

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, R. Ferdinand, J-M. Lagniel, J-F Leyge, M. Michel
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 March 2016 of the SARAF-LINAC Project.

INTRODUCTION

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

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

The < 8 year project can be simplified in 3 overlapping phases (Fig. 1):

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

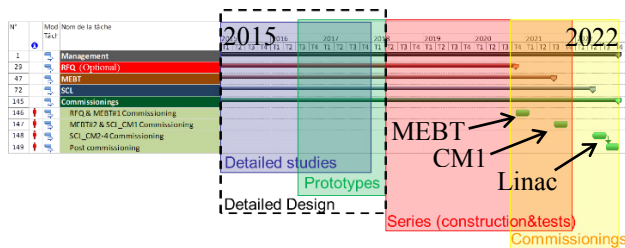


Figure 1: SARAF-LINAC major schedule.

During the first years, two Preliminary Design Reviews took place at Saclay:

- October 2015: for major components with prototypes.

- January 2016: for system.

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 [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 (Fig. 3) are higher than these observed with the 4-vane RFQ, reaching those specified by the Top-Level Requirements (TLR: below 1 nA/m above 20 MeV). 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).

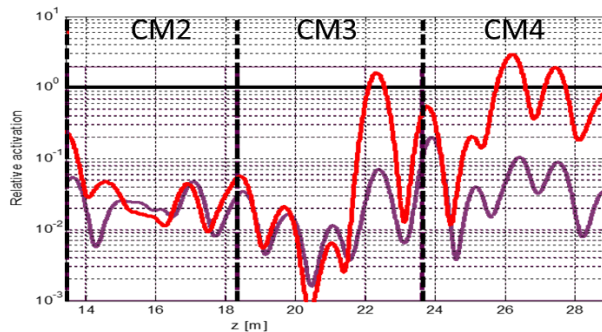


Figure 3: Beam losses relative to allowed by TLR (set by activation considerations) in the three last cryomodules (CM). Purple: with 4-vane RFQ; Red: with 4-rod v1 RFQ.

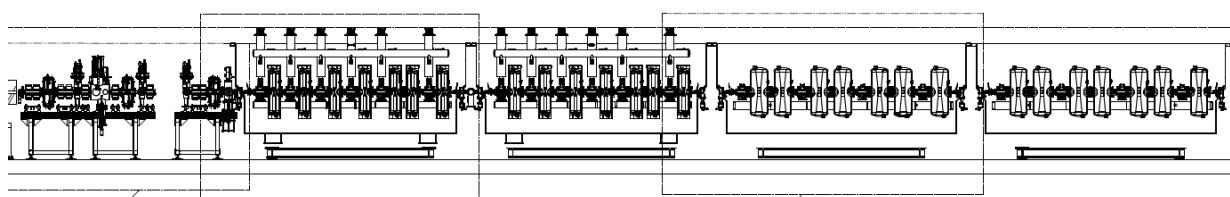


Figure 2: SARAF-LINAC layout.

The vacuum system and associated performances have been estimated using 5 turbo-pumps in the MEBT and 8 in the SCL (calculation result in MEBT are given on Fig. 4).

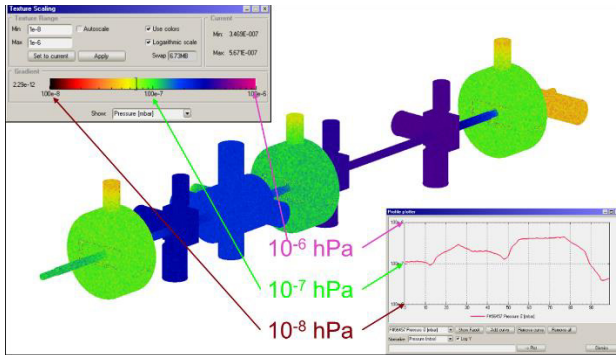


Figure 4: Nitrogen gas pressure in the MEBT.

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 SC solenoid. 2 diagnostics boxes are planned in MEBT and 4 along the superconducting linac distributed downstream each cryomodules. The diagnostics detailed requirements will be produced by beam dynamics this summer and their Preliminary Design Review is foreseen for the end of 2016.

MAJOR ELEMENTS

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 Preliminary Design Reviews (PDR) of these elements took place at Saclay on October 2015. A status on the cryomodule design was also presented. The Critical Design Reviews (CDR) of these major elements are planned in June 2016.

The MEBT Rebuncher

The Medium Energy Beam Transport line (MEBT) contains 3 rebunchers operating at 176 MHz. After comparisons between different types of possible geometries, we decided to adopt a split spoke geometry presented on Fig. 5.

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

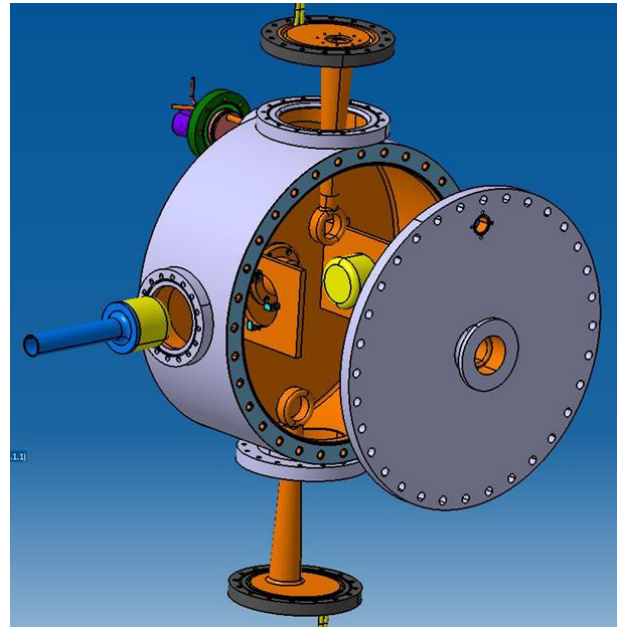


Figure 5: Rebuncher split spoke geometry.

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 are now completed (Fig. 6). The maximal power delivered by the RF couplers to the beam are 4.8 kW and 11.4 kW. A dedicated paper exhibits their details [5].

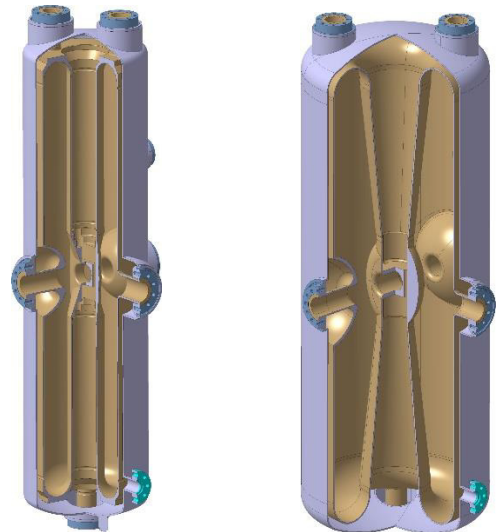


Figure 6: Low-beta (left) and high-beta (right) HR cavities.

The SC Magnet

The SC magnet design is almost completed. A 3D view is plotted on Fig. 7. Beam dynamics required operation at 2.9 T.m² and the magnet is designed to work at 3.5 T.m². The fringe field on cavity is kept below 20 mT. The

steering coils designed to operate up to 8 mT.m are now placed between the fringe field compensation solenoids. The component can be completely disassembled if necessary.

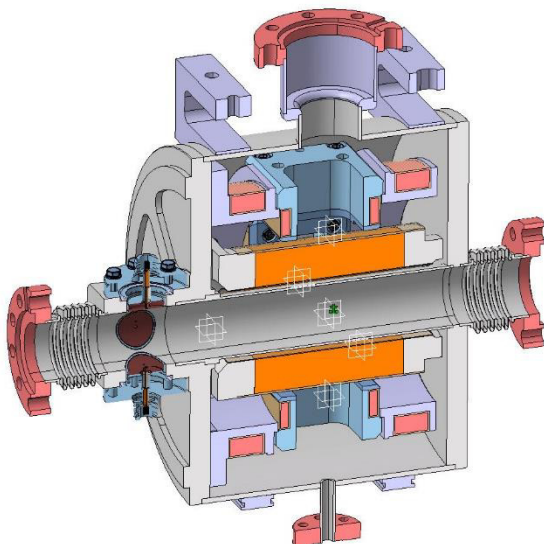


Figure 7: SC magnet 3D view.

positions, types and numbers of strengthening bars. These simulations were accomplished with a simplified model of the top plate with the finite-element software Cast3M as shown on Fig. 9.

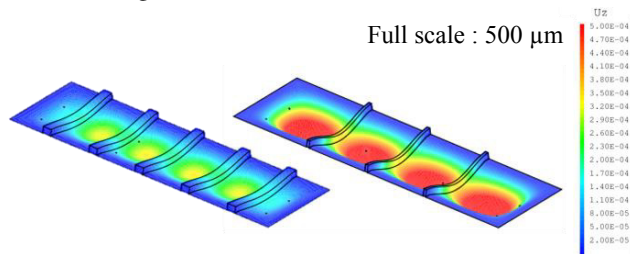


Figure 9: Top plate simulations with Cast3M.

CONCLUSION

The SARAF-LINAC project is close to finish the first part of the detailed design phase leading to CDR of the prototypes of major elements. In the second part of this phase (leading to end of 2017), the major element prototypes will be constructed and tested and the cryomodule design will be completed.

REFERENCES

- [1] N. Pichoff et al., “The SARAF-LINAC Project for SARAF-Phase 2”, THPF005, IPAC’15, Richmond, VA, USA (2015).
- [2] N. Pichoff et al., “The SARAF-LINAC beam dynamics”, MOPWA007, IPAC’15, Richmond, VA, USA (2015).
- [3] D. Uriot et al., “Status of TraceWIN code”, MOPWA008, IPAC’15, Richmond, VA, USA (2015).
- [4] P. Bertrand, R. Ferdinand, “SPIRAL2 accelerator construction progress”, LINAC’12, Tel-Aviv, Israel (2012).
- [5] G. Ferrand et al., “Design of the HWR cavities for SARAF”, this conference (WEPMB003), IPAC’16, Busan, Korea (2016).

The Cryomodules

The cryomodule CDR is planned at end of 2017. However, its design, especially its setting interfaces with the major elements has to be ready for June 2016. Titanium frame supporting the cavities strain is placed over the beam line in order to facilitate the assembly of the cryomodule (in yellow on Fig. 8). Indeed, the cavities strain will be assembled with specific tools inside the clean room, and then integrated to the support frame outside the clean room.

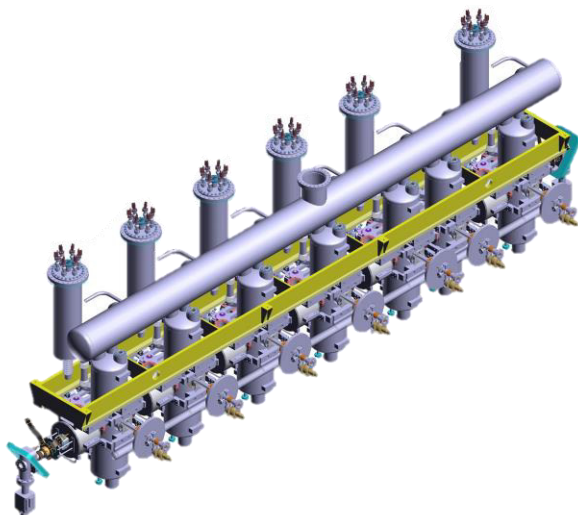


Figure 8: 3D view of the cavity strain in low beta cryomodule.

Mechanical simulations of the top plate were performed in order to estimate the deformations and to optimize the