

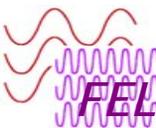
Highlights of the 2004 FEL Conference

Carlos Hernández García
Beam Physics Seminar, September 10, 2004

Thomas Jefferson National Accelerator Facility

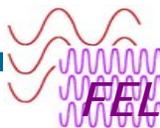


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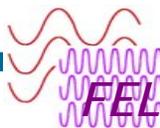
General Remarks

- Conference held at Trieste, Italy. Hosted by ELETTRA
- FEL prize winners:
 - Vladimir Litvinenko (BNL) and Hiroyuki Hama (Tohoku) for contributions to the use of SRFELs into the field of nuclear physics
- Power Records: *JLab FEL 10 kW in 1 sec pulses!!!*
- First light lasing: ELBE at Rossendorf in the mid-IR (3 W, 0.6 ms, 50 pC, 16.1 MeV, 1mA CW)



JLab FEL contributions

- High Power Lasing in the IR Upgrade FEL at Jefferson Lab (S. Benson)
- Making an Inexpensive Electromagnetic Wiggler Using Sheet Materials for the Coils (G.Biallas)
- Performance and Modeling of the IR FEL Upgrade Injector (C. Hernandez-Garcia)
- Longitudinal Space Charge Effects in the JLab IR FEL SRF Linac (C. Hernandez-Garcia)
- High Average Power Operation of a Scraper-Outcoupled Free Electron Laser (M. Shinn)
- Suppression of Multipass, Multibunch Beam Breakup in Two Pass Recirculating Accelerators (C. Tennant)
- Short Electron Beam Bunch Characterization through Measurements of THz Radiation (S.Zhang)



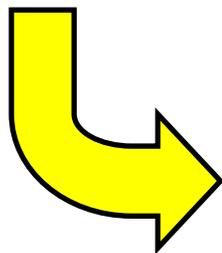
Conference highlights by Mike Poole

- . Biggest topic: New concepts in guns/cathodes
 - . Diamond cathode (Ilan Ben-Zvi at BNL)
 - . Needle cathodes (C. Brau at Vanderbilt, and R. Ganter ETH, Zürich)
 - . Field Emitter Arrays (K. Li at ETH, Zürich)
 - . **But no mention of JLab FEL DC Gun!!!**
- . Nice historical overview:
 - . First ever FEL conference in 1979 held at Stanford ~20 people
 - . 1979-1983 the early days
 - . 1983-1990 Star Wars! Mature FEL theory, IR users, ~200 people
 - . 1990-2000 Worldwide recognition of FELs
 - . 2000-2004 X-FEL projects, High CW power demonstrated, ultra-high brightness beam source development
- . Steve, Michelle, and T. Smith talks mentioned in the highlights, but no LSC

Looks like I failed to transmit the message:

- . It's not CSR
- . It's not the RF system
- . It's not the wake fields...

...It's SPACE CHARGE!!!



Bunch is too short at injection!

*LONGITUDINAL SPACE
CHARGE MATTERS!!!*

However, two groups recognized importance of LSC and longitudinal emittance compensation in the injector

- Rossendorf:
 - P. Evtushenko will extend PARMELA modeling to the entrance of the wiggler following our injector setup, lengthening the pulse at the entrance of the accelerator
- LCLS
 - Z. Huang (SLAC) agrees with our observations/modeling on growth of intrinsic energy spread. They observe microbunching instability driven by LSC, since intrinsic energy spread from SRF gun is only 3 keV (11 keV for our DC photocathode gun).

High power lasers

- Status of the Novosibirsk THz FEL by N. A. Vinokurov
 - Commissioned in 2003
 - Normal conducting ERL
 - 100 W CW lasing at 120-180 microns
- High Power Lasing in the IR Upgrade FEL at Jefferson Lab by S. Benson
 - Very well received (everyone sends congrats to JLab team)
 - JLab FEL recognized as the only and true high CW power FEL in the world
 - George Neil and Avraham Gover (U. of Tel-Aviv) put the new bet on the table for 100 kW lasing in 1 sec. pulses

FEL Theory

- Benchmarking codes, getting closer and closer in predicting machine behavior
 - Start-to-end simulations (PARMELA > ELEGANT > GENESIS)
- Still, everyone stops PARMELA modeling at injection!
- Microbunching instabilities, CSR/LSC after bunch compression
- New theories for Smith-Purcell FEL (C. Brau, K.J. Kim)

Short wavelength FELs

- UV FELs
 - TTF injector for the DESY VUV-FEL project
 - VUV Optics Development for ELETTRA SR FEL
 - CHG with OK at ELETTRA
 - HGHG with the DUVFEL at NSLS/ BNL (FEL Prize talk by Li-Hua Yu, BNL)
- X-Ray FELs (they all need $\varepsilon < 1$ mm-mrad @ few nCs, and ultra-short pulse lengths)
 - Using eRHIC ERL for FELs (V. Litvinenko), SASE, HGHG, X-ray FELs
 - The European X-FEL project at DESY with SASE undulator
 - X-ray FEL project at Spring8 in Japan
 - Where should the money go for X-ray FEL? Gun research or lowering emittance in the LINAC?

THz is becoming a hot topic

- Compact systems
 - Vanderbilt, needle cathode > Smith-Purcell FEL
 - ANL-ENEA, Laser-assisted thermionic emission > Smith-Purcell, Cerenkov FELs
- S. J. Allen (UCSB) THz FEL
 - Wide variety of experiments since 2001
 - Radiation tuned from 140 GHz to 4.8 THz
 - 1 Hz rep. rate, pulses from tens of μs to several ps
- G. P. Gallerano (ENEA) gave a nice overview of THz sources
 - JLab highlighted as the most powerful, CW THz source
- JAERI is proposing a THz beamline for the 2.5 MeV injector ($20\text{mA}=0.5\text{nC} \times 40\text{ MHz}$)
- KAERI is developing user facilities for their THz compact FEL (0.3 to 3 THz)
- S. Zhang (JLab FEL) bunch length measurements with THz radiation

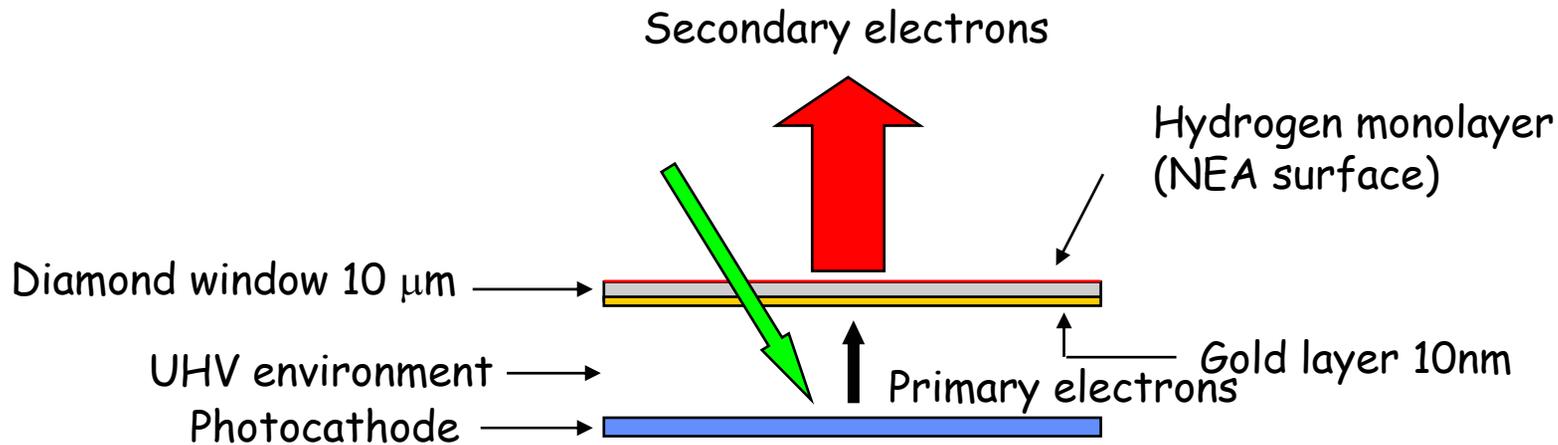
Guns and Injectors...

...everyone wants the brightest beam!!

- Big crowd at the joint session on Gun/Injector Technology
- There were five talks in this session:
 - J. Rosenzweig (UCLA) Technologies (SRF Guns) for e-Beam Generation
 - For SASE X-ray sources:
 - $\varepsilon_{xy} < 1$ mm-mrad, $Q \sim 1$ nC, $\sigma_t \sim 250$ fs, $I_{\text{peak}} = 4$ kA at wiggler
 - High duty factor a problem (Not enough RF power)
 - Problems with voltage breakdown, QE uniformity, lifetime, etc...
 - Emittance preservation is not trivial (LSC dictates compression, collective effects)

- F. Stephan (DESY) Results of photo injector at PITZ
 - RF Gun at 1 nC
 - Measured intrinsic $\sigma_E \sim 16$ keV, $\varepsilon_{xy} \sim 1.5 \pi$ mm-mrad, $\sigma_t \sim 20$ ps
 - Observed increase in thermal emittance with accelerating voltage
- K. Togawa (Spring-8, Japan) Emittance measurement on CeB6 electron gun Compact SASE source
 - Thermionic gun CeB6
 - 500 kV, 10 MV/m with 5 cm gap, 60 Hz, 3- μ s
 - Measured 1 A peak current in 1 ns pulse, $\varepsilon_{xy} \sim 1 \pi$ mm-mrad
- D. Janssen (Rossendorf) Development of SRF Gun
 - Cs2Te cathode
 - First test measurements performed
 - Emittance compensation by an additional magnetic RF field instead of static magnetic field

- I. Ben-Zvi (BNL) Diamond cathode
 - Based on secondary-electron emission in diamond
 - No experimental data yet
 - Expecting 1 A CW current from photocathode RF gun
 - Offered to send us one of this cathodes for testing



Also, some posters on DC Guns:

- Peking University is developing a CsTe DC cathode coupled to a 1.5 cell SC cavity
 - 4 MV/m at cathode
 - 100 mW drive laser power at 266 nm
- JAERI (Japan) is just starting to build a load-lock chamber for a 200 kV DC gun with a NEA-GaAs cathode. *Sounds familiar?*

Closing Remarks

- 287 registered participants from 18 countries
- Big discussion on annual/bi-annual meetings
 - Annual meetings won 2 to 1 with participants vote (IPC divided 50/50)
- Upcoming FEL Conferences:
 - 2005 at SLAC in Menlo Park, California
 - 2006 at Berlin sponsored by BESSY and Rossendorf (One day at Dresden)
 - 2007 at BINP in Novosibirsk

