Luigi Picardi (ENEA)
*Advances in **TOP-LINAC** Construction*

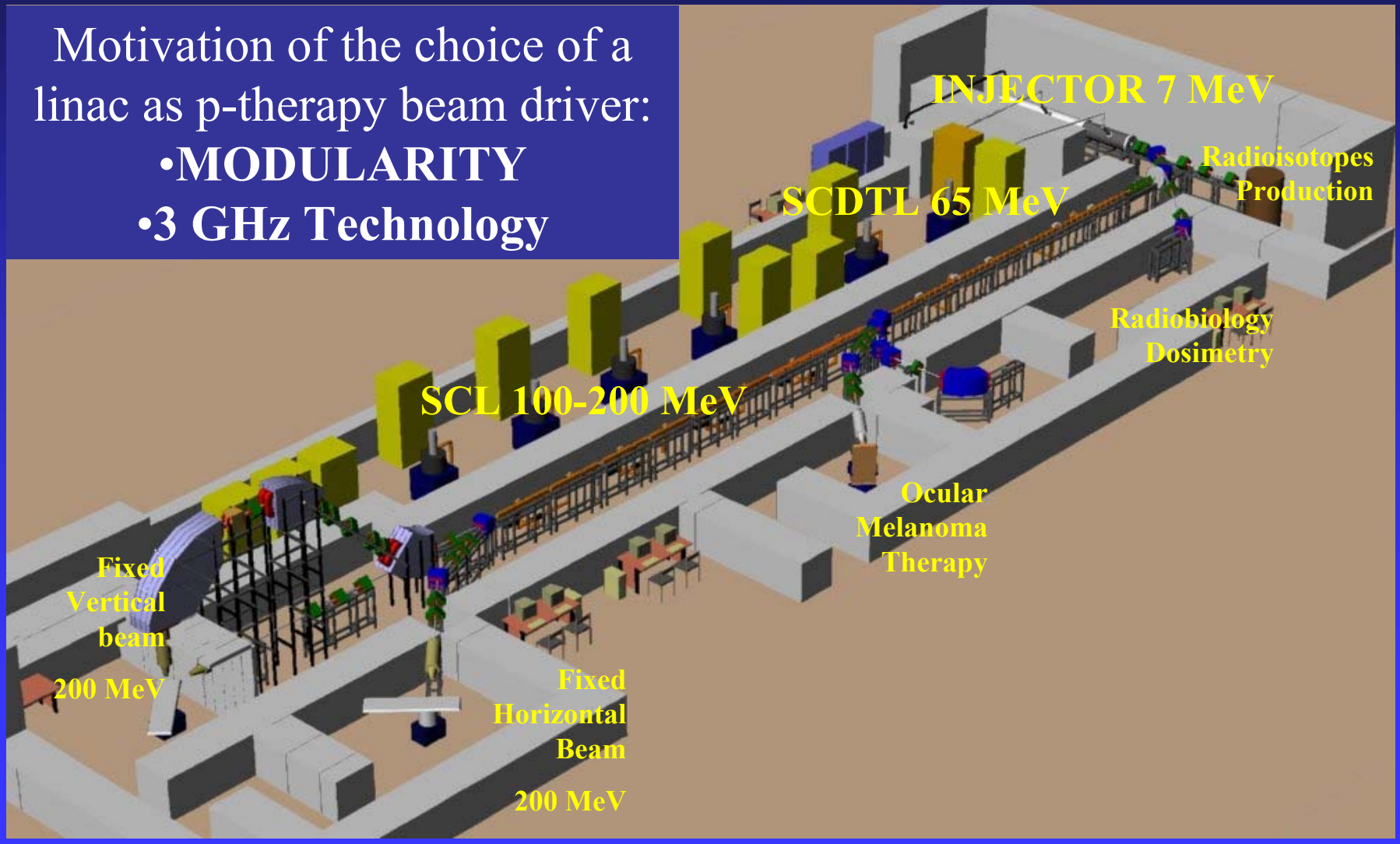
EPAC2002 Paris, 2-7 June 2002

The TOP (Terapia Oncologica con Protoni) Project of the National Health Institute has received an initial fund of 4.1 M€ from National Health Service to develop a design of a compact protontherapy accelerator to be host by an existing oncologycal Hospital and to promote ancyllary fields like dosimetry, radiobiology and treatment planning

TOP LINAC Layout

Motivation of the choice of a linac as p-therapy beam driver:

- **MODULARITY**
- **3 GHz Technology**

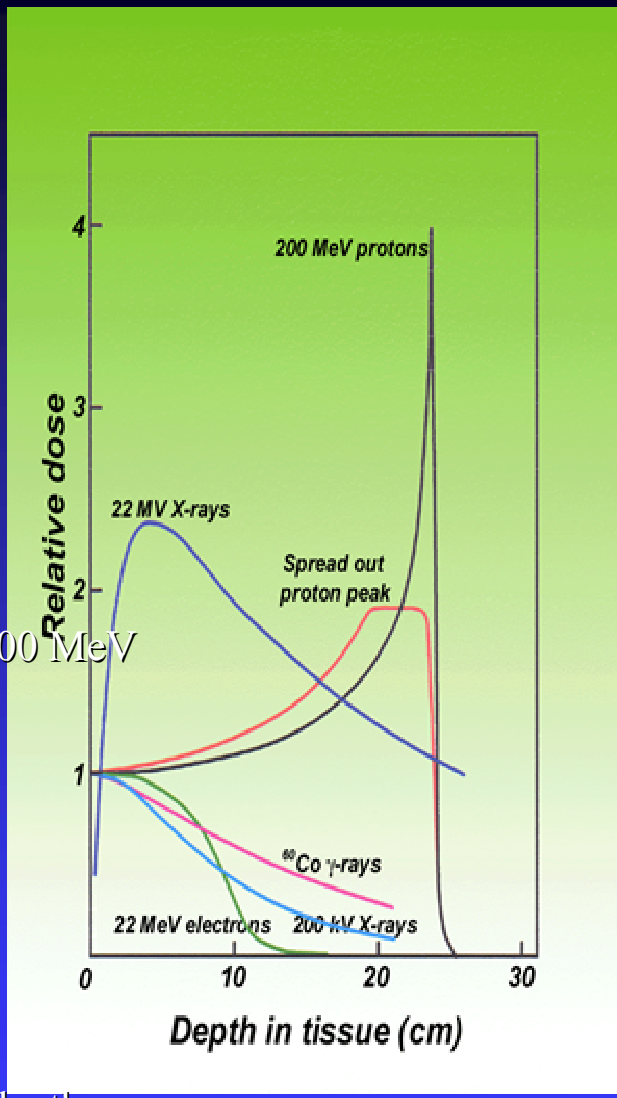


PARAMETERS

"PHYSICAL" BEAM PARAMETERS

Energy (*)	65, 82, 100 – 200	MeV
Pulse Duration (*)	2 – 7	μs
Repetition Frequency	50 – 300	Hz
Pulse Current (*)	≤ 0.05 – 5	μA
Average Current (max)	10	nA
Energy Spread (rms)	≤ 7 10^{-3}	@ >100 MeV
	< 2.2%	@ 65 MeV
Transverse Emittance (rms)	1.2	π mm mrad @200 MeV

(*) Can be changed on a pulse to pulse basis



"CLINICAL" BEAM PARAMETERS

Minimum and maximum Depth	3.5 g/cm2 - 25 g/cm2
Range variation Accuracy	0.5 g/cm2
Distal dose fall off – any energy	2 mm (80%-20%)

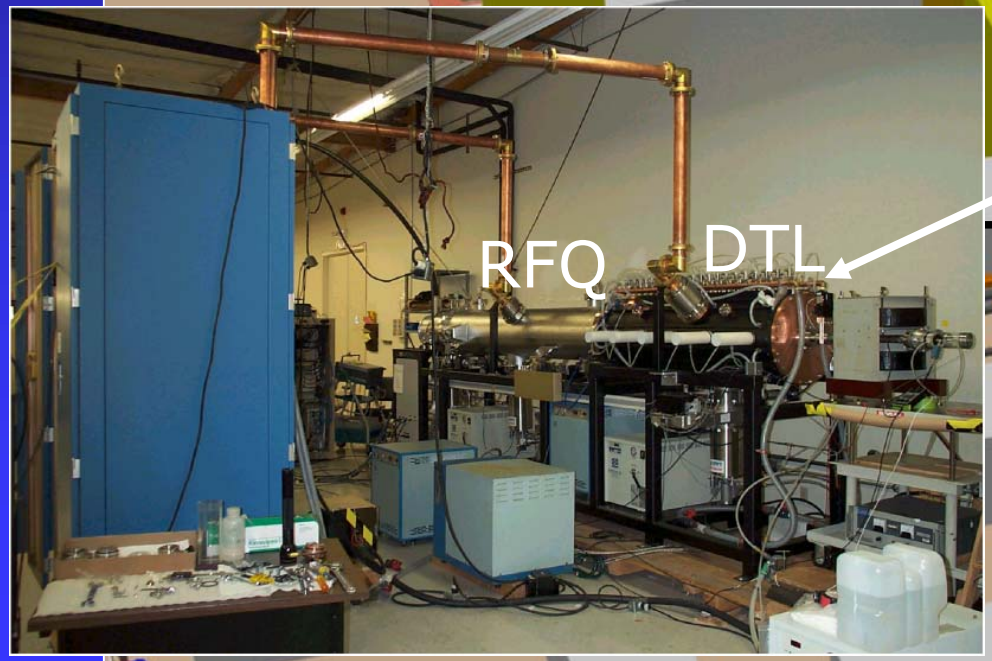
Dose > 2 Gy/min in 1 lt volume and for a 20x20 cm2 field at 25 g/cm2 depth

Maximum irradiation field: 20x20 cm2

"Scanning ready" System with possibility of active changing of beam energy and current and multiple painting

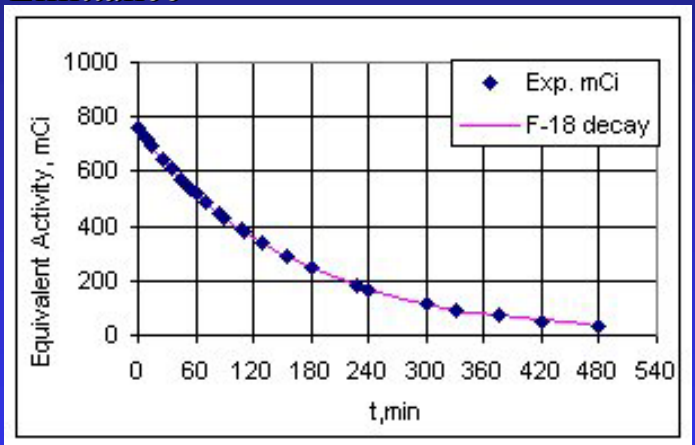
Injector: PL7- AccSys 7 MeV Proton linac

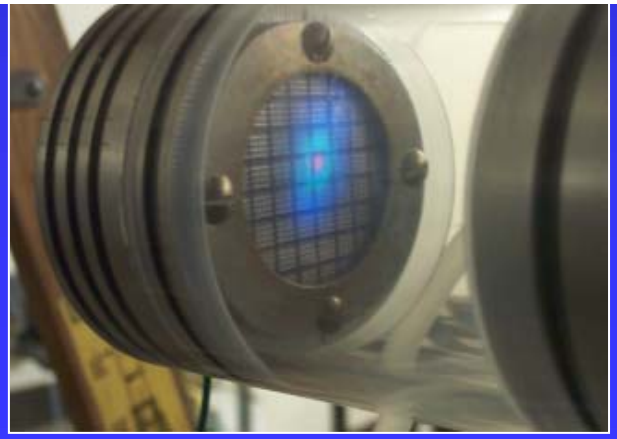
- Source (Duplasmatron), RFQ 3 MeV, DTL 4 MeV, RF 425 MHz
- From AccSys Inc. Pleasanton, CA
- FAT on Spring 2001 for ^{18}F production and protontherapy beam
- Delivered in Frascati in May 2001

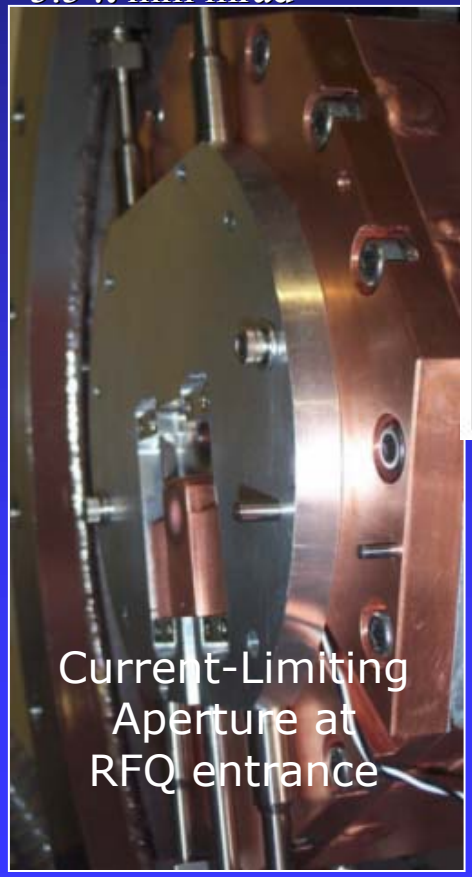


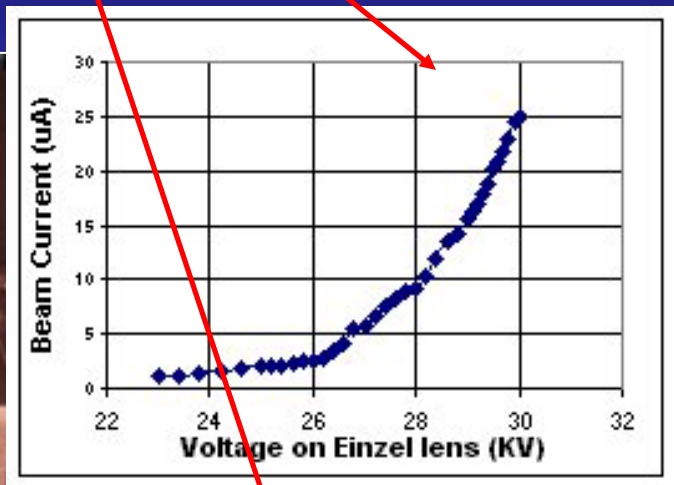
Injector Performances

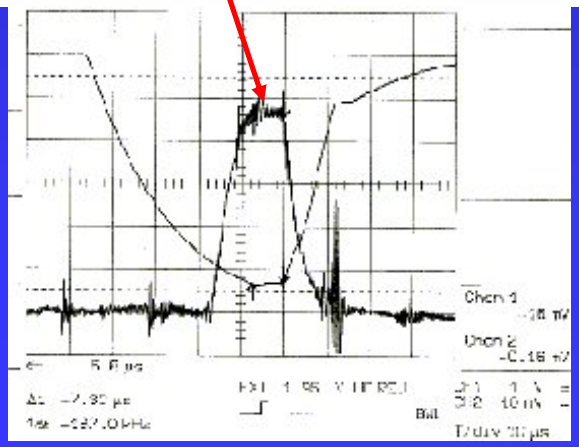
	F- mode		P- mode
Pulse current,	8 mA		1-30 μA
Pulse duration,	60 μs		2 - 7 μs
Pulse rep freq.	60 Hz		250 Hz
Energy spread		± 100 keV	
Emittance		5.5 π mm mrad	





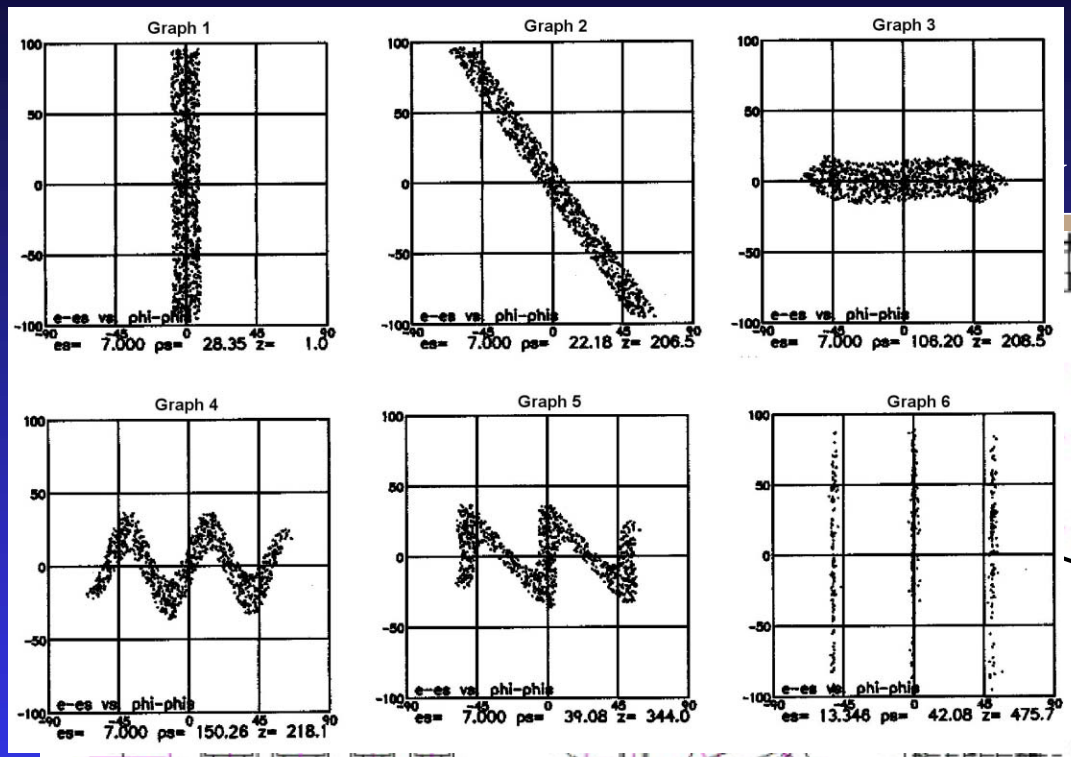


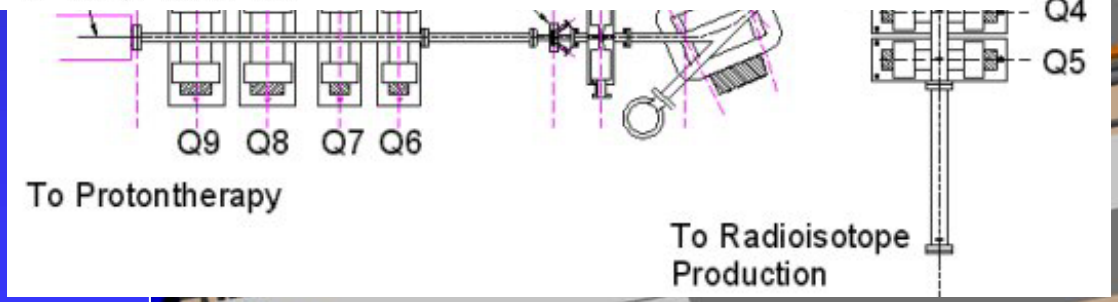




Low Energy Beam Transport line

injection



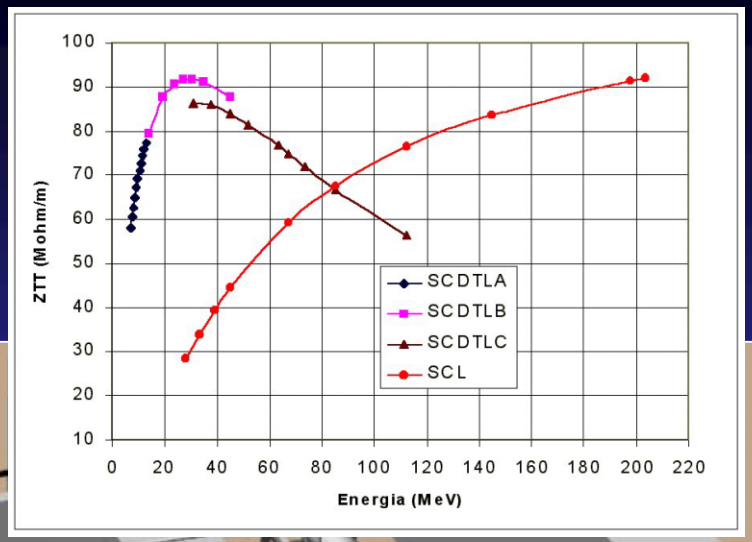


SCDTL 7 – 65 MeV

Single module length 1.4 m

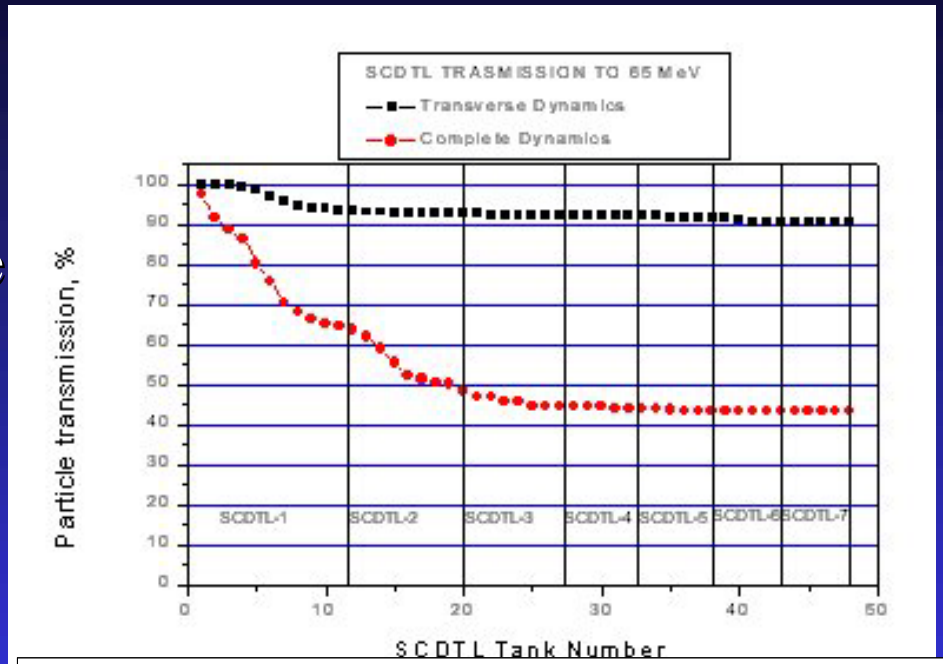
7 modules ⇒ length 10 m

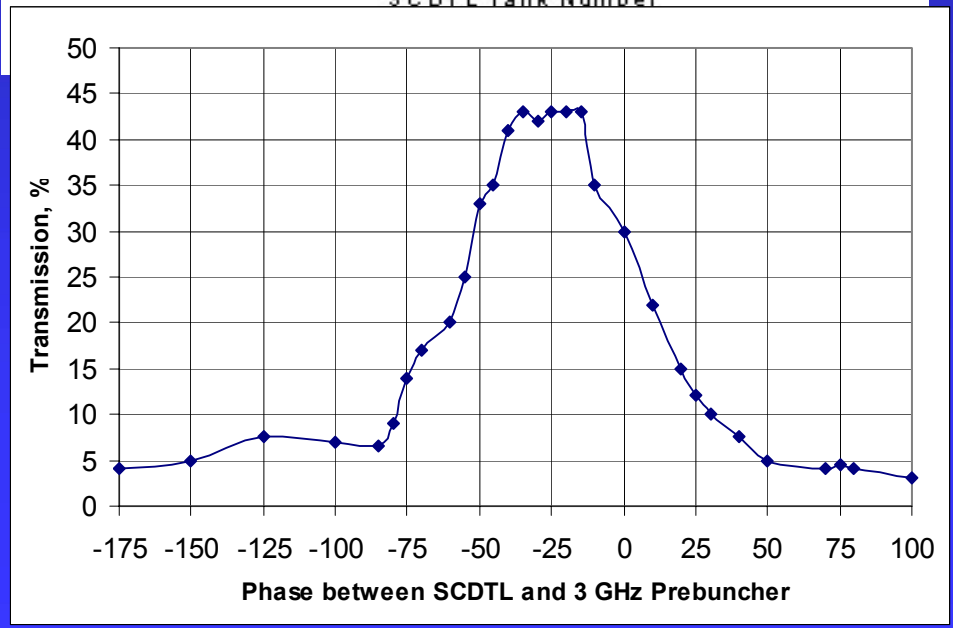
RF power 8 MW @ 2.998 MHz



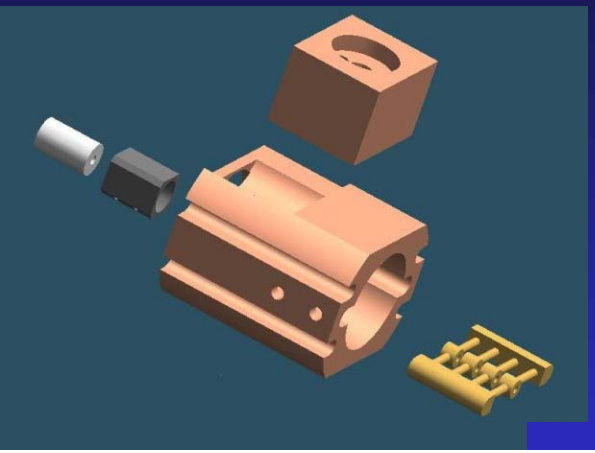
SCDTL Transmission

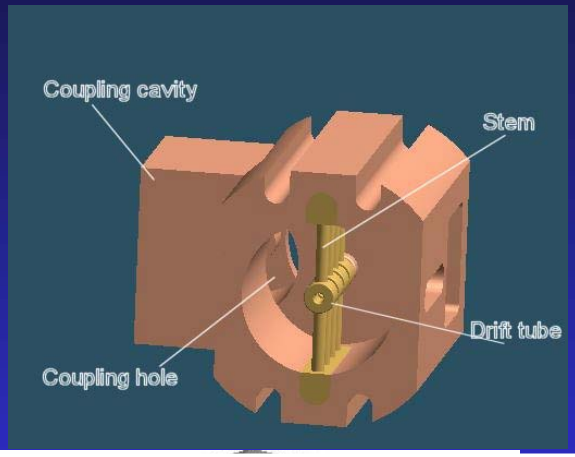
- Beam from injection line is sufficiently matched in transverse plane (10% losses). Main losses are due to longitudinal mismatching (insufficient bunching)
- However no problems arise due to the low current level (~ 10 μA pulsed) needed for p-therapy
- The phase between prebuncher and SCDTL changes the transmission giving the possibilitry of changing the current shot by shot

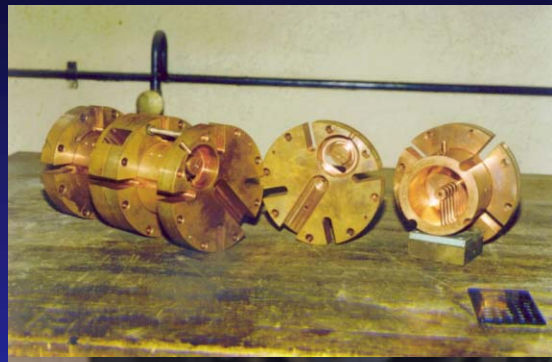


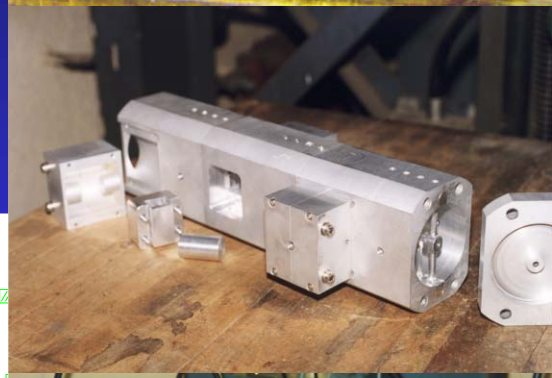


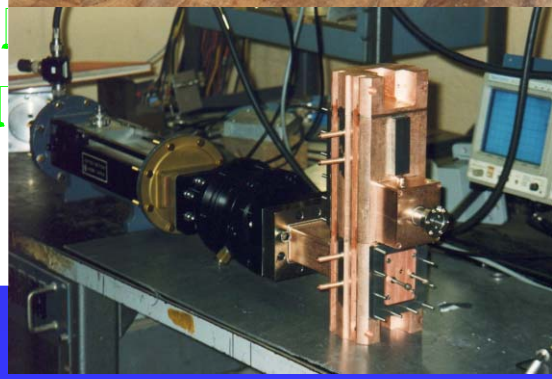
SCDTL construction

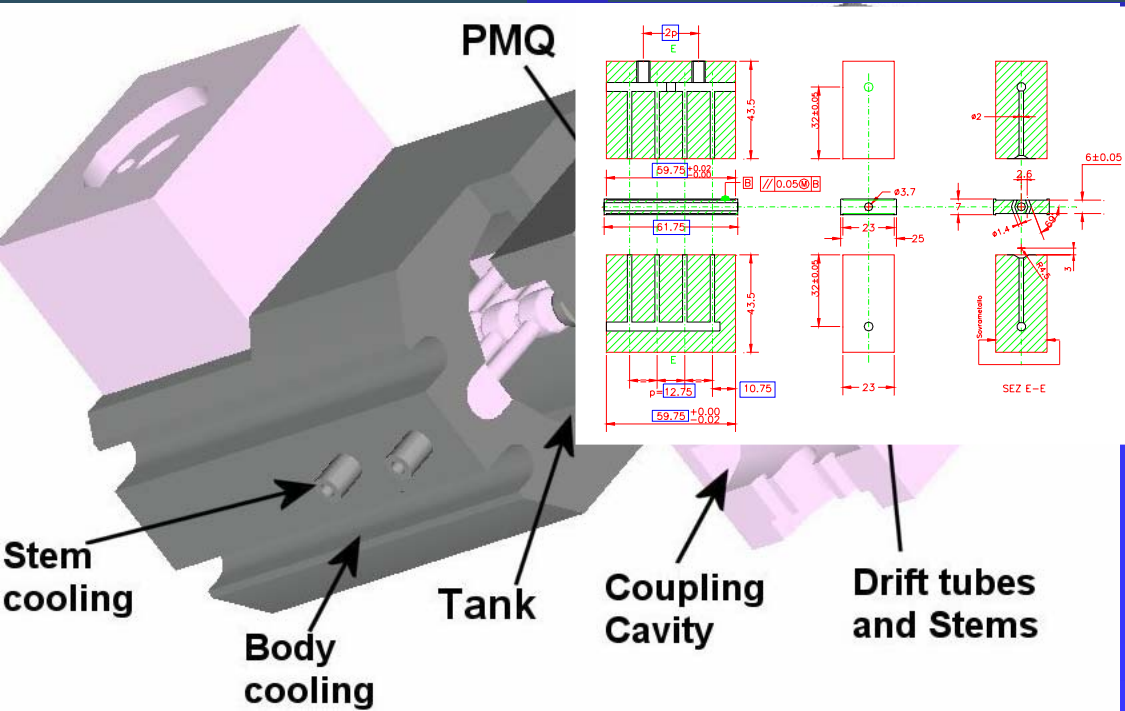










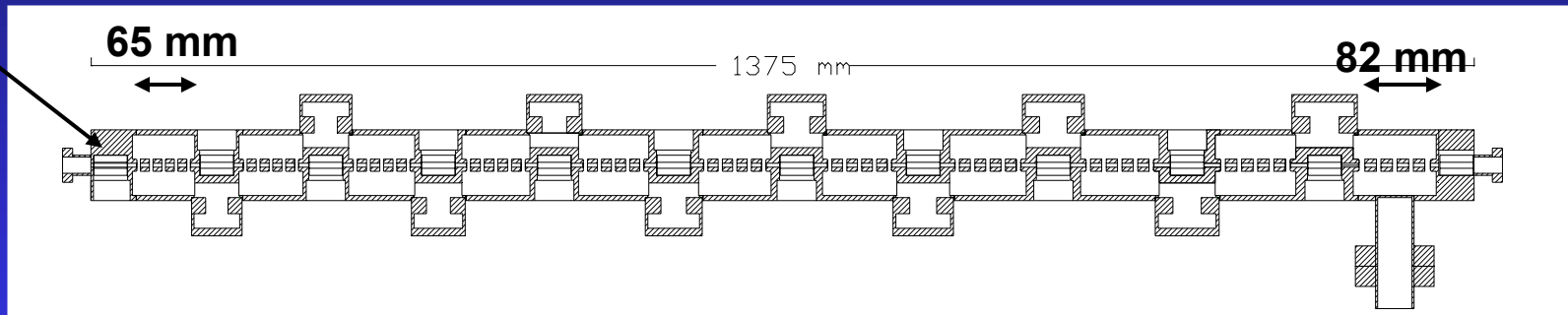


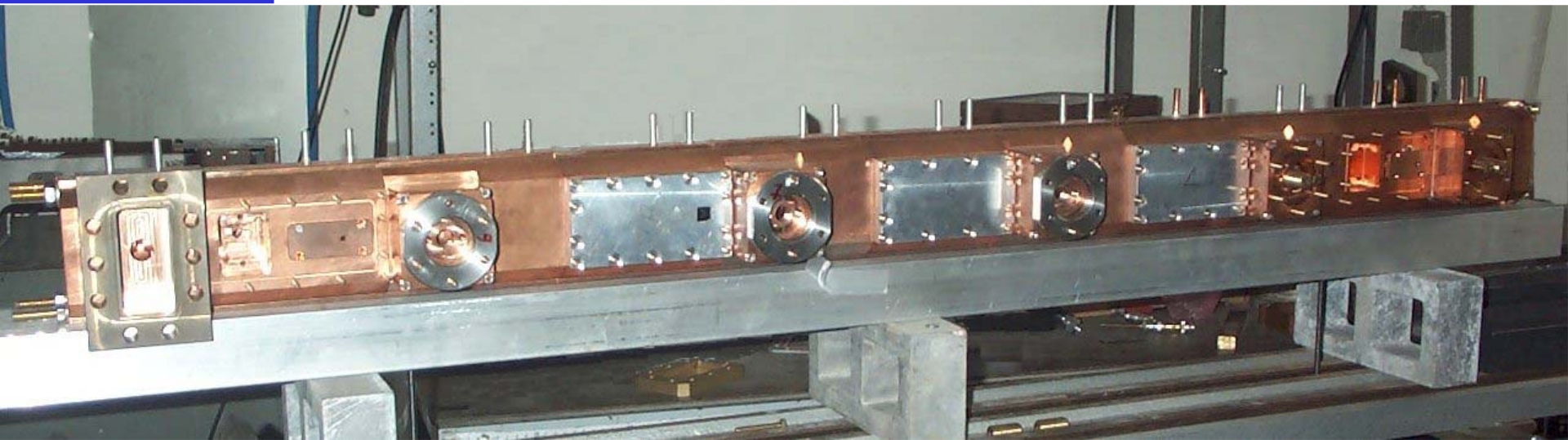
SCDTL First Module (7 – 13.5 MeV)

11 Tanks with 5 cells/tank
10 Coupling cavities
10 PMQs for focusing

RF Frequency
2.998 GHz

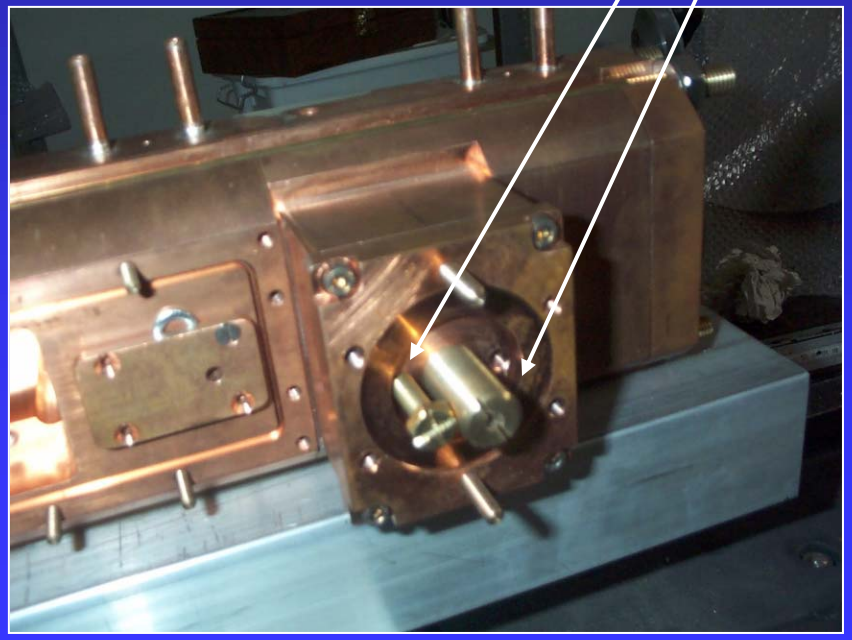
PMQ

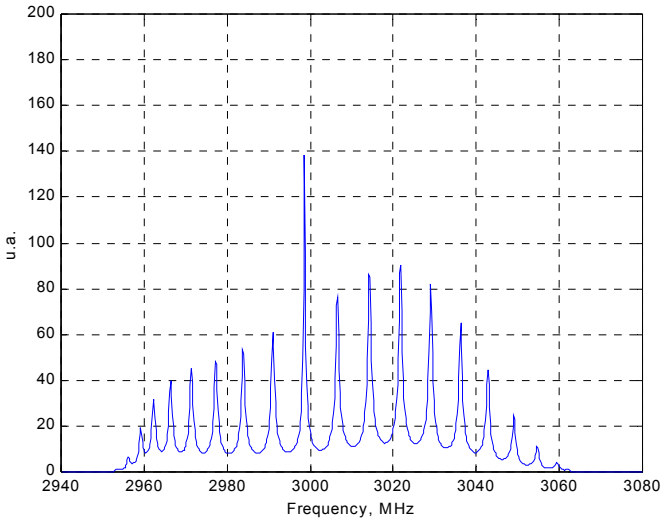


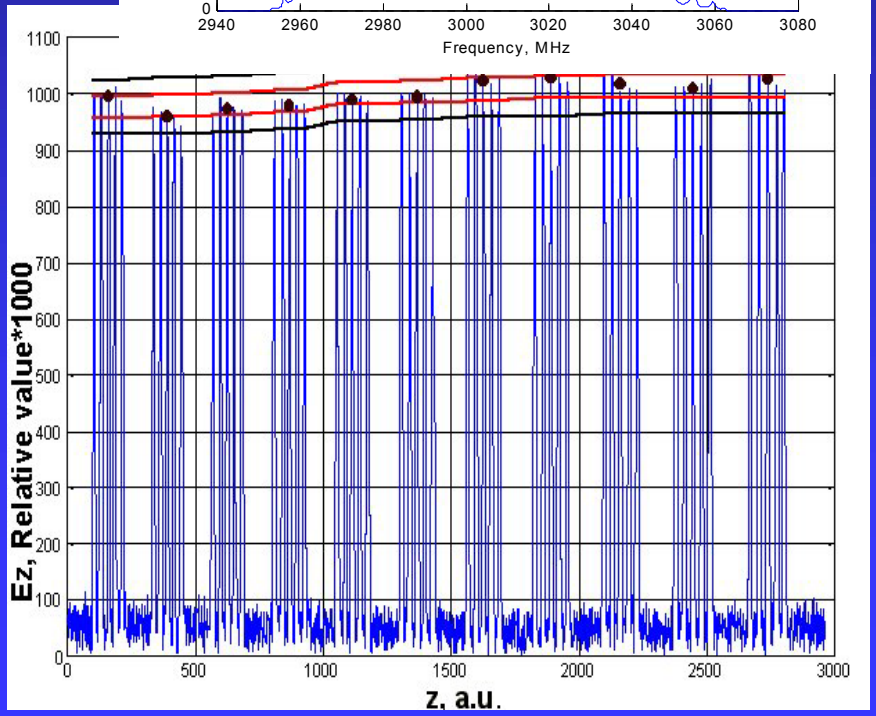


SCDTL First Module (7 – 13.5 MeV)

In order to tune the structure for the electric field uniformity throughout the structure, two additional tuners were added to each coupling cavity







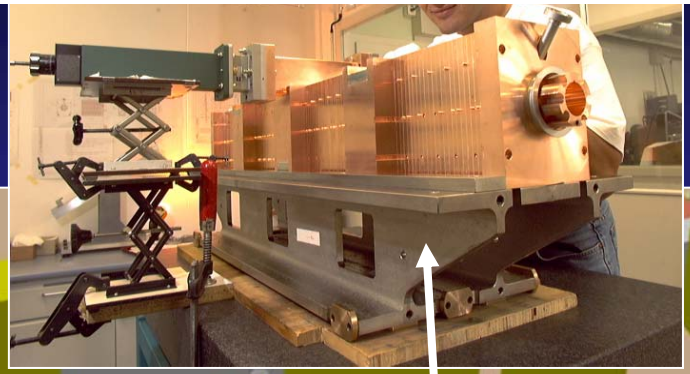
SCL 65 – 200 MeV

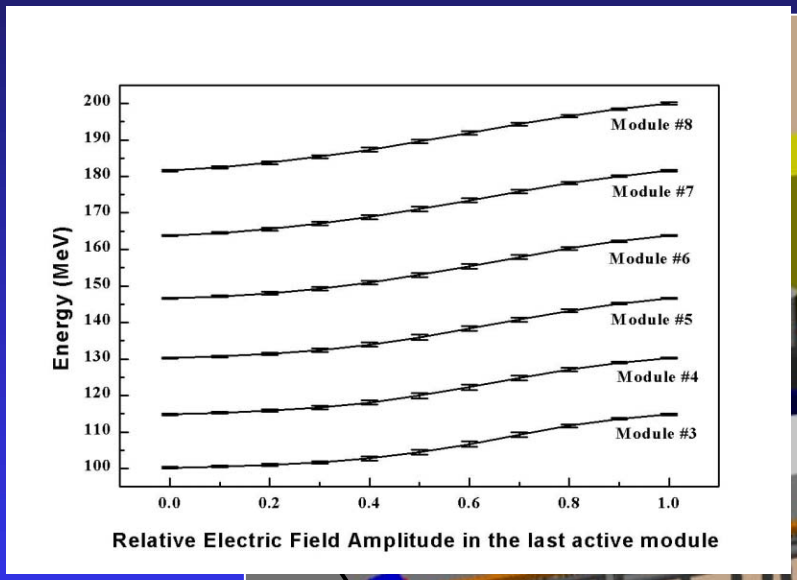
Single module length 1.5 m

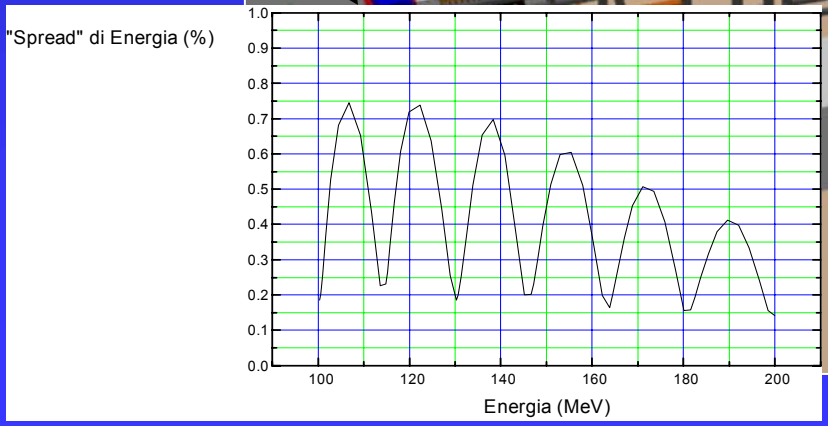
8 modules ⇒ length 12 m

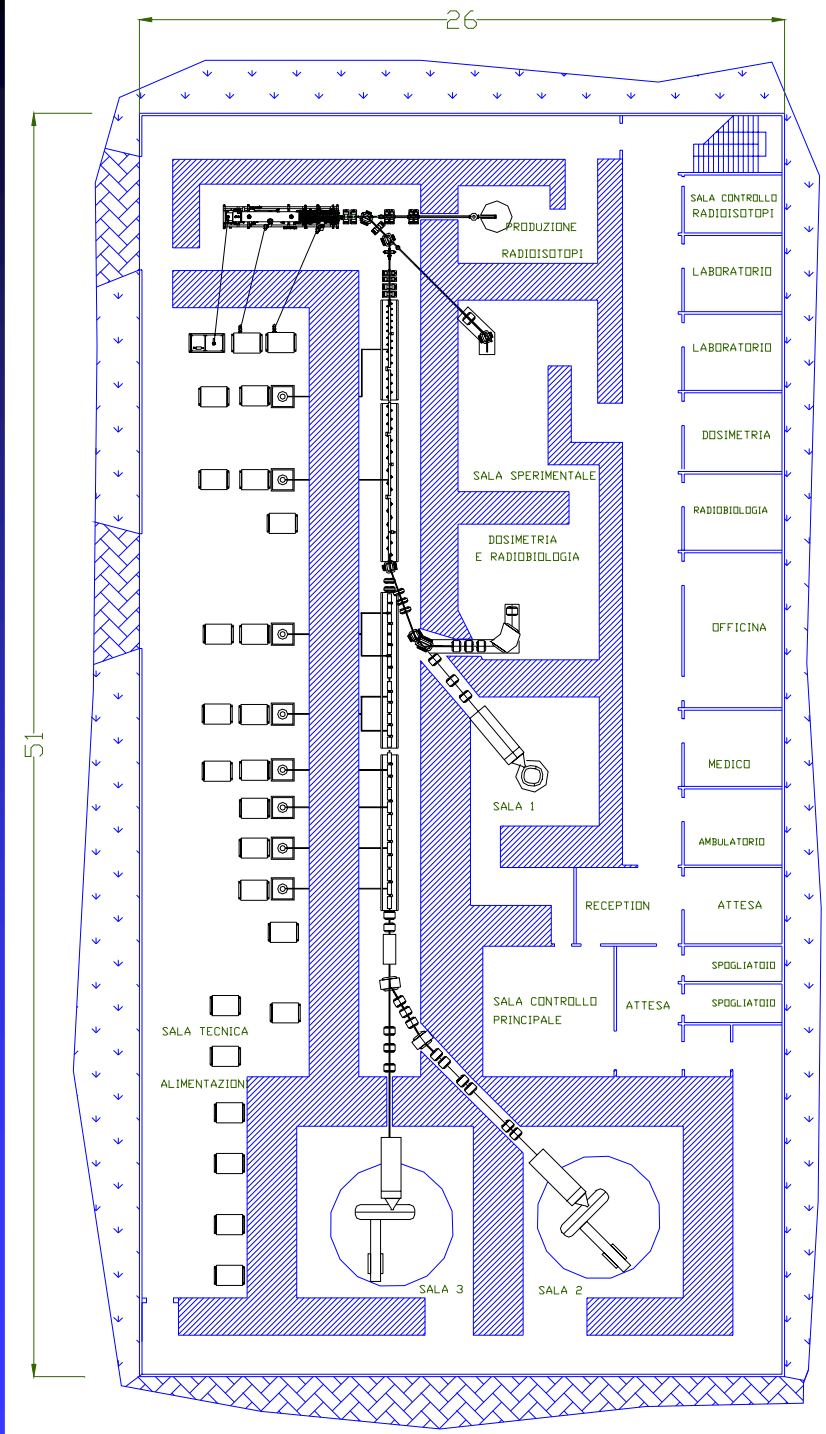
RF power 26 MW @ 2.998 MHz

Work done by TERA-CERN- INFN (LIBO Project) Poster MOPRI095 - 3 June 2002









TOP Linac Plant (IRE Installation)

Facility dimensions ≈ 1250 mq

Underground floor:

- 2 Experimental rooms for radiobiology e dosimetry
- 3 Rooms for radiation therapy
- 1 Bunker
- 1 Modulators – Technical Room
- 2 control rooms
- Ancyllary medical rooms, offices, laboratories

Electrical Power during Therapy 350 kW

Project status and Conclusions - 1

- Of the 4.1 M€, 2.6 M€ were transferred from ISS (National Institute of Health) to ENEA to acquire Injector and to built and test the first SCDTL module at Frascati Labs
- Cold tests of the SCDTL and SCL (LIBO type) moules have demonstrated performances even better than what required for the TOP Linac.

Project status and Conclusions -2

- Within one year both structures will be fully tested (energy gain , beam transmission, power consumption etc.) with beam in Frascati for SCDTL, and in Catania LNS for SCL LIBO-type, modules.
- With tests successfully passed the main challenging problems are demonstrated to be solved. It is reasonable to expect at that time the final green light
- ISS, ENEA, IRE (main oncologycal Hospital in Rome) are pushing forward to get total funding (30 M€ incl. Bunker)