Factors affecting the resolution of Femtochrome SHG Autocorrelators:

- Material Dispersion .... <<1 fs
- Delay Resolution .... << 1fs
- Group Velocity Dispersion (GVD) in air .... < 1fs
- Group Delay Dispersion (GDD) of Mirror Reflections .... < 1fs
- Beamsplitter .... < 1fs
- Focus Mirror .... << 1fs
- NL crystal thickness

Using only reflective optics, material dispersion is nonexistent in **Femtochrome** Autocorrelators.

Delay Resolution is also << 1fs, w/ **Femtochrome**'s unique //Mirrors rapid scan delay technique*.

GVD in Air

Travelling a length z of material, a Gaussian pulse $\mathbf{E(t) = \exp[-t^2/(2T_o^2)]}$ of initial duration T_o

($\mathbf{To = 0.6T_{fwhm}}$) stays Gaussian with duration broadening as:

$$\mathbf{T = To\,[1 + (zk''/T_o^2)^2]^{1/2}}$$

where k" is the GVD parameter. In the case of air, $\mathbf{k'' = 0.2(fs)^2/cm}$ at 800nm, and $k'' = 0.1(fs)^2/cm$ around 1.5µm.

The pathlength travelled in air within the FR-103XL before the NL crystal is ~ 60cm.

It follows that, broadening in air is negligible for pulsewidths > 10fs.

For T_{ofwhm}= **5fs** (To=3fs), T= 1.17T_o and T_{fwhm} = **5.8fs**

Hence, the affect of GVD in air is < 1fs down to 5fs pulsewidth!

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* See accrcy.pdf

GDD of High Refecting Metallic Mirrors

There are 5-6 reflections from metallic coated mirrors for either beam in the FR-103XL.

k"=GDD/unit length, and assuming that $T = T_o[1+ (GDD/T_o^2)^2]^{1/2}$ in analogy with the above,

$T = T_o [1+(GDD/T_o^2)^2]^3$ after 6 reflections. [This is an upper limit!].

For Femtochrome Ag coated mirrors, **$|GDD| < 3(fs)^2$** .

For an input pulsewidth of **T_{ofwhm} = 6fs**,   To = 3.6fs, and it follows that

$T = To[1+0.05]^3 = 1.16T_o$ Hence **T_{fwhm} = 6.95fs**

Hence, the affect of GDD of mirror reflections is <1fs, down to a 6fs pulsewidth!

Focus Mirror

Use **parabolic mirror** for < 30fs pulsewidths, to have <<1fs resolution

NL Crystal

Depending on the crystal and wavelength ~100µm crystal thickness would be generally sufficient , down to ~20fs pulsewidth. For shorter pulsewidhs, a thinner NL crystal needs to be user

specified.

Beamsplitter

Femtochrome utilizes < .25 µm thick beamsplitters yielding close to 33/67 (R/T) ratio with good uniformity over a broad wavelength range. This is close to ideal(R/T=50/50) since the intensity of beams incident on the NL crystal (RT) is then ~ .22 as compared to .25 for the ideal case.

Motor Jitter

The uniform rotation mode with high angular momentum leads to generation of optical delay with a precisely known functional form, as shown above. This motion is phase locked loop (PLL) crystal controlled, and its jitter is measured to be < 10µsec/100ms peak-to-peak.

Hence, due to this jitter

$$\Delta T_j/T < 10^{-4}.$$

For instance, if T=10ps, ΔT_j <1fs.

// Mirrors accuracy

Parallelism of delay mirrors is < 0.5×10^{-3} radians in all FR-103 units, to assure <1%/100ps affect on measured pulsewidth.