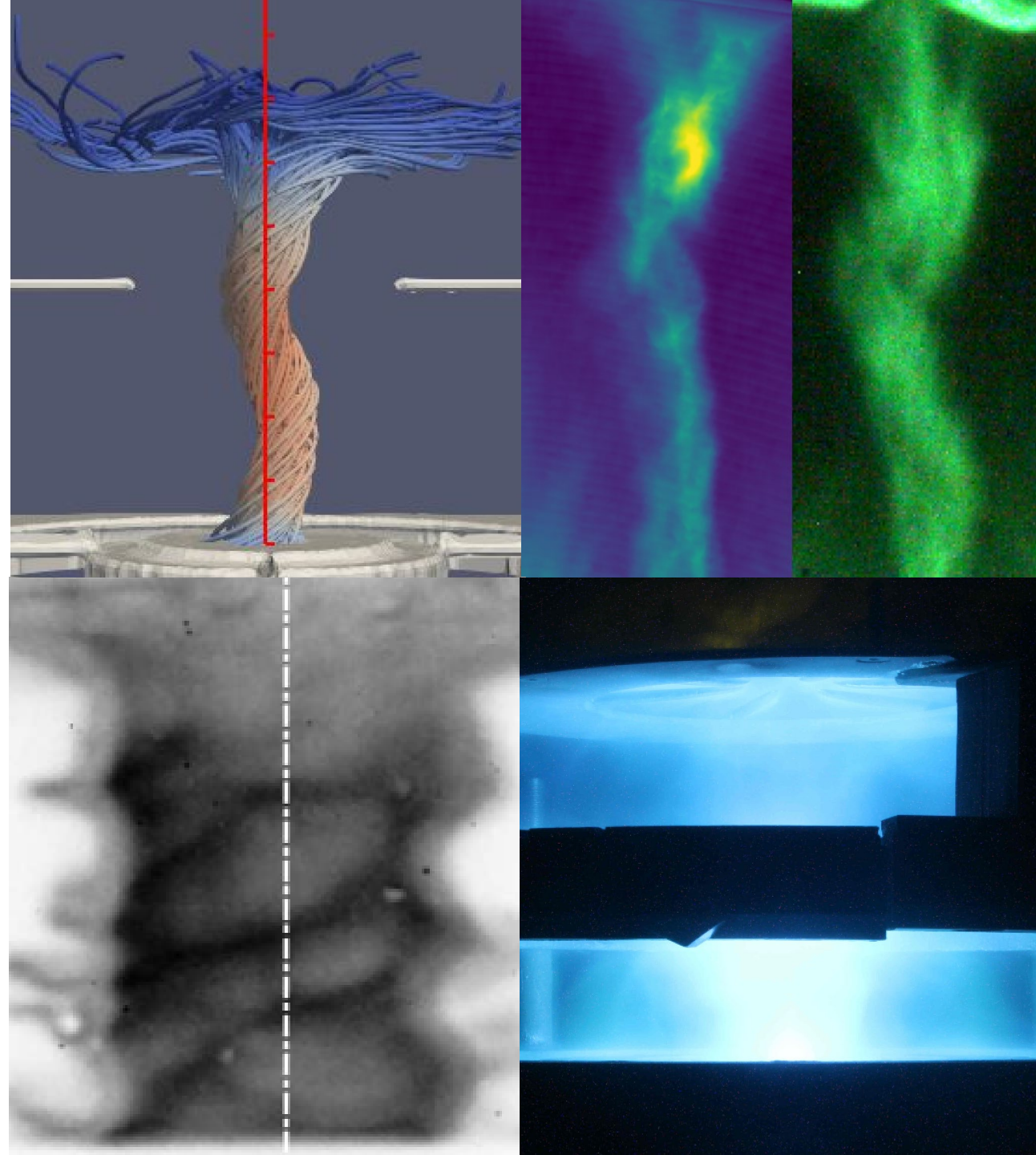
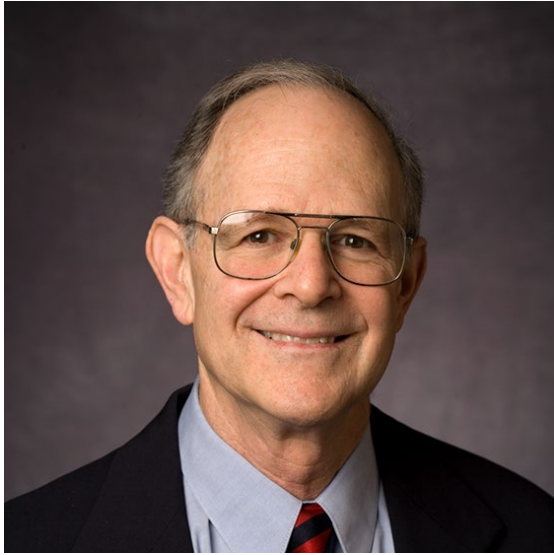


COBRA and PUFFIN at the Cornell Laboratory of Plasma Studies

Jack Hare on behalf of
Dave Hammer, Bruce Kusse, and
Sander Lavine



Faculty



David Hammer
Professor,
Electrical and
Computer
Engineering (ECE)



Jack Hare
Assistant Professor,
Electrical and
Computer
Engineering (ECE)



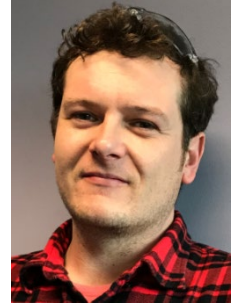
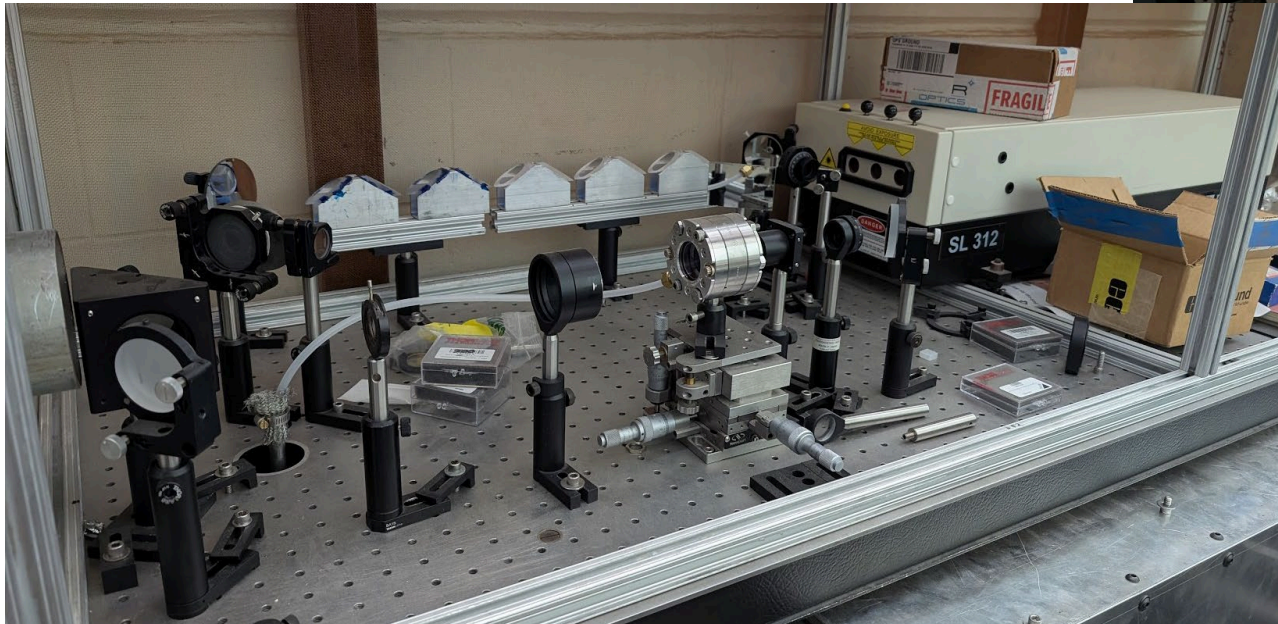
Bruce Kusse
Professor Emeritus,
Applied and
Engineering Physics
(AEP)



Sander Lavine
Assistant Research
Professor,
Electrical and
Computer
Engineering (ECE)

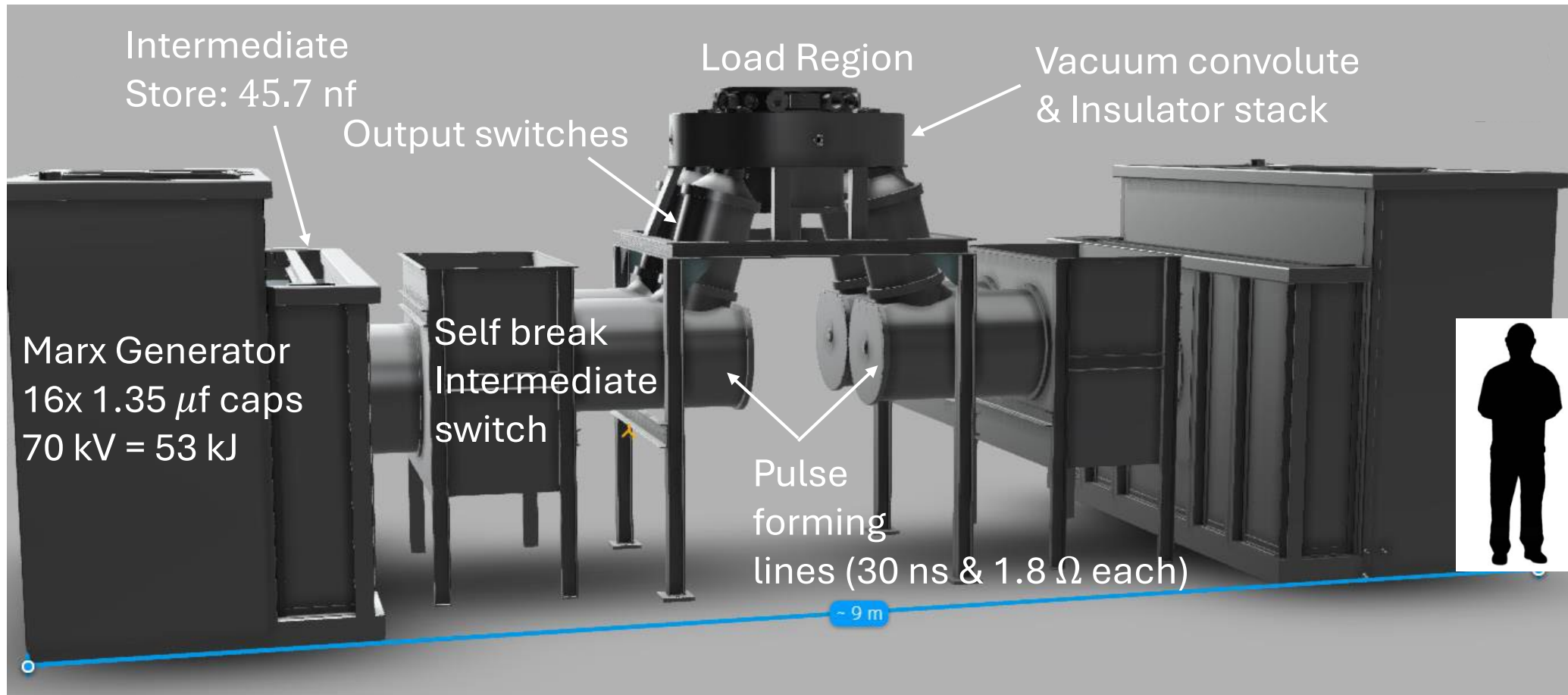
Facilities and Staff

- Fully equipped machine shop with full-time machinist
- Two technicians to maintain and run pulsers
- Laser engineer for diagnostic maintenance and alignment



Harry Wilhelm, Todd Blanchard, William Potter, Daniel Hawkes

COBRA: Cornell Beam Research Accelerator



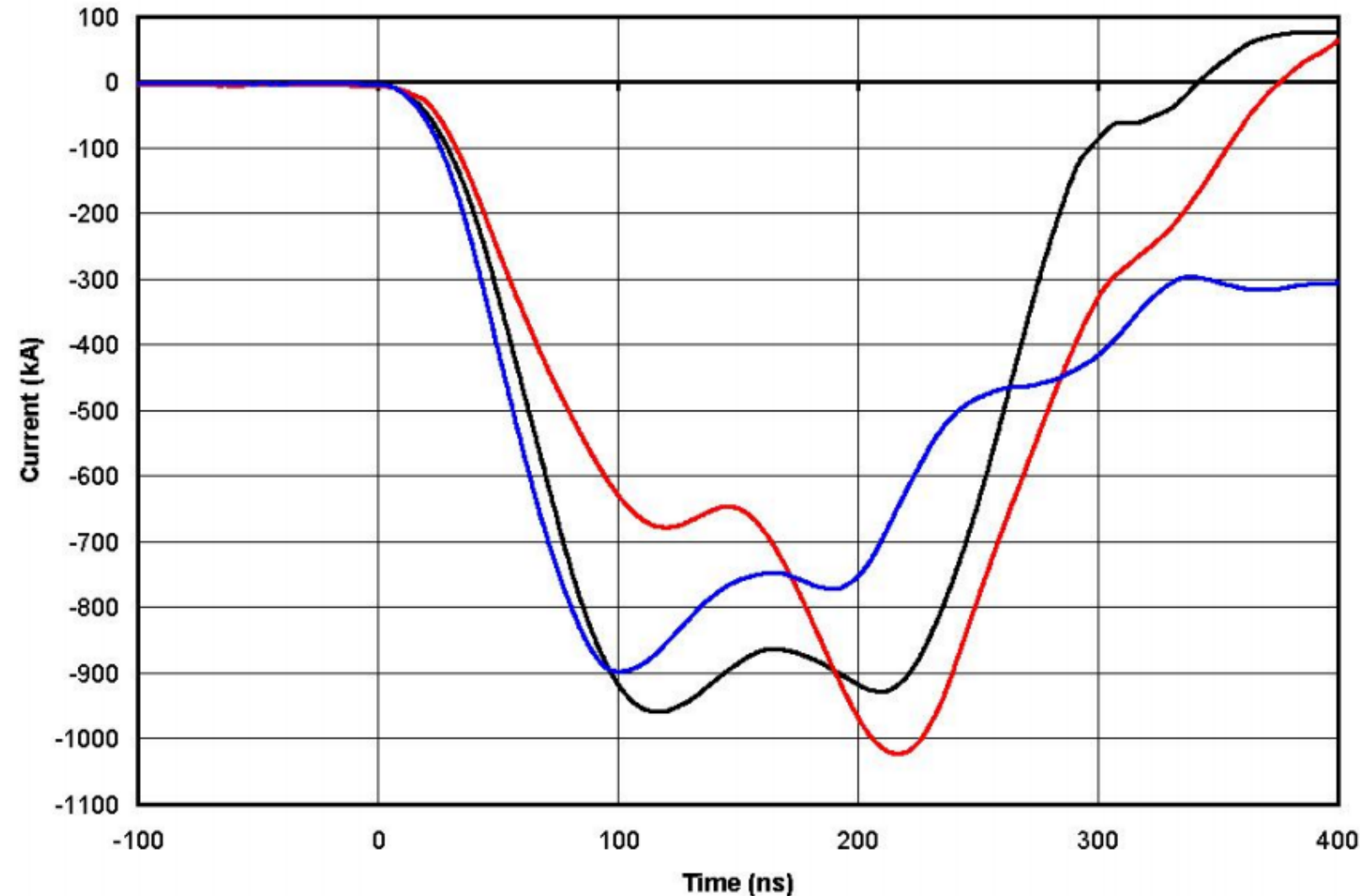
COBRA: 1 TW, 1 MA, 100-220 ns rise time pulser
Produces high energy density plasmas. >7000 shots

COBRA is a versatile, stiff generator

- 0.5 Ohm can drive a range of high inductance and dynamic loads
- Standard loads include:
 - gas puffs: imploding, jets
 - wire arrays: cylindrical, radial, conical, exploding
 - radial foils
 - power-flow
- We can co-design and fabricate a new load with you!



Pulse-shaping through control of switch timing



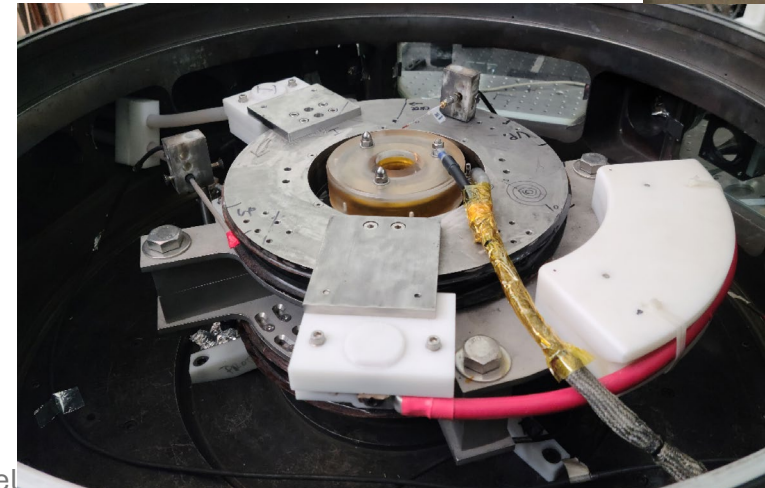
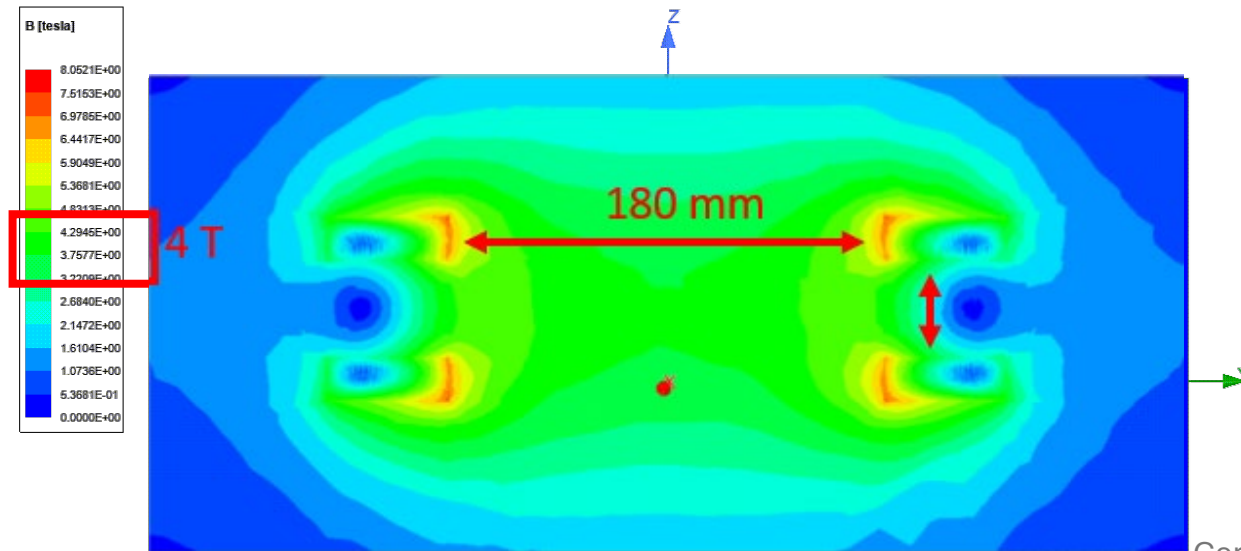
- One bank:
900 kA, 100 ns rise
- Short pulse (synchronous):
1 to 1.2 MA, 110 ns
- Long pulse (async):
1 MA, 220 ns

Shot rate:

High pump speed (2x cryos)
8 shots a day possible,
depending on load and
diagnostic turn-around

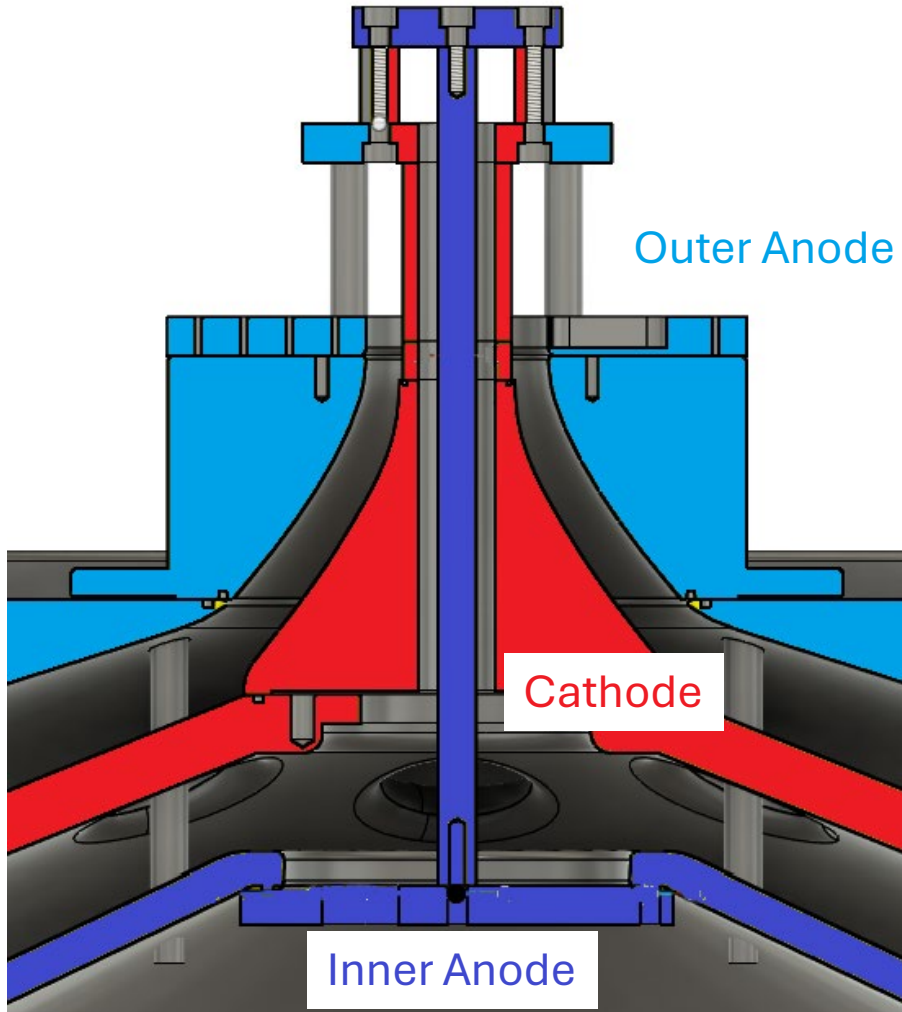
B-field On Axis: large bore, high field coil

- 200 kJ Bank: 4 x 830 μF capacitors (11 kV max)
- 18 cm ID coil (fits around gas-puff current return structure) *Coil built by Simon Bland at ICL*
- 70 turns of 20x0.5 mm copper tape in each coil
- ~ 6 ms rise time: soaks through all hardware
- Tested up to 9 kV charge $\rightarrow \sim 3$ Tesla



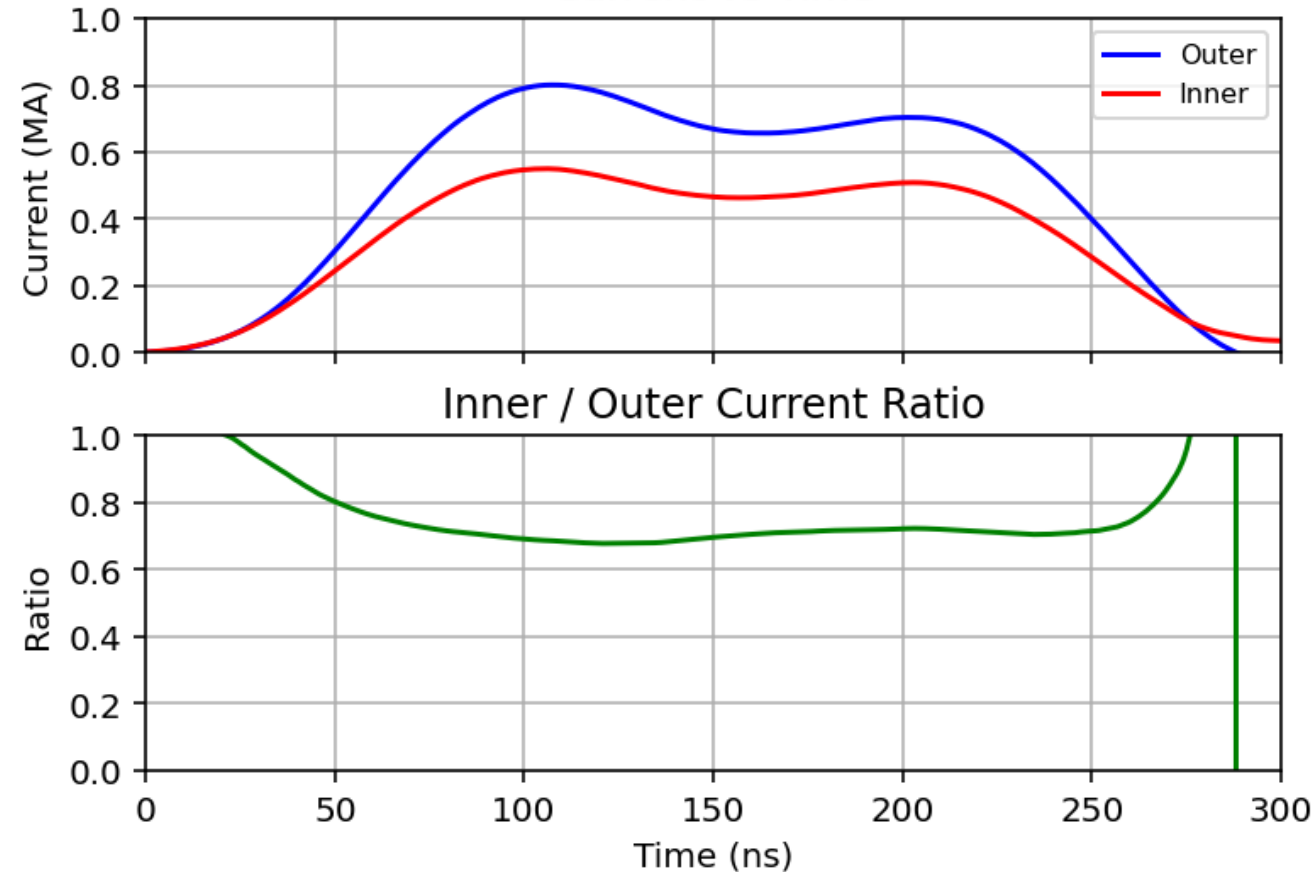
Coaxial split anodes

Dual current path lowers overall load inductance, increases total current



Shot 7535: Static Load, Short Pulse

Current vs Time



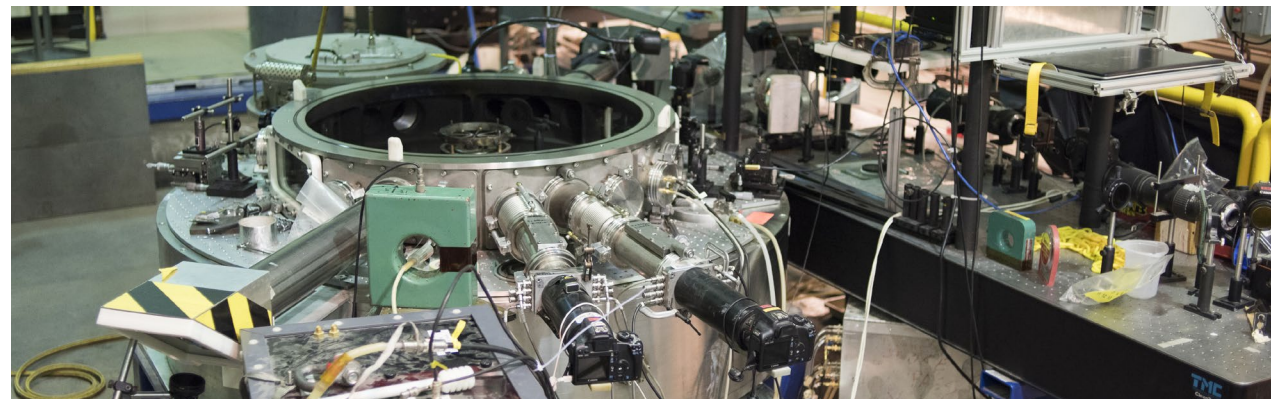
Total current: **1.35 MA**

> 1.2 MA on typical COBRA short pulse

Two paths: lower total inductance

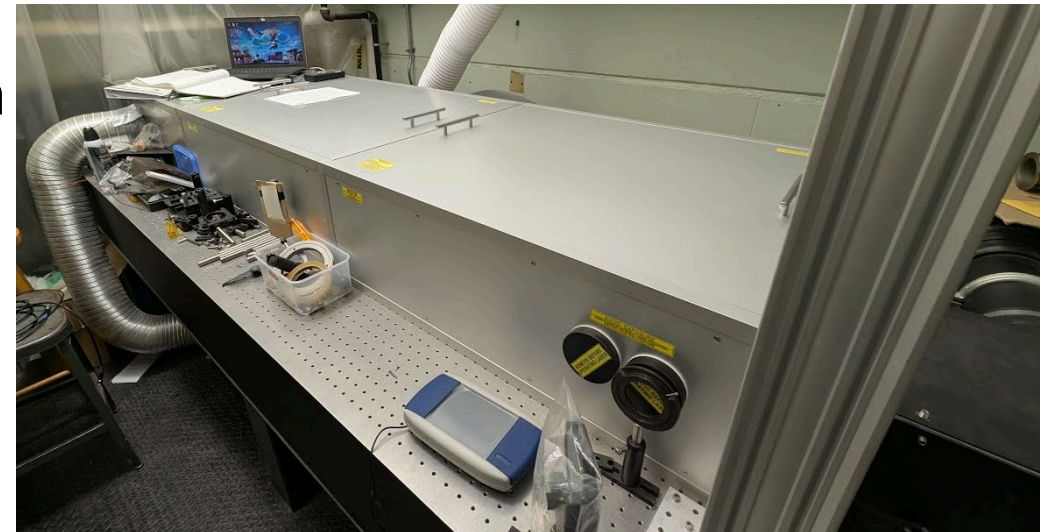
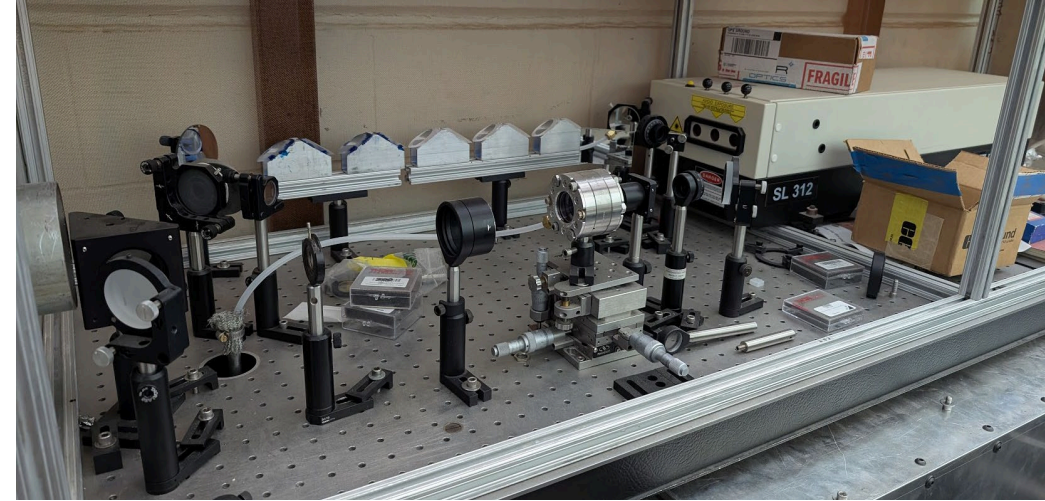
COBRA Self-emission Diagnostics

- Up to three gated pinhole images (4 frames each, 10 ns between frames, variable)
- 12 gated frames of visible imaging, >5 ns interframe
- Streaked and gated fiber-coupled visible spectrometers
 - Zeeman polarization possible
- PCDs and SiDs for time resolved X-ray measurements
- Bolometer for time resolved total radiated power measurements
- FSSR (time integrated imaging X-ray spectrometer)



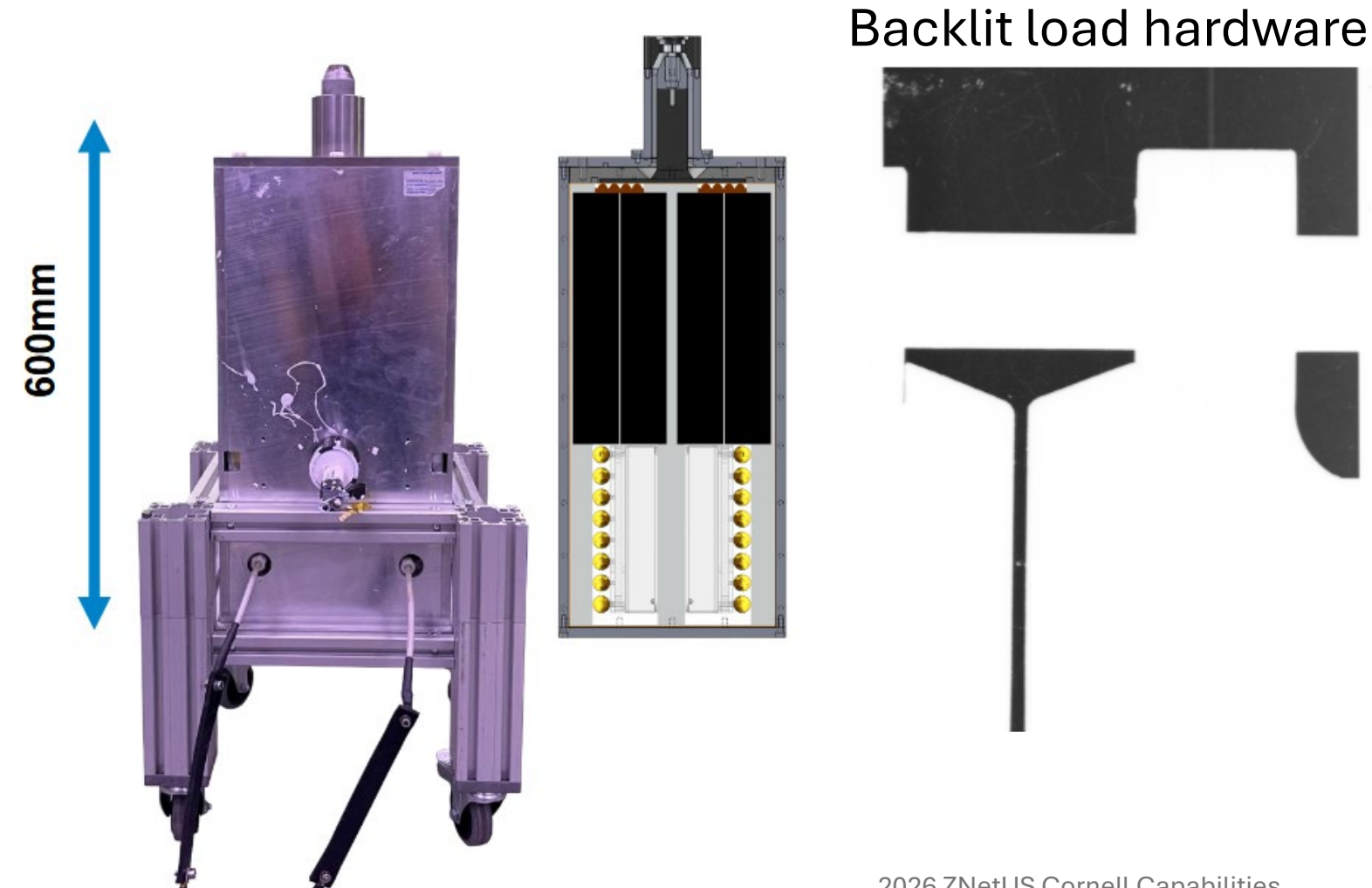
COBRA Laser Diagnostics

- Ekspla Nd:YAG SL312 (140 mJ, 532 nm)
 - Schlieren, shadowgraphy, shearing and Mach Zehnder interferometry
- Ekspla Nd:YAG SL312 (140 mJ, 532 nm)
 - Vacuum spatial filter: good for Faraday rotation imaging and imaging refractometer
- Ekspla Nd:YLF NL937 (25 J max at 1053 nm or 15 J max at 527 nm)
 - Streaked or gated Thomson scattering
 - Drive laser for [your target here]?



Dry X-pinch for X-ray backlighting

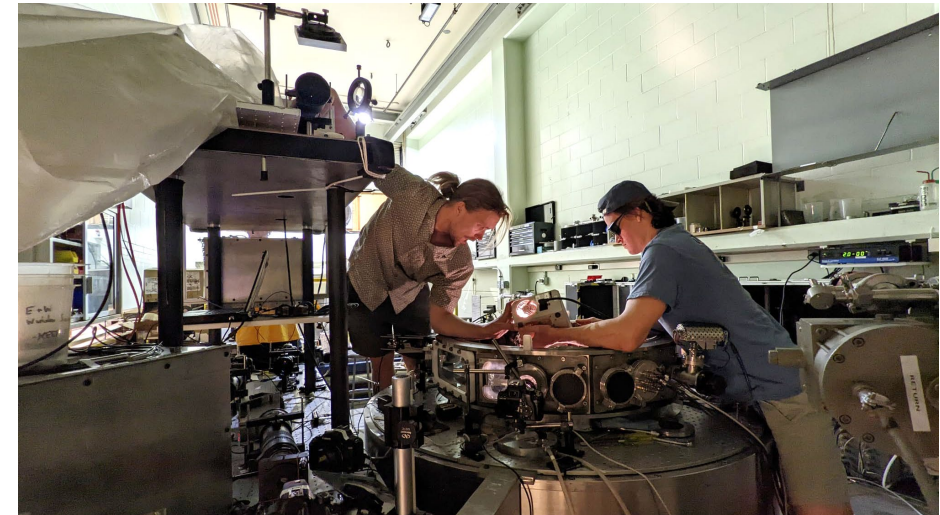
- Portable X-pinch driver for X-ray backlighting, built by Simon Bland (ICL)



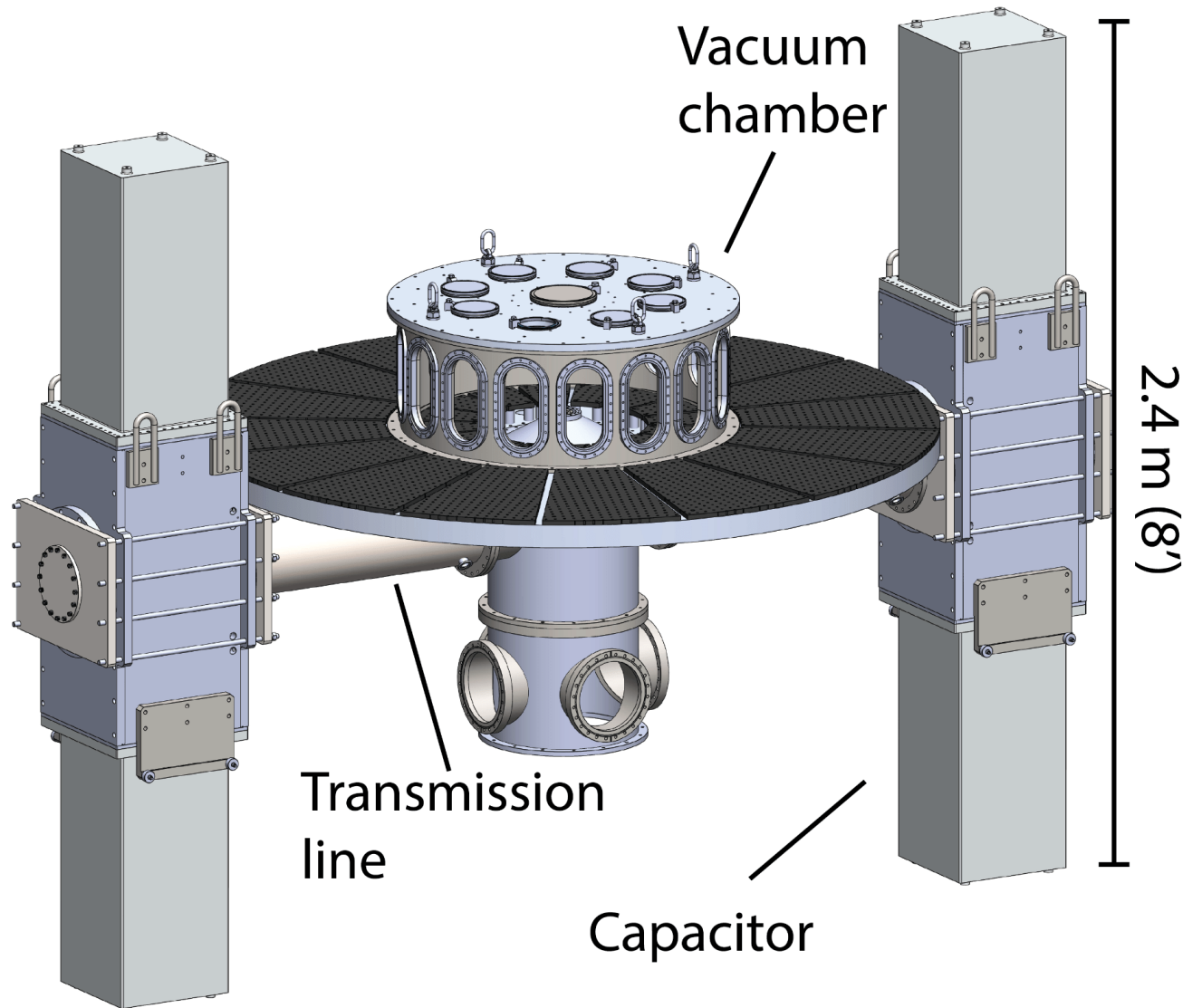
- Coupled to COBRA via vacuum pipe
- 4x Ag wires for point projection radiography (onto film or image plate)
- Good for near-solid density plasmas
- Absorption X-ray spectroscopy possible, not yet tested

ZNetUS experiments on COBRA

- Bott-Suzuki, UCSD: “Quantitative examination of radiative pre-heat in high Mach number shocks”
- Datta/Hare, MIT: “Measurement of Mach Number and Adiabatic Index in High-Energy-Density Plasmas”
- Beg, UCSD: “Effect of gas species, density profiling, and external magnetic field on stability and dynamics”
- Gourdain, Rochester: “Testing a true optical derivative to measure low-k turbulence on COBRA for astrophysically relevant”
- Bott-Suzuki UCSD/Chaturvedi ICL: “Characterization of nonlinear diffusion using radial foils”
- Beattie-Rossberg, UCSD: “Study of the dynamics of noble gases in gas puff Z-pinch experiments at a 1 MA current generator”



PUFFIN: Pulser For Fundamental Investigations

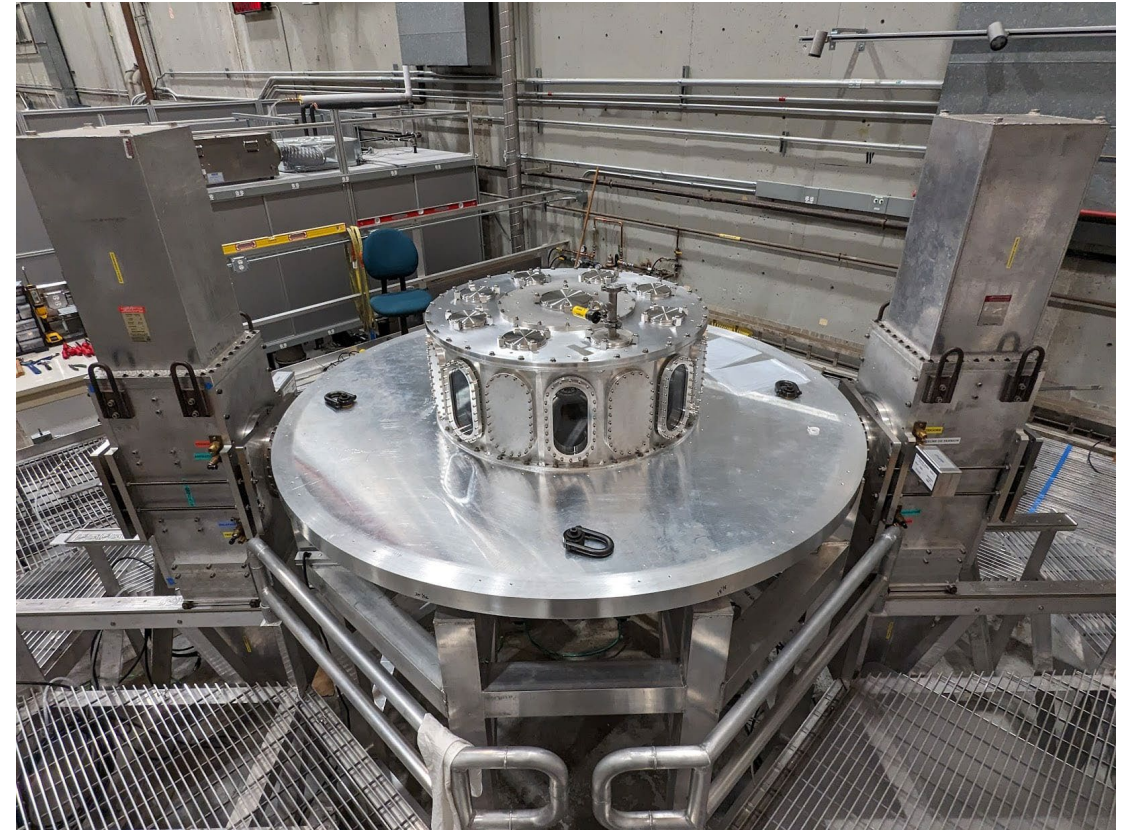


- Uses LTD5 modules developed at CEA Gramat for SPHINX
- Longer pulse ($2\text{ }\mu\text{s}$) for fundamental plasma physics
- 700 kA peak current
- Commissioned at MIT in December 2024, moved to Cornell in Fall 2026

More info: puffin.ece.cornell.edu

PUFFIN diagnostics

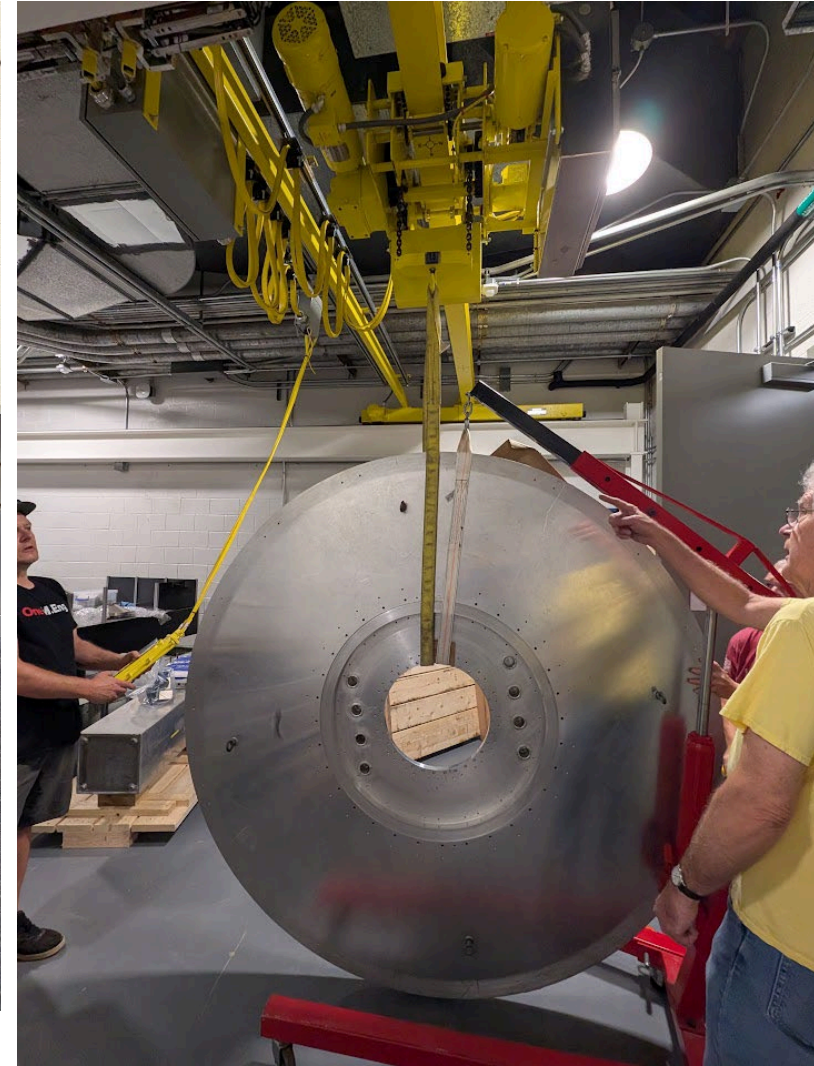
- Ekspla Diagnostic laser
 - 100 mJ, 2ns pulses simultaneously in 1064 nm, 532 nm and 355 ns
 - Gaussian beam – good for imaging!
 - Shadowgraphy, Mach-Zehnder and Moiré interferometry, Faraday rotation imaging
- Gated visible spectrometer with 300, 600 and 2400 l/mm grating and a linear fiber array with 50 fibers
- Gated pinhole imager (4 frames each, 10 ns between frames, variable)
- 12 gated frames of visible imaging, >5 ns interframe
- Thomson scattering soon!



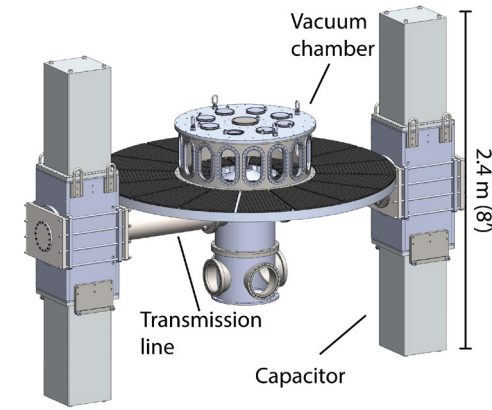
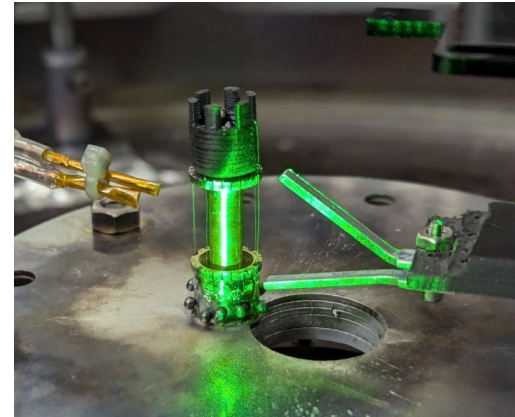
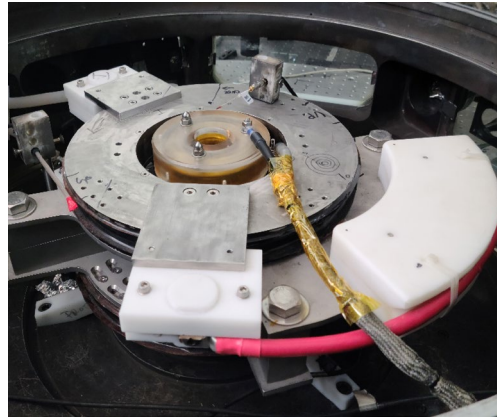
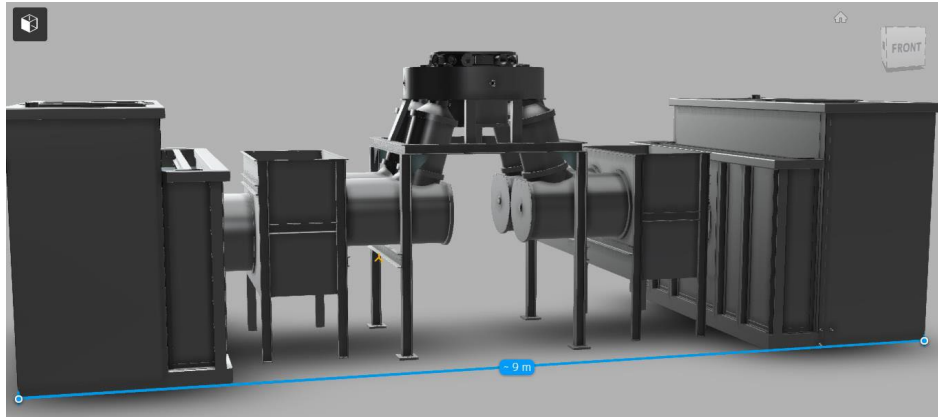
PUFFIN arrives at Cornell



PUFFIN arrives at Cornell



Conclusions



- Extensive support team: machinist, technicians, diagnosticians
- COBRA: Flagship NNSA facility, 1-1.2 MA, 100-220 ns rise time
 - Variable rise time, fast pump down, external field coil, split anode, dry pinch, extensive diagnostic suite
- PUFFIN: new long-pulse facility, 700 kA, 1.5 μ s rise time
 - Planned to be online by the end of the year, initial diagnostics suite focused on laser imaging and spectroscopy
- Ithaca: beautiful town in the Finger lakes region, lovely sunny weather*
**subject to availability*