Portable two LTD Bricks
X-Pinch Driver
at Idaho Accelerator Center

Roman Shapovalov

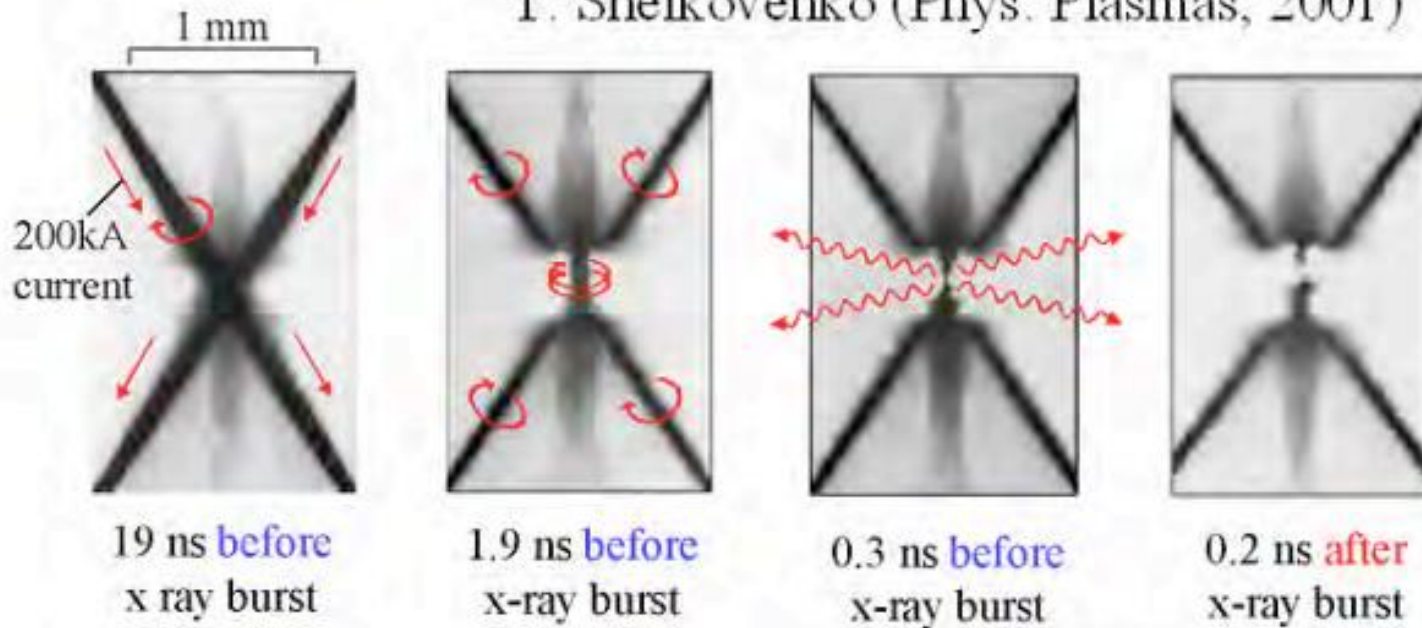June 3, 2013

Idaho State University

What is X–pinch? Why?

T. Shelkovenko (Phys. Plasmas, 2001)

1 mm

200kA current

| 19 ns before x ray burst | 1.9 ns before x-ray burst | 0.3 ns before x-ray burst | 0.2 ns after x-ray burst |

Remarkable X-Ray Source:

- **fast (< 1 ns)**
- **small (1-10 μm)**
- **bright (> 100-200 mJ)**
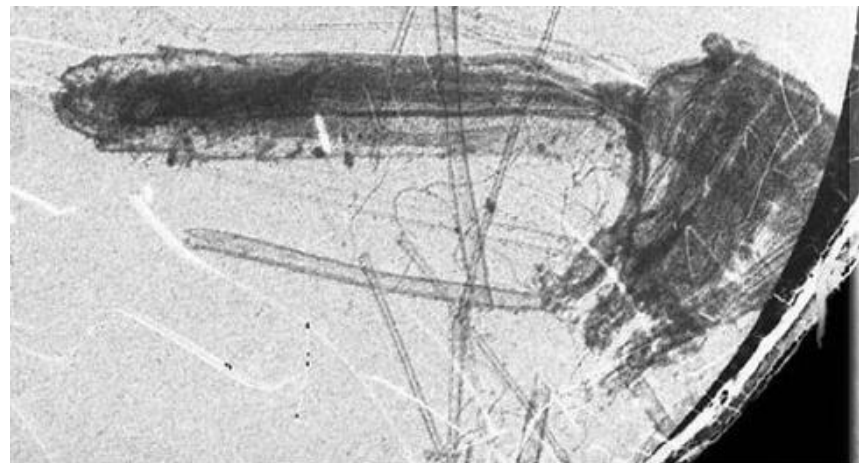
Driver: GA 35465 capacitor

GENERAL ATOMICS
ELECTRONIC SYSTEMS

CAPACITOR SPECIFICATION

PART NUMBERS: 35465

PARAMETER	VALUE	UNITS	Q.A.	METHOD
CAPACITANCE:	0.14	uF	100%	120 Hz, R.T.*
TOLERANCE:	± 10	%		
RATED VOLTAGE:	100	kV		
TEST VOLTAGE:	110 min.	kV	100%	60 sec HIPOT
RATED ENERGY:	700	Joules		
RATED VOLTAGE REVERSAL:	10	%		
MAX. VOLTAGE REVERSAL:	80	%		
RATED PEAK CURRENT:	50	kA		
MAX. PEAK CURRENT:	75 (FAULT)	kA		
MAX. OPERATING TEMP.	40	°C		
MIN. OPERATING TEMP.	-10	°C		
DESIGN LIFE AT RATED:	3.4E+04	charge / discharge cycles		
DC LIFE:	N/A	hours		
RELIABILITY AT LIFE:	90	%		
MAX. DISSIPATION FACTOR	0.40	%	100%	120 Hz, R.T.*
APPROX. INDUCTANCE	10	nH	SAMPLE	STANDING WAVE
MIN. INSULATION RESISTANCE	1000	Mohm-uF	SAMPLE	DECAY Vr / R.T.* /

CASE STYLE:	PLASTIC CASE, DOUBLE ENDED
BUSHING:	2 x .88 wide x 3" long Brass Rails
ELECTRODE:	1 RAIL with 2 ea 10-32 UNF-2B Holes on each End.

DIMENSIONS:	2.2 x 8.0 x 12.50	inches
	56 x 203 x 318	mm
APPROXIMATE WEIGHT:	12.2	lbs
	5.6	kg

NOTES:

NOTE 1: LEAK TEST: 100 % test and inspection

NOTE 2: Castor Oil IMPREGNANT (non-PCB)

0.3 MAXIMUM ALLOWABLE BULGE

10-32 UNCx 0.3" DEEP 4 PLCS

FILL HOLE

LABEL SIDE

High Potential End
GENERAL ATOMICS
ELECTRONIC SYSTEMS
PART No. 35465
0.14 uF ± 10%
100 kV
XXXX-A-XXXX
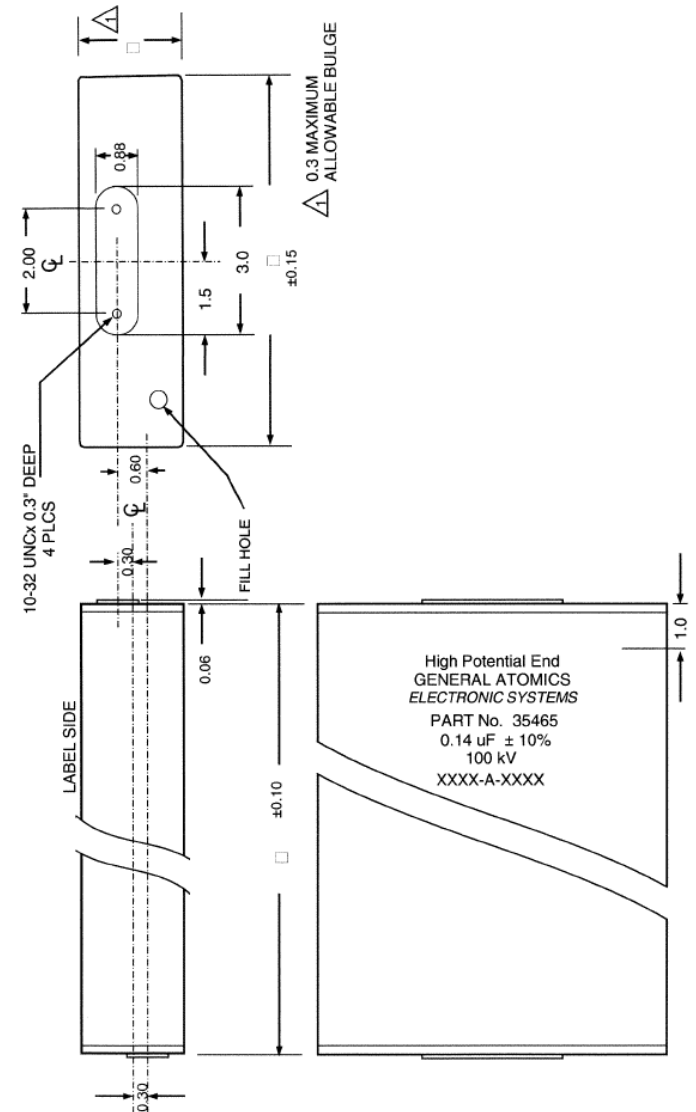
Load Inductance: X-Pinch
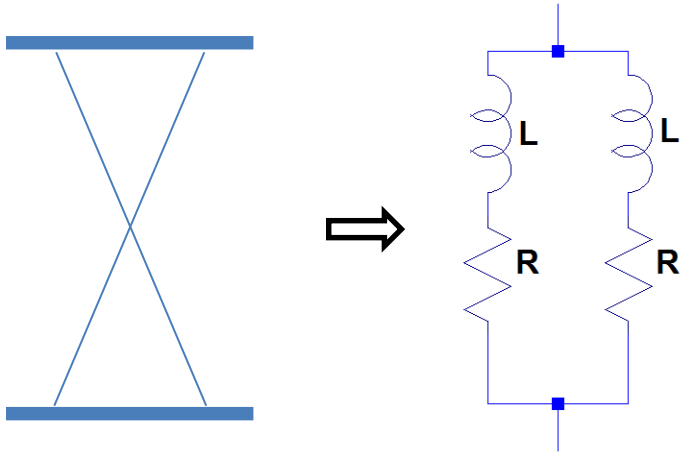
$$L = 0.2 \left(\ln\left(\frac{4 \cdot L}{d}\right) - 0.75 \right)$$

$$L_{Total} = L/2$$

material	Density g/cm^3	Resistivity 10^{-8} Ω*m	L, mm	d, um	R, Ω	L, nH	R, Ω	L, nH	L, nH
					one wire	one wire	two ↑↑ wires	two ↑↑ wires	double diameter wire
Gold	19.3	2.44	20	50	0.25	26.5	0.12	13.3	23.7
Aluminium	2.7	2.82	20	50	0.29	26.5	0.14	13.3	23.7
Tungsten	19.25	5.60	20	50	0.57	26.5	0.29	13.3	23.7
Molybdenum	10.28	5.34	20	50	0.54	26.5	0.27	13.3	23.7
Titanium	4.51	42.00	20	50	4.28	26.5	2.14	13.3	23.7

Load Inductance: Header, Lower and Upper Feeds
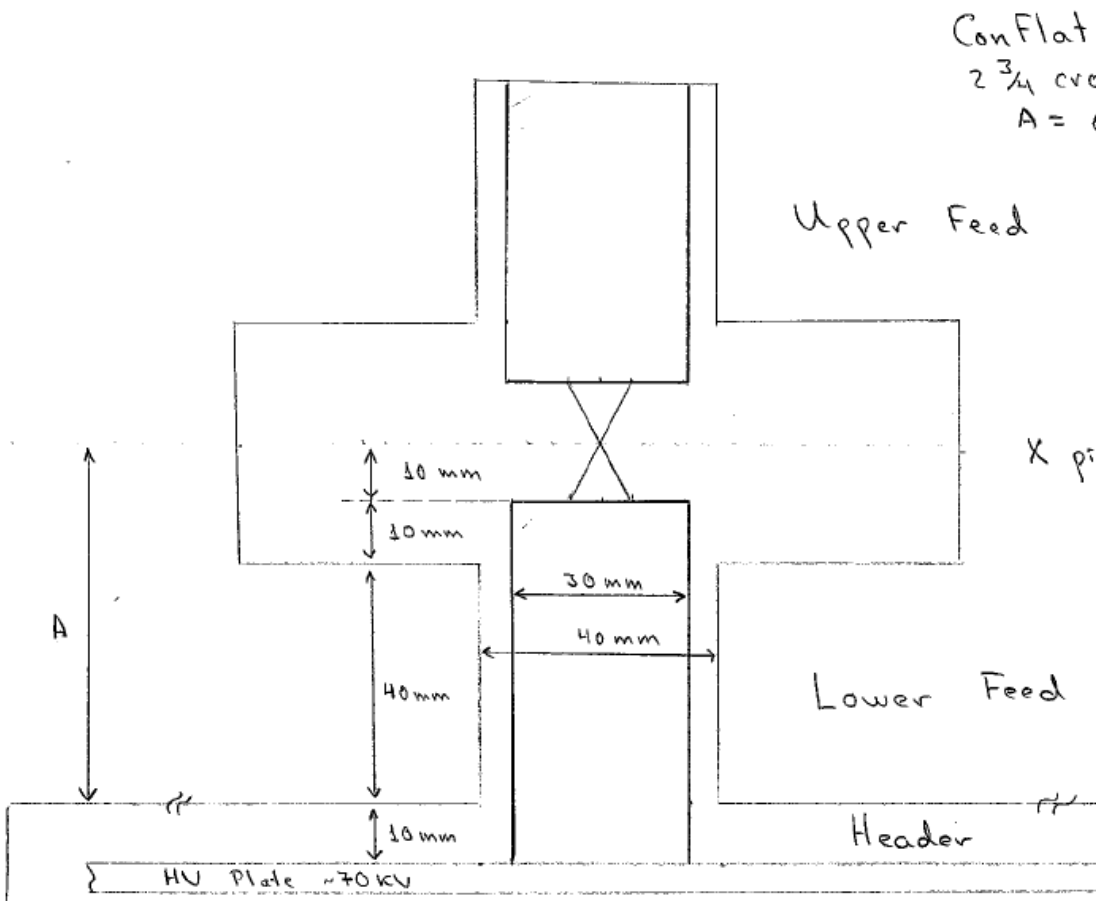
ConFlat
2 ¾ cross
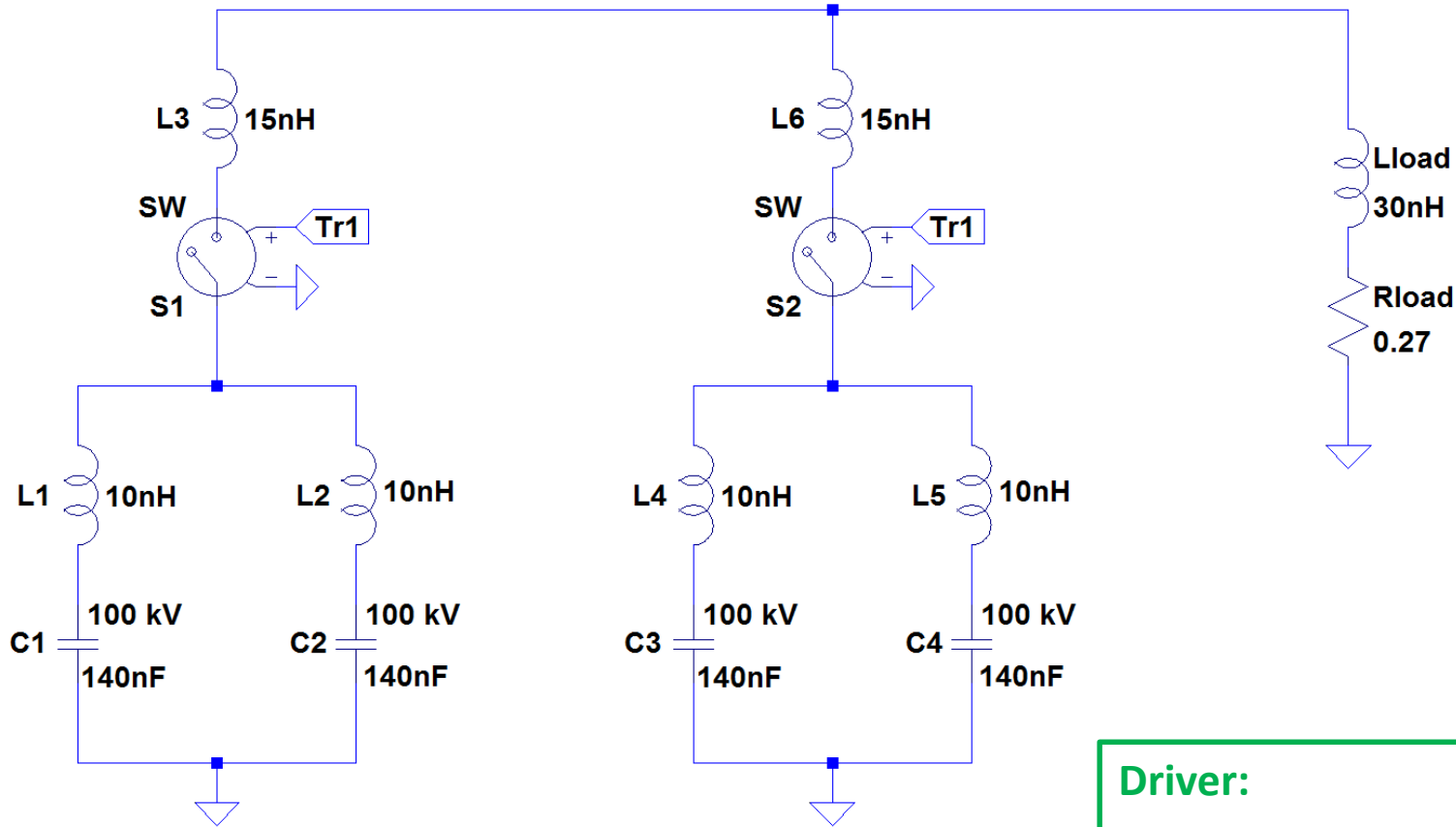A = 62.5 mm

$$L_{header} = 0.2L \cdot \ln\left(\frac{R_{outer}}{R_{inner}}\right) \ [nH]$$

$$L_{lower\ feed} = 0.2L \cdot \ln\left(\frac{R_{outer}}{R_{inner}}\right) \ [nH]$$

$$L_{upper\ feed} = 0.2L \cdot \ln\left(\frac{R_{outer}}{R_{inner}}\right) \ [nH]$$

Upper Feed

X pinch

Lower Feed

Header

HV Plate ~70 KV

		l_{cyl}, mm	R_{outer}, mm	R_{inner}, mm	L, nH	L, nH
header		10.00	125	15	**4.2**	**4.2**
lower feed		40.00	20	15	**2.3**	**2.3**
		10.00	125	15	**4.2**	**4.2**
upper feed					**6.5**	**6.5**
x pinch	2 ↑↑ wires	20	0.025		**13.3**	
	double diameter	20	0.050			**23.7**
Total					**30.6**	**41.1**

Substance	Dielectric Strength (MV/m)
Helium (relative to nitrogen)[2]	0.15
Air [3]	3.0
Alumina[2]	13.4
Window glass[2]	9.8 - 13.8
Silicone oil, Mineral oil[2][4]	10 - 15
Benzene[2]	163
Polystyrene[2]	19.7 200 kv/cm
Polyethylene[5]	18.9 - 21.7
Neoprene rubber[2]	15.7 - 26.7
Distilled Water[2]	65 - 70
High Vacuum (field emission limited)[6]	20 - 40 (depends on electrode shape)
Fused silica[7]	25–40 at 20 °C
Waxed paper[8]	40 - 60
PTFE (Teflon, Extruded)[2]	19.7
PTFE (Teflon, Insulating Film)[2][9]	60 - 173
Mica[2]	118

Driver with X-pinch load: electrical circuit

L3 15nH

SW

Tr1

S1

L6 15nH

SW

Tr1

S2

Lload
30nH

Rload
0.27

L1 10nH   L2 10nH

100 kV   100 kV

C1   C2
140nF   140nF

L4 10nH   L5 10nH

100 kV   100 kV

C3   C4
140nF   140nF

X-Pinch:

- **Inductance L = 30 nH**

- **Resistance R = 0.27 Ω**

Driver:

- **Inductance L = 10 nH**

- **Capacitance C = 560 nF**

- **Max Voltage V = 100 kV**

- **Max Current I = 200 − 300 kA**

- **Max stored energy E = 2.8 kJ**

Driver with X-pinch load: simulation results

I_{peak} = 200 kA

t_{peak} = 180 ns

t_{rise} = 110 ns (10-90%)

1.5 kA/ns (10-90%)

- load's current
- load's voltage
- capacitor's voltage

Voltage, kV

Current, kA

time, ns

vaccum pipp

1.25cm

25 cm

foam

cathode

steel case

Rexolite

Brick 1

Brick 2