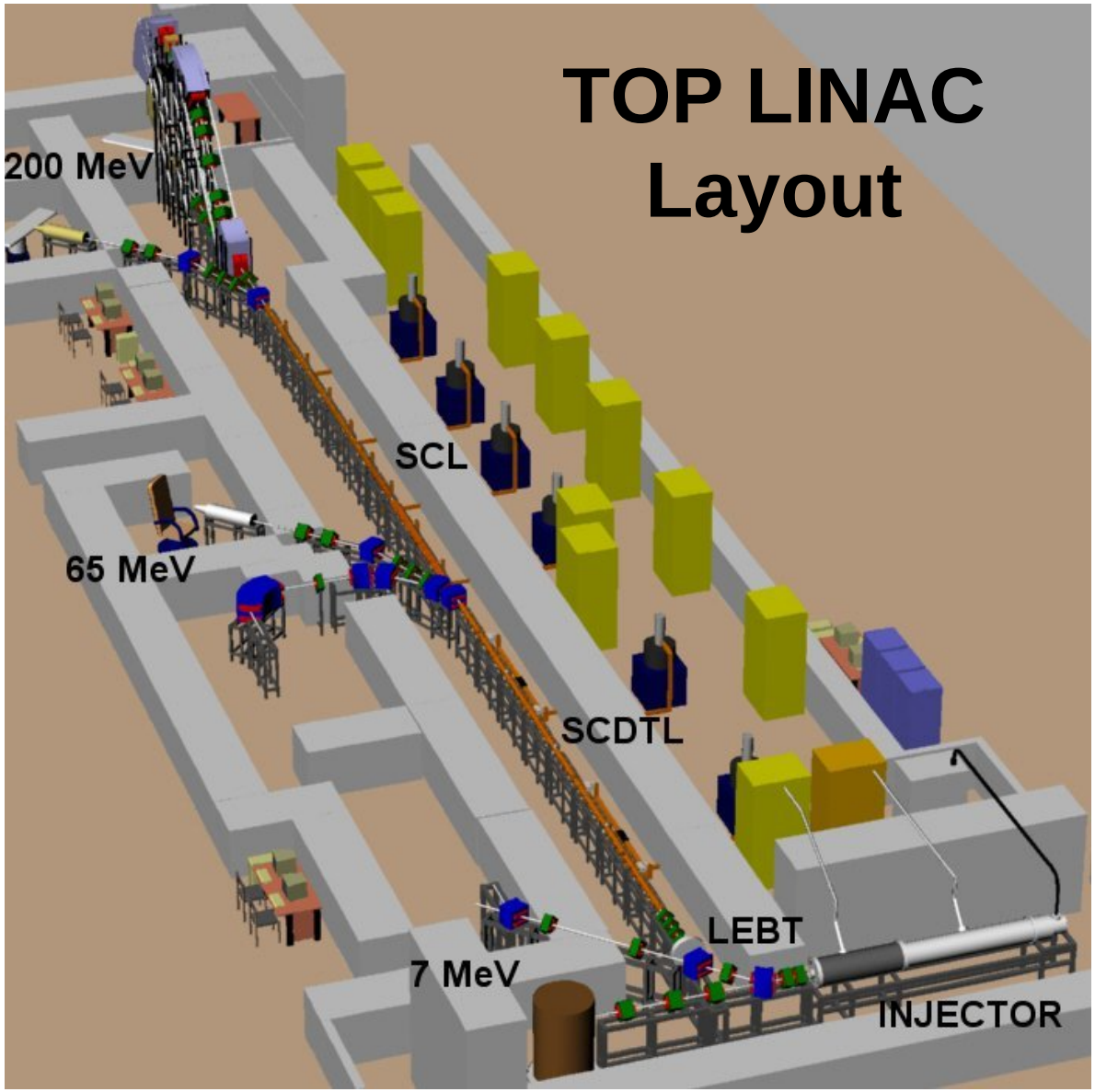
PROGRESS IN THE DEVELOPMENT OF THE TOP LINAC

The TOP Linac (Oncological Therapy with Protons), is under development by ENEA and ISS. It is a linear accelerator designed for Protontherapy and medical applications.
It has been designed as a sequence of three pulsed linear accelerators with the following output beams

- **7 MeV**, 700 W beam for F-18 radioisotope production
- **65 MeV**, 10nA (average) beam for proton eye therapy;
- **100-200** MeV, variable energy, 10 nA (average) beam for deep seated tumours proton therapy.



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Characteristics:

•2nd and 3rd sections are high Frequency (3 GHz) pulsed proton Linacs

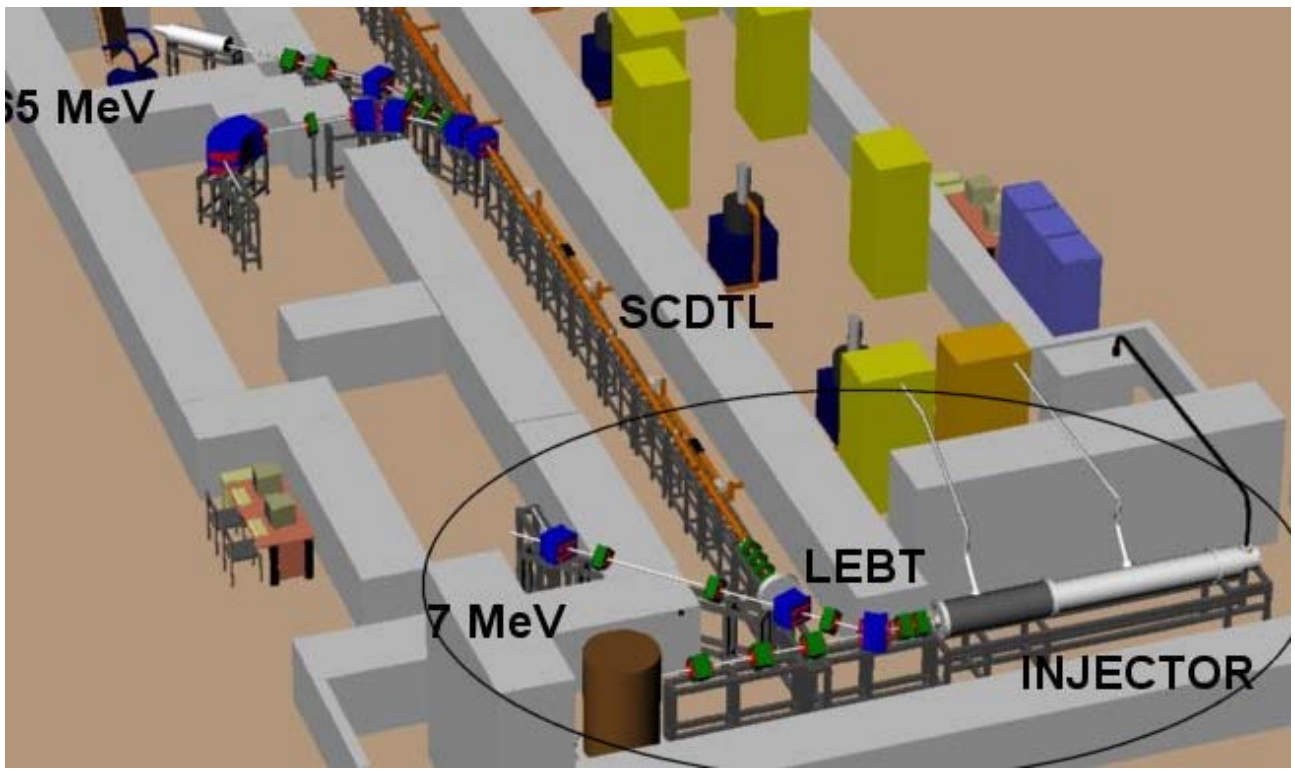
•Modularity of the construction, as the linac can be expanded in at least 3 steps, each of them able to be operated for a specific task

•Compactness, as the linac extends in the area used by beam transport lines in other types of machine (cyclotron or synchrotrons).

STATUS

•Unfortunately actually the project has been only partially funded with 4.1 M€ from National Health Service that were used to start the construction of injector, LEBT and first SCDTL module.

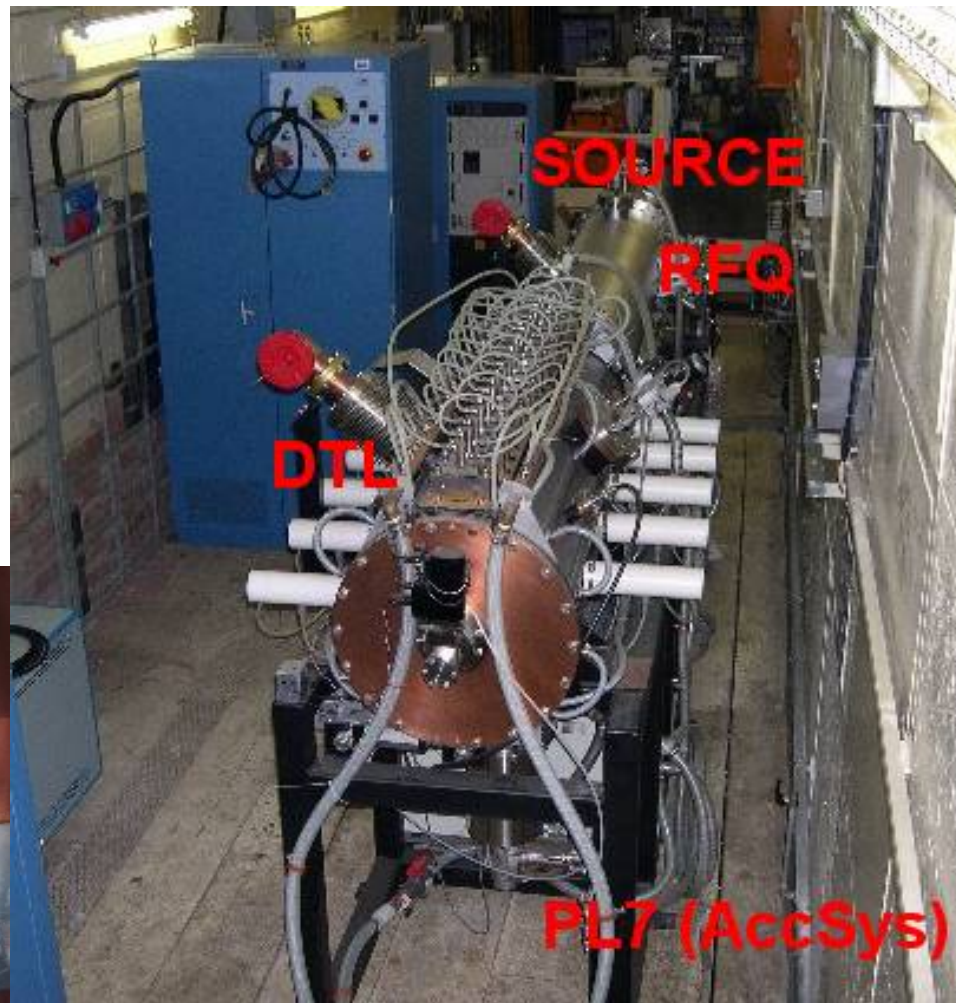
•Agreements with large University hospitals in Rome are under way to get the total funding.

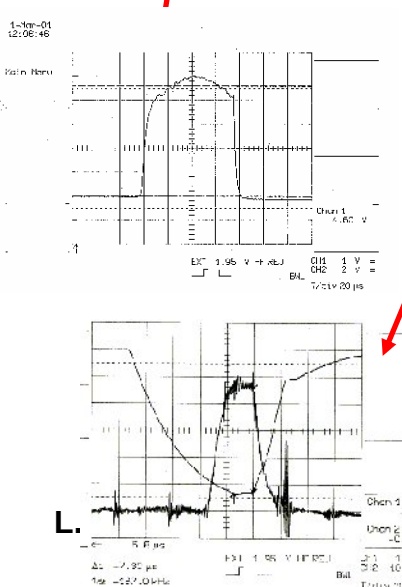


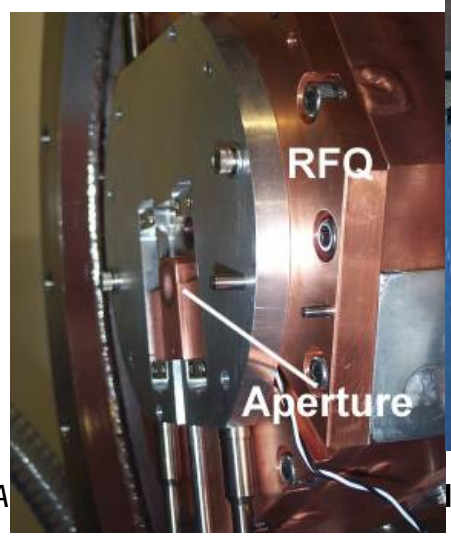
INJECTOR

- 7 MeV proton Linac
- PL-7 -003 model by AccSys (USA)
- RFQ 3 MeV+DTL 4 MeV
- 2 Modes of operation
  - Radioisotope Production (high current, 8 mA, 100µs, 100 Hz)
  - Protontherapy injector (low current, 1-30 µA, 7 µs, 250 Hz)

Injector is now installed in a bunker at CR Frascati.
Full operation is scheduled in September 2004







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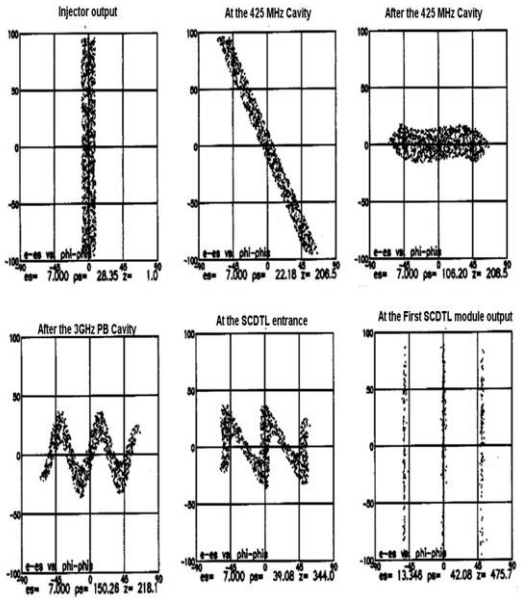
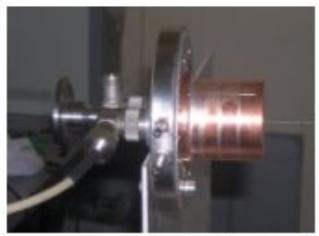
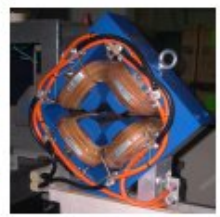
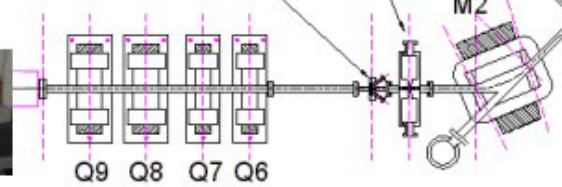
7 MeV LEBT: Beam goes straight on for radioisotope production and 90° for injection in protontherapy linac



Schematics







To Protontherapy

To Radioisotope Production

Beam Dynamics:The longitudinal matching is obtained by allowing the bunch to lengthen to much more than one 2998 MHz RF period, under the velocity spread. Then two RF cavities are used: the first (425 MHz, 65 KV) for reducing the beam energy spread and the second (2998 MHz, 16 KV) for re-bunching at 2998 MHz to increase the beam capture in the SCDTL.

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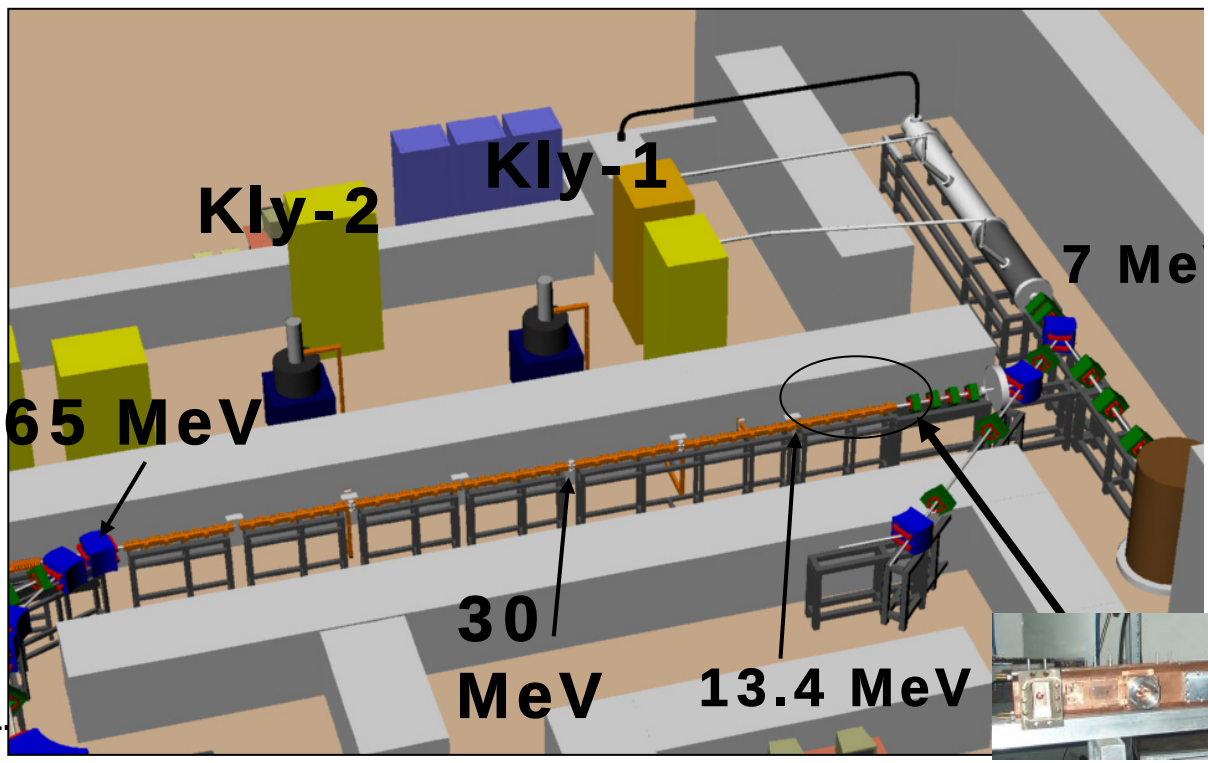
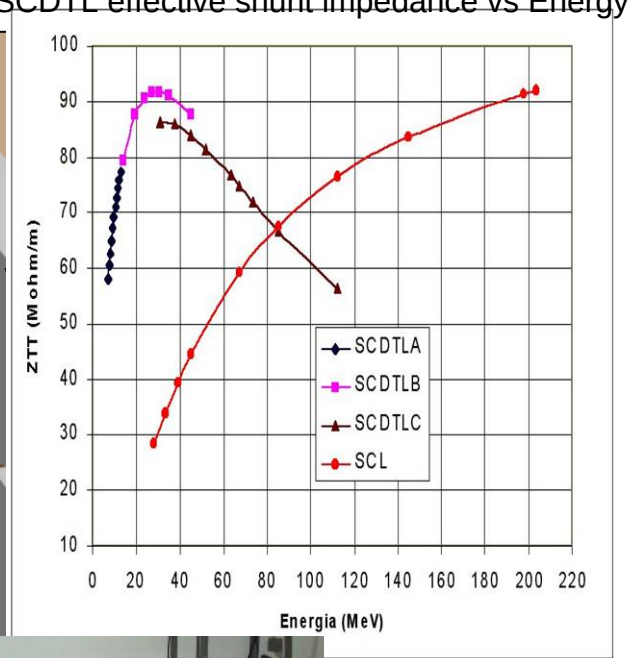
SCDTL 7 – 65 MeV

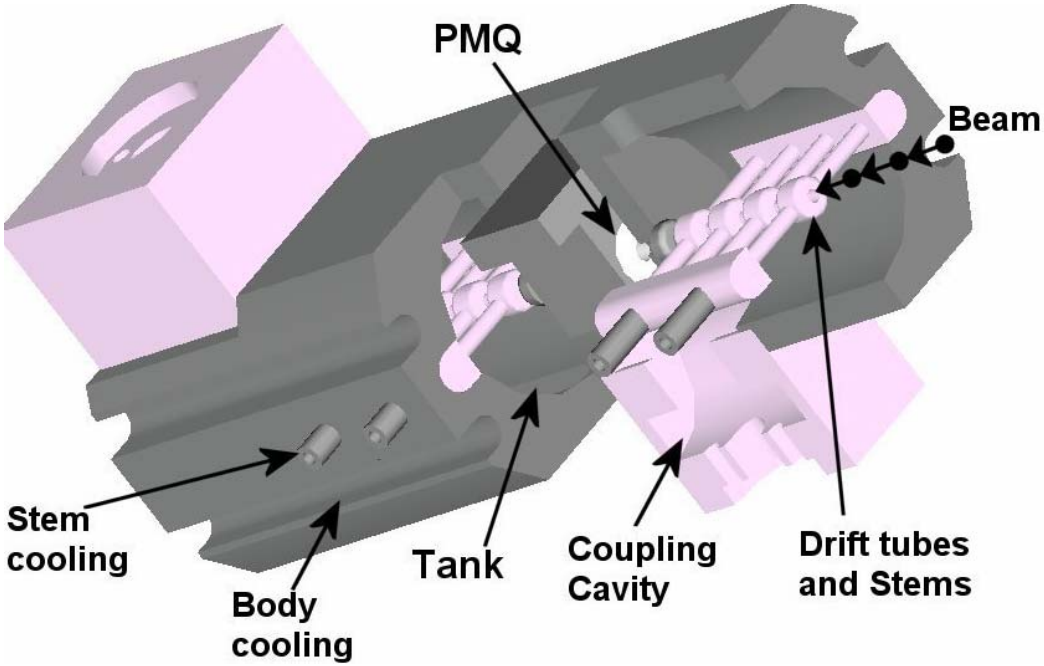
The Intermediate energy (7-65 MeV) part of the TOP Linac is a 3 GHz linac booster bases on the SCDTL (Side Coupled Drift Tube Linac) accelerating structure, that was developed to satisfy the requirement of a high shunt impedance in the low-beta part of the TOP Linac. According to the original design the SCDTL tanks are grouped in seven modules. A total RF power of 7.5 MW is required, that should be given by two klystrons.



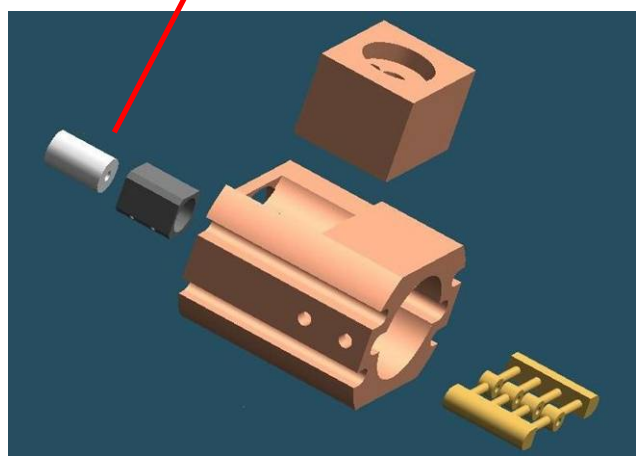
SCDTL effective shunt impedance vs Energy



SCDTL Structure

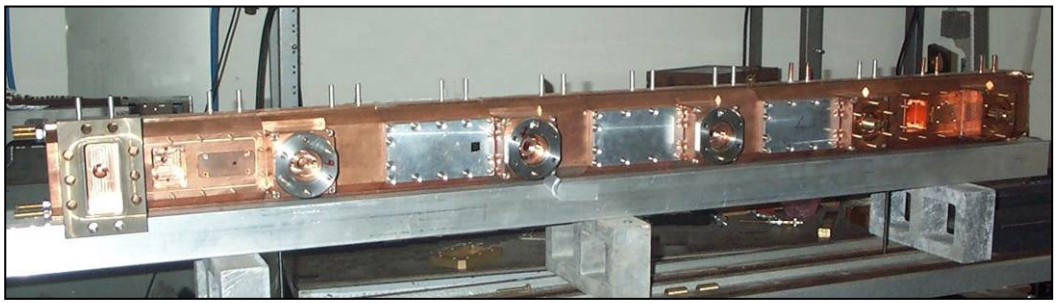


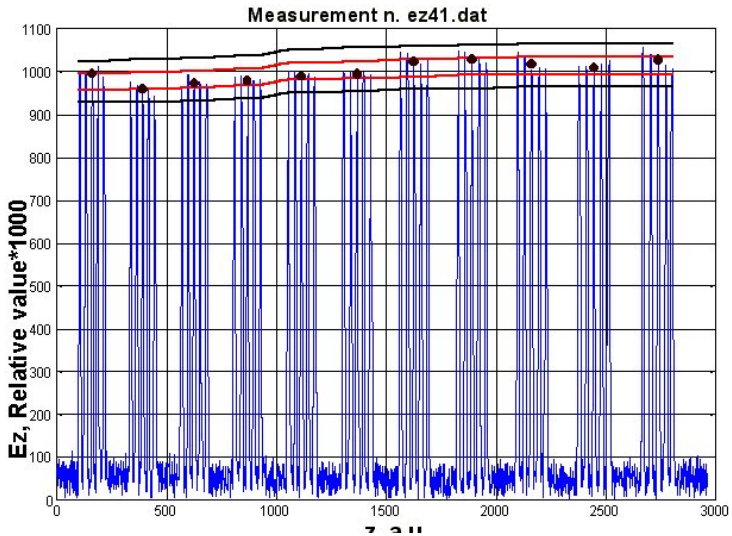
PMQ



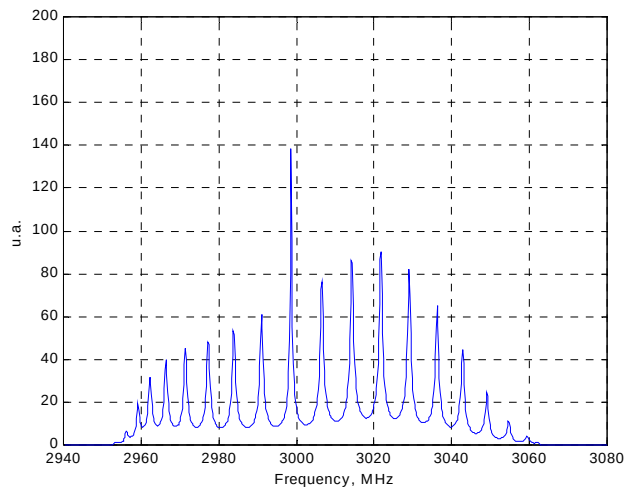
It consists of short DTL tanks coupled together by side cavities. The DTLs are short tanks, each having 5 to 7 cells of $\beta\lambda$ length, and the side cavity extends in a space left free on the axis for the accommodation of a very short (3 cm long, 2 cm o.d., 6 mm i.d.) PMQ (Permanent Magnet Quadrupole) for transverse focusing

SCDTL module #1 measurements





All tanks and coupling cavities of the first module (7-13.4 MeV, 1.32 m long, 11 DTL tanks, 5 cells per tank) were built. All the intermediate brazing steps were performed but for the final braze. The whole structure was bolted and measured on RF bench. With the structure correctly tuned at the proper frequency the electric field was adjusted with tuning screws in the coupling cells to obtain the axial distribution uniform within ±2% among the 11 average tank fields and ±5% among the 55 cells fields



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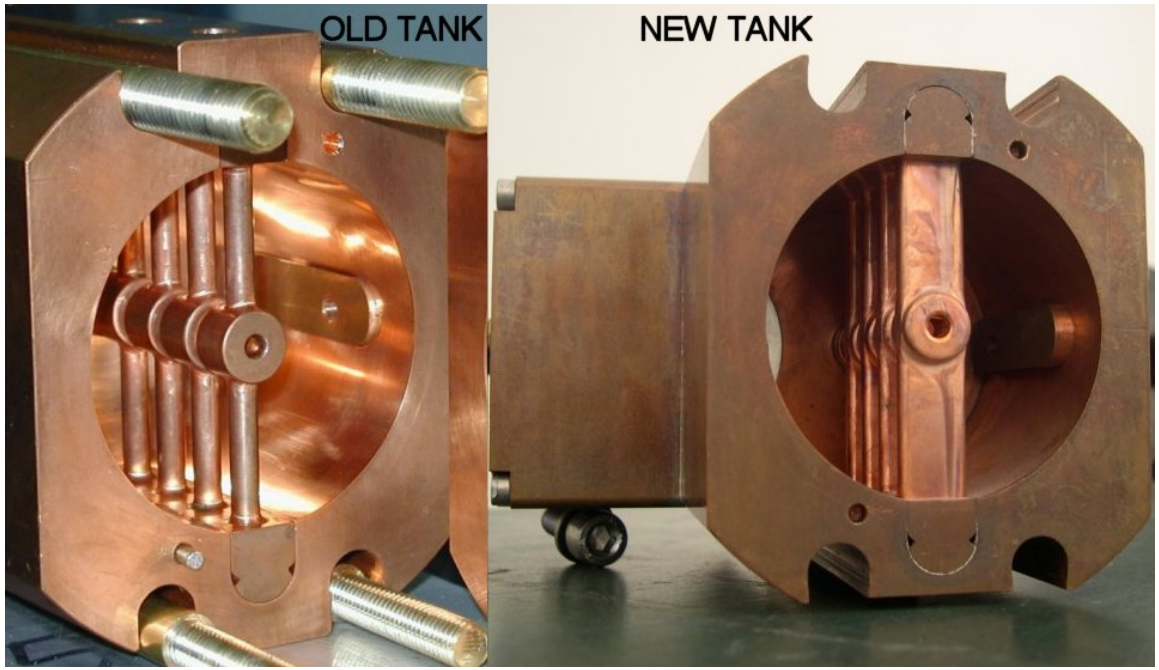
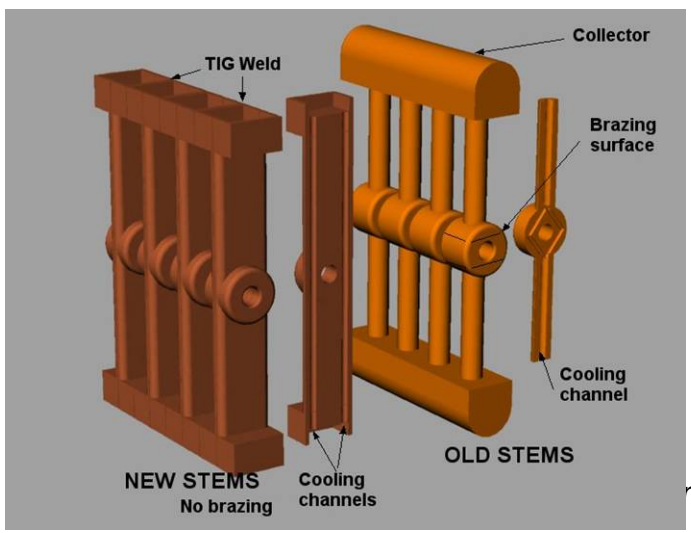
SCDTL: NEW stems





The stem and drift tube are now machined from a solid piece and two parallel 1.5 mm diameter holes are drilled trough the 60 mm long rectangular stem with smoothed edges, for the coolant flow. Each stem is then TIG welded to the tank outer surface to provide for vacuum/coolant tightness, while thin channels are drilled at the inner surface of the tank body and filled with brazing alloy that will melt during final braze and will provide the correct electric contact between surfaces. Due to some manufacture delay, not all tanks are ready; the ones already manufactured have been measured and are within the frequency specifications. The structure is expected to be completed within this year.

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Conclusions

The injector has been installed in bunker at ENEA Frascati Laboratory and will be put in operation in September.

Many components of the 7 MeV LEBT are ready.

Within a few months the first module of the SCDTL structure will be completed, and if the cold test are passed, a beam line will be arranged to test it with the 7 MeV protons from injector.

Any future development is subjected to the definitive funding of the total project.