# Modeling and Meshing the Neutral Particle Spectrometer for Ansys Fluent Simulation

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This note describes the modelling and meshing of the Neutral Particle spectrometer (NPS) for steady state and transient Ansys Fluent thermal simulations and analysis.

An NPS-CAD-file-based 3D model in which the crystal array was approximated as a single block, and which included the cooling system and electronics zone [1] was generated for thermal simulation. Analysis of the simulation data showed that the model had to be improved.

An improved model that replaced the crystal block with 1080 individual crystals and eliminated contact issues between the cooling plate and the crystals located at the outer section of the array was developed. In addition to the electronics zone and the cooling system components, detector enclosure and fluid regions were added, Fig. 1. Cell zone conditions for the crystals were changed and the heat source for the crystals was placed at the face that attaches to the photomultiplier tube.

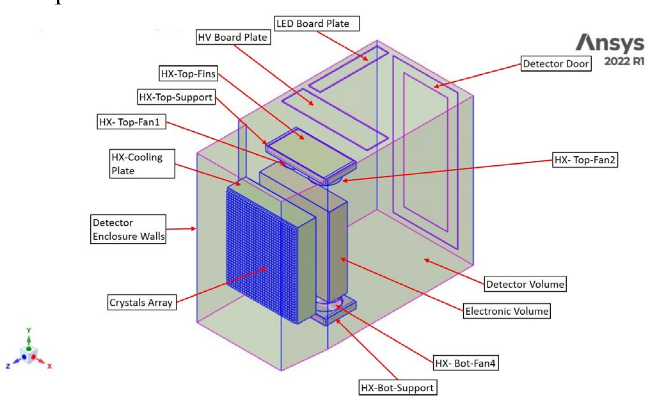



FIG. 1. Isometric view of the detector enclosure, electronics zone, cooling system components, and individual crystals.

For the crystal array, dividers, and cooling plates, which comprise numerous parts, the meshing file size was reduced with the Shell Conduction options in Fluent, with which an inter-crystal spacing of 0.5 mm could be substituted for the dividers, Fig. 2.

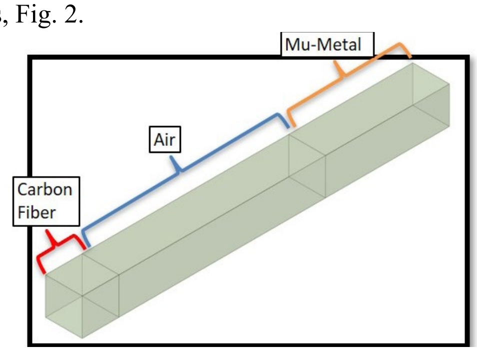



FIG. 2. Crystal with no dividers sectioned for thermal transfer of each section. Air section has no wrapping material.

The model's cooling system [2] consists of the cooling copper plate that surrounds the crystals, the heat exchanger supports with the fin area, and four heat exchanger fans. A key modeling task—using Design tools, such as Split Body, Combine, and Fill—was to combine the fan blades of each of the fans with its surrounding fluid, Fig. 3, and to ensure proper rotation.

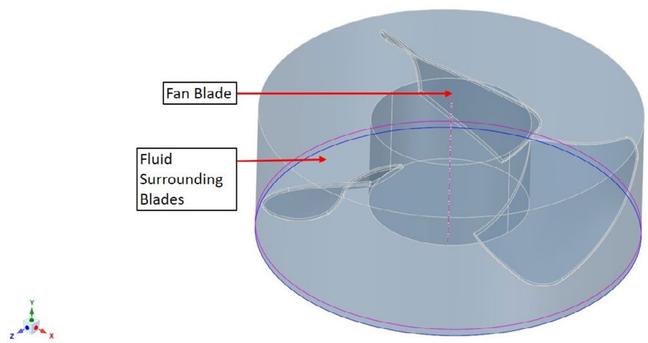



FIG 3. Heat exchanger fan.

Using Fluent Meshing for the entire system resulted in 100 million cells, file size of which was too large to run on the computer. The number of mesh cells was reduced to 13 million by dividing the detector enclosure hut volume into 10 fluid zones, Fig. 4.

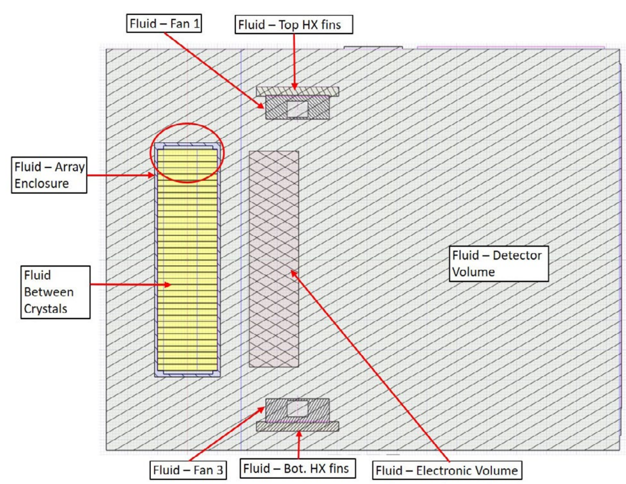
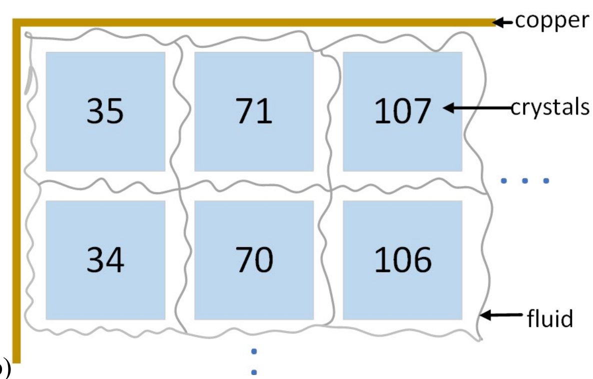



FIG 4. Right side, cross-section of the detector model showing the partition into 10 fluid zones—one zone for each fan (4), one for each heat exchanger (2), detector volume, array enclosure around the crystals, fluid between the crystals, and electronics volume.

Figures 5a and 5b show a close-up view of the crystal array fluid volume.


(a)




(b)

FIG 5(a). Right side, cross section, close-up of the fluid surrounding the crystal array in the upper section (red oval in Fig. 4). (b). Close-up of front view of the top left corner of the crystal array.

Reducing the number of mesh cells from 100 million to 13 million affected the mesh quality—not fine enough for thermal analysis, Fig. 6.

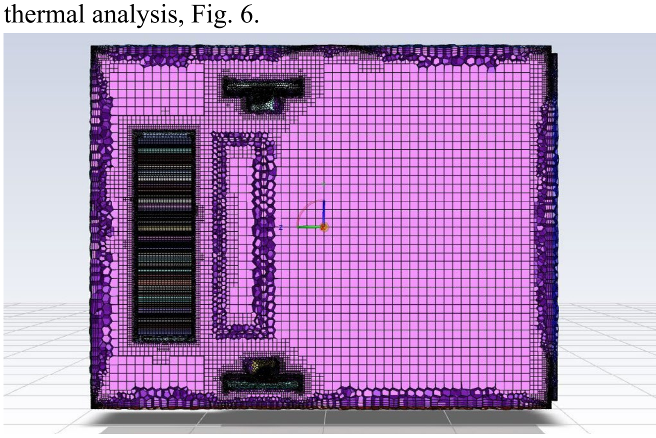


FIG 6. Right side, cross-section view of the entire meshed model.

To generate a fine mesh, two layers of mesh between the crystals were generated, Fig. 7, resulting in 17 million cells. Four boundary layers around each crystal, Fig. 5b, were added to ensure proper thermal transition for each wall in contact with a fluid region.

When the model was transferred to Fluent Meshing, all outer wall partitions for the crystals were lost. To solve the problem, Separate Face Zones tools in Fluent Meshing was used to separate each crystal into five regions—front, carbon fiber, air, mu-metal, and back, Fig. 8.

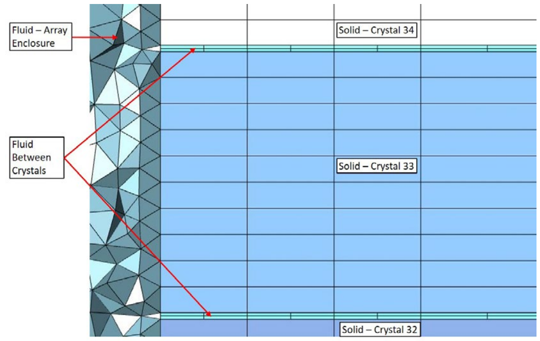



FIG 7. Right side, cross-section, close-up of the fluid surrounding the crystal array in its upper right section. Model has two layers for the fluid between each crystal.

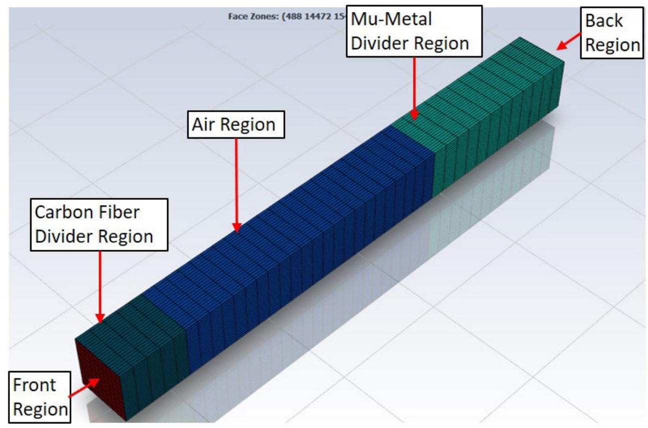



FIG 8. Isometric view of a crystal meshed and sectioned into five regions.

Finally, the 3D model with critical fluid and solid parts required, and a surface and volume mesh, which can be used for thermal analysis, was completed.

[1] Pablo Campero, et al. *DSG Thermal Analysis of the Neutral Particle Spectrometer,* DSG Note 2023-21, 2023.
[2] E. Rindel, *NPS Cooling System*, Unite Mixte de Recherche, Universite of Paris-Sud 11, January, 2021.