ngVLA Project Update

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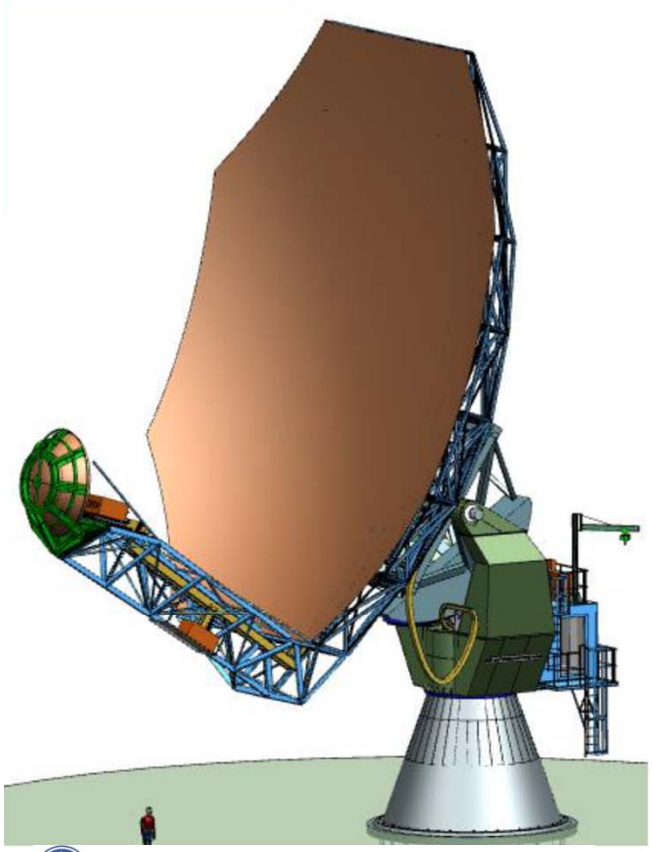
South America Astronomy Coordination Committee, 04/2021

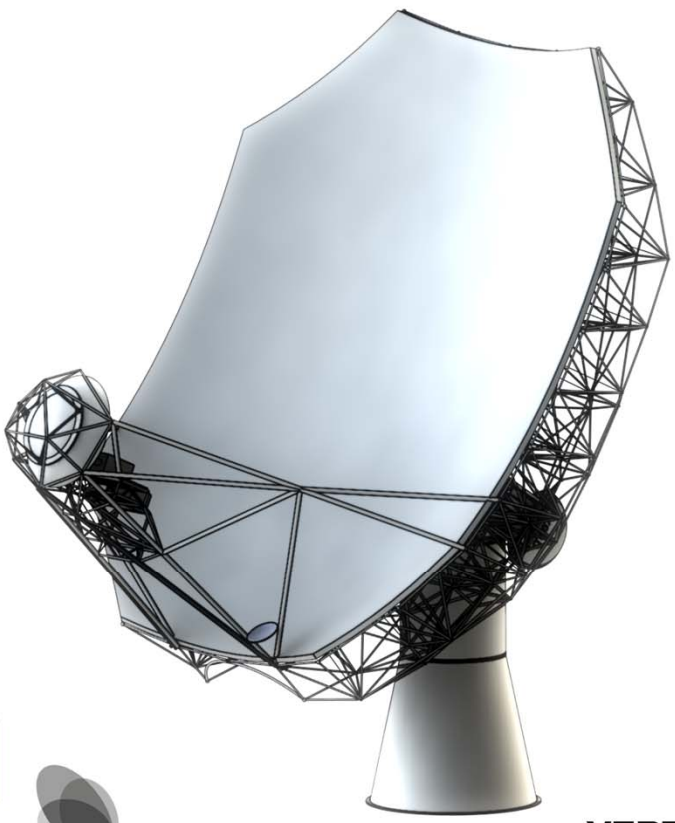
NSF AUI NRAO

A next generation VLA

- Scientific Frontier: thermal imaging at milli-arcsecond resolution
  - 10x Sensitivity, 10-100x Resolution of VLA
  - Frequency range: 1.2-116 GHz
- Bridge SKA – ALMA
- Proposal driven, pointed telescope
  - Deep single fields, small area mapping.
- Centered on present location of VLA in Southwest USA
- Under evaluation as part of the Astro2020 Decadal Survey.



MT MECHATRONICS
An OHB Company



mtex | antenna technology

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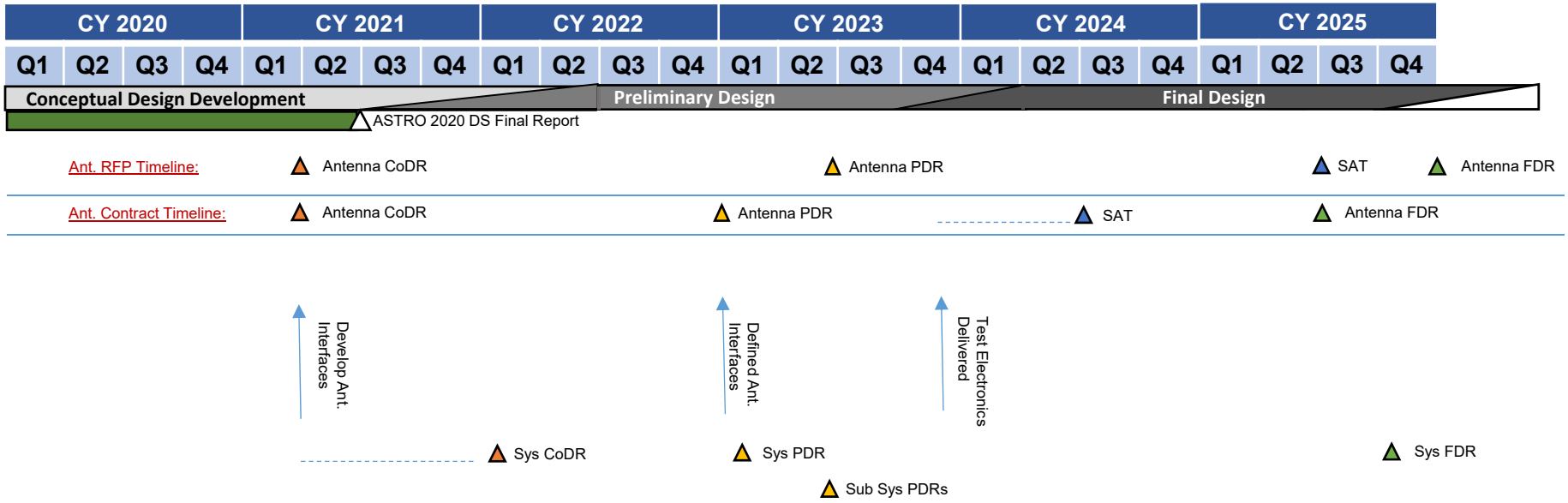
Next Generation Very Large Array (ngVLA) Project Timeline



Sys CoDR: All high-level conceptual decisions; driving subsystem requirements.
Sys PDR: Focus is on architectural definition. Interfaces settled by Sys. PDR. Precedes sub-system PDRs.
Sub. Sys PDRs: Demonstrate prototype-ready design.

Construction: 2025-2035
Operations: 2028+

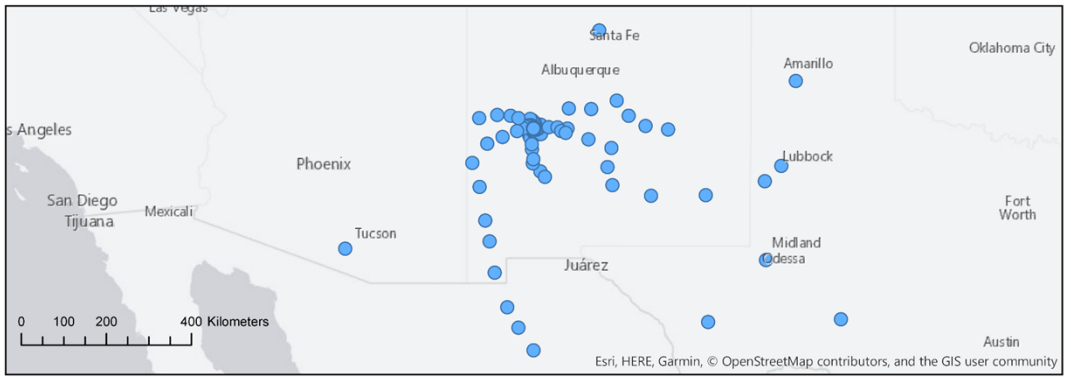
- **1.2 - 116 GHz** Frequency Coverage
- **Main Array**: 214 x 18m offset Gregorian Antennas
  - Fixed antenna locations across NM, TX, AZ, MX.
- **Short Baseline Array**: 19 x 6m offset Greg. Antenna
  - Use 4 x 18m in TP mode to fill in (*u, v*) hole
- **Long Baseline Array**: 30 x 18m antennas located across continent for baselines up to 8860km

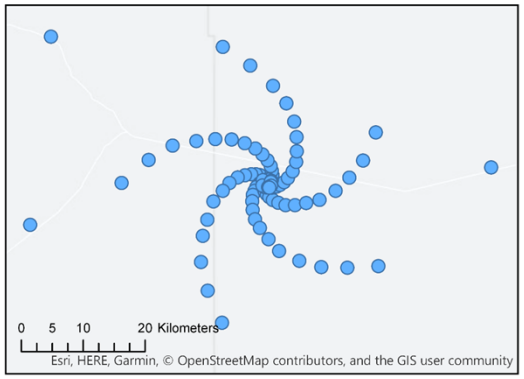
Band #	Dewar	f_L GHz	f_M GHz	f_H GHz	f_H: f_L	BW GHz
1	A	1.2	2.35	3.5	2.91	2.3
2	B	3.5	7.90	12.3	3.51	8.8
3	B	12.3	16.4	20.5	1.67	8.2
4	B	20.5	27.3	34.0	1.66	13.5
5	B	30.5	40.5	50.5	1.66	20.0
6	B	70.0	93.0	116	1.66	46.0

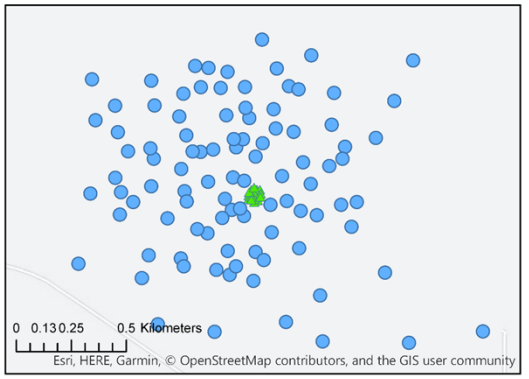
Main Array (MA) Configuration

- 214 x 18m Antennas

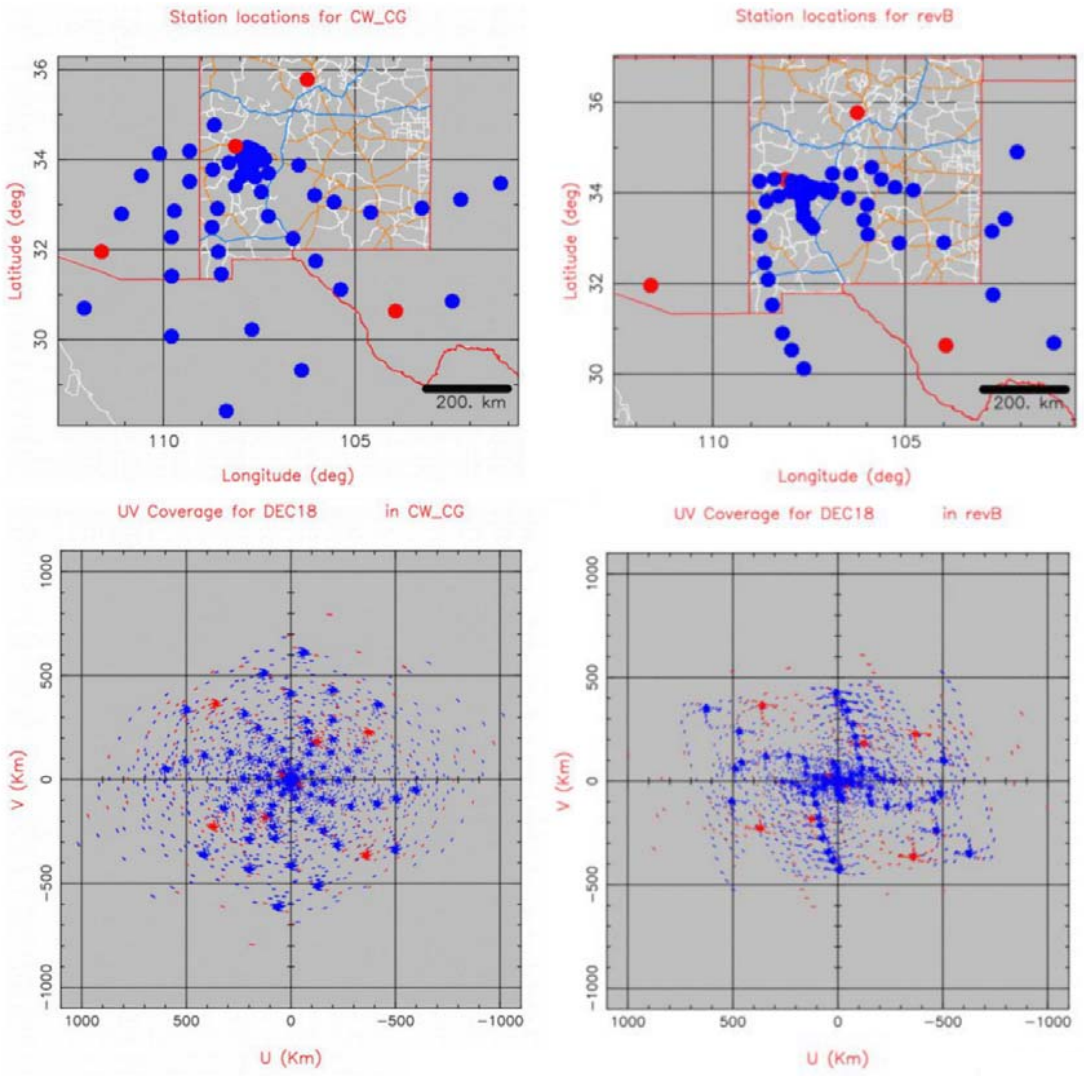
Radius	Collecting Area Fraction
0 km < R < 1.3 km	44%
1.3 km < R < 36 km	35%
36 km < R < 1000 km	21%







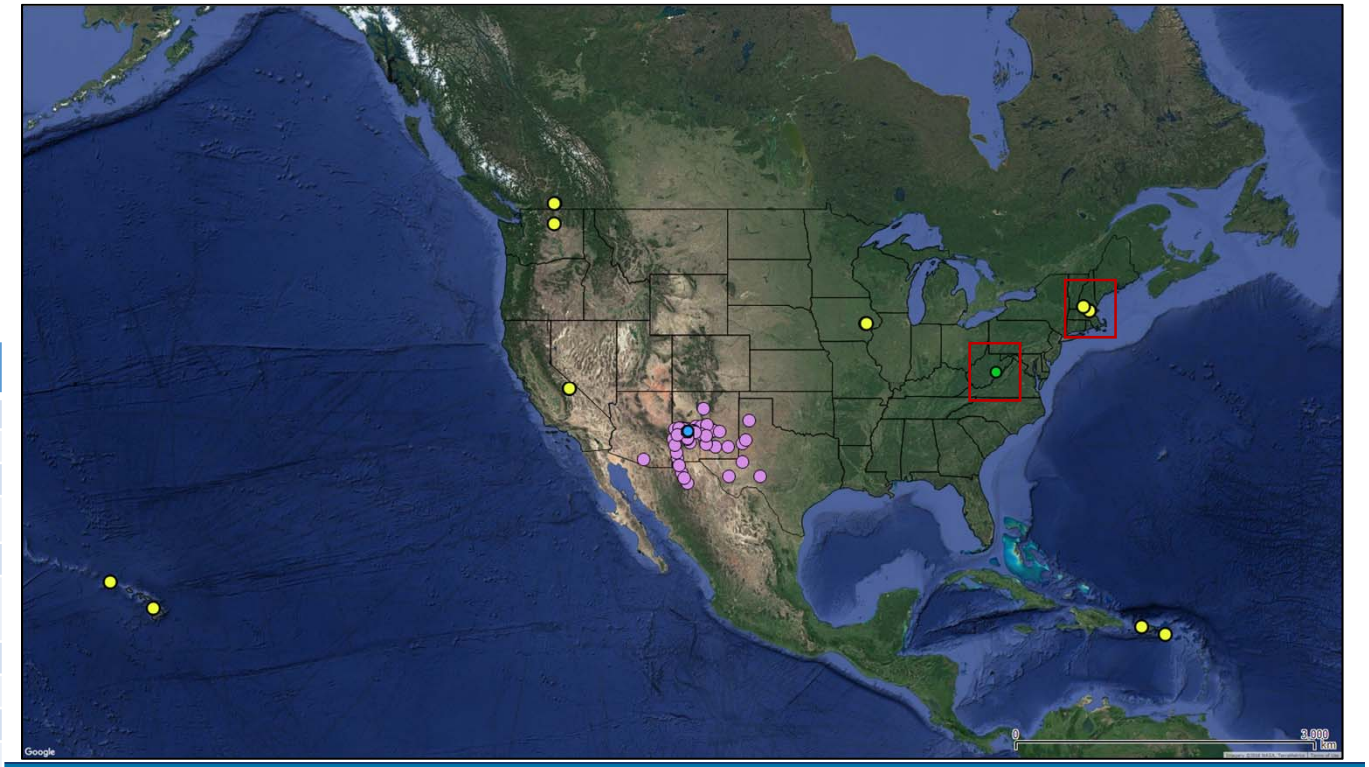
Mid-Scale Baseline Optimization: the Walker Configuration



Long Baseline Array (LBA)

- 30 x 18m Antennas at 10 sites
- Balance between Astrometry & Imaging Use Cases

Qty	Location	*Possible* Site
3	Puerto Rico	Arecibo Site
3	St. Croix, US VA	VLBA Site
3	Kauai, HI	Kokee Park Geo. Obs.
3	Hawaii, HI	New Site (off MK)
2	Hancock, NH	VLBA Site
3	~~Westford, MA~~ Green Bank WV	~~Haystack~~ GBO
2	Brewster, WA	VLBA Site
3	Penticton, BC, CA	DRAO
4	North Liberty, IA	VLBA site
4	Owens Valley, CA	OVRO



Arecibo Observatory LBA Site

- Proposals submitted to NSF for 1-8 LBA 18m ngVLA Antennas, associated infrastructure.
  - Joint proposals with UPR, UCF, AO.
  - Includes 100 gbps fiber link from AO to Internet2.

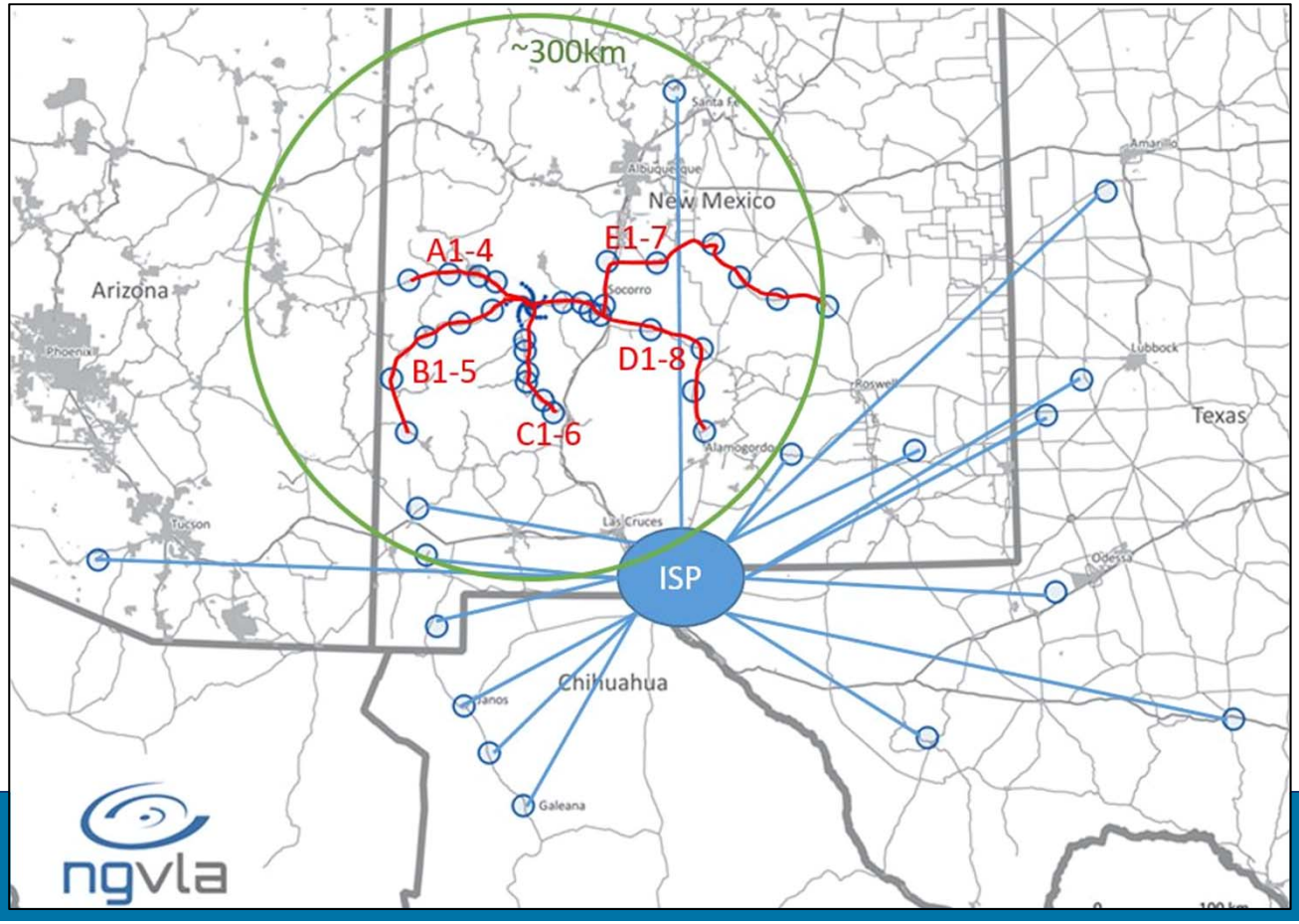
- Feedback expected May-June
- Full proposal (8 Antenna option) due Sept.
- Oct 2022 project start, if funded.

Antenna Data Rates

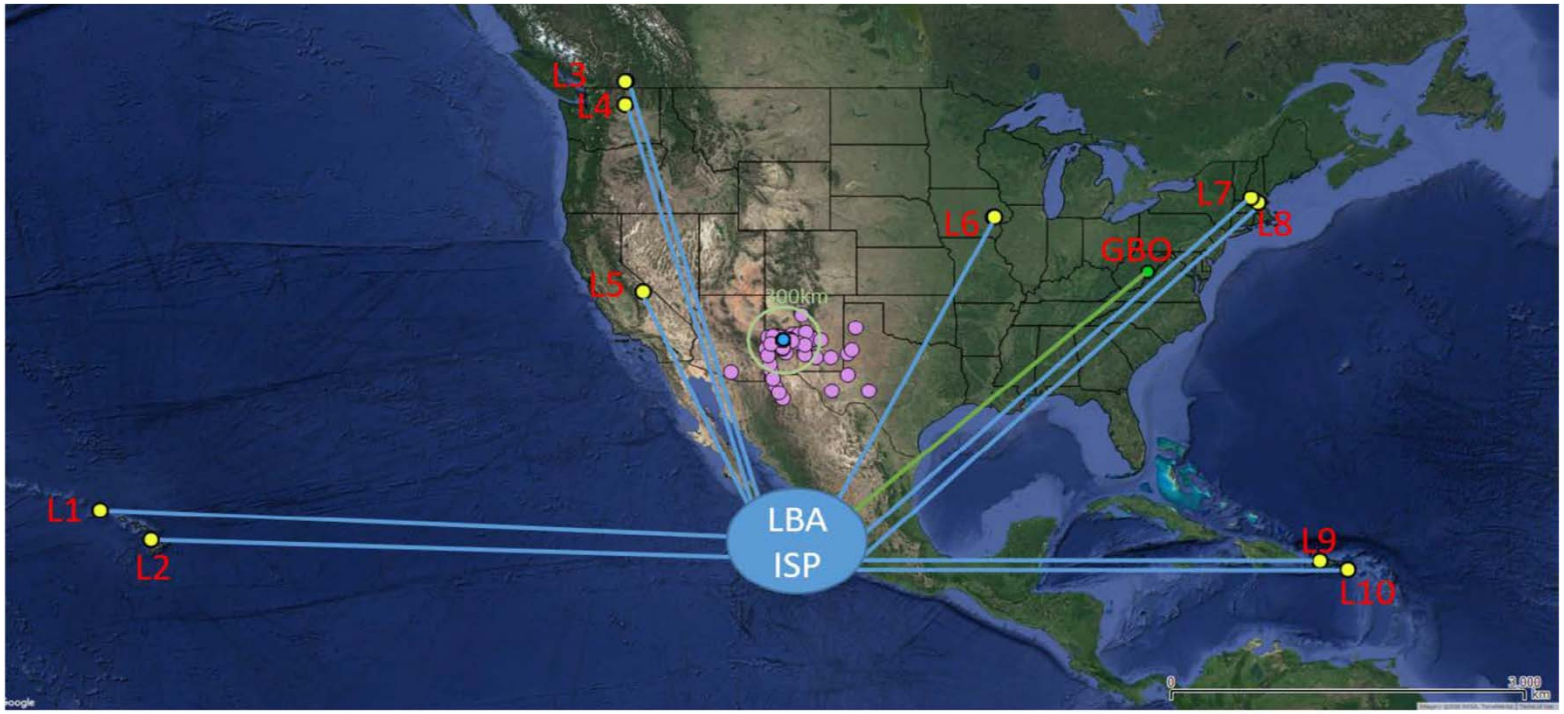
- Real-time correlation of all 244 18m array elements.
- Up to 20 GHz of instantaneous bandwidth per polarization.
- 8-bit digitization at all bands.
- 723 Gbps per antenna, over 8x100 / 2x400 Gbps links on ngVLA installed fiber.
- Requantized and formatted for data transmission on packet-switched networks
- ~3 antenna LBA sites = ~1 Tbps link (goal, TBC)

Main Array Fiber Optic Network

- Dedicated point-to-point fiber links for ~196 antennas in NM within ~300 km radius of core.
- ISP connected elements beyond inner stations.
- ISP connections to LBA sites.
- Leased fiber vs spectrum vs bandwidth (TBD)



VLB Fiber Optic Network



Facility Integration

- VLBI Recording Capabilities:
  - 3 beams, VDIF, Mark-X recorder standard
- eVLBI Integration:
  - ~270 element correlator
  - Built-in data buffers and packet re-ordering for packet switched network interfaces.
  - Real time links to GBT? LMT? ALMA? Others?

Data Processing

- **Post Processing**: storing the raw visibilities will be possible.
  - Data processing is post-facto, with system sized for average throughput.
  - Data Rates:
    - Average – 8 GB/s.
    - Peak - 128 GB/s.
- **Computing:** Challenging, but feasible with current technology.
  - Sized by time resolution, spectral resolution, and multi-faceting in imaging.
  - ~60 PFLOPS/s (inc. efficiency factors) matches average data throughput.

Serving Data to Users

- “Science Ready Data Products” Operations Model
- Process-in-place for data to most PIs.
- Data products requested in proposal; Pipeline interaction possible.
- Low-level data products (visibilities, flagging tables)
- High-level data products for Standard Observing Modes (e..g, calibrated image cubes)
- Archive reprocessing interface for users.
- Data Reduction S/W; Data Analysis S/W
- Distributed archive and re-processing capacity amongst international partners. (ALMA-like model)

SAACC Considerations

- ngVLA will require a significant investment in new fiber optic infrastructure in the Southwest USA, with connections across North America.

- Are there areas of collaboration with SAACC members?
- Pitfalls or lessons learned we should consider in our design phase?


ngvla
Next Generation Very Large Array