Analysis of CV-28's multipurpose activation line Proton Beam energy

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The CV-28 cyclotron currently has 5 lines in use, one of which was recently developed for research purposes, especially solid target activations. Since the cyclotron operates in vacuum condition it requires a vacuum seal between the actual line and the target's apparatus, which consists of a beam diagnose device and structures to support the targets. For this line the seal used was a Tantalum window. Besides the window, the whole apparatus also has a few structures that creates an air gap between the seal and the actual target to be active. However, some applications require specific energies on the proton beams for its efficiency and reliability. Thus, an evaluation of the effective energy at which the protons will hit the target is a necessity. Figure 1 shows the line's end structure.

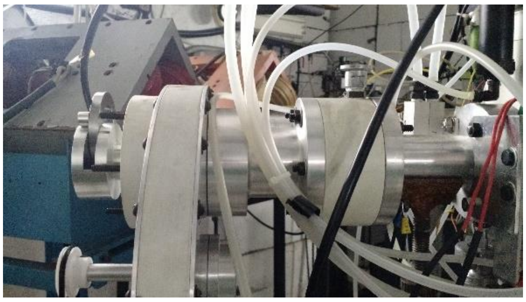

Figure 1. Transport line for activation

The evaluation was developed around a Thin Layer Activation experiment, which requires protons at 13.3 MeV [1], however at current state, CV-28 produces a proton beam at 24 MeV, thus, decreasing it to the required energy is the challenge. The methodology consists of two steps, both using IAEA's stopping power data [2]: the step was to determine at which energy the protons have after the Ta window, using the data previously mentioned and fitting functions, a curve of Stopping Power vs. Energy for Protons on Tantalum was obtained, through this curve it was possible to obtain the decrease in the beam's energy after each µm traveled in the material and thus, determined the final energy after 500 µm (the Ta window's thickness); secondly, using the same method the proton at dry air Stopping power vs. Energy function was obtained. Through this function it is possible to adjust the distance from the Ta window and the target's surface and thus adjust the energy at which the proton beam hits the target. The fitted curve and data can be seen on Figure 2.

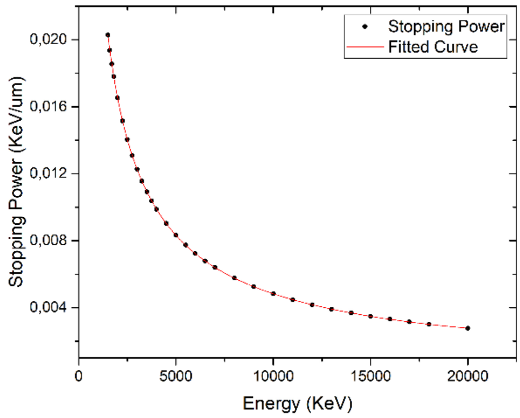

Figure 2. Protons on Dry Air

And for this curve we got Equation 1 (SP vs. Energy fit) through the fitting process. Note that the values are approximated.

$$SP = 43.8 * exp(E/-3888.9) + 30.2 * exp(E/-11318.9) + 17.6 * exp(E/-49218.3) + 4.8$$

The CV-28 produces proton beams of 24±0.2 MeV, after the Ta window, the beam has 13.9 MeV. Using the Dry Air function, the distance from the Ta window to the steel ring was set as 18.2 cm to hit the target with protons of the desired 13.3 MeV. The next step is to conduct activations using the same geometry and steel using foils of 0.1 mm thickness, this will allow us to analyze 3 to 4 slices of the activation profile, and from the ratios between them and the total activity (given a previous calibration using a HPGe detector for example) it is possible to evaluate the resultant activation.

References

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