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The Case for a 30m Diameter Submillimeter Telescope on the Antarctic Plateau

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Abstract. A large single-dish submillimeter-wave telescope equipped with a focal plane array containing $\sim 10^4$ bolometers and costing about $120M could locate most protogalaxies in the southern sky within a year of operation.

Many of the telescopes planned for the next few decades are designed to observe high-redshift galaxies in the process of formation (NRC 2001). These instruments, such as the James Webb Space Telescope (JWST), the Overwhelmingly Large Telescope (OWL), and the Atacama Large Millimeter Array (ALMA), will have sufficient sensitivity and resolution to observe detailed structure within protogalaxies; they will not, however, have sufficient field of view to survey large areas of sky and discover objects to study. Consider, for example, the ALMA. As seen in Figure 1, protogalaxies typically have a flux density at $\lambda 450\mu$m which is $\lesssim 10$ mJy. The ALMA can detect such a source in 3 minutes of observing time. That's really fast. The size of an ALMA map, however, is $\sim 2 \times 10^{-5}$ square degree, so to survey a square degree at this sensitivity would require ~ 100 days. If the ALMA were dedicated to a sky survey for ten years, it would be able to cover about 10^{-3} of the entire sky.

A 30-m submillimeter-wave telescope operating on the Antarctic Plateau with a focal-plane array of bolometers would be able to survey the southernmost $\frac{1}{3}$, of the sky in a year. Observatory sites on the Antarctic Plateau have exceptional submillimeter-wave sky transparency and stability (Chamberlin 2001, Peterson et al. 2003). Technological progress in submillimeter-wave detectors will make possible focal-plane arrays containing many thousands of bolometers. A 10-meter class single-dish telescope designed for such arrays and located at the South Pole has been approved, and construction is expected to begin this year (Stark 2003). Looking ahead, a 30-meter class telescope could be made sufficiently accurate for submillimeter and far-infrared work through a modest application of active surface techniques. A basic design similar to the IRAM 30-m could be combined with crude active control of the primary mirror panel alignment for a total cost of $\sim$ $120M. The $2''$ to $5''$ beam size of such a telescope would be well-coupled to protogalaxies. With a field of view $\sim 10^{-1}$ square degree in size, this instrument could survey the entire sky south of $\delta \approx -25^\circ$ with 1 mJy sensitivity in a year. Almost all protogalaxies and protostellar cores would be found, and could be distinguished on the basis of $\lambda 350\mu$m to $\lambda 450\mu$m color. The resulting catalog would be a treasure trove of objects for high-resolution study with the giant telescopes to come.

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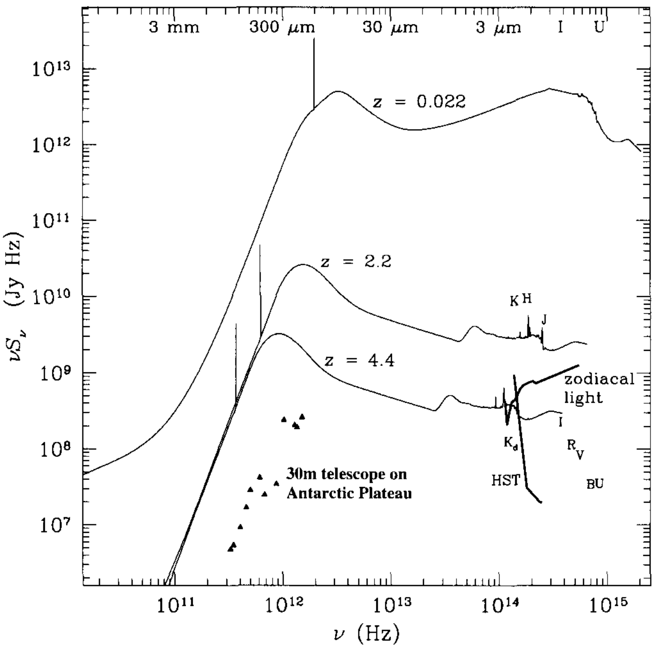

Figure 1. Normal galaxies at low and high redshift. The broad-band galaxy spectrum labeled $z = 0.022$ has the luminosity and spectrum of M99, a normal L^* spiral. The spectra labeled $z = 2.2$ and $z = 4.4$ are models of the initial star burst in such a galaxy at two possible eras, evolved in a standard CDM model (Katz 1992) with $h_{75} = 1$ and $\Omega = 1$. The 158μm C^+ line is shown to scale; other lines are suppressed. The points KHJIRVBU are 1% of the sky brightness in a square arcsecond at Mauna Kea (CFHT Observer's Handbook). The point K_d is 1% of the sky brightness in a square arcsecond at the South Pole at $\lambda 2.3\mu$m. The curve labeled HST is the limiting sensitivity of the NICMOS on the Hubble Space Telescope. The triangles show the continuum sensitivity in one hour of a 30 meter Antarctic telescope in the submillimeter-wave atmospheric windows (Stark 1997).

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