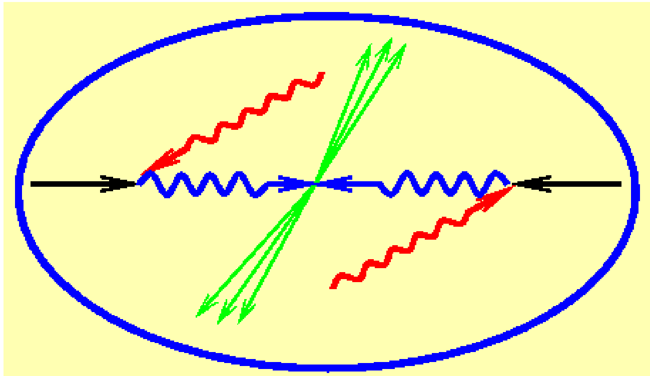

A FEL pumped solid state laser system for the photon collider at CLIC

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Requirements
to a laser system for a photon collider at CLIC

Laser wavelength	~ 1 μm
Flash energy	A~5 J
Number of bunches in one train	354
Length of the train	177 ns=53 m
Distance between bunches	0.5 nc
Repetition rate	50 Hz

The train is too short for the optical cavity, so one pass laser should be used.

The average power of one laser is 90 kW (two lasers 180 kW).

Possible approaches

•FELs based on CLIC drive beams.

Drive beams: 8.4 nC, E=2.37 GeV, (19 J/ bunch)

It is impossible to convert to photons 5/19=26% of the beam energy. In addition, the laser pulse should be several times shorter than the CLIC drive bunch.

•Solid state lasers pumped by diodes.

Storage time of the laser medium is about 1 ms. Two laser trains contain the energy about 4 kJ, efficiency of diode pumping about 25%, therefore the total power of diodes should be P~4000/0.001/0.25~15 MW. The cost of 1 W is about 5$, so the cost of diodes for the laser system ~ 100 M$. Quite expensive, though reduction of the diode cost is possible in future.

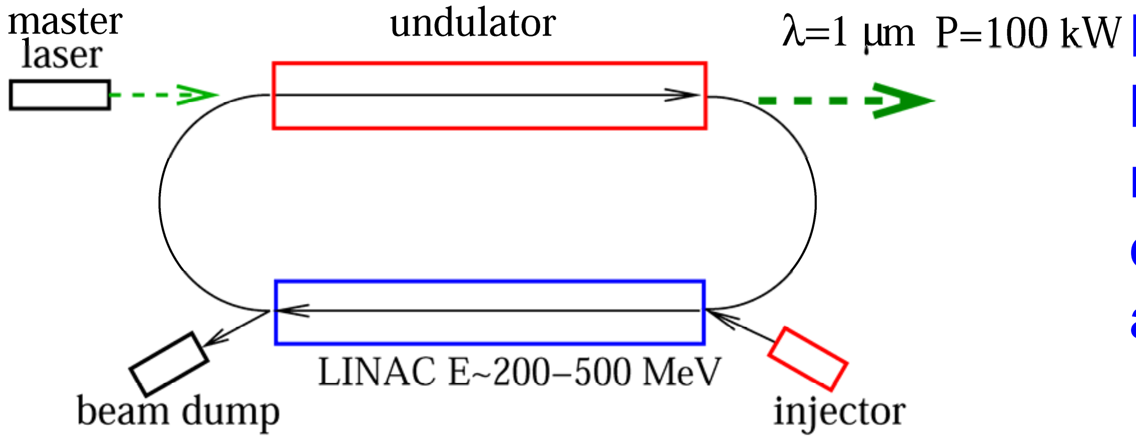
So, this technology is possible, LLNL works in this direction for laser fusion applications.

Present suggestion:

to use FELs instead of diode for pumping of the same solid state laser medium.

As we have seen it is difficult for FEL to produce 5J laser pulse by one electron bunch. In addition, for production of one train there are only 177 ns. So, the peak electron beam power at 3% FEL efficiency should be 330 GW !

In the suggested scheme we have ~1 ms storage time of the solid medium, 5000 more time than in the case of the direct usage of FEL. The electron beam peak power is only 60 MW and the average power 60*0.001*50=3 MW.



Moreover, the electron beam energy can be recuperated. Only 3% of energy is lost to photons and not recuperated.

With recuperation and 10% wall plug RF efficiency the total power consumption of the electron accelerator from the plug will be about 1-2 MW only.

The FEL can have rather low electron energy, E~100 MeV is sufficient. This should be SC linac (with recuperation).

All the rest is the same as in solid state lasers with diode pumping. It is not excluded that the FEL pumping gives less heat than diodes (because its wavelength can be adjusted to the laser medium).

Conclusion

The FEL pumped solid state laser with recuperation of electron beam energy is very attractive approach for short train linear colliders, such as CLIC.