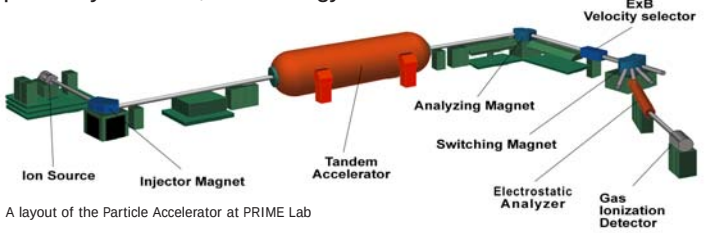
# NOVEL IMPROVEMENTS IN ACCELERATOR MASS SPECTROMETRY

MUHAMMAD HASAN
RICHARD FLAREND
Division of Mathematics & Natural Science,
Penn State Altoona, Altoona PA 16601

In Accelerator Mass Spectrometry (AMS), $Al_2O_3$ is used as a target that results in a very low source efficiency. A typical $Al_2O_3$ beam current is about 100nA. The objective of this research project is the development of an Aluminum-26 material that is much more efficient than $Al_2O_3$. The research was initiated by testing various Aluminum-26 compounds such as Aluminum Boride ($AlB_2$), Aluminum Carbide ($Al_4C_3$), Aluminum powder and Aluminum Nitride (AlN). This process took time and effort in preparation of samples, their storage and then the actual processing of the data. Funded by the National Science Foundation (EAR-0216207), this research is carried out at both Penn State Altoona and PRIME lab at Purdue University.

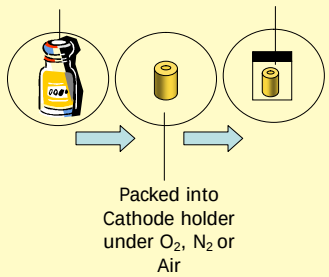
## What is Accelerator Mass Spectrometry?

Accelerator mass spectrometry (AMS) is a technique for measuring long-lived radio-nuclides that occur naturally in our environment. AMS uses a particle accelerator in conjunction with an ion source, large magnets, and detectors to separate out interferences so that single rare radio-nuclides can be counted in the presence of $1x10^{15}$ (a million billion) stable atoms. AMS is used for a wide variety of dating and tracing applications in the geological and planetary sciences, archaeology and biomedicine.




A layout of the Particle Accelerator at PRIME Lab

## STEP 1 Preparation of Samples




For every sample, different combinations of atmosphere are tested.

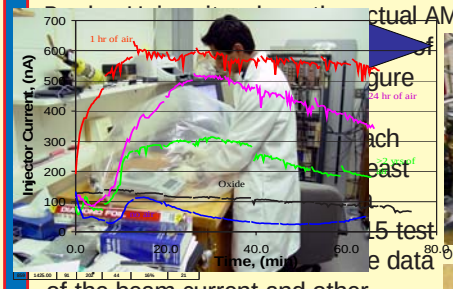
Samples used are commercially available and are shipped in container with Nitrogen or Argon so that there is no exposure to air. Then from their original containers they are hand packed into the cathode holder as shown in the figure on the left. After that their long term storage can also be varied. Hence, this gives us several different combinations to test during AMS. Some samples have to be stored in a different gas due to their reaction with air. An air bag is used to keep the sample from being contaminated by air as shown in the figure below.

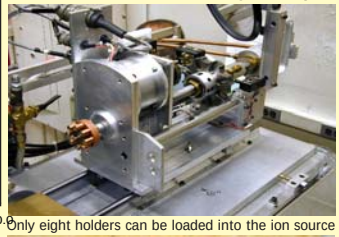
Apparatus used to pack samples

A glove bag is used to prevent contamination from air

## STEP 2 Accelerator Mass Spectrometry

Once all the samples are prepared they are taken to PRIME lab at [illegible] actual AMS is conducted. Every sample [illegible] of [illegible] figure [illegible] each [illegible] least [illegible] 15 test [illegible] e data of the beam current and other accelerator parameters are collected and stored on a computer.



Only eight holders can be loaded into the ion source

Cathode holders

## STEP 3 Analysis of Data

```
26-JUL-02  14  10| ALZ7 injector field: 43333.8kG
22:21:180  14  5|0| Ursula HOLDING, push START (F6) when ready
22:21:554  14  3|0| MODES: 1 5 9 19
22:22:319  14 5|10| M1FINJCYC: 1 ==> 100 default number of cycles for a sample or
22:22:403  14 5|10| M1FINJCYC: 1 ==> 100 default maximum cycles for a blank
22:24:391  14 5|10| M1FINJCYC: 1 ==> 100 default number of cycles the first time
22:24:459  14  1|| New wheel crossed, changed to sample 101
22:25:221  14 5|10| M1FINJCYC: 100 ==> 99 default number of cycles for a sample or
22:25:277  14 5|10| M1FINJCYC: 100 ==> 500 default maximum cycles for a blank
22:25:343  14 5|10| M1FINJCYC: 500 ==> 99 default maximum cycles for a blank
22:25:448  14 5|10| M1FINJCYC: 100 ==> 99 default number of cycles the first time
22:26:101  14  1|| New wheel crossed, changed to sample 101
22:26:235  14  6| TK disconnected from URSULA
22:26:363  14  6| TK connected to URSULA
22:26:403  14  6| TK disconnected from URSULA
22:28:176  14  6| TK connected to URSULA
22:28:211  14  1|| New wheel crossed, changed to sample 101
22:30:460  14 5|10| FMBVAR 5.000 ==> 25.00 allowed variation in currents
22:34:455  14  6| TK disconnected from URSULA
22:39:857  14  6| TK connected to URSULA
22:39:921  14  1|| New wheel crossed, changed to sample 201
22:40:235  14  1|1| Started data acquisition after 19.1 min
26-JUL-02  14 300| Begin cycling, sample 101
26-JUL-02  14 330| MODES: 1 5 9 19
22:40:264  15  1|| ++++++ ALZ7 +++ ALZ7 +++  Sample: 201  ID: B93-0833,3A
26-JUL-02  15  10| ALZ7 injector field: 43333.8kG
22:40:269  15  5|0| Ursula HOLDING, push START (F6) when ready
22:43:249  15 330| MODES: 1 5 9 19
22:44:164  15 330| MODES: 1 5 9 19
22:47:500  15 5|10| M1FMAFTB, 50 ==> 0 time in ticks to wait for NEW sample to
22:48:046  15 5|10| M1FMAFTB 10 ==> 0 time in ticks to wait for OLD sample to
23:10:268  15 330| MODES: 1 5 9 10 19
```

STAGE 1

First the raw data, over 20,000 lines of text for every eight samples, is converted to a database format which can be manipulated using Microsoft® Excel.

STAGE 2

Once converted to database, all the unwanted data is eliminated. The remaining data is then sorted by sample and used for graphing and final analysis.

| Sample | Sample Time (min) | Cycle | Injector Current (nA) | Transmission | Image Current (pA) | Charge C |
|---|---|---|---|---|---|---|
| 201 | 0.0 | 2565 | 126 | 0.15 | 56.7 | 6438.6 |
| 201 | 0.3 | 2561 | 127 | 0.16 | 57.16 | 8813.5 |
| 201 | 0.6 | 2562 | 128 | 0.15 | 57.8 | 11210.9 |
| 201 | 0.9 | 2563 | 129 | 0.15 | 58.05 | 13602.2 |
| 201 | 1.2 | 2564 | 129 | 0.16 | 61.92 | 16004.5 |
| 201 | 1.6 | 2565 | 129 | 0.16 | 61.92 | 18406.8 |
| 201 | 1.9 | 2566 | 130 | 0.16 | 62.4 | 20900.8 |
| 201 | 2.2 | 2567 | 130 | 0.16 | 62.4 | 23391.8 |
| 201 | 2.5 | 2568 | 130 | 0.16 | 62.4 | 25775.8 |
| 201 | 2.8 | 2569 | 130 | 0.16 | 62.4 | 28306.8 |
| 201 | 3.1 | 2560 | 129 | 0.16 | 61.92 | 30867.8 |
| 201 | 3.4 | 2561 | 128 | 0.16 | 61.44 | 33038.6 |
| 201 | 3.7 | 2562 | 127 | 0.16 | 60.96 | 35413.5 |
| 201 | 4.1 | 2563 | 127 | 0.16 | 60.96 | 37826.5 |
| 201 | 4.4 | 2564 | 128 | 0.16 | 61.44 | 40194.5 |
| 201 | 4.7 | 2565 | 129 | 0.16 | 61.92 | 42619.7 |
| 201 | 5.0 | 2566 | 129 | 0.16 | 61.92 | 45022 |
| 201 | 5.3 | 2567 | 130 | 0.16 | 62.4 | 47463 |
| 201 | 5.6 | 2568 | 129 | 0.16 | 61.92 | 49875.2 |
| 201 | 6.0 | 2569 | 129 | 0.16 | 61.92 | 52502.6 |
| 201 | 6.4 | 2709 | 139 | 0.15 | 62.55 | 55796 |
| 201 | 6.8 | 2710 | 138 | 0.14 | 58.38 | 58049.6 |
| 201 | 7.1 | 2711 | 139 | 0.16 | 66.72 | 61634 |
| 201 | 7.4 | 2712 | 139 | 0.16 | 66.72 | 64347.2 |
| 201 | 7.8 | 2713 | 136 | 0.15 | 60.75 | 67362.2 |
| 201 | 8.1 | 2714 | 139 | 0.14 | 58.38 | 69961.5 |
| 201 | 8.4 | 2715 | 137 | 0.15 | 61.65 | 72513.4 |

STAGE 3

## RESULTS

- Aluminum Nitride samples perform 300% to 500% better than Aluminum Oxide.
- For some unknown factor, the exposure to air of the samples improves the results dramatically.
- The most optimum exposure to air appears to be less than one hour.
- Additional samples, with different combinations of exposure to air, need to be measured in order to reach a full conclusion about this research..

| Sample | Injector Currents (nA) | | | |
|---|---|---|---|---|
| | Start | Maximum | Average (1hr) | Average (20mins) |
| Oxide | 130 | 140 | 100 | 120 |
| Nitride, exposed to air for < 1 hr | 200 | 490 | 370 | 370 |
| Nitride, exposed to air for 1-4 days | 110 | 490 | 320 | 300 |
| Nitride, exposed to air for >2 yrs | 60 | 300 | 225 | 170 |
| Nitride, no exposure to air (<45 sec) | 90 | 220 | 140 | 150 |