Summary

Significant variety in the submitted Science Use cases, ranging from HI to molecules, from molecular clouds to AGN

Several of these were pulled together in a preliminary Key Science Goal

- ngVLA_SciCase_NGA_1.pdf: Physics of Radio Jet-ISM Feedback
- ngVLA_SciCase_NGA_2.pdf: Atomic Hydrogen in the Local Universe
- ngVLA_SciCase_NGA_3.pdf: Radio Continuum Emission from Galaxies: An Accounting of Energetic Processes
- ngVLA_SciCase_NGA_4.pdf: Black hole accretion probed by linear and circular polarimetry
- ngVLA_SciCase_NGA_5.pdf: A High-Resolution Kinematic View of Neaby Galaxy Nuclei
- ngVLA_SciCase_NGA_6.pdf: Star Formation in a range of extremephysical envirmonemtns
- ngVLA_SciCase_NGA_7.pdf: Direct Measurements of Density and Temperature in Star-Forming Gas
- ngVLA_SciCase_NGA_8.pdf: Parsec-Scale Cold Gas Structure Across the Whole Local Galaxy Population
- ngVLA_SciCase_NGA_9.pdf: A Complete Line Survey and Sub-Pc Map of Every Local Group Molecular Cloud
- ngVLA_SciCase_NGA_10.pdf: Gas Density Across the Local Universe
- ngVLA_SciCase_NGA_11.pdf: Thomson Scattering
- ngVLA_SciCase_NGA_12.pdf: Accurate Massive Black Hole Mass
- ngVLA_SciCase_NGA_13.pdf: How Do Cold Galaxy Outflows Shape Galaxies?
- ngVLA_SciCase_NGA_14.pdf: The Definitive Census of the Molecular ISM in the Milky Way

Understanding How Galaxies Produce New Generations of Stars

Driving Science Use Cases

Galaxy Ecosystems: NGA2, NGA8

Related Science Use Cases

Galaxy Ecosystems: NGA5, NGA6, NGA7, NGA9, and NGA10

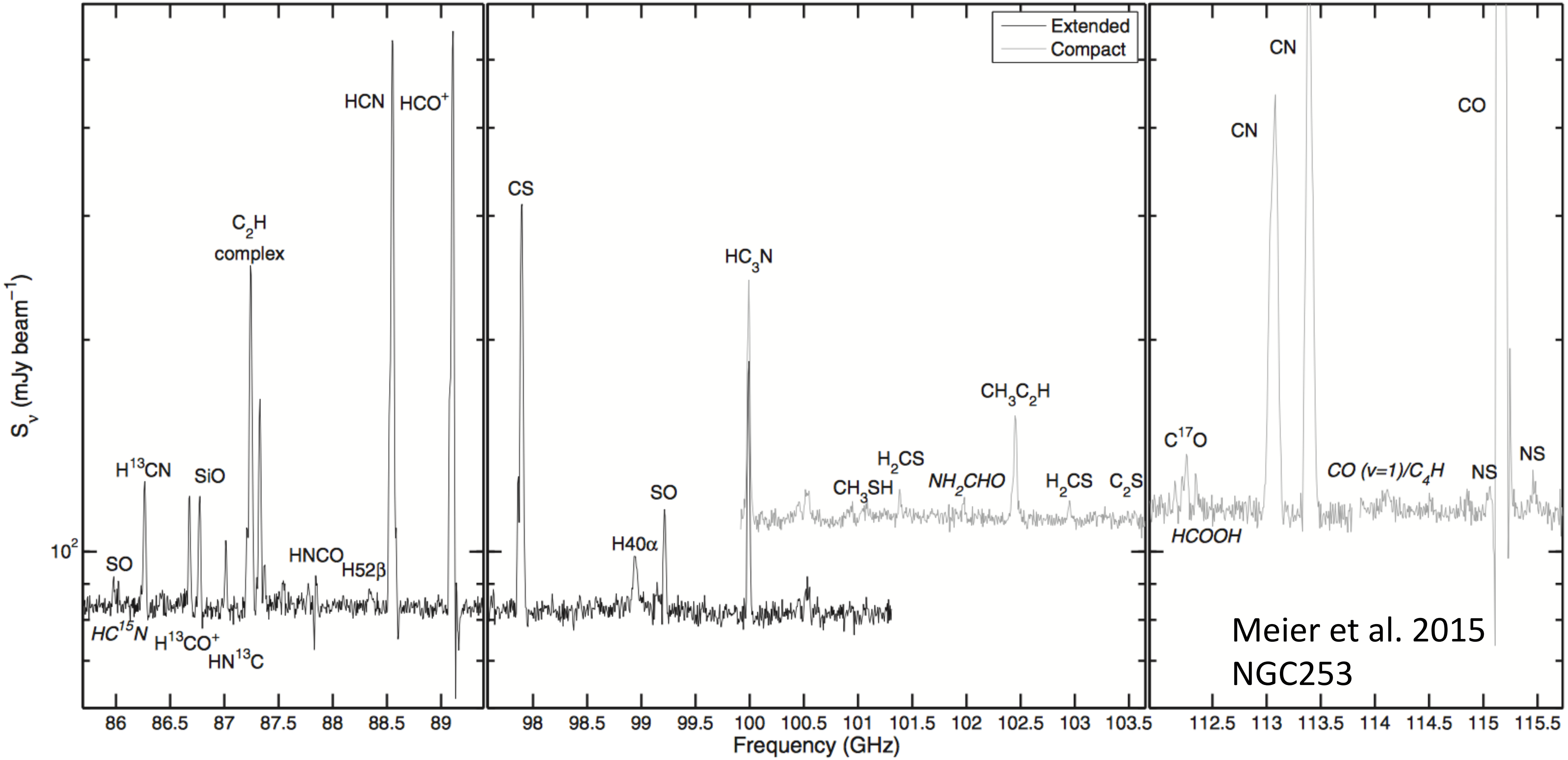
Scientific Rationale

Galaxy formation and evolution are regulated by a complex interplay between the hierarchical merging of dark matter halos, the accretion of primordial and recycled gas, the transport of gas in galaxy disks, and the formation of molecular clouds which subsequently collapse and fragment. The resulting star formation gives rise to nucleosynthesis, and metal-enriched outflows driven by stellar winds, radiation pressure, supernovae, and AGN activity. How is gas accreted onto galaxies? How is the gas influenced by the star formation process and transported within galaxies? How do the energetics, turbulent structure, self-gravity, density, and chemical state of clouds change as gas cycles between atomic and molecular phases and how do they depend on galaxy properties or location in a galaxy? Observations of these processes would not only constrain dominant feedback mechanisms and timescales, but also establish useful chemical clocks and produce the observations necessary for interpreting spectroscopy across the universe out the highest redshifts.

Galaxies continue to accrete material from their surroundings throughout their existence. This material gathers in their outer disks as HI gas, constituting the largest gas reservoir in galaxies: the ngVLA will provide the combination of surface brightness sensitivity and resolution necessary to understand the physical makeup of these reservoirs. Most of the star formation activity, however, occurs in inner disks where the gas is denser and mostly in molecular form. Transport of gas from the outer reservoirs to the inner regions is a key and poorly understood feature of galaxy evolution. As the gas moves inward it becomes denser and gathers into molecular clouds, which disperse and reform during inter-arm passages. In the path of gas to stars, the formation of molecular clouds is likely one of the key poorly-understood bottlenecks that leads to regulation of star formation in galaxies. Star formation occurs within portions of these clouds with an efficiency that is much lower than the naïve expectation of collapse in a free-fall time scale, due to feedback effects that are probably mediated by turbulence, likely injected on large scales. Episodes of concentrated massive star formation drive fountains, where enriched gas is cycled through the galaxy halo, and even larger episodes such as starbursts or accretion onto central super-massive black holes can drive substantial galaxy winds. These phenomena constrain and regulate the stellar mass growth in galaxies, as well as injecting metals, dust, and energy into the

Key consideration for galaxy ecosystems: Sensitivity to ”thermal” emission

- CO is by far the brightest line, by factors of 10-20 (off chart in this log scale plot)
- Emission is extended
- Pushing to the astrophysics enabled by access to the weaker lines requires excellent surface brightness sensitivity (in K)
- Hence this type of science requires significant collecting area in a compact core
- It also requires recovery of all spatial scales



Recommendations

- Access to 1.4 GHz and 20-115 GHz
- Sensitivity, particularly surface brightness sensitivity
  - Collecting area within 1-30 km
  - Long baselines are important for the non-thermal universe (e.g. AGN), so we support a combination of core+extended baselines
- Recovery of all spatial scales
  - Either a dedicated array of small dishes plus total power antennas or a larger single-dish
- Mild preference for the homogeneous 18m concept
  - Simplicity, maximizing collecting area