Introduction and Overview of HiBEF

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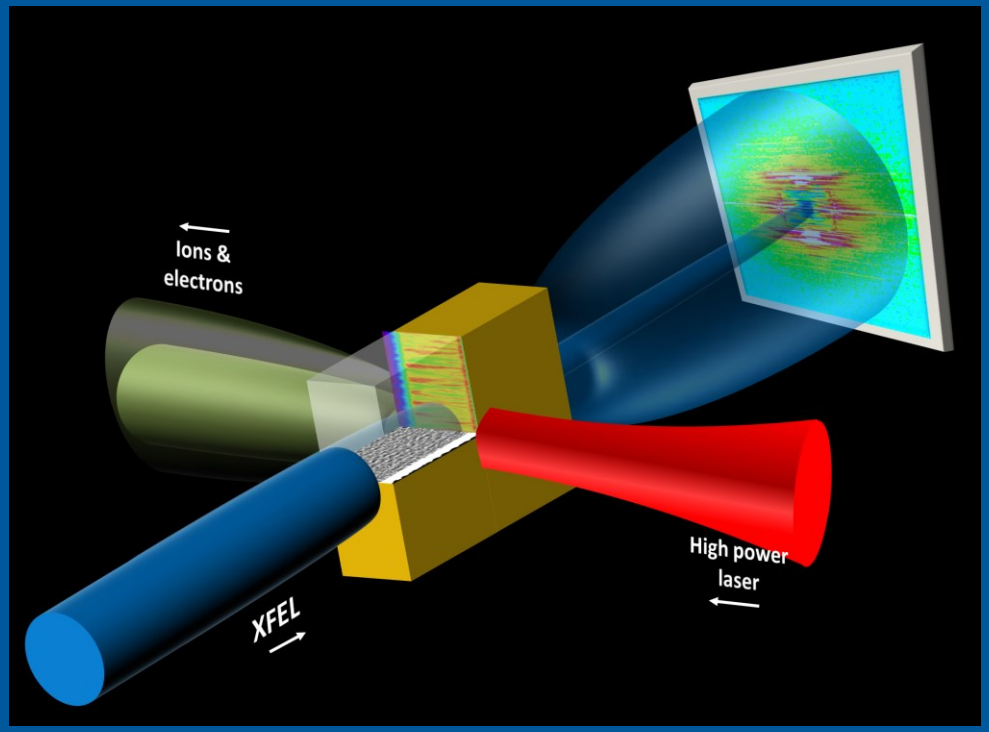
and on behalf of the HIBEF User Consortium



XFEL User Meeting
HED-HiBEF Satellite
22. January 2019

Goals of this meeting

- HiBEF Overview
- Driver Status
  - Installation
  - Commissioning with x-rays (internal, no proposal)
  - User Assisted Commissioning (collaborative proposals)
  - Open for General User proposals
- Science workshops & Day 1 experiment planning
- Outstanding needs & opportunities for UC members to contribute
- Suggestions from UC vis-à-vis priorities, needs

HiBEF – A short history

- First concept drafted at XFEL Users Meeting 2011.
- First Meeting in Dresden, September 2011

- Approval of User Consortium application by European XFEL, summer 2012
- Kick-off meeting for the HIBEF UC, 2 June 2013, DESY Hamburg.
- EPSRC funding of the DIPOLE D100-X laser (Oxford, STFC), autumn 2014.
- Final approval for HiBEF funding by Helmholtz Association, June 2015
- First user experiment at HED, 1. May 2019.

HiBEF – Helmholtz International Beamline for Extreme Fields

European XFEL

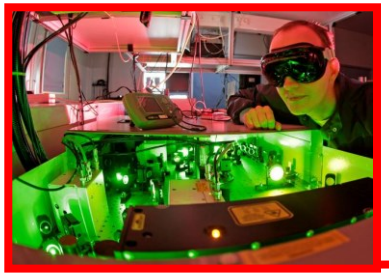
HiBEF User Consortium

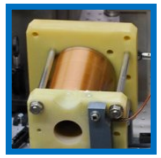
HED High-Energy Density science

HZDR DESY STFC, Oxford, CAEP

>80 institutions, 20 countries

(ca. 40 M€ committed, 12 M€ pending)



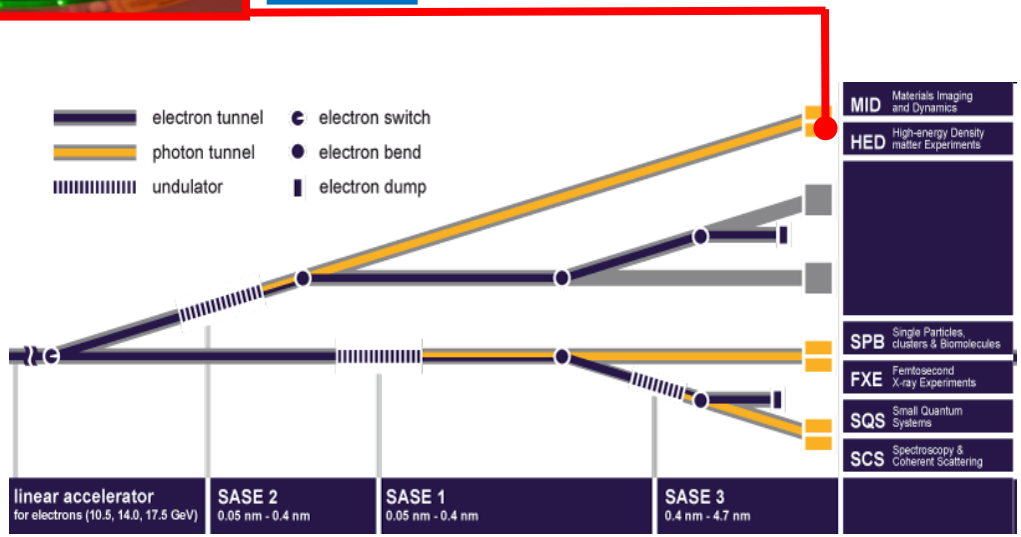


HIBEF: Laser Systems (0.1-10 Hz)

~PW, 30 J/30 fs (Ti:Sapphire)

~kJ, 2-20 ns shaped (Diode)

Pulsed Magnets (60 T, 1 ms)



1st lasing (SASE1)
04 May 2017

European XFEL

DRESDEN concept HZDR

HiBEF – Instrumentation Phase 1

European XFEL

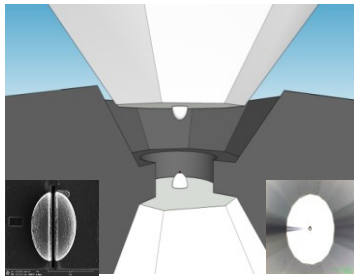
HiBEF User Consortium

HED High-Energy Density science

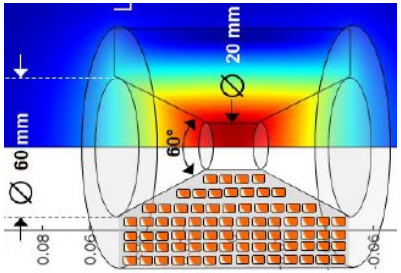
Amplitude Tech Pulsar 300 TW
Ti:Sa, 5 Hz (10.5 J / 25 fs)

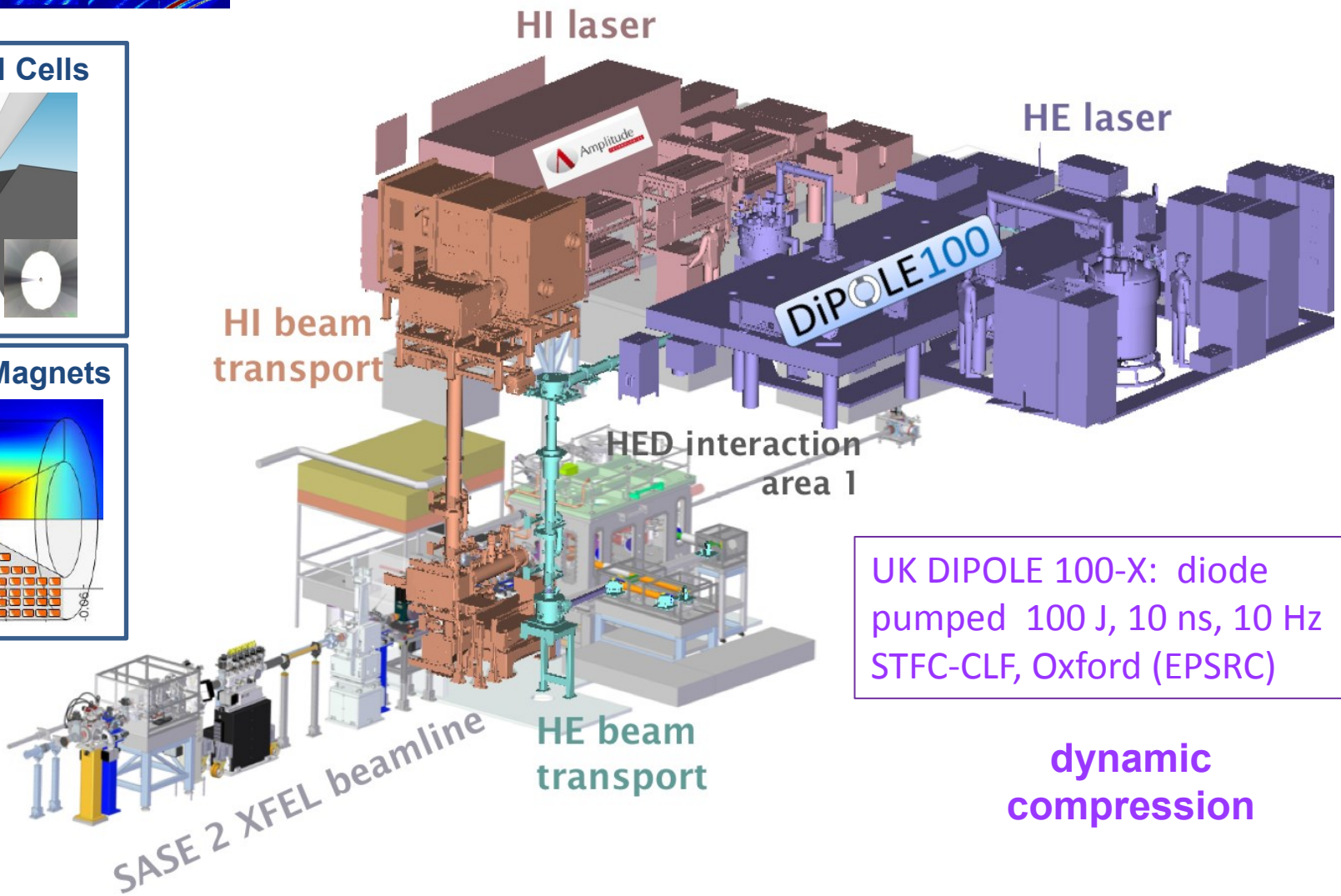
relativistic plasmas

Diamond Anvil Cells



50-60T Pulsed Magnets





UK DIPOLE 100-X: diode pumped 100 J, 10 ns, 10 Hz
STFC-CLF, Oxford (EPSRC)

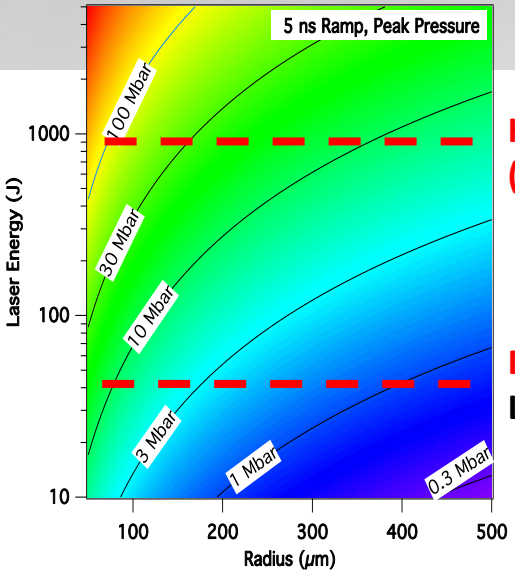
dynamic compression

HiBEF – Instrumentation Phase 2 (2023 -)

1 kJ (526.5 nm), 1-20 ns (shaped), 1 shot/hr, upgradable

中国工程物理研究院
CHINA ACADEMY OF ENGINEERING PHYSICS

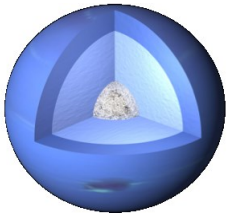
New Horizons in High Pressure Research

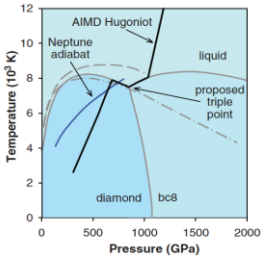


HiBEF-kJ (CAEP)

DiPOLE* LCLS/MEC

- ramp compression to 50 Mbar
- planetary interiors
- new phases, e.g. BC8 carbon
- Shock-ionized plasma
- kT magnetic fields





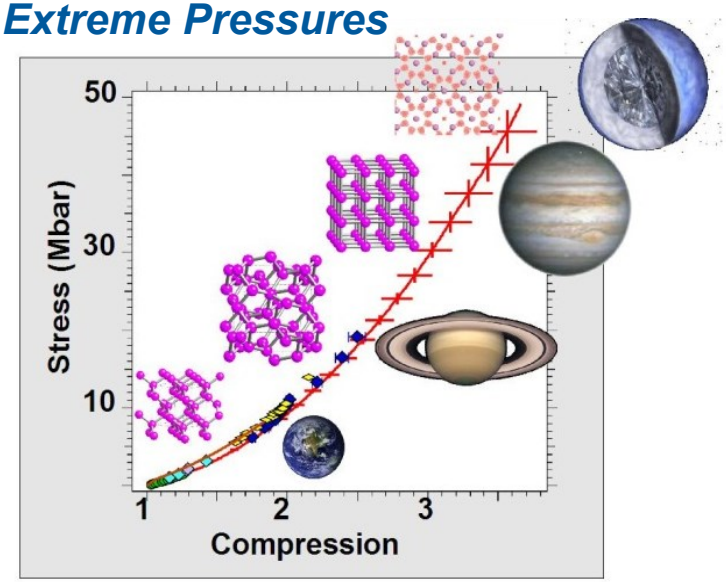
*Hz rep rate

DRESDEN concept HZDR

HiBEF – Exploring New Phases of Matter

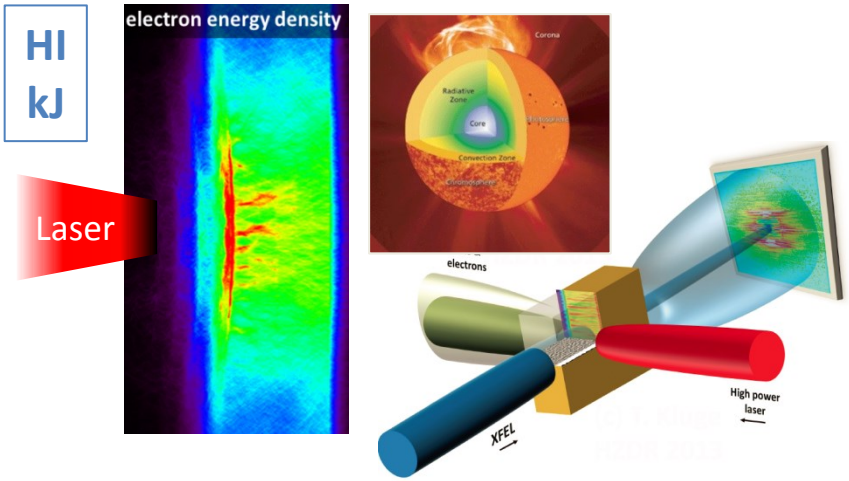
Extreme Pressures

DAC
HE
kJ



Extreme Plasmas & Temperatures

HI
kJ



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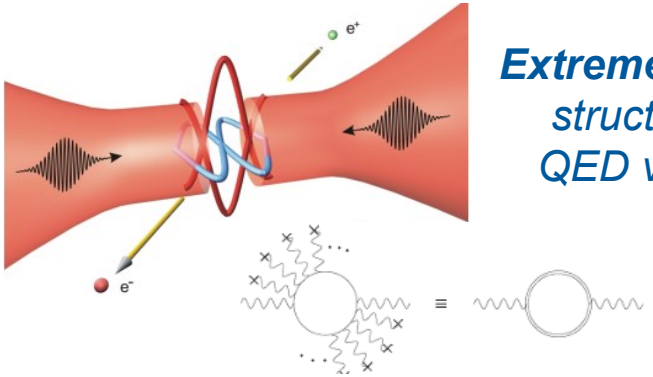
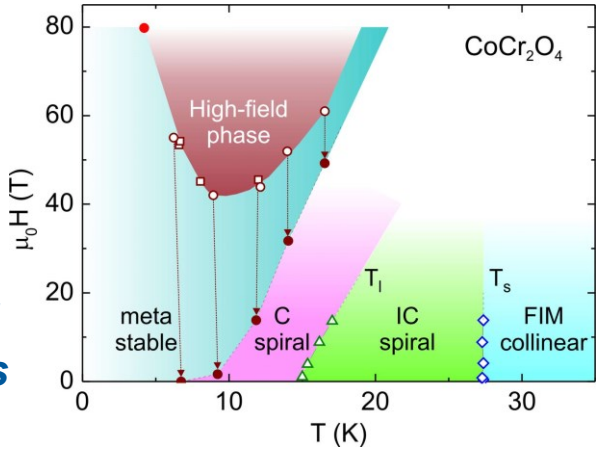


Extreme Fields:
structure of QED vacuum

PM



Magneto-structural transitions

Nat Mater **9** (2010) 624; Rev Mod Phys **84** (2012) 1607 (2012), Nat Comm 7 (2016) 10970 (2016); Phys Plasmas **21** (2014) 033110, Phys Plasmas **23** (2016) 033103 ; New J Phys **16** (2014) 023008; Phys Scr **91** (2016) 023010; Phys Rev Lett **110** (2013) 115502

HiBEF – User Consortium

Spokesman: T.E. Cowan (*HZDR*); **Management Board**: *E. Weckert (DESY), J. Wark (Oxford), R.Redmer (Rostock);* **Coordinator:** *C. Baehtz (HZDR*). **Laser Director:** *T. Toncian (HZDR).*

Germany: 29

CFEL, DESY, FZJ, GFZ, **GSI, HI-Jena,** HZB, **HZDR,** MBI, MPIC, MPIK, MPI-S, MPQ, MPSD, **Bayreuth**, HU Berlin, TU Darmstadt, **TU Dresden**, Duisburg, Erlangen, Frankfurt, Freiburg, Hamburg, **FSU-Jena**, Kiel, LMU-Munich, TU München, **Rostock, Siegen**

Europe & Assoc. Countries: 46

Graz, TU Wien (AT); PSI, EP-Lausanne, **ETH-Zurich**(CH); IOP-ASCR, CTU-Prague (CZ); Salamanca, UPM-Madrid (ES); IRAMIS-CEA, CEA-Arpajon, CELIA-Bordeaux, ESRF, Jussieu, **LULI, UPMC,** LNCMI, U Toulouse (FR); U Pecs, U Szeged (HU); Weizmann (IS); Politecnico-Milano, Sapienza-Rome (IT); MUT-Warsaw, NCBJ-Swierk, U Wroclaw (PL); IST-Lisbon (PO); JIHT-RAS (RU); Chalmers, Stockholm, Umea, Uppsala (SE); **Cambridge, Edinburgh, Imperial, QUB, UCL, Oxford, Plymouth, STFC, SUPA, Strathclyde, Warwick, York (UK)**; Eu-XFEL, ELI-DC, EMFL (EU);

Asia: 11

CAEP, IOP-CAS, PKU, **SIOM, SJTU (CN)**; Tata IFR, RRCAT (IN); GSE Osaka, ILE-Osaka, KPSI, Uni Kyoto (JP);

North America: 17

Alberta (CA), BNL, **UC Berkeley**, Carnegie Inst. Wash., Gen At, **LANL**, **LBL, LLNL**, Michigan, ORNL, **Ohio State**, U Penn, Rockefeller, **SLAC, UC San Diego**, UNR, UT Austin, **WSU** (US)

Major funding & In-kind contributions:

	HGF, HZDR, DESY:	28 M€	TW laser, DAC, PM, AGIPD,...
	UK (STFC, Oxford):	11 M€	DiPOLE Laser
Planned:	China (CAEP):	12 M€	kJ laser + operations *(CAEP approved)*
	US (6 inst.):	4-5 M€	*instrumentation (in planning)*

Operations (HZDR): + 3.5 M€ / year
(DESY): 0.3
(CAEP): 0.3

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	HI	HE	DAC	PM	kJ
Installation	2019-A	2020-A	2019-A	2020-A	2023-A
X-ray Commissioning (internal HED/HiBEF)	2019-B	2020-B	2019-B	2020-B	2023-B
User Assisted Commissioning (proposal)	2020-A	2021-A	2019-B / 2020-A	2021-A	2024-A
General User Proposals	2020-B	2021-B	2020-B	2021-B	2024-B

Workshops & Early experiment planning

- "DAC setup at the HED instrument at Eu.XFEL," 26 Jan 2016 , DESY *(CDR)*
- "Dynamic Laser Compression Experiments at the HED instrument at Eu.XFEL," 12-14 Sept 2016 , Schenefeld *(XFEL Proceedings)*
- "High Intensity Laser Matter Science at the HED instrument at Eu.XFEL," 5-6 April 2017, Schenefeld (Presentations online. summary in progress)
- "X-ray diffraction and spectroscopy in very high magnetic fields at the HIBEF," XUM Satellite meeting 22 Jan 2018 , Schenefeld *(PM science case document)*
- "kJ laser science case for HiBEF," XUM Satellite meeting 22 Jan. 2018, DESY *(kJ science case).*
  "kJ Laser Site Visit & CDR review", 15-17 May 2018, Minyang *(laser expert report)*
- "Early DAC experiments at the HED instrument at Eu.XFEL," 15-16 May 2018, DESY
- "Workshop on X-ray Polarimetry Experiments with HiBEF", 9. July 2018, Dresden (jointly organized by IOQ Jena &HZDR)

Workshops & Early experiment planning (2)

Recent Developments:

- VAREX detector for DAC experiments (until AGIPD ready...)
- Installation of Amplitude High Intensity HI laser at spec (OSAT pending)
- 100 J demonstration of DiPOLE laser at CLF (Acceptance Test pending)
  - *initially 70 J for expts, until sufficient operation experience (spare parts)*
- Advances in X-ray Polarimetry (FSU-Jena, HI Jena):
  New world record: 1.2e-10 for C(004) in diamond (9.83 keV)
  Limited by ESRF beam divergence – predicted <1e-12 at XFEL – approved for HED (May 19)
  → *Vacuum Birefringence may be feasible at present HiBEF HI (S/N ~1, vs 1e-3)*
  → *Near-single-shot x-ray Faraday rotation*

Upcoming Meetings:

- "Realization of high rep-rate compression science with DiPOLE at XFEL," spring 2019, at CLF (DiPOLE) -- *"Alleinstellungsmerkmal" – exploitation of high rep rate*
- "Early High Intensity Laser experiments at the HED instrument at XFEL", summer/fall 2019 - *community interests; SAXS, FR,... prioritization.*

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Next Steps -- legal / organizational

- XFEL – HZDR contract for HiBEF UC coordination
  - (hopefully) near final negotiation on 28.01.2019
    - responsibilities, liabilities....
- Specific HiBEF contributions (HI, DAC, HE, IC2, ...) are detailed in Annex
  - Announce planned contributions to XFEL Management Board
  - Select specific contributions for initial contract
- Review and Approval of XFEL-HZDR contract by XFEL Council
- Bilateral contracts with UC Members (HZDR–CLF, HZDR–DESY, etc...)
  - Add to the Annex , Approval by XFEL Management Board
- XFEL approval requires Funding Plan for Operations Costs
  - !

Investments, Operations costs & funding (no overhead*)

Major Systems (TW, DAC, PM, DiPOLE, kJ, XUL):

	Construction	Operating/yr	Sum
HGF – Strategic (HZDR, DESY)**	20.5 M€		20.5 M
HZDR - own contribution **	~5 M€	3.5 M€ (10 yr)	40 M
DESY - own contribution**	~2 M€	3 FTE+	5 M
UK (STFC, EPSRC-Oxford)	11 M€		11 M
China (CAEP, kJ)	12 M€	0.3 M€ (7 yr)	14 M
	50 M€*		90 M€*

X-ray Polarimetry (HI Jena)
SAXS (HZDR)
Nano-focus (DESY)
VISAR (HZDR, LULI, LANL)
Betatron (? - HZDR, LLNL, York...)
Others :
LANL, LLNL, UR, Stanford, ETH-Z,...

** TW, laser room, beam transport, controls, IC2,DAC, Det. Bench, PCI, AGIPD, XUL

Goals of this meeting

- Outstanding needs -- opportunities for UC member contributions

  - DiPOLE spares and consumables (cash, or purchased to spec)
  - SHG at high rep rate
  - Back-reflection Isolation

  - Other laser optics (purchased to spec)
  - Coatings (?)

  - VISAR (guaranteed by HZDR) -- contribution by LULI or LANL frees budget
  - Spectrometers & diagnostics (particle, x-ray, laser)
  - X-ray detectors

  - Diamonds (for DACs)
  - Target fabrication service; target component supply (e.g., Visar windows)
  - Debris shields

  - Laser Operations staff

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