

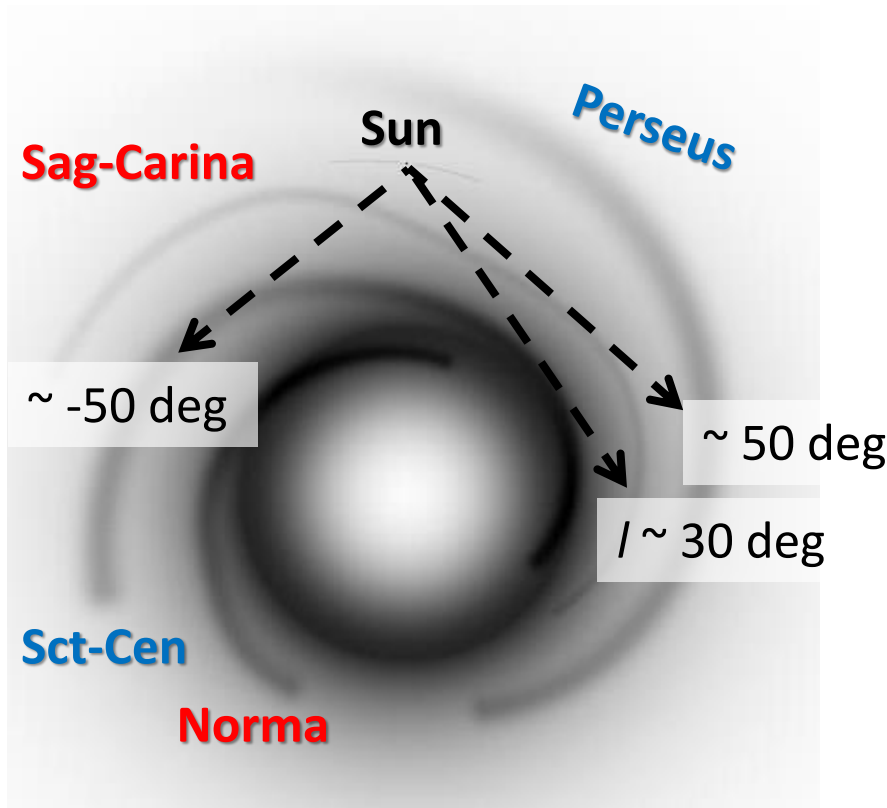
# Perseus Arm Gap project with VERA

Nobuyuki Sakai (NAOJ)

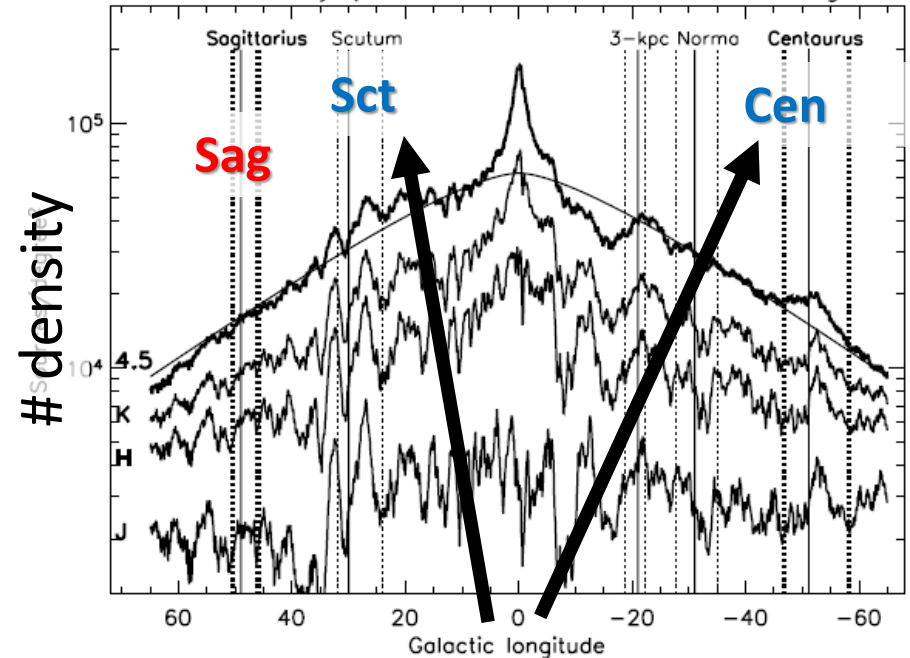
September 26th(Tue)@VERA UM, Mitaka

# 2 main spiral arms ? Or 4 arms in the MW ??

## Dust density map



Star count density (all sources from 12th to 6th magnitude)



**NIR bump**

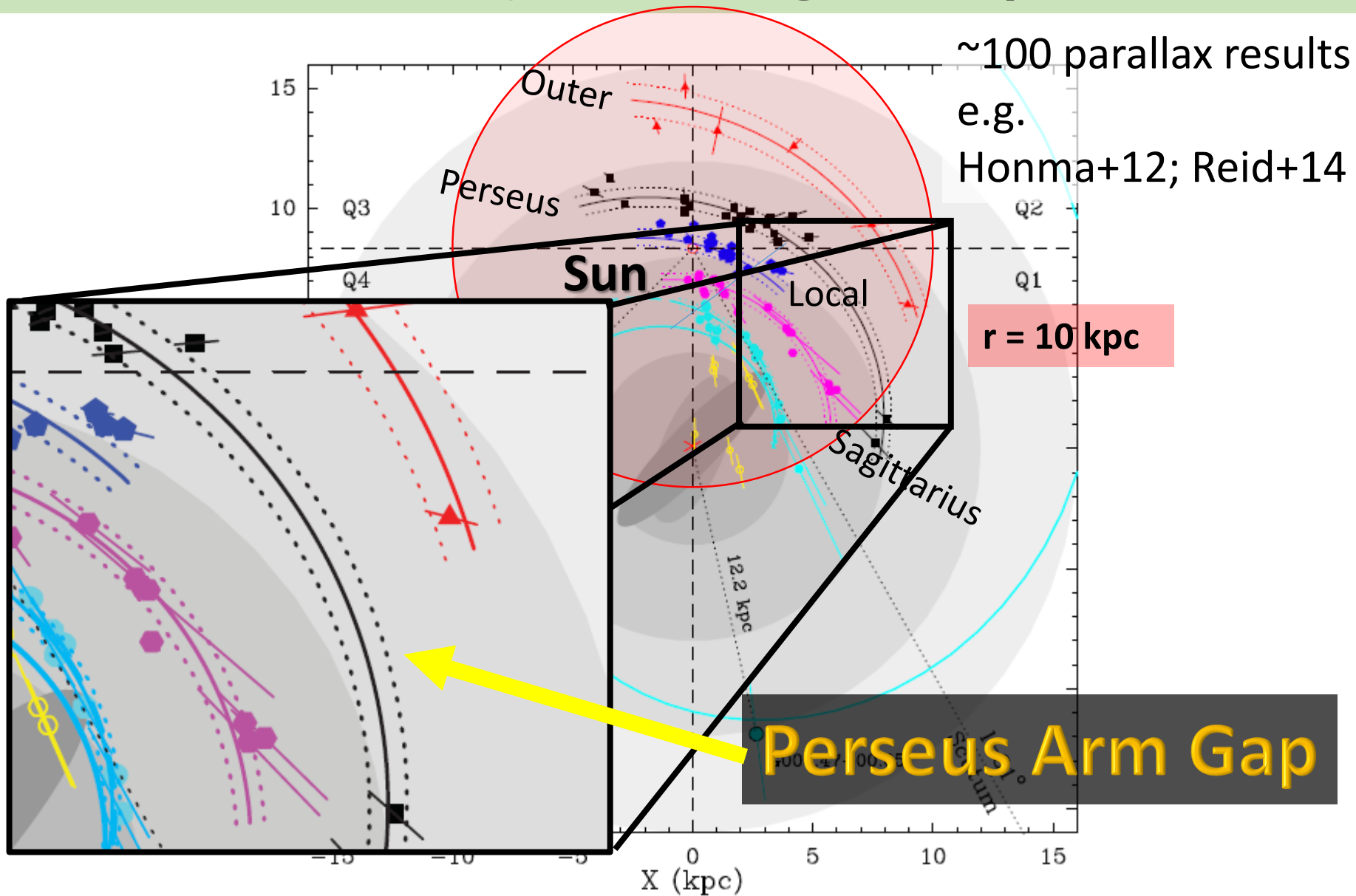
FIR—Galactic dust (Sag-Carina & Norma)

NIR—Stars (Perseus & Sct-Cen)

(Prominent) Sag-Carina is the secondary arm ?

Distance error of the arm.

# VLBI astrometry revealing the Spiral arms



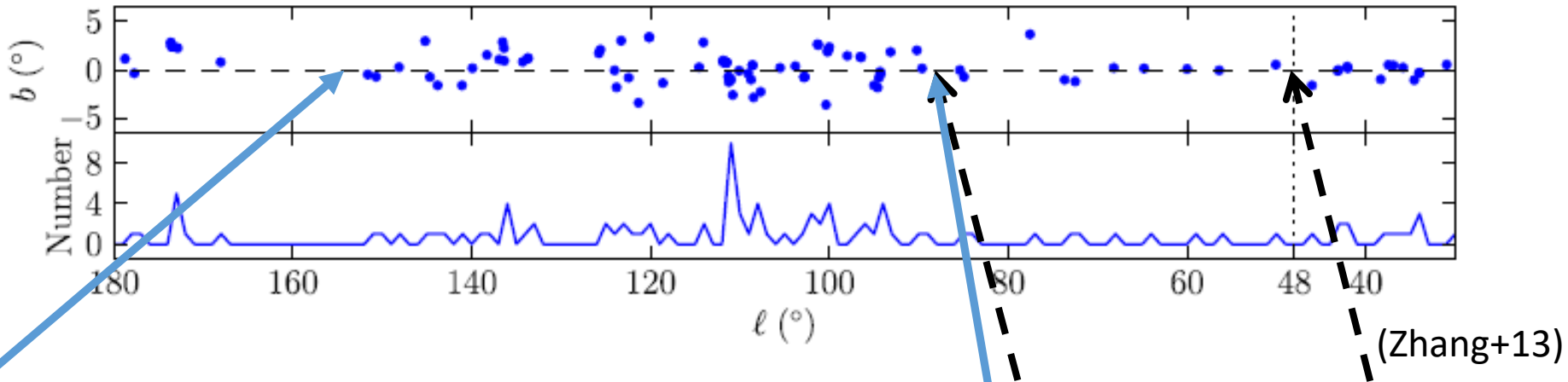
# Structure & Kinematics of the PAG

① Arm length of the Perseus (main) arm ?

Typical arm length (with a single pitch angle) is  $\sim 5$  kpc (Honig & Reid 2015)

② Relationship between star formation activity and spiral arm (structure & motion) ?

# of massive young stellar objects in the Perseus arm



(2a) Systematic ( $\sim 20$  km s<sup>-1</sup>) non-circular motion  
-Sakai+12; Choi+14

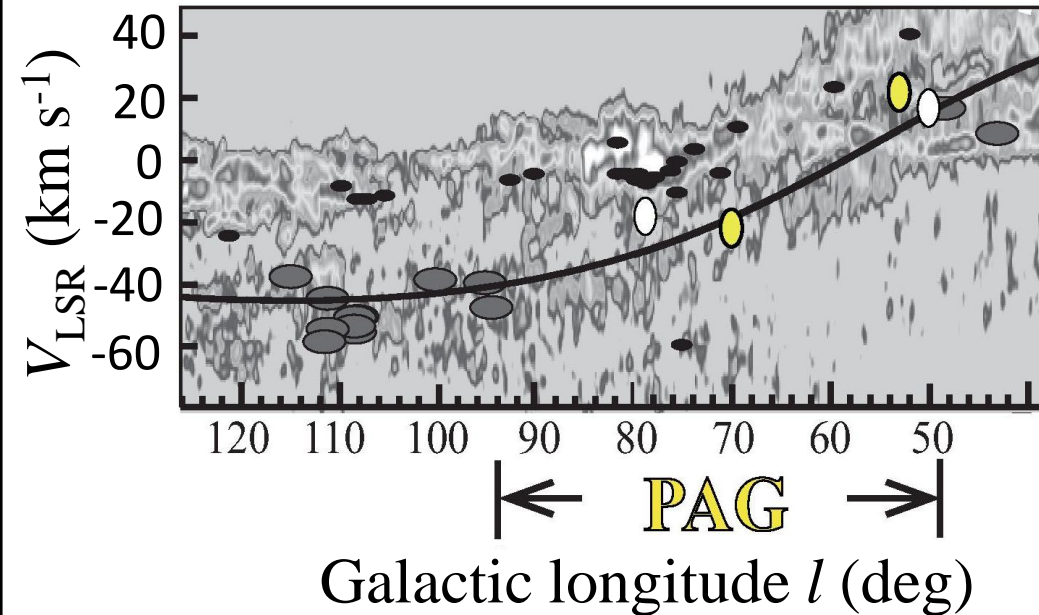
(2b) Arm amplitude  $\propto$  Pitch angle  
-Grosbol+04; Baba+13

**PAG**  
-Pitch angle ?  
-Kinematics ??

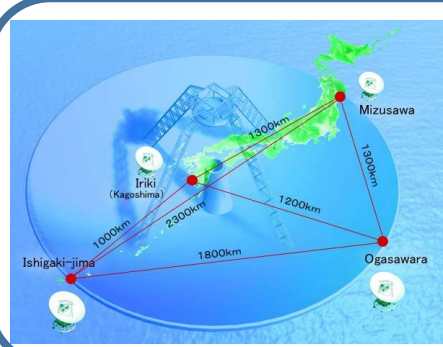
(Zhang+13)

# PAG source selection & VERA obs.

CO (J=1-0) integrated intensity (Dame+01)



Curve : Perseus-arm model (Sakai+15)



**2016.0 ~ 2018.4**  
 ○ : 2 sources observed

(2018.7 ~ 2020.2)  
 ● : Observing 2 sources

**H<sub>2</sub>O Maser catalogs**

- ① Valdetaro+01, # = 1013
- ② Sunada+07, # = 222
- ③ Svoboda+16, # = 439

**Total : # = 1674**

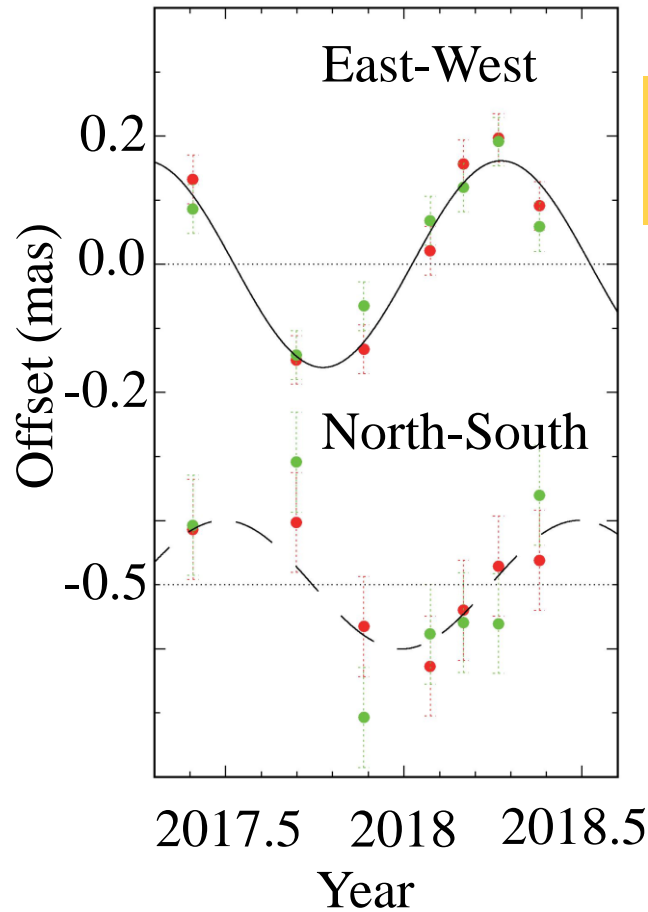
**Thin disk**  
 $|b| < 10$  deg

**Perseus-arm model** (Sakai+15)  
 $49 < l$  (deg)  $< 94$   
 $V_{\text{LSR}} = V_{\text{LSR, Model}} \pm 19 \text{ km s}^{-1}$

32 sources / 1674 ~ 2%

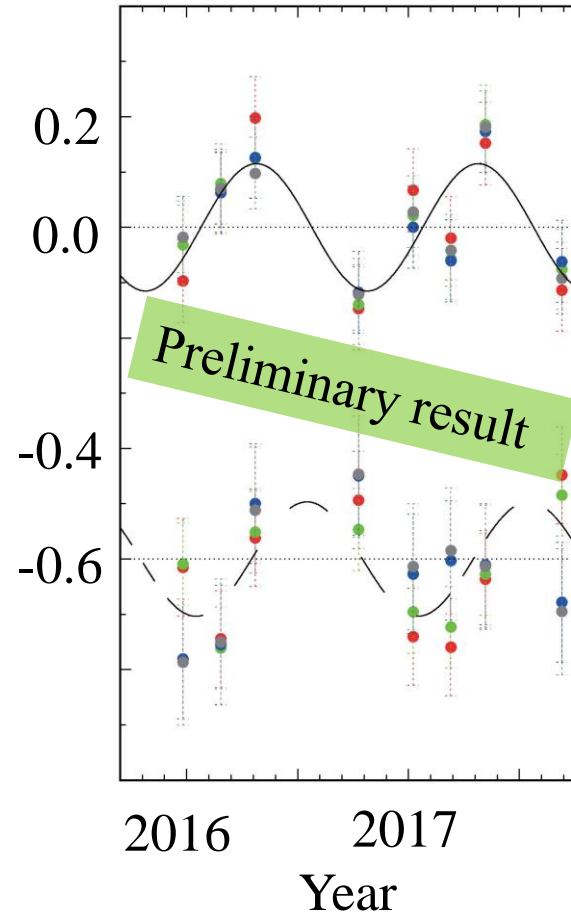
# Parallax results for the PAG sources

G050.28-0.39,  $V_{\text{LSR}} = 16.7 \text{ km s}^{-1}$



2 QSOs  
observed

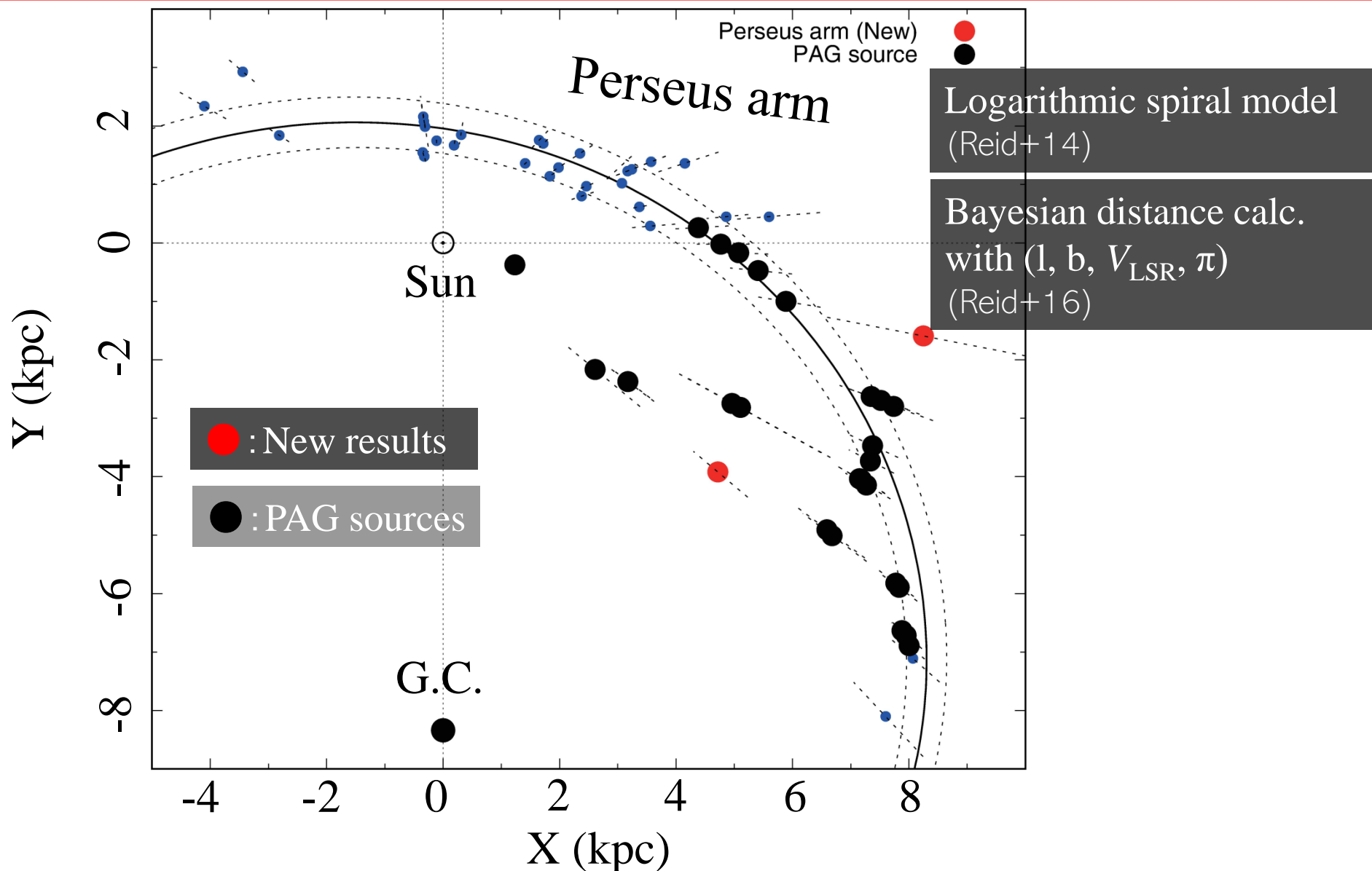
G079.08+1.33,  $V_{\text{LSR}} = -18.2 \text{ km s}^{-1}$



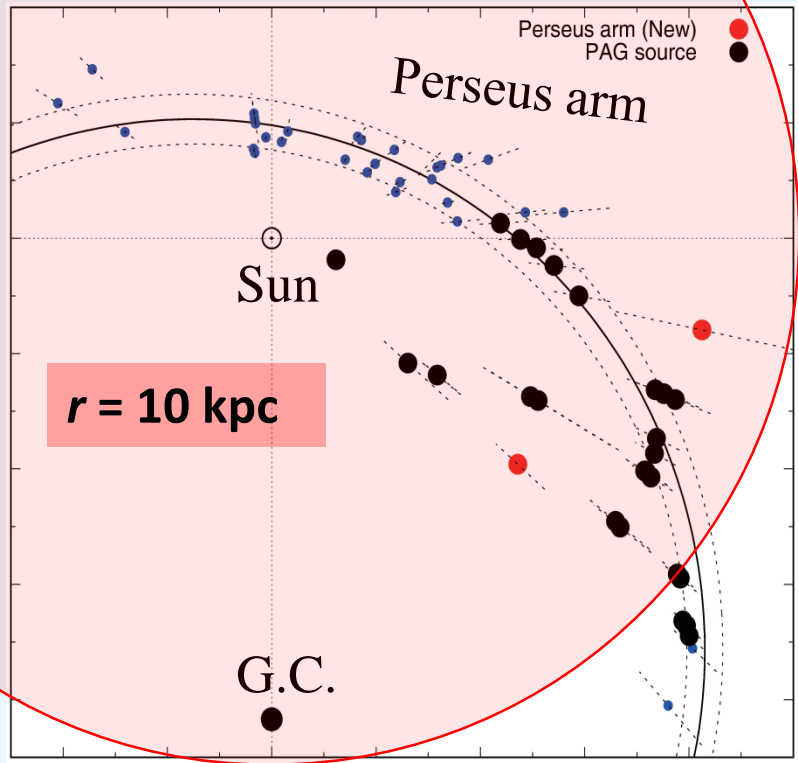
1 QSO &  
4 maser spots,  
observed

Preliminary result

# Structure of the PAG



# Toward 2022 & Beyond



VERA & VLBA ~ 20 sources

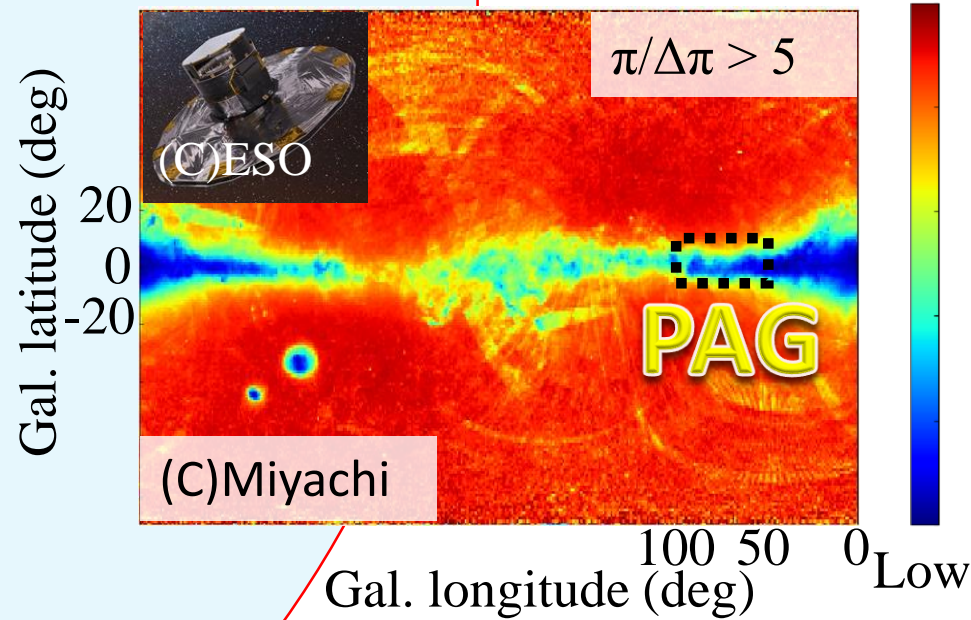
KaVA & EAVN & (SKA) < ~100 sources ?

See talks by Kawaguchi-san, Hada-san, Oh-san, Kobayashi-san, others.

Third release: likely the first half of 2021

Final release for the nominal mission: TBD

XMATCH (*Gaia* vs. 2MASS)



See the *Gaia* talks by Nakagawa-san, Sudou-san, and Miyachi-san

$r = 20$  kpc