ANL/CSE-13/5

FY-12 Results of Phase-1 Mini-SHINE/MIPS Experiments

Chemical Science and Engineering Division

About Argonne National Laboratory
Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC under contract DE-AC02-06CH11357. The Laboratory's main facility is outside Chicago, at 9700 South Cass Avenue, Argonne, Illinois 60439. For information about Argonne and its pioneering science and technology programs, see www.anl.gov.

DOCUMENT AVAILABILITY

Online Access: U.S. Department of Energy (DOE) reports produced after 1991 and a growing number of pre-1991 documents are available free via DOE's SciTech Connect (http://www.osti.gov/scitech/)

Reports not in digital format may be purchased by the public from the National Technical Information Service (NTIS):
U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Rd
Alexandra, VA 22312
www.ntis.gov
Phone: (800) 553-NTIS (6847) or (703) 605-6000
Fax: (703) 605-6900
Email: **orders@ntis.gov**

Reports not in digital format are available to DOE and DOE contractors from the Office of Scientific and Technical Information (OSTI):
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
www.osti.gov
Phone: (865) 576-8401
Fax: (865) 576-5728
Email: **reports@osti.gov**

Disclaimer
This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor UChicago Argonne, LLC, nor any of their employees or officers, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of document authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, Argonne National Laboratory, or UChicago Argonne, LLC.

ANL/CSE-13/5

FY-12 Results of Phase-1 Mini-SHINE/MIPS Experiments

by
Sergey Chemerisov, Amanda Youker, Andrew Hebden, Peter Tkac, Vakhtang Makarashvili,
Michael Kalensky, Elizabeth Krahn, John Krebs, and George F. Vandegrift
Chemical Science and Engineering Division, Argonne National Laboratory

prepared for
U.S. Department of Energy, National Nuclear Security Administration,
Office of Defense Nuclear Nonproliferation

September 28, 2012

CONTENTS

1 EXPERIMENTAL DESCRIPTION 1

2 ACHIEVEMENTS 2

3 FINDINGS 3

4 MODIFICATION TO THE MINI-SHINE/MIPS SETUP BASED ON LESSONS LEARNED 4

5 CONCLUSIONS 6

FIGURE

1 New Arrangement of the Gas Collection Cabinet 5

FY-12 RESULTS OF PHASE-1 MINI-SHINE/MIPS EXPERIMENTS

1 EXPERIMENTAL DESCRIPTION

This report describes Fiscal Year 2012 (FY-12) results for the first part of the phase 1 mini-SHINE/Medical Isotope Production System (MIPS) experiments, water irradiation. Water-irradiation experiments were implemented to shake down/test equipment that will be used in the mini-SHINE/MIPS experiment with uranyl-salt solutions without the potential hazard of producing radioactive solutions and gases. Test parameters were as follows:

- Beam energy was 10–12 MeV.
- Beam current was 20–400 μA.
- The photo-neutron target was tantalum (Ta).
- The Ta target was surrounded by 5 L of deionized (DI) water in the reaction volume, which was surrounded by a 4-in. light water reflector.
- The temperature of the 5-L reaction volume was controlled by the temperature of the reflector.
- The temperature of the reflector was controlled with a precision of ±0.2°C.
- The 5-L volume was instrumented with temperature-profiling thermocouples.

We also had thermocouples on the entrance and exit of the target-cooling water, the catalytic converter, and the reflector water.

The experiment ran for approximately 60 hr and was stopped due to a vacuum failure at alpha magnet 1. Because it could not be repaired in the short term without extensive beamline work (approximately 3 weeks' worth), we moved directly to the linac upgrade. The water irradiations will be repeated in Fiscal Year 2013 (FY-13) before moving on to sodium- and uranyl-salt irradiations.

2 ACHIEVEMENTS

We verified the following:

- Ta-target performance for up to 4.5-kW beam power;
- Catalytic conversion operation;
- Gas-chromatography with a mass-spectrometer detector (GC/MS) and residual gas analyzer (RGA) performance in a high-radiation field;
- Efficiency of the shielding around sensitive equipment;
- Performance of the data-acquisition system (for temperature); and
- Performance of the gas-analysis and -collection system over long periods of time in a high-radiation field.

We were also able to collect data on beam-transport operations and beam stability, and to test overall linac stability over long periods of operation.

3 FINDINGS

Findings from this study were both positive and negative. These findings were as follows:

- We saw much less hydrogen in the off-gas system than we anticipated. This was likely due to the superb performance of the catalyst for hydrogen/oxygen recombination.

- We need to optimize beam transport.

- The gas-analysis and gas-collection system—as built—was prone to leaks.

- There appeared to be galvanic hydrogen generation due to contact between aluminum and stainless-steel solution vessel parts.

4 MODIFICATION TO THE MINI-SHINE/MIPS SETUP BASED ON LESSONS LEARNED

Improvements to beam transport include the following:

- A new, wider 10-degree bend;
- Water-cooled apertures at all narrow spaces to prevent accidental beam deposition to the beam-pipe wall;
- A new redesigned and fabricated 10-degree magnet; and
- Additional diagnostics (beam-current monitors and beam position monitors) for better beam tuning.

Improvements to the gas-analysis and gas-collection system include the following:

- We installed isolation valves for the catalytic converter so we can bypass it when necessary to measure low hydrogen/oxygen yields.
- We added water traps to prevent water vapor from entering the gas-analysis system.
- The design of the gas-collection system was changed to enclose all compressors inside sealed volumes (see Figure 1).
- We replaced controls that were based on external-pressure switches and relays with pressure transducers located directly on the containment vessels.

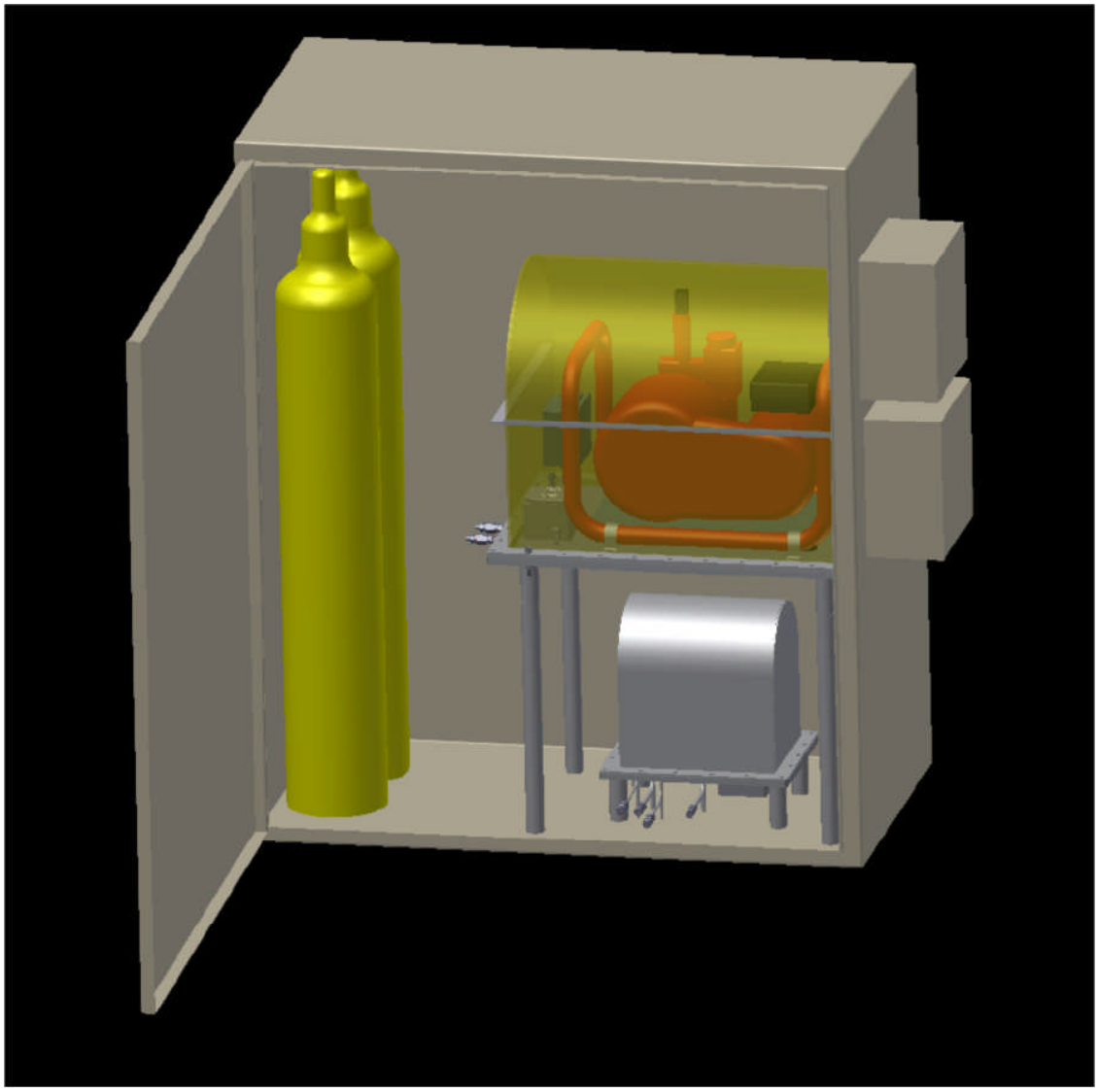

FIGURE 1 New Arrangement of the Gas Collection Cabinet (All compressors are enclosed into sealed volumes.)

5 CONCLUSIONS

Although the FY-12 mini-SHINE/MIPS experiments were far from a complete success, they were certainly fruitful. The lessons learned and the responses/modification they led to have provided a much-improved mini-SHINE/MIPS system.

Chemical Science and Engineering Division
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 205
Argonne, IL 60439-4837

www.anl.gov

Argonne National Laboratory is a U.S. Department of Energy
laboratory managed by UChicago Argonne, LLC