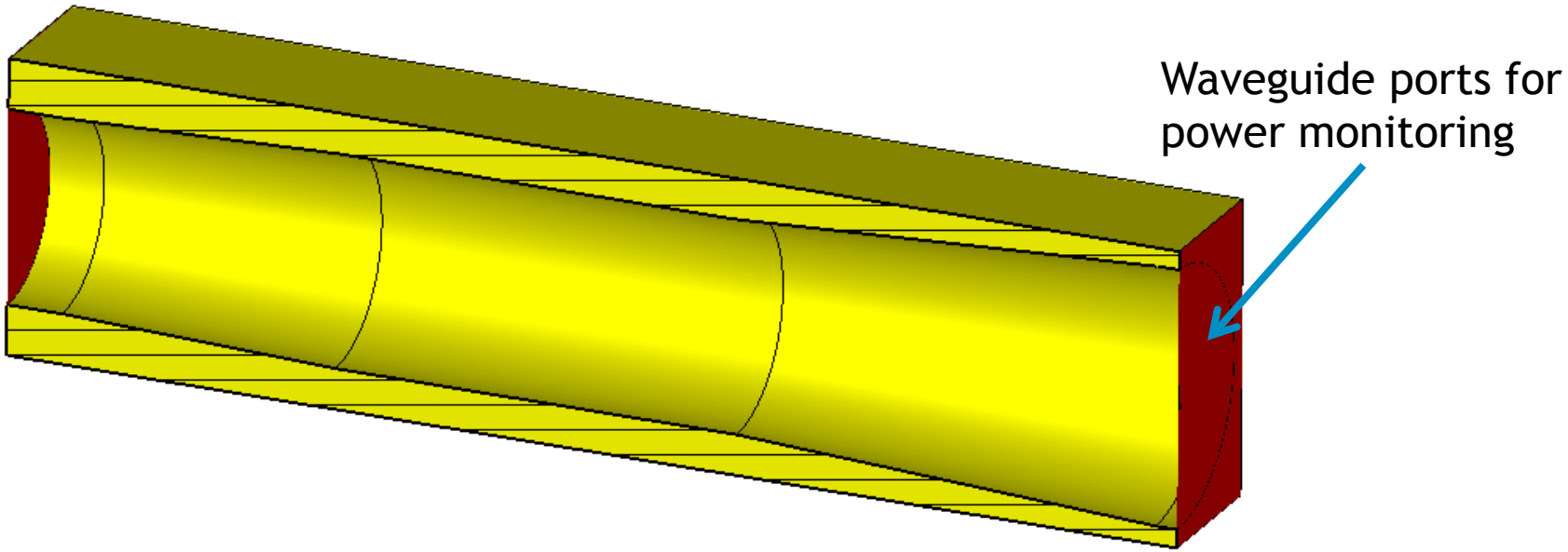
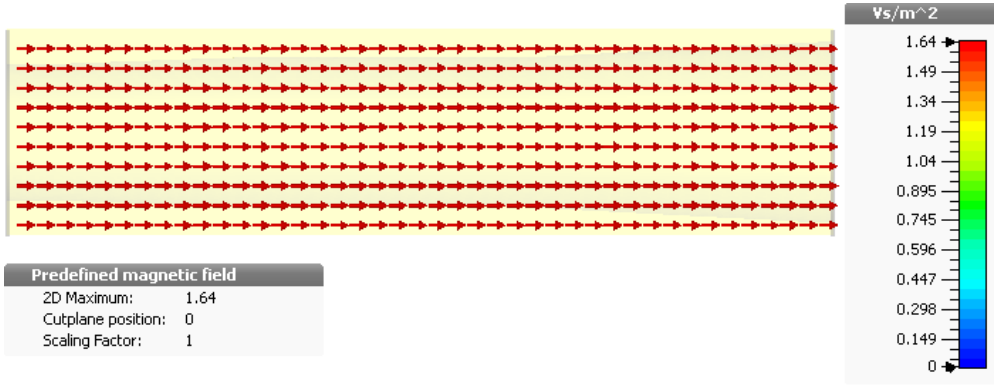
3D Gyrotron Simulation with CST STUDIO SUITE™

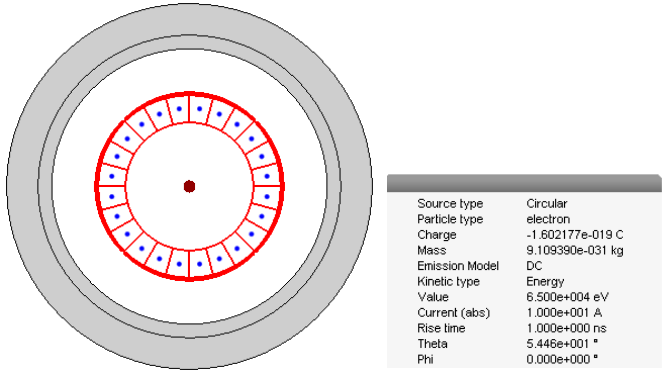
Structure of Investigation



[1] Ashutosh, B. Ravi Chandra, and P. K. Jain, “Multimode Behavior of a 42 GHz, 200 kW Gyrotron,” Progress In Electromagnetics Research B, Vol. 42, pp. 75-91, 2012

Source Parameters and Settings

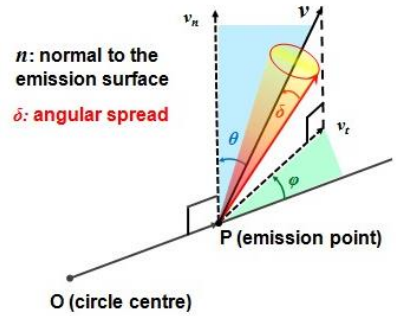




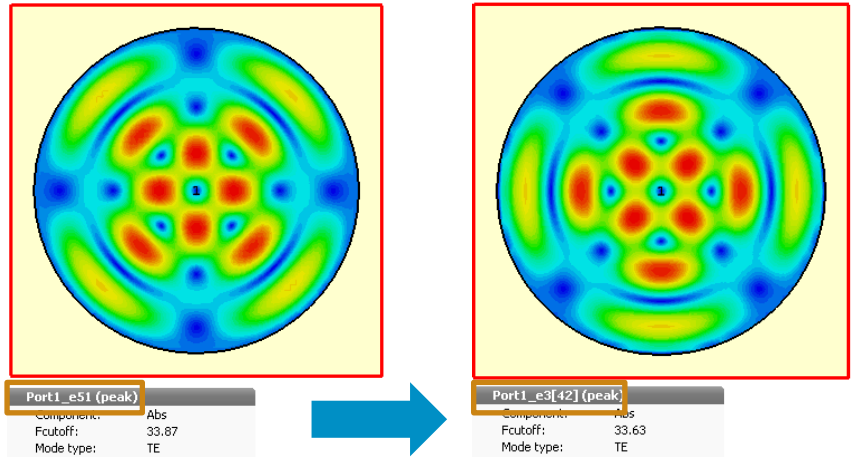
Annular Beam Properties:

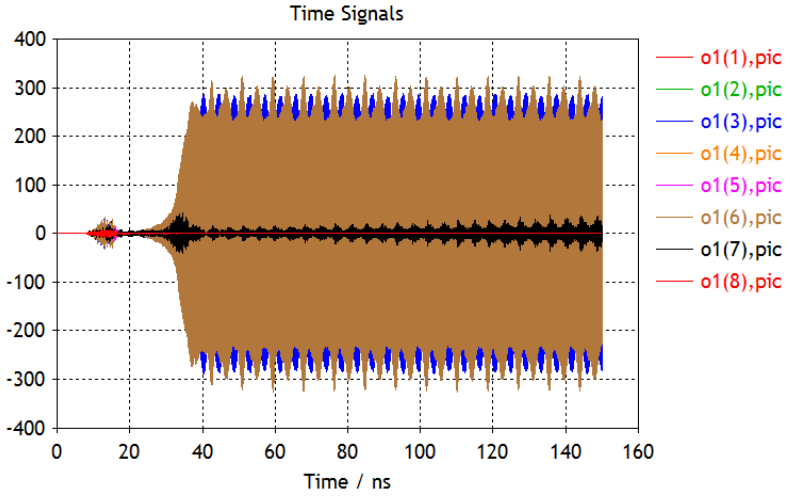
→ Particle emission with θ and φ according to pitch factor 1.4

→ Interaction with constant B field sustains gyration



Target Frequency





Properties for 2D Port-Eigenmode Solver:

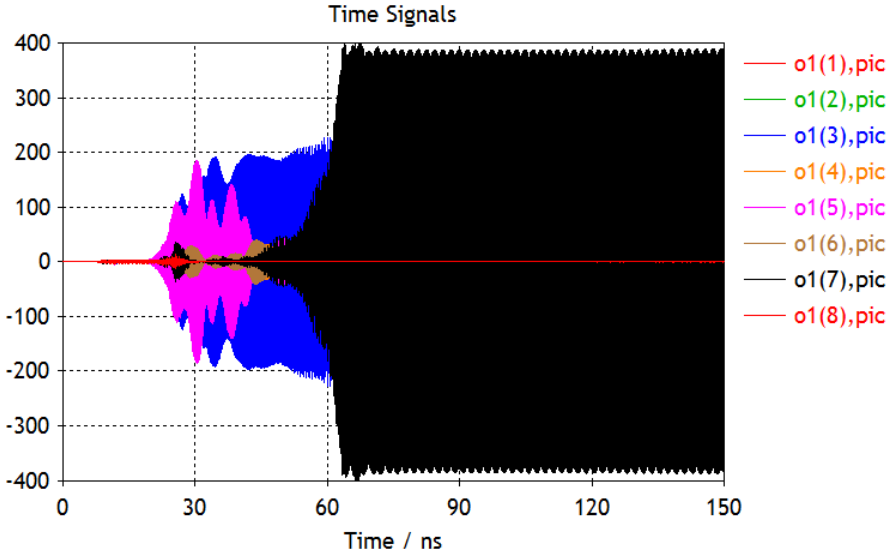
→ Reduction of evaluated port modes

→ Absorption of unconsidered port modes

→ Reduction in simulation time by factor 8.7

2h 54 m 31s with target, 25h 24m 49s without target on a Tesla C20 card

Results

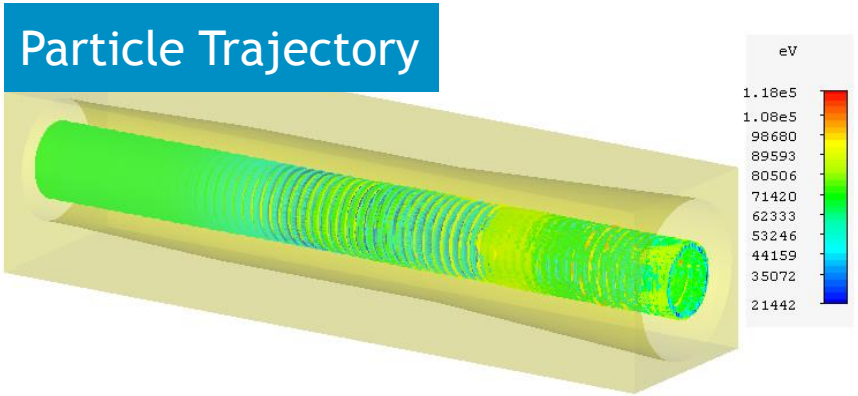


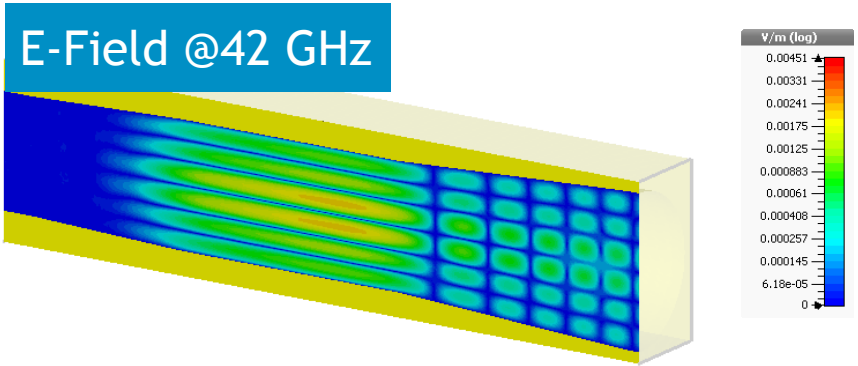
Output Signals:

→ Output power of 385^2/2 = 74.1 kW

→ MAGIC simulations of [1] showed ~80kW

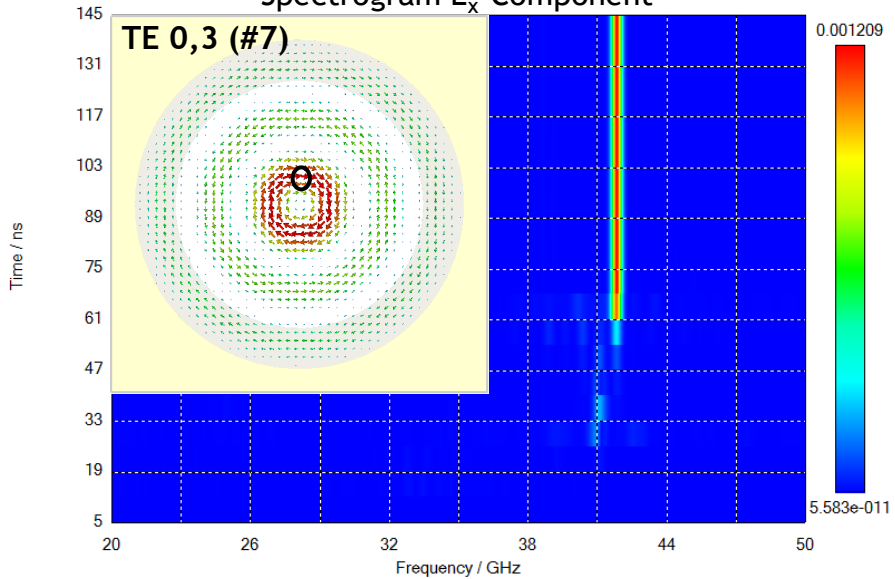
→ Output in TE 0,3 Mode



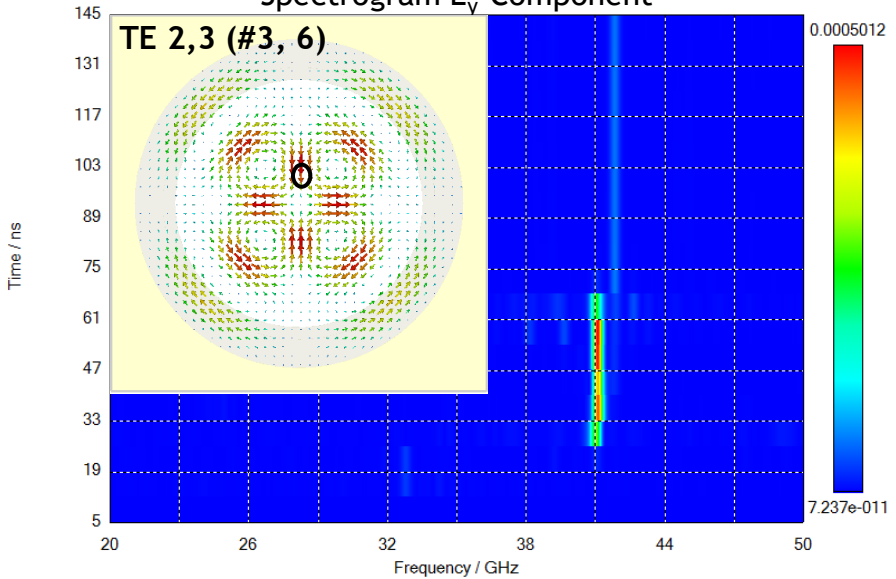


Start Up Behaviour

Spectrogram E_x-Component

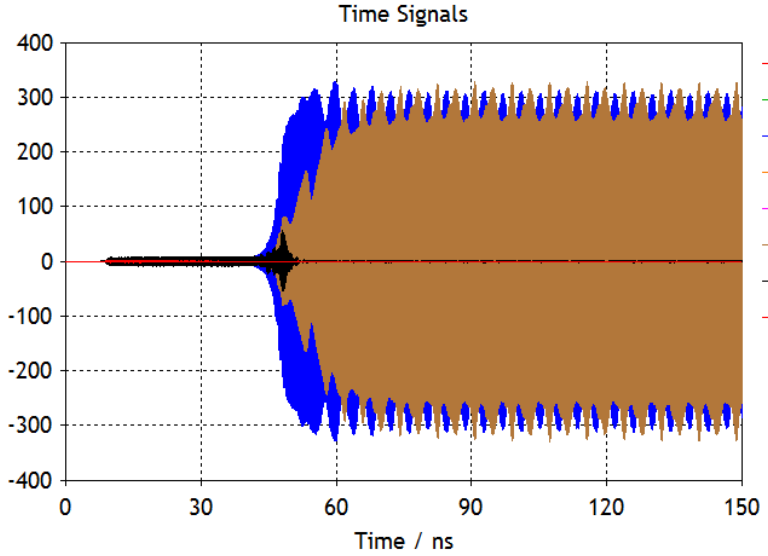


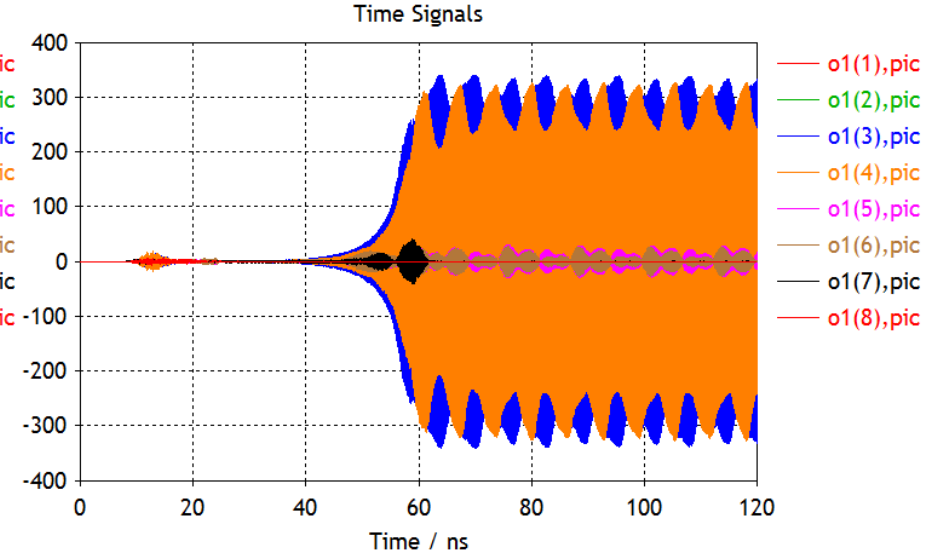
Spectrogram E_y-Component



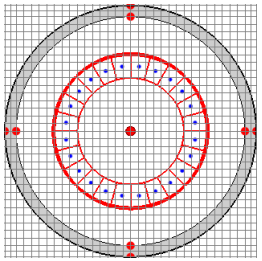
- → Start up first in TE2,3 mode
- → Stabilization in TE0,3 mode
- → Observation of port signals confirmed

Mesh Study (B=1.61 T)

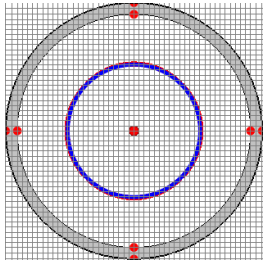




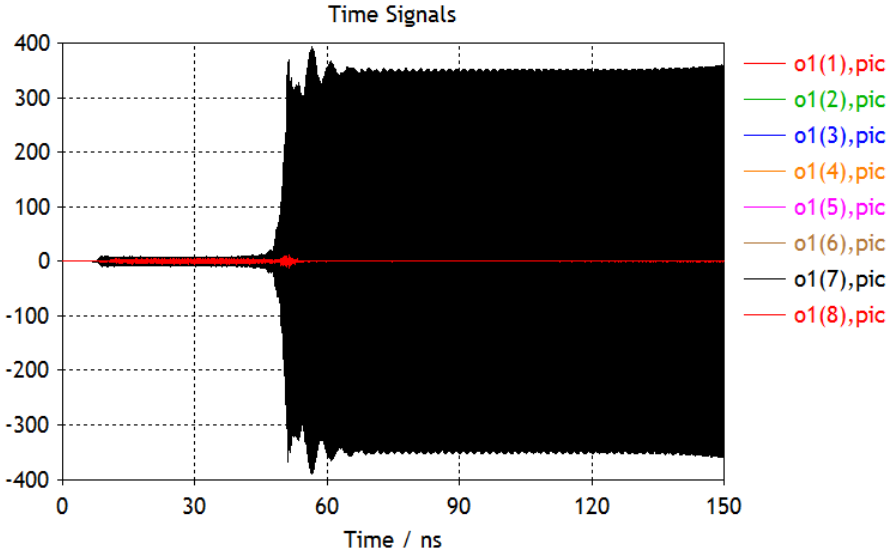
Coarse:
389 344 Mesh Cells
82 000 Particles
→ 51.2 kW Pout

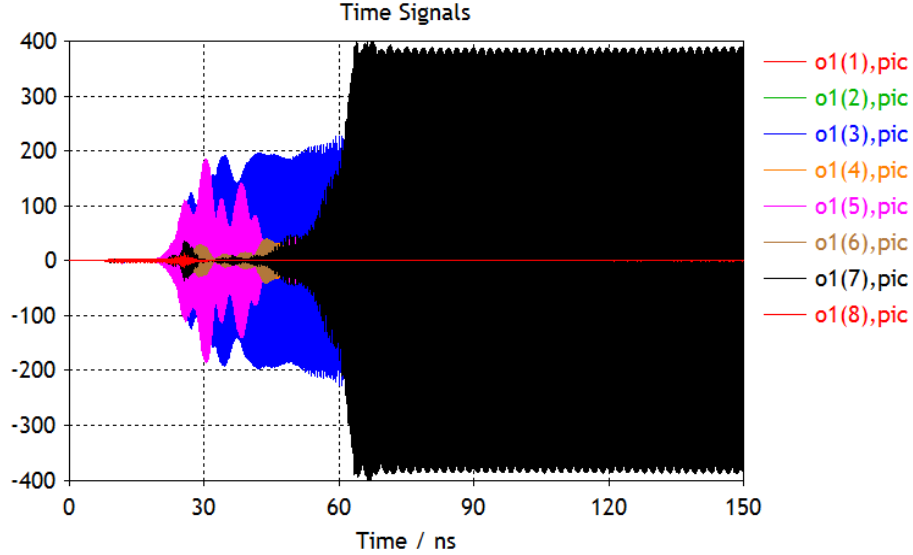


Fine:
1,280,848 Mesh Cells
1e6 Particles
→ 57.8 kW P_{out}

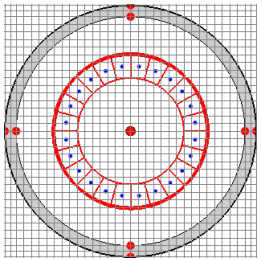


Mesh Study (B=1.64 T)

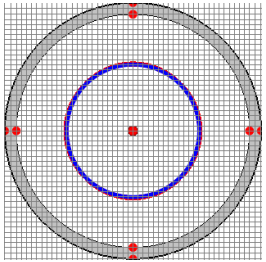




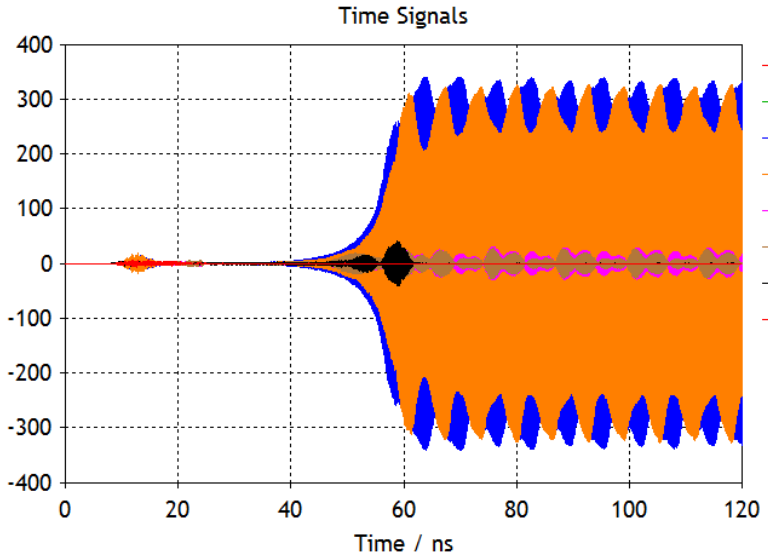
Coarse:
389 344 Mesh Cells
82 000 Particles
→ 61.25 kW Pout

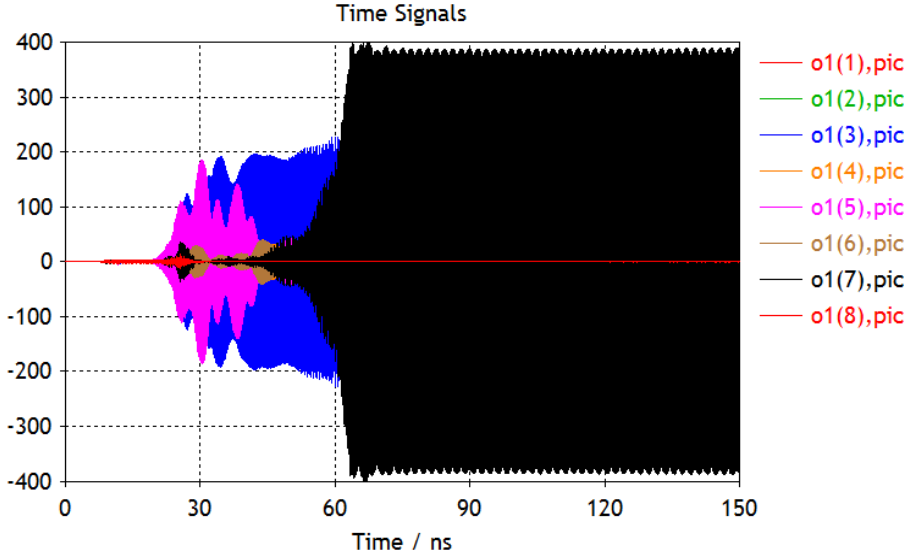


Fine:
1,280,848 Mesh Cells
1e6 Particles
→ 75.27 kW P_{out}



B-Field Variation





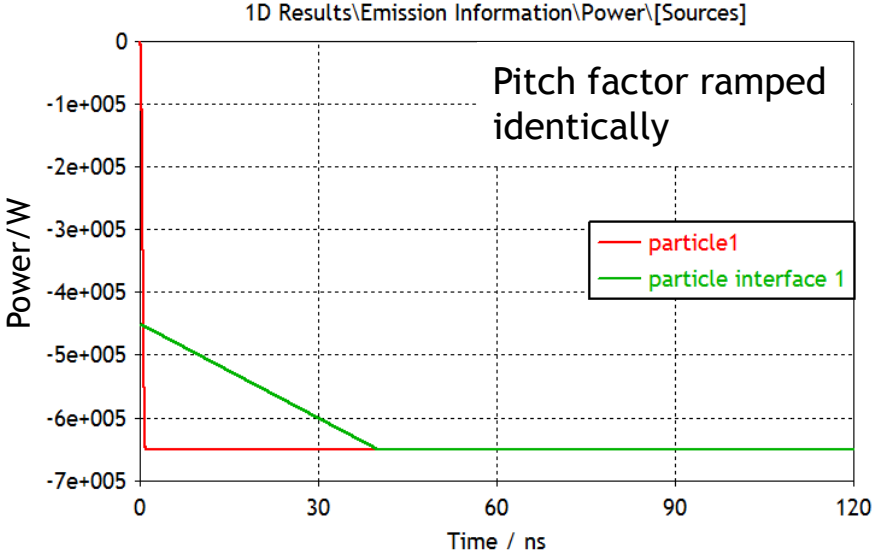
B=1.61T:

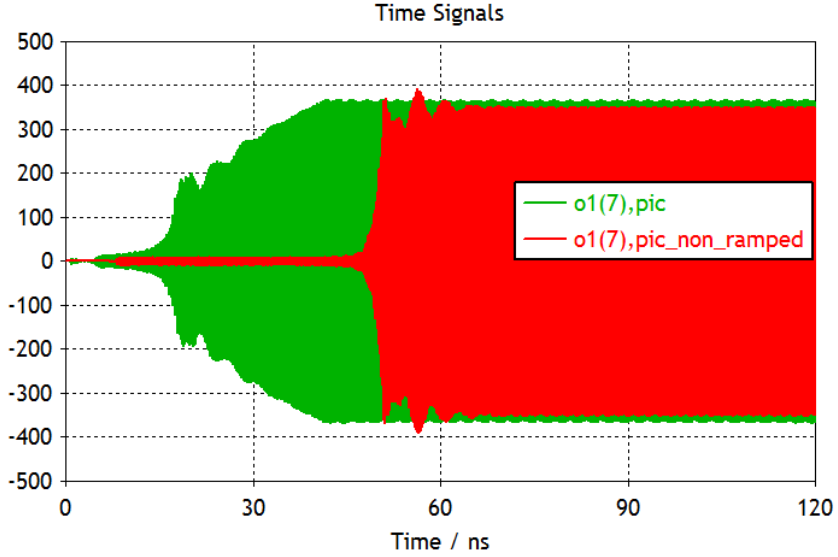
- → Stabilization in TE2,3 Mode
- → 57.8 kW output power
- → 70 kW from MAGIC

B=1.64T:

- → Stabilization in TE0,3 Mode
- → 75.27 kW output power (74.12 finer)
- → 81kW from MAGIC

Ramped Beam Properties





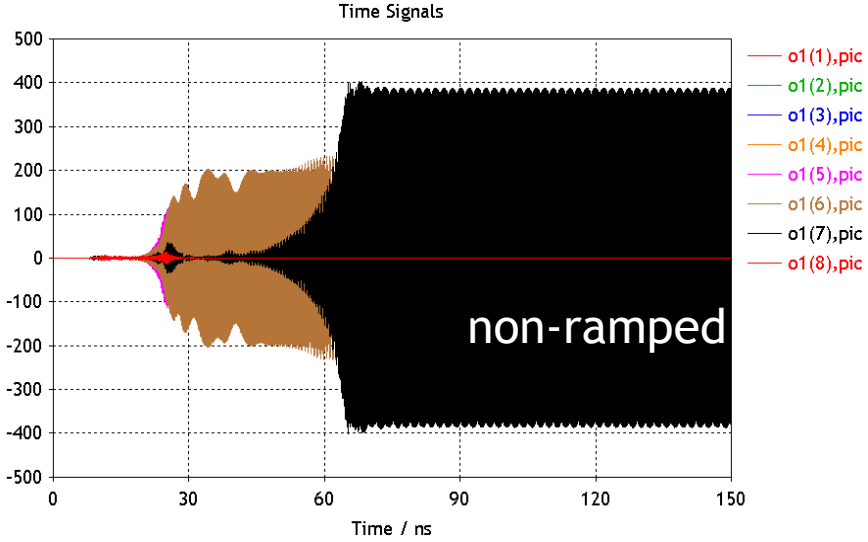
B=1.64T, Coarse Mesh:

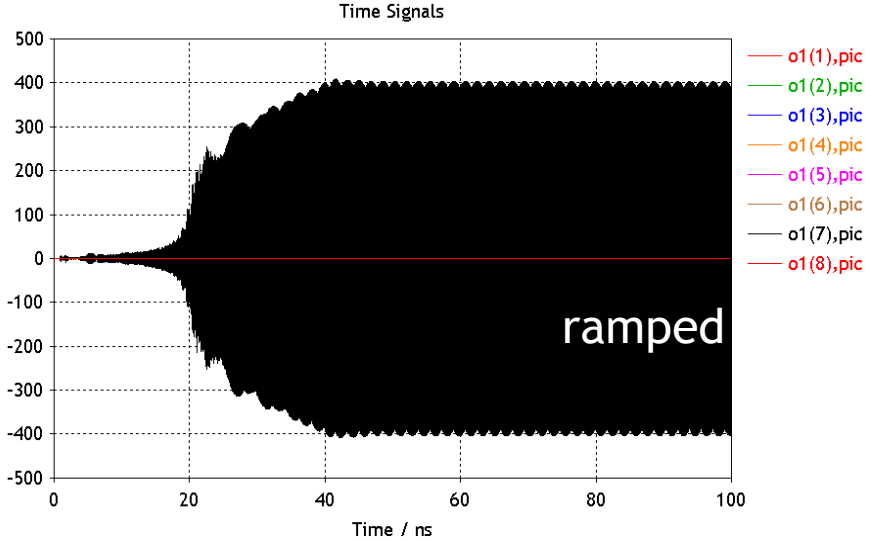
→ Stabilization still in TE0,3 mode

→ Earlier start up

→ Slightly higher output power

Ramped Beam Properties





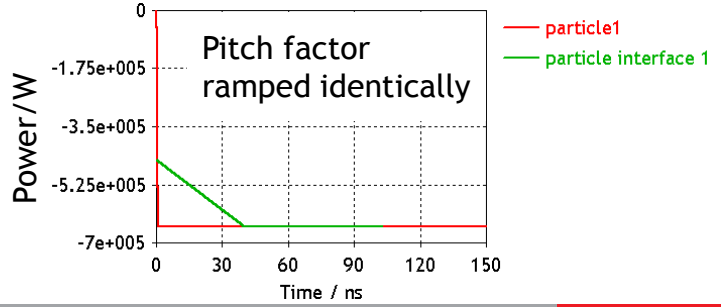
B=1.64T, Fine Mesh:

→ Less Mode Competition

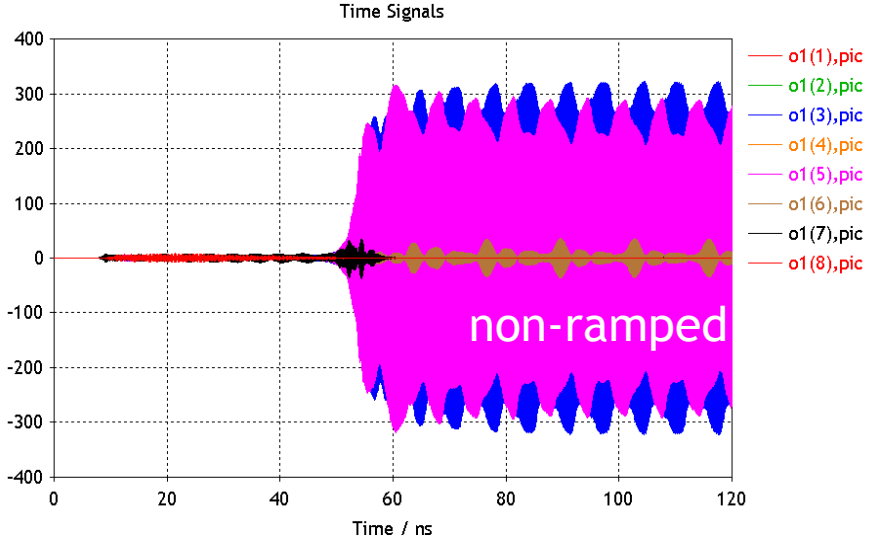
→ Stabilization still in TE0,3 mode

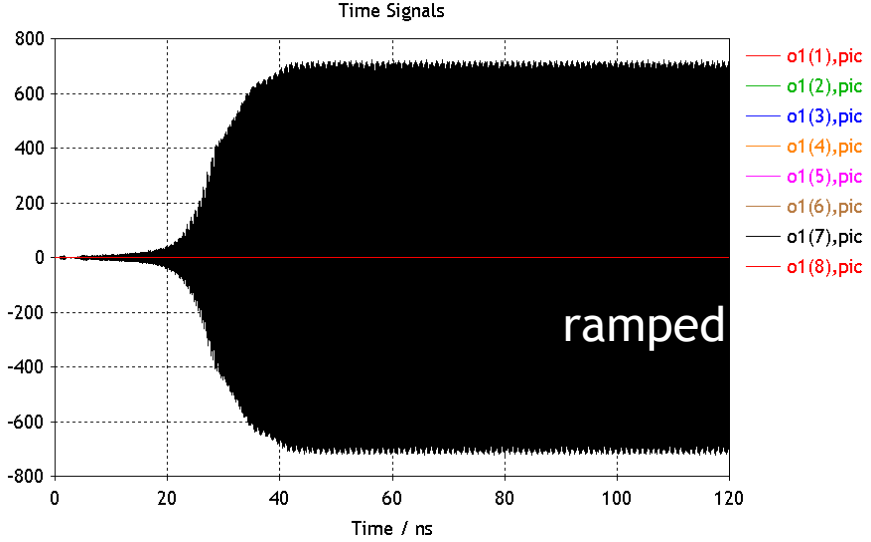
→ Earlier start up

→ Slightly higher output power



Ramped Beam Properties



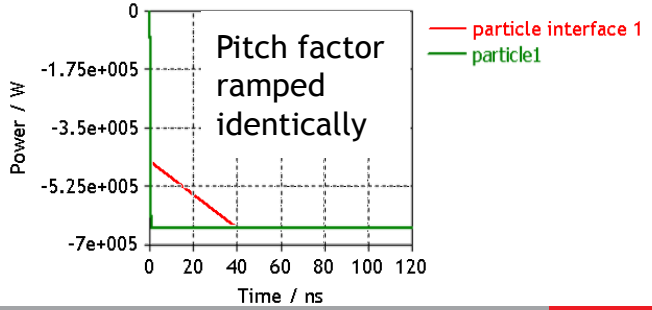


B=1.61T, Fine Mesh:

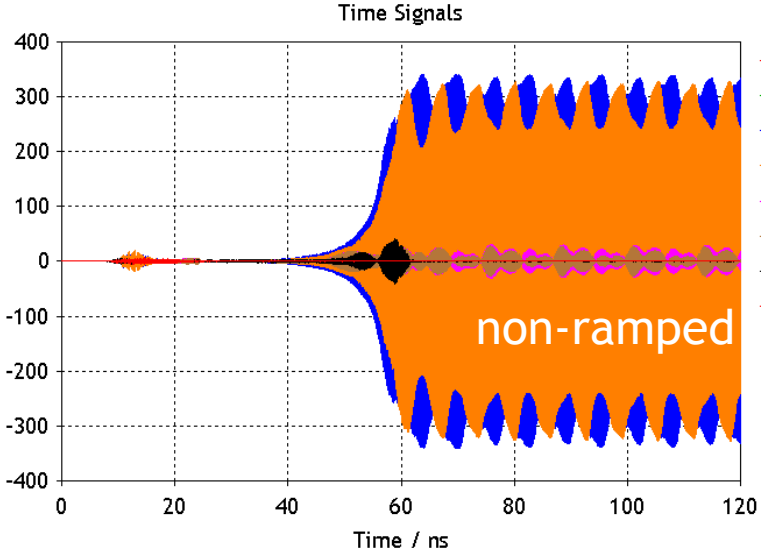
→ 10A

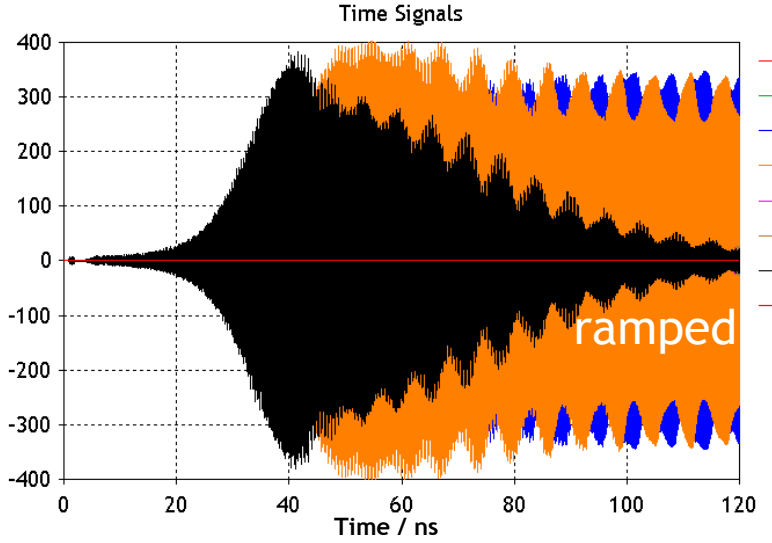
→ Runs into the other mode

→ 245kW in TE0,3 mode instead of 2x48 kW in TE 2,3 mode



Ramped Beam Properties



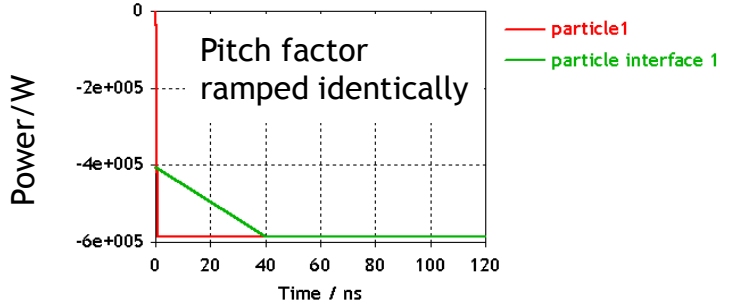


B=1.61T, Fine Mesh:

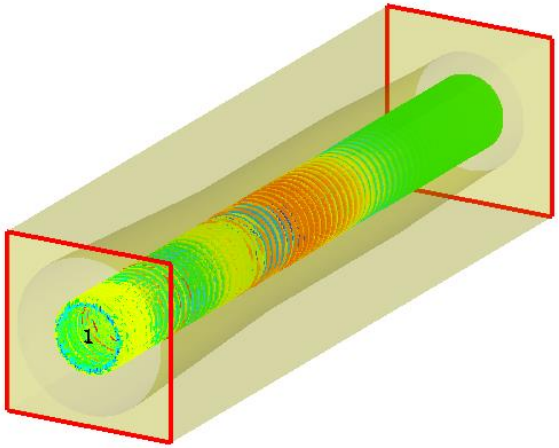
→ 9A Beam current

→ Runs into the same mode

→ 2x57.8 kW in TE 2,3 mode



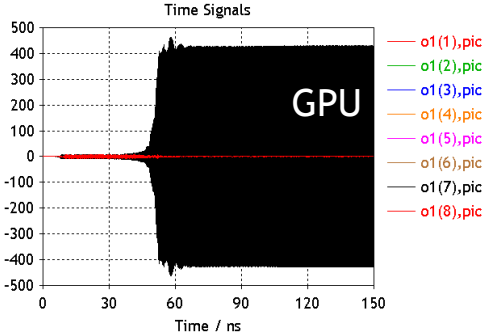
GPU Speed Up

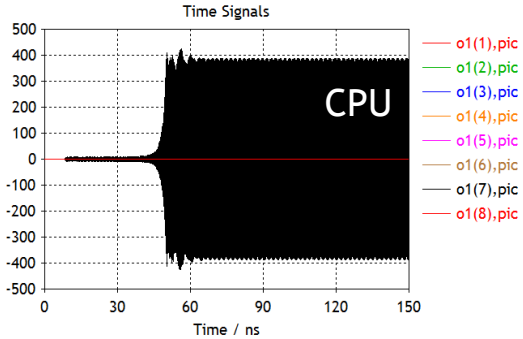


Number of Mesh Cells	1,280,848
Av. Particle Number	1e6
Simulation Time CPU	8h 01m 22s
Simulation Time GPU	3h 16m 54s
Total Speed Up*	2.45

*) Speed up factor of total time (not MCells/s)

Kepler 40 Card vs.
Dual Xeon E5-2650 v2, 262GB RAM





Conclusion

Convergence study is important.

Ramping of the current can have an influence on start up as well as stabilized mode.

Simulation can be done conveniently on a GPU.