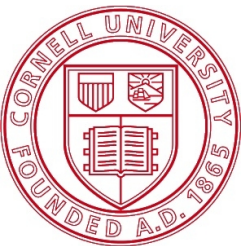
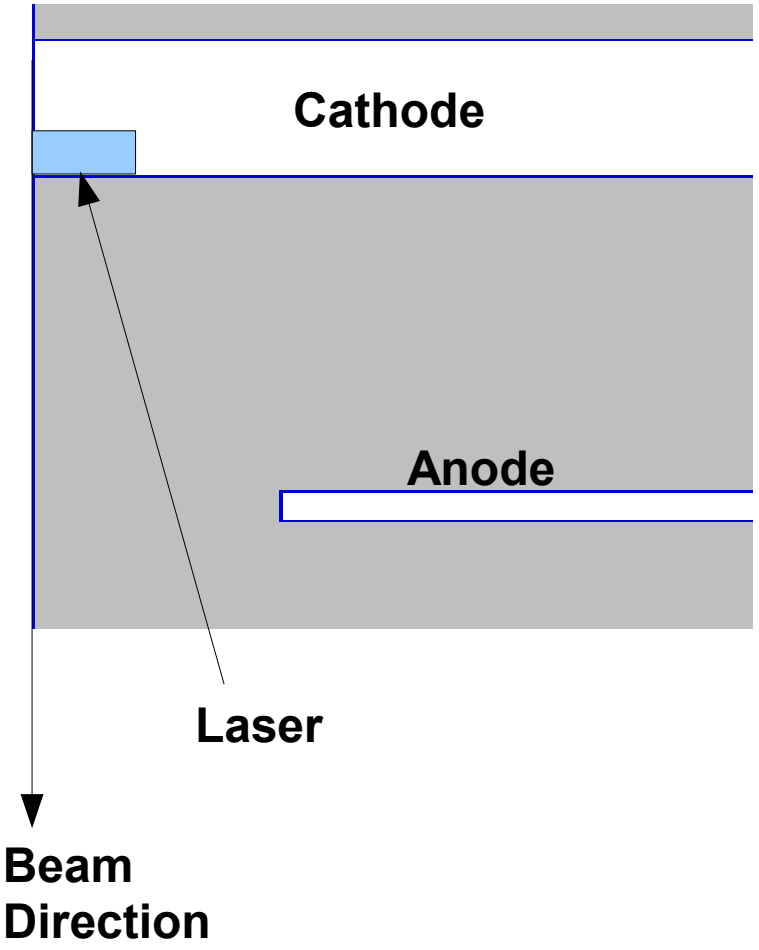
Gun Focusing and Electrode Geometry

Cornell ERL Phase 1B Gun: *External Review*
1/5/11

Jared Maxson



Electrode Fundamentals



- The simplest electrode design is defocusing.
- Anode hole will curve equipotential lines.

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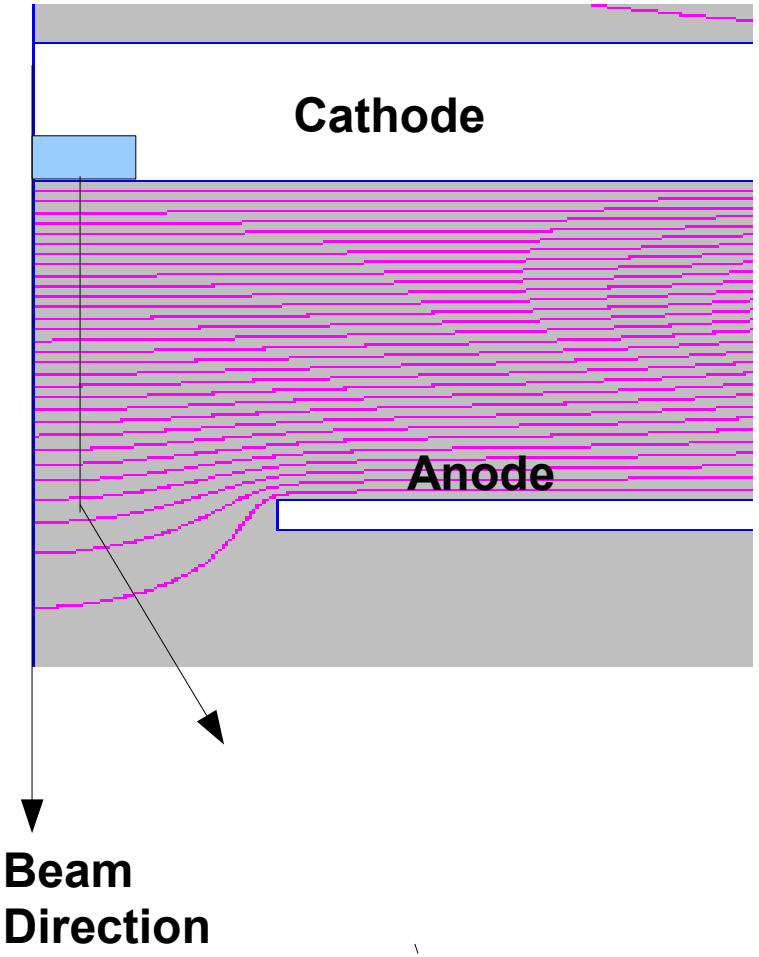
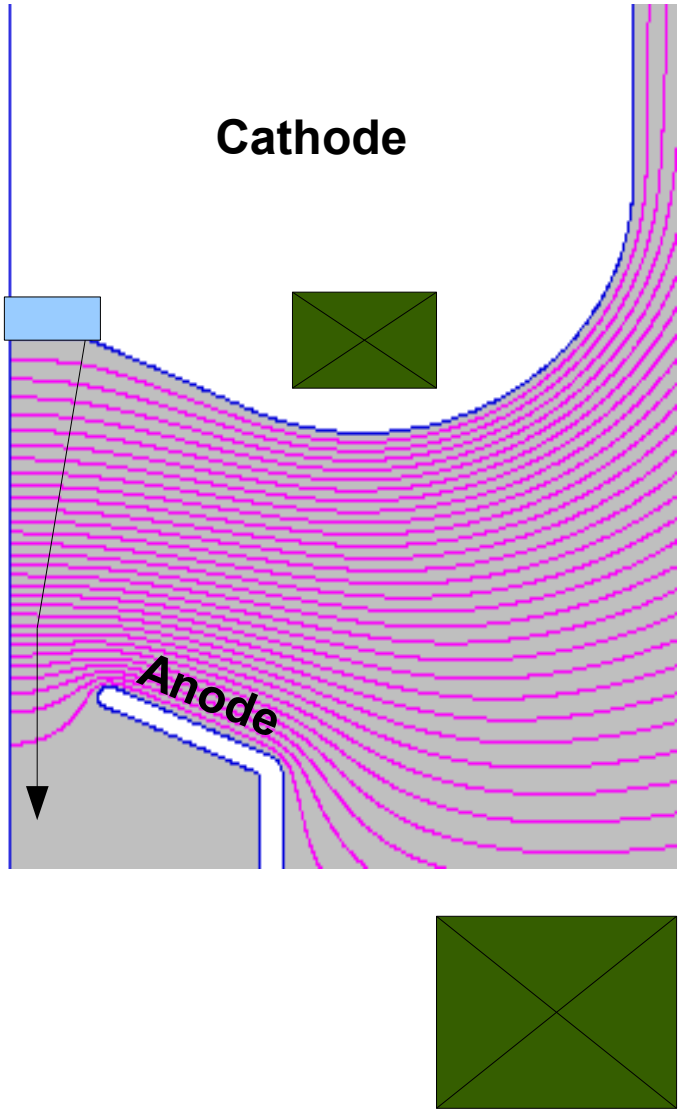


- The simplest electrode design is defocusing.
- Anode hole will curve equipotential lines.
- Cannot be avoided.
- Must implement focusing to fight emittance growth.

Methods of Focusing

- Magnetostatic:
  - Next talk.
- Traditional Electrostatic:
  - Using GaAs, conventionally make photocathode puck flat—for convenience in cathode growth.
  - Bend region next to p.c.
  - Terminate electrode in smooth arc.
- May end up with both.

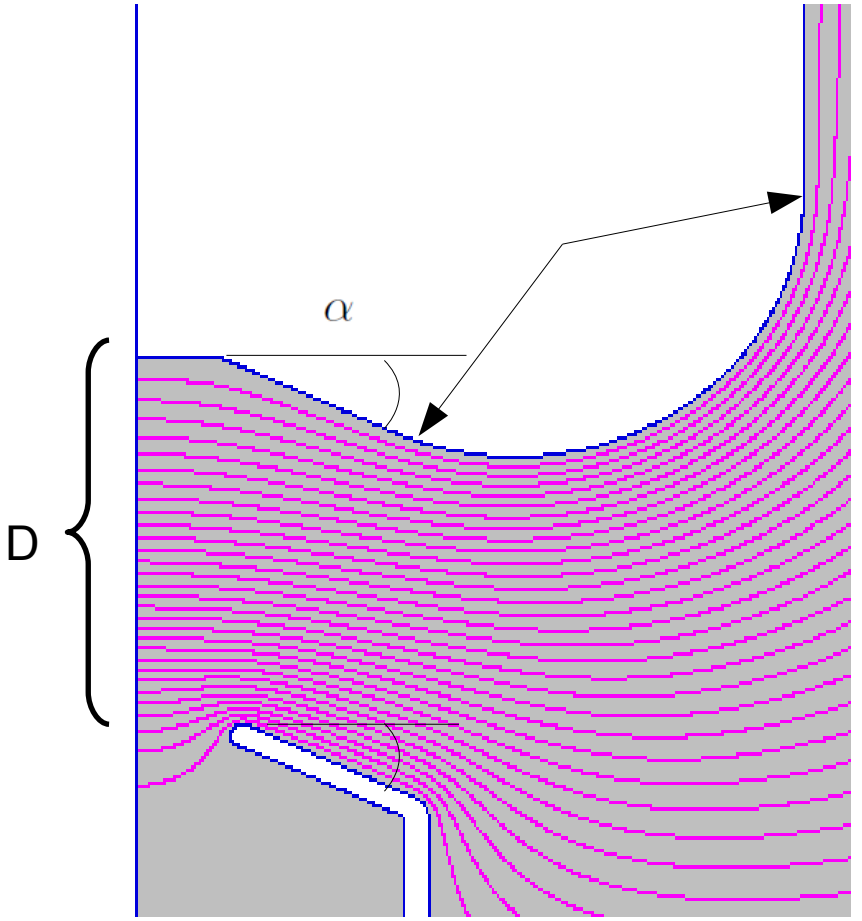


Beam Dynamics

- Want:
  - Minimum Emittance—Does this mean maximal focusing? Assume so for now.
  - Large electric field at the photocathode—larger surface charge for extraction.
  - Larger voltage—Do we want maximal voltage?
    - Constrained here by field emission/vacuum breakdown.
  - Ion back-bombardment damage minimized.
    - Can electrode shaping help?

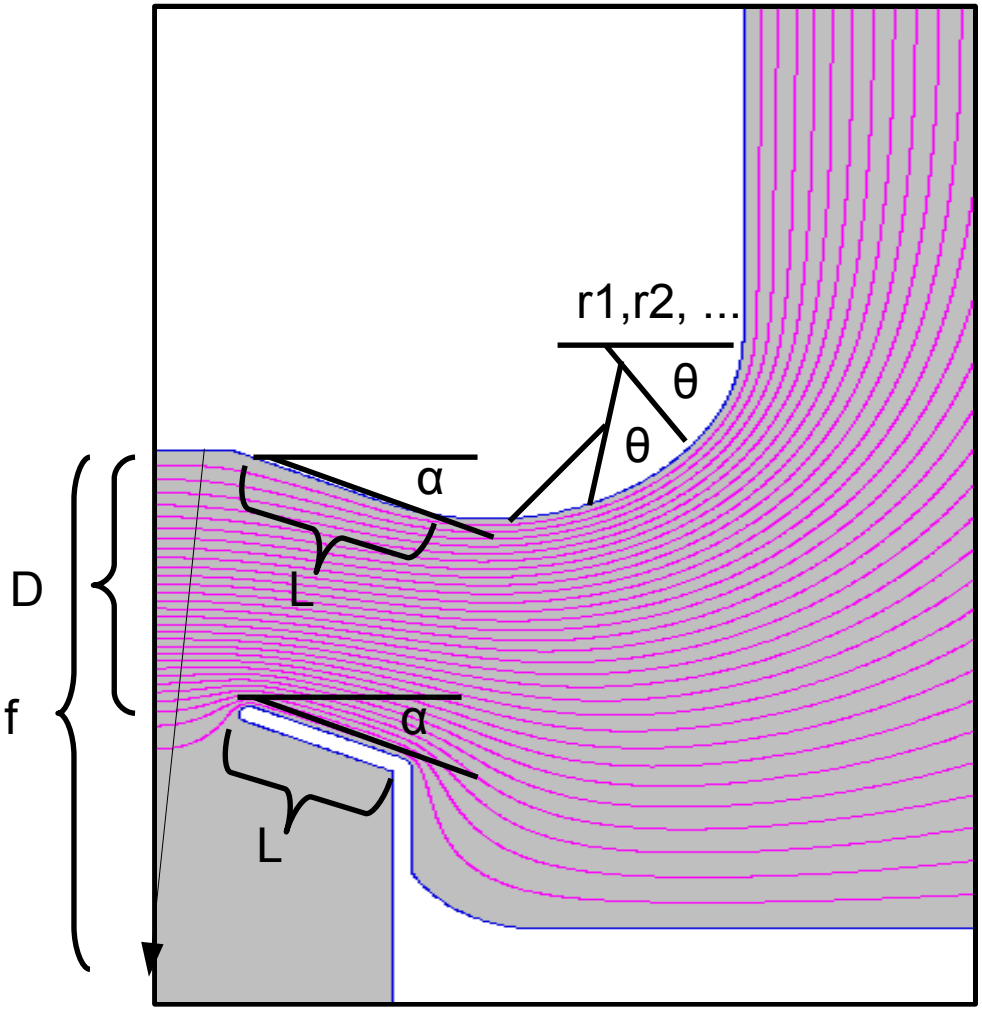
Geometry Parameters

- Current Gun @ 500kV
  - One radius, $\alpha = 25°$
    $D = 50\text{mm}$
  - $f_e = 0.2\text{m}$
    $E_{pc} = 5\text{MV/m}$
    $E_{max} = 12\text{MV/m}$
- Can we do better by introducing more geometrical parameters?



Geometry Parameters

- Goal: Vary geometrical parameters to obtain
  - Max: 1/f, Epc
  - Constrain: Emax to below breakdown.
  - Set V=500kV
- Leave anode alone—hole size set by p.c. radius.
- Large multivariate optimization problem.



Optimization

- Software written to build/vary geometry, to interface Poisson with optimization routines.
- Problem with many decision varibles: Local Minima.
  - Use a 'genetic' optimizer to 'mutate' out of local minima.
- Optimize two parameters, constrain others.
  - **O:** f, Ecath, **C:** Emax
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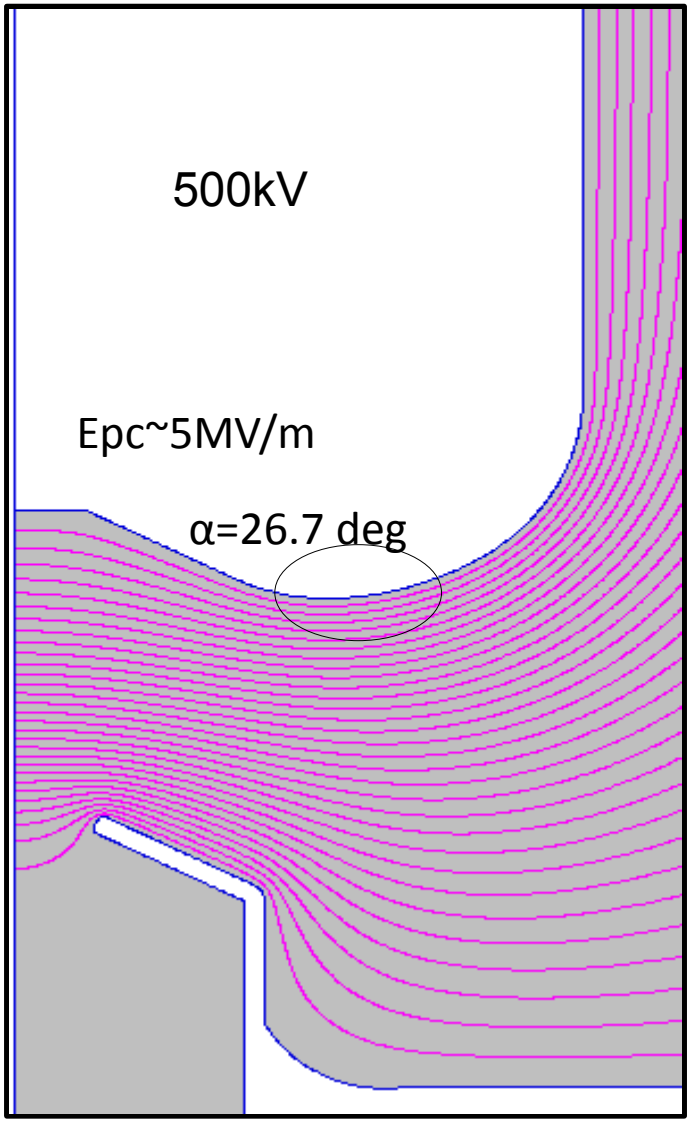
Optimization Results

- The current (simple) geometry always lies close to the optimal solutions.
  - Seems no 'magic' geometry lied in wait.
- Best solution has focal length gains on the 5% level (alpha=26.5 deg),comparable field strengths, gap.
  - Achieved via flattening of rounded edge face.



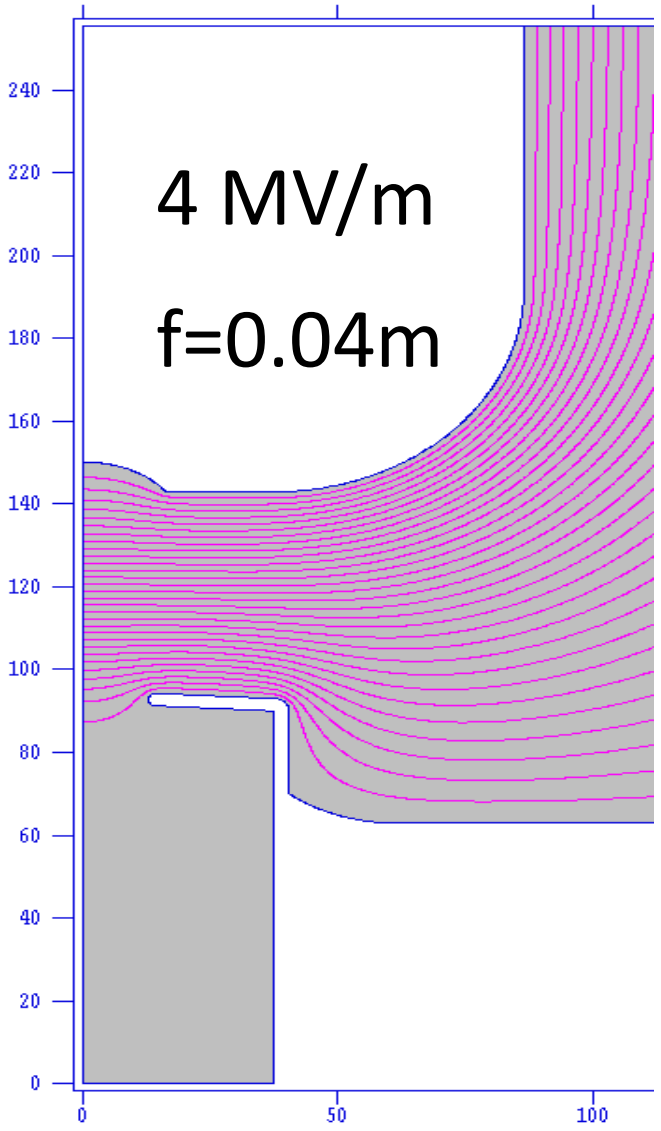
Significance

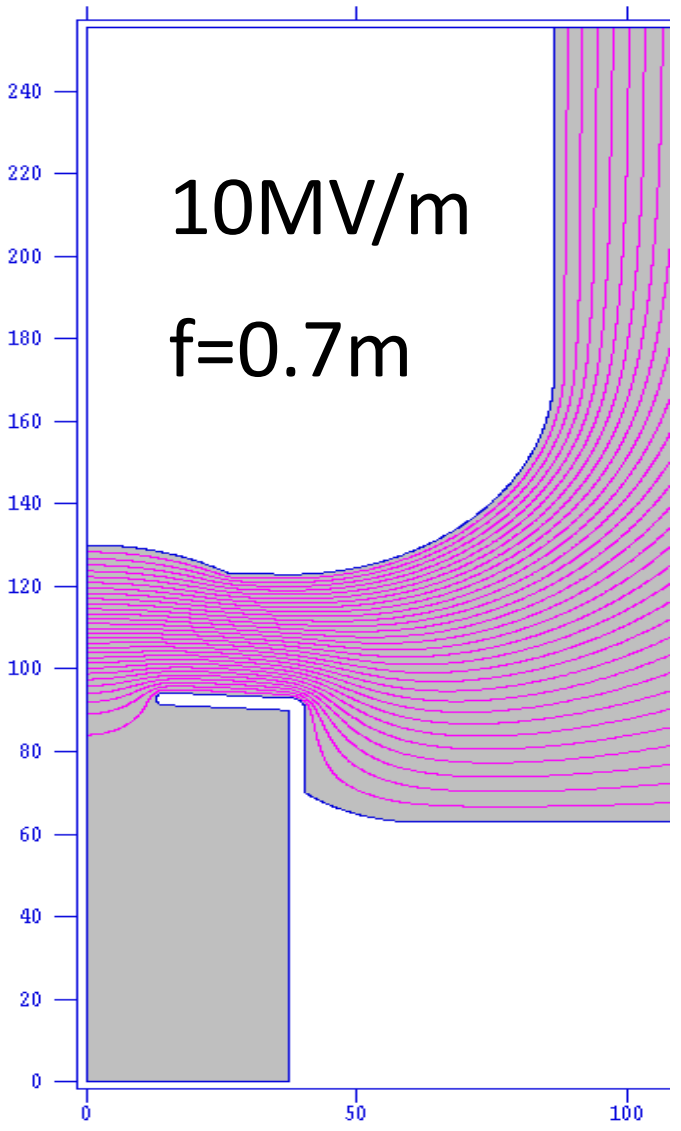
- What is the connection between focusing and emittance?
  - Need a larger scale beam-dynamics simulation.
- These simulations employ simple, 1-D gun field maps as a function of angle and gap.
  - Will need to convert these to actual designs to optimized geometries.
- Given angle and gap, can optimize for higher p.c. fields, and lower Emax.

Aside: Shaped Photocathodes

- We have used flat GaAs cathodes for simplicity.
- What if the photocathode itself bends the field lines?
  - If otherwise flat, could provide greater Epc.
  - Multialkali cathodes can easily be deposited on curved surfaces.
- What would such a thing look like? Could it alone provide focal length necessary?

Shaped Photocathodes: Examples





Discussion

- Geometry parameterization: Over/underkill? Other parameters?
- Effect of anode shaping?
- 'Wild' Suggestions/Other geometries:
  - Shaped p.c.'s
    - Could be viable.
    - What to do with laser?
  - ...