

# The Very Long(lived) Baseline Array

Walter Bricken



# 6 years and 1 day ago

## Bordeaux

### Future of the VLBA? (see <http://www.nrao.edu>)

- I was hoping to have a happy message to announce at this meeting, but...
- The NSF/AST Portfolio Review suggested **Divestment** of the VLBA and GBT (NRAO budget reduced by 35%) starting in 1-2 years.
  - Why?: Keep ALMA alive despite failure to double NSF budget
- NSF is not ignoring the report; conflicted regarding NRAO
- NRAO's response:
  - Note impact of premature VLBA closure
  - Point out that **today's VLBA is a new instrument w/ new science**
    - Significant evolution since input to decadal survey
- Possible outcomes for the VLBA:
  - We survive, somehow (more NSF, partnerships, ...)
  - Full or partial closure
  - Completely new operating model that preserves long baseline science
  - Some mix of the above



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# VLBA status now

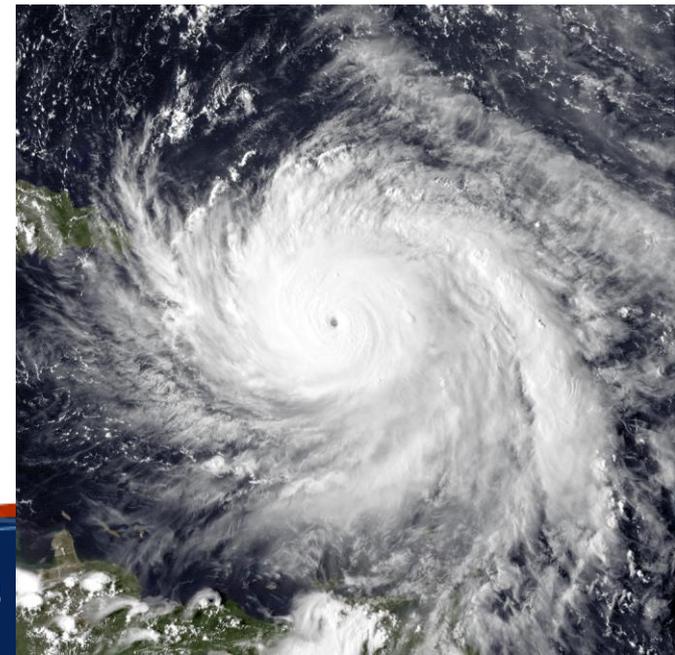
- VLBA celebrates 25 years of operation
- USNO became 50% partner for VLBA operations
  - Reduction in open skies time to about 50%
  - Huge increase in VLBA's contribution to reference frame work
- Long Baseline Observatory (LBO) formed and dissolved
  - Fair NRAO management recompetition not possible with uncertain future of VLBA
  - NSF requested proposal for reintegration and 8 years operation of VLBA
    - Proposal was well reviewed
    - Nominal start date: Oct 1, 2018
    - Outcome: to be determined any moment now

# 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
  - 2 months of downtime expected in next year



*These are not galaxies!*



# Technical direction

## Ongoing developments

- Mark6
  - 4 Gbps initially, 8+ Gbps later
  - Deployment process has begun
  - Full array testing before end of winter
  - Offered as Shared Risk Observing at last call
- Flexible 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



# Technical direction

## New initiatives

- 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
- 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
  - Details of design still TBD

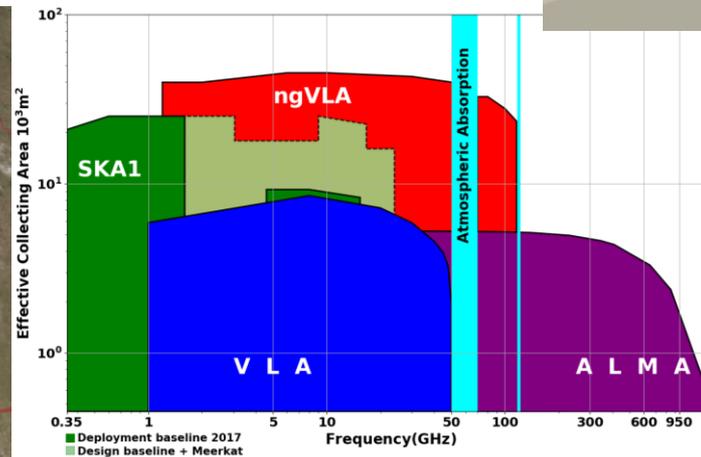
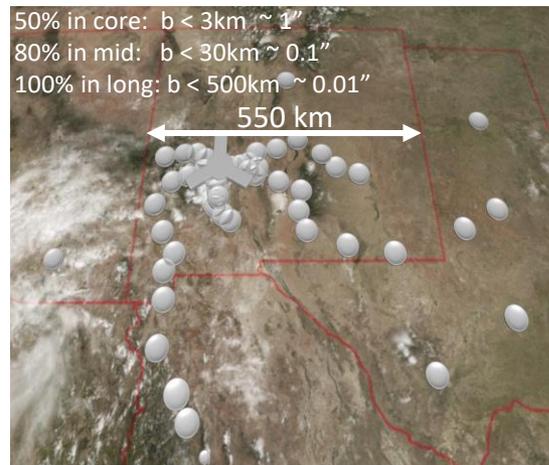
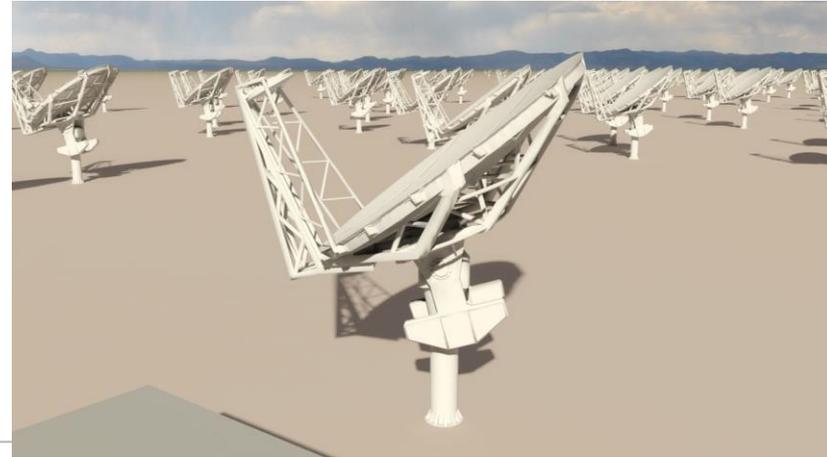
# Technical direction

## Possible receiver upgrades

- X-/Ka-band dual-band capability
  - Option 1: 26-40 GHz EVLA-based receiver + VLBA X-band
  - Option 1: 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
- *User input wanted for prioritization*

# 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-21<sup>st</sup> century

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

<http://ngvla.nrao.edu>

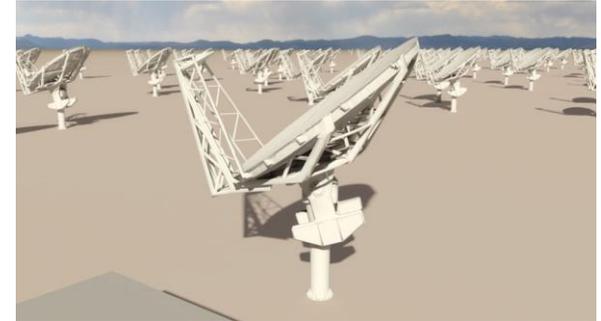
Slide from Eric Murphy / ngVLA project



# 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

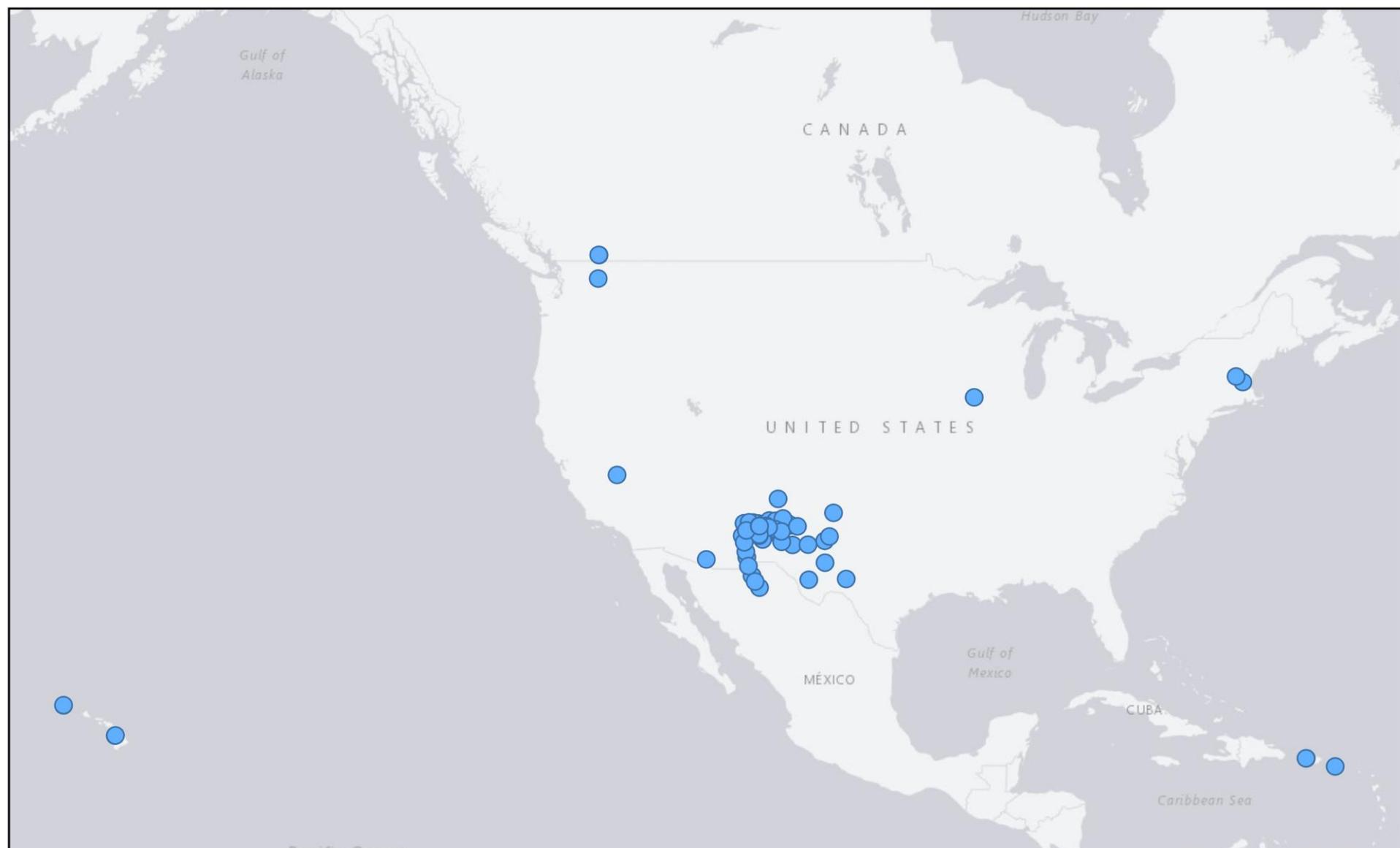
- Continuum Sensitivity:  $\sim 0.1$   $\mu\text{Jy/bm}$  @ 1cm, 10mas, 10hr  $\Rightarrow T_B \sim 1.7$  K
- Line sensitivity:  $\sim 19$   $\mu\text{Jy/bm}$  @ 1cm, 10 km/s, 1", 10hr  $\Rightarrow T_B \sim 25$  mK

*Slide from Eric Murphy / ngVLA project*



# ngVLA Long Baselines

## Conceptual distribution of antenna clusters



# VLBA+

- Current extended array participation
  - High Sensitivity Array: 4%
    - VLA, Arecibo, GBT, Effelsberg
  - EVN Globals: 3%
  - GMVA: 3%
  - IVS: 4%
- Opportunity exists for broader participation
  - L-band, C-band: existing EVN+VLBA seems to be suffice
  - 3mm,  $\leq 1$ mm: enabled by GMVA and EHT/BHC
  - K-band, Q-band: room for improvement?
  - Need to hear from (potential) users!
- *Percentages are of total observing hours*

# 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



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