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The key to success is tailoring the FROG Scan specifications to the pulse measurements you wish to make, and FROG Scan is field changeable so its specifications can change with your needs.

How do I determine the FROG Scan Specifications I need?

With the servo on the delay stage of FROG Scan, we can easily achieve any pulse length you need—from 12 fs to nearly 30 ps. However, there are other specifications that are important for accurately measuring ultrashort laser pulses. What are these considerations?

1) What is the shortest pulse I want to measure?
2) What is the maximum bandwidth I need to consider?
3) What is the longest transform limited pulse/feature I need to measure?
4) Will I be doing pulse shaping?
5) What wavelength ranges am I interested in?
6) What is the minimum intensity I need to detect?

Bandwidth

The answers to the first two questions go hand in hand. A rough idea of the bandwidth needed can be determined by the time-bandwidth calculation $\Delta\tau_{FWHM}\Delta f_{FWHM}$~0.44. Thus, if you what to measure a transform-limited 30 fs laser pulse, the widest spectral width is 14.7 THz, or 489 cm^{-1}. From this, we can determine the crystal thickness appropriate for your needs by determining the group delay in the SHG crystal between the fundamental and the second harmonic. A 30 μm thick BBO crystal can be used to measure pulses as short as 12 fs at 800 nm. A 100 μm thick BBO crystal can be used to measure a transform-limited pulse slightly less 40 fs in duration at 800 nm. If you pulse is chirped, then you will need a thinner crystal.

Spectral Resolution

Good spectral resolution is needed for two situations-measuring long pulses and pulse shaping. The first is for measuring long, transform-limited pulses. In this case, we use the time-bandwidth formula to determine the bandwidth of the longest transform limited pulse. For a 1 ps pulse, its bandwidth is only 15 cm^{-1}. However, the bandwidth of the pulse increases by roughly a factor of the $\sqrt{2}$ when frequency doubled, increasing the bandwidth to 21 cm^{-1} at the second harmonic. For an 800 nm 1 ps laser pulse, we would need a resolution of 0.34 nm at 400 nm.

For pulse shaping, you also need good spectral resolution because of the spectral filtering and the higher order phase distortions that can create structure in the FROG trace that requires spectral resolution to resolve and provide good contrast.

Sensitivity

We determine the sensitivity by specifying the peak power multiplied by the average power. This allows us to compare lasers with different pulse widths and repetition rates. Thus, for an oscillator outputting 100 fs pulses at an 88 MHz repetition rate, with an average power of 100 mW, we have a peak power of about 100mW/(100fs * 88MHz) = 11.4 kW, which gives an average power times the peak power of 1140 W^2. This is much greater than the sensitivity rating of 4 W^2 for FROG Scan fitted with a 30 μm thick crystal so FROG Scan can easily detect pulses from a laser with these specifications. The SHG signal is proportional to the thickness of the crystal squared so a 100 μm thick crystal provides about 10 times the signal and, consequently, 10 times the sensitivity.

Wavelength Considerations

As the wavelength decreases, the required crystal thickness decreases for a given pulse width. Therefore, measurement of a 500 nm 30 fs pulse requires a 20 μm thick BBO crystal. Just the opposite is true for the IR.