Radial velocities from the GCDS and the kinematic groups induced by the bar and the spiral arms of the MW

Teresa Antoja

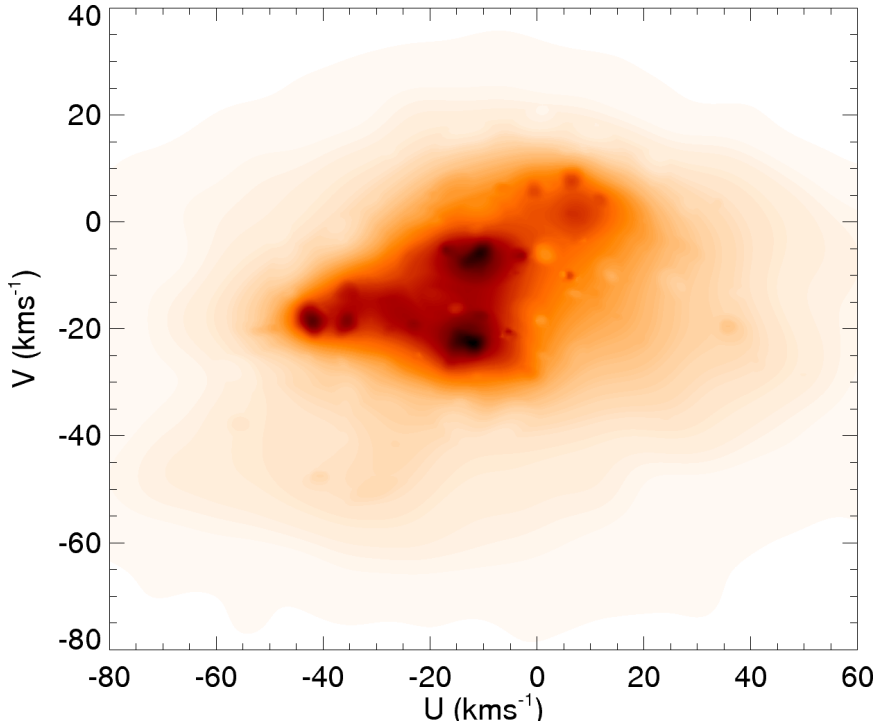
Kapteyn Astronomical Institute, University of Groningen, the Netherlands

GCDS SURVEY SCIENCE
Nice, France
2-4 November 2010

Velocity distribution in the Solar neighbourhood

- FGK (Nordström et al. 2004); OB (Asiain et al. 1999a); A (Torra et al. 2000); M (Reid et al. 2002); M (Bochanski et al. 2005); KM giants (Famaey et al. 2005)
- $\sim 200\,\mathrm{pc}$
- 24190 *

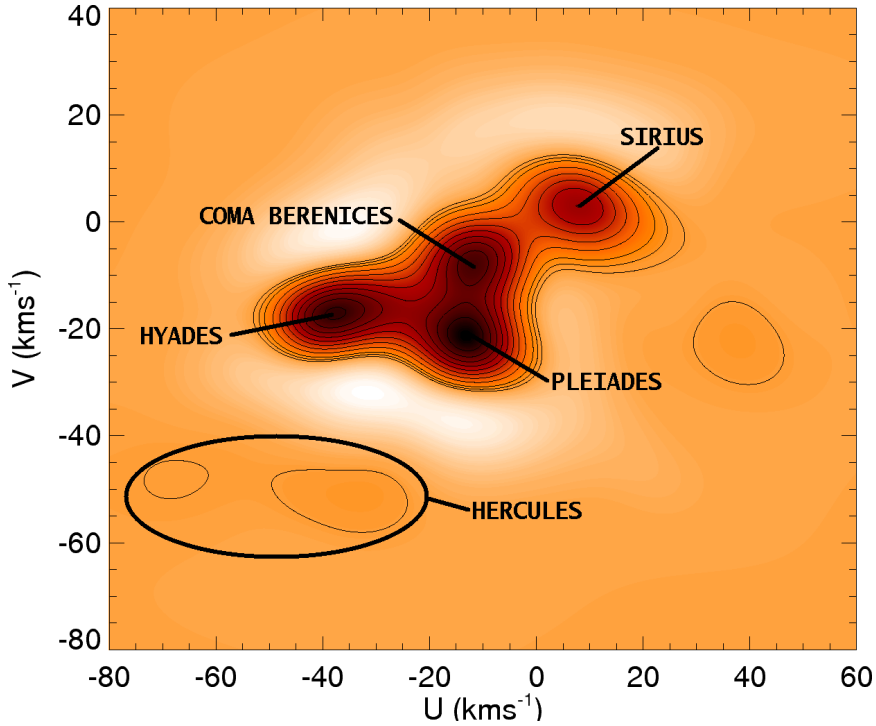
Antoja et al. 2008



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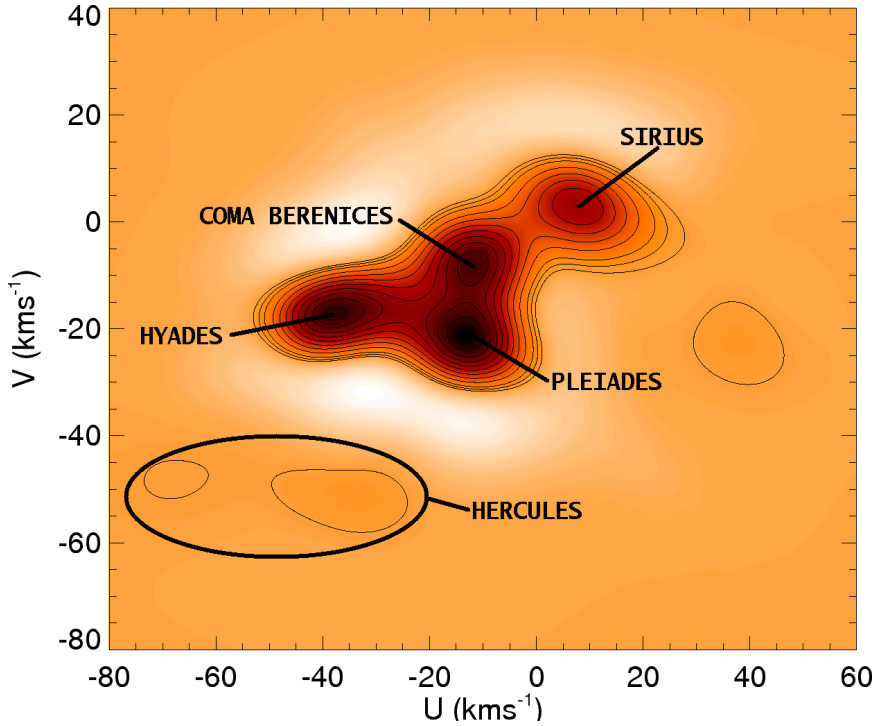
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GAIA: velocity distributions at different positions of the Galaxy

- Why do we care about the kinematic substructures at different positions of the MW disc?
- How far is Gaia going to go in providing these velocity distributions at different positions? In which regions of the Galaxy is crucial that we obtain the missing radial velocities?
- Can these radial velocities from the complementary spectroscopic surveys be useful by themselves for the detection of kinematic substructure?

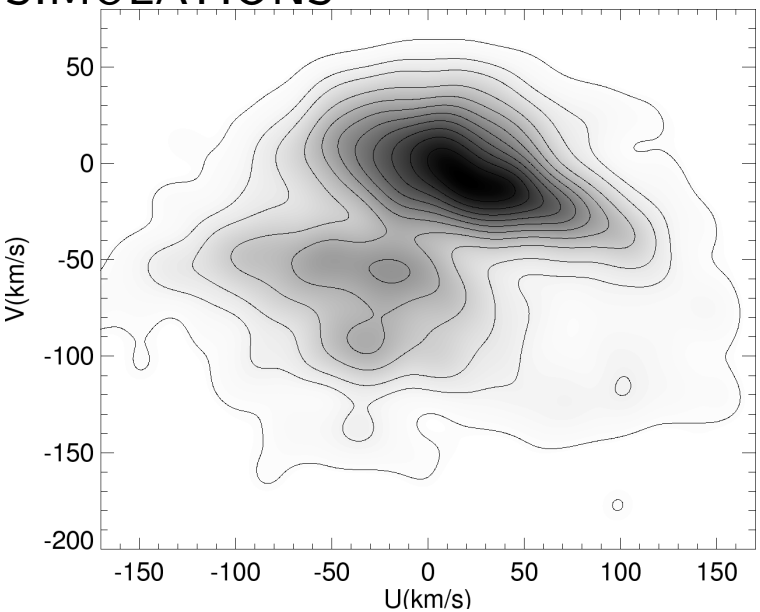
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Model for the Hercules stream

Test particle simulations
e.g. Dehnen 2000, Antoja et al. 2009

BAR
Pattern speed $\Omega_b = 47.5\,\mathrm{km\,s^{-1}kpc^{-1}}$
$(R_\odot / R_{OLR} \sim 1.06)$
Orientation $\phi_b = 20°$
Strength $\alpha = 0.05$

SIMULATIONS



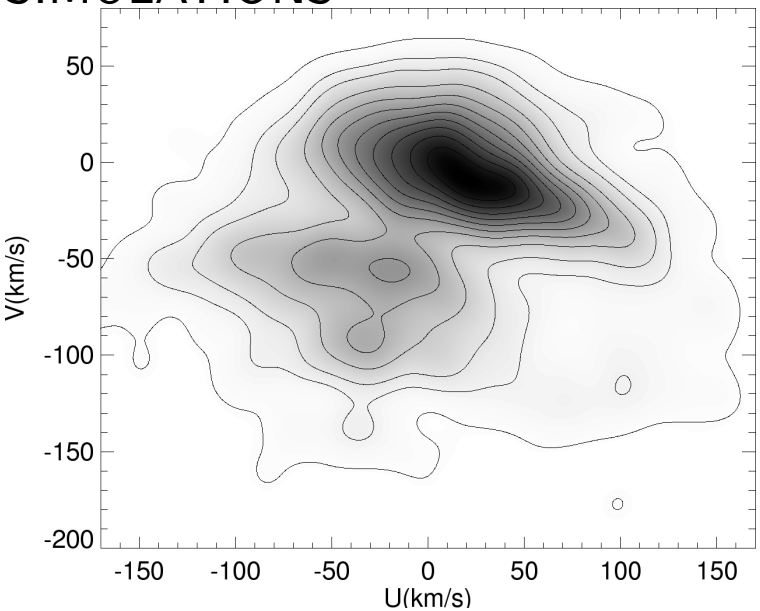
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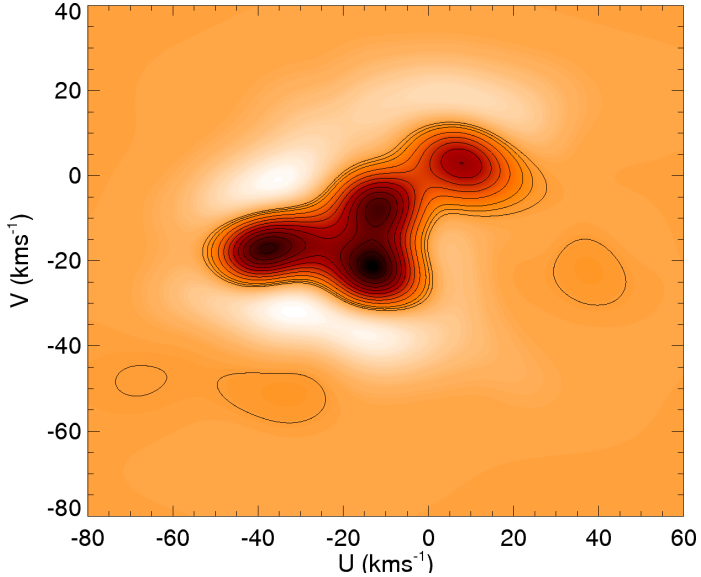
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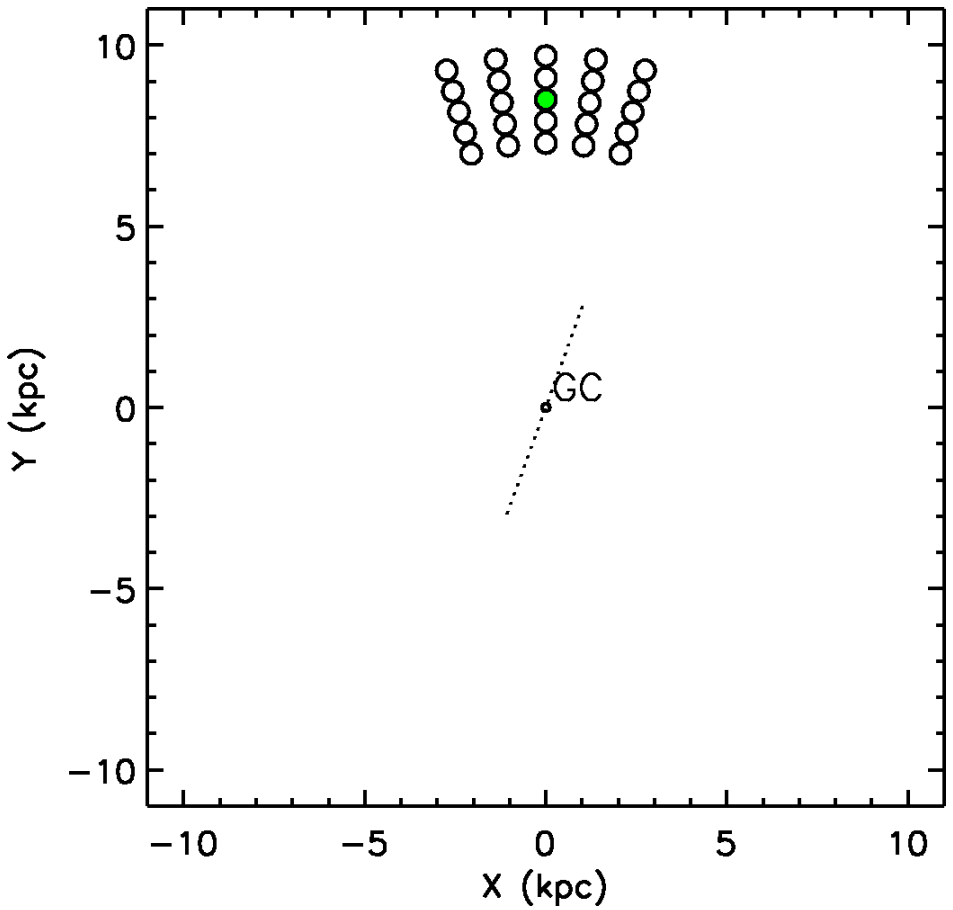
OBSERVATIONS

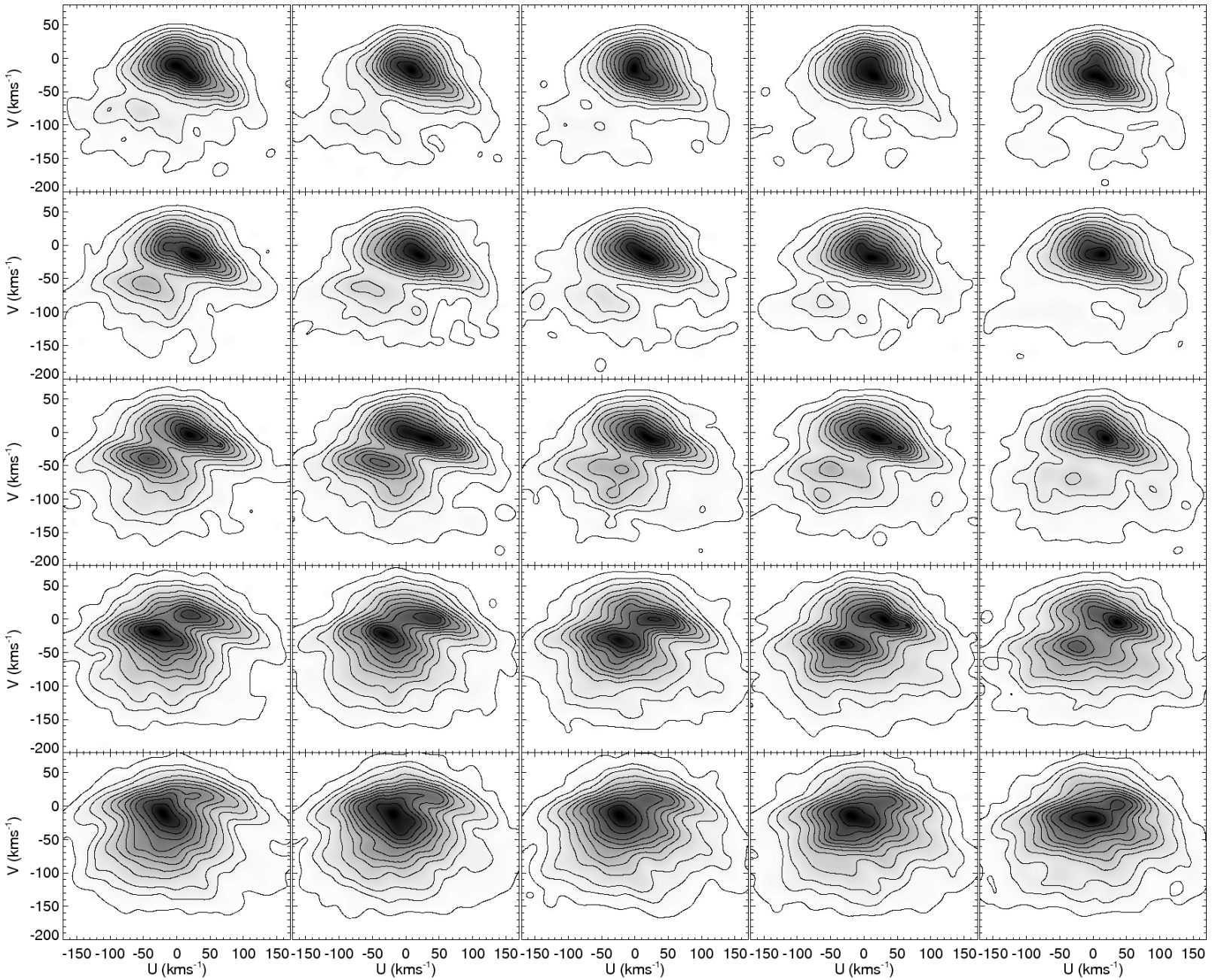


Problems or unknowns:

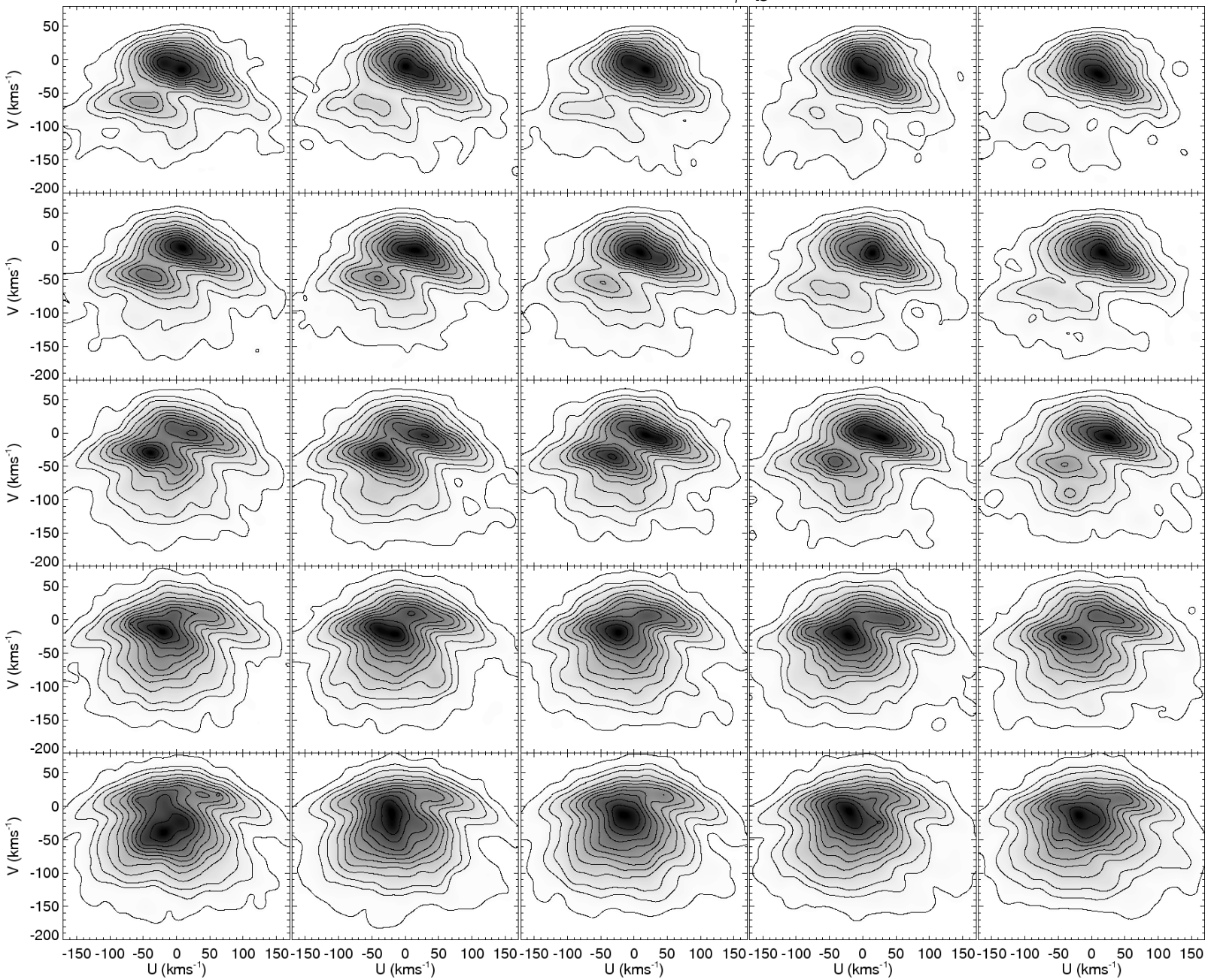
- Two peaks in the observed Hercules
- Structure at $U \sim 100\,\mathrm{km\,s^{-1}}$
- Effects of the long bar of the MW
- Effects of the spiral arms
- Orbits scattered from the OLR of the bar or chaotic orbits coming from the bar: implications in the metallicity?
- Degeneracy

MODELS: Hercules at different positions of the Galaxy

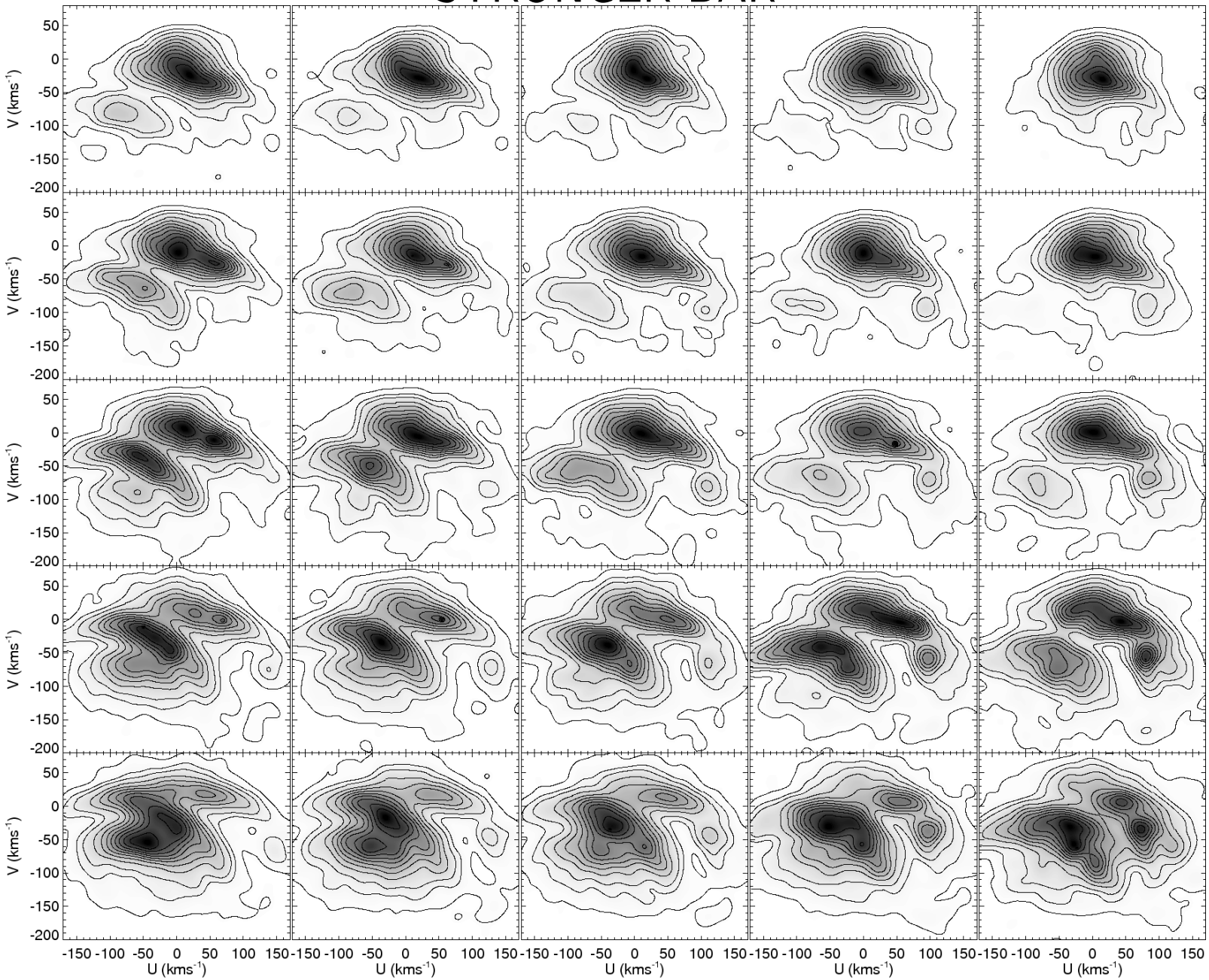



V (kms^{-1})
50
0
-50
-100
-150
-200
-150 -100 -50 0 50 100 150
U (kms^{-1})

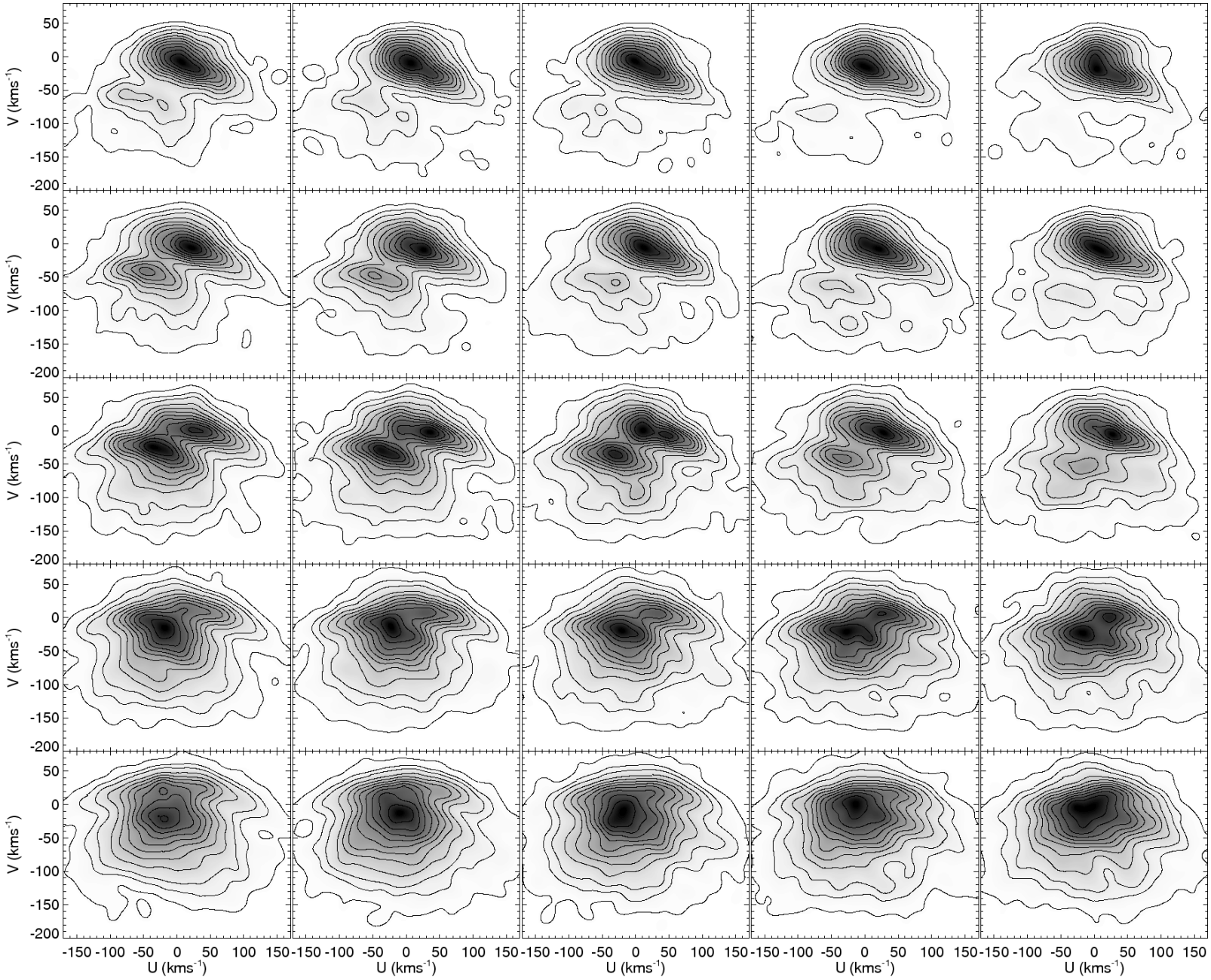
BAR ORIENTATION $\phi_b = 40°$



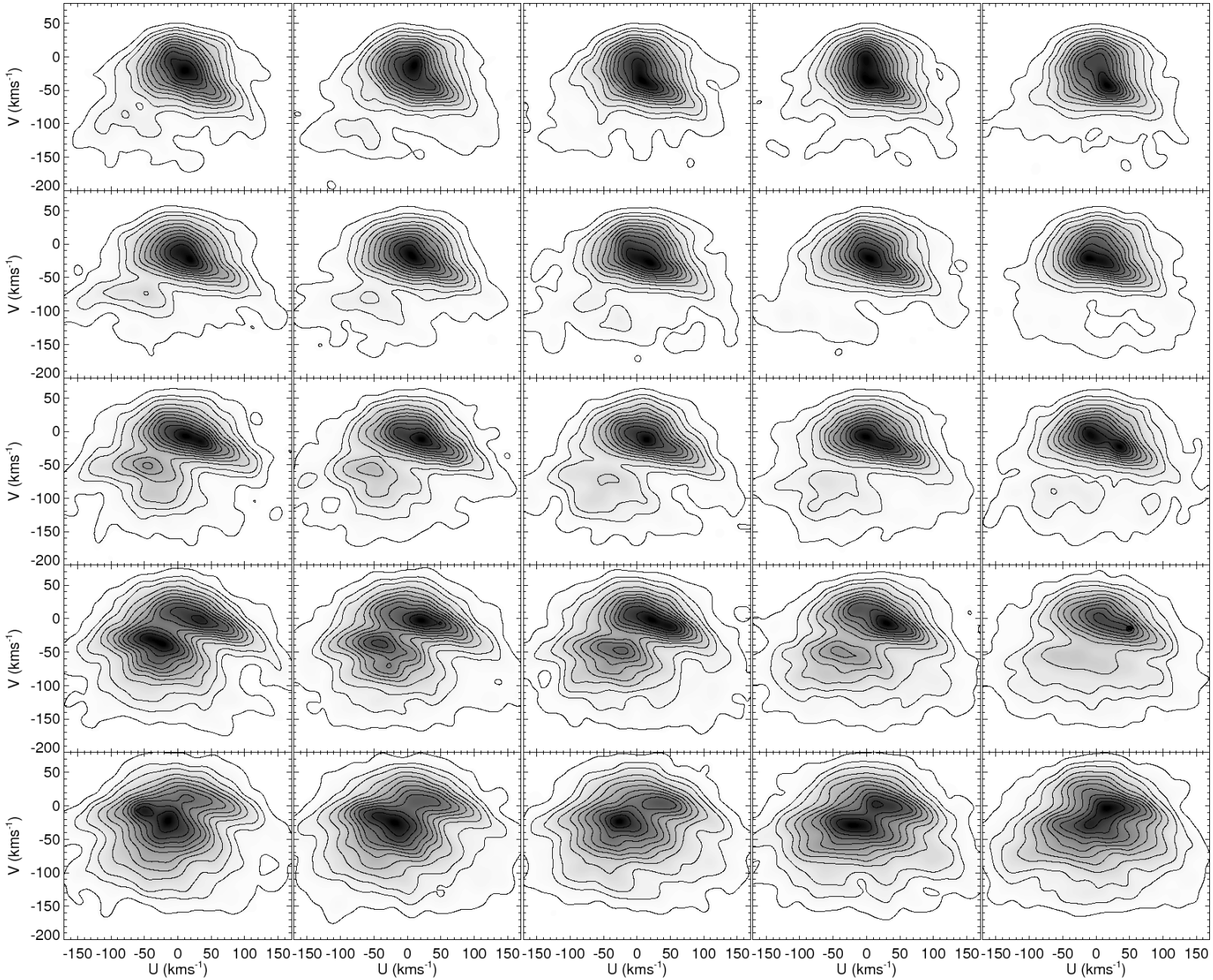
STRONGER BAR



SLOWER BAR $\Omega_b = 45\,\mathrm{km\,s^{-1}kpc^{-1}}$



FASTER BAR $\Omega_b = 50\,\mathrm{km\,s^{-1}kpc^{-1}}$



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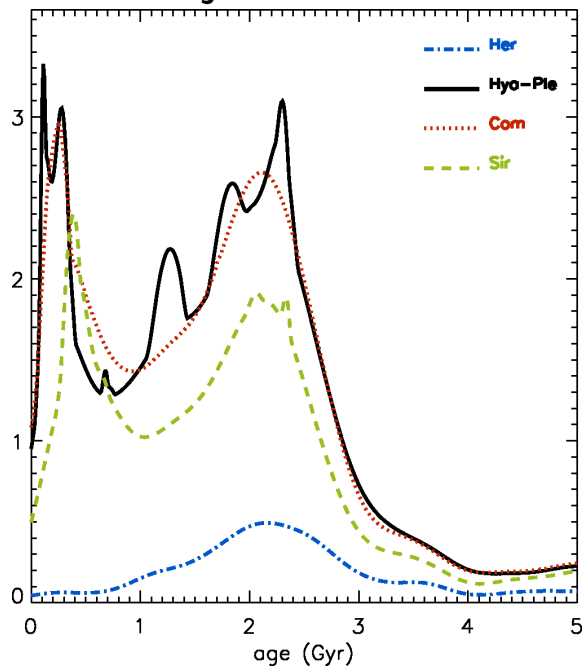
Observations by Gaia

Hercules: stars older than 1 Gyr, spectral types FGK

Evolutionary tracks (Schaller et al. 1992, Haywood 1994):

F0V: 70% stars younger than 1 Gyr
F5V: 50% 1Gyr-2Gyr
G0V: 70% stars older than 5 Gyr
$\geq$ G5V: age mixing

Antoja et al. 2008



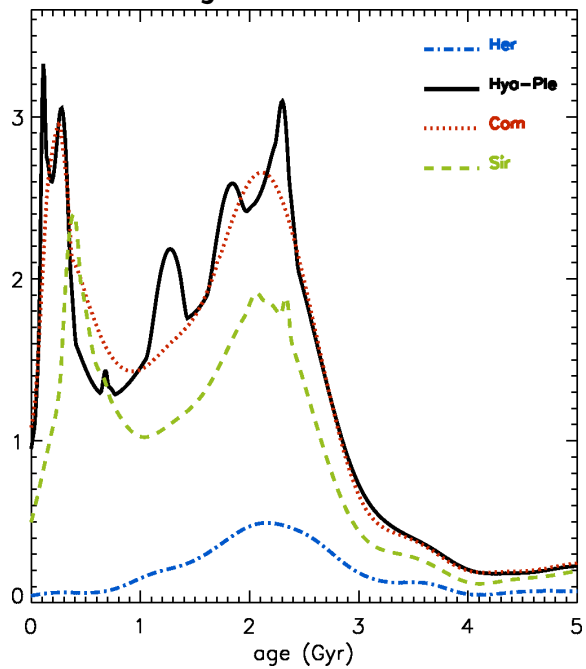
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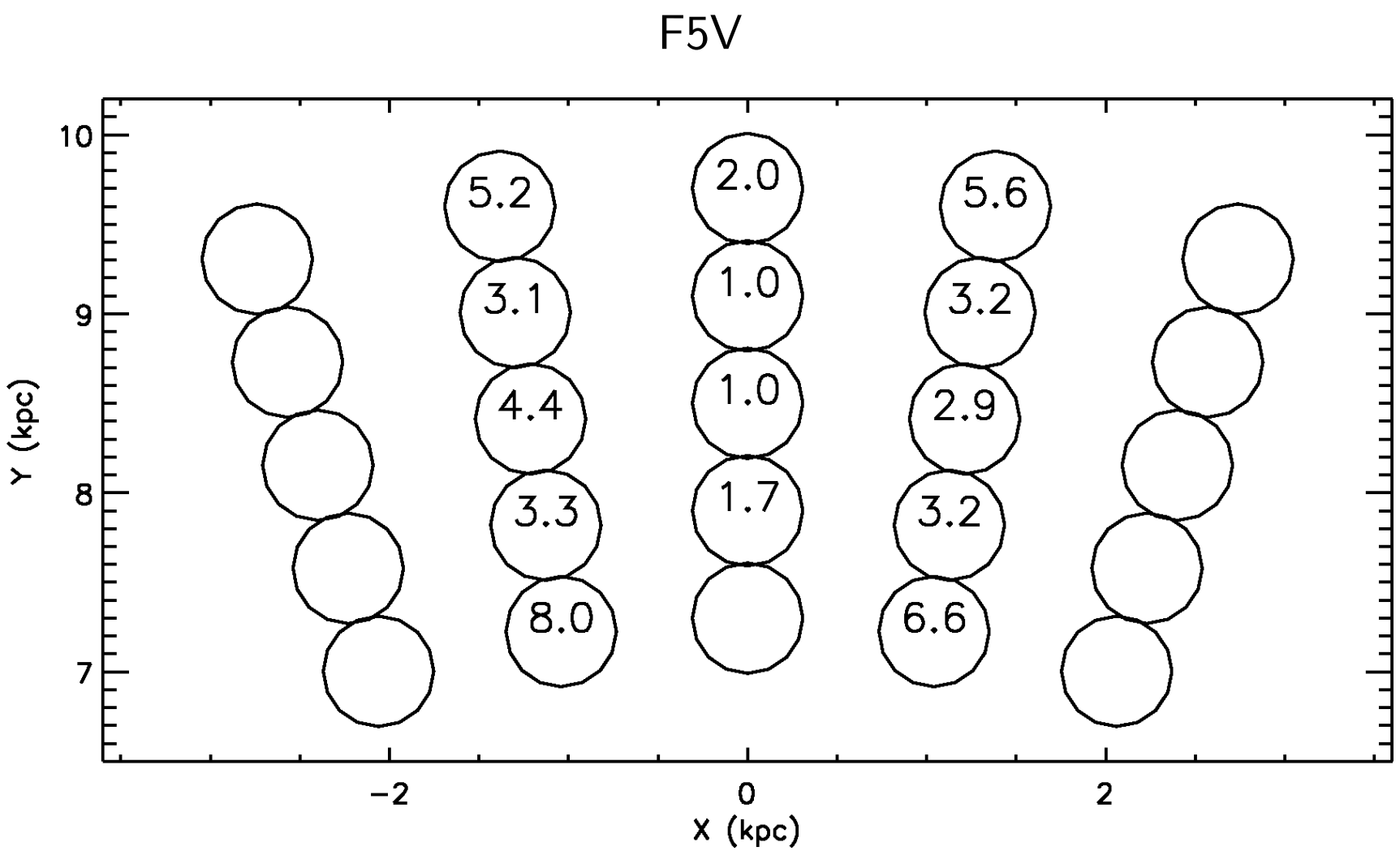


- Sample of old stars: F5V - G0V
- M_V, (V-I)$_i$
- Absorption $A_V(l, d, \beta)$ (Drimmel 2002)
- Gaia Science Performance

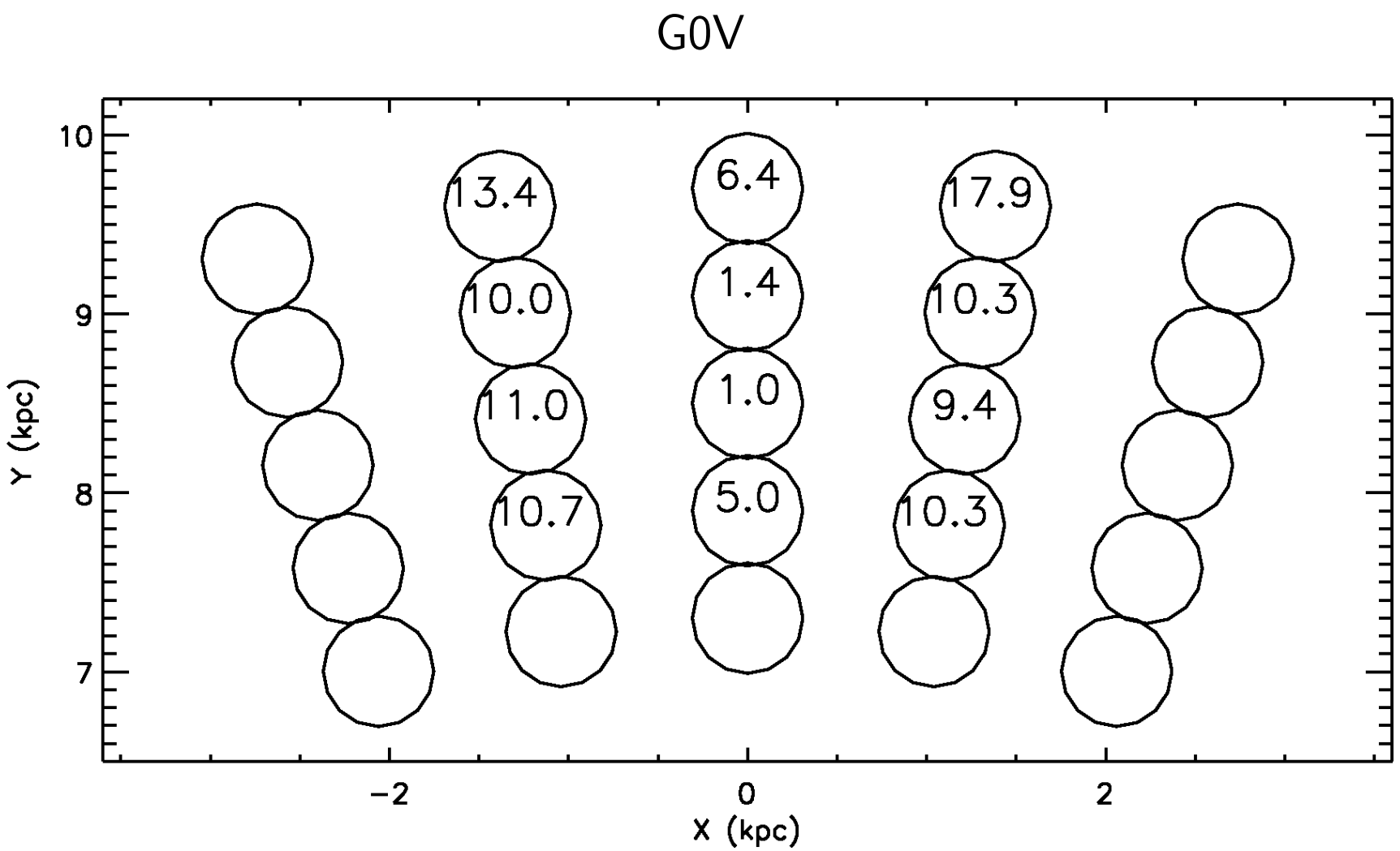
$\Longrightarrow$

e_π
e_μ
e_{VR}

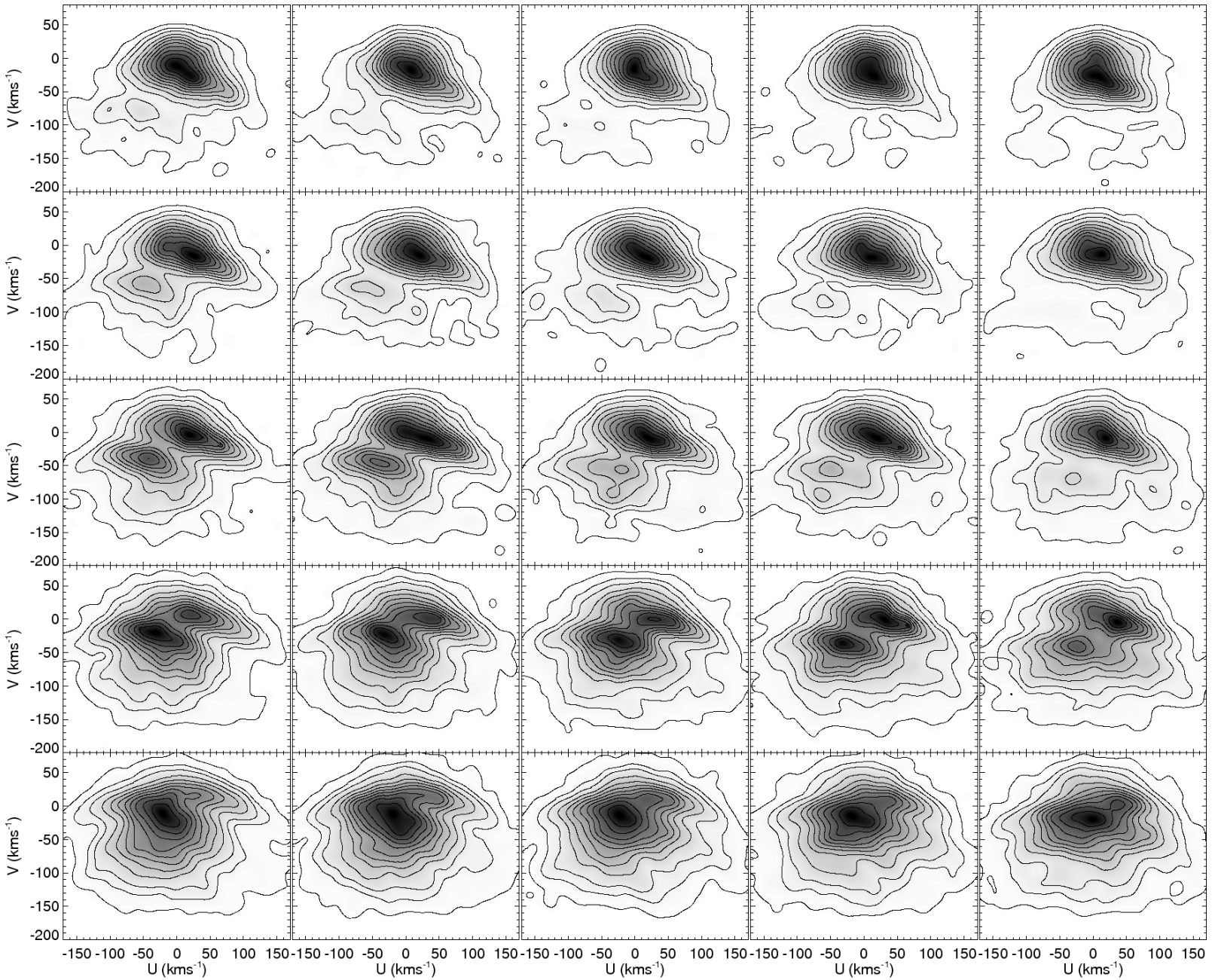
Gaia errors in radial velocity



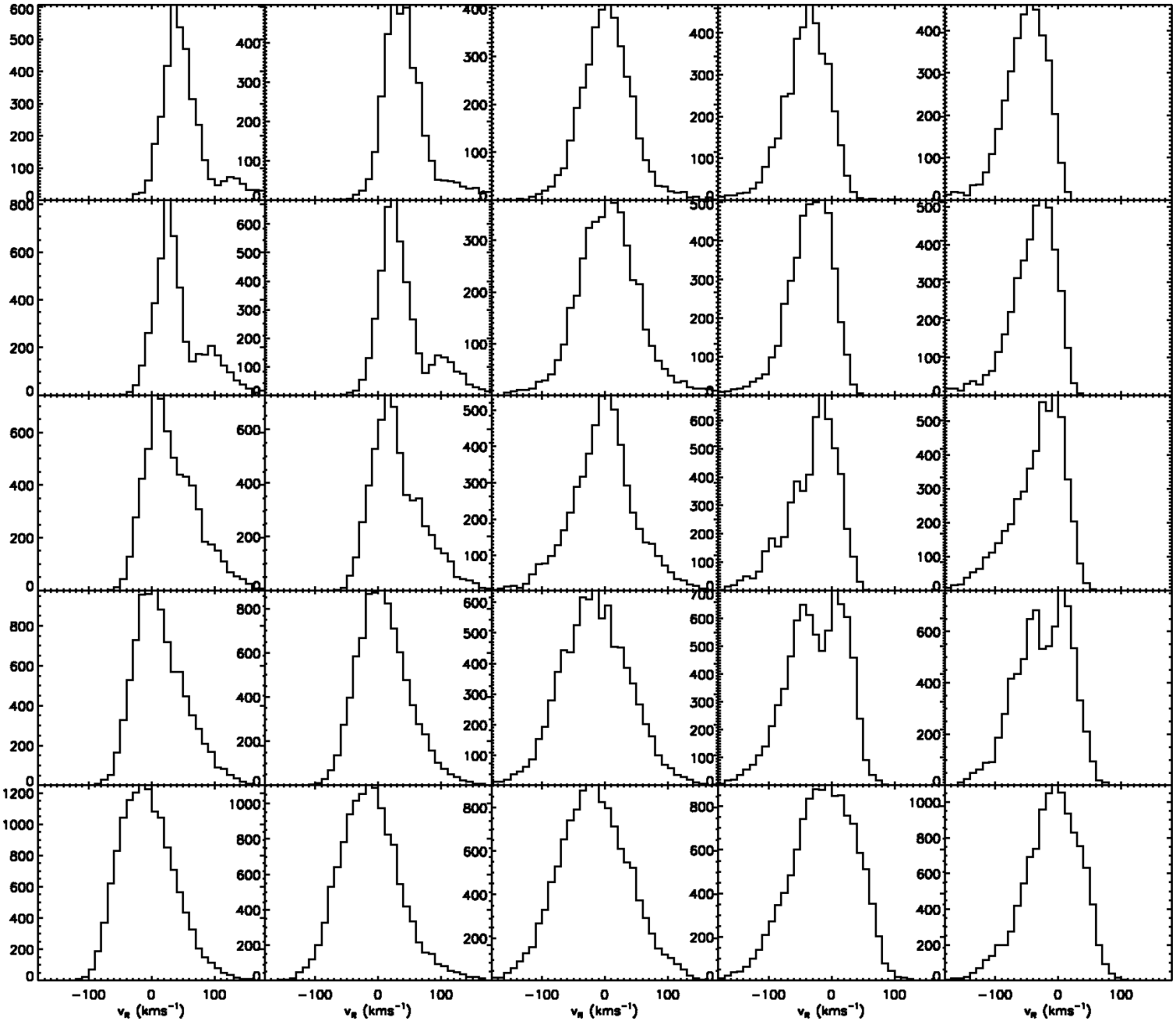
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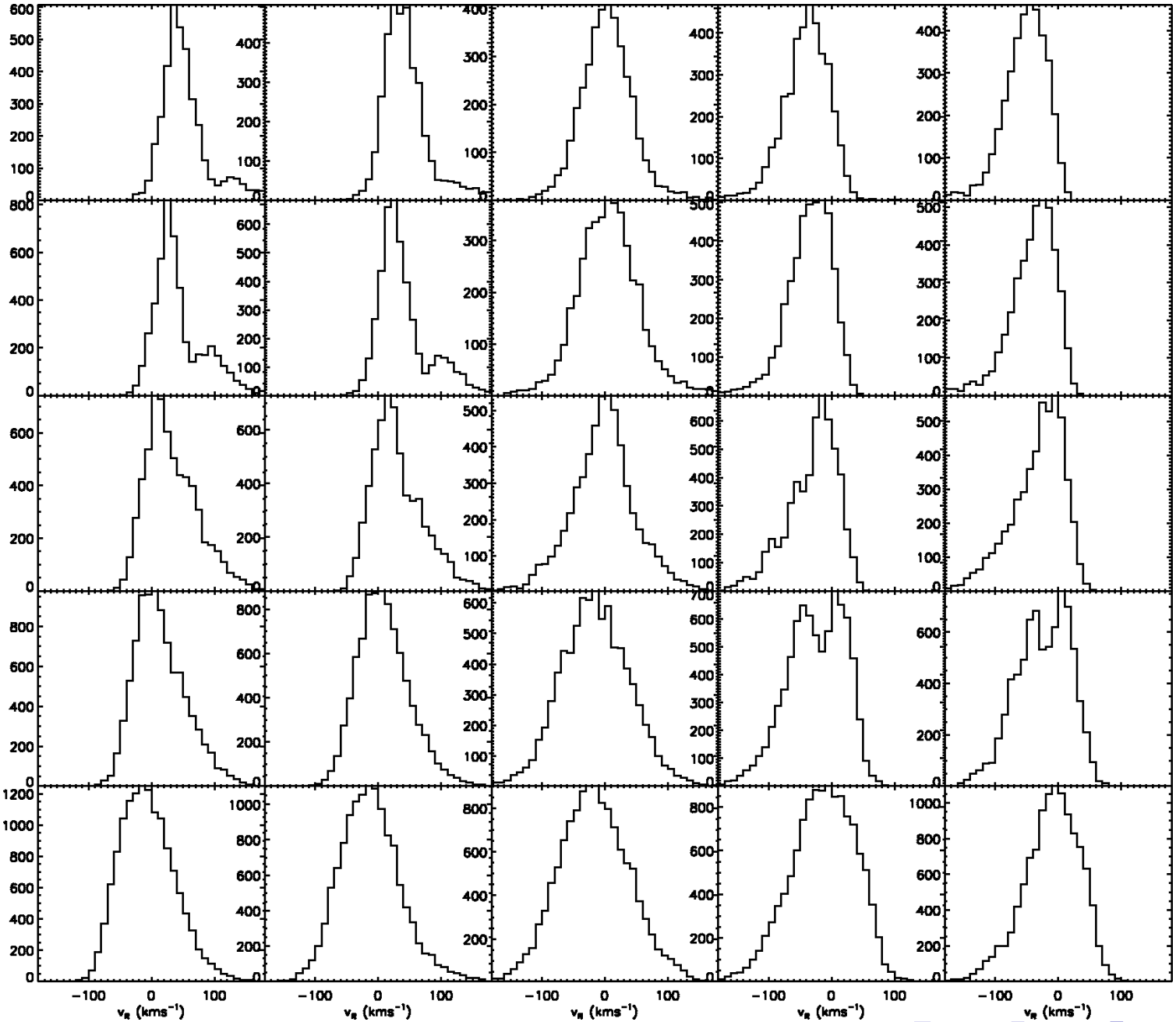

V (kms^{-1})
50
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U (kms^{-1})

BAR

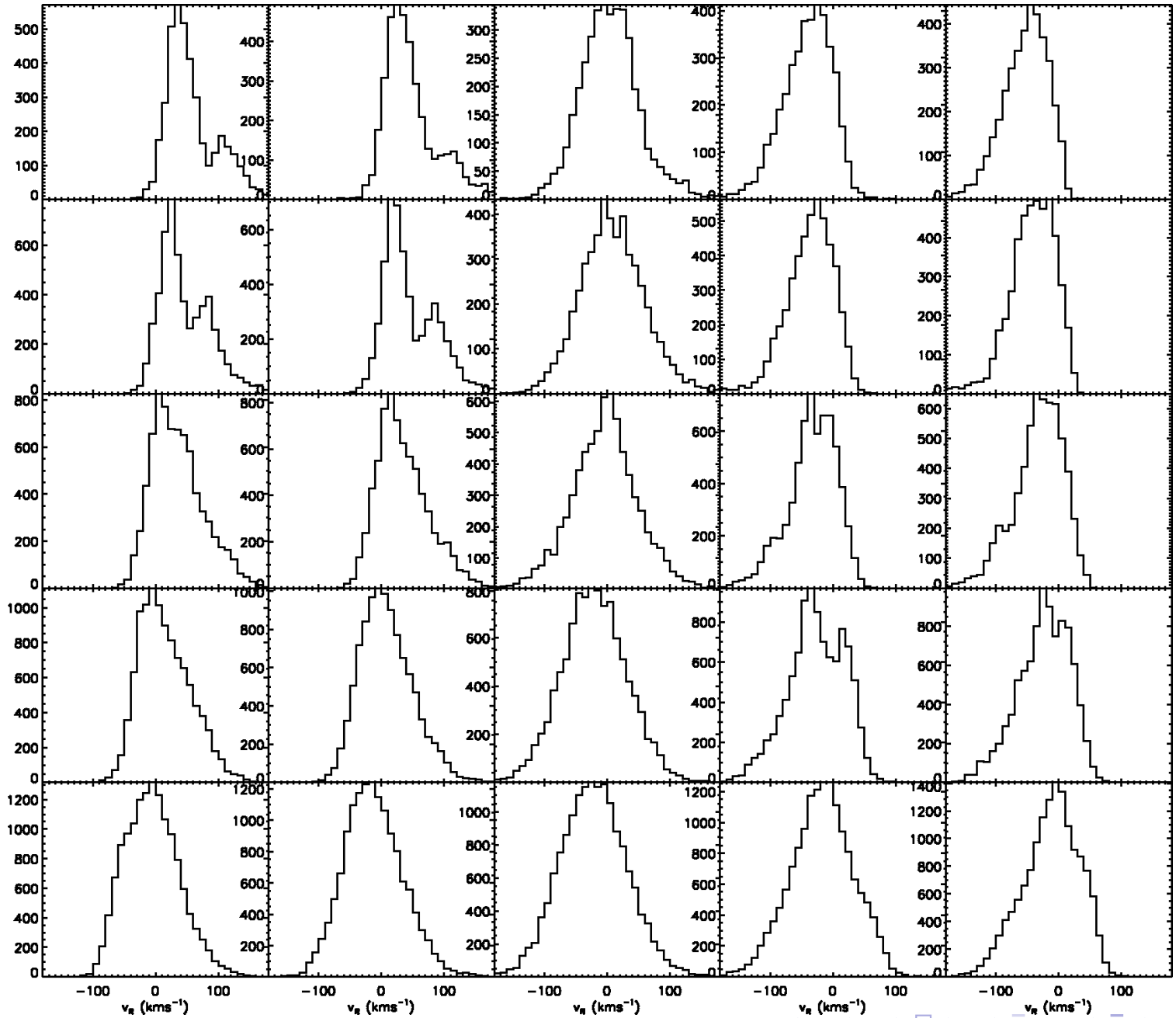


BAR

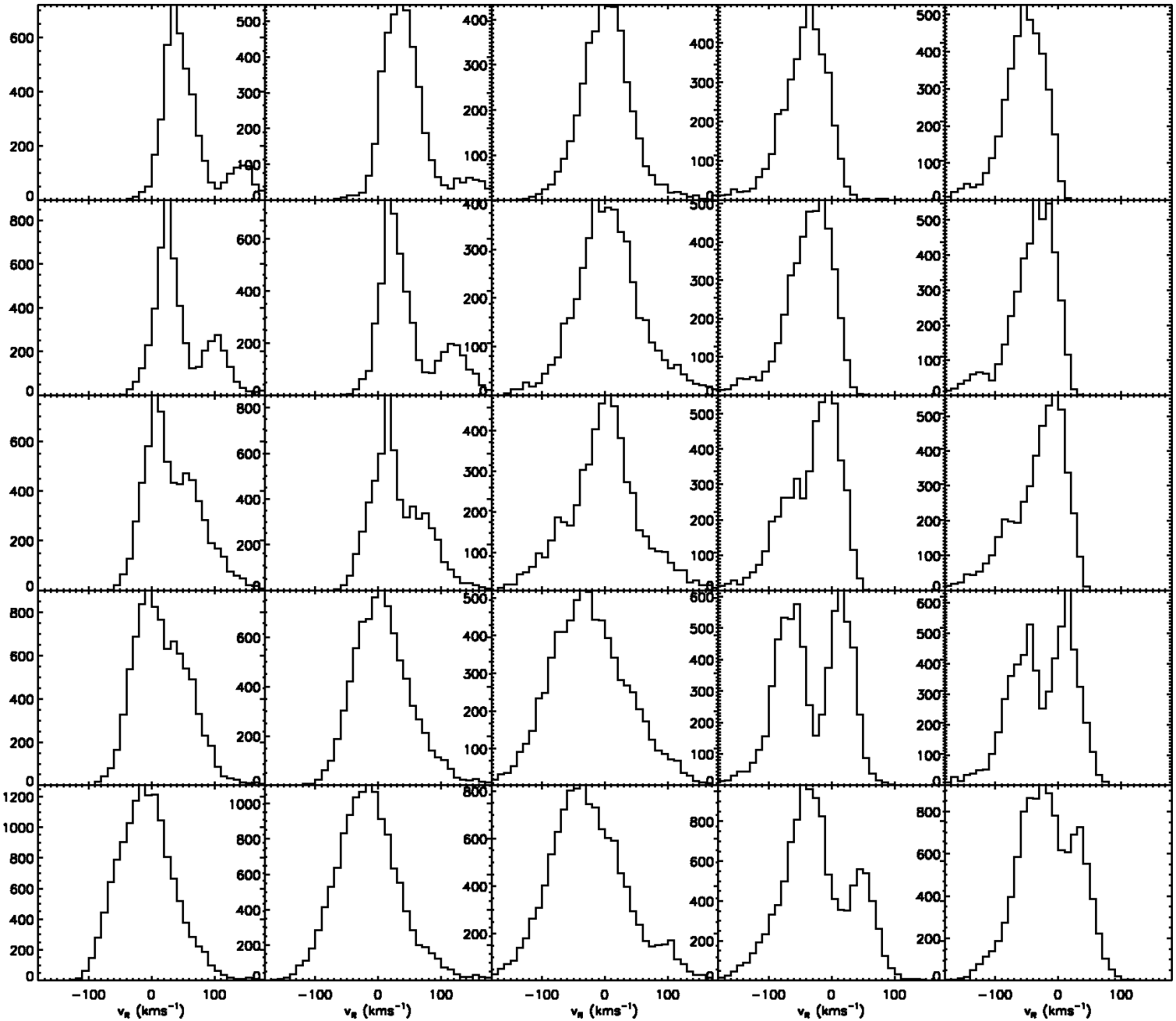
Hercules: $l \sim 50^\circ - 70^\circ$ & $\sim 230^\circ - 270^\circ$



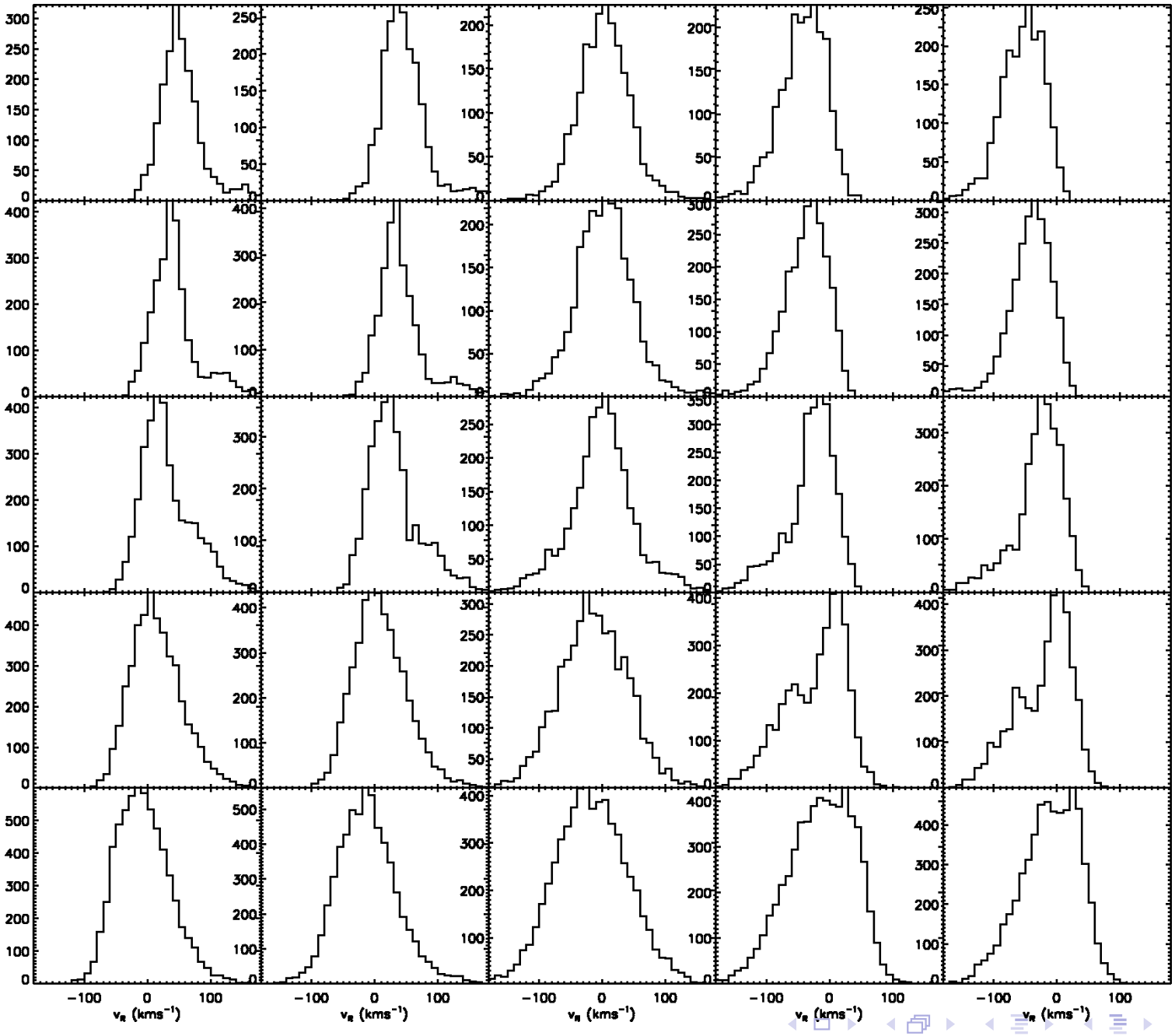
ORIENTATION $\phi_b = 40°$



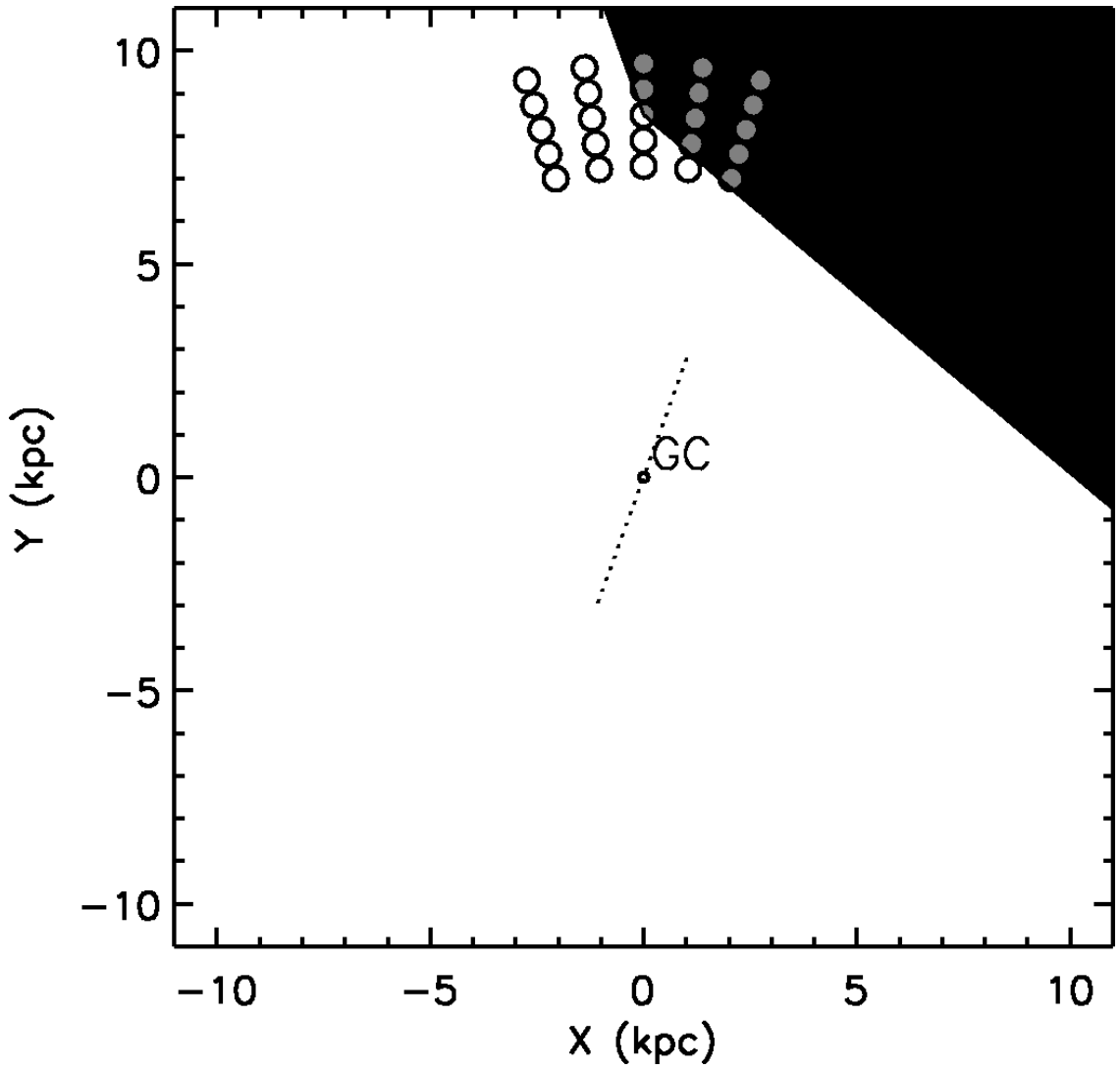
STRONGER BAR



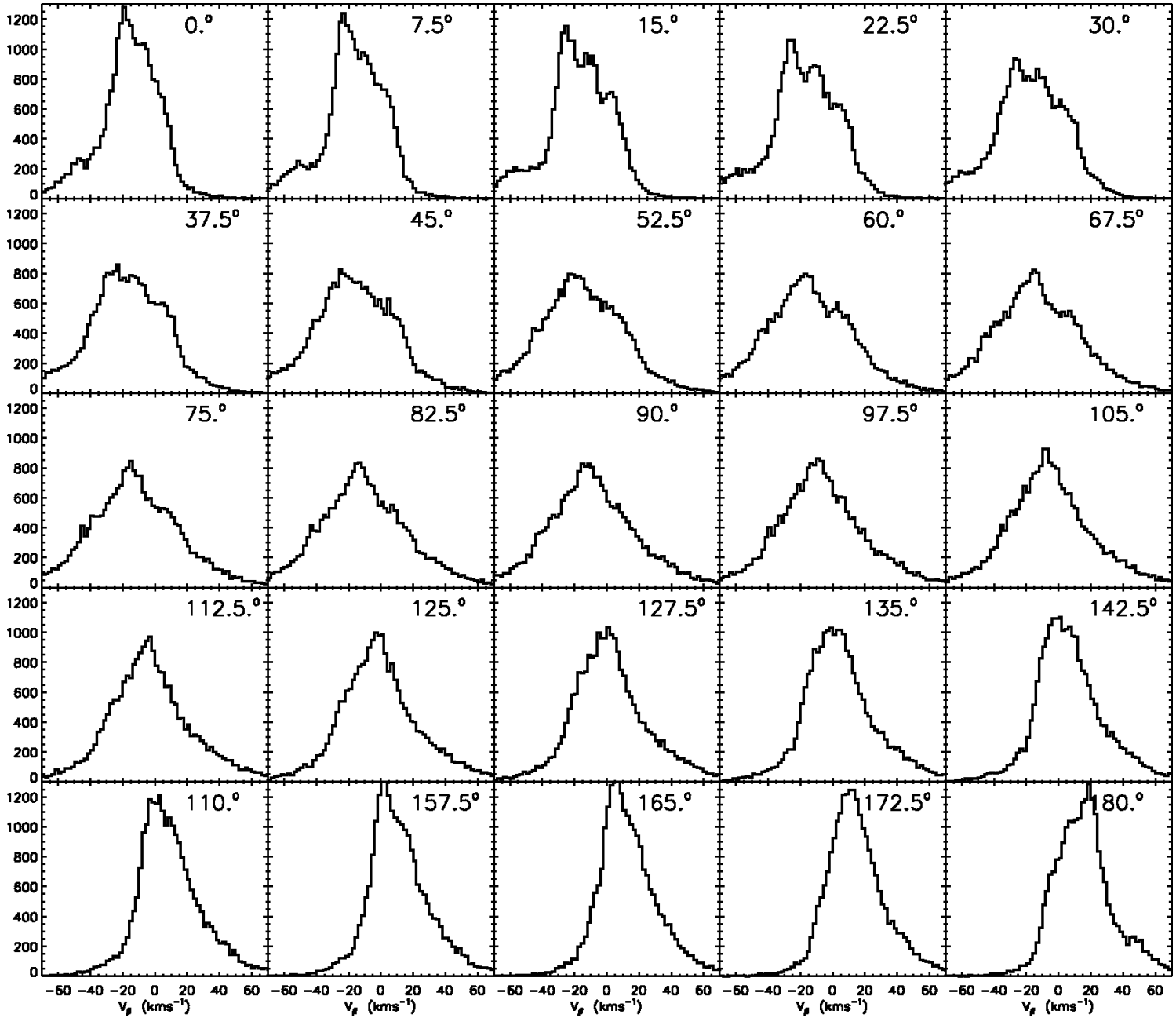
FASTER BAR $\Omega_b = 50\,\mathrm{km\,s^{-1}kpc^{-1}}$

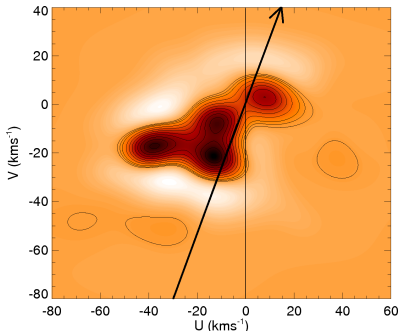


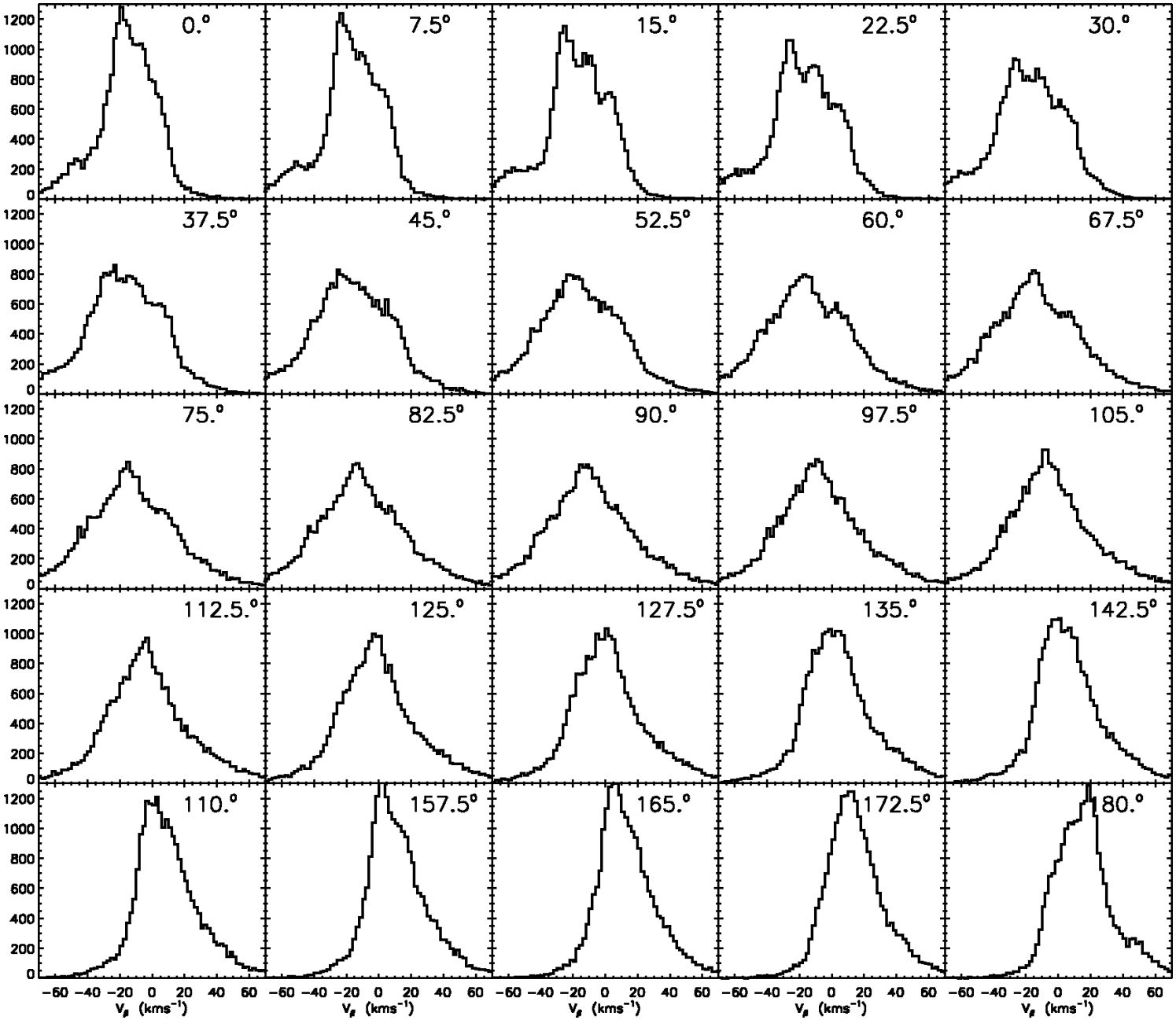
Fields @ ESO

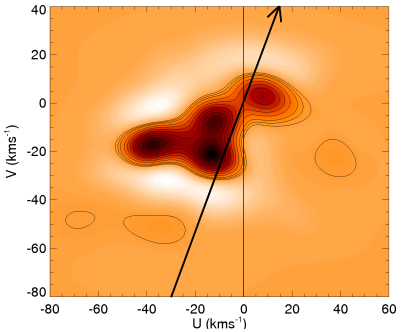


Hercules: $l \sim 230 - 270^{\circ}$


0.°
7.5°
15.°
22.5°
30.°
37.5°
45.°
52.5°
60.°
67.5°
75.°
82.5°
90.°
97.5°
105.°
112.5°
125.°
127.5°
135.°
142.5°
110.°
157.5°
165.°
172.5°
180.°
V_β (kms^{-1})


V (kms^{-1})
U (kms^{-1})





Sirius, Coma Berenices, Hyades-Pleiades:
$l \sim 20 \pm 10^{\circ}$
$l \sim 250 \pm 10^{\circ}$

Conclusions

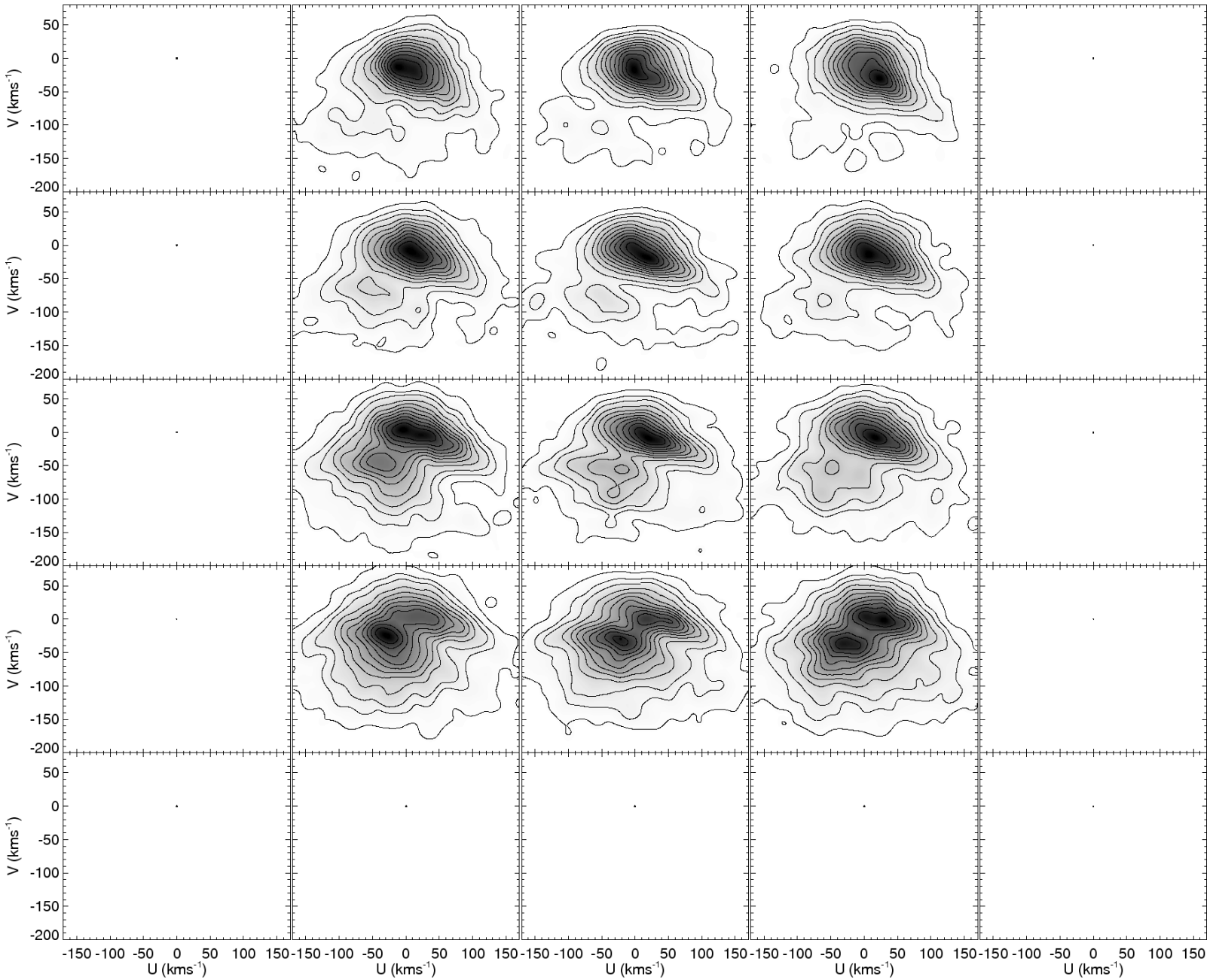
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  - Prove the validity of the models that relate the kinematic structures with the effects of the bar and the spiral arms
  - Use them to definitively constrain the properties of the bar and the spiral arms

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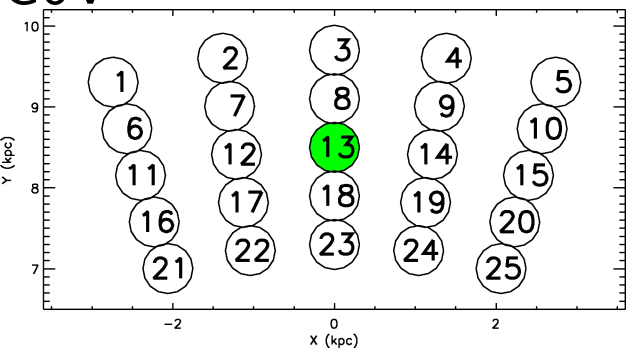
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- **Can these radial velocities from the complementary spectroscopic surveys be useful by themselves for the detection of kinematic substructure?**
  - Radial velocities from complementary surveys such as Gaia-Eso can be helpful to detect kinematic structures before the Gaia astrometric data
  - Our models can help in predicting the strategic directions to detect kinematic groups and therefore in designing the complementary surveys
  - Interesting directions to detect the main moving groups with dwarf stars are: $l \sim 50^\circ$ and $l \sim 250^\circ$
  - With red clump giants (regions far from the Sun): new groups other resonances, more constraints!!

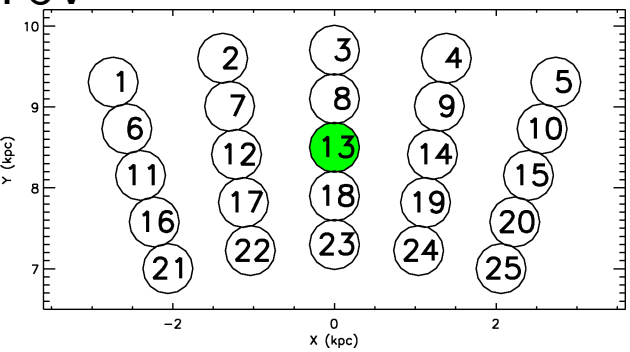

V (kms^{-1})
50
0
-50
-100
-150
-200
U (kms^{-1})
-150 -100 -50 0 50 100 150

G0V



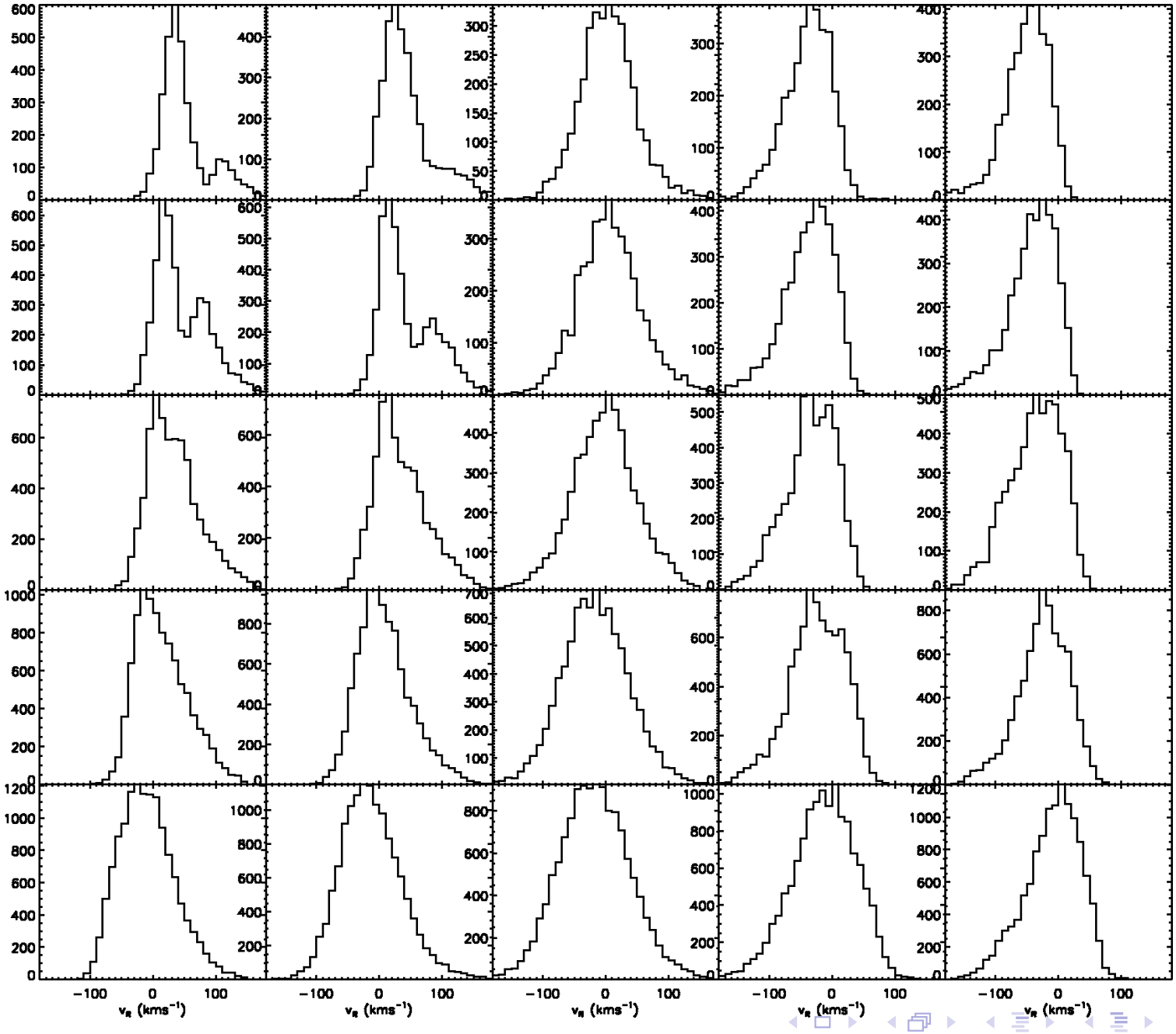
	V	G	d (kpc)	l (°)	A_v (mag)	ϵ_d (kpc)	ϵ_{pm} ($\mu as/yr$)	ϵ_{VR} (km/s)
1	21.1	19.7	2.9	253	4.3	-	-	-
2	16.6	16.3	1.8	231	0.8	0.12	20.52	13.4
3	15.5	15.3	1.2	180	0.6	0.03	12.57	6.4
4	16.7	16.4	1.8	128	0.9	0.13	21.38	17.9
5	18.4	17.9	2.9	106	1.5	0.70	44.93	-
6	19.3	18.4	2.6	264	2.6	0.72	57.19	-
7	16.0	15.7	1.4	248	0.7	0.06	15.53	10.0
8	13.7	13.5	0.6	180	0.3	0.00	5.78	1.4
9	16.0	15.7	1.4	111	0.7	0.06	15.71	10.3
10	18.0	17.6	2.6	95	1.4	0.49	38.74	-
11	19.0	18.2	2.4	278	2.5	0.58	52.30	-
12	16.4	16.0	1.2	274	1.4	0.05	17.56	11.0
13	9.6	9.4	0.1	90	0.1	0.00	3.82	1.0
14	15.9	15.6	1.2	85	0.9	0.04	14.69	9.4
15	20.4	19.1	2.4	81	3.9	0.66	58.85	-
16	18.8	18.1	2.4	292	2.4	0.55	50.04	-
17	16.1	15.7	1.3	301	0.9	0.05	15.75	10.7
18	15.3	14.7	0.6	0	1.8	0.01	9.84	5.0
19	16.0	15.7	1.3	58	0.9	0.05	15.53	10.3
20	18.1	17.6	2.4	67	1.6	0.43	38.86	-
21	19.2	18.4	2.5	305	2.6	0.69	56.30	-
22	17.1	16.6	1.6	320	1.5	0.13	24.43	-
23	19.2	17.7	1.2	0	4.2	0.12	42.79	-
24	16.9	16.5	1.6	39	1.2	0.12	22.57	-
25	18.5	17.9	2.5	54	2.0	0.57	46.28	-

F5V

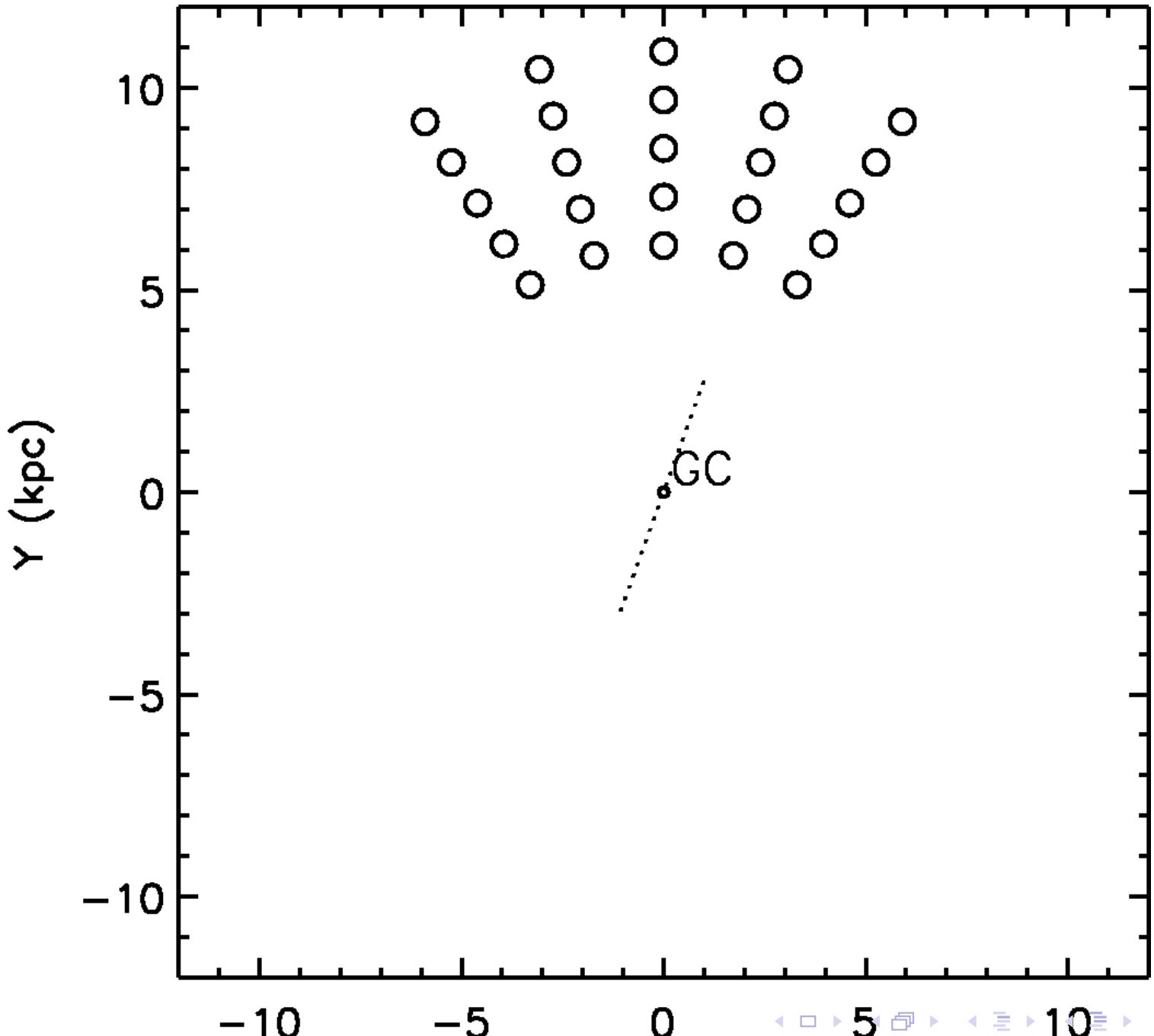


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8	12.1	12.0	0.6	180	0.3	0.00	3.06	1.0
9	14.4	14.2	1.4	111	0.7	0.03	7.68	3.2
10	16.4	16.0	2.6	95	1.4	0.23	18.28	-
11	17.4	16.7	2.4	278	2.5	0.28	25.20	-
12	14.8	14.4	1.2	274	1.4	0.02	8.58	4.4
13	8.0	7.9	0.1	90	0.1	0.00	7.08	1.0
14	14.3	14.0	1.2	85	0.9	0.02	7.21	2.9
15	18.8	17.6	2.4	81	3.9	0.44	39.42	-
16	17.2	16.6	2.4	292	2.4	0.27	23.95	-
17	14.5	14.2	1.3	301	0.9	0.03	7.70	3.3
18	13.7	13.2	0.6	0	1.8	0.00	4.98	1.7
19	14.4	14.2	1.3	58	0.9	0.03	7.60	3.2
20	16.5	16.0	2.4	67	1.6	0.20	18.36	-
21	17.6	16.9	2.5	305	2.6	0.34	27.63	-
22	15.5	15.1	1.6	320	1.5	0.06	11.75	8.0
23	17.6	16.2	1.2	0	4.2	0.06	20.58	-
24	15.3	14.9	1.6	39	1.2	0.06	10.88	6.6
25	16.9	16.4	2.5	54	2.0	0.27	21.96	-

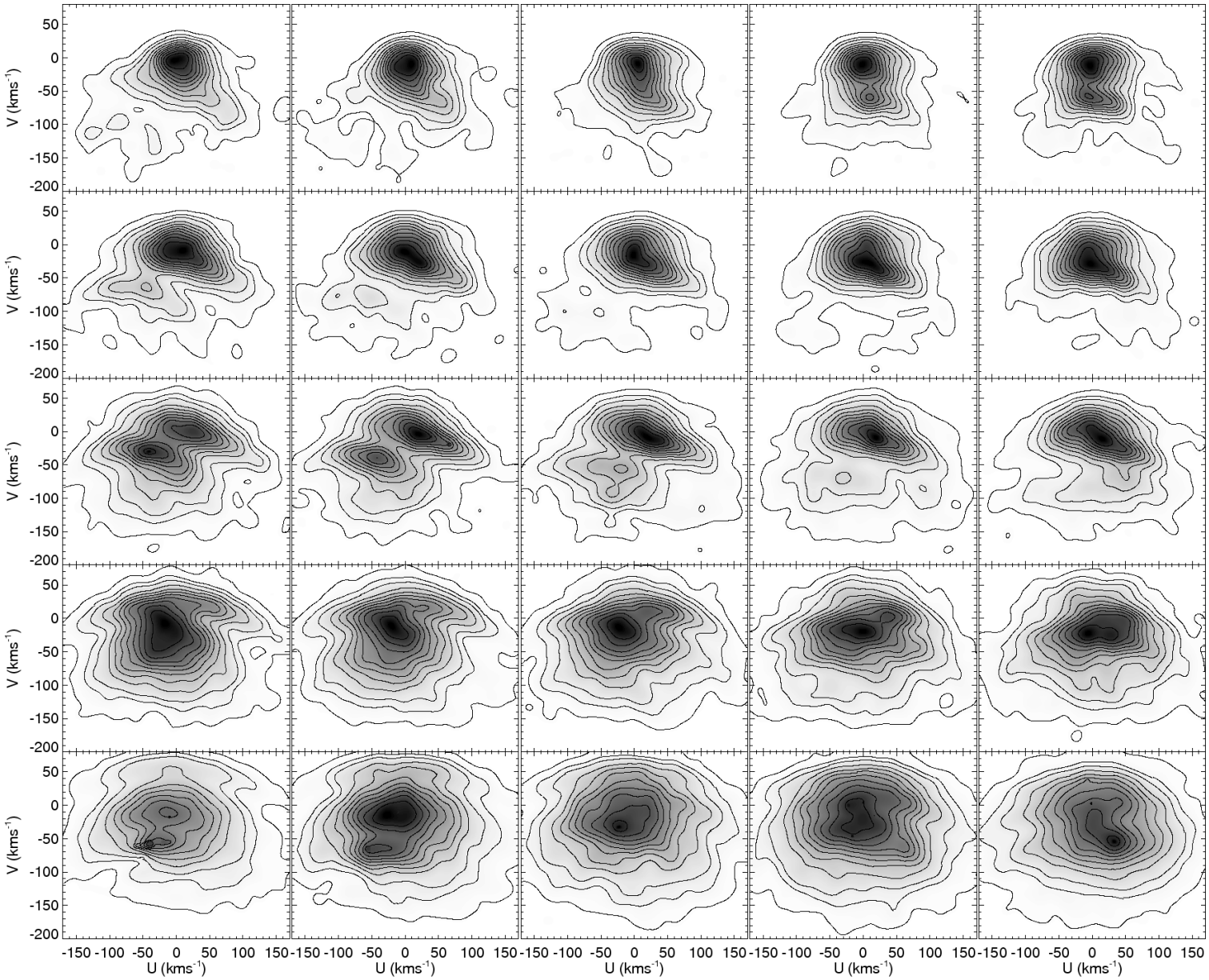
DIFFERENT PATTERN SPEED $\Omega_b = 45\,\mathrm{km\,s^{-1}kpc^{-1}}$



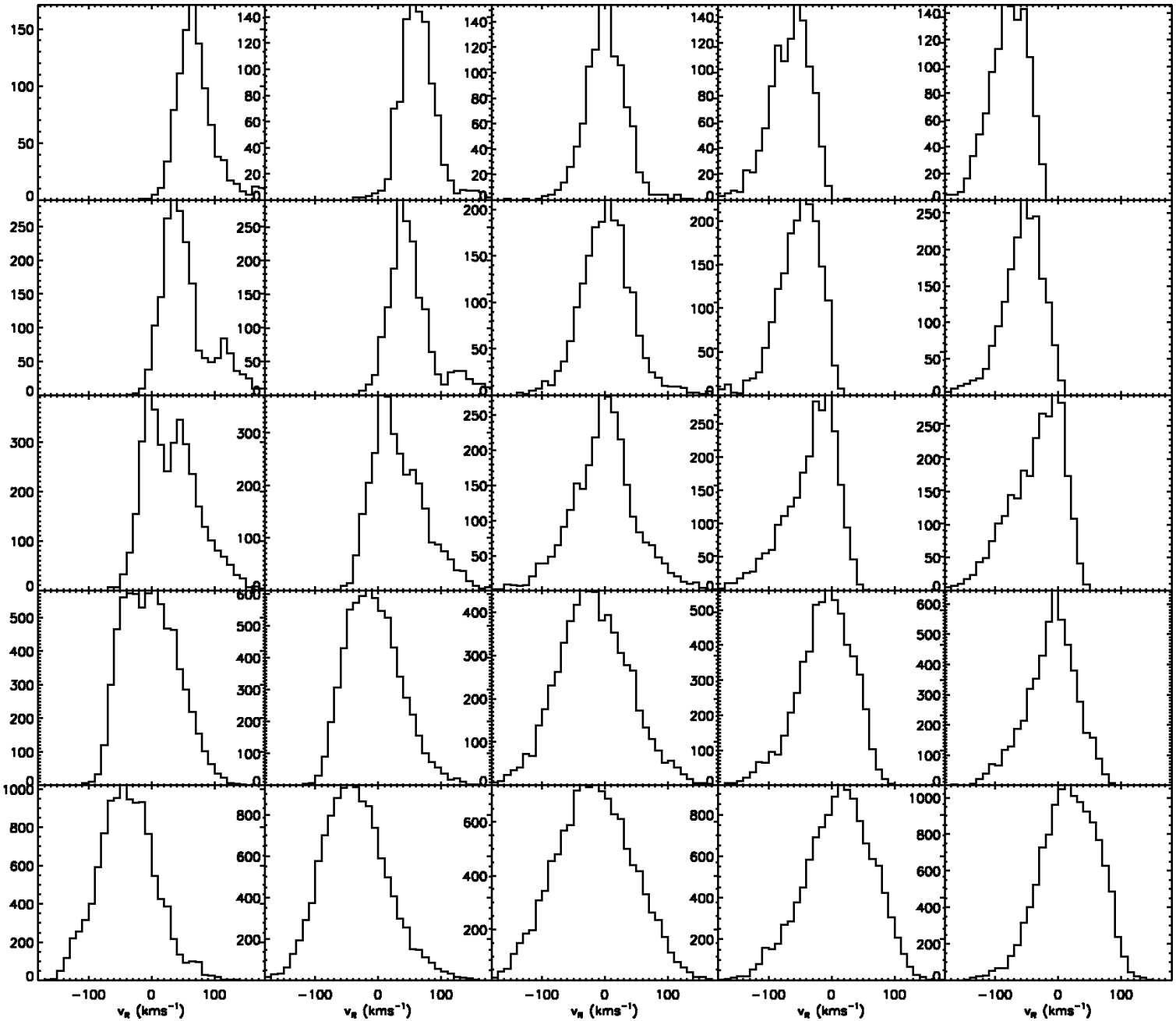
GOING FURTHER



GOING FURTHER



GOING FURTHER



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