Distribution of 1612 MHz OH maser sources in the SPLASH field

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Estimation of the OH maser source distribution in the Galaxy by comparison between the data and a toy model.

We present statistical analysis of 407 evolved stars observed with ATCA (H.H.Qiao, 2019) in a follow up observation of an unbiased sky survey, SPLASH (Southern Parkes Large-Area Survey for Hydroxyl).

OBSERVATIONAL DATA

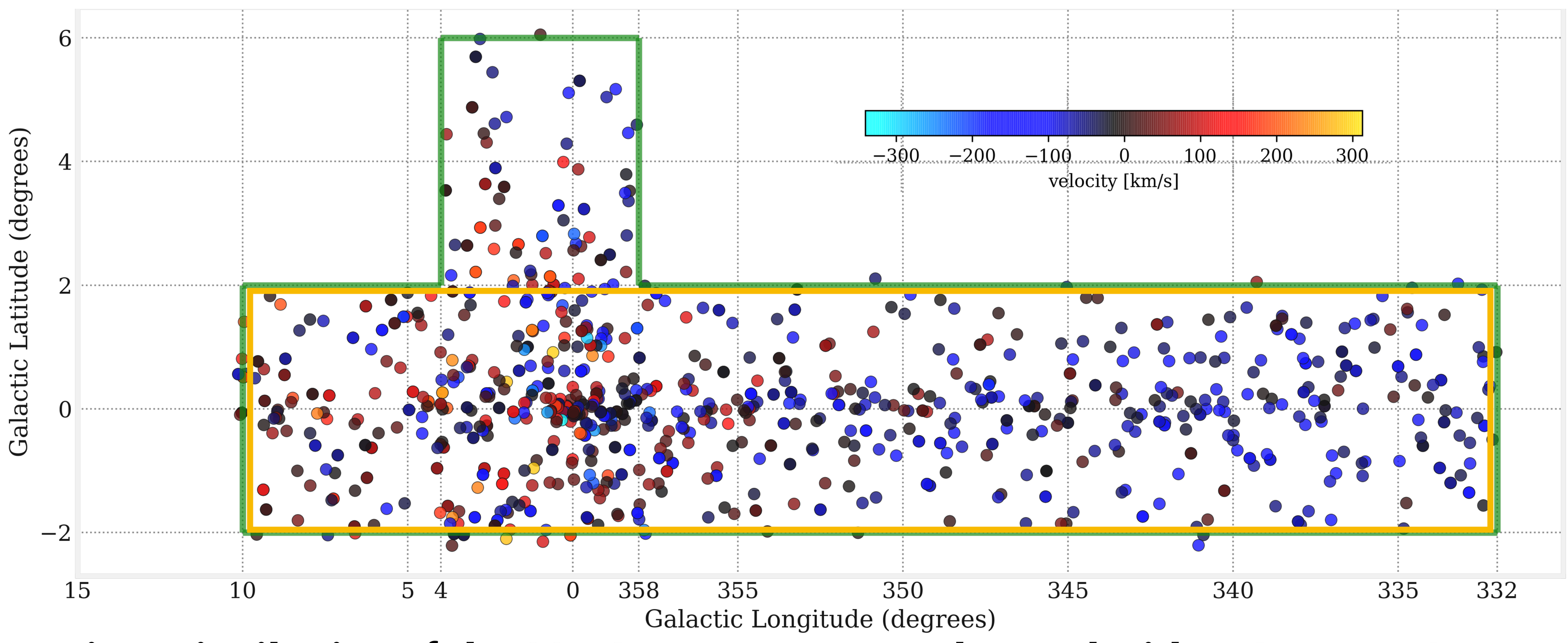

Fig1. Distribution of the 921 OH maser sources detected with ATCA at 1612 MHz. 774 (84.0%) of them are confirmed to be evolved stars (ES), with 407 maser sources exhibiting double peak spectra whose centre velocity indicates the systematic velocity of the circumstellar envelop. Here we assume these 407 maser sources to be OH/IR stars. The area surrounded by green lines is the SPLASH field. The OH maser sources inside of the yellow square was used for our statistical analysis.

SPLASH Survey	Parkes 64m	ATCA (follow-up)
Region	332° ≦ l ≦ 10°, b ≦ | ±2 | and 358° ≦ l ≦4°, +4 ≦ b ≦	
Frequency	1612, 1665, 1667, 1720 MHz	
Sensitivity (1σ)	0.065 Jy	0.070 Jy
Spatial resolution	13.0′	6.5″ x 4.4″ ~ 22″ x 5″
Velocity resolution	0.18 km/s	0.09 km/s

TOY MODEL

The number density across and perpendicular to the galactic plane are given by uniform and Gaussian distribution respectively. The solution to simultaneous equation with a dynamical equilibrium of a self-gravity system of a disk and a Poisson equation for the mass density profile is given by

$$n(z) = n(0)sec\frac{z^2}{h}$$

Luminosity function is given by

$$y = \frac{1}{\sqrt{2\pi}\sigma}e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

where

$\mu = 15.3\ (\log L_\nu)$, $\sigma = 0.53$,

$L_\nu = f_{peak} \times 4\pi D^2$

(Engels and Buzel, 2015)

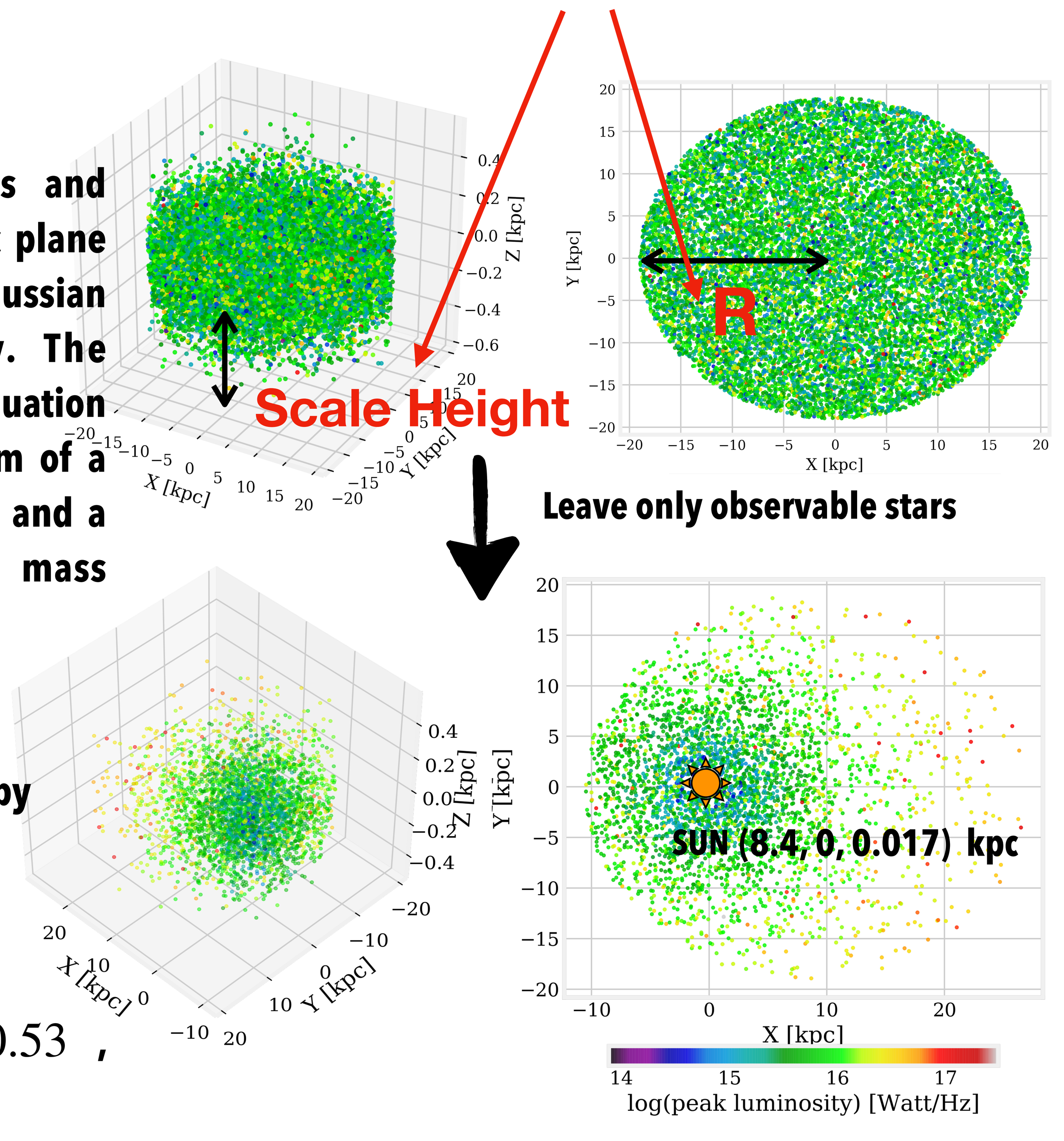

Fig2. Toy model of a Galactic maser distribution constructed to compare with the sky distribution of the observed masers sources.

METHOD

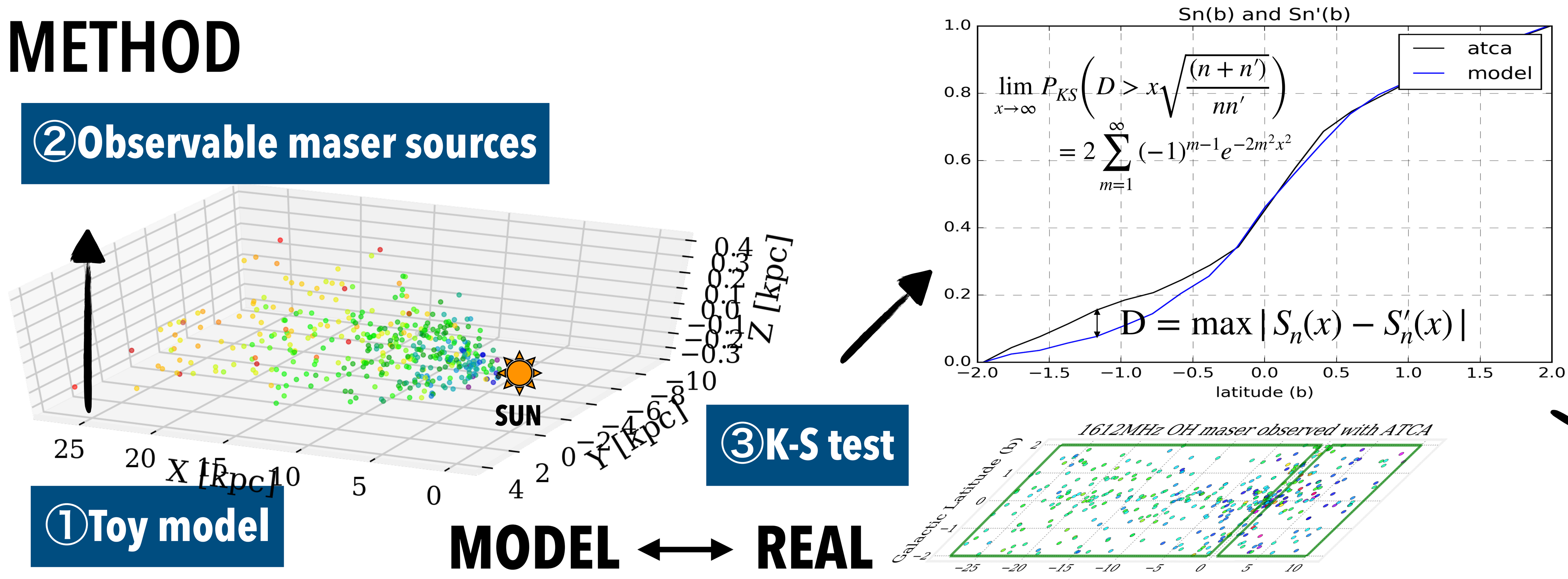

Fig3. Schematic work flow to determine a scale height of the OH maser sources along Galactic latitude

We used Kolmogorov-Smirnov test (K-S test) for evaluating the probability that the each probability density function comes from a same population. The models having p-value from K-S test that is more than 0.77 were considered good models.

RESULTS

Scale height

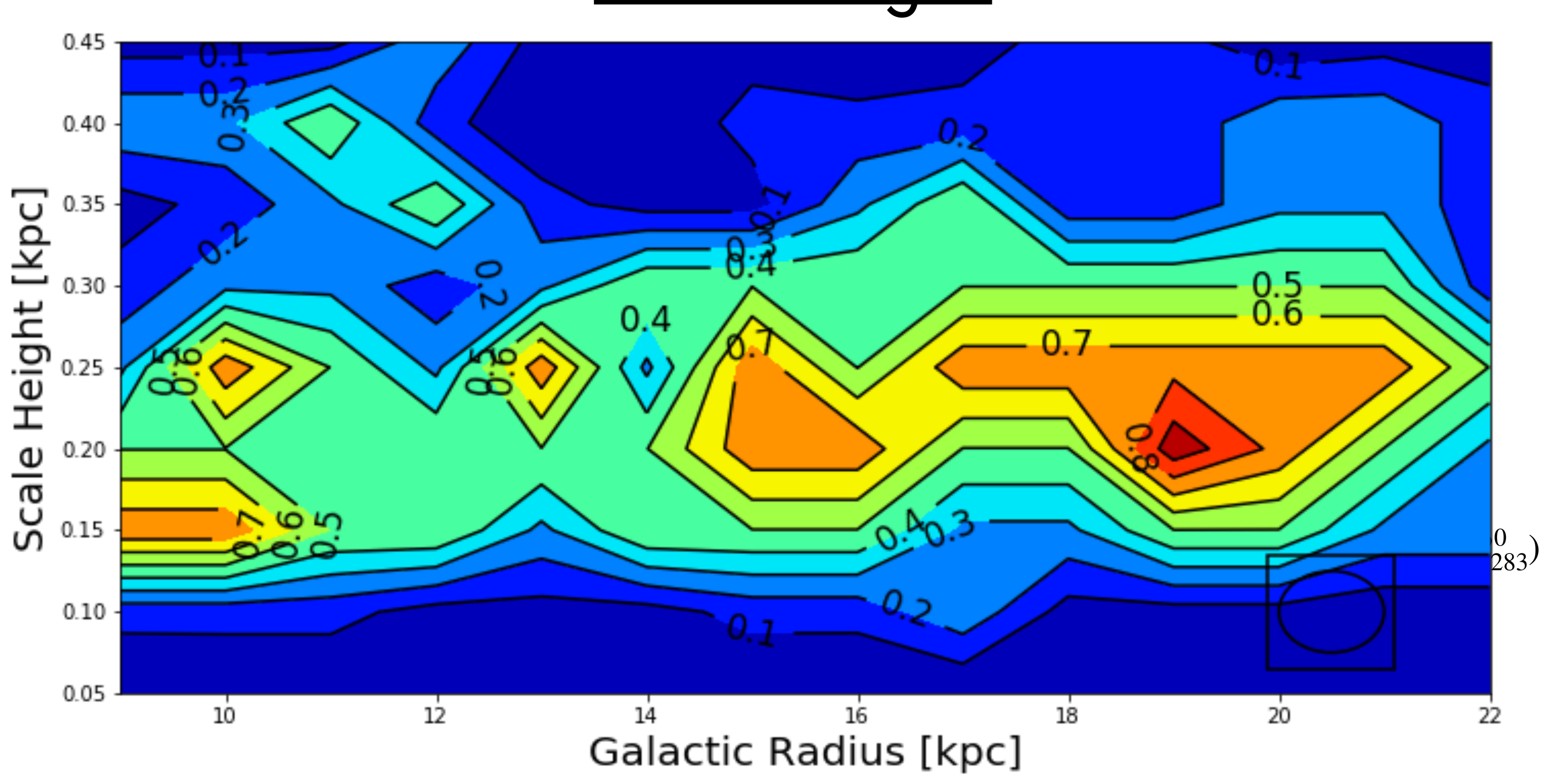

Fig4. P-value distribution in the K-S test. High (>0.77) P-value is seen only in the scale height range between 150 pc and 250 pc. A unique peak of P-value is seen around the point of the scale height and the Galactic radius to e 200 pc and 19 kph, respectively.

Lifetime of OH maser sources

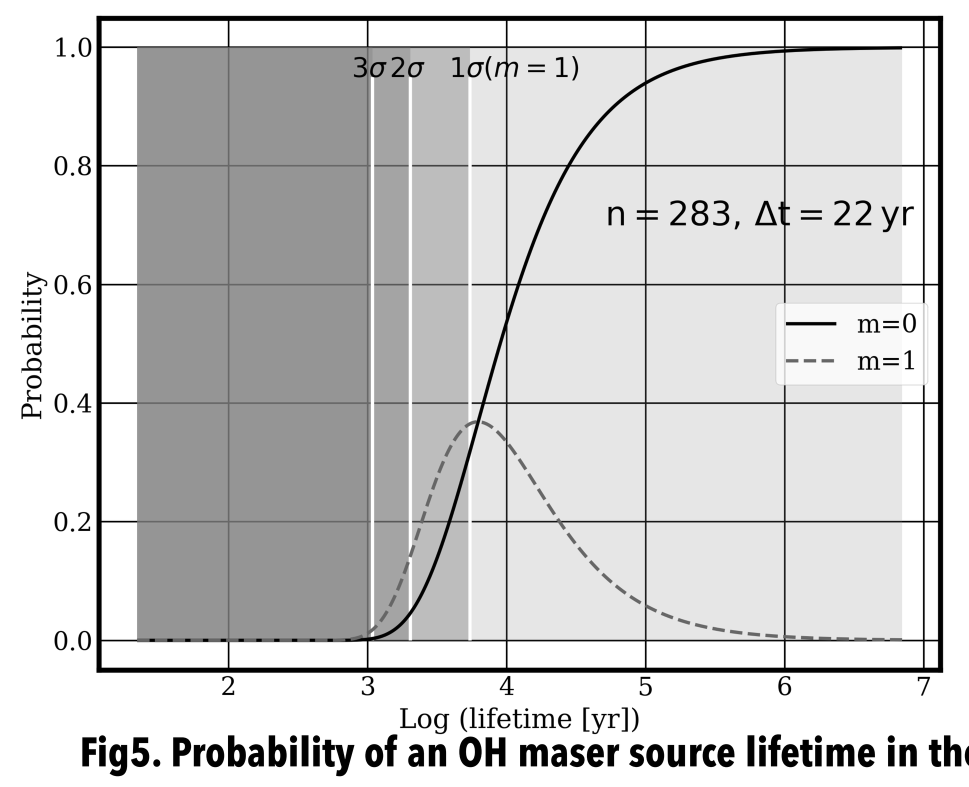

Fig5. Probability of an OH maser source lifetime in the case where all the 283 observed masers have survived over 22 years.

$$P^m_n = \frac{n!}{m!(n-m)!}\cdot\left(\frac{\Delta t}{T}\right)^m\cdot\left(1-\frac{\Delta t}{T}\right)^n \quad (1)$$

Engels and Esteban (2007)

n	m	Δt [yr]	T_{min} [yr]	P^m_n [%]	Comment
283	0	22	1.0k	0.3	3σ
283	0	22	2.0k	4.6	2σ
283	0	22	5.4k	31.7	1σ

Table1. Revised Lower lifetime limits T_{min} according to our result. Lifetime of 1612 MHz OH masers seems much longer than previously considered; 0.4k years for Lewis et al. (2002) and 3k years for Engels and Esteban (2007) compared to 5.4k (ours).

The probability function is given as (1). T is the average lifetime of OH maser, Δ the elapsed time after the first observation, n is the total number of maser sources , and m is the number of maser sources which disappeared in ΔT years. As a result, all maser sources are revisited.

Towards SKA era…

Number of predicted observable OH/IR stars in the Galaxy : 1.5×10^4

(Detection limit 10mJy)

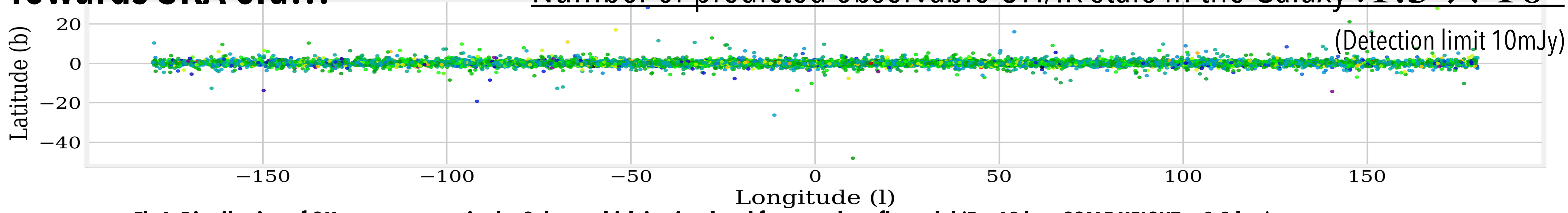

Fig6. Distribution of OH maser sources in the Galaxy, which is simulated from our best fit model (R =19 kpc, SCALE HEIGHT = 0.2 kpc).

The number of simulated maser sources would be the same as that derived with the ATCA data in the comparing field. This number is also consistent with the number estimated from distribution of OH/IR stars in the solar neighbourhood by R. Ortiz and W.J. Maciel (1996), 1.7×10^4

13,14 December 2019@Mizusawa, JAPAN *"Mizusawa VLBI User's Meeting"*