VERA UM @Mizusawa
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Current State of WVR Development

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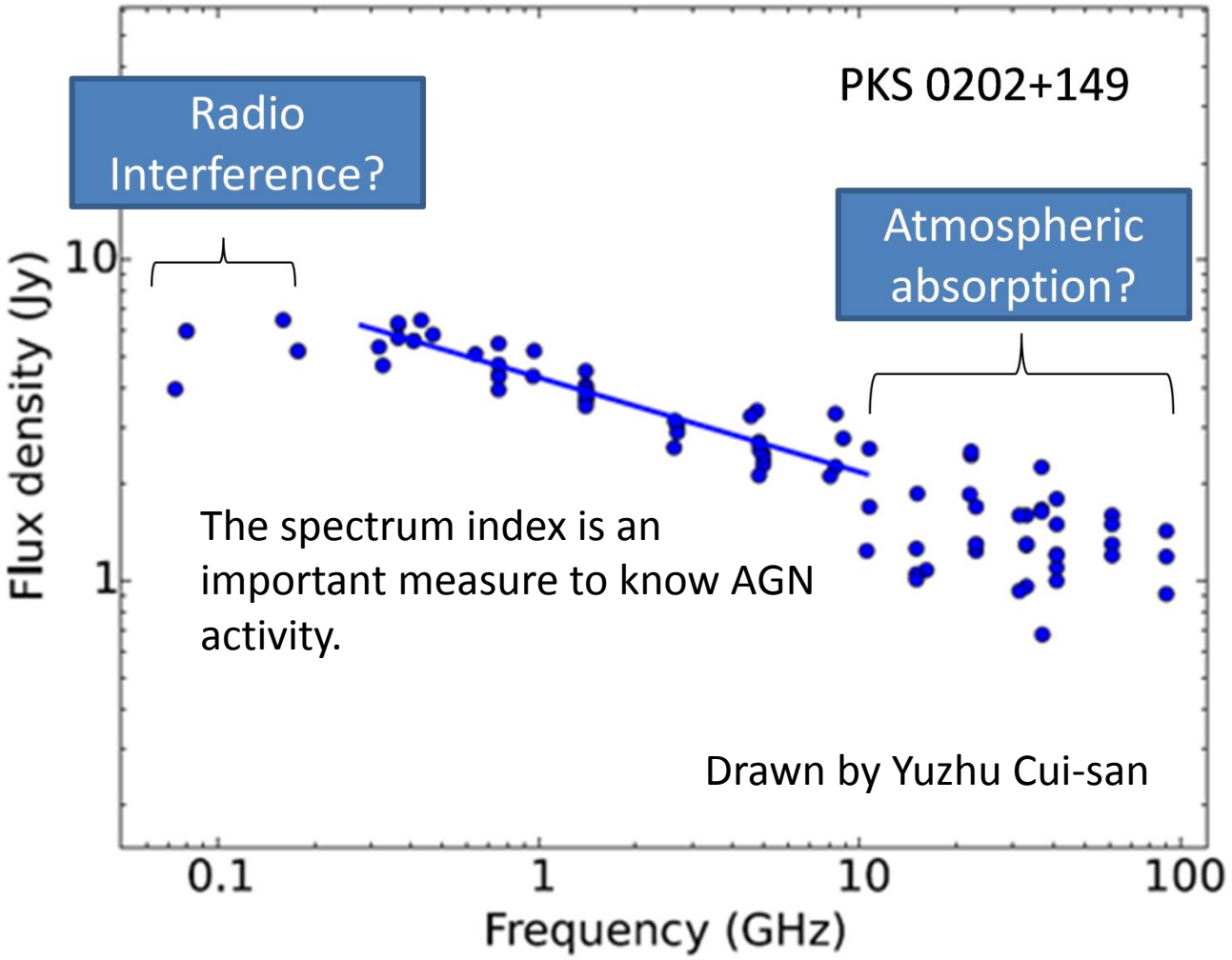
Contents

- Scientific Importance
  - Correction of atmospheric absorption for source brightness
  - Correction of delay for geodetic/astrometric VLBI
  - Correction of phase fluctuation to keep longer coherence time
- Performance Criterion
  - ASD statistics
  - World Ranking
- Cost Effective Design and Performance

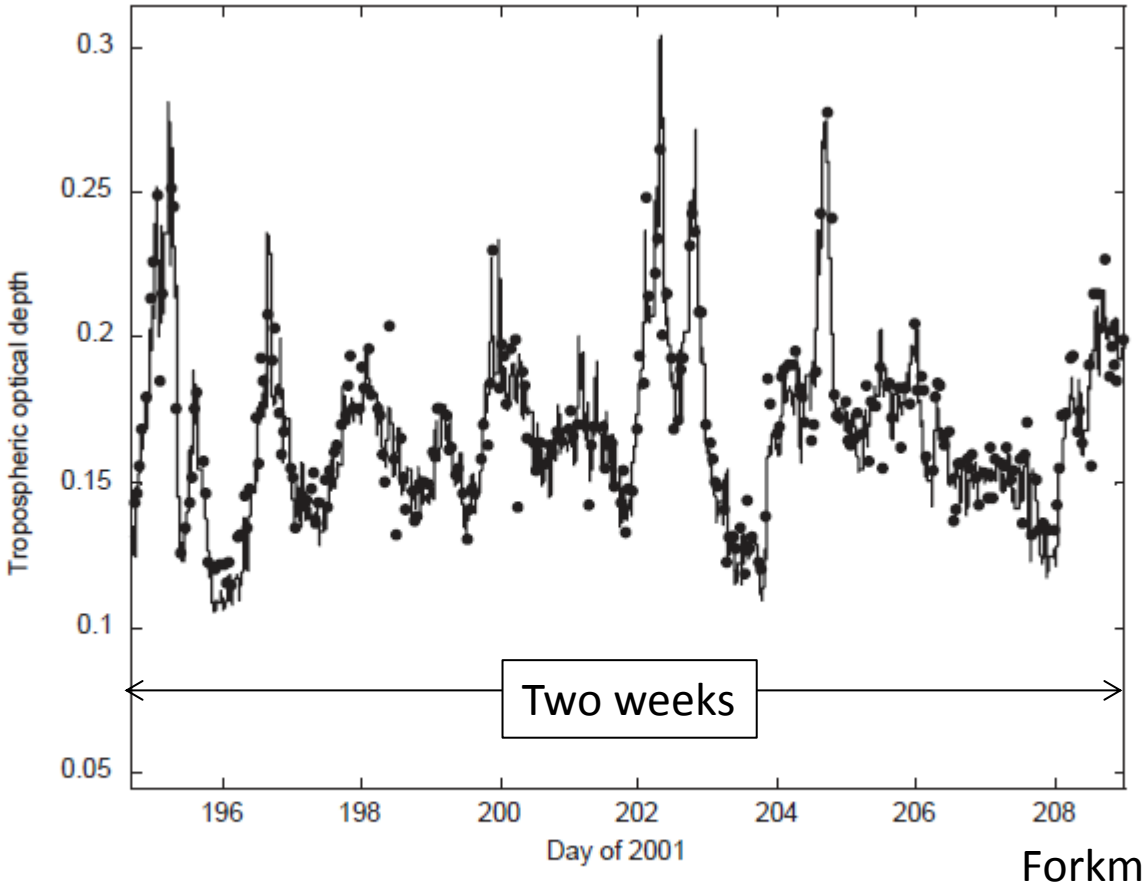
Uncertainty in radio brightness



A variable star or sky fluctuation?

-1.3dB

-0.43dB



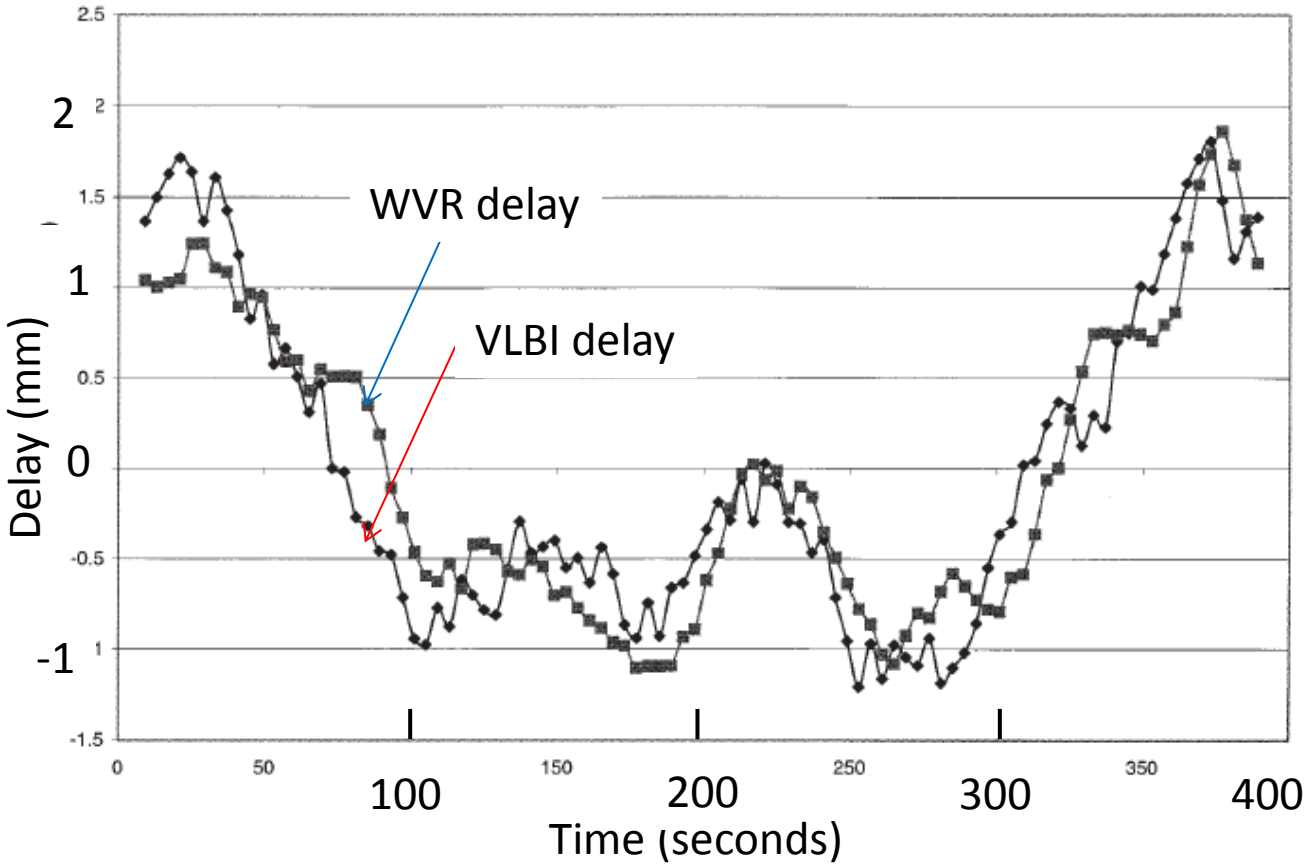
←1.2Jy
(1.6Jy
@El=30deg)

←1Jy

Forkman_Onsala_2003

Fig. 7. The tropospheric optical depth calculated from the output of the dual channel radiometer, solid line, and from the 22.2-GHz receiver, dots.

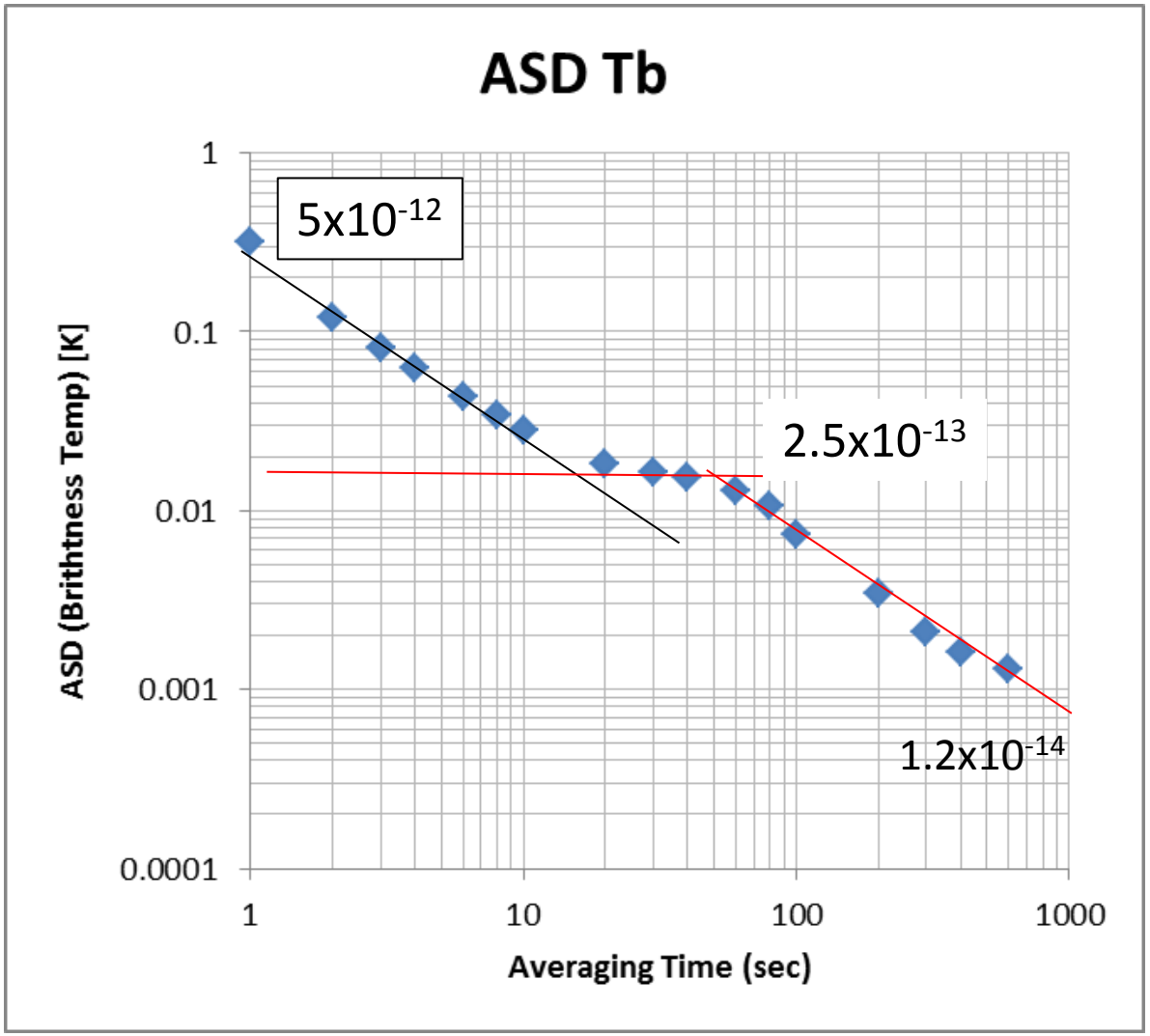
VLBI vs WVR



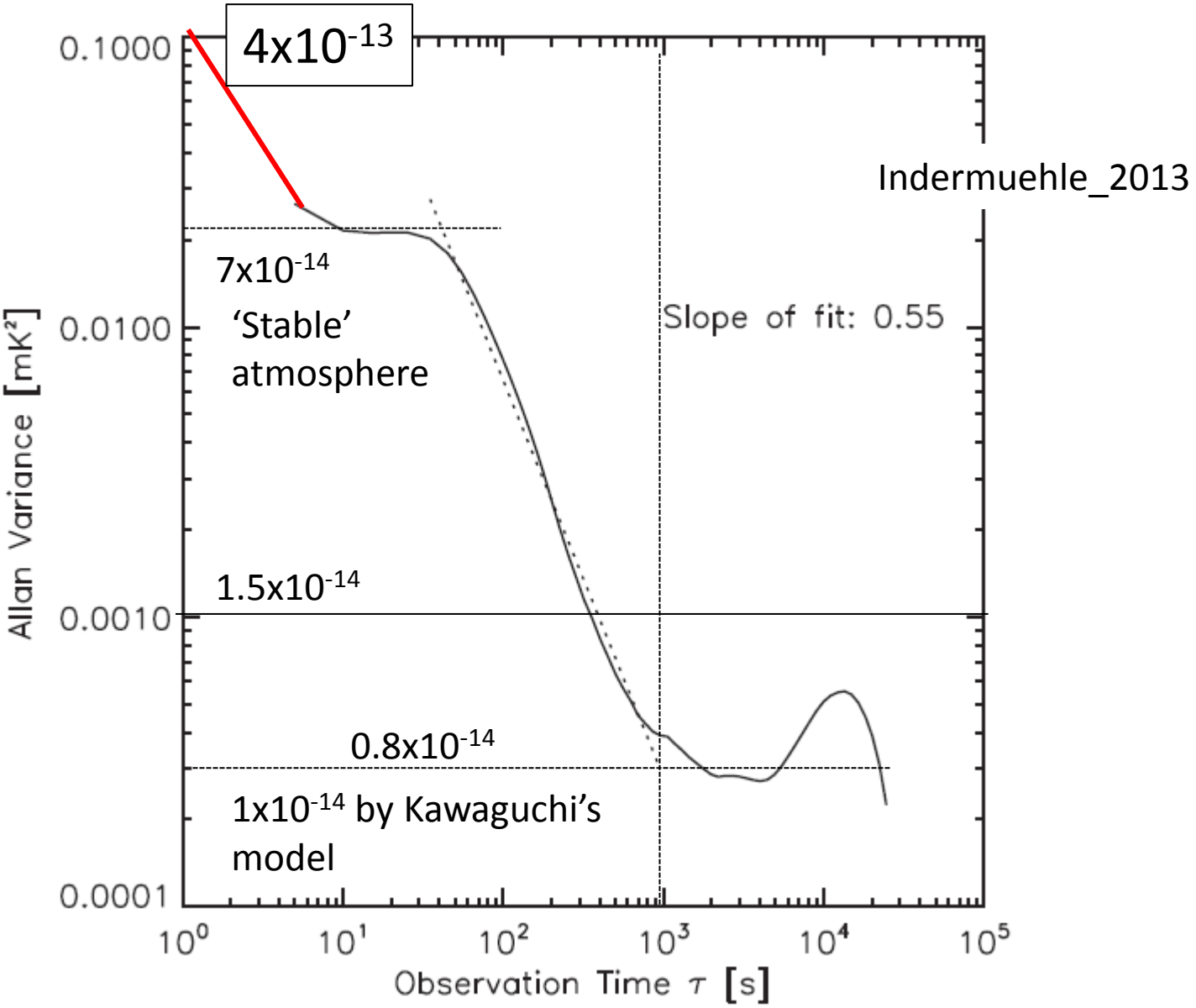
David A. Tahmoush and Alan E. E. Rogers, Correcting atmospheric path variations in millimeter wavelength very long baseline interferometry using a scanning water vapor spectrometer, *Radio Science*, Volume 35, Number 5, Pages 1241–1251, September–October 2000

Stability of SHAO WVR

First 6-hour on May 31, 2016



Stability of Australian WVR



Stabilities of world WVRs

Name	Stability @ 1second
DSN WVR	5×10^{-12}
SHAO WVR	5×10^{-12}
University of Bern （UoB)	1.7×10^{-12}
HALCA Phase Transfer	1.0×10^{-12}
UoB Correlation WVR	1.0×10^{-12}
DSN Advanced WVR for Cassini of NASA	6×10^{-13}
Australian WVR	4×10^{-13}
Hydrogen Maser Oscillator	1×10^{-13}

Cost Effective Design

Radio Metrics (USA)

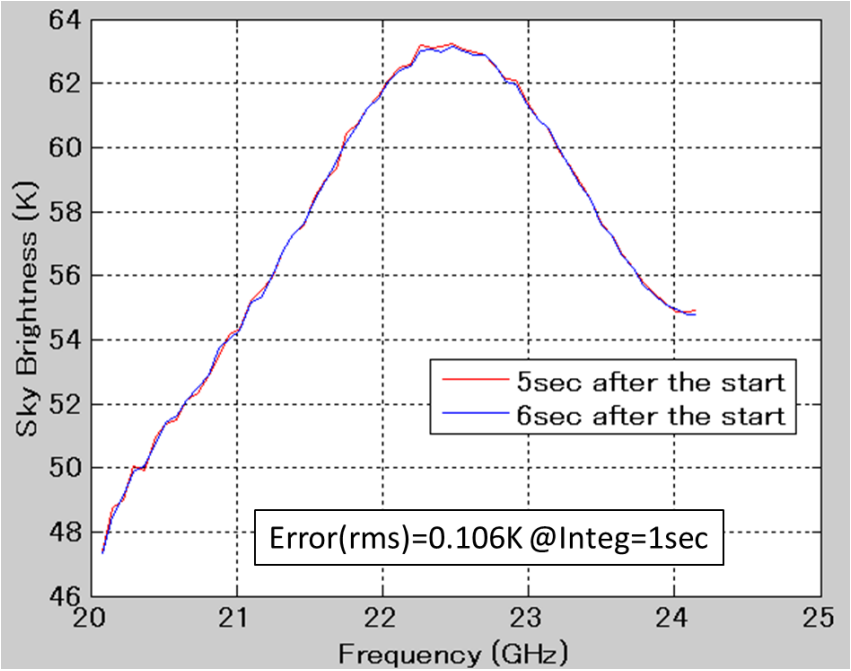
RPG (Germany)

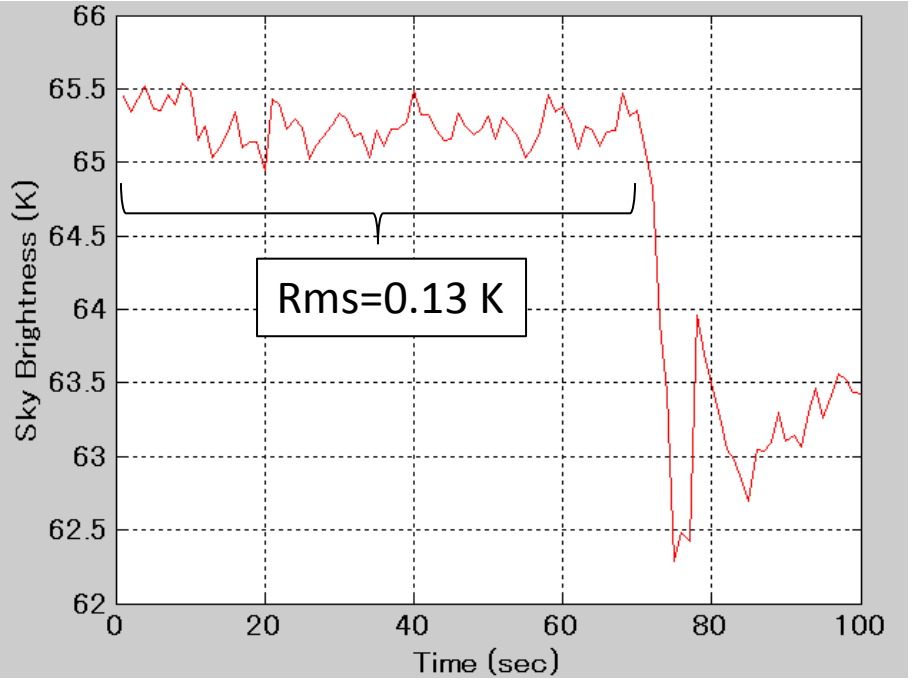
These commercial available WVRs are expensive, 200K USD or more.

- No driving motors, to be mounted on a radio telescope
- No GPS receiver, to be used GPS at a VLBI station
- No optical monitoring system
- No weather sensors, to be used information from a VLBI weather station
- No high speed AD, to be shared with that in a VLBI station

KEK Experiment

2016.12





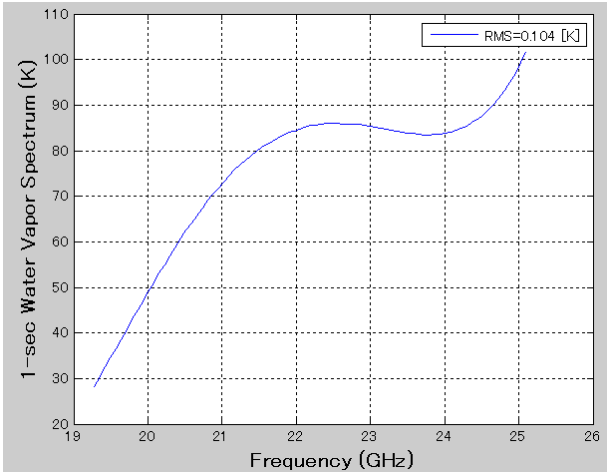
$$\frac{0.13 \times 4.5}{\sqrt{128} \times 3 \times 10^{11}} = 1.7 \times 10^{-13}$$

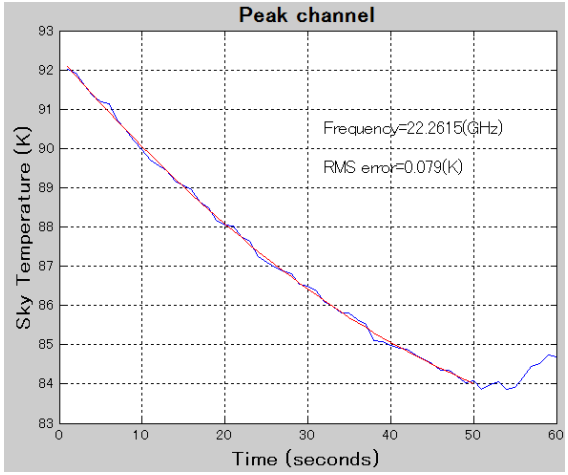
The best stability in the world!

The error of 0.1 mm is corresponding to the EPL error of 0.45mm.
By fitting 256-point of spectrum, one order of magnitude better error can be expected.

Roof Top Experiment

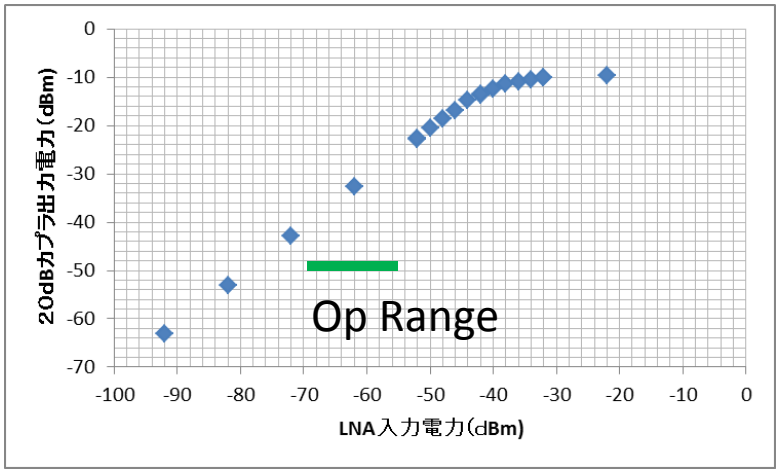
2017.7.3





Water Vapor Spectrum
0.1K_rms over 19-25GHz

Time Profile
0.08K rms at 22.2615GHz,
A rapid change of liquid absorption was observed.



- The almost same stability as the KEK experiment was achieved.
- Linearity has already been tested.
- Stability test of T_{rx} is now under going.

Conclusion

- The WVR development sponsored by NAOJ is going on track.
- The best stability in the world is expected.
- Remaining works
  - Assembling to a unit and set it on Mizusawa 20m
  - One more unit for a VERA station or Kashima 34m
  - VLBI/WVR experiment
  - A ceramic package for future applications including water vapor detection in a volcanic fume. The astronomical technique of imaging will be introduced.

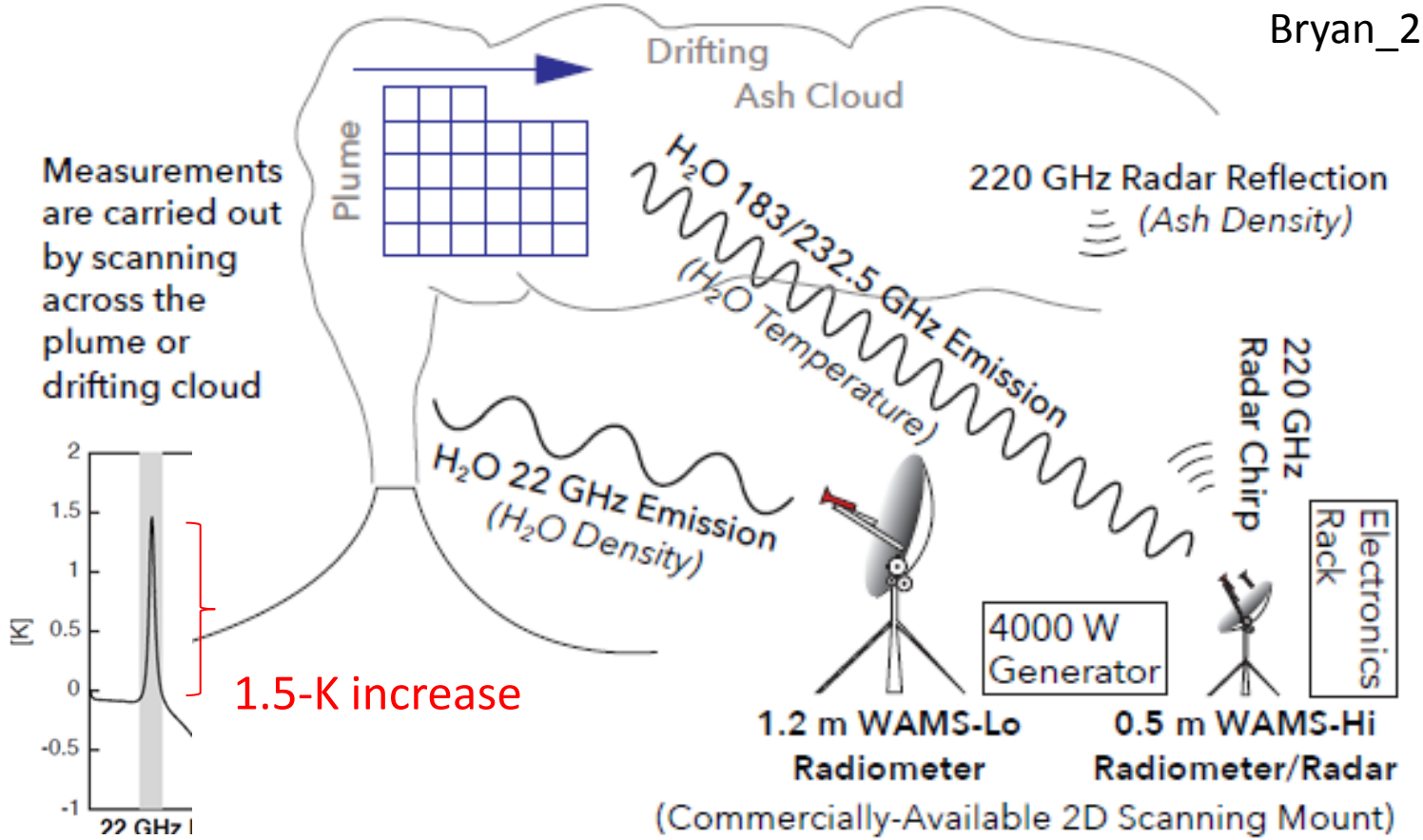
Disaster in Ontake in 2014, Japan

56 confirmed dead and seven still missing

After deadly eruption, Japan ponders how to improve predictions,
By Dennis Normile Oct. 17, 2014, Science News

H_2O monitoring of a volcano fume

Bryan_2016



1.5K in Tb ↔ 6.8 mm in EPL↔1 mm in PWV ↔ 1 kg/m^2 in column density