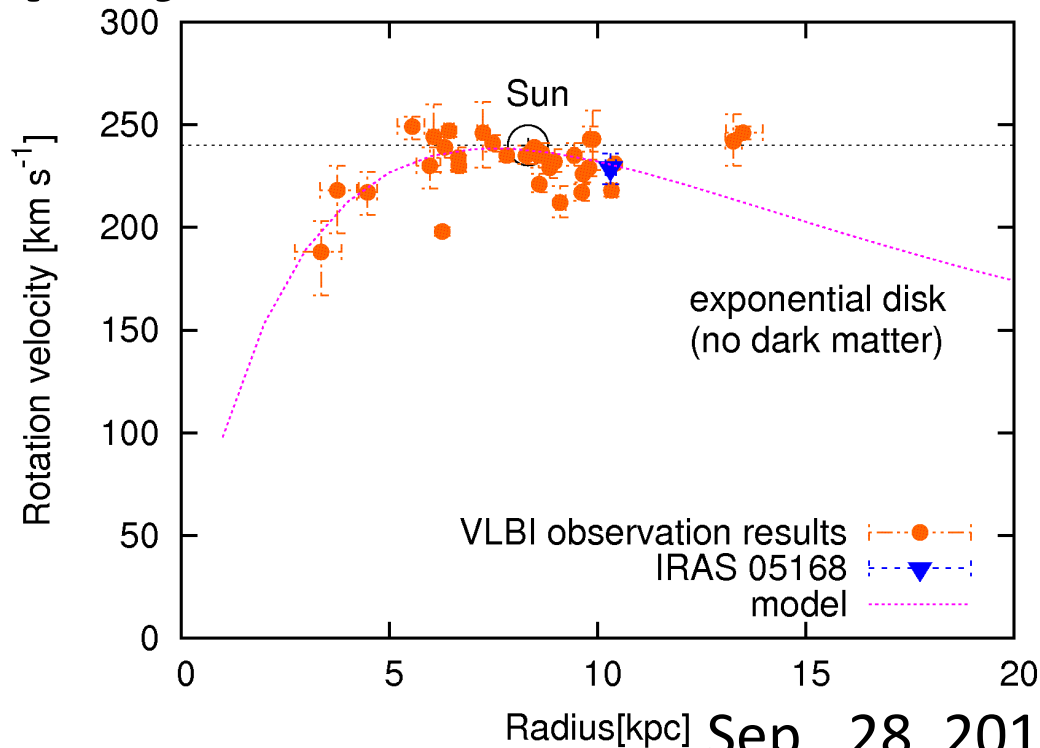


Outer Rotation Curve of the Galaxy

with VERA & (KVN):

Peculiar motion in the Perseus arm, project status, and future plan



Sep., 28, 2011: VERA UM@NAOJ

Nobuyuki SAKAI D1, SOKENDAI



(SOKENDAI)

1. Introduction: Research goal and RC

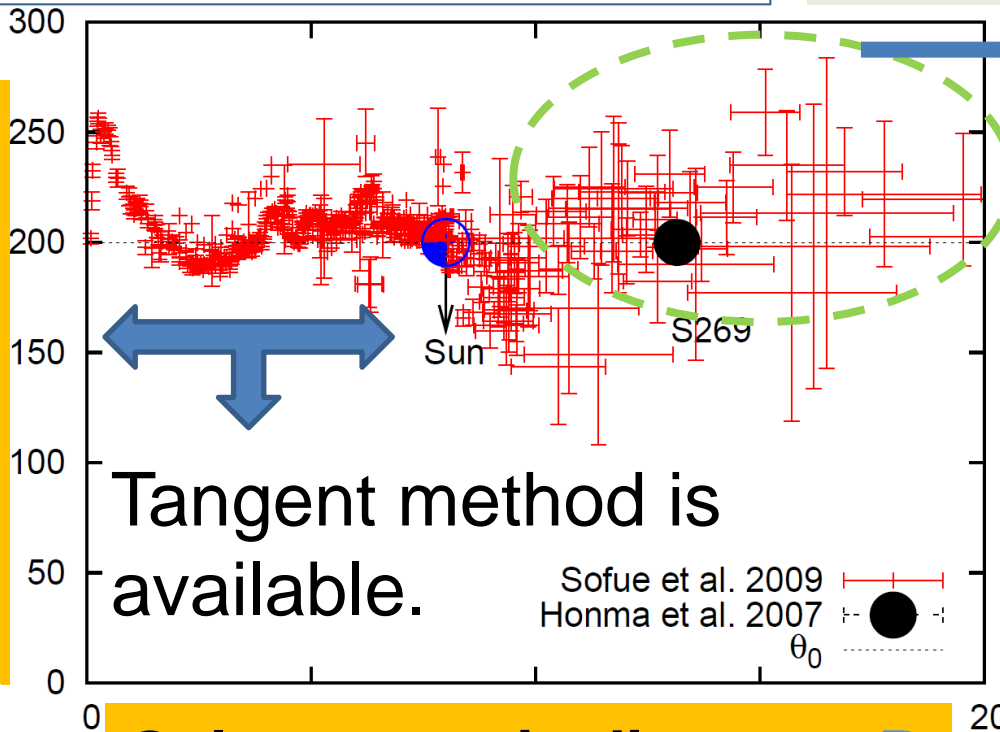
✓ Understandings of mass distribution, dynamics, and structure of the Galaxy !

✓ RC is useful tool to estimate mass distribution!

Rotation Curve of the Galaxy

$$M = \frac{RV^2}{G}, \quad M = \int 4\pi R^2 \rho(r) dr$$

Rotation speed: V



Tangent method is available.

∴ Large error because of distance ambiguity.

✓ VERA can remove the problem !

Galactocentric distance: R



1. Introduction: ORC project

(Member): Nakanishi(PI), Sakai(D1), Sakanoue(B4),
Kurayama(adviser), VERA project member

(Beginning period): 2008~

How to select **fifty project-objects**

- References of H₂O maser (Arcetri catalogue, Sunada et al., 2007)

- $90^\circ < l < 240^\circ$, $|b| < 10^\circ$

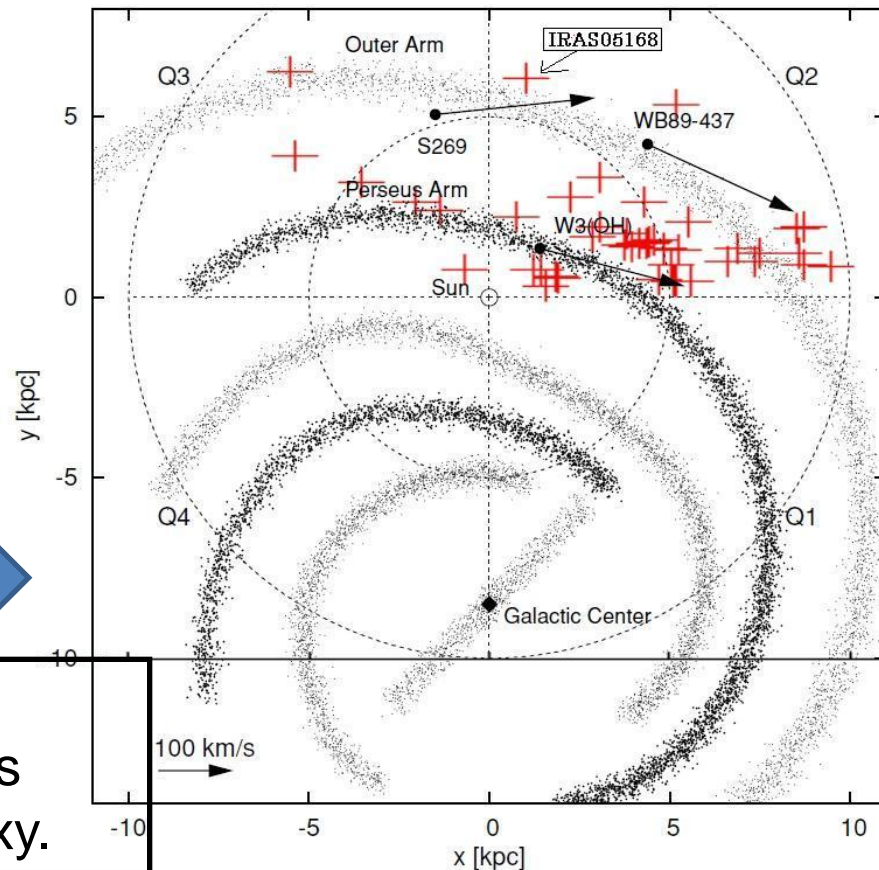
- H₂O maser: $> 5\text{Jy}$

- QSO: X-band $> 0.1\text{Jy}$, S.A. $< 2.2^\circ$

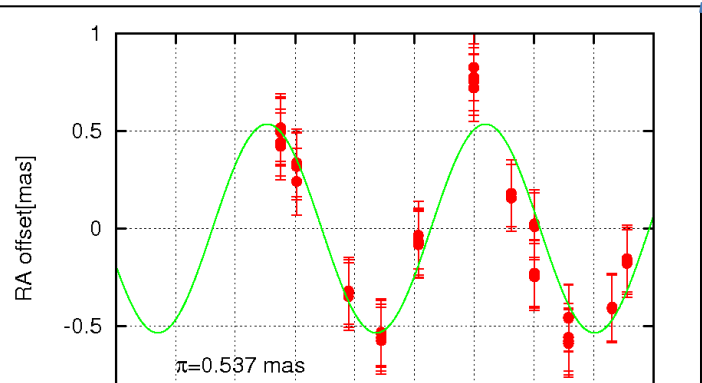
- Removing of overlap.



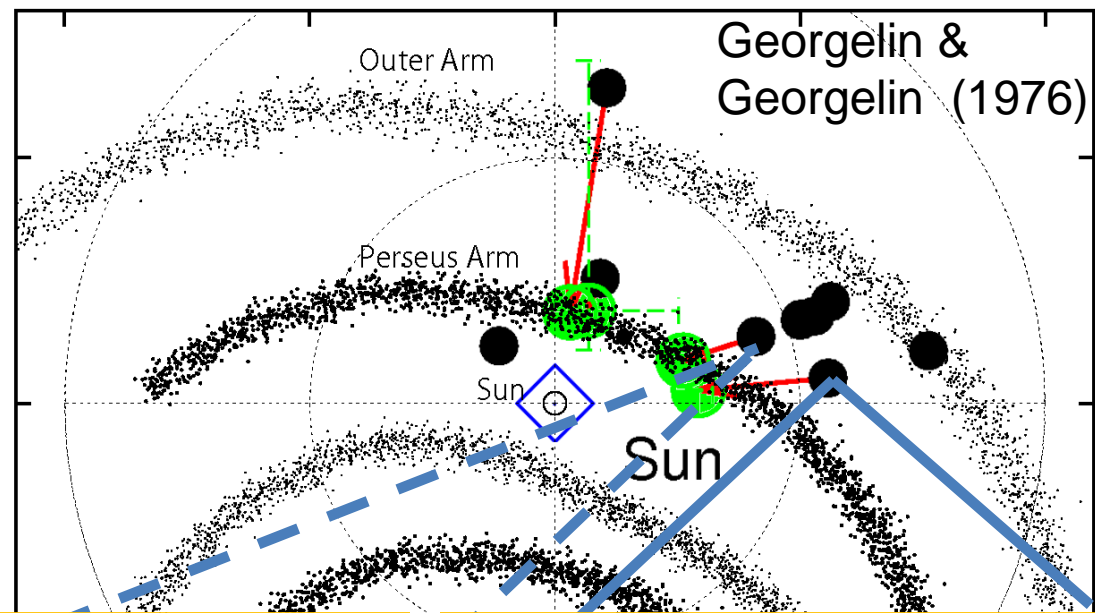
Georgelin & Georgelin, (1976):
Fifty-objects based on kinematic distances
are superposed on the image of the Galaxy.



2. Result: IRAS 04579, 05168, 21379, & 22480



IRAS 05168+3634 PI: Sakai
 $\pi=0.537\pm0.038$ mas



Preliminary! PI: Imai

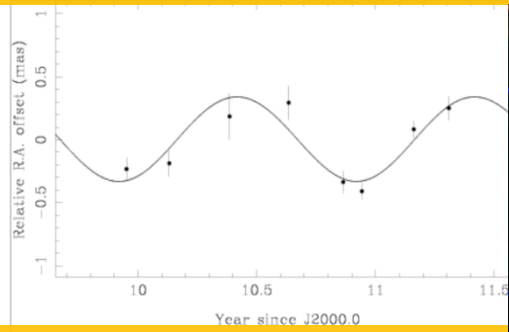
Preliminary! PI: Nakanishi

●--Kinematic distance
 (assumption of circular orbit)

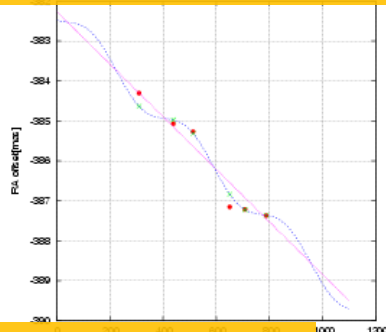
●--Trigonometric parallax



Implication of
 non-circular orbit !



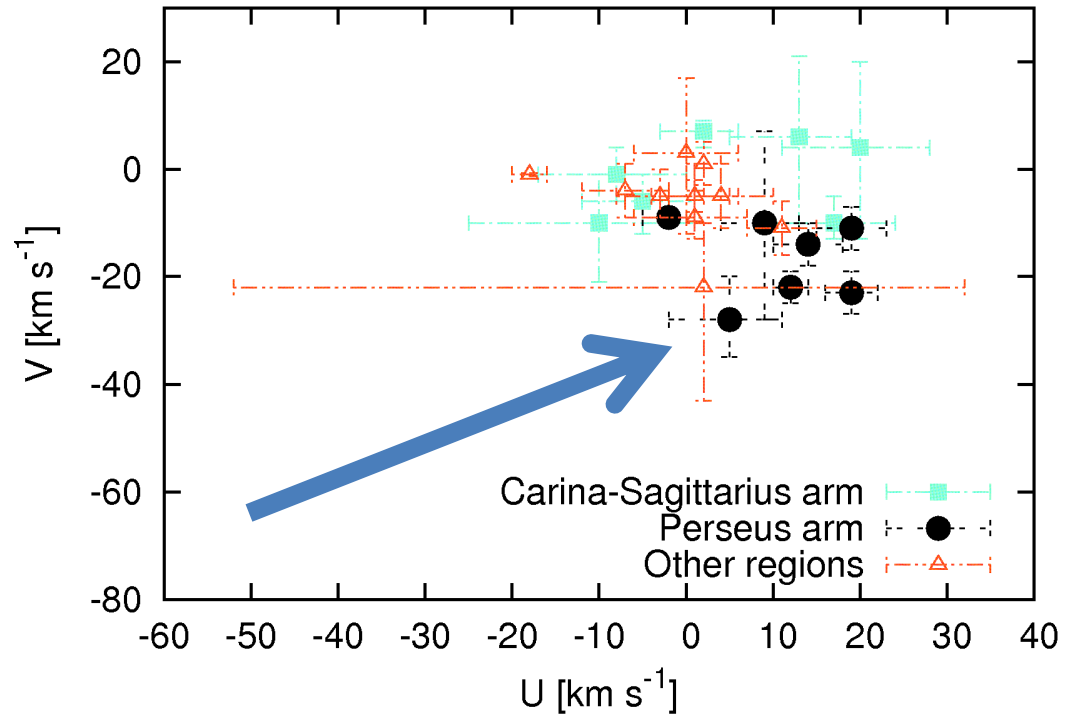
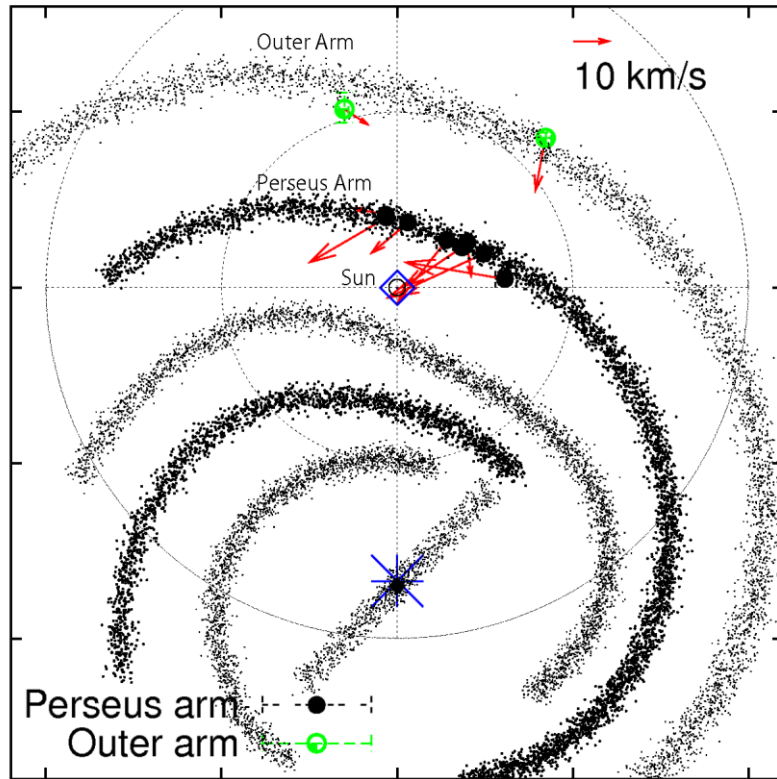
IRAS 22480+6002
 $\pi=0.363\pm0.043$ mas



IRAS 21379+5106
 $\pi=0.326\pm0.031$ mas



3. Discussion: Peculiar motion in the Perseus



(Left) Compilations of previous results and v_{rot} assumed.

(Right) U (toward galactic center) vs V (direction of Galactic rotation).

Perseus arm is located in the lower right.



3. Discussion: Peculiar motion in the Perseus

Russeil et al. (2007)

• $V_{dep.} \equiv V_{lsr_obs} - V_{lsr_phot_D}$.
based on photometry & spectroscopy.

$$V_r = R_0 \sin l \left(\frac{\Omega}{R} - \frac{\Omega_0}{R_0} \right)$$

• Perseus arm

$V_{dep.} = -14.9 \pm 8.9$ km/s

– Minus –

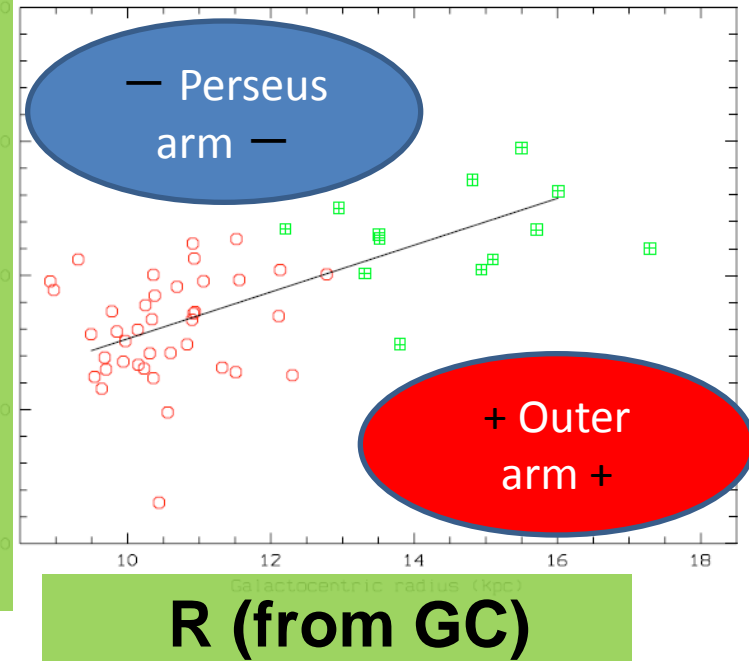
• Outer arm

$V_{dep.} = 8.06 \pm 9.95$ km/s

+ Plus +

* Rotation model is Brand & Blitz (1993)

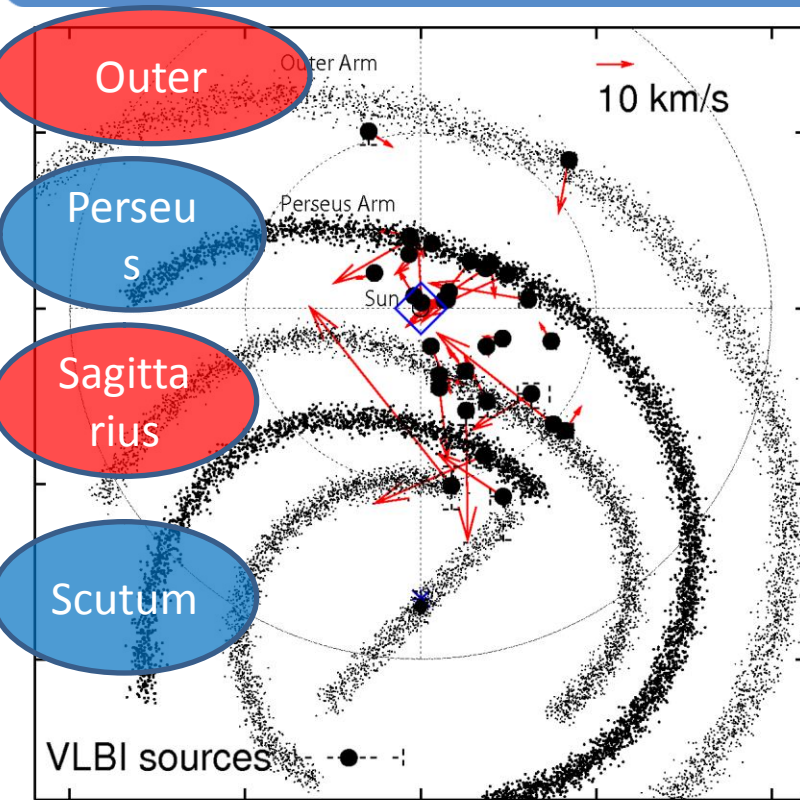
Peculiar motion: V



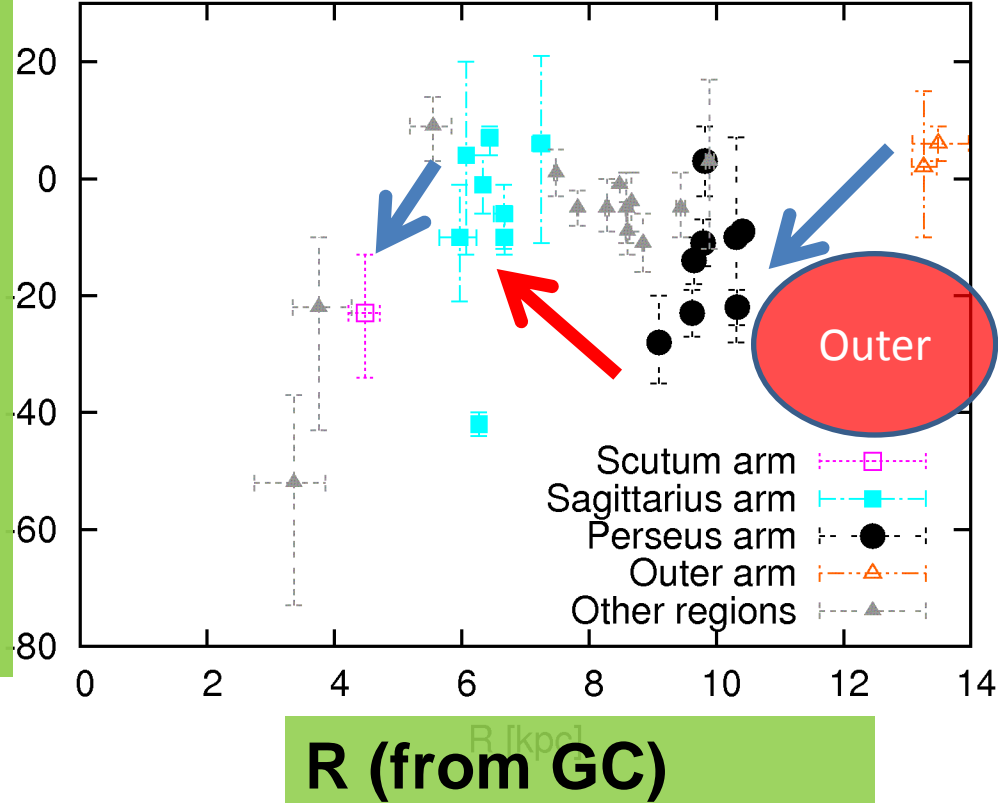
The periodic variation is consistent with the density wave theory.



3. Discussion: Peculiar motion in the Perseus



Peculiar motion: V



VLBI observations among four-arms are consistent with the periodic variation of the density wave.

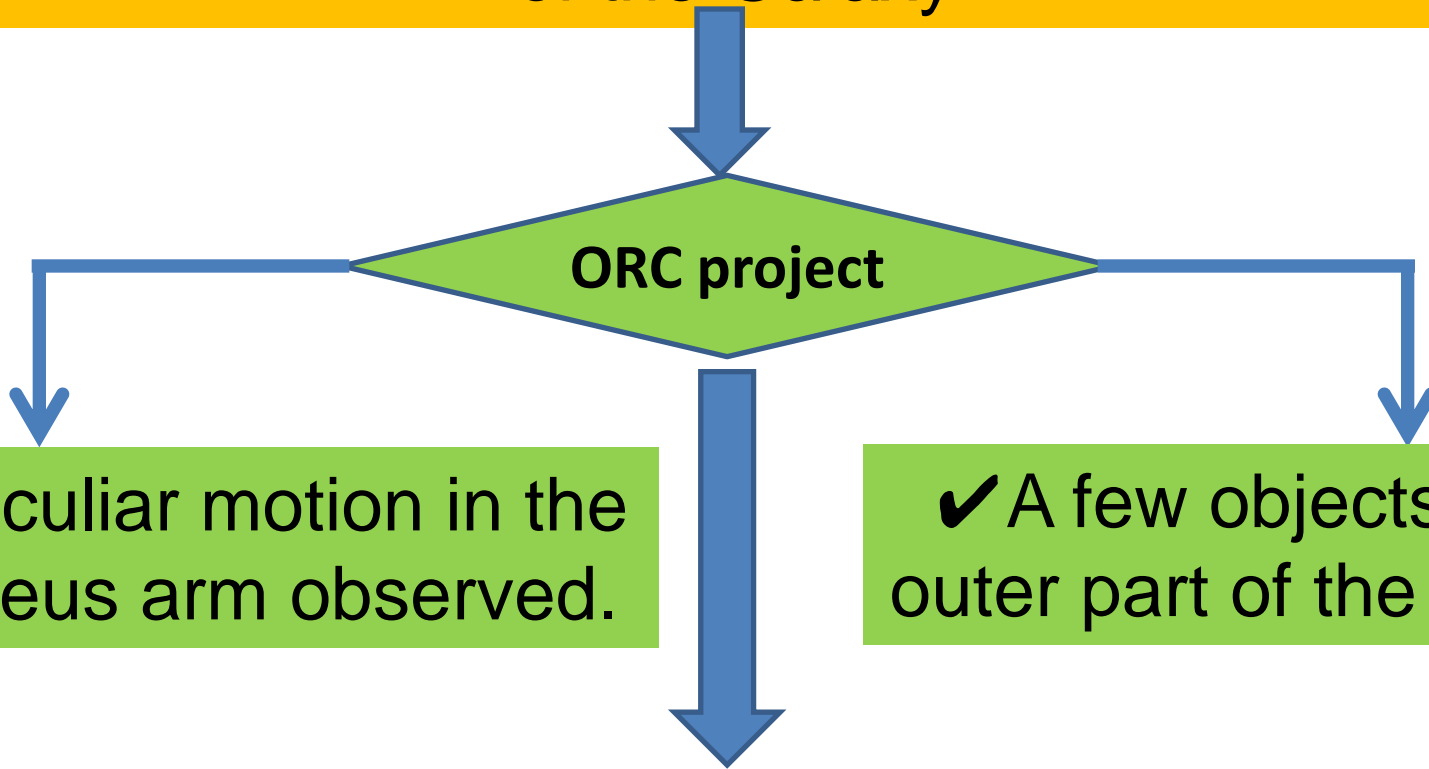
*Rotation model is flat.





4. Conclusion & Future work :

- ✓ Mass distribution, dynamics, and structure of the Galaxy !



✓ Peculiar motion in the Perseus arm observed.

✓ A few objects in the outer part of the Galaxy!

- ✓ We have been selecting again ORC objects for far outer Galaxy !

4. Conclusion & Future work : Far outer sources

Fabulous objects.

1. IRAS 05137+3919

(Honma et al. 2011)
 $\pi=0.069\pm 0.020$ mas

\Rightarrow We have been observing it again to reduce err!

2. IRAS 21144+5430 & 21306+5540

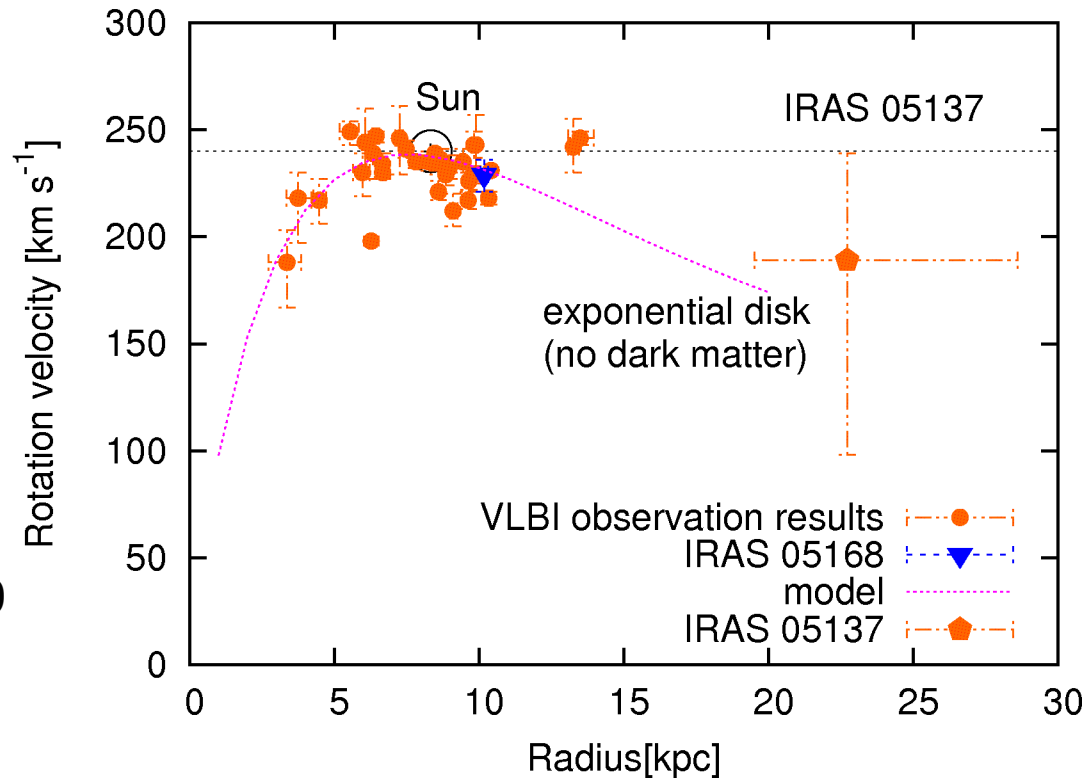
(FSF project: PI, K. SUNADA)
 \rightarrow Assistant, N. SAKAI

$V_{lsr} = -83.2, -72.1$ km/s. $R = 13.9, 12.8$ kpc

3. NEW References

We have been searching new H₂O-maser references.

\rightarrow Wouterloot et al. 1993, AKARI sources, etc.



Fin.

