Optimization of the Extraction Efficiency of a Gas stopper using a Th-228 Source

CYCLOTRON INSTITUTE
TEXAS A&M UNIVERSITY

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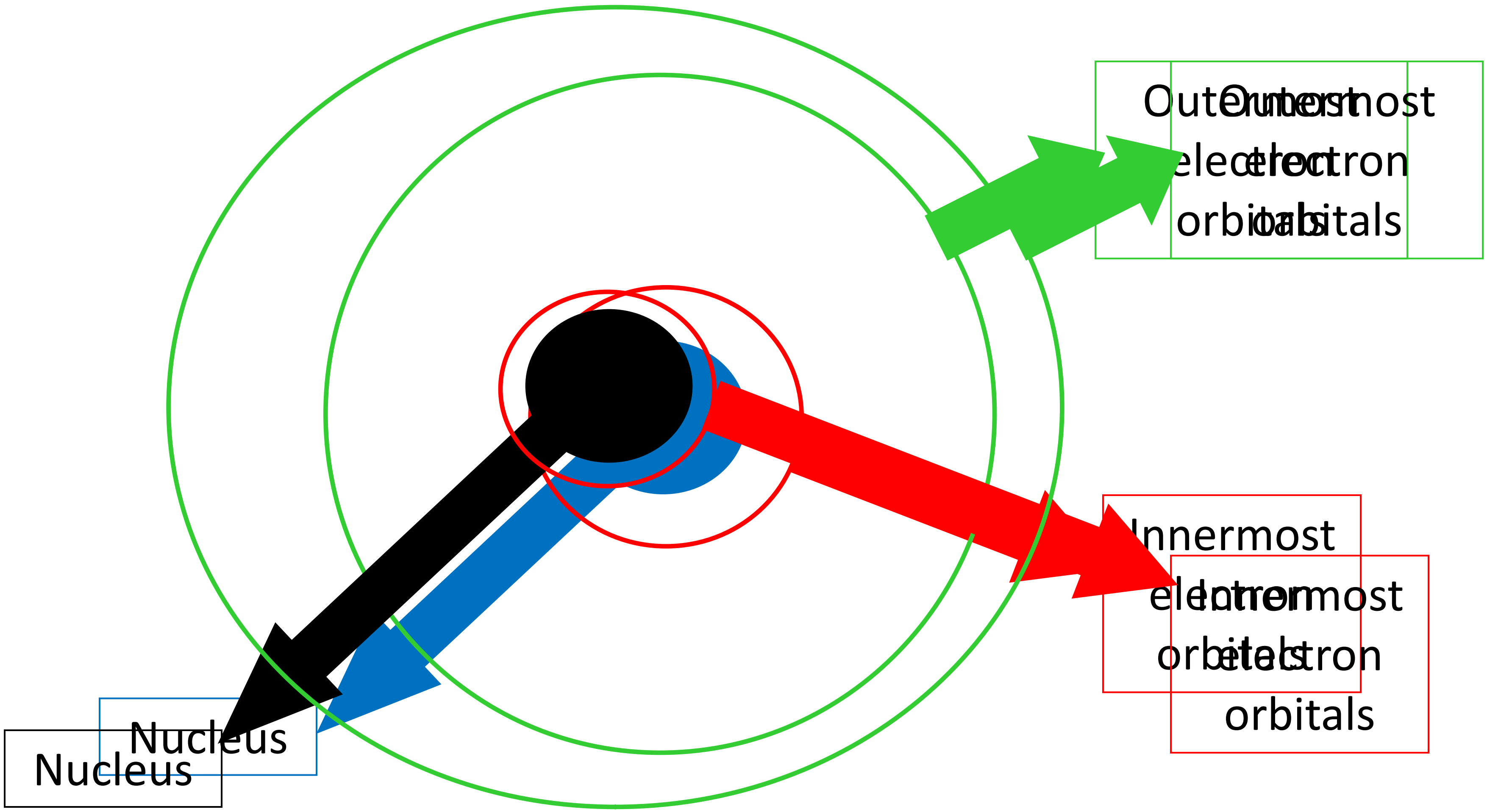
“Heavy” interest in Gas Stopper

1 1.01 H Hydrogen																	2 4.003 He Helium
3 6.94 Li Lithium	4 9.01 Be Beryllium											5 10.81 B Boron	6 12.01 C Carbon	7 14.01 N Nitrogen	8 15.999 O Oxygen	9 18.998 F Fluorine	10 20.18 Ne Neon
11 22.99 Na Sodium	12 24.31 Mg Magnesium											13 26.98 Al Aluminium	14 28.09 Si Silicon	15 30.97 P Phosphorus	16 32.06 S Sulfur	17 35.45 Cl Chlorine	18 39.95 Ar Argon
19 39.10 K Potassium	20 40.08 Ca Calcium	21 44.96 Sc Scandium	22 47.90 Ti Titanium	23 50.94 V Vanadium	24 51.996 Cr Chromium	25 54.94 Mn Manganese	26 55.85 Fe Manganese	27 58.93 Co Cobalt	28 58.70 Ni Nickel	29 63.55 Cu Copper	30 65.37 Zn Zinc	31 69.72 Ga Gallium	32 72.59 Ge Germanium	33 74.92 As Arsenic	34 78.96 Se Selenium	35 79.90 Br Bromine	36 83.80 Kr Krypton
37 85.47 Rb Rubidium	38 87.62 Sr Strontium	39 88.91 Y Yttrium	40 91.22 Zr Zirconium	41 92.91 Nb Niobium	42 95.94 Mo Molybdenum	43 (98) Tc Technetium	44 101.7 Ru Ruthenium	45 102.91 Rh Rhodium	46 106.40 Pd Palladium	47 107.87 Ag Silver	48 112.41 Cd Cadmium	49 114.82 In Indium	50 118.69 Sn Tin	51 121.75 Sb Antimony	52 127.60 Te Tellurium	53 126.90 I Iodine	54 131.30 Xe Xenon
55 132.91 Cs Cesium	56 137.33 Ba Barium	57 138.91 La Lanthanum	72 178.49 Hf Hafnium	73 180.85 Ta Tantalum	74 183.85 W Tungsten	75 186.21 Re Rhenium	76 190.20 Os Osmium	77 192.22 Ir Iridium	78 195.09 Pt Platinum	79 196.97 Au Gold	80 200.59 Hg Mercury	81 204.37 Tl Thallium	82 207.19 Pb Lead	83 208.98 Bi Bismuth	84 (209) Po Polonium	85 (210) At Astatine	86 (222) Rn Radon
87 (223) Fr Francium	88 226.03 Ra Radium	89 227.0 Ac Actinium	104 (261) Rf Rutherfordium	105 (262) Db Dubnium	106 (266) Sg Seaborgium	107 (262) Bh Bohrium	108 (265) Hs Hassium	109 (266) Mt Meitnerium	110 (271) Ds Darmstadtium	111 (272) Rg Roentgenium	112 (277) Cn Copernicium	113 (284) 113	114 (288) Fl Flerovium	115 (288) 115	116 (292) Lv Livermorium	117 (293) 117	118 (294) 118

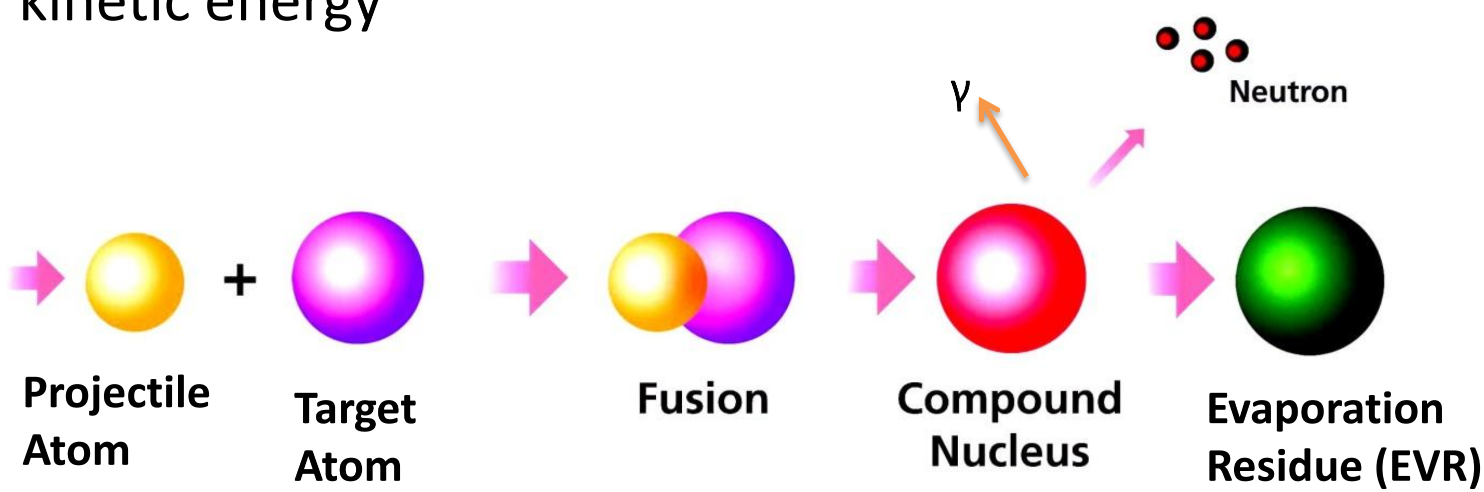
Lanthanides	58 140.12 Ce Cerium	59 140.91 Pr Praseodymium	60 144.24 Nd Neodymium	61 (145) Pm Promethium	62 150.40 Sm Samarium	63 151.96 Eu Europium	64 157.25 Gd Gadolinium	65 158.93 Tb Terbium	66 162.50 Dy Dysprosium	67 164.93 Ho Holmium	68 167.93 Er Erbium	69 168.93 Tm Thulium	70 173.04 Yb Ytterbium	71 174.97 Lu Lutetium
Actinides	90 232.04 Th Thorium	91 231.04 Pa Protactinium	92 238.03 U Uranium	93 237.05 Np Neptunium	94 (244) Pu Plutonium	95 (243) Am Americium	96 (247) Cm Curium	97 (247) Bk Berkelium	98 (251) Cf Californium	99 (252) Es Einsteinium	100 (257) Fm Fermium	101 (260) Md Mendelevium	102 (259) No Nobelium	103 (262) Lr Lawrencium

Relativistic Effects

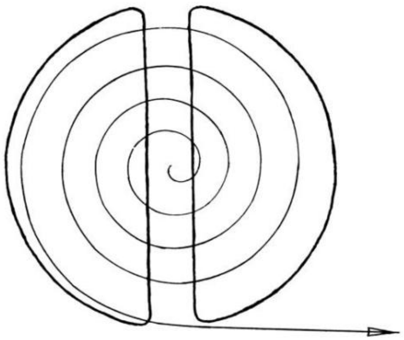


Fusion Evaporation Reactions

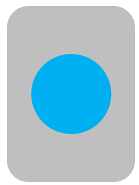
- Irradiate a target with accelerated particles
- Atoms fuse into highly excited compound nucleus
- Compound nucleus de-excites through the emission of nucleons and gamma rays
- Evaporation Residues (EVRs) also have 30 -50 MeV of kinetic energy



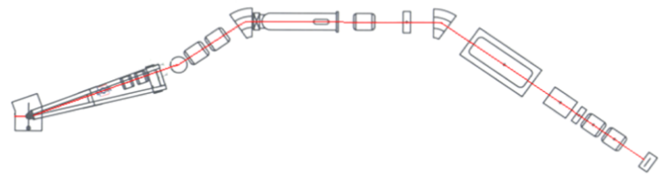
Turning Theory into Reality



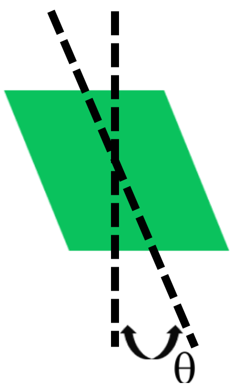
Beam From
Cyclotron



Target

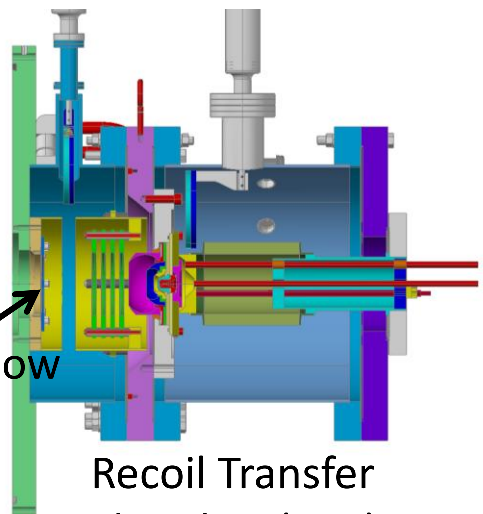


MARS
Physical Pre-Separator



Variable Angle
Degrader

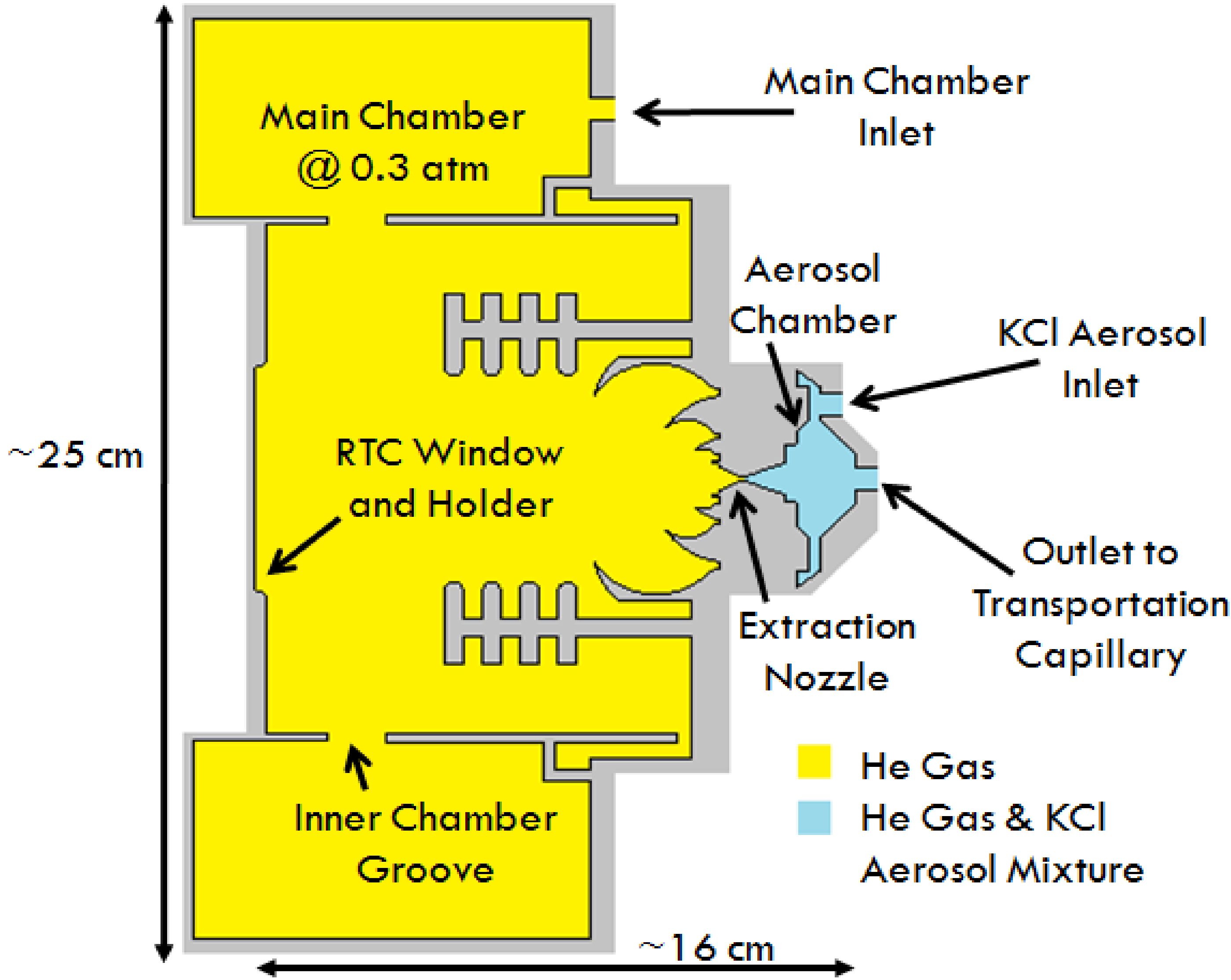
RTC Window



Recoil Transfer
Chamber (RTC)

Chemistry
Experiment

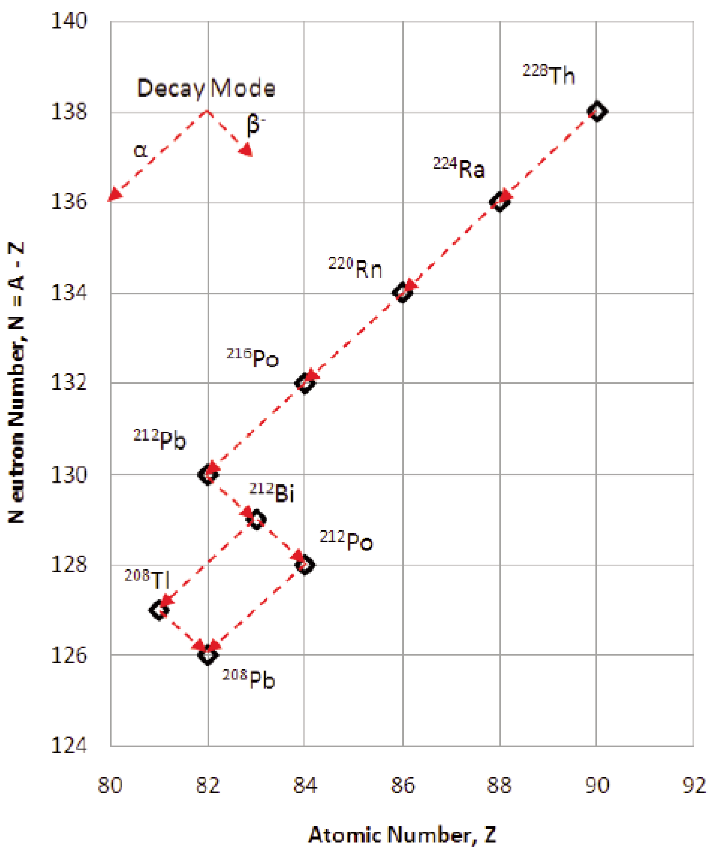
Inside RTC

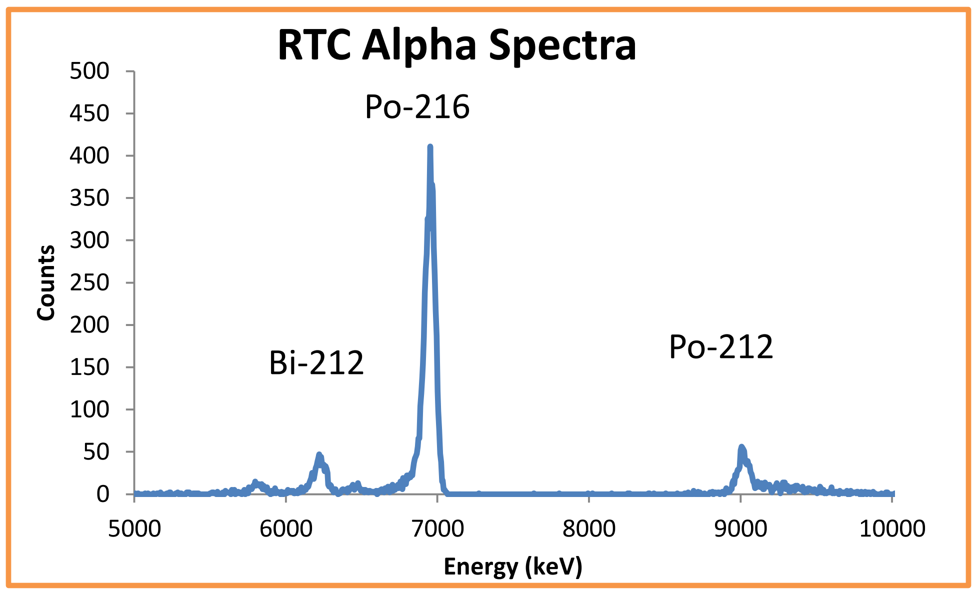


Courtesy of Marisa C. Alfonso

Experimentation

Monitor Po-216 recoils from a Th-228 source with varying potential difference on electrodes

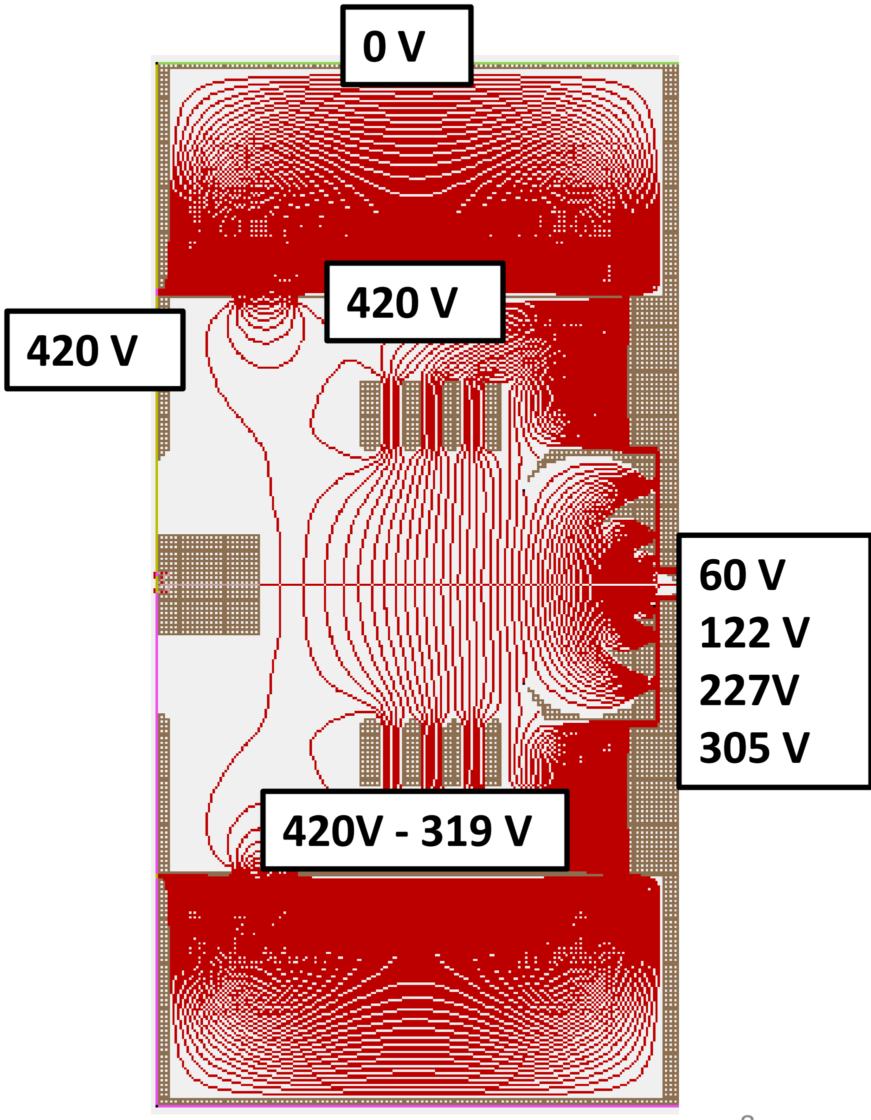




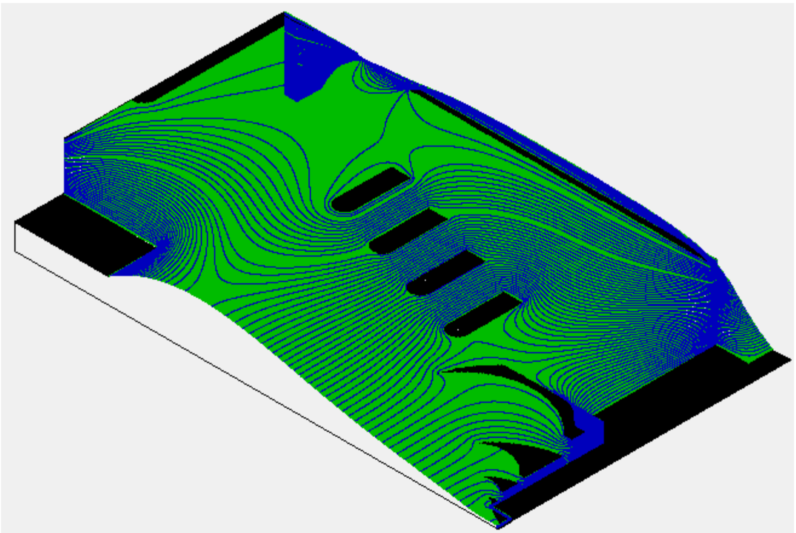
http://www.ortec-online.com/Solutions/RadiationDetectors/silicon-charged-particle-detectors.aspx

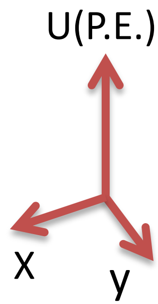
Optimization set-up

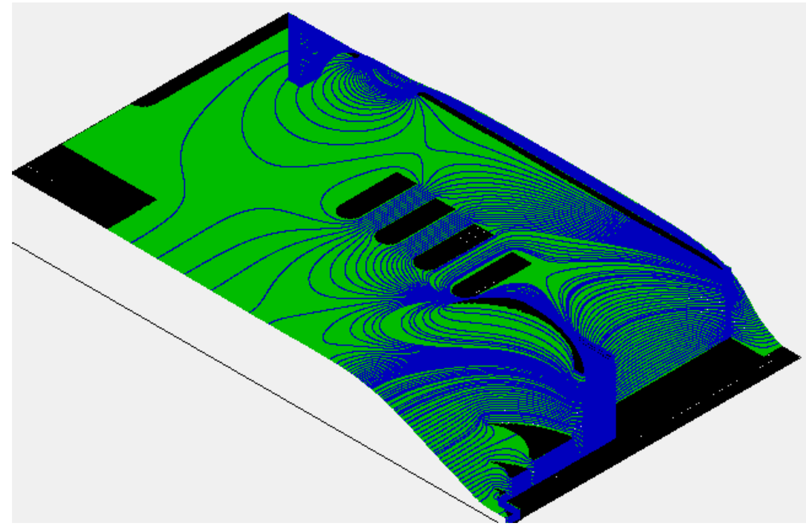
- Mount Th-228 source to source holder
- Ions travel perpendicular to the equipotential lines (red lines)

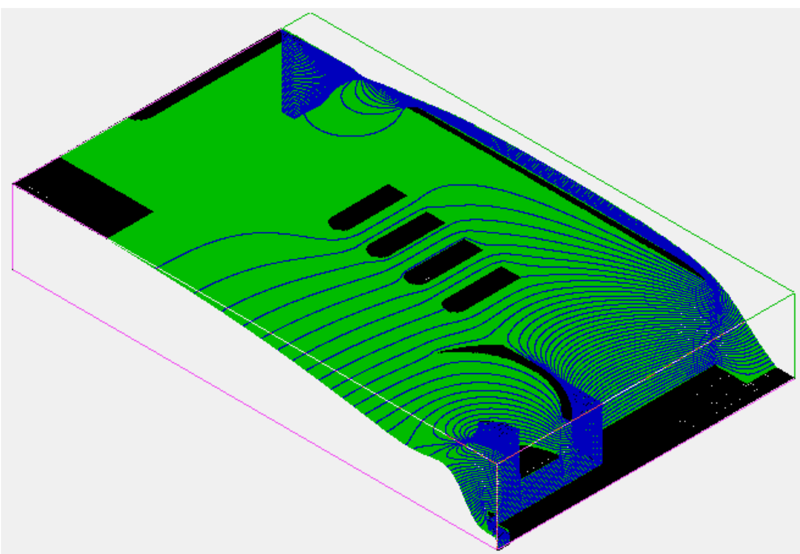


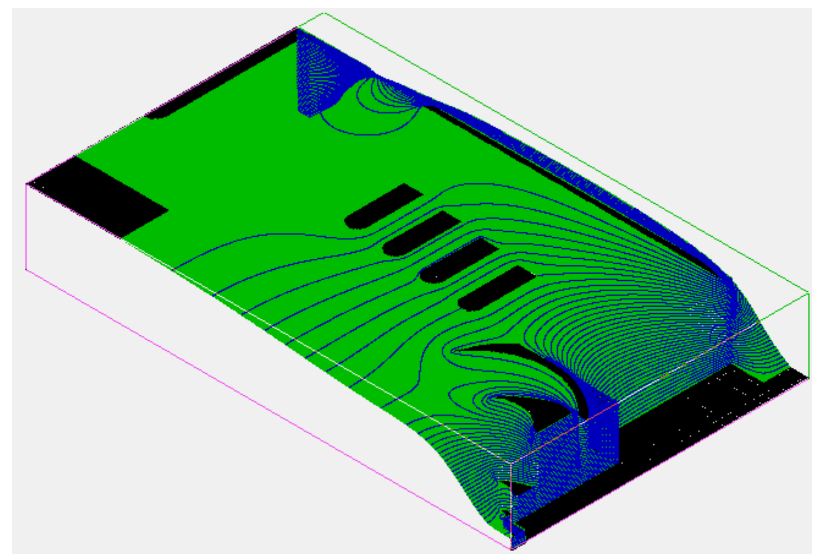
Undesirable Potential Energy Surfaces





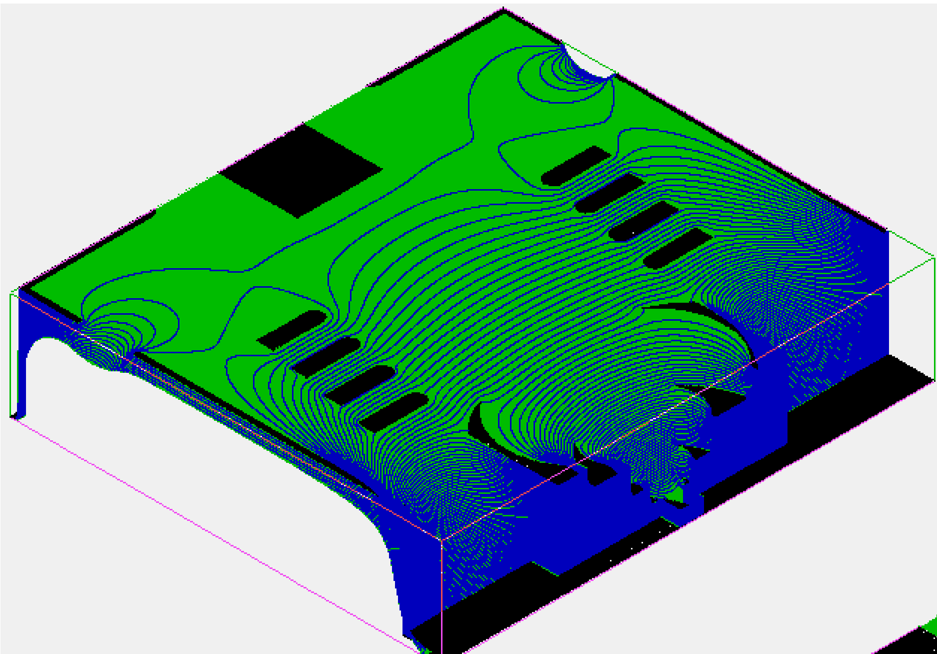




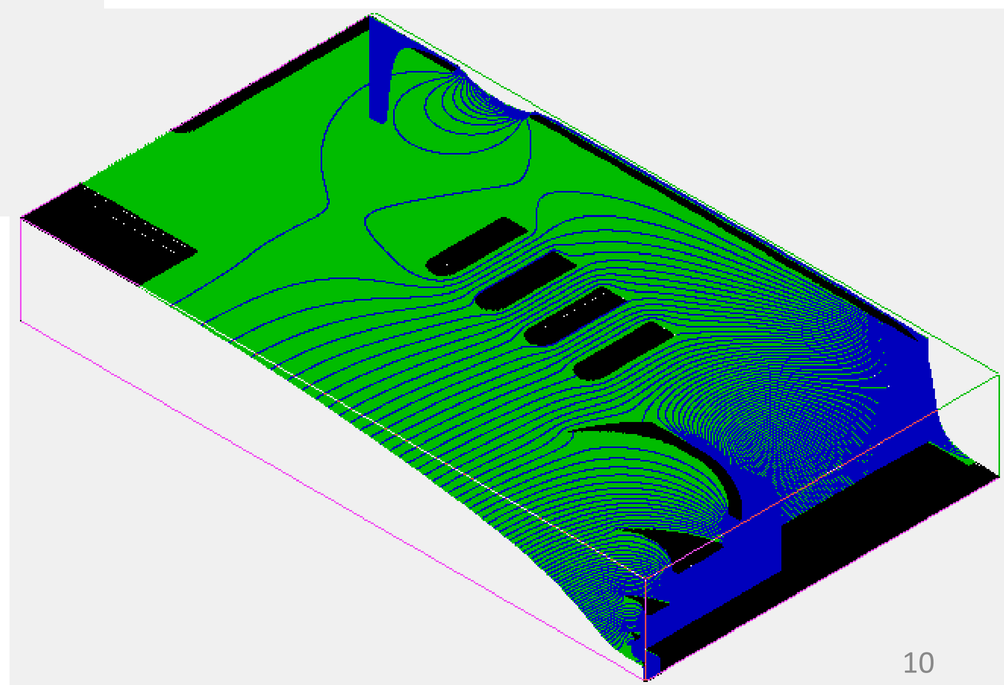


Try **not** to create these environments

Desirable Potential Energy Surfaces



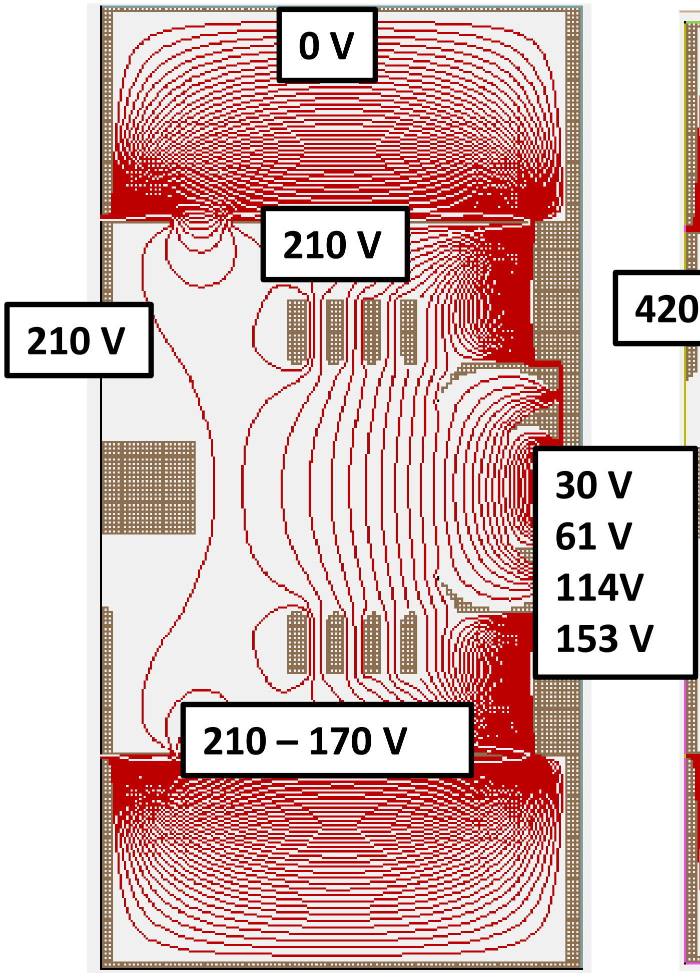
Goal : Have EVRs “roll down” the potential energy surface



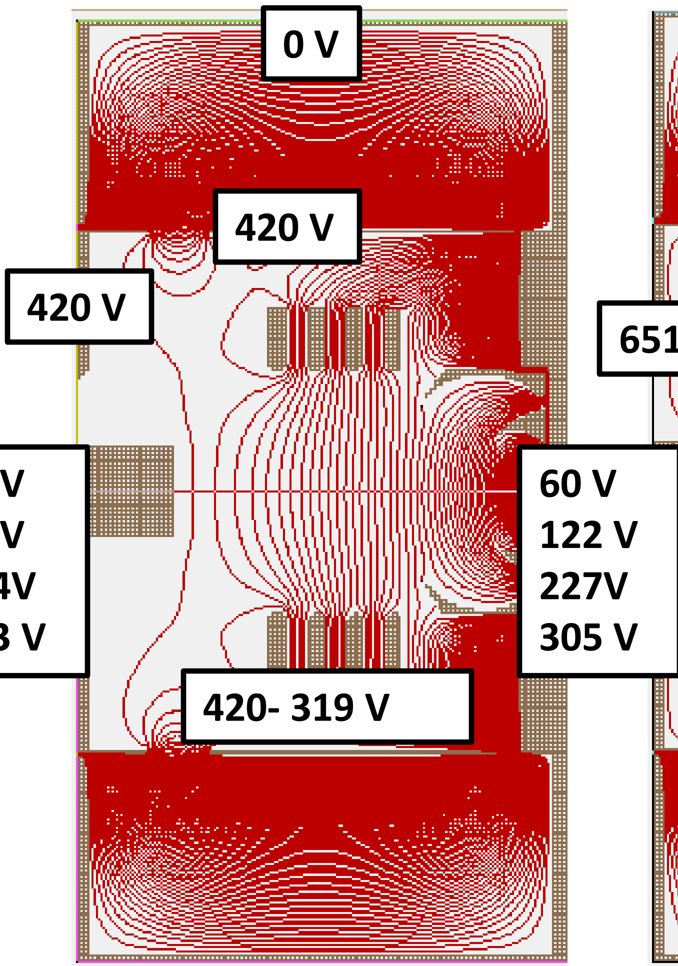
• Gentle slope to extraction nozzle
• Focusing of ions/EVRs prior to first ring electrode and first spherical electrode
• Lack of radial electric fields

Scales

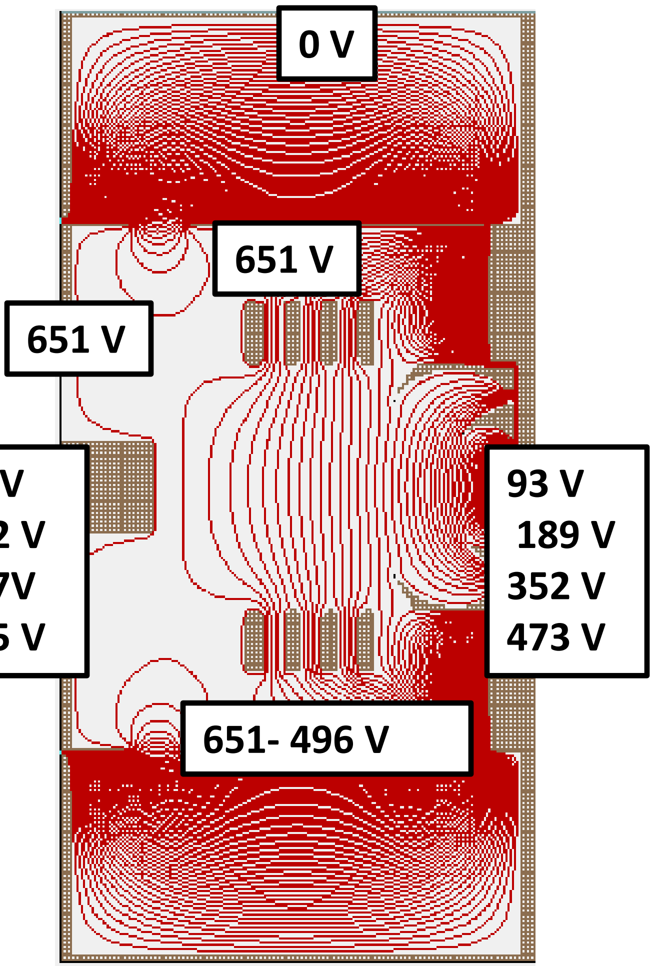
0.5 Scale



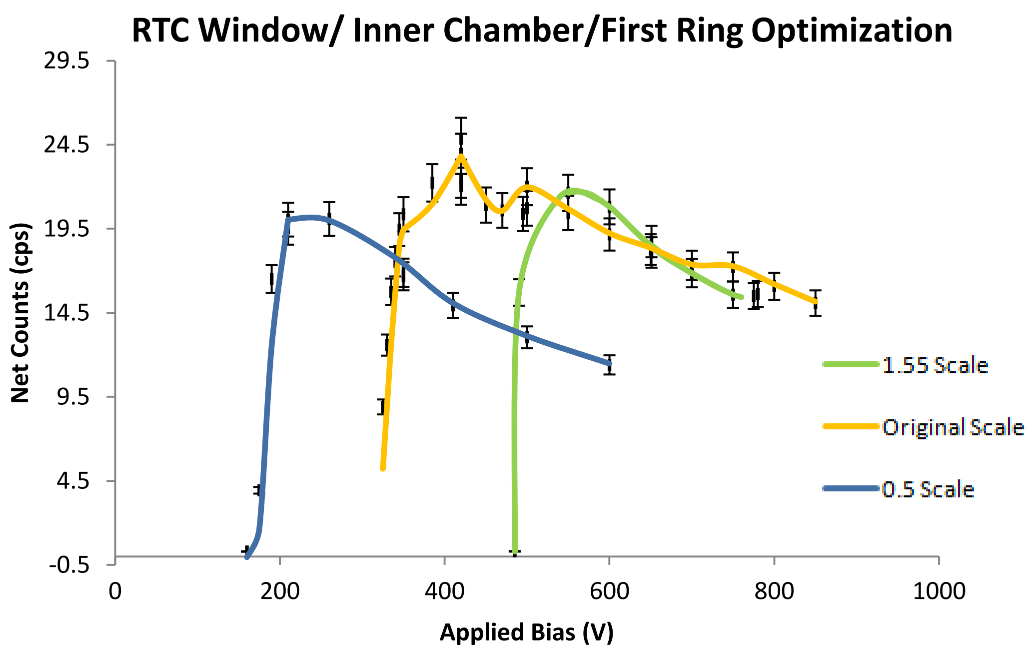
Original Scale

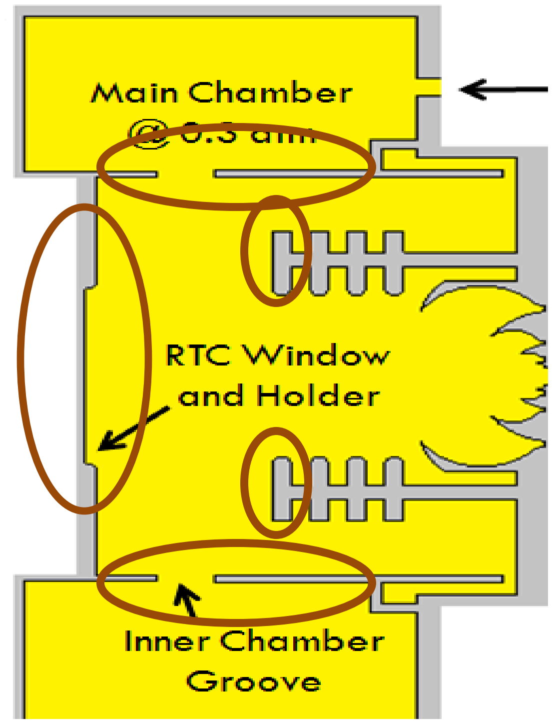


1.55 Scale



Experimental Data

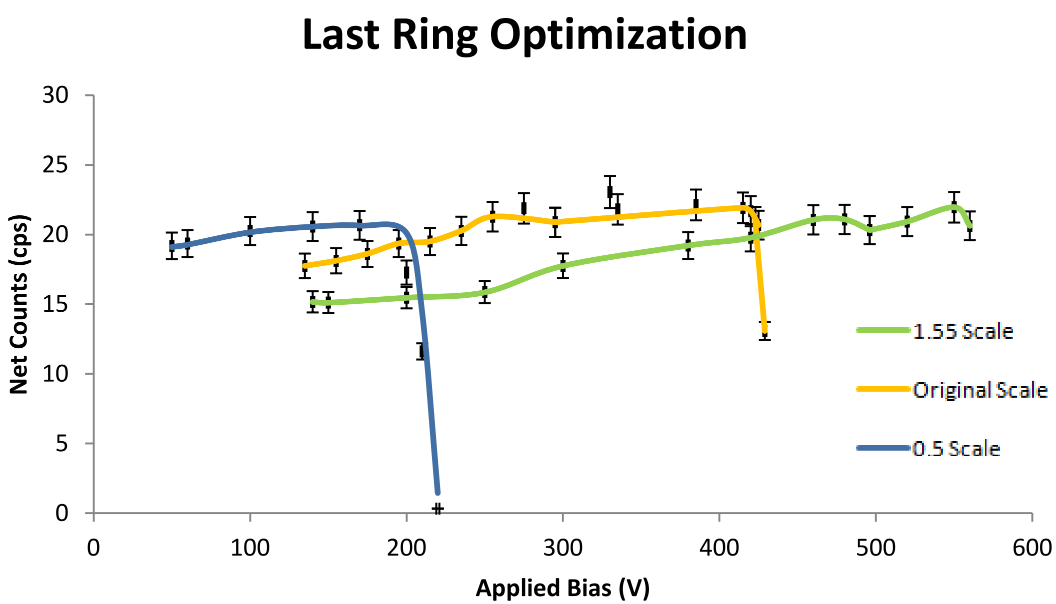


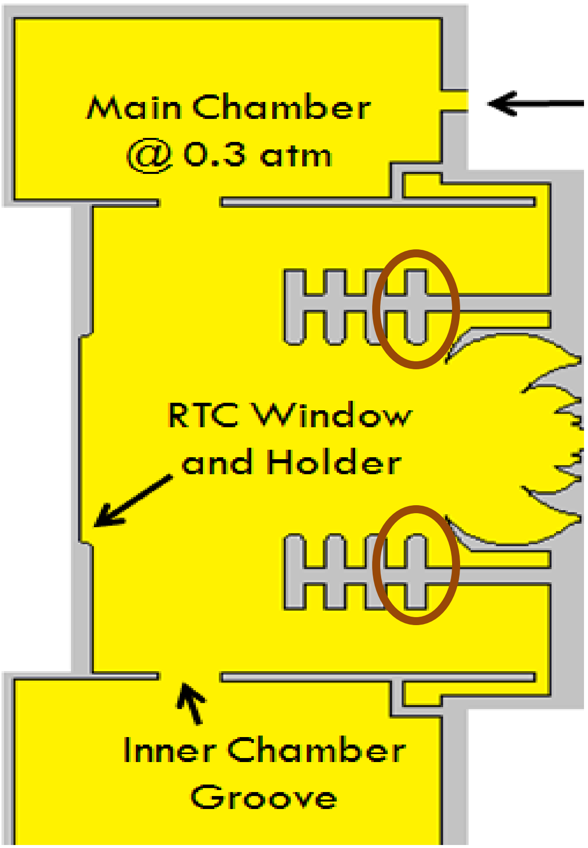


Courtesy of M.C. Alfonso

Disclaimer: Trend line shown above is to guide the eye.

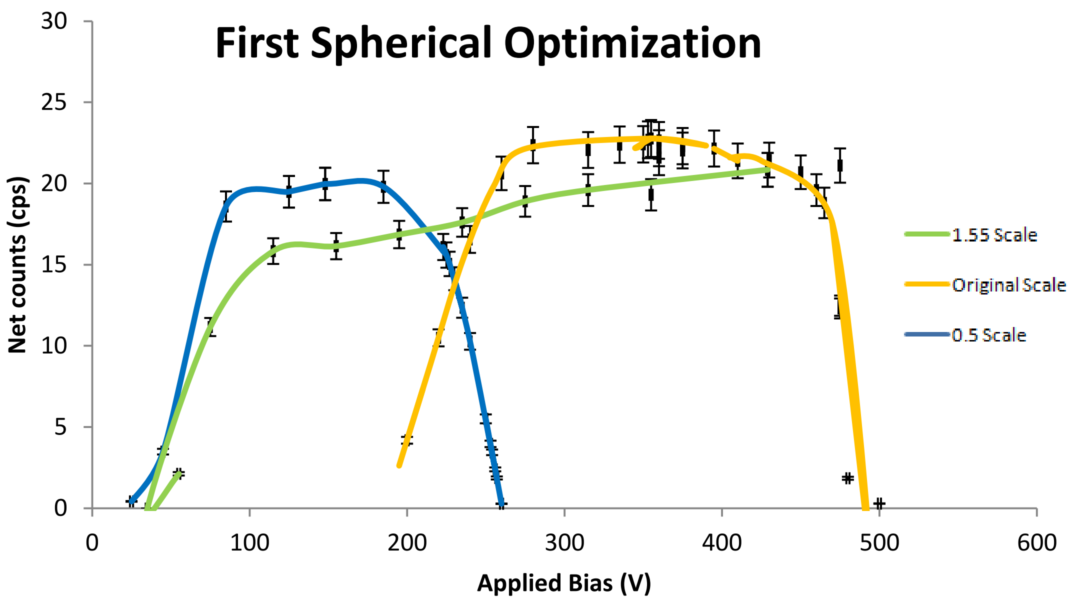
Experimental Data

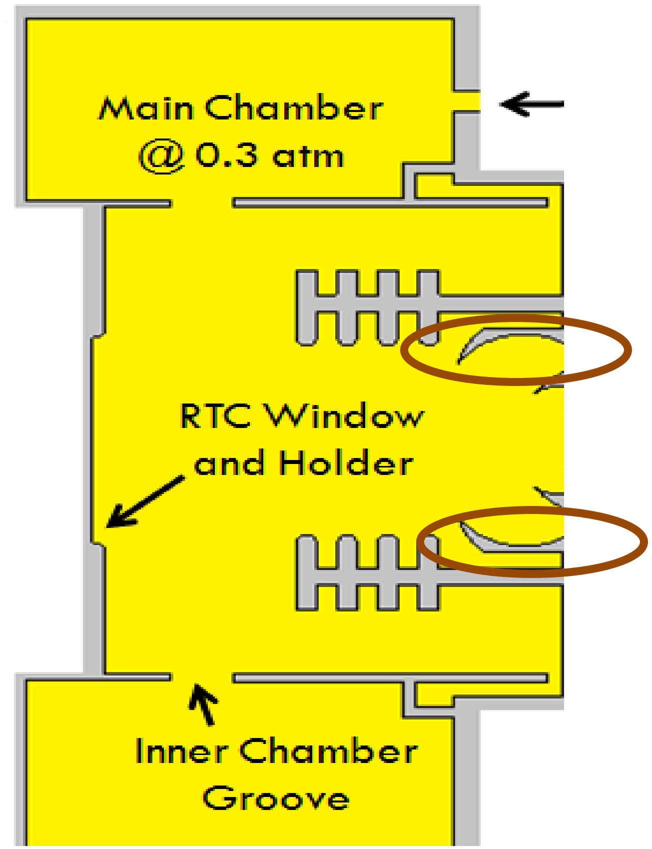




Courtesy of M.C. Alfonso

Experimental Data



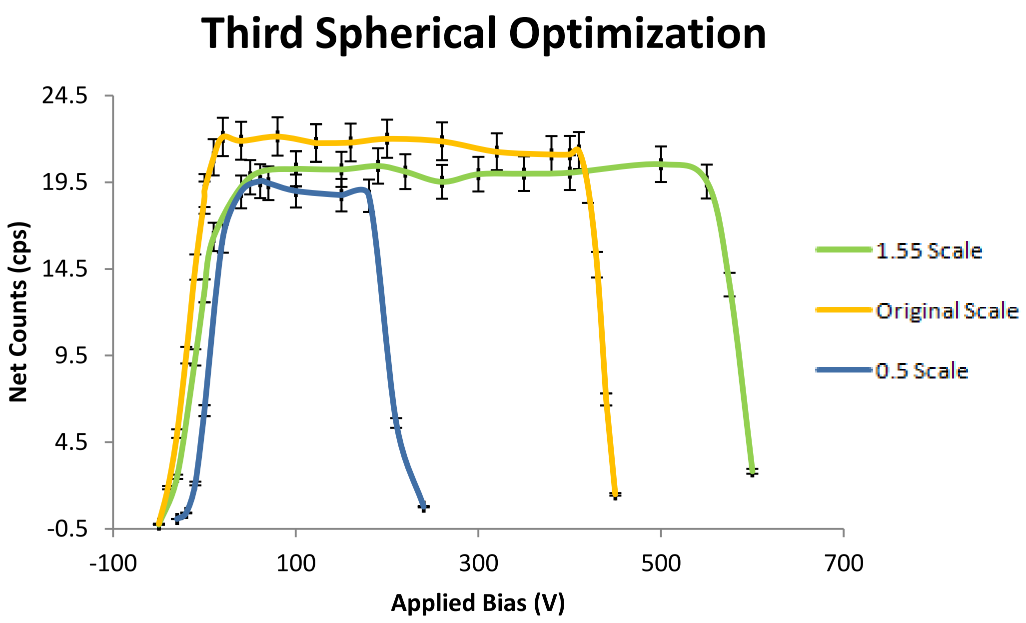


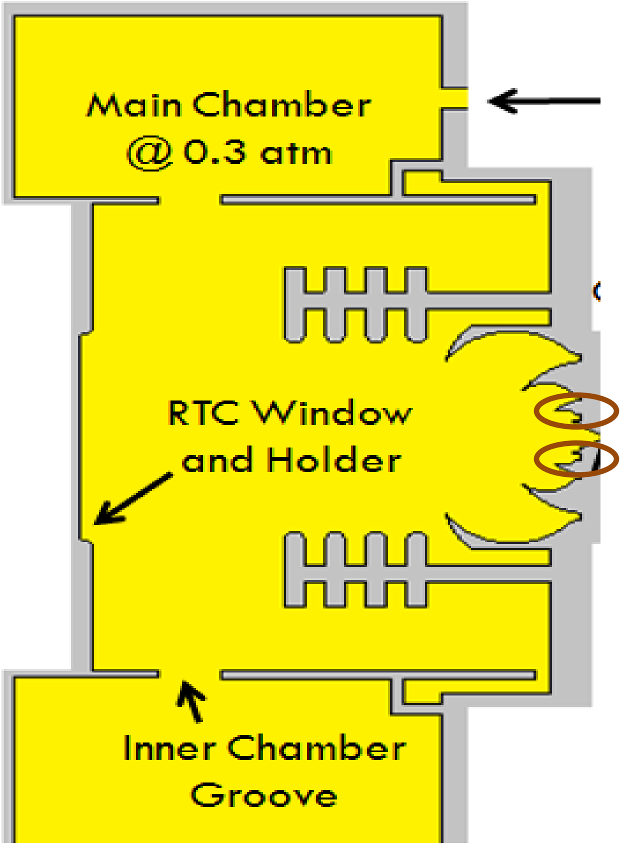
Courtesy of M.C. Alfonso

Irregularity and Sensitivity of First Petal:

- Proximity to last ring (arc discharging at high voltages)
- Sharp points and uniform electric fields are not compatible

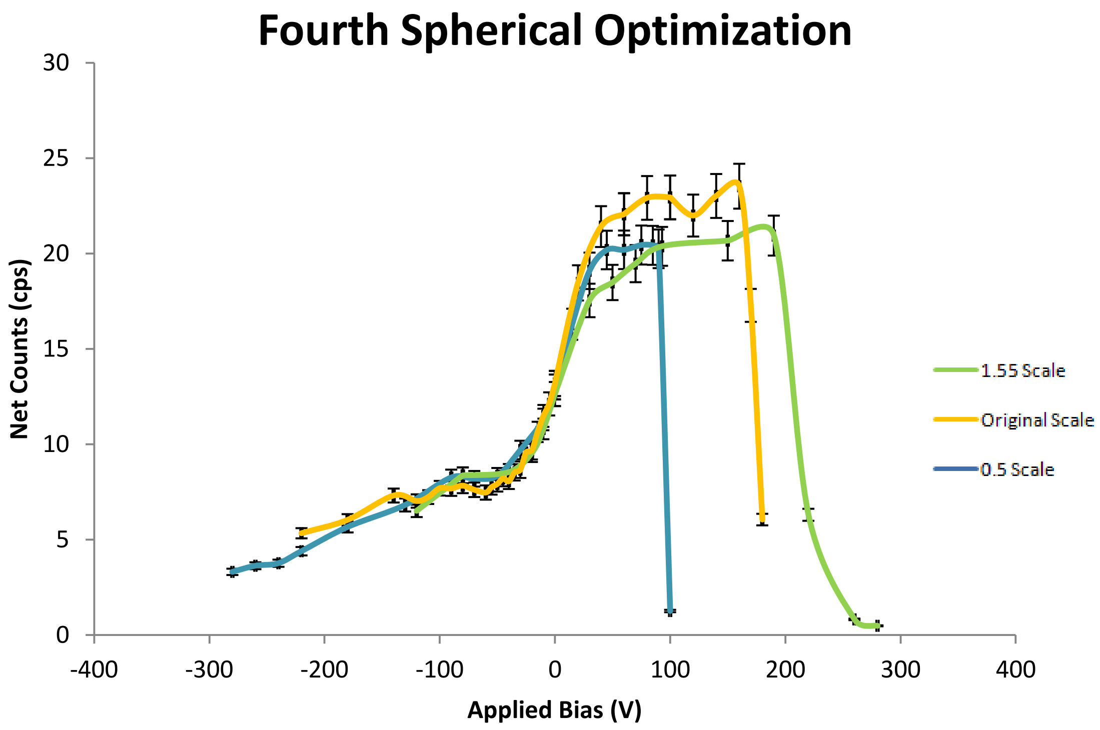
Experimental Data

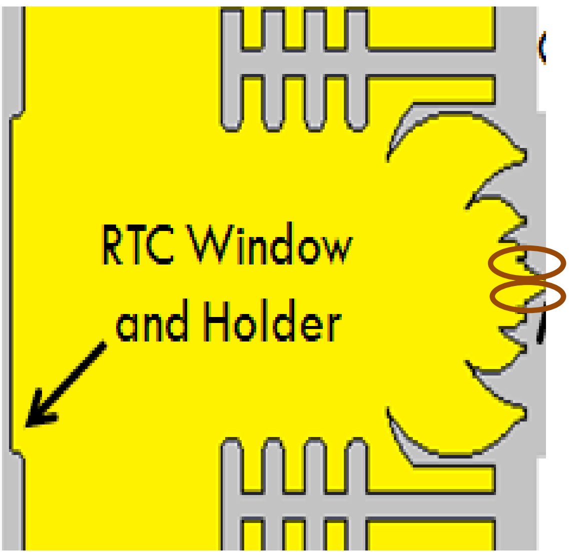




Courtesy of M.C. Alfonso

Experimental Data

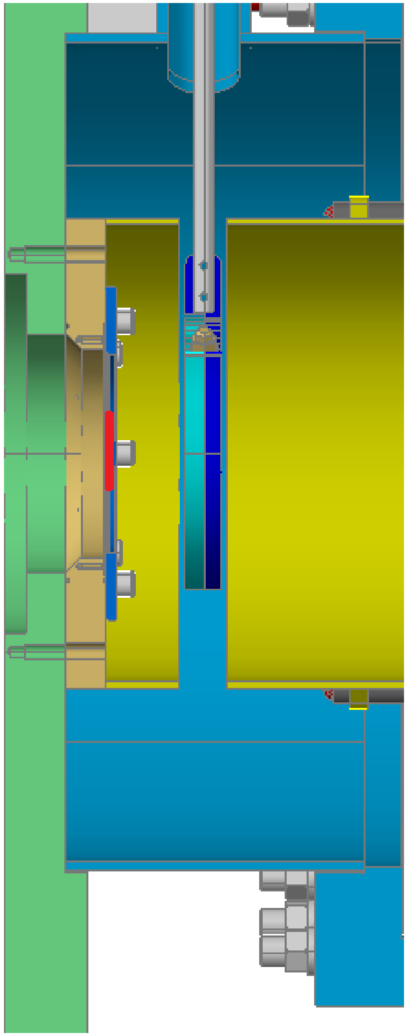




Courtesy of M.C. Alfonso

Radon Emanation

- Removed of ring and spherical electrodes and source holder
- Assuming 3% radon emanation
- Maximum count rate attained : 30 cps
- Highest experimental count rate : 21 cps
- Extraction efficiency up to 70%



Courtesy of M. C. Alfonso and Stephen Molitor

Conclusions and Future Endeavors

- Optimal electrode configuration were observed with the original scale.
- A range or tolerance on individual electrodes has been determined.
- Extraction efficiency up to 70%

Future Work

- Modifications to RTC window
- Replace Spherical electrodes with RF carpet

Acknowledgements

A genuine thank you goes to Marisa C. Alfonso for training on the RTC and assistance in data analysis.

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