

Building a Target Network for Advanced Laser Light Sources

Workshop

29-31 August 2016

Helmholtz-Zentrum Dresden-Rossendorf

Organizing Committee

M Cernaianu, T Cowan, G Fiquet, Z Konopkova, D Margarone, S Pascarelli, I Prencipe, M Tolley

i.prencipe@hzdr.de

HZDR



Science & Technology
Facilities Council



scitech PRECISION
MICRO LASER TARGETS



Credits Anna Ferrari

Advanced Laser Light Source User Facilities

→ Emerging demands for high repetition-rate targetry

High repetition rate lasers:

from **shot(s)/hour** → **shot-on-demand** → **0.01-10 Hz**

→ Efficient use of major X-ray User Facilities



HIBEF @ HED / XFEL,



HPLF @ ID24 / ESRF

→ Realizing the Promise of the **ELI** infrastructures



→ Long-term development of our User Community

- lower the Barriers-to-Entry for new users/small groups
- exploit synergies between Euro-, national & institutional laser facilities
- promote innovation, education & training




Meeting Agenda

Monday 29		Tuesday 30		Wednesday 31	
		08:00	Bus from the Intercity Hotel	08:00	Bus from the Intercity Hotel
		08:20	Bus from the Eckberg Schloss Hotel	08:20	Bus from the Eckberg Schloss Hotel
		09:00	Introduction to panel discussions – T. Cowan	09:00	Summary of the panel discussion results
		09:30	Panel discussions /1	09:00	High repetition rate challenges - D. Schumacher
			PANEL DISCUSSIONS		SUMMARY & NEXT STEPS
			- max community involvement		
		10:15	Coffee Break	09:15	Targetry for electron transport and isochoric heating - S. Fuchs
		11:30	Panel discussions /2	09:30	Targetry for laser-driven particle and radiation sources - J. Fuchs
			High repetition rate challenges	09:45	Targetry for shock compression physics - S. Pascarelli
			D. Schumacher (Lecture Hall)	10:00	Coffee Break
		12:15	Group Picture	10:30	Panel discussion/3
		13:20	Lunch Break		Consideration of a target network for advanced laser-light sources – J. Cowan (Lecture Hall)
		14:15	Session - Advanced laser light facilities	11:30	Summary and conclusions
		14:15	ELI Beams - P. Litoslawski	12:00	Closure
		14:30	ELI Nuclear Physics - M. Cernaianu	12:30	Bus to the Hotels
		14:45	ELI Alps - C. Voss		
		15:00	Shocking targets - S. Pascarelli		
		16:15	HED instrument at the European XFEL		
		16:30	Apollo - S. Fuchs		
		16:45	Coffee Break		
		16:15	Session - Target production capabilities		
		16:15	Low-temperature plasma-based techniques for target production - A. G. Sedykhov		
		16:35	Target fabrication at CEA - J. J. Vermeir		
		16:50	Cryogenic and polarized targets for kHz to MHz		
		17:05	Laser repetition rates - M. Büscher		
		17:05	Possible laser target fabrication at the IBC		
		17:05	J. Fassbender		
		17:00	Bus to the Lingerterassen Restaurant		
		19:30	Social Dinner		
12:15	Bus from the Intercity Hotel				
12:35	Bus from the Eckberg Schloss Hotel				
12:30	Registration				
13:30	Opening Session				
13:30	Welcome				
13:40	The EUCA				
14:00	A target network for advanced laser light				
14:25	Funding strategies and EU lobbying				
14:45	TSN - Targetry strategies				
15:30	M. Tolley				
16:00	General atomics: target fabrication and supply strategies - N. Alexander				
16:30	ELITA: Targets for the Extreme Light Infrastructure - M. Smid				
16:45	EUCALL HIREP: High repetition rate sample delivery - J. Schulte				
17:00	K. Nagai - Large scale target production				
17:20	Poster Clip, Poster Session and Dinner				
21:00	Bus to the Hotels				

Advanced Laser Light Source User Facilities

→ Panel Discussions

Science topic

			
• Particle & Radiation Generation	2	-	1
• Electron transport & isochoric heating	1	-	1
• Compression & material dynamics	1	1	2
• High Rep-rate Challenges	1	1	1

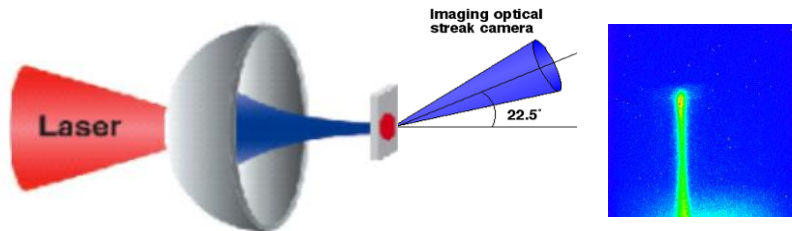
Synergies & Complementarities:

- XFEL: fs, coherent, narrow band → XRD, CXDI, resonant SAXS, FR, ultrafast pp
- ESRF: 100 ps, pink → absorption, XRD
- ELI: fs, multi-beams → absorption, ultrafast, multi-species p-p

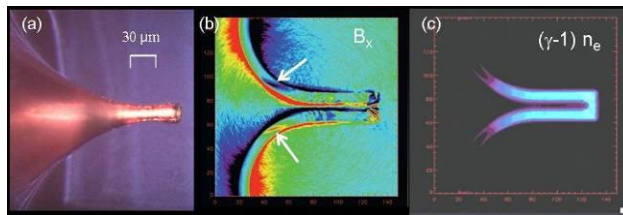
Improve basic understanding ↔ Develop new techniques

Example: Extreme matter in relativistic laser-plasma interactions

Isochoric heating with laser-accelerated protons
Patel *et al.*, Phys. Rev. Lett. **91**, 125004 (2003)

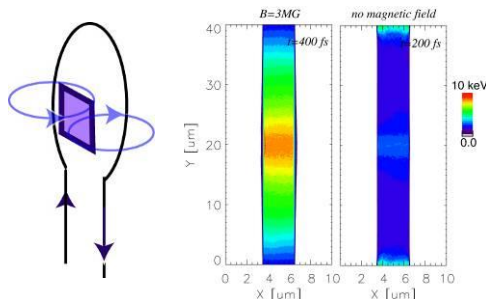


Self-generated magnetic confinement of hot electrons and enhanced heating
Rassuchine *et al.*, PRE **79**, 036408 (2009)

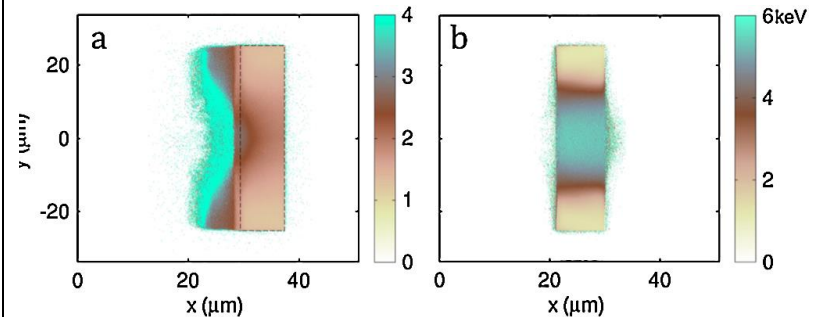


Pulsed external ~MG magnetic transport inhibition
Bakeman *et al.*, Megagauss XI (2007)

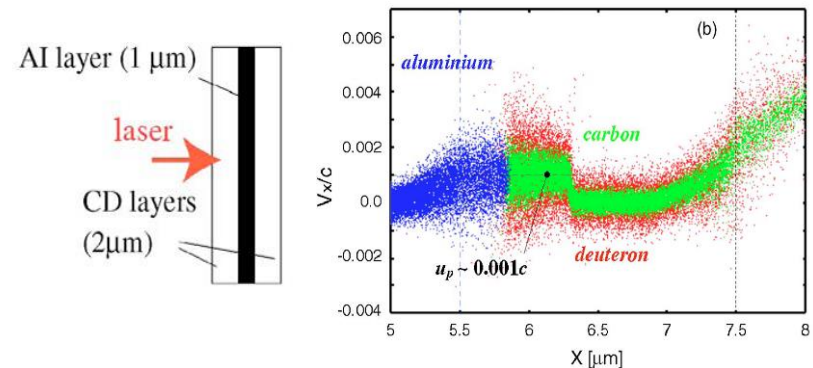
<http://conferences.theiet.org/mg-xi/mgxi-final-v7.0.pdf>



Electrostatic-confinement of hot electrons using reduced-mass targets
Perez *et al.*, Phys. Rev. Lett. **104**, 085001 (2010)



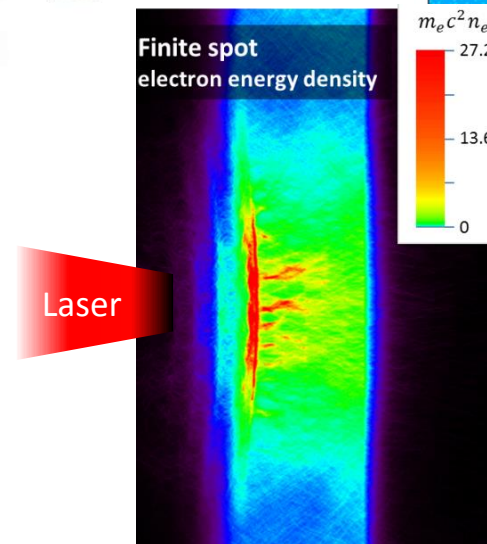
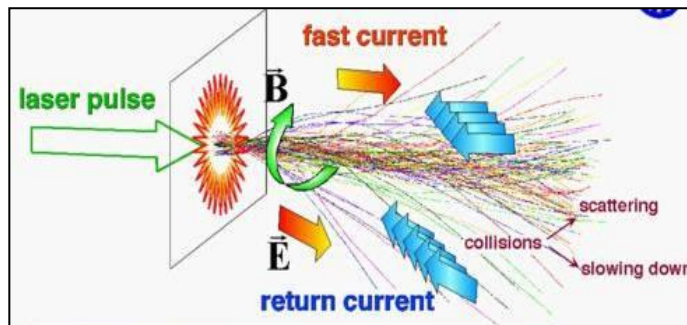
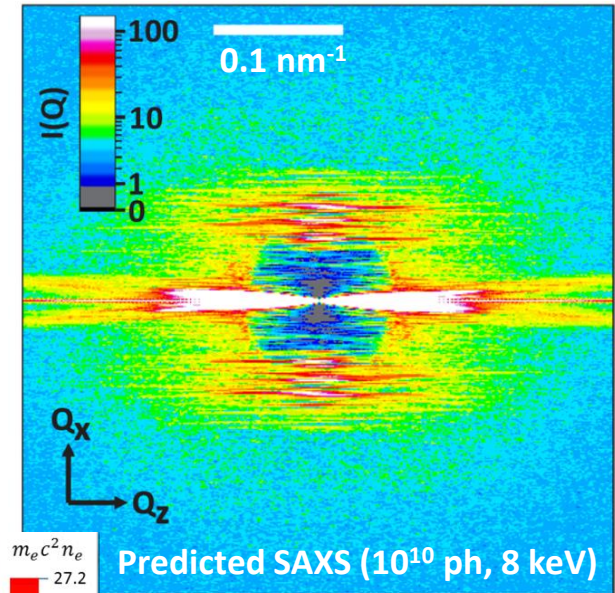
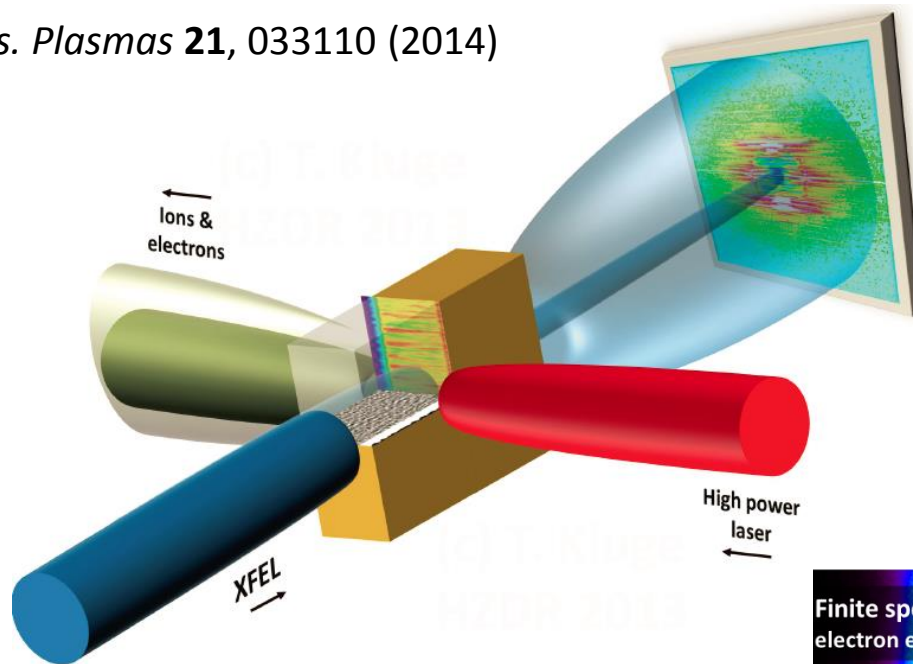
Interface shock heating in heterogenous targets
Sentoku *et al.*, Phys. Plasmas **14**, 122701 (2007)



→ XFEL to probe and understand spatial- & temporal-gradients → improve PW science

HIBEF: Relativistic laser-matter interactions -- Probing solid-density plasma with coherent x-ray diffraction

Phys. Plasmas **21**, 033110 (2014)



- ionization dynamics, heating & resistivity
- electron transport, return current neutralization
- filamentation, hole boring
- e-e & e-i equilibration
- quasi-static fields
-

Advanced Laser Light Source User Facilities

→ Emerging demands for high repetition-rate targetry

High repetition rate lasers:

from **shot(s)/hour** → **shot-on-demand** → **0.01-10 Hz**

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→ Realizing the Promise of the **ELI** infrastructures

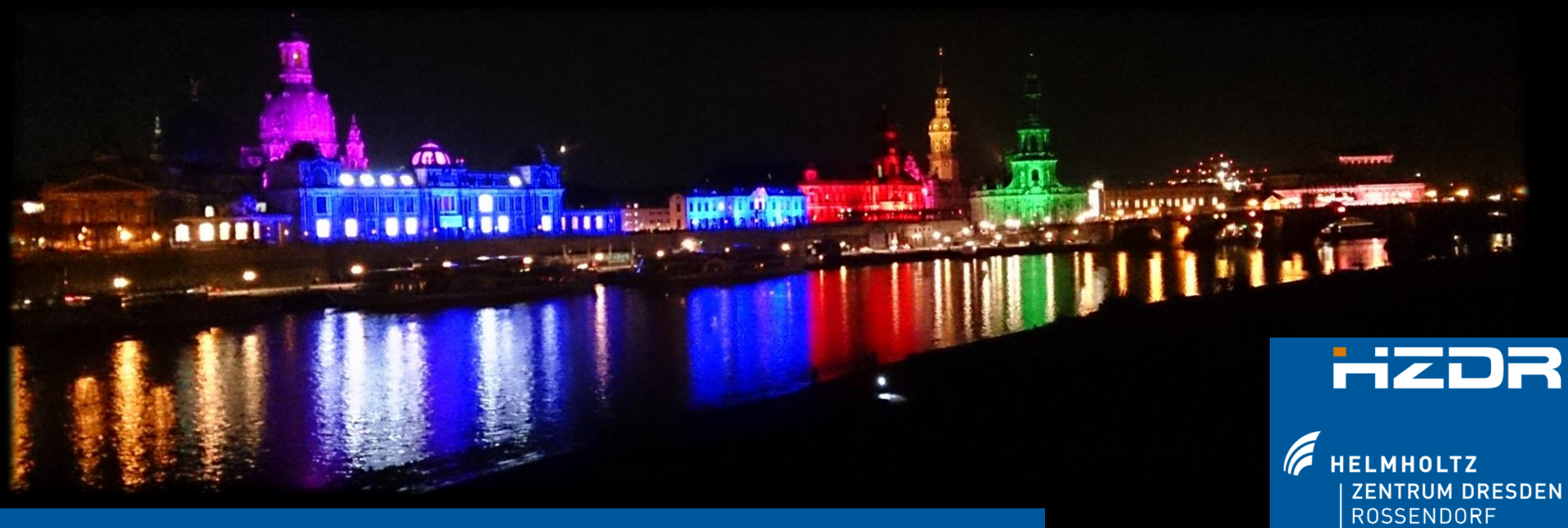


→ Long-term development of our User Community

- lower the Barriers-to-Entry for new users/small groups
- exploit synergies between Euro-, national & institutional laser facilities
- promote innovation, education & training

Conclusions

- Welcome to Dresden
- And let us have a very productive workshop



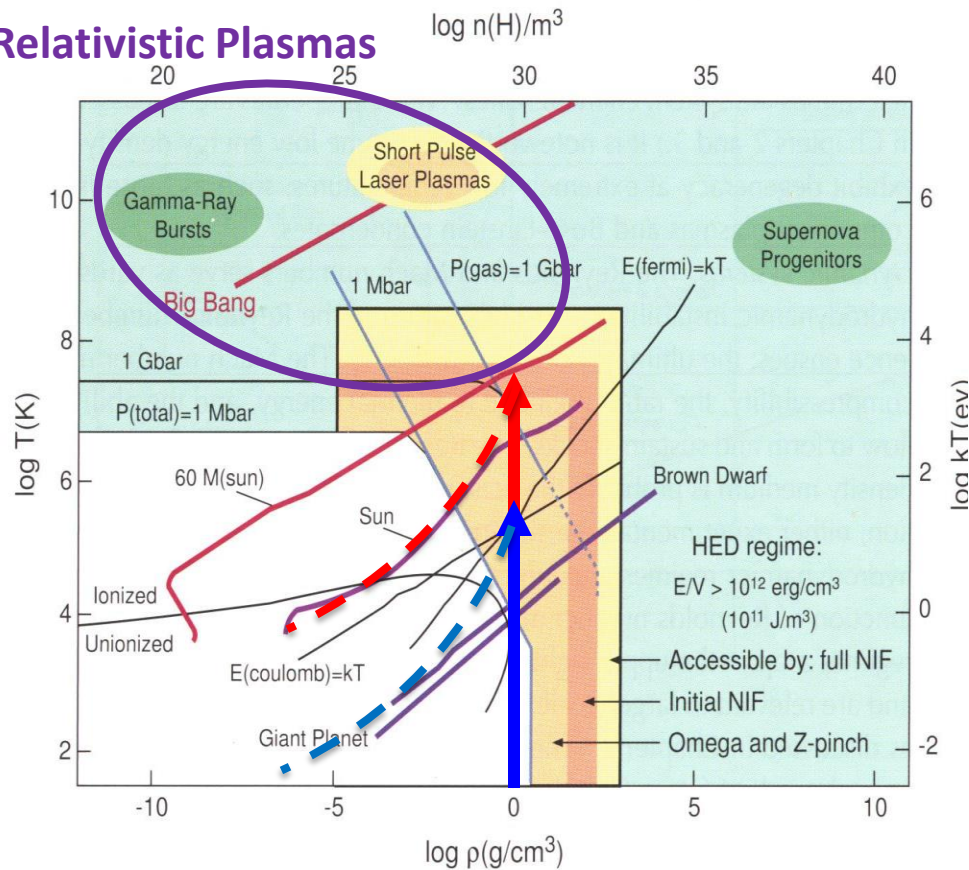
HZDR



HELMHOLTZ
ZENTRUM DRESDEN
ROSSENDORF

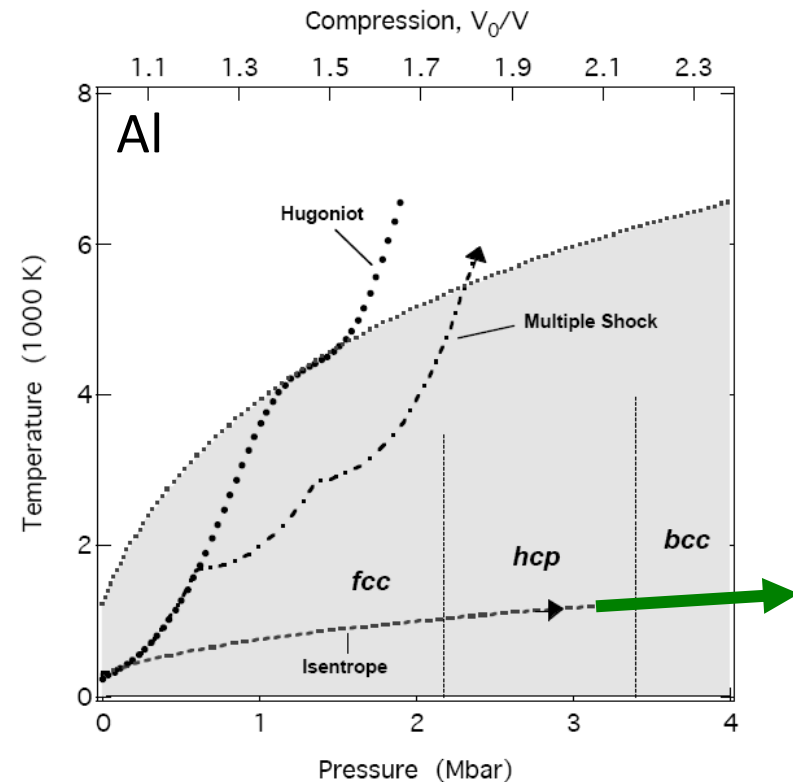
Isochoric Heating

Relativistic Plasmas



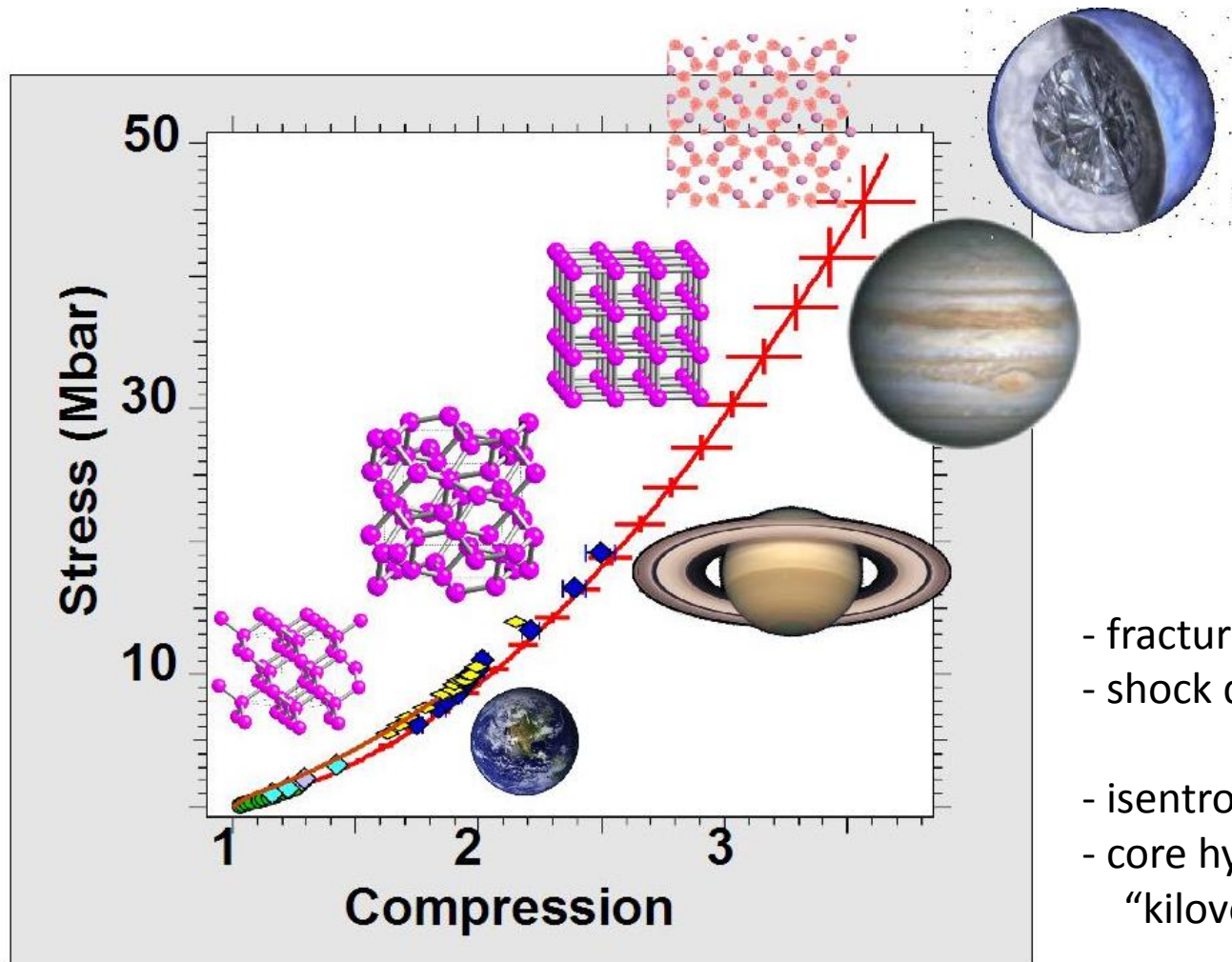
- Short-pulse laser-driven
- XFEL-driven

Compression



- Ramped (\sim kJ, \sim ns) cold compression to TPa

Extreme States of Matter at High Compression



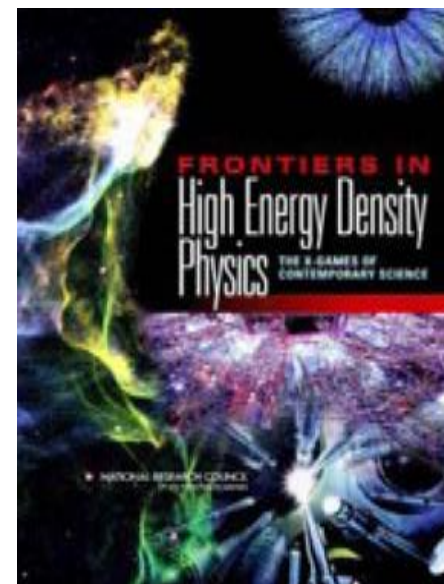
- fracture & deformation
- shock dynamics
- isentropic compression
- core hybridization
“kilovolt chemistry”
- “materials by design”

with Rostock, Oxford, DESY, Edinburgh, LLNL,
LANL, LCLS, LULI, CEA, CELIA-Bordeaux, IOE-MUT,
and many more....

Scientific synergies: ultra-intense laser physics & applications

XFEL-quality probing inside of dense plasma (with time-resolved, brilliant, and fully coherent x-rays) will:

- revolutionize our fundamental understanding of laser-matter interactions...
- advance High Energy Density Physics with ultra-intense lasers...
- benefit ultra-intense laser research worldwide, in many fundamental & applied areas...



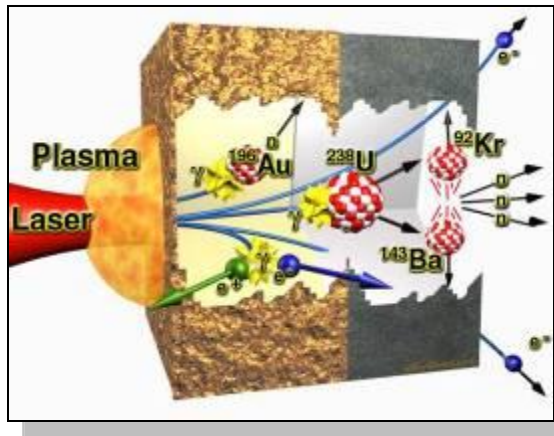
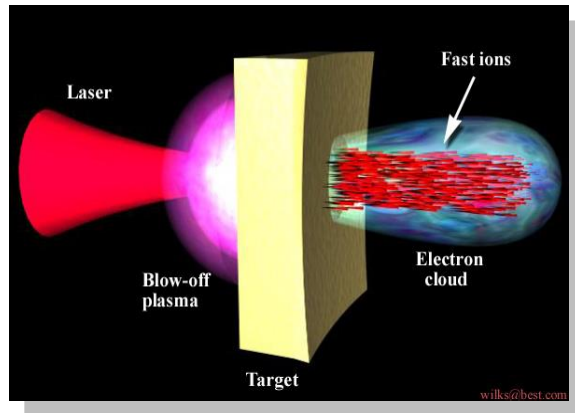
- Compact Accelerators
- Table-top light sources
- Radiation research in Oncology
- Fusion energy research
- Material dynamics

- Ultrafast physics, attosec. sources
- Warm Dense Matter
- Hot Dense Plasma
- Planetary Science
- Laboratory Astrophysics



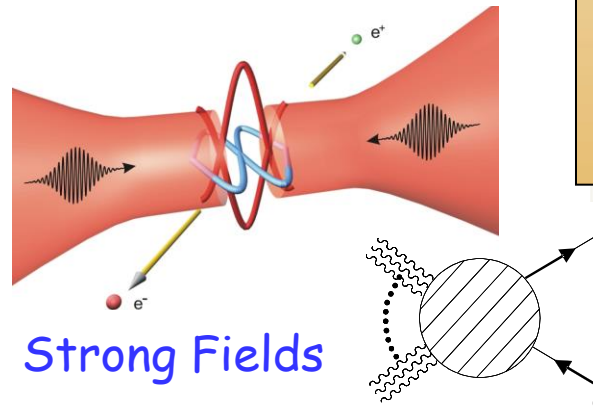
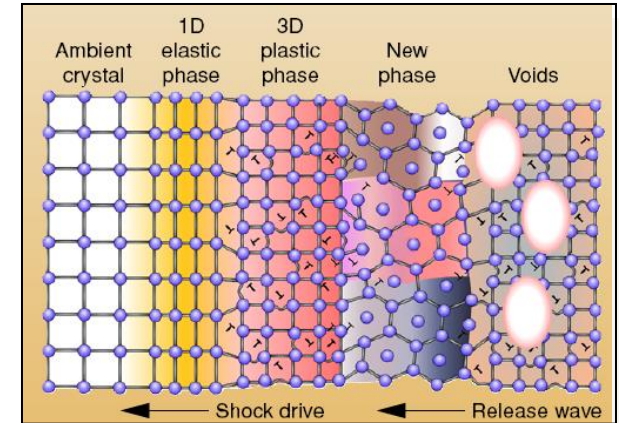
Extreme Conditions with Ultra-intense & High-energy Lasers

Extreme particle beams



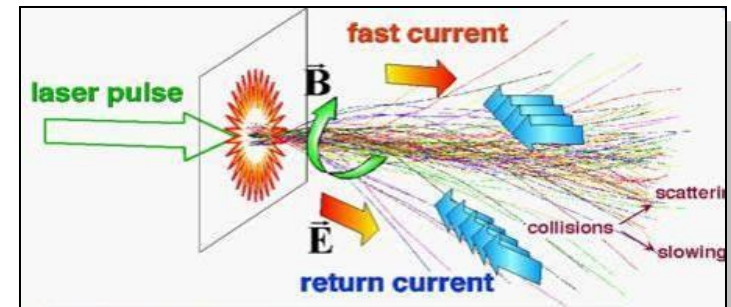
Extreme radiations

Extreme pressures



Strong Fields

Extreme currents



Helmholtz-Zentrum Dresden-Rossendorf

EUCALL Satellite Meeting

“Building a Target Network for Advanced Laser Light Sources”

29 August 2016

Research for the World of Tomorrow



HZDR – Facts and Figures

- Member of the **Helmholtz Association**
- **Foundation** 01.01.1992 (e.V.)
- **Employees approx. 1,100**
350 scientists
150 doctoral students
> **50** countries



- **Sites**
DRESDEN
Leipzig, Freiberg, Grenoble
Hamburg (coming soon...)
organized in 8 Institutes



Credits: Killig, Schmidtfoto, ESRF/Ginter

Images: 1. HZDR Entrance Building | Cyclotron at the HZDR Research Site
Leipzig | 3. European Synchrotron Radiation Facility in Grenoble

HERMANN VON HELMHOLTZ – His Name is Our Mission

Strategic Research for National Needs

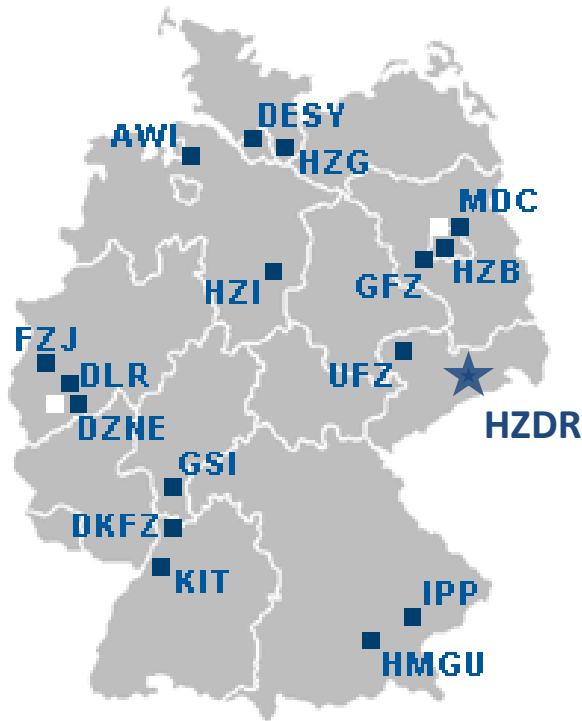


H. von Helmholtz
(1821 - 1894)

- **Solving major challenges** with cutting-edge research
- Commitment to **interdisciplinary research**
- **Think big, act big:** Developing and operating **complex infrastructures** and **large-scale facilities** for the national and international scientific community
- **Creating wealth** for society and industry through knowledge transformation and innovation

HERMANN VON HELMHOLTZ – His Name is Our Mission

Strategic Research for National Needs



Helmholtz Association
of Research Centers
(HGF)

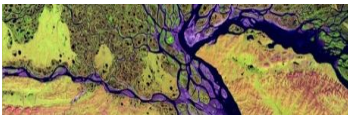
- **Solving major challenges** with cutting-edge research
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Cutting-Edge Science in Networks

The six research fields of the Helmholtz Association



ENERGY*



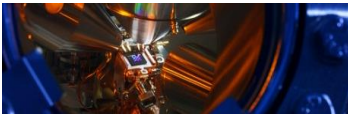
EARTH AND ENVIRONMENT



HEALTH*



AERONAUTICS, SPACE AND TRANSPORT



KEY TECHNOLOGIES



MATTER*

* HZDR Participation

HZDR Research Programs

- addressing Grand Challenges in the research fields *Energy, Health, and Matter*

ENERGY

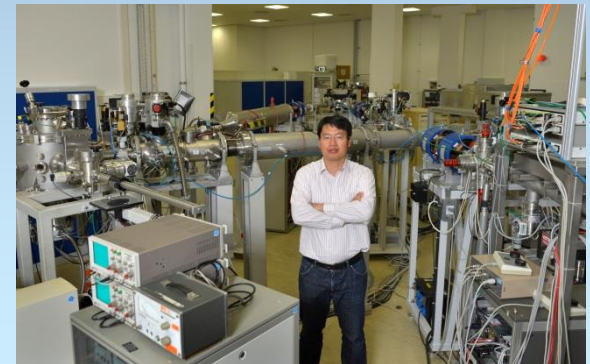
How can energy and resources be utilized in an efficient, safe, and sustainable way?

HEALTH

How can malignant tumors be more precisely visualized, characterized, and more effectively treated?

MATTER

How do matter and materials behave under the influence of strong fields and in smallest dimensions?



Credits: Weisflog, Bierstedt, Rietschel

Images: 1. At the TOPFLOW Facility | 2. PET/MRI-Full-Body Scan
Tomograph | 3. Ion Beam Center

Large Research Infrastructures

ELBE – Center for High-Power Radiation Sources

Electron accelerator (ELBE), free electron lasers (FELBE), terahertz facility (TELBE), and high-intensity lasers (DRACO & PENELOPE)

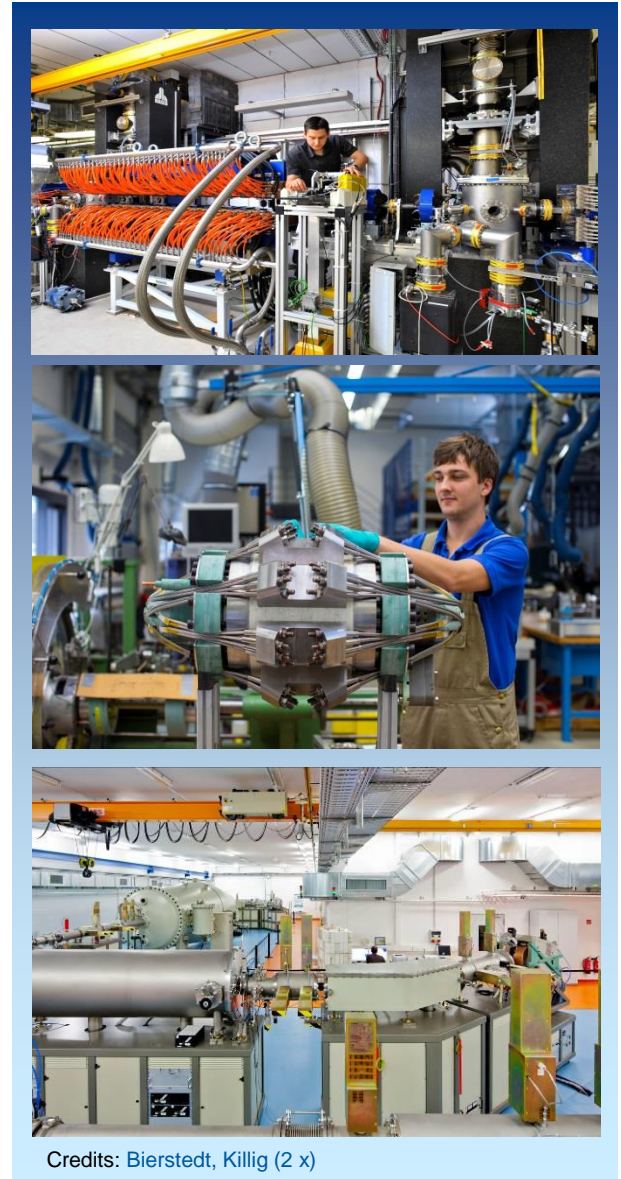
→ generating electron, positron, proton, neutron, X-ray, infrared, terahertz, & gamma-ray beams

Dresden High Magnetic Field Laboratory (HLD)

Producing Europe's highest pulsed magnetic fields for materials research

Ion Beam Center (IBC)

Nanoscale surface analysis and modification



Images: 1. THz Source TELBE | 2. Magnet Coil at the HLD | 3. Accelerator (6 MV) at the Ion Beam Center

Projects for the Future

DRESDYN – European platform for dynamo experiments and thermohydraulic studies with liquid sodium

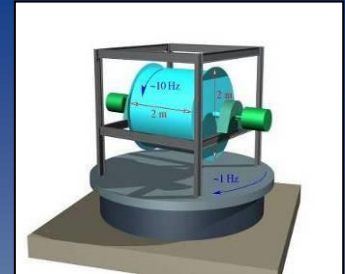
Center for Radiopharmaceutical Tumor Research

New research platform integrating and expanding the experimental infrastructure

Helmholtz International Beamline for Extreme Fields

at High Energy Density beamline at the European XFEL

- 200 TW @ 5 Hz, 100 J-ns @ 10 Hz, 50-60 T - ms
- User Consortium HIBEF, 100 institutions, 20 countries
- future kJ, PW

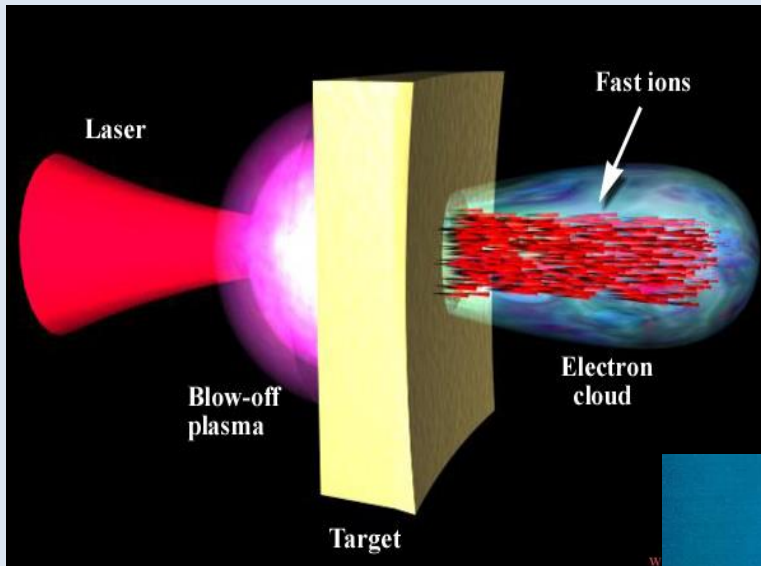


Credits: Bierstedt, HZDR, XFEL

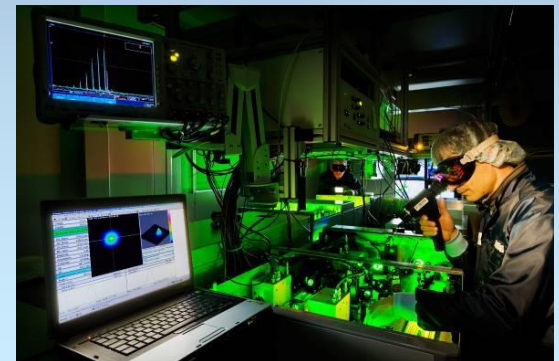
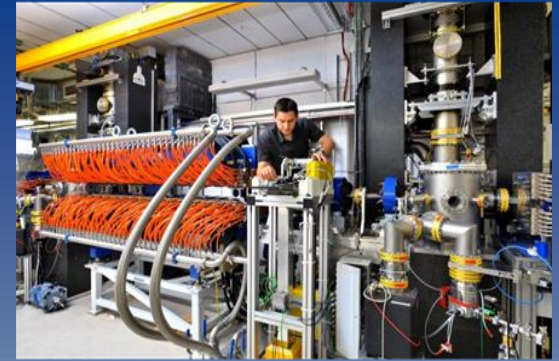
Images: 1. Precession Dynamo | 2. Center for Radiopharmaceutical Tumor Research
| 3. Accelerator Tunnel at European XFEL

Unique environment for world-leading multi-disciplinary research

MATTER + HEALTH



Laser-acceleration of ion beams for research in radiation oncology

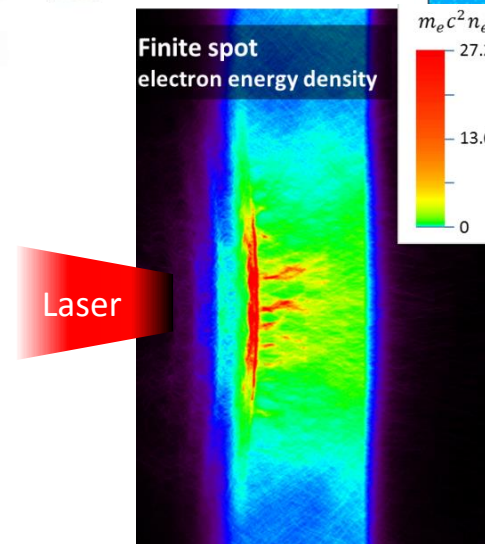
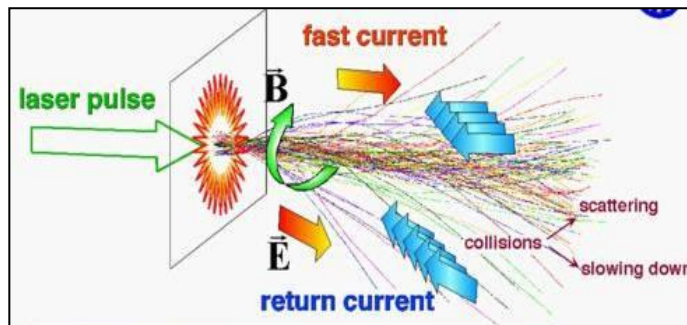
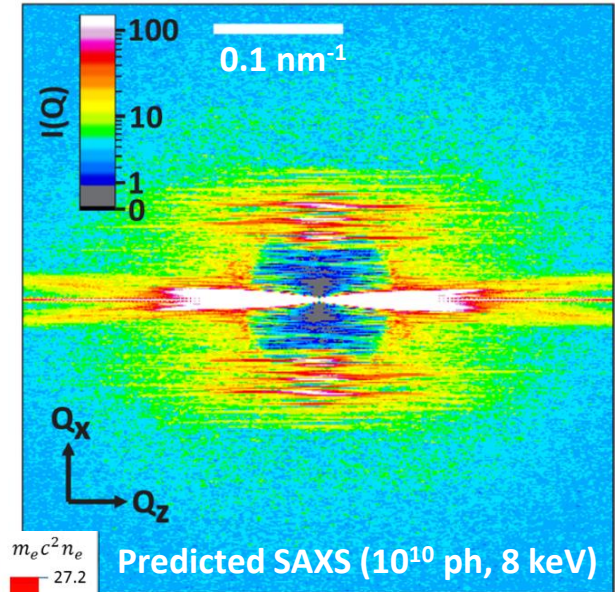
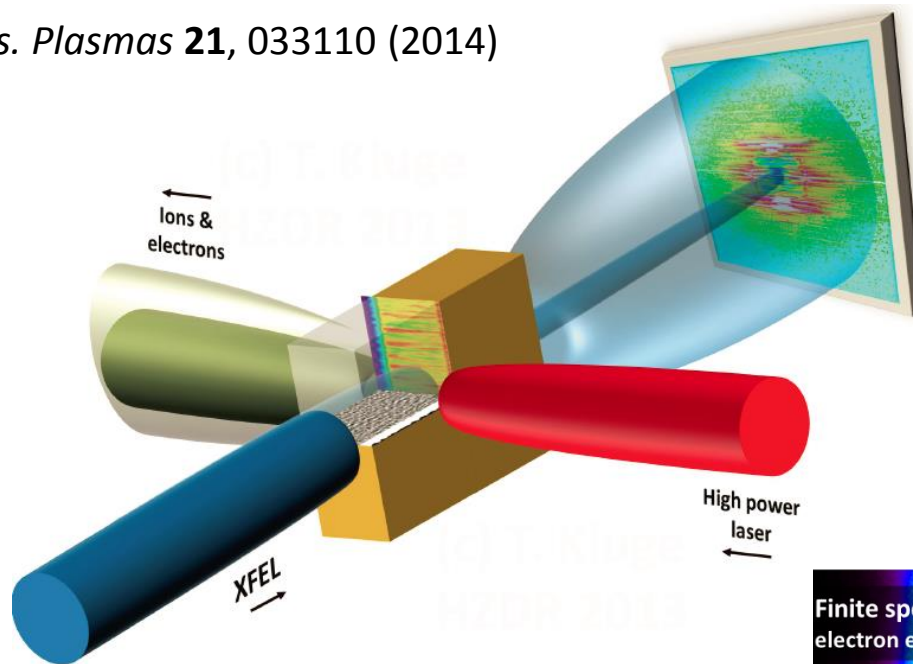


Credits: Bierstadt, Lösel

Images: 1. ELBE accelerator facility | 2. Proton therapy cave at OncoRay | 3. Particle Acceleration at the DRACO Laser

HIBEF: Relativistic laser-matter interactions -- Probing solid-density plasma with coherent x-ray diffraction

Phys. Plasmas **21**, 033110 (2014)



- ionization dynamics, heating & resistivity
- electron transport, return current neutralization
- filamentation, hole boring
- e-e & e-i equilibration
- quasi-static fields

DRESDEN
concept



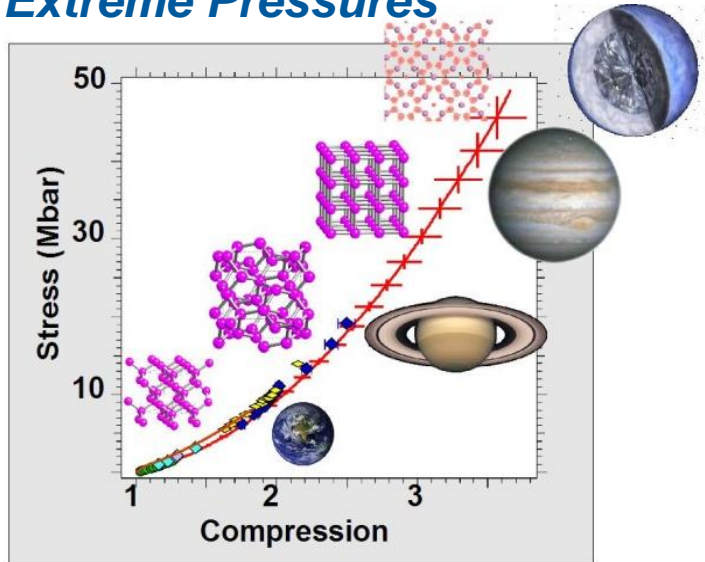
HZDR

Member of the Helmholtz Association

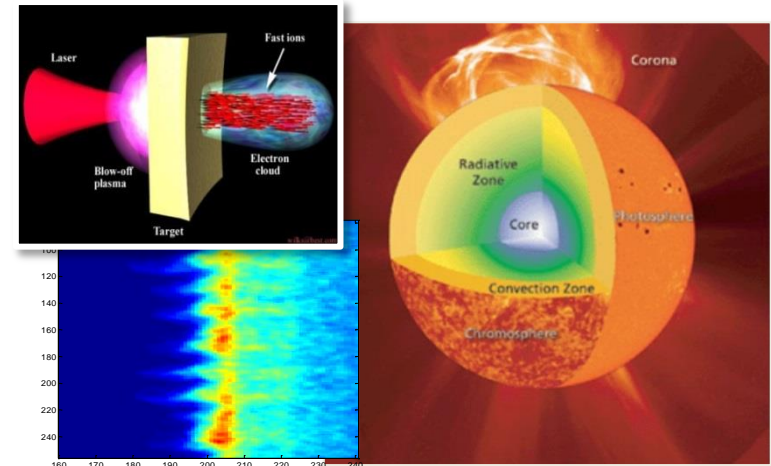
Prof. Dr. T.E. Cowan | Institute of Radiation Physics | www.hzdr.de

HIBEF: New States of Matter

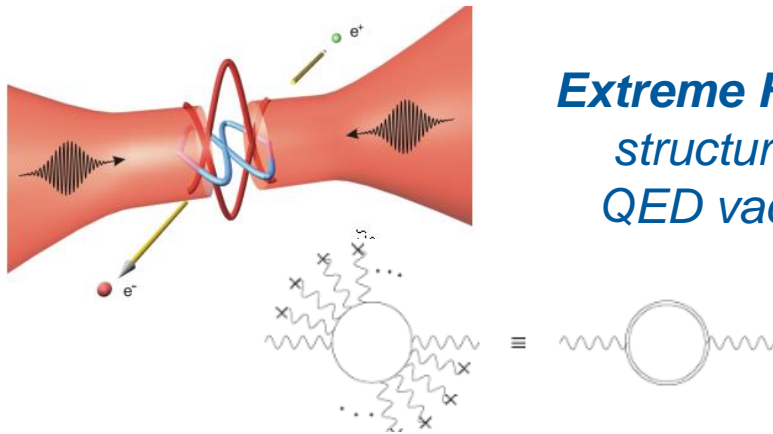
Extreme Pressures



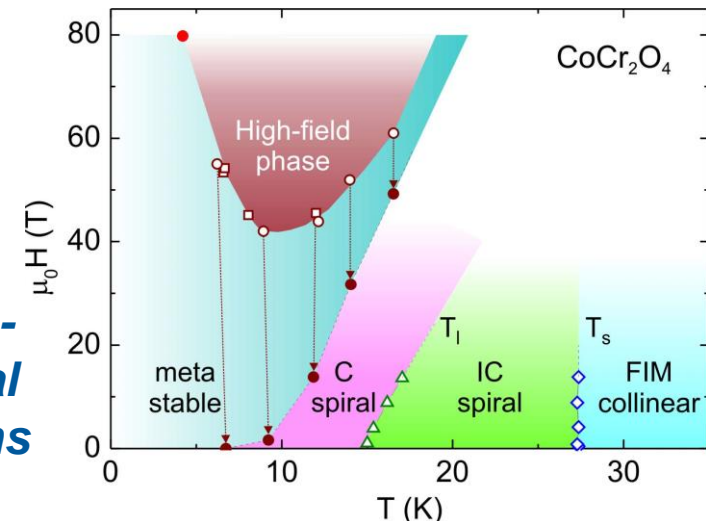
Extreme Temperatures



Extreme Fields: structure of QED vacuum

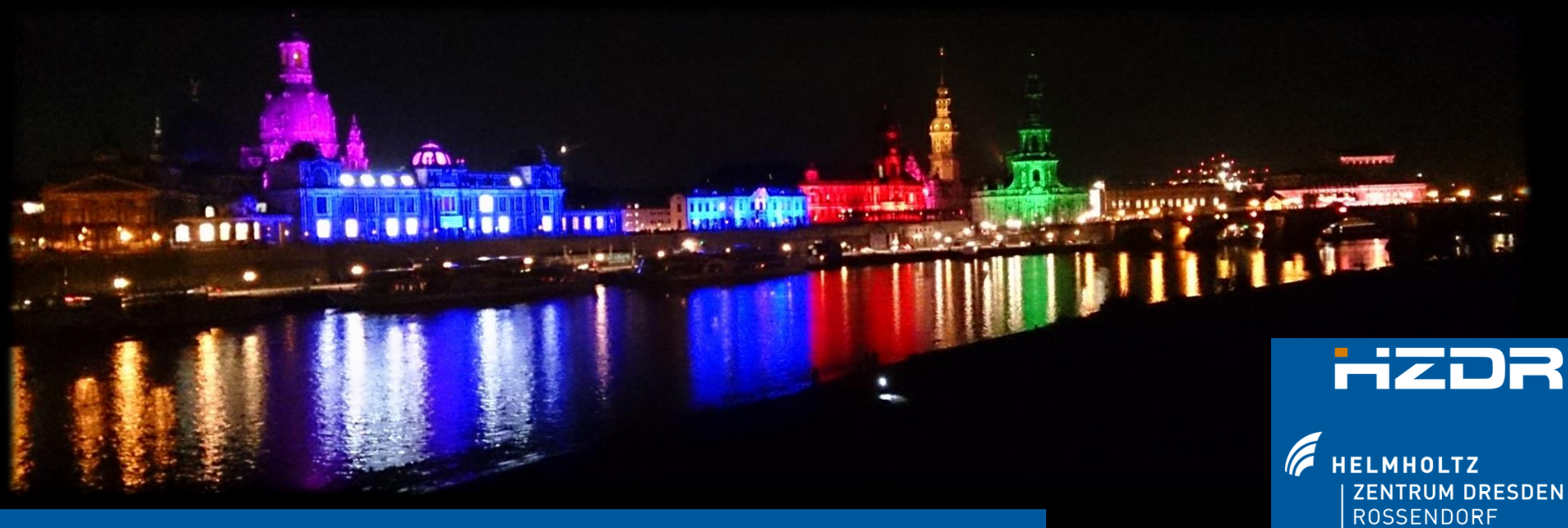


Magneto- structural transitions



Nat Mater **9**, 624 (2010), Rev Mod Phys **84**, 1607 (2012); Phys Plasmas **21**, 033110 (2014);
New J Phys **16**, 023008 (2014); Opt Comm **267**, 318 (2006); Phys Rev Lett **110**, 115502 (2013)

Thank you for your attention!



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