

Hall Probe Calibration System Design for the Mu2e Solenoid Field Mapping System

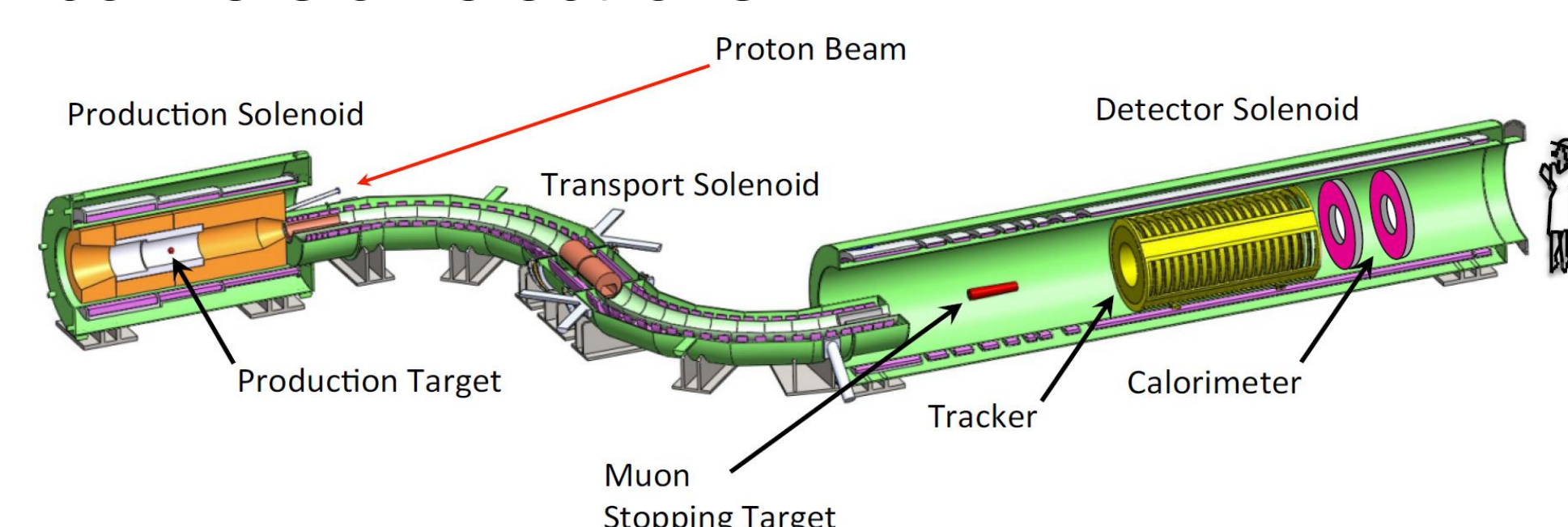
C. Orozco, S. Feher, L. Elementi, H.W. Friedsam, M.J. Lamm, J.M. Nogiec, T. Strauss, FNAL

J.J. Grudzinski, R.L. Talaga, R.G. Wagner, J.L. White, H. Zhao, ANL B. Pollack, M.H. Schmitt, NU

Thu-Af-Po4.10-02

The Mu2e Experiment

The Mu2e experiment at Fermilab is designed to search for charged-lepton flavor violation by searching for neutrino-less muon to electron conversions in the field of a target nucleus. The concept of the experiment is to generate a low momentum muon beam, stopping the muons in a target and measuring the momentum of the conversion electrons.

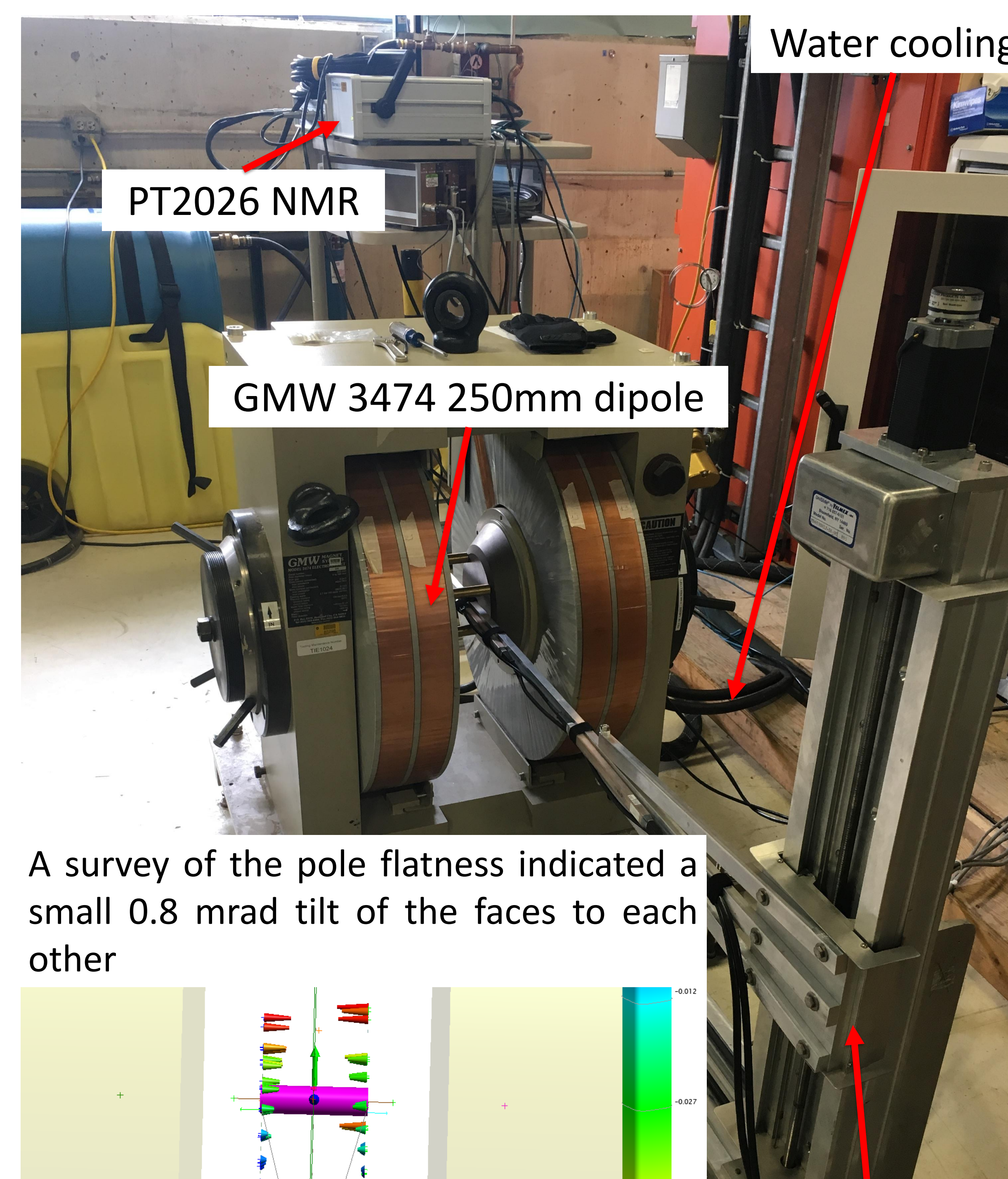


The Mu2e Solenoids

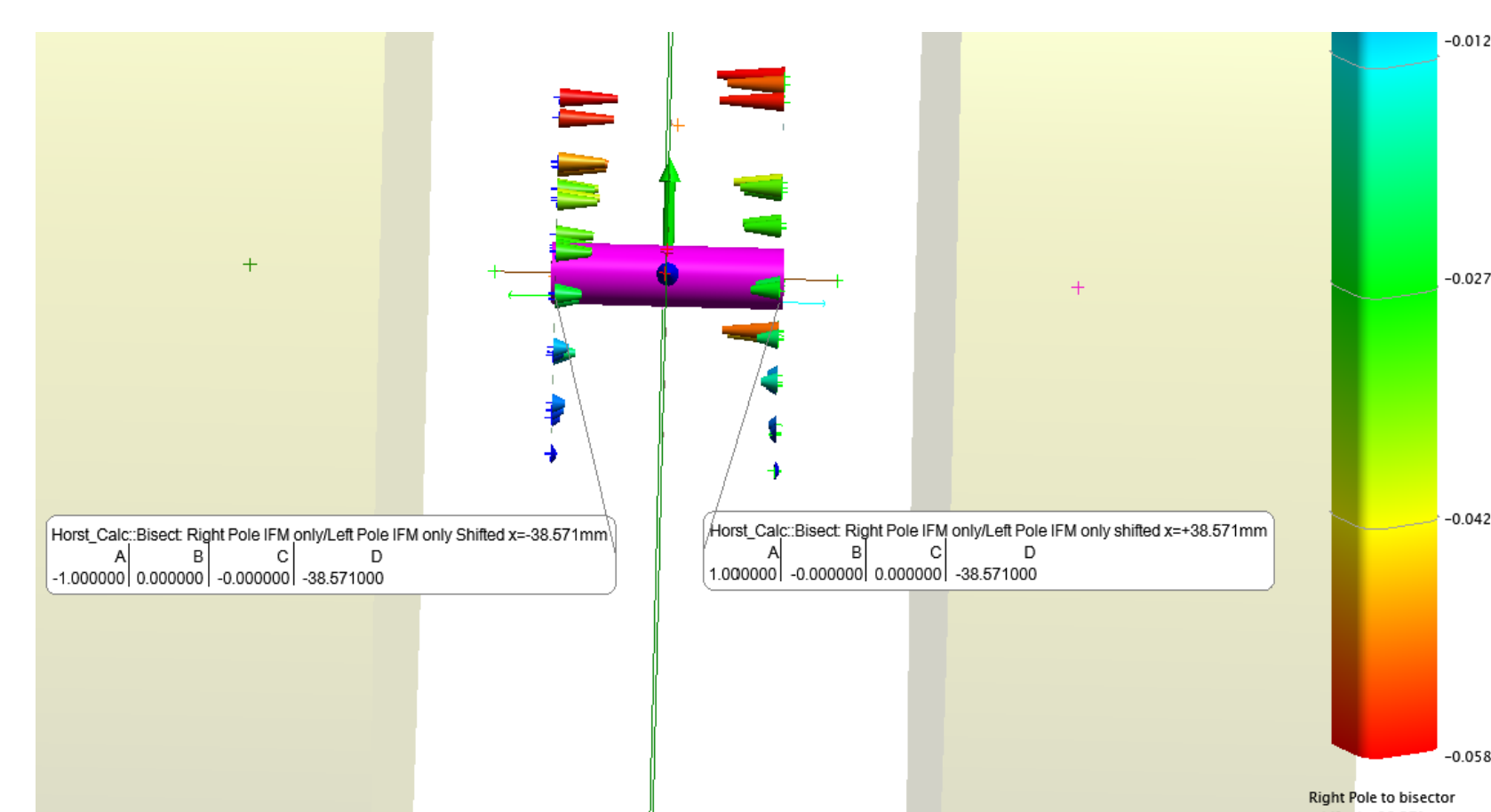
Three different solenoids create a complex magnetic field with graded solenoidal and toroidal components to guide muons created in the Production Target to the Muon Stopping Target. The magnet coils will operate at 1-4.5 T at gradients from 0.01-0.25 T/m. These fields must be measured accurately to ensure the Mu2e experiment produces quality data.

Further information is available at:
[1] <http://mu2e.fnal.gov>
[2] Mu2e Technical Design Report, arXiv:1501.05241

The Calibration Magnet and NMR survey



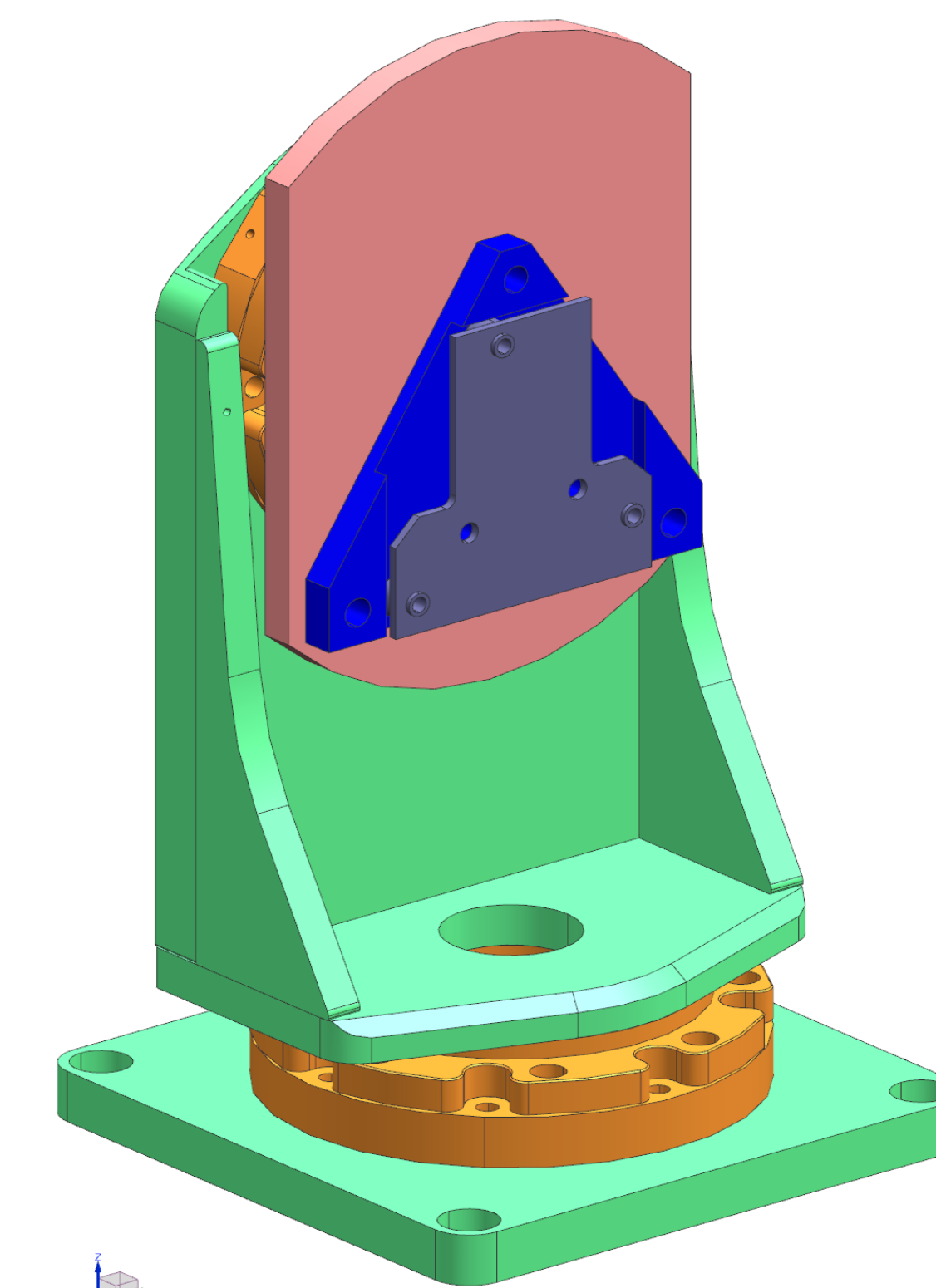
A survey of the pole flatness indicated a small 0.8 mrad tilt of the faces to each other



XY stage with arm for mapping with NMR

The Hall Probe Calibration Motion System

Two SmarAct SR-7021 rotary actuators perform the two motions necessary to form the required set of angular positions. These two actuators sit in the assembly at a 90° angle, connected by an aluminum bracket. On the mounting surface, survey reflectors can be attached for determining the initial position of the device with respect to the calibration magnets. The SR-7021 exceeds the requirement of knowing the position to within 0.1 mrad while allowing for as many as 180,000 steps in the $\pm 180^\circ$ phi motion and 5000 steps in the $\pm 5^\circ$ theta motion.



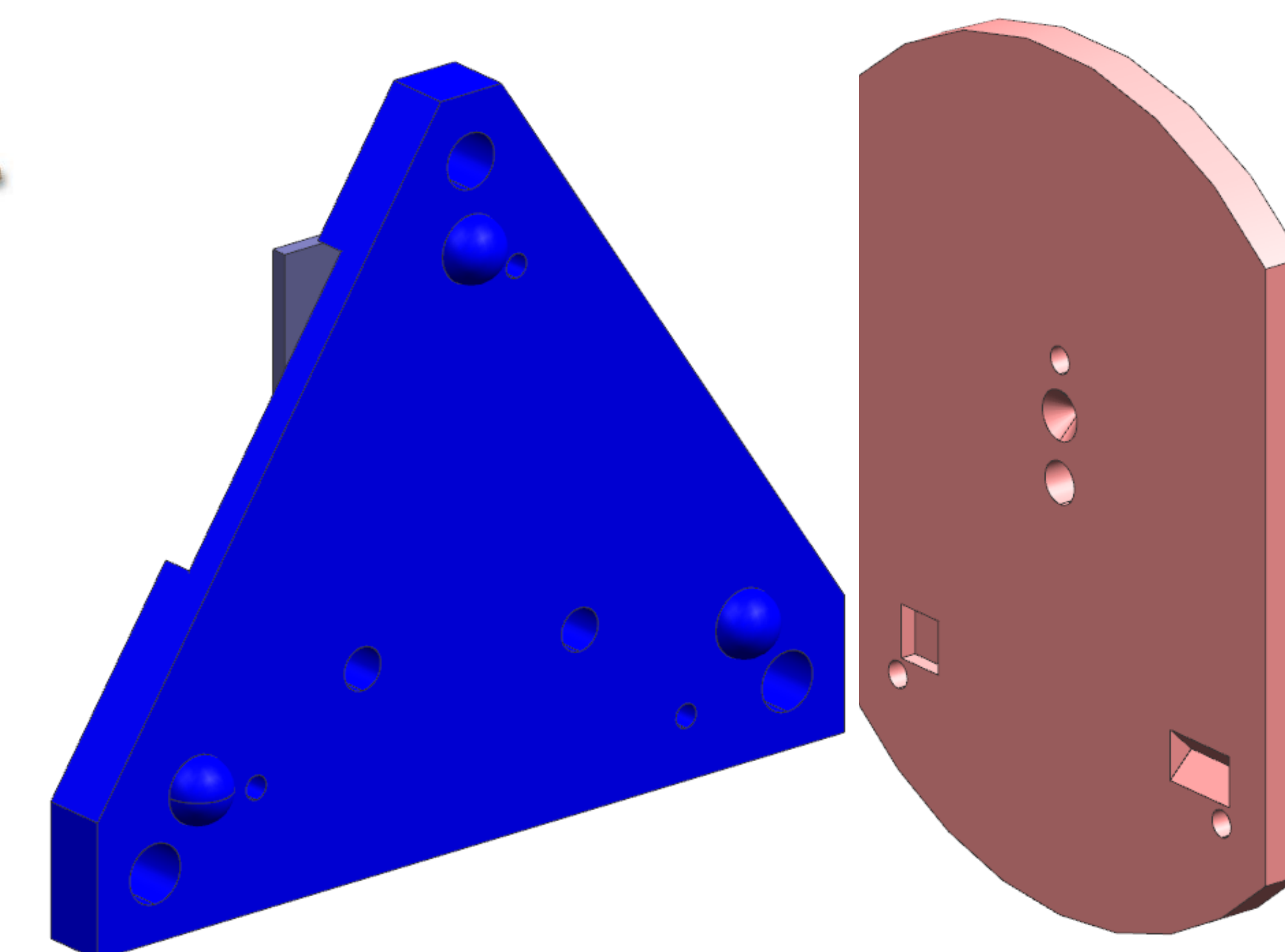
The NMR probe

The Metrolab PT2026 NMR is a Precision Teslameter, a pulsed wave NMR detector and advanced signal processing allows a fast tracking of magnetic field changes better than 10 ppb at 3 T. The PT2026 can measure gradients of 1620 ppm/cm, allowing us to map a large volume of our calibration magnet.



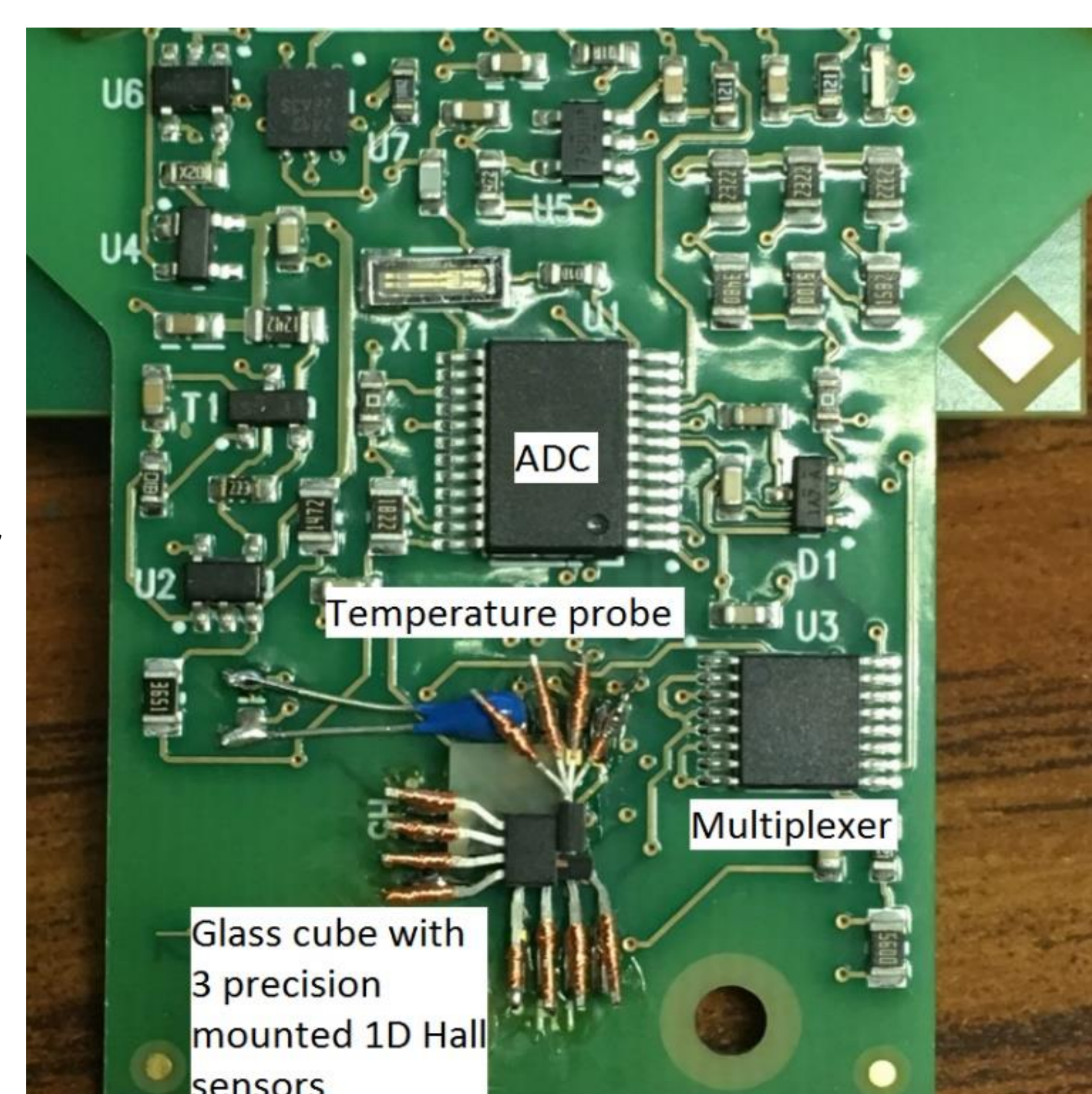
The Kinematic Mounting System

Three precision balls will mate with three features machined into the mounting plate of the HPCE and the propellers of the DSFM: a flat, a V groove, and a cone (below). These three features form a kinematic mounting system; each feature restricts an additional degree of freedom without over-constraining the system. The result is a repeatable mounting system that provides a consistent relationship between the HPCE and the Hall probes



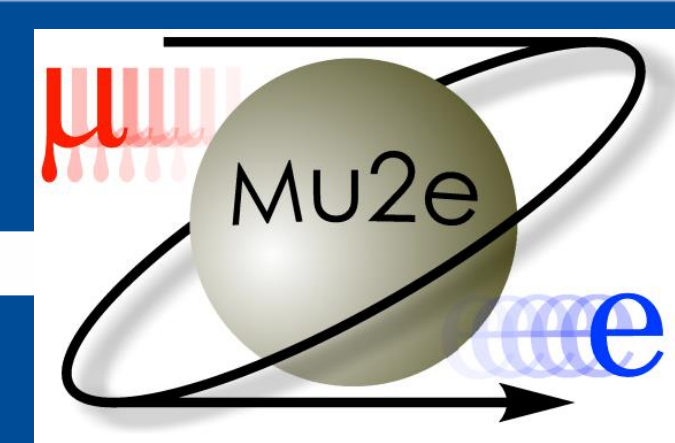
The Hall Probes

The 3D Hall probes are designed by CERN and manufactured by NIKHEF. Three 1D Hall sensors are orthogonally mounted to a precision glass cube. A temperature probe is mounted nearby to compensate for temperature effects. The glass cube resides on a printed circuit board (PCB) containing an analog to digital converter (ADC), a multiplexer, and a microcontroller. Interfaced with a CANopen communication protocol, up to 60 sensor boards can be read by a computer.



To control the temperature effect on the Hall Probe calibration, we will enclose the FNAL calibration magnet within an environmental room of 2.5 m x 2.5 m and control the temperature with a T224-31Eo HVAC unit.

See also S. Feher, et. al., "Mu2e Solenoid Field Mapping System Design," *IEEE Trans. Magnet Technology*, submitted for publication.



The United States Government retains and the publisher, by accepting the article for publication, acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this manuscript, or allow others to do so, for United States Government purposes.

Fermi National Accelerator Laboratory

This work was supported by the US Department of Energy; the Italian Istituto Nazionale di Fisica Nucleare; the Science and Technology Facilities Council, UK; the Ministry of Education and Science of the Russian Federation; the US National Science Foundation; the Thousand Talents Plan of China; the Helmholtz Association of Germany; and the EU Horizon 2020 Research and Innovation Program under the Marie Skłodowska-Curie Grant Agreement No.690385. Fermilab is operated by Fermi Research Alliance, LLC under Contract No. De-AC02-07CH11359 with the US Department of Energy.

Fermilab

U.S. DEPARTMENT OF
ENERGY