Modeling and Meshing of the NPS Detector

Pablo Campero
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To run the proposed Ansys-Fluent thermal simulations, a 3D model with the critical components to study the thermal effect inside the NPS detector enclosure had to be developed. Previously a simplified model was developed with the cooling system, electronic zone and the crystals as a single block. During the thermal simulation of the simplified model, I noted that there were points to be improved to allow a simulation with conditions close to the real detector, some of these points were: correcting the geometry of the model (due to contact issues), changing cell zone conditions for the crystal block (heat source applied need to be applied to its front face rather than to the whole volume).

The new 3D model was intended to eliminated the geometry issues and add detailed components to improve the thermal simulations, the new 3D model includes the detector enclosure, electronic zone, cooling system components, 1080 individual crystals, and fluid regions. See Fig.1.

Prior to the modeling, I noted that a model consisting only on the crystal array, dividers and cooling plate had a mesh size file of ~ 16GB, which slowed the system down and difficulted the operability functions, the big file was due to the numerous parts and thin parts, to ensure an optimum model, I made a research on the methods to analyze thin structures in Ansys-Fluent and I found that the “Shell Conduction” could be utilized to avoid the implementation of the dividers as a physical parts to the model allowing a simpler and reduced mesh.

I used Ansys-SpaceClaim software for the modeling, actual dimensions from the NPS detector group CAD file were used and to generate each component of the model. To generate the crystal array a 0.5 mm separation between each crystal was considered. Carbon and Mu-Metal dividers were removed from the model as noted in Fig.2.

- **Completed the development of a 3D model with critical components to allow thermal simulations**
- **Creation of sub-zones for fluid domain inside the detector and partition of the crystals into section were required**
- **Completed meshing of the model with an acceptable quality**

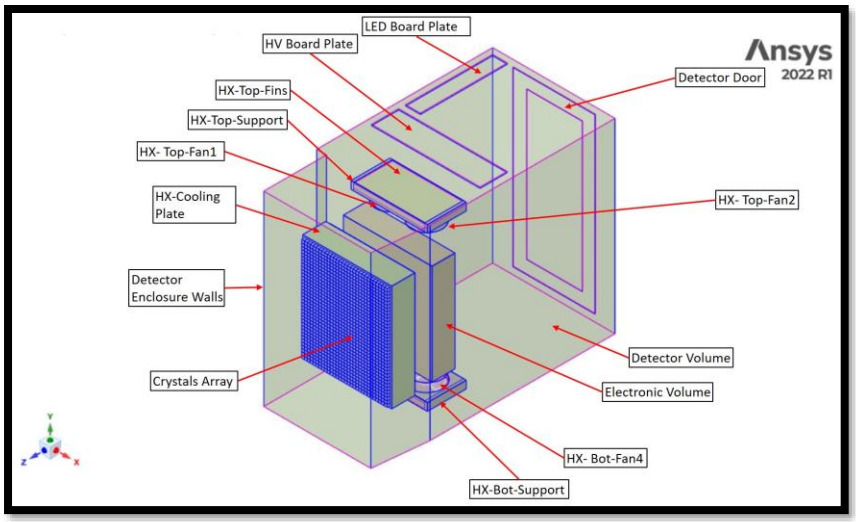

Fig.1. NPS Detector enclosure, electronic zone, cooling system components, and individual crystals

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For the meshing of the model two approaches were considered, the first was by using Fluent Meshing and the second was by using Ansys Mechanical Meshing, each of them has different tools to achieve a high quality mesh of the model. for both meshing approaches the complications appeared due to numerous parts and the thin separation space between each crystal.

The attempt of meshing the model with Ansys Mechanical Meshing failed and did not was completed.

First attempt with the Fluent Meshing approach resulted in a mesh of 100 M cell and did no run on EXPCAMPERO computer because of the RAM memory limitations, therefore, the reduction of the number of cells without affecting the quality of the mesh was required. An extra step to allow the reduction of the mesh cells consisted in the division of the internal volume into 10 zones, especially for the fluid surrounding the crystal array. For the second attempt with Fluent Meshing I was able to reduce the number of cells to 13 M but the mesh quality for the space between the crystals wasn't fine. Finally, in the third attempt I was able to refine the mesh between the crystals with two layer, this model resulted in 17 M cells and the operability for post setup in Fluent Solver was acceptable. See Fig.3 and Fig.4.

I had another issue to preserve the wall partition of the crystals, I noted that even after sectioning each crystal in SpaceClaim once the model was transferred to Fluent Meshing all otter walls partitions for the crystals were lost, to solve the matter, I had to use *Separate Face Zones* tools in Ansys-Fluent Meshing software to separate each crystal into five regions—Front, carbon fiber, air, and back. See Fig.5.

After resolving all issues I was able to complete the the model (with all critical fluid and solid parts required) and also a high quality mesh.

I plan to continue with the next stage of the project which is the setup of the materials, cell zones and boundary conditions to proceed with the thermal simulations.

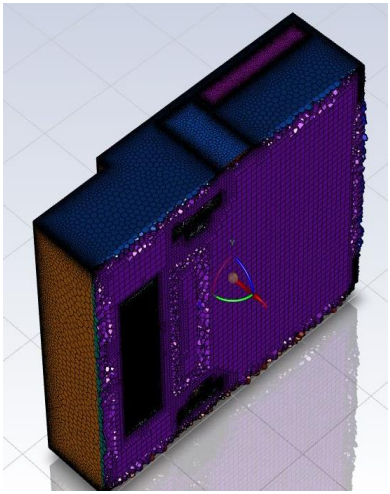

Fig.3. Isometric, cross section view of the NPS detector model mesh with ~ 13 M cells

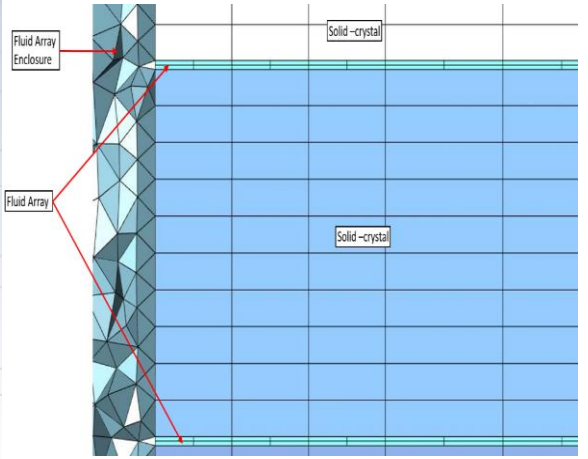

Fig.4. Right side, cross-section, close-up of the fluid surrounding the crystal array in its upper right section. Model has 17 M cells with two layers for the fluid between each crystal.

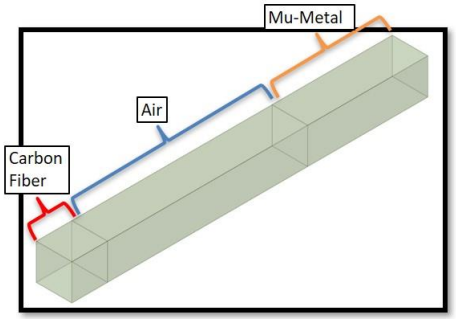

Fig.2. Isometric view of crystal-1 with no dividers but sectioned to proceed the thermal transfer for each section using "Shell Conduction" options in Ansys Fluent

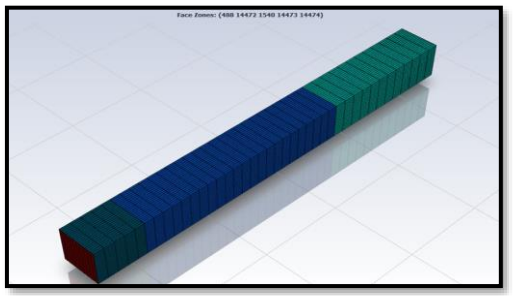

Fig.5. Isometric view of crystal-1 meshed and sectioned into five regions