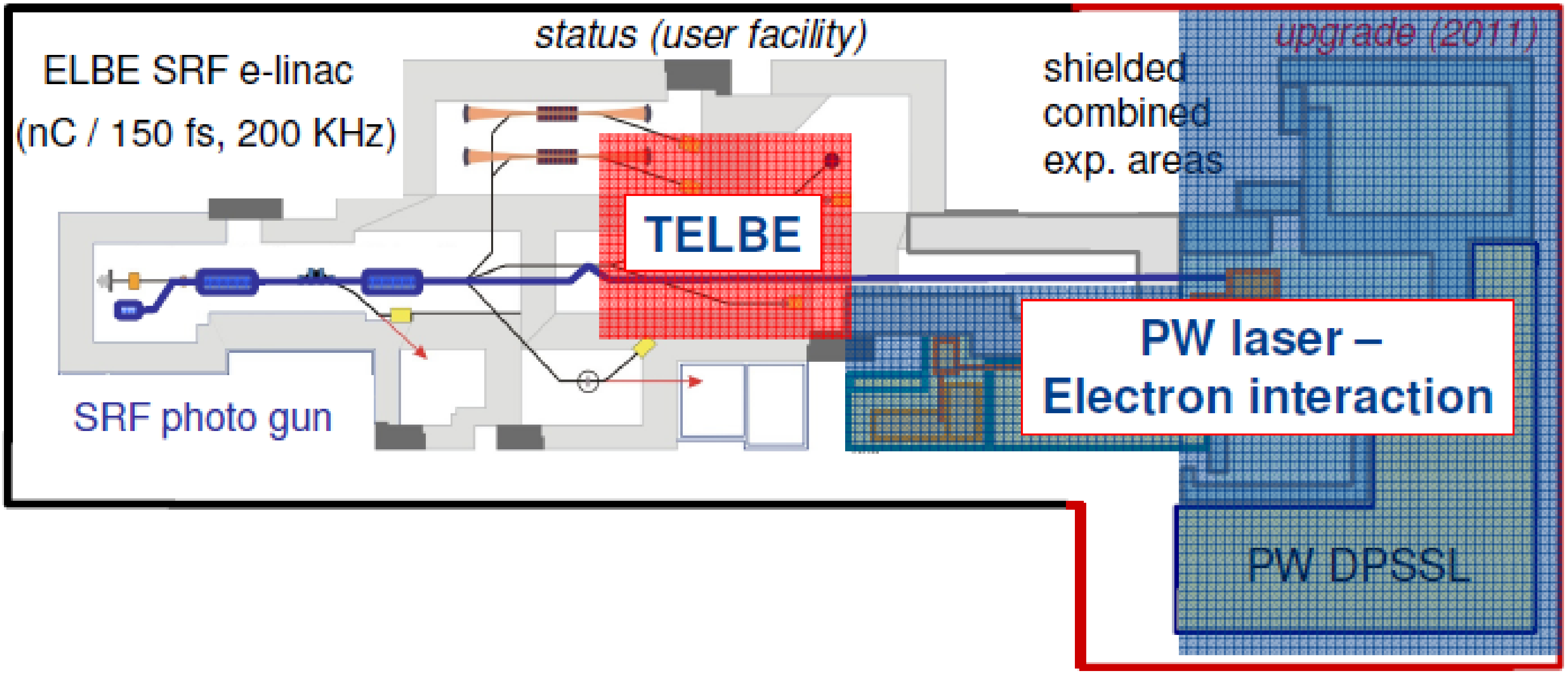
Quasi – cw superradiant THz facilitiy TELBE:
Opportunities and Challenges

M. Gensch
HZDR
&
THODIAC collaboration

HZDR

HELMHOLTZ
ZENTRUM DRESDEN
ROSSENDORF

New space for
- PW DPSSL development
- 500 TW Ti:Sapphire upgrade
- Combined exp. areas with ELBE (compressed)
- *Coherent THz lab*

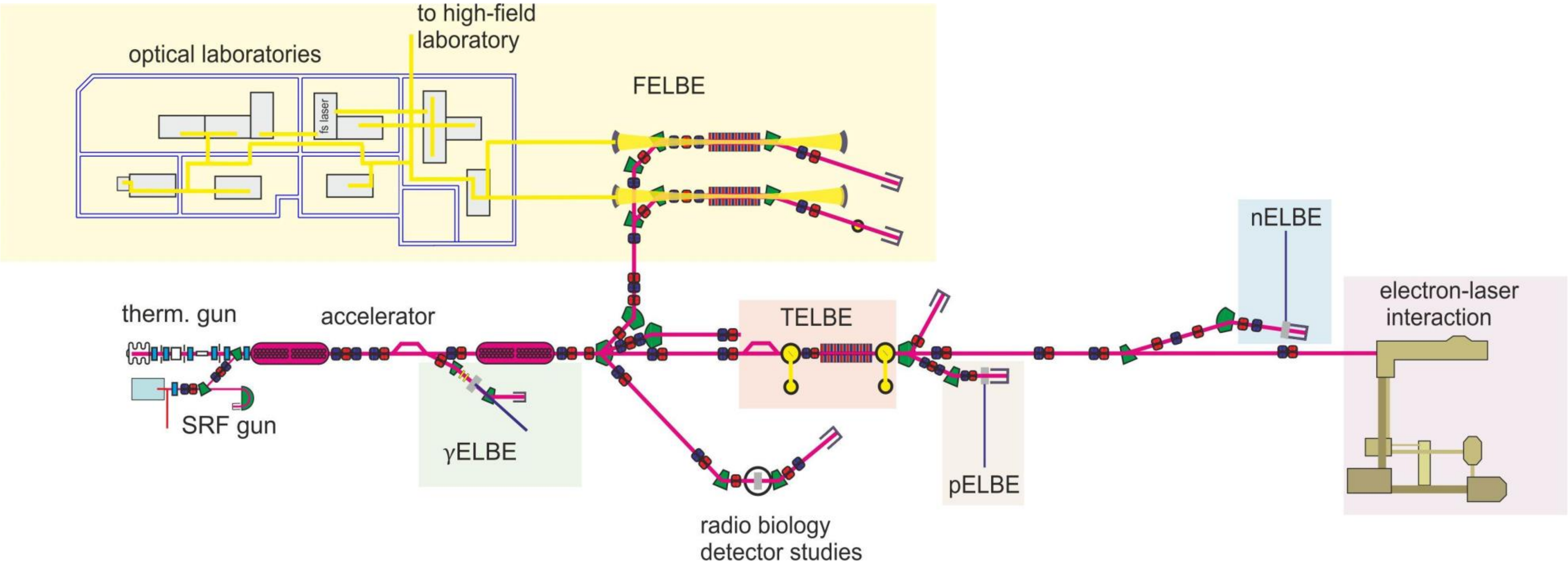


upgraded ELBE accelerator

beam energy:
up to 40 MeV

three modes of operation:

1. **up to 70 pC @ 13 MHz (thermionic gun)**
2. **up to 1 nC @ few Hz to 500 kHz (SRF Gun)**
3. **diagnostic mode (not more than 100 μA): e.g. 100 pc @ 100 kHz**



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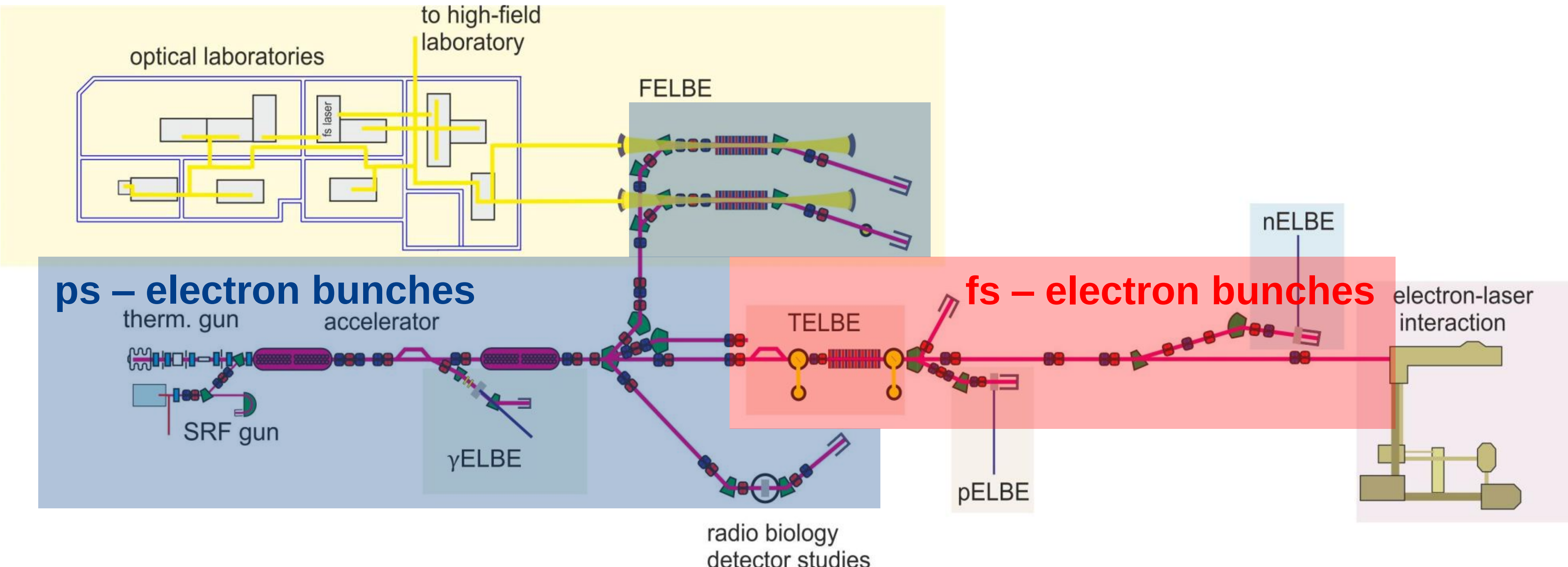
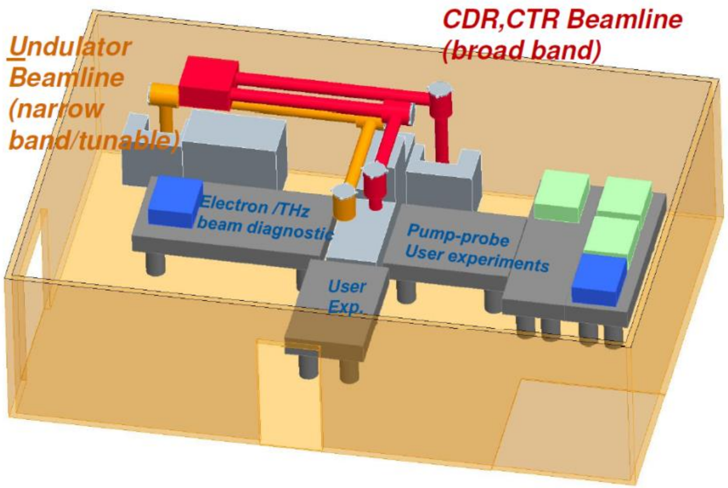


Opportunities



ARD – test facility for e bunch diagnostic on quasi – cw electron beams:

- quasi – cw reprates: few Hz to 13 MHz (adjustable)
- e-bunch charge: few pC – 1 nC
- diagnostic table in TELBE lab (access to undulator & CTR source + fs laser + FTIR spectrometer)
- monitor test stand in e-beamline directly after THz sources

-> access via THODIAC collaboration

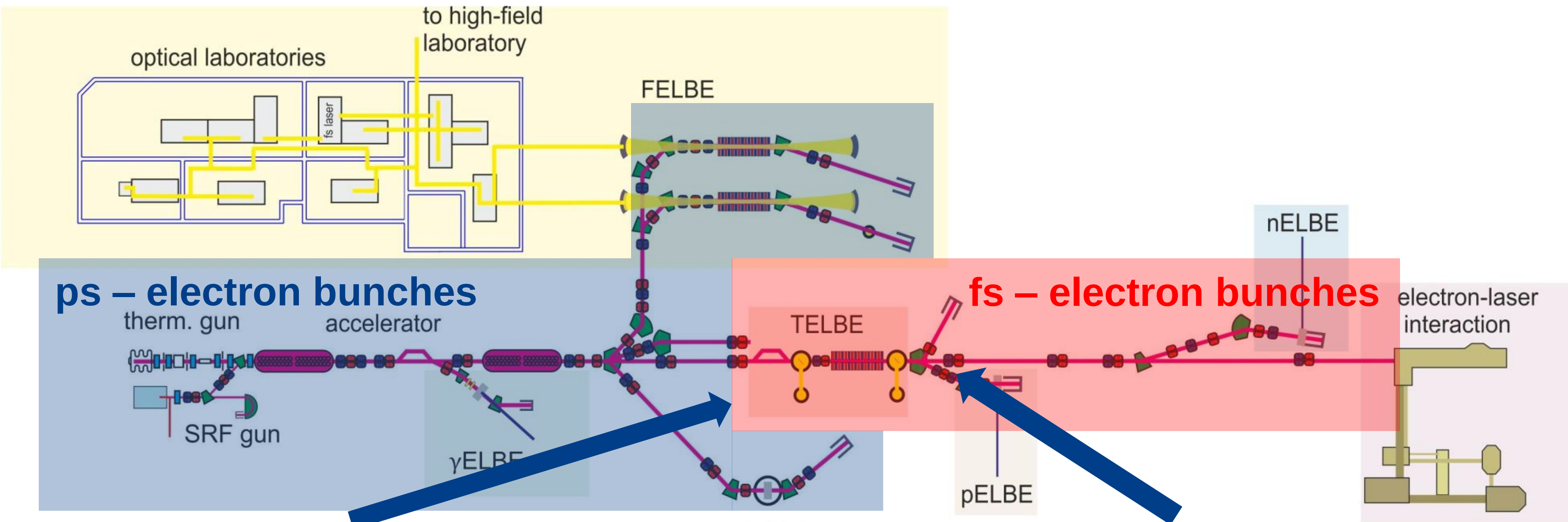
Super-radiant THz user facility:

design goals:

- quasi – cw rep rates: few Hz to 13 MHz (adjustable)
- pulsenergies: up to 100 μJ
- spectral properties: 0.1 – 3 THz narrow band (10-20%) / broad band
- polarization: linear/radially
- sub 100 fs synchronisation to fs-laser
- intrinsic synchonisation CTR<->undulator

-> commissioning by THODIAC until 2016?

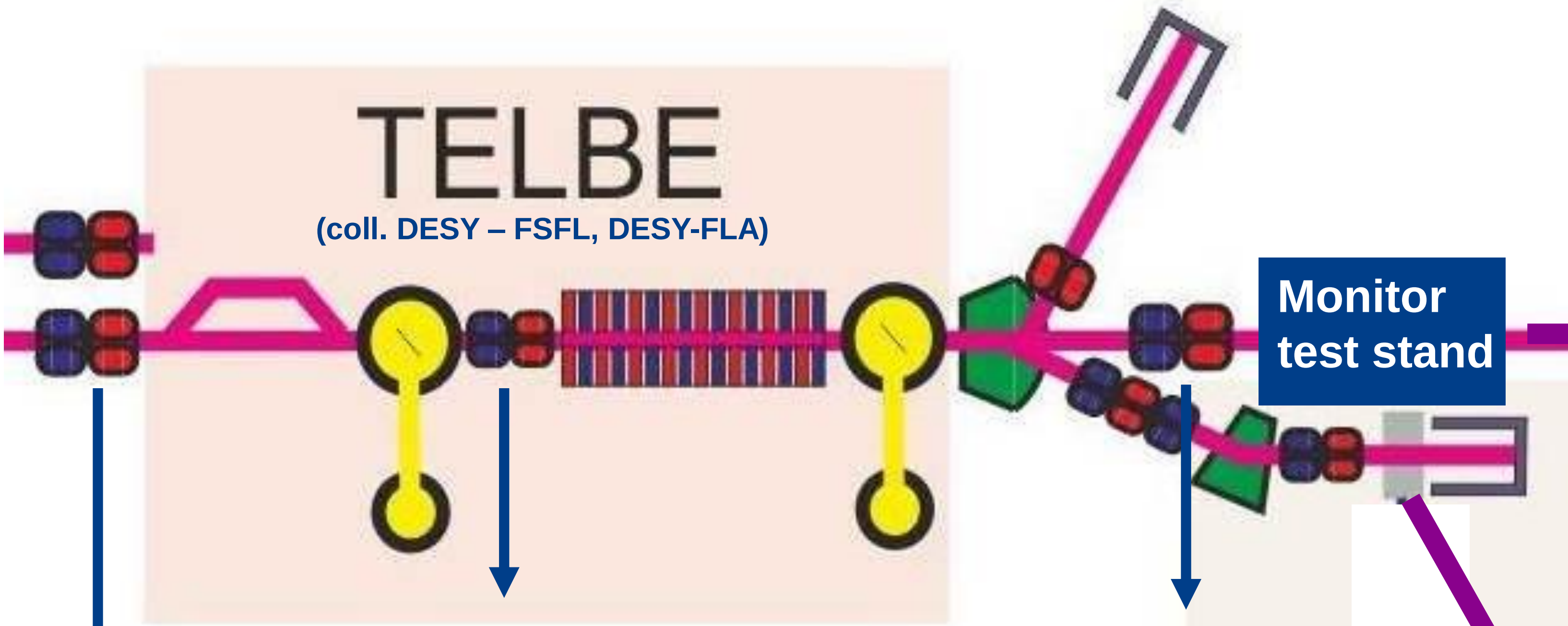
Opportunities: ARD test facility



TELBE lab:

Monitor test stand:

Opportunities: ARD test facility



neutron source (n-ELBE) & laser-electron interaction exp.

BCM & BAM **BCM & BAM**

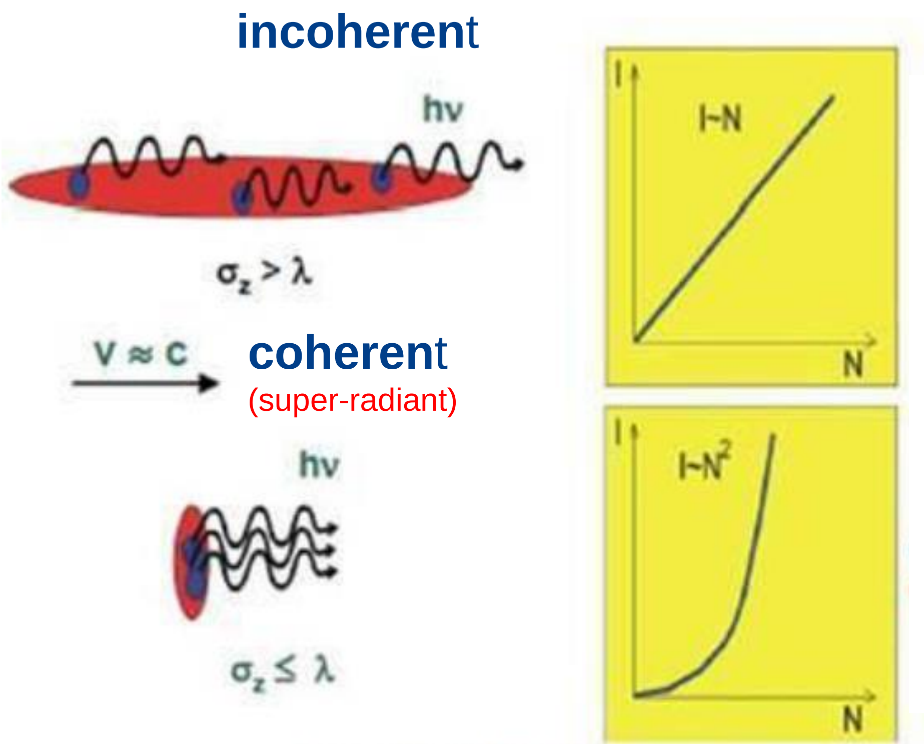
(coll. DESY – FLA, DESY-MSK, DESY-MDI)

BCM **(coll. DESY-FLA)**

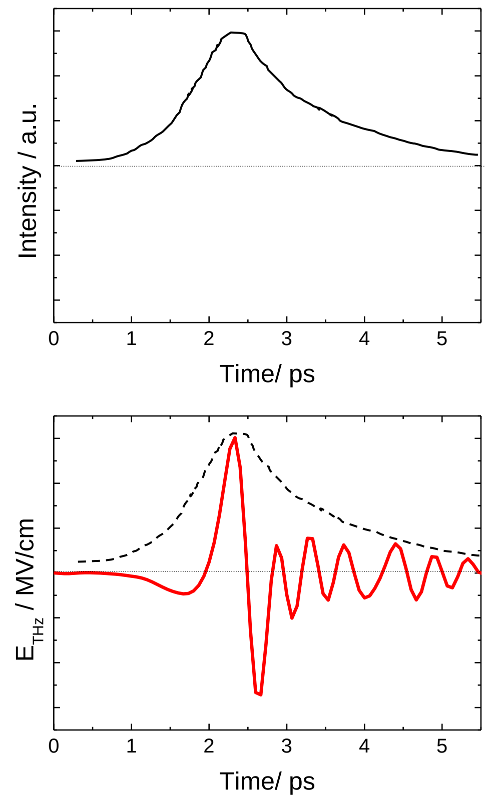
positron source (p-ELBE).

DRESDEN concept HZDR

Opportunities: TELBE



courtesy G. Wüstefeld / HZB

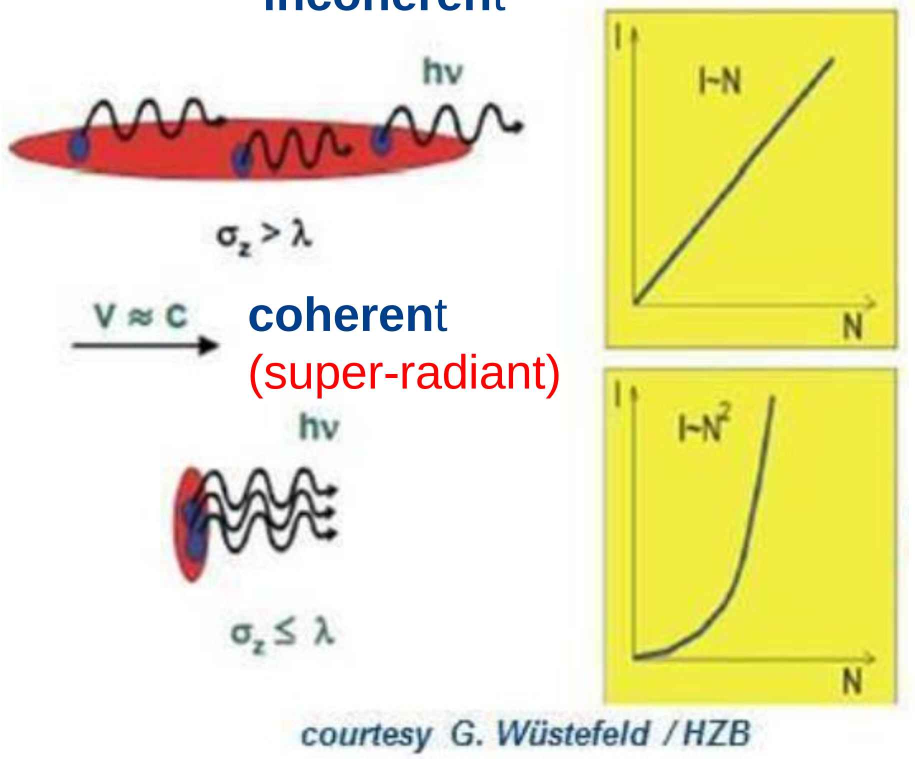


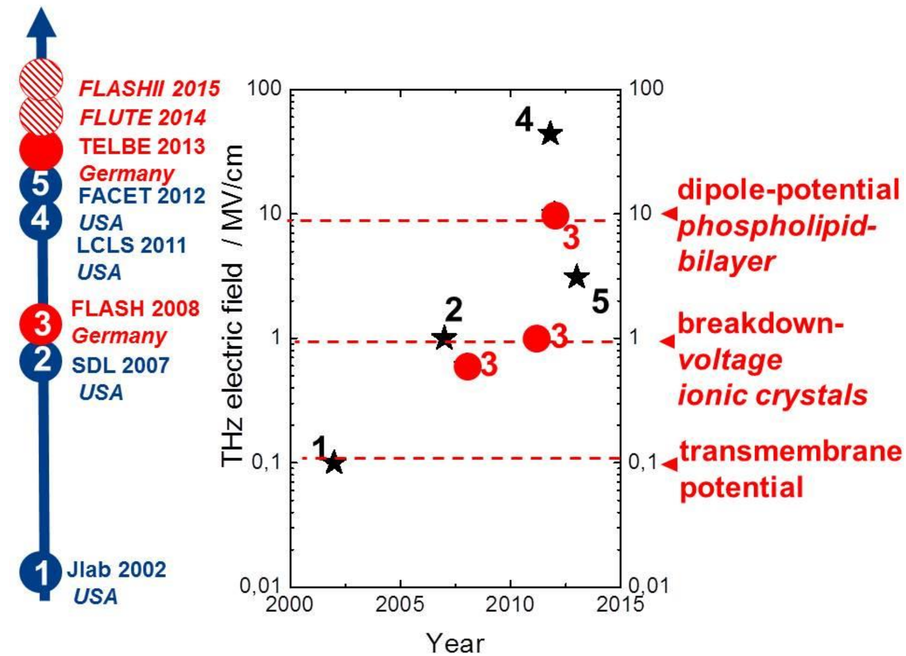
3 THz ~ 100 μm ~ 300 fs

- ***hot topic in ultra fast science are THz field driven processes***
- ***super-radiant THz sources provide the highest THz peak fields available to date!***

incoherent

development of peak-field since 2001



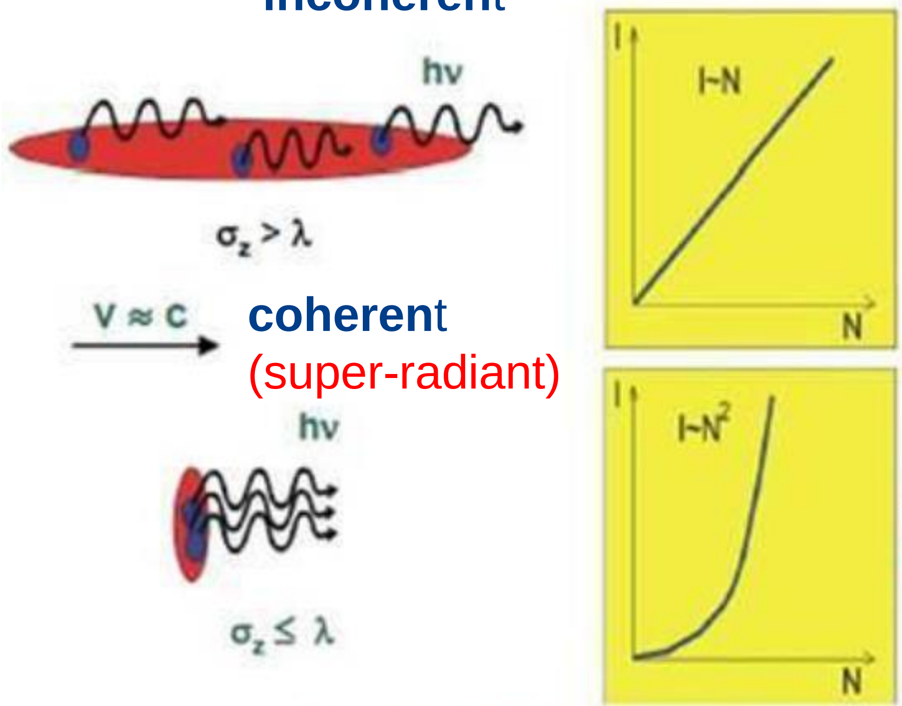


- *hot topic in ultra fast science are THz field driven processes*
- *super-radiant THz sources provide the highest THz peak fields available to date!*

Opportunities: TELBE

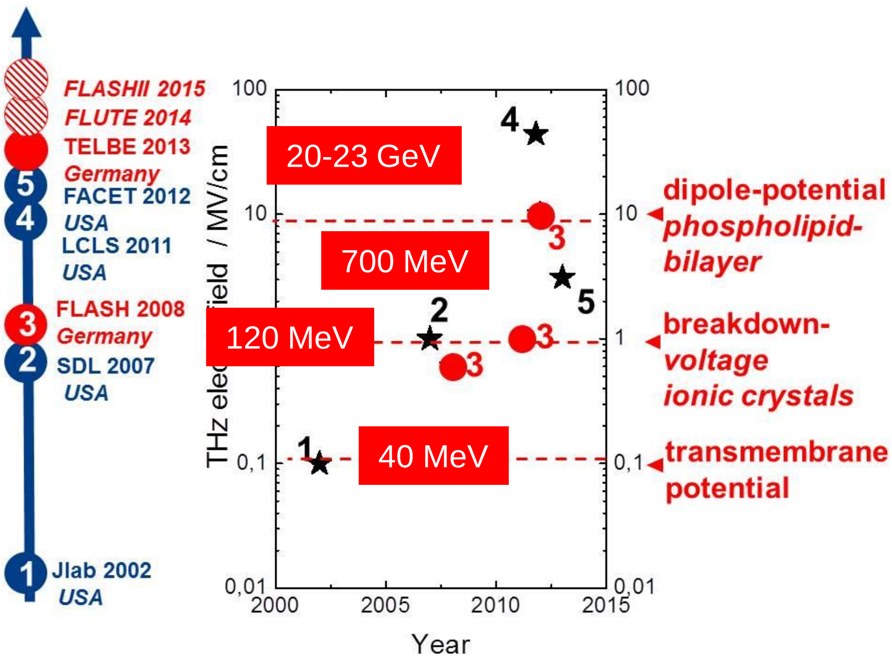
incoherent

coherent (super-radiant)



courtesy G. Wüstefeld / HZB

development of peak-field since 2001

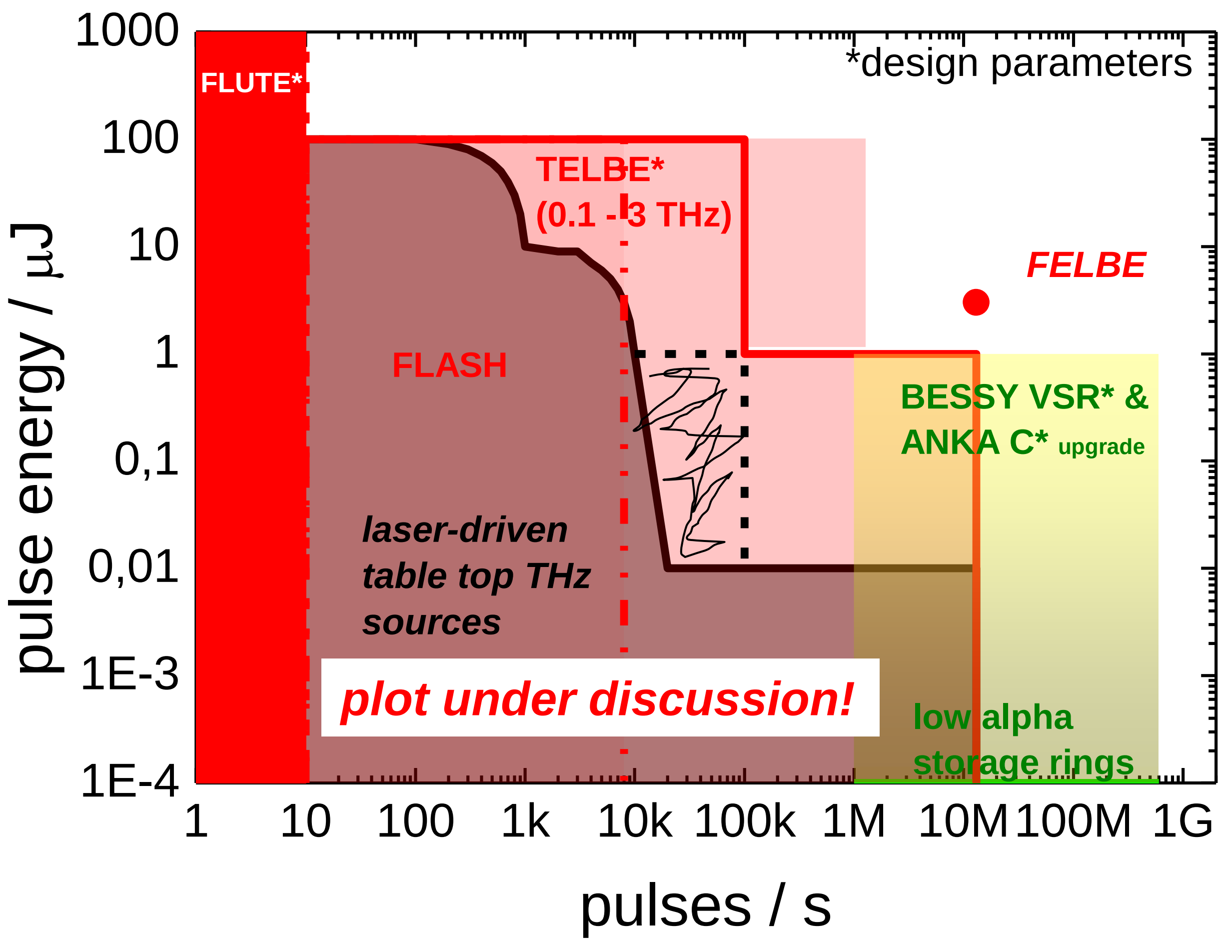


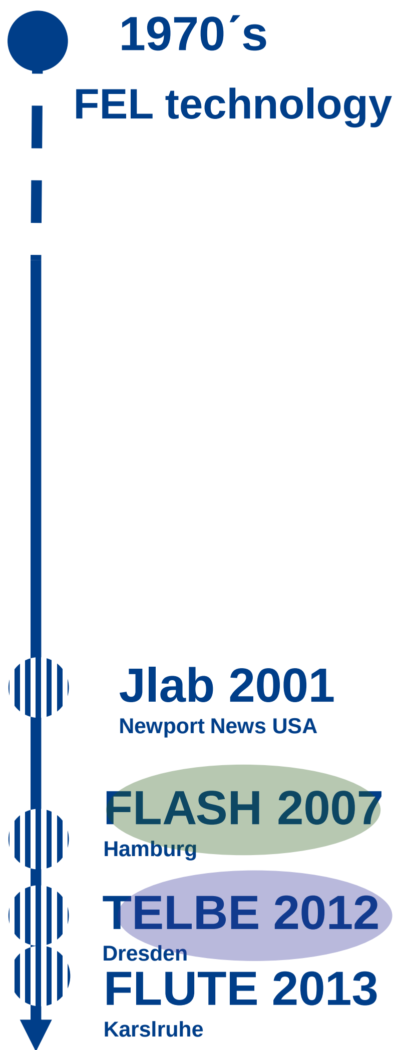
hot topic in ultra-fast science have recently become THz field driven processes

super-radiant THz sources provide the highest THz peak fields available to date!

up to now record fields at high electron energy linacs

Challenge: TELBE





fundamental question:

Is a super-radiant THz user facility based on a low energy electron accelerator feasible?

THz photondiagnostic collab. (THODIAC)

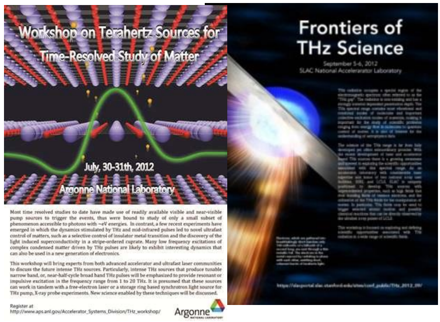
N. Stojanovic / DESY
H.W. Hübers / TUB, DLR
A. Fisher / SLAC
A.S. Müller / KIT
G.P. Williams / Jlab
G. Ulm / PTB
M. Gensch / HZDR
S. Kovalev / HZDR
G. Geloni / X-FEL
…..

THODIAC – TELBE team (nightshift 03/2013)

DESY
SLAC NATIONAL ACCELERATOR LABORATORY
PTB
Jefferson Lab Thomas Jefferson National Accelerator Facility
KIT Karlsruhe Institute of Technology
HZDR

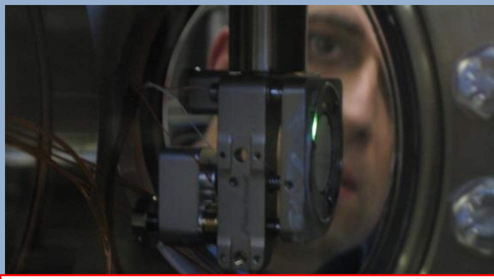
pilot „friendly" users/advisors:

A. Cavalleri – MPSD
T. Cowan - HZDR
A. Deac – HZDR
J. Heberle – FUB
M. Helm - HZDR
R. Huber – U Regensburg
A. Irmann - HZDR
T. Kampfrath – FHI
S. Kehr/L.M.Eng – TUD
J. Lindner – HZDR
A. Lindenberg - SLAC
A. Malnasi – U Budapest
I. Radu – HZB
H. Schneider - HZDR
R. Tobey – U Groningen
S. Wall – ICFO
S. Winnerl - HZDR
S. Zvyagin – HZDR



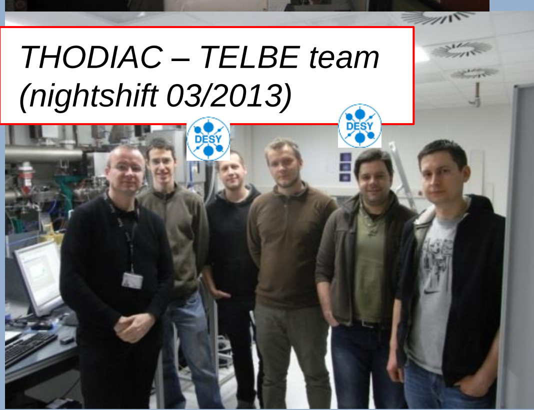
DESY (FLASH) <-> HZDR (TELBE)

joint beamtimes:



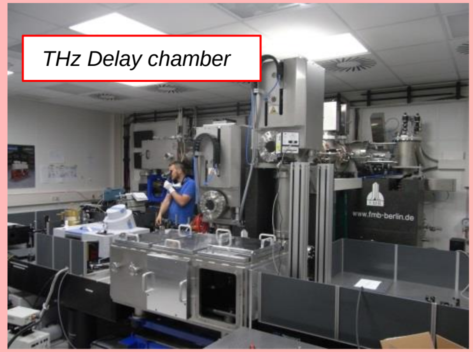
joint experiments @ FELBE and FLASH

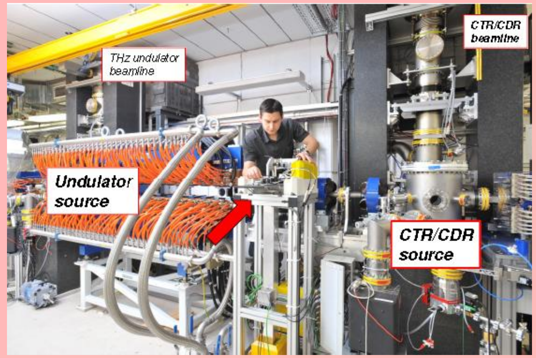
HZDR – FTIR spectrometer @ FLASH (03/2012)

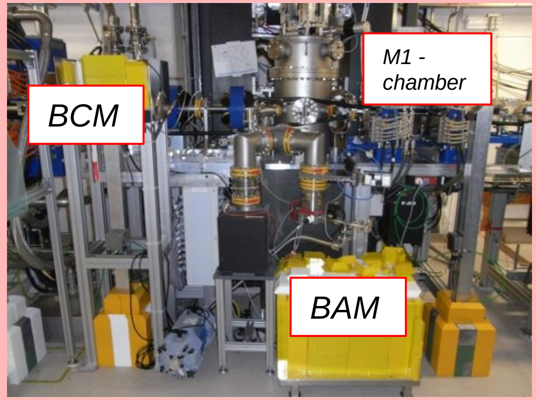


THODIAC – TELBE team (nightshift 03/2013)

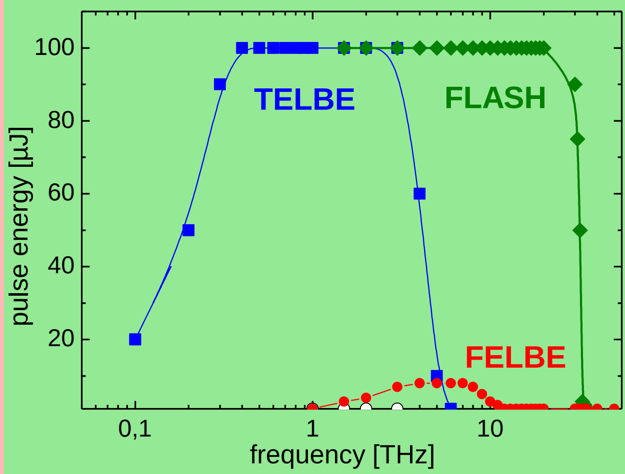
joint developements/ know how transfer







joint projects



BMBF projects:

1. **PIDID (2010 – 2013)**

- EOS at ELBE

- optical afterburner at FLASH

2. High repetion rate THz sources at FLASH II (2012 – 2015)

- CTR/CDR source

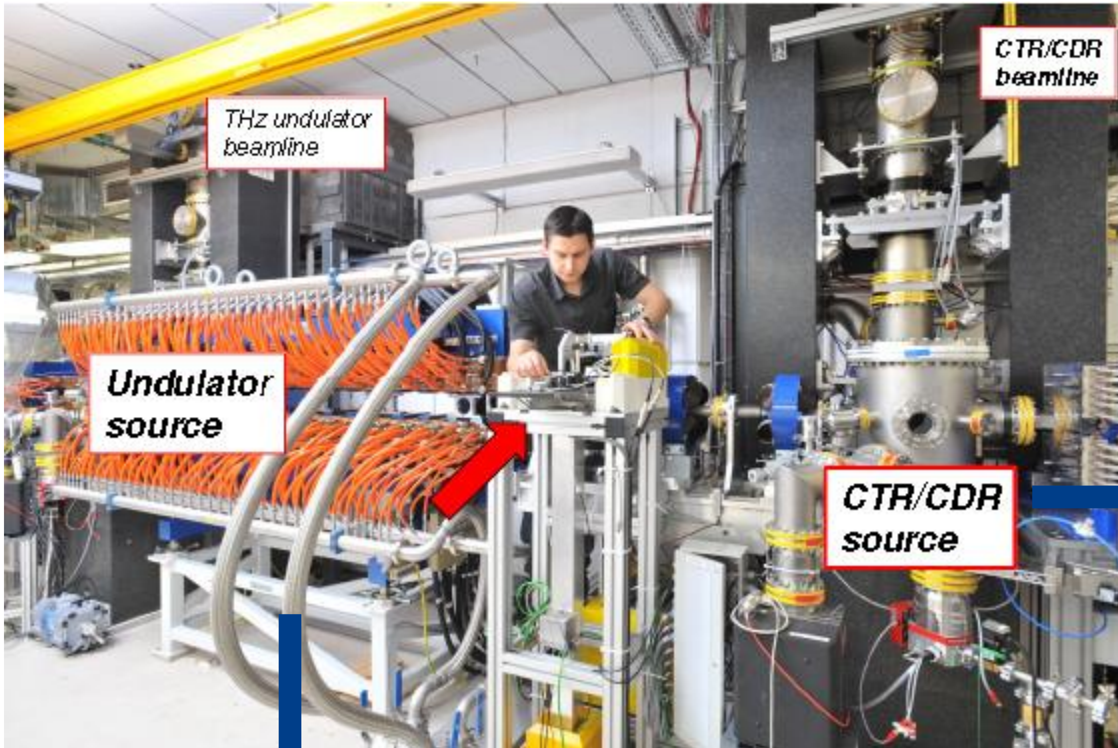
HGF:

ARD – ST3 (diagnostic/synch)

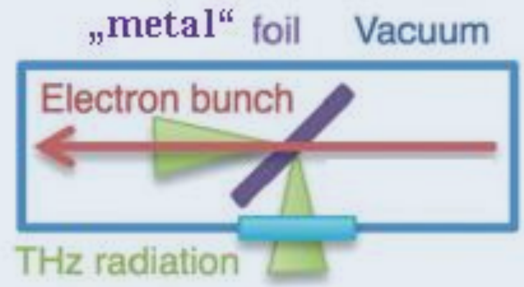
- **TELBE**

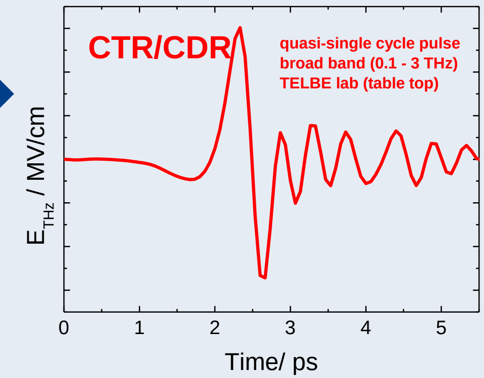
  - **First results from Commissioning**

TELBE facility

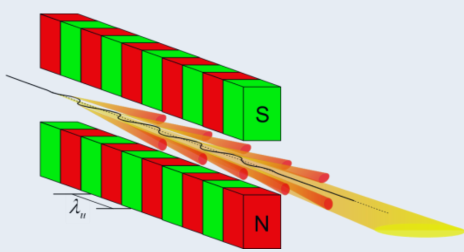


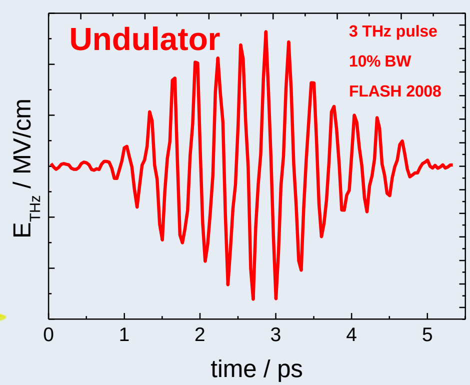
CDR/CTR source





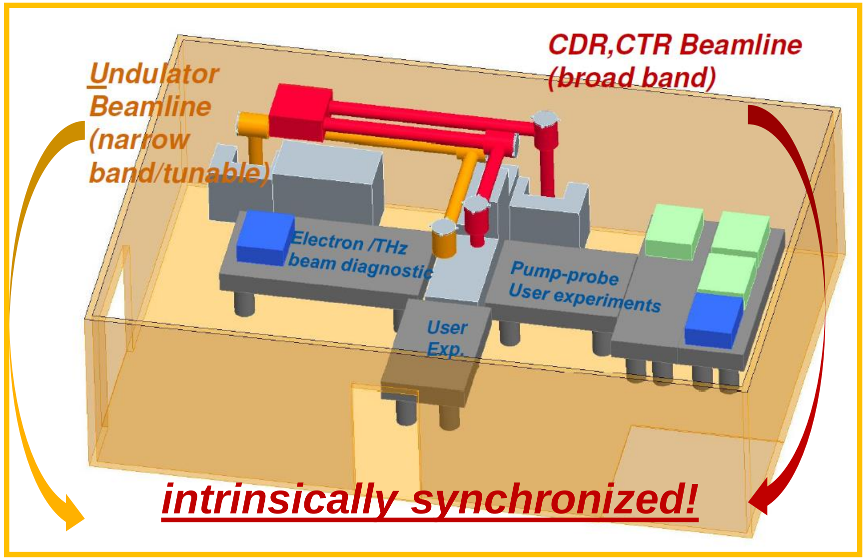
Undulator

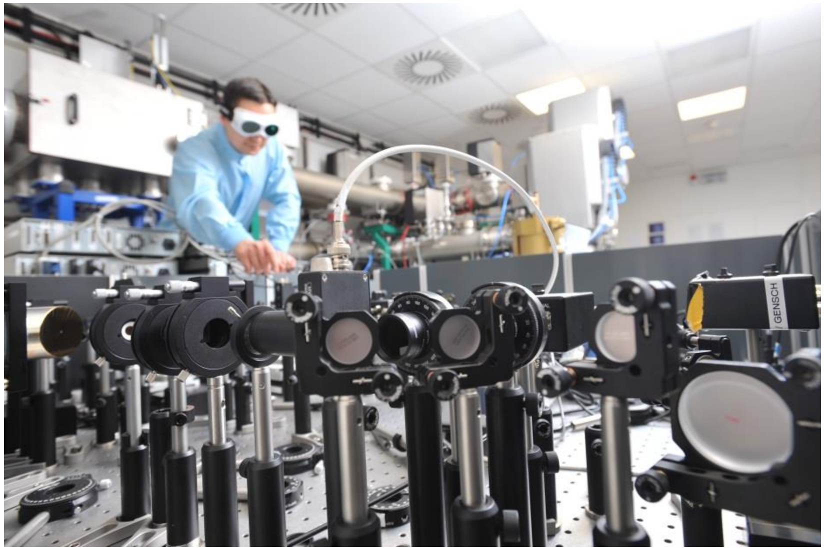


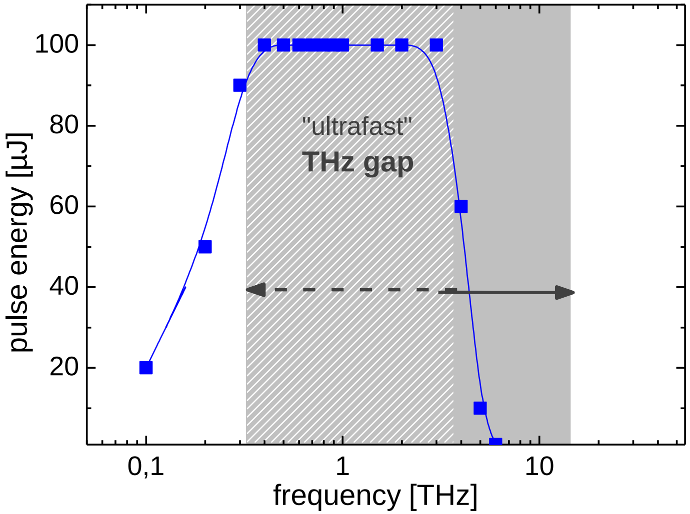


if generated by same electron bunch:
-> intrinsically synchronized to one another!

TELBE facility







TELBE / HZDR

- Spectral range: 3 – 0.1 THz
- Spectral bandwidth: 11% (undulator), 100% (CTR)
- Reprate: 100 kHz/13 MHz
- Pulse energy: 100 µJ/ 1 µJ
- Average power: 10 W
- polarization linear (undulator), radial (CTR)
- Pulse duration: $8*\tau_{THz}$(undulator), < 1 ps (CDR/CTR)

TELBE facility: timeline (status 08/2012)

2013
- first sub ps electron bunches
- first bunches from SRF Gun
- first beam in THz laboratory

2014
- *establish low charge mode*
- *establish high charge mode*
- *bunch form and arrival time meas.*

2015
- *100 µJ/100 kHz @ 3 THz for 12h*
- *1 µJ/ 13 MHz @ 3 THz for 12h*
- *sub 100 fs timing and diagnostics for 12h*

2016: THz user facility!

until 2016 only comissioning but if possible:

Pilotexperiments with "friendly" users

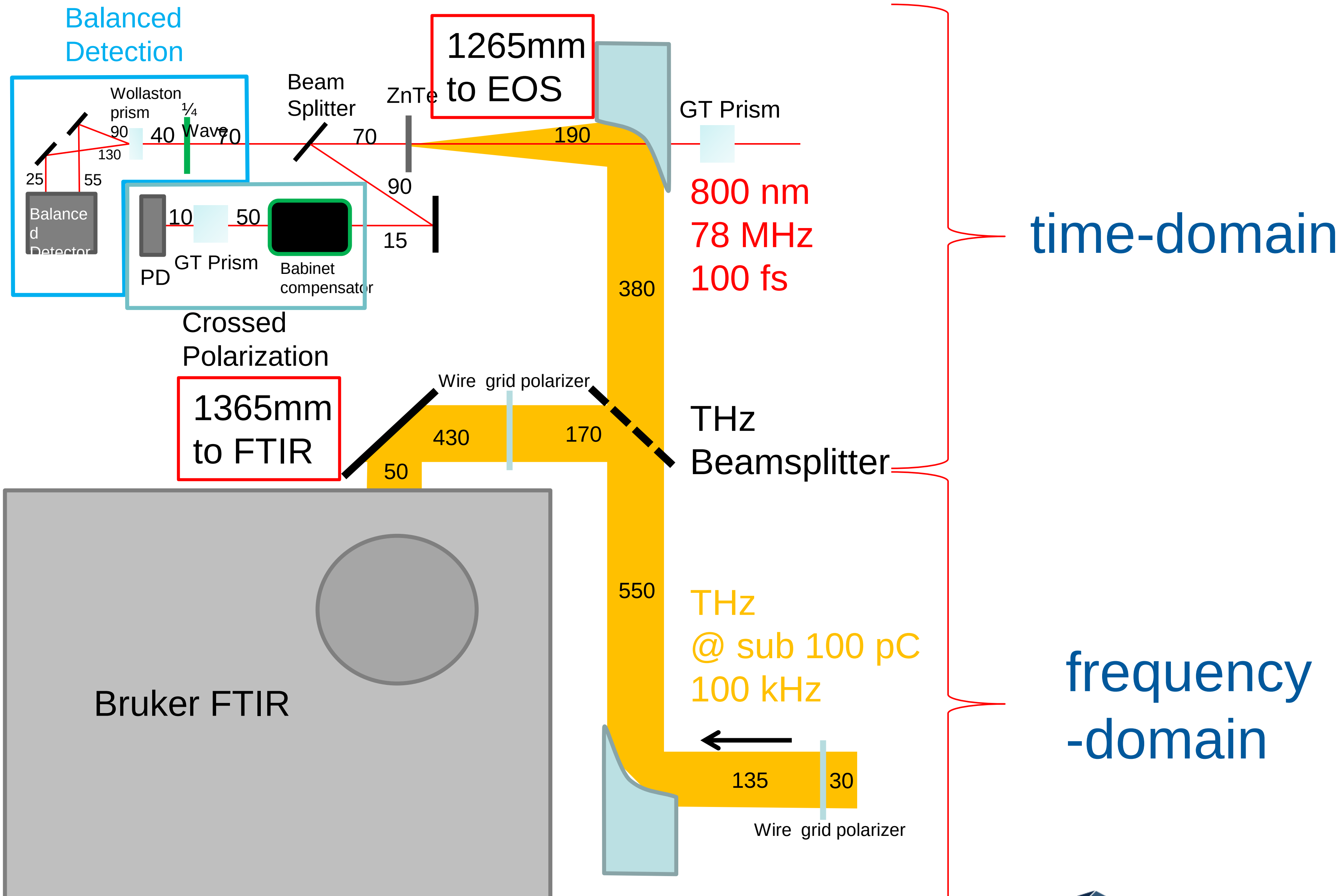
in the meantime TELBE serves as HGF test facility for diagnostic on quasi-cw electron beams

DRESDEN concept

- **TELBE**

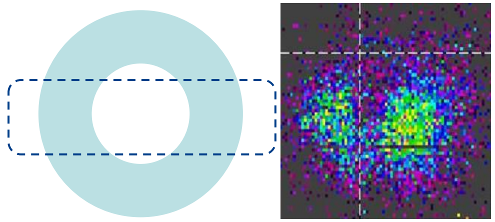
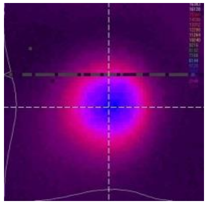
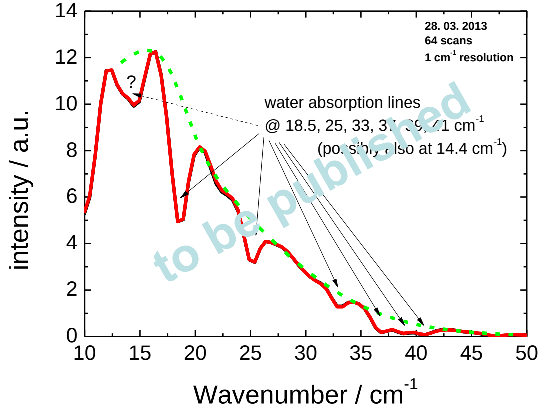
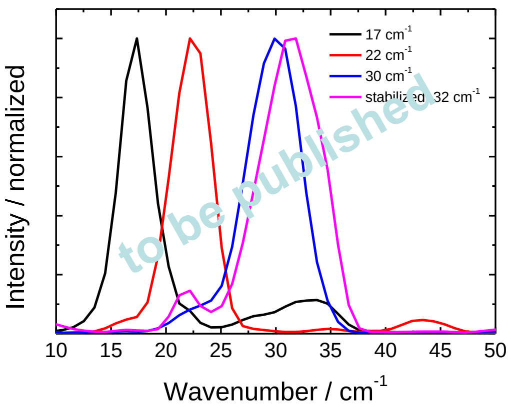
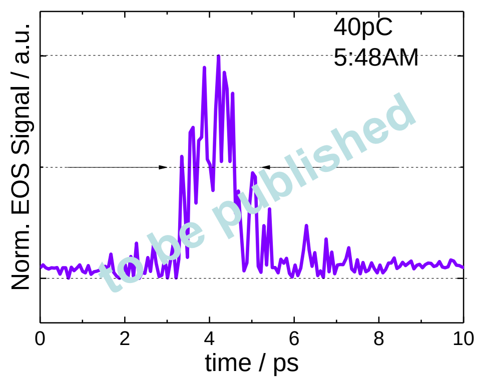
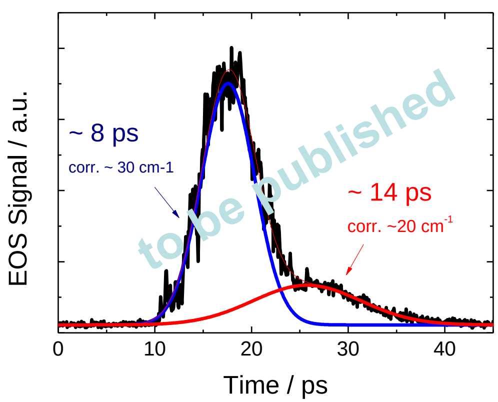
• First results (commissioning)

THz photon diagnostic for first MD shifts



+various pulse energy meters/detectors/cameras

Results of first few MD shifts

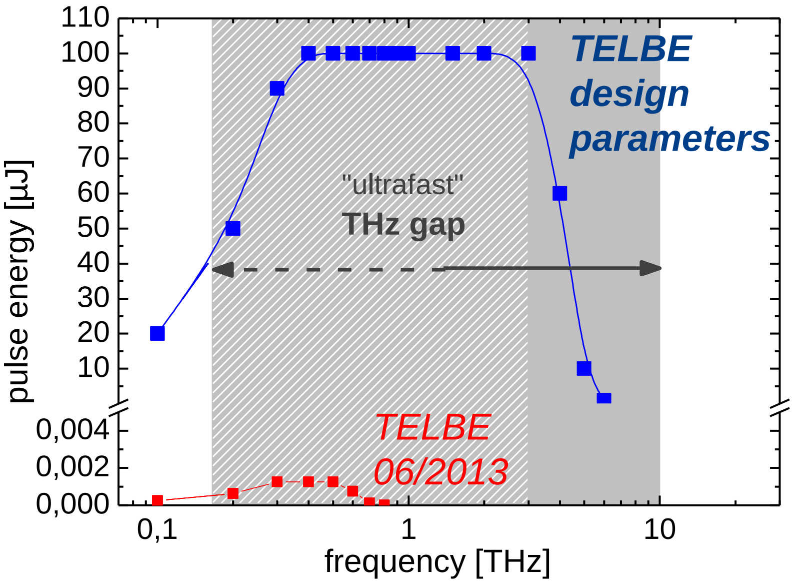
	CDR/CTR source	THz undulator
beam profile		
Frequency-domain		
Time-domain		

Pulse energy: **few nJ to few 10 nJ**

Summary & Outlook

"a long and winding road"

- low pulse energies
- bunch duration still long (sub ps?)
- spectral bw of undulator not yet understood
- jitter and drift on few ps timescale
- low energy electrons <-> high THz fields?



but:

- coherent radiation clearly observed
- real time FTIR + EOS available in control room
- single shot EOS (at 40 Hz reprate) under development

problems:

- calibrated power measurements between 0.1 – 1 THz?
- operate with new SRF Gun
- electron beam dynamics (optimize bunch compression)

Next THODIAC comissioning shifts -> october/november 2013!

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C. Bauer, S. Winnerl, H. Schneider, B. Green, S. Kovalev, U. Lehnert, Jochen Teichert, Rico Schurig, M. Kuntzsch, M Justus, J. Hauser,

+ FWF & FWK+ FWI

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THODIAC – TELBE team
(nightshift 03/2013)

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(HZB), J. Ulric
ner (SLAC) , A.
TH. Rasing, Kimel (U Niemwegen), R.I. Tobey (U C

Thank you for your attention

DRESDEN concept
HZDR