ASU Compact XFEL

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Arizona State University

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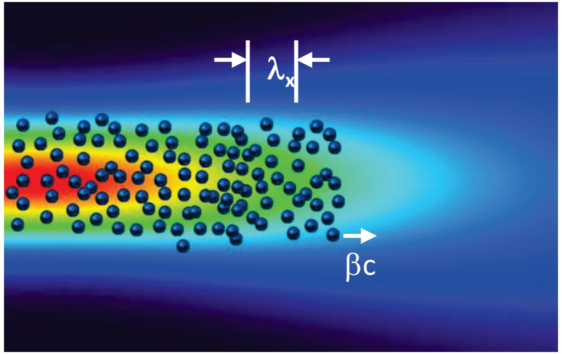
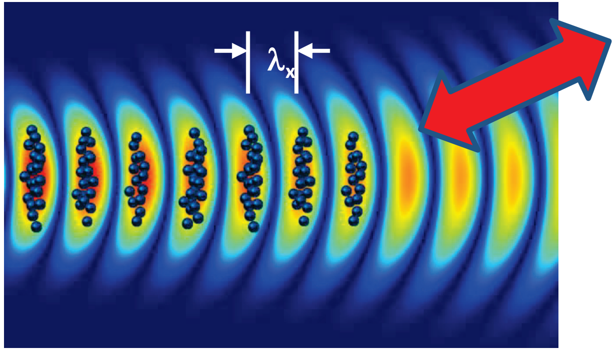
Coherent x-rays require coherent electron bunching



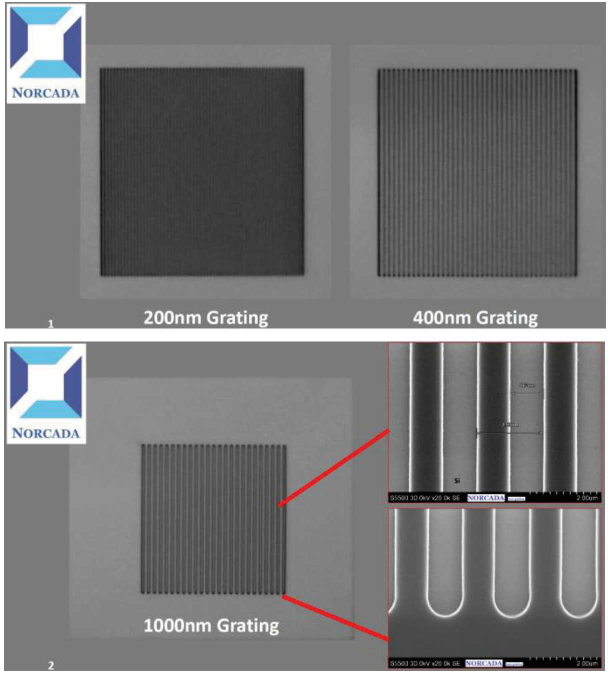
Random electron positioning for Undulator radiation with **GeV** electrons or Inverse Compton Scattering with **MeV** electrons

Pendellosung fringes: electron diffraction varies periodically with wedge thickness

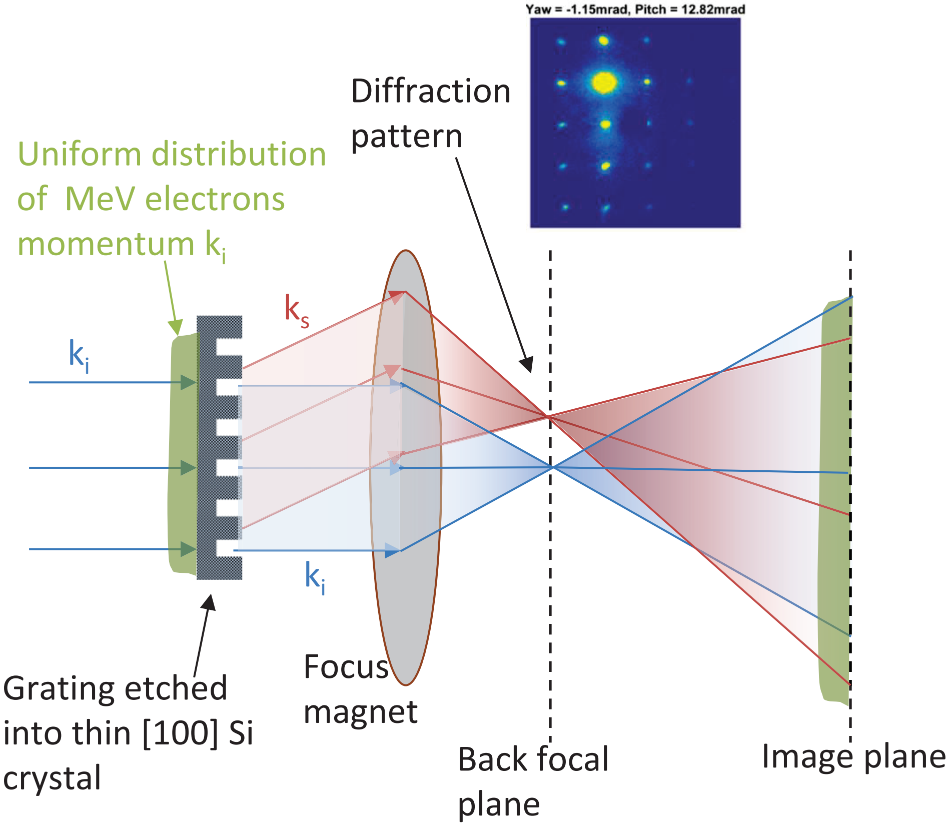


Coherently bunched electrons for **XFEL** radiation (GeV electrons) or Coherent ICS, compact **CXFEL** (MeV electrons)

Nanopatterning Electrons via Diffraction



Prototype Si gratings at various pitches. Production gratings now in fabrication.
First tests with beam will occur in September at UCLA's Pegasus lab.



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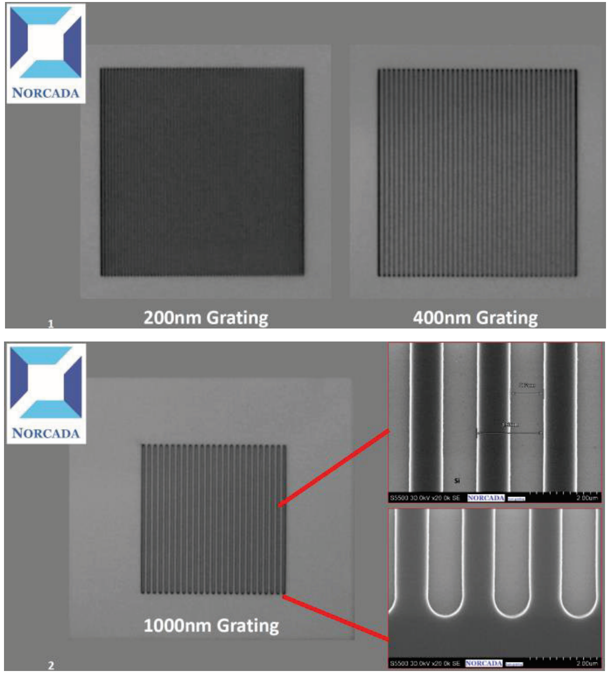

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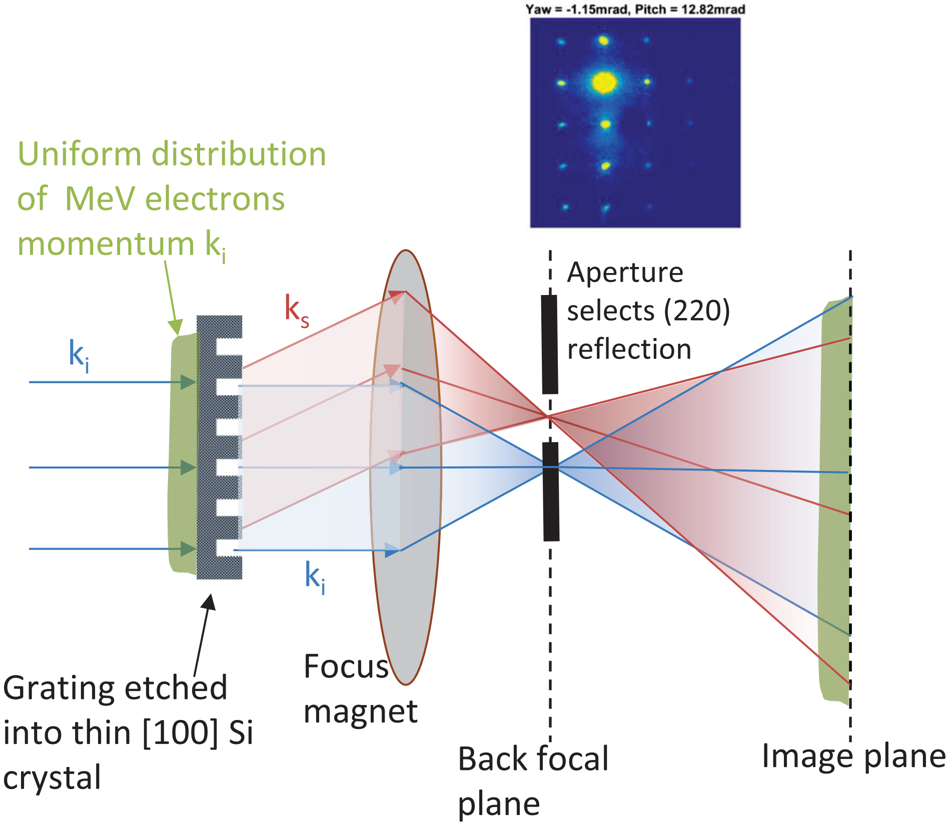
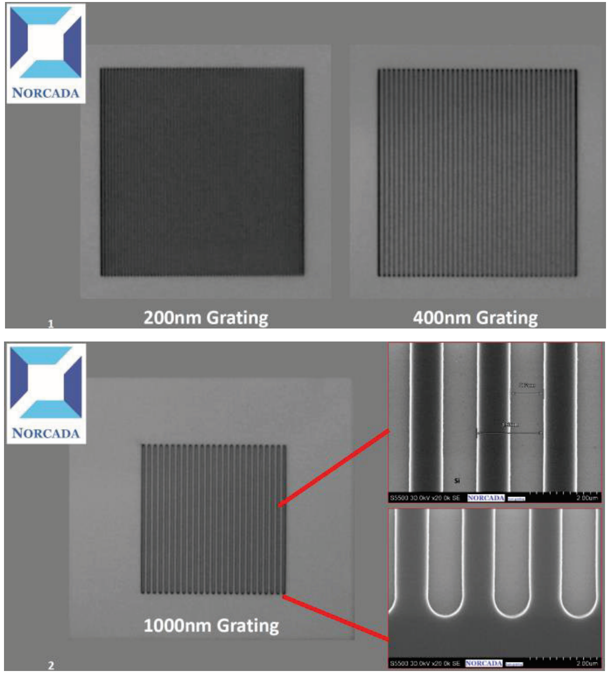


Nanopatterning Electrons via Diffraction



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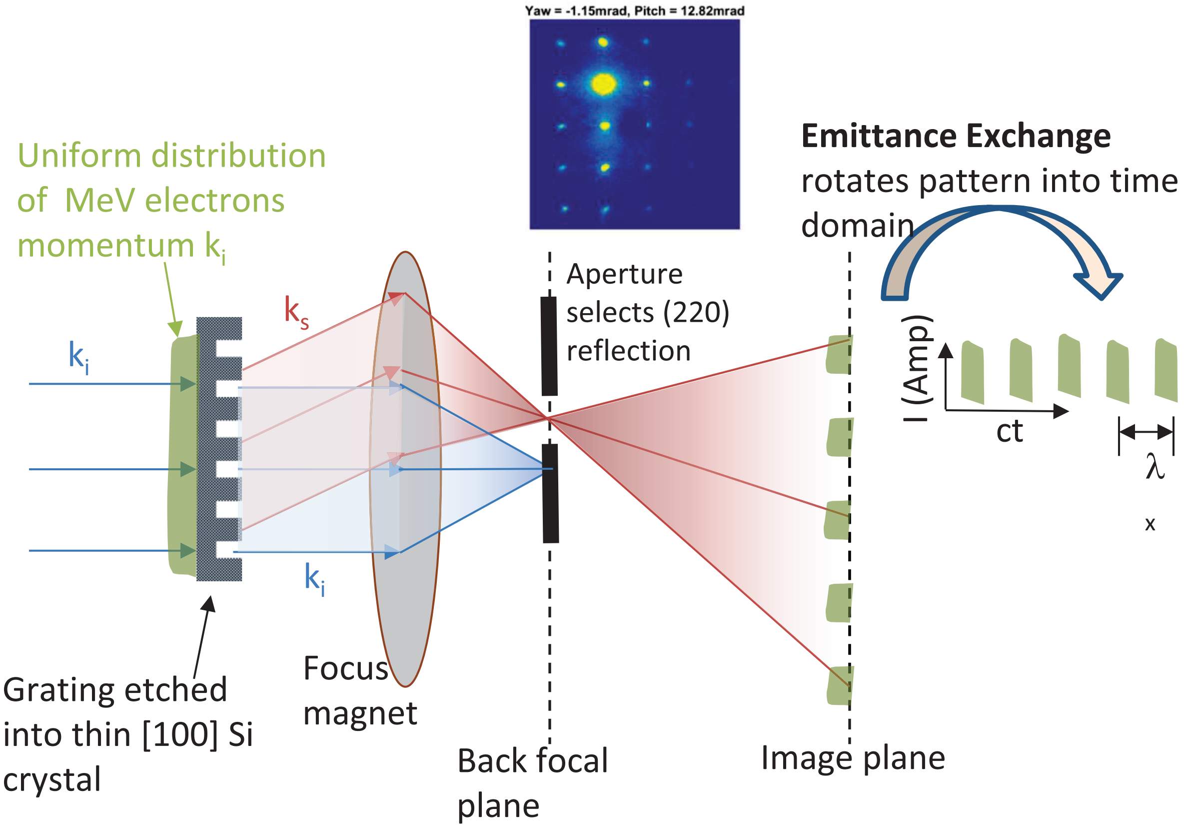
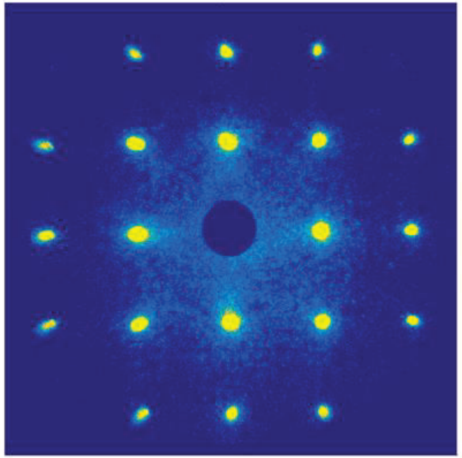


Electron Diffraction Experiments

See Poster TUP038 on Tuesday afternoon

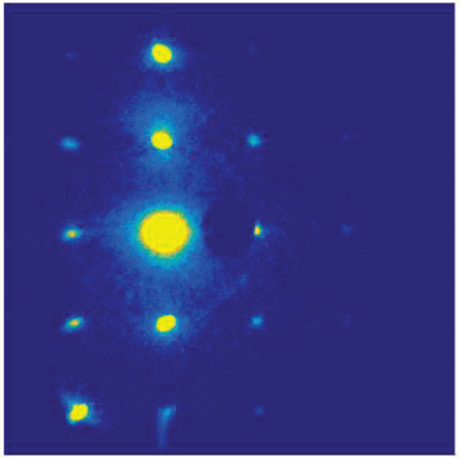
Yaw = 0.06mrad, Pitch = 0.02mrad



Electron beam aligned perpendicular to Si crystal

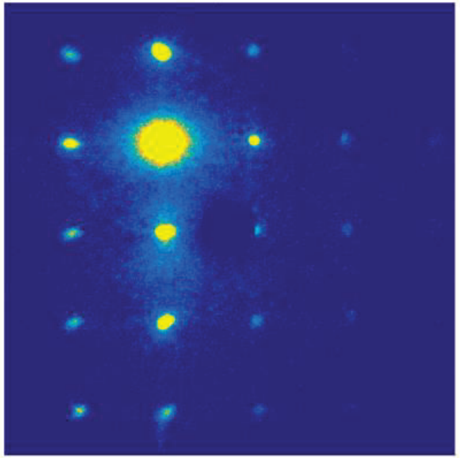
Dark circle is hole in YAG scintillator

Yaw = -2.19mrad, Pitch = 12.82mrad



Crystal tilted to forward scatter 80% of electrons into (000) Bragg spot

Yaw = -1.15mrad, Pitch = 12.82mrad



Crystal tilted to scatter **80% of electrons into (-220) Bragg spot demonstrating 'dynamical extinction' of main beam**

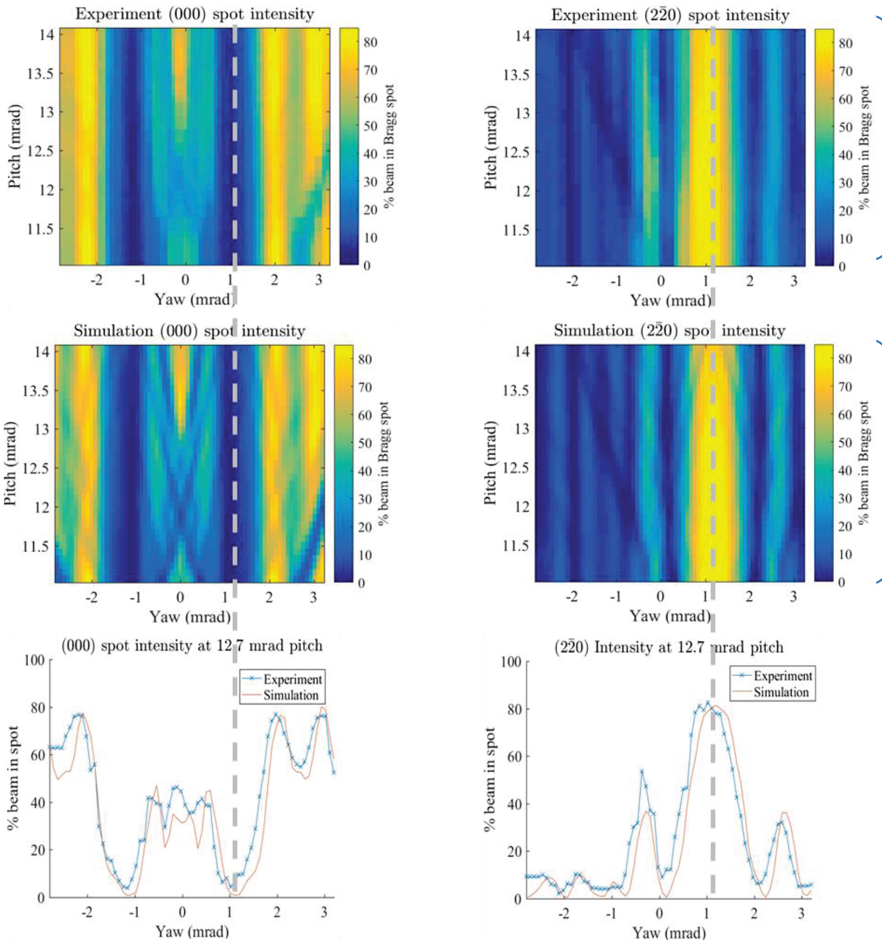
Experiments at SLAC's Ultrafast Electron Diffraction facility using 100 fs, 2.3 MeV, <100 fC ebeam to demonstrate principle of diffracting most of the electrons through a 20 nm thin perfect Si crystal into a single Bragg spot

Electron Diffraction Experiments

See Poster TUP038 on Tuesday afternoon

Left column shows map of (000) Bragg spot intensity vs pitch and yaw angles of Si crystal relative to electron beam

Right column shows map of (2-20) Bragg spot intensity vs pitch and yaw angles of Si crystal relative to electron beam



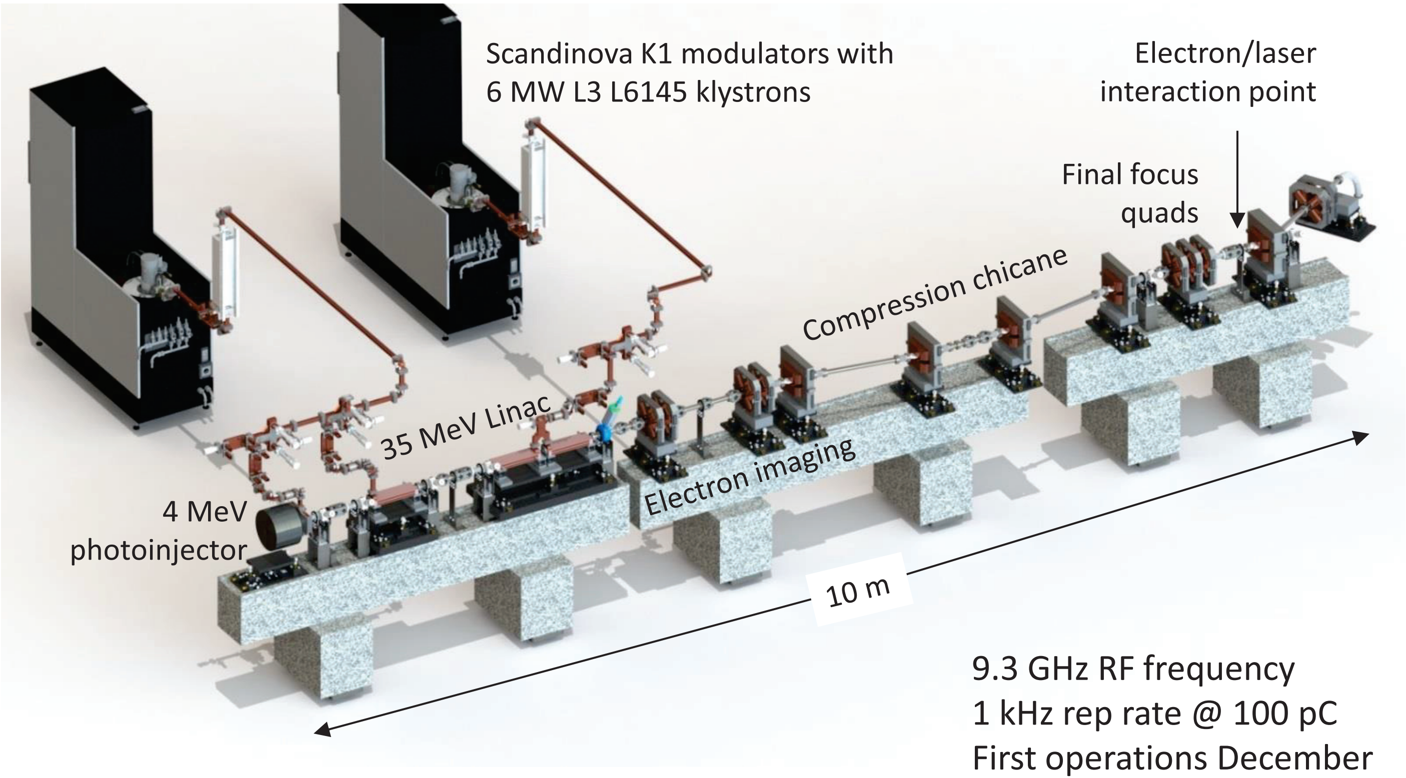
Experiments

Simulations

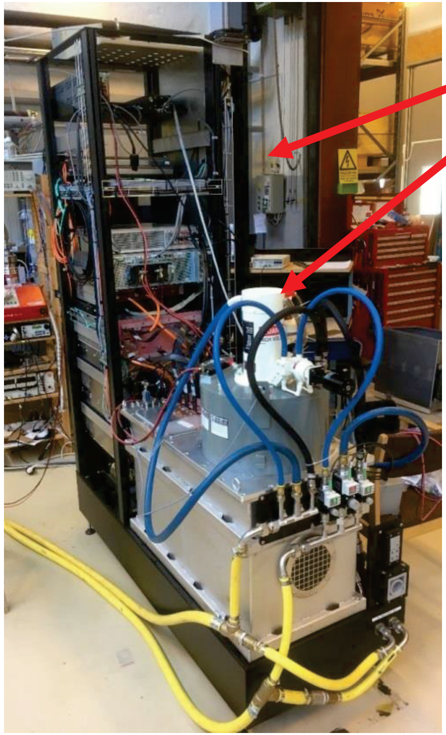
(no free parameters)

Experiment & simulation at pitch angle = 12.7 mrad showing **80% of electrons into 1 Bragg spot**

ASU Compact X-ray Light Source

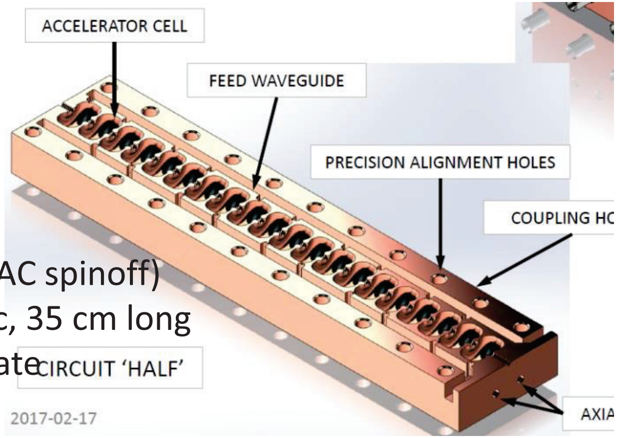


9.3 GHz RF frequency
1 kHz rep rate @ 100 pC
First operations December 2017

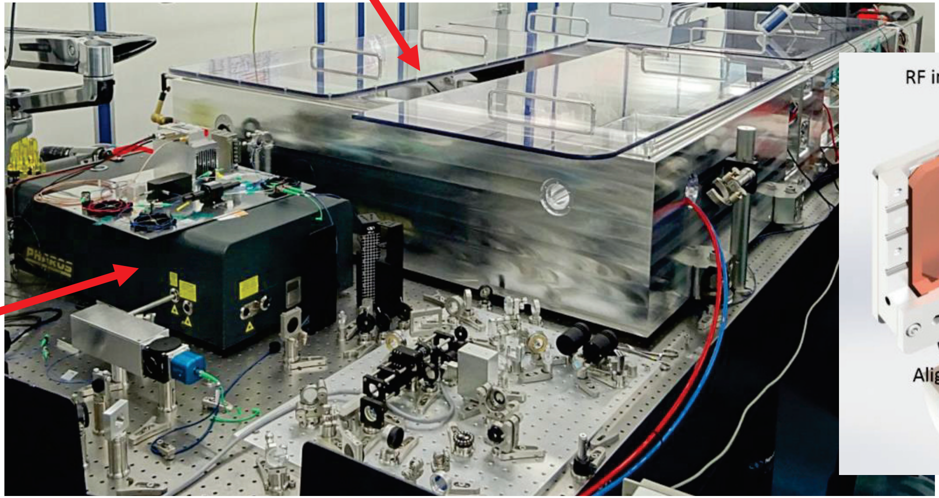


RF modulator – Scandinova K1A
6 MW klystron by L-3
9.3 GHz RF frequency
1 kHz repetition rate
<100 ppm amplitude stability
<0.1 degree RF phase stability

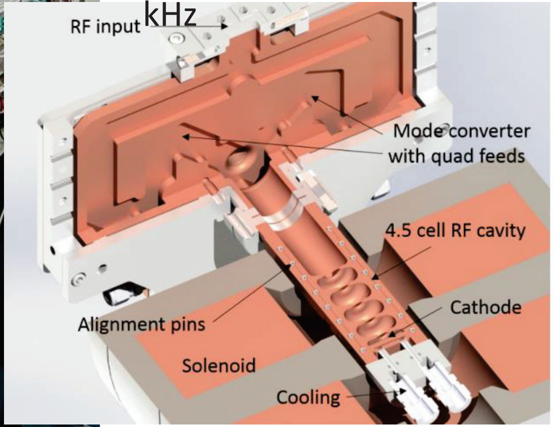
Tibaray (SLAC spinoff)
20 cell linac, 35 cm long
1 kHz rep rate



ICS laser – Trumpf Dira Yb:YAG
200 mJ, 1 ps, 1030 nm @ 1 kHz



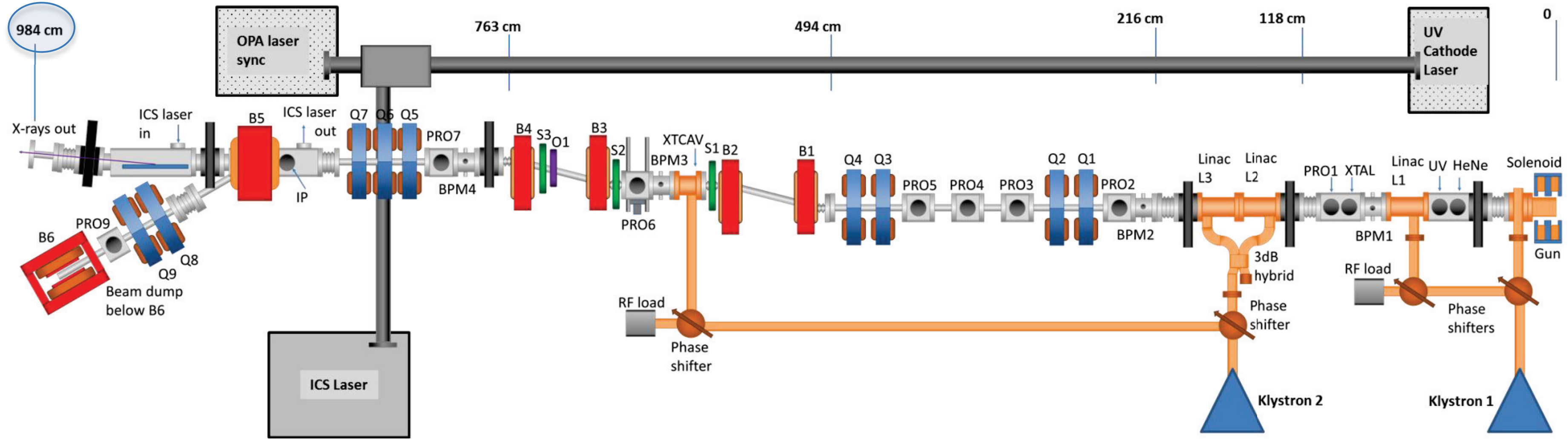
4.5 cell gun with RF mode launcher, 120 MV/m, 1 kHz



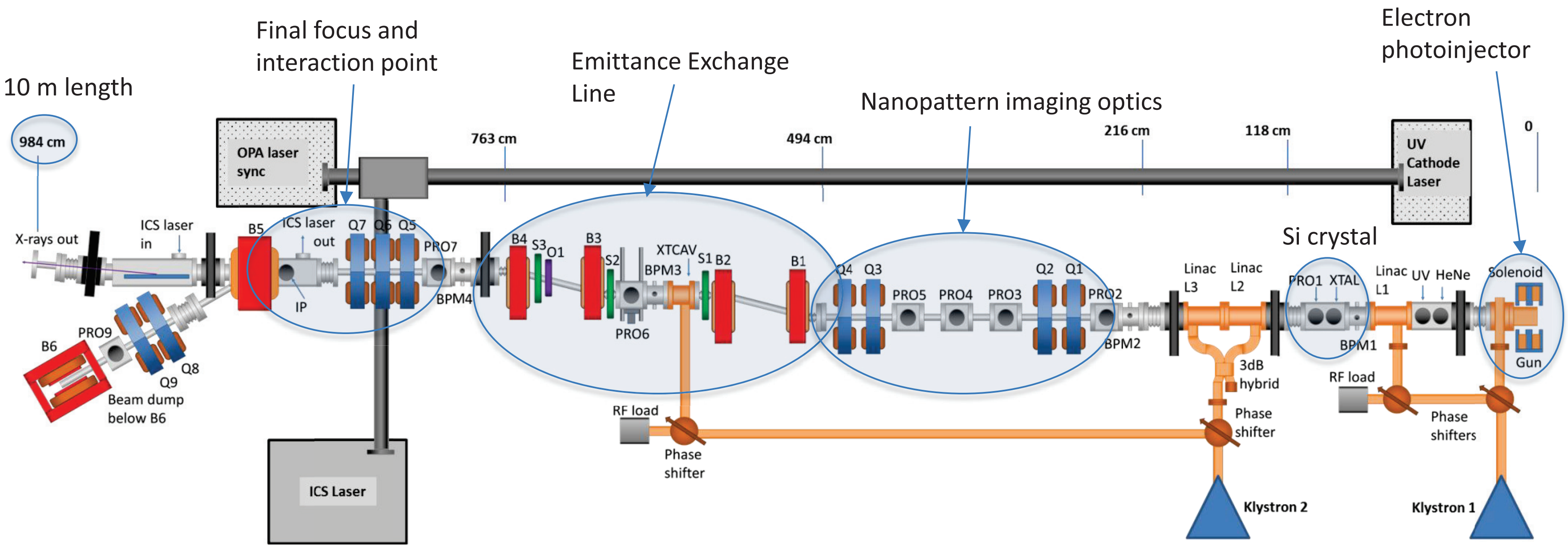
Cathode laser
LightConversion Pharos
Yb:KGW 150 uJ, 180 fs
258 nm @ 1 kHz

CXFEL

10 m length

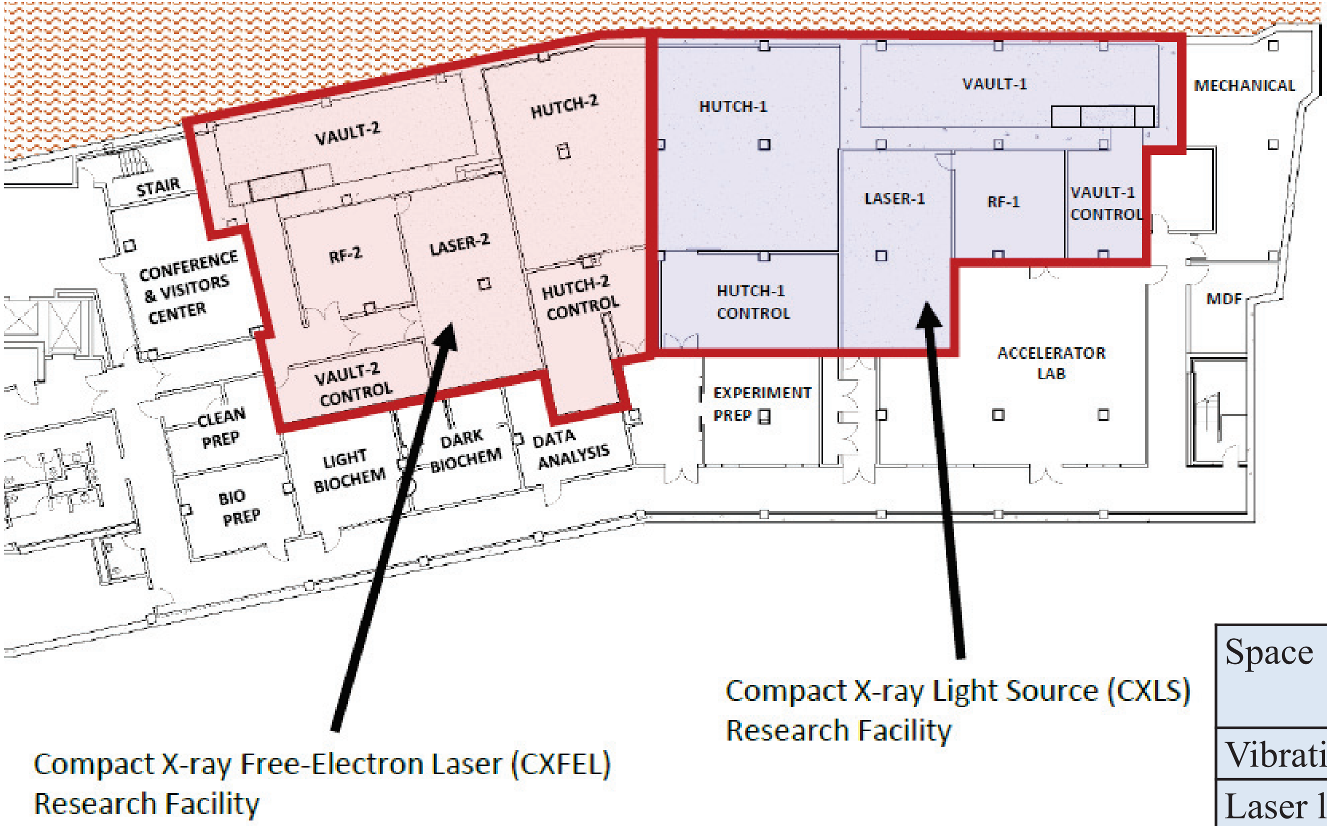


CXFEL



10 m length
Final focus and interaction point
Emittance Exchange Line
Nanopattern imaging optics
Electron photoinjector
984 cm
OPA laser sync
763 cm
494 cm
216 cm
118 cm
0
UV Cathode Laser
Si crystal
X-rays out
ICS laser in
B5
ICS laser out
IP
Q7
Q6
Q5
PRO7
BPM4
B4
S3
O1
B3
S2
XTCAV
BPM3
S1
B2
PRO6
B1
Q4
Q3
PRO5
PRO4
PRO3
Q2
Q1
PRO2
BPM2
Linac L3
Linac L2
PRO1
XTAL
BPM1
Linac L1
UV
HeNe
Solenoid
Gun
3dB hybrid
Phase shifter
RF load
Phase shifters
Klystron 2
Klystron 1
ICS Laser
PRO9
B6
Q8
Q9
Beam dump below B6

ASU Biodesign C Labs for CXLS, CXFEL



Slab is 2 m thick under vault, laser, and hutch, and isolated from building structure.

Iron rebar hand selected and degaussed for low B-field

RF room is welded Al Faraday cage for EMI isolation

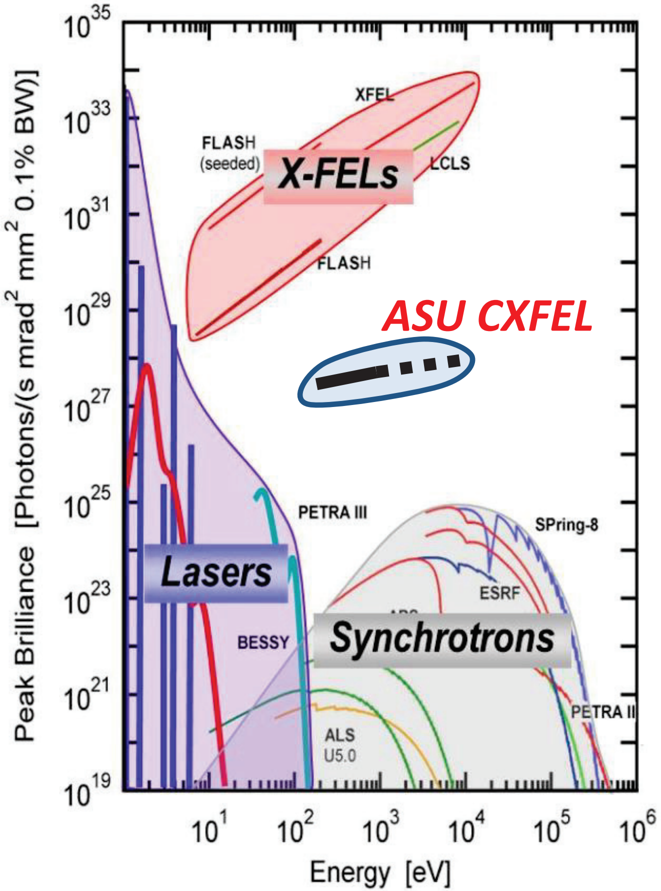
Space	25,000 sq ft
Vibration	VC-E
Laser lab air temp	+/- 0.25° C
Vault air temp	+/- 0.5° C
Precision chilled water	+/- 0.01° C

Power Scaling for XFELs

Rough estimates of parameters

	LCLS	CXFEL
	$h\upsilon = 1$ keV	$h\upsilon = 1$ keV
	$I = 2000$ A	$I = 200$ A
	$V = 5$ GeV	$V = 25$ MeV
	$P_e = IV = 10^{13}$ W	$P_e = IV = 5\times10^{9}$ W
	$\Delta t = 100$ fs	$\Delta t = 10$ fs
Electron pulse energy	$U_e = P_e\Delta t = 1$ J	$U_e = P_e\Delta t = 50\ \mu$J
FEL parameter	$\rho_{FEL} = 10^{-3}$	$\rho_{FEL} = 10^{-3}$
	$P_{FEL} = \rho P_e = 10^{10}$ W	$P_{FEL} = \rho P_e = 5\times10^{6}$ W
FEL pulse energy	$U_{FEL} = \rho U_e = 1$ mJ	$U_{FEL} = \rho U_e = 50$ nJ

CXFEL Estimated Performance



Full coherence in temporal and transverse dimensions, but lower power than large XFELs.

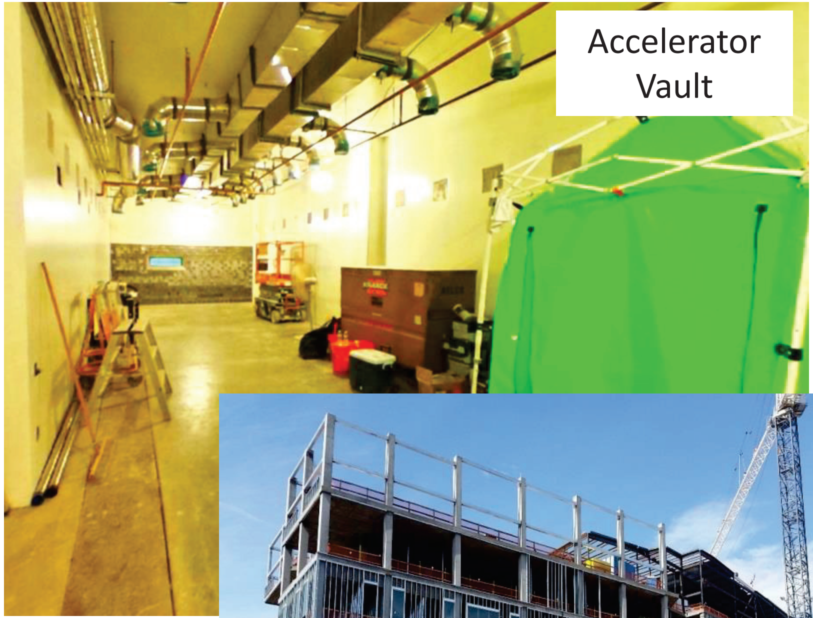
The ASU CXFEL uniquely controls the x-ray phase and amplitude.

CXFEL can seed large XFELs to increase their brilliance X100

ASU CXLS/CXFEL Program

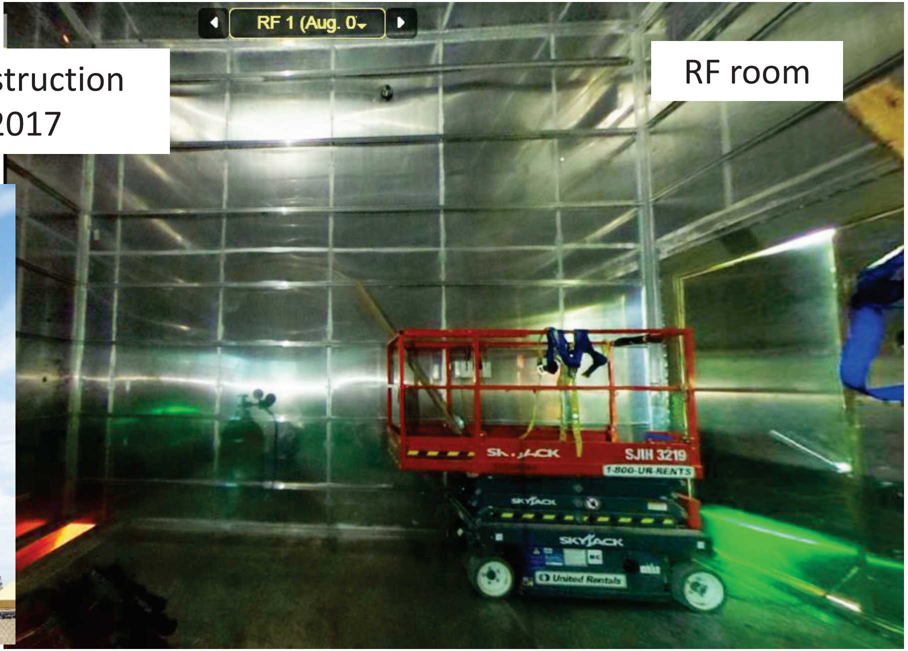
Job openings now for laser and accel phys postdocs

Faculty hiring beginning across ultrafast science and engineering



Accelerator Vault

Lab construction August 2017



RF room