Principles of Temporal Dispersion in Ultra-short Laser Pulse

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Presentation Outline

- Focusing elements for laser beam
- 1-1 imaging , using singlet lens.
- Short principles of physical optics propagation @ ZEMAX
- Conclusions

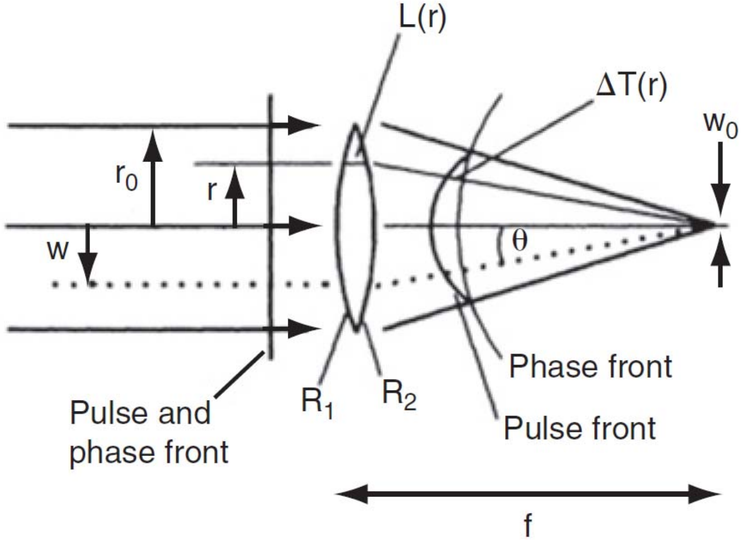
Focusing Element

The group velocity dispersion leads to reduction of peak intensity by stretching the pulse in time.

When simple focusing singlet lenses are used, the former effect can lead to several picosecond lengthening of the time required to deposit the energy of a fs pulse on focus.

$$\nu_g = \left(\frac{dk}{d\Omega}\right)^{-1} = \frac{c}{n - \lambda_\ell \frac{dn}{d\lambda}} \neq \nu_p = c/n$$

λ_ℓ : is the wavelength in vacuum.

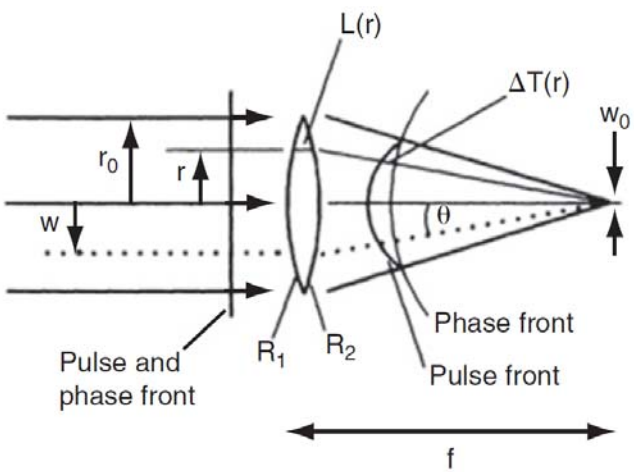


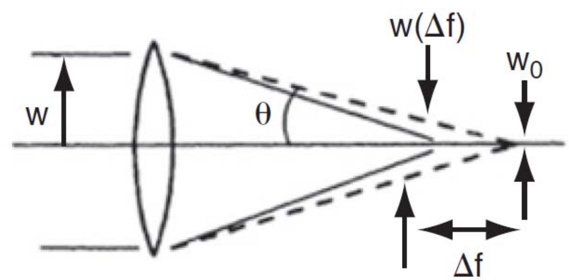
Singlet Lens, 1:1 imaging

The difference in propagation time between the phase front and pulse front after the lens at the radius coordinate *r* is :

$$\Delta T(r) = \left(\frac{1}{\nu_p} - \frac{1}{\nu_g}\right) L(r)$$

$L(r)$: is the lens thickness.





Singlet Lens, 1:1 imaging (case study)

Excimer Laser (KrF):

T_{pulse} (FWHM) = 50 fs

w_o = 0.6 μm

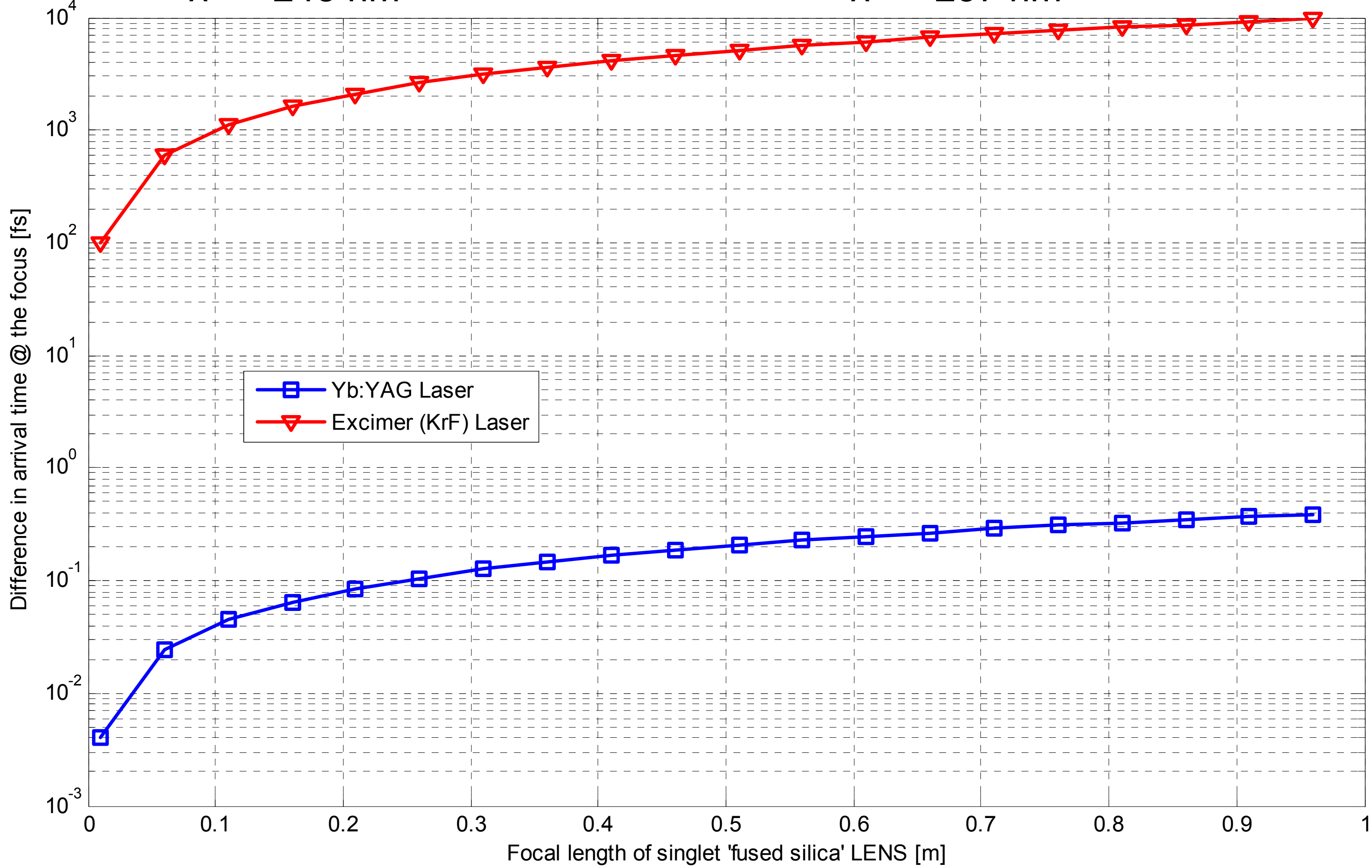
λ = 248 nm

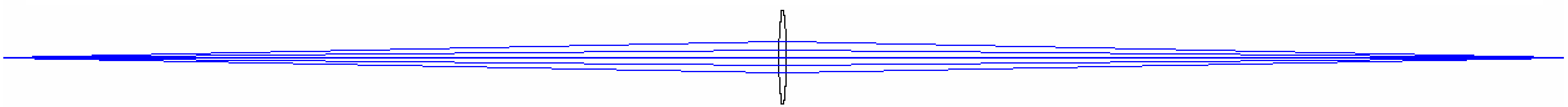
Yb:YAG Laser:

T_{pulse}(FWHM) = 20 ps

w_o = 100 μm

λ = 257 nm





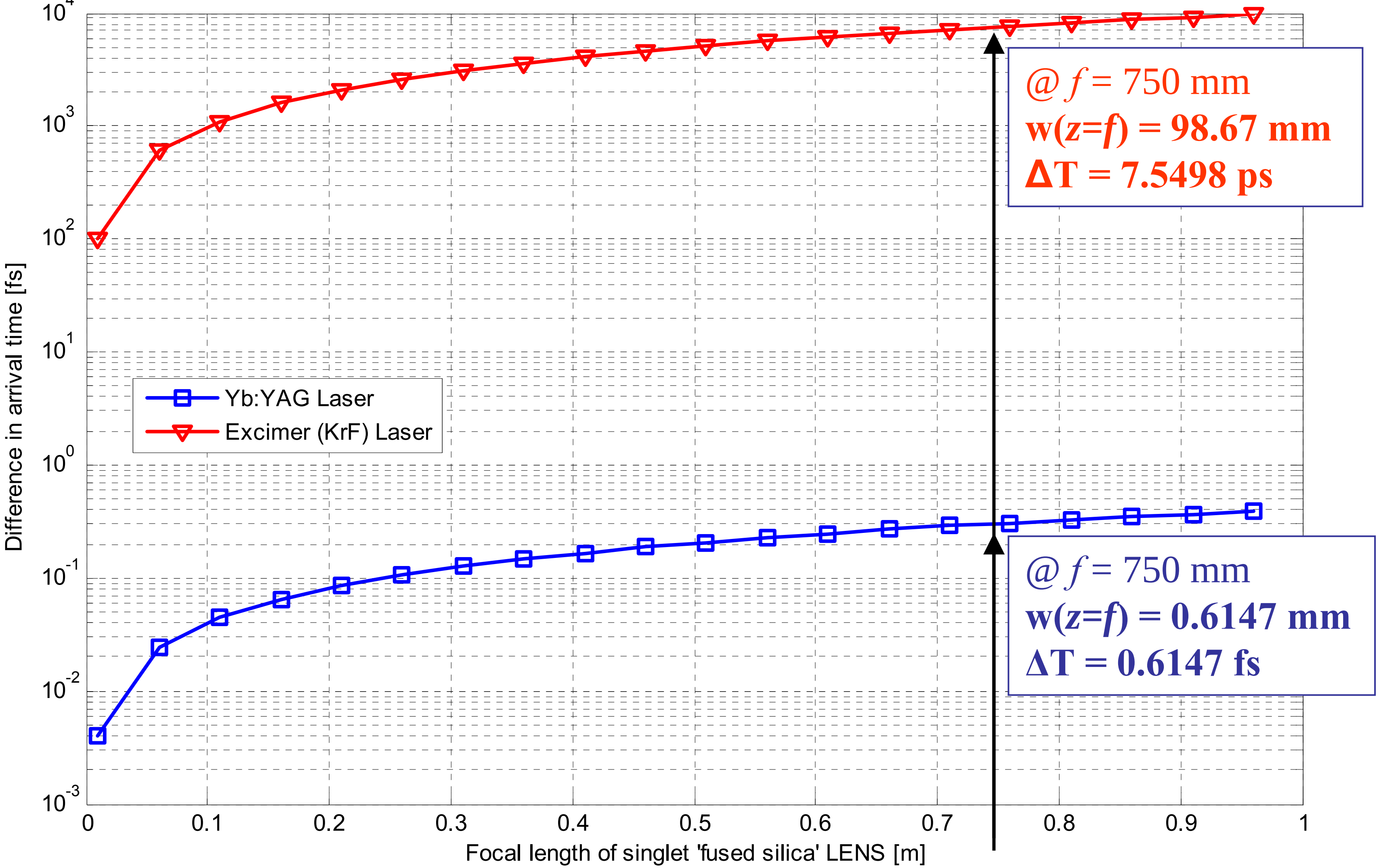
Singlet Lens, 1:1 imaging

Excimer Laser (KrF):

T_{pulse} (FWHM) = 50 fs
w_o = 0.6 μm
λ = 248 nm

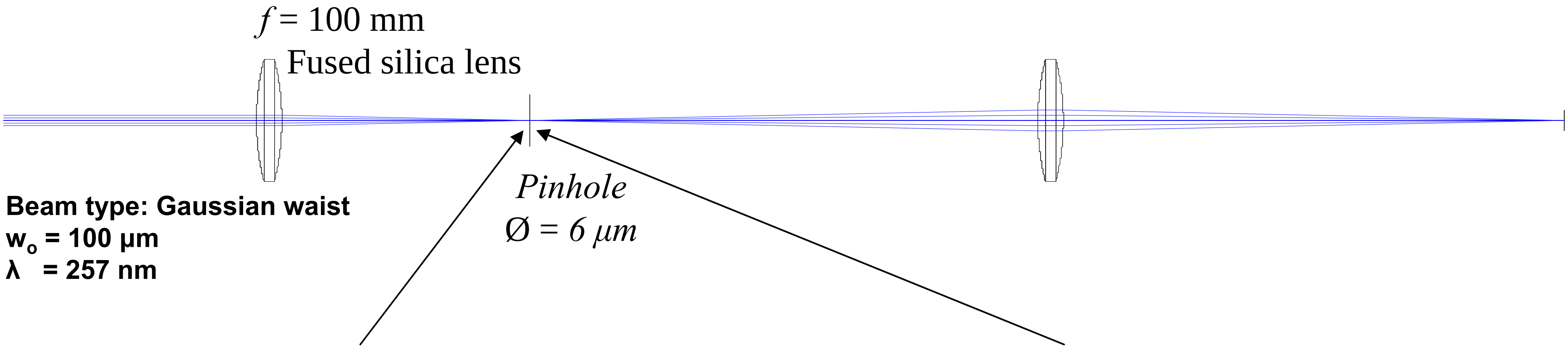
Ytterbium-doped YAG Laser:

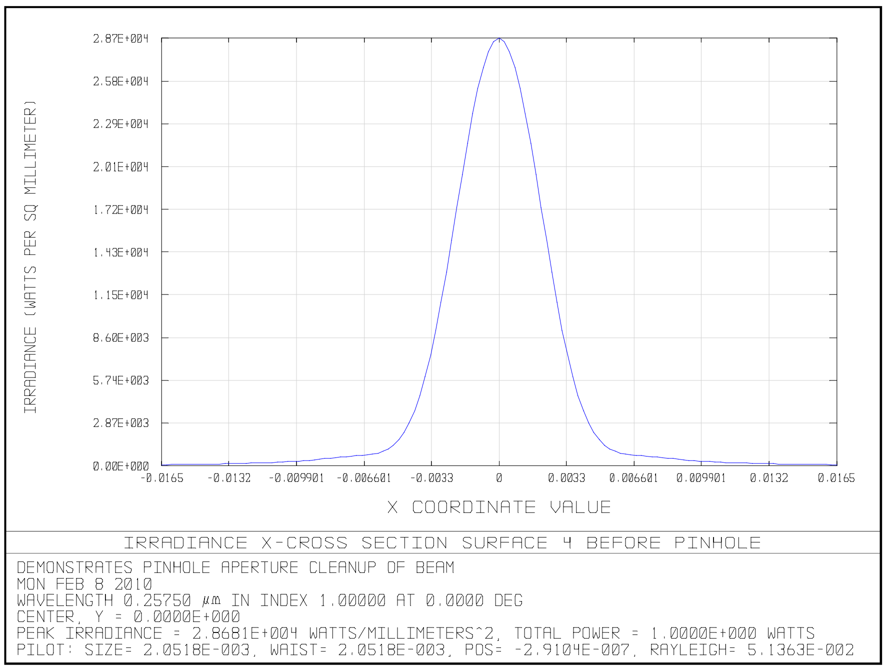
T_{pulse}(FWHM) = 20 ps
w_o = 100 μm
λ = 257 nm

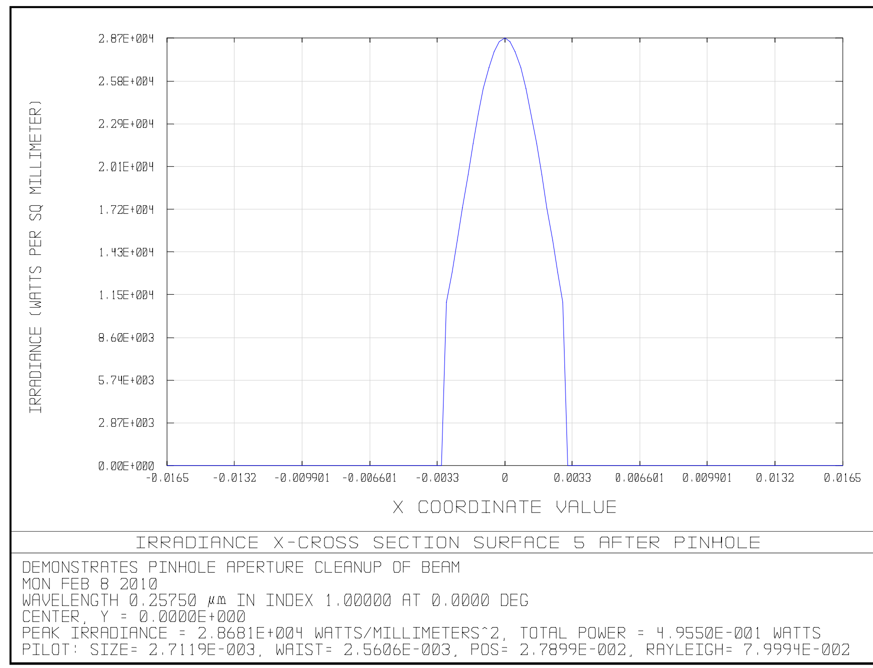


Physical Optics Propagation @ ZEMAX

Beam type: Gaussian waist
w_o = 100 μm
λ = 257 nm







Conclusions

$$\nu_g = \left(\frac{dk}{d\Omega}\right)^{-1} = \frac{c}{n - \lambda_\ell \frac{dn}{d\lambda}} \neq \nu_p = c/n$$

1. The difference in arrival time of laser pulse in Air is ~ 47fs per meter

   for $L = 30$ m, $\Delta T \sim 1.4$ ps.

2. The time dispersion in the first lens will accumulate with the next lenses, the relationship will be nonlinear.

3. According to Fermat's principle, the dispersion will increase in case of magnification ($M_s \neq 1$).

Thank you