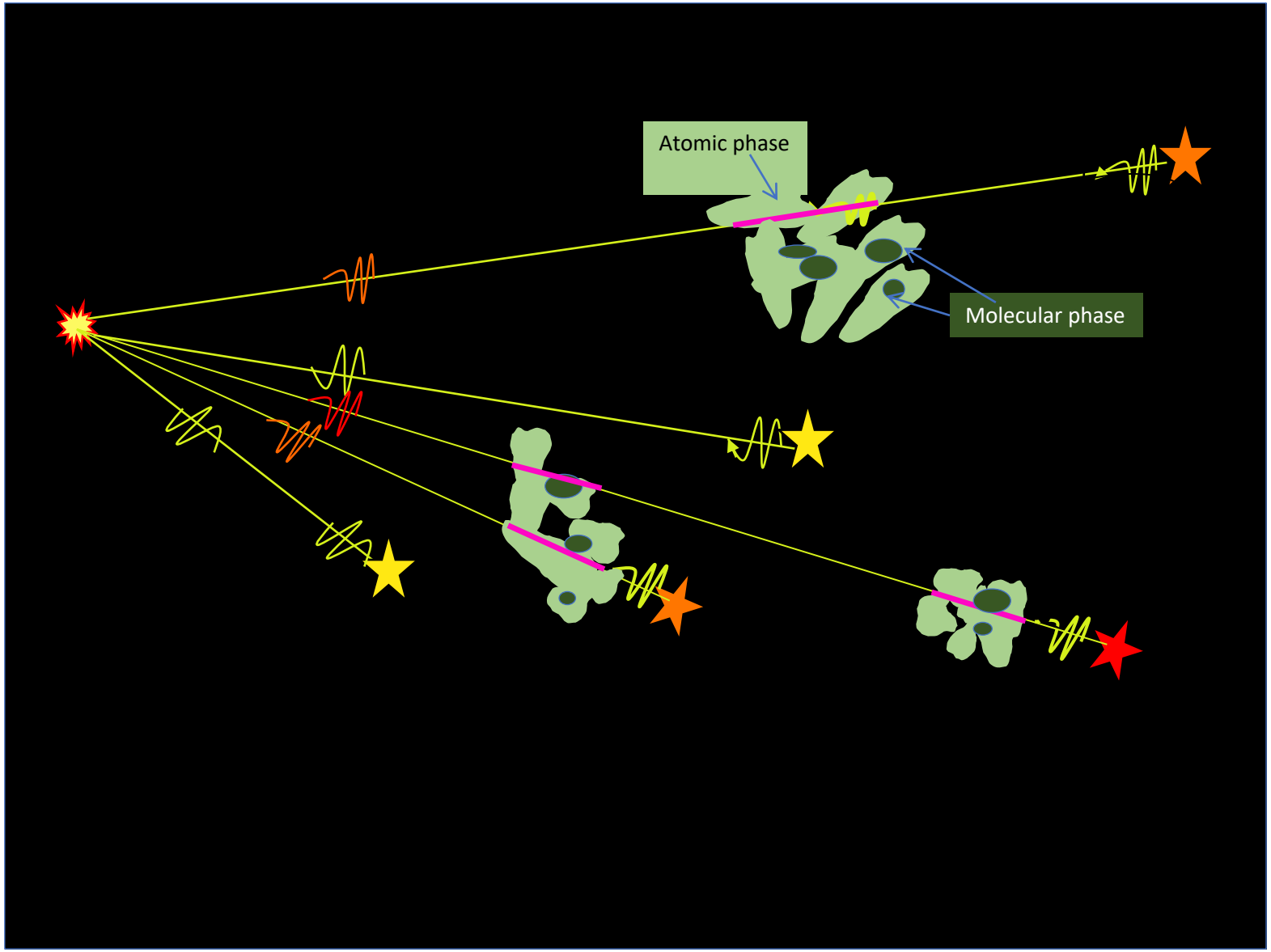
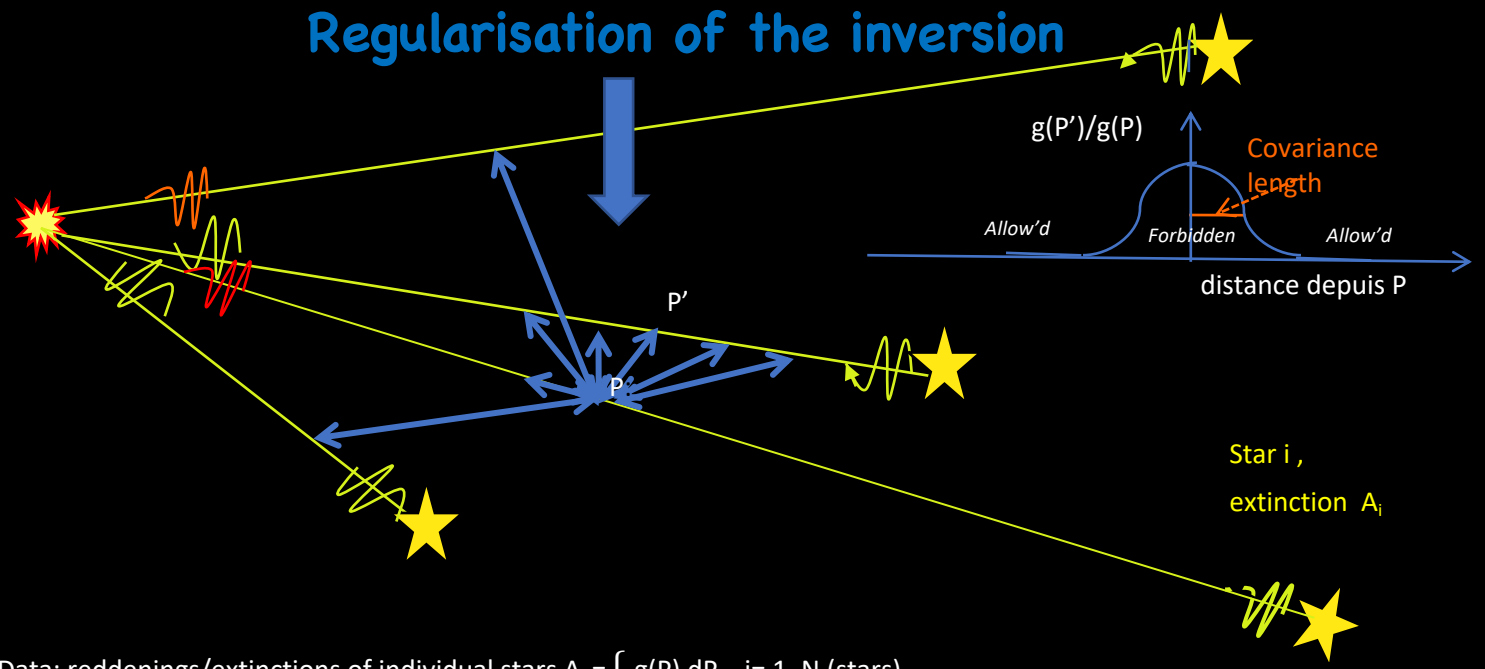
Reconstruction of extinction density distribution (equivalent to dust grain volume density) based on individual extinctions of stars



=> Solving an inverse problem


Atomic phase
Molecular phase

Regularisation of the inversion



- Data: reddenings/extinctions of individual stars $A_i = \int g(P)\, dP$ i= 1, N (stars)
- Prior conditions on the 3D distribution 3D (Bayesian aspect)

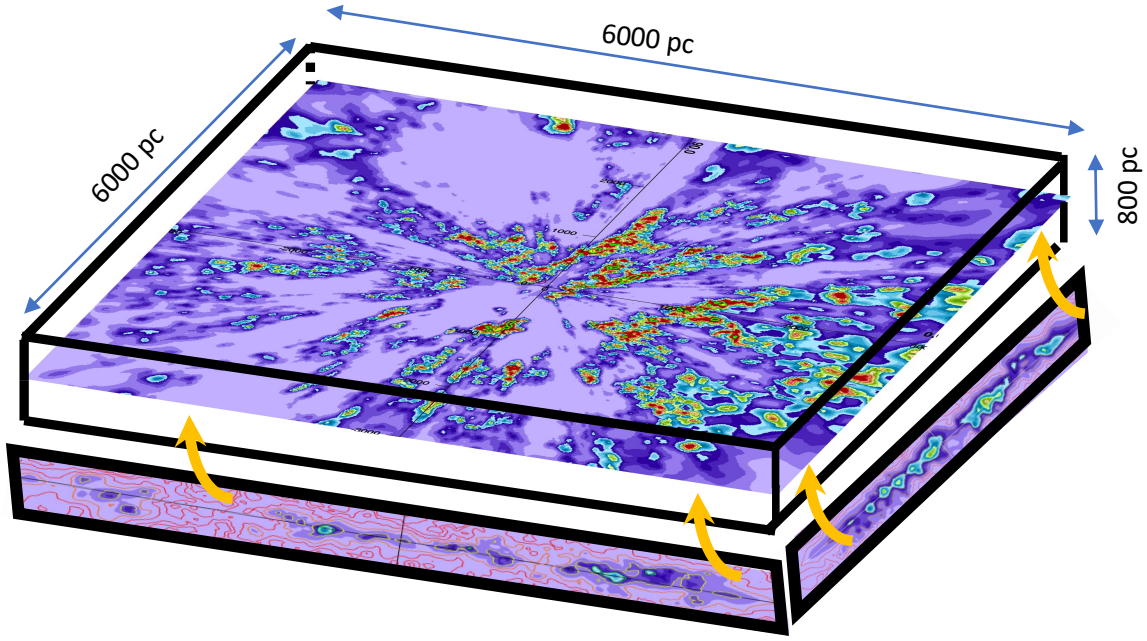
- **Covariance kernel 3D** => minimum size of structures (regularisation)=> limits g(P')/g(P)

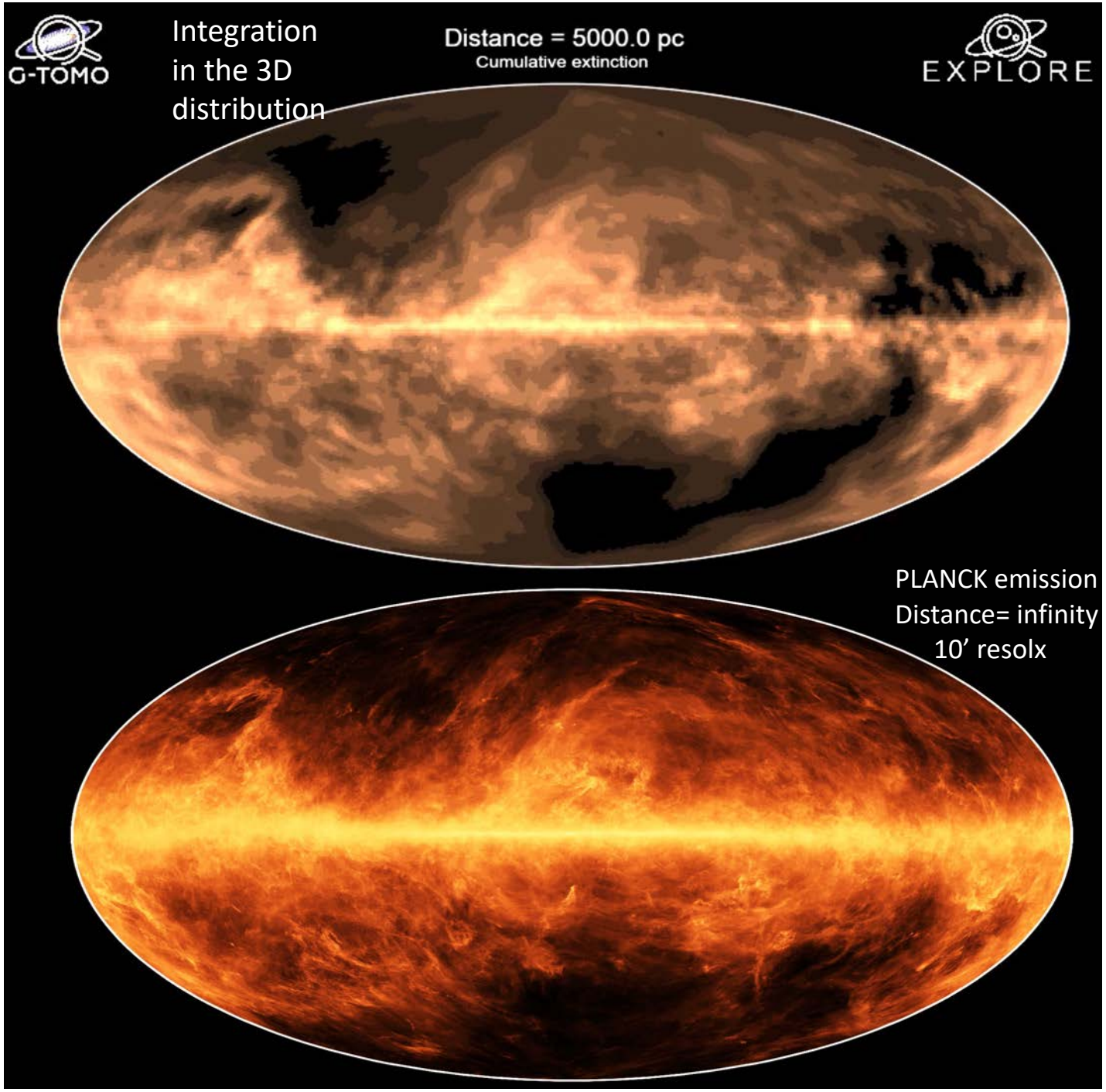
Inspired from methods used in geophysics: Tarantola & Valette, 1982

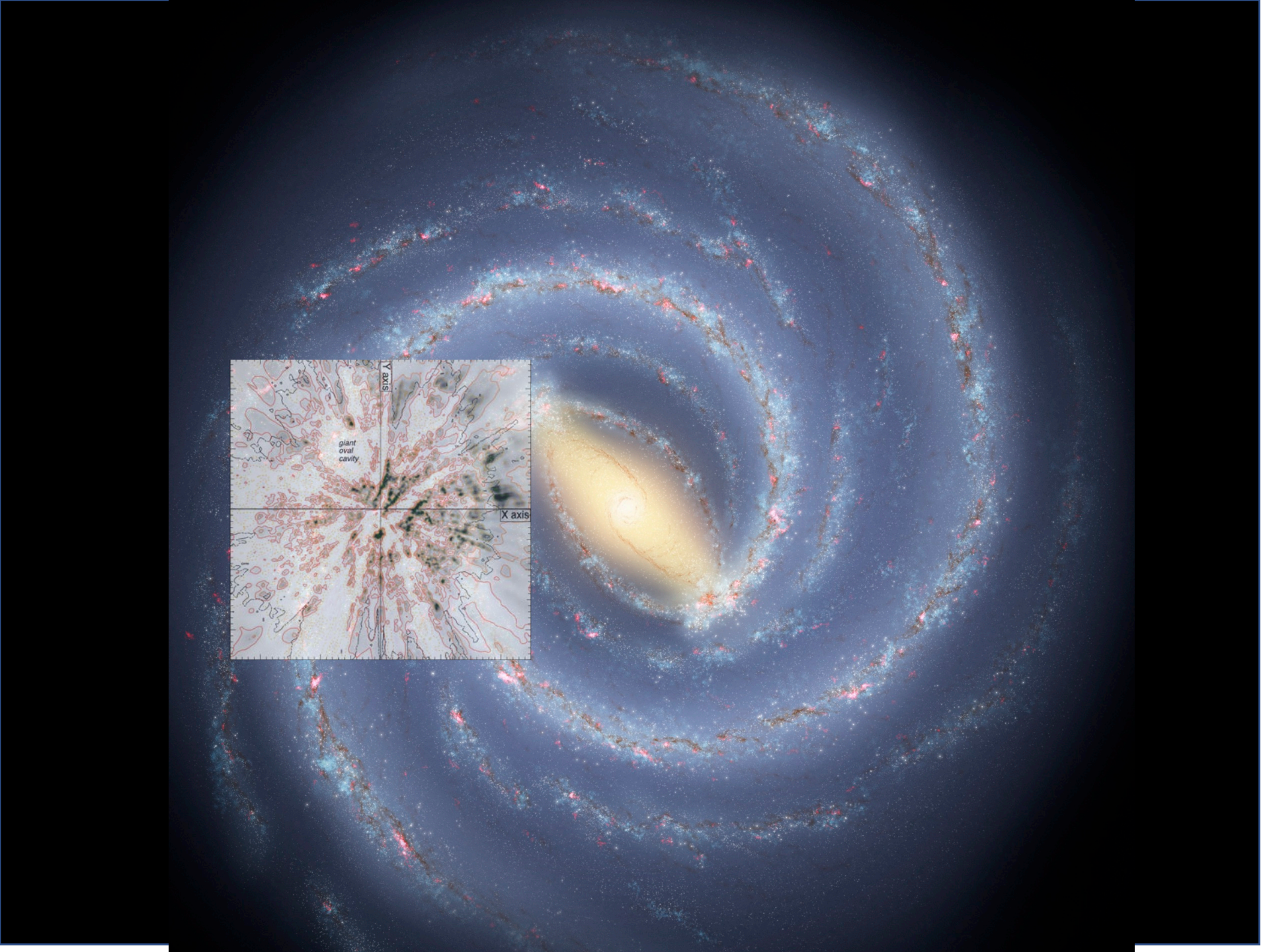
Description of methods : Vergely et al, 200, 2010, Lallement et al, 2014, 2019 , Capitanio et al, 2017

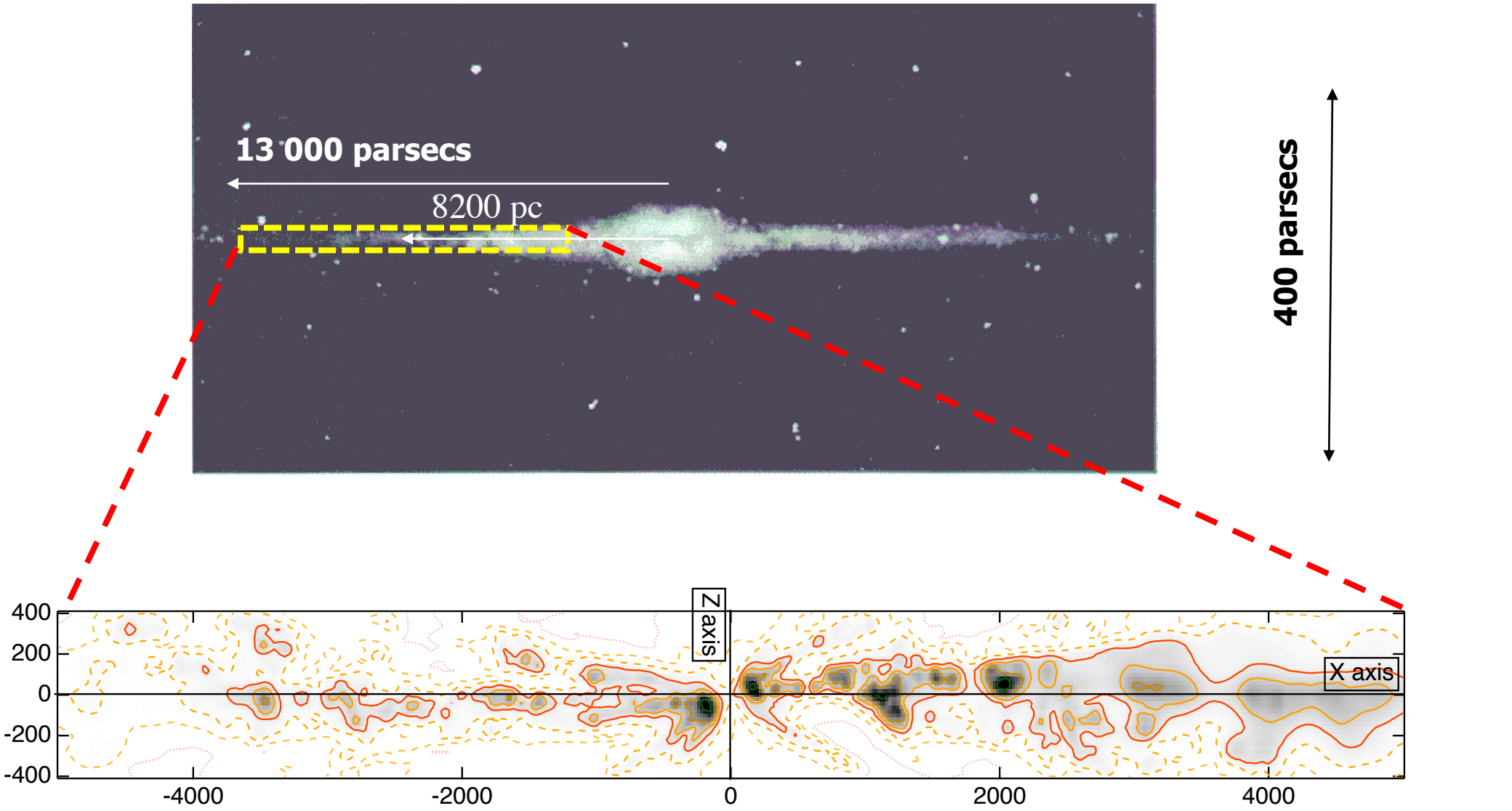
3D distribution around the Sun of the **extinction density (in units of magnitudes per parsec)** at 5500 A

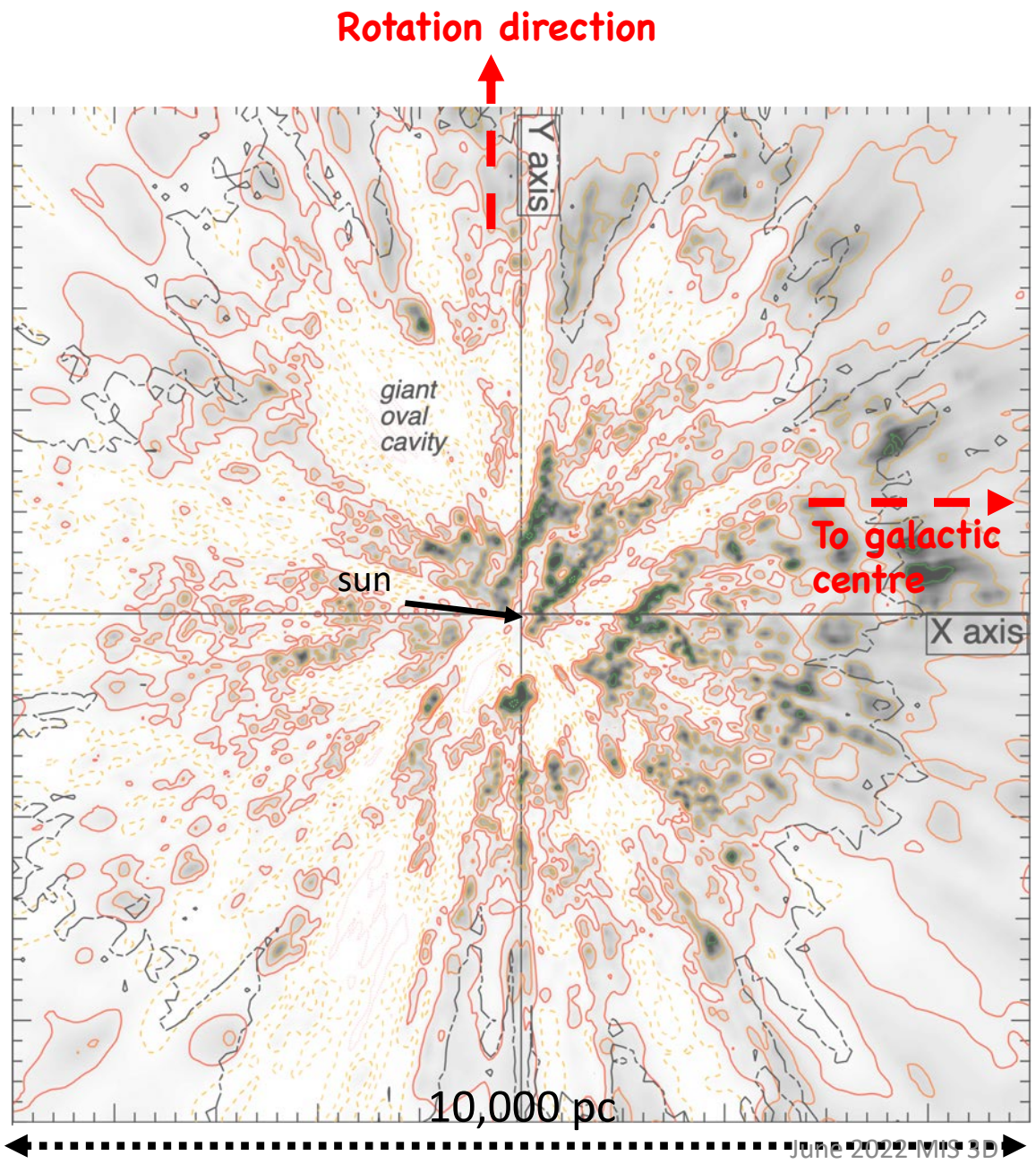
Here a 6 kpc x 6 kpc x 0.8 kpc volume




G-TOMO
Integration in the 3D distribution
Distance = 5000.0 pc
Cumulative extinction
EXPLORE
PLANCK emission
Distance= infinity
10’ resolx


Y axis
giant
oval
cavity
X axis

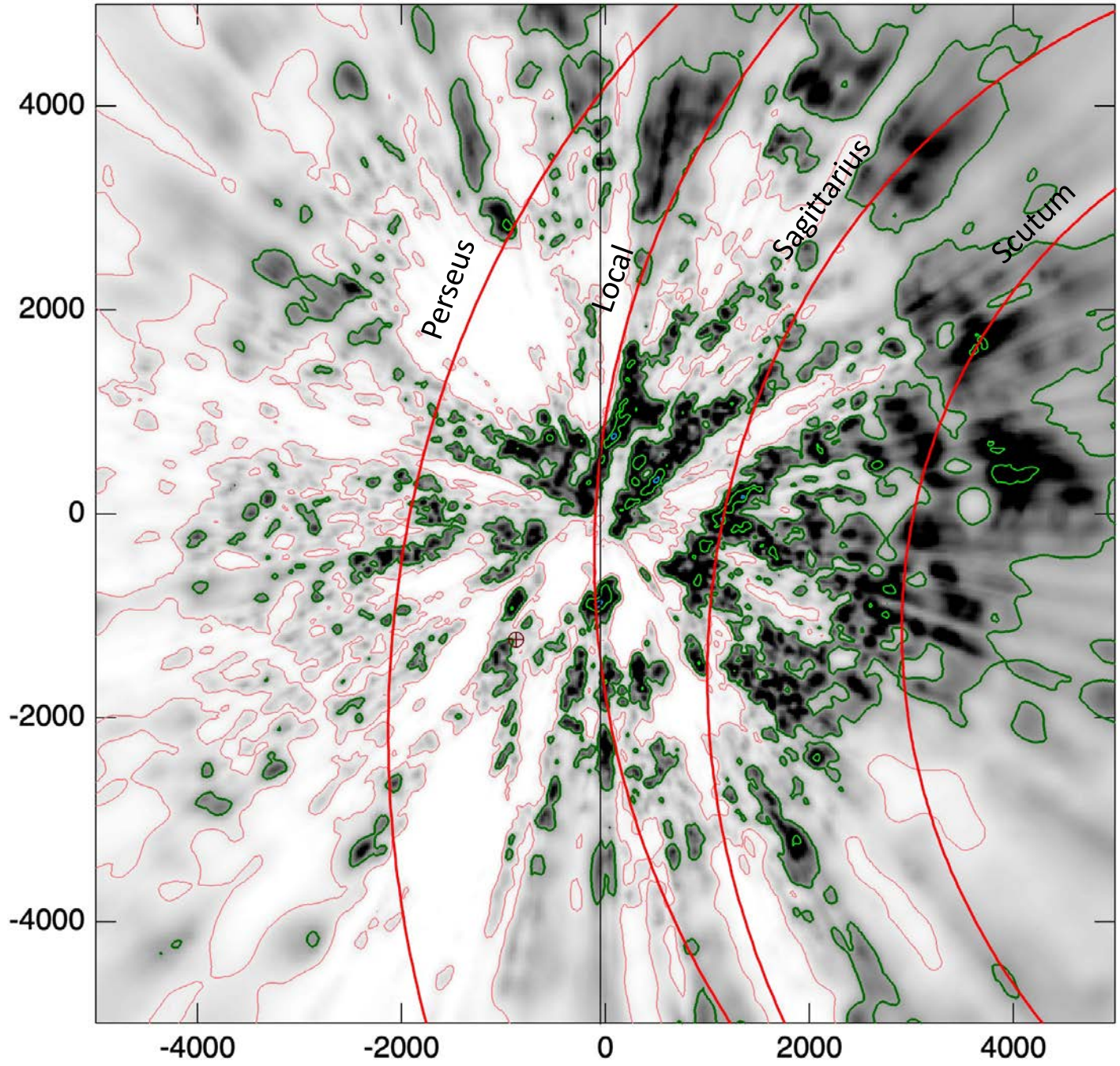

13 000 parsecs
8200 pc
400 parsecs
400
200
0
-200
-400
Z axis
X axis
-4000
-2000
0
2000
4000

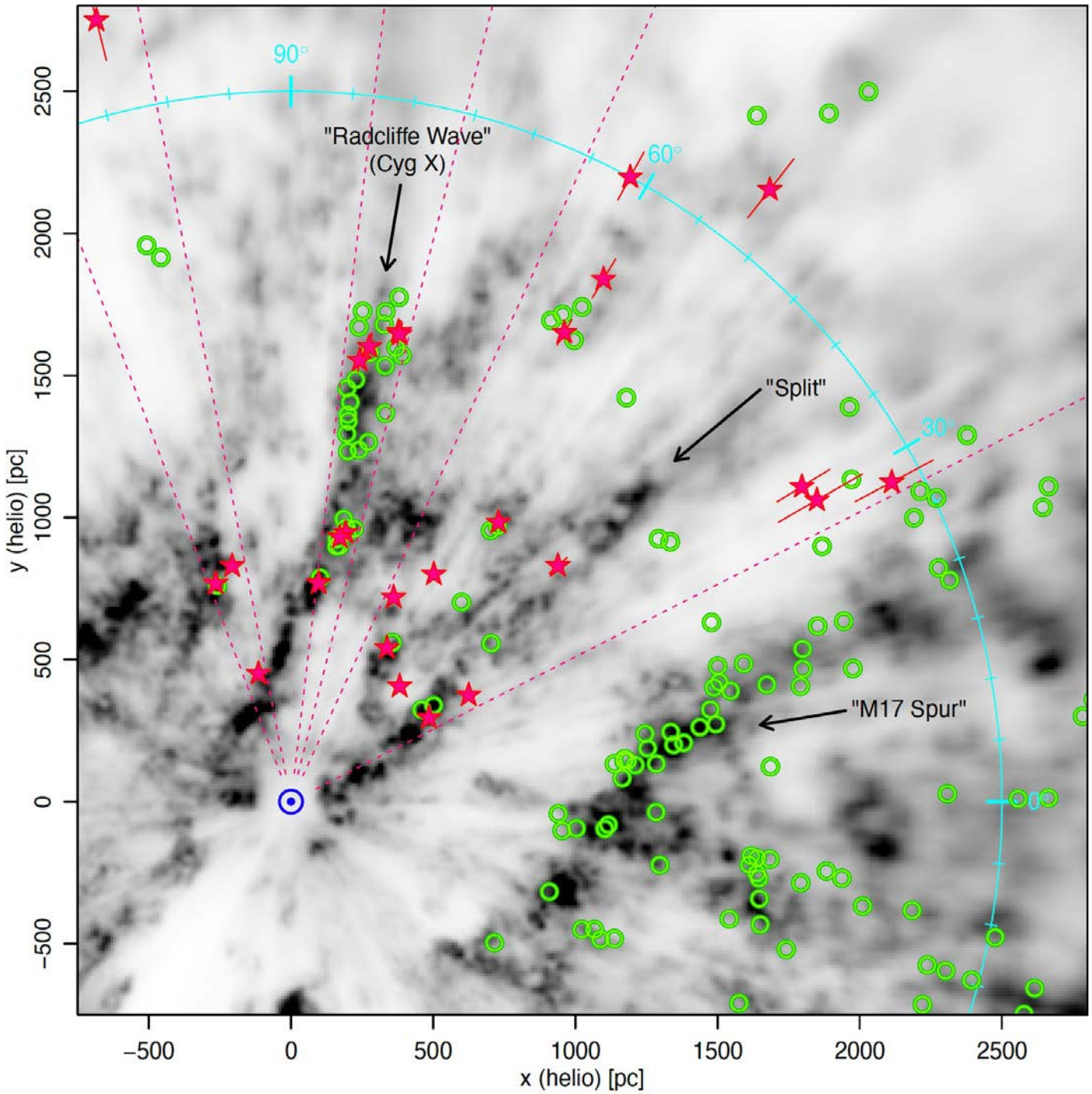


Galactic Plane = Plane of the image

Black: dense dust

Color-coded quantity:
extinction per parsec

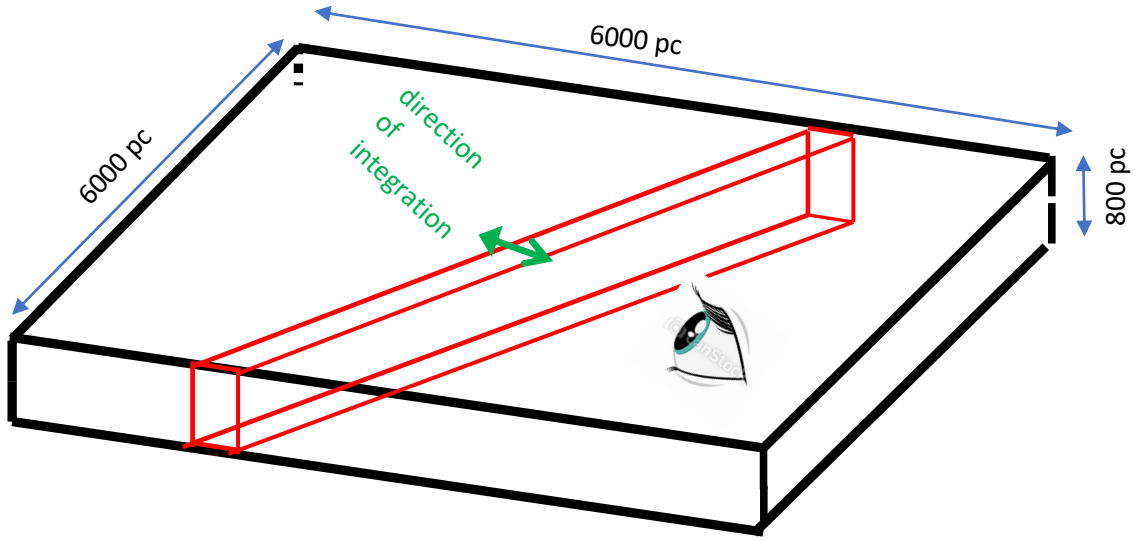

4000
2000
0
-2000
-4000
-4000
-2000
0
2000
4000
Perseus
Local
Sagittarius
Scutum

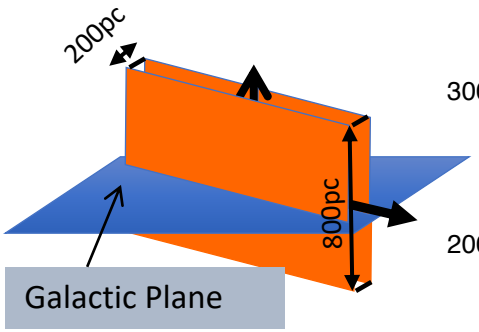


Young stellar objects (YSOs) coïncide with the dense dust clouds

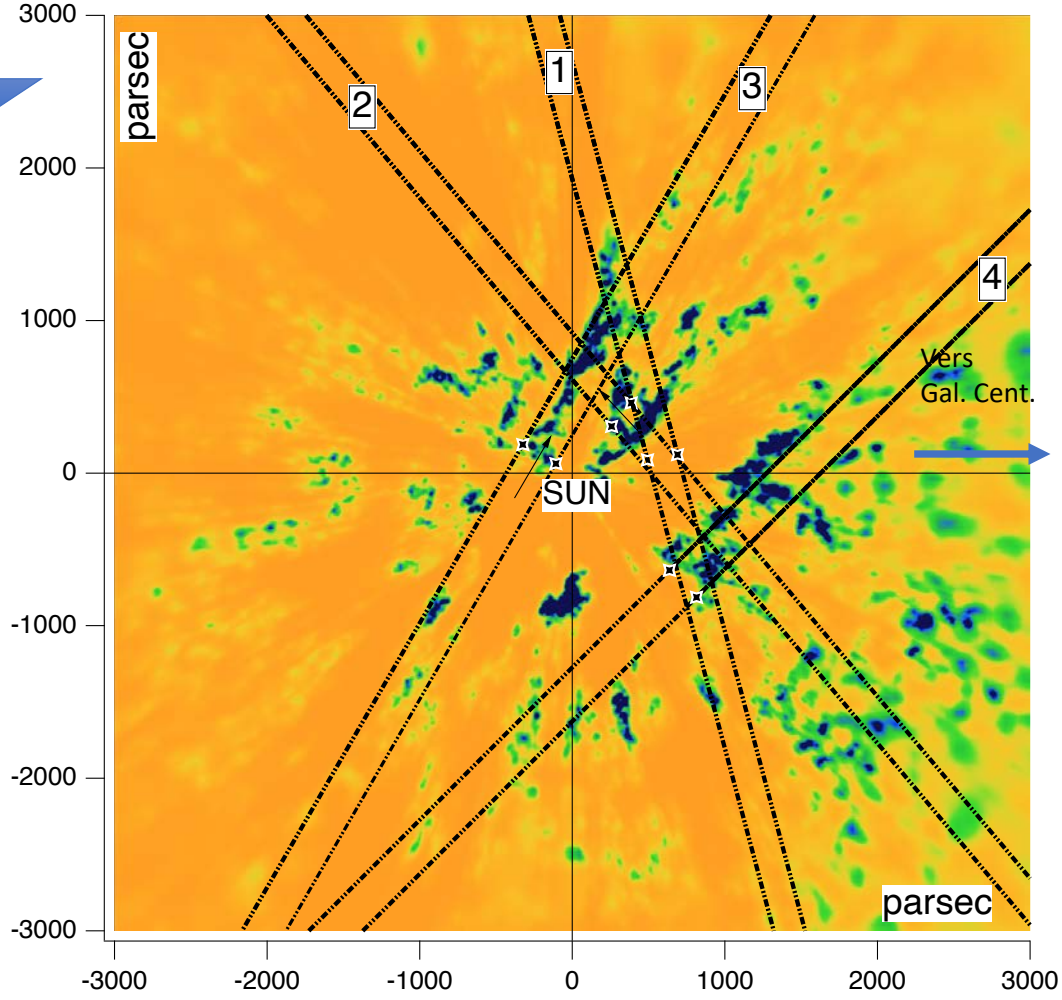
Kuhn et al, 2022
arXiv:2206.04090v

Vertical slices in the 3D distribution

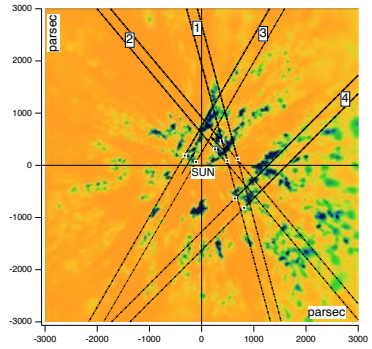


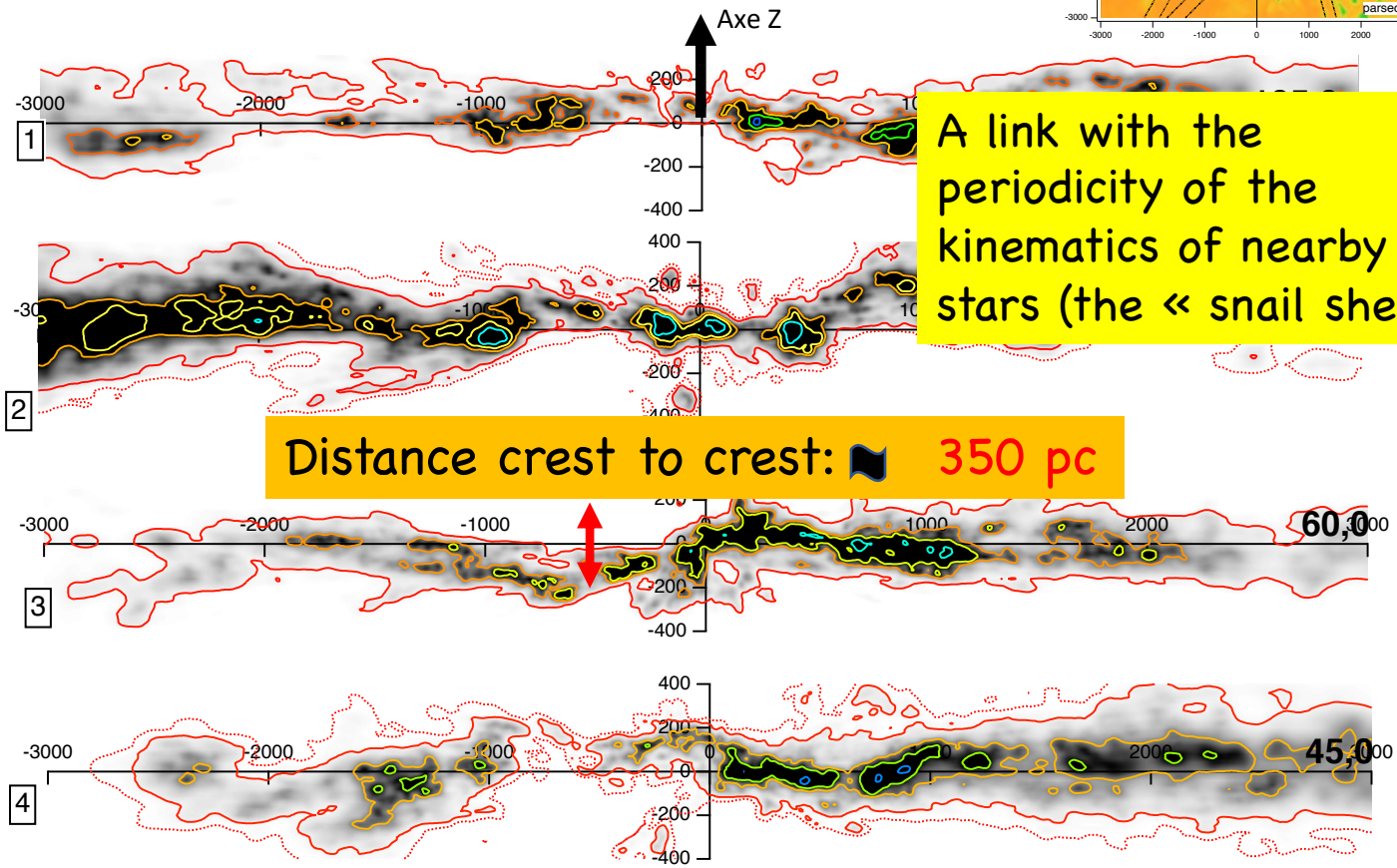


Traces of vertical slices on the Gal. Plane



Ondulations of the interstellar dust layer around the disc mid-plane





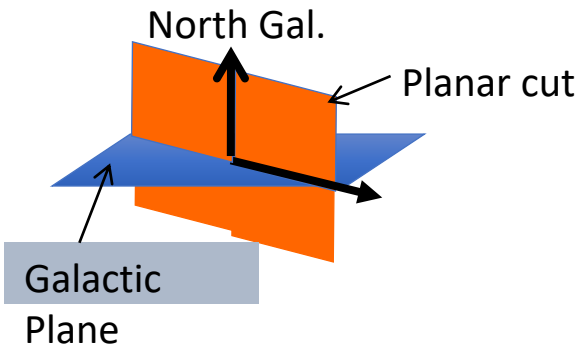
A link with the periodicity of the kinematics of nearby stars (the « snail shell ») ?

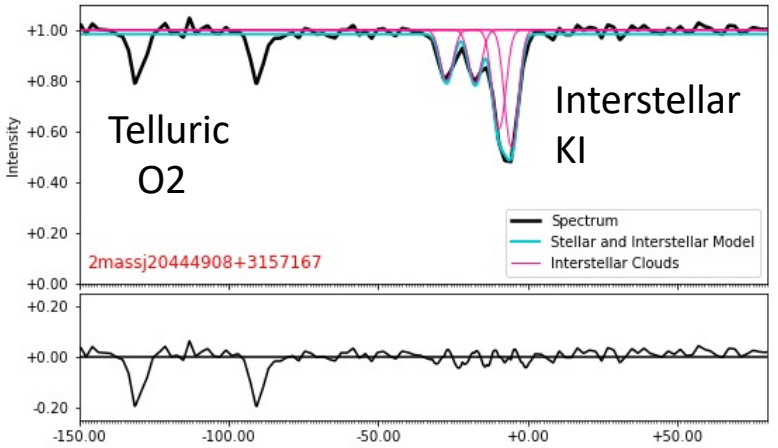
Distance crest to crest: 350 pc

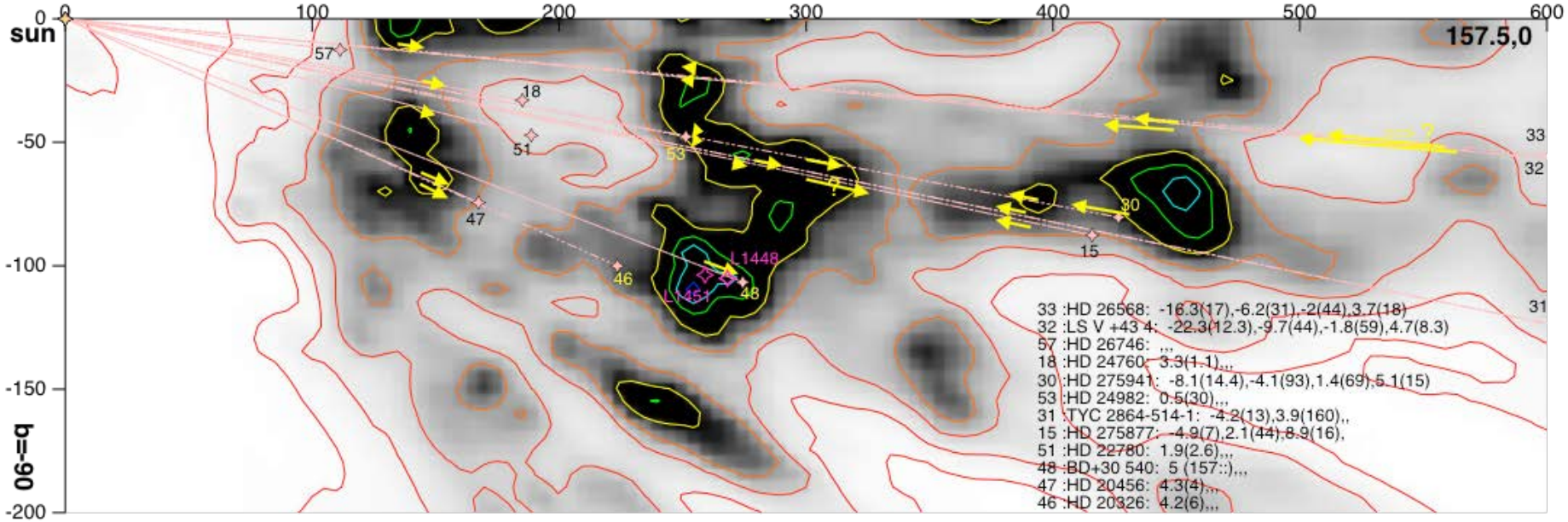
Towards 3D kinetic tomography: assigning velocities to dust clouds extracted from the 3D

-Combination of 3D extinction maps and absorption data: KI towards stars from the anti-centre area Taurus-Perseus-California=> « manual » positioning *Ivanova et al, 2021*

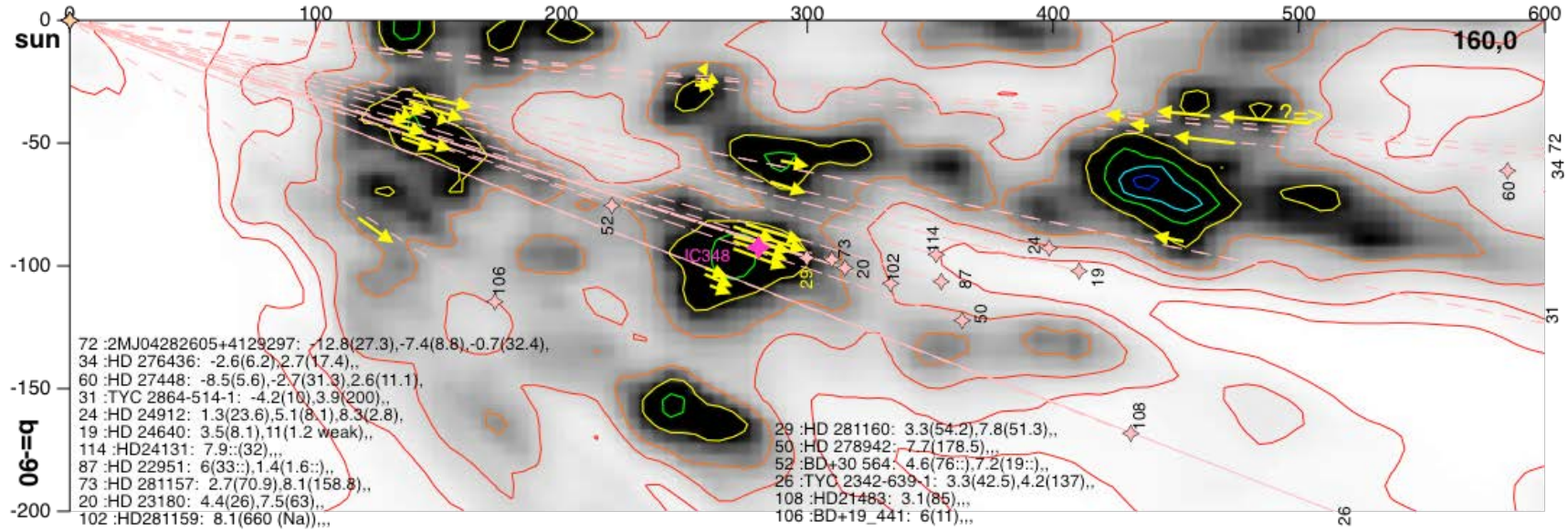
-Work in progress: automated combination of 3D extinction maps and radio CO spectral cubes



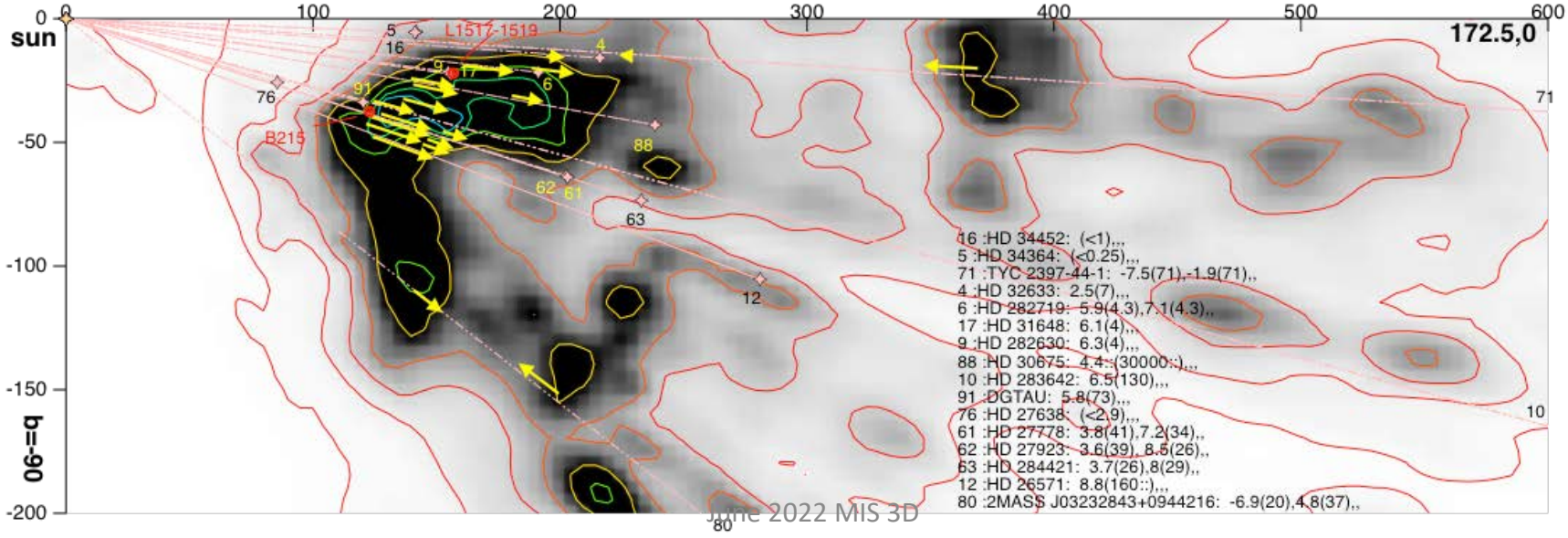


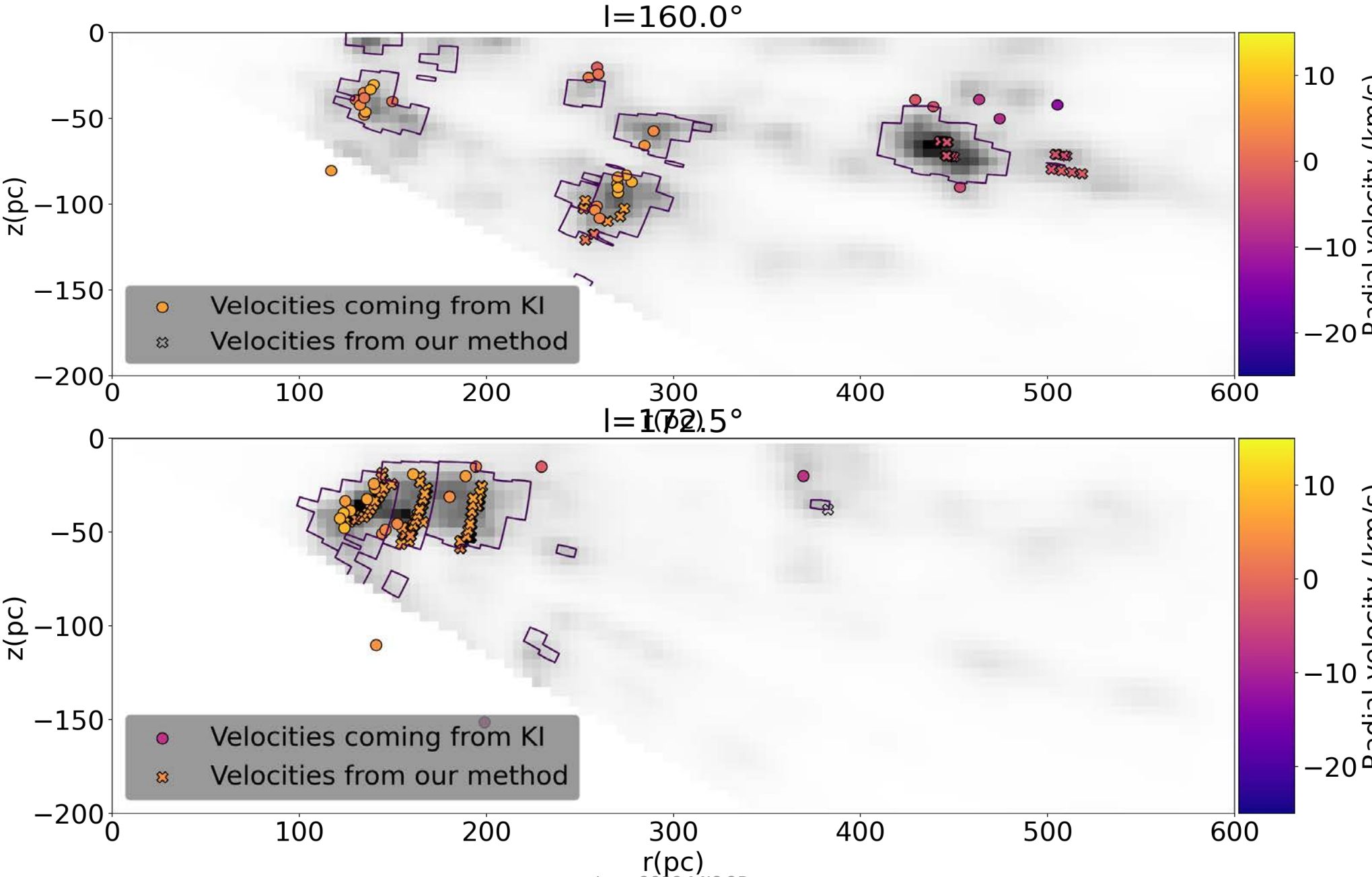


Ivanova et al, 2021

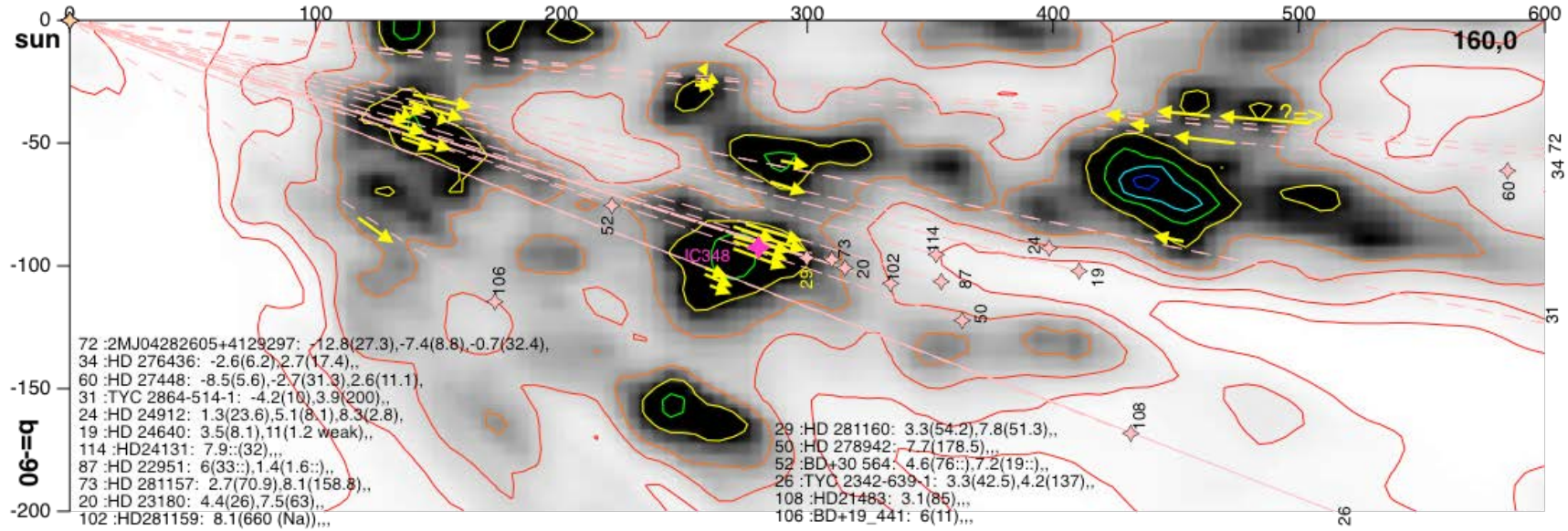


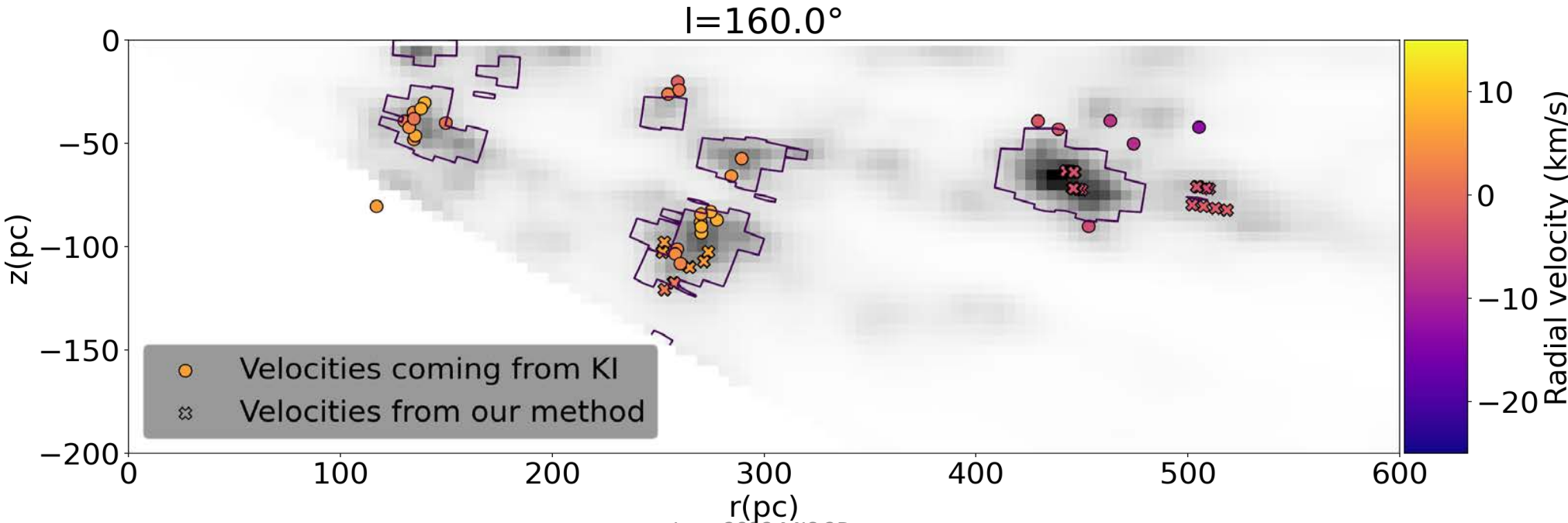
Ivanova et al, 2021

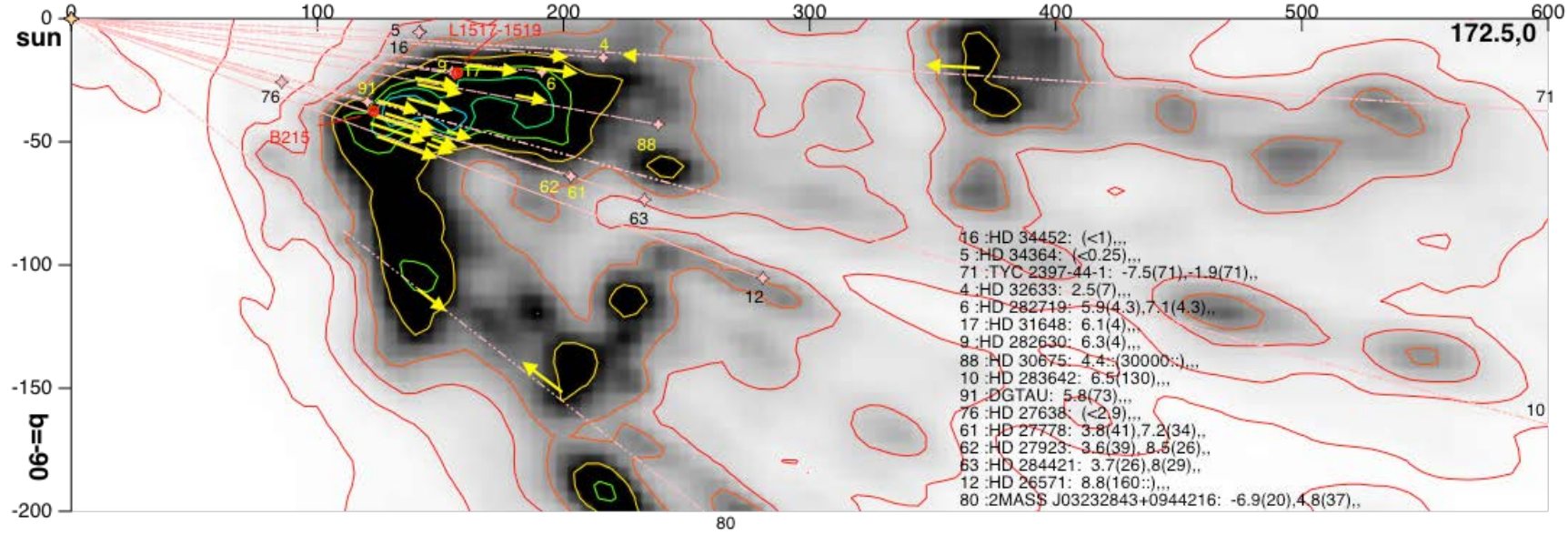


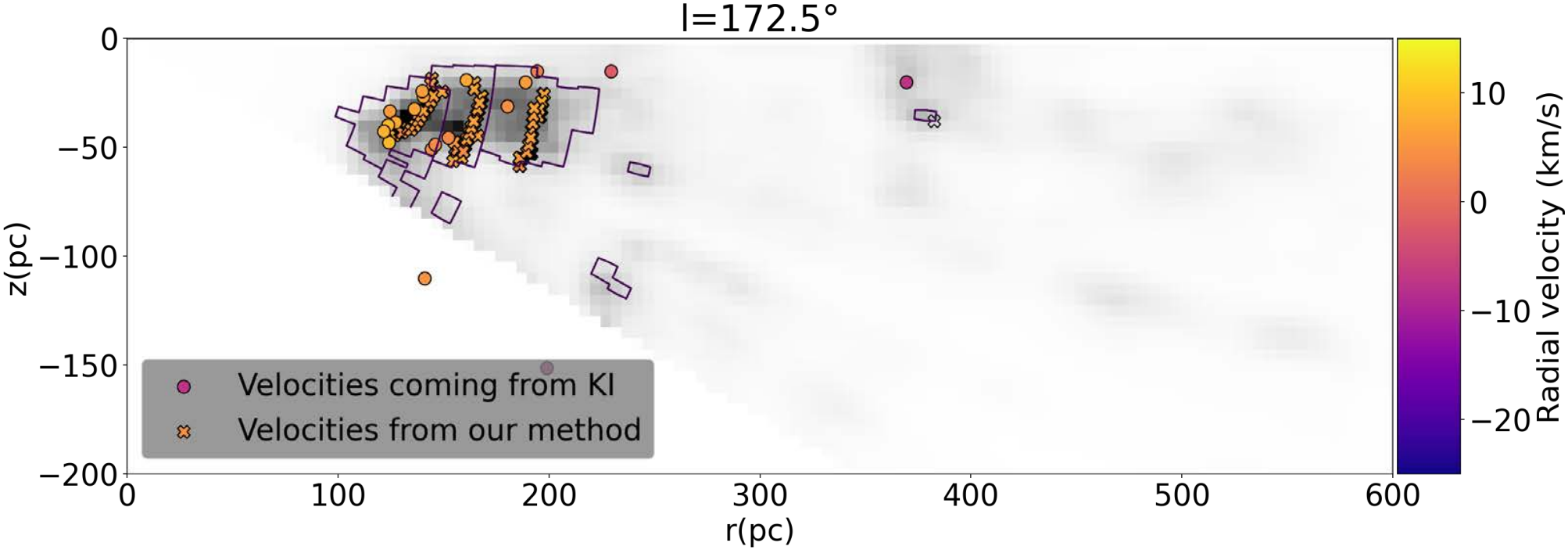


Duchêne et al, in prep.


sun
160,0
IC348
72 :2MJ04282605+4129297: -12.8(27.3),-7.4(8.8),-0.7(32.4),,
34 :HD 276436: -2.6(6.2),2.7(17.4),,
60 :HD 27448: -8.5(5.6),-2.7(31.3),2.6(11.1),,
31 :TYC 2864-514-1: -4.2(16),3.9(200),,
24 :HD 24912: 1.3(23.6),5.1(8.1),8.3(2.8),,
19 :HD 24640: 3.5(8.1),11(1.2 weak),,
114 :HD24131: 7.9::(32),,,
87 :HD 22951: 6(33::),1.4(1.6::),,
73 :HD 281157: 2.7(70.9),8.1(158.8),,
20 :HD 23180: 4.4(26),7.5(63),,
102 :HD281159: 8.1(660 (Na)),,,
29 :HD 281160: 3.3(54.2),7.8(51.3),,
50 :HD 278942: 7.7(178.5),,,
52 :BD+30 564: 4.6(76::),7.2(19::),,
26 :TYC 2342-639-1: 3.3(42.5),4.2(137),,
108 :HD21483: 3.1(85),,,
106 :BD+19_441: 6(11),,,
b=-90


l=160.0°
z(pc)
r(pc)
Radial velocity (km/s)
Velocities coming from KI
Velocities from our method


sun
b=-90
172.5,0
L1517-1519
B215
16 :HD 34452: (<1),,,
5 :HD 34364: (<0.25),,,
71 :TYC 2397-44-1: -7.5(71),-1.9(71),,
4 :HD 32633: 2.5(7),,,
6 :HD 282719: 5.9(4.3),7.1(4.3),,
17 :HD 31648: 6.1(4),,,
9 :HD 282630: 6.3(4),,,
88 :HD 30675: 4.4:-(30000:),,,
10 :HD 283642: 6.5(130),,,
91 :DGTAU: 5.8(73),,,
76 :HD 27638: (<2.9),,,
61 :HD 27778: 3.8(41),7.2(34),,
62 :HD 27923: 3.6(39), 8.5(26),,
63 :HD 284421: 3.7(26),8(29),,
12 :HD 26571: 8.8(160::),,,
80 :2MASS J03232843+0944216: -6.9(20),4.8(37),,


l=172.5°
z(pc)
r(pc)
Radial velocity (km/s)
Velocities coming from KI
Velocities from our method

Perspectives

-Developing more precise and extended dust extinction maps based on additional DR3 information

-Developing the kinetic tomography techniques

-Extending the kinetic tomography to dust + CO + HI

thank you!