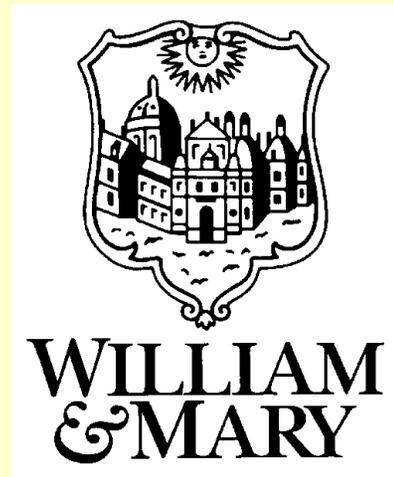


Materials Processing with FEL Radiation An Overview

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Materials Processing - The Goal

Effect a controlled transformation that reliably imparts properties having more value than the cost of the process

Laser-based processing opportunities:

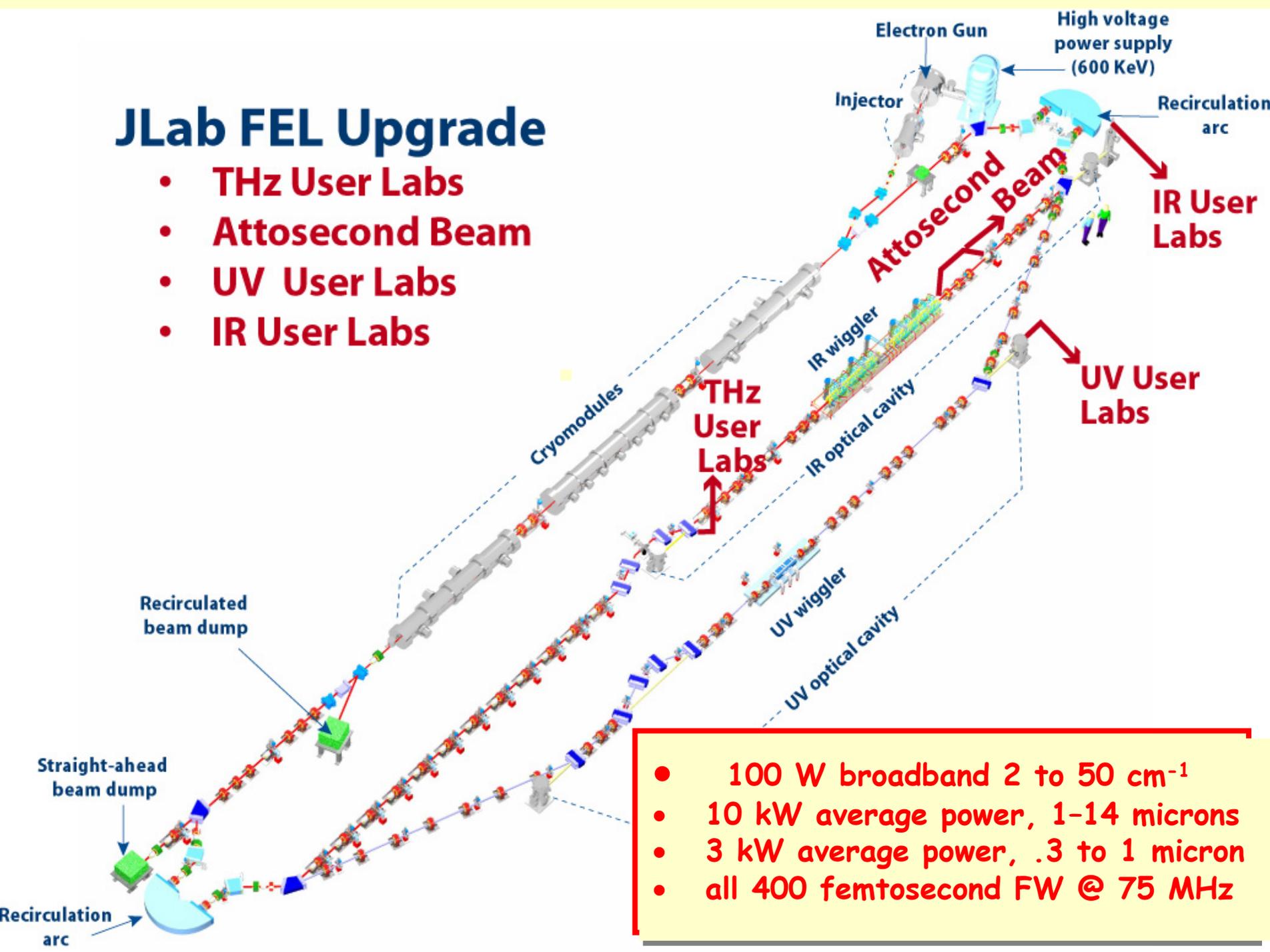
- Micromachining - smaller dimensions, new materials
- Pulsed Laser Deposition - complex compositions, organics
- Rapid Thermal Processing - surface homogenization, reaction

Potential FEL Contributions

- Develop and demonstrate products and processes
- Provide a uniquely valuable manufacturing tool

JLab FEL Upgrade

- THz User Labs
- Attosecond Beam
- UV User Labs
- IR User Labs



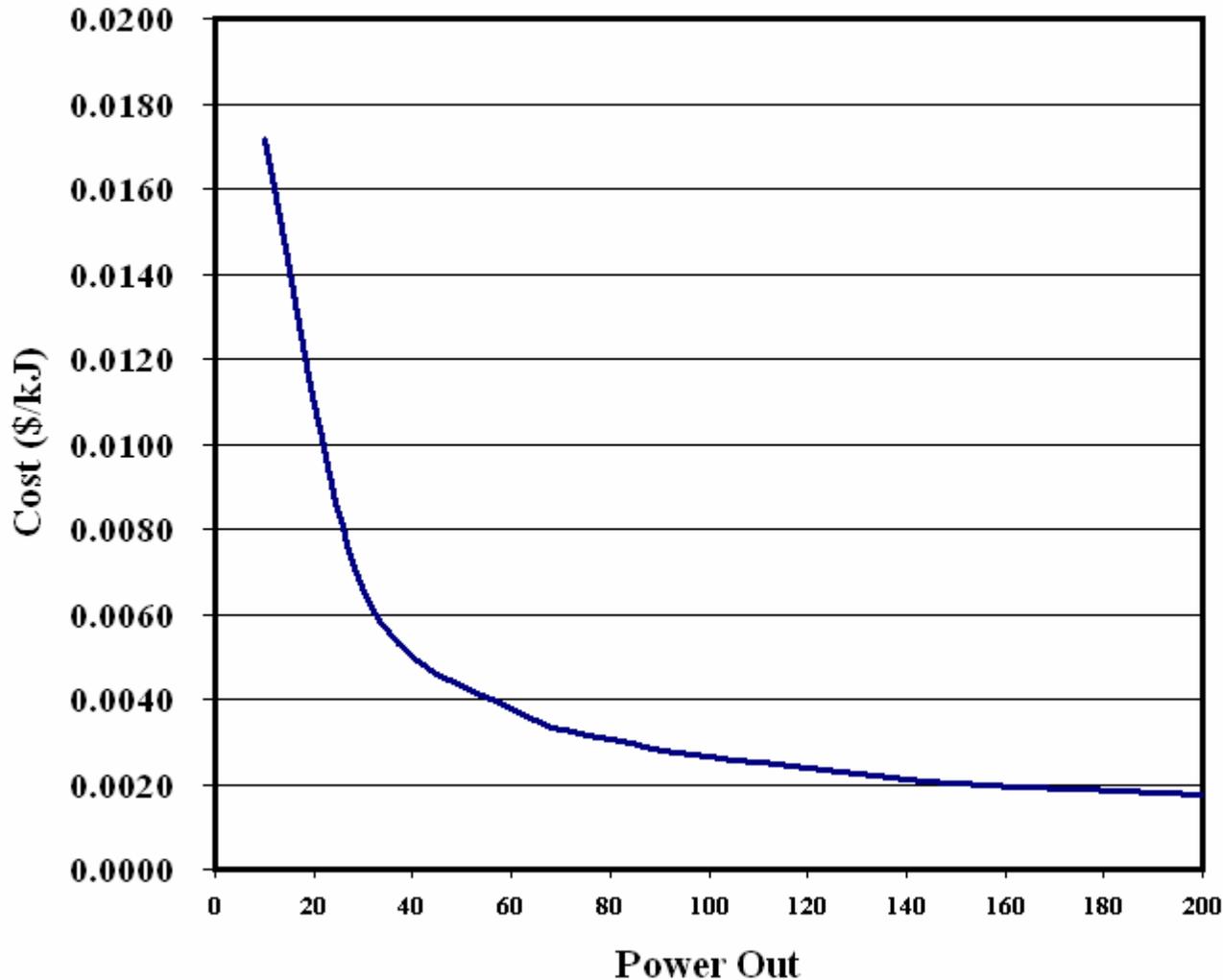
- 100 W broadband 2 to 50 cm^{-1}
- 10 kW average power, 1-14 microns
- 3 kW average power, .3 to 1 micron
- all 400 femtosecond FW @ 75 MHz

IR Upgrade Specifications

- **Average Power** > 10 kW (1 kW)
- **Wavelength range** 1 to 14 μm (0.3 - 1 μm)
- **Micropulse energy** > 100 (10) μJ , in pulse train 50 μs to
CW, arbitrary prf
- **Micropulse length** \sim 0.1-2 ps FWHM (adjustable)
- **PRF** 74.85 MHz \div 2x down to 4.68 MHz
- **Bandwidth** \sim 0.2–3 % (always Fourier transform limited!)
- **Position/Angle jitter** < 100 μm , 10 μrad
- **Polarization** linear, > 1000:1
- **Transverse mode** < 2x diffraction limit. Gaussian profile
- **Beam dia. at lab** 2 - 6 cm, wavelength dependent

Updated IR Cost vs Power Out based on JLab Upgrade

Amortized Cost



Under all scenarios, depreciation dominates and the cryomodules are the largest cost element

Materials Processing Demonstrations

Wavelength Tunability - ablate organics by selective bond scission to produce films - Haglund

Wavelength Tunability, Pulse Parameters - carve otherwise-unattainable structures - Helvajian

Rapid Thermal Processing - surface melt and react with gaseous ambient to obtain desired composition and microstructure - Schaaf

Pulse Duration, Repetition Rate - ablate carbon and irradiate plume to selectively yield desired nanotubes in quantity - Smith

Novel Wavelength - prospects for X-rays ! - Hastings

Materials Processing Demo Capabilities

Beam Conditioning - Dumpable cavity stacker, stretcher- compressor
-funded

Microengineering Workstation - Hardware in place, final software needs
funding - Helvajian

Pulsed Laser Deposition Workstation - just funded !! Kelley/Haglund.
Join us ??

TeraHertz User Station - Hardware in place, development underway.
Gwyn Williams (not at this meeting)

“Manipulator” workstation - Surface RTP - a device to maintain constant
optical positioning while an object having a complex shape is
moved at a chosen rate in front of the beam. Definition - Kelley

“Ablative Synthesis” - a versatile relative of Mike Smith’s apparatus -
definition - Kelley

Materials Processing Scale-Up

FEL - need more than 10 kW, robust hardware and controls:
defense developments expected to achieve it

Scale Match - many applications use a few watts at a
workstation. Technology/cost to distribute the light ?

Large Area Applications - use full beam. No demos yet

Alternative Lasers ? - high/low power fiber lasers ?

Significant Technology Issues -

< 1 MHz PRF - optical cavity dimensions

< 200 nm light - cavity mirror reflectivity/absorption

< 100 μ J pulse energy - accelerator charge transport

Need for Radiation Vault - FEL is accelerator-based