Ion Back-Bombardment

Cornell ERL Phase 1B Gun: *External Review*
1/6/11

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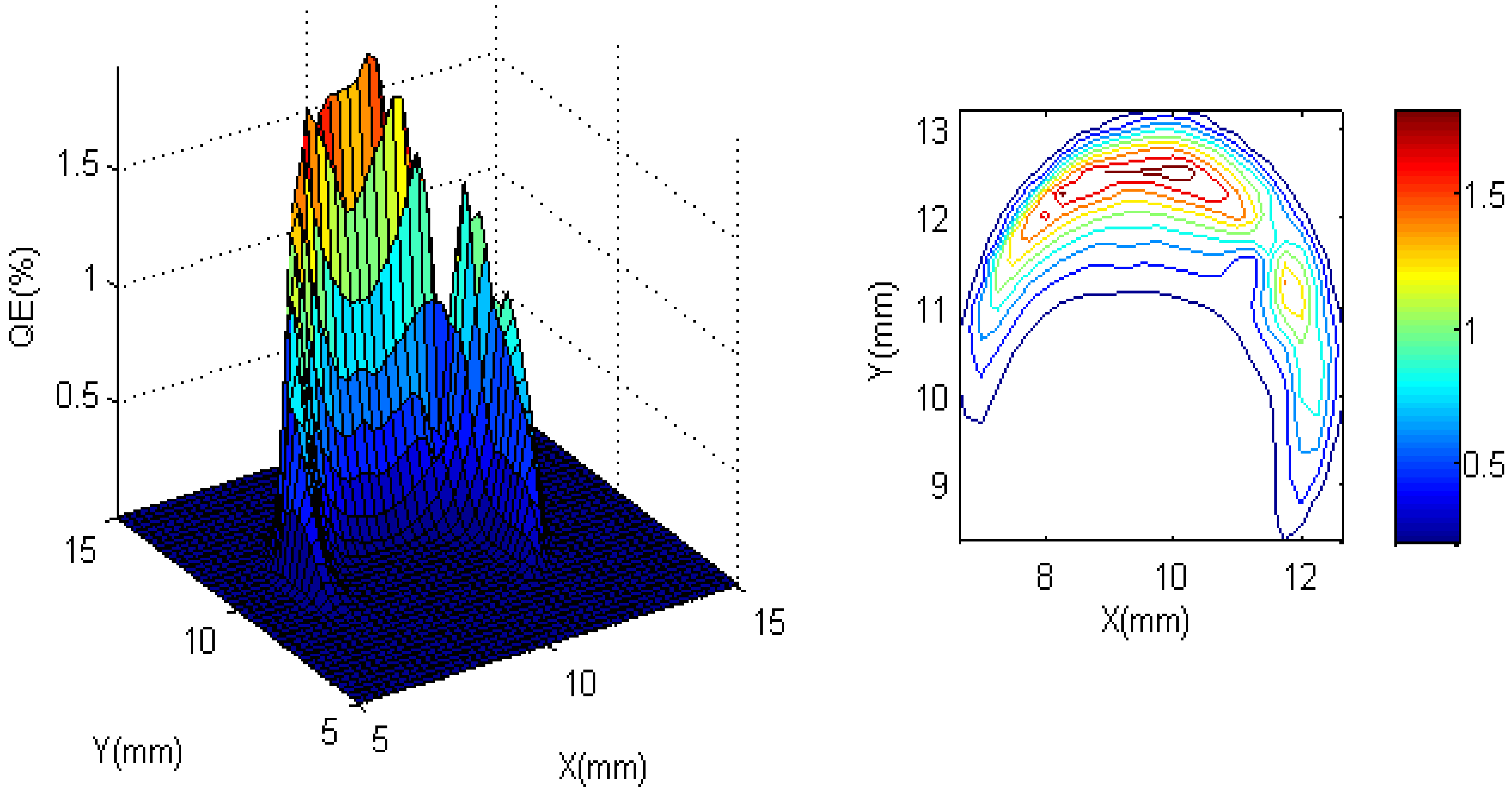
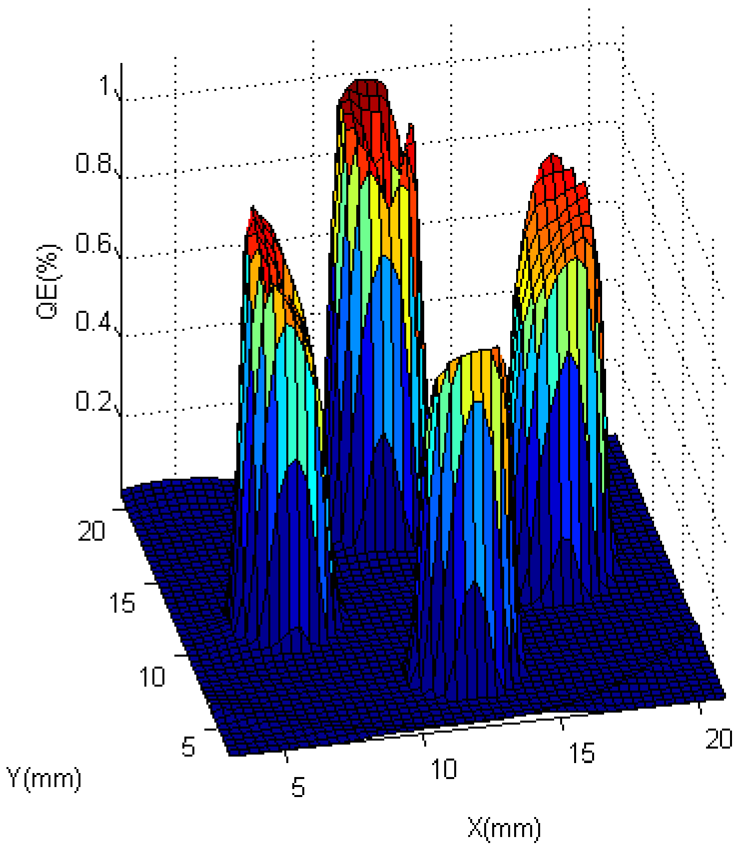
Ions and QE Death

- Partial pressure in gun and beyond is dominated by molecular hydrogen.
- High current running is currently limited by cathode damage/QE death.
  - Pressure spikes from vacuum/HV irregularity (mins)
  - Gradual QE erosion from h2+ ions (hour)
- When running high current, can never run in the center of the cathode.

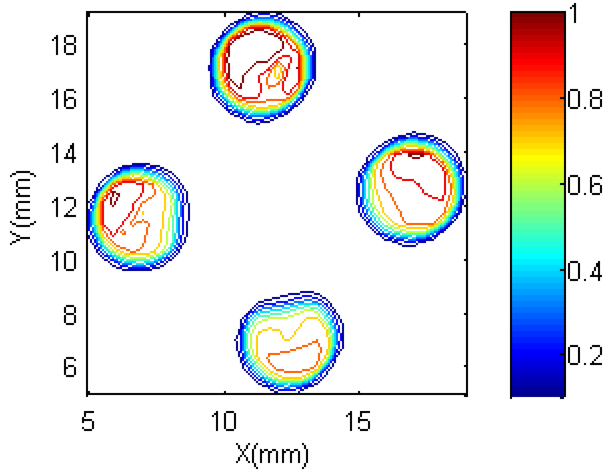
QE Scans



QE Scans



QE(%)
1
0.8
0.6
0.4
0.2
20
15
10
5
Y(mm)
5
10
15
20
X(mm)



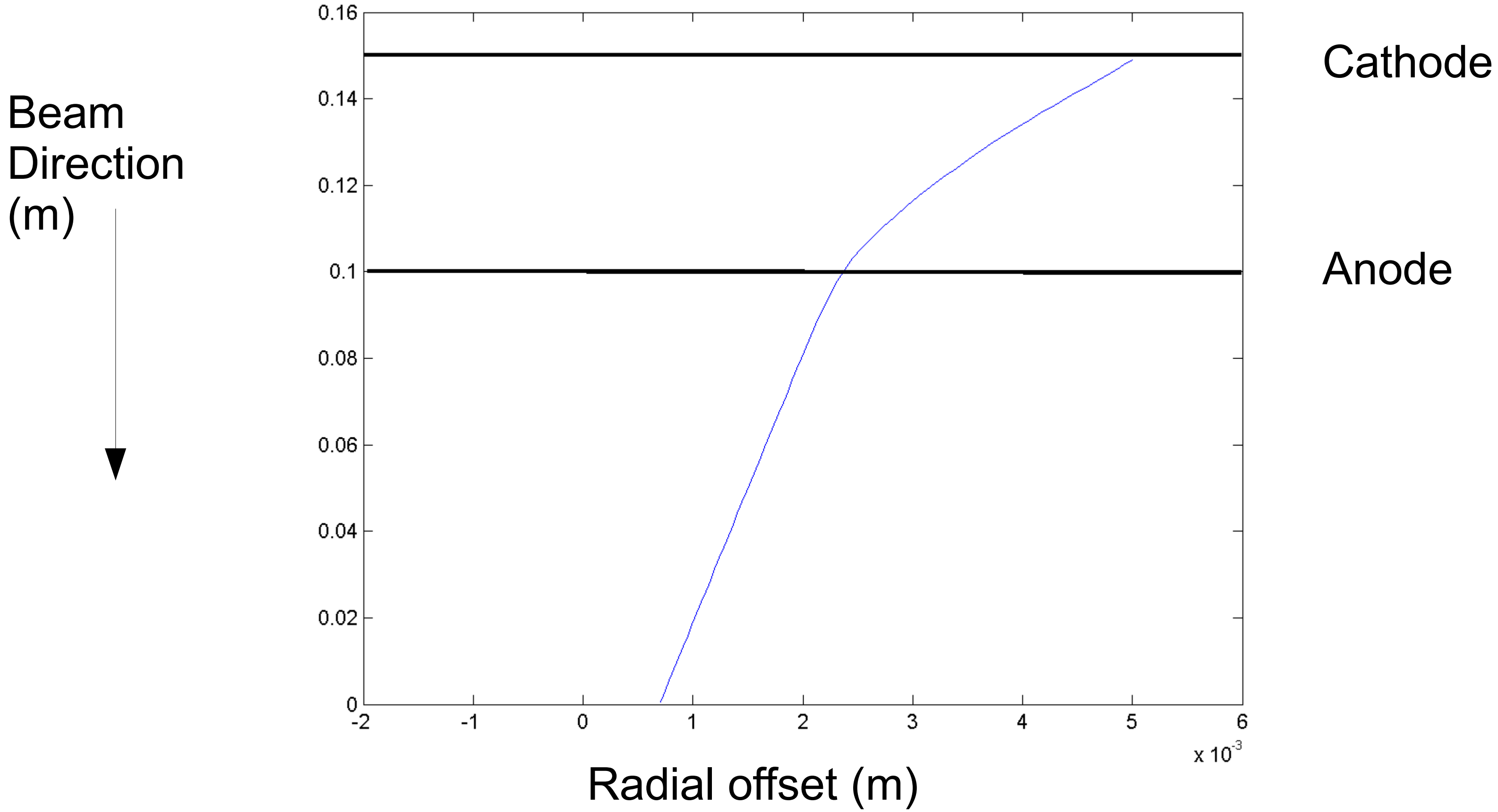
18
16
14
12
10
8
6
Y(mm)
5
10
15
X(mm)
1
0.8
0.6
0.4
0.2

Calculating Damage Profiles

- Ion damage is distributed and complex.
- Current L0 Gun: heavy pumping in gun, perhaps 20x higher pressure in drift.
  - Is the damage mostly from gun ions?
- Given gun field maps, want to calculate p.c. QE damage profile.
  - Associate radial p.c. position (damage site) with ion production location.

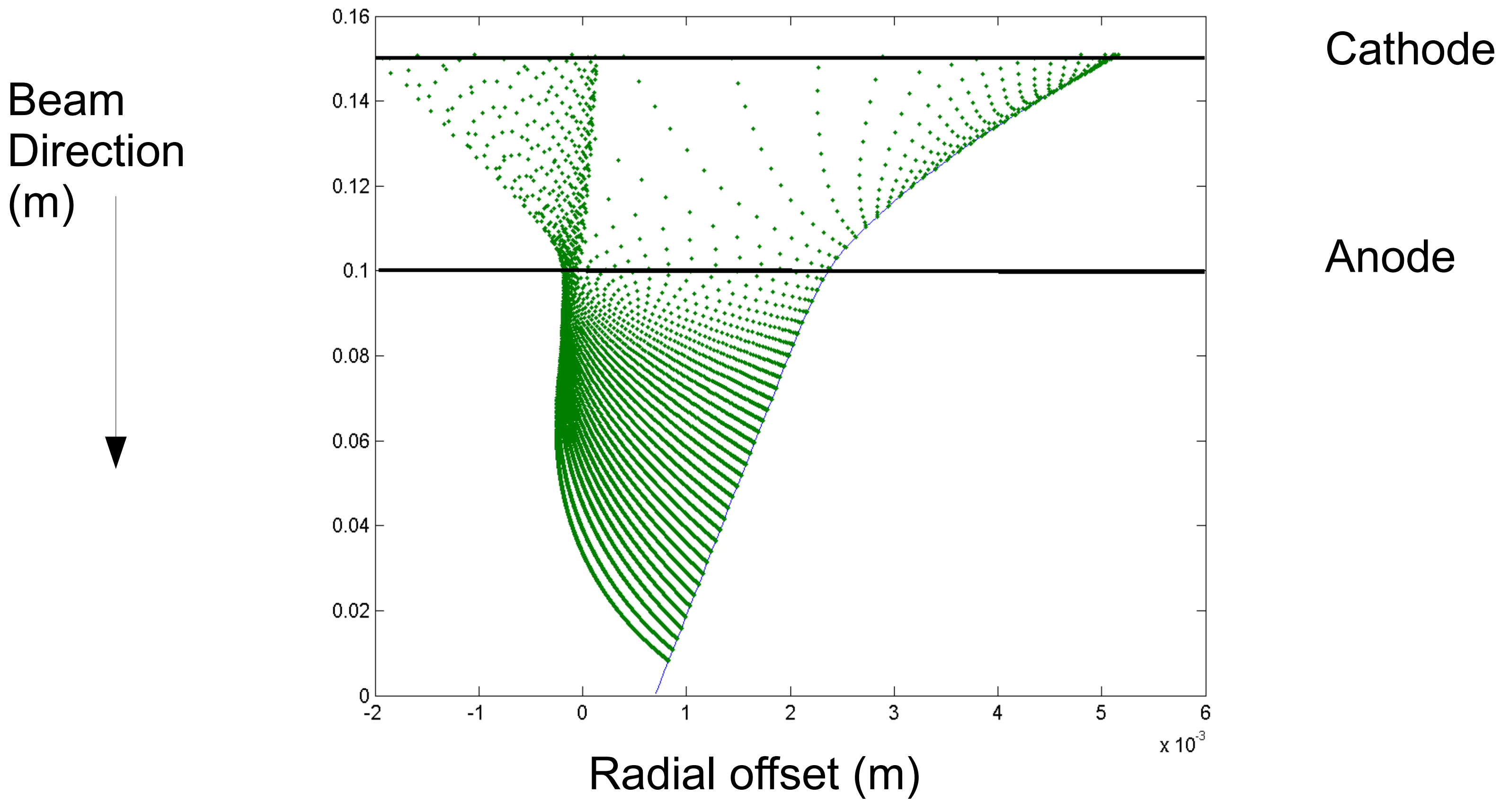
Calculating Damage Profile

- First, launch and electron from r=5mm
  - Here, current gun geometry.



Calculating Damage Profile

- Next, we generate ions along z within the field map.



Calculating Damage Profile

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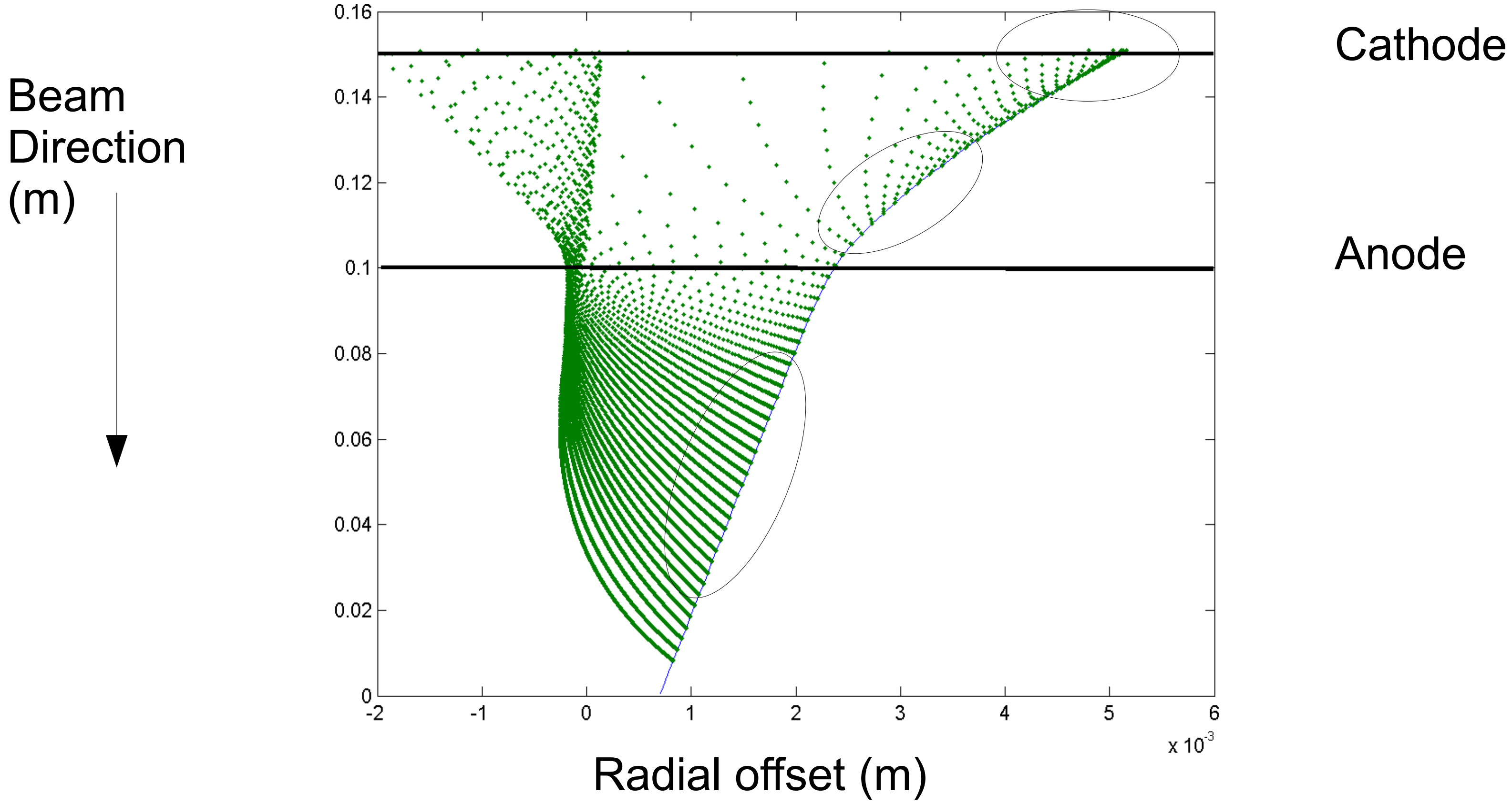


Calculating Damage Profile

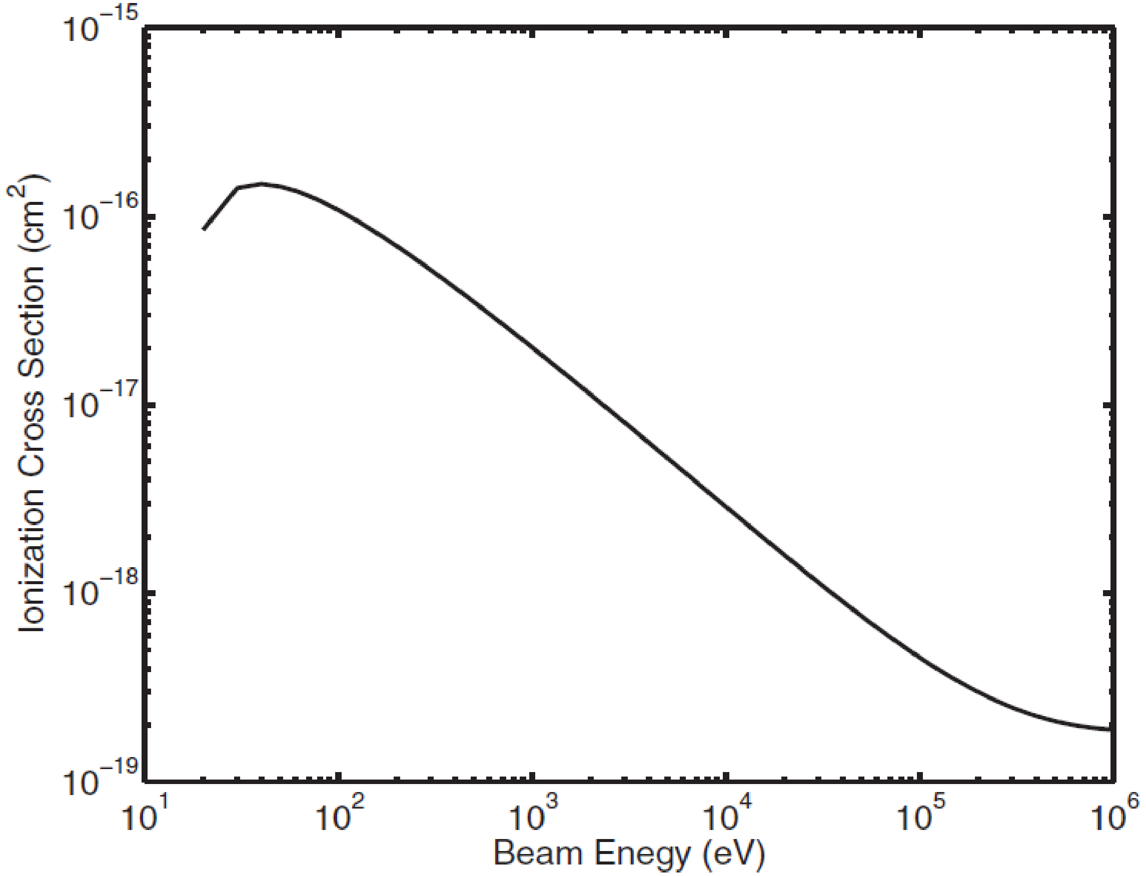
- Assume beam is centered via correctors.
  - Ions far away will hit the center.
- We can then interpolate the function r(z)
- Looking for number of ions/C, N.

$$\frac{dN(z)}{dz} = \frac{1}{e} n_H(z) \sigma(E(z))$$

- Integrate along and use r(z), giving N(r).

Cross Section

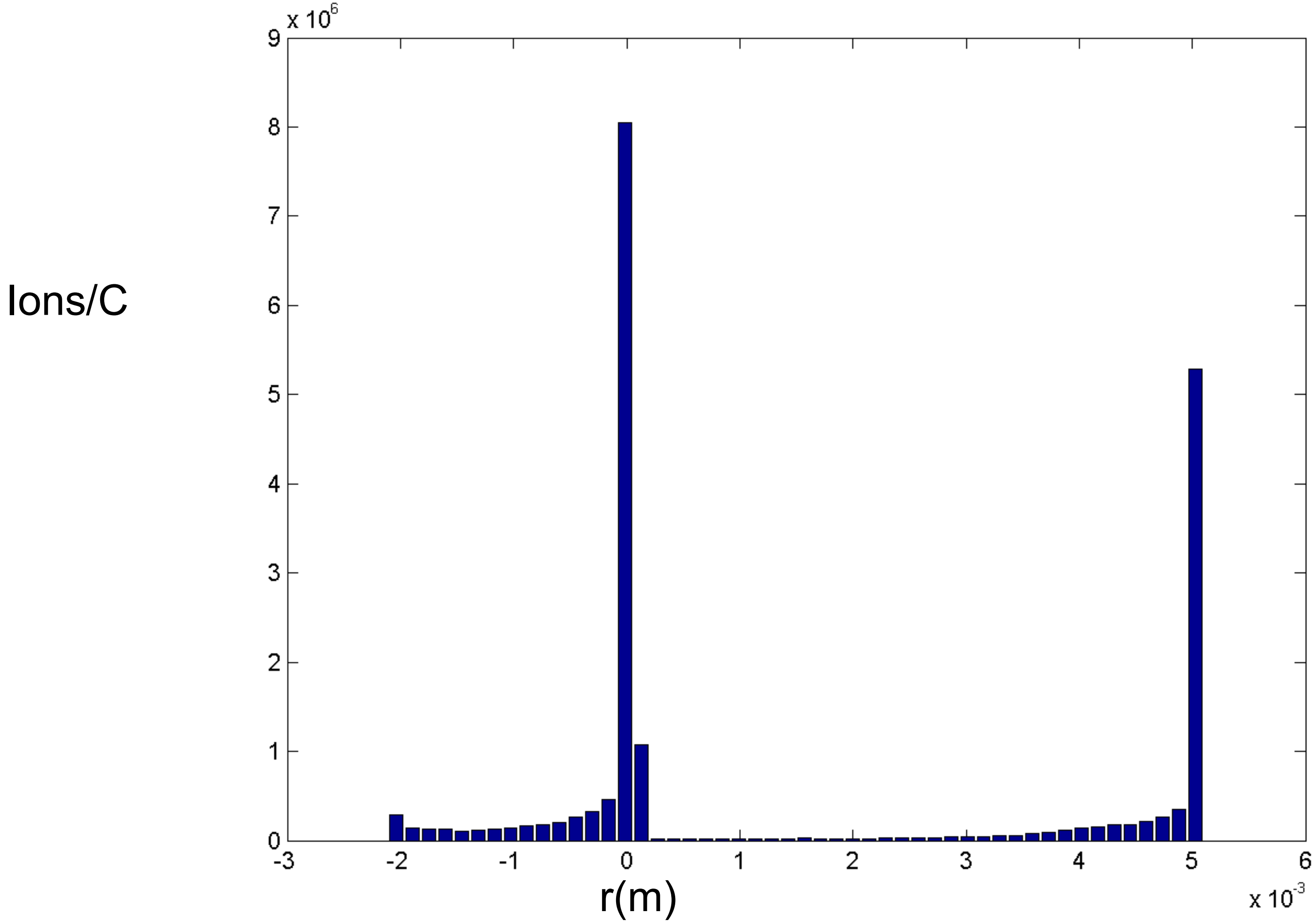
- We'll need the hydrogen density, and the ionization cross section.
  - Assume constant 1e-11 torr first.



From Pozdeyev PRST, 2007

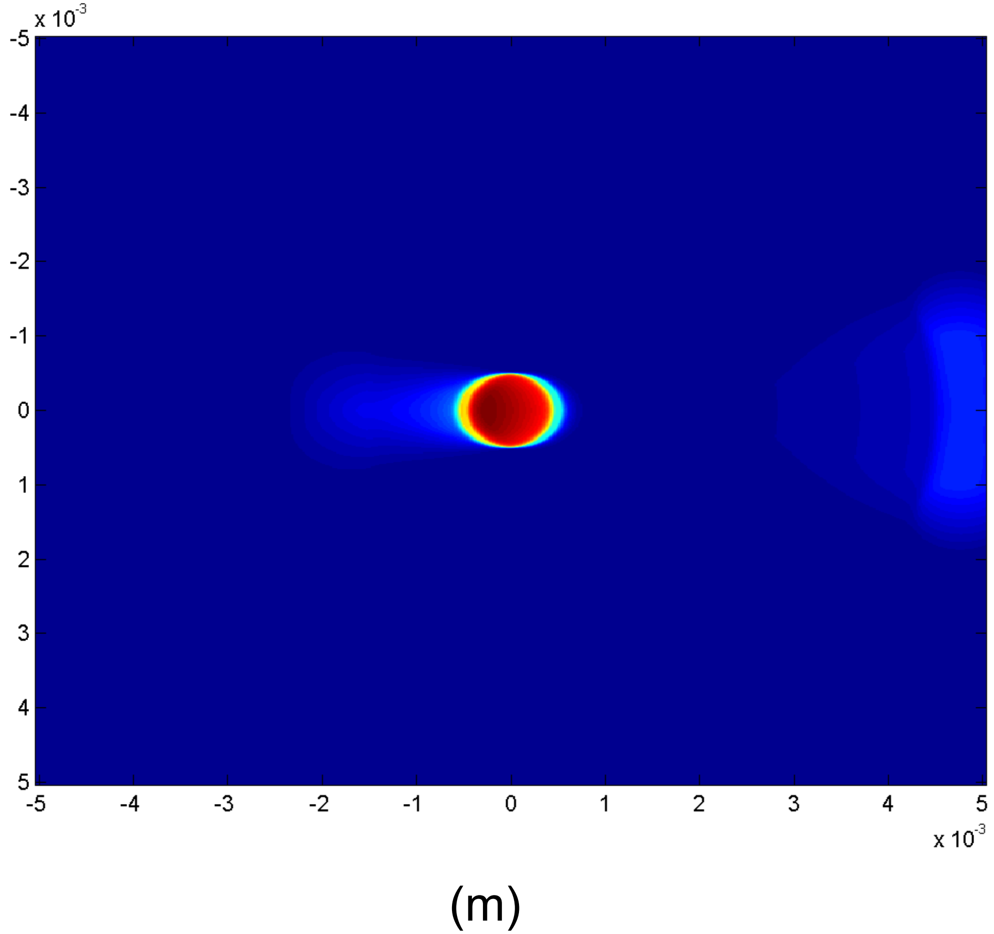
Damage Profile: Constant P

- Integrating out to 30cm:



Damage Profile: Constant P

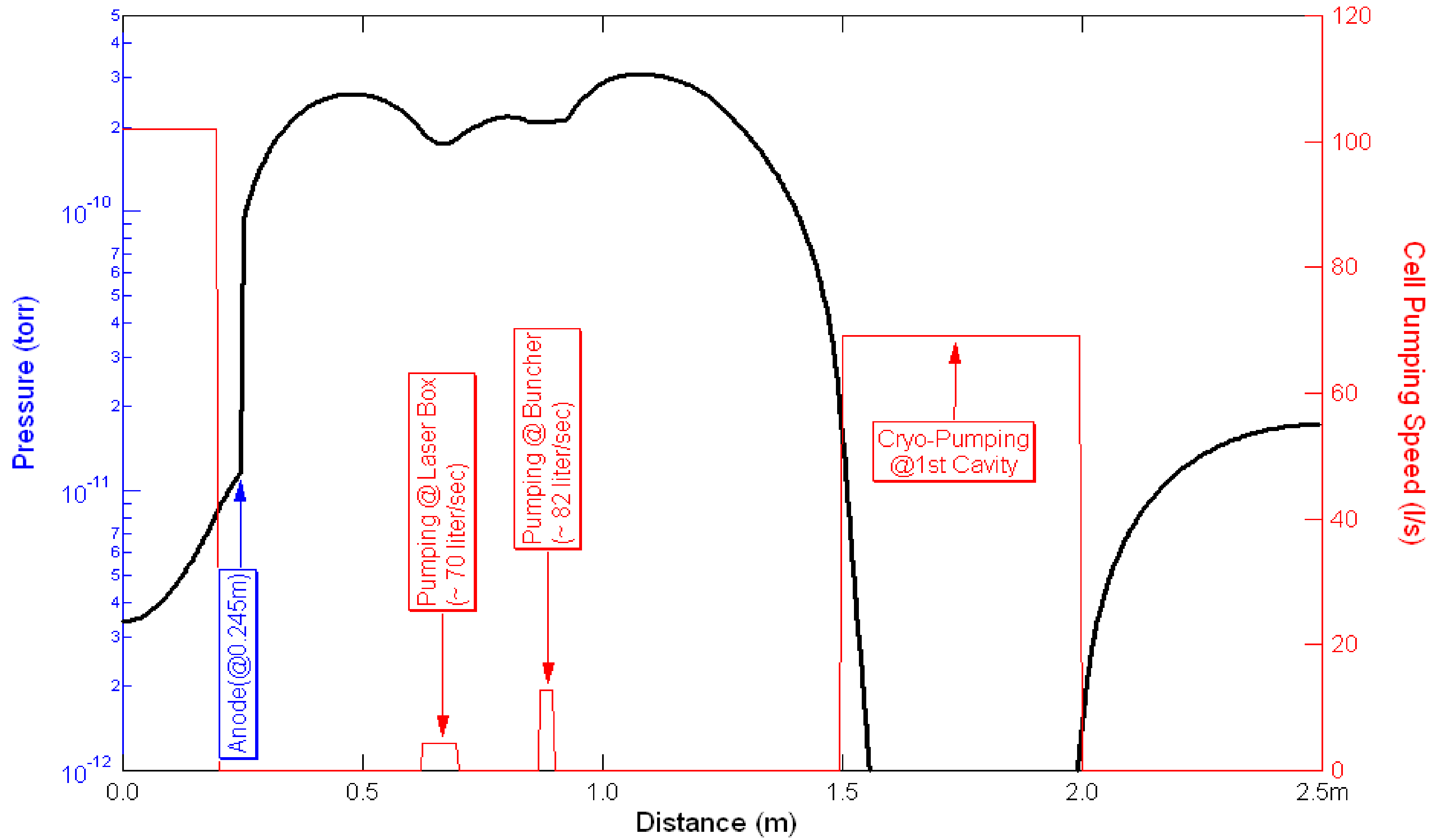
- Make a faux 2D plot:



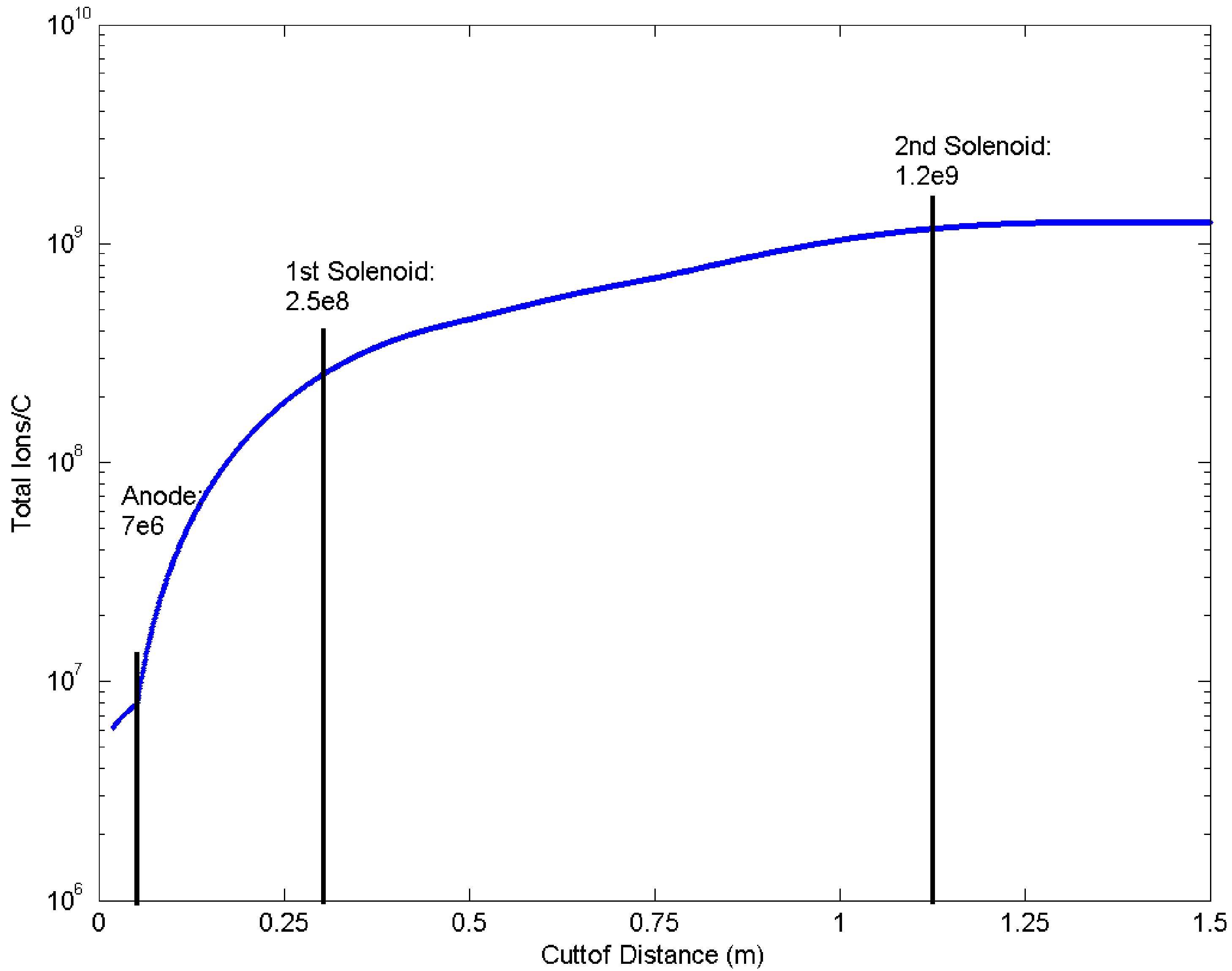
Refinements

- Thus far we have not considered:
  - Realistic Pressures
  - Where to cut off the integral? Where do ions cease to contribute?
- Can mock-up pressure profile up to cryomodule, using known conductances, pump speeds, and outgassing.

Pressure Profile

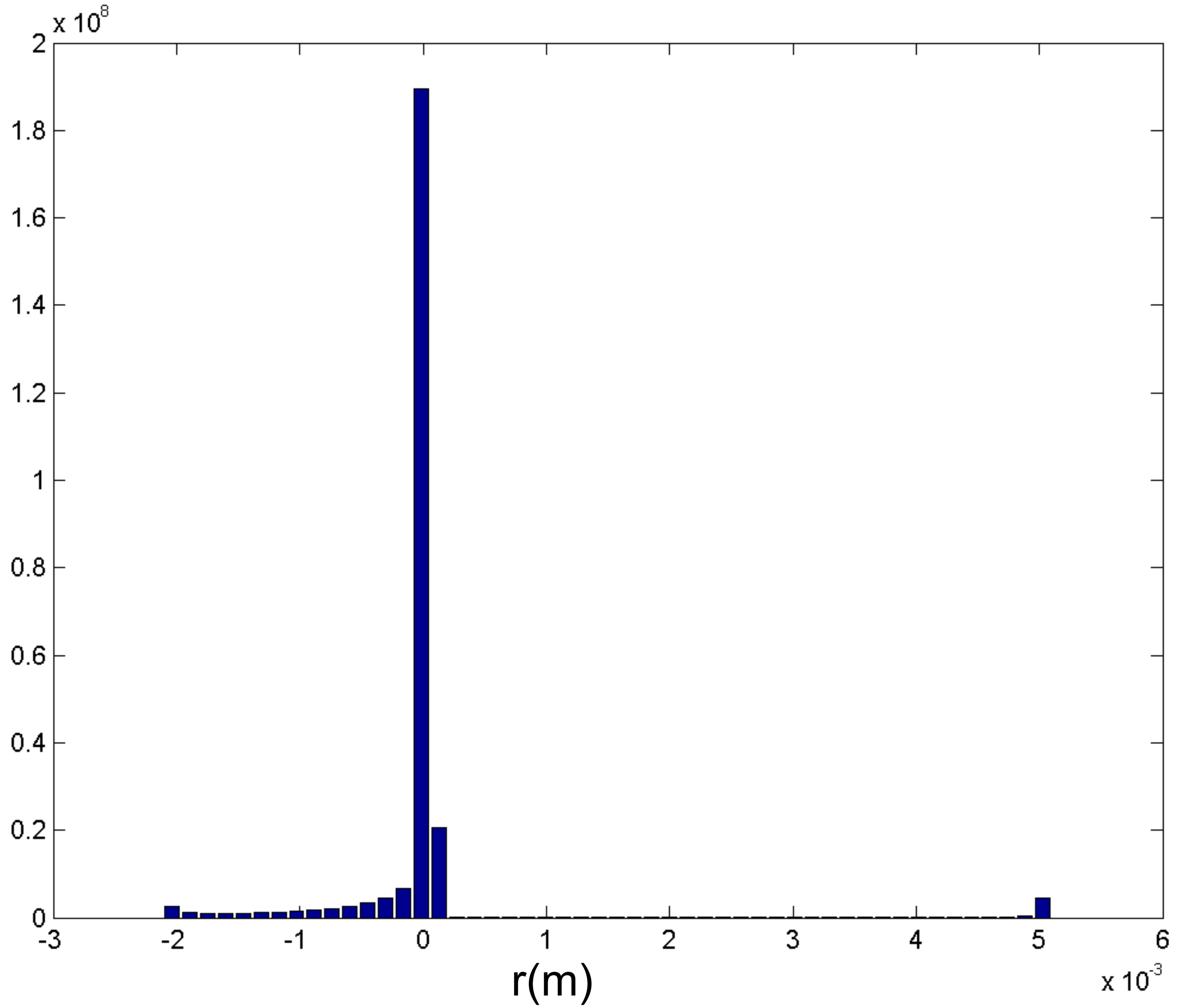


Ions vs. Cutoff



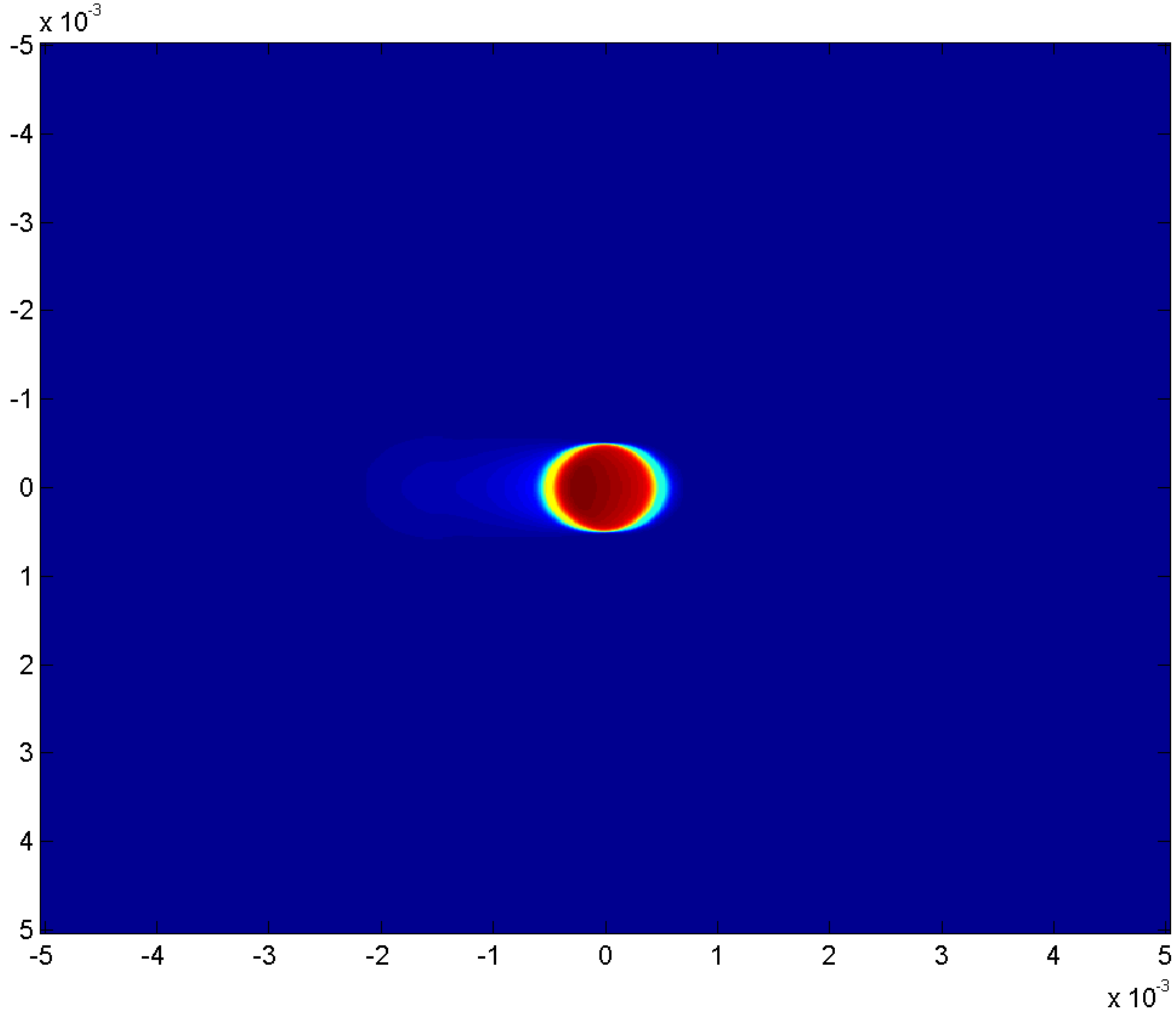
Damage Profile (30cm): Realistic P

Ions/C



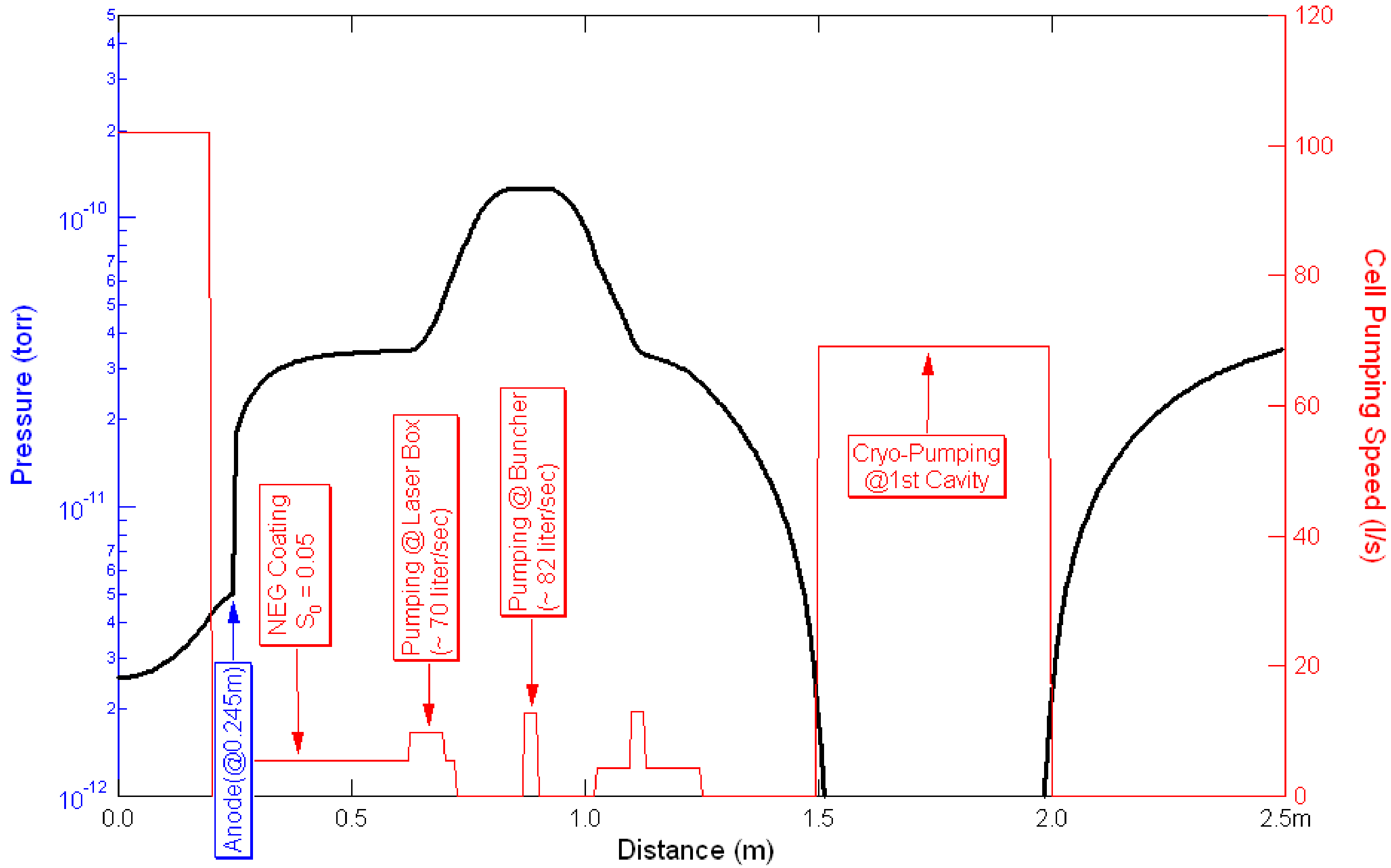
r(m)

Damage Profile: Realistic P

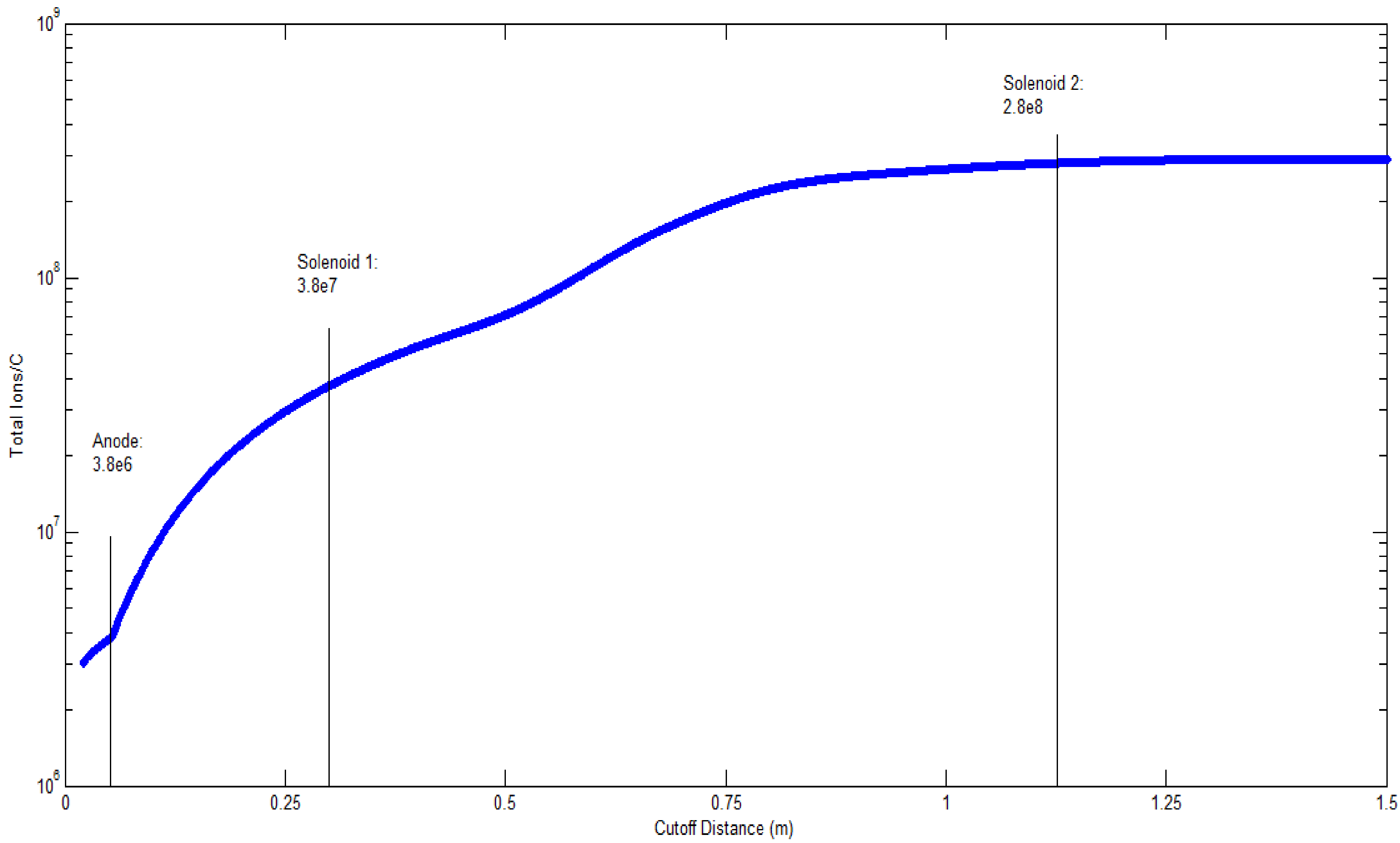


NEG Coating Drift

- Add a sticking coefficient in our pressure profile beyond the gun.

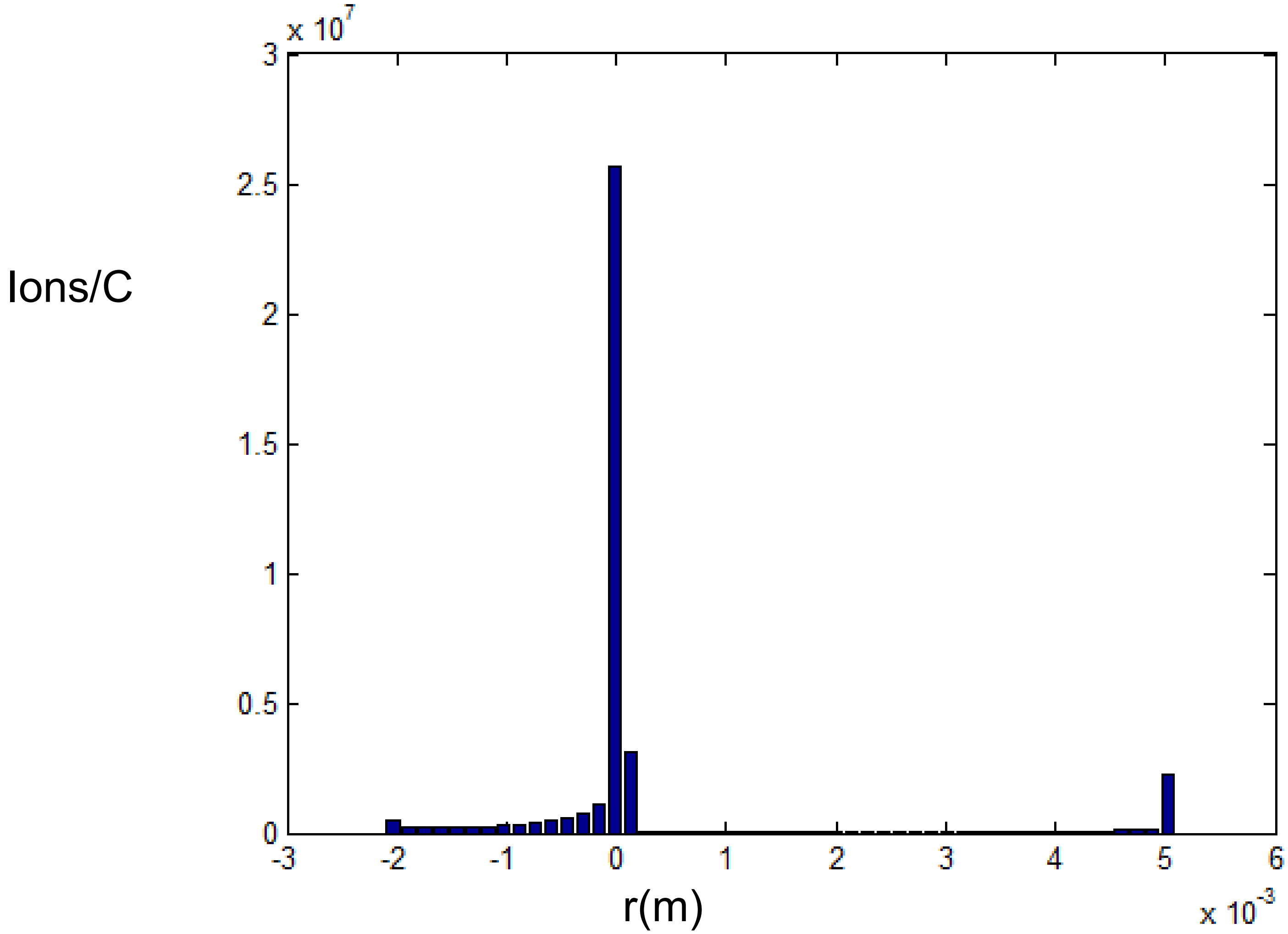


NEG Coating: Ions vs. Cutoff

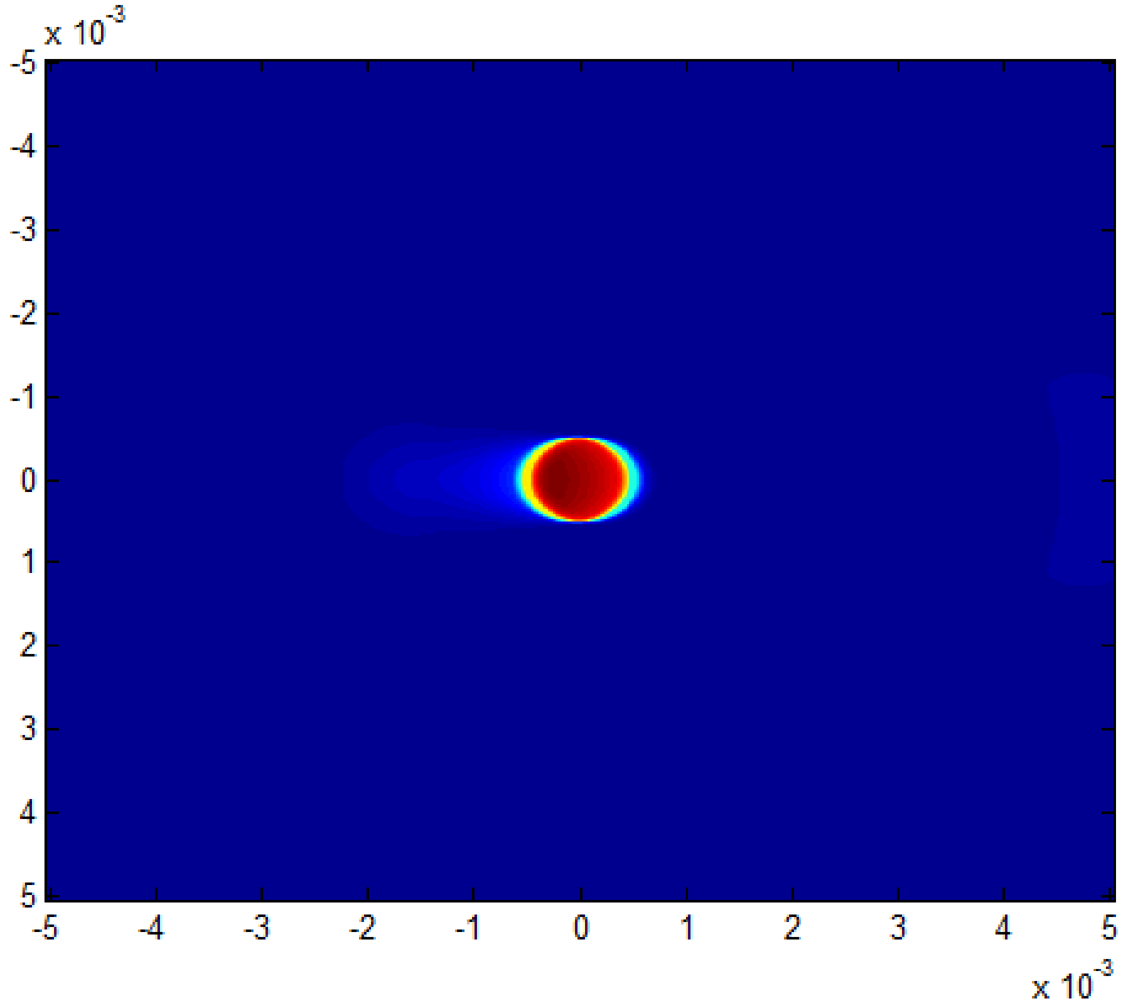


Neg Coating Damage Profile

- Integrate out to first solenoid:

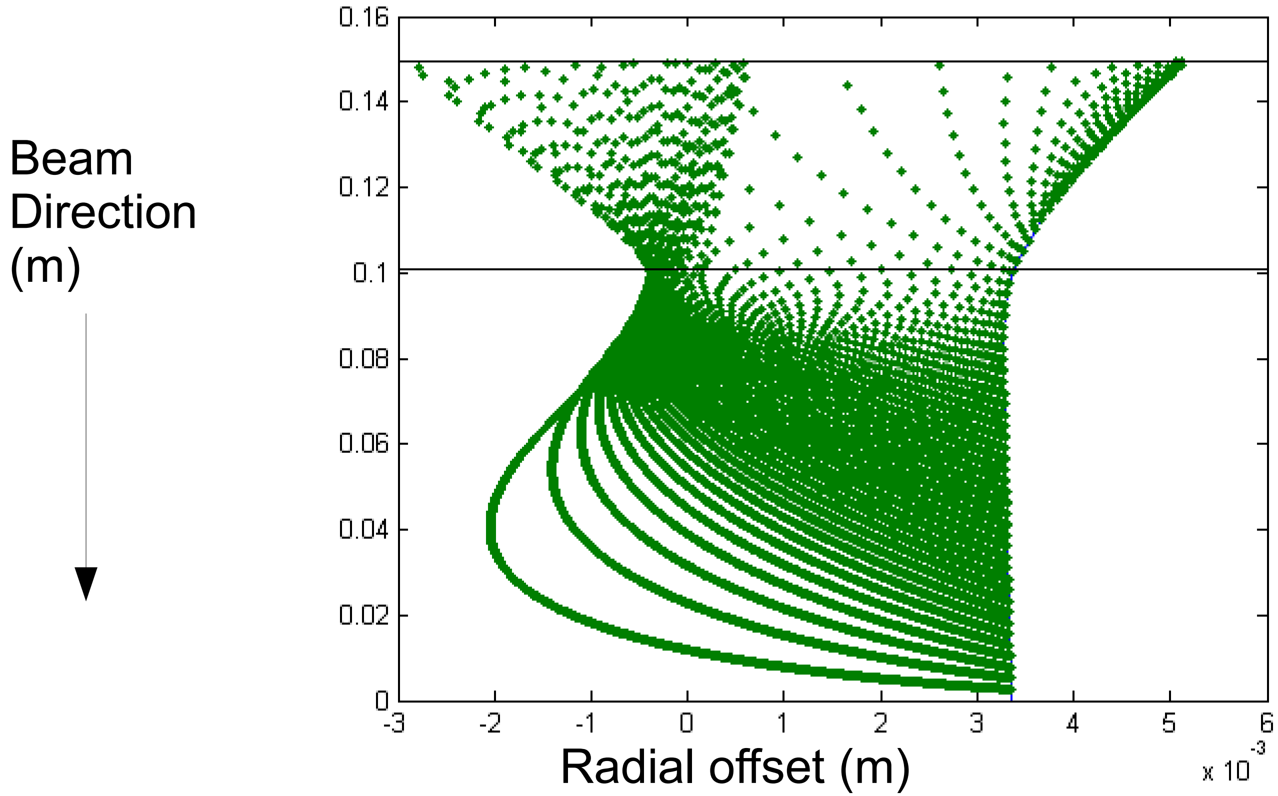


Neg Coating Damage Profile



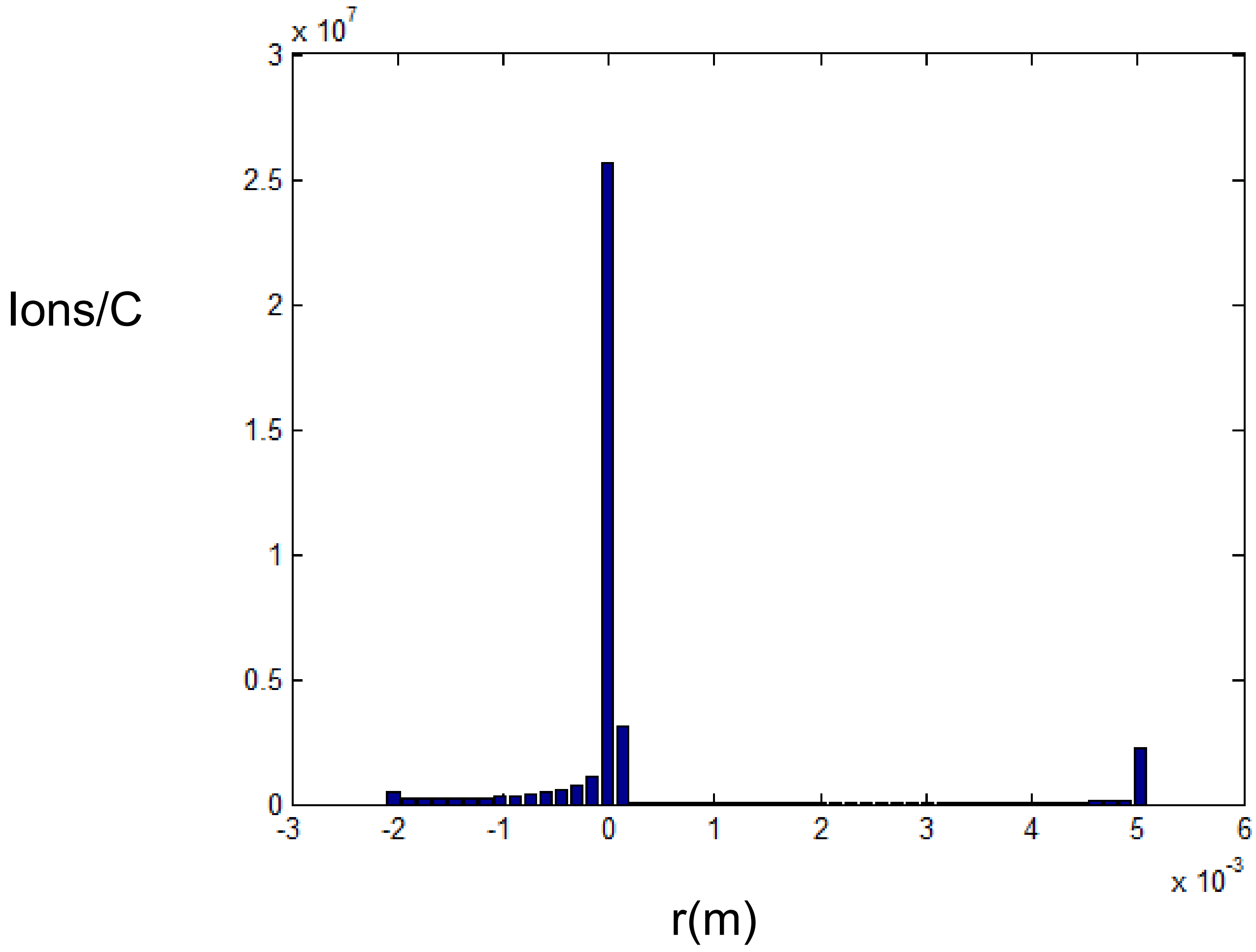
Flatter Cathode?

- What would the effect of a flatter cathode be?
- Retrack an initial electron, 5mm offset.
  - Alpha~17 deg—Slightly defocused. Assume solenoids/correctors will center the beam.



Flatter Cathode, NEG Coat

- Essentially the same damage:



Conclusions

- Ions from inside the gun impact at/around emission site.
- Currently, damage dominated by post-gun ions hitting p.c. center.
- NEG Coating subsequent drift could reduce ions in/around center of p.c. by a factor of 10.
- Characteristic damage profile if beam offset held constant.
- Can allow for a prediction of 1/e charge lifetime.

Discussion

- Damage caused by a single 500kV ion:
  - Sputtering yield?
  - Cs loss vs. QE degradation?
- Improvements to model
  - Beam envelope potential
  - Solenoid fields
  - SRIM/TRIM