credits:
Sören Jalas and
Manuel Kirchen (UHH)

# A Laser-Plasma Accelerator

*European Advanced Accelerator Concepts, Sept. 16th 2019*

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# LUX Group

*At Hamburg University*

operate ANGUS laser

build and operate the LUX beamline for
laser-plasma driven undulator radiation

LUX is built and operated in a close
collaboration of Hamburg University,
DESY w/ support by ELI Beamlines

lux.cfel.de

# LUX - A Laser Plasma Accelerator

*Combine Plasma Acceleration with State-of-the-art Accelerator Technology*

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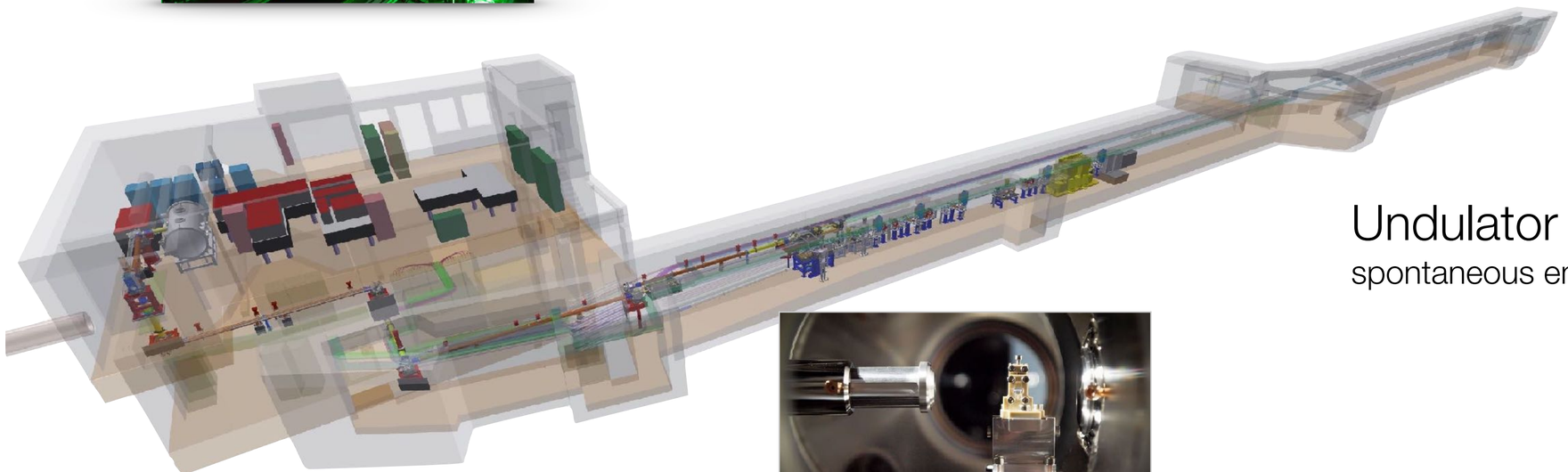
LUX group:

**Mission:**
demonstration of stable laser-plasma electron beams.

ANGUS
laser

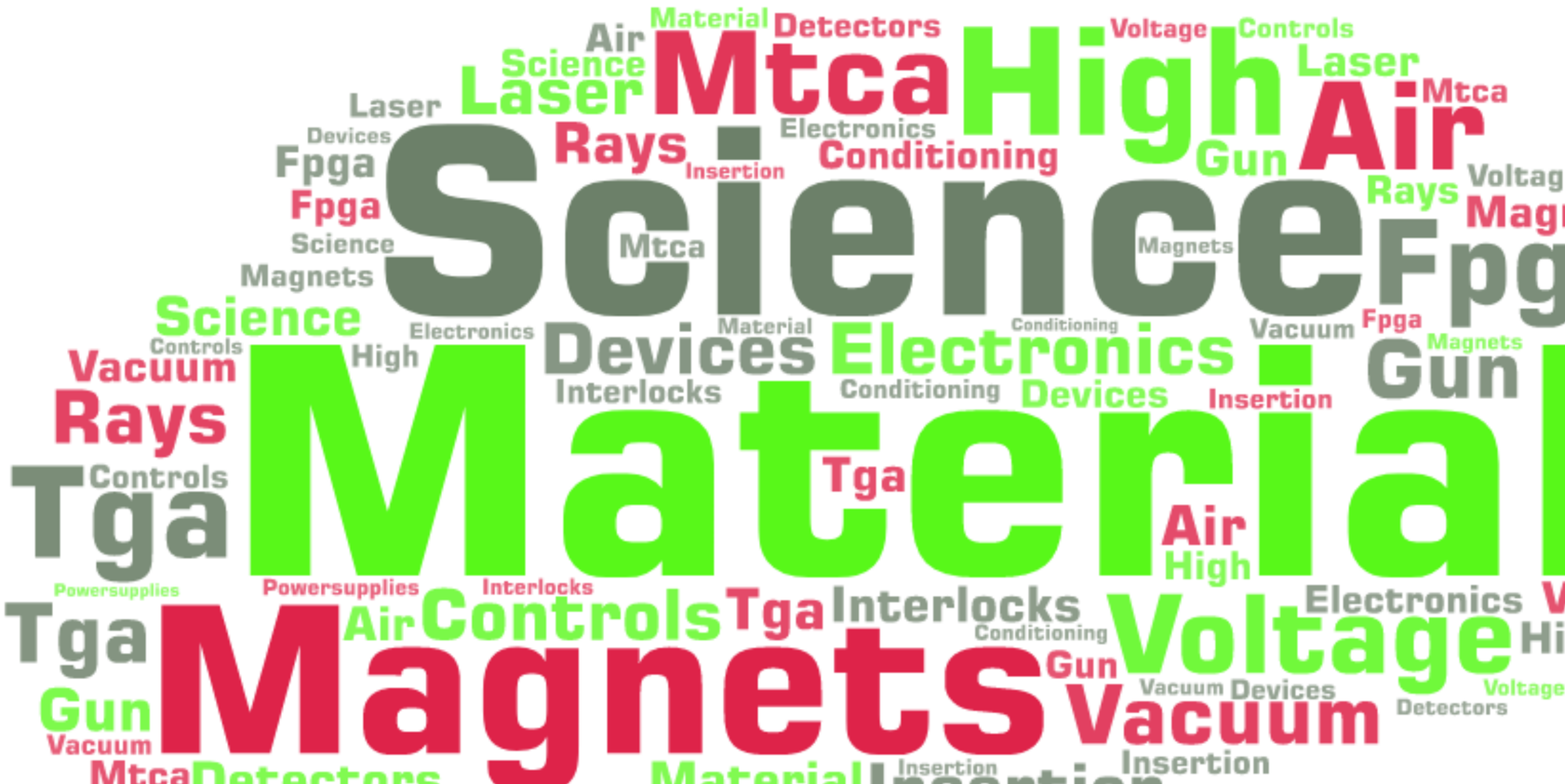


Undulator radiation
spontaneous emission



Plasma electrons
Few hundred MeV @ 1 Hz

# Let’s build an accelerator



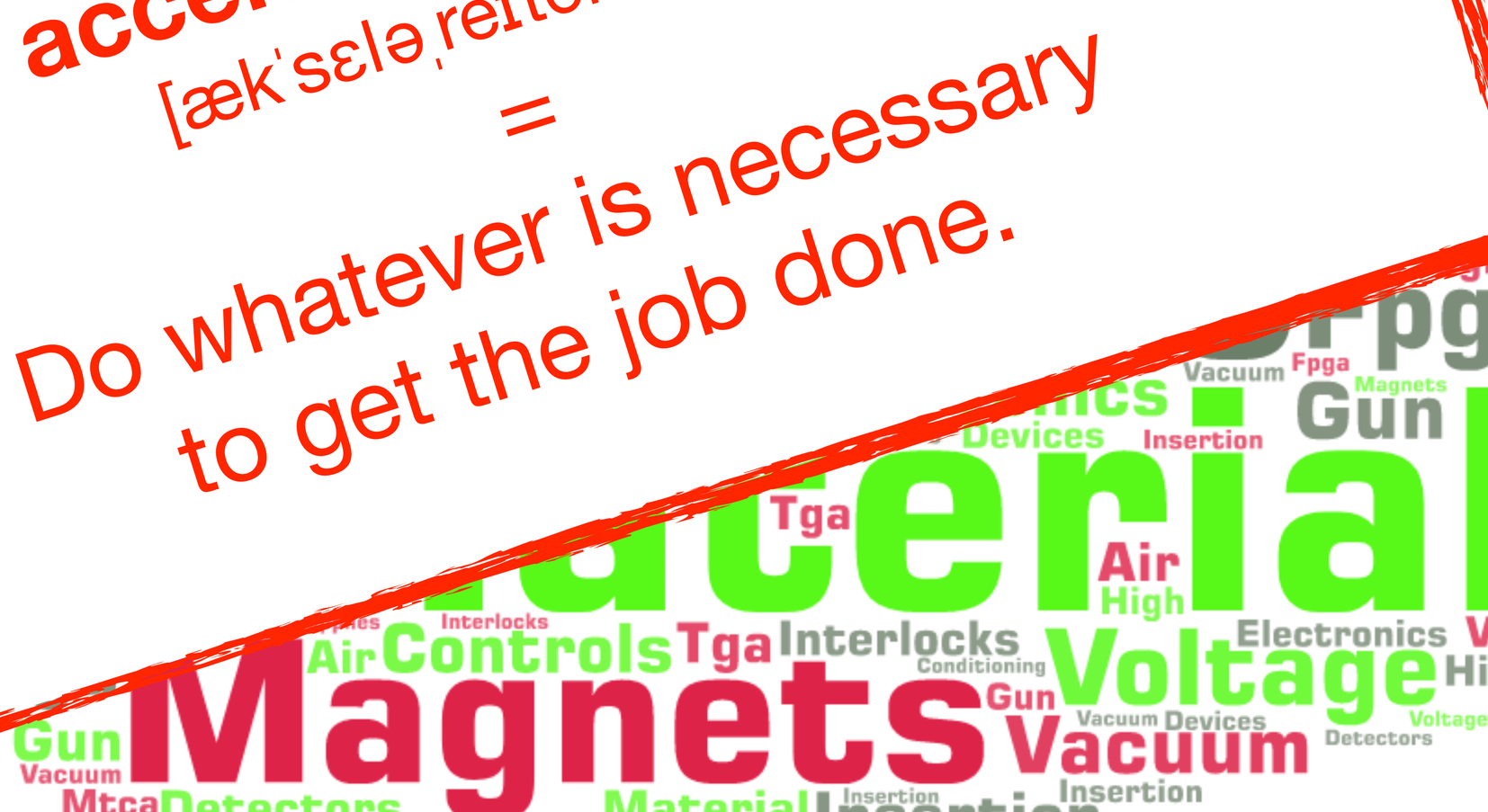
Let’s bu

**accelerator physics**

[ækˈsɛlə ˌreɪtər ˈfɪzɪks]

=

Do whatever is necessary to get the job done.



# The laser is key.

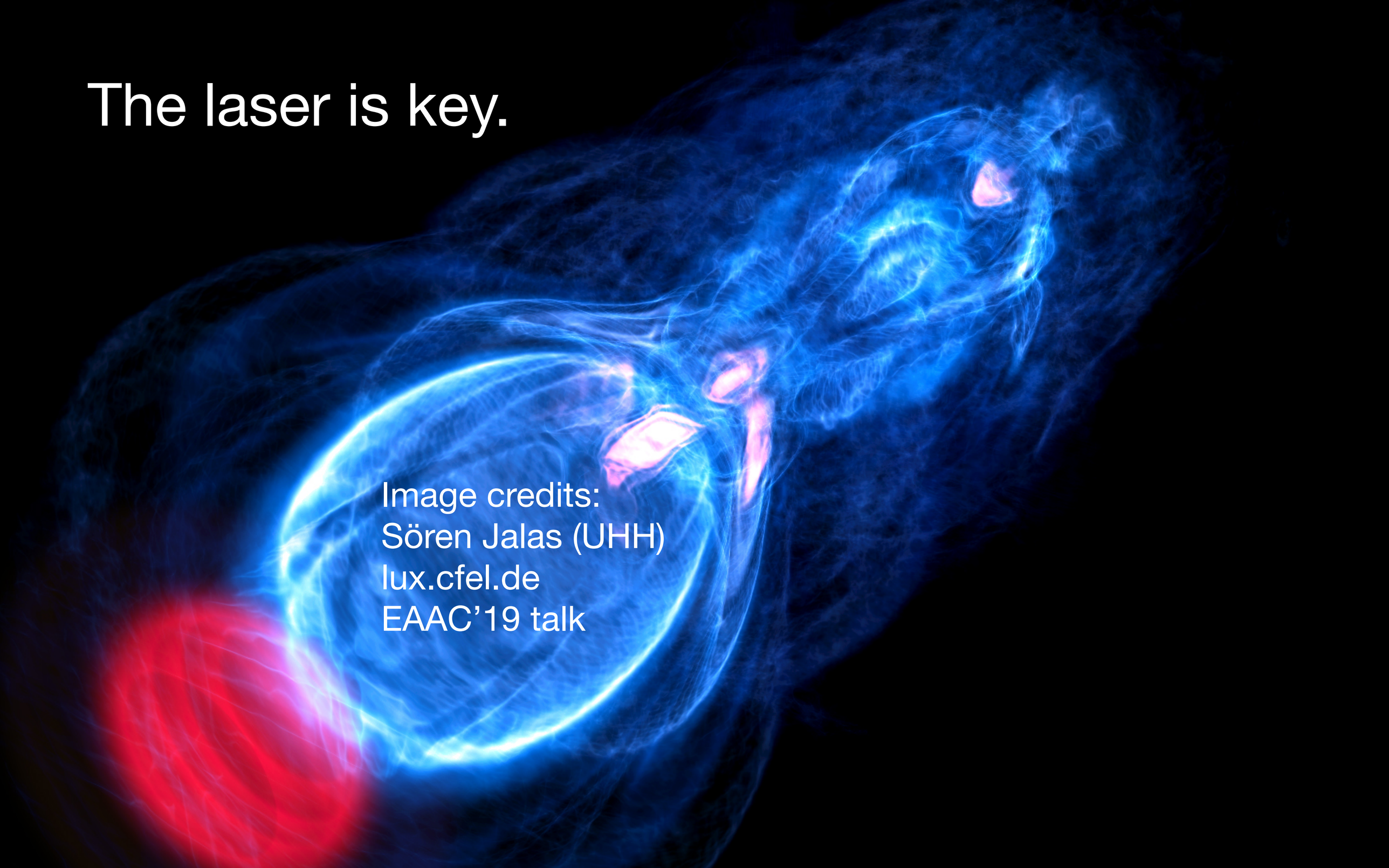


Image credits:
Sören Jalas (UHH)
lux.cfel.de
EAAC’19 talk

# Two major challenges of LPA

*Reproducibility and Average Power*

LPA

## Reproducibility

> Depends largely on the drive laser.
> We need a better understanding of the parameters affecting reproducibility.

> No fundamental limit why high-power lasers should not be super stable.
**➜ Requires laser engineering.**

> We need to bring simulation-supported tolerance studies to laser-plasma acceleration.
**➜ Requires super-fast PIC codes.**

> High-quality LPA electron beams have been shown, but parameter space is HUGE.
**➜ Requires a platform that continuously delivers electron beams to enable machine studies.**

## Average Power

**➜ Requires a road-map for high average power laser development.**

# Two major challenges of LPA

*Reproducibility and Average Power*

LPA

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## Average Power

**➜ Requires a road-map for high average power laser development.**

**Our approach:**
First, continuously deliver electron beams
Second, understand & tune the parameters

# ANGUS Laser

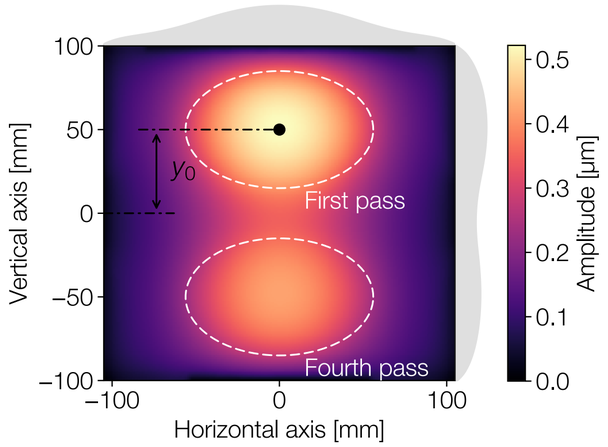
- typical operation:
  4J @ 35 fs 1 Hz
- complex controls system
- 169 diagnostic:
  - 62 cameras
  - 10 spectrometers
  - 17 energy/pwr sensors
  - …

credits:
H-E Müller

# Compressor Gratings

*Issue: Heat-induced grating deformation*

*T. Eichner*
*Thursday, 16:20, WG7*




> Absorption of gold coating leads to heat-induced deformation of compressor gratings
> Significantly distorted pulses

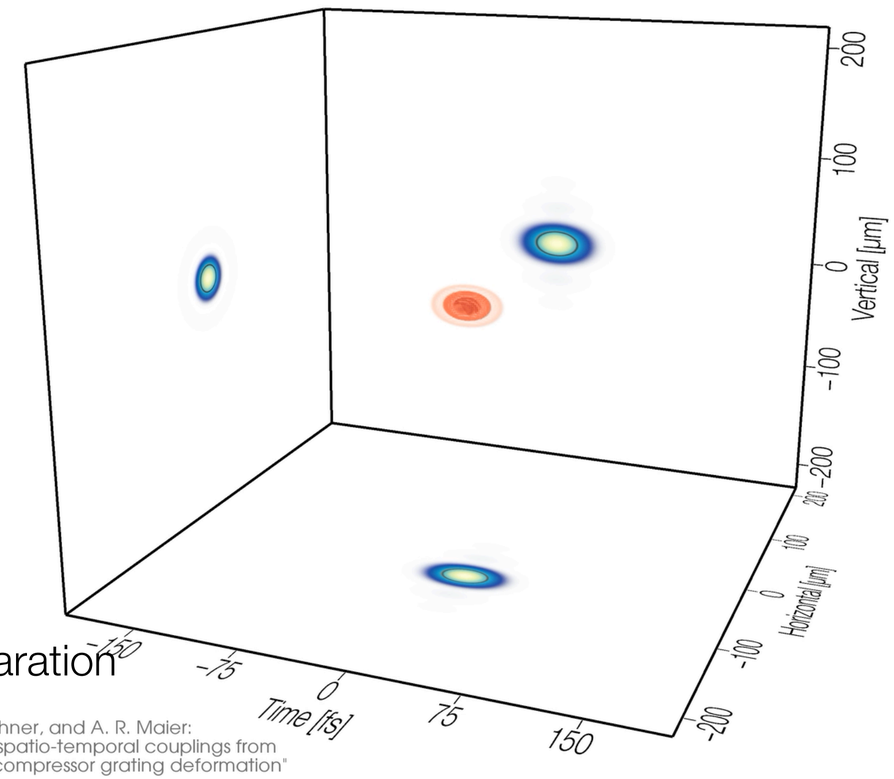
> Know the physics to chose operation point:
  > *V. Leroux et al., Opt. Express 26, 13061 (2018)*
  > *V. Leroux et al.: in preparation, (2019)*

> *There are solutions, see for example:*
*D. Alessi et al., Opt. and Laser Tec. 117, 239 (2019)*

Average Power into compressor:

P = 0.0W

Pyrex substrates




In preparation

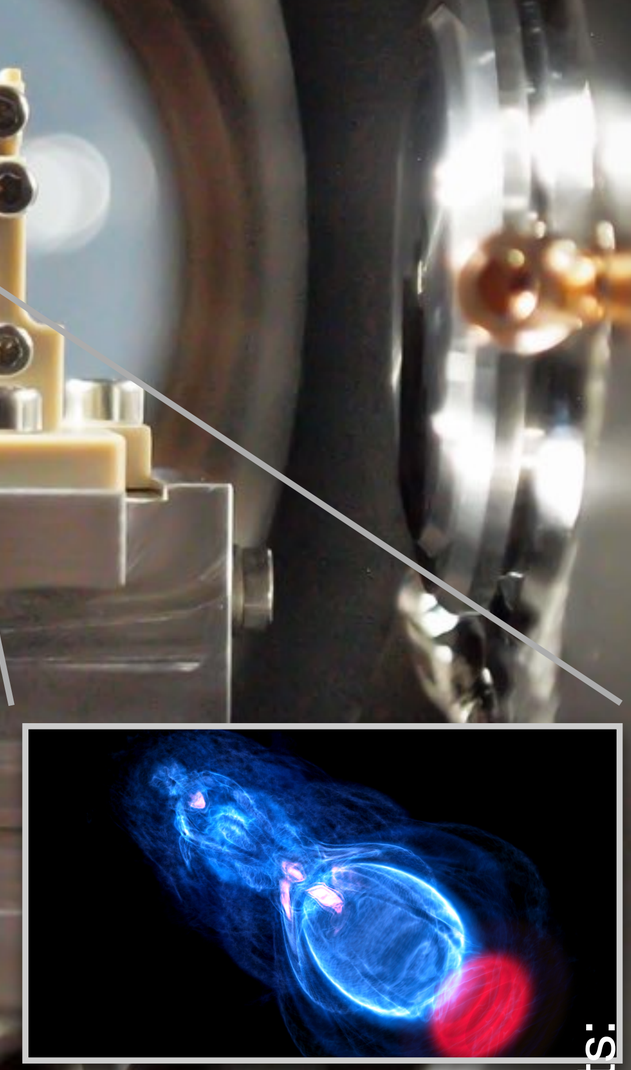
V. Leroux, T. Eichner, and A. R. Maier:
"Description of spatio-temporal couplings from heat-induced compressor grating deformation"

# Better laser better life.

[Universal law]

credits:
H-E Müller

# Lux Plasma Target



credits:
Niels Delbios and Sören Jalas (UHH)

> Continuous-flow target
> see also lux.cfel.de

# What to do next?

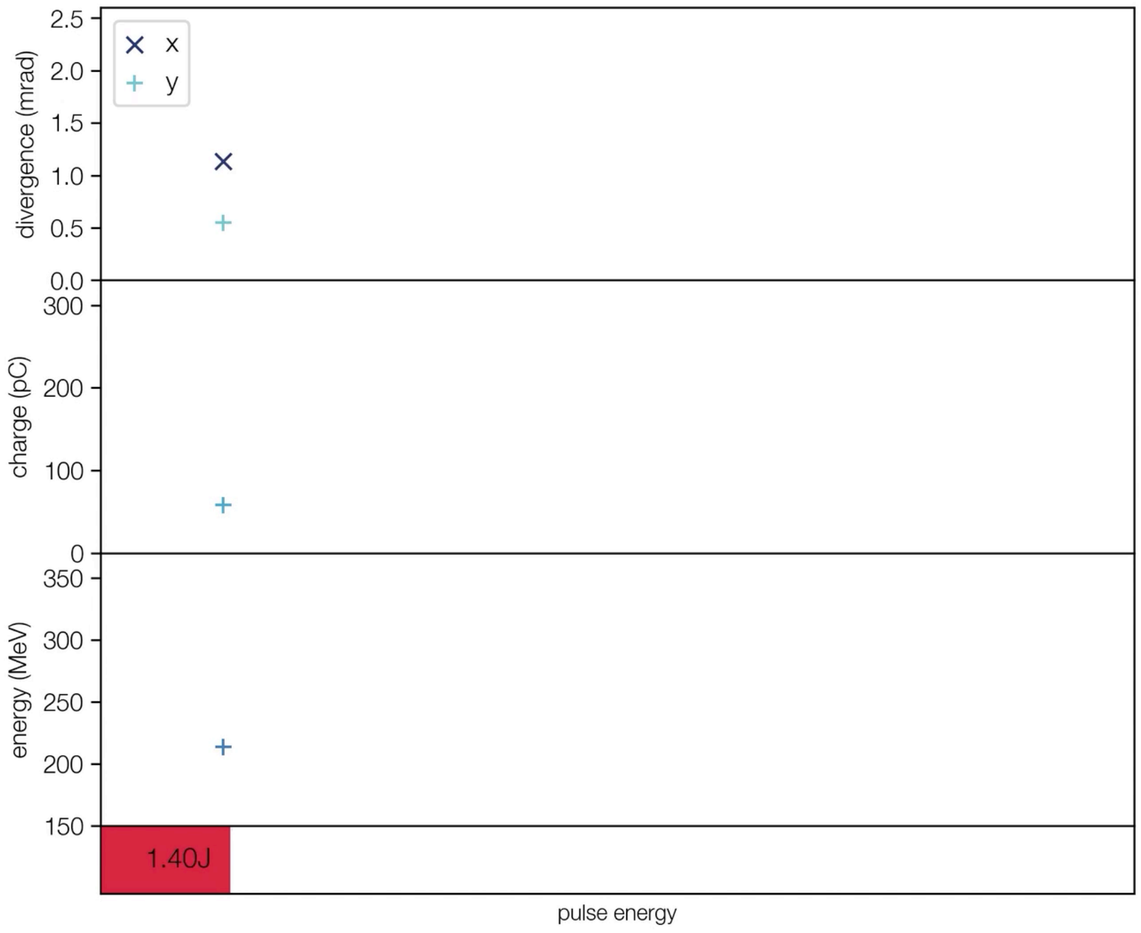
Setup the electron beam.

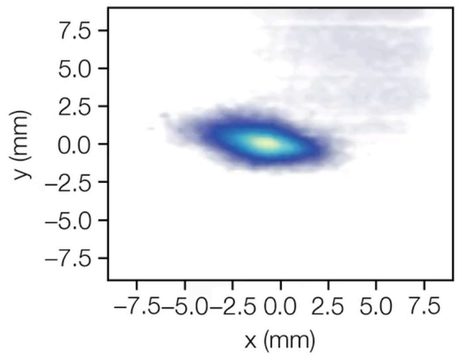
# Learn how to tune the machine

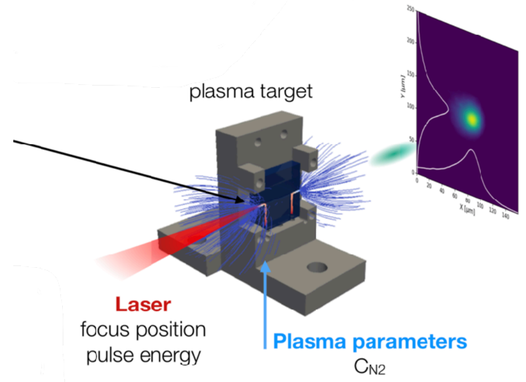
*Online Tuning of Parameters*

*P. Messner*
*Monday, 19:00, Poster*

*in preparation*



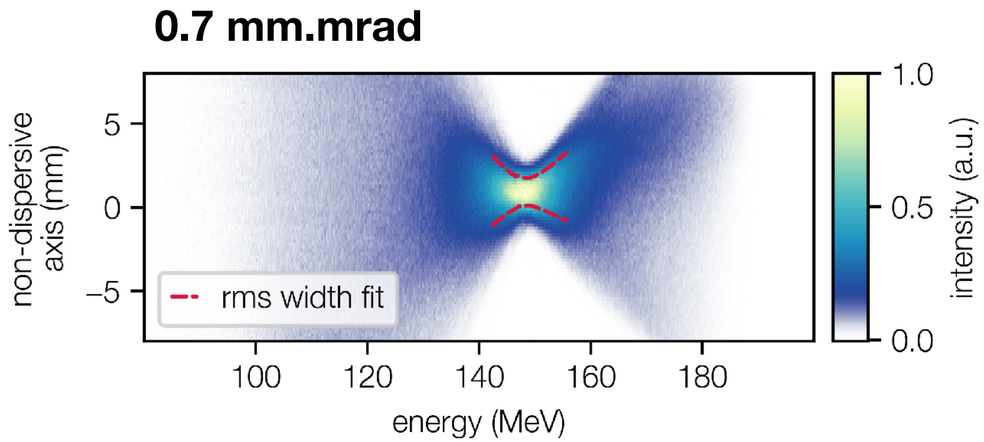



# Characterization

*Online Emittance Measurement*

*P. Winkler*
*Monday, 16:40, WG1*

*in preparation*




> Compare single-shot method and quad-scan technique
> Do they provide the same results?

> Measure chromatic emittance growth

# What else?

Let it run.

# Day-long plasma accelerator operation

*Enables Machine Studies.*

*A. R. Maier et al., in preparation*

# What else?

Energy Spread

# Reproducible high beam quality

*Fine tuning based on correlations and different target design*

*M. Kirchen*
*Wednesday, 18:20, WG1*

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*in preparation*

# Outlook

# Frosty's coming home…

*demoFEL undulator*

*M. Trunk*
*Monday, 19:00, Poster*

- The final aim of all our efforts is to operate a plasma driven FEL
- Using decompression scheme

- Frosty undulator (tailored design)
  - K=3
  - $\lambda_u$=15 mm

- Under Commissioning

# Conclusion

- The LPA community starts building accelerators.
- Our approach
  - First, continuously deliver beams
  - Second, tune the beams

# Acknowledgement


**In particular**
Jens Osterhoff and his crew
Georg Korn
Remi Lehe and Jean-Luc Vay
Wim Leemans