# ILC Phase Distribution System

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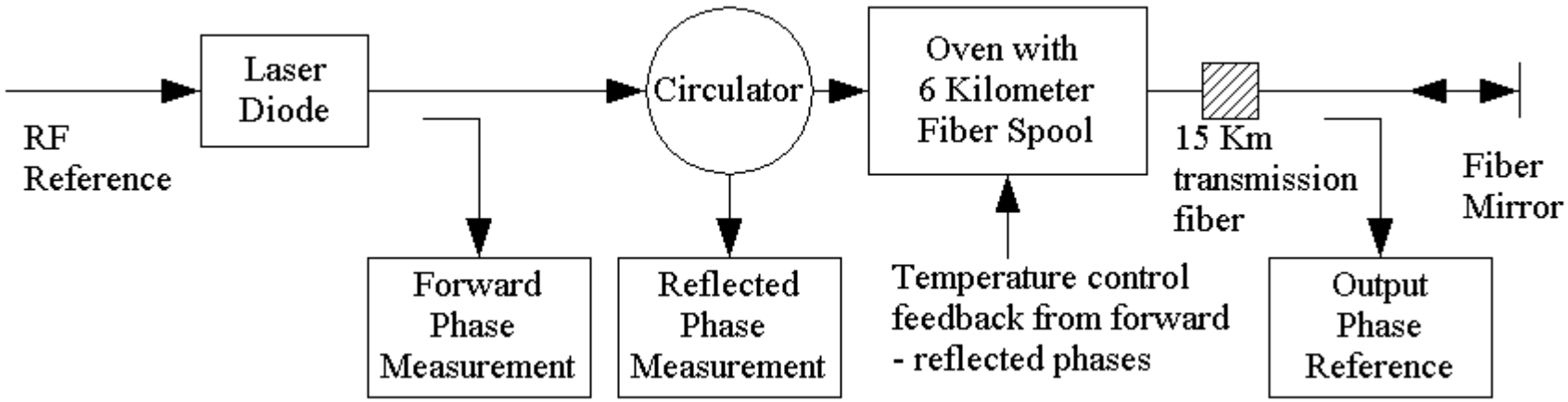
# Overall System Description

- Long-haul phase distribution system provides <1 degree L-band synchronization
  - Timing derived from count-down of phase system – similar to SLAC system
  - Prototype completed
- Beam to RF phase information derived from low level RF signals for optimization, and possibly very slow feedback.
- Short haul (~500 Meter) distribution through conventional Coax,
  - Option - similar to SLAC interferometer (3000 Meter)
  - Alternate – phase average scheme (discussed later)

# Long Haul Distribution

- Most technically challenging part of system
- Previous work done for X-band linear collider – demonstration system
  - few degree X-band long term, fraction of a degree short-term stability
  - Should meet requirements for L-band machine
- Uses point – to – point fibers
- Distribution on commercial SMF-28 fiber
- Uses low cost telecom components.
- Dual redundant system with auto fail-over conceptual design.

# Principal of Operation

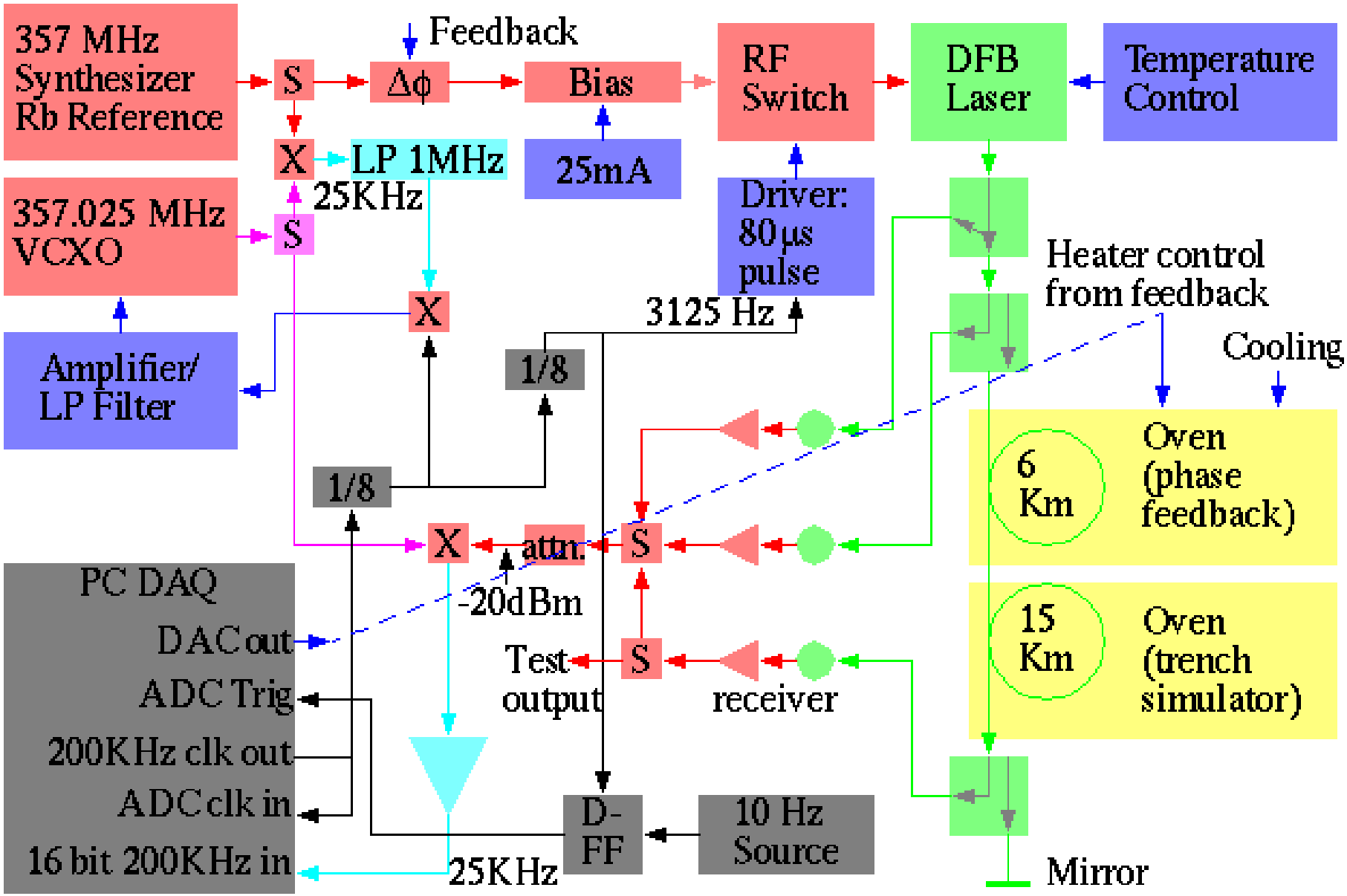



- RF signal is transmitted as amplitude modulated laser
- Fiber length including compensation fiber is measured from reflected power from end of fiber
- Compensation fiber temperature is controlled to stabilize reflected phase
- In real system, laser runs in pulses, to prevent interference between forward and reverse signals

# Prototype System

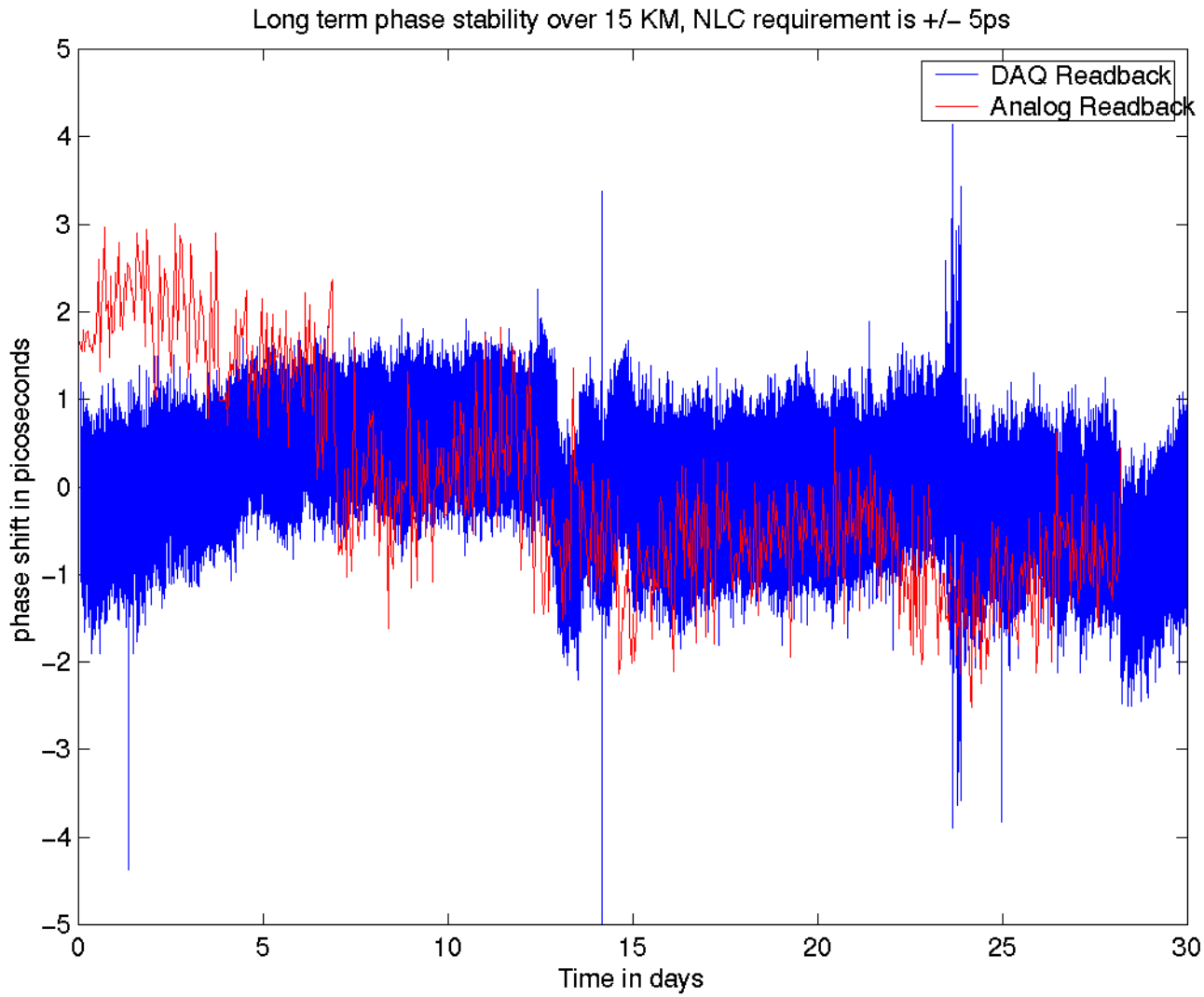
- Designed for X-band accelerator
  - 357MHz carrier frequency
  - 15 Kilometer main fiber length
  - 6 Kilometer compensation fiber
- Digital downconversion using PC based data acquisition system
- PID feedback loop from measured phase to oven temperature

# Prototype System

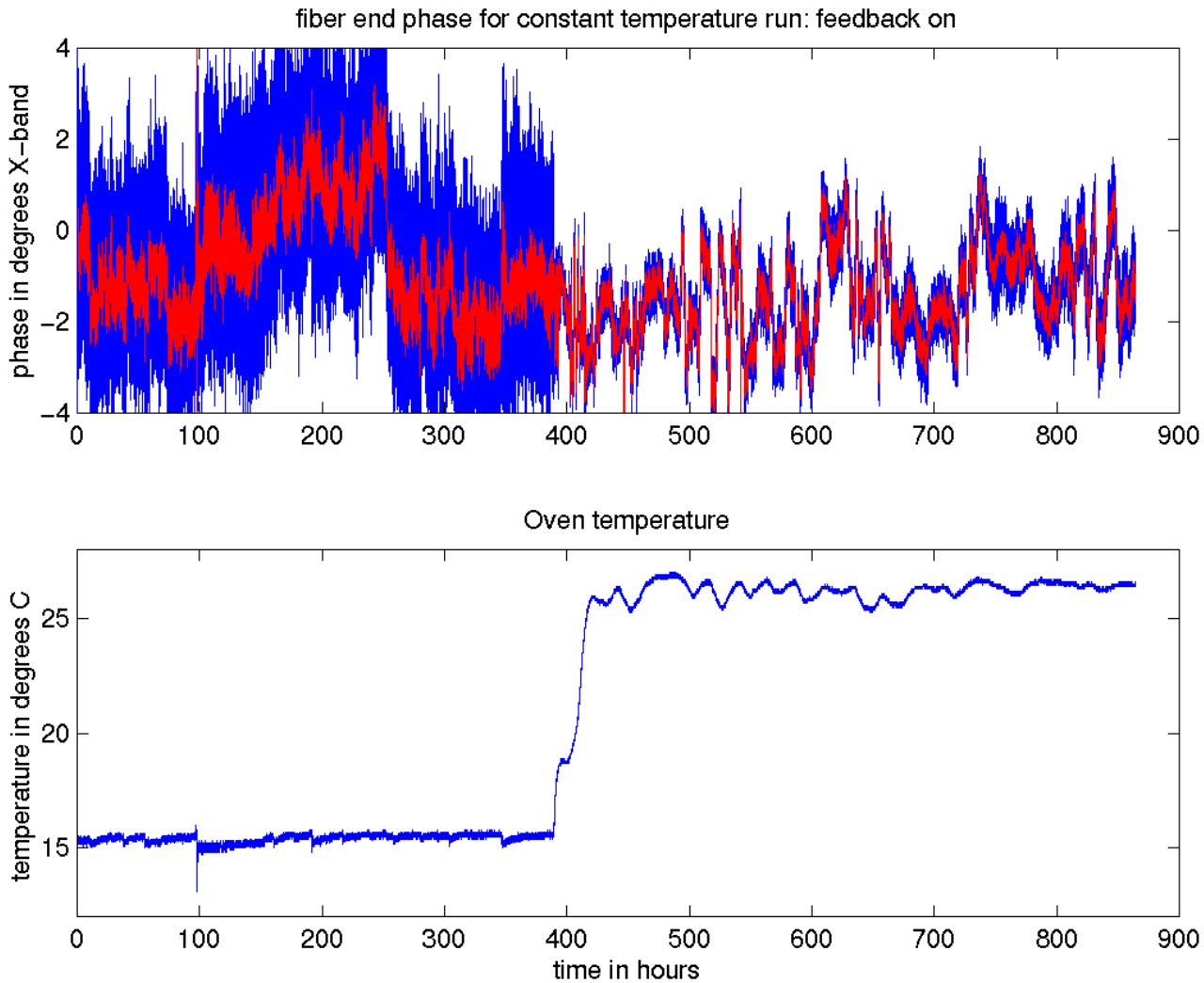



POWER FOR THIS BUS
DUCT FED FROM:
Panel: LP 34 A
Breaker: 25,27,29
Located: outside east wall of
central stairwell

# 1 Month Data: +/- 1 Picosecond



# Performance for 10 degree C temperature step (<1ps)



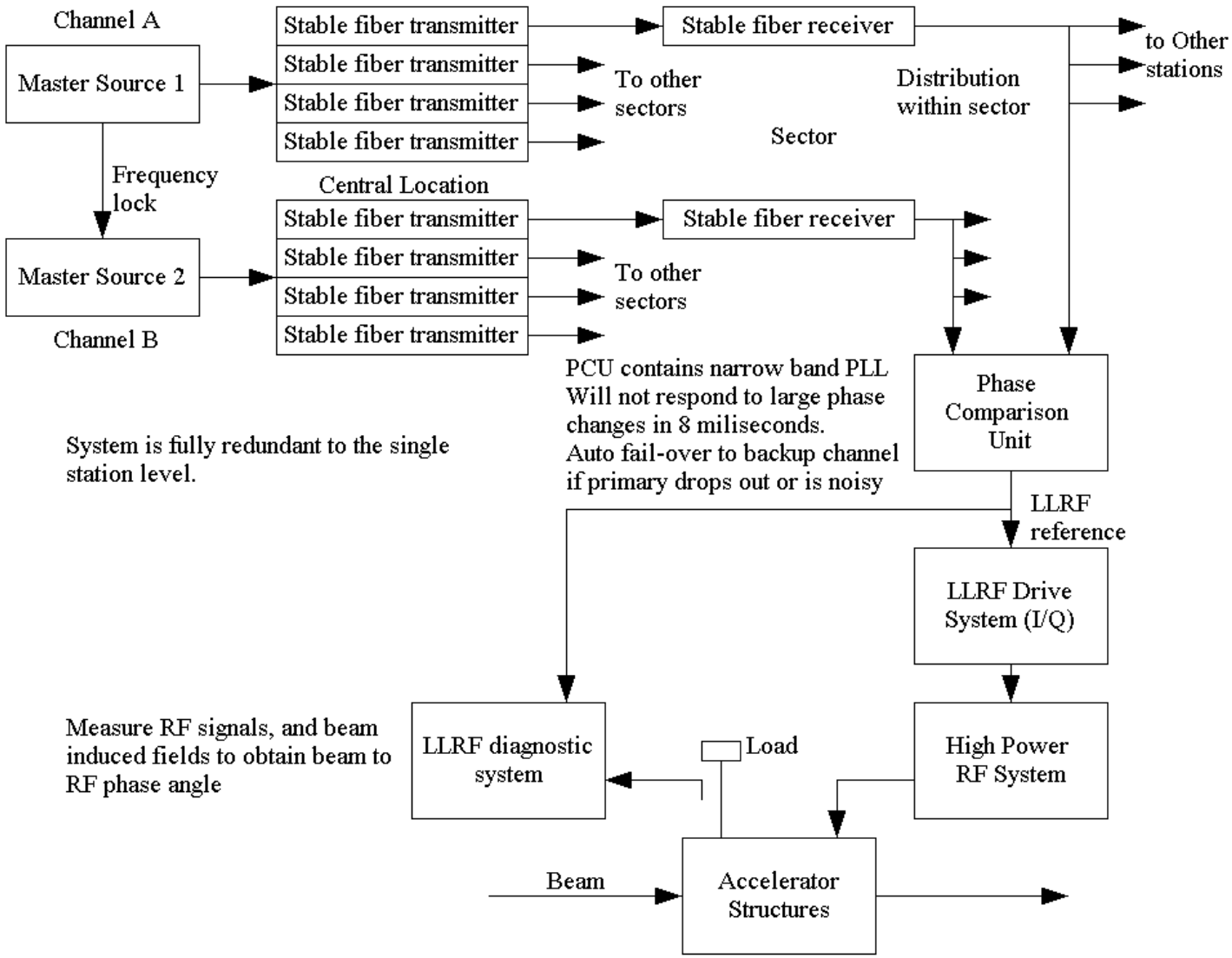
# Performance

- Long term stability ~+/- 1 Picosecond
  - 0.5 degree L-band
- Phase Noise: Measured at ~0.1 picosecond integrated from ~0.1Hz to 10KHz.
  - Probably OK for ILC
  - Limited by feed through of laser pulses – could be fixed with more sophisticated output PLL
- Improvements in laser diodes would probably result in reduced system noise

# Redundant System

- Duplicate sources, transmitters and receivers.
- For X-band design, last timing / phase reference units dominated costs, additional cost to duplicate upstream system was relatively small
- Dual system is self-checking for errors and noise.

# Redundant System



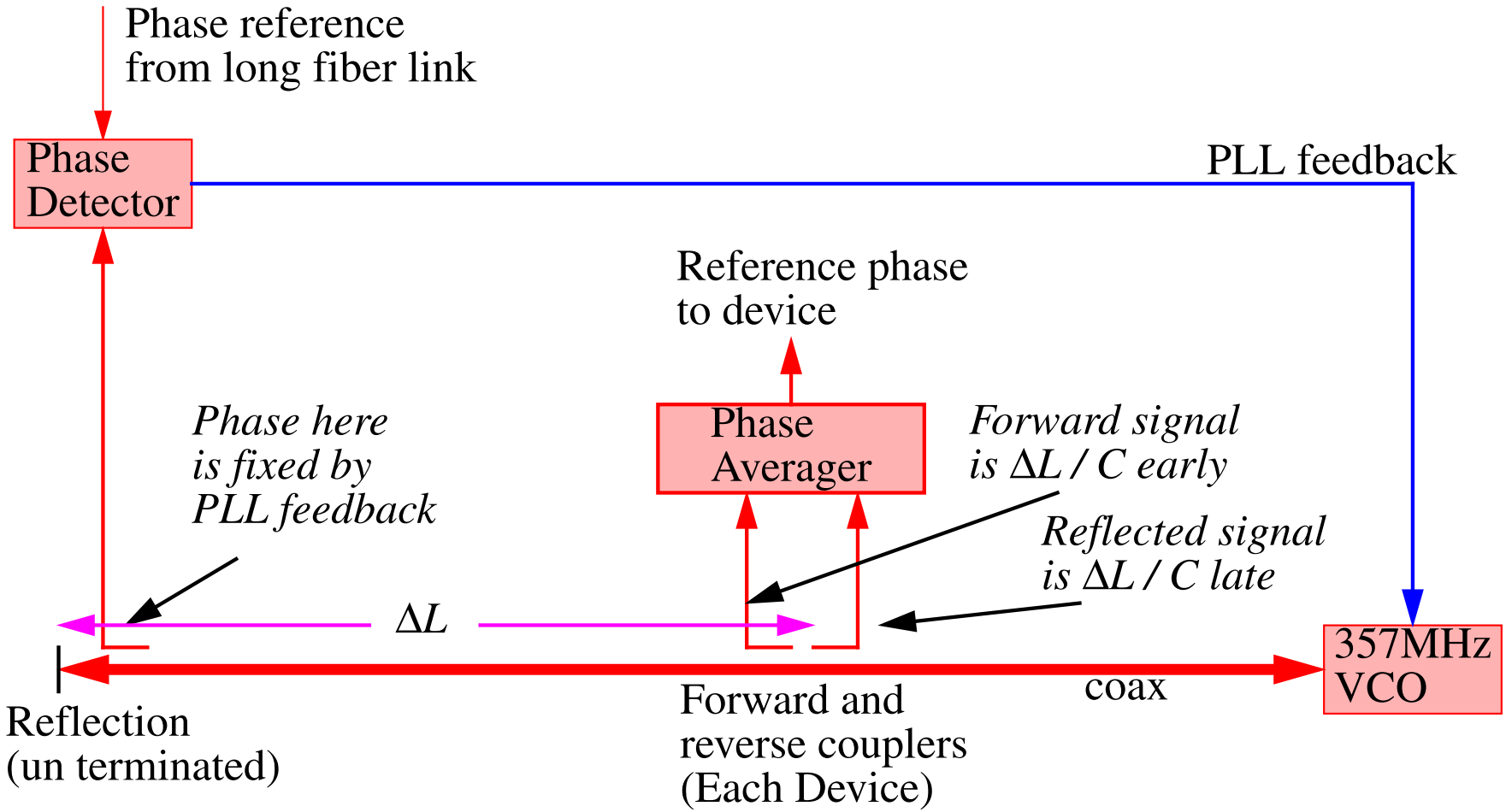
# System modifications / upgrades

- Fiber ovens work, but are somewhat large (~10 rack units), consume a lot of power (~1KW / fiber), and are ugly.
- Original plan was to use wavelength – tunable laser (working against the fiber dispersion) to change the effective fiber length.
  - Need about 4 nanometers / degree C, or about 40 nanometers total
  - Developments in DWDM lasers may make this practical.
- Polarization preserving fiber would probably improve phase noise, but so far losses are too large.

# Radiation Damage

- Low loss fibers are radiation sensitive. NLC design had long haul fibers in separate trench, only coax in accelerator housing.
  - Not a lot of data on low – loss fiber.
  - Results depend on composition, optical power (healing), etc
  - ~ 1000 Rads -> 1 dB/Km loss
  - Safe dose for our system ~100 Rads lifetime!
- Probably need to put fibers in trench, or in parallel tunnel, not in main housing.

# Short Haul System
# Multi-drop, Coax (in tunnel)



# Work to Do

- Prototype Short Haul System
- Second generation long haul system
  - Use new, low noise laser diodes
  - Use 1.3 GHz transmission frequency
  - Superimpose timing fiducial
    - System constructed, but not installed on prototype fiber system
- System design for Cold Machine
  - Specifications
  - Fiber location