SAND2017-4832C

Sandia National Laboratories

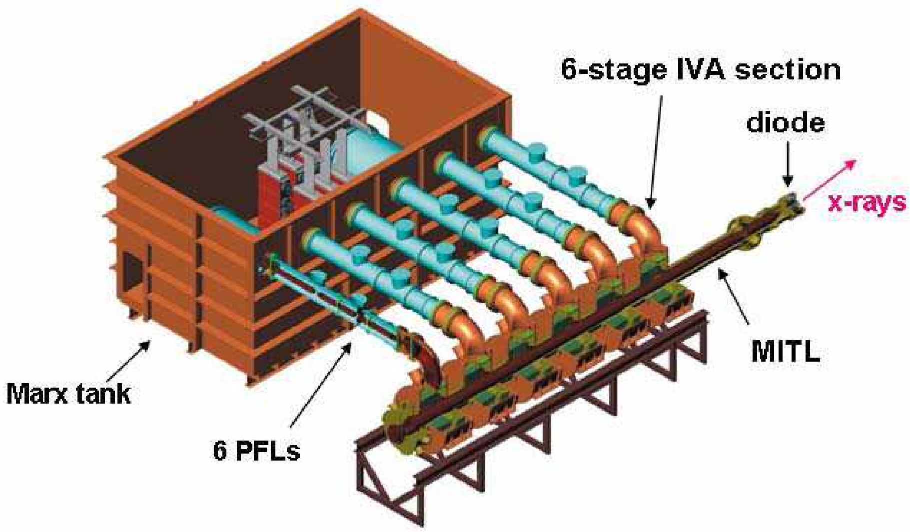
"Ion" b-dot results located inside the cathode knob of the self magnetic pinch (SMP) diode

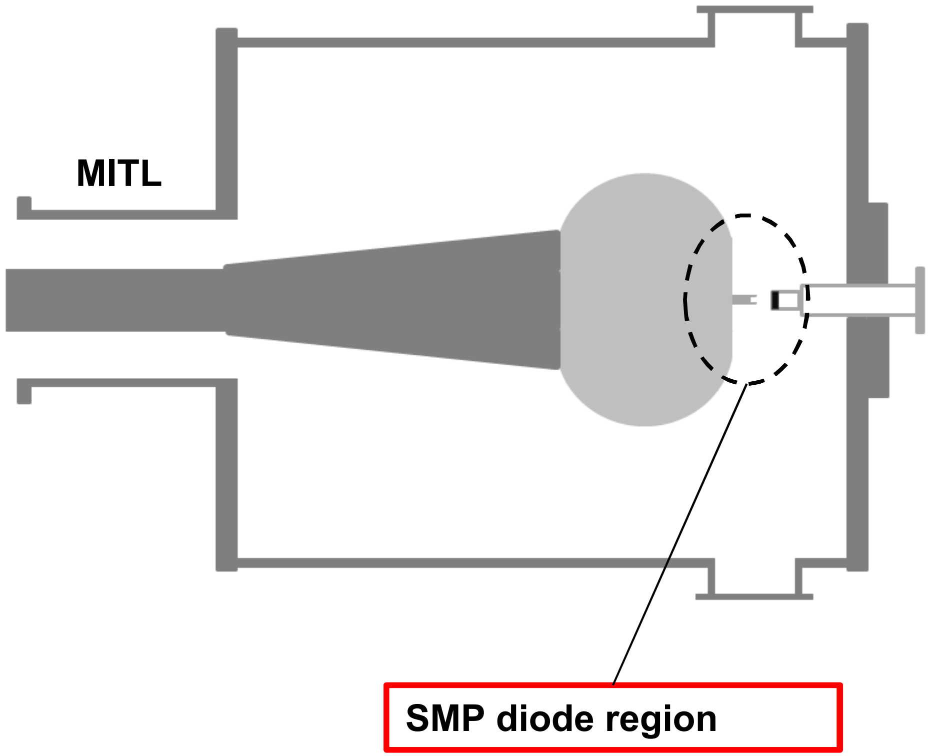
Michael G. Mazarakis, Michael E. Cuneo,
Mark L. Kiefer, Joshua J. Leckbee,
Dan S. Nielsen, and Derek Ziska

SANDIA NATIONALLABORATORY
Albuquerque NM

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.

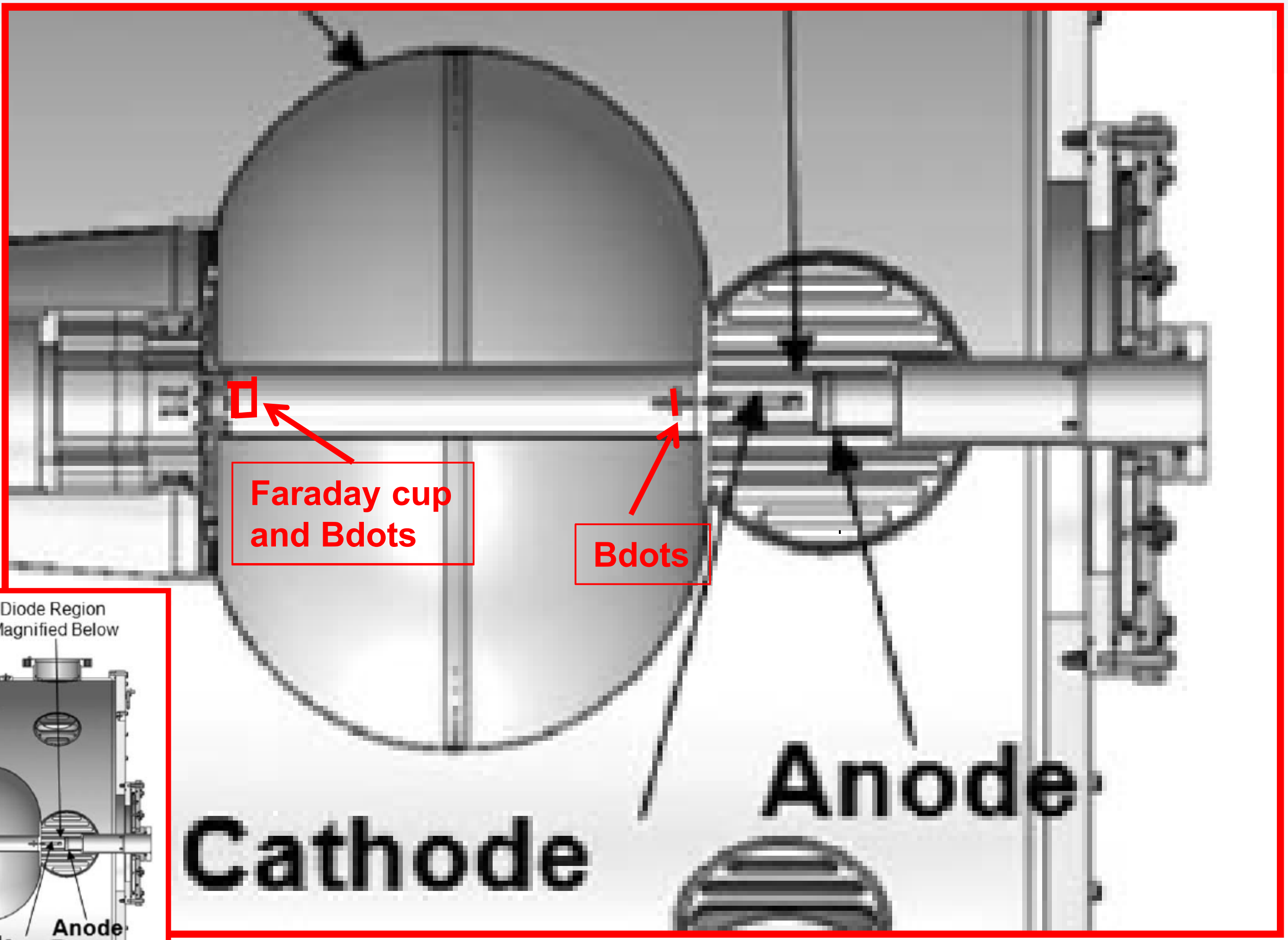
Radiographic Integrated Test Stand: RITS-6

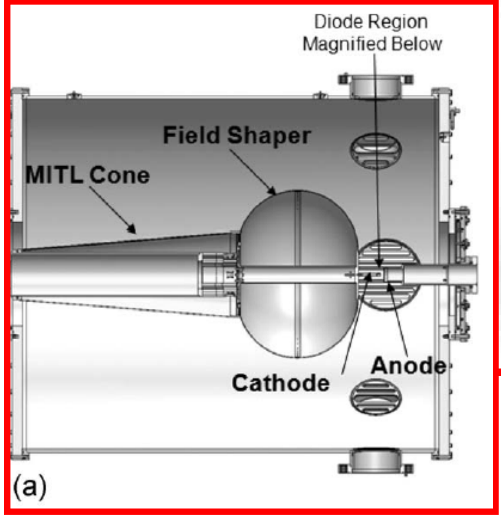




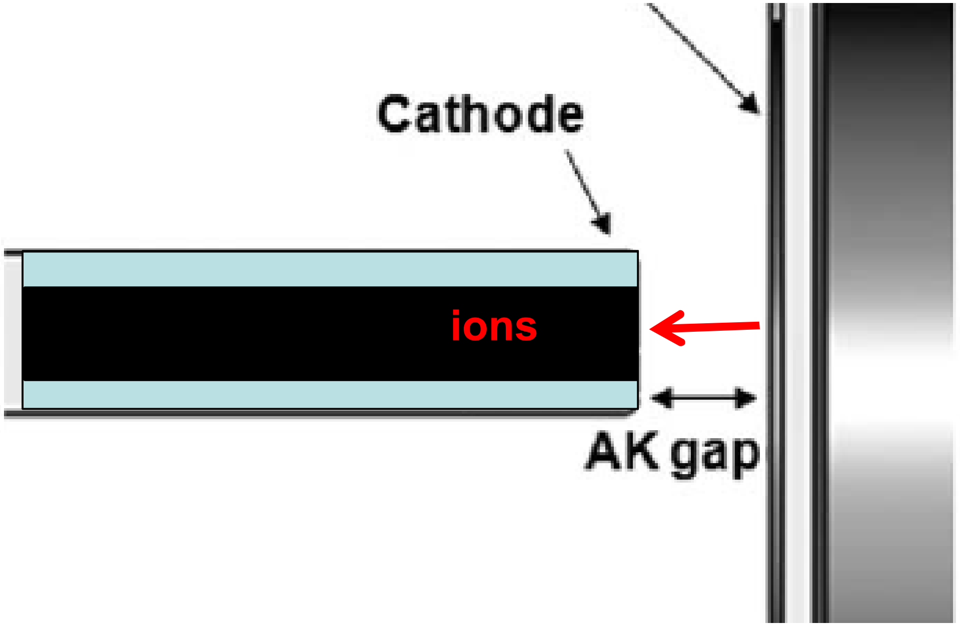
RITS-6 is a 5-11 MV Marx driven six-stage Inductive Voltage Adder (IVA) capable of driving a variety of flash x-ray radiography diode configurations

The idea was originally to use B-dots and filtered Faraday cups and /or time of flight techniques along the bin axis to measure the ion currents and energy.



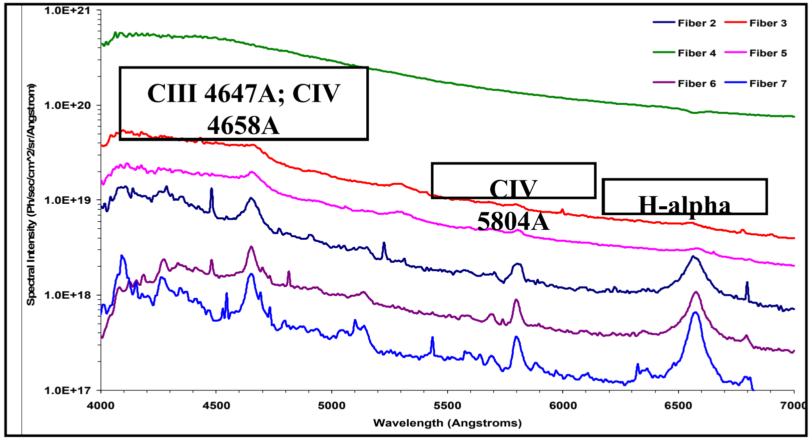


Close-up of the SMP diode



Times of flight for the ion species observed with spectroscopy.

- The plasma formed at the anode electrode during the radiation pulse due to electron beam energy deposition is mainly composed of hydrogen neutrals, protons and carbon ions.
- The times of flight through the bin axis (~44.86 cm length) of the different ionic species for 8 MV diode voltage are as follows:
- t-proton = 11.4 ns
- t- C^{+} (CII) = 39.6 ns
- t- C^{2+} (CIII) = 28 ns
- t- C^{3+} (CIV) =22.9 ns
- It appears that the second group to arrive at the detectors will be the C^{3+} followed by the C^{2+}.

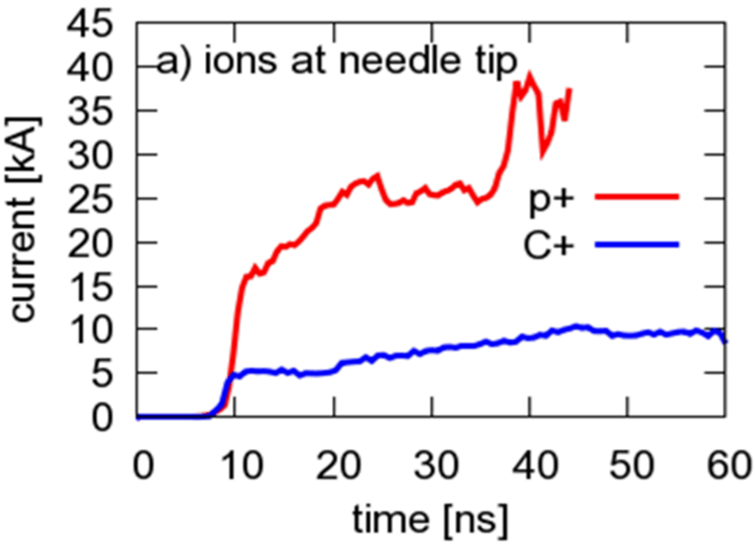


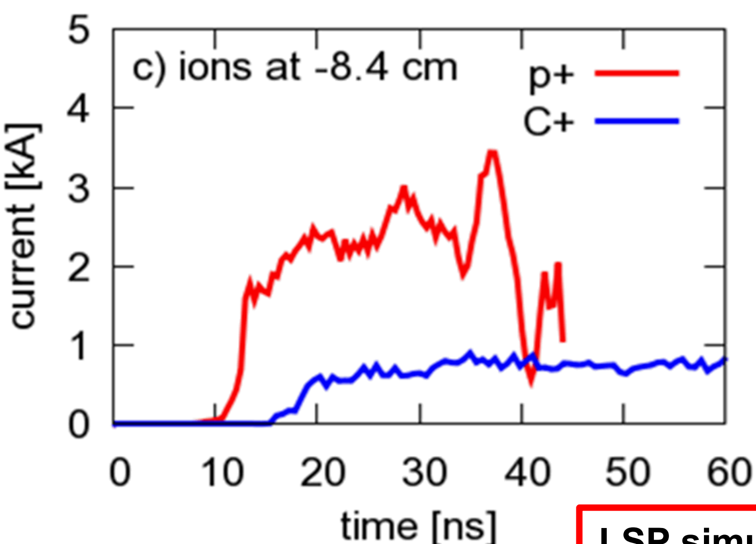
From Mark Johnston at al. IEEE Pulsed Power Conference 2013.

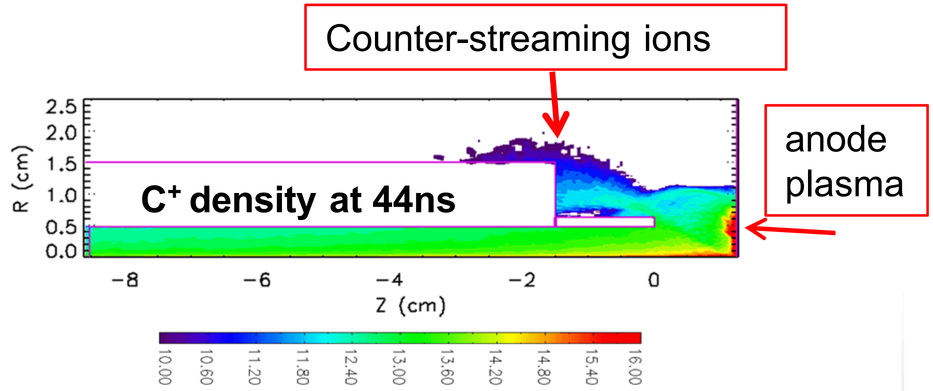
Since the RITS pulse has ~ 50ns flat top, there would be some overlapping of the various ion arrivals at the detectors.

Sandia National Laboratories

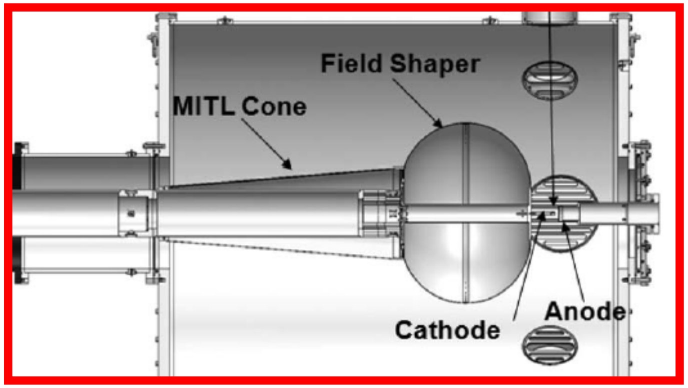
Ion propagation simulation results







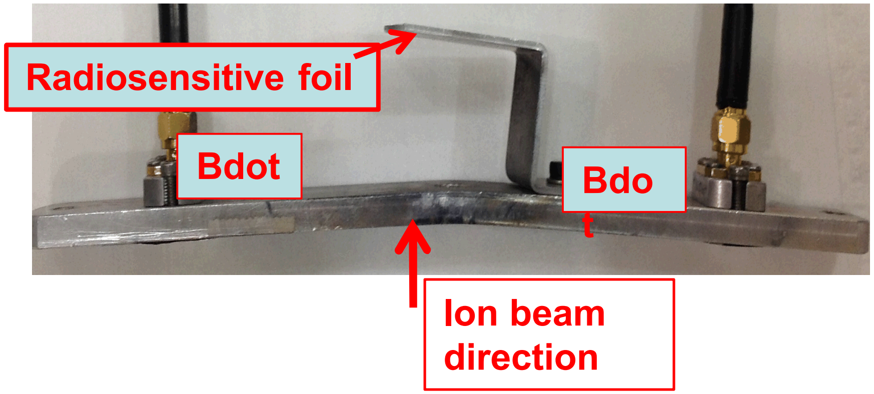
density scale (log_{10})

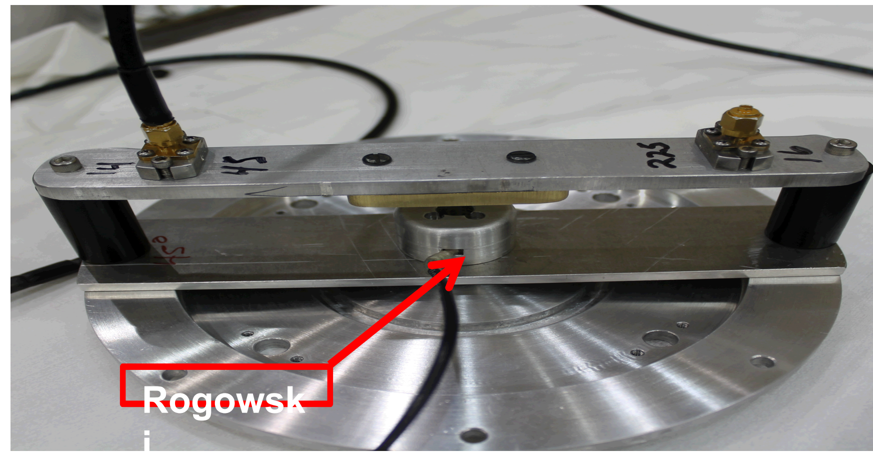


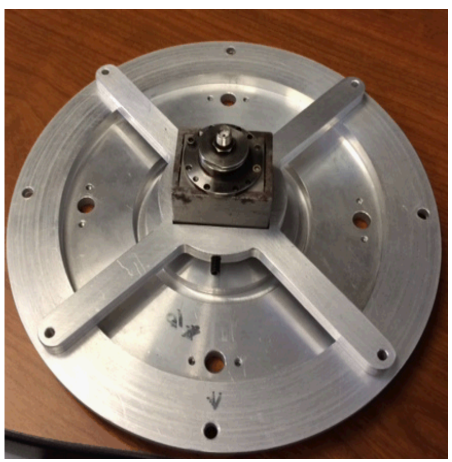
LSP simulations by Nichelle (Nicky) Bennett

Sandia National Laboratories

Ion beam diagnostics



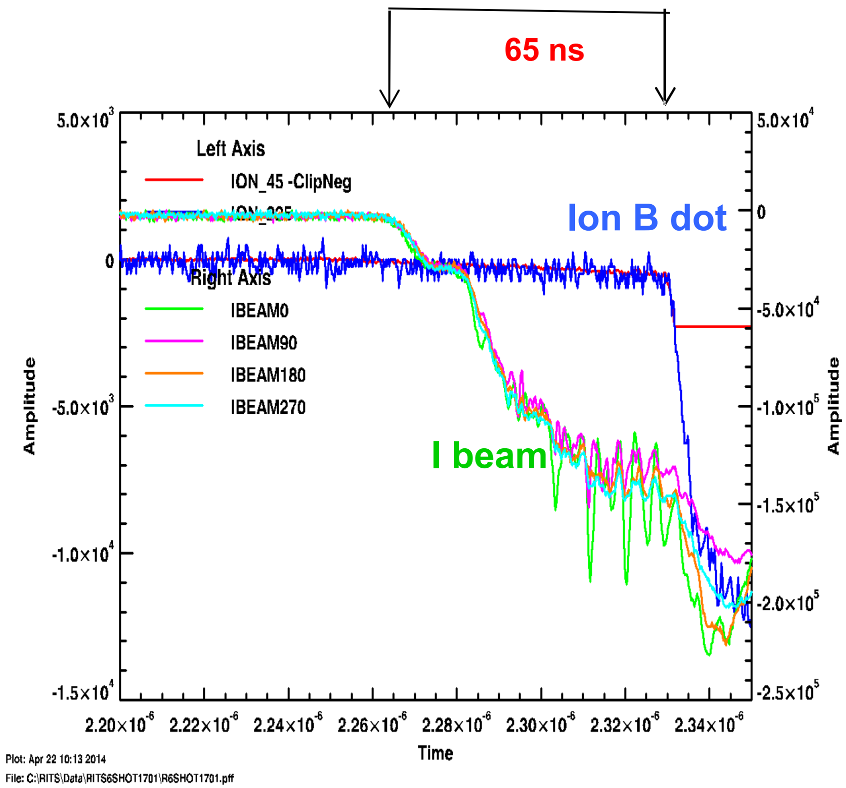


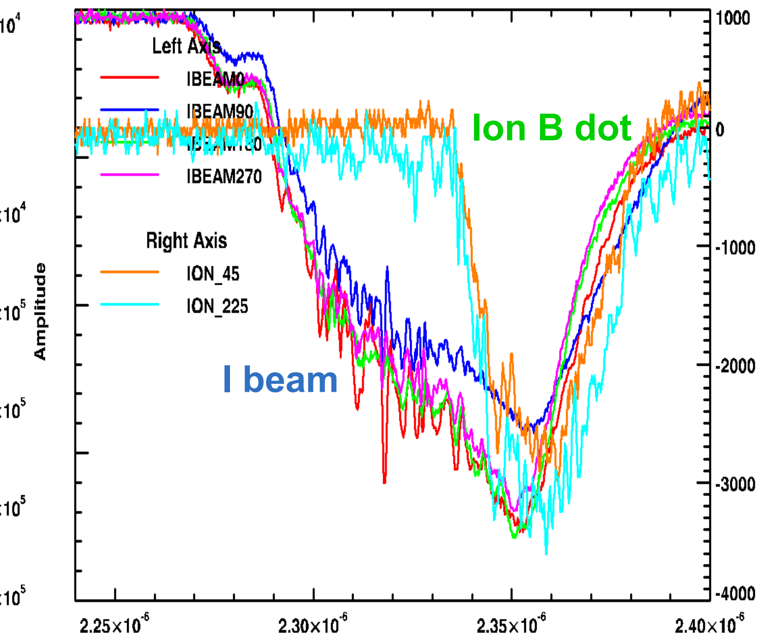


Faraday cup back

Faraday cap front

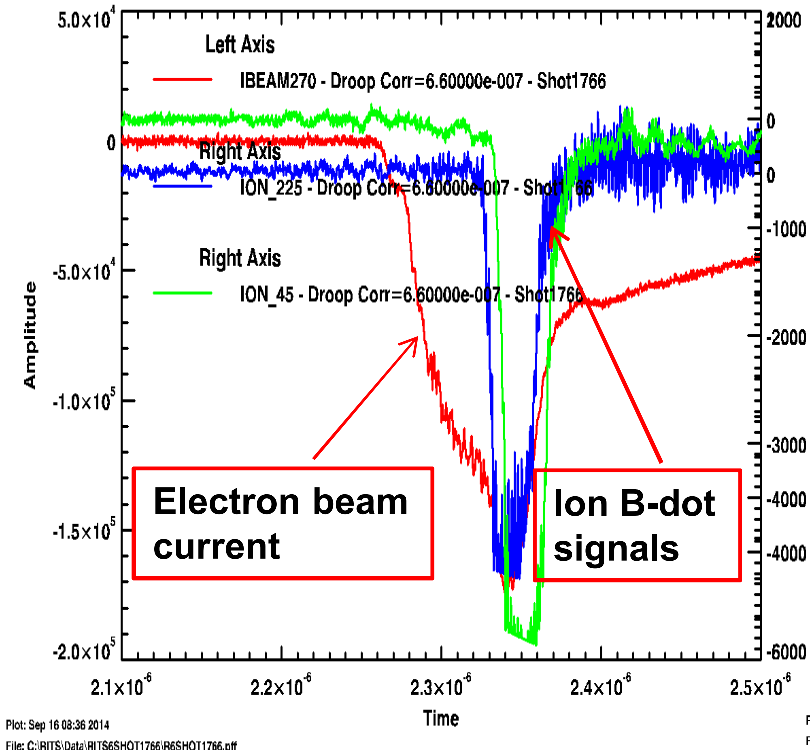
The timing of the ion B-dot signals was much longer than expected



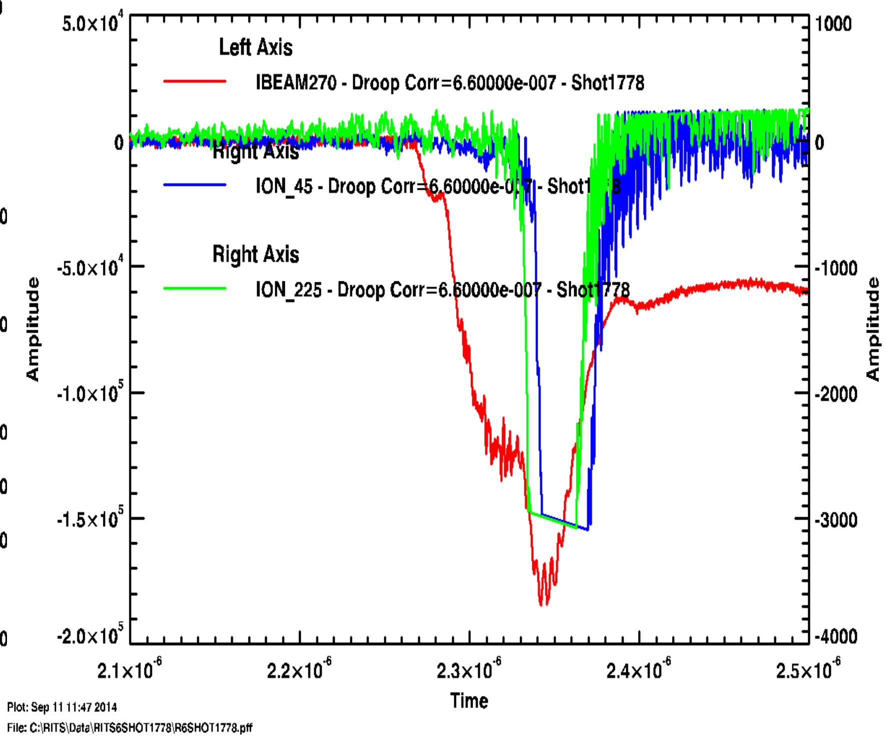


Null ion B-dot tests to check if the signals were indeed due to back-streaming ions or not

Null ion B-dot tests to check if the signals were due to back-streaming ions

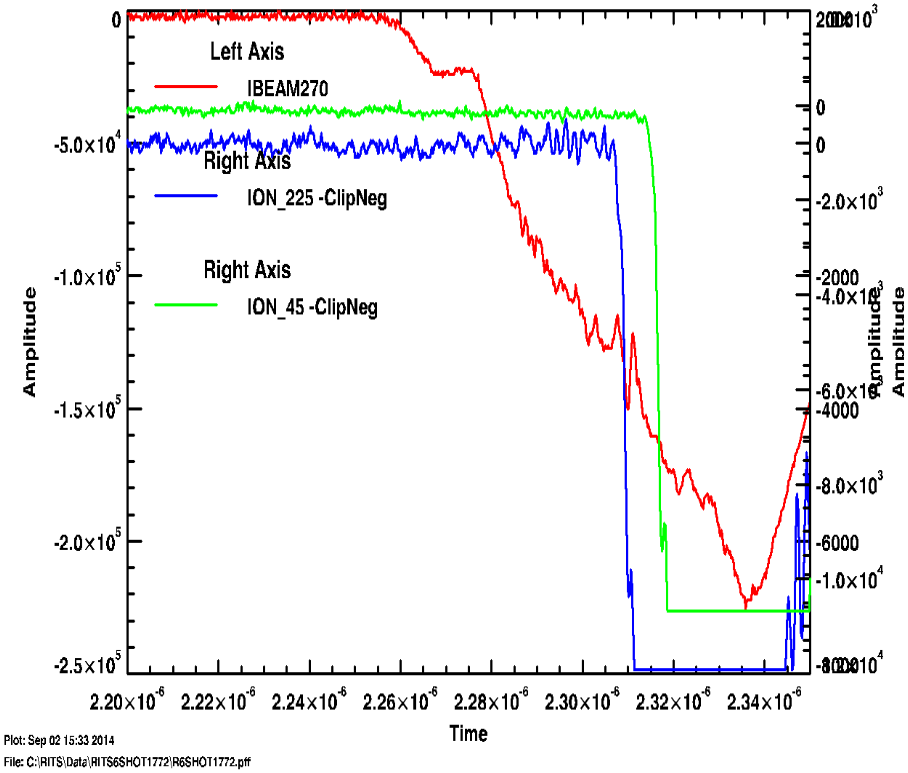


One B-dot covered with Al foil

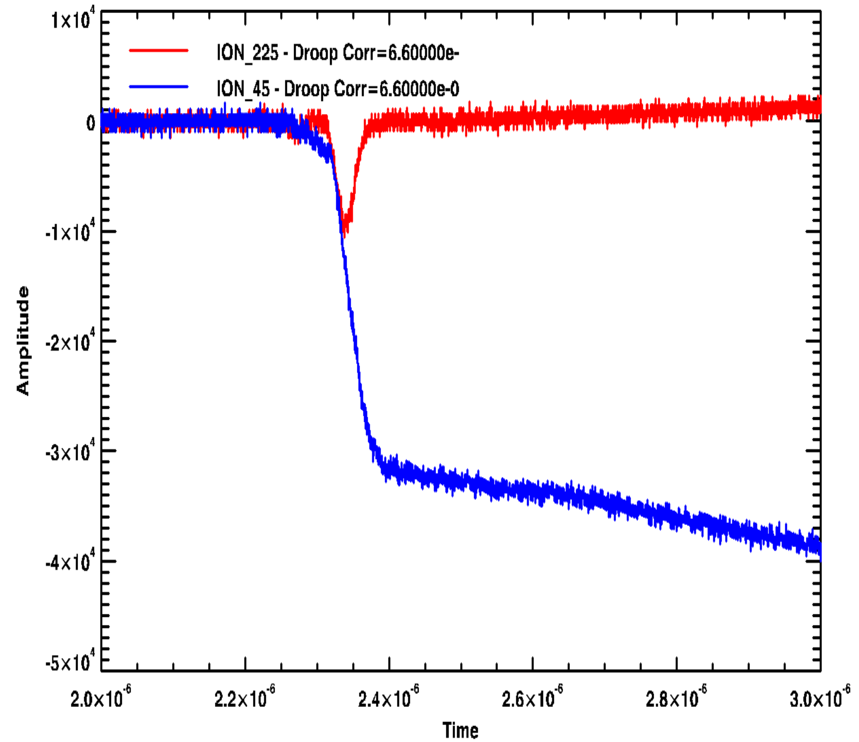


Cathode solid. No cylindrical through hole

Null ion B-dot tests to check if the signals were due to back-streaming ions (continued)

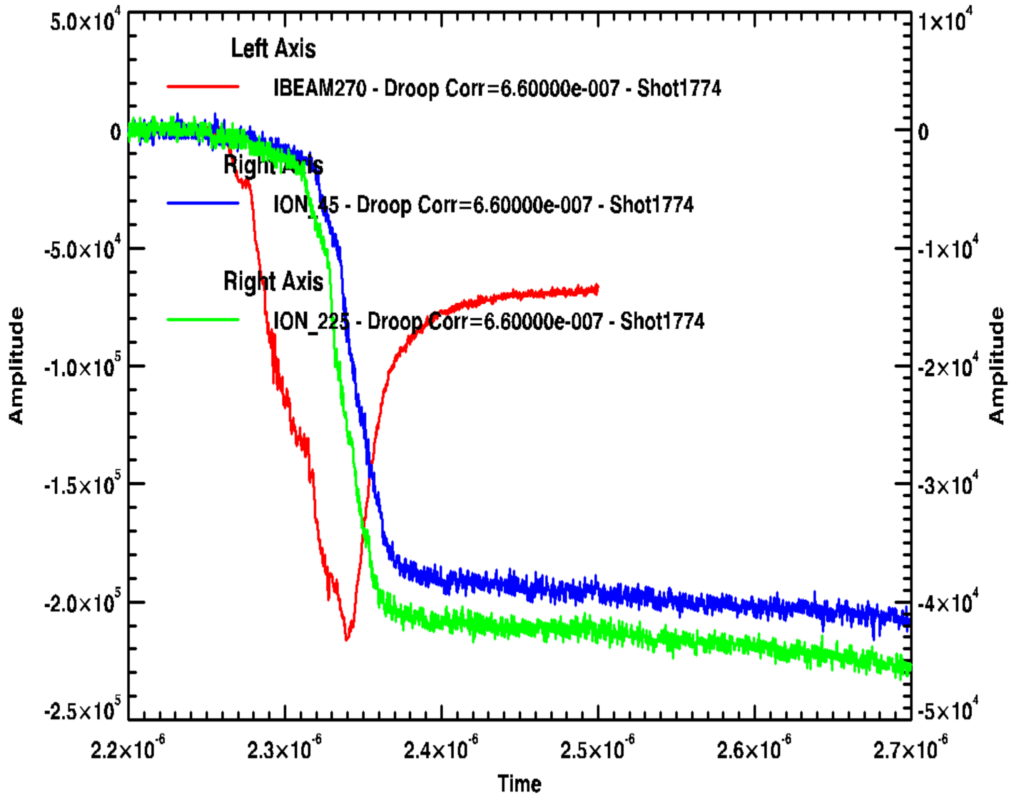


B-dot #45 rotated by 180^0



Cables disconnected from B-dots.
One cable shorted and the other opened.

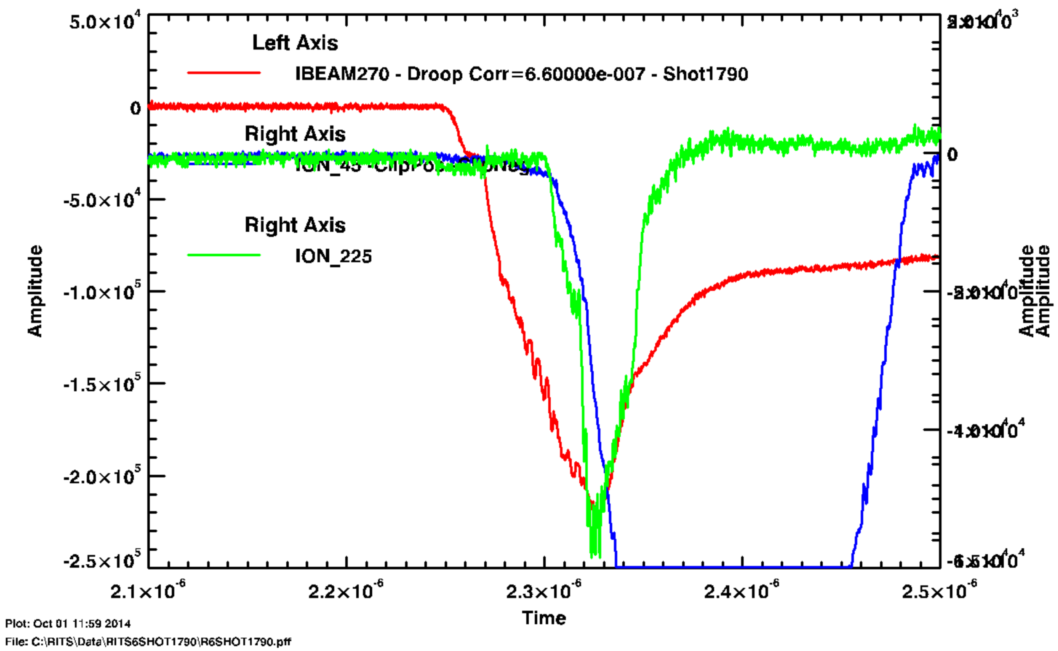
Null ion B-dot tests to check if the signals were due to back-streaming ions (continued)



Both diagnostic cables disconnected from B-dots and opened

Tests to find where the cables were picking up that charge

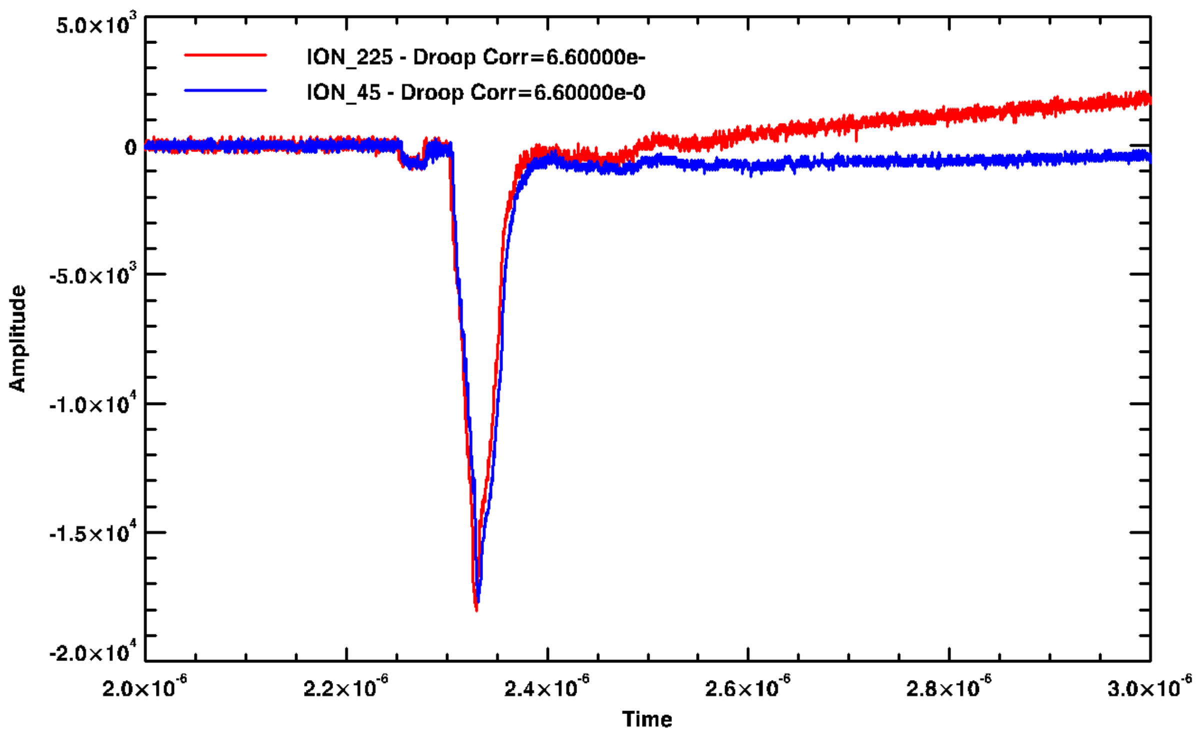
Tests to find where the cables were picking up that charge



Suspecting a charge pick-up inside the knob, we lengthened one of the cables (#45) inside the knob with a 15-m long (50') cable loop. The signal went skyrocketing high. Also, the trace was wider by almost 75 ns. Obviously the capacitance of the longer cable was much larger and the discharge pulse length was much longer.

Sandia National Laboratories

Tests to find where the cables were picking up that charge (continued)



- **Then we shielded the section of the cables located inside the knob with a 0.5mm Al and 0.5mm stainless steel thick tubes. This did not reduce or eliminate the observed signals.**

Sandia National Laboratories

Null ion B-dot tests to check if the signals were due to back-streaming ions (summary)

- First we covered one of the B-dots with an aluminum foil. To our surprise both B-dots, the aluminum covered as well as the uncovered, showed the same amplitude of “current”.
- The signal persisted even when we used a solid cathode tip without bore-hole.
- Then we rotated one of the B-dots by 180^0 (B-dot #45) to no avail. Both B-dot signals appeared with the same polarity and same intensity.
- In the following test we disconnected the diagnostic cables from the ion B-dots. The cable of the # 45 B-dot was left open while the #225 cable was shorted. As we predicted, the shorted cable gave a signal similar to that obtained when it was connected to B-dot while the open cable registered a very strong step-function pulse.
- In the following tests we disconnected the cables from the B-dots and left them open (not shorted). The integrated signals appeared at the scope as step functions because the cables did not have a path to discharge to ground.

Summary

- **It was established following a quite exhaustive null investigation that the signals registered by the two ion B-dots were not ion currents but diagnostic cable charge pick–ups.**

- **It is speculated that those signals might be due to energetic electrons entering the MITL cathode stalk and striking the cables during the retrapping of the sheath current following the diode impedance collapse.**

- **Those signals could be used as diagnostic means to monitor the diode impedance behavior.**

Back-up slides

Sandia National Laboratories