PHELIX, a Petawatt High Energy Laser for Heavy-Ion Experiments

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Construction at the PHELIX laser project [1] continued during the year 2001. A major milestone was reached in May, when the projected performance values were demonstrated at the femtosecond front-end (see Fig.1.). This front-end comprises of a commercial femtosecond oscillator (Coherent Mira), pumped by a 10 W diode-pumped Nd:YVO_3 laser, a compact chirped-pulse stretcher unit, and a specially designed combination of each a linear and a ring-configuration regenerative amplifier. Each of these regenerative amplifiers is pumped by a Nd:YAG laser operating at 10 Hz repetition rate. The laser system provides frequency chirped, stretched pulses with nearly 10 nm bandwidth (FWHM) and an energy of 40 mJoule for the injection into the pre-amplifier section.

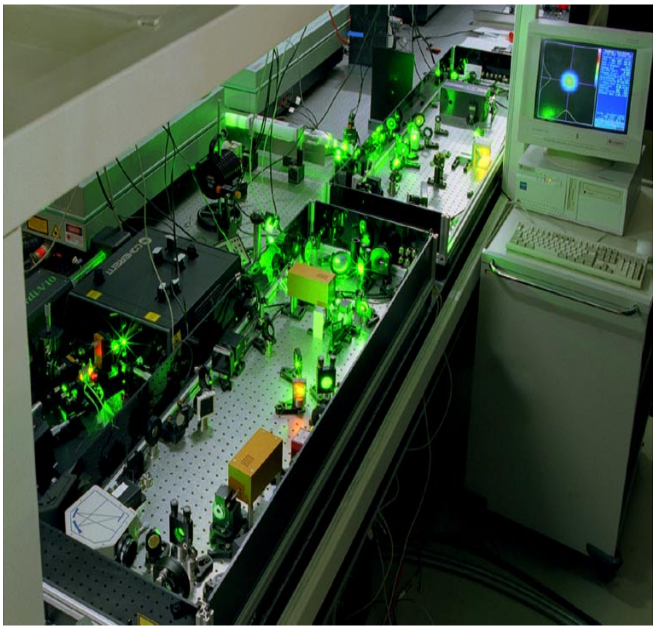

Figure 1.: In May the required performance data were demonstrated of the femtosecond-frontend. In the foreground linear regenerative amplifier is shown, behind it the ring amplifier. In the background the two Nd:YAG pump lasers are visible. Lids normally covering the light pass have been removed for better visibility.

These laser pulses are synchronized to sub-ns precision to an external RF-clock and it is feasible to link the clock to the timing of the UNILAC or the SIS. The synchronization between laser pulses and ion pulses has been worked out to ns precision and is straightforward to implement.

Fig. 2 : The 45 mm amplifier of the pre-amplifier section. The Nd:Glass amplifier rod is surrounded by 12 flash lamps.

Components of the pre-amplifier were tested and delivered later in the year, including the 45 mm amplifier shown in Fig. 2. The implementation into the front-end section was prepared and will soon start. Implementation of adaptive optics is now foreseen using an 80 mm deformable mirror immediately after the pre-amplifier section. This will compensate for distortion in the glass rods and partly also pre-compensate the effects of the high-energy amplifier. Components of this system will be evaluated in a test set-up at the Vulcan-Laser facility at the CLF [2] in spring 2002.

For the diagnosis of the laser pulse profile at various positions along the beamline, which requires simultaneously triggered acquisition of several pictures, a FireWire based camera solution has been successfully implemented and tested using LabVIEW.

The prototype of the charging and firing circuits of the capacitor bank that powers the flash-lamps of the main amplifiers has been developed and tested. For the control of these components a fiber optic based Profibus system with LabVIEW has been implemented and taken into operation.

The optical pass through the amplifier chain was simulated using a raytracing code and a beam propagation code. While the raytracing code is more suitable to minimize wavefront aberrations and to design missing lenses for beam transport telescopes, the beam propagation code includes the laser gain, B-integral, and spatial filter effects. Wavefront distortions, laser gain, and beam shape were simultaneously optimized. Critical parameters like the amplification of stray reflections from the optical surfaces and the fluence on delicate components have been studied in detail.

In parallel, the mechanical preparation of the main amplifier section was continued. The GSI design [3], using components of the Phebus- and Nova-lasers in a folded double-pass, instead of the original single-pass linear chain, requires a number of modifications. In particular the center section of the large spatial-filter telescope on the left side in Fig. 3 has to be changed. Here the pulse from the pre-amplifier is injected through a slightly off-axis pinhole in the focal plane. It will then be directed through the amplifiers on the right hand side via two mirrors, and send back for a second amplification pass.

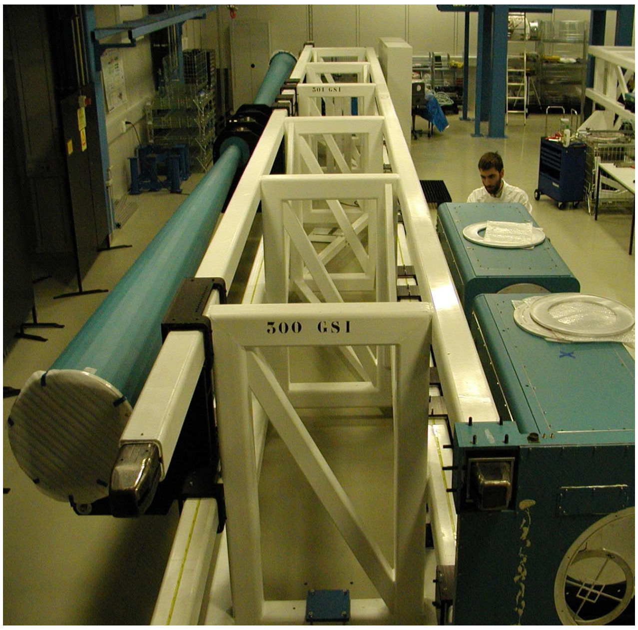

Fig. 3: Mechanical adaptation of the laser components for the main amplifier chain has proceeded. On the right hand side, amplifier modules are mounted. On the left hand side, the spatial filter telescope is modified for the 2-pass design.

An important step towards the installation of laser optics was the completion of the class-100 clean room area. This facility is needed for the final cleaning and assembly of the main amplifier components. It is located in the upper floor of the laser building. As the last missing equipment the large high pressure water spray booth for the cleaning of the amplifier housings, shown in Fig. 4, was installed in November. This unit also serves as an entrance gateway for mechanical components being introduced into the clean-room.

Fig. 4: The high pressure water spray booth for the cleaning of the amplifier housings operates with de-ionized water to avoid residues on the optics, at temperatures up to 60C. It also serves as lock-gate for components being introduced into the class-100 clean room facility located at the other side of the wall.

References

[1] PHELIX Project, GSI-98-10 Report, December 1998

[2] Adaptive Optics trials on Vulcan, S. Hawkes, J. Collier, C.Hooker, C.Reason, C. Edwards, C.Hernadez-Gomez, C.Danson, I.Ross, C. Haefner, Central Laser Facility Annual Report 2000/2001, RAL-TR-2001-030, ISBN 0902376160, P153-155

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