THE SARAF-LINAC PROJECT STATUS

N. Pichoff, N. Bazin, L. Boudjaoui, P. Bredy, D. Chirpaz-Cerbat, R. Cubizolle, B. Dalena, G. Ferrand, B. Gastineau, P. Gastinel, P. Girardot, F. Gougnaud, P. Hardy, M. Jacquemet, F. Leseigneur, C. Madec, N. Misiara, P. Nghiem, F. Rossi, D. Uriot
CEA/IRFU, Gif-sur-Yvette, France
P. Bertrand, M. Di Giacomo, J-M. Lagniel, J-F Leyge, M. Michel, P. Toussaint
CEA/GANIL, Caen, France

Abstract

SNRC and CEA collaborate to the upgrade of the SARAF accelerator to 5 mA CW 40 MeV deuteron and proton beams (Phase 2). CEA is in charge of the design, construction and commissioning of the superconducting linac (SARAF-LINAC Project). This paper presents to the accelerator community the status at August 2016 of the SARAF-LINAC Project.

INTRODUCTION

The SARAF-LINAC project, managed by CEA (France), is integrated to the SARAF-Phase 2 project managed by SNRC (Israel) and has been already introduced in [1].

In 2014, a first System Design Report (on the base of which [1] was written) was presented and provided a basis for an agreement between CEA and SNRC.

The project can be simplified in 3 overlapping phases (Fig. 1) lasting less than 8 years:

- ~3 years of detailed design, including prototyping,
- ~4 years of construction, assembly and test at Saclay,
- ~2 years of installation and commissioning at Soreq.

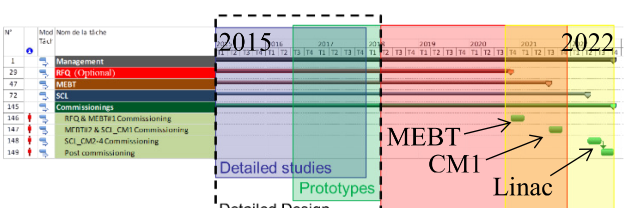

Figure 1 SARAF-LINAC major schedule.

During the first phase, two Preliminary Design Reviews and one Critical Design Review took place at Saclay:

- October 2015: major components PDR.
- January 2016: system PDR.
- June 2016: major components CDR.

In this paper, the status of these developments after the first year of detailed design phase is presented.

SYSTEM

The SARAF-LINAC System Preliminary Design Review (PDR) took place at Saclay on January 2016. Status on beam dynamics, vacuum design, beam diagnostics, local control systems was presented. The linac layout is given on Fig. 2.

Since then [2], the project decided to use a modified version (exiting with 1.3 MeV/u) of SNRC 4-rod RFQ (the 4-vane RFQ being optional). A first pole geometry (v1) has been established and implemented in the TraceWIN package code [3]. The calculated beam losses with errors are higher than those observed with the 4-vane RFQ, reaching those specified by the Top-Level Requirements by activation considerations (below 1 nA/m above 20 MeV) (TLR level = 1 on vertical on Fig. 3). A new pole design is in progress to reduce the losses in the linac (mainly due to particle exiting the RFQ in the longitudinal tails).

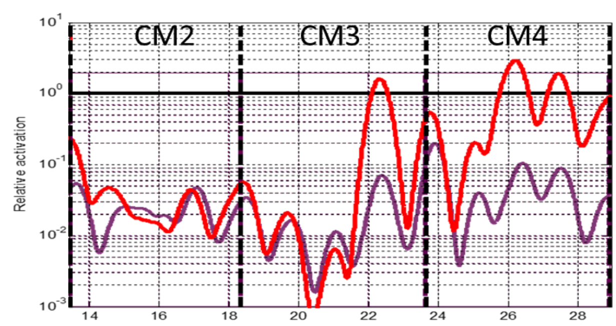

Figure 3 : Beam losses in the three last cryomodules (CM). Purple: with 4-vane RFQ; Red: with 4-rod v1 RFQ.

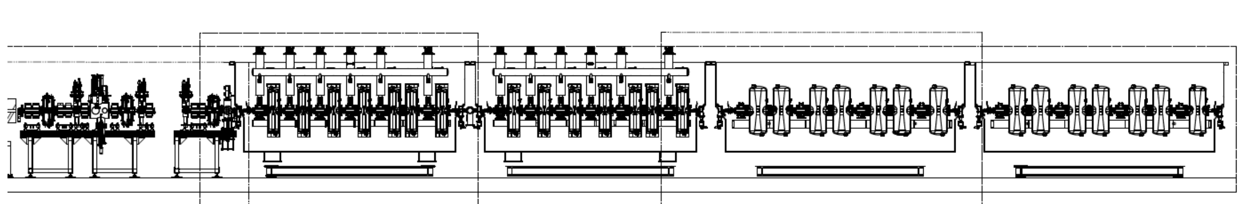

Figure 2: SARAF-LINAC layout.

The vacuum system in the Medium Energy Beam Transfer line (MEBT) has been calculated to grant < 10^{-6} mbar along the line and to go down to almost 10^{-8} mbar right at the entrance of the first cryomodule. The SuperConducting Linac (SCL) is pumped to reach <10^{-6} mbar before cooling down. Calculations have been performed to optimize the number of turbo-molecular pumps needed along the MEBT and SCL (see results for MEBT on Figure 4) : 5 turbo-pumps are used for the MEBT (one/rebuncher and one/diagbox) and 8 for the SCL (one/CM and one/warm section). 4 more turbopumps are used for the insulation vacuum in the CM.

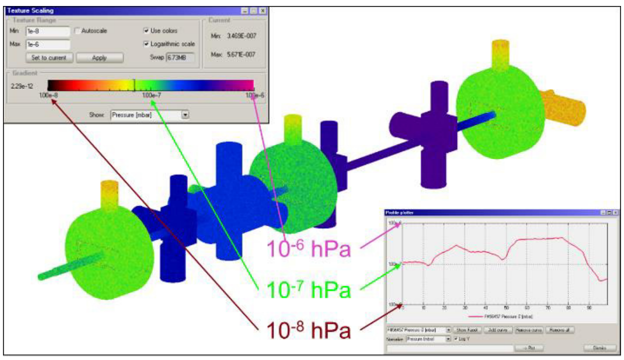

Figure 4: Nitrogen gas pressure diagram in the MEBT.

The exhaustive list of diagnostics which could be used on SARAF with minimum development has been established (mostly adapted from SPIRAL2 [4]). Beam current monitors will be placed at MEBT extremities and SCL end. BPM will be placed in some MEBT quadrupoles and upstream each superconductig (SC) magnets. 2 diagnostic boxes are planned in the MEBT and 4 along the superconducting linac, distributed downstream each cryomodule. The diagnostics detailed requirements will have been produced by the detailed beam dynamics study this summer and their Preliminary Design Review is foreseen in December 2016.

MAJOR COMPONENT PROTOTYPING

During the detailed design phase, we planned to build prototypes for elements exhibiting the highest technological risks (major components):

- the MEBT 176 MHz rebuncher (first of series),
- the low- and high-beta SC HWR cavities,
- the cold RF couplers,
- the SC magnets.

The Critical Design Reviews (CDR) of these elements took place at Saclay on June 2016. A status on the cryomodule design was also presented.

The MEBT Rebuncher

The MEBT contains 3 rebunchers operating at 176 MHz. After comparison between different types of possible geometries, we decided to adopt a split spoke geometry presented on Fig. 5.

Beam dynamics requires to operate the rebunchers to a maximum effective voltage of 105 kV in nominal operation (cw or pulsed), and longitudinal emittance measurement could lead to operate one rebuncher at 160 kV, but only in pulsed mode. The rebuncher has been specified for 120 kV cw operation. A 30% margin on surface resistance and 20% on thermal conductance have been used to design its cooling mode. The maximal temperature is kept below 90 °C. A dedicated paper is providing more design details [5].

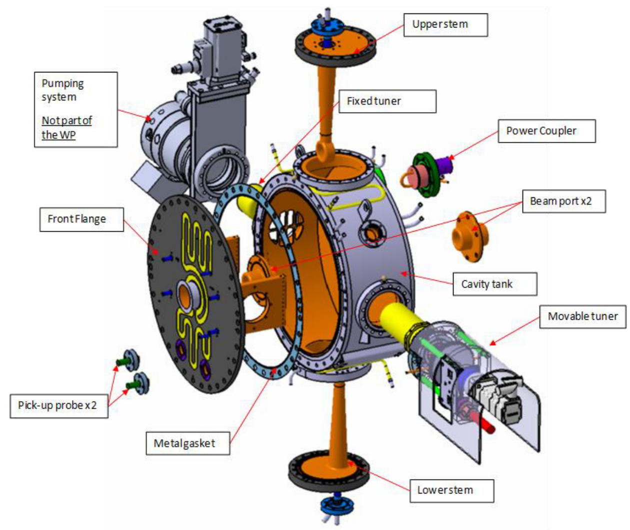

Figure 5: Rebuncher split spoke geometry.

The SC HWR Cavities and RF Coupler

12 low-beta (0.091) and 14 high-beta (0.181) HWR cavities will be used in 4 cryomodules. Their maximal accelerating fields are respectively 6.5 MV/m and 7.5 MV/m. Their designs, including the coupler and tuner are now completed (Fig. 6). The maximal power delivered by the RF couplers to the beam are respectively 4.8 kW and 11.4 kW. Two dedicated papers are providing their details [6][7].

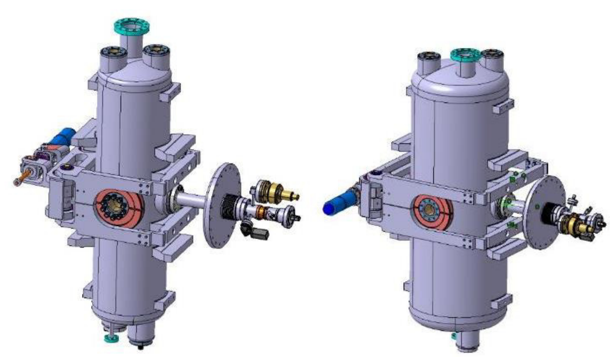

Figure 6: low-beta (left) and high-beta (right) fully equipped cavities.

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The SC Magnet

The SC magnet design is completed. A 3D view is plotted on Fig. 7. Beam dynamics required operation at 2.9 T.m^2 and the magnet is designed to work at 3.5 T.m^2. The fringe field on neighbour SC cavity is kept below 20 mT thanks to the fringe field compensation solenoids. The steering coils designed to operate up to 8 mT.m are placed between the compensation solenoids. The components can be completely disassembled if necessary.

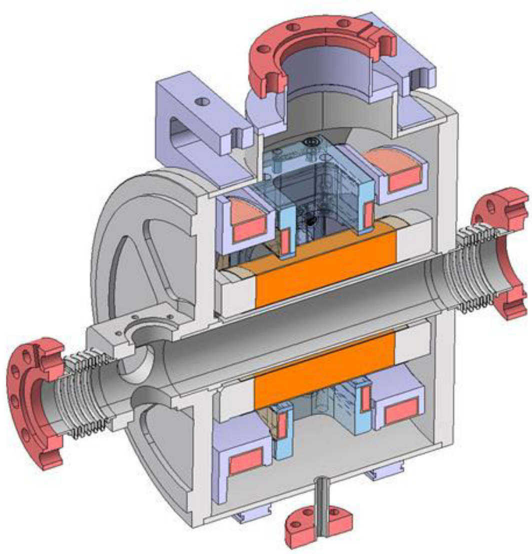

Figure 7: SC magnet 3D view.

The Cryomodules

The cryomodule CDR is planned at the end of 2017. However, its internal interfaces with the major elements are now set. The Titanium frame supporting the cavity and solenoid is placed above the beam line in order to facilitate the assembly of the cryomodule (in yellow on Fig. 8). Indeed, the cavity and solenoid string will be assembled with specific tools inside the clean room, and then integrated to the support frame outside the clean room.

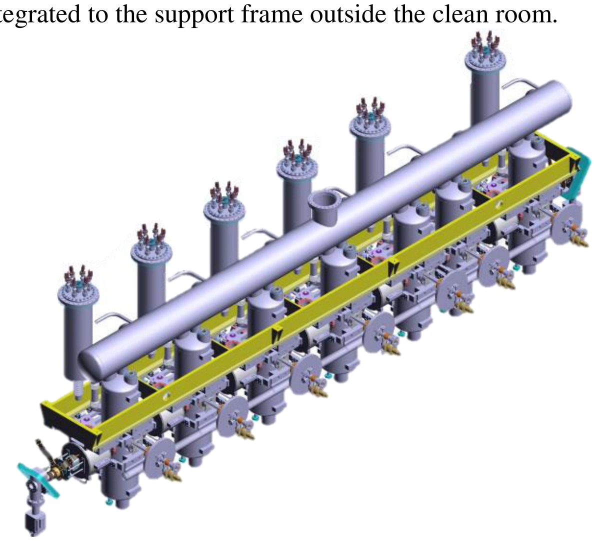

Figure 8: 3D view of the cavity and solenoid string in low beta cryomodule.

Mechanical simulations of the top plate were performed in order to estimate the deformation and to optimize the position, type and number of strengthening bars. These simulations were performed with a simplified model of the top plate with the finite element software Cast3M as shown on Fig. 9.

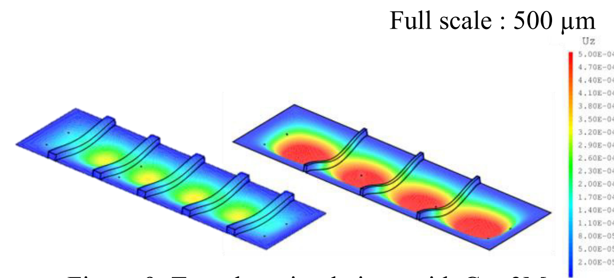

Figure 9: Top plate simulations with Cast3M.

CONCLUSION

The SARAF-LINAC project has just completed the first part of the detailed design phase leading to the CDR of its major components. In the second part of this phase (leading to end of 2017), the major component prototypes will be constructed and tested, and the cryomodule design completed.

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