FIVE QUESTIONS WITH DR. ALEJANDRO CASTILLA

Superconducting RF technology: High acceleration efficiency

Superconducting Radio Frequency (SRF) technology is becoming a mainstream implementation for particle accelerators around the world. The **SRF** cavities are made of superconducting material (whose electrical resistivity drops to a very low values at a given temperature) to operate with high quality factor (or Q, which represents the number of oscillations that a cavity takes to dissipate its stored energy) and accelerating gradient (or Eacc, which proportional to energy gain of the particles), consequently, **SRF** cavities are able to accelerate the beam with high efficiency [1].

Could you introduce yourself?

My name is *Alejandro Castilla*, I am a Mexican physicist working on topics related to the technology of particle accelerators.

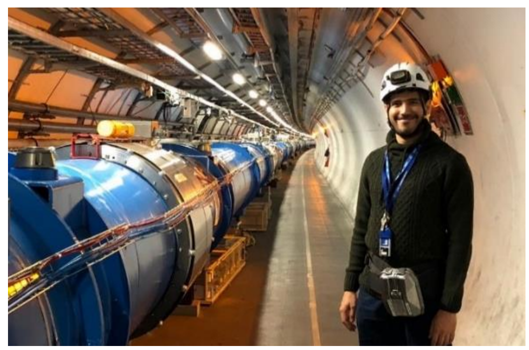

Figure 1. Dr. Alejandro Castilla.

Could you tell me about your institute and research topic?

I am a postdoctoral research assistant for the engineering department of Lancaster University in the United Kingdom. However, I develop my work at the European Organization of Nuclear Research (CERN) [2] in Switzerland, as an associate researcher collaborator in the Radiofrequency (RF) group of the Beams (BE) department, where I work in different projects that can be divided in two main technologies:

- The first one is **SRF** technology, where we work with RF structures made of materials like Niobium (Nb). This element transitions to a superconductor state, this means it has virtually zero electric resistance, when cooled down at very low temperatures (below 9.3 Kelvin or -263.8 Celsius) using liquid Helium. Obtaining low surface resistances, **SRF** cavities can sustain high electromagnetic fields in their interior, we then can use these fields to accelerate or deflect the beams of charged particles in our accelerators. Part of my research with these devices is focused in finding cleaver designs that allow us to construct, prepare, and operate **SRF** structures in our machines.

Manufacturing these structures involve many steps and complex methodologies, where the cleanliness and precision of every step affects the end result and final performance of the device. In my day to day, I get to work with many specialists from: machinists, material scientists, mechanical engineers, vacuum and cryogenics technicians, etc. and there is not a single day when I do not get to learn something new and interesting from my colleagues.

- For the second technology, we use high purity oxygen free Copper, to build up RF structures, whose rapidly oscillating electromagnetic fields, change polarity several tens of billion times per second, that is to say ~12,000,000,000 cycles per second (~12 GHz). These high frequency fields carry an incredible amount of energy, sustaining potentials up to 100 MV (100,000,000 Volts), that, when properly synchronized to the moving beam, will accelerate electrons for future colliders and compact light sources. Other applications of these type of devices include, but are not limited to: cancer radiation therapy systems, cargo scanning, etc.

How or why did you choose that topic?

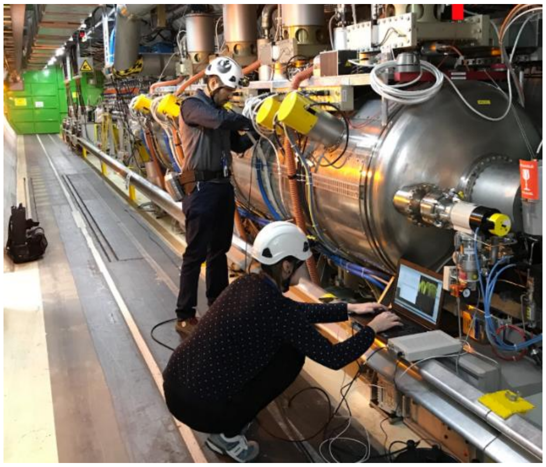

Figure 2. Dr. Castilla and M.S. K Turaj (CERN/BE-RF-SRF) making RF tests in the LHC tunnel. Courtesy of Daniel Valuch, CERN.

I got interested in accelerator physics as I was working on my Master's degree with Dr Mauro Napsuciale in the University of Guanajuato in Mexico. At that time, I developed my thesis work on "Inverse Compton Scattering" in which after some basic calculations of the kinematic regime, we proposed a table top experiment to prove that one could shift photons from a laser to higher energies, using an energetic beam of electrons. Light sources that work under this principle are known as "Compton Sources". After my master, I was lucky enough to go to Jefferson National Accelerator Facility (JLab) in Virginia, to do my PhD research. At the beginning I was meant to work on a project for a Compton Source, but at the same time, I was exposed to many other aspects of accelerator physics, including radiofrequency, and more specifically **SRF** technology, since JLab was, and still is, one of the world's leading research centers for **SRF** technology for particle accelerators. Therefore, there I started working on the topic that I have been developing for close to 10 years now.

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

The biggest challenge in my discipline, is to make these devices more and more efficient and robust. Cheaper manufacturing and operation would mean compact or mobile machines that need smaller buildings or can be brought to challenging areas to perform medical treatments, for example. More reliable operation and less maintenance needed on these machines would allow remote places to be able to operate devices that could benefit directly the society. All these things can be achieved with better understanding of the physical principles associated with these systems, but also with new materials like high temperature superconductors, and cheaper and more efficient manufacturing processes. Thus, there is plenty of room for research and development.

What did you think that will be the future of you research area?

There are many exciting new and missing topics to develop in this area. For instance: wake field plasma acceleration, where one uses a charged particle beam to excite wake fields in a plasma, similar to the wakes left on the water after a jet ski or fast boat passes by, then one can use the energy left in those strong wakes to accelerate other charged particles of a secondary beam. Currently, the stability of these plasmas is a big issue, due to the fact that plasmas are complex dynamic systems and we are just learning to control them to the required level to have practical systems following this principle. Laser acceleration in dielectrics is another very interesting hot topic, even when at the moment it is not fully developed to a practical stage, if we manage to make it work, it will change the nature of our particle accelerators completely. Long story short, I believe that there is plenty of room for radiofrequency to evolve into better and cheaper devices, but also for its competitors if we are able to find alternatives to imprint energy to charged beams are equally exciting and I look forward to see when we can make these future machines a reality.

References

[1] H. Padamsee, et al., *RF Superconductivity for Accelerators*, John Wiley & Sons, 2008.

[2] CERN main page https://home.cern/

[3] JLab main page https://www.jlab.org/