National Aeronautics and Space Administration

Simultaneous X- and Ka-Band Receiver for Astrometry and Navigation

Principal Investigator: Jacob Kooi (386); Co-Investigators: James Bowen (333), King Man Fung (386), Daniel Hoppe (333), Raju Manthena (333), Zubair Abdulla (333), Anthony Beasley (NRAO)

Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: Advanced Celestial Reference Frames - Strategic Initiative Leader: Melissa A Soriano

Objective:

The objectives of this proposal is to develop a wideband cryogenic monolithic microwave integrated circuit (MMIC)- based receiver, to cover 8-36 GHz, simultaneously covering X and Ka band, for potential use in developing an X-Ka reference frame for astrometry and navigation. The receivers are needed to provide reference frames to navigate, including determining positions of quasars for navigation beacons, measuring station locations, and measuring earth orientation to the nano-radian level or better. The measurements of X and Ka band simultaneously allows for calibrations of both the Earth's ionosphere and solar plasma at the exact time and direction of the observations. The measurements of X and Ka band simultaneously allows for calibrations of both the Earth's ionosphere and solar plasma at the exact time and direction of the observations.

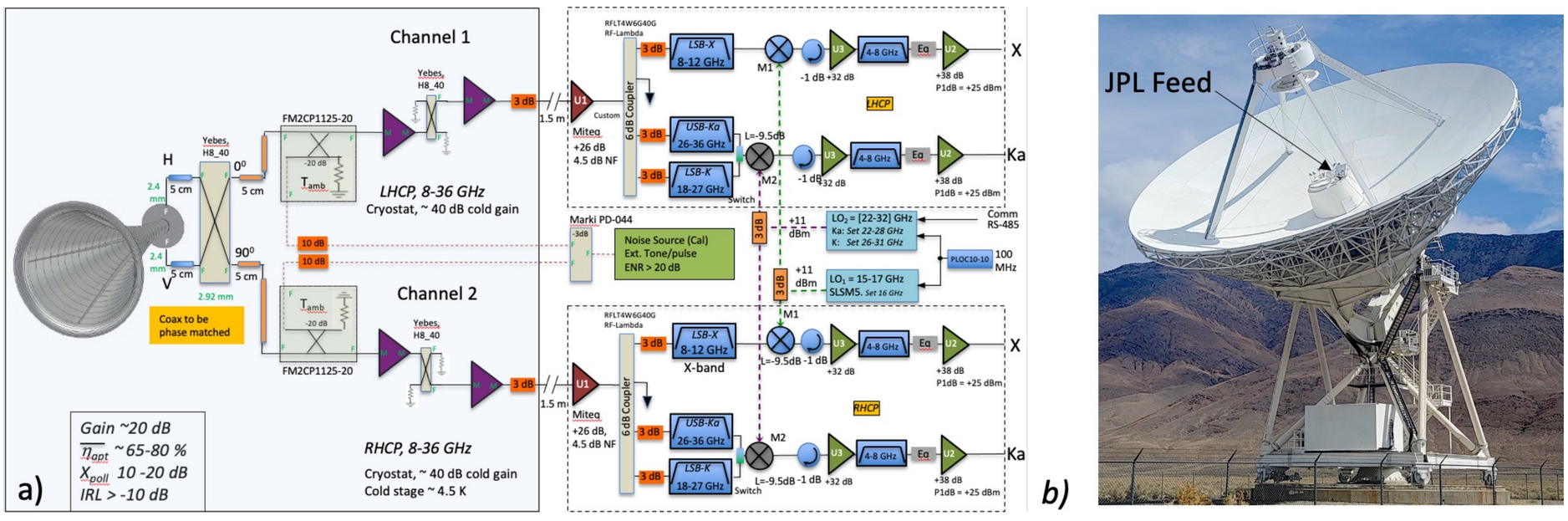

Figure 1a) Schematic diagram of the new simultaneous X-Ka Band receiver under development. On the left is the front-end, which utilizes three key components developed under this task: a Quad-Ridge Feedhorn, Wideband LNAs, and the 90 degree quadrature hybrids from YEBES Observatory, Spain. To the right is the IF processor / IF downconverter. To interface to the VLBA antenna the IF output is down converted into the 4-8 GHz frequency range. b) Owens Valley VLBA antenna at which the X-Ka band receiver will be installed.

Background: This Strategic Initiative is designed to strengthen JPL's leadership in defining the next-generation of celestial reference frames. As part of its vision to be a world leader in deep space telecommunications, the Interplanetary Network Directorate (IND) has invested in higher radio frequency (Ka-band, 36 GHz).

Approach and Results: A prior LNA designed in NGC's 35 nm InP process by then-graduate student Ahmed Akgiray, has achieved between 13-20 K from 8-40 GHz [PhD dissertation, Caltech 2013]. Similar results were obtained at JPL in a design using OMMIC, again intended for the wider 8-50 GHz frequency range. Both of these chips, with their wider bandwidth, have compromised noise performance in order to obtain the gain up to 50 GHz. By reducing the bandwidth requirement to 8-36 GHz, the LNA performance is expected to improve substantially.
In Fig. 3a we show the Simultaneous X- and Ka-Band Receiver wideband receiver being hoisted up to the 'Apex' room of the Owens Valley 25-meter VLBA Antenna (operated by the NRAO) with final installation in the Rx room in Figure 3b. A letter of intent was sent to Anthony Beasley, Director of the NRAO, in 2021 from JPL 9x indicating the objective of demonstrating this receiver on one of the VLBA antennae. Anthony Beasley and NRAO have indicated their interest in collaboration by providing a VLBA antenna and observing time for demonstration.

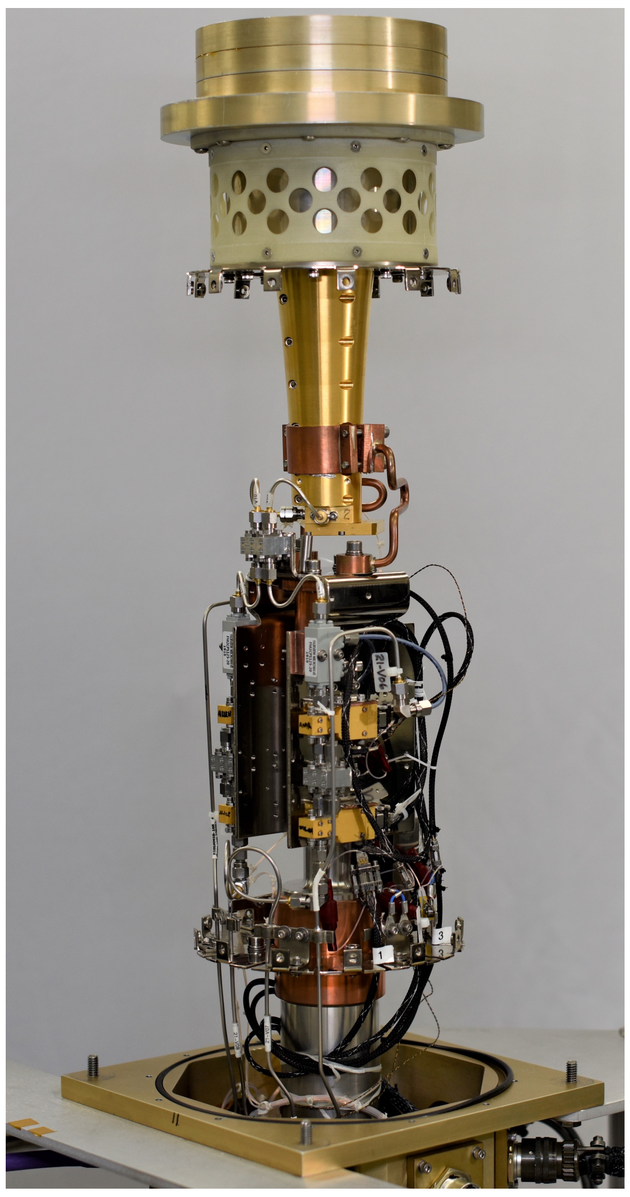

Figure 2) Fully assembled 'circular' polarized X-Ka band receiver.

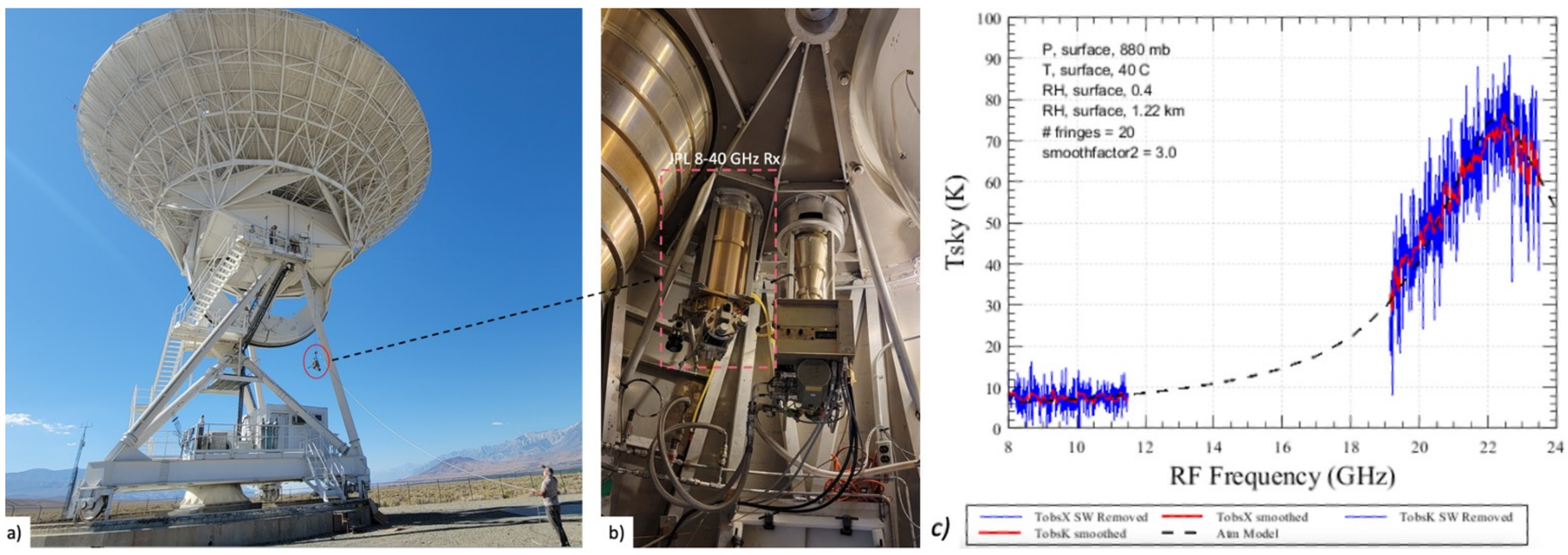

Figure 3) JPL 8-40 GHz Celestial Reference Frame Receiver being hoisted up to the Owens Valley 25m VLBA . *b) Installed* 8-40 GHz wideband *receiver in the Rx cabin on top of the apex room visible on the left. The quad-ridged feedhorn protrudes out the ceiling ~40 cm (Fig 1b) to illuminate the secondary mirror. c) 'First light', observed H2O line on the sky in zenith.*

Innovation: No other wideband 8-40 GHz LNAs exist covering the full frequency range, in industry or on any radio telescope. The JVLA achieves excellent noise performance in separate LNA designs for 8 different bands

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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Publications:
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PI/Task Mgr. Contact Information:
Email: Jacob.W.Kooi@jpl.nasa.gov