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Sandia National Laboratories

Optical measurement of the new Saturn gas switch as a timing fiducial

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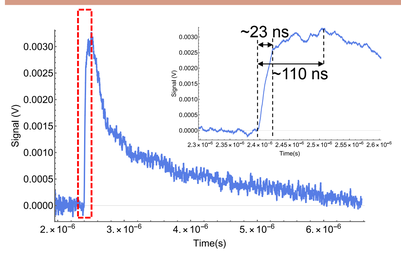
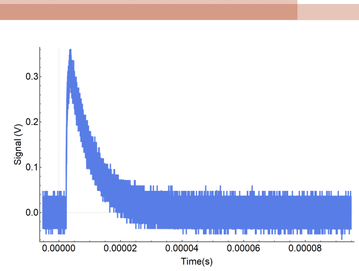
Background and Motivation

- The Saturn accelerator is undergoing a refurbishment and a new electrical triggered gas switch has been designed and tested in the water section
- The intent of the Saturn spark detector is intended to provide an electrical-noise-immune timing fiducial to determine when the switch breaks to help assess switch performance and jitter
- The diagnostic was deployed alongside gas switch testing in 2021

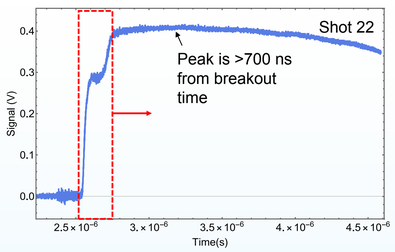
Characteristic Light from Switch

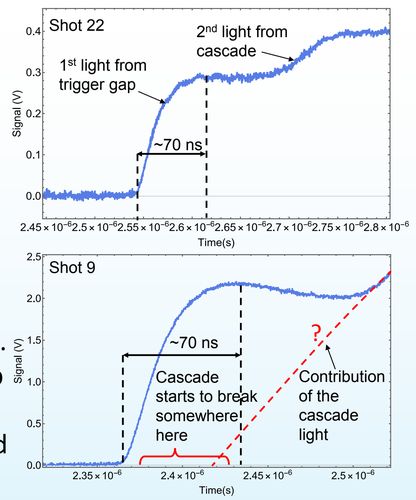


The light from the trigger electrode spark during a trigger check rises quickly in about 23 ns and peaks about 110 ns. The spark light lasts about 5 µs.



The light in the trigger gap during a switching event lasts about 30 µs.





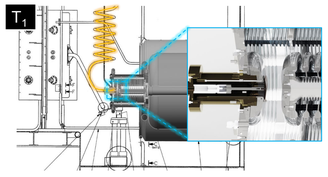
- The light from the trigger gap has a characteristic double peak structure.
- The first peak is from the trigger gap itself.
- The second peak is light contributed from the cascade section.

Spark Detector Design

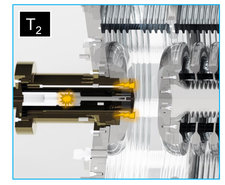
The lens enclosure is connected to a fiber detector via a 75 m 400 µm core fiber. A fiber laser was used to shine a spot on the switch housing for alignment.

The lens enclosure is shown pointing at the trigger gap with a laser alignment spot.

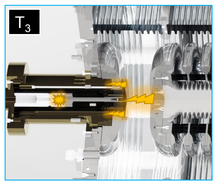
Event Sequence



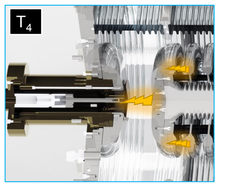
Electrical trigger pulse arrives at switch



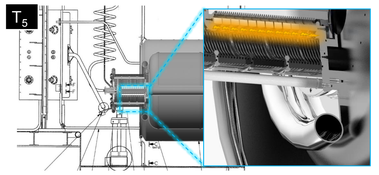
Trigger gap electrode spark initiates



Trigger gap breaks down (first light)

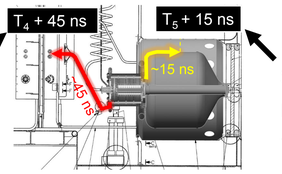


Cascade gap begins to break down



Cascade gap fully broken

Pulse forming line (PFL) monitor sees the switching event

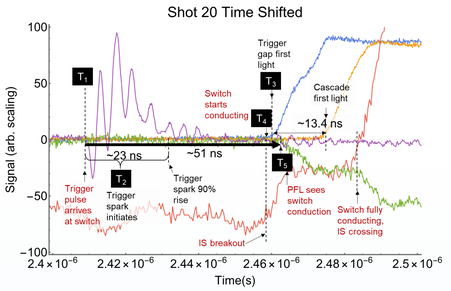


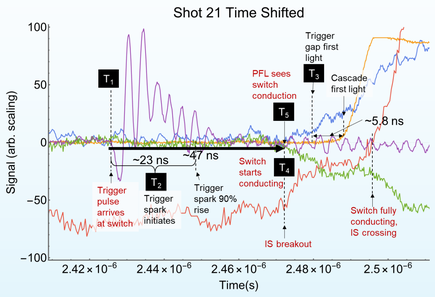
Intermediate store (IS) monitor sees the switching event

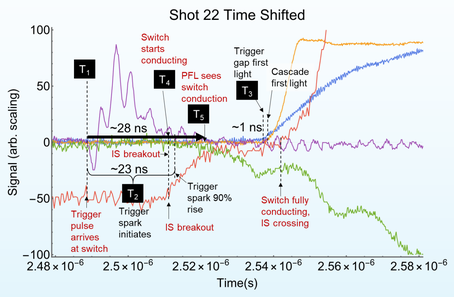
Comparison to Electrical Signals

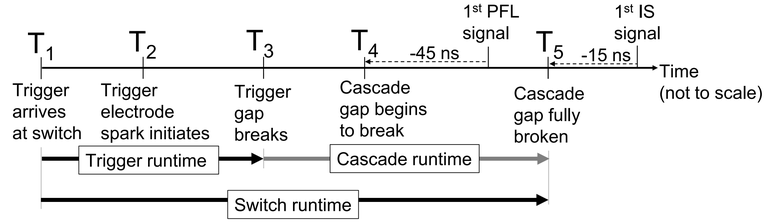
- Switch trigger light
- Switch cascade light
- I–Store V–dot (timeshifted –15 ns)
- Pulse forming line V–dot (timeshifted –45 ns)
- Electrical trigger (timeshifted 132 ns)

- Timing accuracy uncertainty for electrical signals is ± a few ns but is ± ~10 ns for optical signals
- Timing accuracy will improve in future tests









Take Away

- It is possible using this technique to see light signatures from all critical switching events: the trigger spark, the trigger gap closure, and the breakover of the cascade section.
- The light signals can be compared to the electrical signals to create a complete understanding of how the switch is performing.
- When deployed on all switches and monitored over many shots, this diagnostic could be an important early indicator of switch performance degradation allowing replacement before failure.

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SATURN RECAP