The Very Long Baseline Array

Walter Brisken

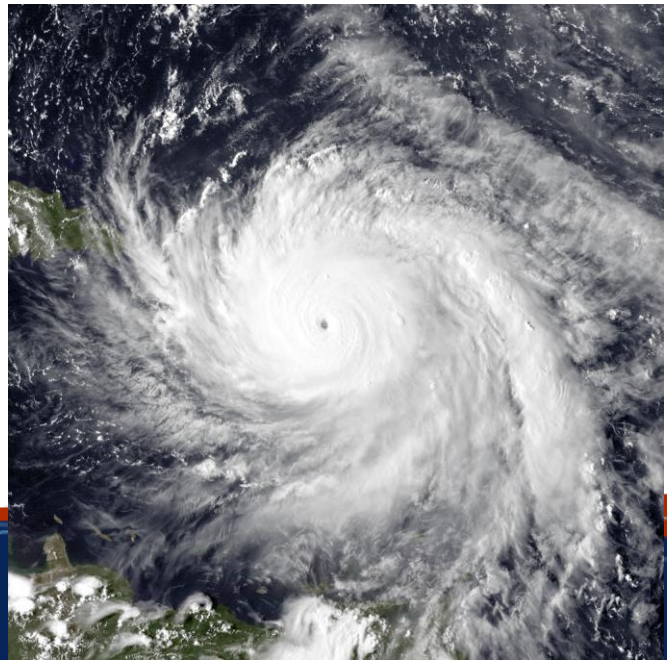
VLBA status now

- 25 years of operation in 2018
- USNO became 50% partner for VLBA operations
  - Reduction in Open Skies time to about 50%
  - Huge increase in VLBA's contribution to geodetic VLBI
- Long Baseline Observatory (LBO) formed and dissolved
  - Fair NRAO management recompetition not possible with uncertain future of VLBA
- NSF awarded to NRAO 8 years of continued operation
  - 2018-2026
- In 2026 all of NRAO will be up for renewal
- Scientific staffing of VLBA is recovering; 2 hires this year

Hurricane Irma, Maria

- Two hurricanes hit St. Croix in Sep 2017
- Island power, comms down for months
  - Antenna down for 6 months
- Antenna minimally damaged, but incurred significant corrosion though disuse
- Received NSF funds to restore antenna and site to full work working condition
  - 4.5 months of downtime expected starting in April or May

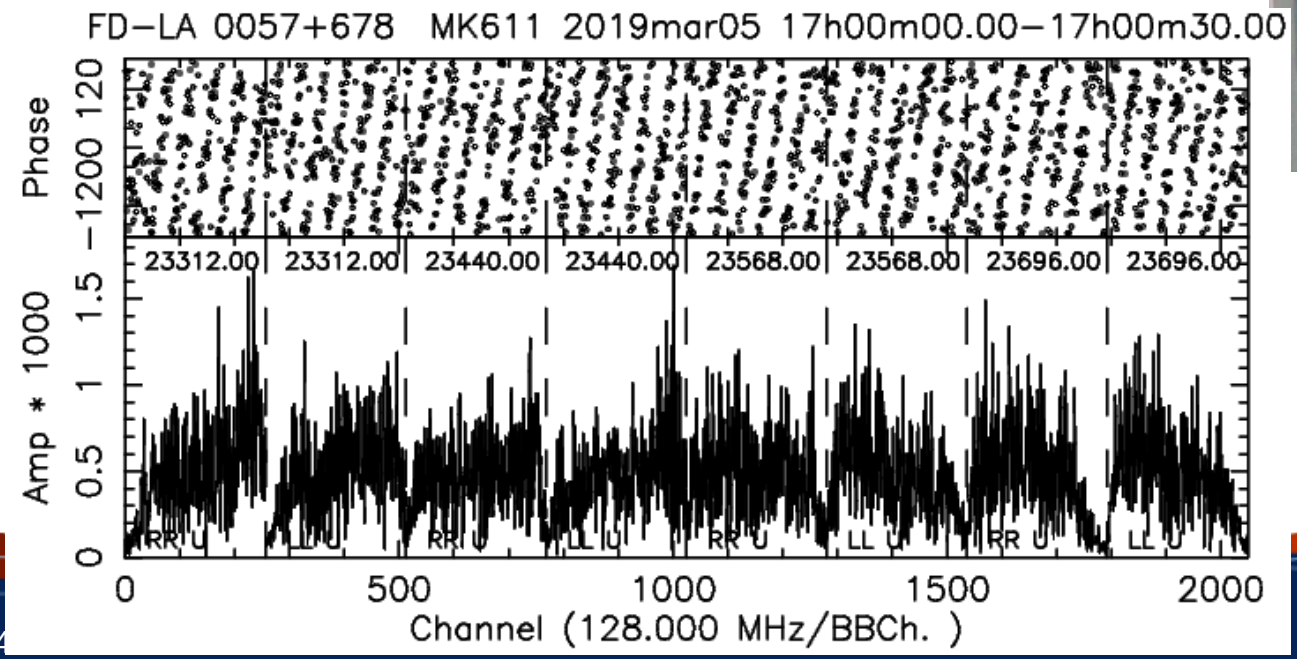
These are not galaxies!



Technical direction

Ongoing developments: Mark6

- 4 Gbps initially, 8+ Gbps later
- Units deployed at 8 sites
- Full array testing very soon
- Offered as Shared Risk Observing
- Will operate Mark5C for about 1 more yr.



Technical direction

Ongoing developments:

- New flexible frequency synthesizers
  - Currently VLBA tuning is in >100 MHz steps
  - New synthesizers will tune precisely in 1 Hz steps
  - Will improve frequency matching with EVN, GMVA, IVS
  - Will allow improved avoidance of RFI
- Fiber
  - To be installed at *all* VLBA antennas
  - Infrastructure to 10 Gbps
  - 100 to 300 Mbps initial service
  - Support diagnostics, some rapid-response science, maybe real-time spectroscopic VLBI

Technical direction

Ongoing developments:

- Migration to Linux-based control system
  - Purely vex driven system
  - Move to vex2 in a couple years???
- Installation of geodetic grade GNSS receivers at VLBA sites
  - 5 VLBA sites currently have these
  - In direct contact with NOAA/NGS
  - 2 new receivers expected in 2019
  - 3 more in future years

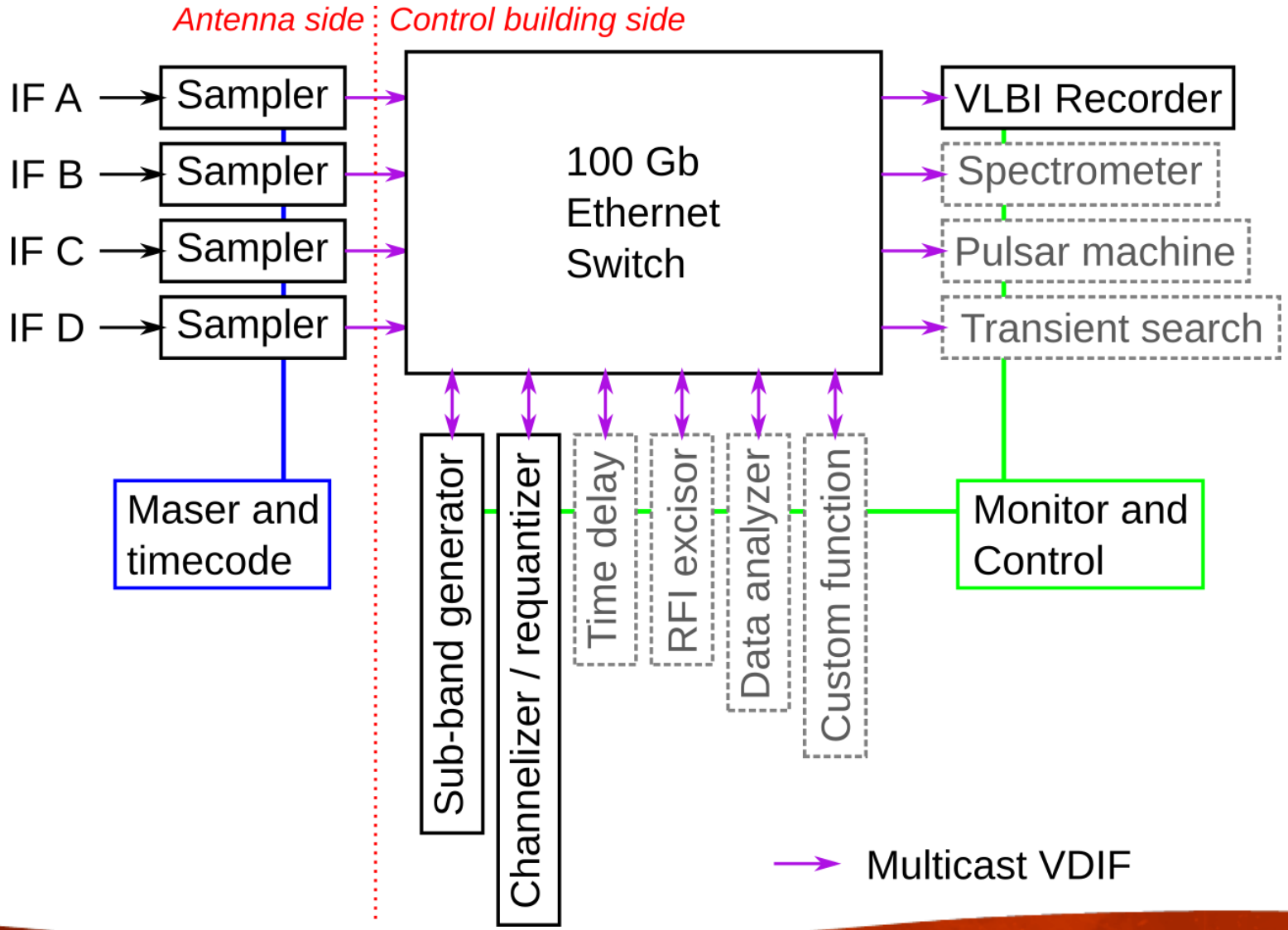
Technical direction

New initiatives: New Digital Infrastructure

- Replace ROACH Digital Back Ends (RDBEs)
  - Hard to maintain, no future
- Scalable system with 100 Gbps Ethernet switch at core
- Will support > 2 bits, non-VLBI instrumentation
- Will achieve 1 GHz per polarization (8 Gbps at 2-bit samples)
  - Will support wider bandwidth after analog update (unfunded)

- Project phases
  - Phase 1: Risk reduction and proposal development (2019)
  - Phase 2: Develop and install 2 units (2020)
  - Phase 3: Deploy across the VLBA (2021; funding not yet secure)

VLBA New Digital Architecture



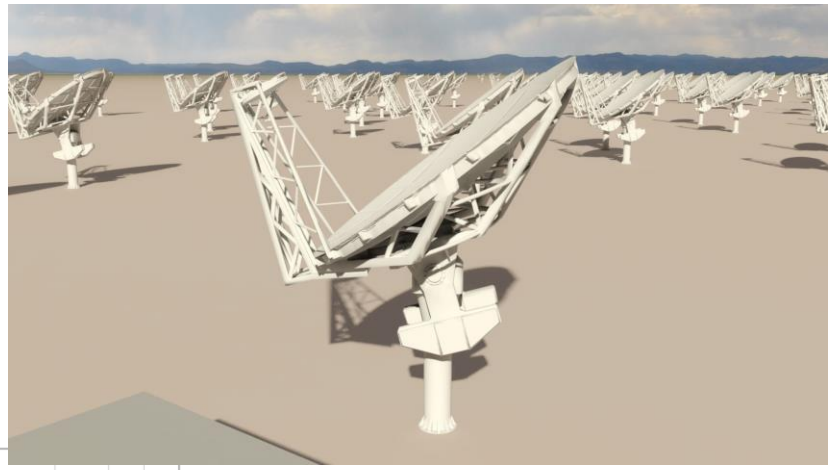
Technical direction

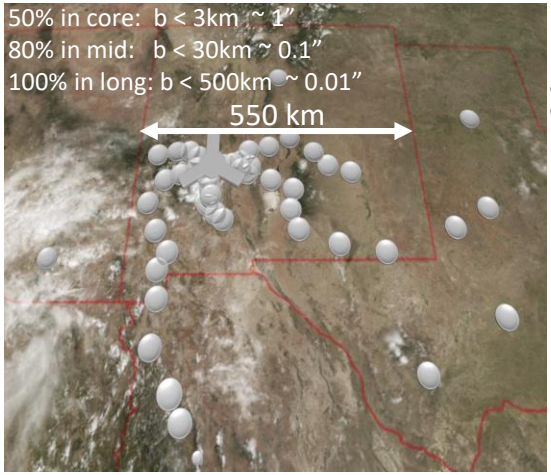
Possible receiver upgrades

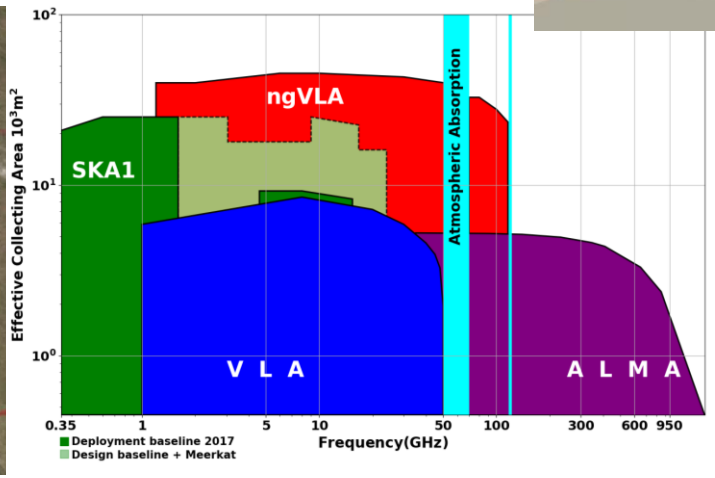
- X-/Ka-band dual-band capability
  - Option 1: 26-40 GHz EVLA-based receiver + VLBA X-band
    - Funding for 2-station deployment looking promising
  - Option 2: 8-35 GHz single receiver (JPL effort)
    - Linear polarized
- KVN-style multi-band receiver
  - Simultaneous 22, 43, 86 GHz receiver bands
- LNA upgrades possible to improve performance
  - X-band, Ku-band, Q-band

A next-generation Very Large Array (ngVLA)

- Scientific Frontier: ***Thermal imaging at milli-arcsec resolution***
- Sensitivity/Resolution Goal:
  - ***10x sensitivity & resolution of JVLA/ALMA***
- Frequency range: ***1.2 –116 GHz***
- Located in Southwest U.S., centered on VLA
- Baseline design under active development
- Low technical risk (reasonable step beyond state of the art)







Complementary suite from meter to submm arrays for the mid-21st century

- **< 0.3cm:** ALMA 2030
- **0.3 to 3cm: ngVLA**
- **> 3cm:** SKA

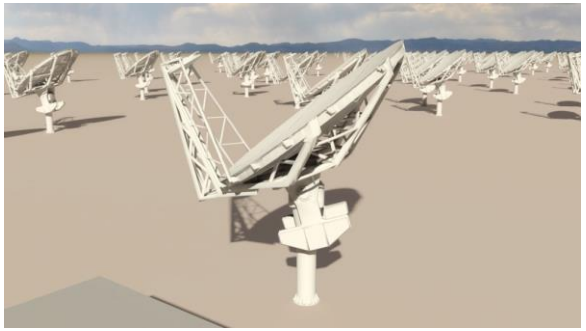
http://ngvla.nrao.edu

Slide from Eric Murphy / ngVLA project

Current Reference Design Specifications

(ngVLA Memo #17)

- 244 18m offset Gregorian (feed-low) Antennas
  - Supported by internal cost-performance analysis
  - 30 antennas to replace VLBA
- 19 6m short spacing array + 4 18m in TP mode to fill in (*u, v*) hole
- Fixed antenna locations centered in New Mexico
- 1.2 – 50.5 GHz; 70 – 116 GHz
  - Single-pixel feeds
  - 6 feeds / 2 dewar package



Receiver Configuration

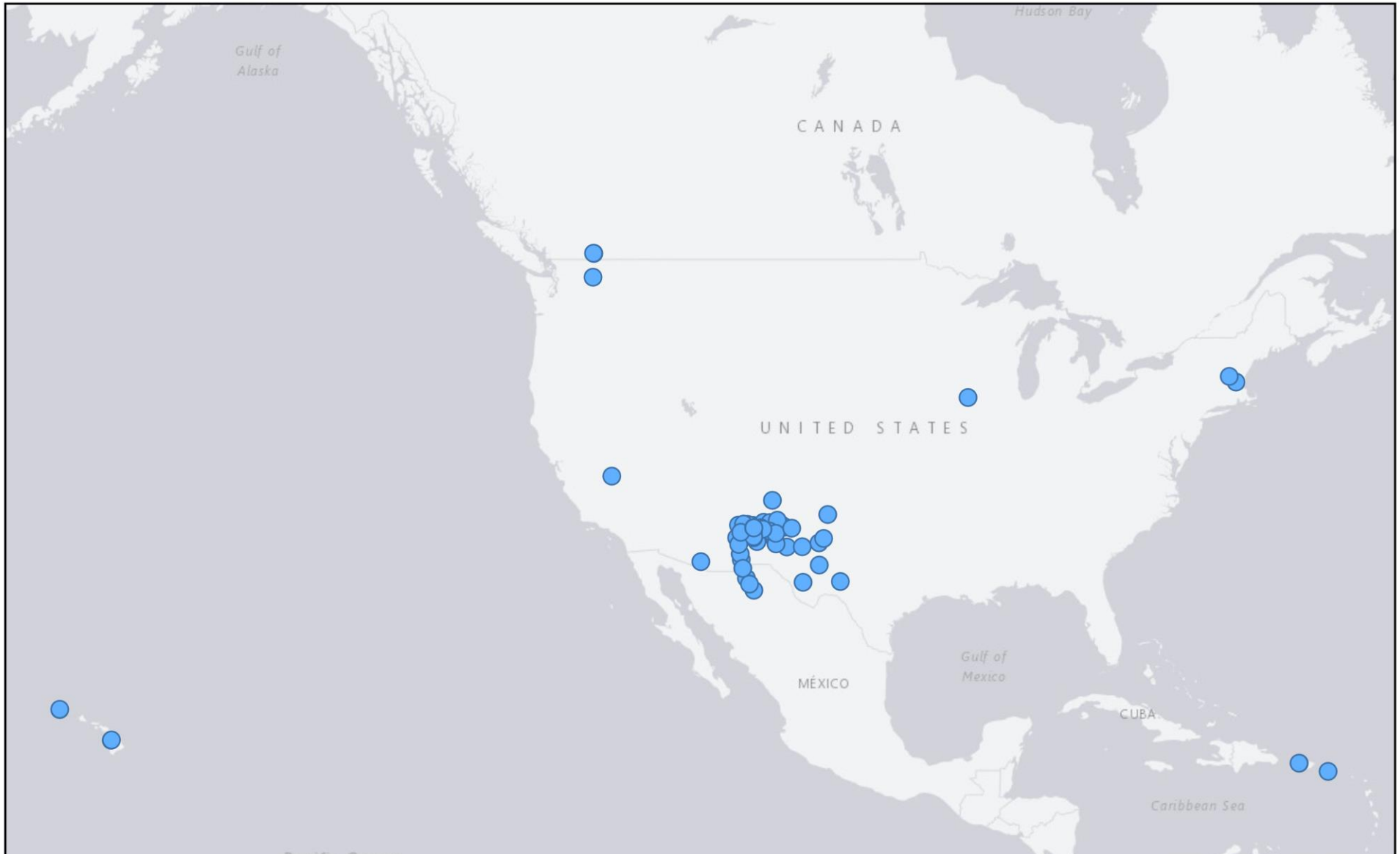
Band #	Dewar	f_L GHz	f_M GHz	f_H GHz	f_H: f_L	BW GHz
1	A	1.2	2.35	3.5	2.91	2.3
2	B	3.5	7.90	12.3	3.51	8.8
3	B	12.3	16.4	20.5	1.67	8.2
4	B	20.5	27.3	34.0	1.66	13.5
5	B	30.5	40.5	50.5	1.66	20.0
6	B	70.0	93.0	116	1.66	46.0

- Continuum Sensitivity: ~0.1 uJy/bm @ 1cm, 10mas, 10hr => T_B ~ 1.7 K
- Line sensitivity: ~19 uJy/bm @ 1cm, 10 km/s, 1”, 10hr => T_B ~ 25 mK

Slide from Eric Murphy / ngVLA project

ngVLA Long Baselines

Conceptual distribution of antenna clusters



Conclusion

- Great VLBI science over past decade enable continued operation of VLBA
  - No immediate threat of closure
- ngVLA with long baselines poised to supplant the VLBA in 2030s
  - Will aim for continued VLBA operations until this time
- Significant capability increase expected at VLBA in next 10 years
  - 2x bandwidth in 2019
  - Geodetic grade GNSS receivers at all VLBA sites (now only 5)
  - New digital back-ends by 2021?
  - Ka-band receivers?

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