CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

Self-consistent modelling of the Milky Way structure using live potentials

Eva Durán Camacho, Ana Duarte Cabral

Visit my website!

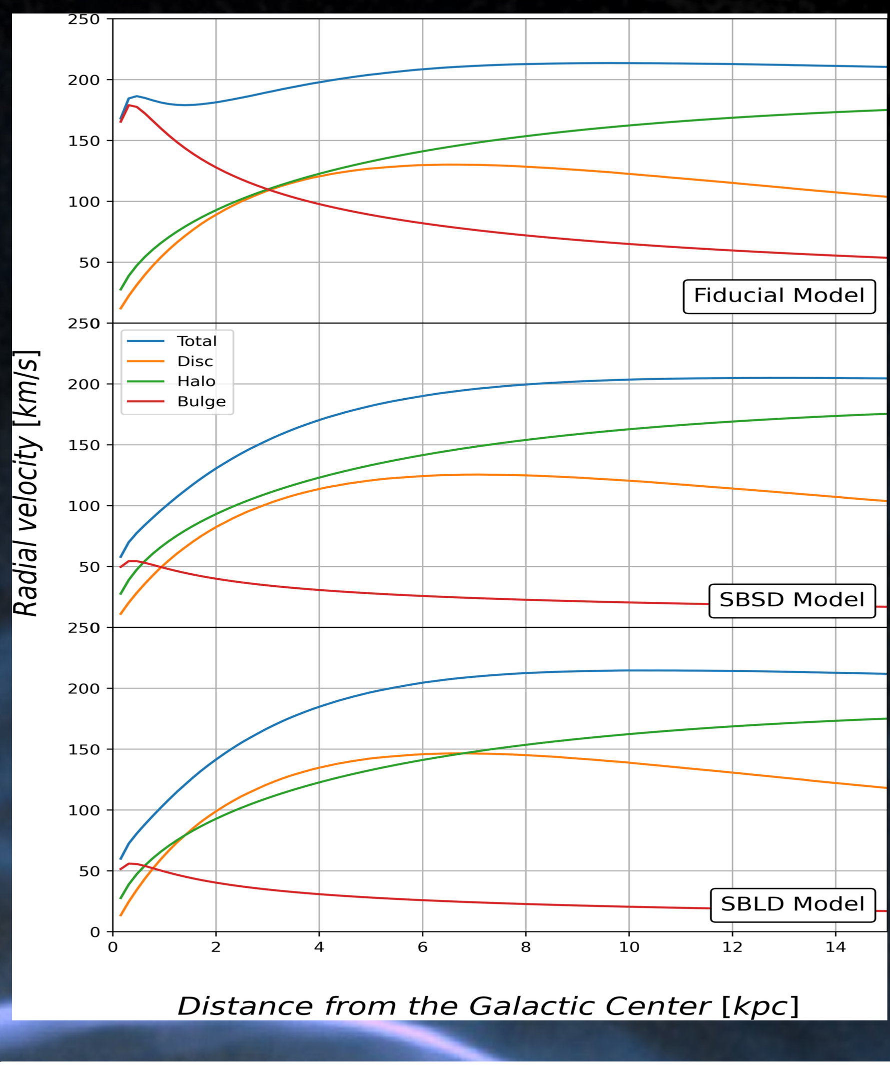
We use the hydrodynamical AREPO moving-mesh code to perform numerical simulations of the Milky Way. In our models, the structures are obtained via the evolution of a live stellar disc and bulge, as well as a live dark matter halo and a gaseous disc, all of which move self-consistently under isothermal conditions. We produce longitude-velocity (lv) plots of the projected gas surface densities to extract the skeletons of the main features (arms, bar), as well as the contours defining the terminal velocities of the gas. We then compare these with observations via minimisation of the symmetrised distance between the observed and simulated features for a best fit

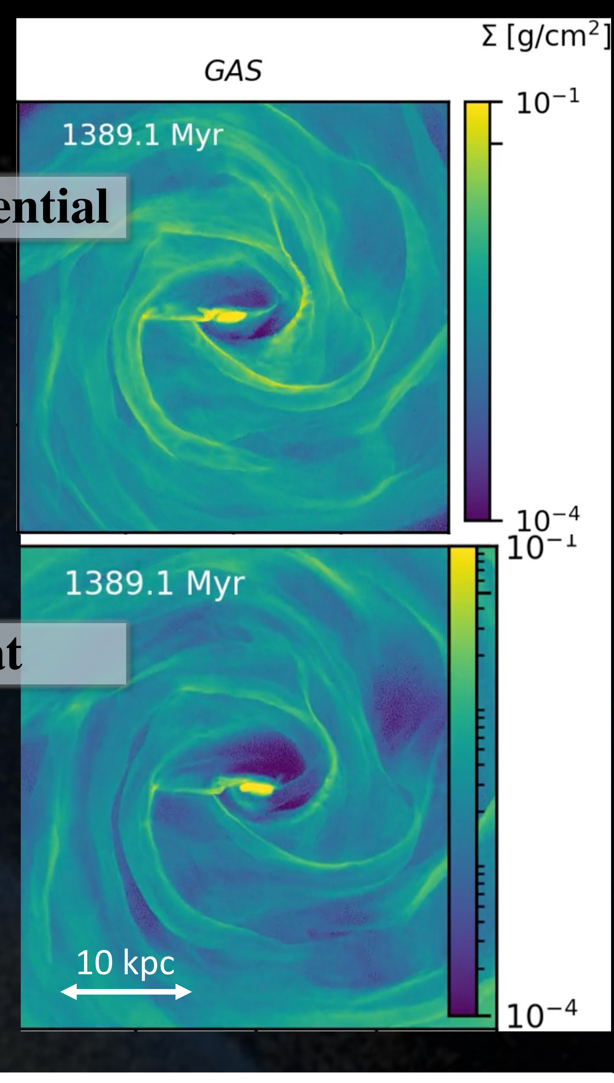
1 Initial conditions

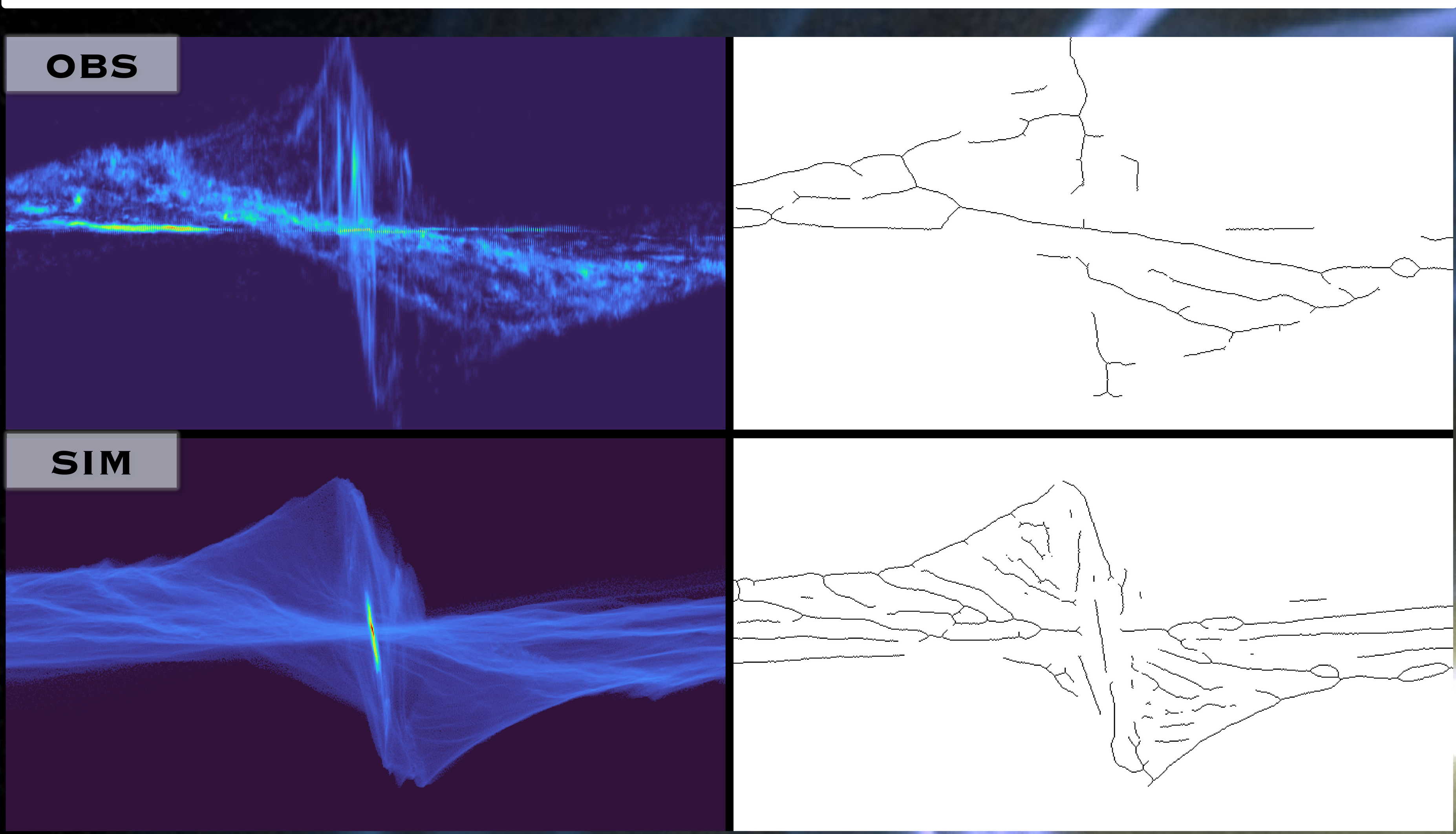
We set up **six models**, all following an Hernquist profile for the dark matter halo and stellar bulge, as well as an exponential profile for the stellar disc:

Model	$M^*_{bulge}[10^{10}M_\odot]$	$M^*_{disc}\,[10^{10}M_\odot]$
Fiducial [2]	1.05	3.2
SBSD	0.105	3.2
SBLD	0.105	4.15

For each model (*Fiducial*[2]*, Small Bulge Small Disc, and Small Bulge Large Disc*) we distribute the gas following two surface density profiles: **exponential** and **flat**







2 Mapping the galactic structure

We extract the **skeletons** tracing the main features of the CO[3] *lv* map, as well as in our simulations. We then follow a series of steps:

I. Smooth the image with a Gaussian 2D Kernel

II. Create a binary image after finding the peaks via a Hessian matrix.

III. Final skeleton is obtained computing the medial axis of the previous image.

3 Finding the best model

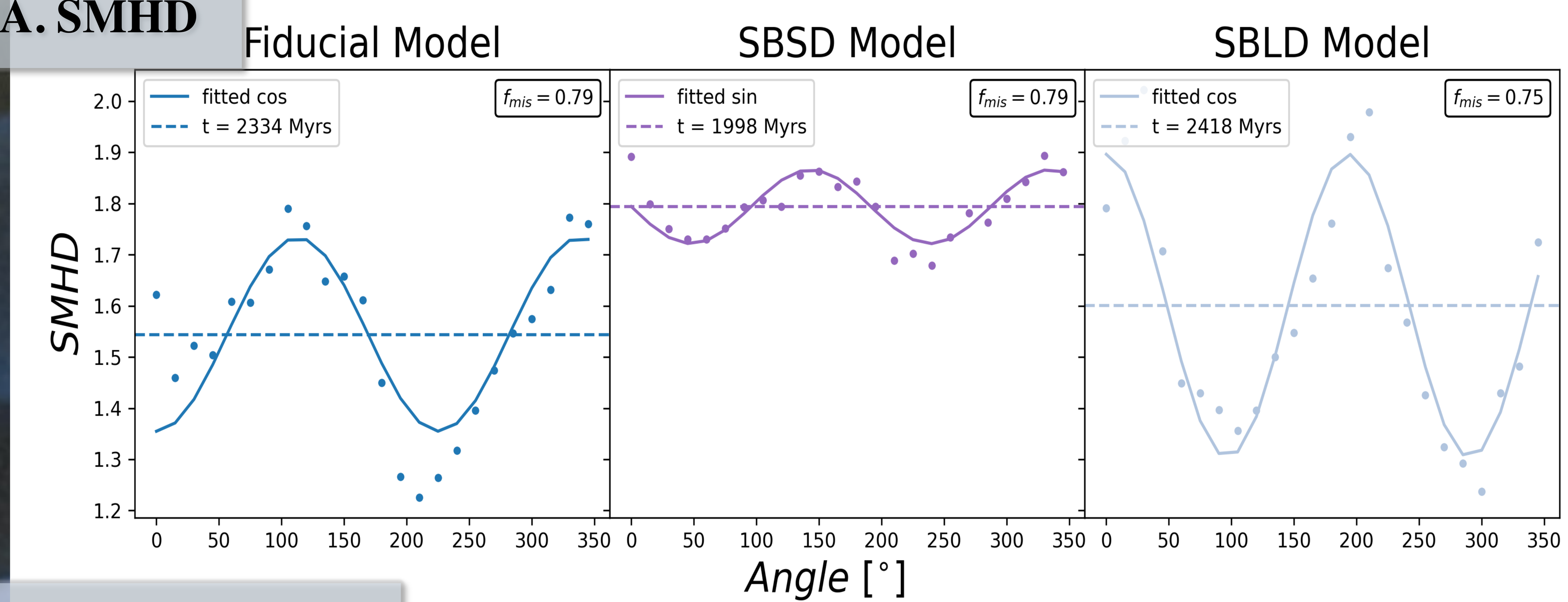
For each model, we look at a range of times and viewing angles and we compute three different metrics comparing with observations:

A. Symmetrized Modified Hausdorff Distance[5] (SMHD) between OBS and SIM skeletons. The lower the metric, the better the fit.

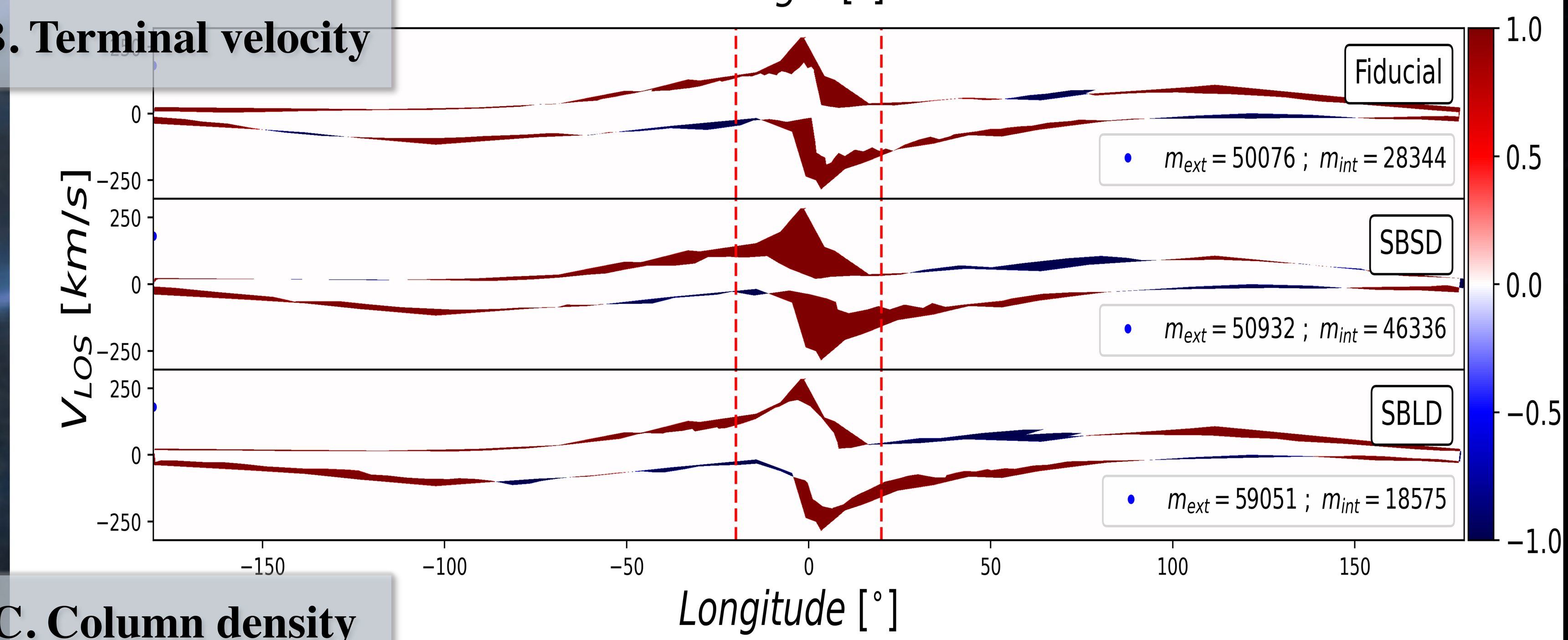
B. Terminal velocity comparing the lv-space occupied by OBS and SIM, favouring the SBLD model

C. Gas column density distribution for each model versus the observed total gas (CO+*HI*[4]). These favour models with a flatter profile.

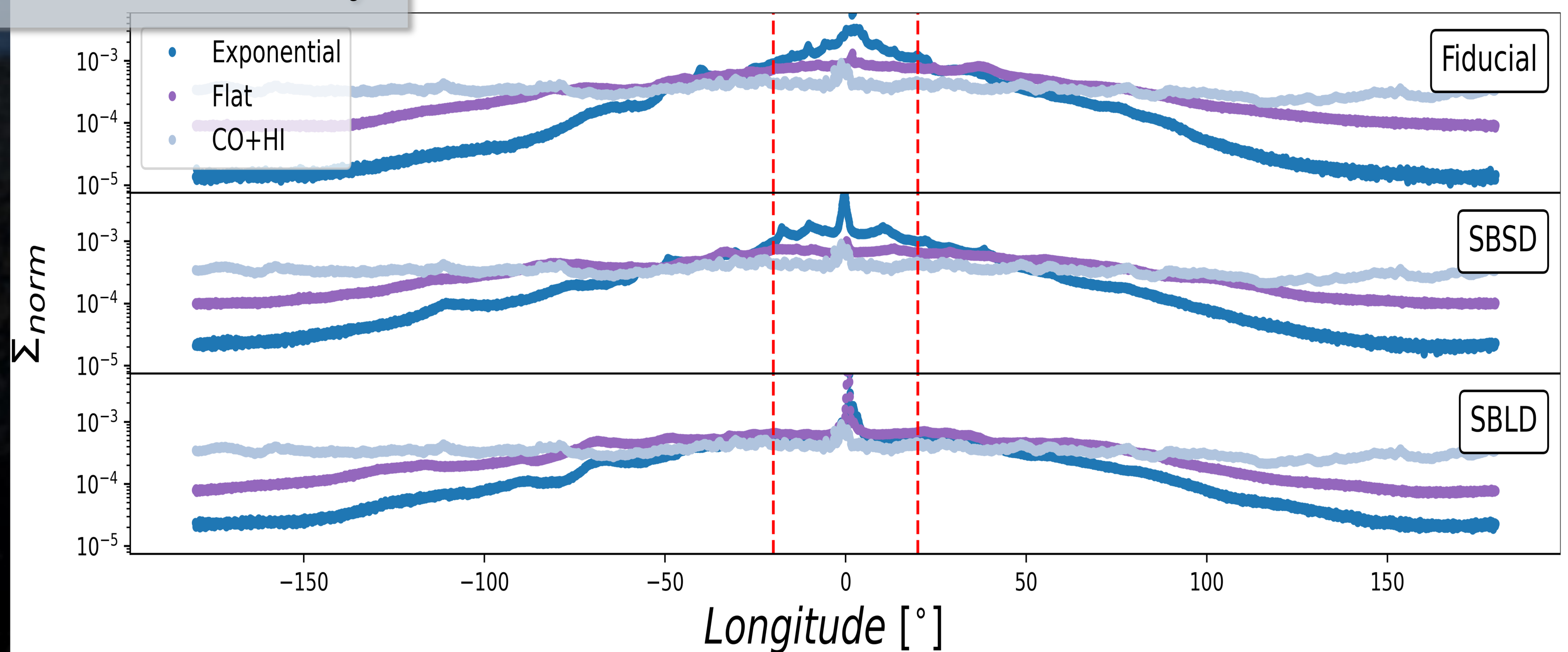
A. SMHD



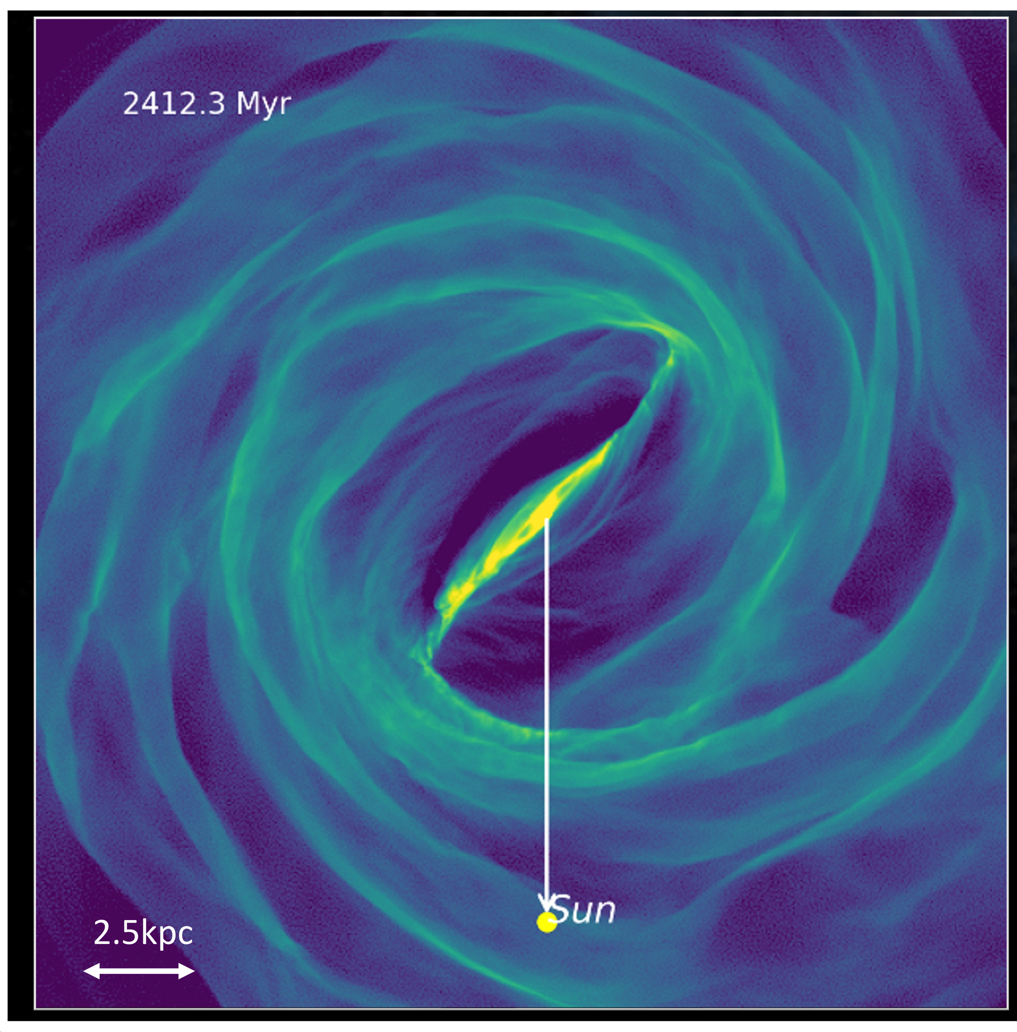
B. Terminal velocity



C. Column density



4 Results



Best fit for the galactic structure:

- **SBLD** at a time ~ 2.4 Gyrs
- Transient arms + inner bar
- Bar pattern speed: ~ **22 km/s/kpc**
- Bar length: ~ **6 kpc**
- Bar orientation: **30°**

What's next?

Base model for the inclusion of chemistry, SNe and stellar feedback. Study environmental effects on star formation

References

[1] Springel, V., & Hernquist, L. (2003). Cosmological smoothed particle hydrodynamics simulations: a hybrid multiphase model for star formation. *Monthly Notices of the Royal Astronomical Society*, *339*(2), 289-311

[2] Pettitt, A. R., Dobbs, C. L., Acreman, D. M., & Bate, M. R. (2015). The morphology of the Milky Way–II. Reconstructing CO maps from disc galaxies with live stellar distributions. Monthly Notices of the Royal Astronomical Society, 449(4), 3911-3926.

[3] Dame, T. M., Hartmann, D., & Thaddeus, P. (2001). The Milky Way in molecular clouds: a new complete CO survey. The Astrophysical Journal, 547(2), 792.

[4] Bekhti, N. B., Flöer, L., Keller, R., Kerp, J., Lenz, D., Winkel, B., ... & Staveley-Smith, L. (2016). HI4PI: a full-sky H i survey based on EBHIS and GASS. Astronomy & Astrophysics, 594, A116.

[5] Sormani, M. C., & Magorrian, J. (2015). Recognizing the fingerprints of the Galactic bar: a quantitative approach to comparing model (l, v) distributions to observations. Monthly Notices of the Royal Astronomical Society, 446(4), 4186-4204.

Acknowledgements

Calculations were performed using the supercomputing facilities at Cardiff University operated by Advanced Research Computing at Cardiff (ARCCA) on behalf of the Cardiff Supercomputing Facility and the HPC Wales and Supercomputing Wales (SCW) projects.
EDC and ADC acknowledge the support from the Royal Society University Research Fellowship (URF/R1/191609