VLBI2010 Prototype Status

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and

The Broadband Delay Development Team

Broadband Delay Team

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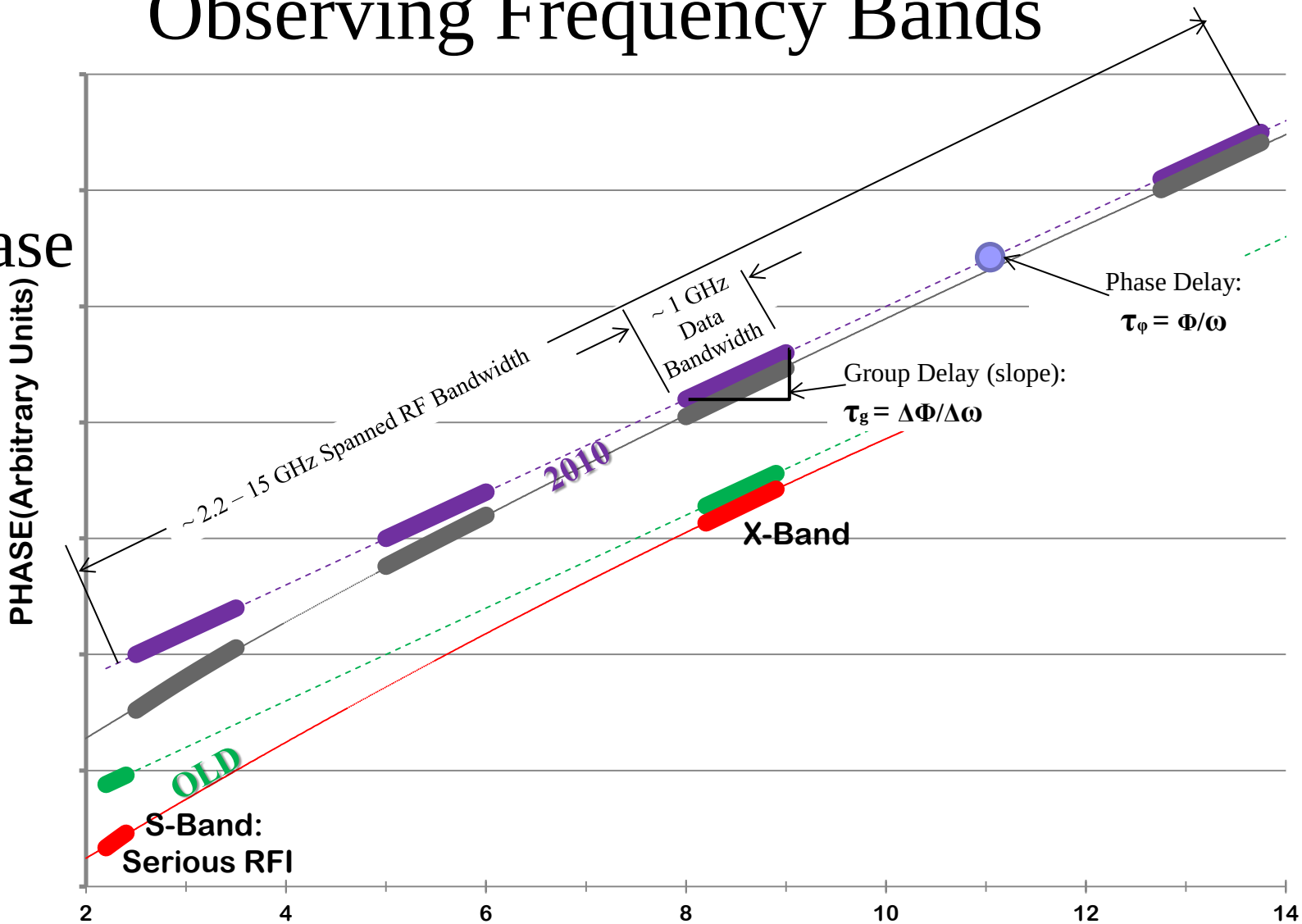
VLBI2010 Project Overview

- New geodetic VLBI system
  - Smaller (~12m), fast slewing antennas with
  - Four bands of RF between 2 and 14 GHz.
- Proof-of-concept equipment was installed on two existing antennas and observations taken
  - Westford 18m antenna, Massachusetts
  - MV3 5m antenna, near Washington, D.C.
- New 12m antenna installed at Goddard Space Flight Center
  - Eleven feed installed

Observing Frequency Bands



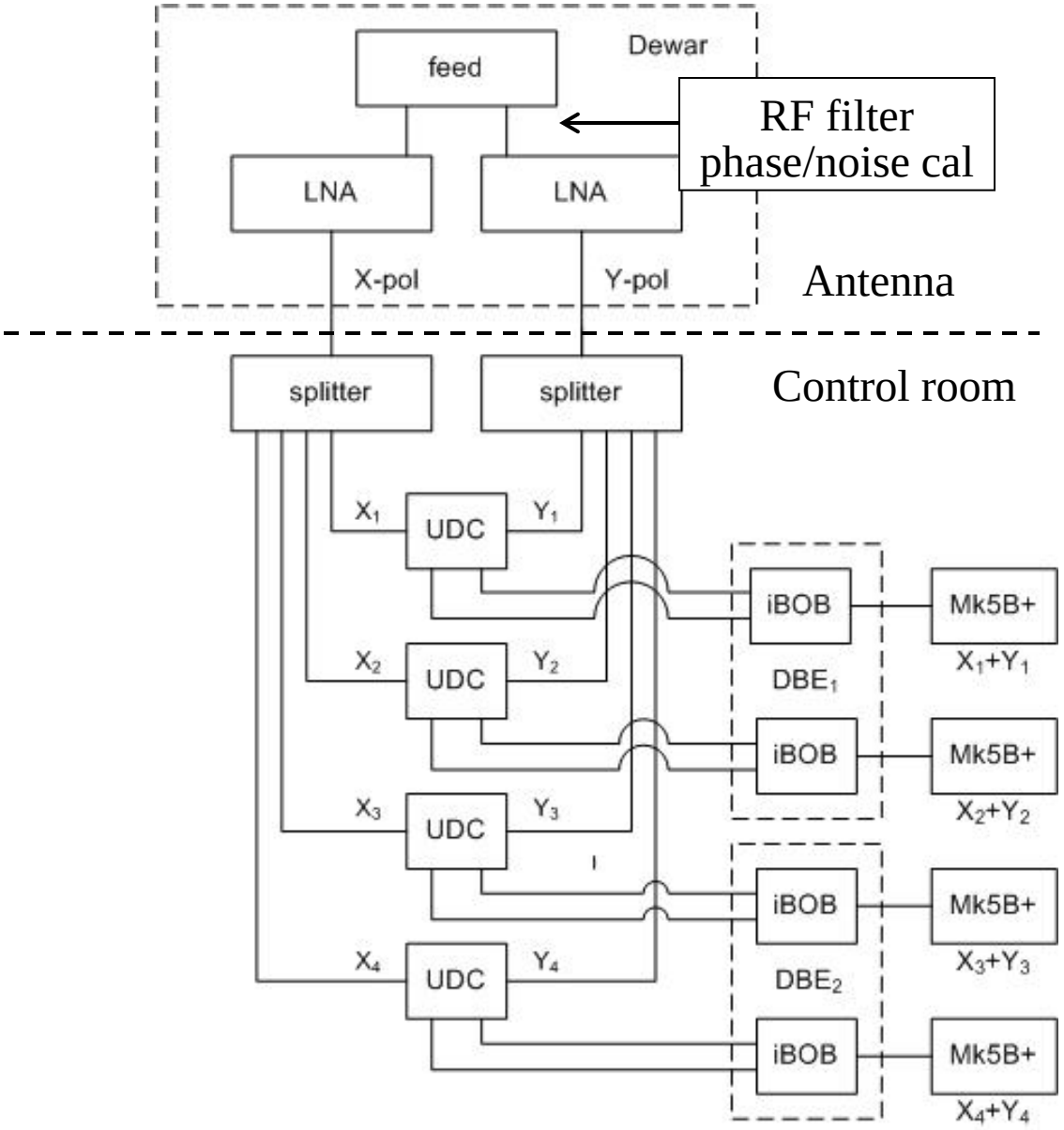
Phase

2 14

Frequency (GHz)

System components

- High-slew-rate antenna (≥ 12m diameter; >5°/sec)
- Broadband (2-12 GHz) feed
- Low noise broadband amplifiers
- Phase and noise calibration system
- Flexible local oscillator for band selection (4)
- Digital backend (4)
- High data rate recorder (4)



Feed and LNAs cooled to ~20K

Both senses of linear polarization used

Odd channels from each pol'n for one band output to each Mk5B+.

2 gigabits/sec recorded on each Mk5B+.

Total data rate: 8 gbps

Impact on geodetic VLBI

- Dual linear polarization
  - Intrinsic to broadband feed
- Very high data record rate

  (Current data rate 0.256 Gbps)
  - Per polarization in each band: 1 Gbps
  - Per band: 2 Gbps
  - Total data rate : 8 Gbps
- Post-correlation fringe fitting
  - Combine data from both polarizations to estimate phase delay and ionosphere.

Broadband Back-End Hardware

8 gigabit/sec LOs and back end

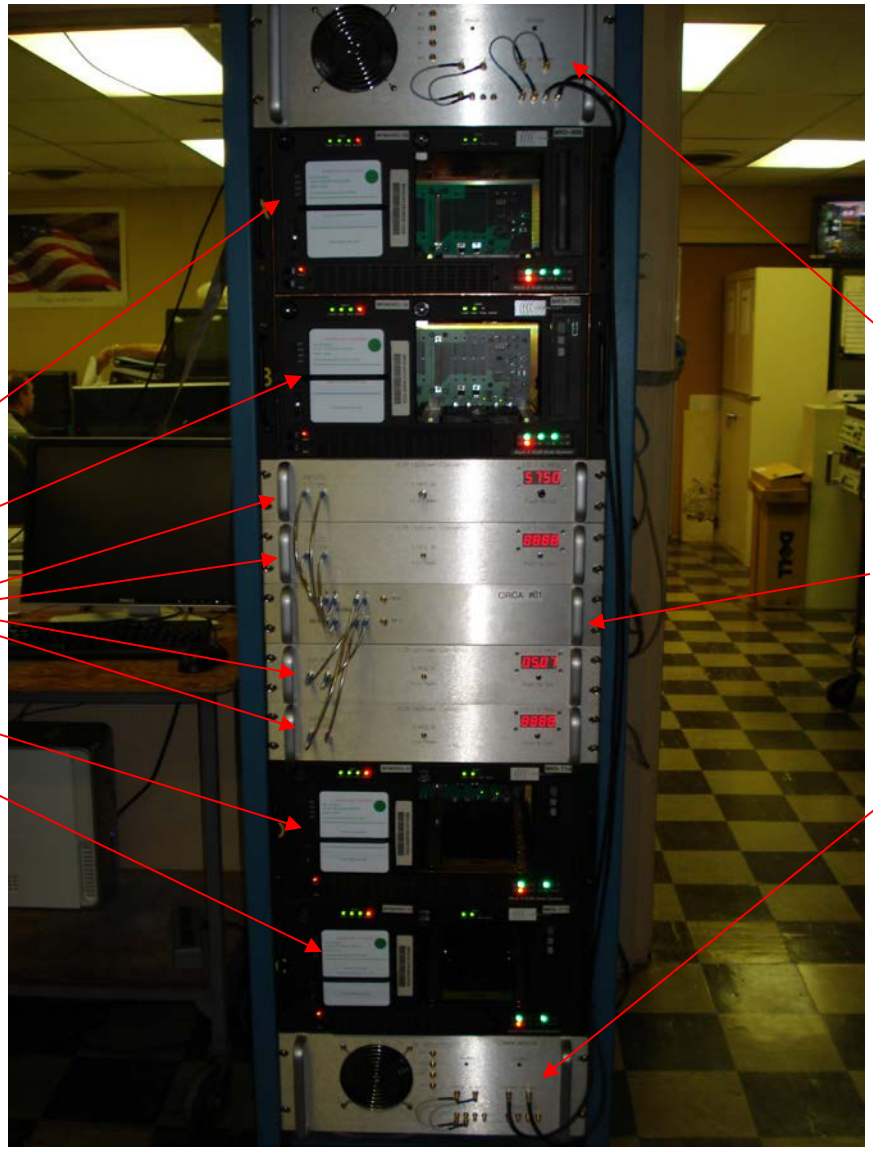


Figure C. 12m antenna at Goddard Geophysical and Astronomical Observatory, Greenbelt, Marylandbb

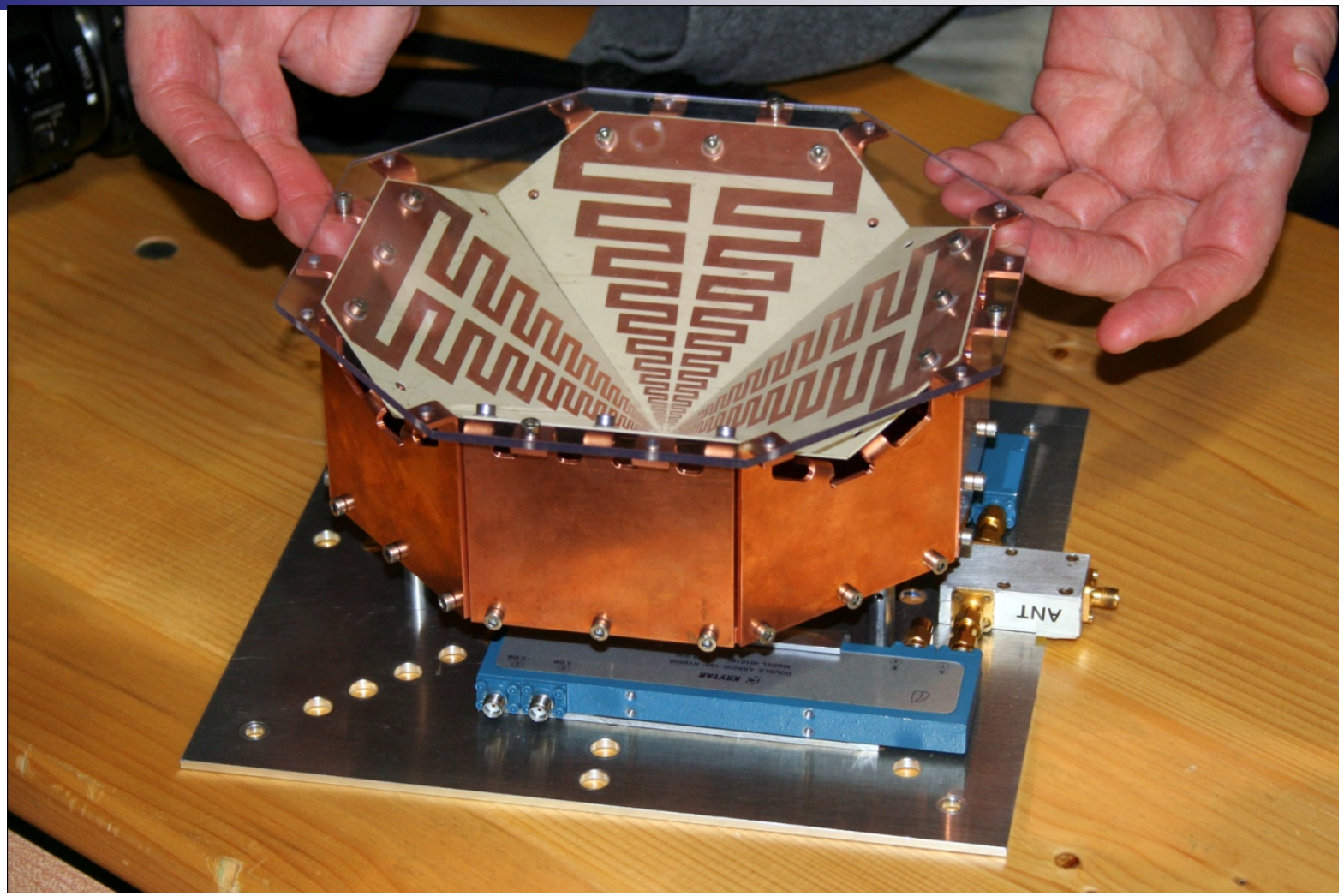


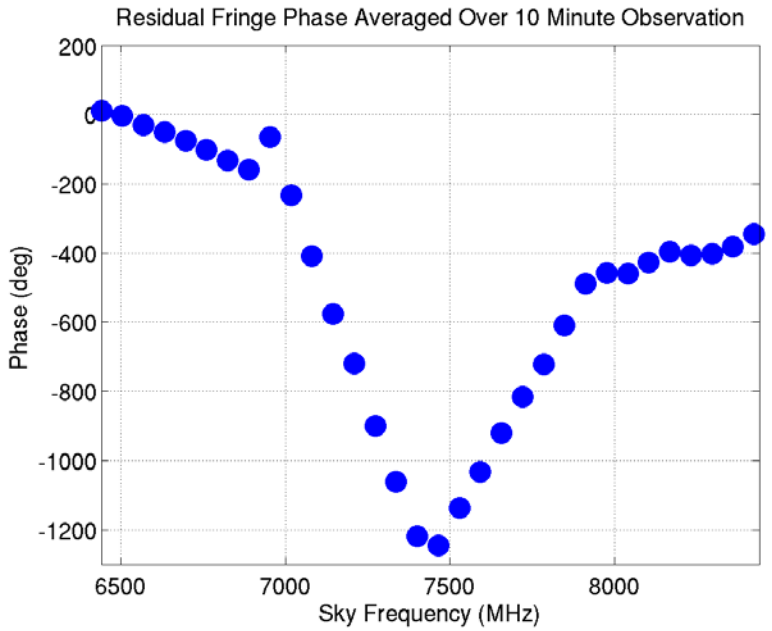
Figure D. The Eleven feed: 2-12 GHz dual linear polarization; frequency independent phase center and beam shape.

Prior activities

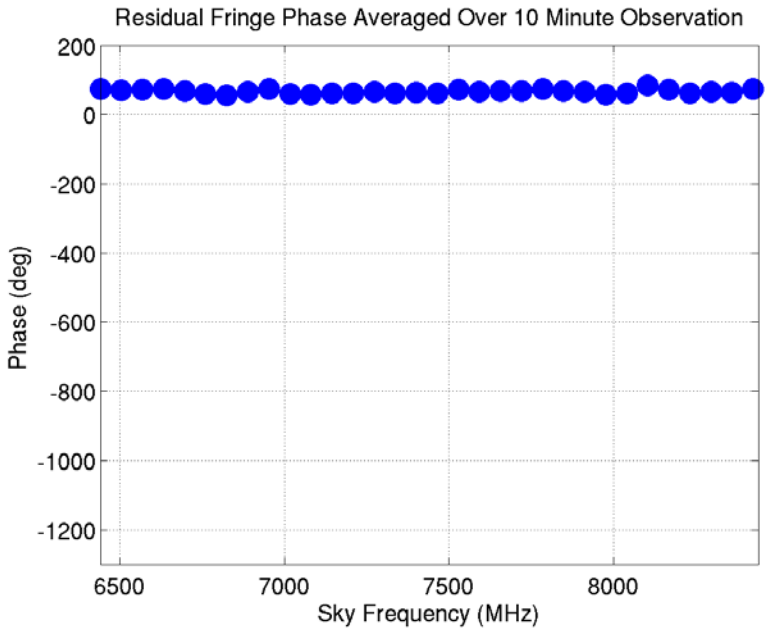
- Proof-of-concept equipment was installed on two existing antennas
  - Westford 18m antenna, Massachusetts
  - MV-3 5m antenna, Washington, D.C.
- Phase-calibrated observations obtained
  - Polarization test on 4C39.25
  - Switching between 3C273 and 3C279
- Correlation/post-correlation
  - Correlated on Mk4 hardware correlator
  - *Fourfit*'d as separate polarizations

Contiguous bands
6.4 GHz – 8.4 Ghz

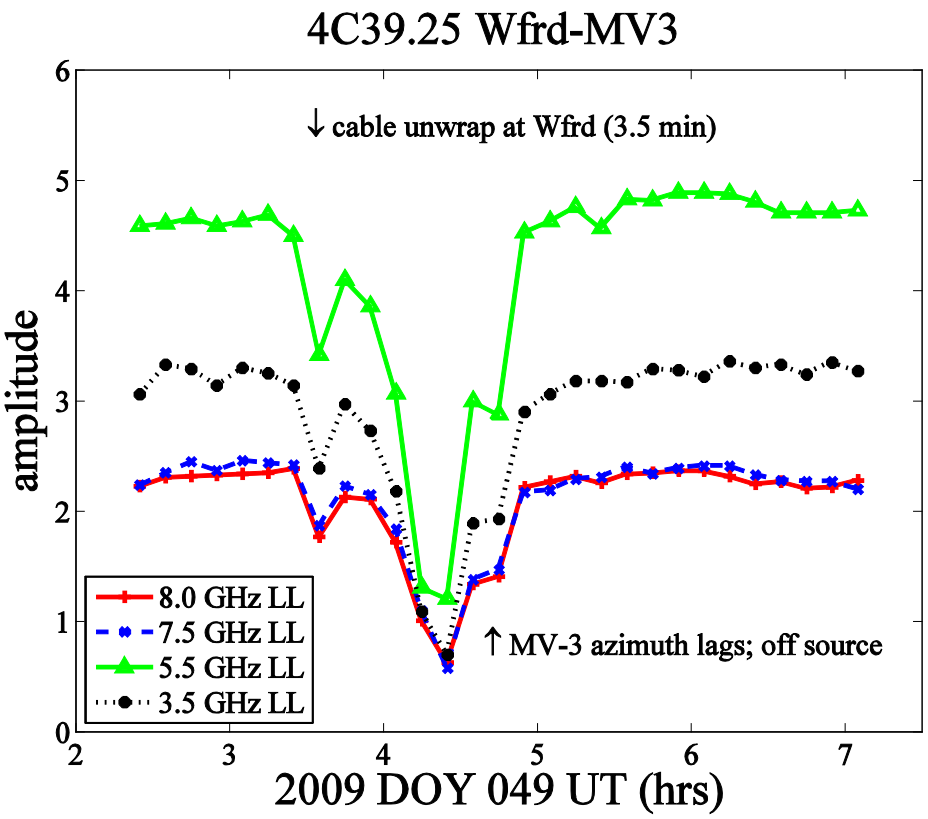
No phase cal

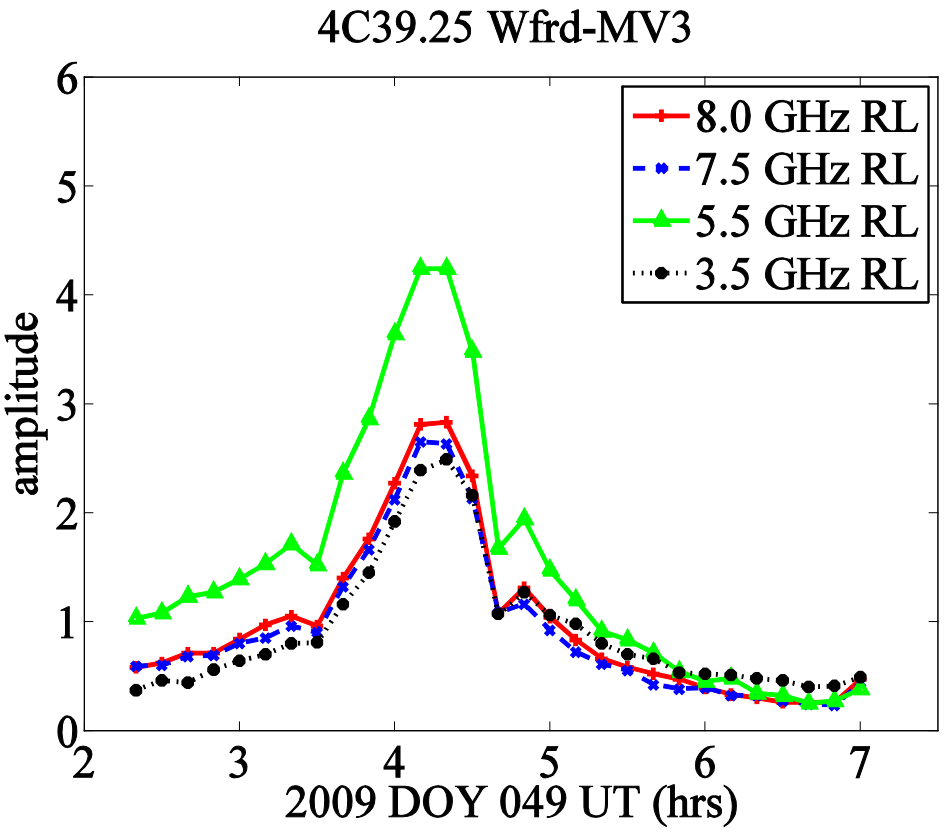


With phase cal



Polarization test





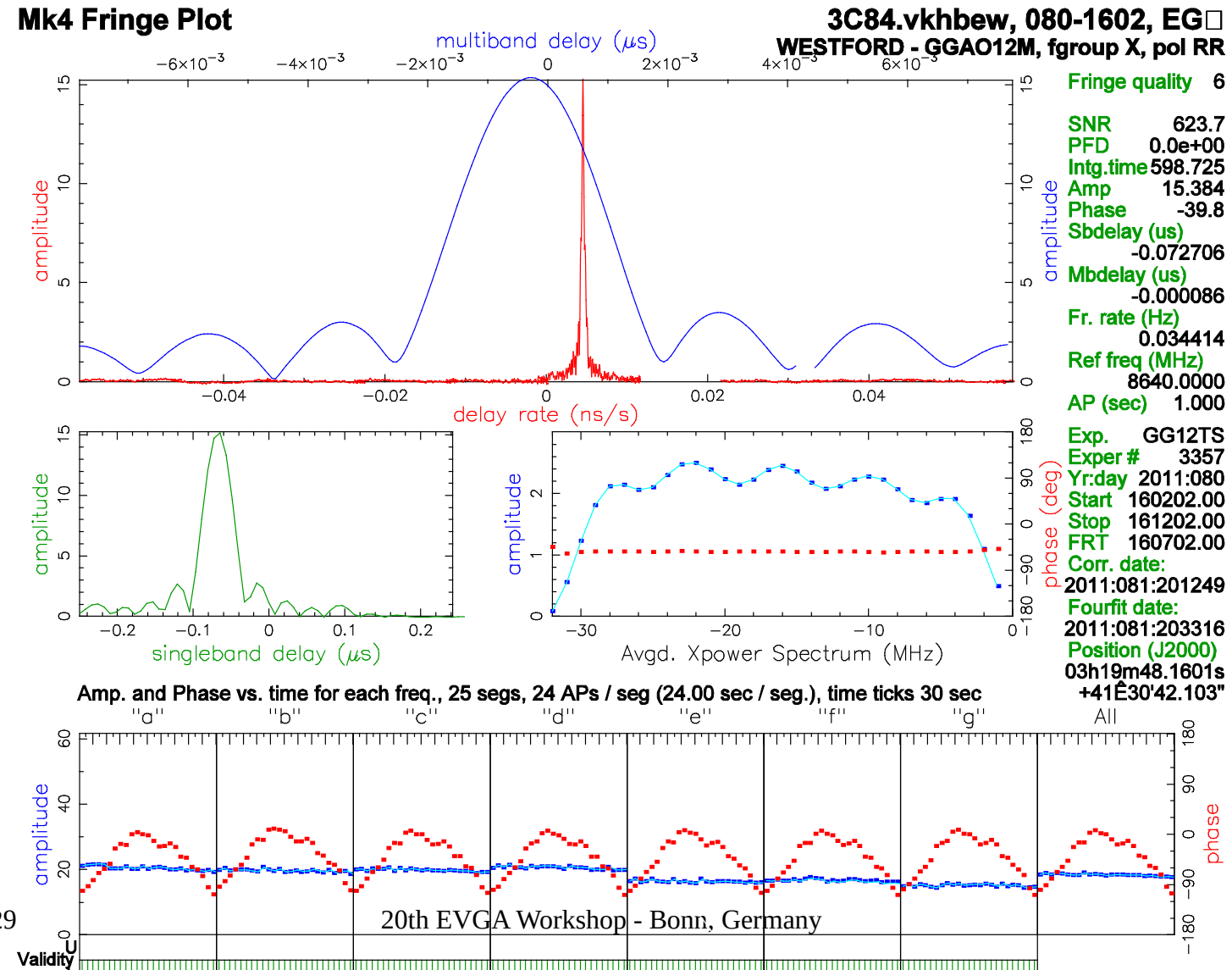
Recent Progress

- Patriot 12m antenna
  - Antenna assembled near MV3 at GGAO
  - Dewar with new feed and LNAs installed
  - Uses same control room as MV3 antenna, but separate control computer
- First light checkout (Monday March 21)
  - Pointing checks revealed small corrections
  - Correction to apriori focus was only 3 cm
  - SEFD found to be higher than expected by factor of 4 – 8 (sensitivity lower).

First Fringes!!

- Observation
  - GV12 at GGAO, Maryland, to Westford 18m
  - VLBI2010 broadband system at GV12
  - Standard S/X feed/receiver at Westford
  - VLBI2010 backend both sites
  - X-band only
  - 512 MHz polyphase filter bank in DBE1
  - Linear polarizations at GV12; circular at Westford
  - New SigmaTau maser at GGAO
  - Clock within 0.2 μsec

First Fringes!!



Next steps

- Antenna
  - Understand loss of signal
  - Increase phasecal level
  - Measure performance over full frequency range
- Back end (control room)
  - Make broadband delay observations with DBE1s and Mark5B+s
  - Then replace DBE1/Mark5B+s with RDBE/Mark5Cs
  - Install QRFH (Caltech) feed as soon as Dewar is ready
- Post-correlation
  - In *fourfit* be able to estimate two delays and ionosphere from each scan

Future developments

- Digital back end
  - Reduce channel bandwidth to 8 MHz for compatibility with current Mark4 R1/R4 observations
  - Reduce number of RDBEs to two
- Recorder
  - Record on two Mark5Cs at 4 Gbps each
  - Record on one Mark6 at 8 Gbps
- Frequency coverage
  - Double the number of 512 MHz bands to increase sensitivity and improve delay accuracy.

Thank you!

Status - 3

- DiFX software correlator
  - Phase cal implementation almost complete
  - Control scripting and output path not complete
- Post-correlation fringe fitting
  - Delay coherently estimated in each polarization
  - Polarization combination and ionosphere estimation not implemented

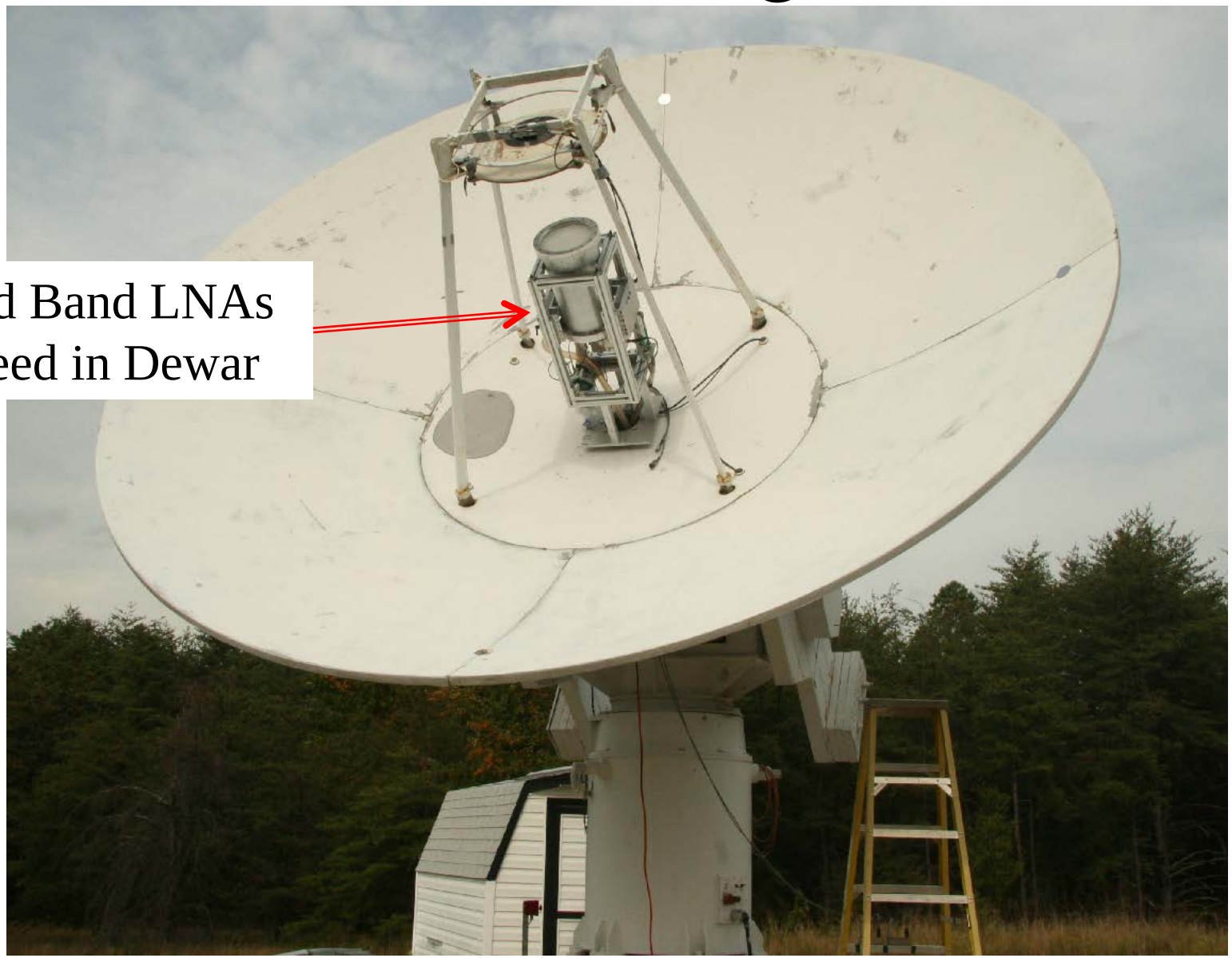
System Components - 2

	Current (PofC)	Next (Prototype)
Feed	Lindgren	Eleven
RF amplif'n	2 LNAs	8 LNAs
Calibration	Phase/noise	same
Flexible LO	UpDown Conv	same
Digital Back End	DBE1(iBOB)	RDBE (ROACH)
Recorder	Mk5B+	Mk5C
Correlator	Mk4 (hardware)	DiFX (software)

Proof of Concept System

- New equipment
  - Commercial broadband feed and LNAs
    - Cover entire frequency range in one feed
  - Flexible frequency converter (UDC)
    - Choose best frequencies
    - Avoid RFI
  - New phase cal generator
  - Digital back end (DBE)
  - High data rate recorder

MV-3 5M Antenna @ GGAO



Proof-of-Concept Development

- Goal: demonstrate four-band phase delay measurement
- Install the proof-of-concept equipment on two existing antennas
  - Westford 18m antenna, Massachusetts
  - MV-3 5m antenna, Washington, D.C.
- Develop improved components as prototype for operational system
- Install the prototype equipment on a 12m antenna that meets the WG3 requirements

The End