W. M. Keck-Vanderbilt Free Electron Laser Center

Dave Piston, Director

- College of Arts and Sciences
- College of Engineering
- School of Medicine

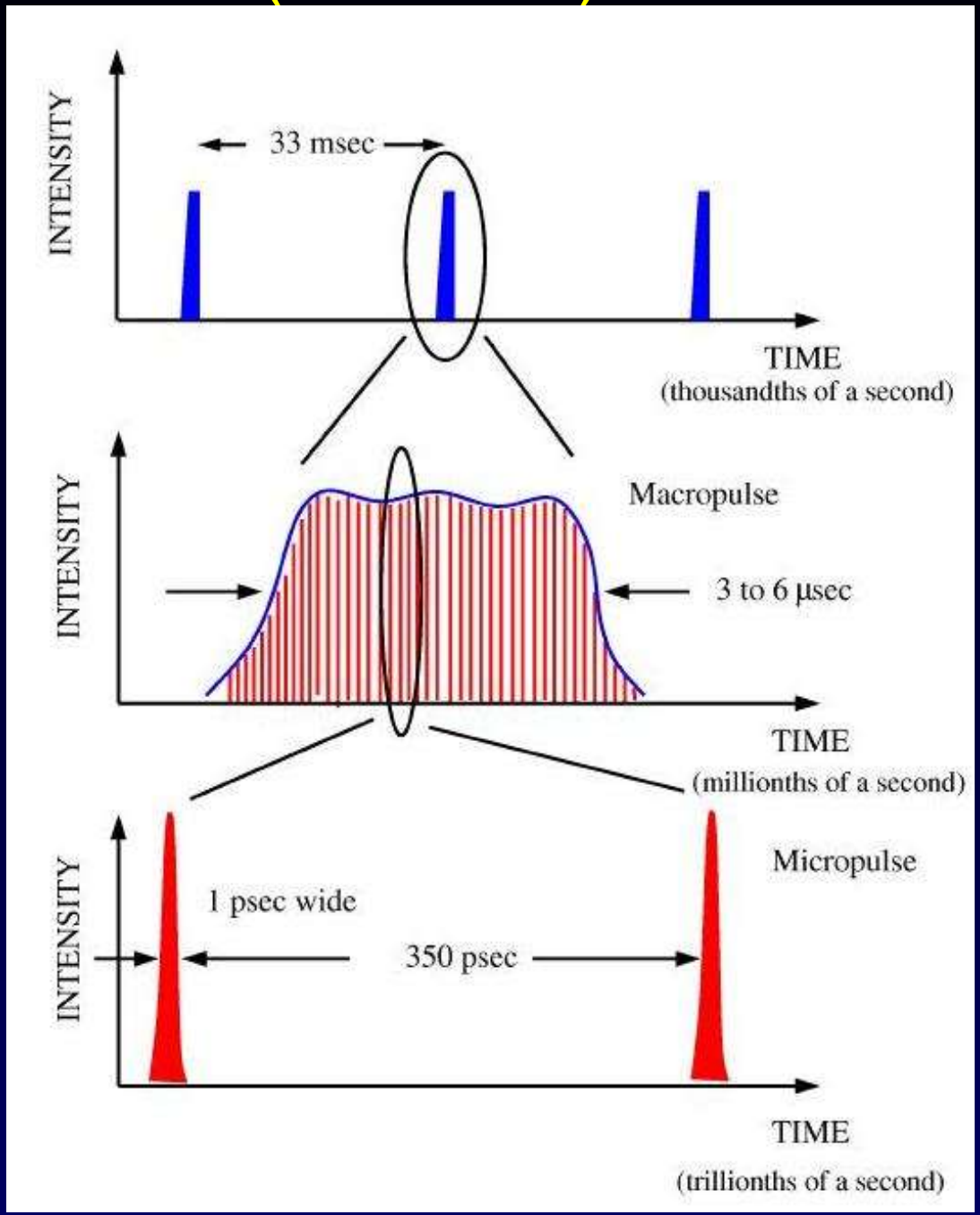
Bill Gabella, June 8, 2005, Jefferson Lab, LBC05

The free-electron laser is 60 feet long and takes up the entire basement at the FEL center.

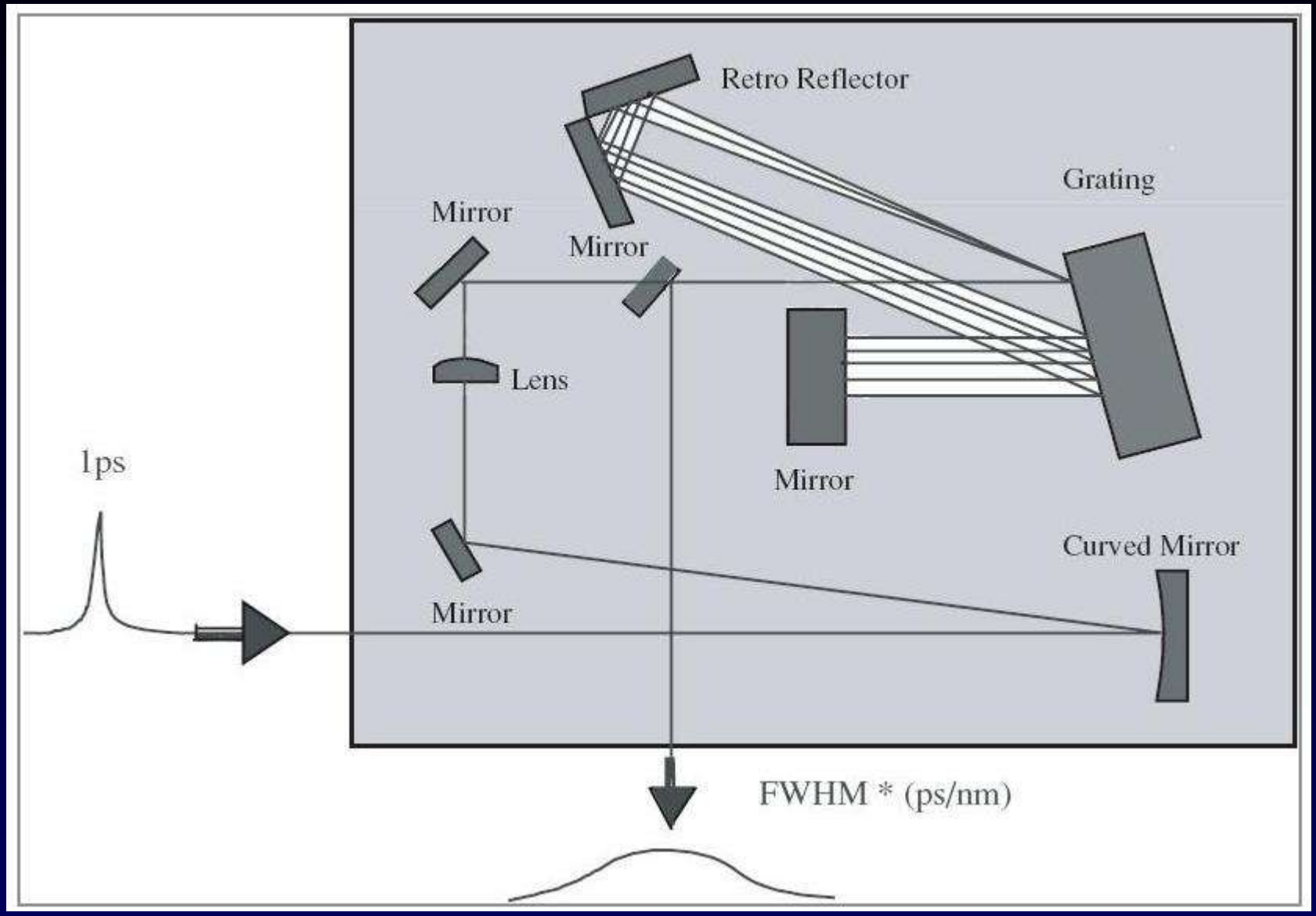
Photo by: Neil Brake

FEL pulse structure (Mark-III)

- FEL *macro*pulse:
  - repetition rate: 1-30 Hz
  - electron duration 8 μs
  - IR pulse duration ~ 3-5 μs
- FEL *micro*pulse:
  - pulse duration ~1 ps
  - pulse separation ~ 350 ps (pulse-to-pulse thermal confinement)



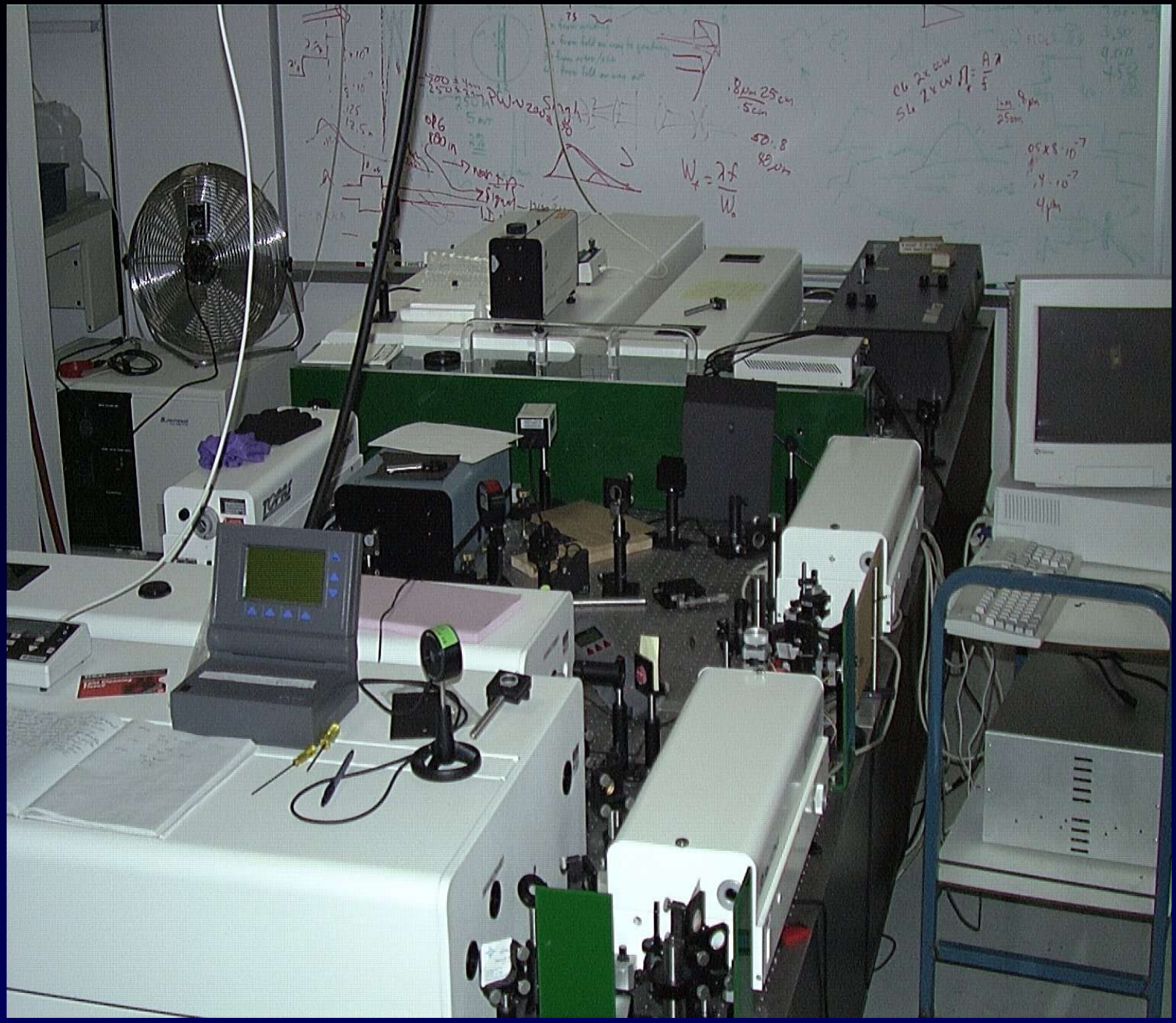
Pulse stretcher



Courtesy of John Kozub

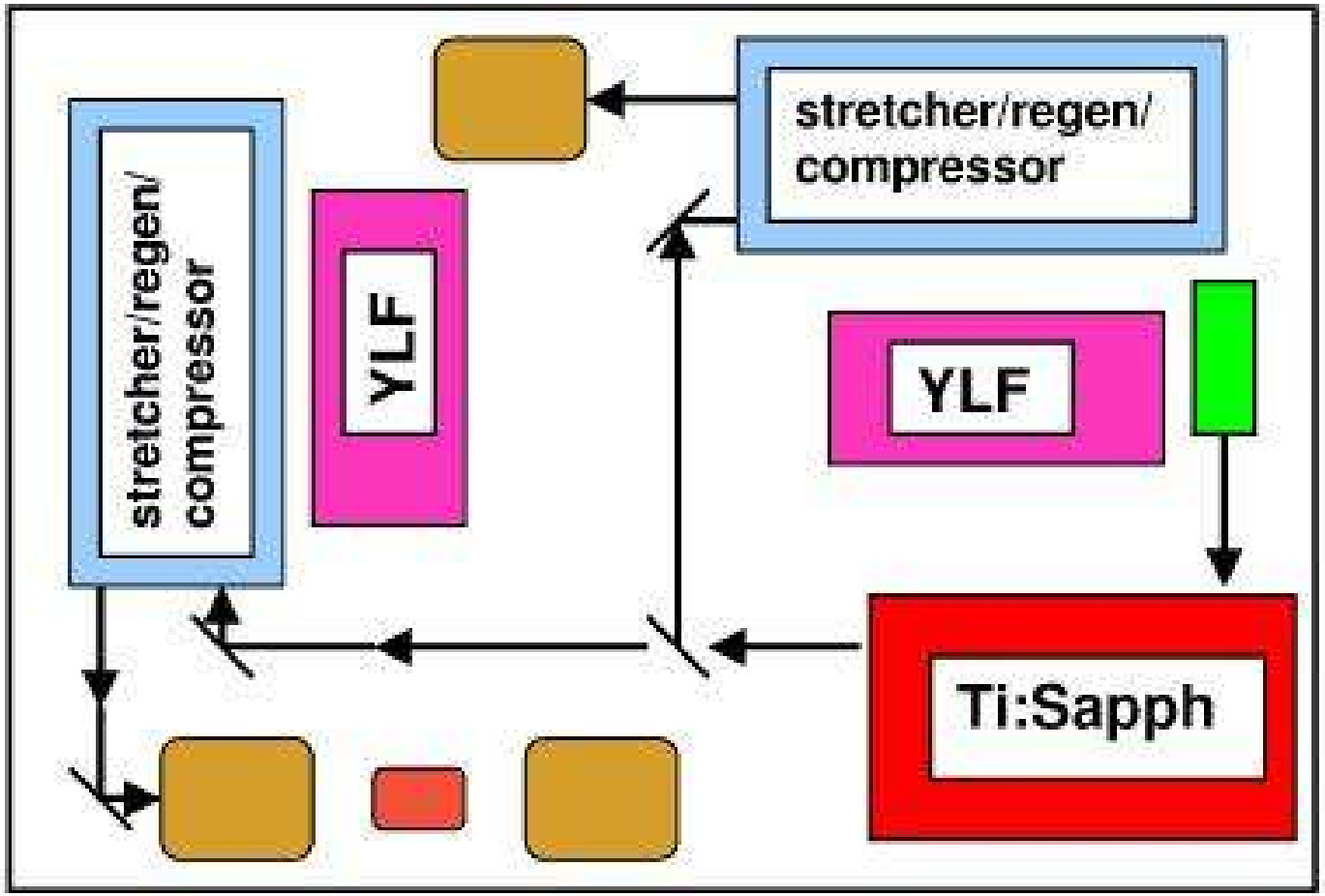
Some FEL Applications

- Human surgery at 6.45 micron: 3 meningioma resections (M. Copeland, P. Conrad), 5 optic nerve sheath fenestrations (K. Joos, L. Mawn)
- IR-MALDI (K. Schriver, R. Haglund)
- PLD (D. Bubb, J. Horwitz, K. Schriver, R. Haglund)
- Ablation of tissue (S. Hutson, D. Jansen)
- Bright field imaging of plumes (D. Jansen, M. Mackanos)
- Optic nerve sheath fenestration through an endoscope (K. Joos)
- NSOM (A. Cricenti)



System built/integrated by Quantronix.

Optical Parametric Generators



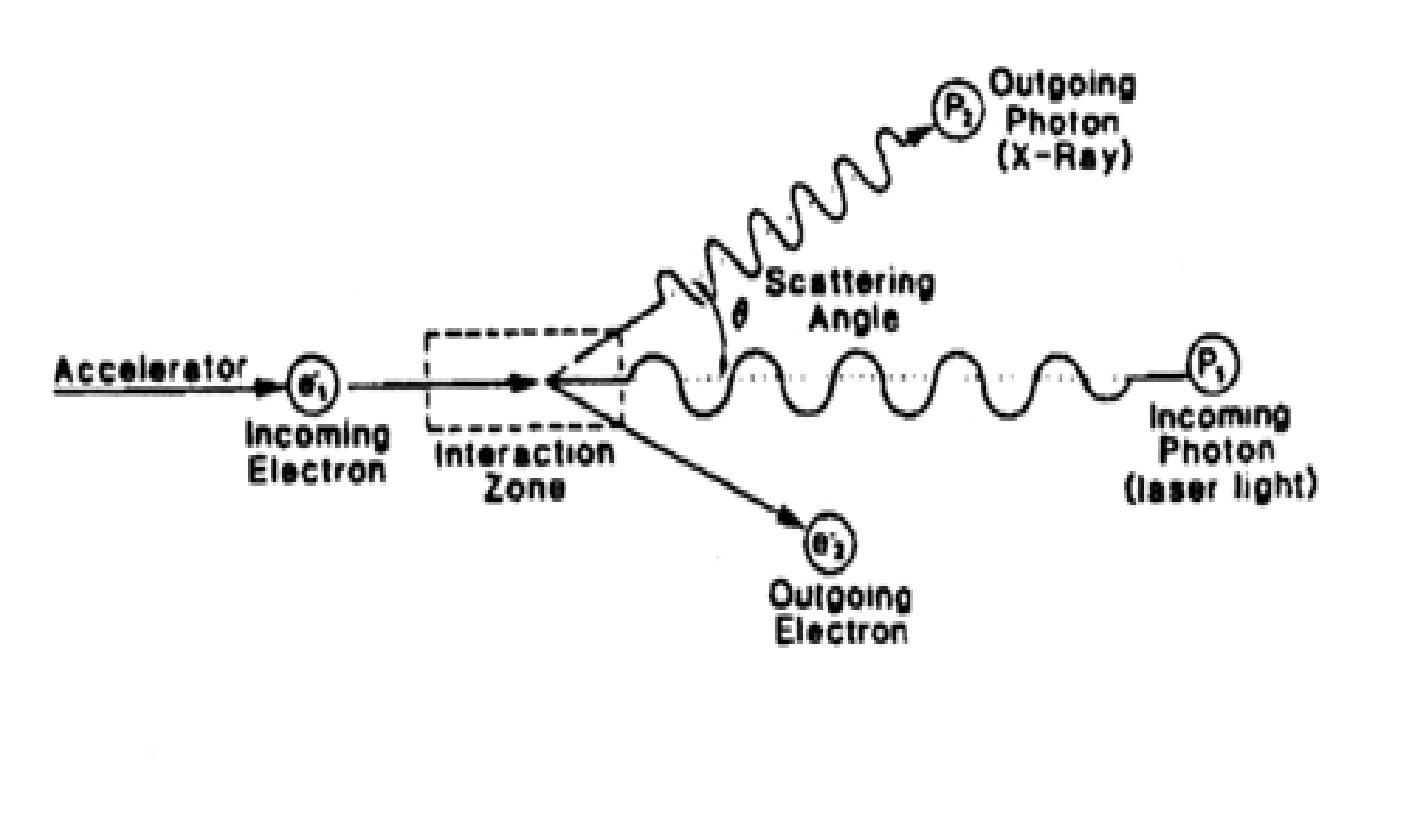
Optical Parametric Generator

- Two OPG's driven by single Ti:Sapph
- Vis/IR with picosecond or femtosecond pulses
- UV/Vis with femtosecond pulses
- 1 kHz "micropulses" can be made to resemble FEL micropulses
- Good for spectroscopy, low average power

Some OPG Applications

- Tissue ablation comparison with FEL (G. Edwards, K. Joos)
- H in Si (G. Luepke)
- Materials research (N. Tolk, L. Feldman)

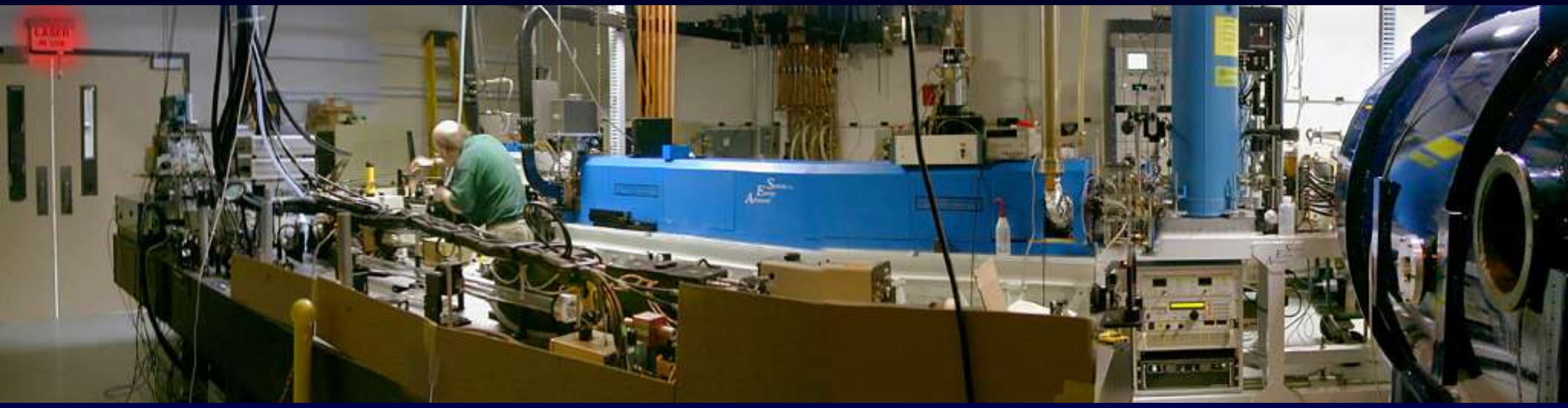
Inverse Compton Scattering



This process lends itself well to production of tunable, monochromatic X-rays

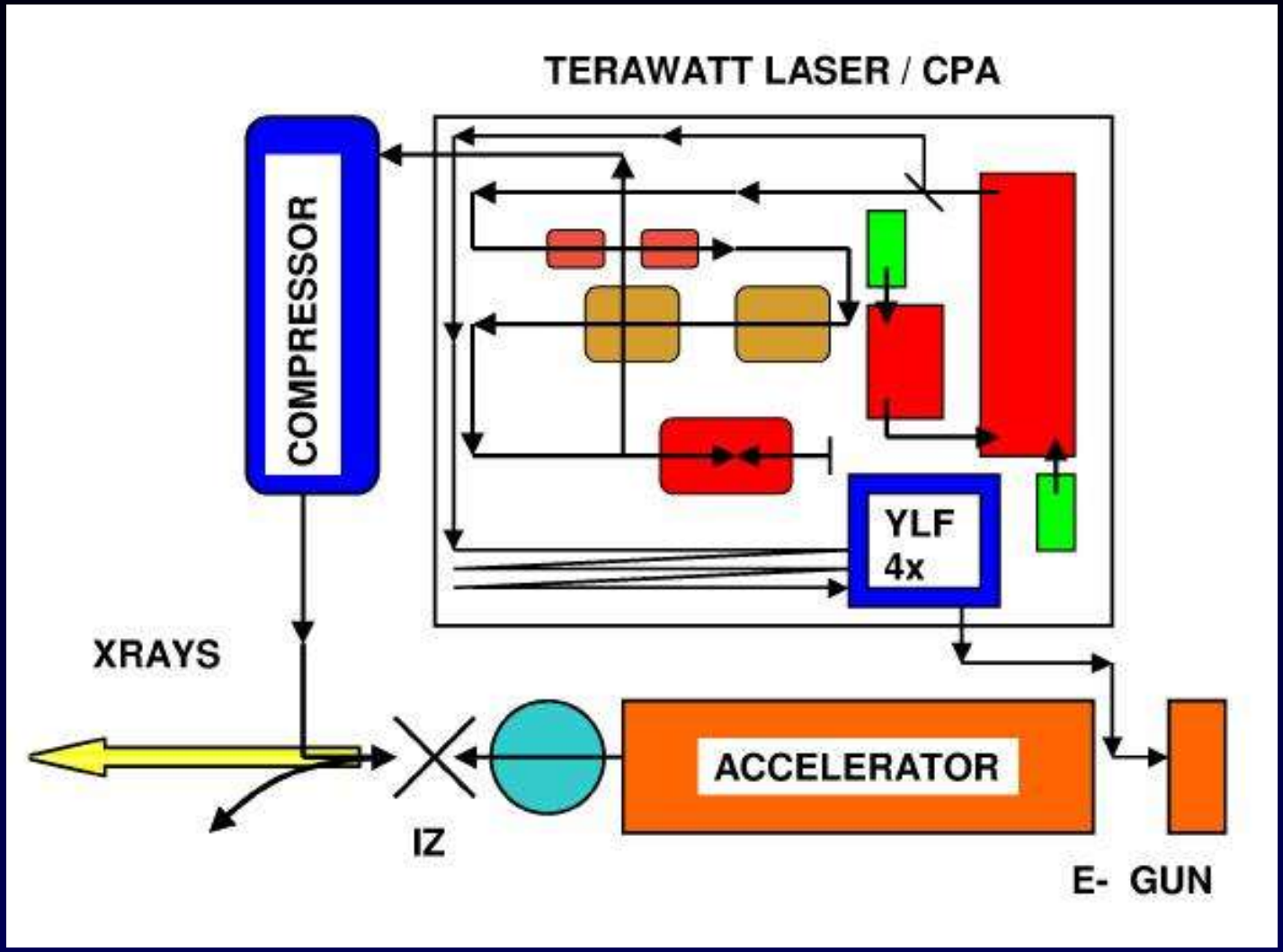
Pulsed, tunable, monochromatic X-ray machine

- Demonstrated on the FEL
- Standalone device constructed by MXISystems, Inc.
- 10-50 keV x-rays, 10^9 photons in an 8 ps pulse
- Imaging including mammography using phase imaging/time of flight imaging; more information with 2% xray dose



- "First light" in April 2001, laser rods damaged in early 2004
- Currently an FEL Center facility, laser being rebuilt, "next light" in fall 2005

Simplified Schematic of Xray Source



Laser by Positive Light, accelerator/gun by AES.

Some Xray Applications

- Single pulse imaging (M. Mendenhall, F. Carroll)
- Imaging and contrast agents (F. Carroll)
- Phase contrast imaging (E. Donnelly)
- Photocascade therapy (F. Carroll)

Vanderbilt Sources:

- FEL with wavelengths 2.1 to 9.6 microns
- OPG at 1 kHz, UV to MIR
- Xray with 8 ps pulse, 1% BW, 0.1 to 0.02 nm
- THz source, lots less than 100 W, but very small (C. Brau)

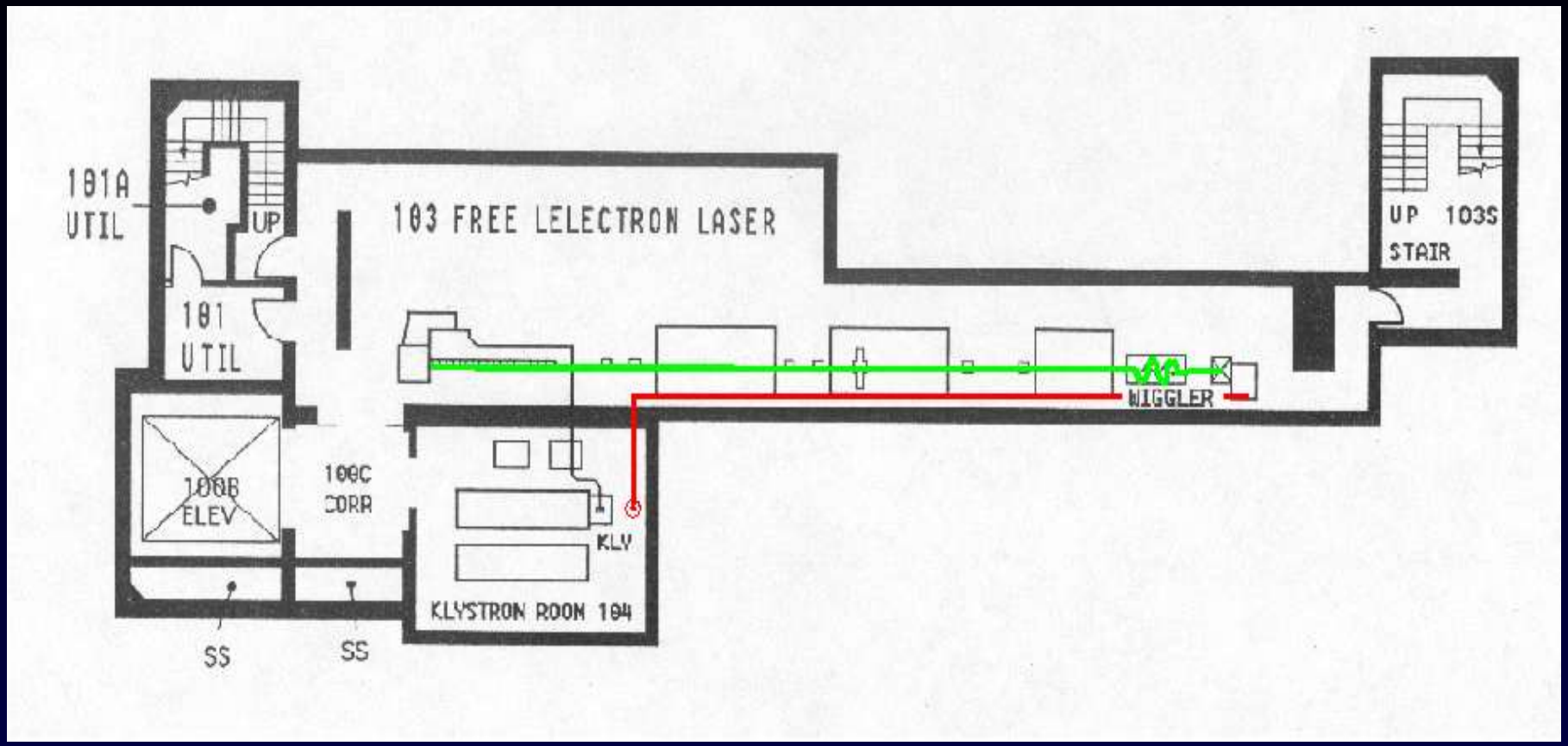
Complements JLab FEL:

- Vanderbilt and JLab have a similar micropulse
- JLab FEL has a much higher repetition rate for better signal to noise; especially in NSOM
- Vanderbilt with small spots is like JLab with very large spots; more material/animals irradiated

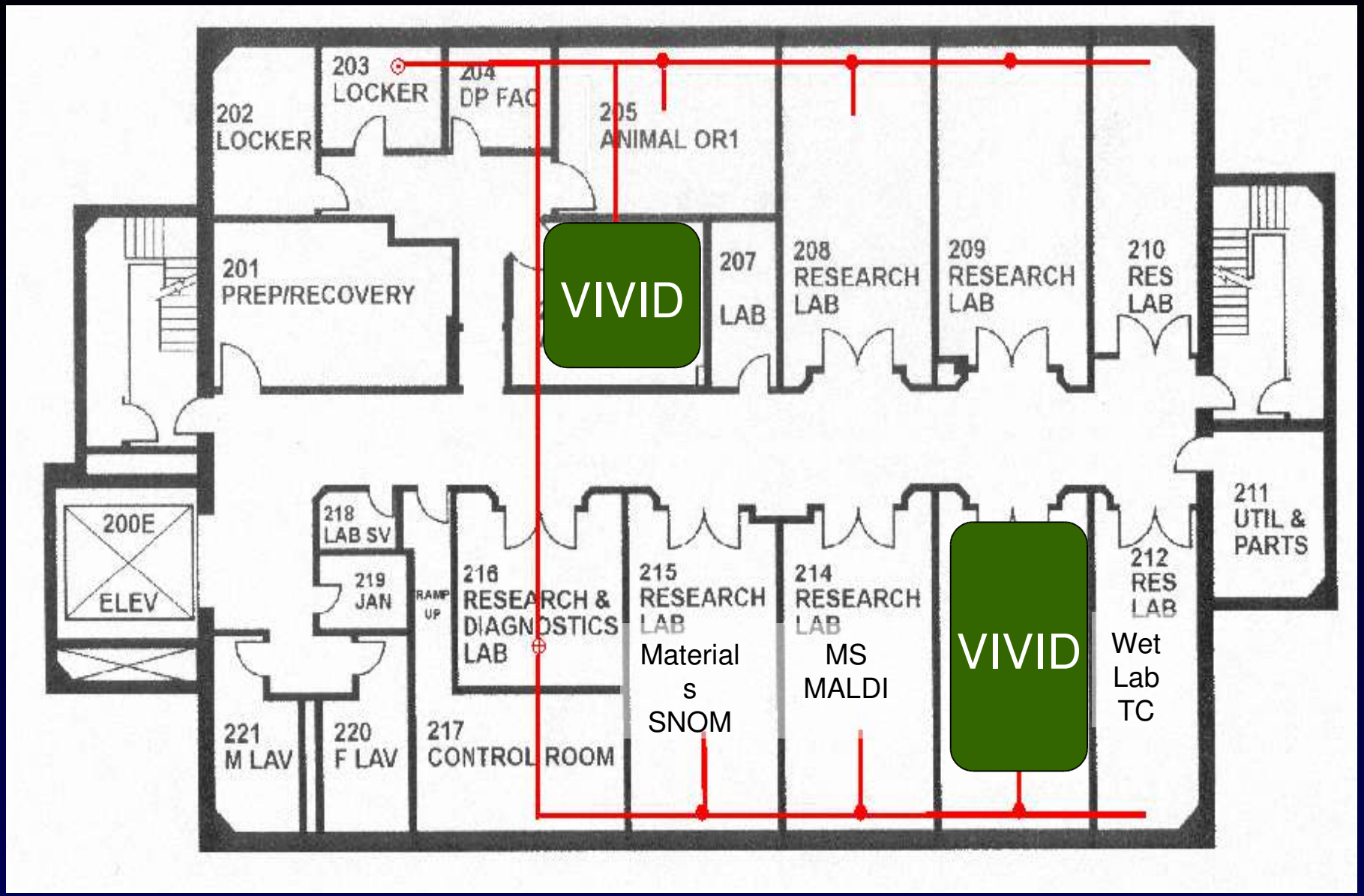
http://www.vanderbilt.edu/fel

The End

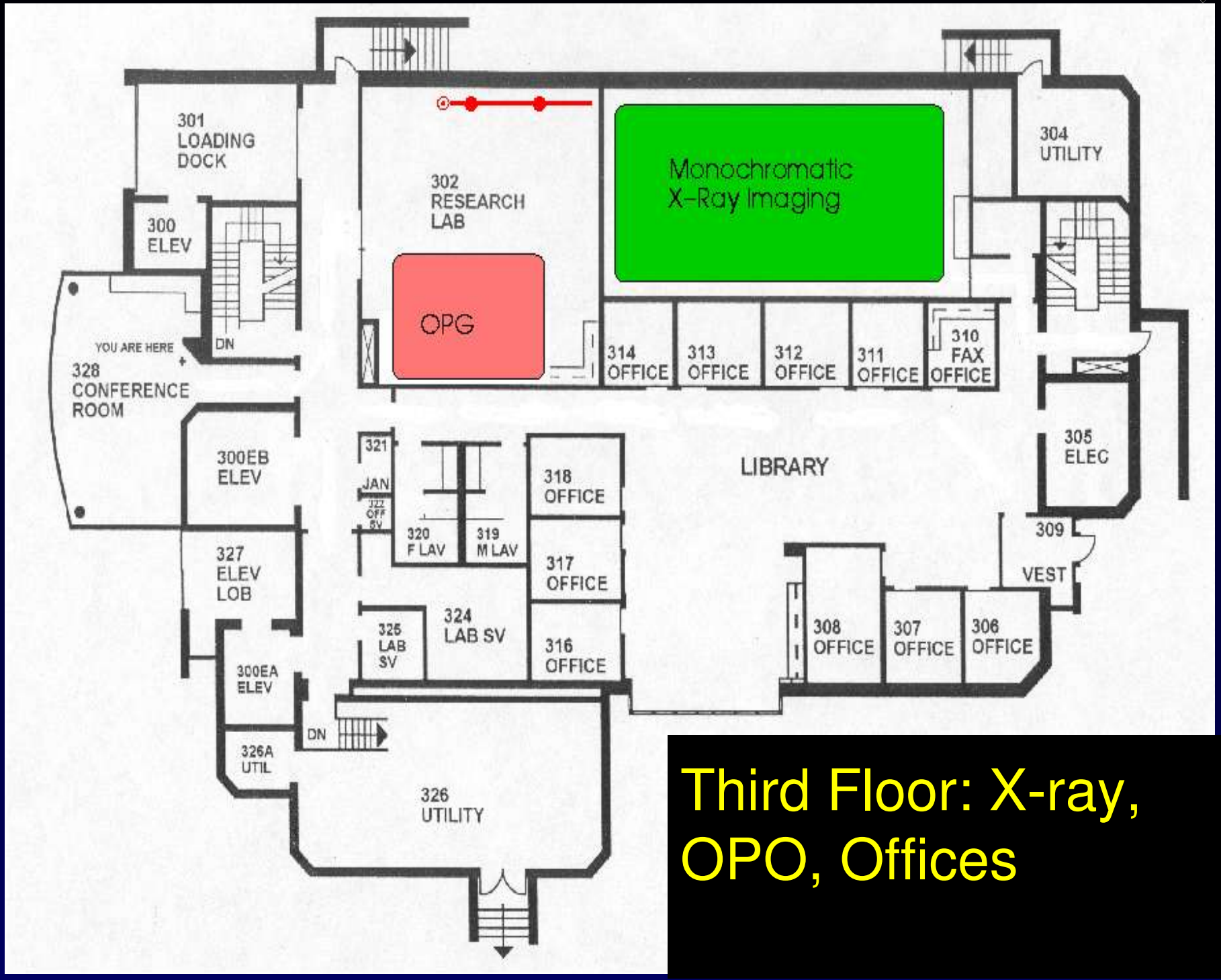
Building



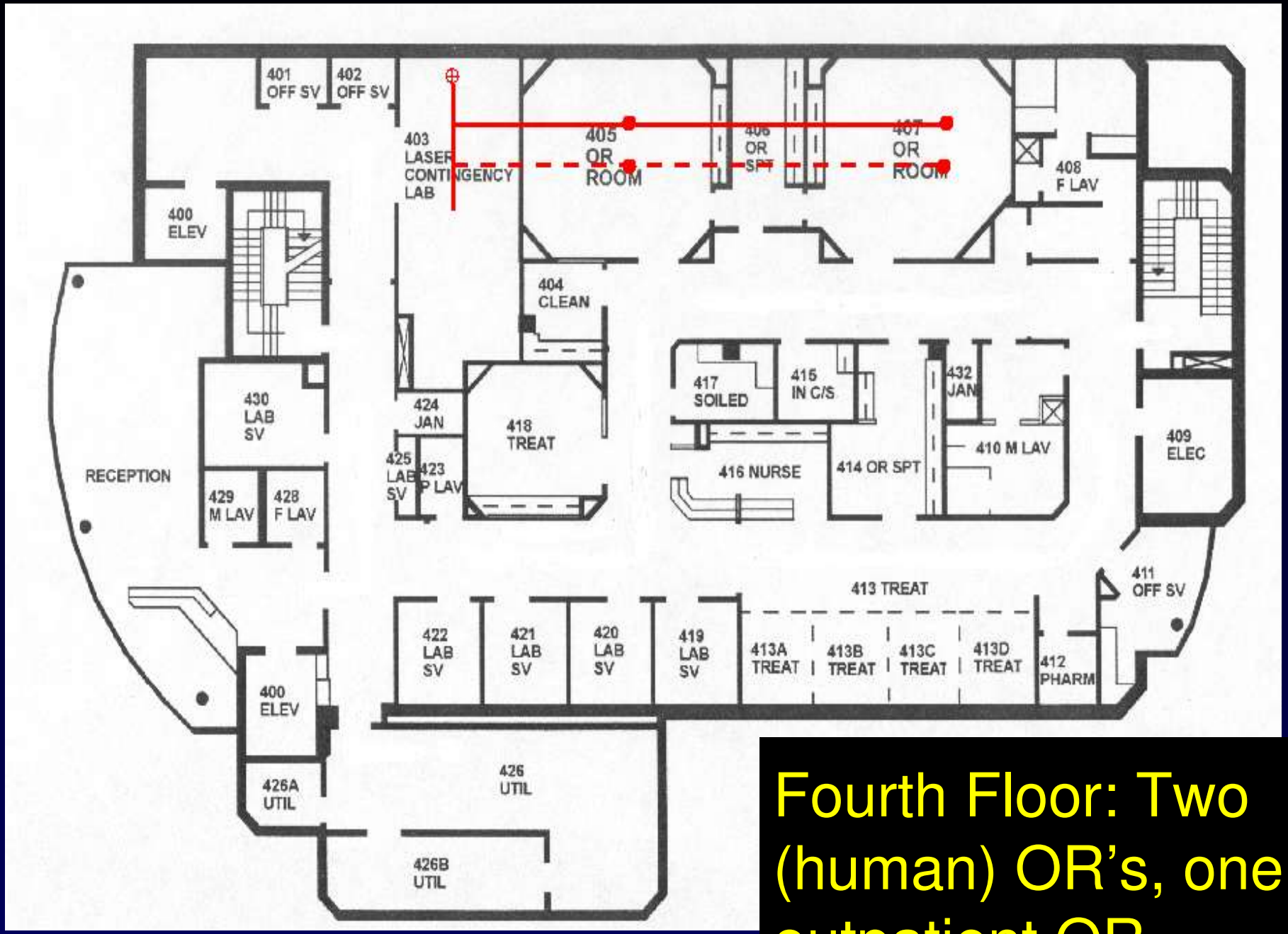
First Floor: FEL level



Second Floor Research Space



Third Floor: X-ray, OPO, Offices



Fourth Floor: Two (human) OR's, one outpatient OR

Electron energy	24-45 MeV
Electron macropulse length	8 μs
Electron/IR micropulse length	Approx. 1 ps
Electron macropulse current	Variable, 150 mA
IR macropulse length	Variable, 5 μs
IR macropulse energy	Variable, > 50 mJ
IR micropulse power	5 MW peak, 5 μJ/pulse
IR wavelength	2.1 to 9.6 microns