

REGAE

DESY Beschleuniger-Betriebsseminar 2019

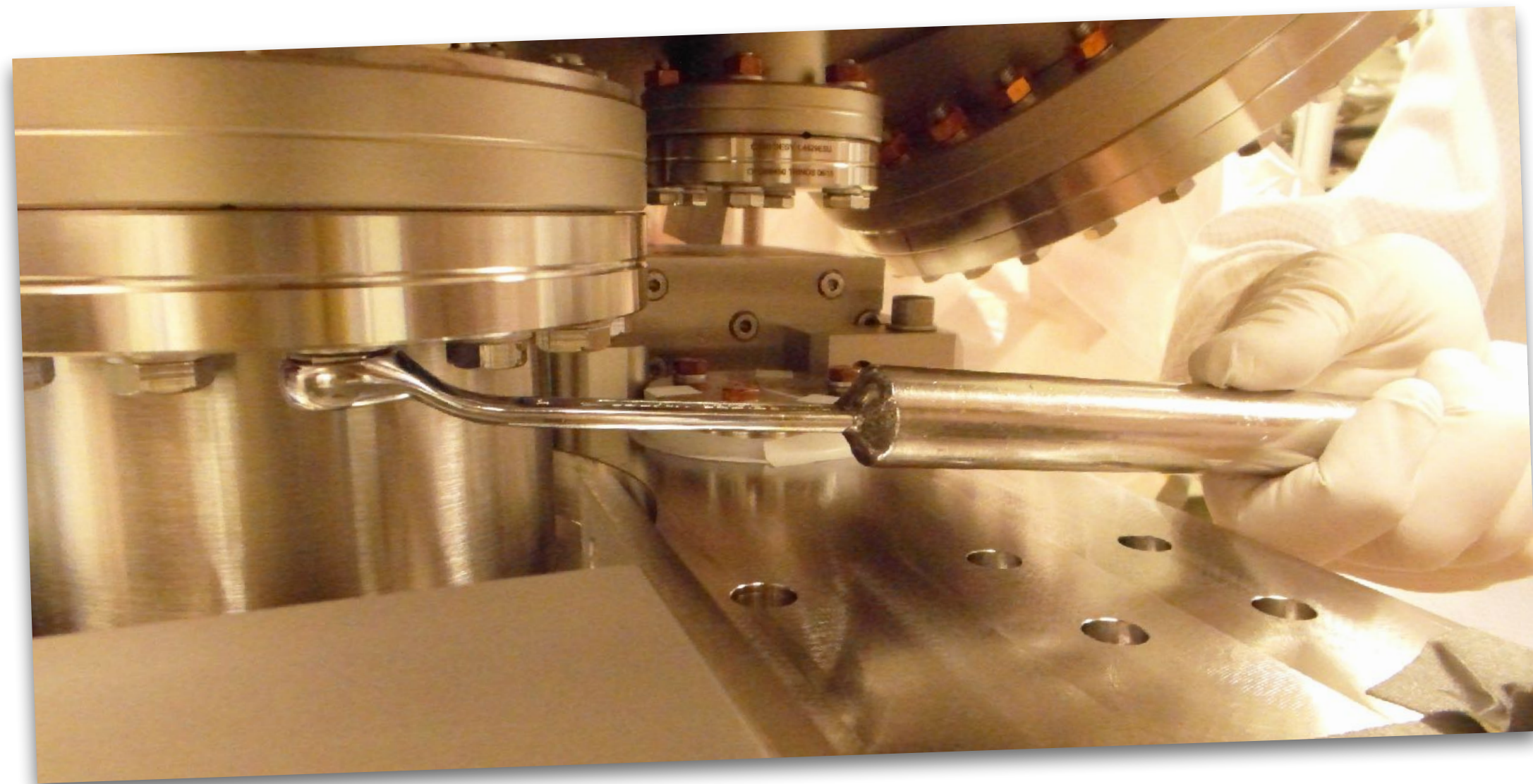
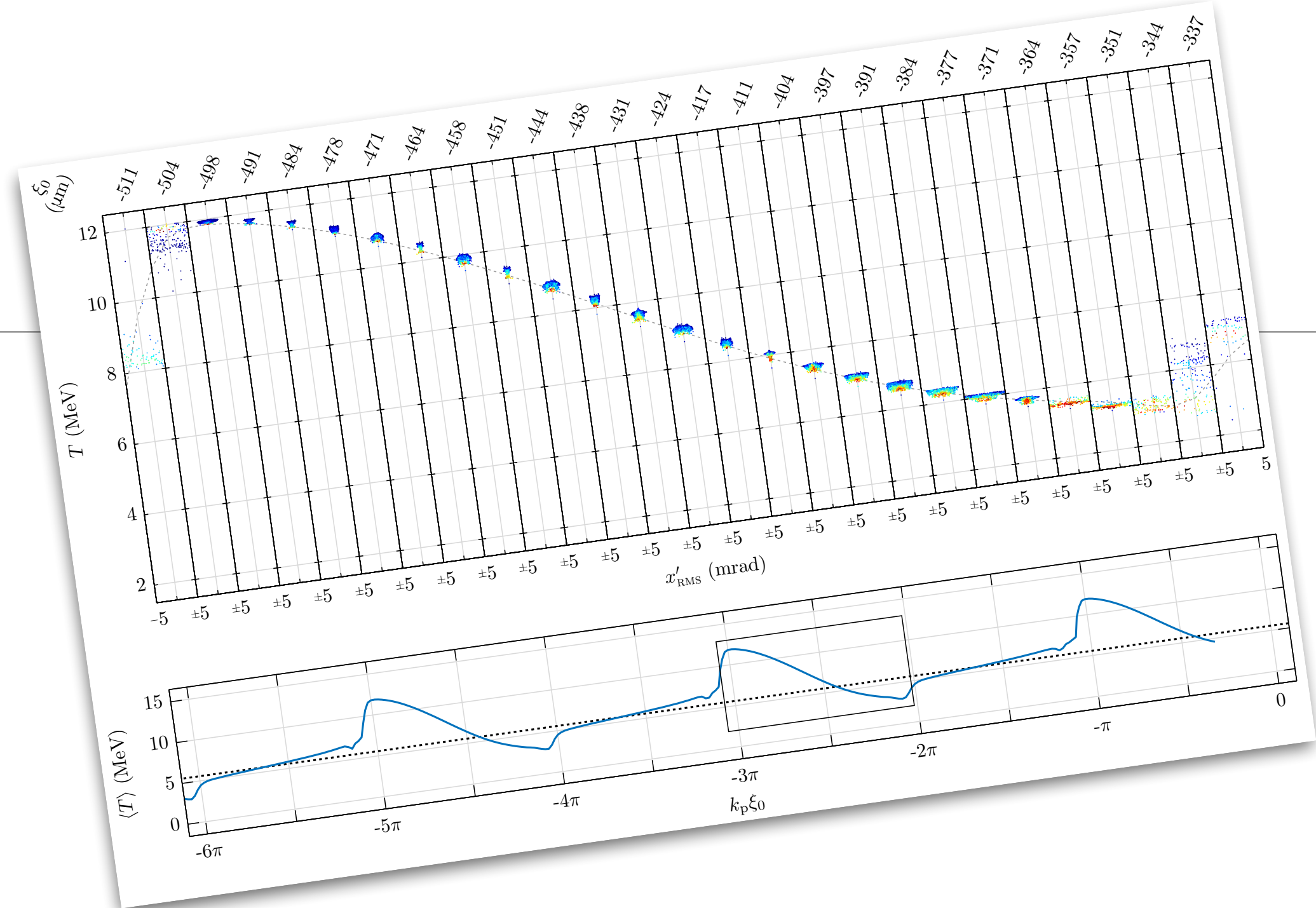
Benno Zeitler
CFEL, UHH, NOVA



REGAE

- > projects & goals
 - > (time-resolved electron diffraction)
 - > external injection of electron bunches into laser-driven plasma wakefields
 - > linearization of the longitudinal phase space without higher harmonic field
 - > THz-based acceleration

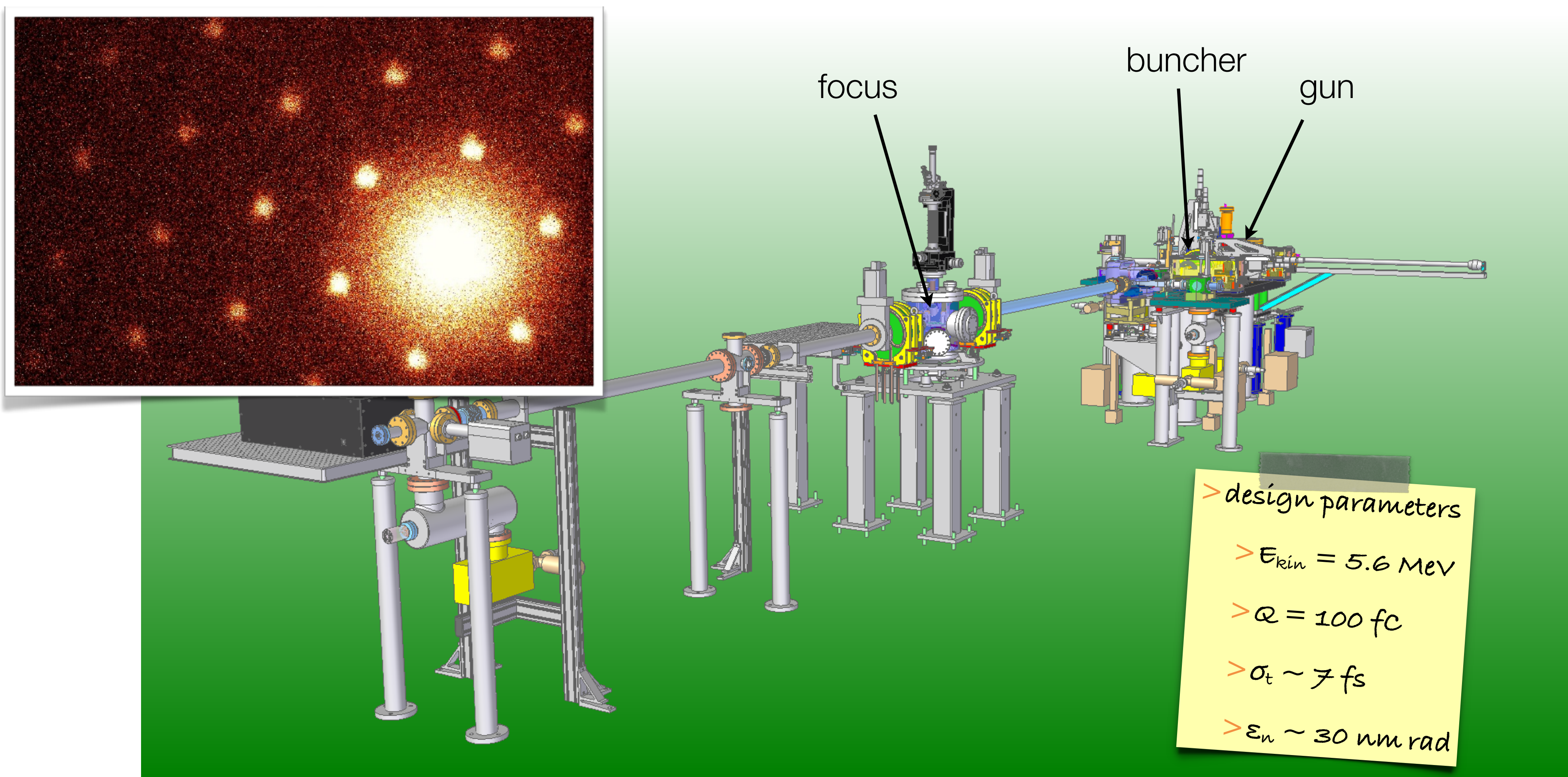
- > REGAE beamline upgrade
 - > REGAE beamline
 - > laser transport beamline
 - > commissioning



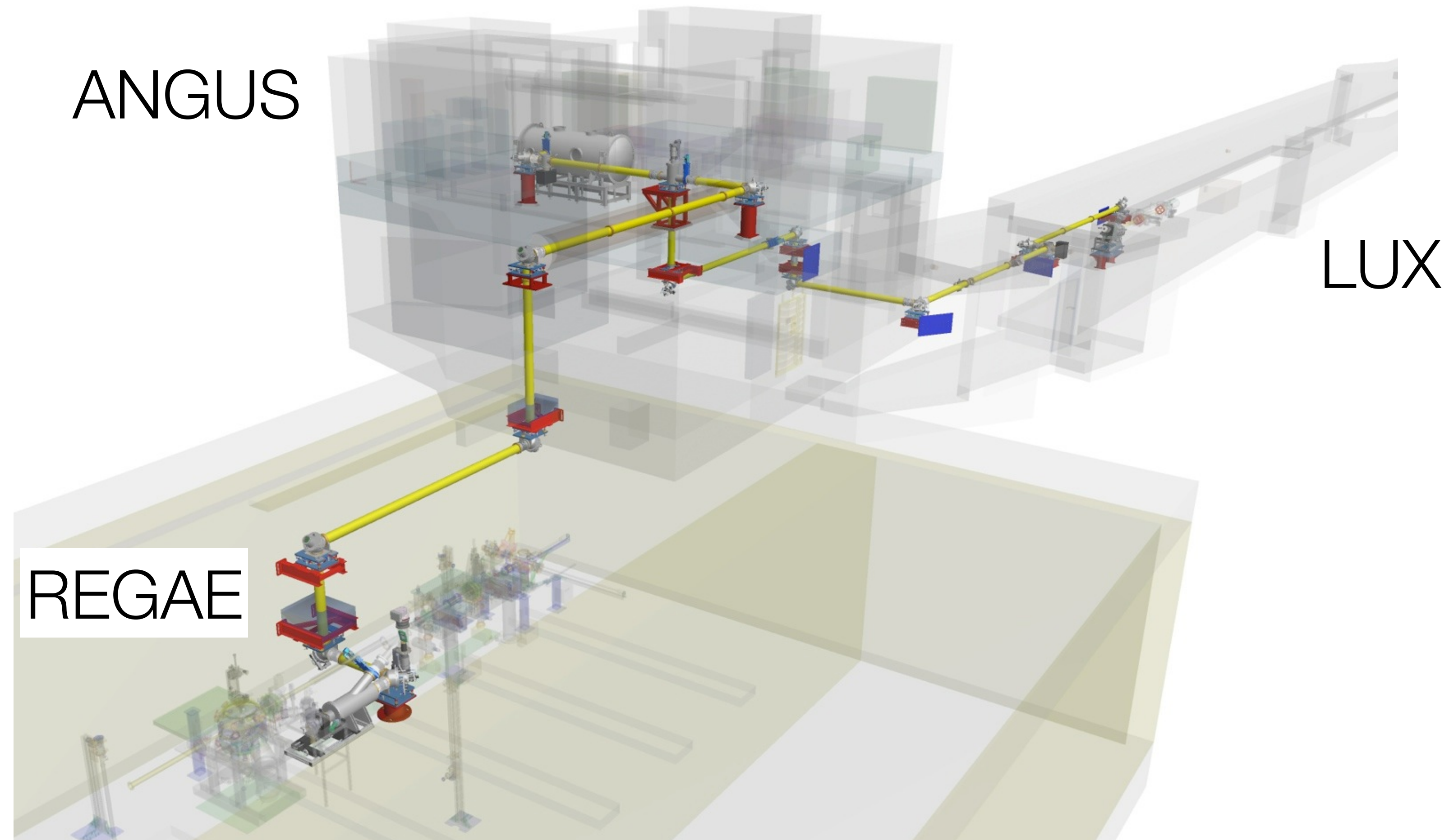
REGAE — Relativistic Electron Gun for Atomic Exploration

Projects & Goals

REGAE — Relativistic Electron Gun for Atomic Exploration



External Injection at REGAE: Facilities

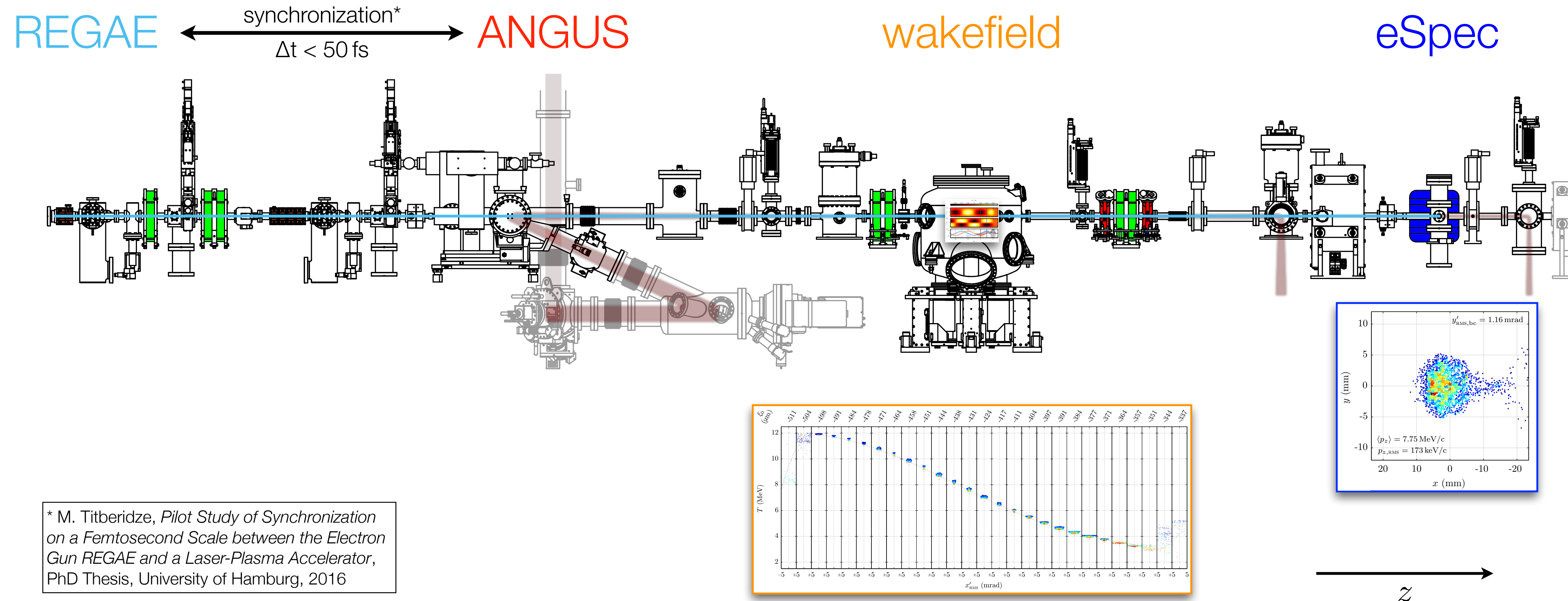


External Injection at REGAE: Concept



Joint DESY / UHH Project
DESY funding (ARD/POF)
UHH funding
Third party EU funding

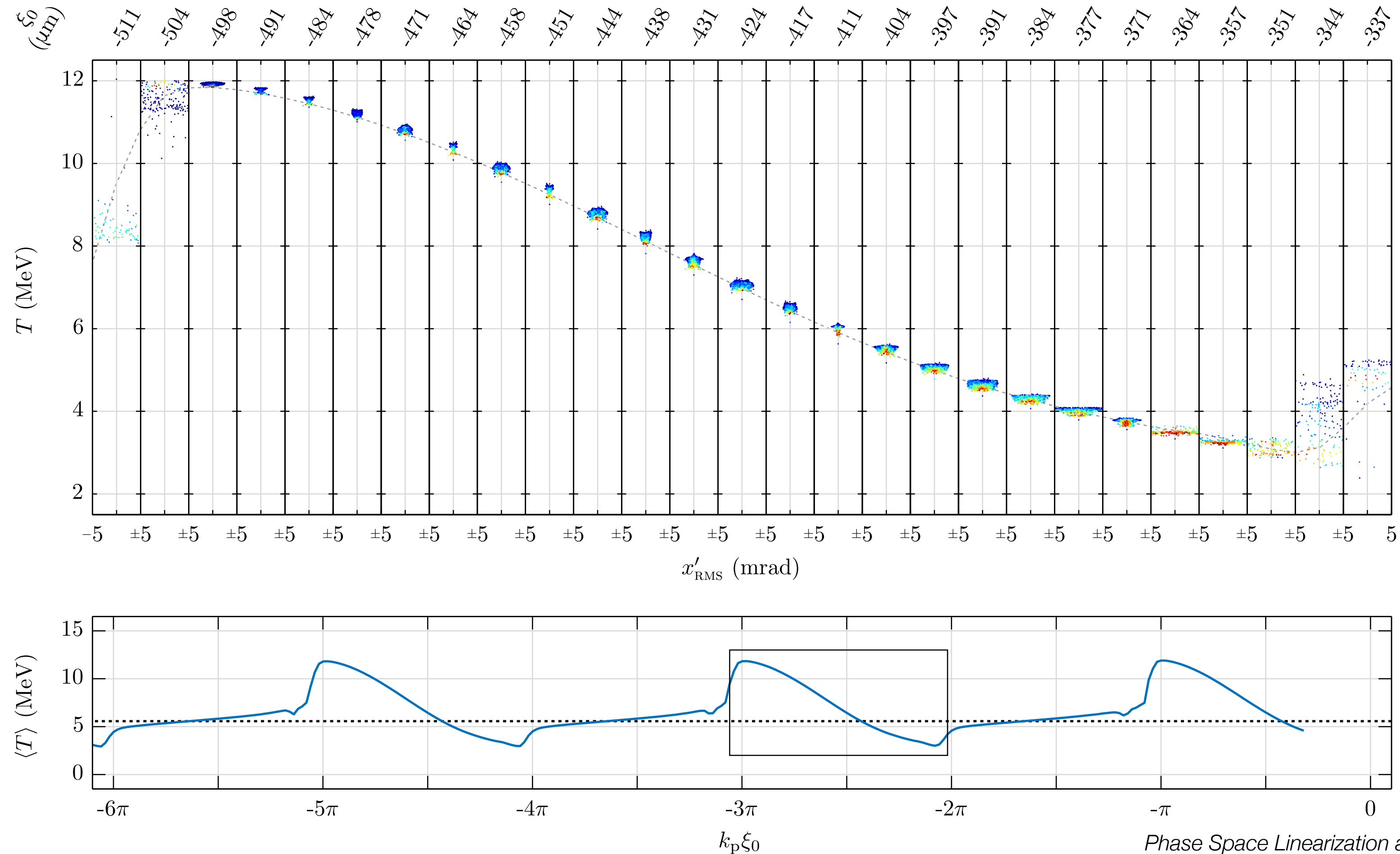
External Injection at REGAE forms an ARD milestone



* M. Titberidze, *Pilot Study of Synchronization on a Femtosecond Scale between the Electron Gun REGAE and a Laser-Plasma Accelerator*, PhD Thesis, University of Hamburg, 2016



External Injection at REGAE: S2E(nd of Plasma) Simulation



Benno Zeitler,
Phase Space Linearization and External Injection of Electron
Bunches into Laser-Driven Plasma Wakefields at REGAE,
PhD thesis, University of Hamburg, 2016



Linearization of the Longitudinal Phase Space

- > ... without higher harmonic fields
 - > bunch length minimum limited by non-linearities
 - > typical approach: higher harmonic cavity
 - > new concept: stretcher mode
 - > no additional cavity required

- > promising simulation results for REGAE
 - > possible bunch length (well) below 1 fs
 - > energy spread compensation: $\Delta E/E < 10^{-5}$

- > REGAE: proof of principle experiment
 - > step 1: energy spread compensation
 - > step 2: phase space analysis using TDS

PHYSICAL REVIEW SPECIAL TOPICS—ACCELERATORS AND BEAMS 18, 120102 (2015)

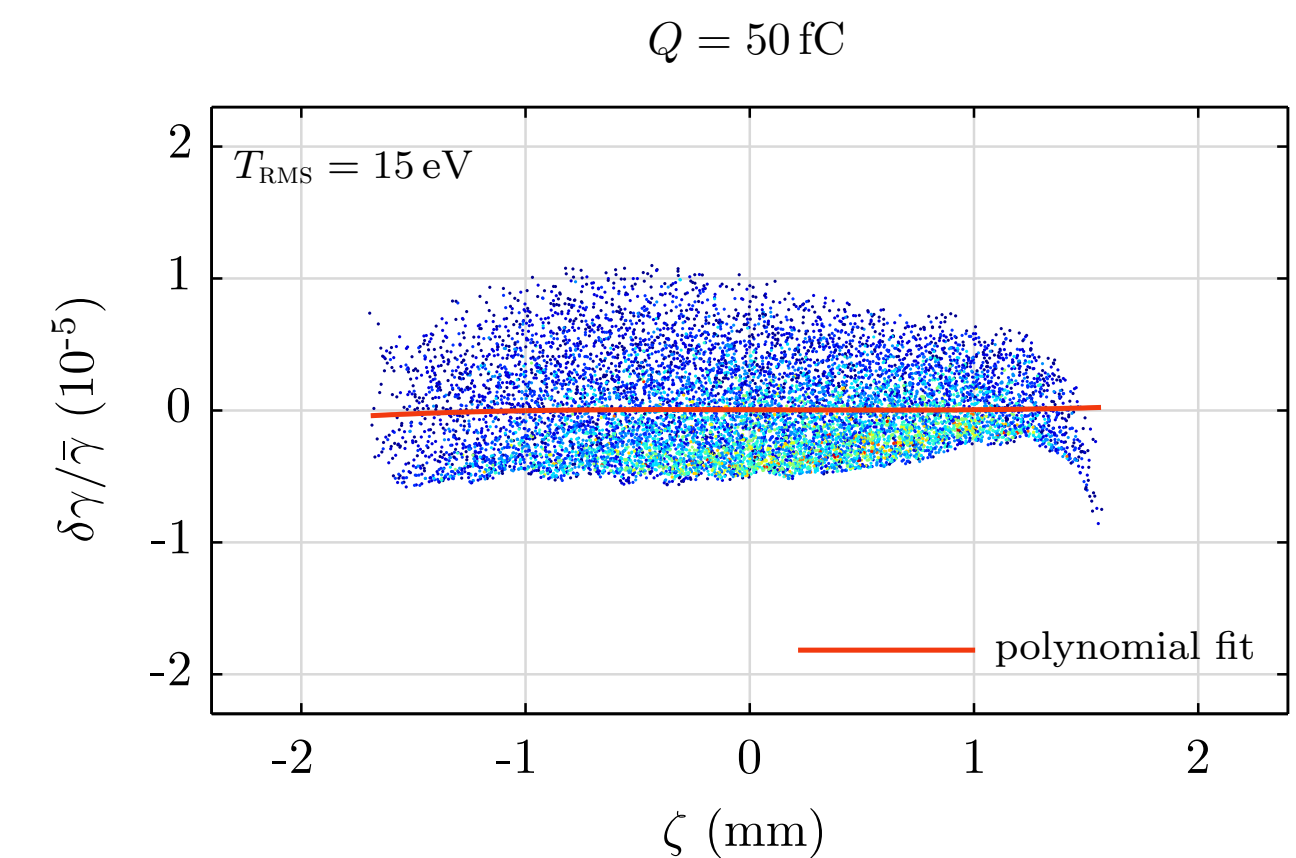
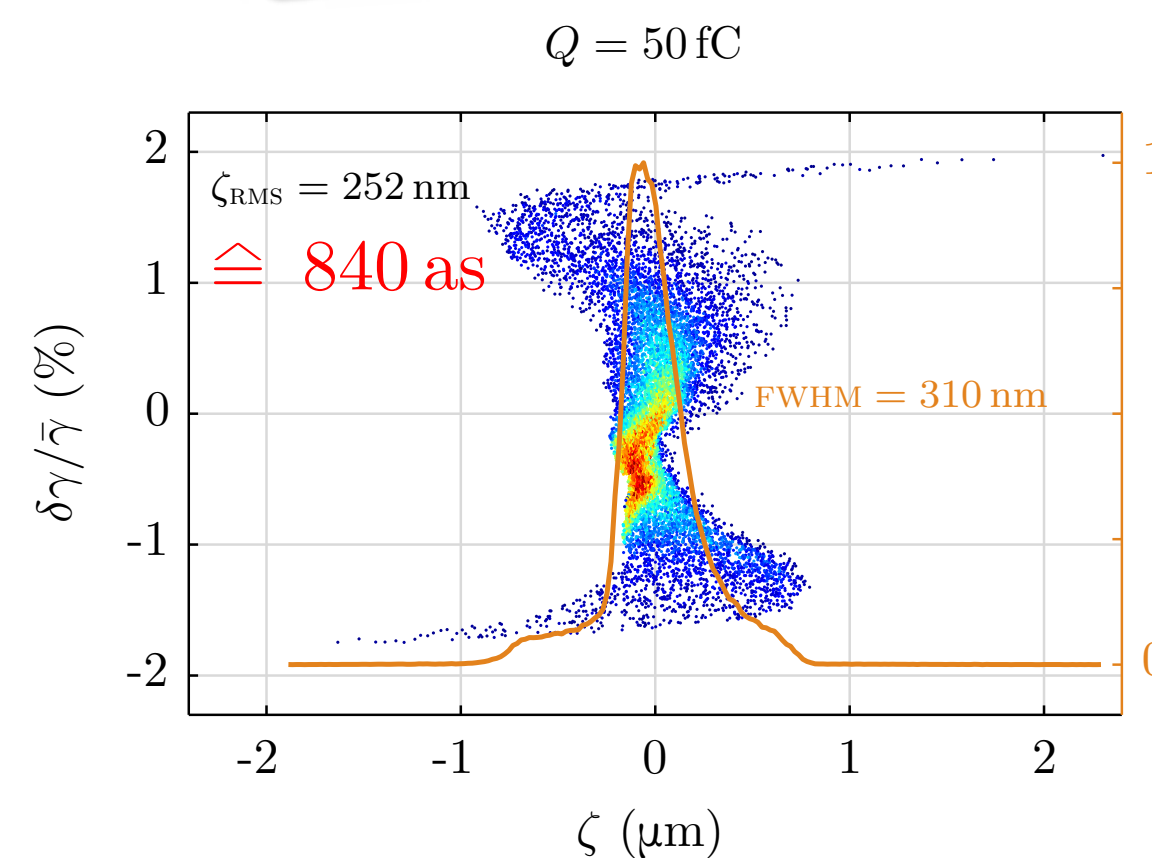
Linearization of the longitudinal phase space without higher harmonic field

Benno Zeitler,^{1,*} Klaus Floettmann,² and Florian Grüner¹

¹Center for Free-Electron Laser Science and Department of Physics,
University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

²Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22603 Hamburg, Germany
(Received 20 July 2015; published 30 December 2015)

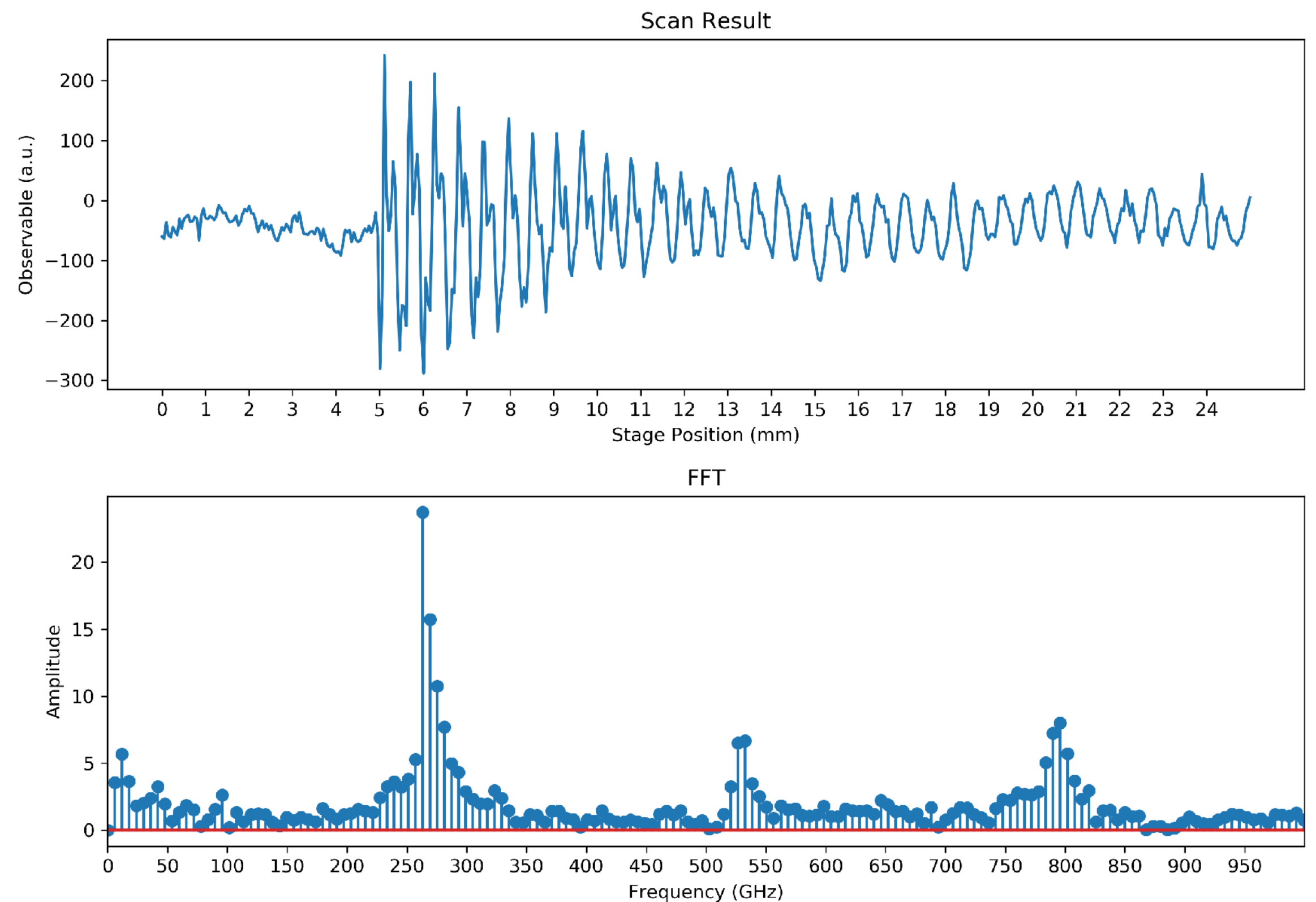
Accelerator applications like free-electron lasers, time-resolved electron diffraction, and advanced



Benno Zeitler,
*Phase Space Linearization and External Injection of Electron
Bunches into Laser-Driven Plasma Wakefields at REGAE,*
PhD thesis, University of Hamburg, 2016

THz-based Acceleration at REGAE

- > use THz fields instead of RF for...
 - > acceleration: similar to external injection
 - > *(almost) everything is there anyways!*
 - > diagnostics: THz-based TDS
 - > resolution on fs scale (and better)
 - > synergy with linearization
- > THz pulses created by REGAE gun laser
 - > pulse energy: ~200 nJ
 - > frequency: 270 GHz
- > 3D printed THz cavities



Courtesy: F. Lemery, F. Mayet



REGAE Beamline Upgrade

REGAE Beamline Upgrade: Team



LUX and ANGUS
crew
ft. Theresa Staufer*



Ryan Stark*



Christian Werle*



Benno Zeitler*

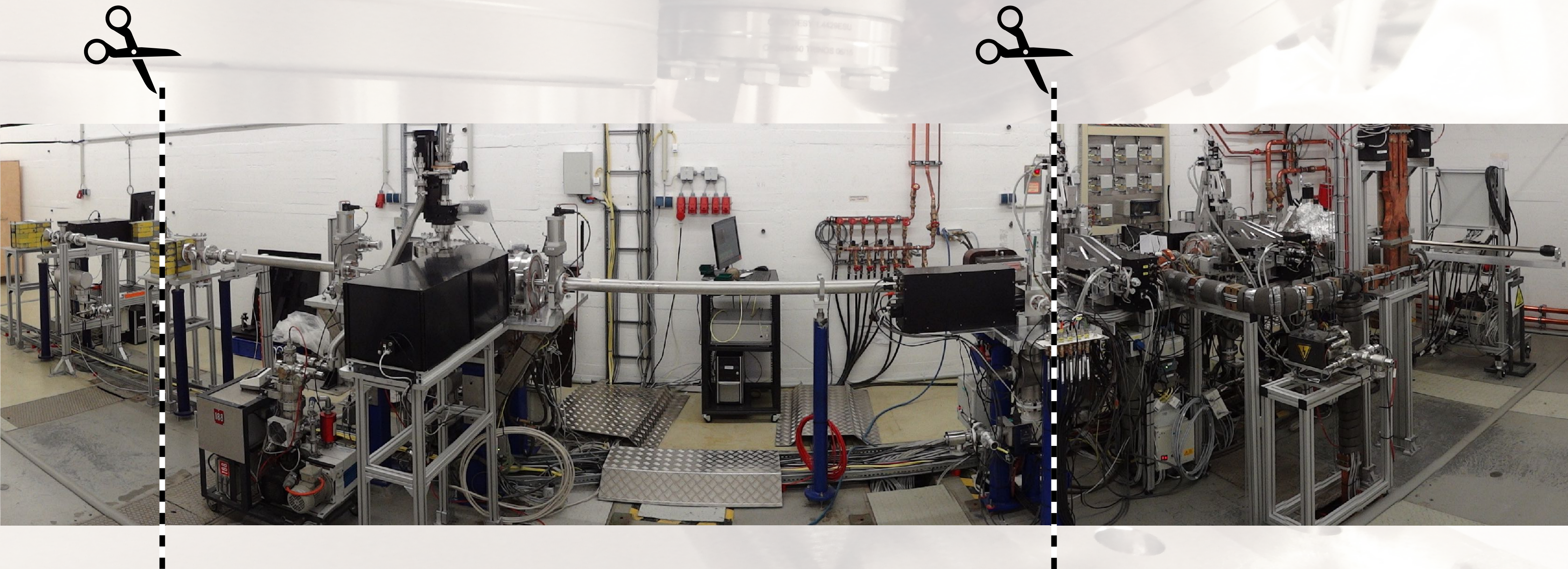
Nick Guse

Klaus Flöttmann
Hossein Delsim-Hashemi
Max Hachmann

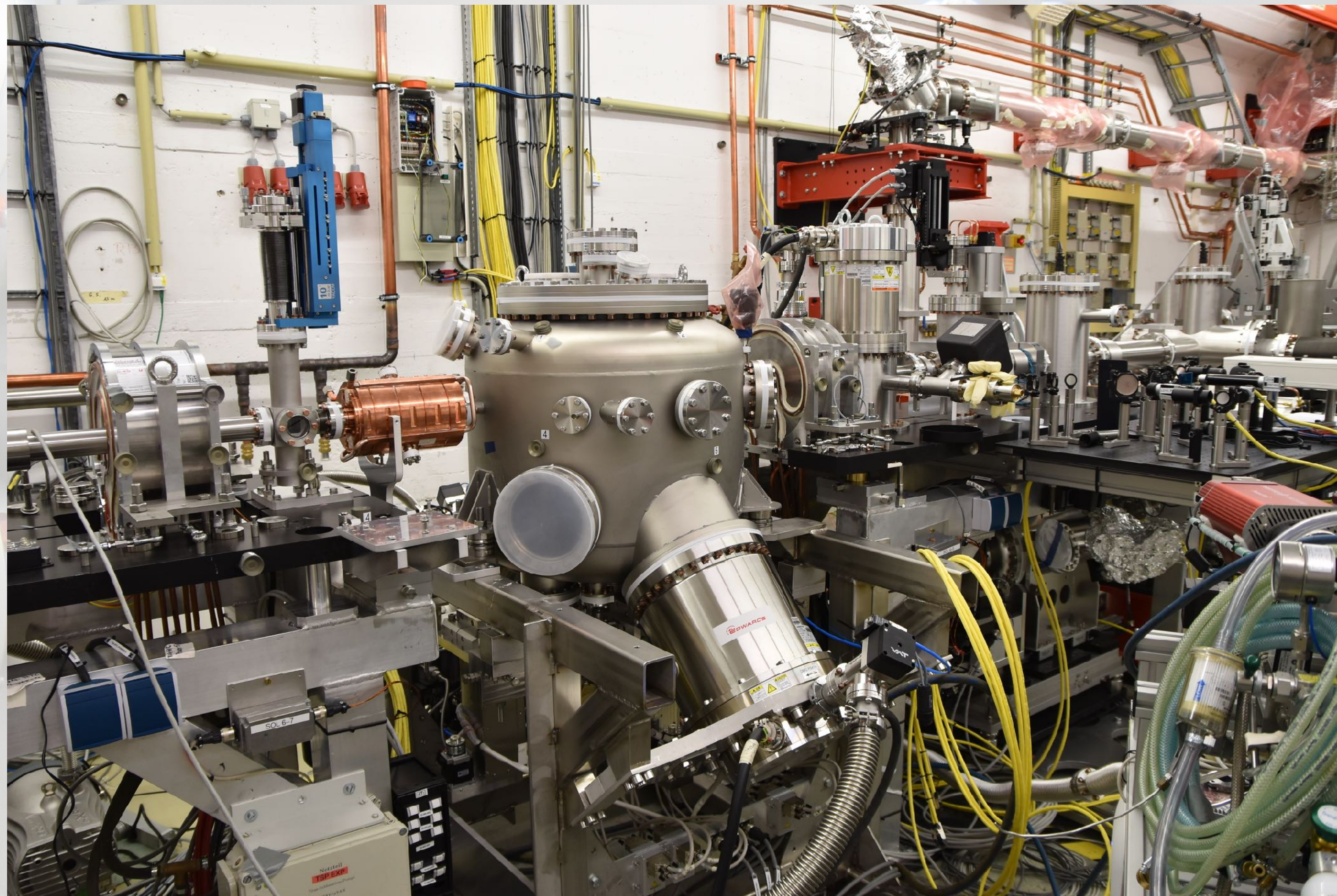
technical groups
(DESY, UHH, MPSD)

* group of
Florian Grüner

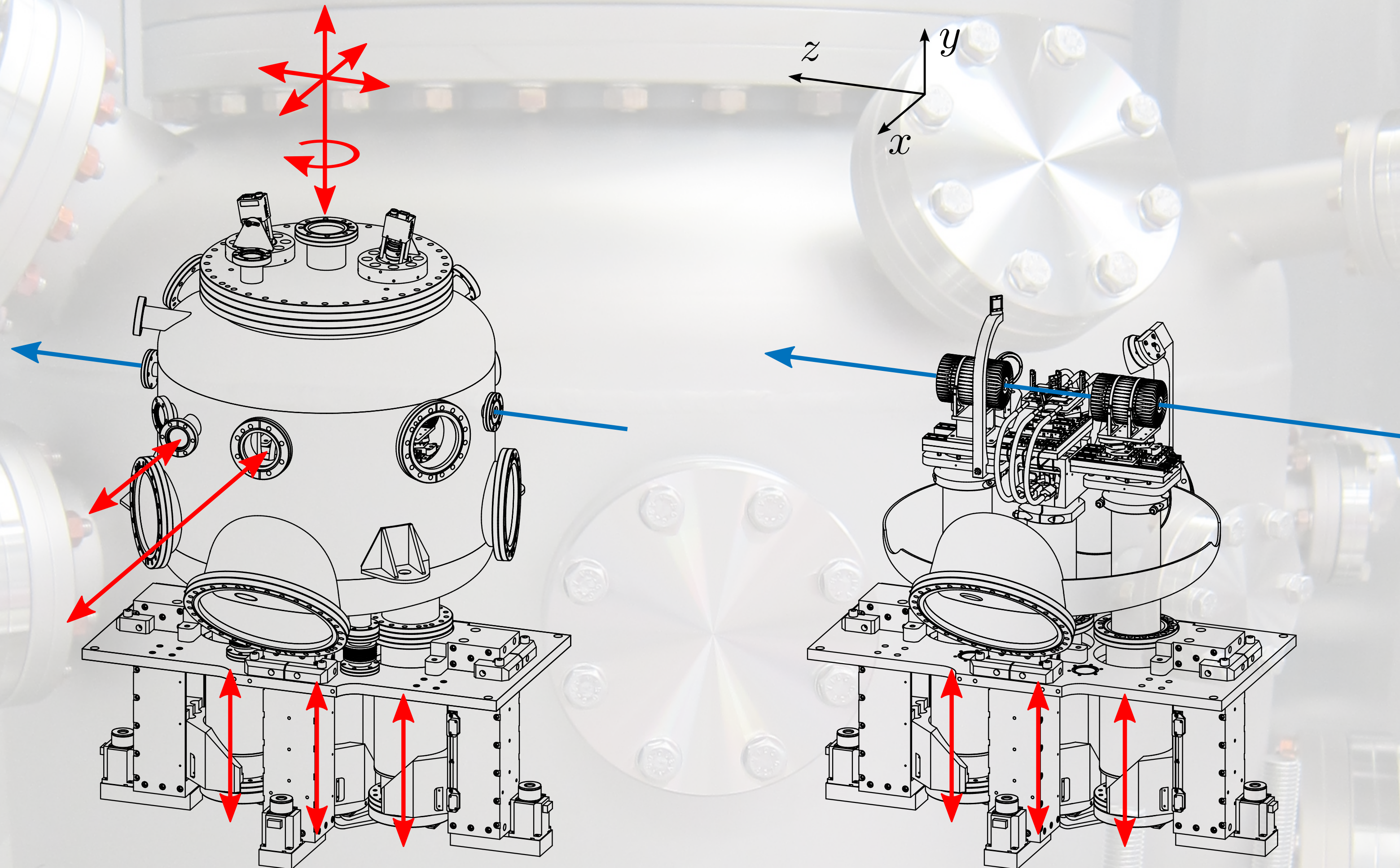
REGAE Beamline Upgrade: Dismantling



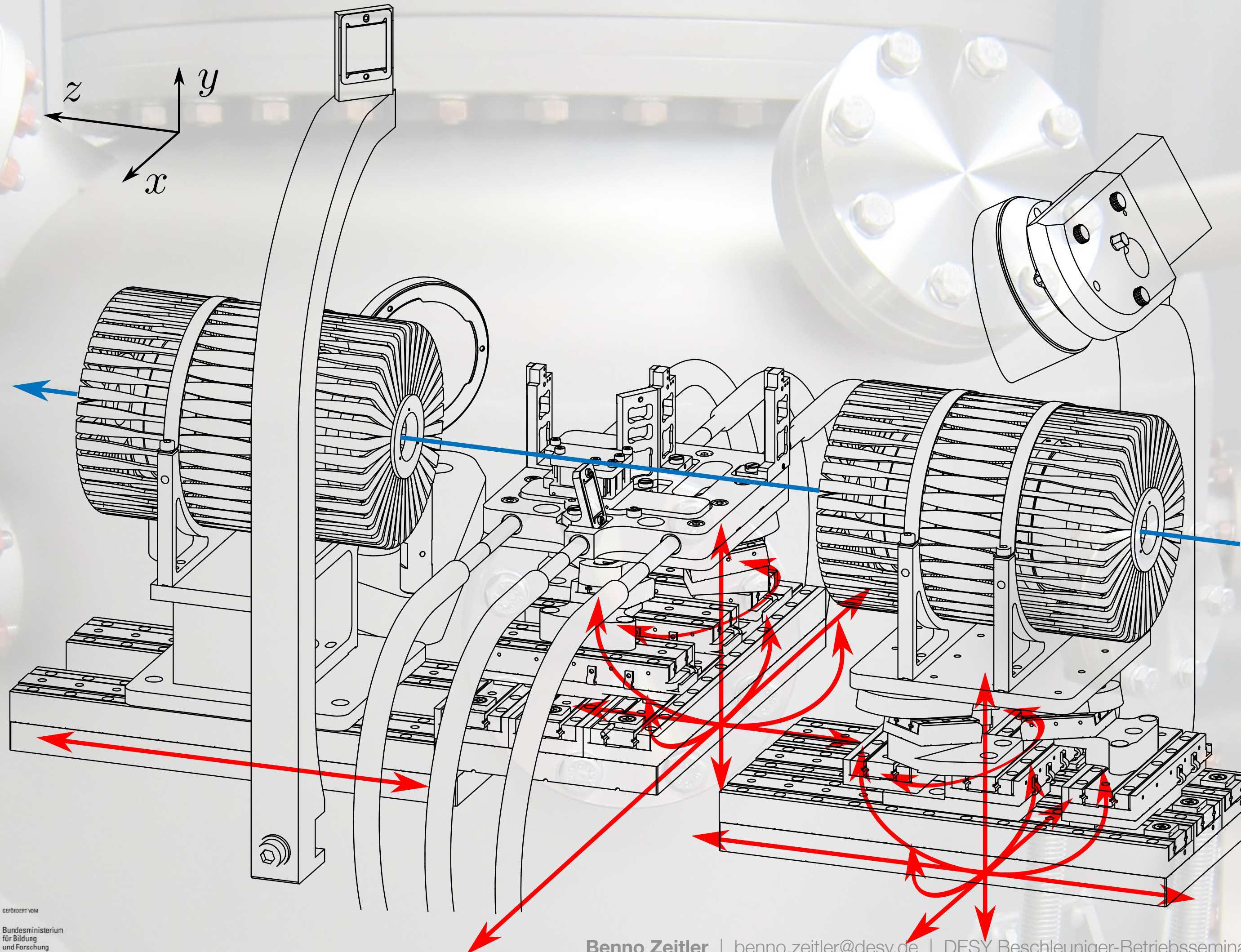
REGAE Beamline Upgrade

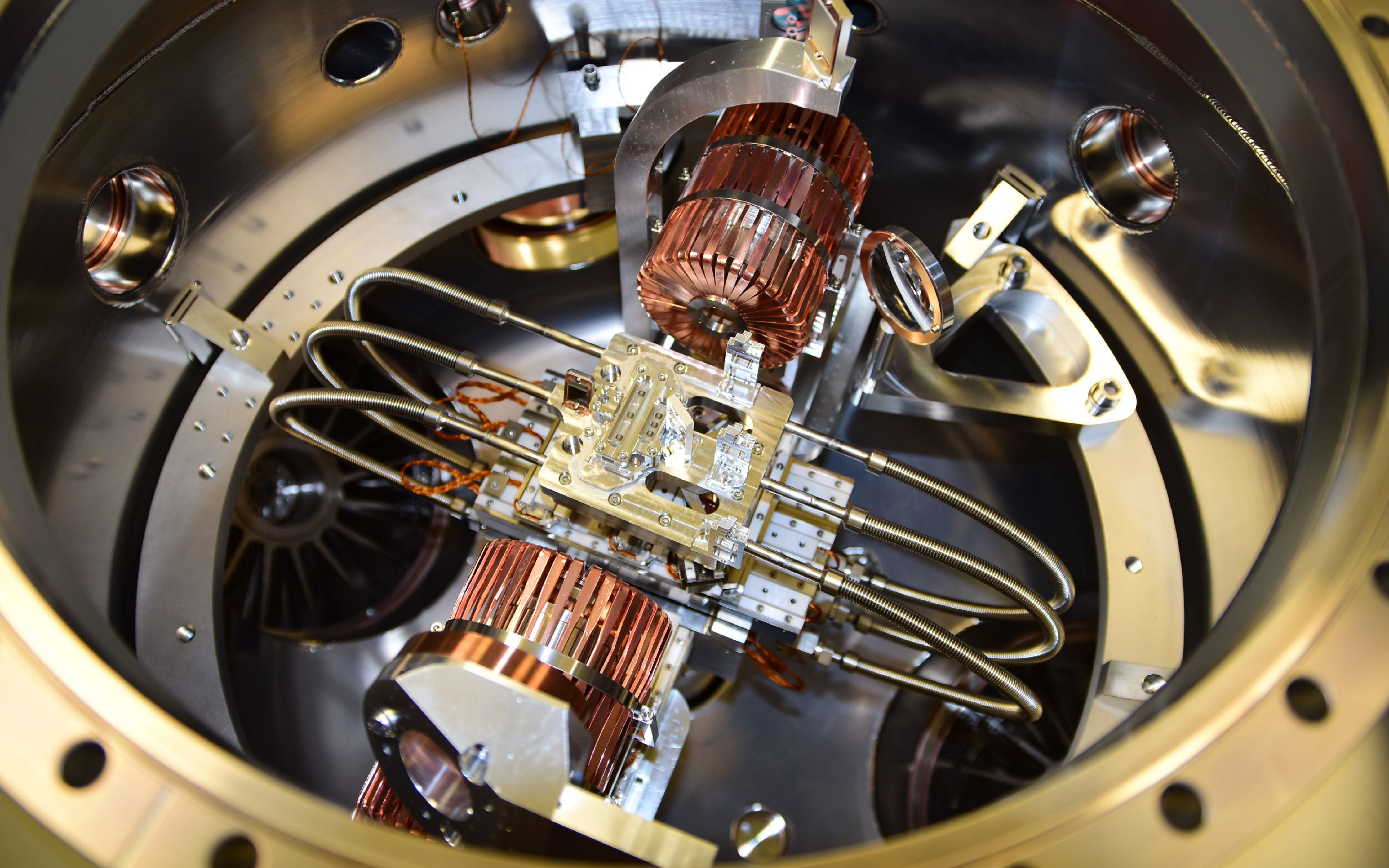


Interaction Chamber: *Sancho Panza*

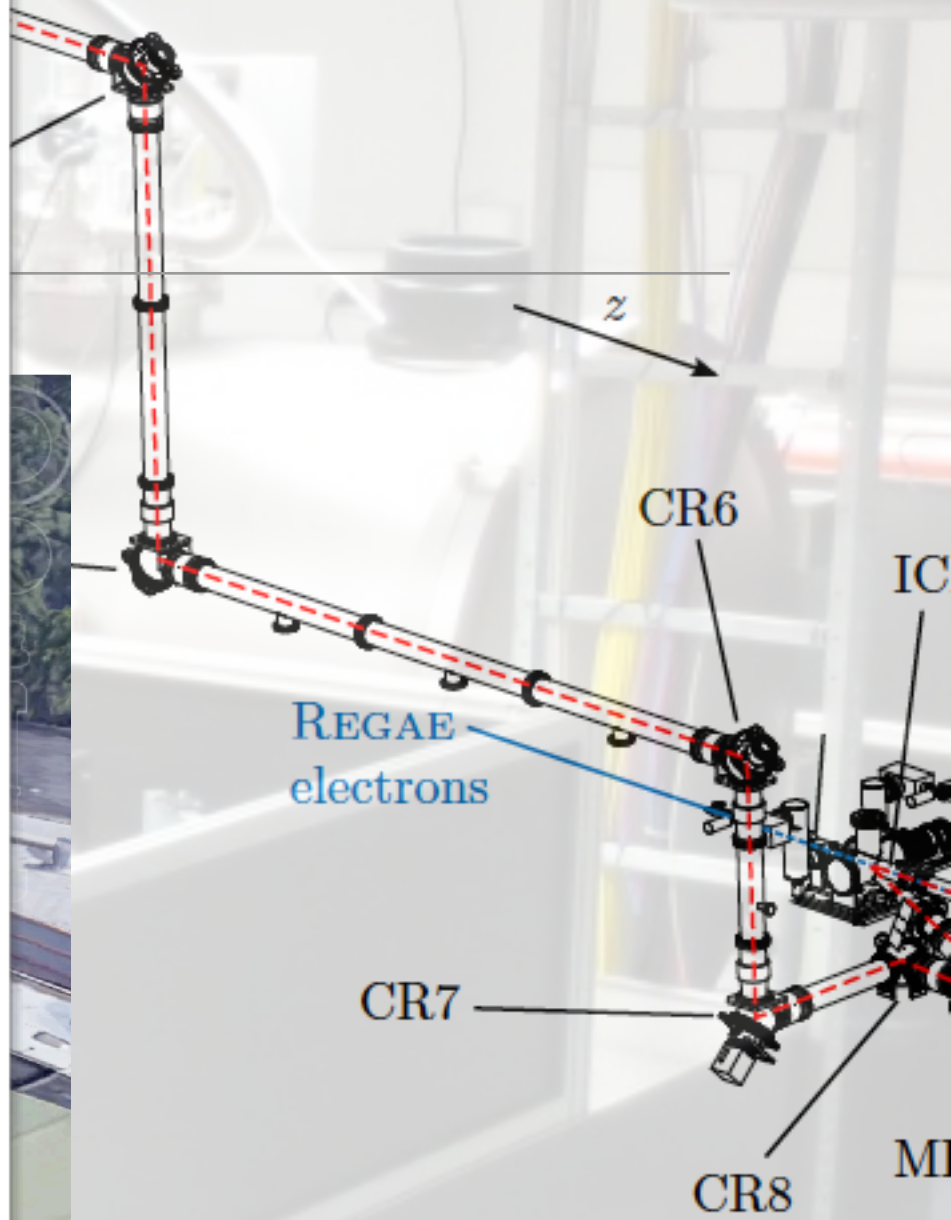
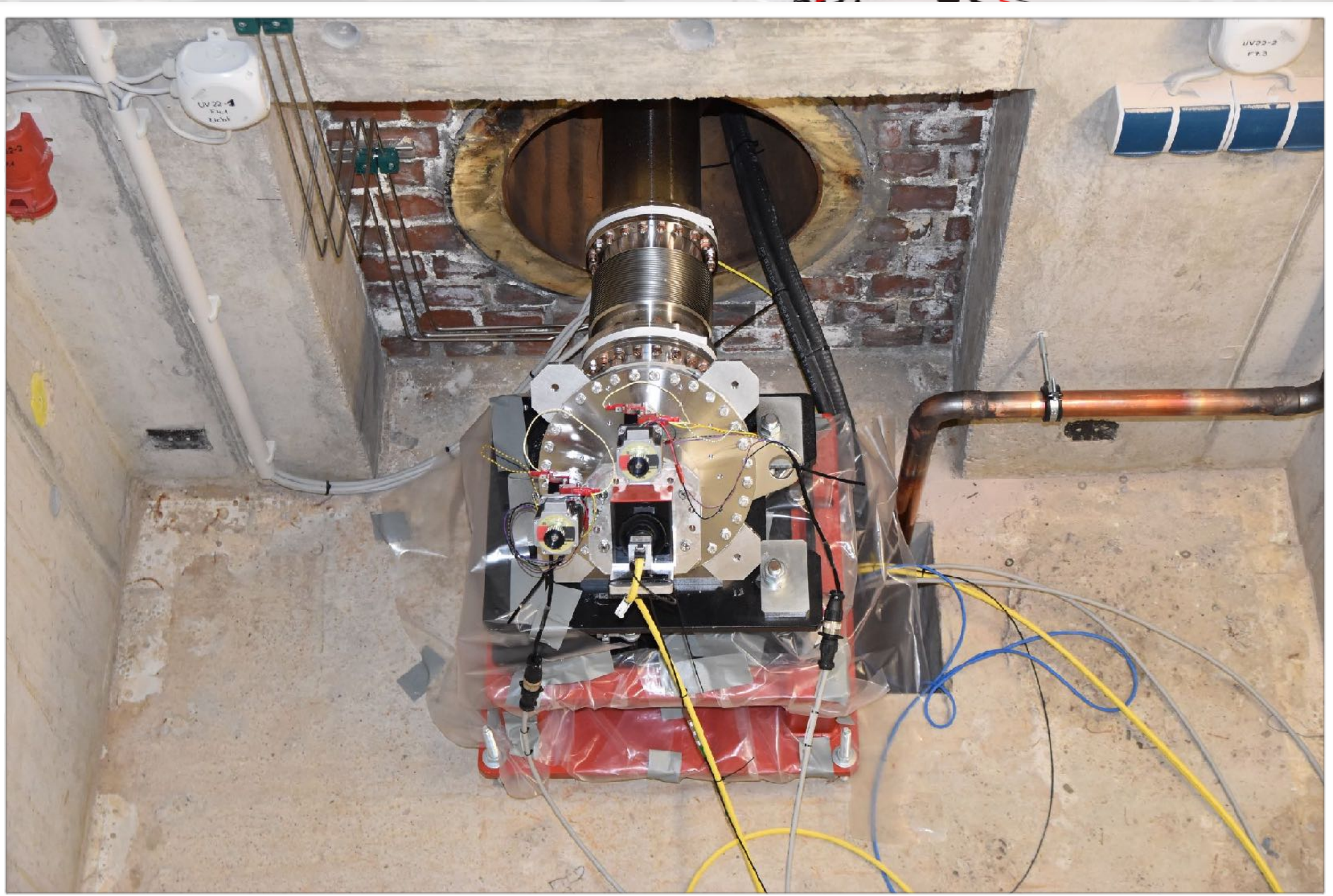


Interaction Chamber: Inside *Sancho Panza*

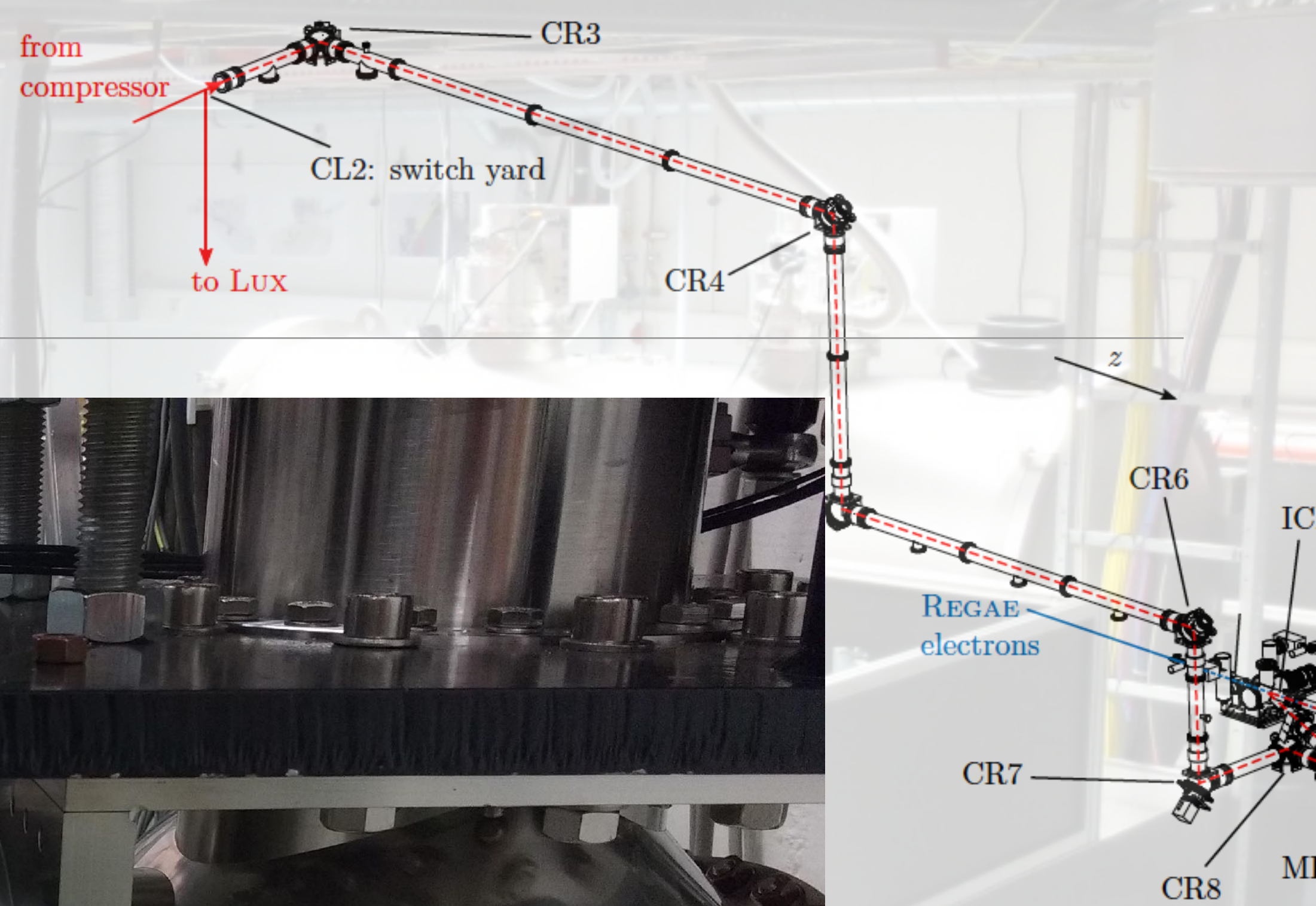
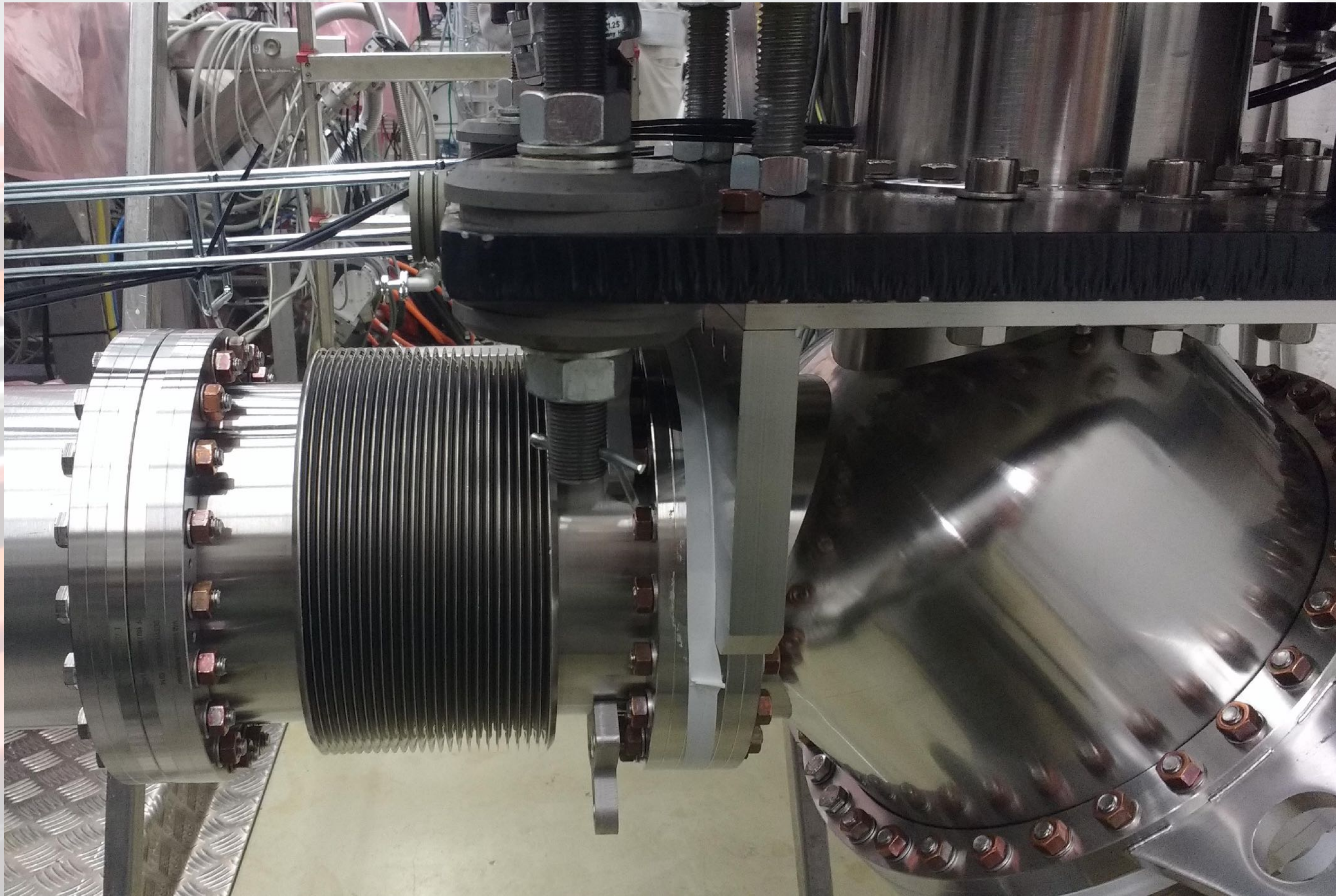




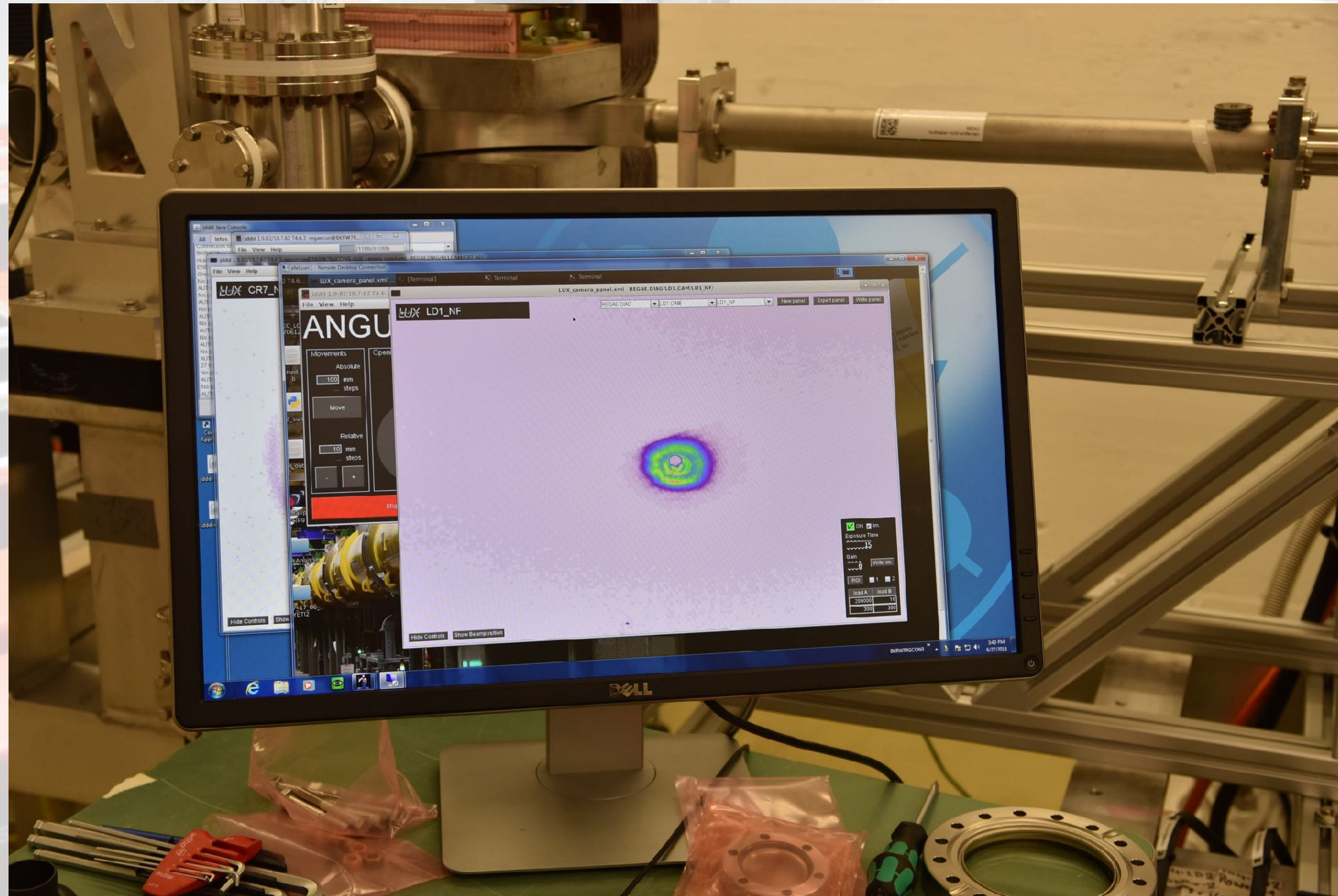
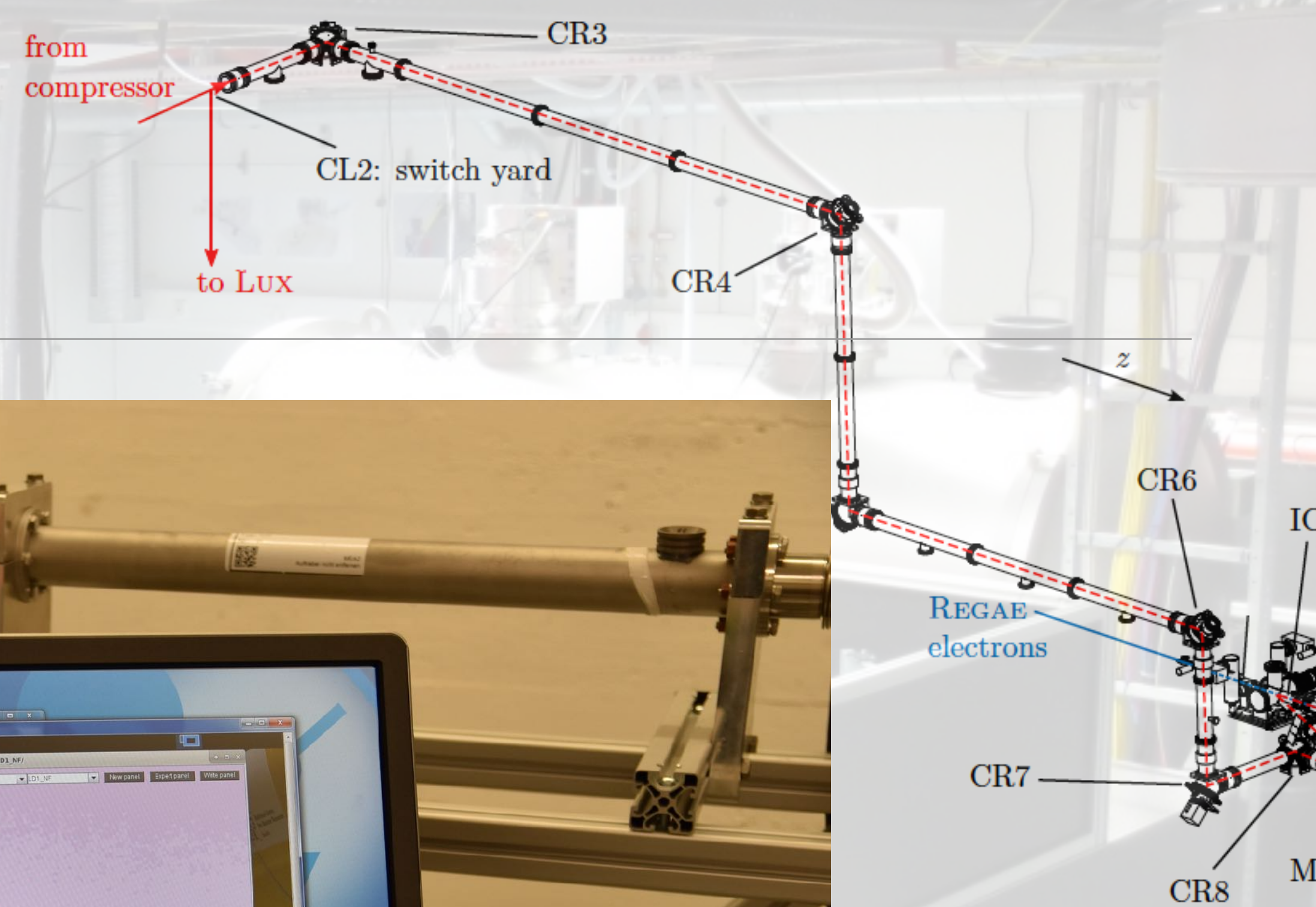
Laser Transport E

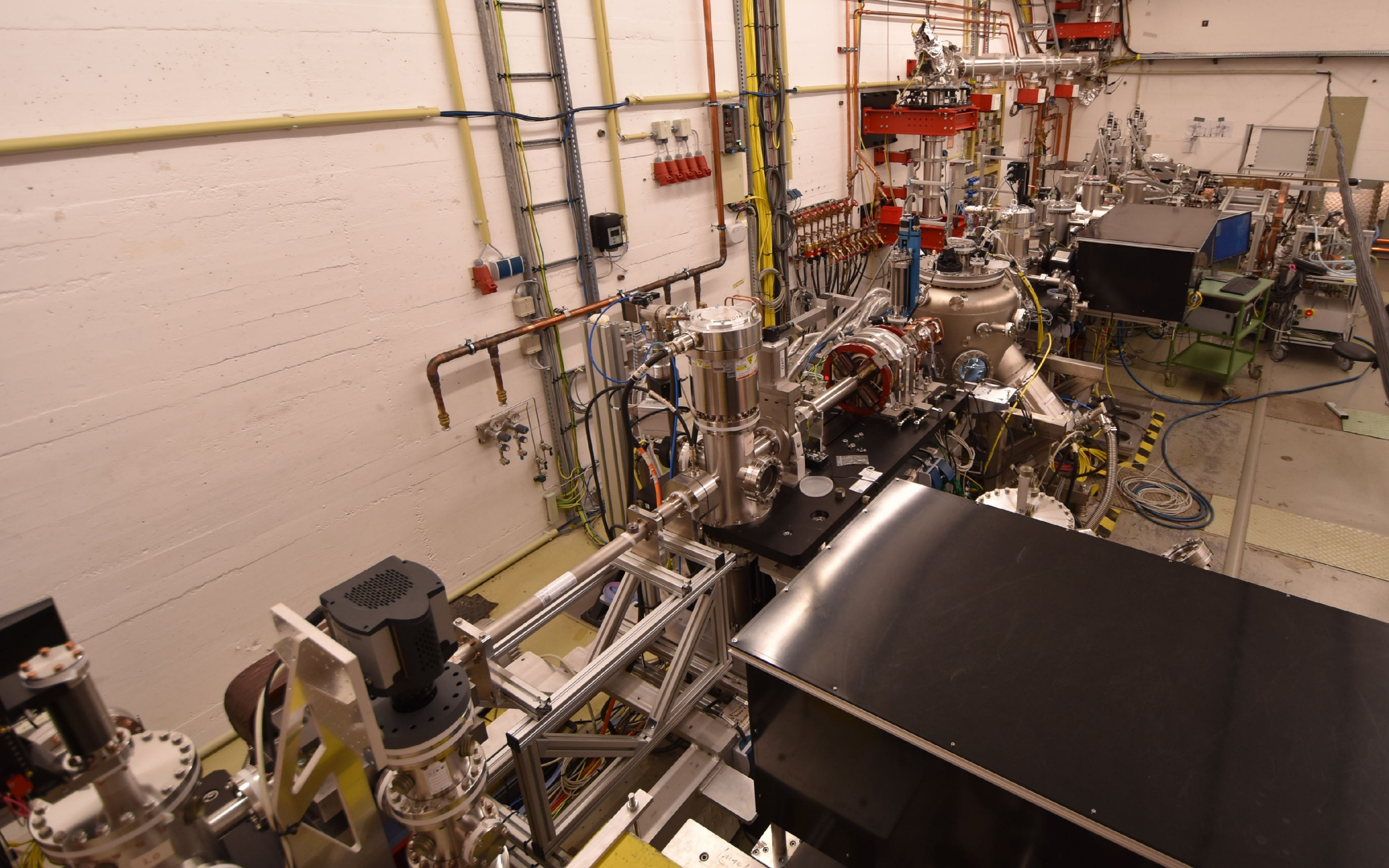


Laser Transport Beamline



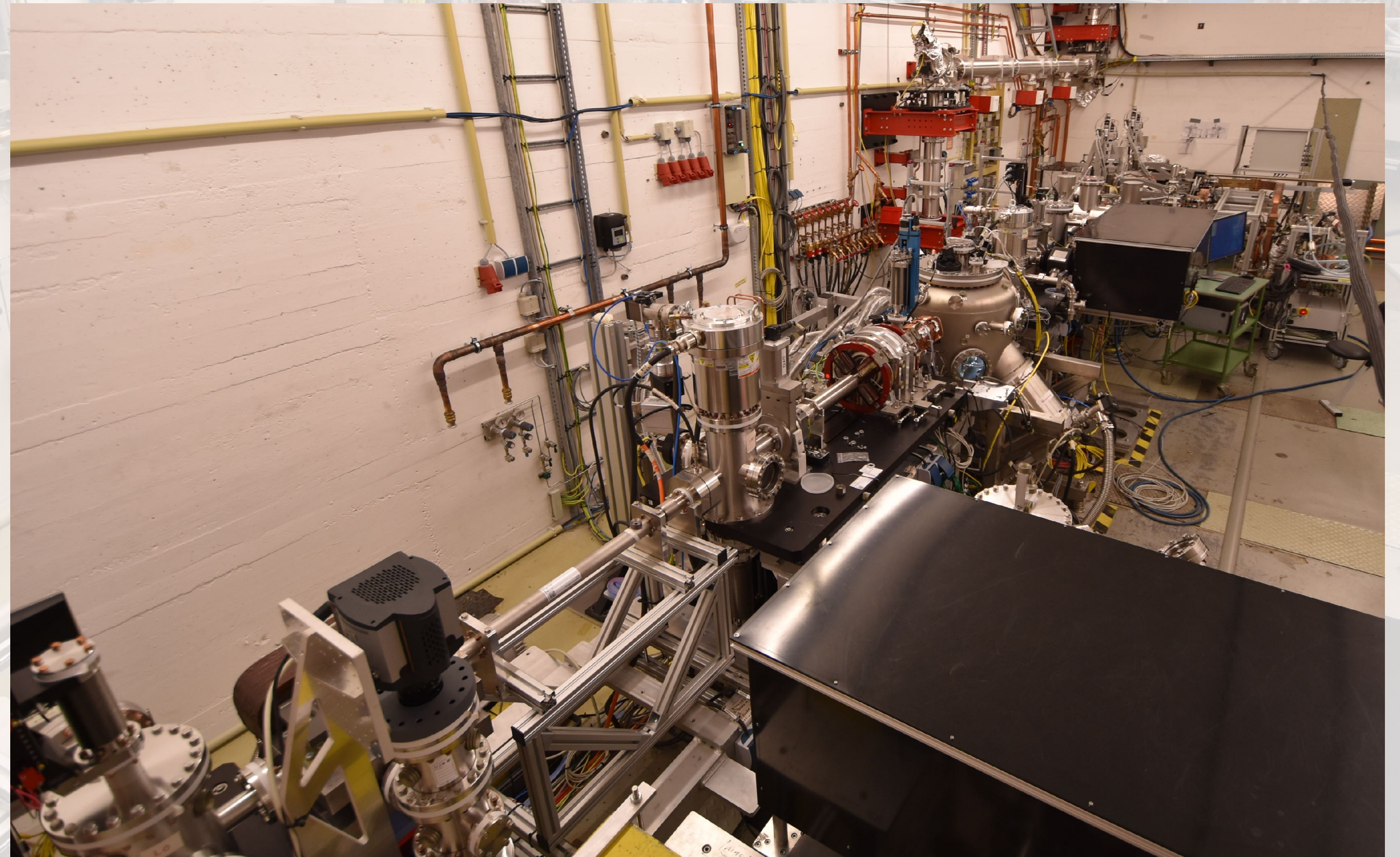
Laser Transport Beamline





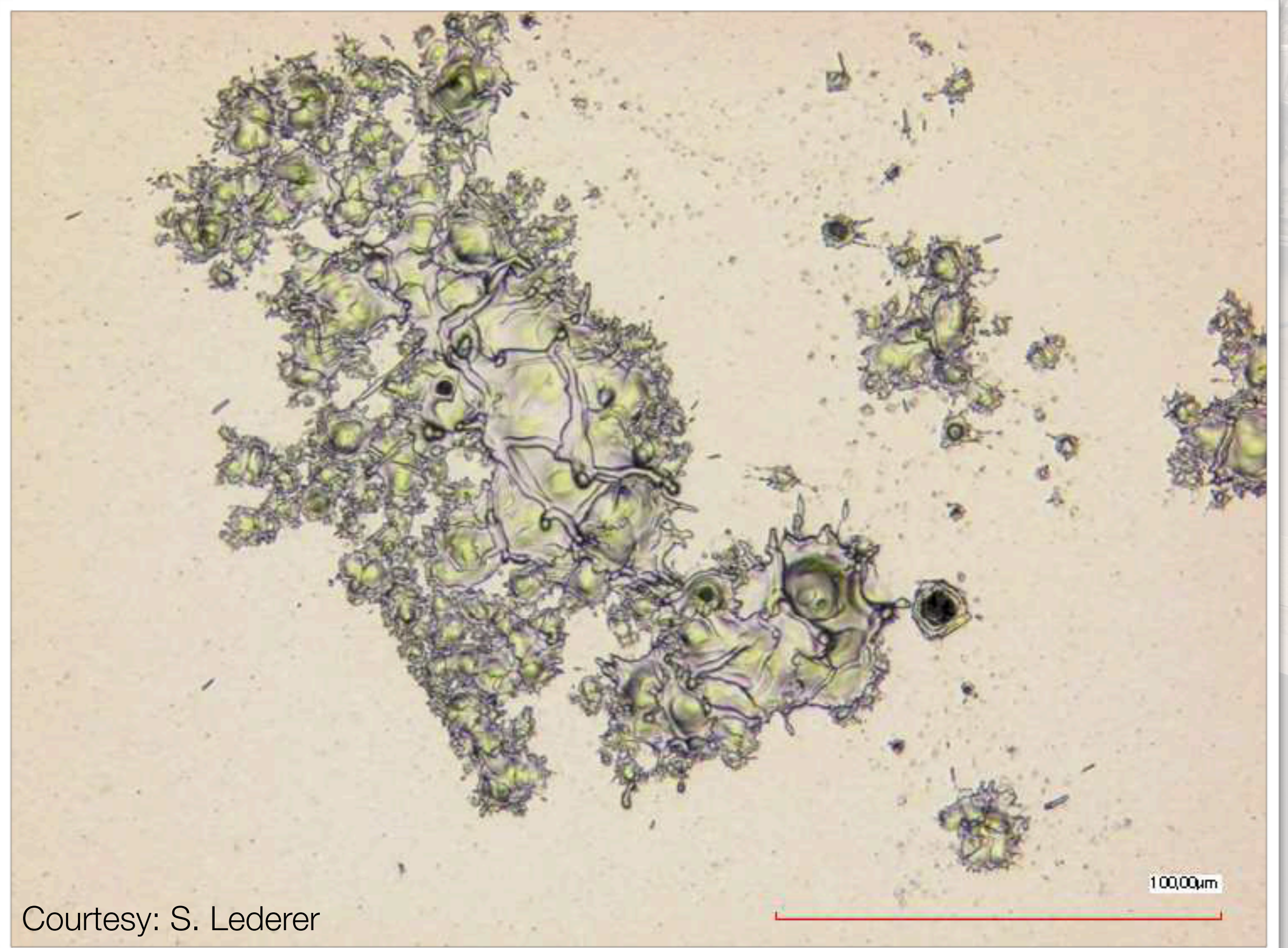
REGAE Beamline Upgrade: Status... *completed*

- > REGAE beamline
 - > interaction chamber
 - > differential pumping
 - > transverse deflecting structure
 - > beam arrival cavity
 - > additional klystron & modulator
- > laser transport beamline
 - > connection to ANGUS vacuum system
 - > final focusing chamber
 - > in-coupling chamber
 - > ANGUS beam in the tunnel
 - > synchronization



Commissioning

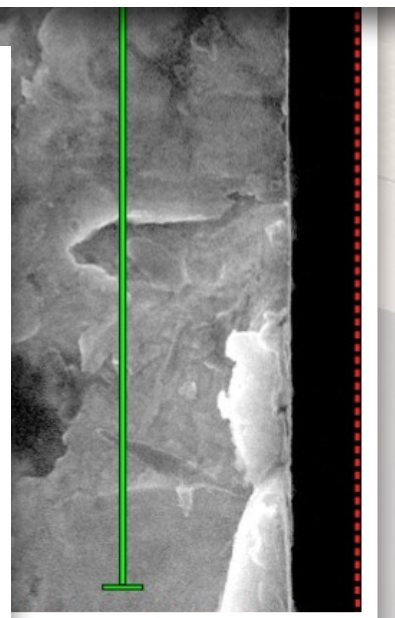
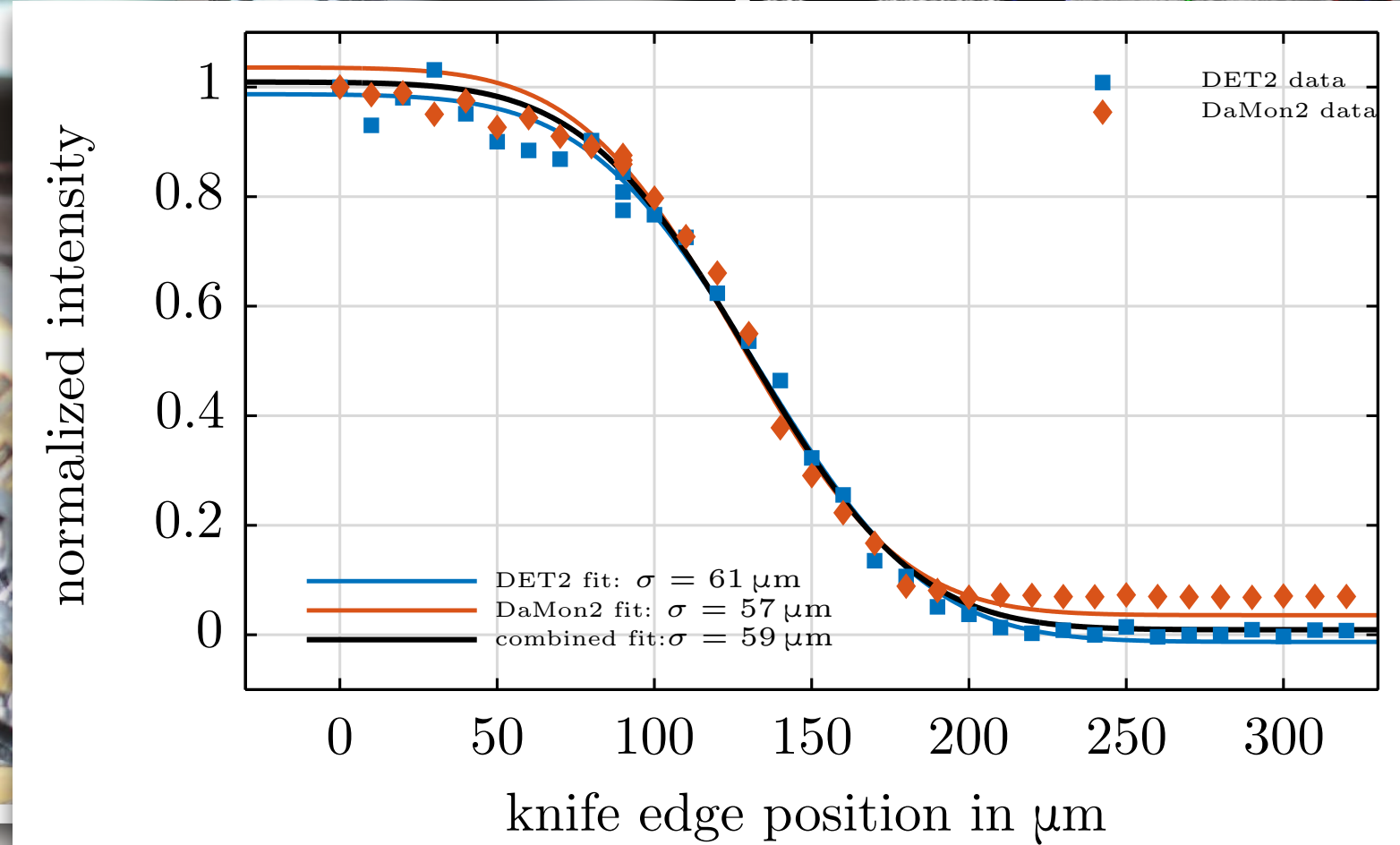
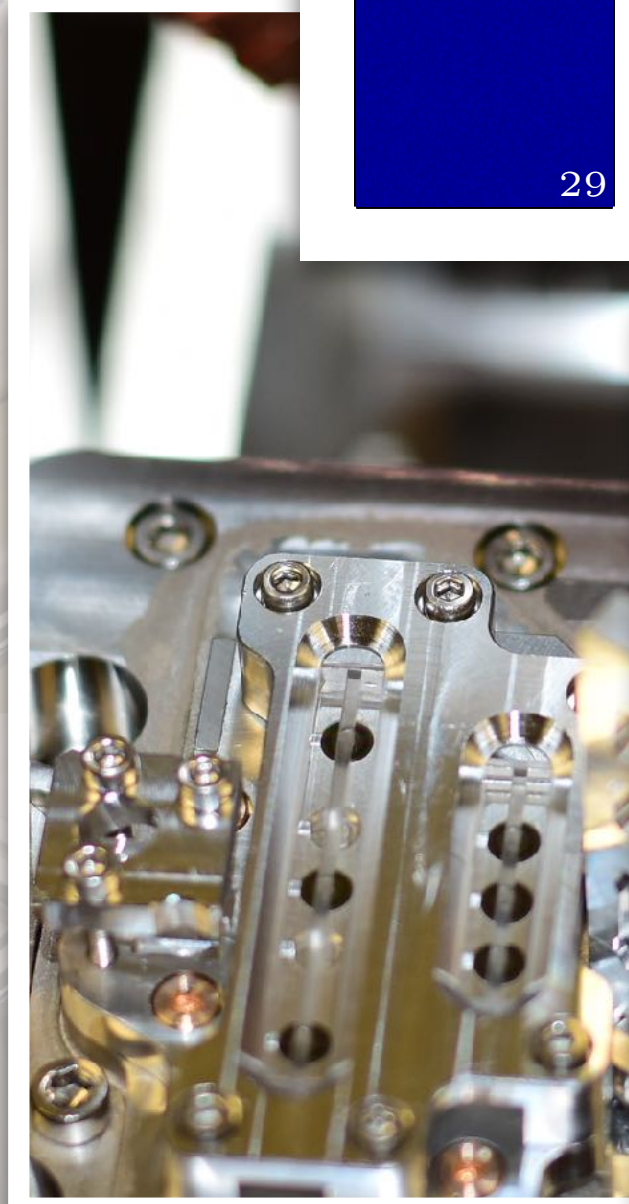
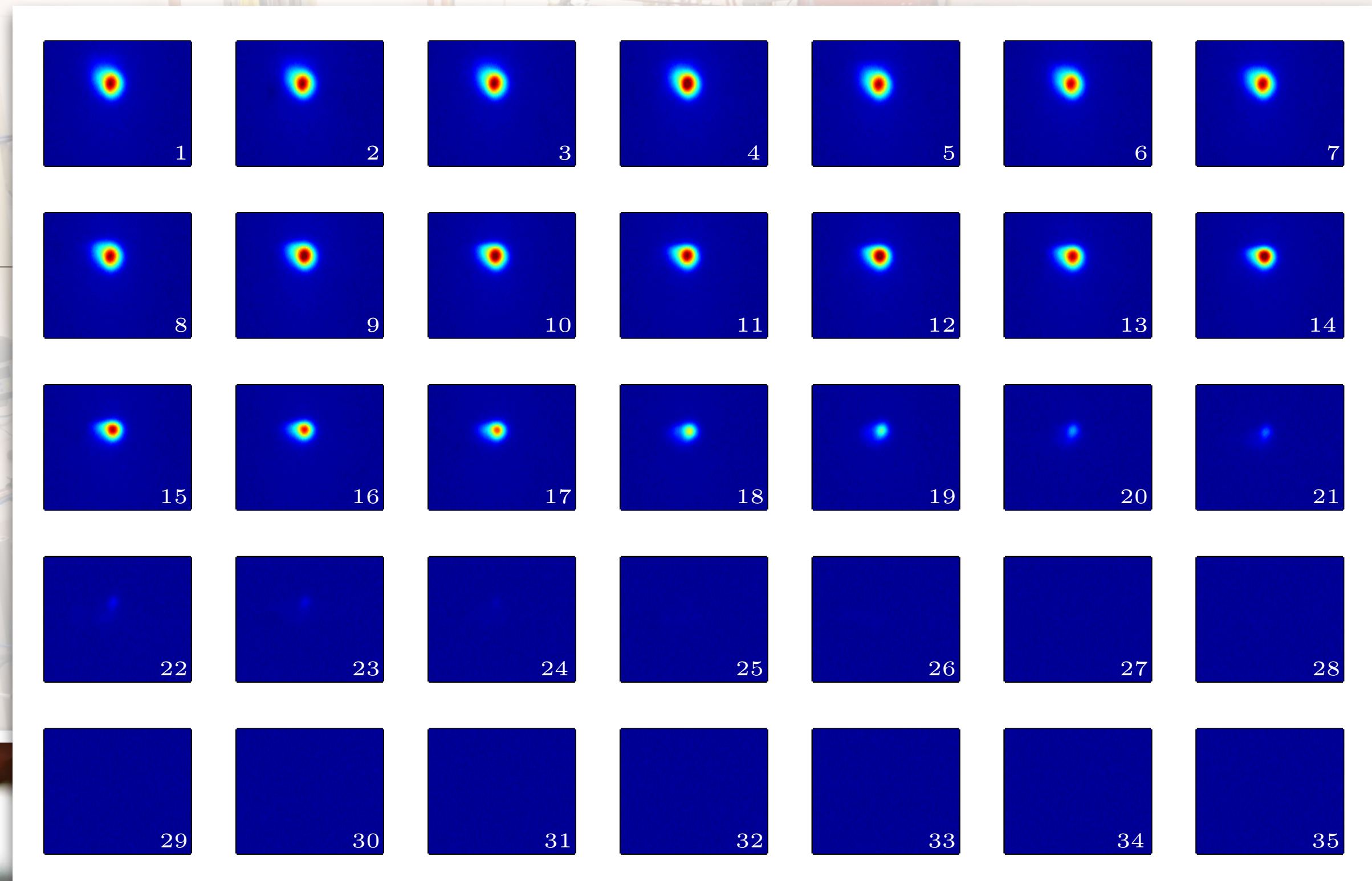
- > ANGUS transported to REGAE
 - > diagnostics vs. mirror reflectivity
 - > synchronlization
- > cavities & rf system
 - > gun, buncher, and TDS operational
 - > issues with dark current
 - > replacement of gun
 - > replacement of cathode
 - > hight offset of beam axis



Courtesy: S. Lederer

Commissioning

- > gas system and differential pumping
 - > all pumps operational
 - > pressure profile promising
 - > target pressure
 - > less flow required than estimated
 - > issues with sensors
- > motors and SmarPods operational
- > diagnostics: work in progress
 - > example: knife edge scan

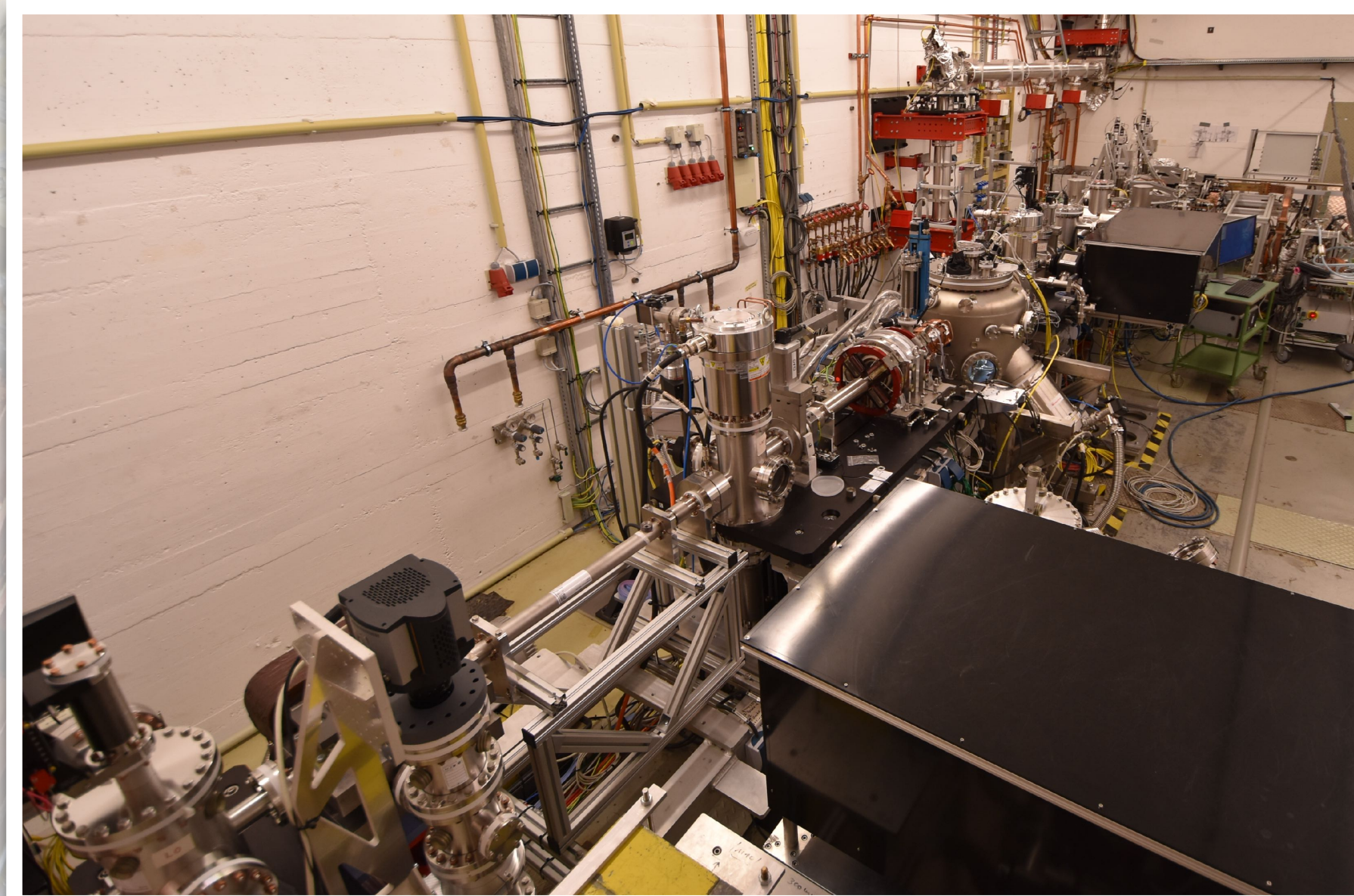
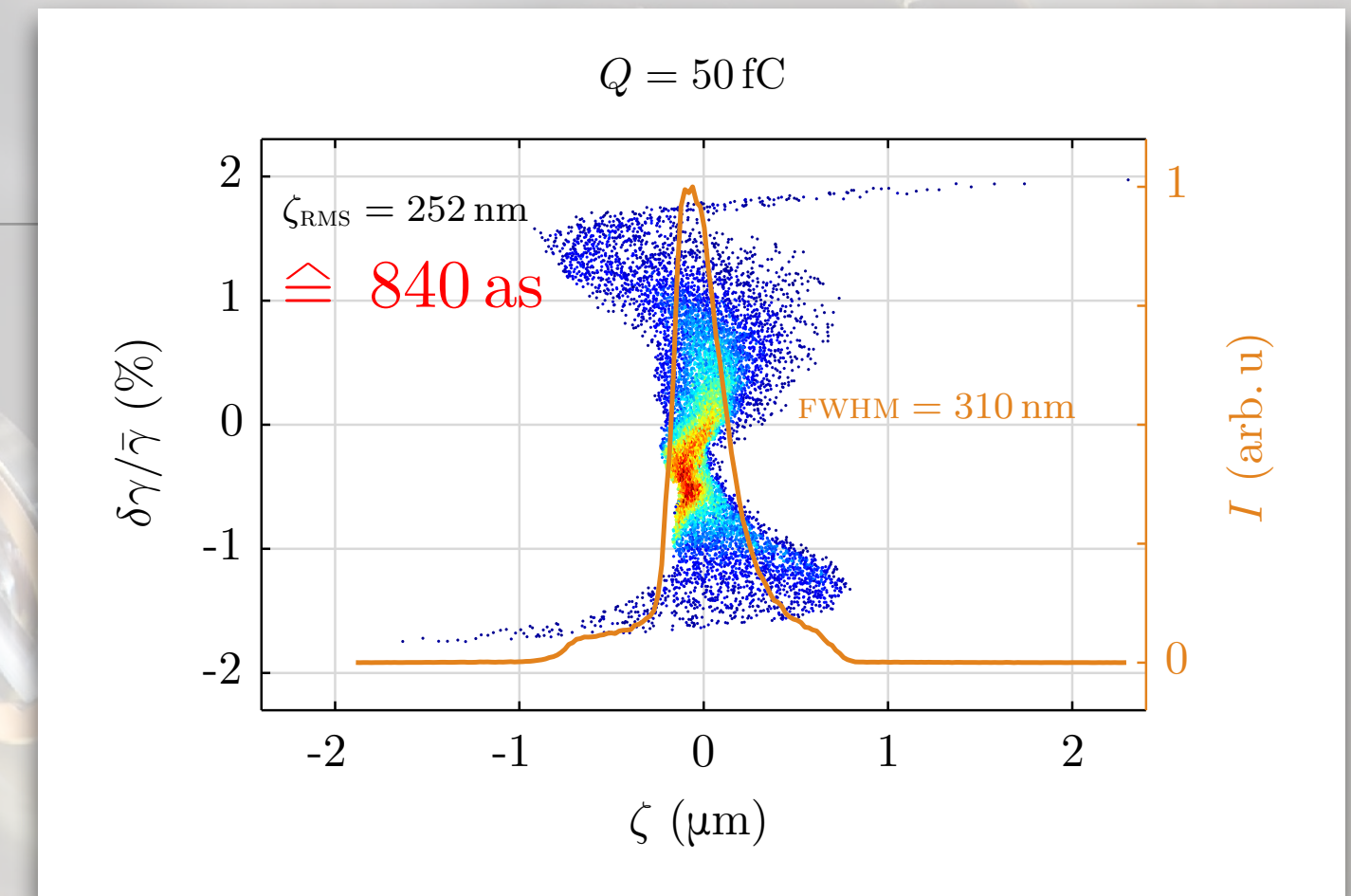
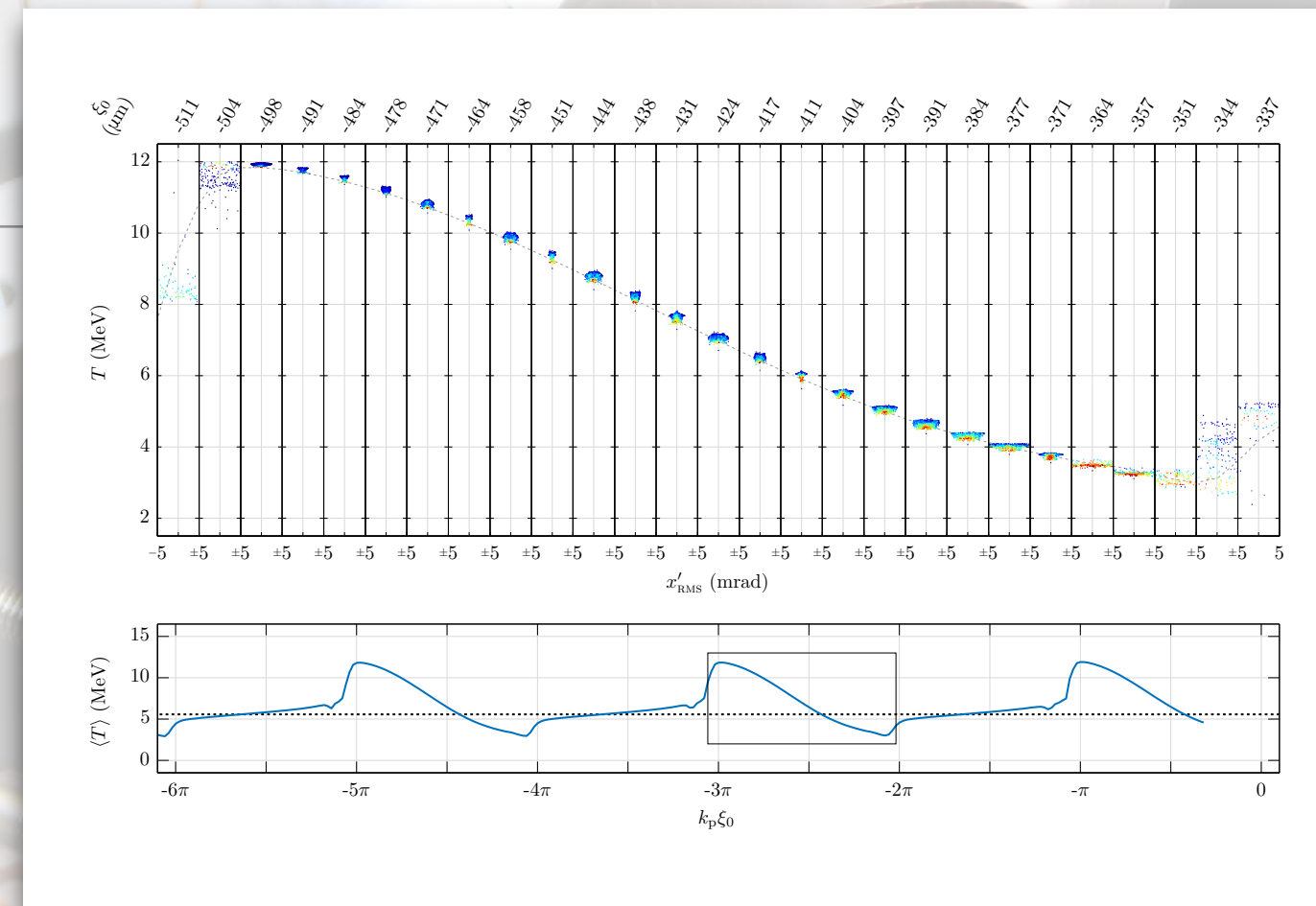


Conclusion

- > REGAE beamline upgrade completed
- > commissioning in progress

- > projects
 - > external injection project
 - > phase space linearization
 - > (THz acceleration/diagnostics)

- > test bed for future injection experiments
 - > components: BAC, hexapods, (Si-)mirrors, ...
 - > concepts: synchronization, matching, electron-laser-overlap, in-coupling, differential pumping, THz, ...



Thank you for your attention



GEFÖRDERT VOM



Bundesministerium
für Bildung
und Forschung

05K16GUB



