Neutron Profiling for Neutron Activation Analysis

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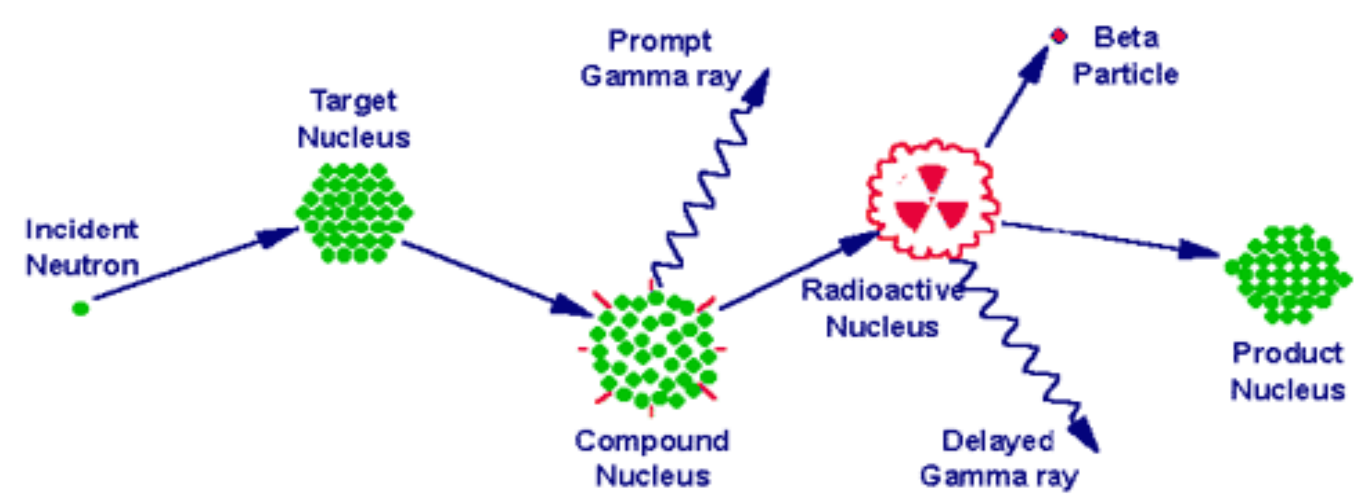
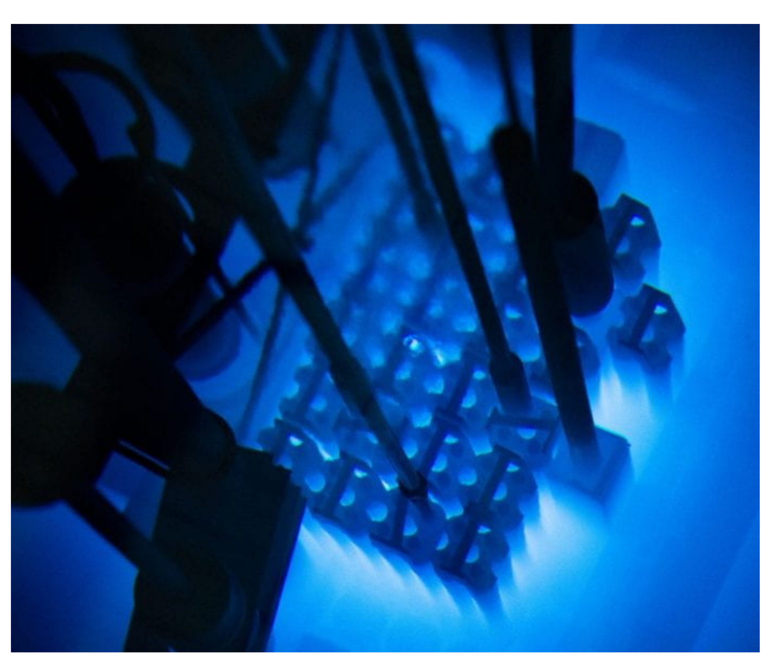
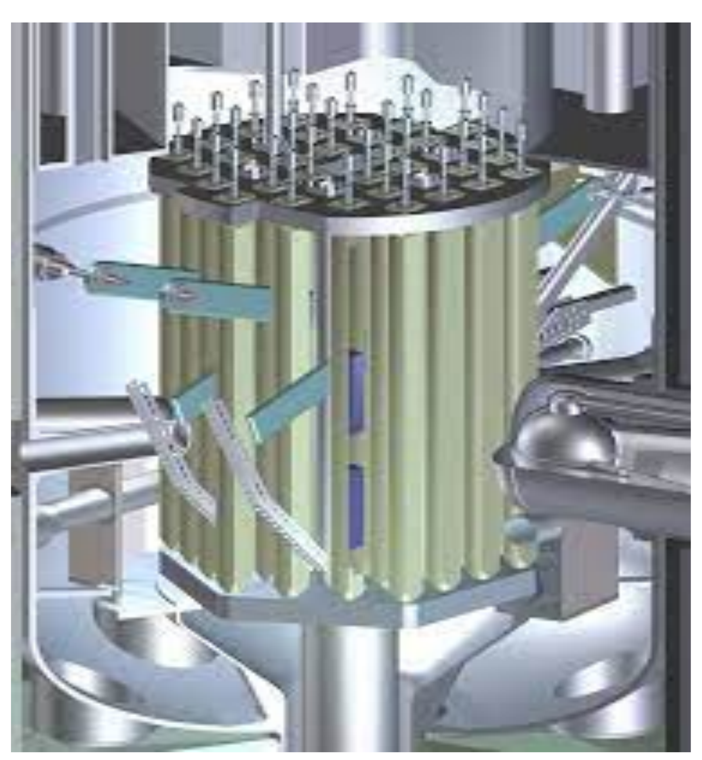
INTRODUCTION

Neutron Activation Analysis is a tool to quantify the number of elements inside a given sample by measuring the gamma rays emitted from a sample that was irradiated by neutrons. Using the reactor core at the University of Maryland as a neutron source, the samples are carried in a capsule to be irradiated inside of the core.

Samples can be irradiated using the system in place, but without knowing the relative neutron flux as well as distribution of neutrons at different energies, experiments that need to know the neutron field at the specific position of the samples during irradiation will not work. In this project, we developed a neutron flux profile of the UMD reactor core as a collaborative effort between NIST and UMD.







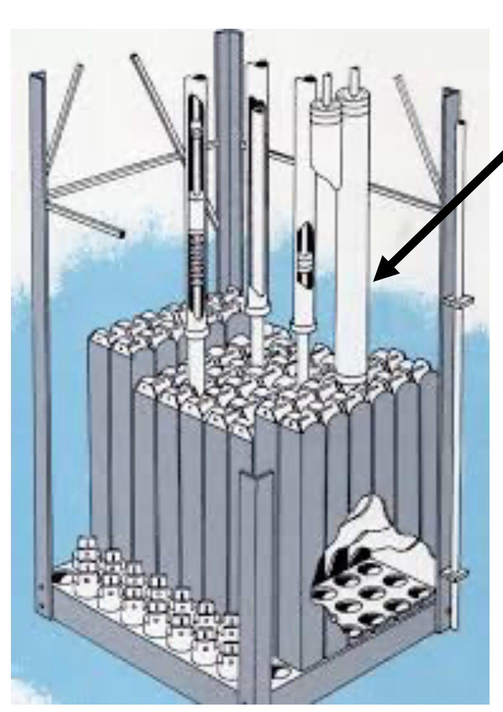
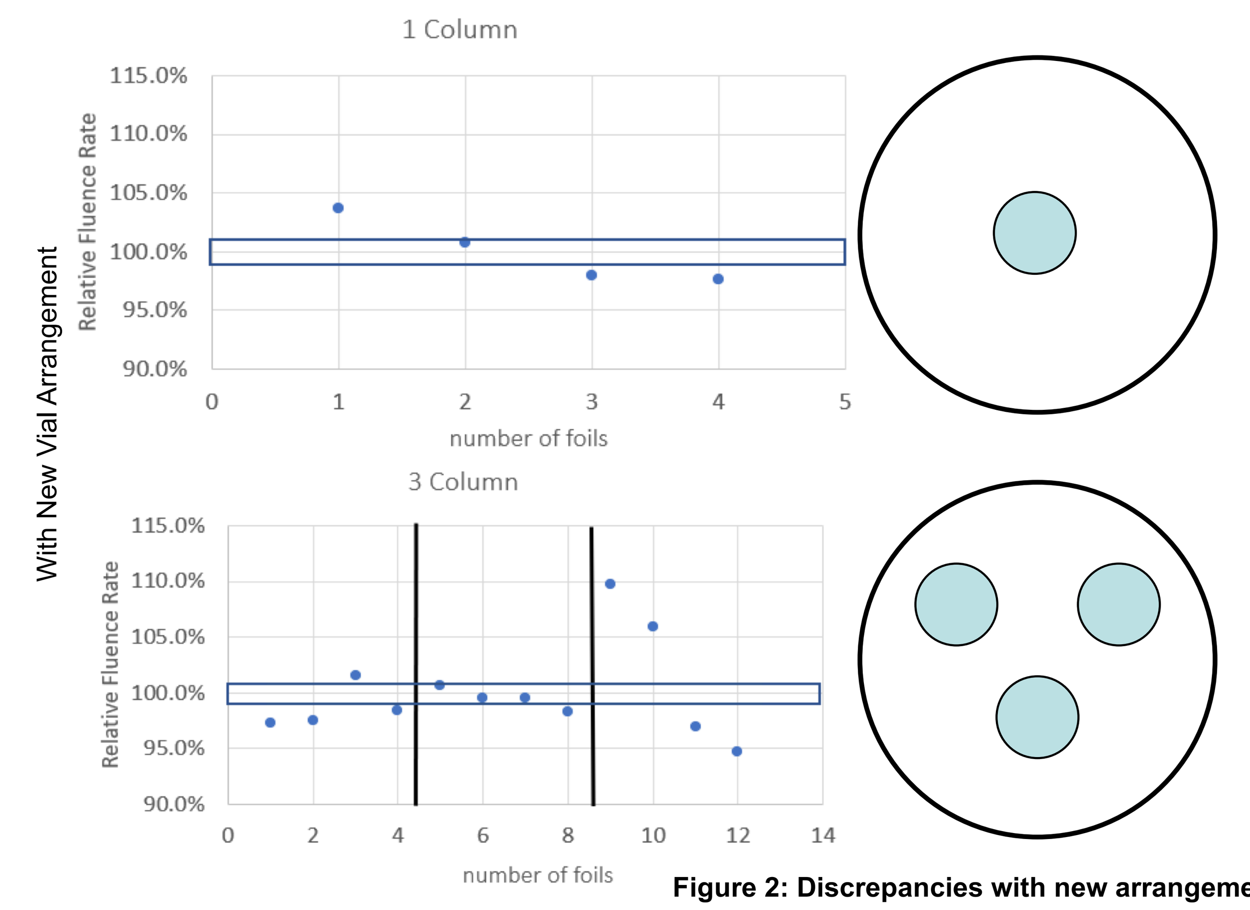


Figure 1: Schematic of nuclear reactor core with rabbit tube identified

Background

The samples first taken down into the core of the reactor via a rabbit system (Figure 1.) into the core of the reactor to be irradiated during a certain amount of time. During irradiation, the neutrons in the core collide with the target nucleus of the sample inside the rabbit and make a radioactive nucleus which will decay into a more stable product by emitting a beta particle and delayed gamma ray. This gamma ray tells us a lot about the specific element from which it is emitted, which is also proportional to the amount of that element, as well as the energy of the neutrons captured.



Fe1		
Fe2	1	Std 1
Fe3	5	Sample
Fe4	2	Std 2
Fe5	6	Sample
Fe6	3	Std 3
Fe7	9	QC
Fe8	7	Sample
Fe9	4	Std 4
Fe10	8	Sample

Figure 2: Discrepancies with new arrangement of vials within the rabbit.

Problem/Motivation

In the reactor at NIST, when irradiating samples there is a neutron drop inside of the capsule. To correct for this, the capsule is rotated 180° during irradiation. When introducing new vials to hold powered samples within the rabbit, it was discovered that the traditional corrections for neutron flux drop-off was no longer accurate (Figure 2). The three-column arrangement was worth investigating and so we begun at UMD.

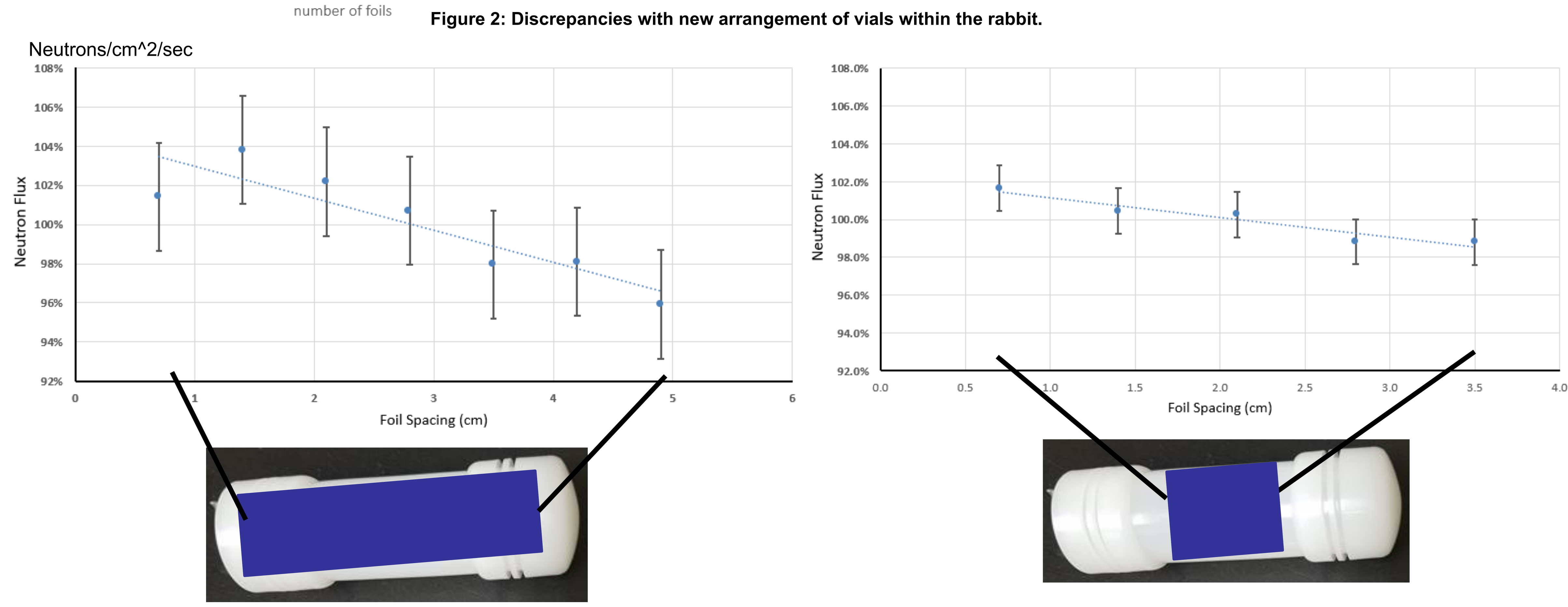


Figure 3: Neutron Flux inside rabbit during irradiation.

Table 1: Values for the thermal and epithermal neutron fields.

	Thermal+Epithermal Neutrons/cm^2/sec	rsd%	Epithermal Neutrons/cm^2/sec	rsd%	Thermal only Neutrons/cm^2/sec	rsd%
Cu	1.75E+12	5%	6.19E+10	9%	1.70E+12	4%
Zn	1.85E+12	3%	6.69E+10	1%	1.75E+12	7%
Ni	1.75E+12	7%	N/A	N/A	N/A	N/A

METHODS AND MATERIALS

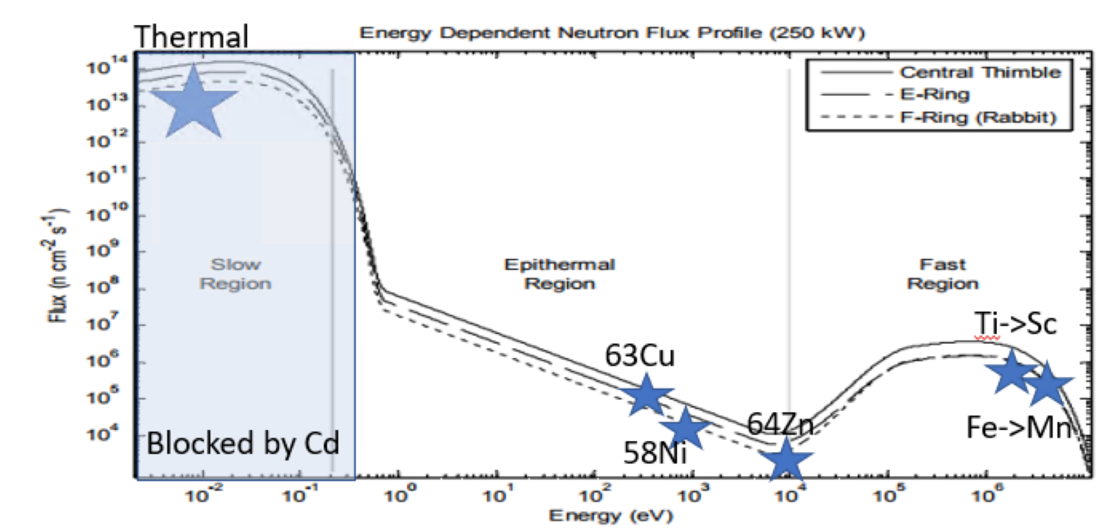
- ❖If enough samples are irradiated, a graph can be generated that is representative of the neutron field at the rabbit's specific position.
- ❖Using different foils to irradiate, we have the advantage of being able to target different regions of neutron energies
- ❖Using Fe, Zn, Ni, and Cu metal foils as samples as well as Cd covers on some foils.
- ❖Using High Purity Germanium detectors for gamma acquisition, we measure the number of captured neutrons by the release of gamma rays
- ❖Since neutron capture is dependent on the type of metal, as well as the energy of the neutron, we can calculate the total neutrons in the foils as well as their energies.

RESULTS

Figure 3. Iron Foils plot out the shape of Neutron Flux of Rabbit

The irradiated iron samples serve to show the shape of the flux within the rabbit during irradiation. To the left is a view of the full length of the neutron profile of the rabbit which is useful for irradiations with many samples and to the right a view with a focus on the center region of the rabbit for a more accurate reading of the neutron field for fewer samples.

Figure 4. Neutron Energy via Copper, Zinc, and Nickel foils



Using different metal foils give us the advantage of being able to target different regions of neutron energy. The first column in Table 1 shows the foils exposed to the full range of neutron energy. Next, to isolate the neutrons in the epithermal and fast energy regions, cadmium covers were used to block the thermal neutrons. This method allowed us to know the energy of neutrons inside the core which helps us better understand the UMD reactor.

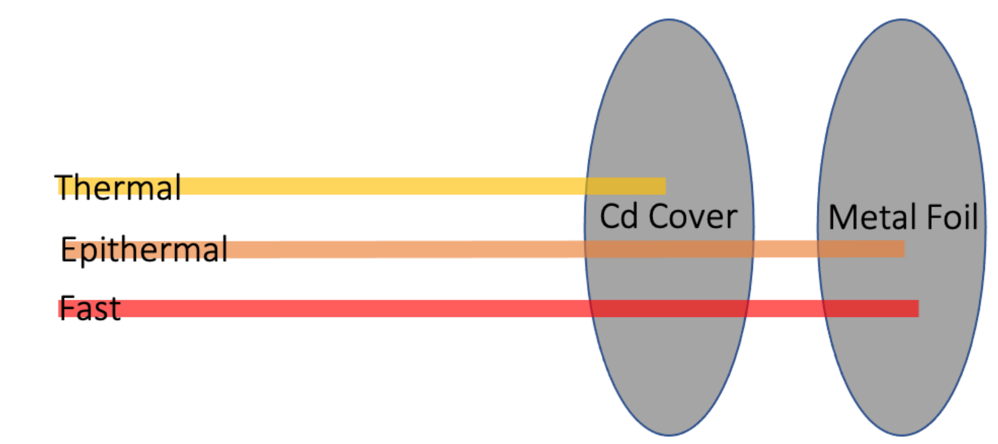


Figure 4:Cadmiun coverings block out thermal energy neutrons

SUMMARY AND FUTURE WORK

- ❖We developed the shape of neutron flux within the UMD reactor
- ❖We discovered the number of neutrons in different energy regions that are within the neutron field during irradiation
- ❖With all this we would also like to plot out the neutron energy shape of the reactor
- ❖We plan to also use this moving forward to investigate the reasons for discrepancies with the new vials and arrangement