Solenoid Superconducting Magnet

Thomas Jefferson National Accelerator Facility

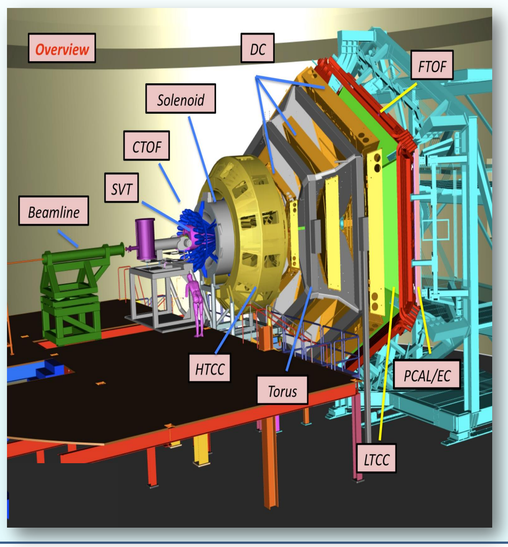
What is it?

The Solenoid Superconducting Magnet is used to:

1. **Channel sub-atomic particles into the various Physics detector systems**

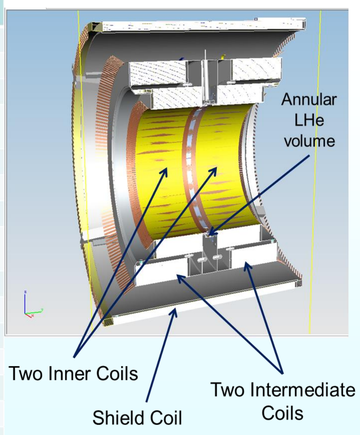
When the tightly focused electron beam from the accelerator impacts a target, a whole spray of sub-atomic particles is produced. These particles are then steered by the Solenoid's magnetic field so that they can be detected by the different Physics detectors.

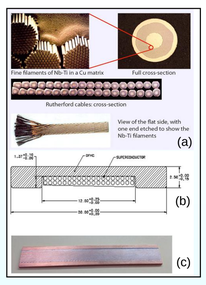
Left: The Solenoid magnet has 5 superconducting coils located within a vacuum jacket. The coils are cooled to -268°C (-450°F). The vacuum jacket is like a thermos flask but in this case helps to keep the coils cold rather than hot.
Below: The Solenoid magnet surrounded by Physics detectors



Tech Specs

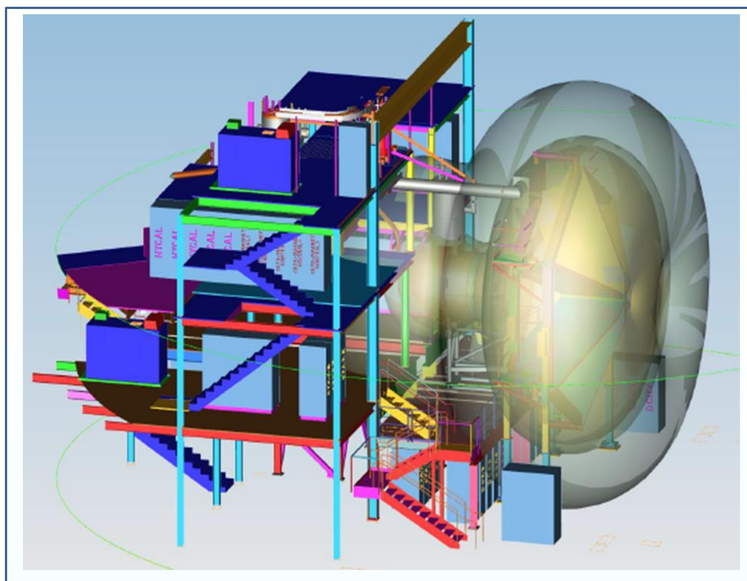
Parameter	Design Value
B_0	5 T
Peak Field	6.6 T
$L=1/B_0\int Bdl$ (m)	1 - 1.4
Field Uniformity in target area	$\Delta B/B_0 \leq 100$ ppm over a cylinder 0.04 m L x 0.025 m Ø
Field at HTCC PMTs	B ≤ 35 G
Field at TOF PMTs	B ≤ 1200 G
Number of Coils	5
Maximum/Operating Current	2500 A/2416 A
Bore	780mm
Cooling Method	Conduction (4.2K supply)
Temperature Margin	1.5K (@4.2K)
Stored Energy	< 20 MJ
Fast Discharge Voltage	< 500 V
MQE	20 mJ
Inductance	5.89 H

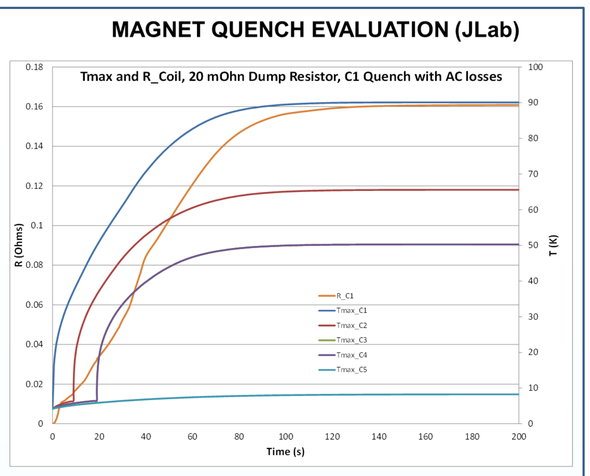




Superconducting wire (Niobium Titanium or NbTi)

Designing the Solenoid Magnet





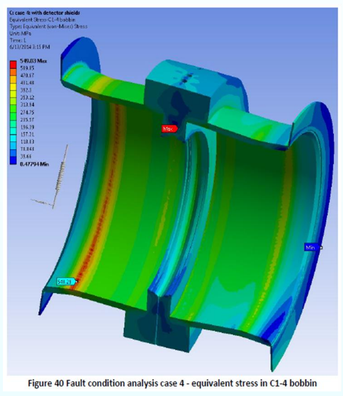


Figure 40 Fault condition analysis case 4 - equivalent stress in C1-4 bobbin

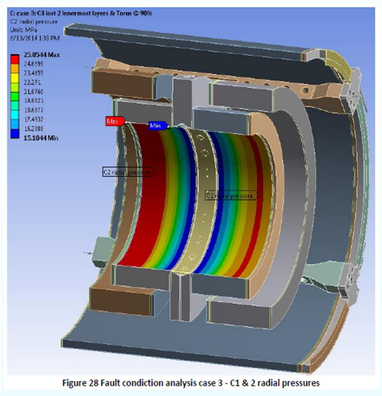
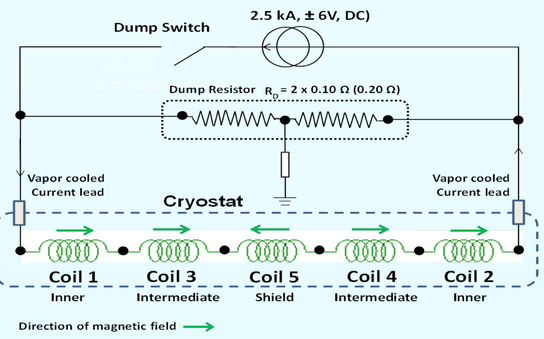
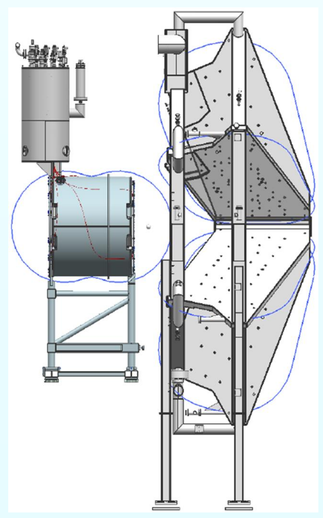


Figure 28 Fault condiction analysis case 3 - C1 & 2 radial pressures





Some design calculations and tests. *Top left*: Magnetic field produced by the solenoid *Top Right*: Calculation of coil resistances, voltages and temperatures during a quench. *Middle Left*: Design of the superconducting coils. *Bottom Left*: Testing the mechanical strength of a stack of superconductors. *Bottom Middle:* Electrical circuit for the Solenoid *Bottom Right* : Checking to see how the magnetic fields from the Torus and the Solenoid interact with each other.

Building and Installing the Solenoid

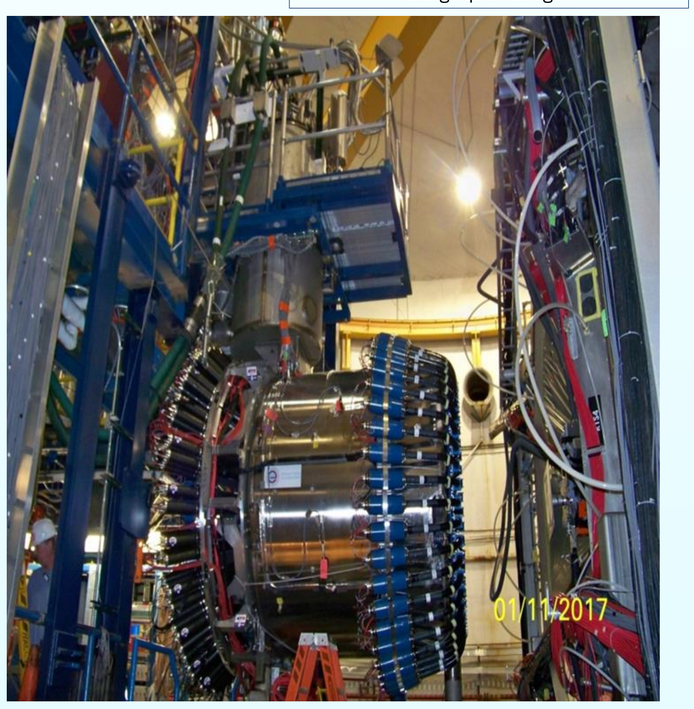
Superconducting coils being wound at Everson-Tesla Inc, Nazareth, PA

Superconducting coils being prepared for potting with epoxy resin

Superconducting coils being fitted together using liquid Nitrogen

Inserting the finished superconducting coils into its vacuum jacket

Installing the Copper cooling fingers which are used to cool the coils to liquid Helium temperatures



Installing Physics detectors in and around the solenoid at JLab

Did you know?

- The freezer in your refrigerator at home keeps your ice-cream cold at -18°C (about 0°F). The Solenoid superconducting coils are kept cold at -268°C (-450°F) – nearly as cold as outer space! We use liquid Helium to do that!
- Helium gas was first discovered on August 18th 1868 during a total solar eclipse of the sun. A scientist managed to liquefy it on July 10th 1908 – yes….the same scientist who discovered superconductivity, Kamerlingh Onnes. That was on a Friday, in case you were wondering.
- The Solenoid magnet was designed in a little town on the South coast of England, built in the heart of coal country in Pennsylvania and is now installed in the greatest state of the nation, Virginia – the birthplace of America!
- When the Solenoid is fully powered up, it has as much energy as 11 Toyota SUVs traveling at 75 MPH on the highway or 8 pounds of TNT! Yes….even more energy than that Torus magnet next to it.
- Niobium Titanium is the superconductor used in the Solenoid coils. The metal Niobium is presently only mined in two places on Earth – Brazil and Canada.
- The magnetic field produced by the Solenoid magnet is more than 100000 times stronger that the Earth's magnetic field!
- The central bore of the Solenoid is large enough for you to crawl into it…….don't do it though!
- YOU ARE STANDING NEXT TO THE ONLY SUPERCONDUCTING MAGNET OF THIS TYPE IN THE WORLD! Go on …….take a selfie with the Solenoid and tell the world!

Contributing Institutions

- Jefferson Lab, Newport News, VA, USA
- Everson-Tesla Inc, Nazareth, PA, USA
- Tesla Engineering, England, UK