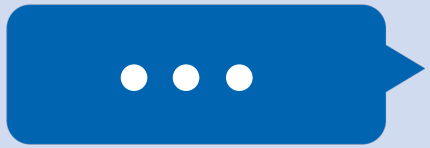
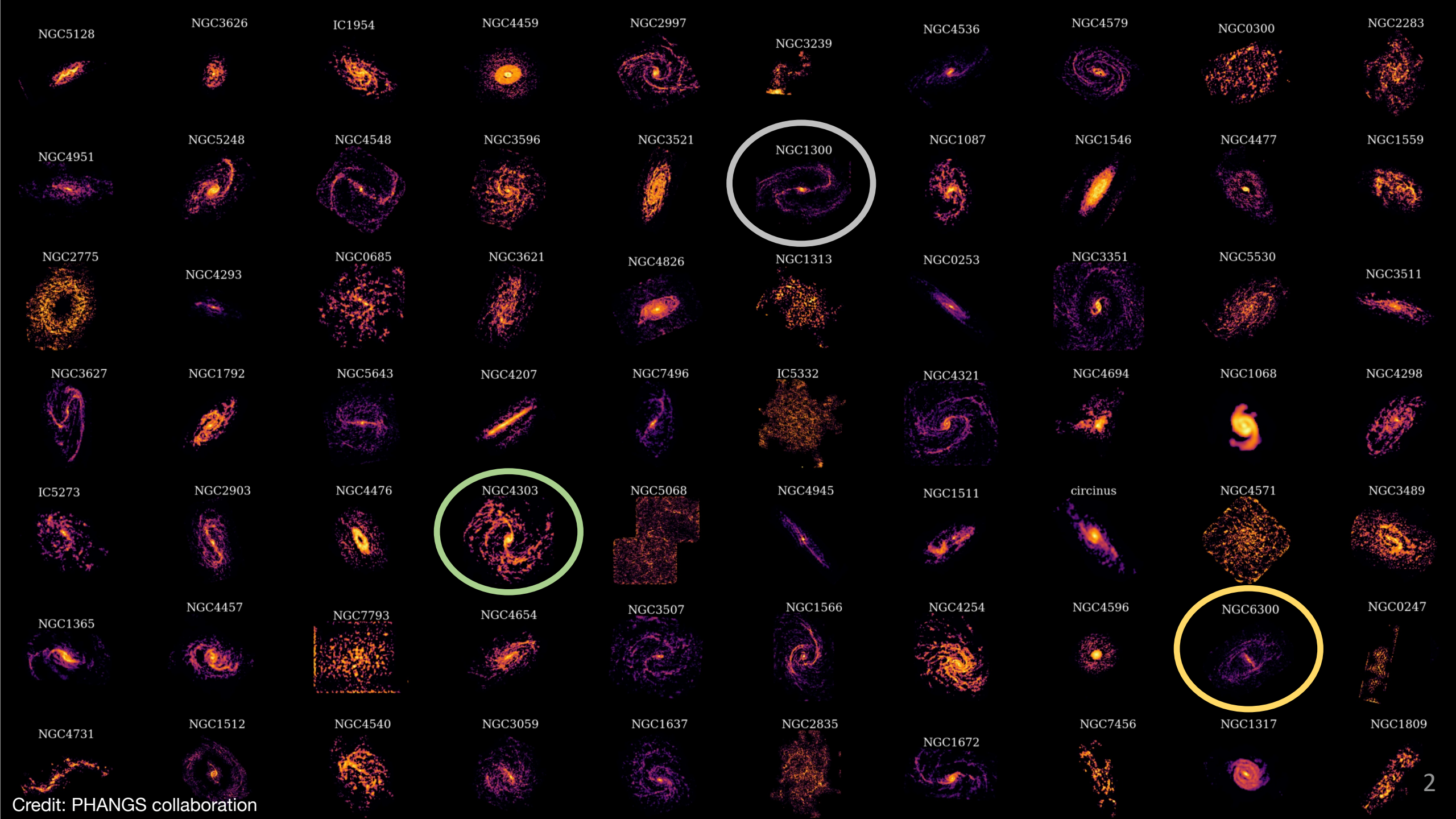
On the Tremaine-Weinberg method:

Olga Borodina
Thomas Williams
Eva Schinnerer
Mattia Sormani
Sharon Meidt

can we trust gas tracers to measure pattern speeds?

14:02



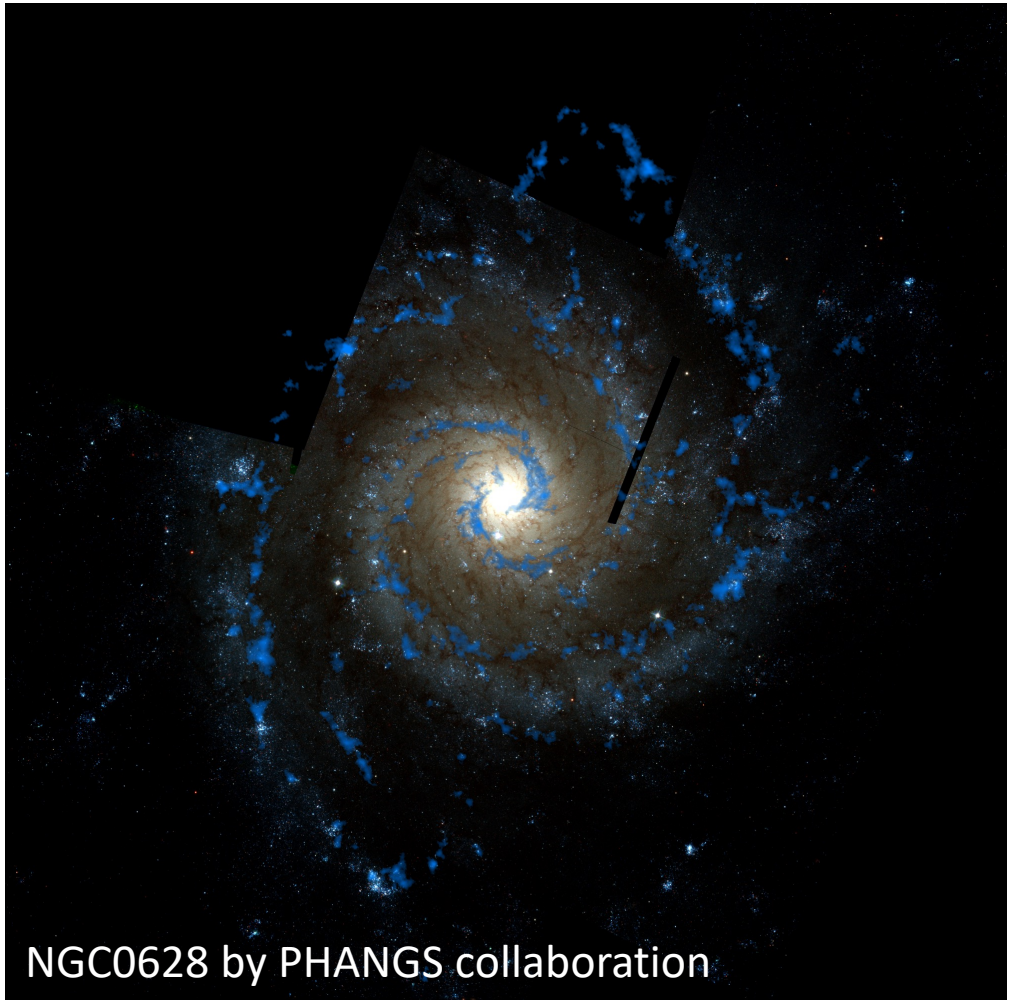


Credit: PHANGS collaboration

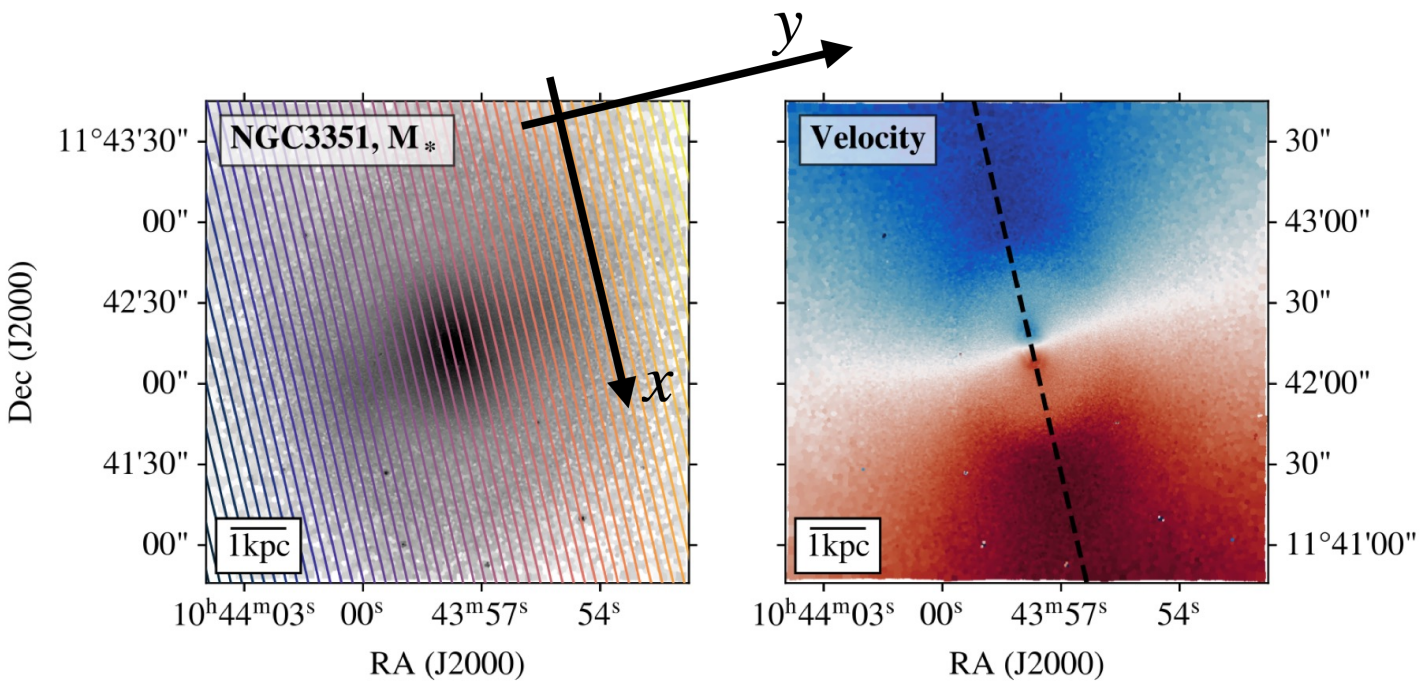
Tremaine-Weinberg Method (1984)

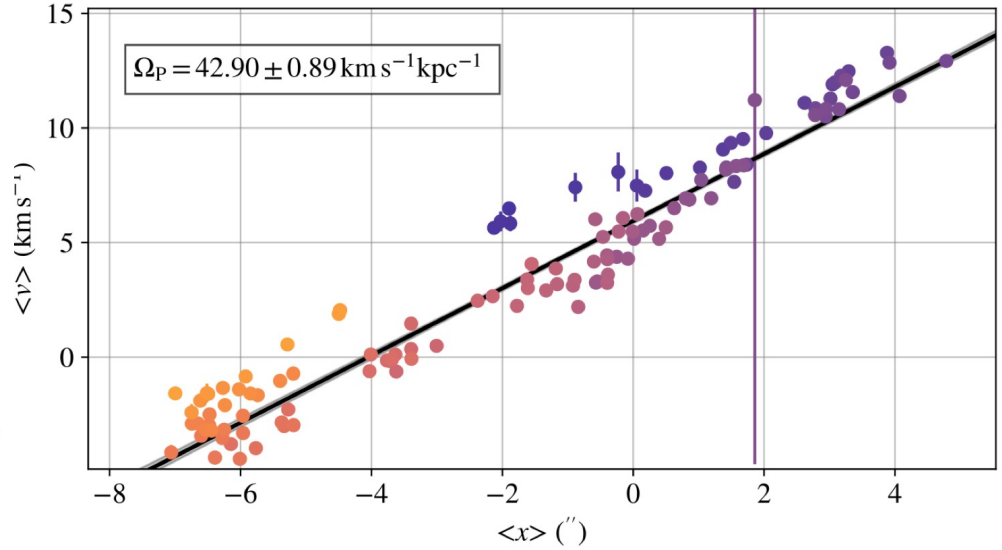
Three conditions:

- The galaxy disk is flat;
- The disk contains a constant, well-defined pattern speed;
- The tracer obeys the continuity equation.


NGC0628 by PHANGS collaboration

Tremaine-Weinberg Method (1984)

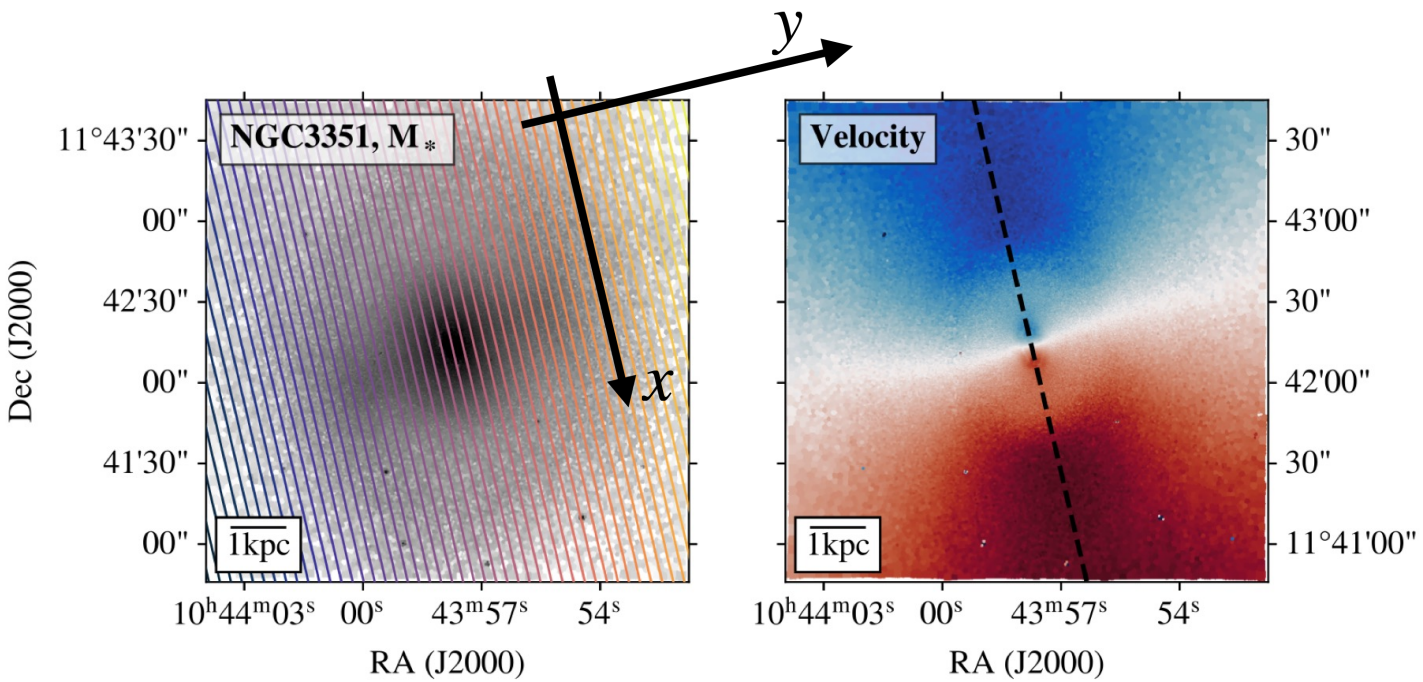


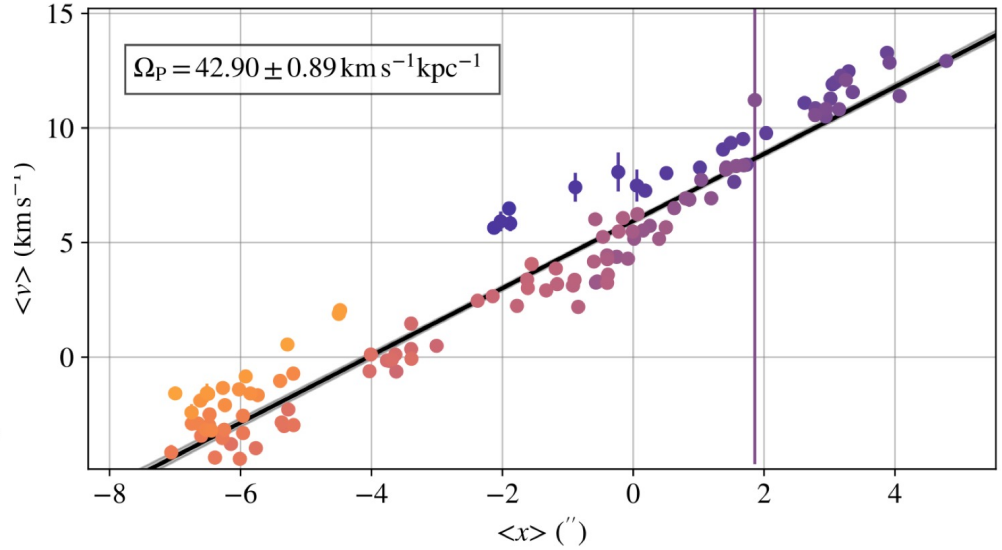


T. Williams et al. (2021)

$$\Omega_{\rm P}\sin(i) = \frac{\int_{-\infty}^{\infty} h(y) \int_{-\infty}^{\infty} v_{\rm LOS}(x,y)\,\Sigma(x,y)\,{\rm d}x{\rm d}y}{\int_{-\infty}^{\infty} h(y) \int_{-\infty}^{\infty} x\,\Sigma(x,y)\,{\rm d}x{\rm d}y} = \frac{\langle v\rangle}{\langle x\rangle}$$

Tremaine-Weinberg Method (1984)



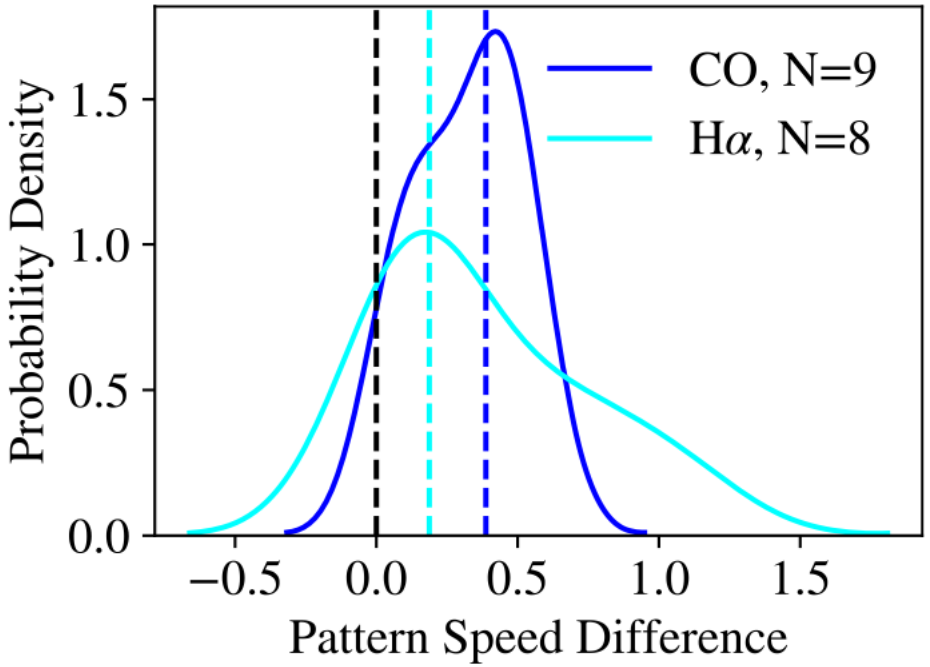


T. Williams et al. (2021)

$$\Omega_{\mathrm{P}} \sin(i) = \frac{\text{sum of weighted velocities}}{\text{sum of weighted x-coordinates}} = \frac{\langle v \rangle}{\langle x \rangle}$$

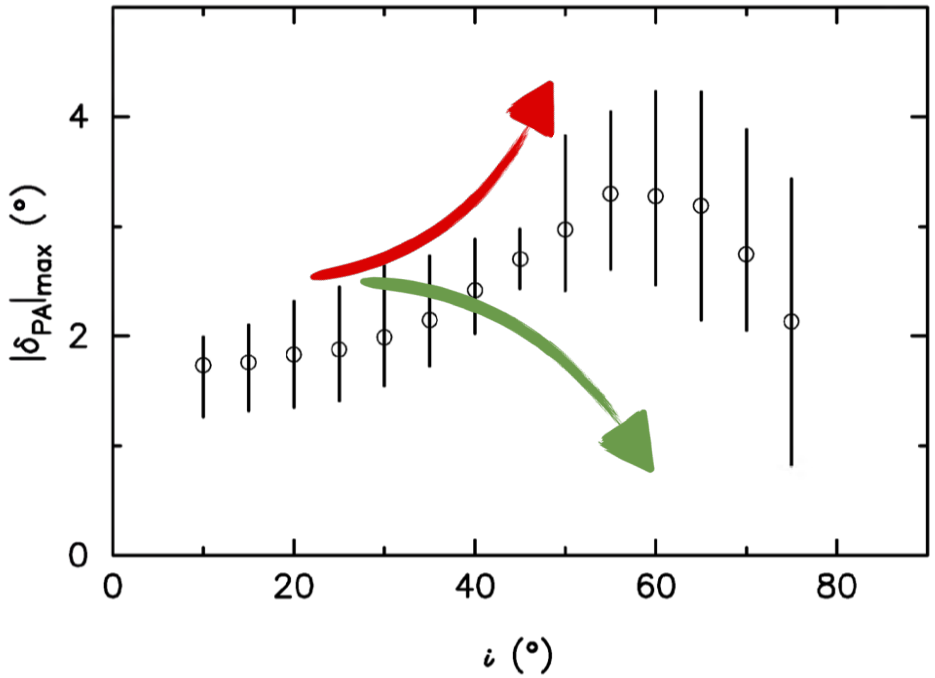
Previous studies

Observations



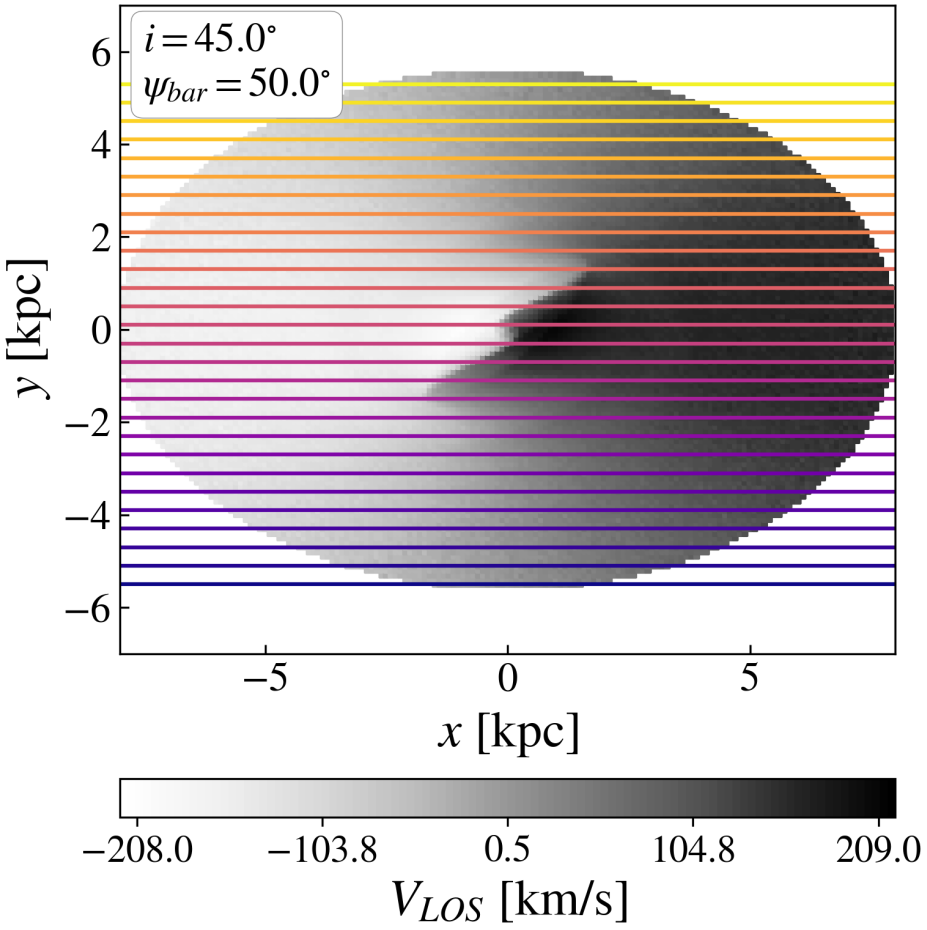
T. Williams et al. (2021)

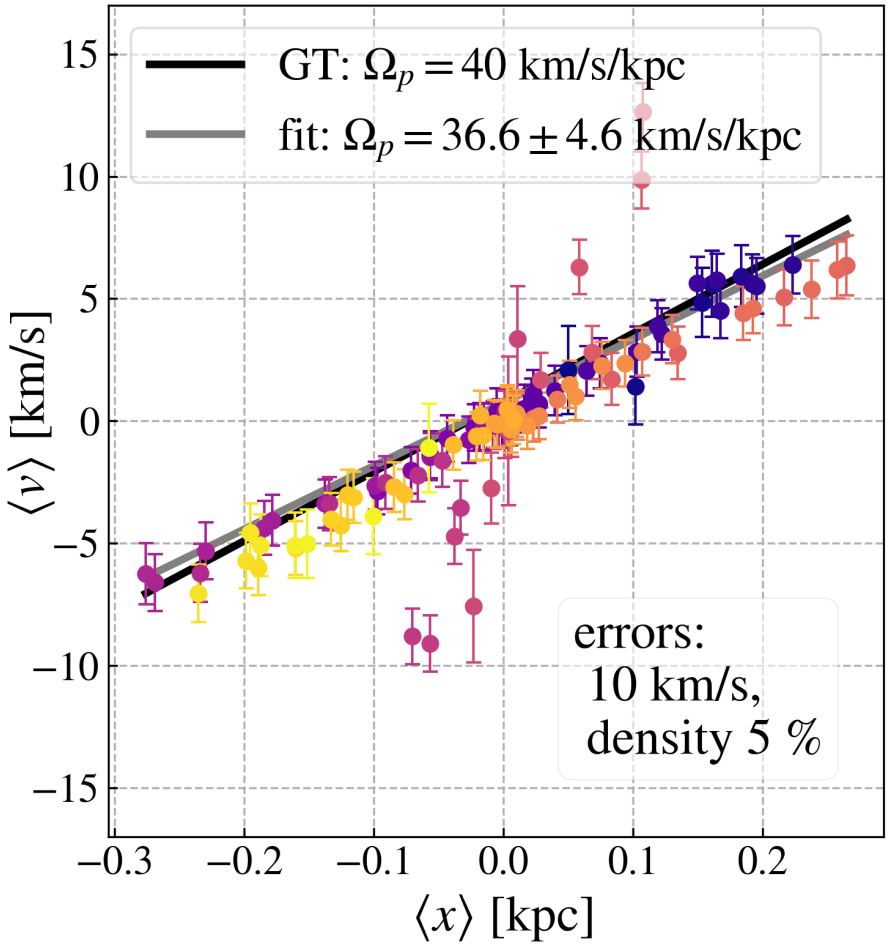
Simulations



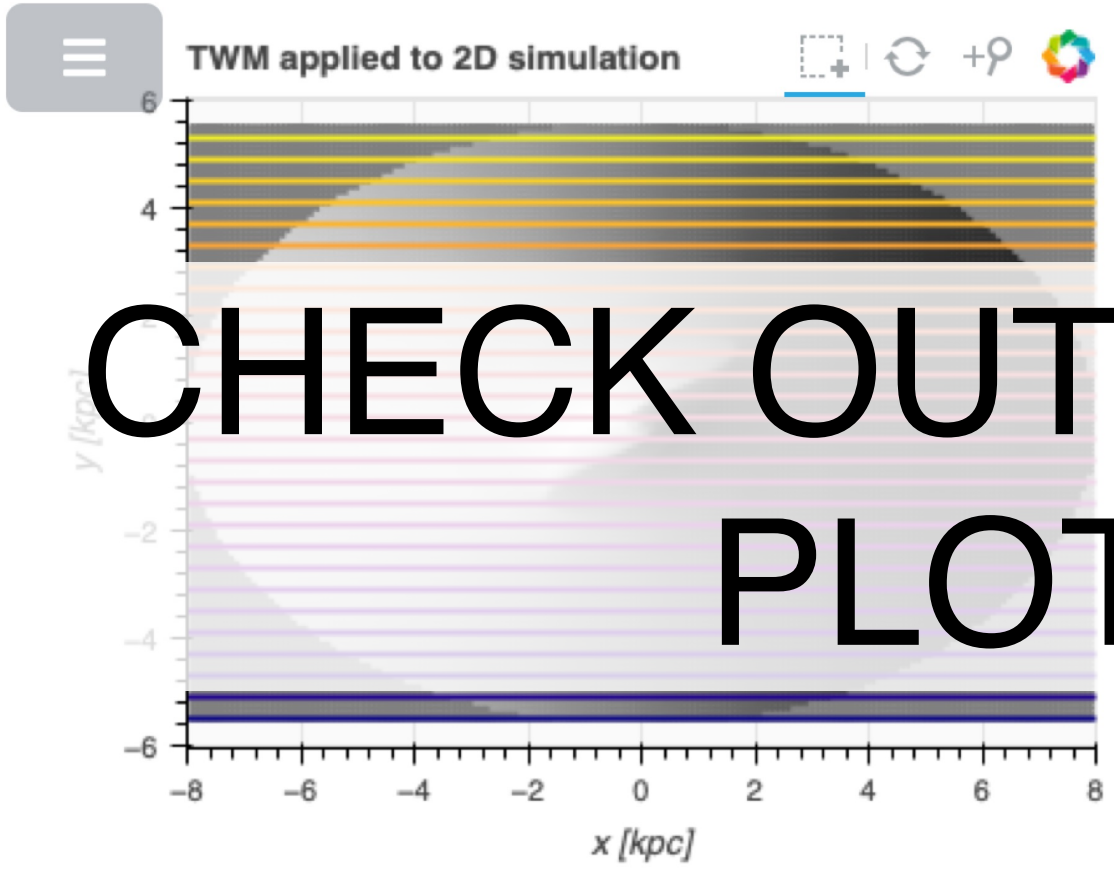
V. Debattista (2003): the higher inclination, the bigger errors in PA we can tolerate

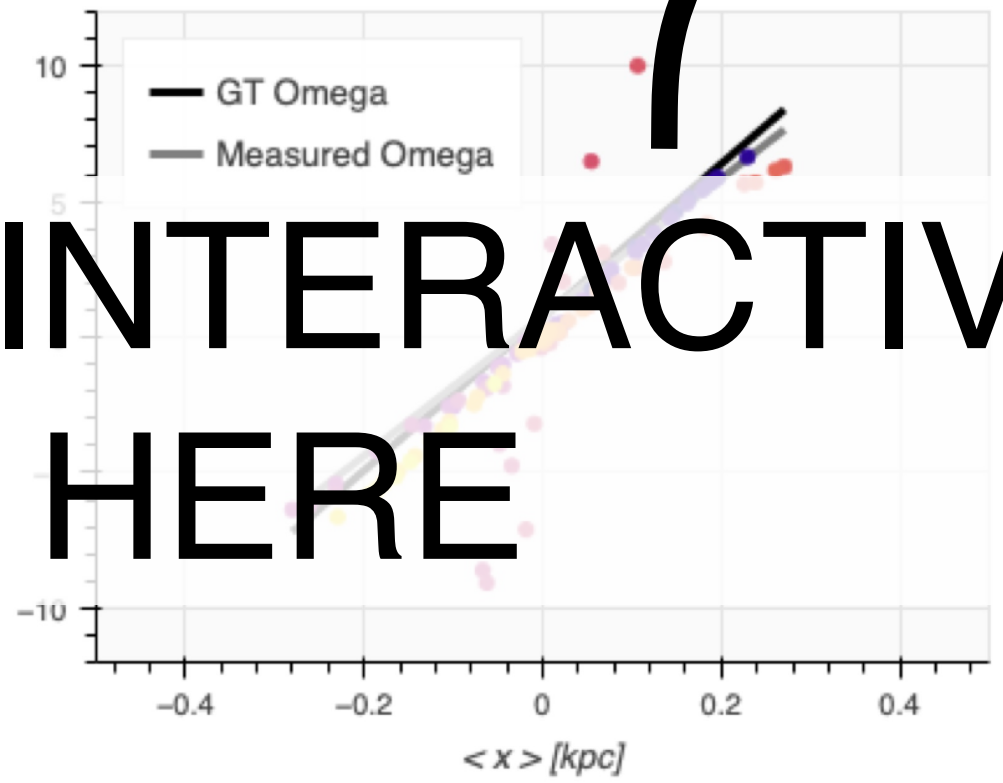
2D simulations: everything works, but…



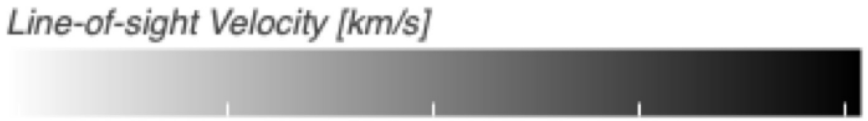


… some slits show wrong result

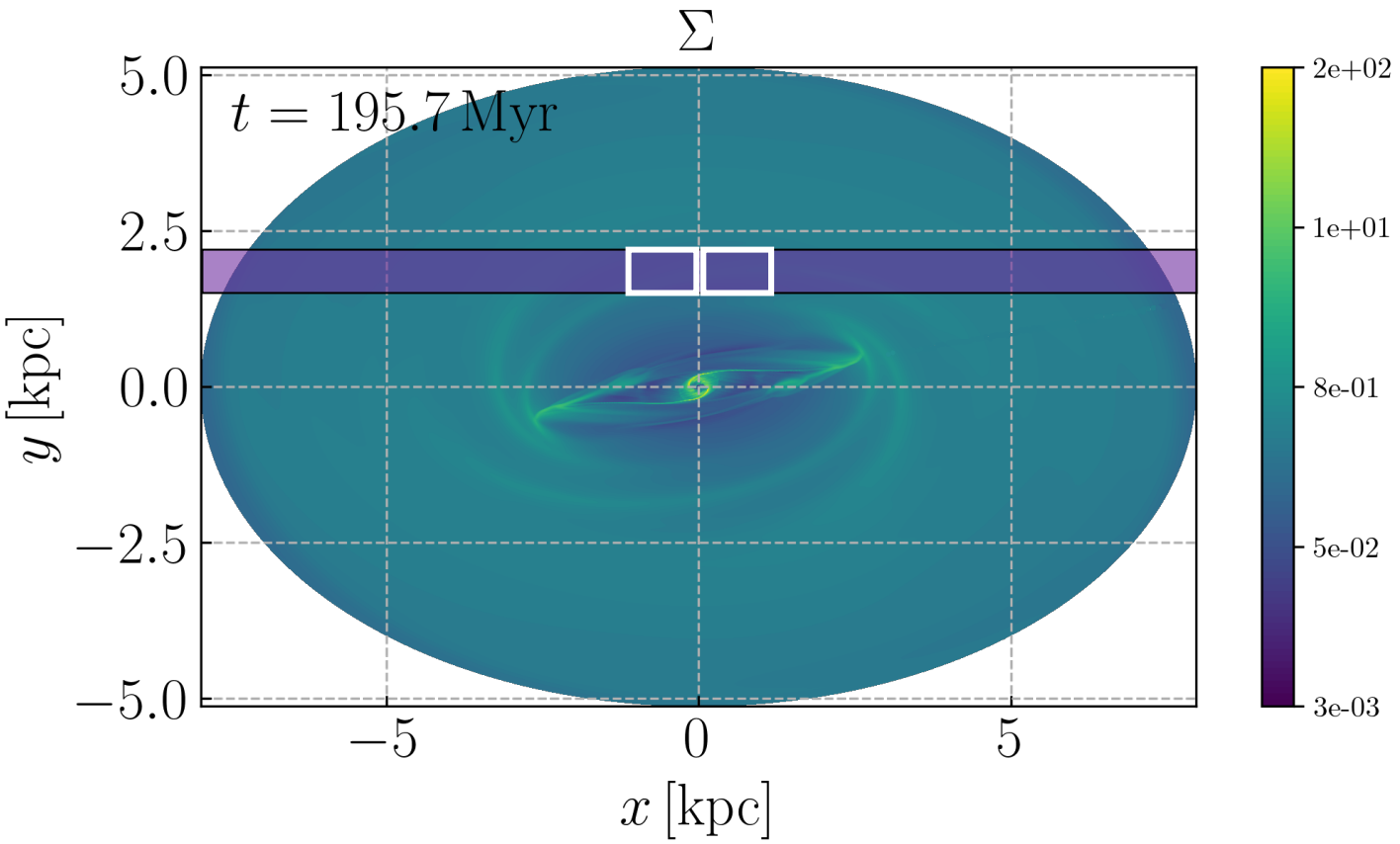




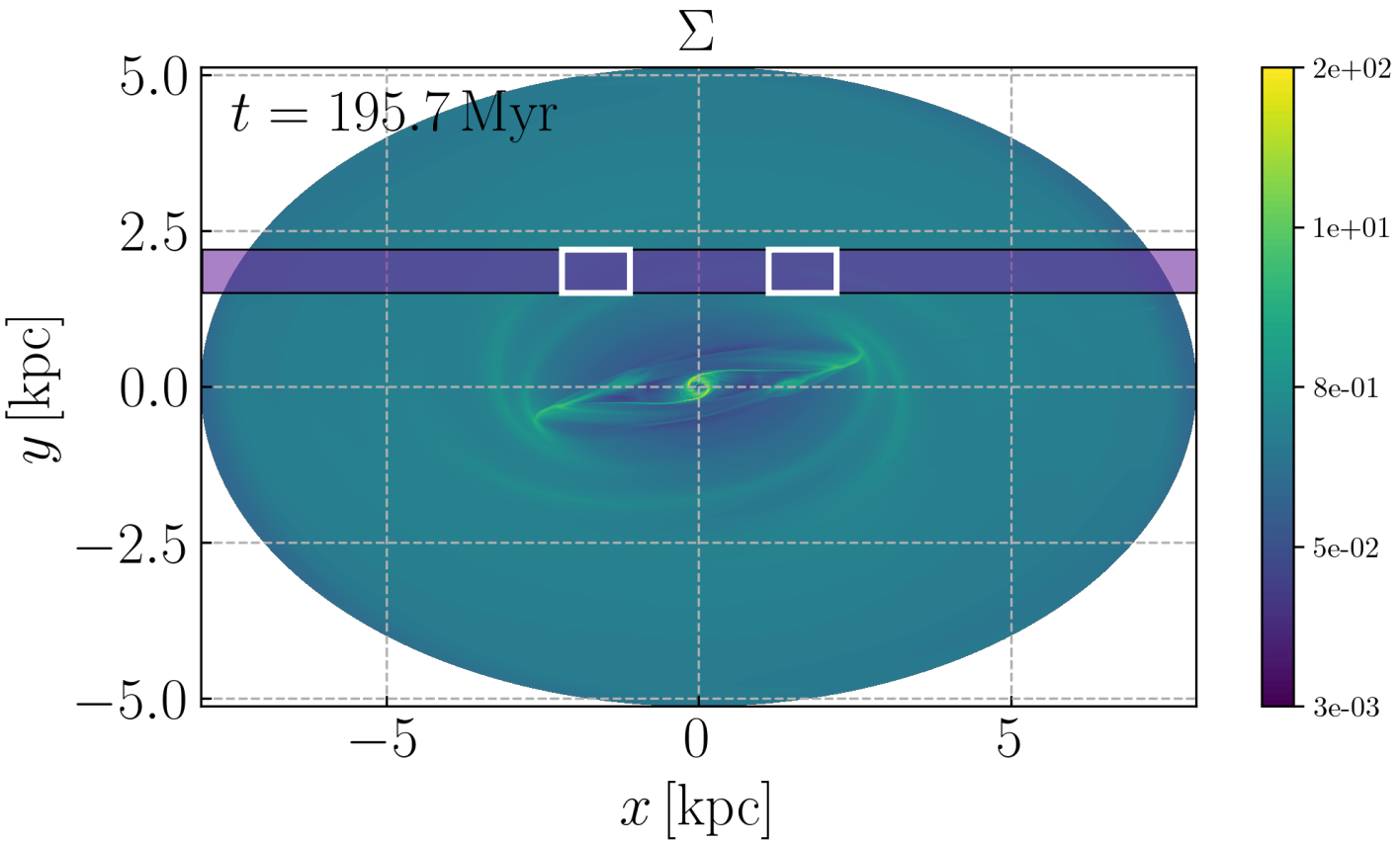
CHECK OUT INTERACTIVE PLOT HERE



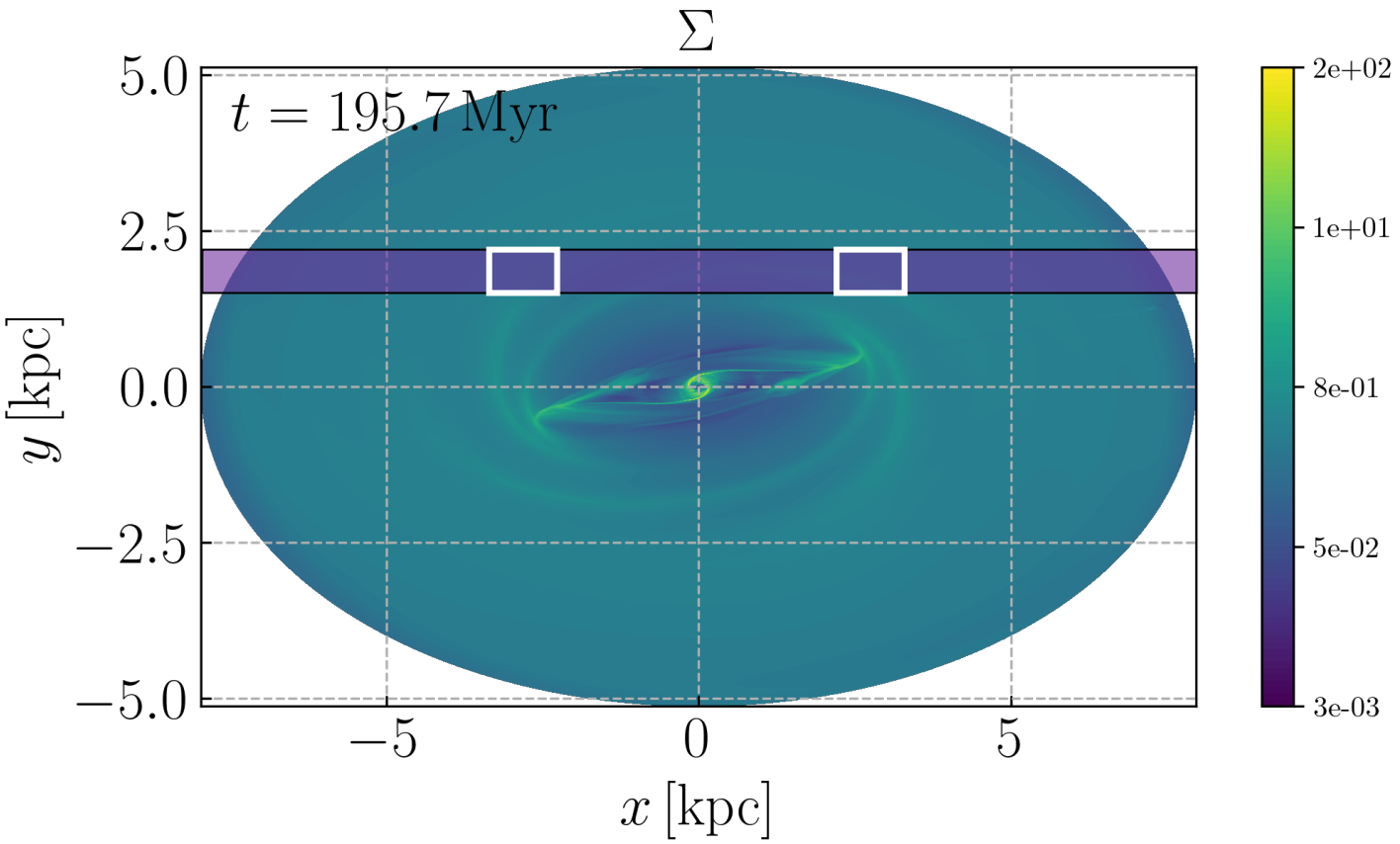
Possible explanation



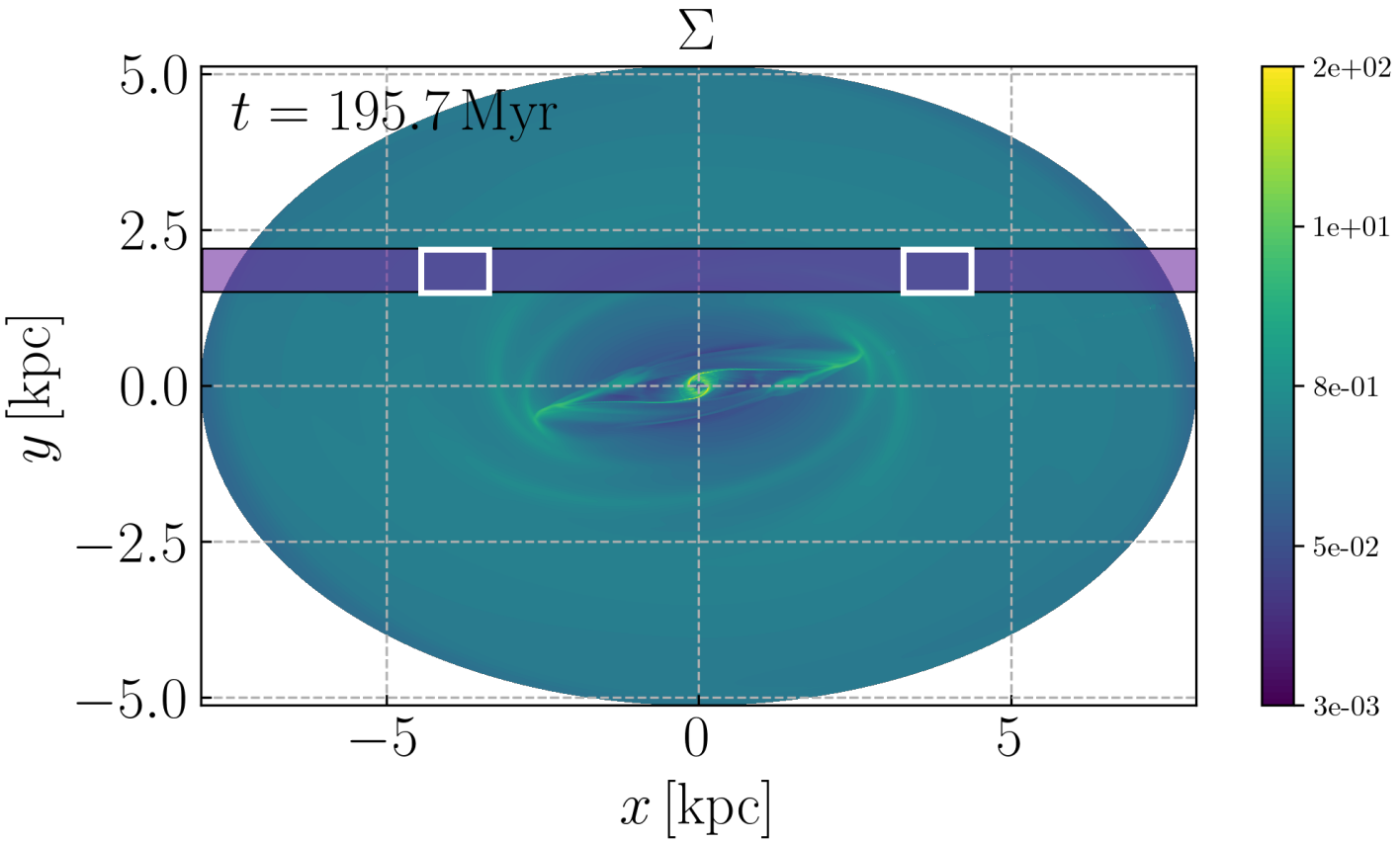
Possible explanation



Possible explanation

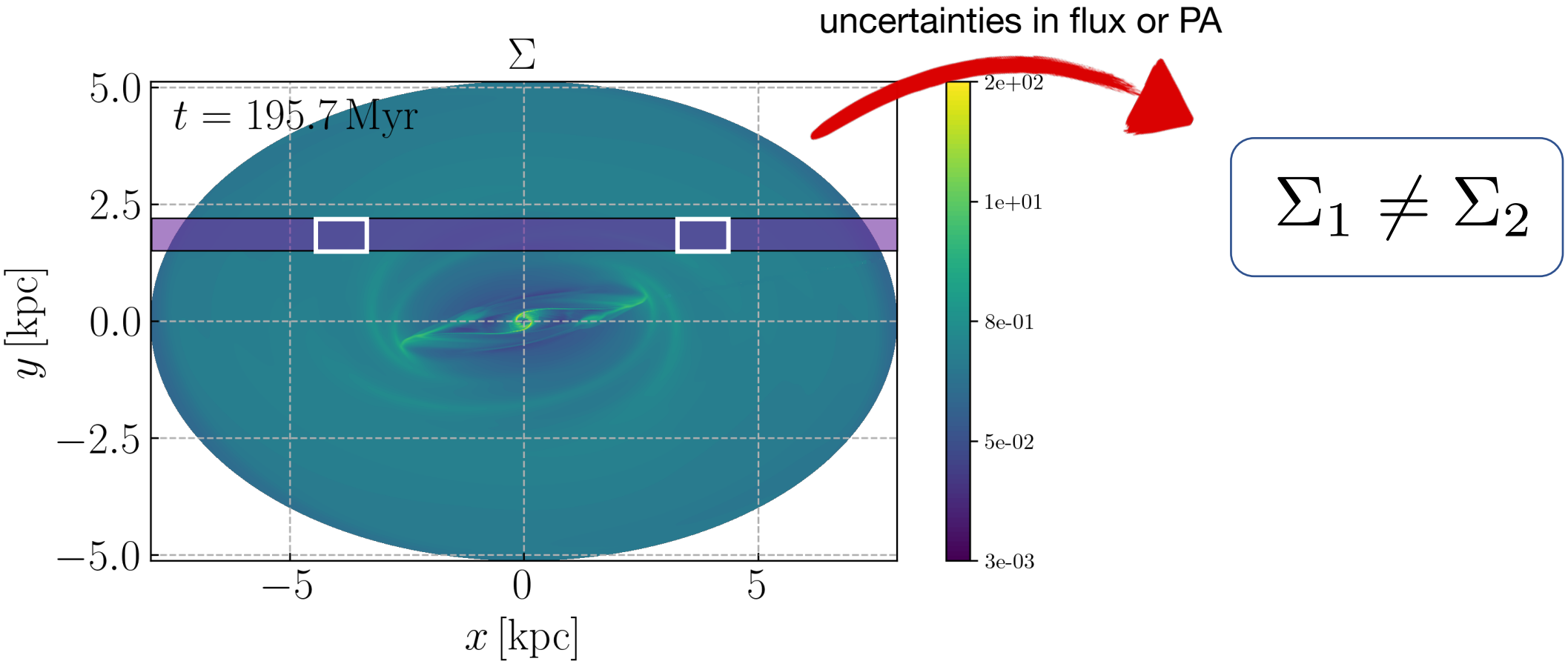


Possible explanation

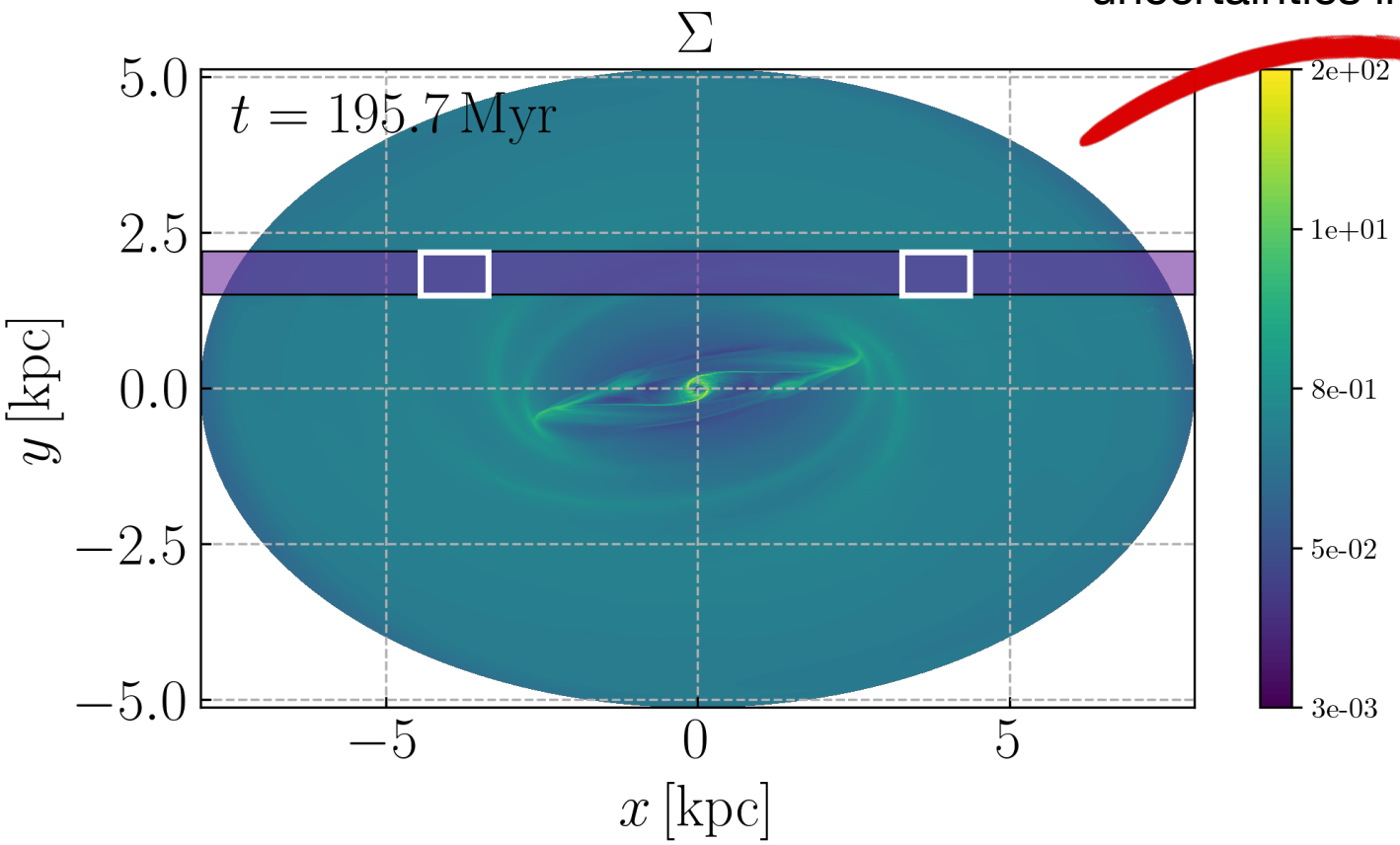


$$\langle v \rangle = 0$$
$$\langle x \rangle = 0$$

Possible explanation



Possible explanation



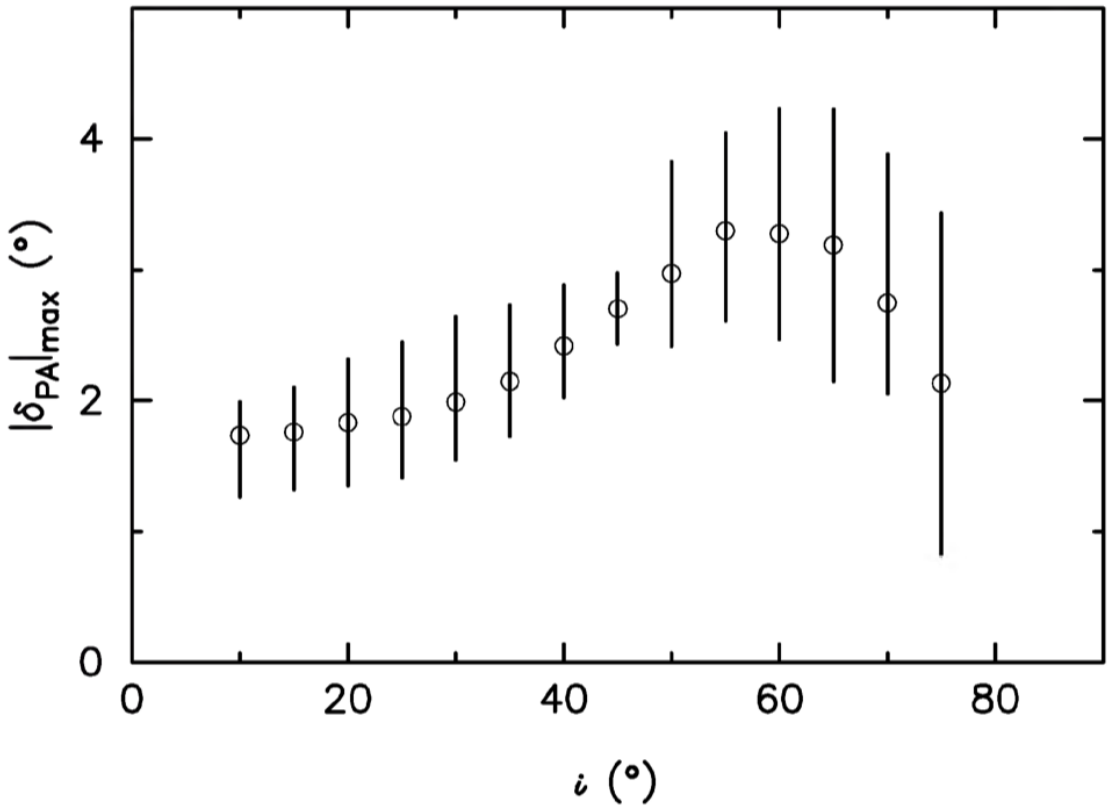
uncertainties in flux or PA

$$\Sigma_1 \neq \Sigma_2$$

$$\Omega$$

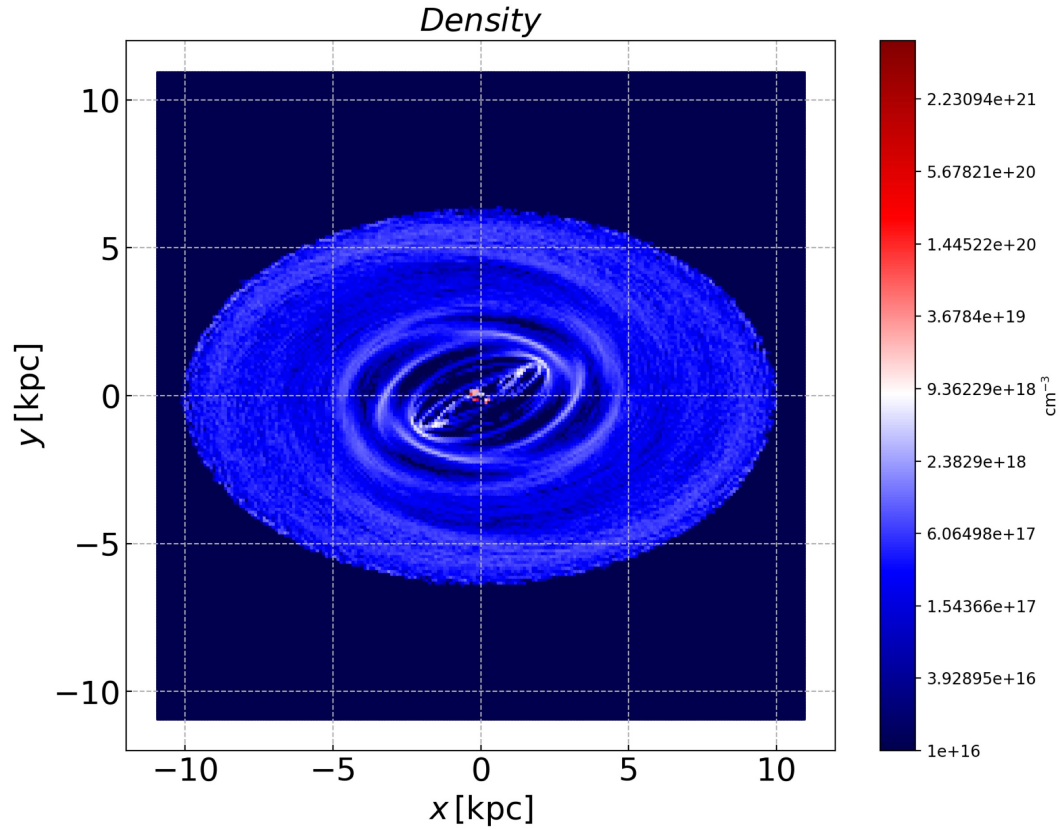
Possible explanation

We pick up weighted velocity field and **not** the actual pattern speed



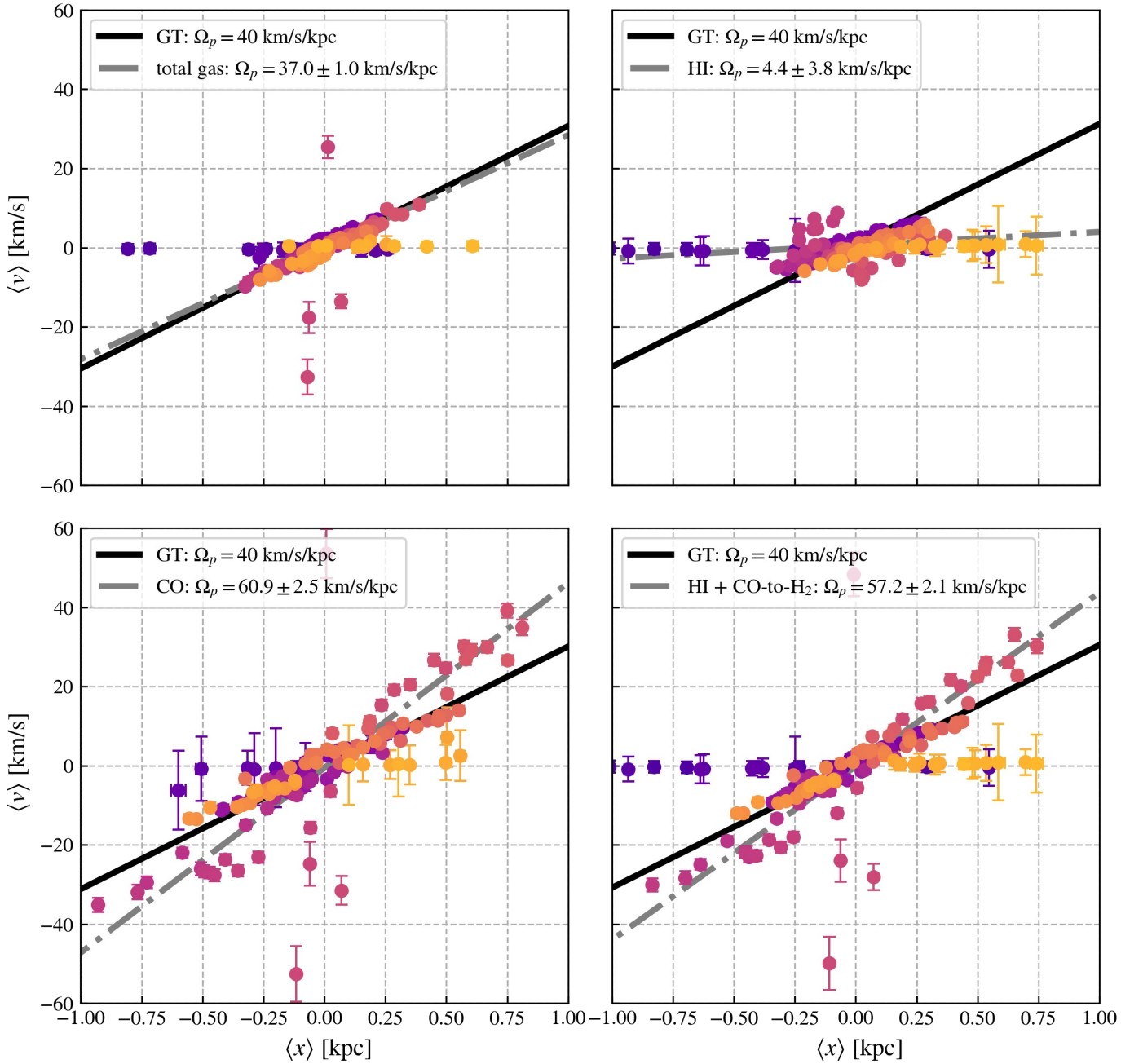
3D simulations: different gas tracers

- different chemical components
- separately they don't obey continuity equation
- clumpiness!



M. Sormani et al. (2018)

Total gas



HI

M. Bureau et al. (1999)
A. Banerjee et al. (2013)

CO

mocked total H

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can we trust gas tracers to measure pattern speeds?

14:02

not really

15:19 ✓✓

PHANGS

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