Jena Contribution to ICAN-B

General:

The ICAN laser concept is based on coherent combining of ultrashort-pulse fiber laser systems. Several techniques have been proposed in order to increase the pulse energy, which is otherwise limited by nonlinear effects in a fiber amplifier. As a result from the considerations done within ICAN, it is advisable to employ, besides the spatially separated amplification and coherent combination, additionally a temporal pulse stacking. A promising technique of achieving this is to use an enhancement cavity (EC). An EC coherently overlaps multiply pulses of a high repetition rate fiber laser into a single pulse, which is coupled out with high efficiency at a lower repetition rate, converting average power to pulse energy. This approach ensure to remain the benefits of fiber laser, especially high average power and convert it to high pulse energies. Several issues have to be addressed to evaluate and assess the limitation of these new approaches.

Goal:

Jena's contribution to ICAN-B will focus on the temporal combining scheme with an enhancement cavity and by using a burst of pulses. It is the overall goal to demonstrate a fiber based system with >100mJ pulse energy (compressible) at 10kHz repetition frequency (i.e. 1kW of average power).

A) high energy burst fiber amplifier

   objectives: 100MHz micro pulse repetition rate, 5-50 pulses, overall 25mJ per burst, 10kHz macro pulse repetition rate from one fiber
   coherent addition of up to 8 burst amplifiers
   investigations on high-energy high-average power burst operation (energy extraction, pulse shaping, intra-burst mode instabilities)

B) pulse stacking in low-finesse enhancement cavity

   optimization of input coupler
   targeted efficiency of enhancement >70%
   i.e. >140mJ stacked pulse energy

C) Dumping

   Investigation of dumping ratio vs. built up efficiency
   Investigation of suitable dumper
   Power handling considerations (EOD, AOM, PC, …)
   Investigation of non-steady state locking

Firstly, a high-energy burst amplifier has to be set up capable of emitting a burst of pulses (5-50), with an adjustable pulse-train shape. In order to achieve the targeted project parameters of <100mJ compressible pulses, eight of these amplifiers have to be spatially combined before the pulse stacking. Afterwards, a low-finesse enhancement cavity (pulse stacker) will be developed, where the enhancement and out-coupling strategy is experimentally tested. The cavity will be seeded by a burst of pulses that are temporally stacked. This will help to advance the scheme and estimate parameters for scaling to higher power and efficiency levels.

Possible work packages, advances beyond state of the art:

(1) Burst Enhancement

- optical and thermo-optical design of enhancement cavity
- design und realization of enhancement cavity incoupling/ outcoupling & locking scheme
- optimization of cavity loading and efficiency calculations
- Experimental burst-mode enhancement by use of available CPA system

Demonstration of >10mJ, 10kHz

(2) Fiber Development

- development of fiber core material for ICAN fibers (uniformity, large core)
- single-mode excitation of large core fibers
- end-caping and packaging of ICAN fibers for opto-mechanical stable (interferometric) setups

Budget (real cost, not funded):

Personal: 2 x 120 TEUR/year = 720 TEUR (typically funded: 60%)

Sub-contracting IAP/FSU: 70 TEUR/year = 210 TEUR

Sub-contracting MPQ: 150 TEUR

Material: Cavity: 100 TEUR (part of SC MPQ)

Fibers: 150 TEUR

Consumables: 100 TEUR

Travel etc: 20 TEUR