NAG Optimization Algorithm Speeds up Configuration Testing of Powerful MRI Magnet and Helps Secure Development

Background

The most powerful MRI magnet in the world has been developed by Irfu, Institut de Recherche sur les lois fondamentales de l'univers (Institute of Research into the Fundamental Laws of the Universe), a CEA Institute in Saclay, France. Magnetic resonance imaging (MRI) is a diagnostic and research tool used in the clinical research and diagnosis. The whole body "Iseult" magnet is the core component of a magnetic resonance imaging (MRI) scanner that is expected to set new standards for cerebral imaging.

The Iseult magnet is a 11.7 teslas superconducting actively shielded magnet of about 120t with a warm aperture of 900mm in diameter and 5000mm in length. Once built, the Iseult will be installed in the NeuroSpin Imaging Centre at Saclay and dedicated to brain neuroimaging. It will be most powerful MRI magnet in the world.

The Challenge

Mr Thierry Schild is the Project Leader of the Iseult MRI Magnet and works within the Irfu, Institut de Recherche sur les lois fondamentales de l'univers, a CEA Institute. He explains that the Iseult magnet has an original design using a stack of double pancakes plunged into a superfluid helium bath. All MRI magnets require a field homogeneity better than 0.05ppm in the field of view, a sphere of 22cm of diameter in our case. This homogeneity is very important as it is directly linked to the final image quality. The issue is then to find the geometry that minimizes the mass of superconductors; that is the most expensive component.

The Solution

The NAG routine used by Mr Schild and his team to solve their minimization problem is from the Optimization Chapter of the NAG Library*. The objective of the problem is to minimize the superconductor mass by moving or changing the number of double pancakes. The free parameters are in the range of 200. The problem is nonlinear because the field quality, that is a constraint of our problem, is nonlinear versus the pancakes displacement. The team picked the relevant routine from the NAG Library, knowing that it has been extensively tested and documented and therefore could be trusted to give accurate and robust answers. Thanks to the NAG routine, the minimization problem was solved in a matter of seconds. This resulted

in the team being able to quickly and easily test many magnet configurations. Based on these calculations, the magnet is now under manufacture.
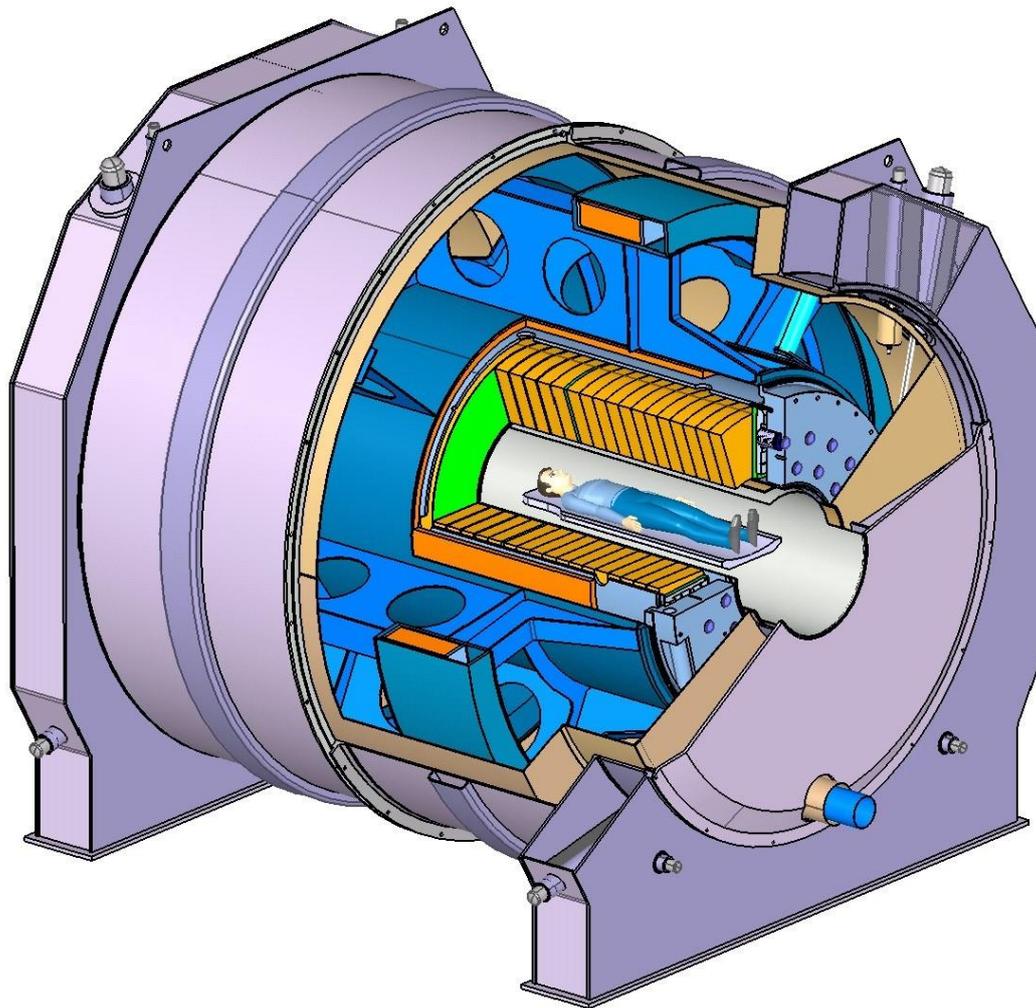
This image shows a cross-section of the Iseult magnet ©Irfu, Institut de Recherche sur les lois fondamentales de l'univers (Institute of Research into the Fundamental Laws of the Universe), a CEA Institute

*E04UCF (nagf_opt_nlp1_solve_old) : Minimum, function of several variables, sequential QP method, nonlinear constraints, using function values and optionally first derivatives (comprehensive).