XKCD: Time (frame 2395)
http://xkcd.com/1190/

Parallaxes at 1.6 GHz

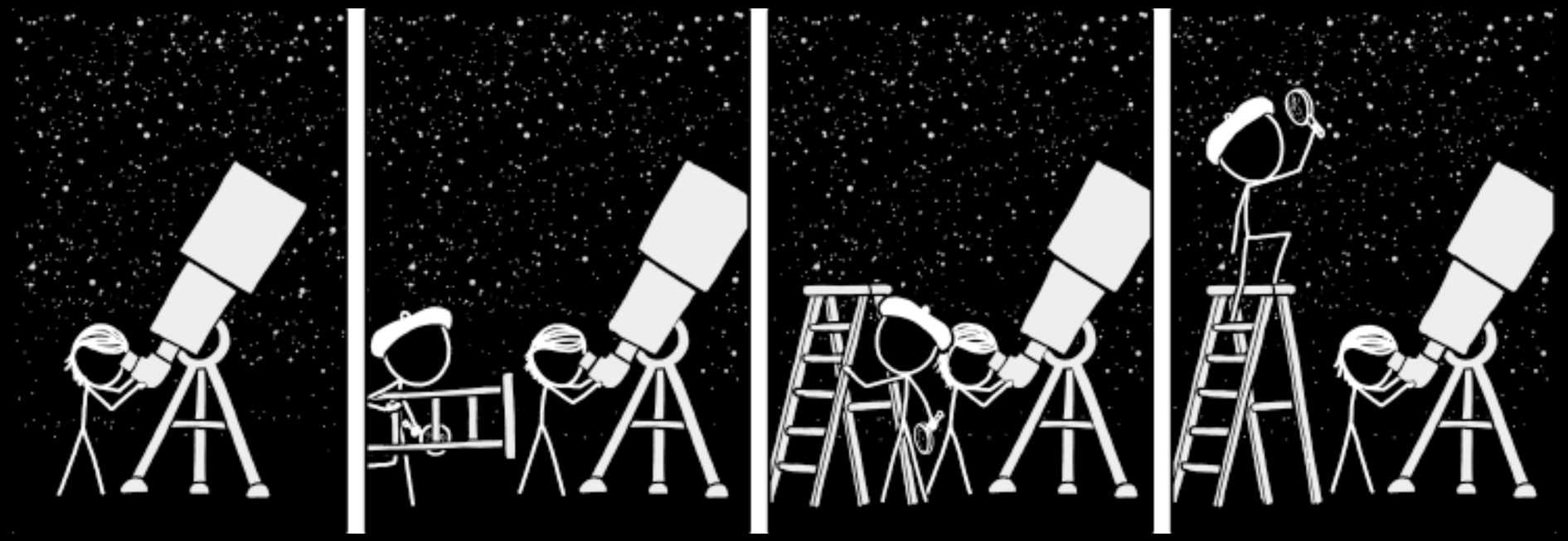
OH maser and AGBs (:
aka
“why should we care about the SKA?”

Gabor Orosz
Kagoshima University
Kagoshima, Japan

2016.10.04.
“VERA”UM14
Mitaka, Tokyo, Japan

Thank you for the financial support!

XKCD: Astronomy
http://xkcd.com/1522/



Hiroshi Imai

Maria Rioja

Richard Dodson

Sandor Frey

Akiharu Nakagawa

Ross Burns

Dieter Engels

Sandra Etoka

Steve Goldman

Ambra Nanni

Paola Marigo

Daniel Tafoya

Yoshiharu Asaki

Hiroyuki Nakanishi

A motivational speech

A motivational speech

Why care about

low frequencies?

A motivational speech

Why care about

low frequencies?

Why care about

OH masers?

A motivational speech

Why care about

low frequencies?

Why care about

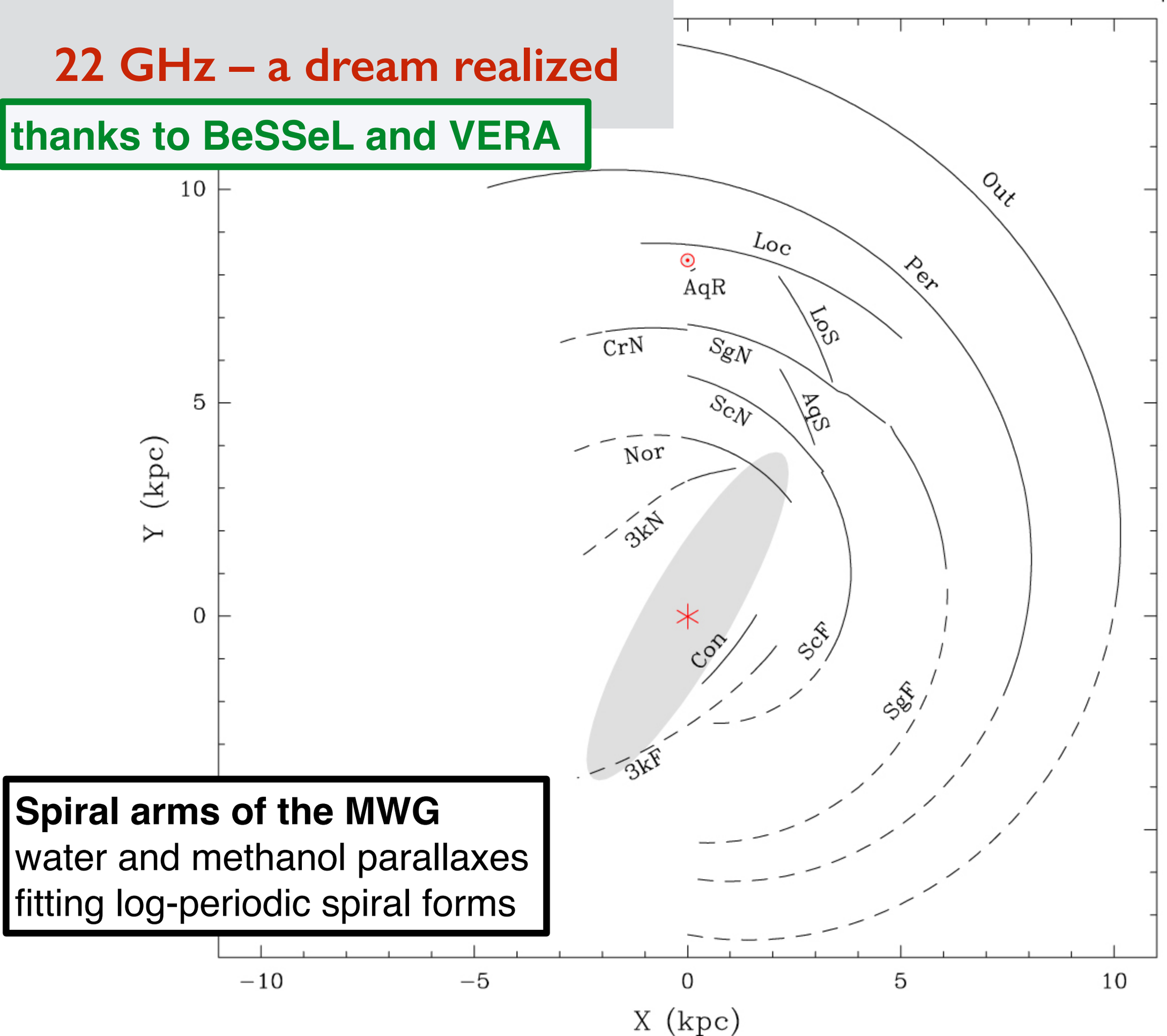
OH masers?

Why care about

old stars?

22 GHz – a dream realized

thanks to BeSSeL and VERA

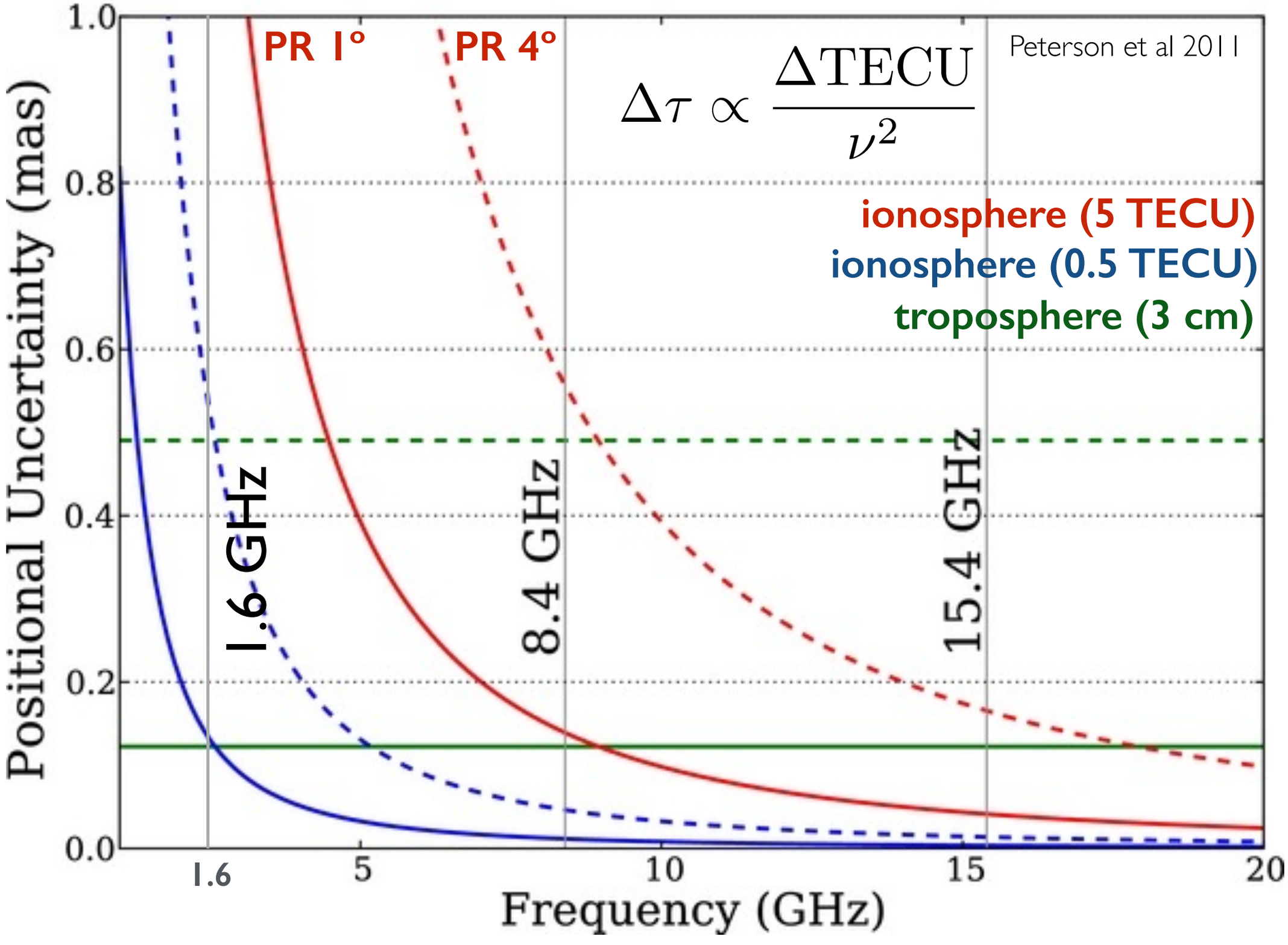


Spiral arms of the MWG
water and methanol parallaxes
fitting log-periodic spiral forms

Reid et al 2016

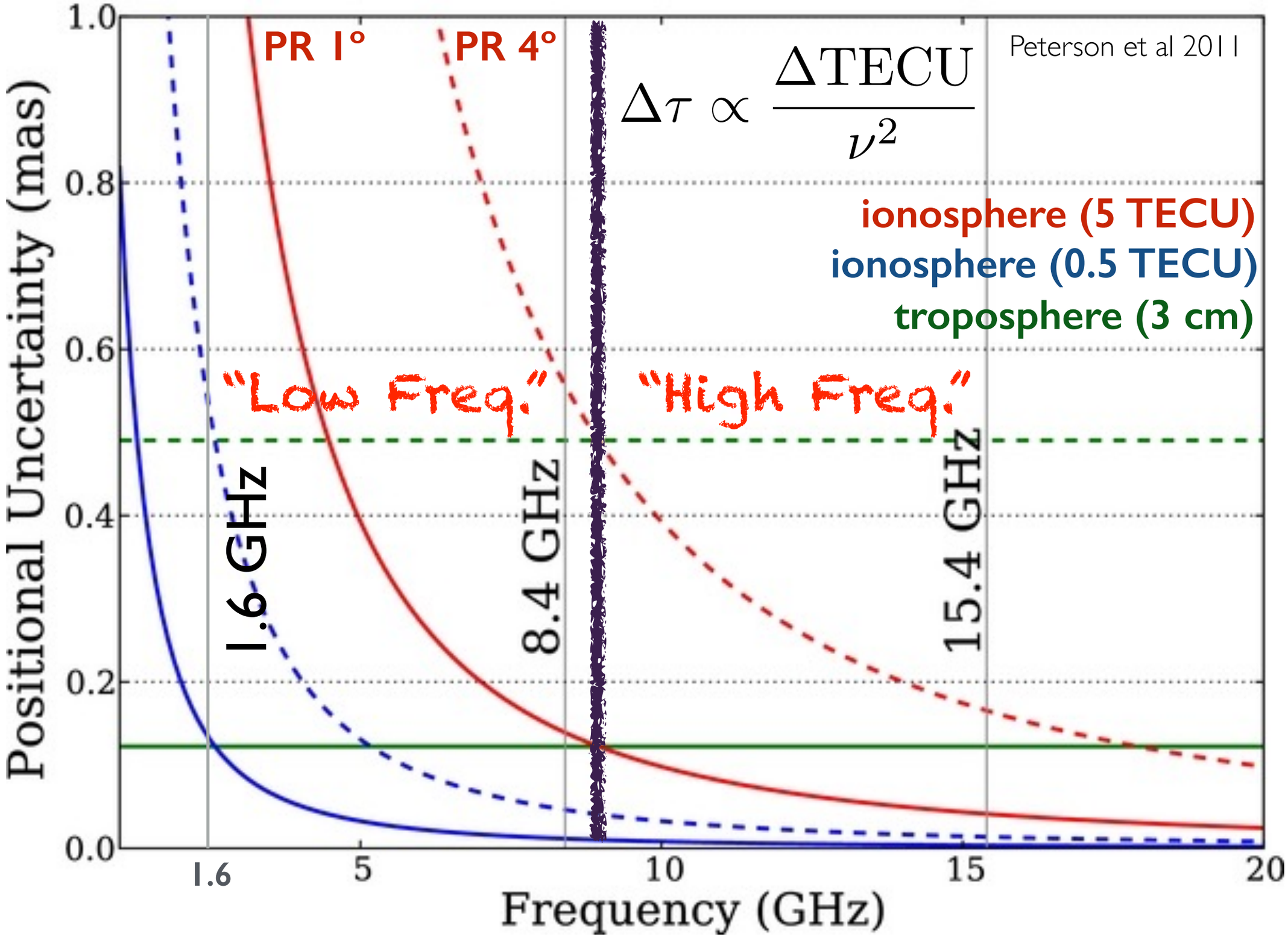
The challenge of low frequency phase-referencing

The dispersive ionosphere!



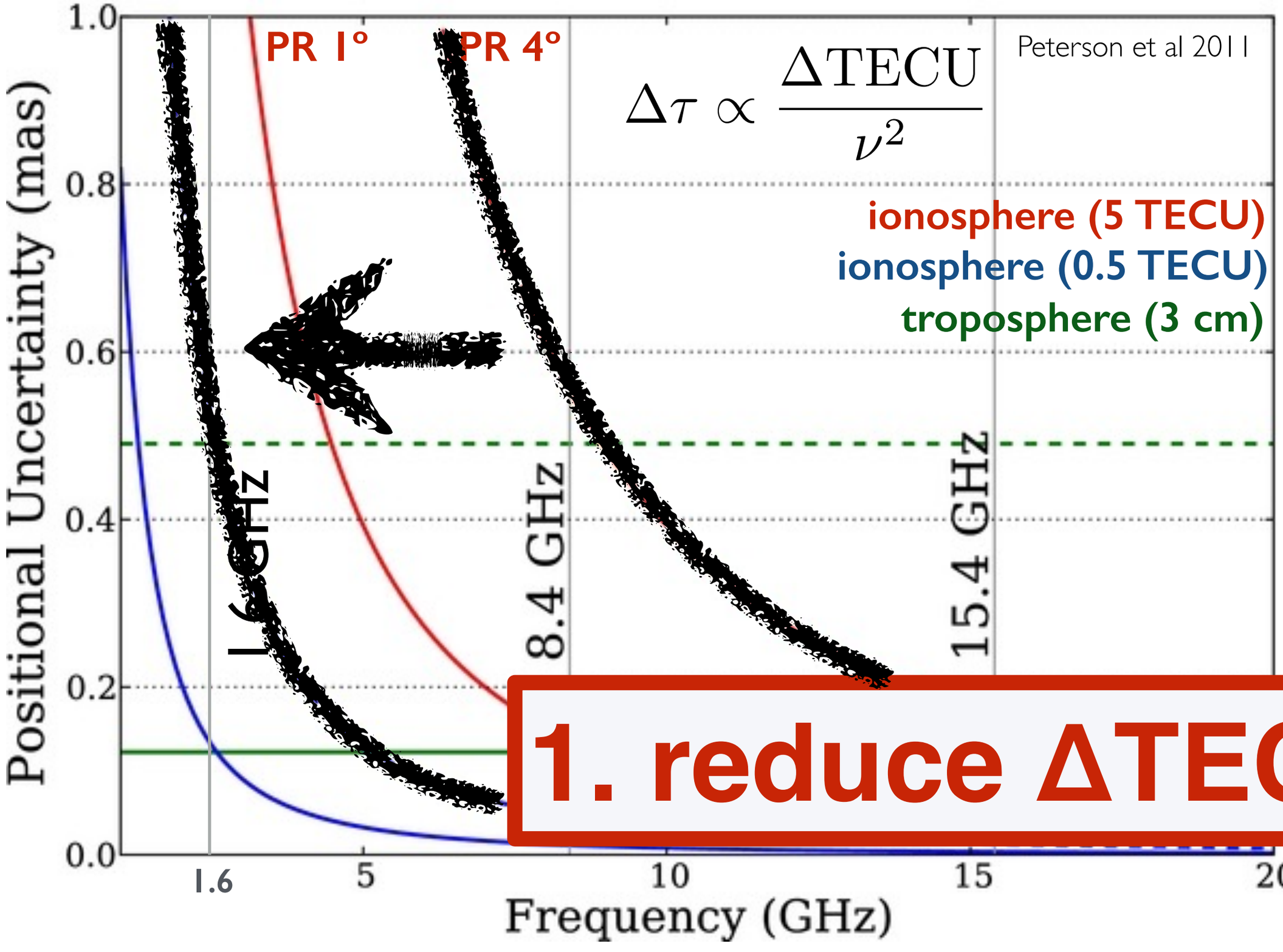
The challenge of low frequency phase-referencing

The dispersive ionosphere!



The challenge of low frequency phase-referencing

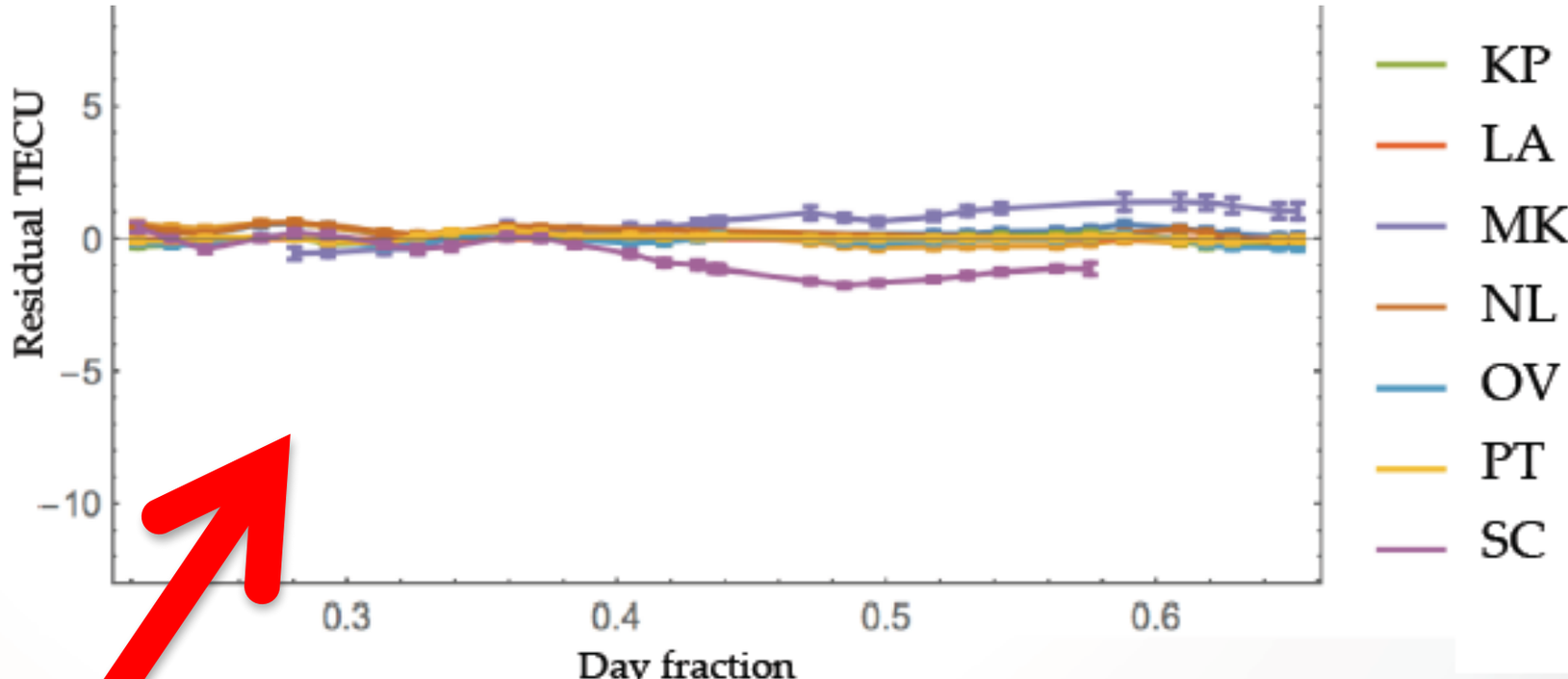
The dispersive ionosphere!



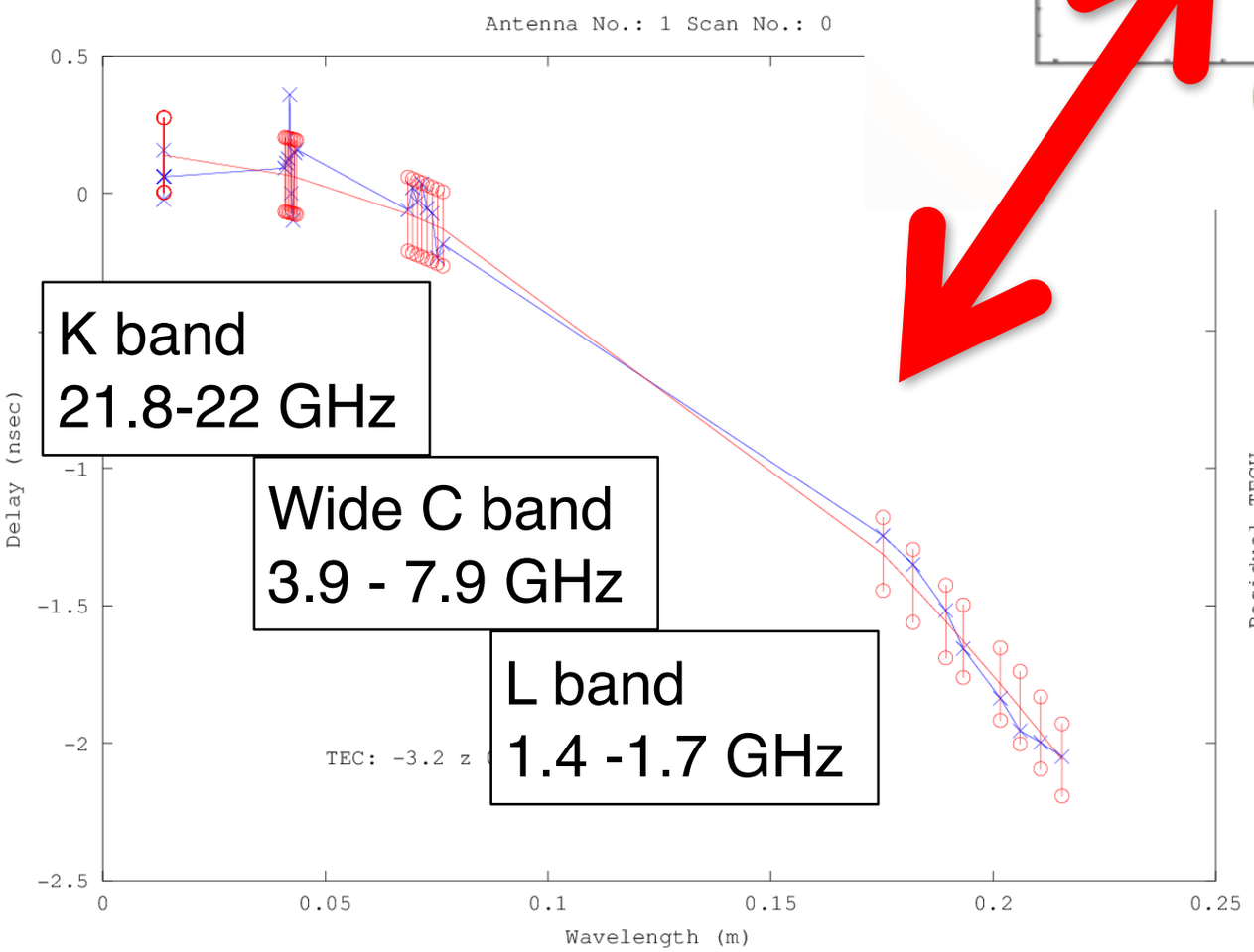
1. reduce ΔTECU

Multi-freq phase-ref (from Richard Dodson) – BL Lac

Solve for delays (per IF) across all frequencies



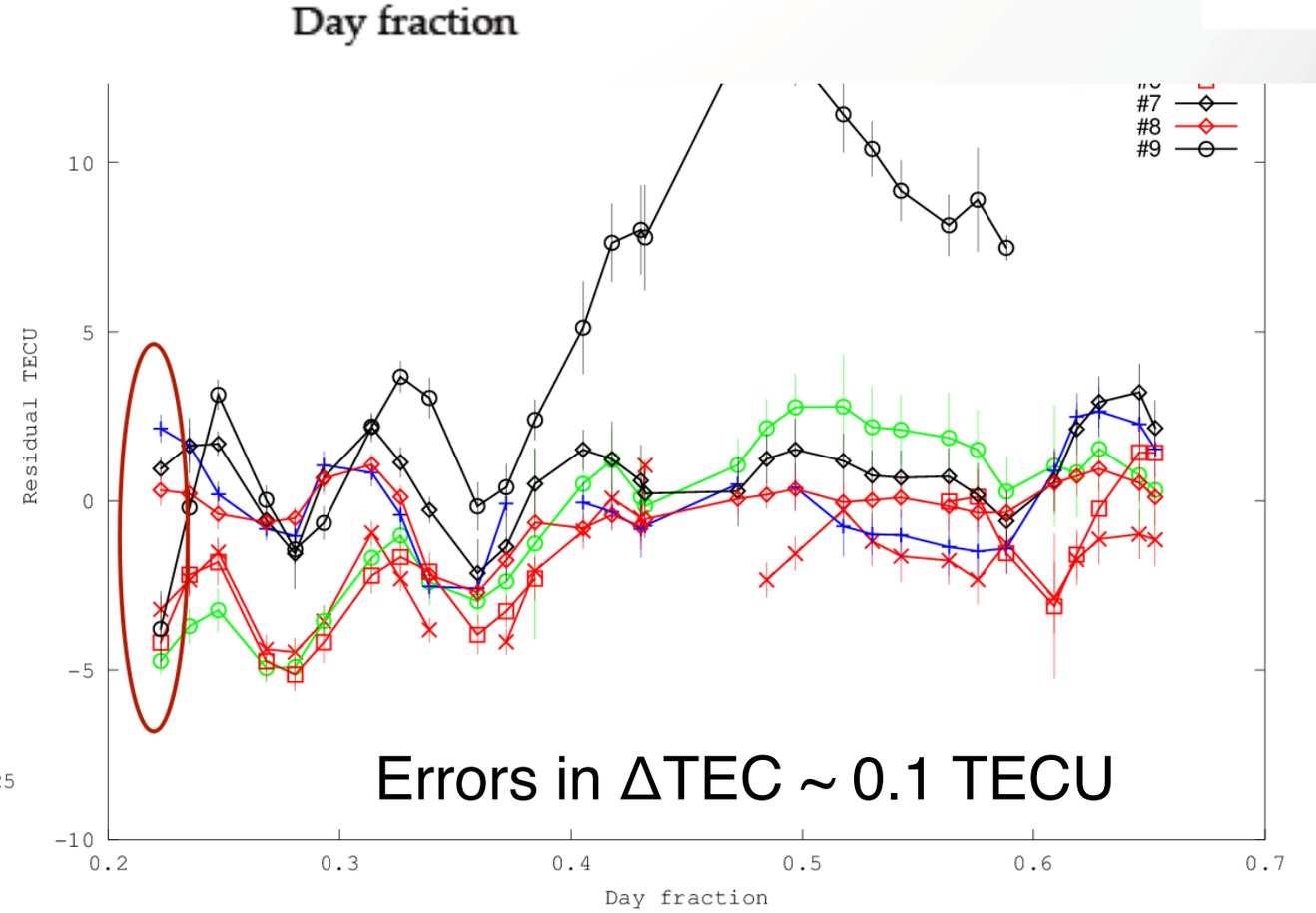
TEC from τ



K band
21.8-22 GHz

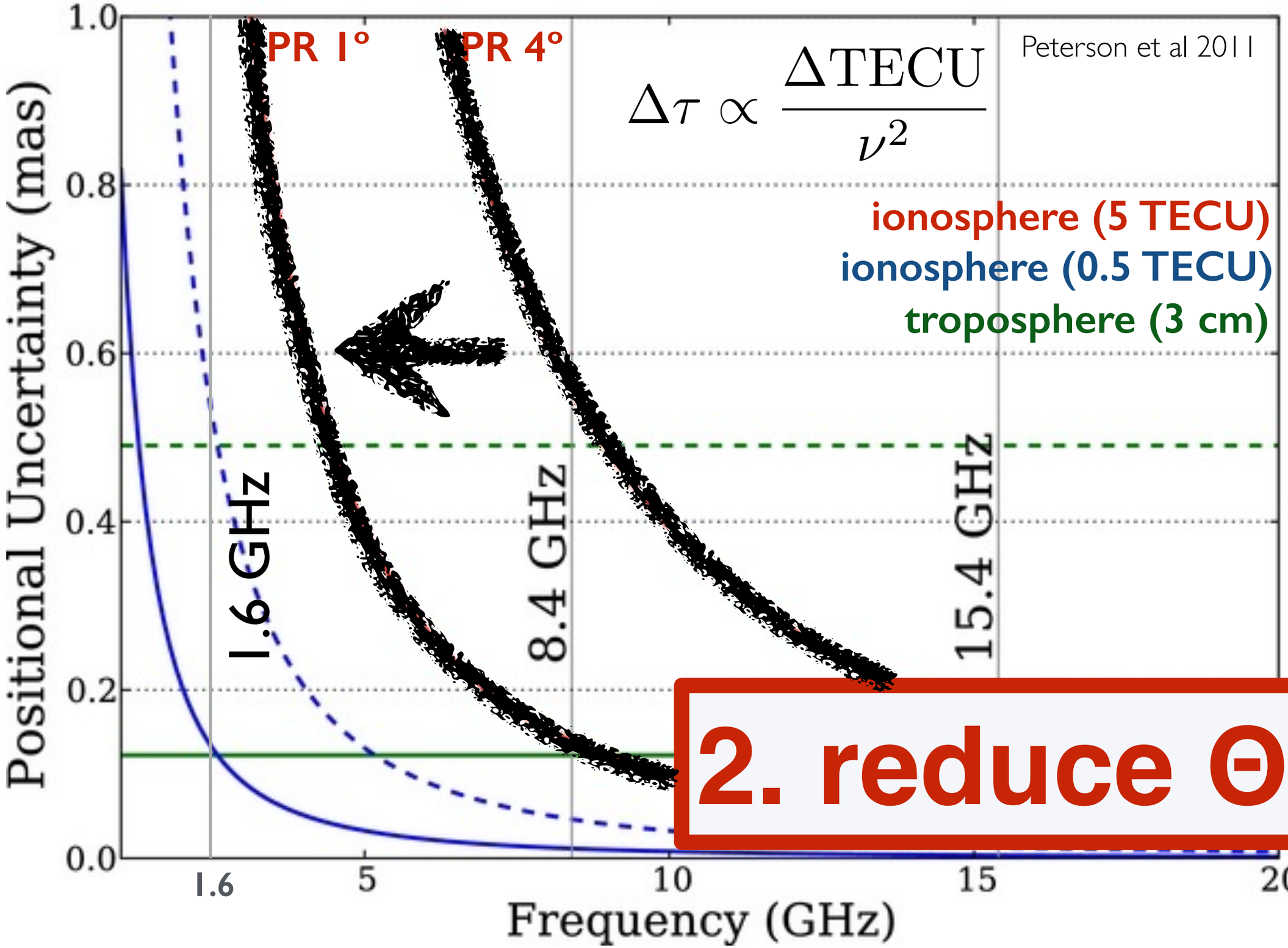
Wide C band
3.9 - 7.9 GHz

L band
1.4 -1.7 GHz



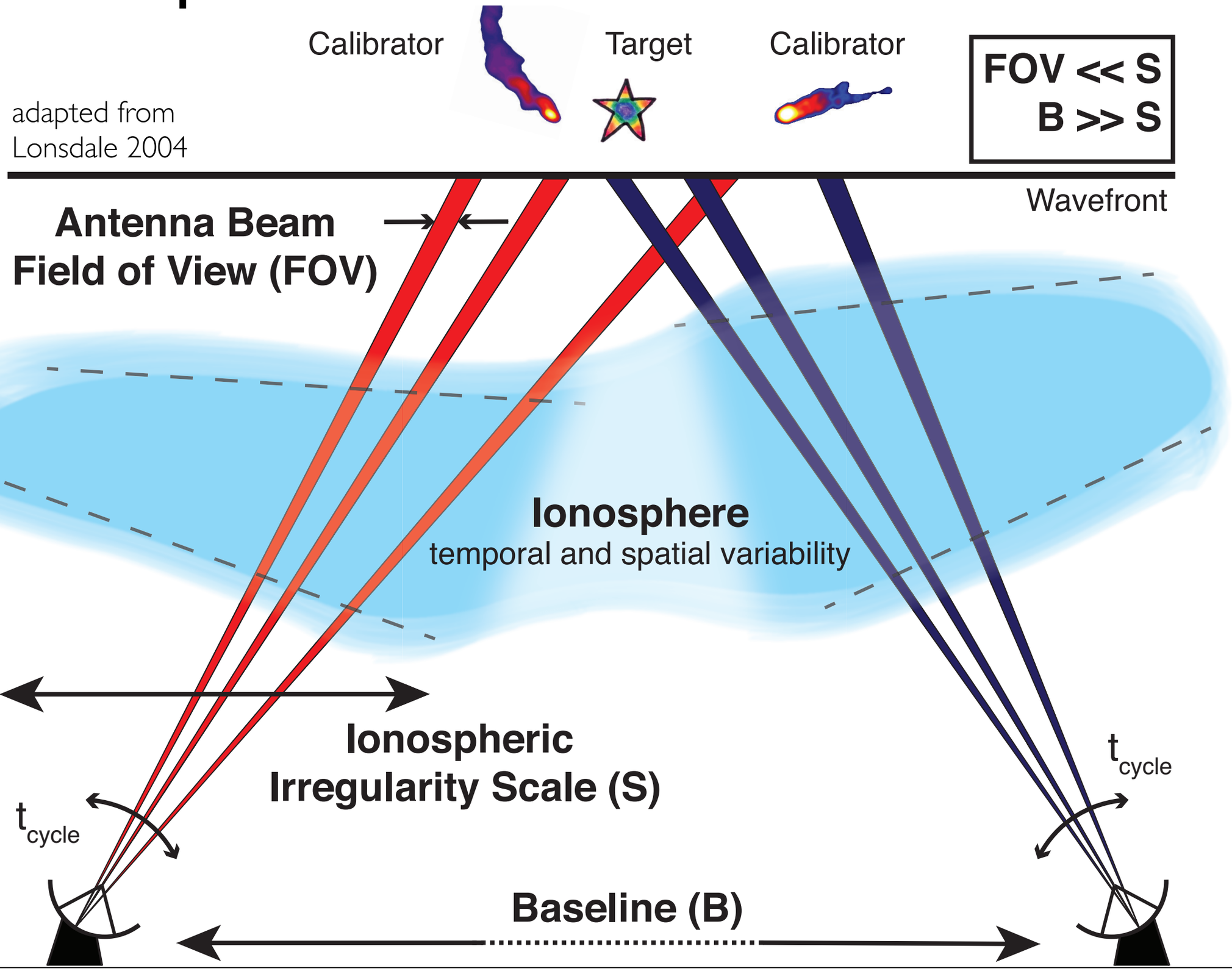
The challenge of low frequency phase-referencing

The dispersive ionosphere!

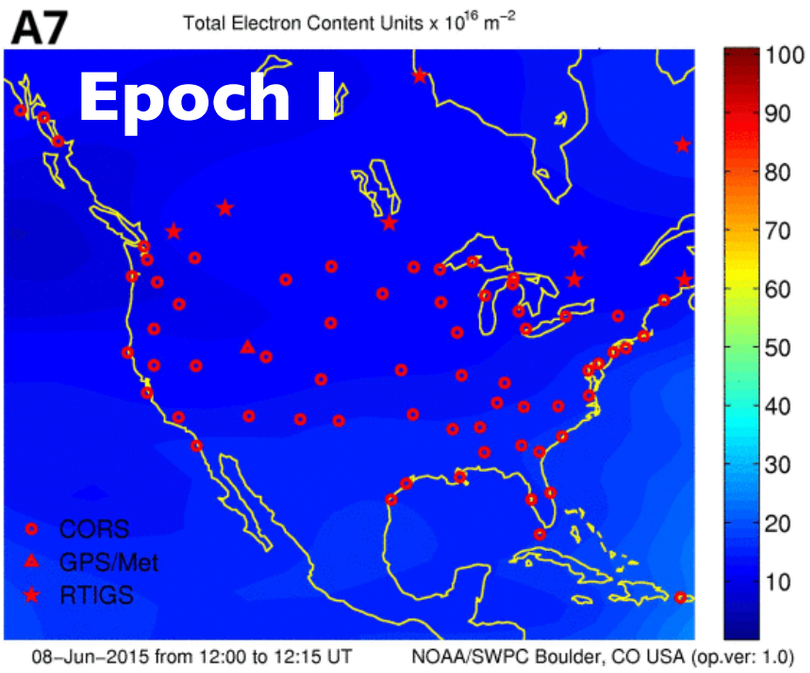


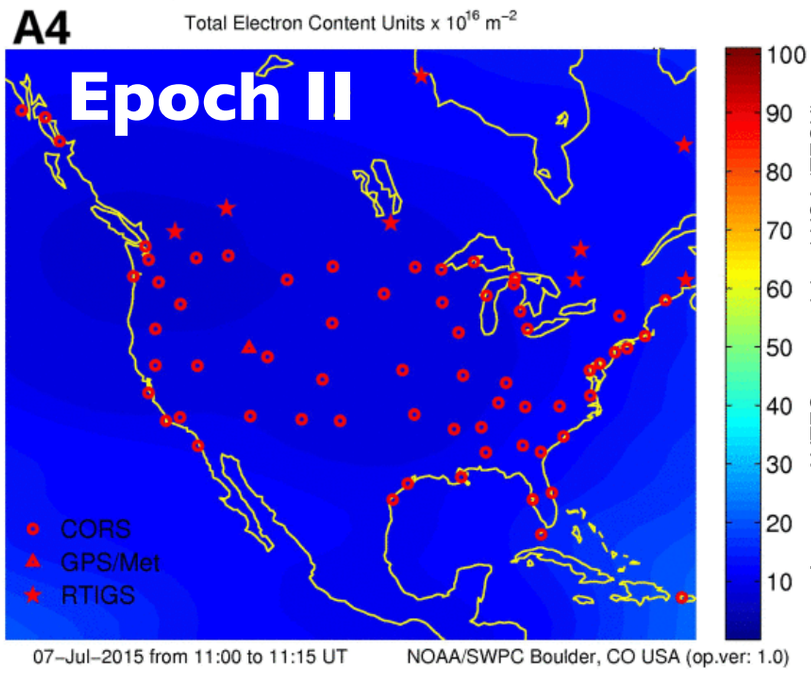
2. reduce Θ_{sep}

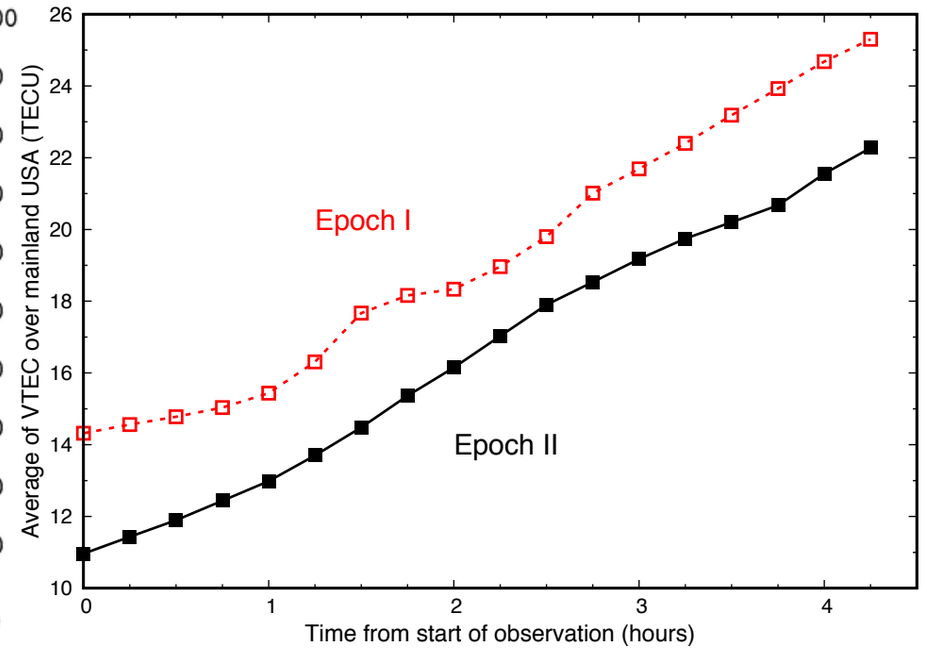
Concept of multi-calibrator PR: MultiView

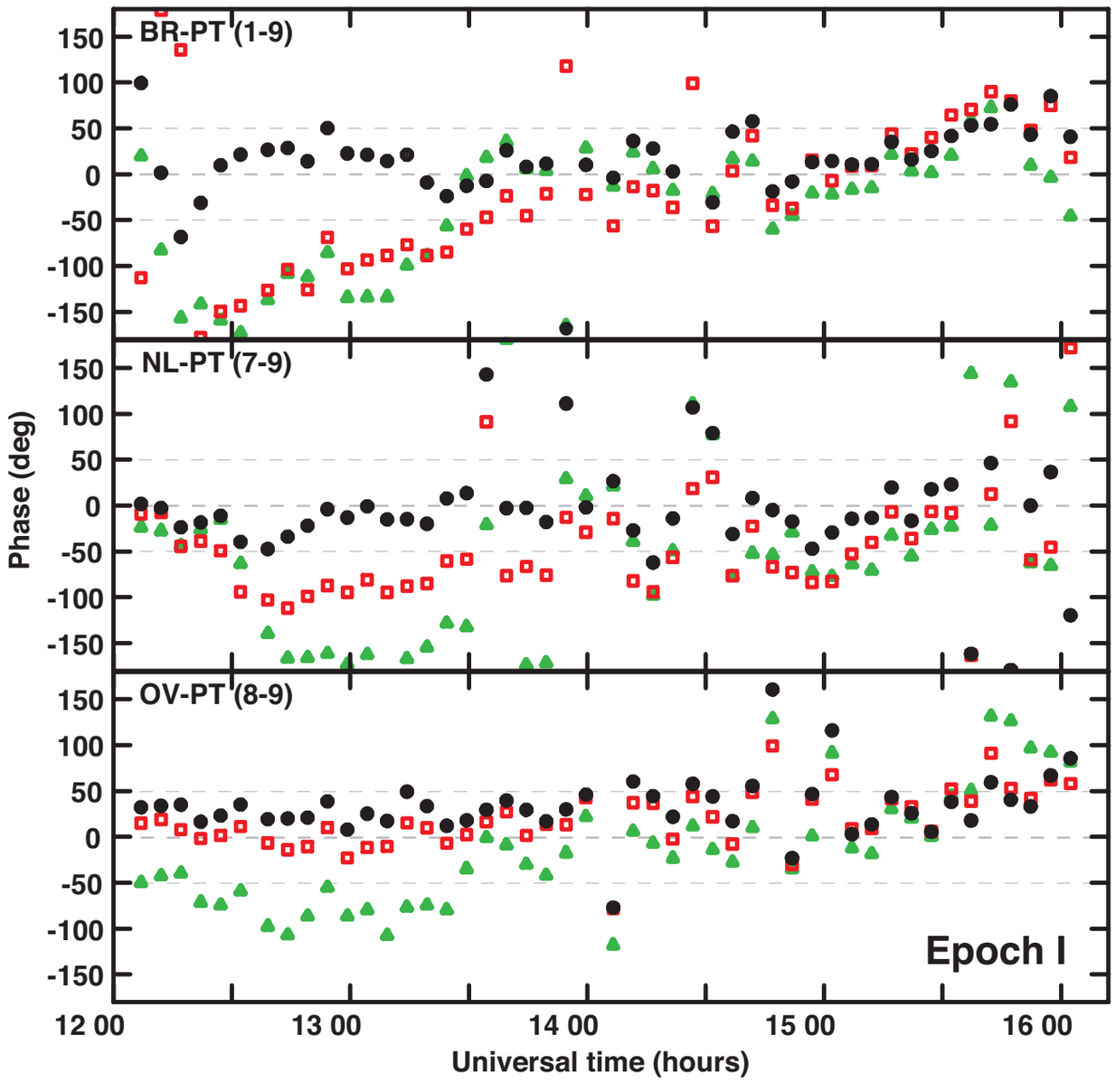


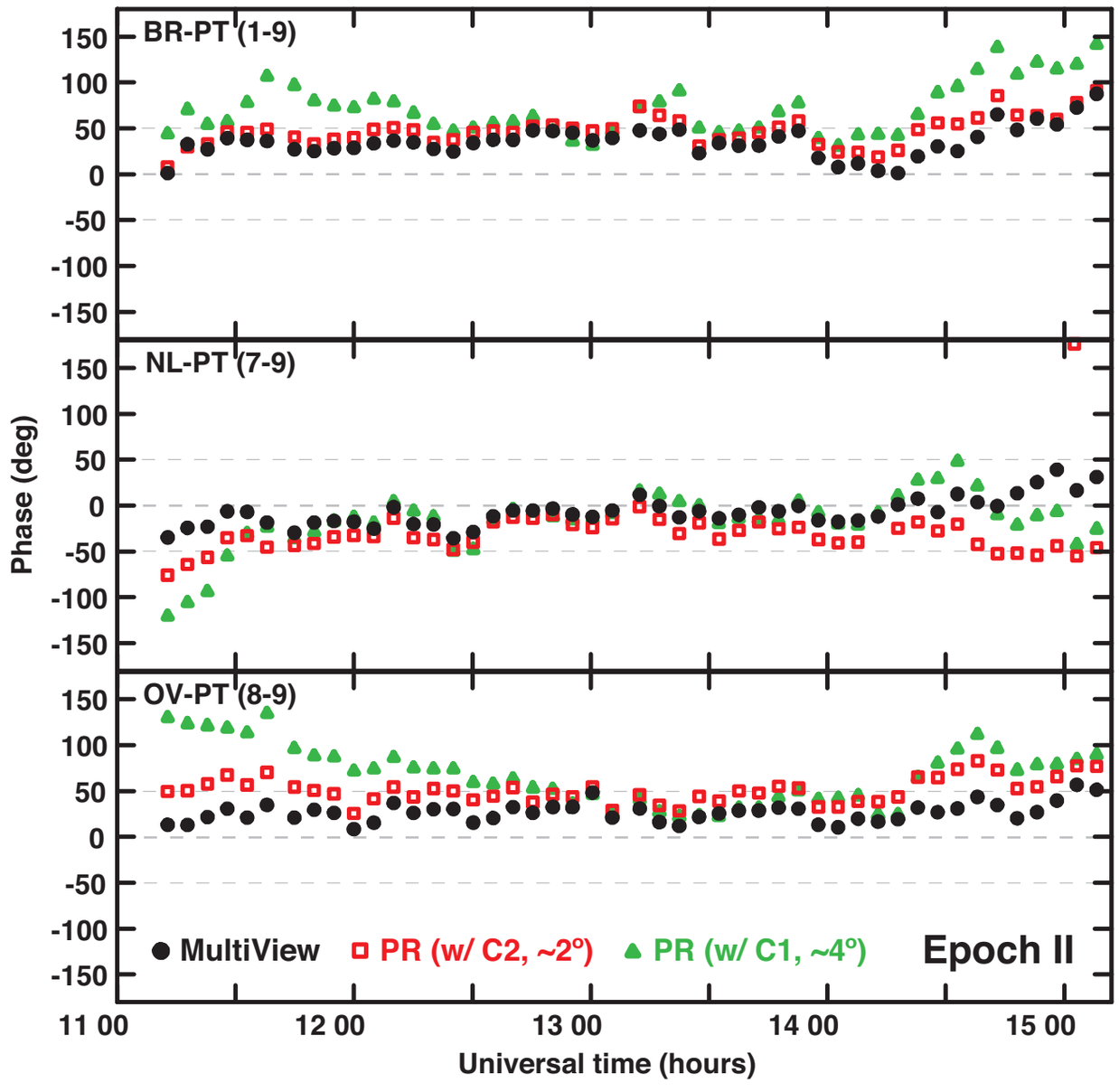
"IONOSPHERIC WEDGE" → Spatial structure (frequency/weather/direction)
MultiView models the phase-screen around the target: direction dependent calibration


A7
Total Electron Content Units x 10^16 m^-2
Epoch I
CORS
GPS/Met
RTIGS
08–Jun–2015 from 12:00 to 12:15 UT
NOAA/SWPC Boulder, CO USA (op.ver: 1.0)


A4
Total Electron Content Units x 10^16 m^-2
Epoch II
CORS
GPS/Met
RTIGS
07–Jul–2015 from 11:00 to 11:15 UT
NOAA/SWPC Boulder, CO USA (op.ver: 1.0)


Epoch I
Epoch II
Average of VTEC over mainland USA (TECU)
Time from start of observation (hours)

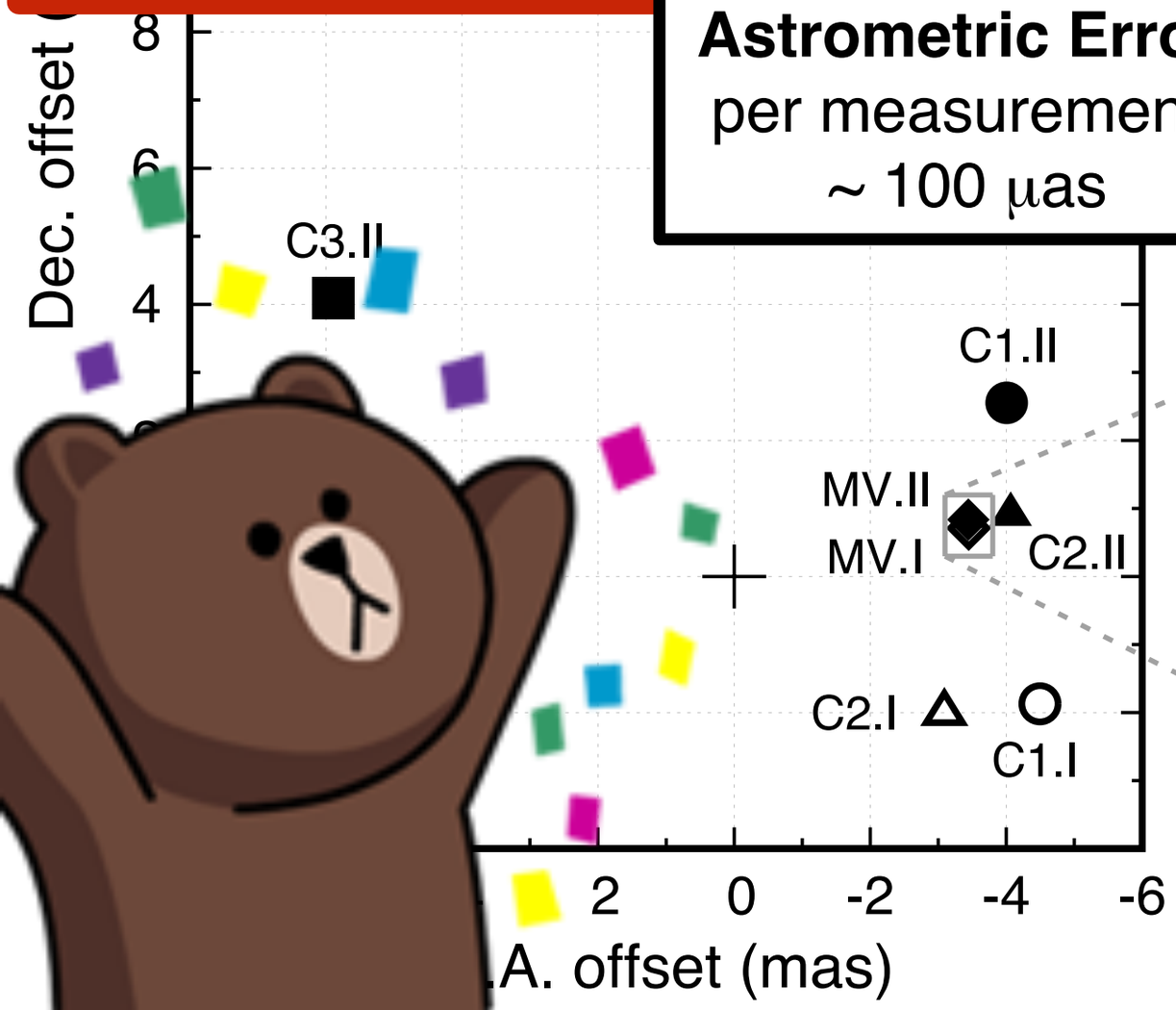

BR-PT (1-9)
NL-PT (7-9)
OV-PT (8-9)
Phase (deg)
Epoch I
12 00
13 00
14 00
15 00
16 00
Universal time (hours)

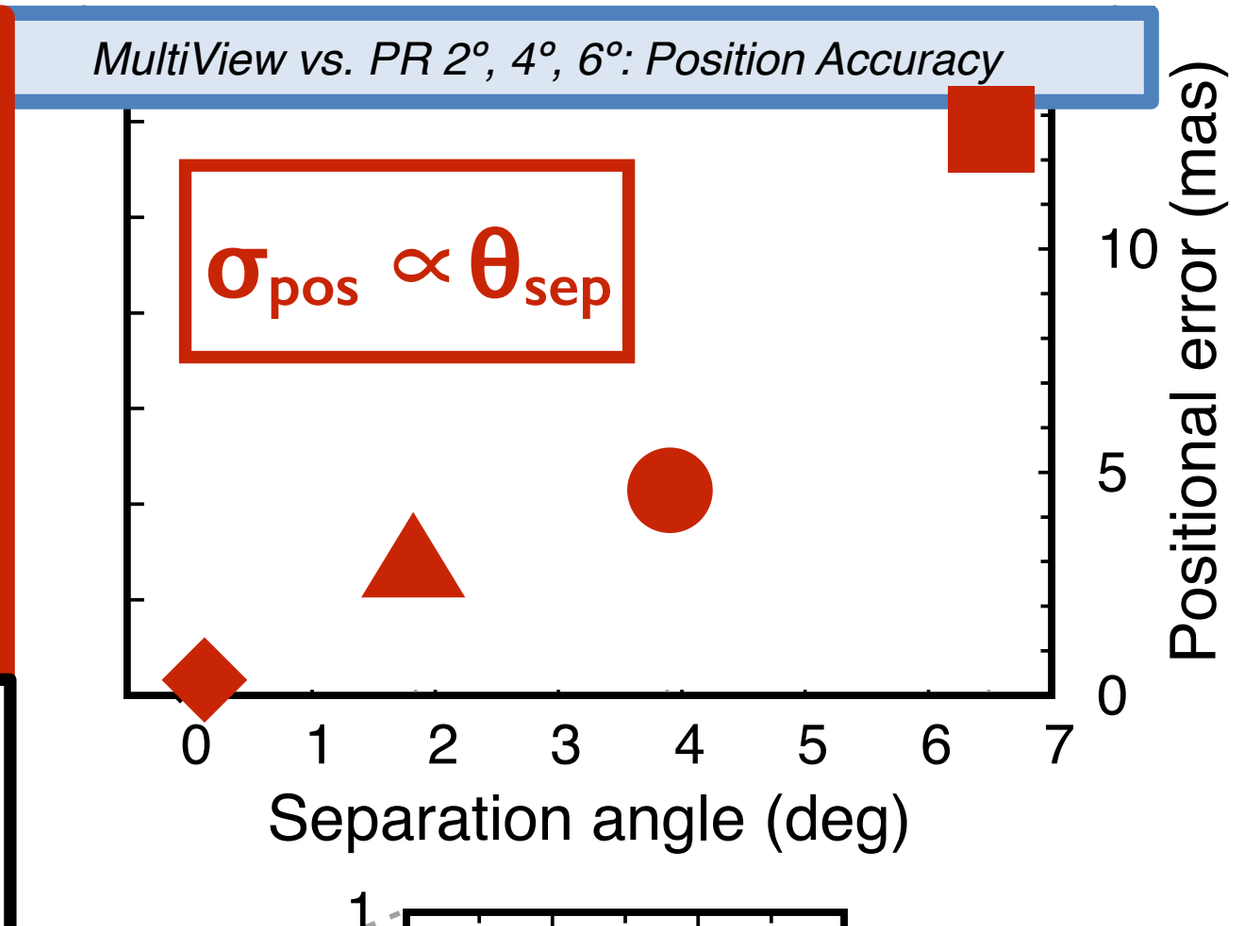

BR-PT (1-9)
NL-PT (7-9)
OV-PT (8-9)
Phase (deg)
MultiView
PR (w/ C2, ~2°)
PR (w/ C1, ~4°)
Epoch II
11 00
12 00
13 00
14 00
15 00
Universal time (hours)

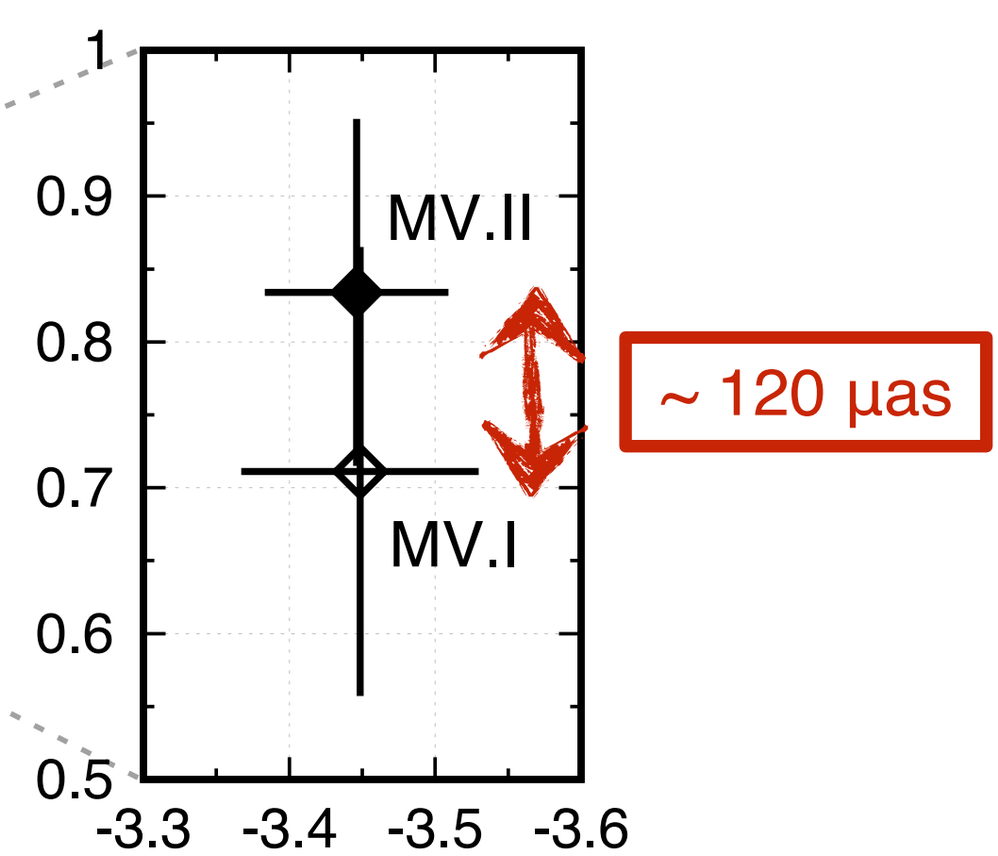
MV Demo: Quasar astrometry

Astrometry at thermal noise level!

Astrometric Error
per measurement
~ 100 μas

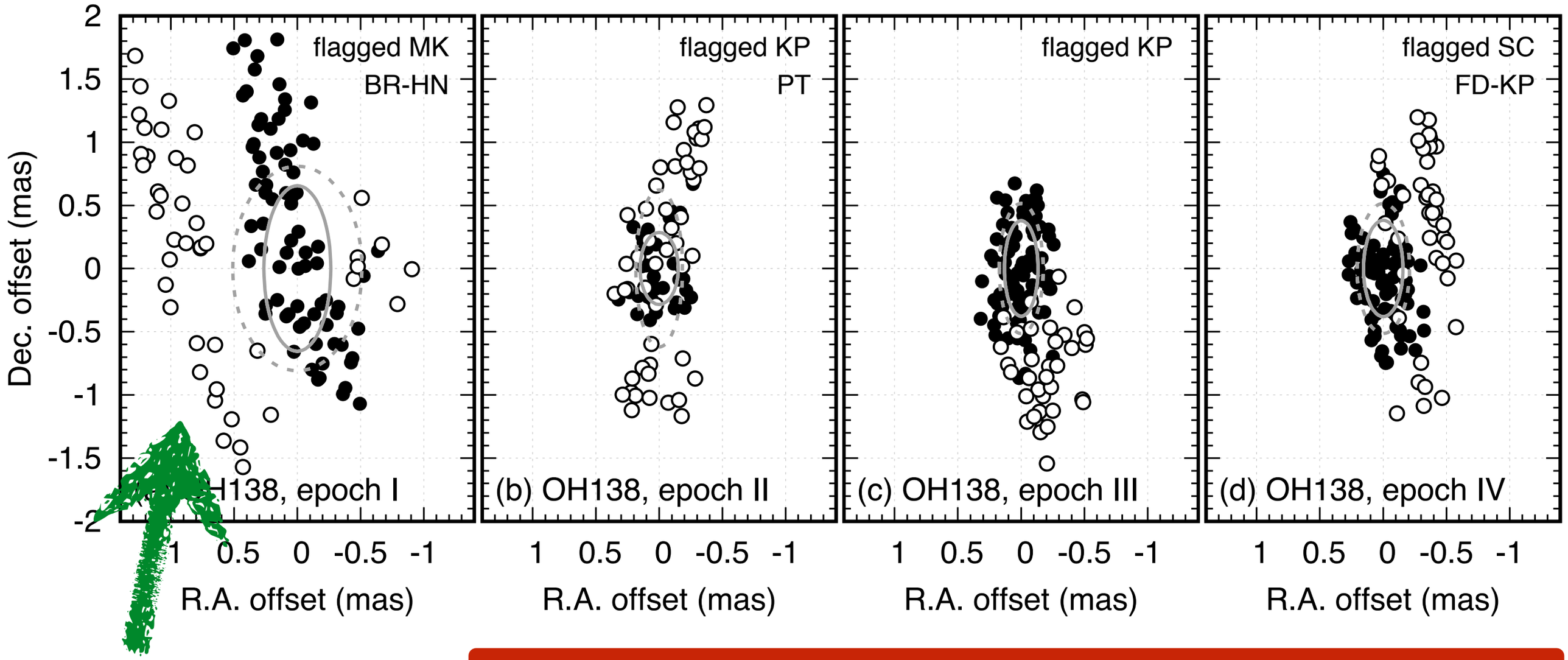






The challenge of low frequency phase-referencing

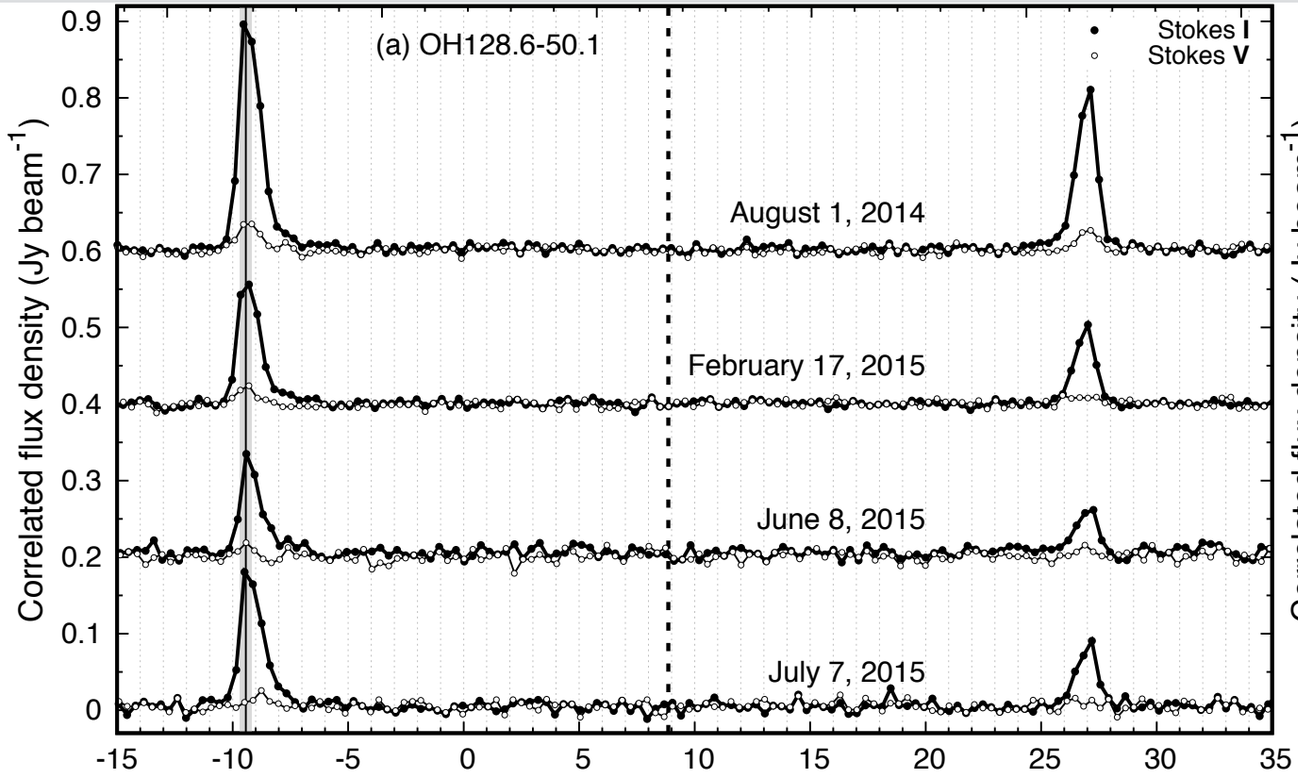
The dispersive ionosphere!

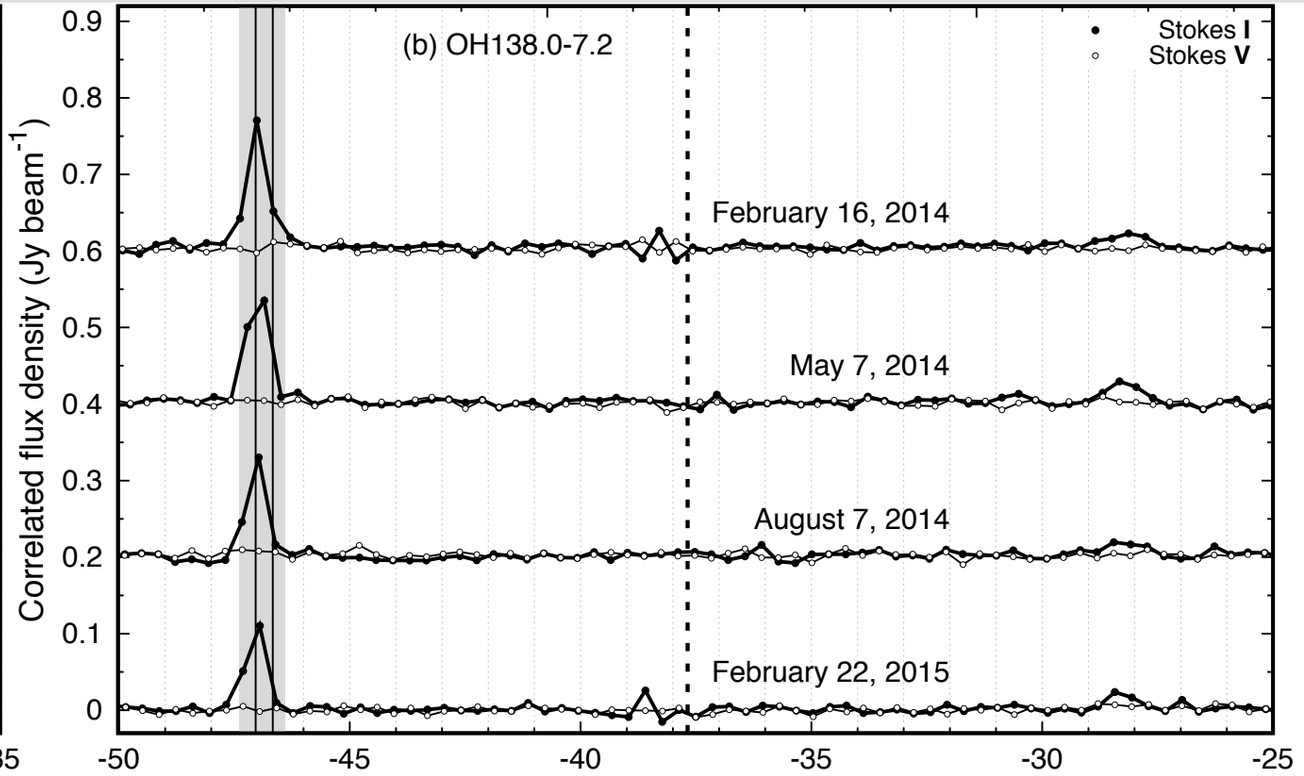


all systematically shifted positions include data from SAME ANTENNA

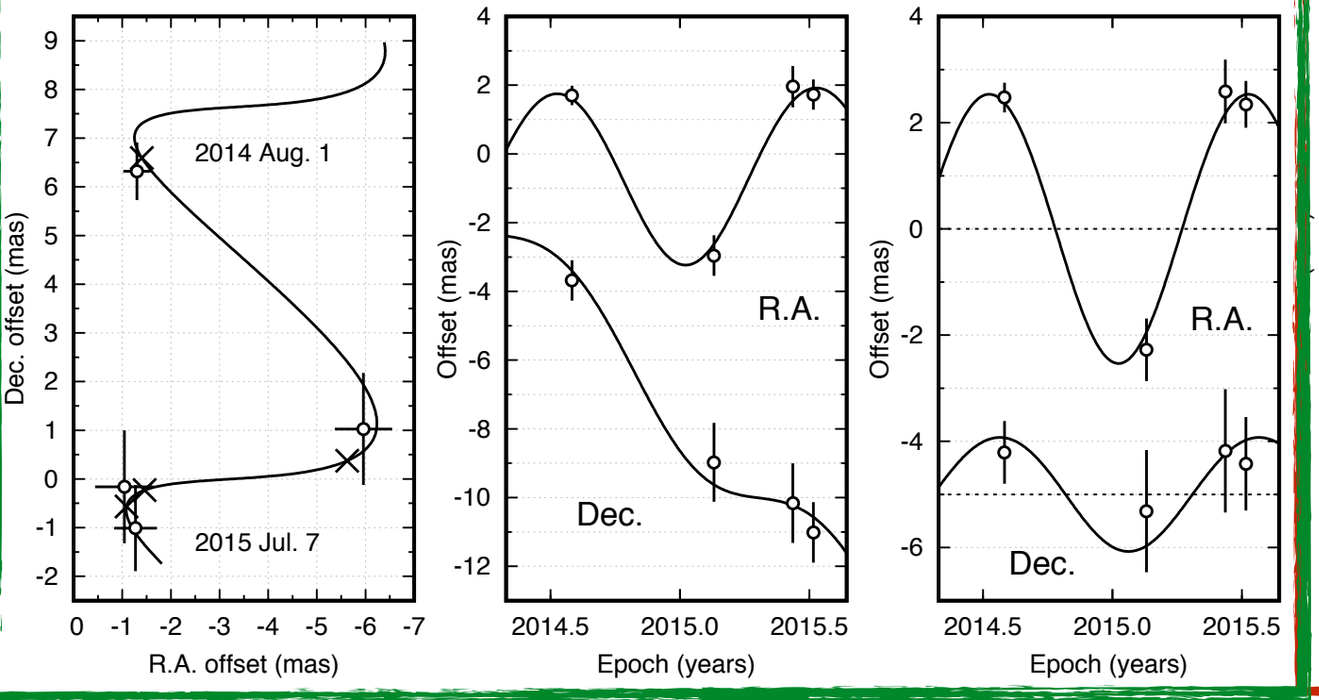
3. flag data showing systematic errors

Trig. distances to OH/IR stars using 1612 MHz masers

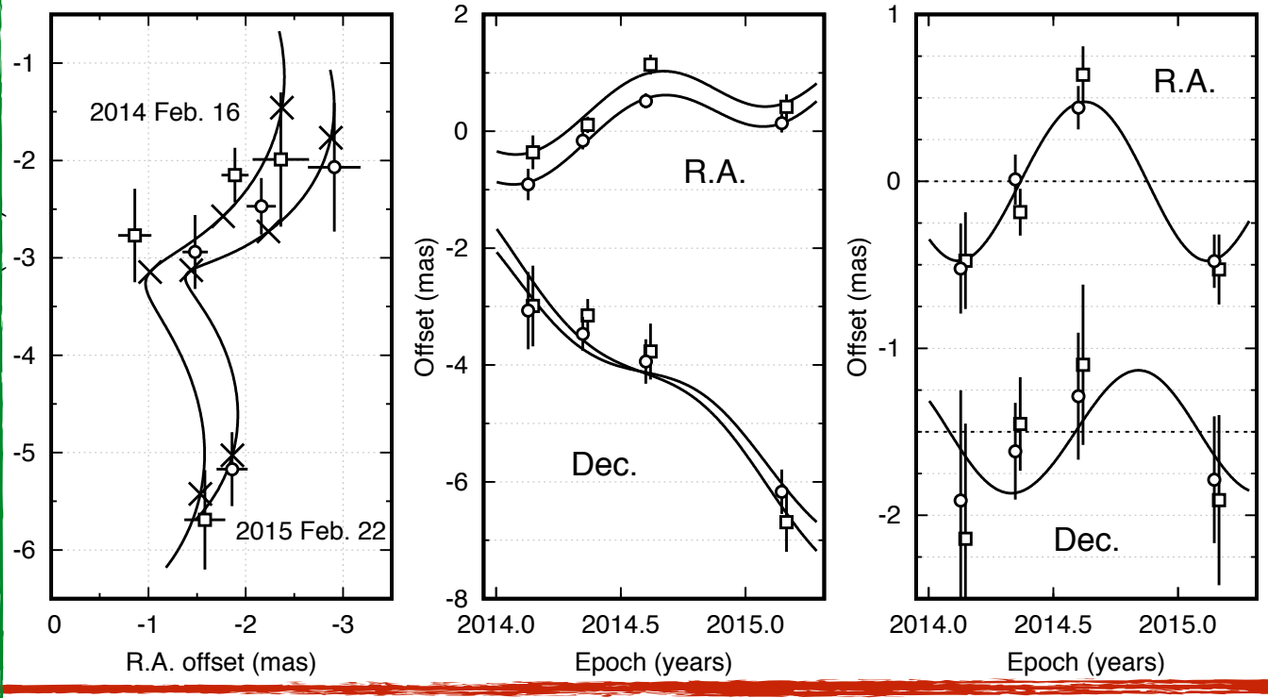




2.74 ± 0.39 mas (14%)



0.49 ± 0.14 mas (29%)



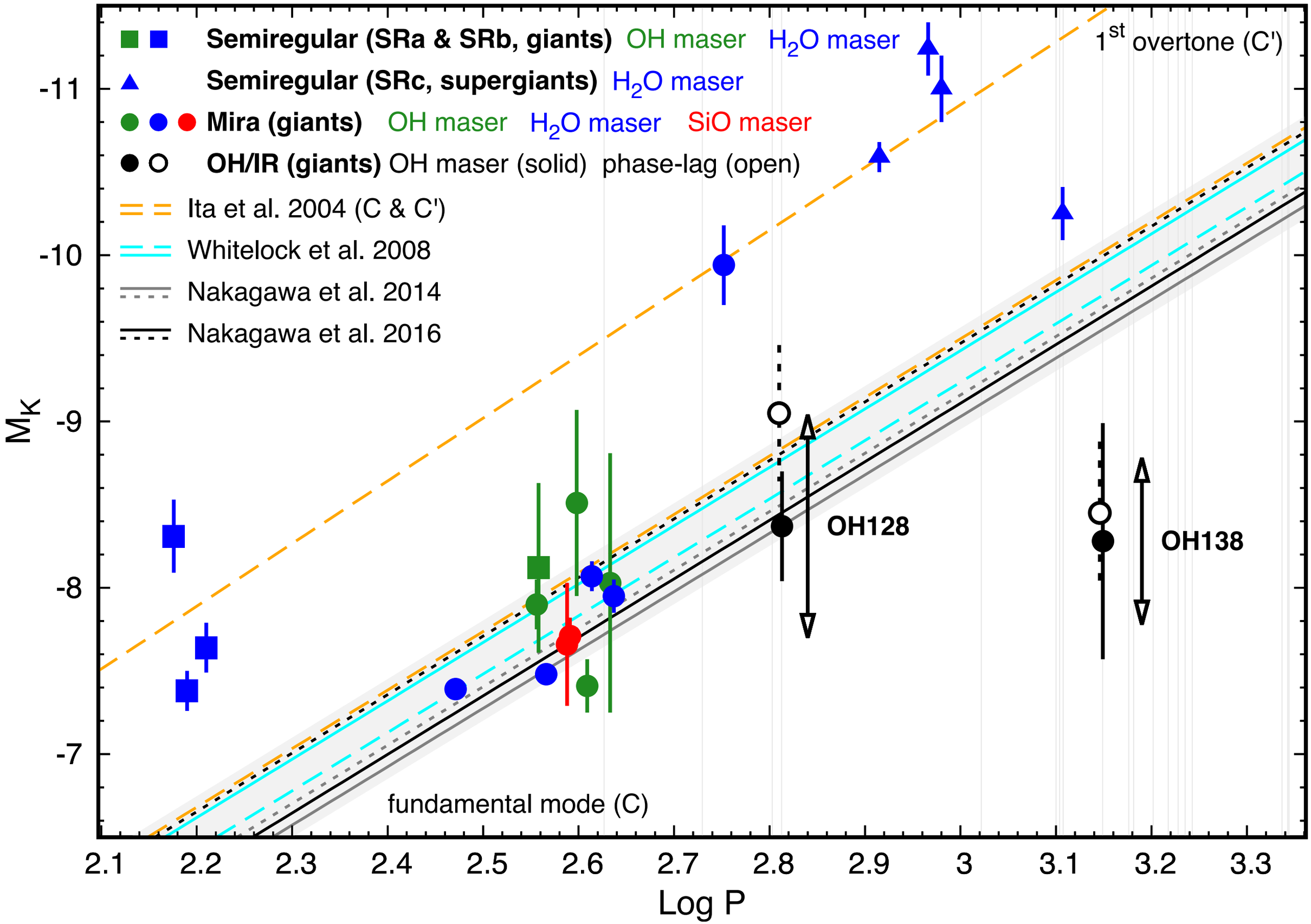
So we have our trigonometric **distances to old stars**

The question remains:

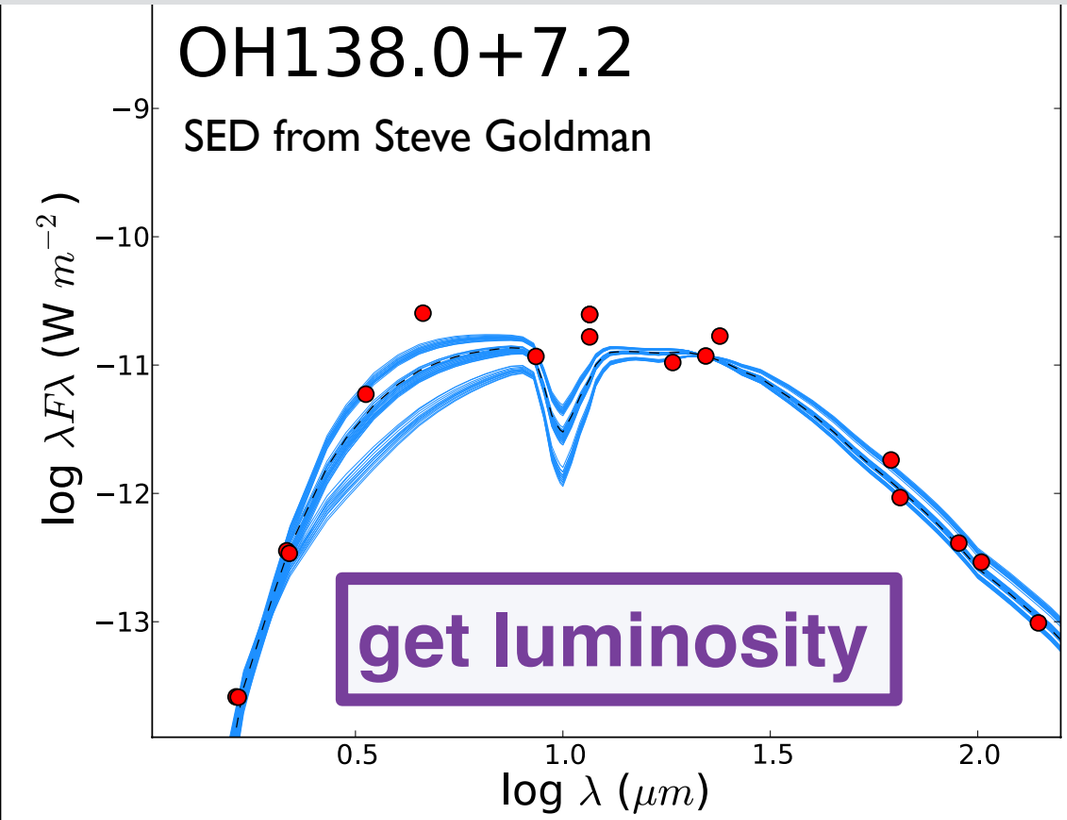
Why care about old stars?

gori gori gori gori

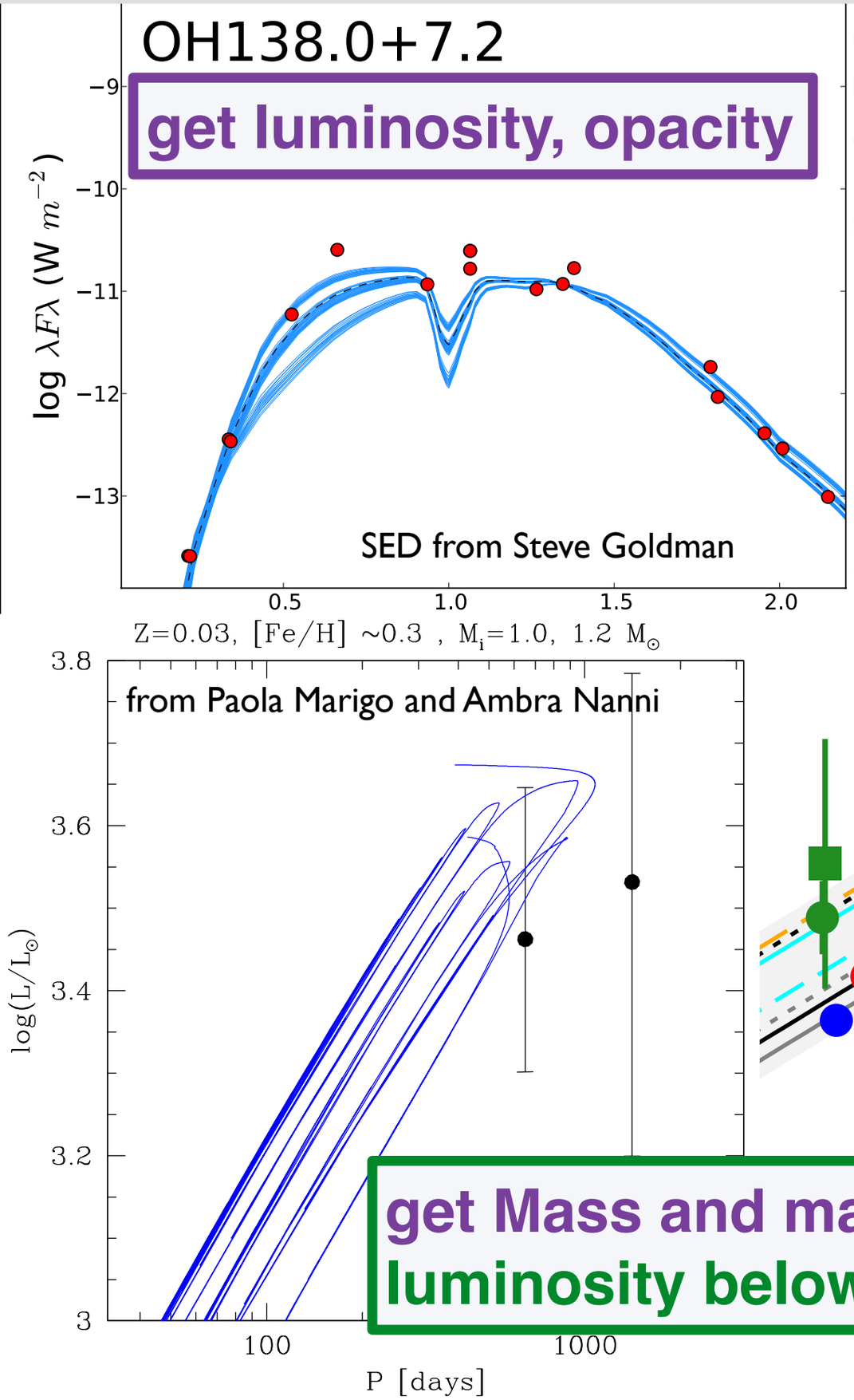
Stellar evolution and physics

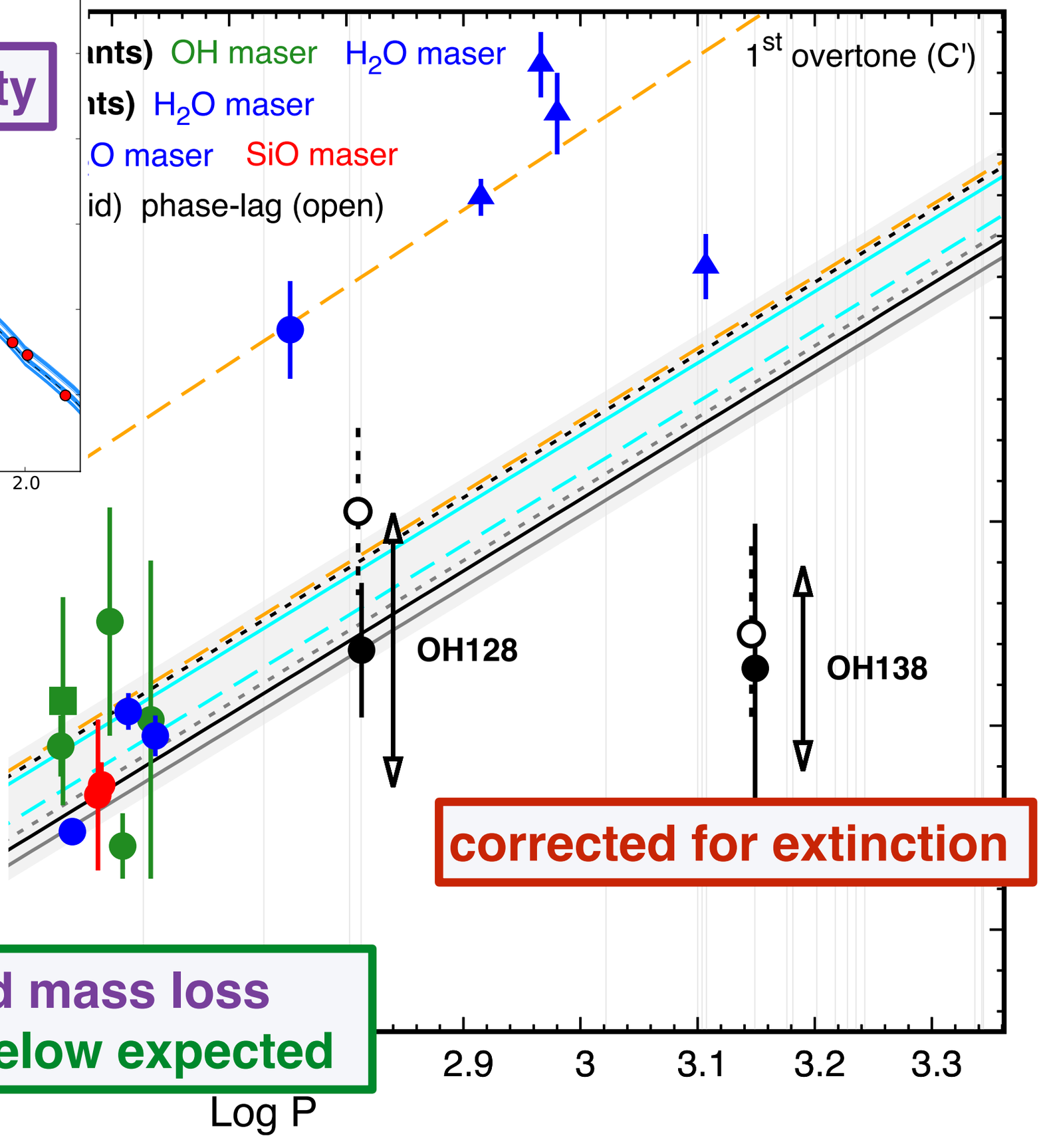


Stellar evolution and physics

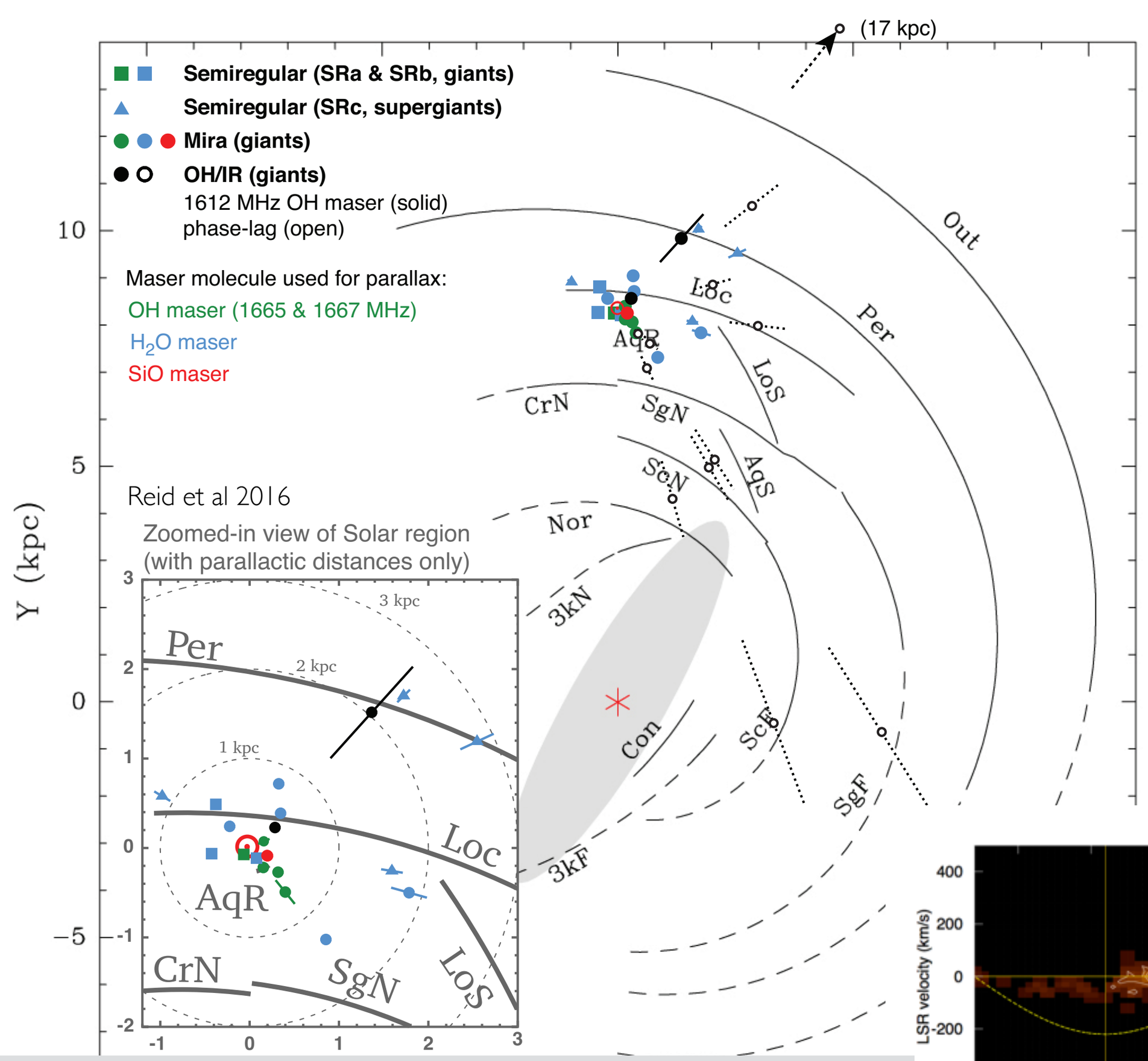


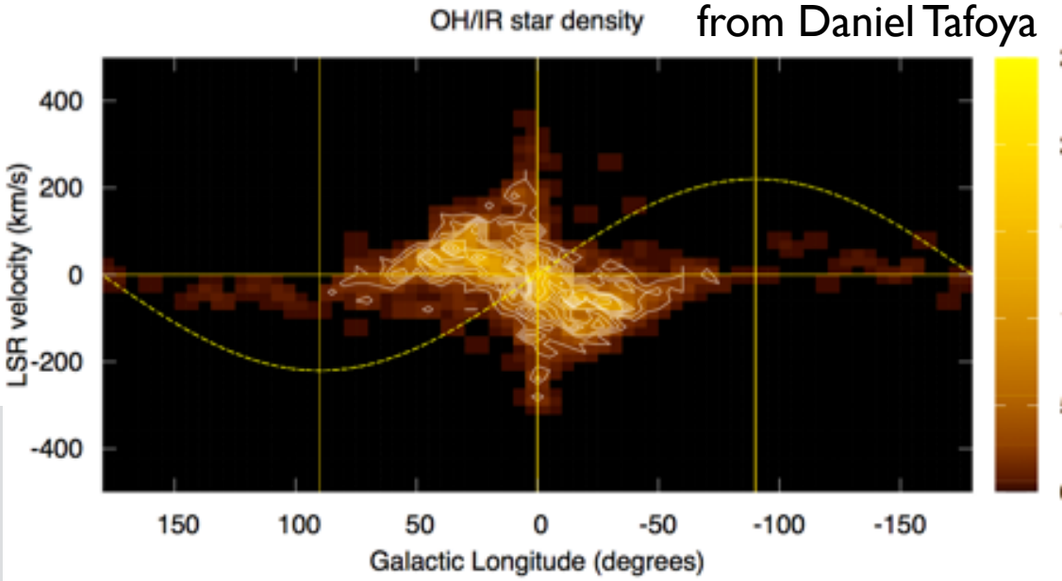
Stellar evolution and physics





Galactic dynamics using AGBs

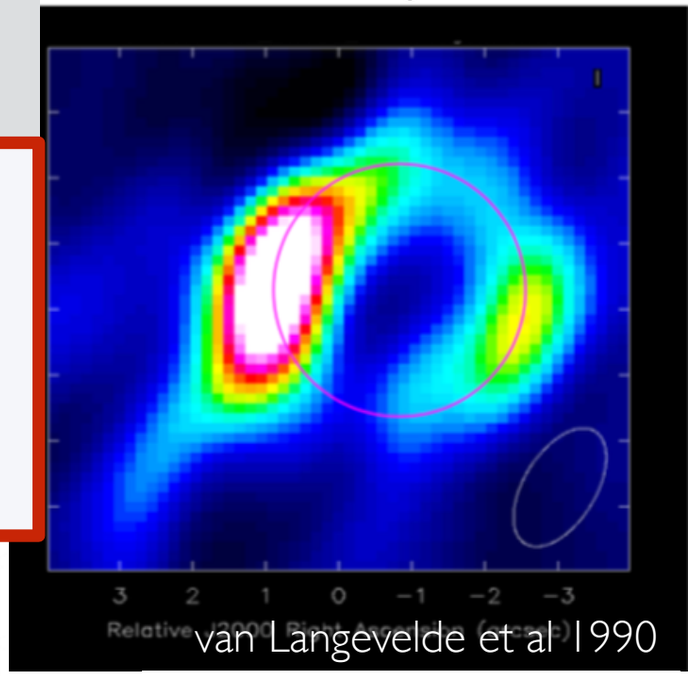




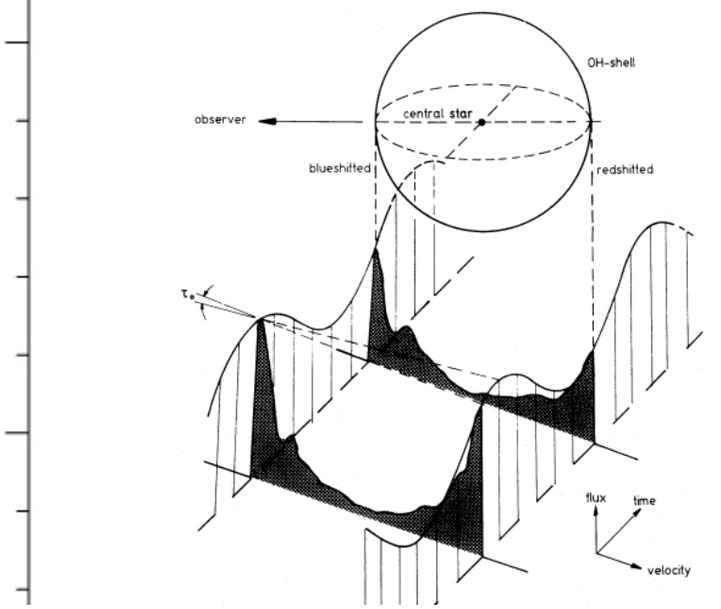
Phase-lag distance calibration

ϕ-lag distances don't need VLBI!
single dish for OH phase-lag
interferometry for size of OH shell
ideal SKA surveys!!!

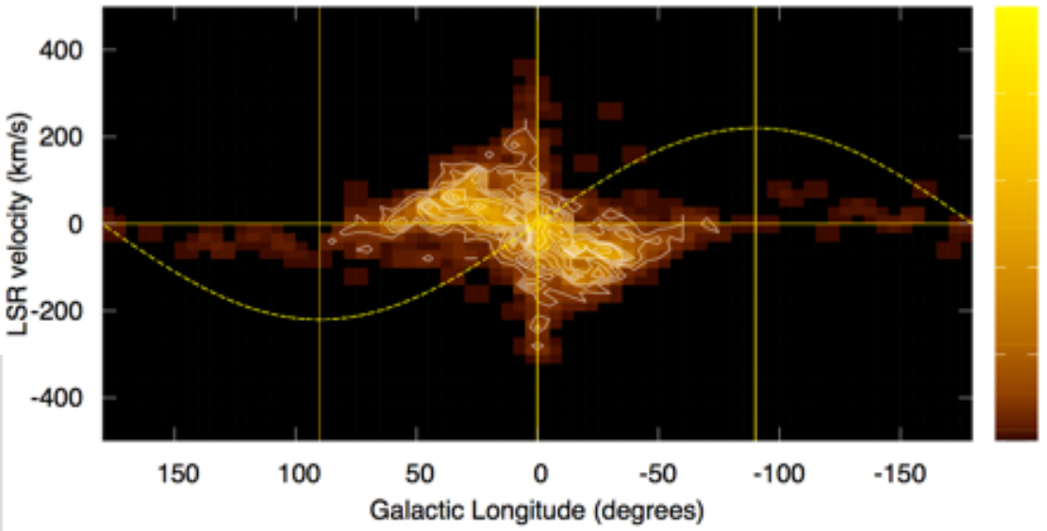
Engels et al 2015

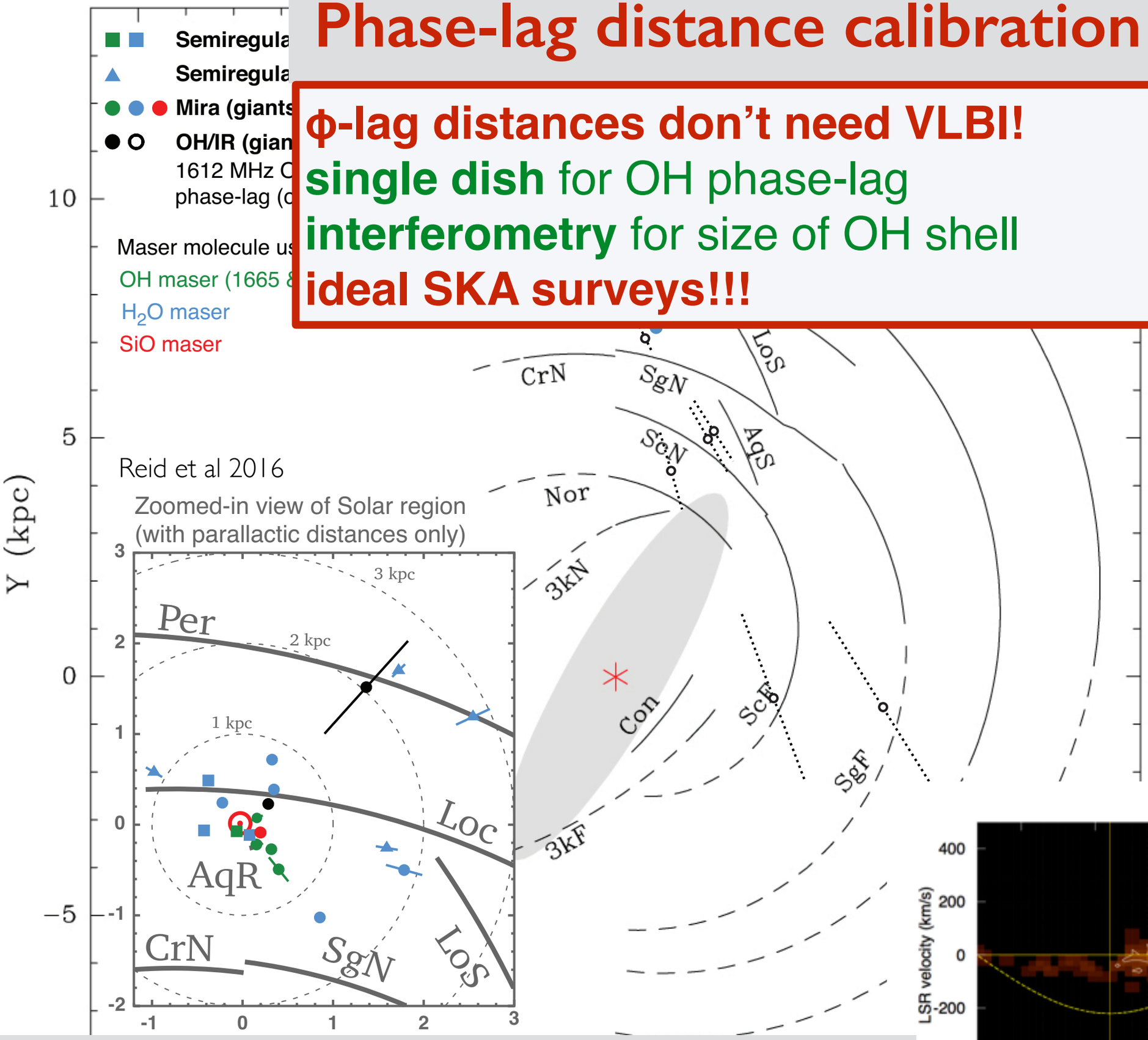


van Langevelde et al 1990



OH/IR star density from Daniel Tafoya





Galactic dynamics using AGBs

Science #1 Stellar Evolution

Luminosity of our long-period variable AGBs are low and don't seem to depend on puls. period

Simulations can't reproduce values for M-type stars and Gal. metallicities

Calculated masses are also smaller than thought

Effect of metallicity on stellar evolution? Comparison with LMC

Science #2 Galactic dynamics

AGB stars can be new relaxed tracers of Galactic dynamics

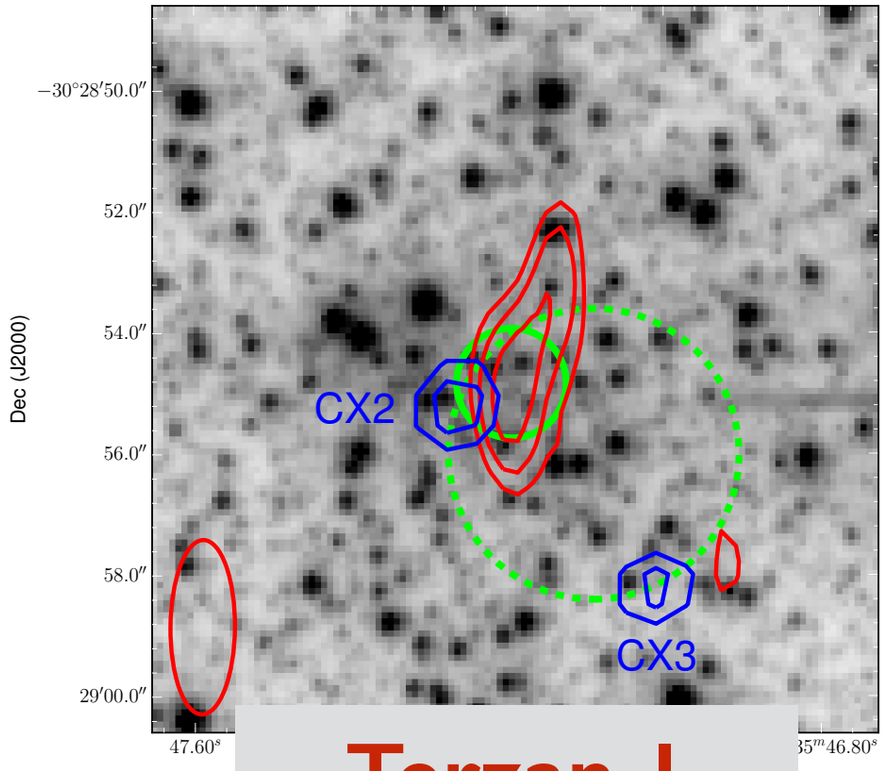
Mapping the dynamics of evolved stars is important for understanding how matter circulates in the MWG/Local Group

We need good distances to Galactic sources…A LOT

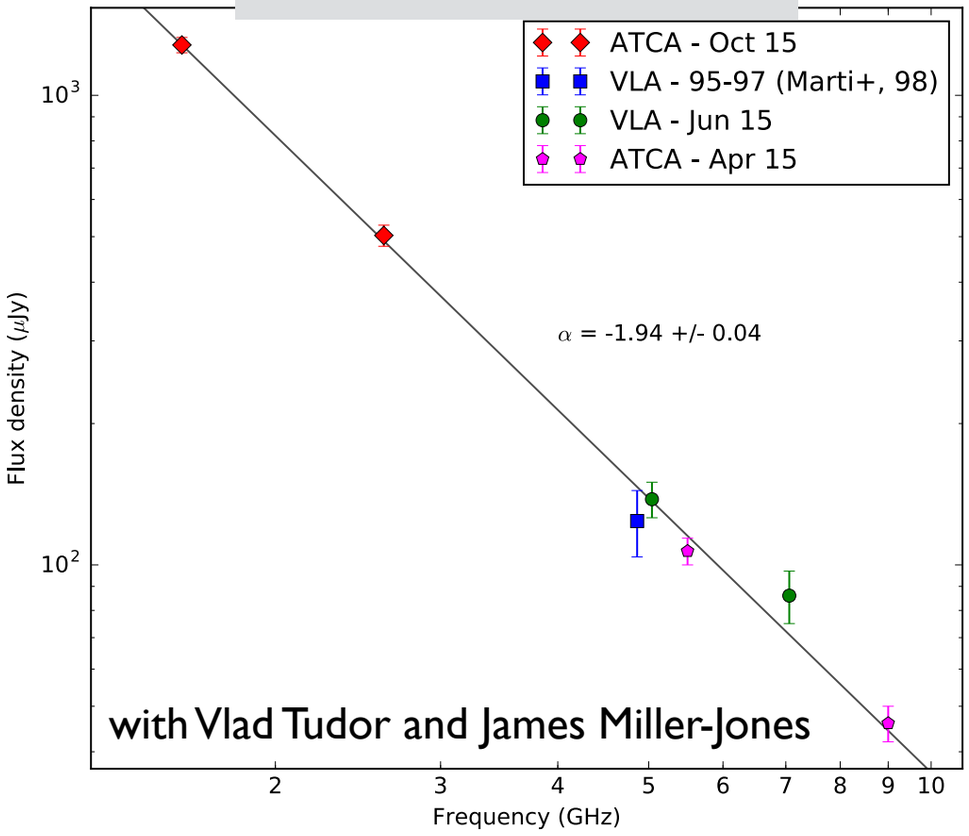
OH maser parallaxes + phase-lag distance calibration

SKA surveys to measure OH shell sizes and phase-lags

Pulsar astrometry (L-band VLBI and MultiView)



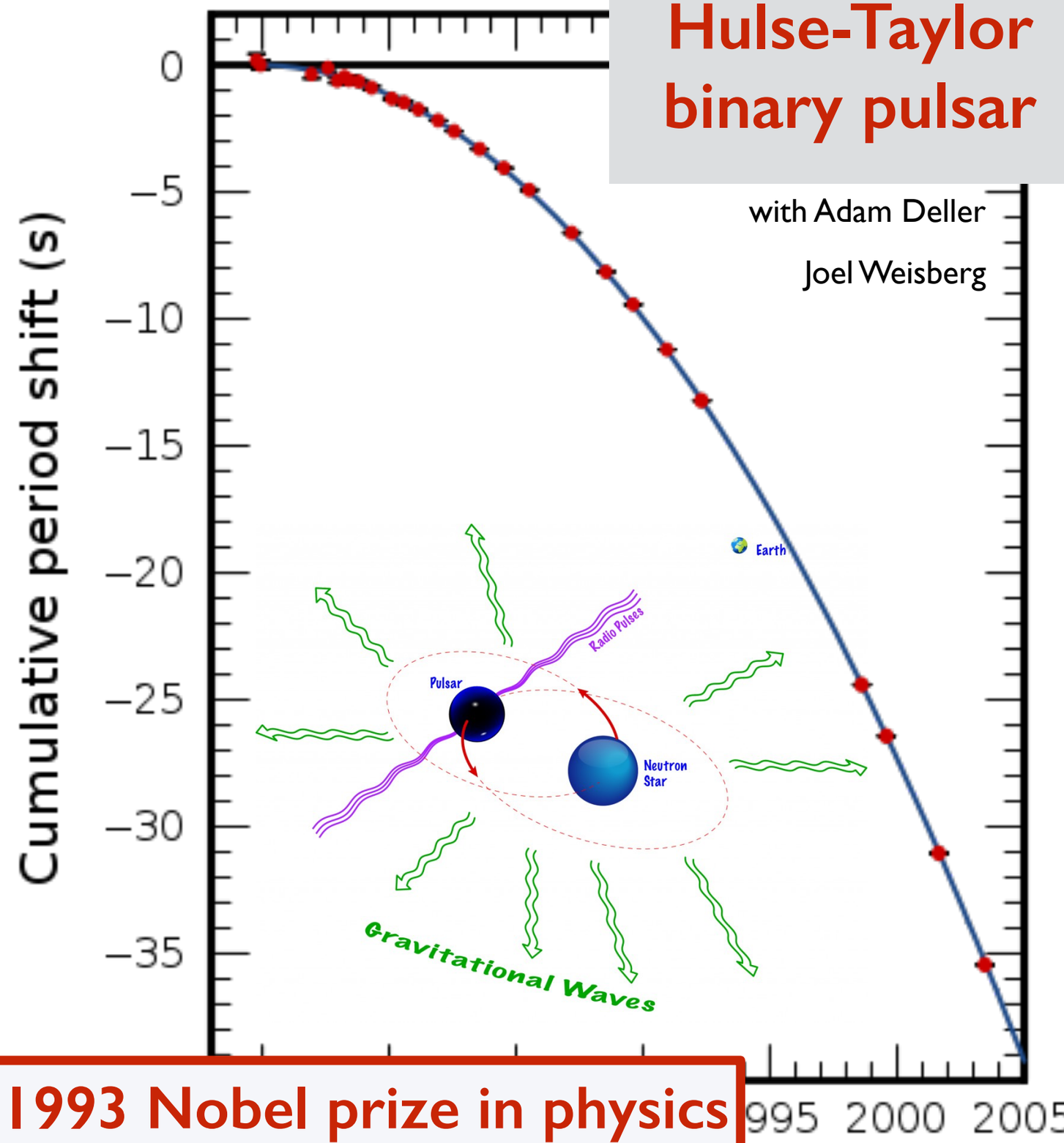
Terzan I



Hulse-Taylor binary pulsar

with Adam Deller

Joel Weisberg



1993 Nobel prize in physics

proof of gravitational waves

Why should we care?

1. Japan and Korea is the center of AGB astrometry: large KVN, KaVA, VERA projects

2. No one is doing low-frequency astrometry for AGBs besides us (yet): VLBA, LBA, EVN

3. A huge interest from AGB astrophysics community for distances: stellar evolution

4. Good follow-up projects when SKA comes