DESY Perspective on LPA for VHEE

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Andreas Maier

Lead Scientist Lasers & Secondary Sources

andreas.maier@desy.de
mls.desy.de
kaldera.desy.de

Fig: SciCom Lab & S. Jalas, M. Kirchen (DESY)

Laser-Driven Electron Acceleration

A compact accelerator technology

Few-100 MeV electrons

Shooting a very powerful laser into a mm-length plasma (hydrogen-gas target)

1000x stronger acceleration

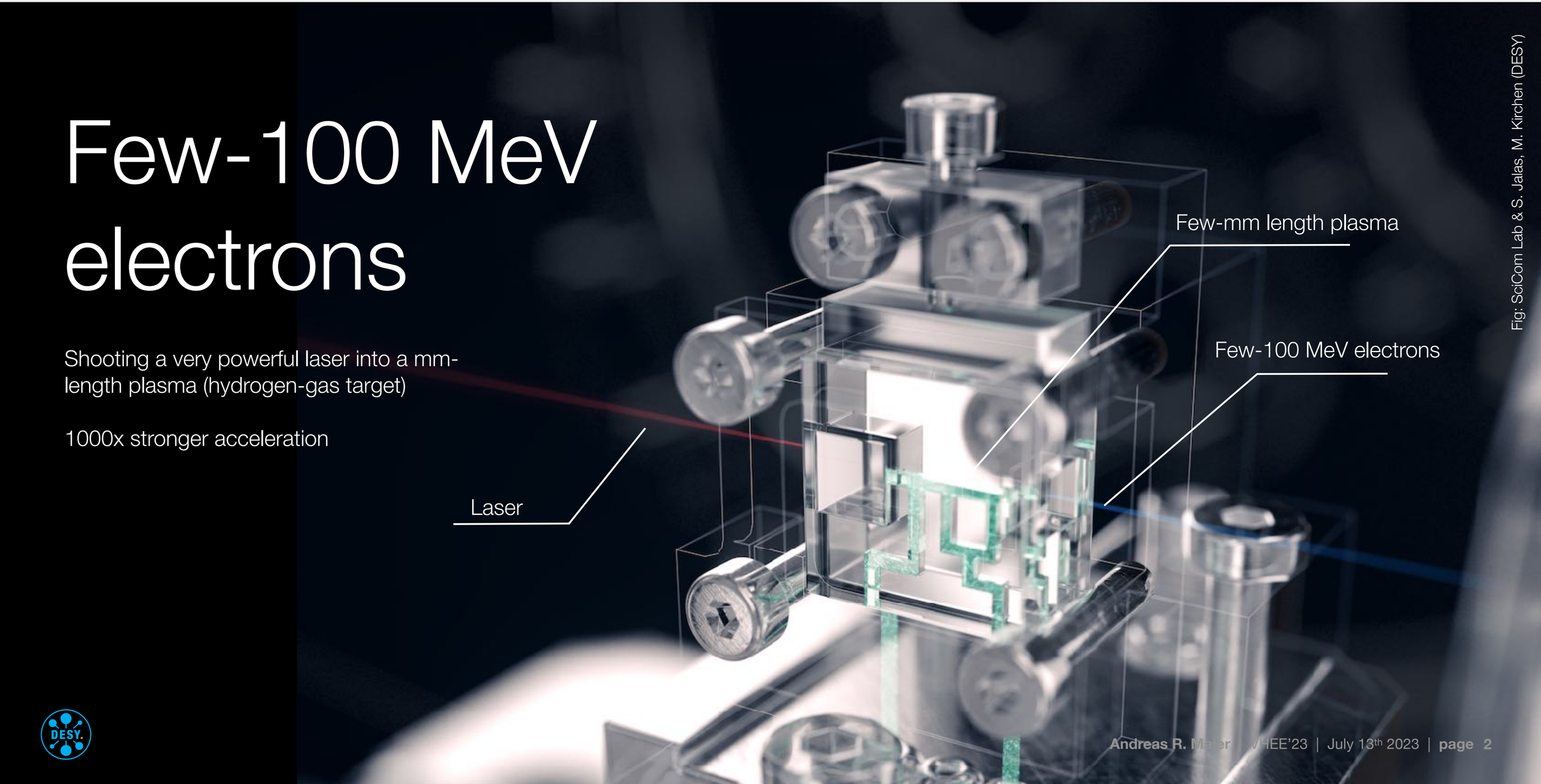


Fig: SciCom Lab & S. Jalas, M. Kirchen (DESY)

Laser Quality is Key

Details matter

A new accelerator cavity with every laser shot.

Subtle variations in the drive laser pulse can have a huge effect on the electron beams. (Still a big gap in performance compared to RF machines)

Electron acceleration up to several GeV has been demonstrated again and again, it's now all about getting the laser under control.

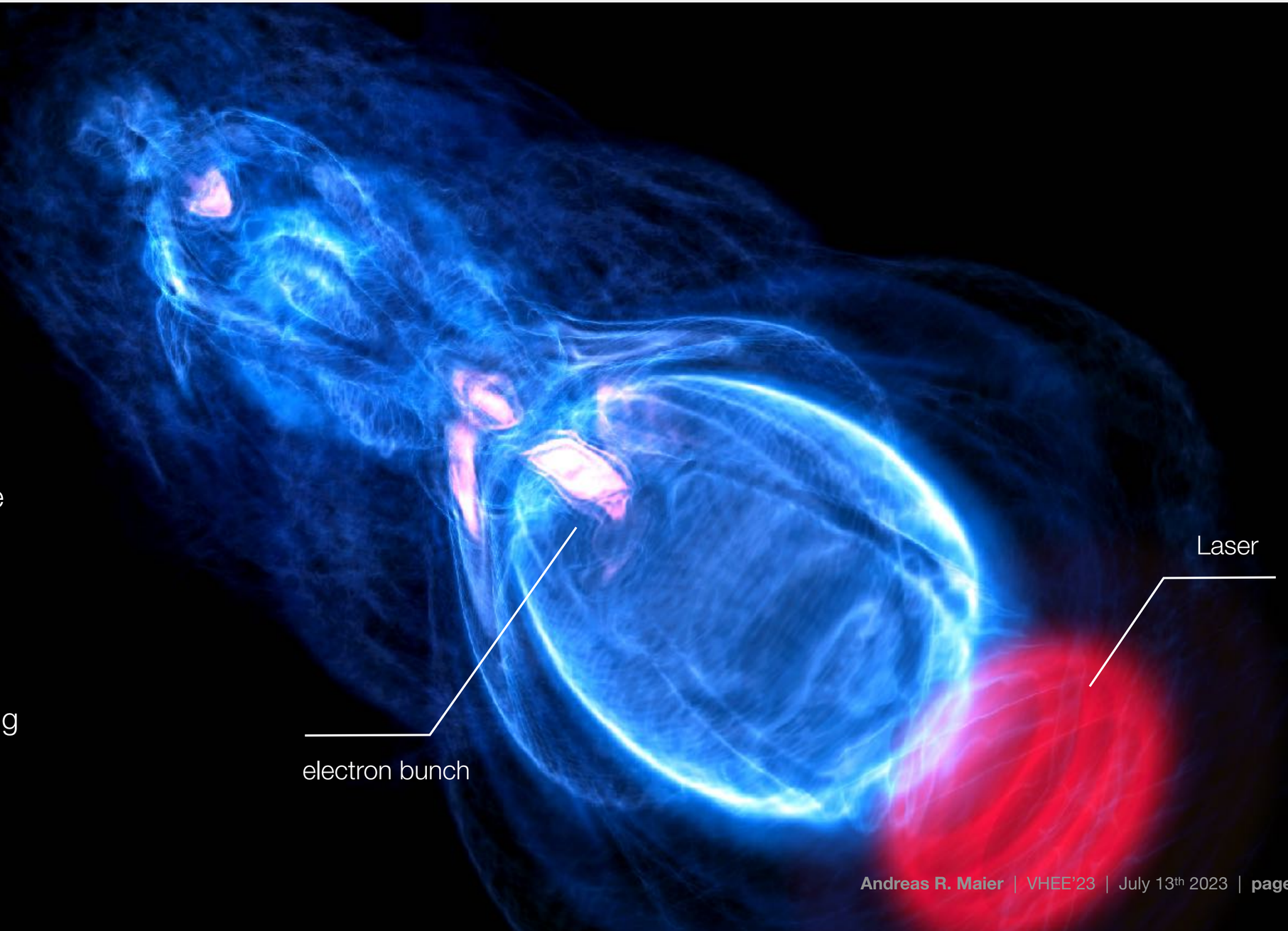


Fig: S. Jalas (DESY)

Bring the Machine to the Problem

Size matters

Science

Shrink our km-sized facilities
to a laboratory scale

Health and industry

Enable high-energy applications
that have previously been
prevented by size and cost.
New applications enabled by
unique beam parameters.

DESY's Plasma Strategy

Following Our Core Mission and Preparing for the Future

Electrons	Up to 100 MeV	0.3 - 1 GeV	2 GeV	6 GeV (MoonShot)	+10 GeV (MarsShot)
Driver	KALDERA 10 TW class laser kHz level	KALDERA 100 TW class laser kHz level	FFWD FLASH ebeam kHz (to MHz)	<Laser> PW class laser 10 Hz level	<Laser> PW class laser Hz level
Time	1 to 5 years for prototype development			5 to 10 to 15 years	
Application	> Thomson Source (Plasmed-X) > cSTART Injektor > Medical	> Plasma FEL	> 10 kW SCRF booster module > Energy doubling > Quality preservation	> Injector into PetraIV storage ring (synchrotron)	> Non-linear QED > Collider building block

Fig: SciCom Lab

Plasma Crew at DESY

Relying on the expertise of DESY's machine division and its 23 technical groups (~750 people)

> Director: Wim Leemans
> Two Groups with a focus on plasma acceleration, led by Jens Osterhoff (MPA) and Andi Maier (MLS)

Fig: Marta Mayer (DESY)

Placing LPA in context

My view on LPA for FLASH and VHEE

LPA parameters (typical for the community)

> Few-10 to Few-100 pC bunch charge
> Few-100 MeV up to several GeV
> Energy tunable (*)
> 1% level energy spread (**)
but often much larger
> 1Hz repetition rate
> few-10 fs pulse length
> Operational stability and availability is often an issue (see slides above)
> Today, LPAs are not (yet) compact, considering the size of the laser lab
> Today, not (yet) necessarily cheaper

LPA perspective (next 5-10 years)

> Drastically more compact lasers
> Bring down the cost
> Increase repetition rate to kHz-level (while keeping all other parameters)
> Improve operational performance with active feedback

Relation to RF-accelerators (not DESY specific)

> ARES and similar machines feature marvelous performance, very good reliability, and are the go-to-place for VHEE/FLASH research today
> In parallel, we (as a community) will mature LPA technology to be ready when we have a good idea on the FLASH/VHEE modalities
> In parallel, we (as a community) can do some VHEE/FLASH research with LPAs to verify and explore possibilities to benefit from unique LPA bunch parameters
> The goal is to have another tool in the box, and we foresee both RF and LPA technology to play a role.

DESY perspective

> Mature LPA technology — make it turn-key benefit from DESY's expertise building rock-solid accelerators
> We could, in principle, complement some of the activities at ARES using our laser-plasma facilities (with all the constraints that come with an experimental technology)

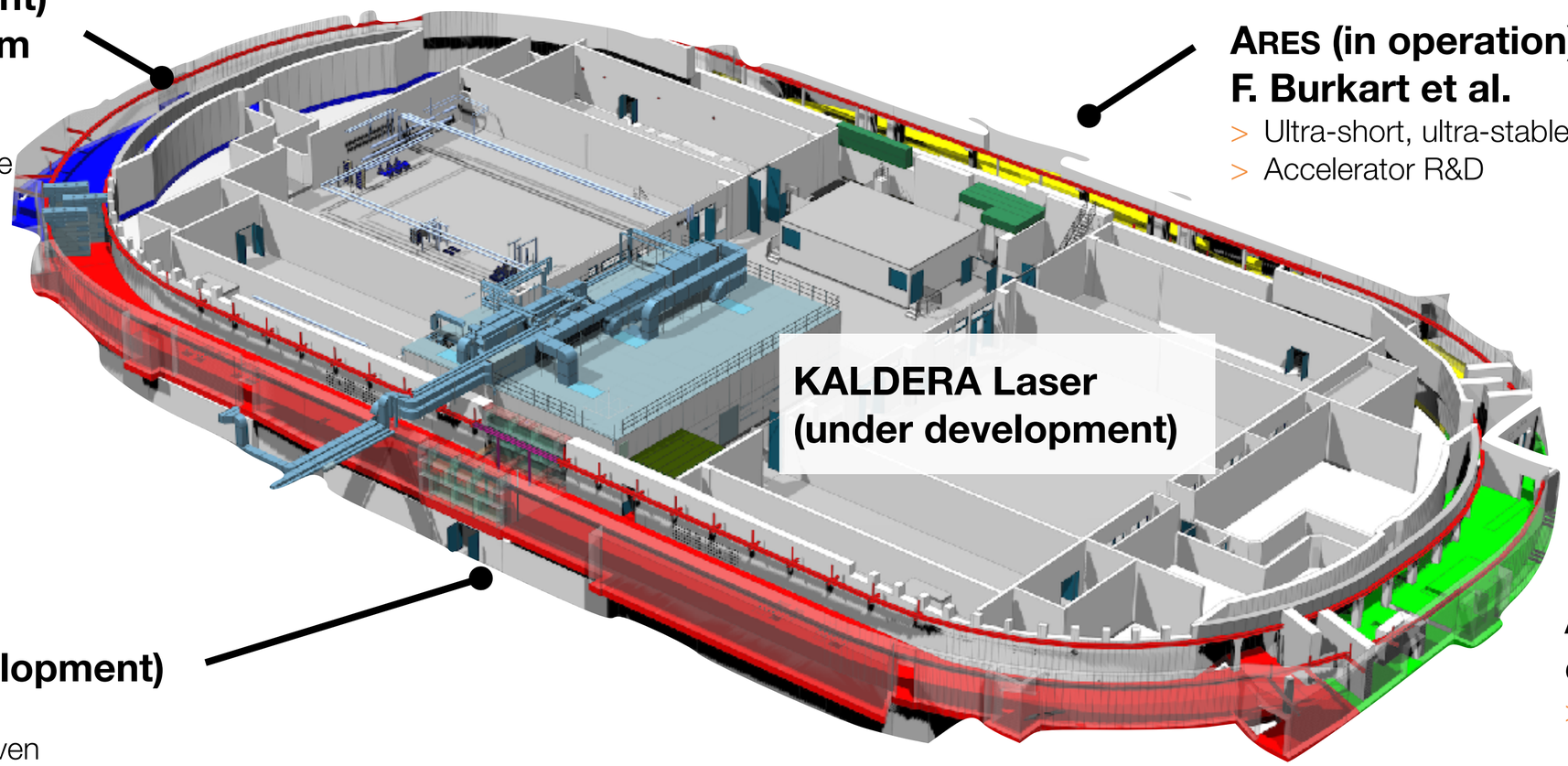
** S. Jalas et al., „Tuning curves for a laser-plasma accelerator", accepted*

*** typical tradeoff between charge, energy spread and energy efficiency*

Accelerator R&D at SINBAD

Former DORIS Facility

BLUE AREA
(under development)
J. Osterhoff & Team
> Staging
> Guiding
> Thomson X-Ray Source (move PlasmedX)
> KALDERA-driven



ARES (in operation)
F. Burkart et al.
> Ultra-short, ultra-stable bunches
> Accelerator R&D

LUX-2
(under development)
> Plasma FEL
> KALDERA-driven

AXSIS (under commissioning)
> THz Acceleration

LUX
(in operation)
> Improving LPA reliability
> Improving LPA availability

LUX Laser-Plasma Accelerator

Closing the performance gap

4 mm Laser-plasma accelerator

photo: C. Schmid, DESY

Fig.: C. Schmid for DESY

LUX Laser-Plasma Accelerator

Closing the performance gap

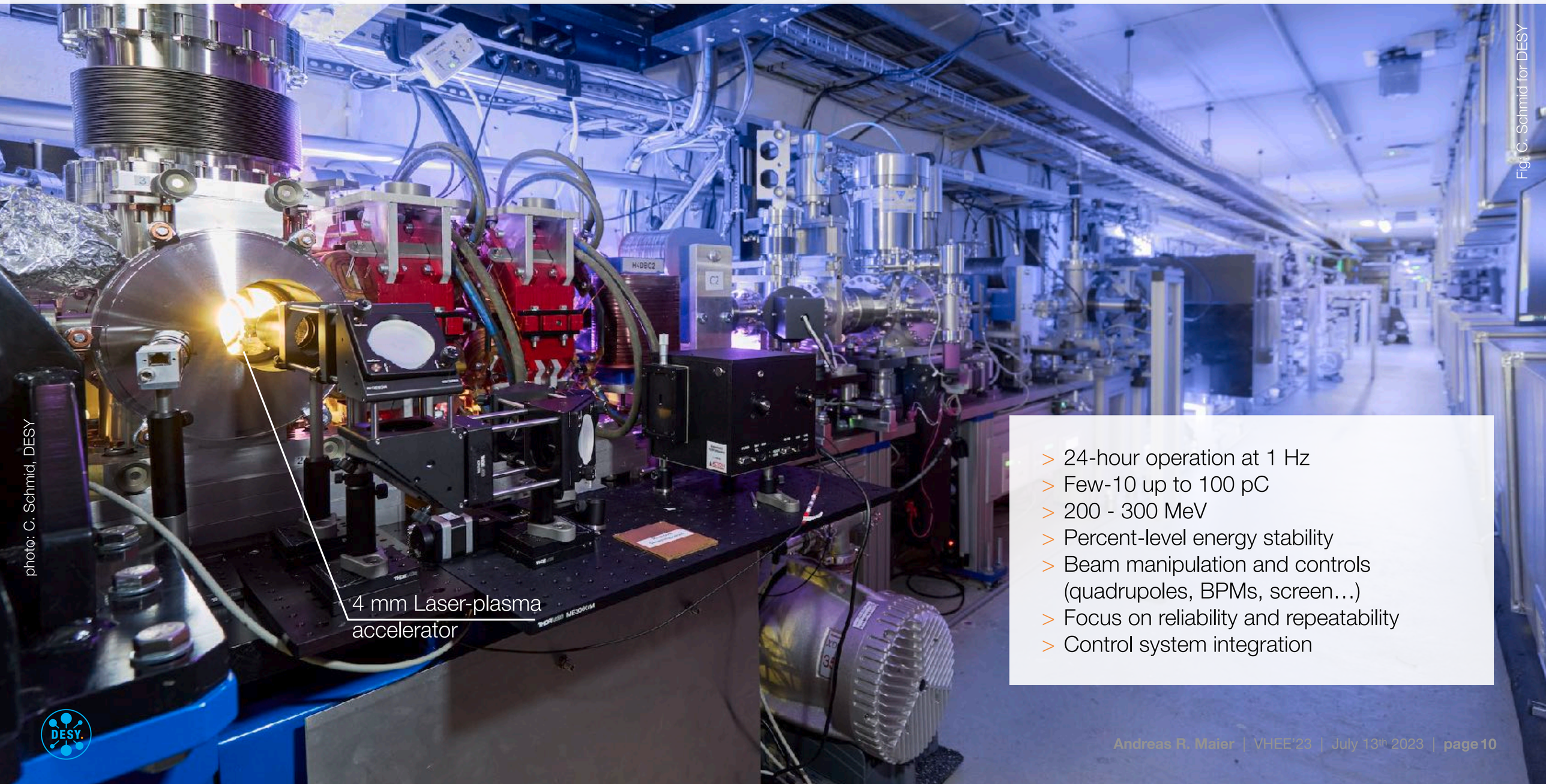


photo: C. Schmid, DESY

Fig.: C. Schmid for DESY

- 24-hour operation at 1 Hz
- Few-10 up to 100 pC
- 200 - 300 MeV
- Percent-level energy stability
- Beam manipulation and controls (quadrupoles, BPMs, screen…)
- Focus on reliability and repeatability
- Control system integration

KALDERA: High Average Power Laser Development

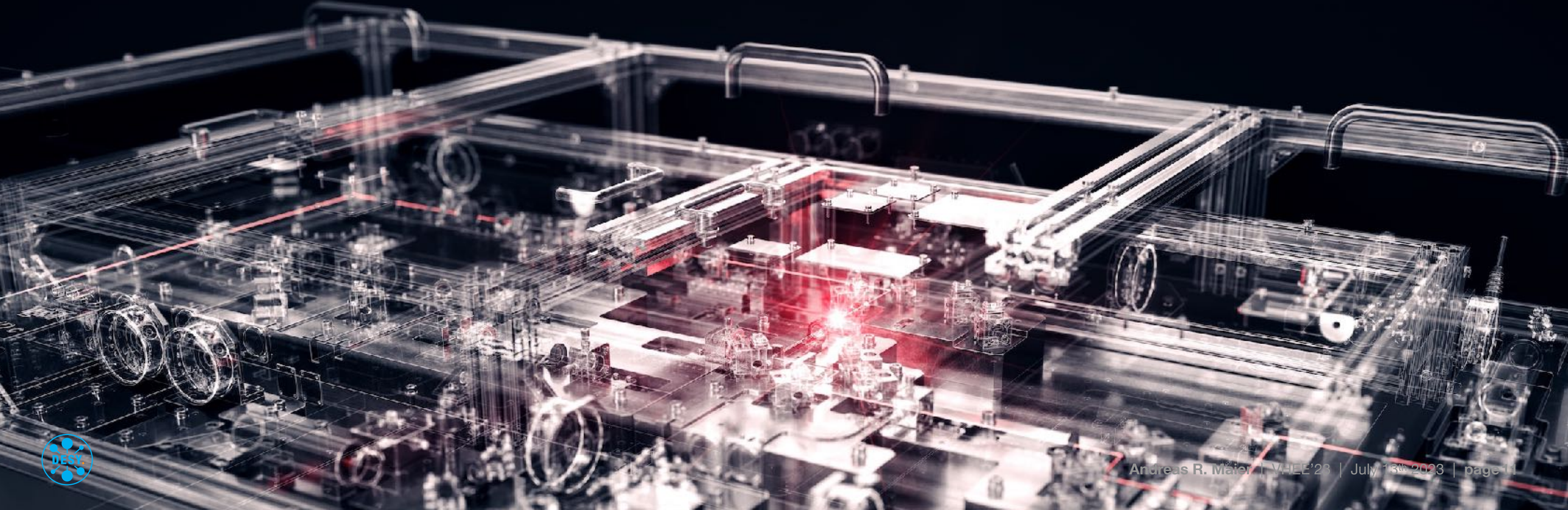
Key to Future Accelerator Technology

Goal:

> application-ready LPA electron beams
> kHz-level rep rate
> active feedback

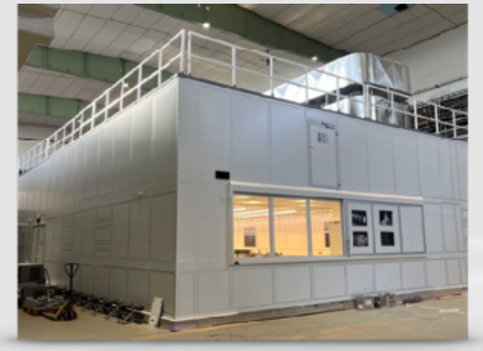
kaldera.desy.de

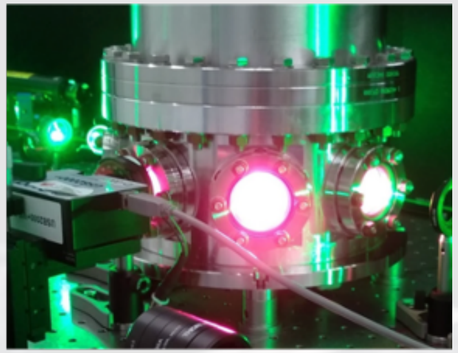
Fig: SciCom Lab & MLS Group DESY

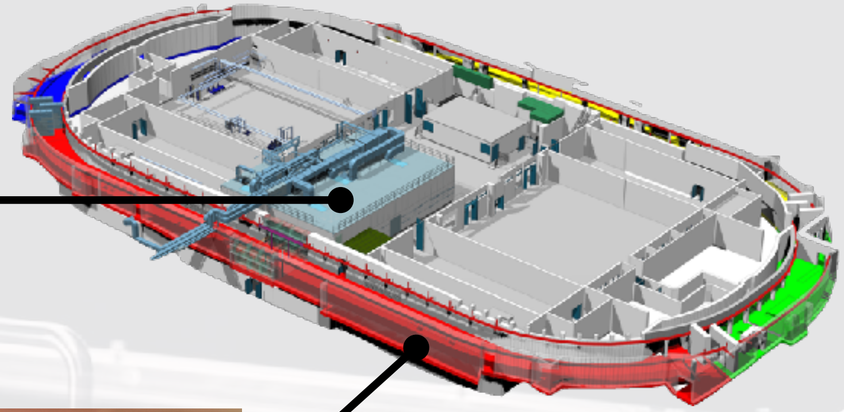


KALDERA: High Average Power Laser Development

Key to Future Accelerator Technology







- Laser lab completed
  - 400m2 ISO5/6 clean room
- Laser development has started
  - Setting up laser subsystems in parallel
  - Developing feedback mechanism as part of HI-ACTS innovation platform

- Generic infrastructure for experiments (many different experiments over time)
- Supports up to 1GeV @ 1kHz

Fig: SciCom Lab & MLS Group DESY

KALDERA: High Average Power Laser Development

Key to Future Accelerator Technology

www.hi-acts.de

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