What do we learn from surveys (GAIA, Pan-STARRS, VISTA, etc) concerning the structure and phases of the ISM (3D ISM, extinction curve and diffuse bands studies)

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ISM history: In the beginning there was extinction...

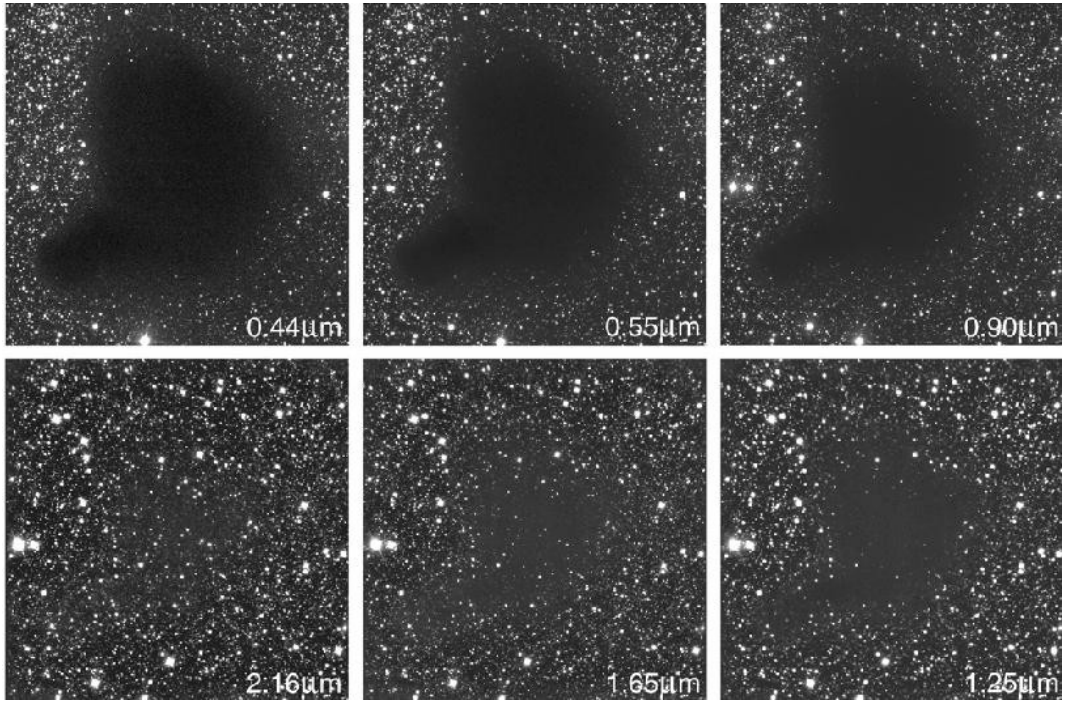
- 1823 Olbers and the *dark night sky paradox*

«I have recently sent to Bode's Jahrbuch a small essay on the transparency of the cosmic spaces, in which, in my opinion, even if I have not demonstrated, but at least I have made it very probable, that the cosmic spaces are not absolutely transparent»

- 1919 Barnard: holes in star distribution are due to extinction

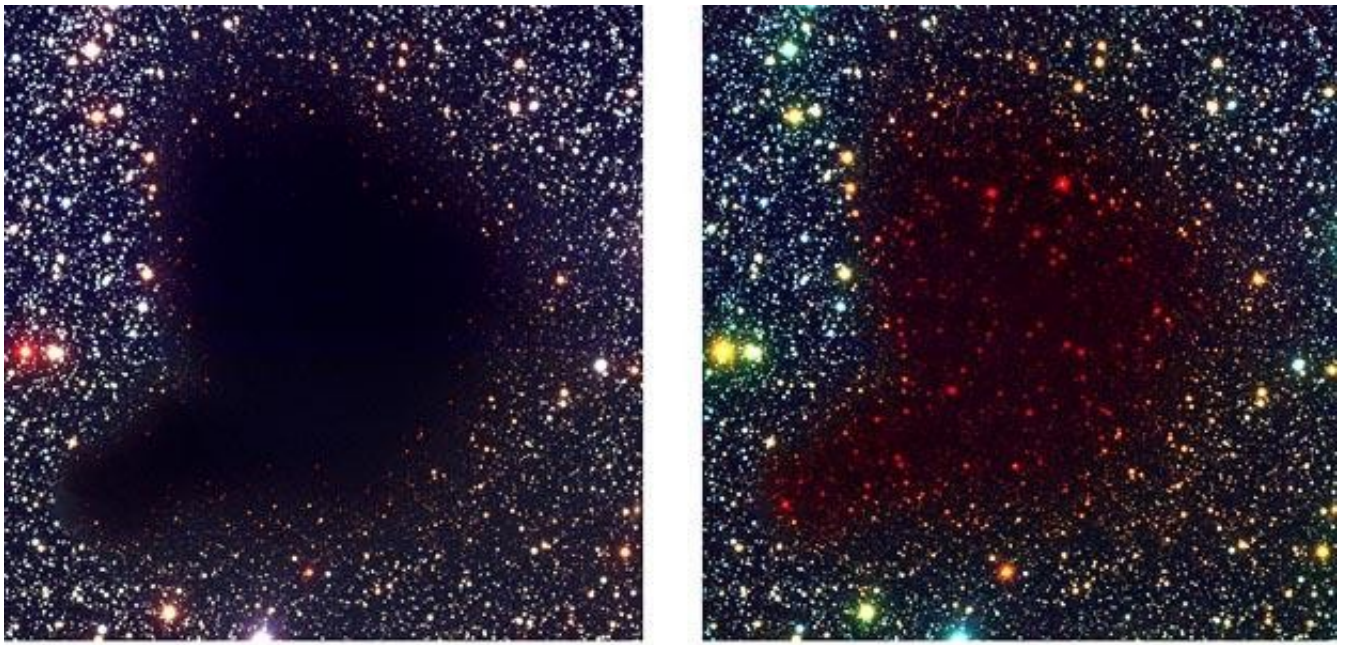
Extinction and wavelength

- B68: Av~35 mag *(Alves et al. 2001)*



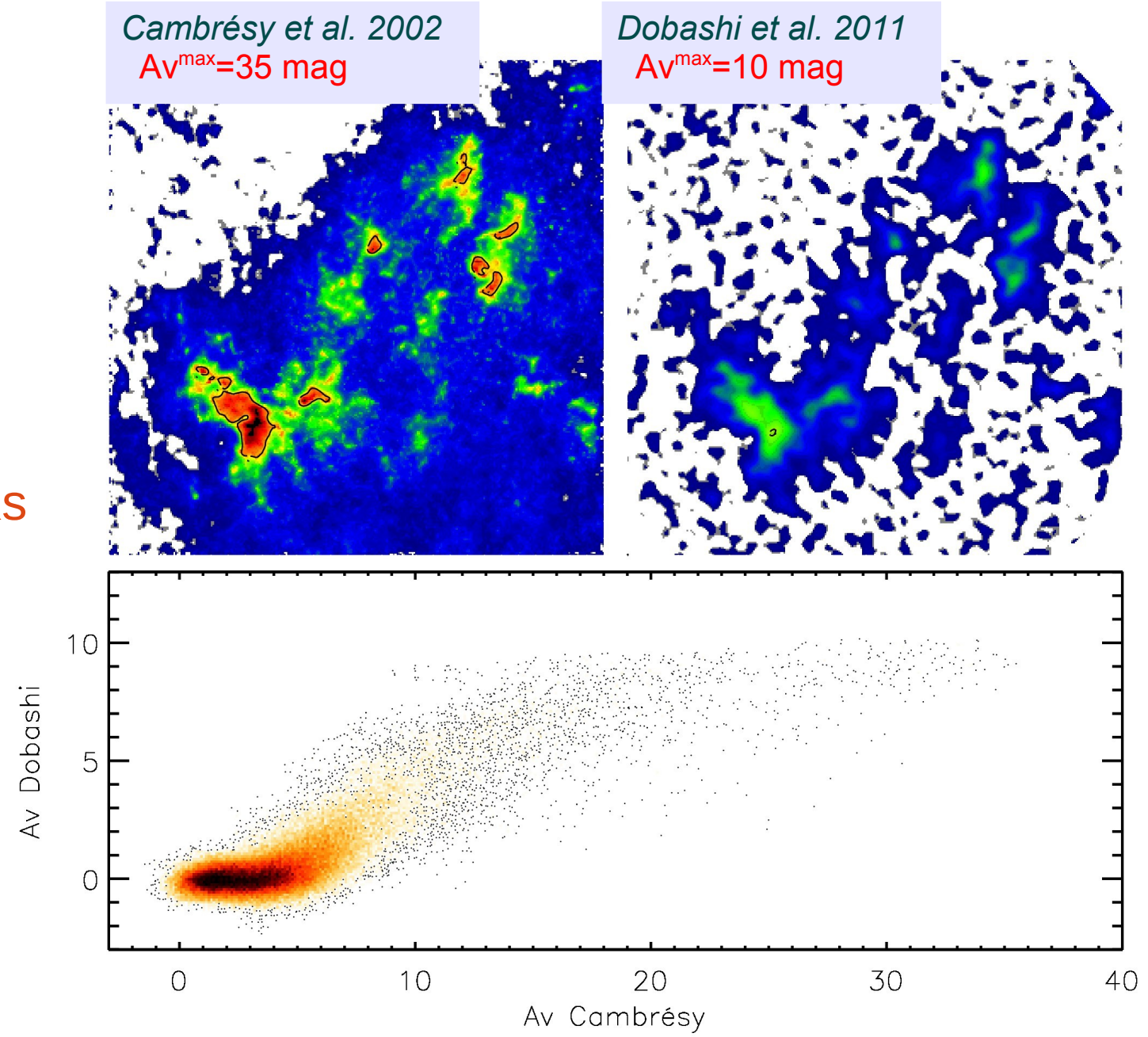
- Star counts
  - *Wolf 1923*, optical
  - 3 mag of extinction decrease the star density by a factor of ~10

- Color Excess
  - *Lada et al. 1994*, near-infrared

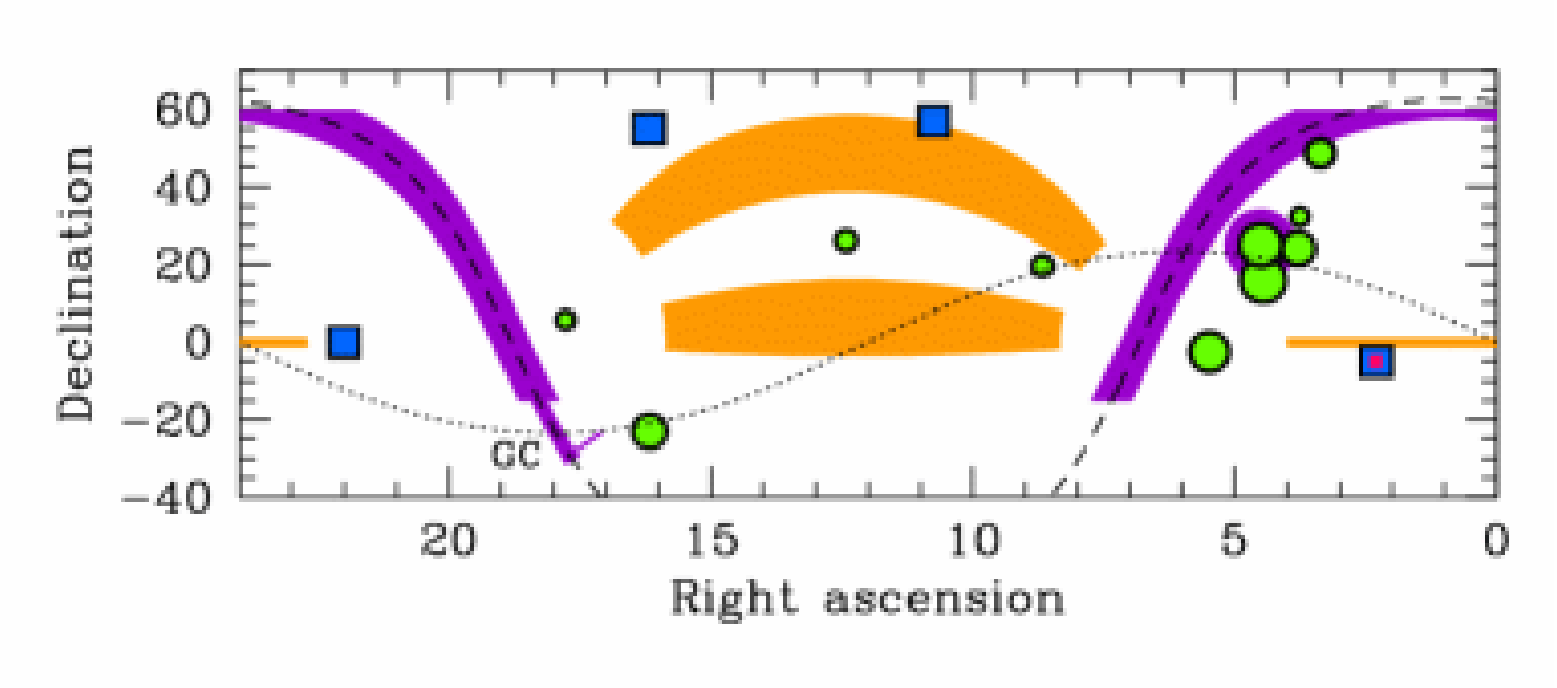


Extinction mapping

- 2MASS H-Ks

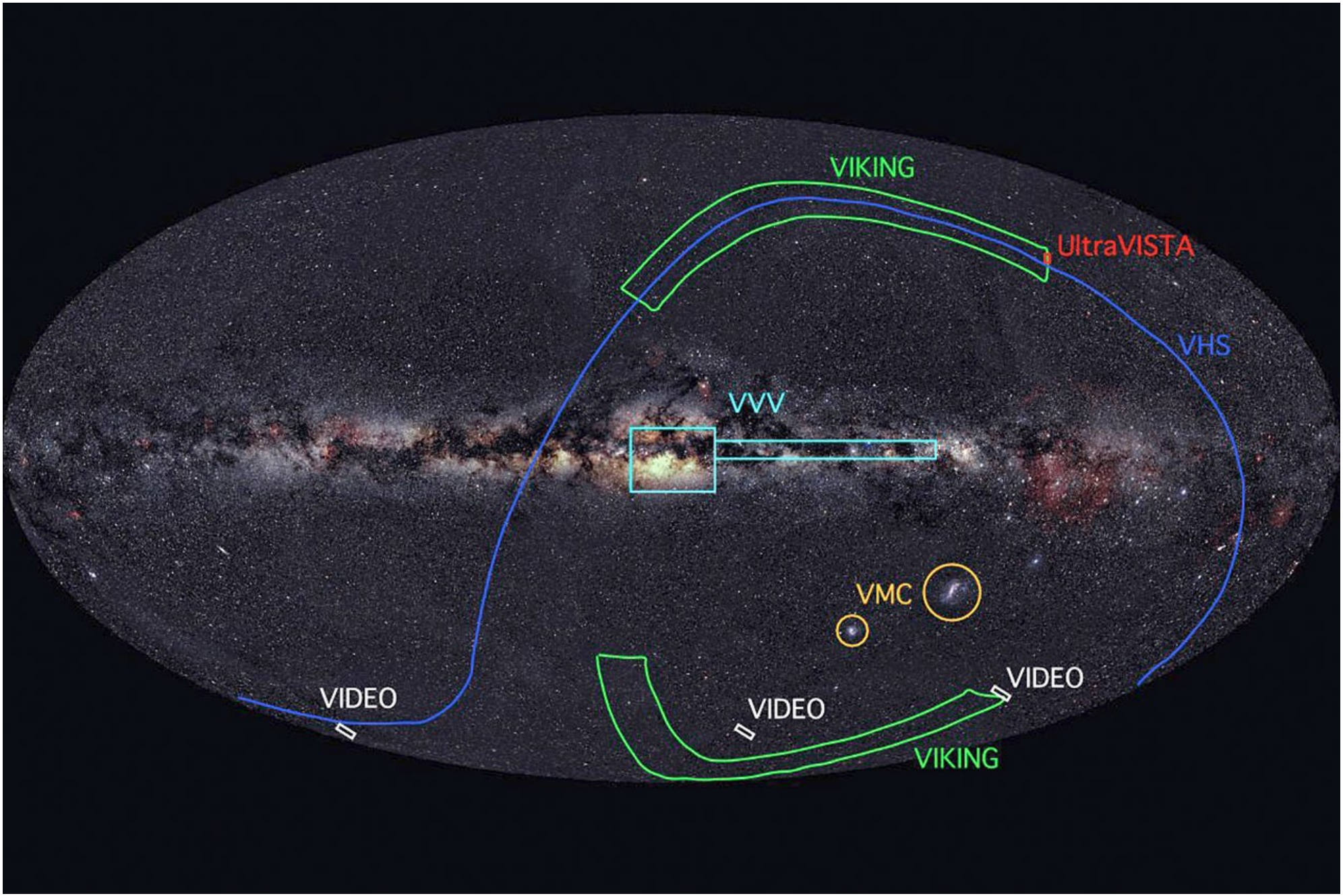


UKIDSS



1.	Large Area Survey (LAS)	4000 sq. degs	K=18.4	extraGalactic
2.	Galactic Plane Survey (GPS)	1800 sq. degs	K=19.0	Galactic
3.	Galactic Clusters Survey (GCS)	1400 sq. degs	K=18.7	Galactic
4.	Deep Extragalactic Survey (DXS)	35 sq. degs	K=21.0	extraGalactic
5.	Ultra Deep Survey (UDS)	0.77 sq. degs	K=23.0	extraGalactic

The VISTA surveys (4m, 1.6° FOV)



Spatial resolution vs wavelength and extinction

		Av=5	Av=30	Av=50	Av=80
2MASS	H - Ks	**1.0**	4.5	15.2	93
UKIDSS / VISTA	H - Ks	0.3	1.3	4.2	26
UKIDSS / VISTA GLIMPSE	Ks - [3.6]	1.1	2.1	3.6	7.9
GLIMPSE	[3.6] - [4.5]	1.6	2.6	4.0	7.9
GLIMPSE	[4.5] - [5.8]	3.1	4.9	7.0	12.0

- 2MASS, Ks~14.3 mag
- UKIDSS-**GPS** and VISTA-**VVV**, Ks~18 mag
- Spitzer **GLIMPSE**, [3.6]~14 mag, [4.5]~13 mag, [5.8]~11 mag

Spatial resolution vs sky position

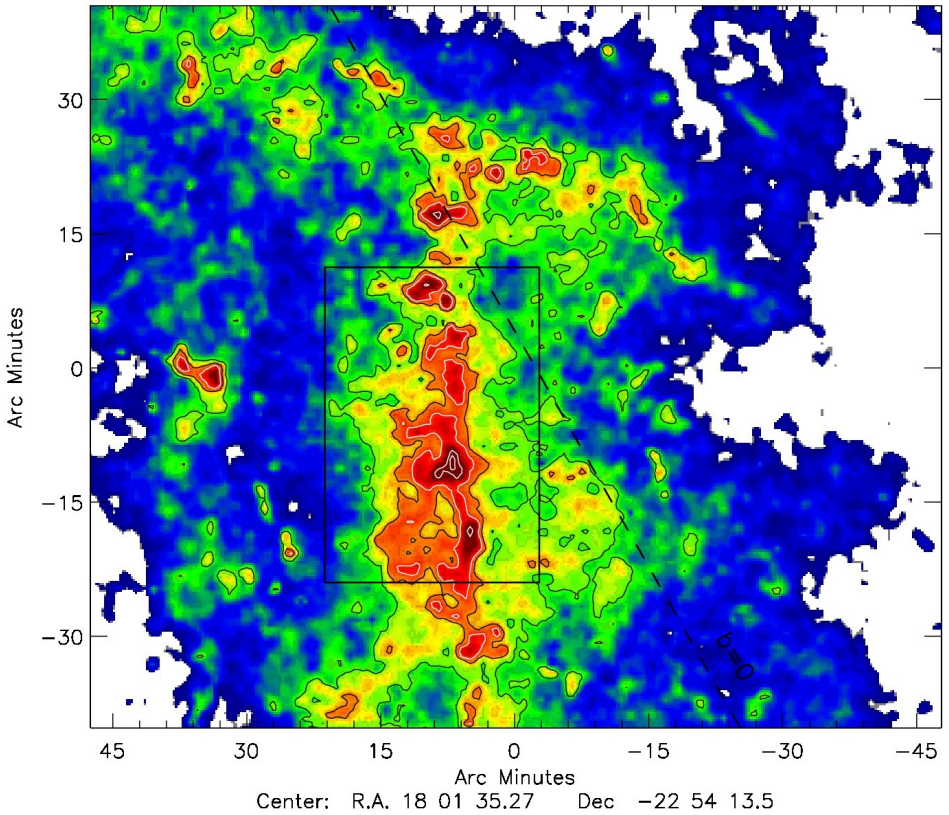
Fixed Av GLON=10°					
GLAT (deg)	0	5	10	15	20
Resolution	**1.0**	1.3	1.7	2.7	3.4

Cloud name (l, b)	Trifid (7.0, -0.2)	Perseus (150.6, -13.3)	L183 (6.1, +36.7)
Resolution	1.0	4.0	7.2

Extinction map in the Trifid cloud

(Cambrésy et al. 2011)

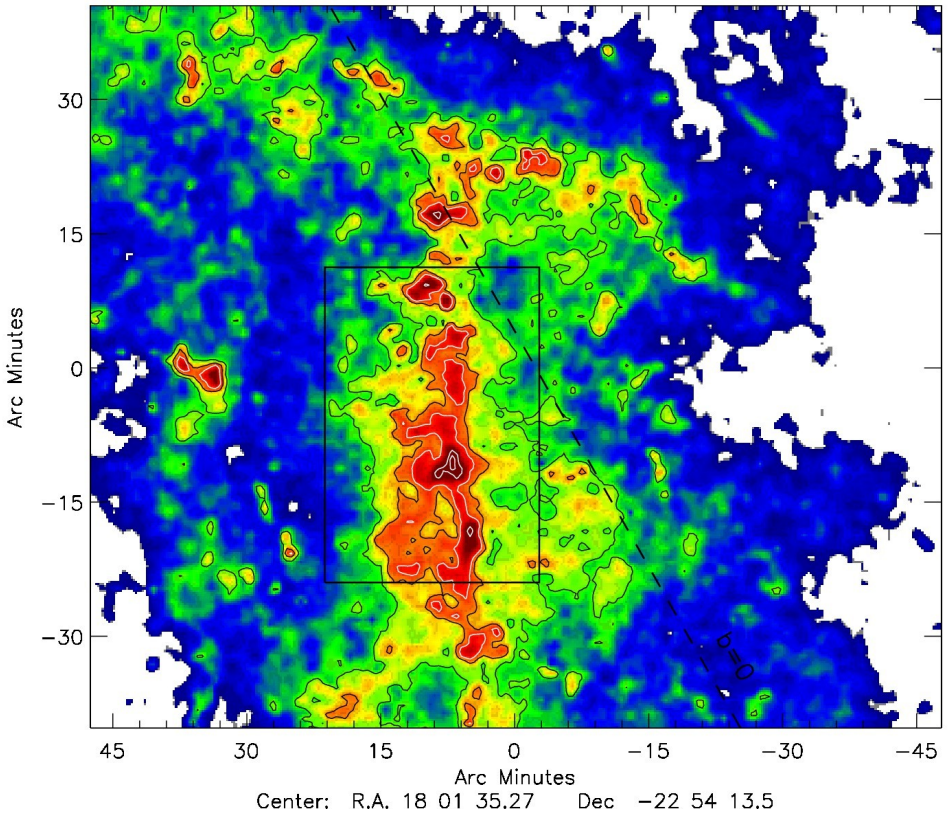
- Av(max)=80 mag
  (2MASS+UKIDSS+Spitzer)



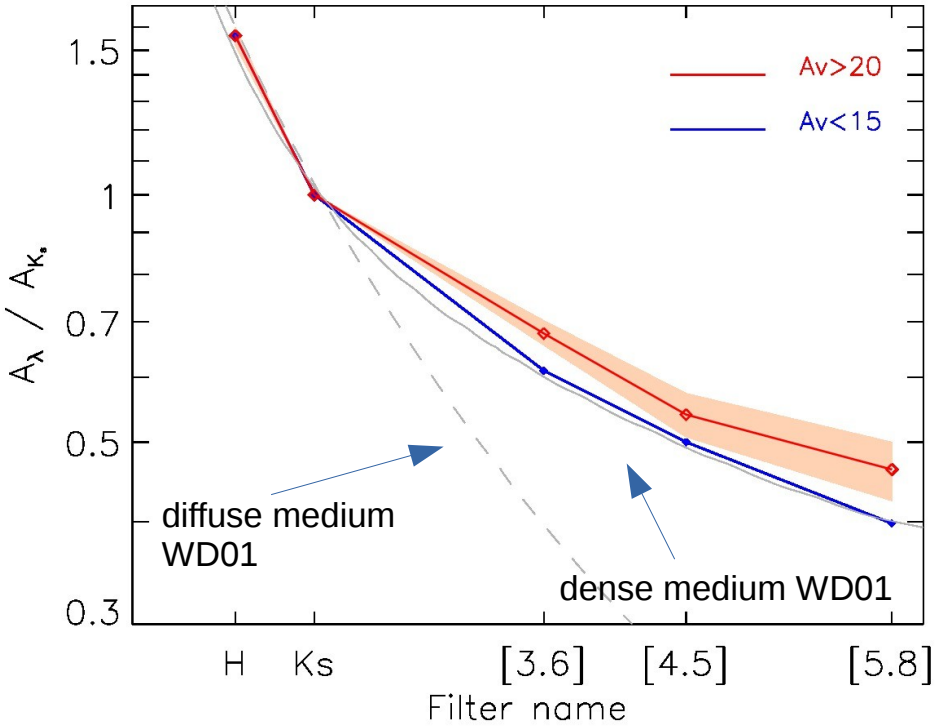
Extinction curve in the Trifid cloud

(Cambrésy et al. 2011)

- Av(max)=80 mag (2MASS+UKIDSS+Spitzer)

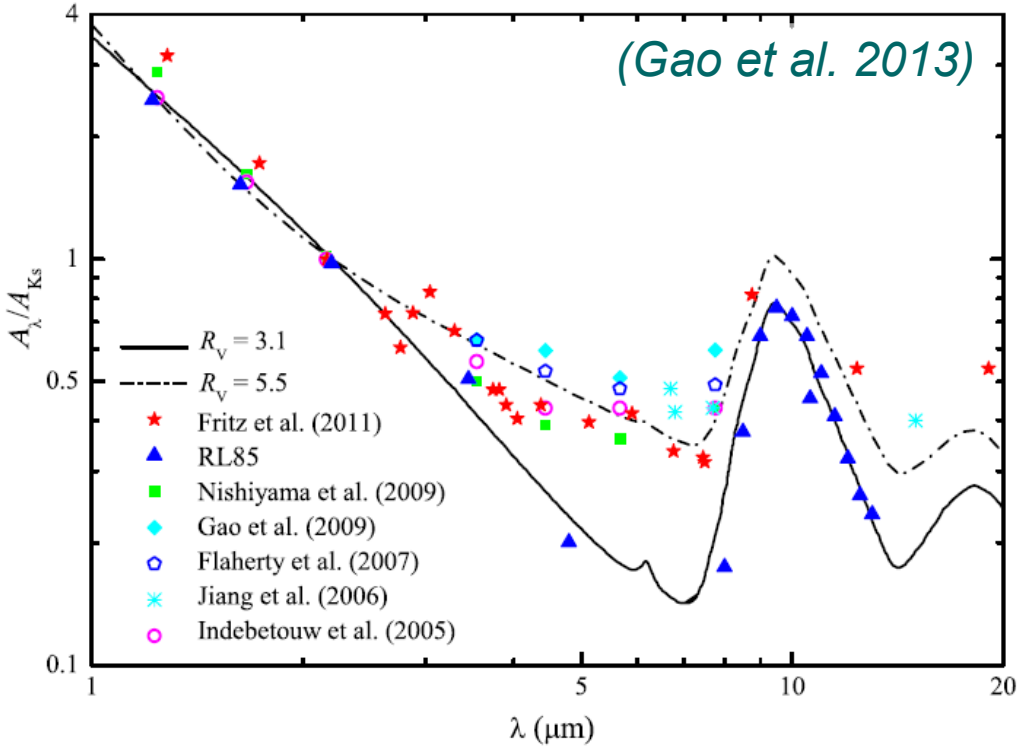


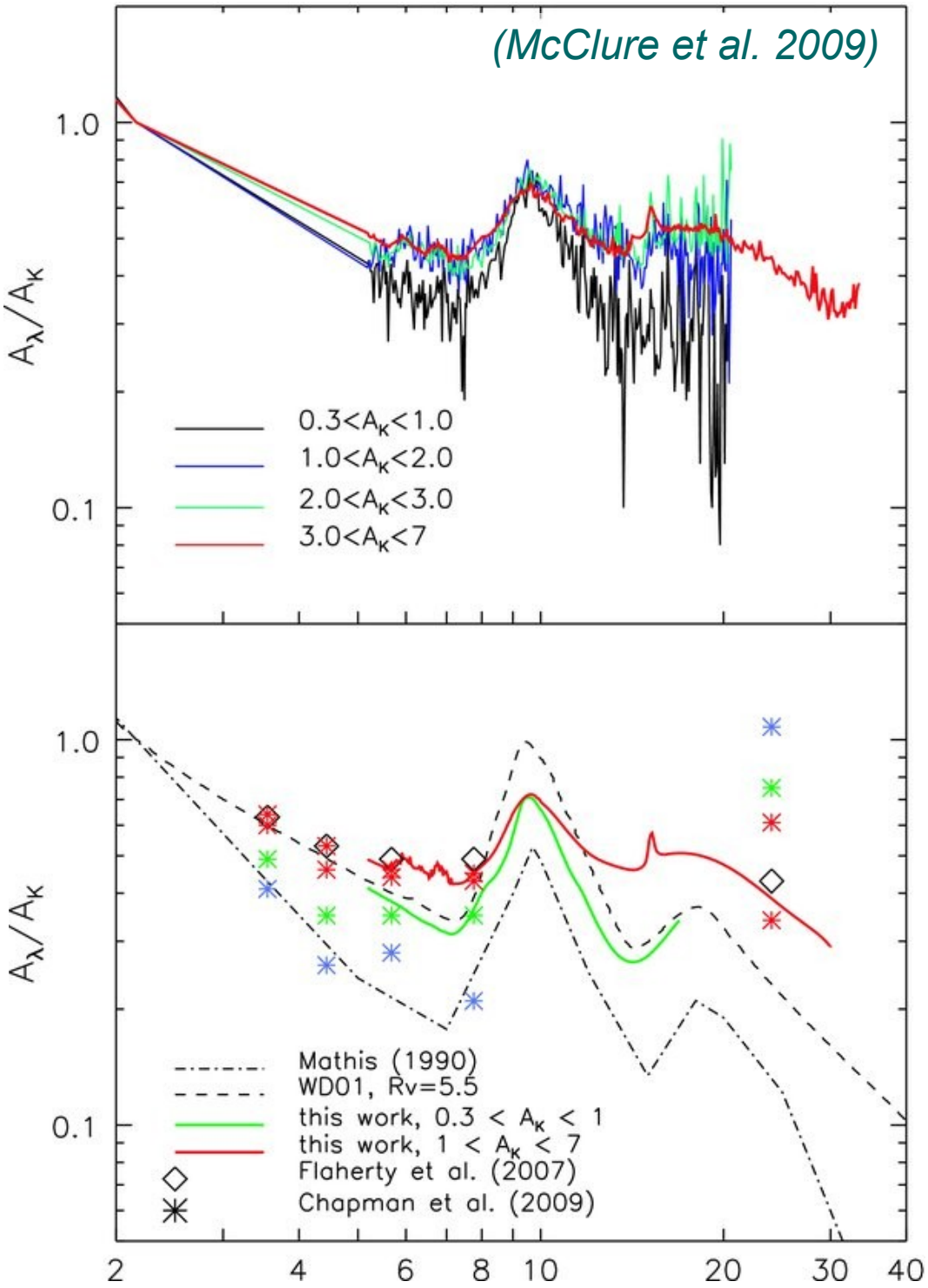
- Extinction law variations
  - larger grains of several microns at Av>20 mag ?



Extinction curve

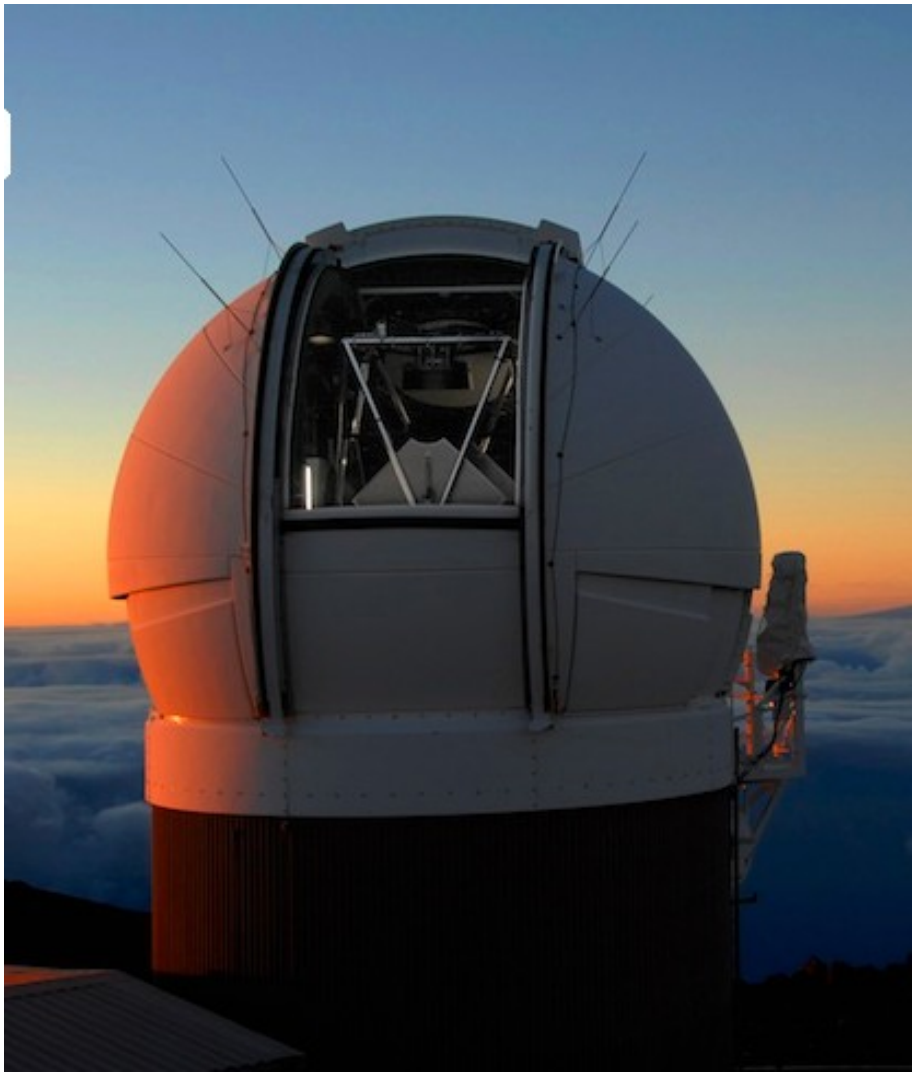
- Universality in the infrared: between 1 and 2 μm, at best
- Separation at λ>2 μm
  - evidence for grain evolution with the density (growth, ice)





Pan-STARRS, 3π survey

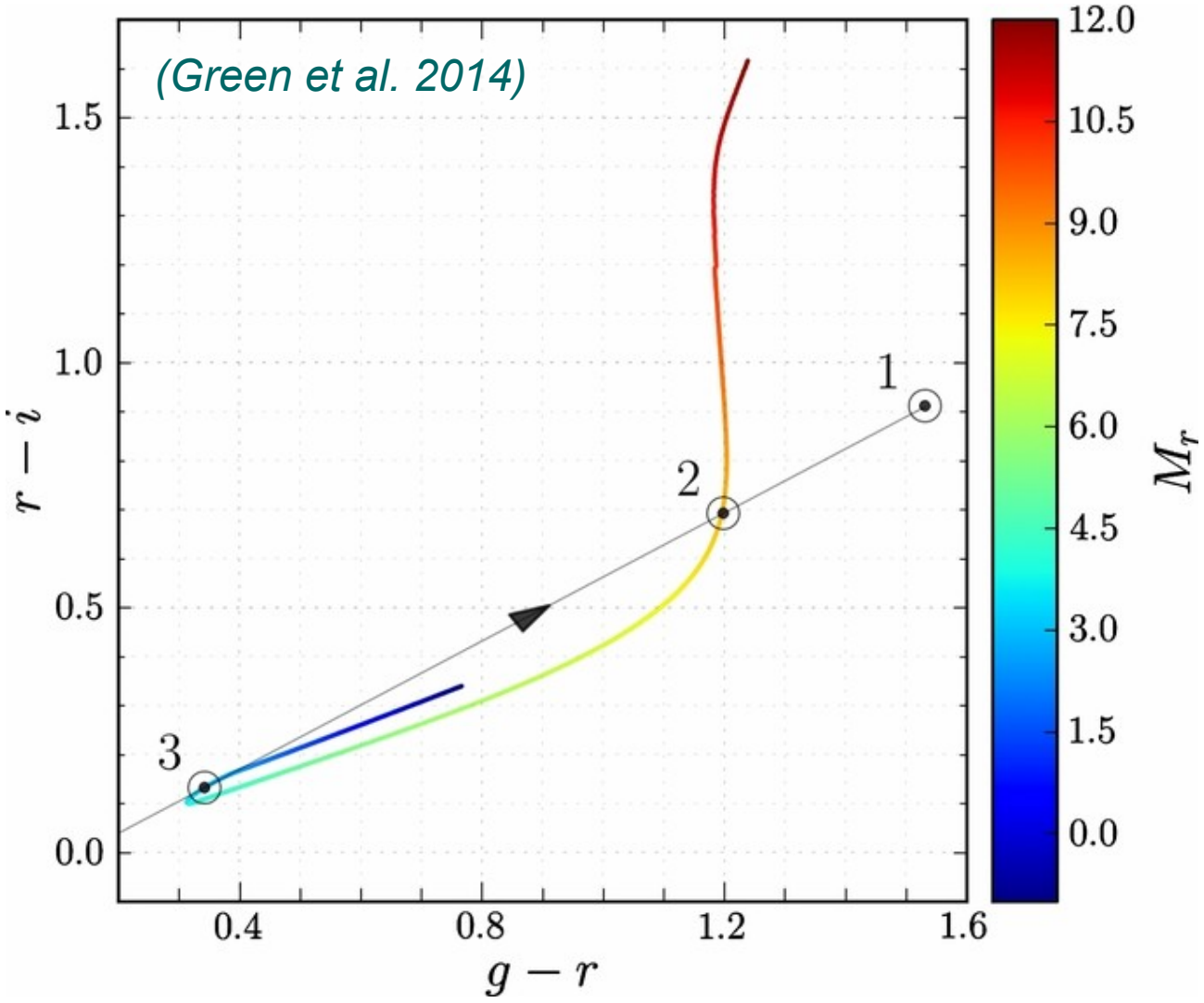
- PS1: 1.8m telescope
- 3.2° FOV
- Each point of the sky is observed ~10x in each filter
- Filters: g r i z y
  - from 0.48 to 0.96μm
  - 2 billions objects
- Parallax accuracy 15 mas
  - distance < 60 pc
- Data release: mid-2015



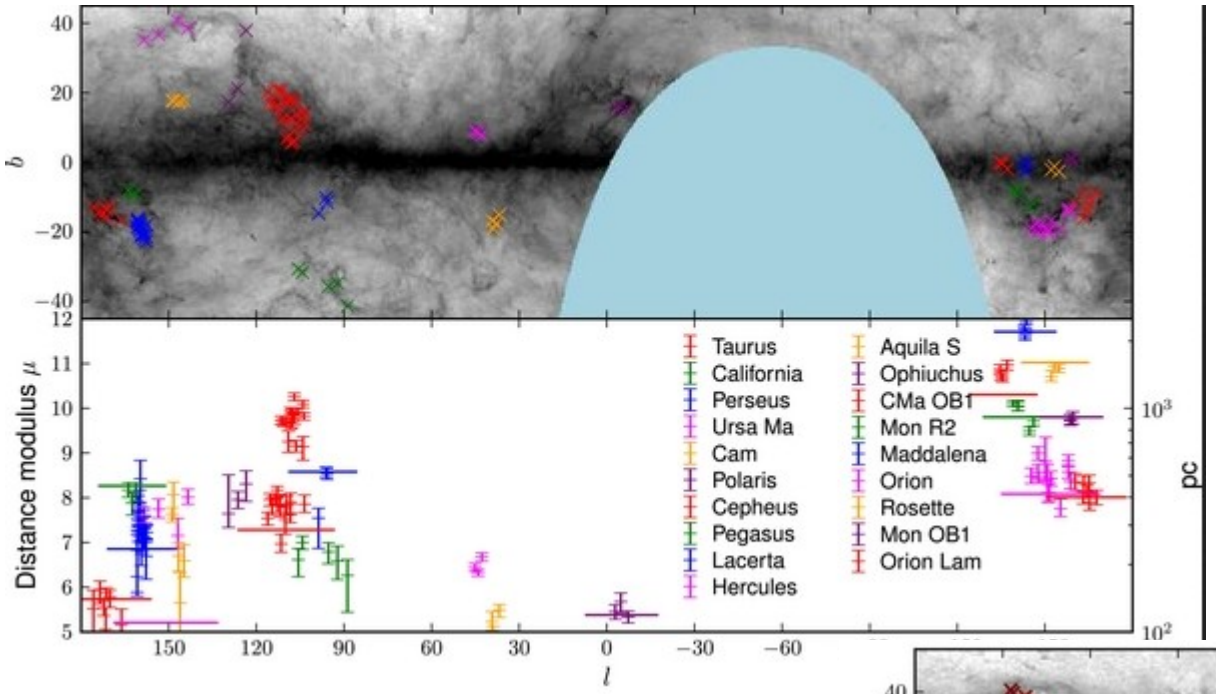
Pan-STARRS, distance and reddening

photometric parallaxes

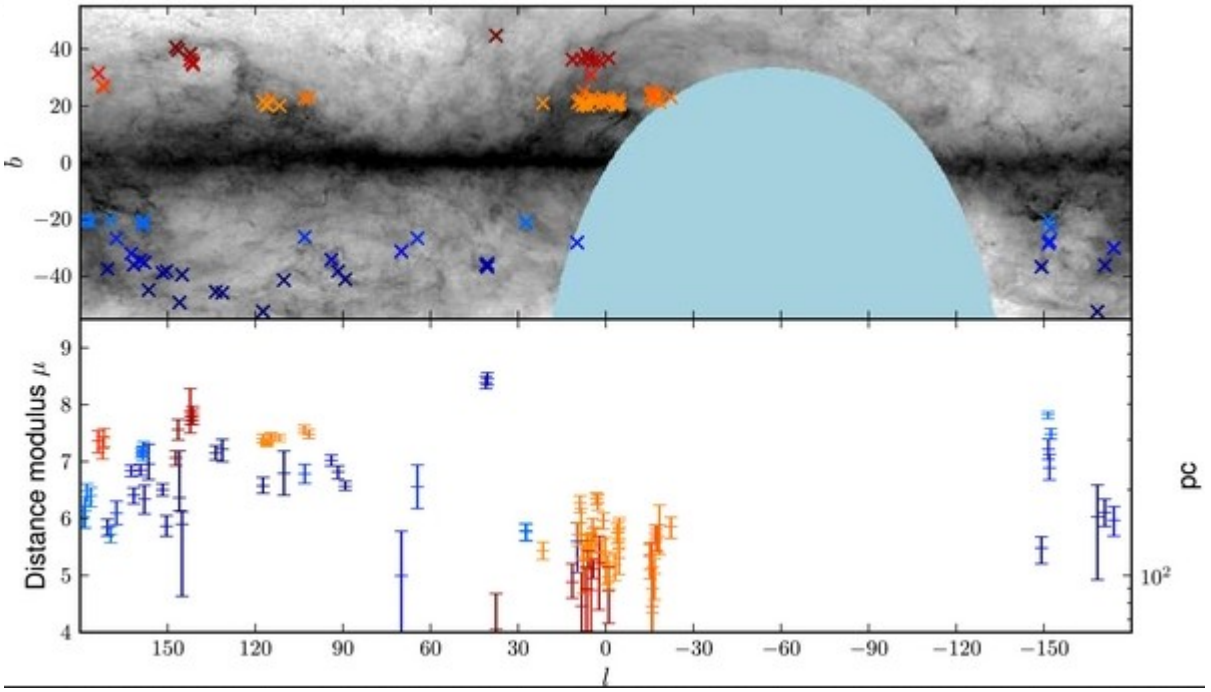
- Prior on the star distribution
  - Jurić et al. 2008: thin disk, thick disk, oblate halo
- Variant approach of Marshall et al. 2006 with the Besançon model



Pan-STARRS, cloud distances *(Schlafly et al. 2014)*



Major molecular clouds

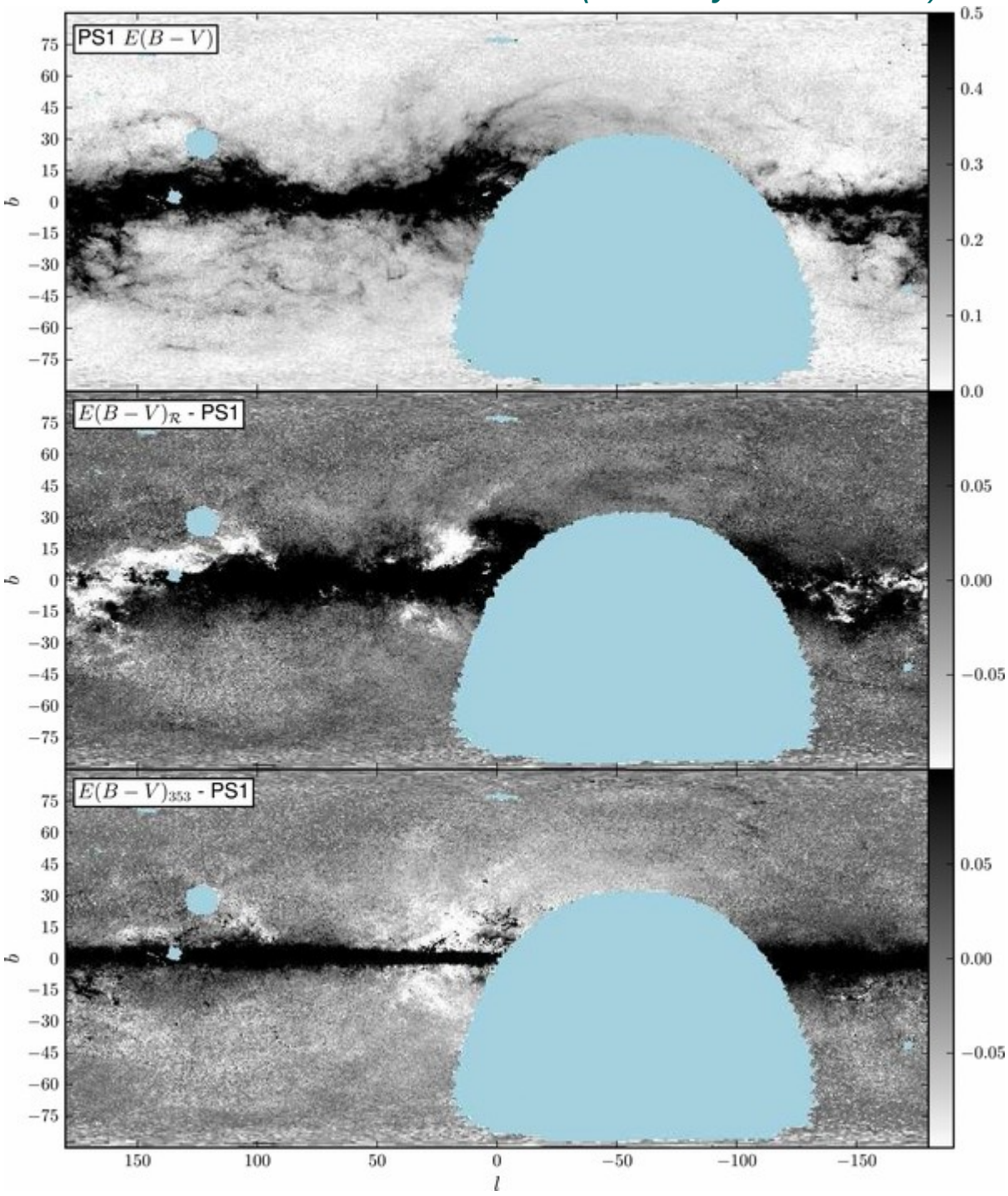


MBM clouds

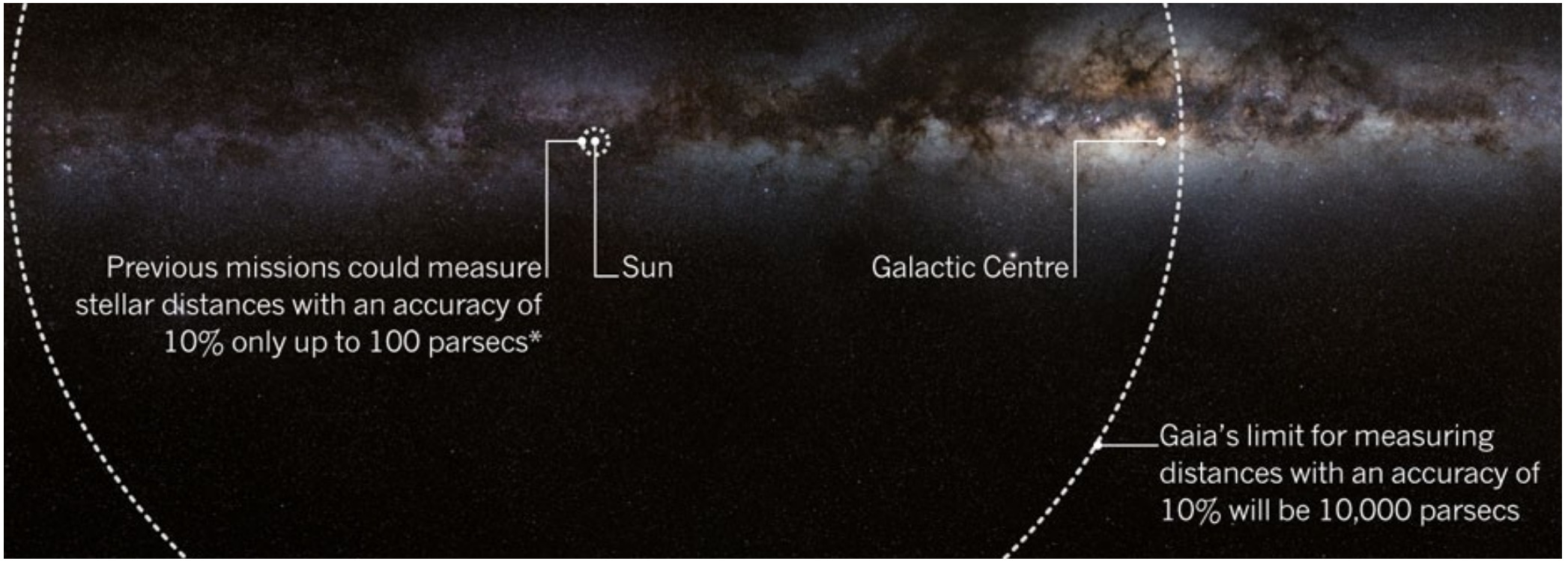
Pan-STARRS, dust mapping

- Extinction to 4.5 kpc
- Comparison with Planck maps
- A 3D version should be published soon

(Schlafly et al. 2014)



Gaia



- Photometry down to V=20 mag (1 billion stars)
- Parallax at 10 μas for V=10, 200-300 μas for V=20
  - distance error of ~0.2 pc at 200 pc (20 pc for Hipparcos)
- Spectrometry for V<16(?) mag at R=11500

  → Diffuse Interstellar Band at 862 nm

Gaia: ISM/star interactions in 3D

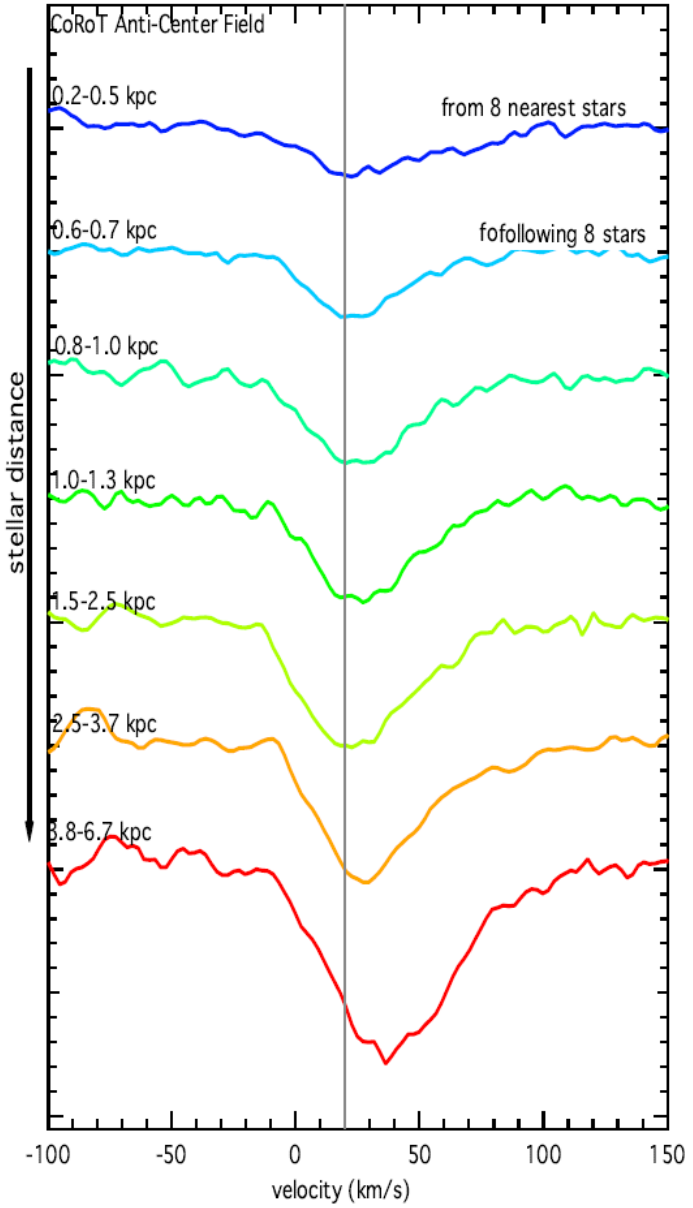
Cloud size
10 – 100 pc

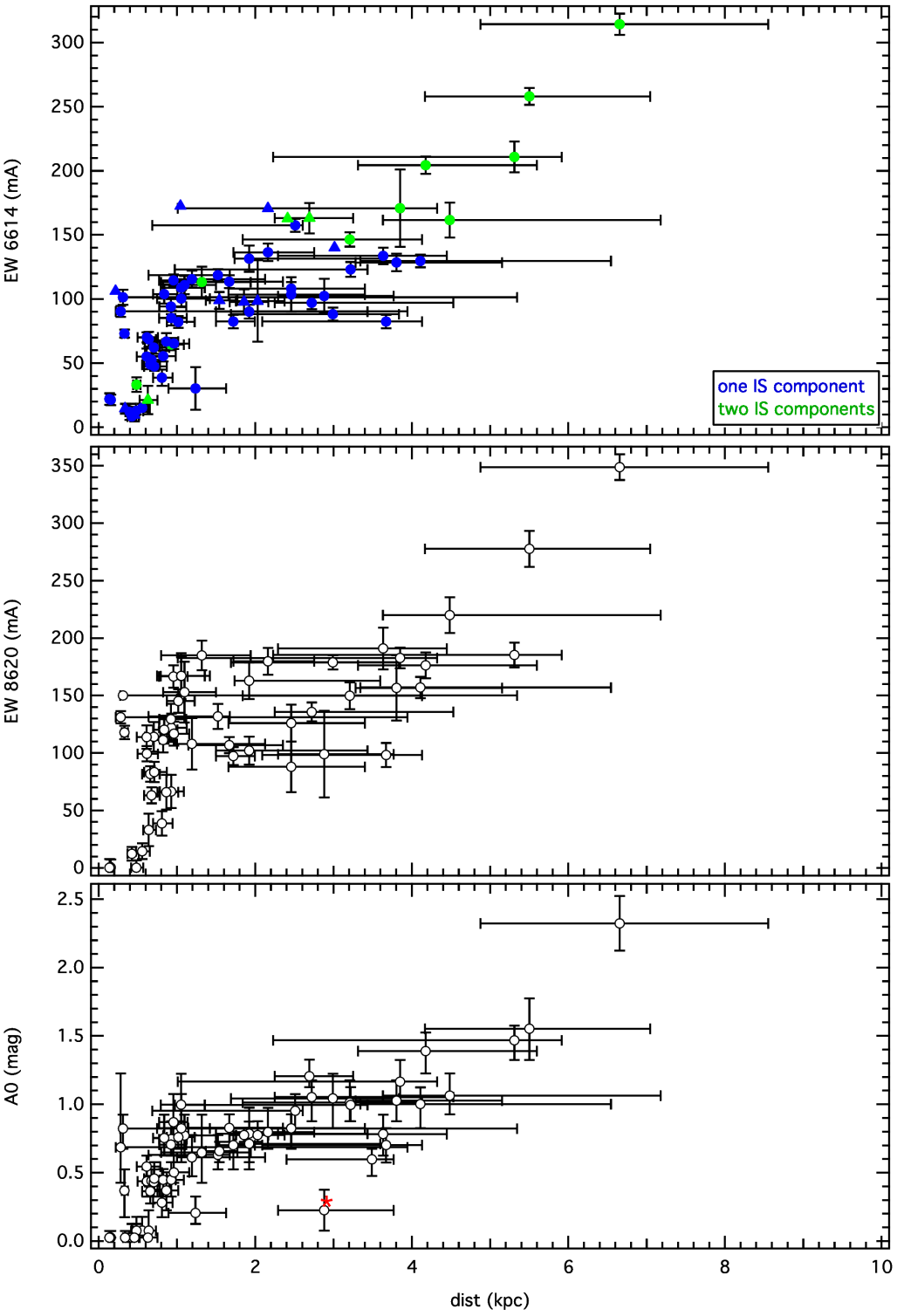
OB star distance known at 0.1 – 1 pc

- Radiation transfer
- Dust heating
- photo-dissociation and ionization
- 3D morphology

DIBs from the Gaia-ESO Survey

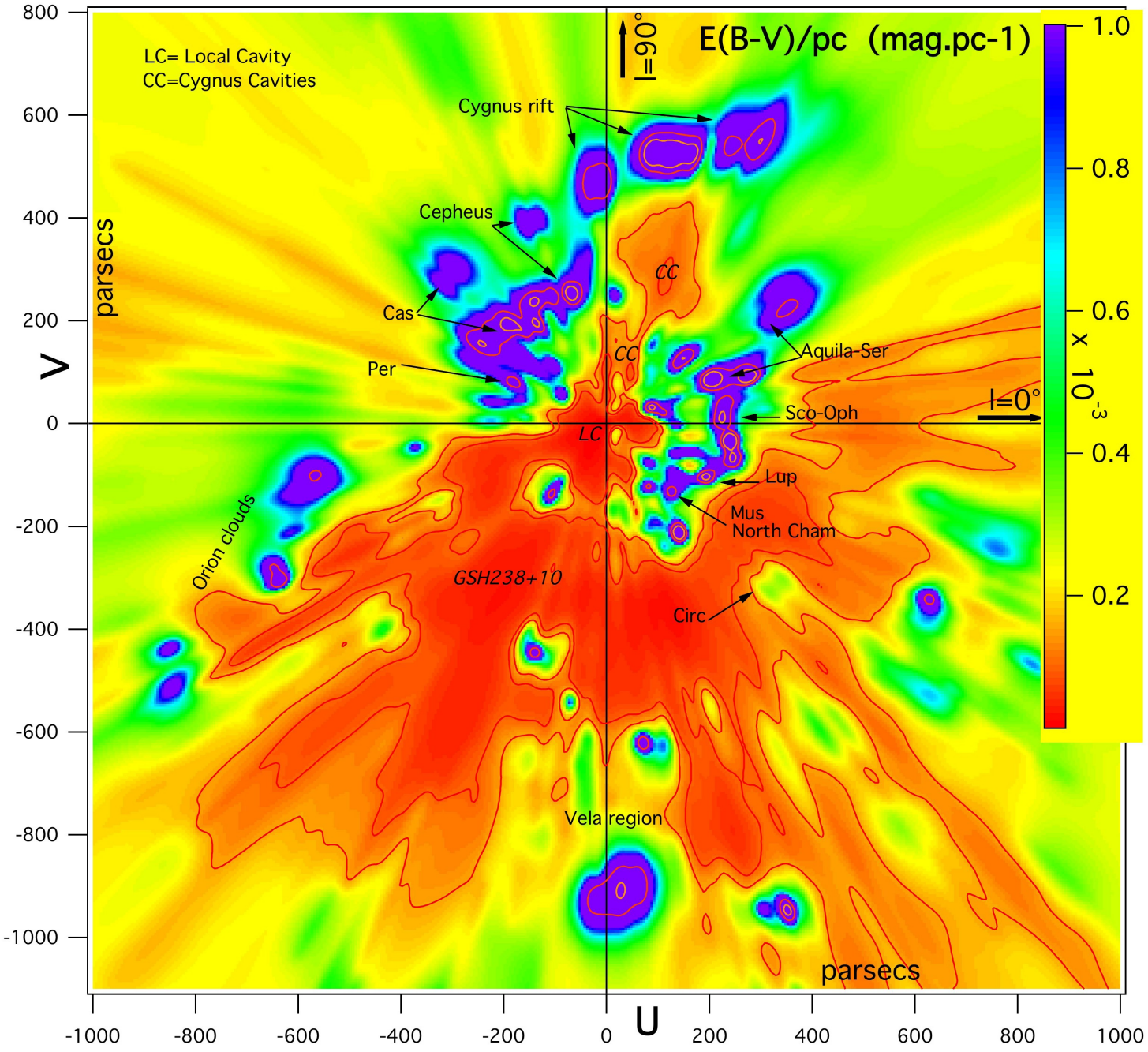
(Puspitarini et al. 2014)





Inversion of line-of-sight

- Differential opacity within the Galactic plane



(Lallement et al. 2014)

Conclusion

- UKIDSS, VISTA, Spitzer
  - Extinction in dense regions
  - 3D mapping
    - Besançon model
  - Extinction law variations
  - Grain evolution with density
- Pan-STARRS, Gaia and GES
  - Diffuse extinction
  - 3D ISM/star interactions (Gaia)
  - 3D mapping
    - galaxy model
    - using DIBs
      - 4 kpc in the plane
      - 8 kpc at higher latitudes

NIR color excess vs submm dust emission

- (a): extinction from Herschel submm (*Schneider et al. 2012*)
- (b): extinction from UKIDSS H-Ks (*Cambrésy et al. 2013*)
- (a) – (b): longitude variation caused by heating from the nearby OB star