The Perseus arm stellar overdensity at 1.6 kpc

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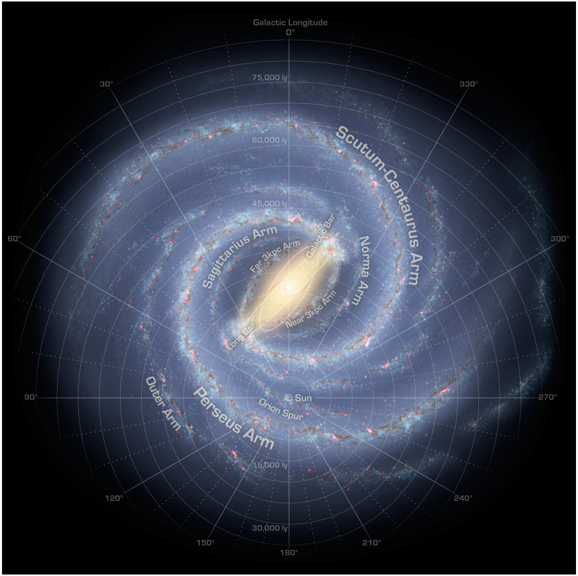
The Milky Way Unravelled by Gaia,
Barcelona, December 4, 2014

Aims of the project



Strategy

1. Strömgren photometric survey (Monguió et al. 2013)
2. Individual stellar physical parameters (Monguió et al. 2014)
3. The Perseus spiral arm (Monguió et al. 2015, submitted)
   - Stellar overdensity
   - Dust distribution

Highly demanding requirements:

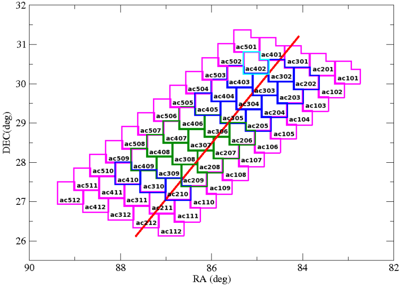
- Accurate distances (and age estimator) ⇒ Strömgren photometry
- Low intrinsic velocity dispersion: A3 stars
- Old enough to feel the perturbation B5 stars
- Complete in distances up to ∼2.5-3 kpc
- Enough statistics

The Strömgren photometric catalog

- WFC@INT

Monguió et al. (2013), A&A, 549, 78

- Strömgren filters
  $u, v, b, y, H\beta w, H\beta n$
- 16□°: 5x12 fields
  - Inner survey 8□°
    - 27 fields with 3exp
    - $V \sim 17^m$
  - Outer survey 8□° (to increase statistics at closer distances):
    - 33 fields with 1exp
    - $V \sim 15.5^m$

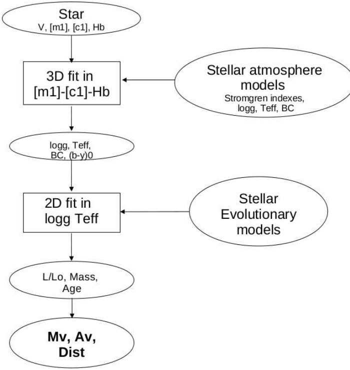


- 35974 stars with all Strömgren indexes
- 96980 stars with partial data
- Available in CDS

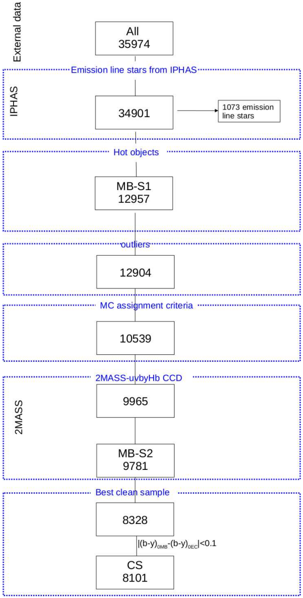
Stellar physical parameters

Monguió et al. (2014) A&A, 568, A119

- New method to derive physical parameters
- Based on atmospheric models and evolutionary tracks
- Optimezed only up to $T_{eff} = 7000\,K$
- Errors from Monte Carlo simulations
- Comparison with Hipparcos data
- compared with pervious empirical calibrations methods
- Available in CDS



Working samples

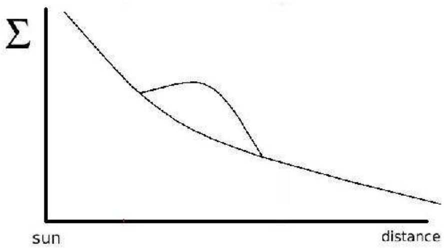


Monguió et al. (2015), submitted

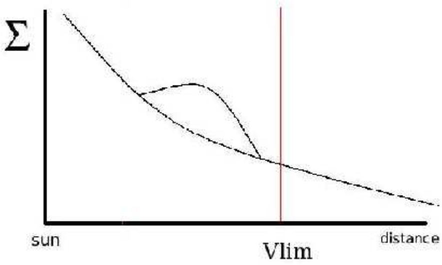
- Emission line stars (IPHAS + $H\beta$)
- stars until 7000K
- Outliers (out of the grid)
- Good assignment criteria
- 2MASS
- discrepancies with EC method

MB-S1
MB-S2
CS

Distance complete samples



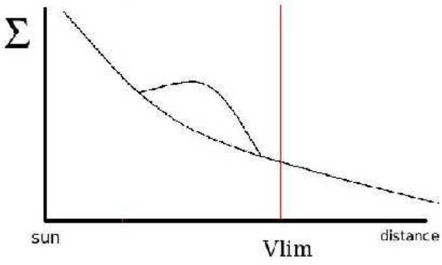
Distance complete samples



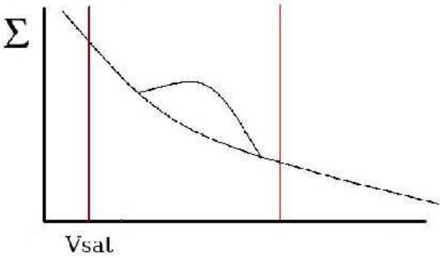
$$r_{max} = 3kpc$$
$$A_V(3kpc)$$
$$M_{Vmin}$$

$$M_{Vmin} = V_{lim} - A_{Vmax}(3kpc) - 5\log(3kpc) + 5$$

Distance complete samples



$$r_{max} = 3kpc$$
$$A_V(3kpc)$$
$$M_{Vmin}$$



$$r_{min} = 1.2kpc$$
$$A_V(1.2kpc)$$
$$M_{Vmax}$$

$$M_{Vmax} = V_{sat} - A_V(1.2kpc) - 5\log(1.2kpc) + 5$$

Surface density

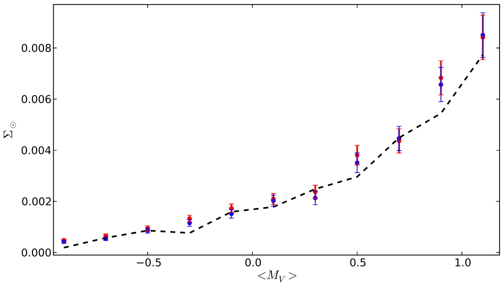
- We take into account:
  - Volume correction
  - Density gradient in z: $sech^2(z/h_z)$
  - Scale height $h_z(M_V)$
  - Warp: $z_W = r \cdot \tan b_W$, (b_W ~-0.5° at $l = 180°$)

- We fit an exponential law to the surface density distribution:

$$\Sigma(r) = \Sigma_0 \exp\left(\frac{-r}{h_r}\right) \quad (1)$$

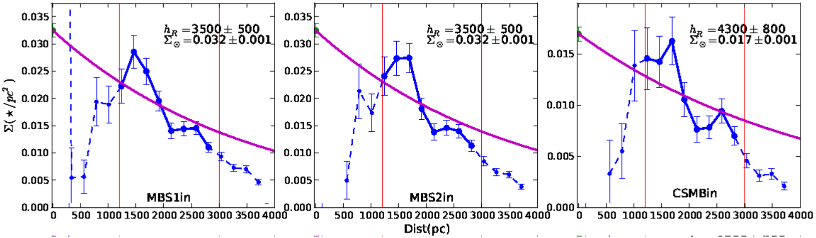
Surface density at the Sun position

- Hauck & Mermilliod (1998) photometry
- We check completeness for OA stars (>96% up to V∼6.5)
- Mimic the same samples assuming M_V ranges, and so r_{lim}
- Compute surface density using the same parameters and methods



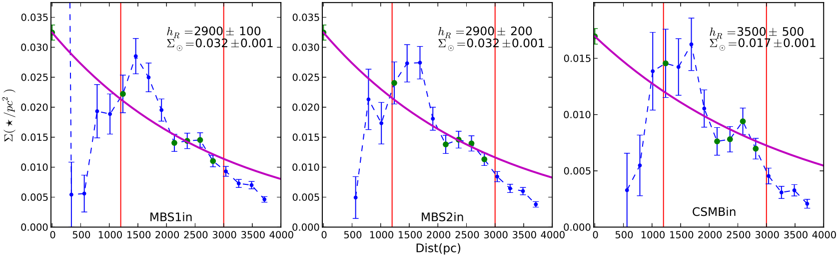
— — —Besançon Galaxy model (Czekaj et al. 2014)

Surface density in the anticenter direction

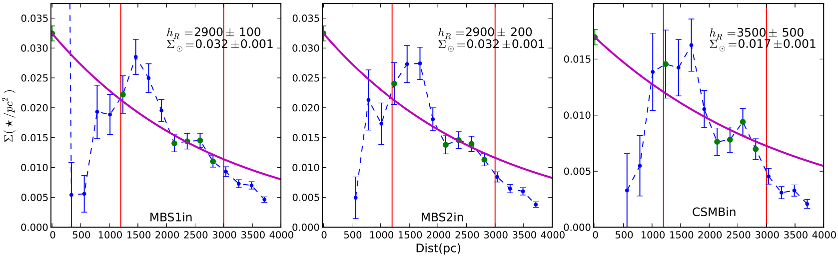


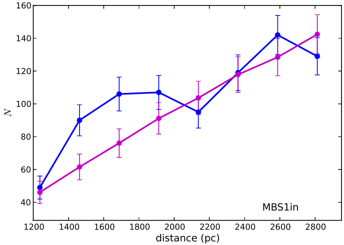
Overdensity at ∼1.6 kpc

Surface density in the anticenter direction

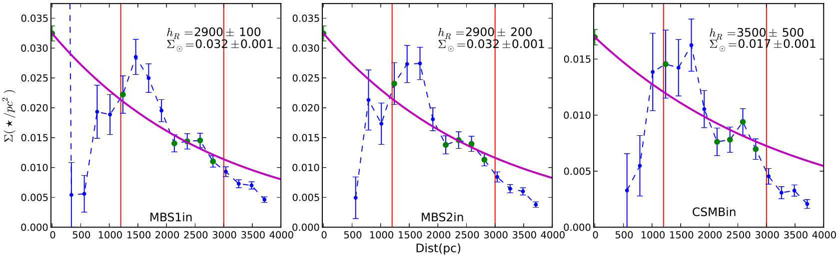


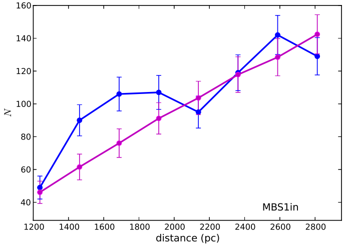
Surface density in the anticenter direction





Surface density in the anticenter direction

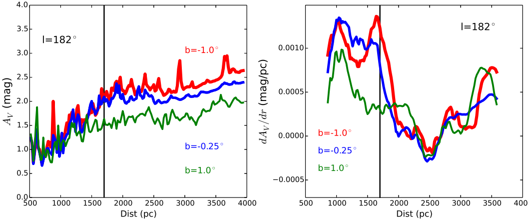




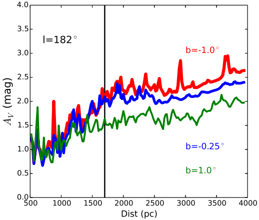
	n_{arm}^{obs}	n_{arm}^{fit}	Sig.	A
MB-S1	303	228	4.3%	0.14
MB-S2	302	227	4.3%	0.14
CS-MB	182	142	3.0%	0.12

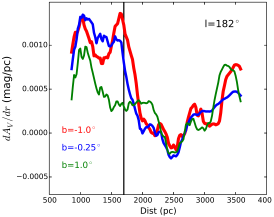
$$Sig = \frac{(n_{arm}^{obs} - n_{arm}^{fit})}{\sqrt{n_{arm}^{obs}}} \quad A = \frac{(n_{arm}^{obs} - n_{arm}^{fit})}{(n_{arm}^{obs} + n_{arm}^{fit})}$$

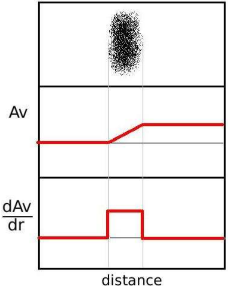
Perseus dust lane



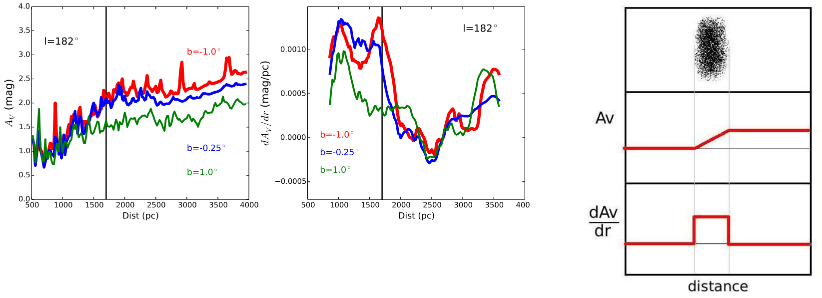
Perseus dust lane





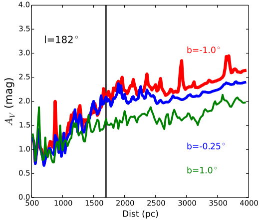


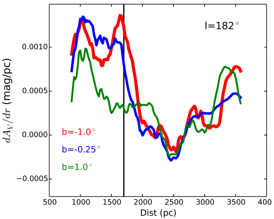
Perseus dust lane

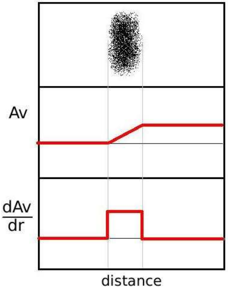


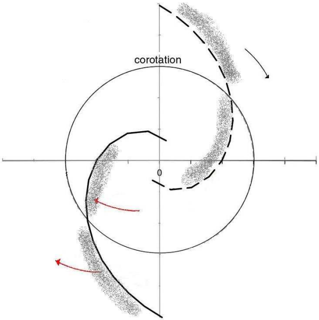
Dust lane before 1.6kpc

Perseus dust lane









Dust lane before 1.6kpc

- $\Omega_{disk} > \Omega_p$ at Sun's radius
- R_{CR} >10.1 kpc

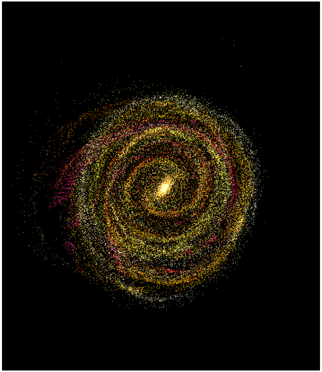
Gaia prospects in the anticenter

- To check photometric calibrations
- To trace the overdensity
- To trace age tends

σ_π (μas, %)	1.5kpc	2kpc	3kpc
B5	7 - 1%	8 - 2%	14 - 4%
A0	15 - 2%	22 - 4%	37 - 11%

Spiral arms theories:

- Material density Structures
- Density wave theory
- Swing Amplification
- Invariant manifolds



(see poster 32 from S.Roca-Fàbrega)

Kinematics

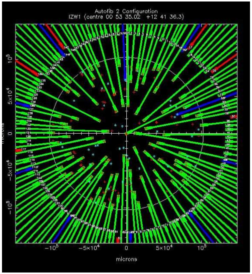
- Good proper motions:

$\sigma_\mu(\mu as/s)$	1.5kpc	2kpc	3kpc
B5	4	4	6
A0	8	11	19

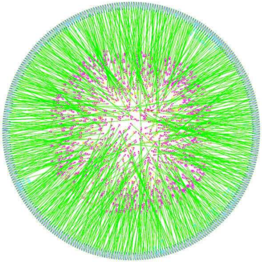
- Poor or none radial velocities for blue stars

Other options:

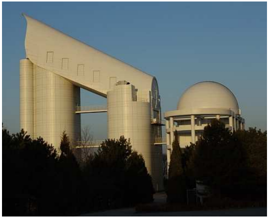
WYFFOS



WEAVE



LAMOST



Conclusions

- A $uvbyH\beta$ Strömgren photometric survey
  - $16\square^{\circ}$ in the anticenter direction
  - 35974 stars with all Strömgren indexes
  - 96980 stars with partial data
  - Monguió et al. (2013) A&A,549,78, Available through CDS
- Catalog of physical parameters for young stars
  - Monguió et al. (2014), A&A,568,A110
  - Catalog of 13687 stars available through CDS
- Detection of the Perseus arm stellar overdensity
  - Different distance complete samples [1.2-3] kpc
  - Stellar overdensity at 1.6±0.2 kpc with a significance of 3-4σ
  - Amplitude $\sim$ 10%
  - Radial scale length for BA: h_R $\sim$[2.0-2.6] kpc
  - $\Sigma_{\odot}$ $\sim$0.019$\star/pc^2$ for B4-A1
- A new 3D extinction map in the anticenter
  - Dust layer in front the Perseus arm
  - Corrotation radius R_{CR} >10.1 kpc (assuming $R_{\odot} = 8.5$ kpc)
  - $\Omega_p < 22$ km/s/kpc (assuming flat rotation curve with 220 km/s)


Thanks!
Gràcies!