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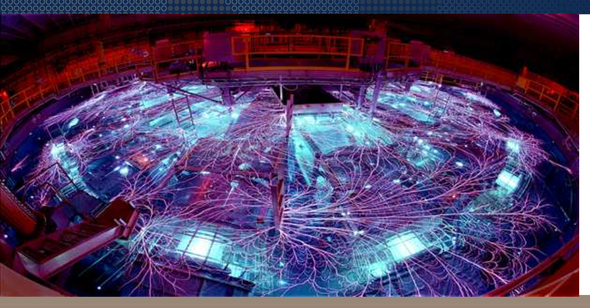

A Greater Than 6 MV Laser Triggered Gas Switch Used on Z

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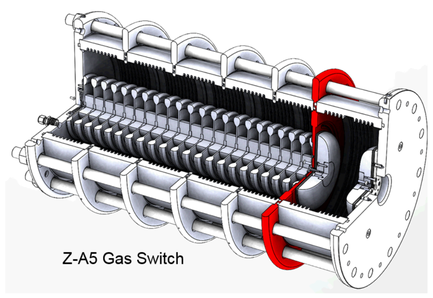
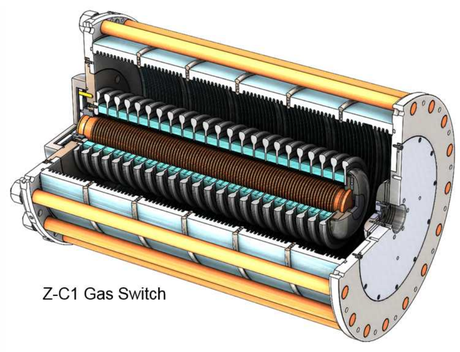
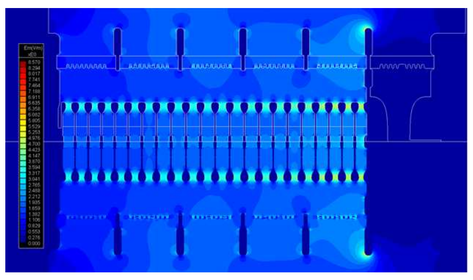
Abstract

The Z pulsed power driver at Sandia National Laboratories is used for a wide range of high energy density physics experiments in areas such as inertial confinement fusion, radiation effects, and dynamic material properties. Experimental demands are pushing for the highest energy attainable with more reliability and precision in timing and pulse compression. A previous version of the laser-triggered gas switch had been made reliable at voltages up to 5.7 MV, allowing 5 nanosecond load accuracy. The desire for higher energy and higher precision dictated a new laser-triggered switch design. In Z, 36 DC-charged Marx generators pulse-charge a water-insulated capacitor in 1.5 microseconds. The laser-triggered gas switch commutes the energy stored in the water-insulated capacitor to subsequent pulse compression stages that utilize self-closing water switches. The laser-triggered switch is the last command triggered switch in the chain, and largely determines the time accuracy of the total load current. Both switches consist of a laser triggered section and a self-closing cascade section. The previous design required a trigger plate to provided support for compressing the cascade section. With fixed laser energy, it was impossible to increase the triggered fraction of the switch. Because of the trigger support plate, establishing an operating pressure that provides a reliable balance between low pre-fire rate and low jitter becomes difficult, and more so at higher voltage. The new switch uses a cantilevered design that increases the electric stress in the self-closing section after triggering, even with a slightly-reduced trigger gap. It was required that the new design work within the same operating space and infrastructure as the previous. We will show details of the design and features necessary for reliable operation in the extreme electrical and mechanical environment presented by daily operation on Z.

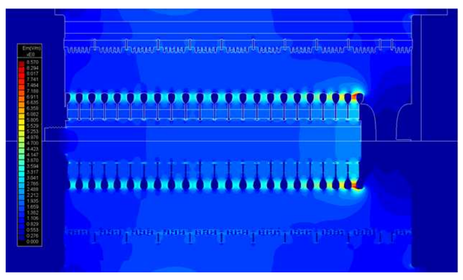
A5 vs. C1 Cascade Section





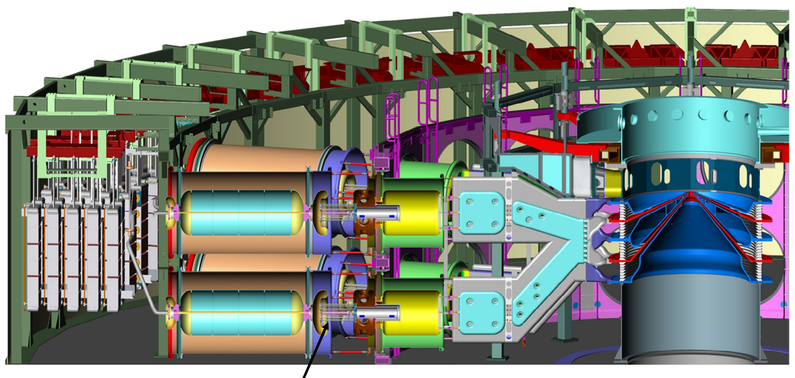


Peak electric field after trigger occurs at edge of trigger plate on oil side.



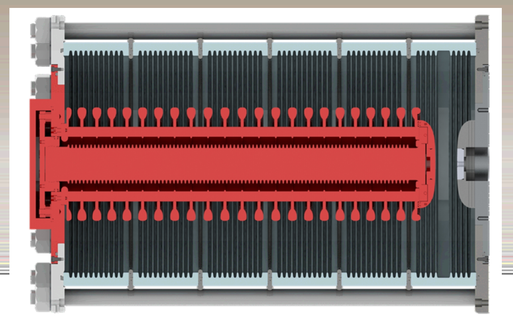
Without a trigger plate, the field is 70% higher across the first cascade gap.

Cross Section of Z Accelerator



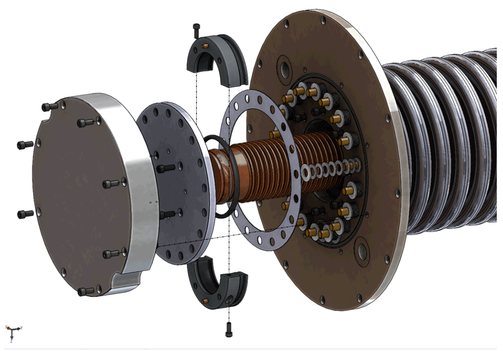
As the last command triggered switch in the machine, the LTGS is largely responsible for timing and pulse shaping.

Cantilevered Cascade Section Design



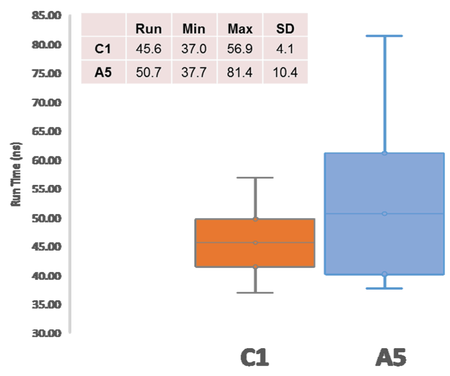
Cascade Design Features:

- 150 lb. cantilever
- 30 inches in length
- Subjected to mechanical shock from Z Machine
- Each individual gap between electrodes is slightly different to maintain a uniform field across the cascade section.



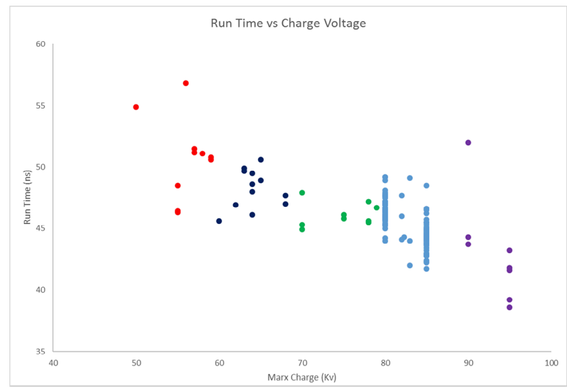
- Belleville stack is compressed to set height to preload cascade section.
- This design allows motion at the free end, and reduces stresses in the tensioning rod.

Switch Performance



	Run	Min	Max	SD
C1	45.6	37.0	56.9	4.1
A5	50.7	37.7	81.4	10.4

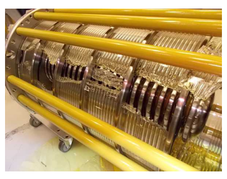
C1 jitter reduced by more than a factor of 2 from A5 predecessor.



Runtime varies with charge voltage, but this can be compensated for in shot timing.

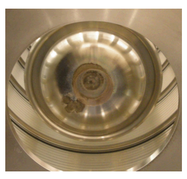
Failure Modes

External (oil side)



- Oil side failures are generally caused by debris, impurities in the oil, and surface or internal defects on the tie rods.
- Flashed tie rods
- Flashed insulator housings

Internal



- Off axis pre-fire of trigger electrode.
- Tracked cascade insulator pucks
- Flashed insulator housings
- Flashed support rod

Summary

The C1 laser-triggered gas switch was created because of a demand for higher charge voltages in Z experiments. The elimination of the trigger plate is a major contributor to the success of this switch, along with tailored electrode gaps and insulator scalloping. The removal of the trigger plate presented some unique mechanical design challenges and required that insulator materials be carefully selected. These design requirements were driven by the necessity of increased switch performance. The C1 laser triggered gas switch is able to safely operate at 95 kV Marx charge voltages. To date, in ~17,500 switch shots, the C1 gas switch has maintained a pre-fire rate of < 0.2% and an average switch lifetime of 116 shots. The new switch is also more tolerant to voltage back pulses on shaped pulse shots. Overall, this gas switch has much lower runtime jitter, a lower pre-fire rate, and a significantly longer lifespan than its predecessor.

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