Progress towards 36 GHz and 48 GHz high power microwave sources

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on behalf of research teams of

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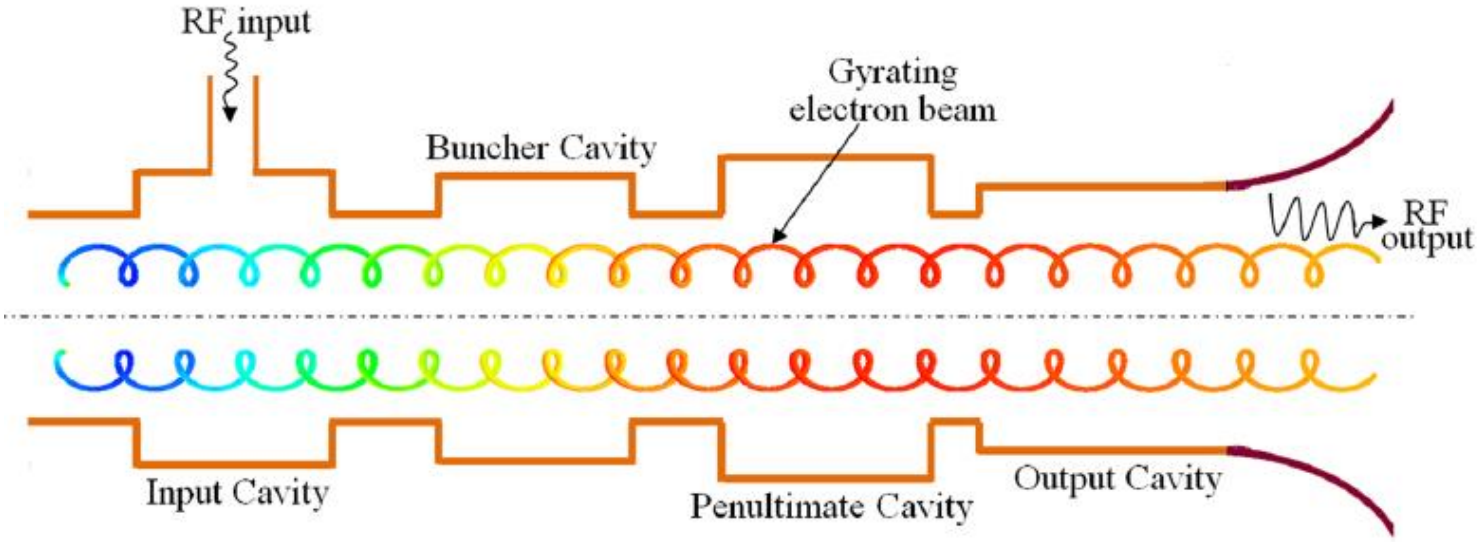
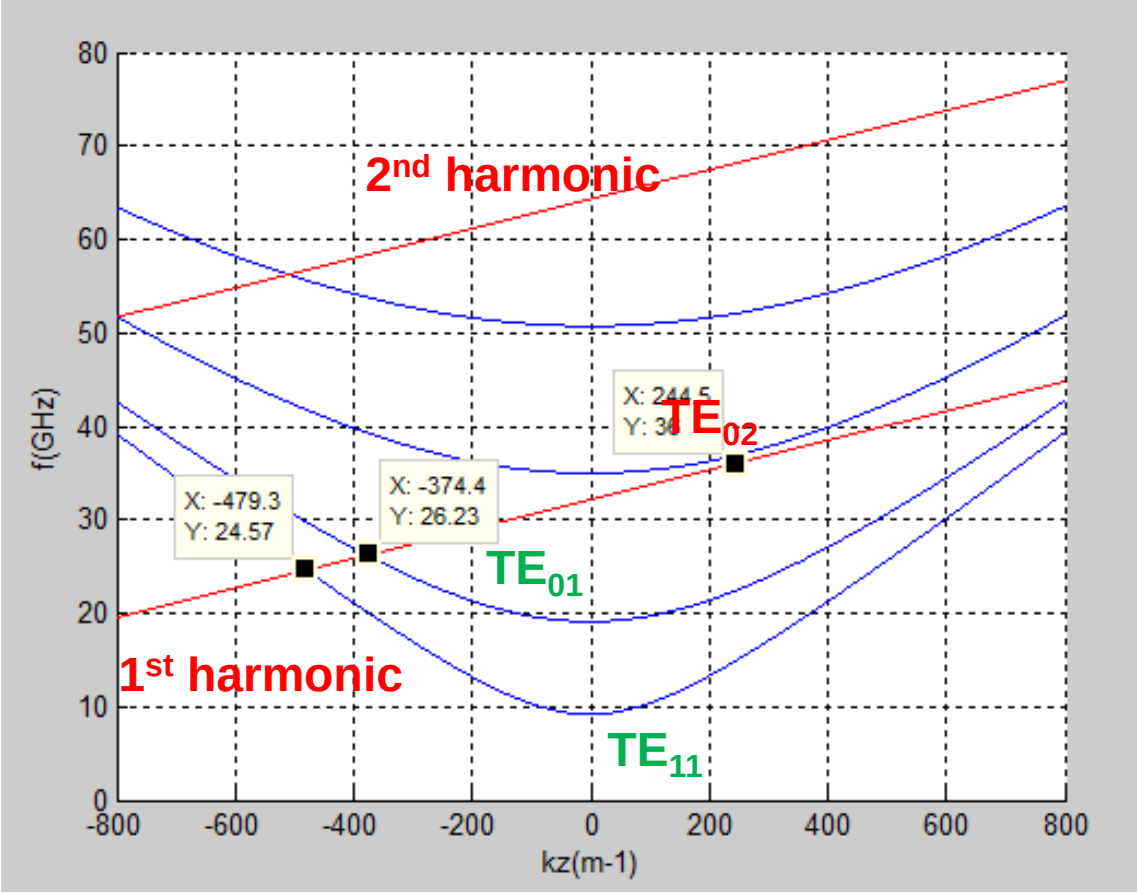
Gyro-klystron Principle

- Gyro-klystron
  - Bunching in azimuthal direction, TE modes.
  - Lower axial velocity due to the beam alpha results in larger cavity size.
  - Operating frequency determined by the external magnetic field.
  - Open output cavity, high power capability



Linear gain theory



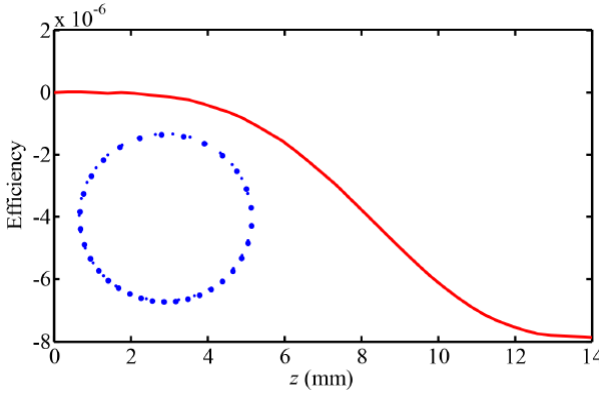
Three-cavity design;
The operating mode (output cavity) is TE_{02};
Competing modes: TE_{11} & TE_{01}

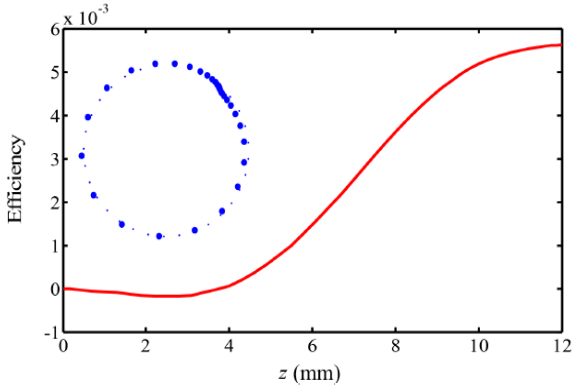
Output power (kW)	3200
Beam voltage (kV)	150
Beam current (A)	50
Magnetic field (T)	1.5
Frequency (GHz)	36
Drive power (W)	40
Gain (dB)	48
Efficiency	42%
Bandwidth (MHz)	190

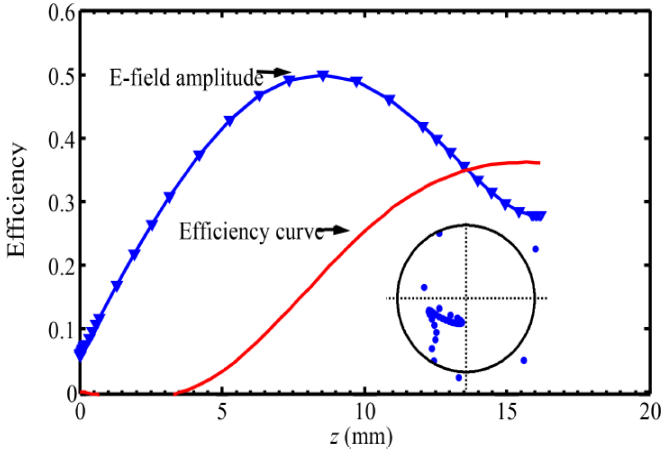
Funded by the European Union

Beam-wave interaction

- Optimized by nonlinear theory;
- Cavity structure verified by EM simulations;

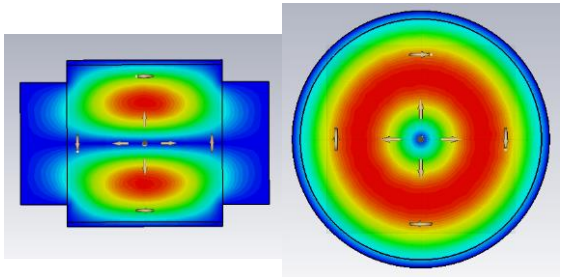




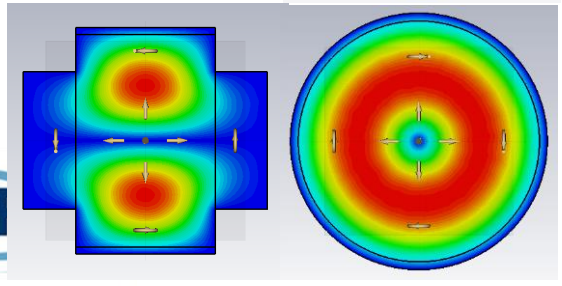


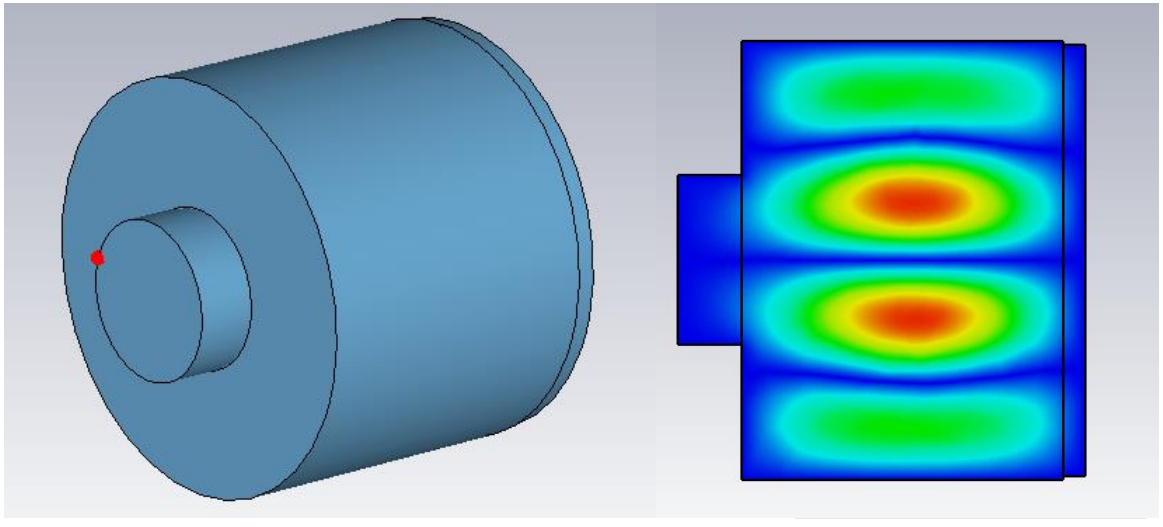
Output cavity, TE_{02}, frequency 36.098GHz

Cavity 1

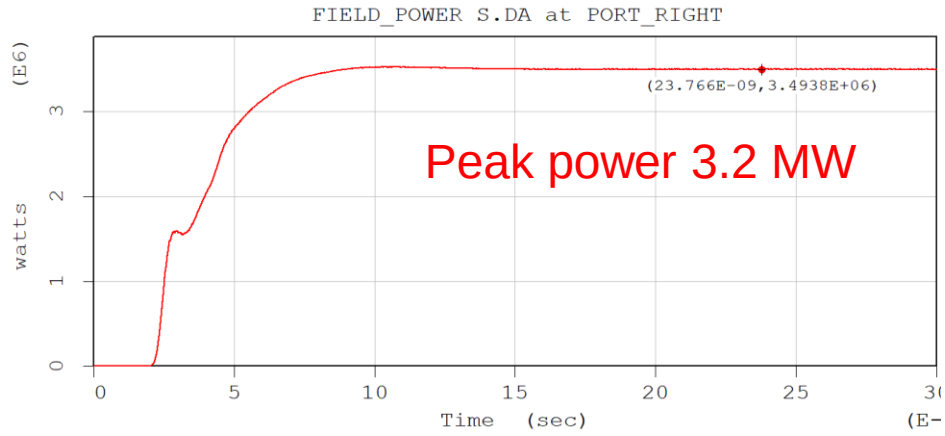


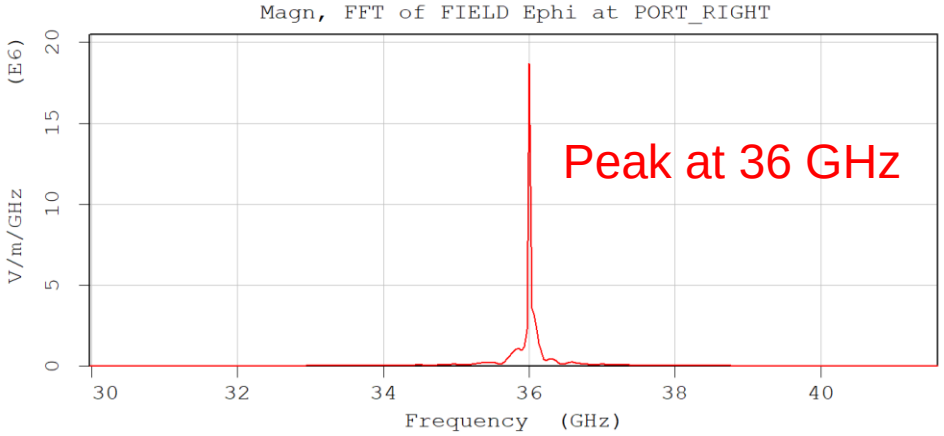
Cavity 2

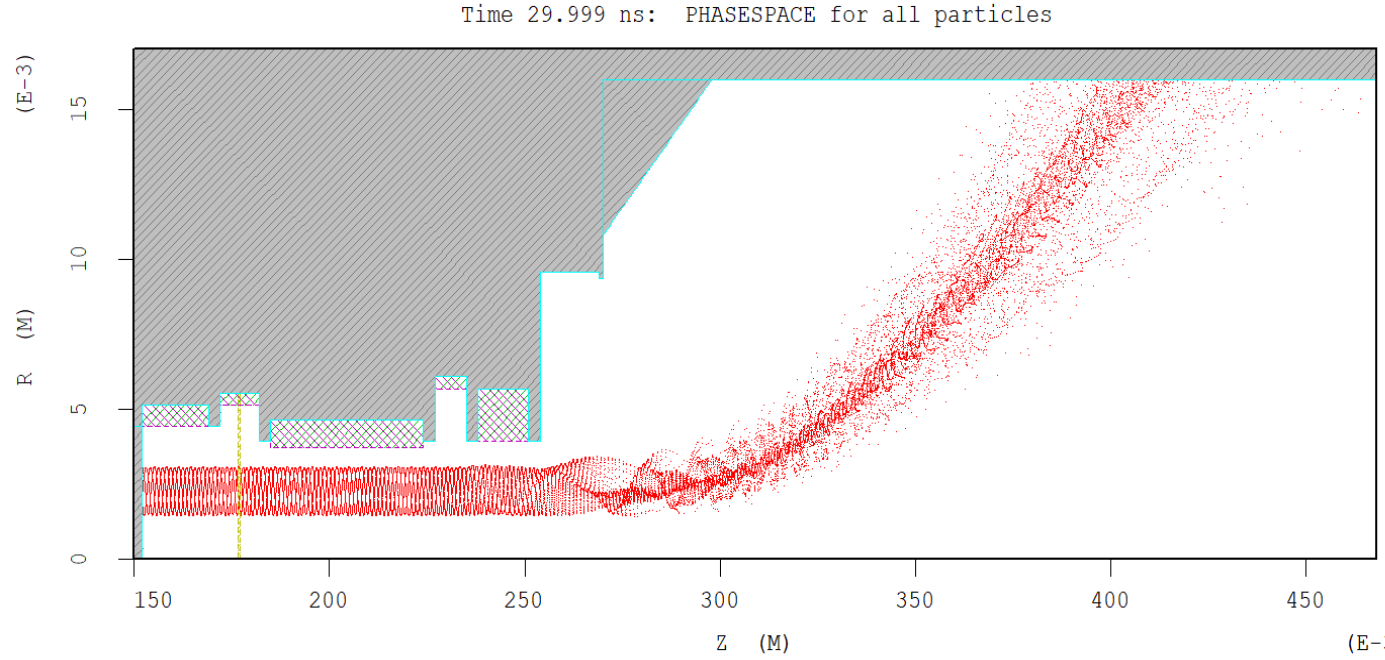




PIC simulation results





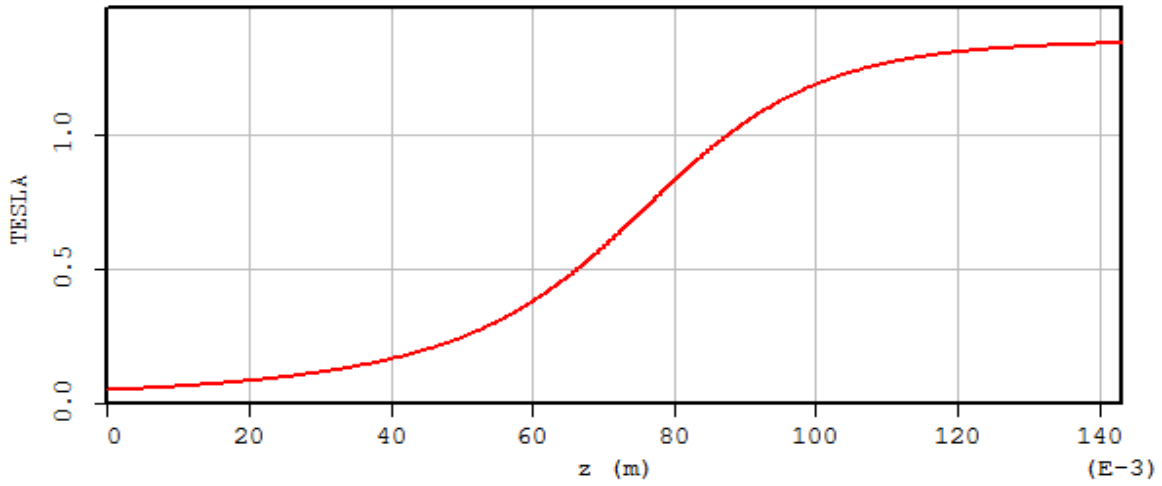


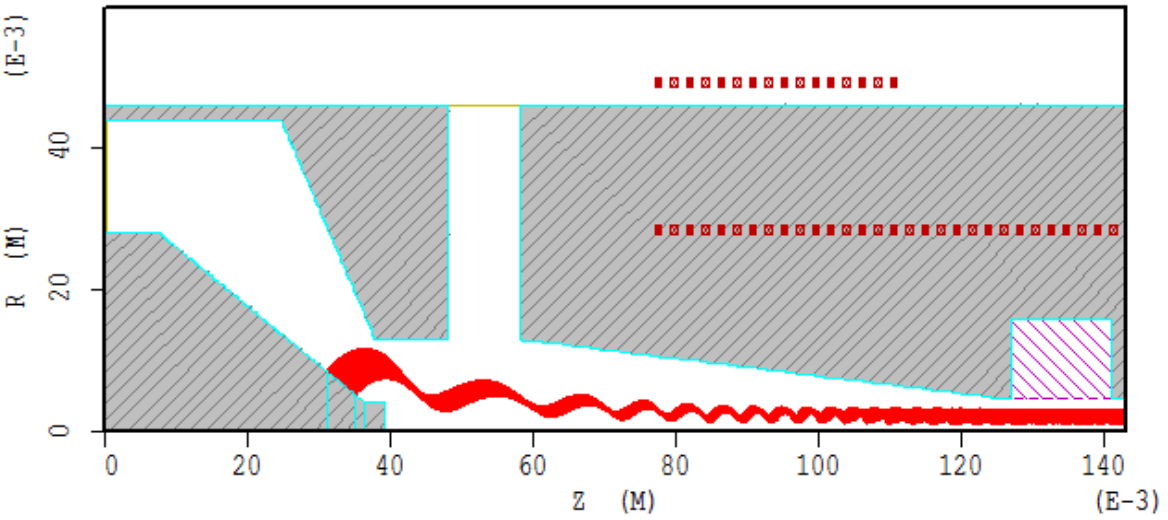
Driving power: 400W
Bandwidth: 0.3%
Gain: 39 dB
Efficiency: 40%

MIG-type electron gun

Emitter width L_s (mm)	5.23
Emitter average radius R_c (mm)	6.85
Anode angle φ_a (deg)	66.9
Current I_0 (A)	**50**
Anode voltage V_0 (kV)	**150**
Magnetic field @ gun exit B_0 (T)	1.46
Magnetic compression ratio f_m	10.5
Velocity ratio α	1.40
Transverse velocity spread $\Delta\beta_t$ (%)	2.31
Axial velocity spread $\Delta\beta_z$ (%)	4.09
Mean guiding center radius r_{g0} (mm)	2.25

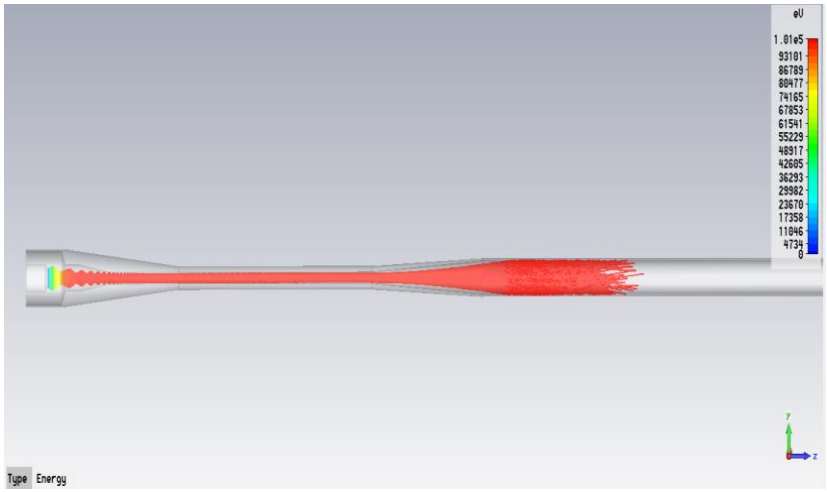
Magnetic field



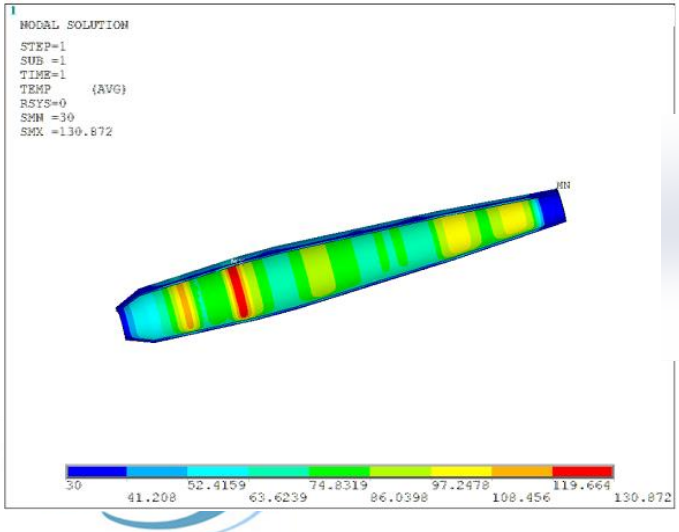


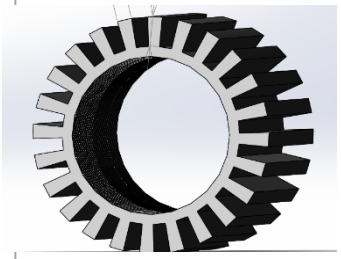
Beam trajectories

36GHz Collector Simulations

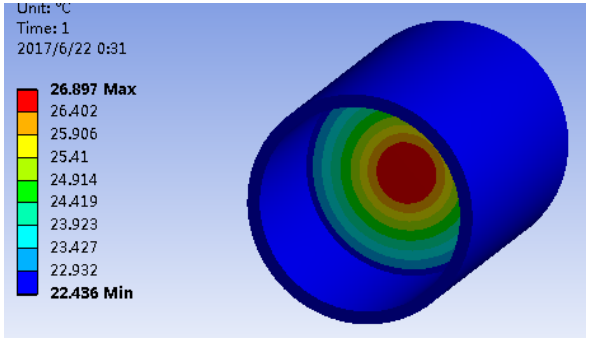


τ=1.5μs，f=1000Hz；U=150kV；I=50A，η=40%；
Electron beam power 7.5MW;
Output microwave power 3MW;
We ignore the loss power（for it is small)
Power in the spent beam 4.5MW;
While the average of spent beam power is more than 6.75kW；
Collector design for full electron beam power 7.5MW; Average spent beam power is 15kW；
Structure optimized for higher average power capability with the addition of fins



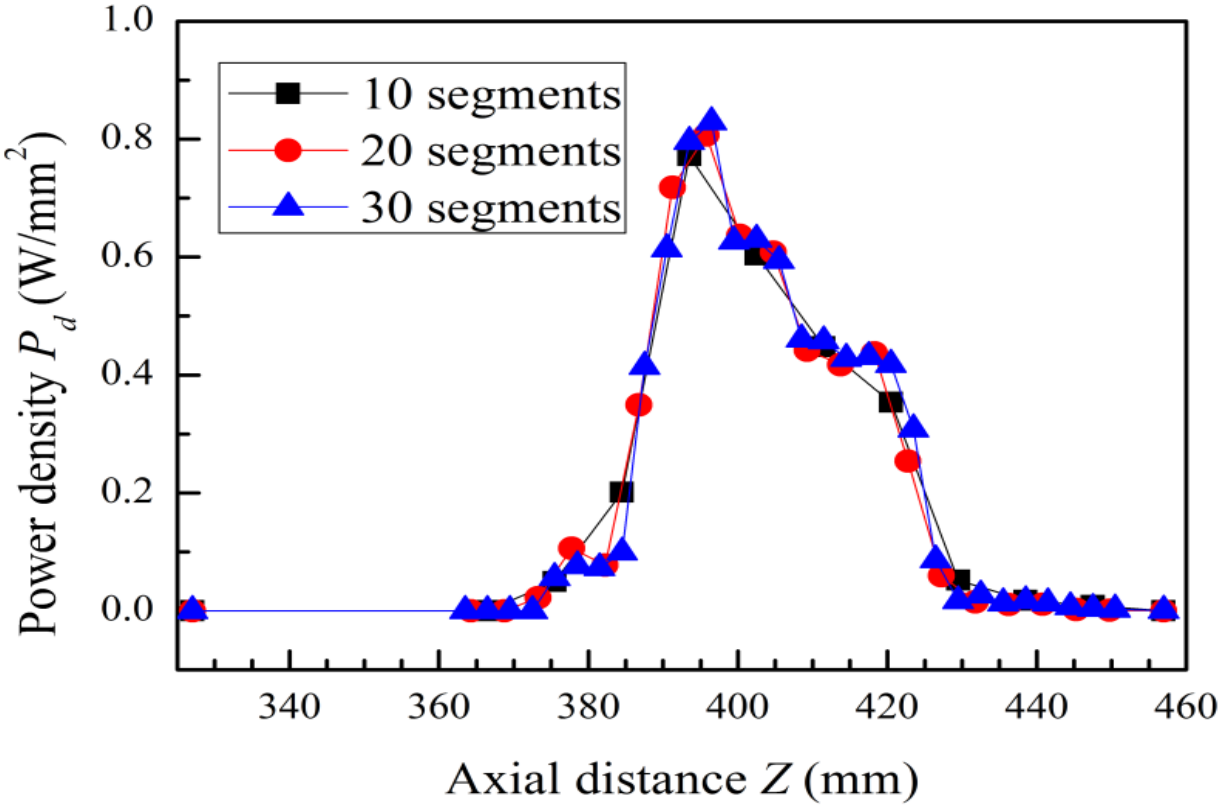


Output Window



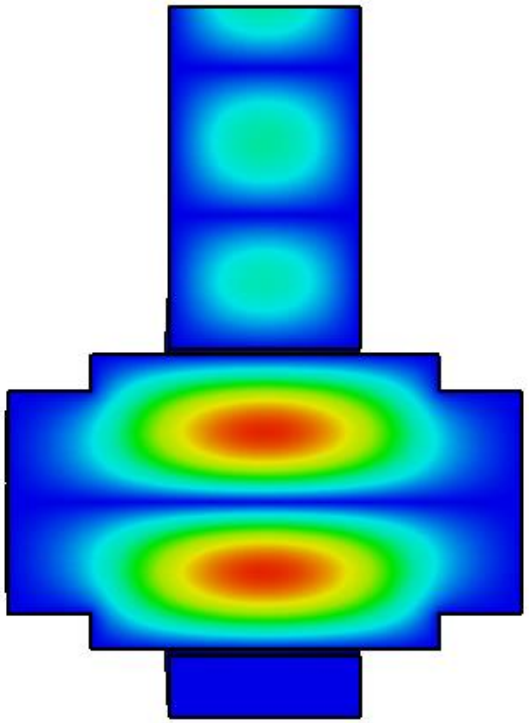
Average power is 4.5kW, the temperature of window is less than 40℃

36GHz Collector Design



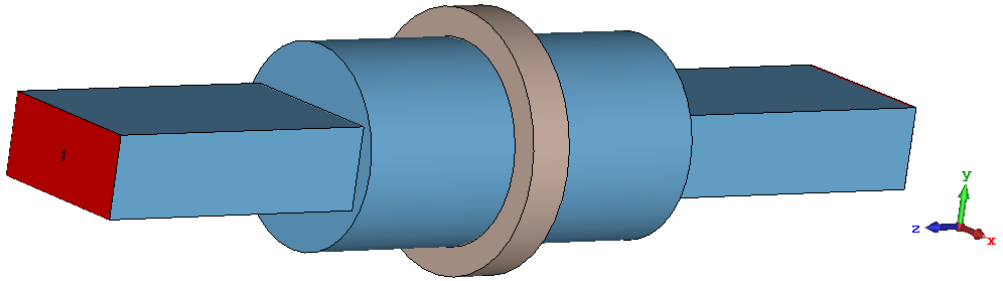
Electron beam power 6.75 MW;
Output microwave power 2.75 MW;
Power loss 100 kW;
Power in the spent beam 3.9 MW;
The designed collector power density is 85W/cm^2.

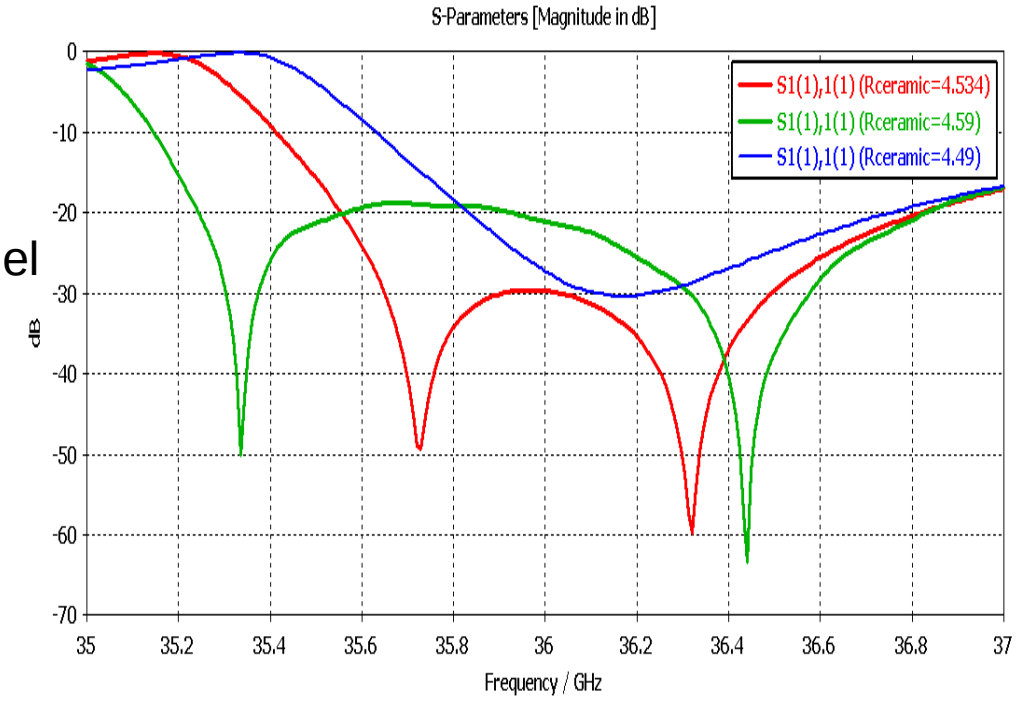
Input coupler & window



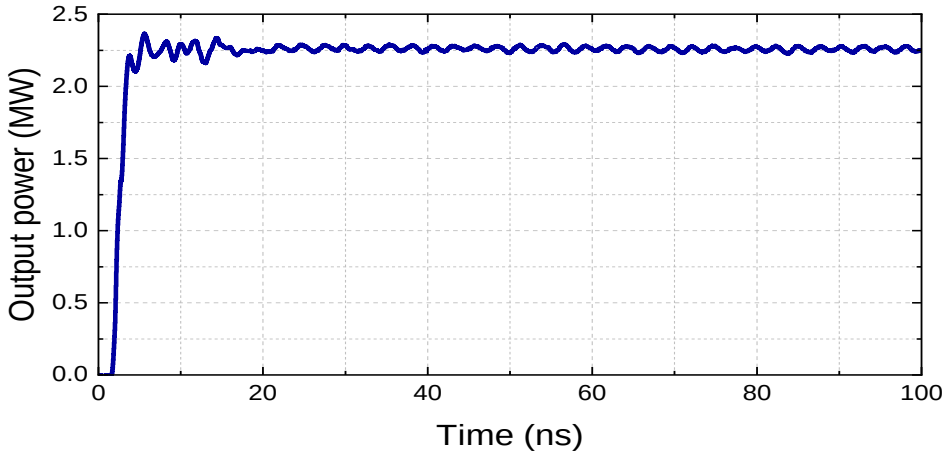
Coaxial coupler

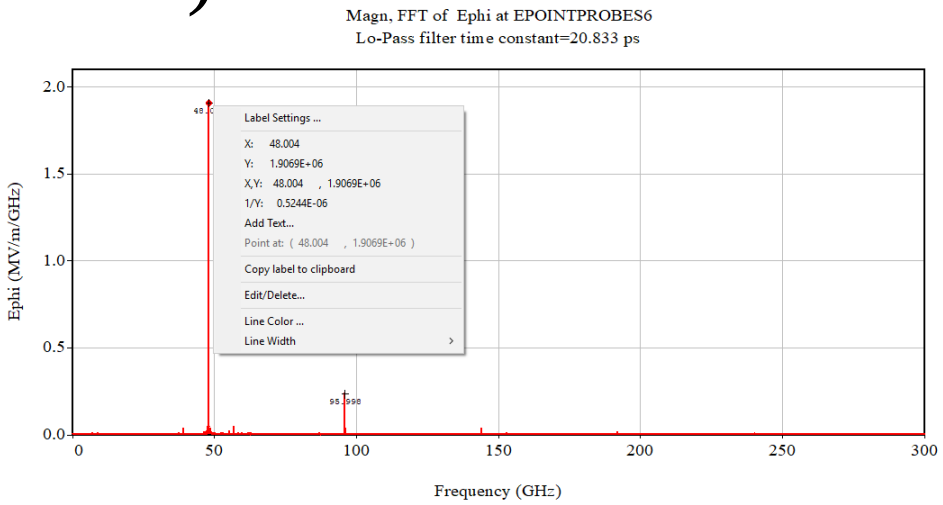
Beam tunnel

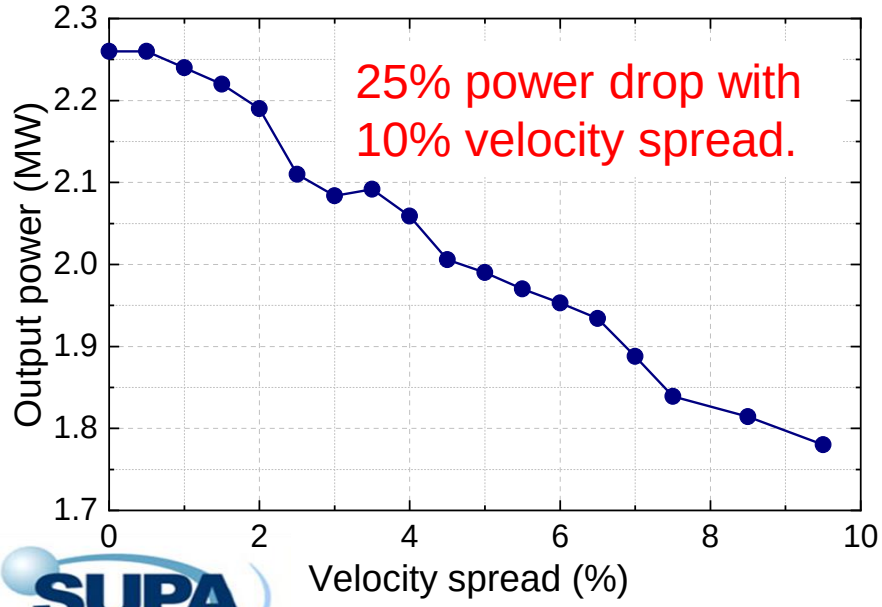


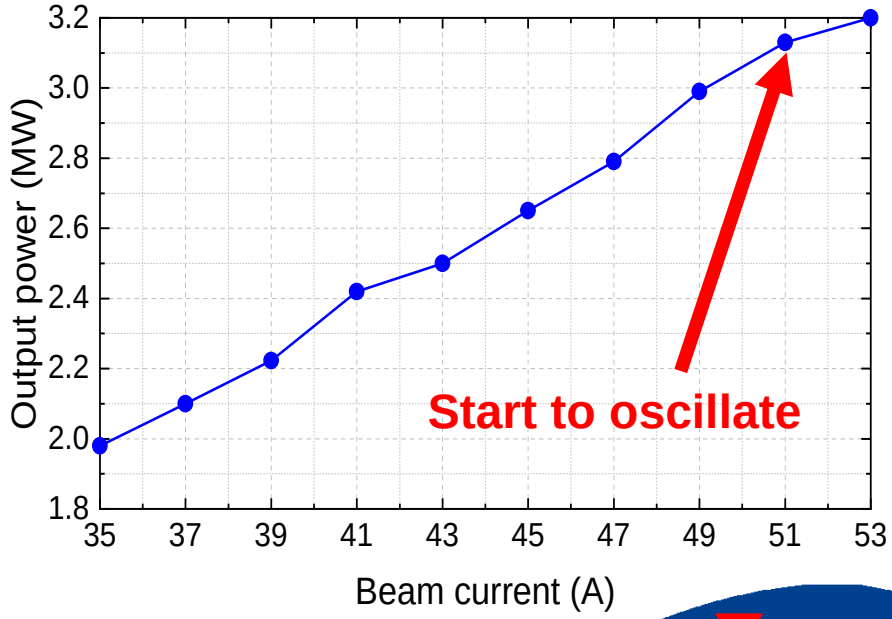


Updates on 48 GHz Gyro-Klystron (Laurence Nix)









Acknowledgement

This work is supported by the European Commission Horizon 2020 Project “CompactLight” (777431-XLS), and the State Scholarship Fund from the China Scholarship Council and the STFC, UK (Cockcroft Institute Core Grant)

Thank you for your attention!

Funded by the European Union