Highlights of the 27th International FEL Conference

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CASA Beam Physics Seminar, September 15, 2005

Thomas Jefferson National Accelerator Facility

General

- **Conference hosted by SLAC**
  - **held at Arrillaga Alumni Center, Stanford University**
    - **Aug.21~26, 2005**
    - **~254 presented papers**
    - **~285 participants**

- **FEL Prize went to**
  - **Prof. Avrahama Gover,**
    Israeli FEL Project, Tel-Aviv University

- **New power records: JLab**
  - 4.2 kW at 2.8 microns,1.1 kW at 1.1 microns
  - 1 kW at 1.6 microns,80 W broadband tunable from 1.1 to 3.1 μm

- **New ideas and ambitious plans**
  - **X-Ray FEL increased momentum (LCLS, 4GLS…)**
  - **100KW optics-free FEL proposal**

FEL Prize Talks

- ***Hiroyuki Hama***

Dream of Isochronous Ring Again

Concept to preserve microbunch form-factor

fs pulse production through thermionic RF gun
preserve "microbunches" in a ring
"zero" momentum compaction factor
Cancel out path-length deviation from betatron motion
Coherent THz SR and RING-SASE-MODE
Possible extended performance of isochronous ring

- ***Valdimir N. Litvinenko***

Optics-Free FEL Oscillator

"Electron-out-coupling"/e-beam feedback
Free from the spectral/power limitation caused by optics
Requires high quality electron beam

The Year of Physics and New Lasing

➢**The Year of Physics Talk** *Andrew Sessler (LBNL)*

Einstein: His Impact on Accelerator, His impact on the world

Interesting history about his work and life

➢**New Lasing**

- *S. Schreiber* (DESY), VUV-FEL at DESY

  SASE, saturated at 32nm
- *H.Yamada* (SLLS, Shiga)

  Photon Storage Ring FIR Laser

  20Mev Synchrotron/ Lase at 30, 100 and 160 μm
- *S.Benson* (JLab), Progress and status at JLab

  4.2 kW at 2.8 microns,1.1 kW at 1.1 microns

  1 kW at 1.6 microns,80 W broadband tunable from 1.1 to 3.1 μm
- *Y.Wu* (Duke FEL)

  Two OK-5 wigglers in optical klystron configuration

High Gain Single Pass FELs

- ***Luca Giannessi'***
  - Superradiant pulse passing through cascade FEL
  - Regeneration at wavelength of higher order harmonic
  - Strongly chirped, compression to as pulses

- **Pohang Accelerator Laboratory(Korea)**
  - Started SASE-based XFEL project (*PAL-XFEL)*
  - Upgrading 2.5GeV to 3.7GeV possibly 4.5GeV
  - Wavelength ~ 0.18nm. Use IVU.

- **Project at Spring-8 Compact SASE**
  - Source (13th harmonic of Ti:S laser generated in Xe gas)
  - Very short wavelengths, compactness, tunability
  - Demonstration experiment expected in 2006

High Power, Long Wavelength FELs

- *Progress in high-power FEL oscillators* (*S.Benson,JLab)*
  - Challenges towards higher power:
    energy recovery with large exhaust energy spread,
    output coupling and maintaining mirror figure
    High current operation in ERL
  - Achievements and future roadmap

- *BNL likes amplifiers (Ilan Ben-zvi)*
  - Application for very high average power generation
  - High power, high brightness/efficiency photo-injectors plus ERL
  - 100 kW FEL/0.5 ampere ERL plan

- KAERI developed a user facility with compact THz FEL
  - FEL wavelength 100-1200um
  - 1KW peak power, pulse 30 ps, 0.3 mJ/3us
  - . Application: THz bio-medical imaging
    THz spectral characteristics of several materials studied

FEL Technology I: Accelerators

- *ERL, L.Merminga(JLab)*
  - Challenges in designing various ERLs
  - Progress and development plans

- *Overview of XFEL facilities (Winfried Decking,DESY)*
  - LCLS, XFEL (DESY), SCSS (Spring8), all SASEs!
  - Challenges of required e-beam quality
    Space charge forces, CSR, wakefields
    Low-emittance gun, buncher, accelerating structure/undulator

- *Compression*
  Luca Serafini talked about
    - Velocity and Magnetic Compressions
    - How to achieve the merits of both and to mitigate issues

  T. Limberg analytical and numerically studied
    - *Stability Dependence on RF Parameters*
    - Sensitivity of compression factor on phase and amplitude jitter

FEL Technology II: Undulators

- In-vacuum undulator (IVU) *T. Tanaka(Spring8)*
  - Technical challenge, PM, Impedance, Field correction
  - 1st at KEK, 20 installed at Spring8. Future CryoUndulator

- European XFEL ~ 0.1nm *J. Pflueger (DESY)*
  - . Stringent requirements on performance
    200m/40-50 segments
  - A Photon Diagnostic Station,
    beam steering in undulator, gap tuning, phase matching

- Chamber material for LCLS undulator *S.H.Lee (ANL)*
  - Fabrication, investigation of relative magnetic permeabilities
    316LN, 20Cb-3, Nitronic 33, Nitronic 40 and 310S
  - 3" long vacuum chambers fabricated with
    permeability measurement, field variations i/o vacuum

FEL Oscillator and Storage Ring FELs

- *"Chaos Control" Serge Bielawski(PhLAM/CERCLA)*
  - Feedback Control Of Dynamical Instabilities
  - Results on the stabilization of ML lasers, super-ACO, ELETTRA and UVSOR FELs

- *M. Hosaka (UVSOR, Okazaki)*
  - Saturation and bunch heating
  - Energy spread, bunch lengthening from bunch-laser pulse interaction
  - New beam optics for low emittance
  - Change of saturation process according to the chromatic or achromatic optics

- *K. Chalnut (Duke U.)*
  - Giant Pulses Phase-Space Tomography
  - Two profiles to reconstruct phase space

High Brightness E-Beams and Diagnostics

- *PITZ(Photo Injector Test Facility at DESY Zeuthen)*
  - Tested, optimized transverse emittance,
    1.4 mm mrad for 90% of a 1 nC bunch/127Mev
  - Longitudinal bunch profile/structure revealed (<50fs Res.)

- *Cornell 100mA injector*
  - 100mA/ 570KV DC gun, 5-15 MeV/5 two-cell/1300 MHz cavities.
    Power limited to 575 kW
  - Genetic algorithm based computational, rms normalized emittances
    0.1 mm-mrad at 80 pC/bunch, 0.7 mm-mrad at 1 nC/bunch.

- *Three ongoing injectors at AES*
  LANL/700MHz/NRF/100mA (2006),
  JLab/748.5 MHz/SRF/100mA(2007)
  BNL/half-cell 703.75 MHz/ SRF/500mA(2007)

High Brightness E-Beams and Diagnostics

- *"Dream Beam"*
  - shaping bunch *Luiten (TUE, Eindhiven)*
    - Real problem: space charge density distribution,
      Not high space charge density
    - Ideal "Waterbag" electron bunches –
      Uniformly filled, hard-edged ellipsoids
    - Linear self-fields/thermal-emittance-limited
      KA bunch by compression
    - Extracting electrons from ultra-cold plasma,
      Thermal emittance below 0.1 micron

  - shaping laser pulse *Limborg-Deprey (SLAC)*
    - To compensate space charge effects with arbitrarily shaped laser pulse
    - Normal conducting RF guns, ideal 3D-ellipsoidal shape bunch

New Concepts

- *Laser Plasma Sources for High Brightness Beams: From THz to X-rays*
  W.Leemans (LBNL)

  Laser driven accelerator, 2 laser beam, channel guiding, 100Mev/0.3nC produced

- *FEL Applications in EUV Lithography* *Michael Goldstein* (Intel Co.)
  Novel hybrid klystron, high gain harmonic generation FEL with oblique laser seeding
  Opportunity/challenges for FELs as 2nd generation (year 2011-2013) source

- *Feasibility Study of a Beat-Wave Seeded THz FEL at the Neptune Laboratory*
  Sven Teiche (UCLA)
  - seed the FEL with two external laser beams
  - Difference (beatwave) frequency matched to resonant FEL frequency in THz range

- *Femtosecond Synchronism of X-Rays to Visible Light in an XFEL*
  Berhard Adams (ANL)

  Emittance slicing in a free-electron laser with transition undulator radiation (TUR)

- *Harmonic Lasing in an FEL Amplifier* *Brian McNeil* (Strathclyde U)
  Harmonic lasing by disrupting the interaction between the fundamental radiation field and electrons while allowing harmonic interaction to evolve unhindered

- *A Coherent Compton Backscattering High Gain FEL using an X-Band Microwave Undulator* *Claudio Pellegrini (UCLA)*

FEL Theory

- *Z.Huang(SLAC) presented*
  understanding ***startup, exponential growth and saturation*** *of high-gain process, emphasizing SASE, various errors/wakefield effects*

- *Rodolfo Bonifacio (INFN-Milano) introduced*
  Quantum Theory *of SASE-FEL with Propagation Effects, demonstrate* ***"quantum purification"*** *of SASE*

- *Avraham Gover (Tel-Aviv) showed*
  Unified analysis *for Superradiant emission from bunched e-beams in various kinds of radiation scheme*

- *Giuseppe Dattoli has extended*
  Pulse propagation *of low gain FEL oscillators to high gain regime*

Soft and Hard X-Ray FELs

- *Overview*

- *Reviews of Existing Soft and Hard X-Ray FEL Projects*

  Giuseppe Dattoli

- *Recent Results from SPPS, Includg. Pump-Probe Timing Measurements*

  David A. Reis

- *Characterization of X-Ray FEL Radiation*

  Richard Bionta (LLNL)

- **Advantages/drawbacks of different conception**
- **Outlook to future development**
- **SLAC hard x-ray pulses as short as 80fs**
- **Plans for the instrumentation in LCLS**

Soft and Hard X-Ray FELs

❑ *FS Pulses, Reduced Line Width, Synchronization*

- Pump-probe and EO sampling measurement down to 100fs
  Philip Bucksbaum (Mich. U)

- Distributed optical system tested, 200fs jitter/over 1 km fiber link
  Axel Winter (DESY, MIT)

- FERMI FEL, single-stage HG > 40 nm, 2-stage cascade from 40 ~10 nm, <1ps *C. Bocchetta (ELETTRA)*

- Optical Heterodyning Techniques and Synchronization of ML Lasers Using Two Spectral Lines for jitter down to few fs *J. Staples (LBNL)*

- *OPA Synchronized to DESY VUV-FEL, 0.5ps jitter/Two-Color Pump-Probe Experiments* *Ingo Will (MBI)*

Soft and Hard X-Rays FELs

- *X-Ray Optics, Detectors, Absorption, Scattering and Imaging*

- *Nano-Focusing: to focus hard x-rays below 100 nm, toward 1 nm*
  T. Ishikawa (Riken)

- *3D Coherent X-Ray Diffraction Microscopy: a novel form of diffraction microscopy, 7nm resolution at Spring8*
  J.Miao (UCLA)

- *Diffraction Simulations of the LCLS FEL Pulse on Crystals. Coherence degradation due to multi-eigenmodes and collective beam motion, proposed TC measurement*
  Sven Reiche(UCLA)

JLab Presentations

- *Recent Results from the IR Upgrade FEL at Jefferson Lab* — *S.Benson*
- *Design Challenges in High Power Free-Electron Laser Oscillators* (Invited) — *S.Benson*
- *High Power CW Operation of a Hole-Outcoupled Free-Electron Laser* — *M.Shinn*
- *Calculations and Mitigation of THz Mirror Heating at the Jefferson Lab FEL* — *G.Williams*
- *Incorporation of a PbSe Array Based Spectrograph into EPICS using LabView at the JLab FEL Facility* — *D.Hardy*
- *Laser Safety System for the IR Upgrade FEL at Jefferson Lab* — *J.Coleman*
- *Temporal Characterization of Electron Beam Bunches with a Fast Streak Camera at the JLab FEL Facility* — *S.Zhang*
- *Characterization and Performance of a High-power Solid-State Laser for a High-Current Photocathode Injector* — *S.Zhang*

Information

- ***FEL2006 will be in Berlin, Germany***