INL/EXP-22-68290-Revision-0

Nuclear Remote System Design: Radiation and Electronics

August 2022

Nathan Mark Peck

Changing the World's Energy Future

INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance, LLC

INL/EXP-22-68290-Revision-0

Nuclear Remote System Design: Radiation and Electronics

Nathan Mark Peck

August 2022

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

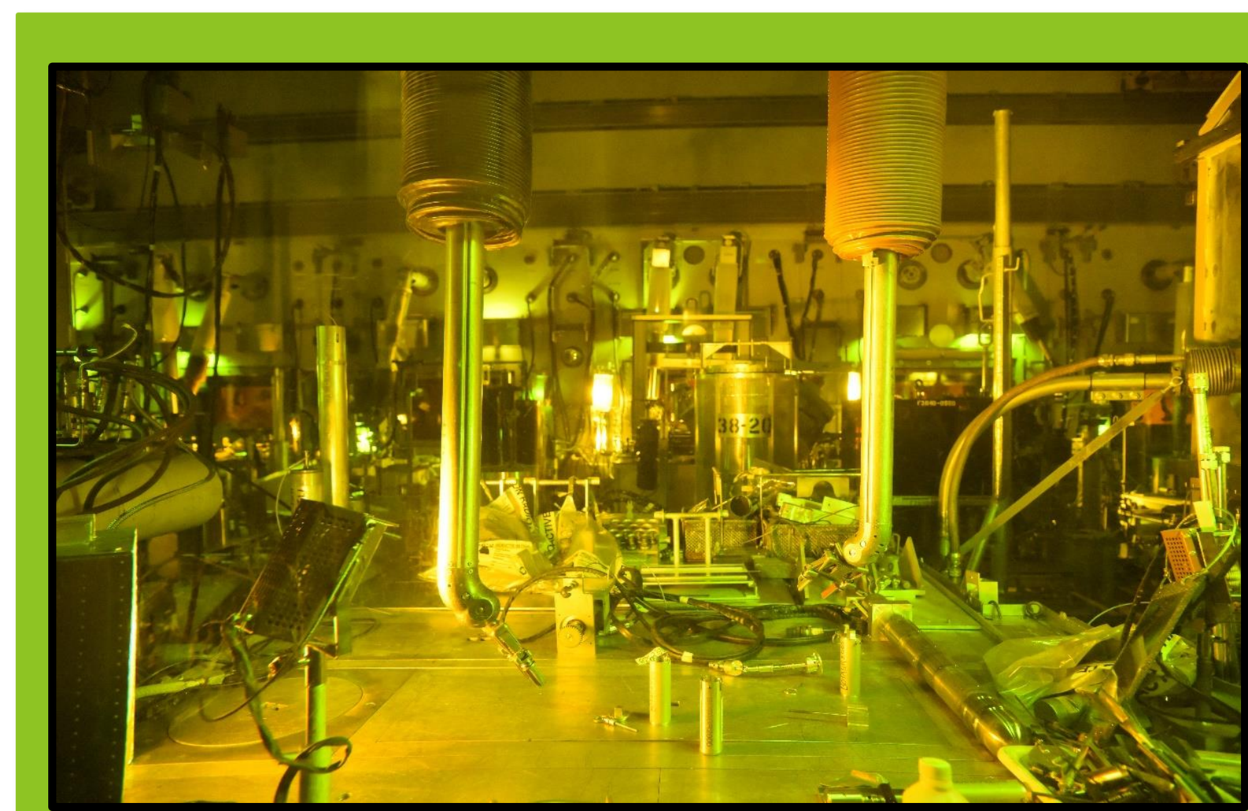
Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

Nuclear Remote System Design: Radiation and Electronics

Nathan Peck | Idaho State University | Nuclear Remote Systems | Mentors: Glen Papaioannou, TJ Harman

What is Nuclear Remote System Design?

The Hot Fuels Examination Facility (HFEF) at INL is dedicated to examining post-irradiated fuels and other materials. The main cell located at the Materials and Fuels Complex (MFC) has a highly radioactive argon atmosphere that presents challenges when conducting research. *Nuclear Remote System Design (NRSD) is the designing, altering, or configuring of systems that would be placed into a controlled radioactive environment.* NRSD at HFEF requires engineers to consider how individual parts in a system will be moved remotely and what type of materials or shielding will be used to increase the durability of in-cell projects.



Inside of the hot cell at HFEF showing a pair of manipulators, *U.S. Department of Energy*

How Radiation Affects the Design Process

When referencing nuclear radiation, three main types of are normally identified, alpha particles, beta particles, and gamma rays. Of these three types, gamma rays have the most penetration capabilities and require shielding of either lead, steel, or concrete. Without shielding, excessive radiation can have detrimental effects to the functionality and lifespan of a variety of materials, especially electronics. When exposed to high amounts of radiation, electronics can experience voltage spikes in analog circuits providing inaccurate results. Wire insulation can also deteriorate and cause shorts in circuits. To combat these and other similar issues, a change in the design process needs to occur. What material is the device made of? What type of shielding would protect it best? How can it be made to simplify the installation process? How can it be operated remotely? These are all questions that become very relevant when designing in-cell equipment and require innovative thinking to find solutions.

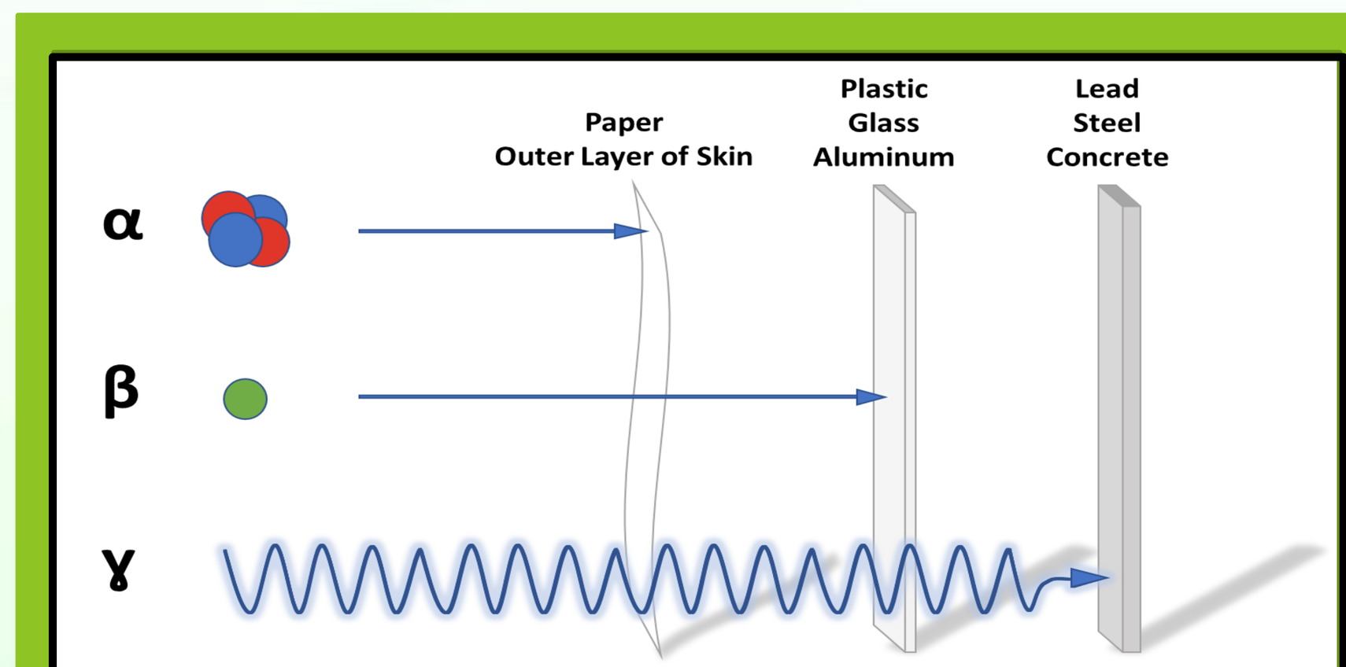
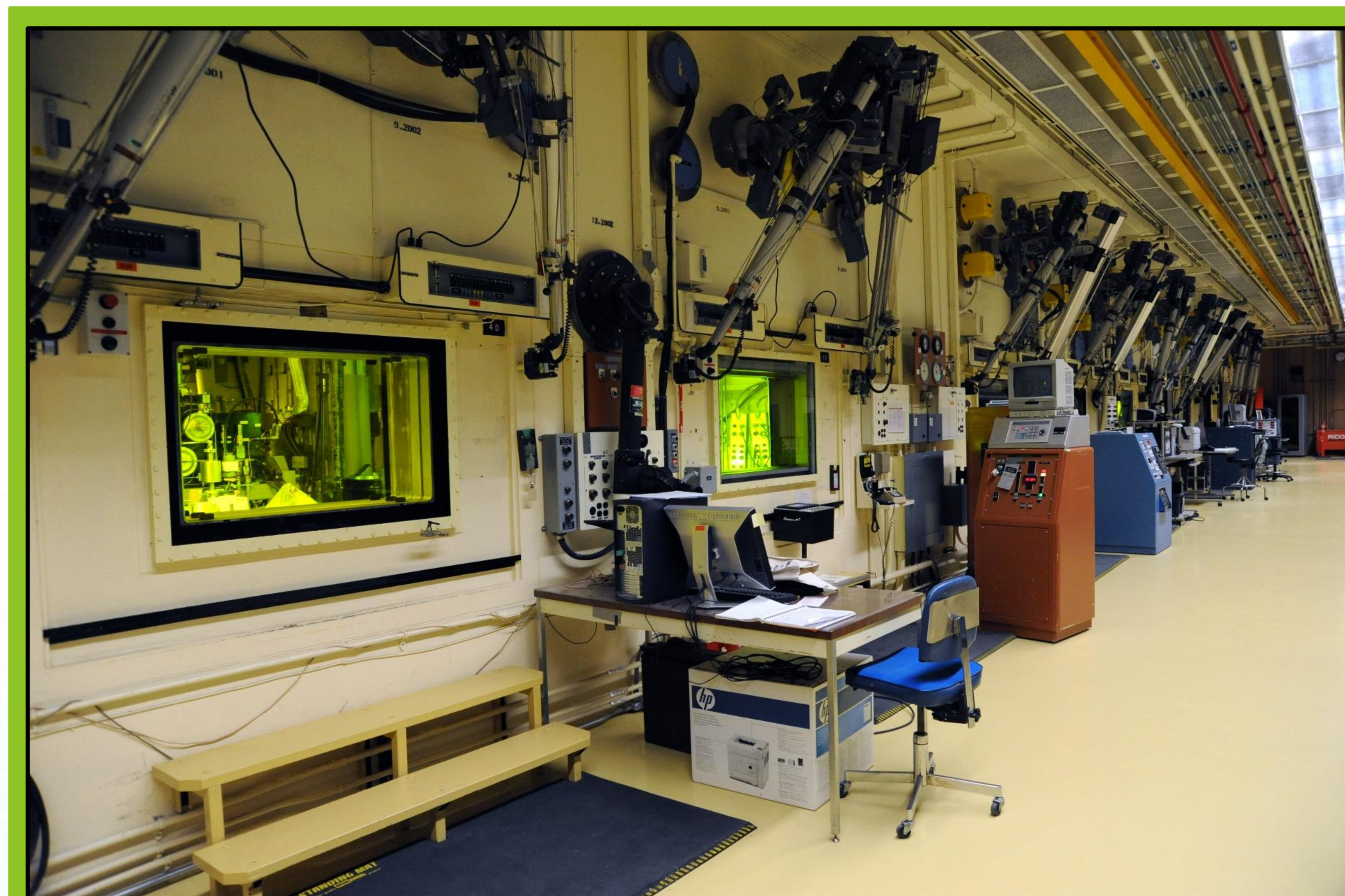


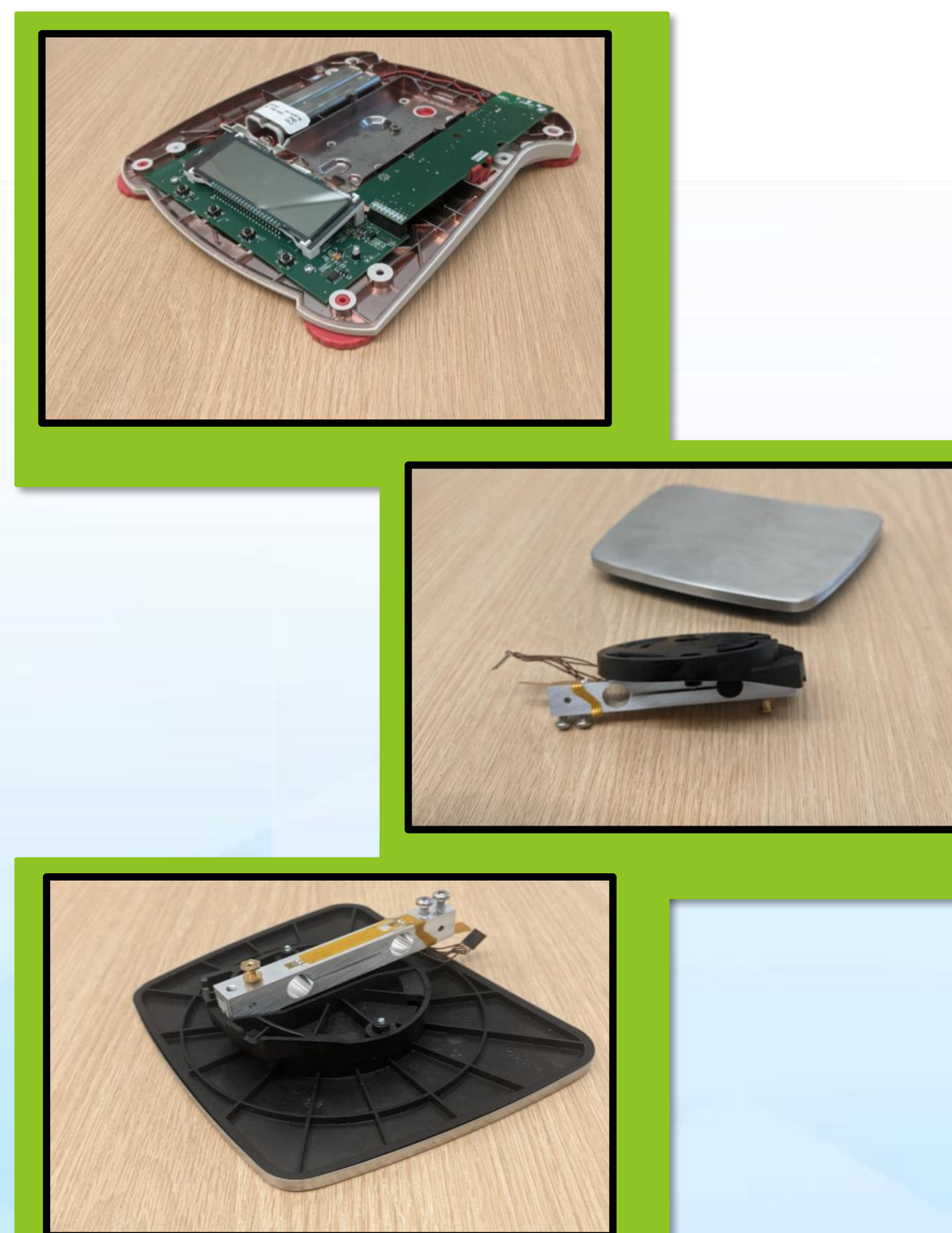
Diagram showing the penetration capabilities of alpha particles, beta particles, and gamma rays

Analytical Balance Replacement

A problem arose when an analytical balance in the hot cell at HFEF began showing signs of periodic failure. For a new analytical balance to be operational for in-cell measurements, several design changes are needed to ensure its functionality and lifespan. Radiologically sensitive portions of the balance are to remain outside of the cell while the essential measuring portions are to be placed in-cell. The two portions are to be connected through a variety of junction boxes and a feedthrough. Crucial design factors include wiring pinouts, compatible junction box connectors, and proper resistant shielding for the wiring and other in-cell balance components. If that isn't difficult enough, all these components must be designed to be picked up, connected, and adjusted by the in-cell manipulators.



Workstation windows outside of the hot cell at HFEF, *U.S. Department of Energy*



Top: Electronics of a balance
Middle, Bottom: Views of a measuring plate

The Impact

Nuclear Remote Systems Design is vital in the functionality and longevity of systems that further the advancement of nuclear study and fuel examination. Well-designed systems for projects like the analytical scale allow for fully functional and reliable measuring equipment to be readily available for future in-cell studies.

www.inl.gov

INL/EXP-22-68290

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy

Idaho National Laboratory