REVIEW AND STATUS OF THE CERN NEW 50 MEV LINAC PROJECT

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Introduction

In 1973 the construction of a new linac injector for the CPS was launched. The main reasons for this decision were :

- instability of operation of present linac ;
- the risk of not achieving the beam required for the new Booster (designed to obtain 10^{13} ppp from the CPS) ;
- risk of an increasing fault rate due to ageing ;
- the use of the CPS complex as injector for the 400 GeV SPS which enhances the requirement for excellent performance of the CPS.

The design proposal [1] for this machine was worked out between April and October and the project was authorized at the end of October 1973.

Specifications

The essential performance specifications [1] for this project are listed in Table 1.

Table 1

Performance Parameters

current	50-150 mA	
pulse duration	200-70 μs	
max. energy spread at Booster input (after debunching)	± 150 keV	for 100 mA
emittance (at 50 MeV)	< 25π mm mrad	for 100 mA
repetition rate	2 pps	

Reliability and ease of adjustment in order to provide the beam conditions required by the various users were further important specifications.

Description

Table 2 lists the main design parameters for this project.

Table 2

Design Parameters

Particles	Protons
Repetition rate	2 pps max.
Preaccelerator	
Current	up to 400 mA
Source	duoplasmatron
Energy	0.75 MeV
H.T. Generator	cascade set
voltage	850 kV
stability	$\pm 5.10^{-4}$
current	5 mA
Acceleration column	high gradient, double gap configuration
750 keV beam transfer	
Transverse matching	
number of quadrupoles	18
max. gradient	40 T/m
Longitudinal	
number of bunchers	2 at 202.56 MHz 1 at 405.12 MHz
Linear Accelerator	
Current	operating range 50 < i < 150 mA
Pulse length	operating range 200 μs > t > 70μs
Beam quality at 50 MeV	
emittance	ε < 25 π mm mrad
energy spread after debunching	ΔW < ± 150 keV
Energy	50.0 MeV
Structure	
type	Alvarez stabilized by post couplers
number of tanks	3
tank frequency	202.56 MHz

acceleration rate	varying between 0.99MeV m^{-1} and 1.58 MeV m^{-1} up to 10.4 MeV (Tank I)
	varying between 1.58 MeV^{-1} and 1.42 MeV m^{-1} from 10.4 MeV to 50.0 MeV (Tank II and III).
synchronous phase	at input Tank I $\phi_s = -35^o$
	at output Tank I $\phi_s = -25^o$
	in Tanks II and III $\phi_s = -25^o$
number of cells	128
total length	33.6 m (inc. interspaces)
Quadrupole Focusing	N=1 (FD) configuration
max. gradient	100 T/m
RF System	5 amplifier chains
peak output power	2.6 MW per chain
<u>50 MeV Beam Transfer</u>	
Bending magnets	
BH1	±60 mrad (pulsed)
BH2	300 mrad (DC)
BH3 (IBH1)	385 mrad } pulsed
	85 mrad } pulsed
stability	$\pm 2.10^{-4}$
Transverse matching :	
number of quad.	4 doublets, 5 singlets
max. gradient	2.5 T/m
Longitudinal matching :	
number of debunchers	2 at 202.56 MHz
	1 at 405.12 MHz

For the location of the machine a small free area at the end of the South Experimental Hall, with axis nearly parallel to the old linac, was found.

The description of the project as given in the design proposal [1] is still essentially valid. It follows in many respects the designs of linacs built around 1970.

The beam from a duoplasmatron source is accelerated to 750 keV in a high gradient double gap column which is suspended in the air. The 750 keV beam transfer system [2] consists of a modular structure with four triplets and extensive beam diagnosis, followed by a section which matches the beam into the acceptance of Tank I with six quadrupoles and a bunching system consisting of a double buncher (202.56 and 405.12 MHz) and an energy spread corrector (202.56 MHz).

The design of the Alvarez structure [3] follows our experience with the 3 MeV experimental linac [4] and includes stabilization by post couplers. The beam dynamics takes into account the space charge forces up to 150 mA beam current [5].

The linac is followed by an analysis section [6] designed for evaluation of beam characteristics in all the three phase planes. The beam is then inflected into the existing 50 MeV transport line at a point where it can be directed either directly into the PS or into the Booster.

The RF system consists of independent chains, each with low-level amplitude and phase servos. The tanks are supplied by FTH 470 tubes in the driver and final stages. The Siemens 2024 tetrode is used in the predriver stage, which also serves as output stage for the 200 MHz bunchers and debunchers. Commercial RCA cavities are used for the 2nd harmonic buncher and debuncher.

The controls system [7] uses a PDP 11/40 and PDP 11/45 as front-end and main computers respectively and serial CAMAC for data transfer.

Progress and Status

Ground was broken for this project before the end of 1973 and the control room and the hall for the pre-accelerator were terminated in March 1975, the whole building being finished by the end of 1975 (Figs. 1 and 2).

Installation of the pre-accelerator began with the arrival of the Haefely cascade in April 1975 and the first 750 keV beam was obtained at the end of that year. After tedious trouble shooting on the bouncer circuit a stability of 400 V during a 100 μs, 250 mA beam pulse has now been achieved (Fig. 3)

The emittance of a 200 mA beam and its mass spectrum have been measured[8]. The first part of the LEBT has recently been installed (Fig. 4) and by the end of the year, the whole LEBT will be installed and tested.

The shells for all linac tank sections have arrived and the manufacture of the drift-tubes and other structure components are under way (Fig. 5). The installation of tank 1 is expected for early 1977.

All quadrupoles, essentially copied from BNL design, and all pulsers[9] have been received. Most of the hardware for the controls system[7] is on order or has been received and software development has made good progress. Prototypes of the RF modulators and of the RF output stage (FTH 470) exist and the final mechanical design is well advanced. The somewhat ambitious plan to go in one stage (Siemens 2024 tube) from the 400 W output of a transistor amplifier to 50 kW level has been abandoned in favour of an intermediate stage. The development of the low-level fast feedback system is well advanced.

It is expected to complete this machine by the end of 1977.

References

1) Project study for a new 50 MeV linear accelerator for the CPS, CERN/MPS/LINP 73-1.

2) Design of the low energy transport system, B. Bru and M. Weiss, CERN/MPS/LIN 74-1.

3) Accelerating structure of the CERN new 50 MeV Linac, D.J. Warner, Paper submitted to this conference.

4) Accelerator research and development with the CERN 3 MeV Linac, D.J. Warner, MPS/LIN 72-5 and 1972 Linac conference, p.33.

5) Beam optics in the CERN new 50 MeV Linac, D.J. Warner and M. Weiss, paper submitted to this conference.

6) Système de mesure des plans de phase à 50 MeV pour le nouveau Linac, P. Têtu, MPS/LIN/Note 74-16.

7) The control system of the CERN new 50 MeV Linac, A. Cheretakis, J. Knott, P. Mead, A. Van der Schueren and U. Tallgren, paper submitted to this conference.

8) Summary of 750 keV beam tests (stage 1), H. Haseroth, M. Weiss, MPS/LIN/Note 76-22.

9) Etude d'une alimentation pulsée et régulée en courant, M. Bourgeois, MPS/LIN/Note 74-17.

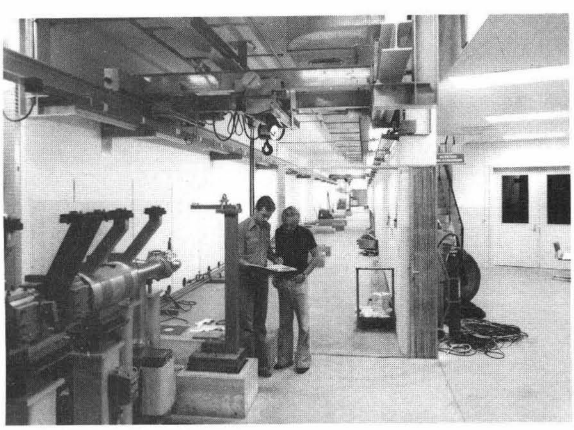

Fig. 1 New linac tunnel. In foreground at left is triplet 4 of LEBT. Supplies are installed in a gallery of approx. double width on top of the tunnel.

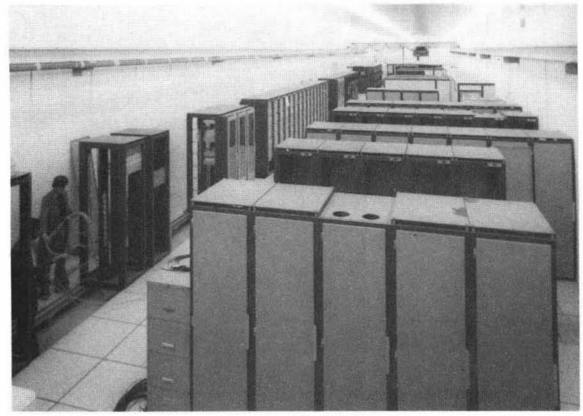

Fig. 2 Equipment gallery. The accelerator tunnel is below the row of racks at the left and the main aisle.

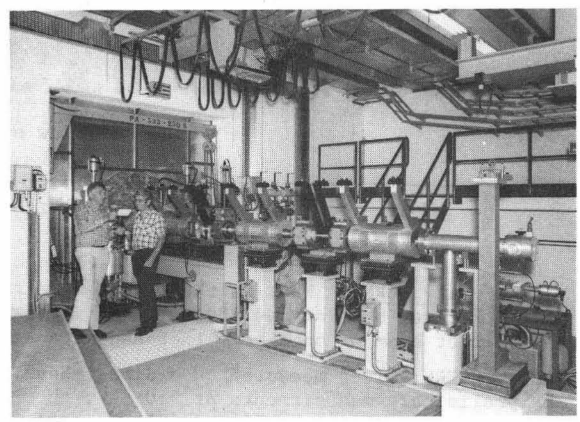

Fig. 4 LEBT as installed by beginning of September 1976.

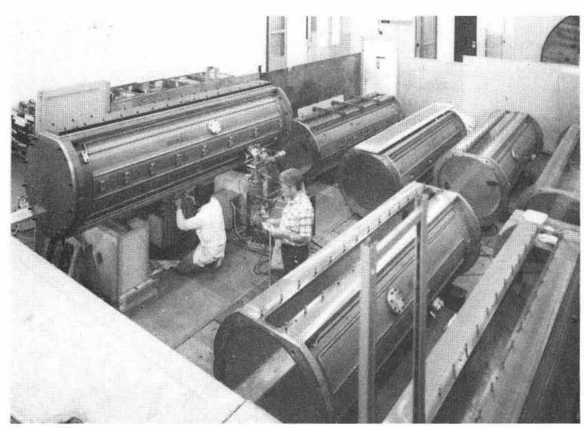

Fig. 5 Storage and testing area for tank sections.

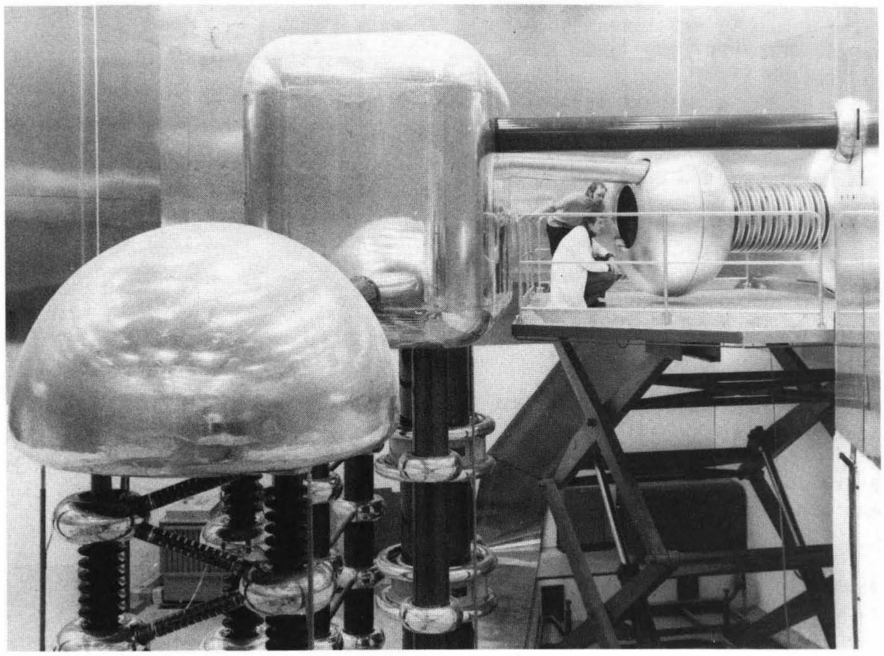

Fig. 3 View of the 750 keV preaccelerator.

DISCUSSION

M.R. Shubaly, CRNL: What is the measured emittance of the 750 keV beam at say 150 mA? Was it measured on a direct beam or on a beam that had been bent?

Warner, CERN: It's measured on a direct beam. For the preliminary measurements at 750 keV, the range of emittances is between 50 and 80 π.mm.mrad. Cy Curtis has the figure that we quote to the public.

C.D. Curtis, FNAL: The emittance into the linac for 200 mA is 3/10 π cm.mrad. That's the design figure I believe and on the old linac it's essentially the same, for 190 mA it is 3/10 π mm.mrad.