INSTRUMENT DESIGN OVERVIEW

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Filename = GLT_instrument_design
Version = May 1, 2014

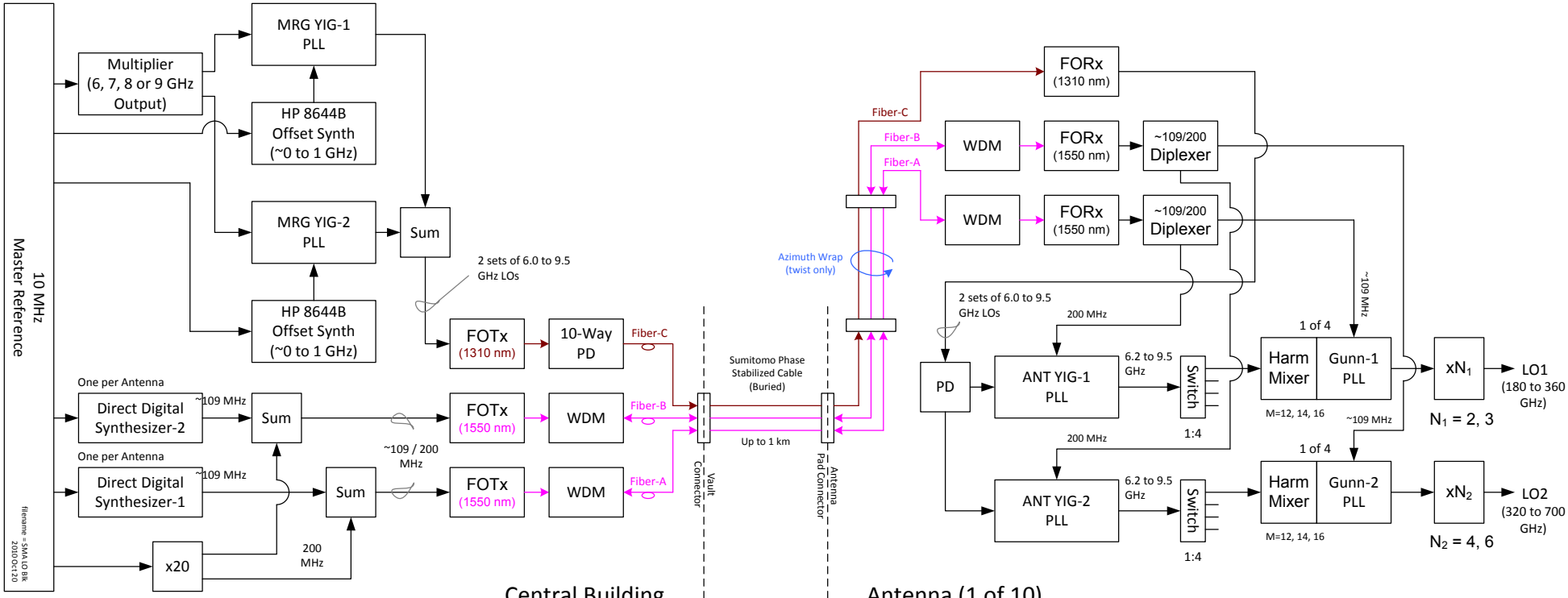
GLT INSTRUMENT DESIGN OVERVIEW

GLT LOCAL OSCILLATOR SUBSYSTEM

- The LO Subsystem Design
  - Critical element to the success and quality of VLBI fringes
  - Comparison of design approaches of SMA and ALMA to the proposed GLT design
    - We know the SMA design approach works for VLBI
    - The ALMA design is complete and is presently in use for normal interferometry
      - ALMA has performed LO tests to confirm that they meet the VLBI phase stability requirement
      - No actual VLBI tests as of yet

GLT LOCAL OSCILLATOR SUBSYSTEM

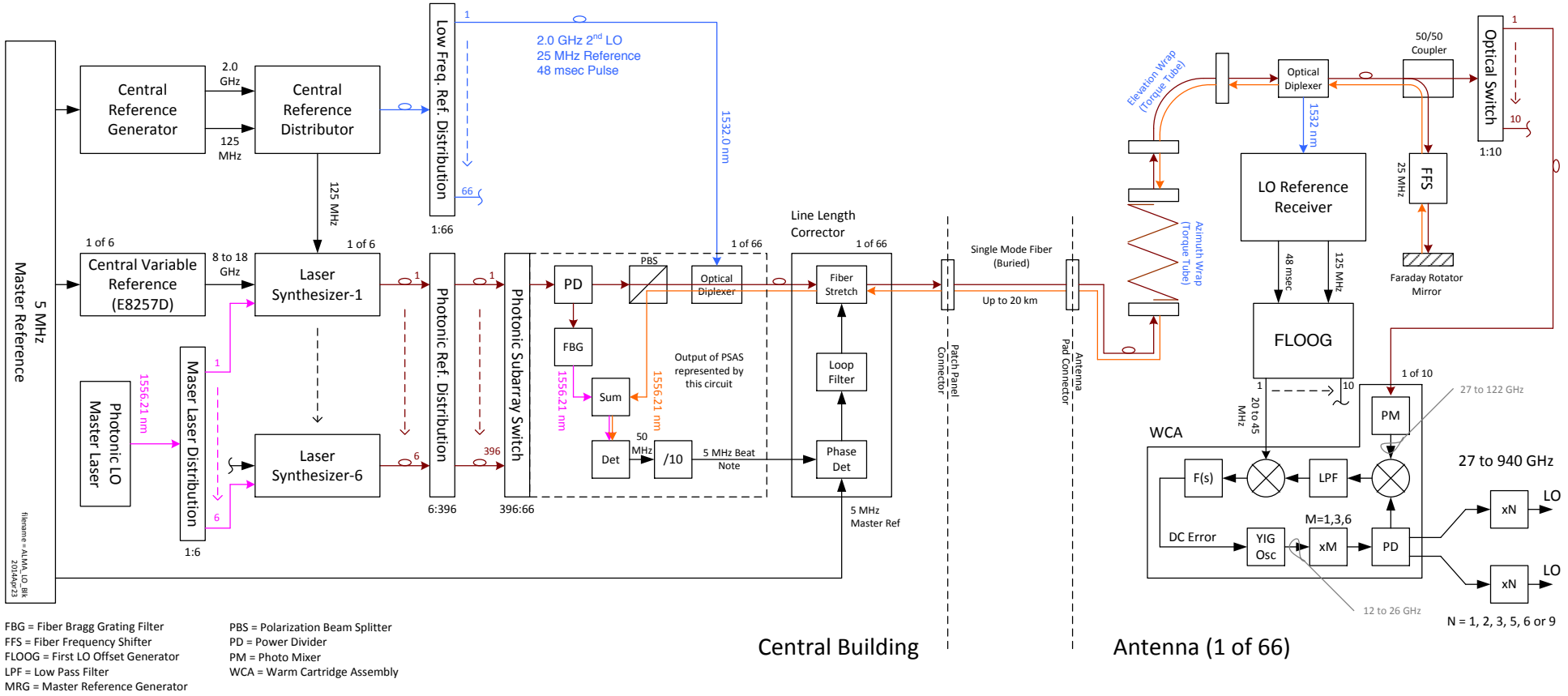
- SMA LO Subsystem Description (simplified)



FORx = Fiber Optic Receiver
FOTx = Fiber Optic Transmitter
MRG = Master Reference Generator
PD = Power Divider
WDM = Wave Division Multiplexer

GLT LOCAL OSCILLATOR SUBSYSTEM

- ALMA LO Subsystem Description (simplified)

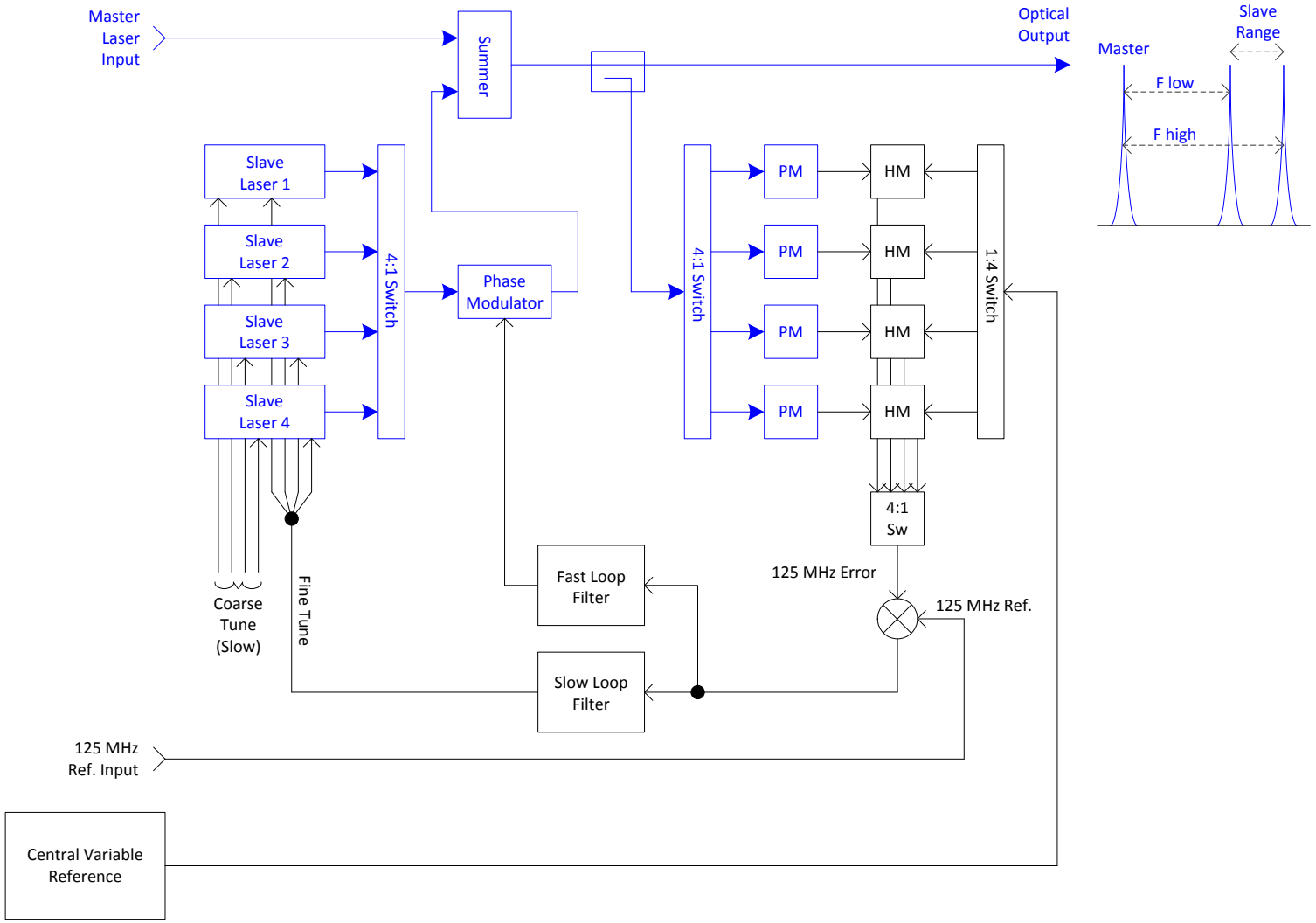


FBG = Fiber Bragg Grating Filter
FFS = Fiber Frequency Shifter
FLOOG = First LO Offset Generator
LPF = Low Pass Filter
MRG = Master Reference Generator

PBS = Polarization Beam Splitter
PD = Power Divider
PM = Photo Mixer
WCA = Warm Cartridge Assembly

GLT LOCAL OSCILLATOR SUBSYSTEM

- ALMA TeraXion Laser Synthesizer Description (simplified)

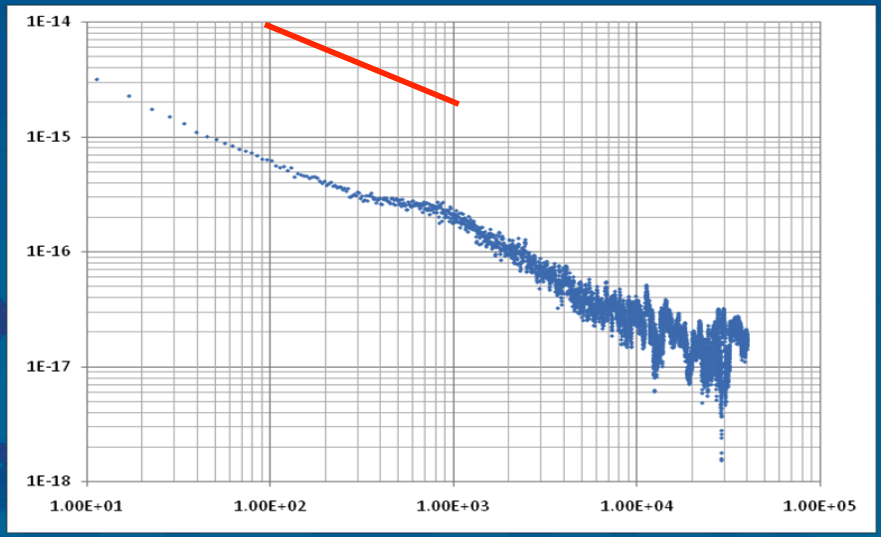


- ALMA LO Stability Performance
  - https://science.nrao.edu/facilities/alma/alma2011/ALMA-CDP/30-Shillue/ALMA_Dev_Meeting_Shillue_revD.pdf

Atacama Large Millimeter/submillimeter Array

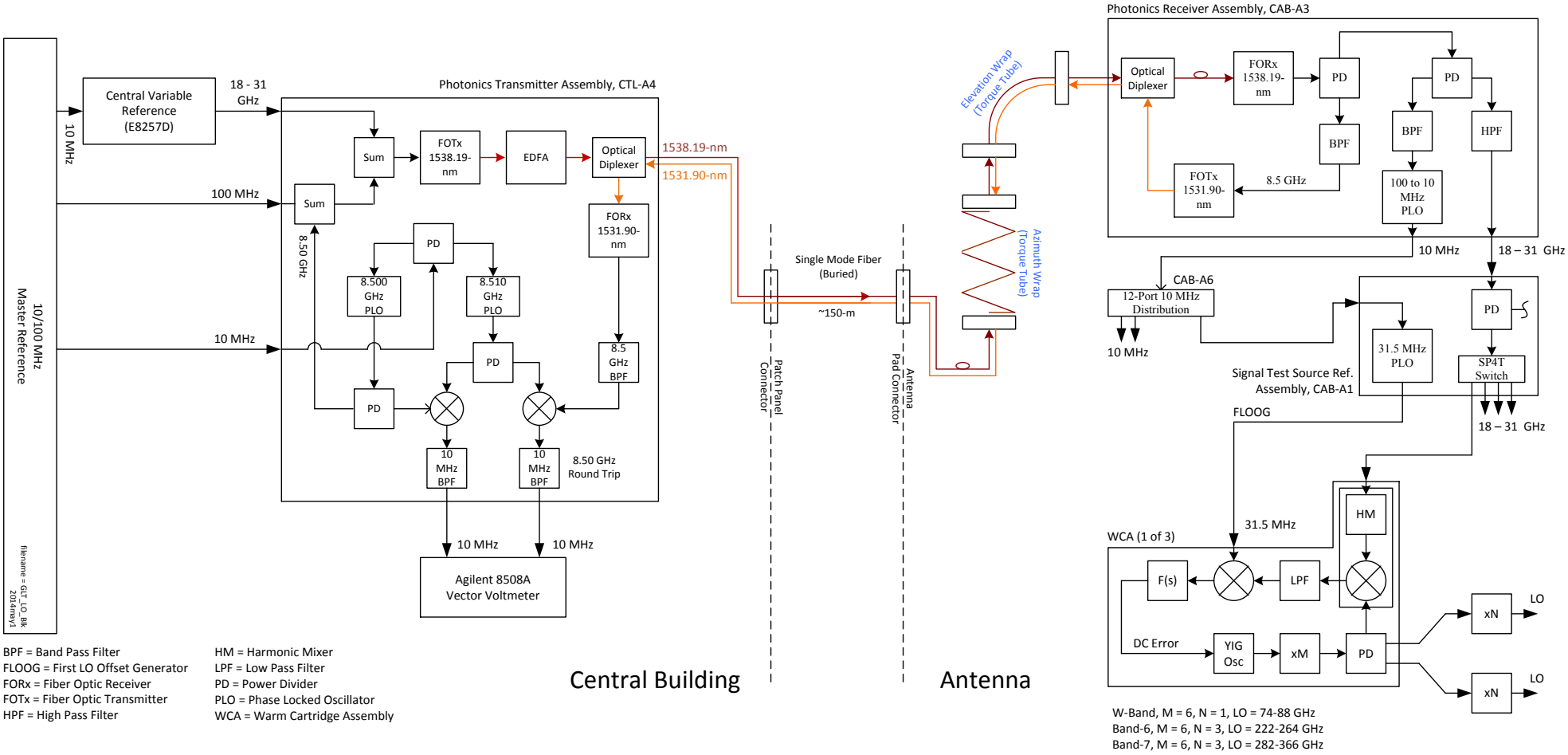
Performance Summary

- The Central LO meets the ALMA specifications for tuning range, tuning speed, phase noise, phase drift.
- The Central LO is well ***under*** the required stability for VLBI



GLT LOCAL OSCILLATOR SUBSYSTEM

- GLT LO Subsystem Description (simplified)



BPF = Band Pass Filter
FLOOG = First LO Offset Generator
FORx = Fiber Optic Receiver
FOTx = Fiber Optic Transmitter
HPF = High Pass Filter
HM = Harmonic Mixer
LPF = Low Pass Filter
PD = Power Divider
PLO = Phase Locked Oscillator
WCA = Warm Cartridge Assembly

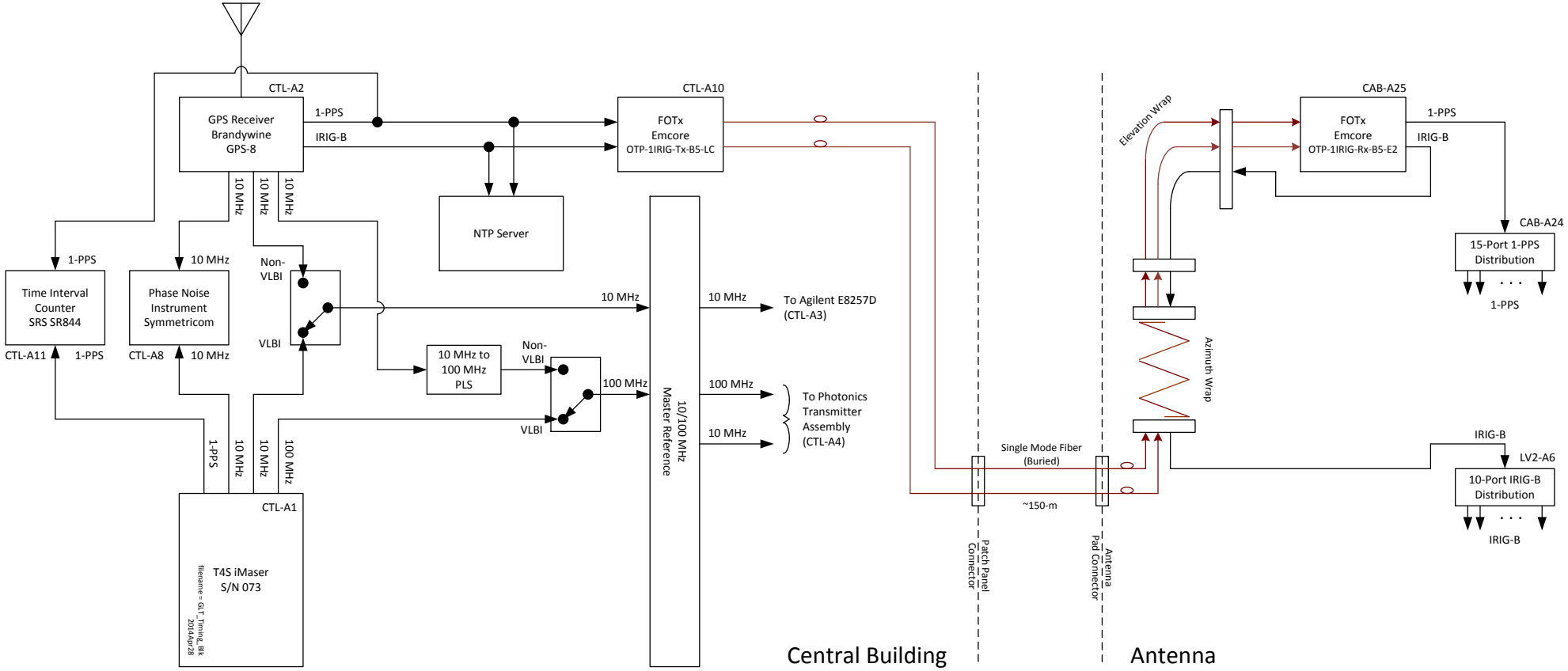
W-Band, M = 6, N = 1, LO = 74-88 GHz
Band-6, M = 6, N = 3, LO = 222-264 GHz
Band-7, M = 6, N = 3, LO = 282-366 GHz

GLT LOCAL OSCILLATOR SUBSYSTEM

- GLT LO Subsystem Summary
  - The GLT LO subsystem design is a simplified version of the ALMA design
    - All of the LO hardware must be kept in a temperature stabilized environment
      - Monotonic temperature change is better than oscillations
      - The better the temperature stability, the better ADEV performance
    - Utilizes the same Agilent E8257D low phase noise synthesizer (option UNX) already purchased by Johnson
      - We plan to perform an ADEV test between two E8257D units located in the temperature stable SMA vault at Mauna Kea (need to have one of Johnson's units shipped to Hilo)
      - We may someday replace this E8257D unit with a custom design to provide better phase noise and ADEV performance for future higher frequency VLBI work (690 GHz?)
    - Laser Synthesizer and Photomixer are replaced by an Optical Transmitter and Receiver
      - Plan to use OE Quest for both Transmitter and Receiver
      - $43k USD including spares (Sept 20, 2013 quote)
      - Will characterize residual phase noise performance of optical link by comparing the LO signal before and after the optical link
    - A 8.5 GHz pilot tone is used to measure round trip phase of the fiber system
      - The weakness of this approach is that the 8.5 GHz pilot tone goes through an extra set of Optical Transmitters and Receivers on the return path that the main LO does not encounter
      - We will have the ability to continuously monitor and record the round trip phase even when the telescope is not used
      - No Line Length Corrector

GLT TIMING SUBSYSTEM

- 10 MHz, 100 MHz, 1-PPS and IRIG-B Subsystem Description (simplified)

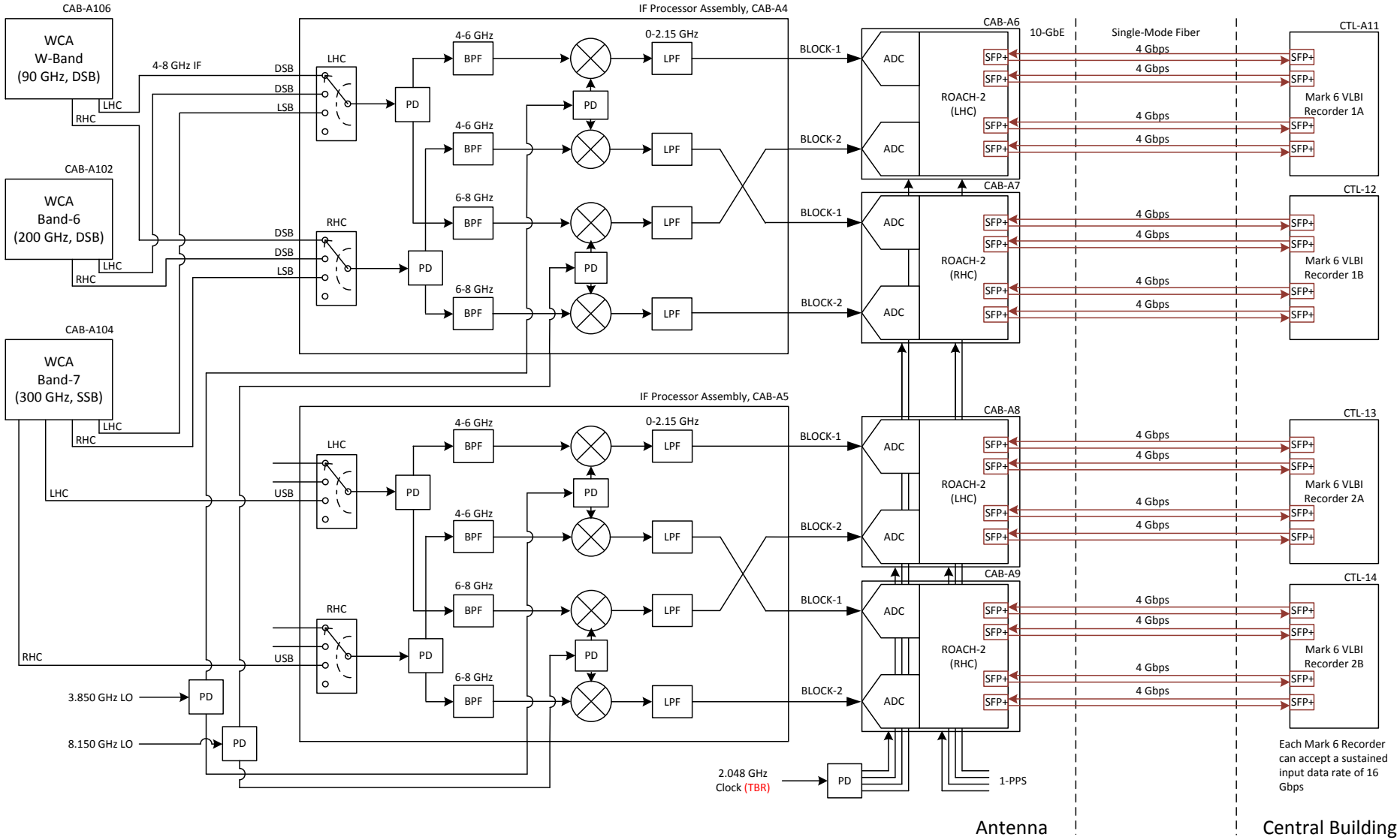


GLT TIMING SUBSYSTEM

- Timing Subsystem Summary
  - 1-PPS and IRIG-B are derived from GPS receiver located in Control Building
    - Distributed to antenna via a pair of dedicated single-mode fibers
    - Provided as NTP over local network
    - A time interval counter is used to compare and record the 1-PPS signals from the GPS and maser
    - All of the LO and Timing subsystem hardware should be co-located in a temperature stabilized room within the control building
  - T4S maser will provide references for 10 and 100 MHz in VLBI mode
    - For single dish observations, we have built in the option to use either the maser or Brandywine GPS
    - The SMA used the same Brandywine GPS for normal observations
    - A phase noise instrument is used to compare and record the 10 MHz signals from the GPS and maser
      - The absolute frequency accuracy of the maser is dependent on the temperature environment
      - 10 MHz maser frequency is adjustable through software control
      - Operating specification for the maser is +20 to +30 degrees C, 10 to 90% humidity
        - For the SMA, the maser is located in the vault where the temperature is always < +20 degrees C
        - The temperature reading is in the red, but operationally it seems to be OK

GLT IF AND DBE SUBSYSTEMS

- Intermediate Frequency and Digital Backend Subsystem Description (simplified)



GLT IF AND DBE SUBSYSTEMS

- Intermediate Frequency and Digital Backend Subsystem Summary
  - The IF and DBE subsystems can process the signals for one of four dual polarization heterodyne receivers
    - Currently 90 GHz (Band-3), 200 GHz (Band-6), and 300 GHz (Band-7) receivers
    - 90 and 200 GHz are double sideband (DSB) dual polarization receivers with two IF output channels of 4-8 GHz each
      - SMA receivers are all DSB dual polarization receivers (4-12 GHz goal for wideband upgrade)
      - Supported by one IF Processor, two ROACH-2s, and two Mark 6 VLBI recorders
      - Each Mark 6 unit has 16 Gbps sustained recording capacity for a total of 32 Gbps
    - 300 GHz is single sideband (SSB) dual polarization receiver with four IF output channels of 4-8 GHz each
      - ALMA uses SSB dual polarization receivers for Band-3 through Band-8 (4-8 GHz for each of the four IF outputs)
      - The GLT 300 GHz receiver will be directly compatible with ALMA in terms of sideband separation
      - Requires two IF Processors, four ROACH-2s, and four Mark 6 VLBI recorders
      - Total of 64 Gbps recording capacity required