Fibre Transfer of RFG drive laser

KURIKI Masao (Hiroshima/KEK)

Requirements

- L-band RF Gun for STF should be compatible to ILC beam format
  - **2625 bunches with 369.2ns spacing (2.71MHz)**
  - **Bunch charge 3.2nC**
  - **Laser pulse energy 1.5uJ (1%QE) with 10ps FWHM.**
- For Quantum Beam project, an example of parameter sets is
  - **162500 bunches with 6.15ns (162.5 MHz)**
  - **Bunch charge 62pC**
  - **Laser pulse energy 29nJ (1%QE) with 10ps FWHM**
  - **Less peak power, an equivalent average power**

Issues

- There are several concerns for fiber transfer of the drive laser light.
  - **Fused silica bulk damage limit**
  - **Fused silica surface damage limit**
  - **Non-linear effects**
- 1.5uJ/10ps has the highest peak power among the parameters.
- For single mode propagation,

$$V=\frac{2\pi}{\lambda}a\sqrt{n_{core}^2-n_{clad}^2}<2.405$$

- By considering practical limits on controlling the refractive index, 35um MFD is the largest one. Larger MFD is possible by employing PCF, etc.

Bulk Damage Limit

- Bulk damage limit for 1ns pulse : 220 J/cm2
  - **For 35um MFD, it is $\pi 17.5^2 \times 10^{-8} \times 10^3 \times 220 = 2.12$mJ**
  - **STF pulse : 1.5uJ for 10ps. If this pulse is simply extended to 1ns, the energy is 150uJ, which is well below than the damage limit.**
  - **According to the bulk damage limit, the laser pulse transportation has no difficulty.**

Surface Damage Limit

- Surface damage limit on the fused silica fiber is given as

$$E_{sd} = 22\tau^{0.4}(ns^{0.4})(J/cm^2)$$

  - **Which gives 3.5 J/cm² for 10ps pulse.**
  - **For 35um MFD, the limit is 10.7uJ for 10ps.**
  - **This limit is 7 times larger than our pulse energy. Our laser is transferable by the optical fiber without the surface damage.**

Non-linear effects

- Non-linear effects disturb the laser light transmission through the optical fiber.
  - **Self Phase Modulation : Refractive index has a dispersion relation, which depends on the wave length. The phase is modulated and the pulse shape is deformed.**
  - **Stimulated Raman Scattering (SRS) : Raman scattering is interaction between the laser photon and phonon. In SRS case, the interaction is a "stimulated" phenomena, in where the laser light acts as "pump light" for Raman-Stokes photon.**

SRS

- SRS case, the critical power P_{cr} is

$$P_{cr} = \frac{16 A_{eff}}{g_R L}$$

  - **A_{eff}: is effective mode area, g_R is Raman gain~ 1E-13m/W for Silica fiber at 1um, L is fiber length.**
  - **35μm core 10m fiber gives 15kW.**
  - **For 35μm and 150kW peak power, L becomes 1m. That means SRS is significant for this peak energy. Laser frequency is modulated by SRS (longer wave length) , which is useless for beam generation.**

SRS (2)

- Depending on g_R for UV region, feasibility of the fiber transfer of the driver laser light is decided, but it is basically larger for shorter wavelength and it is likely to be difficult.
- When it is critical, possible solutions are
  - **Place the laser in near of the gun,**
  - **Change the operation mode. less peak power, high repetition operation,**
  - **Chirped pulse transportation,**
  - **Give up the fiber transportation; Free space transfer.**

Summary

- Fiber transfer of the drive laser light is considered.
- Our operation regime is well below the damage threshold.
- SRS may be critical, depending on Raman gain at 260 nm region.
- Continue investigations.