ngVLA Session Summary

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US RMS Futures II

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https://science.nrao.edu/futures/ngvla

Thanks to the ngVLA SOC

- Bryan Butler
- Chris Carilli
- Alessandra Corsi
- Andrea Isella
- Amanda Kepley
- Mark McKinnon
- Steve Myers
- Alexandra Pope
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Next Generation VLA

- Thermal imaging at milli-arcsecond resolution
- 10x effective area and resolution of JVLA
  - ~300x18m antennas; ~300km baselines
- Frequency range: 1.2 –116GHz
- Located in southwest US, centered on present location of JVLA

Next Generation VLA

- Reasonably conceived baseline design
- Low technical risk (could be built today)
- Need to iron out a number of challenges/options
  - e.g., frequency bands, configuration, phase calibration…
  - ***A Series of Compromises and tough decisions***

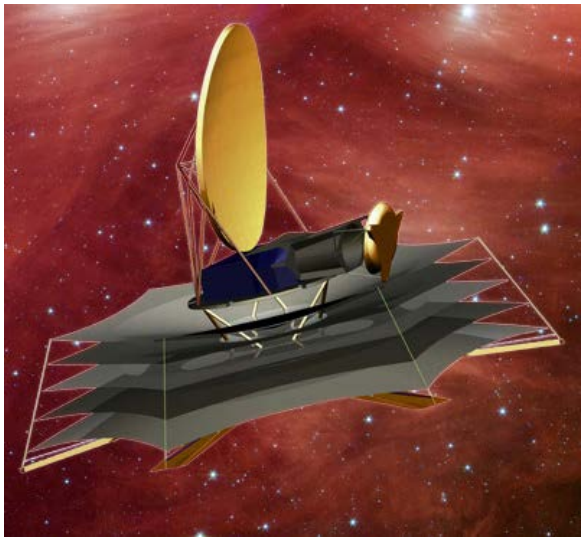
Notional Parameters

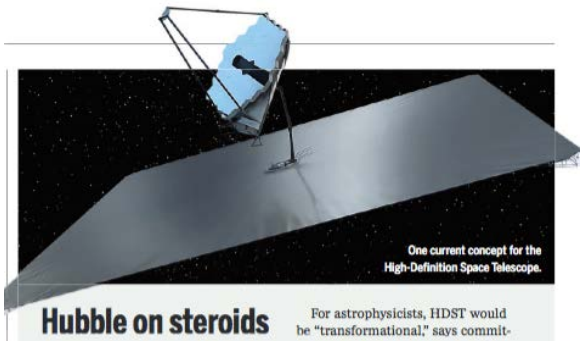
Carilli et al. 2015, ngVLA memo #5

	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	–

Highly Synergistic with Other Facilities on Similar Timescales

- SKA
  - Atomic/non-thermal
  - *Molecular/thermal*
- ALMA
  - Warm/star-forming
  - *Cold/dense fuel for SF*
- LUVOIR
  - Image earth-like planets
  - *Image forming planets*
- FIRS
  - C/WNM & WIM
  - *Cold Molecular Medium*





SWGs & Key Requirements (2yr effort to date)

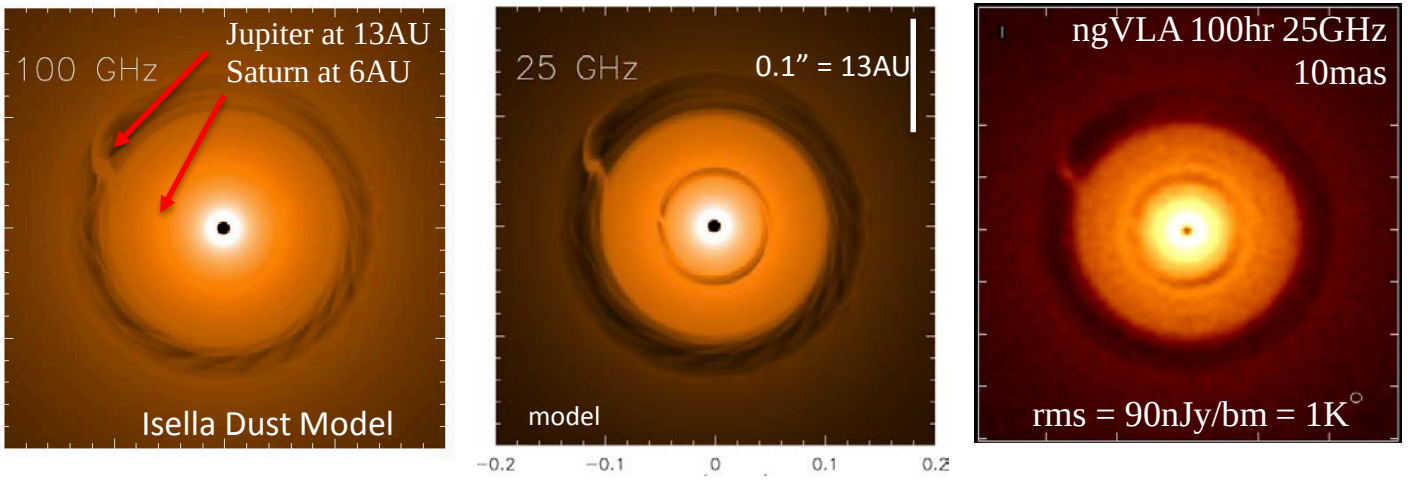
- Four science working groups (SWGs) established at ngVLA workshop at 2015 AAS
  - Cradle of Life (Isella, Moullet, Hull)
  - Galaxy Ecosystems (Leroy, Murphy)
  - Galaxy Assembly through Cosmic Time (Casey, Hodge, Lacy)
  - Time Domain, Cosmology, Physics (Bower, Demorest)

- SWG white papers (ngVLA science goals – 125 authors, 200 pages) published in *http://library.nrao.edu/ngvla.shtml* and on arXiv.

- Preliminary science requirements developed from white papers
  - ***Still early times in design and we need more community input***

Image terrestrial zone planet formation

AU-scale imaging 1Myr protoplanetary disk at 140pc distance



- Frequency: need low optical depth on AU-scales => 30GHz
- Resolution: need 1AU resolution at 130pc = distance to nearest star forming regions (eg. Taurus, Ophiucus) => 10mas
- Sensitivity: need 1K brightness at full resolution => 10x VLA, ALMA

CHEMISTRY OF STAR AND PLANET FORMATION

- Complex organic (including prebiotic) molecules are the building blocks of life.
- Warm sources are more easily detected in the submm, but line blending is a killer.
- For cold sources, $\lambda \sim 0.5$ to 1 cm may be ideal.

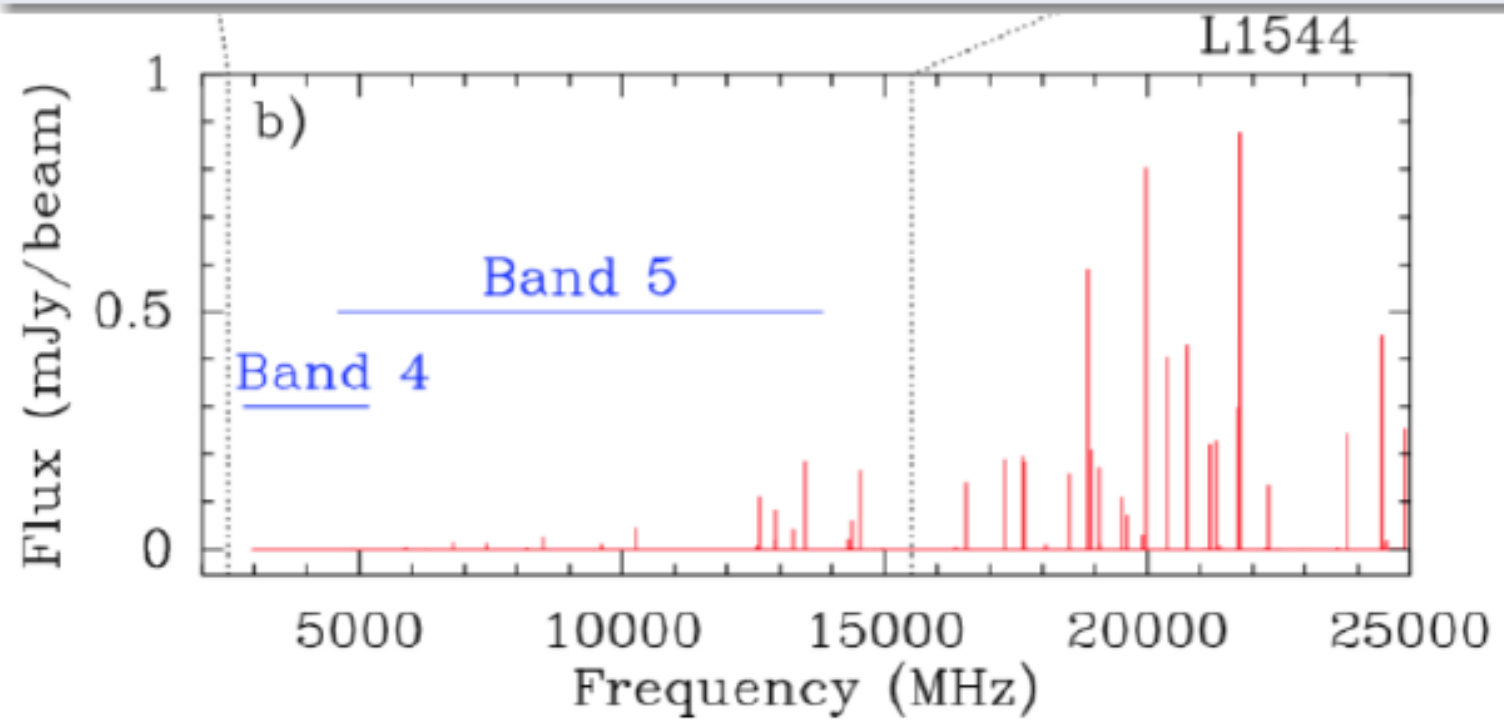
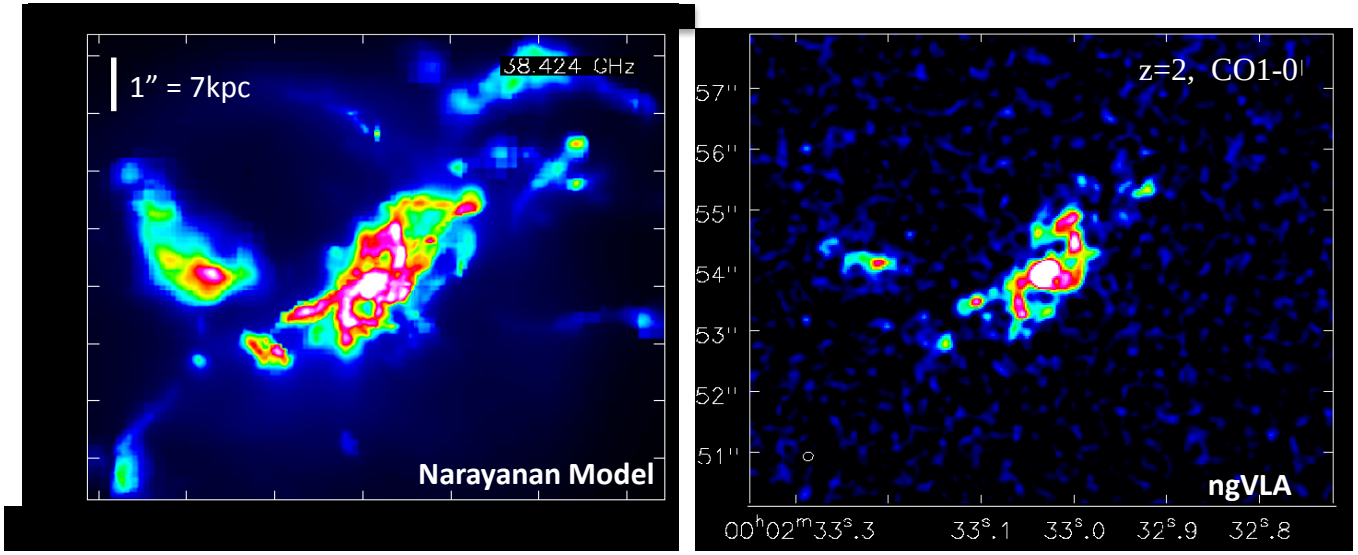


Fig: Simulations of the spectrum of Glycine (NH_2CH_2COOH) for a pre-stellar core in SKA bands. Codella+2014.

Dense gas history of Universe

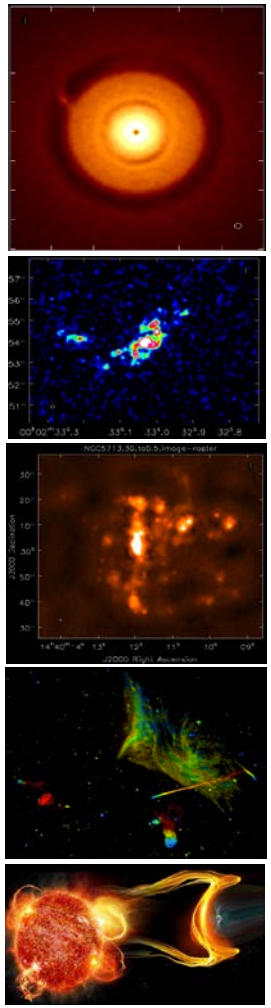
Imaging 'fuel for star formation' during epoch of galaxy assembly



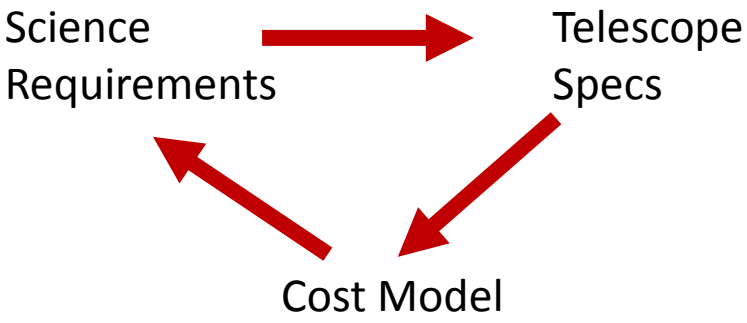
- Frequency: need low order CO at z ~ 1 to 5 => 20 to 50GHz
- Resolution: need ~ 1kpc => 0.15"
- Sensitivity: need to reach few 10^8 M_o at z ~ 2 => 12uJy @ 100 km/s
- FoV, BW: 100x JVLA, ALMA spectral deep field survey speed (1000's vs 10's of galaxies) => 18m antenna, 20GHz BW

Next step: Fine-tune Science Requirements and map to Telescope Specifications

Goal	Science Requirement	Array Specification
TPF	Optically thin	Freq ~ 15 to 50GHz
	1AU at 130pc @ 30GHz	B ~ 300km
	1K in 10hrs @ 10mas, 30GHz	A_{full} ~ 300 x 18m; BW ~ 20GHz
CGHU	CO 1-0 to z=8	Freq = 15 to 115GHz
	$M_{gas} = 10^9 M_o$ at z = 3 in 1hr	A_{mid} ~ 70% to B ~ 30km
	500pc resolution at z = 3 (60mas)	30km
	Large volume surveys	Octave Band Ratio
Baryon Cycle	$T_B < 0.2K$ (1hr, 10 km/s, 80GHz, 1")	A_{core} ~ 30% to B ~ 2km
	Continuum science	Octave BR; Linear pol to 0.1%
Time Domain	Explosive follow-up (GRBs, GW/EM…)	Minute trigger response time
	Blind discoveries (eg. FRBs)	millisec searches
	Exo-space weather: 1uJy in 1min	Freq ~ 1 to 20GHz A_{full} ~ 300 x 18m Circular pol to few %



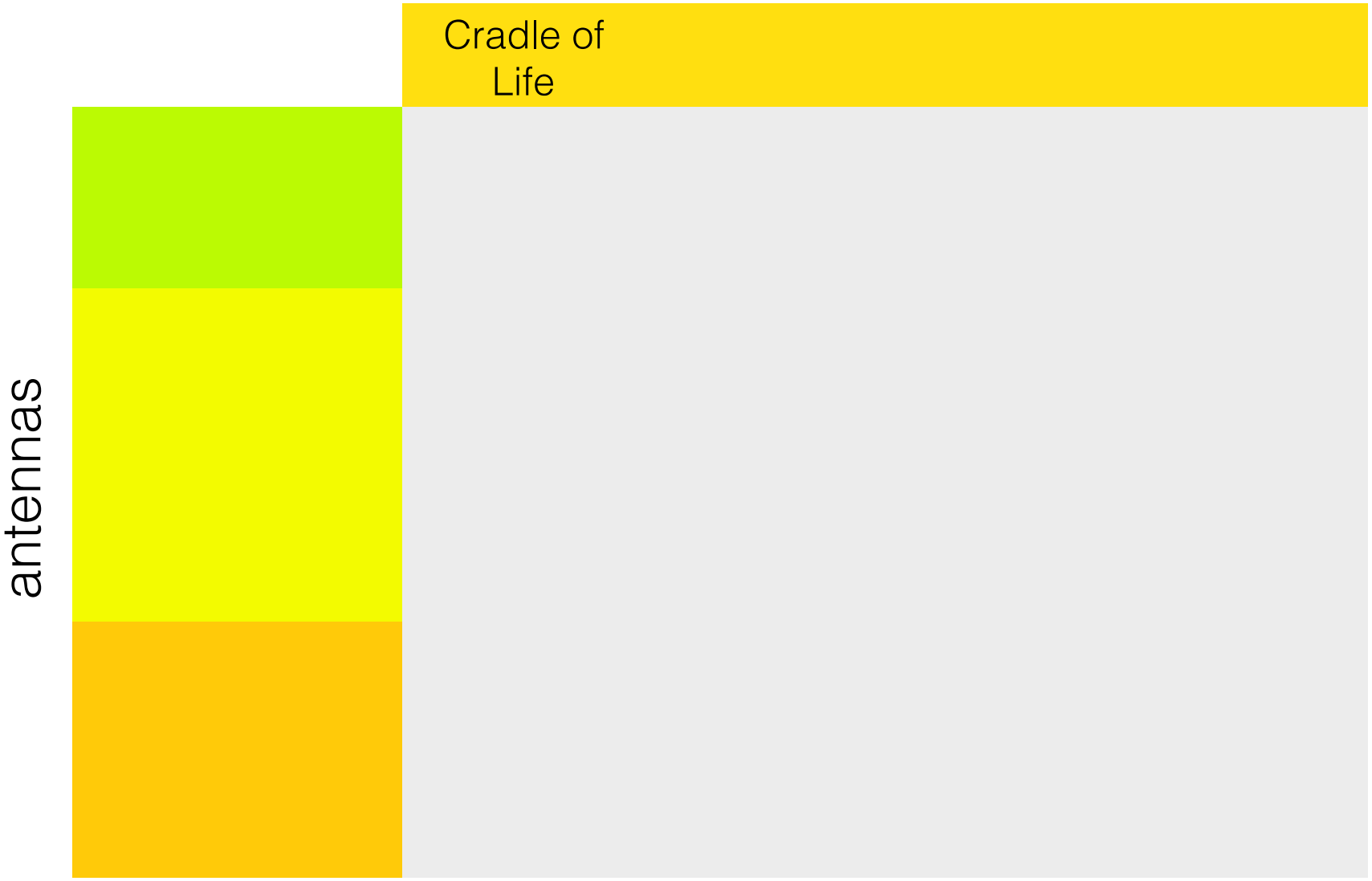
Close the loop for tradeoffs



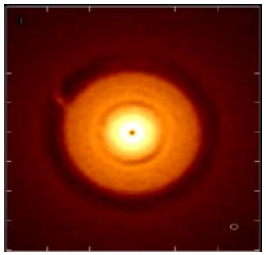
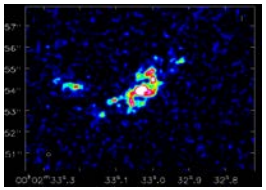
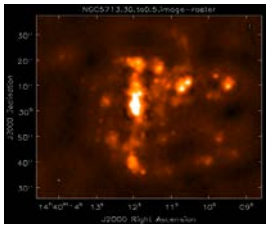
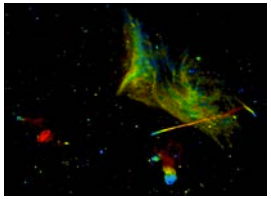
Goal: PDR-level 'proposal' to 2020 Decade Survey

- Compelling science program
- Defensibly costed design of all major elements

WBS #	Description
1	Project Management & Administration
2	Systems Engineering & AIV
3	Scientific Support & Commissioning
4	Antennas
5	Antenna Electronics
5.01	*Analog Front End (Feed, Receiver)*
5.02	*Cryogenic System*
5.03	*Integrated Down Converters*
5.04	*Integrated Unformatted Samplers*
5.05	*Formatter/DBE & DTS*
5.06	*Antenna LO References & RTP*
5.07	*Monitor & Control System*
5.08	*DC Power Supply System*
5.09	*Bins, Modules & Racks*
5.1	*HVAC & Electrical System*
5.11	*Non Recurring Engineering Effort*
6	Central/Distribution Electronics (LO, DTS)
7	Correlator
8	Computing & Software
8.01	*Proposal Submission & Handling (PST, PHT)*
8.02	*Observation Preparation (OST)*
8.03	*Array Monitor & Control (Executor, M&C, etc.)*
8.04	*Array Operations Tools (Operator Console & Screens*
8.05	*Array Calibration (TelCal, AntSol, etc)*
8.06	*Calibration Pipeline (CASA Pipeline)*
8.07	*Imaging Pipeline (Casa Pipeline)*
8.08	*Archive*
9	IT Infrastructure
10	Array Infrastructure
10.01	*Antenna Pads*
10.02	*Operations Roads*
10.03	*Utility Trench Cost*
10.04	*Fiber Utility*
10.05	*Electrical Utility*
10.06	*Relocation System*
10.07	*Non Recurring Engineering Effort*
11	Buildings
11.01	*Science Operations Building*
11.02	*Central Operations Building*
11.03	*Small Operations Stations*
11.04	*Technical Services Building(s)*
11.05	*Visitor Center*
	Construction Project Sub-Total


Cradle of
Life
antennas

Science/Technical Issues under Discussion


- Need to refine science program (open ended)
- Phase calibration
  - Paired antennas, dedicated reference array, water vapor radiometers, fast switching, self-calibration
- Array configuration
  - Sensitivity to low surface brightness
  - Fixed or moveable antennas
  - VLBI implementation
- Antenna optical configuration
  - offset Gregorian, symmetric Cassegrain, other
- Receiver band definition & Frequency cutoffs
  - Tradeoffs between system temperature, aperture efficiency, beam shape, operating cost, etc. with receiver band ratio

Moving Forward: ngVLA Project Office

- ngVLA Project Office will be established in Q4 CY2016
- Office will initially consist of:
  - Project Scientist: serves as liaison between NRAO and Science Advisory Committee/astronomy community
  - Project Director: sets direction, consolidates scientific and technical requirements, and arranges for development of the ngVLA proposal to the 2020 Decadal Survey

- ***Sign up for ngVLA mailing list:***

https://science.nrao.edu/futures/ngvla

Moving Forward: ngVLA Community Studies Program

- Purpose: Provide astronomy community the opportunity to make in-depth contributions on issues related to the ngVLA design
- Information: https://science.nrao.edu/futures/ngvla/ngvla-community-studies-program-call-for-proposals
- NRAO support for studies program:
  - Provide travel and page charge support for most accepted proposals
  - **Fund ~6 grants for study support at level of ~$10K – $25K**
  - NRAO scientist assigned to each study for assistance and to monitor progress
- Proposals reviewed by experts from the community and NRAO
- Study reports to take the form of a refereed publication or ngVLA memorandum

Schedule for Community Studies Program

- August 8: call for proposals
- August 15: pre-proposal teleconference
- September 15: proposal submission deadline
- October: announce accepted proposals/funding awards
- ~June 2017: report findings at ngVLA Science Meeting
- August 2017: final reports due

ngVLA Community Studies

Science Studies

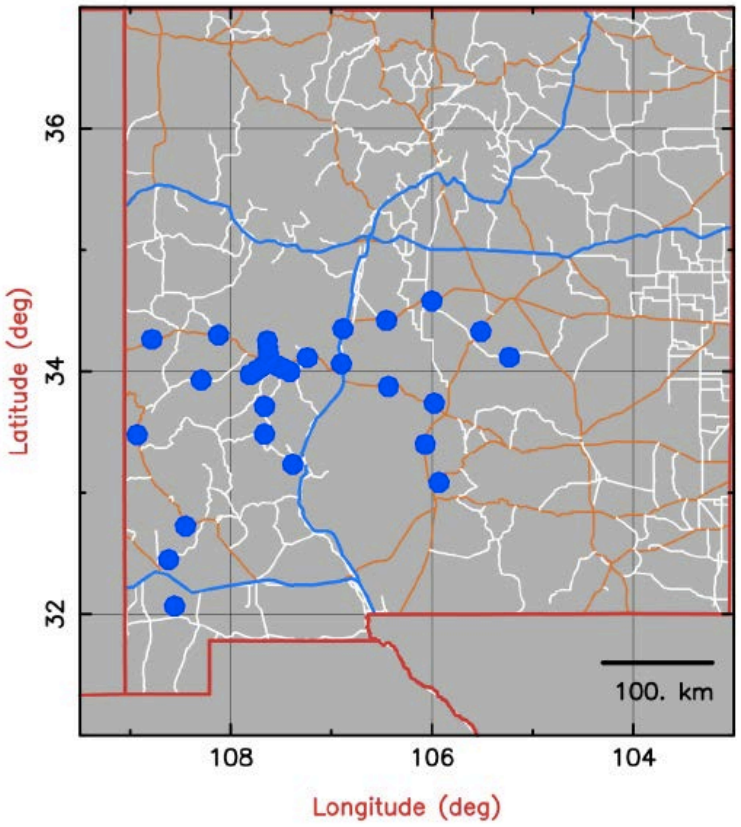
- Terrestrial Planets and Astrochemistry
- Chemistry of the Early Universe
- Exo-space Weather
- Dynamic Sky
- Near Earth Sensing
- Baryon Cycling: 3mm Science and Implications
- Low frequency options
- VLBI/Astrometry
- Plasma Physics
- SETI
- Other…

Technical Studies

- Advanced Cryo-cooling
- Ultra-wideband Feed tradeoffs
- Phase Calibration Options
- Total Power
- Re-Configurability /Configuration
- Data Backhaul
- Time Distribution
- Other

Example CS: Configuration

- Can we come up with a configuration design that delivers :
  1. A core array that has ~4x better T_B sensitivity at 1" than ALMA
  2. A ~10km array that has ~7x better point source sensitivity at 30GHz than VLA/ALMA for high-z CO
  3. A ~300km array that has factor ~10 better imaging capability than VLA/ALMA at30GHz (1K rms at 10mas)



Science Advisory Council (SAC)

- SAC is the interface between the science community & NRAO
  - ngVLA project scientist will be the SAC point of contact
- SAC composed of SWG chairs & at-large members. Composition:
  - Baryon Cycling (2)
  - Galaxy Assembly (2)
  - Cradle of Life (2)
  - Time Domain/Physics/Cosmology (~3)
  - At-large (4-6)
    - Includes representation from non-radio astronomers & strategic partners
- SAC co-chairs selected from above

ngVLA 2017 Science Meeting

- To be held in/around Socorro in early June 2017
- Tentative general program:
  - Highlight recent VLA science (2010+)
  - Reports from grant recipients and participants in ngVLA Community Studies program
  - Presentations on transformational science in astronomy and astrophysics that can be done with ngVLA
  - Definition of path forward for the ngVLA design to be presented at US RMS Futures III

Strategic Partnerships (franchising)

- Need ~3 agencies on board to get funding
  - e.g., NSF, NASA/DSN, Near Earth Sensing
    - VLBI: Astrometry post GAIA, satellite tracking
    - Low-frequencies: exoplanet imaging, Radar
  - Student training:
    - University participation during commissioning
    - Leave a couple of dishes for training

Tentative Plan Forward

- Fall 16: CSs funded; SAC established
- Winter 16/17: TAC established; CSs ongoing
- June 2017: CSs report out
- Summer 2017: work into consensus design
- Aug. 2017: K3 – Converged Concept
- 2018: Write up for Astro2020
- ***Sign up, listen, actively contribute:***

https://science.nrao.edu/futures/ngvla

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Current Project Timeline

- Early 2019: Propose ngVLA concept to 2020 Decadal Survey
- Early/mid 2020s: with Decadal Survey endorsement, seek funding for design and development phase
- Mid/late 2020s: Seek construction finding