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

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## Abstract

Introduction

Nitrogen [13N] NH3 is a liquid radioisotope, produced by medical cyclotrons for nuclear medicine application and widely applied for evaluation of myocardial perfusion in clincal assessmnets [1]. Owing to its short half-life (10 minutes), the unloading procedure of the radioactive solution of [13N]NH3 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 Multiphysics® 4.3 a [2] 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 [13N] Ammonia target.

Use of COMSOL Multiphysics®

A 2D model was developed using COMSOL Multiphysics® 4.3a to simulate the inner geometry of the [13N] Ammonia target. In this 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 come from the Turbulent, k-ε Interface which is included in the 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 initial Simulation results have revealed that such a design is not optimum in relation to collection time, and thus the activity collected will be less as shown in figure 2. Therefore, the geometry of inner target was changed to create turbulent flow and thus push the solution as shown finally in figure 3.

The final design was implemented and fabricated as suggested by the simulation, and now is used for producing [13N]NH3. Figure 4 shows the data collected using the new designed target. The graph presents examples of the amount of activity produced in milliCuri (mCi) and the radiochemical purity (%) of the [13N]NH3 as function of beam current (uA) delivered from the Cyclotron. The activity reached in some experiments up to 330 mCi and this is satisfactory to be

delivered to nuclear medicine for patient injection. Moreover, [13N] purity was above 90% to which it meets the standard regulation for patient injection.

Conclusion
A successful target was developed and fabricated based on COMSOL Multiphysics® simulation results. The activity and purity of the [13N] Ammonia solution produced inside the simulated target was satisfactory. Target now is under regularity testing for full operation at King Faisal Specialist Hospital and Research Centre (KFSHRC) in Saudi Arabia.

## Reference


1. 1. R.N. Krasikova et. al., "Improved [13N] ammonia yield from proton irradiation of water using methane gas" Applied Radiation and Isotopes, vol. 51, page 395-401, 1999.
2. www.COMSOL.com


## Figures used in the abstract

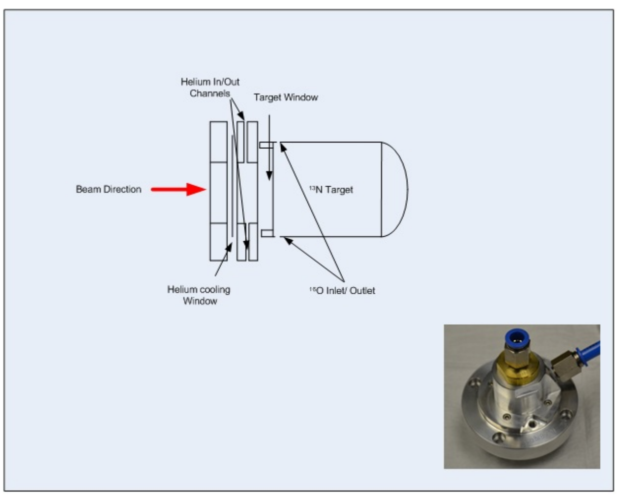


**Figure 1**: Simplified diagram of the N-13 target and a photo of the real target after fabrication

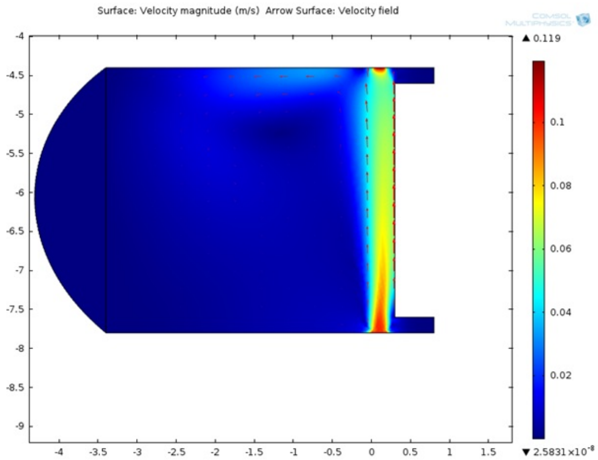


**Figure 2**: Simulation results before modifying the target

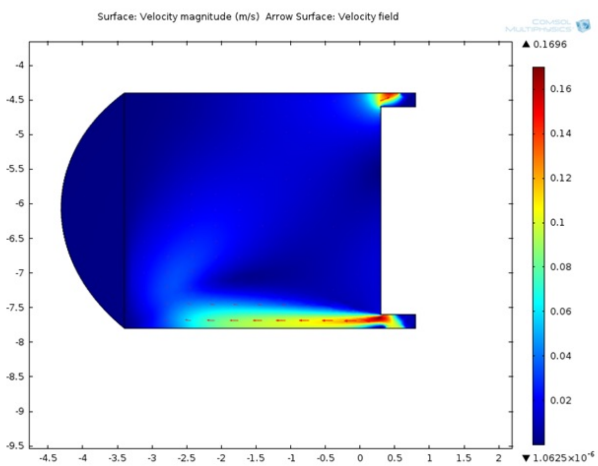


**Figure 3**: Simulation results after modifying the target

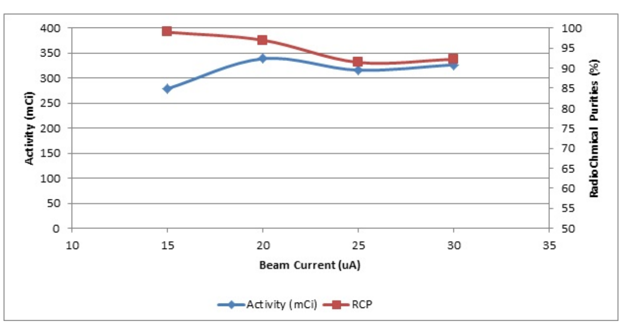


**Figure 4**: Collected activity and its purity level from the improved target