Status and Future Prospects for the APS FEL Project

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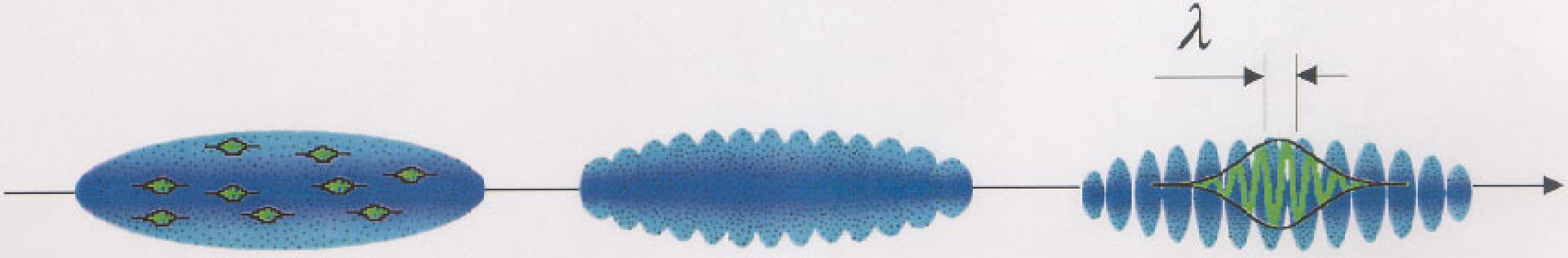
Trieste Dec. 01

e-Beam Microbunching



$P \sim N_e$

$P \sim N_e \bullet N_{l_c}$

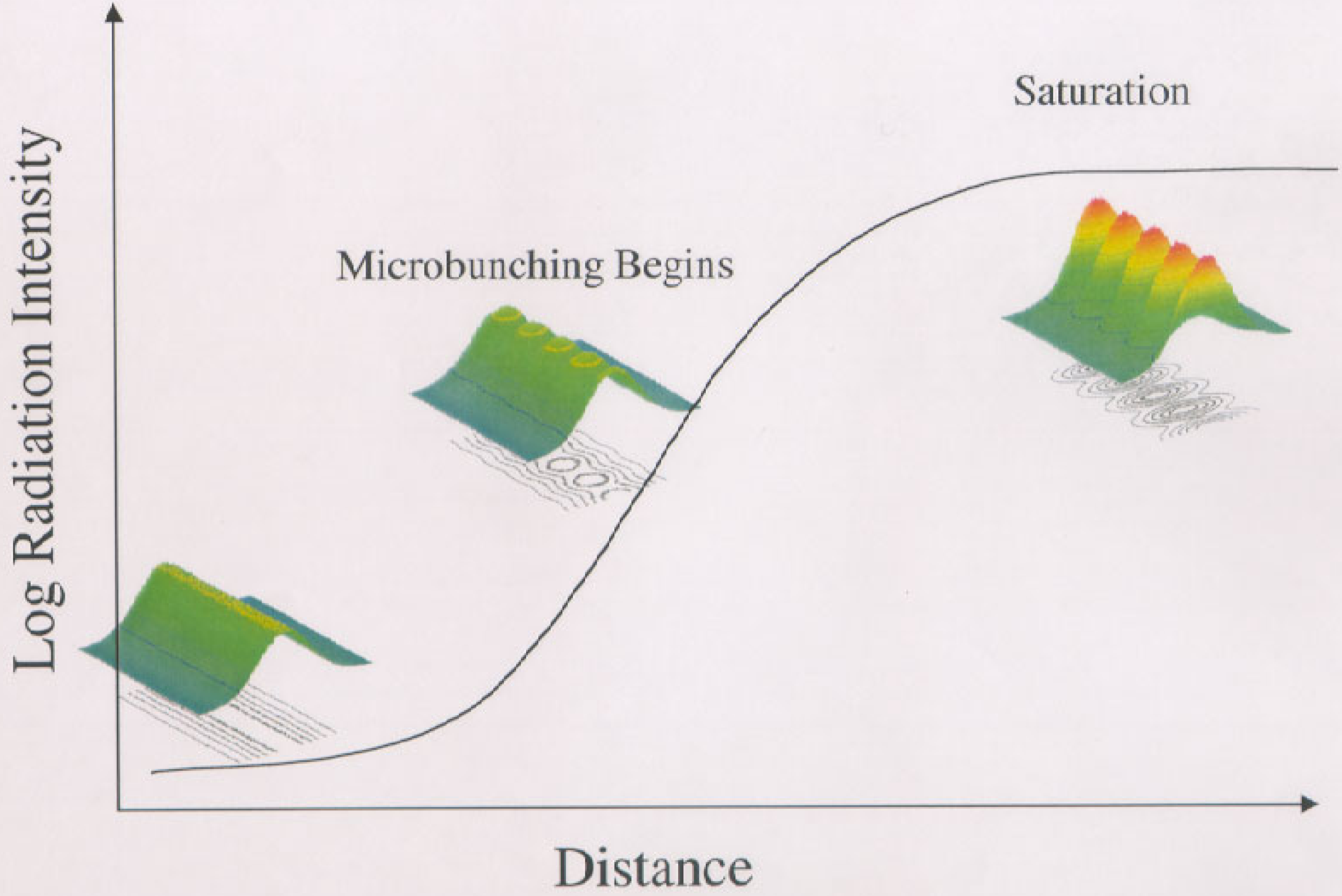
P - Radiation Power

N_e - Number of particles in the bunch

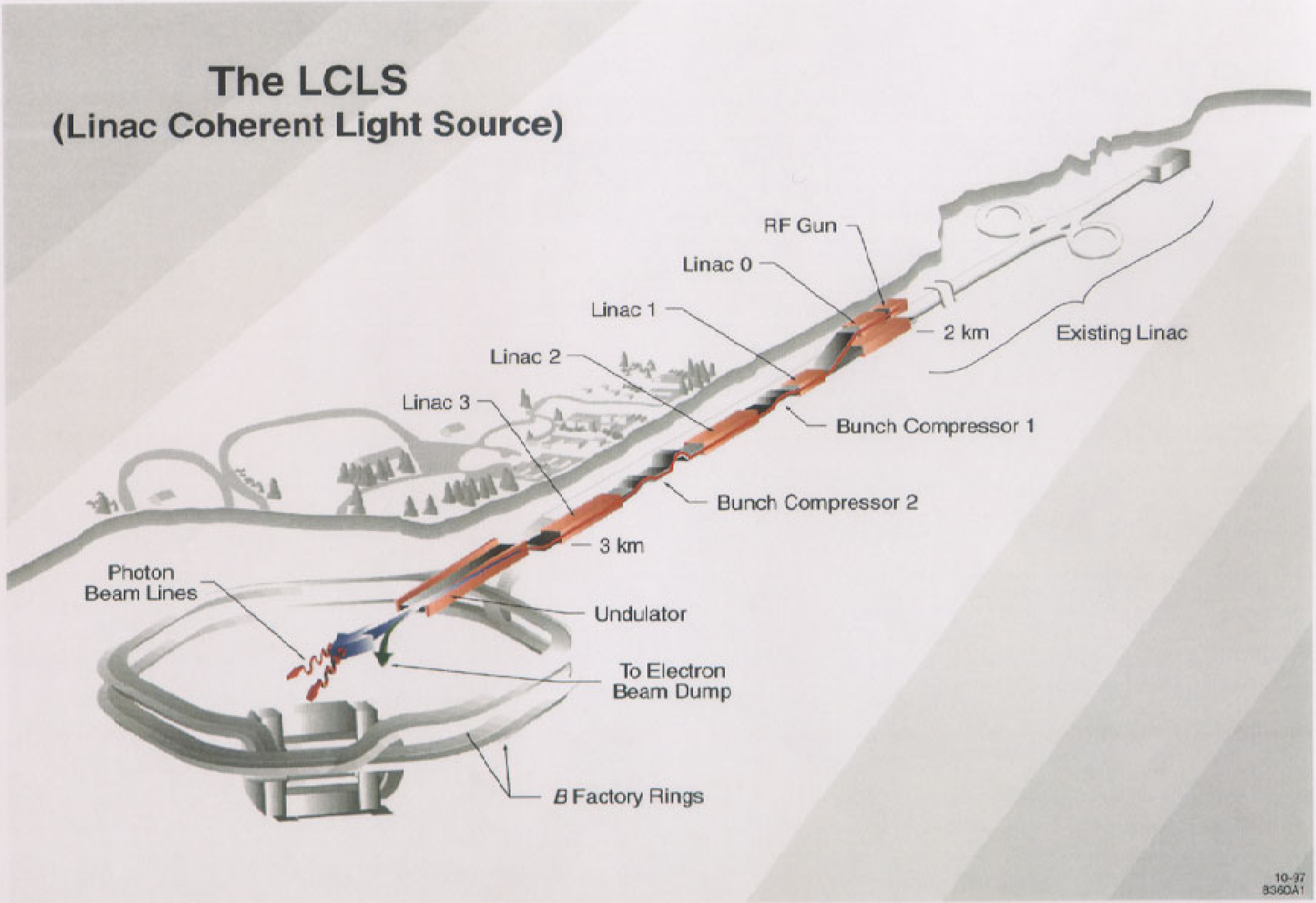
$E_u + E_R \Rightarrow$ potential wells

N_{l_c} - Number of particles in coherence volume

Exponential Growth



Prototype for the Next Generation



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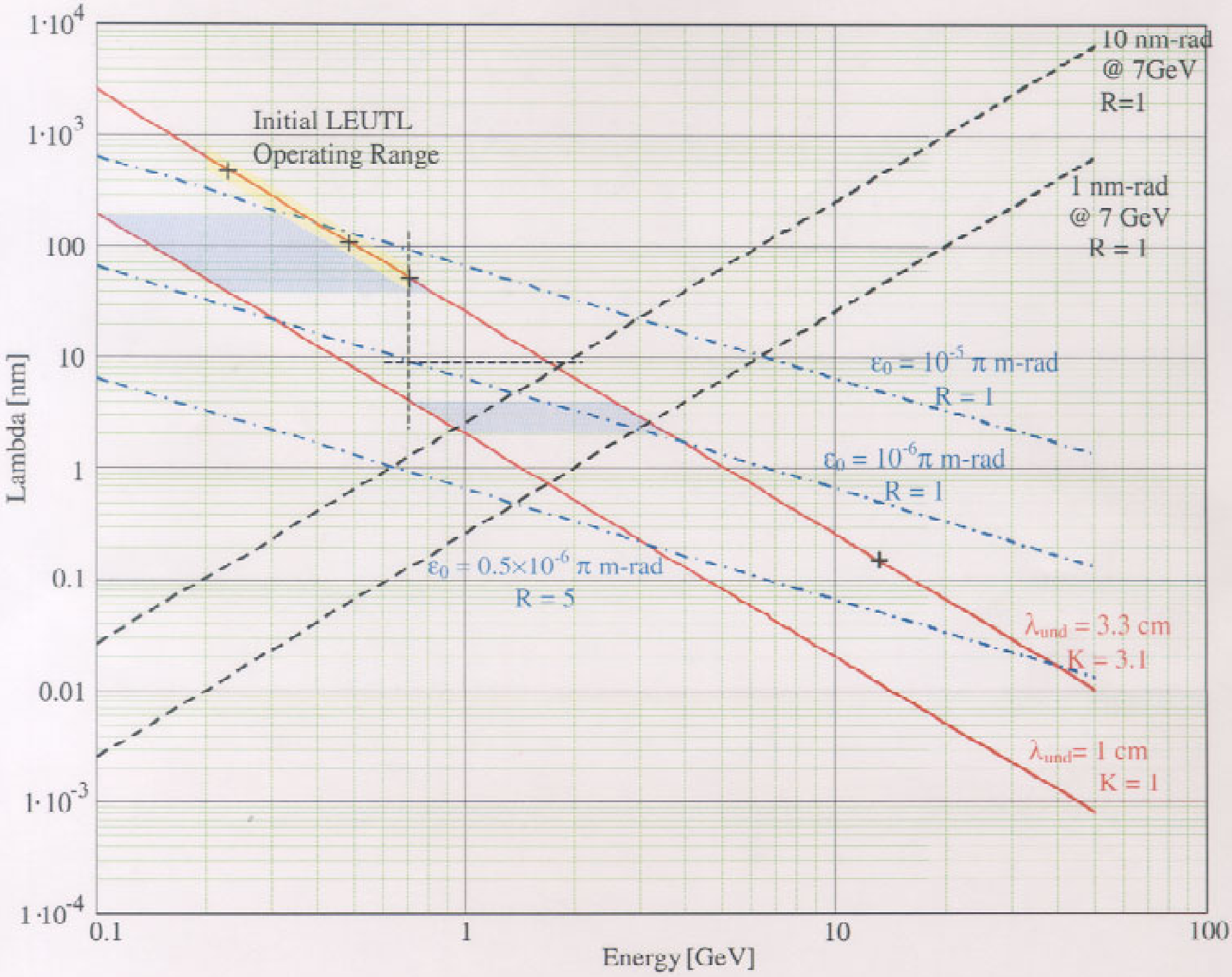


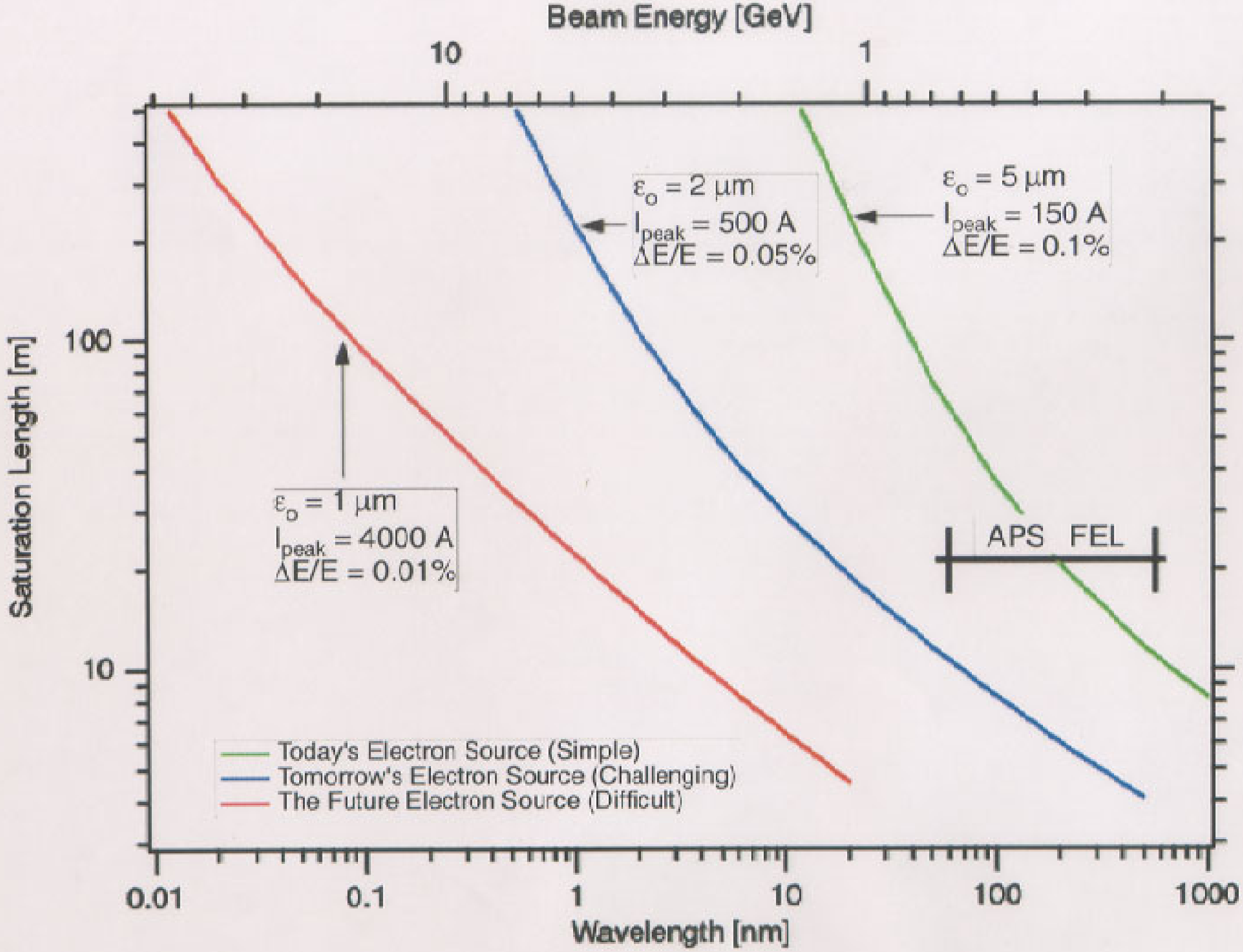
Undulator Resonant Condition: $$\lambda_L = \frac{\lambda_{und}}{2\gamma^2}\left(1+\frac{K^2}{2}\right)$$

Diffraction Limit Requirement: $$\lambda_L > \lambda_{diff} = \frac{4\pi\varepsilon}{R}$$

Linac Emittance Scaling: $$\varepsilon = \frac{\varepsilon_o}{\gamma}$$ $$\gamma = \frac{E}{m_e c^2}$$

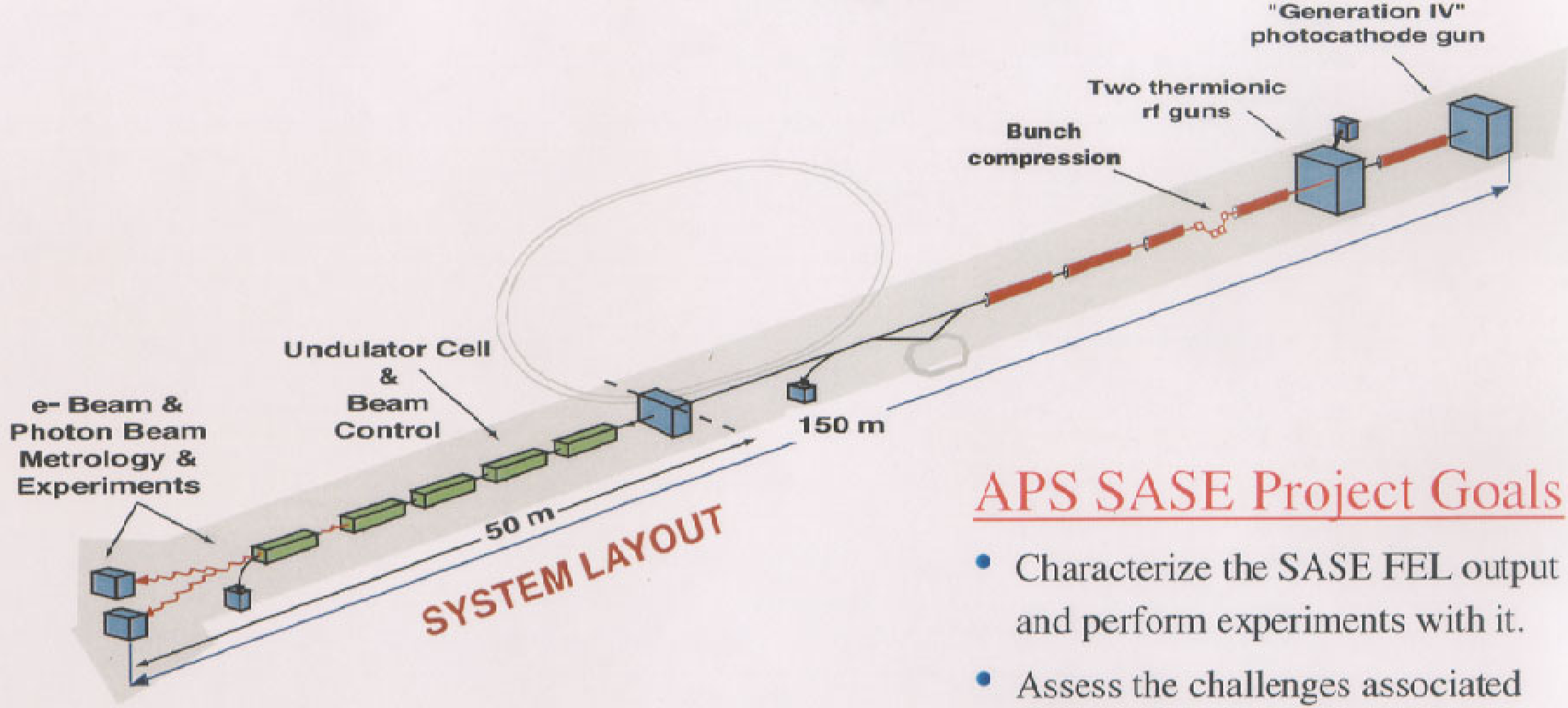
Storage Ring Emittance Scaling: $$\varepsilon \propto \gamma^2$$

Beam Requirements



The APS SASE FEL Schematic

The Low-Energy Undulator Test Line System
Present Configuration



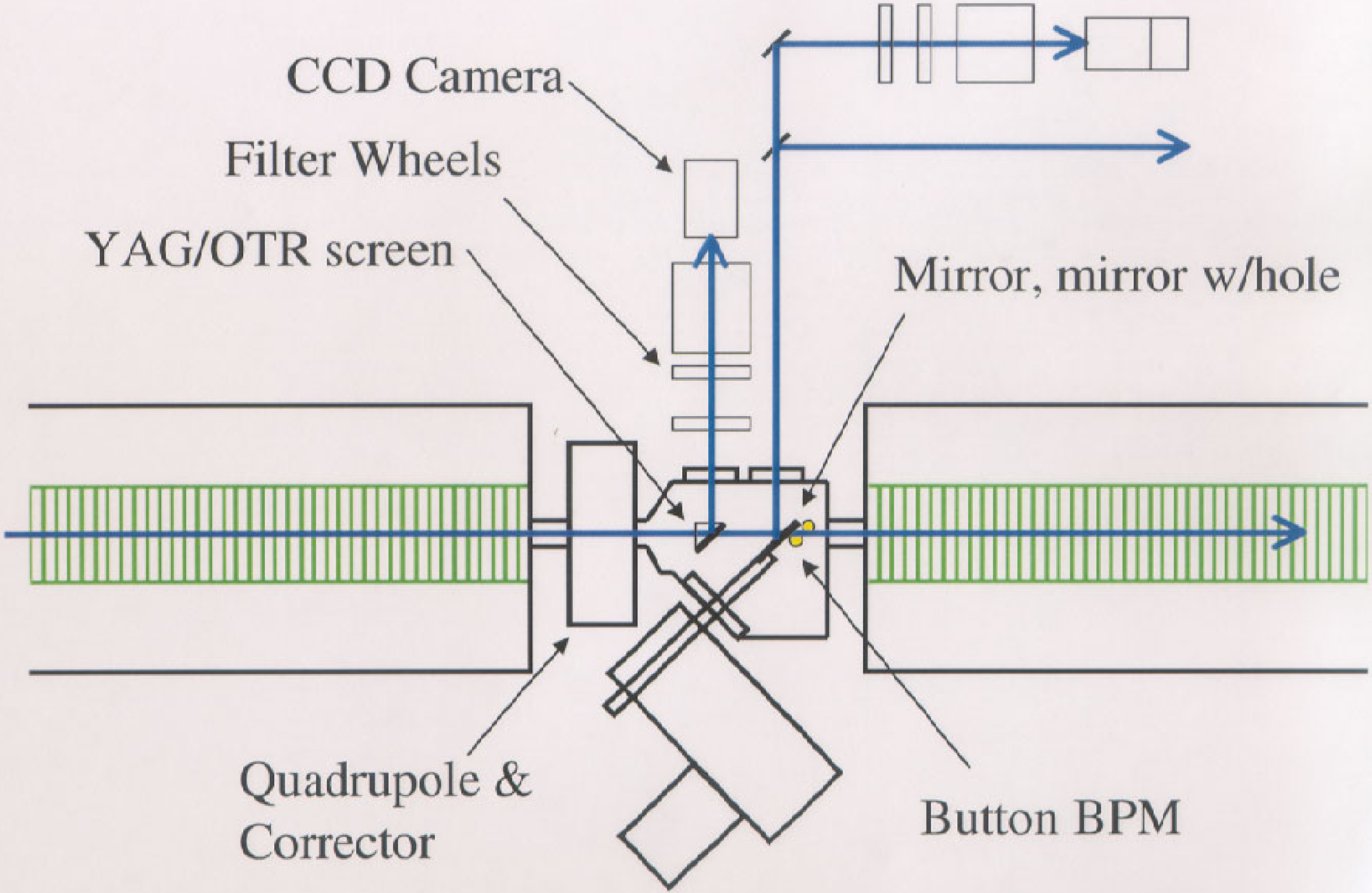
APS SASE Project Goals

- Characterize the SASE FEL output and perform experiments with it.
- Assess the challenges associated with producing a SASE FEL in preparation for an x-ray regime machine.

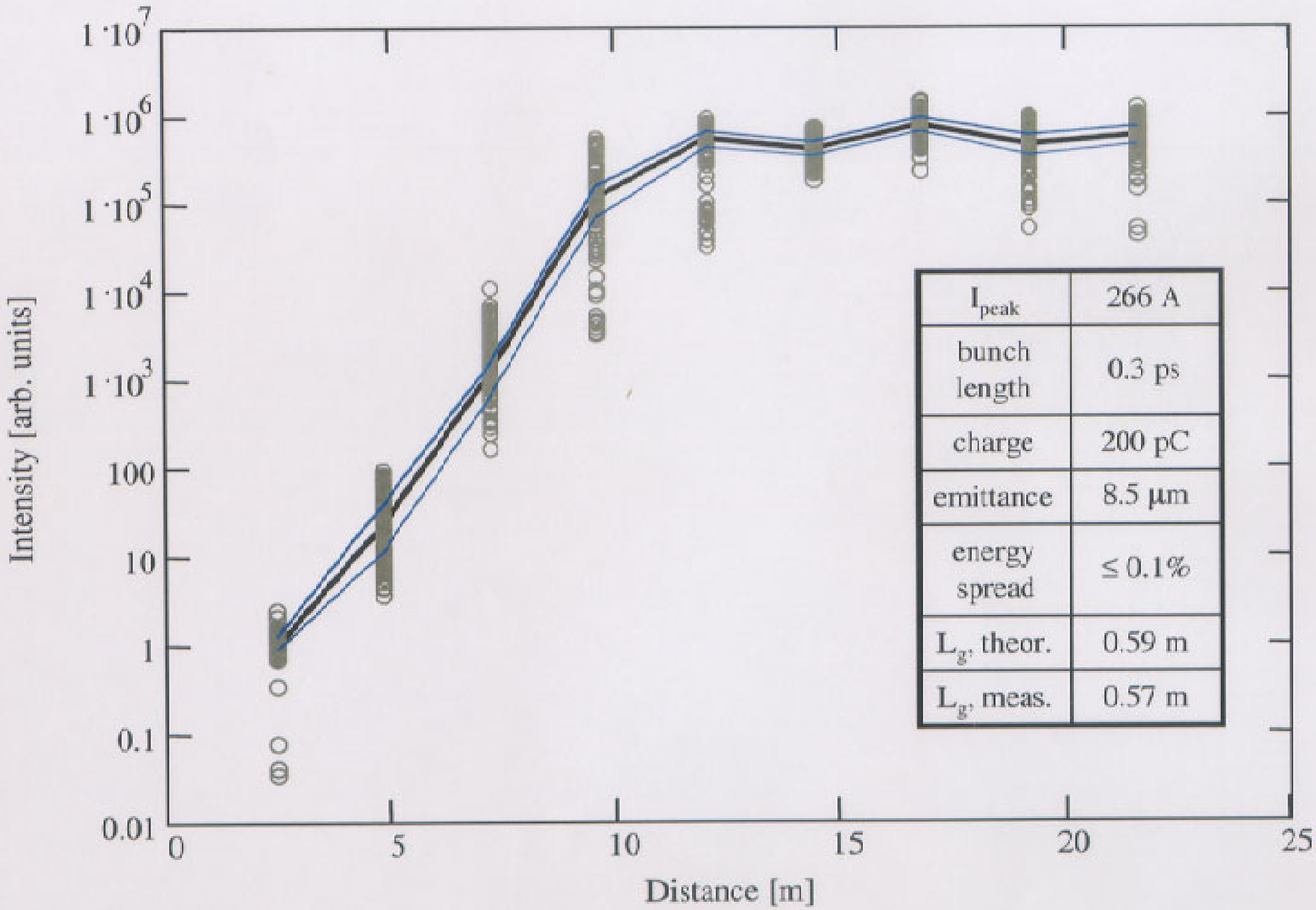
Basic Parameters for the APS FEL

PARAMETERS			
Wavelength [nm]	Regime 1 530	Regime 2 120	Regime 3 51
Electron Energy [MeV]	217	457	700
Normalized rms Emittance (π mm-mrad)	5	3	3
Energy Spread [%]	0.1	0.1	0.1
Peak Current [A]	100	300	500
Undulator Period [mm]	33		
Magnetic Field [T]	1.0		
Undulator Gap [mm]	9.3		
Cell Length [m]	2.73		
Gain Length [m]	0.81	0.72	1.2
Undulator Length [m]	5 x 2.4 then 9 x 2.4	9 x 2.4	10 x 2.4

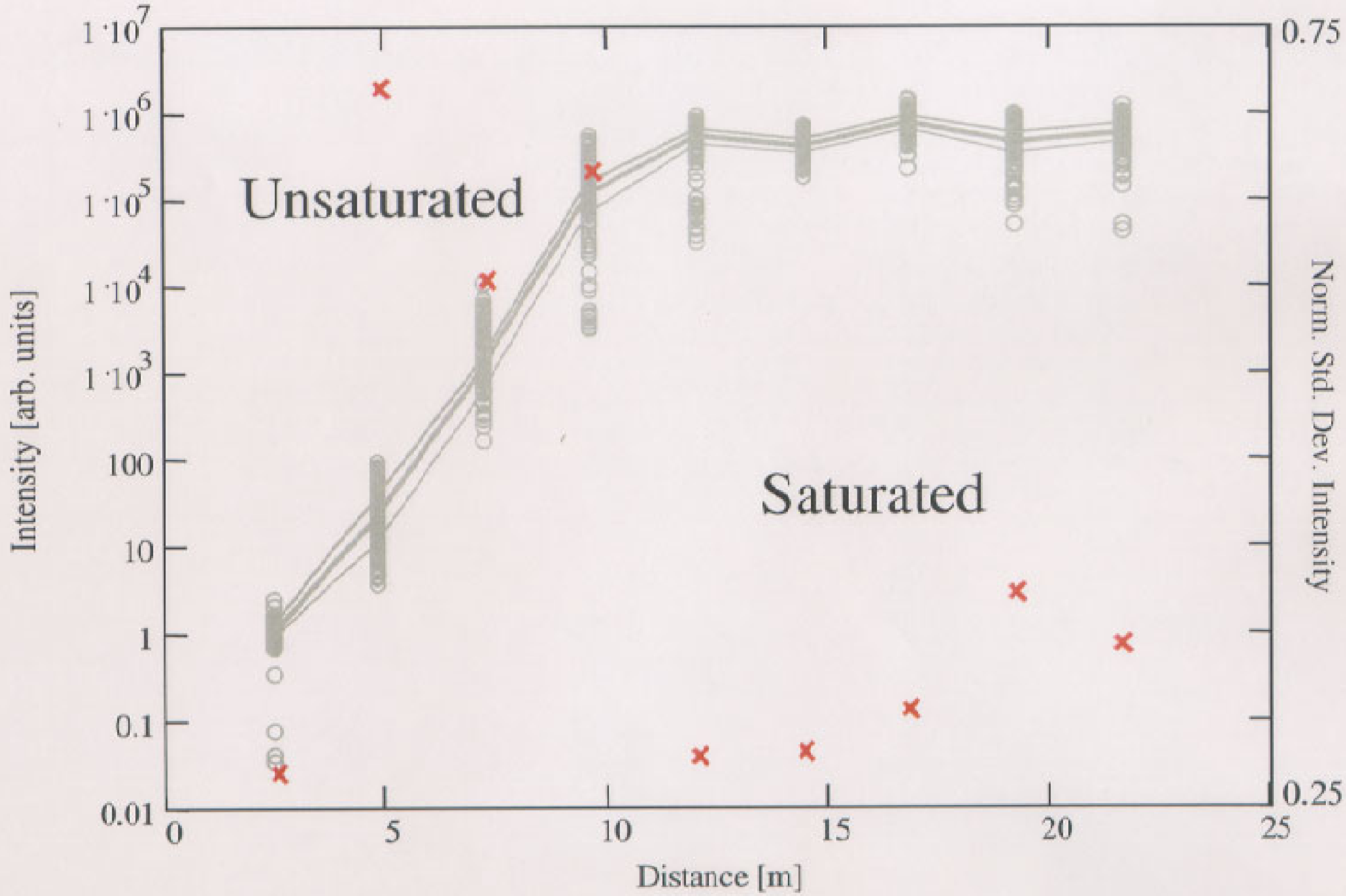
Undulator Line Diagnostics



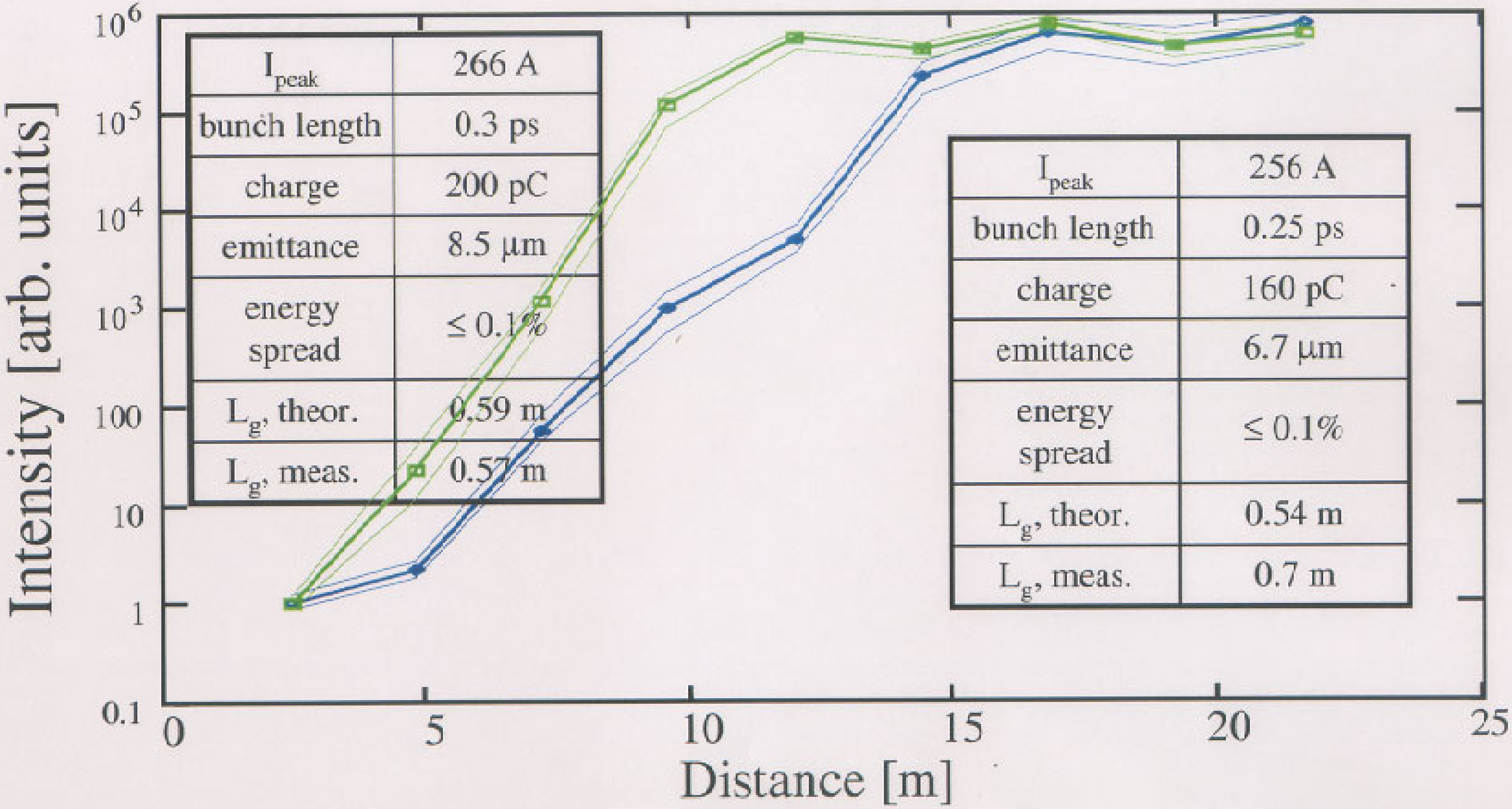
Optical Intensity vs. Distance: Gain



Optical Intensity Statistics

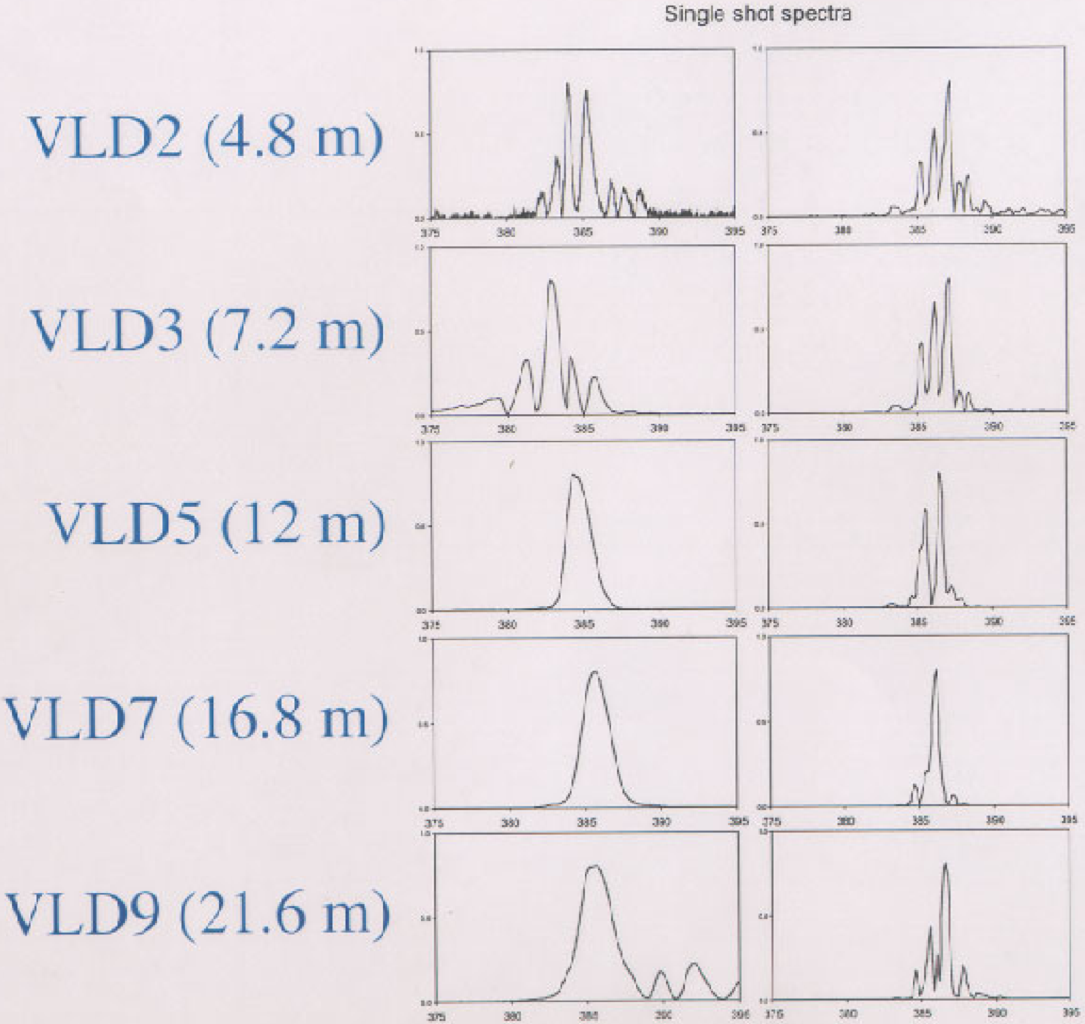


Trajectory & Matching Effects

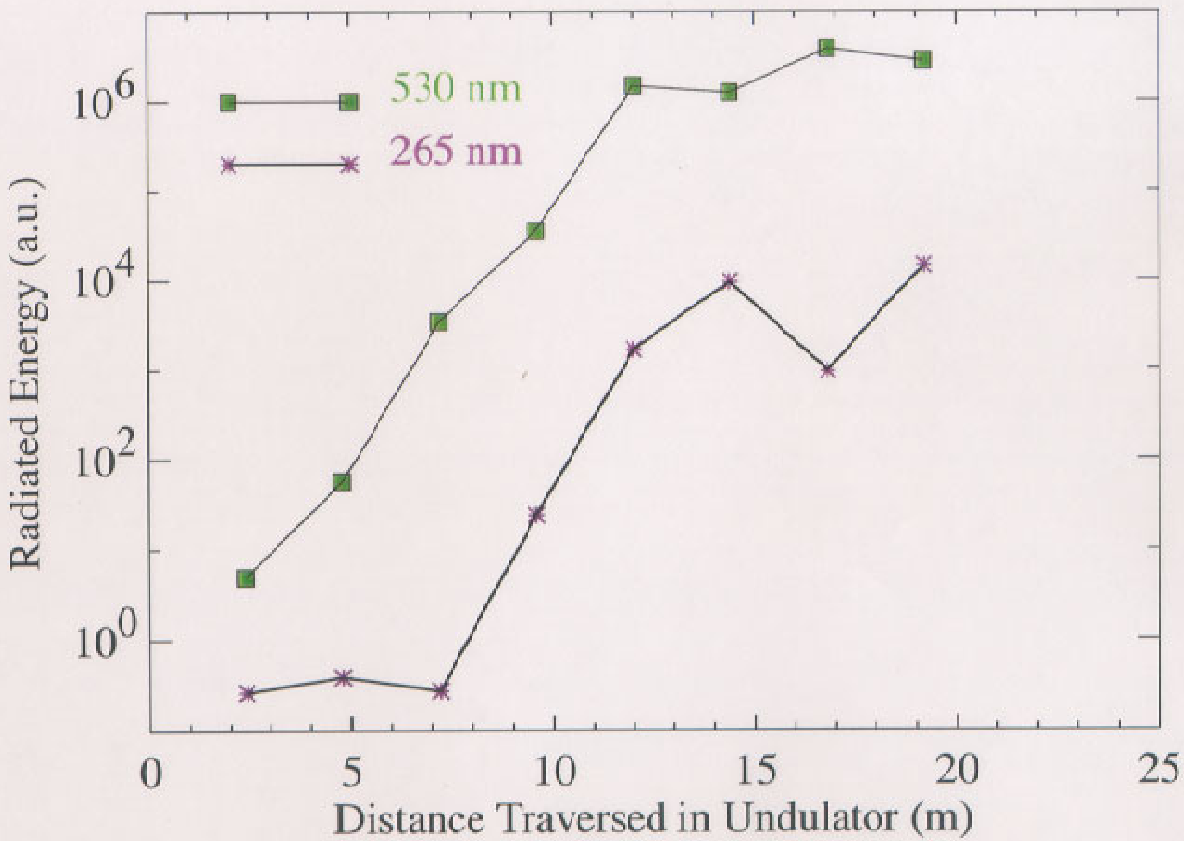


SASE Spectra – 385 nm

Measurement Simulation

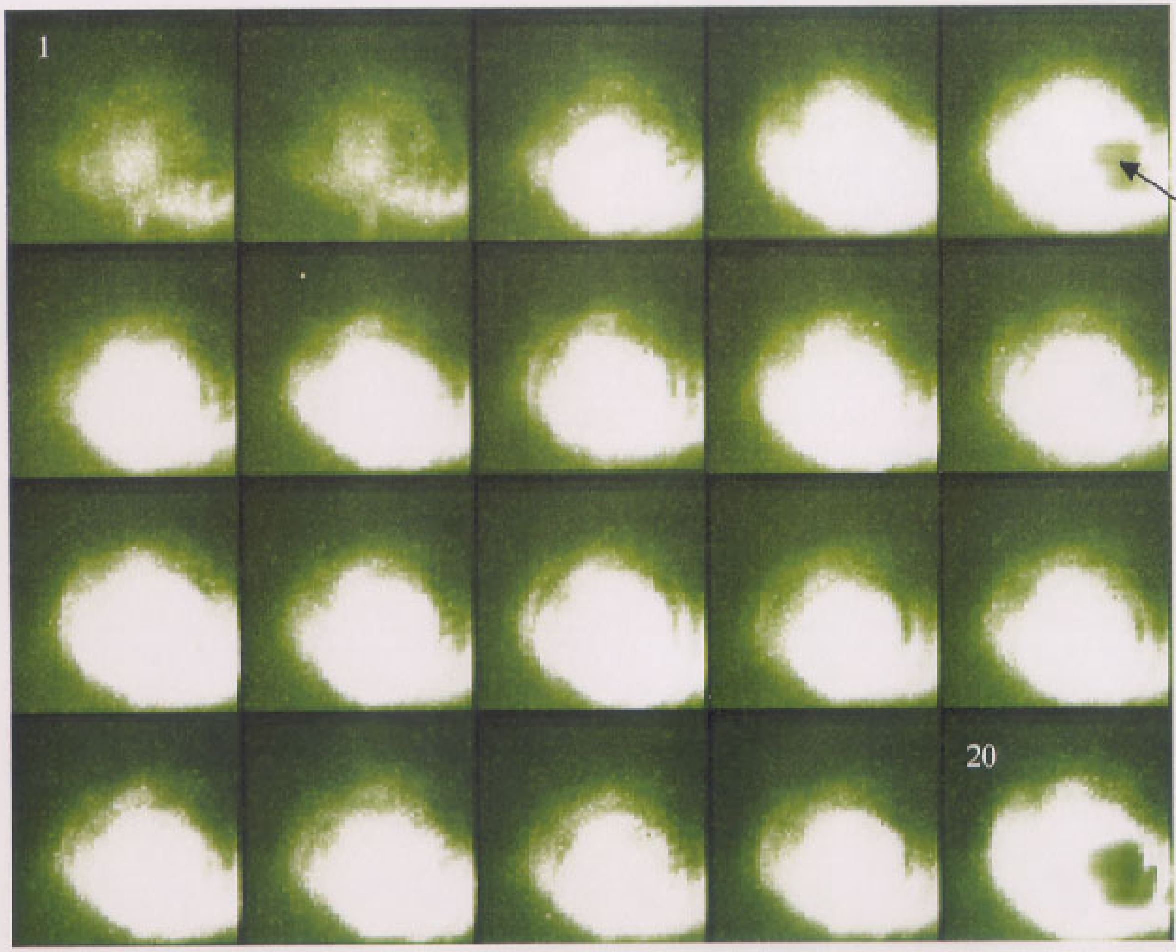


Harmonics vs. Distance

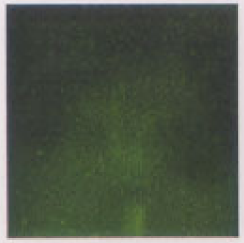


First SASE Gain at 120 nm

Sequential Images of 120 nm SASE Signal

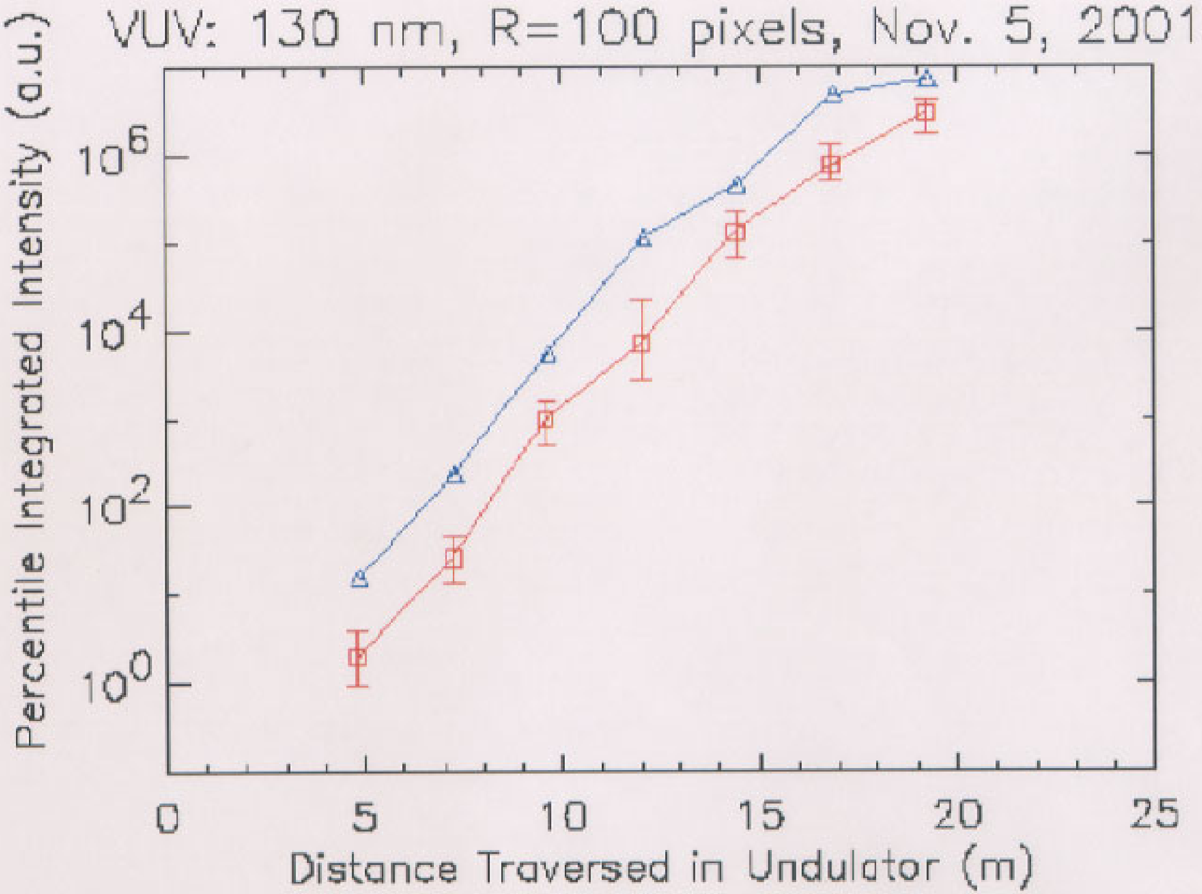


- Charge and other beam parameters constant. Only steering varied.
- "Burn" hole due to extreme saturation of the CCD detector.
- Inherent fluctuations not clearly visible due to saturated CCD.



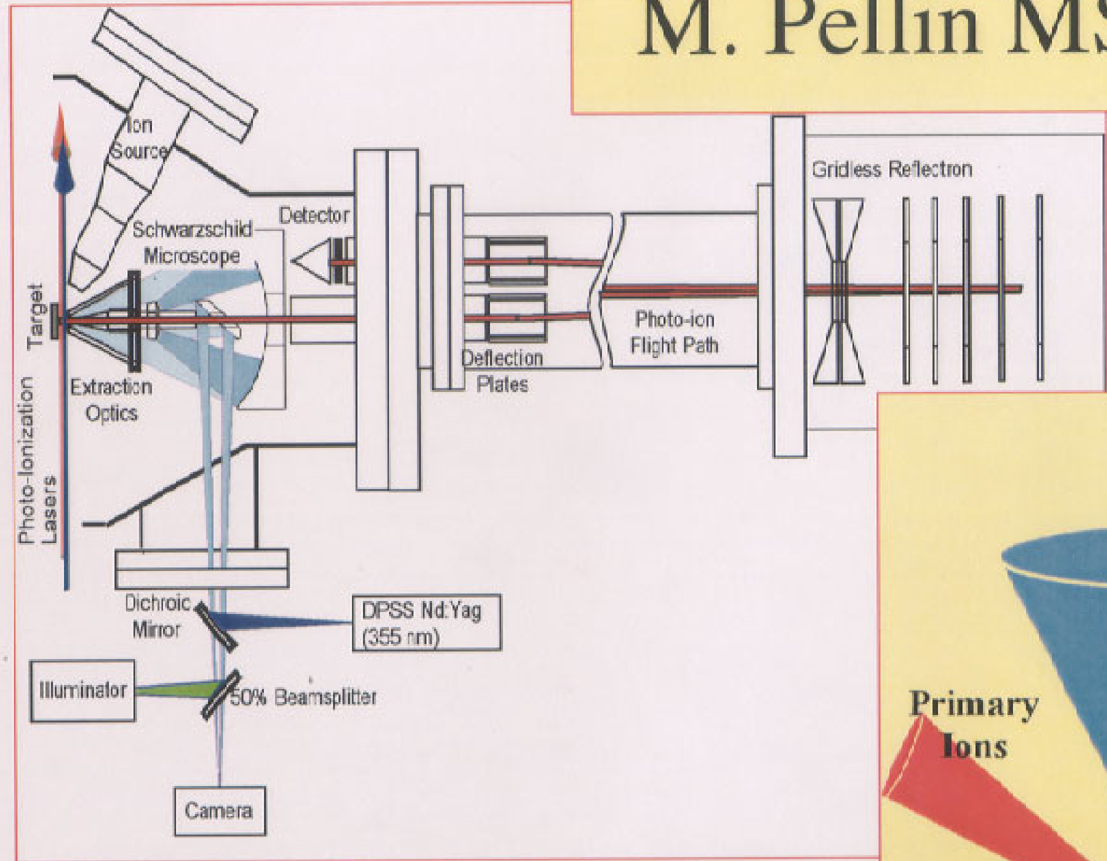
Spontaneous Signal

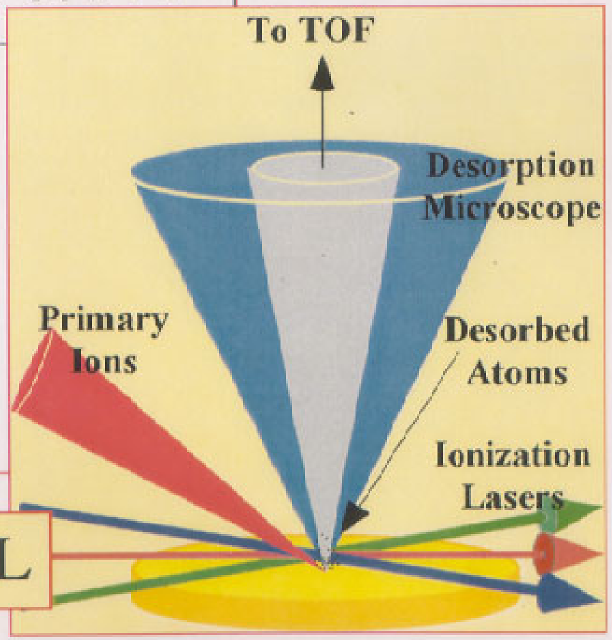
Recent Results at 130 nm



The First APS FEL Experiment

M. Pellin MSD/ANL



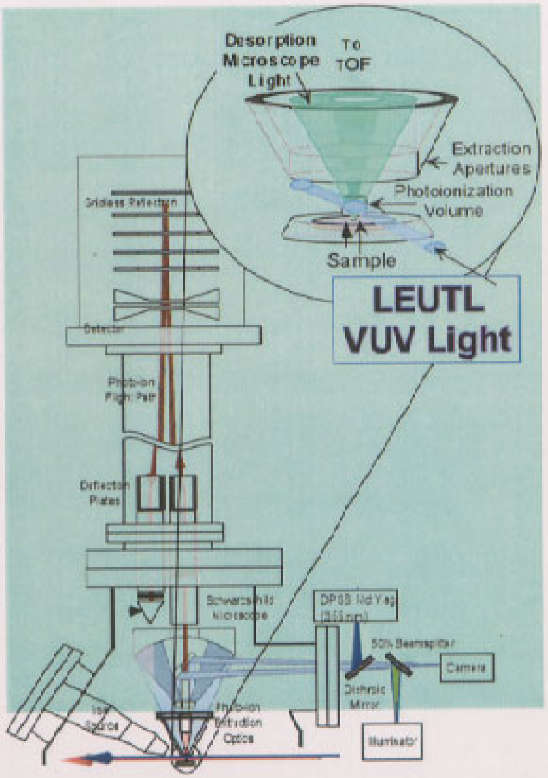


LEUTL

The First APS FEL Experiment

Single Photon Ionization / Resonant Ionization to Threshold (SPIRIT)

M. Pellin MSD/ANL



Coming 2002

SPIRIT will use the high VUV pulse energy from LEUTL to uniquely study –

- **Trace quantities of light elements:**
  H, C, N, O in semiconductors with
  100 times lower detection limit
- **Organic molecules <u>with minimal</u> <u>fragmentation</u>**
  cell mapping by mass becomes feasible
  polymer surfaces
  modified (carcinogenic) DNA
  photoionization thresholds
- **Excited states of molecules**
  cold wall desorption in accelerators
  sputtering of clusters

Future Plans/Upgrades

- Interleaving Operations For Top-up
- Shorter Wavelengths
- Complete VUV Optics Upgrade
- First Pioneering Experiment
- Beam Energy Upgrade (4 additional accelerating structures)
- 2nd-Generation SASE Devices
  - RAFEL
  - Self-Seeding
  - "After burner"
  - ......?

Summary

- The APS SASE FEL has been used to explore in detail the SASE process over a fully tunable wavelength range of from 660 nm -> 120 nm.
- The first user pioneering experiment (SPIRIT) will be installed early in 2002 and we expect result shortly after.
- Plans to extend further the capabilities of the facility will depend strongly on the voice of the external scientific community.