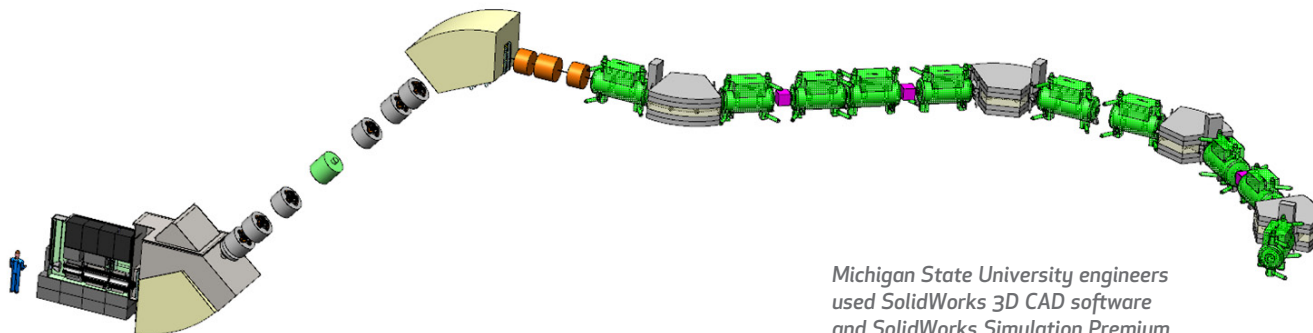


THE FACILITY FOR RARE ISOTOPE BEAMS

Designing a system to study the origin of the elements with SolidWorks Simulation



Michigan State University engineers used SolidWorks 3D CAD software and SolidWorks Simulation Premium to develop the university's successful proposal to build the \$550 million Facility for Rare Isotope Beams.

When the Office of Science in the US Department of Energy (DOE) sought proposals to develop the world's most powerful rare isotope accelerator, Michigan State University (MSU) set out to win the project. MSU was an obvious candidate, having operated a world-class rare isotope accelerator, the National Superconducting Cyclotron Laboratory, for two decades, but was by no means assured of securing DOE's selection for the award.

The Facility for Rare Isotope Beams (FRIB) represents a new approach to rare isotope physics research. FRIB will accelerate elements from hydrogen to uranium to 40 percent of the speed of light and prepare rare isotope beams—short-lived nuclei not normally found on Earth—for scientists. The rare isotope beams are fast, stopped, or reaccelerated to advance research into the origin of elements, the birth of stars, and the evolution of the cosmos.

"FRIB pushes the envelope of what's known and unknown," explains Dr. John Oliva, mechanical analysis and simulation group leader on the project. "Until now, facilities could only accelerate particles up to a certain size because of power limitations. FRIB will ramp up the power and enable the acceleration of all isotopes to intermediate energies. In terms of nuclear and astrophysics research, these rare isotopes represent a big empty page of knowledge. FRIB will help researchers look for answers to many of the mysteries remaining about the origin of the universe."

To win the DOE award to design and establish FRIB—a \$550 million facility that will take about a decade to build—MSU had to propose a preconceptual design for the FRIB accelerator and demonstrate how the system would work. Competing against research organizations nationwide, MSU needed to prove that its proposed design concept would work.

MSU chose SolidWorks® 3D CAD software and SolidWorks Simulation Premium to develop the FRIB proposal, because the software's ease of use, integration, and range of analysis capabilities allowed the team to advance the design as far as possible.

Challenge:

Design the Facility for Rare Isotope Beams, the world's most powerful superconducting radio frequency linear accelerator, which will create intense beams of rare isotopes and advance nuclear and astrophysics research..

Solution:

Develop the facility using SolidWorks 3D design software and demonstrate its proof-of-concept with integrated SolidWorks Simulation Premium analysis software.

Results:

- Won \$550 million award to design and build FRIB
- Proved concept validity with virtual simulations
- Cut time and expense of creating prototypes
- Demonstrated accelerator concept with 3D animations

"It came down to a competition between the Argonne National Laboratory and us," Oliva recalls. "Using SolidWorks software allowed us to prepare a strong proposal. The ability to virtually test the accelerating cryomodules was an important factor in substantially improving our credibility."

The stuff of stars

After securing the \$550 million project in early 2009, the FRIB team used SolidWorks software to transform its concept for one of the facility's systems into its first prototype. The facility—scheduled for completion in 2020—will help researchers answer one of the most intriguing questions about the universe. Scientists know that the Big Bang created hydrogen, helium, and other light atoms. However, all of the other elements, including the carbon and oxygen that are the basis for plants and animals, were made by stars. FRIB will help researchers investigate how we came to be the stuff of stars.

"We have now moved from early conceptual design to prototyping, and recently completed our first small prototype," Oliva notes. "Having integrated design and analysis capabilities like SolidWorks software has enabled us to cut time and expense in creating prototypes. By running hundreds of virtual simulations, we avoid repetitive prototyping, which we anticipate will result in huge cost savings."

Spinning through the hot zone

The team also used the software's thermal analysis capabilities to analyze the performance of two key components. The thermal simulations of the graphite target wheel, which operates in a temperature range of 1600° to 1630° K, and the aluminum beam dump system, which requires a cooling system, helped FRIB prove the validity of its concept.

"On the graphite target wheel, we were able to investigate different target diameters and thicknesses, and experiment with rotational speeds," Oliva points out. "With the beam dump system, we looked at different drum diameters, rotational speeds, beam profiles, and aluminum-cooling requirements. These studies enabled us to optimize our design before building a single prototype."

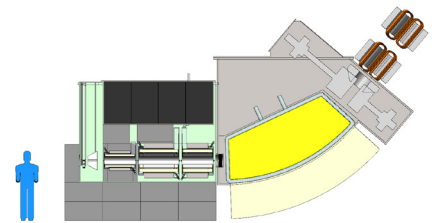
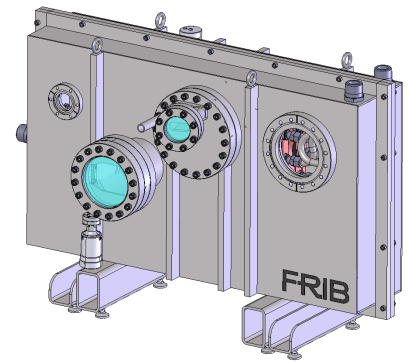
Showing how FRIB will work

On a project as complicated as FRIB, the ability to not only simulate the performance of key components, but also show the results of those studies through 3D design visualizations, helped the team demonstrate its proof-of-concept. In addition to 3D models, the team used SolidWorks Simulation animations of analysis results to simulate system performance.

"We were able to animate the hot region on the target wheel to show how it cools down as it rotates," Oliva says. "The animation function in SolidWorks Simulation is extremely helpful versus static color pictures for demonstrating what's happening temperature-wise with the design."

"USING SOLIDWORKS SOFTWARE ALLOWED US TO PREPARE A STRONG PROPOSAL. THE ABILITY TO VIRTUALLY TEST THE ACCELERATING CRYOMODULES WAS AN IMPORTANT FACTOR IN SUBSTANTIALLY IMPROVING OUR CREDIBILITY."

Dr. John Oliva
Mechanical Analysis and
Simulation Group Leader



Michigan State University engineers leveraged SolidWorks Simulation Premium software's structural and thermal analysis capabilities to demonstrate how the FRIB system will operate.



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