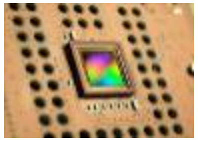
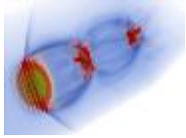
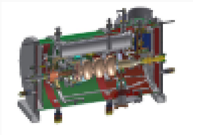






# Status ARD

## *Accelerator Research and Development*

Andreas Jankowiak, HZB

*Spokesperson ARD program topic*

March 8th, 2016
2nd Annual MT Meeting
KIT, Karlsruhe

# Outline

- **A**ccelerator **R**esearch and **D**evelopment within **M**atter and **T**echnologies

- Applications for Strategic Invest > 15 Mio€, Helmholtz Association

  **ATHENA** = **A**ccelerator **T**echnology **HE**lmholtz i**N**fr**A**structure

  **BESSY VSR** = **V**ariable Pulse Length **S**torage **R**ing upgrade of **BESSY** II

- Highlights

- ARD Workshops and Meetings

  2015 and upcoming events 2016

# ARD organizational structure

Matter and Technology

Ties Behnke, DESY
Peter Michel, HZDR

Accelerator Research and Development

Andreas Jankowiak, HZB
N.N.

Detector Technology and Systems

Marc Weber, KIT
Fine Fiedler, HZDR

**Many thanks to Reinhard Brinkmann, DESY, who chaired ARD from the beginning of the portfolio phase in 2010, through the application and implementation phase as part of the MT programme till end of 2015!**

## Accelerator Research and Development

*Speaker: A. Jankowiak, HZB / deputy: N.N.*

**ST1**

**Superconducting RF Science and Technology**

J. Knobloch, HZB
P. Michel, HZDR

**ST2**

**Concepts and Technologies for Hadron Accelerators**

A. Lehrach, FZJ
P. Spiller, GSI

**ST3**

**Picosecond and Femtosecond Electron and Photon Beams**

H. Schlarb, DESY
A.-S. Müller, KIT

**ST4**

**Novel Acceleration Concepts**

U. Schramm, HZDR
F. Grüner, U-Hamburg

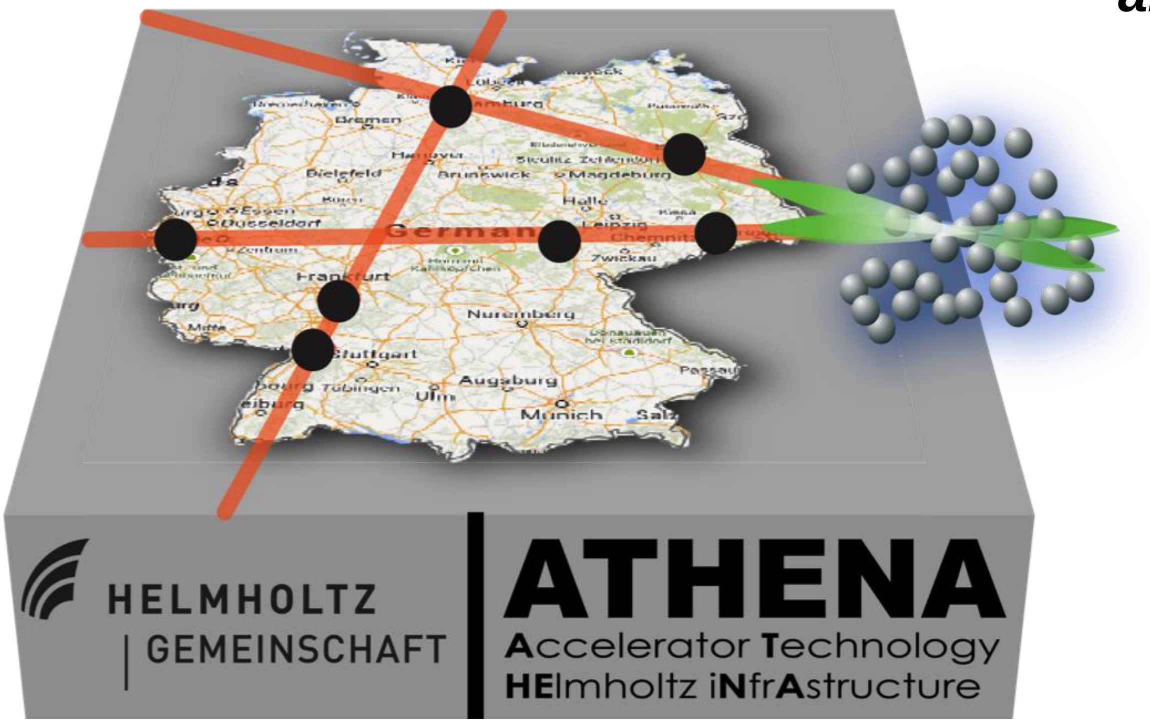
DESY — JÜLICH FORSCHUNGSZENTRUM — GSI — HELMHOLTZ GEMEINSCHAFT Helmholtz-Institut Mainz — HELMHOLTZ GEMEINSCHAFT Helmholtz-Institut Jena — HZB Helmholtz Zentrum Berlin — HZDR — KIT Karlsruhe Institute of Technology

# ATHENA – A Helmholtz Project for Germany

Development of ultra-compact* plasma accelerators and radiation facilities for science and medicine

*from acceleration to accelerators*

***and highly cost-efficient**

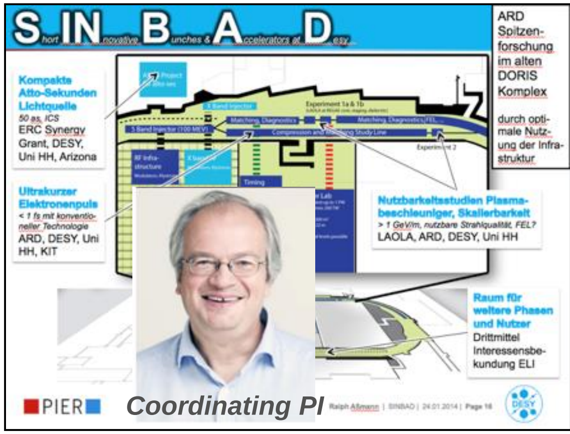


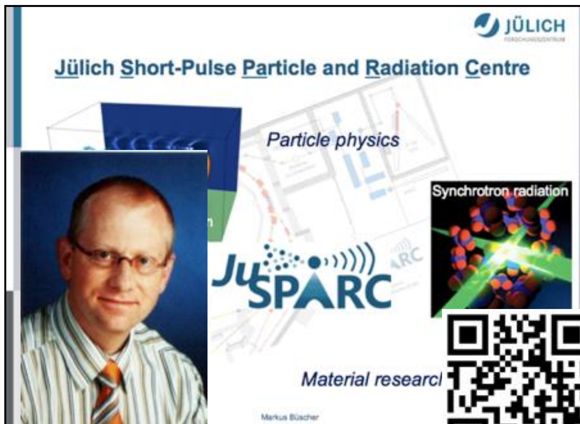

Reviewed with result

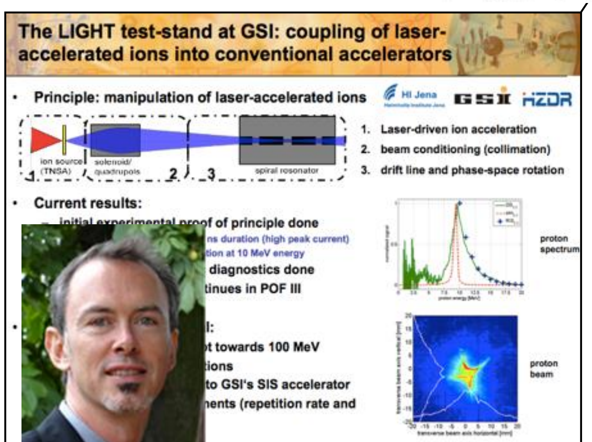
OUTSTANDING

by external review that Helmholtz conducted on this proposal

Waiting for official decision for funding approval (2016 or later?)

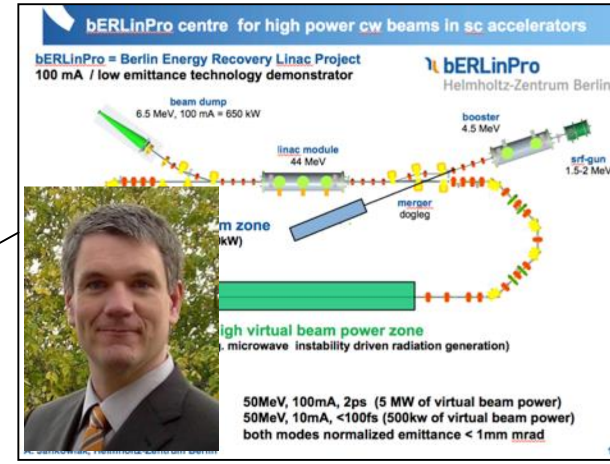


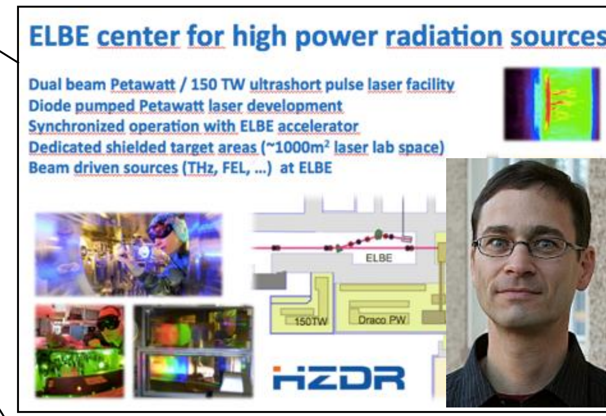



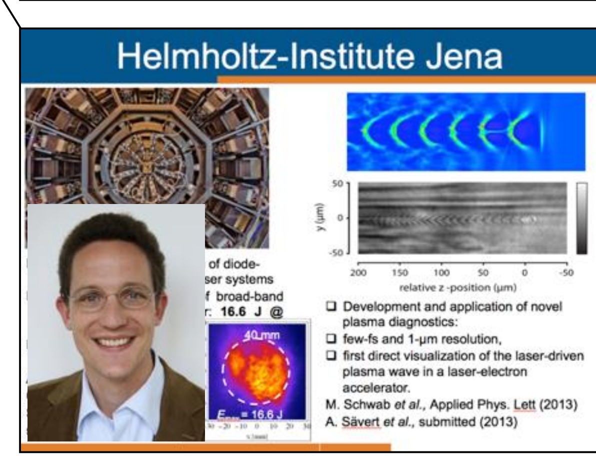



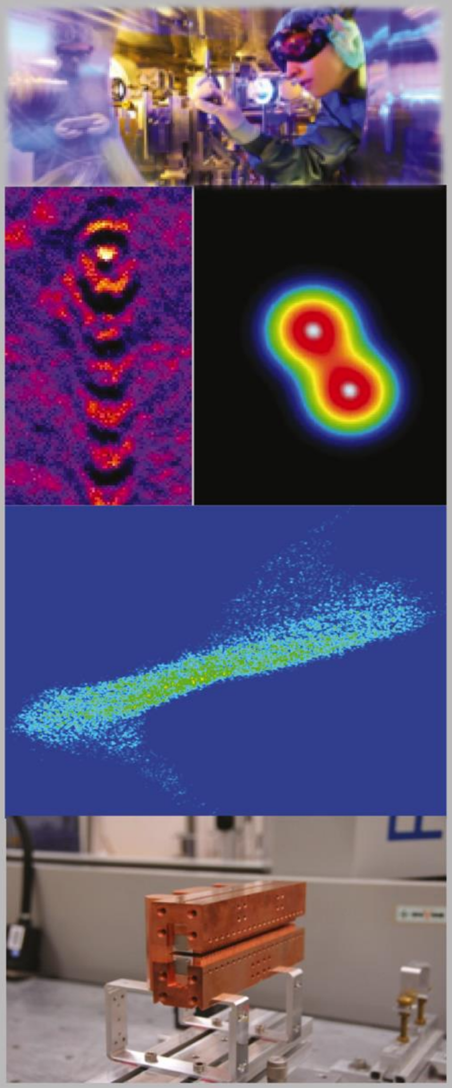


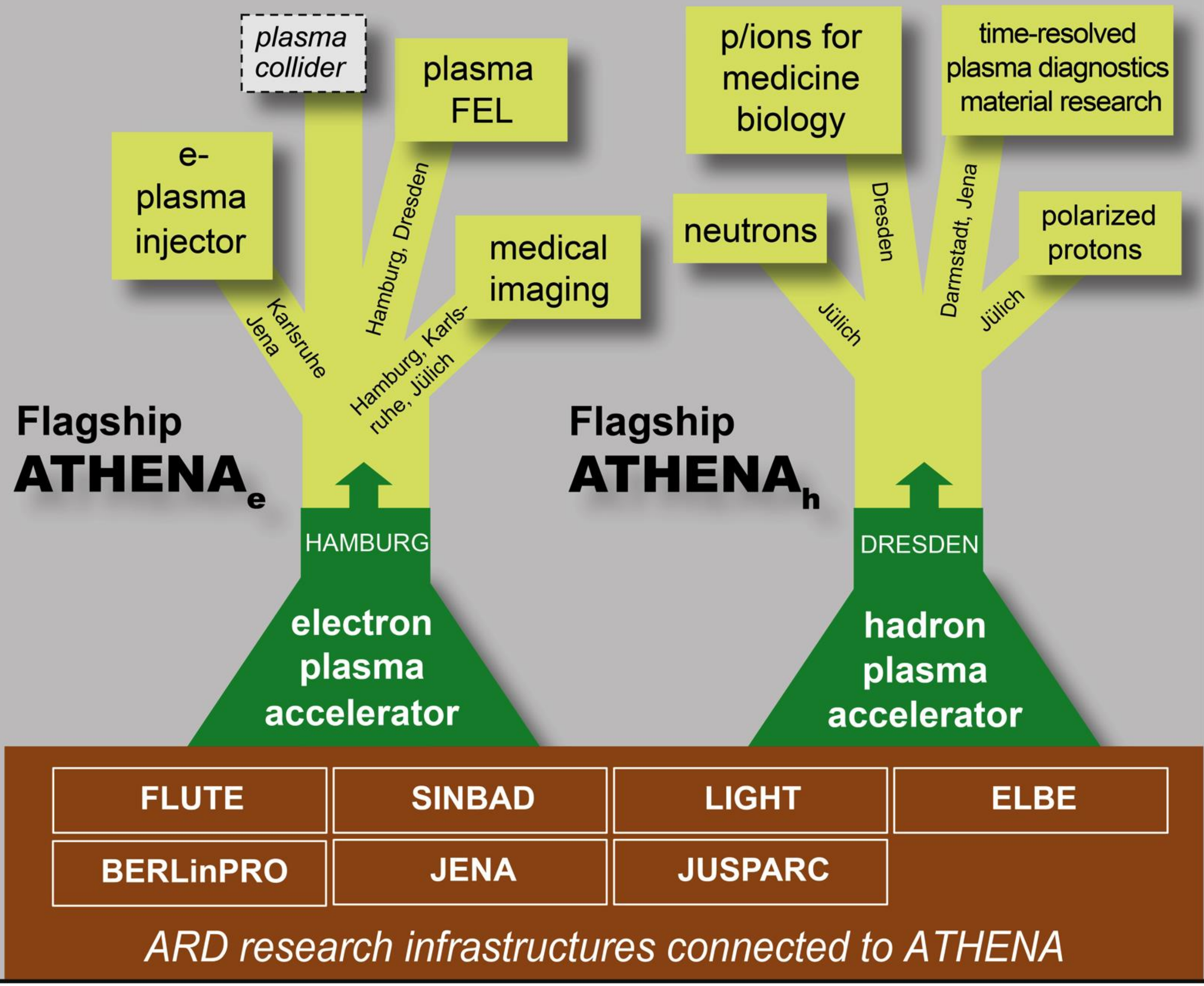

Details on included facilities see presentations on the Helmholtz ARD web site or contact PI's!



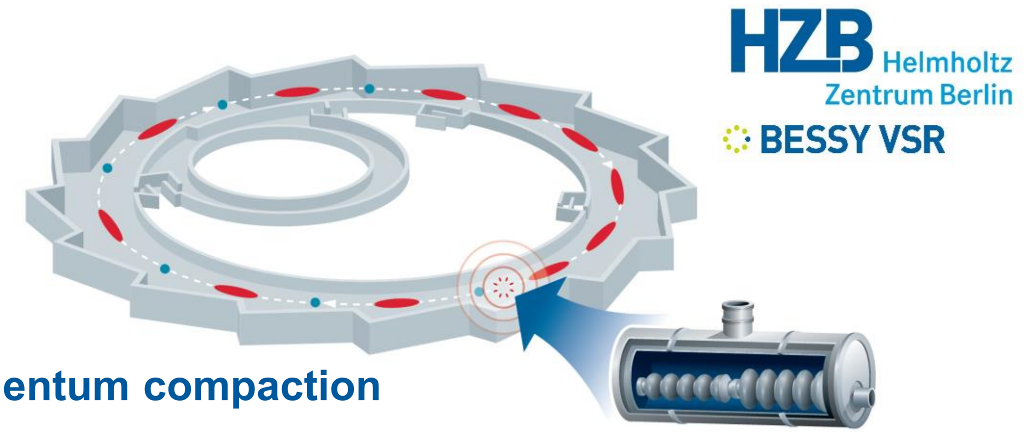





***ATHENA: construction 2018 – 2021, total invest 93 M€ (if 30 M€ grant from Helmholtz awarded), proposal submitted June 30$^{th}$, 6 Helmholtz centers + 1 institute + universities + 1 international collaborator, using infrastructures together, 2 future technologies for the Helmholtz strategy, high relevance for applications in many centers.***

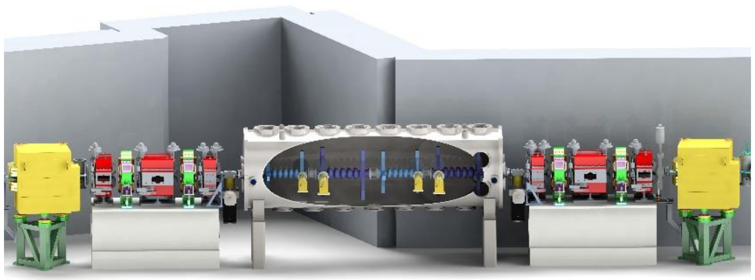
# BESSY VSR – Variable Pulse Length Storage Ring upgrade

$$\sigma \propto \sqrt{\frac{\alpha}{\dot{V}_{rf}}} \qquad I \propto \alpha$$

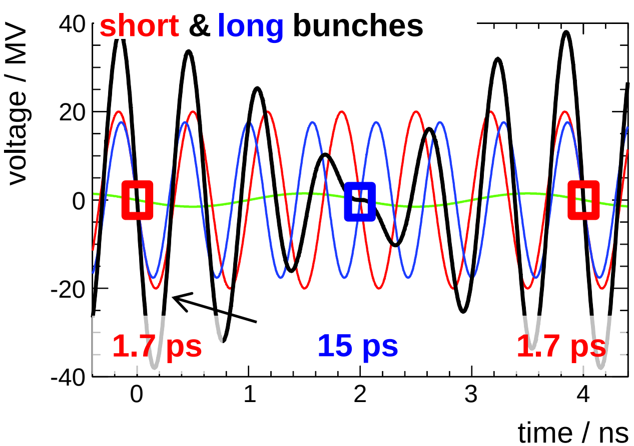



**high voltage (20 MV/m) cw multi-cell SC cavities allow to increase the total voltage gradient by a factor ~ 100**
**→ 1/10 bunch length @ constant momentum compaction**

**Combining two RF systems with different frequencies (1.5 GHz & 1.75 GHz) generates long and short buckets, which can be filled individually to generate optimized fill pattern.**

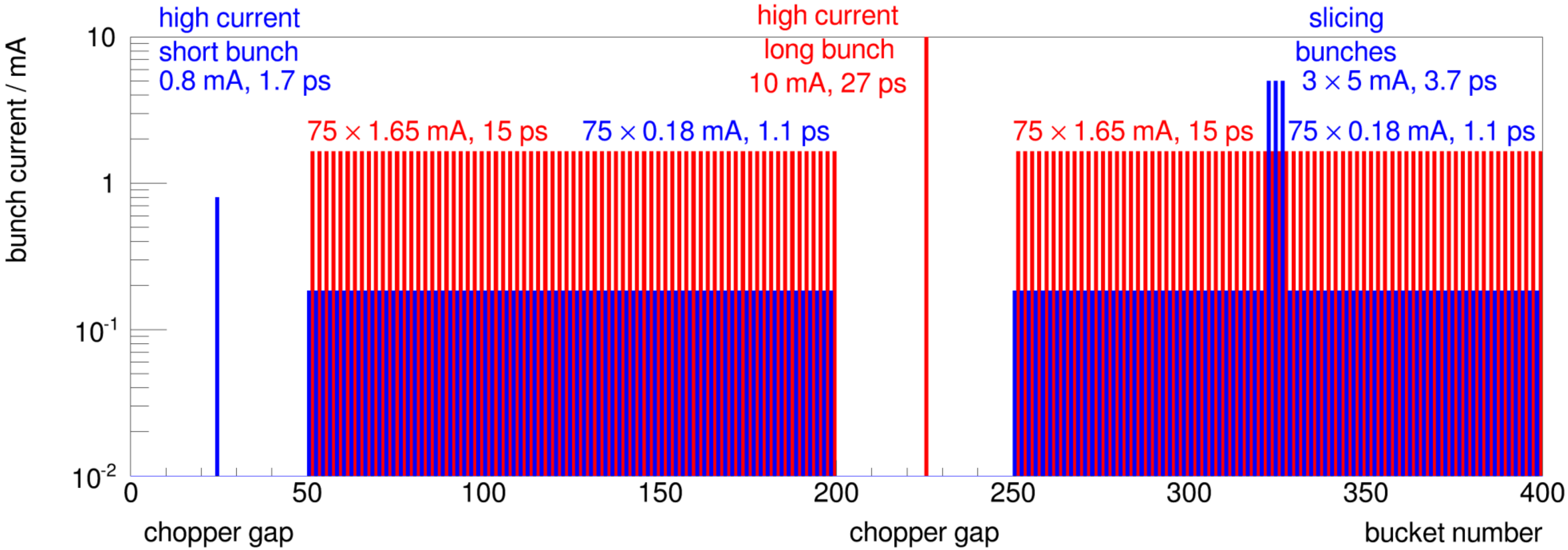


**One cryo-module** with:
**2 x 5 cell @ 1.5 GHz & 2 x 5 cell @ 1.75 GHz**
operating at **1.8 K LHe** temperature
active length: **1.86 m** with **20 MV/m**
total gradient: **2π 60 MV×GHz ( x 80 increase)**




**Installed voltage: 20 MV @ 1.5 GHz**
**17.1 MV @ 1.75 GHz**

# BESSY VSR – Project parameter




- 300 mA average current
- camshaft single bunches (short and long) in gaps
- ion clearing provided through gaps

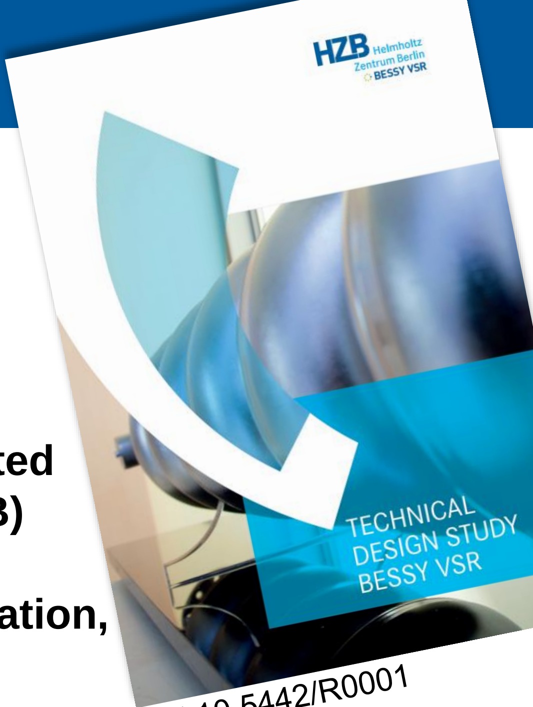
**in low alpha mode**
**350 fs @ 0.04 mA / bunch**

## multi functional hybrid mode

ps short single bunch, high current single bunch, slicing bunches, high average brilliance, background of intense CSR/THz radiation

## preserving BESSY II emittance and TopUp capabilities

# BESSY VSR – Status and timeline




doi:10.5442/R0001

| | |
|---|---|
| since 2013 | BESSY VSR Science Workshops |
| 03/2015 | Technical Design Study completed |
| 04/2015 | successful review TDS BESSY VSR |
| 06/2015 | application to Helmholtz Association submitted (strategic investment, 19 Mio€ + 10 Mio€ HZB) |
| 10/2015 | scientific evaluation (by Helmholtz) of application, result: "outstanding" project |
| 2016 | priorisation of all applications from all research fields, decision about funding still pending, available budget "overbooked" decision in 2016 (or later ?) |
| 2018 | first tranche of strategic invest expected |
| 2020/2021 | start of full user operation |

- R&D for BESSY VSR embedded in ARD (ST1 and ST3)
  HOM damped SRF cavities / bunch by bunch resolved diagnostics
- preparatory experiment = 1.5 GHz module @ BESSY II planned 2018/19

# EU Design Study → DESY / Helmholtz ARD Coordinated


http://www.eupraxia-project.eu

## EuPRAXIA as EU Design Study:

2nd accelerator design study financed by EU in Horizon2020 after the FCC/EuroCirCol led by CERN.

If compared to FP7 experience (only 2 EU design studies accelerator-related) → outstanding success

**Fully funded design study**

# EuPRAXIA Consortium

DESY

INFN

Consiglio Nazionale delle Ricerche

CNRS

University of Strathclyde Glasgow

cea

Sapienza Università di Roma

SOLEIL Synchrotron

University of Liverpool

IST-ID Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento

Imperial College London

University of Oxford

ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Science & Technology Facilities Council

UHH Universität Hamburg

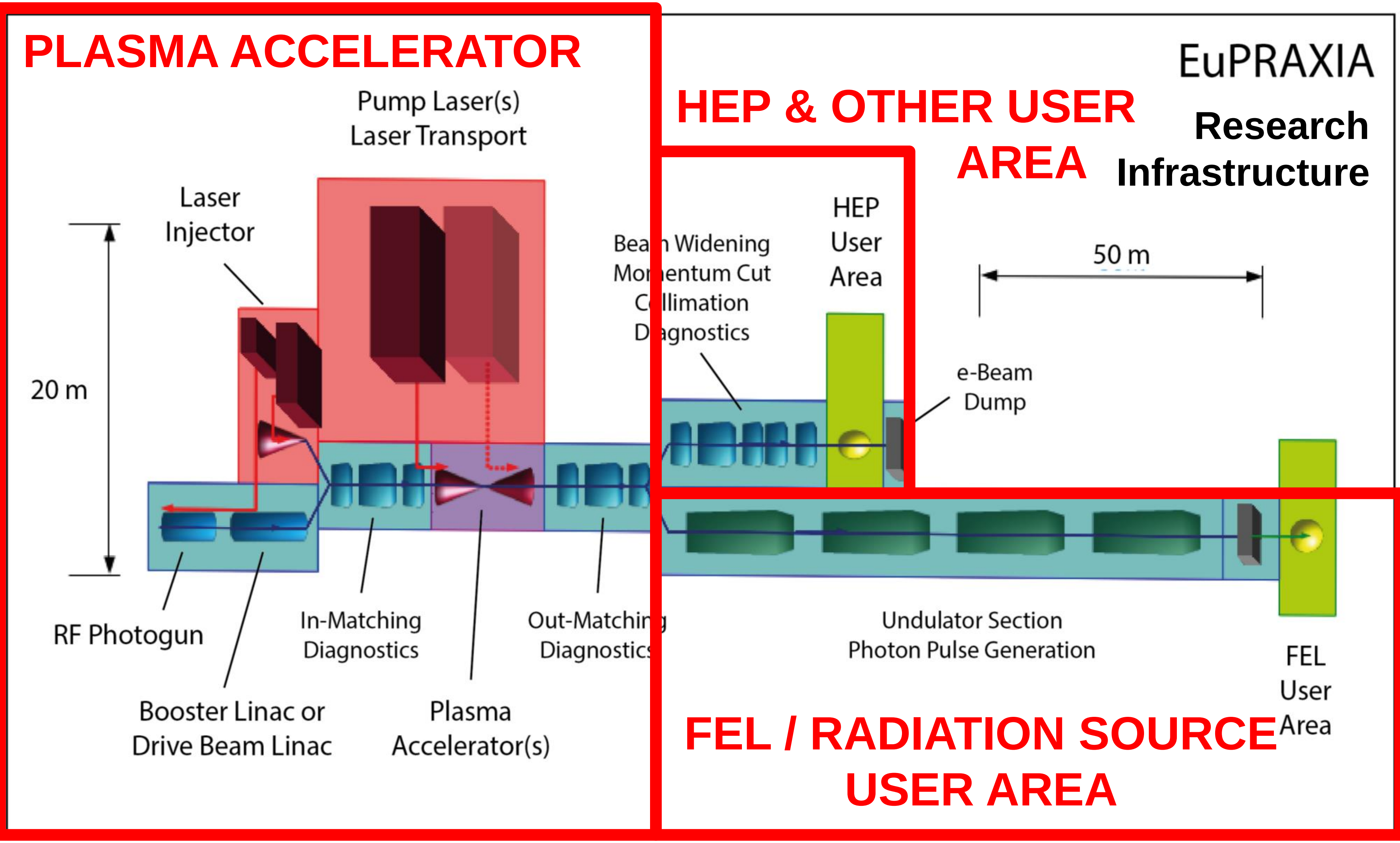
Manchester 1824 The University of Manchester

plus 18 associated partner institutes

Kick-off meeting at DESY on Nov $26^{th}$ – $27^{th}$, 2015

# EuPRAXIA Research Infrastructure for the 2020's

*5 GeV electron beam*



# ST1 - CW / high duty cycle operation of FLASH & E-XFEL

E-XFEL and FLASH originate from the TESLA collider and therefore their nominal operation is the short pulse (sp) mode, with low duty factor (DF).

Duty Factor of the nominal sp operation

| RF-pulses | Max RF pulse length [ms] | Rep. Rate [Hz] | Max RF DF [%] |
|---|---|---|---|
| | 1.4 | 10 | 1.40 |

Time structure of the nominal E-XFEL electron beam at 17.5 GeV

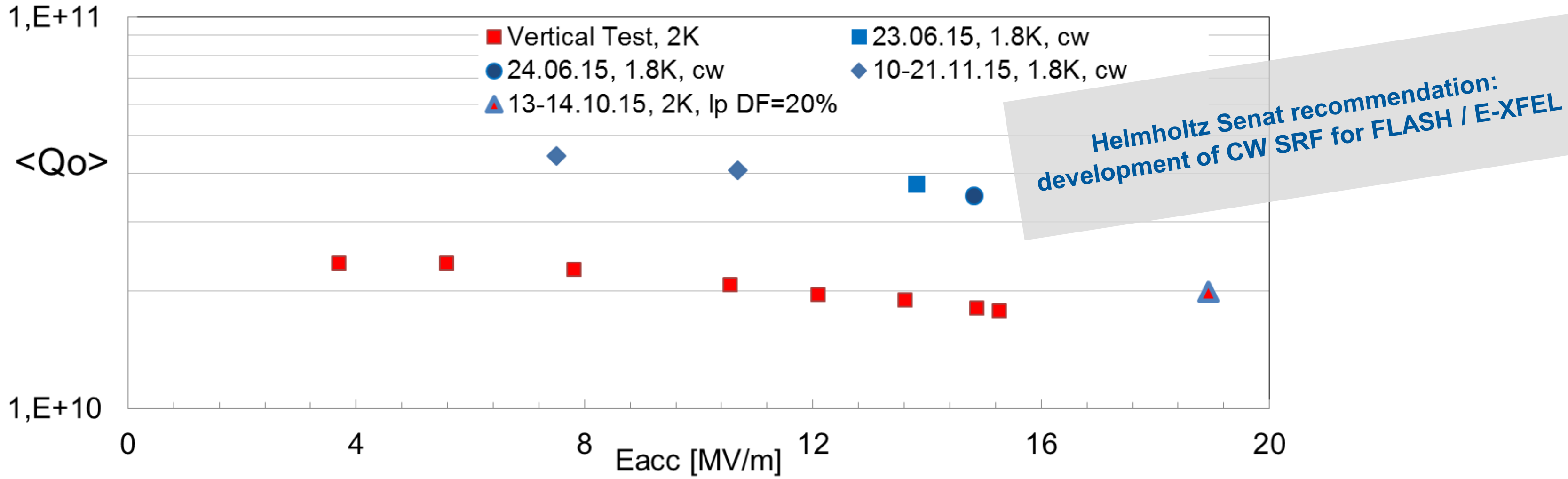
| E-XFEL beam | Bunches/RF pulse | Rep. Rate [Hz] | Bunches/s |
|---|---|---|---|
| | 2700 | 10 | 27000 |

Both accelerators are based on the SRF technology and therefore they have potential for much larger DF, up to 100% (cw).

The additional cw and long pulse, lp, (100÷800ms, rep. 1Hz) modes will allow for more flexibility in the time structure of the photon beams and will make both facilities even more attractive to the users (*vide* LCLS II project at SLAC with beam energy of 4 GeV).

# ST1 - CW / high duty cycle operation of FLASH & E-XFEL

XM4 data at 1.8 and 2K in cw/lp modes. Vert. test data for XM4 cavities is shown for comparison

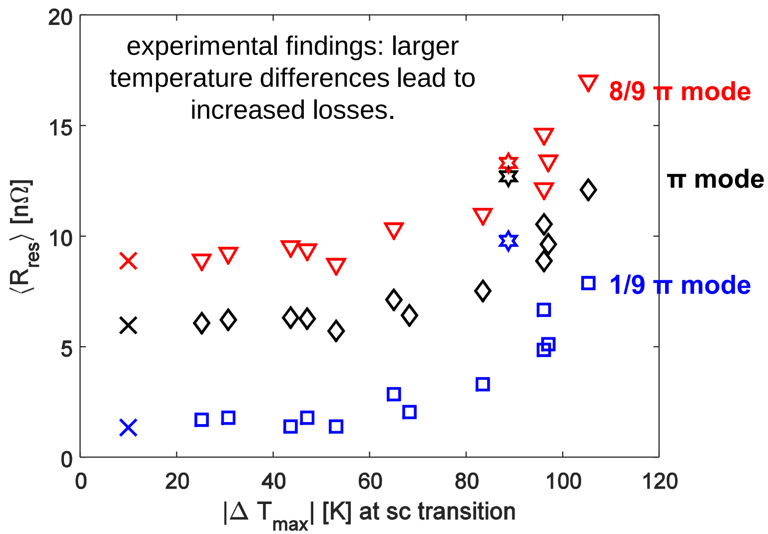



Accelerating gradient <Eacc> in [MV/m] demonstrated for 3 operation modes

| CM No. | sp | lp DF 20% | cw | Comments |
|---|---|---|---|---|
| XM-3 | 33.5 | 14.7** | 9.5** | Prototype CM, large grain Nb, high Qo*=4.7E10@9.5MV/m@1.8K, (cw/lp) |
| XM4 | 31.8 | 19 | 15 | Standard E-XFEL CM, fine grain Nb, Qo=3.3E10@15MV/m@1.8K, (cw/lp) |

**Extrapolation: E-XFEL@100kHz with 7.7 GeV (cw) and 15.4 GeV (17% DF)**

# ST1 – Thermocurrents in SRF Cavities limiting $Q_0$




additional losses

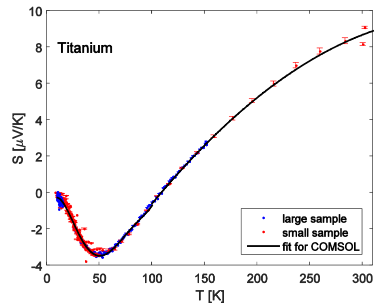
**experimental evidence of correlation between additional losses in TESLA 9-cell cavities with high temperature gradients during cool-down**

**confirmed by simulations an direct measurements of thermos currents**

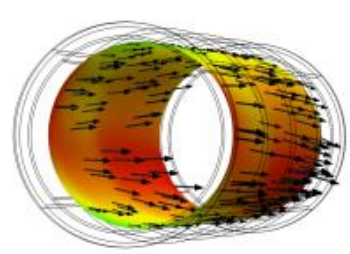
**temperature difference along cavity**

↓

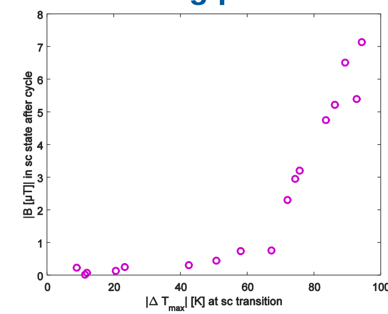
**thermoelectric currents** → **induced magnetic fields on RF surface** → **freeze in of magnetic flux during superconducting phase transition**




Seebeck-coefficent (measure of thermoelectric effects) determined at low temperatures.



Simulation shows magnetic fields of >10 µT at the RF surface, generated by an asymmetric distributions of the thermocurrents

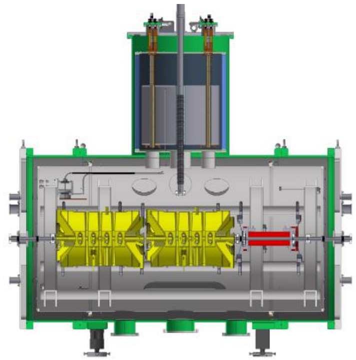


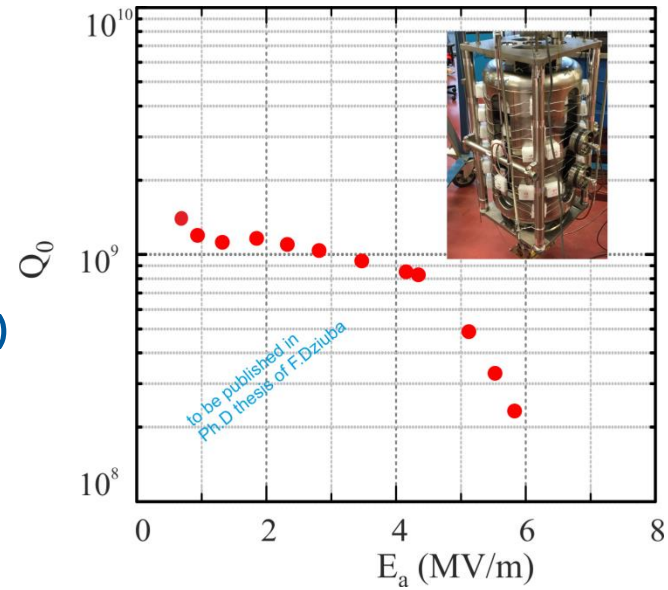

Direct measurement of the frozen thermoelectric fields in the cavity. Higher temperature differences generates higher fields..

*Publication: J. Vogt, O. Kugeler, J. Knobloch, Phys. Rev. ST Accel. Beams 18, 042001 (2015)*

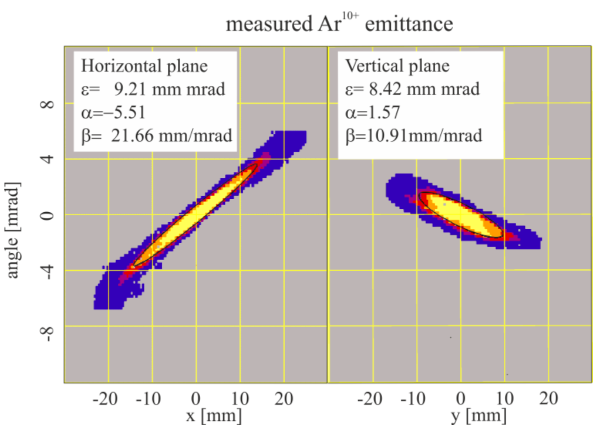
# ST1 – cw LINAC for Super Heavy Element production SHE @GSI

- **Status CH-cavity**
  - **RF-testing is completed**
  - **5 MV/m (design acc. gradient)**
  - **Demonstrator cavity is in final production step**
  - **Production of two further (short) CH-cavities already started**



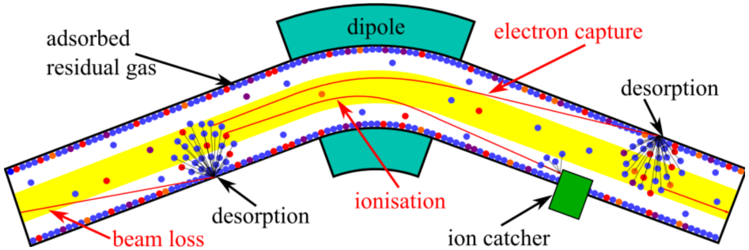



- **Status Cryostat and Infrastructure**
  - **Cold test of entire Demonstrator cryostat (incl. dummy cavity)**
  - **sc-solenoids (B = 9.3 T) successfully tested**
  - **Transversal emittance after matching line is measured**
  - **3D matching to CH-cavity accomplished**
- **Activities in 2016**
  - **HPR out of beam axis / Argon discharge for Q0 improvement**
  - **in July beam test of fully equipped cryostat**
  - **Start commissioning of new HI-Mainz facilities (clean room, HPR, BCP, Module tests)**

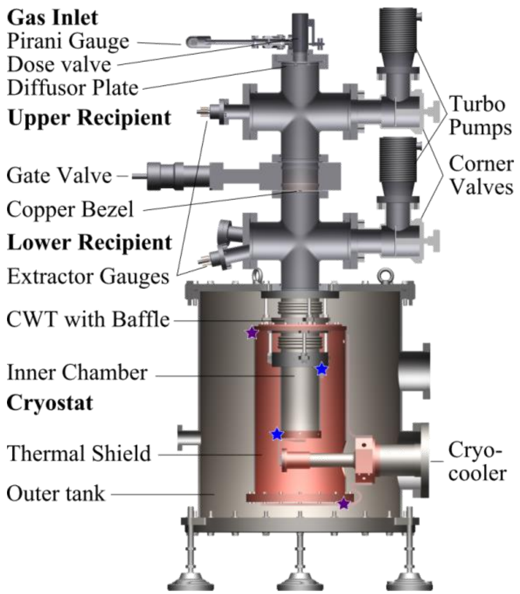



# ST2 – Ultimate Heavy Ion Beam Intensities

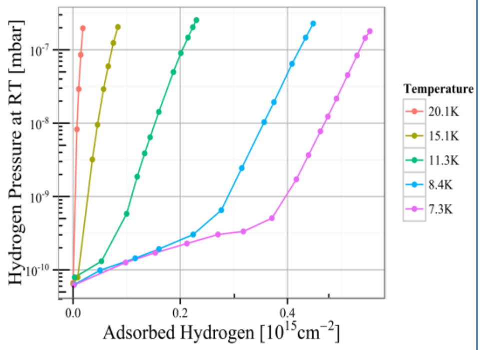
## Ionization loss and dynamic vacuum effects limit ultimate high intensities in heavy ion synchrotrons




## Static and dynamic pressure need to be controlled and extremely low



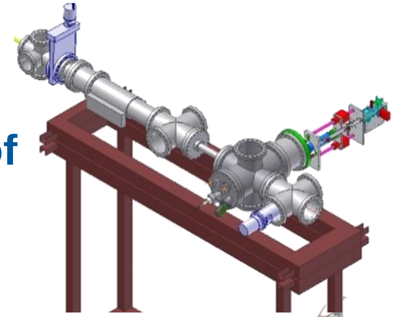

**Pumping properties of cryogenic surfaces are investigated with a dedicated measurement setup**

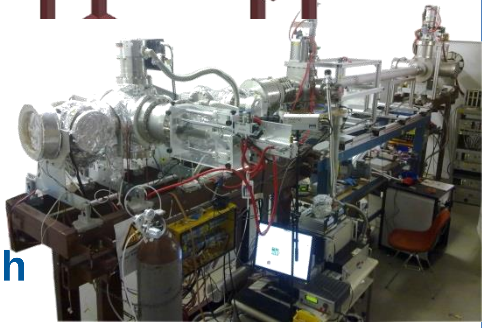



**Adsorption isotherms are measured for different temperatures → included into dynamic vacuum simulations**

## Beam loss induced gas production has to be minimized

**Heavy Ion induced gas desorption of cryogenic surfaces is investigated**





**Optimized ion catcher material under research**

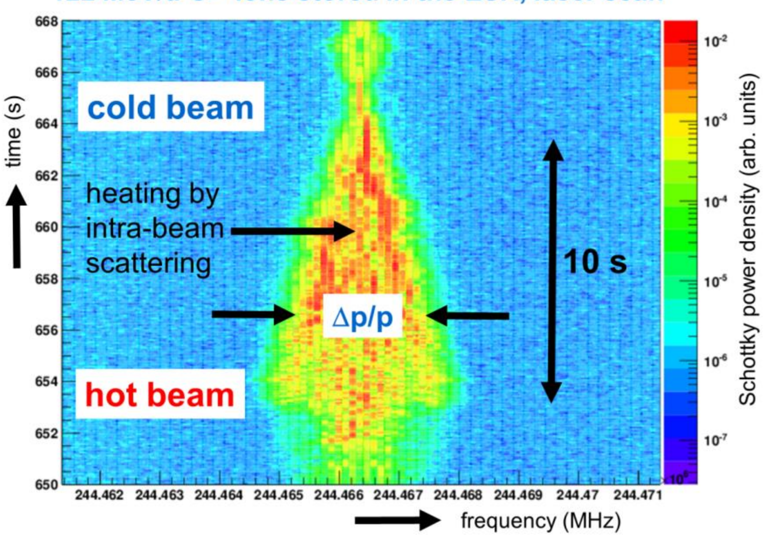
# ST2 – Heavy Ion Laser Cooling Pilot Facility

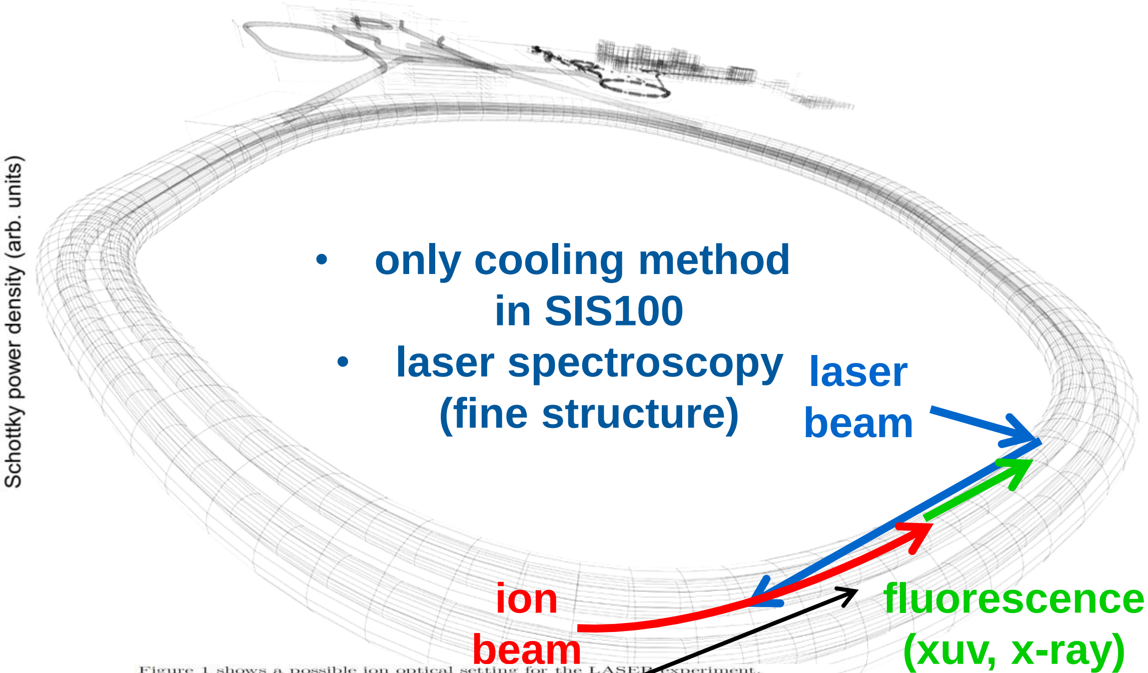
## Laser-cooled relativistic heavy ion beams

## Goal: Cooling of relativistic heavy ion beams at final energy
## Extraction of very cold and very short heavy ion bunches

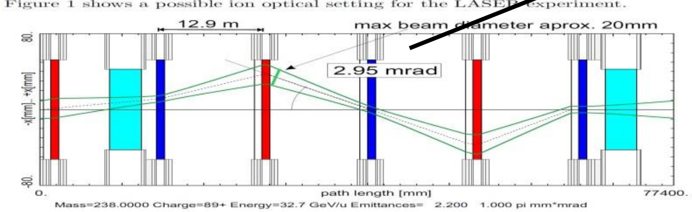
- **$Z_{ion}$= 10 – 60** (3 – 19 electrons)
- **$\gamma$ up to 13** (huge Doppler-shift)

122 MeV/u $C^{3+}$ ions stored in the ESR, laser scan



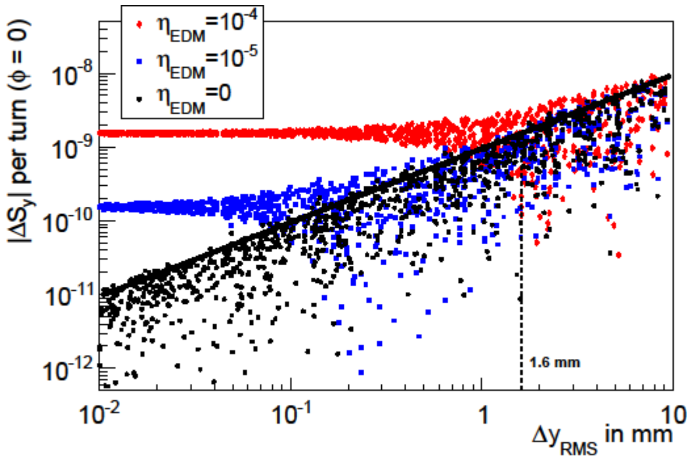

- only cooling method in SIS100
- laser spectroscopy (fine structure)



# ST2 – High Precision Spin Dynamics for EDM Measurements

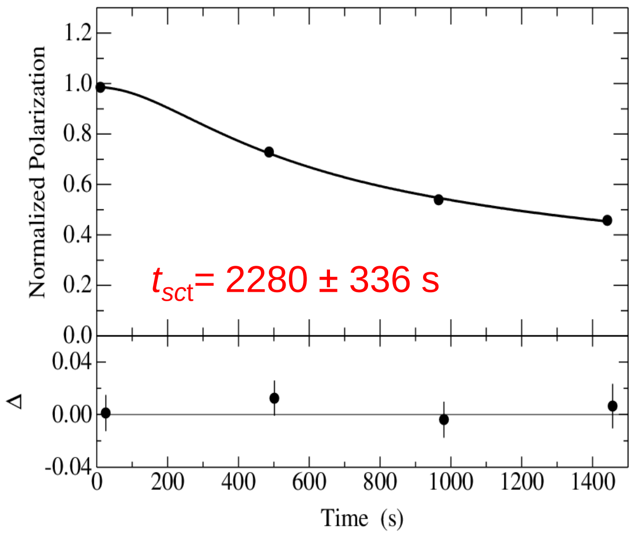
- **Simulation results**

Systematic Limitations for an EDM Measurements at COSY due to Magnet Misalignments by M. Rosenthal (FZJ)

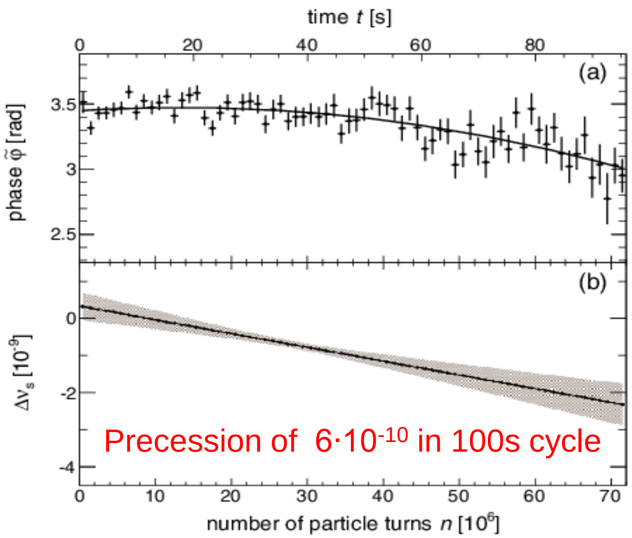



90% upper confidence limit of the false signal at $\Delta y_{RMS} \approx$ **1.6 mm** is of equal magnitude as a pure EDM signal corresponding to $\eta_{EDM} = 10^{-4}$. This value corresponds to an EDM magnitude of $d \approx 5 \cdot 10^{-19}$ ***e* cm**.

- **Measurements at COSY (by the JEDI collaboration)**



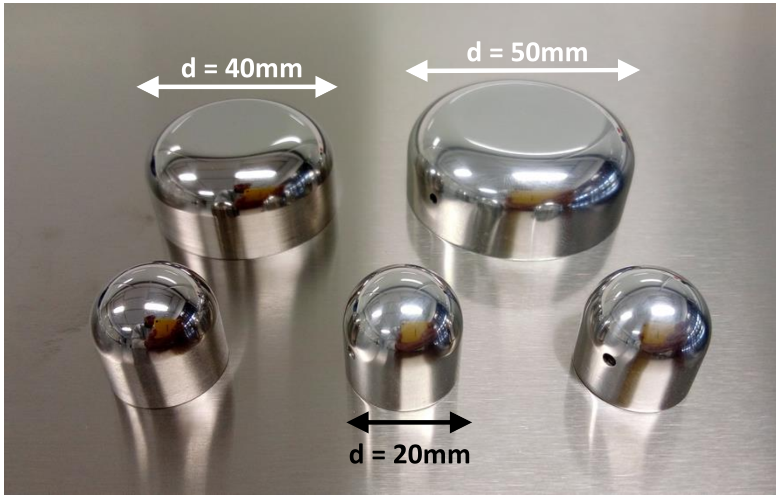

**Ultra-High Precision Spin Tune Measurement**




**Record in-plane polarization Lifetime (spin coherence time)**

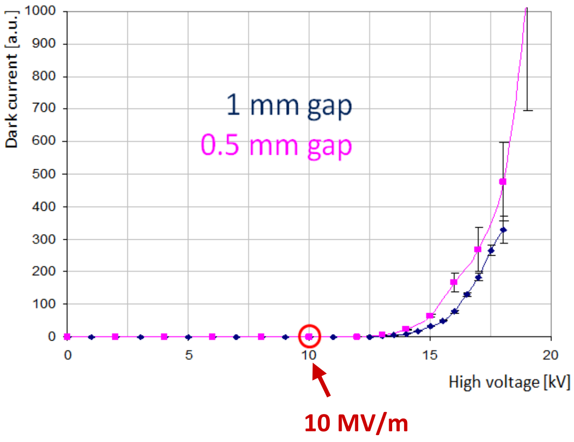
# ST2 – High-Field Electrostatic Deflector Development

High Voltage UHV setup in the clean room at RWTH Aachen




Test electrodes from polished stainless steel and aluminum

## Simulation and results





**Stainless steel**

**Two small half-spheres (R = 10mm)**
**17kV at 1mm distance → 17 MV/m**

**Half-sphere vs. flat surface**
**12kV at 0.05mm distance → 240 MV/m**

**Aluminum**

**Two small half-spheres (R = 10mm)**
**3kV at 0.1mm distance → 30 MV/m**

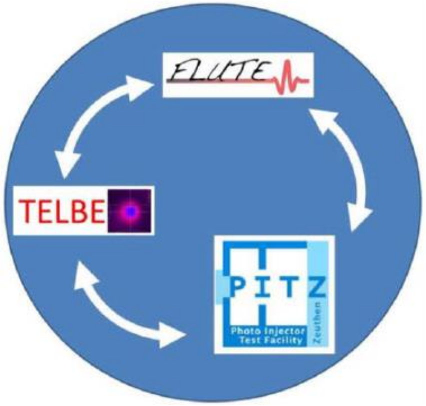
# ST3 – ps-fs Electron and Photon Beams

DESY
HZB Helmholtz Zentrum Berlin
HZDR
JÜLICH FORSCHUNGSZENTRUM
KIT Karlsruhe Institute of Technology

## ST3: ps-fs electron and photon beams

| Beam dynamics & Photon Sources | ps-fs beam diagnostics | Stability, Controls & Synchronization |
|---|---|---|
| Short bunches in linear accelerators | Time domain | Synchronization References |
| Coh. radiation & high fields in storage rings | Frequency domain | RF Controls |
| Custom beams: bunch shape manipulation | Electron beams | Control System Advances |
| Advanced photon sources development | Photon beams | Coherence control XUV Seeding |

Technology transfer & Networking & Test Facilities




## Test Facilities

SINBAD
*Novel Acc. Concepts:*
*PWA multi-staged;*
*X-ray source compact;*
*Diagnostics/Dynamics*
*Synchronization/*
*Feedbacks*

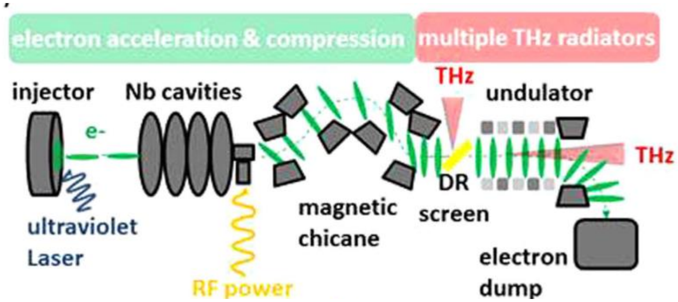
## Technology Transfer

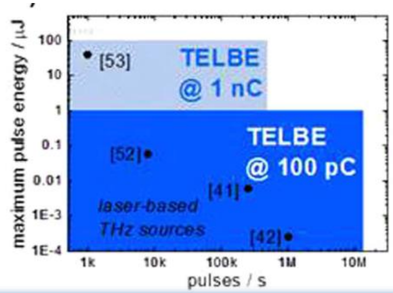
S. Jablonski [WUT/ISE], H. Schlarb [DESY]
**Patent** EP15 159 267.2, Mar 16, 2015
**Patent** EP15 159 268.0, Mar 16, 2015

## Networking


ST4: Novel Acceleration Concepts

## Compact High Field High Repetition Rate THz Sources



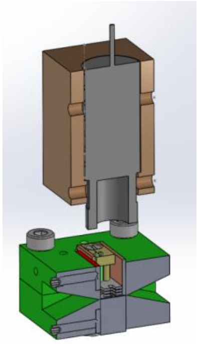

**TELBE (HZDR)**

- 30 MeV
- 100 pC
- 30 fs, ~MHz
- E ~ 100 kV/cm

M. Gensch (HZDR)

Scientific Rep. 6, 22256 (2016)

**+ HZDR Innovationspreis 2015!**



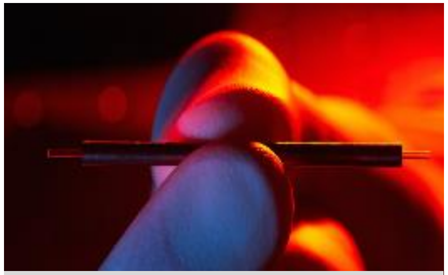
## THz-Driven Linear Electron Acceleration

**THz Gun** Nat. Comm. 6, 8486 (2015)

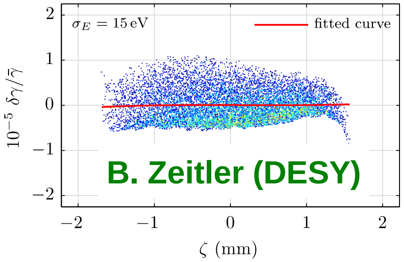
- Single cycle ultrafast electron guns

**THz Linac**

- Dielectric-loaded metallic waveguide
- Cascaded cavities



ST3-Talk: A. Fallahi (CFEL/DESY)




B. Zeitler (DESY)

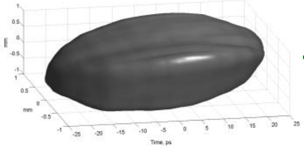
## Longitudinal phase space linearization without higher harmonic field

PRSTAB 18, 120102

## IR/THz generation for XFEL pump-probe exp. with PITZ

P. Boonpornprasert (DESY)

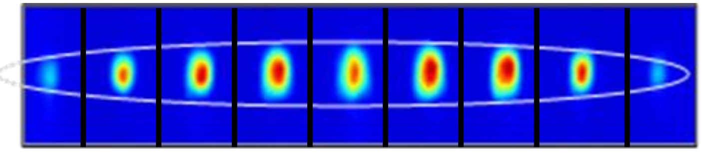
Proc. FEL15, MOP033



## PITZ: Advanced laser pulse shaping

T. Rublack (DESY)

Appl. Opt., accepted



Δt = 1.7 ps

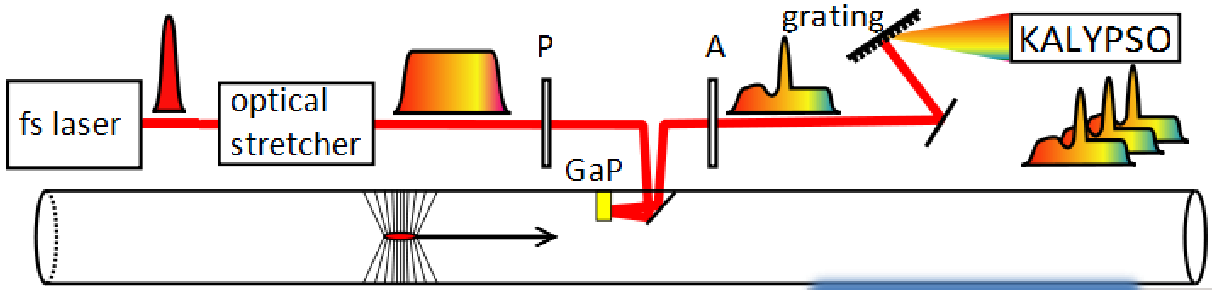
# ST3 – ps-fs Beam Diagnostics



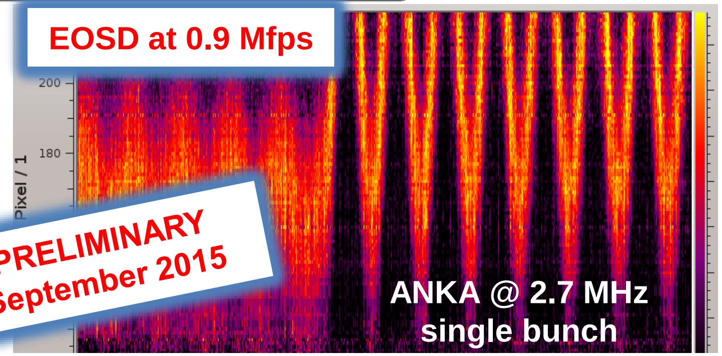
## Bunch Lengths: Electro-Optical Spectral Decoding (EOSD)

Collaboration

KIT Karlsruhe Institute of Technology
DESY
PAUL SCHERRER INSTITUT PSI
Lodz University of Technology
HZDR
GSI




**Networking**
**ARD & DTS in MT**




N. Hiller, M.J. Nasse, G. Niehues, P. Schönfeldt, S. Walther, L. Rota, M. Caselle (KIT)

**KArlsruhe Linear arraY detector for MHz-rePetition rate SpectrOscopy (KALYPSO)**

**2015: First Offline Tests @ HZDR & KIT**

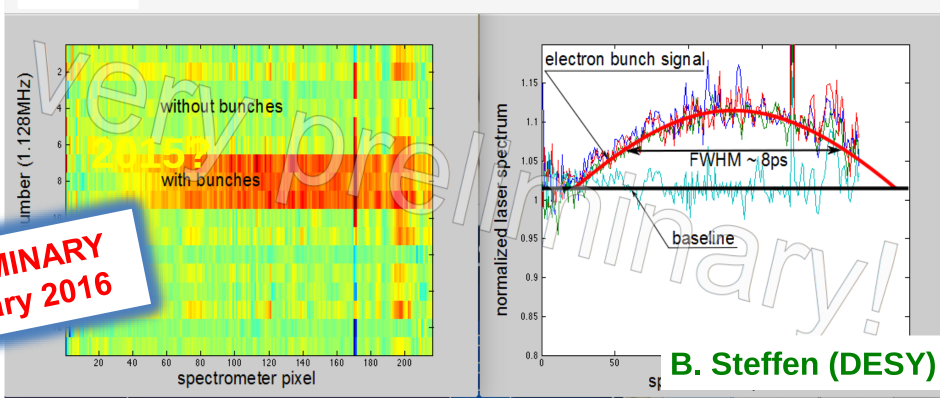
**Electro-Optical bunch length Detection at XFEL Injector with 1 MHz bunch rate**

First system now ready for (expert) operation at the XFEL-injector

**ST3-Talk: M. Caselle (KIT)**

PRELIMINARY
February 2016

First EOD bunch length measurements with KALYPSO at XFEL

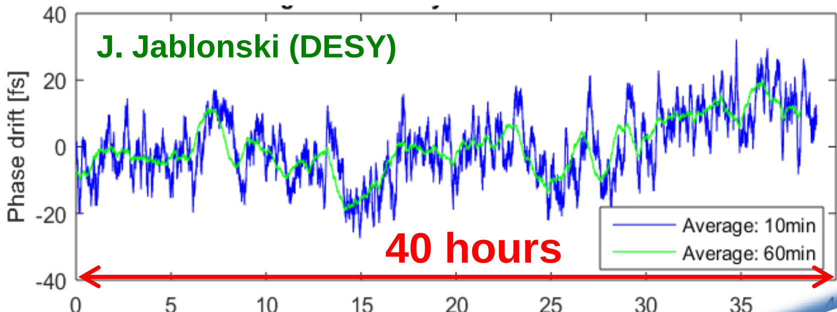



B. Steffen (DESY)

# ST3 – Stability, Controls & Synchronization

## CW Optical Synchronization System

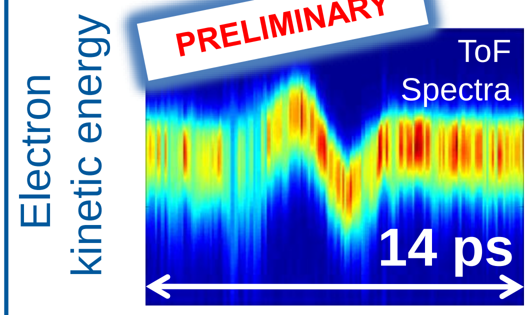
- Low budget applications
- RF signals distribution to remote locations
- <10 fs rms @ 1.3 GHz, low phase noise
- Long-term stability < 50 fs pk-pk of 2-km link




S. Jablonski, K. Czuba, F. Ludwig, H. Schlarb
IEEE Trans. Nucl. Sci. 62, 1142 (2015)
S. Jablonski, H. Schlarb, C. Sydlo, Proc. IBIC2015

Plans for 2016: Production in Series

## HGHG Seeding at FLASH




Time delay THz vs. FEL

J. Boedewardt (DESY)

**Technology Transfer**

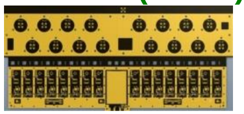
**2 Patents**

## fs-precision RF measurements

Universal LO Generation Module (1 GHz…6 GHz)
Drift Calibration Module for CW operation

M. Hoffmann (DESY)

U. Mavric (DESY)



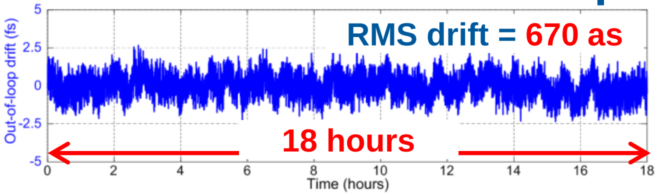
## Drift Free Laser-to-RF Synchronization

Long term ~ 45 hours
REGAE photo-injector LO
M. Titberize (Uni-HH)

$\Delta t_{pk-pk} = 31$ fs
$\Delta t_{rms} = 7$ fs

CFEL SCIENCE

## Laser-microwave network setup

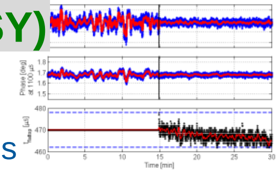



K. Shafak (CFEL/DESY)

## Low Level RF control of NRF cavities

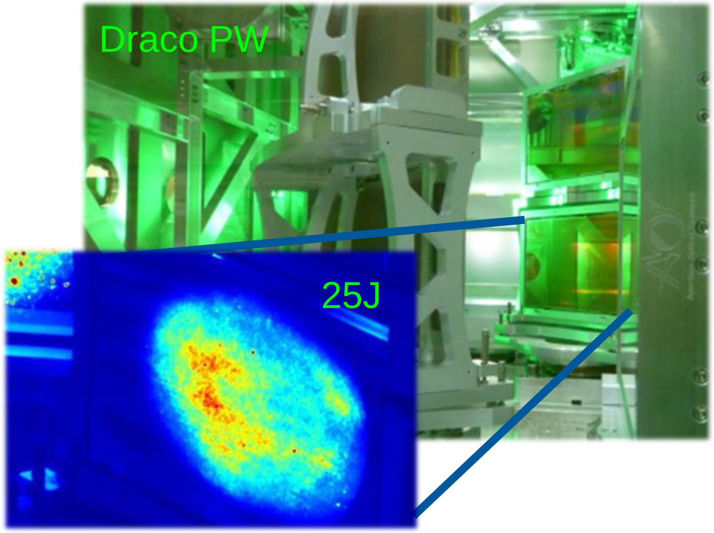
**ST3-Talk: S. Peiffer (DESY)**

Cooling water &
LLRF based RF field regulation
⇒ Temperature Stability: 4-6 times



# ST4 – High power laser installation and upgrades

***Focus on laser driven plasma acceleration evident by large investment in unique world leading and complementary facilities***

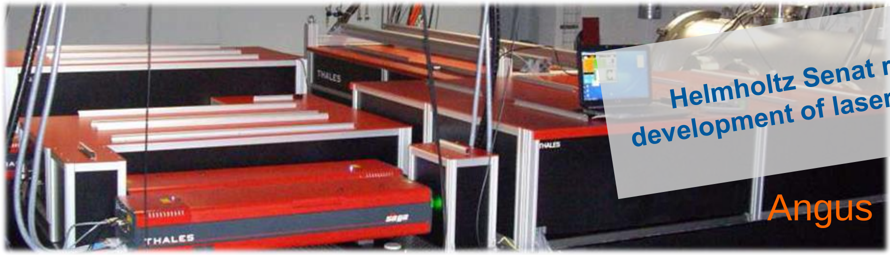


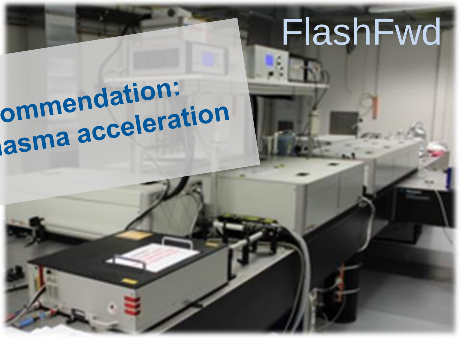

HZDR: Commissioning of Petawatt dual beam facility DRACO almost completed with up to 0.75 PW on target
150 TW in routine operation at ELBE

DESY (UHH): 200TW laser ANGUS and FLASHForward▸▸ Laser operational and integrated into accelerator control system


HIJ: Ultrashort pulse (17 fs) 200TW laser JETI200 implemented, POLARIS energy upgrade shown

GSI: High contrast OPA front-end upgrade for PHELIX in use

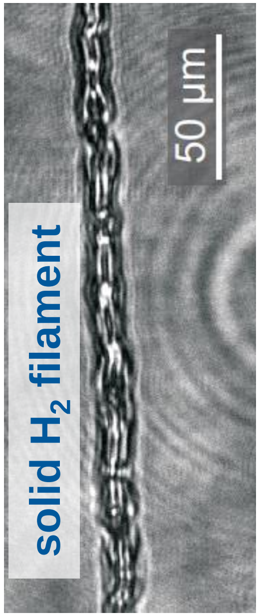



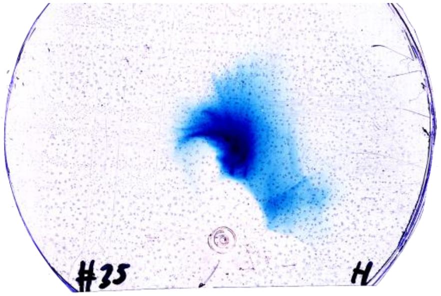

**Helmholtz Senat recommendation: development of laser plasma acceleration**

# ST4 – Laser ion acceleration

- Solid hydrogen jets established at HIJ and HZDR (collab. with GSI and Stanford) for high rep.rate and high efficiency proton acceleration (with energies similar to reference foils).

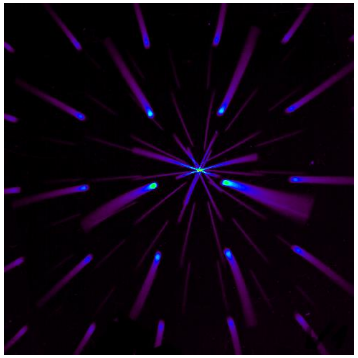


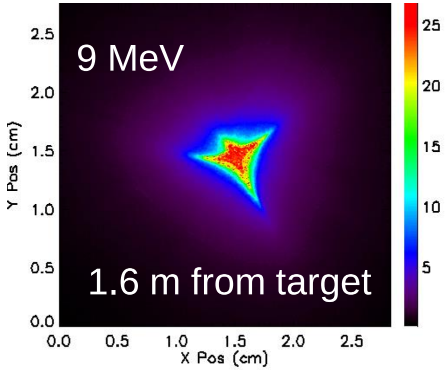

- Transport and refocusing of ions (and protons) over 6m in the LIGHT collaboration at GSI. Recompression of energy selected pulses to 200ps.

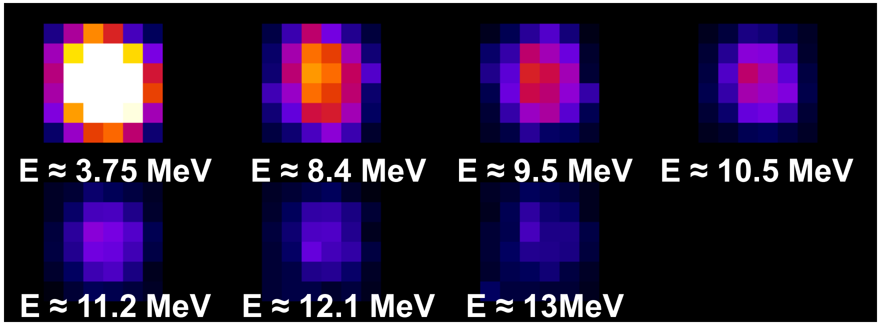



- Record scale proton energies at contrast improved Phelix

- Pulsed beam transport revisited at HZDR with reduced aberrations and online detector development

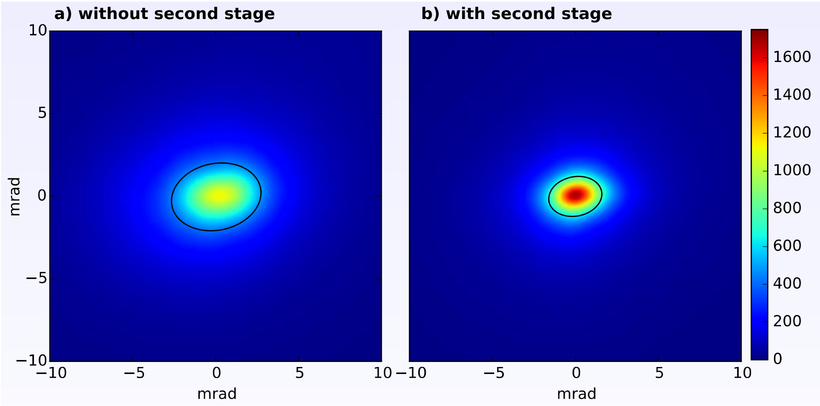


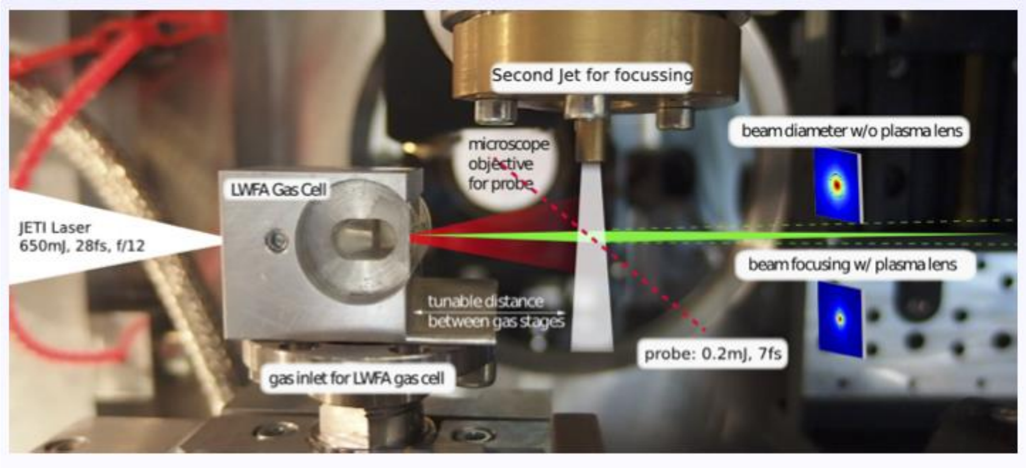


# ST4 – Laser electron (wakefield) acceleration

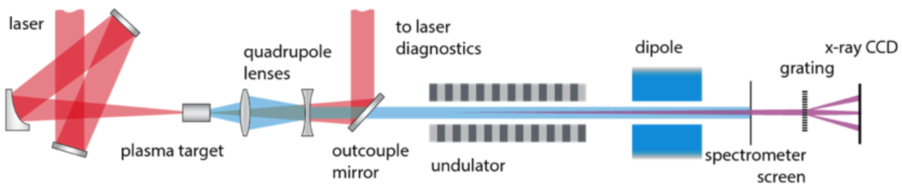
- Scale-matched plasma based electron lenses (HIJ with DESY, UHH)

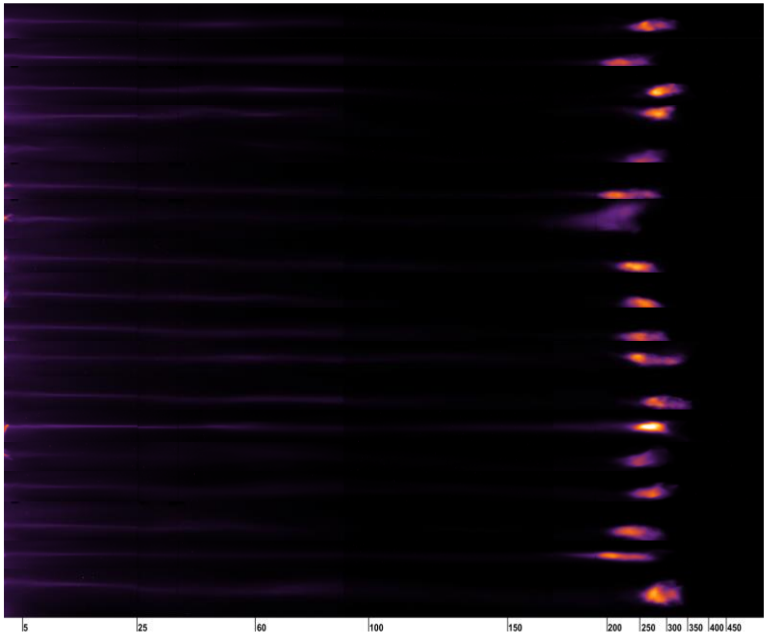



- Stable high bunch charge electron acceleration at HZDR from nozzles with X-ray and single shot spectrometer diagnostics

- Undulator beamline at DESY prepared



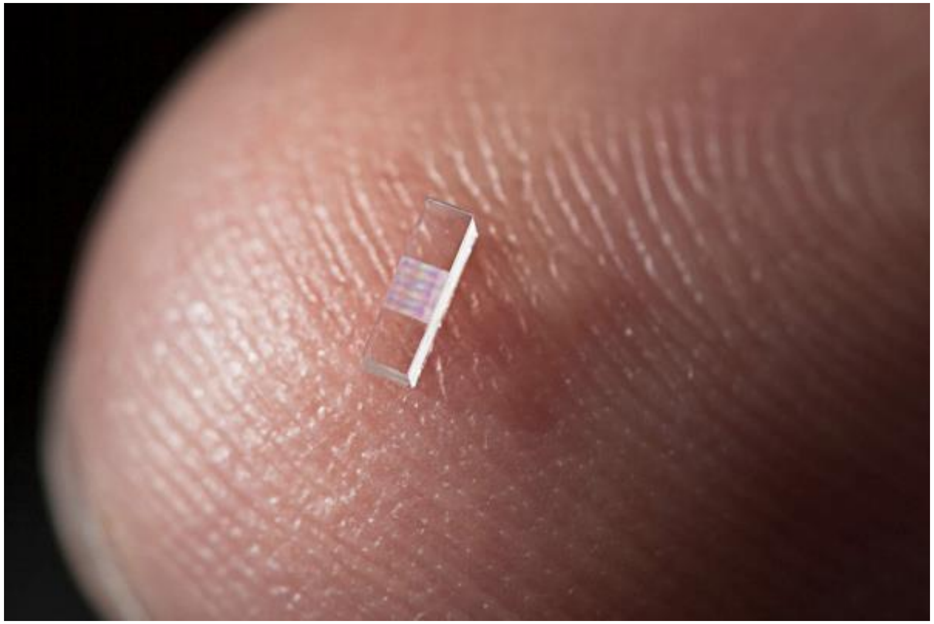

300 MeV

# ST4 – Helmholtz Science & Facilities → Attracting Science

- ACHIP project → Laser-driven “Accelerator on a Chip”
- Financed by 13.5 M$ grant by Gordon & Betty Moore Foundation (Silicon Valley – Moore’s Law)
- Stanford, SLAC, University Erlangen, DESY, University Hamburg, PSI, EPFL, University Darmstadt, CST
- 10% of funding through University Hamburg to DESY work
- Use DESY ARD facilities (“SINBAD”) for further developing this technology

ACHIP

Accelerator on a Chip International Program



# ARD programme MT days 2016

| Afternoon Session Tuesday, March 8 | |
|---|---|
| TIARA<br>- A European Initiative to promote Sustainable Accelerator R&D | Roy Aleksan<br>DSM/IRFU/SPP |
| Accelerator for Hadron Therapy<br>- The Industry Perspective | Heiko Rohdjess<br>Siemens Healthcare |
| Accelerator Physics and Technology Activities in China | Qing Qin<br>IHEP, Beijing |

Poster Session, Tuesday evening

| Wednesday, March 9 | |
|---|---|
| ST1 – SRF Science and Technology (5 talks)<br>ST2 – Concepts and Technology Hadron Acc. (4 talks) | morning session<br>2 x 90 min |
| ST3 – FS and PS Beams (5 talks)<br>ST4 – Novel Acceleration Concepts (5 talks) | afternoon session<br>2 x 90 min |

| Morning Session Thursday, March 10 | |
|---|---|
| The ImPACT Programme in Japan<br>(**Im**pulsing **PA**radigm **C**hange through Disruptive **T**echnologies | Tomonao Hosokai<br>Osaka University |
| Realization of a Stable Electron Beam by<br>Laser Wakefield Acceleration | Tomonao Hosokai<br>Osaka University |

# ARD Workshops and Meetings 2015/2016

## 2015

4th ST3 Workshop “Longitudinal Instrumentation for Future Accelerators”, PSI, 01/2015
https://indico.psi.ch/conferenceDisplay.py?ovw=True&confId=3287 , 32 participants

ST2 Satellite Meeting “Spin Tracking for Precision Measurements”, IPAC15, 05/2015

3rd ST3 Annual Meeting, KIT, 07/2015, 63 participants
https://indico.desy.de/conferenceDisplay.py?ovw=True&confId=12130

5th ST3 Mini-Workshop “Longitudinal Diagnostics for FELs”, DESY HH, 11/2015
https://indico.desy.de/conferenceDisplay.py?confId=13339 , 40 participants

ST3 Mini-Workshop „SRF controls and CW operation“, HZDR, 11/2015
https://indico.desy.de/conferenceDisplay.py?ovw=True&confId=13427 , 31 participants

ST1 Workshop “Emitting Materials – Photocathodes for Photoinjectors”, HZDR, 12/2015
https://indico.desy.de/conferenceDisplay.py?confId=13497, 23 participants

## 2016

ARD Workshop “ARD in MT”, GSI, 02/2016
http://indico.gsi.de/confRegistrantsDisplay.py/list?confId=4547

**4th ST3 Annual Meeting, HZB, 13. - 15.07.2016 (up coming event)**
http://www.helmholtz-berlin.de/events/ard-st3/programme_de.html

## German Committee for Accelerator Physics

http://www.beschleunigerphysik.de/

Komitee für Beschleunigerphysik

Founded 2010
- 12 members (Helmholtz, Universities, Labs),
- elected by registered engineers and scientist working in the field of accelerator physics (ca. 400 registered) = "Forum Accelerator Physics" *(please register)*

| | |
|---|---|
| 1st period | 2011 – 2013, Speaker Th. Weiland |
| 2nd period | 2014 – 2016, Speaker W. Hillert |
| next elections | 2016 |

**2016: new brochure "Accelerators"**


http://www.beschleunigerphysik.de/e70720/e265540/kfb-broschuere_2016-01-31_web_ger.pdf

DPG

## Arbeitskreis Beschleunigerphysik, DPG
### (AKBP = Working Committee Accelerator Physics)

Founded 2014
Speaker W. Hillert (deputy A. Meseck)
441 members

## Annual DPG Spring Meetings
### AKBP teams up with
### Hadrons and Nuclei (2016), Particle Physics (2017), Condensed Matter(2018)

**14.-18. March 2016, TU Darmstadt, ~ 130 contributions (thereof ca. 40% ARD related)**
**Symposium "Energy Recovery Linac Physics and Applications", Wednesday, March 16**

## Thank you for your attention.

## Have a joyful meeting and intense and fruitful discussions (across all topics).

Special thanks to all colleagues providing information and slides:
R. Assmann, W. Bahrt, E. Bründermann, F. Grüner, H. Schlarb, J. Köszegi,
A. Lehrach, M. Miski-Oglu, A.-S. Müller, U. Schramm, J. Sekutowicz,
P. Spiller, D. Winters and others I certainly forgot to mention (Sorry)