The Realization and Assembly of the 3 MeV Chopper Line for the Linac4

C. Rossi[1]

1) CERN, Geneva, Switzerland

Abstract

A Chopper Line operating at the beam energy of 3 MeV has been designed and built at CERN within the High-Intensity Pulsed Proton Injectors (HIPPI) program, the Joint Research Activity funded by the European Community under the EU Sixth Framework Programme (FP6). This MEBT (Medium Energy Beam Transfer) line fulfils the longitudinal and transverse matching of the H^- beam from the RFQ to the DTL in the Linac4 accelerator that is under construction in the frame of the LHC injector upgrade program.

This paper is in support of deliverable CARE-HIPPI-2007-37. The deliverables included the results of a measurement campaign on the 3 MeV test stand at CERN, that turned out to be impossible during the HIPPI time frame. The IPHI-RFQ, which was initially foreseen to be operational in 2007, is not anymore the baseline RFQ for the CERN Linac4. The RFQ has gone through a phase of redesign and will be delivered only in 2010

Introduction

The 3 MeV Chopper Line has been designed and built at CERN within the HIPPI program, the Joint Research Activity that has been funded by the European Community during the years from 2003 to 2008 under the EU FP6 (Sixth Framework Programme).
This chopper line has been designed to operate as the Medium Energy Beam Transfer (MEBT) line realizing the longitudinal and transverse matching of the beam parameters between the Linac4 RFQ and the following DTL.
The construction of the Chopper line aimed first at demonstrating the effectiveness of a chopper pulser, based on a meander stripline, capable of producing the longitudinal beam pattern demanded by the operational characteristics of the Superconducting Proton Linac (SPL) as LHC injector and as the driver of a neutrino factory complex.

Main Characteristics of the Chopper Line

The most challenging component in the line is represented by the chopper structure and by its pulser. The requirements on the chopper pulser are very severe: it must provide the voltage excitation, ± 600 V, at a maximum repetition rate of 45 MHz, with a pulse length varying from 8 ns to 2 μs while assuring a 2 ns rise/fall time.
The Chopper line is designed to provide the longitudinal and transverse matching of the beam parameters to the following DTL structure for the beam that is extracted from the RFQ at the energy of 3 MeV. In a high intensity injector this is a critical operation since all the emittance budget could be compromised at this point. The emittance growth expected at the MEBT exit is 4% in the longitudinal plane and 8% in the horizontal.
The line is very compact: in 3.7 m three pillbox buncher cavities are installed to preserve the longitudinal emittance and eleven quadrupoles provide the necessary transverse focusing. Mechanically speaking, the line has been organized in ten sectors that could be dismounted independently, which appears as an important characteristic due to the high component density of the line itself.
With respect to vacuum, high vacuum technology has been chosen for the design of this line, by employing CF standard flanges and copper seals. Due to the high compactness of the line, it has been decided to pump the line through a manifold chamber that is connected to the three RF buncher cavities. The expected vacuum profile is shown in Figure 1.

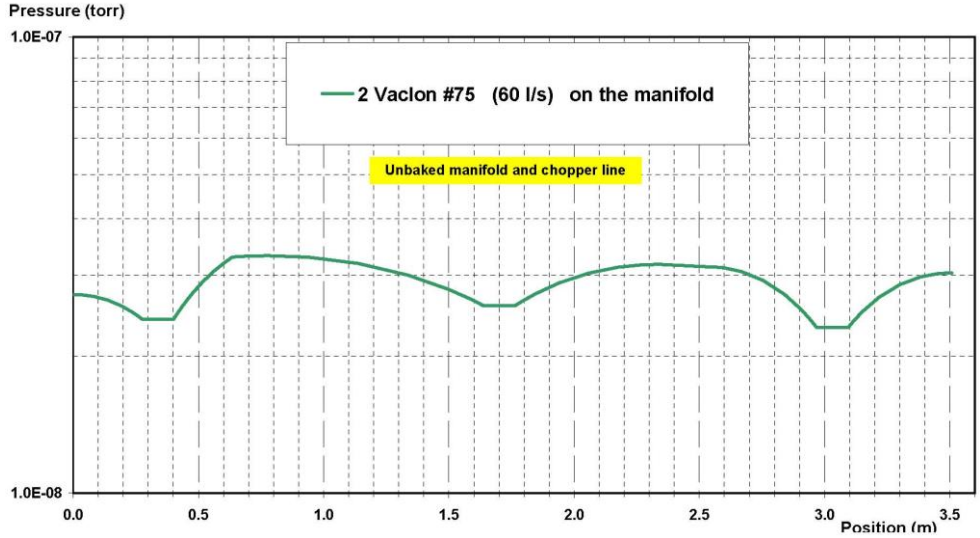


Figure 1: Vacuum pressure profile of the chopper line.

Figure 2 shows the detailed drawing of the line.

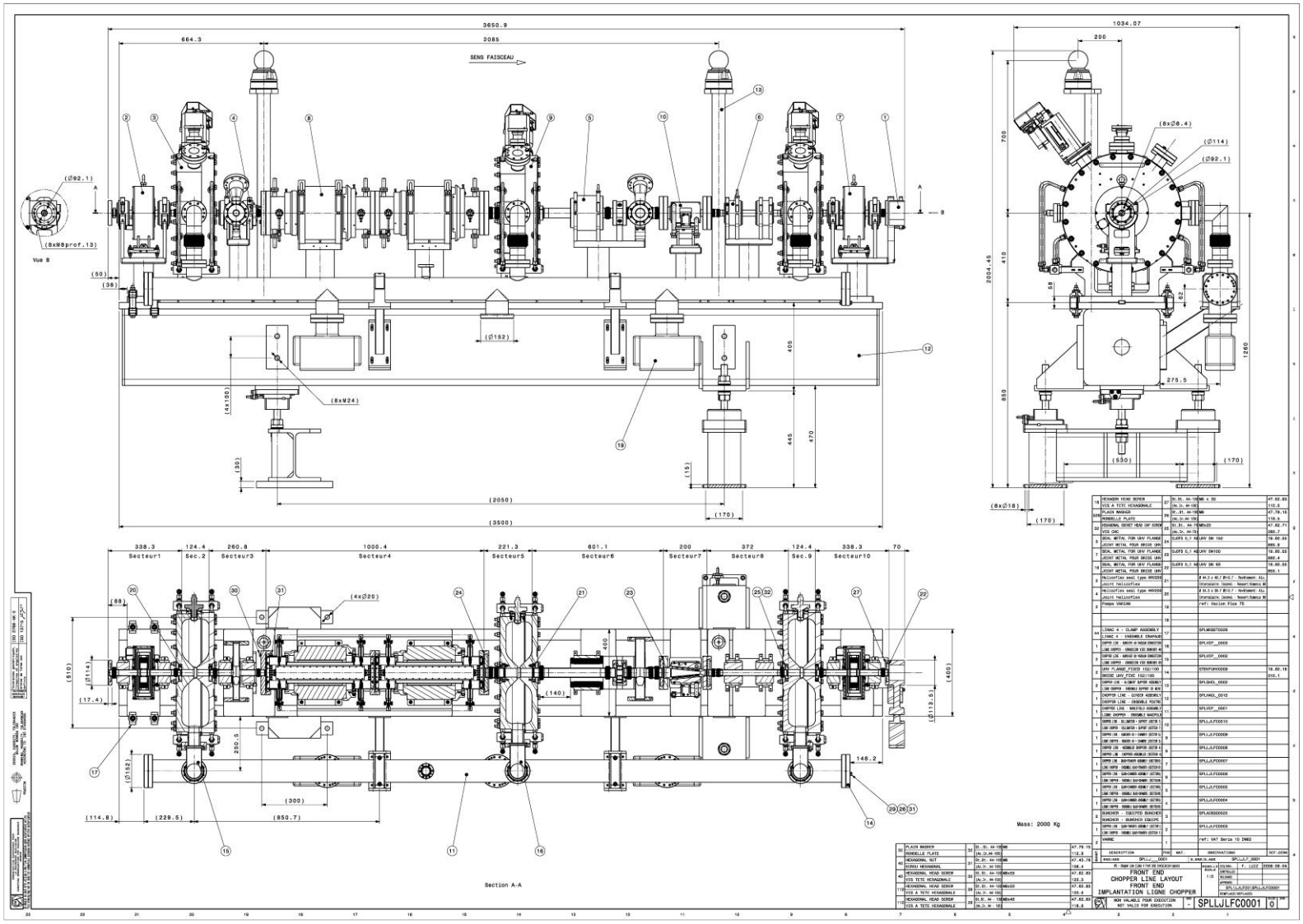
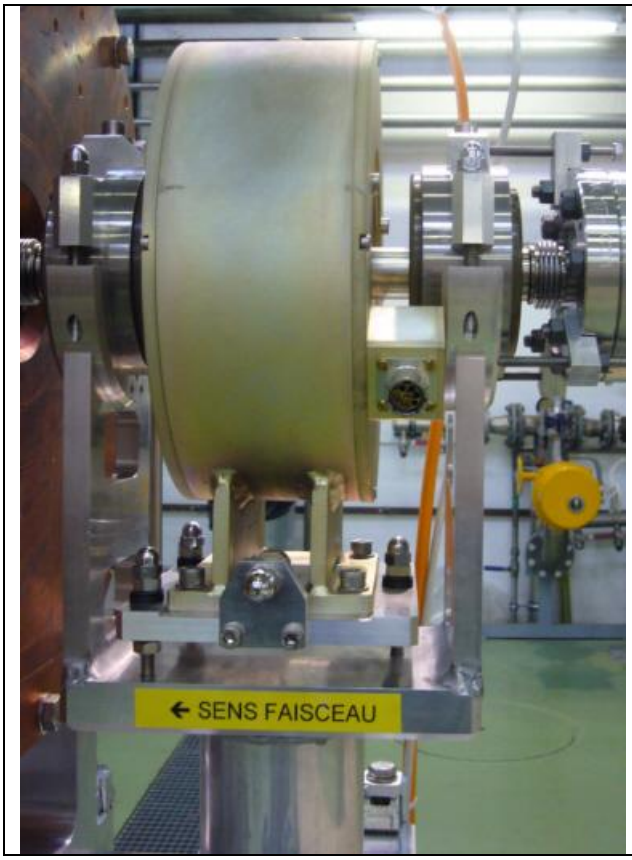


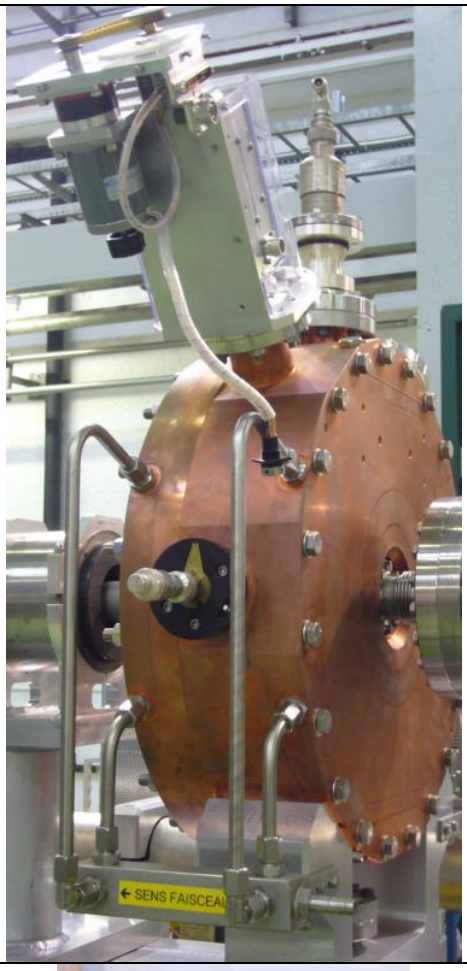
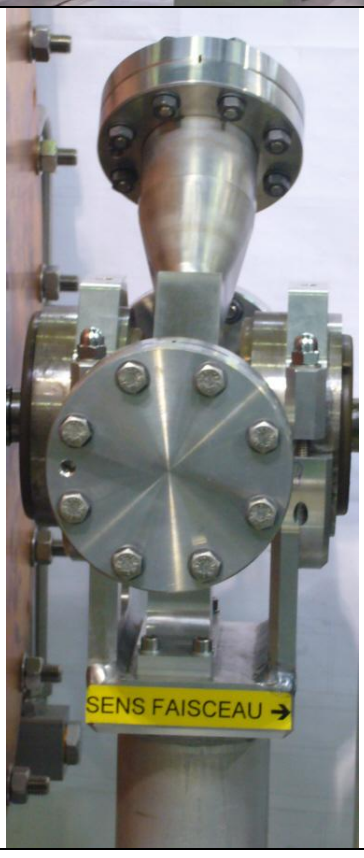
Figure 1: Detailed drawing of the 3 MeV Chopper Line.

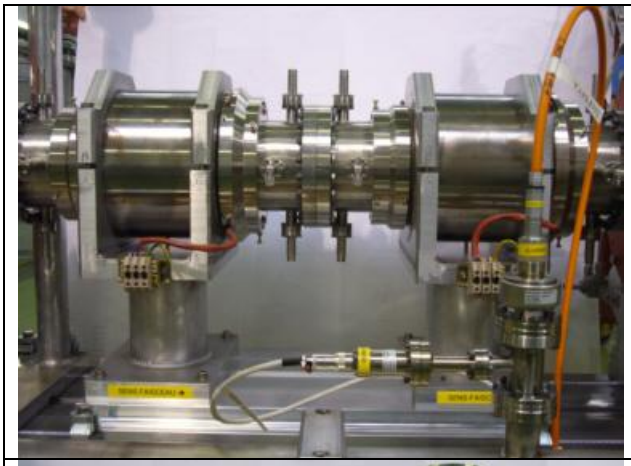
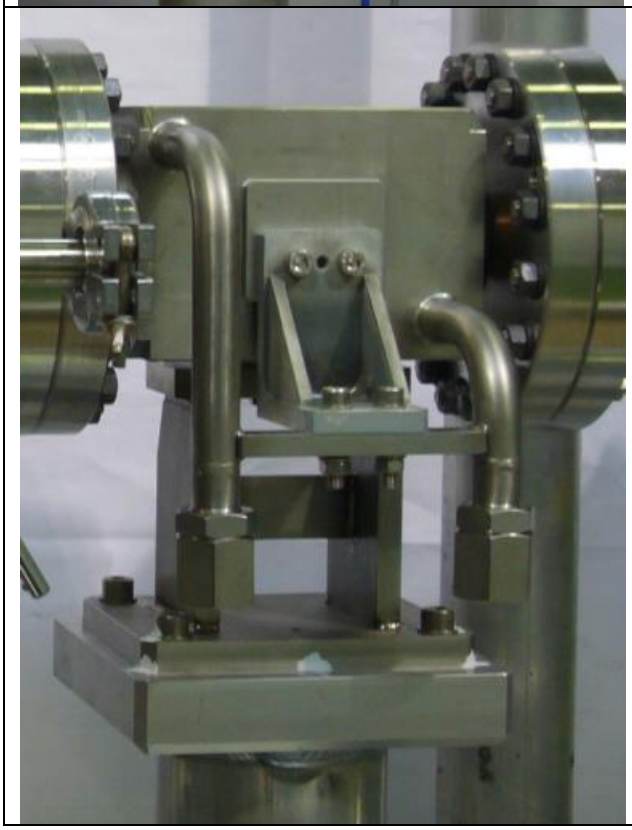
Realization of the Chopper Line

The construction started in 2006. All components but the third buncher cavity were received before the end of 2007 and in 2008 the assembly could start. The third buncher cavity is presently under construction and is expected for delivery in mid-2009.
All the stainless steel vacuum chambers have been built and assembled at the CERN workshop. The supports, the bellows and the ceramic gaps have been outsourced.
All components have been pre-assembled and aligned on their individual supports that were beforehand measured at the metrology workshop. The final installation on the main support beam was done by means of a system of alignment keys and clamps that are expected to provide the alignment precision of ± 0.1 mm.
The following pictures show all sectors in their assembled configuration.

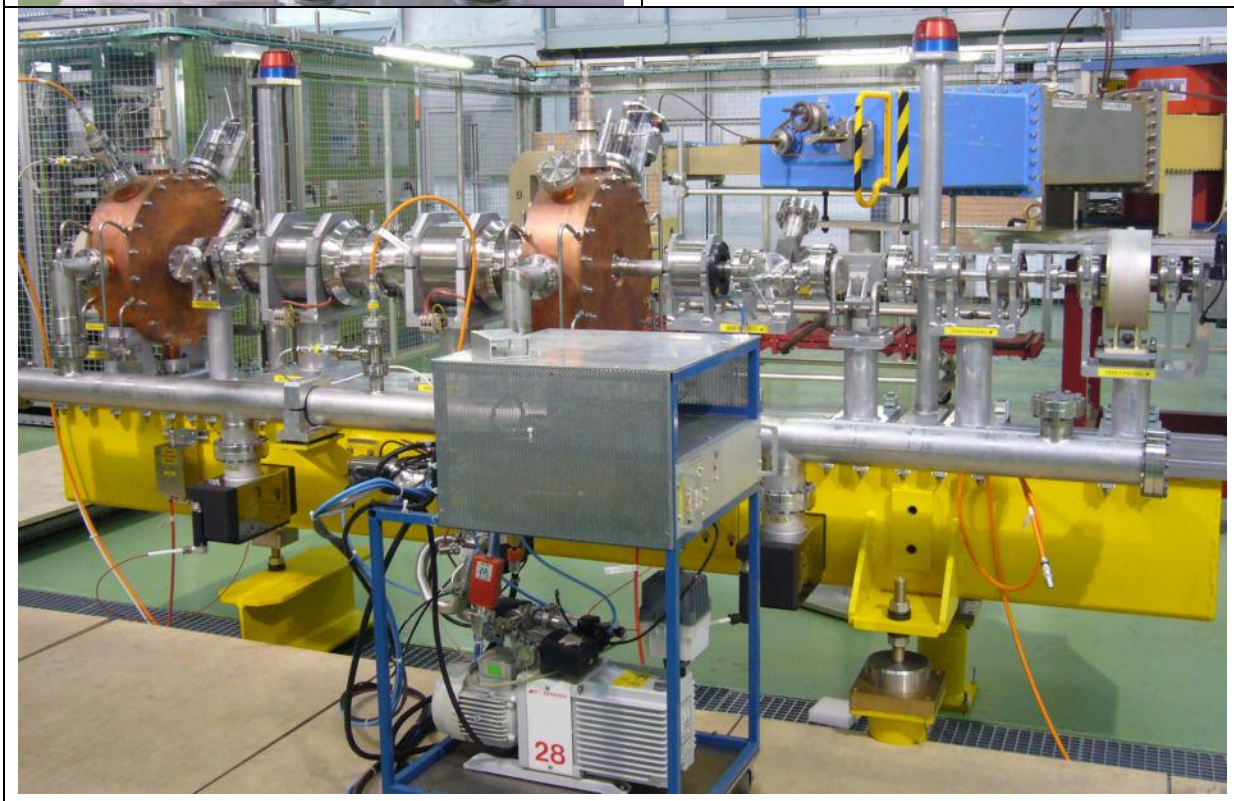


Sector 1: Beam Current Transformer between two quadrupoles.

	Sectors 2, 5 and 9: RF buncher cavities.
	Sectors 3: Wire scanner vacuum chamber (the wire scanner itself will be retrieved from the CERN stock).

	Sector 4: Chopper chamber with quadrupoles.
	Sector 6: Beam pick-up and wire scanner.
	Sector 7: Beam dump

Sector 10: Beam Current Transformer between two quadrupoles, with sector valve at the beam exit.



View of the line assembled and under vacuum.

	Power supplies for the MEBT optics.

All quadrupoles were recovered from the Linac2 stock of spares. Brand new power supplies were built to operate the magnets in pulsed mode.
The MEBT line assembly was completed in October 2008. The vacuum in the line reached the level of 10^{-8} mbar easily and no major problem was met during the vacuum test. In 2009 a complete electrical check of the MEBT line is foreseen, while the beam tests will be possible only after delivery of the Linac4 RFQ, which is expected in 2010.

Acknowledgements

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