

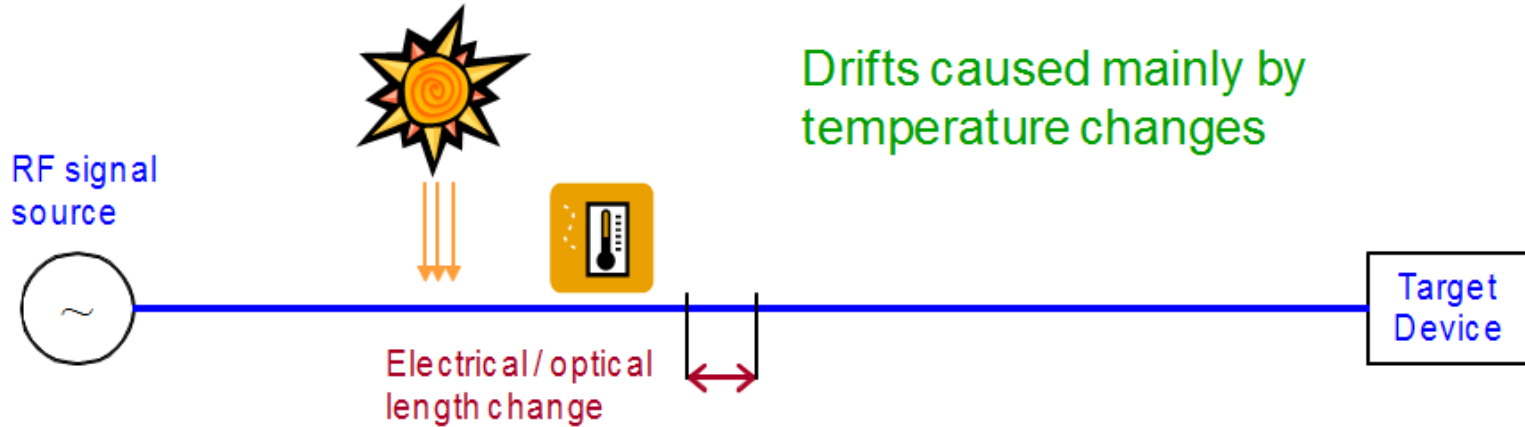
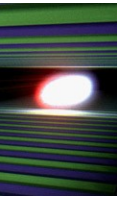
Femtosecond RF reflectometry for synchronization

Dominik Sikora

Warsaw University of Technology

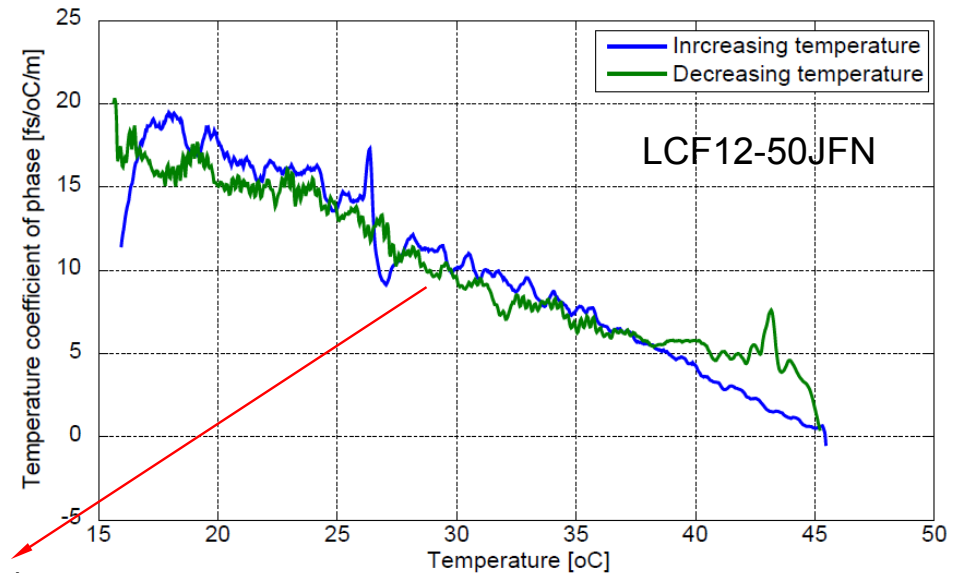
Hamburg 21.08.2012

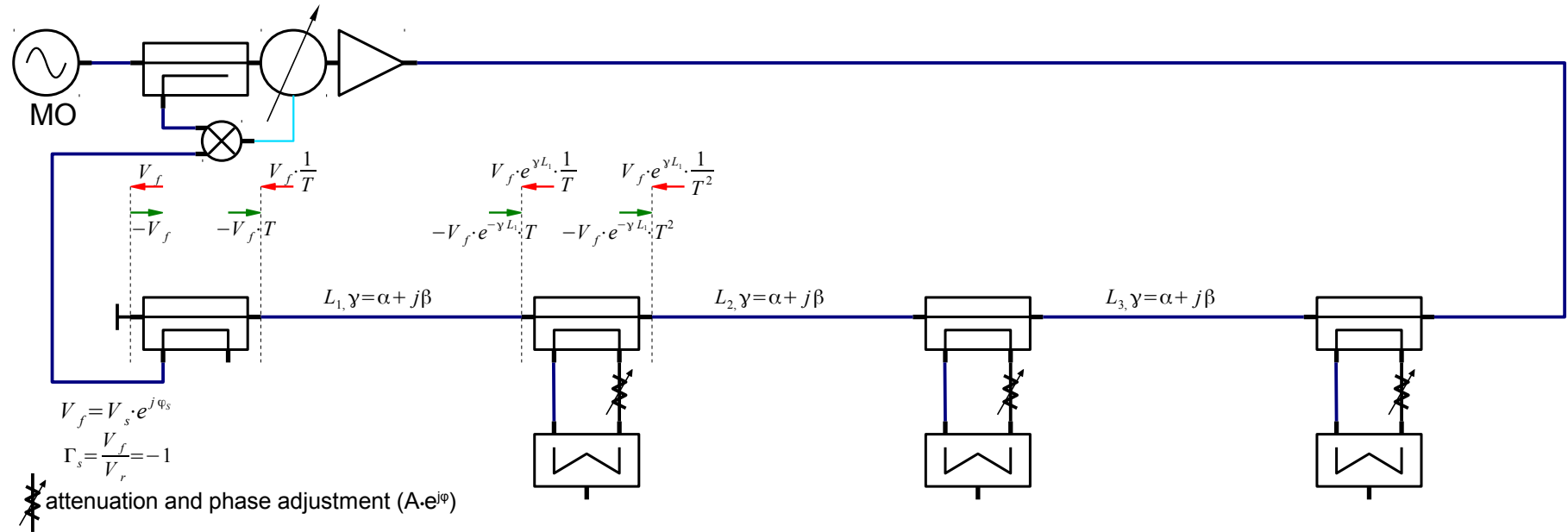
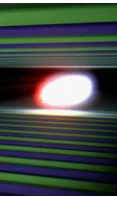




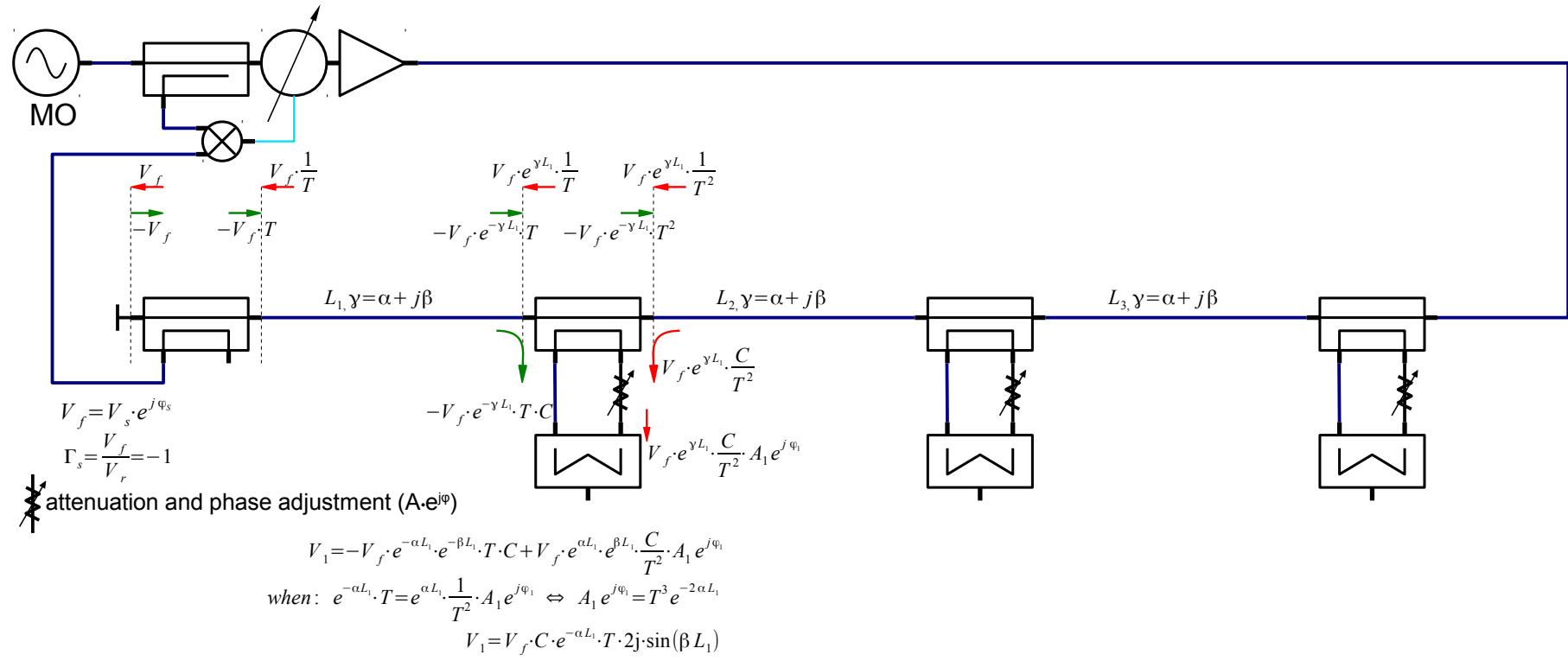
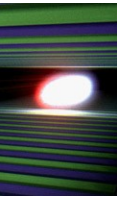
- Reasons of phase drifts:
 - in cables: physical dimension (L) and dielectric properties (β) changes
 - in fibers: n_{eff} changes
- XFEL requirement: 100fs of phase drifts
- Feedback on phase required!

@30 °C phase drift coefficient: 10fs/m/K
correspond to 33ps/K for XFEL length (3.3km)



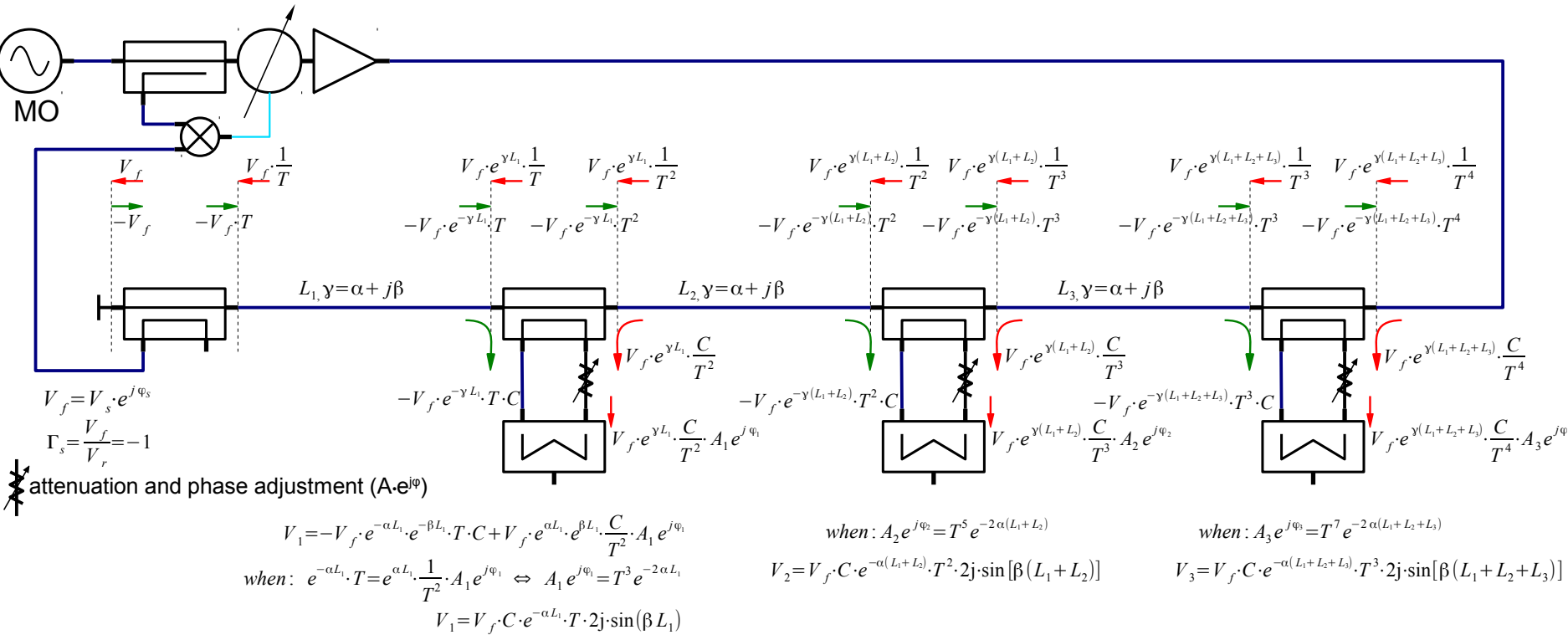
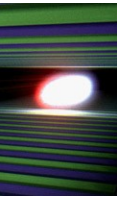


- Interferometer idea developed in Fermilab (Ed Cullerton and Brian Chase)
- Conditions:
 - constant φ_s - fixed by feedback loop

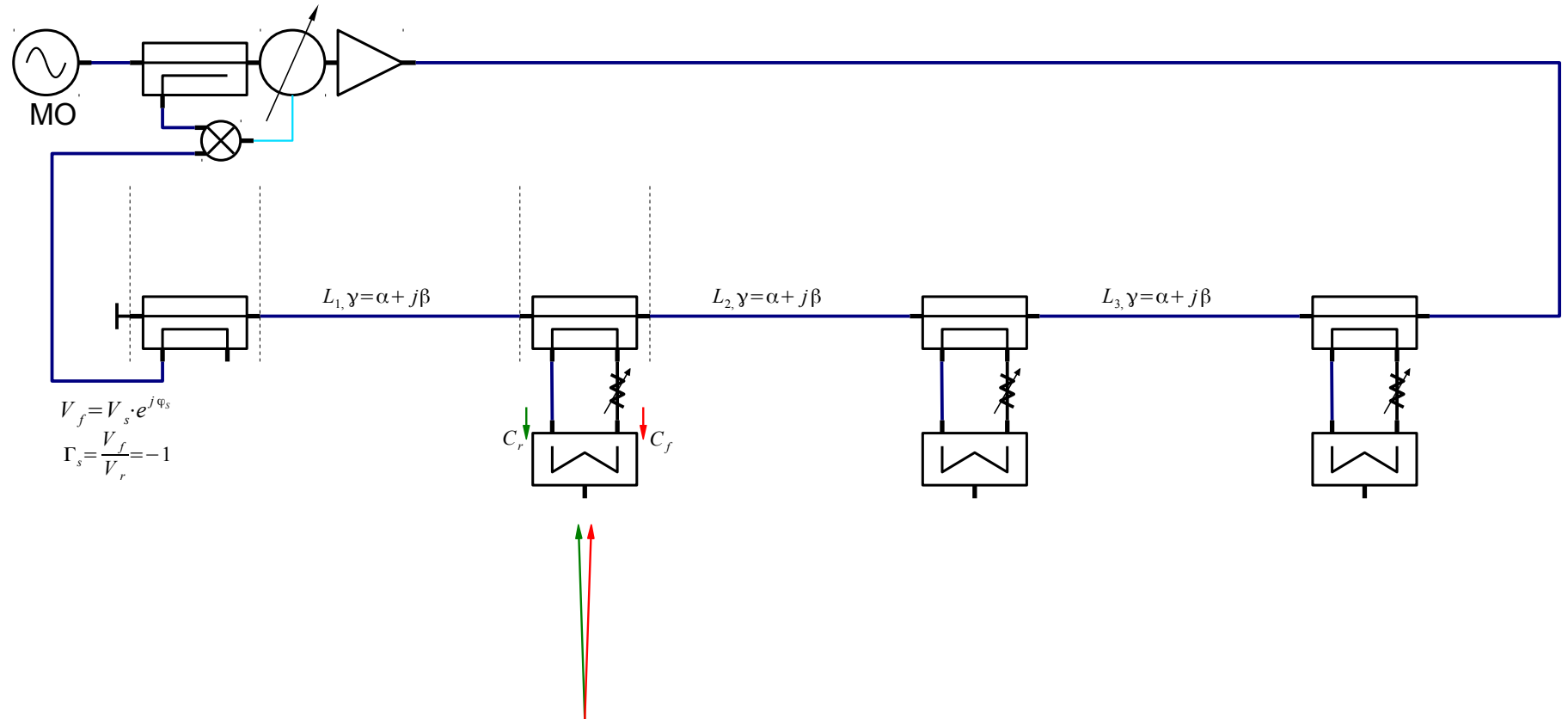
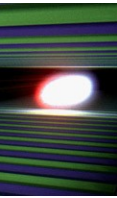


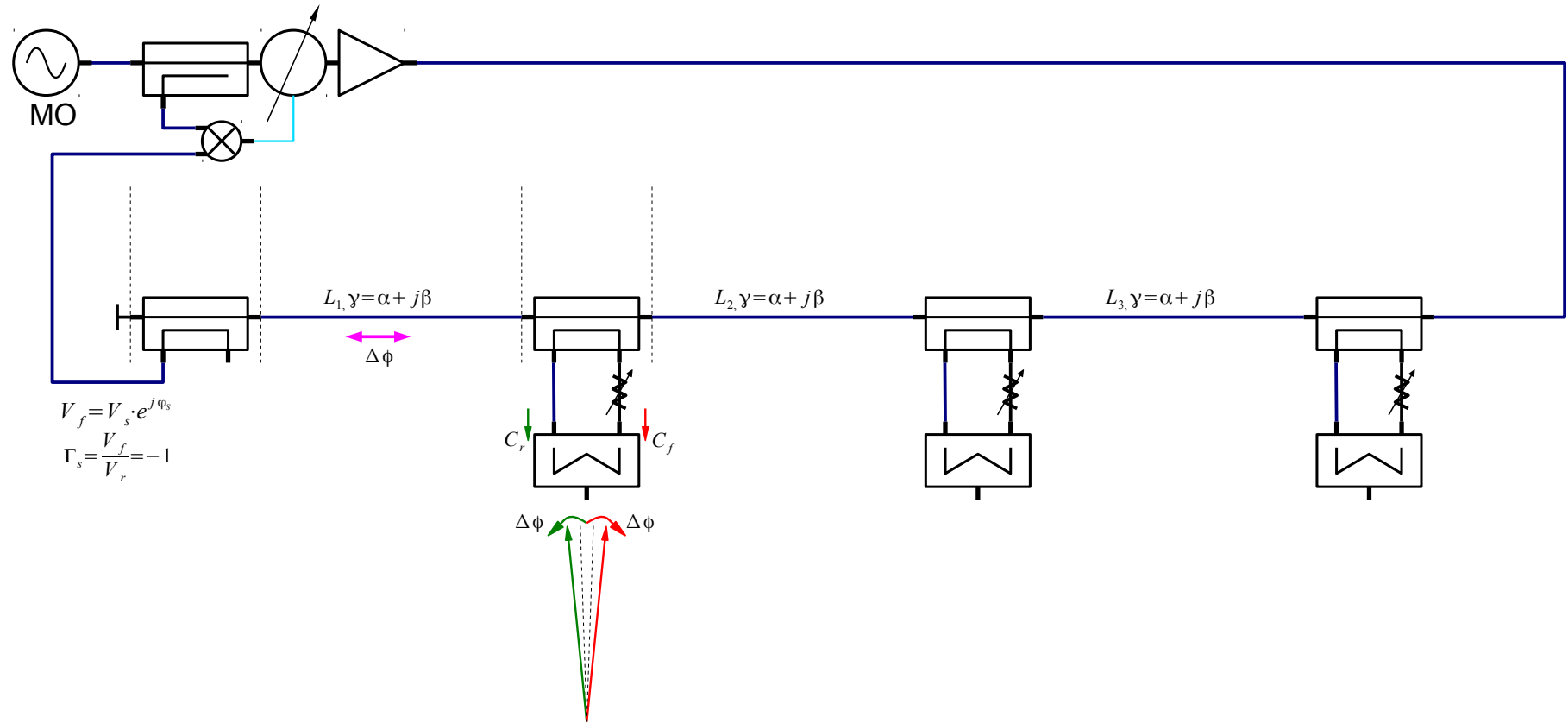
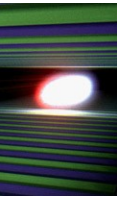
- Conditions:
 - constant φ_s - fixed by feedback loop
 - signals at combiner inputs are equal – attenuation and phase adjustment ($A \cdot e^{j\varphi}$)

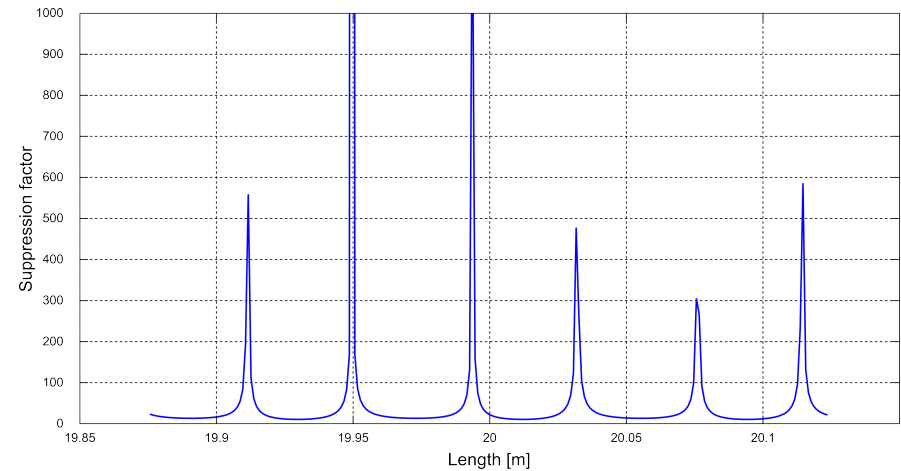
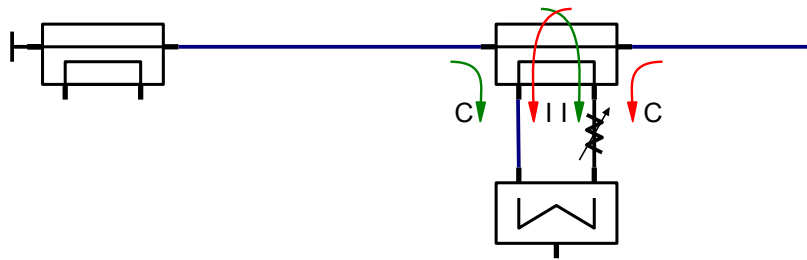
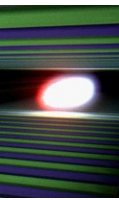
Interferometer fundamentals



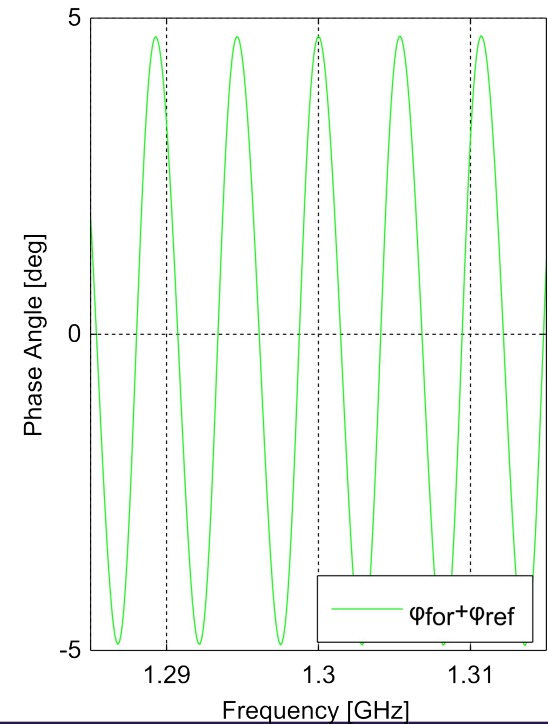
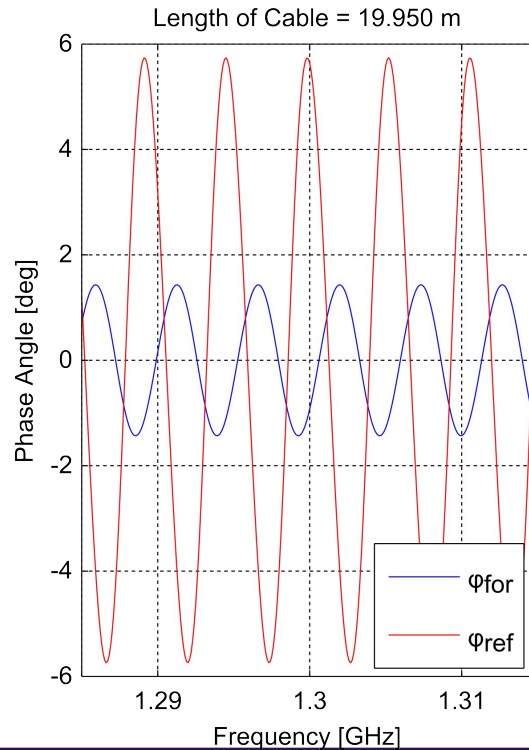
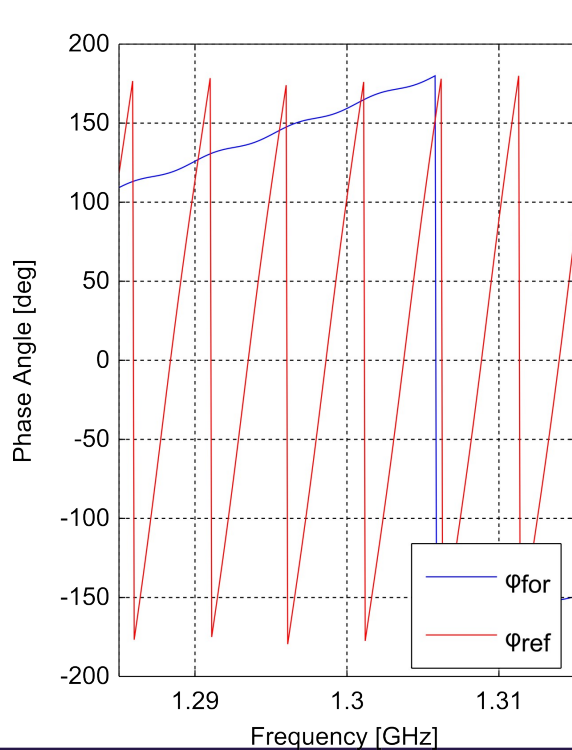
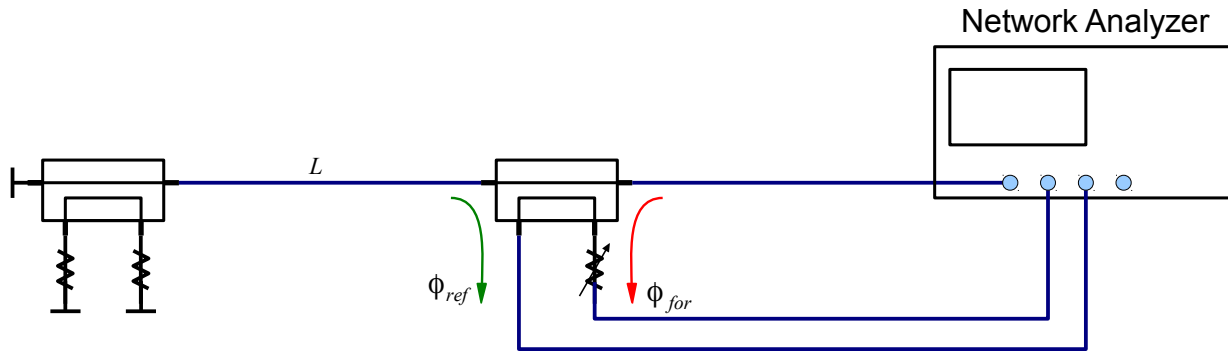
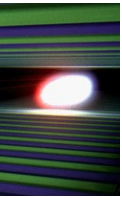
- Conditions:
 - constant φ_s - fixed by feedback loop
 - signals at combiner inputs are equal – attenuation and phase adjustment ($A \cdot e^{j\varphi}$)

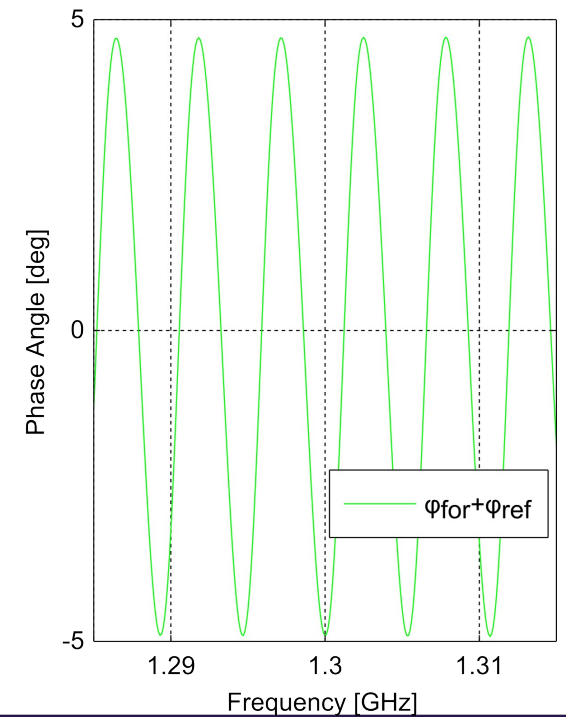
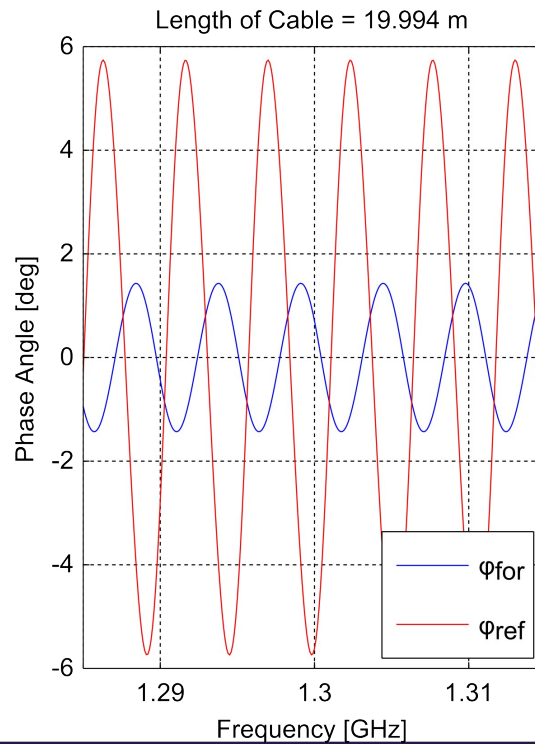
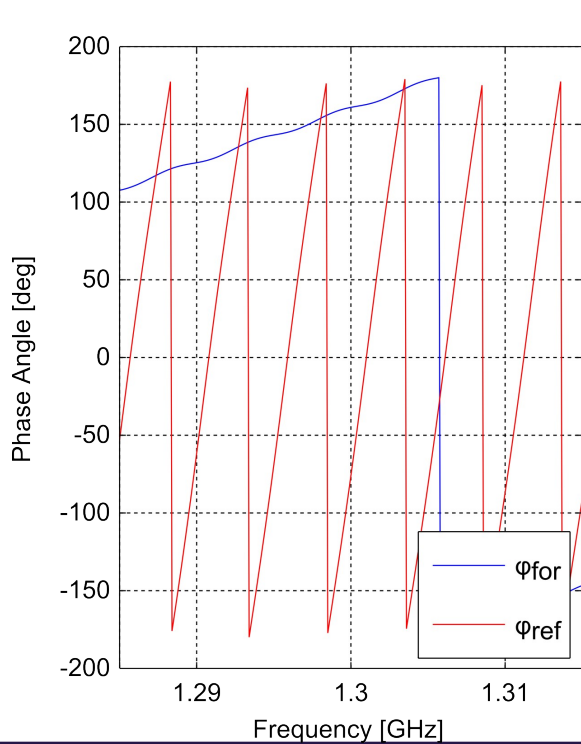
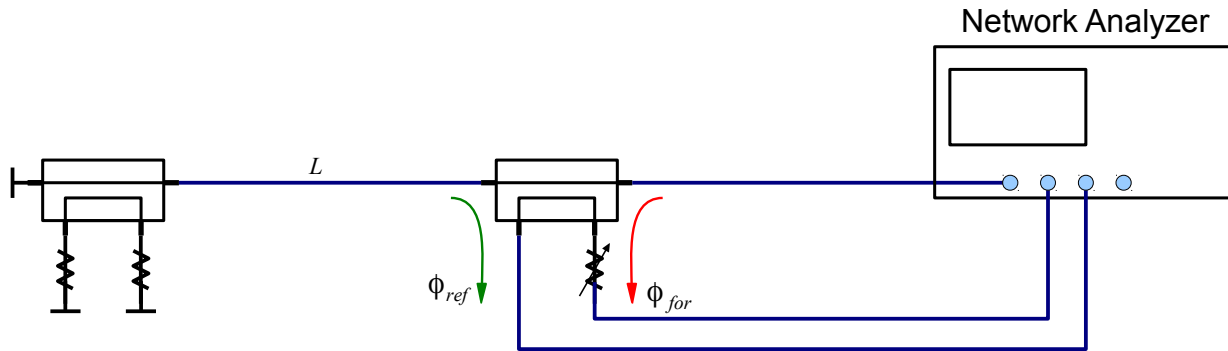
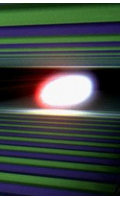


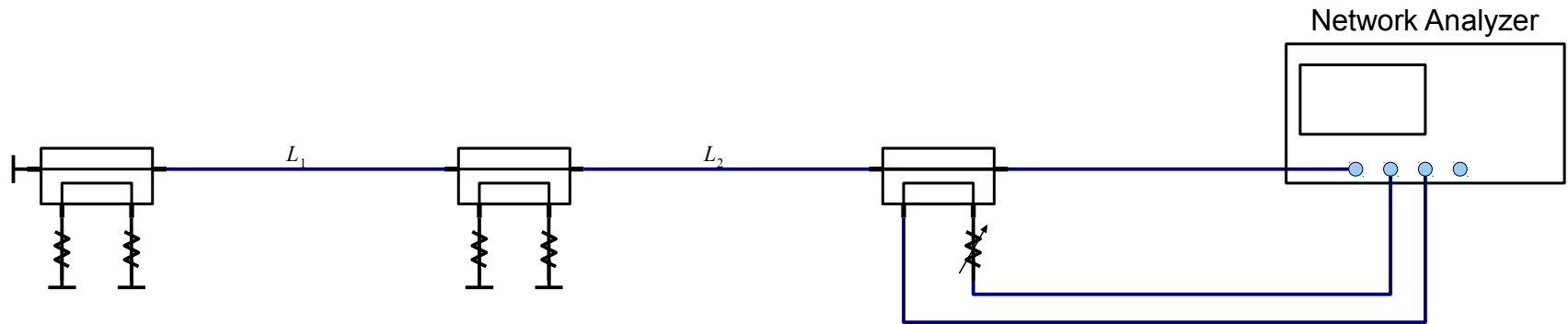
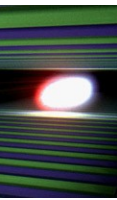


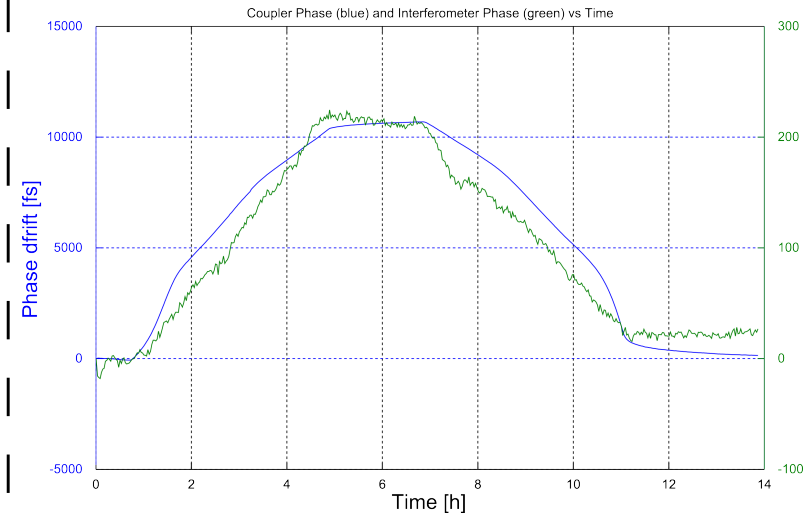
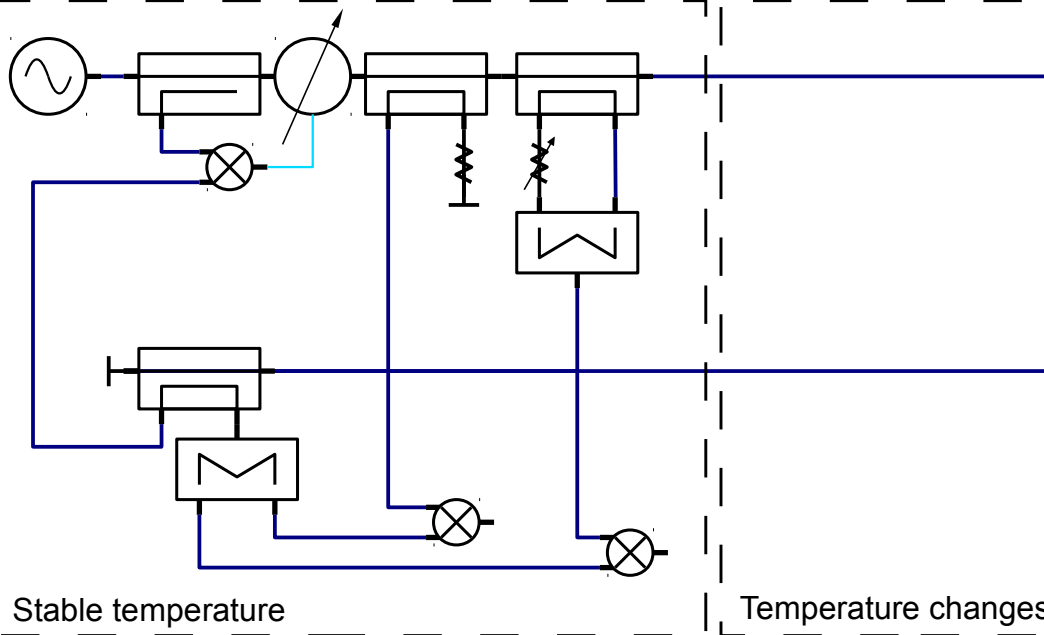
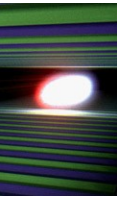


- Suppression factor of phase drifts limited by coupler isolation and port mismatches
- Maximum suppression factors occur at every quarter of wavelength
- Operating point at proper length of cable to obtain maximum suppression factor

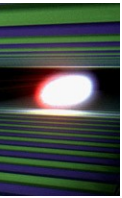






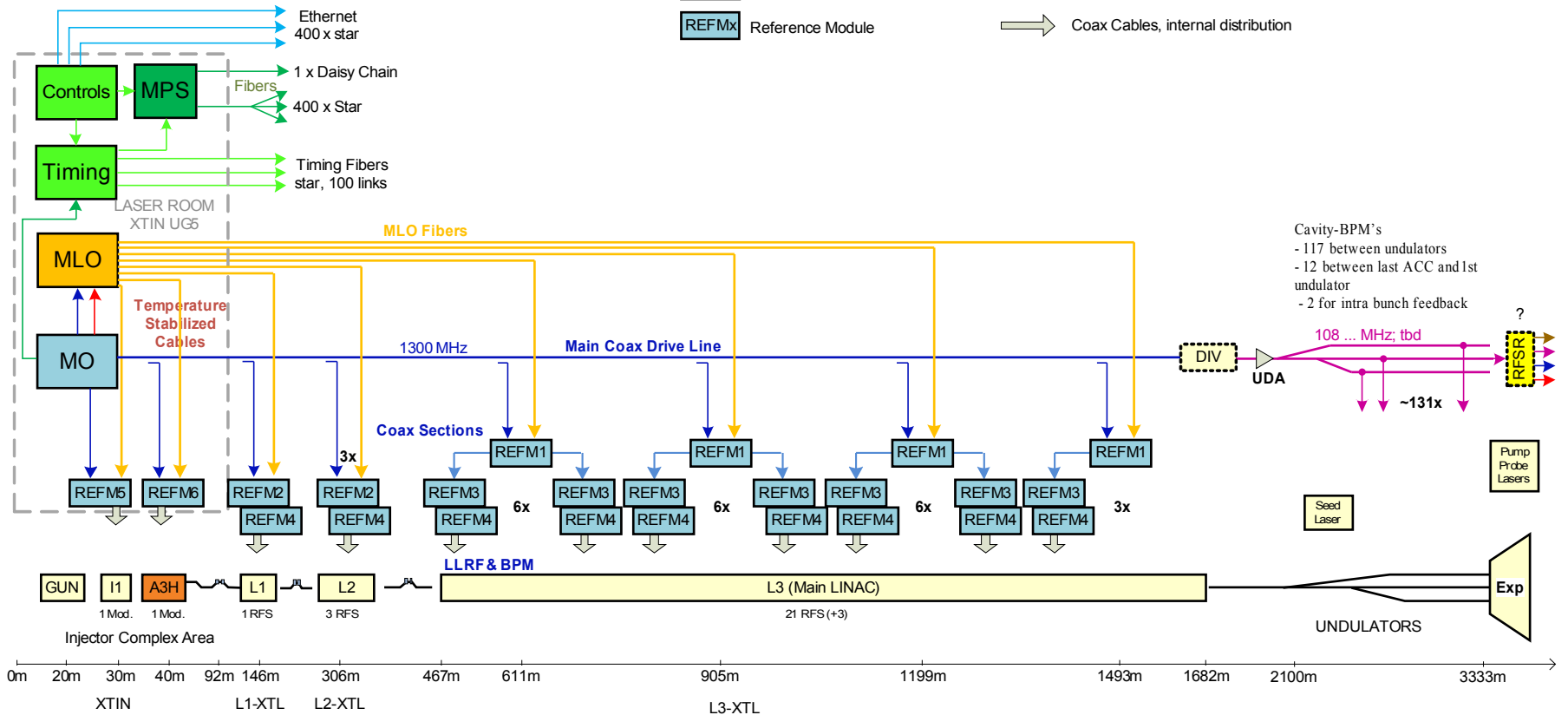


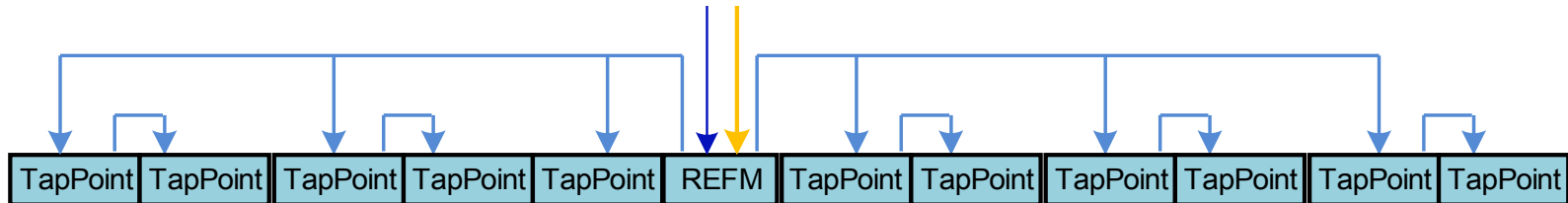
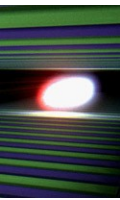
- Fermilab test result: $\sim 30\text{mDeg}$ ($\sim 65\text{fs}$) of phase drift over 20 degrees F ($\sim 10\text{K}$)
- Our first result: $\sim 200\text{fs}$ of phase drift over 25 K compared to 10ps without interferometer
- Suppression factor: ~ 50



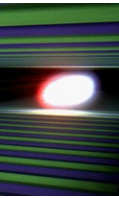
LEGEND

MO	Master Oscillator	→	Coax Cable, 1300 MHz
MLO	Master Laser Oscillator	→	Coax Cable (Interferometer), 1300 MHz
A3H	3rd Harmonic Receiver	→	Coax Cable, 10 MHz
MPS	Machine Protection System	→	Coax Cable, frequency tbd
REFMx	Reference Module	→	Coax Cables, internal distribution

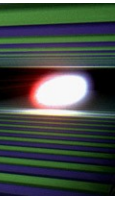




- Two interferometers at each section
- Three tap points (~50m) of each interferometer
- Tap point with easily configurable electronics



- Interferometer is being developed for XFEL and REGAE
- Interferometer circuit has limitations
- Phase drifts from distribution cables can be suppressed by interferometer idea
- Design procedure was developed – to obtain maximum suppression factor
- Tap points with easily configurable electronics are being developed



Thank you for your attention
