The ALMA Level One Science Goals

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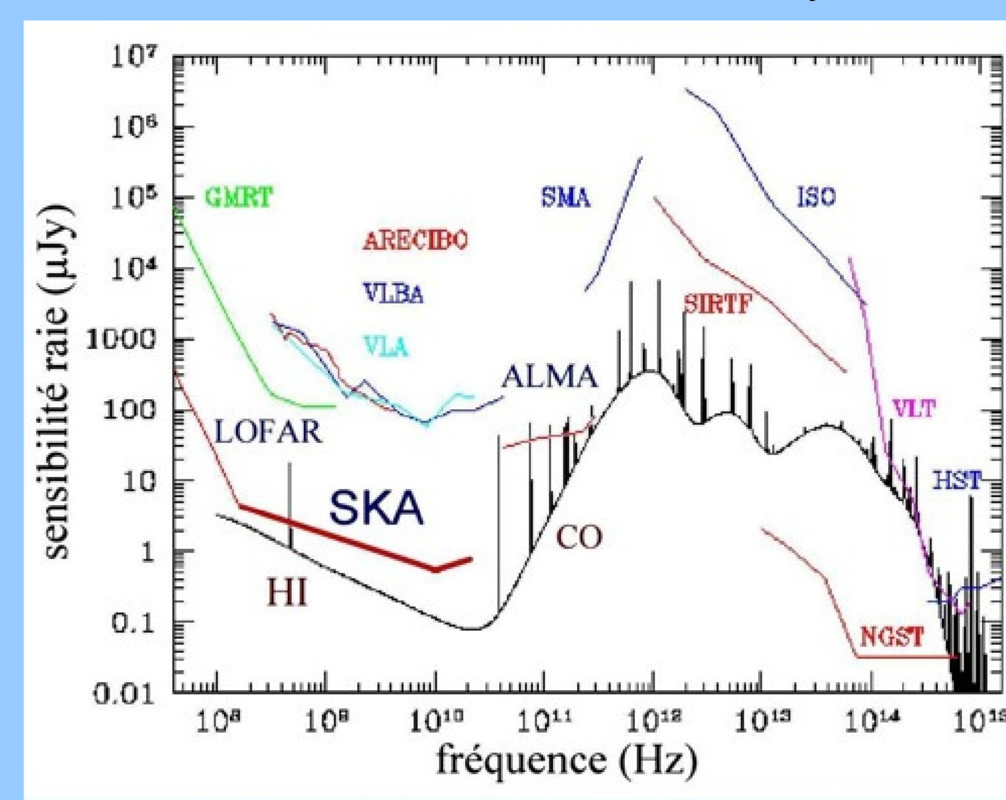
The highest level document governing the Atacama Large Millimeter Array (ALMA) Project is the *Bilateral Agreement*. Annex B of this agreement details ALMA's three highest level science goals.

A galaxy Spectral Energy Distribution similar to that of the Milky Way at a redshift of z=2 is shown. The 5σ signal levels in a one hour integration are shown for various instruments.

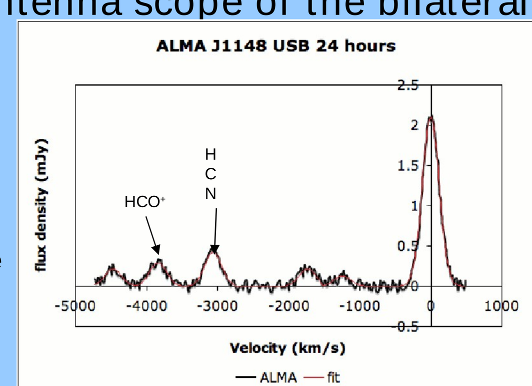
Figure: F. Combes



1 ***ALMA will have: The ability to detect spectral line emission from CO or C+ in a normal galaxy like the Milky Way at a redshift of z = 3, in less than 24 hours of observation.***

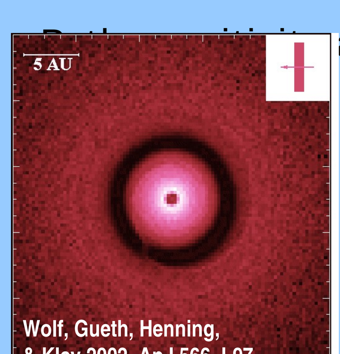
With the entry of Japan into the project, bringing an additional 16 antennas, the sensitivity of the array will increase, even if the currently contracted complement of 50 antennas is not augmented to reach the 64-antenna scope of the bilateral ALMA.

A spectrum observed toward a hypothetical J1148+525-like source at a declination appropriate for ALMA. A 24 hour integration is shown, at full resolution without the ALMA tunable filters deployed. An Upper Sideband spectrum (centered at 94.8 GHz) with the frequency set so that the CO line is included and adventitious lines are optimally placed within the spectrometer bandpass.



2 ***ALMA will have: The ability to image the gas kinematics in a solar-mass protostellar/protoplanetary disk at a distance of 150 pc (roughly, the distance of the star-forming clouds in Ophiuchus or Corona Australis), enabling one to study the physical, chemical, and magnetic field structure of the disk and to detect the tidal gaps created by planets undergoing formation.***

Both sensitivity and superb resolution combine to enable this primary goal of ALMA



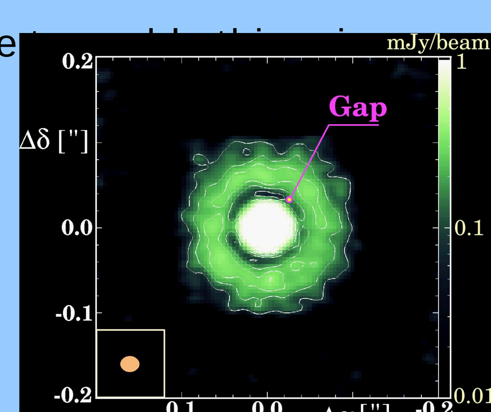
Protoplanetary disk at 140pc, with Jupiter mass planet at 5AU

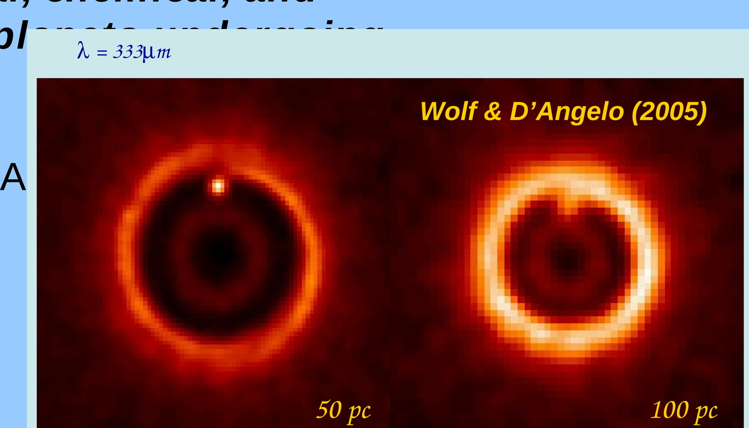
ALMA simulation (right)

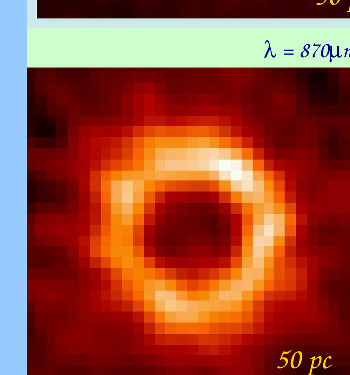
428GHz, bandwidth 8GHz

total integration time: 4h

max. baseline: 10km







Maximum baseline: 10km.

t_{int}=8h.

30deg phase noise

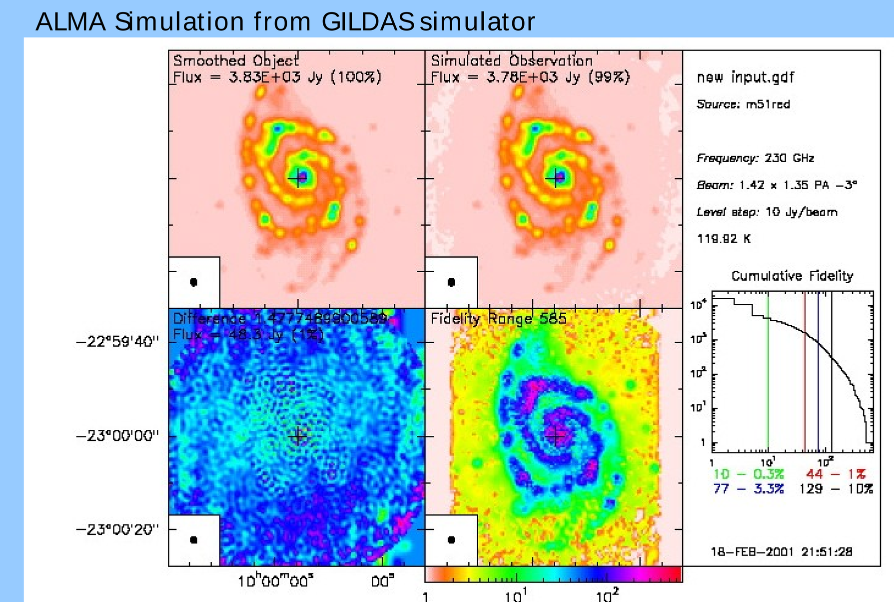
pointing error 0.6"

Tsys = 1200K (333mu) / 220K (870mu)

A good paradigm for imaging such a system is provided by a model published by S. Wolf (2005). In this model, a planet of M_{planet} / M_{star} = $1.0 M_{Jup}$ / $0.5 M_{sun}$ orbits the star at a radius of 5 AU accompanied by a disk of mass as in the circumstellar disk as around the Butterfly Star in Taurus. The very young planet may be directly detected (panels at right) at the highest frequency on the longest baselines.

3 ***ALMA will have: The ability to provide precise images at an angular resolution of 0.1". Here the term precise image means accurately representing the sky brightness at all points where the brightness is greater than 0.1% of the peak image brightness. This requirement applies to all sources visible to ALMA that transit at an elevation greater than 20 degrees.***

ALMA Simulation from GILDAS simulator



- The Fidelity Image is defined as:

  model * beam / abs(model * beam – reconstruction)

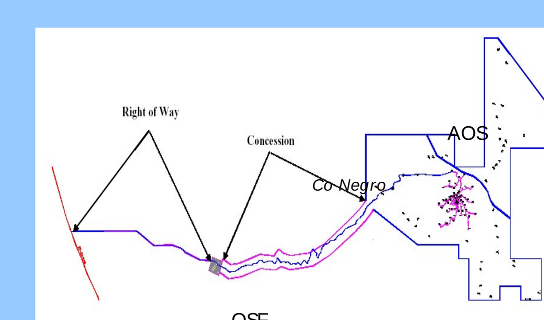
  where the asterisk represents convolution.

  It is a convenient measure of how accurately it is possible to make an image which reproduces the flux distribution on the sky.
- The 1% Image Fidelity is the median value of Fidelity Image pixels where the model*beam is > 1% of the Peak
- Image Fidelity as a measure of "on source SNR". Image Fidelity is LOWER than Dynamic Range.

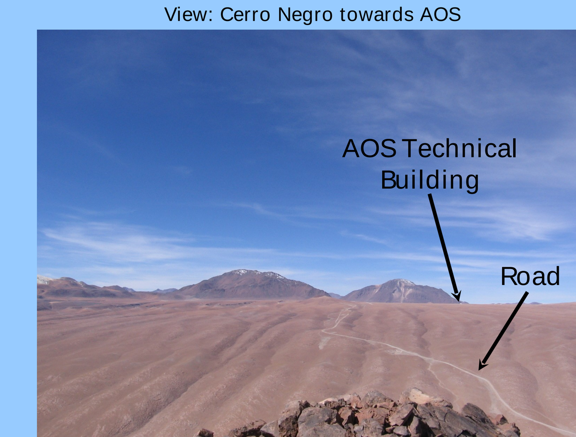
Current Developments at the ALMA Site

ALMA Operations Site (AOS) Technical Building

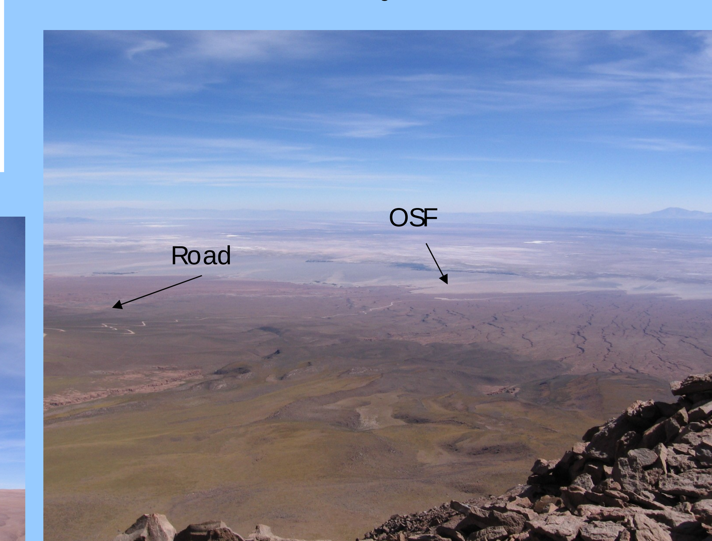
ALMA Road Finished from CH23 to AOS



View: Cerro Negro towards AOS



View: Cerro Negro towards OSF



Photos: C. Ocampo

ALMA Camp and Contractor's Camp Complete

Negotiations leading to contract signing for the Operations Support Facility at 9000' are under way; this facility will augment those at the ALMA Camp. Currently the camps house ~100 ALMA and contract personnel. First antennas arrive here in early 2007 and interferometer assembly, integration and verification occurs here, taking over the function of the ATF in New Mexico near the VLA.

General Science Requirements, from ALMA Project Plan v2.0:

"ALMA should provide astronomers with a general purpose telescope which they can use to study at a range of angular resolutions millimeter and submillimeter wavelength emission from all kinds of astronomical sources. ALMA will be an appropriate successor to the present generation of millimeter wave interferometric arrays and will allow astronomers to:

- Image the redshifted dust continuum emission from evolving galaxies at epochs of formation as early as z=10;
- Trace through molecular and atomic spectroscopic observations the chemical composition of star-forming gas in galaxies throughout the history of the Universe;
- Reveal the kinematics of obscured galactic nuclei and Quasi-Stellar Objects on spatial scales smaller than 300 light years;
- Image gas rich, heavily obscured regions that are spawning protostars, protoplanets and pre-planetary disks;
- Reveal the crucial isotopic and chemical gradients within circumstellar shells that reflect the chronology of invisible stellar nuclear processing;
- Obtain unobscured, sub-arcsecond images of cometary nuclei, hundreds of asteroids, Centaurs, and Kuiper Belt Objects in the solar system along with images of the planets and their satellites;
- Image solar active regions and investigate the physics of particle acceleration on the surface of the sun.

No instrument, other than ALMA, existing or planned, has the combination of angular resolution, sensitivity and frequency coverage necessary to address adequately these science objectives.