

EXPERIENCE ON FABRICATION AND ASSEMBLY OF THE FIRST CLIC TWO-BEAM MODULE PROTOTYPE

D. Gudkov, A. Samochkine, JINR, Dubna, Russia
 G. Riddone, F. Rossi, CERN, Geneva, Switzerland
 S. Lebet, INEO, St-Genis, France

Abstract

The CLIC two-beam module prototypes are intended to prove the design of all technical systems under the different operation modes. Two validation programs are currently under way and they foresee the construction of four prototype modules for mechanical tests without beam and three prototype modules for tests with RF and beam. The program without beam will show the capability of the technical solutions proposed to fulfil the stringent requirements on radio-frequency, supporting, pre-alignment, stabilization, vacuum and cooling systems. The engineering design was performed with the use of CAD/CAE software. Dedicated mock-ups of RF structures, with all mechanical interfaces and chosen technical solutions, are used for the tests and therefore reliable results are expected. The components were fabricated by applying different technologies and methods for manufacturing and joining. The first full-size prototype module was assembled in 2012. This paper is focused on the production process including the comparison of several technical solutions adopted during the realization. The module assembly procedure and quality control measurements are also recalled.

INTRODUCTION

The first two-beam module [1] prototype type 0 has been built for a test program to be conducted without RF and beam in a dedicated laboratory. The aim of this first prototype is to show the feasibility of the proposed solutions for the different technical systems, such as RF, supporting, pre-alignment, vacuum and cooling systems. To simplify the production and to avoid overlapping with other test programs, real components were replaced by mock-ups whenever possible. The 3D view of the prototype module type 0 is shown in Fig. 1.

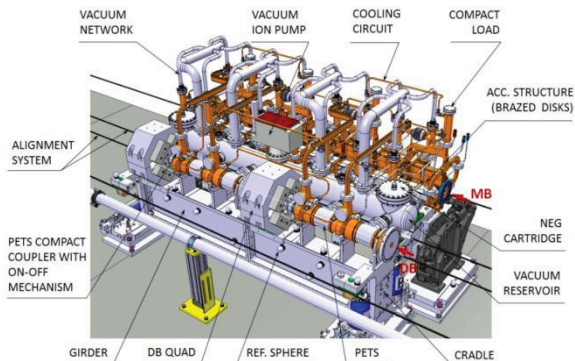


Figure 1: Prototype module type 0.

SUPPORTING AND ALIGNMENT SYSTEM

All the RF components of the CLIC Two-Beam Modules (TBM) are installed and aligned on an innovative supporting and alignment systems. The supporting system is constituted of several components (girders, V-shaped supports, cradles, U-clamps, etc.) to fulfil the technical requirements for support and stabilization of the RF components. The alignment and repositioning system is constituted of actuators, alignment plates, capacitive Wire Positioning Sensor (cWPS), optical Wire Positioning Sensor (oWPS) and a Hydraulic Levelling System (HLS) network.

Girders

The girder design constraints are mainly dictated by the beam physics and RF requirements. The position of the girders is monitored and re-aligned.

For the TBM in the laboratory, several manufacturing techniques and strategies [2, 3] have been explored. It had been decided to proceed with girders made of silicon carbide (SiC).

For the Main Beam (MB) girders an integrated approach has been adopted, comprising both, supporting and positioning systems. The girders are made of hollow tubes glued together to form the entire structure.

For the Drive Beam (DB) girders, the positioning system was supplied separately. The girders are made of two sections brazed together.

V-shaped Supports

The V-shaped supports provide the interface between the RF components and the supporting system underneath. Consequently, they have to be fixed and well-positioned on the top side of the girder. The V-shaped supports for the DB were brazed on the girder. The MB V-shaped supports were glued and screwed. As for material, all V-shaped supports of the prototype module type 0 are made of SiC. The girders equipped with V-shaped supports and cradles are shown in Fig. 2.

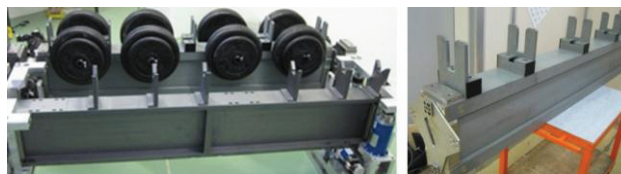


Figure 2: Girders equipped with V-shaped supports and cradles.

Cradles, Actuators and Alignment Sensors

The girder itself is supported on its extremities by the so-called cradles, which are mechanically connected to the actuators and house the alignment sensors (see Fig. 3). The surfaces at the interfaces between cradles and girders are machined with micrometric precision.

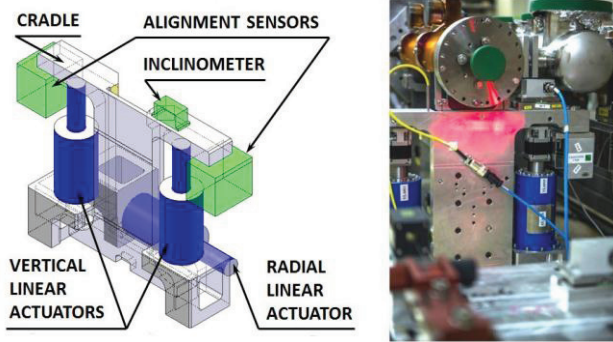


Figure 3: Cradle assembly.

The cradles are also equipped with an inclinometer. Thus each cradle hosts the following instrumentation:

- 1 inclinometer;
- 1 cWPS;
- 1 oWPS.

The combination of measurements of these sensors provides the accurate positioning of the beam axis. Therefore, the alignment of the machine and its successful operation are guaranteed.

RF STRUCTURES AND NETWORK

The first prototype module type 0 is equipped with mock-ups for RF components and RF structures. Their main features are listed below:

- Simplified internal RF geometry;
- Real mechanical interfaces to verify the manufacturing and assembly procedures;
- Real reference surfaces for positioning and alignment, therefore the same accuracy;
- For the reliable test of the vacuum system, the surface area of the internal volume matches with the surface area of the RF volume of the real structures;
- Reduced cost of the components, while keeping the necessary functionality for the tests.

Accelerating Structures

For the first prototype module type 0, a 2-meter long accelerating structure (AS) mock-up is used. The assembly of the AS mock-up consists of several brazing, electron beam welding (EBW) and tungsten inert gas (TIG) welding operations (see Fig. 4). All the parts of the mock-up were machined within the required tolerance of 10 μm. The first structure was successfully assembled and installed on the MB girder.



Figure 4: Accelerating structure mock-up after the last assembly operation (EBW).

Power Extraction and Transfer Structure (PETS)

The assembly procedure is very similar to the one for real PETS. It consists of brazing, EBW and TIG welding operations (see Fig. 5). In order to reduce the price of the mock-up, the high-precision octants were replaced by a copper block with holes and slots simulating the same internal volume and surface area for the vacuum tests.

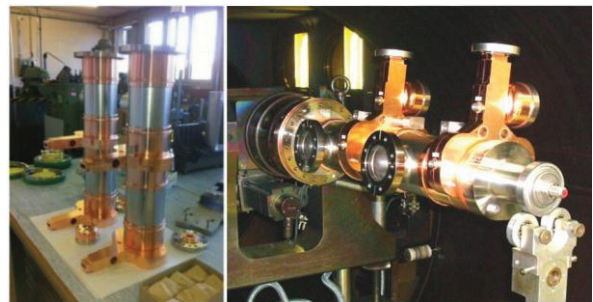


Figure 5: PETS pre-assembly; EBW of PETS couplers.

RF Network

The RF network mock-up connects PETS to AS (see Fig. 6). The internal geometry of the choke mode flange (CMF), hybrid and splitter was simplified to reduce the component cost. The main mock-up features are listed below:

- Bended waveguide WR90, with relaxed tolerances.
- Real cooling system for the waveguides.
- RF flanges for the RF interfaces.

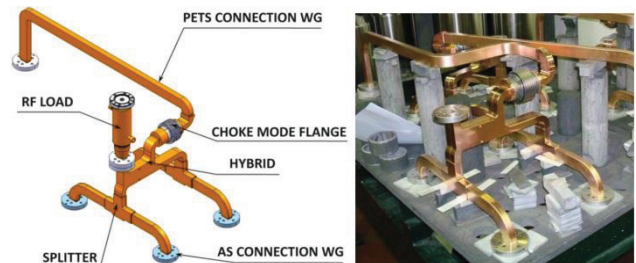


Figure 6: RF-network 3D view; RF-network assembly.

Assembly of the RF network mock-up consists of brazing, intermediate machining and welding operations.

Copyright © 2013 by IACoW — cc Creative Commons Attribution 3.0 (CC-BY-3.0)

VACUUM SYSTEM

The vacuum system consists of central vacuum tank, located between main beam and drive beam, and four vacuum network subassemblies connecting the central vacuum tank to the accelerating structure loads. One ion pump and two Non-Evaporable Getter (NEG) cartridges are installed on this central tank to provide the required vacuum level of 10^{-9} mbar.

The vacuum chambers inside the DB quadrupoles are also part of the vacuum system.

DRIVE BEAM QUADRUPOLE (DBQ) AND INSTRUMENTATION SYSTEM

For the first prototype module type 0, it was decided to replace the real quadrupoles by dedicated mock-ups. These mock-ups have the same interfaces and weight as the real ones. The 3D model and mock-up are shown in Fig. 7. The Beam Positioning Monitor (BPM) mock-ups mechanically connected to PETS on one side and to the DBQ vacuum chamber on the other side were designed with the same external volume as the real ones.

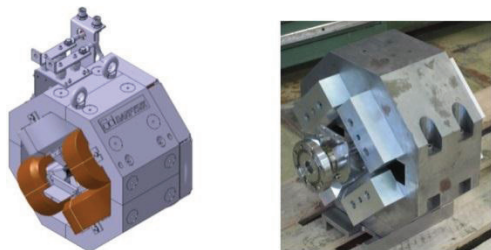


Figure 7: DB Quadrupole. 3D model and mock-up.

COOLING SYSTEM

Each prototype module component has a cooling system [4] equipped with standard Swagelok fittings connected via copper tubes according to the agreed layout (see Fig. 8). The cooling system is able to extract about 8 kW of dissipated power per module.

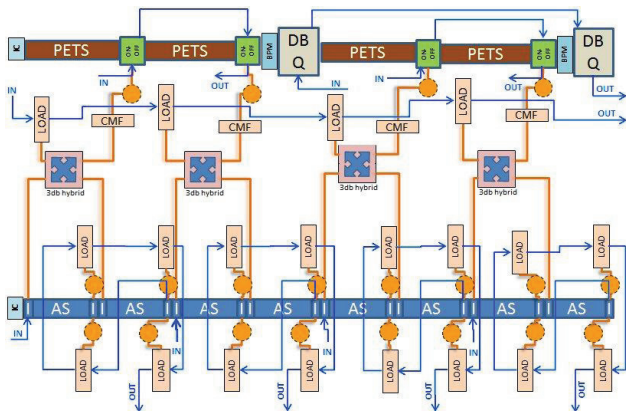


Figure 8: Schematic cooling layout. Module type 0.

ASSEMBLY OF THE MODULE

The assembly of the prototype module type 0 (see Fig. 9) started with installation of the supporting and alignment system on the floor. Several positioning tests were done throughout the different installation phases [2, 3]. Actuators and girders have been successfully qualified. After installing the AS and PETS on the respective girder V-shaped supports, the vacuum system and RF network were connected to them. The last operation was the installation of the cooling system.

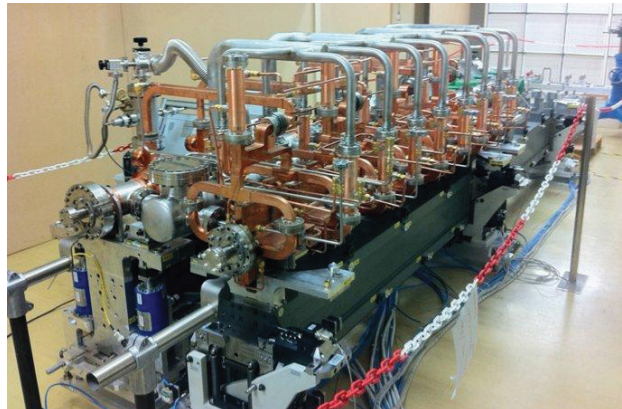


Figure 9: Assembled prototype module type 0.

ACKNOWLEDGMENT

The results presented in this paper are the outcome of a research funded by the European Commission under the FP7 Research Infrastructures project EuCARD, grant agreement no. 227579. Authors sincerely thank all members of the "CLIC Module Working Group" for their valuable contribution.

REFERENCES

- [1] S. Steinar et al., CLIC Conceptual Design Report (CDR), Vol. 1, <https://edms.cern.ch/document/1234244/>
- [2] Gazis, N., et al. Study of the supporting system for the CLIC Two-Beam Module CERN-OPEN-2010-023. CLIC-Note-857 (CERN, Geneva, 2010). <http://cdsweb.cern.ch/record/1308174/files/CERN-OPEN-2010-023.pdf>
- [3] Gazis, N., et al, Study and application of micrometric alignment on the prototype girders of the CLIC Two-Beam Module, CERN-OPEN-2011-020 ; CLIC-Note-878 (CERN, Geneva, 2011). <http://cds.cern.ch/record/1351798/files/CERN-OPEN-2011-020.pdf>
- [4] Riddone, G., Schulte, D., Syratcev, I. & et al. in Proc. 11th European Particle Accelerator Conf., 23-27 June 2008, Genoa, Italy (2008), 607-609. <http://accelconf.web.cern.ch/accelconf/e08/papers/mopp028.pdf>