FIVE QUESTIONS WITH

DR. MAMAD ESHRAQI

Spallation Neutron Source: high-intensity accelerator frontier

Spallation neutron sources require a high-power proton beam to produce neutrons by impacting a target. The produced neutrons are used in several fields, such as engineering, medicine, biology chemistry, among others. There are several spallation sources operating around the world [1,2,3], and others will start operation in the near future. That is the case of the European Spallation Source (**ESS**) [4], which will start user operation in 2023.

Could you introduce yourself?

Figure 1: **Dr. Mamad Esharqi**.

I am Mamad Eshraqi, born and raised in the northern edge of the Great Salt Desert, in the city of Sabzevar, Iran. I did my bachelor's and master's degree in physics at Shiraz University, you probably have heard of Shiraz Wine or Persepolis. Later I moved to IPM, Institute for studies in theoretical physics and mathematics [5], in Tehran, Iran to do a Ph.D. in accelerator physics. As part of my Ph.D. studies, I joined the JUAS, Joint Universities Accelerator School, in France. After JUAS I moved to CERN to work on my Ph.D. thesis and worked on emittance increase in linear accelerators, and linac design. In 2009 I finished my thesis, got married, and started a Postdoc with Lund University/**ESS**, Sweden, to work on the design, optimization, simulations, and commissioning of the **ESS** linear accelerator.

Could you tell me about your institute and research topic?

ESS will be the brightest neutron source on the planet when in full operation. The aim is to produce pulsed high brightness neutron beams which will be used in studies of life science, soft matter, energy and superconductivity, engineering, biology, semiconductors, archeology, etc. By having a higher flux and brightness of neutrons, we will be able to deepen our understanding of such materials, how they function, and how we can improve them. To produce such a high flux of neutrons we need a high-power accelerator, which can provide a high intensity of protons at high energy to a dedicated target. The acceleration and transport of protons should be done efficiently, this requires optimization of the linac design, selecting the correct type of cavities and at right vector fields. As we are accelerating a high intensity beam of protons, the Coulomb repulsive forces, called space-charge, could cause major losses if not considered properly for a beam of protons composed of bunches of 1E9 protons which come in pulses of 1E6 bunches, 14 times a second. Bringing these many protons to 2 GeV with losses that do not cause activation of the components, is a pleasant challenge that has kept me busy for the last 12 years.

Figure 2. Artist illustration of the ESS. Credit to ESS [3].

How or why did you choose that topic?

Where I am today, valid for every single person, is a good example of the butterfly effect. I can't pinpoint a single event in my life that lead me to where I am today, maybe it was my older brother who was good with electronics that made me curious, maybe it was my teacher in 4th grade or my math teacher in 6th grade who encouraged me in my math, or maybe the physics teacher in my 9th grade who was a very enthusiastic physicist, unknowingly made me interested to choose physics as my field of studies in university. When I started with physics, like all other physicists, it was very easy to fall more in love with it and somewhere in the middle of my bachelor I developed an interest in particle accelerators, but with no possibility to pursue the field of particle accelerators at that time in my home country. A fun fact; during my first year of bachelor studies there was an announcement on the news board, about doing Physics in Mexico; which I eagerly read through to join; one of the conditions was knowing Spanish which I didn't, otherwise, the whole story would have been different, maybe I would have been a classmate of yours! In 2005, while I was doing a Ph.D. in nuclear physics at Shiraz University, I learned that the IPM was starting a Ph.D. program on particle accelerators, I quitted my Ph.D. at Shiraz University and started a new Ph.D., this time on accelerator physics. By this time in my life, I was on a train which brought me to where I am today.

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

Now we are done with the design of the **ESS** linac, components are being delivered by our In-kind partners or industry and are getting installed, and our biggest challenge is to commission the accelerator, analyze the results of the previous commissioning phases, and based on those, improve our plans for the upcoming commission stages and eventually be ready to operate the accelerator with an unprecedented average power of 5 MW.

Right now, COVID-19 restrictions are preventing us from doing this. Besides, there are some issues with securing the funding.

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

Looking at the bigger picture and history of physics, accelerator physics and more specifically physics of high-intensity beams is very young. In the **ESS** linac, the loss limit we have is equivalent to one single particle in every one million particles! Even though the Maxwell equations have been proven right on numerous occasions, how to implement them for an ensemble of particles and how to properly model that in a simulation code with even more precision, is one area of interest, to improve the design criteria of high-intensity accelerators based on the experience from **ESS** and to make better tools for the commissioning and tuning of the linac are the top three areas which come to my mind.

References

[1] Spallation Neutron Source, https://neutrons.ornl.gov/

[2] Japan Proton Accelerator Research Complex, https://j-parc.jp/c/en/

[3] Chinese Spallation Neutron Source, http://english.ihep.cas.cn/csns/

[4] European Spallation Source, www.ess.eu

[5] Institute for studies in theoretical physics and mathematics, www.ipm.ir