

— The Consortium for X-ray Lithography —

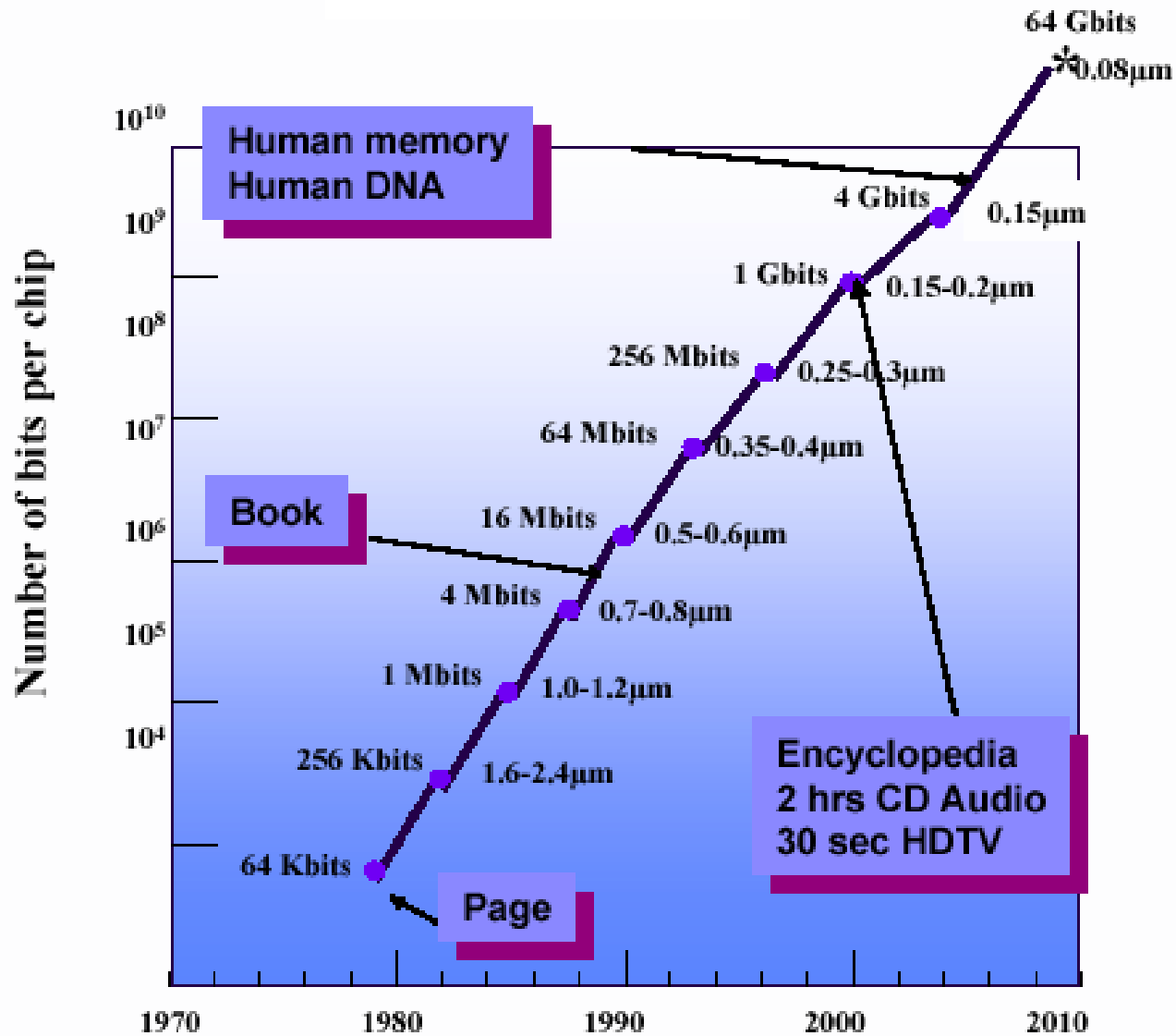
GWYN P. WILLIAMS

Jefferson Lab
12000 Jefferson Avenue - MS 7A
Newport News, VA 23606
gwyn@mailaps.org

User / LPC Meeting, March 19-20, 2003



Moore's Law



X-ray Lithography

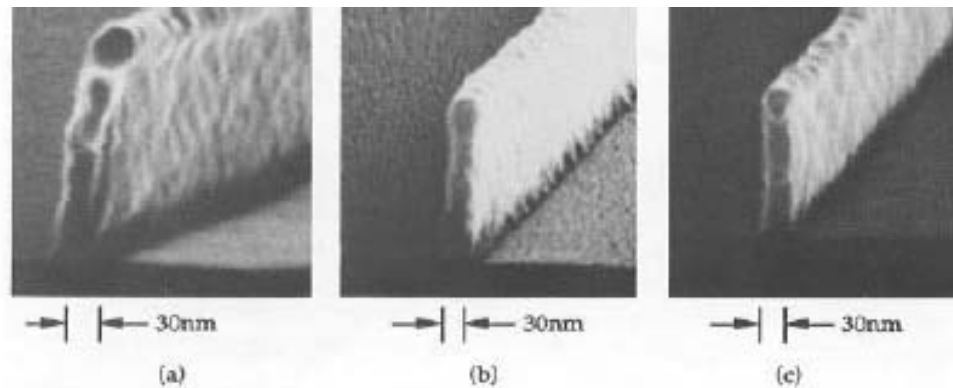


Figure 3. Replication in PMMA of a 30nm-wide gold absorber line with (a) C_K ($\lambda = 4.5\text{nm}$), (b) Cu_L ($\lambda = 1.3\text{nm}$), and (c) Al_K ($\lambda = 0.83\text{nm}$).

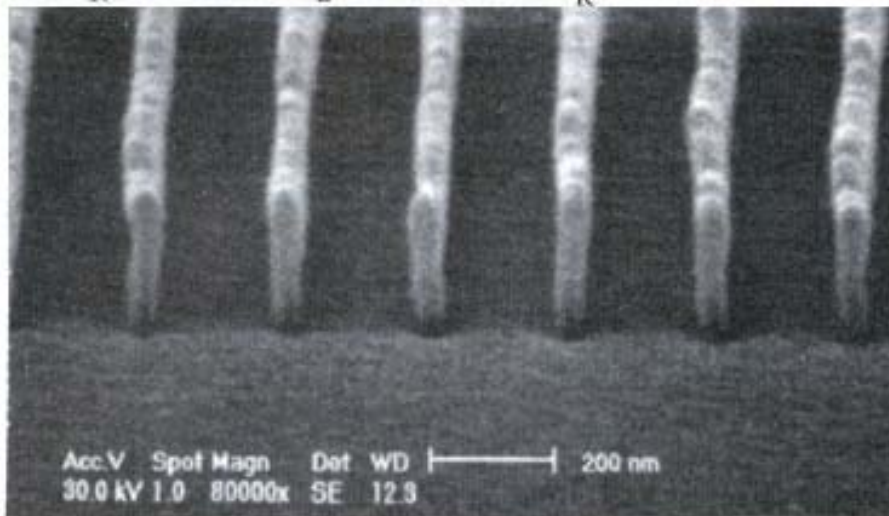


FIG. 6. SEM image of 20 nm lines replicated in PMMA under soft-contact printing condition ($g < 2 \mu\text{m}$).

K.Early, et al.: Absence of resolution degradation in X-ray lithography, *Microelectronic Engineering* **11** (1990) 317-321

Chen et al.: Edge diffraction enhanced printability in X-ray lithography, *J. Vac. Sci. Technol.* **B 16 (6)**, Nov/Dec 1998, 3521-3525

History of lithography

- 1970's – visible light prints to few microns
- 1980's – mercury lamps, G-line 436 nm, I-line 365 nm
 - development of XRL at 250 nm
- 1990's – excimer lasers come in at 248 nm KrF, ArF at 193 nm
 - XRL abandoned in 1998
- 2000's – last excimer F2 at 157??

Next Generation Lithography (NGL)

	cost (\$M)	# wafers/hour
Ion beam	15	32
Electron beam	13	33
EUVL	60	2
XRL	10	47

Proximity X-ray Lithography Consortium

Antony Bourdillon	UHRl Masc
Mitch J. Burte	BAES
Swapan Chattopadhyay	JLab
Fred Dylla	JLab
John Heaton	BAES
Mike Kelley	CWM/JLab
Dennis Manos	CWM
Hadis Morkoc	VCU
Dr. Omkaram (Om) Nalamasu	Lucent/RPI
Andy Pomerene	BAES
Marueen Roche	BAES
Steve Schnur	BAES
Bob Selzer	JSAL
Nathan Swami	VA
Raman Viswanathan	IBM
Yuli Vladimirsky	ASML
Gwyn Williams	JLab

Meeting held
January 24, 2003



Image Formation in PXRL

Diffraction of x-rays $\lambda = 8\text{\AA}$ from a 150 nm slit

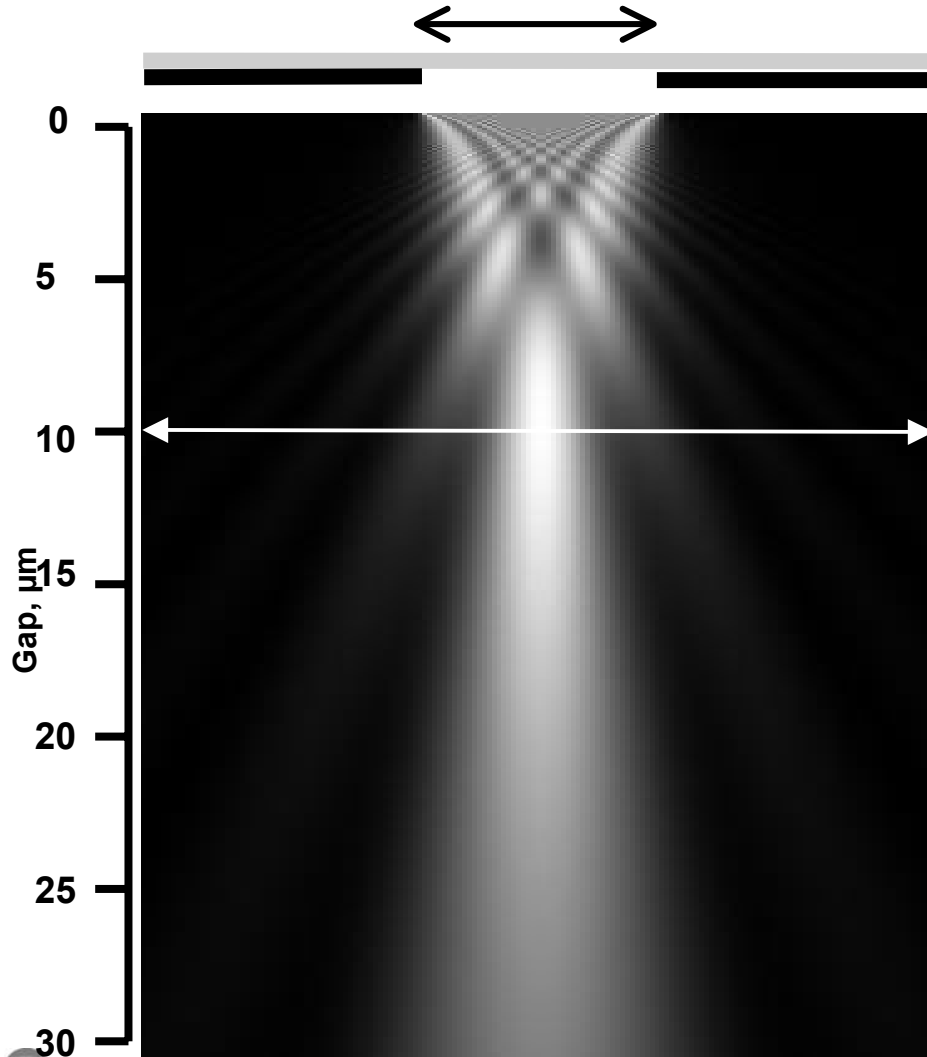


Image formation in proximity is described by Fresnel diffraction

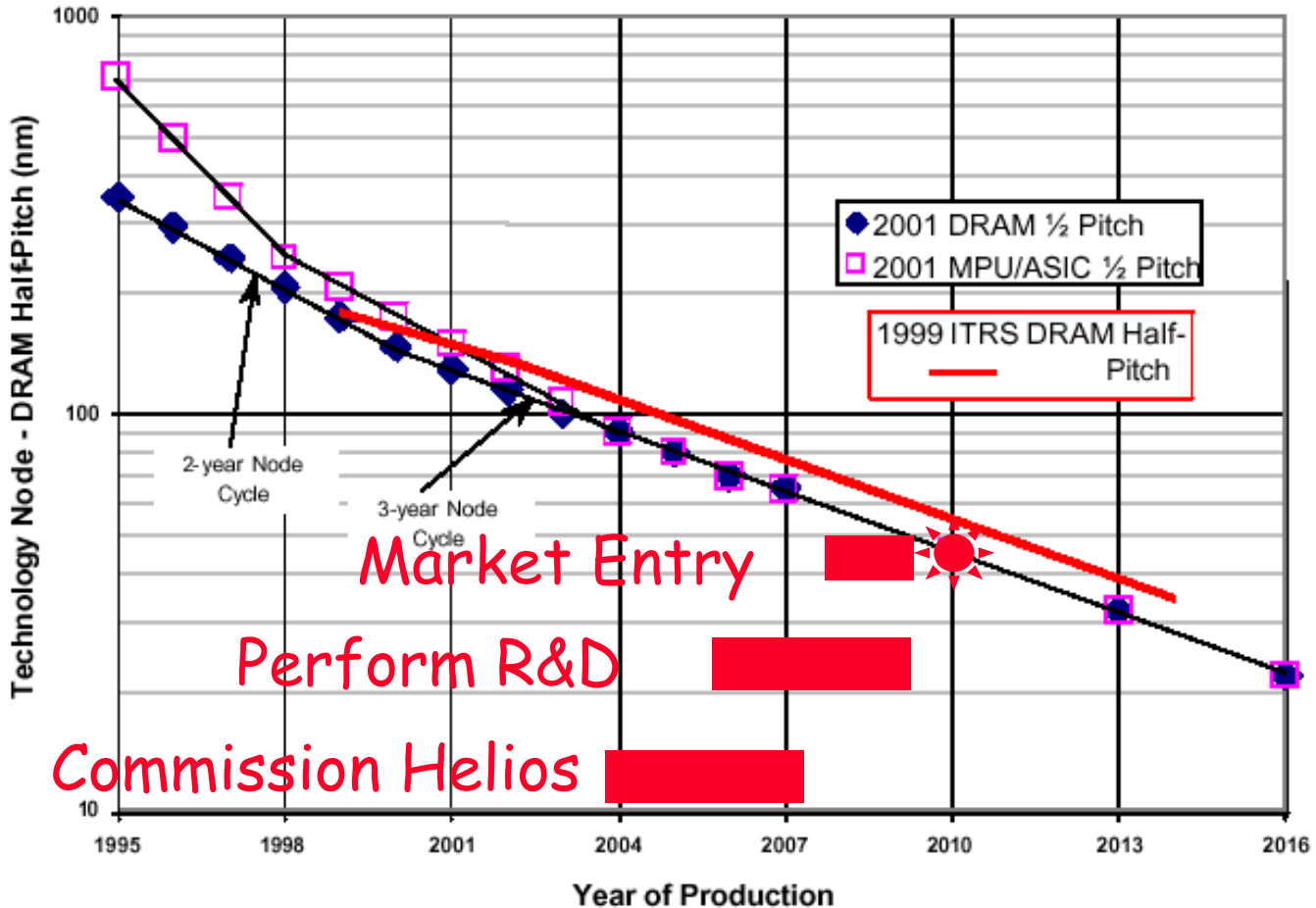
Executive summary of workshop

- Proximity x-ray lithography (PXL) is one of the leading candidates for semiconductor manufacturing at the sub 30nm level in terms of cost and throughput.
- No show-stoppers.
- A modest program to define a road-map should be developed as soon as possible.



— Semiconductors :JLab could re-commission Helios — and enter the road-map in 2010.

JLab



International Technology Roadmap for Semiconductors

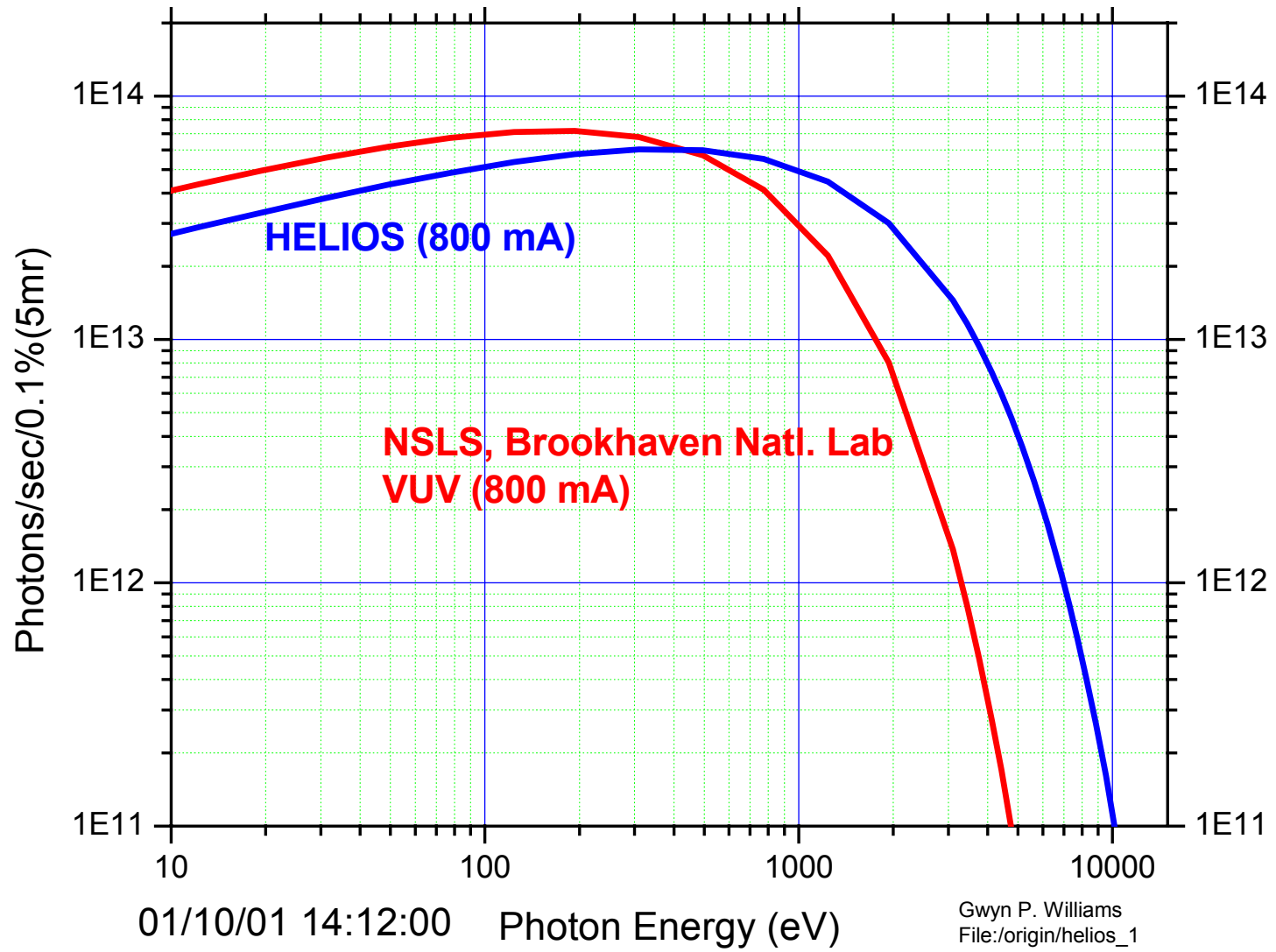
JLab Synchrotron Radiation Source - HELIOS-1



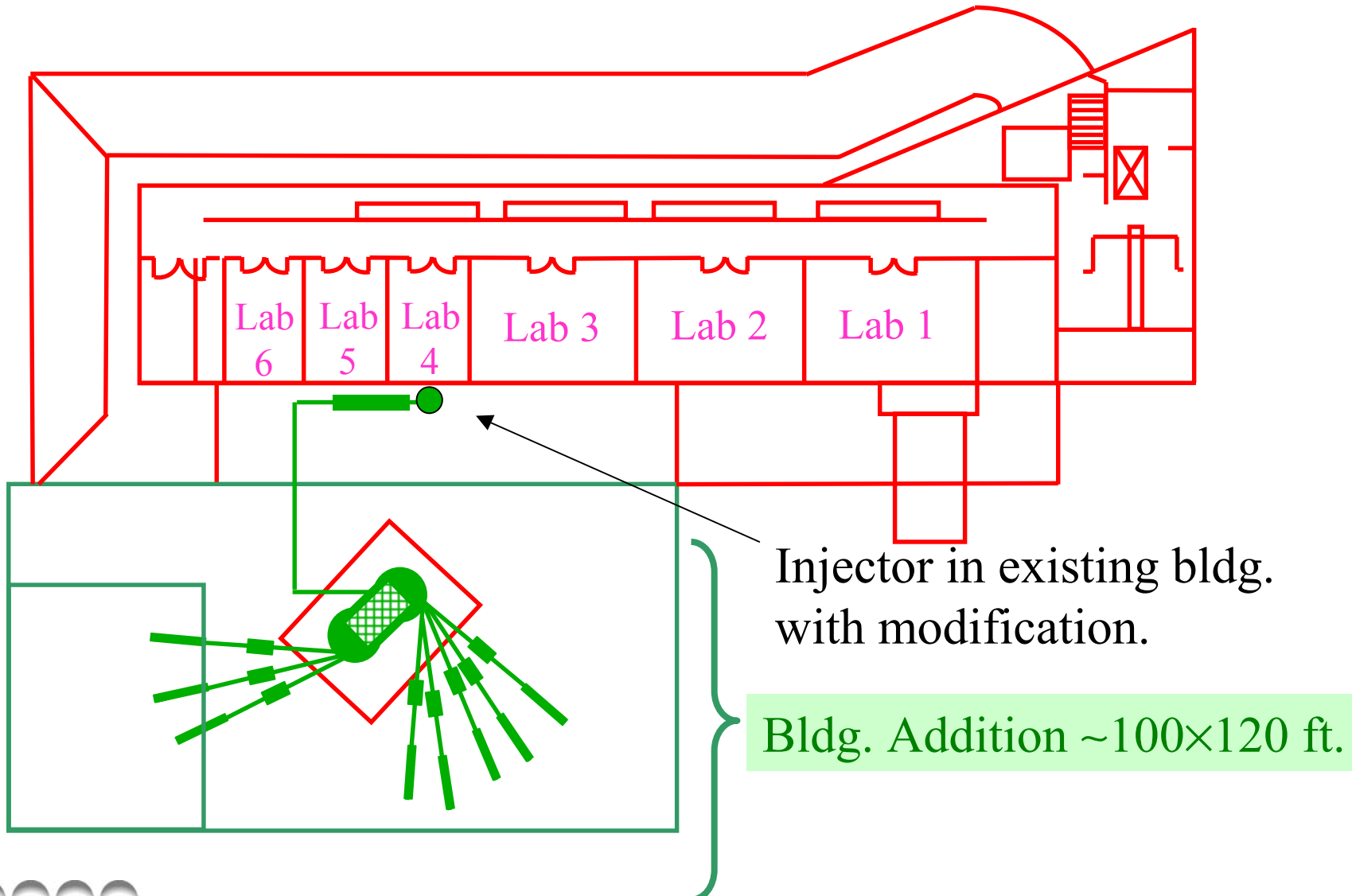
Synchrotron Specifications

- Superconducting ring, 4.5T max. field
- 700 MeV Electron Energy
- 500 MHz rf with 16 bunches
- synchronized with FEL at 125 MHz
- 10Å critical wavelength
- 800 milliamps of stored current

Helios-1 and NSLS Spectra



Helios-1 in JLab FEL building



Conclusions

- PXL very promising, modest cost to implement
- Following up with a proposal to DARPA
- Considerably enhances capability of JLab light source complex.

