A Short Introduction to

Radio Astronomy

and the

ALMA Observatory

(for Engineers)

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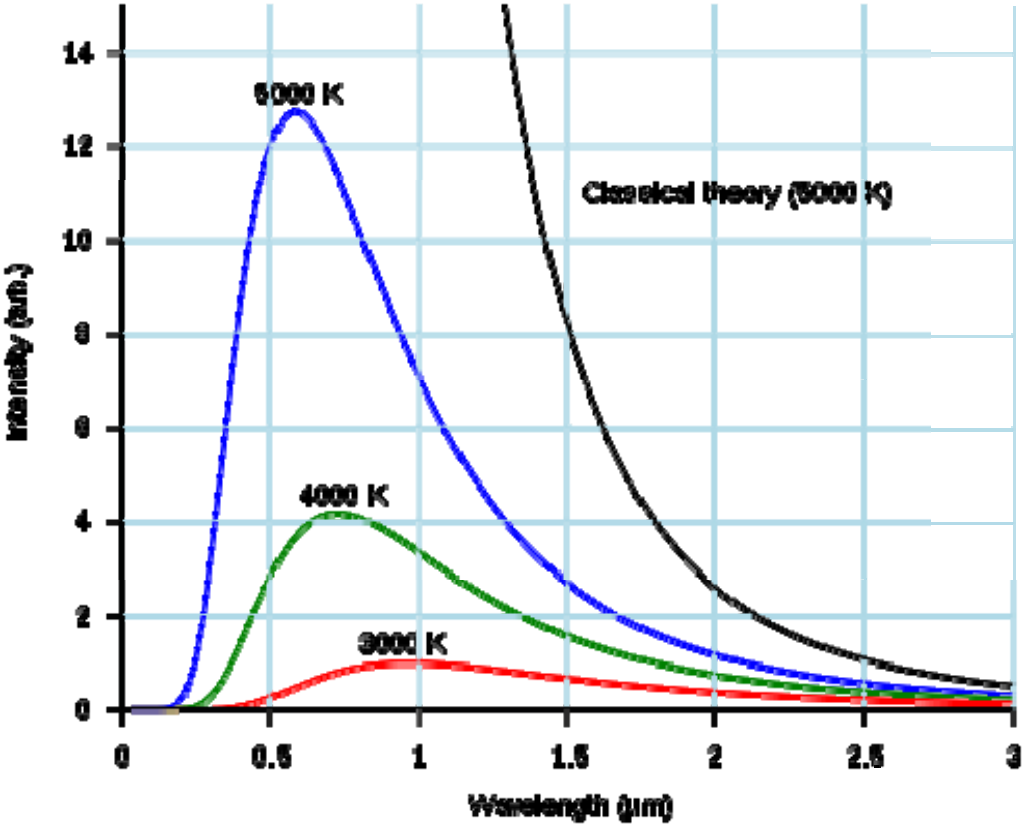
"Radio Astronomy" as in radio waves from the stars?

- Every object at a temperature above 0 Kelvin radiates electromagnetic waves.



$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2$$

$$P_r = P_t + G_t + G_r + 20\log_{10}\left(\frac{\lambda}{4\pi R}\right)$$

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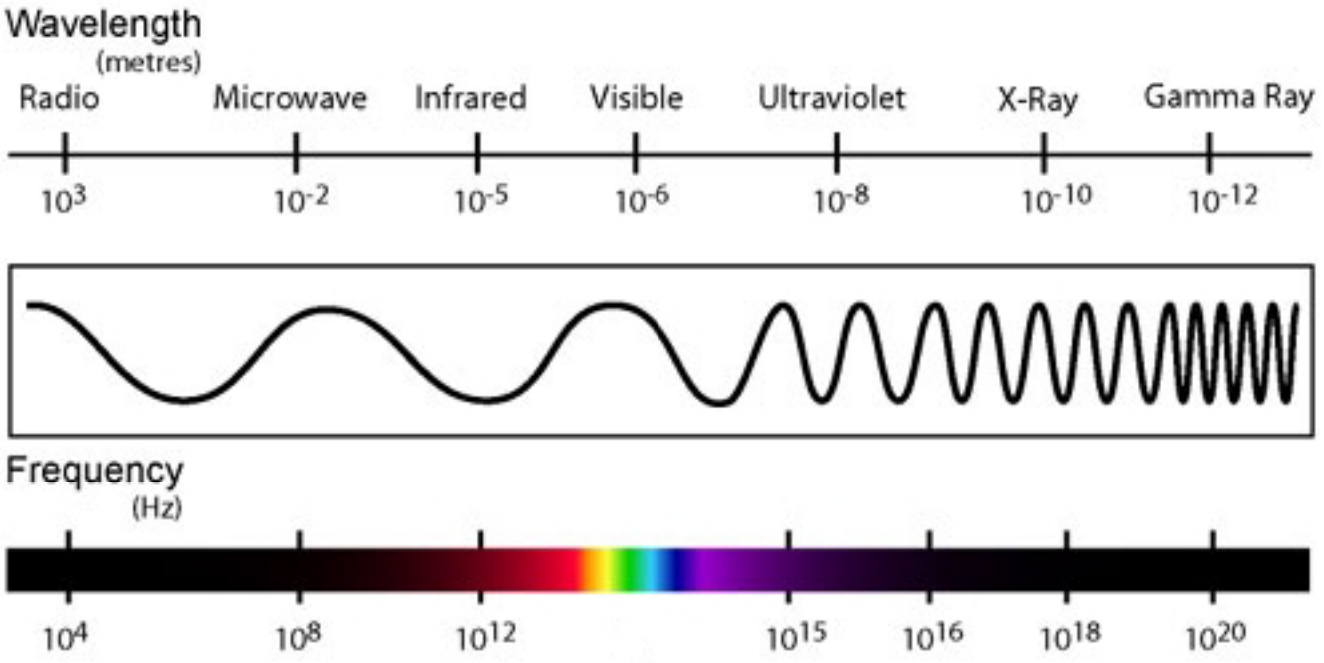
What can we "see" at millimeter-wave frequencies?

- Chemical compounds and reactions
- Colder (older and further away) sources
- Easier to analyze!



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How do we observe radio sources?

- **No CCD/CMOS sensors**. Wavelength are too large. No lenses.
- Use very **directional antennas**, and **ultra-sensitive ultra-broadband receivers**.
- **Antenna Arrays and interferometry**: Like an image sensor, but without a lens.
- Need to accurately **measure relative phase** and amplitude at every antenna.
- **Spectral analysis** and **image synthesis**.

The Atacama Large Millimeter/Sub-millimeter Array

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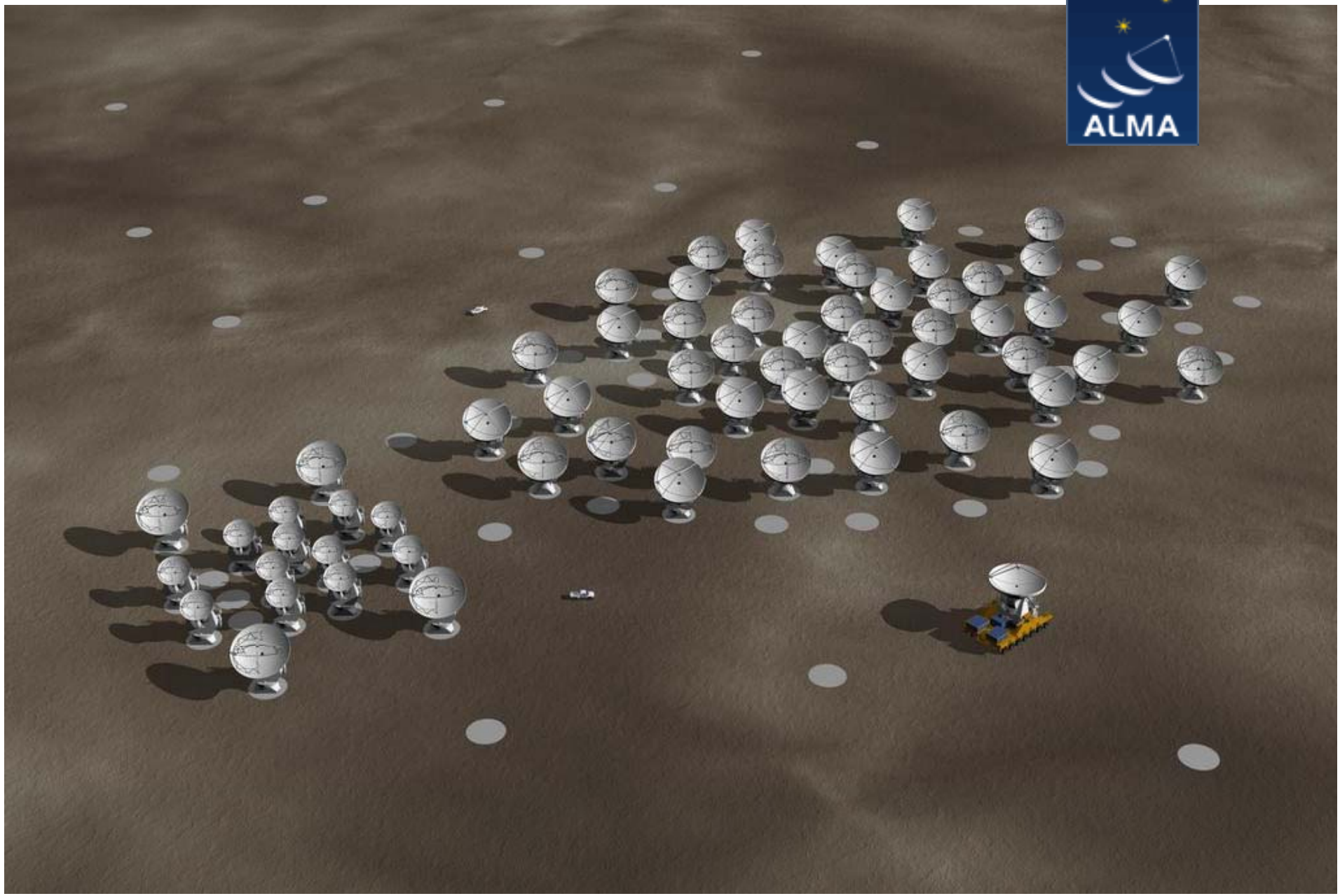

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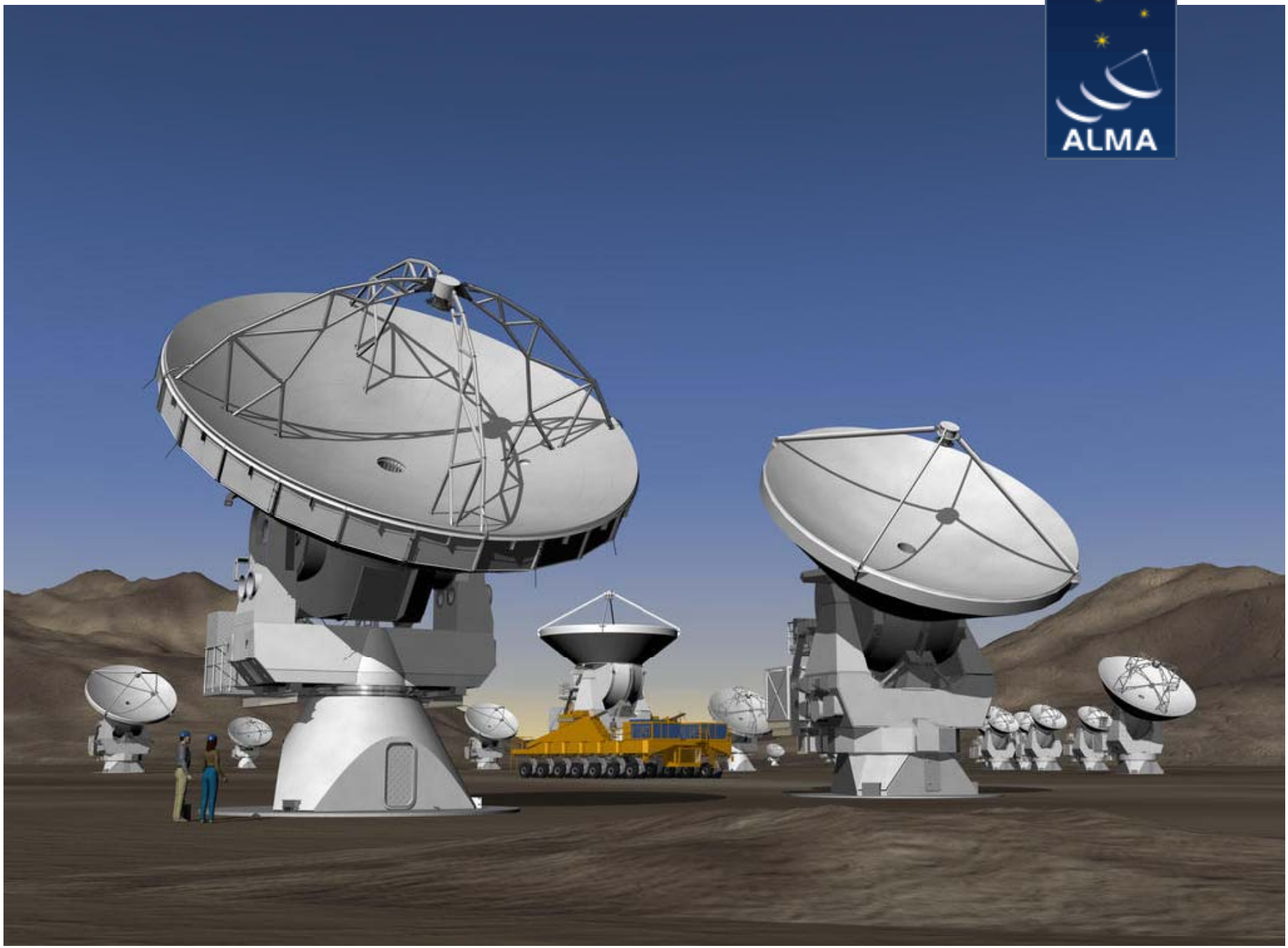

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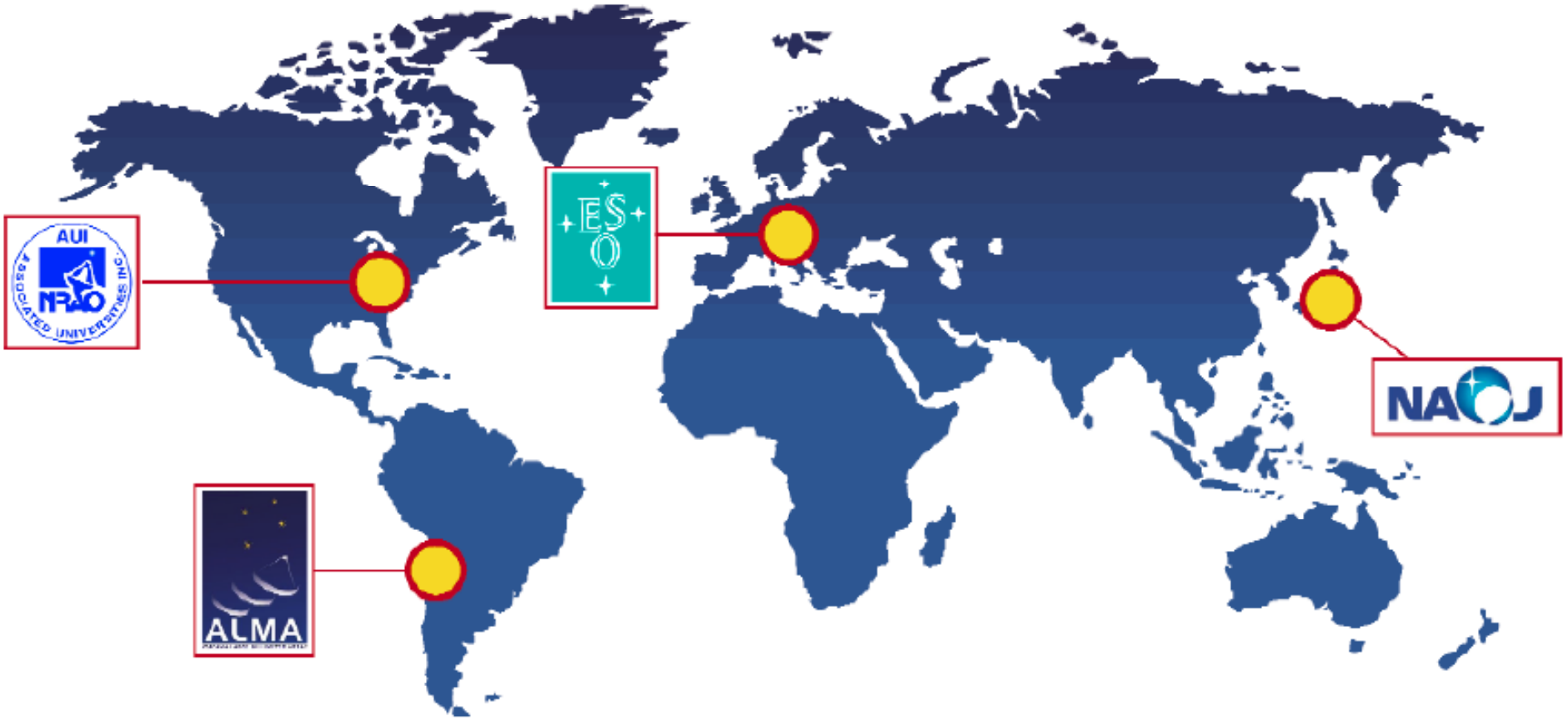
A Global Project



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Where do we build this thing?

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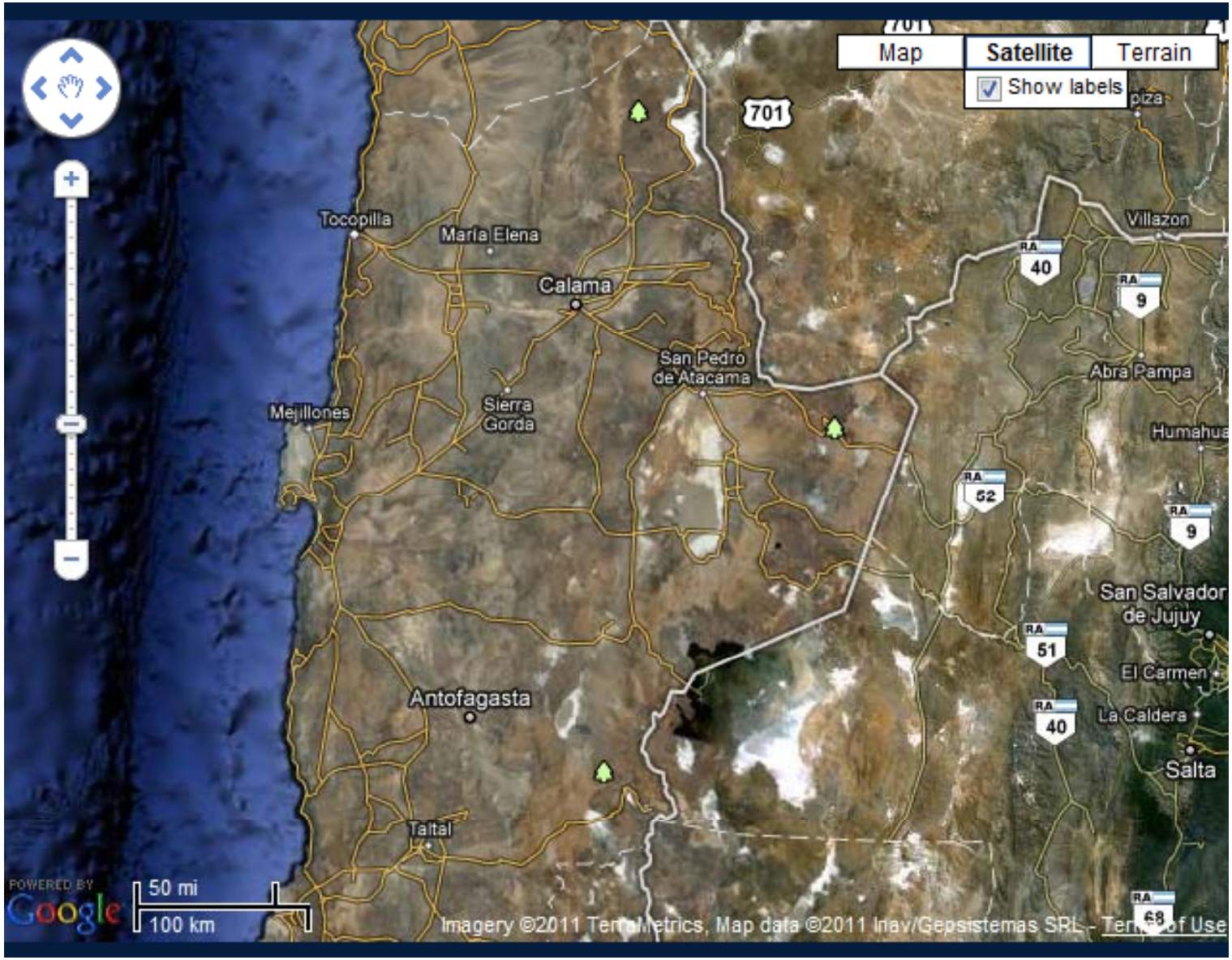

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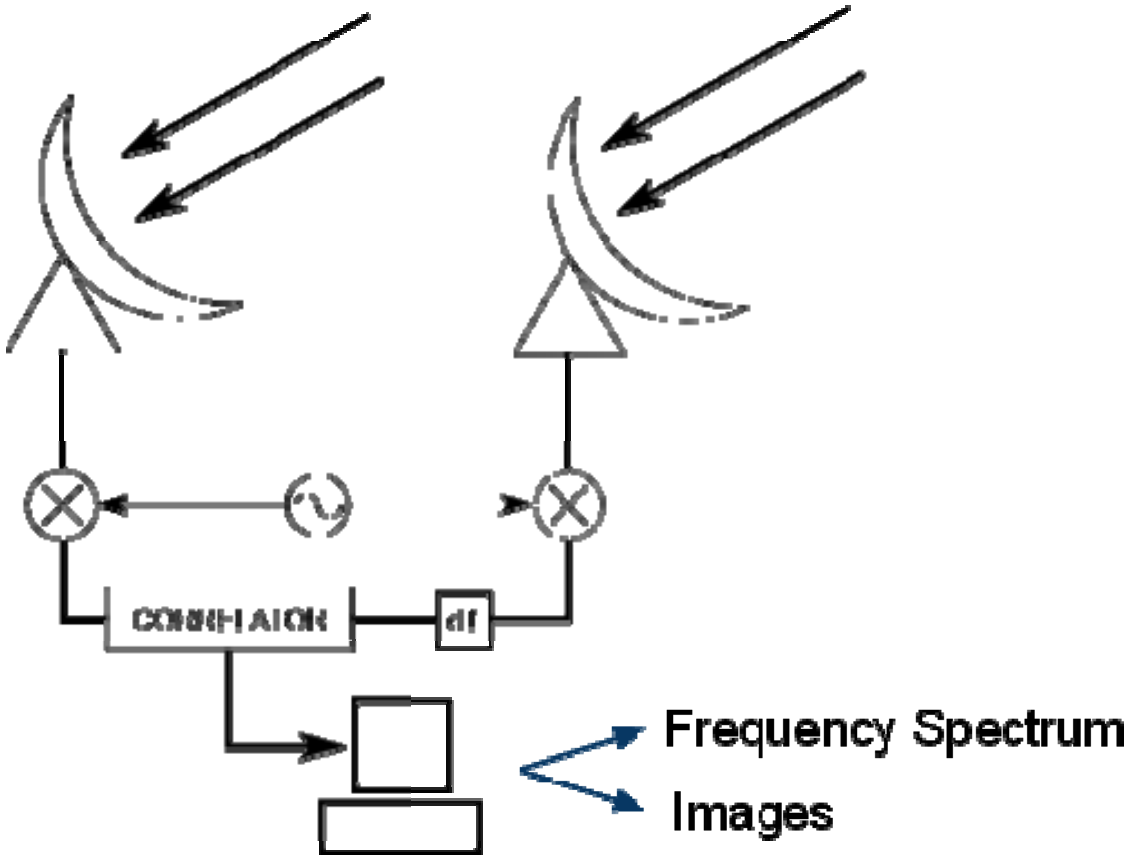
Basics of ALMA Electronics & Interferometry



$$(f \star g)[n] \stackrel{\text{def}}{=} \sum_{m=-\infty}^{\infty} f^*[m]\ g[n+m].$$

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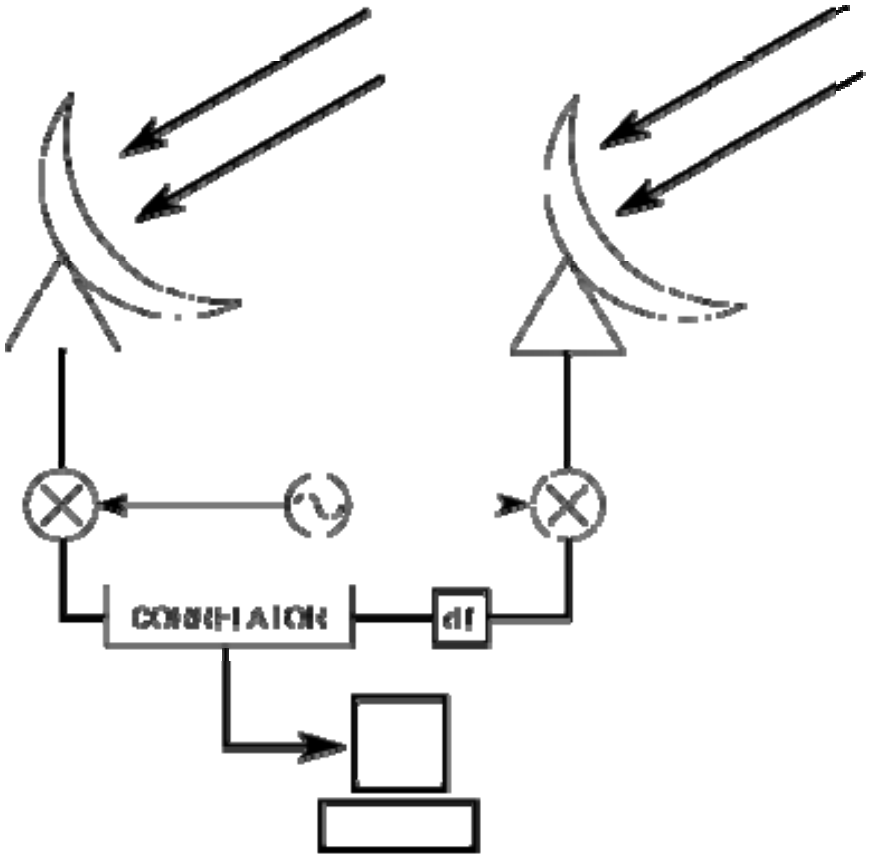

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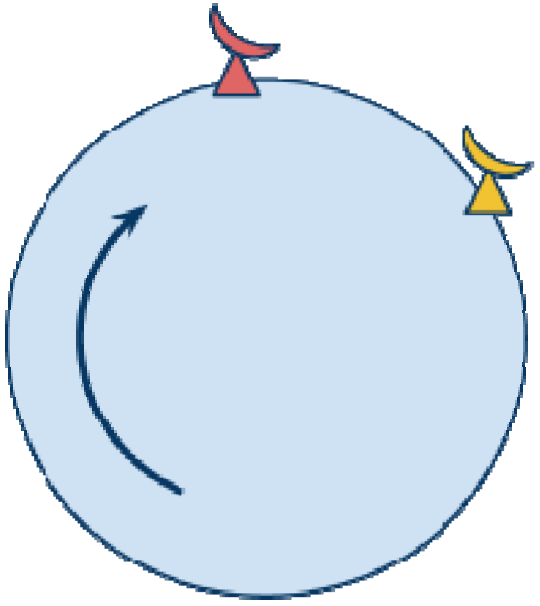

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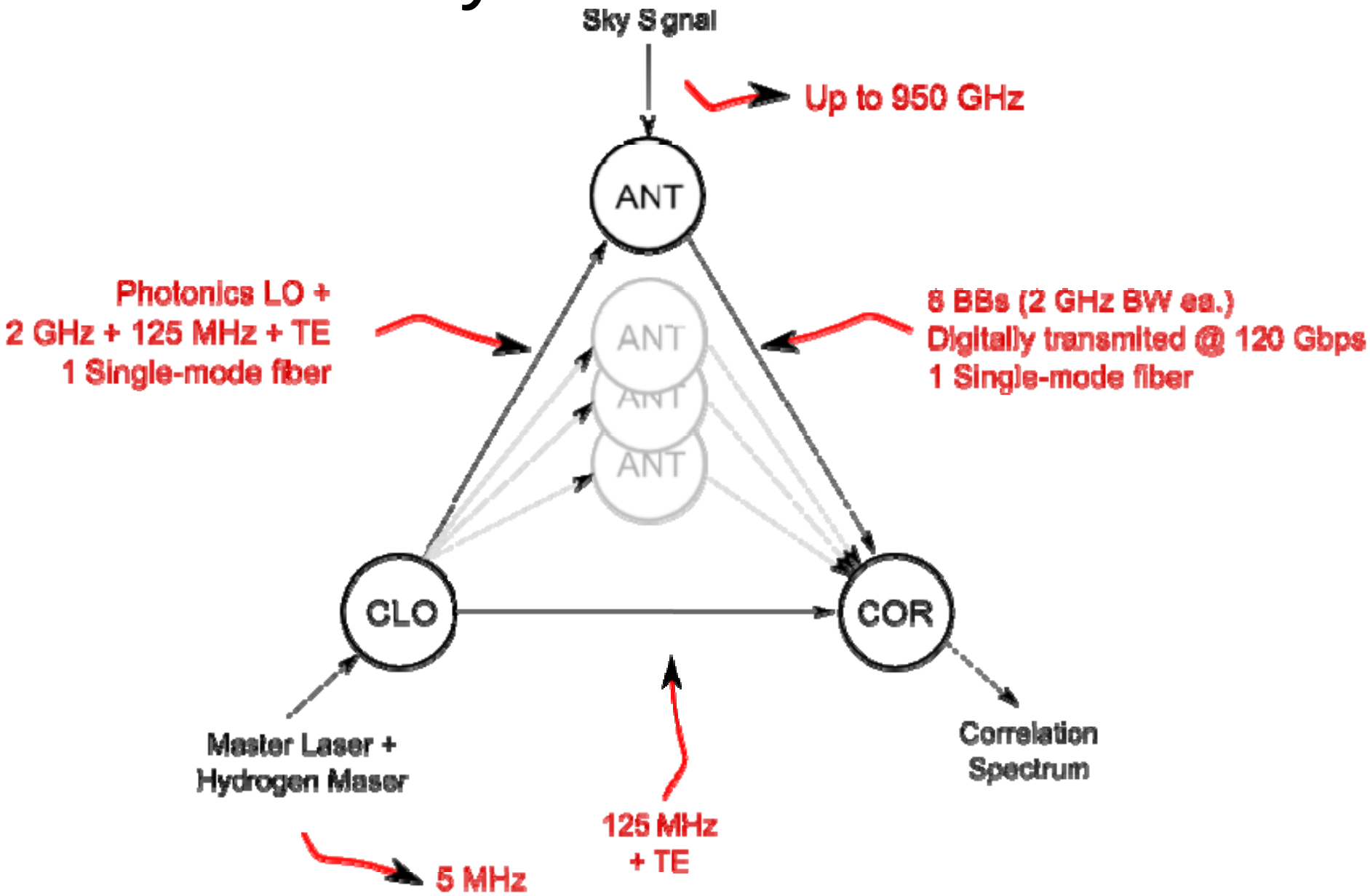
The Array



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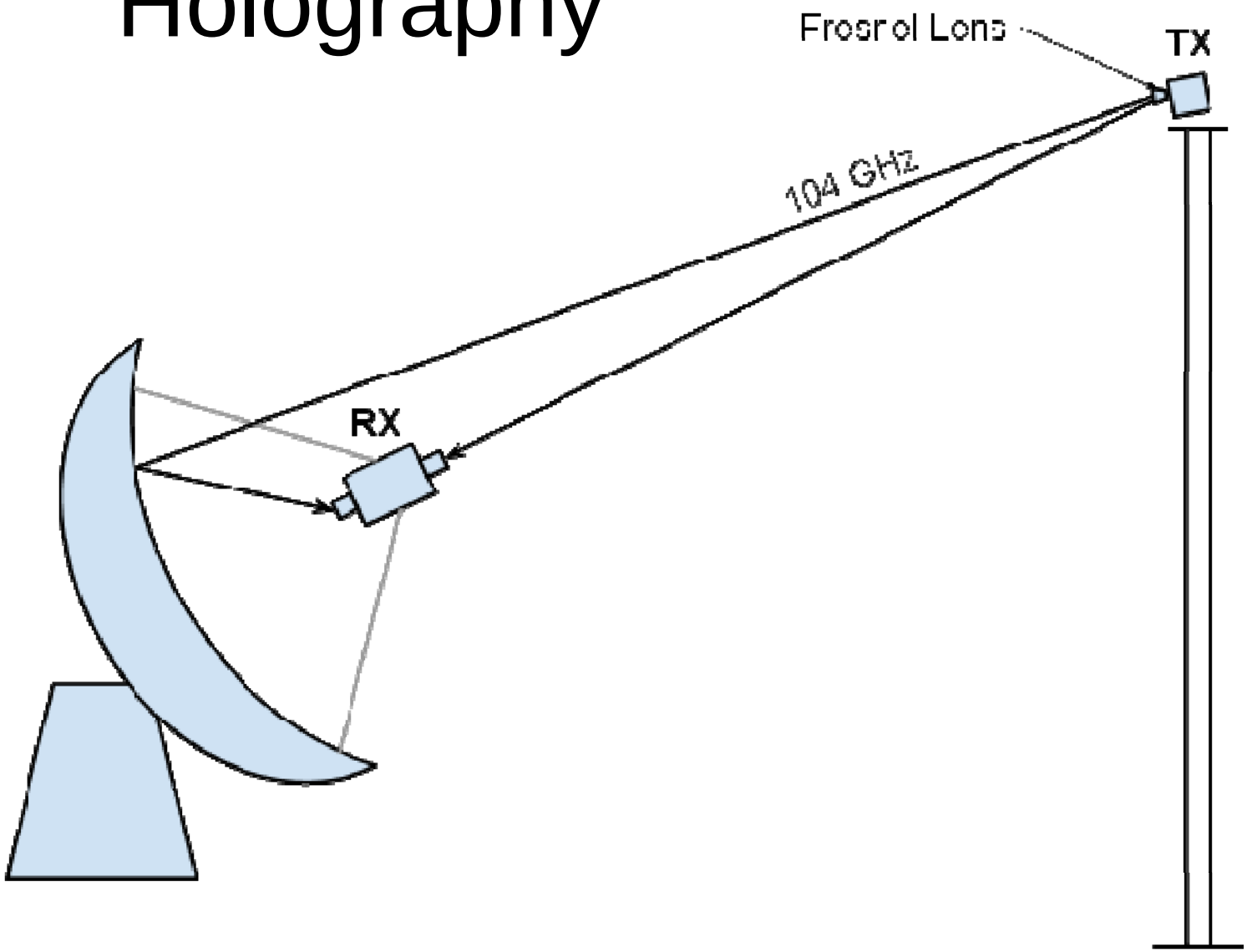
Holography



Not to scale!

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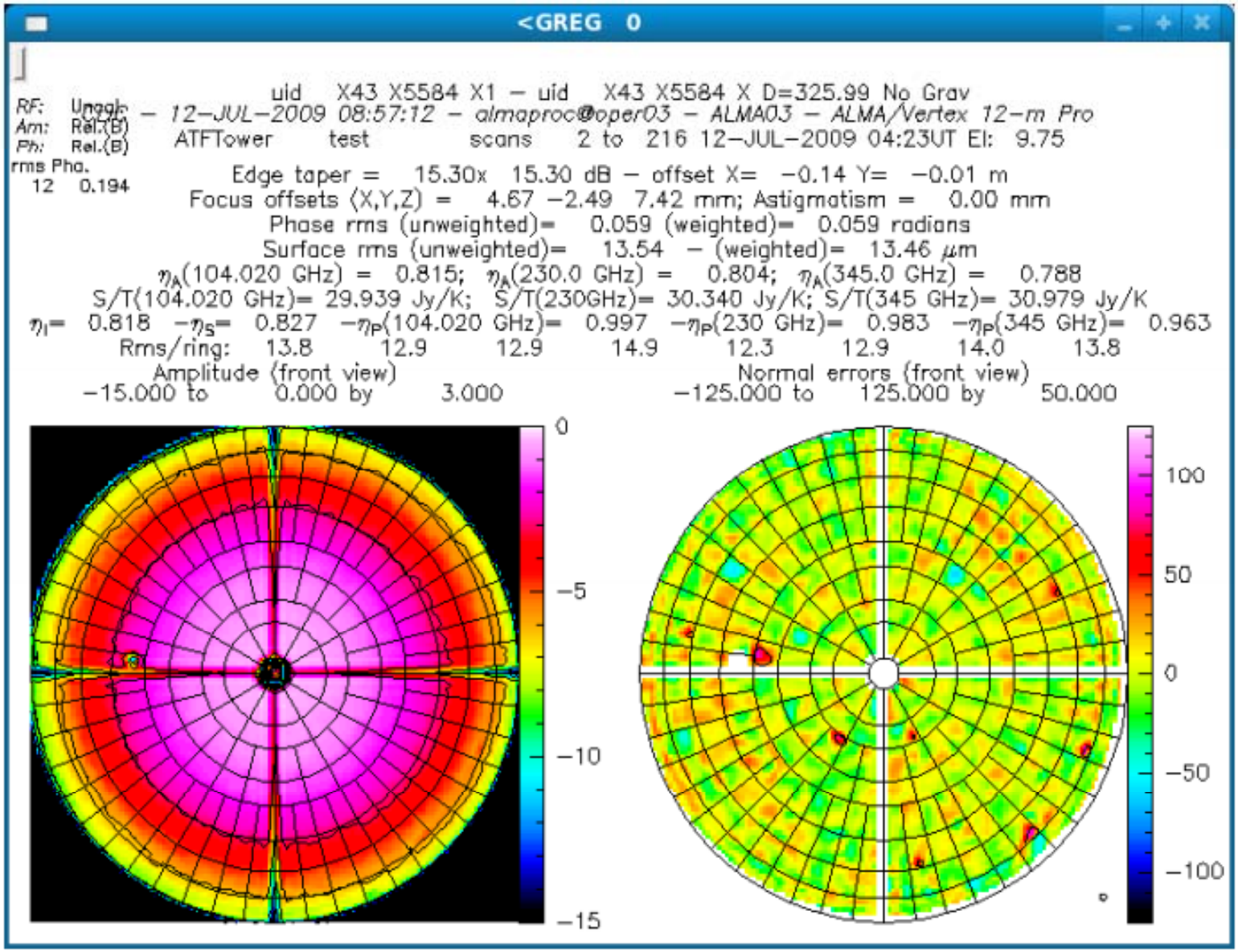
Holography



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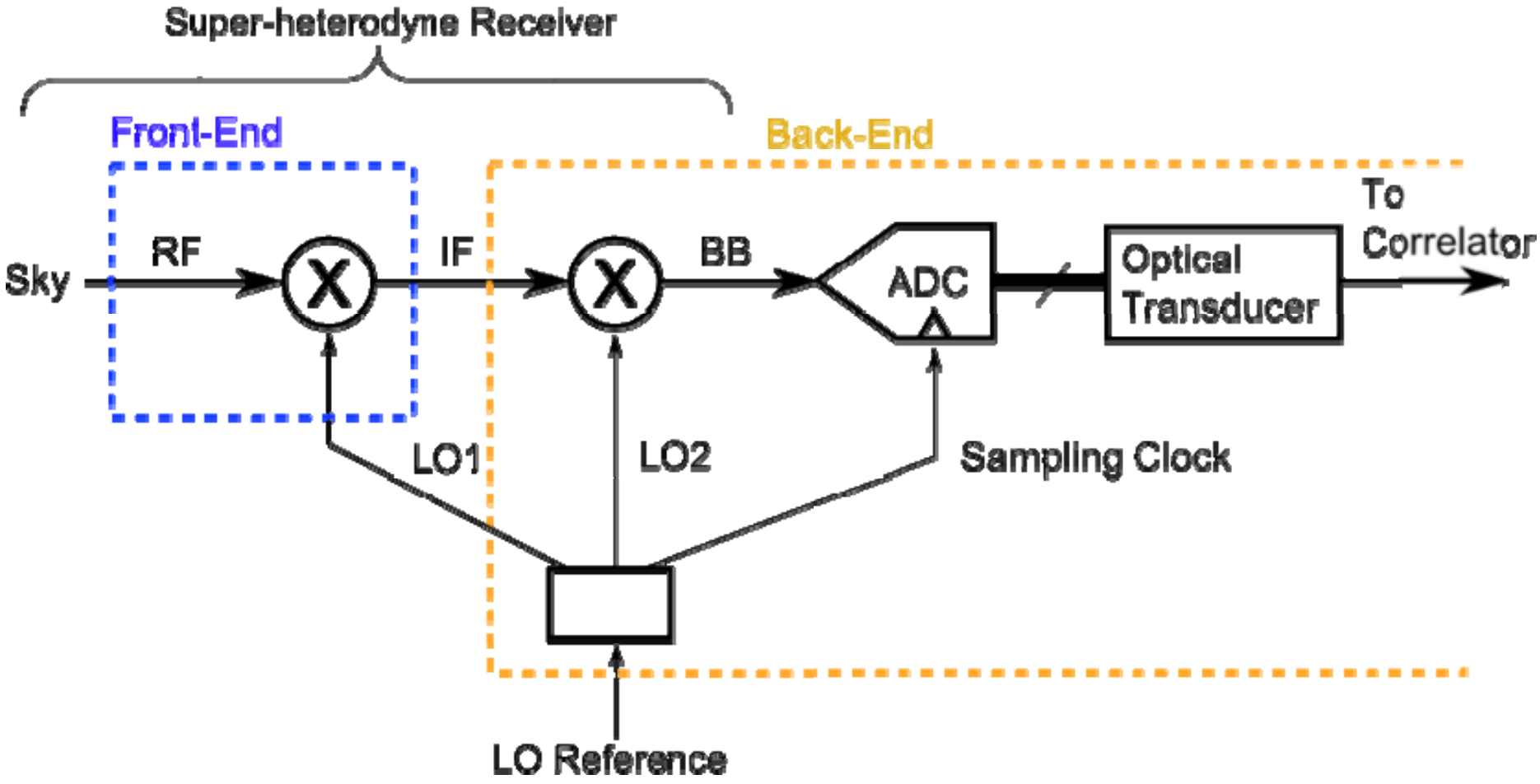
The Receiver



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Front End

- 1st Down-conversion
- 1st LO Synthesis

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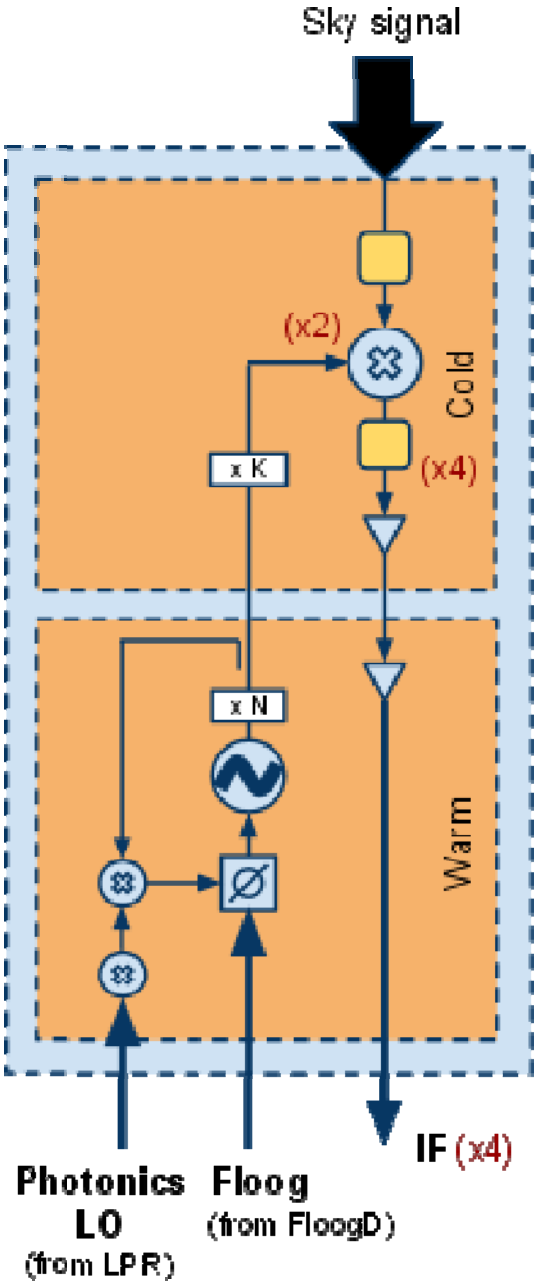
Band Cartridge



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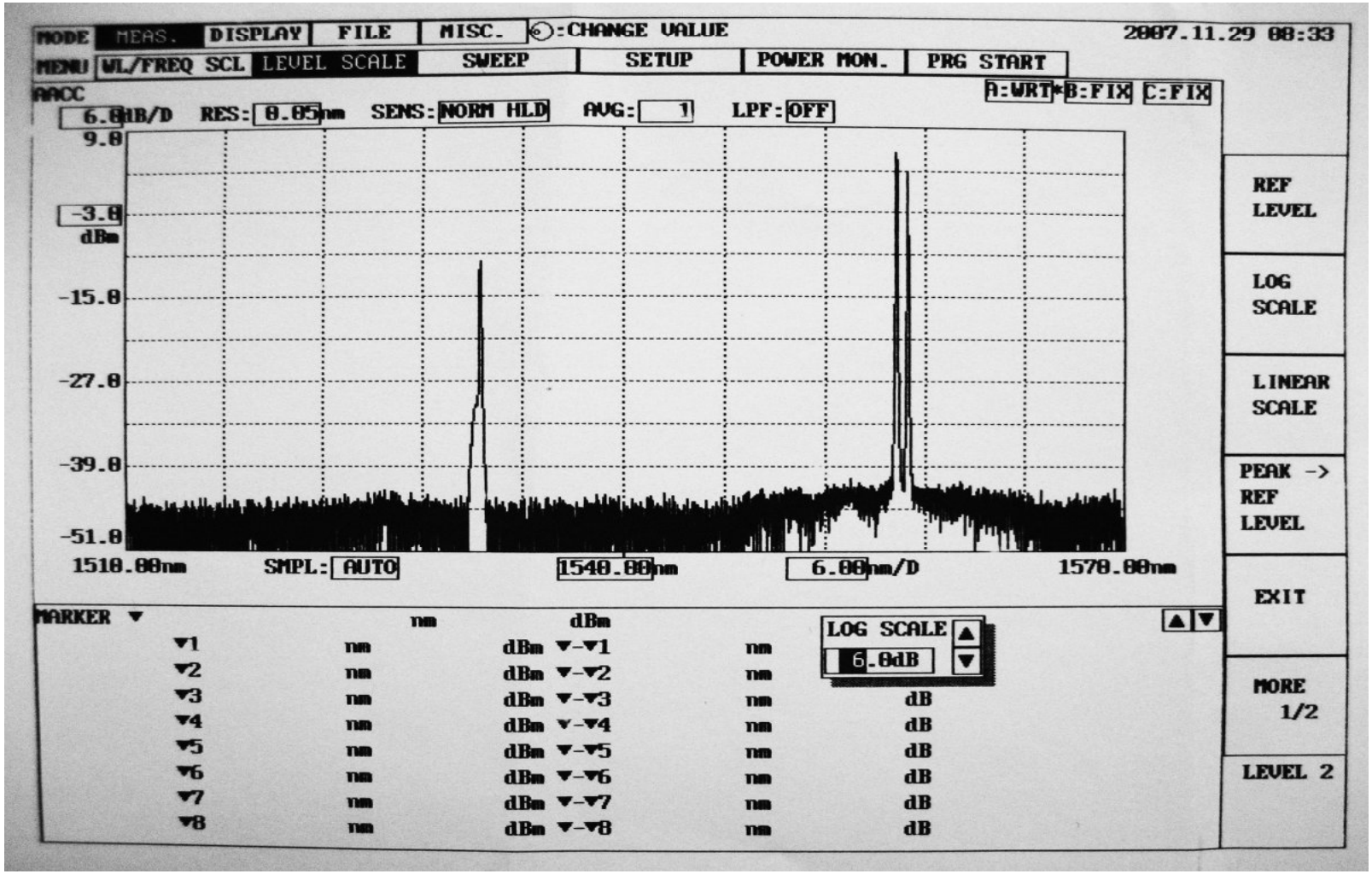
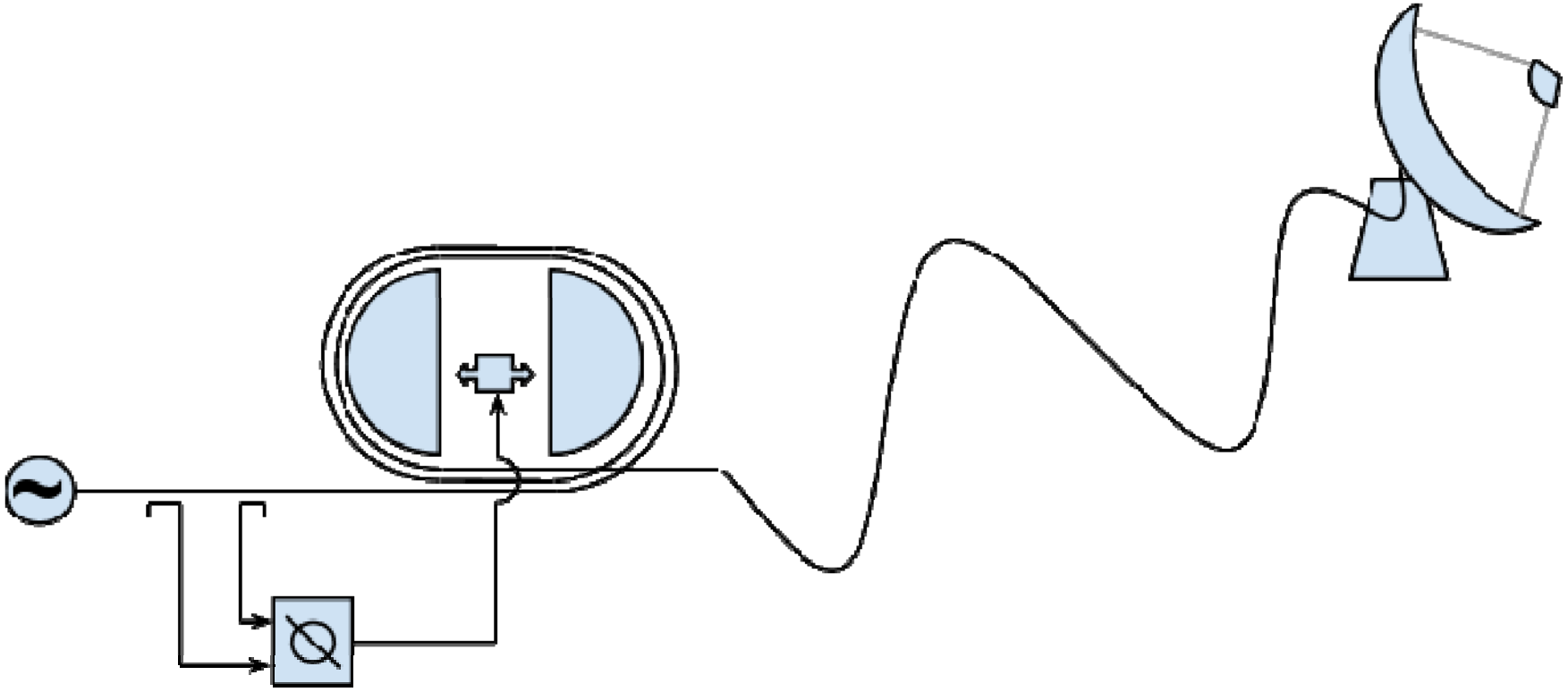
Reference Signals

- All reference signals combined and delivered through 1 single-mode fiber.



Line-Length Correction



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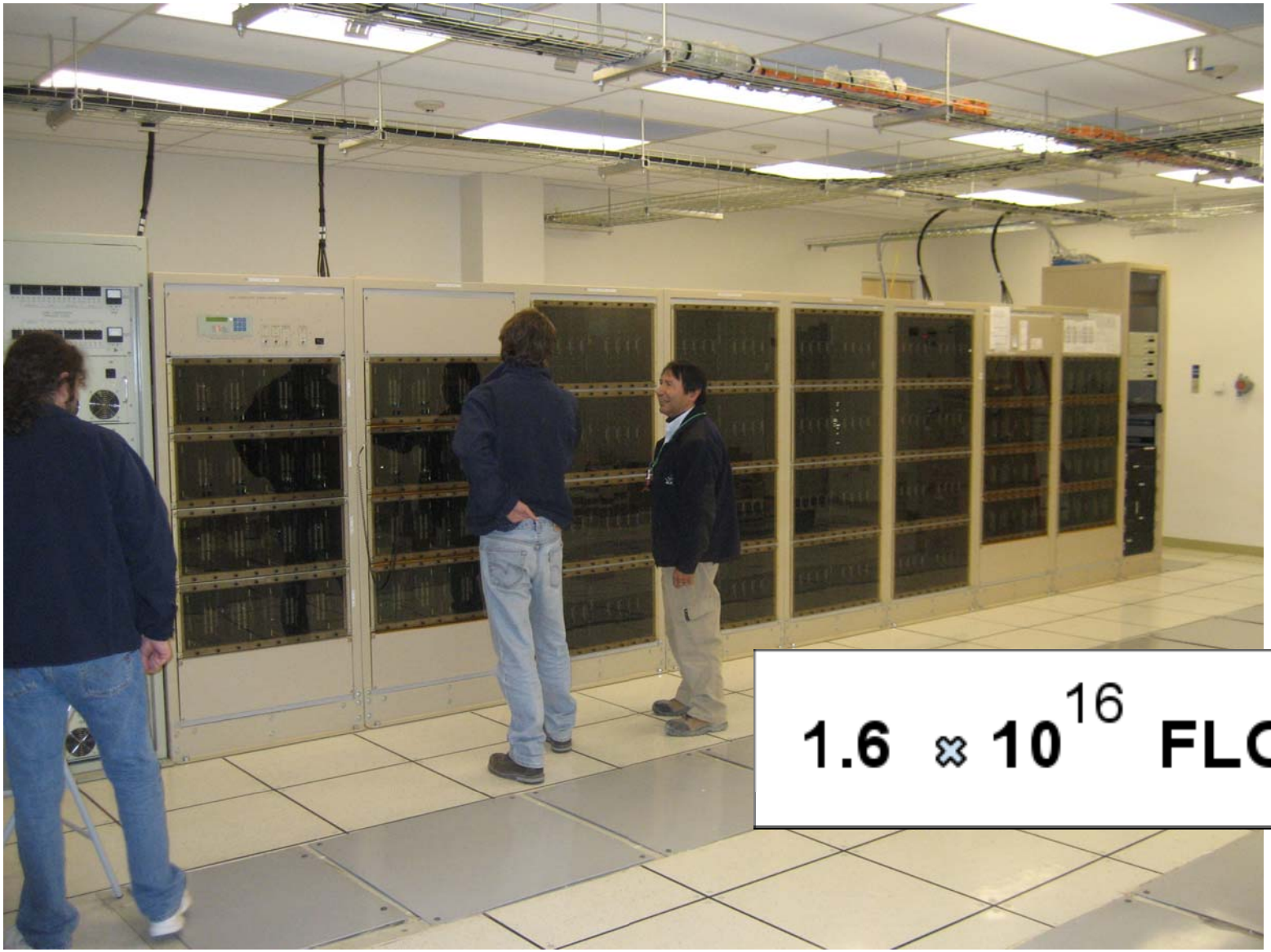
Correlator



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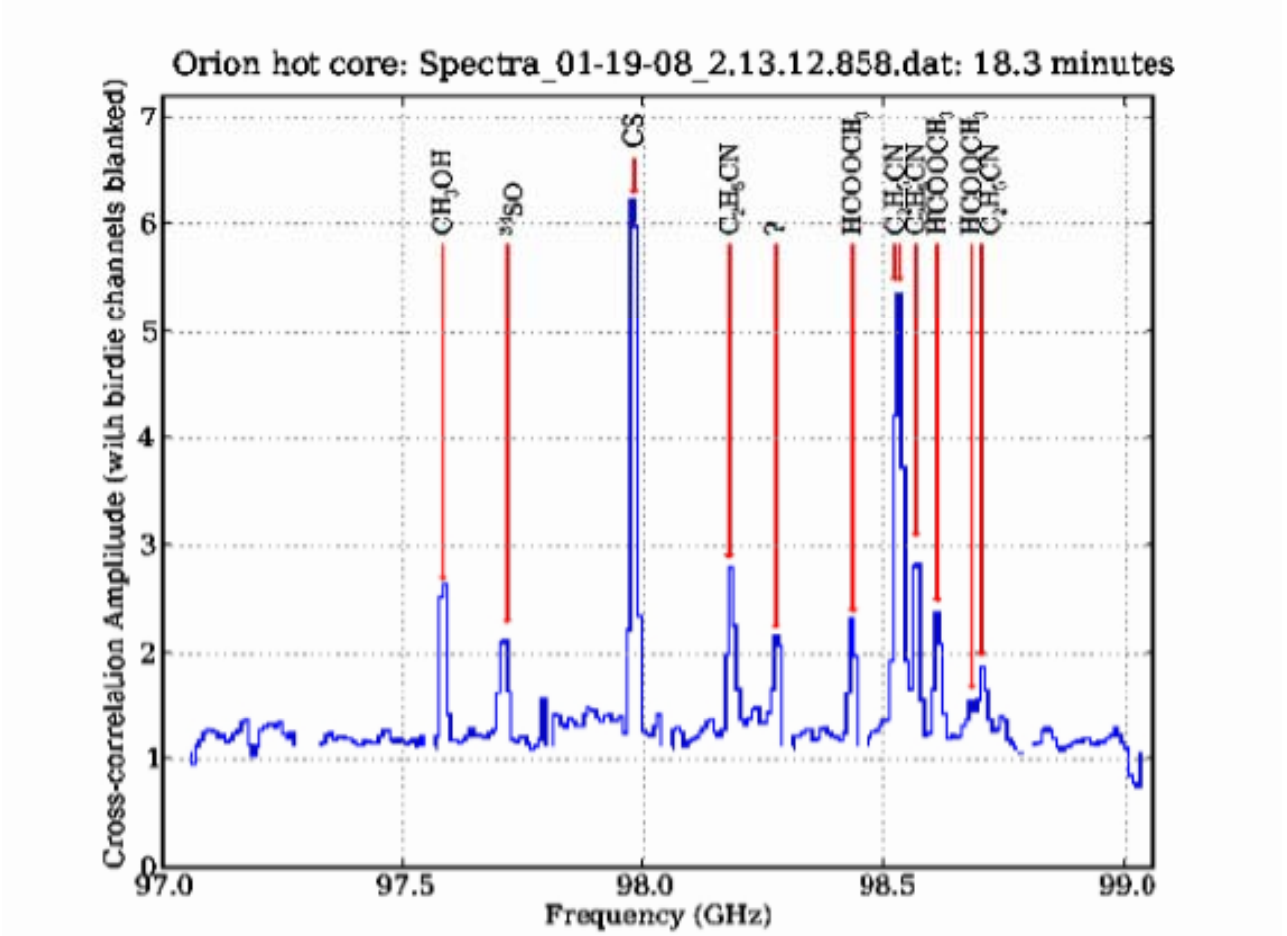
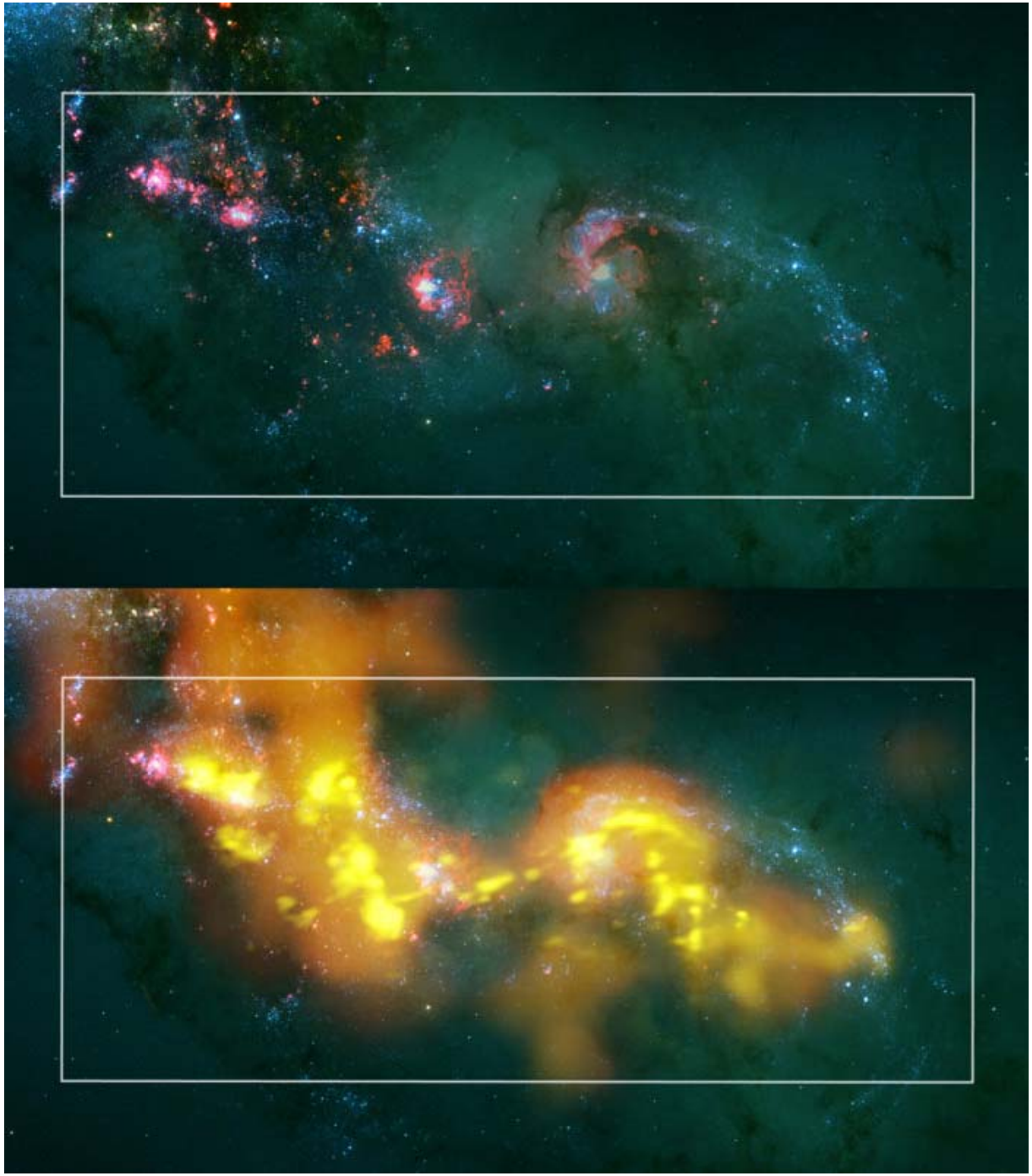
Final Products



Power Spectrum Example: First Interferometric Spectrum at the ATF, Orion Hot Core (19 January, 2008)

Final Products



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19 Antennas

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Credits: Some material has been taken from the ALMAObservatory.org website.
Please visit for further credit details.