

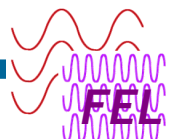
Highlights of the 27th International FEL Conference

Shukui(Joseph) Zhang
CASA Beam Physics Seminar, September 15, 2005

Thomas Jefferson National Accelerator Facility



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

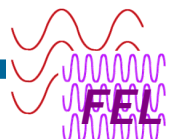
X-Ray FEL increased momentum (LCLS, 4GLS...)

100KW optics-free FEL proposal



Thomas Jefferson National Accelerator Facility

Operated by the Southeastern Universities Research Association for the U.S. Dept. of Energy



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

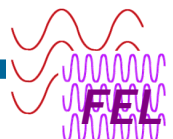
Free from the spectral/power limitation caused by optics

Requires high quality electron beam



Thomas Jefferson National Accelerator Facility

Operated by the Southeastern Universities Research Association for the U.S. Dept. of Energy



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

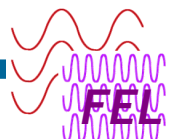
➤ New Lasing

- *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



Thomas Jefferson National Accelerator Facility

Operated by the Southeastern Universities Research Association for the U.S. Dept. of Energy



High Gain Single Pass FELs

▪ *Luca Giannessi'*

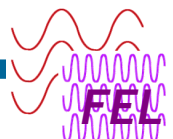
- Superradiant pulse passing through cascade FEL
- Regeneration at wavelength of higher order harmonic
- Strongly chirped, compression to as pulses

▪ **Pohang Accelerator Laboratory(Korea)**

- Started SASE-based XFEL project (*PAL-XFEL*)
- Upgrading 2.5GeV to 3.7GeV possibly 4.5GeV
- Wavelength $\sim 0.18\text{nm}$. Use IVU.

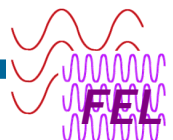
▪ **Project at Spring-8 Compact SASE**

- Source (13th harmonic of Ti:S laser generated in Xe gas)
- Very short wavelengths, compactness, tunability
- Demonstration experiment expected in 2006



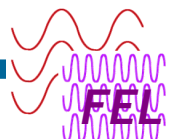
High Power, Long Wavelength FELs

- *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



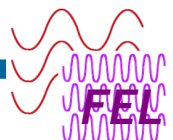
FEL Technology I: Accelerators

- *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



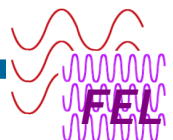
FEL Technology II: Undulators

- **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



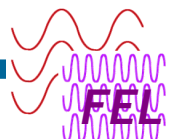
FEL Oscillator and Storage Ring FELs

- *“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



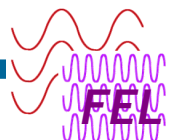
High Brightness E-Beams and Diagnostics

- *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, Eindhoven)*
 - 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)

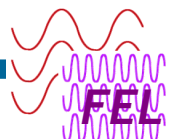
Harmonic lasing by disrupting the interaction between the fundamental radiation field and electrons while allowing harmonic interaction to evolve unhindered

- *A Coherent Compton Backscattering High Gain FEL using an X-Band Microwave Undulator*

Claudio Pellegrini (UCLA)

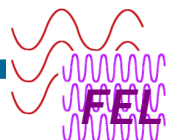


Thomas Jefferson National Accelerator Facility



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*

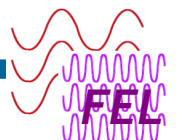
Richard Bionta (LLNL)

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



Thomas Jefferson National Accelerator Facility

Operated by the Southeastern Universities Research Association for the U.S. Dept. of Energy



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)

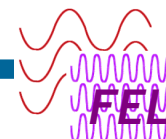
- OPA Synchronized to DESY VUV-FEL, 0.5ps jitter/Two-Color Pump-Probe Experiments

Ingo Will (MBI)



Thomas Jefferson National Accelerator Facility

Operated by the Southeastern Universities Research Association for the U.S. Dept. of Energy



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*

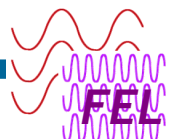
J.Miao (UCLA)

- *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)

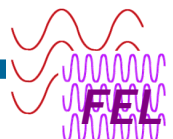


Thomas Jefferson National Accelerator Facility



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*



Thomas Jefferson National Accelerator Facility

Operated by the Southeastern Universities Research Association for the U.S. Dept. of Energy

