Improvements on Liquid Cyclotron Target Loading/Unloading System Using COMSOL Multiphysics®

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Introduction: The Nitrogen [^{13}N] NH_3 is a liquid radioisotope, produced by medical cyclotrons for nuclear medicine application such cardiac Positron Emission Tomography (PET) studies. Owing to its short half-life (10 minutes), the unloading procedure of the radioactive solution of [^{13}N]NH_3 inside the target is crucial in saving the activity produced for patient. Therefore, an efficient technique in unloading the radioactive solution from the target body is needed. This will save collection time of the produce radioactivity. In this regards COMSOL 4.3 was used to simulate the geometry of the inner target for best location of the loading and unloading target openings. Figure 1 shows a simplified diagram for the [^{13}N] Ammonia target.

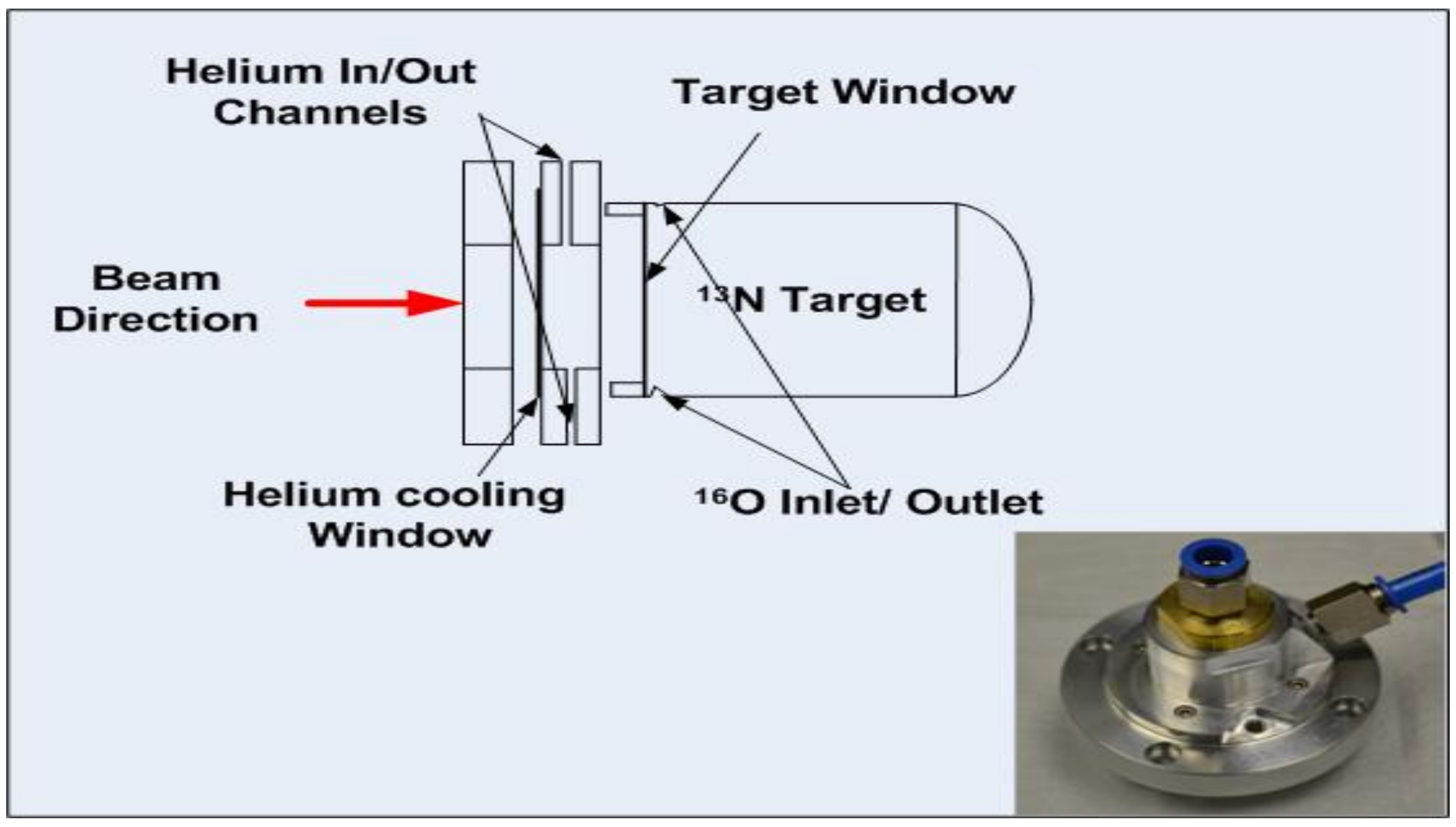

Figure 1. Simplified diagram of the N-13 target and a photo of the real target after fabrication.

Computational Methods: A 2D and 3D models were developed using COMSOL 4.3a to simulate the inner geometry of [^{13}N] Ammonia target. In the 2D model, water and aluminum were used as materials for, respectably, the inner body and outer boundary (walls) of the geometry. The physics equations used to solve the problem of allocating proper place for the loading/unloading opening is Turbulent, k-ε Module being extracted from fluid flow module. By using meshing system of normal element size, simulation results took 16s using HP Z1 workstation of 8GB of Memory and xenon processor.

Results: The simulation in Figure 2 shows the initial design where the location of unloading /loading opening was chosen. The initial Simulations results have revealed that such a design is not optimum in relation to collection time, and thus the activity collected will be less.

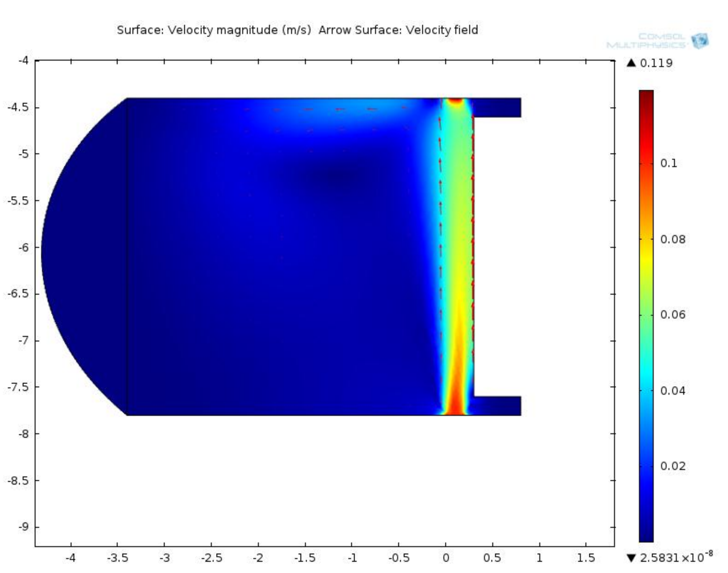

Figure 2. Simulation result before modifying the target.

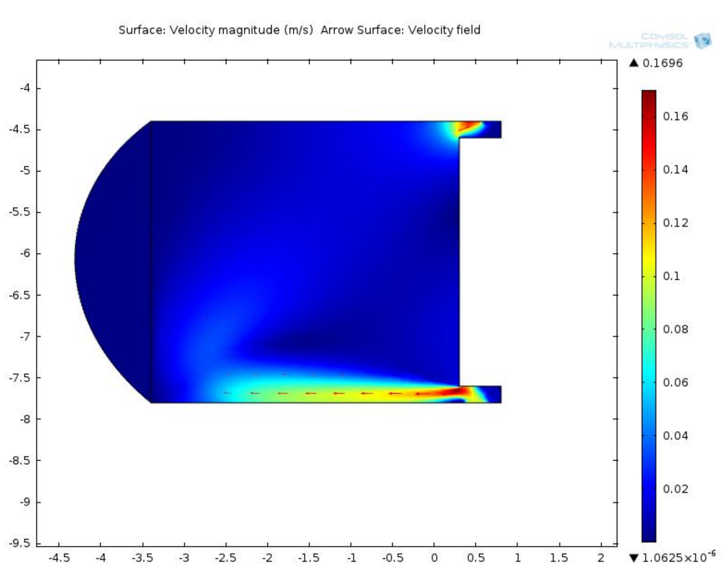

Figure 3. Simulation result after modifying the target.

Therefore, the geometry of inner target was changed to create turbulent flow and thus push the solution as shown finally in figure 3. Figure 4A shows a 3D model of of N-13 target model as developed by solid work. The model was imported into Comsol for further analyses. Figure 3B, on the other hand, shows a cross section view.

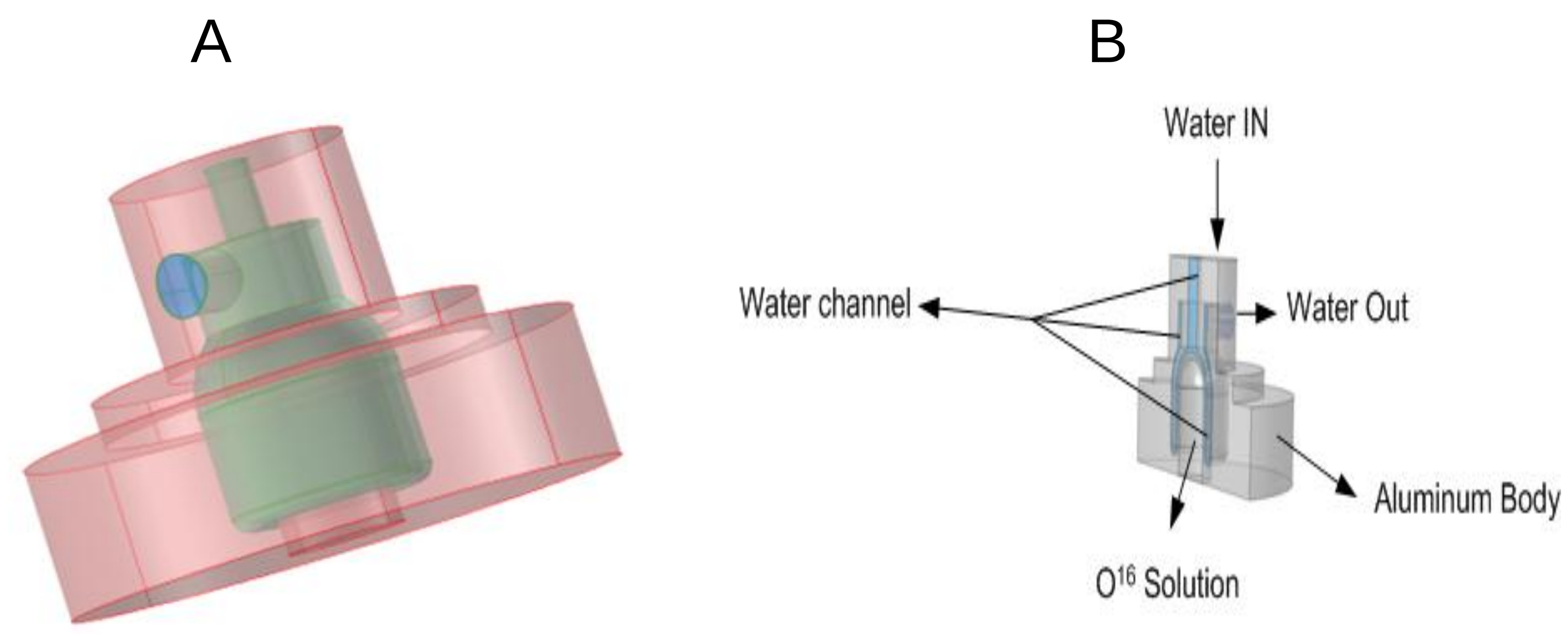

Figure 4. A) Target Model and B) a cross section view.

Figure 5 shows the result of simulating water flow on the target water channels. During these simulation, 0.1 m/s was chosen as speed of velocity of the water.

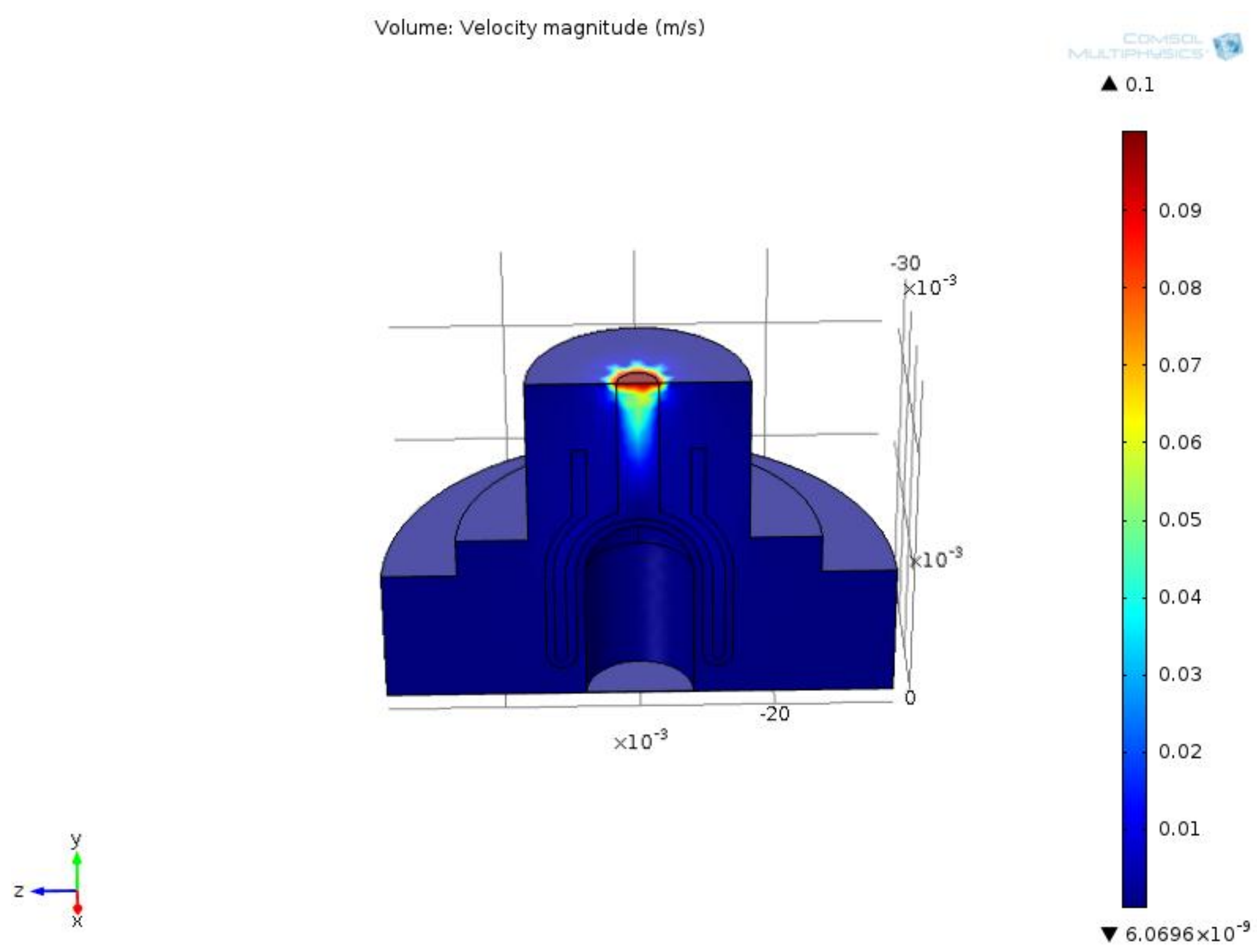

Figure 5. Simulations of water flow direction inside the target model.

The final design was implemented and fabricated as suggested by the simulation, and now is used for producing [^{13}N]NH_3. The activity reached in some experiments up to 330 mCi and this is satisfactory to be delivered to nuclear medicine for patient injection. Moreover, [^{13}N] purity was above 90% to which it meets the standard regulation for patient injection.

Conclusions: A successful target was developed and fabricated based on Comsol simulation results. The final design was implemented and fabricated as suggested by the simulation, and now is used for producing [^{13}N]NH_3

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