
# Activity of SKA-JP Astrometry sub-Working Group

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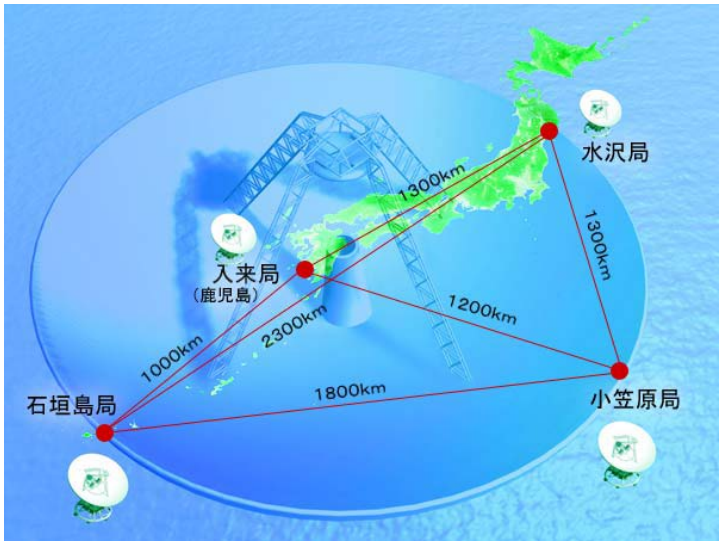
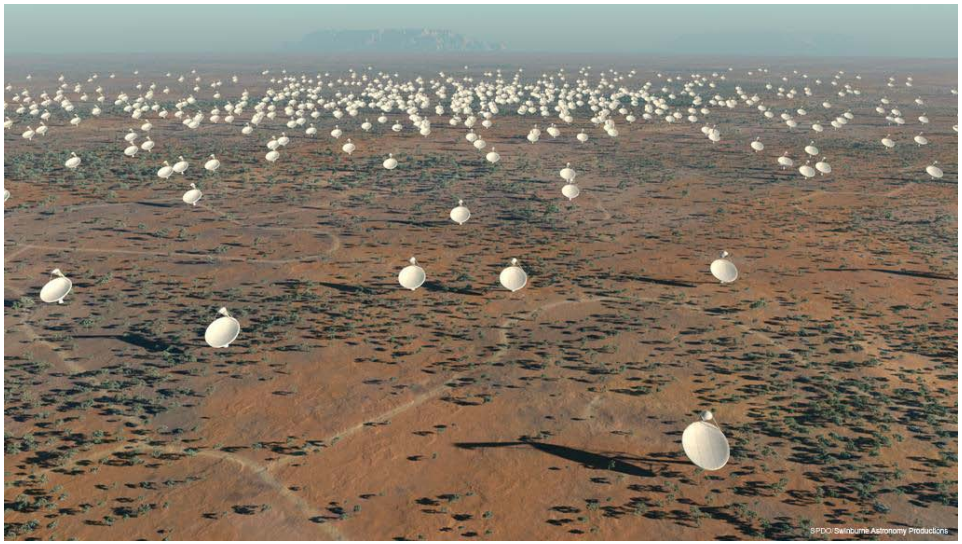
**on behalf of Japan SKA Consortium Astrometry sub-Working Group**

# Radio astrometry from present to future



Present (~2030?)

- **VERA(4 x 20m)**
- VLBA(10 x 25m)
- EVN(~15 antennas)
- **HSA(VLBA+GBT+Ef)**
- LBA(5-6 antennas)

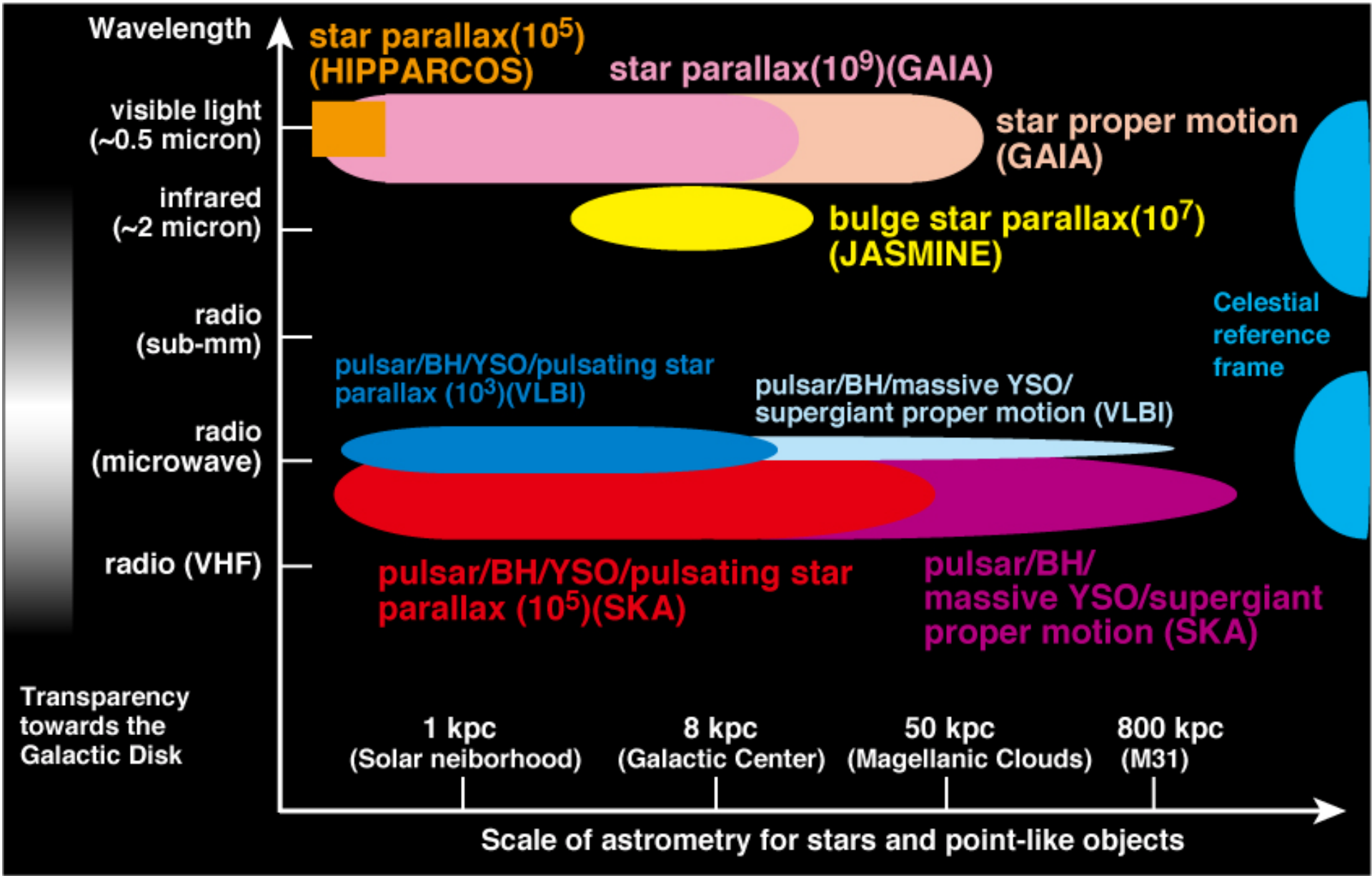
**<2000 annual parallaxes**

Near future (2020?~)

- **SKA1 (~140 x 15m)**
  + global VLBI (~10 x ~20m)
- **SKA2 core (~700 x 15m)**+SKA2 remote stations (??)
  (~40 sta. x 25 ant. x 15m)
  + global VLBI (~10 x ~20m)

**>>10,000 annual parallaxes**

# Scientific scope of SKA astrometry




http://milkyway.sci.kagoshima-u.ac.jp/groups/ska-jp/wiki/a8d3e/Astrometry.html

# Possible science cases in SKA era

- "Spiral arm tomography" in the Milky Way
  - finding chronological sequence of star forming regions across the spiral arms : >1 000 stars/arm
  - including southern Sky where SKA is operated
- Mapping the *whole* Milky Way System
  - Galactic center, bulge, and halo (including pulsars)
  - Magellanic System (LMC & SMC proper motions)
- 3D dynamics of the Local Group of galaxies
  - dynamical history of the LG and the MW
- Science with the radio reference frame
  - ~30 000 reference sources ($S_\nu$ > 0.5 mJy)
  - "Galactic aberration" (50 μas/century)
  - astrometric micro-lensing events
- Synergy with pulsar and transient science cases
  - gravitational waves, ….

# SKA-JP Astrometry sub-WG※

Since 2009

Chair: Hiroshi Imai (Kagoshima University)
Yoshiharu Asaki (ISAS/JAXA)
Gabor Orosz, Yuta Uchino, Ross Burns Alexander,
Hiroyuki Nakanishi (Kagoshima University)
Yoshiyuki Yamada (Kyoto University)
Koji Ohnishi (Nagano Collage of Technology)
James Chibueze Okwe (NAOJ/ALMA)
Naoteru Gouda, Takuji Tsujimoto, Tahei Yano (NAOJ/JASMIN)
Osamu Kameya, Naoko Matsumoto, Tomoya Hirota (NAOJ/VLBI)
Daniel Tafoya (UNAM, Mexico)
Mitsumi Fujishita (Tokai University)
Kenji Bekki (University of Western Australia/ICRAR)
Kotaro Niinuma (Yamaguchi University)

※Members in institutes alphabetically ordered

# Action lists in SKA-JP Astrometry sub-WG

- WG meetings (Skype): 3—4 meetings/year (since 2012)
- Case studies
  - VERA/KaVA astrometry ($H_2O$/$CH_3OH$ masers) .... **ongoing**
  - VLBA astrometry (OH masers) ..... **ongoing**
  - $H_2O$ maser proper motions in the Magellanic Clouds ..... **ongoing**
  - Synergy with JASMINE/Nano-JASMINE ..... **forthcoming**
- OH maser surveys
  - SPLASH (Dawson et al. 2014, 2012—2014) ..... **ongoing**
  - GASKAP (Dickey et al. 2013, from 2015) ..... **planning**
- SKA Astrometry simulation (ARIS+AIPS) ..... **developing**
- (International and domestic) SKA Science Book ..... **drafting**
- International SKA meetings (participation & organization)

# Demonstrating L-band astrometry (VLBA)

- OH maser + QSO(s) **within a single beam** **Lead by G. Orosz**

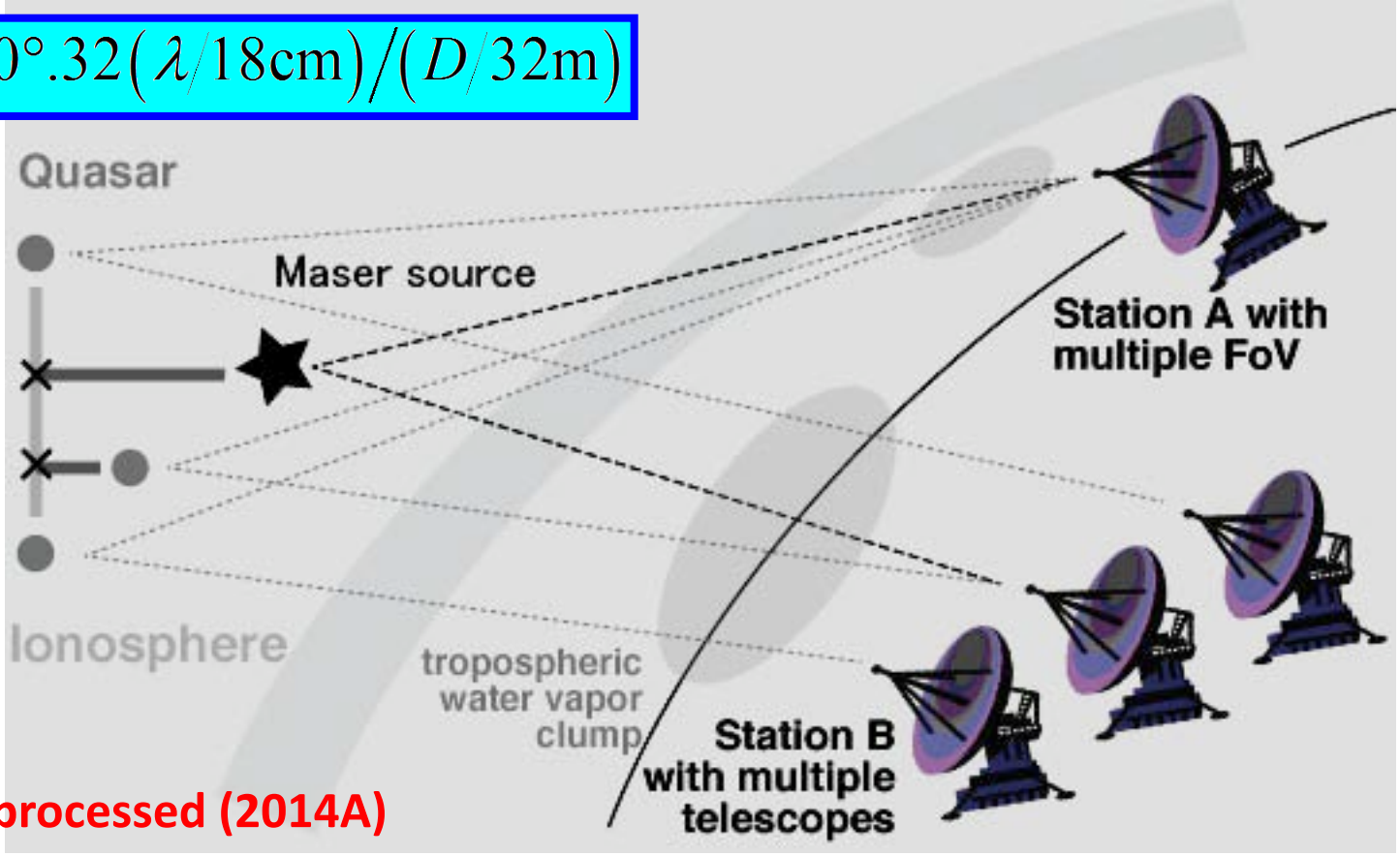
for perfect phase-referencing

a few pairs available from the OH maser catalog (Engels 2012)

- More calibrators within ~5 deg from

For estimating error contribution due to different angles

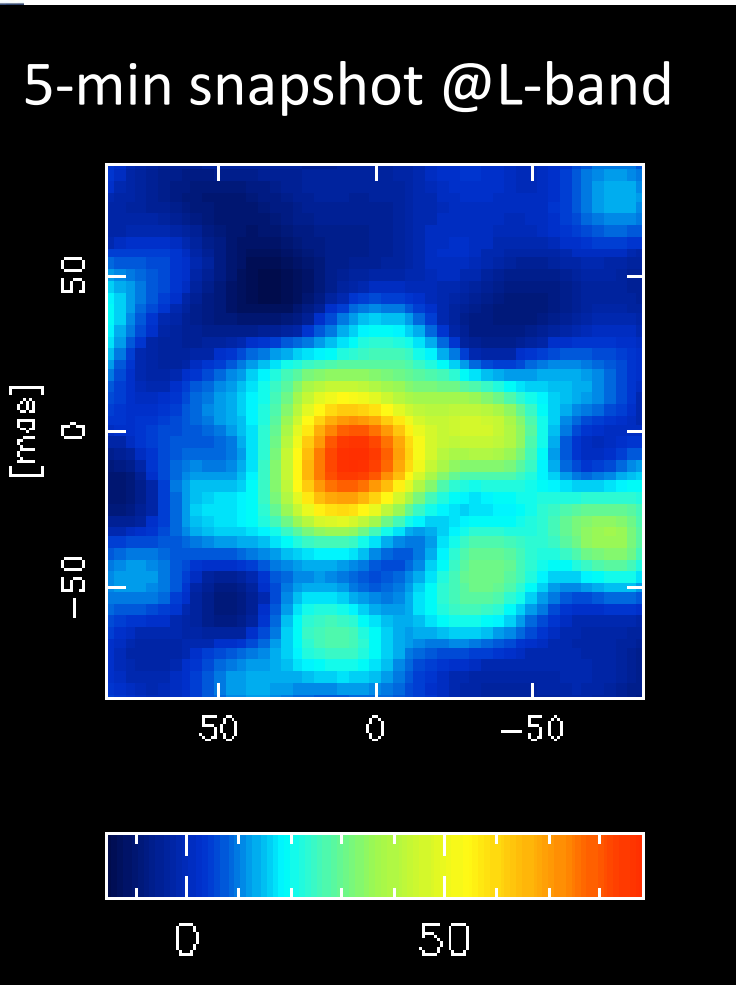
$$\theta_{\mathrm{FoV}} \approx 0^{\circ}.32\left(\lambda/18\mathrm{cm}\right)/\left(D/32\mathrm{m}\right)$$




**3 targets processed (2014A)**

# SKA2 astrometry simulations

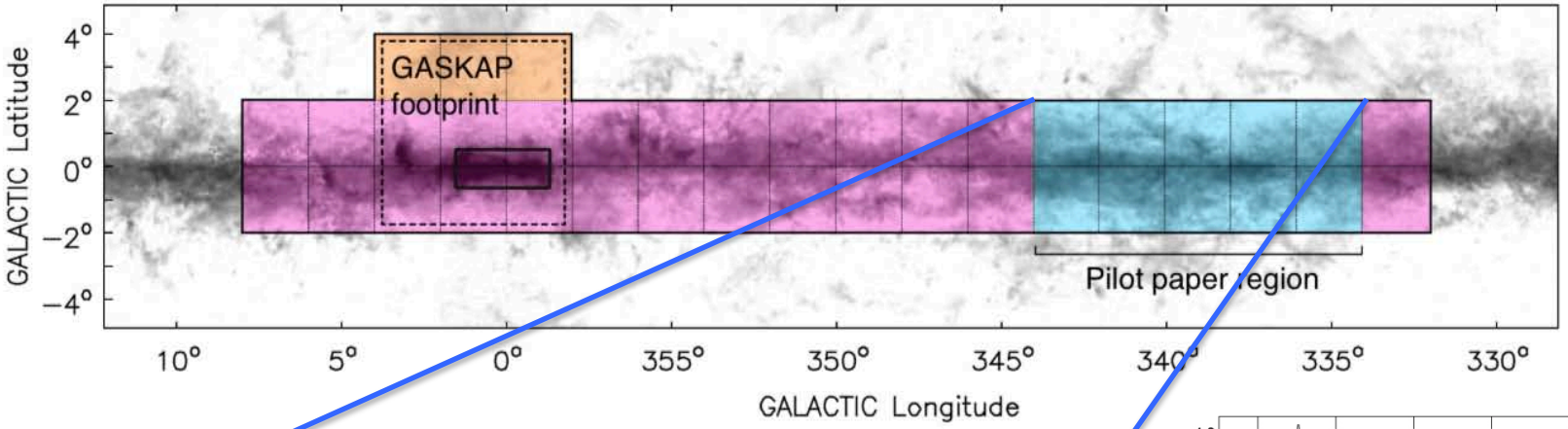
ARIS (Asaki et al. 2007)+AIPS/ParselTongue (Y. Uchino)

# SPLASH (Southern Parkes Large Area Survey in Hydroxyl)

Dawson et al.

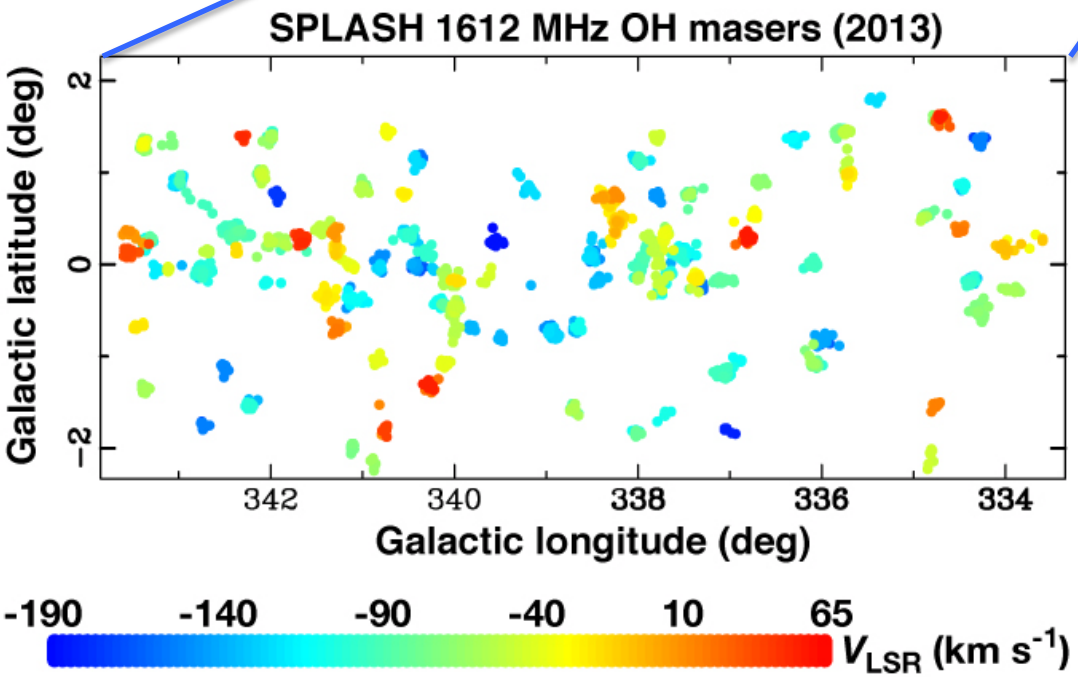
## 1612/1665/1667/1720 MHz thermal (emission, absorption) maser

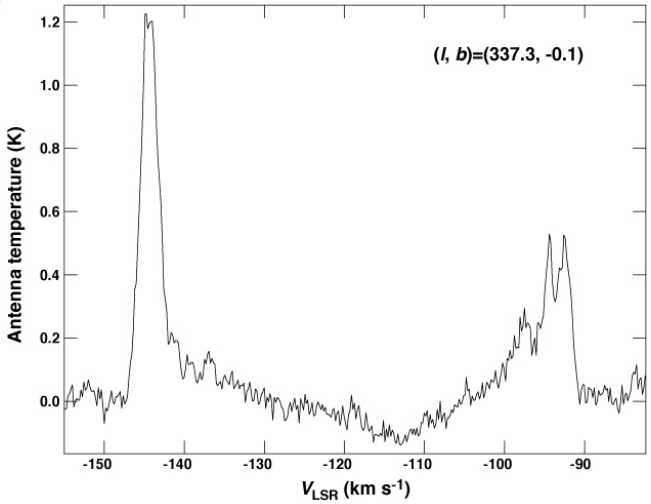



Observations complete. Data fully reduced

Observations complete.

Partially or un-observed




**Reanalysis of intensity image cube (by K. Shinano & H. Imai)**

# Statistics of OH maser sources in the SPLASH area



Confidential

- Possibly ~5000 1612-MHz OH maser sources brighter than 0.4 Jy.
- Constant expansion velocity ($V_{exp}$~15 km/s) of the circumstellar envelopes, similar to those in the Galactic bulge and the outer Galaxy (Sjouwerman 2000)

**$V_{exp}$dependent on only metalicity (heavy element abundance) of stars (?)**

# Milestones of the sub-WG

- Quantitative and realistic science evaluation
  - simulations, source statistics, system specification
- Realization
  - VLBI astrometry demos with low-frequency bands
  - VLBI astrometry with SKA pathfinders (EVN, LBA, APT) and precursors (ASKAP, MeerKAT)
- Team formation
  - International and domestic collaborations
  - Synergy with wider scientific fields (pulsars, transients, cradle of life, ……..)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- JSPS Bilateral Program (Researcher Exchange): 2012 Nov.
- Yamada Foundation: FY2012—2013