Plans for Laser Ablation of Actinides into an ECRIS for Accelerator Mass Spectroscopy

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A project using accelerator mass spectrometry (AMS) at the ATLAS facility to measure neutron capture rates on a wide range of actinides in a reactor environment is underway. This project will require the measurement of many samples with high precision and accuracy. The AMS technique at ATLAS is based on production of highly-charged positive ions in an ECRIS followed acceleration in ATLAS and detection is a Fragment Mass Analyser. We have chosen to use laser ablation as the best means of feeding the actinide material into the ion source because we believe this technique will have more efficiency and lower chamber contamination thus reducing 'cross talk' between samples. In addition a multi-sample holder/changer is part of the project to allow quick change between multiple samples. The status of the project, design, and goals for initial off-line ablation tests will be discussed as well as the overall project schedule. This work is supported by the U.S. DOE, Office of Nuclear Physics, under contract No. DE-AC02-06CH11357.

The Experiment

An integral reactor physics experiment whose objective is to determine actinide neutron capture cross-sections.

a) Irradiate very pure samples in the Advanced Test Reactor at Idaho National Laboratory. Samples of Th^{232}, U^{235}, U^{236}, U^{238}, Np^{237}, Pu^{238}, Pu^{239}, Pu^{240}, Pu^{241}, Pu^{242}, Am^{241}, Am^{243}, Cm^{244} and Cm^{248} are planned

b) Use accelerator mass spectroscopy to measure the nuclide densities of actinides produced in irradiation through sequential n-capture processes. Then infer capture cross-sections from these ratios.

c) High precision (~5%) is required to make meaningful inferences of cross-sections.

Controlled Laser Ablation

We will use laser ablation at relatively low power levels to efficiently introduce solid materials into plasma. Benefits of laser ablation expected are:

a) Efficient use of solid materials for AMS and enriched isotopes.

b) Less sensitive to material chemical composition.

c) Cleaner source operation (yet to be proven).

d) Decouples source operation from material insertion.

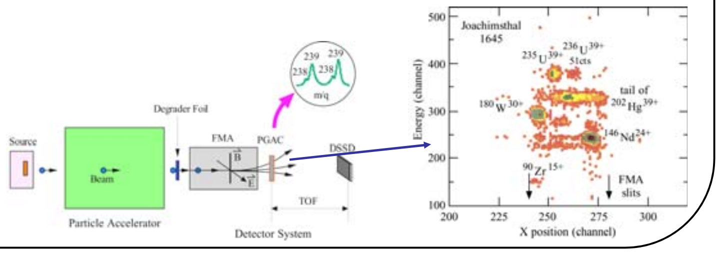
A Passat Diode-Pumped Solid-State HELPP 1064 Laser has been ordered.

- λ =1064 nm
- ≤10^{11} W/cm^2
- 8 ps pulse width
- Rep Rate up to 400 Hz
- Laser beam size ~7 mm maximum
- less than 1 mm diameter spot on sample
- Pulse energy: variable, up to 10 mJ/p
- Delivery in October 2010

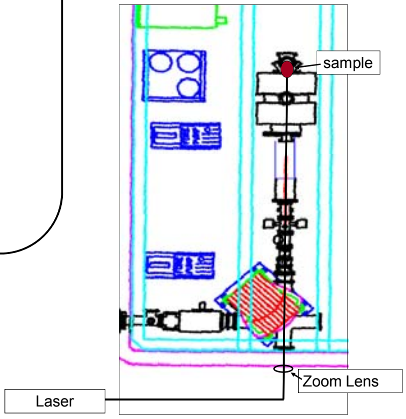
AMS Challenges for this Experiment Include:

- Small sample size (few mg total, actinide component <1mg)
- large number of samples desired to reduce errors
- No cross-talk between samples
- Stable, repeatable transmission between source and ion detector
- Limited "Z" element resolution in detectors

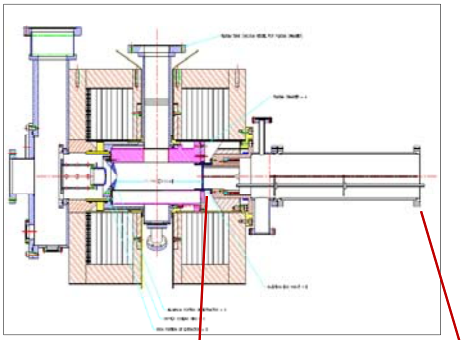
AMS of ^{236}U



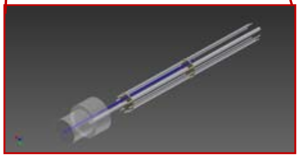
Axial Geometry planned.



ECR-II shown with 20-sample changer



Multisample Changer



Earlier work measured ablation rates at low power

	Laser Ablation Rate Measured with Pulsed Nd:YAG Laser					
Rep Rate (kHz)	Pb	Ta	Ni	Sn	Al	
6	1.6	0.01	0.053	8.8	0.21	ng/pulse
	35	0.21	1.6	191	4.6	mg/h
	3.7	12.5	12.5	3.7	12.5	W
	0.62	2.1	2.1	0.62	2.1	mJ/pulse
	0.42	1.5	1.5	0.42	1.5	10^7 W/cm^2
2	0.93	0.057	0.046	17	0.17	ng/pulse
	6.7	0.41	0.33	122	1.2	mg/h
	2	5.3	5.3	2	5.3	W
	1	2.7	2.7	1	2.7	mJ/pulse
	0.68	1.9	1.9	0.68	1.9	10^7 W/cm^2

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