Feasibility of an extraction line for radiobiology studies

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3. Design of acceleration cavities for $10MeV/u < E < 70MeV/u$
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Motivation

Motivation

- **Present:** the latest IH structure of the injector accelerates carbon ions $^{12}C^{6+}$ with the following specifications:

E	β	I_p (Source)	F_{rep}	L_{pulse}	F_{RF}	ϕ_{RF}
12 MeV/u	0.16	3 mA	400 Hz	$< 5\ \mu s$	750 MHz	10 deg

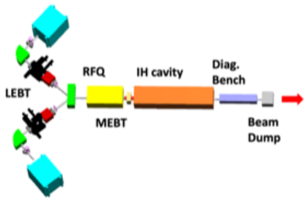


Figure: Inyector diagram.

- **Future:** we need to accelerate the ions to an energy of $\sim$ 450 MeV/u for use in hadrontherapy. In addition, the possibility of building an extraction line for radiobiology studies is being studied.

Feasibility of an extraction line for radiobiology studies

Needs in radiobiology studies

When irradiating biological samples, some important requirements must be taken into account.

- To cover the entire sample, a wide irradiation field is necessary.
- All cells in the sample must receive the same dose.

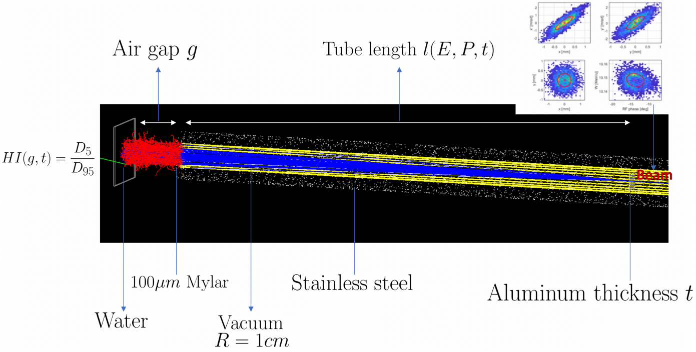
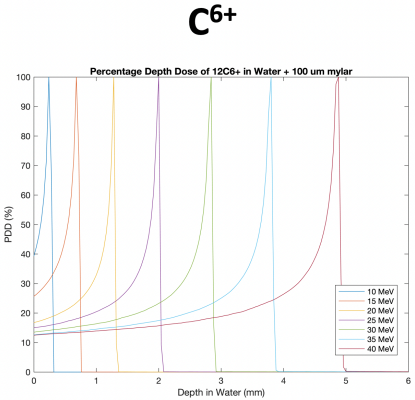


Figure: TOPAS (Geant4) simulation geometry.

What energy do we need to irradiate cells?



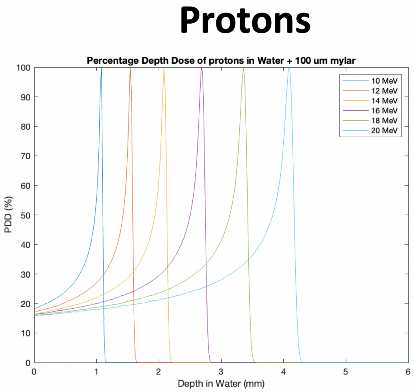


Figure: Depth dose curves for different monoenergetic beams of carbon ions and protons, $g = t = 0$.

Calculation of the HI

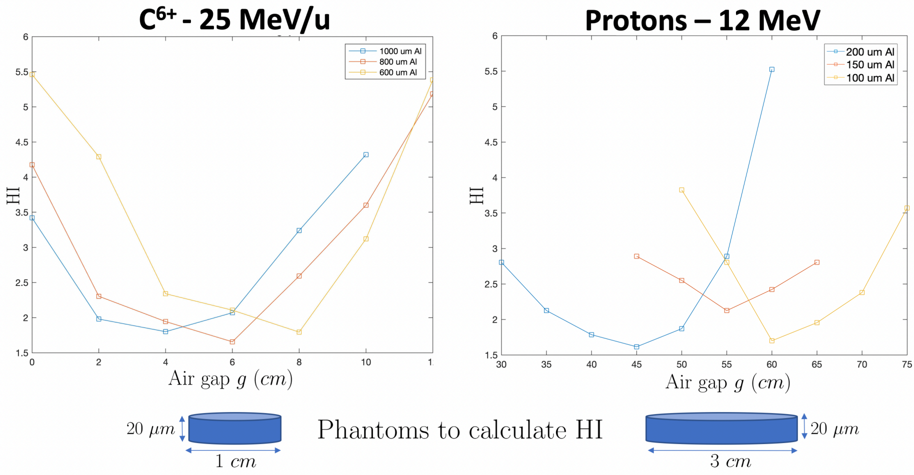


Figure: HI as a function of the air gap and the thickness of the aluminum scattering foil for 25 MeV/u carbon ions (left) and 12 MeV protons (right).

Radiation fields in optimal cases

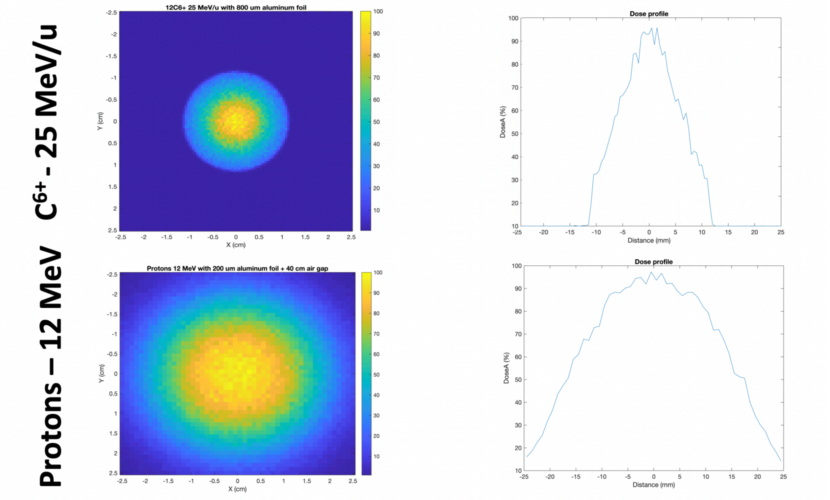


Figure: Dosimetry 2D and dose profile for optimal cases. Above: $t = 800\mu$m Al, $g = 6cm$, $E = 25MeV/u$. Below: $t = 200\mu$m Al, $g = 45cm$, $E = 12MeV$.

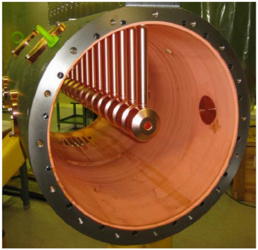
Design of acceleration cavities for $10MeV/u < E < 70MeV/u$

Low β cavity design

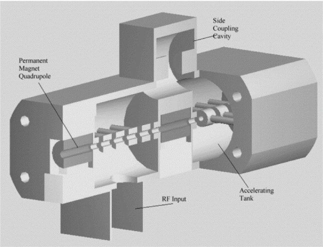
- Effective Shut Impedance per unit length ZTT is the most important figure to optimize in normal conduction cavities because

$$\Delta W \propto \sqrt{ZTT \times P_d \times L}$$

- The structures with the best ZTT for the energy range of interest are:



Drift Tube Linac (DTL)



Side Coupled Drift Tube Linac (SCDTL)

- I carried out a preliminary optimization of the design of that structures.

DTL structure optimization

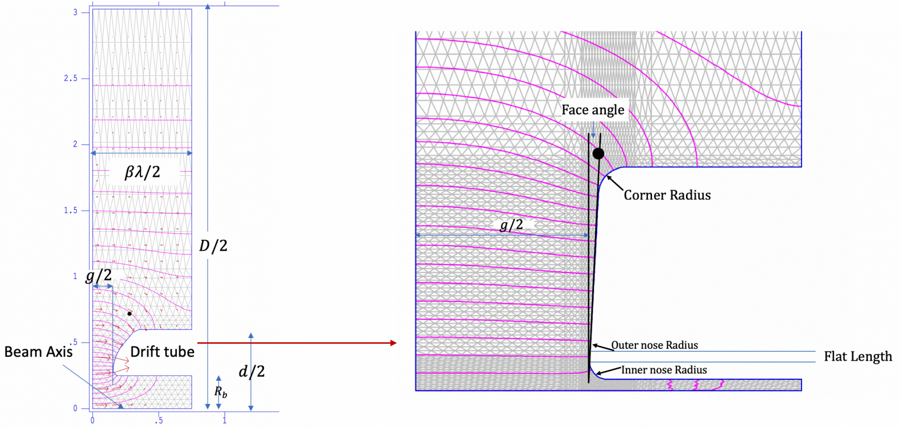


Figure: Optimization parameters in a DTL structure.

SCDTL structure optimization

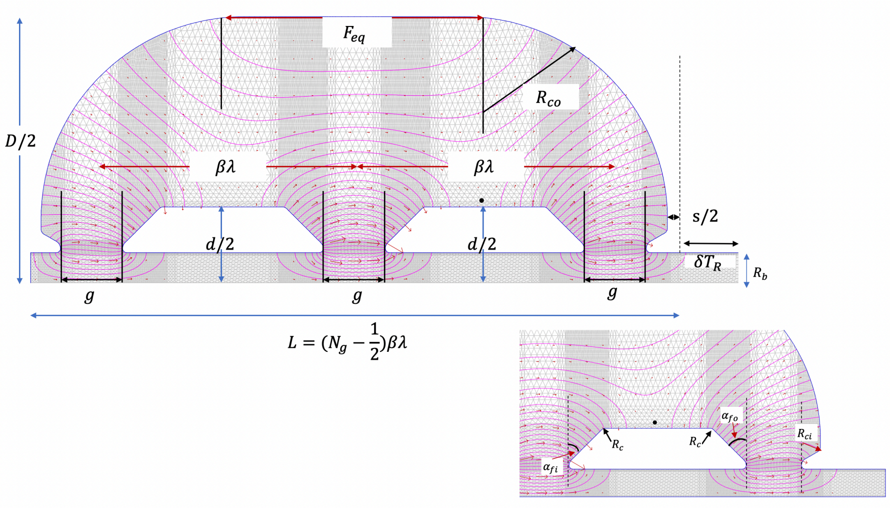
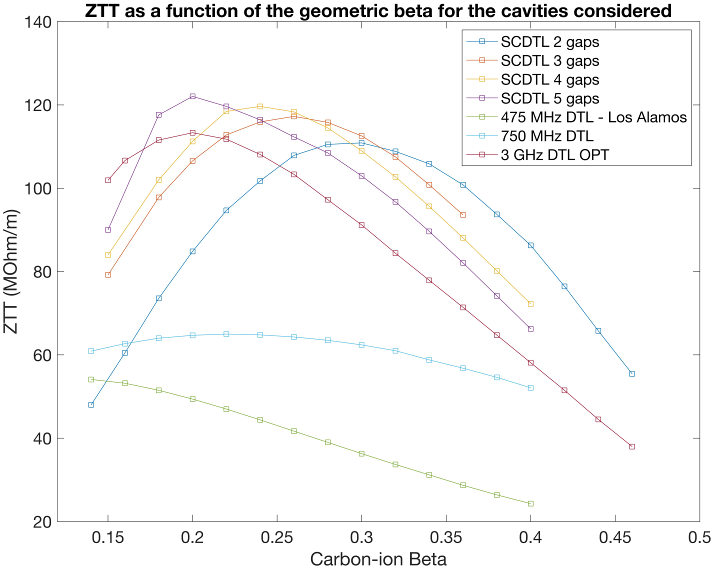


Figure: Optimization parameters in a SCDTL structure.

ZTT as a function of ion carbon β



Tomodosimetry: reconstructions of dose maps from scintillating optical fibers

Tomodosimetry: reconstructions of dose maps from scintillating optical fibers

- I implemented new reconstruction algorithms + regularization methods and changed the tomodosimetry formalism in order to obtain more precise reconstructions with a smaller number of measurements.

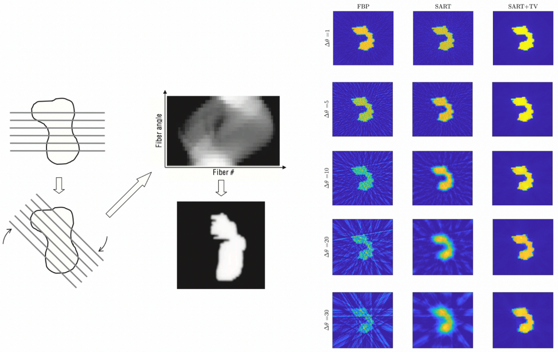


Figure: Idea of tomodosimetry (left). Reconstructions obtained with different reconstruction algorithms with different numbers of measurements (right).