

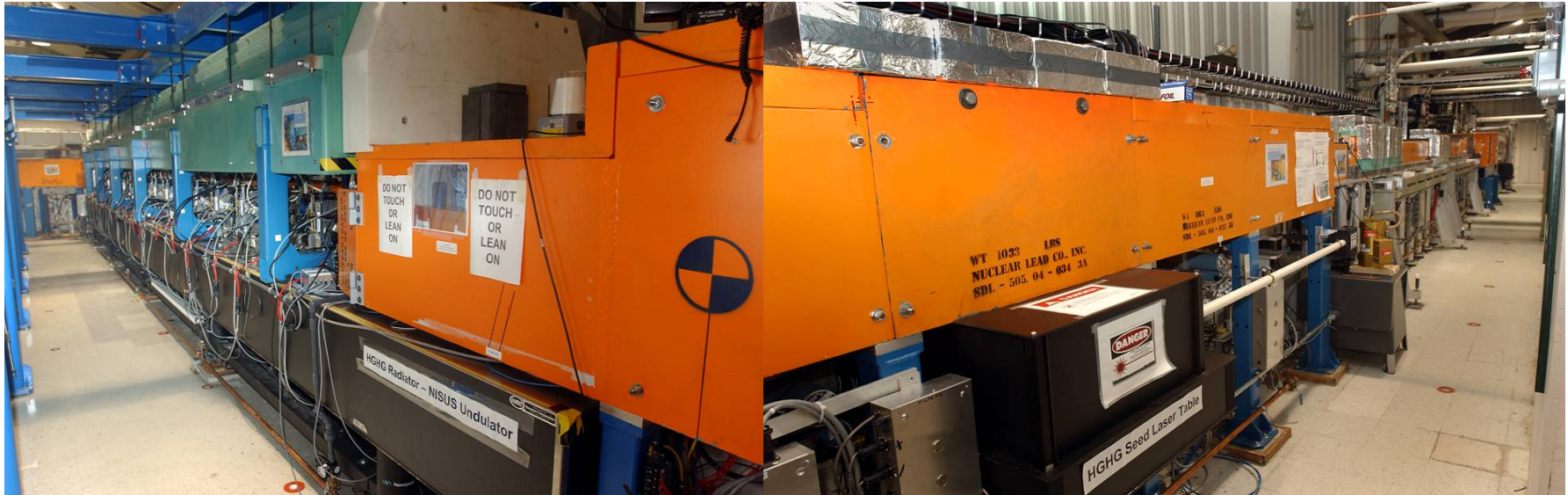
Efficiency and spectrum enhancement in a tapered free-electron laser amplifier*

X.J. Wang¹, H.P. Freund², D. Harder¹, W.H. Miner, Jr.², J.B. Murphy¹, H. Qian¹, Y. Shen¹, and X. Yang¹

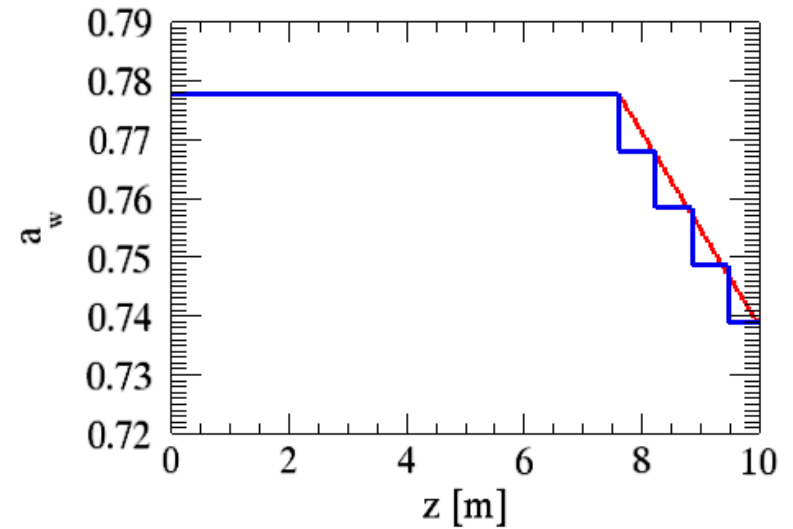
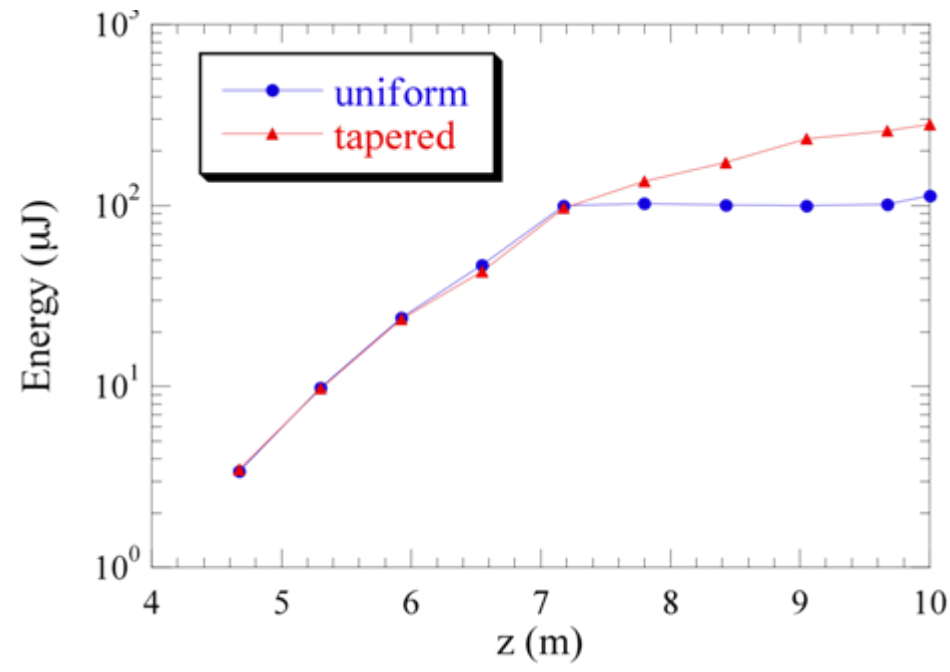
¹*National Synchrotron Light Source, Brookhaven National Laboratory, Upton, NY 11973*

²*Science Applications International Corp., McLean, VA 22102*

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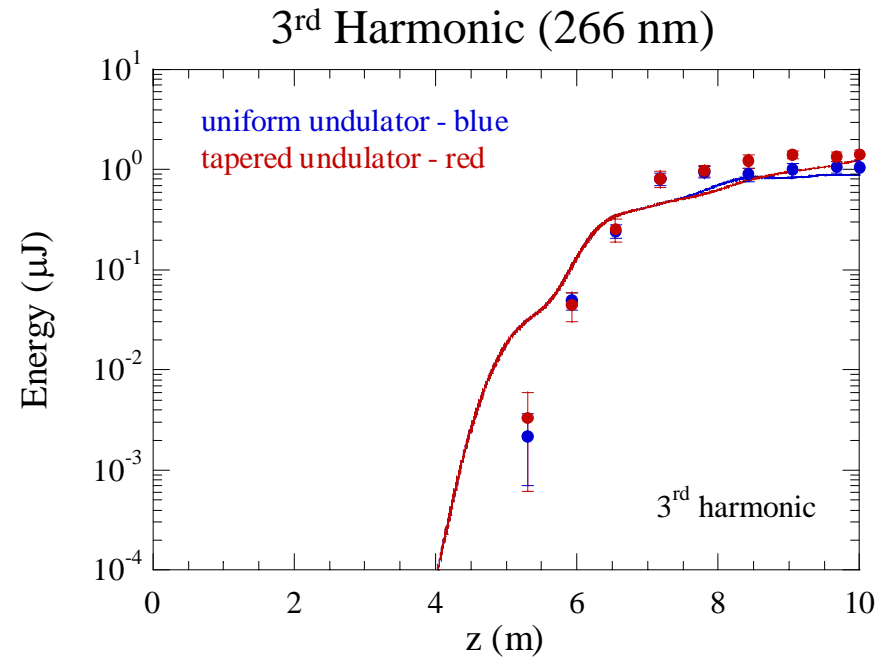
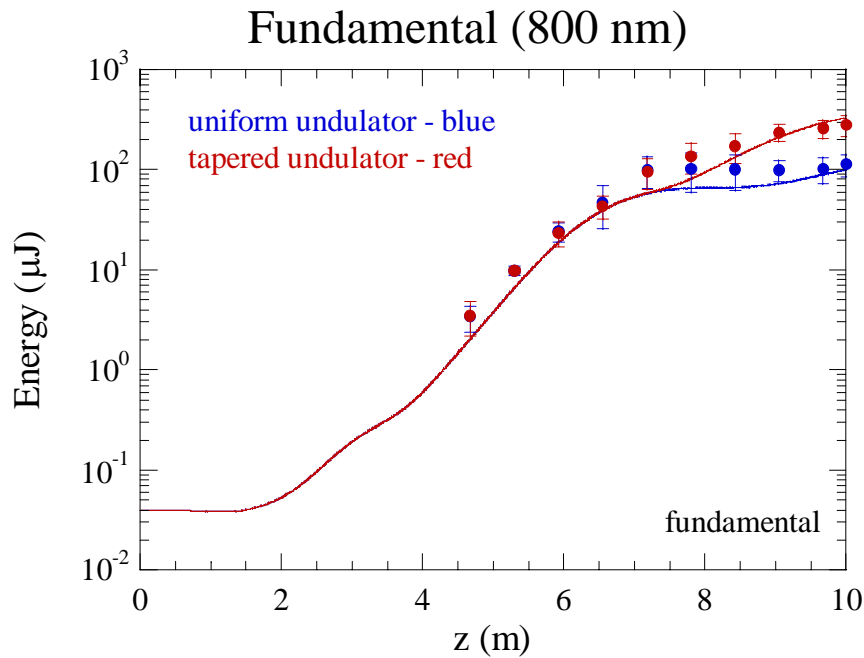
The Source Development Laboratory (SDL) is a laser linac facility consisting of RF synchronized Ti:sapphire laser system, high-brightness electron source, 300 MeV linac and FEL undulators. It is an ideal platform for laser seeded FEL amplifier R&D.



Electron Beam	
Energy	101.37 MeV
Bunch Charge	350 pC
Peak Current	250-350 A
Bunch Duration	1-2 psec
Energy Spread	0.1%
Normalized Emittance	3-4 mm-mrad
Undulator (NISUS)	
Period	3.89 cm
Peak Amplitude	3.016 kG
K	0.775 (rms)
Length	10.0 m
Start-Taper Point	7.0 m
Taper Magnitude ($\Delta B_w/B_w$)	-4%
Radiation	
Wavelength	793.5 nm
Seed Power	10 kW

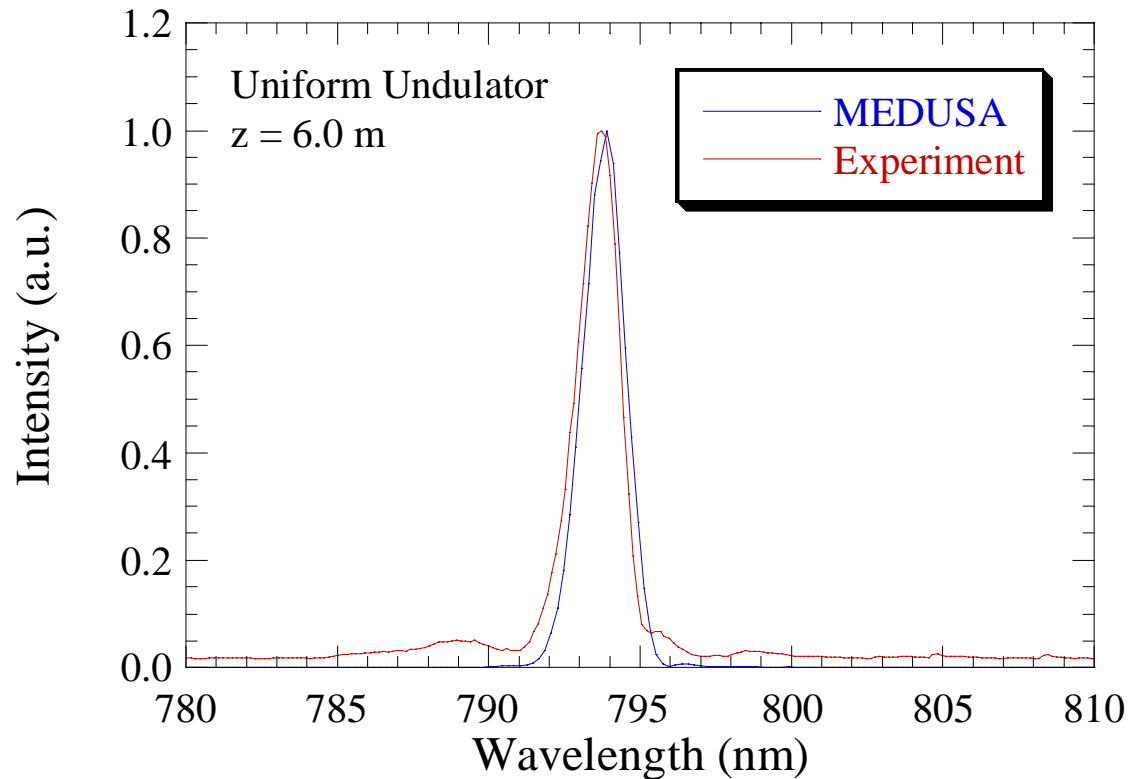
- Fully 3-D
- E&M fields treated using the polychromatic SVEA approximation
 - Time-dependent and/or polychromatic physics
 - Modal decomposition of the fields
 - Amplifier/Oscillator
- Particle dynamics are treated from first principles (not KMR)
 - Harmonics & sidebands implicitly included
 - Start-Up from Noise Distribution
- Can easily add of new features for Engineering Design Evaluation
 - New wiggler models
 - New beam models
- **For present simulations, MEDUSA was run with:**
 - **Time-Dependent Mode with 3rd harmonic**
 - **700 slices/69984 particles per slice**
 - **Integration window of 7 psec**
 - **Electron bunch length of 1.8 psec – parabolic pulse**
 - **Seed laser pulse length of 6 psec – parabolic pulse**

Good Agreement found between experiment and simulation

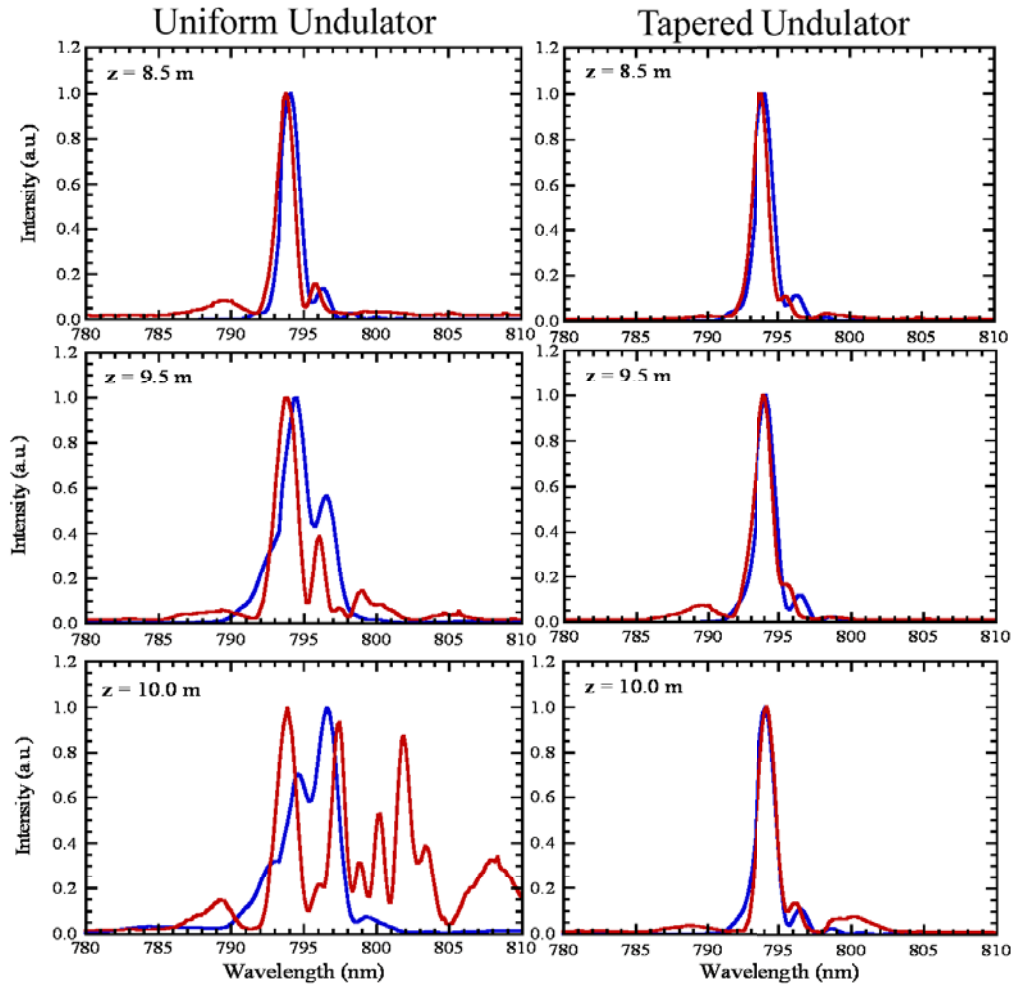


Dots are measured data & solid curves are the MEDUSA Simulation

Comparison made for uniform wiggler prior to saturation



Agreement between experiment & simulation is very good.



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- **Efficiency enhancement observed for both fundamental and 3rd harmonic using a tapered undulator.**
- **There is a difference in efficiency enhancement between the fundamental (~300 %) and 3rd harmonic (~50 %).**
- **Spectral enhancement and elimination of the side-band was experimentally characterized.**