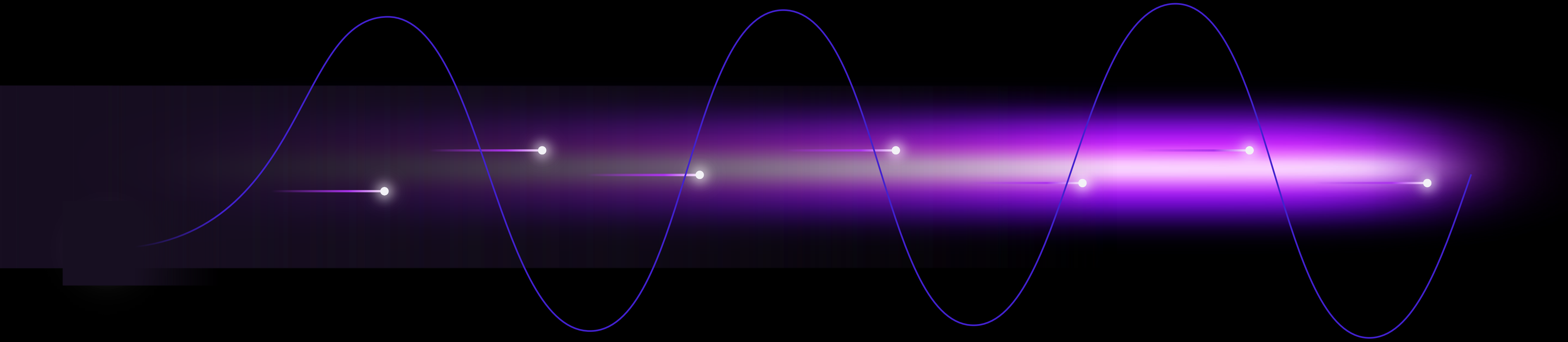
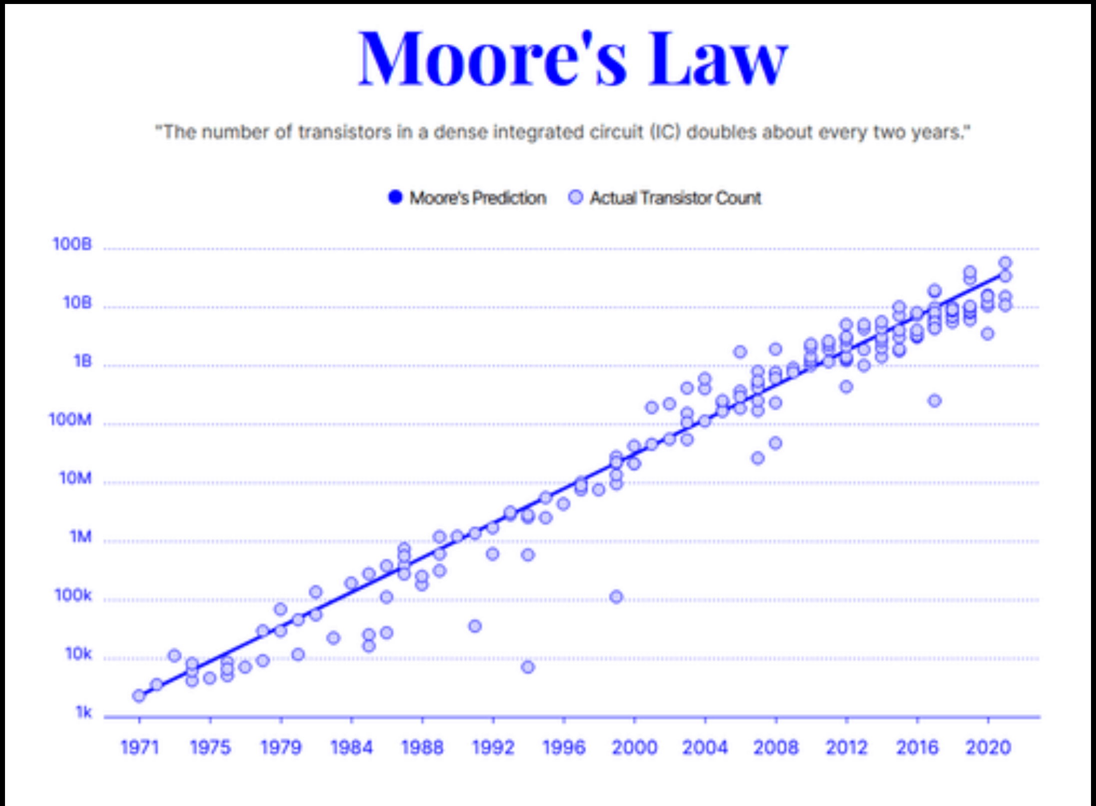


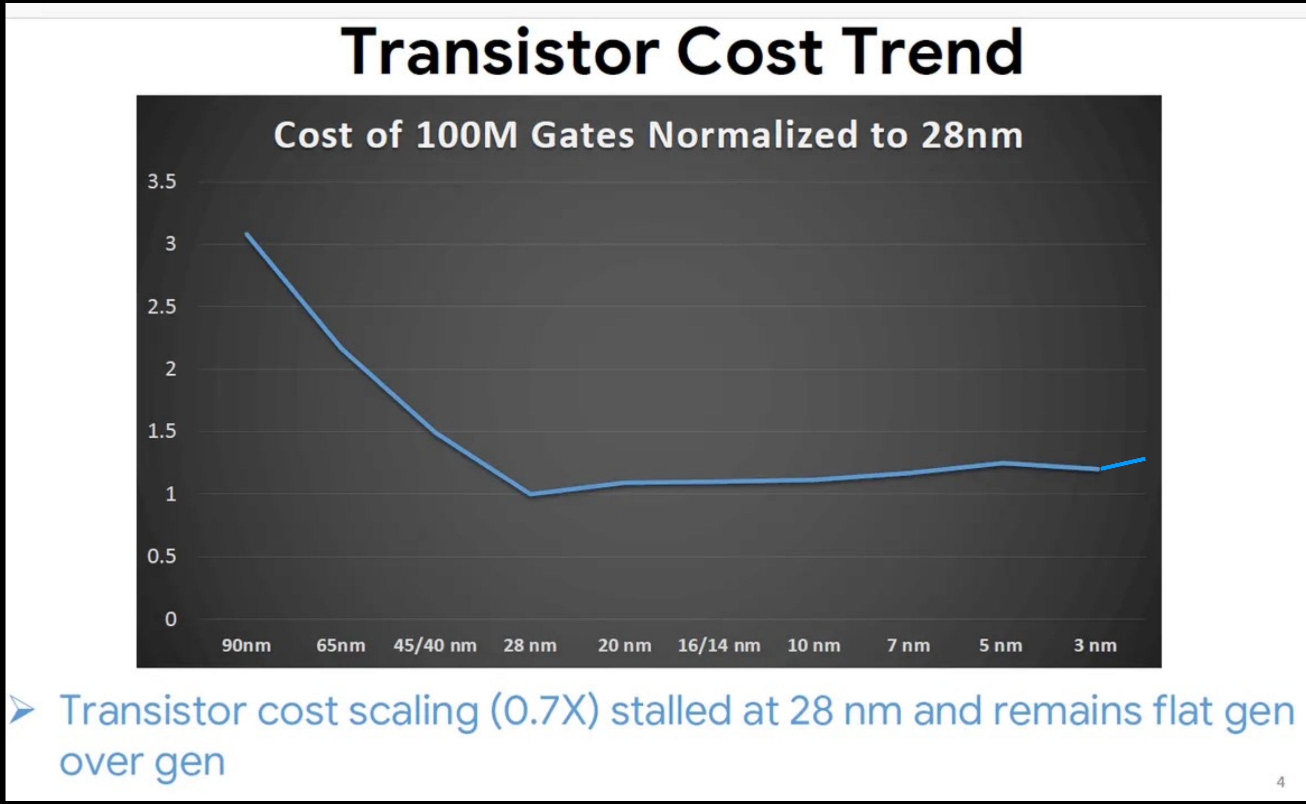
Reviving Moore’s Law with an EUV FEL

Nicholas Kelez

xLight

What is Moore's Law?



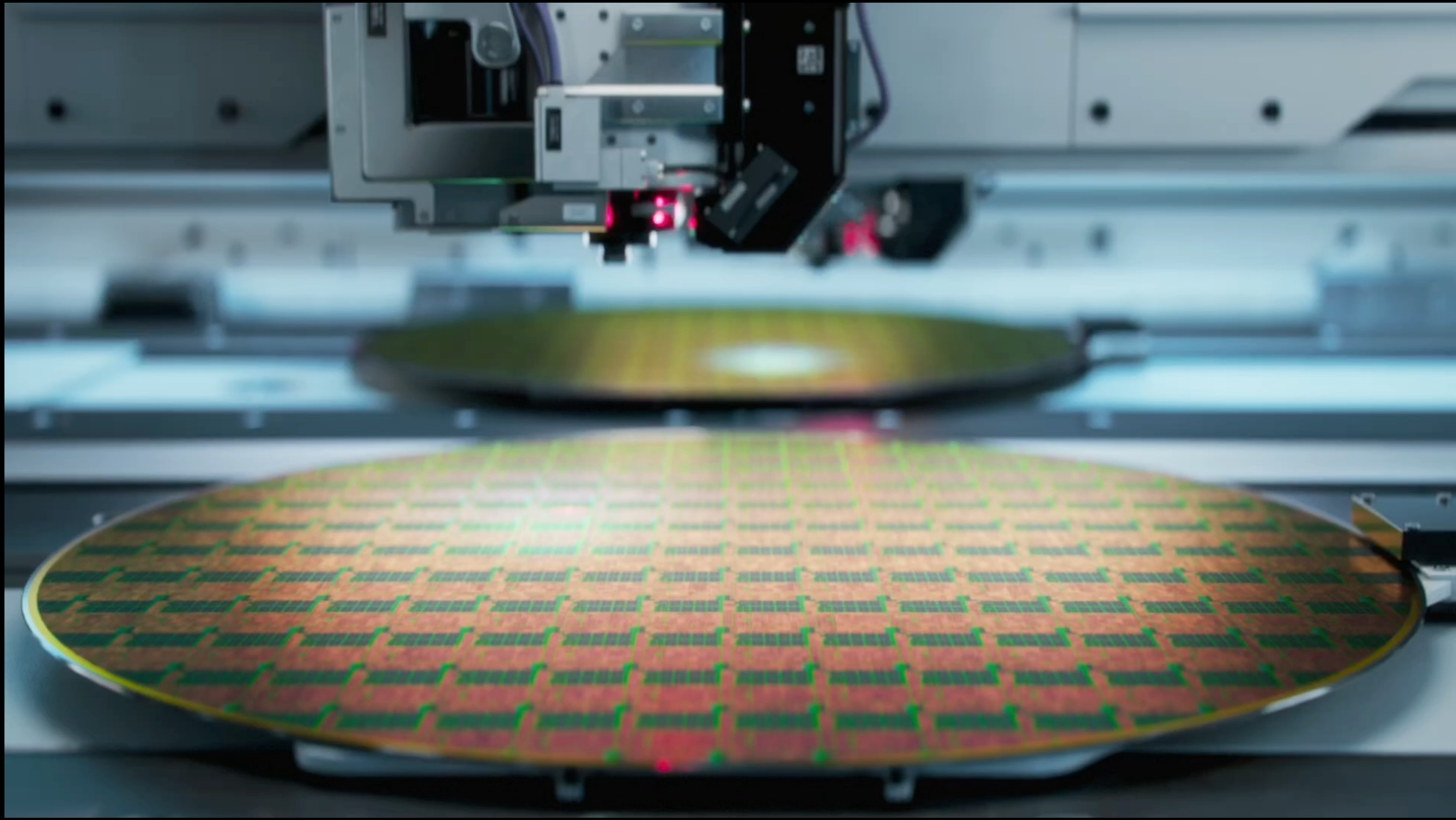


xLight

Transforming Semiconductor Manufacturing

EUV FEL makes advanced chip manufacturing:

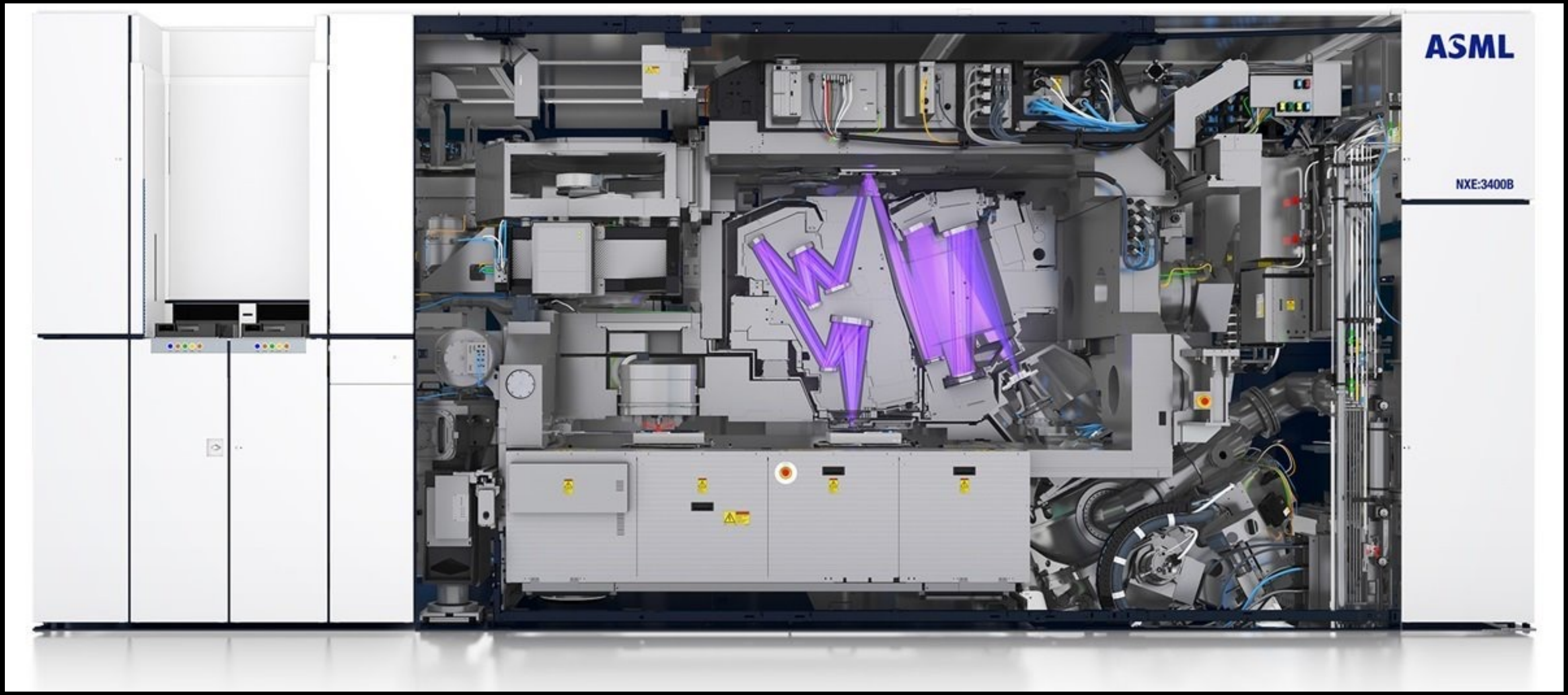
- Better
- Faster
- Cheaper
- More efficient



xLight

Delivering Unlimited Light

Partner with ASML
to unlock capabilities
and enable future
advancements



EUV LITHOGRAPHY

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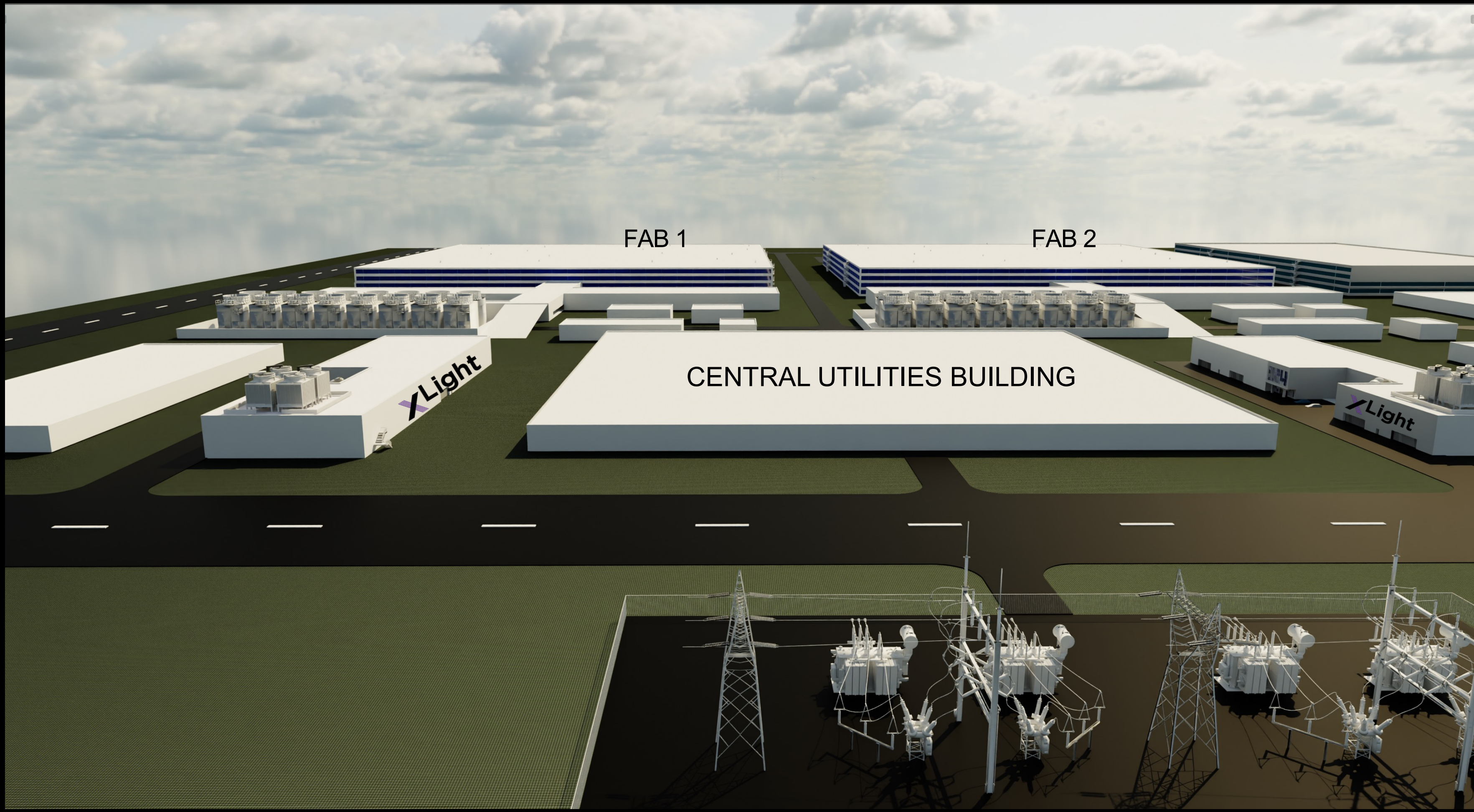
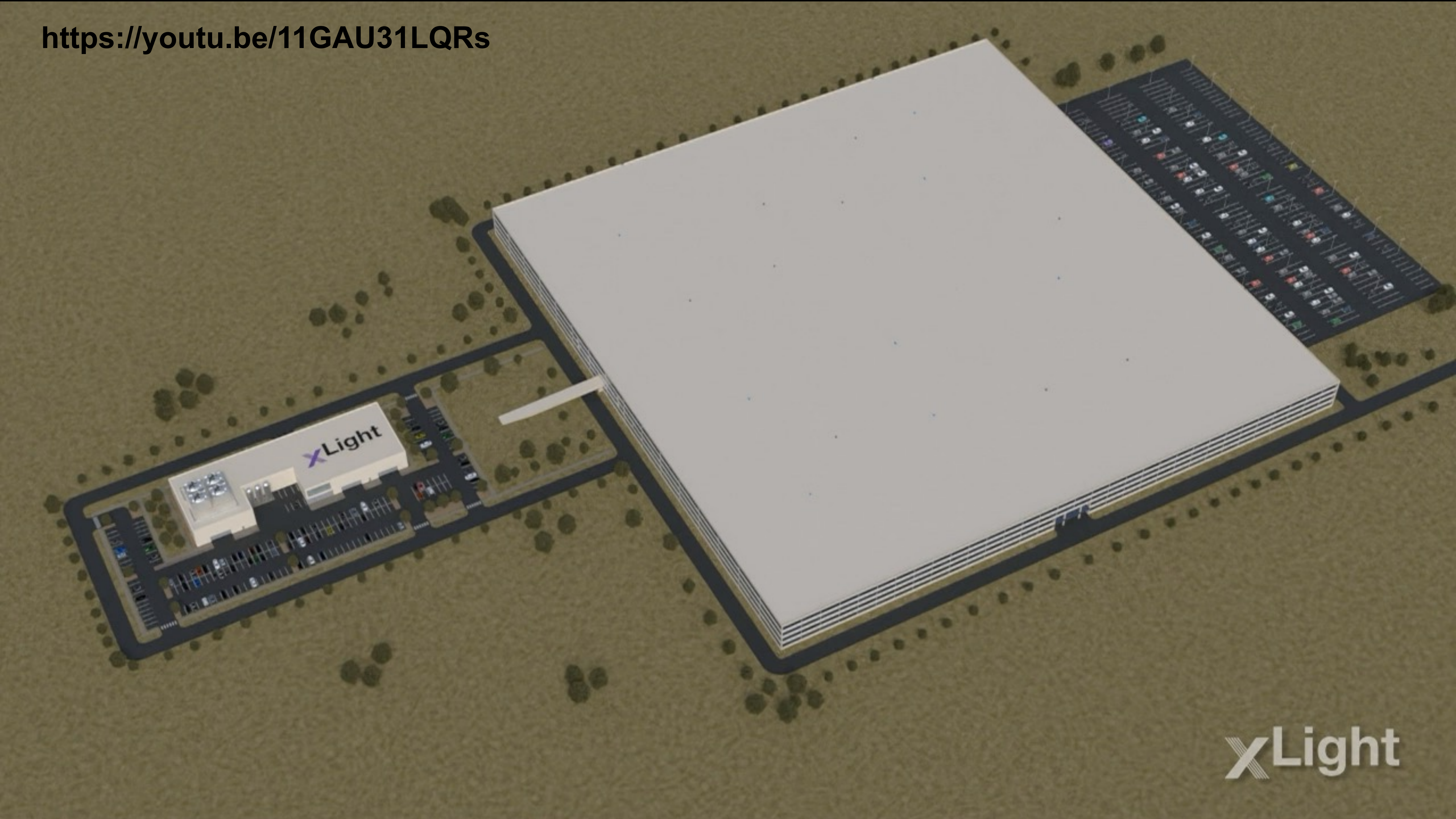
Building Utility-Scale Systems

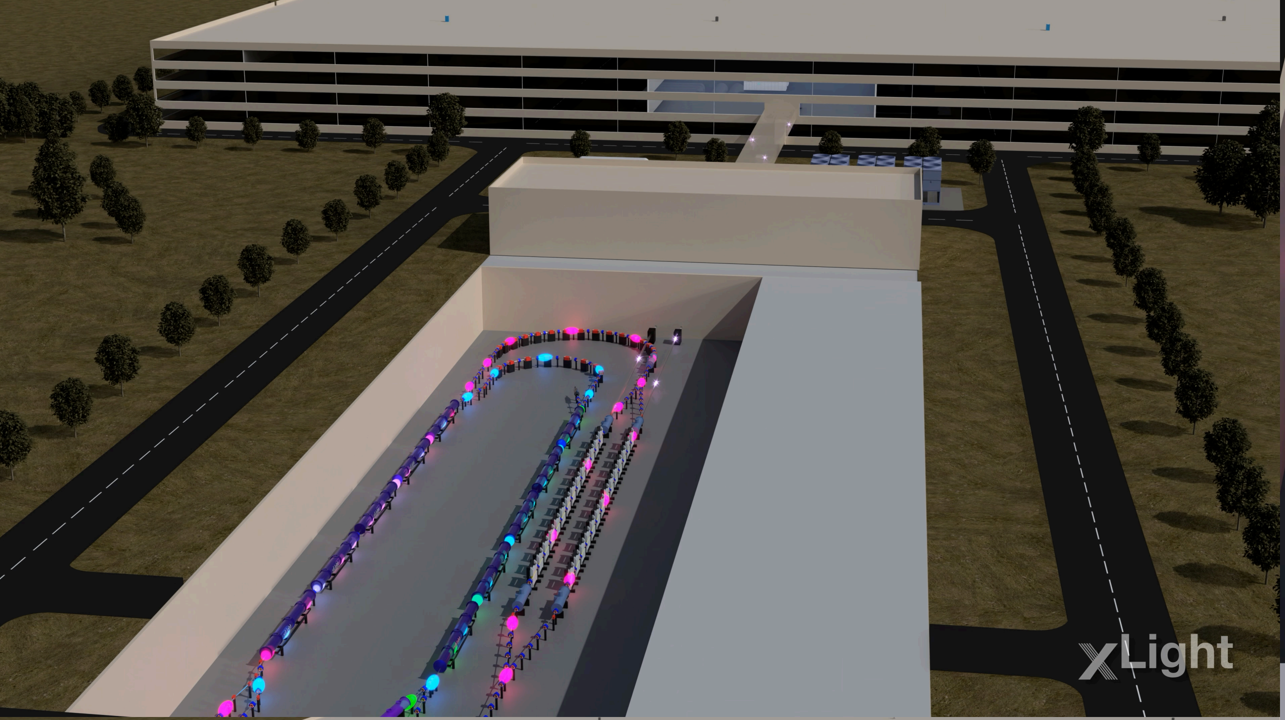
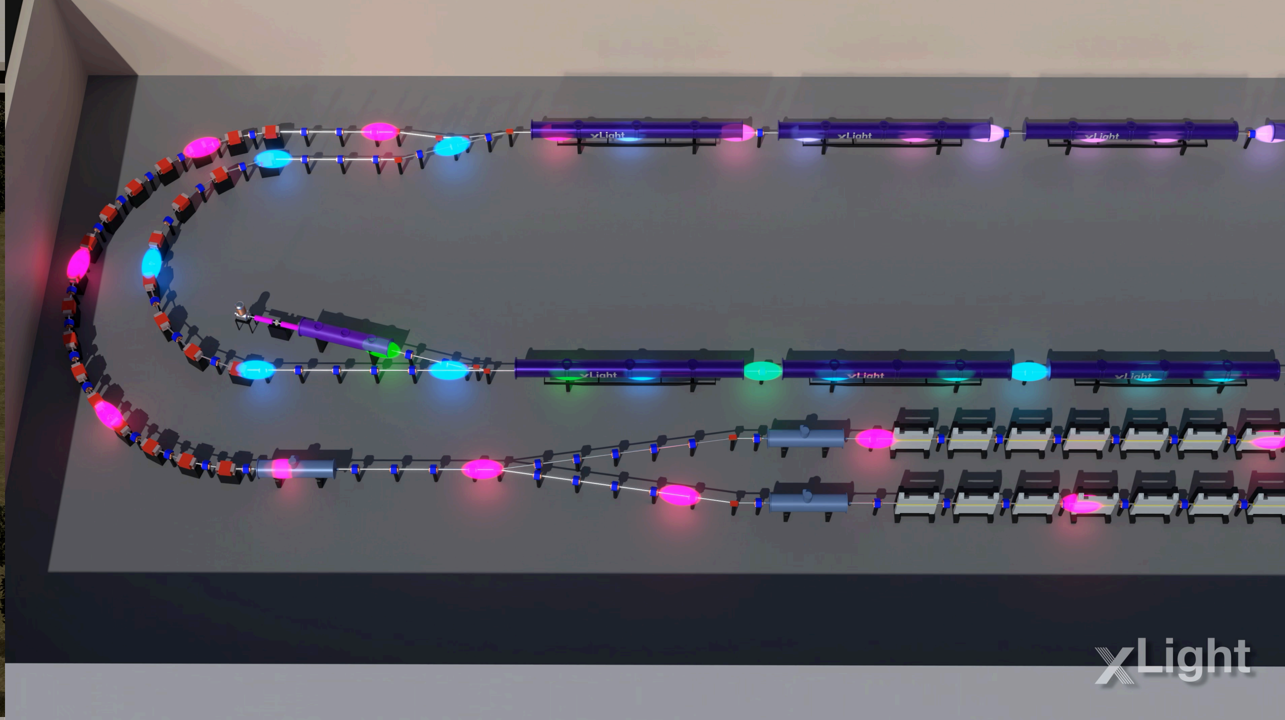
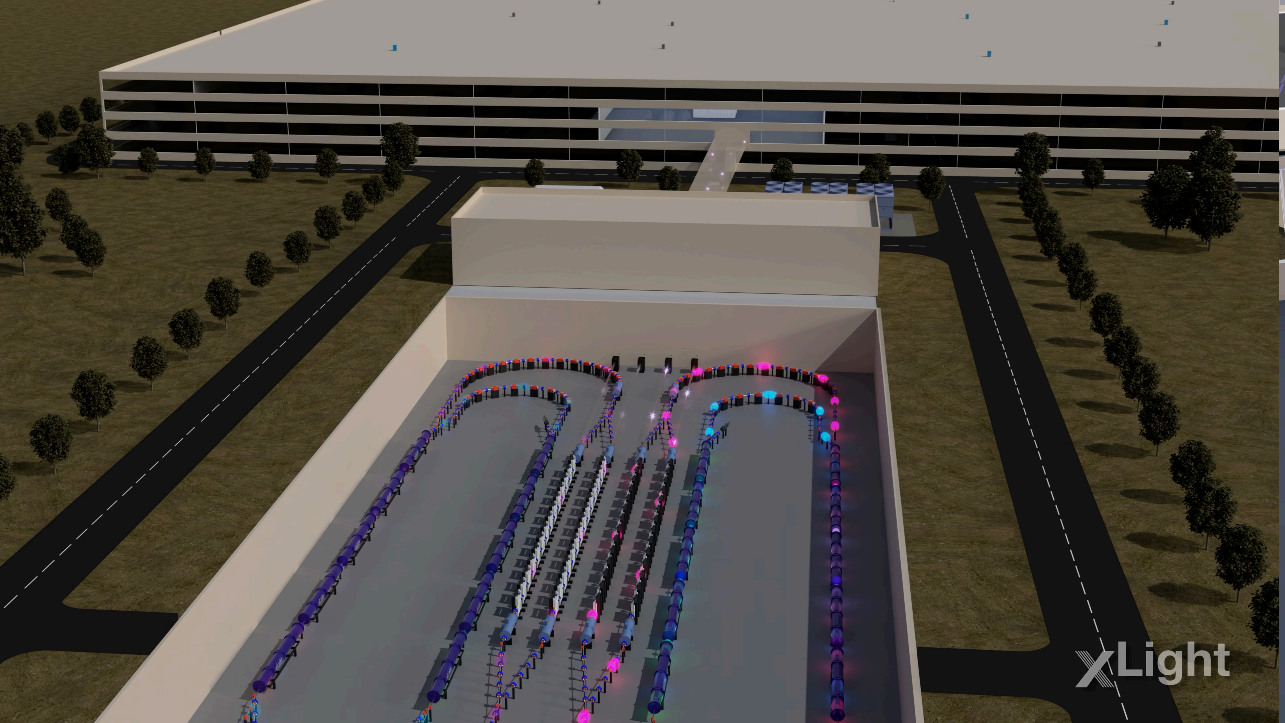
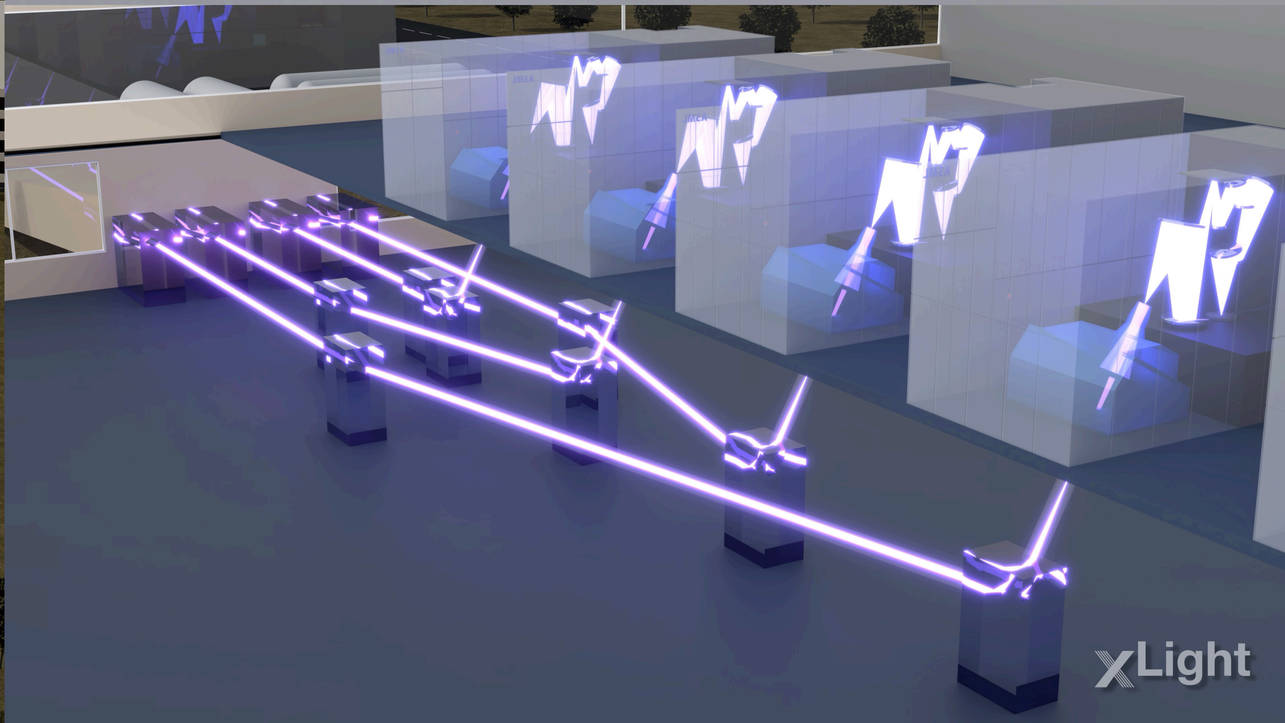
- More power
- Tunable platform
- Light as a Service (LaaS)



xLight

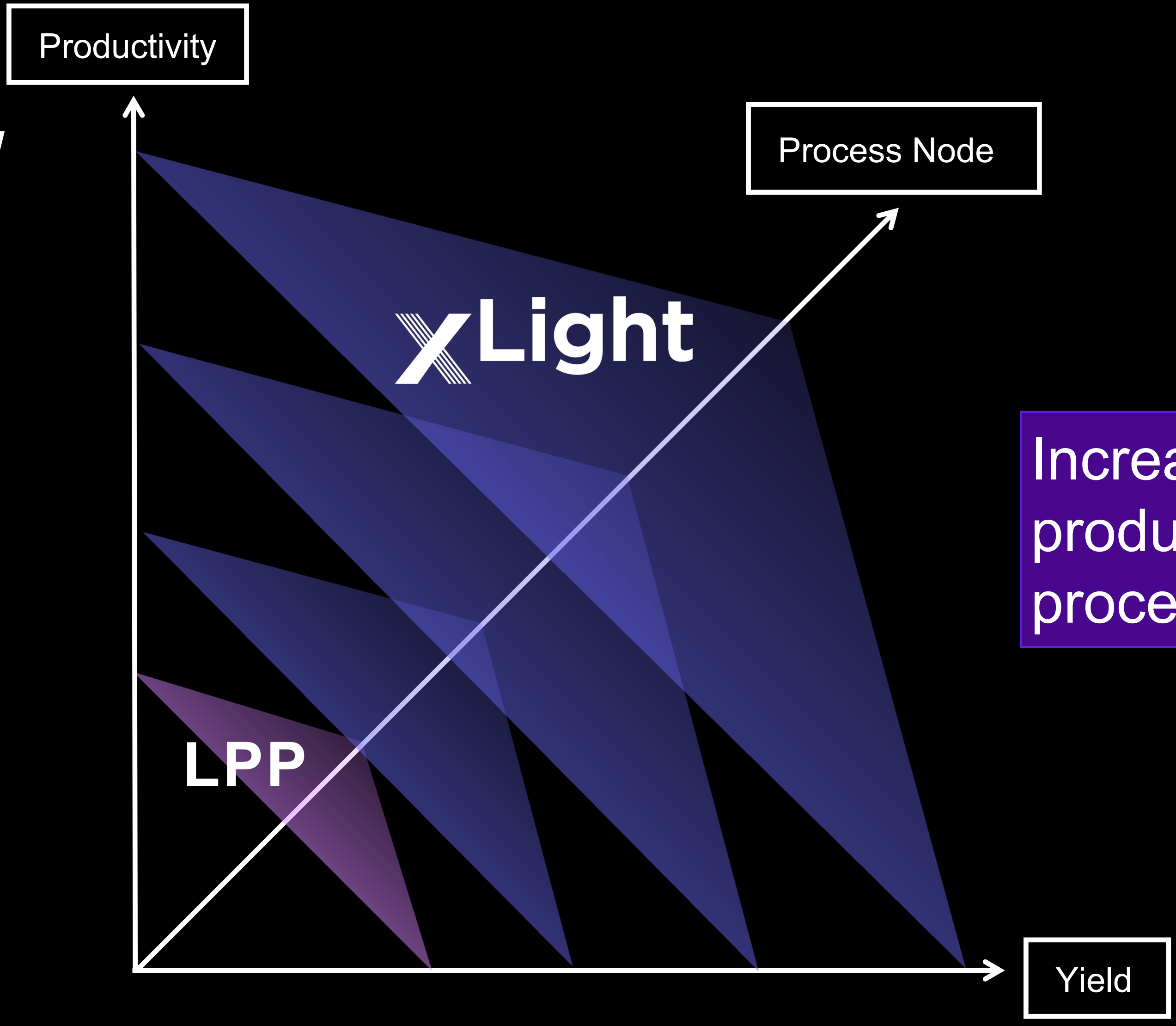
https://youtu.be/11GAU31LQRs



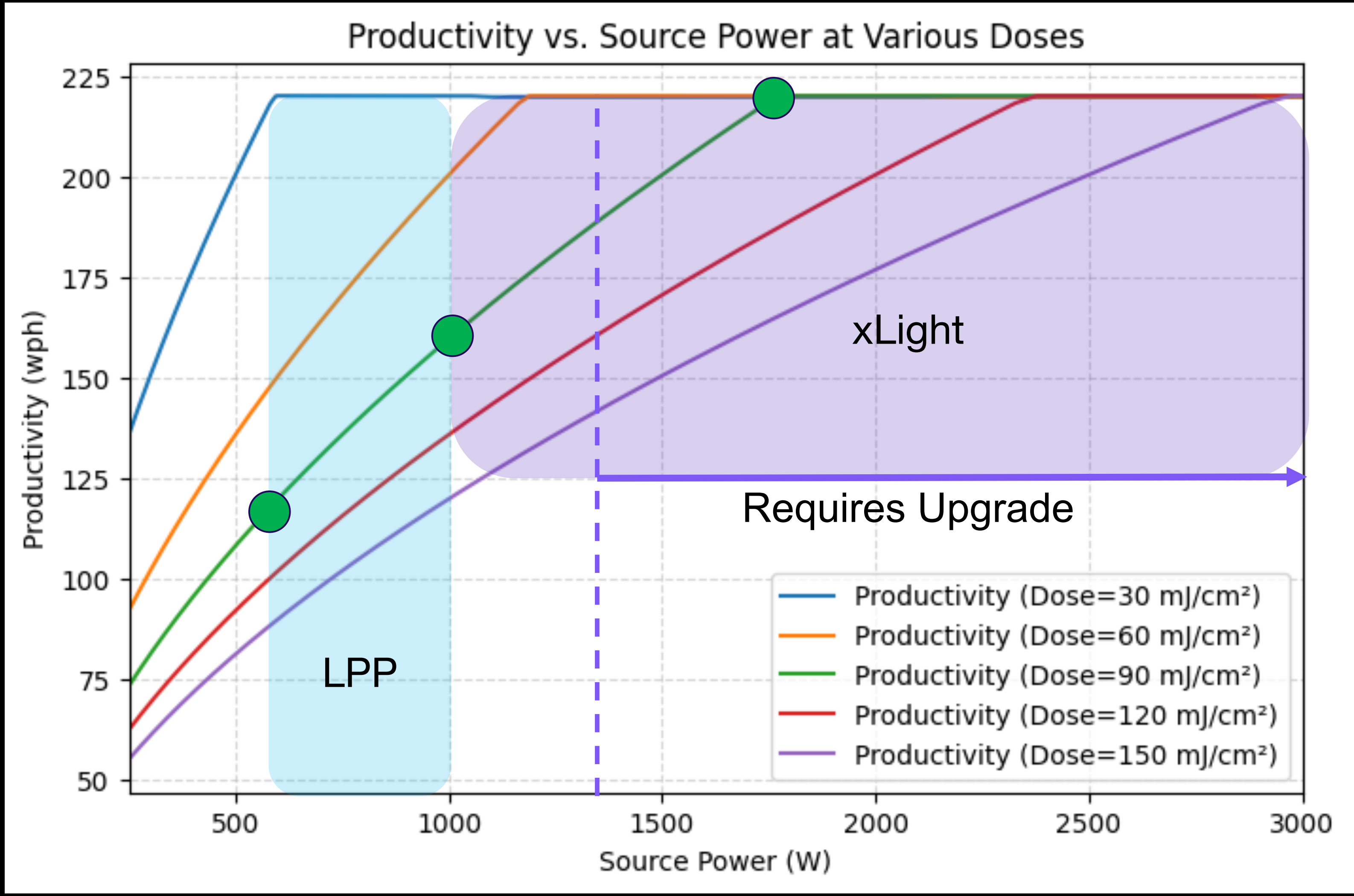
Power Unlocks Performance, Productivity, & Yield

xLight Gen3	3000W
xLight Gen2	2000W
xLight Gen1	1500W
ASML LPP - 2031	1000W



Increased dose and productivity simplify process flow

Source Power Drives Productivity



Dose Scales with Critical Dimension

Reduction in Feature Size Drives Resist Dose Increases

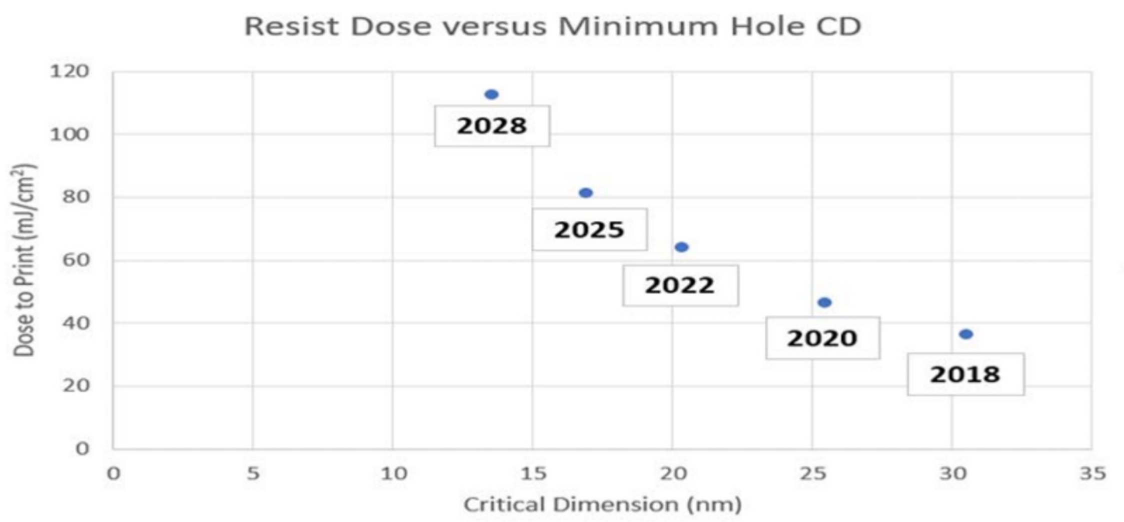


Figure LITH-1 2020 Projected EUV Photo-Speed as a Function of Printed Contact Hole Size

$$Dose = \frac{576}{\alpha\, d} \frac{hv}{f^2 CD^2 NILS^2}$$

Geh equation predicts that doses for equivalent LCDU will have to increase as $1/CD^2$

Doses at 14 nm will be 5x higher that doses at 32 nm.

More about that in a future talk!

IDRS 2020 Lithography Roadmap predicts rise in dose requirements due to more demanding LCDU requirements as as feature sizes get smaller.

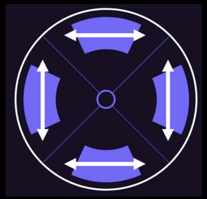
https://irds.ieee.org/images/files/pdf/2020/2020IRDS_Litho.pdf

xLight

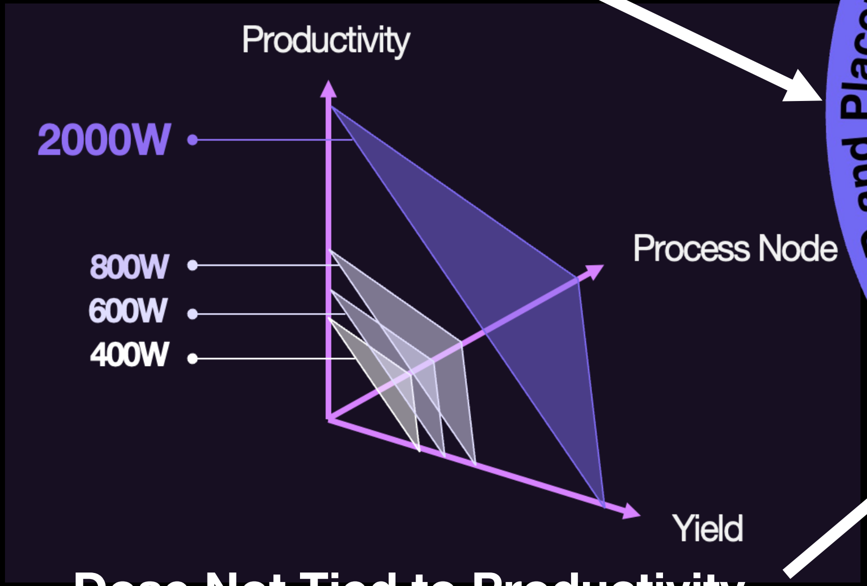
Better Patterning with an EUV FEL

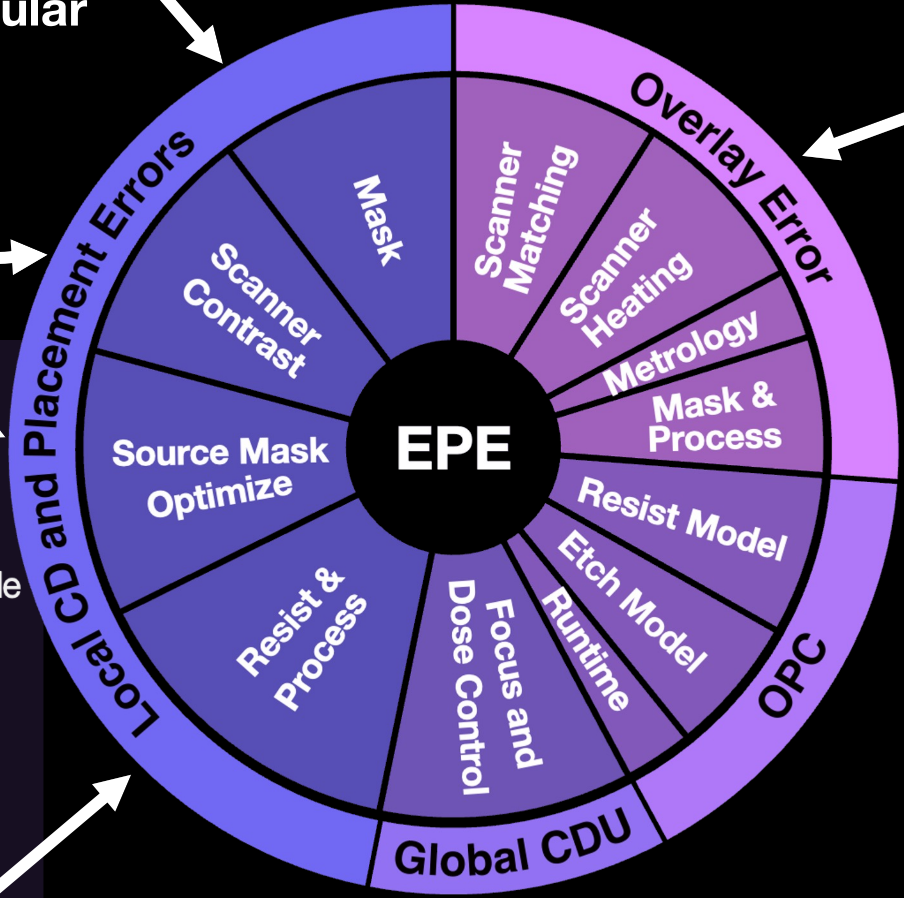
Power + Polarization Trade for Improved Angular Bandwidth

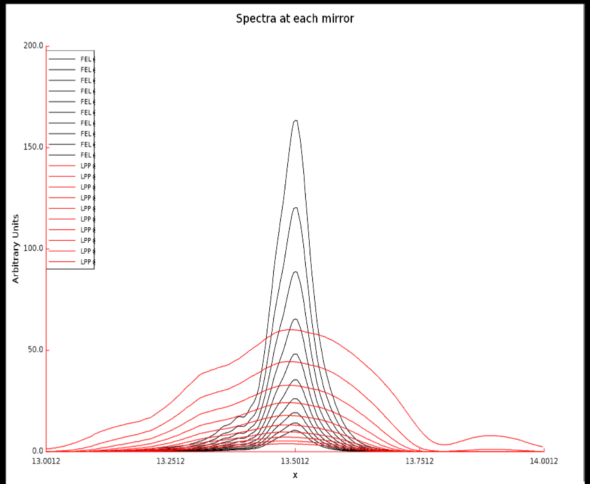
Reduced Optics Heating

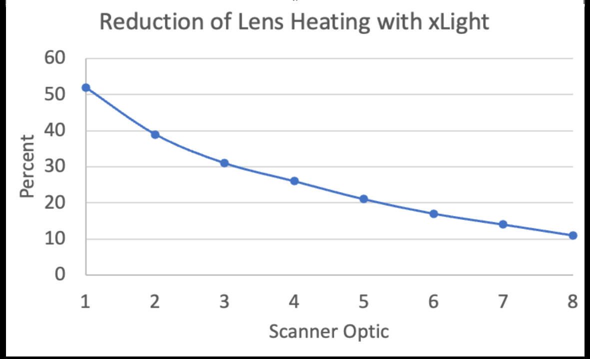


Zone Polarization









Dose Not Tied to Productivity

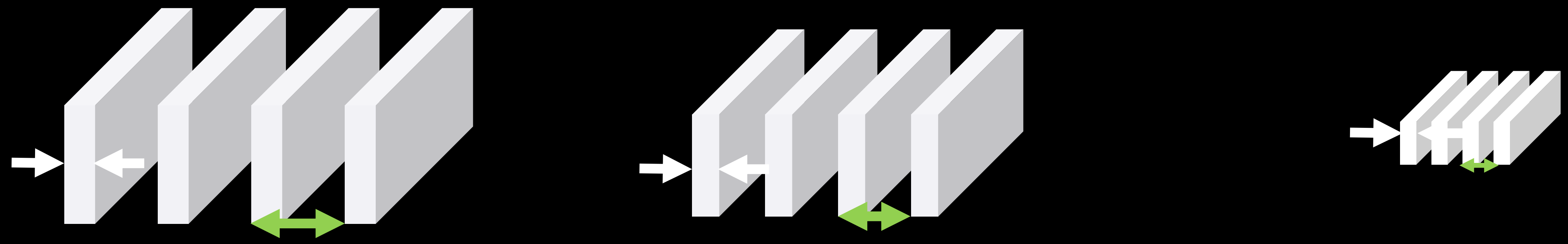
EPE budget recreated from ASML public data.

xLight

Tunable Source Enables Next Generation Lithography

Critical Dimension (CD) = $k1 \times \lambda / NA$

Current 13.5nm	13.5nm w/ xLight	Future 4.5nm w/ xLight



9.5nm / 29nm	6.8nm / 22nm	3.2nm / 10nm

k1 reduction: Polarization → 40% Area Scaling

λ reduction: 4.5nm → 80% Area Scaling

xLight

FEL enables generations of cost and performance scaling

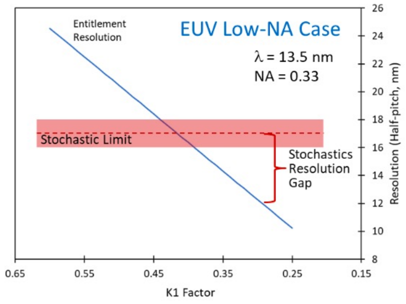
Source:
IBM Research
SPIE EUVLitho
Sept 22, 2025

xLight

FEL source enablement for EPE control: aligning scaling needs with productivity goals

$$\text{LER} \propto \frac{1}{\sqrt{N}} \times \frac{1}{ILS}$$

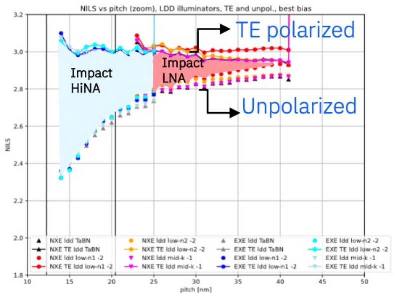
Closing Stochastic Gap for low NA EUV Through Photon Abundance



Fractilia LLC, *White Paper* 2025

Now

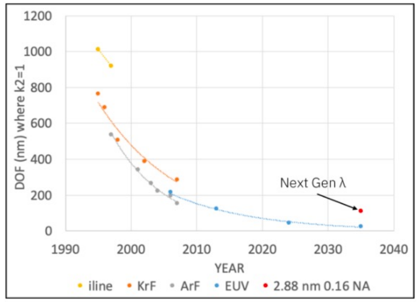
Low k1 Imaging for High NA with Polarization Control



M. Burkhardt, Fraunhofer Workshop, 2025

Next

Short λ Lithography Tooling Enablement for Scaling



A. Gabor, EUVL Workshop, 2025

Future

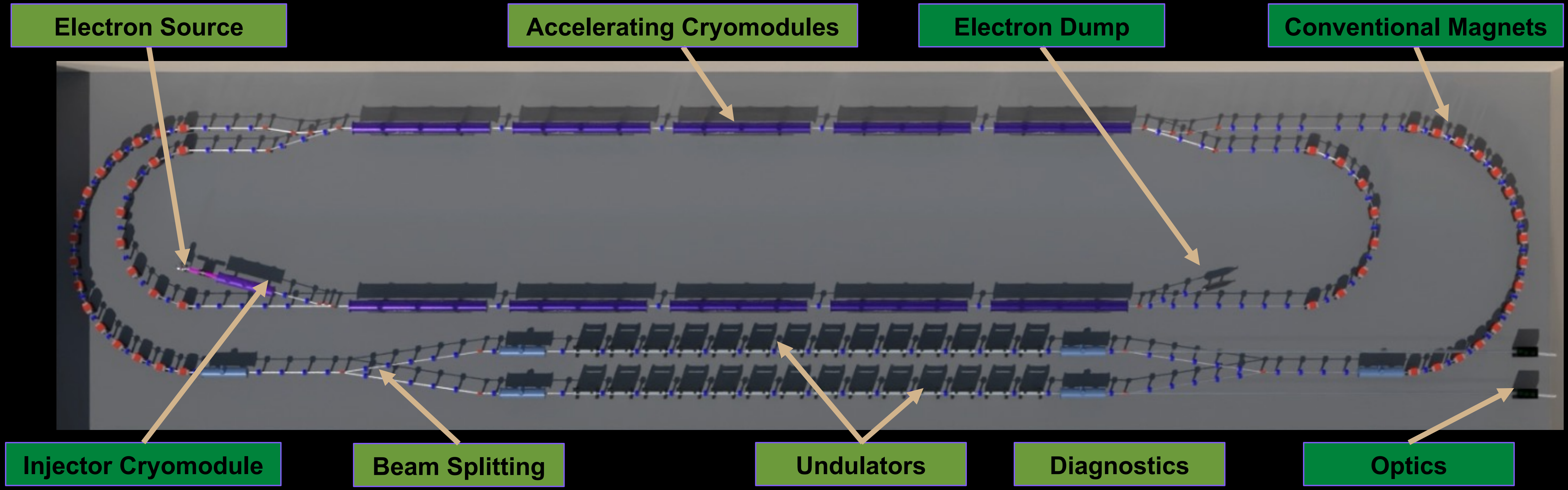
	Nominal	Enable single-exposure at max tpt	Comparison
28nm pitch line/space	2x Low-NA EUV LELE	1x Low-NA EUV with high-dose but max tpt	Reduce cost of module by 36% (stochastics improvement)
21nm pitch line/space	3x Low-NA EUV SALELE	1x High-NA EUV with high-dose but max tpt	Module cost 2x cheaper (previously 1.7x cheaper)
21nm pitch line/space	1x High-NA EUV	1x High-NA EUV with high-dose but max tpt	Reduce exposure cost by 40%
16nm pitch line/space	2x High-NA EUV LELE	1x High-NA EUV with high-dose but max tpt	Module cost 2x cheaper (resolution improvement)

One Light Source Enables an Ecosystem

Accelerator	Independent FEL Lines	End Systems		
xLight Source	EUV Lithography FEL	6X Low NA Scanner	13.5nm	Cleanroom Bay
		4X High NA Scanner	13.5nm	Cleanroom Bay
		Next Gen Lithography	<13.5nm	Lab Bay
	Metrology & Inspection FEL	Actinic Inspection (tunable)	30 to 50nm	Cleanroom Bay
		Metrology CD-SAXS	3nm	Lab Bay
	Advanced Packaging FEL	Ablation Dicing	6.7nm	Lab Bay
		Package Inspection	<2nm	Lab Bay

Lab to Fab - New Applications of Proven Technologies

Building prototypes & first articles now



Argonne NATIONAL LABORATORY

BERKELEY LAB

Fermilab

Jefferson Lab

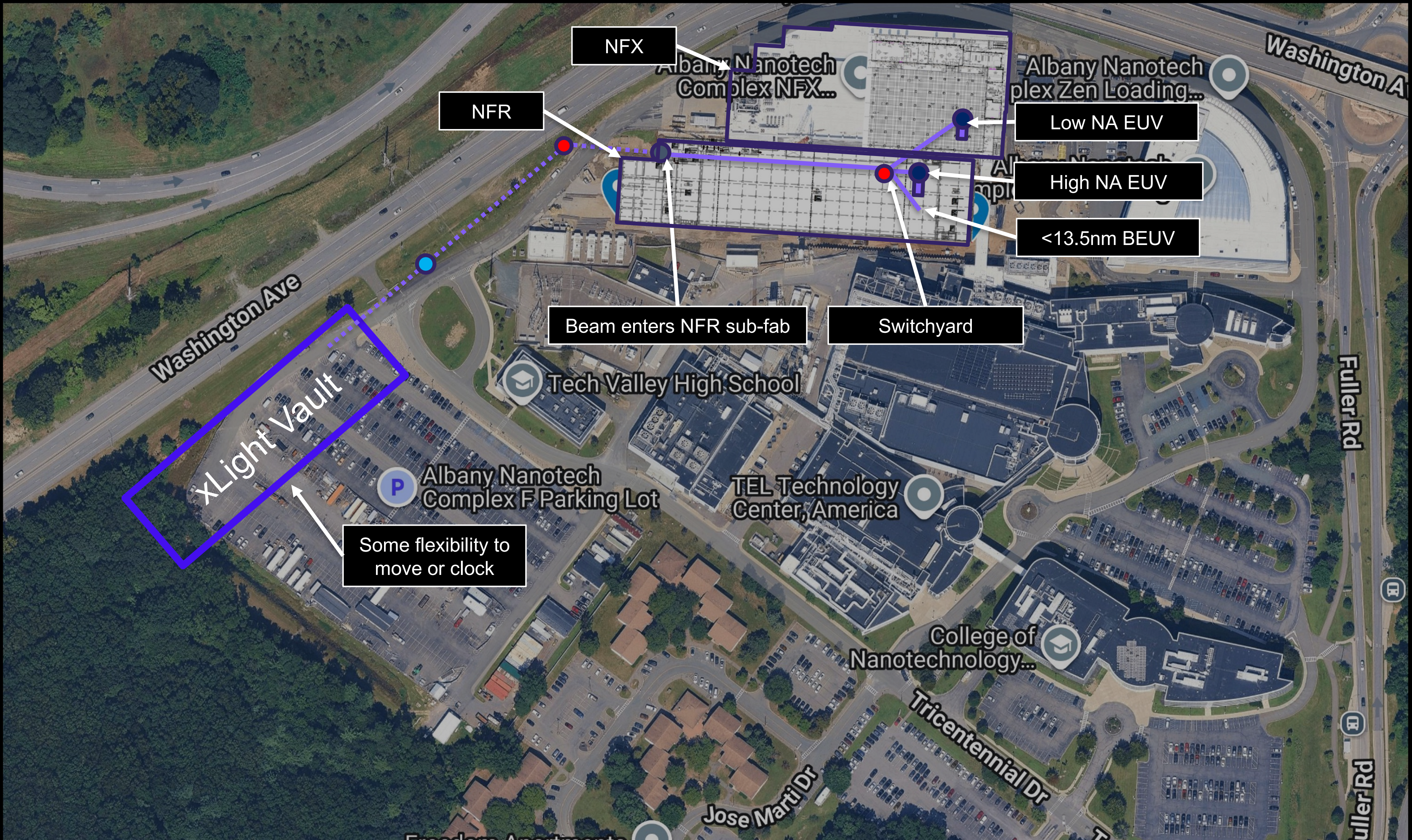
Los Alamos NATIONAL LABORATORY

OAK RIDGE National Laboratory

SLAC NATIONAL ACCELERATOR LABORATORY

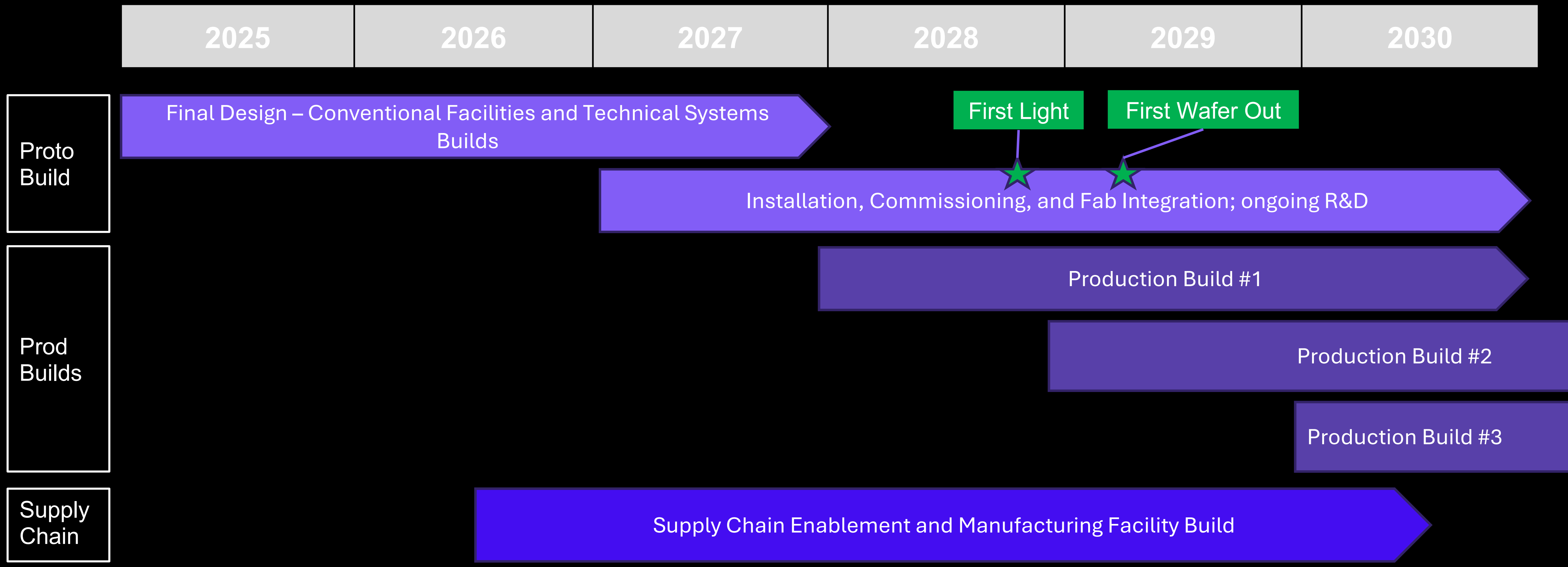
xLight

Building Partnerships and Prototype Now



- Horizontal Reflection
- Vertical Reflection
- Compound Reflection
- Ground Penetration
- Underground

Roadmap



2025
2026
2027
2028
2029
2030
Proto Build
Final Design – Conventional Facilities and Technical Systems Builds
First Light
First Wafer Out
Installation, Commissioning, and Fab Integration; ongoing R&D
Prod Builds
Production Build #1
Production Build #2
Production Build #3
Supply Chain
Supply Chain Enablement and Manufacturing Facility Build

xLight