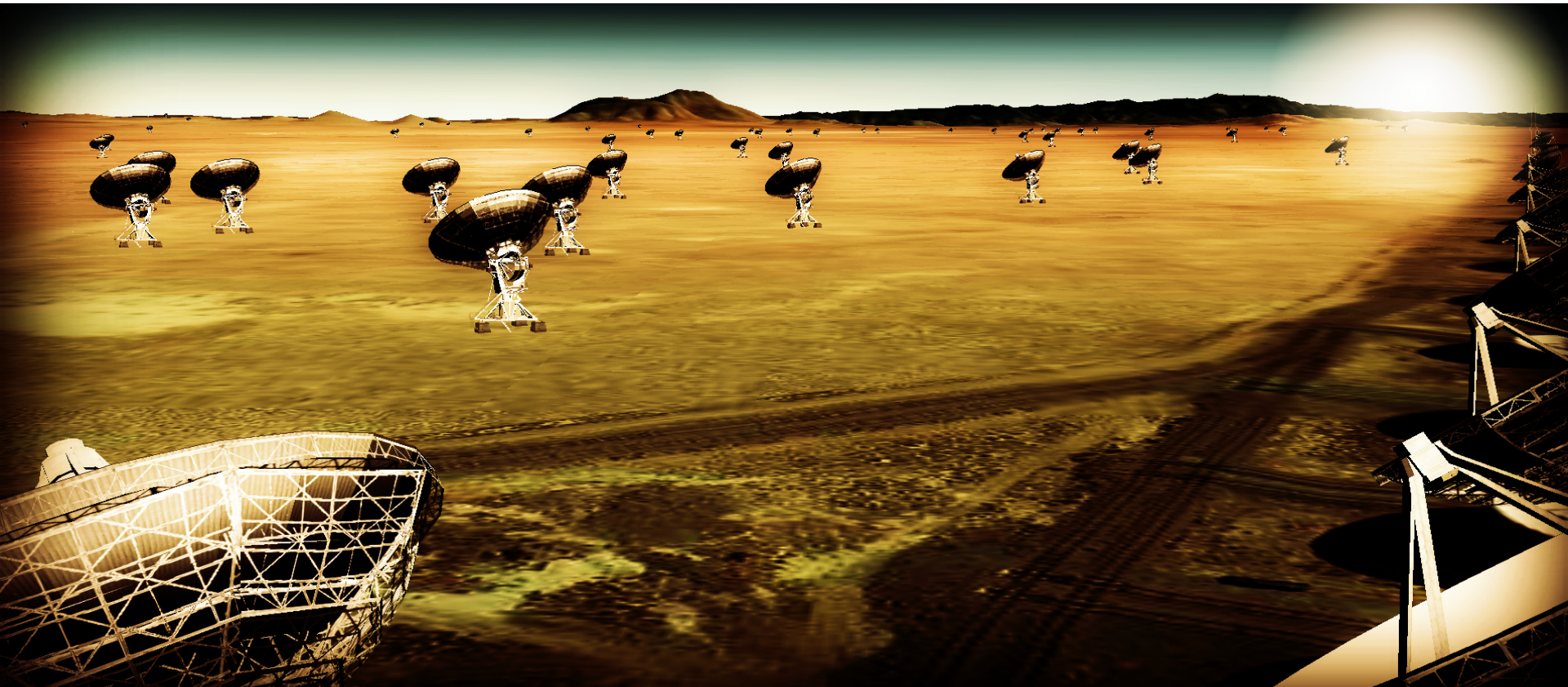
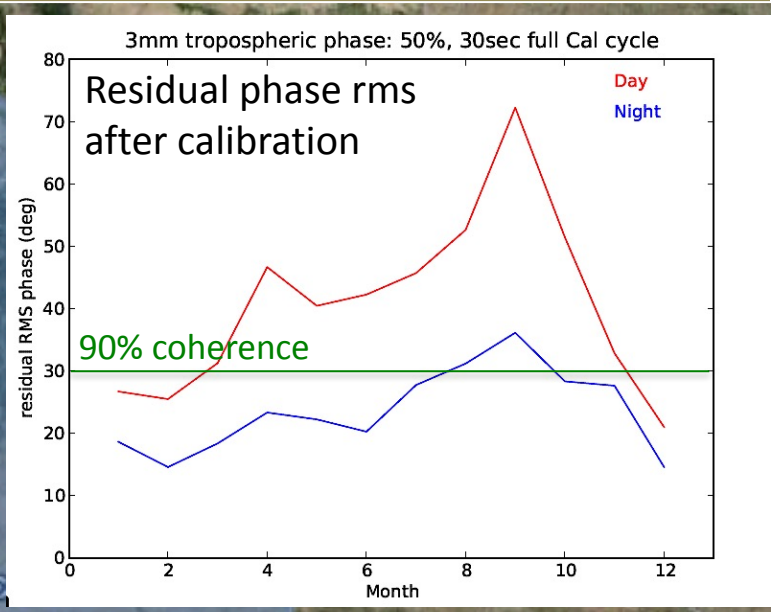
THE VERY LARGE ARRAY

THE NEXT GENERATION

- 10x Effective area JVLA, ALMA
- 10x Resolution w. 50% to few km + 50% to 300km
- Frequency range: 1 – 50, 70 – 115 GHz



JVLA: Good 3mm site, elev. ~ 2200m

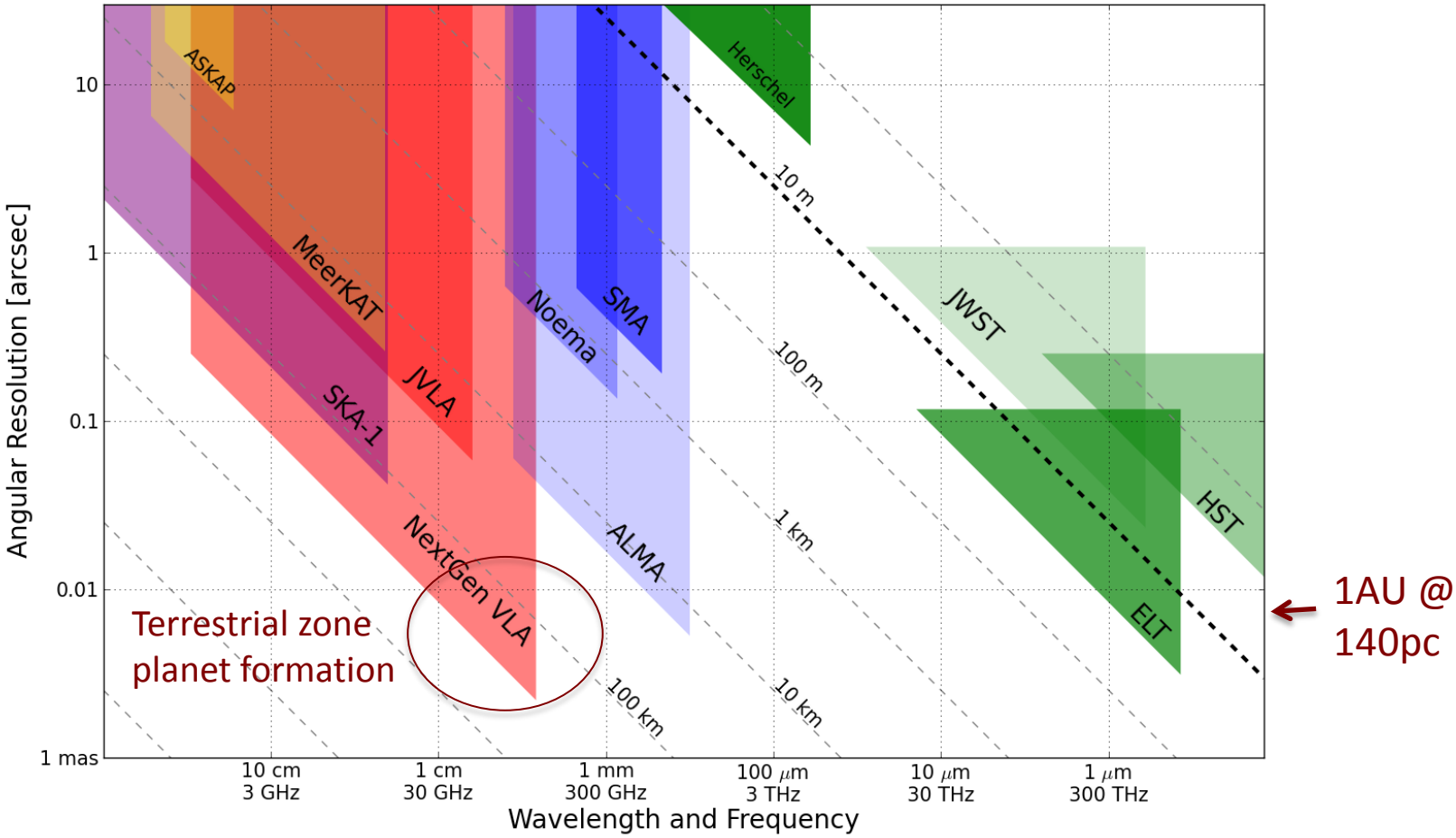


Process to date https://science.nrao.edu/futures/ngvla

- AAS Community Day January 2015
- Science working group reports October 2015
  - Circle of Life (Isella, Moullet, Hull)
  - Galaxy ecosystems (Murphy, Leroy)
  - Galaxy assembly (Lacy, Casey, Hodge)
  - Time domain, Cosmology, Physics (Bower, Demorest)
- Technical meetings
  - April 2015 Pasadena: Antennas, Receivers, Correlator
  - December 2015 Socorro: Operations, Post-processing, LO/IF
- Future
  - AAS Community Day January 4 2015
  - Key Use Cases → science requirements → telescope specs (small grants?)
  - Third Technical meeting ??

Killer Gap

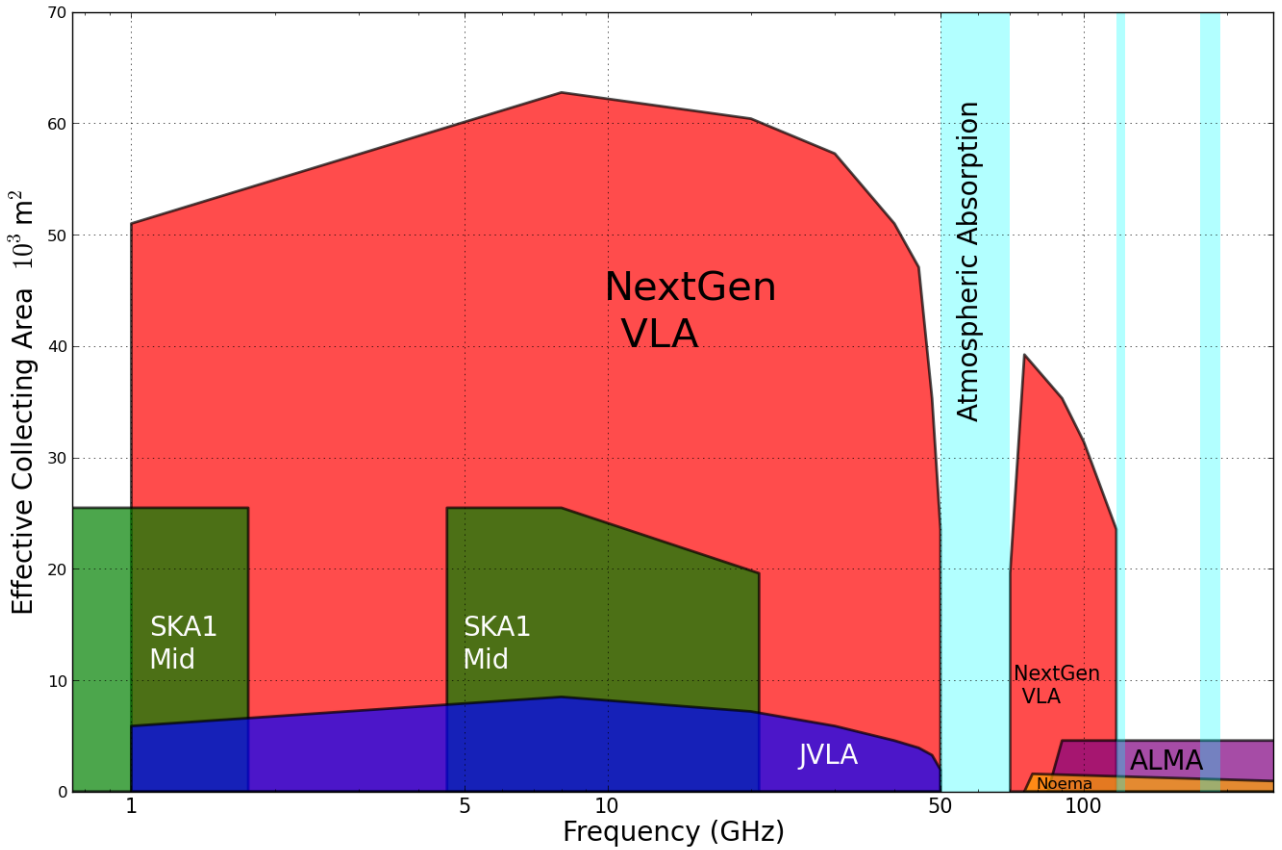
Thermal imaging on mas scales at λ ~ 0.3cm to 3cm



- Resolution ~ 10mas @ 1cm (300km)

Killer Gap

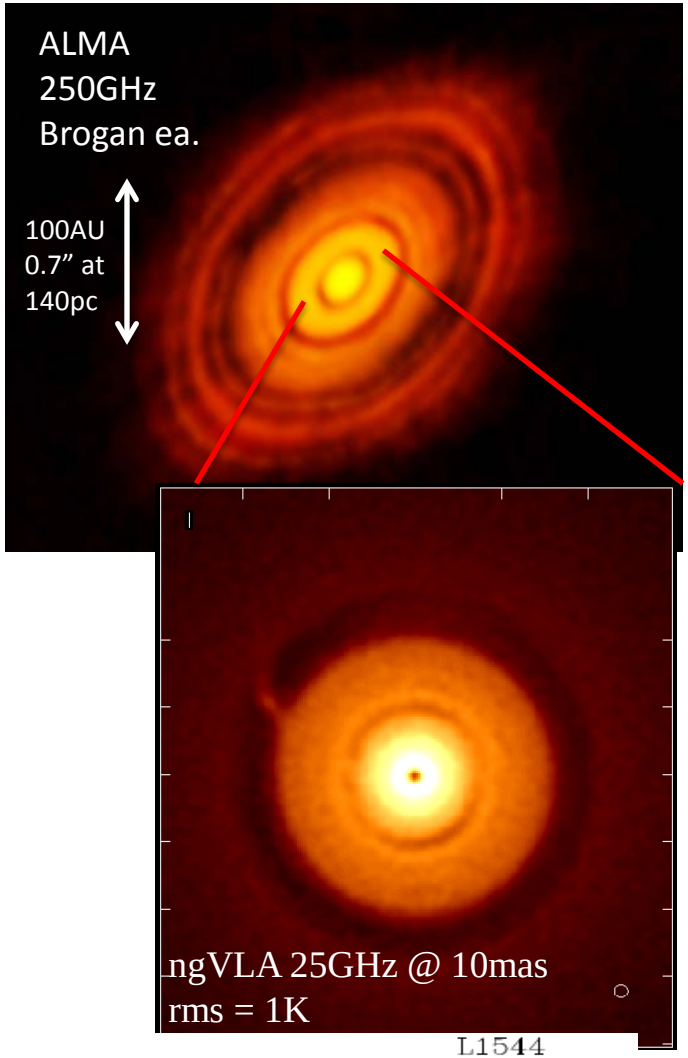
Thermal imaging on mas scales at λ ~ 0.3cm to 3cm

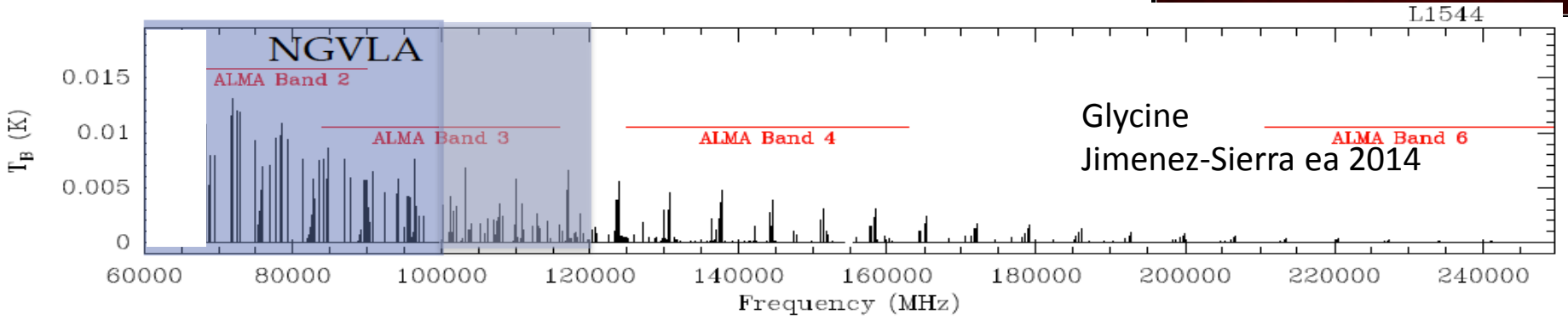


- Sensitivity ~ 0.1uJy @ 1cm, 10hr, BW = 20GHz
- T_B ~ 1K @ 1cm, 10mas
- Molecular lines become prevalent above 15GHz

SWG1: Terrestrial zone planet formation imager

- Protoplantary disks: Inner ~ 20AU disk optically thick in mm/submm
- ngVLA cm: Grain growth and stratification from dust to pebbles to planets. Simulation:
  - Jupiter at 13AU, Saturn at 6AU: annual motions
  - Circumplanetary disks: planet accretion
- Pre-biotic molecules: rich spectra in 0.3cm to 3cm regime



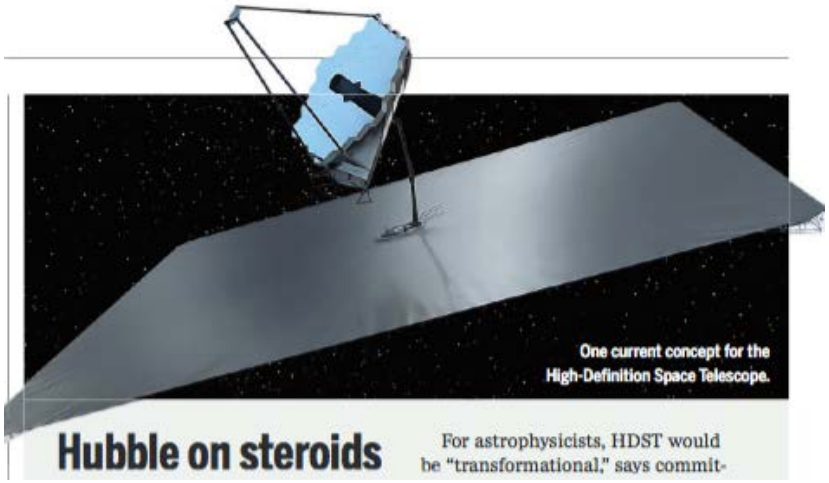


Next-Gen Synergy: Solar-system zone exoplanets

‘ALMA is to HST/Kepler as ngVLA is to HDST’

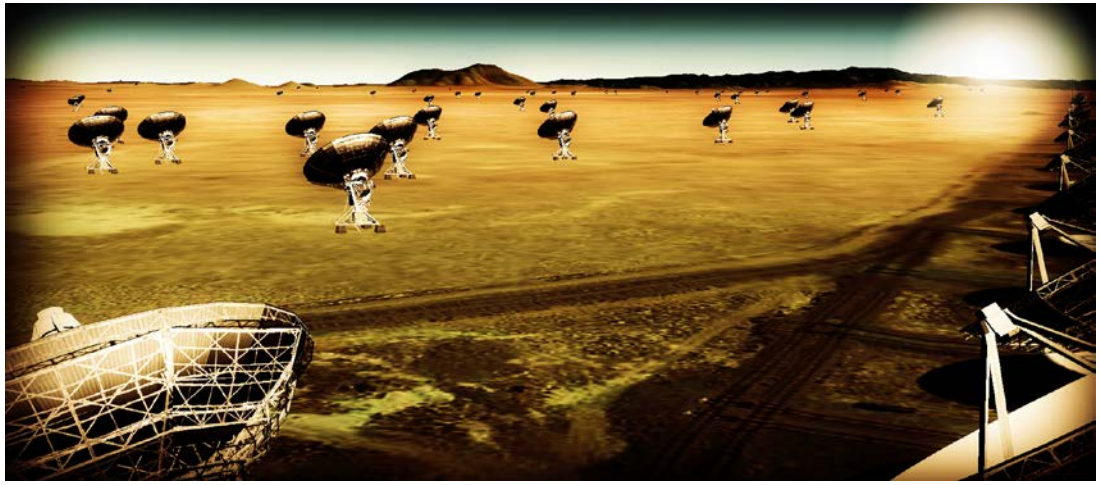
High Definition Space Telescope
Terrestrial planets: top science goal

- Direct detection of earth-like planets
- Search for atmospheric bio-signatures



ngVLA

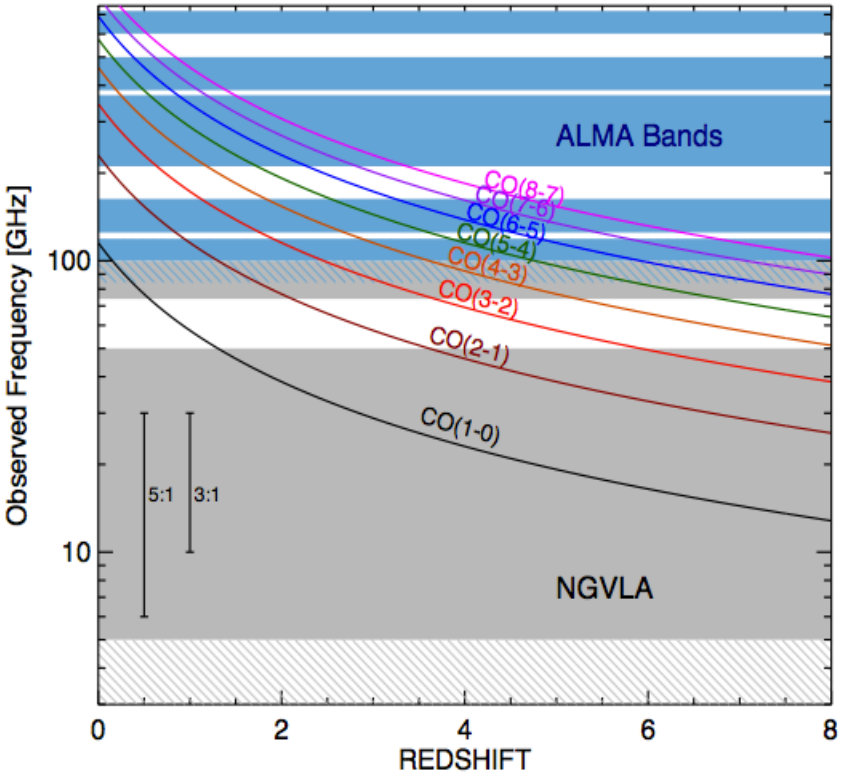
- Imaging *formation* of terrestrial planets
- Pre-biotic chemistry



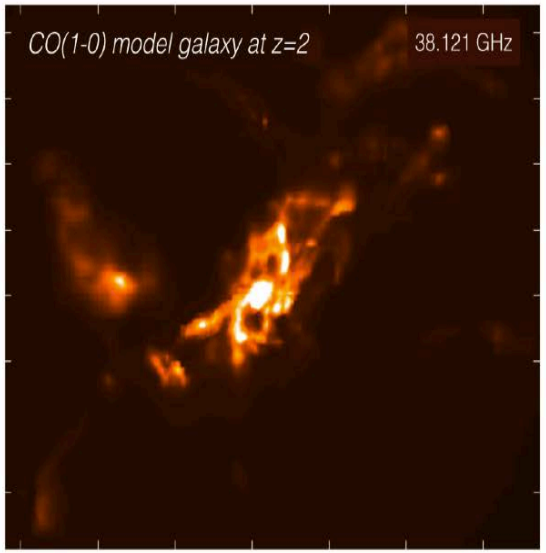
SWG3: Cool Gas History of the Universe

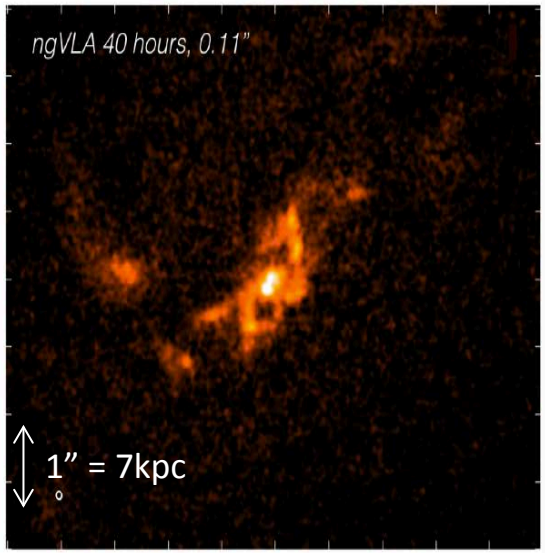
Tracing the fuel for star formation through time

- Low order CO = molec. gas mass tracer
- Dense gas tracers (HCN, HCO+…)
- 10x sens. => CO emission z > 1 'main sequence' galaxies in 1hr: $M_{gas} \sim 10^9 M_o$

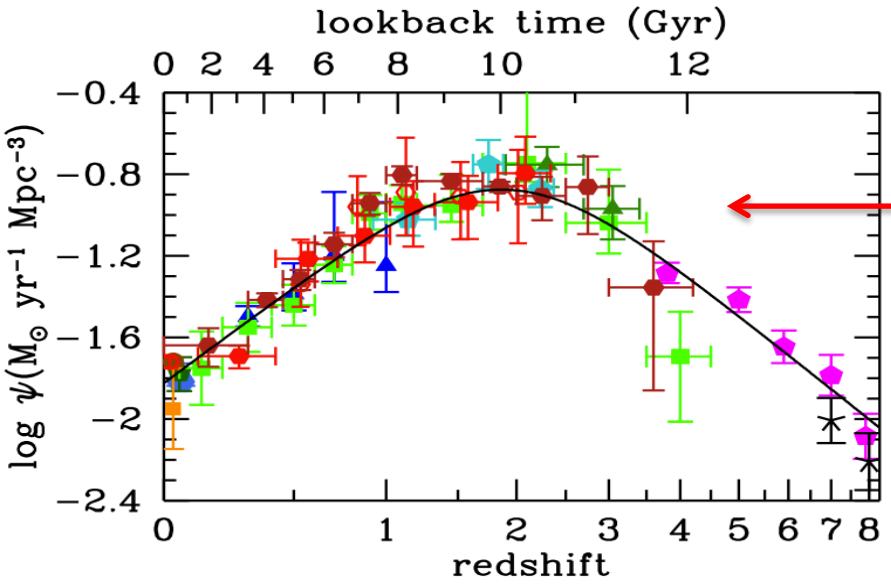


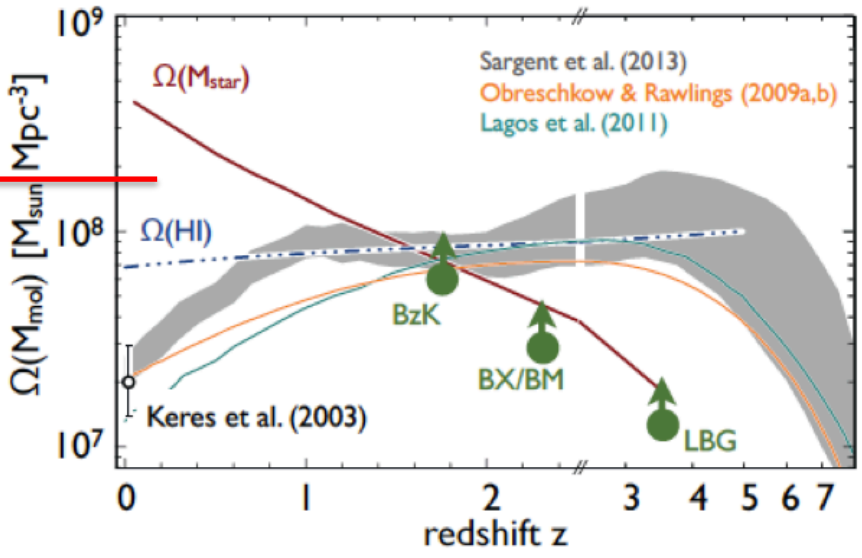
- Blind surveys: hundreds of galaxies per hour (vs. ~ 1 w. JVLA)
- Sub-kpc imaging
  - large scale gas dynamics (not just dense cores)
  - w. ALMA: Gas excitation, dust + SF laws





Next-Gen Synergy: Cosmic Gas to Stars Cycle



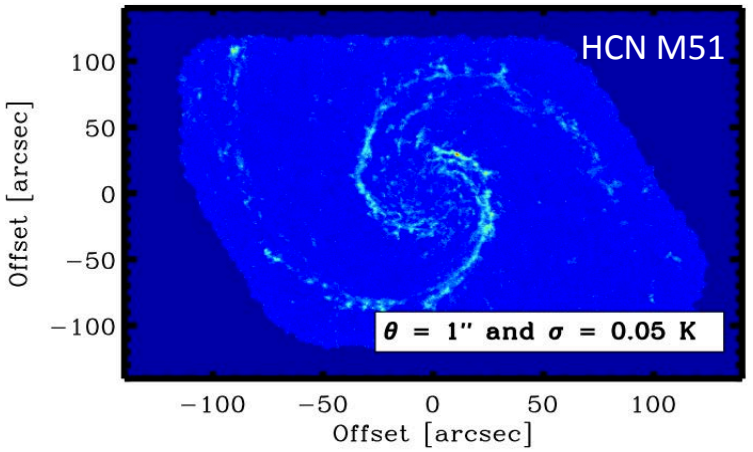


JWST/TMT: stars and star formation

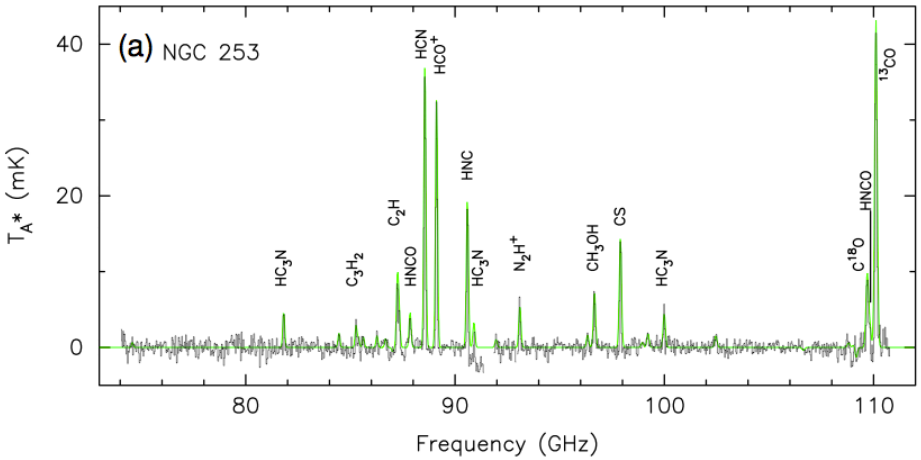
ngVLA: cold gas driving cosmic star formation

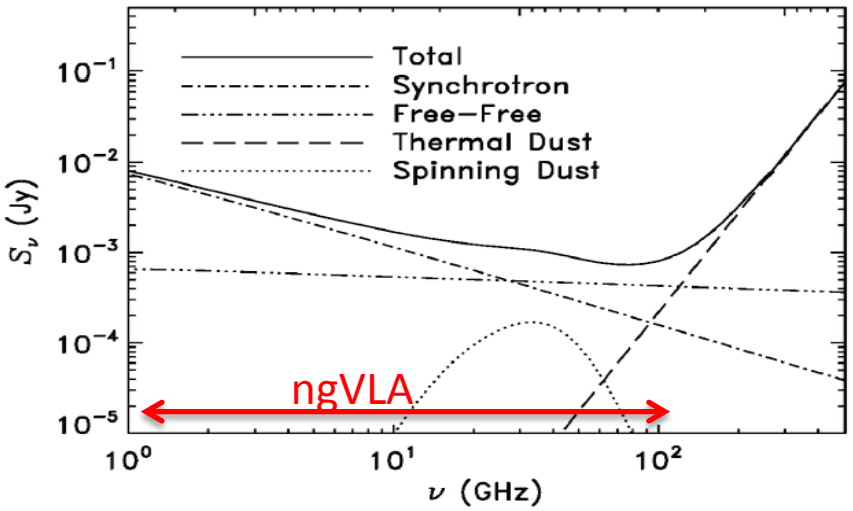
SWG2: wide field imaging10x faster than ALMA (‘gold mine’ Leroy)

MW/Local group science out to Virgo!



- Spectral lines
  - Ground state transitions of primary astrochemical, dense gas tracers
  - Unprecedented view of Baryon Cycle
- Broad-Band Continuum
  - Synchrotron, free-free, cold (spinning? dust, SZ effect
  - Obscuration free estimates of SFR
  - Physics of cosmic rays, ionized gas, dust, and hot gas around galaxies
- Synergy: FIR Explorer, TMT…





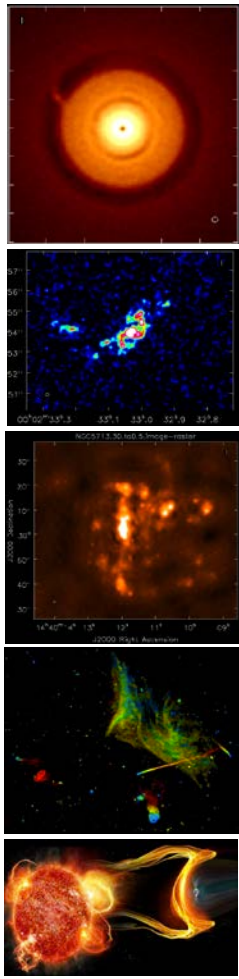
SWG4: Exploring the Time Domain

NGVLA most sensitive telescope to study broad-band temporal phenomena

- Explosive Universe (TDEs, GRBs, Blazars, GW/EM, FRBs?): high frequency peaks higher and earlier
- Exo-space weather: exo-planet environments and the development of life
  - Thermal stellar winds to 10^{-13} M_o/yr
  - Brown dwarf Auroras: Star-planet magnetospheric interactions
  - Key drivers of exo-space weather
- Synergy: LSST, LIGO, FERMI++…

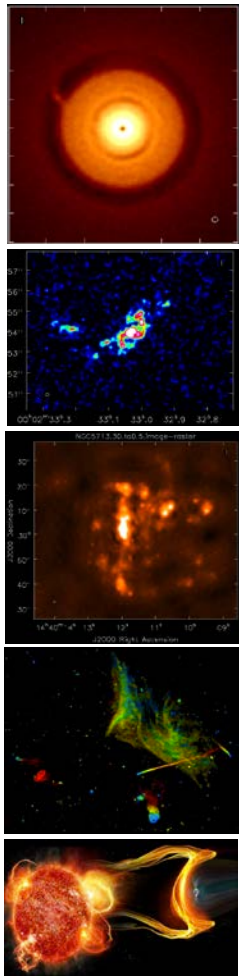
SWG Reports: Requirements to Specifications

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 %



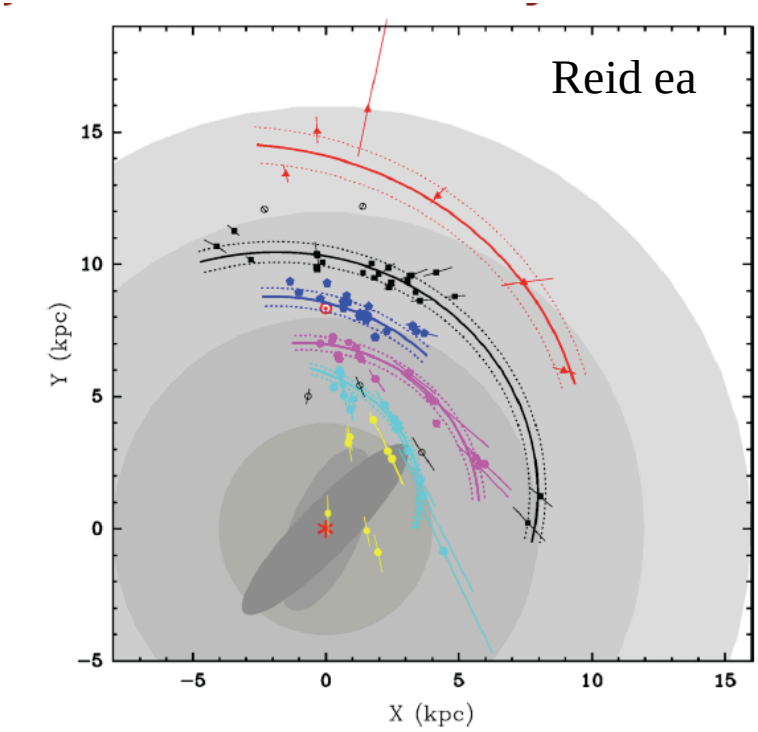
Next Steps: Requirements to Specifications

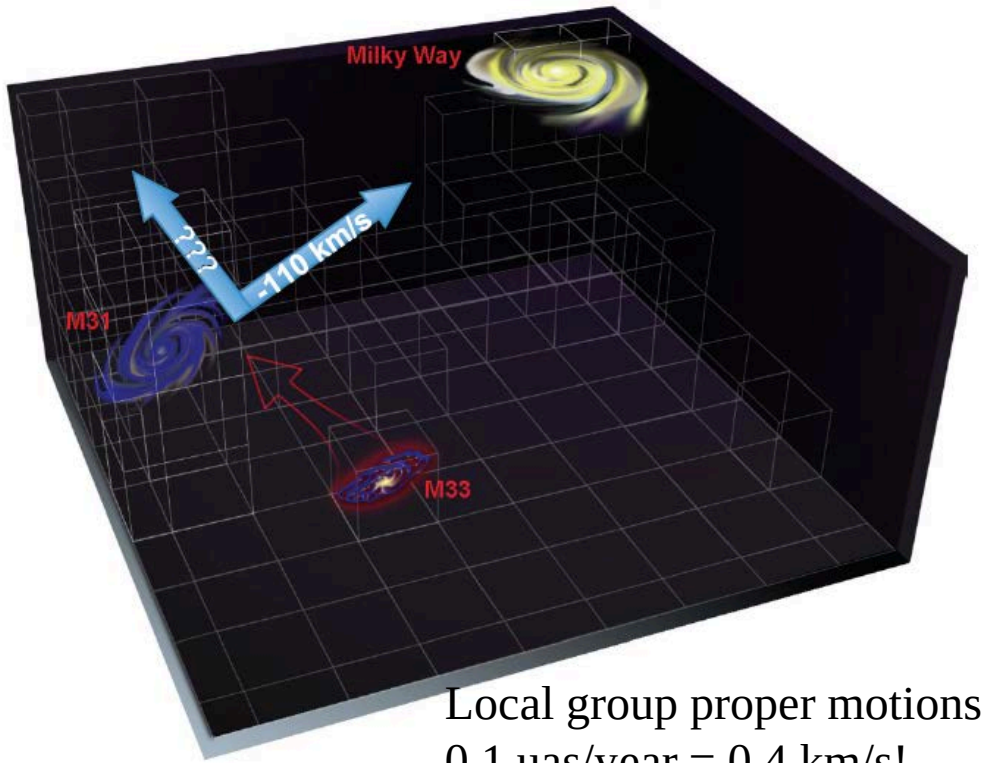
- Antennas
  - 12m to 25m: FoV requirements
  - On vs. off axis
- Configuration: need simulations
  - Balance: Core (1km) vs. mid (30km) vs. long (300km)
  - Some fraction reconfigurable
  - Need for large single dish + cameras or compact array
- Receivers
  - Band ratios: performance v. number
  - Low frequency limit
- Phase Calibration: testing at JVLA
- VLBI implementation: need simulations
  - New stations vs. ‘ad hoc’



VLBI uas astrometry

- Spiral structure of MW: masers in SF regions to far side of Galaxy
- Local group cosmology: proper motions + parallax w. masers + AGN: 0.1 uas/yr => dark matter, fate MW, real-time cosmology (local Hubble expansion)
- Not DNR limited imaging => include few big antennas ~ 10% area?





Local group proper motions
0.1 uas/year = 0.4 km/s!
(Darling)