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Simulations of a Self-Magnetic-Pinch Radiographic Diode with a Heated Anode

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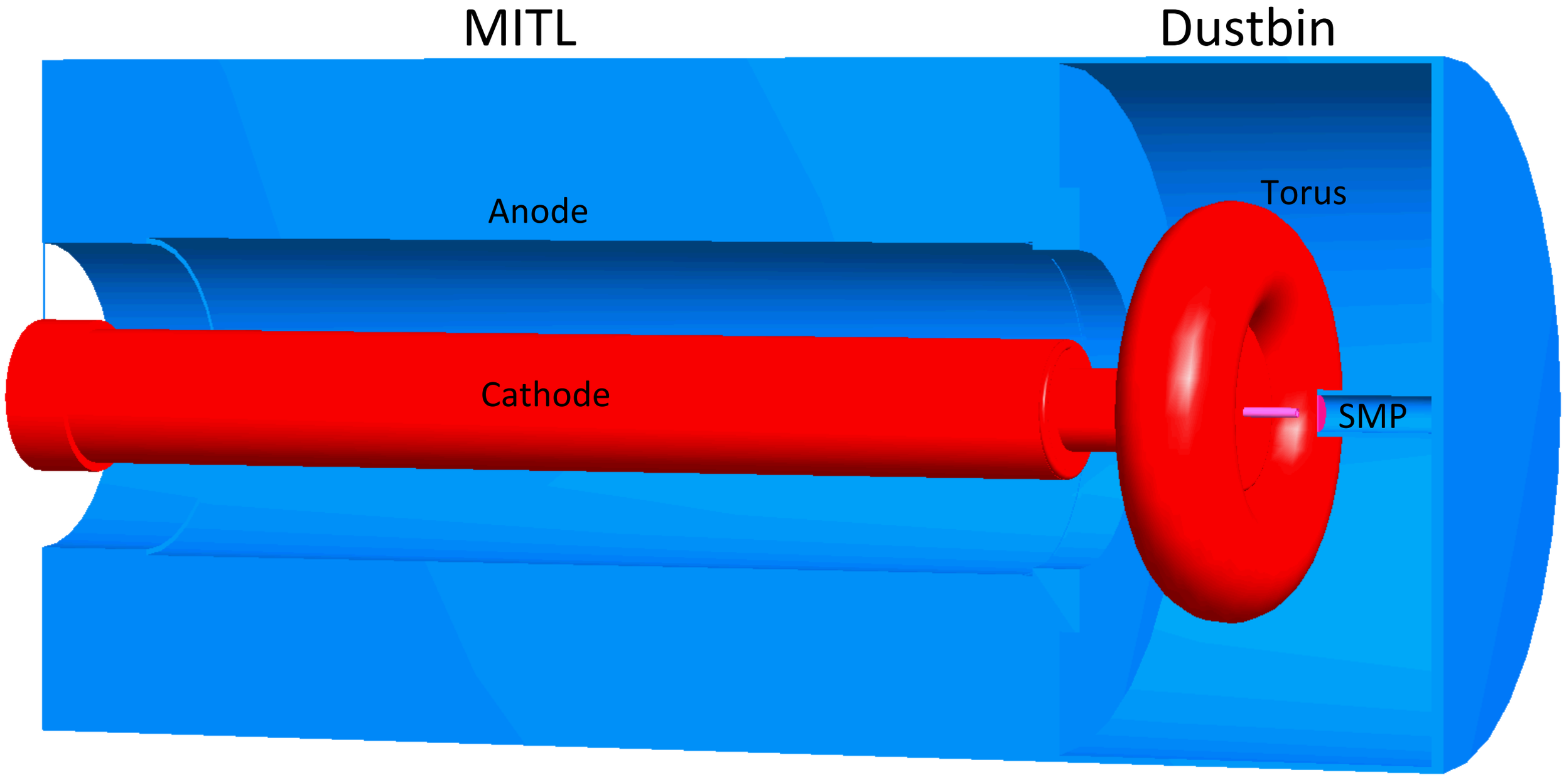
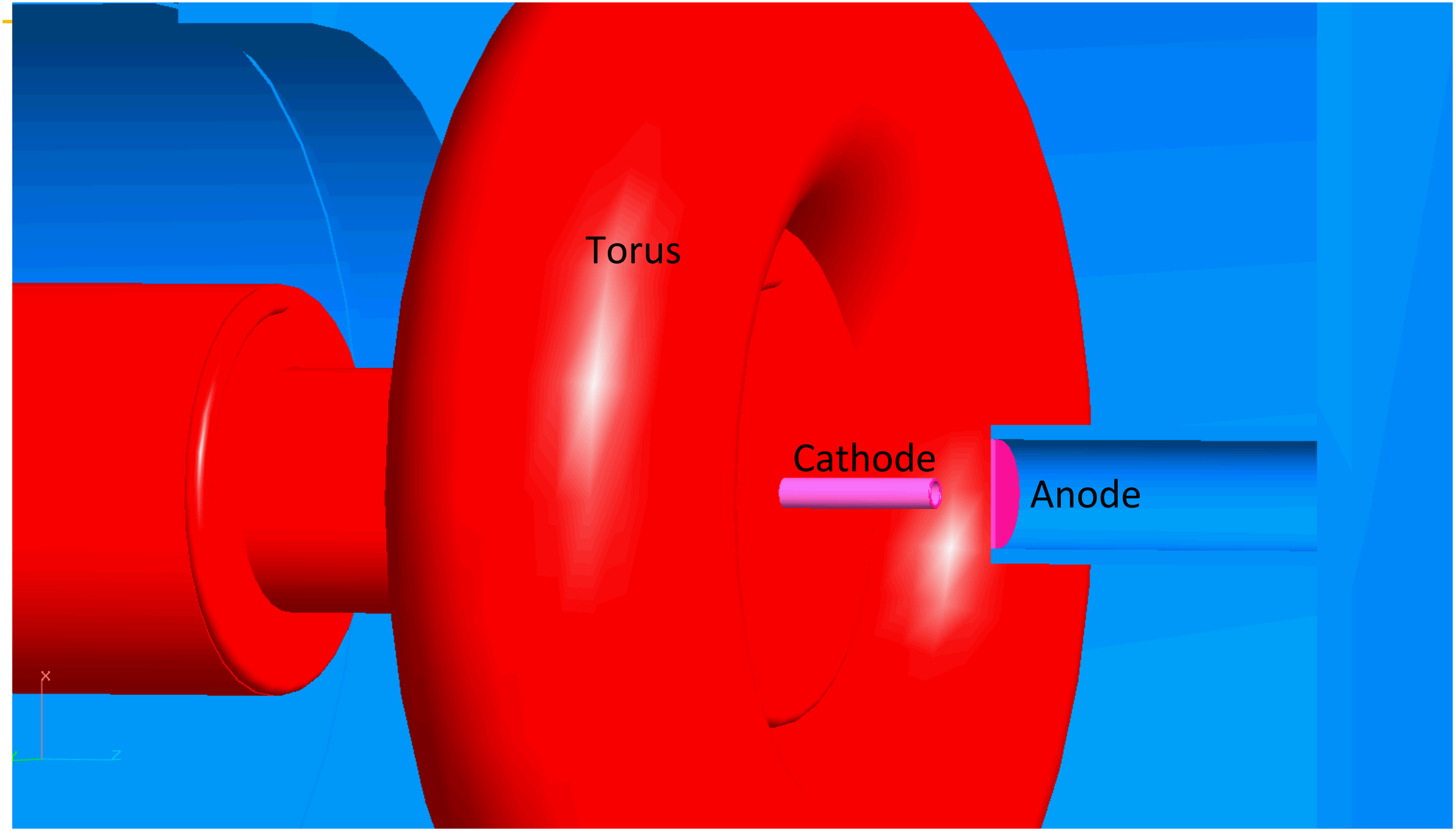
LSP simulations of the SMP diode

- Simulations include some of the MITL, including flow electrons
- Flow shedding region has a dustbin and torus as fielded on Mercury
- Some model parameters are varied in a series of simulations:
  - Torus emission threshold
  - Diode impedance (anode-cathode gap size)
- Heated anode is modeled by varying anode material and ion emission characteristics
- Simulation diagnostics include diode voltage and current, diode ion current fraction, electron distribution at the anode/converter, photon distribution from the converter

Mercury power flow and SMP geometry



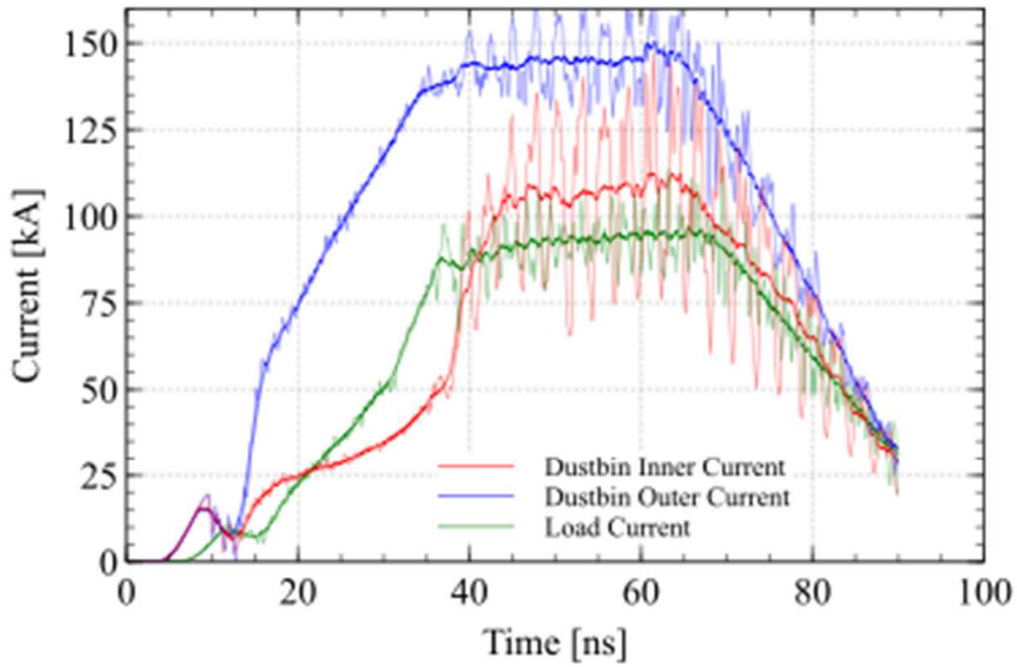
SMP Diode geometry

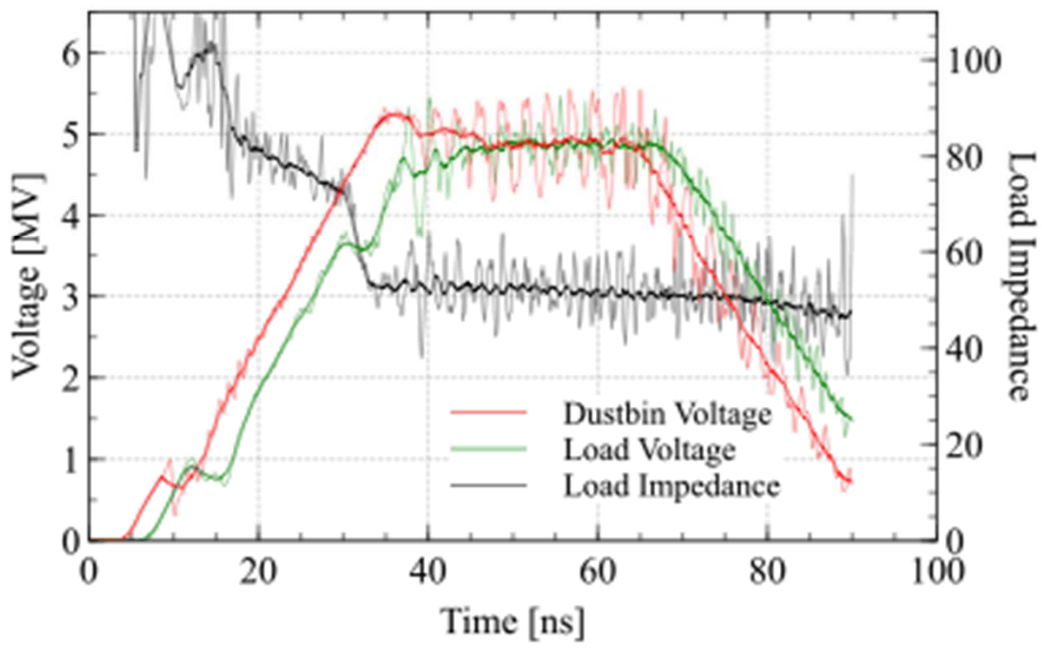


12.5/12 diode shows large-scale current/voltage fluctuations

12.5/12 = 12.5 mm diameter cathode
12 mm A-K gap

- Fluctuations appear in the "dustbin" measurements
- 50 Ohm impedance after pinch

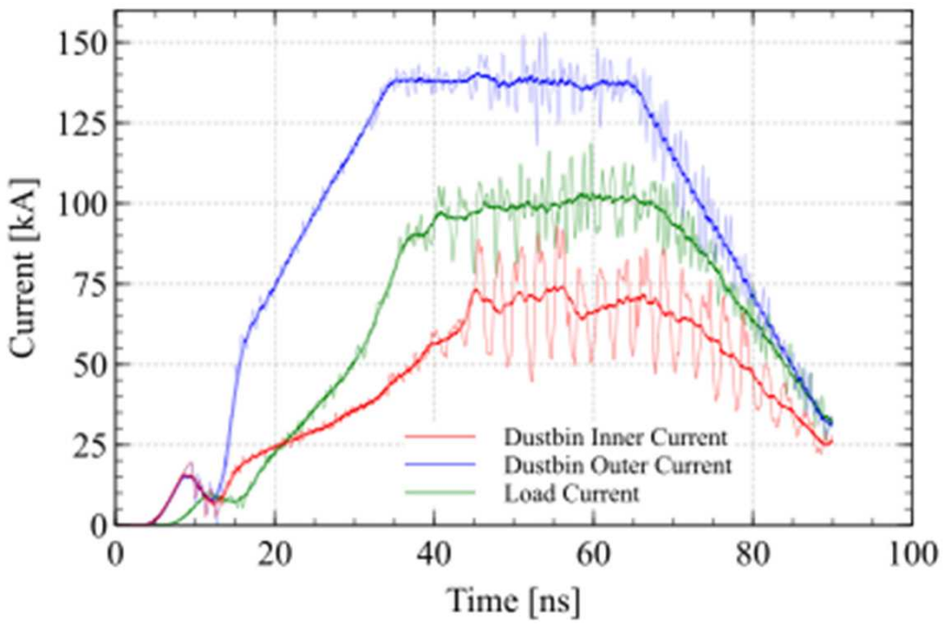


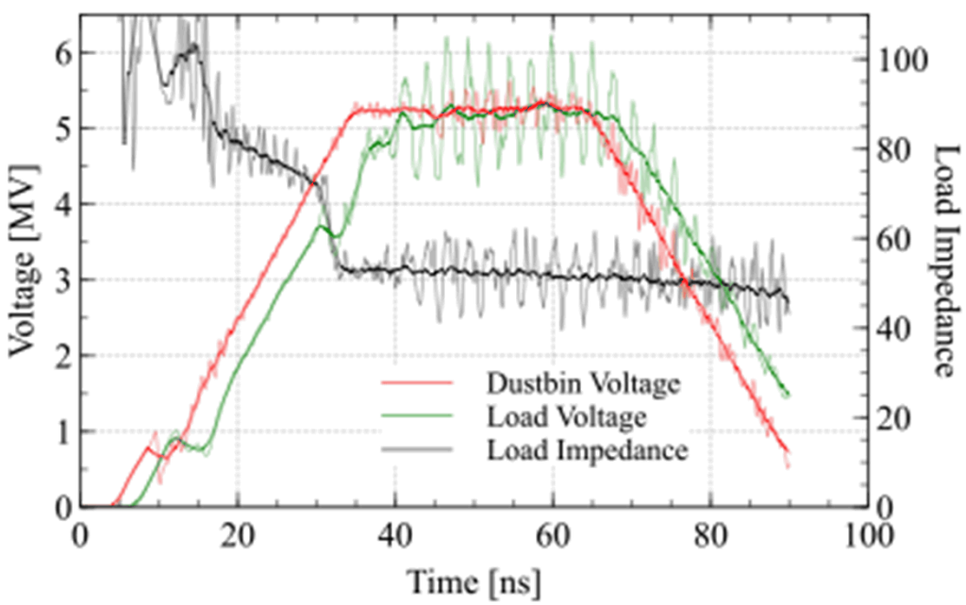


With Torus Emission

12.5/12 diode without torus emission shows larger fluctuation in diode voltage

- Load impedance still about 50 Ohms
- Large fluctuations now appear in the load voltage instead of the dustbin voltage
- Load **current and voltage both higher** compared to case with torus emission

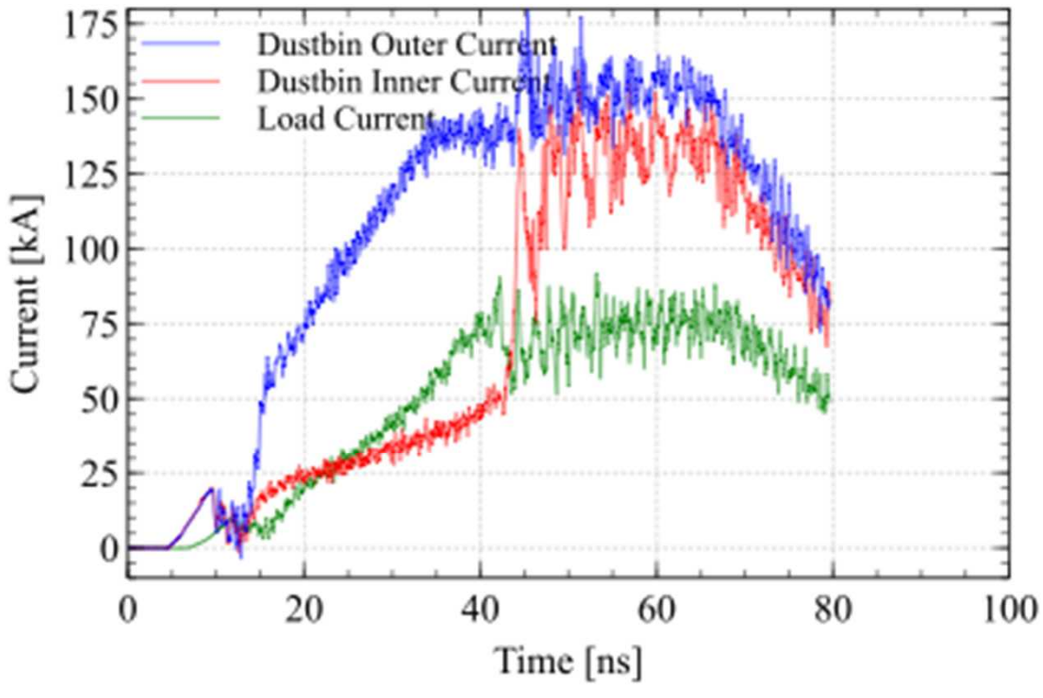


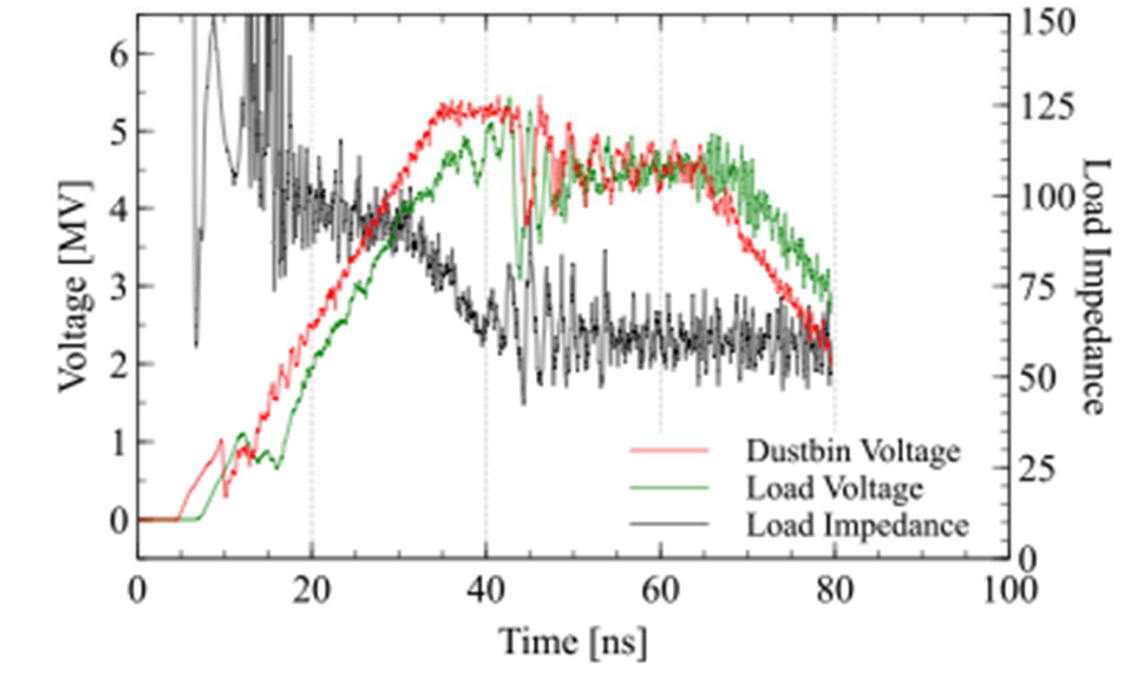


No Torus Emission

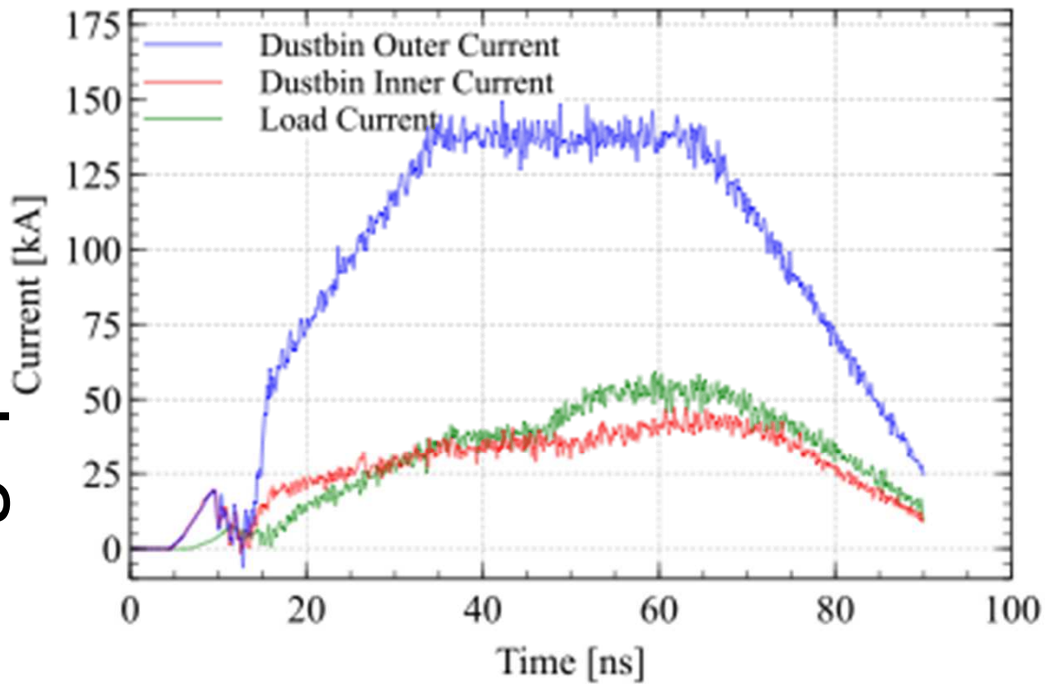
12.5/6 and 12.5/24 diodes show little large-scale fluctuations

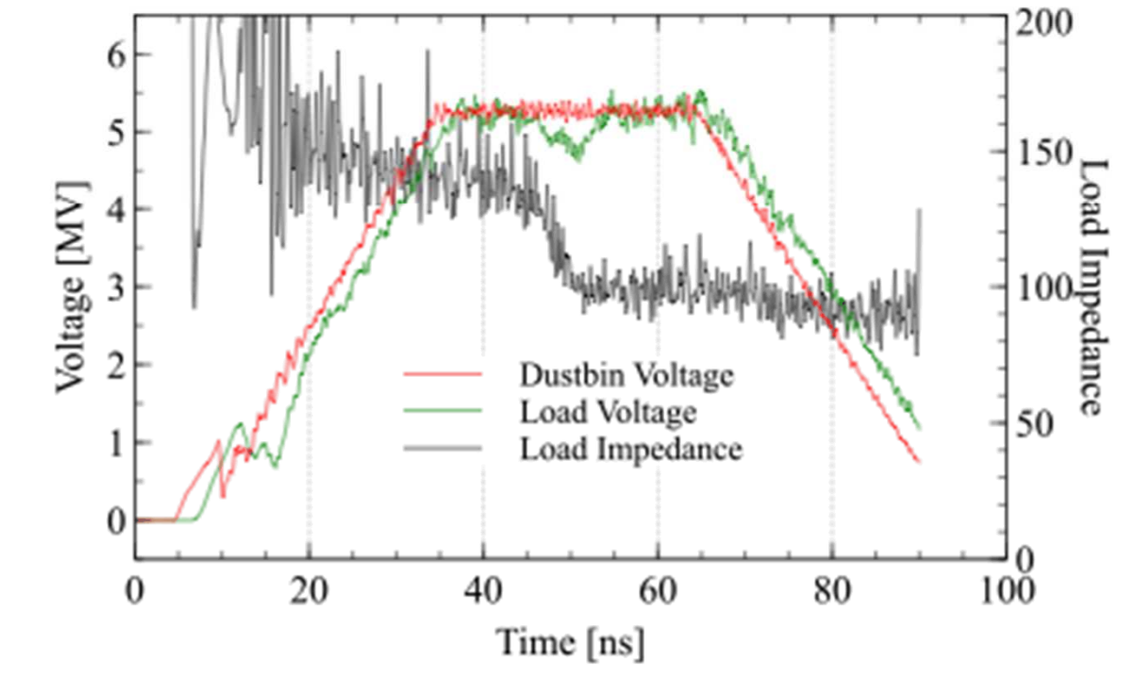
6 mm A-K gap





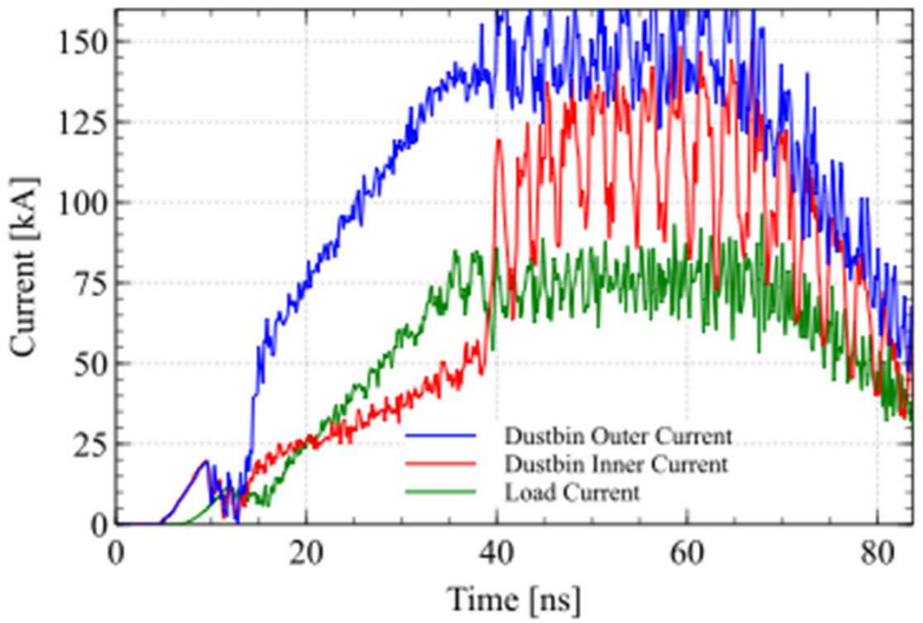
24 mm A-K gap

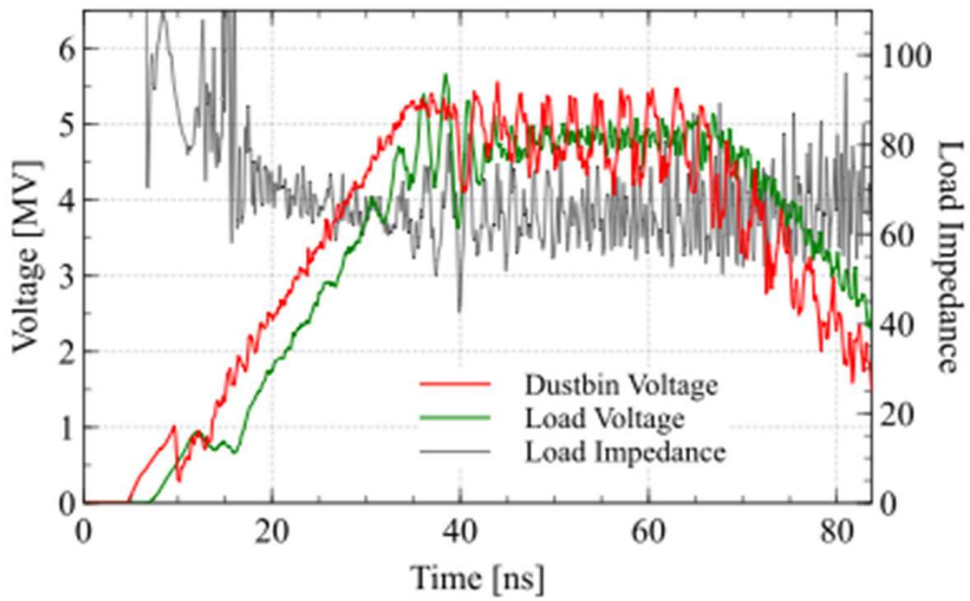




Fluctuations persist in 12.5/10 diode simulation without ions

- Gap closed to maintain impedance even without ions
- Ions in diode were turned off
- Large fluctuations in current/voltage persist
- Could be related to “flowball” electrons upstream of the torus, or cavity mode of the dustbin





No Ions in Diode

Simulations of heated anode focus on diode physics

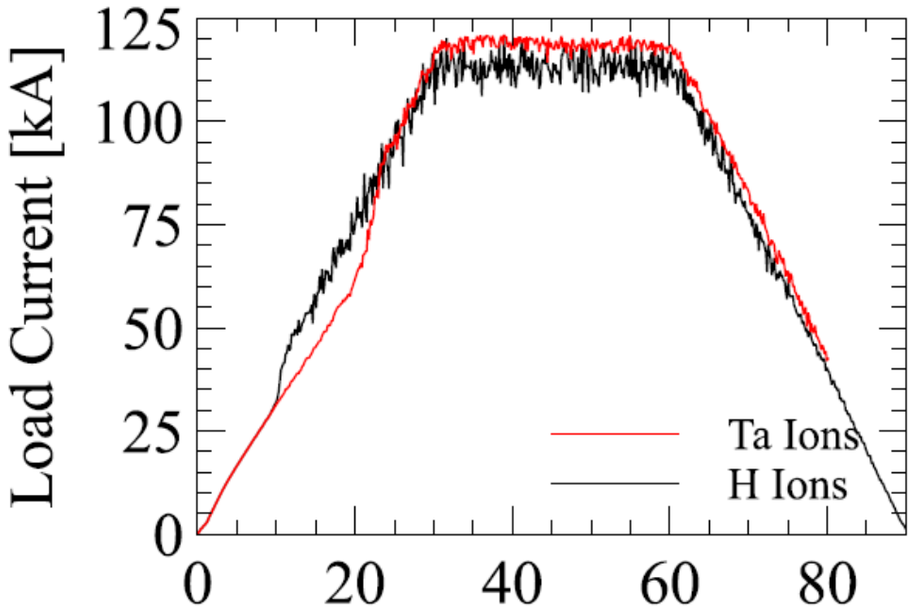
- Geometry modified to allow higher resolution (0.1 mm grid)

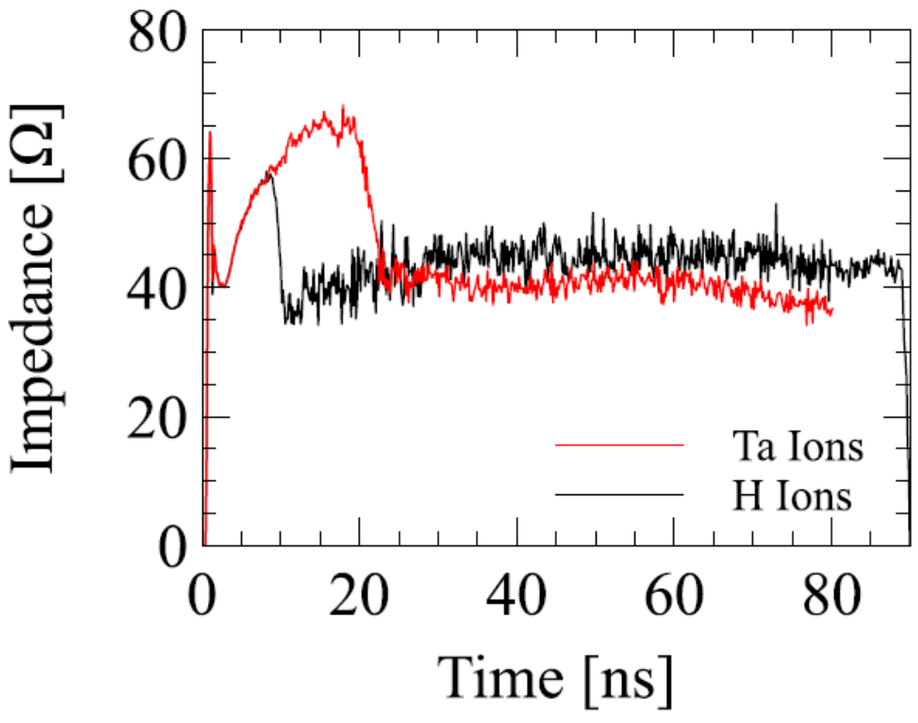
- Parameters of the anode ion emission model are modified to represent the heated anode

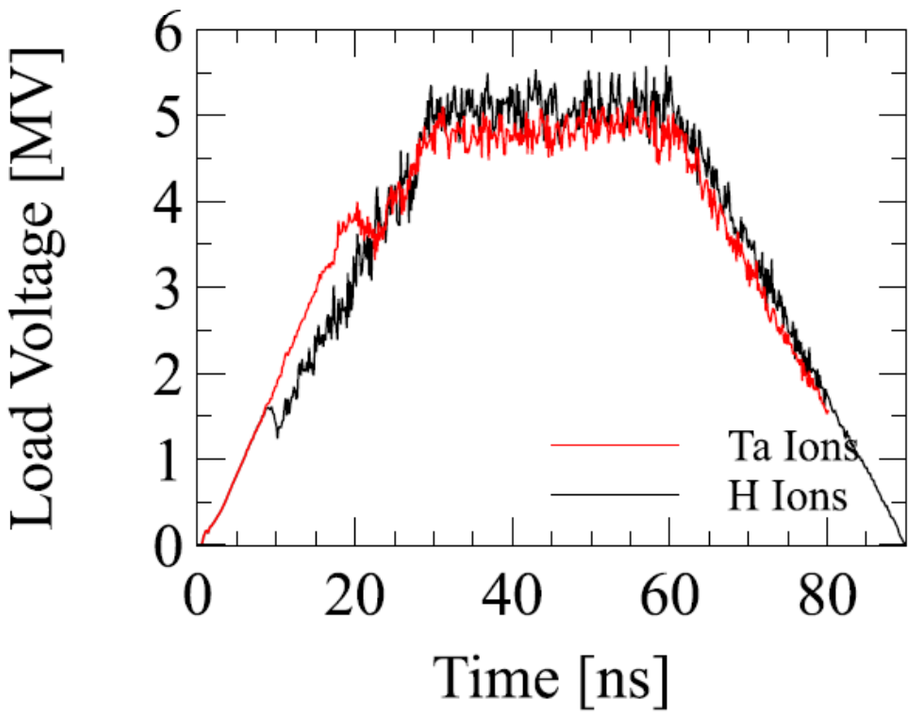
Ion Species	Initial Temperature	Emission Threshold
Hydrogen	300 K	700 K (outgassing)
Tantalum	2500 K	3300 K (Ta Melts)

Current/Voltage traces very similar for both cases

- Pinch occurs slightly later in Ta case
- Impedance slightly different, giving different total current/voltage

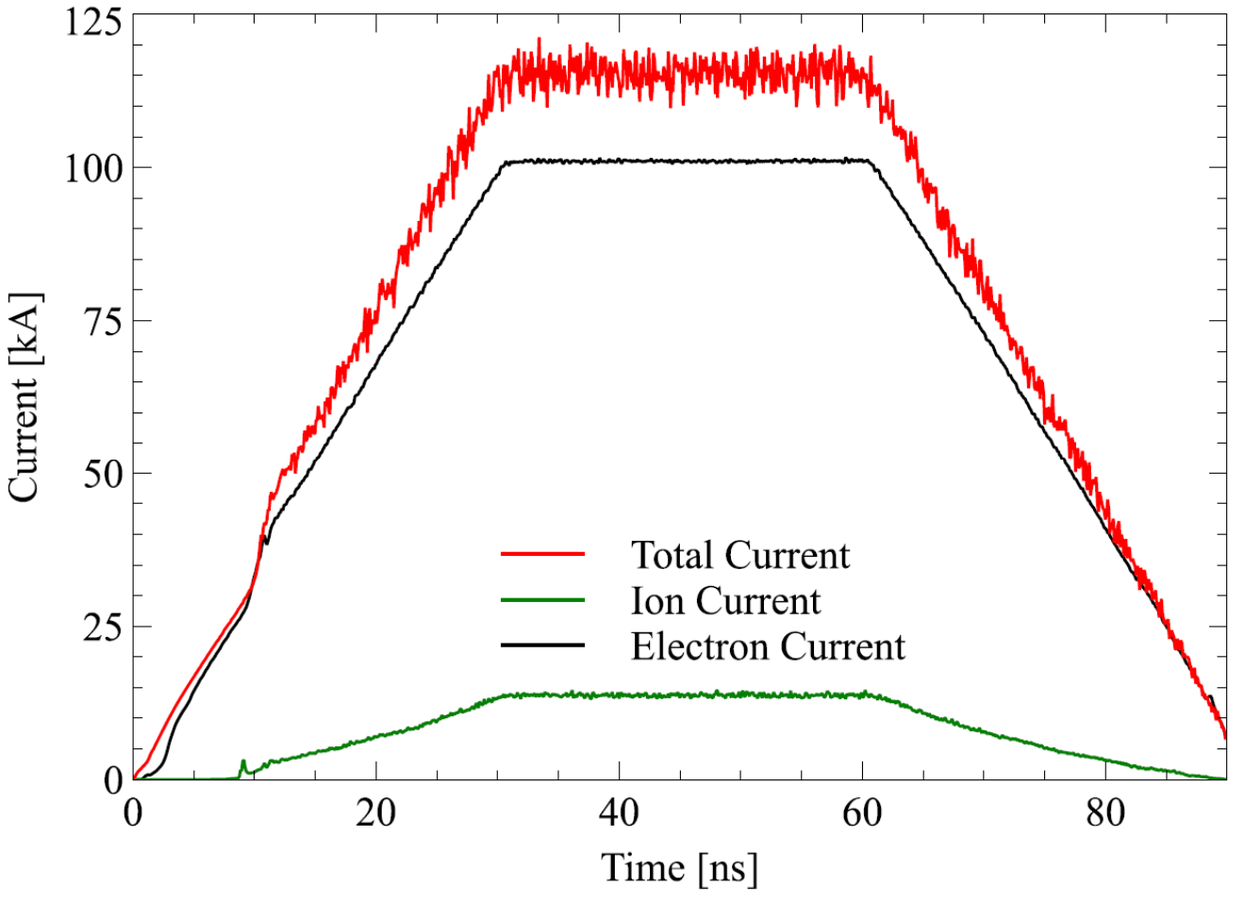




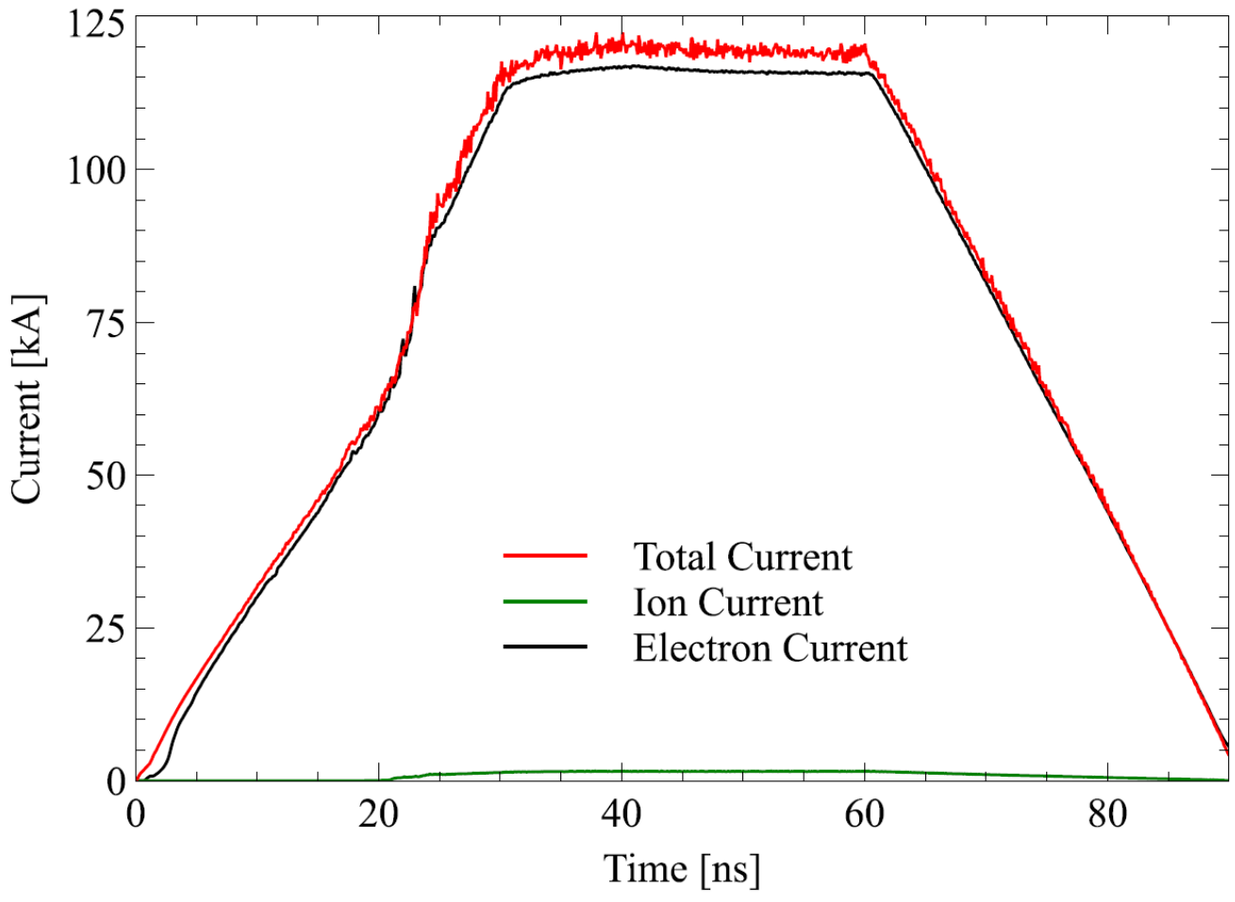


Electron current significantly larger in Ta simulation

Hydrogen Ions, I_H ~15%

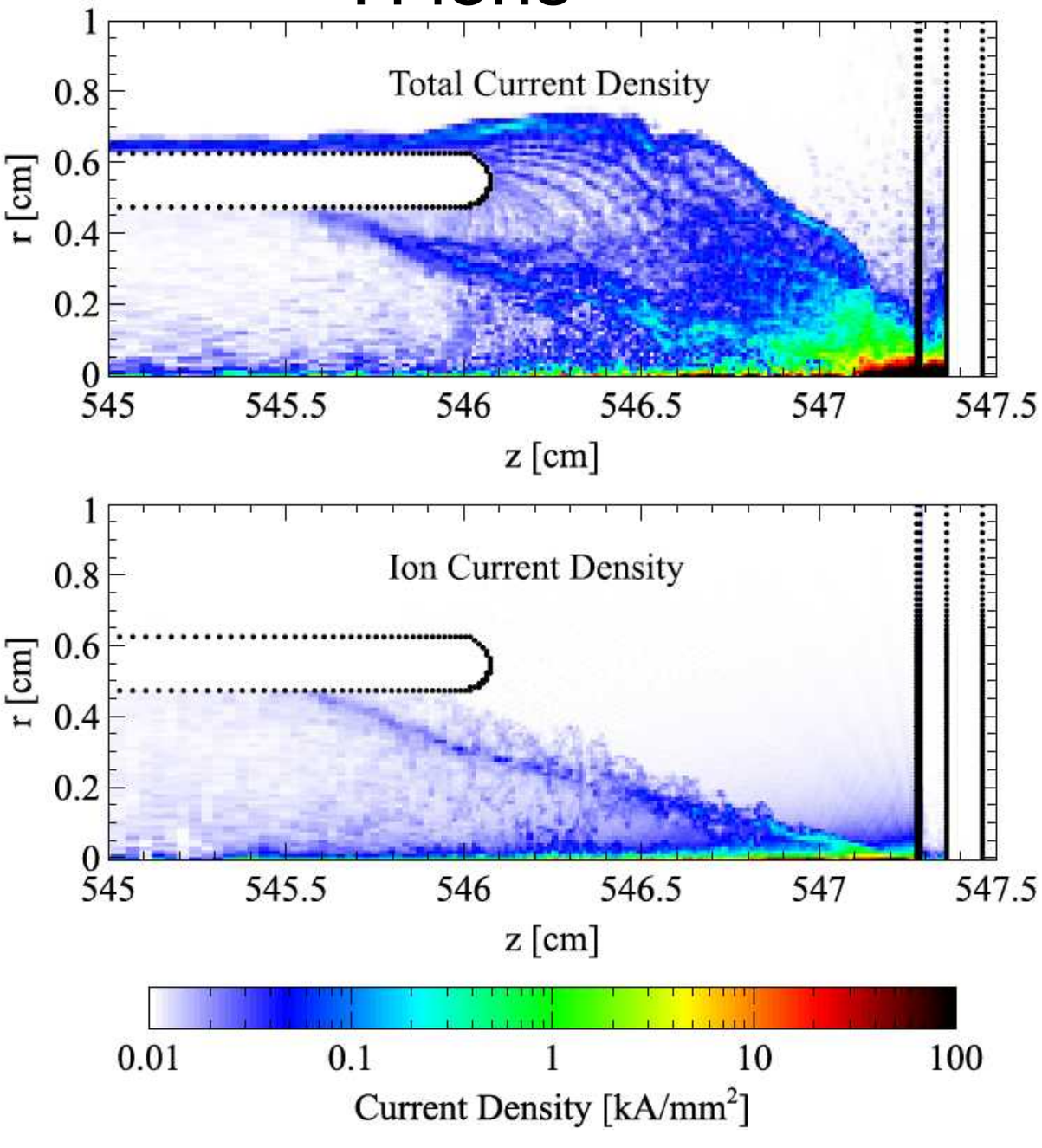


Tantalum Ions, I_{Ta} ~1.5%

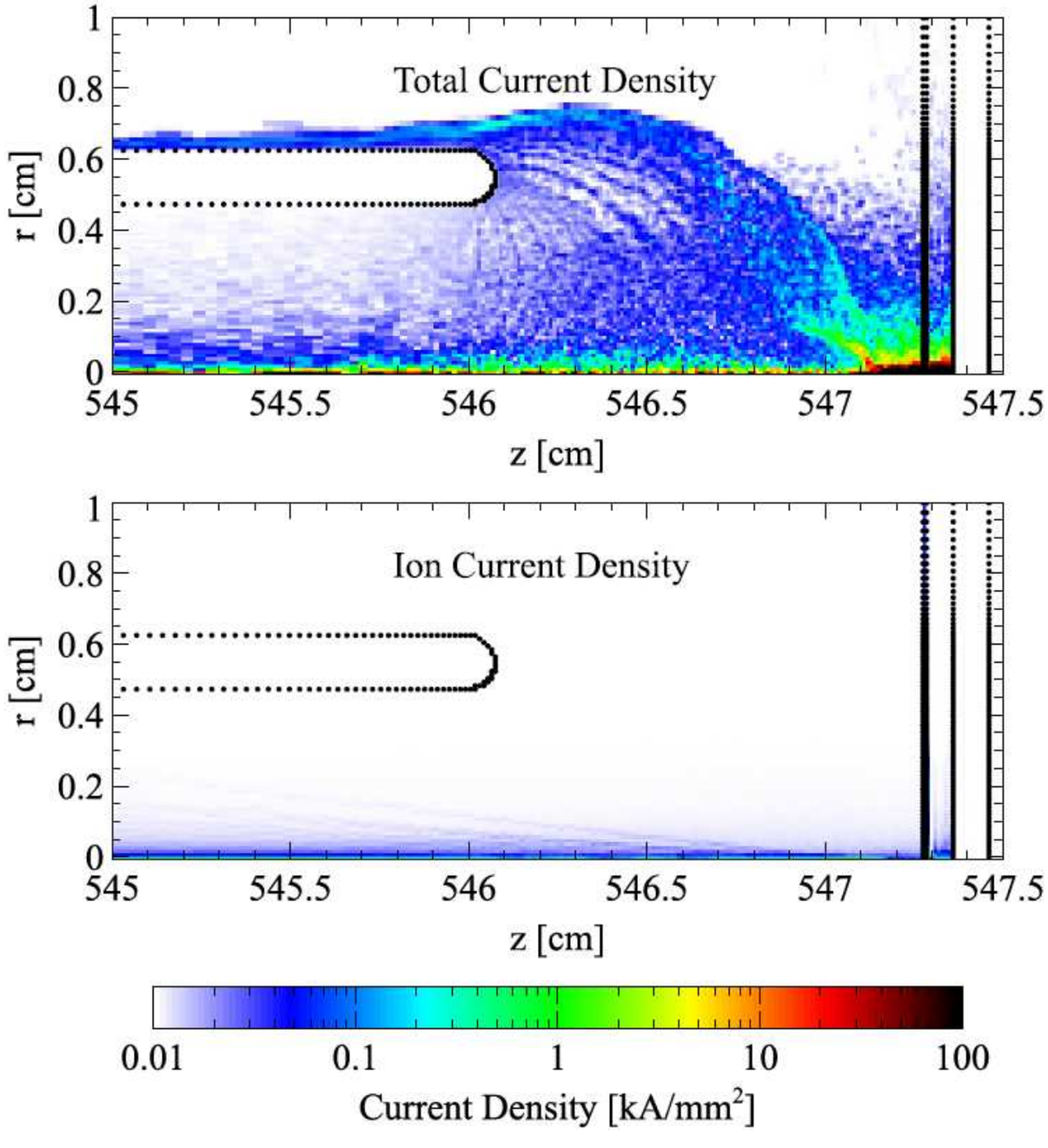


Comparison of current density at t=40 ns

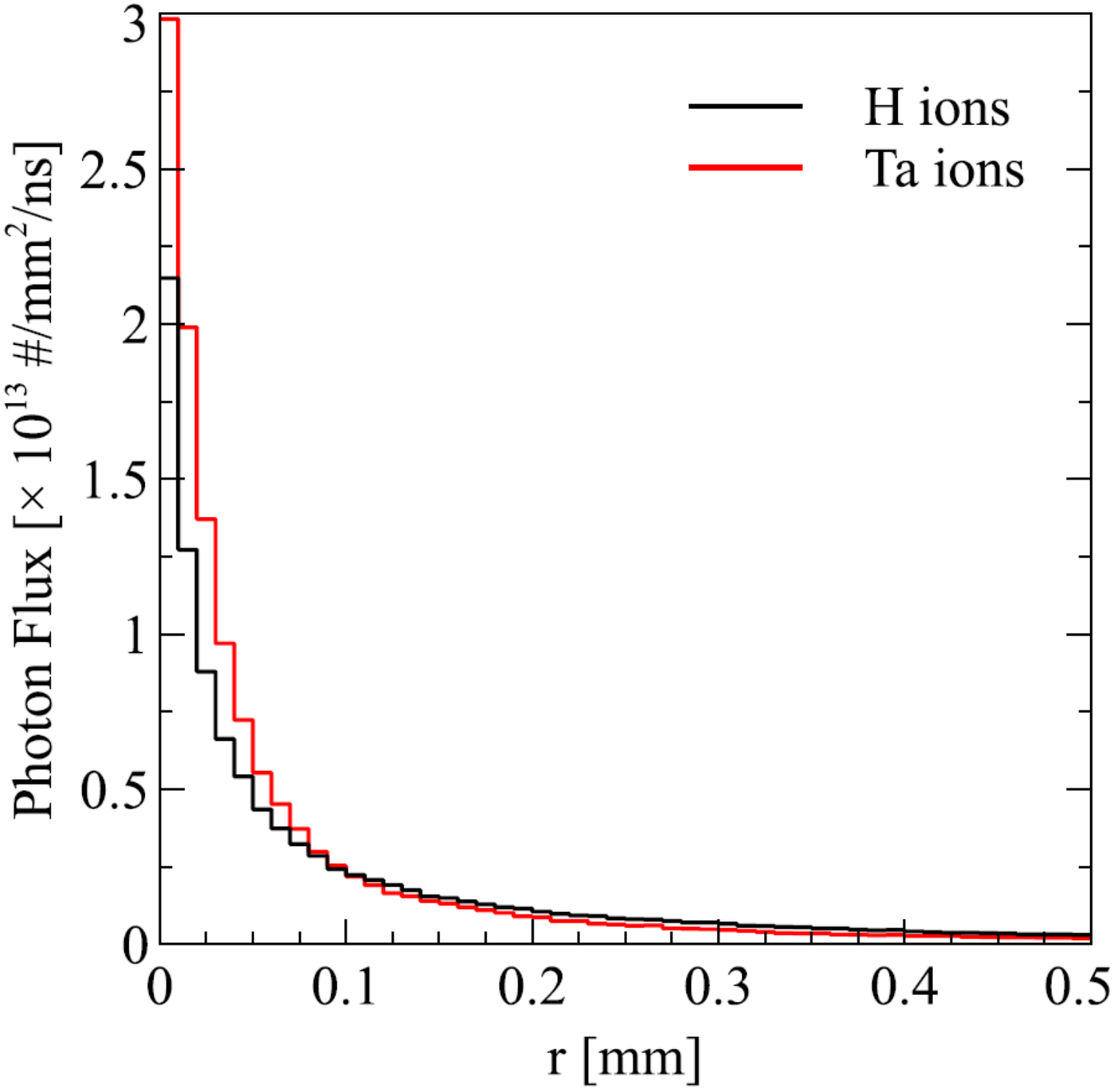
H ions



Ta ions



The spot size is smaller with Ta ions



Conclusion

- Bad things happen when the knob emits.
- Large-scale oscillation not due to diode instability. Likely due to retrapping wave and/or cavity oscillations in the dustbin
- Ta ion simulations shows the beam still pinches
- Spot size is smaller with Ta ions.