Phase calibration in SMA

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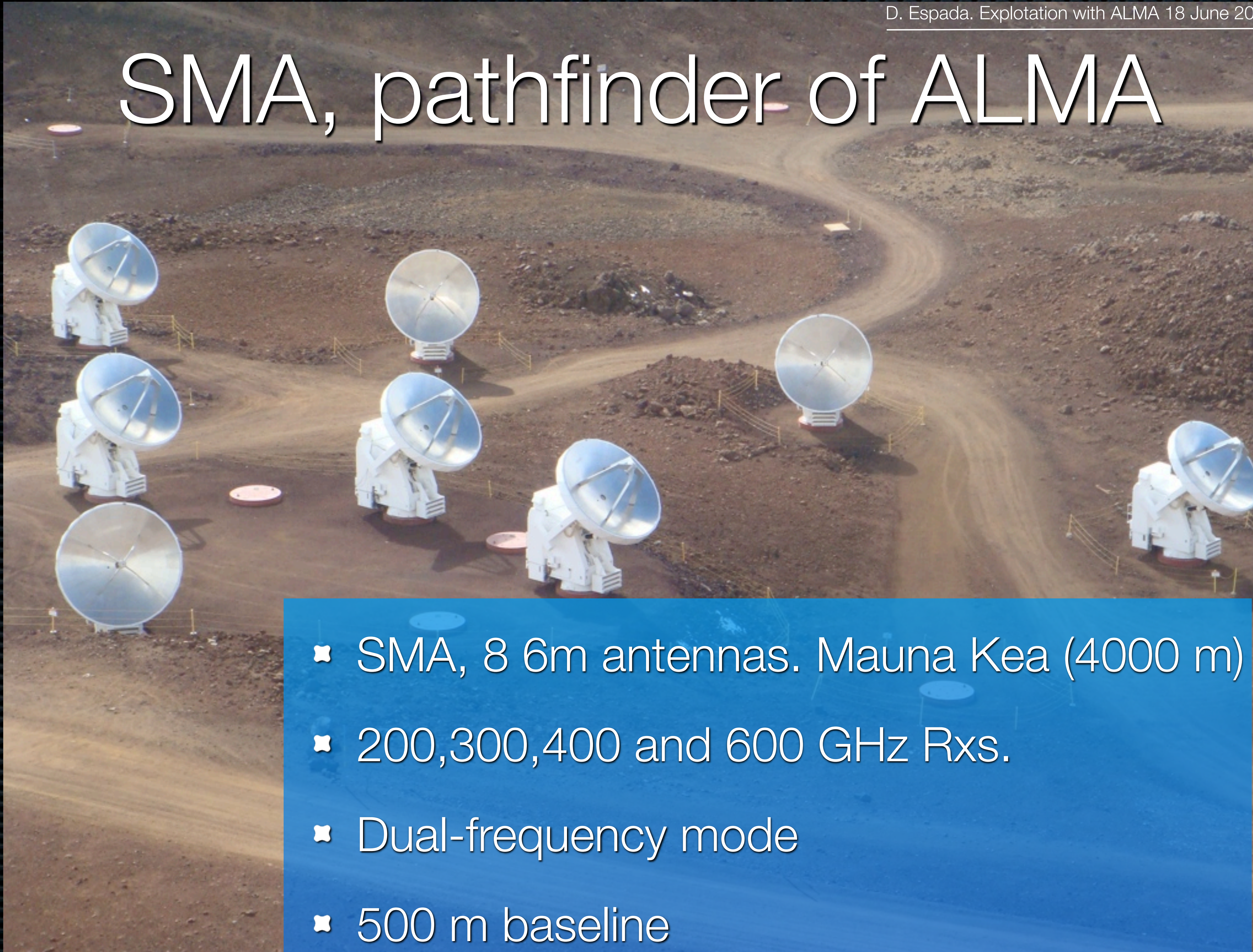
Marie Curie fellowship

- ASIAA (alphabetical order)
  - Derek Kubo, Sheng-Yuan Liu, Satoki Matsushita, Yu-Nung Su
- CfA:
  - Rob Christensen, Brian Koge, (T. Hunter), T.K. Sridharan, Paul Yamaguchi
- IAA:
  - Vicent Martinez, AMIGA group

Why gain calibration in mm/submm?

- Water vapor content fluctuations in the troposphere:
  - Absorption
  - Excess path delay (decorrelation of the phase)

SMA, pathfinder of ALMA



- SMA, 8 6m antennas. Mauna Kea (4000 m)
- 200,300,400 and 600 GHz Rxs.
- Dual-frequency mode
- 500 m baseline

Phase calibration techniques

- Water Vapor Radiometer
- Fast switching
- Phase Transfer

Phase calibration techniques

- Water Vapor Radiometer (e.g. #210, # 252, #496)
  - Sufficient system stability.
  - Good calibration to convert from water vapor to path delay.
  - Rely on atmospheric models.

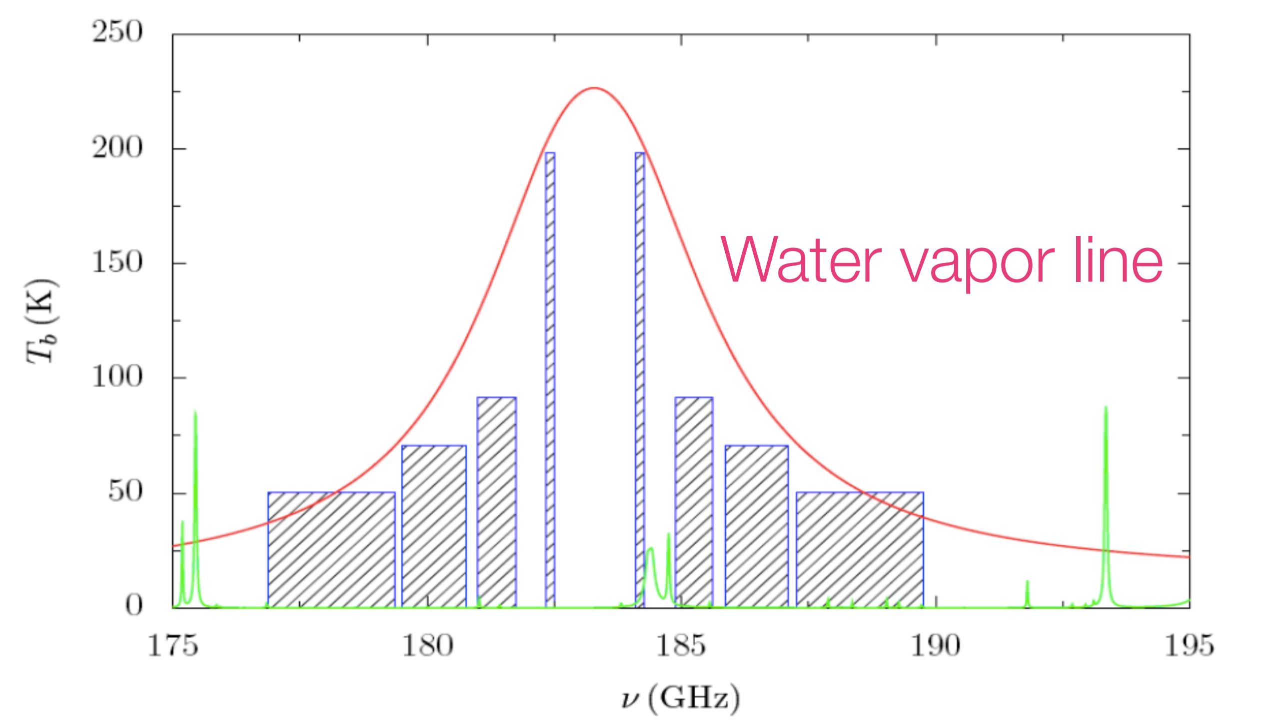


Figure 1. RF coverage produced by the filters in the prototype radiometers.

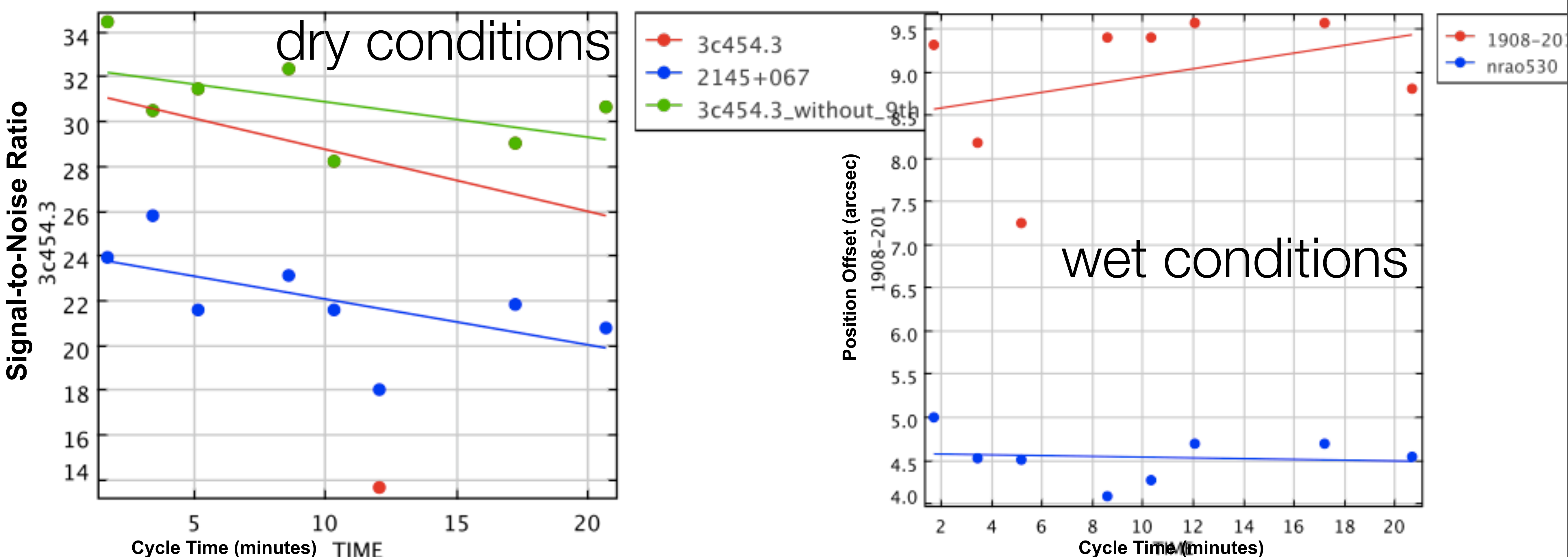
#568

Phase calibration techniques

- Fast switching (e.g.#262, #403, #404)
  - Track phase fluctuations with a calibrator source.
  - Strong calibrator (optimum at 90 GHz), and closeby to minimize slewing time to target source.
  - r.m.s phase structure function: rms phase increase with the baseline length (up to 16 km!)
  - How to scale the phase from 90 GHz to target freq.?

Fast Switching Test (Master thesis V. Martinez)

- -3 QSOs imaging data
- –7 SMA datasets. Maximum baselines ~ 260 m. 345 GHz.
- –Cycle= Primary calibrator - QSO1 - QSO 2. 20 sec integration each (5 sec integration time) during 4 hours.



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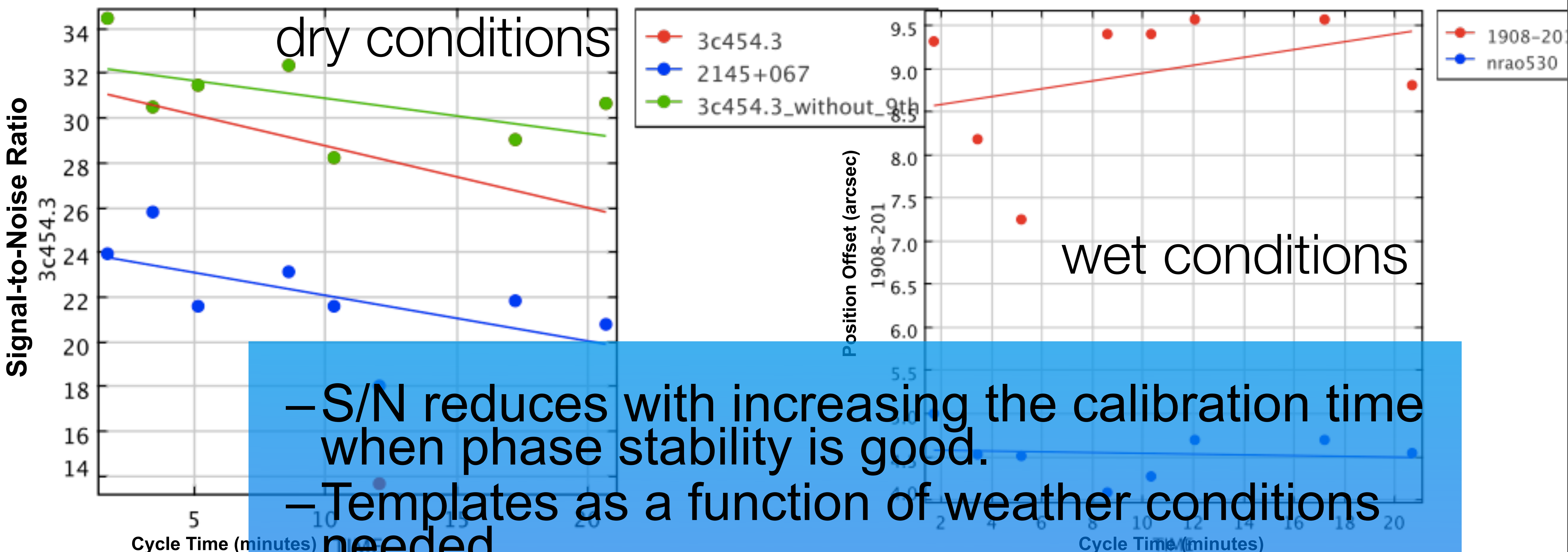


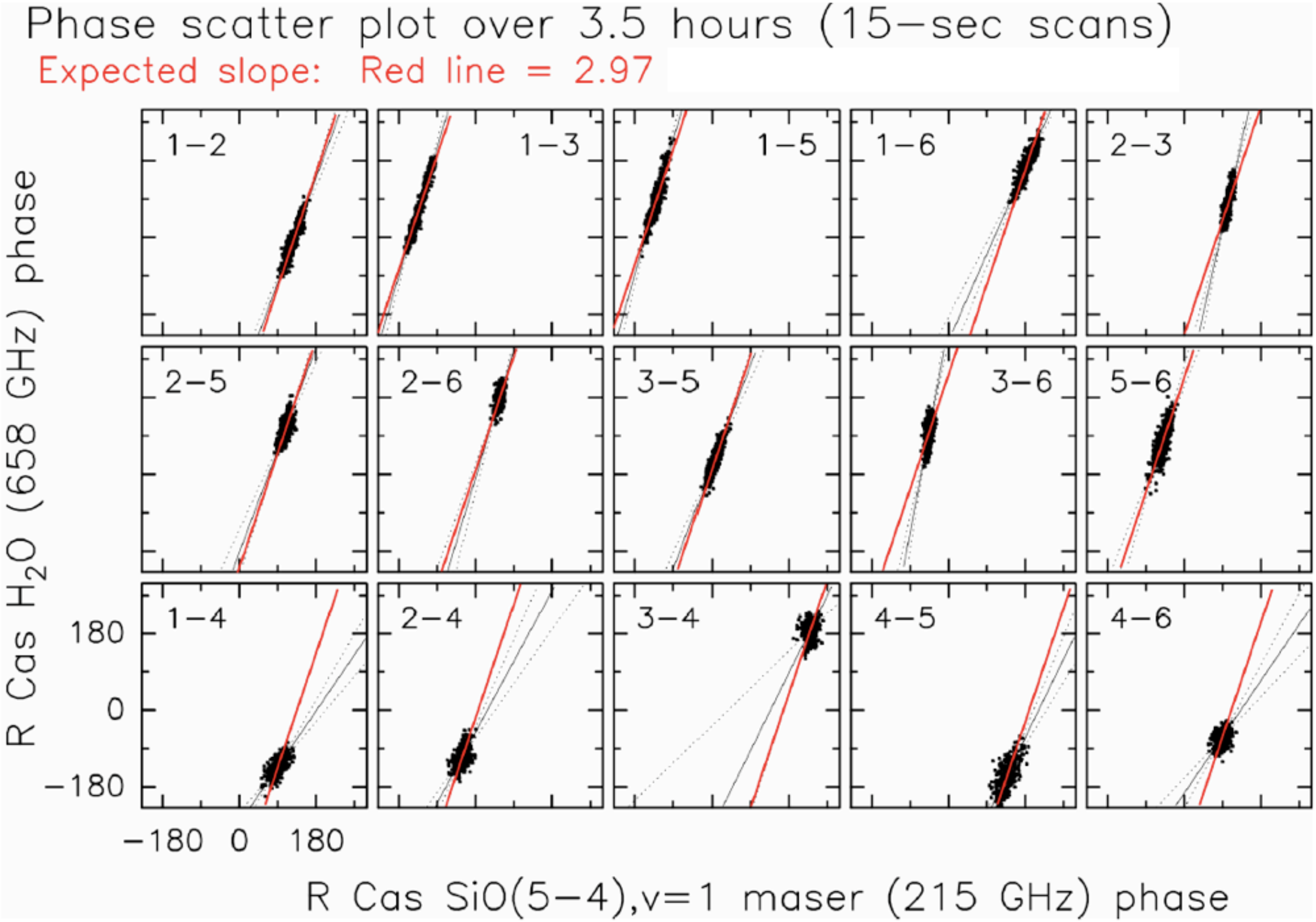
- –S/N reduces with increasing the calibration time when phase stability is good.
- –Templates as a function of weather conditions needed.

Phase calibration techniques

- Phase Transfer
  - Atmosphere:
    - Ratio of phases between high freq and low freq: $R = (\Delta L_2/\lambda_2) / (\Delta L_1/\lambda_1) = f * (\nu_2/\nu_1)$
    - f depends on the AM model. Ex. f =0.97 in Mauna Kea (S. Paine's), R= 2.97 for **658.006 / 215.595.**
      - Non-linearity close to H_2O absorptions (e.g. #404).
  - Instrumental effects: Artificial phase drifts (and jumps)

SMA Phase Transfer test, T. Hunter, December 2005

Dec 2005 @ SMA, T. Hunter



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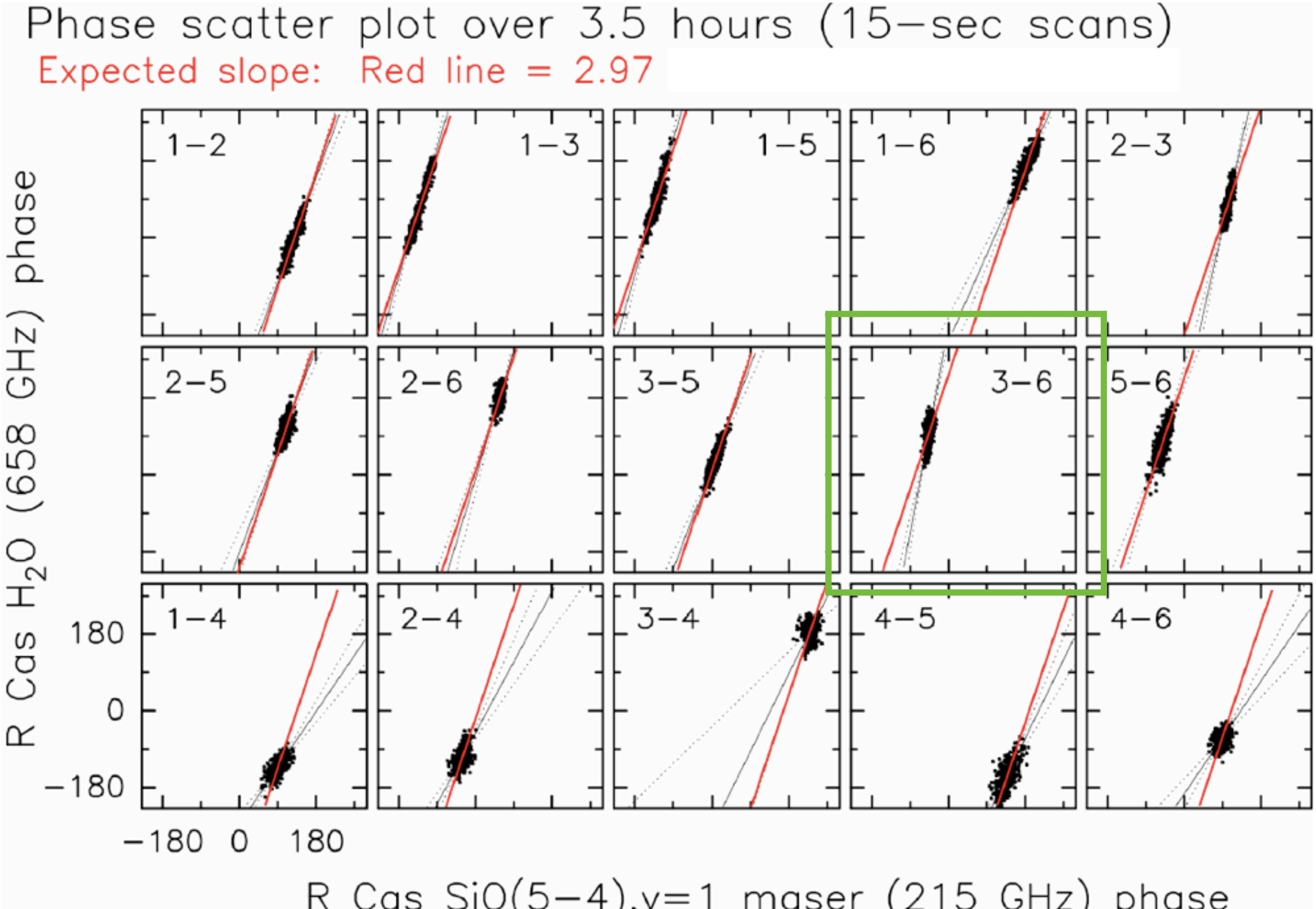

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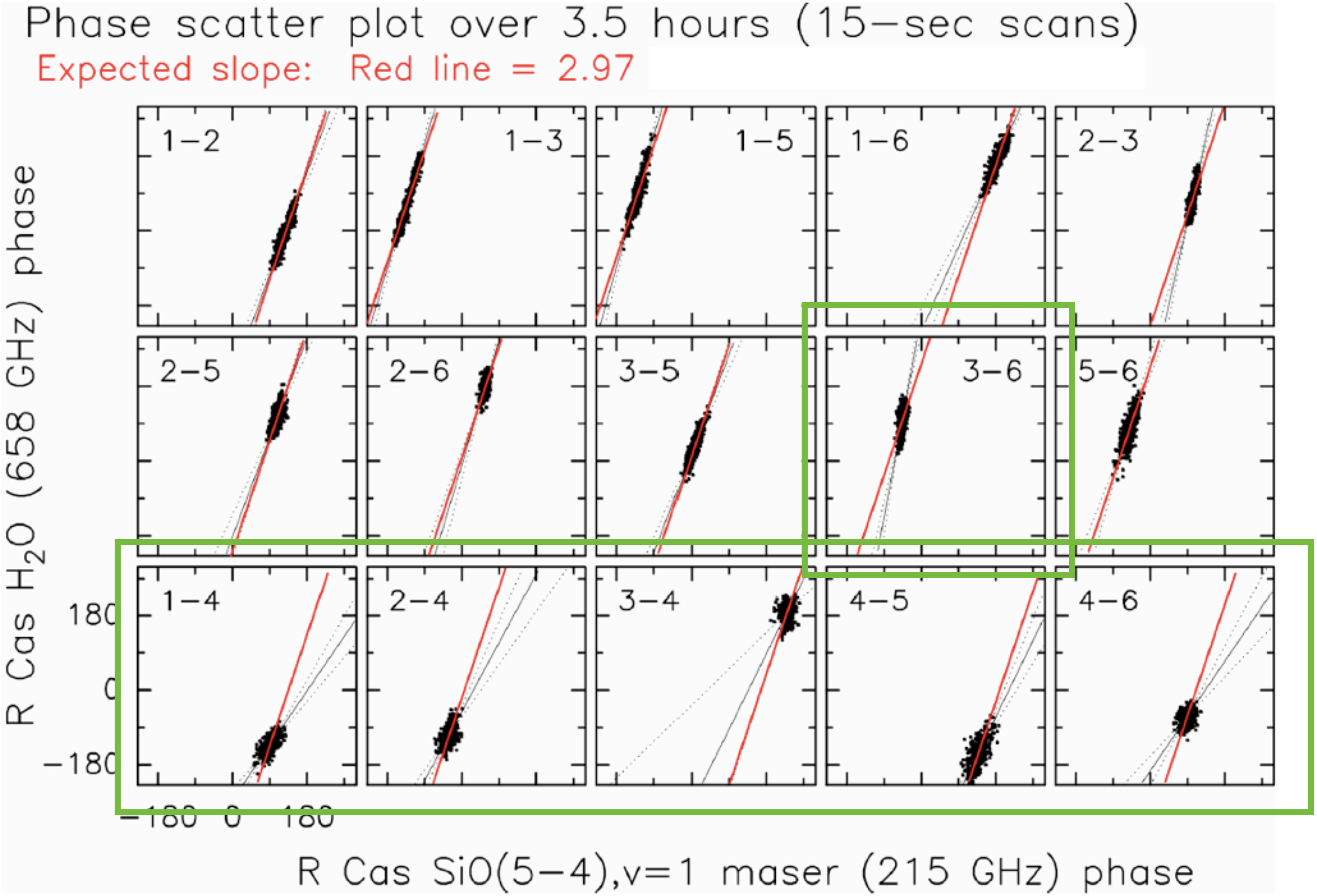

SMA Dual Receiver Beacon Test -- Setup

October 2007

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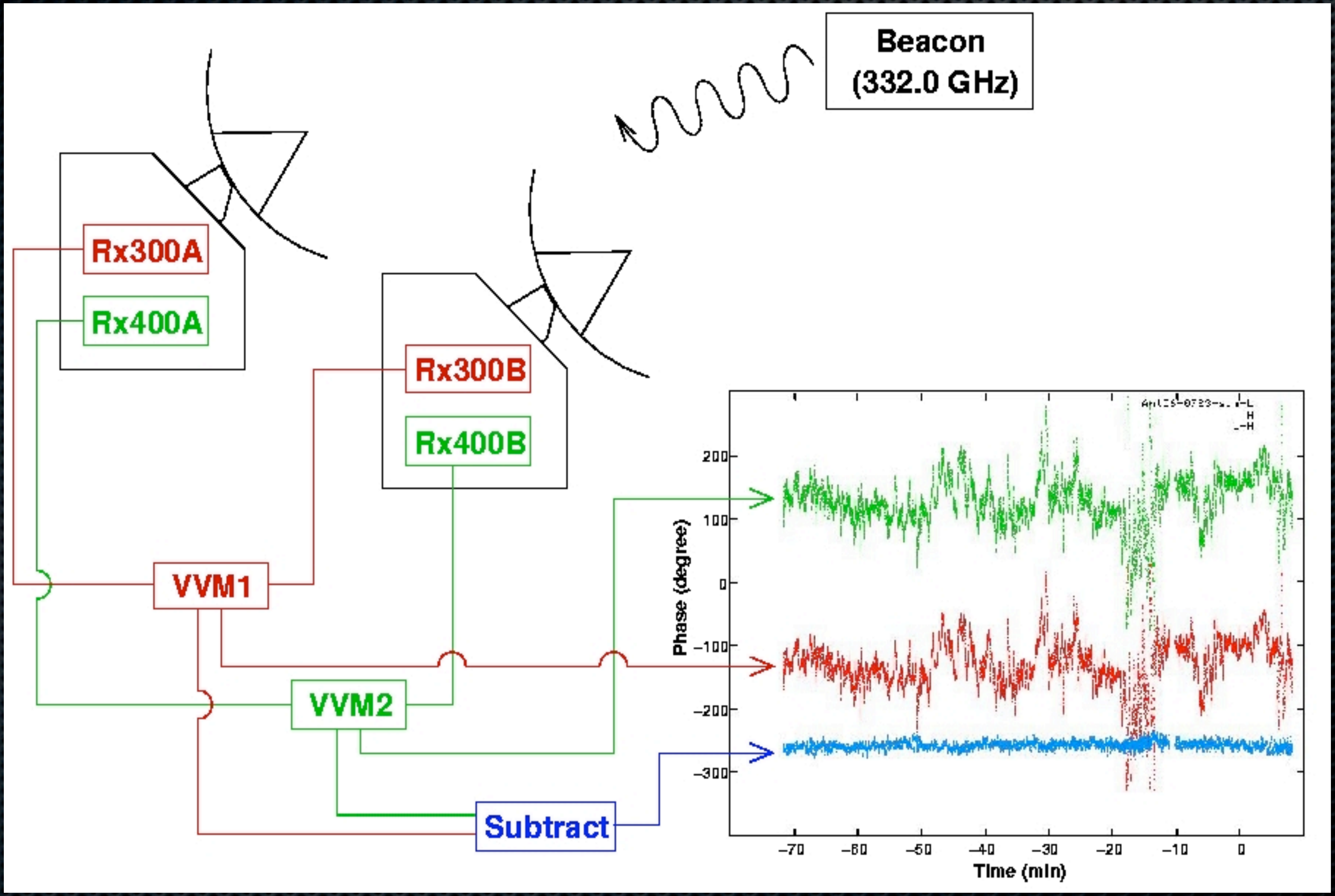
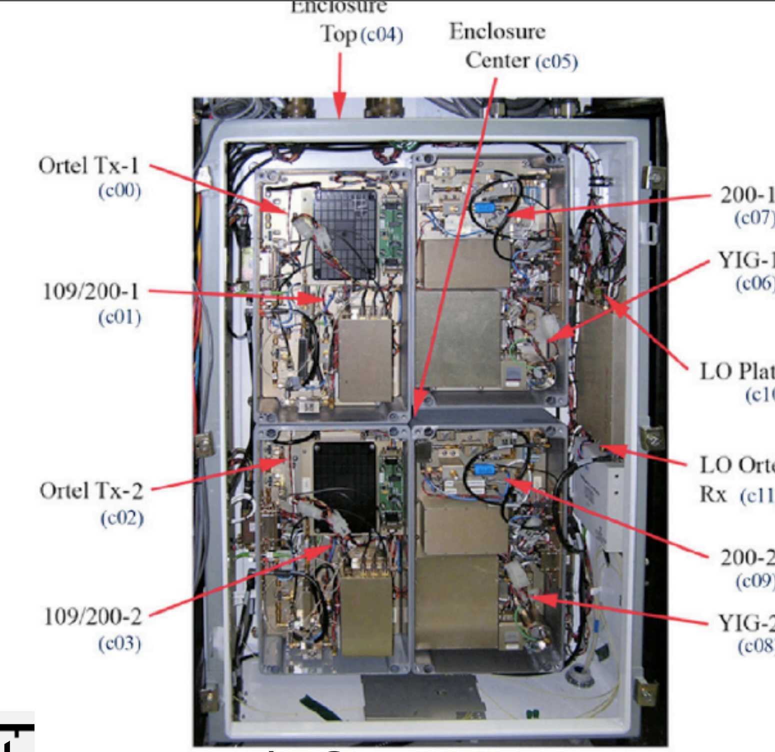
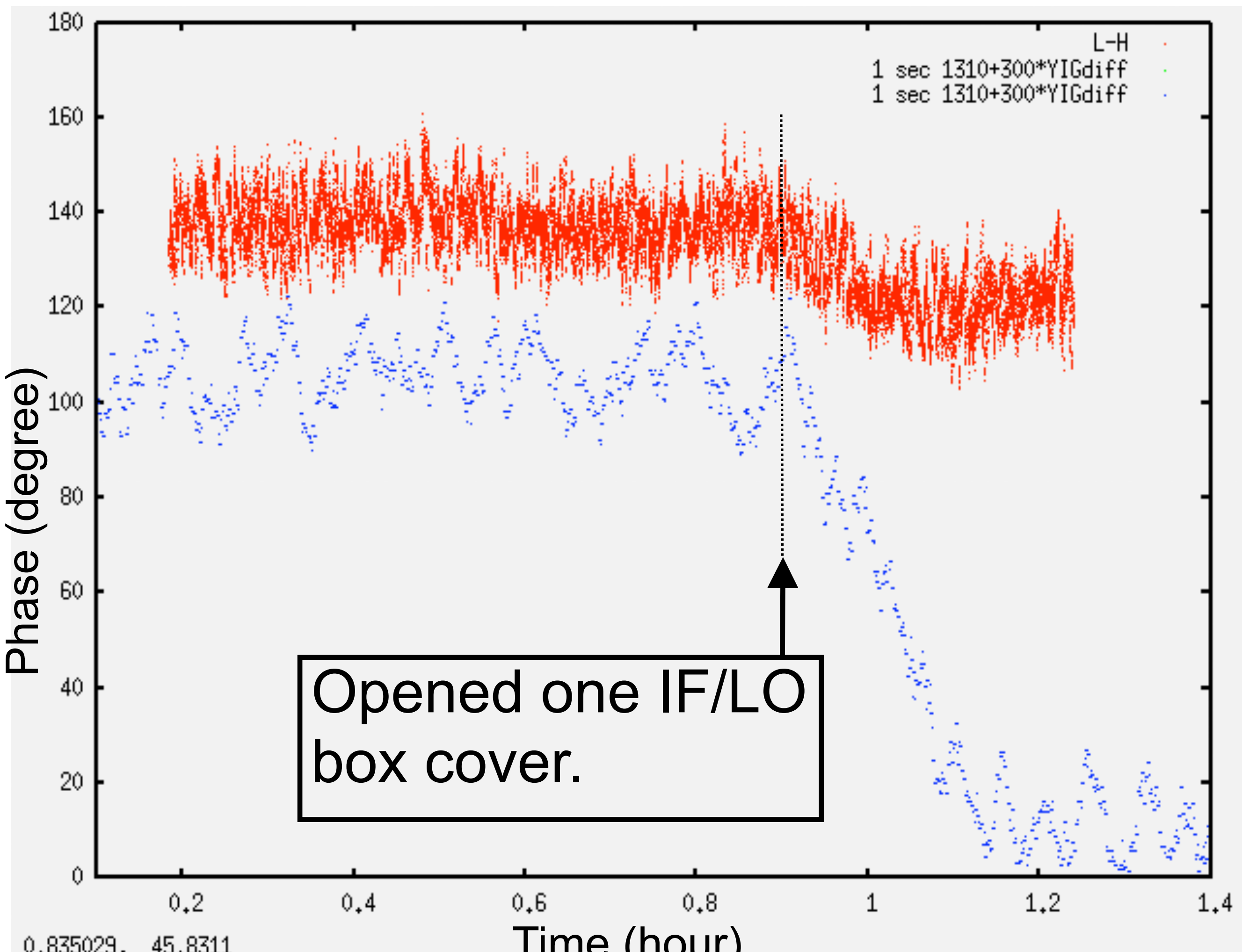
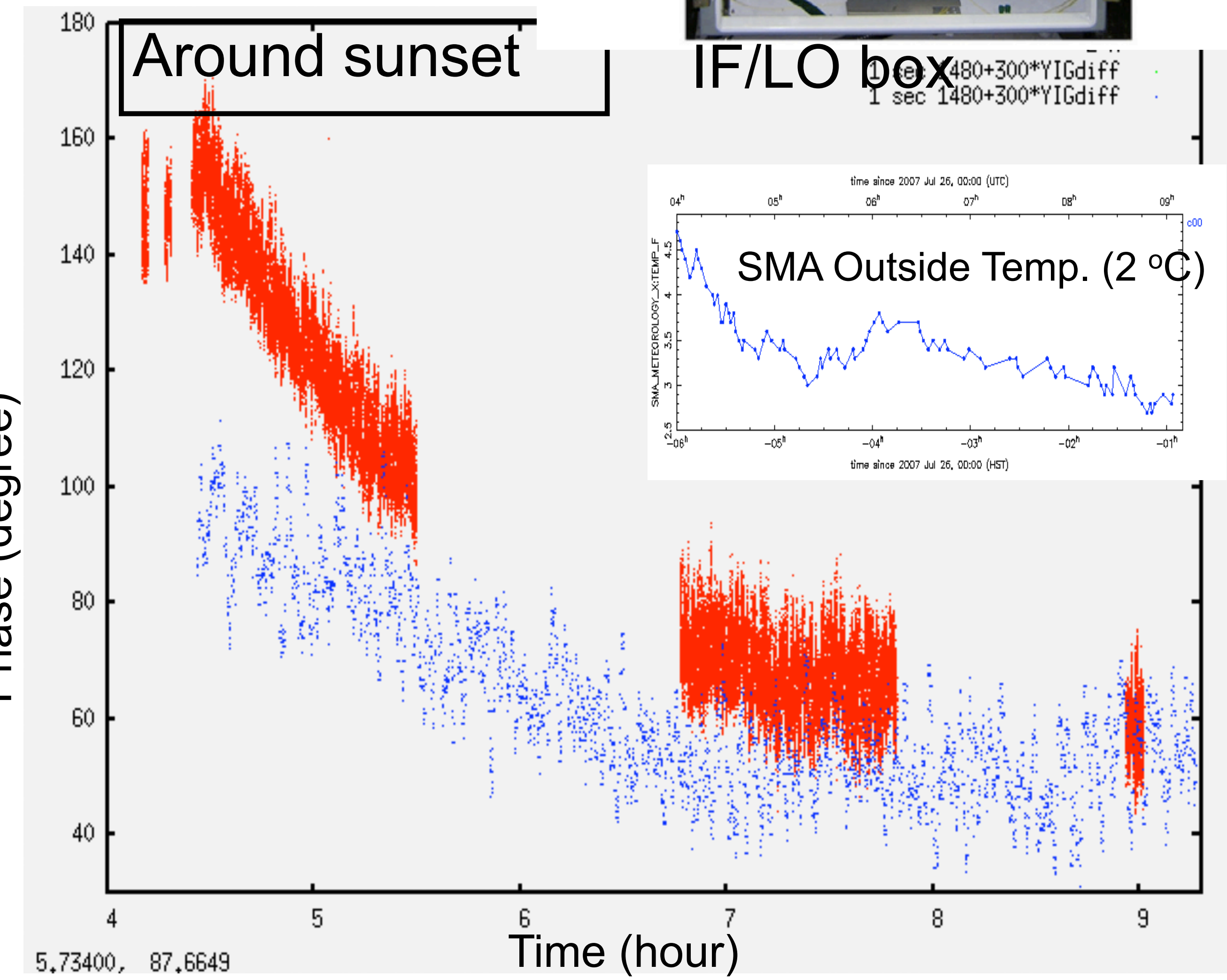


Dual Receiver Beacon Test Preliminary Results (1): IF/LO box





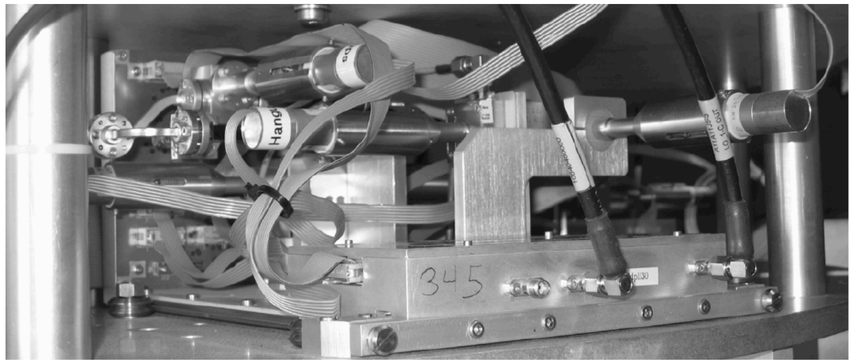


Red data: Phase fluctuation (Rx300A - Rx300B) – (Rx400A – Rx400B)

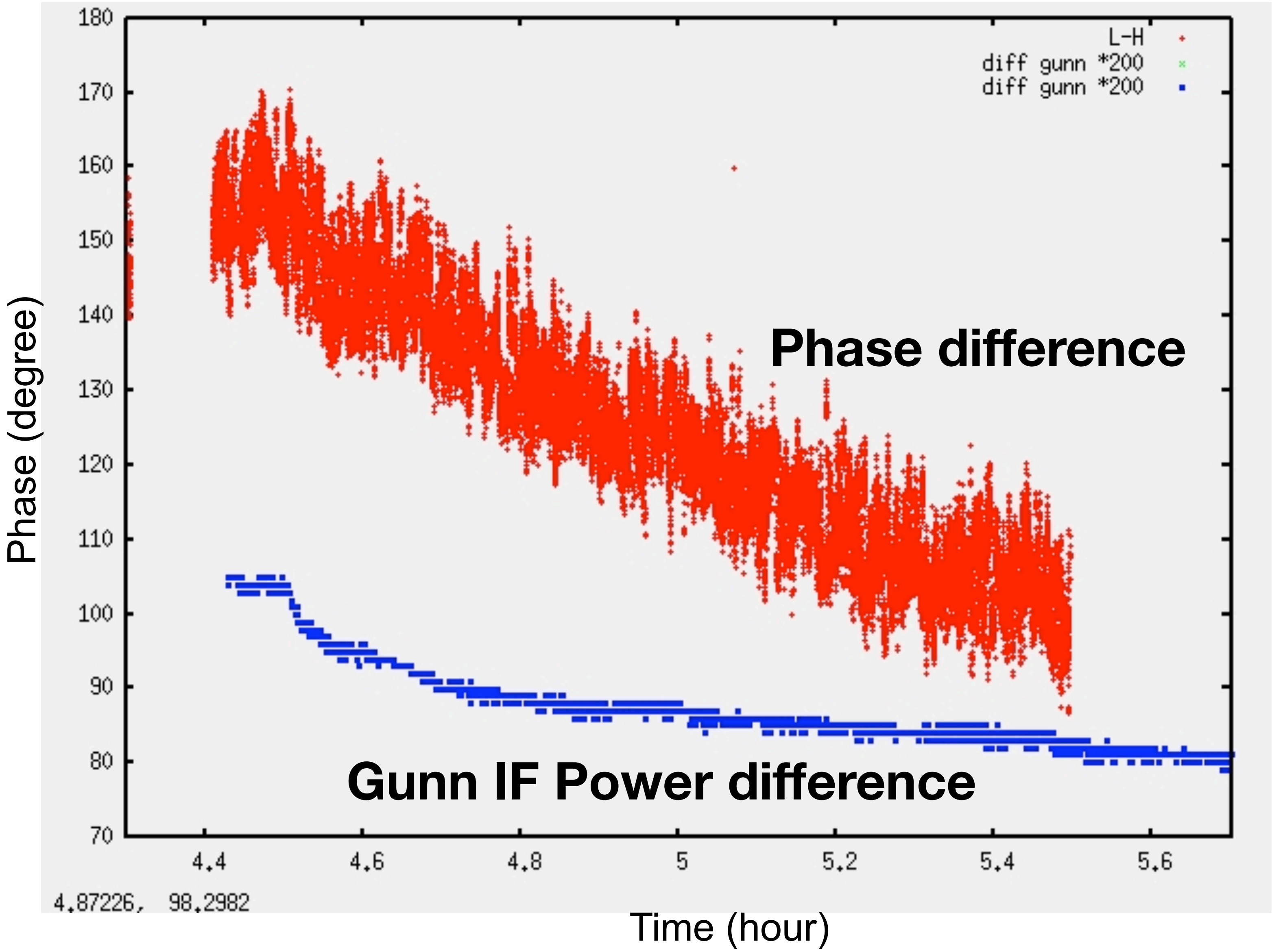
Blue data: YIG temperature (Rx300A - Rx300B) – (Rx400A – Rx400B)

(YIG temp. scale is the vertical scale divided by 300)

Dual Receiver Beacon Test Preliminary Results (2): Gunn LO plate



Gunn LO plate

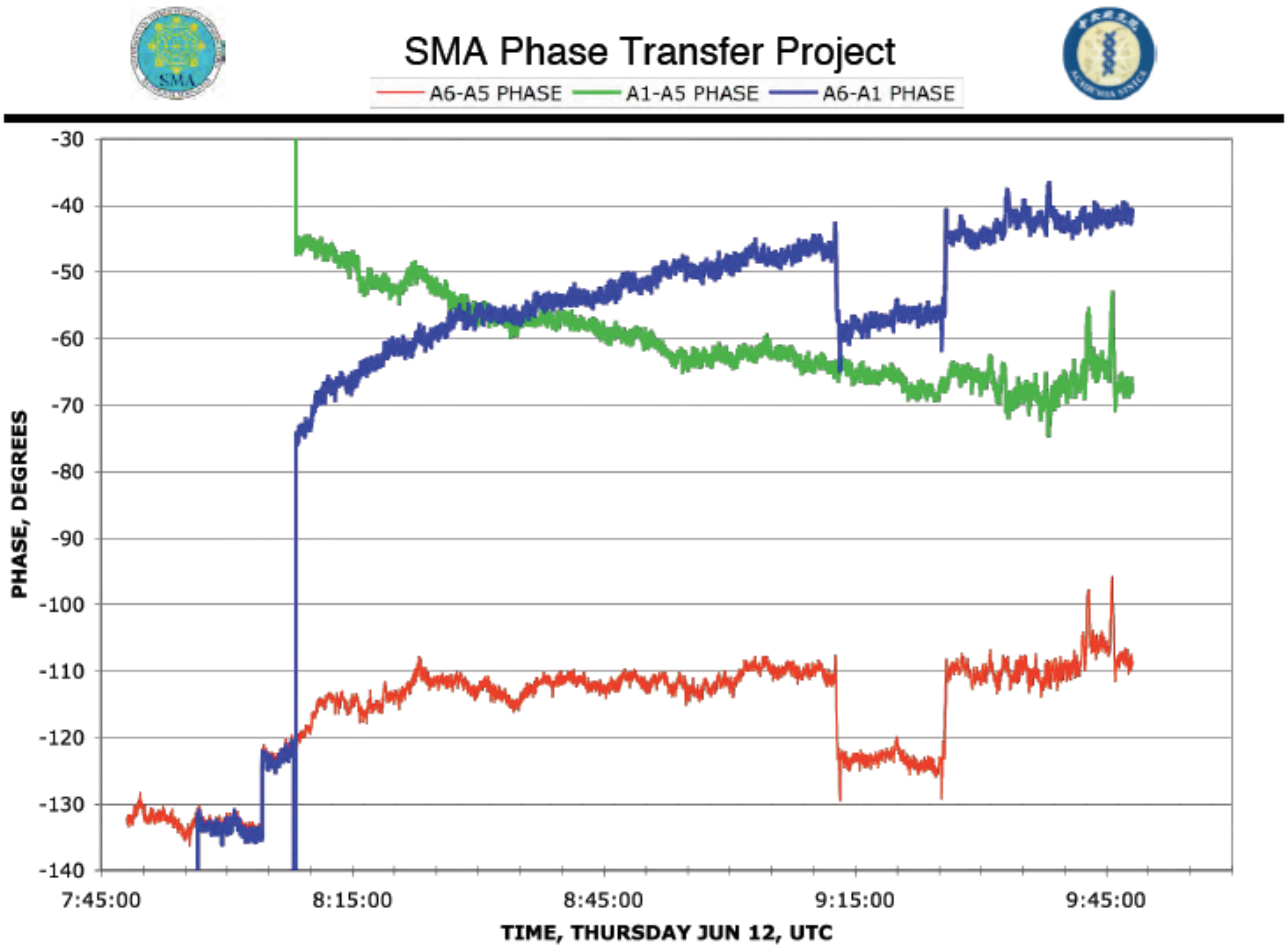


Red data: Phase (Rx300A - Rx300B) – (Rx400A – Rx400B)

Blue data: Gunn IF power (Rx300A - Rx300B) – (Rx400A – Rx400B)

Actual temperature scale is the vertical scale divide by 200.

Dual Receiver Test Preliminary Results (3): Azimuth (RA: 0-180°)



D. Kubo, R. Christensen, R. Blundell

Dual Receiver Beacon Test
Next Step

- Stabilize temperatures of IF/LO boxes and Gunn plates.
- Install more thermistors in sensible components.
- Study possible correlation of eng. variables and phase drifts and jumps.
- Other effects: azimuth, etc.

Summary

- SMA is suited as pathfinder to study phase calibration of ALMA since covers the mm/submm range and located in a relatively dry place.
- FS: It works in SMA. We are characterizing cycle time with atm. weather and rms structure function.
- PT: It does not work in SMA. We find difficult to correct instrumental effects from the IF/LO box and Gunn plate.
- ALMA calibration scheme is a combination of WVR+FS, but little is planned according to the needed PT, especially instrumental effects. Nice tests for CSV...