RF DESIGN OF A NOVEL S-BAND BACKWARD TRAVELLING WAVE LINAC FOR PROTON THERAPY

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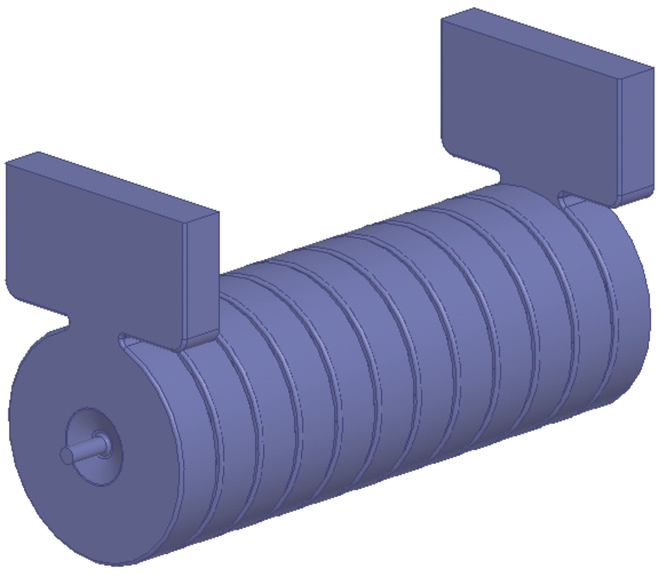
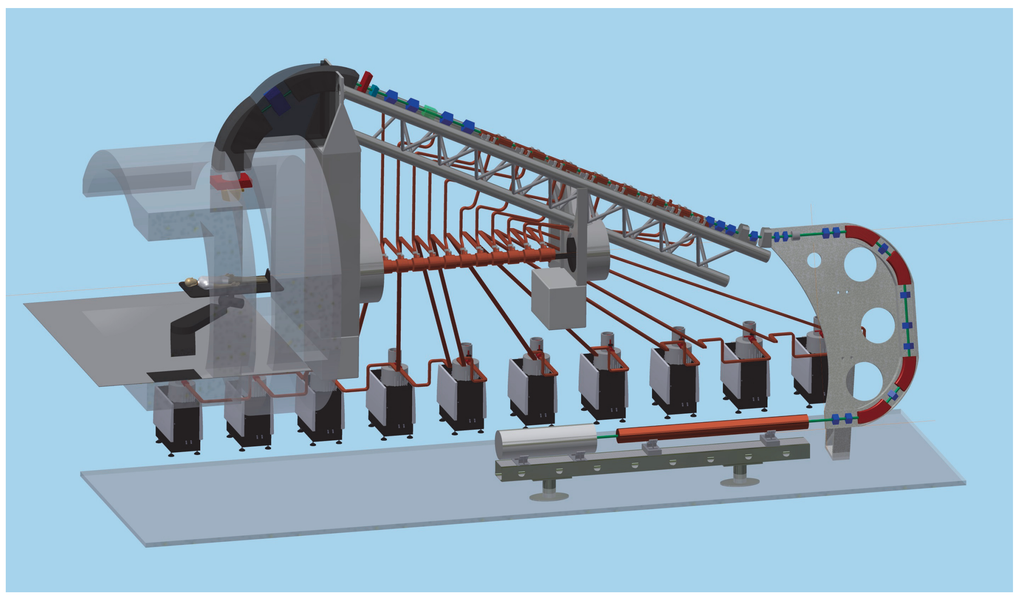
INTRODUCTION

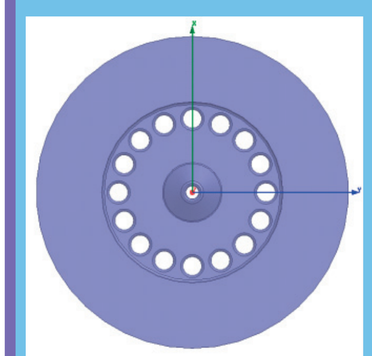


- A collaboration between the TERA Foundation and CLIC
- Design of a novel high gradient S-band accelerating structure for the TULIP project [1]
- The design accelerating gradient almost double that obtained before [2]
- Novel approach to RF design
- The complete 3D RF design of the full structure for beta equal to 0.38 is hereafter presented



RF DESIGN

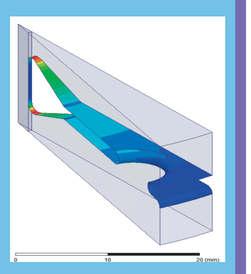
REGULAR CELL DESIGN

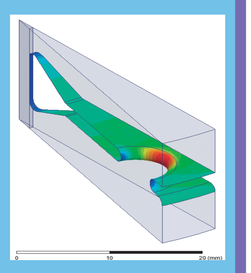


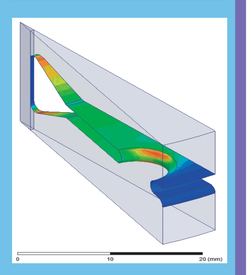
- Magnetic coupling between cells through *coupling holes*
- Cell geometry designed in order to minimize the quantity [3]:

$$\mu = \frac{P_w}{E_a^2} \cdot \frac{S_c}{E_a^2} = \frac{v_g}{\omega} \cdot \frac{S_c / E_a^2}{R' / Q}$$

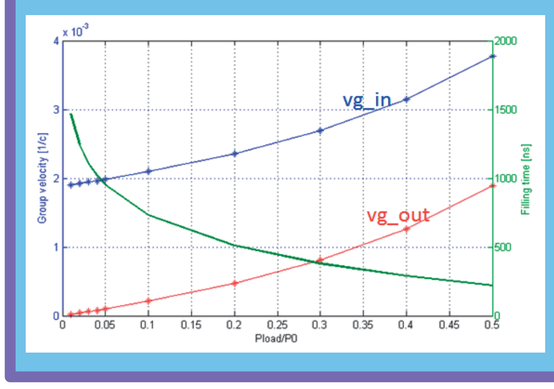
- Optimum found when μ is equal on the nose and on the coupling holes
- Optimization accomplished by varying gap, cone angle and phase advance
- Iris thickness chosen considering the results of the creep test and of the thermal simulations







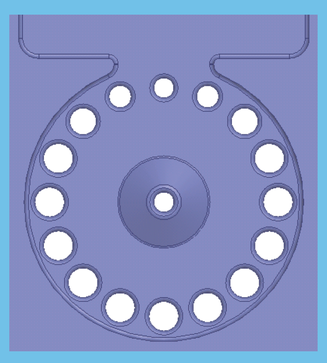
TAPERING

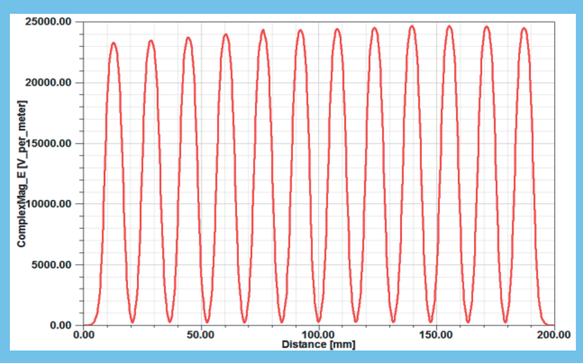


- *Constant-gradient* structure, with group velocity ranging between 0.4 % and 0.2 % of c
- Linear variation of the coupling holes radii; cell diameters adjusted accordingly
- All the other parameters are kept constant throughout the structure

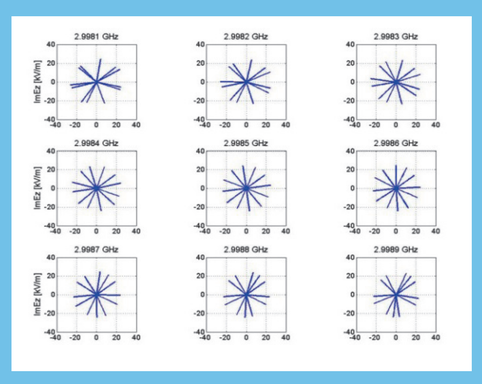
COUPLERS DESIGN

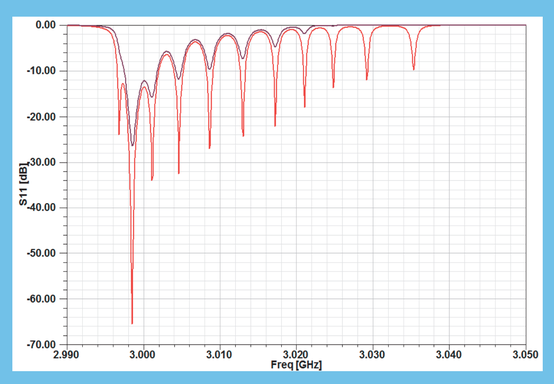
- RF power coupled magnetically via a single slot
- Coupling holes radii in the input coupler sized to compensate for local enhancement of S_c due to the local increase of the power flow





- End-cells provide the same acceleration as the regular cells
- Even distribution of S_c on the accelerating structure noses and coupling holes reached
- Phase advance is 150° at the design frequency and reflection lower than -50 dB





SUMMARY AND FUTURE STEPS

Parameter	bwTW	CCL [4]
RF phase advance per accelerating cell [rad]	5π/6	π
Iris thickness [mm]	2	3
Gap [mm]	7	5.1
Nose cone angle [deg]	65	25
Number of cells	12	10
Structure length including end-cells [mm]	189.9 (active)	189.9 (active)
Average accelerating gradient [MV/m]	50	31
Q factor (first/last cell)	6997/7463	8290
R'/Q (first/last cell)	7425/7369	8410
Normalized shunt impedance (first/last cell) [MΩ/m]	52.0/ 55.0	69.7
Filling time (w/o re-circulator) [ns]	900 (224)	1050
Peak input power (w/o re-circulator) [MW]	9.3 (20.6)	2.6
Max S_c/E_a^2 [A/V]	3.1e-4	7.8e-4
Max E_a (for BDR of 10^{-6} bpp/m) [MV/m]	74.9	47.1
Maximum surface electric field [MV/m]	219	159

- A novel high gradient S-band accelerating structure for proton therapy has been designed
- Tender for mechanical pieces has been launched; final assembly will start in Autumn 2014 and test of the prototype in 2015

ACKNOWLEDGMENT

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[2] U. Amaldi, et al., LIBO – a linac-booster for protontherapy: construction and tests of a prototype , NIMA 521 (2004) 512
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[4] A. Degiovanni, High Gradient Proton Linacs for Medical Applications, EPFL PhD Thesis (2014)