DTL: preliminary cavity design

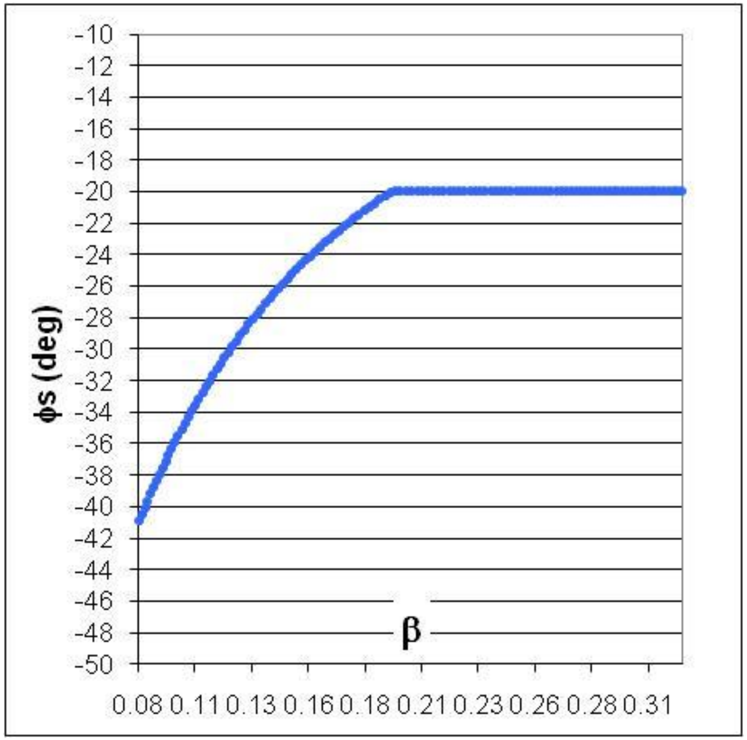
- Beam dynamics input
- RF design refinement
- Stabilization and Tuning: preliminary considerations
- Possible R&D program: ZTT optimization

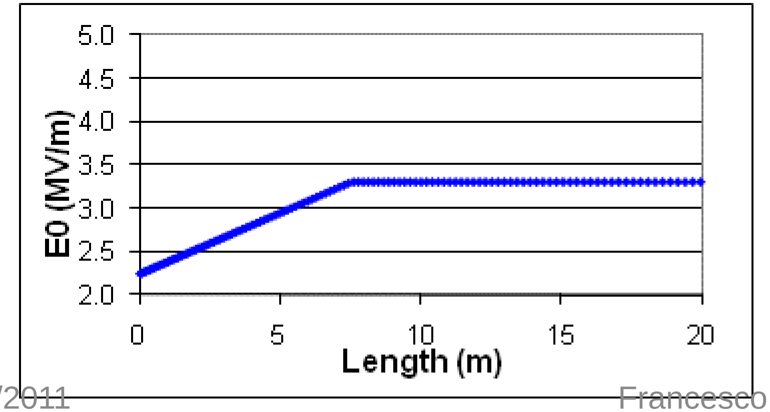
Beam dynamics input

- E0
- Sync.Phase law
- Number of Cells
- Cell and Gap lengths
- First extimation of Tanks

Design Summary

Tank	No of Cells	Length m	Wfinal Mev	Power MW
1	66	7.47	19.20	2.050
2	29	5.75	34.88	2.045
3	24	5.93	50.26	2.072
Total	119	19.15		6.17



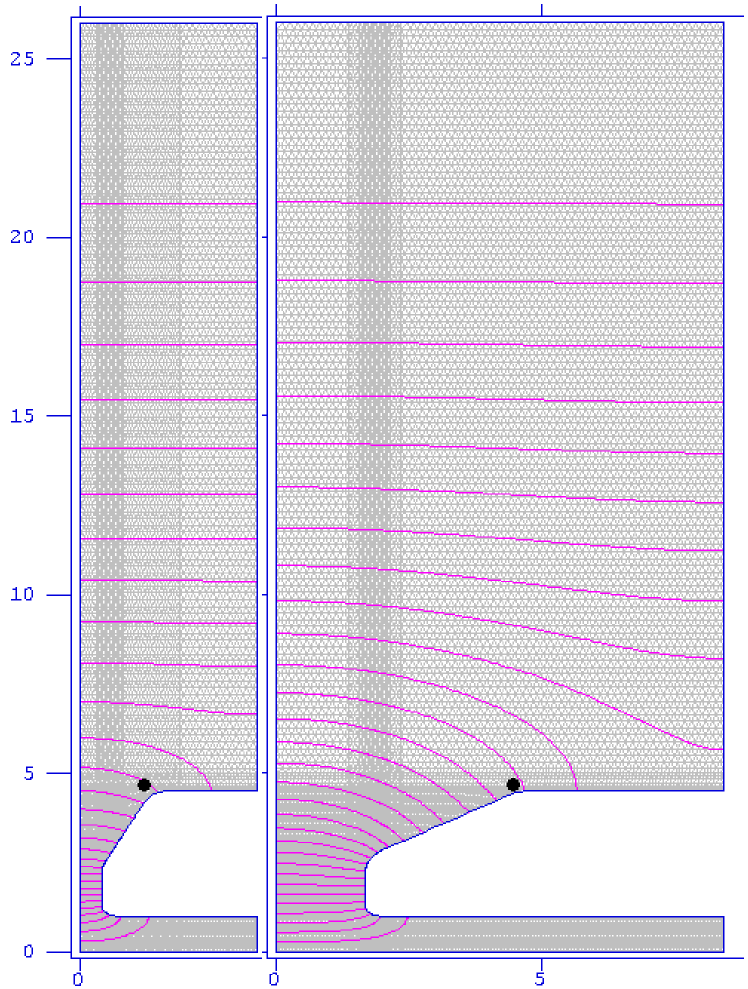


SuperFish refinement

- Tuning adjusting FACE ANGLE
- Losses, Q, Stored Energy, ZTT
- Stem Detuning
- Study of sensitivity
  - Stabilization
  - Frequency budget

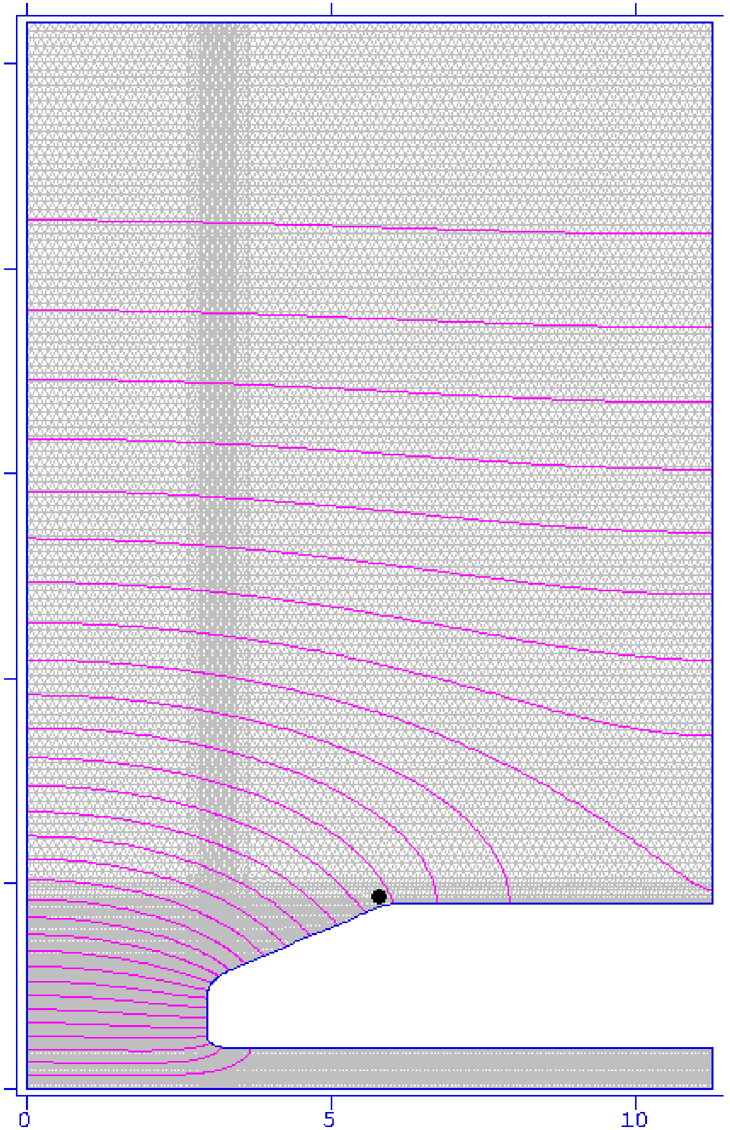
TANK1

- Diameter=52cm, DT diameter=9cm
- Length =7.43m (8.7 βλ)
- Energy Gain =15.9 MeV
- Stored Energy = 17.7 J
- End Wall Power (1.25 kW @ 1MV/m = 19.8 kW
- Cavity Power(SF) = 755 kW
- Beam Power (Peak) = 1114 kW
- Total Power (1.2×SF) = 2020 kW
- ZTT = 45.1 Mohm/m
- Q0 (SF) = 51630



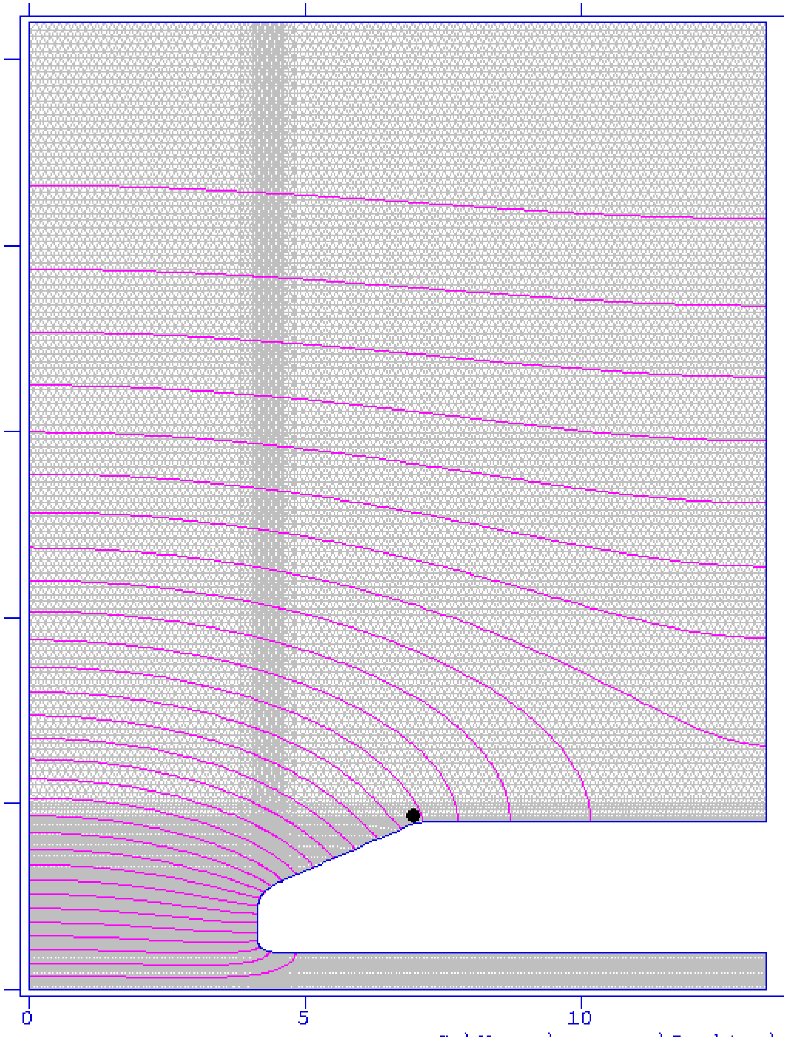
TANK2

- Diameter=52cm, DT diameter=9cm
- Length =5.72 m (6.7 $\beta\lambda$)
- Energy Gain =14.9 MeV
- Stored Energy =19.3 J
- End Wall Power =27.2 kW
- Cavity Power =788.8 kW
- BeamPower (Peak)= 1046.7 kW
- Total Power =1993.3 kW
- ZTT = 49.5 Mohm/m
- Q0 = 53870

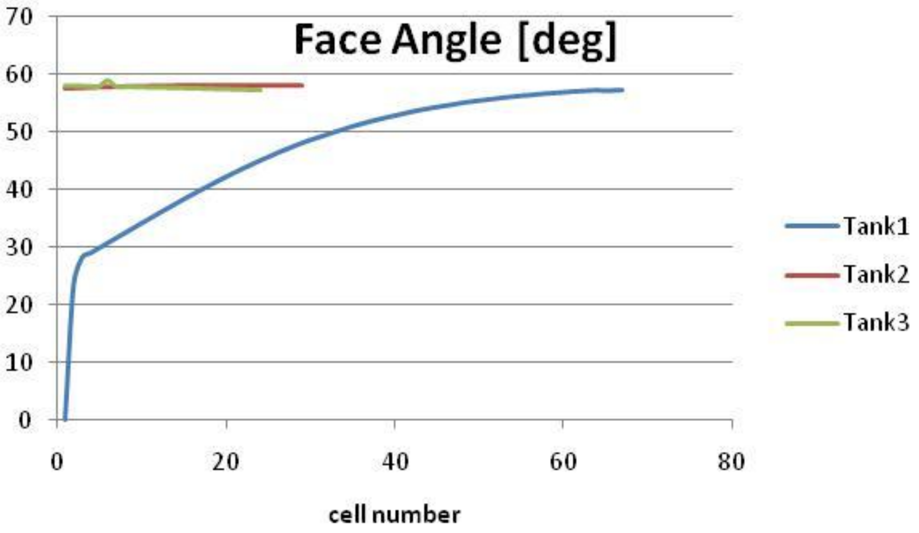


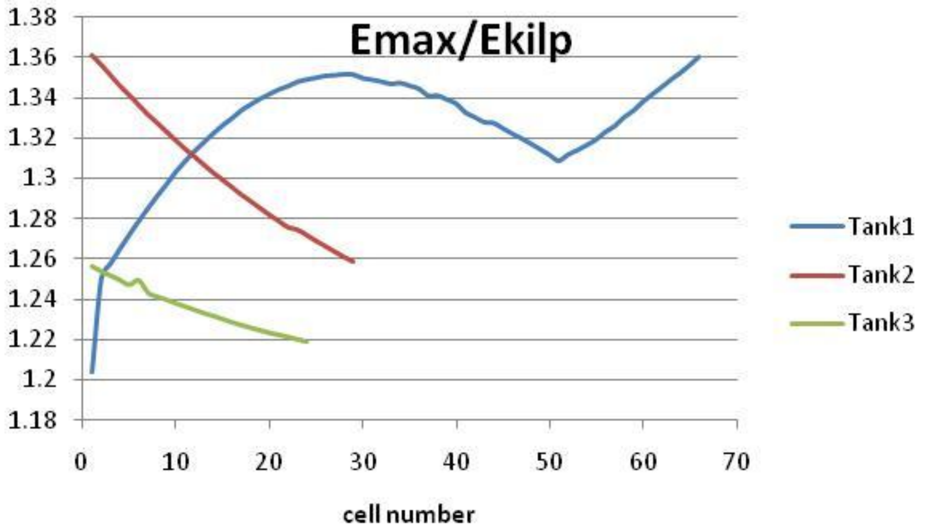
TANK3

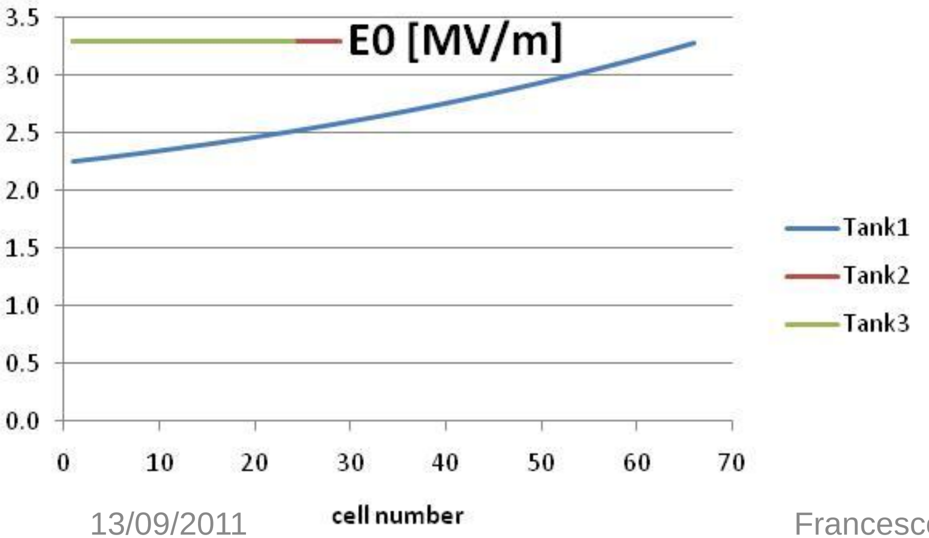
- Diameter=52cm, DT diameter=9cm
- Length= 5.91 m (6.9 $\beta\lambda$)
- Energy Gain =14.5 MeV
- Stored Energy = 20.1 J
- End Wall Power =27.2 kW
- Cavity Power = 824.6 kW
- Beam Power (Peak) = 1018 kW
- Total Power = 2007.8 kW
- ZTT = 43.4 Mohm/m
- Q0 = 53724

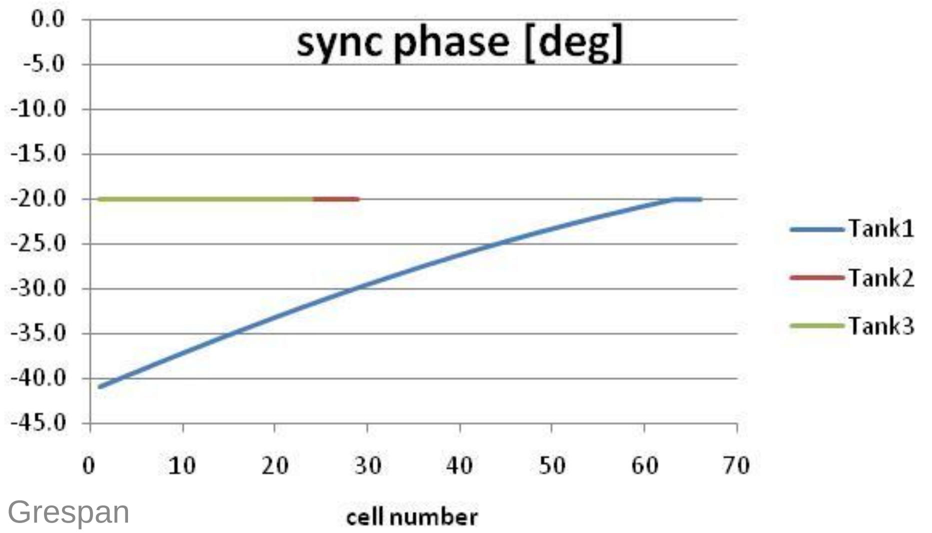


Tank parameter summary

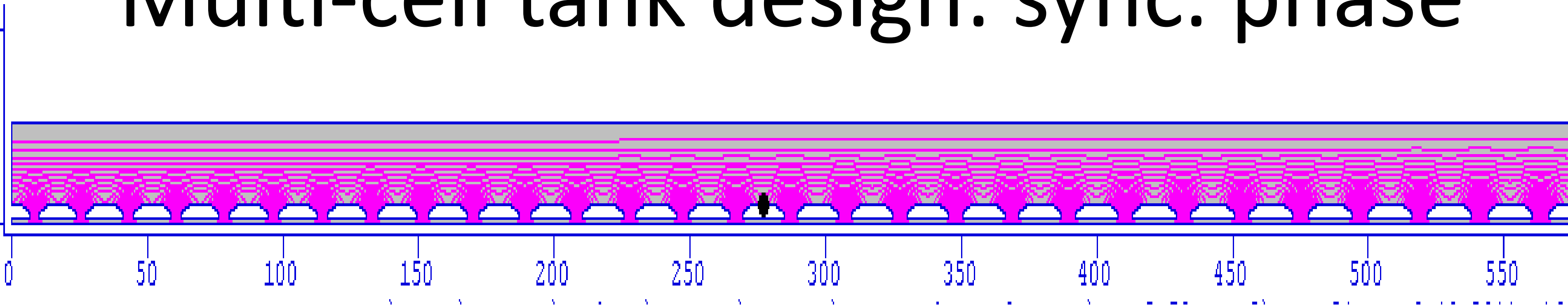


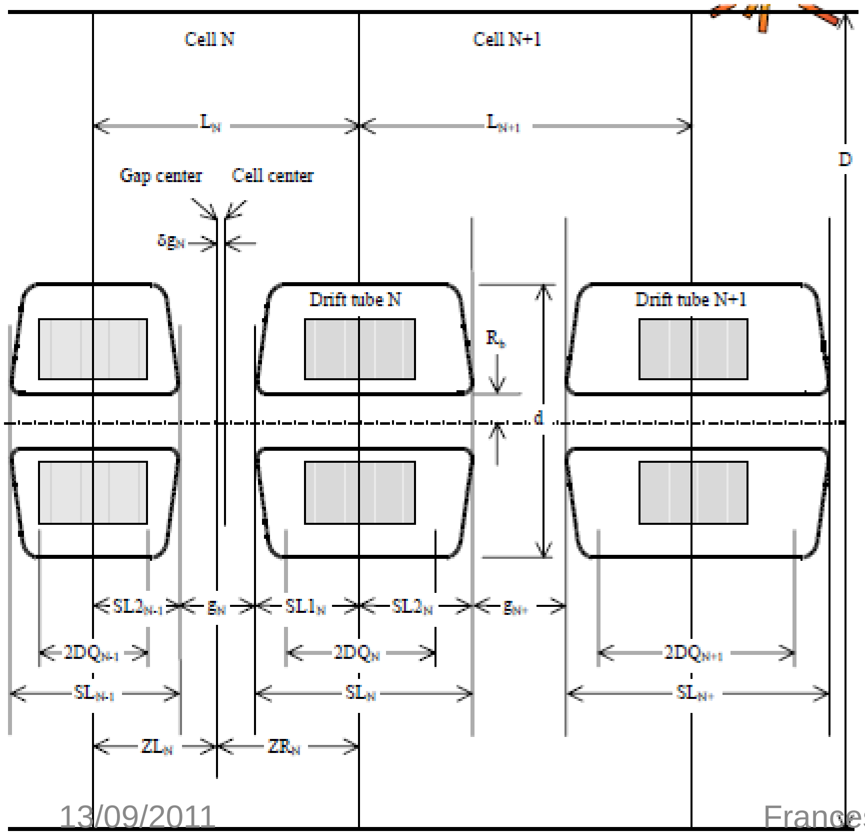


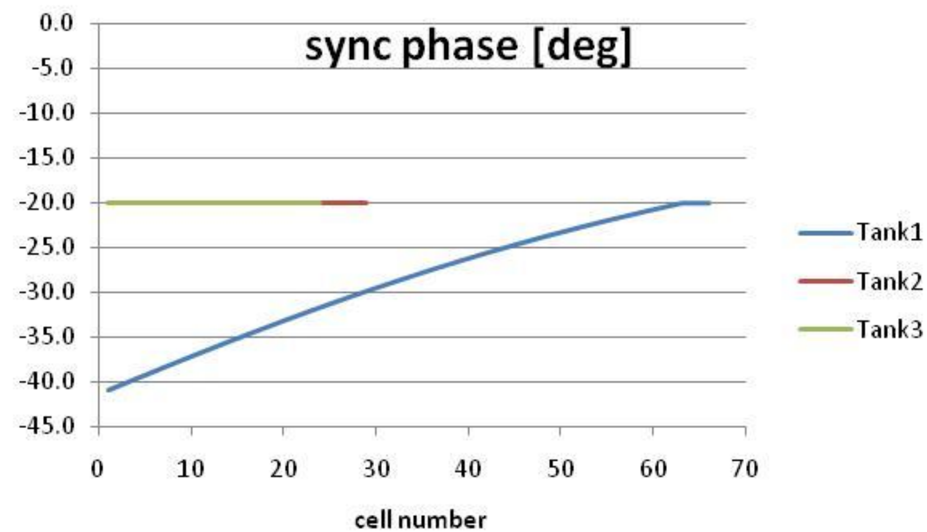




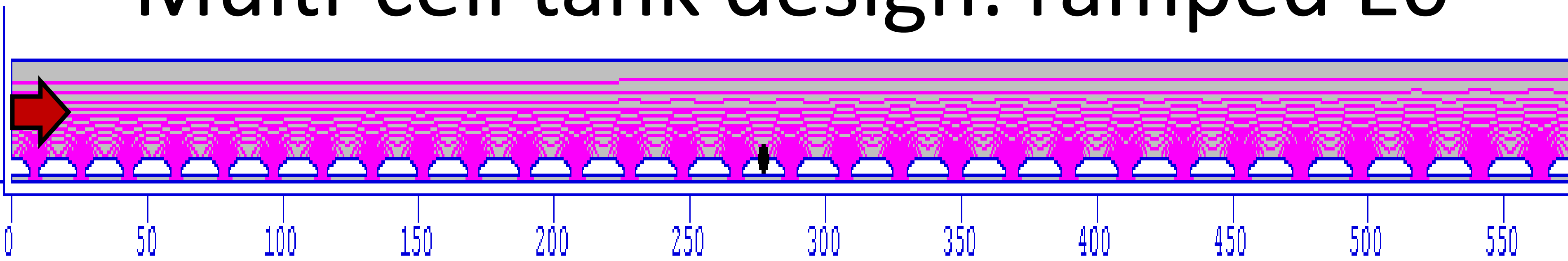
Multi-cell tank design: sync. phase



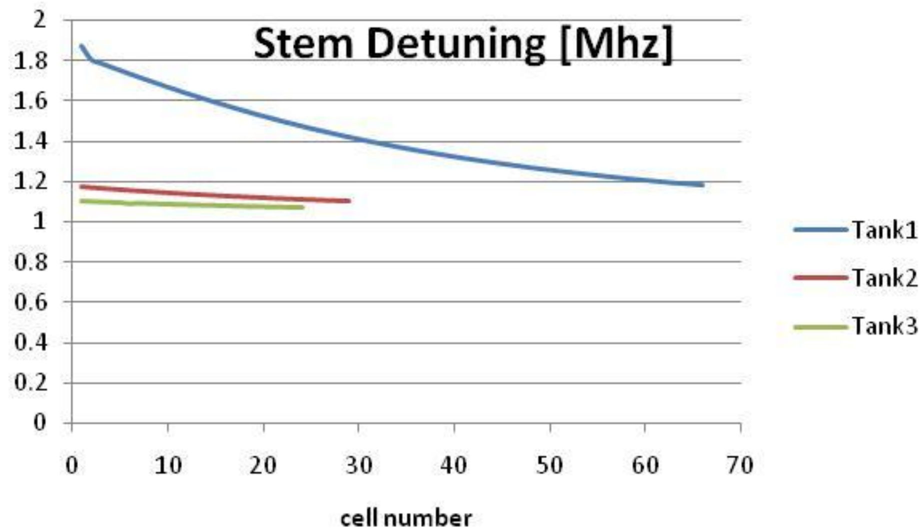


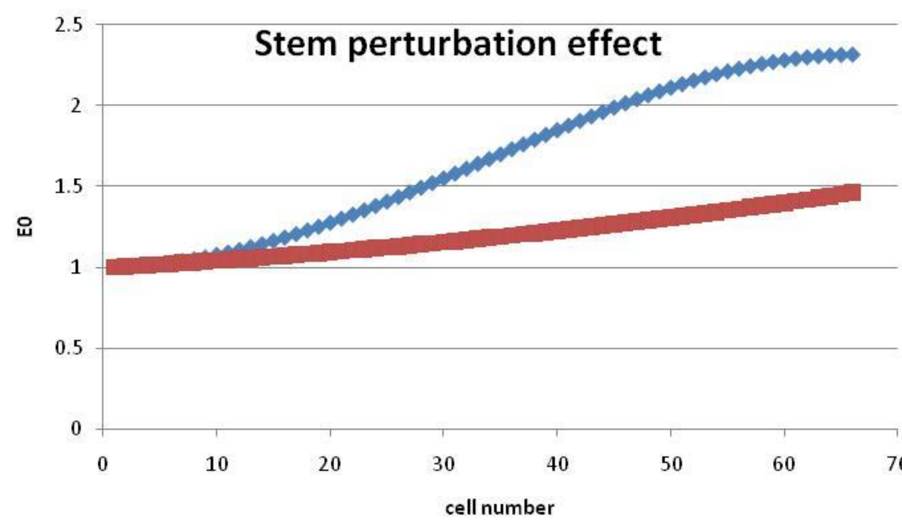


Multi-cell tank design: ramped E0



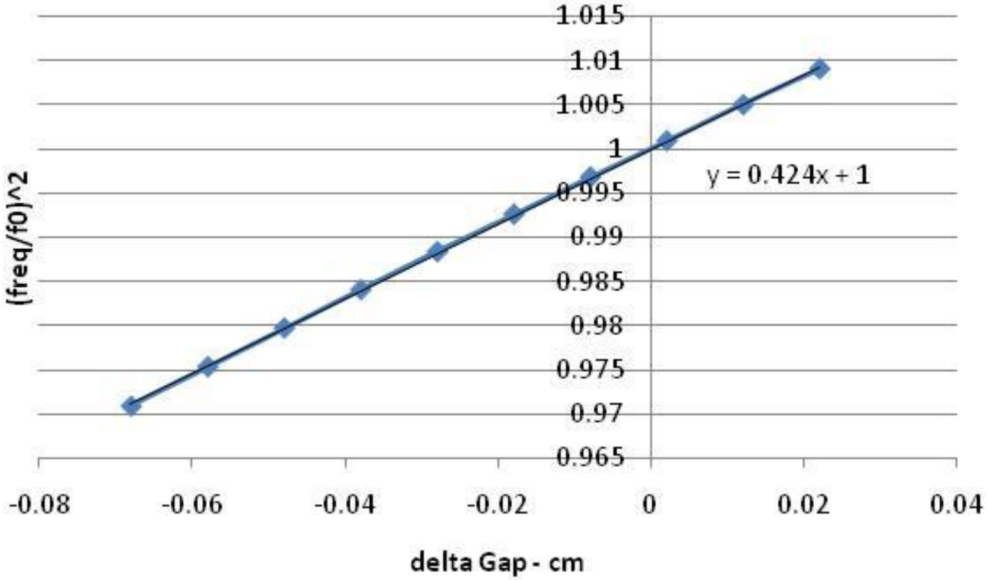
Freq Cells (i) = f0 + ΔfStem(i)

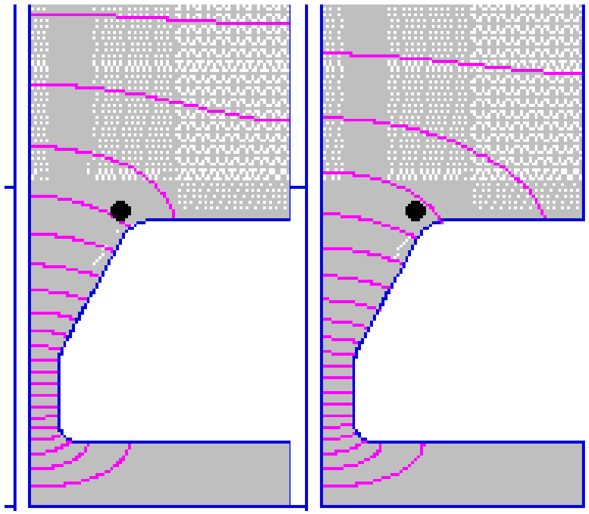




Stabilization: number of Posts/m

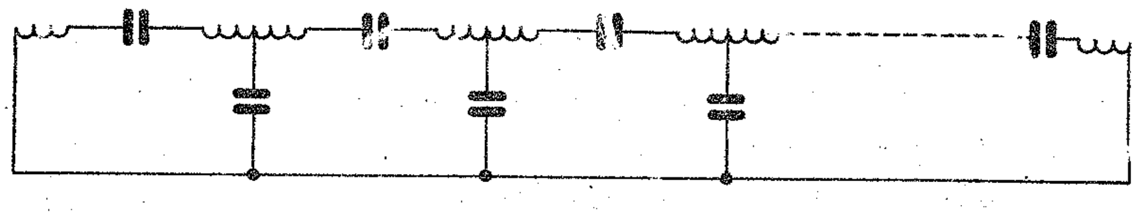
1st cell sensitivity





$$\omega_0^2 = \frac{1}{C_0 L_0} = \frac{gap}{\varepsilon_0 \cdot A \cdot L_0}$$

Stabilization: number of Posts/m



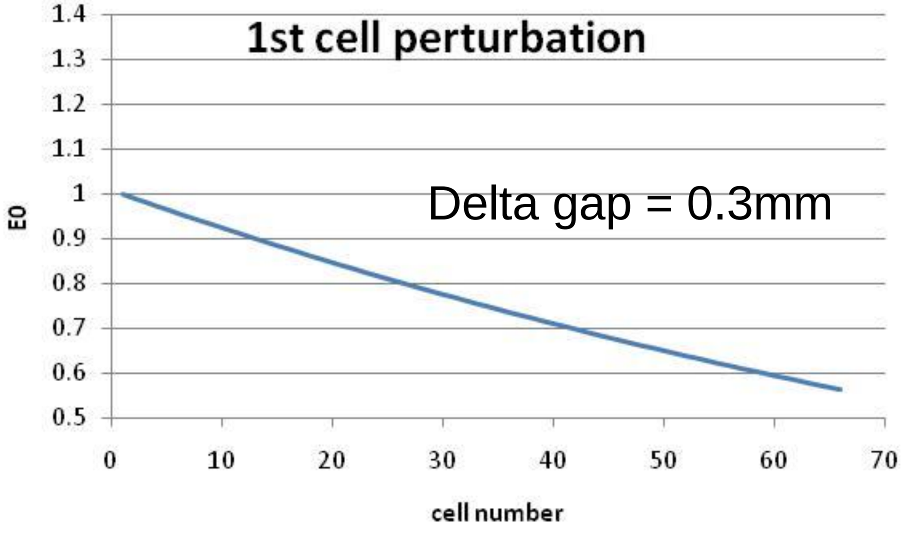
$$
\begin{pmatrix}
\left(1+\frac{C0}{C}\right) f0^2 & -\frac{C0\, f0^2}{C} & 0 & 0 & 0 \\
-\frac{C0\, f0^2}{C} & \left(1+\frac{2\,C0}{C}\right) f0^2 & -\frac{C0\, f0^2}{C} & 0 & 0 \\
0 & -\frac{C0\, f0^2}{C} & \left(1+\frac{2\,C0}{C}\right) f0^2 & -\frac{C0\, f0^2}{C} & 0 \\
0 & 0 & -\frac{C0\, f0^2}{C} & \left(1+\frac{2\,C0}{C}\right) f0^2 & -\frac{C0\, f0^2}{C} \\
0 & 0 & 0 & -\frac{C0\, f0^2}{C} & \left(1+\frac{C0}{C}\right) f0^2
\end{pmatrix}
$$

$$\Delta\varphi_q = \frac{\pi \cdot q}{NCells} : q^{th}\_\mathrm{mod}\, e\_\, phase\_shift.$$

$$f_q = f_0 \sqrt{2\frac{C_0}{C}(1-\cos\Delta\varphi_q)+1} : q^{th}\_eigenfreq.$$

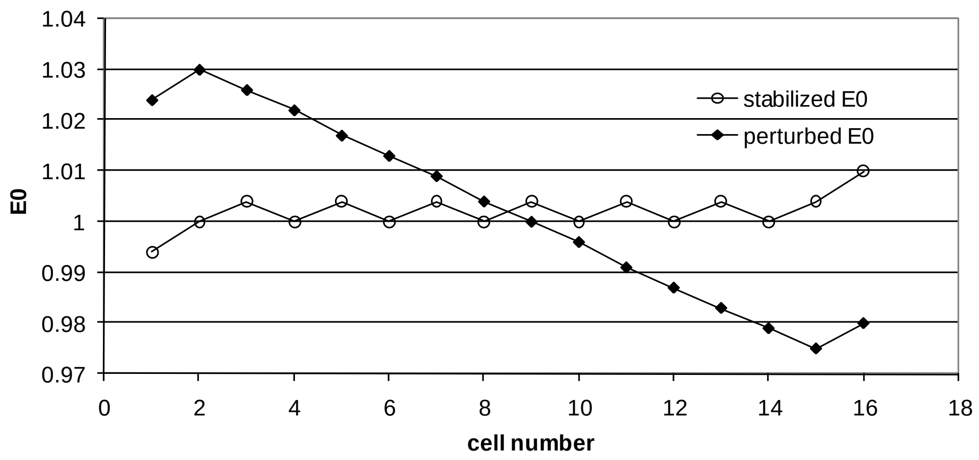
$$f_q = \frac{1}{2\pi}\sqrt{\omega_0^2 + \left(\frac{\pi \cdot q \cdot c}{L}\right)^2}$$

Stabilization: number of Posts/m



ΔE/E0 = ± 20%
ΔE/E0/L = ± 3%/m

With 3 PCs/m the Field is stabilized within ± 1%



Length 1st cell Tank1 = 6.7 cm
Length Last cell Tank1 = 16.7 cm

Many points to be considered

- Frequency margin
- Tuners
- Frequency control in operation
- Mismatches between tanks
- Power Couplers
- …

Shunt impedance study

$$ZT^2 = \frac{V_0^2}{P_{diss}} \frac{T^2}{L} [M\Omega / m]$$

1. **Increase the Transit Time Factor T → decrease the gap length**
   - adjusting the Face Angle - main limitation: in the initial cells for PMQ accommodation
   - adjusting the Tank Diameter - main limitation: Post Coupler stabilization

$$T = \frac{\sin(\pi g / \beta\lambda)}{\pi g / \beta\lambda}$$

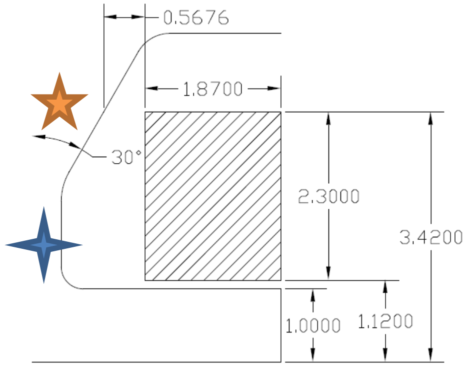
$$\frac{V_0^2}{P_{diss}} = \frac{V_0^2}{R_{wall} I_{wall}^2}$$

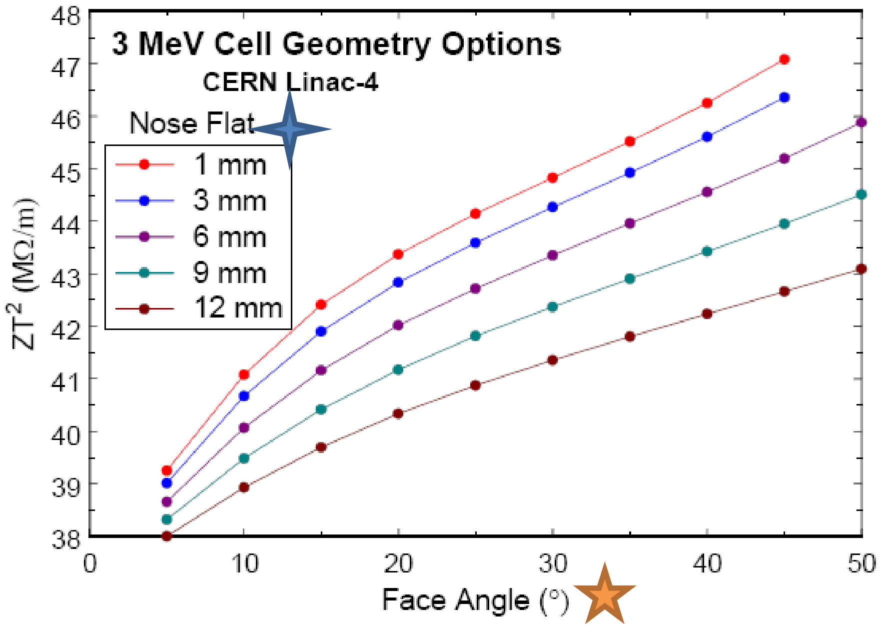
2. **Increase the ratio V_0/I_{wall} → decrease the gap capacitance, i.e. the Drift Tube Diameter**
   - adjusting the Tank Diameter - main limitation: Post Coupler stabilization

$$V_0 = \frac{I_{displ}}{\omega C}, I_{displ} = I_{wall}$$

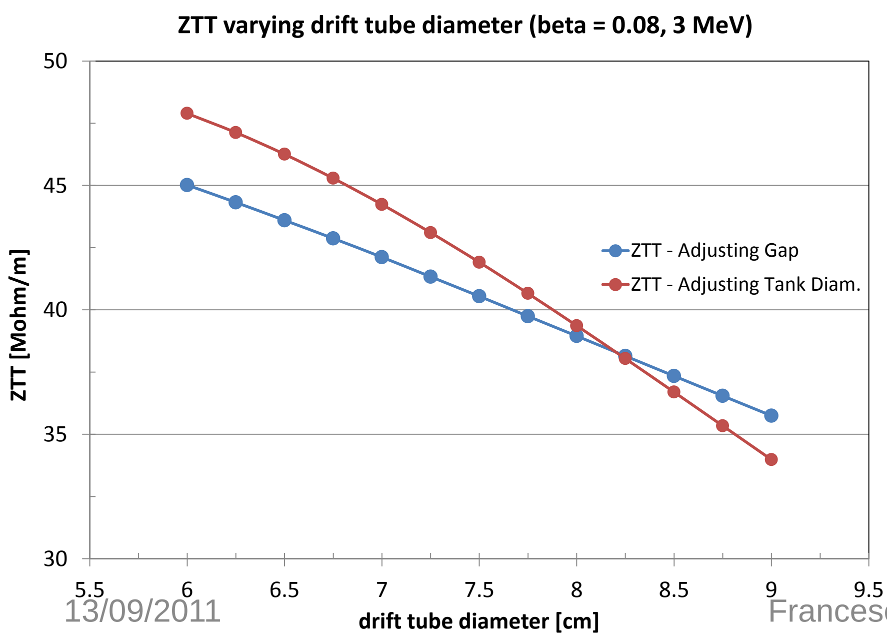
$$\frac{V_0}{I_{wall}} = \frac{1}{\omega C}$$

Shunt impedance study





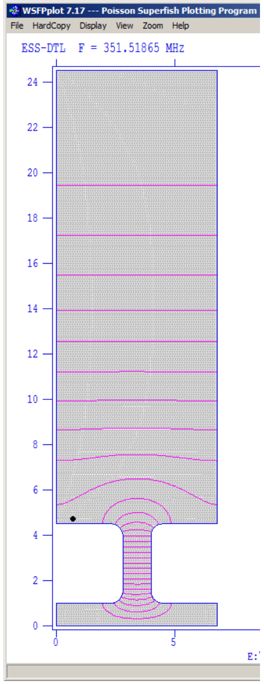
An initial small face angle is necessary to accommodate the PMQ.



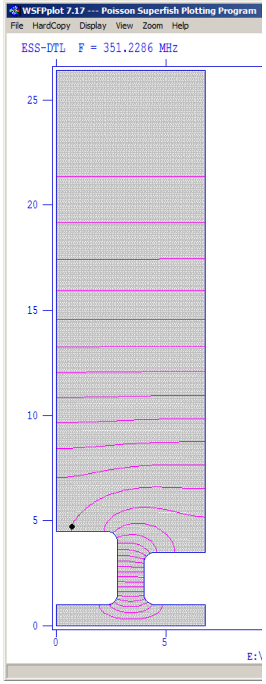
Optimized Gap Length for TTF, a smaller Drift Tube Diameter reduces power losses.

Shunt impedance study

ZTT=39.397 MOhm/m



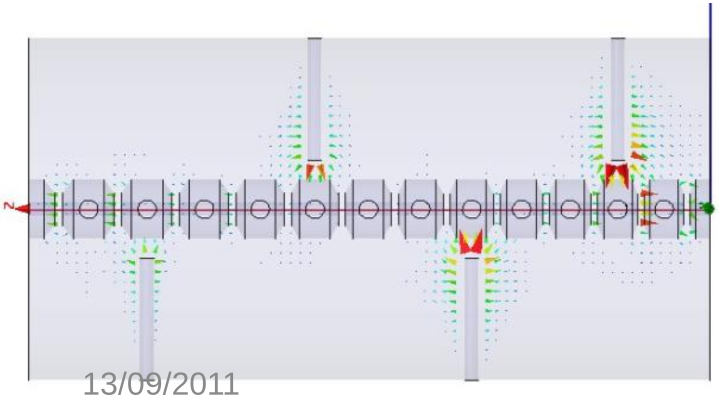
ZTT=47.331 MOhm/m



FODO lattice solution with asymmetric cell unit:

- PMQ every second drift tube
- periodic structure on βλ
- Post Coupler every second drift tube

$$\omega_p^2 = \frac{\omega_0^2}{1 + \frac{n \cdot C_p}{C}}$$



Post Coupler stabilization requires

- a number of Post Coupler per unit-length (n)
- a certain capacitive coupling between Post and Tubes (C_p)

→ under study the stabilization of a DTL tank design with asymmetric cells.