CALA and Garching plans

S Karsch

Max-Planck-Institut für Quantenoptik
Ludwig-Maximilians-Universität München
(Germany)

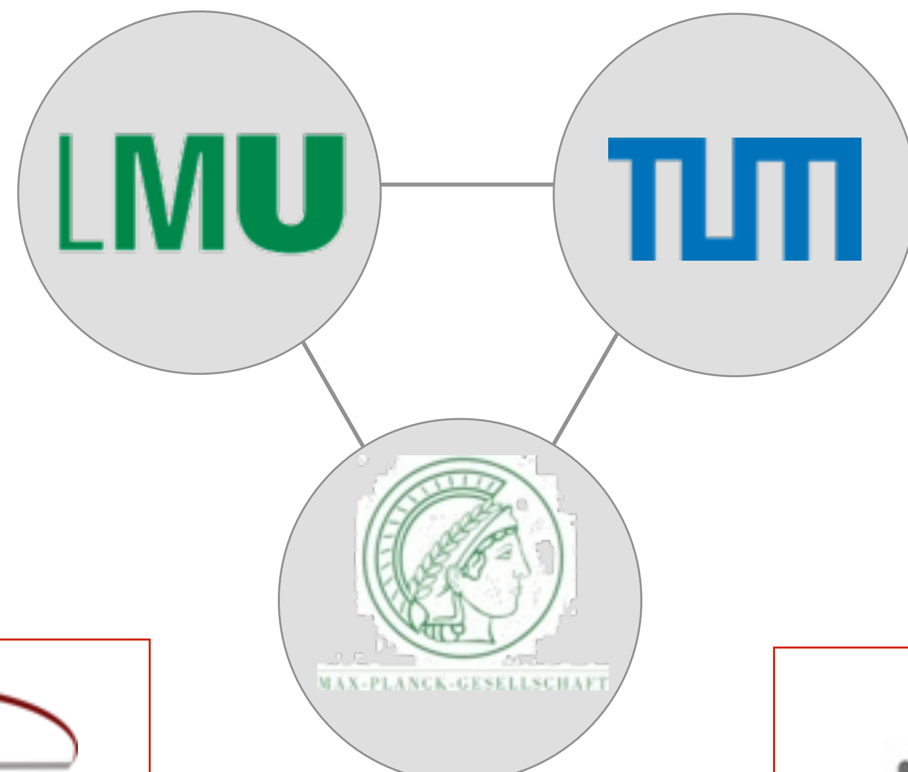
EuroNNAc Workshop, CERN, Geneva, May 3-6, 2011

Munich Research Network

Munich Centre
for Advanced
Photonics (MAP)

MAP - Munich Centre for Advanced Photonics

Munich Center for Integrated Protein Science (CIPSM)



Origin and Structure of the Universe

Cognition for Technical Systems (CoTeSys)

Nanosystems Initiative Munich (NIM)

What is CALA?


Max-Planck-Inst. f. Quantenoptik (MPQ)
TUM Informatik
TUM Maschinenwesen
FRM II
TUM Chemie
LMU Physik
TUM Physik
CALA

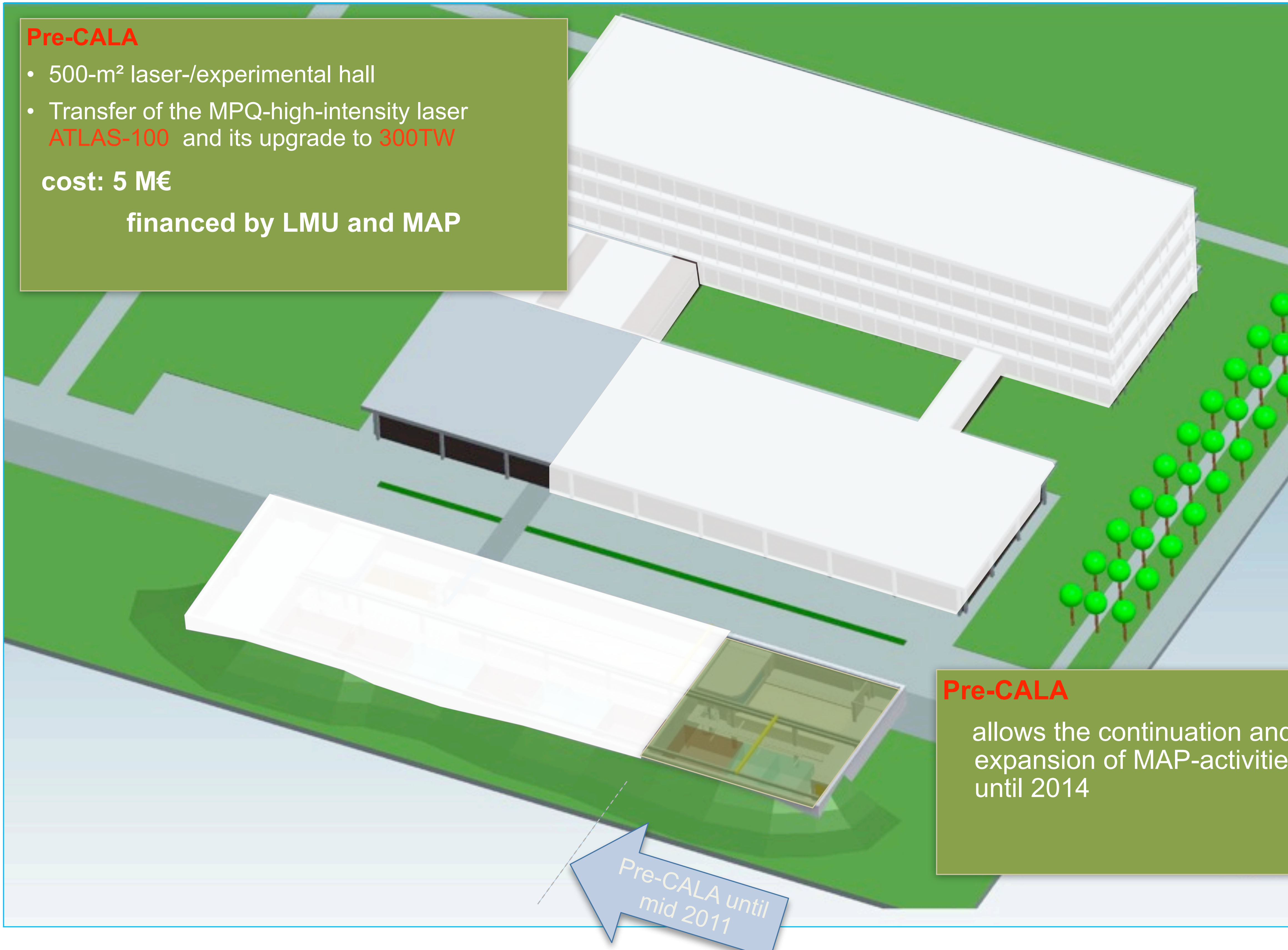
Step 1: Pre-CALA until mid 2011

Pre-CALA

- 500-m² laser-/experimental hall
- Transfer of the MPQ-high-intensity laser ATLAS-100 and its upgrade to 300TW

cost: 5 M€

financed by LMU and MAP



Pre-CALA

allows the continuation and expansion of MAP-activities until 2014

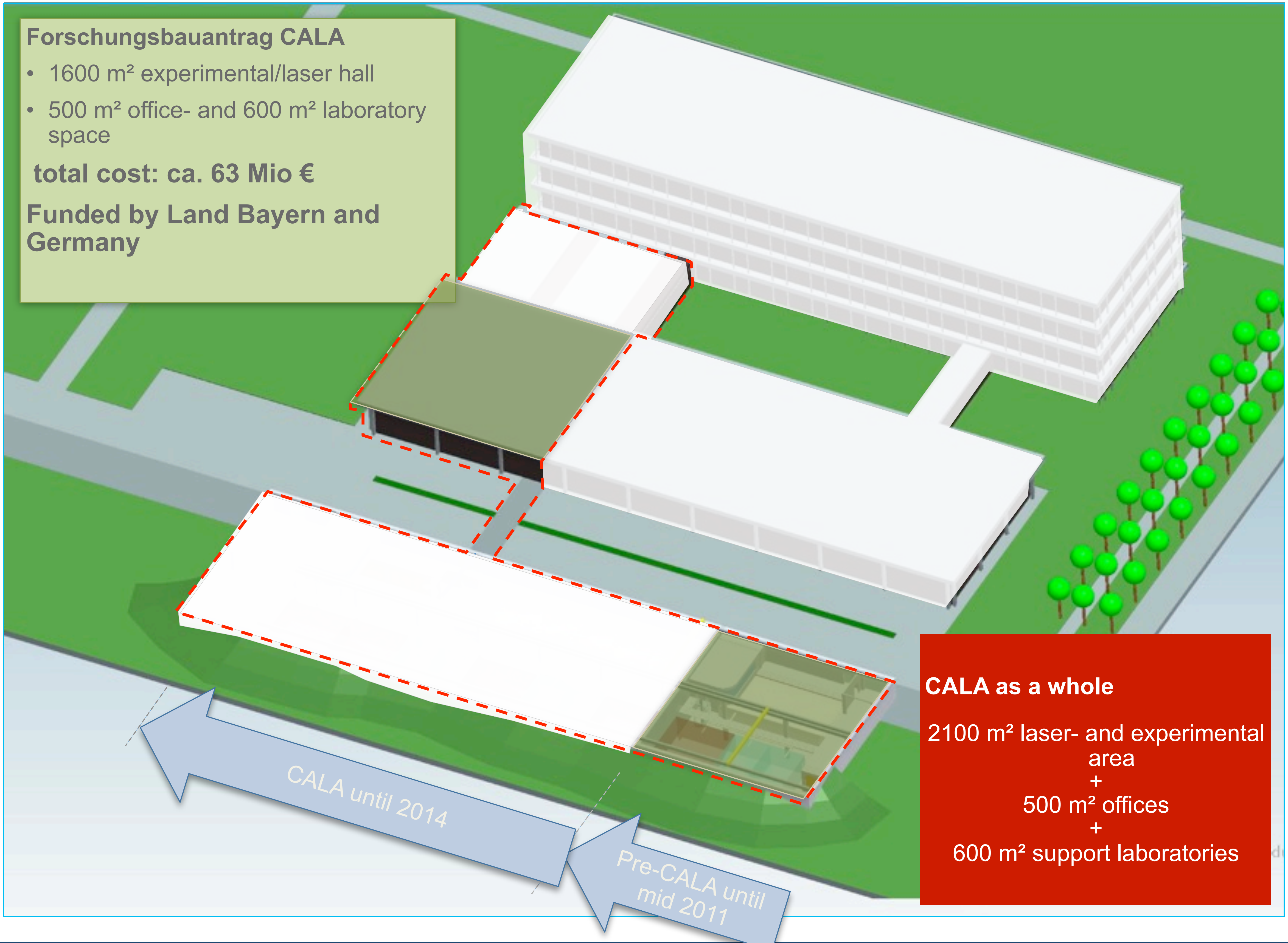
Step 2: CALA

Forschungsbauantrag CALA

- 1600 m² experimental/laser hall
- 500 m² office- and 600 m² laboratory space

total cost: ca. 63 Mio €

Funded by Land Bayern and Germany



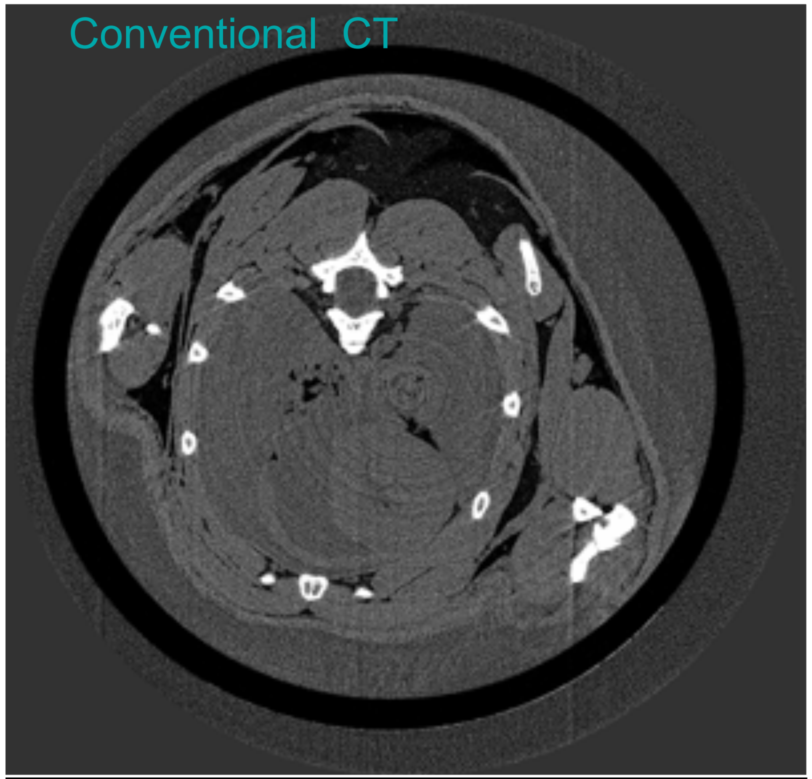
CALA as a whole

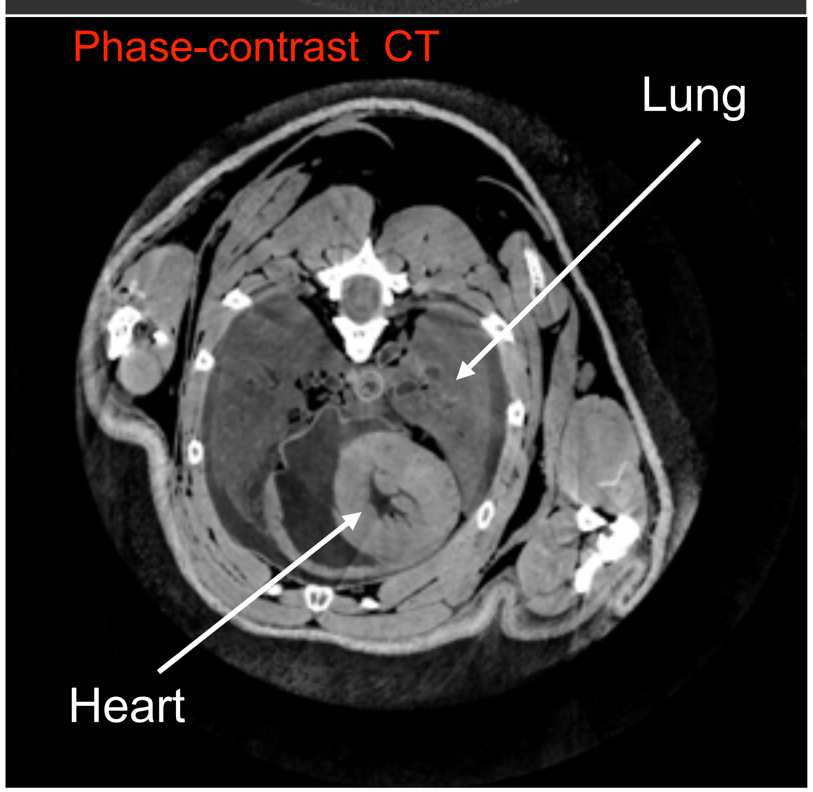
2100 m² laser- and experimental area
+
500 m² offices
+
600 m² support laboratories

Ultimate goal: Improve and combine both diagnostics and therapy

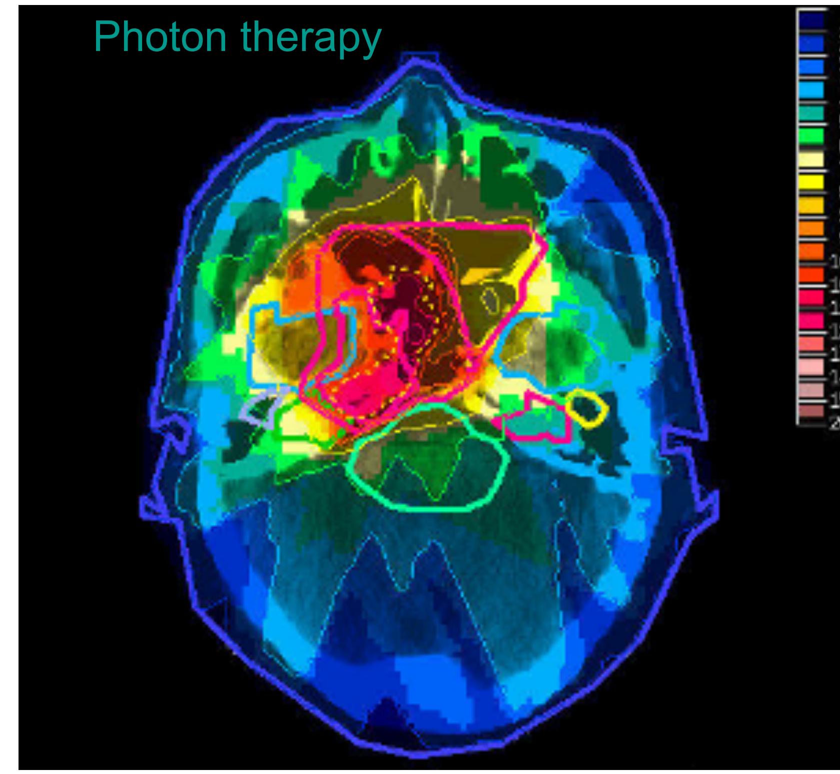
Diagnostics: Phase-contrast imaging dramatically improves visibility of structures (F. Pfeiffer et al.)

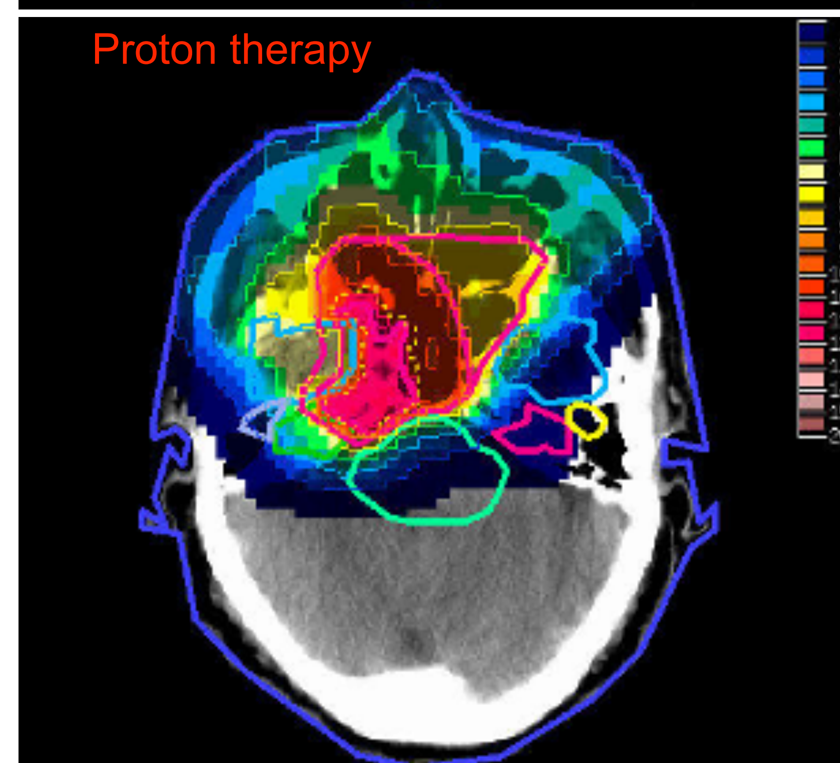
Therapy: Ion therapy promises higher irradiation accuracy with lower dose to healthy tissue (Molls et al.)

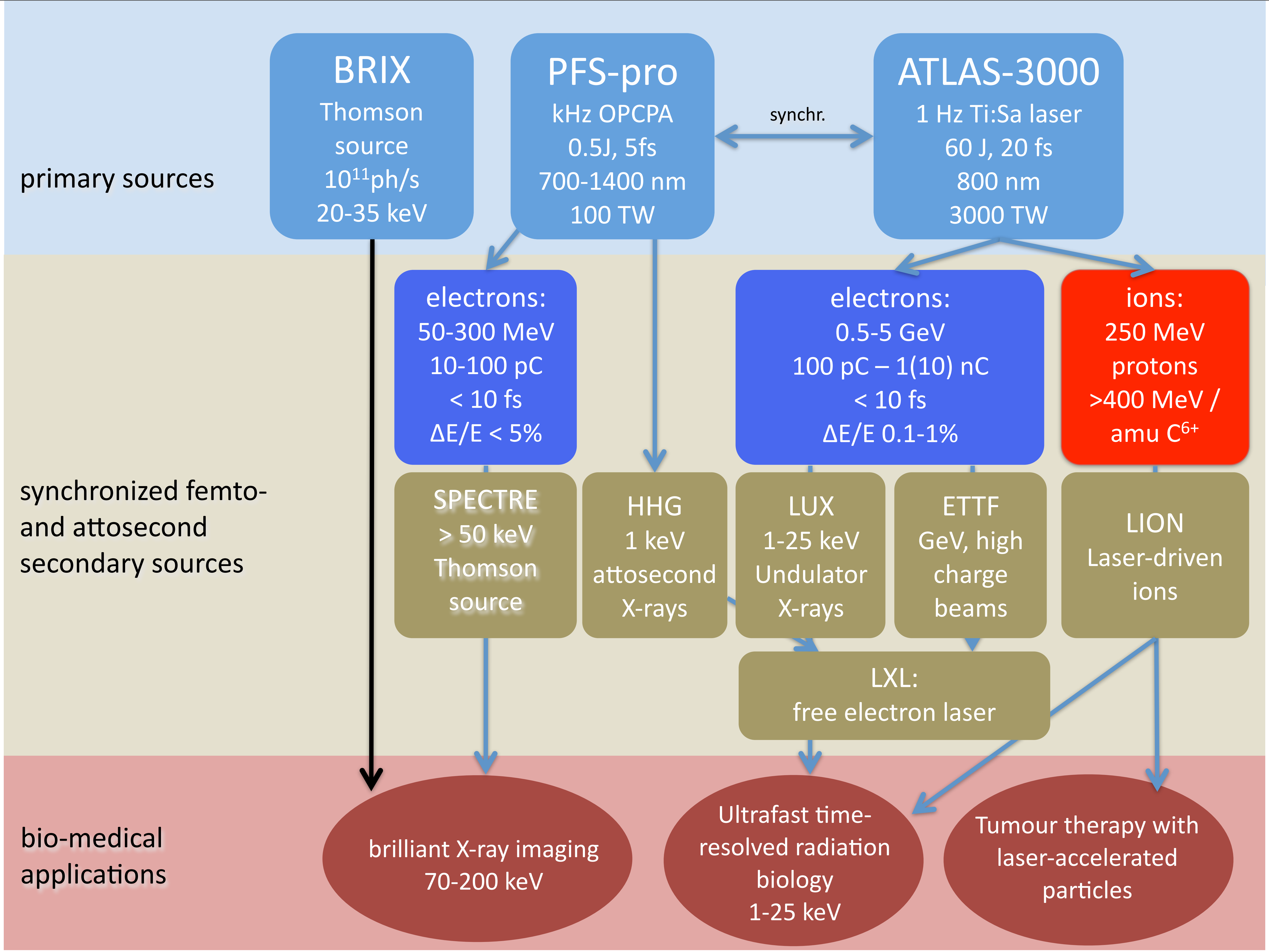




High-quality laser-driven beams may become an attractive alternative for large-scale conventional facilities



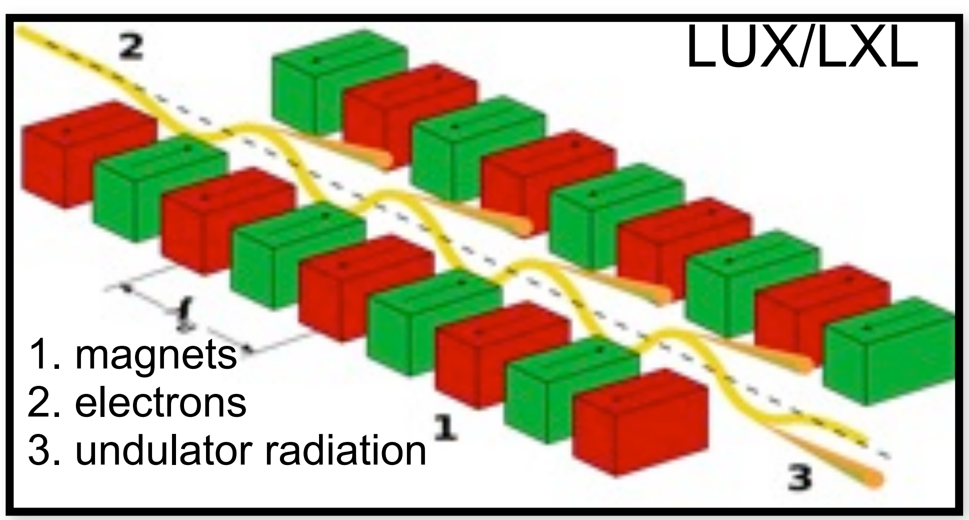




Montag, 2. Mai 2011

X-rays: Description of beamlines

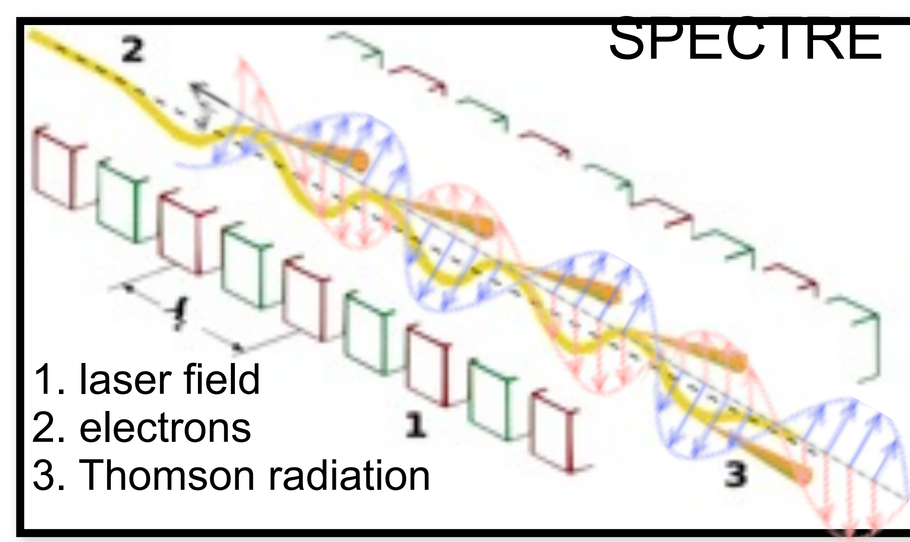
Name	Application	electron energy	photon energy	photon number
SPECTRE Source for Powerful, Energetic, Compact Thomson Radiation Experiments	biomedical imaging with phase contrast method	50-100 MeV	**> 70 keV**	10^{10} ph/s @ **1 kHz**
ETTF Electron and Thomson Test Facility	development of electron acceleration: **basic research** for LUX and LXL, high energy Thomson scattering	1-5 GeV	> 1 MeV	10^{6}-10^{7} ph in 5fs
LUX Laser-driven Undulator X-ray source	ion pump / X-ray probe: preliminary studies for ultrafast radiation biology ions from “mini-LION”	0.5-5 GeV	< 25 keV	10^{8} ph in ~5 fs
LXL Laboratory-scale X-ray free electron Laser	ion pump / X-ray probe for ultrafast radiation biology	0.5-5 GeV	~ 5 keV	**10^{12} ph in 5 fs coherent**!



$\lambda_U \gg \lambda_L$

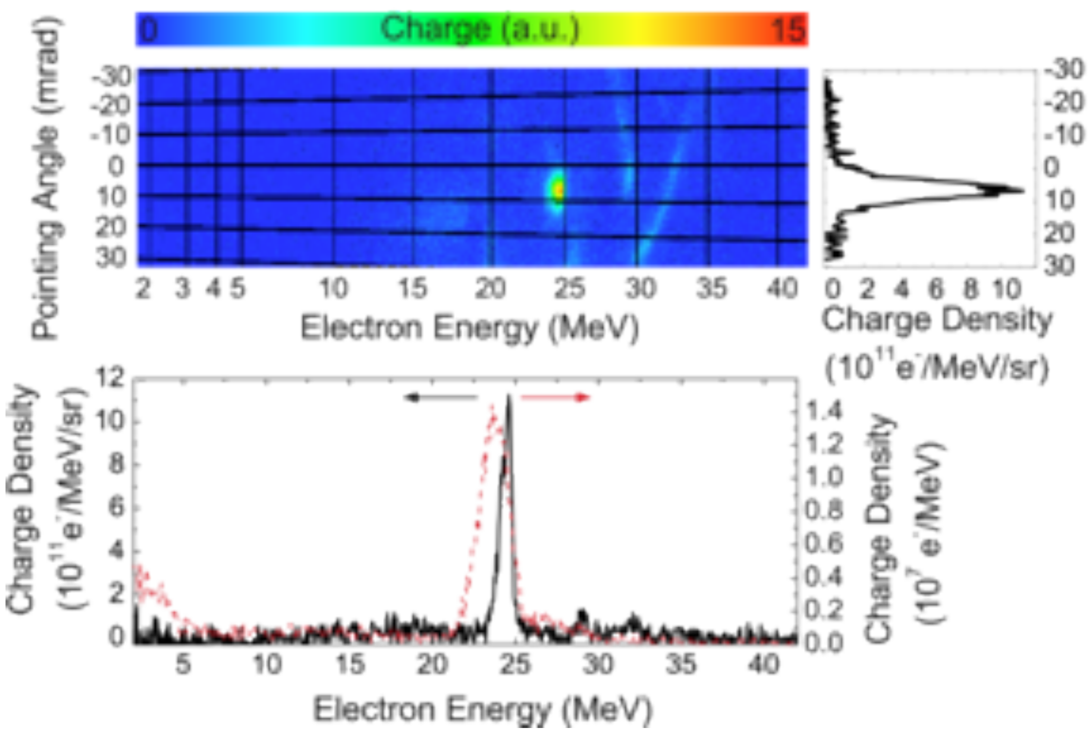
GeV- electrons

70 MeV- electrons

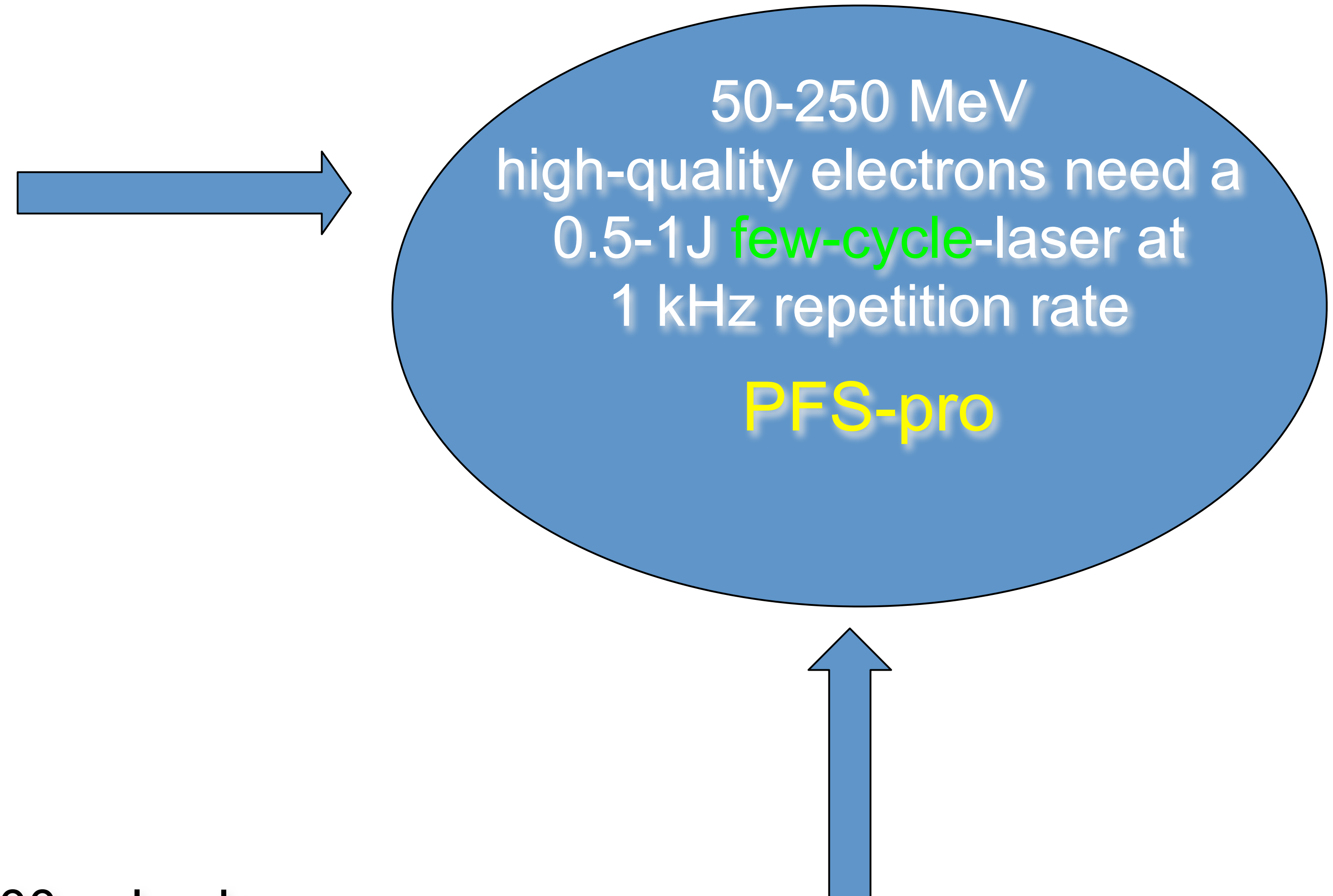


Electron acceleration for SPECTRE: 50 – 300 MeV, 1kHz

Few-cycle-pulses (8 fs, 50 mJ) drive quasi-monoenergetic electrons with low background:

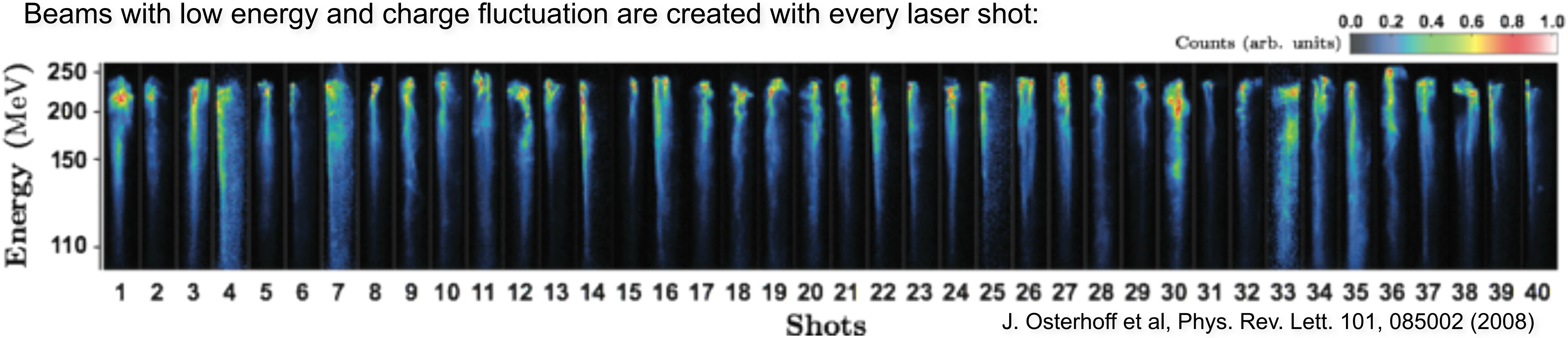


K. Schmid et al, Phys. Rev. Lett. 102, 124801 (2009)



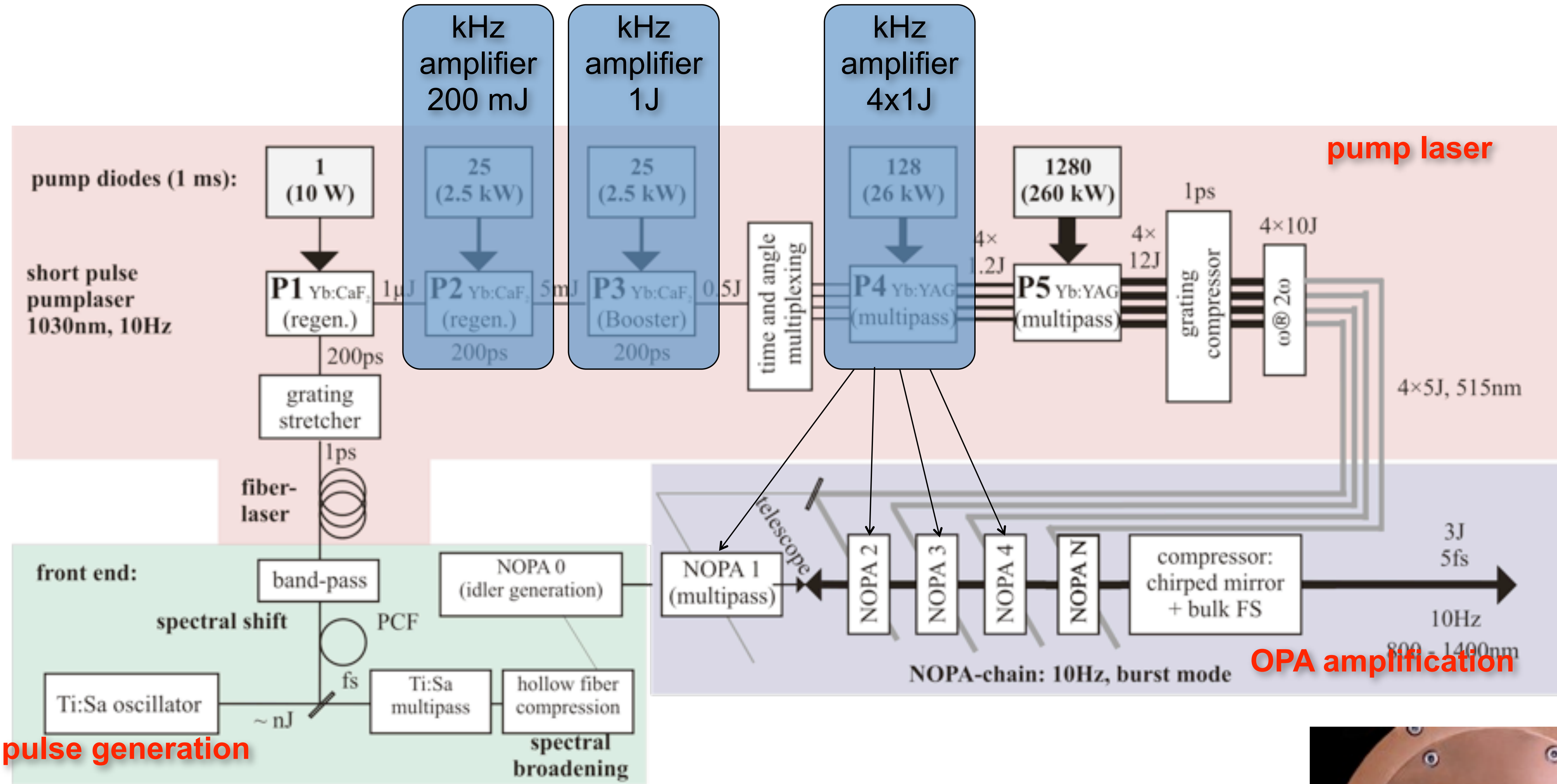
Stable 200 MeV electron beams with 40fs, 800 mJ pulses:

Beams with low energy and charge fluctuation are created with every laser shot:

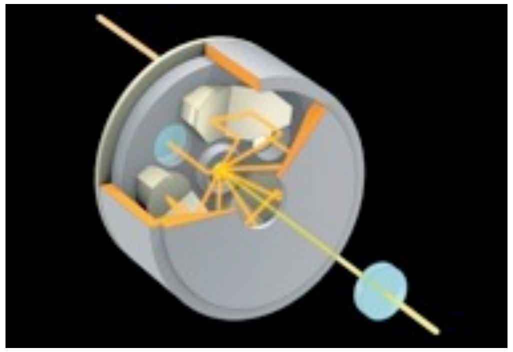


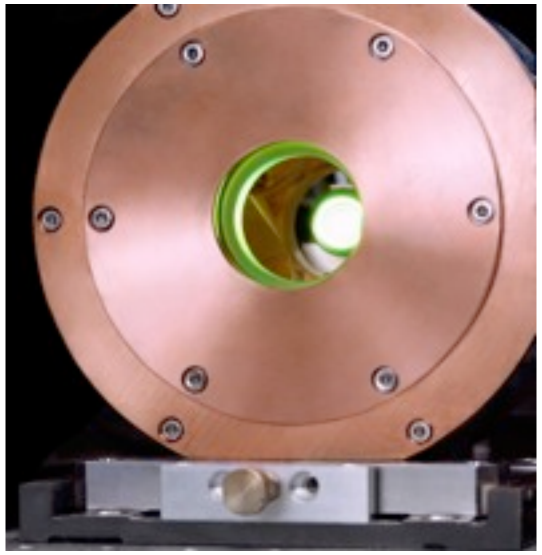
J. Osterhoff et al, Phys. Rev. Lett. 101, 085002 (2008)

PFS-pro

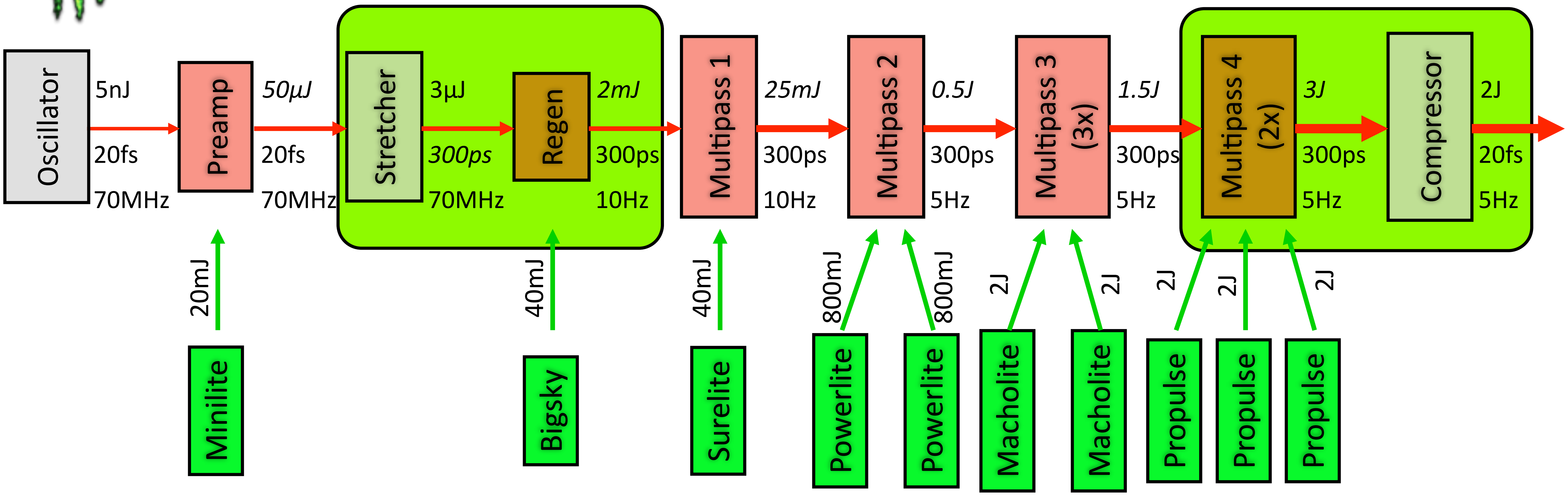


- Upgraded pump laser drives OPA stages at 1 kHz up to the 1 J-level
- remaining last 5 J stage operates at 10 Hz
- Pump upgrade uses disk laser technology

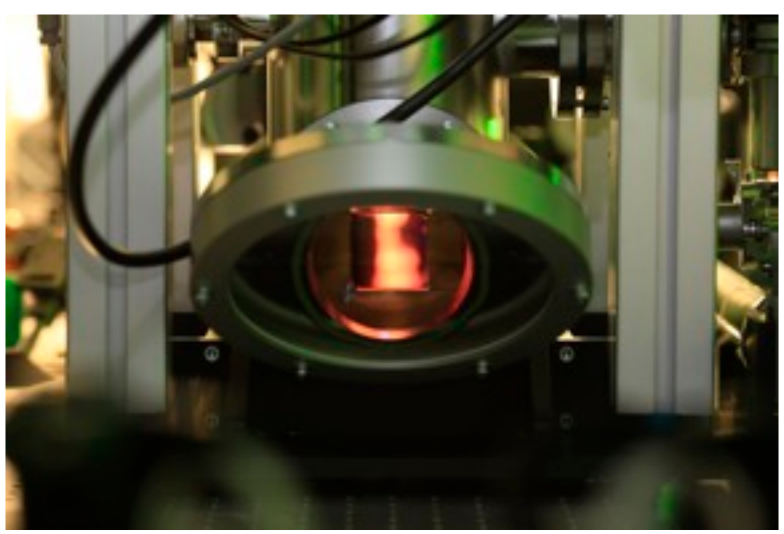




ATLAS



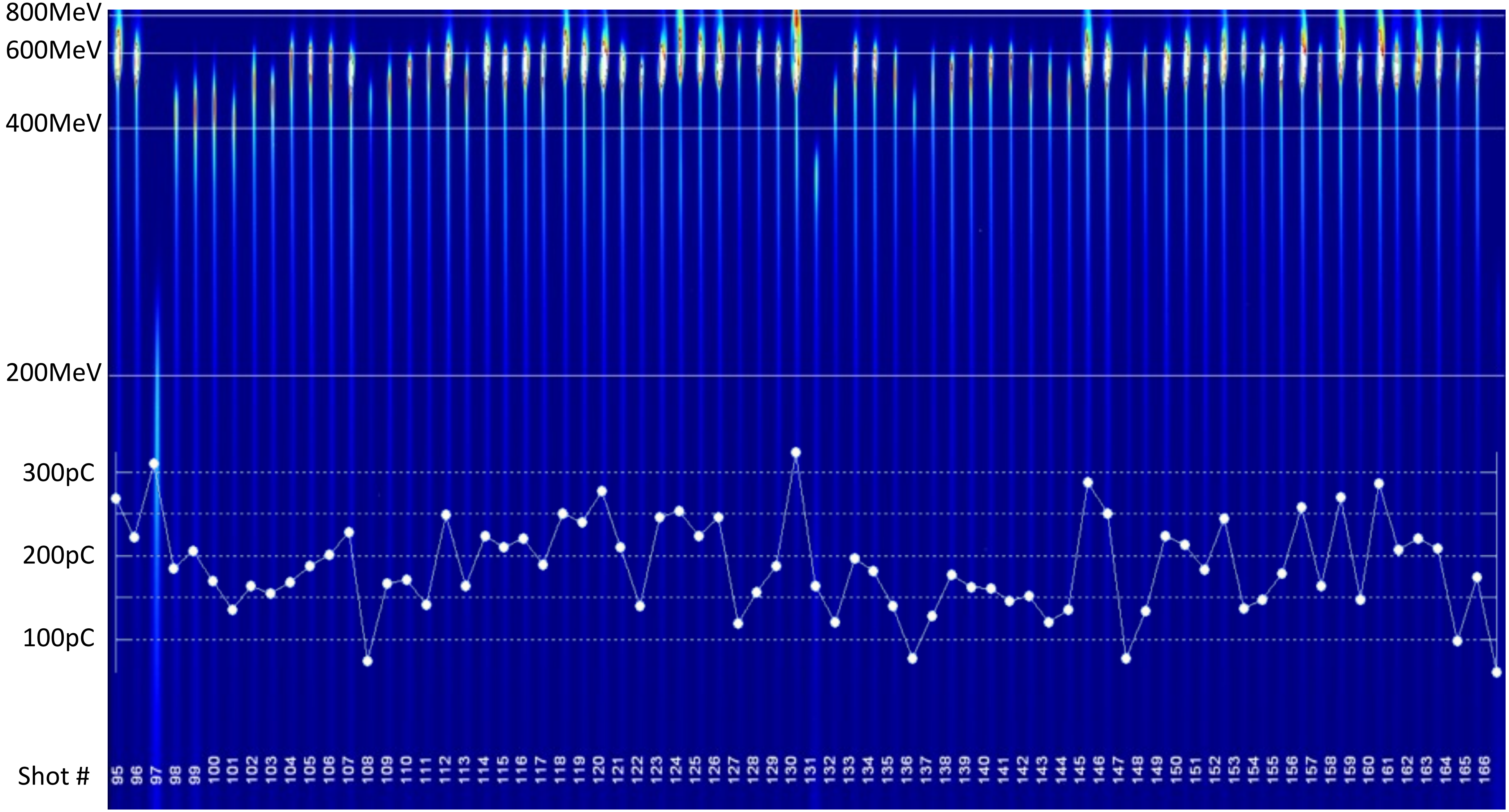
new cryocooled last amplifier under development (Amplitude)



ensures future upgradeablility

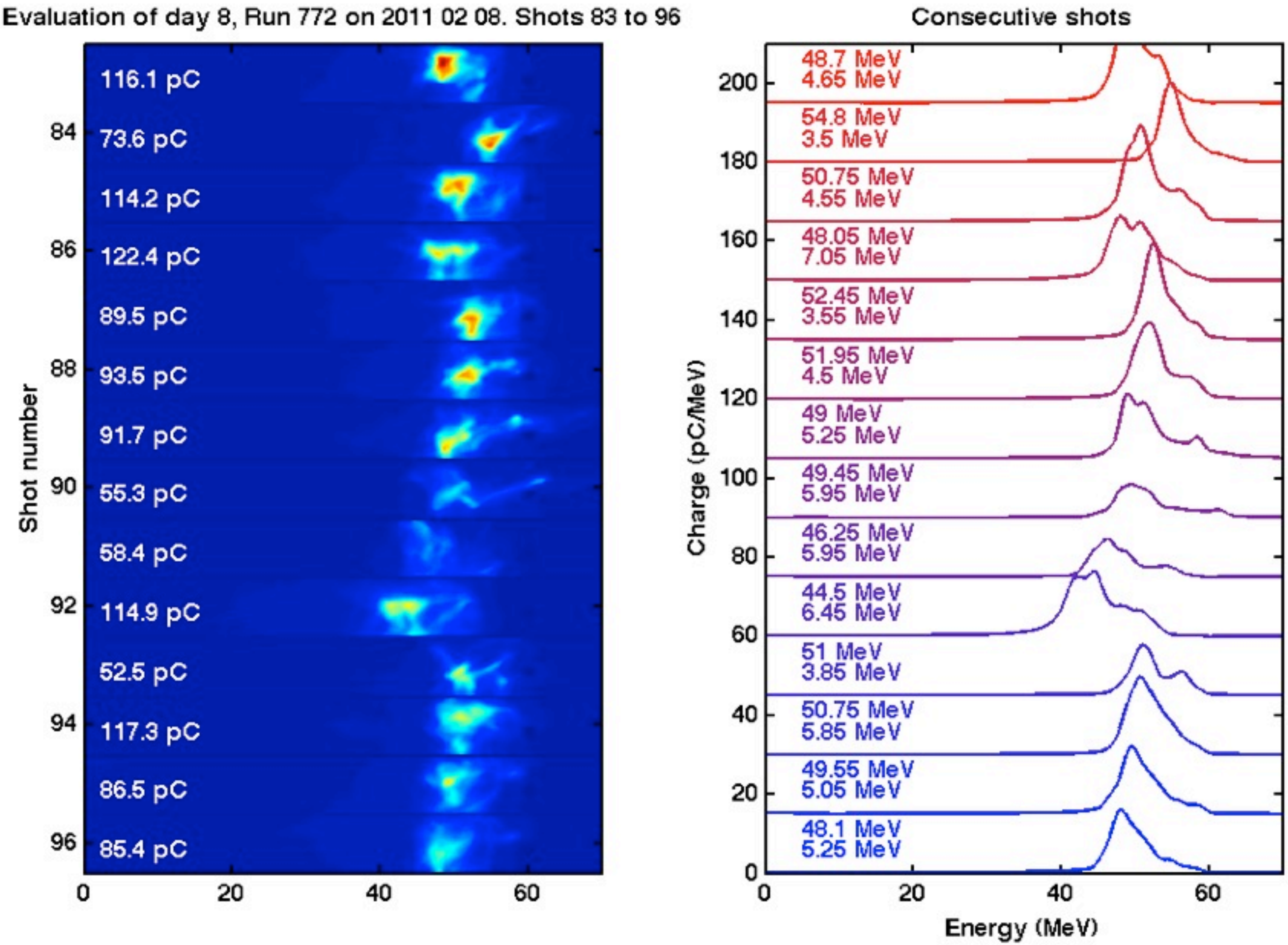
Energy (compressed/on target) (J)	2 / 1,6
pulse duration (fs)	25
contrast @ -10 ps (with absorber)	10^8 (10^{10})
Strehl ratio	0,7

e-beams from gas cell: 600 MeV, 200 pC: allows LUX experiments into water window



injected beams, gas jet: 50 MeV, 100 pC: target parameters for SPECTRE

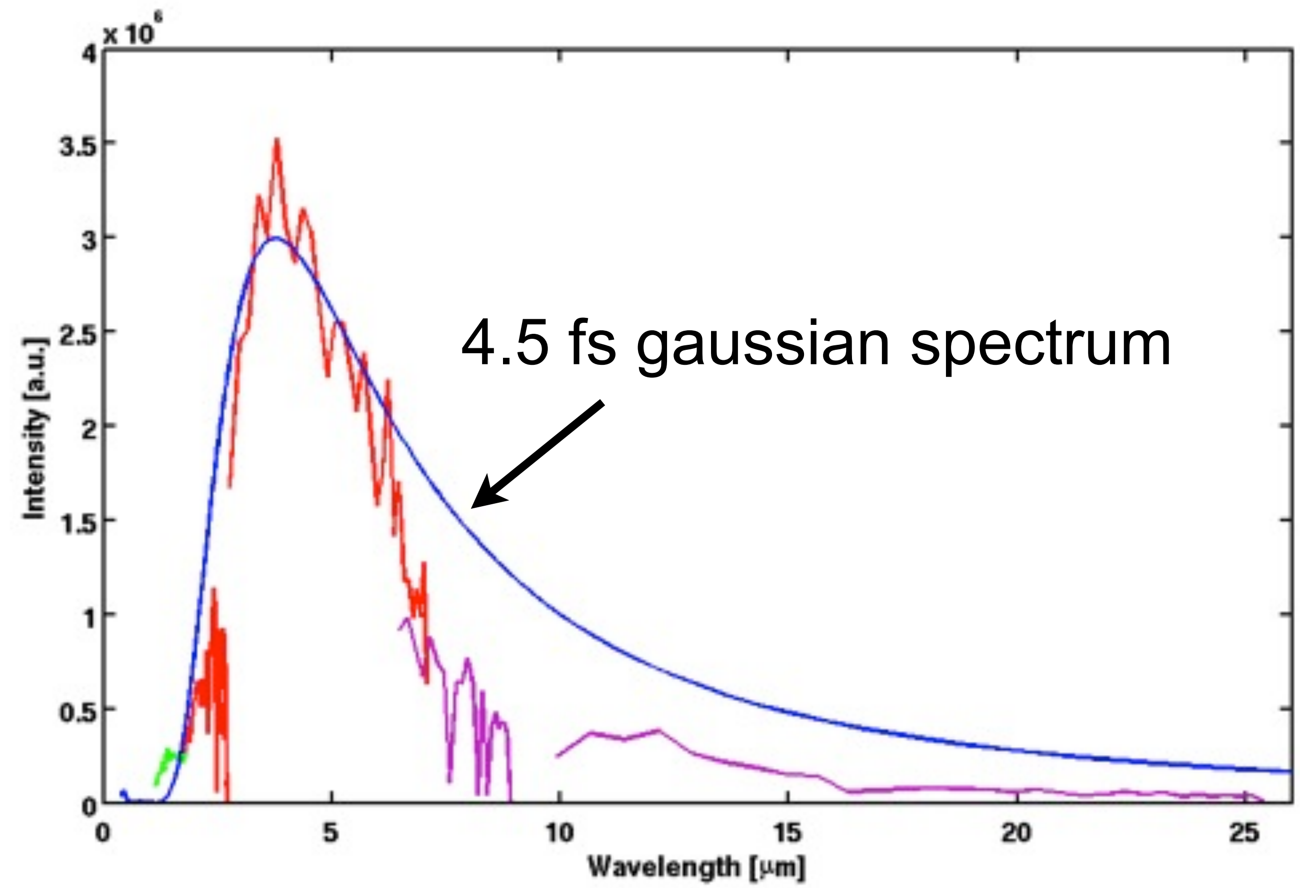
a_0=2.5, n_e= 1.2x10^{18} cm^{-3}



Optical to THz CTR spectra of electrons crossing a metal foil (very preliminary)

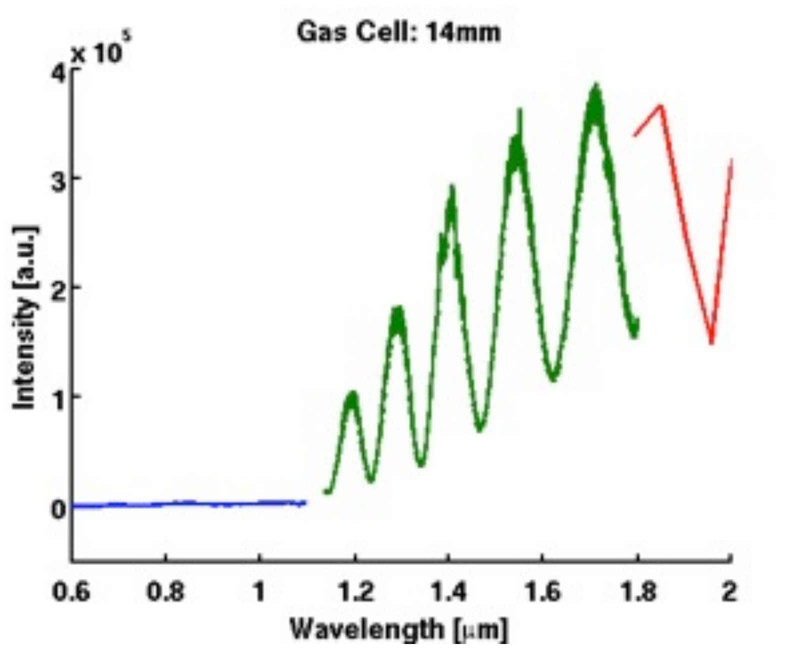
Preliminary wide-bandwidth data:

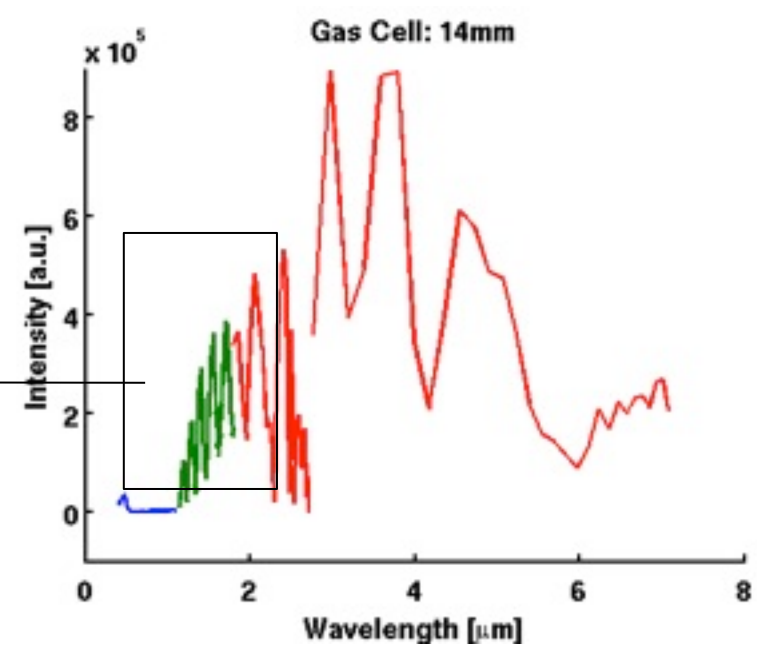
indicate approx. 5 fs duration

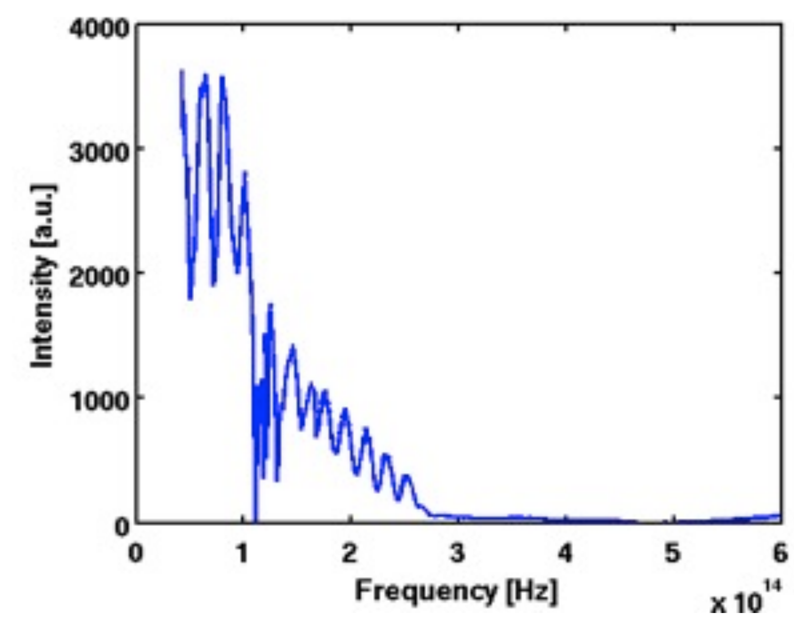


at high pressure and/or long gas cell:

oscillations with a period ~16µm





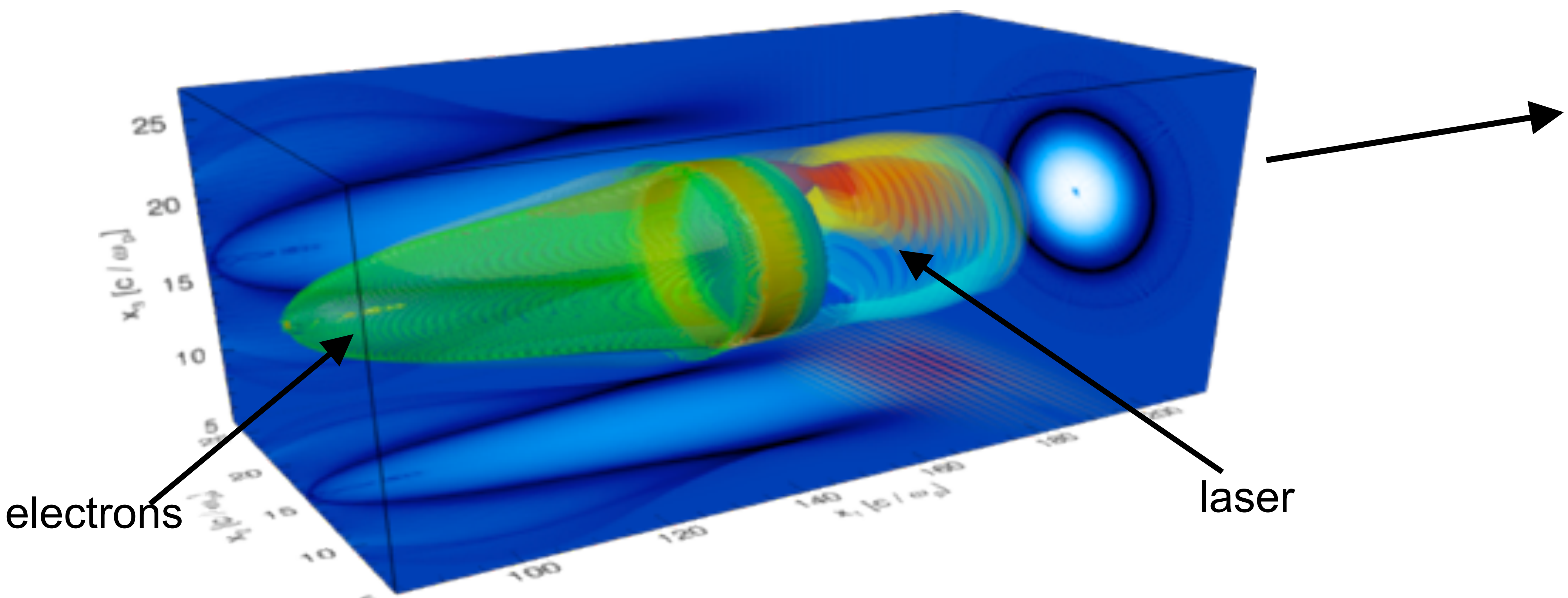


Scaling of electron acceleration to higher energies and charge

(0.5 GeV>5 GeV, 100 pC>1 nC):

- Energy conservation: 100x higher laser energy needed (0.6 J > 60 J)
- analytical scaling laws have been confirmed experimentally

Boosted-Frame Particle-in-Cell simulations recently have demonstrated the ability to simulate m-scale laser-wakefield interactions with multi-PW lasers:



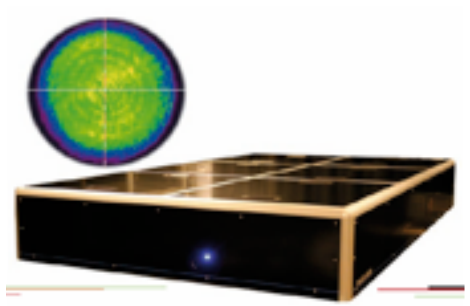
ATLAS-3000: schematic layout

ELI and its spin-offs started several new enabling technologies for large-scale Ti:Sa lasers:

Large Ti:Sa crystals:

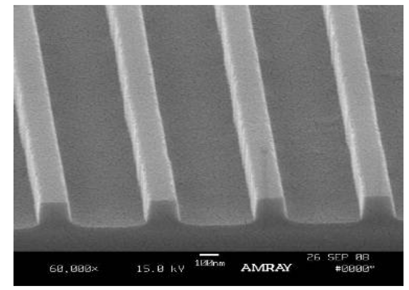
192 mm dia. Ti:Sa crystal
(image courtesy Crystal Systems)

high-power, rep-rated pump lasers

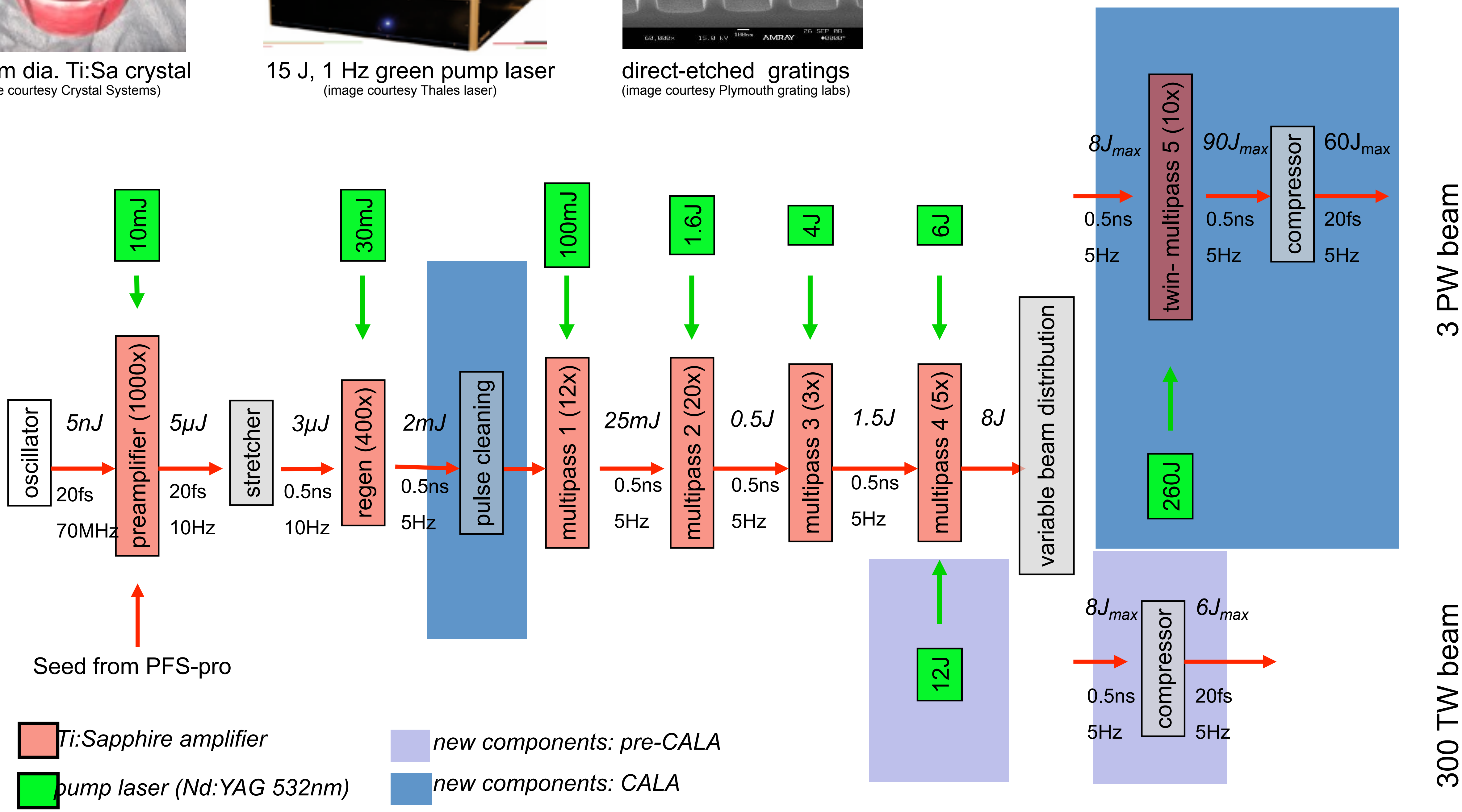


15 J, 1 Hz green pump laser
(image courtesy Thales laser)

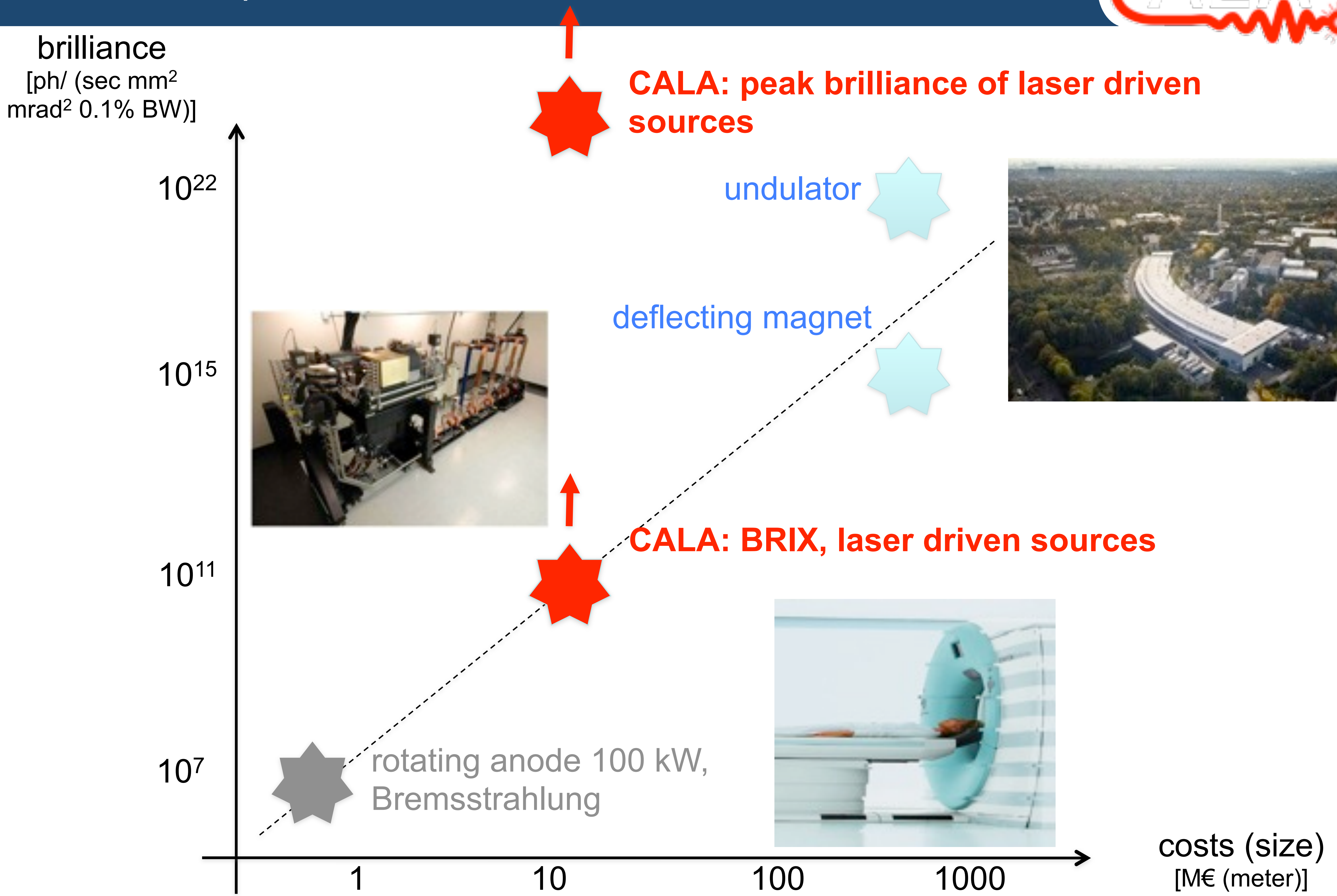
new large-size, high-efficiency gratings



direct-etched gratings
(image courtesy Plymouth grating labs)



brilliance comparison (© F. Pfeiffer)



Conclusions

- CALA is going to become the backbone for laser acceleration research in Munich from 2014/15 onwards

- CALA applications focus on compact accelerators for medical purposes - but with EuroNNAc, we are keen for more...

- CALA aims at combining medical diagnosis and therapy, and at developing new imaging/treatment techniques early on

- Key electron parameters for CALA projects have been realized even with the current laser systems at MPQ

- Access to CALA is possible through collaboration with Munich groups in the MAP framework