

# IF/LO Systems

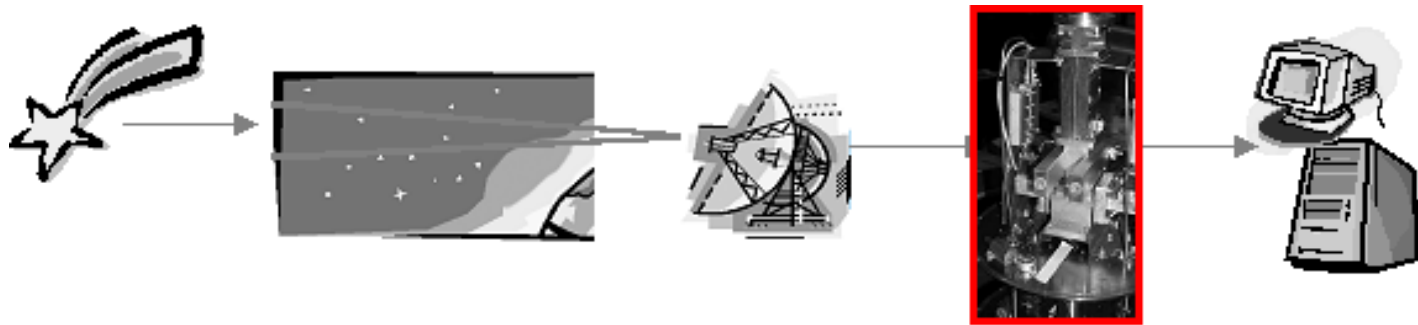
for Single Dish Radio Astronomy cm-wave Receivers

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NRAO/NAIC  
Single Dish  
Summer School  
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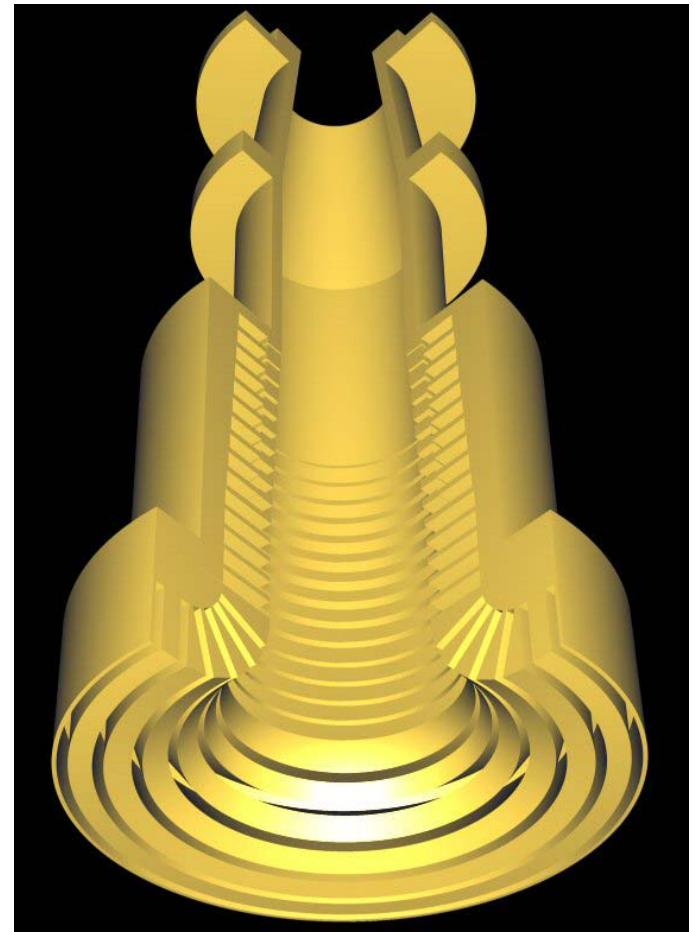


# Introduction to Receivers

- a specialized class of microwave receivers
- function to amplify, filter and shift in frequency if needed
- Characteristics:
  - coherent (preserves phase)
  - low noise (for high sensitivity)
  - dual channels (polarization work)
  - high dynamic range

# Front End Stage

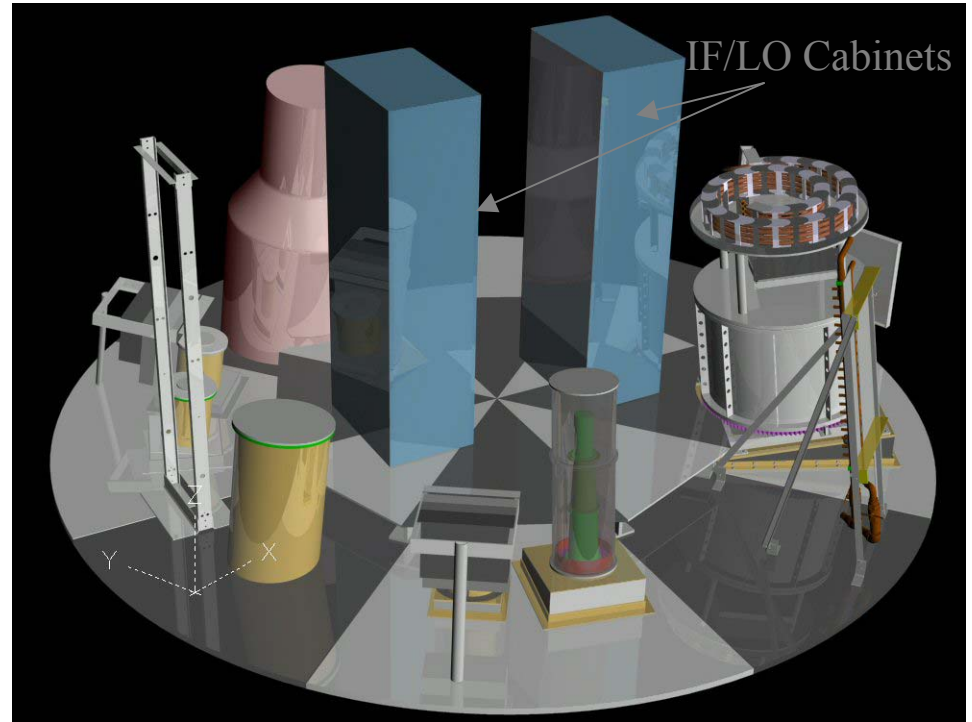
- components: up to and including the first frequency shifting (mixing) stage, including the feed horn, orthomode transducer (polarizer), noise calibration coupler, low noise amplifier, band defining filter and often the first mixer.
- highly frequency specific
- noise performance is a critical parameter



C-band Horn Model  
3D AutoCAD design by Homero Cersosimo

# IF/LO Stage

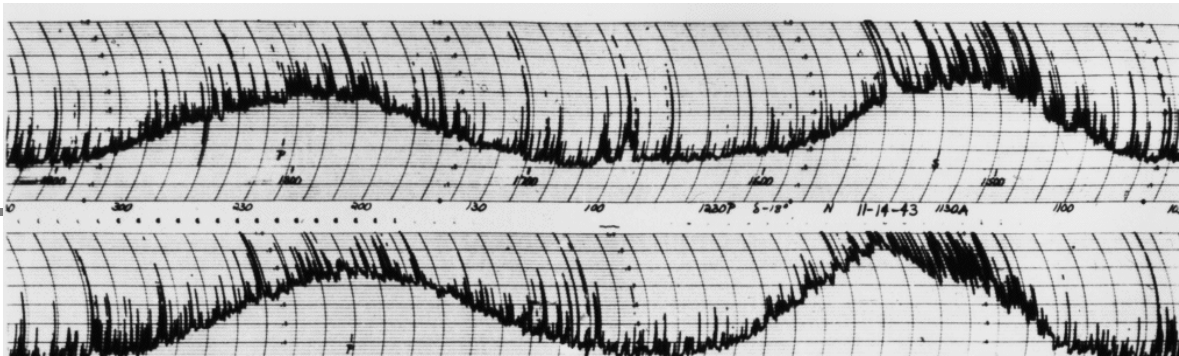
- follows front end stage, precedes backends
- may include any of:
  - first, second and possibly third mixing stages
  - amplification and filtering
  - power monitoring and level adjusting
  - transmission over long distances via fiber optic cable
  - distribution system to multiple backends



Gregorian Dome Rotary Floor Model  
3D AutoCAD design by Homero Cersosimo

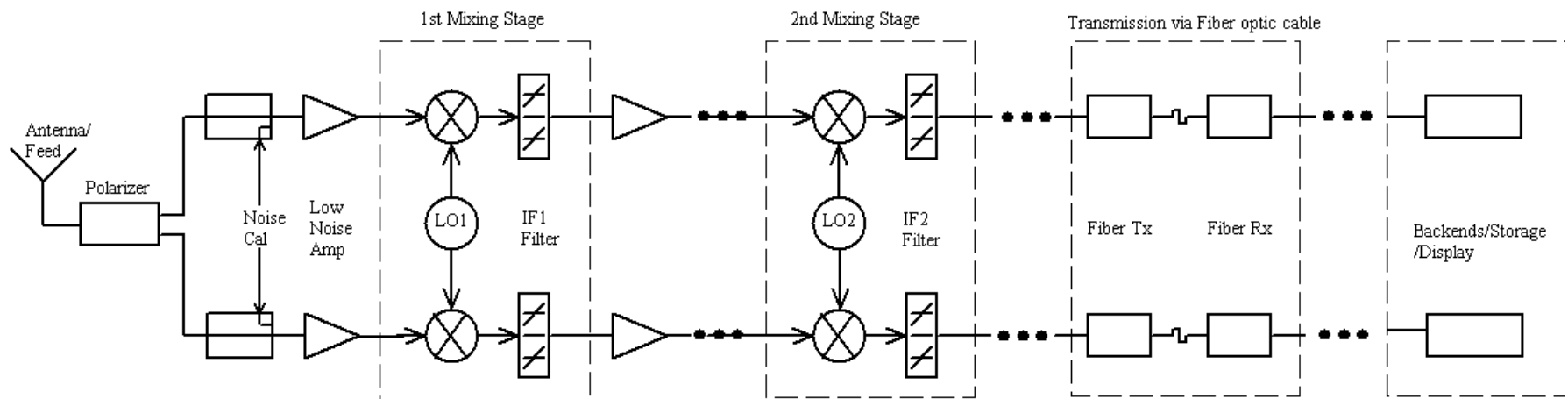
# Backend Stage

- Input: amplified signal, common low frequency band
- Function: spectral, polarization, timing or pulse analysis, or total power measurements
- Instruments:
  - Total power measurements use square-law detector followed by integrator
  - Spectral line: auto-correlation or FFT spectrometer
  - Pulsar: spectrometer or special purpose machine



# IF/LO Systems - Components

- typical IF/LO system can be modeled as a combination of mixing, amplifying, power monitoring, and transmission stages

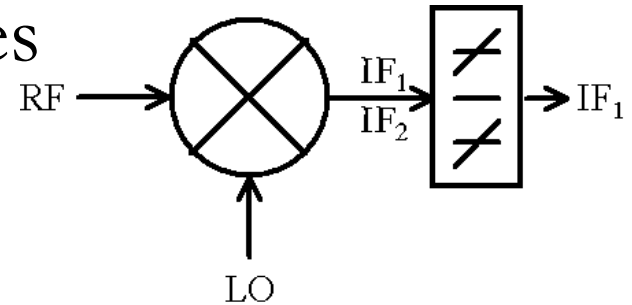


# Mixers

- provide ability to shift the frequency band
- Why use them?
  - power loss through coaxial cable is reduced at lower frequencies
  - possibility of feedback minimized if IF amps have different frequency than RF amps
  - allows use of standard IF/LO paths and backends
  - high gain low noise amps and filters easier to construct at lower frequencies

# Mixers 2

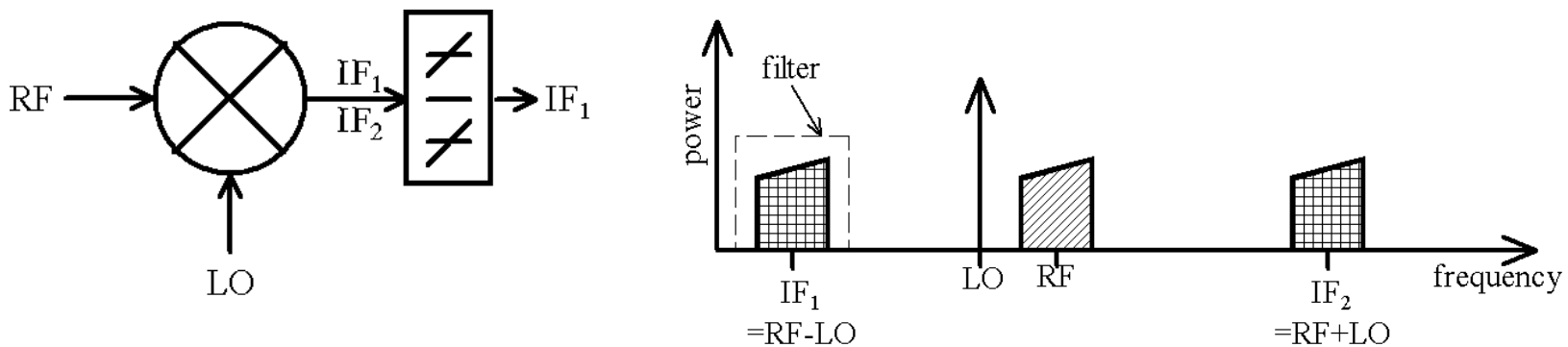
- the radio frequency (RF) signal is combined, or "mixed" with a local oscillator (LO) signal
- Mixers are three-port devices, one input RF, one input LO, and one output IF (intermediate frequency) port
- most commonly used outputs are the sum and/or difference frequencies





# Mixers 3

- the envelope impressed on the two IF frequency bands carrying the information is unchanged by the mixing operation
- filter on the IF port chooses the desired output band



# Local Oscillators (LOs)

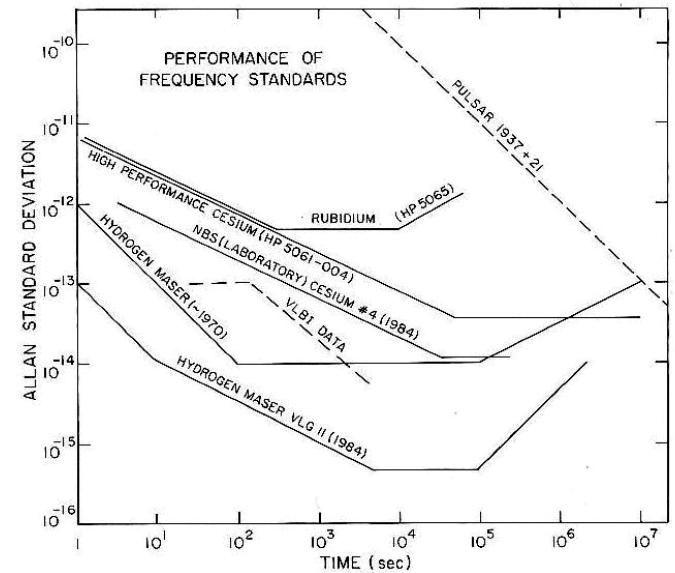
- produce continuous wave signals used as inputs to mixers
- usually locked to a site frequency/time standard such as a hydrogen maser to ensure high accuracy and long term stability.
- can be generated by:
  - Gunn oscillators, crystal oscillators, frequency multiplication

# LOs 2

- Some requirements:
  - High spectral purity
  - Frequency agility -- speed and resolution
- Phase stability: changes in frequency due to changes in temperature, humidity, vibration, component aging, power supply and load variations
- Short term stability proportional to circuit  $Q$

# LOs - Frequency Standards

- Atomic frequency standards (rubidium, cesium, hydrogen) based on detection of molecular resonance
- Use crystal oscillators to lock the process, improving short term stability



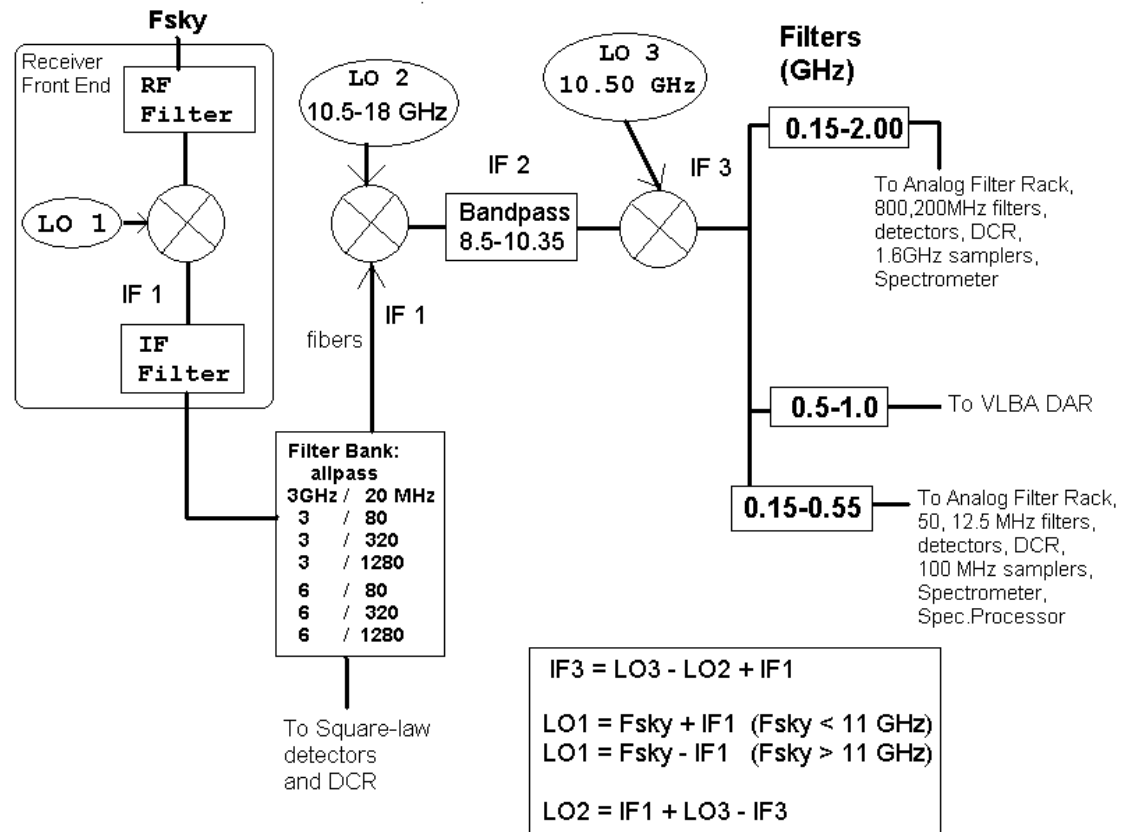
Stability of standard oscillators

graph: Thompson, Moran & Swenson, Jr

# IF/LO Systems - GBT

- Front ends at receiver room include first mixing stage
- IF Router collects from all front ends --> fiber
- Equipment room optical fiber --> Converter Rack for 2nd and 3rd mixers
- --> back ends

Simplified GBT LO/IF system

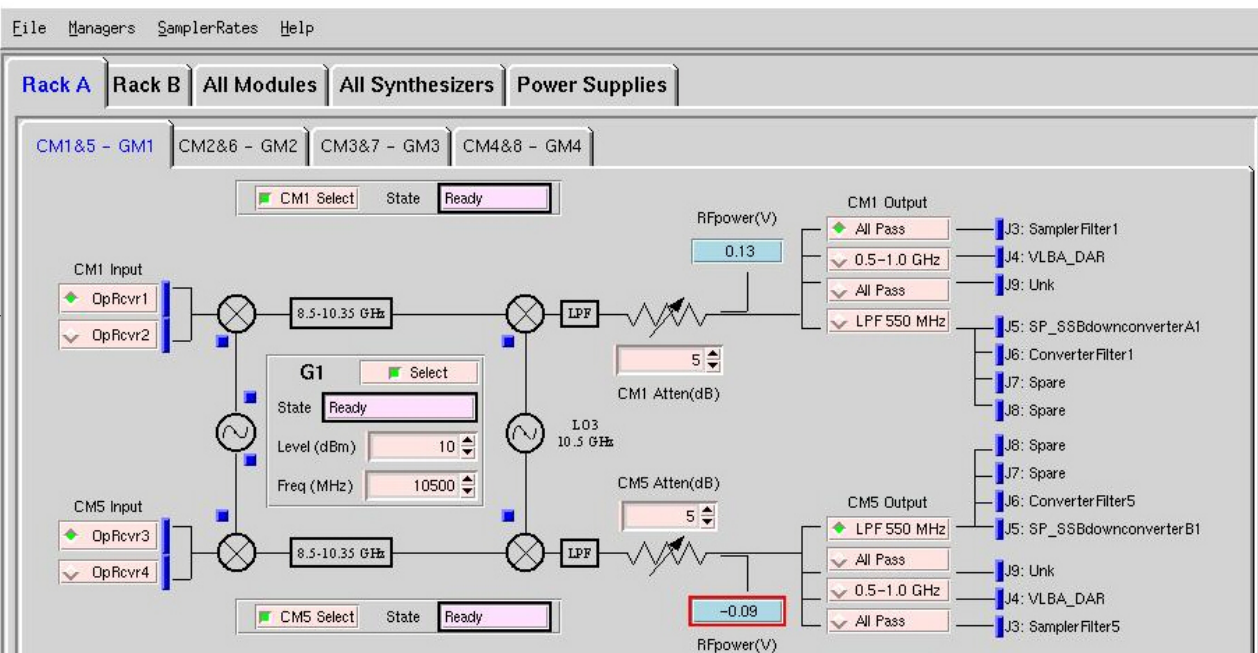


thank-you Frank: <http://www.gb.nrao.edu/~fghigo/gbtdoc/loif.html>

# IF/LO Systems - GBT software

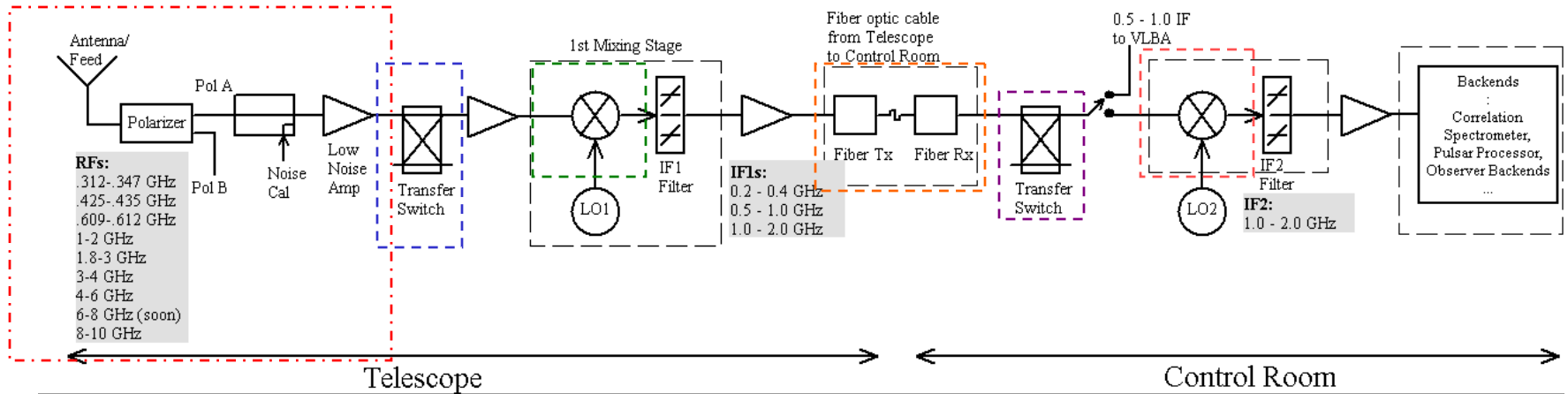
- CLEO display shows settings, tweakable parameters and monitor points.
- Converter rack screen shows setup for second and third mixing stages

Initial CLEO Converter Rack Screen:



- 2nd LO level and frequency, power level control, desired backend
- information and control possibilities a treat for nerdy engineers and astronomers

# IF/LO System - Arecibo (Gregorian Dome)



- RF front ends selectable by rotating turret floor
- All RF bands switched into common system including transfer switch and first mixer
- Fiber off of telescope to control room
- Transfer switch and second mixer then to backends

# Useful Books & Sites

- Books:
  - Rohde & Bucher, *Communications Receivers*, McGraw-Hill, 1988
  - Thompson, Moran and Swenson Jr., *Interferometry and Synthesis in Radio Astronomy*, John Wiley & Sons, 1986
  - Goldsmith, ed., *Instrumentation and Techniques for Radio Astronomy*, IEEE Press, 1988
  - Rieke, *Detection of Light from the Ultraviolet to the Submillimeter*, Cambridge, 1994
- Sites:
  - Arecibo Obs IF/LO technical info page:  
<http://www.naic.edu/~astro/techinfo/iflo/>
  - GBT IF/LO and other info page:  
[http://wwwlocal.gb.nrao.edu/electronics/GBTelectronics/IF/gbt\\_if.html](http://wwwlocal.gb.nrao.edu/electronics/GBTelectronics/IF/gbt_if.html)