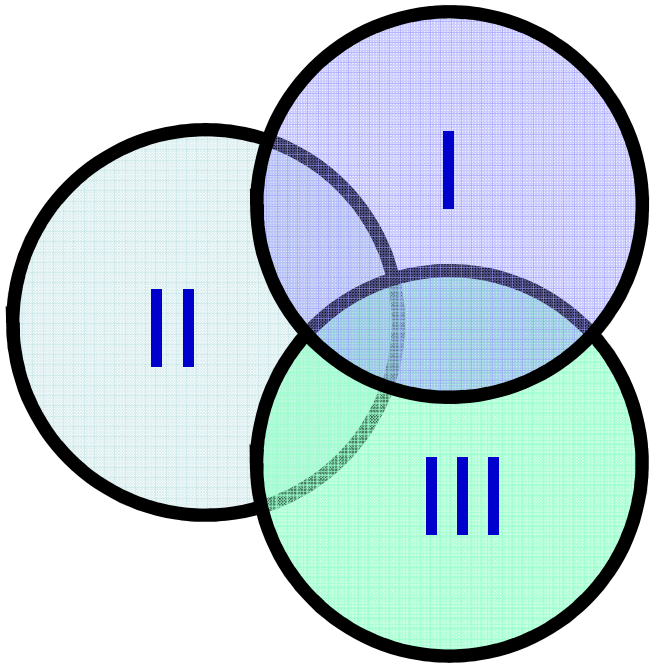
Introduction ARD – Subtopic 3
“ps – fs Electron and Photon beams”

H. Schlarb (DESY)	**ST3-I**
Michael Gensch (HZDR)	**ST3-II**
Anke-Susanne Mueller (KIT)	**ST3-III**



- I Laser induced radiation & synchronization
- II Ultra-fast pulse diagnostics
- III (Coh.) photon radiation & interaction

DESY KIT GSI HZDR HZB Helmholtz Zentrum Berlin

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Introduction ST3: “ps – fs Electron and Photon beams”

Categorization of different activities to sub-tasks

- **I Laser induced radiation & synchronization**
  - High power lasers usage for the photon radiation generation process
  - Precision synchronization as pre-requisite for future accelerators / application
- **II Ultra-fast pulse diagnostics**
  - ps – fs electron bunch profiling & control
  - ps – fs photon pulse profiling & control
  - At low / high charge & low / high repetition rates (dynamic range!)
- **III (Coh.) photon radiation & interaction**
  - Frontier of photon radiation from electron bunches w.r.t. to user operation
  - Self-interaction & dynamics due to coherent radiation (CSR/Micro-bunch inst.)
  - Advanced photon radiation source development

Strong overlap and interaction among Sub-Topics3 I,II, III

Introduction ST3: “ps – fs Electron and Photon beams”

Recommendation “*ARD reviewers*” & *internal discussions*:

> Activities within ST3 should **focus** on few goals of **strategic importance**

> Activities **directly supporting** ARD programs **PT1 & PT4**

> **Optimal use** of **exist research infrastructure** to carry out R&D program

> Improved **networking** among HGF accelerator research facilities to **maximize synergies** (exchange of know-how/resource & technologies)

> **Education and training** of young researchers / students / scientists

ARD advisory committee Nov 2011:

> Generally **ST3 program and goals** were well received!

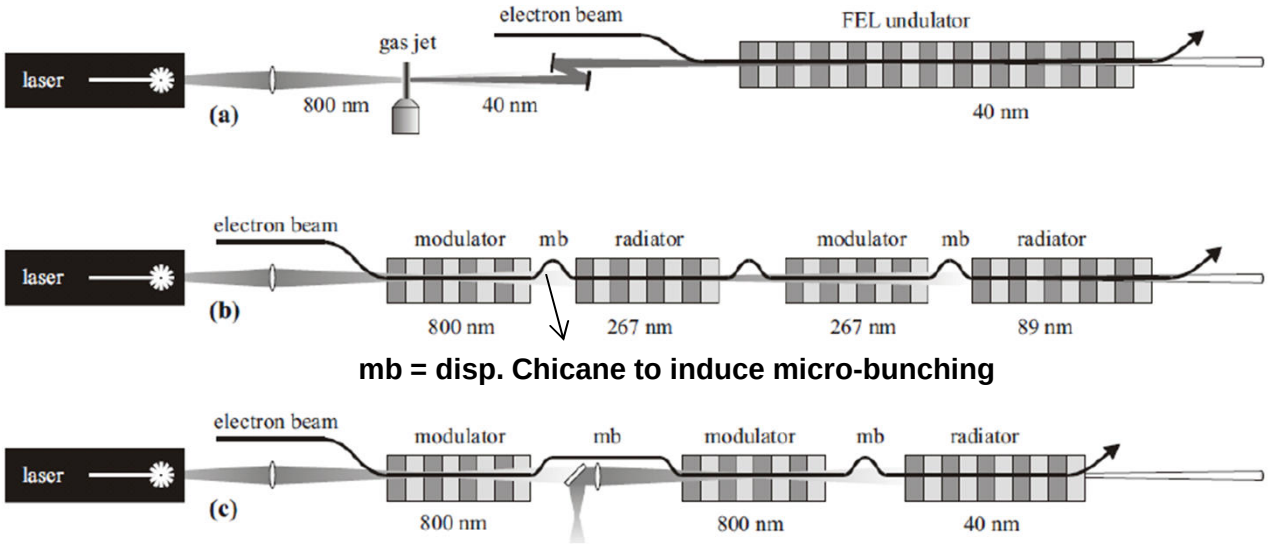
> **ST3** play an **important role** in a wide spectrum of HGF centers

> Establish clear **objectives and milestones** for ‘short term’ R&D projects

> Short pulse from **PWA for injection** in accelerators ⇔ **ST4**

Introduction ST3-I: Laser induced seeding

> Different frequency up-conversion schemes envisioned



Courtesy: S.Khan

HHG (proven ~ 60nm)
High Harmonic Generation
(D. Garzella et al. [2004])

HGHG (established ~30nm)
High gain Harmonic Generation
(J.Wu et al. [2001])

EEHG (proven ~ 350nm)
Echo-Enabled Harm. Generation
(E. Stupakov [2009])

> Different Tolerance & Flexibility & Capability depending on schemes

> Fundamental to all: <u>up-conversion limitation</u> (~1-10nm expected)

- Problem with phase noise & spatial – frequency errors of laser pulse
- Frontier of laser physics: Diagnostics / Optics / Actuators to level of < 1/10 * λ_{laser} / m

> 'Short term' objectives:

- Establish XUV seeding down to ~ 10 nm @ FLASH
- Establish EEHG at storage ring DELTA

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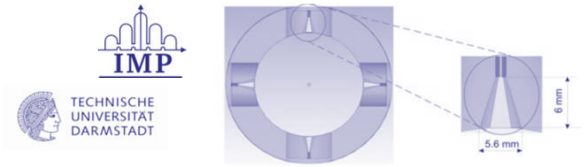
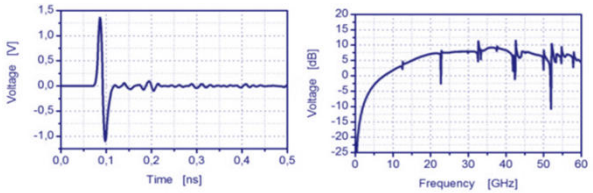
Introduction ST3-I: Synchronization

- Precision (fs) synchronization required for:
  - External laser seeding
  - Pump-probe experiments using photon pulses from ultra-short e- pulses
  - Laser plasma acceleration using external injection
  - Laser pulse - electron pulse collision





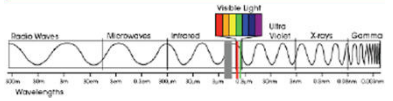
- Main challenges:
  - HL / LLRF controls [RF power source | SRF / NRF & Pulsed / CW]
  - Synchronization reference [Pulse optical / CW optical / CW RF interferometer]
  - High power laser [Osc./Reg./Multipass/OPAs/Transport]
- Achievable synchronization depends on
  - Environmental conditions [Temp/humidity/EMI/pressure/vibration/ground motion]
  - Beamline layout/operation [R56/Current/Compression scheme]
  - Control system capabilities [Slow/Fast FB/DAQ system/flexibility]
- 'Short term' objectives:
  - Establish 10 fs rms synchr. of electron beam w.r.t. synchr. reference
  - Establish precision synchronization techniques at HGF centers

Courtesy: Bock/Schultz/Lamb

Introduction ST3-II: Ultra-fast pulse diagnostics

- Precision ps-fs profile diagnostic demands
  - Pump-probe exp. with ps-fs electron pulses or hereby generated ps-fs photon pulses
  - Laser plasma acceleration using external injection
  - Laser pulse - electron pulse collision
  - Understand and debug of accelerator sub-system & dynamics
- Main challenges:
  - Low charge / Low energy / Dynamic range [sensitivity/transverse coherence]
  - Single shot diagnostic at high repetition rates [fast read outs/processing/feedbacks]
  - Phase sensitive detection at GHz rep.rates [GHz LockIn amplifiers]
  - Reasonable costs
- Achievable diagnostic depends on
  - Repetition rate/fill pattern [e.g. for phase sensitive detection or single shot meas.]
  - Bunch charge/beam current [pC - nC regime, uA – 100mA regime]
- 'Short term' objectives:
  - Establish 10 fs resolution profiling of electron bunch (incl. arrival time)
  - Spread established diagnostics tools into HGF centers. / may tailored / may improved
  - Establish test bench for ps-fs diagnostics development

Introduction ST3-III: Coh. photon radiation & interaction



> Short electron - photon pulse demands
  - Provide variable & broadband photon source in THz regime (photon gap)
  - Ultra-short electron pulses for XUV/X-ray photons production (evolution dynamics)
  - Time resolved pump-probe electron diffraction spectroscopy (evolution dynamics)
  - Single spike operation for FELs (coherence length)
  - Ultra-short electron pulse generation for LWA (plasma wake)

> Main challenges:
  - Linacs: destructive coherent effects e.g. in chicanes/SC instability
    non-linearities and correlations
  - Rings: short pulse in multi-user operation mode with VSR
    coh. THz generation in multi-user operation with seeded micro structures
  - General: complex radiation process especially if beam dynamics is effected
  - Improved wavelength reach by HTS ultra-short period undulators

> ‘Short term’ objectives:
  - Design, build & test first HTS undulator prototype
  - Test schemes for multi-user operation with CSR from short bunches or micro-bunches
  - Establish Helmoltz-wide virtual facility for CSR studies
  - Establish task force for the development / benchmarking of common simulation codes (micro-bunch instability, instabilities, pulse formation, beam transport, etc.) …

Introduction ST3: Workshop goals & structure

- Strengthen networking and identify further collaboration topics
- Identify synergies among centers:
  - Exchange of know-how exchange
  - Exchange of personnel
  - Technology transfer
  - Research / test opportunities
- Educate and attract young scientist to ARD
- **Update on accelerator facility infrastructure & scheduling & plans**
- Exchange of information on current activities related to ST3

09:30	[2] TELBE	Dr. GENSCH, Michael
09:50	[3] ANKA & FLUTE	Dr. MUELLER, Anke-Susanne
10:10	[4] FLASH & FLASH II	Dr. SCHREIBER, Siegfried
10:50	[5] REGAE	Dr. FLOETTMANN, Klaus
11:10	[6] DELTA	Mr. MOLO, Robert
11:30	[7] BERLinPro & BESSY II perspectives	Mr. JANKOWIAK, Andreas

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- **Exchange of information on current activities related to ST3-I**

14:00	[13] Seeding schemes & EEHG at DELTA	Prof. KHAN, Shaukat
14:25	[10] sFLASH first seeding results	Dr. MILTCHEV, Velizar
14:50	[11] Status of EEHG seeding at FLASH	Dr. HACKER, Kirsten
15:10	[12] UV Frog for laser pulse characterization	Mr. LEE, Dongjoo
15:50	[31] LLRF development at DESY for SRF / NRF cavities	Dr. SCHMIDT, Christian
16:15	[15] Optical synchronisation at HZDR	Mr. KUNTZSCH, Michael
16:40	[14] Optical synchronization developments at FLASH	Mr. SYDLO, Cezary
17:00	[16] Femtosecond RF reflectometry for synchronization	Mr. SIKORA, Dominik

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- **Exchange of information on current activities related to ST3-II**

09:00	[18] Challenges of pulse length measurements at REGAE	Dr. SCHMIDT, Bernhard
09:25	[21] Photon pulse length measurement techniques	Dr. STOJANOVIC, Nikola
09:50	[19] Latest results with the THz spectrometer CRISP4	Mr. WESCH, Stephan
10:10	[20] First ultra-short pulse diagnostics at ELBE	Dr. GENSCH, Michael
10:50	[32] Ultra-fast data acquisition of CSR	Dr. CASELLE, Michele
11:10	[22] Time domain studies on bursting CSR	Mr. JUDIN, Vitali
11:30	[23] EOS at storage rings	Ms. HILLER, Nicole
11:50	[24] Discussion ST3-II	

Introduction ST3: Workshop goals & structure

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- Update on accelerator facility infrastructure & scheduling & plans
- **Exchange of information on current activities related to ST3-III**

13:30	[25] Short photon pulse generation at storage rings	Mr. WUESTEFELD, Godehard
14:00	[26] Field propagation and formation of CSR	Dr. SCHWARZ, Markus
14:20	[27] Recent developments in high temp. SC undulators	Dr. HOLUBEK, Tomas
14:40	[28] Radiation loss & CSR at BERLinPro	Dr. BONDARENKO, Alexey

15:20	[29] Discussion ST3-III	
16:00	[30] Close out	Dr. SCHLARB, Holger

Introduction ST3: Workshop goals & structure

- Strengthen networking and identify further collaboration topics
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  - Exchange of personnel
  - **Technology transfer**
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11:50	[8] Validation Fond "MTCA.4 for Industry"	Mr. REHLICH, Kay

Satellite workshop:

MTCA.4 for Industry and Research
09:00-15:00 Thursday, August 23, 2012
Room: Sem. Room 04b, Building 01b

PT3: ps – fs Electron and Photon beams

Organization:

- Lunch in Seminar room next door!
- 2 REGAE tours (~12.40 / ~13.20)
- Appetitive DESY Bistro 18.30
- Dinner ~ 19.00
- Tomorrow lunch in canteen
- WLAN: passwd
- Like to thank: Karin Brandis/Gohar Ayvazyan/ Syzmon Jablonski

PT3: ps – fs Electron and Photon beams

Thanks for attention