Laser ion acceleration research activities at Munich and ongoing facility upgrades from LEX towards CALA

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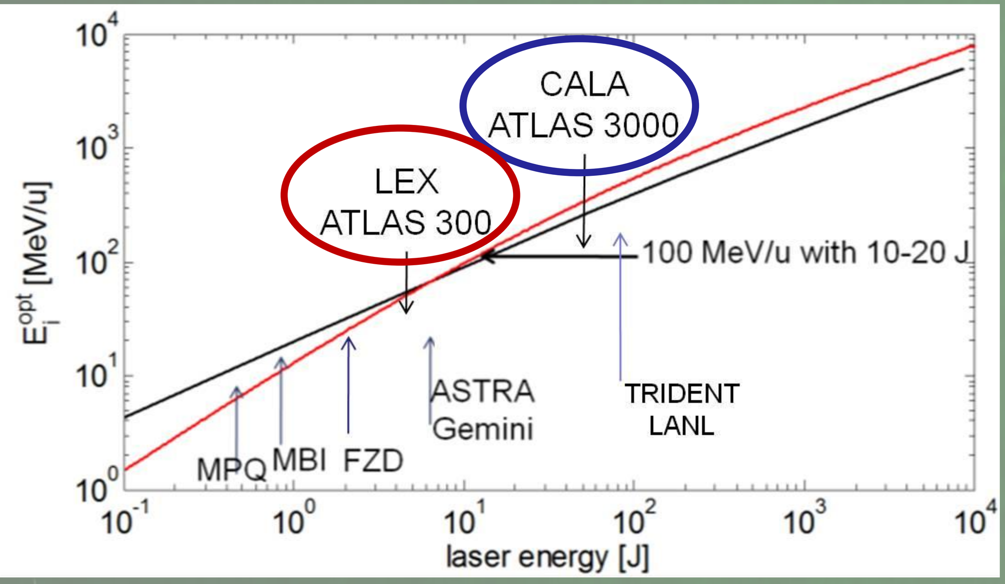
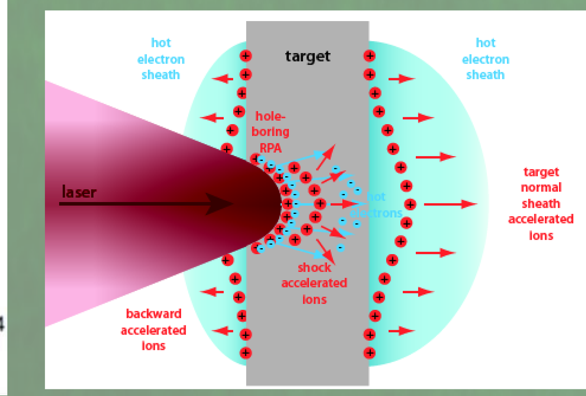
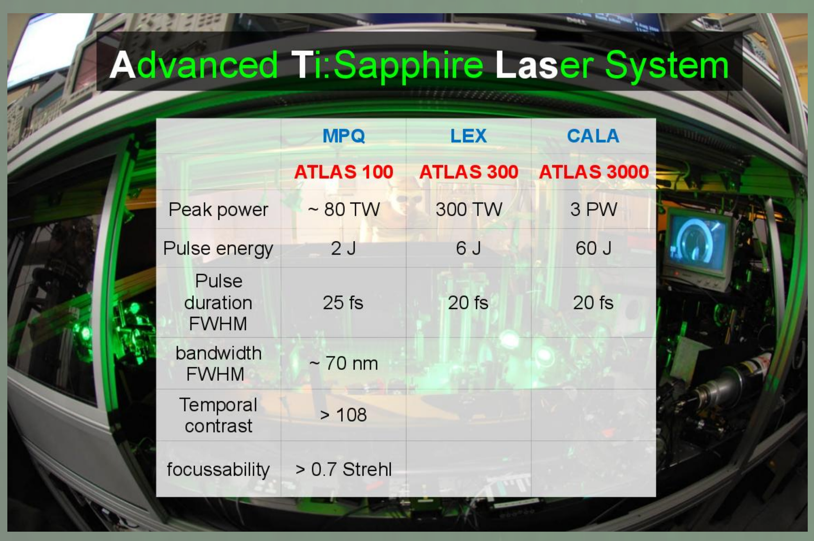
LEX and CALA

Mission: novel high-power, ultrashort, pulsed light-source development

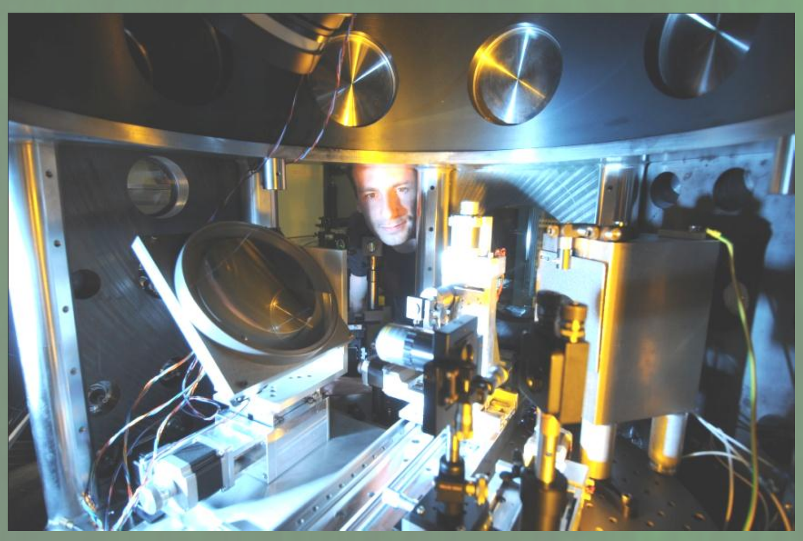
- Drivers for compact secondary brilliant X-ray and particle sources for novel methods in medical imaging and therapy
- In the future CALA infrastructure these sources will be used to develop novel methods for medical imaging with the aim of early-stage cancer detection and also for their therapy using laser generated stable multi MeV ions



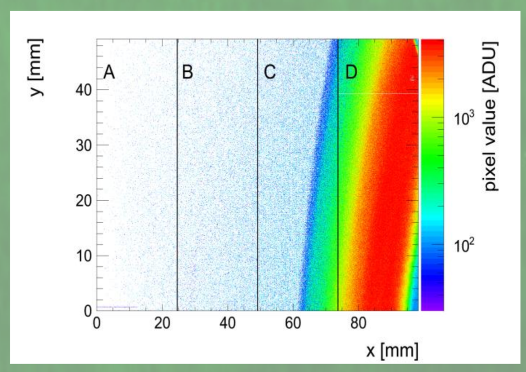




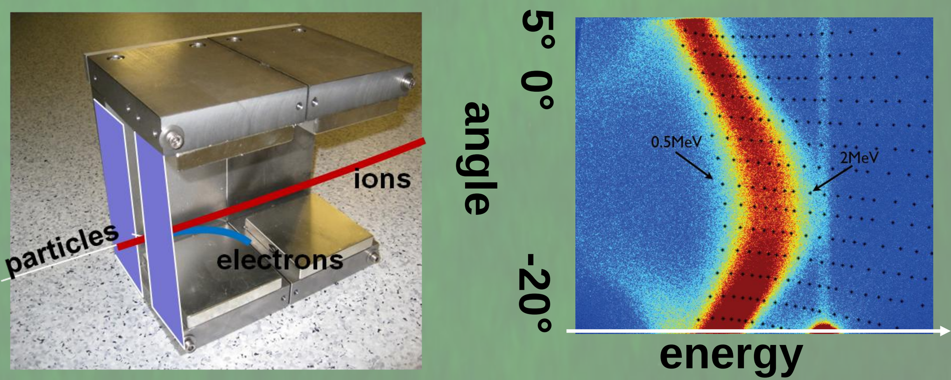
	MPQ	LEX	CALA
	ATLAS 100	ATLAS 300	ATLAS 3000
Peak power	~ 80 TW	300 TW	3 PW
Pulse energy	2 J	6 J	60 J
Pulse duration FWHM	25 fs	20 fs	20 fs
bandwidth FWHM	~ 70 nm		
Temporal contrast	> 108		
focussability	> 0.7 Strehl		



Detector development



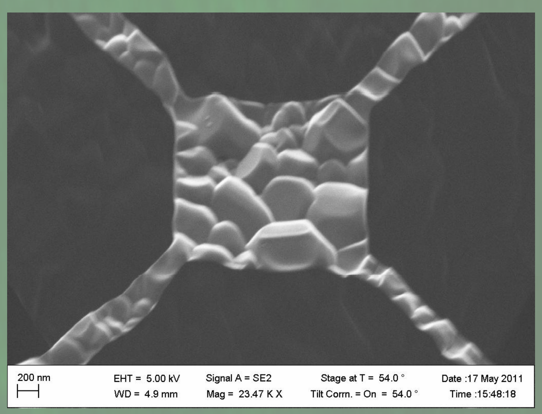
-Large size stackable pixel detector with dynamic range of 12 bits and very high sensitivity. Capable of detecting single particles

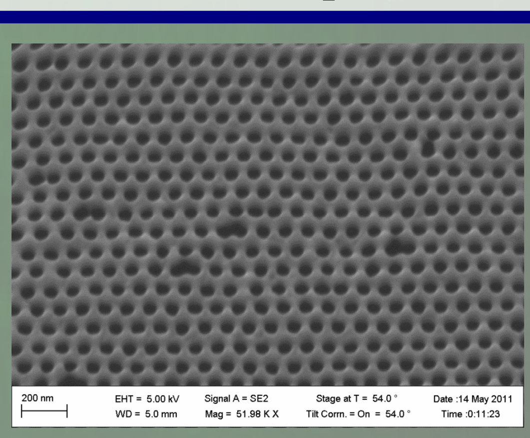


-vWASP: very Wide angle electron spectrometer

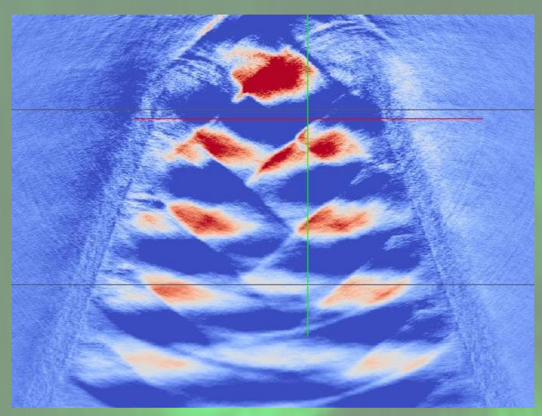
Electron Spectrometer with energy spectrum ranging from 0.5 MeV to 60 MeV and large angle range

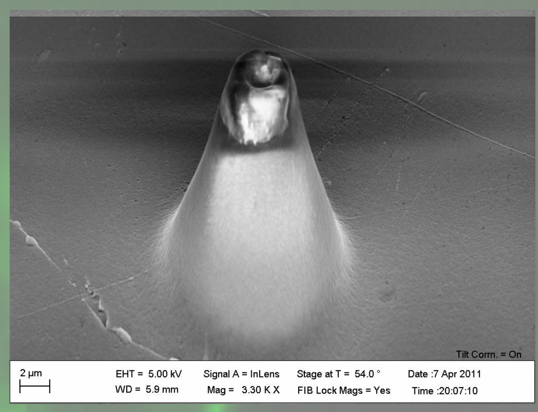
Target fabrication and development



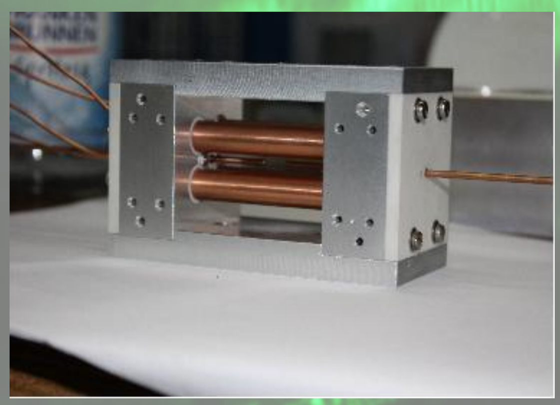


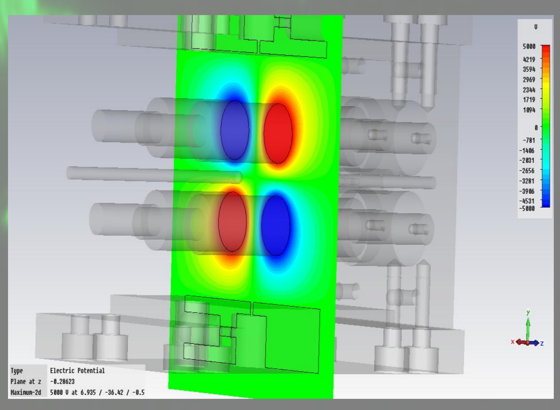
- Nanostructured targets give access to new phenomena such as electron blowout, directed coulomb explosion or heavy ion acceleration etc



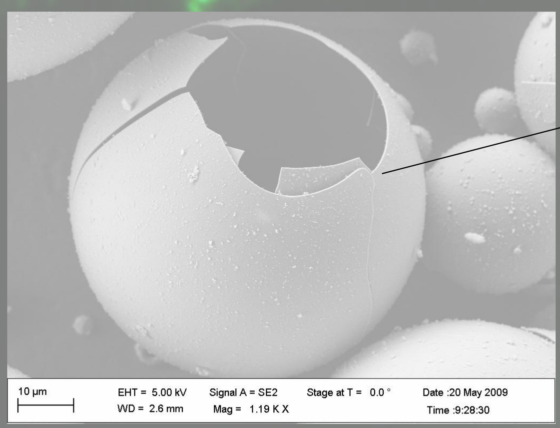


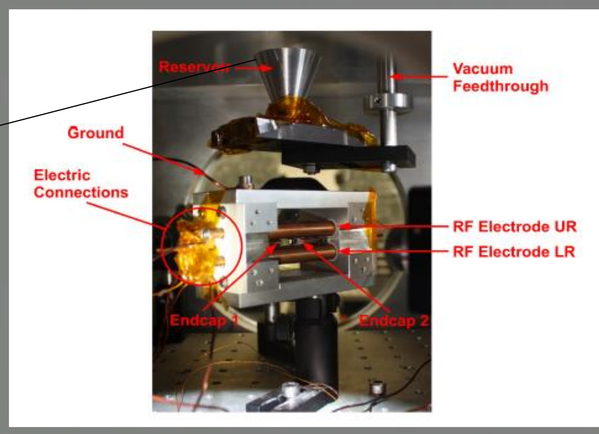
- Nonlinear effects in micro cone targets enable to "squeeze" light beyond the diffraction limit, hereby achieving intensity enhancements of one order of magnitude



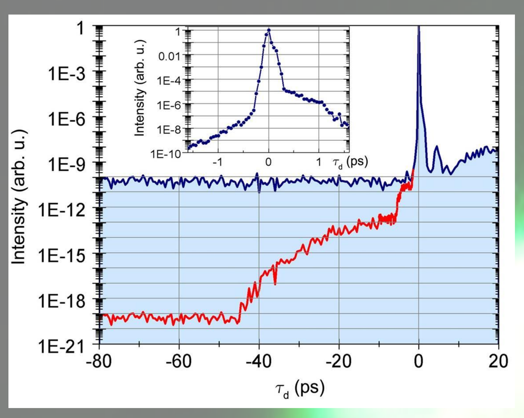


- Single, truly isolated, levitated targets (d= 100*nm* – 30*µm*) in a Paul Trap enable a wide range of new experiments (MLT 3D Target, direct bunch acceleration, overhauling coulomb explosion)



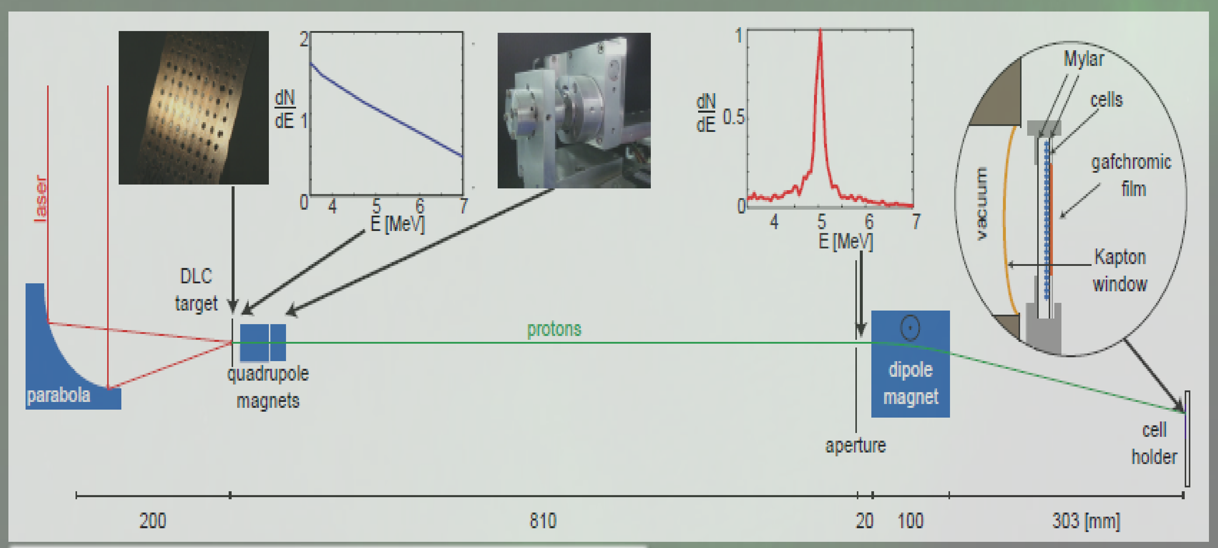


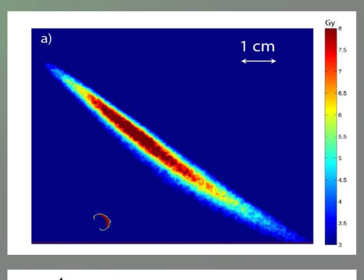
- Large reservoir for fast trapping and cooling of various target geometries such as hollow spheres and even nano plates

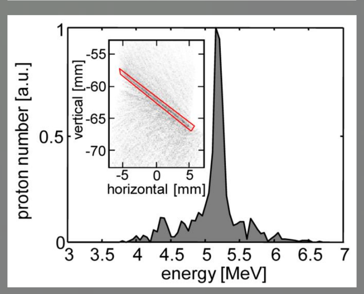


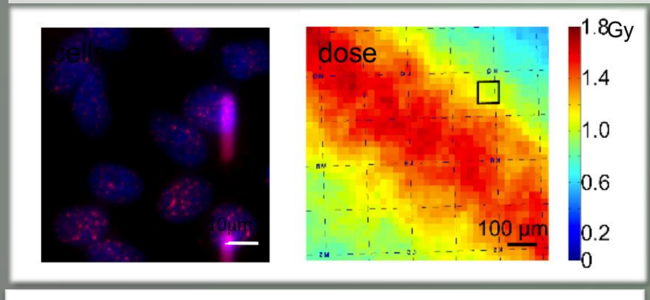
- LWS-20 OPCPA system with 5 *fs* duration will be upgraded from 100 *mJ* to 500 *mJ*. The unsurpassed contrast of the system makes it the ideal tool for furter investigations of RPA

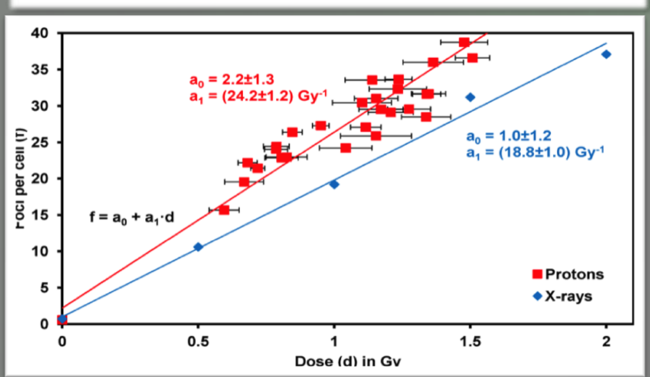
Radiobiological studies











- Demonstrating the potential of small, high repetition rate lasers for generating high proton yield, a nearly mono energetic spectrum and a reduction of background radiation

- Demonstrating the feasibility of a compact beamline for proton acceleration, transport and delivery

- Full dose response analysis in a single shot Radiation dose up to 7 Gy in a single, ns proton bunch

Selected project-related publications

[1] J. Bin, K. Allinger, J. Schreiber and J. Wilkens,, A laserdriven nanosecond proton source for radiobiological studies (accepted J Appl Phys)

[2] D. Habs, P.G. Thirolf, M. Gross, K. Allinger, J. Bin, A. Henig, D. Kiefer, W. Ma, J. Schreiber, Introducing the fission-fusion reaction process: using a laser-accelerated Th beam to produce neutron-rich nuclei towards the N = 126 waiting point of the r-process, Appl. Phys. B. 103, 471-484 (2011)

[3] S. Steinke, M. Schnürer, T. Sokollik, A.A. Andreev, P.V. Nickles, A. Henig, R. Hörlein, D. Kiefer, D. Jung, J. Schreiber, T. Tajima, M. Hegelich, D. Habs, W. Sandner, Optimization of laser-generated ion beams, Contrib. Plasma Phys. 51, 444-450 (2011)

[4] R. Hörlein, S. Steinke, A. Henig, S. G. Rykovanov, M. Schnürer, T.Sokollik, D. Kiefer, D. Jung, X.Q. Yan, T. Tajima, J. Schreiber, M. Hegelich, P.V. Nickles, M. Zepf, G.D. Tsakiris, W. Sandner, D. Habs, Dynamics of Nanometer-Scale Foil Targets Irradiated with Relativistically Intense Laser Pulses, Laser and Particle Beams, DOI:10.1017/S0263034611000462. 112

[5] T. Paasch-Colberg, T. Sokollik, K. Gorling, U. Eichmann, S. Steinke, M. Schnürer, P.V. Nickles, A. Andreev, W. Sandner, New method for laser driven ion acceleration with isolated, mass-limited targets, Nucl. Instr. Meth. A, DOI:10.1016/j.nima.2011.02.031.

[6] Wenjun Ma, V.Kh. Liechtenstein, J. Szerypo, D. Jung, P. Hilz, B.M. Hegelich, H.J. Maier,J. Schreiber, D. Habs Preparation of self-supporting diamond-like carbon nanofoils with thickness less than 5nm for laser-driven ion acceleration

[7] S. Steinke, A. Henig, M. Schnürer, T. Sokollik, P.V. Nickles, D. Jung, D. Kiefer, R. Hörlein, J. Schreiber, T. Tajima, X.Q. Yan, M. Hegelich, J. Meyer-ter-Vehn, W. Sandner, D. Habs, Efficient ion acceleration by collective laser-driven electron dynamics with ultra-thin foil targets, Laser & Part. Beams 28, 215 (2010)

[8] A. Henig, S. Steinke, M. Schnürer, T. Sokollik, R. Hörlein, D. Kiefer, D. Jung, J. Schreiber, B.M. Hegelich, X.Q. Yan, J. Meyer-ter-Vehn, T. Tajima, P.V. Nickles, W. Sandner, D. Habs, Radiation-Pressure Acceleration of Ion Beams Driven by Circularly Polarized Laser Pulses, Phys. Rev. Lett. 103, 245003 (2009)

[9] A. Henig, D. Kiefer, K. Markey, D.C. Gauthier, K.A. Flippo, S. Letzring, R.P. Johnson, T. Shimada, L. Yin, B.J. Albright, K.J. Bowers, J.C. Fernandez, S.G. Rykovanov, H.C. Wu, M. Zepf, D. Jung, V.K. Liechtenstein, J. Schreiber, D. Habs, B.M. Hegelich, Enhanced laser-driven Ion Acceleration in the Relativistic Transparency Regime, Phys. Rev. Lett. 13, 045002 (2009)

[10] A. Henig, D. Kiefer, M. Geissler, S.G. Rykovanov, R. Ramis, R. Hörlein, J. Osterhoff, Z. Major, L. Veisz, S. Karsch, F. Krausz, D. Habs, J. Schreiber, Laser-Driven Shock Acceleration of Ion Beams from Spherical Mass-Limited Targets, Phys. Rev. Lett. 102, 095022 (2009)

[11] S.G. Rykovanov, J. Schreiber, J.Meyer-ter-Vehn, C. Bellei, A. Henig, H.C.Wu, M. Geissler, Ion acceleration with ultra-thin foils using elliptically polarized laser pulses, New J. Phys. 10, 113005 (2008)