Tomography of the Central Molecular Zone

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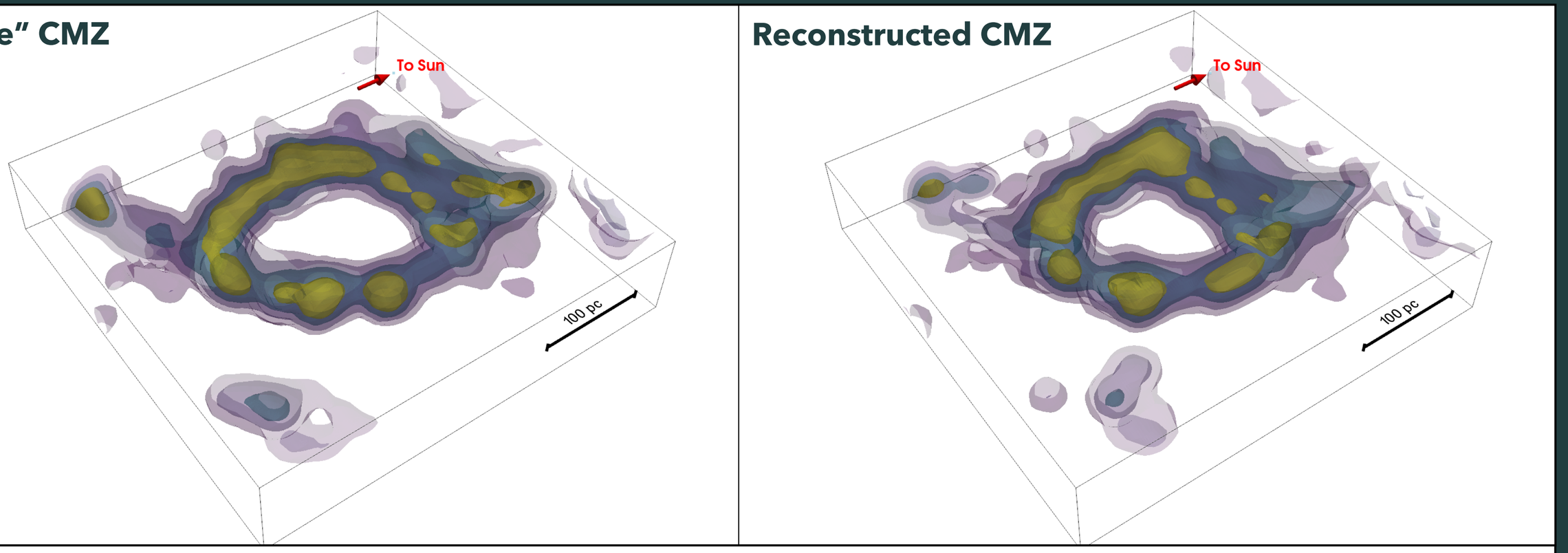


Fig. 1: CMZ gas distribution from hydrodynamical simulation (left) vs. reconstructed CMZ (right) obtained with our Bayesian method. The results are obtained with a non parametric MCMC that does not include any assumption on the shape of the CMZ. All the reconstructed features arise from the extinction and dynamical constraints.

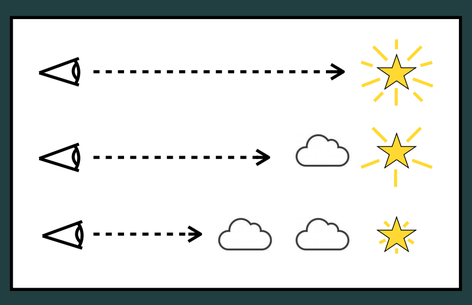
What is the 3D gas distribution in the CMZ?

The three-dimensional gas distribution of the CMZ is related to the physics behind the star formation processes occurring in the clouds and to the interaction between the CMZ gas and the inner structures, such as the Circum Nuclear Disc and Sgr A*. The current methods to infer the 3D CMZ map rely on gas observations but provide conflicting results. We developed a Bayesian method to reconstruct the CMZ gas distribution that exploits the proper motions and the extinctions of Nuclear Stellar Disc stars. We simulated different CMZ distributions, both analytically generated and simulation-derived, and applied our Monte Carlo Markov Chain to reconstruct them adopting simulated NSD stars. This represents the proof of concept of a method applicable to real data sets provided by the current and upcoming Galactic Center surveys such as GALACTICNUCLEUS, KMOS, JWST, MOONS, Roman, JASMINE etc.

How does it work?

Extinction A as proxy of gas density

The gas density on the line of sight correlates with the stellar extinction:



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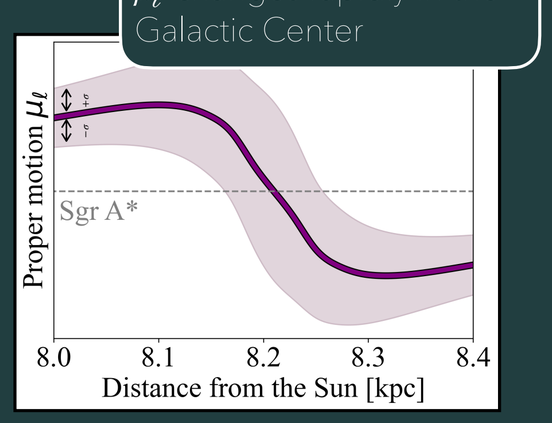
Proper motions μ_ℓ as proxy for stellar distances

The NSD dynamical model (Sormani+2022) associates a 3D position in the GC to a proper motion distribution:



Bayesian formulation

How good is a gas profile?

$$P(A \mid \mu_\ell, A_{\mathrm{obs}}) \propto \int \Big(P(y) \cdot P(\mu_\ell \mid y) \cdot P(A_{\mathrm{obs}} \mid A, y) \Big) \mathrm{d}y$$

NSD stellar distribution — stellar proper motions — stellar extinction

Testing the method

We tested our method by reconstructing mock CMZ distributions adopting mock NSD stars.

Fig. 1 shows a mock distribution (left panel) from a hydrodynamical simulation compared to the reconstructed one (right panel): we are able to distinguish near-side from far-side clouds and to reconstruct gas features on different spatial scales.

Fig. 2 shows the reconstruction of a 2D slice of an analytical gas distribution with mock NSD stars: we recovered the main features as well as the fainter over-densities on smaller spatial scales.

All the results are obtained with a non parametric approach without assumption on the shape of the mock distribution. In the same way, the coherent structures arise from the mock data, without imposing it a priori.

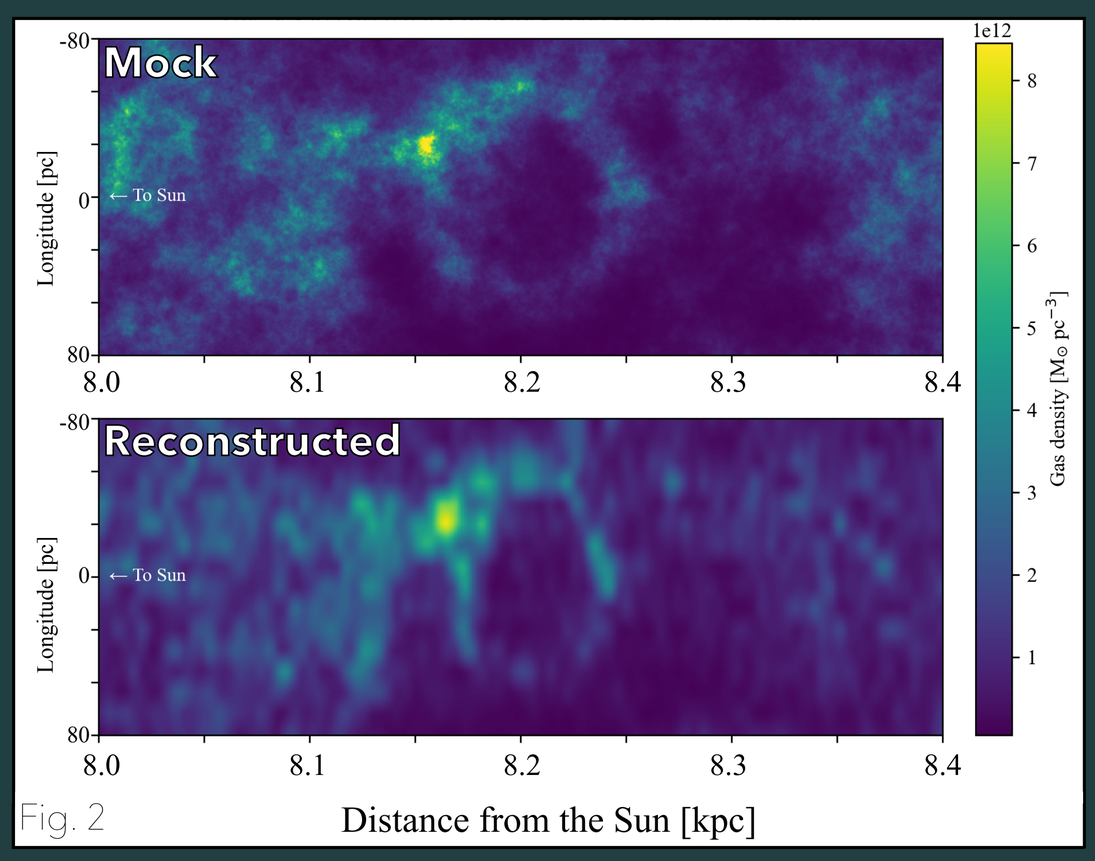


Fig. 2