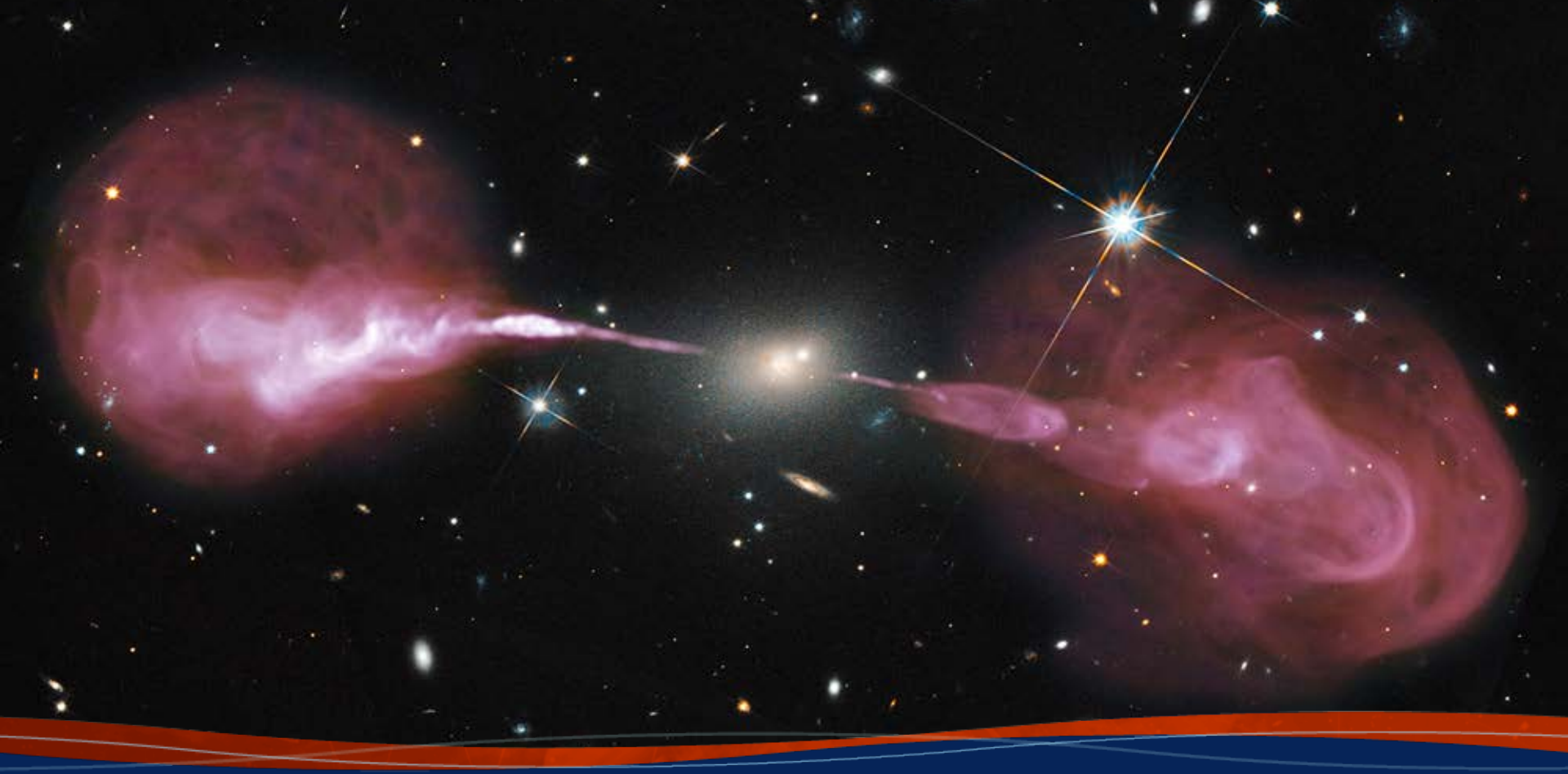

Long baselines in the ngVLA context

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Long baseline science drivers

- Imaging AGN jets
  - Big goal is to measure polarization of counter-jets
- Parallax distances to star forming regions (> 10 kpc)
  - Improve knowledge of shape/scale of Milky Way
- Stellar and pulsar astrometry
  - Planet hunting, multiplicity determination/orbitology
- Megamaser Cosmology Project
  - Geometric distances to galaxies in the Hubble flow $\rightarrow H_0$
- Local group dynamics
  - Determine 3D velocities of M31, M33, IC10, …

VLBI synergy with ngVLA

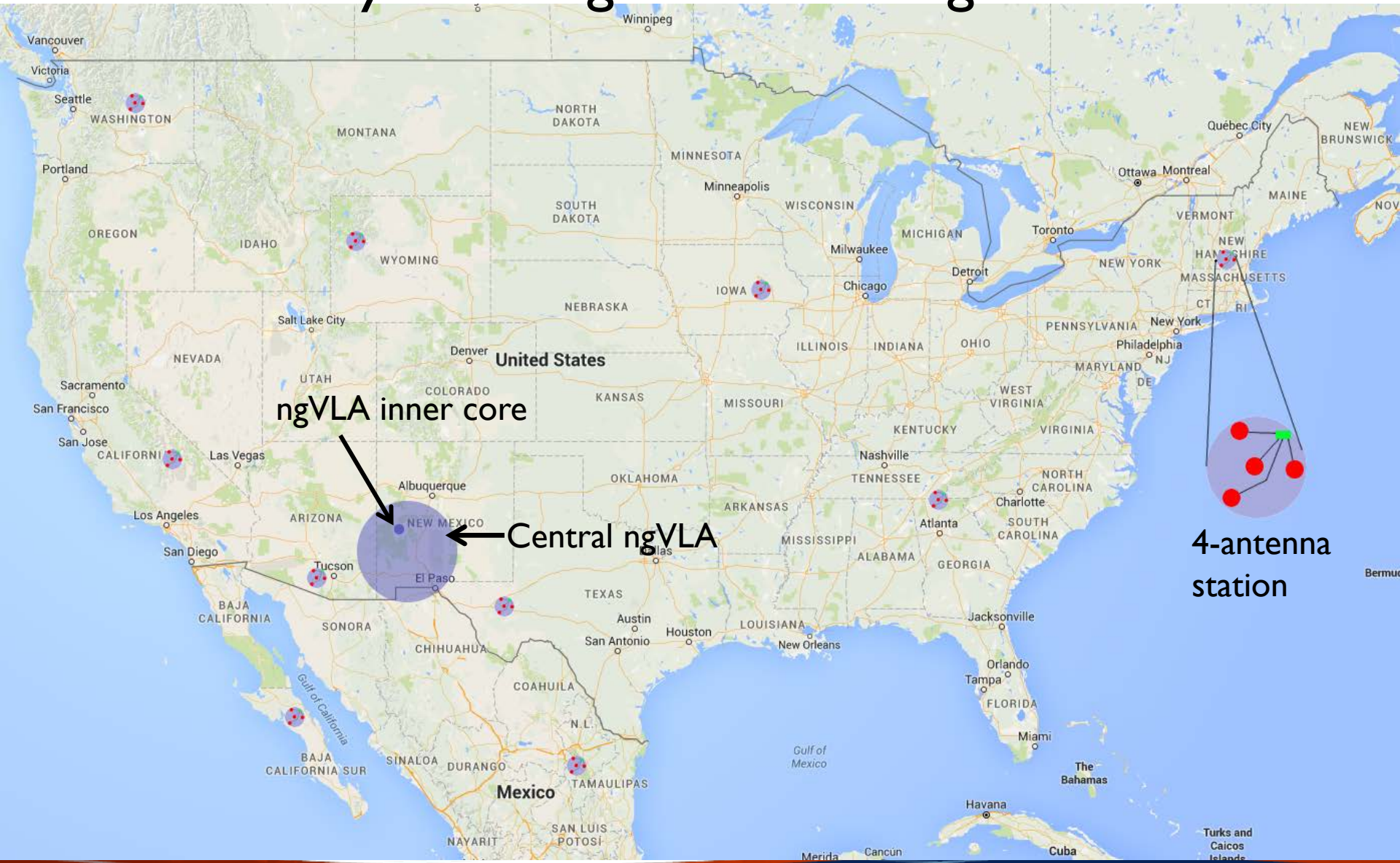
- Possibility for a single array spanning baselines between 50 m and 5000 km
- ngVLA will provide a modern antenna and electronics design
  - Cost will be optimized due to quantity of antennas
  - Ultra-low maintenance will be a strong driver
- Identical antenna types would lead to low VLBI maintenance costs
  - Common software
  - Single spare part pool
  - Merged operations

- This talk describes a possible concept for implementing VLB capability on the ngVLA.

Goals of VLBI capability on the ngVLA

- Lower cost operations on a per-station basis than VLBA
- 10x the continuum sensitivity of the VLBA
  - At least double the collecting area on long baselines
  - At least double the aperture efficiency above 70 GHz
  - At least 64 times the bandwidth (>= 16 GHz per pol.)
- Robust calibration via paired antennas, WVRs, …
- Good imaging capabilities
  - Carefully designed UV coverage
  - Possibly > 10 stations (VLBA imaging is marginal)
- Geodetic VLBI capabilities compatible with VGOS standard
- Continuity of VLBI capabilities in the US well into 21st century

Schematic layout of ngVLA with long baselines



Antennas and stations

- All antennas (central & VLB) built to same specification
  - Possibly some special electronics (e.g., pulse cal)
- 8 to 12 long baseline stations outside the central ngVLA
  - To be mainly, but not exclusively, used for VLBI
- ngVLA *pseudo-stations* could be formed from central ngVLA antennas as required by scientific programs
  - Could double or more long baseline collecting area on demand at moderate and temporary costs to shorter baselines
- Could add phased ngVLA inner core (up to 1 or 5 km)
- There is desire for more southerly antennas
  - A few stations in Mexico would improve low declination science

Station concept

- Collecting area to be in clusters with local infrastucture (stations)
  - 3 to 5 ngVLA antennas
  - Approx. 2x collecting area of a 25m antenna
  - Station size: ~100m
  - Common power, network, clock infrastructure for the cluster
- Each station could be:
  - Phased
  - Sub-arrayed (pointing, tuning, calibration)
  - Used independently
- In the phased mode, clusters provide smooth fail-over

Station locations

- Driven by:
  - Imaging UV coverage
  - Access to high speed network and power
    - Note: 4 antennas at 32 GHz → 1 Tb/sec data rate!
  - High frequency performance: *high and dry*
- A mix of existing and new VLBI sites will be used
  - Some sites may support only cm wavelength observations

Operations concept

- Common operations and maintenance with ngVLA
- Antenna stations will be unstaffed
  - Routine (maybe semi-annual) visits for PM and repairs
- All electronic-transfer to ngVLA correlator
- Real-time correlation
- Increase ties with EVN and EAVN for long (>5000km) baseline science

Continuum performance

Frequency (GHz)	Resolution (mas)	Bandwidth (GHz)	Image Sens. (μJy)	Image Sens. (K)
2	8.6	1	3.8	24000
10	1.7	4	1.8	14000
30	0.57	16	1.3	9400
80	0.21	16	3.7	15000
100	0.17	16	5.7	17000

- Assumes:
  - Close to natural weighting
  - Array dimensions: 4500 km x 2500 km
  - 10 stations, each with 4 antennas
  - 1 hour on-source integration

Enhanced continuum performance

Frequency (GHz)	Resolution (mas)	Bandwidth (GHz)	Image Sens. (μJy)	Image Sens. (K)
2	12	1	2.2	4600
10	2.6	4	1.0	2700
30	0.9	16	0.75	1800
80	0.3	16	2.2	2900
100	0.25	16	3.3	3300

- Assumes:
  - Close to natural weighting
  - Array dimensions: 4500 km x 2500 km
  - 10 stations, each with 4 antennas
  - 120 ngVLA antennas from central array added (4x collecting area)
  - 1 hour on-source integration

Spectral line performance

Frequency (GHz)	Resolution (mas)	Bandwidth (MHz)	Image Sens. (μJy)
2	8.6	0.066	467
10	1.7	0.333	200
30	0.57	1	162
80	0.21	2.666	290
100	0.17	3.333	400

- Assumes:
  - 10 km/s line width
  - Close to natural weighting
  - Array dimensions: 4500 km x 2500 km
  - 10 stations, each with 4 antennas
  - 1 hour on-source integration

Enhanced spectral line performance

Frequency (GHz)	Resolution (mas)	Bandwidth (MHz)	Image Sens. (μJy)
2	12	0.066	260
10	2.6	0.333	110
30	0.9	1	90
80	0.3	2.666	160
100	0.25	3.333	220

- Assumes:
  - 10 km/s line width
  - Close to natural weighting
  - Array dimensions: 4500 km x 2500 km
  - 10 stations, each with 4 antennas
  - 120 ngVLA antennas from central array added (4x collecting area)
  - 1 hour on-source integration

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