Accelerator Physics in Germany

Oliver Boine-Frankenheim, TU Darmstadt and GSI

Komitee für Beschleunigerphysik (KfB)

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Komitee für Beschleunigerphysik

Komitee für Beschleunigerphysik (KfB)

Registered members: > 400
(approx. 50 % of the community)

Elected members (2014-2016):
O. Boine-F. (GSI and TU Darmstadt)
F. Grüner (Uni Hamburg)
W. Hillert (Uni Bonn)
A. Jankowiak (HZB, Berlin)
S. Khan (TU Dortmund)
A. Meseck (DESY)
A.-S. Müller (KIT, Karlsruhe)
A. Peters (HIT, Heidelberg)
J. Rossbach (Uni Hamburg)
R. Schmidt (CERN)
H. Weise (DESY)

Chair: Wolfgang Hillert
Vice-chair: Oliver Boine-F.

Organization of the accelerator sessions at the DPG spring meetings.

- Dresden 2013 (with HK): 150 contributions
- Dresden 2014 (with KM): 120 contributions
- Wuppertal 2015 (with T): xxx contributions

DPG

Since March 2014:
AK Beschleunigerphysik in der DPG

http://www.beschleunigerphysik.de

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BESCHLEUNIGER
SCHAFFEN ERKENNTNIS

BESCHLEUNIGER
RETTEN LEBEN

BESCHLEUNIGER
SIND BRILLANT

BESCHLEUNIGER
SIND SPANNEND

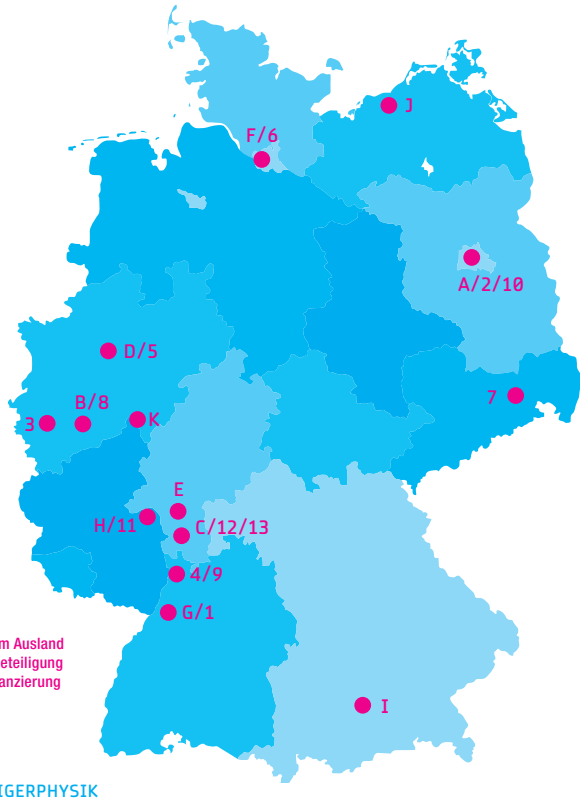
BESCHLEUNIGER
SIND AKTUELL

BESCHLEUNIGER
SIND INTERDISZIPLINÄR

BESCHLEUNIGER
SIND INTERNATIONAL

BESCHLEUNIGER
BIETEN PERSPEKTIVEN

BESCHLEUNIGERPHYSIK IN DEUTSCHLAND



\+
Beschleuniger im Ausland
mit deutscher Beteiligung
an der Grundfinanzierung

BESCHLEUNIGERPHYSIK AN UNIVERSITÄTEN
(eine Auswahl)

HU Berlin (A)
www.physik.hu-berlin.de/forschung

Uni Bonn (B)
www-elsa.physik.uni-bonn.de

TU Darmstadt (C)
www.temf.tu-darmstadt.de
www.ikp.tu-darmstadt.de

TU Dortmund (D)
www.delta.tu-dortmund.de

Uni Frankfurt (E)
www.uni-frankfurt.de/fb/fb13/iap

Uni Hamburg (F)
www.beschleunigerphysik.desy.de

KIT Karlsruhe (G)
las.physik.kit.edu

Uni Mainz (H)
www.kph.uni-mainz.de

LMU München (I)
www.physik.uni-muenchen.de

Uni Rostock (J)
www.ief.uni-rostock.de

Uni Siegen (K)
www.uni-siegen.de/physik

BESCHLEUNIGERSCHULEN

CERN Accelerator School
cas.web.cern.ch

Joint Universities Accelerator School
juas.in2p3.fr

BESCHLEUNIGERANLAGEN
(eine Auswahl)

ANKA (1)
Synchrotronlichtquelle am
KIT Karlsruhe
www.kit.edu

BESSY (2)
Synchrotronlichtquelle am
Helmholtz-Zentrum Berlin
www.hzb-berlin.de

COSY (3)
Kühlersynchrotron für polarisierte Protonen/
Deuteronen am Forschungszentrum Jülich
www2.fz-juelich.de/ikp

CSR, TSR (4)
Ionenspeicherringe am
MPI für Kernphysik Heidelberg
www.mpi-hd.mpg.de

DELTA (5)
Synchrotronlichtquelle an der
TU Dortmund
www.delta.tu-dortmund.de

DORIS, FLASH, PETRA III, European XFEL (6)
Synchrotronlichtquellen und Freie-Elektronen-
Laser bei DESY bzw. European XFEL in
der Metropolregion Hamburg
www.desy.de, www.xfel.eu

ELBE (7)
Freie-Elektronen-Laser am Helmholtz-
Zentrum Dresden-Rossendorf
www.hzdr.de

ELSA (8)
Elektronenspeicherring an der Uni Bonn
www-elsa.physik.uni-bonn.de

ESRF (+)
Europäische Synchrotronstrahlungsquelle
in Grenoble/Frankreich
www.esrf.eu

HIT (9)
Ionenstrahl-Therapiezentrum
an der Uni Heidelberg
www.klinikum.uni-heidelberg.de

ISOLDE, LEIR, CTF, SPS, LHC (+)
Beschleunigerkomplex am CERN
bei Genf/Schweiz
www.cern.ch

MAMI - RTM1-3, HDSM (10)
Elektronenbeschleuniger (Mikrotrons)
an der Uni Mainz
www.kph.uni-mainz.de

MLS (11)
Synchrotronstrahlungsquelle der
Physikalisch-Technischen Bundesanstalt
www.ptb.de/mls

S-DALINAC (12)
Supraleitender Elektronenbeschleuniger
an der TU Darmstadt
www.ikp.tu-darmstadt.de

UNILAC, SIS, ESR, FAIR (13)
Schwerionenbeschleuniger
an der GSI Darmstadt
www.gsi.de

KfB Flyer (2012)

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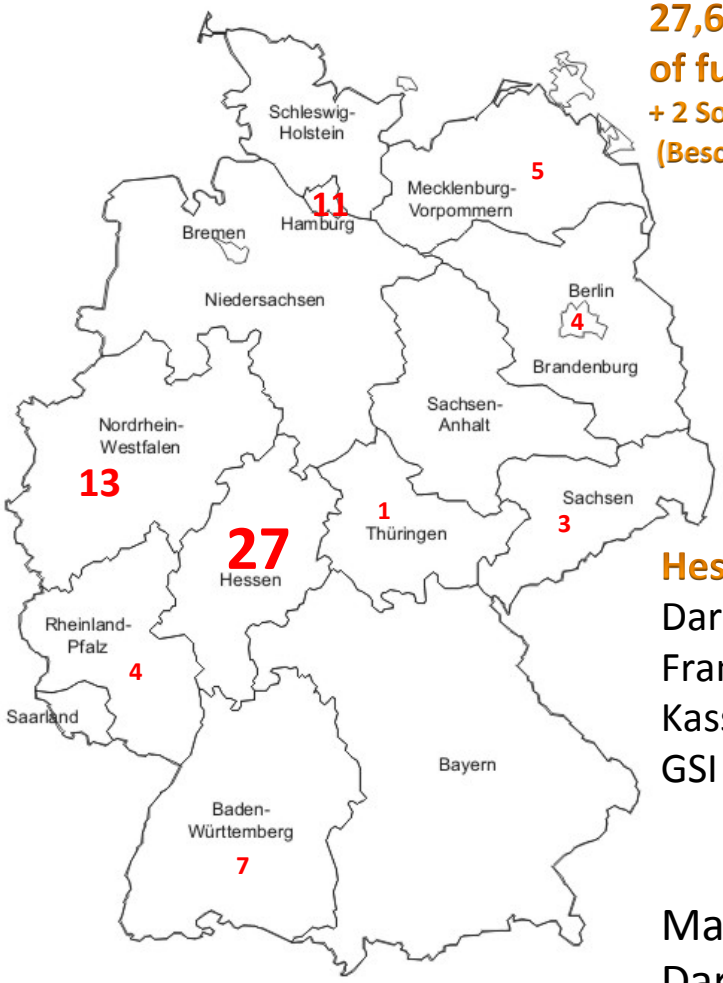
BMBF funding: T/HK (2012-2014), KM (2013-2016)

Verbundforschung

Status November 2013

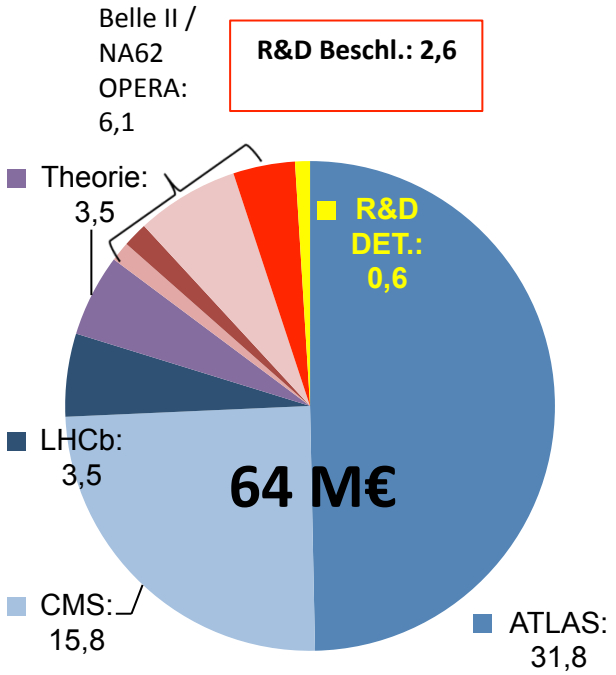


76 funded projects
27,6 M€ total amount of funding
+ 2 Sondervorhaben (Beschleunigerentwicklung GSI, ESS)

Hessen:
Darmstadt - 21
Frankfurt - 4
Kassel - 1
GSI - 1

T: 2.6 (4%), HK: 4.0 (8 %), KM: 7.5 (10 %)

High energy physics (T): 4 %



Marius Groll, PT-DESY, KfB Treffen
Darmstadt, 28./29.11.2013

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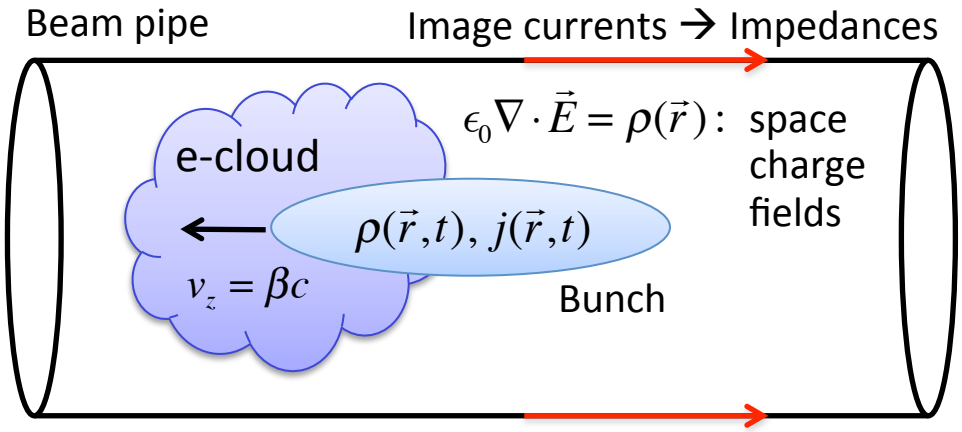
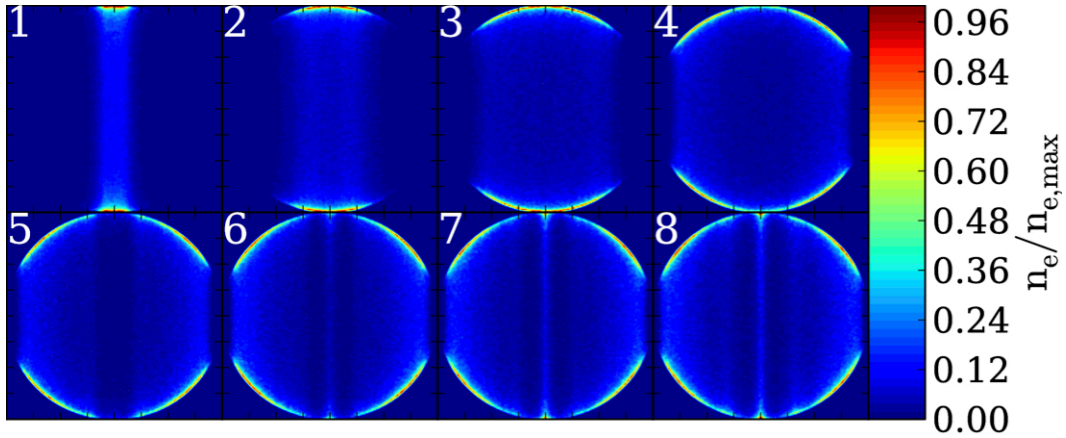
Example: Accelerator Physics for LHC+upgrades

Collective effects in the FAIR synchrotrons



Simulation of the electron density in a LHC dipole magnet



Electron clouds in LHC
- Uni Rostock
- TU Darmstadt
- KIT Karlsruhe

Impedances, instabilities, feedback
- TU Darmstadt
- TU Dortmund

Space charge simulations
- GU Frankfurt

Collimation and machine protection
- TU Darmstadt

FCC design study: Possible leading role of German universities.

HGF: Accelerator Research and Development (ARD)

- **Established in 2011 as a new research topic in the Helmholtz Association**
- 16.7M€ funding for 6 centers for the implementation phase 2011 – 14
- PoF evaluation in March, 2014
- Proposed: Distributed test facility

Topic 1: Accelerator Research and Development ARD

Speaker: R. Brinkmann/DESY, co-speaker: A. Jankowiak/HZB

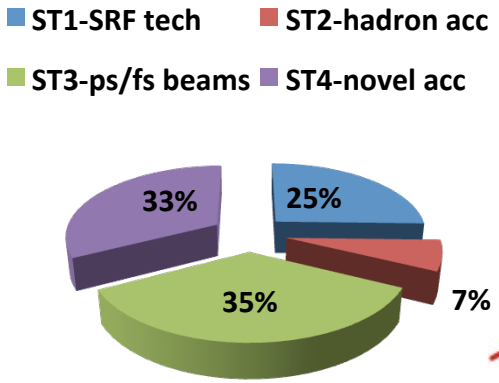
ST1: Superconducting RF technology	ST2: concepts & techn. for hadron acc.	ST3: ps – fs electron and photon beams	ST4: Novel acceleration concepts
Coordination: J. Knobloch/HZB, P. Michel/HZDR	Coordination: R. Maier/FZJ, P. Spiller/GSI	Coordination: H. Schlarb/DESY, A.-S. Müller/KIT	Coordination: U. Schramm/HZDR, F. Grüner/U-Hamburg

Networking, workshops, joint projects and usage of infrastructure, transfer of new technologies between centers

Cooperation with German universities, international cooperation partners and industry

FTEs per sub-topic

172 FTEs total
Including 32 PhD



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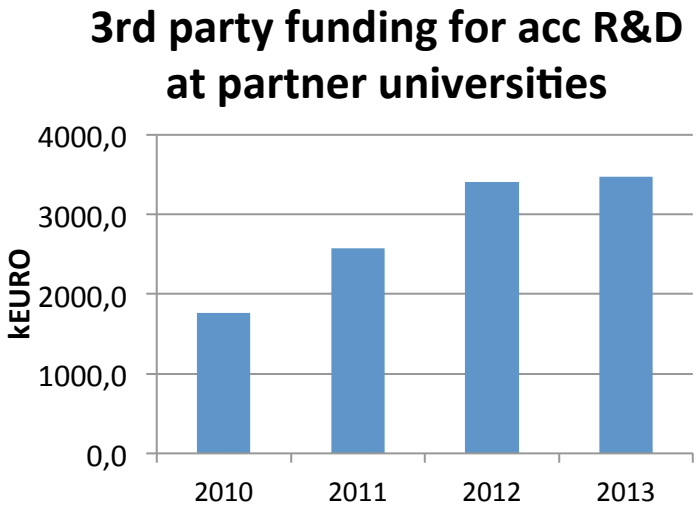
ARD in Helmholtz

- Fostering networking and cooperation
  - Joint projects between Helmholtz centers, transfer of knowledge and technologies, joint usage of infrastructure
  - Generating improvements and novel concepts for existing facilities and new projects (e.g. ANKA, BESSY-II, ELBE, FAIR, EU-XFEL)
  - Collaboration with universities and international partners at top level of science and technology

- Improving visibility of accelerator physics and technology
  - Attract young talents to our field
  - Strengthen accelerator physics education & research at universities



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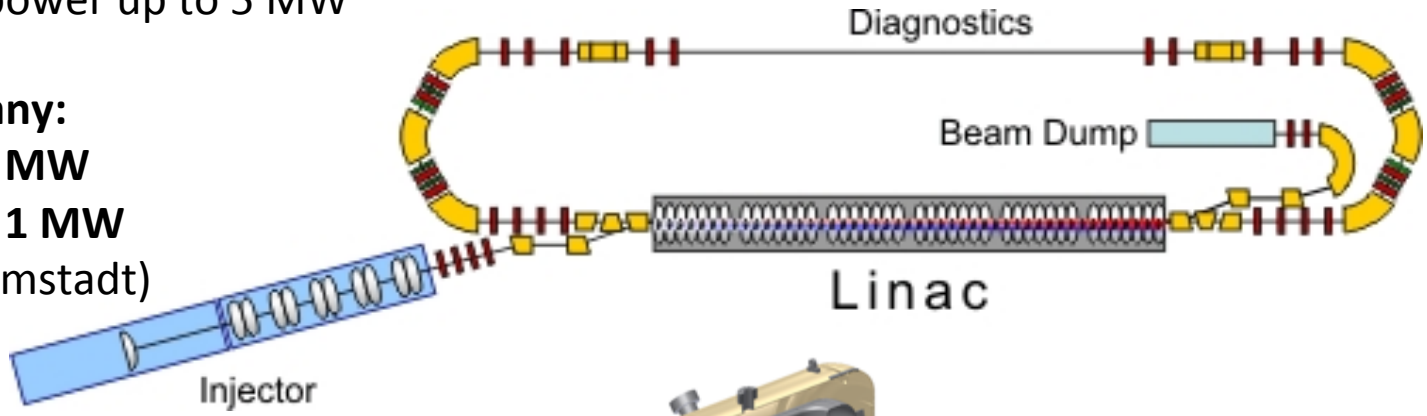
Projects: Energy Recovery Linacs (ERLs)

Advantages:
- Reduced energy consumption
- Reduced hardware costs (HF)
- Reduced beam induced activation

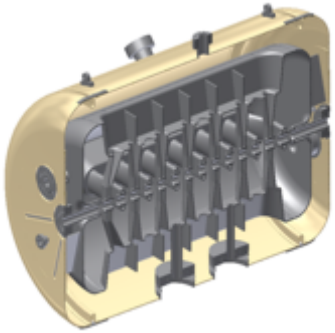
In an **Energy Recovery Linac** (ERL), the high-energy beam, following its use, is returned to the linac in opposite RF phase to be decelerated back to about the injection energy. The beam is dumped at a low energy. (analogy: electric car)

Challenges:
- for example: beam power up to 5 MW

ERL projects in Germany:
- bERLinPro (HZB): **5 MW**
- MESA (Uni Mainz): **1 MW**
- S-DALINAC (TU Darmstadt)



Applications:
- High energy electron cooler
- Electron-hadron colliders
- Light sources



Super conducting RF cavities (-> ARD ST1)

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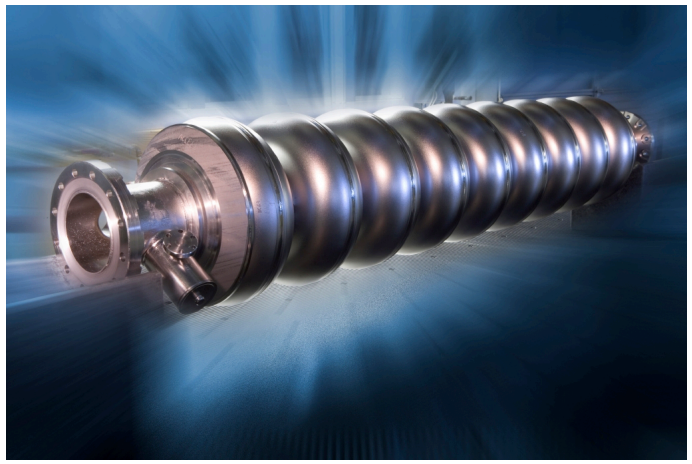
Superconducting RF for high energy colliders

Example case: strong cooperation HGF and universities



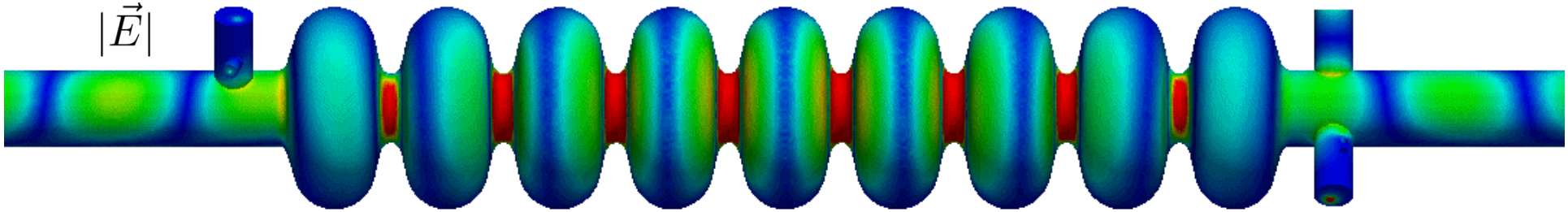
International Linear Collider (ILC) and High Gradient (> 25 MV/m) Superconducting RF-Cavities

Full 3D EM high-precision eigenmode simulations of multi-cell rf cavities.

TECHNISCHE UNIVERSITÄT DARMSTADT

Universität Rostock

Dipole mode



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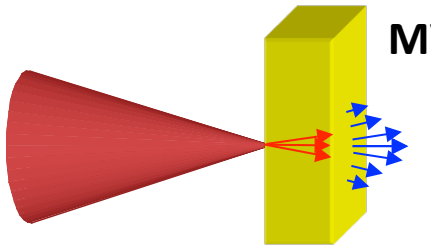
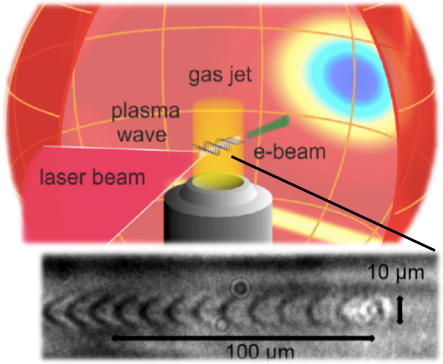
Novel acceleration concepts

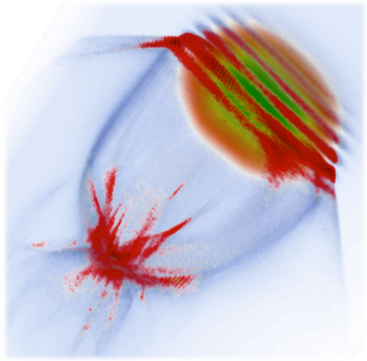
- Laser ion acceleration



MV/µm (TV/m)

- Laser- and beam-driven plasma wake-field electron acceleration





100 GV/m

Universities (examples)

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

TECHNISCHE UNIVERSITÄT DRESDEN

TECHNISCHE UNIVERSITÄT DARMSTADT

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

UHH

ARD ST4

HZDR

JÜLICH FORSCHUNGSZENTRUM

GSI

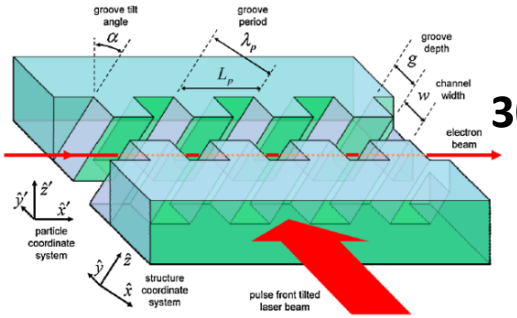
DESY

MPG

MPQ

ARD ST4: *Merging of top-level expertise in plasma acceleration with excellence in "conventional" accelerator technology creates unique potential.*

- Dielectric laser acceleration of electrons



300 MV/m

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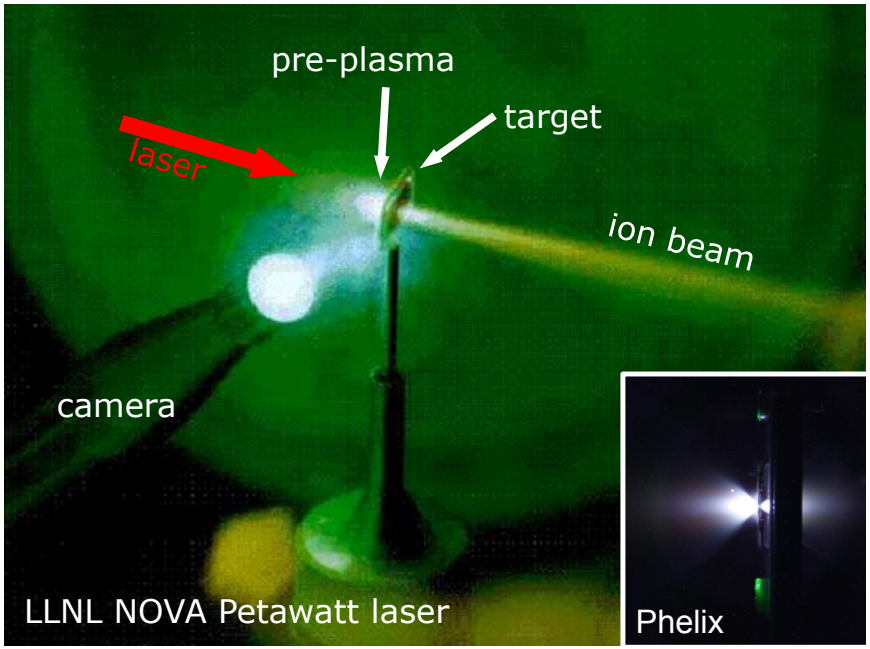
Novel concepts: Laser ion acceleration



TECHNISCHE UNIVERSITÄT DRESDEN

HZDR

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

HELMHOLTZ GEMEINSCHAFT

Helmholtz-Institut Jena

LIGHT

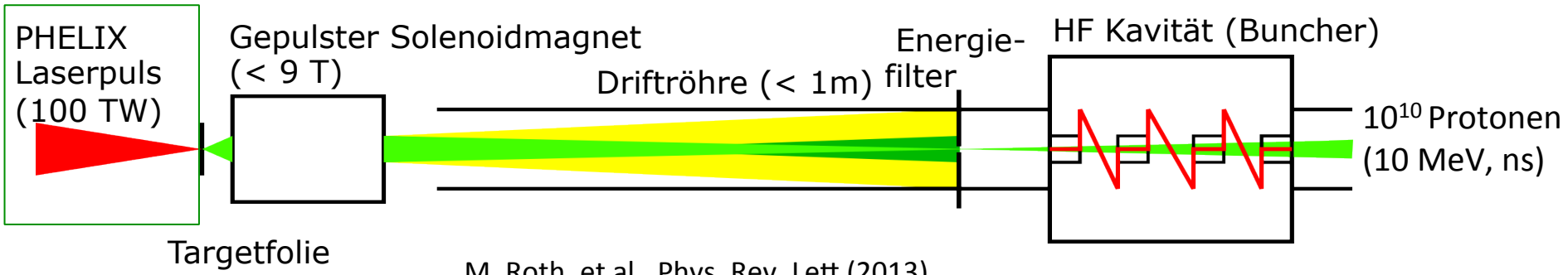
Laser Ion Generation, Handling and Transport

GSI

LIGHT (**L**aser **I**on **G**eneration, **H**andling and **T**ransport)

JOHANN WOLFGANG GOETHE UNIVERSITÄT FRANKFURT AM MAIN

TECHNISCHE UNIVERSITÄT DARMSTADT



M. Roth, et al., Phys. Rev. Lett (2013)
S. Busold, et al., Phys. Rev. ST-AB (2013)
S. Busold, et al., Phys. Rev. ST-AB (2014)

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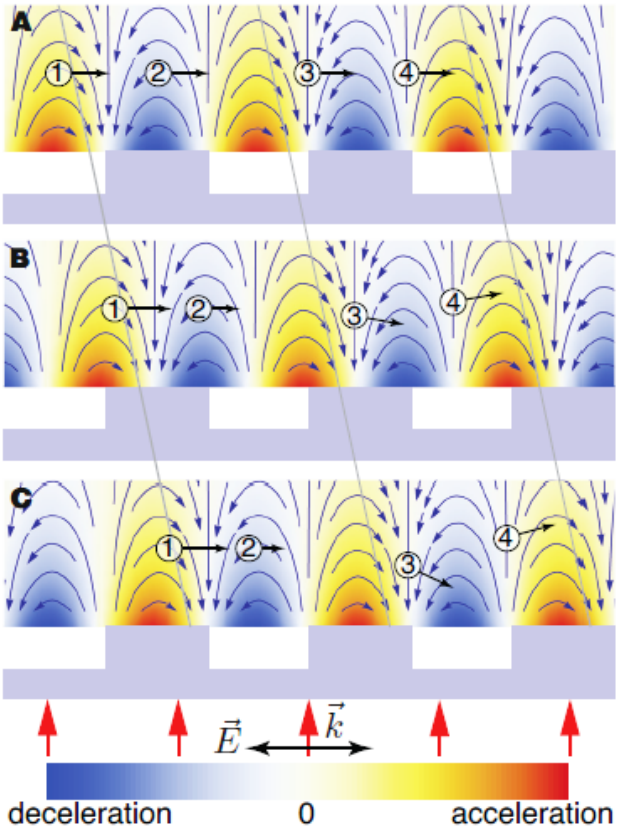
Novel concepts: Dielectric Laser Acceleration

J. Breuer, P. Hommelhoff, Phys. Rev. Lett. 2013
Peralta et al. (Byer group), Nature 2013

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

***Small really is beautiful*, The Economicst, Oct. 19th 2013**



- **Idea:** employ transparent dielectric structure to enable **efficient momentum transfer from a laser beam to a charged-particle beam**
- **Achieved: 25 MeV/m with 30 keV electrons & 300 MeV/m with 60 MeV electrons**

Perfect also to attract young talents at universities !

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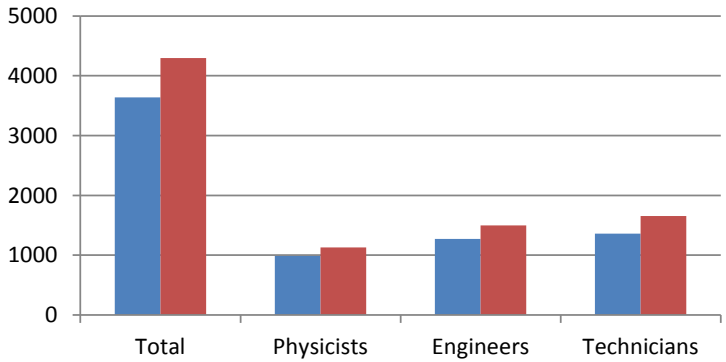
Education and Training

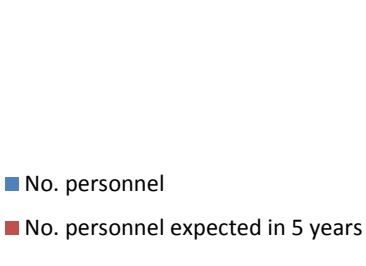
FP7-TIARA: Test Infrastructure and Accelerator Research Area

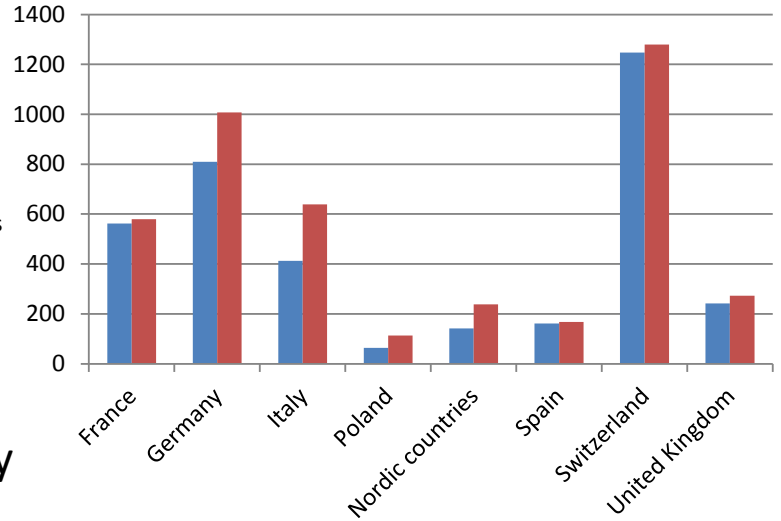
In Germany:

- ca. 600 staff members are engaged in accelerator physics activities (160 at universities)
- ca. 180 PhD students in accelerator physics and related fields
- ca. 200 accelerator physicists/engineers in industry

TIARA report (2013): Needs for accelerator scientists in Europe







+ 1000/1200 No. personnel existing/expected in industry

Importance of increased education/training efforts in accelerator physics:
Graduate schools, DFG research training groups (e.g. *Accelence* proposal), Gentner program at CERN, support for schools (CAS, JUAS)

Summary and Conclusions

Funding and co-operation between labs, universities (and industry):

- Verbundforschung (T,HK, KM)
- HGF/ARD
- DFG
- EU FP7 (TIARA, EUCARD-2,….)

Broad accelerator physics community in Germany (approx. 1000)
Since 2011: KfB (> 400 registered members)

Need for qualified accelerator physicists/engineers by new (large) projects:

- Germany: XFEL/DESY, FAIR/GSI, BerlinPRO/HZB, MESA/Mainz, HIT/Heidelberg….
- Europe: LHC+upgrades/CERN, ESS/Lund, ….

Further investments into accelerator physics education and training needed !
-> DFG graduate schools, cooperation agreements between labs and universities,…

Further establish accelerator science as an interdisciplinary research topic
-> KfB, DPG AK Beschleunigerphysik, DPG spring meetings,…..

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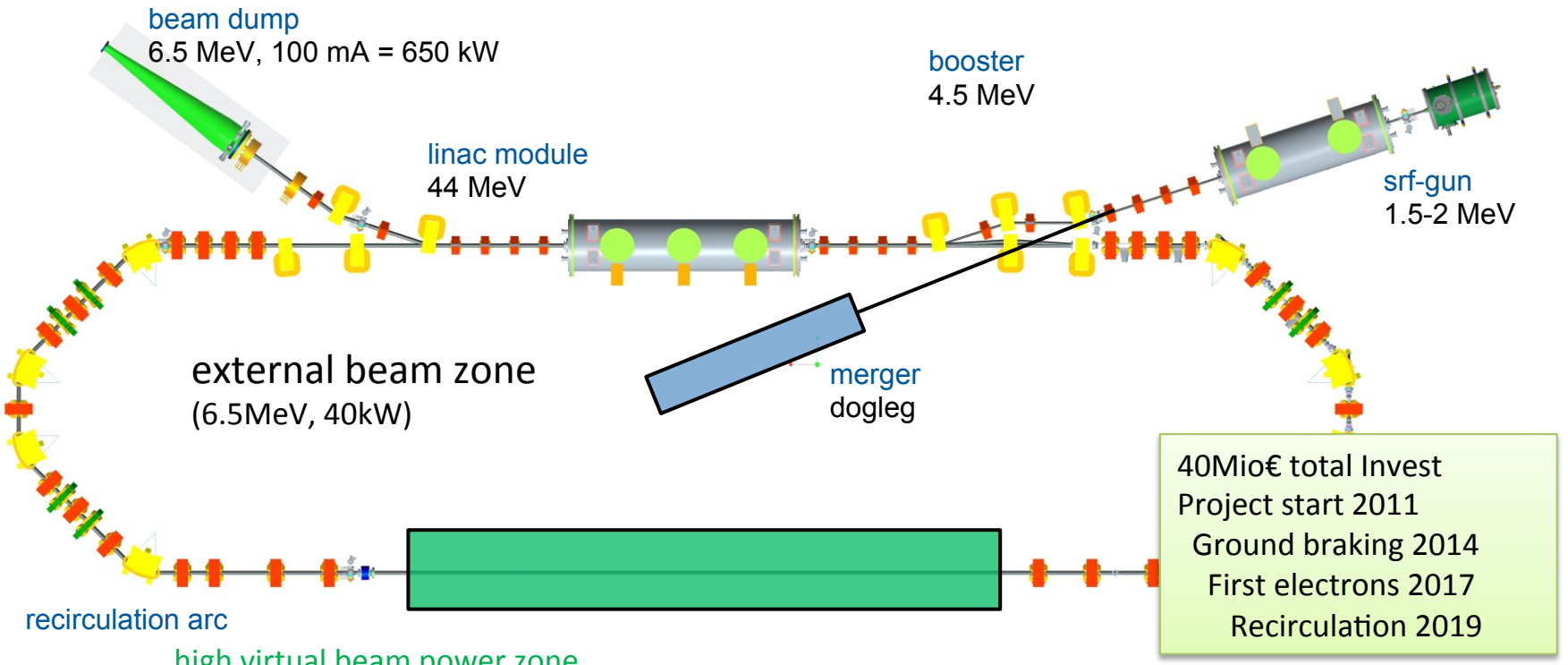
Backup

Ongoing large scale investment (HGF)

bERLinPro
Helmholtz-Zentrum Berlin



Beam parameters
ultra high power mode: 50MeV, 100mA, 2ps (5 MW of virtual beam power)
ultra short pulse mode: 50MeV, 10mA, <100fs (500kw of virtual beam power)
both modes normalized emittance < 1mm mrad

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