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Sandia National Laboratories

Inductively driven transmission lines (IDTLs)

Fringe-field-driven devices for powering diagnostic X-ray sources on the Z Pulsed Power Facility

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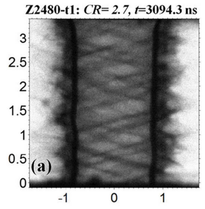
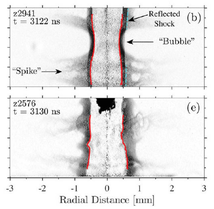
Radiography is a crucial but constrained diagnostic on the Z Pulsed Power Facility



Magnetized liner morphology
Awe et al. *PRL* 2013



Confinement time measurements
Knapp et al. *PoP* 2017

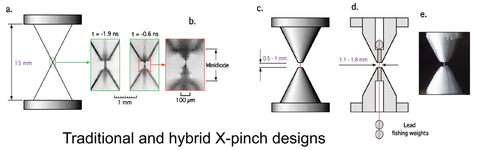
Backlighter X-rays are generated by focusing the 2+ kJ Z Beamlet Laser (ZBL) on foil targets.

Key constraints:

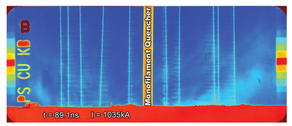
- Maximum of two radiopgraphy frames per shot
- Cannot be used when ZBL is otherwise occupied (e.g., on MagLIF experiments w/ laser preheat)

X-pinches are a pulsed-power-driven alternative to laser-driven X-ray sources

X-pinches concentrate current to create a sub-ns burst of X-rays from a sub-μm hot spot



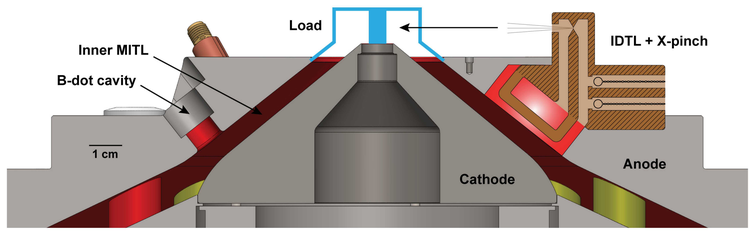
Traditional and hybrid X-pinch designs
Shelkevenko et al. *PoP* 2010



X-pinch backlighter on a wire array Z-pinch
Douglass et al. *RSI* 2008

X-pinches are routinely used to backlight HED experiments on MA-scale facilities.

Inductively driven transmission lines (IDTLs) passively generate enough current to drive an X-pinch by coupling to fringe magnetic fields on Z



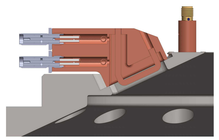
IDTL principles and features:

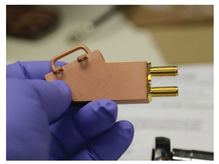
- Use fringe fields in enlarged B-dot cavities to drive current
- Low impedance generates many kA of in-phase current
- Can field up to six IDTLs on dedicated Z experiments

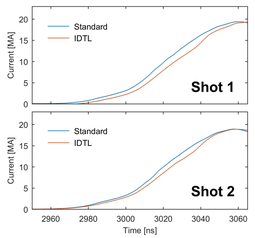
Key questions for IDTL-powered X-pinches:

- Can IDTLs non-perturbatively generate enough current to drive an X-pinch on Z?
- Can IDTLs create an X-pinch with enough X-ray fluence for radiography on Z?
- When in the current pulse can X-pinches be generated?

Short-circuit IDTLs have reproducibly generated 200+ kA of current on Z without perturbing the primary load

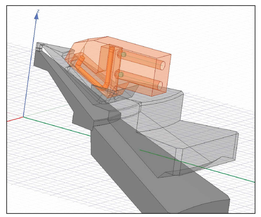






Maxwell modeling provides gauge factors factors for interpreting the amplitude of the IDTL current.

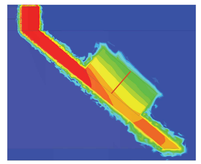
The IDTL achieves its full expected current if and when its internal B-dots match the standard Z B-dot signals.

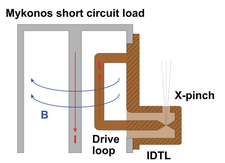


Dedicated IDTL-powered X-pinch source development is being pursued on the 1-MA Mykonos facility

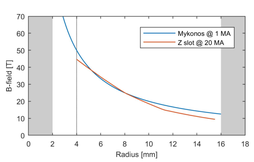
Mykonos is a 5-cavity, 1-MA LTD device located adjacent to Z at Sandia National Laboratories.

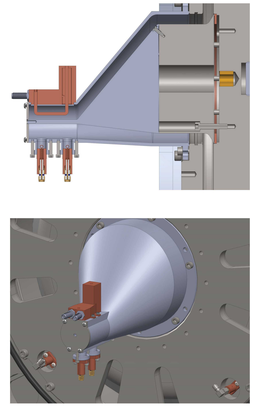
Facilitates rapid testing of IDTLs and/or X-pinches.



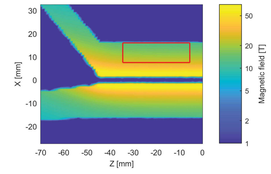


Comparable magnetic fields to those on Z can be produced on Mykonos by dropping the IDTL drive loop into the A-K gap.





Surrogate IDTL hardware for Mykonos has been designed and procured.

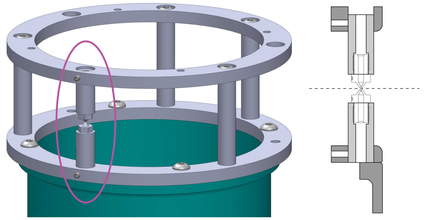


The non-axisymmetric power feed facilitates centered X-pinch diagnostic access.

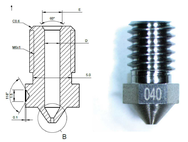
Expect 200+ kA of IDTL current from a 1-MA pulse.

Before coupling to IDTLs, hybrid X-pinches are first being tested on an existing Mykonos platform

Use the electro-thermal instability (ETI) Mykonos platform [Awe et al.] to test hybrid X-pinches in return posts.

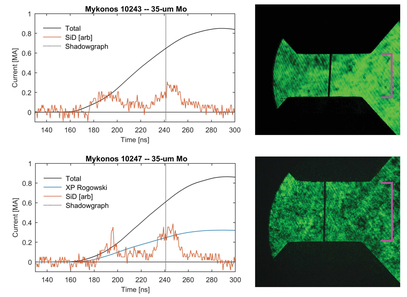


Use COTS 3D printer nozzles as hybrid X-pinch electrodes. Try both stainless steel and tungsten carbide.



We have not yet generated the desired hybrid X-pinch hotspot.

X-pinch wire morphology appearsa to change with electrode spacing.



m10243
35-μm Mo wire
Tungsten carbide
900-μm initial gap
450-μm at pinch

m10247
35-μm Mo wire
Tungsten carbide
1200-μm initial gap
630-μm at pinch

Tungsten carbide electrodes show substantial plasma expansion.

We will likely switch to tungsten-copper to reduce electrode expansion.

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