Field-Widened Michelson Interferometer as the Spectral Discriminator in a 1064 nm HSRL
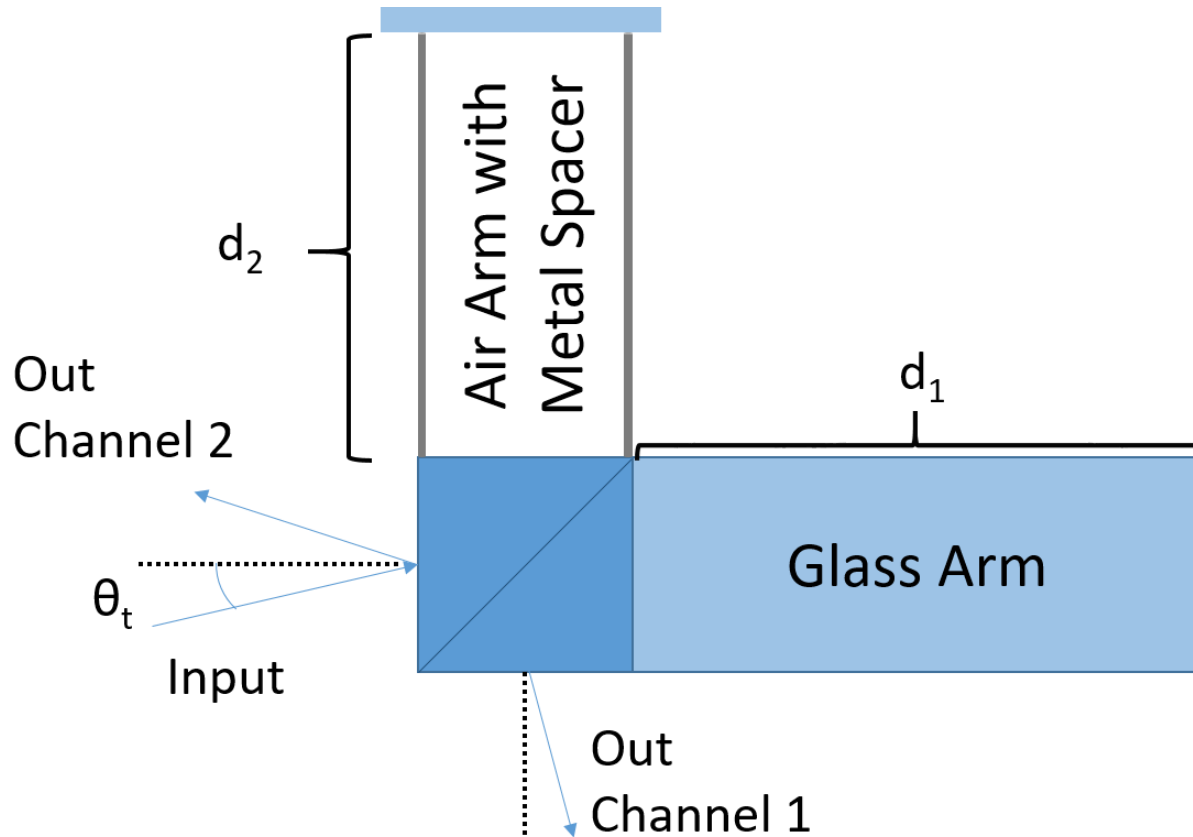
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02. Emerging lidar techniques, methodologies, and discoveries

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- HSRL systems typically have an HSRL channel at 532 nm and standard backscatter channel at 1064 nm
- FWMI can be used as spectral discriminator at 1064 nm
- Would allow for measurement of Angstrom exponent [1]
- Spaceborne lidar CALIOP has 1064 nm standard backscatter channel
- Pressure tuned
- Metal Spacer has CTE to make FWMI thermally invariant

[1] Burton, S. P. et al. Appl. Opt. 57(21) 6061-6075

$$\Delta n_g = \frac{n_g^2 - 1}{2n_g}\left(D_0\Delta T + D_1\Delta T^2 + D_2\Delta T^3 + \frac{E_0\Delta T + E_1\Delta T^2}{\lambda^2 - \lambda_{tk}^2}\right)$$

$$n_{air} = 1 + \frac{\left(6432.8 + \frac{2949810\lambda^2}{146\lambda^2 - 1} + \frac{25540\lambda^2}{41\lambda^2 - 1}\right) \times 10^{-8}P}{1 + 3.14785 \times 10^{-3}(T - 15)}$$

Parameter	Value [2]
D_0	2.06 x 10^{-5}
D_1	2.51 x 10^{-8}
D_2	-2.47 x 10^{-11}
E_0	3.12 x 10^{-7}
E_1	4.22 x 10^{-10}
λ_{tk}	0.16

- Wavelengths are in microns
- ΔT reference temperature is 20 °C
- $n_g = 1.449609$
- P is pressure in atm
- The temperature variation from these two equations, along with the CTE of fused silica, were used to find the proper CTE of the metal spacer to make the FWMI thermally invariant.
- The FWMI is tuned using the pressure (density) dependence of n_{air}

[2] ZEMAX®Optical Design Program User's Manual (ZEMAX Development Corpo ration, 2010)
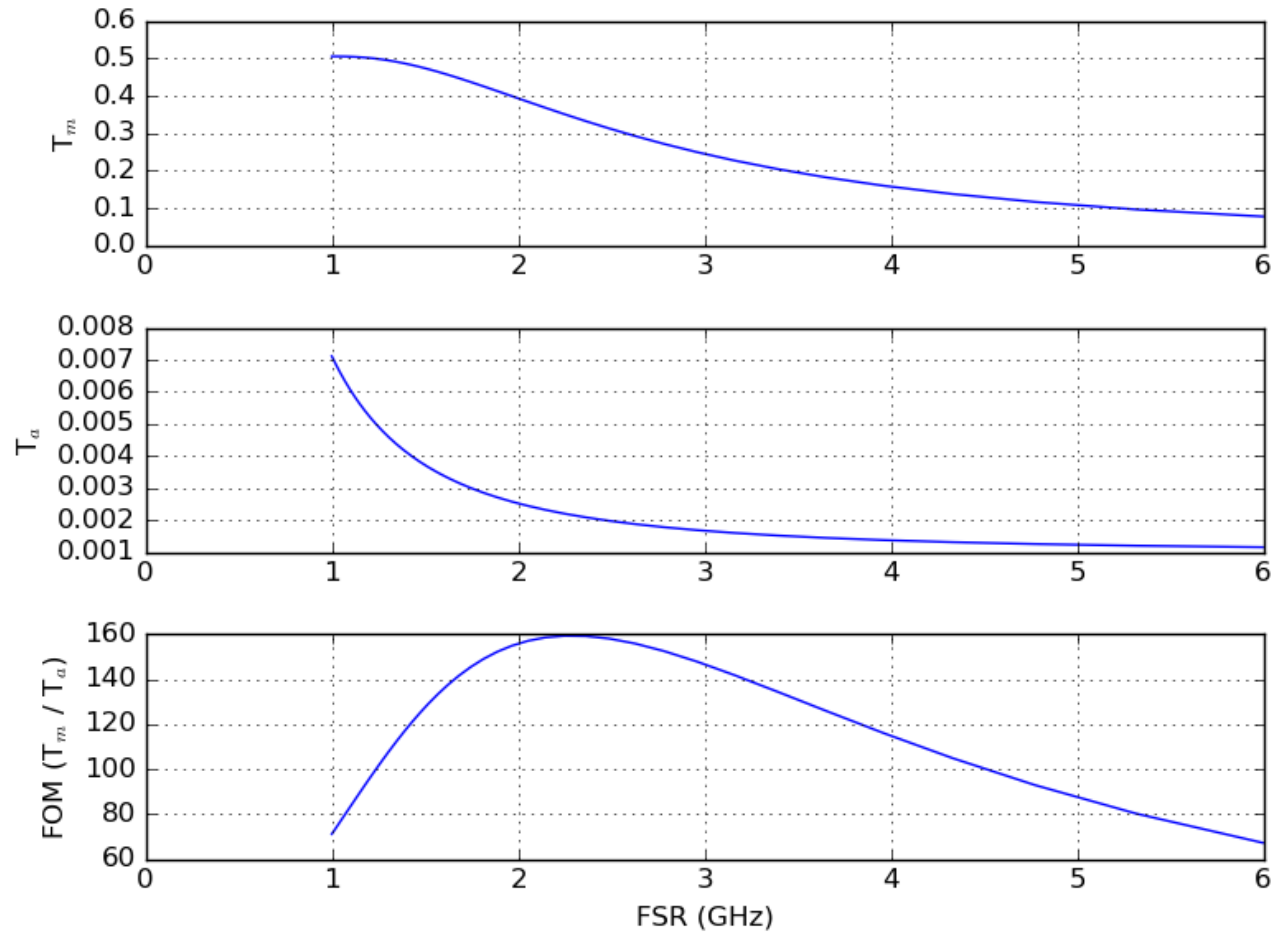
- Free spectral range was chosen to maximize molecular transmission in the molecular channel while minimizing aerosol transmission in this channel.
- Figure of merit is the ratio of these two
- FOM exhibits a peak due to wavefront distortion producing a floor in the aerosol transmission
- 1.5 GHz provides a good compromise
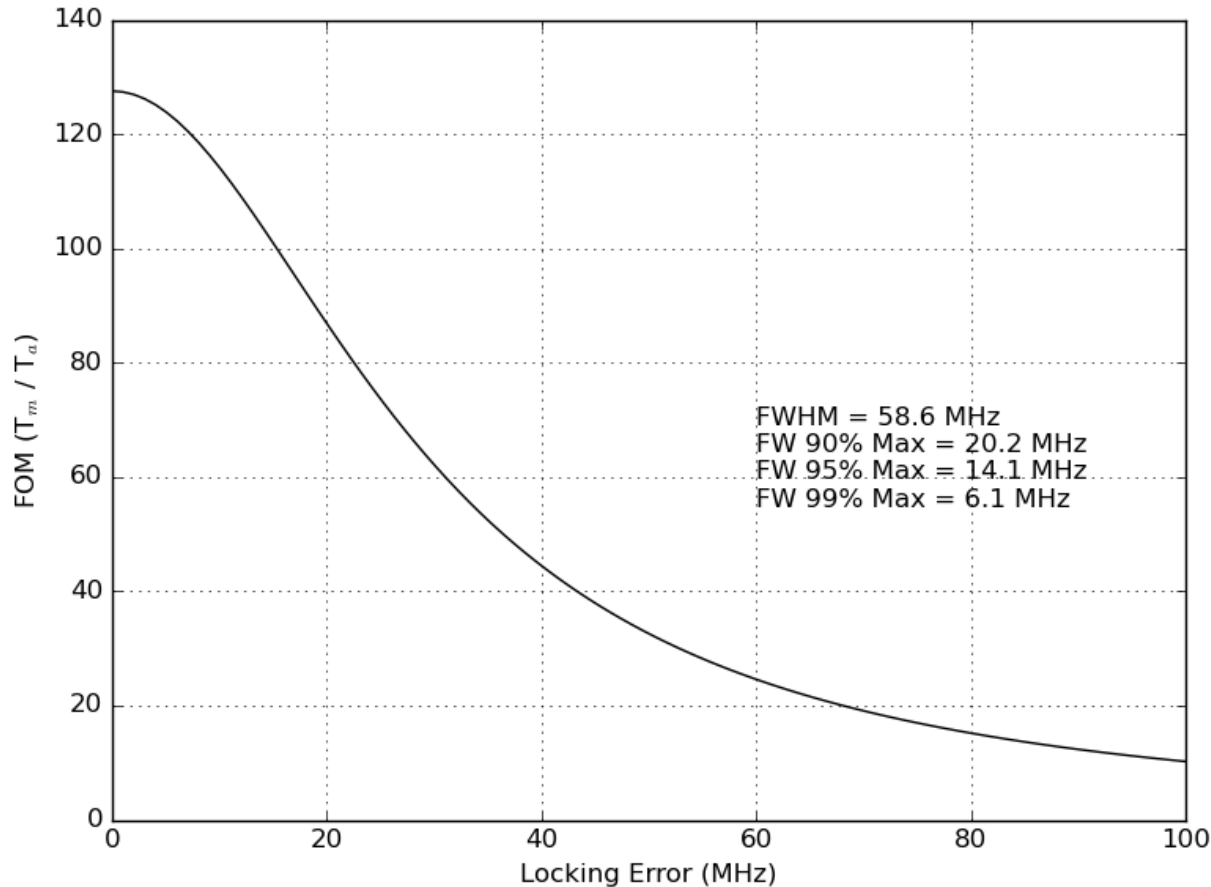
- Figure of merit is molecular transmission in molecular channel divided by aerosol transmission in molecular channel
- FWMI design is insensitive to tilt/divergence angle and temperature
- To keep FOM to within 1 % of its maximum value, the pressure must be stable to 0.086 mbar

Parameter	Value
FSR (GHz)	1.5
Glass Arm Length (mm)	131.571
Air Arm Length (mm)	90.771
Glass Index	1.449609
Glass dn/dT (ppm / $^\circ C$)	7.933
Air Arm Spacer CTE (ppm / $^\circ C$)	13.47
Pressure Tuning Rate (FSR / atm)	47.62
Tilt Angle (deg)	1.5
Wavefront Error (λ)	0.01
Aperture (mm)	25