IGEMs/HERC Project Status Report
Idaho Incubation Fund Program

Annual Progress Report

June 30, 2014

Proposal No.	**AHRC03**
P.I. Name:	**Dr. Alan Hunt**
Name of Institution:	**Idaho State University/ Idaho Accelerator Center**
Project Title:	**Development of Commercially viable accelerator produced Isotopes**

Proprietary Information – not for public review

Executive Summary:

During FY2014 the IGEMs funded project **Development of Commercially Viable Accelerator Produced Isotopes** at ISU/IAC succeeded in all of our milestones except delivery of material to our research customers. We were unable to deliver material pending receipt of a license from the Nuclear Regulatory Commission (NRC). However, the NRC did finally complete the inspection for the license on June 24th and plan to issue the license early July. With receipt of the license, we are now able to begin shipments and validation with customers. Our final year of funding will allow us to expand the project into a fully scalable commercial operation.

PROJECT STATUS REPORT MILESTONES

This is the annual status report for FY 2014 for the IGEMs funded project, **Development of commercially viable accelerator produced isotopes**. The project proposal listed the following major project outcomes:

a. Have we established a commercially viable method of producing an isotope that is of economic potential and/or heretofore unavailable?
b. Have we created a technology, method or material that allows the creation of an isotope at a significant improvement in cost (either in direct material expense or capital requirements i.e. “fixed” costs)?
c. Are either a. or b. above proprietary, protectable and licensable to others with the objective of generating a positive return?
d. Have we trained a work force capable of advancing this industry and advancing our technology?

Our milestones are:

1). Simplify and improve the product separation processes suitable for operation in a commercial hot cell 2). Complete all equipment for high power accelerator tests 3). Complete multiple full process tests 4). Transfer separation and purification process to our commercial partner’s hot cell, 5). Delivery of approved quantities to researchers for human trials.

In addition to the above milestones, this project has allowed us to train and support two MS and one PhD graduates, several undergraduates, and partially support 5 key faculty and enginees.

Each of these key milestones will be detailed below with progress.

PROJECT STATUS REPORT – Milestone review

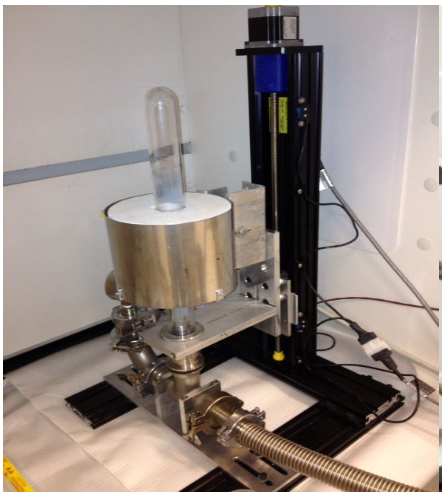
For the year ending June 30th, 2014, (Q4 FY 2014), the following items were completed against the project plan:

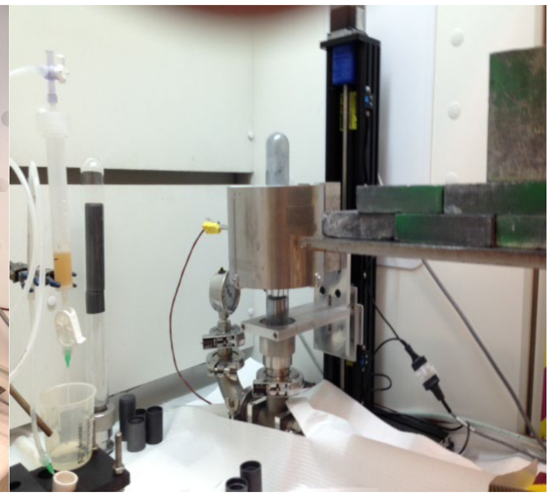
1). Simplify and improve the product separation processes suitable for operation in a commercial hot cell.

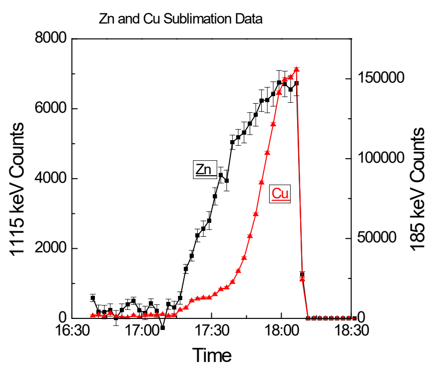
Summary:

This year the team achieved a remarkable advancement in the separation process which has led to two patent applications in progress. Experimental work and optimization has been performed using both natural zinc and highly enriched ^{68}Zn. The process has improved yields to over 96% repeatedly, up from 90% last year.

a). **Sublimation:**







Figures 1, 2, and 3 - Sublimation recovery furnace. Picture on the left shows the newly configured furnace. On the right, the furnace shows the lead brick lined holder for our NaI monitor used to verify the completion of the sublimation cycle. The bottom graph (Figure 3) shows the trace of the accumulation of Zn and the later increase in Cu showing the end of the sublimation cycle.

The sublimation process was substantially changed during this year creating a breakthrough in overall understanding and yield in the process. Figure 1 shows the new sublimation furnace that was notably changed from our previous version (see pictures FY13 final report). The distinctive differences are the use of a quartz tube instead of an alumina tube and internal structures that help collect and separate the sublimated Zn. In addition, the right picture (Figure 2) shows a novel technique we used to determine the actual point that sublimation is completed. This novel technique involved the use of a NaI detector focused on the point of the furnace that the Zn collects after sublimation. By watching the accumulation of Zn and noting if Cu begins to also arrive, the sublimation process can be directly characterized for the many controlling factors. As a result, we made substantial changes to the preparation of the target and the sublimation variables. Figure 3 (bottom) shows an actual graph from the detector monitor process. This monitoring system allowed us to improve sublimation losses of Cu to only 1 or 2 parts per hundred.

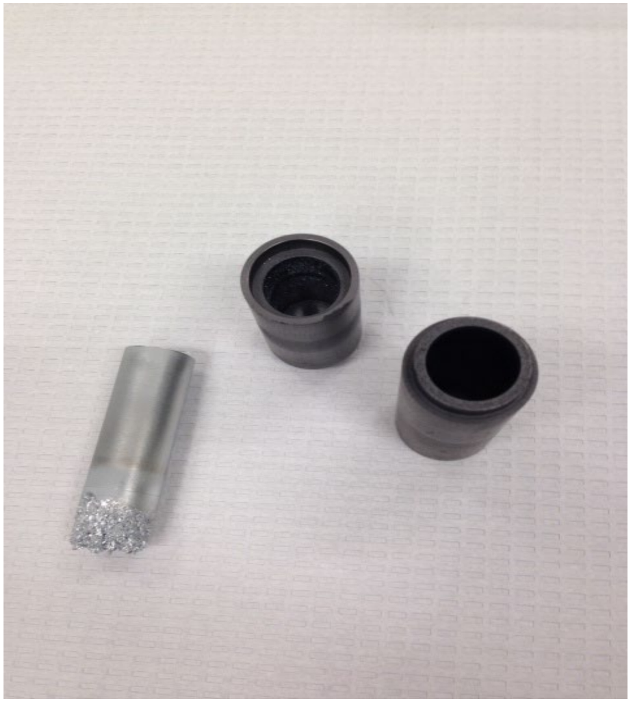


Figure 4 – The patent pending system for Zn recovery.

Figure 4 shows a new system developed to greatly improve the recovery and reuse of expensive Zn starting material. The production process uses enriched ^{68}Zn with a price >$500/gram. It is extremely important for economic reasons to recovery nearly all of the Zn after each run which we have been able to achieve using this new device. The device along with other design ideas and the overall process are in the patenting process therefore we decline to completely disclose the details in this report.

b). **Column separation:**

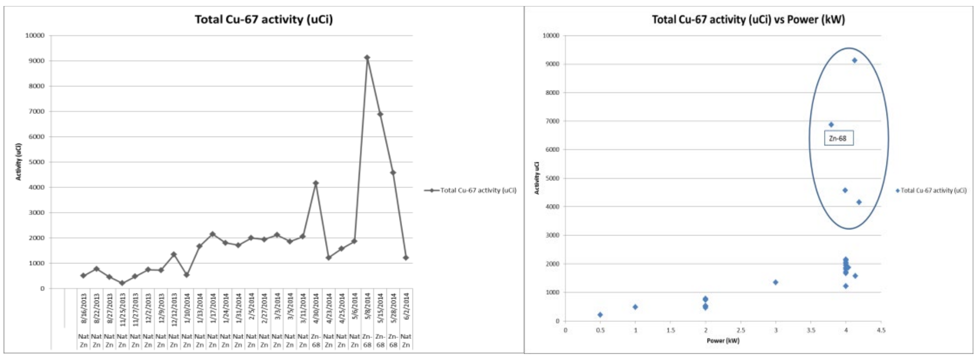
We made only minor modifications to the Column Separation process over the last year.

Figures 5, 6 – The left picture (Fig 5) shows the column separation system outfitted with a specialty adapter for drying the product to a shippable volume. Fig 6, right, shows an actual product vial of Cu-67 for shipment.

Figure 5 shows the product drying system used to evaporate the liquid from the separated ^{67}Cu so it will meet the customer requirements and fit within the specialty shipping vial (shown in figure 6). The drying system uses hot N2 and allows us to complete the drying for shipment in approximately 1 hour.

c). ^{68} **Zinc starting material runs**

We completed runs using our enriched starting material, ^{68}Zn. The initial Zn was refined through multiple “cold” sublimations to remove any trace level metal contaminants. We verified the final quality using an ICP-MS (more on that below). Each target contained approximately $22,000 worth of material, so, maintaining high recovery with no waste (or “oops”) was critical.



Figures 7, and 8 (left) activity created vs date of experiment and type of zinc. Graph 2 (right) activity created vs power in kilo watts.

Our results are shown in Figures 7 and 8. We are pleased with the approximately 5X increase in activity with the enriched Zn – per our physics and economic model.

d). **Analytical testing**

This year we re-installed (at our commercial partner’s facility), tested and utilized an ICP-MS made available by our commercial partner, International Isotopes. The ICP-MS was used to verify the change in purity of our targets with multiple sublimations as well as the total purity of starting materials. The customer base for medical isotopes requires an extremely pure product with a Certificate of Analysis verifying the quality. We have successfully demonstrated this critical analytical tool.

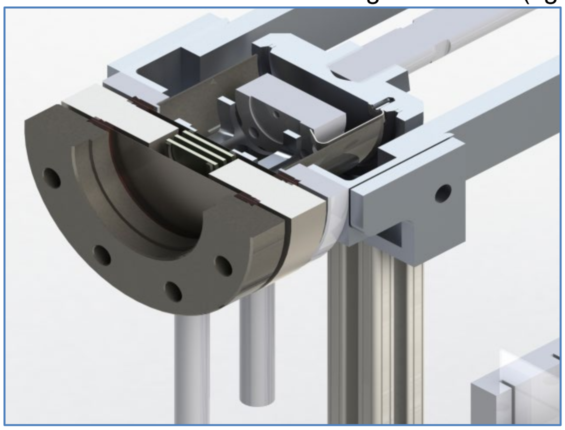
2). Complete all equipment for high power accelerator tests

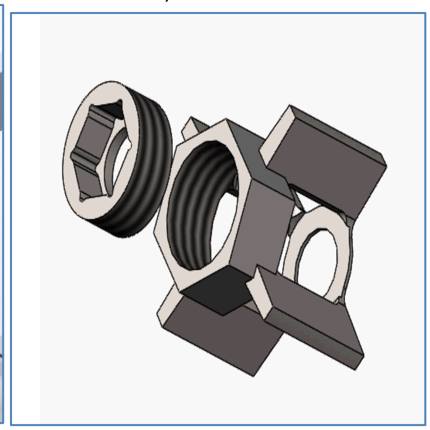
Summary: We completed major upgrades to our accelerator and target handling system so that we can meet our goals of productivity and safety. The currently installed system was designed, manufactured and tested this year with excellent results. We now have a system that is production ready and aspects are incorporated in our pending patents.

Accelerator and target extraction system improvements:

We greatly improved our systems for target irradiation, target cooling, target containment and target extraction.

A filled crucible is placed into a holder that holds a water tight lid on the crucible and centers the crucible into the accelerator target chamber (figures 9 and 10).





Figures 9 and 10. Figure 9 (left)) shows the target chamber with integrated 3 plate converter. Figure 10 (right) shows the target holder.

The target chamber integrates a 3 plate water cooled tungsten converter that is between the beam line and the target holder. The target is also water cooled. Figure 11 shows the target chamber assembly in place behind the accelerator beam exit window.

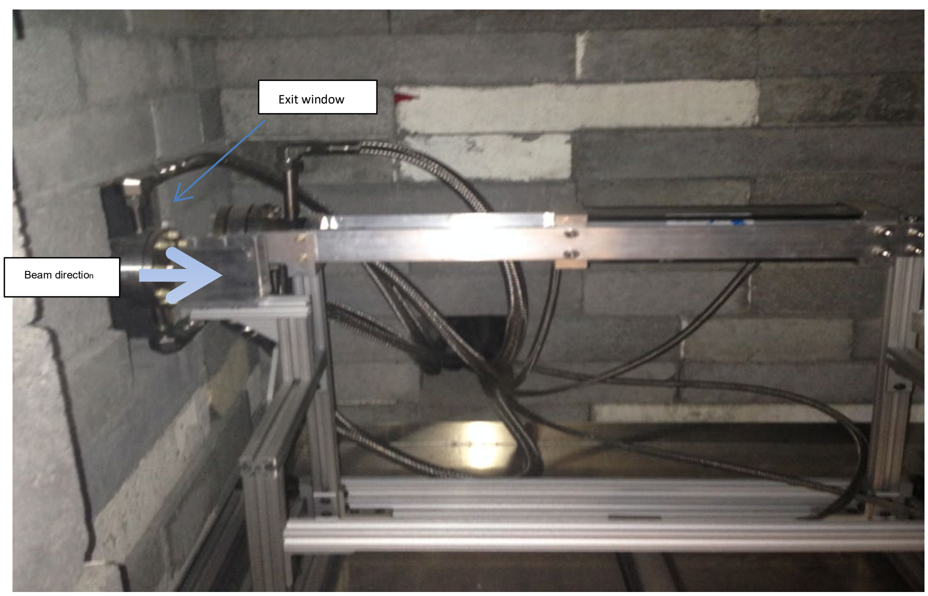


Figure 11 Target irradiation and holding system. This is inside the accelerator radiation chamber and includes a water cooled converter of 3 plates of a suitable bremsstrahlung converting material, This assembly also includes a water cooled target chamber that centers and cools the target during irradiation. This assembly also contains a pneumatic ram for extracting the target automatically after irradiation. Finally, the assembly translates to a position either aligned with the accelerator beam or away from the beam for beam diagnostics or other maintenance tasks.

In addition to the improved target assembly, we developed and tested an automated target shielding and target extraction system. The figure captions explain the operation.

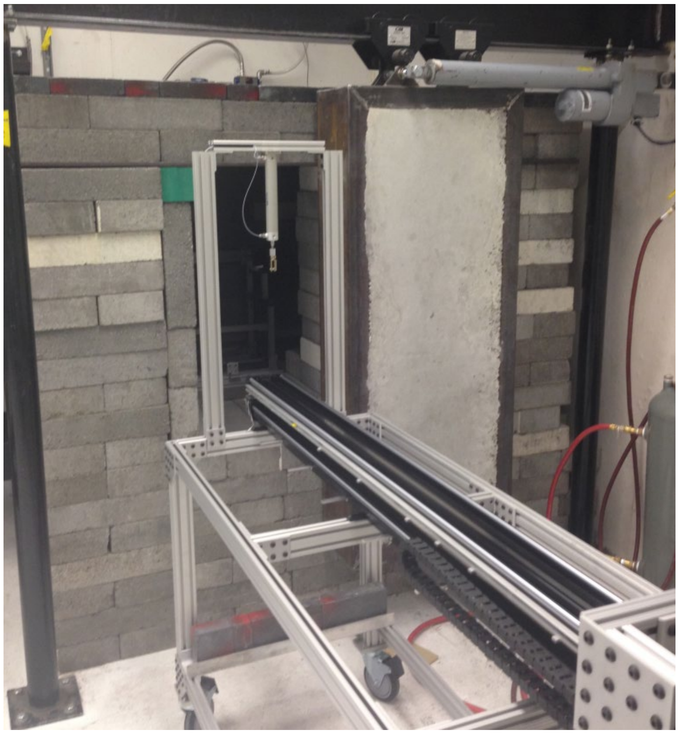


Figure 12 This shows the target extraction system from the accelerator after irradiation. A linear actuating arm travels into the accelerator with a lead pig. The target extraction ram drops the target into the pig then the linear arm removes the pig. Note that the irradiation cell is completely enclosed with an automatic door that only opens for target insertion or extraction – dramatically increasing worker safety.

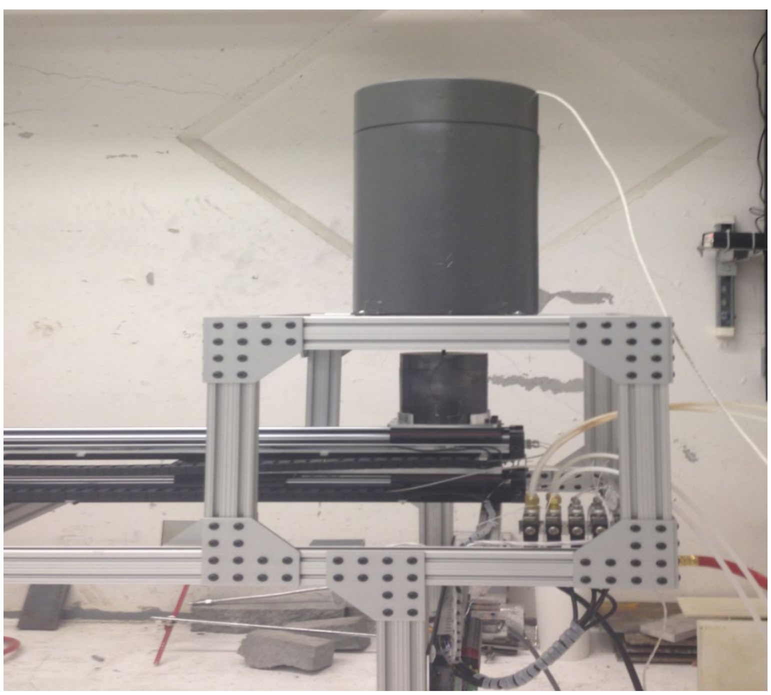


Figure 13 Lead pig in the transport system translated under the ionization chamber used to measure the activity of the sample to determine if the sample was successfully recovered. After this test, the lid is placed on the pig automatically.

3). Complete multiple full process tests

Summary:

The following graphs show the complete runs processed in FY 14. Especially noteworthy is the improvement in overall process yields achieved with the process improvements made during the year. Figure 15 shows that after a key (patent pending) process was added to the target fill system, with the exception of known problems, our yields are consistently in the very high 90's.

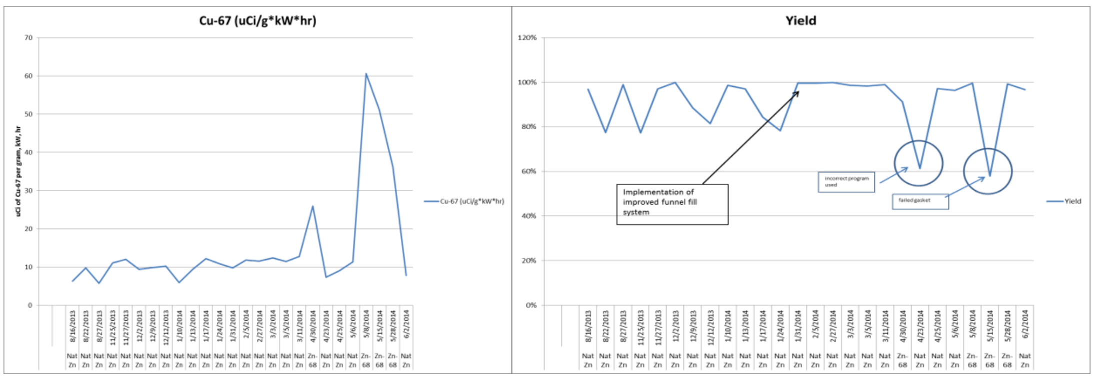


Figure 14 (left) rate of production by date and target type, Figure 15 (right) yield of Cu-67 through separation by date and target.

4). Delivery of approved quantities to researchers for human trials.

Summary:

We were constrained this year in delivering material to customers because of NRC regulations. ISU operates under what is known as a "broad scope" license to hold radioactive materials. We believed based on previous discussions that license would allow us to provide samples to our customers. The NRC ruled in Fall of 2013 that we would not be able to ship without commercial production and distribution licenses. This requirement drove an additional financial investment in the licenses (paid for by other funds) and a very extended process with the NRC. We are pleased to report that the NRC inspected our process and facility on June 24th and verbally indicated that they would issue the license in a very short time (approximately 2 weeks). Finally, we will be able to ship materials to customers.

FINANCIAL

Summary: We believe we have been good stewards of the State's money. We have completed most of our goals well within our budget. The following summary shows our expected

	HERC IGEM
	Alan Hunt
Budget	$541,782.77
Spent	$497,607.05
Remaining	$44,175.72
Encumbered	$22,800.00
Encumbered	$21,375.72
June 30 balance	$0.00

zero balance at the completion of year 2 (June 30th

Intellectual Property and Commercial activity

Intellectual Property

Thanks to additional funding provided by the State of Idaho, we have engaged the patent law firm of Lee and Hays to patent our technology. We have completed an extensive intellectual property disclosure on our process and designs. The applications are in progress.

Commercial Activity

We were unable to provide samples to our customers this fiscal year due to NRC restrictions, however, we have prepared a press-release as well as a go to market plan with our commercial partner, International Isotopes. We have requested funding to centralize all of our process equipment adjacent to our accelerator so that we can easily tour customers and potential licensors of the technology. We are eagerly anticipating commercial deliveries in FY 15.

Summary: We believe we now have a commercial process and infrastructure in place for ^{67}Cu shipments. We are ready to provide material and move this technology development to full commercialization.

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