The PHELIX High Energy Laser Facility

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**GSI Helmholtzzentrum für Schwerionenforschung,
Darmstadt, Germany**

EMMI Workshop

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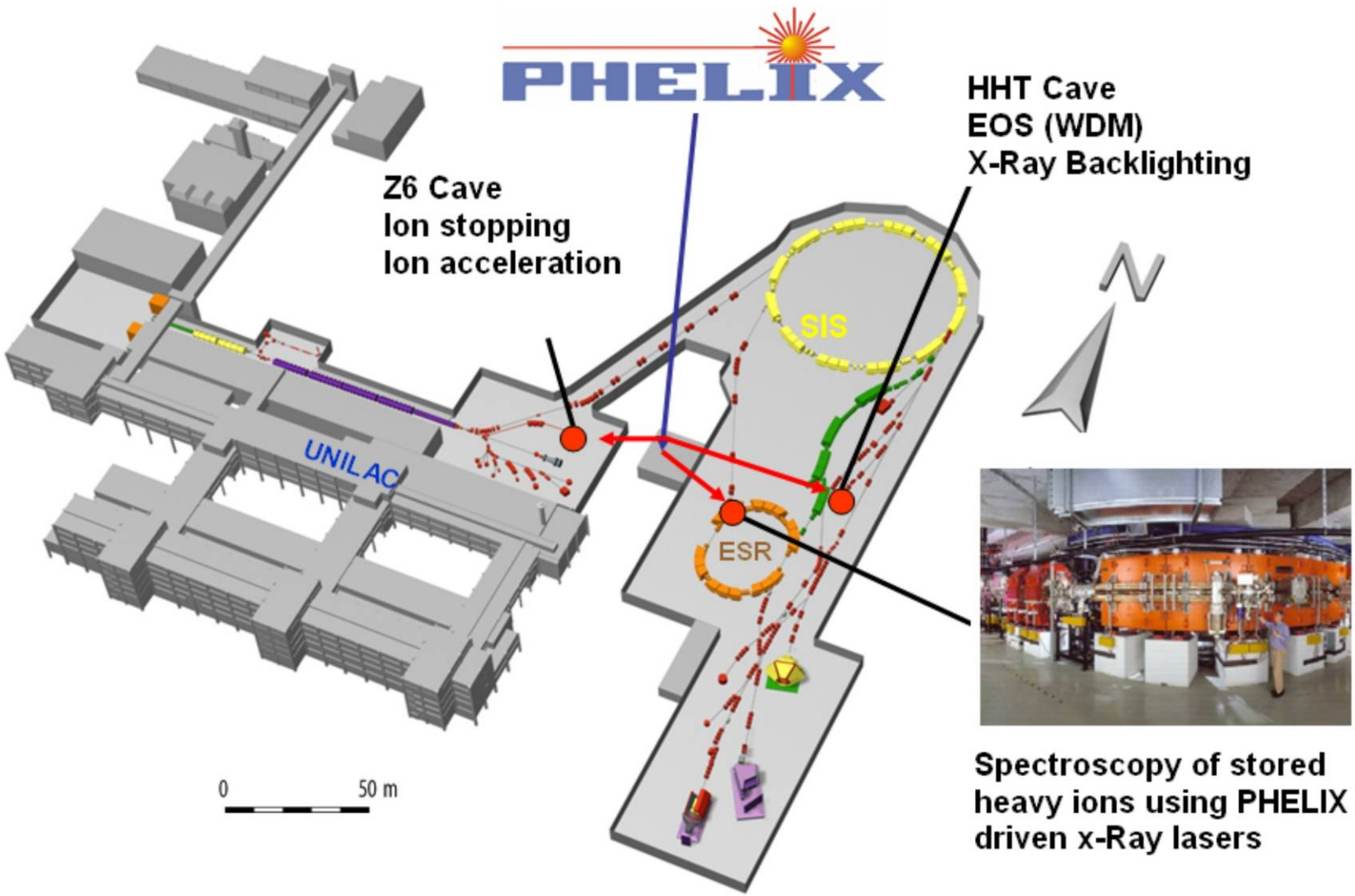
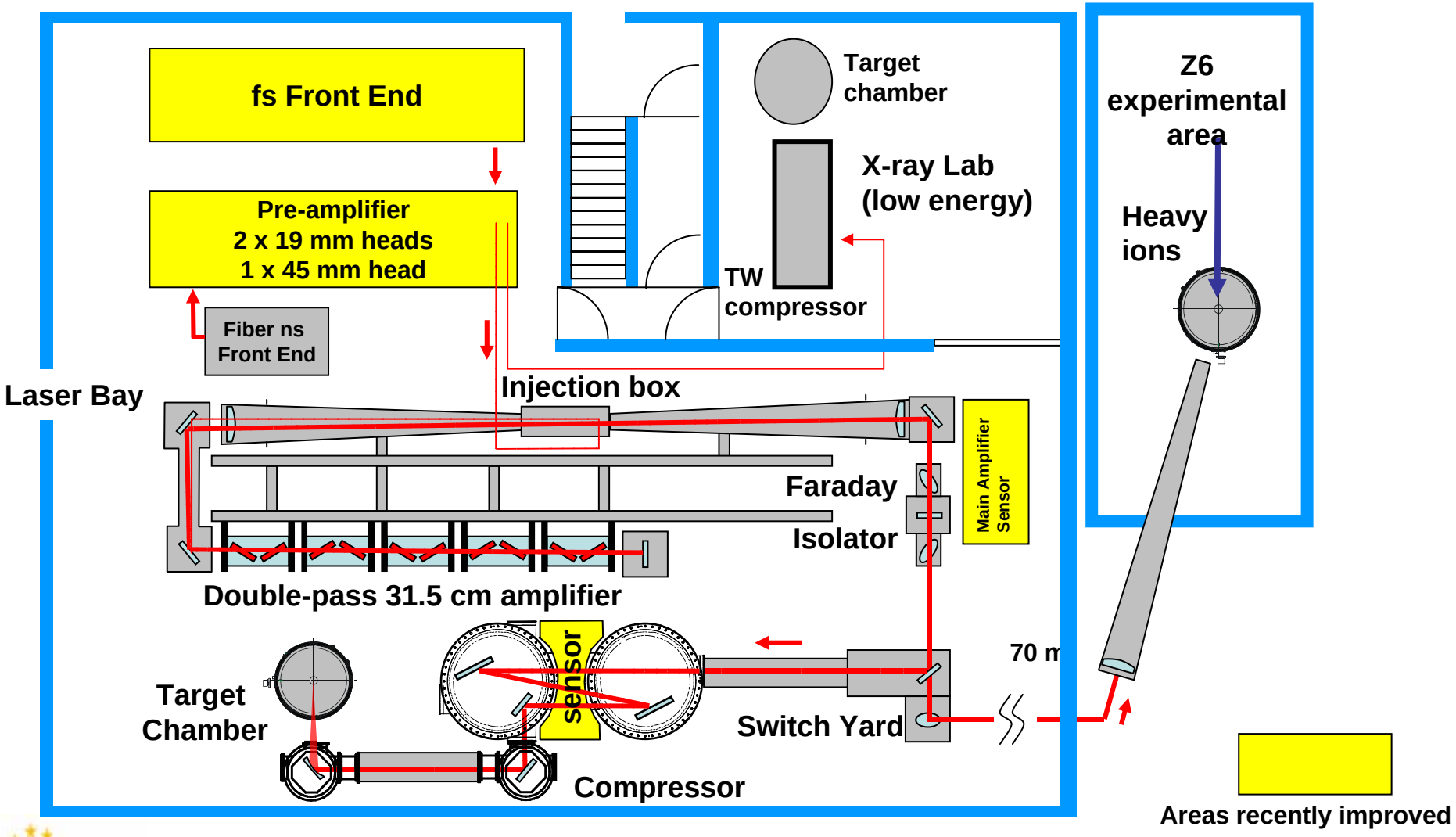
Moscow**

Overview



Spectroscopy of stored heavy ions using PHELIX driven x-Ray lasers

Schematic view of the PHELIX facility



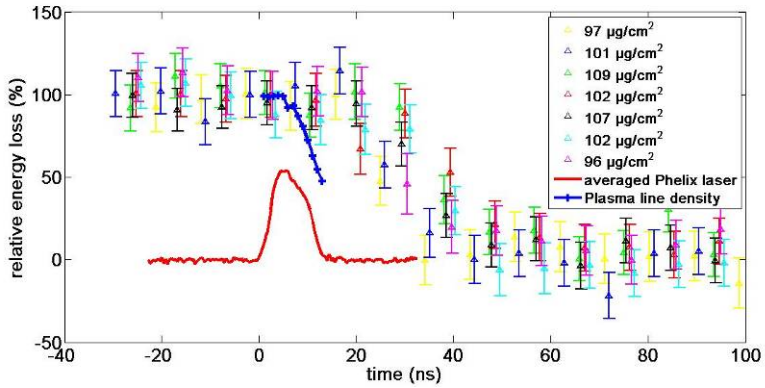
Performance of PHELIX in 2010

	Long pulse	Short pulse
Pulse duration	0.7 – 20 ns	0.5 – 20 ps
On-target energy	0.3 – 1 kJ	120 J
Maximum intensity	10^{16} Wcm^{-2}	10^{20} Wcm^{-2}
Repetition rate at Joule level	1 shot every 3 min	
Repetition rate at maximum power	1 shot every 1h*	
Temporal contrast	50 dB	60 to 80 dB depending on settings

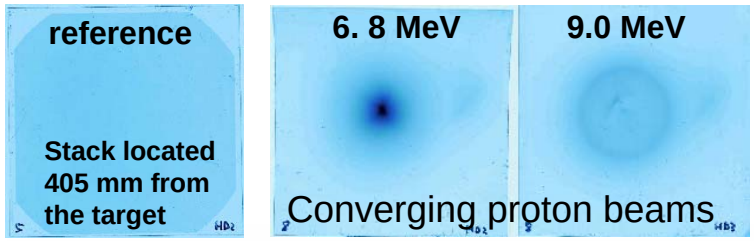
* with use of the adaptive optics

A selection of representative experimental results

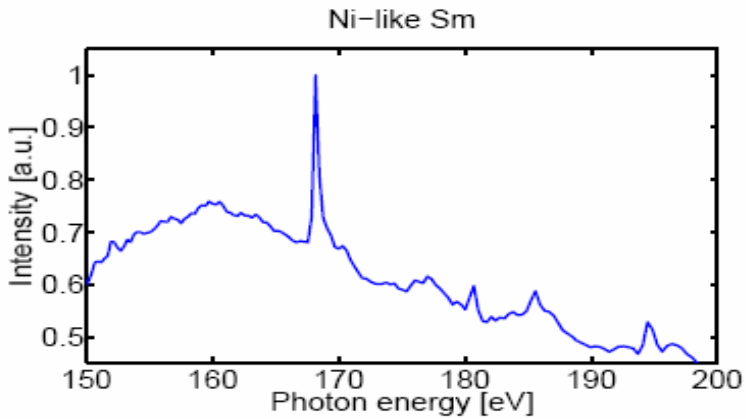
- **Progress in ion stopping (Courtesy of A. Frank)**
  - **PHELIX together with nhelix yields significant improvement in quality of experimental data.**

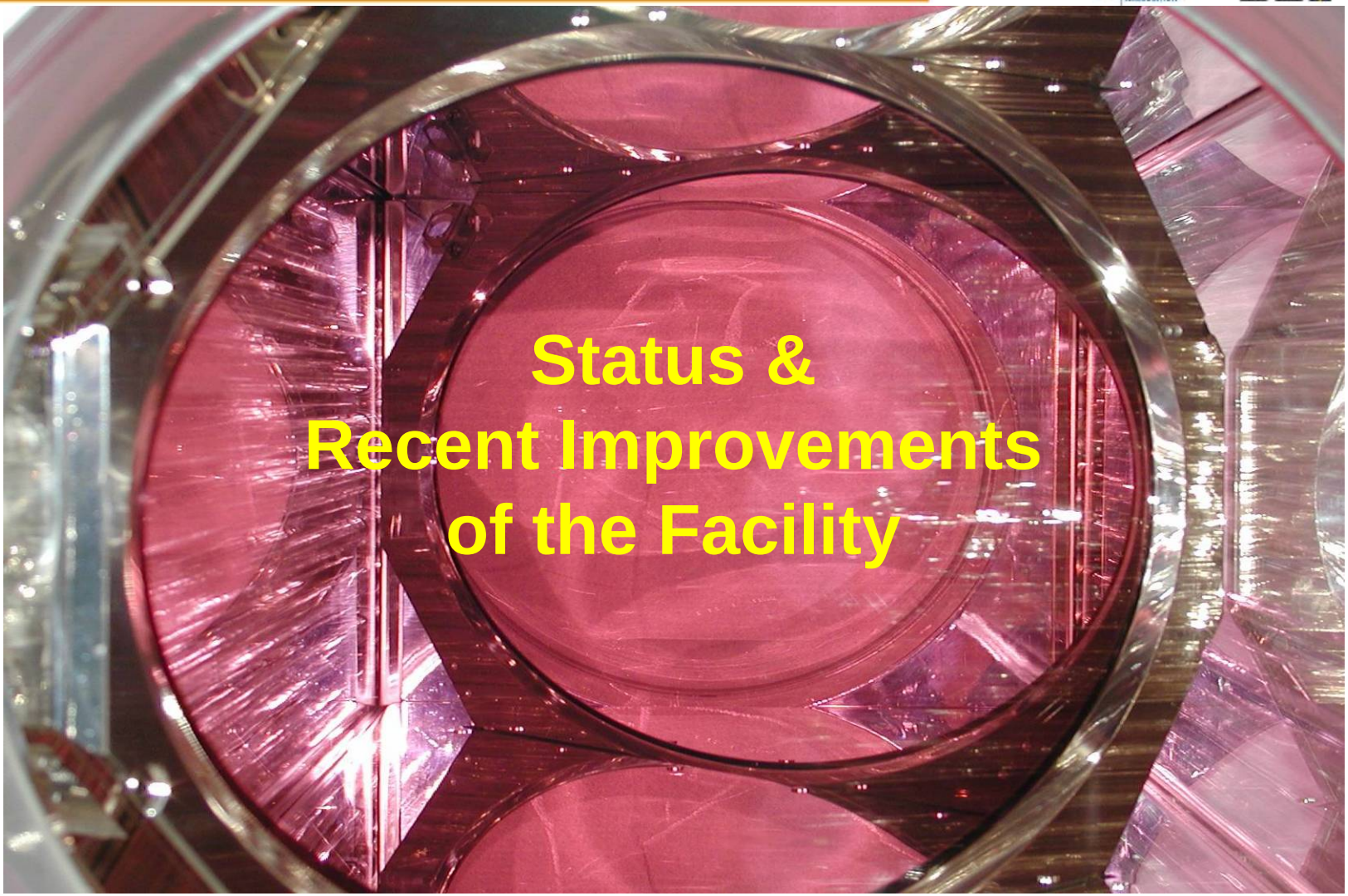


- **Progress in particle acceleration (Courtesy of K. Harres)**
  - **Up to 14 MeV protons were collimated using a coil**



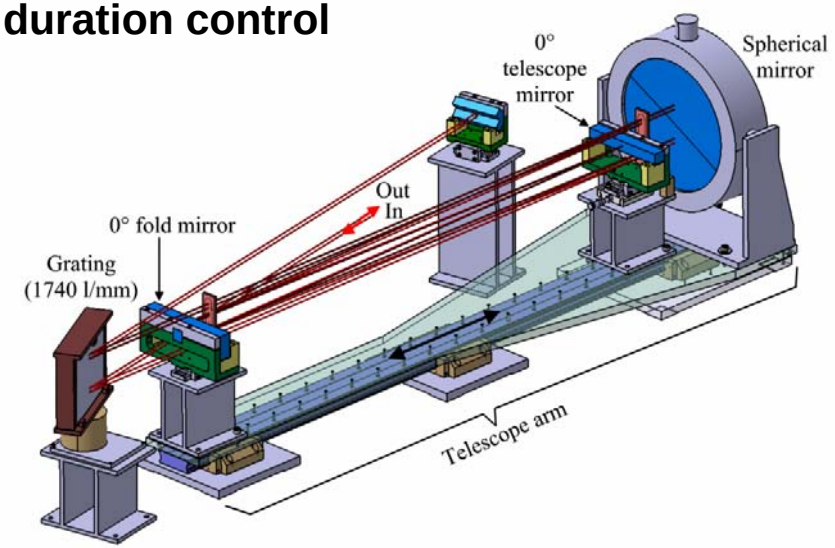
- **Progress in X-ray laser development (Courtesy of D. Zimmer)**
  - **The DGRIP scheme achieves lasing at 7.26 nm with as little as 30 J of pump laser energy.**



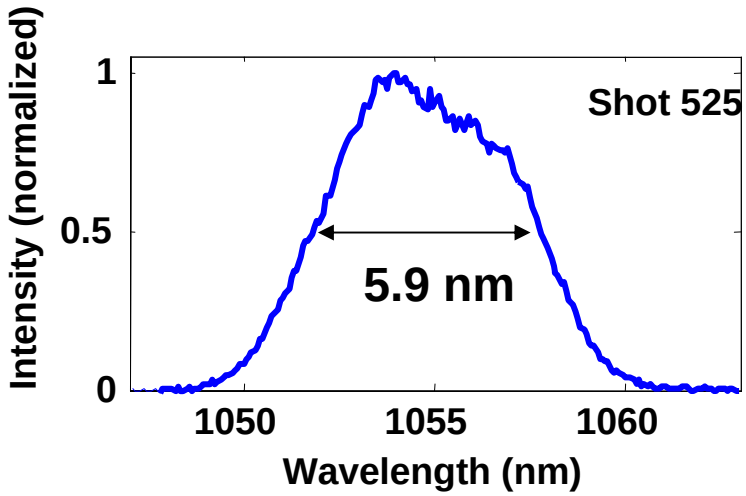

Status &
Recent Improvements
of the Facility

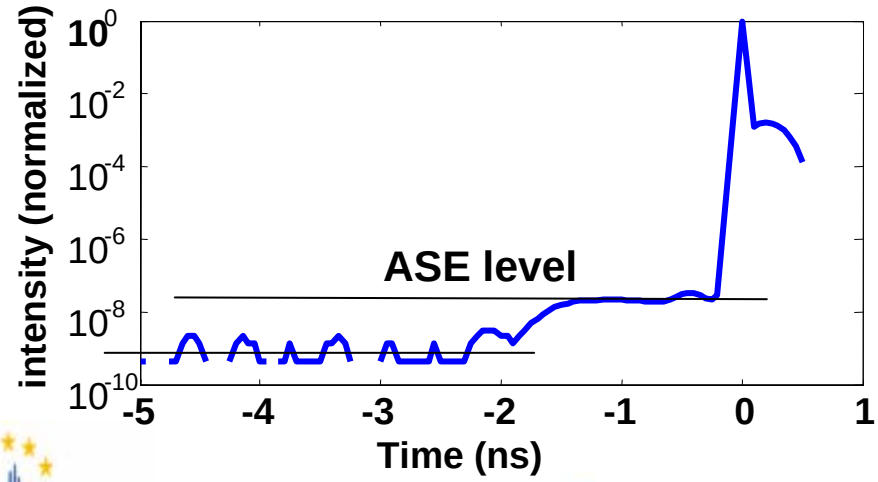
Adjustable pulse length and improved intensity contrast

- **Modified pulse stretcher for adjustable pulse duration control**



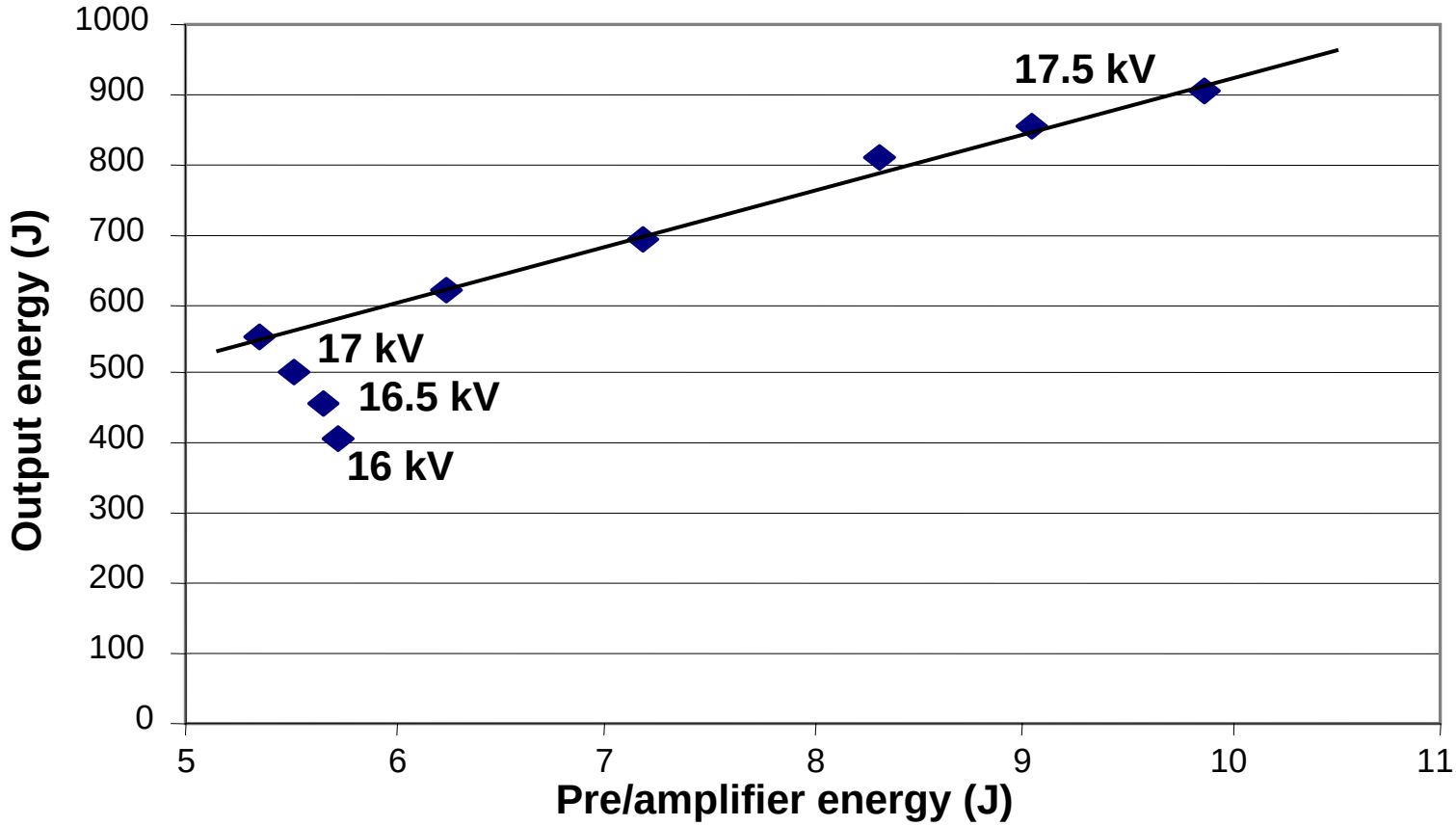
- **Spectral width enhanced by use of a birefringent filter**





- **A series of 4 Pockels cells distributed in the font end avoids pre-pulses**

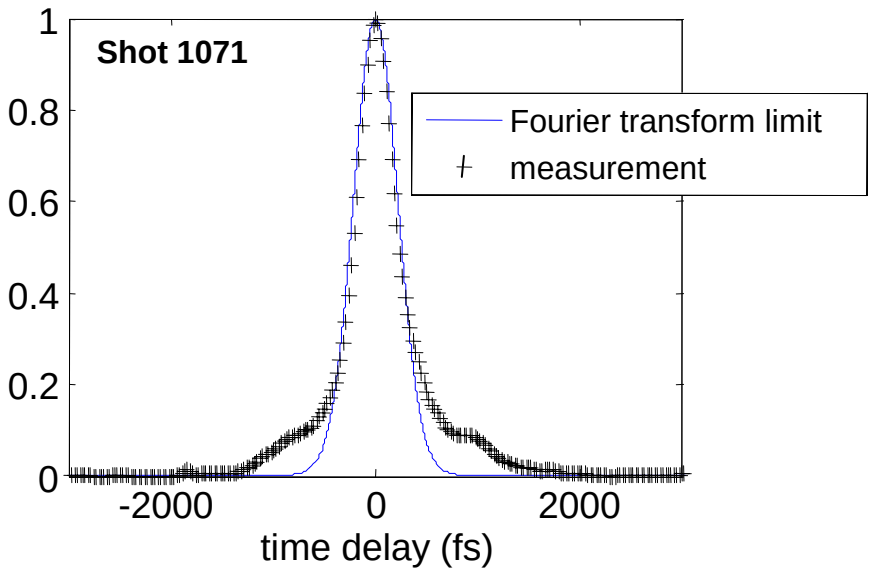
Main amplifier with energies in the kilojoule range



With a gain of up to 100 (17.5 kV), the main amplifier works as expected, only limited by the damage threshold of the Faraday rotator

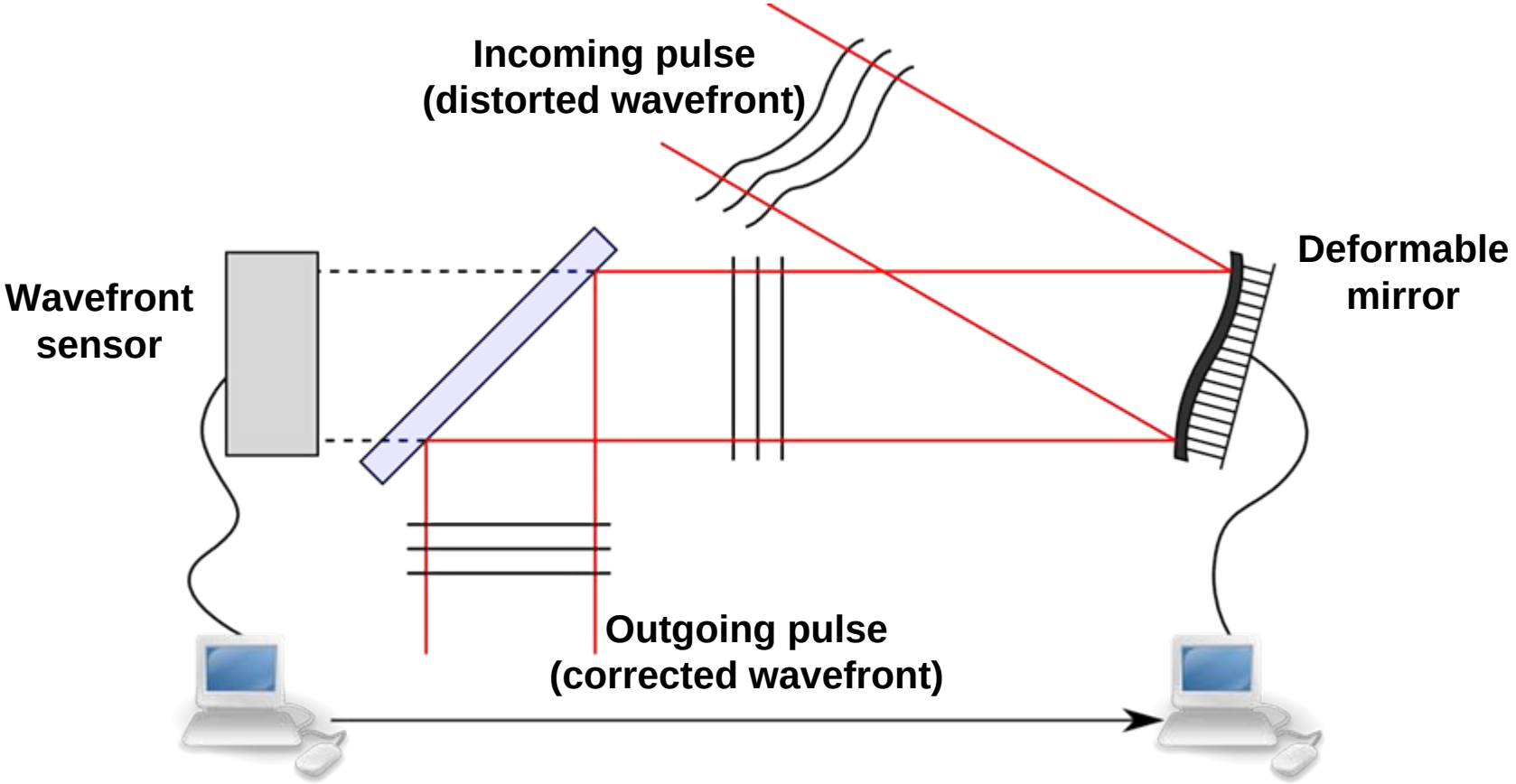
Direct on-shot measurement of the pulse duration

- **A single-shot autocorrelator is used for alignment and on-shot measurements**



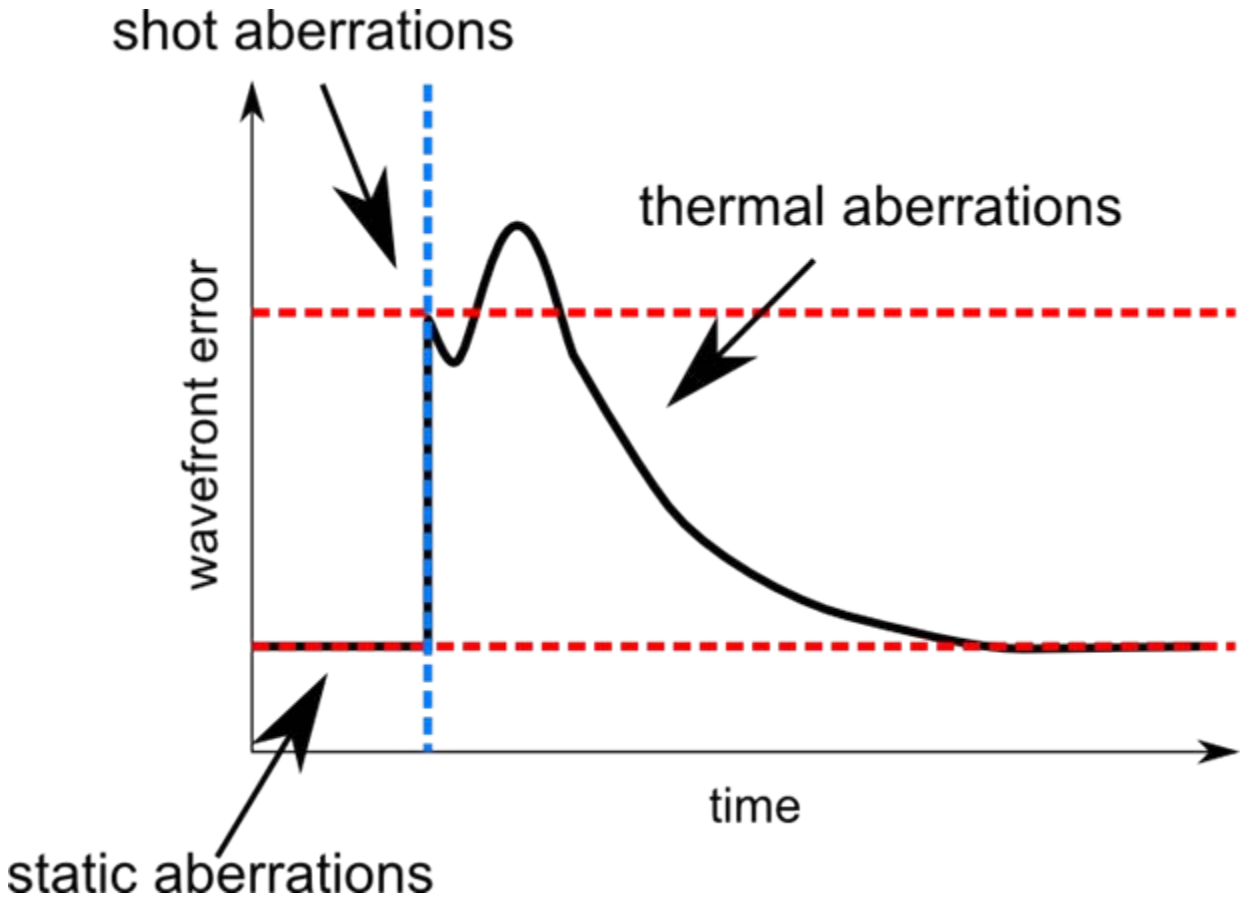
Together with a twofold increase in energy, we plan to upgrade the peak power to more than 750 TW in 2010

Active wavefront correction

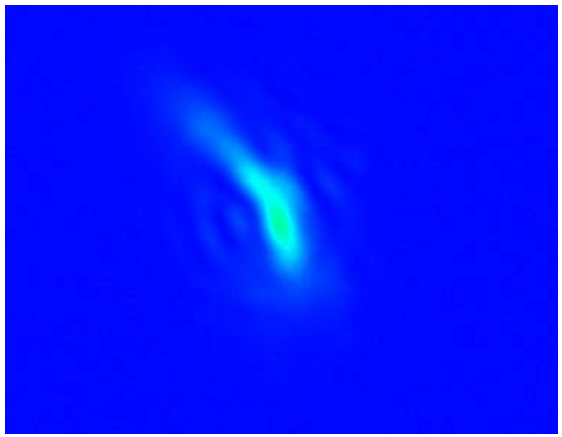


Active wavefront correction

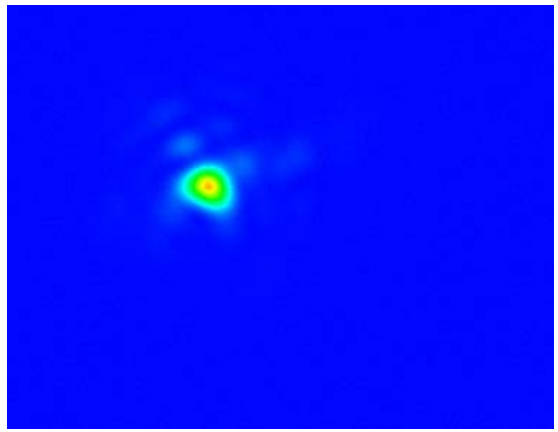
- **Three types of aberrations are being found in a complex laser system**



Active wavefront correction



without correction

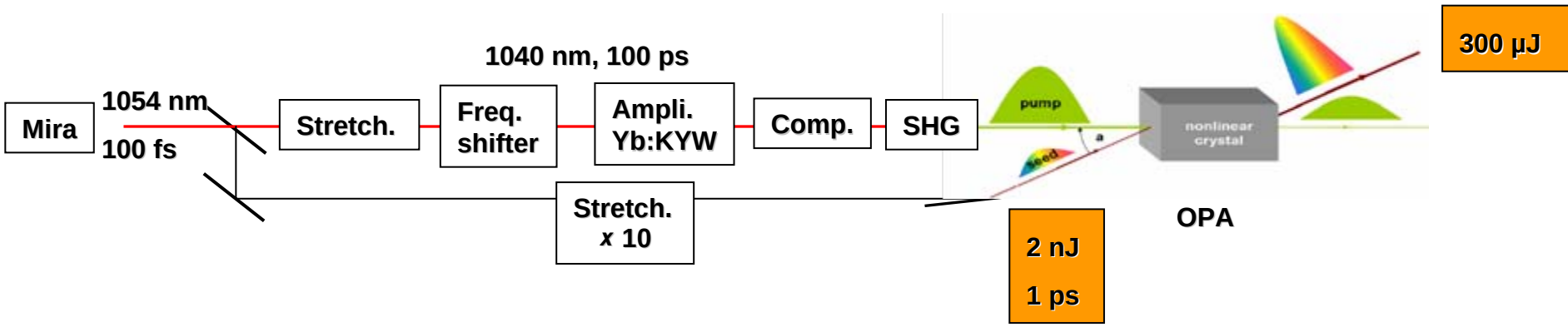


with correction

- On-shot aberrations at pre-amplifier level reduced by 60%
- Waiting time between pre-amplifier shots reduced from 10 down to 3 minutes
- Increase of main-amplifier repetition rate to 1 shot/hour.

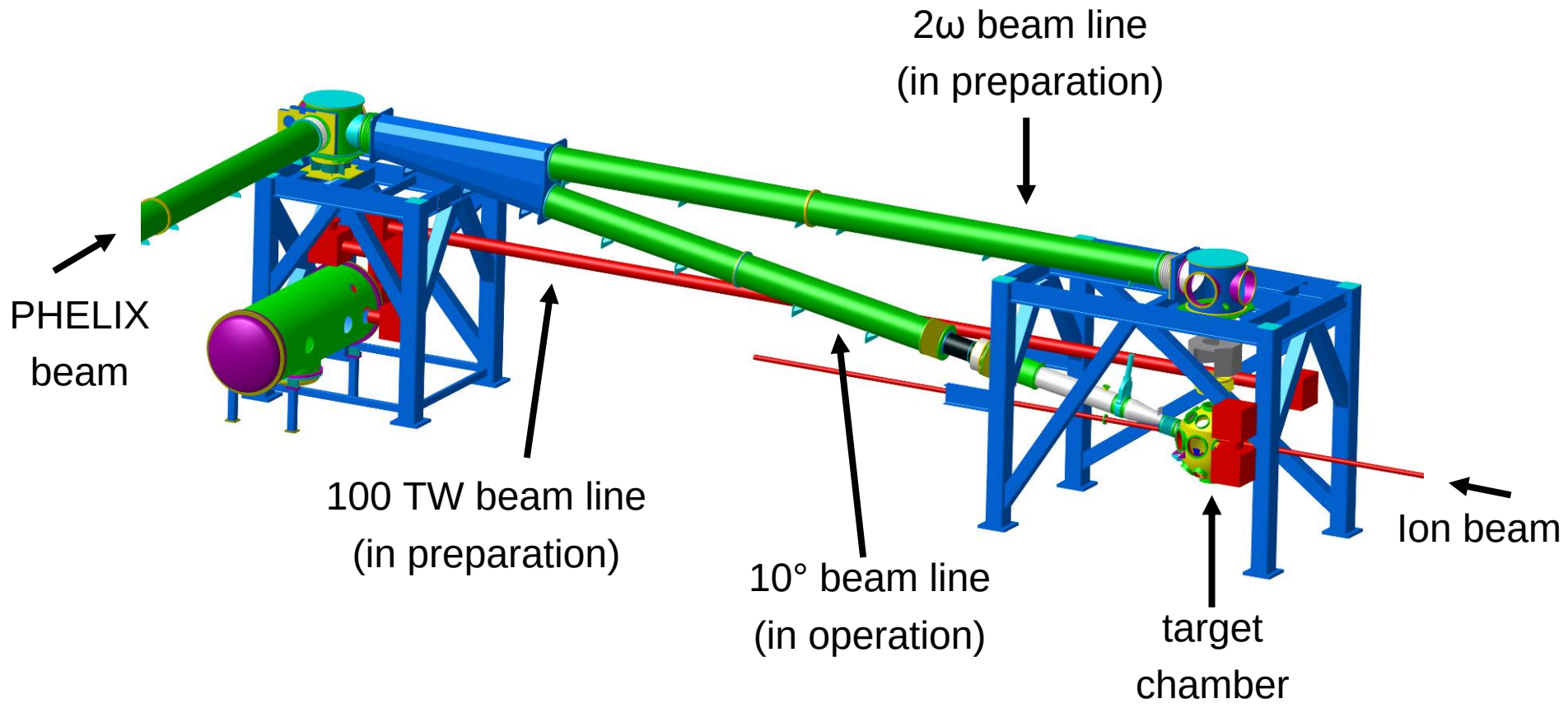
We plan to improve the contrast by use of an ultrafast OPA

- ASE is mostly created in the front-end because of low power available from the oscillator
- Boost this power using an ultrafast optical parametric amplifier
  - A gain in contrast of 10^5 expected
  - Low pre-pulse level
  - Higher energy stability because of diode-pumped amplifier



This development is done within the frame of the Helmholtz Institut Jena (HIJ)

Extension of the experimental capabilities at Z6



Summary

PHELIX celebrates 2 years of operation

- **PHELIX delivered more than 100 shifts in 2009, in line with the prediction**
  - **The facility delivered its 2000th documented shot.**
  - **An internal beamtime allowed to test the amplifier up to 920 J.**

- **PHELIX has a strong impact on the scientific program of GSI.**
  - **Significant results were obtained in ion stopping experiments, manipulation of laser-accelerated particles and coherent X-ray generation**
- **We operate a recent facility which is being constantly improved**
  - **PHELIX operates in the ns to sub-ps regime at three different experimental places**
  - **Innovative solutions in many locations implemented**
  - **Future upgrades are being actively pursued in**
    - **contrast improvement (uOPA project)**
    - **frequency conversion (2ω project)**
    - **experimental capability (100 TW project)**

Thank you for your attention