Characterization of radiation damage effects in high-energy neutrino target graphite using low-energy ion irradiation

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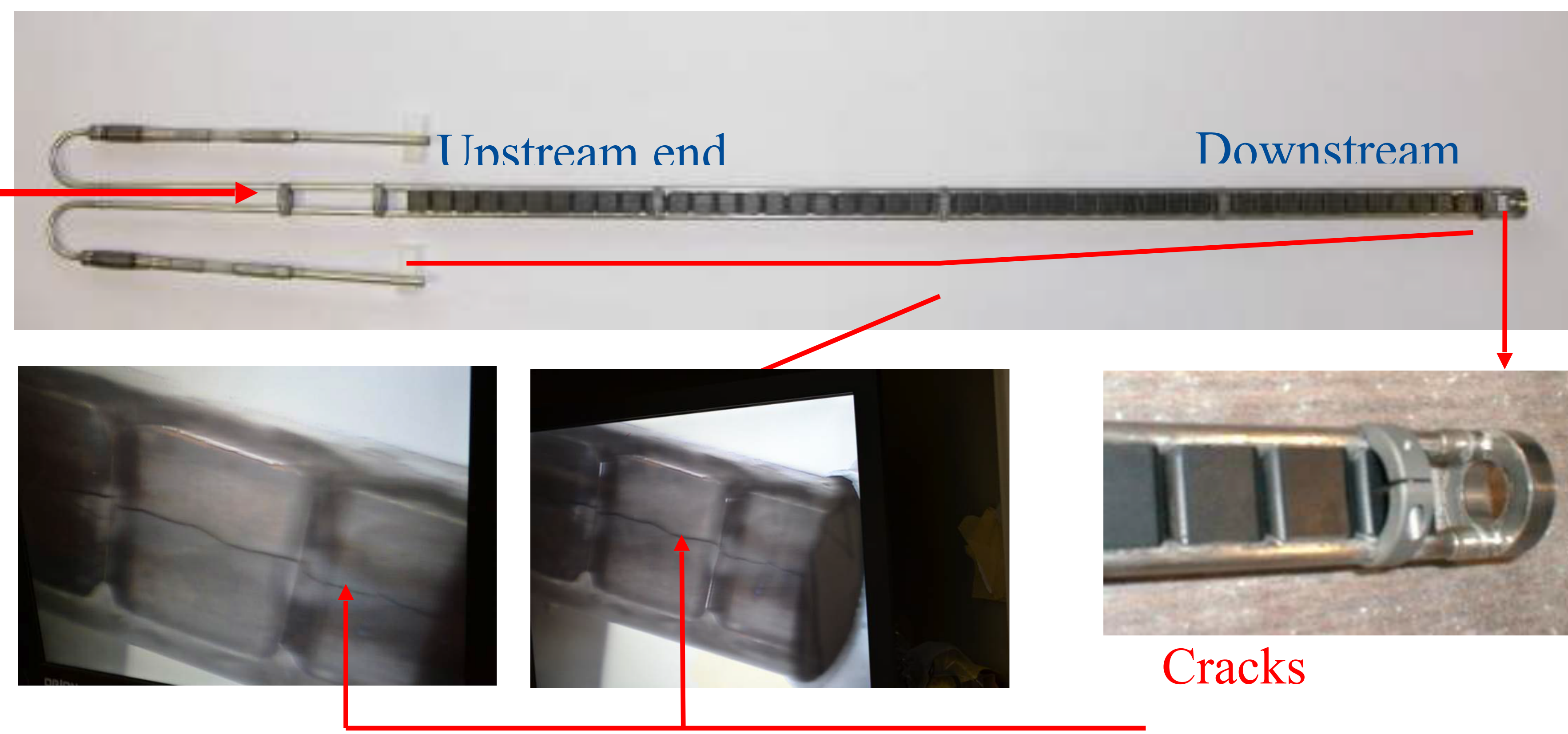
Motivation

- Determination of the effects of increasing beam power and fluence on target materials is essential to avoid component failure.
- High energy proton irradiation presents many difficulties: sample activation, high costs, long irradiation times, rigorous planning and sample preparation.
- Low-energy ion irradiations suggest a method of testing new beam designs without the costly and time consuming high-energy irradiations commonly undertaken while also allowing for faster experiment iteration without sample activation.

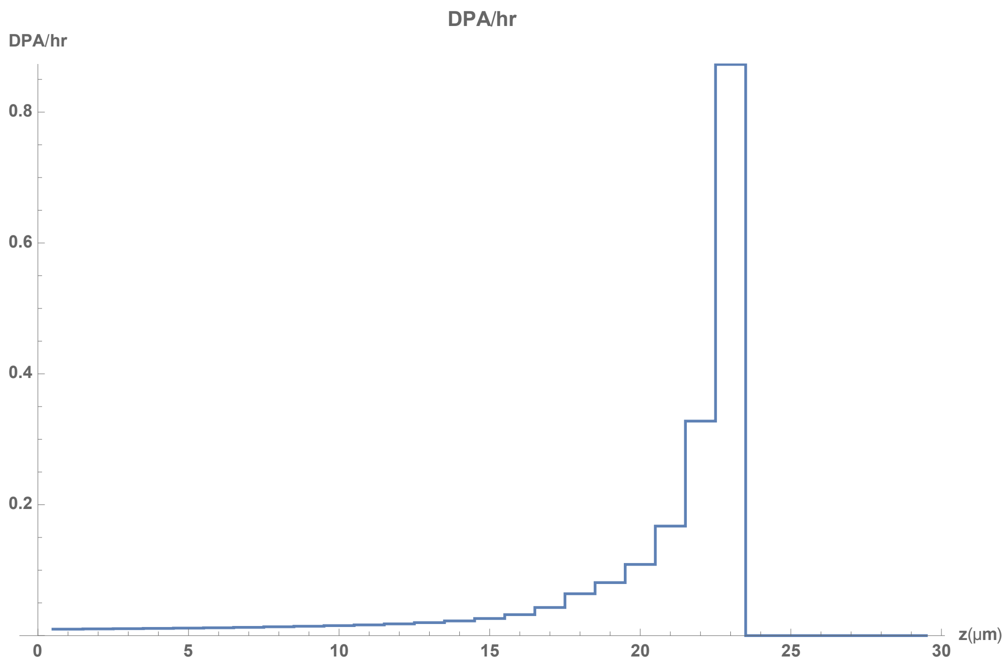
NT-02 Target:
Estimated DPA ~ 0.63
(More on this from Sujit Bidhar later)



Fermilab

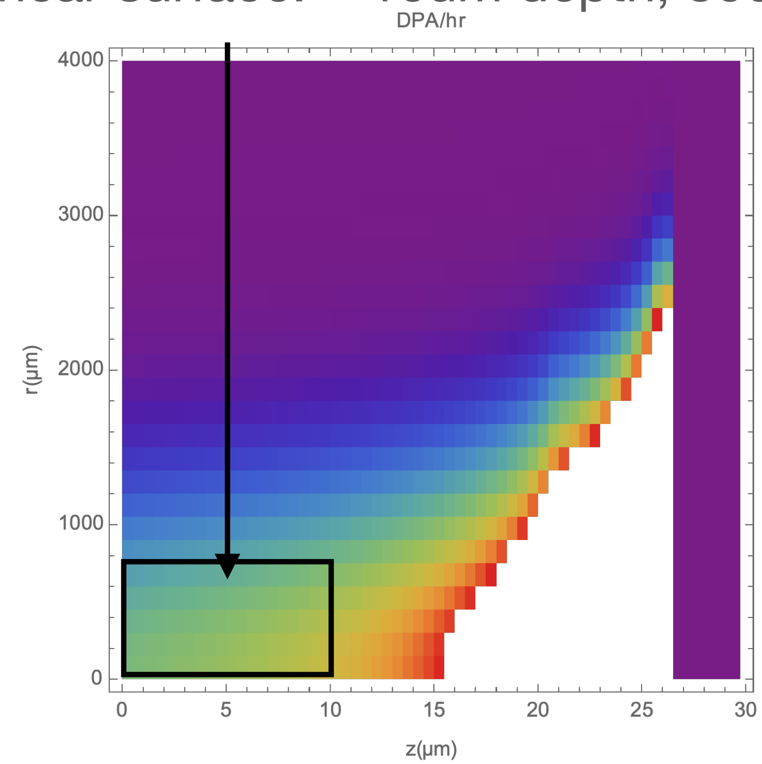
Ion irradiation advantages and limitations

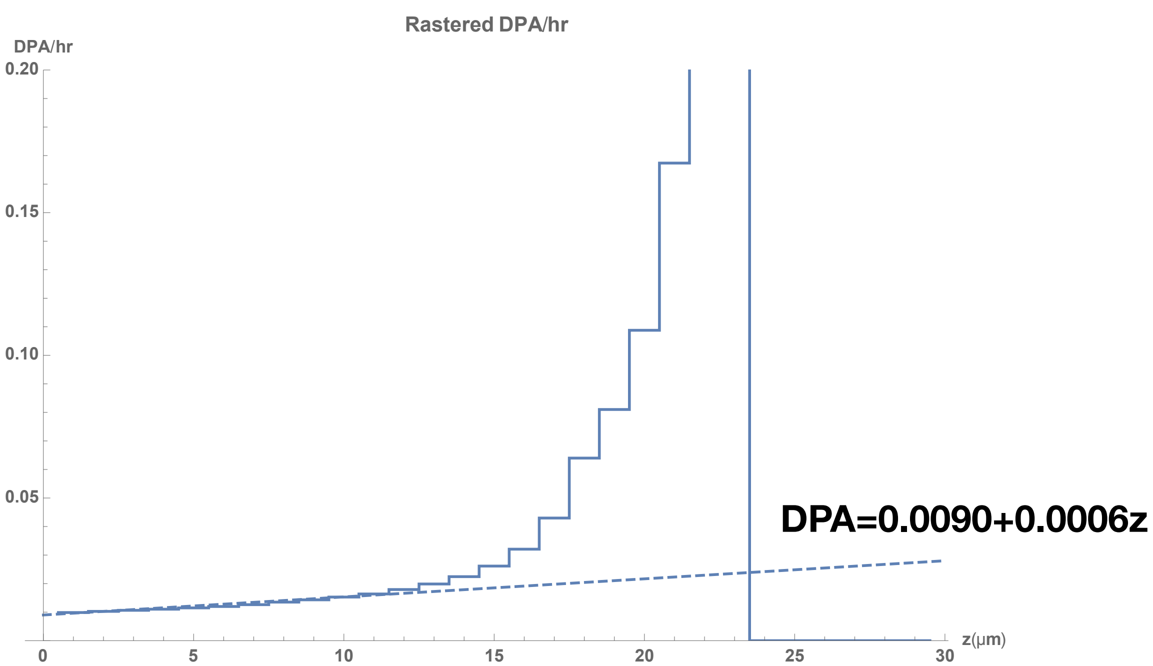
4.5MeV He^{++}



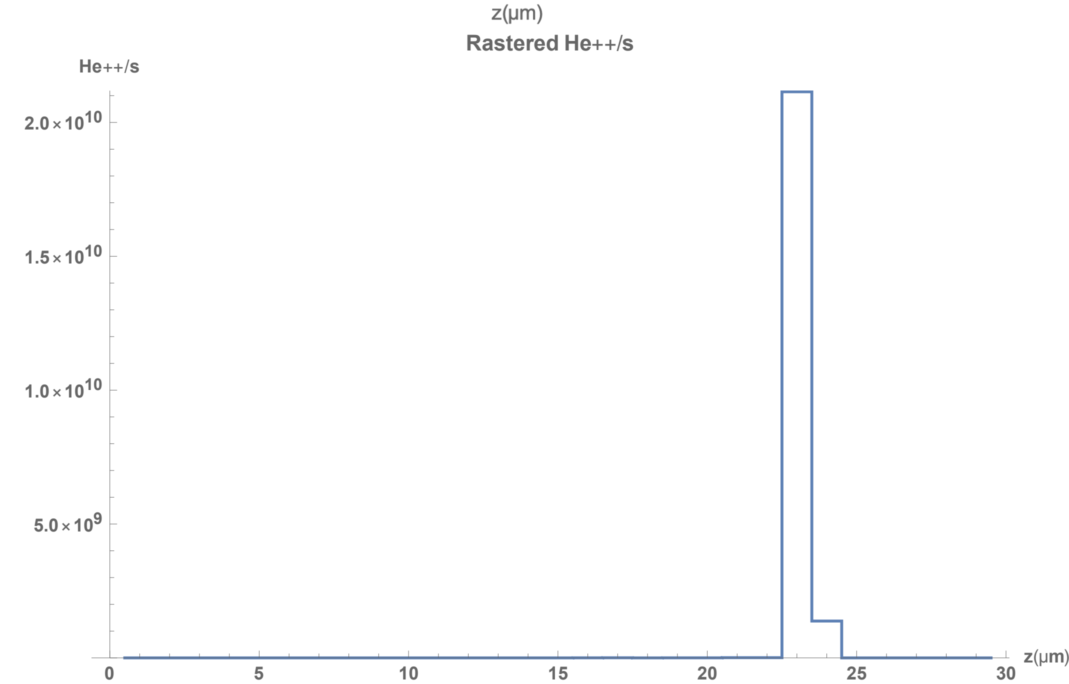
High peak DPA achievable in short times

Very small irradiated volumes compared to HE protons: linearity near surface: ~ 10um depth, 800um radius





Highly linear DPA rate near the surface



Near zero ions come to rest near the surface

Fermilab

HE vs LE irradiations

HE protons

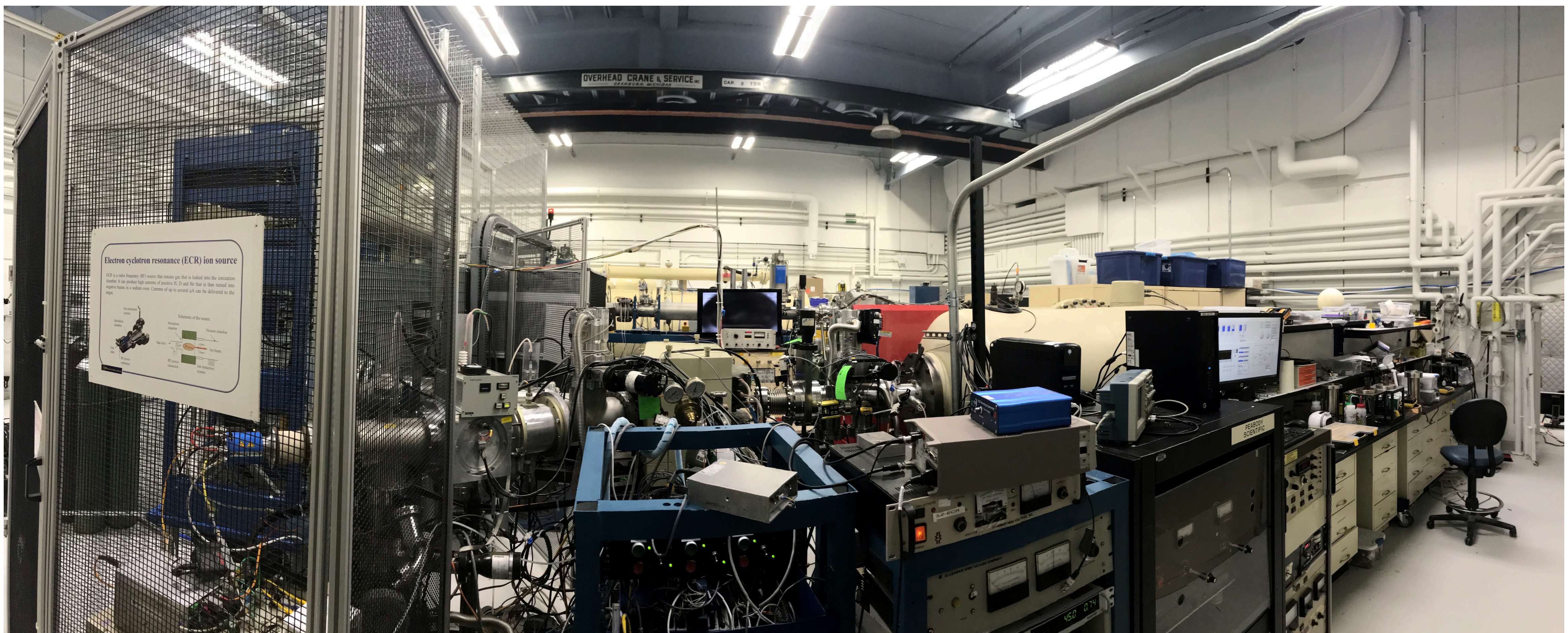
- $420/DPA/mm^3
- Very long irradiation times (months).
- BLIP: 0.11DPA/55days
- Rigorous sample preparation and testing: many people/resources required
- Sample activation requires special shipping & handling
- Hot cell PIE work

LE ions

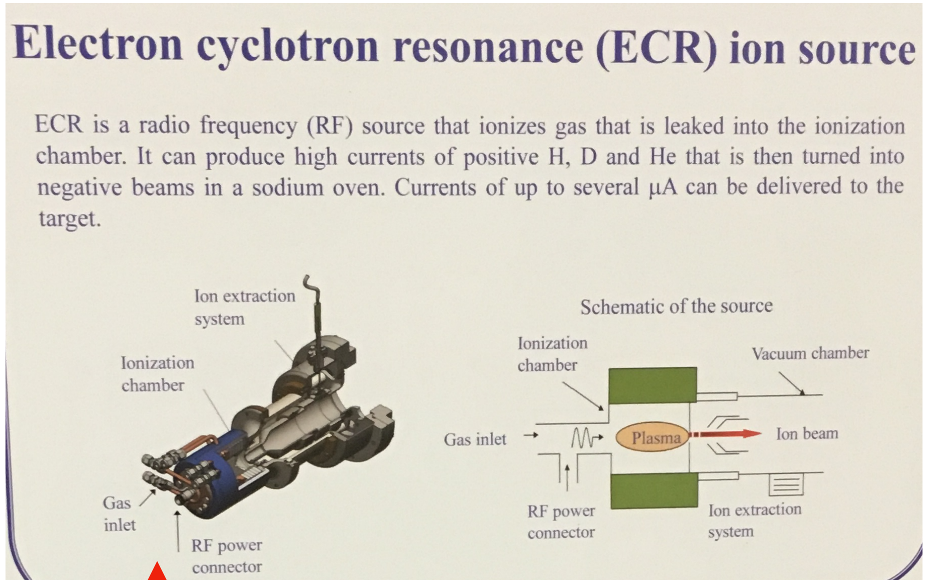
- $20000/DPA/mm^3
- Short irradiations (days)
- MIBL trial: 1DPA/90hrs
- Simple and fast sample preparation
- Transport samples in my backpack on Amtrak
- PIE work at standard laboratories

Trial irradiation objectives

- Attain 3 ion irradiated samples across a range of DPA values corresponding to data from existing or upcoming high energy studies for preliminary characterization of damage effects.
- Familiarization with ion lab capabilities and procedures: sample mounting, temperature control, beam profiling and monitoring, measurement of current on target.

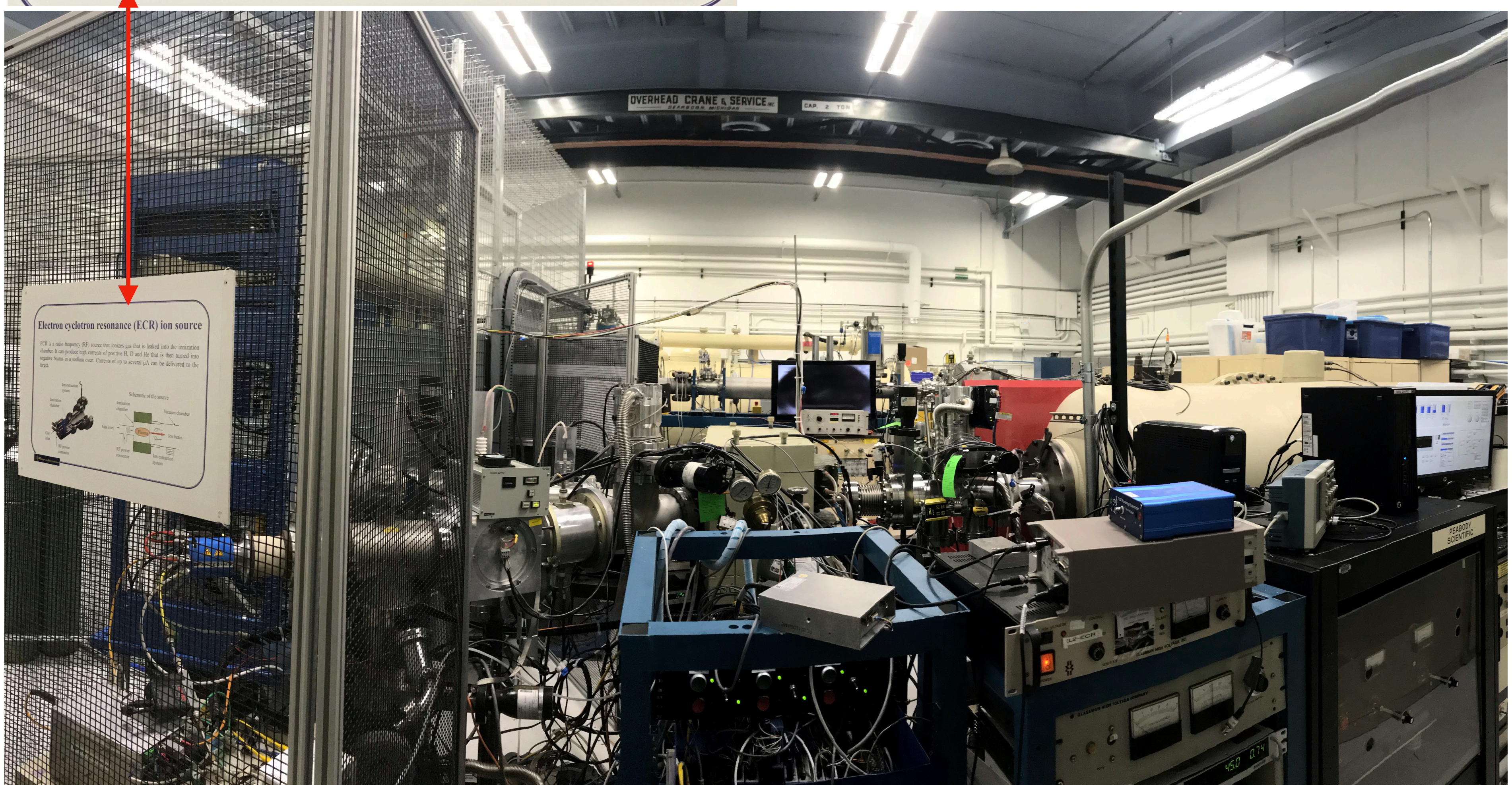


Implementation



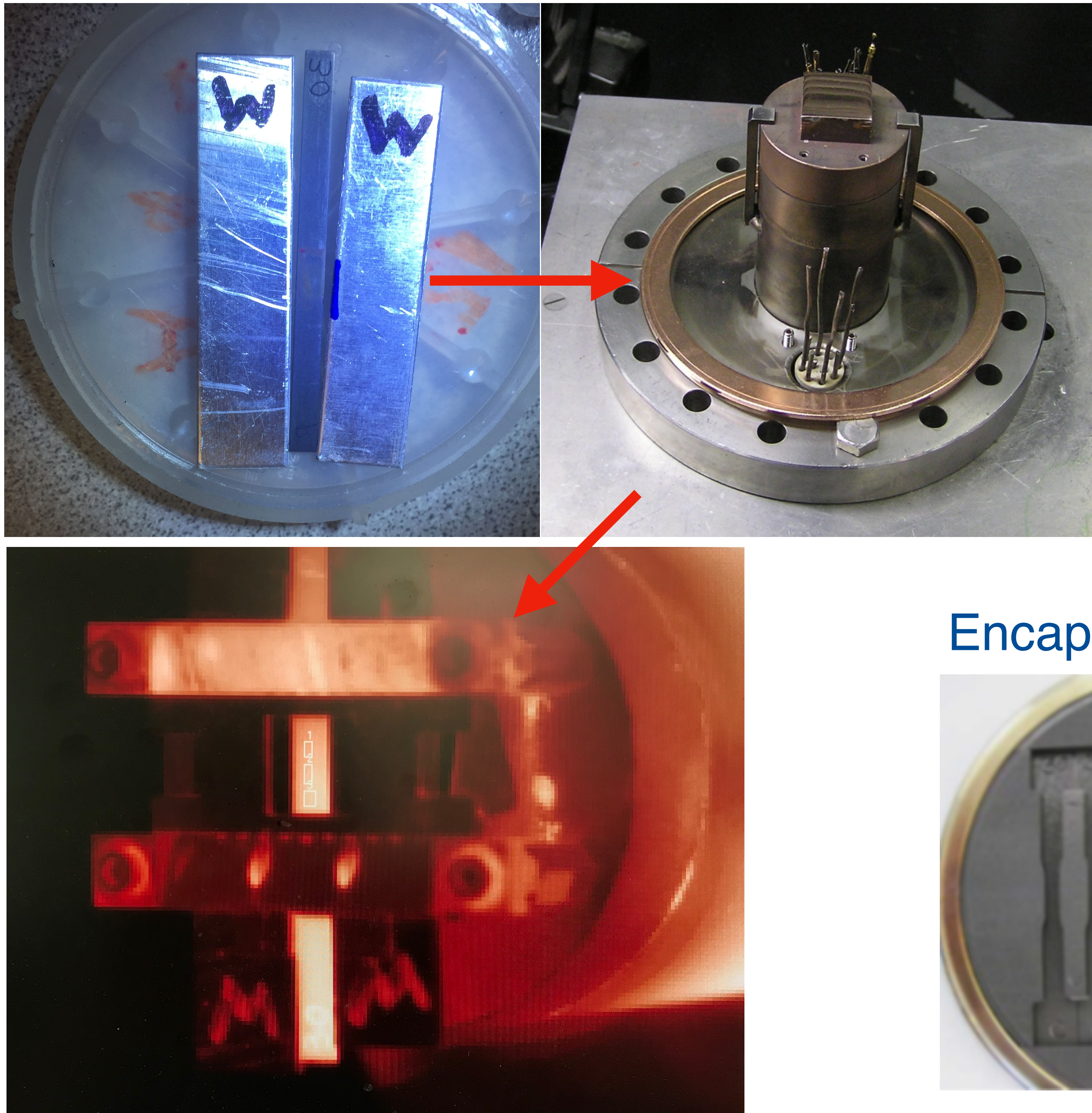
Facility: Michigan Ion Beam Laboratory (MIBL)

- 1.7MV Pelletron accelerator with ECR ion source: 4.5MeV He^{++} with ~1-2µA beam current
- 400kV Implanter for future dual beam irradiation
- In lab TEM

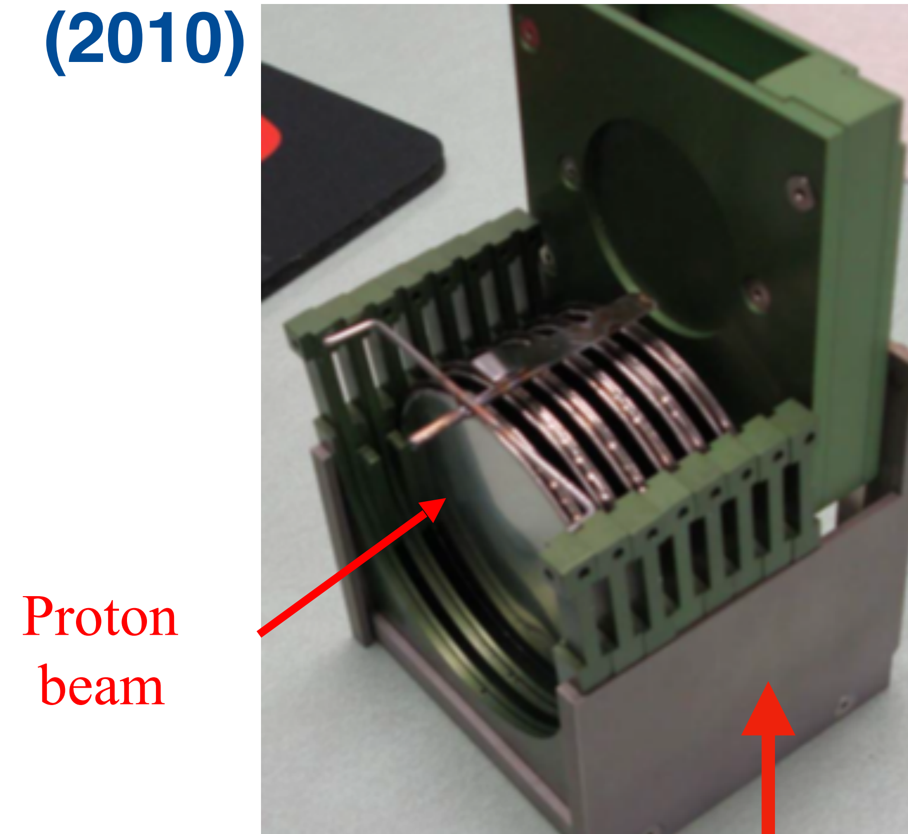


Sample preparation

MIBL Graphite Irradiation



BLIP Graphite Irradiation (2010)

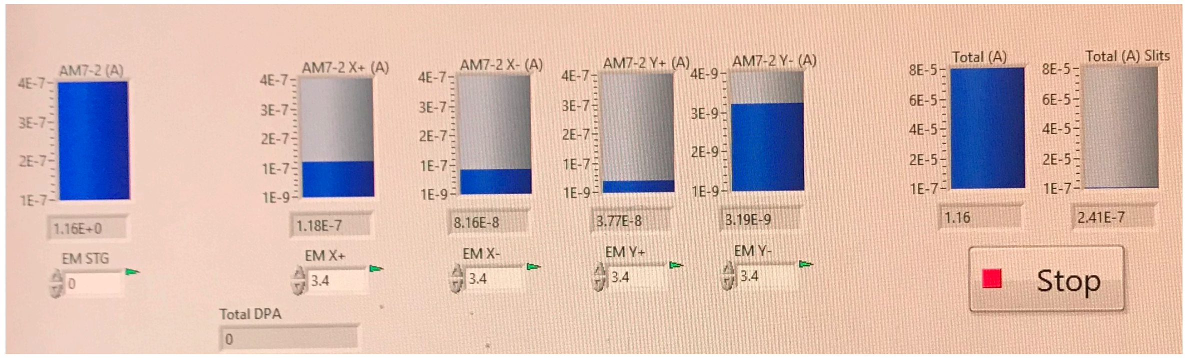


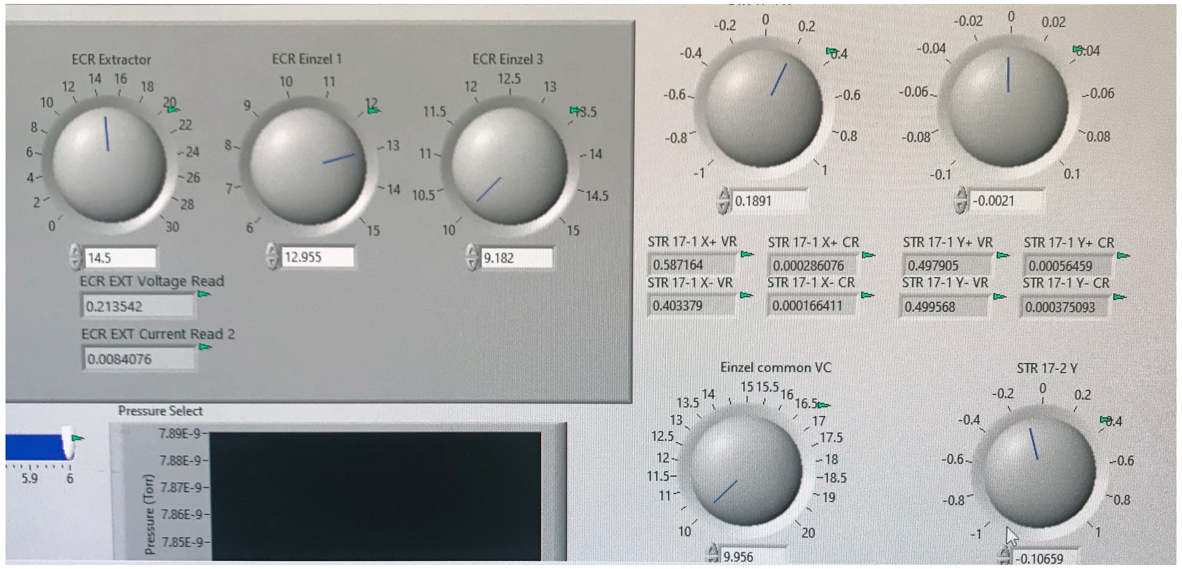
Encapsulated graphite specimens

Beam control and monitoring

MIBL control room

Digital monitors and controls:
Slit currents (TOP)
X steerers and ECR (BOTTOM)





Trial irradiation: beam parameters

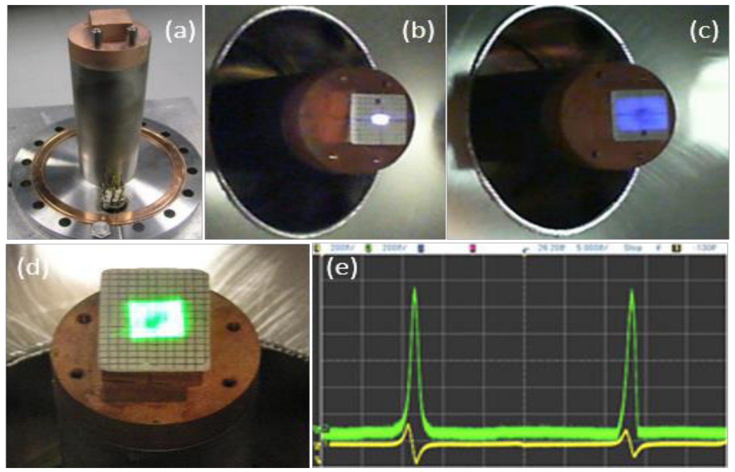
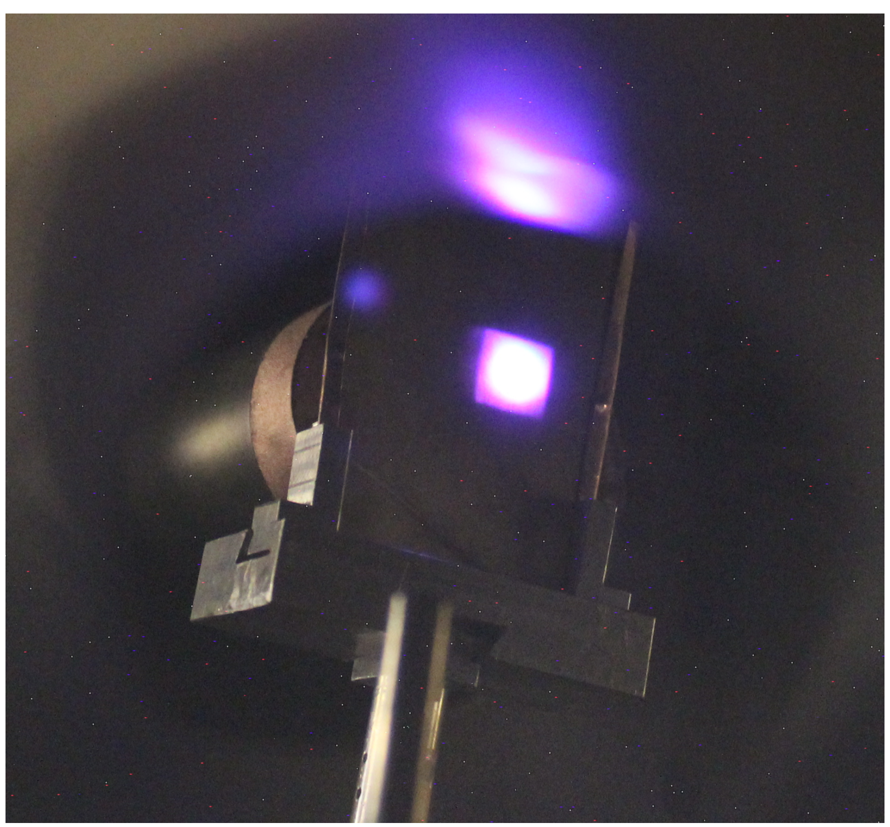


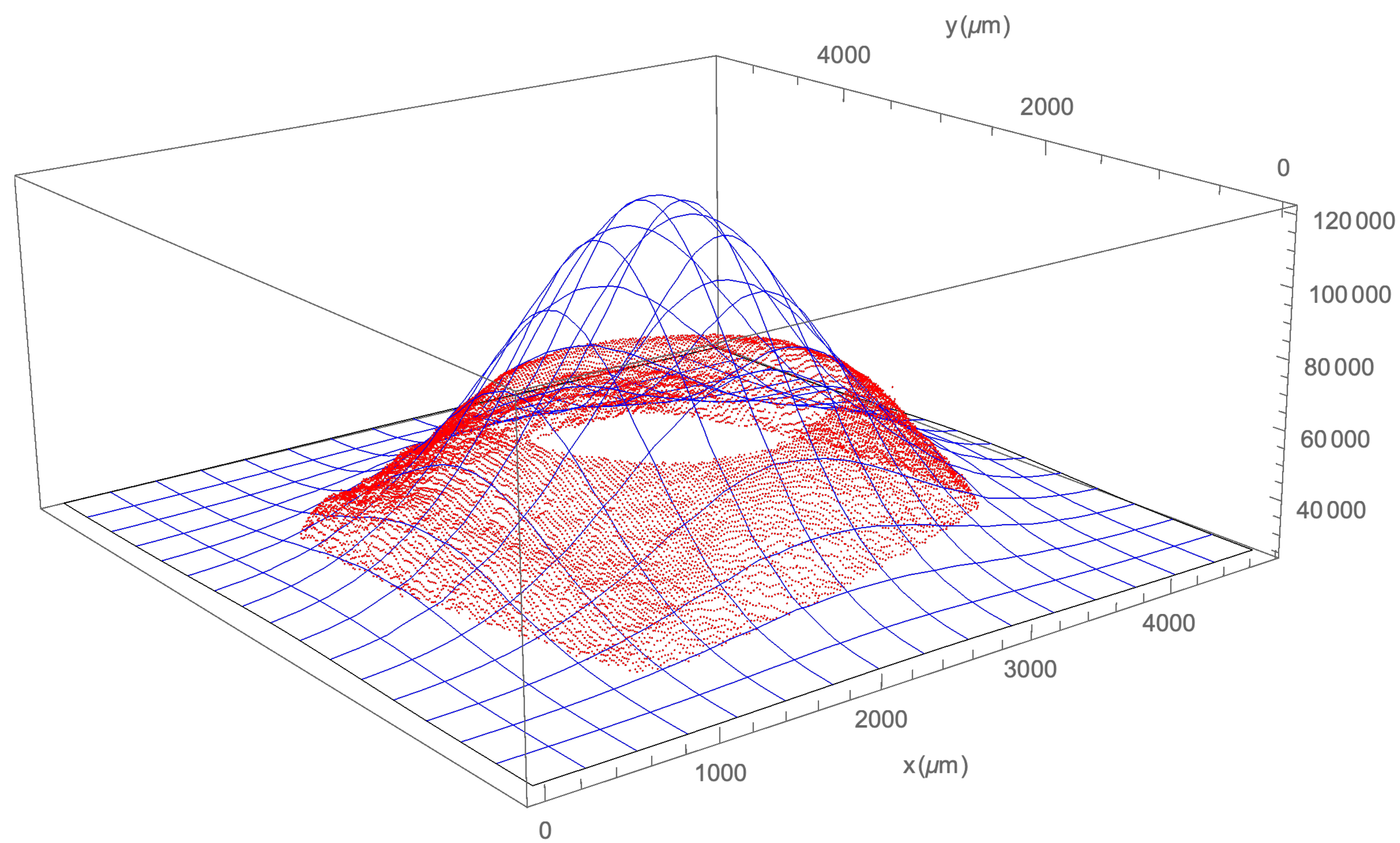
Figure 4: (a) stage, (b) focused beam on the stage, (c) rastered beam on stage, (d) laser light overlap on the ion beam and (e) BPM profile of the focused beam.

THE ALIGNMENT OF CONVERGENT BEMLINES AT A NEW TRIPLE ION BEAM FACILITY

O. F. Toader, T. Kubley, F.U. Naab, E. Uberseder, Michigan Ion Beam Laboratory, University of Michigan, Ann Arbor, Michigan, USA



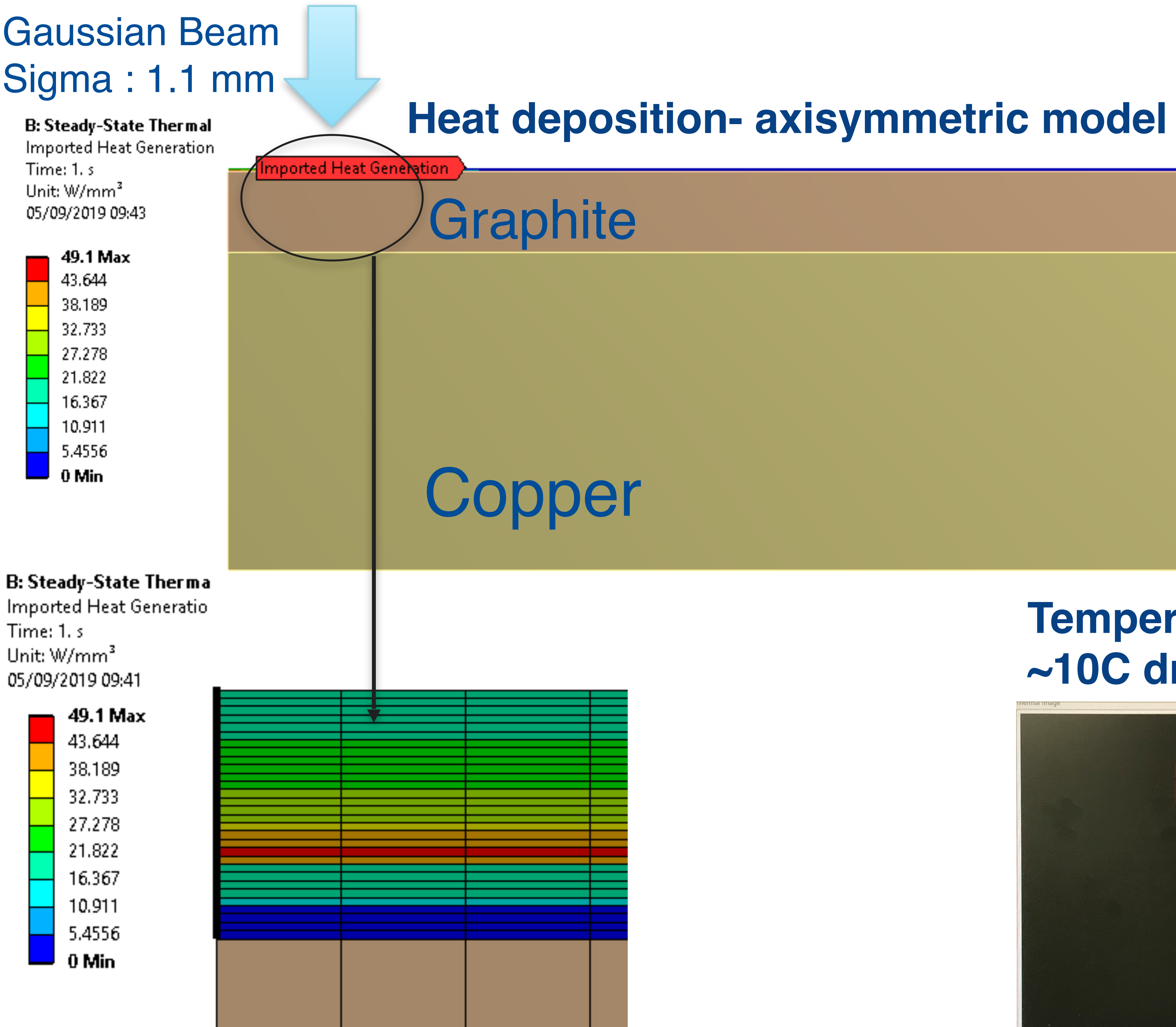
Ion energy: 4.5MeV
FWHM: ~2.2mm
Beam current: ~1.3μA

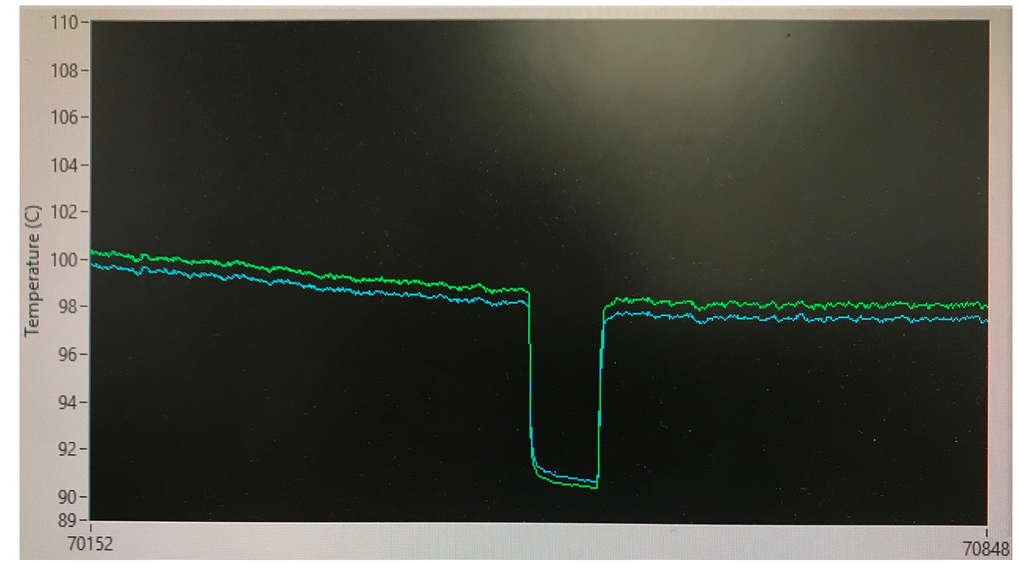


Determination of beam FWHM accomplished by fitting fluorescences data from ceramic plate dropped into beam

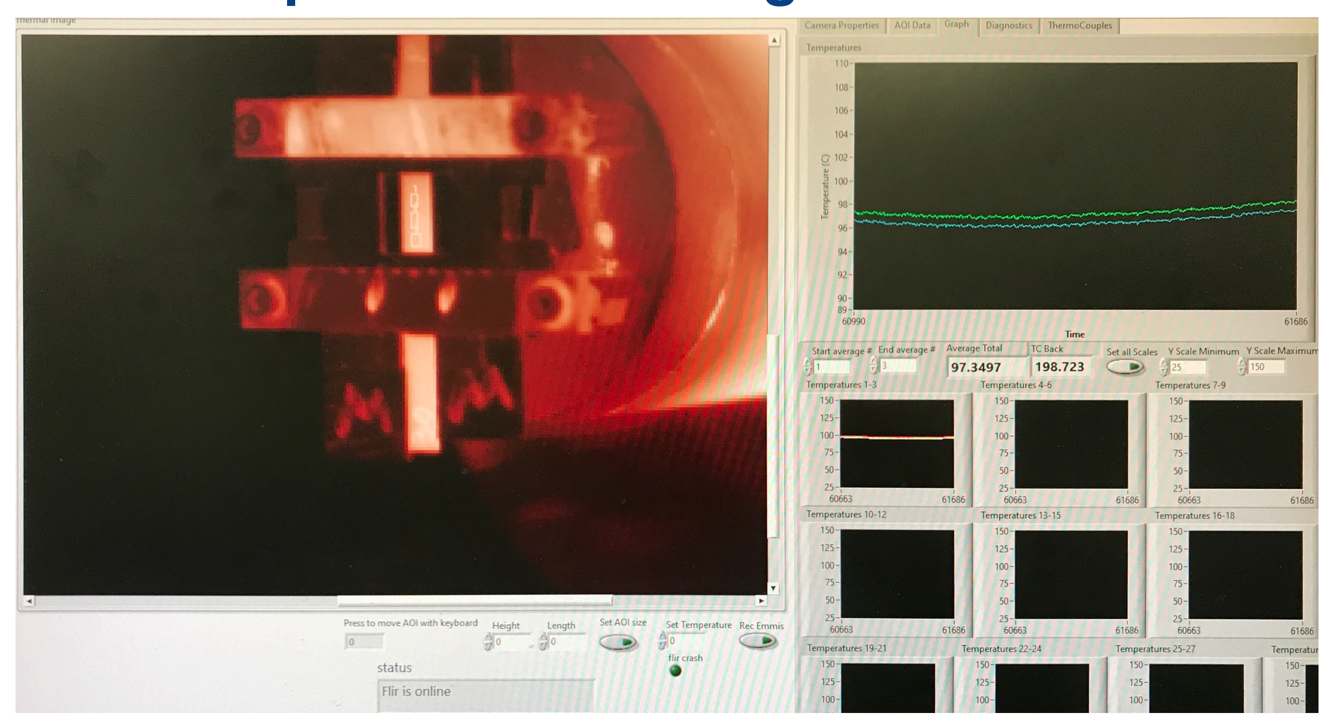
Trial irradiation: Temperature control

Heat deposition- axisymmetric model



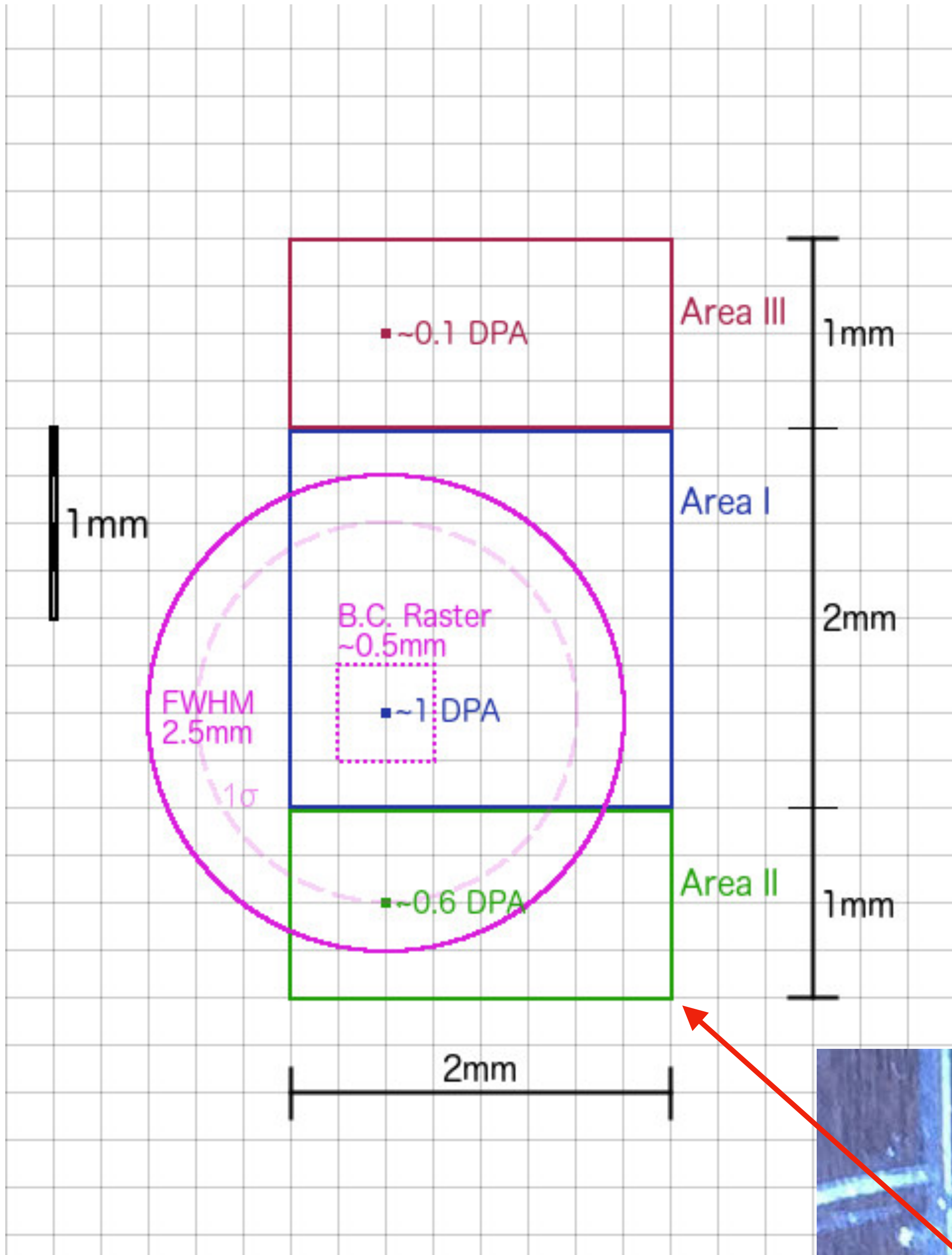


Temperature monitor showing T~100C with ~10C drop when measuring beam current



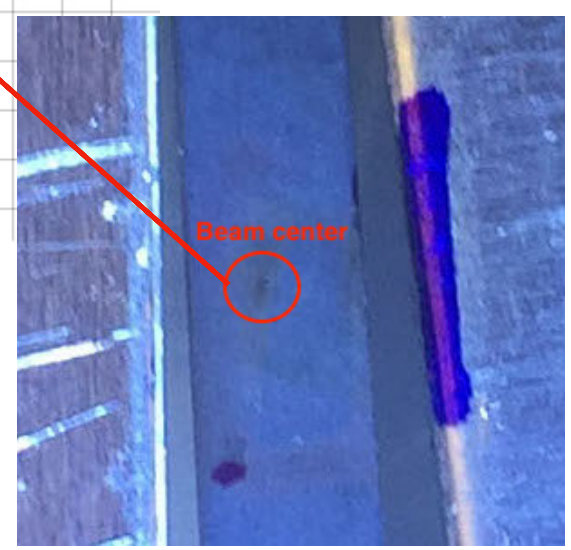
Courtesy: S. Bidhar

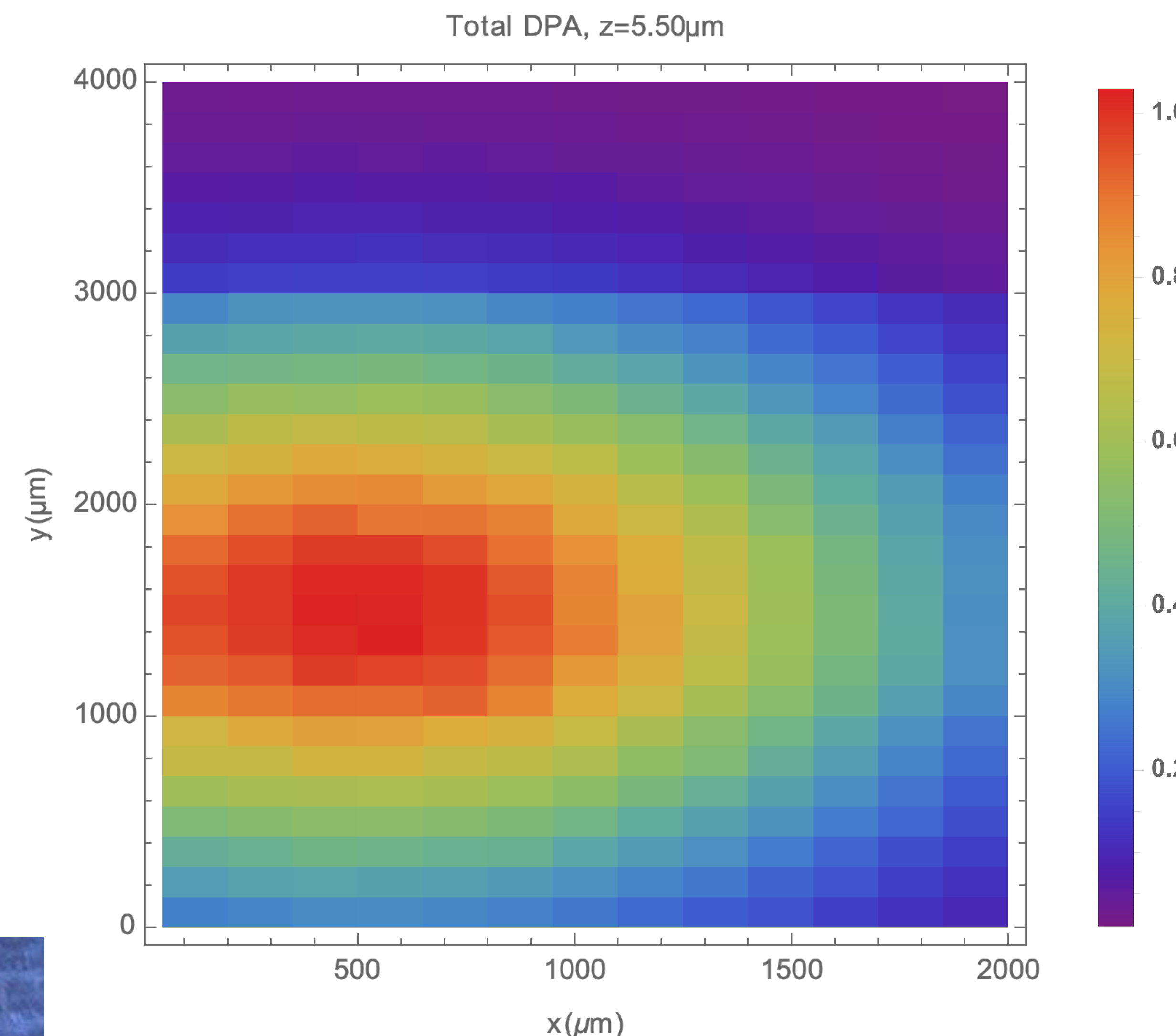
Trial irradiation: Footprint and DPA



Irradiation plan

- Irradiate Area I ~5hrs
- Open slits to Area II ~40hrs
- Open slits to Area III ~50hrs





MARS simulation of total DPA accumulation (NRT w/ Stoller correction)

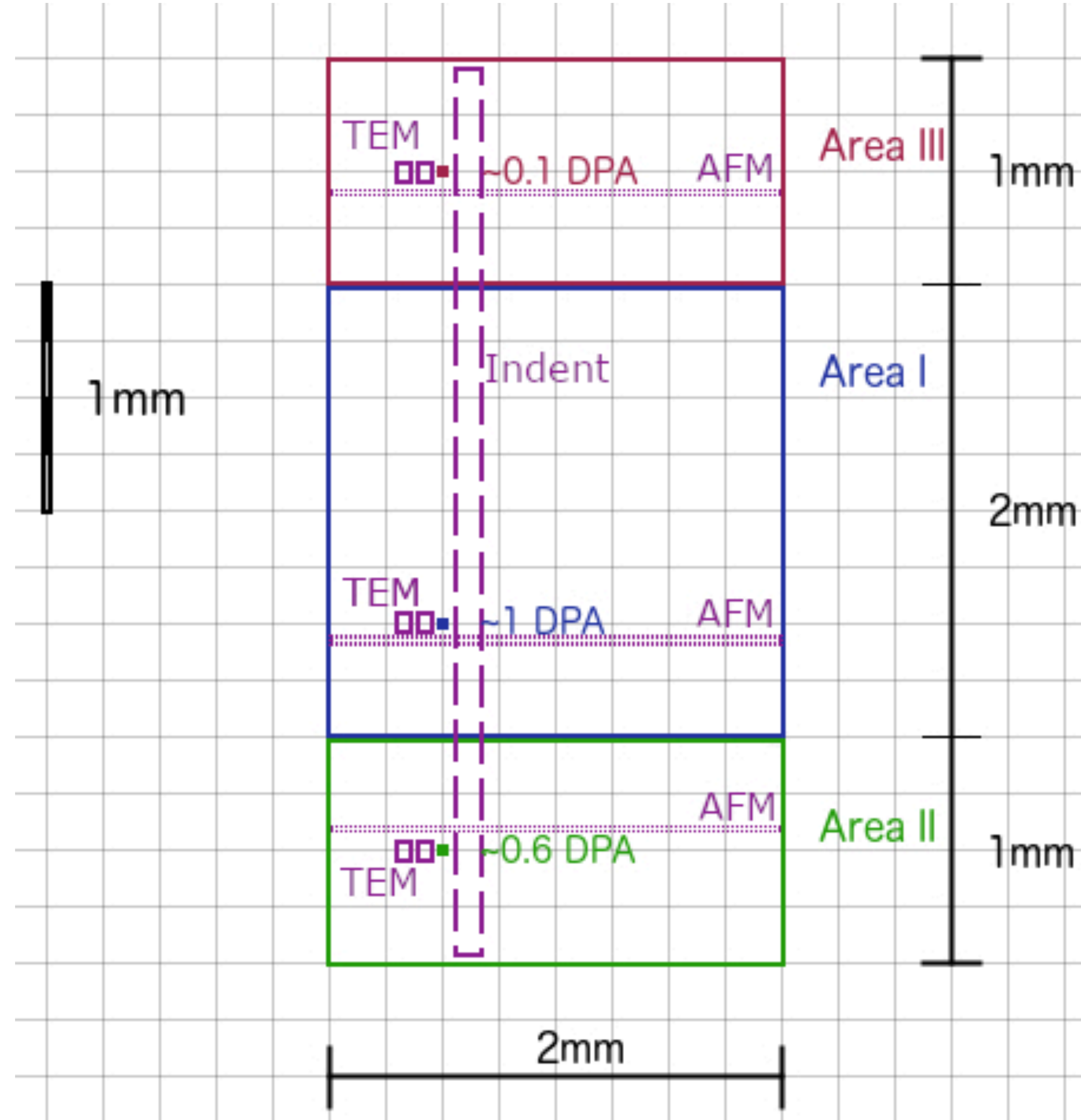
Trial irradiation: Damage rate

Irradiation Source	DPA rate (DPA/s)	He gas prod. (appm/DPA)	Irradiation Temp (˚C)
Mixed spectrum fission reactor	3×10^{-7}	1×10^{-1}	200-600
Fusion reactor	1×10^{-6}	1×10^{1}	400-1000
High energy proton beam	6×10^{-3}	1×10^{3}	100-800
Low energy He^{++} beam	3.25×10^{-4} (Peak)	None (implantable)	<100-650

Courtesy: P. Huhr

Trial irradiation: Upcoming PIE work

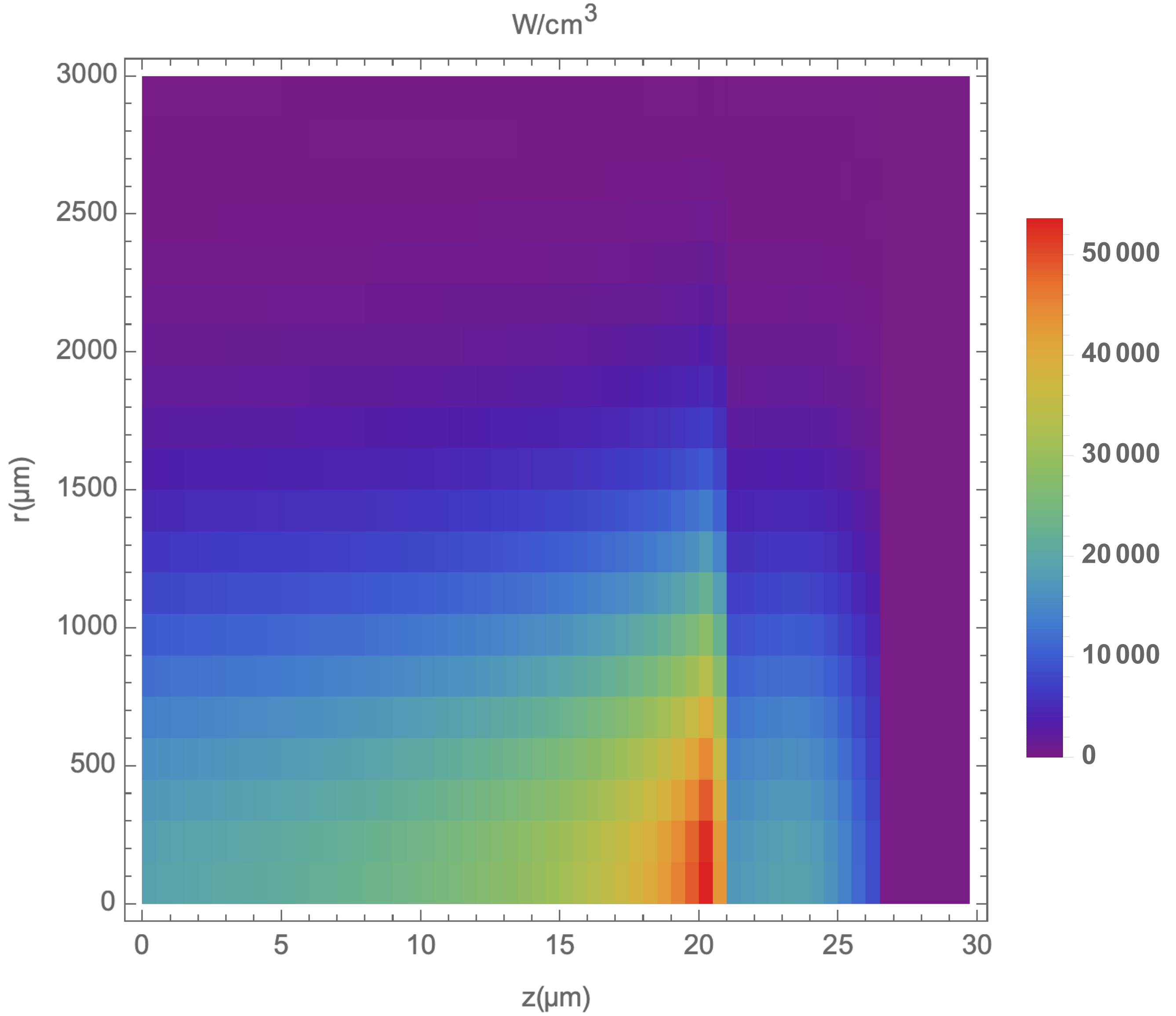
- TEM at University of Michigan Center for Materials Characterization (MC)²
- AFM profilometry measurements of swelling above surface at IIT
- Nano(micro)indentation at IIT



Future PIE work

- X-Ray Diffraction at Argonne National Laboratory Sector 10
- Microcantilever testing, facility TBD

BONUS SLIDES



Current monitoring and logs

Name for experiment									
				Beam current samples					
Starting Beam Current	335	nA		**Current (nA)**	**Time**	**Time Diff. (s)**	**Integrated Charge**	hrs	43
Sample Area	0.06	cm^2		372	11/20/2019 14:45:00	0	0.00E+00	ions	8.75E+15
Charge State	2			372	11/20/2019 14:46:00	60.0	2.23E-05	total ions	
Desired Dose	3.50E+18	atoms/cm^2		350	11/20/2019 15:42:00	3360.0	1.21E-03		
Start Time	11/20/2019 14:45			300	11/20/2019 16:48:00	3960.0	1.29E-03		
				283	11/20/2019 17:28:00	2400.0	7.00E-04		
Coulombs Needed	6.73609E-02			268	11/20/2019 18:31:00	3780.0	1.04E-03		
Coulombs Remaining	-1.68564E-04			254	11/20/2019 19:41:00	4200.0	1.10E-03		
Last Current	640.00			245	11/20/2019 20:31:00	3000.0	7.48E-04		
Last Time	11/22/2019 9:45:00			240	11/20/2019 21:21:00	3000.0	7.27E-04		
Stop Time	**11/22/2019 9:40:37**			240	11/20/2019 22:33:00	4320.0	1.04E-03		
				236	11/20/2019 23:43:00	4200.0	1.00E-03		
RATIO OF Y UP TO DOWN	UP/DOWN	1.86E+01		225	11/21/2019 0:25:00	2520.0	5.81E-04		
				225	11/21/2019 0:54:00	1740.0	3.92E-04		
				220	11/21/2019 2:55:00	7260.0	1.62E-03		
				215	11/21/2019 4:59:00	7440.0	1.62E-03		
				157	11/21/2019 7:05:00	7560.0	1.41E-03		
				157	11/21/2019 8:57:00	6720.0	1.06E-03		
				360	11/21/2019 9:01:00	240.0	6.20E-05		
				360	11/21/2019 9:02:00	60.0	2.16E-05		
				420	11/21/2019 9:12:00	600.0	2.34E-04		
				480	11/21/2019 9:23:00	660.0	2.97E-04		
				516	11/21/2019 9:47:00	1440.0	7.17E-04		
				520	11/21/2019 10:12:00	1500.0	7.77E-04		
				520	11/21/2019 11:43:00	5460.0	2.84E-03		
				590	11/21/2019 12:53:00	4200.0	2.33E-03		
				590	11/21/2019 14:09:00	4560.0	2.69E-03		
				570	11/21/2019 15:33:00	5040.0	2.92E-03		
				568	11/21/2019 16:29:00	3360.0	1.91E-03		
				564	11/21/2019 17:55:00	5160.0	2.92E-03		
				560	11/21/2019 21:21:00	12360.0	6.95E-03		
				640	11/22/2019 6:02:00	31260.0	1.88E-02		
				640	11/22/2019 8:32:00	9000.0	5.76E-03		
				640	11/22/2019 9:45:00	4380.0	2.80E-03		

Current monitoring and logs

Experiment:	t																																															
Date and Time	Average	:IG 4-1	:IG 4-2	:IG MBC	:AM 4-1 X+	:AM 4-1 X-	:AM 4-1 Y+	:AM 4-1 Y-	:AM 4-2	:DPA	:Total Charge	:Total Slits	:Slits + Stage	:IG 7-1	:IG 7-2	:IG MBC	:AM 7-1 X+	:AM 7-1 X-	:AM 7-1 Y+	:AM 7-1 Y-	:AM 7-2	:DPA	:Total Charge	:Total Slits	:Slits + Stage	:TC MBC-1 TR	:TC MBC-2 TR	:TC MBC-3 TR	:TC MBC-4 TR	:TC MBC-5 TR	:TC MBC-6 TR	:TC MBC-1 k-type	:TC MBC-2 k-type	:TC MBC-3 k-type	:TC MBC-4 k-type	:IG 5-0	:IG 5-1	:IG 5-2	:AM 5-1 X+	:AM 5-1 X-	:AM 5-1 Y+	:AM 5-1 Y-	:AM 5-2	:Total Slits	:Slits + Stage			
11/25/2019 2:51:53 PM	25.36	25.36	25.29	25.05	0.00E+00	6.07E-09	1.01E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.01E-07	4.19E-07	1.52E-07	1.74E-08	3.91E-08	-2.49E+02	0.00E+00	0.00E+00	6.27E-07	-2.49E+02	22.41	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:52:08 PM	25.38	25.38	25.31	25.07	0.00E+00	6.10E-09	1.01E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.01E-07	4.36E-07	1.44E-07	1.75E-08	3.89E-08	-2.49E+02	0.00E+00	0.00E+00	6.36E-07	-2.49E+02	22.39	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:52:18 PM	25.39	25.39	25.32	25.09	0.00E+00	6.13E-09	1.01E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.01E-07	4.30E-07	1.47E-07	1.76E-08	3.86E-08	-2.49E+02	0.00E+00	0.00E+00	6.33E-07	-2.49E+02	22.38	1381.43	1381.43	1381.43	1381.43	1381.43	2385.59	2385.59	2385.59	2385.59	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:52:28 PM	25.38	25.38	25.3	25.09	0.00E+00	6.13E-09	1.00E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.00E-07	4.34E-07	1.56E-07	1.62E-08	3.65E-08	-2.49E+02	0.00E+00	0.00E+00	6.43E-07	-2.49E+02	22.37	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:52:38 PM	25.36	25.36	25.3	25.07	0.00E+00	6.08E-09	1.00E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.00E-07	2.85E-07	2.67E-07	1.84E-08	4.03E-08	-2.49E+02	0.00E+00	0.00E+00	6.10E-07	-2.49E+02	22.37	1381.43	1381.43	1381.43	1381.43	1381.43	2385.59	2385.59	2385.59	2385.59	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
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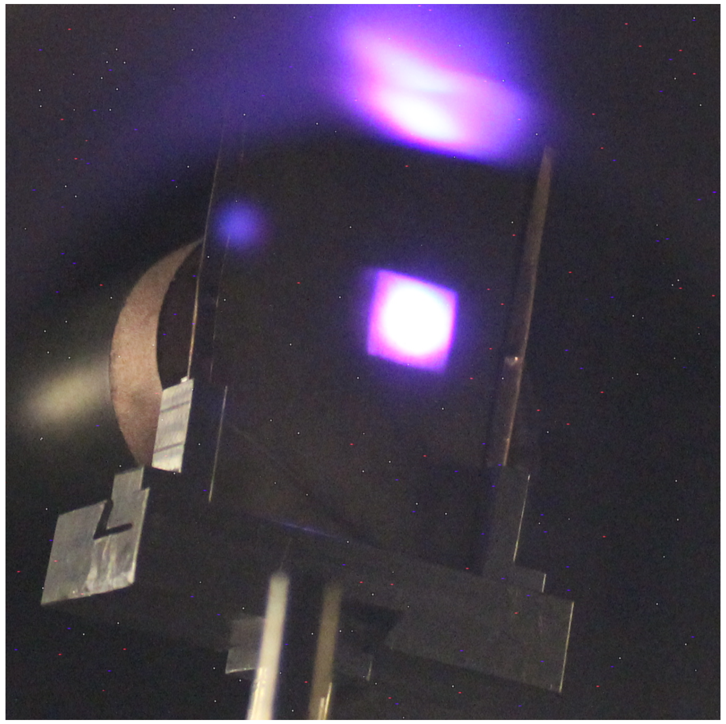
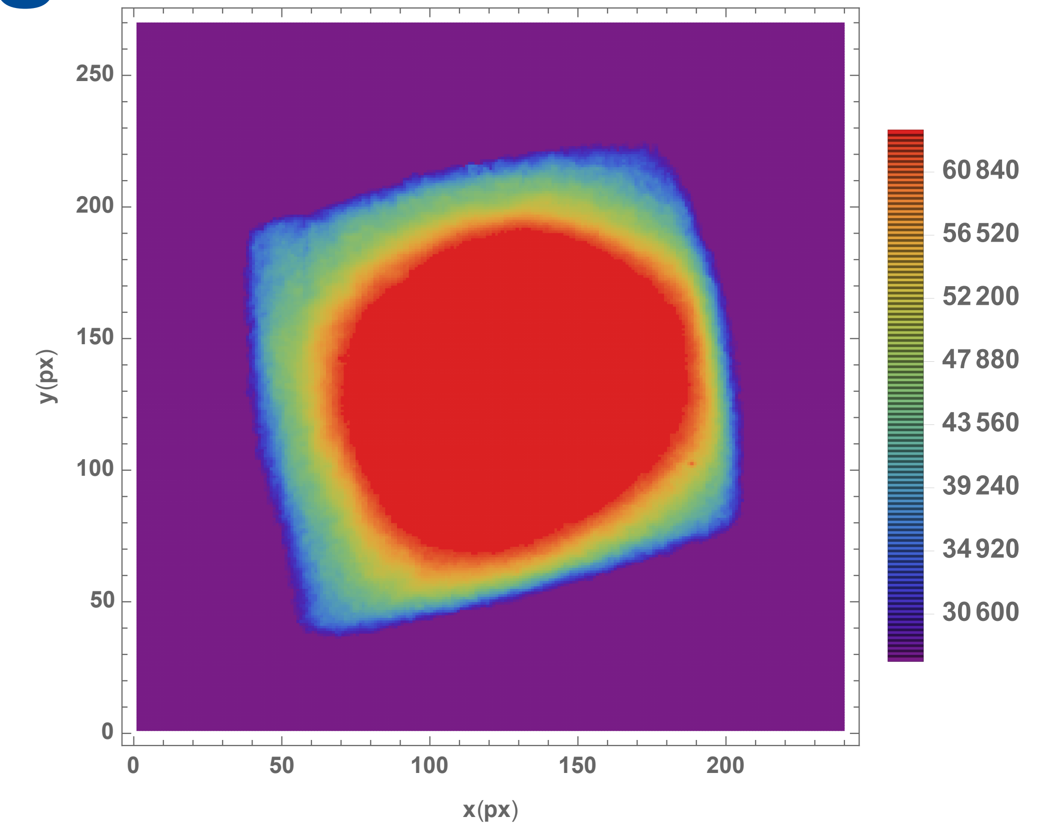
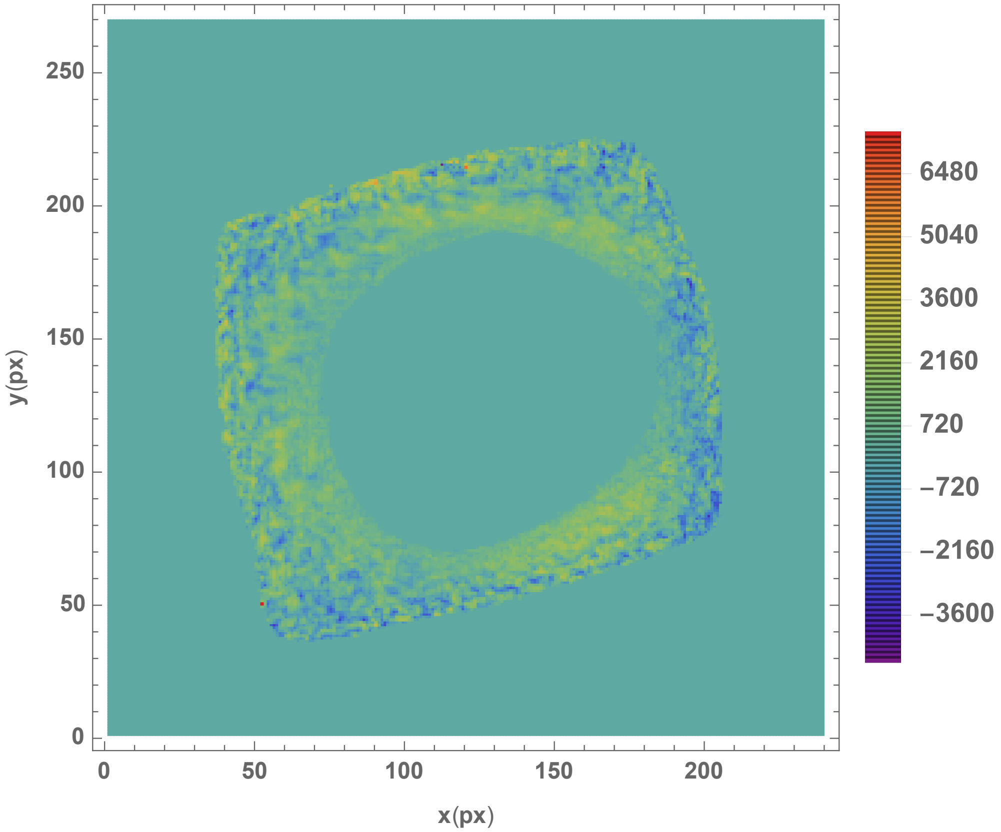
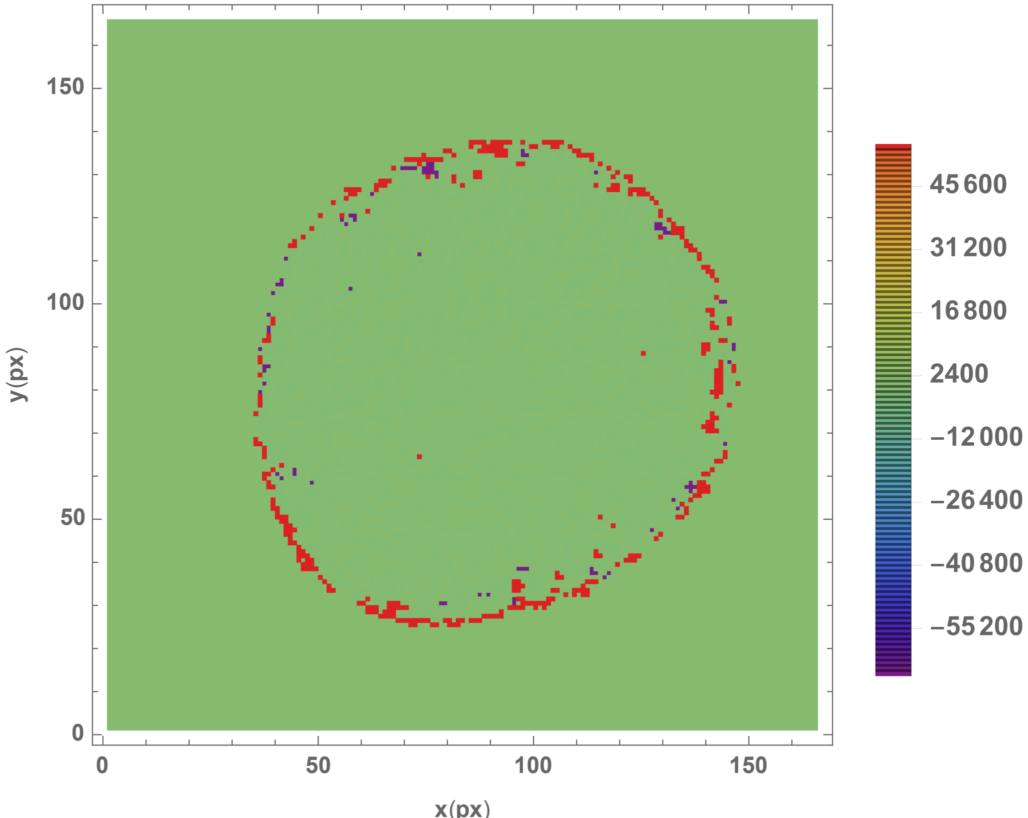
11/25/2019 2:52:58 PM	37.12	37.12	41.03	40.67	0.00E+00	6.05E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.15E-07	2.40E-07	1.71E-08	4.19E-08	-2.49E+02	0.00E+00	0.00E+00	6.14E-07	-2.49E+02	22.39	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:53:08 PM	37.5	37.5	41.54	41.18	0.00E+00	6.02E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	2.99E-07	2.60E-07	1.80E-08	4.17E-08	-2.49E+02	0.00E+00	0.00E+00	6.18E-07	-2.49E+02	22.45	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:53:18 PM	37.46	37.46	41.45	41.11	0.00E+00	6.02E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.19E-07	2.35E-07	1.73E-08	4.16E-08	-2.49E+02	0.00E+00	0.00E+00	6.13E-07	-2.49E+02	22.52	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:53:28 PM	37.61	37.61	41.62	41.26	0.00E+00	6.01E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.08E-07	2.45E-07	1.73E-08	4.20E-08	-2.49E+02	0.00E+00	0.00E+00	6.13E-07	-2.49E+02	22.61	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:53:38 PM	37.66	37.66	41.67	41.31	0.00E+00	6.07E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.00E-07	2.55E-07	1.80E-08	4.17E-08	-2.49E+02	0.00E+00	0.00E+00	6.15E-07	-2.49E+02	22.69	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:53:48 PM	37.56	37.56	41.54	41.19	0.00E+00	6.07E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	2.94E-07	2.58E-07	1.72E-08	4.20E-08	-2.49E+02	0.00E+00	0.00E+00	6.12E-07	-2.49E+02	22.76	1381.44	1381.44	1381.44	1381.44	1381.44	2385.59	2385.59	2385.59	2385.59	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:53:58 PM	37.58	37.58	41.54	41.21	0.00E+00	6.07E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.02E-07	2.49E-07	1.71E-08	4.18E-08	-2.49E+02	0.00E+00	0.00E+00	6.10E-07	-2.49E+02	22.83	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:54:08 PM	37.81	37.81	41.86	41.48	0.00E+00	5.99E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	2.90E-07	2.63E-07	1.78E-08	4.16E-08	-2.49E+02	0.00E+00	0.00E+00	6.13E-07	-2.49E+02	22.91	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.25E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:54:18 PM	37.93	37.93	41.99	41.61	0.00E+00	5.96E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	2.93E-07	2.62E-07	1.81E-08	4.17E-08	-2.49E+02	0.00E+00	0.00E+00	6.15E-07	-2.49E+02	23	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:54:28 PM	37.85	37.85	41.88	41.53	0.00E+00	6.04E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.09E-07	2.46E-07	1.71E-08	4.24E-08	-2.49E+02	0.00E+00	0.00E+00	6.14E-07	-2.49E+02	23.08	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:54:38 PM	37.97	37.97	41.99	41.62	0.00E+00	6.04E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.01E-07	2.52E-07	1.78E-08	4.17E-08	-2.49E+02	0.00E+00	0.00E+00	6.12E-07	-2.49E+02	23.15	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:54:48 PM	38	38	42.01	41.63	0.00E+00	6.06E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	2.97E-07	2.53E-07	1.80E-08	4.12E-08	-2.49E+02	0.00E+00	0.00E+00	6.09E-07	-2.49E+02	23.23	1381.44	1381.44	1381.44	1381.44	1381.44	2385.59	2385.59	2385.59	2385.59	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:54:58 PM	38.04	38.04	42.05	41.63	0.00E+00	6.03E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.02E-07	2.44E-07	1.82E-08	3.99E-08	-2.49E+02	0.00E+00	0.00E+00	6.04E-07	-2.49E+02	23.29	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:55:08 PM	38.16	38.16	42.18	41.7	0.00E+00	6.08E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	2.99E-07	2.50E-07	1.94E-08	3.74E-08	-2.49E+02	0.00E+00	0.00E+00	6.05E-07	-2.49E+02	23.63	1381.43	1381.43	1381.43	1381.43	1381.43	2385.59	2385.59	2385.59	2385.59	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:55:18 PM	38.44	38.44	42.53	42.01	0.00E+00	6.07E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.12E-07	2.48E-07	1.98E-08	3.77E-08	-2.49E+02	0.00E+00	0.00E+00	6.18E-07	-2.49E+02	25.22	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:55:28 PM	38.54	38.54	42.62	42.19	0.00E+00	6.07E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.10E-07	2.50E-07	1.84E-08	4.02E-08	-2.49E+02	0.00E+00	0.00E+00	6.19E-07	-2.49E+02	27.78	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:55:38 PM	39.84	38.58	42.58	42.21	0.00E+00	6.07E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.11E-07	2.47E-07	1.73E-08	4.17E-08	-2.49E+02	0.00E+00	0.00E+00	6.17E-07	-2.49E+02	30.86	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:55:48 PM	41.33	38.8	42.79	42.41	0.00E+00	6.05E-09	1.03E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.03E-07	3.11E-07	2.43E-07	1.76E-08	4.13E-08	-2.49E+02	0.00E+00	0.00E+00	6.13E-07	-2.49E+02	34.18	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:55:58 PM	41.67	39.17	43.12	42.71	0.00E+00	6.07E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	2.99E-07	2.51E-07	1.83E-08	4.01E-08	-2.49E+02	0.00E+00	0.00E+00	6.09E-07	-2.49E+02	38.04	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:56:08 PM	41.96	39.48	43.39	43.01	0.00E+00	6.04E-09	1.02E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.02E-07	3.03E-07	2.50E-07	1.84E-08	4.03E-08	-2.49E+02	0.00E+00	0.00E+00	6.11E-07	-2.49E+02	43.15	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:56:18 PM	42.51	40.04	43.96	43.54	0.00E+00	6.04E-09	1.03E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.03E-07	3.15E-07	2.37E-07	1.83E-08	4.02E-08	-2.49E+02	0.00E+00	0.00E+00	6.11E-07	-2.49E+02	49.06	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:56:28 PM	43.31	40.83	44.75	44.35	0.00E+00	6.04E-09	1.03E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.03E-07	3.05E-07	2.48E-07	1.83E-08	4.02E-08	-2.49E+02	0.00E+00	0.00E+00	6.11E-07	-2.49E+02	55.31	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:56:38 PM	44.04	41.57	45.46	45.09	0.00E+00	6.00E-09	1.03E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.03E-07	3.13E-07	2.39E-07	1.87E-08	4.01E-08	-2.49E+02	0.00E+00	0.00E+00	6.11E-07	-2.49E+02	61.57	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:56:48 PM	44.84	42.37	46.23	45.91	0.00E+00	6.00E-09	1.03E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.03E-07	3.09E-07	2.46E-07	1.83E-08	4.09E-08	-2.49E+02	0.00E+00	0.00E+00	6.14E-07	-2.49E+02	67.63	1381.43	1381.43	1381.43	1381.43	1381.43	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:56:58 PM	45.67	43.21	47.06	46.75	0.00E+00	6.02E-09	1.04E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.04E-07	3.18E-07	2.36E-07	1.78E-08	4.13E-08	-2.49E+02	0.00E+00	0.00E+00	6.13E-07	-2.49E+02	73.32	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:57:08 PM	46.69	44.24	48.08	47.75	0.00E+00	6.07E-09	1.04E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.04E-07	3.34E-07	2.23E-07	1.76E-08	4.08E-08	-2.49E+02	0.00E+00	0.00E+00	6.15E-07	-2.49E+02	78.72	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:57:18 PM	47.55	45.14	48.91	48.6	0.00E+00	6.11E-09	1.05E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.05E-07	3.53E-07	2.05E-07	1.78E-08	4.05E-08	-2.49E+02	0.00E+00	0.00E+00	6.17E-07	-2.49E+02	83.85	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:57:28 PM	48.95	46.57	50.3	49.99	0.00E+00	6.08E-09	1.05E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.05E-07	2.72E-07	2.86E-07	1.78E-08	3.98E-08	-2.49E+02	0.00E+00	0.00E+00	6.15E-07	-2.49E+02	88.78	1381.42	1381.42	1381.42	1381.42	1381.42	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:57:38 PM	50.47	48.04	51.84	51.53	0.00E+00	6.06E-09	1.06E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.06E-07	3.14E-07	2.46E-07	1.86E-08	3.98E-08	-2.49E+02	0.00E+00	0.00E+00	6.18E-07	-2.49E+02	93.43	1381.42	1381.42	1381.42	1381.42	1381.42	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:57:48 PM	51.69	49.35	53.04	52.69	0.00E+00	6.04E-09	1.07E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.07E-07	3.23E-07	2.36E-07	2.18E-08	3.59E-08	-2.49E+02	0.00E+00	0.00E+00	6.18E-07	-2.49E+02	97.88	1381.42	1381.42	1381.42	1381.42	1381.42	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:57:58 PM	53.03	50.78	54.4	53.92	0.00E+00	6.06E-09	1.07E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.07E-07	3.26E-07	2.28E-07	2.60E-08	2.98E-08	-2.49E+02	0.00E+00	0.00E+00	6.10E-07	-2.49E+02	102.13	1381.42	1381.42	1381.42	1381.42	1381.42	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:58:08 PM	54.45	52.26	55.75	55.36	0.00E+00	6.08E-09	1.08E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.08E-07	2.83E-07	2.69E-07	2.62E-08	2.88E-08	-2.49E+02	0.00E+00	0.00E+00	6.07E-07	-2.49E+02	106.22	1381.42	1381.42	1381.42	1381.42	1381.42	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:58:18 PM	55.93	53.78	57.18	56.84	0.00E+00	6.09E-09	1.09E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.09E-07	2.56E-07	2.92E-07	2.61E-08	2.83E-08	-2.49E+02	0.00E+00	0.00E+00	6.03E-07	-2.49E+02	110.22	1381.42	1381.42	1381.42	1381.42	1381.42	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:58:28 PM	57.44	55.31	58.67	58.34	0.00E+00	6.10E-09	1.10E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.10E-07	2.61E-07	2.92E-07	2.59E-08	2.90E-08	-2.49E+02	0.00E+00	0.00E+00	6.07E-07	-2.49E+02	114.15	1381.42	1381.42	1381.42	1381.42	1381.42	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:58:38 PM	59.43	57.26	60.7	60.32	0.00E+00	6.11E-09	1.11E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.11E-07	2.66E-07	2.92E-07	2.62E-08	2.95E-08	-2.49E+02	0.00E+00	0.00E+00	6.14E-07	-2.49E+02	117.94	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:58:48 PM	61.09	58.97	62.32	61.99	0.00E+00	6.09E-09	1.12E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.12E-07	2.57E-07	3.00E-07	2.59E-08	2.95E-08	-2.49E+02	0.00E+00	0.00E+00	6.13E-07	-2.49E+02	121.75	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:58:58 PM	62.85	60.76	64.05	63.73	0.00E+00	6.07E-09	1.13E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.13E-07	2.51E-07	3.04E-07	2.66E-08	2.81E-08	-2.49E+02	0.00E+00	0.00E+00	6.10E-07	-2.49E+02	125.49	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:59:08 PM	64.53	62.5	65.69	65.41	0.00E+00	6.08E-09	1.15E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.15E-07	2.57E-07	2.94E-07	2.60E-08	2.89E-08	-2.49E+02	0.00E+00	0.00E+00	6.06E-07	-2.49E+02	129.11	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:59:18 PM	66.36	64.38	67.46	67.23	0.00E+00	6.05E-09	1.16E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.16E-07	2.52E-07	3.02E-07	2.59E-08	2.92E-08	-2.49E+02	0.00E+00	0.00E+00	6.09E-07	-2.49E+02	132.63	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:59:28 PM	68.23	66.28	69.35	69.07	0.00E+00	6.06E-09	1.17E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.17E-07	2.63E-07	2.88E-07	2.63E-08	2.85E-08	-2.49E+02	0.00E+00	0.00E+00	6.06E-07	-2.49E+02	136.06	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:59:38 PM	70.26	68.33	71.37	71.08	0.00E+00	6.04E-09	1.18E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.18E-07	2.68E-07	2.79E-07	2.67E-08	2.78E-08	-2.49E+02	0.00E+00	0.00E+00	6.02E-07	-2.49E+02	139.42	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.25E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:59:48 PM	72.49	70.57	73.61	73.29	0.00E+00	5.97E-09	1.20E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.20E-07	2.66E-07	2.85E-07	2.76E-08	2.76E-08	-2.49E+02	0.00E+00	0.00E+00	6.05E-07	-2.49E+02	142.67	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 2:59:58 PM	74.52	72.64	75.61	75.31	0.00E+00	6.00E-09	1.22E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.22E-07	2.69E-07	2.79E-07	2.79E-08	2.72E-08	-2.49E+02	0.00E+00	0.00E+00	6.03E-07	-2.49E+02	145.87	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:00:08 PM	76.51	74.67	77.57	77.29	0.00E+00	6.03E-09	1.23E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.23E-07	2.68E-07	2.79E-07	2.77E-08	2.71E-08	-2.49E+02	0.00E+00	0.00E+00	6.02E-07	-2.49E+02	149.02	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:00:18 PM	78.54	76.73	79.57	79.31	0.00E+00	6.09E-09	1.24E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.24E-07	2.71E-07	2.79E-07	2.80E-08	2.73E-08	-2.49E+02	0.00E+00	0.00E+00	6.05E-07	-2.49E+02	152.09	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:00:28 PM	80.58	78.81	81.61	81.31	0.00E+00	6.05E-09	1.26E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.26E-07	2.84E-07	2.64E-07	2.88E-08	2.64E-08	-2.49E+02	0.00E+00	0.00E+00	6.03E-07	-2.49E+02	155.12	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:00:38 PM	82.63	80.94	83.59	83.36	0.00E+00	6.11E-09	1.27E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.27E-07	2.70E-07	2.77E-07	2.92E-08	2.54E-08	-2.49E+02	0.00E+00	0.00E+00	6.01E-07	-2.49E+02	158.08	1381.43	1381.43	1381.43	1381.43	1381.43	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:00:48 PM	74.56	74.74	74.4	74.53	0.00E+00	6.16E-09	1.28E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.28E-07	2.76E-07	2.75E-07	2.94E-08	2.55E-08	-2.49E+02	0.00E+00	0.00E+00	6.06E-07	-2.49E+02	160.97	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:00:58 PM	86.55	85.07	87.52	87.07	0.00E+00	6.16E-09	1.28E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.28E-07	2.65E-07	2.90E-07	2.98E-08	2.53E-08	-2.49E+02	0.00E+00	0.00E+00	6.10E-07	-2.49E+02	163.84	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:01:08 PM	88.93	87.43	89.88	89.49	0.00E+00	6.04E-09	1.32E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.32E-07	2.66E-07	2.86E-07	2.99E-08	2.49E-08	-2.49E+02	0.00E+00	0.00E+00	6.07E-07	-2.49E+02	166.67	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:01:18 PM	91.15	89.66	92.06	91.74	0.00E+00	6.00E-09	1.34E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.34E-07	2.63E-07	2.88E-07	2.95E-08	2.52E-08	-2.49E+02	0.00E+00	0.00E+00	6.05E-07	-2.49E+02	169.47	1381.43	1381.43	1381.43	1381.43	1381.43	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:01:28 PM	93.32	91.87	94.17	93.92	0.00E+00	6.02E-09	1.36E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.36E-07	2.69E-07	2.80E-07	2.88E-08	2.60E-08	-2.49E+02	0.00E+00	0.00E+00	6.04E-07	-2.49E+02	172.27	1381.44	1381.44	1381.44	1381.44	1381.44	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.25E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:01:38 PM	95.53	94.11	96.37	96.11	0.00E+00	6.01E-09	1.38E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.38E-07	2.73E-07	2.69E-07	2.84E-08	2.56E-08	-2.49E+02	0.00E+00	0.00E+00	5.96E-07	-2.49E+02	175.04	1381.44	1381.44	1381.44	1381.44	1381.44	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:01:48 PM	97.78	96.41	98.6	98.35	0.00E+00	5.99E-09	1.40E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.40E-07	2.73E-07	2.66E-07	2.85E-08	2.54E-08	-2.49E+02	0.00E+00	0.00E+00	5.93E-07	-2.49E+02	177.5	1381.44	1381.44	1381.44	1381.44	1381.44	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:01:58 PM	100.24	98.81	101.05	100.87	0.00E+00	5.99E-09	1.43E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.43E-07	2.84E-07	2.67E-07	2.82E-08	2.80E-08	-2.49E+02	0.00E+00	0.00E+00	6.07E-07	-2.49E+02	179.55	1381.44	1381.44	1381.44	1381.44	1381.44	2385.58	2385.58	2385.58	2385.58	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:02:08 PM	102.28	100.87	103.02	102.96	0.00E+00	6.03E-09	1.45E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.45E-07	2.72E-07	2.74E-07	2.55E-08	3.11E-08	-2.49E+02	0.00E+00	0.00E+00	6.03E-07	-2.49E+02	180.98	1381.44	1381.44	1381.44	1381.44	1381.44	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:02:18 PM	104.33	102.96	105.02	105.01	0.00E+00	6.14E-09	1.47E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.47E-07	2.73E-07	2.70E-07	2.50E-08	3.15E-08	-2.49E+02	0.00E+00	0.00E+00	6.00E-07	-2.49E+02	180.36	1381.44	1381.44	1381.44	1381.44	1381.44	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:02:28 PM	106.22	104.87	106.88	106.91	0.00E+00	6.03E-09	1.49E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.49E-07	2.62E-07	2.84E-07	2.46E-08	3.18E-08	-2.49E+02	0.00E+00	0.00E+00	6.02E-07	-2.49E+02	178.23	1381.44	1381.44	1381.44	1381.44	1381.44	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:02:38 PM	107.98	106.67	108.62	108.66	0.00E+00	6.03E-09	1.51E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.51E-07	2.64E-07	2.79E-07	2.43E-08	3.21E-08	-2.49E+02	0.00E+00	0.00E+00	6.00E-07	-2.49E+02	175.94	1381.44	1381.44	1381.44	1381.44	1381.44	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:02:48 PM	109.57	108.31	110.17	110.22	0.00E+00	6.08E-09	1.53E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.53E-07	2.67E-07	2.76E-07	2.45E-08	3.19E-08	-2.49E+02	0.00E+00	0.00E+00	6.00E-07	-2.49E+02	173.83	1381.44	1381.44	1381.44	1381.44	1381.44	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:02:58 PM	111.13	109.87	111.72	111.81	0.00E+00	6.09E-09	1.55E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.55E-07	2.61E-07	2.82E-07	2.41E-08	3.23E-08	-2.49E+02	0.00E+00	0.00E+00	5.99E-07	-2.49E+02	171.81	1381.44	1381.44	1381.44	1381.44	1381.44	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:03:08 PM	112.73	111.45	113.32	113.41	0.00E+00	6.07E-09	1.56E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.56E-07	2.73E-07	2.73E-07	2.41E-08	3.27E-08	-2.49E+02	0.00E+00	0.00E+00	6.03E-07	-2.49E+02	169.9	1381.44	1381.44	1381.44	1381.44	1381.44	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:03:18 PM	113.99	112.72	114.57	114.69	0.00E+00	6.04E-09	1.57E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.57E-07	2.81E-07	2.67E-07	2.38E-08	3.37E-08	-2.49E+02	0.00E+00	0.00E+00	6.05E-07	-2.49E+02	168.1	1381.44	1381.44	1381.44	1381.44	1381.44	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:03:28 PM	115.13	113.88	115.68	115.82	0.00E+00	6.03E-09	1.59E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.59E-07	2.93E-07	2.55E-07	2.37E-08	3.39E-08	-2.49E+02	0.00E+00	0.00E+00	6.06E-07	-2.49E+02	166.44	1381.44	1381.44	1381.44	1381.44	1381.44	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:03:38 PM	116.18	114.95	116.71	116.87	0.00E+00	6.04E-09	1.60E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.60E-07	2.79E-07	2.65E-07	2.41E-08	3.30E-08	-2.49E+02	0.00E+00	0.00E+00	6.01E-07	-2.49E+02	164.94	1381.44	1381.44	1381.44	1381.44	1381.44	2385.57	2385.57	2385.57	2385.57	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:03:48 PM	117.04	115.83	117.54	117.75	0.00E+00	6.08E-09	1.61E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.61E-07	2.71E-07	2.72E-07	2.40E-08	3.29E-08	-2.49E+02	0.00E+00	0.00E+00	6.00E-07	-2.49E+02	163.5	1381.44	1381.44	1381.44	1381.44	1381.44	2385.55	2385.55	2385.55	2385.55	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:03:58 PM	117.12	115.88	117.59	117.87	0.00E+00	6.06E-09	1.62E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.62E-07	2.62E-07	2.80E-07	2.38E-08	3.26E-08	-2.49E+02	0.00E+00	0.00E+00	5.98E-07	-2.49E+02	161.9	1381.44	1381.44	1381.44	1381.44	1381.44	2385.55	2385.55	2385.55	2385.55	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:04:08 PM	116.61	115.34	117.1	117.41	0.00E+00	6.05E-09	1.62E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.62E-07	2.73E-07	2.74E-07	2.33E-08	3.39E-08	-2.49E+02	0.00E+00	0.00E+00	6.04E-07	-2.49E+02	159.89	1381.44	1381.44	1381.44	1381.44	1381.44	2385.56	2385.56	2385.56	2385.56	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:04:18 PM	115.66	114.35	116.15	116.48	0.00E+00	6.05E-09	1.61E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.61E-07	2.73E-07	2.77E-07	2.26E-08	3.49E-08	-2.49E+02	0.00E+00	0.00E+00	6.07E-07	-2.49E+02	157.34	1381.44	1381.44	1381.44	1381.44	1381.44	2385.54	2385.54	2385.54	2385.54	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:04:28 PM	114.5	113.16	115.02	115.31	0.00E+00	6.03E-09	1.61E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.61E-07	2.81E-07	2.70E-07	2.30E-08	3.47E-08	-2.49E+02	0.00E+00	0.00E+00	6.08E-07	-2.49E+02	154.5	1381.44	1381.44	1381.44	1381.44	1381.44	2385.55	2385.55	2385.55	2385.55	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:04:38 PM	113.1	111.76	113.63	113.91	0.00E+00	6.04E-09	1.61E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.61E-07	2.76E-07	2.70E-07	2.33E-08	3.37E-08	-2.49E+02	0.00E+00	0.00E+00	6.04E-07	-2.49E+02	151.61	1381.44	1381.44	1381.44	1381.44	1381.44	2385.55	2385.55	2385.55	2385.55	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:04:48 PM	111.72	110.36	112.26	112.54	0.00E+00	6.09E-09	1.59E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.59E-07	2.75E-07	2.66E-07	2.34E-08	3.35E-08	-2.49E+02	0.00E+00	0.00E+00	5.97E-07	-2.49E+02	148.76	1381.44	1381.44	1381.44	1381.44	1381.44	2385.55	2385.55	2385.55	2385.55	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:04:58 PM	110.29	108.92	110.84	111.13	0.00E+00	6.09E-09	1.58E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.58E-07	2.69E-07	2.72E-07	2.33E-08	3.33E-08	-2.49E+02	0.00E+00	0.00E+00	5.98E-07	-2.49E+02	145.98	1381.44	1381.44	1381.44	1381.44	1381.44	2385.54	2385.54	2385.54	2385.54	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:05:08 PM	108.88	107.5	109.44	109.71	0.00E+00	6.05E-09	1.57E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.57E-07	2.79E-07	2.63E-07	2.37E-08	3.31E-08	-2.49E+02	0.00E+00	0.00E+00	5.99E-07	-2.49E+02	143.22	1381.44	1381.44	1381.44	1381.44	1381.44	2385.54	2385.54	2385.54	2385.54	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:05:18 PM	107.87	106.42	108.46	108.71	0.00E+00	6.04E-09	1.55E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.55E-07	2.85E-07	2.62E-07	2.43E-08	3.32E-08	-2.49E+02	0.00E+00	0.00E+00	6.04E-07	-2.49E+02	140.51	1381.44	1381.44	1381.44	1381.44	1381.44	2385.54	2385.54	2385.54	2385.54	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:05:28 PM	106.47	105.01	107.06	107.33	0.00E+00	6.06E-09	1.53E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.53E-07	2.77E-07	2.69E-07	2.37E-08	3.35E-08	-2.49E+02	0.00E+00	0.00E+00	6.04E-07	-2.49E+02	137.88	1381.44	1381.44	1381.44	1381.44	1381.44	2385.55	2385.55	2385.55	2385.55	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:05:38 PM	105.03	103.56	105.64	105.9	0.00E+00	6.06E-09	1.52E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.52E-07	2.80E-07	2.70E-07	2.34E-08	3.41E-08	-2.49E+02	0.00E+00	0.00E+00	6.08E-07	-2.49E+02	135.31	1381.44	1381.44	1381.44	1381.44	1381.44	2385.54	2385.54	2385.54	2385.54	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:05:48 PM	103.63	102.16	104.2	104.52	0.00E+00	6.09E-09	1.50E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.50E-07	2.82E-07	2.68E-07	2.27E-08	3.47E-08	-2.49E+02	0.00E+00	0.00E+00	6.08E-07	-2.49E+02	132.82	1381.44	1381.44	1381.44	1381.44	1381.44	2385.55	2385.55	2385.55	2385.55	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:05:58 PM	102.31	100.83	102.91	103.2	0.00E+00	6.08E-09	1.48E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.48E-07	2.93E-07	2.55E-07	2.22E-08	3.48E-08	-2.49E+02	0.00E+00	0.00E+00	6.05E-07	-2.49E+02	130.42	1381.44	1381.44	1381.44	1381.44	1381.44	2385.54	2385.54	2385.54	2385.54	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:06:08 PM	100.98	99.5	101.57	101.86	0.00E+00	6.09E-09	1.47E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.47E-07	2.80E-07	2.67E-07	2.15E-08	3.51E-08	-2.49E+02	0.00E+00	0.00E+00	6.03E-07	-2.49E+02	128.15	1381.44	1381.44	1381.44	1381.44	1381.44	2385.54	2385.54	2385.54	2385.54	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:06:18 PM	99.84	98.33	100.46	100.72	0.00E+00	6.04E-09	1.45E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.45E-07	2.97E-07	2.49E-07	2.25E-08	3.43E-08	-2.49E+02	0.00E+00	0.00E+00	6.03E-07	-2.49E+02	126.01	1381.44	1381.44	1381.44	1381.44	1381.44	2385.54	2385.54	2385.54	2385.54	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:06:28 PM	98.87	97.33	99.52	99.76	0.00E+00	6.05E-09	1.43E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.43E-07	3.02E-07	2.50E-07	2.24E-08	3.51E-08	-2.49E+02	0.00E+00	0.00E+00	6.10E-07	-2.49E+02	124.04	1381.44	1381.44	1381.44	1381.44	1381.44	2385.54	2385.54	2385.54	2385.54	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:06:38 PM	97.72	96.18	98.37	98.62	0.00E+00	6.07E-09	1.41E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.41E-07	2.94E-07	2.58E-07	2.30E-08	3.44E-08	-2.49E+02	0.00E+00	0.00E+00	6.09E-07	-2.49E+02	122.26	1381.44	1381.44	1381.44	1381.44	1381.44	2385.53	2385.53	2385.53	2385.53	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:06:48 PM	96.57	95.02	97.22	97.46	0.00E+00	6.08E-09	1.40E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.40E-07	2.90E-07	2.59E-07	2.27E-08	3.43E-08	-2.49E+02	0.00E+00	0.00E+00	6.06E-07	-2.49E+02	121.27	1381.44	1381.44	1381.44	1381.44	1381.44	2385.53	2385.53	2385.53	2385.53	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:06:58 PM	95.57	94	96.26	96.46	0.00E+00	6.23E-09	1.38E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.38E-07	2.96E-07	2.50E-07	2.30E-08	3.41E-08	-2.49E+02	0.00E+00	0.00E+00	6.03E-07	-2.49E+02	121.74	1381.44	1381.44	1381.44	1381.44	1381.44	2385.52	2385.52	2385.52	2385.52	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:07:08 PM	94.61	93.02	95.31	95.49	0.00E+00	6.11E-09	1.36E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.36E-07	2.97E-07	2.46E-07	2.27E-08	3.42E-08	-2.49E+02	0.00E+00	0.00E+00	6.00E-07	-2.49E+02	123.38	1381.44	1381.44	1381.44	1381.44	1381.44	2385.52	2385.52	2385.52	2385.52	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:07:18 PM	93.69	92.11	94.37	94.59	0.00E+00	6.07E-09	1.35E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.35E-07	2.87E-07	2.53E-07	2.27E-08	3.38E-08	-2.49E+02	0.00E+00	0.00E+00	5.96E-07	-2.49E+02	125.7	1381.44	1381.44	1381.44	1381.44	1381.44	2385.52	2385.52	2385.52	2385.52	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:07:28 PM	93.25	91.63	93.97	94.14	0.00E+00	6.10E-09	1.33E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.33E-07	2.89E-07	2.55E-07	2.32E-08	3.38E-08	-2.49E+02	0.00E+00	0.00E+00	6.01E-07	-2.49E+02	128.62	1381.44	1381.44	1381.44	1381.44	1381.44	2385.52	2385.52	2385.52	2385.52	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:07:38 PM	92.77	91.12	93.51	93.69	0.00E+00	6.12E-09	1.32E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.32E-07	2.94E-07	2.55E-07	2.30E-08	3.45E-08	-2.49E+02	0.00E+00	0.00E+00	6.07E-07	-2.49E+02	131.82	1381.44	1381.44	1381.44	1381.44	1381.44	2385.52	2385.52	2385.52	2385.52	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:07:48 PM	92.25	90.61	92.99	93.16	0.00E+00	6.11E-09	1.31E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.31E-07	2.95E-07	2.53E-07	2.25E-08	3.51E-08	-2.49E+02	0.00E+00	0.00E+00	6.06E-07	-2.49E+02	135.13	1381.45	1381.45	1381.45	1381.45	1381.45	2385.52	2385.52	2385.52	2385.52	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:07:58 PM	91.76	90.1	92.51	92.66	0.00E+00	6.10E-09	1.30E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.30E-07	2.85E-07	2.57E-07	2.21E-08	3.48E-08	-2.49E+02	0.00E+00	0.00E+00	5.99E-07	-2.49E+02	138.42	1381.44	1381.44	1381.44	1381.44	1381.44	2385.51	2385.51	2385.51	2385.51	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:08:08 PM	91.44	89.79	92.18	92.34	0.00E+00	6.03E-09	1.30E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.30E-07	2.78E-07	2.64E-07	2.22E-08	3.47E-08	-2.49E+02	0.00E+00	0.00E+00	5.99E-07	-2.49E+02	141.76	1381.45	1381.45	1381.45	1381.45	1381.45	2385.51	2385.51	2385.51	2385.51	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:08:18 PM	91.2	89.57	91.93	92.1	0.00E+00	6.00E-09	1.29E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.29E-07	2.81E-07	2.61E-07	2.26E-08	3.43E-08	-2.49E+02	0.00E+00	0.00E+00	5.99E-07	-2.49E+02	145.15	1381.45	1381.45	1381.45	1381.45	1381.45	2385.51	2385.51	2385.51	2385.51	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:08:28 PM	90.94	89.34	91.67	91.82	0.00E+00	6.04E-09	1.28E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.28E-07	3.02E-07	2.39E-07	2.12E-08	3.54E-08	-2.49E+02	0.00E+00	0.00E+00	5.98E-07	-2.49E+02	148.48	1381.45	1381.45	1381.45	1381.45	1381.45	2385.5	2385.5	2385.5	2385.5	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:08:38 PM	91.3	89.65	92.09	92.17	0.00E+00	6.05E-09	1.28E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.28E-07	3.10E-07	2.39E-07	2.15E-08	3.61E-08	-2.49E+02	0.00E+00	0.00E+00	6.07E-07	-2.49E+02	151.61	1381.45	1381.45	1381.45	1381.45	1381.45	2385.5	2385.5	2385.5	2385.5	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:08:48 PM	91.38	89.73	92.15	92.25	0.00E+00	6.06E-09	1.27E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.27E-07	3.09E-07	2.43E-07	2.18E-08	3.61E-08	-2.49E+02	0.00E+00	0.00E+00	6.09E-07	-2.49E+02	154.55	1381.45	1381.45	1381.45	1381.45	1381.45	2385.5	2385.5	2385.5	2385.5	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:08:58 PM	91.52	89.89	92.28	92.38	0.00E+00	6.08E-09	1.26E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.26E-07	3.06E-07	2.42E-07	2.22E-08	3.51E-08	-2.49E+02	0.00E+00	0.00E+00	6.06E-07	-2.49E+02	157.26	1381.45	1381.45	1381.45	1381.45	1381.45	2385.5	2385.5	2385.5	2385.5	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:09:08 PM	91.65	90.06	92.38	92.51	0.00E+00	5.99E-09	1.25E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.25E-07	3.03E-07	2.45E-07	2.15E-08	3.54E-08	-2.49E+02	0.00E+00	0.00E+00	6.05E-07	-2.49E+02	159.68	1381.45	1381.45	1381.45	1381.45	1381.45	2385.5	2385.5	2385.5	2385.5	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:09:18 PM	91.88	90.31	92.62	92.71	0.00E+00	5.96E-09	1.25E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.25E-07	3.06E-07	2.41E-07	2.09E-08	3.58E-08	-2.49E+02	0.00E+00	0.00E+00	6.04E-07	-2.49E+02	161.76	1381.45	1381.45	1381.45	1381.45	1381.45	2385.5	2385.5	2385.5	2385.5	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:09:28 PM	92.22	90.67	92.96	93.04	0.00E+00	5.95E-09	1.25E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.25E-07	2.94E-07	2.49E-07	2.15E-08	3.50E-08	-2.49E+02	0.00E+00	0.00E+00	5.99E-07	-2.49E+02	163.65	1381.45	1381.45	1381.45	1381.45	1381.45	2385.5	2385.5	2385.5	2385.5	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:09:38 PM	92.68	91.14	93.43	93.49	0.00E+00	5.99E-09	1.24E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.24E-07	3.04E-07	2.38E-07	2.14E-08	3.51E-08	-2.49E+02	0.00E+00	0.00E+00	5.98E-07	-2.49E+02	165.39	1381.45	1381.45	1381.45	1381.45	1381.45	2385.49	2385.49	2385.49	2385.49	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11/25/2019 3:09:48 PM	93.34	91.75	94.11	94.16	0.00E+00	6.05E-09	1.24E-07	1.69E-08	-3.58E-09	1.00E-07	6.15E-10	2.00E-12	0.00E+00	0.00E+00	1.14E-07	1.14E-07	3.47E-12	1.46E-07	1.24E-07	3.07E-07	2.44E-07	2.20E-08	3.57E-08	-2.49E+02	0.00E+00	0.00E+00	6.09E-07	-2.49E+02	167.01	1381.45	1381.45	1381.45	1381.45	1381.45	2385.5	2385.5	2385.5	2385.5	0.00E+00	0.00E+00	3.24E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Rastered beam analysis



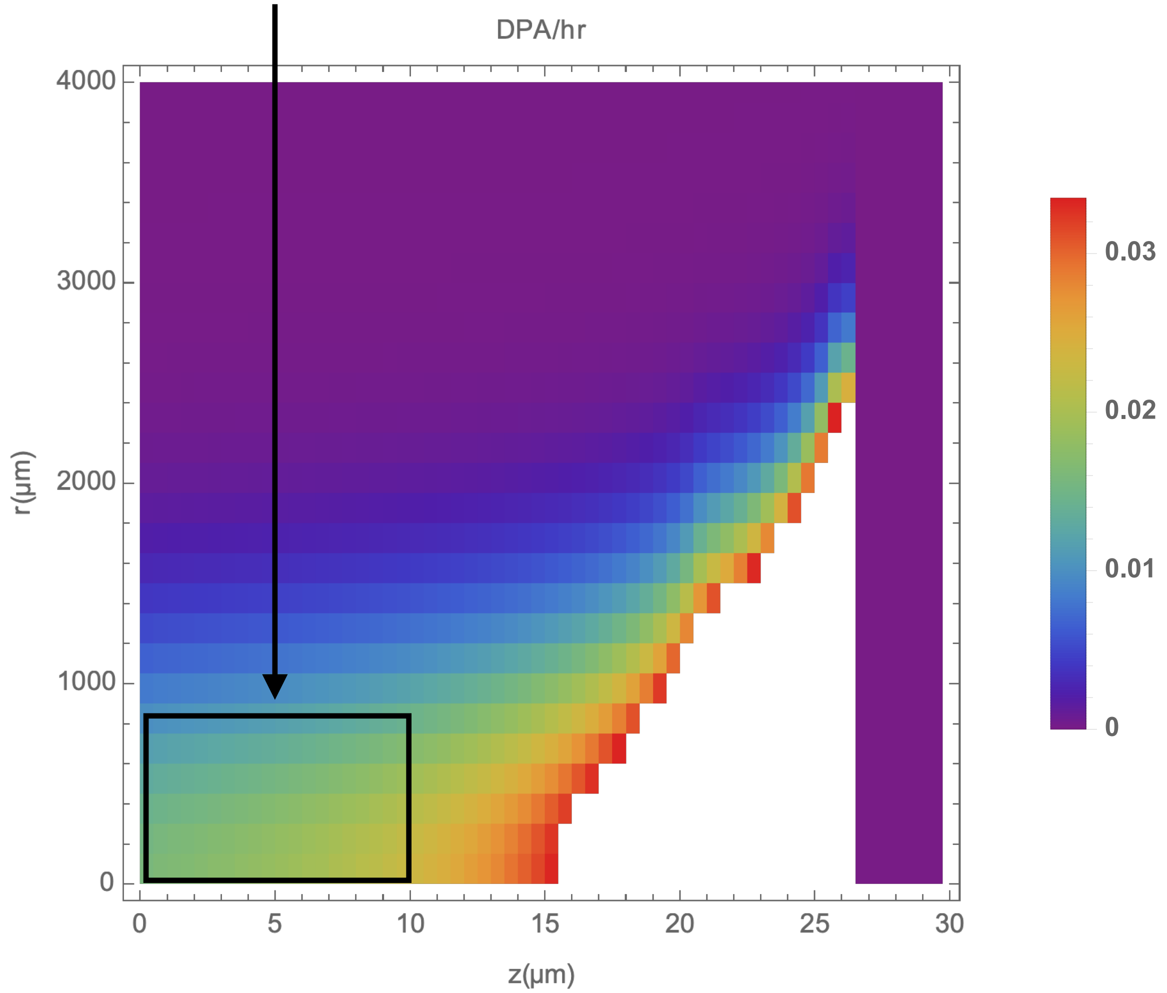


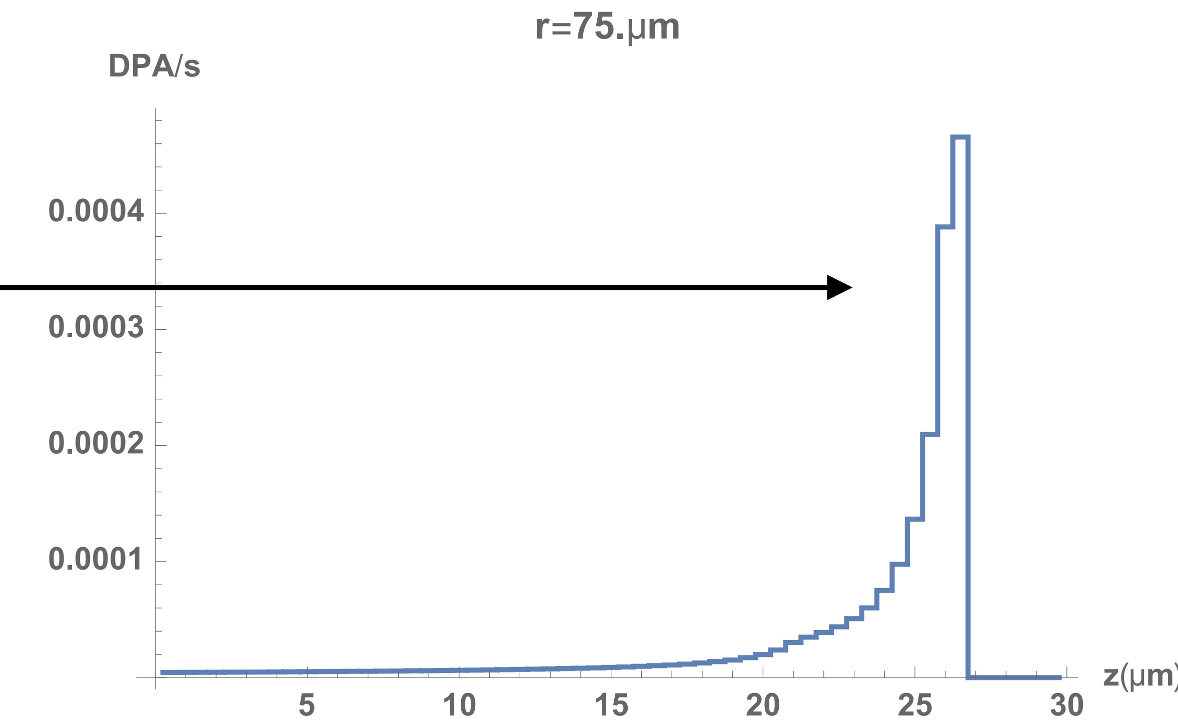


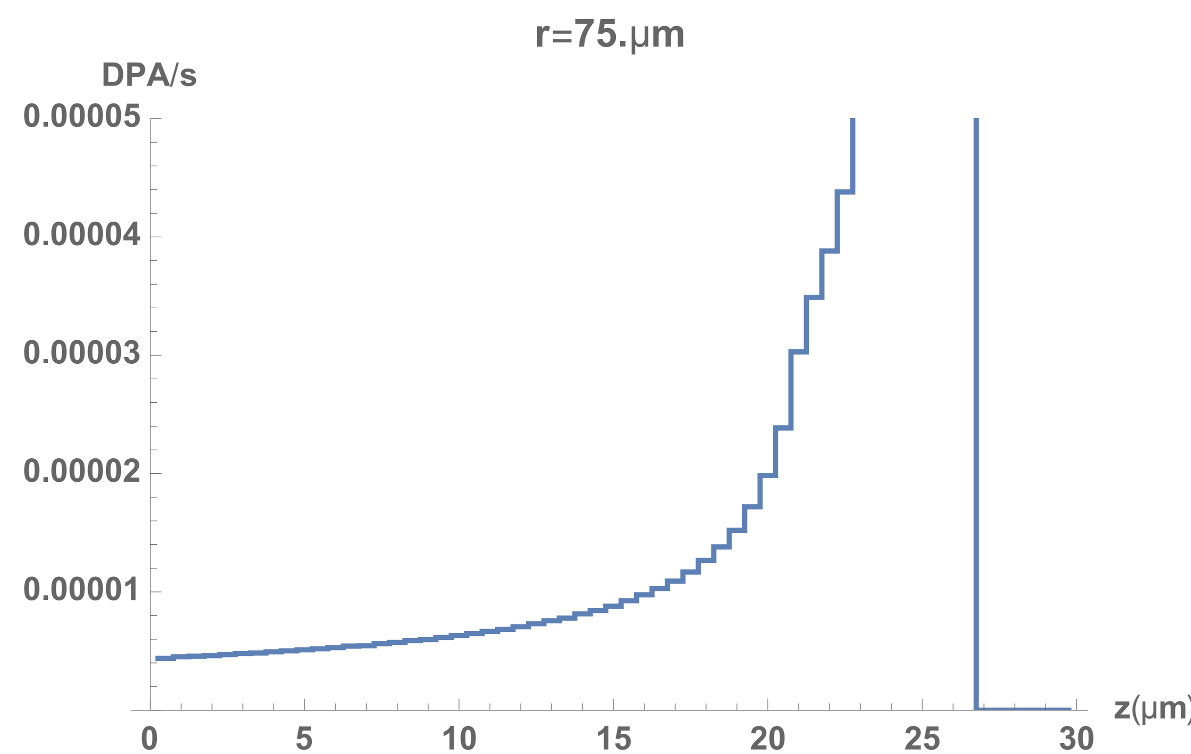


Ion Irradiation Simulations: DPA/activation

- Predicted total activity after 1d irradiation, 15min cooling = $3.91*10^{-9}$ mSv/hr
- Peak DPA/s ~ $5*10^{-4}$
- Time to 1 DPA (near surface) ~ 65hrs
- Linearity near surface: ~ 10um depth, 800um radius





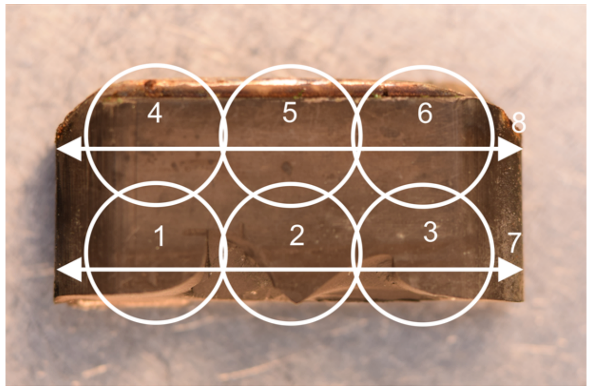


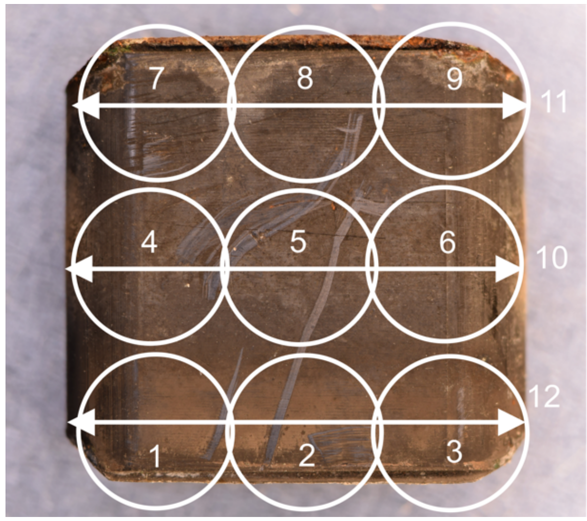
Post-Irradiation-Examination of Target Fins

To determine whether neutrino degradation was a result of radiation damage

- Measure bulk swelling
- Evaluate fracture surfaces
- Evaluate microstructural conditions and extent of radiation damage

Dimensional measurements





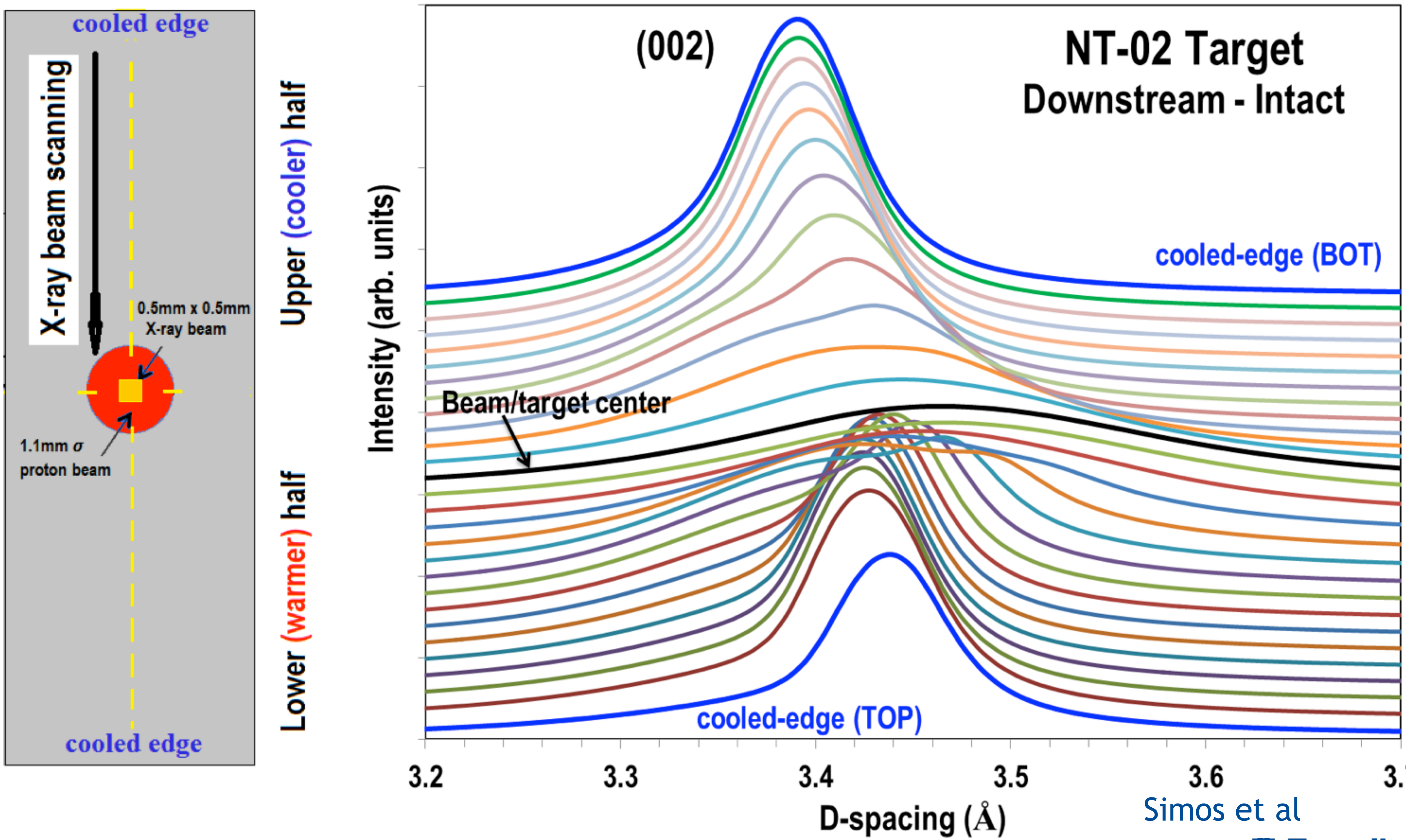
	US Half Fin	US Full Fin	DS Half Fin	DS Full Fin
Avg. End Thickness (mm)	6.54	6.57	6.55	6.55
Avg. Middle Thickness (mm)	6.67	6.64	6.60	6.57
Relative Swelling (%) (Middle-to-end)	2.0	1.1	0.7	0.2
Absolute Swelling (%) (Middle-to-ref*)	4.3	3.8	3.1	2.6

*Ref thickness = 6.4 mm

- Greater swelling in middle vs. ends
- Greater swelling upstream vs. downstream of target
- Greater swelling in half fins vs. full fins

Results are self-consistent and provide indication of bulk swelling

Graphite Results – X-ray diffraction of NuMI graphite fin shows lattice growth and amorphitization at beam center



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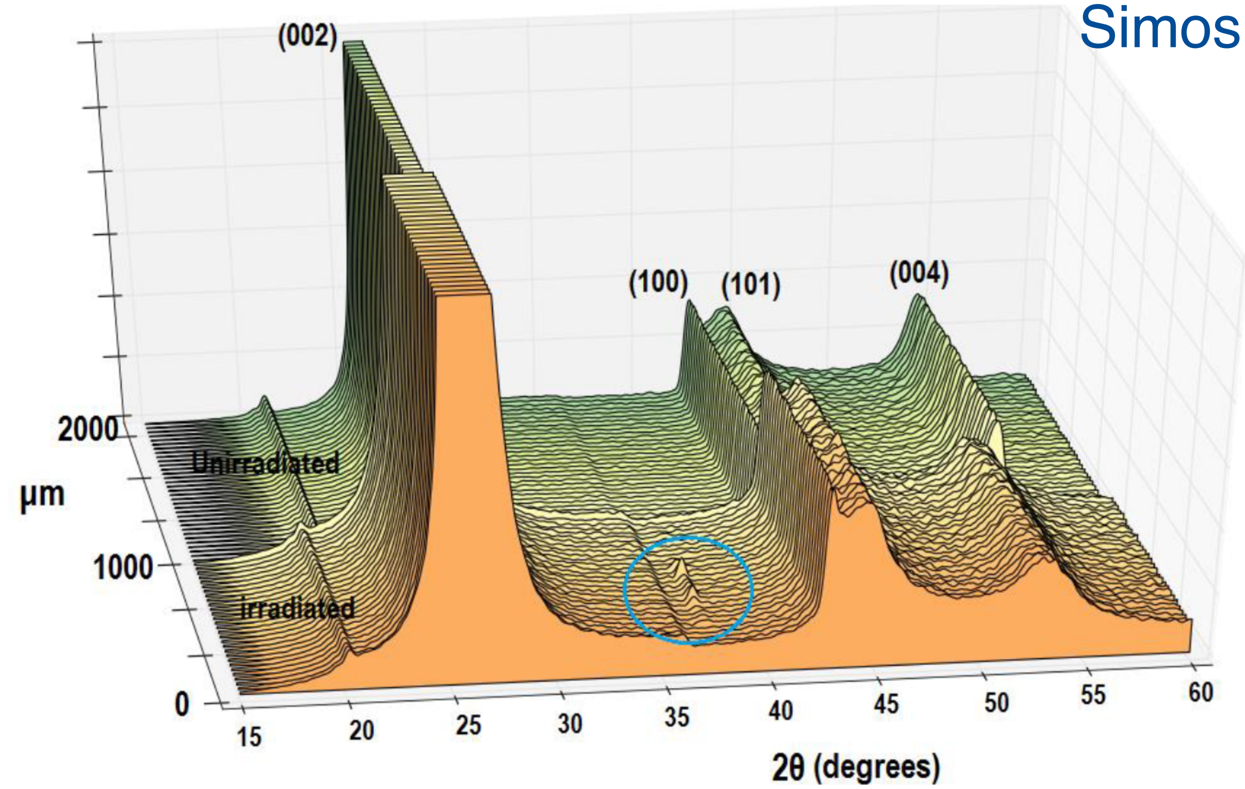
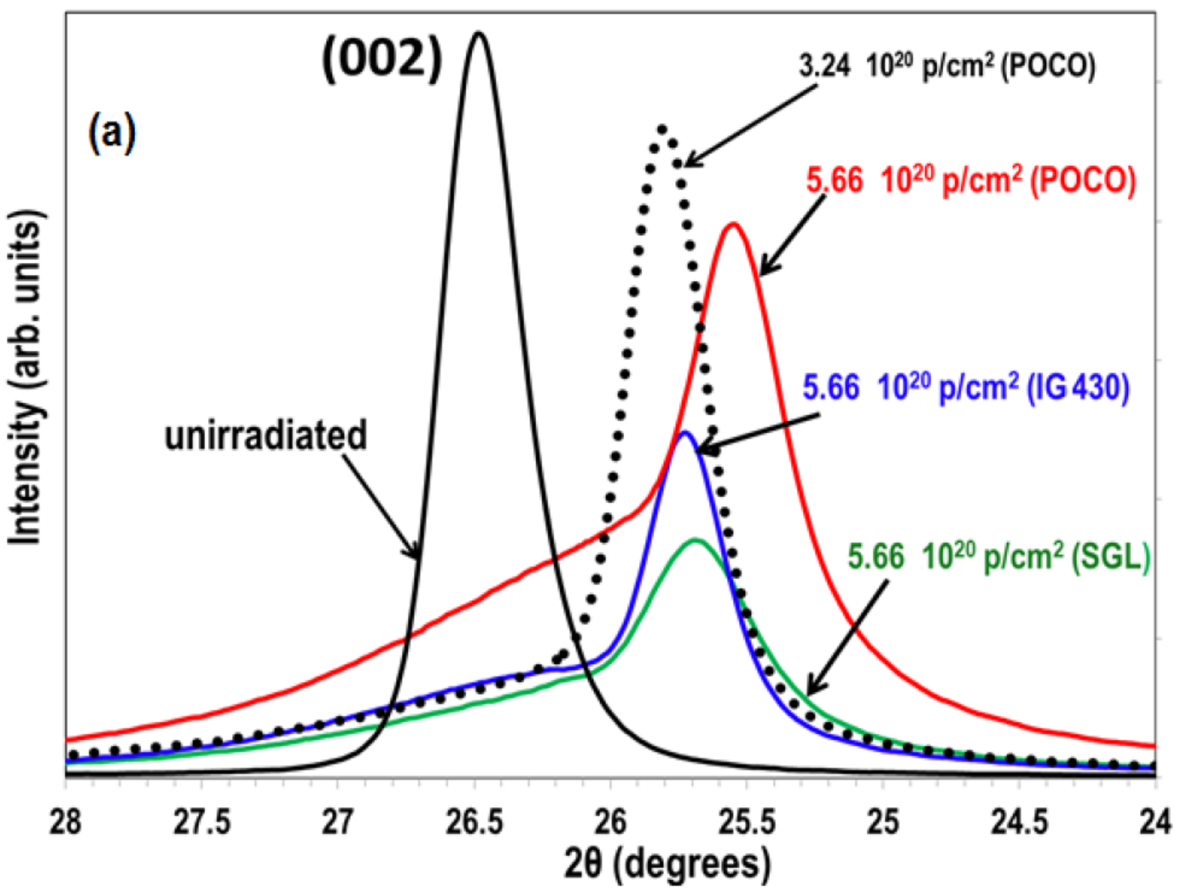
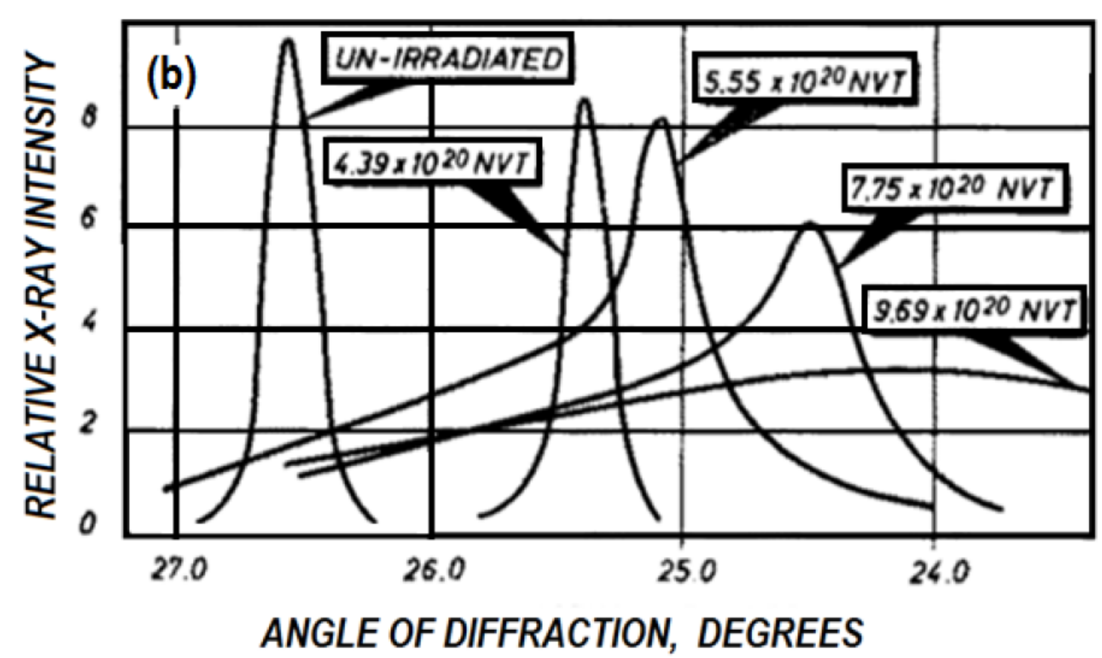
Graphite Results – X-ray diffraction

Simos et al



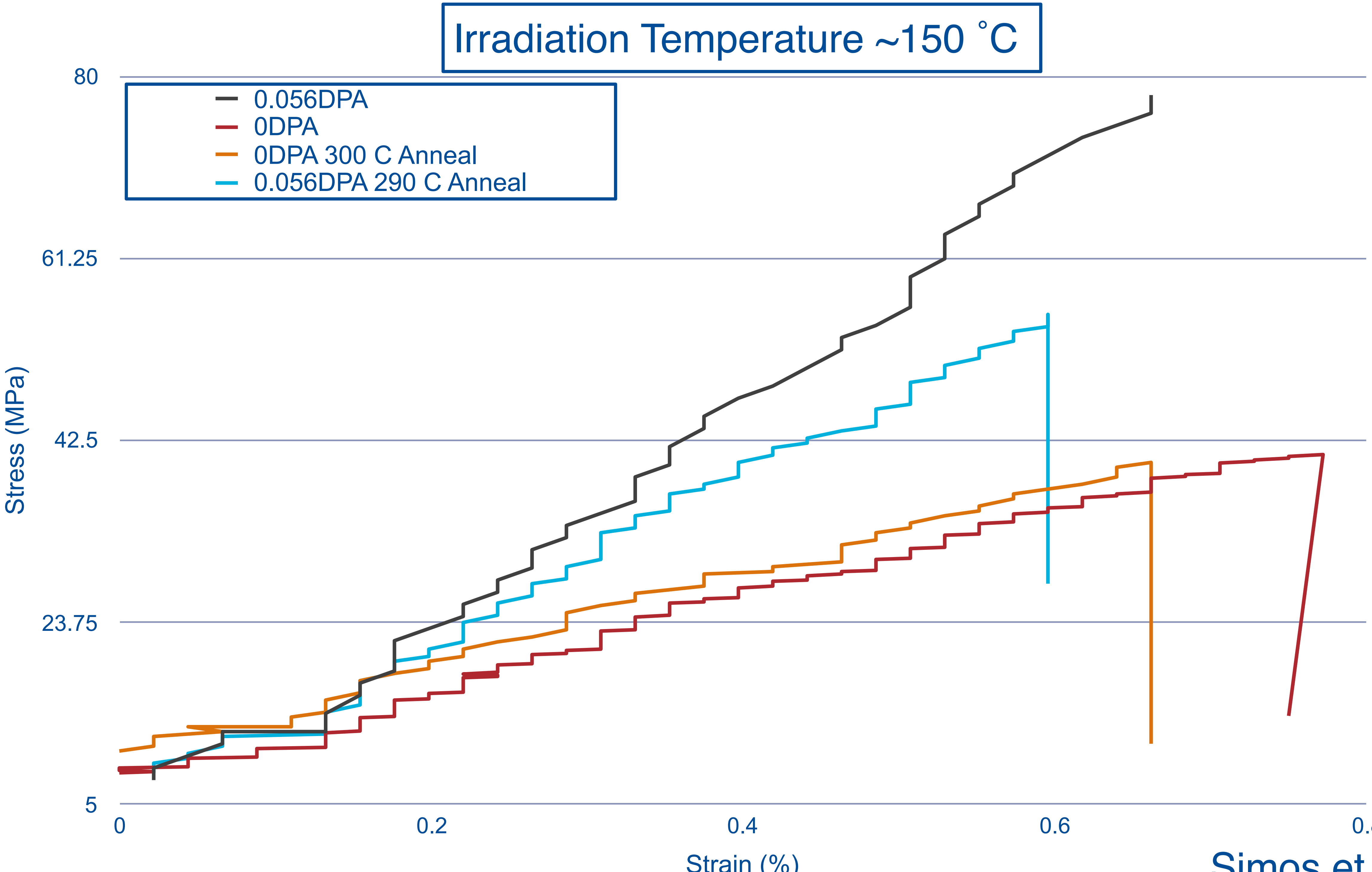
XRD on BLIP irradiated POCO graphite indicates agreement with c-axis lattice growth results from neutron irradiation





W. Bollmann. “Electron-microscopic observations on radiation damage in graphite” Phil. Mag., 5(54):621-624, June 1960.

Graphite Results –Tensile Properties Partially Recover When Annealed



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