laser cooling & spectroscopy @ GSI/FAIR

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Physik der kleinsten Teilchen

atomic physics, laser physics, detector physics, and accelerator physics

KfB Workshop, TEMF, TU-Darmstadt **31 August 2017**

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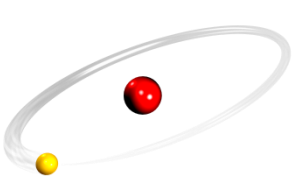
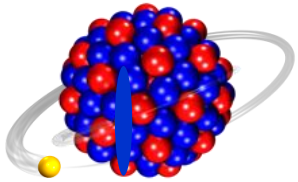
typical		special
light ions	→	heavy ions
low charge states	→	high charge states
low energies	→	high energies

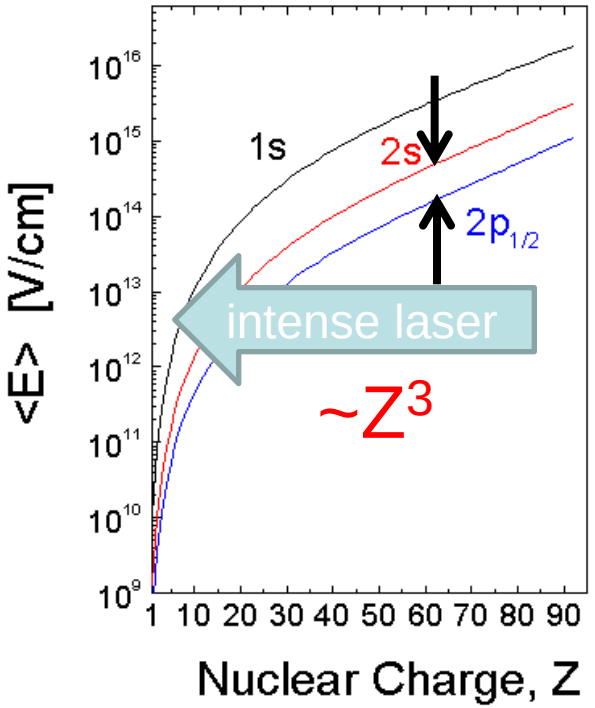
Study simple (few electron) systems to compare theory & experiments.





Tests of QED in extreme electromagnetic fields.
New access to fundamental constants and to nuclear ground state properties.

laser spectroscopy & laser cooling



$E_B \sim 10^5$ eV
$Z\alpha \sim 1$

$E_B \sim 10$ eV
$Z\alpha \sim 10^{-2}$

used laser systems:

cw Ar^+ laser (514 nm) +
1 frequency doubling stage (257 nm)

2004-2006

tuneable cw ECDL (diode, 1028 nm) +
fiber amplifier +
2 frequency doubling stages (514 and 257 nm)

Darmstadt

pulsed laser system (1028 nm) +
2 frequency doubling stages (514 and 257 nm)

Dresden

XUV-detector system

Münster

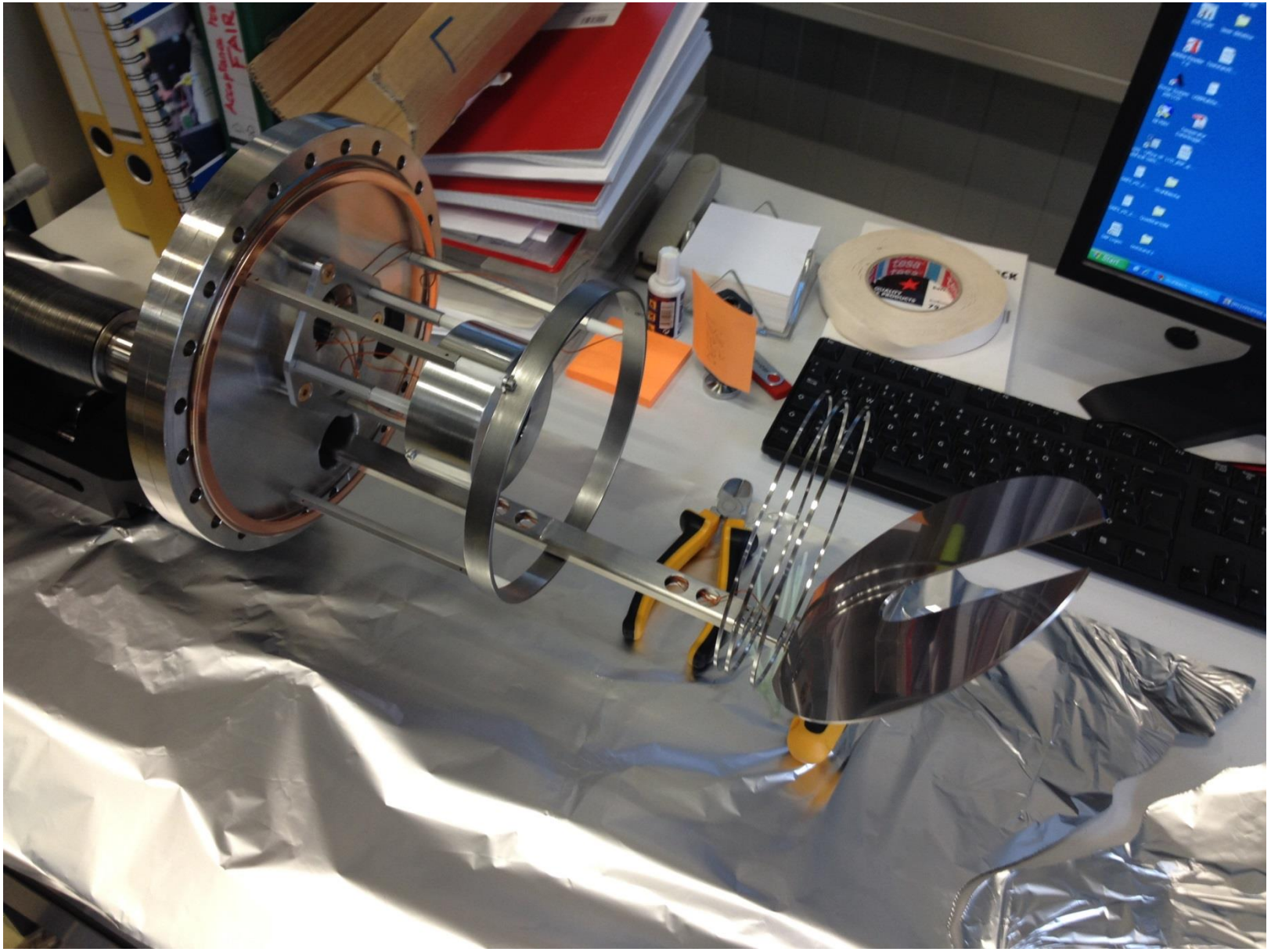
2012-2016

→ test beamtime in April 2016 at CSRe in Lanzhou, China
→ test beamtime at GSI in July 2016 at ESR in Darmstadt

moveable CsI-cathode for XUV fluorescence detection

→ BMBF funding: group of Prof. Christian Weinheimer (Uni Münster)

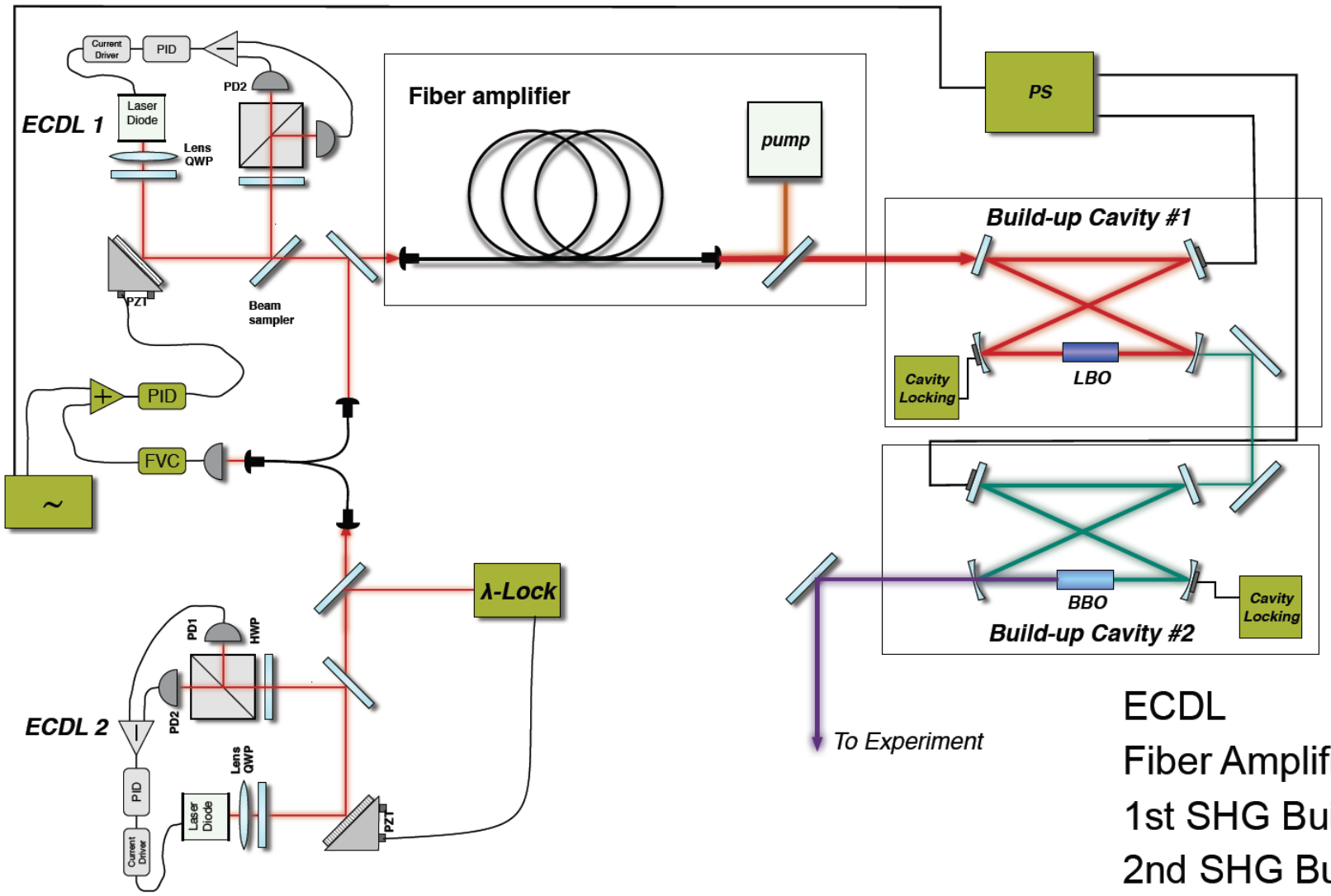
moveable CsI-cathode for XUV fluorescence detection



→ BMBF funding: group of Prof. Christian Weinheimer (Uni Münster)

ECDL scanning cw laser system

(20 GHz IR, 3 GHz needed)



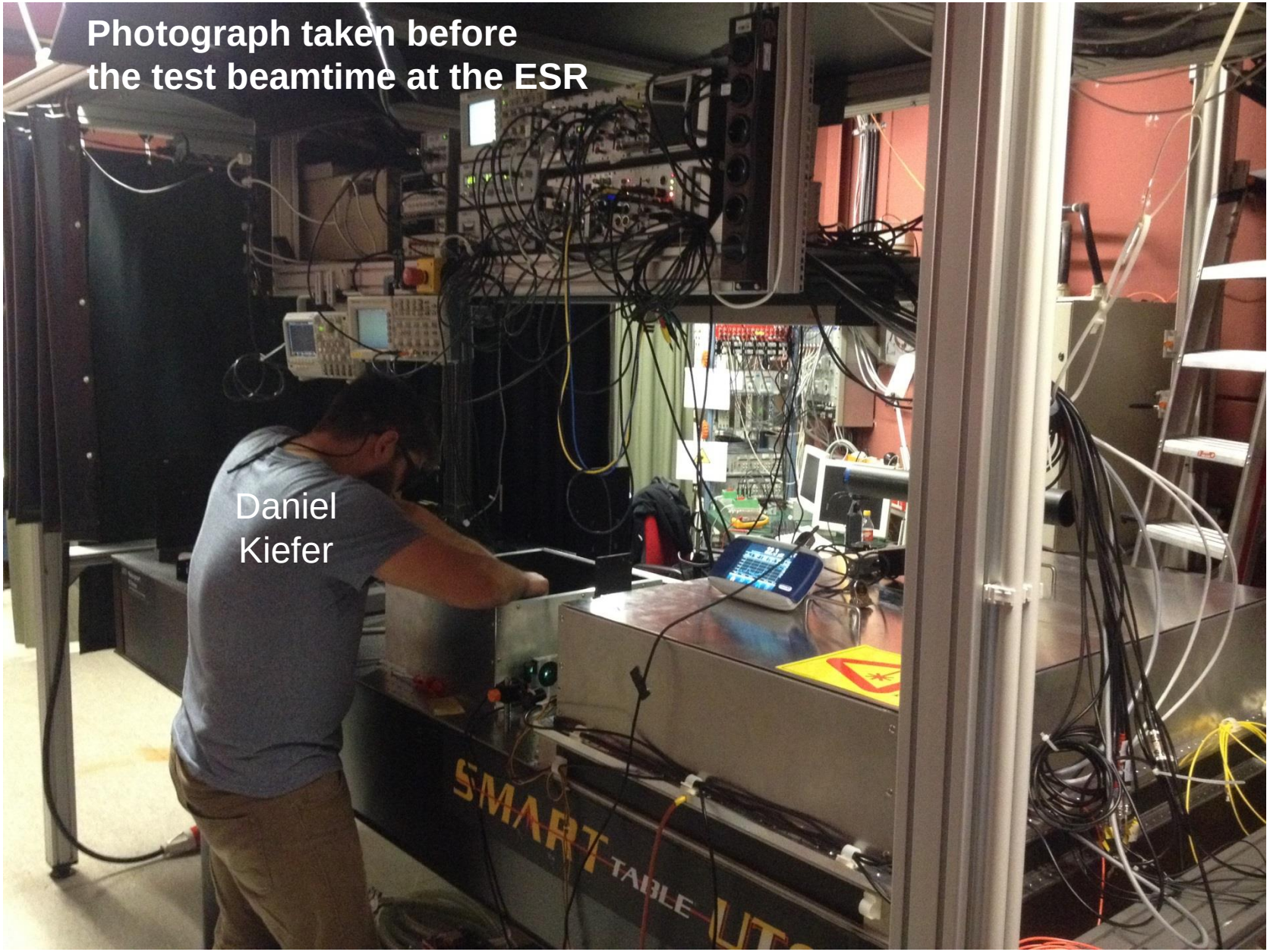
ECDL

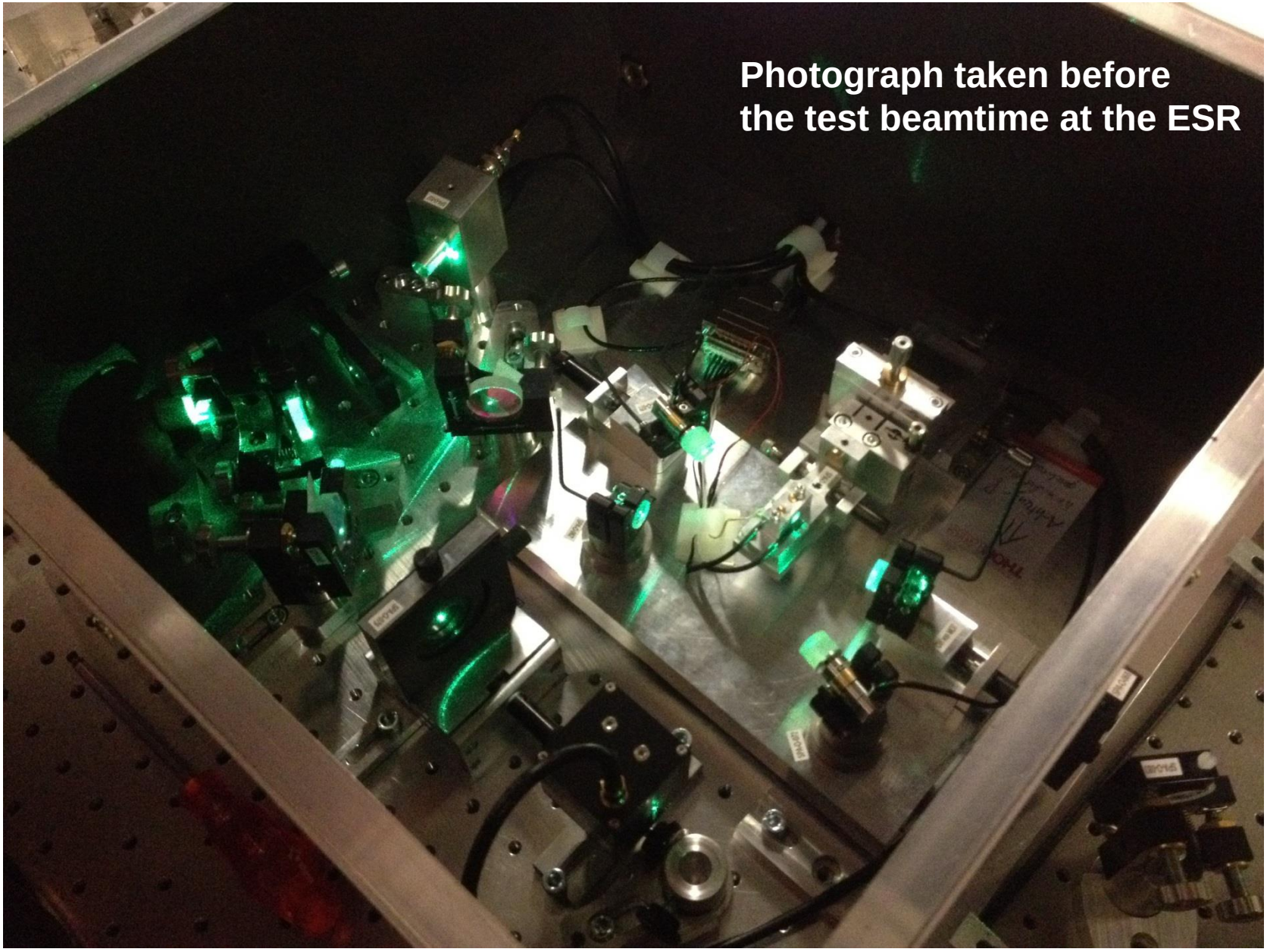
Fiber Amplifier

1st SHG Built-up Cavity

2nd SHG Built-up Cavity

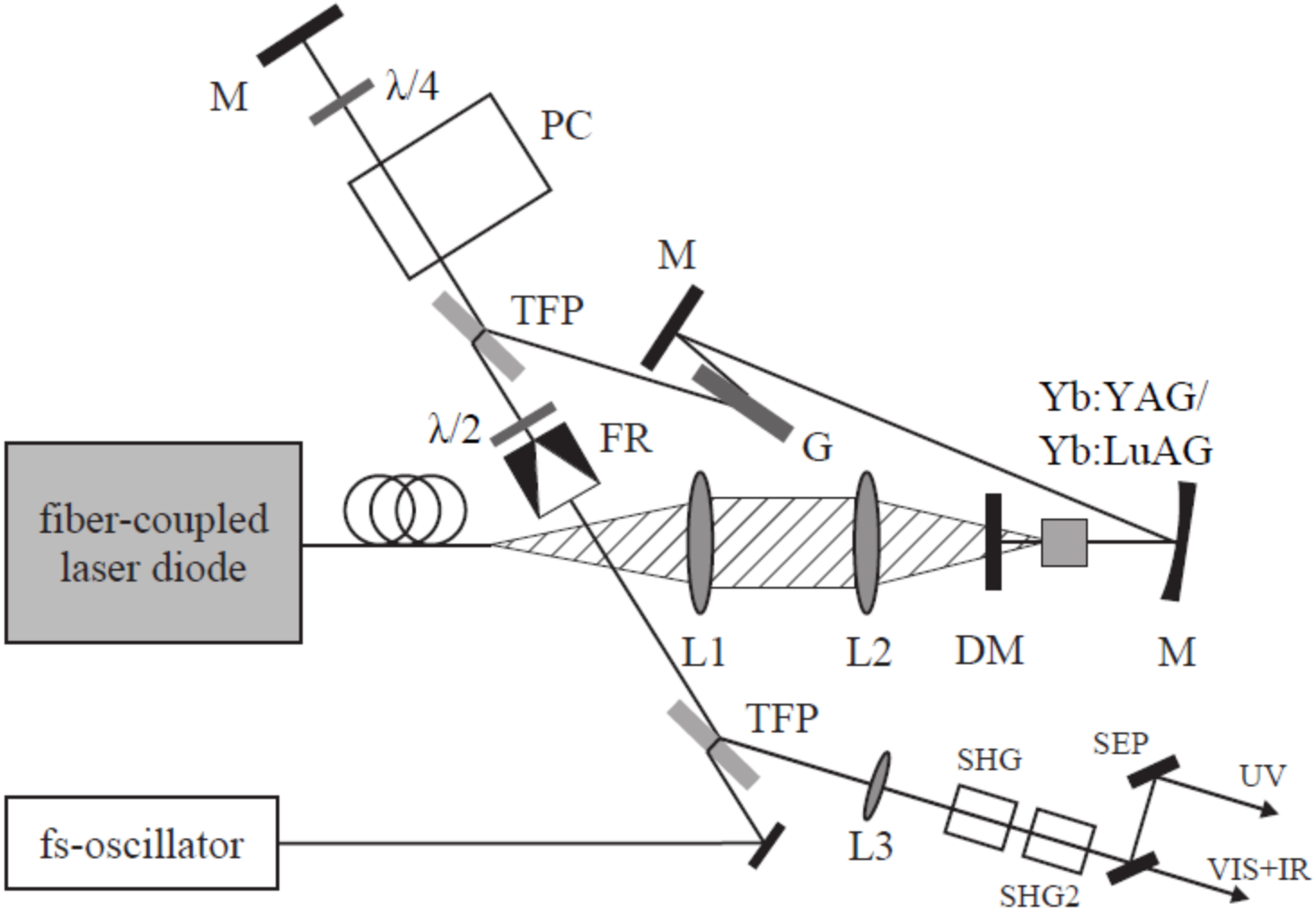
→BMBF funding: group of Prof. Thomas Walther (TU-Darmstadt)


Photograph taken before
the test beamtime at the ESR
Daniel
Kiefer
SMART TABLE

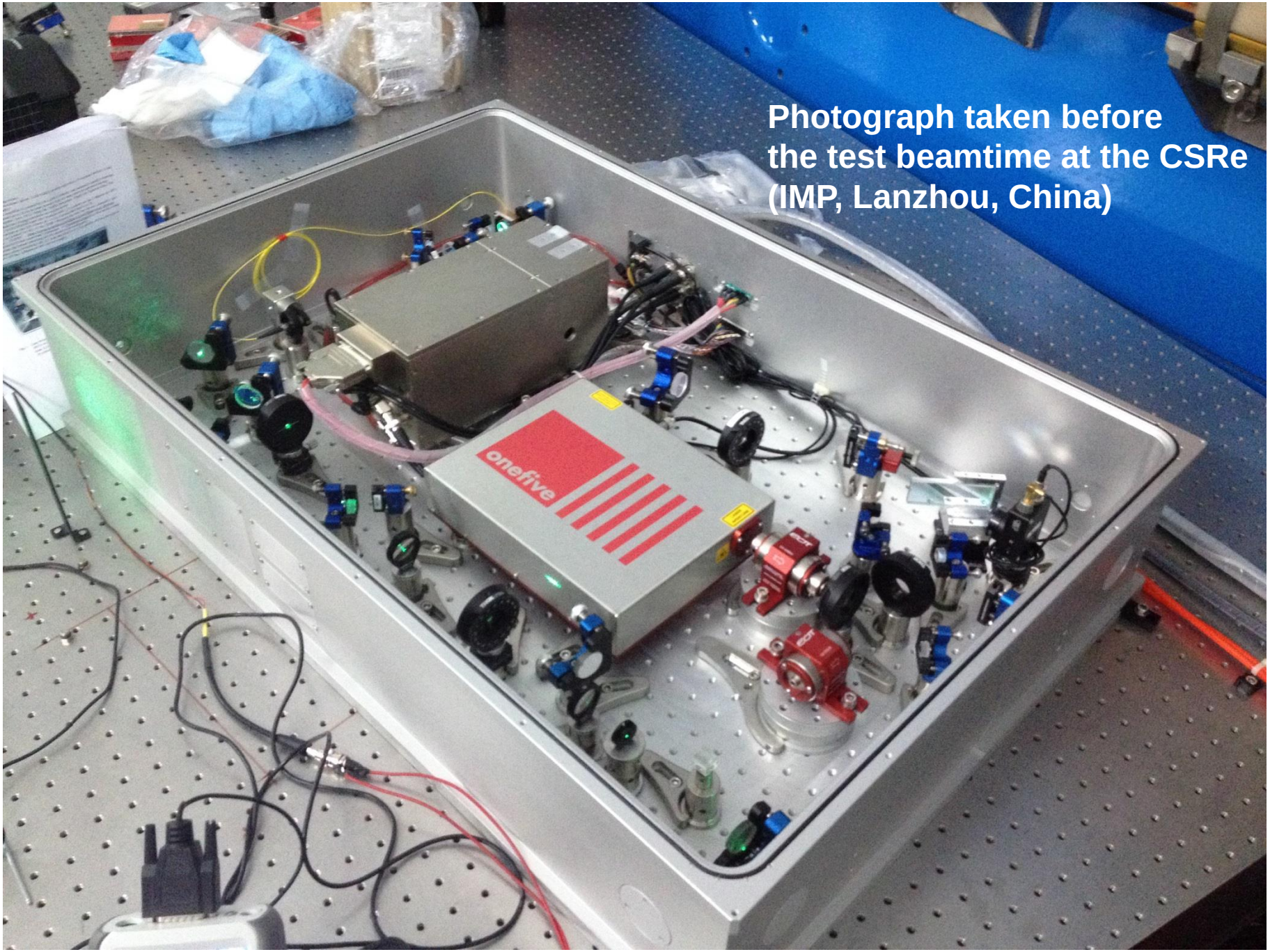

Photograph taken before
the test beamtime at the ESR

Pulsed laser system

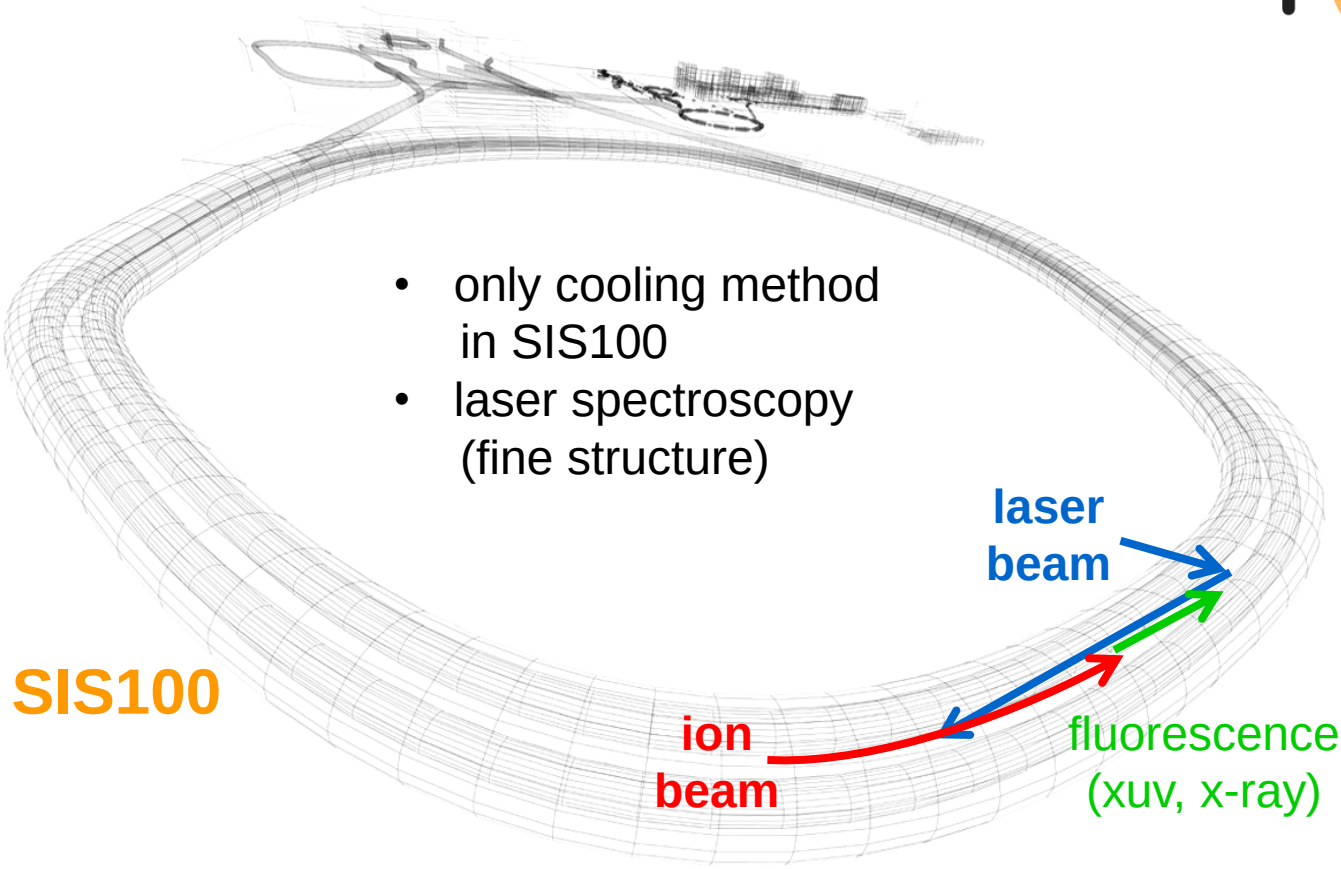
frequency-selective intra-cavity grating



→ BMBF Funding: group of Prof. Ulrich Schramm (HZDR, TU-Dresden)


Photograph taken before
the test beamtime at the CSRe
(IMP, Lanzhou, China)
onefive

executive summary



- laser-cooled relativistic heavy ion beams
- Z_{ion}= 10 – 60 (3 – 19 electrons)
- γ up to 13 (huge Doppler-shift)

- extraction of very cold and very short ultra-relativistic ion bunches

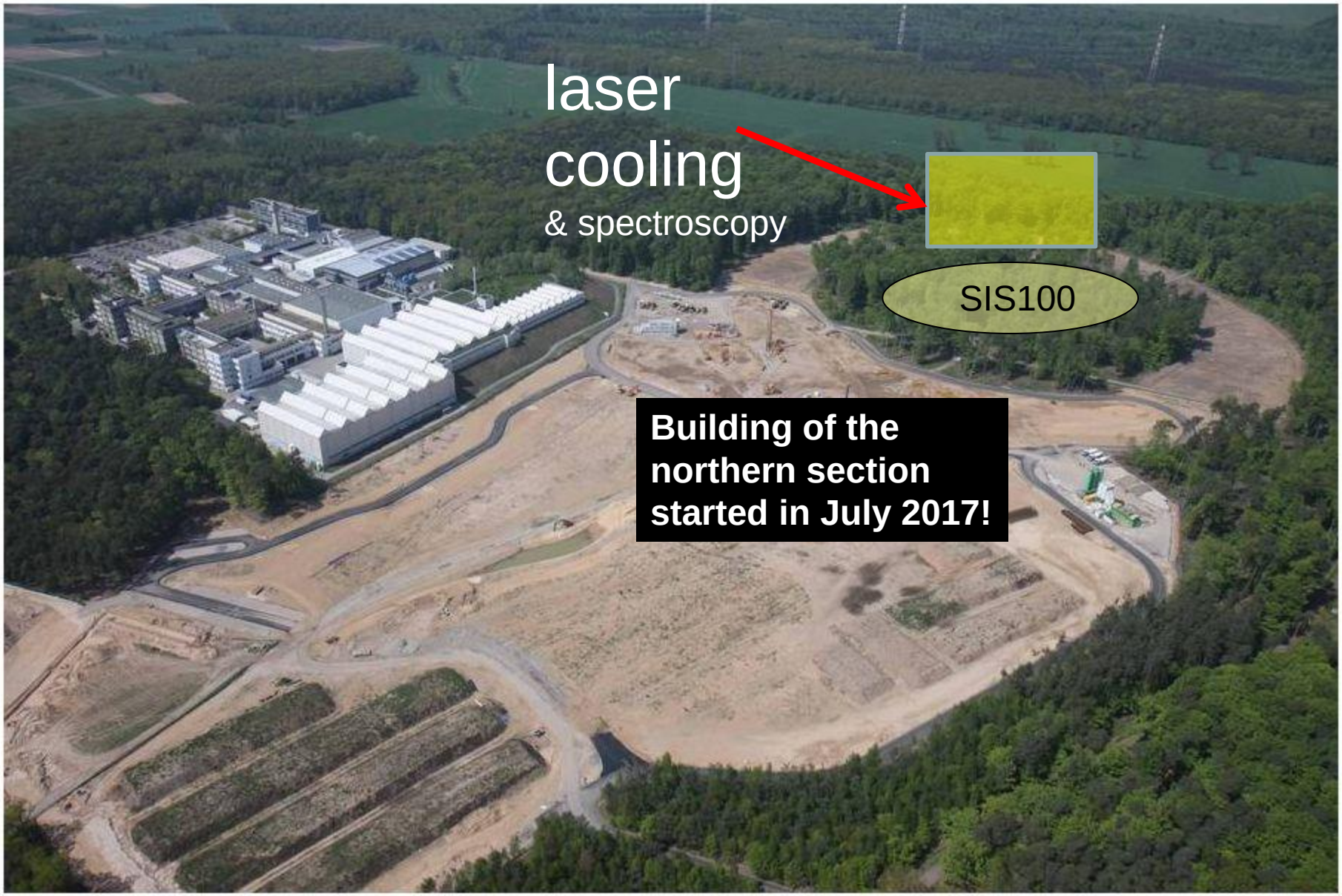
Planned BMBF applications for 2018 – 2012:

(only preliminary titles)

Pulsed laser system – TU Dresden (Prof. Schramm)
high rep. rate (MHz), ultra-short (ps) broadband UV laser pulses of high intensity
→ ESR, HESR, and SIS100 (FAIR)

Pulsed laser system – TU Darmstadt (Prof. Walther)
high rep. rate (MHz), flexible (ps-ns) UV laser pulses with spectral shaping
→ ESR, HESR, and SIS100 (FAIR)

XUV Detektor – Münster University (Prof. Weinheimer)
→ ESR, HESR, and SIS100 (FAIR)



Photograph of the FAIR building site


FAIR
Groundbreaking
4 July 2017 | Darmstadt
CAT
324E


Thank you for your attention ☺