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Beam Diagnostics at the European Spallation Source

Subatomic particles hurtling along at nearly the speed of light, slamming into a metal target causing its very atoms to, quite literally, disintegrate in a massive evaporation of particles. The corona virus has effectively shut down the world, and had severe socio-economic consequences on a global scale. These two sentences might, at first, seem completely disconnected, but in fact, those subatomic evaporations could help fight the world-wide pandemic.

Understanding the material world around us is an ever-ongoing endeavour, and one of the most important frontiers is the realm of the very small. Neutrons, unlike protons or electrons, carry no electric charge which allows them to penetrate much more deeply into objects. Metals are basically translucent to them. Scientists can use neutrons by bouncing them off different materials or objects and gain a detailed image of the materials inner workings and structure.

The European Spallation Source is a research facility in Lund, Sweden which is set to be the brightest neutron source in the world. It will be a powerful tool in our pursuit of understanding the very small. It accelerates proton beams to 96.5% the speed of light before they collide with a tungsten core, generating showers of neutrons which are then transported into a number of smaller, individual research facilities, each equipped with its own suite of instruments. It was at a nearby facility similar to the ESS, the Max IV facility, where in collaboration with scientists from the ESS, that a research team recently imaged the novel coronavirus SARS-CoV-2 and its protein and crystal structure.

The Accelerator

You can imagine the ESS accelerator as consisting of a very long tube, roughly half a kilometer in length, through which the protons are transported. On their way to the target they pass through various types of magnets and instruments, designed to keep the protons going on the right track. This thesis aims to simulate the final portion of the linac called the *accelerator to target*, or A2T for short, which happens to be an incredibly important portion. Separating the accelerator itself and the tungsten target is a wall, with a small aperture through which the proton beams pass through. This means that the proton beam has to be a certain size in order to fit through without striking the wall, which would lead to the loss of a number of particles.

Unfortunately, this section of the accelerator also happens to be a section which, once the ESS linac reaches steady state operation, will not be easily accessible due to the near-constant activation of its elements.

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Maintenance or other access must then be carefully planned, so it’s important to take full advantage of the available diagnostic tools and to obtain as much information from them as possible.

The main goal of this project is to examine the possibility of using the currently available diagnostics near the aperture, which are 2 *beam position monitors,* and as you might expect, they measure position, in order to get a clear image of what the beam looks like towards the end of the A2T. The ability to use BPMs in novel ways to infer other beam parameters, such as the beam envelope, is an optimisation of the currently available diagnostics, and is extremely desirable for that reason.

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