Five Questions with

Dr. Joel Sauza Bedolla

RF structure manufacturing: Ultra-precision work

The present and future accelerator projects such as HL-LHC [1], CLIC [2], and ILC [3] require state-of-the-art equipment to achieve their performance goals. An example of this, the CLIC Radio Frequency (RF) structures, have an error tolerance of 1μm, which is about 100 times smaller the human hair's width. Therefore, **ultra-precision** techniques are mandatory to build those components.

Could you introduce yourself?

My name is Joel Sauza Bedolla, from Morelia, Michoacan, and I am not related to the Tequila brand. I got my B.Sc. in Industrial Engineering and M.Sc. in Mechanical Engineering, both at the Instituto Tecnologico de Morelia (now Tecnologico Nacional). In 2009, I moved to Italy and one year later I started my Ph.D. in Production Systems and Industrial Design at Politecnico di Torino. After successfully completed the Ph.D., I continued to work as a posdoc in the automotive engineering field. Since 2017, I have been working on accelerating structures.

Figure 1. Dr. Joel Sauza holding a CLIC disc.

Could you tell me about your institute and research topic?

I am working as a postdoctoral researcher for Lancaster University (UK), but my work is strongly related to CERN (Switzerland) and the STFC (UK) laboratories. Now, I am participating in one project regarding normal conducting accelerating structures and one in superconducting RF (SRF).

For the former, I have worked in the mechanical design, fabrication, and assembly of **ultra-precise** accelerating structures and components for the Compact Linear Collider (CLIC) project [2]. Lancaster University is developing **ultra-precise** technology in the UK towards the UK X-Ray Free Electron Laser [4]. We are looking for industrial partners to transfer the technology and best practices to produce accelerating cavities in the country.

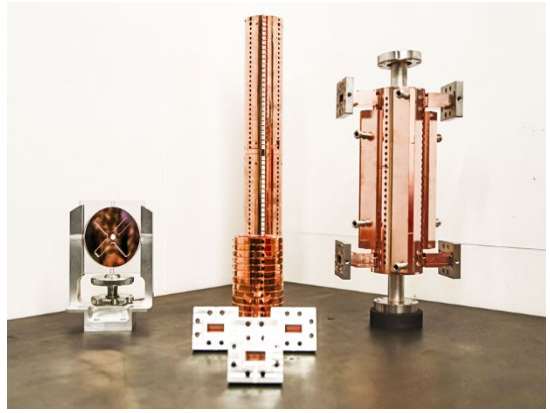

Figure 2. From left to right and bottom to top: a CLIC disc, waveguides, partial disc stack, full disc stack and full X-Band accelerating structure.

For the latter, I am responsible for the fabrication of the Outer Vacuum Chamber (OVC) that is part of the CRAB cavities cryomodule for the HL-LHC project [1]. The OVC is going to be assembled later in STFC/Daresbury and finally installed in the SPS at CERN for testing. In my day-to-day activity, I am interacting with the suppliers, CERN (for the acceptance of the parts), and STFC (to coordinate the delivery and assembly sequence).

How or why did you choose that topic?

After working for five years in the university, on a completely different topic, I was looking for a new challenge. I applied for a fellowship at CERN and was selected for the CLIC project. So, I did not choose, I was chosen. I am very glad that it went that way. The CLIC disc is one of the most precise mechanical components in the world: it has dimensional tolerances of ± 1 μm, form tolerances of 4 μm, and Ra 0.025. To achieve these tolerances, the Oxygen Free Electronic copper disc requires **ultra-precision** diamond machining. The assembly is done by diffusion bonding and vacuum brazing. All these manufacturing processes are cutting-edge technologies.

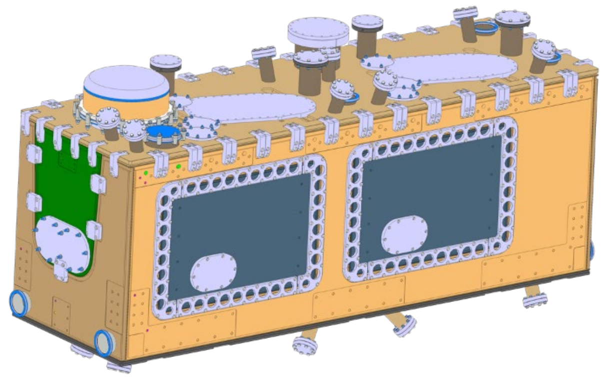

Figure 3. OVC 3D model in leak test configuration

The passage to SRF technology came with my new appointment at Lancaster University, that involves both normal and SRF technologies. The OVC requires traditional machining and TIG welding. The material (stainless steel) and dimensions are completely different (2.5 m x 1 m x 1 m) concerning CLIC. However, the fabrication is also challenging. This is a tank that operates in an ultra-high vacuum (1.0E-07 mbar) at cryogenic temperatures (2-80 °K). This means that the production has to be fully traced (down to the material level) and that the whole enclosure has to be leak-tight.

Right now, what is the biggest challenge of your work?

Regarding the normal conducting project, CERN has only four certified companies for **ultra-precision** machining and only three for the assembly. During my time at CERN, I contacted more than 30 high tech companies, and until today none of them has been able to produce one good disc or to complete a successful assembly. The risk of not finding a suitable company is big. However, this time I will be allowed to work closer to the companies.

Figure 4. CLIC disc.

In 2017, one CRAB cavity prototype has been fabricated at CERN and installed in the SPS for testing. The prototype that I am fabricating is a different design from the one made at CERN. While fabricating the parts for the first time you go into the small details of the drawings, the technical specifications, international standards, and assembly sequences. All this, with the time ticking to deliver the components on time. Every day is a test! Unavoidably, we identify errors, or we encounter problems. The important is not to panic and to find the best solution. Once this prototype will be finished, we need to produce four more cryomodules. They are slightly different from the prototype and again is like building a completely different product.

What do you think the future of you research area will be?

After the European Particle Physics Strategy, the future for the CLIC project is not very promising, since CERN has decided to move forward with the Future Circular Collider (FCC) [5]. Nevertheless, normal conducting technology is more and more used in medical linacs, cargo scanning, and by other laboratories developing linacs (e.g. FEL). The technology is mature enough, but there are many opportunities for improvement. The accelerating structures can still be made cheaper and more robust.

On the other hand, the future of SRF technology is shiny blue. Most probably, the ILC [3] in Japan will receive the green light. The already cited FCC is moving ahead with the feasibility study. Both projects still have to demonstrate technological aspects: the reproducibility of the cavities for the ILC and the 16 T magnets for the FCC. This means that fabrication and testing of prototypes will be needed.

References

[1] CERN, https://hilumilhc.web.cern.ch/

[2] CERN, https://clic.cern/.

[3] ILC, https://linearcollider.org/

[4] Science and Technology Facilities Council, "UK XFEL science case," UK Research and Innovation, 2020.

[5] CERN, https://fcc.web.cern.ch/Pages/default.aspx.