ngVLA Technical Overview

Mark McKinnon

2nd ngVLA Technical Workshop, Socorro, NM

December 8-9, 2015

Outline

- ngVLA Nominal Technical Parameters
- Technical Issues to Consider in Science Use Cases
- Programmatics
- Additional Information

Pointed or Survey Telescope?

- ngVLA is envisioned to be a general purpose, PI-driven, pointed telescope
  - Used much like current JVLA
  - Can be used for occasional, dedicated surveys (e.g. FIRST, NVSS)
- ngVLA is *not* a dedicated survey instrument that delivers generic data products (e.g. a radio-LSST)
  - Drives telescope design in a very different way (large N, small D)

Nominal Technical Parameters

	2GHz	10GHz	30GHz	80GHz	100GHz
Field of View FWHM (18m[a]) arcmin	29	5.9	2	0.6	0.51
Aperture Efficiency (%)	65	80	75	40	30
A^b_{eff} x10^4 m^2	5.1	6.2	5.9	3.1	2.3
T^c_{sys} K	29	34	45	70	80
Bandwidth[d] GHz	2	8	20	30	30
Continuum rms[e] 1hour, μJy beam^{-1}	0.93	0.45	0.39	0.96	1.48
Line rms 1hour, 10 km s^{-1}, μJy beam^{-1}	221	70	57	100	130
Resolution[f] FWHM milliarcsec	140	28	9.2	3.5	2.8
T^g_B rms continuum 1hr K	14	7	6	15	23
Line[h] rms 1hour, 1" taper, 10 km s^{-1}, μJy beam^{-1}	340	140	240	860	–
T^i_B rms line, 1hour, 1" taper, 10 km s^{-1}, K	100	1.8	0.32	0.17	–

[a]Under investigation: antenna diameters from 12m to 25m are being considered.

[b]300 x 18m antennas with given efficiency.

[c]Current performance of JVLA below 50GHz. Above 70GHz we assume the T_{sys} =60K value for ALMA at 86GHz, increased by 15% and 25%, respectively, due to increased sky contribution at 2200m.

[d]Under investigation. For much wider bandwidths, system temperatures are likely to be larger.

Carilli et al. 2015, ngVLA memo #5

Technical Issues for Consideration in Science Use Cases

Phase Calibration

- Options and implications (Clark, ngVLA memo #2)
  - ~~Self calibration~~
    - Too few and too weak sources at high frequency
  - Fast switching (Carilli, ngVLA memo #1)
    - More rigid structure, larger drive motors, enhanced electrical infrastructure, reduced time on source
  - Dedicated reference array (Owen, ngVLA memo #4)
    - Separate antenna design (~100 x 4m); maximizes time on source
  - Paired antennas
    - Identical antennas, with half on source of interest and other half on reference source
  - Water vapor radiometers
    - 183 GHz works well on ALMA; VLA attempts at 22 GHz inconclusive

Array Configuration

- Sensitivity to low surface brightness. Options:
  - Large array of smaller diameter (~12m) antennas
  - Compact array of smaller diameter antennas at the core of the overall array (similar to ALMA)
  - Large single dish (e.g. GBT)
- VLBI implementation. Options:
  - Used in concert with other, existing telescopes
  - ~20% of collecting area, perhaps in groups of antennas, on long baselines
- Fixed or moveable antennas?

Antenna Optical Configuration

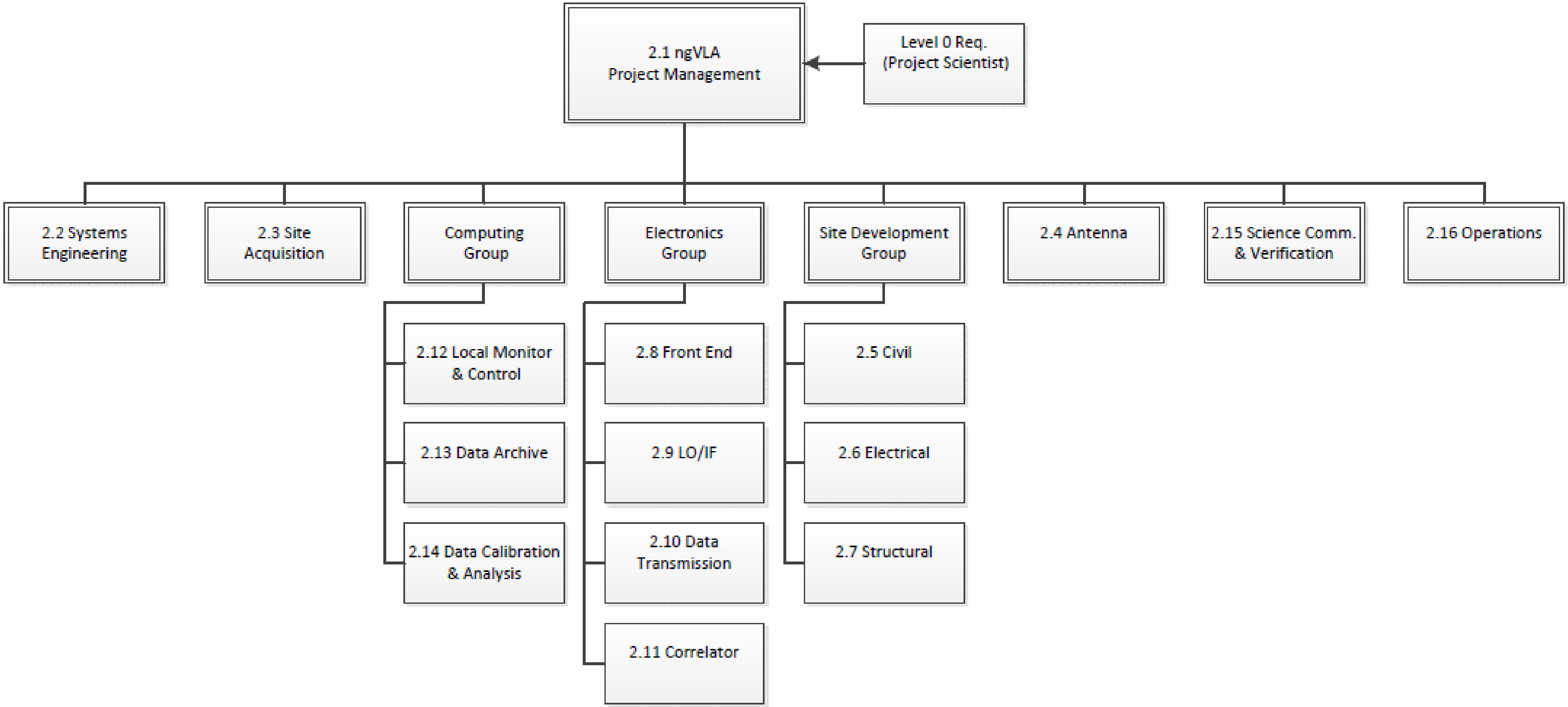
- Options
  - If science priority is high dynamic range imaging at low frequency, optical configuration is likely offset Gregorian
    - Excellent receiver performance (i.e. low Trx) at these frequencies
    - Large number of background sources
    - Tsys dominated by scattering, spillover, sidelobe pick up
      - Mitigate with unblocked aperture
  - If science priority is sensitivity at high frequency, optical configuration might be conventional symmetric Cassegrain
    - Tsys dominated by atmosphere and receiver
    - Fewer background sources (dynamic range not a big science driver?)
    - May be difficult to justify additional cost of offset geometry

Receiver Band Definition

- High bandwidth ratio feed (BWR 3:1 - 7:1)
  - Excellent continuum sensitivity
  - Cover desired frequency range with fewest number of receivers
    - Minimizes operations costs
  - On-antenna performance data appears to be sparse
- But when compared to conventional corrugated horns, high BWR quadridge flared horns (QRFH) tend to have:
  - Higher cross-polarization (by ~10 dB)
  - Freq-dependent beamwidths (lower aperture efficiency at high freq)
  - Higher sidelobes (higher Tsys and RFI susceptibility)
  - Asymmetric beam patterns (adversely impact dynamic range)
- Guidance needed on band definition to capture desired molecular lines in a single band

Programmatics

Project Organization and Work Packages



Partner participation via work package delivery

Cost and Timeline

- Cost
  - Detailed cost estimate of the ngVLA yet to be made
  - Cost will be about XB USD
- Time line (aggressive)
  - Early 2019: Propose ngVLA concept to 2020 Decadal Survey
  - Early/mid 2020s: With Decadal Survey endorsement, seek funding for design and development phase (~3 year duration)
    - Develop construction and operations proposal
  - Mid/late 2020s: Seek construction finding (~10 year duration)

Additional Information

- ngVLA webpage
  - https://science.nrao.edu/futures/ngvla
- ngVLA memo series
  - http://library.nrao.edu/ngvla.shtml
- ngVLA science working groups
  - https://science.nrao.edu/futures/ngvla/science-working-groups
- ngVLA science meeting at 2016 AAS in Kissimmee, FL
  - https://science.nrao.edu/science/meetings/2016/227th-aas-meeting/ngvla

NRAO

www.nrao.edu
science.nrao.edu
public.nrao.edu

The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.