ngVLA Key Science Goal 1:
Unveiling the Formation of Solar System Analogues on Terrestrial Scales

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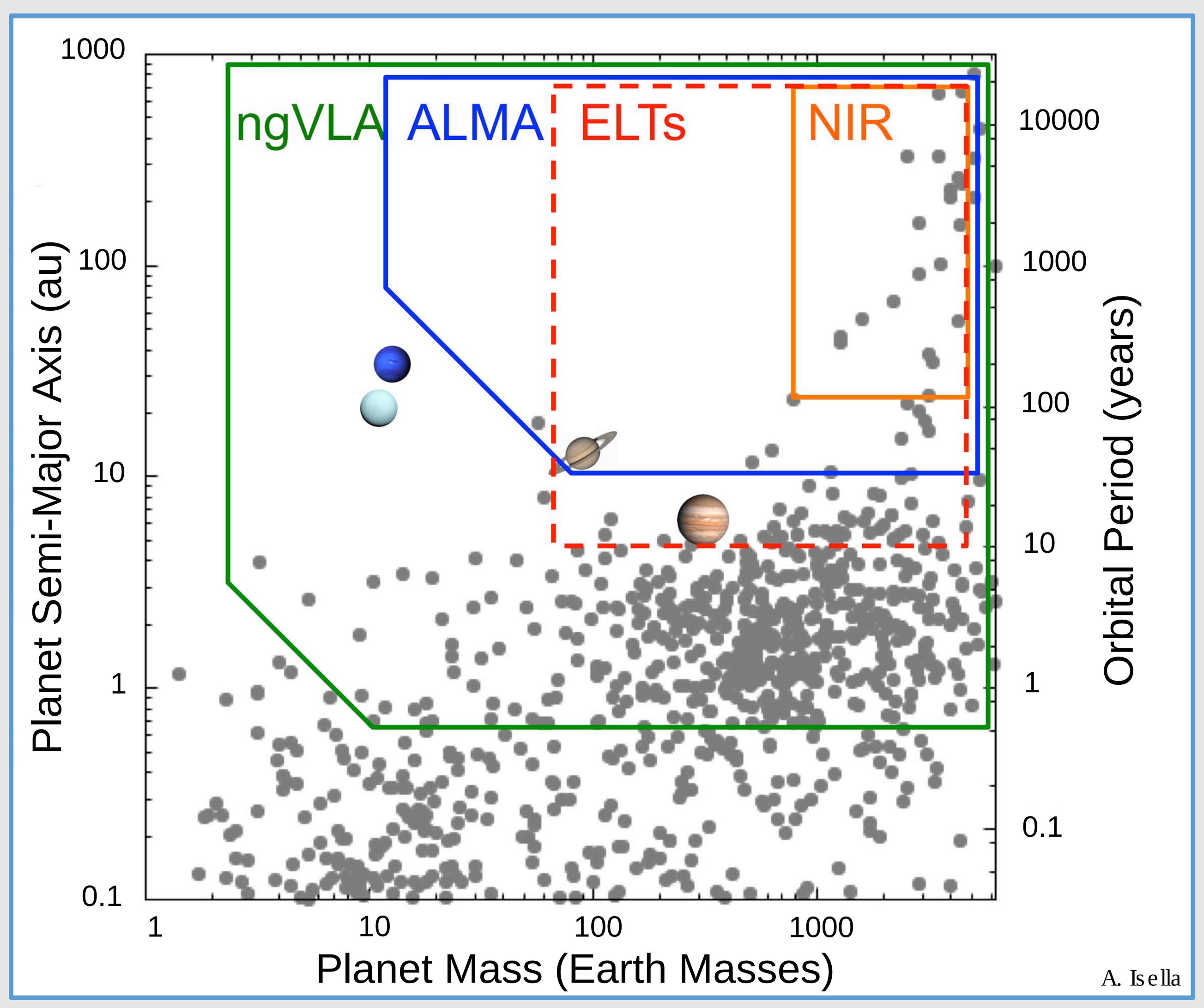
Abstract

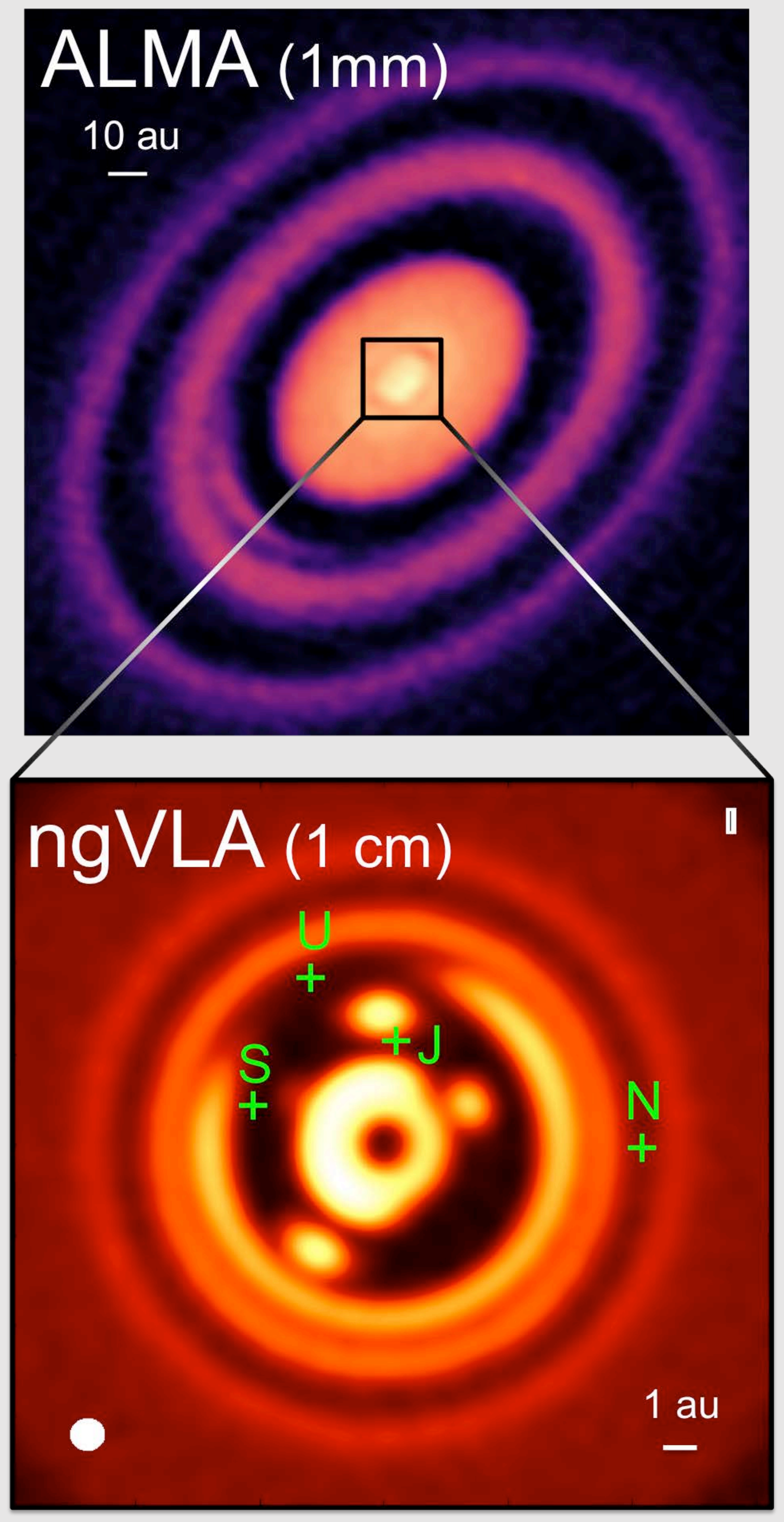
The disks of dust and gas that surround young stars are the birthplaces and material reservoirs for planetary systems. A key science goal of the ngVLA is to image the formation of super-Earths and giant planets in these disks, particularly within 10 au of the central stars. By observing dust continuum emission at wavelengths of 3 to 10 millimeters at angular resolutions approaching 1 mas, the ngVLA will reveal gaps and asymmetries that result from disk-planet interactions in inner disk regions that are opaque at shorter wavelengths (and inaccessible to ALMA and optical facilities). These features will probe the presence of 5 to 10 Earth mass planets with orbital radii as small as 1 au for systems within 500 pc. Observations of 100's of disks will thereby constrain the planet initial mass function. Moreover, such ngVLA observations will unveil planetary systems similar to our own Solar System in the formation phase. Since the inner disk regions evolve on timescales of only a few years or less, multi-epoch ngVLA observations will yield "movies" of dust structures in disks that show directly the orbital motion of close-in planets in formation (and other changes), providing the framework to understand the demographics of exoplanetary systems.

ngVLA will measure the planet initial mass function to 5 – 10 Earth masses



The parameter space of exoplanets around mature stars and young planets in circumstellar disks probed by various facilities. The ngVLA will discover 100's of young planets with orbital periods < 10 yr and masses > 5 - 10 Earth masses from their interactions with parent circumstellar disks. These data will provide strong constraints on the planet initial mass function and birth radius distribution.

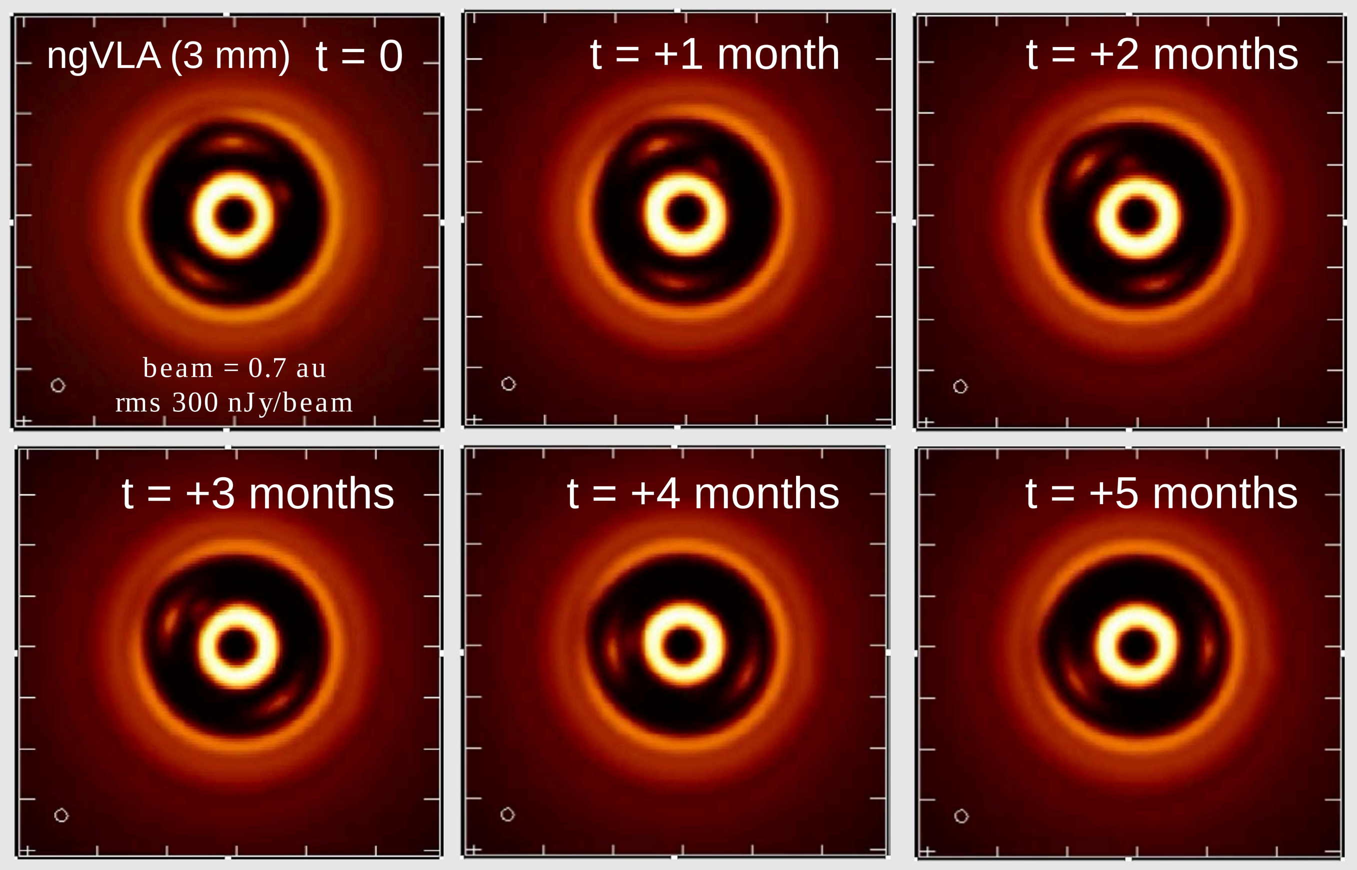
ngVLA will probe young planets in disks at orbital radii to 0.5 au at 140 pc



ALMA 1.3 mm image of the HD 163296 system at 4 au resolution (distance 101 pc) revealing gaps, rings and other asymmetries that suggest the presence of planets (Isella et al. 2018, DSHARP). The inner region, within about 30 au, is optically thick, hampering the detection of density substructures created by planet-disk interaction.

A simulated ngVLA 1 cm image of a young solar nebula disk at 1 au resolution, assuming the presence of (J)upiter-, (S)aturn-, (U)ranus- and (N)eptune-like planets at 3.5, 4.5, 6. and 8 au (Ricci et al. 2018), with rms about 70 nJy/beam.

ngVLA will measures the orbital motion of disk features on monthly timescales



Multi-epoch observations with ngVLA ("movies") of disks around young stars with ~ 1 au resolution will follow the temporal evolution of both flux density and morphology of individual azimuthal structures to constrain properties of inner disk planets (Ricci et al. 2018)

References

Isella et al. 2018, ApJL, 869, L49 (DSHARP IX)
Ricci et al. 2018, ASPC, 517, 147

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