

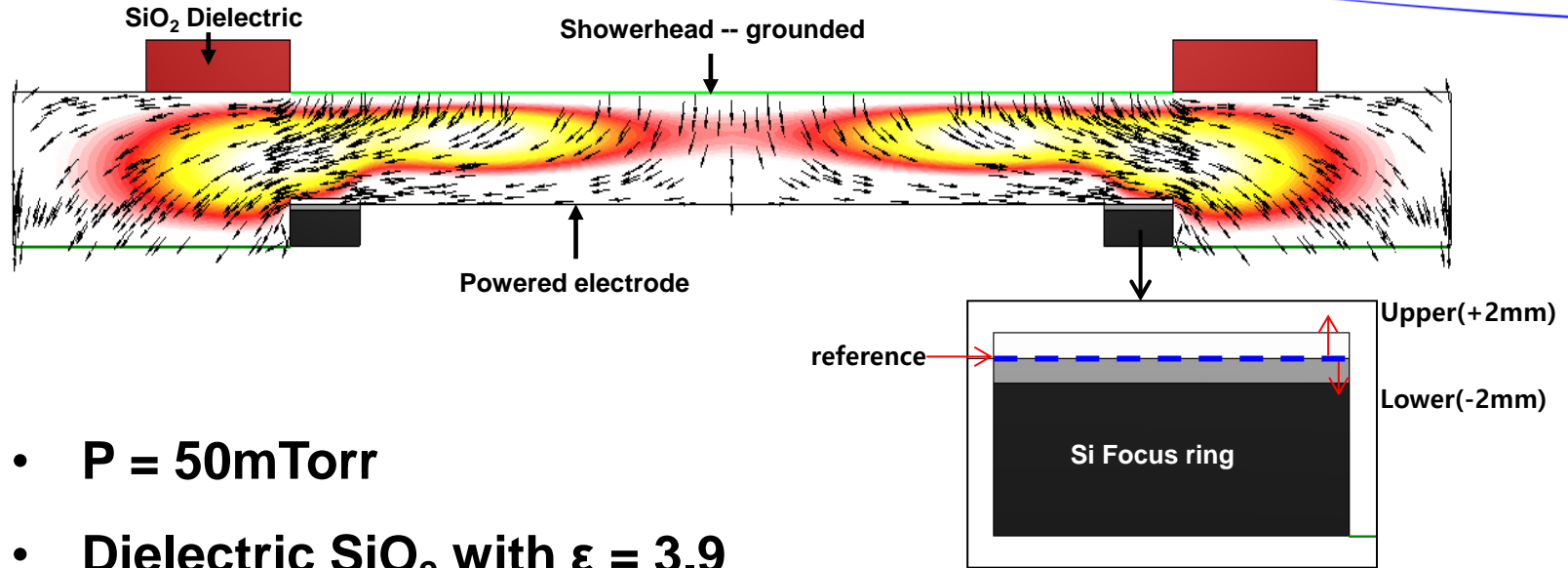
Capacitively Coupled Plasma

1. Edge ring effects

(주)경원이앤씨



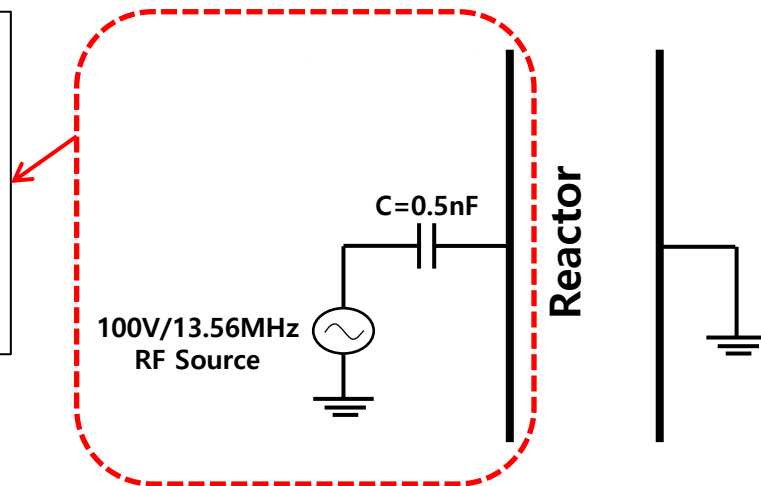
1. Edge Ring 높이에 따른 IEADs



- **P = 50mTorr**
- **Dielectric SiO₂ with $\epsilon = 3.9$**
- **Si focus ring with $\epsilon = 12.0$ and $\sigma = 1 /(\Omega\text{-m})$**
- **Inlet showerhead : V=1m/s(Argon)**
- **rf Powered electrode 100V, 13.56 MHz / 60MHz**

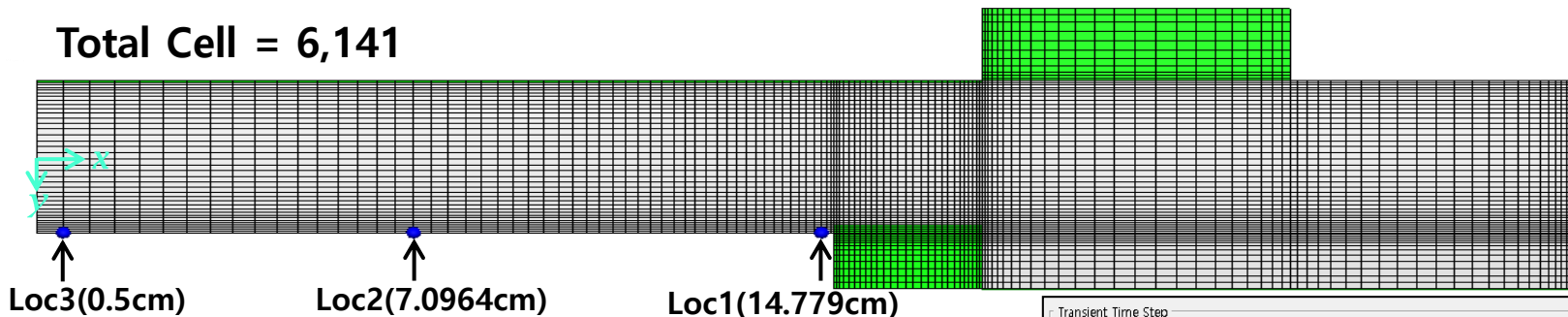
```
SRC-NODE1-NODE2_SIN(_DCOFFSET-_AMPLITUDE_FREQUENCY-_TIMEDELAY-)  
VS1 1 0 SIN( 0.00E+00 1.00E+02 13.56E6 0.00E+00 )  
Ca1 2 1 0.5nF  
Rg2 2 0 1e9  
IS1 0 2 1mA  
.TRAN 3.7000000E-12 3.7000000E-09 0.00 7.4000001E-12 UIC  
.ic V(1) = 0 V(2) = 0  
.PRINT TRAN V(1) V(2)  
.OPTIONS ITL5=0 LIMPTS=1001  
.END
```

Circuit model input

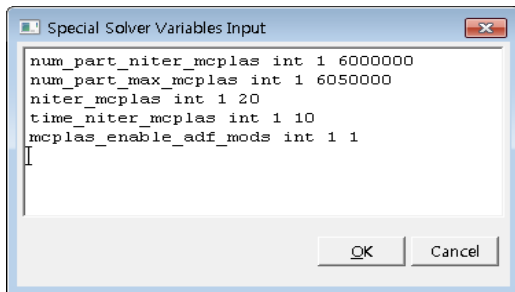


- **Powered electrode : External Circuit model**
 - 100V, 13.56MHz
 - 100V, 60.0 MHz

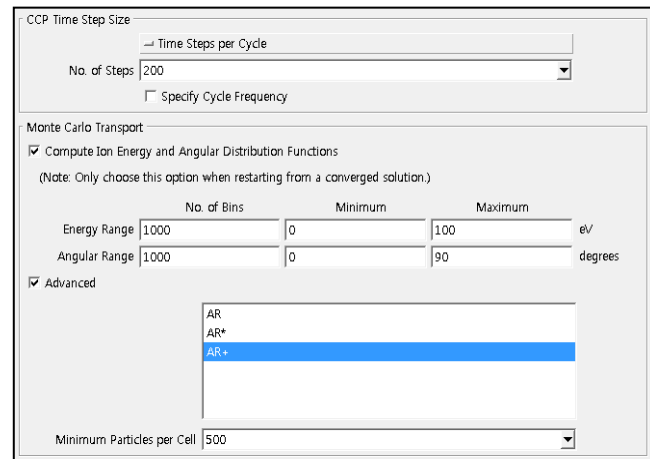
Total Cell = 6,141



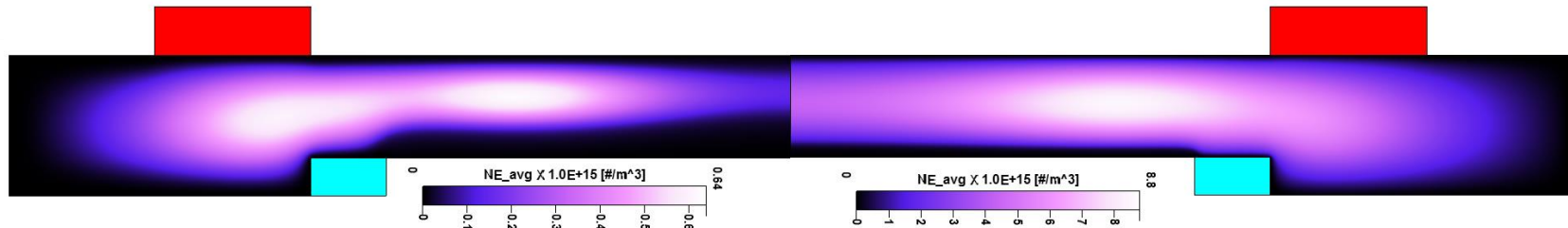
- Wafer 상단 3개의 포인트에서 IEADs 계산
- Max. mcplas = 6,050,000
- Number of bins : ADF 및 EDF 각각 1000ea



CFD-ACE+ V2016.0 Patch1 에서 업데이트 됨
Menu>Tools>Special DTF update...

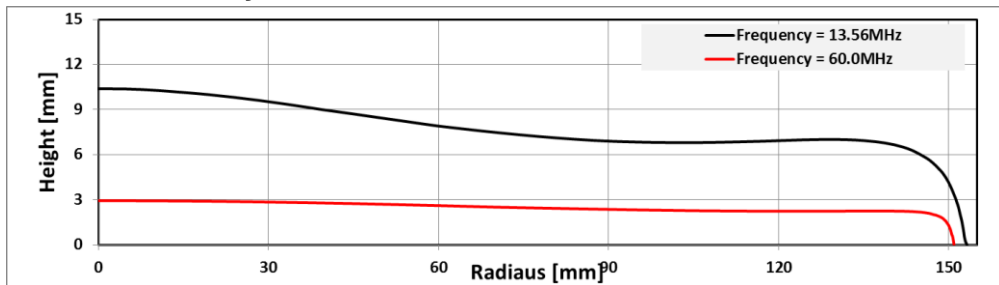


- Plasma field



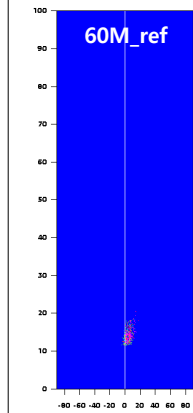
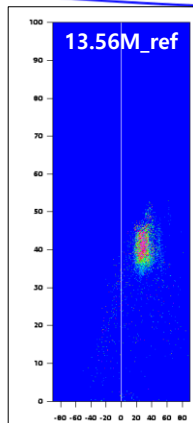
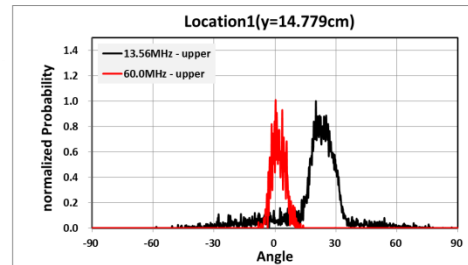
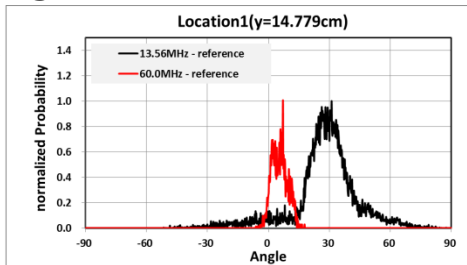
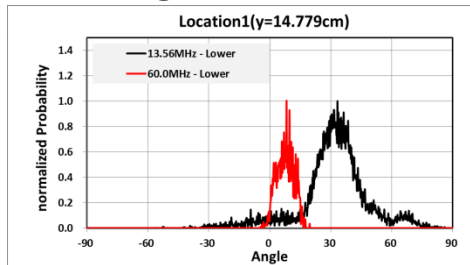
13.56MHz의 경우 NE_avg값은 약 0.64×10^{15} 이고, 60MHz의 경우 8.8×10^{15} 으로 예측 되었으며 약 13.75배 높게 나타남

- Sheath layer thickness



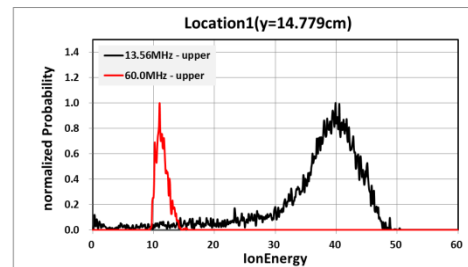
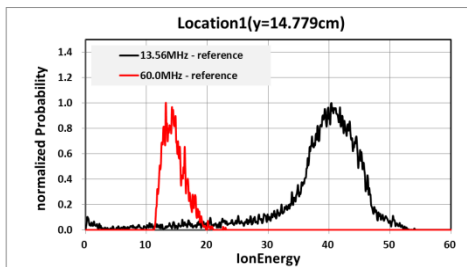
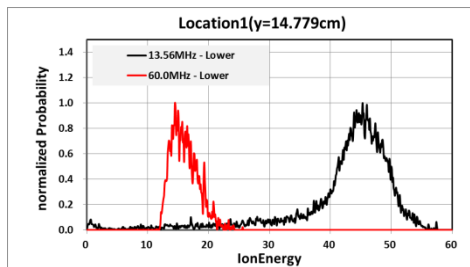
반응기 중심에서 sheath layer가 가장 두껍게 나타나며 13.56MHz에서는 약 10.4mm, 60MHz에서는 약 2.93mm로 나타남. (약 3.54배)

• Ion Angular Distribution(edge)

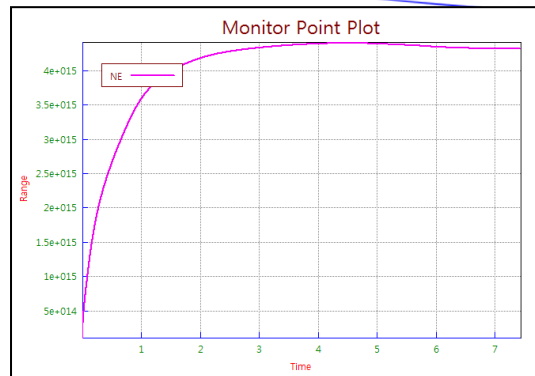
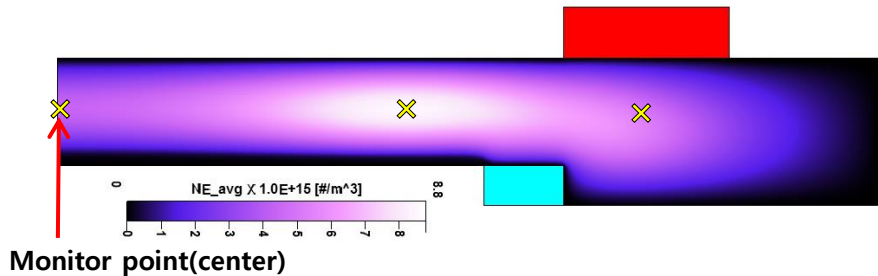


13.56MHz는 30° 전후로 큰 각도로 Ion이 입사가 되며, 60MHz는 0~10로 낮은 주파수에 비해 낮은 각도로 Ion이 입사됨.
Focus ring이 높은 경우가 입사되는 각도가 수직에 가깝게 나타나며, 주파수가 높을수록 수직에 가깝게 나타나는 경향이 나타남.

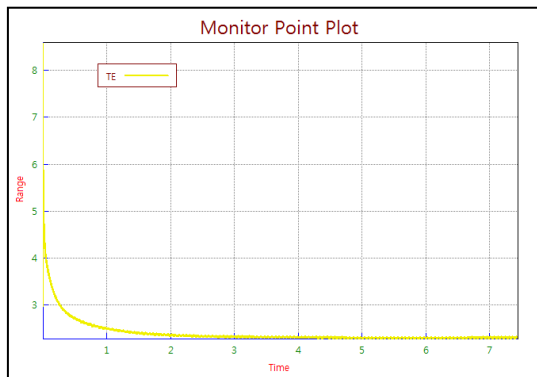
• Ion Energy Distribution(edge)



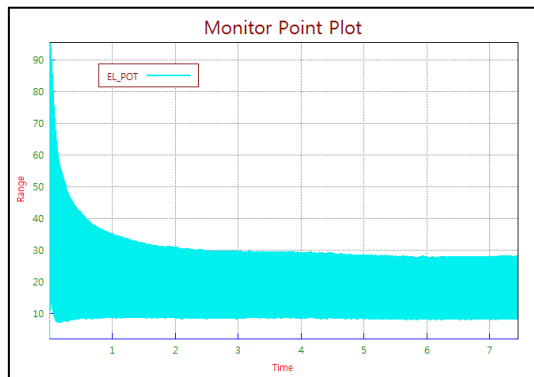
- Convergence
 - 반응기 주요부분의 monitor point로 수렴성 판단



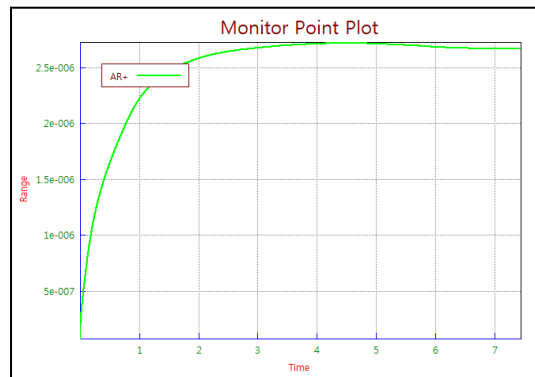
Electron number density



Electron Temperature

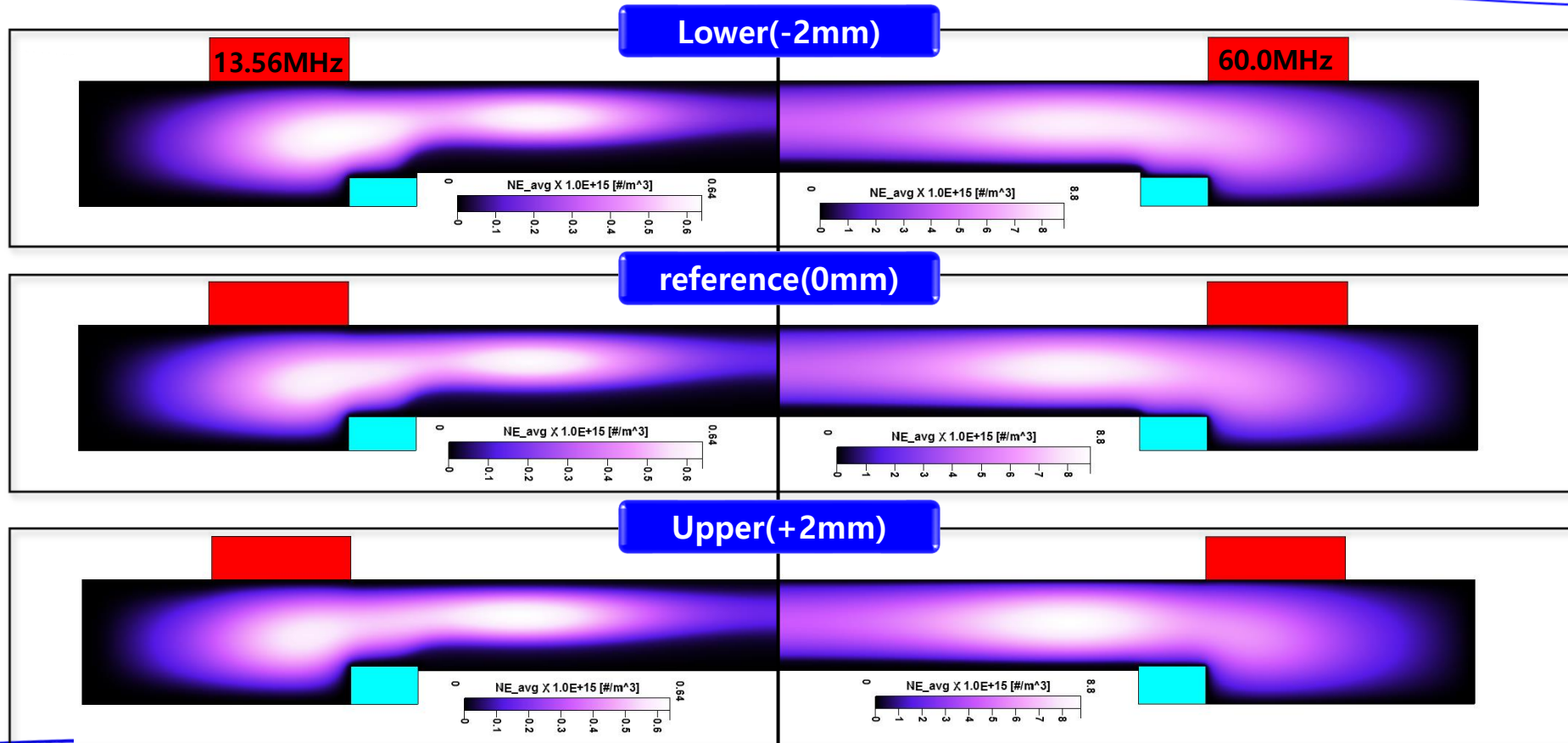


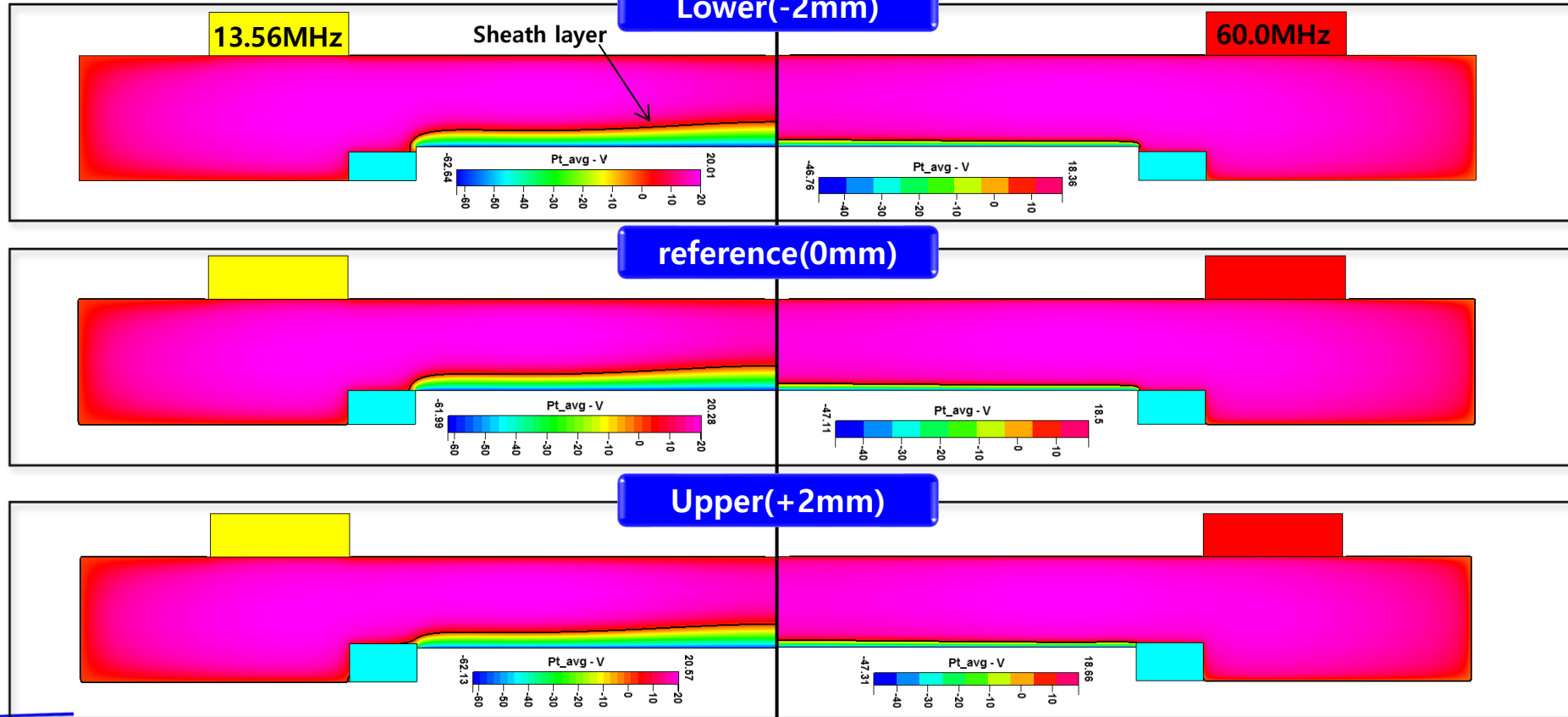
Electric Potential



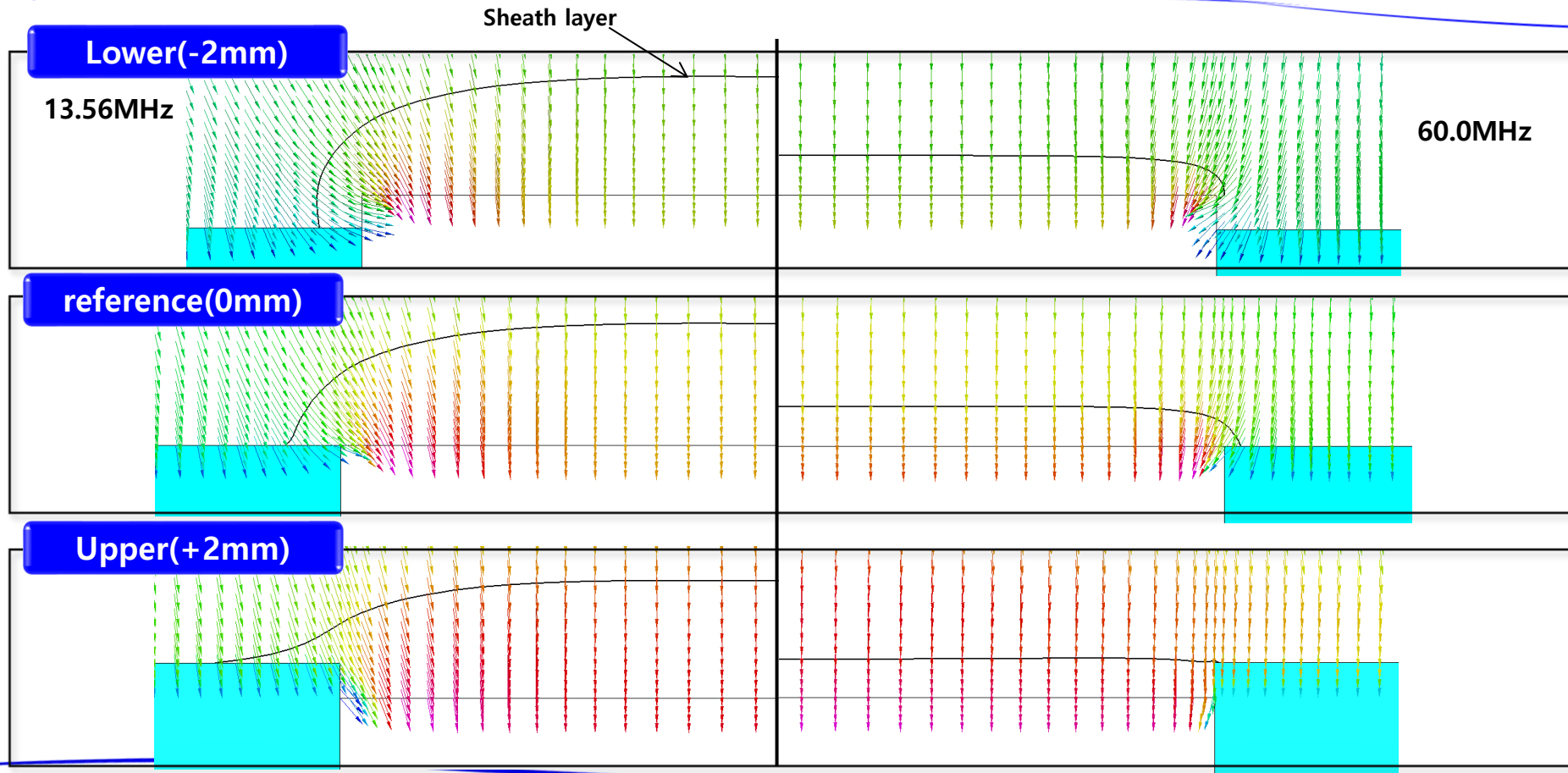
Species (Ar+)

Electron cycle averaged electron number density

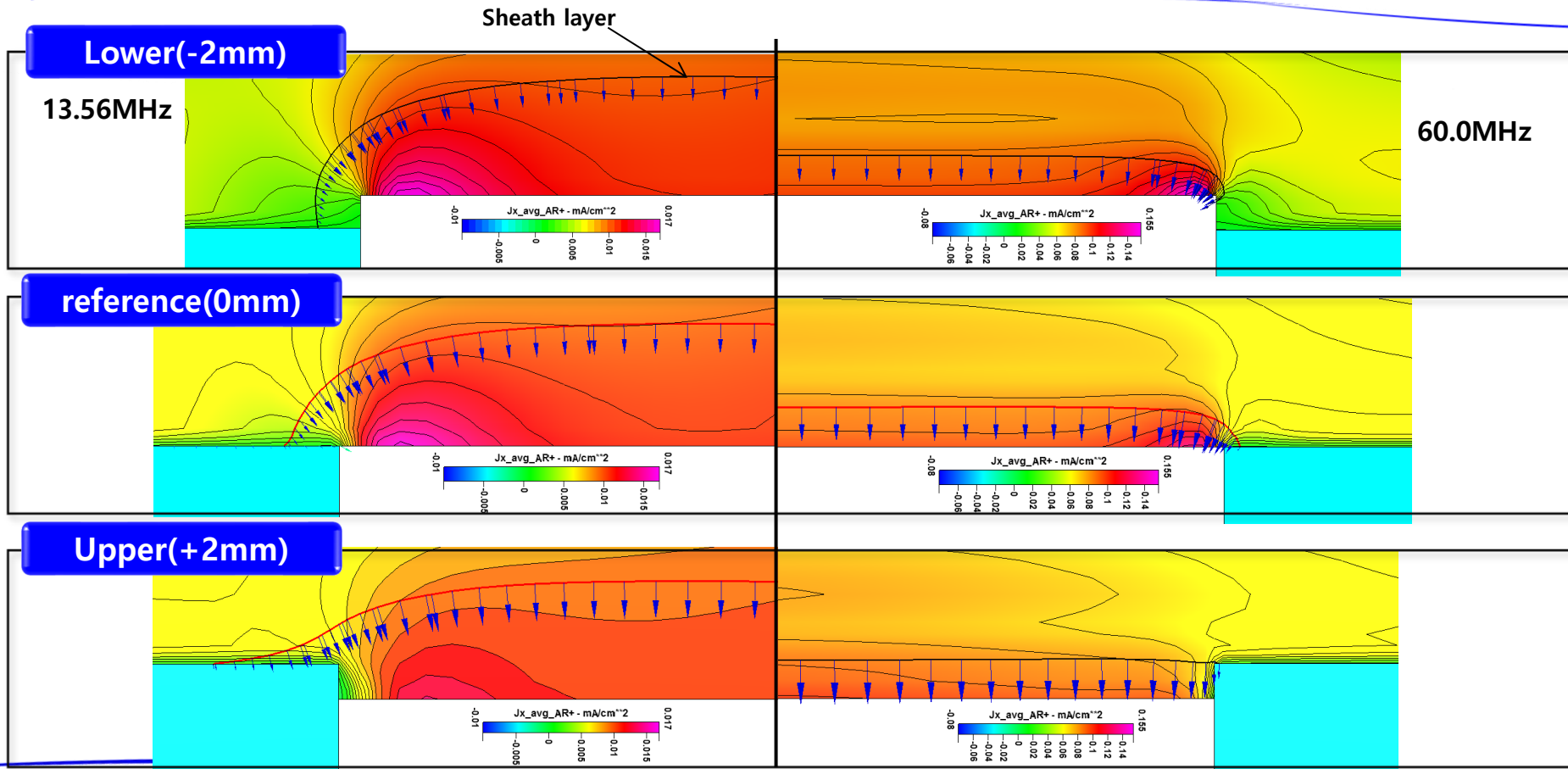




Edge Effects : AR+ current density Vector

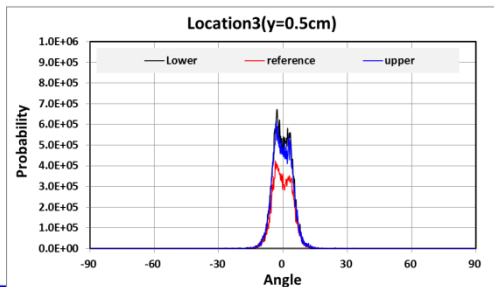
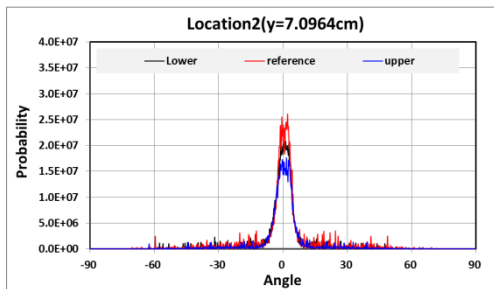
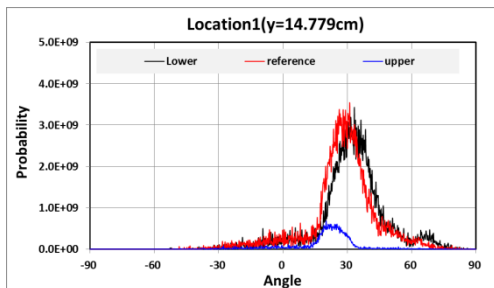


Edge Effects : Species current density in X – AR+

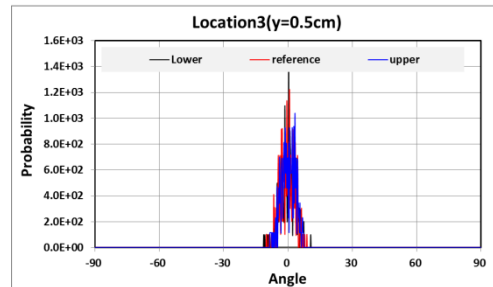
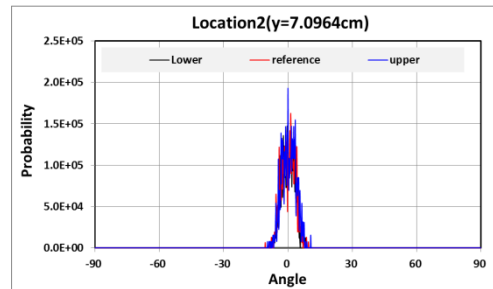
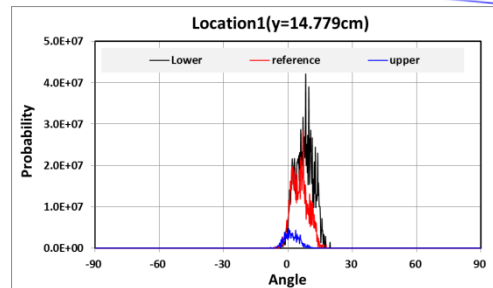




13.56MHz

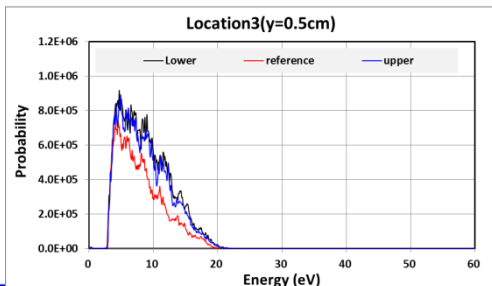
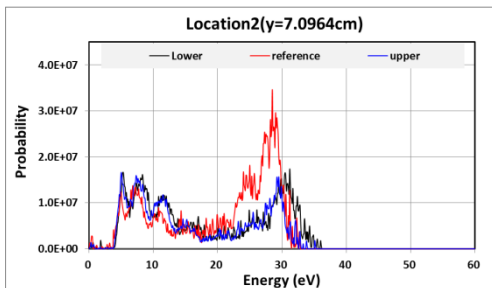
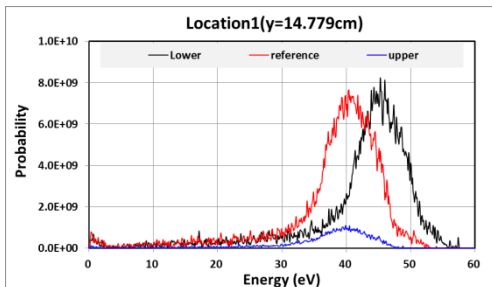


60.0MHz

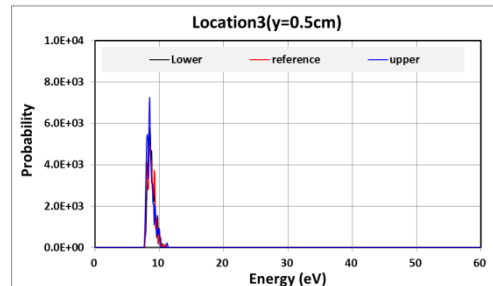
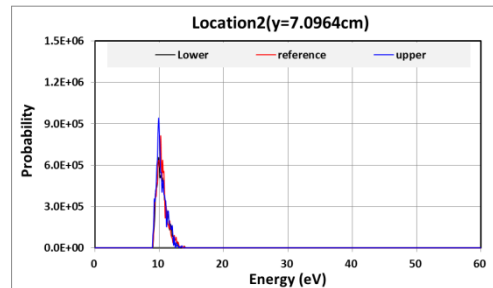
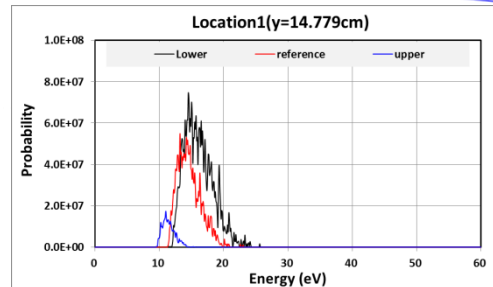


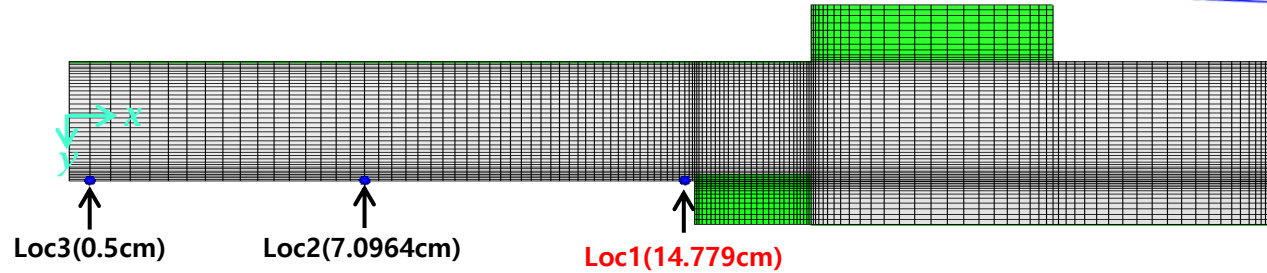


13.56MHz

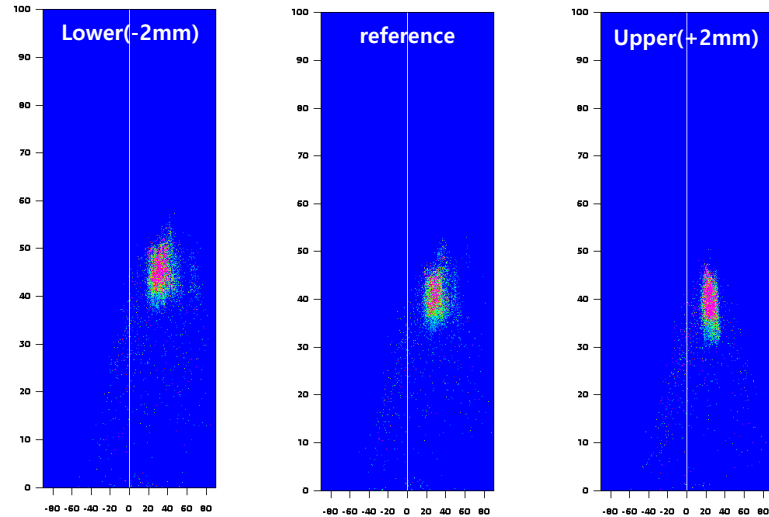


60.0MHz

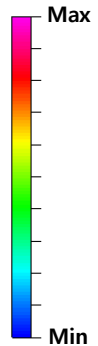
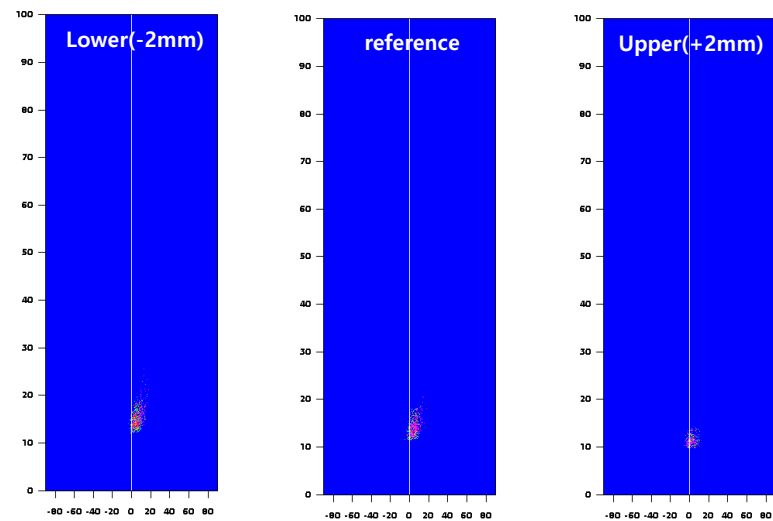


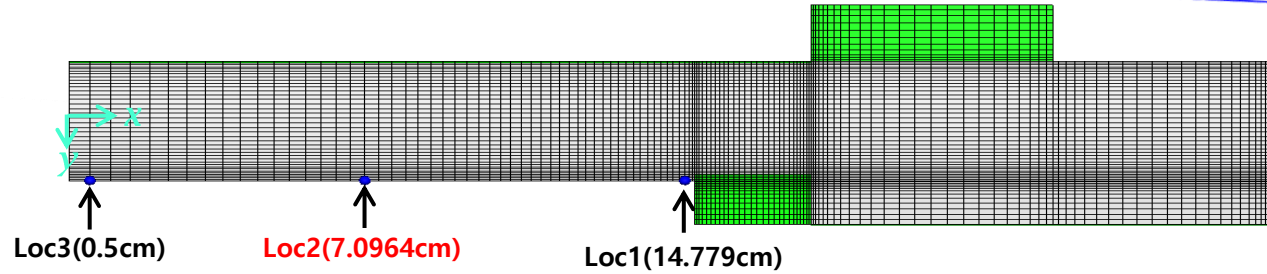


13.56MHz

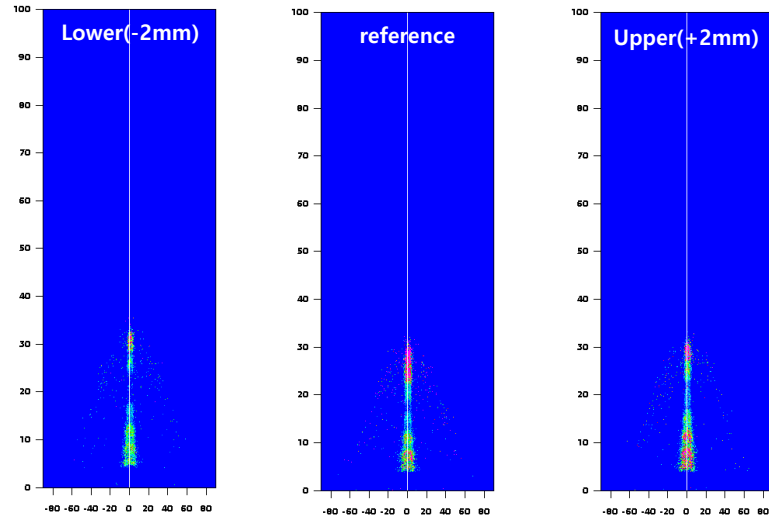


60.0MHz

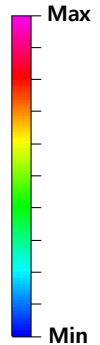
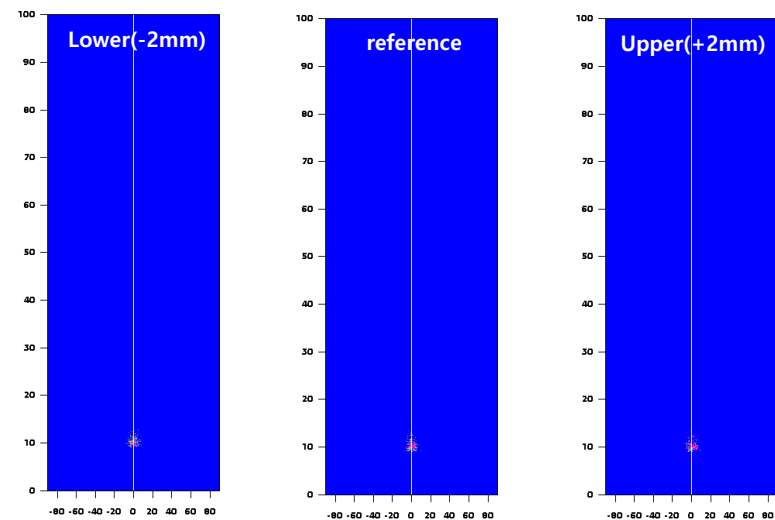


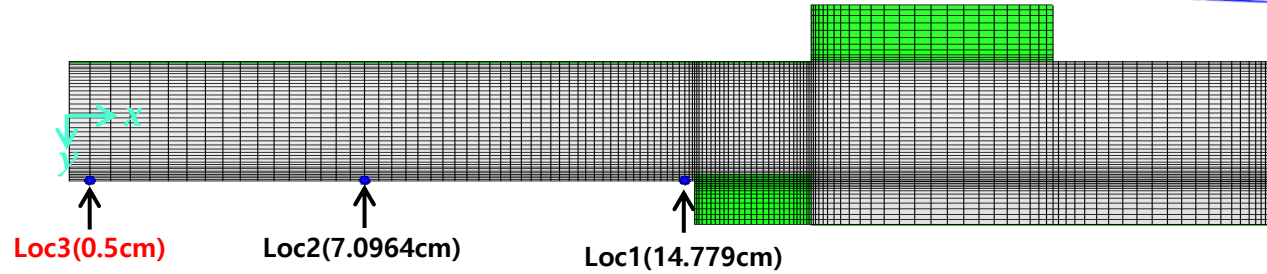


13.56MHz

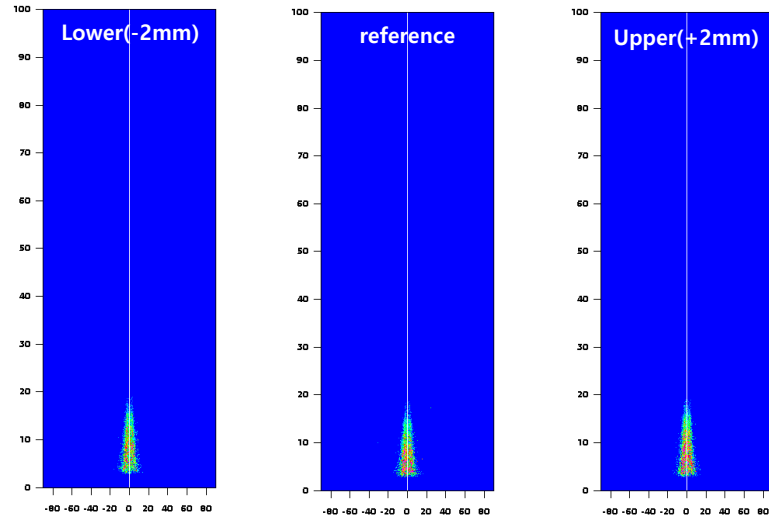


60.0MHz

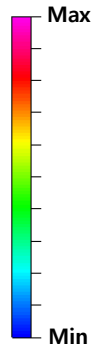
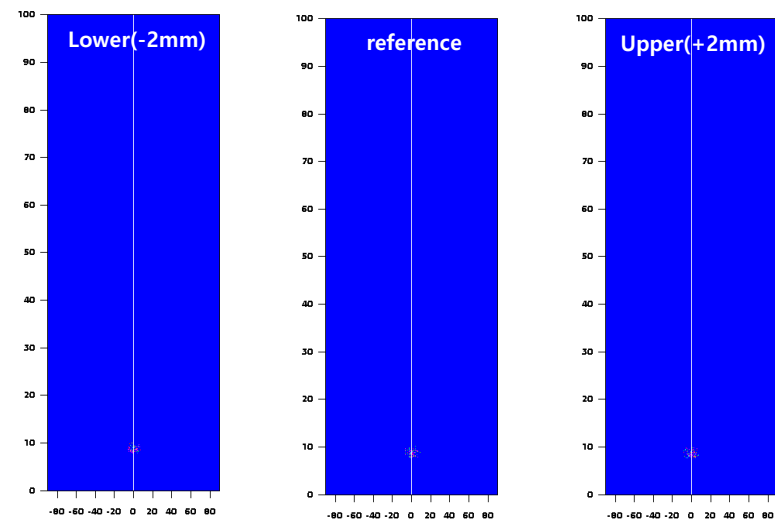




13.56MHz



60.0MHz



CFD-ACE+ V2016.0 P1

- num_part_niter_mcplas int 1 6000000 (default = 3000000)
(# particles per MC iteration)
- num_part_max_mcplas int 1 6050000 (default = 3050000)
(Max# particles per MC iteration)
- niter_mcplas int 1 20 (default = 1)
(# MC iterations)
- time_niter_mcplas int 1 10 (default = 200)
(#rf cycles per MC iteration - multiply by #Steps/CCPcycle for multiF)
- mcplas_enable_adf_mods int 1 1 (default = 0)
(1 enables specific modifications in solver regarding hit_angle for particles coming to the surface)

