36GHz HOM MBK design status

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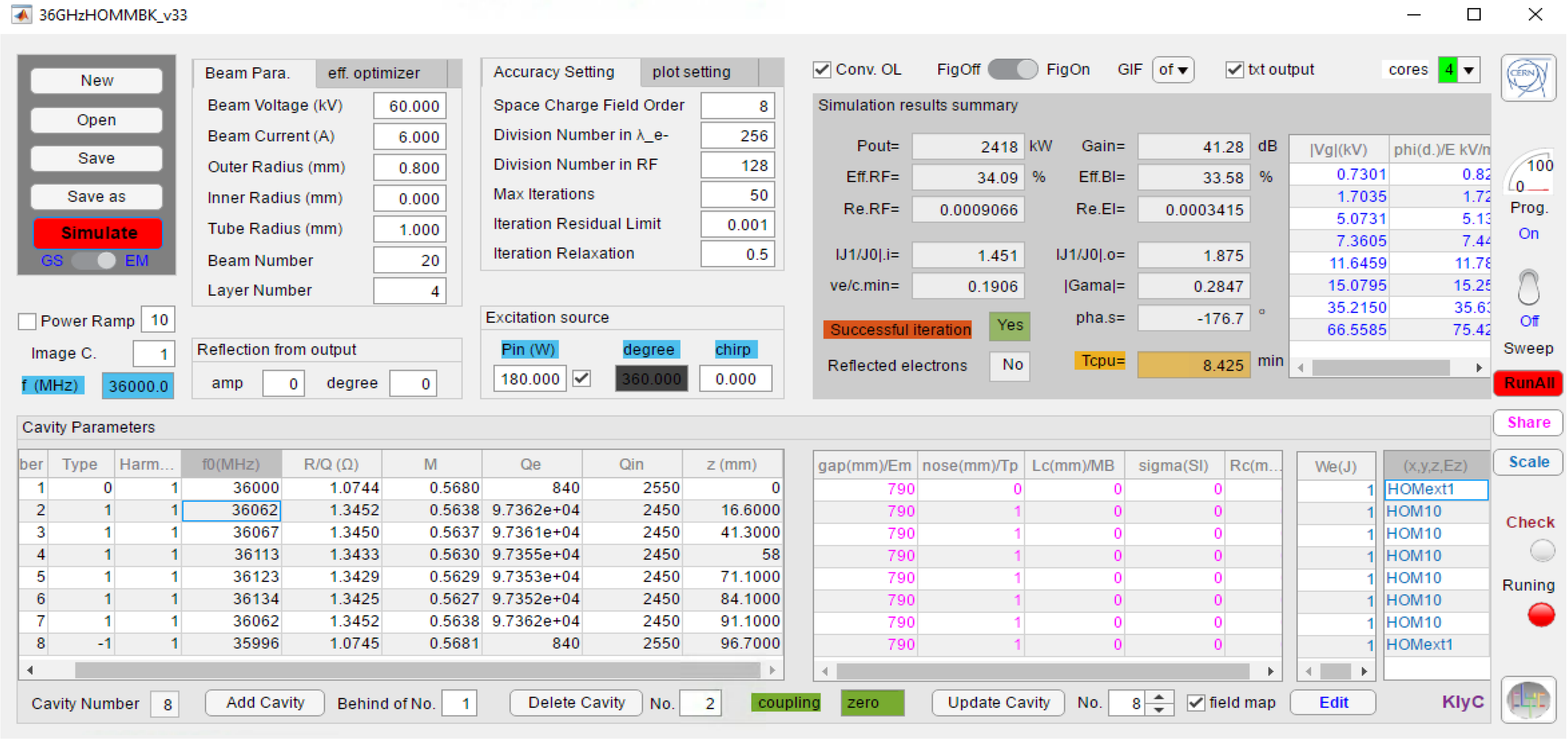
Outline

- Beam-wave interaction analysis
- Beam optics Design

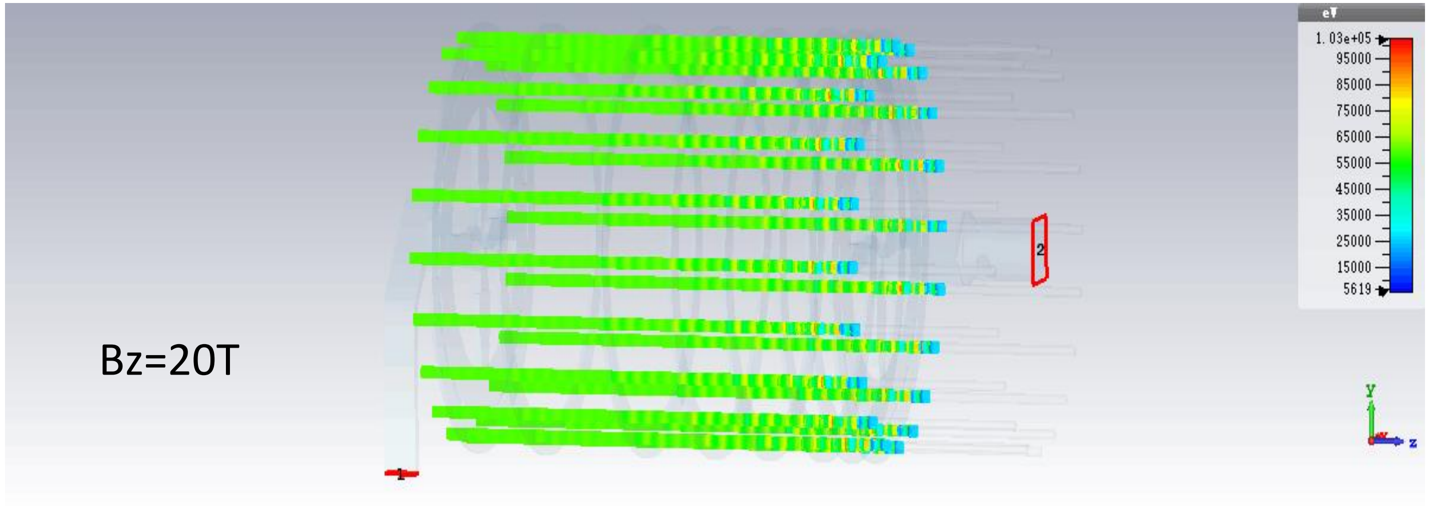
KlyC simulation results

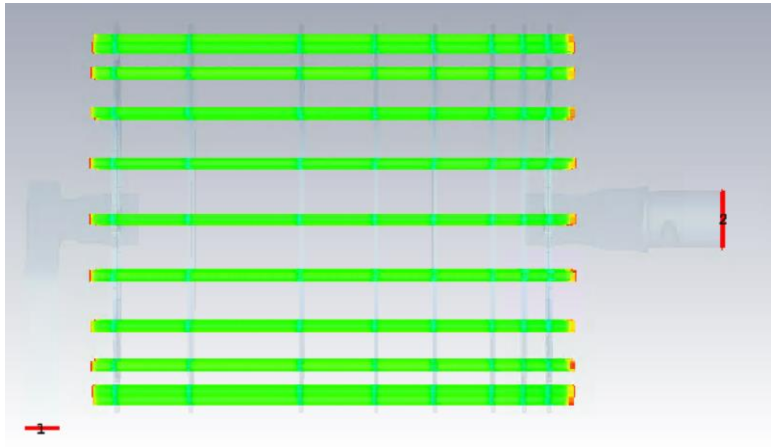


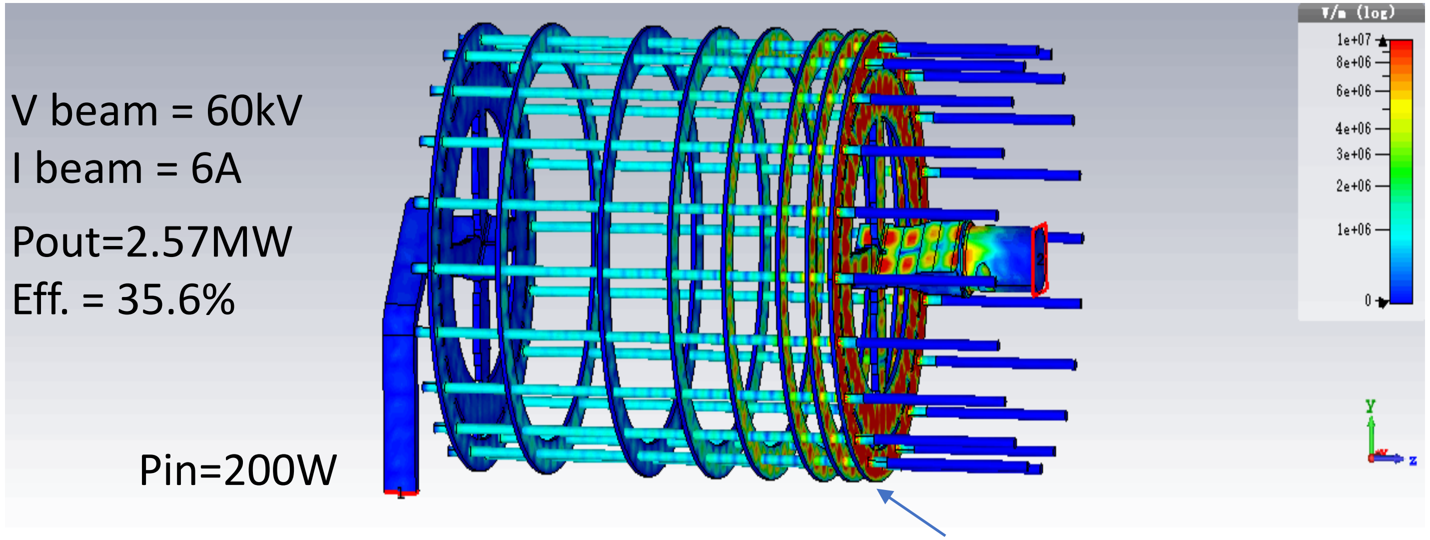
- ✓ The saturation output power is 2.4MW
- ✓ The saturated efficiency is 33.6%
- ✓ Gain=41dB
- ✓ Emax=67kV/mm
- ✓ -3dB bandwidth is [-22MHz, +28MHz]

- ✓ Tube is compact as a whole and could be installed quite close to the linearizer as plug-in/ plug out module
- ✓ Frequency tuning for each cavity will be a technical challenging
- ✓ Bandwidth is little bit narrow, which leads to 80% linearizer performance comparing with infinite bandwidth;
- ✓ More results will be available in coming weeks

CST 3D simulations of entire 20 beams 36GHz MBK (KlyC benchmark, Bz=20T)







Emax~90kV/mm

- RF circuit was optimized in KlyC.
- Input (output) coupler combiner topology provides efficient extraction of RF power into H_{01} in the circular waveguide.
- RF circuit length 11cm.

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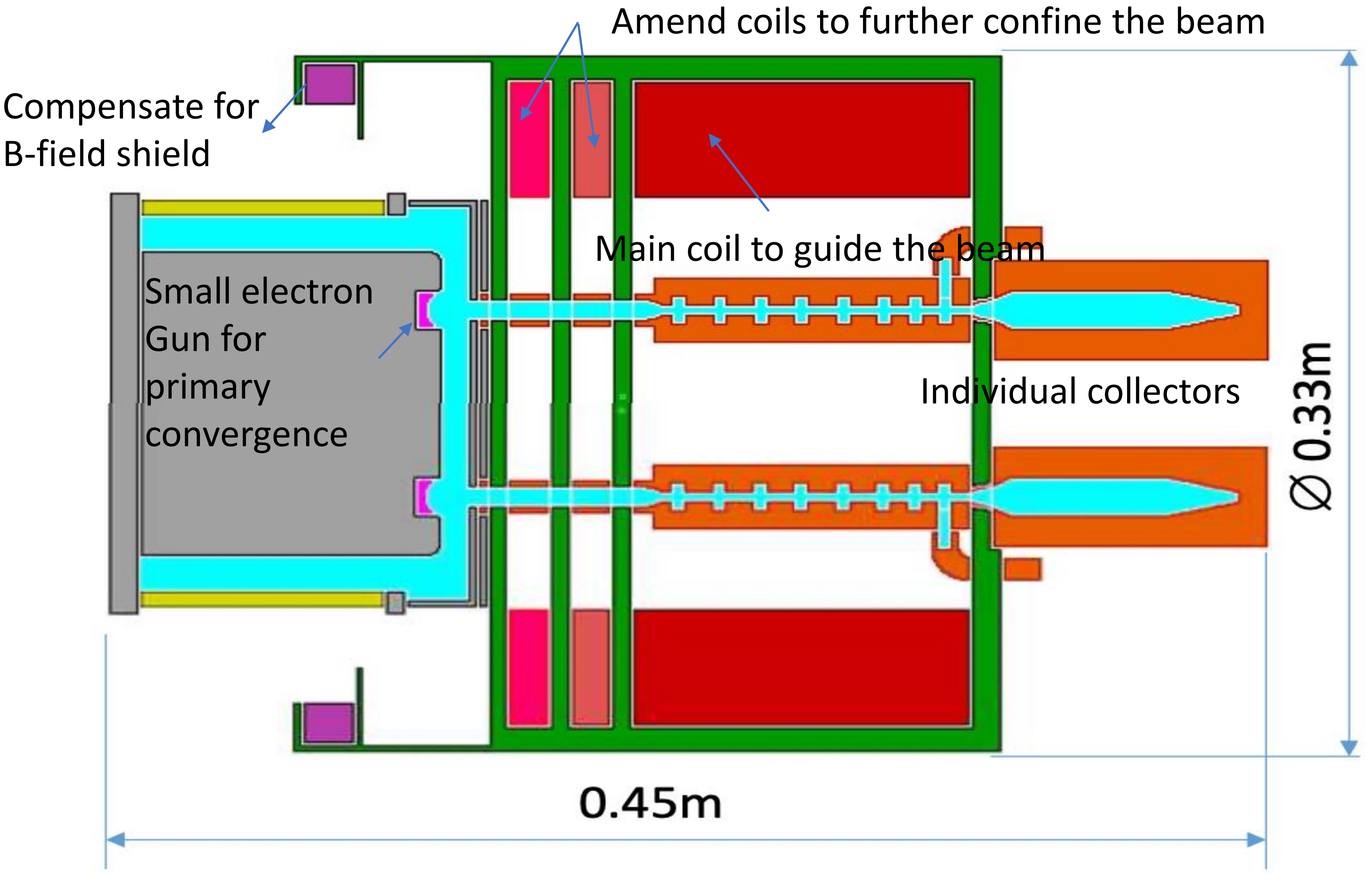
Basic Topology of the optics



- ✓ V=60kV, I=6A, r_m=0.8mm, r_c=1mm
- ✓ 20 beamlets on radial position of 38.4mm
- ✓ The radial margin for each beamlets on the cathode is 6mm;
- ✓ Limited control electrode makes double convergence necessary
- ✓ Individual collectors are used for power dissipation
- ✓ Design could be based on single beamlet if beam-beam interference and transverse magnetic field could be ignored

Simulation Tool

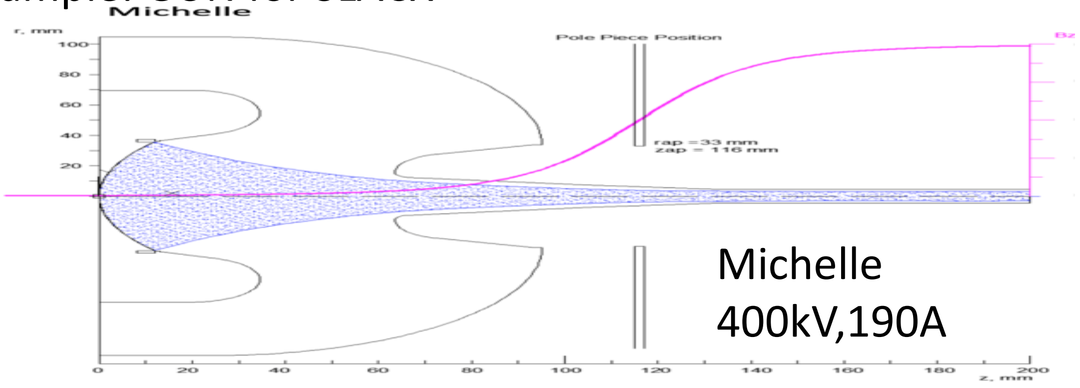
- CGUN (home-made 2D code), benchmarked with CST TRK, DGUN, Michelle…

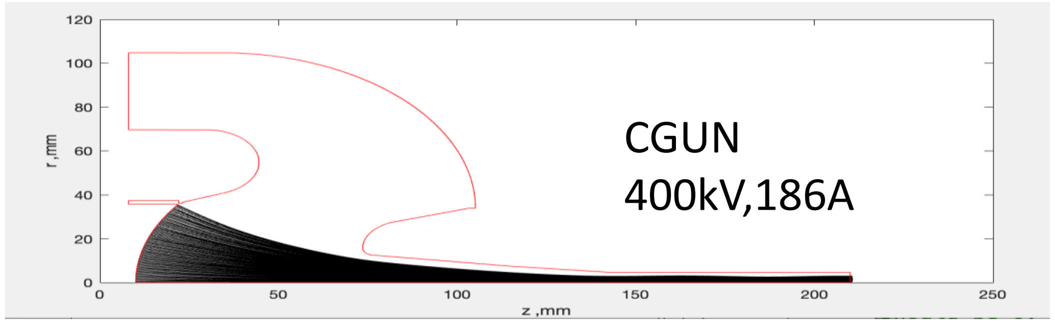
Beam optics module

Some benchmark results for complicated cases

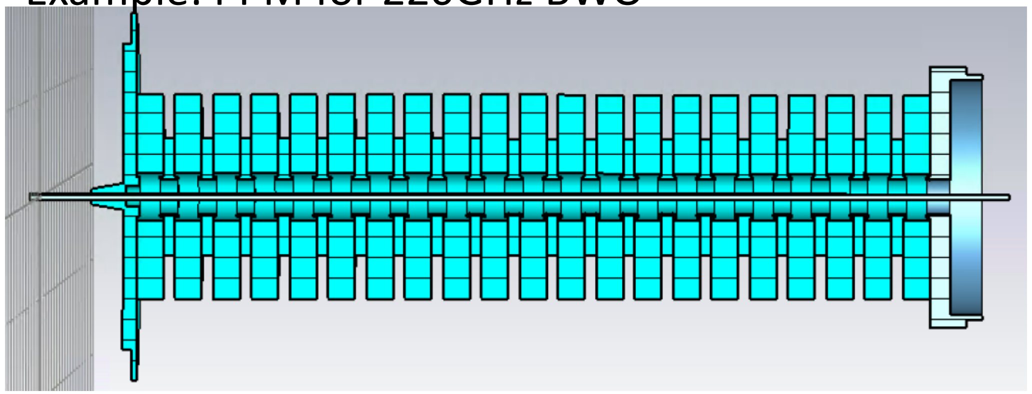
Magnetic module

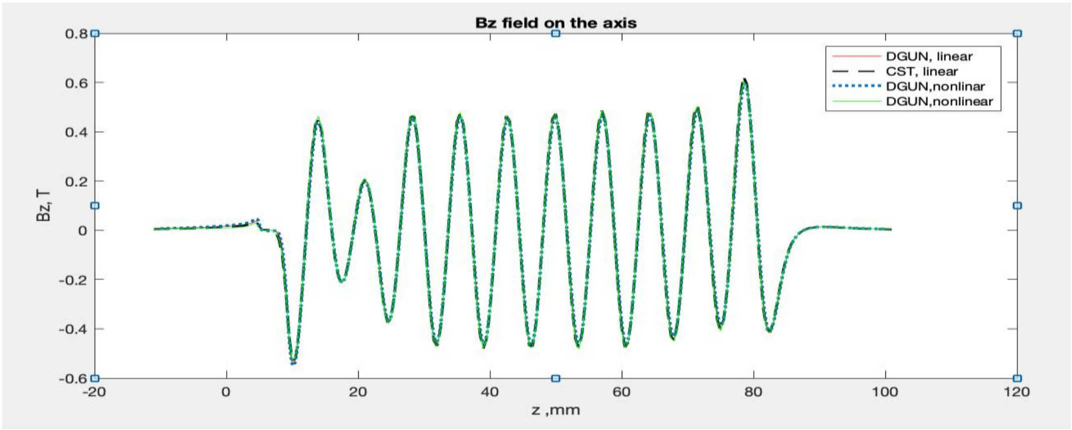
Example: GUN for SLACX



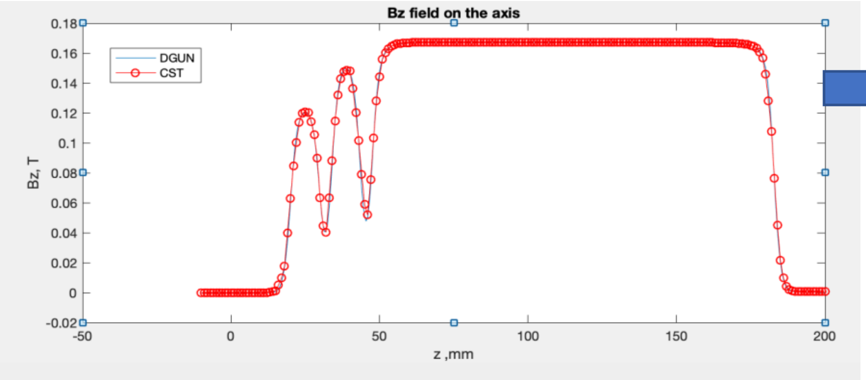


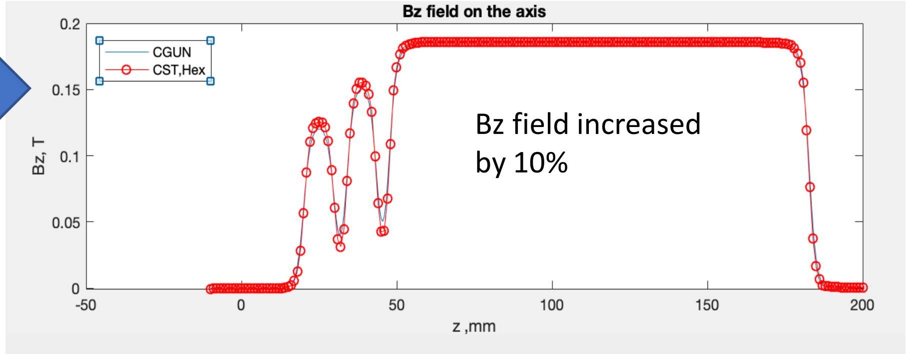
Example: PPM for 220GHz BWO

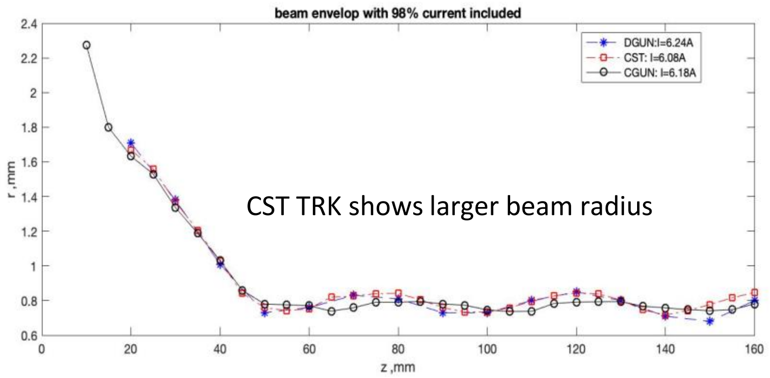


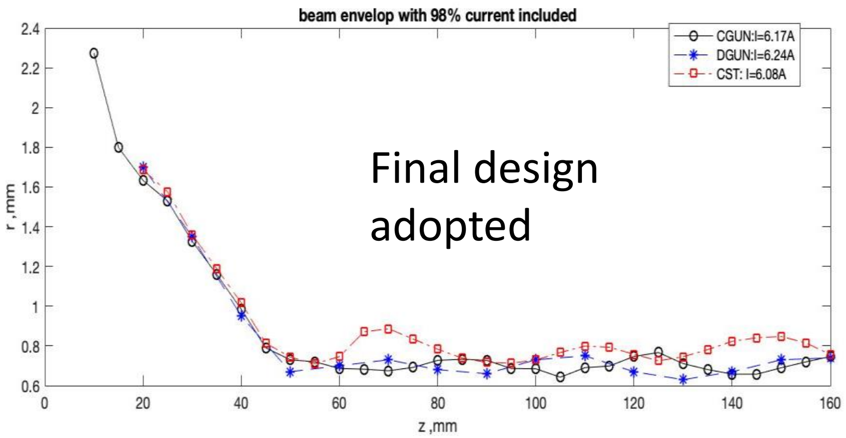


Optimization by CGUN – CERN home made tool (benchmarked with CST)



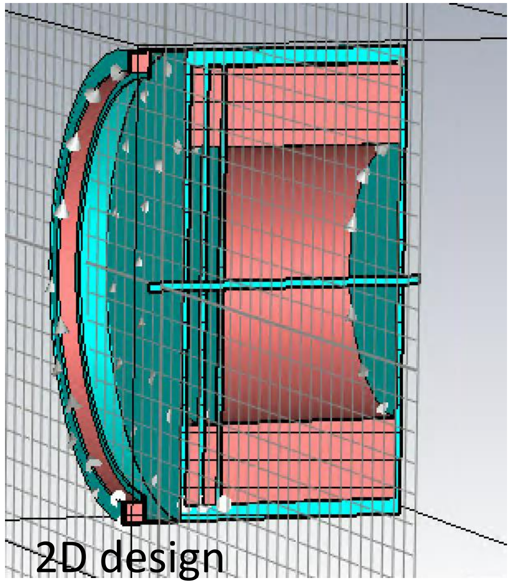


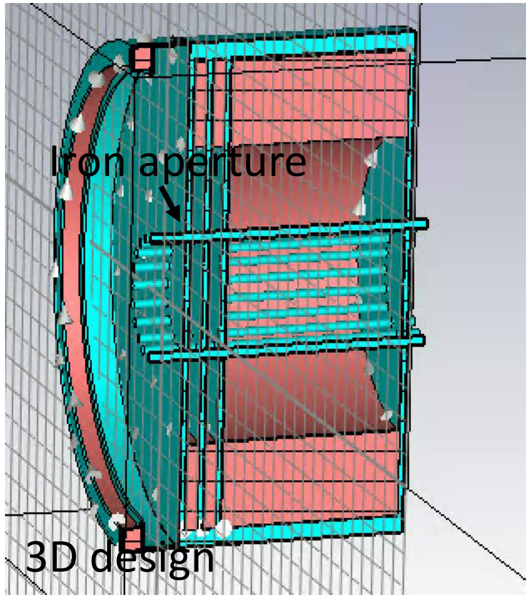


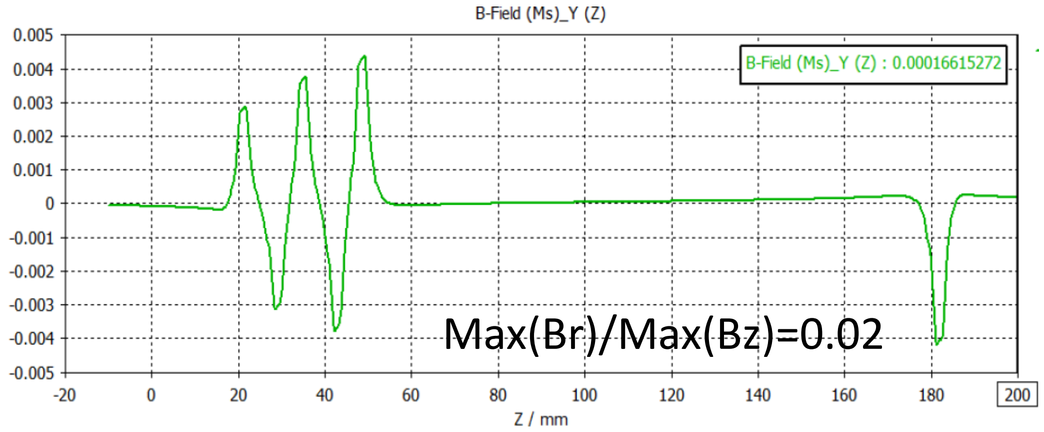


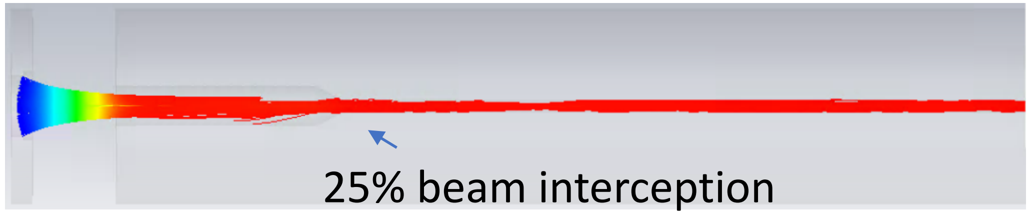
- CGUN demonstrated very good agreement with other available codes.
- Final optics tuning will be done in CST, that allows to include the MB effects.

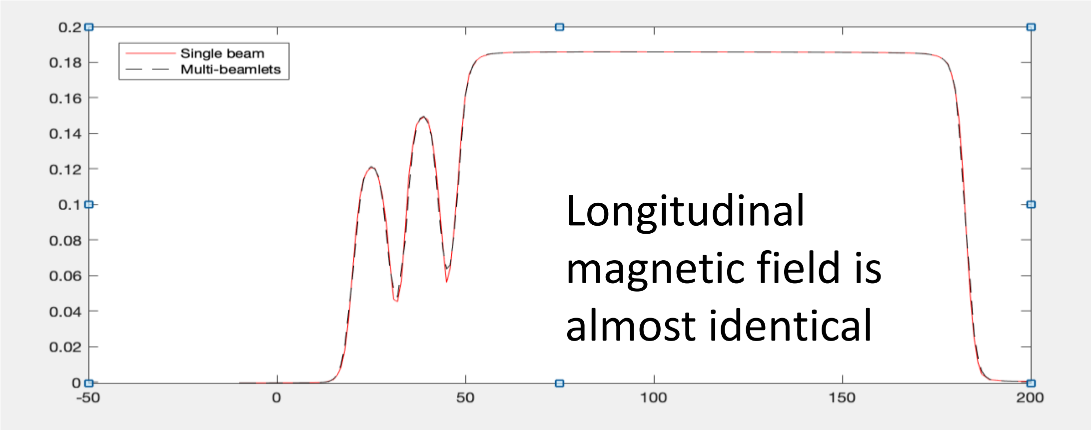
Transverse Magnetic field issues in MBK topology





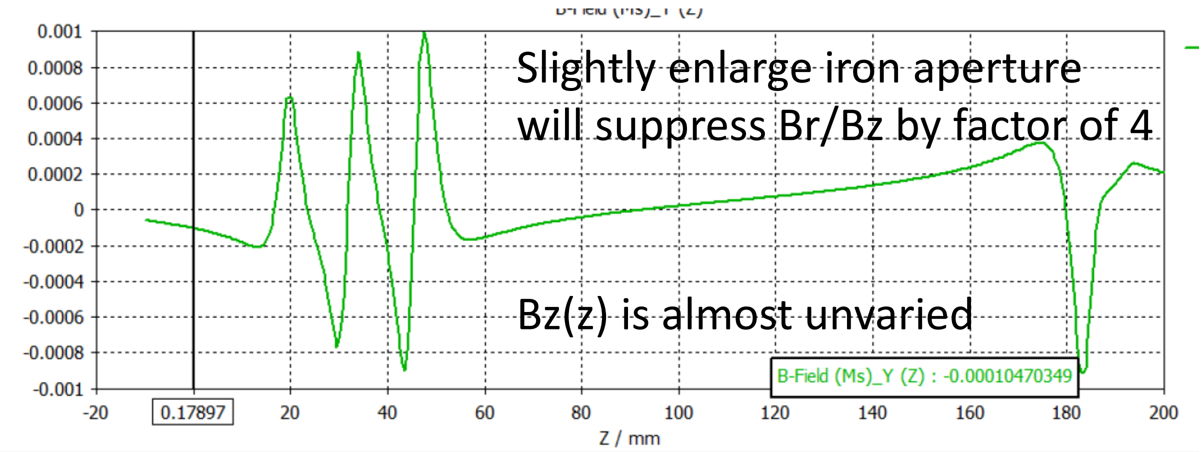


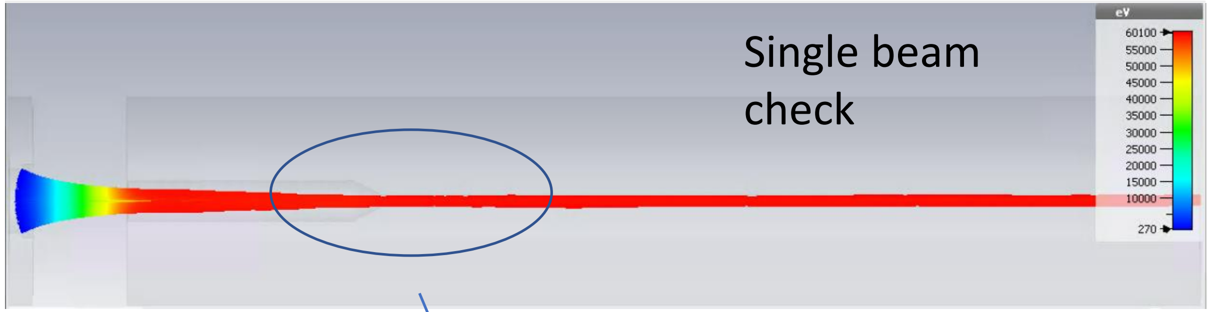


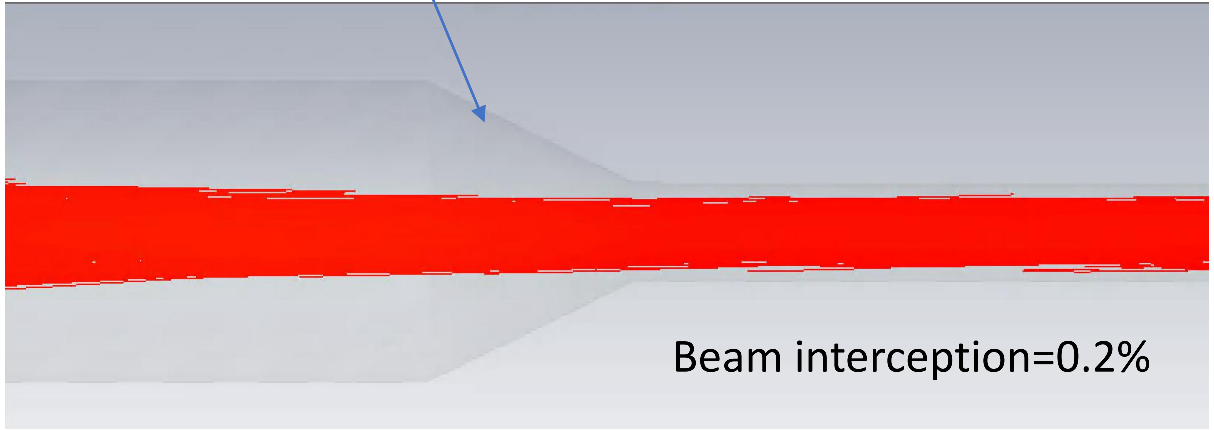


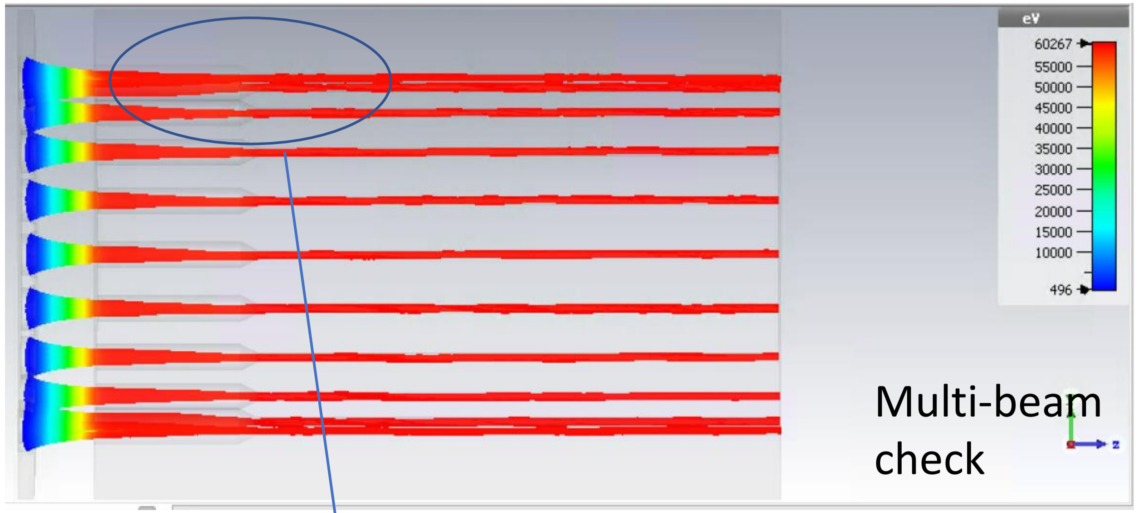
- ✓ 3D magnetic field map used for single beam simulation is done. Beam losses are heavy.
- ✓ To reduce the transverse magnetic field, the inner/outer radii of the magnet, beam apertures in the iron shields have been adjusted.

Efforts to Mitigate the transverse Magnetic field effect



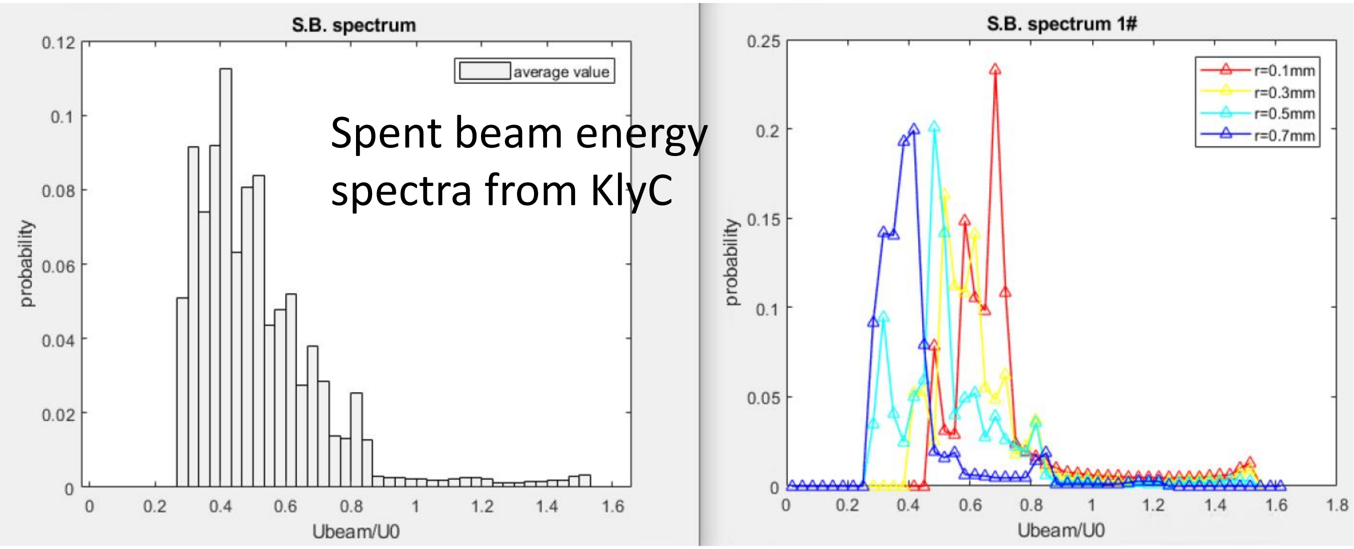






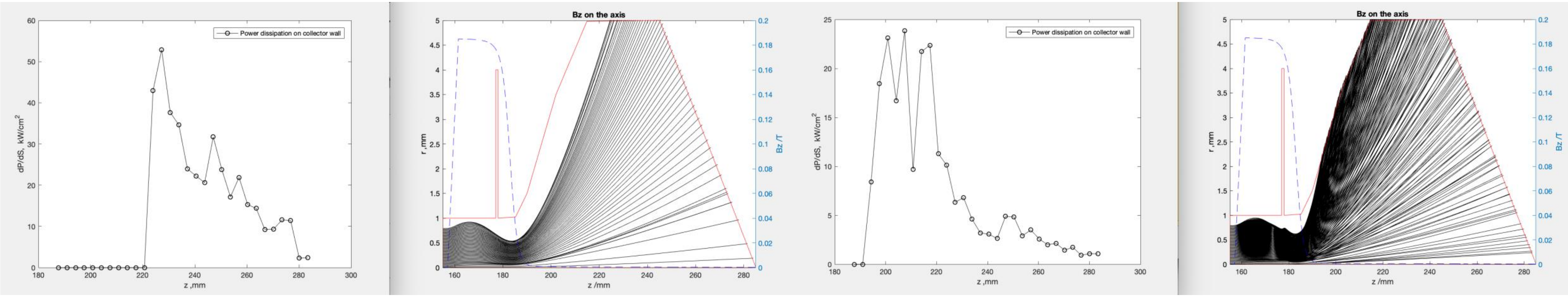
- ✓ Because of beam-beam interference in GUN area, transverse shift of beamlets becomes more pronounced which leads to higher beam interception
- ✓ Next, the radial position of iron apertures will be optimized in attempt to reduce transverse B field further.

Preliminary design of the Individual Collector with KlyC/CGUN



Spent beam energy spectra from KlyC

- ✓ For diode mode, V=60kV, I=6A, rm=0.8mm, rc=1.0mm;
- ✓ For RF mode, V=31.2kV corresponding to electron efficiency (KlyC); In preliminary study, Energy spread of ∓10kV is used for all the radial layers;
- ✓ Considering the duty circle is 1/1000 (1000ns, 1kHz), the Maximum dP/dS should be below 100kW/cm^2 according to empirical recommendations.



For DC, V=60kV, I=6A, max(dP/ds)=**55kW/cm^2.**

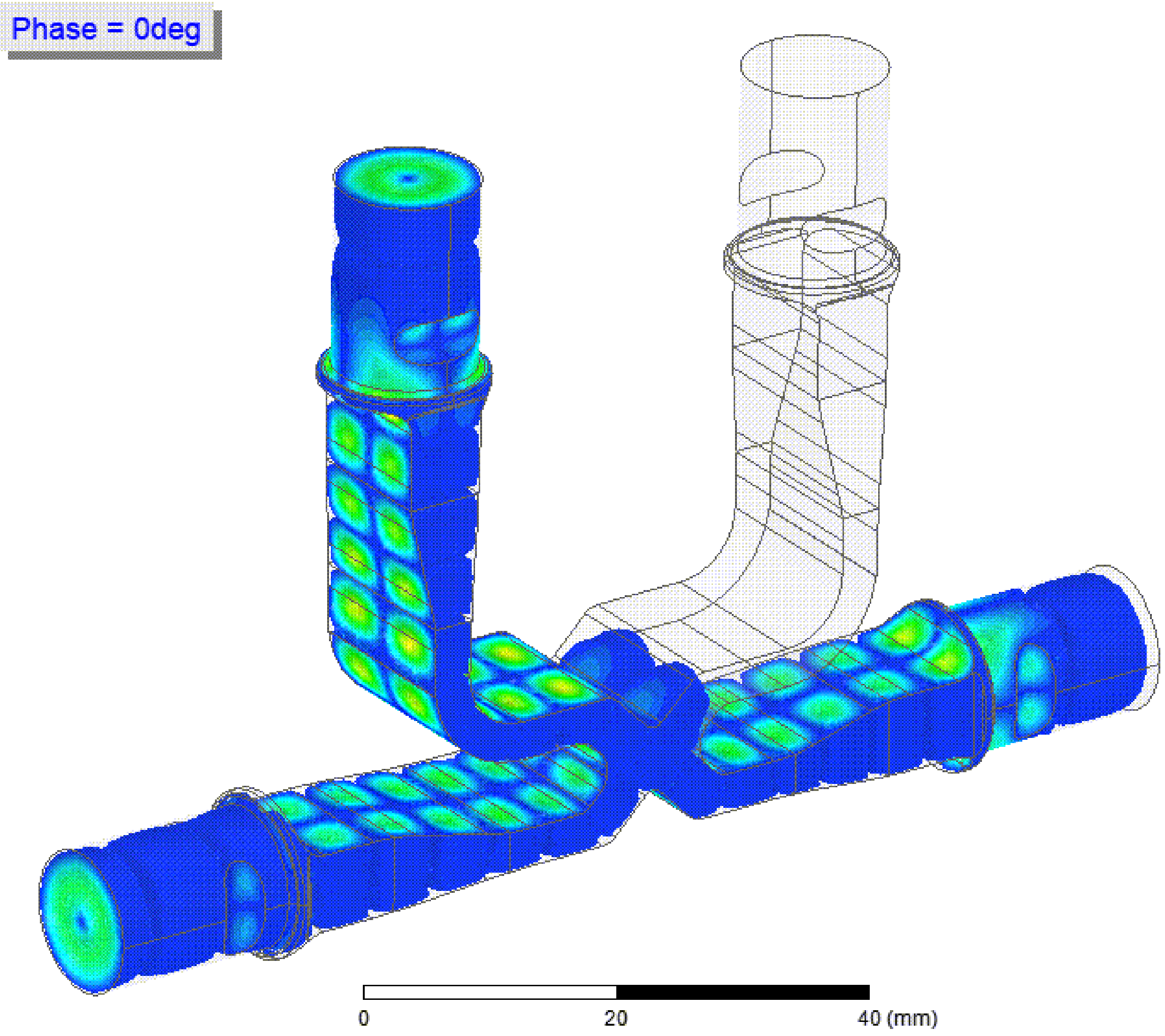
For RF, V=31.2kV ∓10kV, I=6A, max(dP/ds)=**25kW/cm^2.**

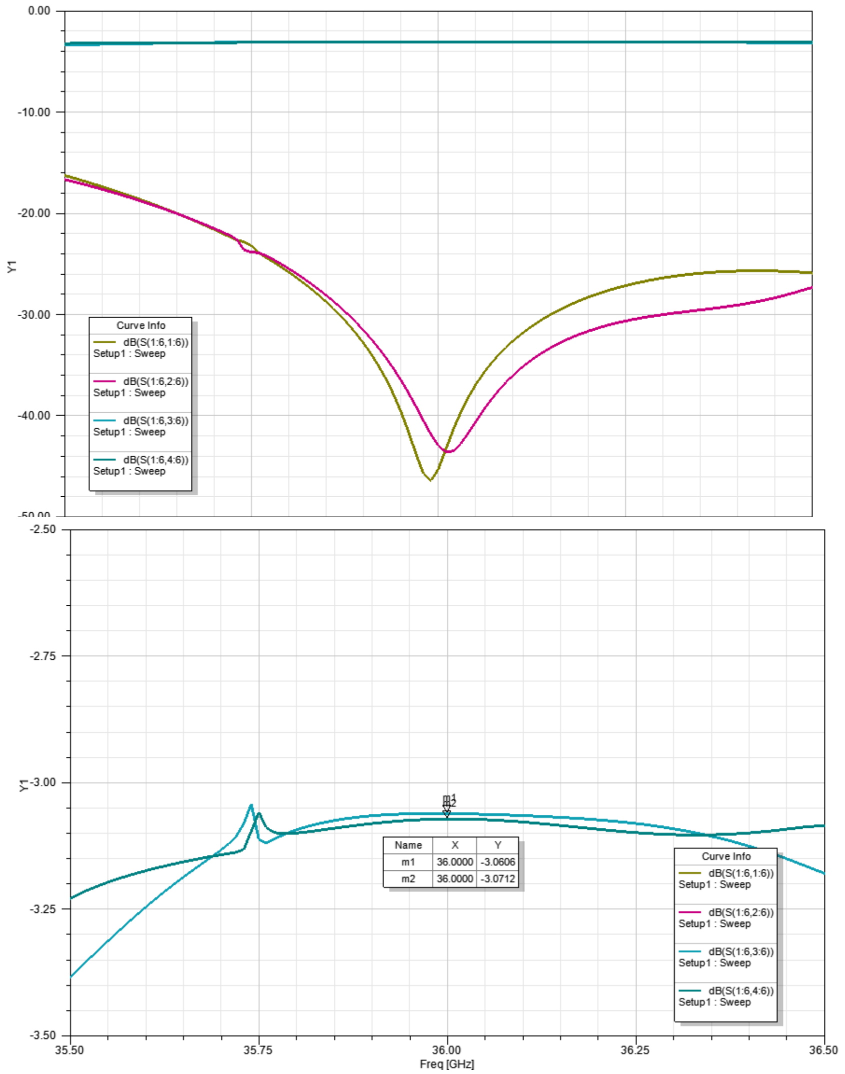
36 GHz, 2.5 MW MBK parameters

Voltage: 60 kV (no oil insulation needed)
N beams: 20
Current/beam: 6A
Current/total: 120 A
Power in saturation: 2.57MW
RF efficiency: 37.5%
Power gain: 41dB
Bandwidth -3dB (KlyC): 50MHz
Solenoidal field: ~0.2T
Tube length total: 0.45m
Max. Cathode current density: 9A/cm^2
RF pulse length (tentative): 1000 ns
Max repetition rate (diode mode): <2kHz
Max repetition rate (RF mode): <4kHz

Designed by Igor

3dB E01_H20 hybrid. Power head for PC and/or klystrons combiner





Summary and outlook

- CGUN code is self-developed and has been well benchmarked with other codes.
- MBK GUN and Magnetic system design are almost finished. Further optimizations are ongoing to improve the beam transmission.
- Preliminary design for Collector is done, to be checked with full tube simulation in CGUN/KlyC (required modification is almost finished).
- PIC simulation with practical beam optics imported from TRK will be done as a final verification (Cathode-RF circuit-Collector).
- Evaluation of the cooling circuit (feasibility analysis)