BNL BLIP Irradiation Experiment Planning

RaDiATE Collaboration

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BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

Office of Science

U.S. DEPARTMENT OF ENERGY

STATUS & CRITICAL Path:

1st presentation of experiment to Safety Committee for consideration and planning purposes for isotope production and other research.

Isotope Production Planning is crucial so they will permit the experiment to go-on.

During the last RUN with research targets upstream of isotopes, a failure occurred – 2nd RbCl capsule burst with loses of 13 days of beam running

That has put an extra pressure and therefore passing the experiment through the committee will be more challenging.

Isotope production loses ~16% of isotope yield with the RaDiATE experiment upstream of it. This translates to hundreds of thousands of $ (BNL contribution towards the experiment)

STATUS & CRITICAL Path:

To get to the 1st meeting with committee (early October) key things MUST happen:

Have a complete assessment of the IMPACT on isotope production (energy at isotope target location 93.5-94 MeV), undisturbed profile, adherence to the amount of water column, and proof that no failure will occur that will disrupt production

Clear Scenario of how the experiment will proceed. Swapping one capsule (CERN heavy capsule) with an equivalent one is easy on paper.

Reconfiguration of the array at the end needs to happen and remotely:
New capsule will require new holder, new vacuum degrader with a new holder.
With precise dimensions getting them in place in the hot cell is a concern

STATUS & CRITICAL Path:

A clear procedure of what happens beyond EOB

- How hot the array will be and should stay at BLIP Hot cell (cannot be very long)
- Transport to the main hot cells (dose assessment ➔ when after EOB?
- Opening in main hot cell (or waiting for entire capsules to cool-down and ship them to appropriate destination)
- Transferring to my experimental area for sorting
- Sorting and shipping
- Shipping requirements (dose/activity measurements, isotopes …)

CRITICAL Path:

All of these activities between EOB and Shipping out (or performing PIE at BNL) ARE laborious and expensive

The PIE phase for every participant in the experiment MUST include funds for BNL EOB phase:

Hot Cell time
Health Physics time
Operator time
Scientist time

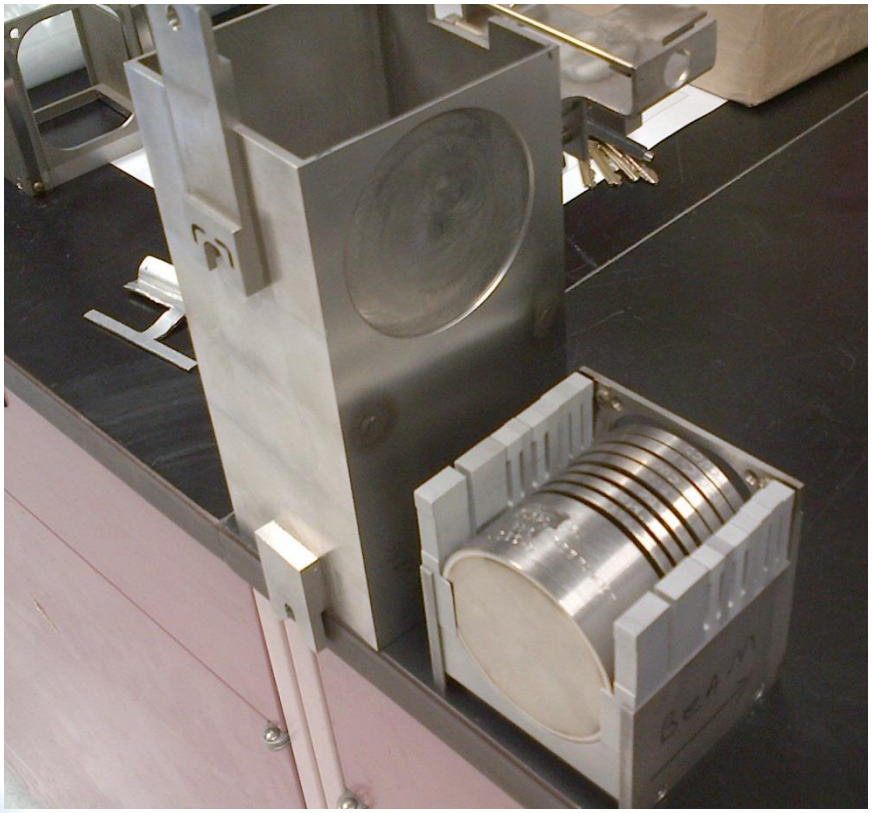
Material capsules (Ti, Al and added Ti) capsule, if the Al capsule calcs are an indicator will require half a year or so at the BNL hot cells before anything

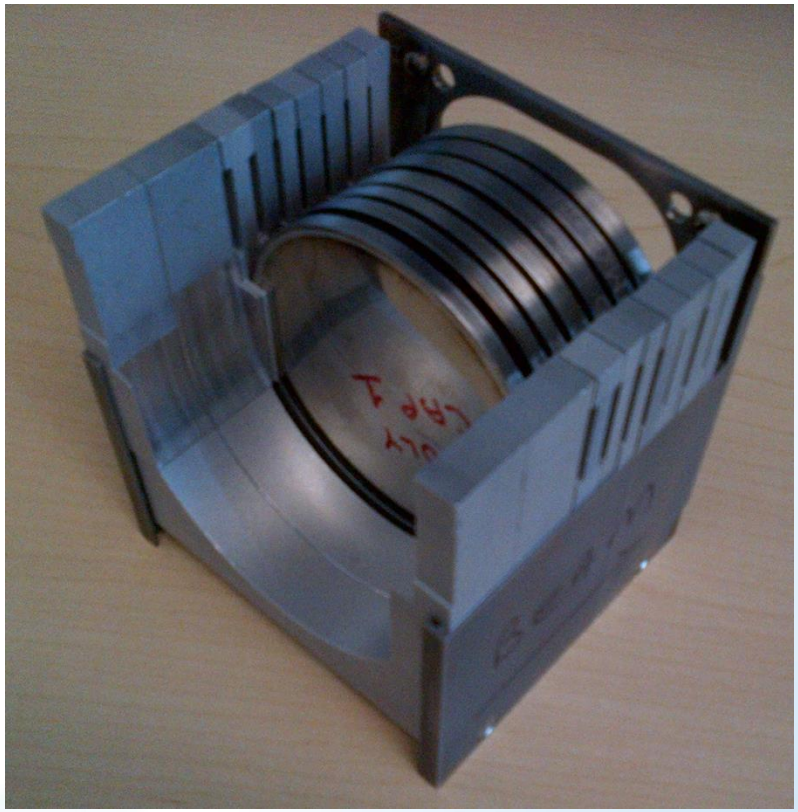
Individual (or in small groups) samples will be easier for shipping BUT there will be instead sorting time.

Therefore: While arrangements are in progress with other institutions for PIE, those arrangements are not in the critical path. Arrangements with BNL are

Now to the Capsules

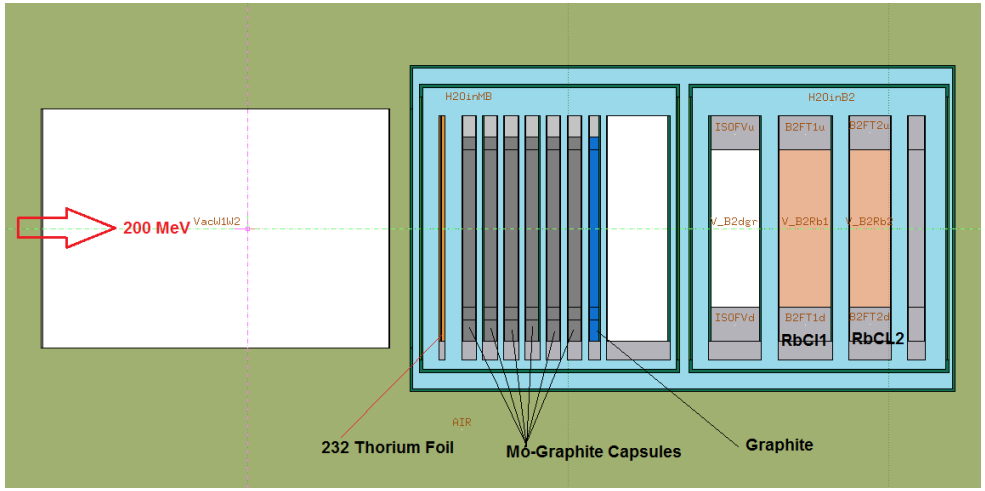
Irradiation DETAILS – Example of a similar arrangement

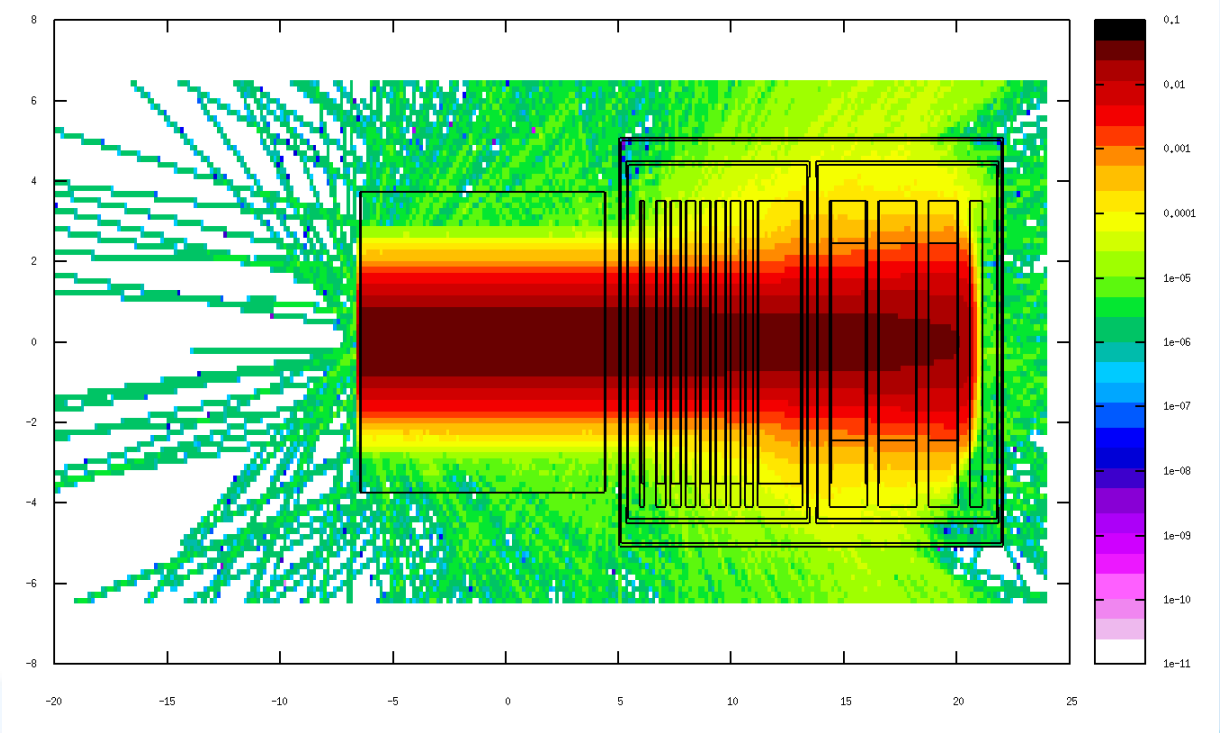


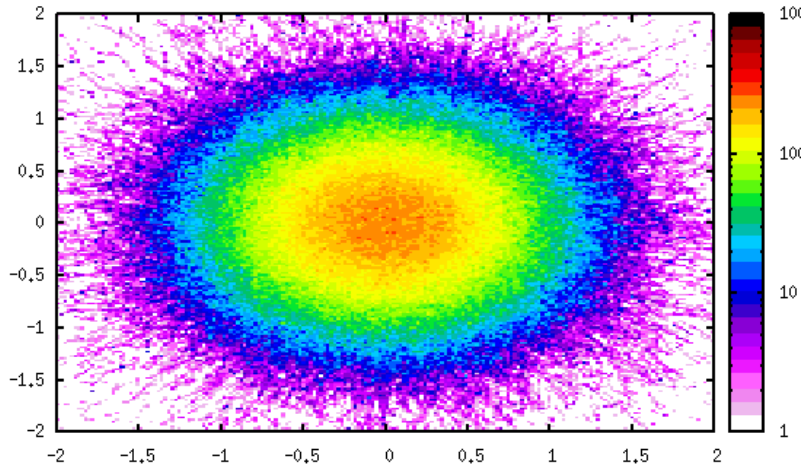


Holders changed (they are not more difficult to fabricate than those shown or more expensive)

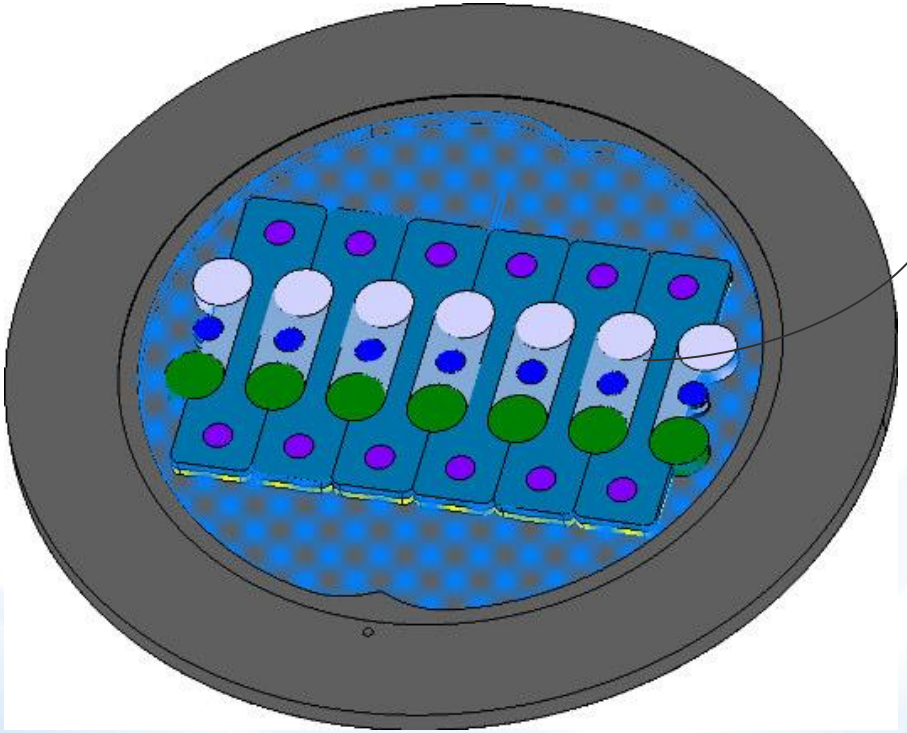
200 MeV Proton Irradiation





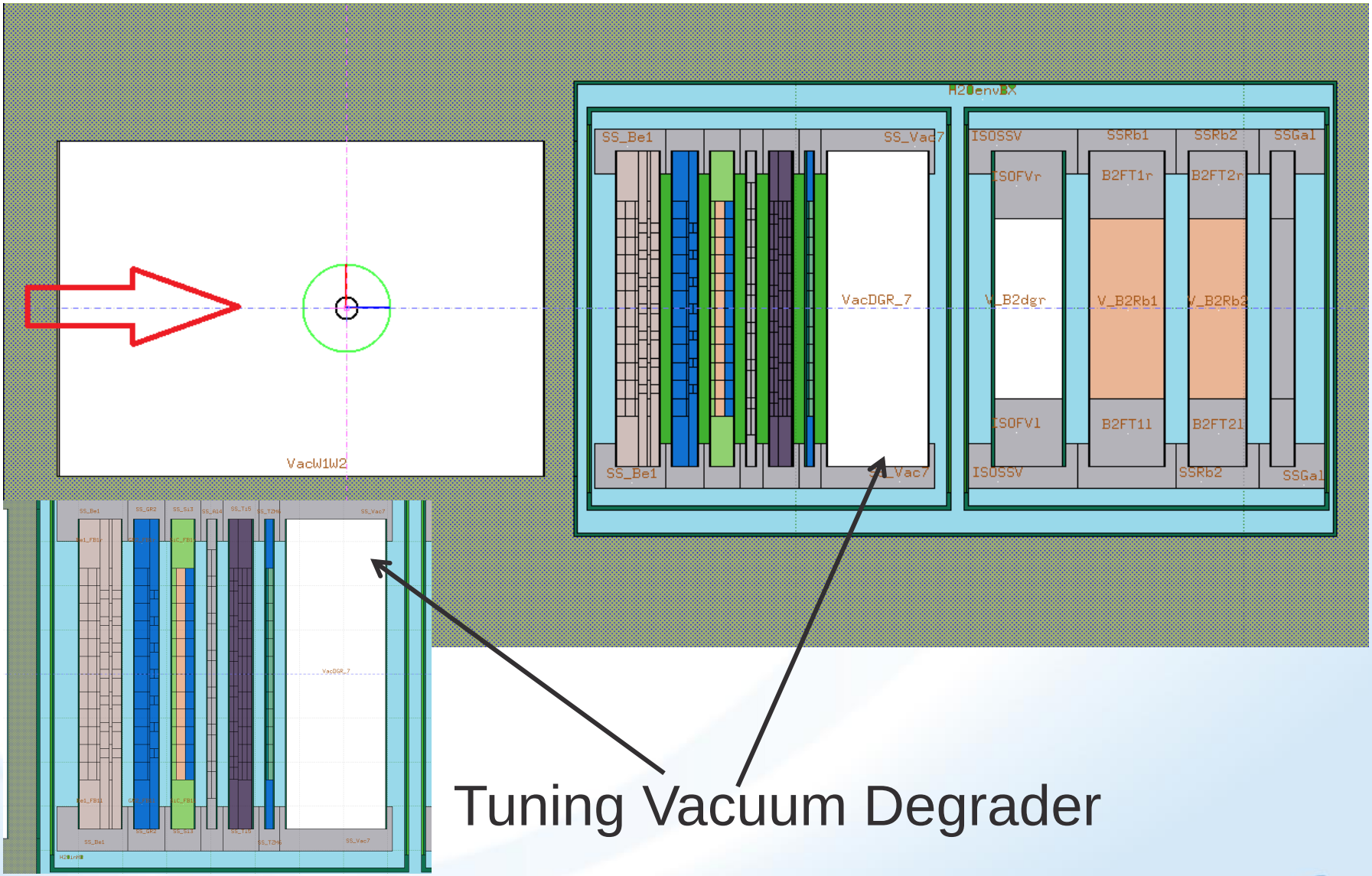


What will the impact be on footprint downstream ?



Filler = ?

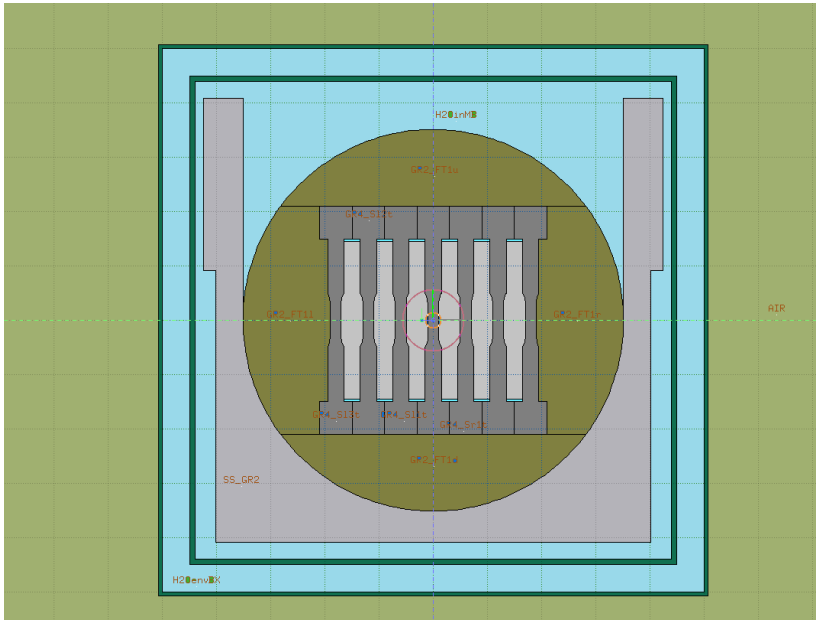
It was recommended that this is a template containing the 3 disks per position, IS IT?

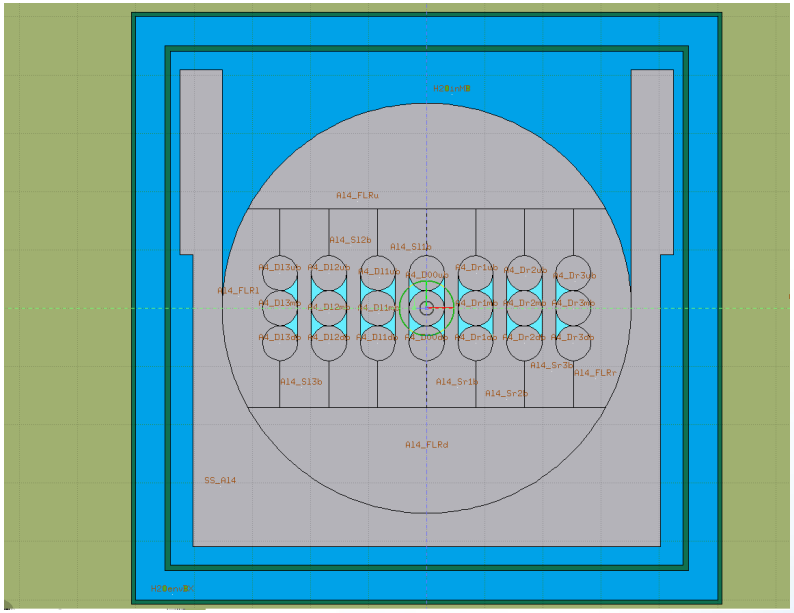


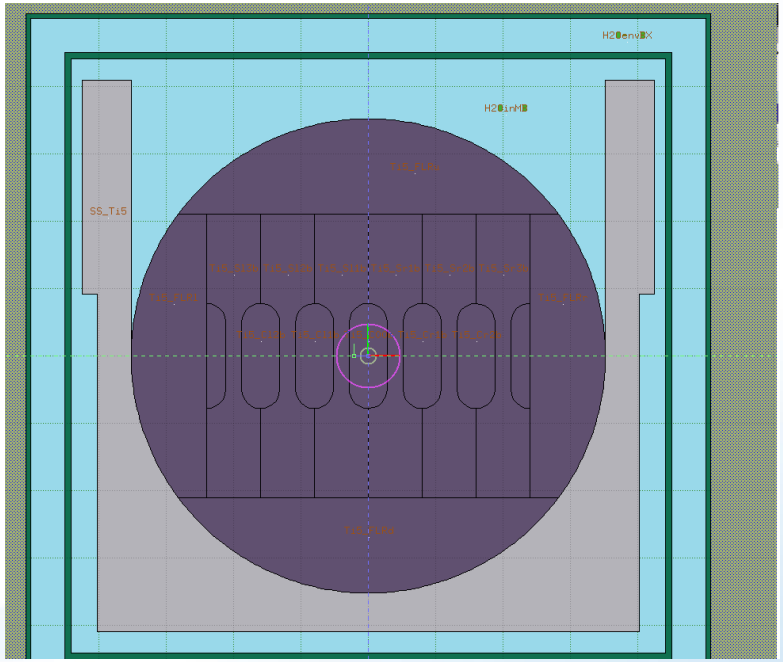
Tuning Vacuum Degrader

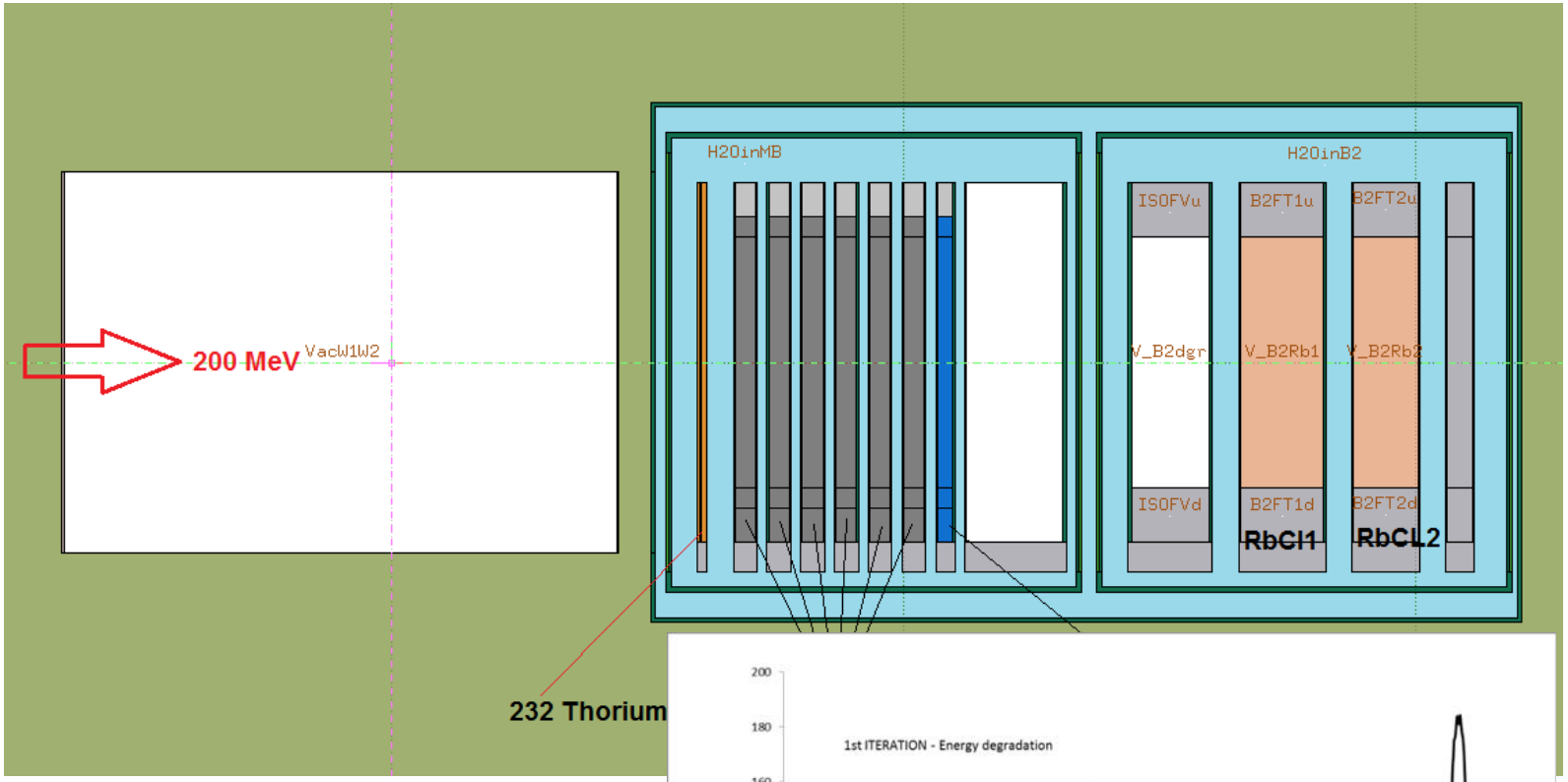
The developed model has all the provided info (as of last week)

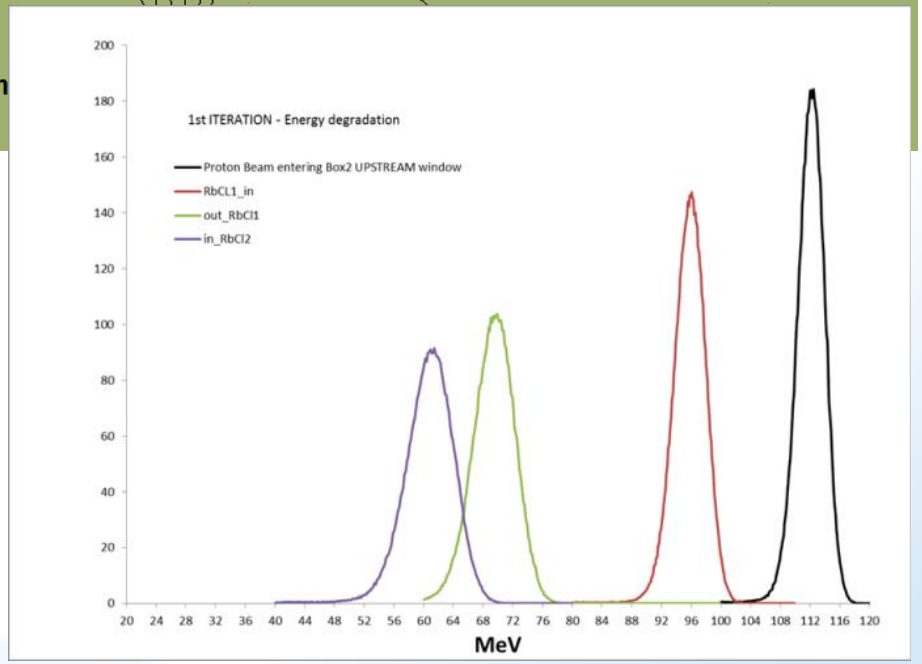
- Every sample is identified individually
- Endstation EXACT details and isotope array precisely modelled
- All beam degradation calculations, energy depositions for safety analysis, dose (model includes the BLIP hot cell structure, not shown here), activity and isotopes will be based on this for the committee.
- I will update based on FINAL details of the capsules.

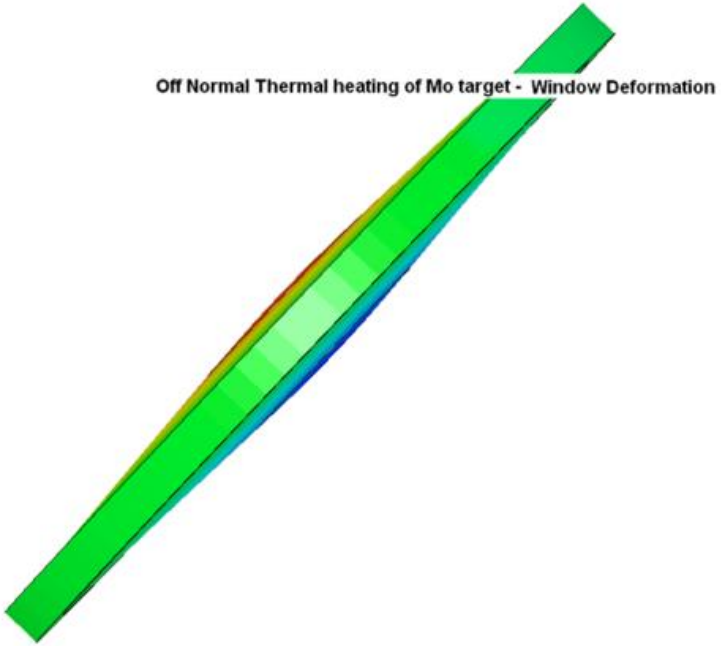

AIR
SS_GR2


A14_FLRu
A14_FLRd
SS_A14


SS_Ti5


200 MeV
VacW1W2
H2OinMB
H2OinB2
ISOFVu
B2FT1u
B2FT2u
V_B2dgr
V_B2Rb1
V_B2Rb2
ISOFVd
B2FT1d
B2FT2d
RbCl1
RbCL2
232 Thorium

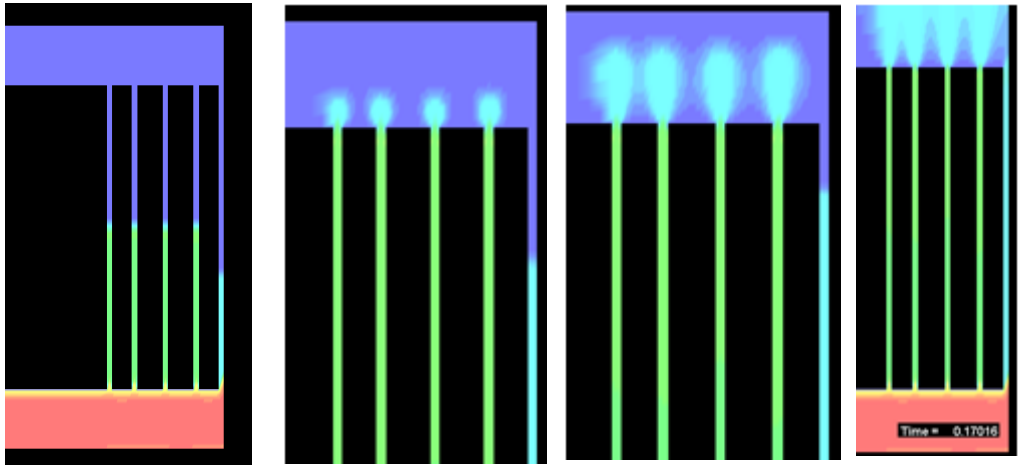

1st ITERATION - Energy degradation
Proton Beam entering Box2 UPSTREAM window
RbCL1_in
out_RbCl1
in_RbCl2
MeV

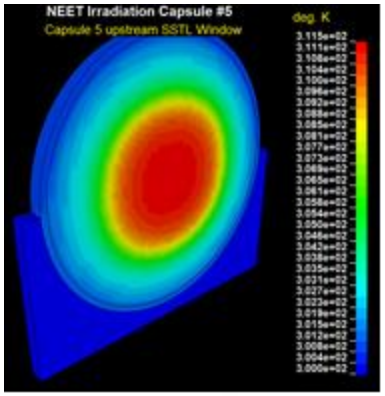


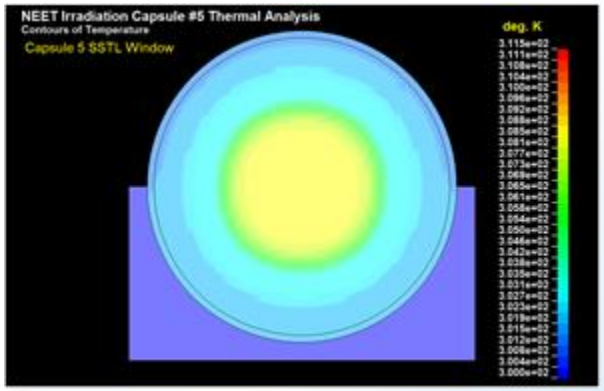
Prediction is not amplified: Actually happened!

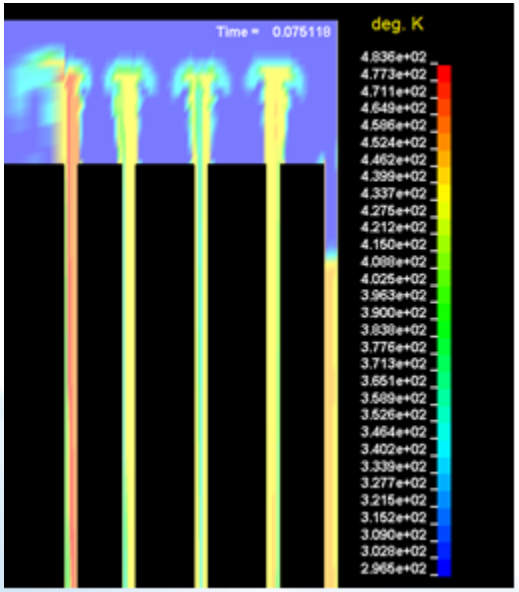
Temperature not important:
Safety Committee requires FLUX <200 W/cm2

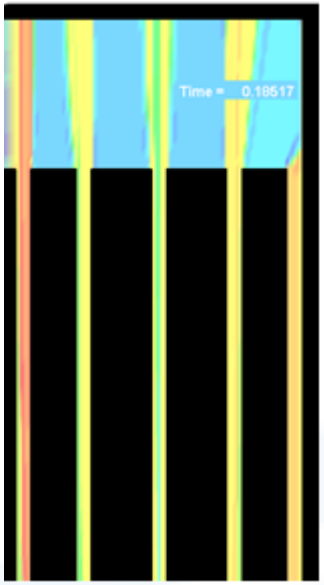
Thermo-mechanical Analyses Supporting Proton Irradiation

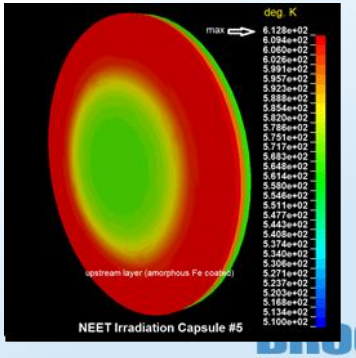




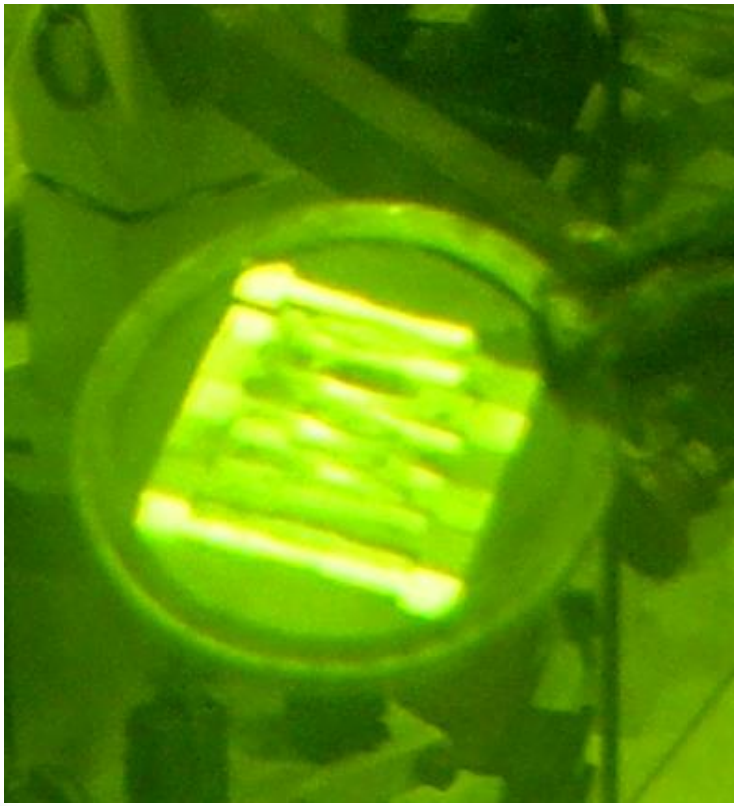


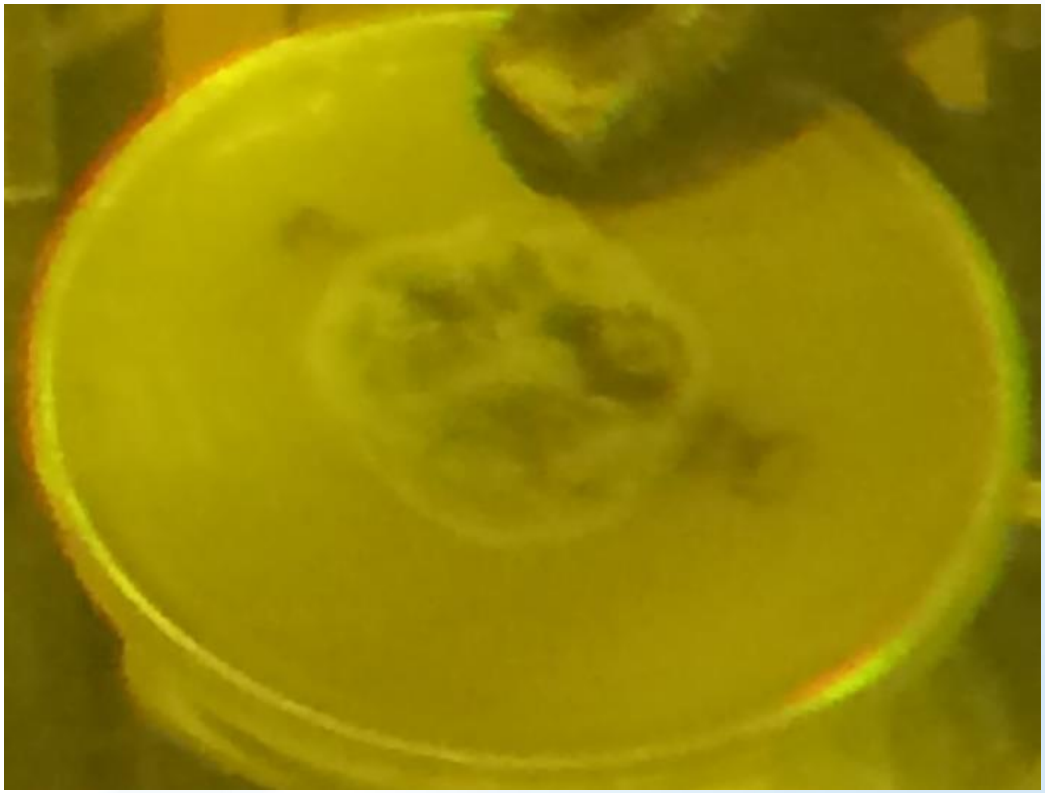






200 MeV Proton Irradiation _ Molybdenum (TZM like)
FLUENCE: ~6.0 x 10^20 p/cm2



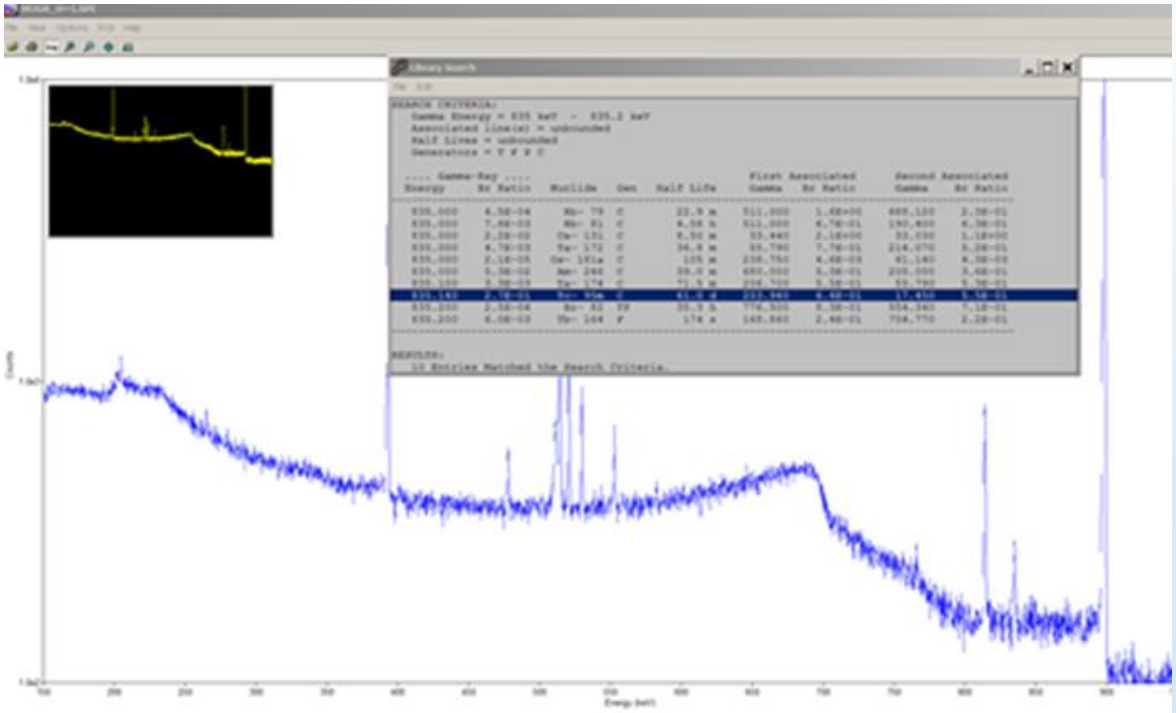


Residual Dose: Whole Aluminium Capsule

Irradiation Time	Beam Current	Cooling Time	Equivalent Dose at 1 foot distance
			Whole Capsule
12 weeks	1.03e15 H^+/s = 165 uA	0 second	3,320 mSv/h
		1 hour	1,800 mSv/h
		2 hours	1,670 mSv/h
		6 hours	1,470 mSv/h
		24 hours	1,180 mSv/h
		48 hours	1,010 mSv/h
		1 weeks	720 mSv/h
		2 weeks	530 mSv/h
		4 weeks	350 mSv/h
		12 weeks	160 mSv/h
		24 weeks	100 mSv/h
		48 weeks	**61 mSv/h = 6.1 R/hour**

Photon Analysis and ISOTOPE Profile

Needed (?) for TRANSPORT: May or may not accept calculations ➔ photonSPECTRA ➔ with these dose levels per capsule, cannot do it un-opened.
Per-sample will most likely be required



BNL – PIE

BNL Post-Irradiation Facilities

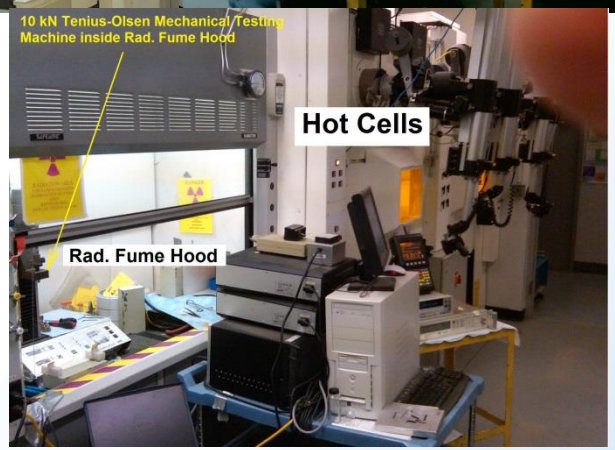
Isotope Extraction and Processing Facility at BNL

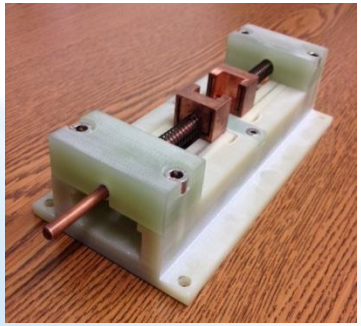
Experimental Facility occupies 2 hot cells and a HEPA-filtered fume hood

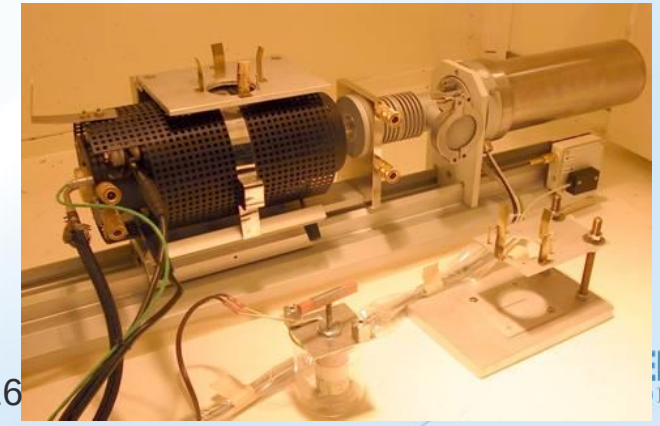
PIE analyses performed are:

Stress-strain (tension, 3-point and 4-point bending)
Thermal Expansion and annealing (extremely sensitive dilatometer)
Thermal Conductivity (electrical resistivity)
Magnetic Whole probe
Ultrasonic measurements

PLUS
Photon spectra and isotopic analysis
Activity measurements
Weight loss or gain







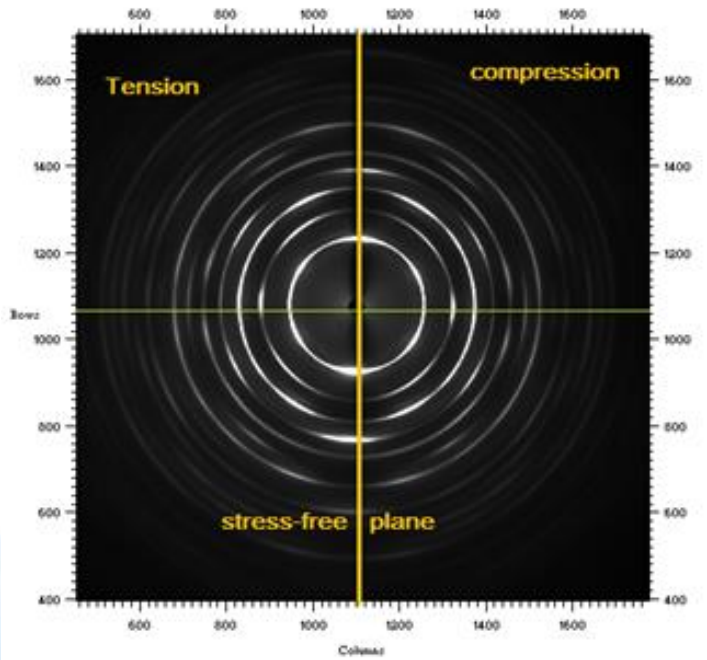
X-ray diffraction at the brightest synchrotron (NSLS II)

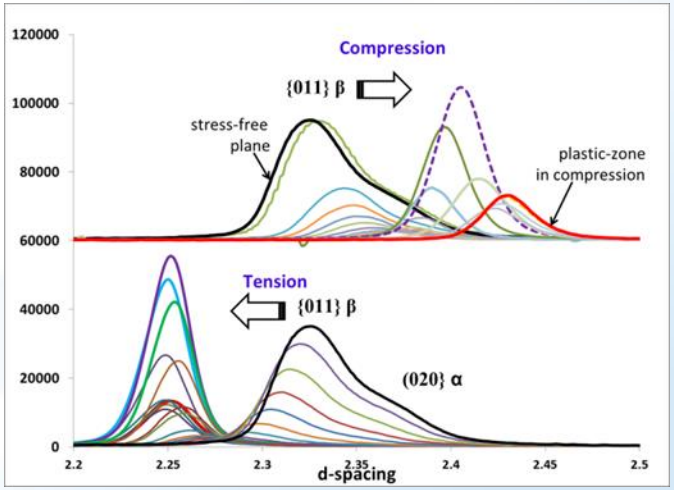
Recent Experiments (August 2016) covered the following materials of interest:

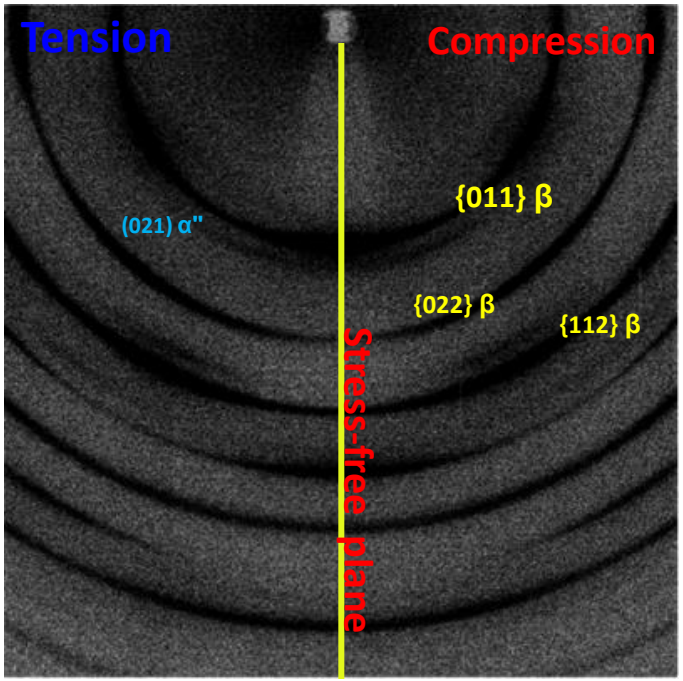
Molybdenum	(fluence > 5×10^{20} p/cm^2)
Tungsten	(fluence ~2×10^{20} p/cm^2)
Ti6Al4V	(fluence ~2×10^{20} p/cm^2)
Graphite	(fluence ~6×10^{20} p/cm^2)
Al_2O_3	

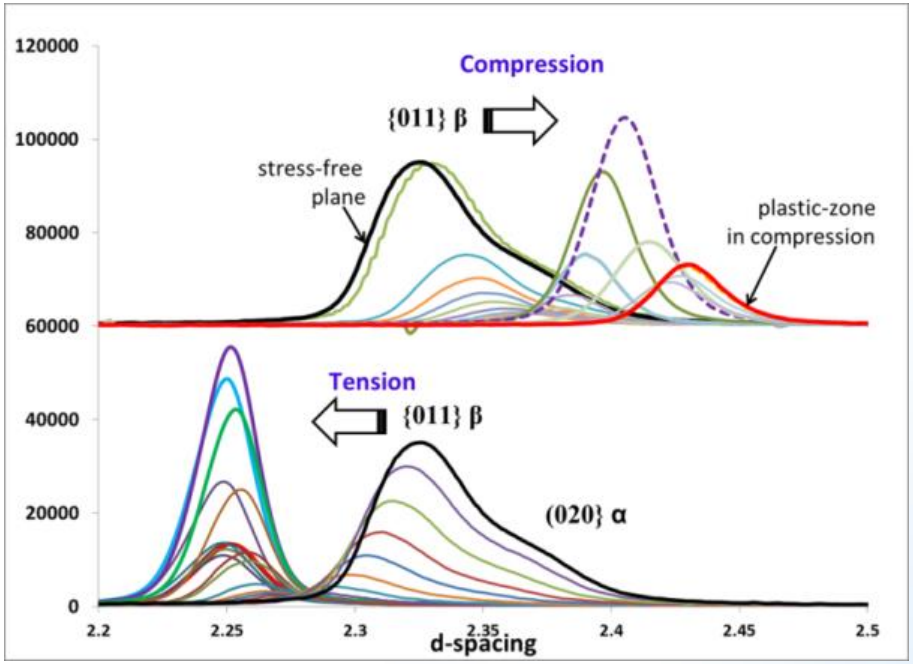
BNL Post-Irradiation Facilities X-ray Diffraction at NSLS II

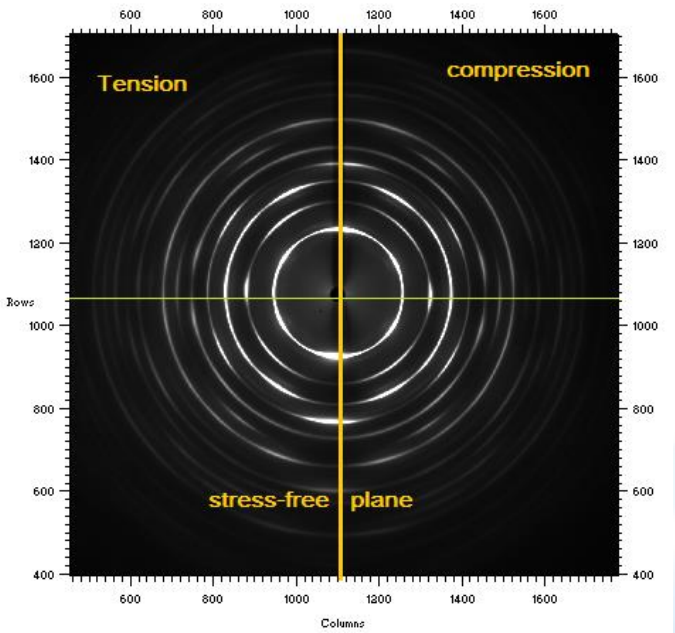
Stage at NSLS II XPD Beamline

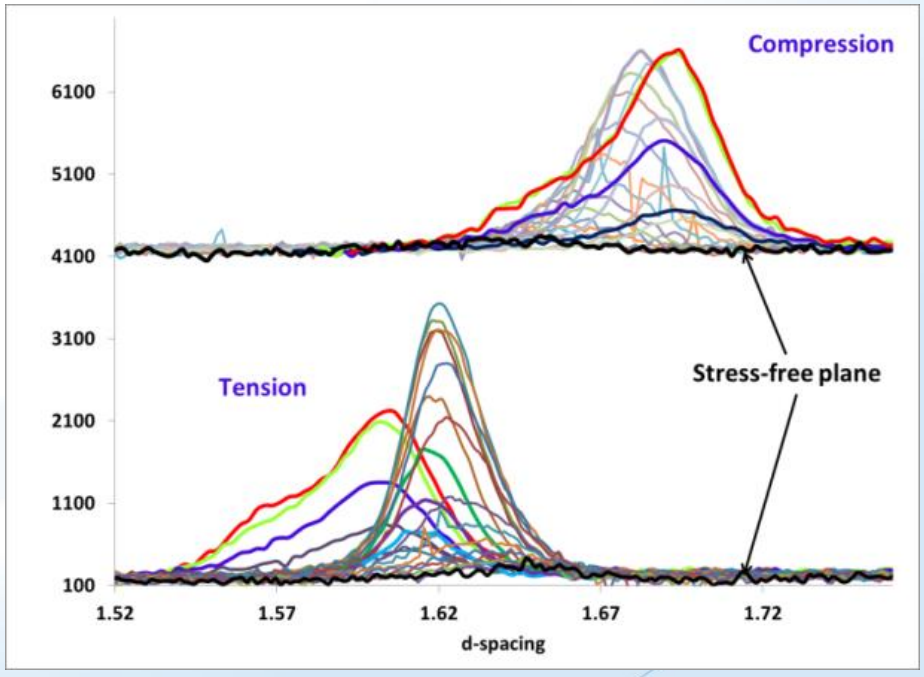


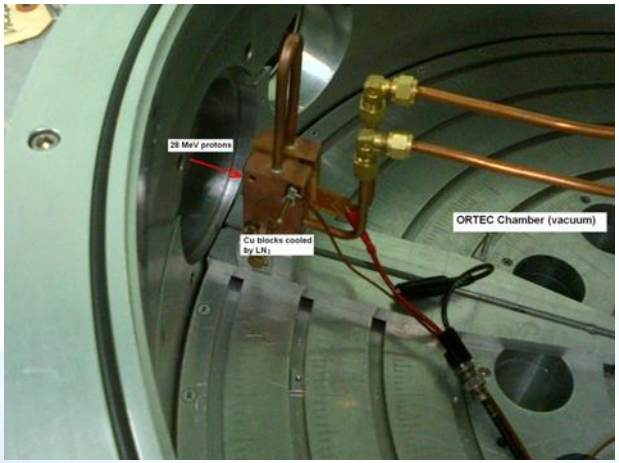



Tension
Compression
(021) α"
{011} β
{022} β
{112} β
Stress-free plane


Compression
{011} β
stress-free plane
plastic-zone in compression
Tension
{011} β
{020} α
d-spacing


Tension
compression
stress-free plane
Rows
Columns


Compression
Tension
Stress-free plane
d-spacing

28 MeV Proton & Heavy ion irradiation at Tandem

Target Irradiation Beamline