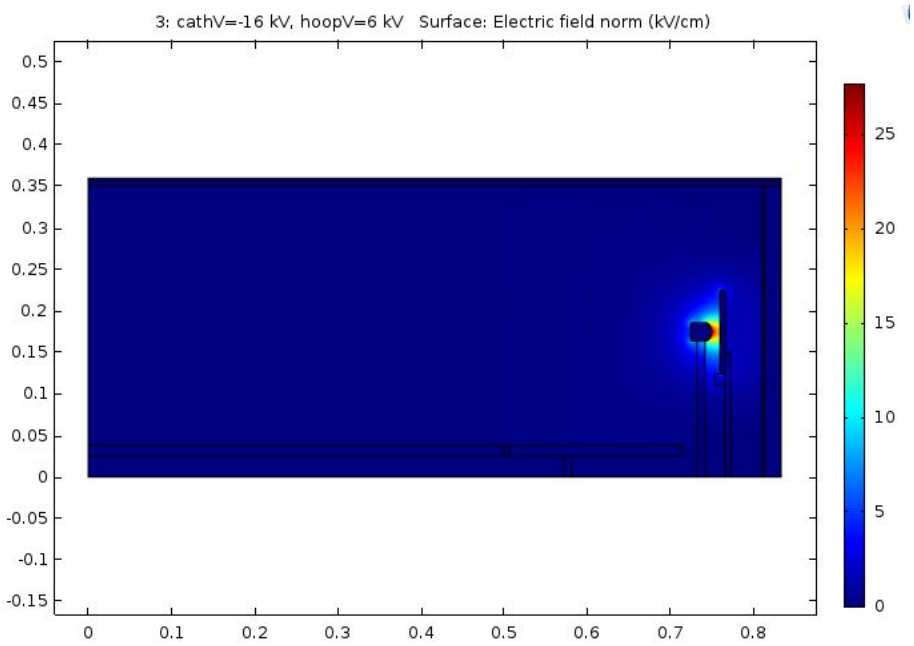
Cathode ring tests

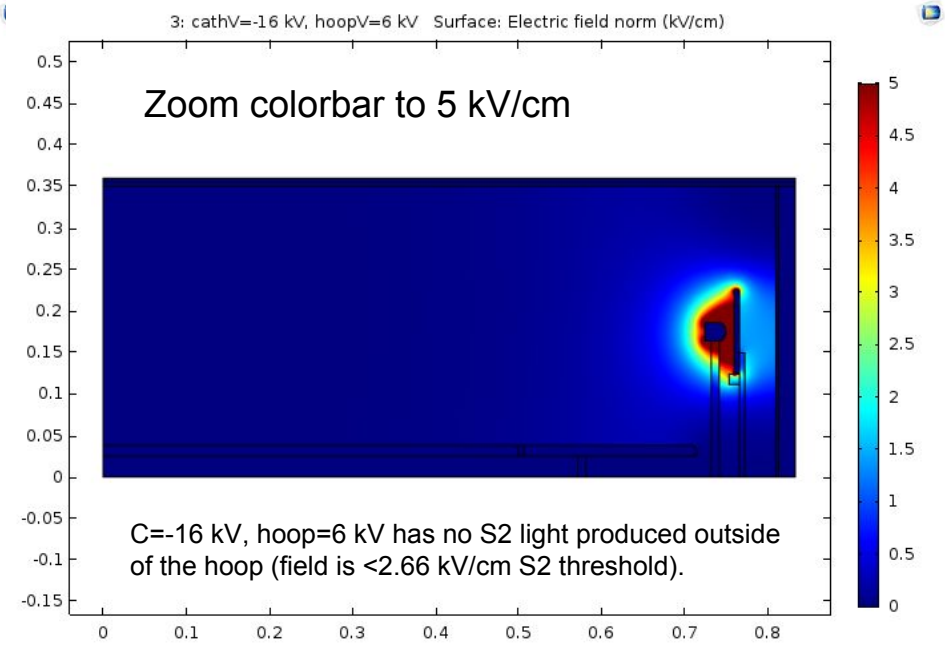
31 July 2017

Cathode ring tests: Introduction

- Testing cathode ring alone (without wires) requires:
  - Cathode ring raised and located at z ≈ center of detector = 17.5 cm above vessel floor = dim3
  - Bottom reflector plate near bottom of chamber (~1 in off vessel bottom) and @ 0V.
  - Field hoop (surface to provide high fields on outside of cathode ring) added to chamber
    - Cylindrical hoop: Pro = Easy to manufacture, Con = Not great for optical properties
    - Oval cross-section hoop: Pro = Easy to avoid sharp edges, Con = Too close to wall
  - Supporting cathode ring and field hoop by PTFE
    - Assume a rod bolted to back of the hoop, but this may not be ideal final design
    - Assume a PTFE rod supports the hoop with a shelf beneath it (engineering can iterate on this design as structural support is most important)

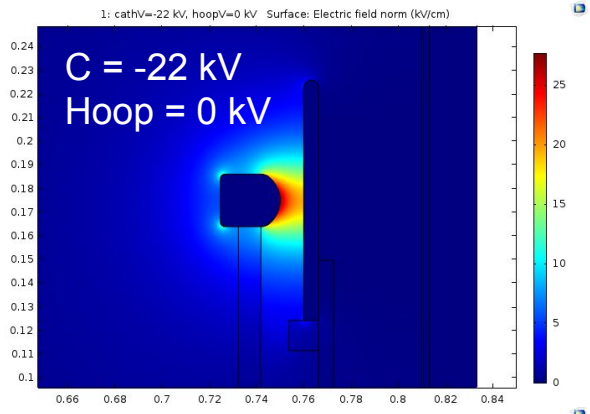
Full-scale view of vessel for cathode ring test

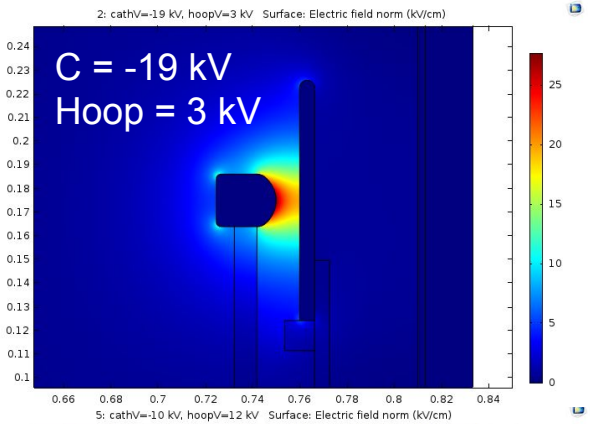


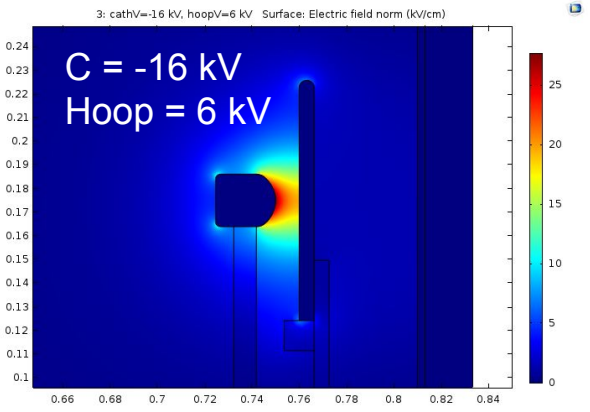


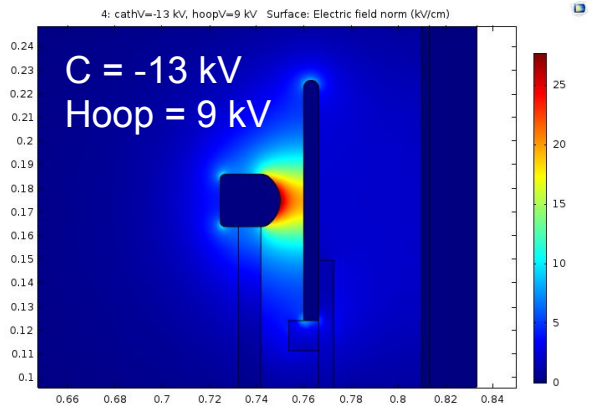
(above) Full-scale view of vessel with cathode ring at 17.5 cm (centered on wire plane). The field hoop is ¼" thick SS sheet which is 4" long with the top 2 corners evenly rounded (fillet radius = ⅛"). Field hoop and cathode ring supported by PTFE with an added PTFE shelf for the field hoop. The bottom reflector plate is grounded with a 1" tall spacer below it.

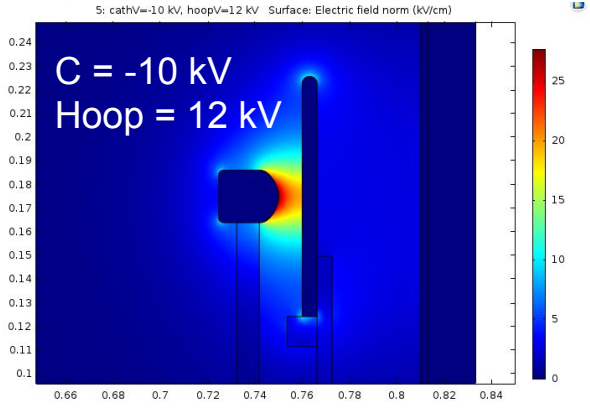
Varying voltage configurations, 1 cm gap, ¼” thick







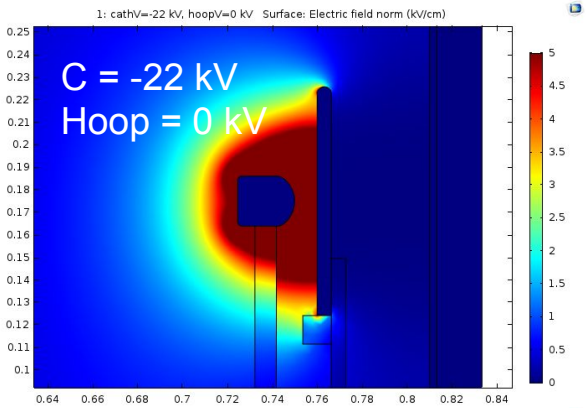


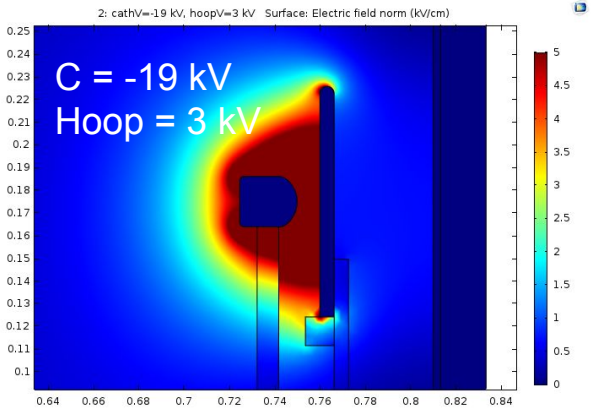


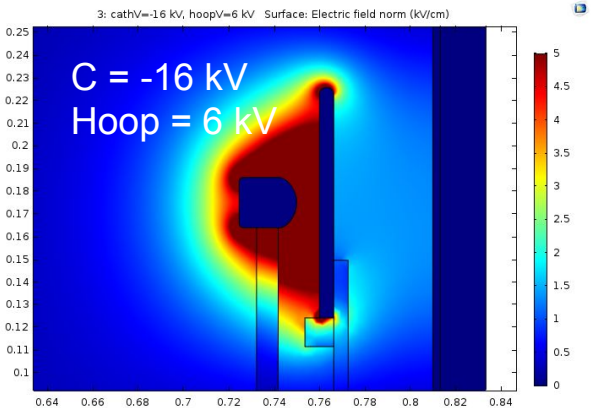
The field in the region between the hoop and reflector wall increases.

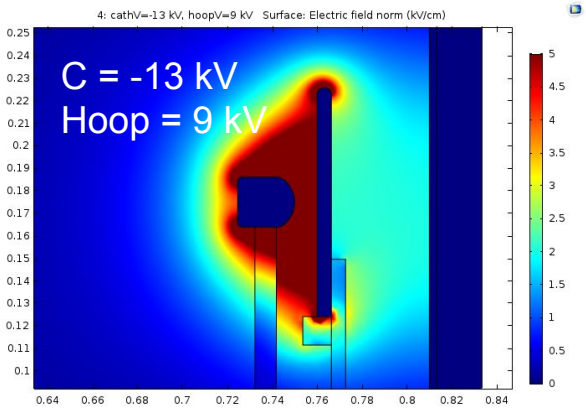
The field on the edges of the 4” high hoop increases.

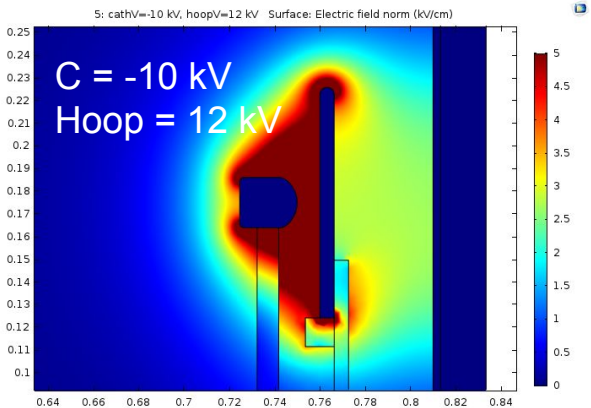
Varying voltage configurations, 1 cm gap, ¼” thick, zoom to 5 kV/cm







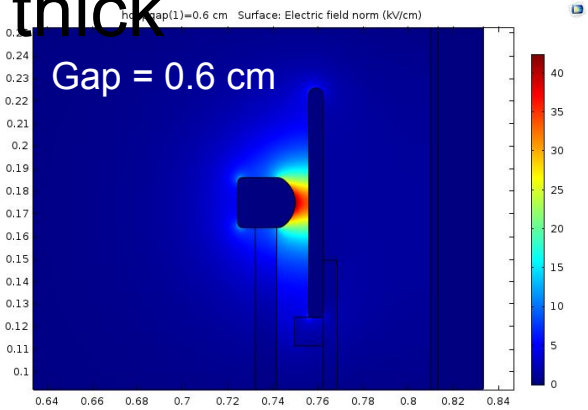


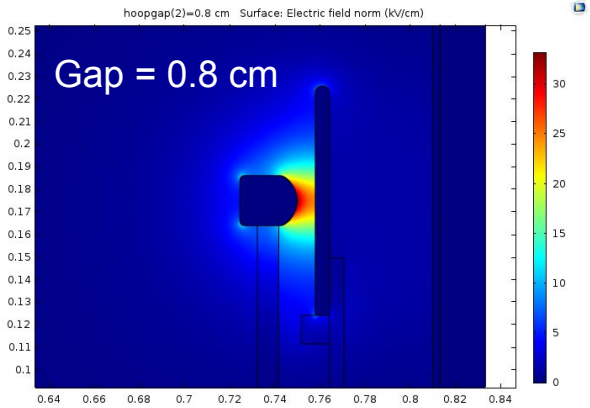


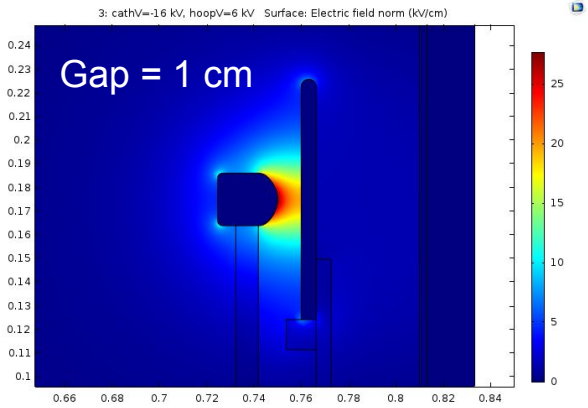
The field in the region between the hoop and reflector wall increases.

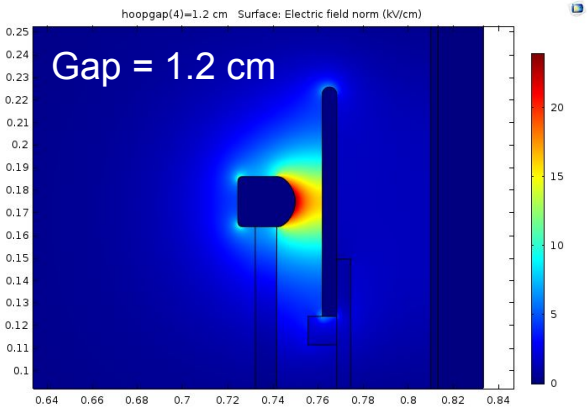
The field on the edges of the 4” high hoop increases.

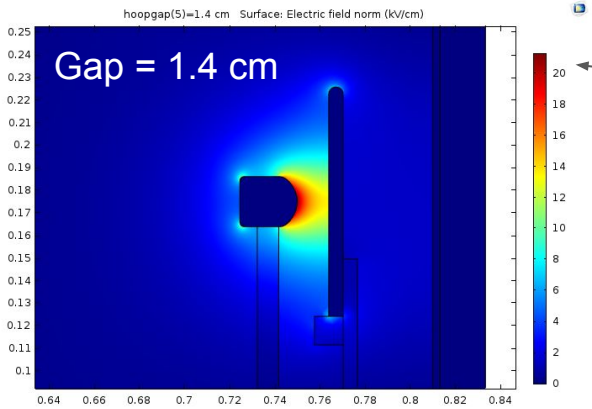
Varying gap length, C = -16 kV, hoop = 6 kV, ¼" thick







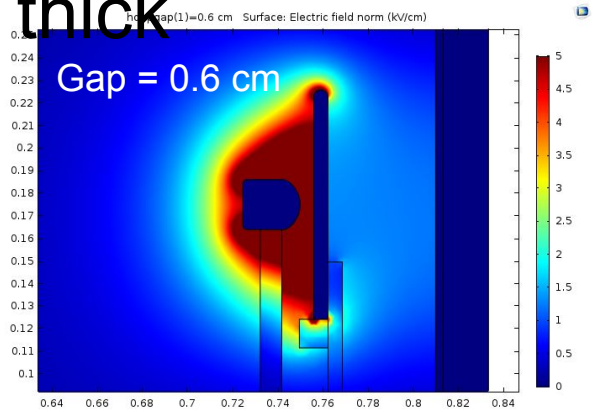


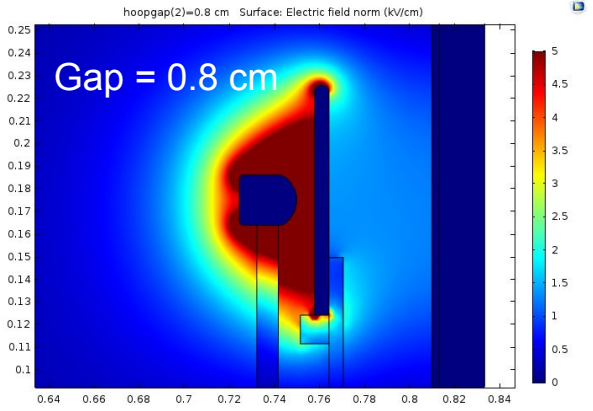


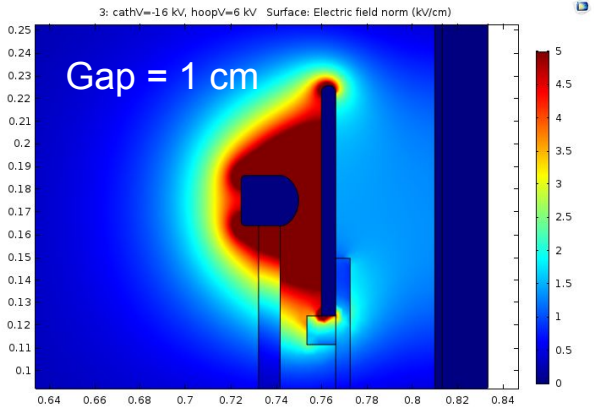
Need to increase the voltages for this large gap to attain 26.4 kV/cm!

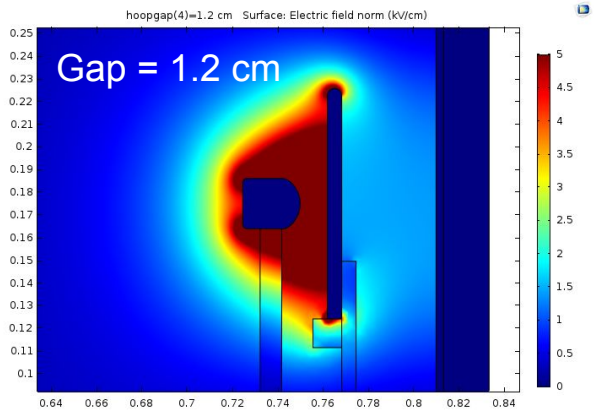
Colorbars rescale for each plot to the maximum field!

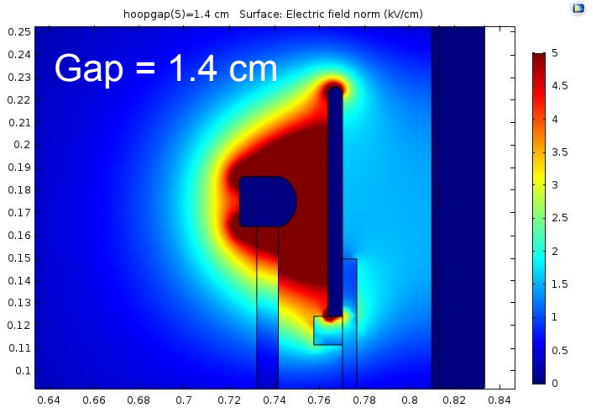
Varying gap length, C = -16 kV, hoop = 6 kV, ¼” thick





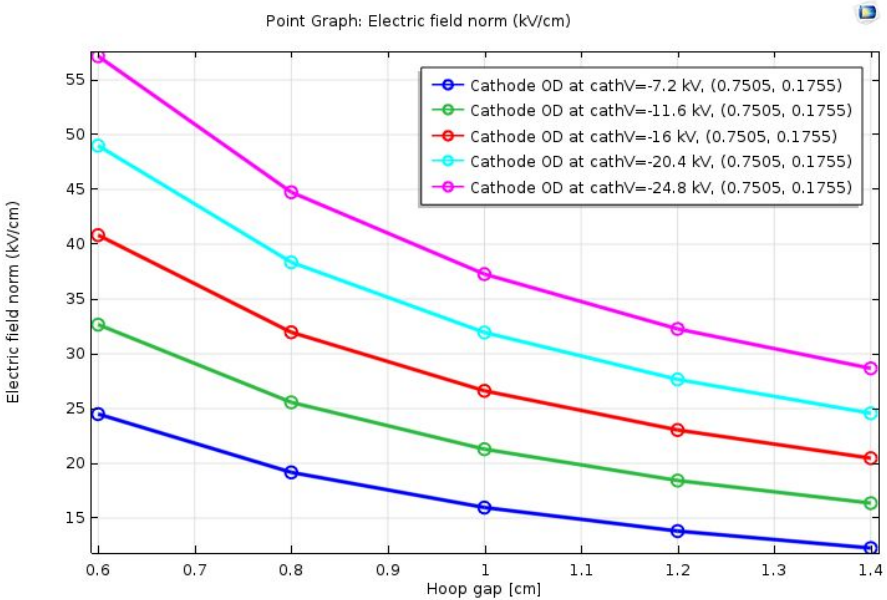




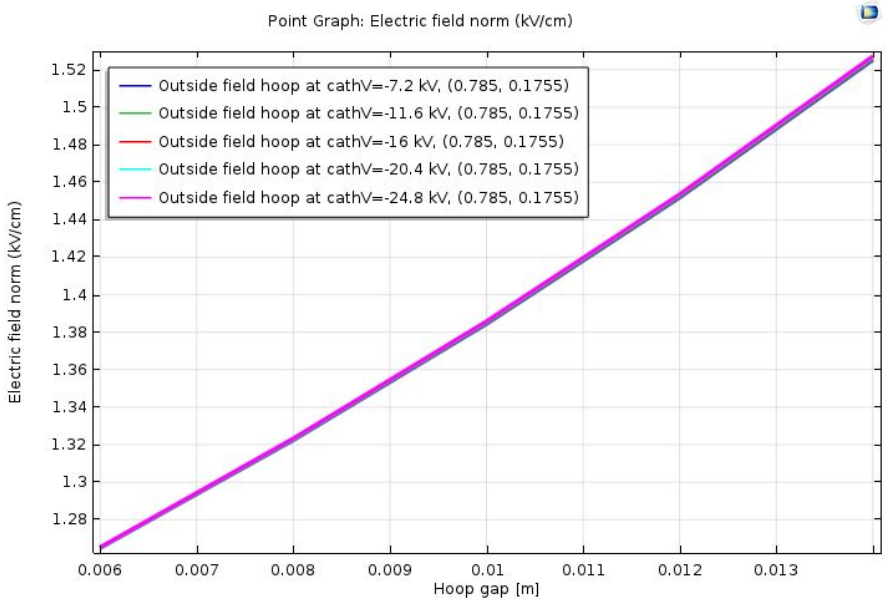


Colorbars scaled to 5 kV/cm

Electric fields measured at critical locations for 6kV on the hoop



Electric field measured at the cathode OD at various cathode voltages for a variety of hoop gaps. Need to test to 26.4 kV/cm to test 20% over the 22 kV/cm field at -100 kV on the cathode calculated by W. Waldron.



Electric field measured outside the field hoop before the reflector wall at various cathode voltages and hoop gaps. This needs to be <2.66 kV/cm which is the S2 threshold for the planned pressure in the vessel of 3.1 bar at room temperature.

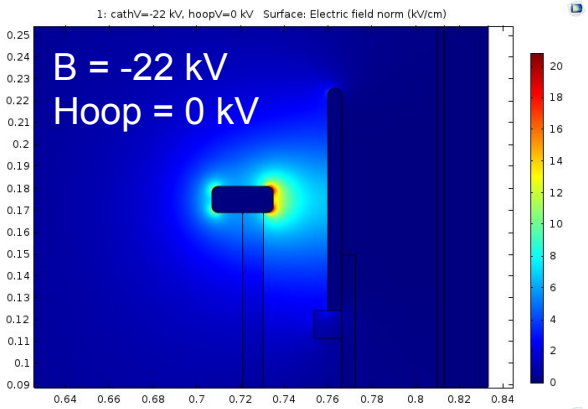
Conclusion: Cathode ring test

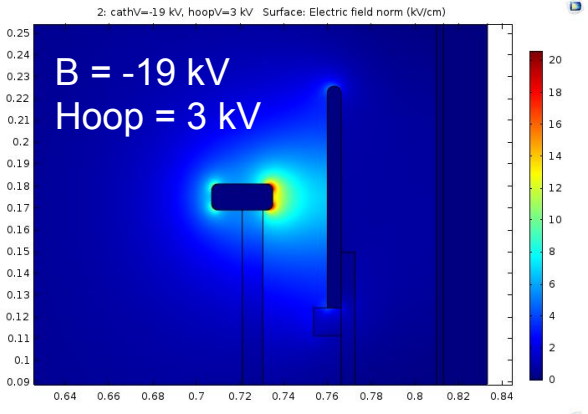
- All voltage configurations preclude using the LUX feedthroughs which are rated to 10 kV only
- Using something like **cathode = -16 kV, field hoop = 6 kV** keeps the fields outside of the gap between the ring and hoop below the S2 threshold
- A gap of **1 cm** seems reasonable
- Field hoop is ¼” thick SS, 4” tall. Top edges are rounded (radius = ¼”), but the bottom edges are not as they sit flush on the PTFE “shelf”

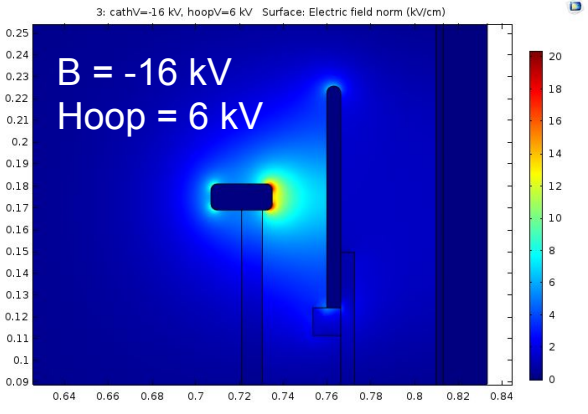
Bottom ring test

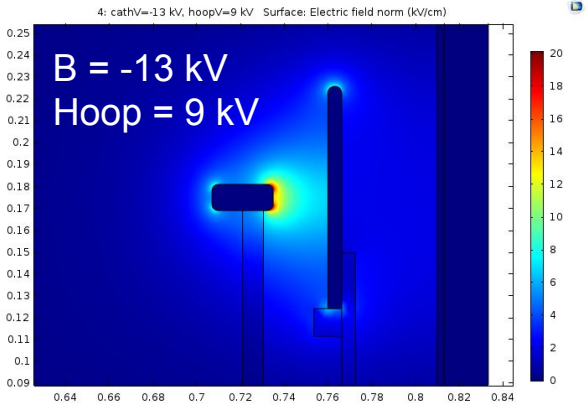
- This is listed as a “desired” test, but is not a priority
  - Bottom ring is one of the earliest delivered, but is unlikely to create high fields
    - Will Waldron didn’t include an electric field map for the bottom grid ring in note. It’s also significantly different from the gate ring, so will not be a test of the gate’s electric fields.
- A bottom ring test will not drive the design of the field hoop
  - Assume radial and vertical locations of the field hoop for the cathode test *does not change*
    - Radial = cathode OD + 1 cm

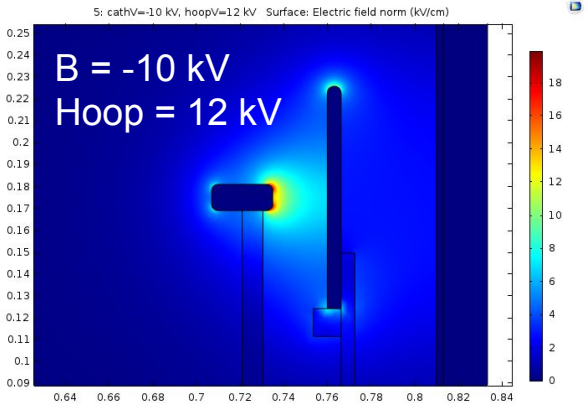
Bottom grid ring, Hoop is ¼” thick with 1 cm gap to cathode







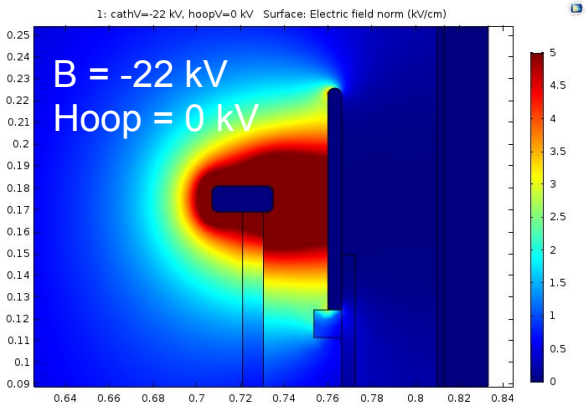


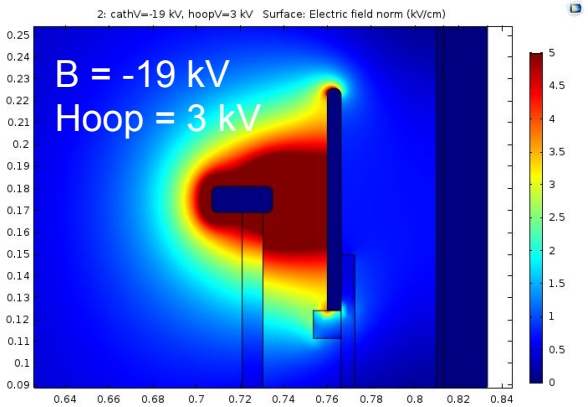


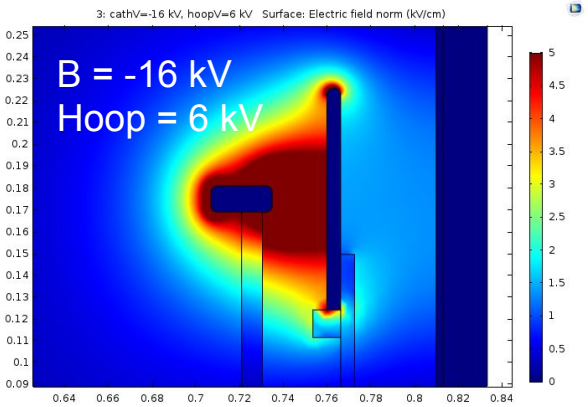
The field in the region between the hoop and reflector wall increases.

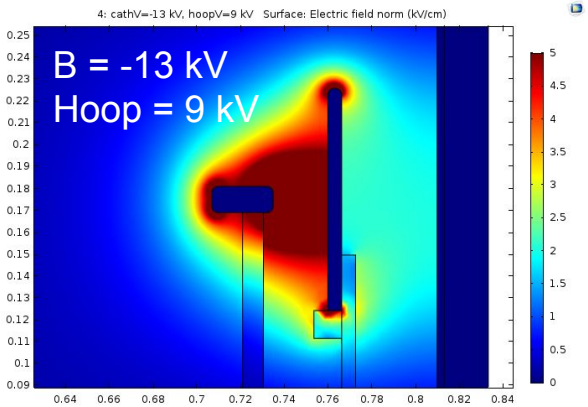
The field on the edges of the 4” high hoop increases.

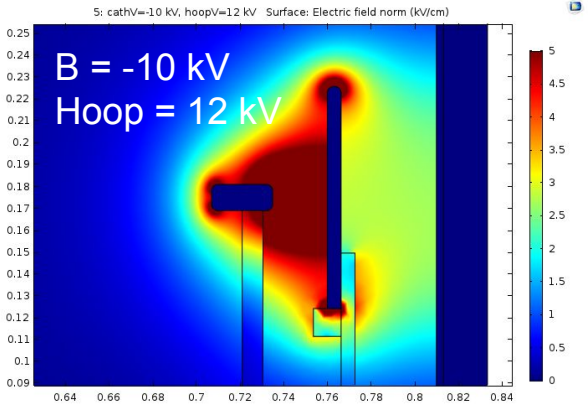
Bottom grid ring, Hoop is ¼” thick with 1 cm gap to cathode











The field in the region between the hoop and reflector wall increases.

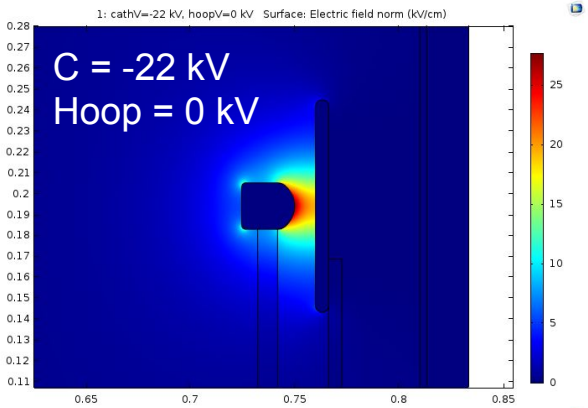
The field on the edges of the 4” high hoop increases.

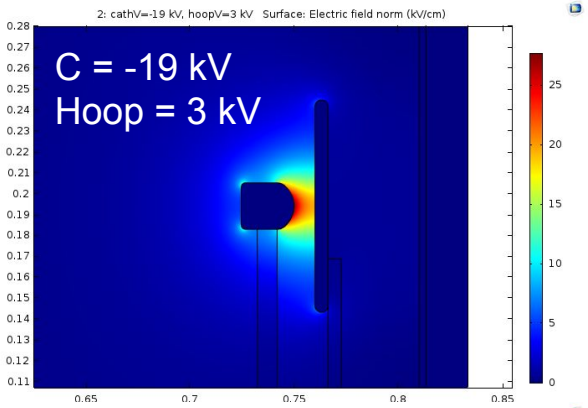
Conclusion: Bottom ring test

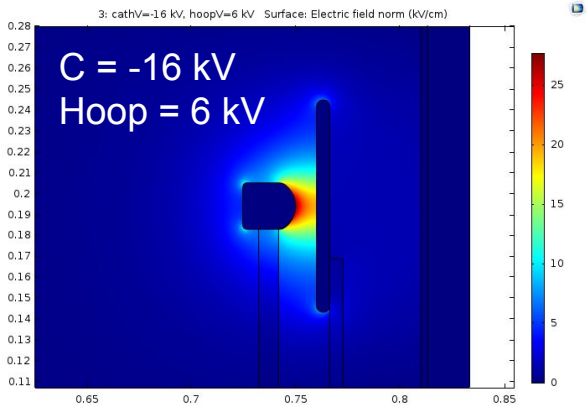
- Not sure what field we are testing with this
- The field hoop dimensions and location chosen for the cathode are sufficient to attain ~20 kV/cm on the corners of the bottom ring with the same voltage configurations tried for the cathode
    - Can easily change these voltages, but am not sure what motivates this test.

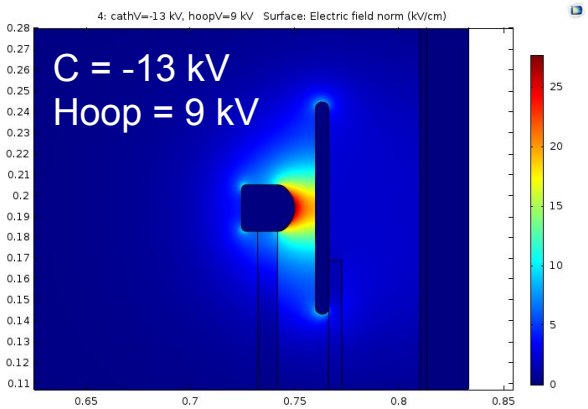
Following slides have ring too high
(above the vessel center which isn't necessary)

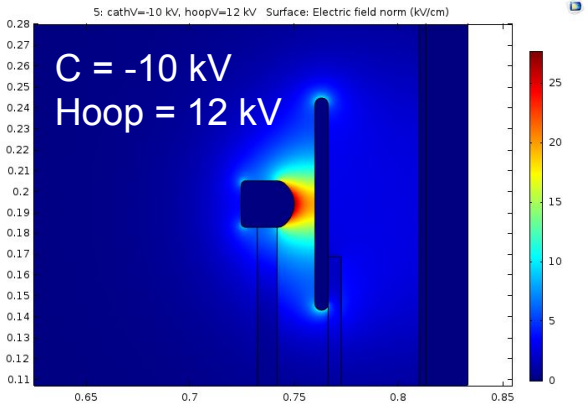
Varying voltage configurations, 1 cm gap, ¼” thick











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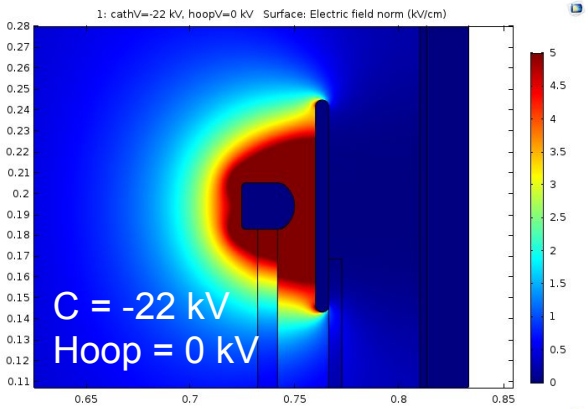
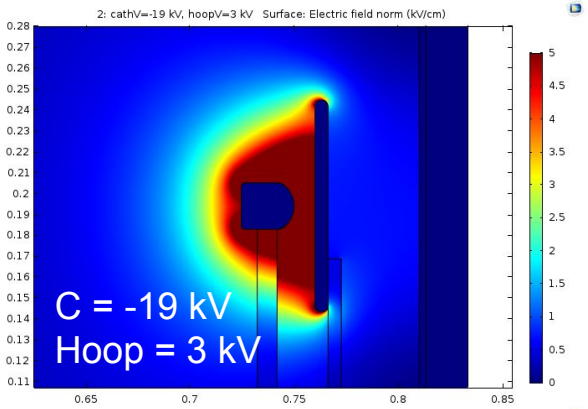
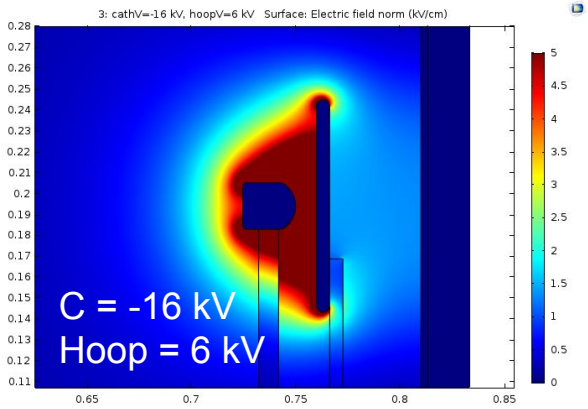
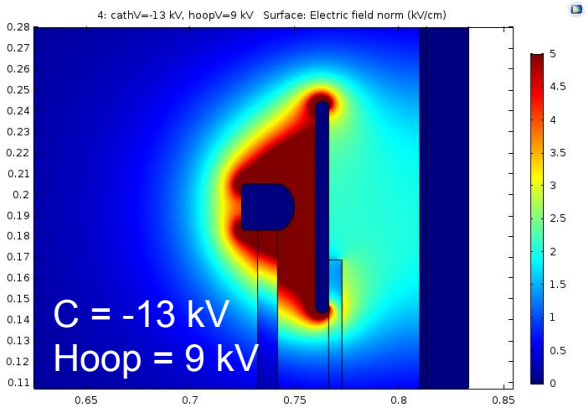
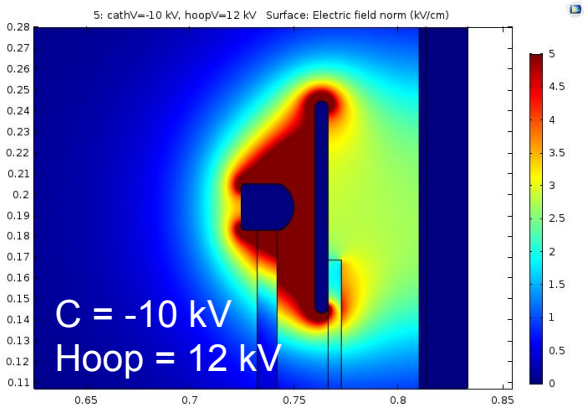
Varying voltage configurations, 1 cm gap, ¼” thick, zoom to 5 kV/cm







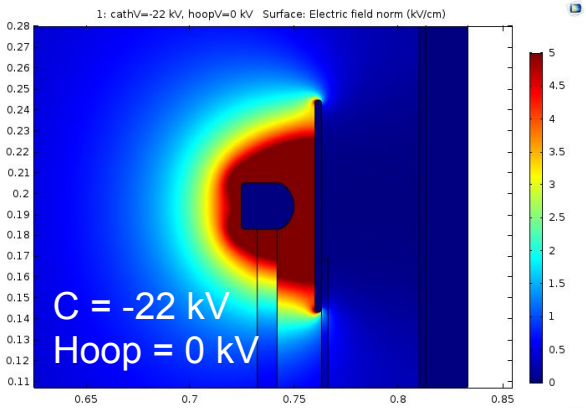


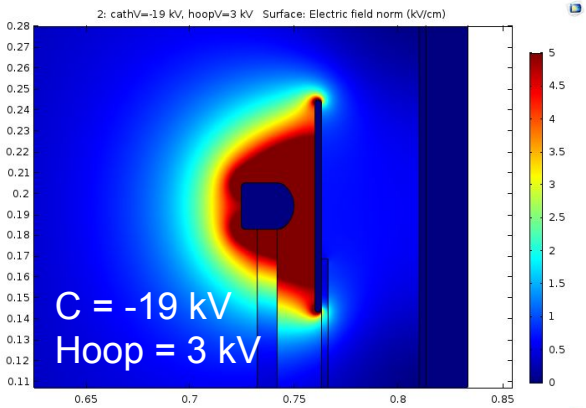


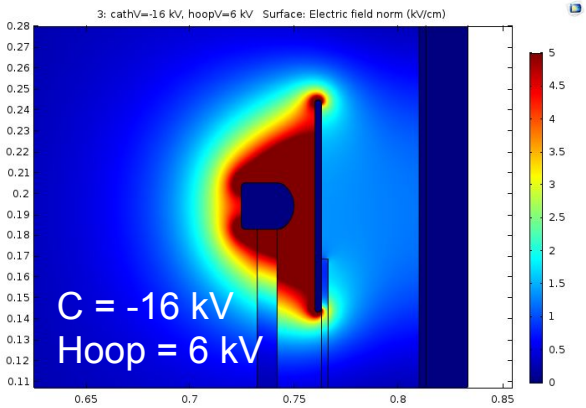
S2 threshold is ~2.66 kV/cm

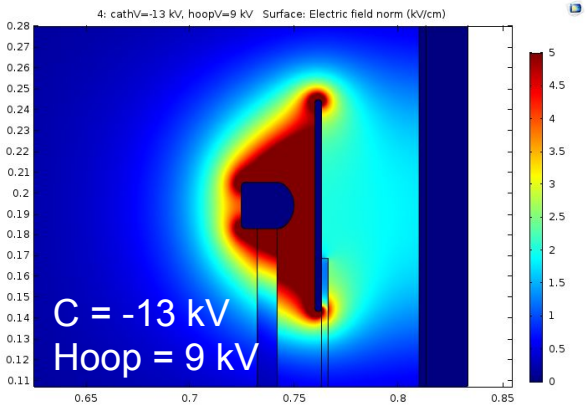
Reach this threshold near the C=-10 kV, hoop=12 kV.

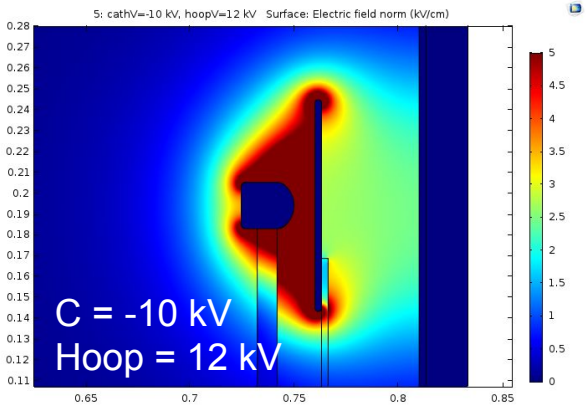
Varying voltage configurations, 1 cm gap, 1/8” thick, zoom to 5 kV/cm









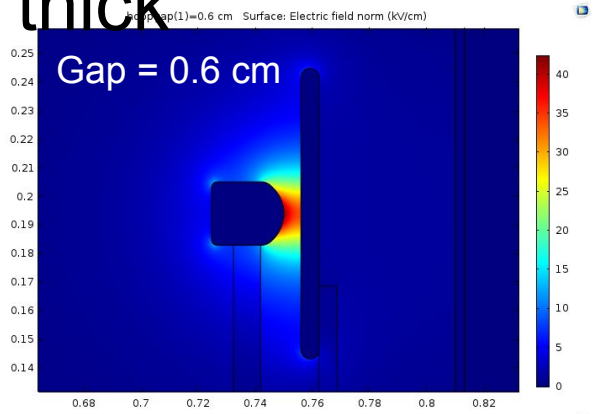


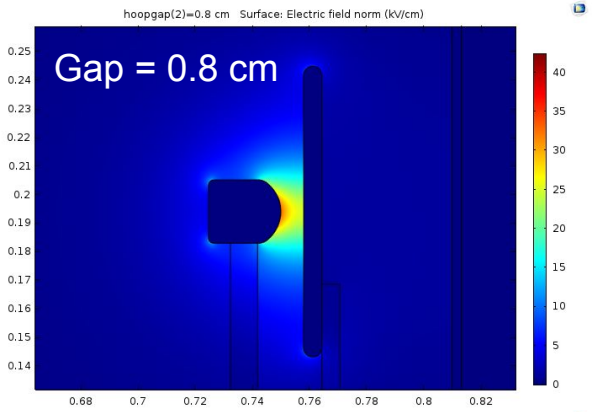
S2 threshold is ~2.66 kV/cm

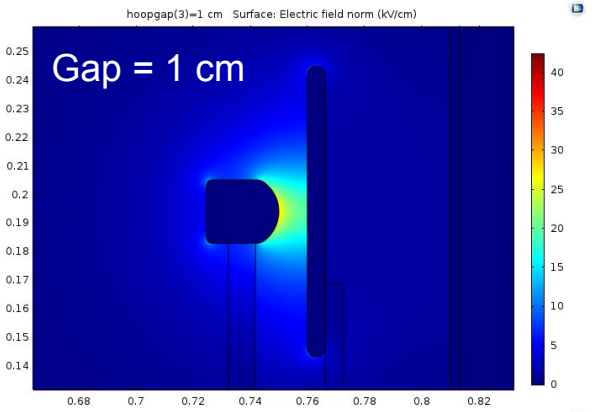
Reach this threshold near the C=-10 kV, hoop=12 kV.

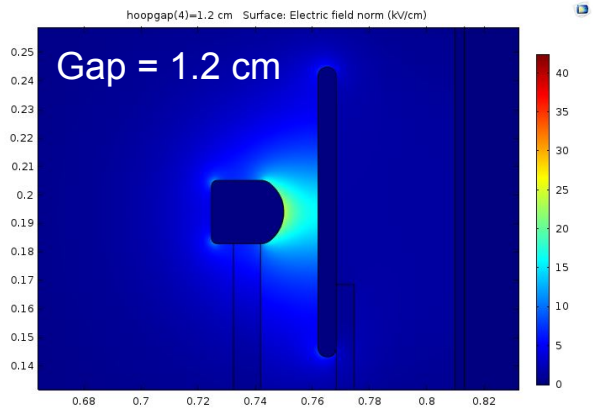
Field outside ⅛” hoop is slightly lower than ¼” thick hoop.

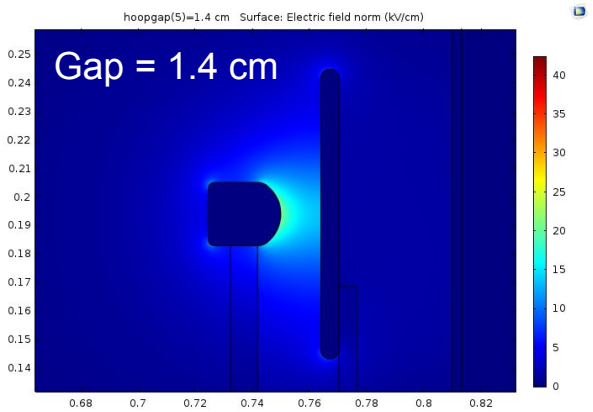
Varying gap length, C = -16 kV, hoop = 6 kV, ¼” thick

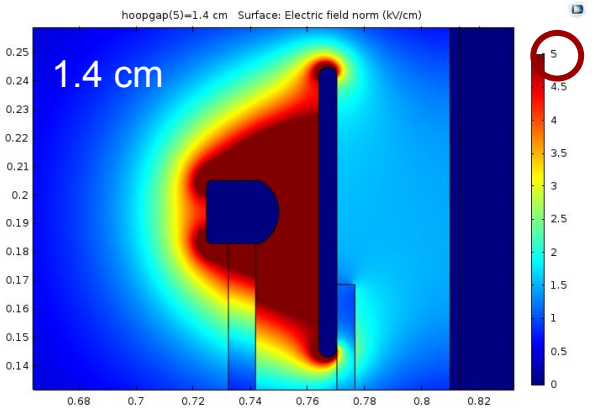




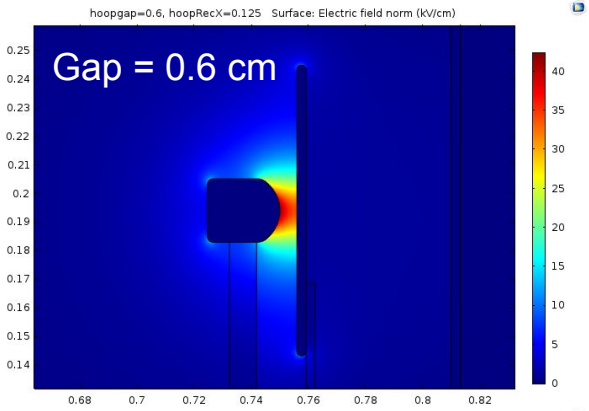


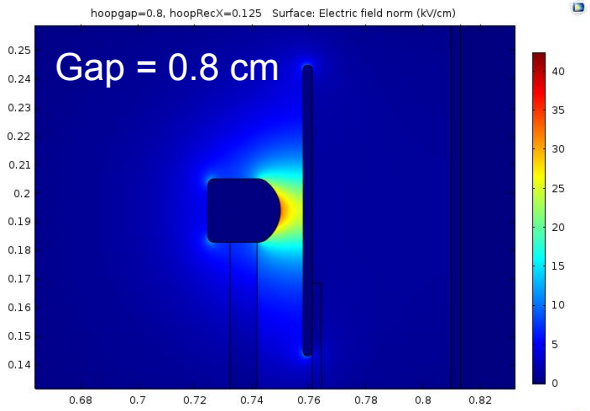


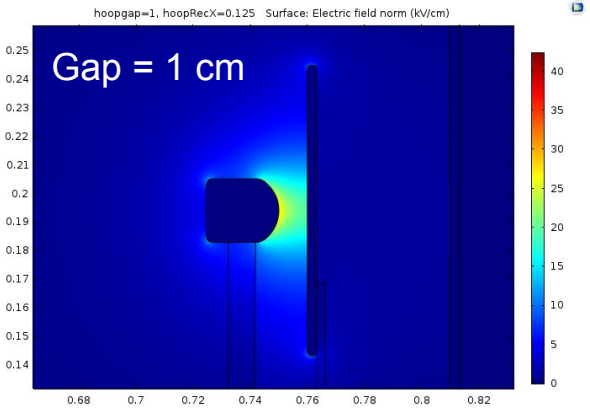


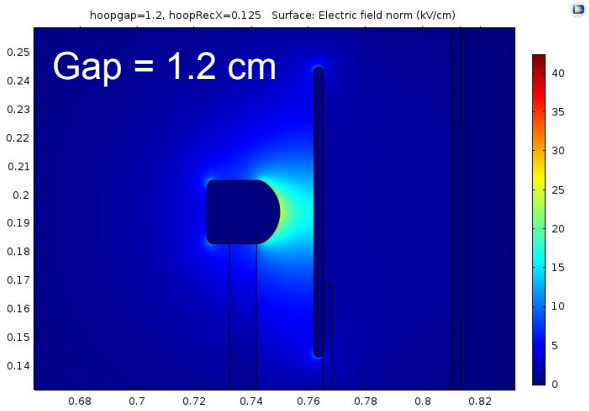


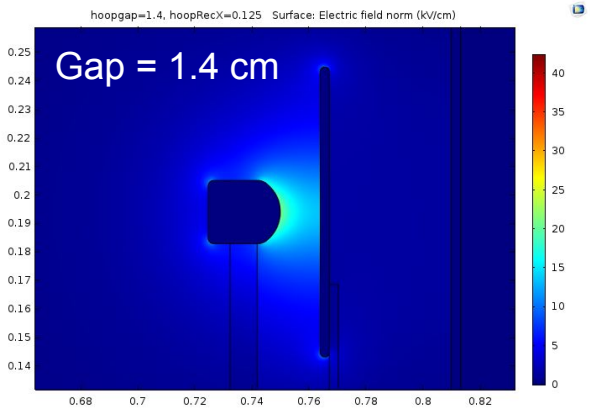
Varying gap length, C = -16 kV, hoop = 6 kV, ⅛” thick



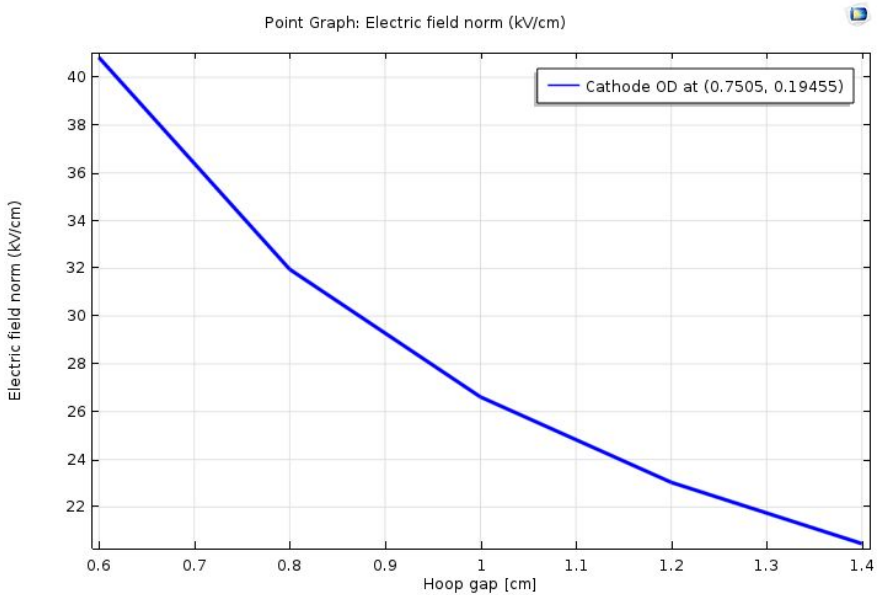


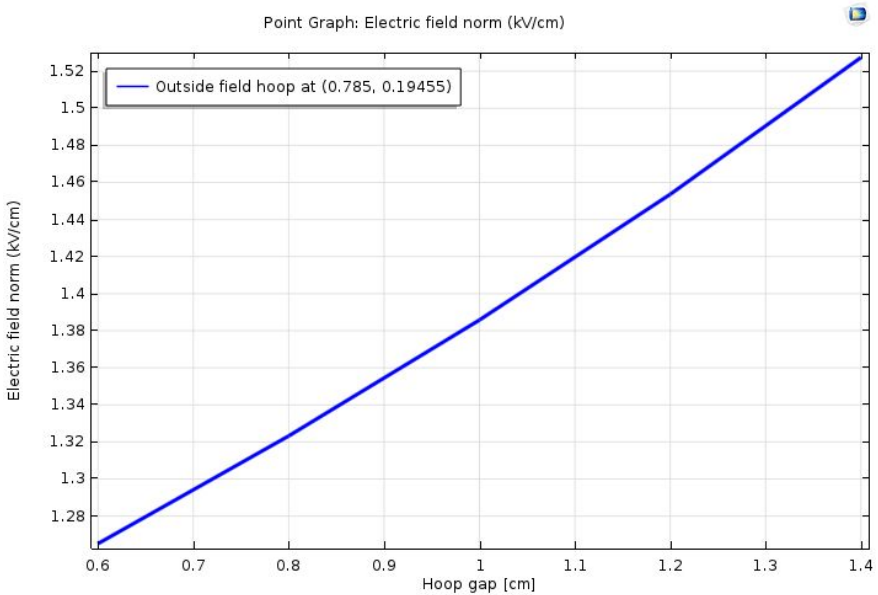






Varying gap length, C = -16 kV, hoop = 6 kV, ¼” thick

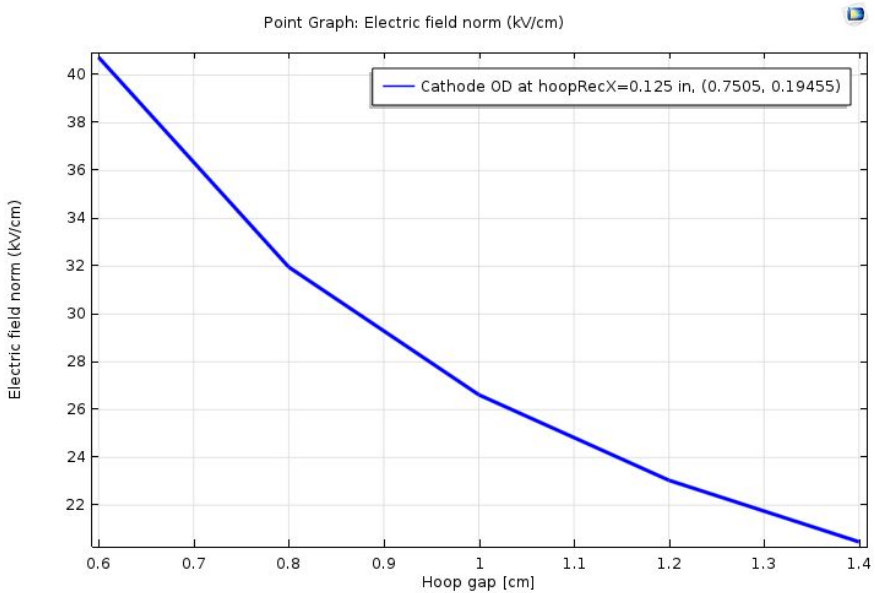


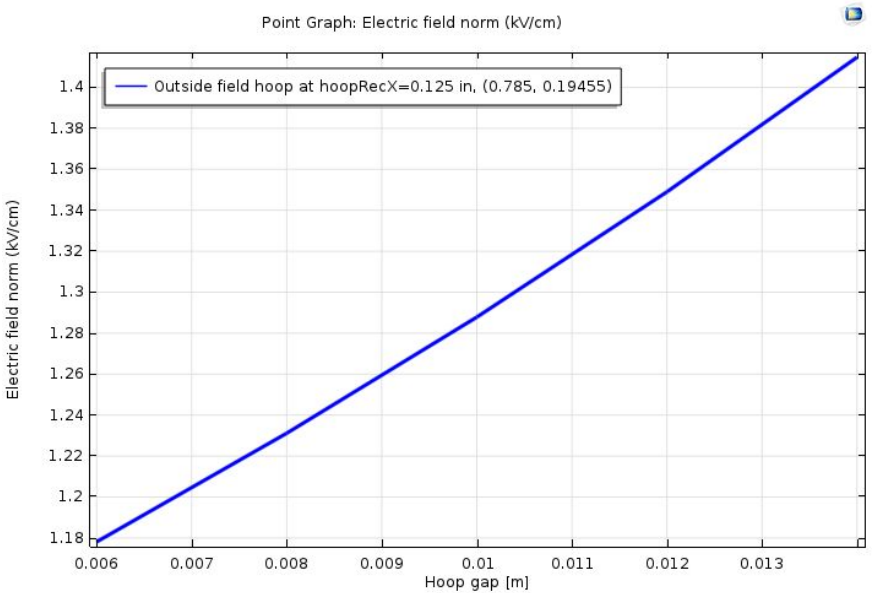


(left) Field on the outside of the cathode ring (OD) as a function of gap between ring and vertical hoop.

(right) Field between hoop and reflector wall. This is **~1.3-1.5 kV/cm**, so it’s below the S2 threshold for this voltage configuration.

Varying gap length, C = -16 kV, hoop = 6 kV, ⅛” thick



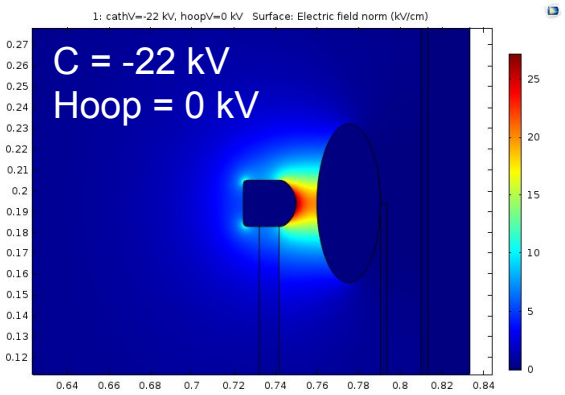


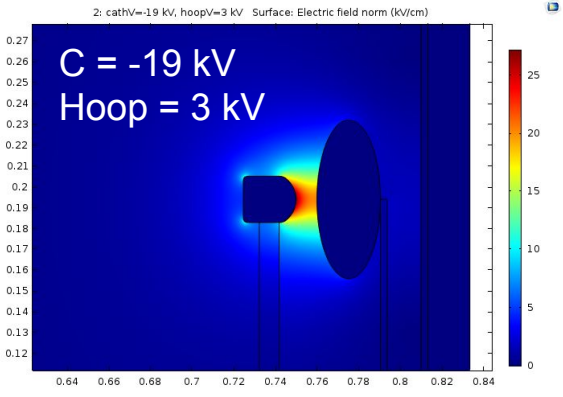
(left) Field on the outside of the cathode ring (OD) as a function of gap between ring and vertical hoop.

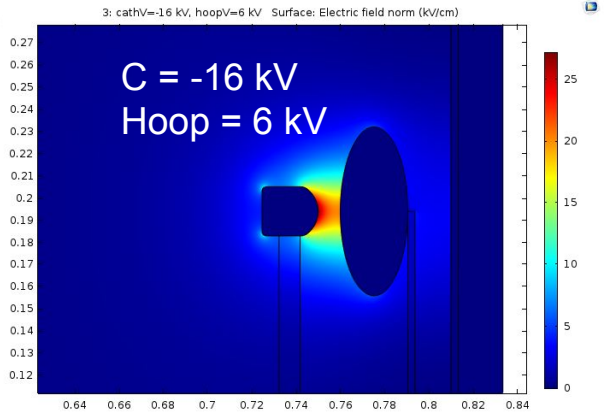
(right) Field between hoop and reflector wall. This is **~1.2-1.4 kV/cm**, so it’s below the S2 threshold for this voltage configuration.

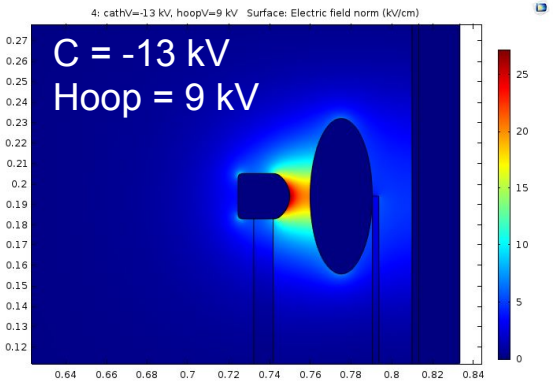
Field hoop with an elliptical cross-section

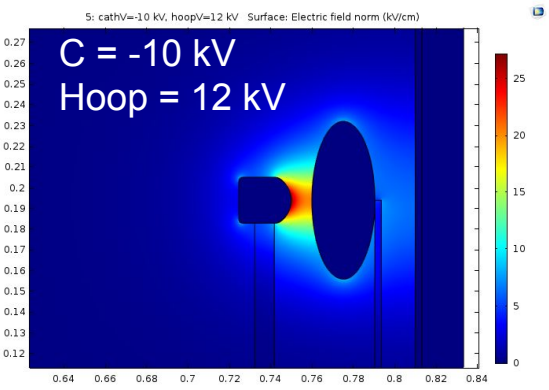
Varying voltage configurations, 1 cm gap







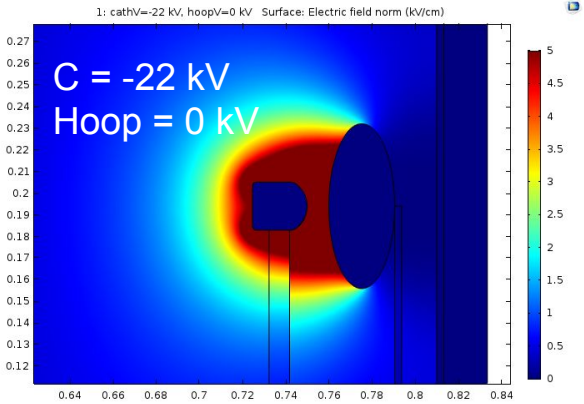


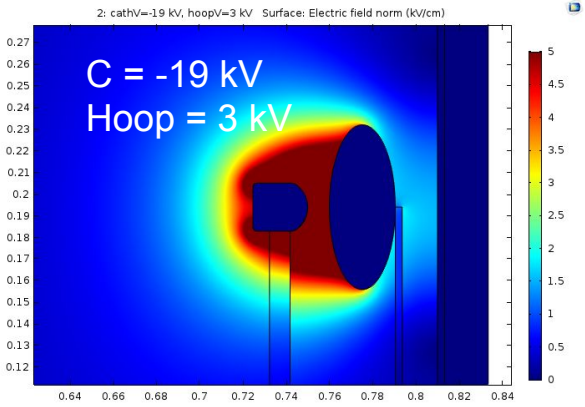


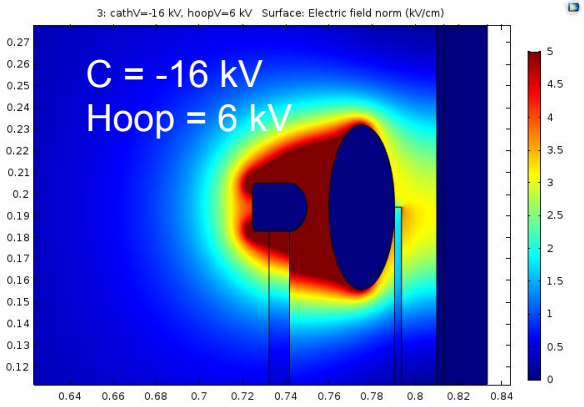
The field in the region between the hoop and reflector wall increases.

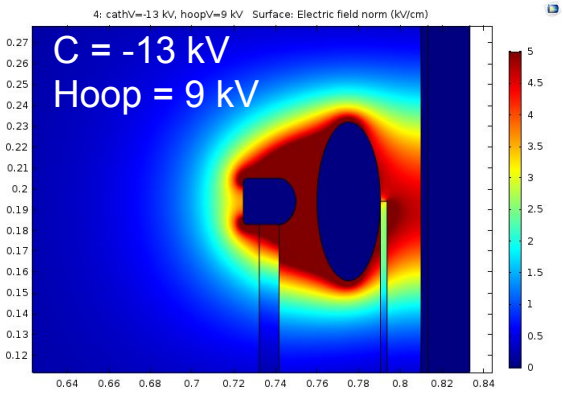
The field on the edges of the 1.5” by 0.6” high hoop increases.

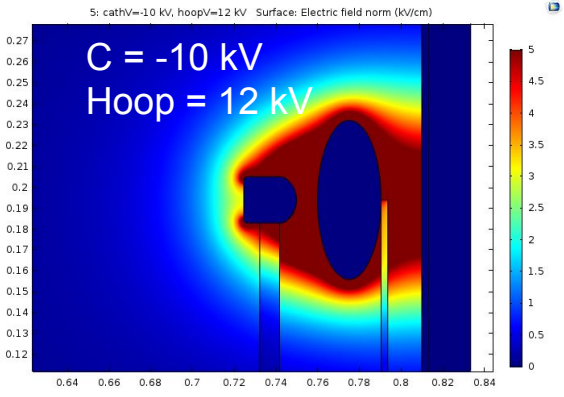
Varying voltage configurations, 1 cm gap, zoom







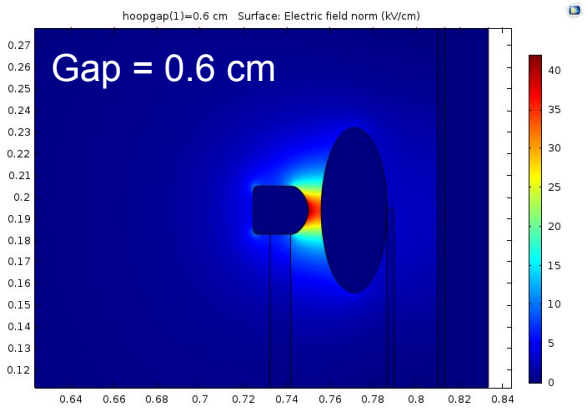


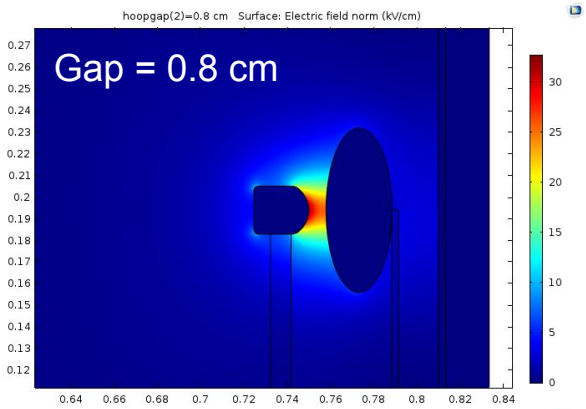


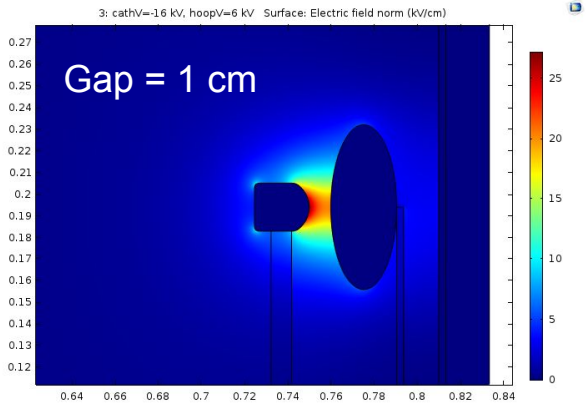
The field in the region between the hoop and reflector wall increases.

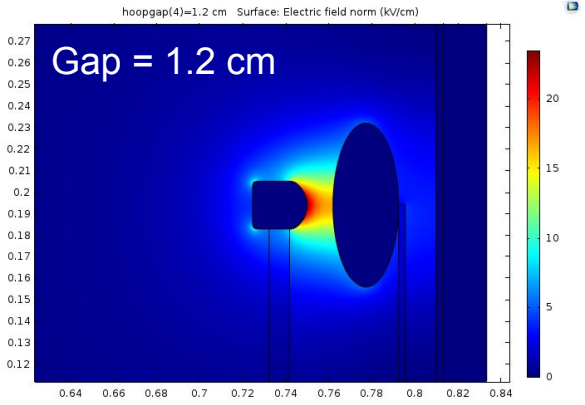
The field on the edges of the 1.5” by 0.6” high hoop increases.

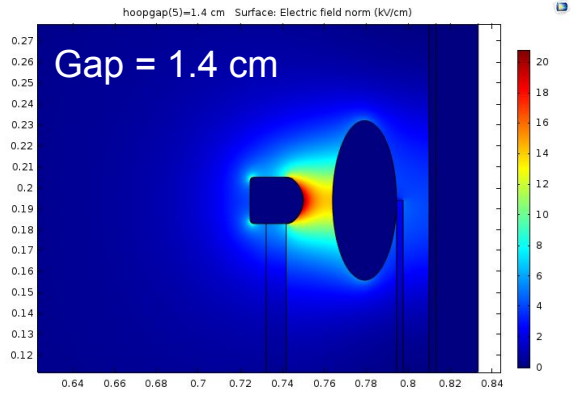
Varying gap length, C = -16 kV, hoop = 6 kV











Varying gap length, C = -16 kV, hoop = 6 kV