

# 400 nights with $\mu$ Herculis

the Hertzsprung SONG Telescope

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# The SONG Team

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- Søren Frandsen
- Vichi Antoci
- Rasmus Handberg
- Uffe Gråe Jørgensen
- Pere Palle
- Licai Deng
- .....







Potential  
target star



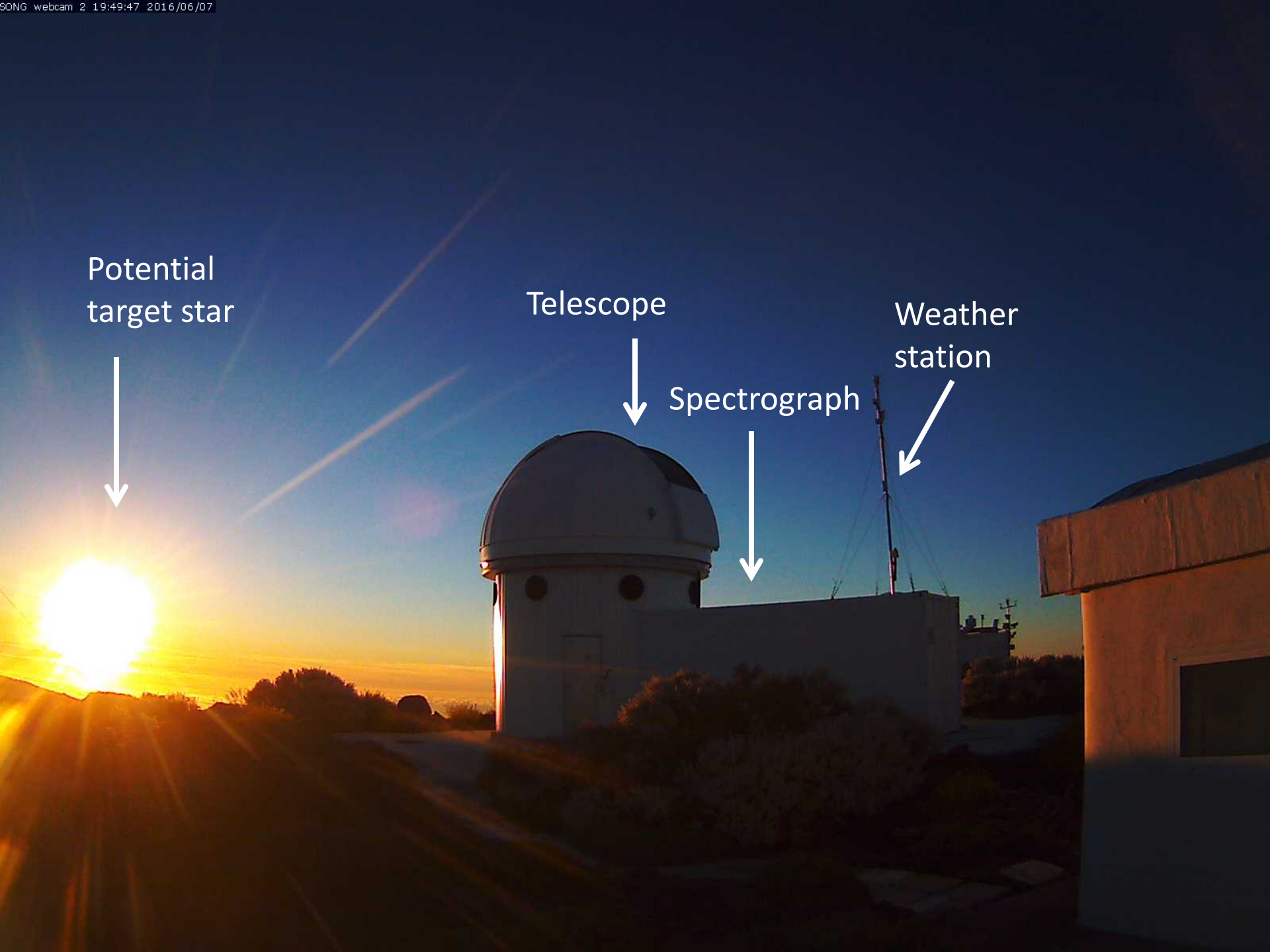
Telescope



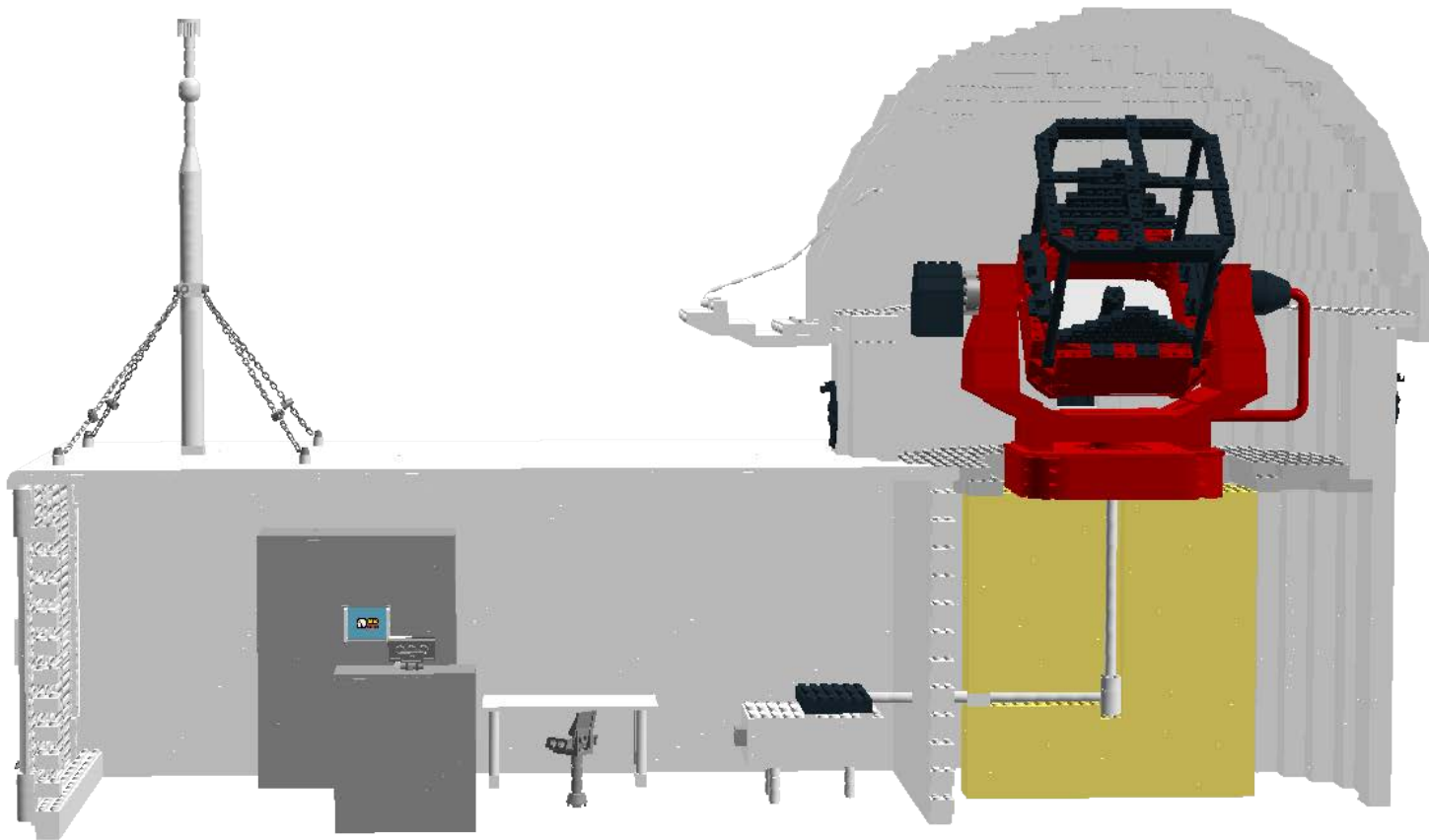
Spectrograph



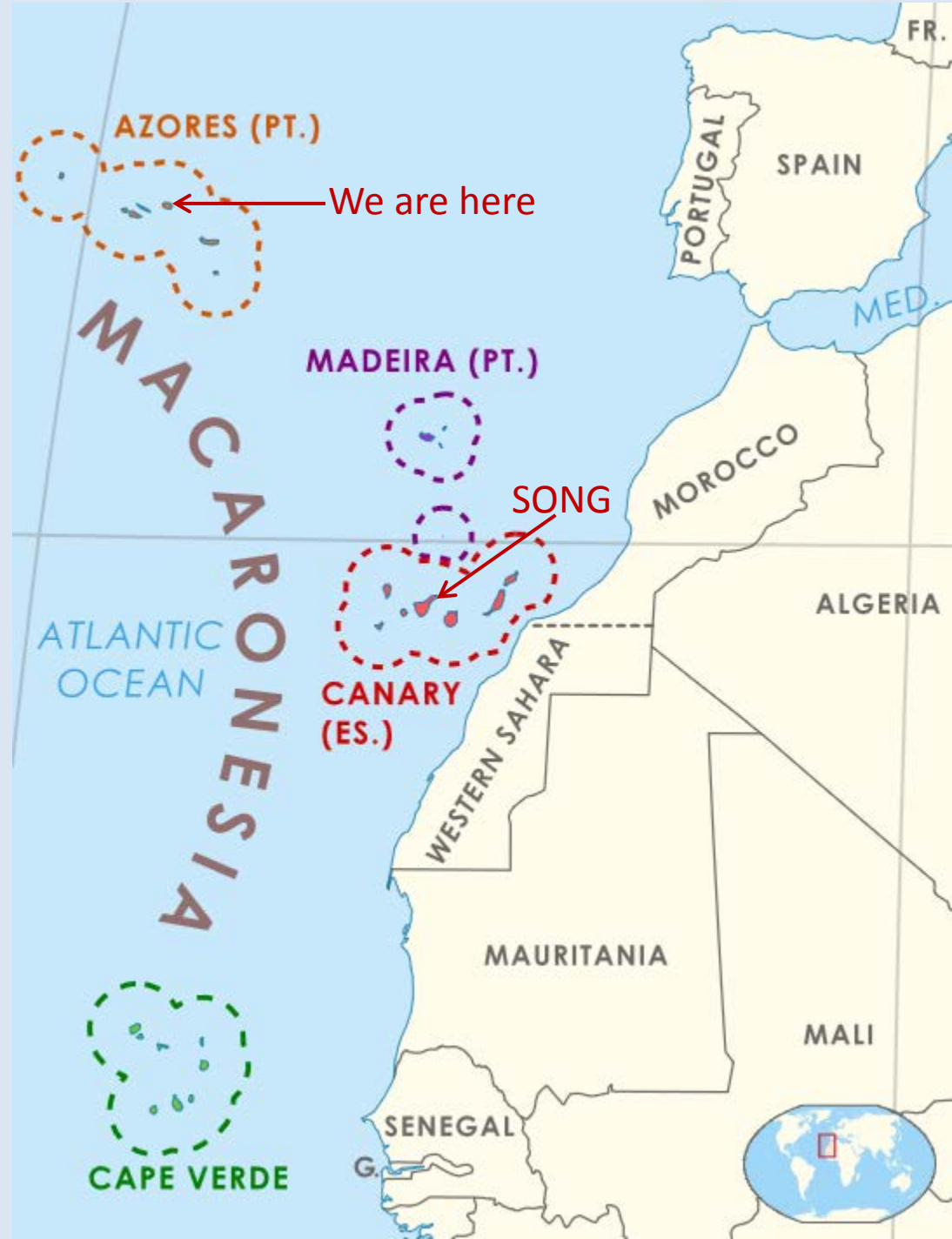
Weather  
station



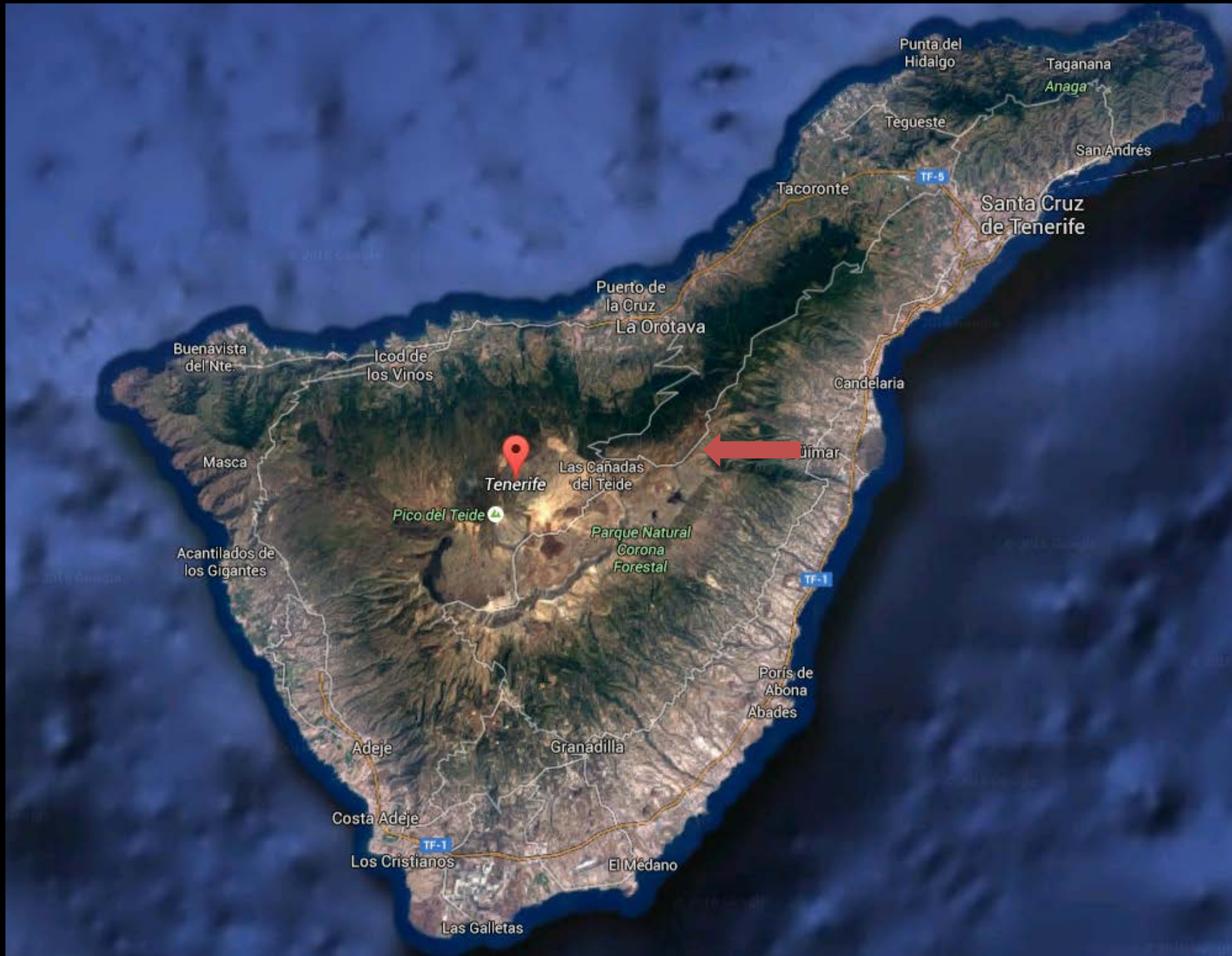
# How to build a SONG site



# Macaronesia













# Inauguration, 25 October 2014





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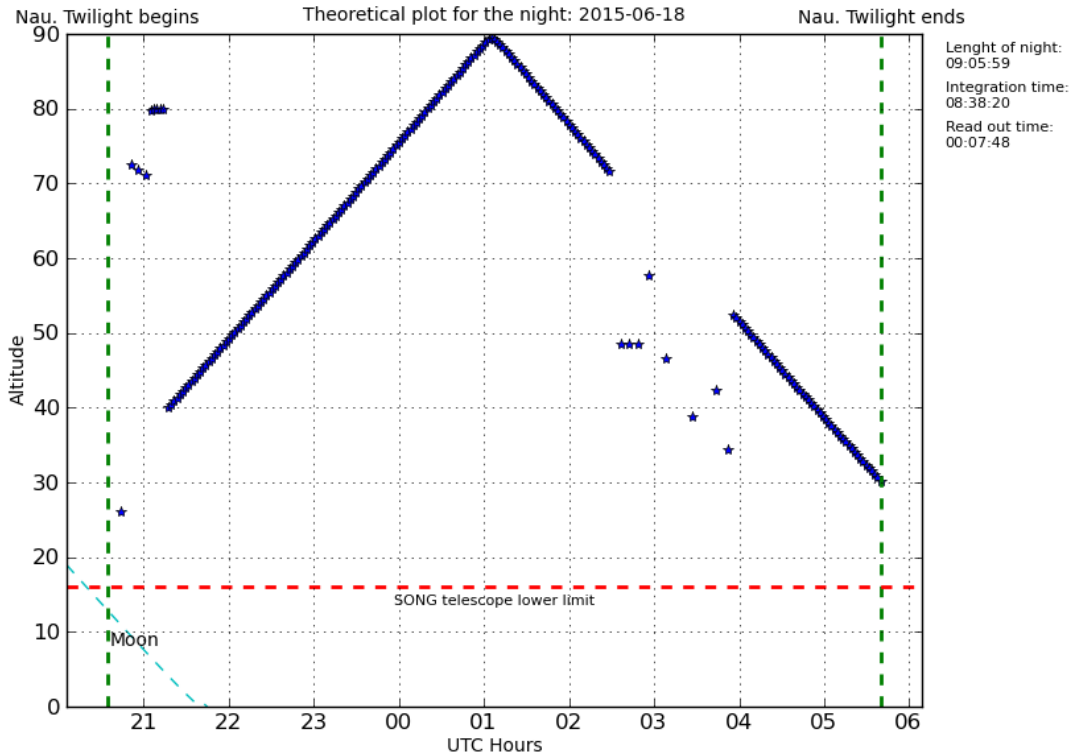
## The Hertzsprung SONG Telescope





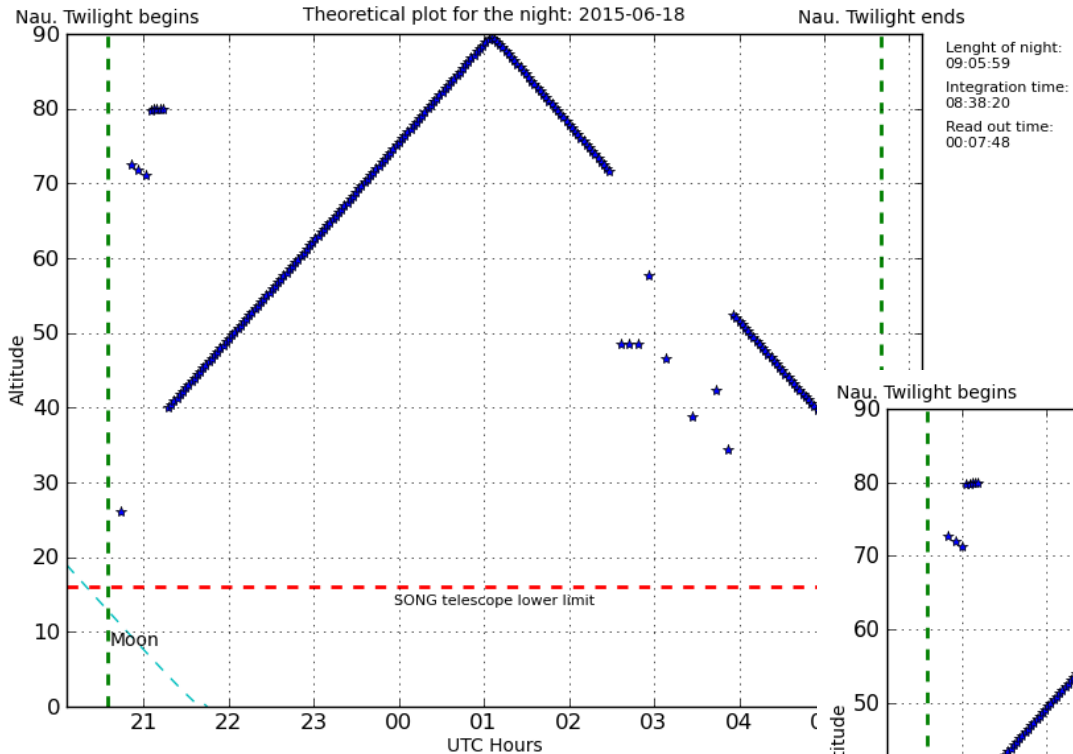
# Robotic operations

## Scheduled observations

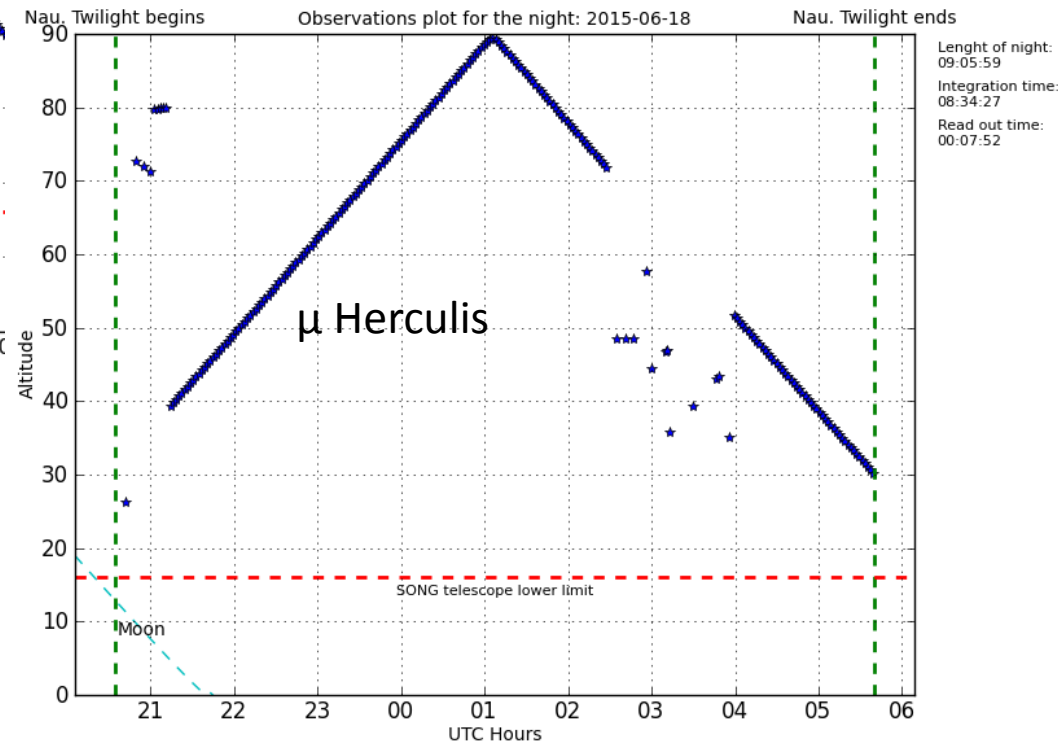


# Robotic operations

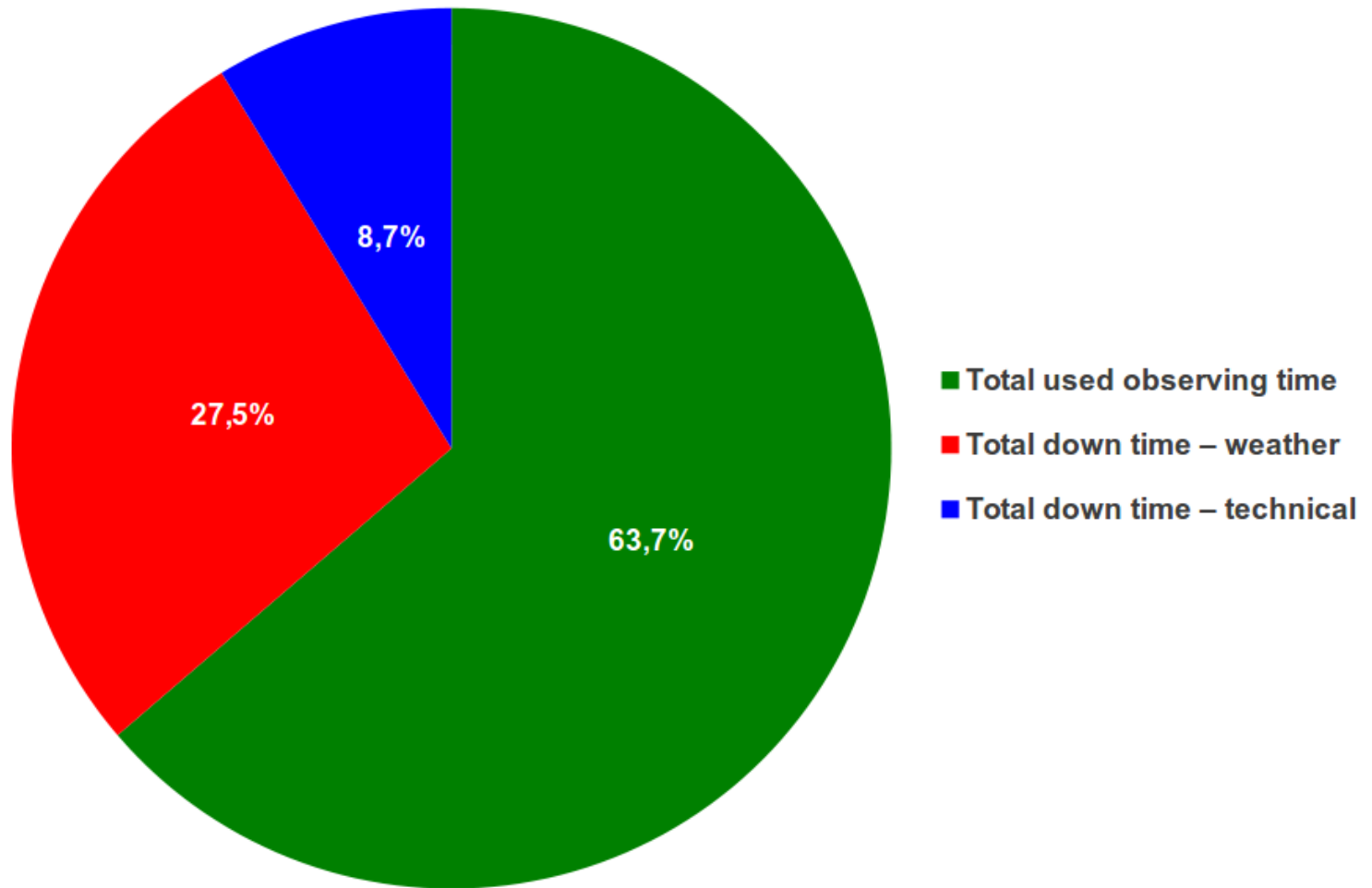
## Scheduled observations



## Achieved observations

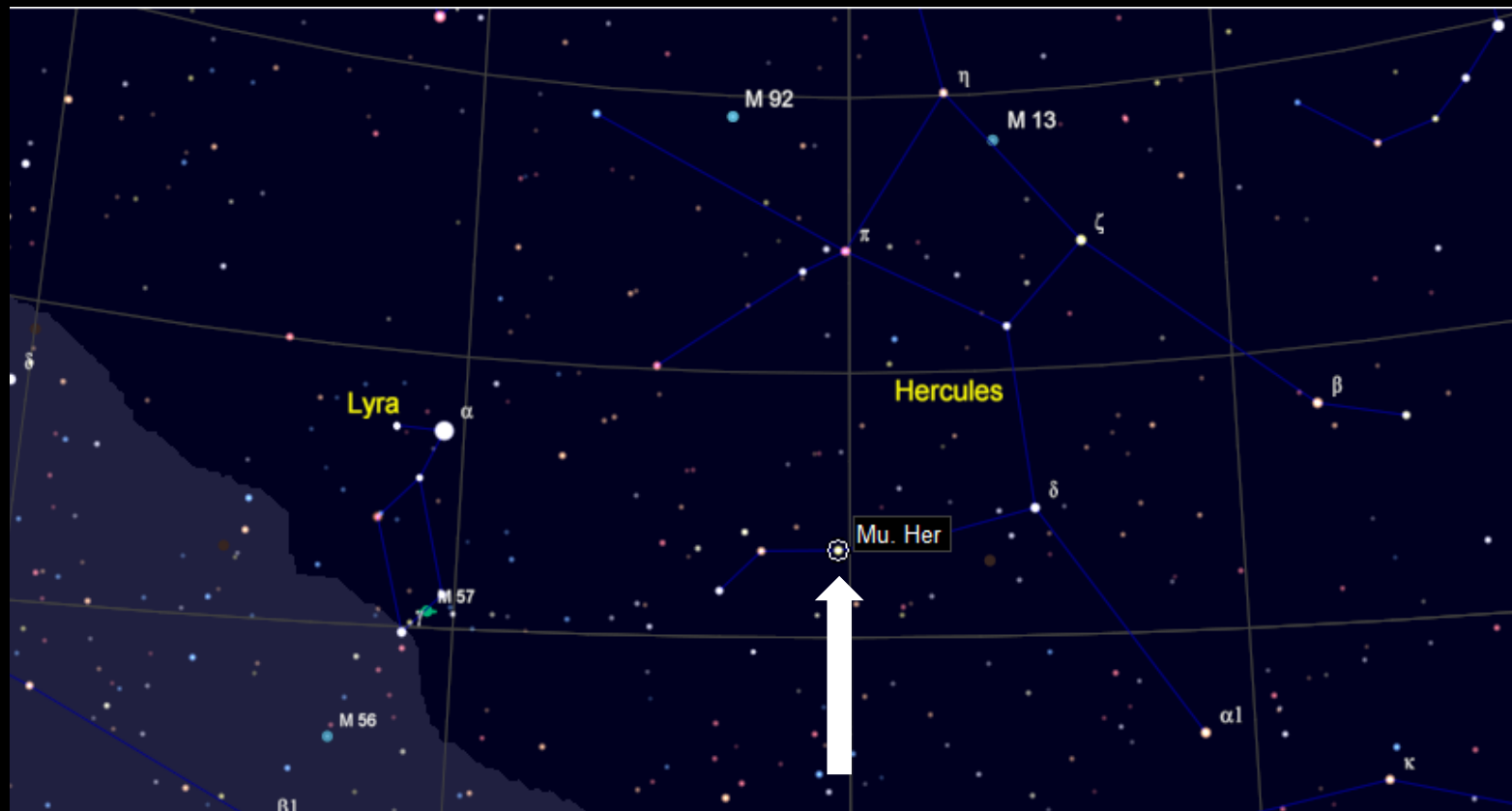


# Operation statistics, 2014 - 2016





# $\mu$ Herculis



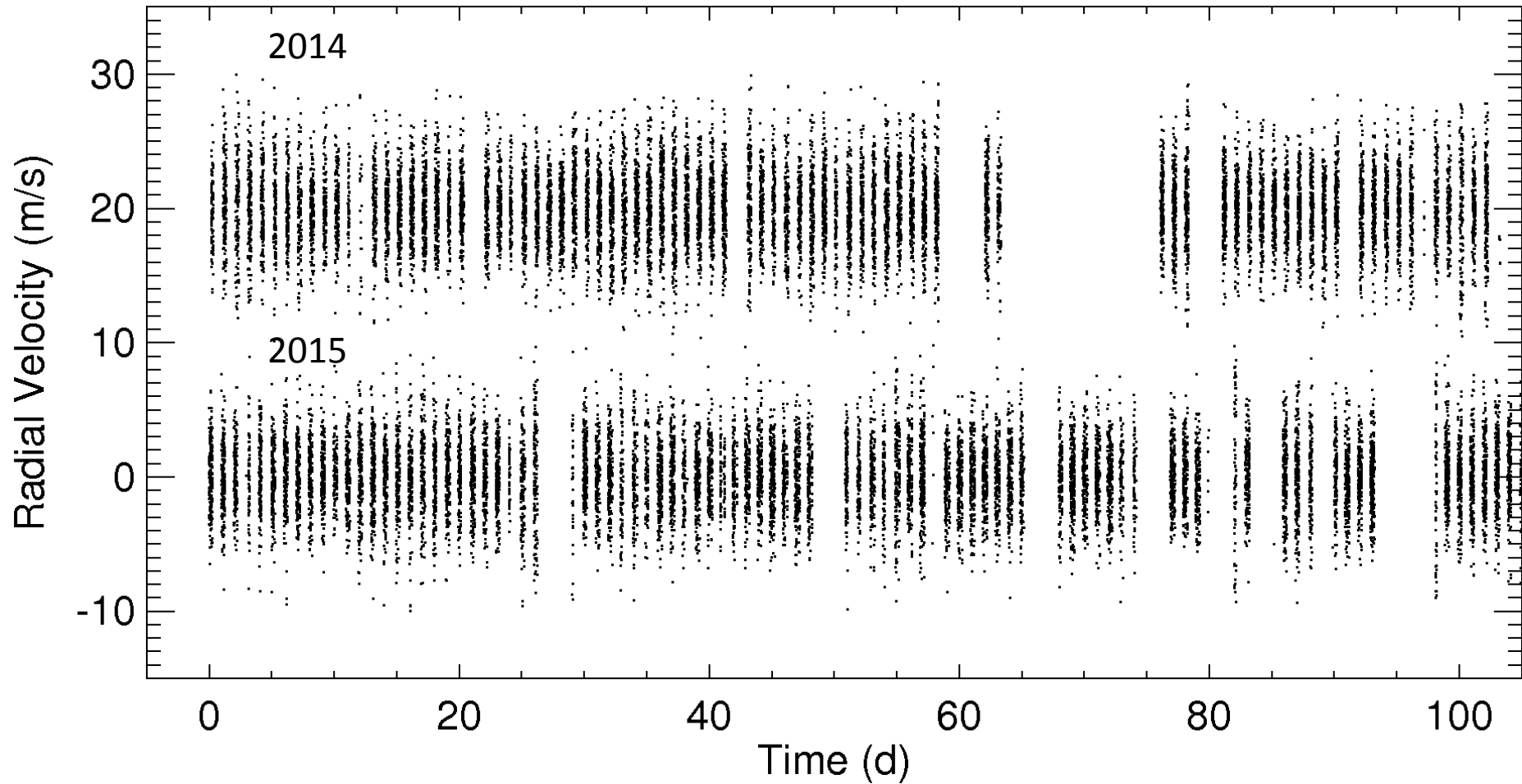
$V = 3.42$

Binary binary

# ‘Classical’ parameters

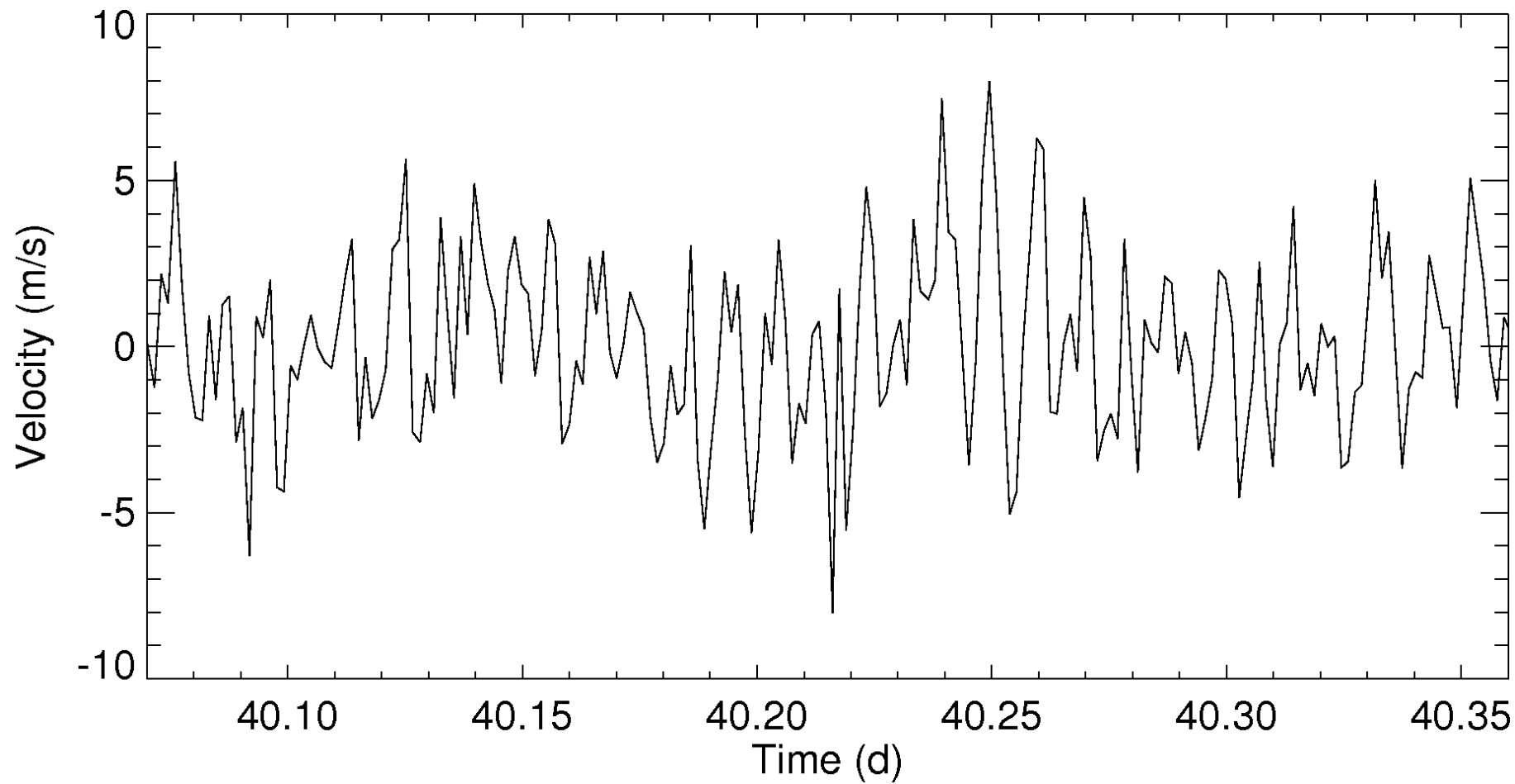
Parameter	Value	Adopted errorbar
$T_{\text{eff}}(\text{K})$	5562	80
$[Fe/H]$	0.28	0.07
$\log g$	3.98	0.1
$v \sin i$	1.73	0.43
Parallax (mas)	120.33	0.16
$\theta_{\text{LD}}(\text{mas})$	1.96	0.03
$R/R_{\odot}$	1.75	0.02
$L/L_{\odot}$	2.64	0.06
$M_V$	3.82	0.03
$M_{\text{Bol}}$	3.73	0.03
Radial velocity	-17.07	0.12

# $\mu$ Herculis observations



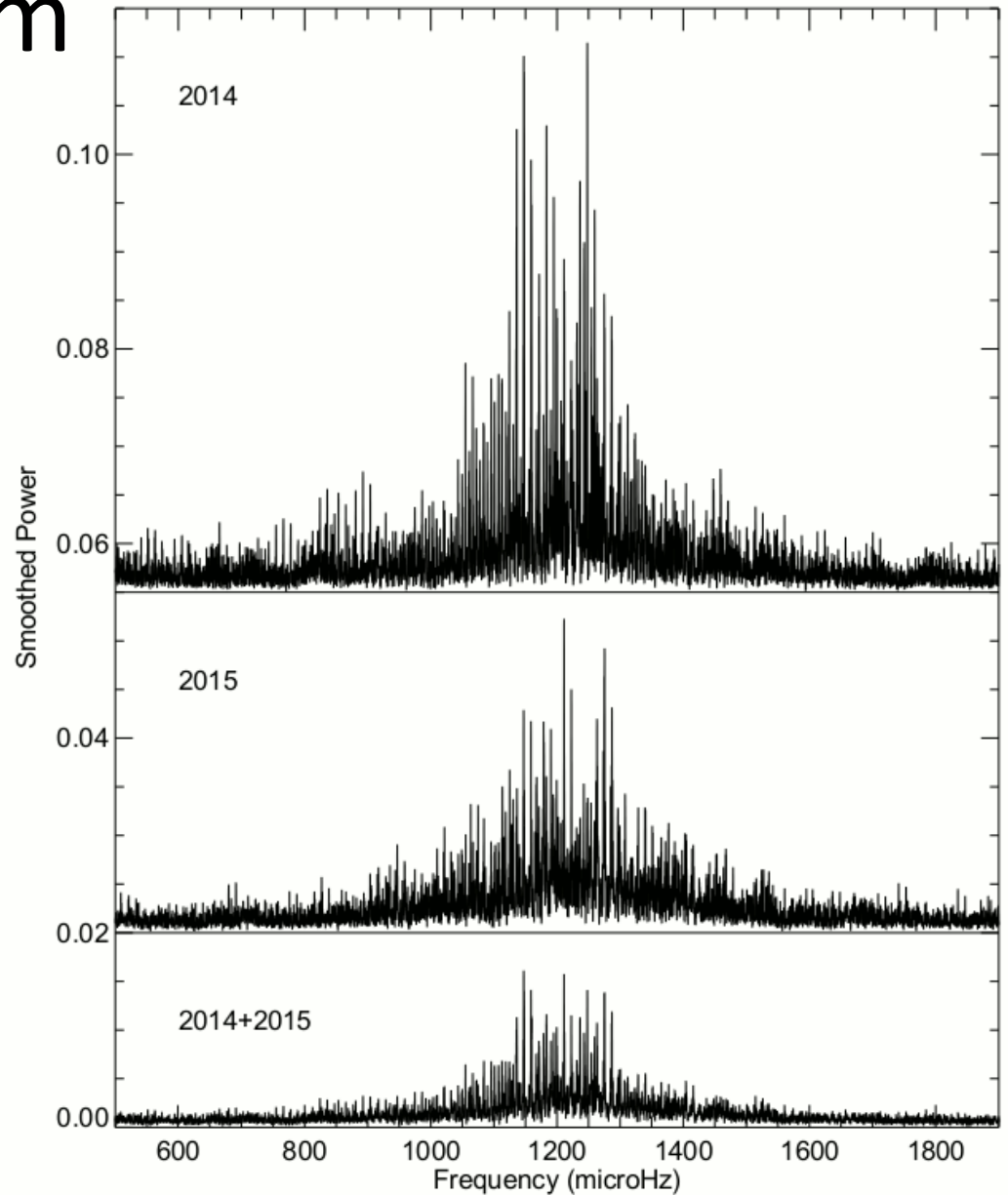


# $\mu$ Herculis observations

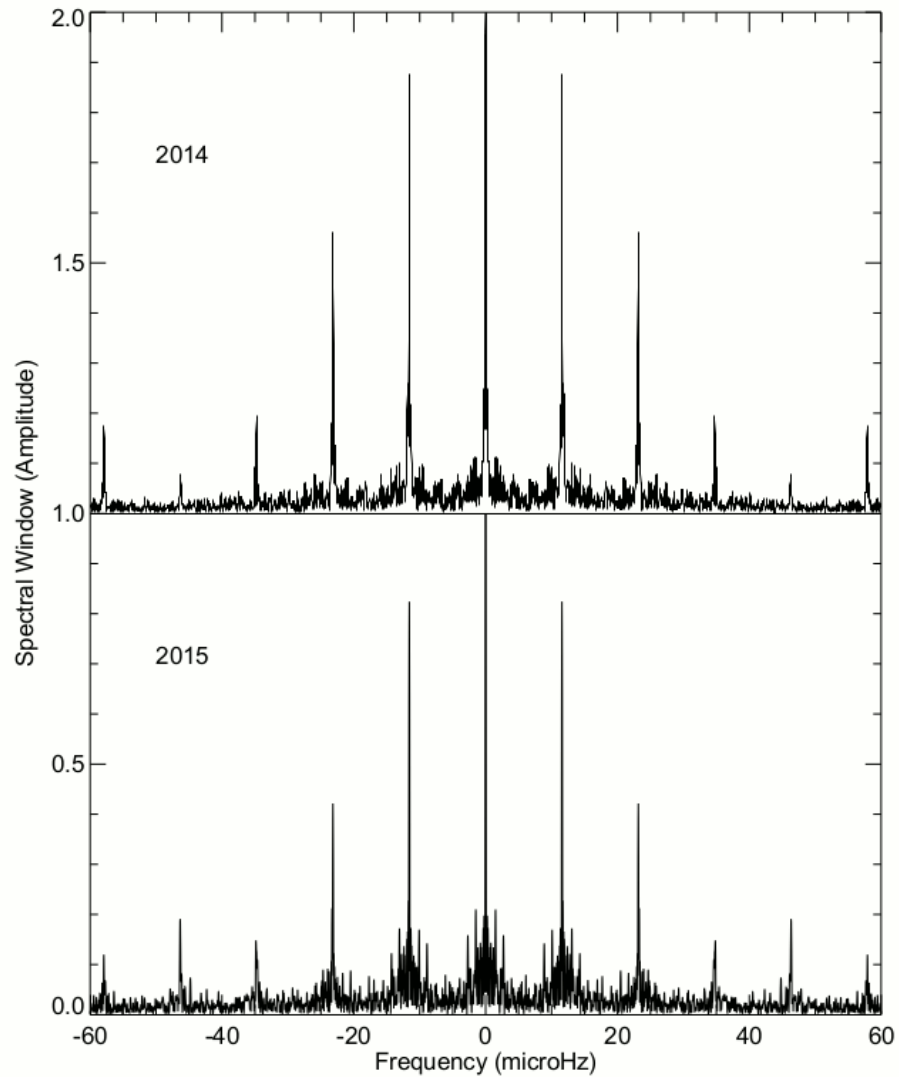


# Power spectrum

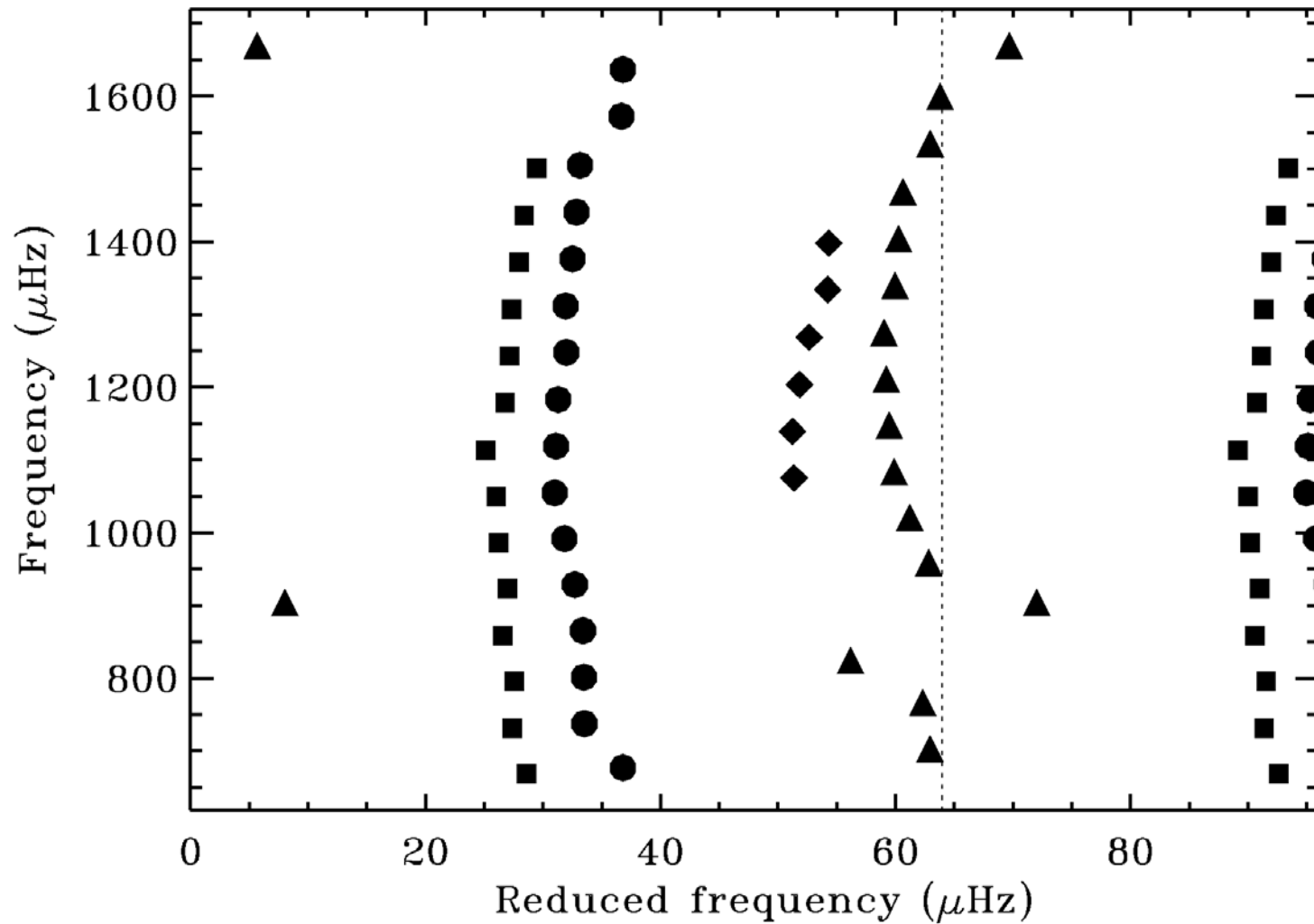
$$\Delta \nu = 64.0 \mu\text{Hz}$$



# Window function



# Observed échelle diagram





# Fitting procedure

- Grid:  $M = 1.0(0.01)1.25 M_{\odot}$ ,  
 $Z = 0.012 - 0.042$ ,  $\Delta Y / \Delta Z \simeq 1.4$

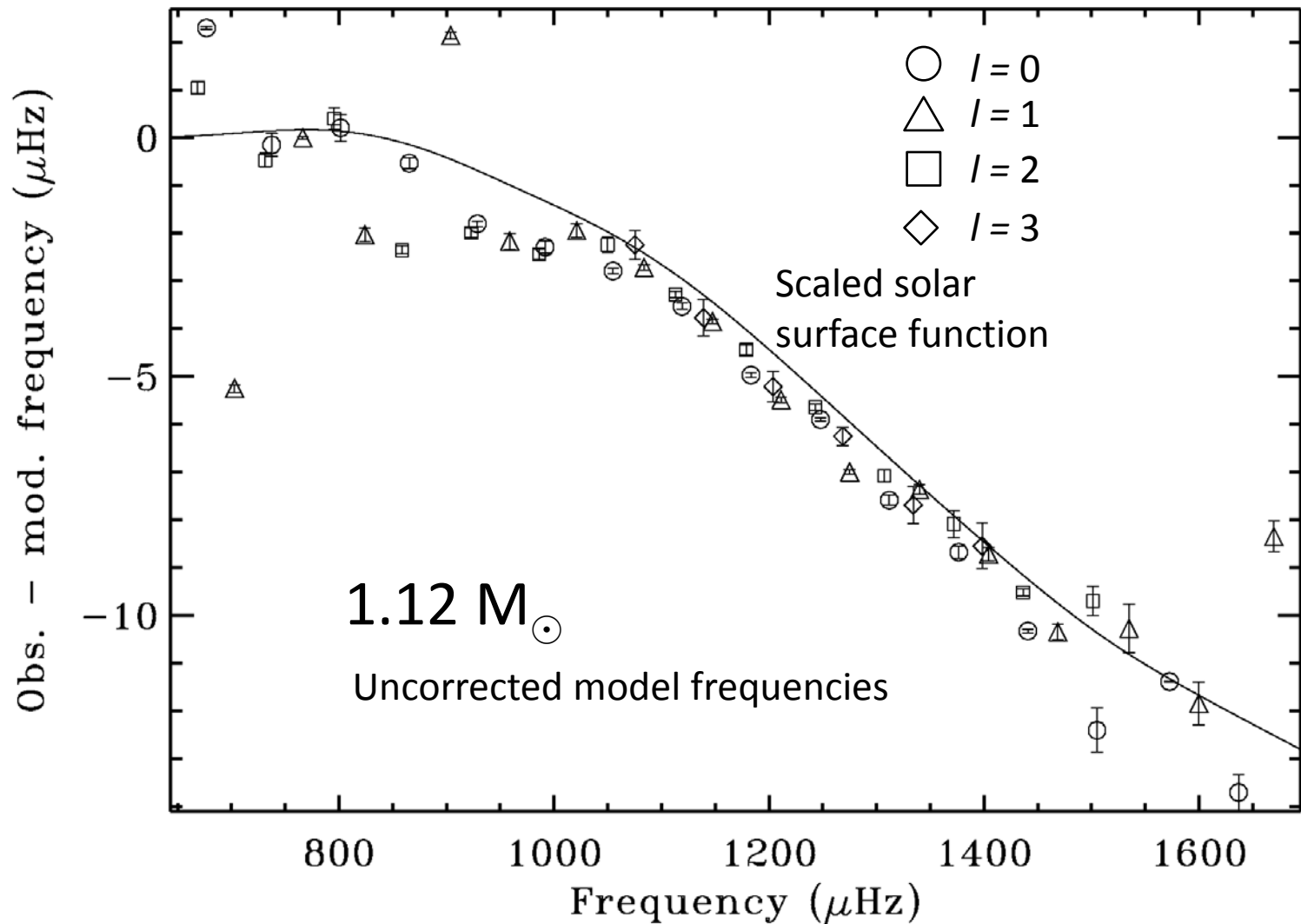
- Minimize  $\chi^2 = \chi_{\text{spec}}^2 + \chi_{\nu}^2$

$$\chi_{\text{spec}}^2 = \left( \frac{T_{\text{eff}}^{(\text{obs})} - T_{\text{eff}}^{(\text{mod})}}{\sigma(T_{\text{eff}})} \right)^2 + \left( \frac{[\text{Fe}/\text{H}]^{(\text{obs})} - [\text{Fe}/\text{H}]^{(\text{mod})}}{\sigma([\text{Fe}/\text{H}])} \right)^2$$

$$\chi_{\nu}^2 = \frac{1}{N-1} \sum_{i=1}^N \left( \frac{\nu_i^{(\text{obs})} - \nu_i^{(\text{mod})}}{\sigma(\nu_i)} \right)^2$$

- Scaled solar surface term

# Fit to observed frequencies

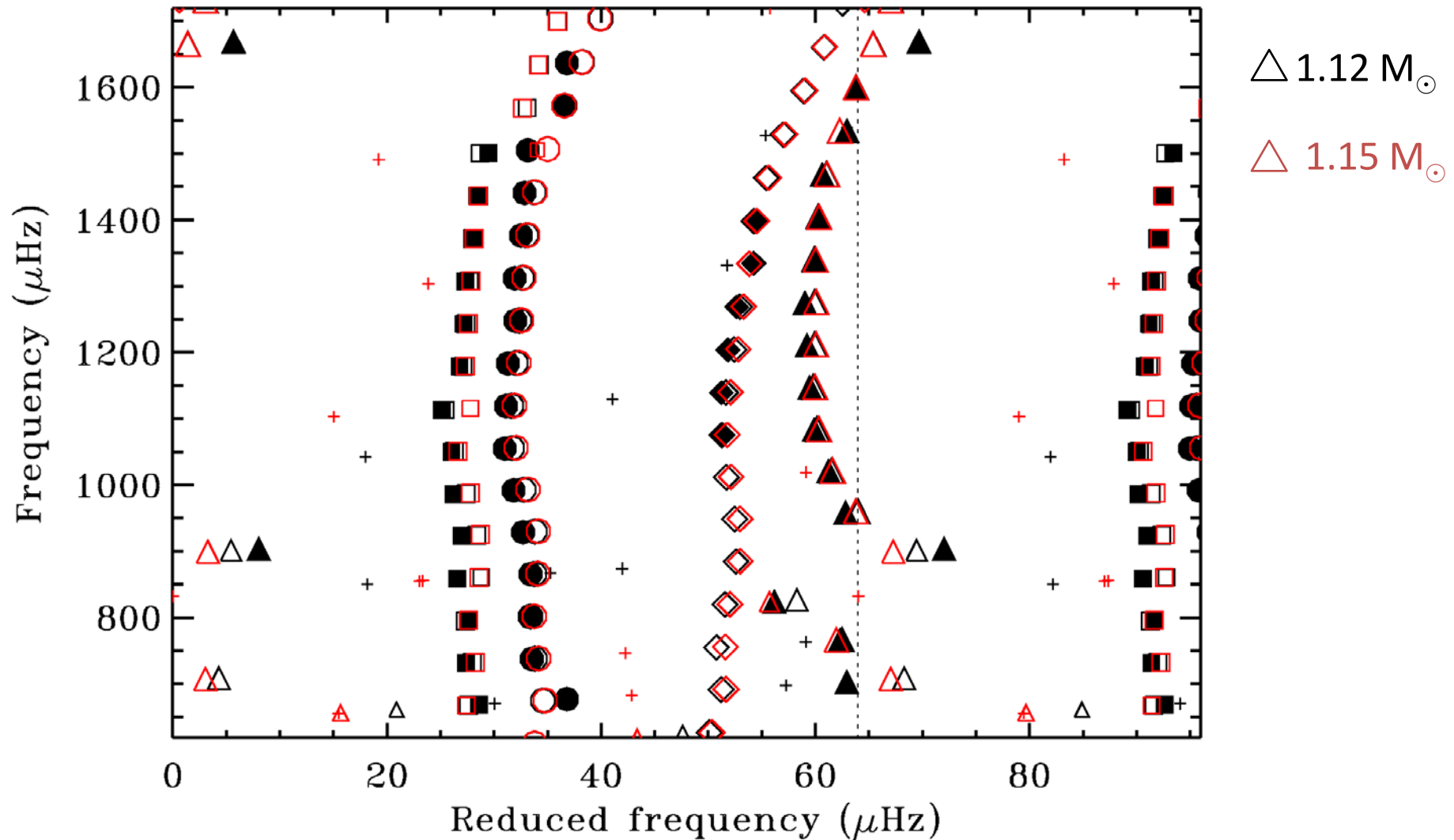


# Results of fits

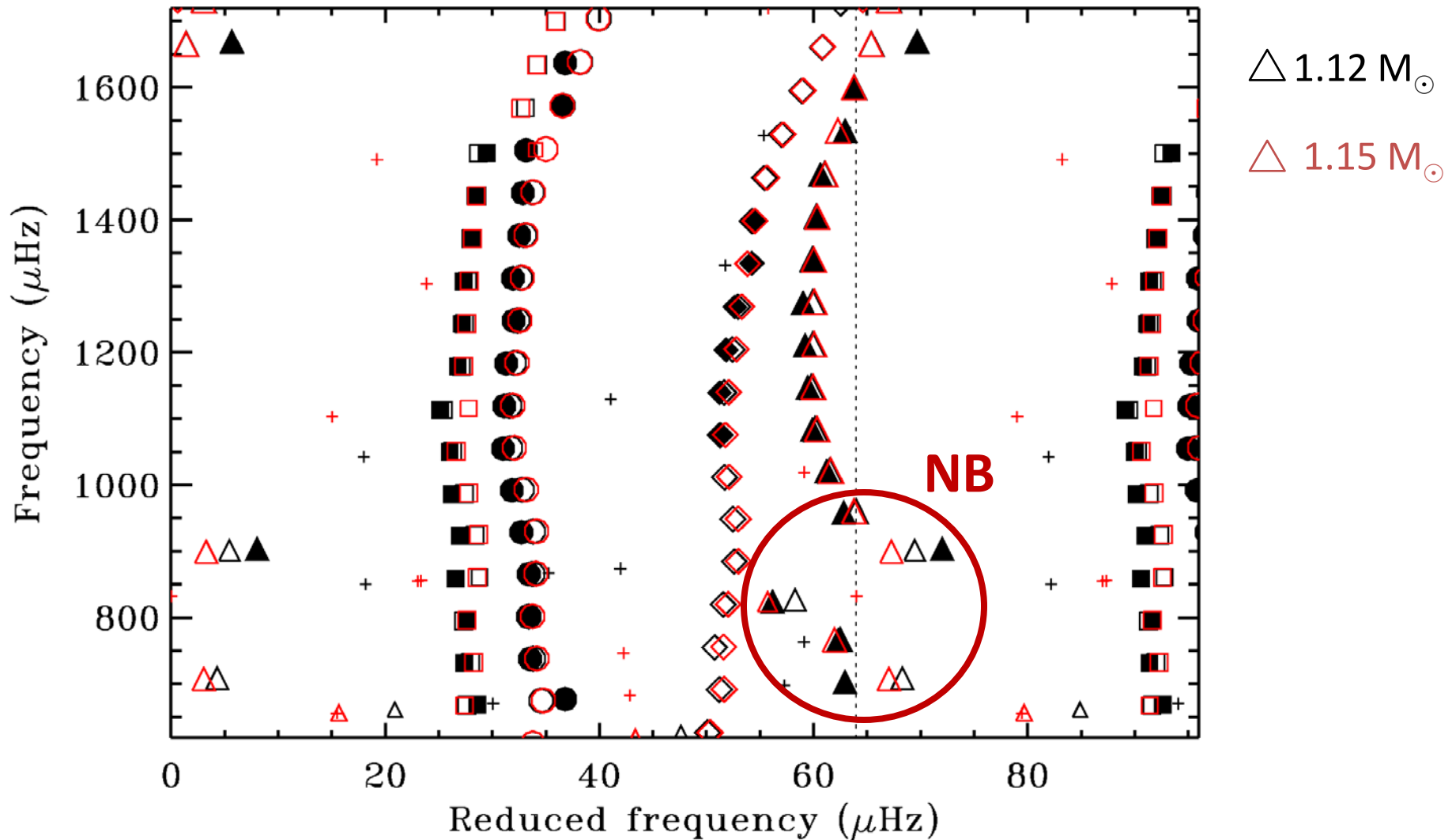
Model	$M / M_{\odot}$	$R / R_{\odot}$	$L / L_{\odot}$	$T_{\text{eff}}$ (K)	[Fe/H]	Age (Gyr)
ASTFIT1	1.12	1.712	2.679	5649	0.255	7.63
ASTFIT2	1.15	1.727	2.620	5592	0.296	7.86
BASTA*	$1.11^{+0.01}_{-0.01}$	$1.710^{+0.012}_{-0.015}$	$2.595^{+0.104}_{-0.140}$	$5601^{+52}_{-52}$	$0.208^{+0.056}_{-0.056}$	$7.79^{+0.34}_{-0.37}$
Obs.		$1.727 \pm 0.024$	$2.54 \pm 0.08$	$5562 \pm 80$	$0.28 \pm 0.07$	

\* Only acoustic modes

# ‘Well-fitting’ models

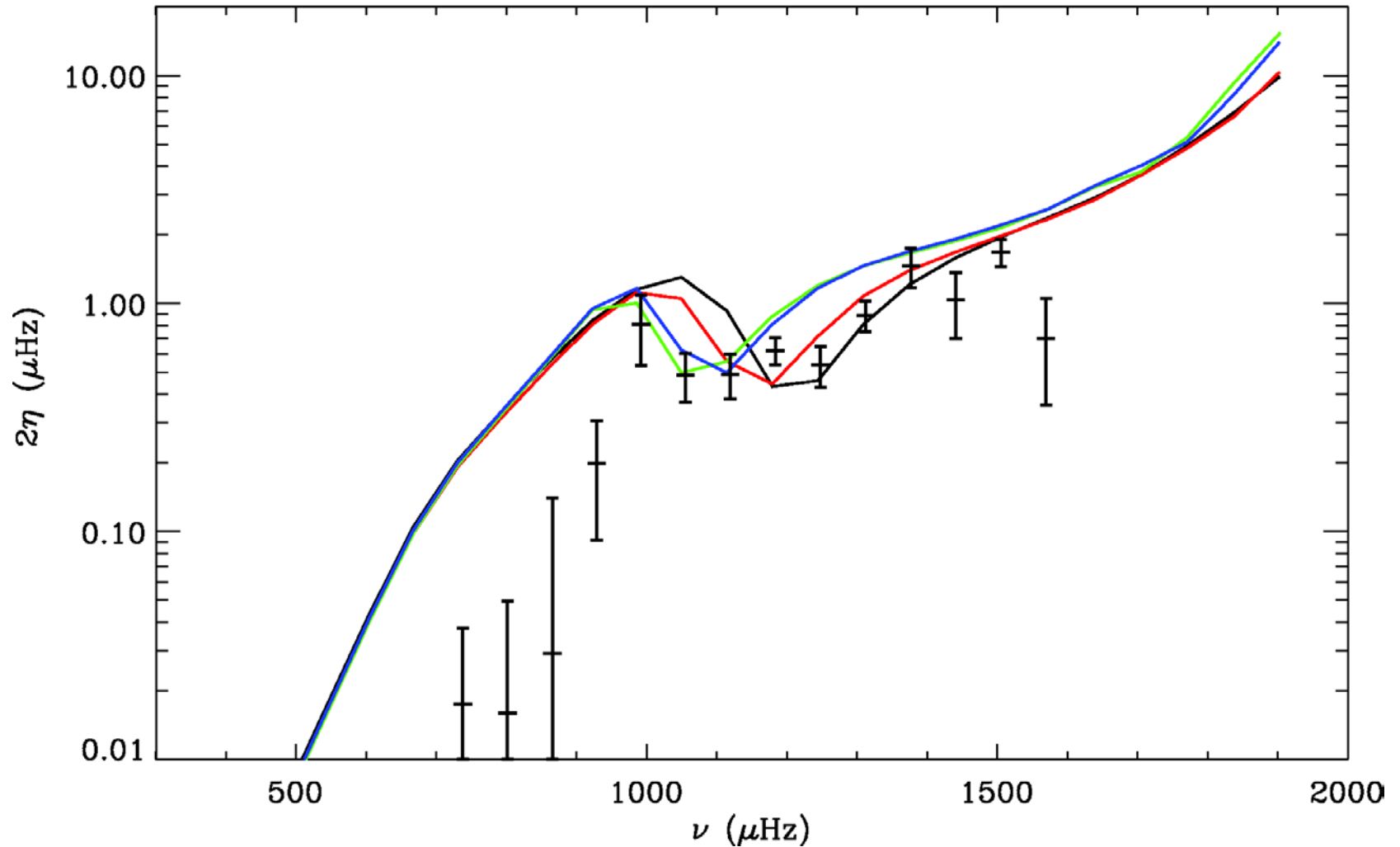


# ‘Well-fitting’ models



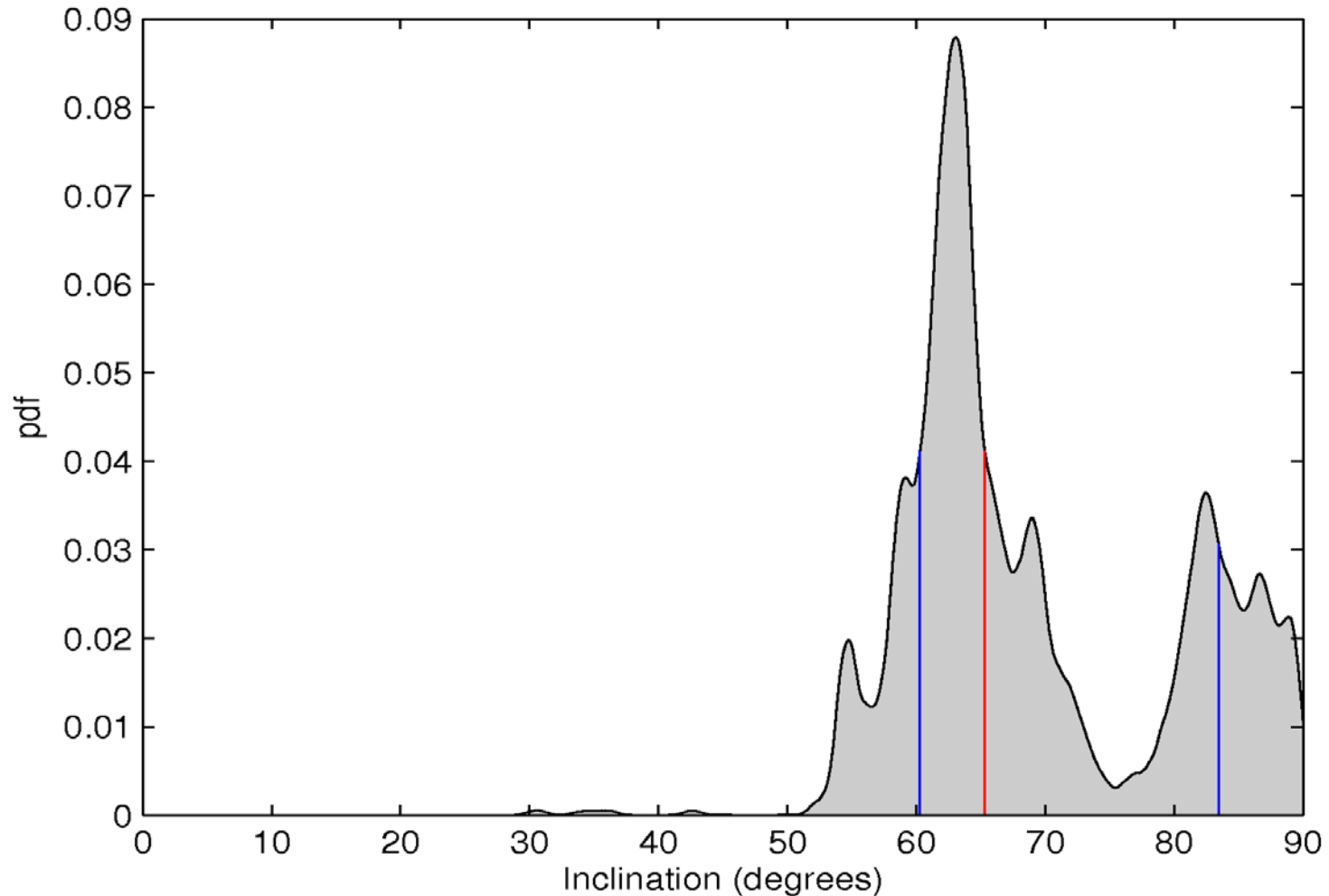


# Observed and modelled linewidths



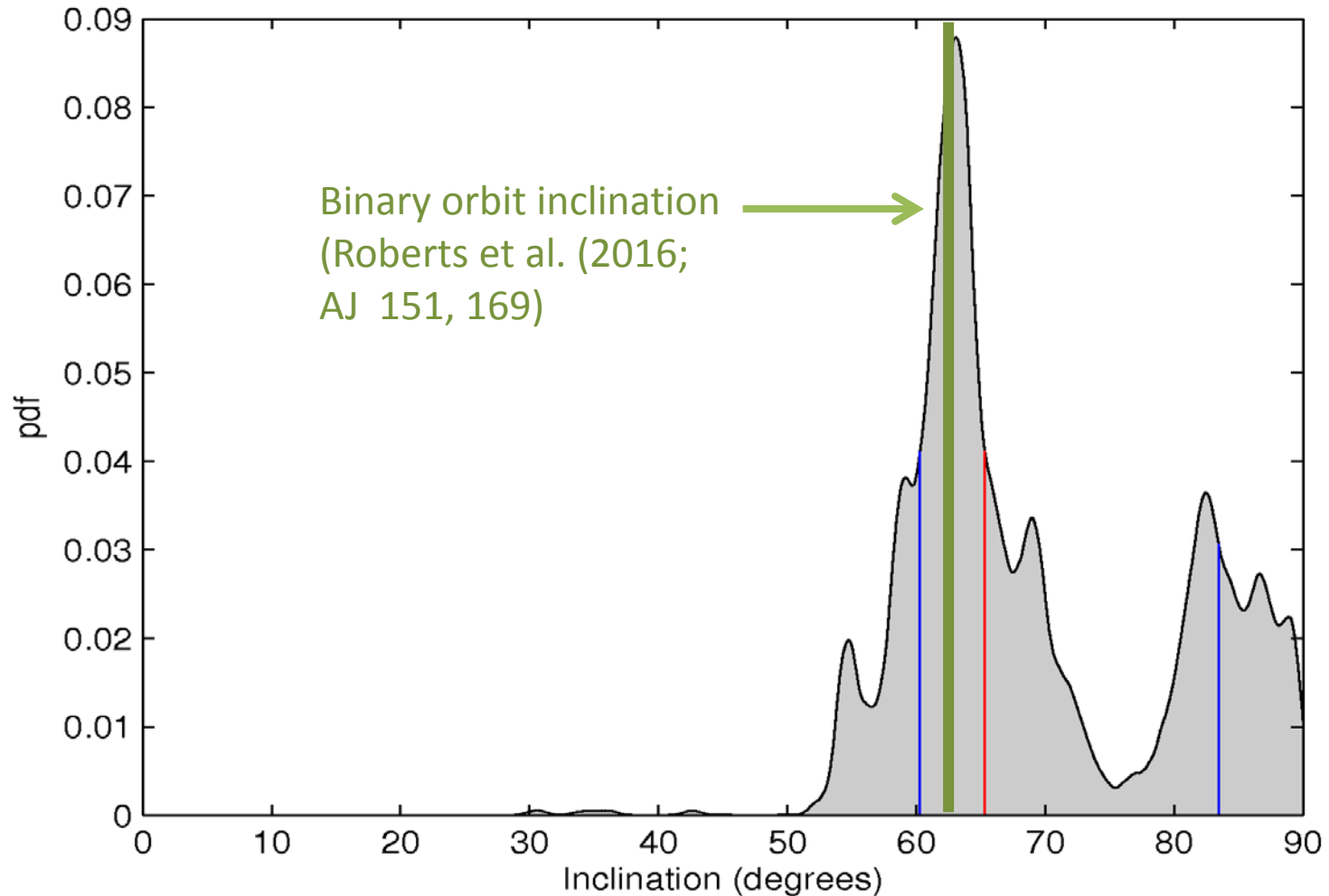
Modelling: Günter Houdek

# Inclination of rotation axis



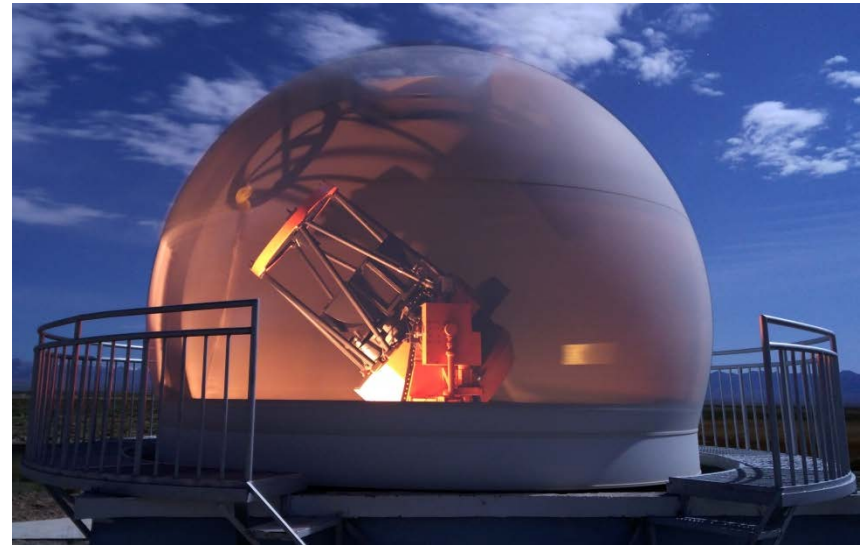
MCMC analysis: Rasmus Handberg

# Inclination of rotation axis



# What is next?

- Another 100 nights with  $\mu$  Herculis
- Chinese node becoming operational



- SONG node no 3, 4, .... **Who is next!**