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COUPLER DESIGN FOR RISP SPOKE CAVITY

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ABSTRACT

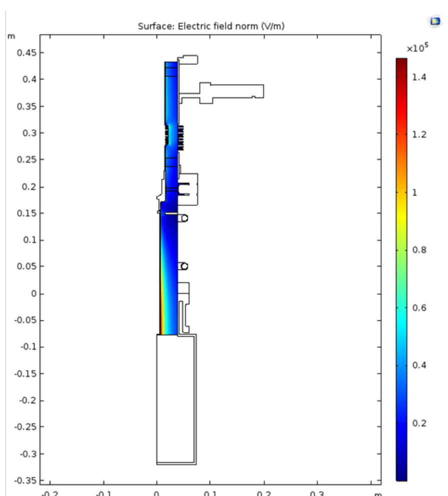
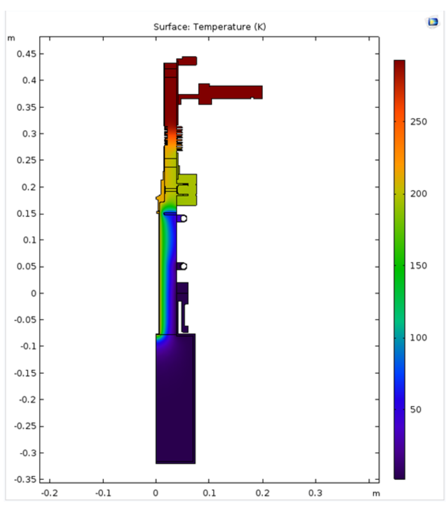
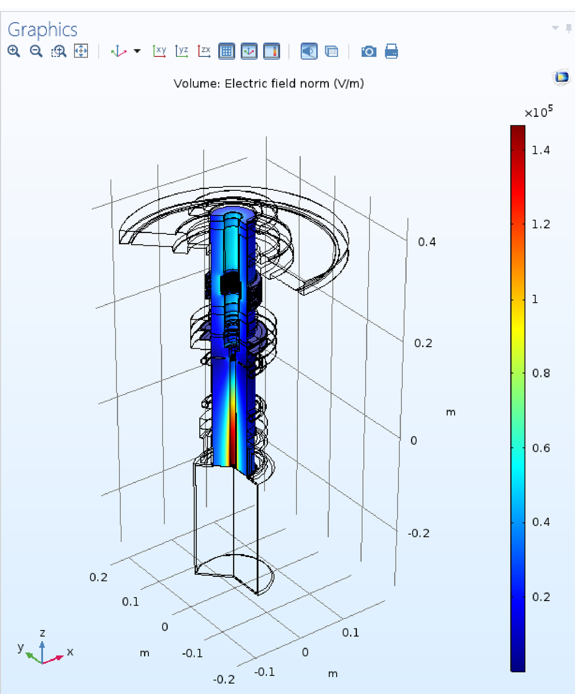
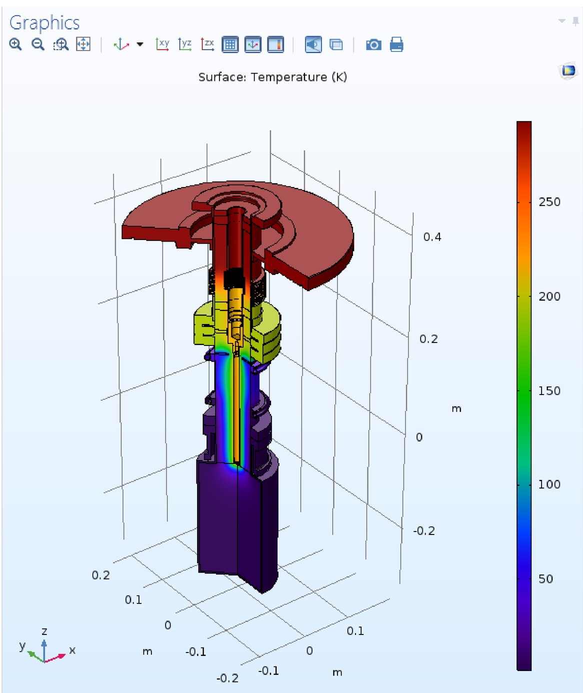
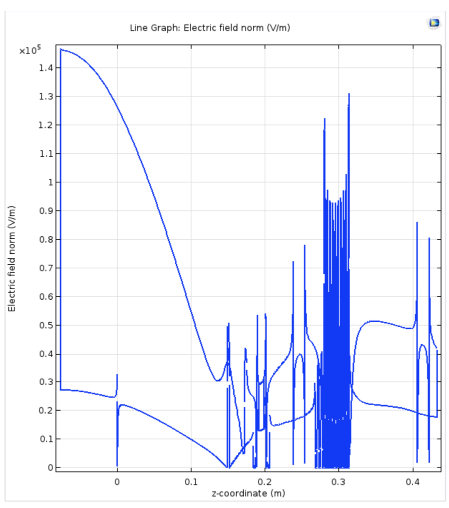
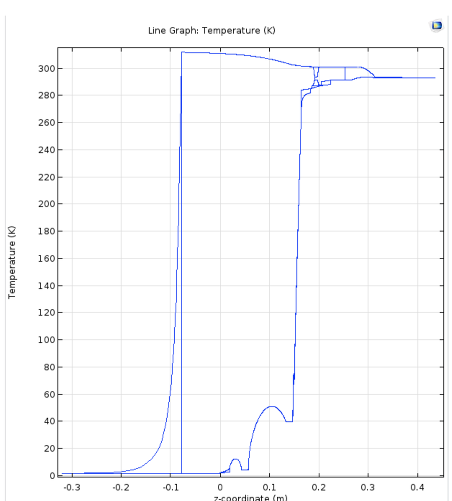
The RISP project includes a heavy ion linac to accelerate ions up to 238U to 200MeV/u with 400kW of beam power. The same accelerator will also be capable of accelerating light ions with proton currents and final energy of 0.66mA and 600MeV. TRIUMF designed the superconducting single spoke resonator for the linac SSR1 at 325 MHz for beta=0.3. In according to specifications the cavity will require the RF coupler capable for operation in CW in regime close to full reflection with forward power of 5 kW. This paper reports about the RF coupler specifications, simulations and design.

Comsol Multiphycics Simulations

The coupler design was developed with modeling and simulation in Comsol Multiphysics environment; coupled RF and Thermal simulations. 2D axial symmetrical geometry. The preliminary model was checked with ANSYS with similar results.
Final design option was checked with Comsol for the cavity maximum regime. The coupler was simulated for maximum regime. We apply 10W to heat up RF window to avoid moisture on air side.

- Heat loads for maximum regime are in the range of heat load guide lines: 0.4W for 2K, 1.0W for 4.5K, 17.5W for 40K
- RF window: temperature gradient across inner and outer conductor is ~20K, RF loss <40mW
- RF loss in the coupler is <10W

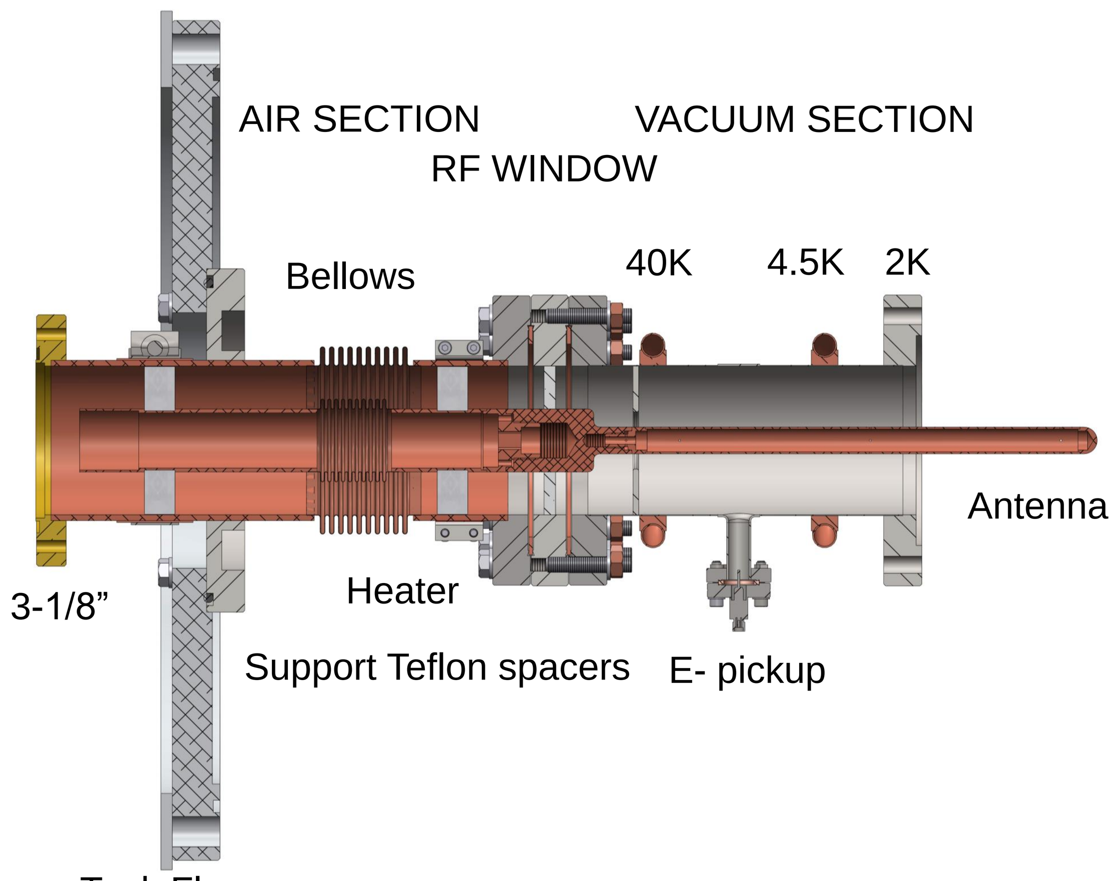
Parameter	Unit	Value
RF input forward power, $P_{for\ in}$	kW	2.68
Input VSWR, $VSWR_{in}$		2.8
RF loss in the coupler, P_{loss}	W	8.8
RF loss in RF window, P_{window}	mW	40
Maximum electric field in air section (bellows), E_{air} (should be <10 kV/cm)	kV/cm	1.4
Temperature gradient across the inner and outer conductor of RF window, DT_{window}	K	20
RF window temperature on air side, T_{window}	K	295
Heat load for 2K	W	0.356
Heat load for 4K	W	0.966
Heat load for 40K	W	17.5

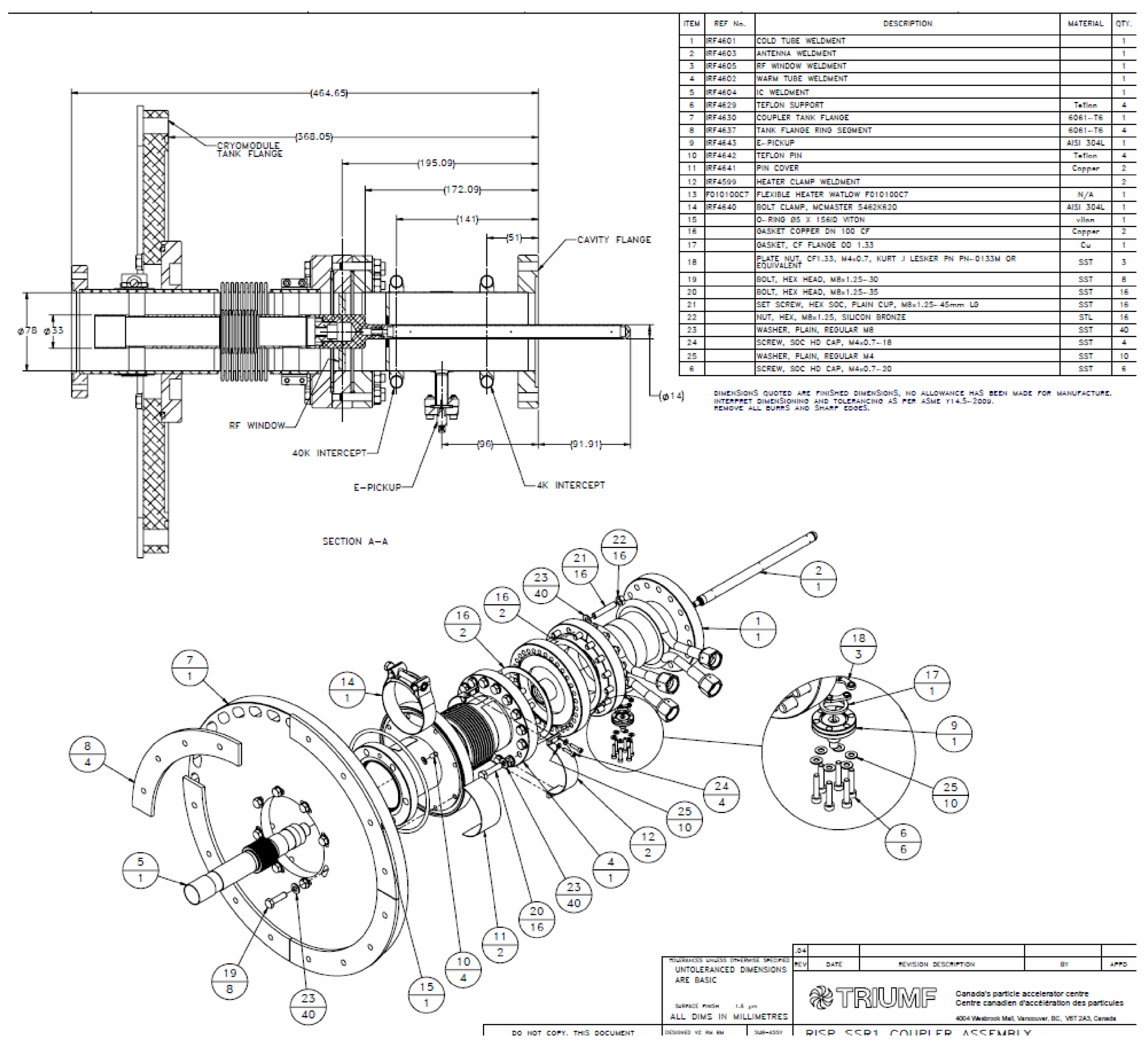







Surface RF Electric Field
<1.5 kV/cm

Surface Temperature

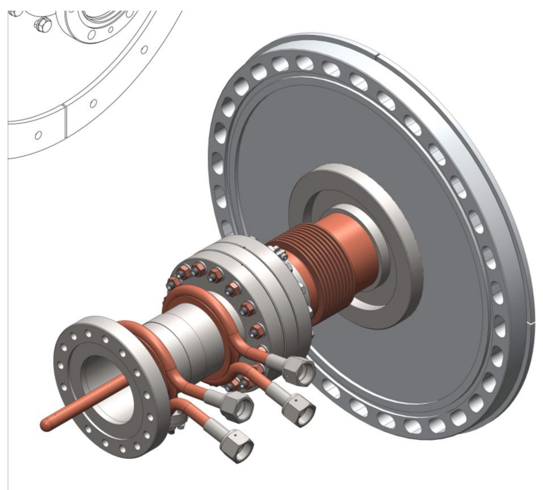
Design





Coupler design for SSR1 cavity

- SW regime, overcoupled to sustain microphonics
- It consist of vacuum section (hermetic unit) with antenna, RF window and air section (50 Ohm coaxial line)
- Electrical copper antenna, 100 Ohm coaxial, SS outer conductor
- Single RF Window, 50 Ohm, in E-field minimum of SW (low RF loss), heater to avoid moisture on air side
- Heat sinks for 4.5K and 40K He to reduce heat load for 2K
- Buffle disk covering RF window from cavity multipactor is also reducing multipacting emission in the coupler vacuum section
- BeCu Bellows in air section protect RF window from mechanical load and match the coupler for cryomodule assembly
- E-pickup for indication of multipacting activity
- 3-1/8" Coaxial Line RF interface



Conclusions

Coupler design for SSR1 cavity is developed at TRIUMF. It successfully went through simulations and verifications. The detailed design is is released in the drawing package.

Next steps:

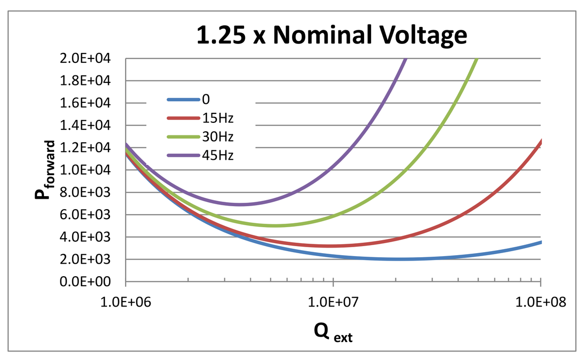
- RF window development; in cooperation with ceramic RF window provider
- Development of DC bias unit to fully mitigate multipacting for reliable coupler operation

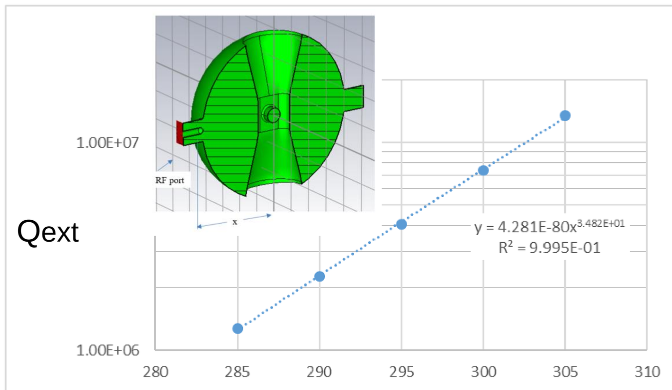
Power requirements

Parameter	Unit	Value
Effective acceleration voltage, Veff (1.25 of nominal)	MV	3.12
Beam current, I_{beam}	mA	0.66
Cavity quality factor, Q_0		5e9
Couper external quality factor, Q_{ext}		5.2e6
RF forward power in 100 Ohm antenna section, $P_{for\ a}$	kW	5.04
RF power transmitted to the cavity, $P_{transmit}$	kW	2.07
VSWR in 100 Ohm antenna section, $VSWR_a$		7.61
RF loss on the antenna tip from the cavity field, $P_{antenna}$	W	0.15
Heater power, P_{heat}	W	10

$$P_{for}=\frac{P_{cav}}{4\beta}\left[(1+\beta+b_0)^2+\left(-2Q_0\frac{\Delta f_d}{f}\right)^2\right]$$

We expect Detuning from microphonics Δfd<30 Hz. Pfor=5 kW provides transmitted power 2 kW at optimum Qext=5.2e6



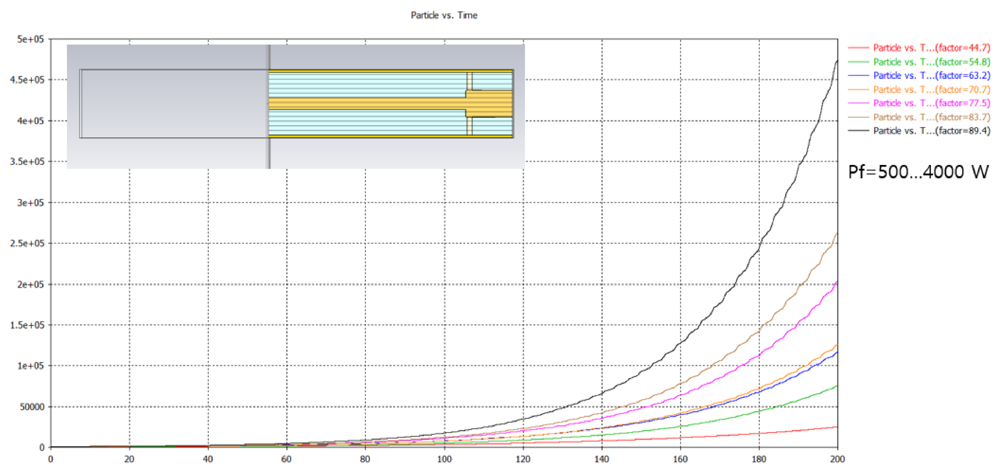


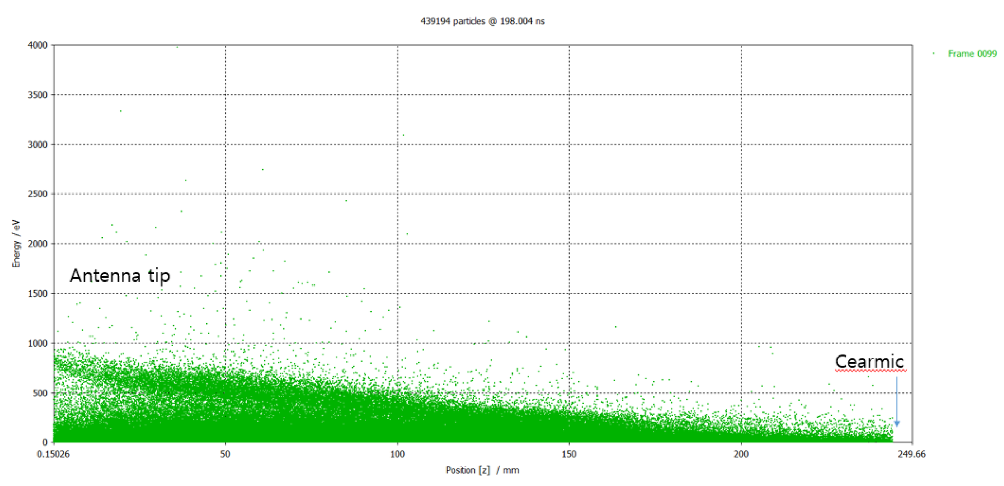
We choose fix coupler

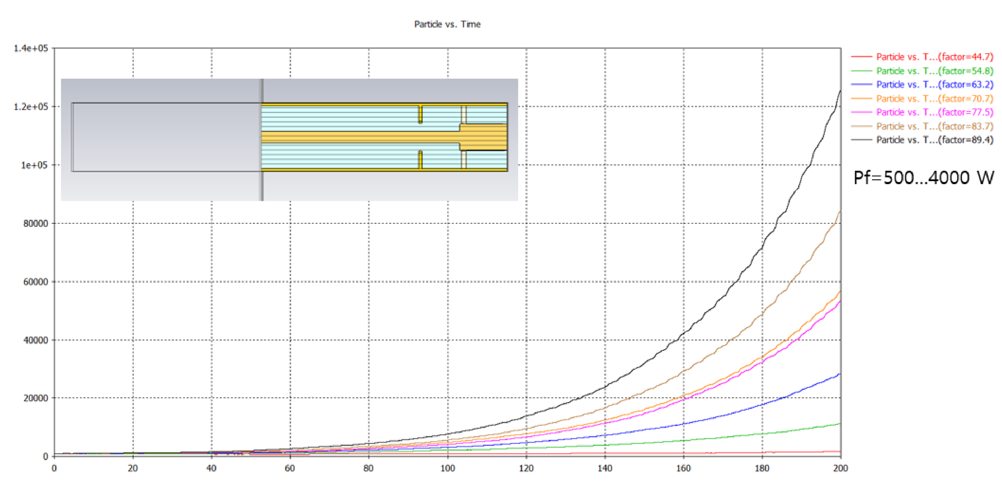
- error of ±2mm antenna position from optimum will lead increase of required Pfor for 2.5%

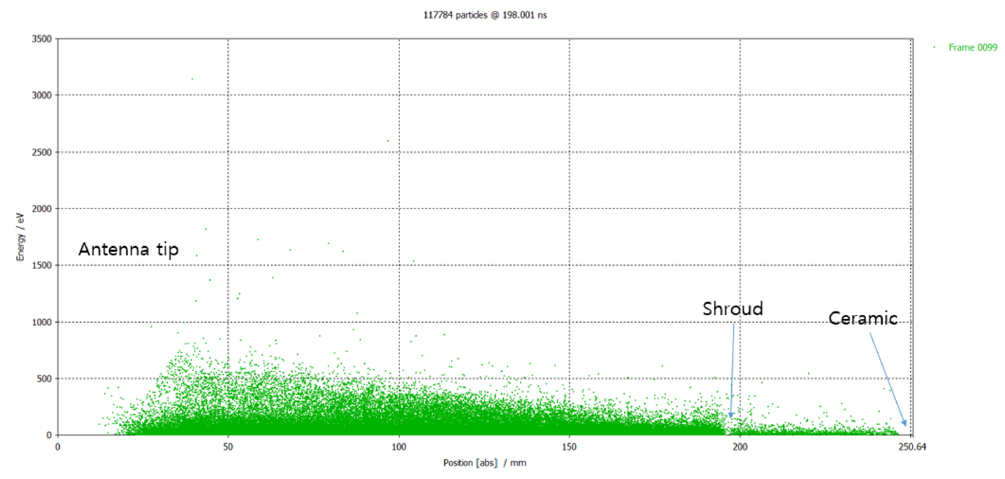
CST Multipacting Simulations

- The baffle disk covering the RF window zone from multipacting decreased emission ~4 times
- A DC bias is required to fully mitigate multipacting for the reliable coupler operation









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