

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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Date: 2008/09/08

Fiber Noise Cancellation scheme

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1 Double Passed AOMs

A pickoff from the stable PSL light with frequency f_0 double passes AOM1, driven at a frequency $f_1/2$. The light then travels to the fiber, gaining some noise n . It is then frequency doubled. Assuming the feedback loop sets $f_1 = n$ and there are no additional noise sources, the output light is given by $f_0 + n'$, where n' is noise caused by the frequency doubling process (Figure 1).

A pickoff from the beam after the fiber double passes through AOM2 and is shifted by a fixed frequency f_2 . The light is reflected back into the fiber, again adding noise n , to give a frequency of $f_0 + 2n - f_1 + 2f_2$. The signal is detected by an RF photodetector and demodulated at $2f_2$, frequency divided by 2, demodulated at $f_1/2$, and frequency divided by 2 again to give an $n/2$ signal. It is low pass filtered, and the resulting signal drives the VCO for AOM1 to compensate for the fiber noise n at low frequencies.

how the GPS will help.

The noise df_2 introduced by AOM2 will be directly present in the output of the fiber.

- Electronics
 - RF frequency doubler and divider have phase noise floors of -178 dBc/Hz and -165 dBc/Hz, respectively.
- Phase matching - the signals that are being demodulated have to have the same phase.

2 Single Pass AOM1

The scheme described above double passes AOM1 in order to reduce beam jitter. However, this introduces the need to digitally divide the frequency by 2 in order to get the necessary feedback signal.

From 40m experience, shifting the drive frequency of a 160 MHz AOM by 1 MHz can shift the beam up to one beam diameter. However, the expected amount of frequency noise due to a 4 km fiber should not exceed 2.4 kHz according to my estimate or 2 kHz in the Jun Ye paper for 6.9 km. Thus the fractional change in the drive frequency is minimal and should not affect the position of the beam, enabling us to single pass the first AOM and simplify the remainder of the setup (Figure 2).

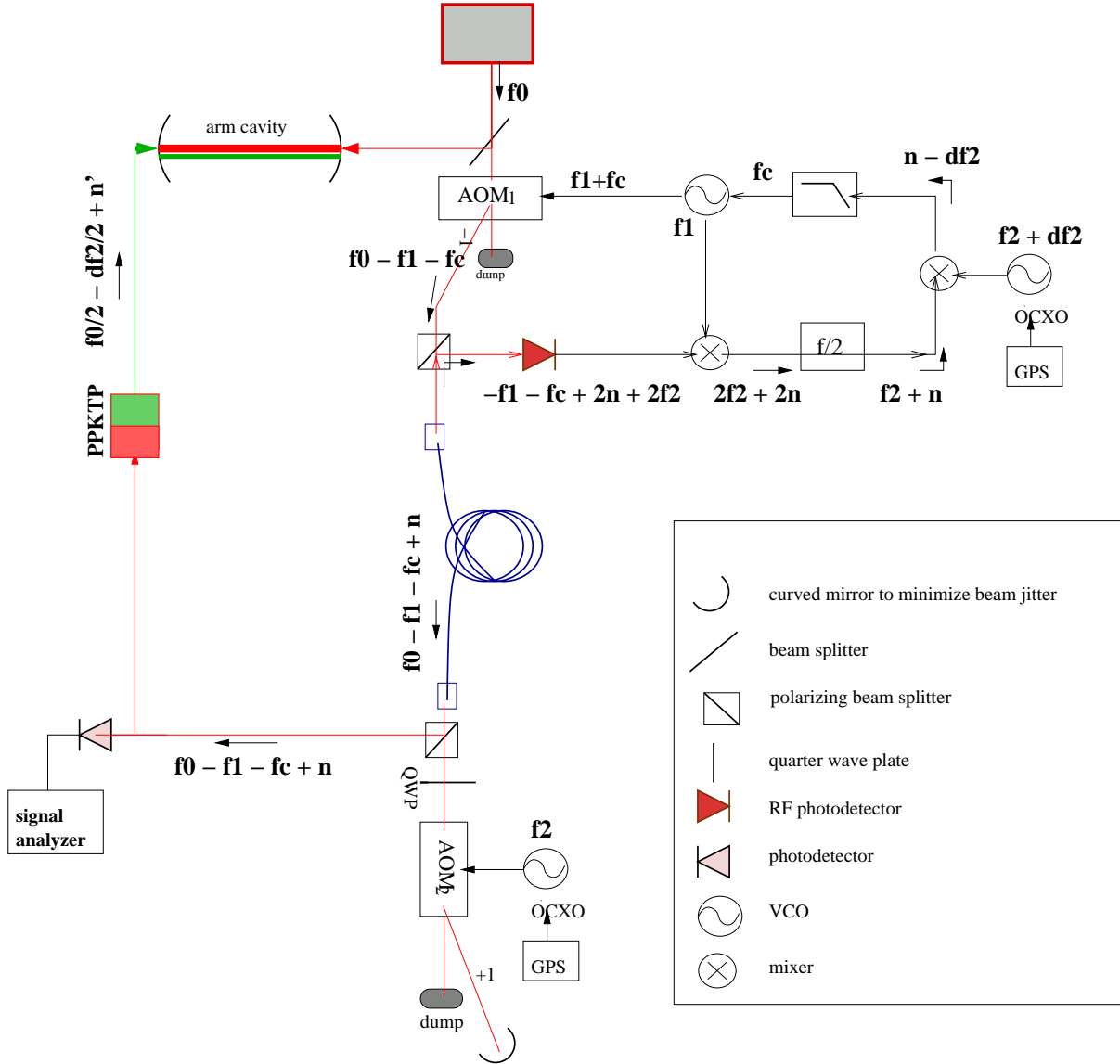


Figure 2: Version 2: Single Pass AOM1

3 Noise cancellation with one AOM

In order to test the noise cancellation scheme as quickly as possible, a simplified setup is proposed. AOM2 is included in the setup in order to distinguish the laser light which has double passes the fiber by introducing a frequency shift equal to the drive frequency of the AOM (for instance 80 MHz). However, since polarization maintaining fiber will be used, it may be possible to distinguish the light using polarization (Figure 3).

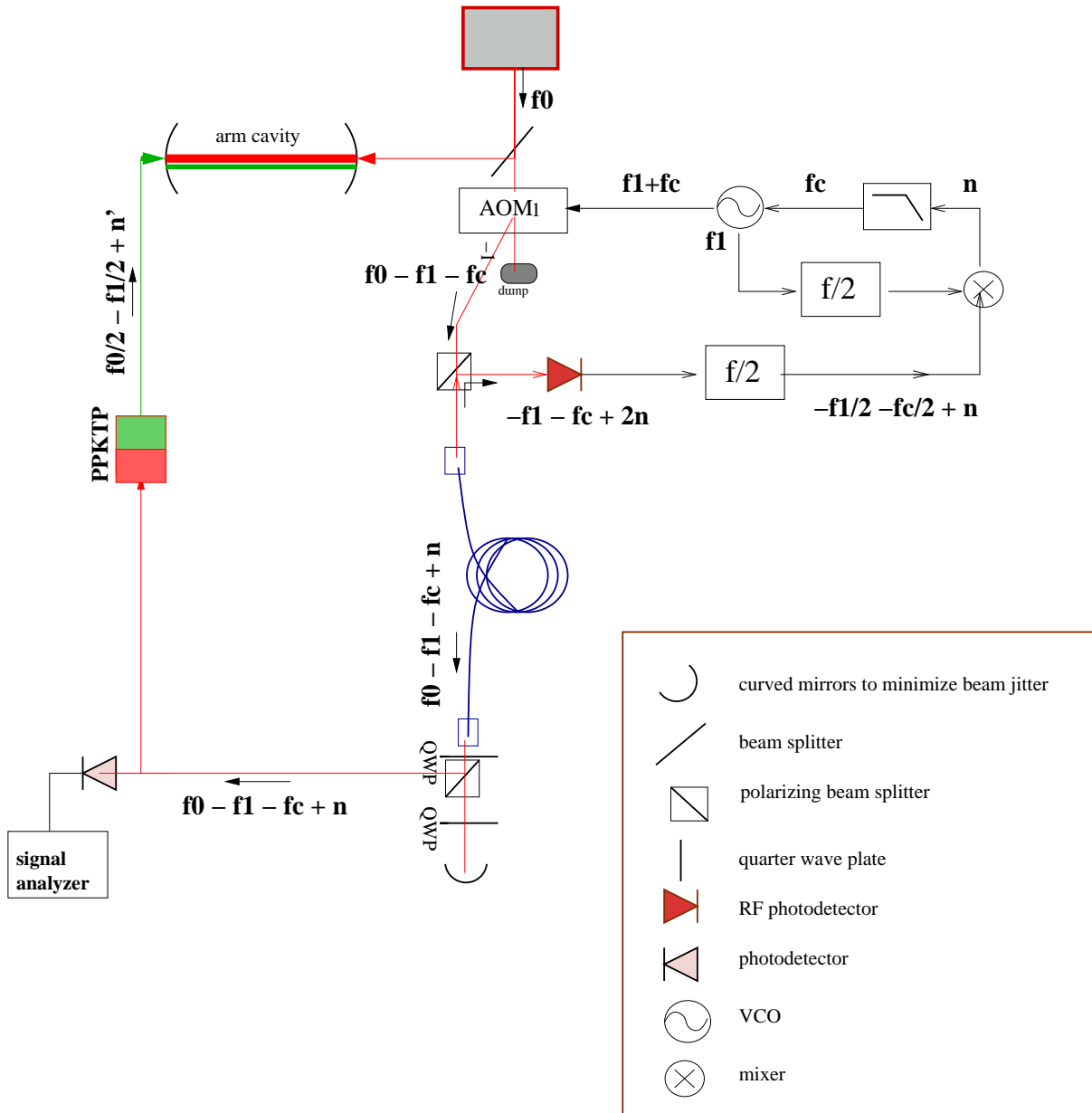


Figure 3: Version 3: Simplified without the second AOM. Double pass beam can be distinguished using polarization, since the fiber we are using is polarization maintaining.