Dynamics of the Galactic bar and spirals

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Milky Way surveys: main objective

Precise **mass model** of the Galaxy and of each of its components (stellar populations, gas, dark matter) **+ history**

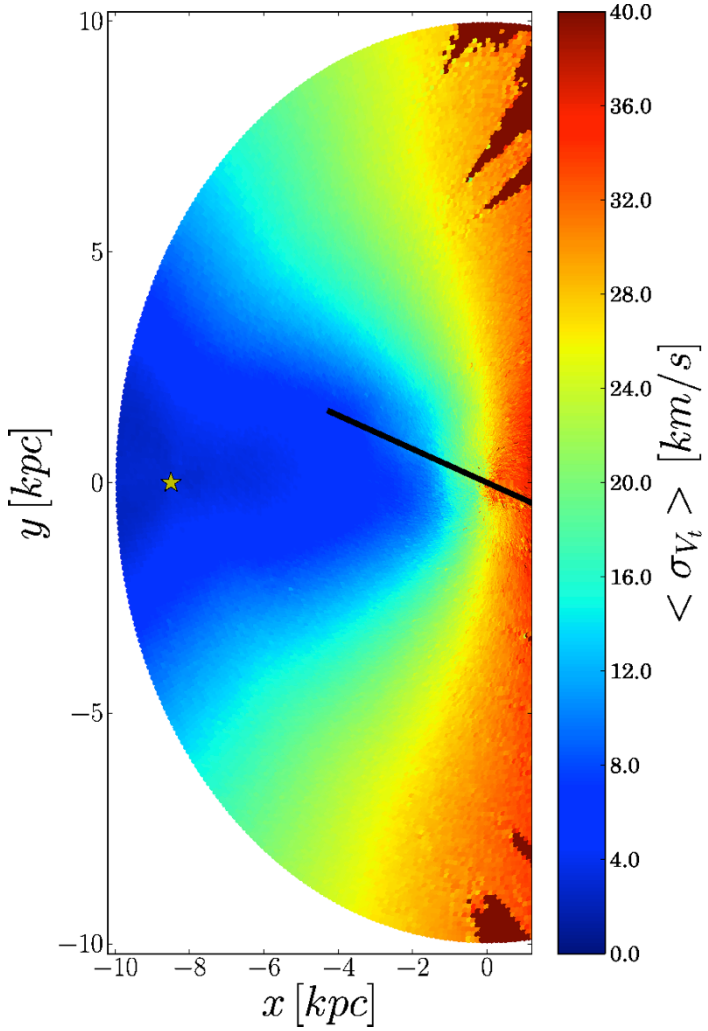
Related questions about the Galaxy:

- Is the Galaxy's structure in accordance with models of galaxy formation in LambdaCDM? How does the MW compare to other spirals?

- Disk questions: respective roles of **hierarchical formation** and **secular evolution** in shaping the Galaxy? How did the **different components** (thin & thick disks…) come into being, what are the roles of spirals (+ number of arms, pitch angle, pattern speed?) and **the bar (length, pattern speed?)**, how massive are they, and how did they evolve?

Gaia alone is not enough

Gaia transverse velocity error for red clump stars with photometric distance error (~10%)

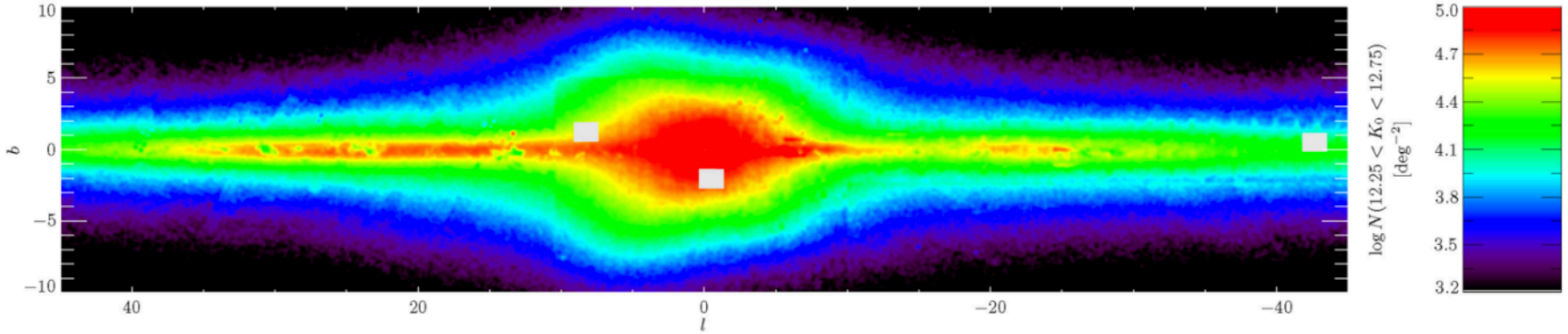


Interested communities:

- GREAT: Gaia Research for European Astronomy Training (~500 members)
- REG: Red para la Explotación Científica de Gaia (SPAIN, ~150 members)
- Complementary surveys: WEAVE, 4MOST

Disk science is good for MOONS because of high number of targets

What's going on with the bar?



Wegg C., Gerhard O., Portail M., 2015, MNRAS, 450, 4050

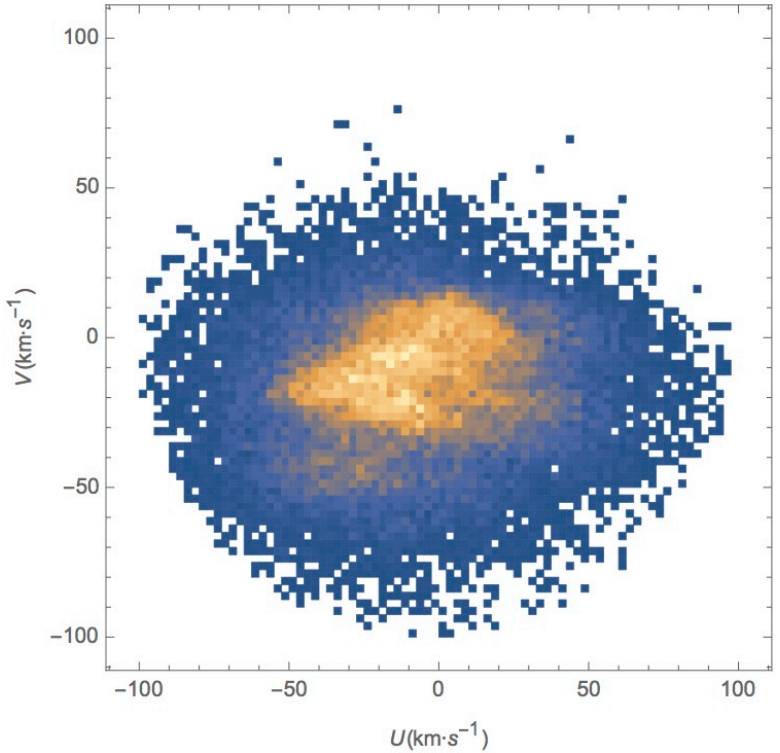
Millions of RC stars from VVV survey + 2MASS+ UKIDDS + GLIMPSE
=> long flat (h_z<50 pc) extension of the bar out to 5 kpc from the center (l>30°)

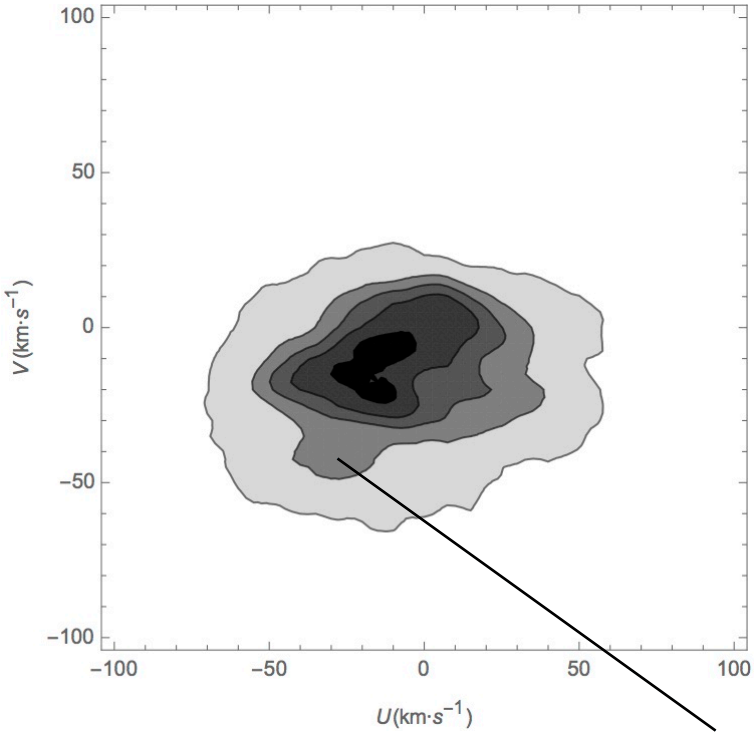
What is this?

Fit to BRAVA (central 10° in long.)
+ARGOS (28000 stars -30°<l<30° and -10°<b<-5°)

⇒ **Ω_b = 40 km/s/kpc ~ 1.35 Ω_0** (Portail et al. 2016)
⇒ Corotation at 6 kpc and OLR beyond 10 kpc

Local signature of the OLR of the bar?





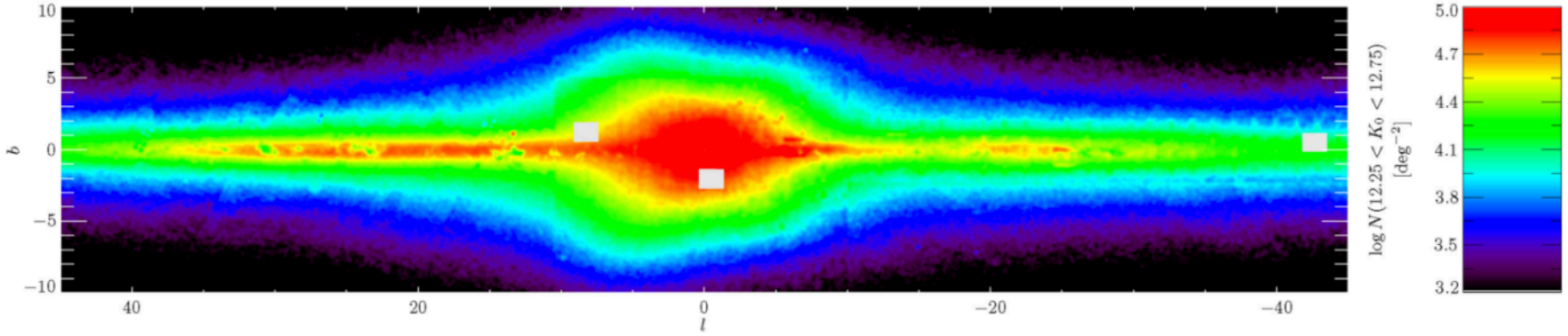
Gaia DR1 (σ_π/π <0.1) + RAVE DR5

Hercules stream

⇒ **Ω_b > 1.8 Ω_0 (~55 km/s/kpc)** see Monari et al. 2016

⇒ Long flat extension of the bar = loosely wound spiral?

Spirals must play a role in the discrepancy



Wegg C., Gerhard O., Portail M., 2015, MNRAS, 450, 4050

M2M modelling typically does not explore full parameter space

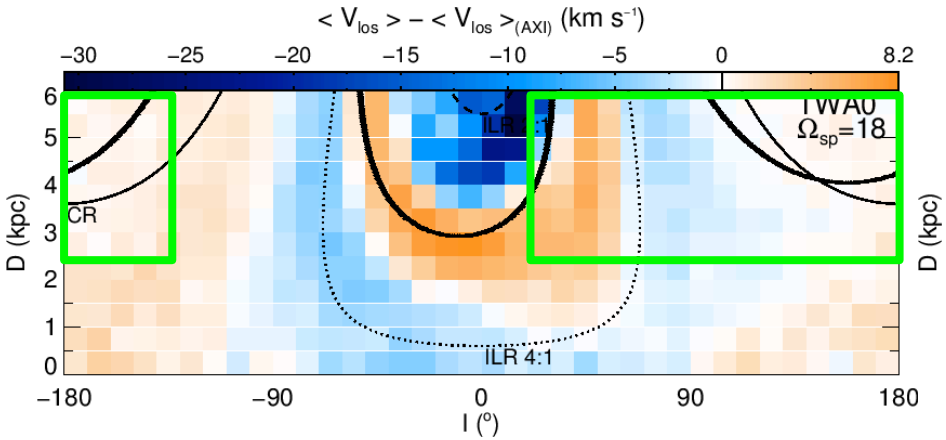
Role of spirals might be badly taken into account?

But which spirals? Transient and corotating? multiple density waves? Pattern speeds? …

spiral arm effects on stellar kinematics

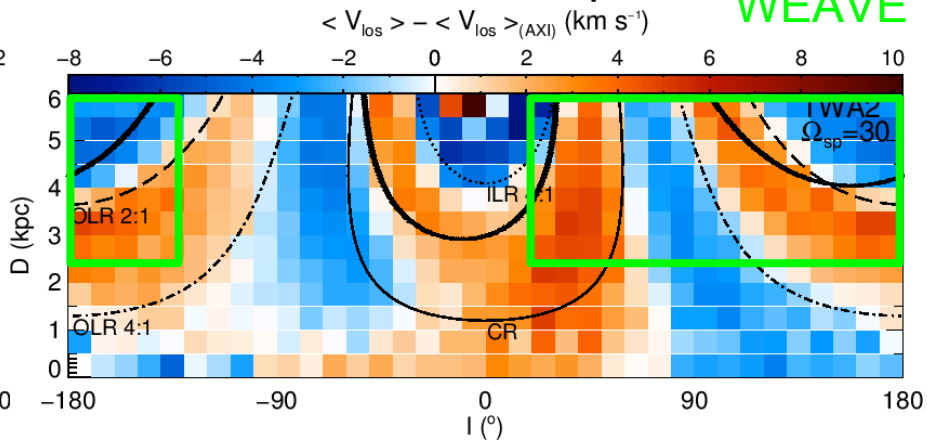
comparison mean Vlos simulations with spiral arms and without spiral arms:
Vlos (spiral) - Vlos (no-spiral)

18 km/s/kpc

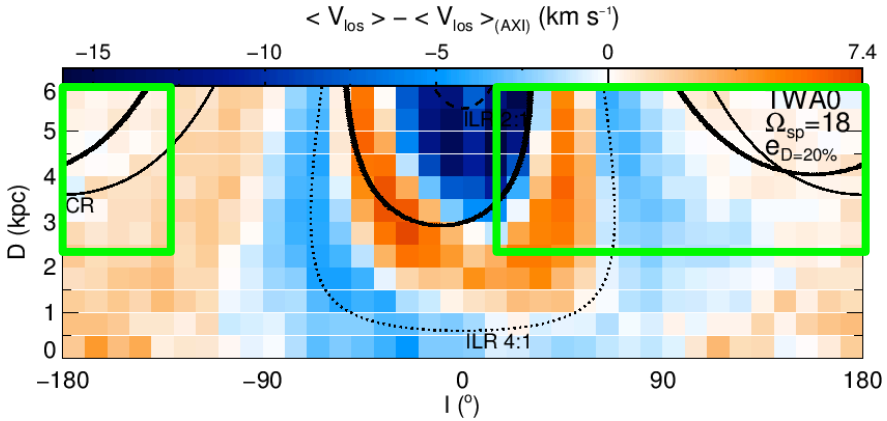


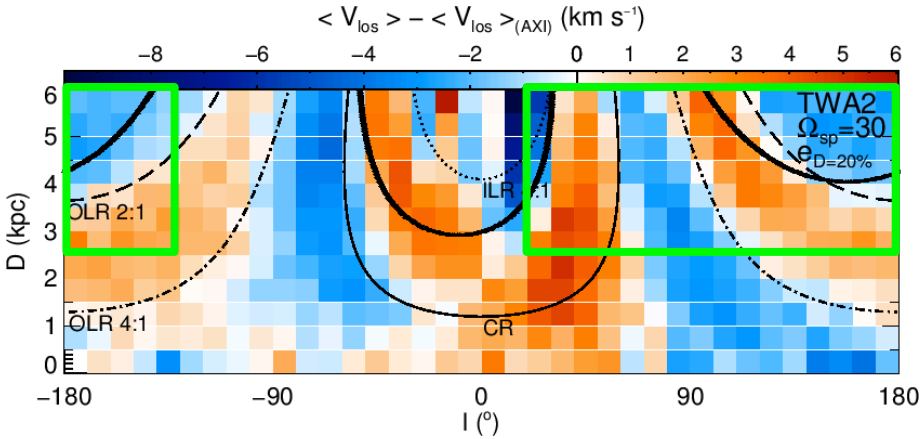
30 km/s/kpc

WEAVE



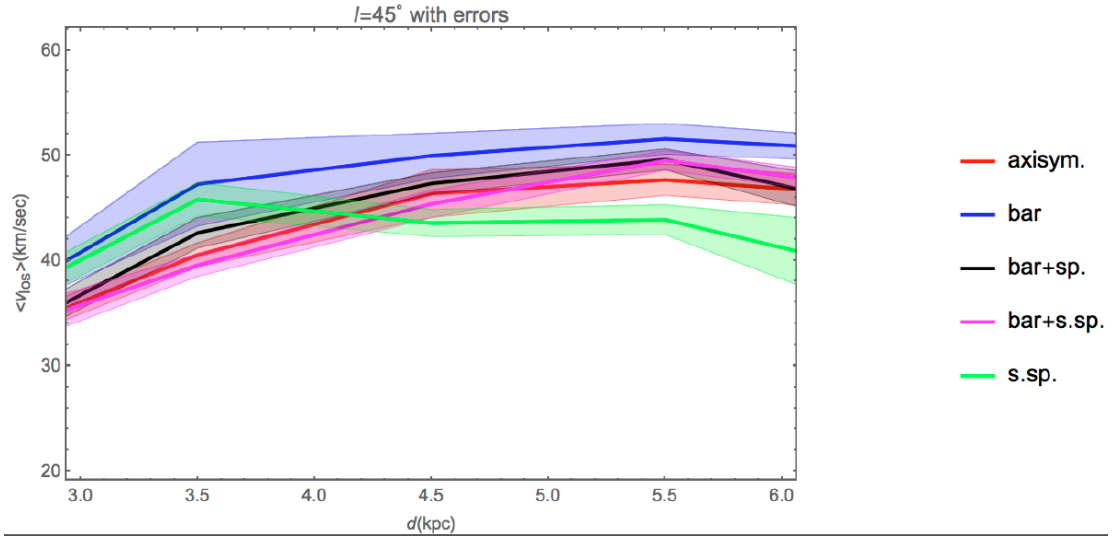
same but distance error 20%

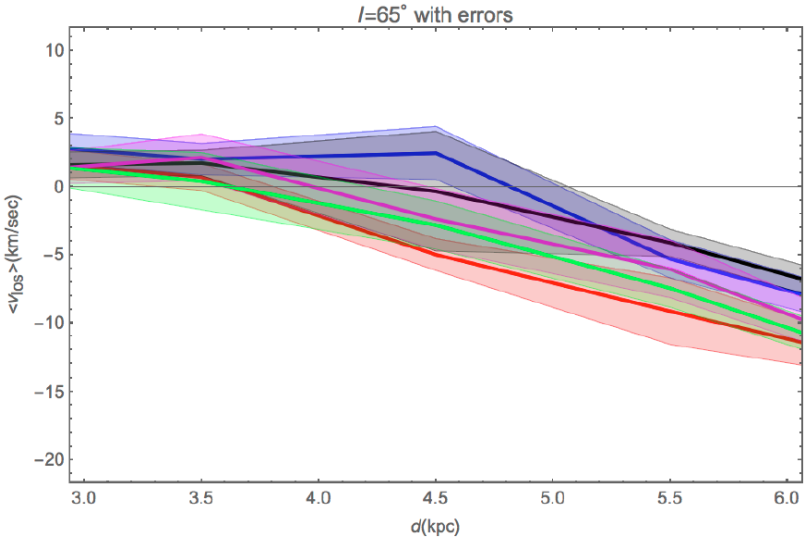


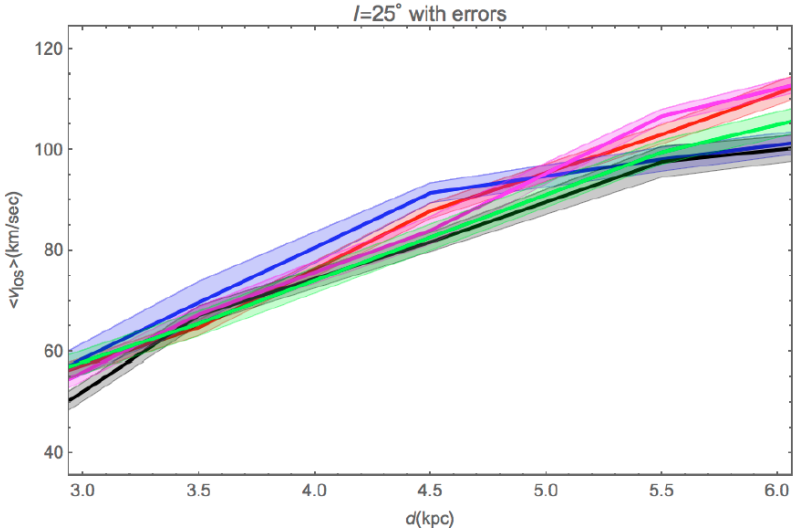


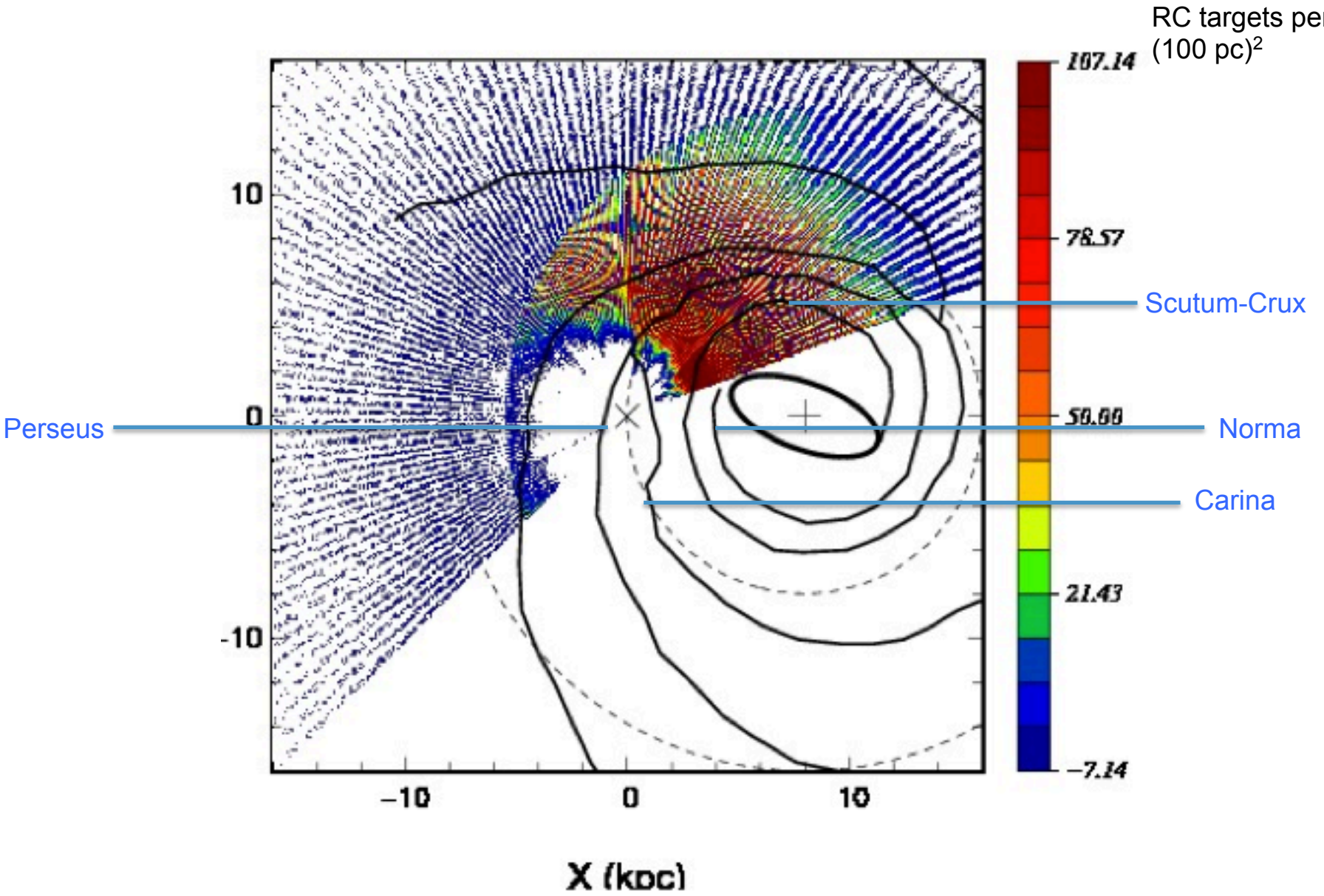
spiral arm + bar effects on stellar kinematics

distance error 20% and <5000 particles

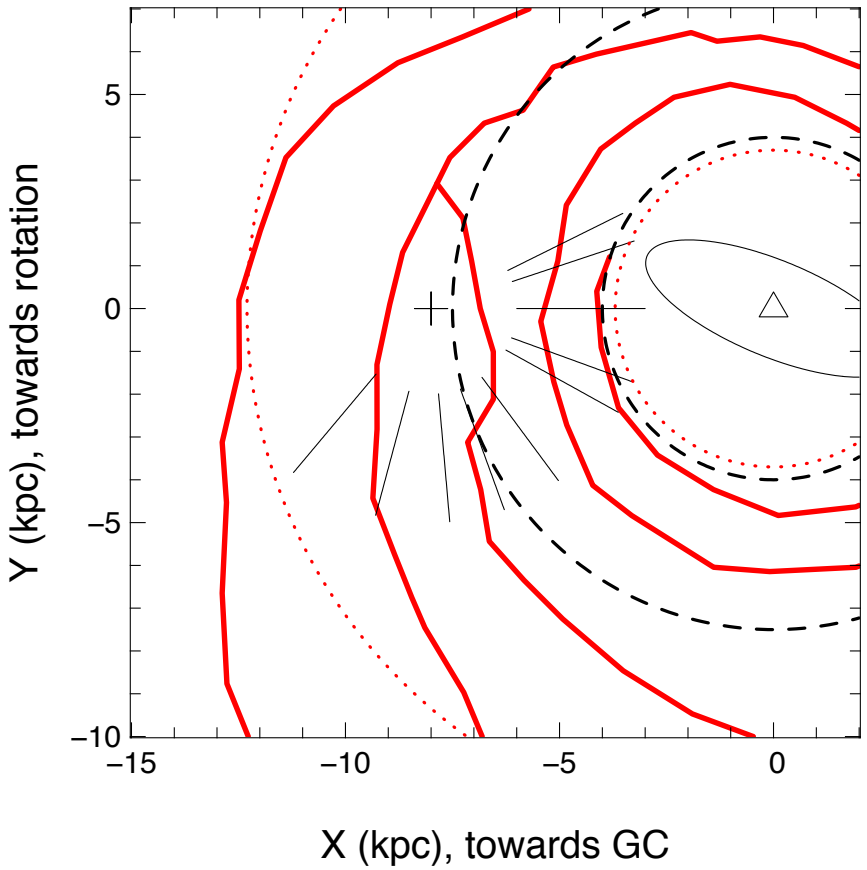







RC targets per
(100 pc)^2
107.14
78.57
50.00
21.43
-7.14
Scutum-Crux
Norma
Carina
Perseus
10
0
-10
-10
0
10
X (kpc)

Some important l.o.s. for MOONS inner Galaxy survey



Proposed MOONS lines-of-sight

l = 18 : Goes through Scutum-Crux stellar arm, extremity of the COBE bar

l = 0 : Very good to not rely on proper motions for mean VR

l = -20 : interesting for the near 3 kpc arm or start of Perseus

l = -29 : the Norma (gaseous arm) tangency

l = -53 : the Crux-Centaurus tangency on the side of the Sagittarius-Carina gaseous arm

l = -73 : the Carina arm tangency (tangency between -73 and -80)

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l = -90 : excellent to constrain spiral structure (see Minchev & Quillen), at *low* distances, good to have a direct measure of angular momentum from los V alone (l=-90 high extiction, ok with MOONS?). Number of targets per field of view?

l = -105

l = -130 : Both good to check effect of Perseus arm and velocity gradient in the outer Galaxy, but problem with number of targets…

MOONS disk science case

=> In the end we'd want to understand:

- Dynamic influence of spiral arms and bar on stars and secular evolution of the disk (+nature of spiral arms, density waves vs transient, number of modes, number of arms of each mode, etc.)

    - effects on the global kinematic moments (mean velocities, dispersions, vertex deviation, etc)
    - resonant trapping, moving groups
    - stellar radial migration in presence of bar