Mott Diamond SBIR Phase 1 @ CEBAF

Mott Asymmetry Runs
August 2021

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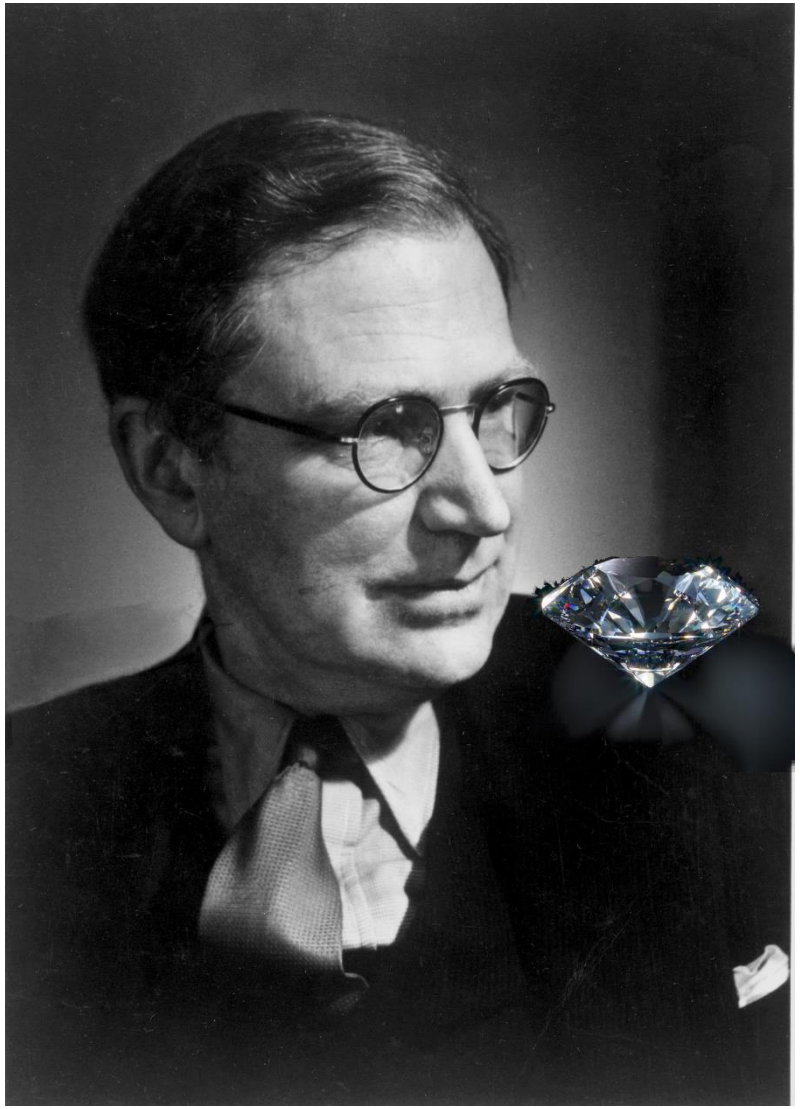
Thursday, August 26, 2021



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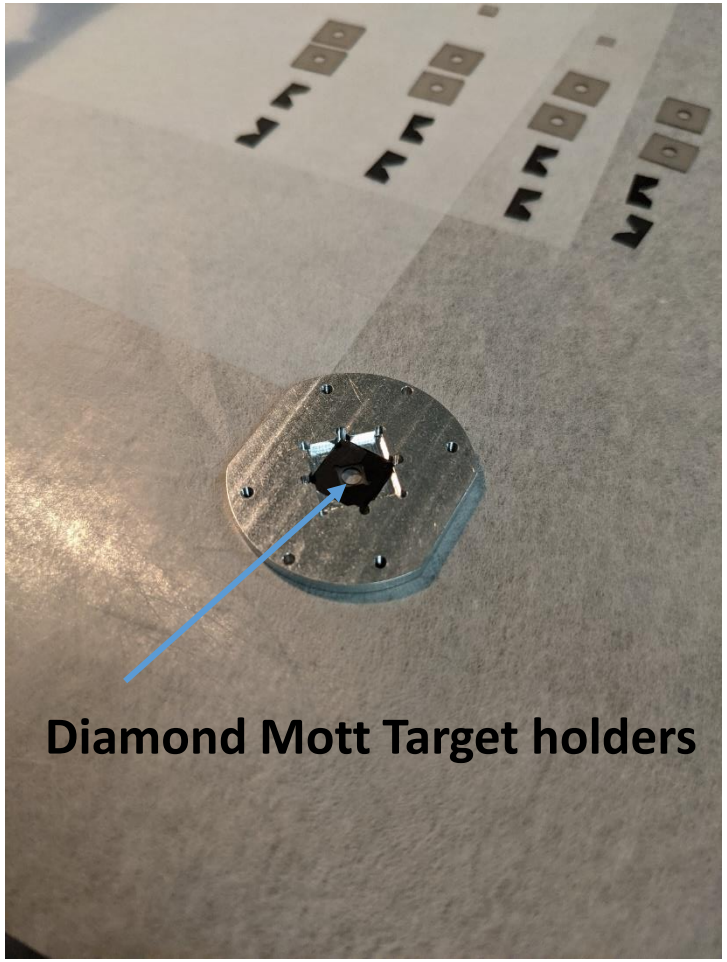
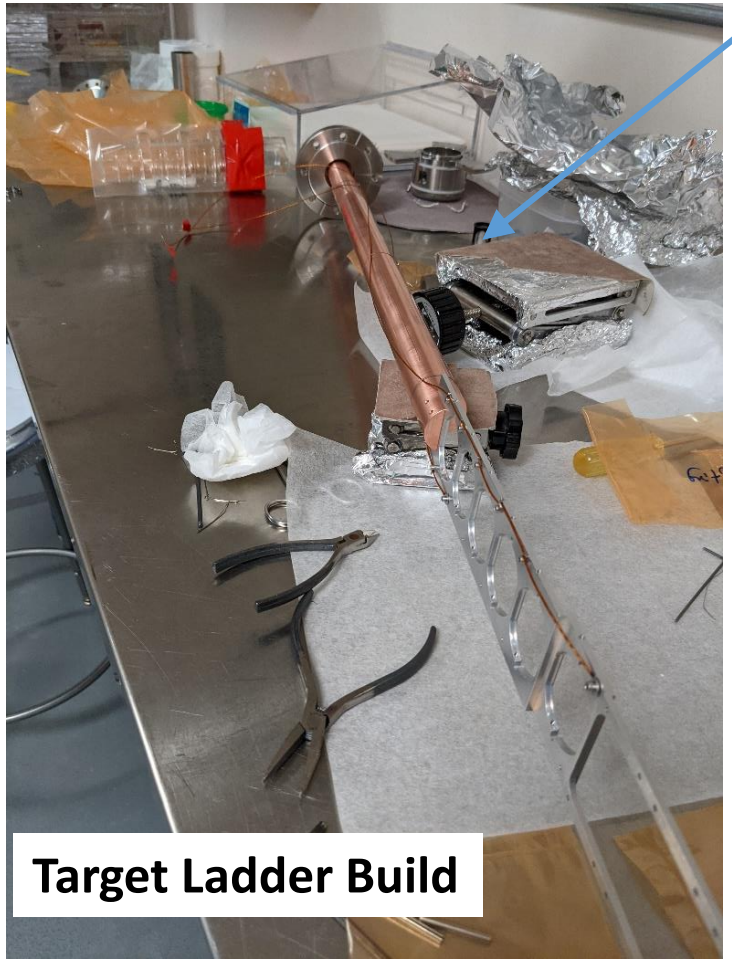
U.S. DEPARTMENT OF ENERGY | Office of Science

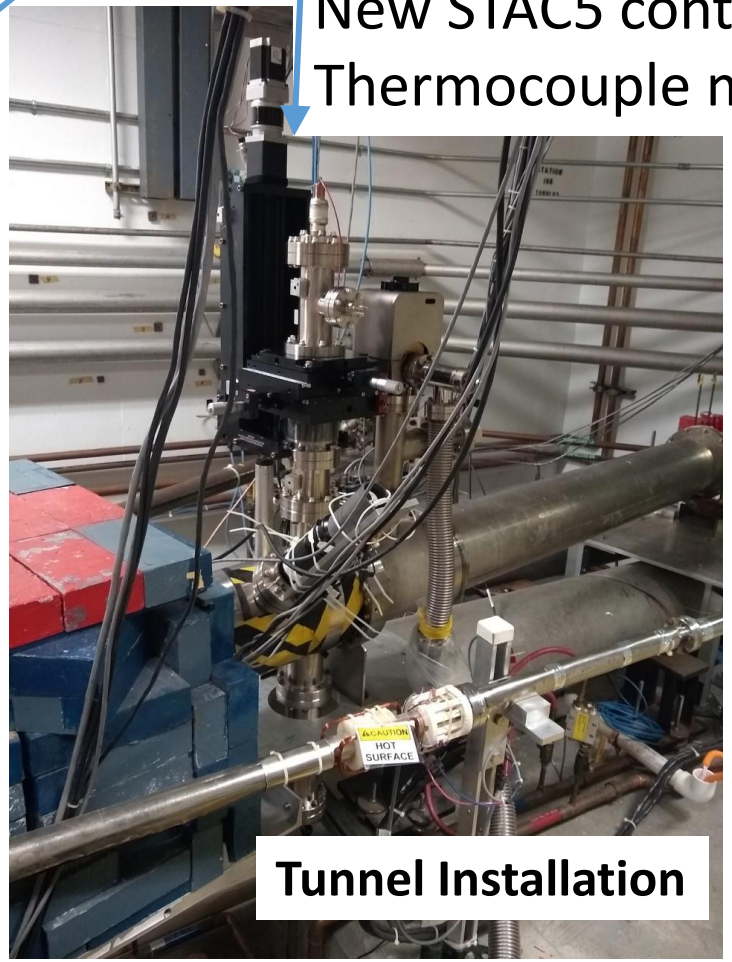
JSA

Diamond Mott Installation

New Ladder
New manipulator
  Survey z, pitch, yaw
New STAC5 controls
Thermocouple monitors







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Three Run periods

	Energy	Targets
Aug 3 8:00-14:30	6.3 MeV Pockles cell off	Open poly 77 µm 487 µm
Aug 5 15:30-19:00	6.3 MeV	Gold 77 µm 487 µm 847 µm Heating test
Aug 13 8:00-16:00	6.3 MeV	Gold 77 µm, steering 487 µm 847 µm
	4 MeV	77 µm 487 µm 847 µm
	4.5 MeV	77 µm
	5 MeV	77 µm

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CEBAF Mott Setup Summary

- Set Wien filter to 90° to have transverse beam in Mott polarimeter
  - Steer to fix orbit after Wien filter change
- Steer beam into Mott polarimeter line
- Adjust SRF cavity phases to crest
- Finalize steering, optimize beam shape
- Insert desired target
- Turn on DAQ, PMT high voltage
- Take data to optimize current
- Take data on Diamond – 500k counts
- Change polarization with insertable laser waveplate
- Repeat taking data

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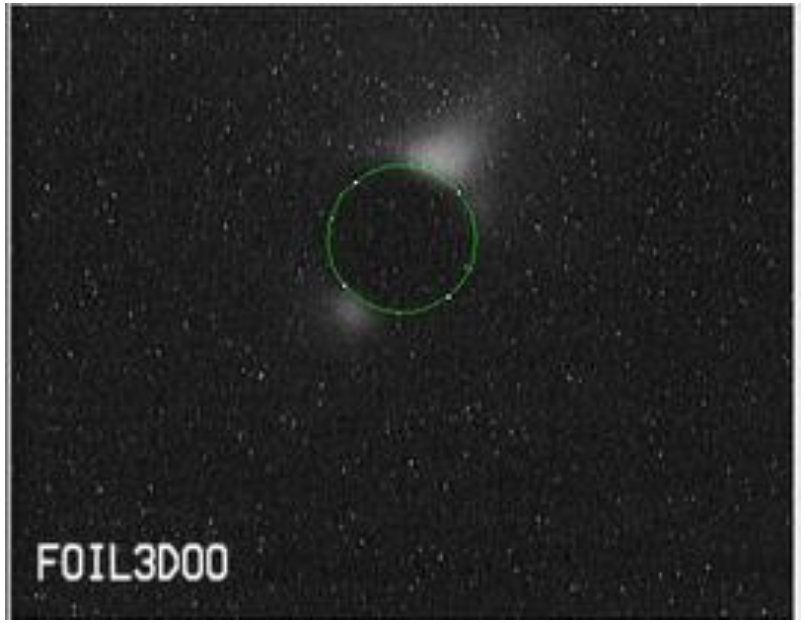
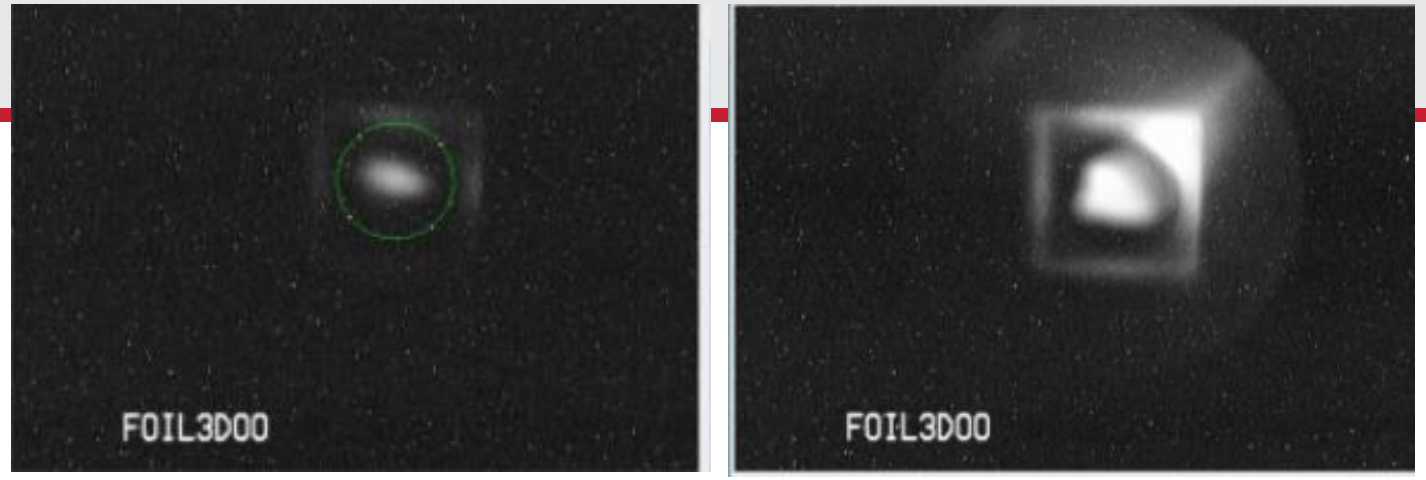
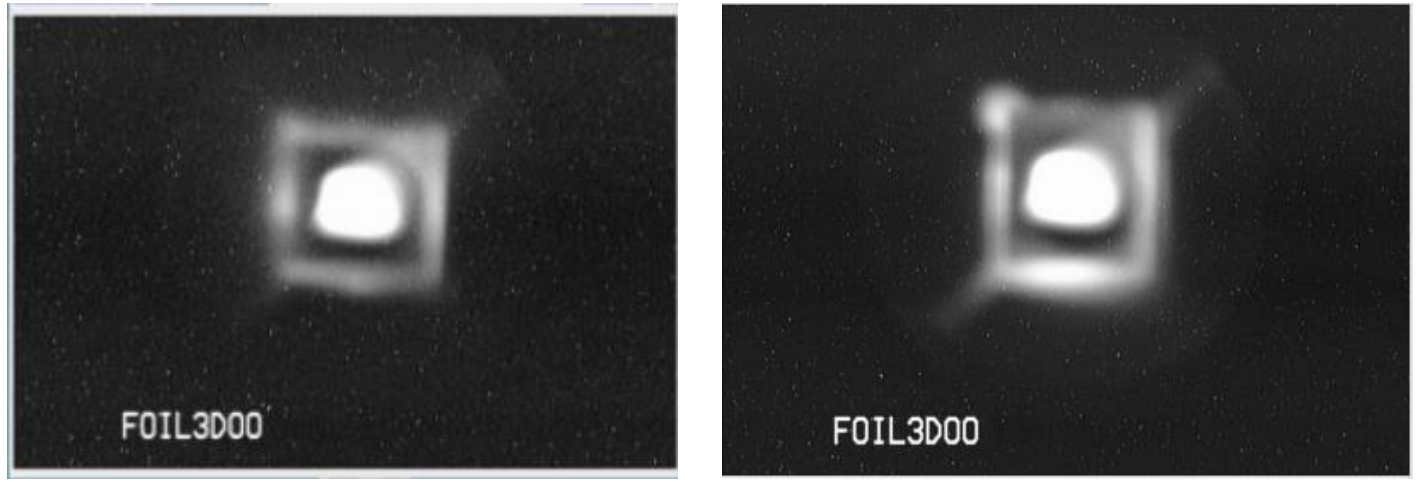
Beam on target



Empty Poly frame for background



77 µm diamond, 100 nA (left), 0.9 µA (right)

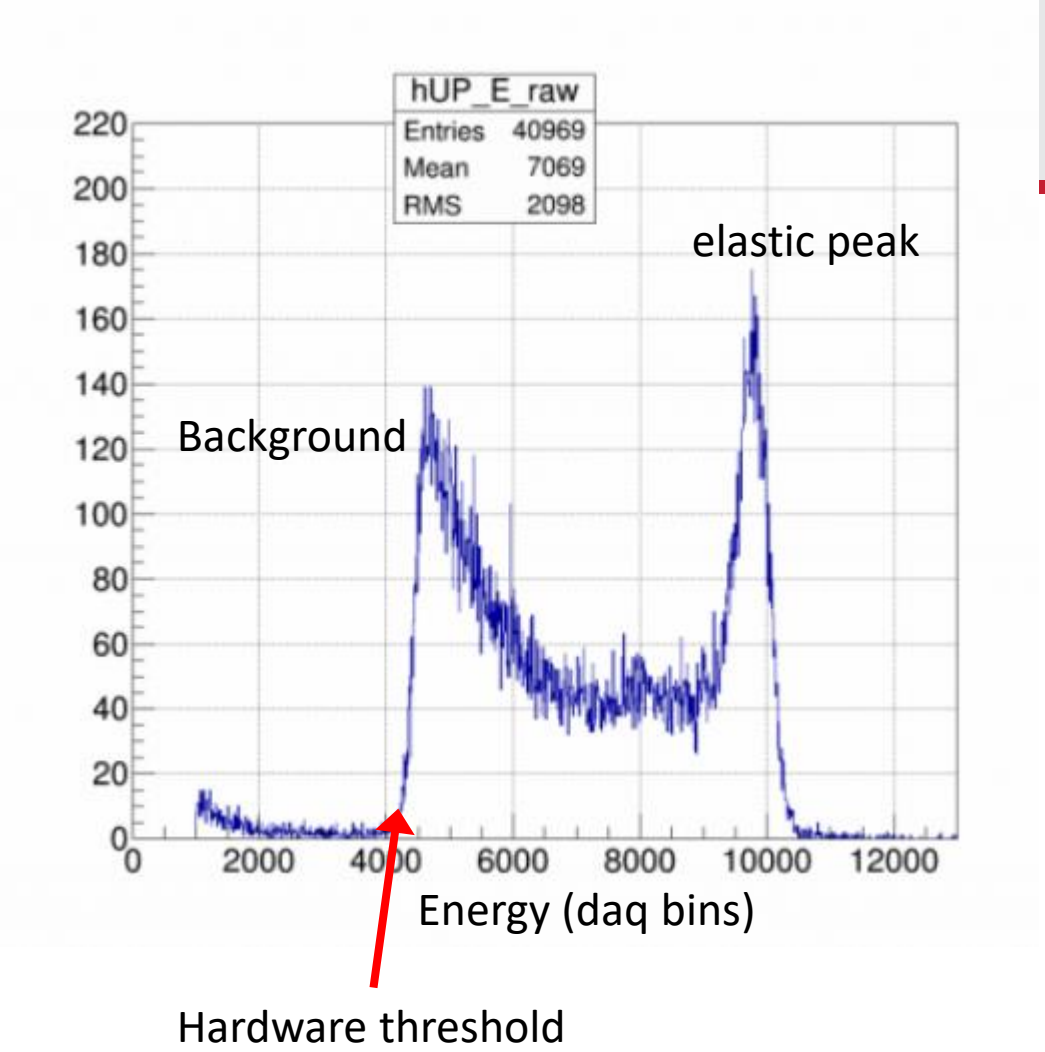


487 µm diamond, 250 nA 847 µm diamond, 130 nA

Data Analysis

- Decode data from CODA (CEBAF Online Data Acquisition) format
- Run online Analyzer to verify energy spectra of scattered electrons as expected
- Determine energy cuts to optimize
- Calculate asymmetry, uncertainty*

$$A = \frac{\sqrt{L^- R^+} - \sqrt{L^+ R^-}}{\sqrt{L^- R^+} + \sqrt{L^+ R^-}}$$



* PhysRevC.102.015501 p. 11

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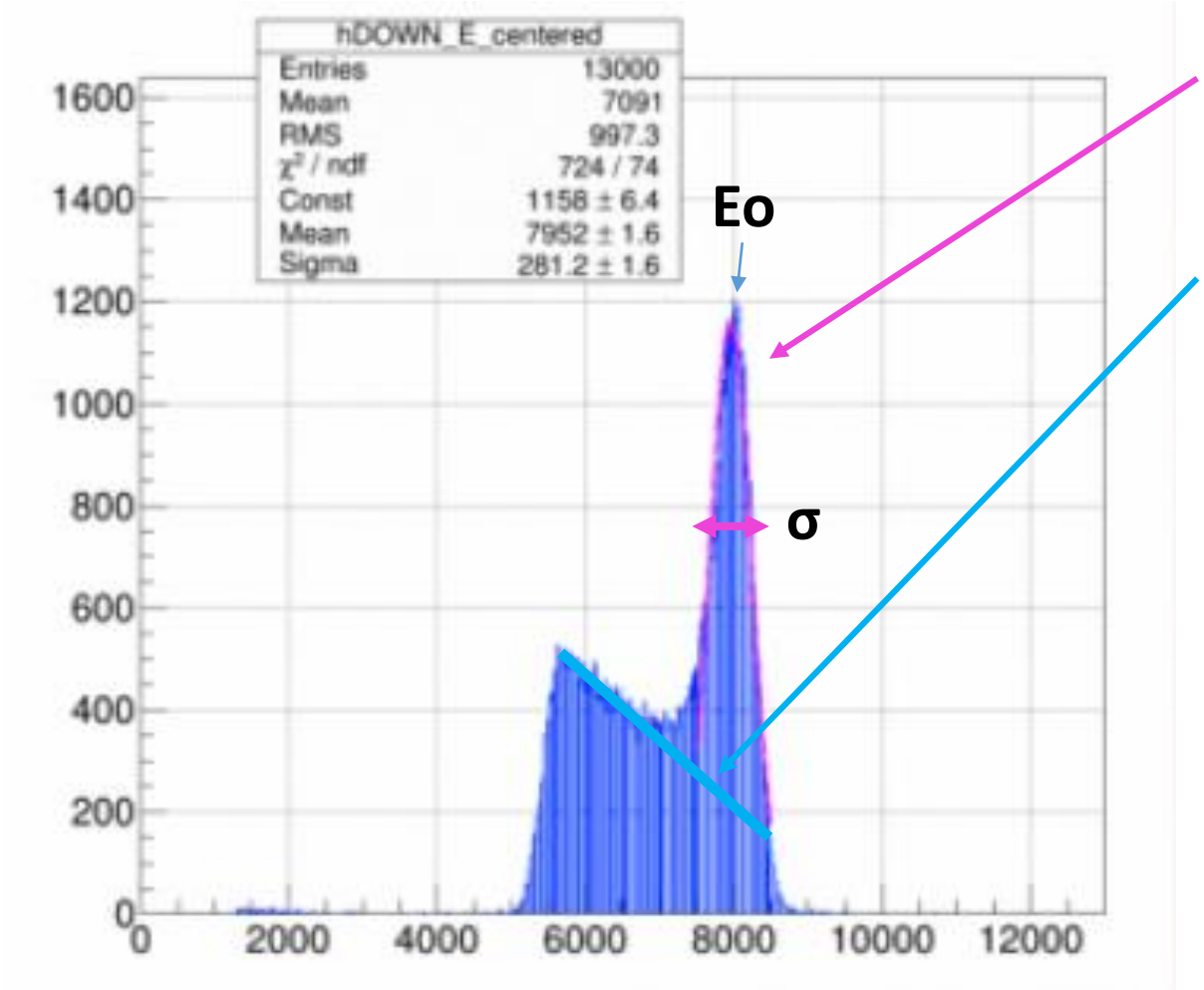
Optimizing energy cuts



Curve fitting working to find peak location, sigma

Background dilutes polarization
-> Optimize cuts to get both high statistics and low dilution

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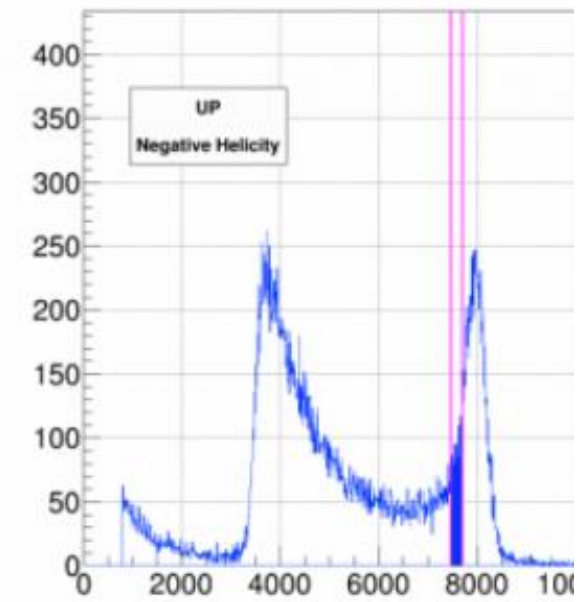
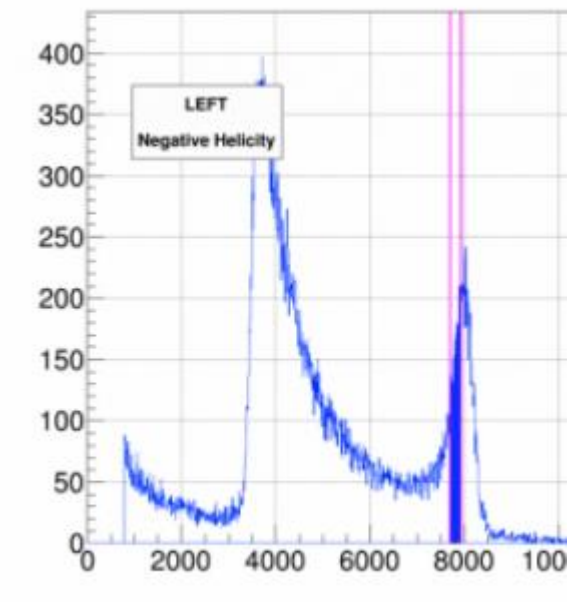
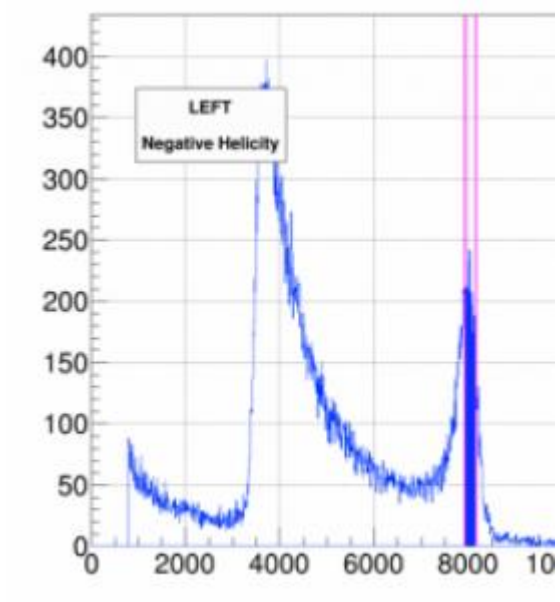
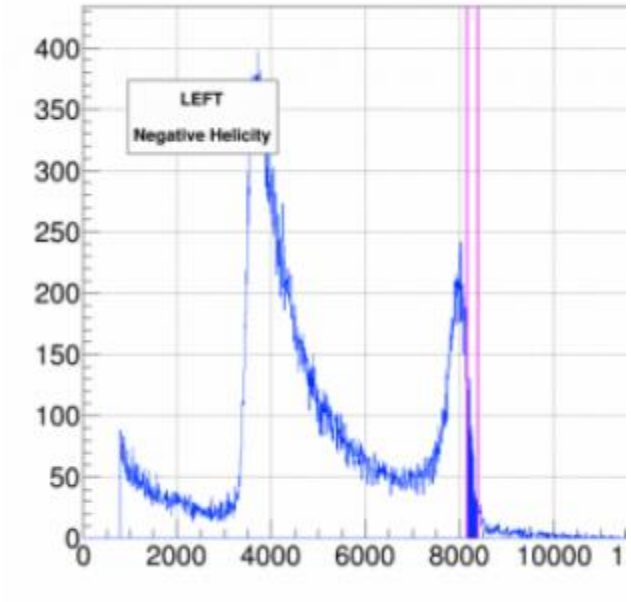
Energy cut scan: Find Asym(Energy Slice)









All good 77 micron, 6.3 GeV runs

- ~ 10 minutes
- ~ 1 microA

Background dilutes polarization for bins with E < Eo (center of elastic peak)

Calculate Asym from bins with E=Eo through E=Eo+2.5

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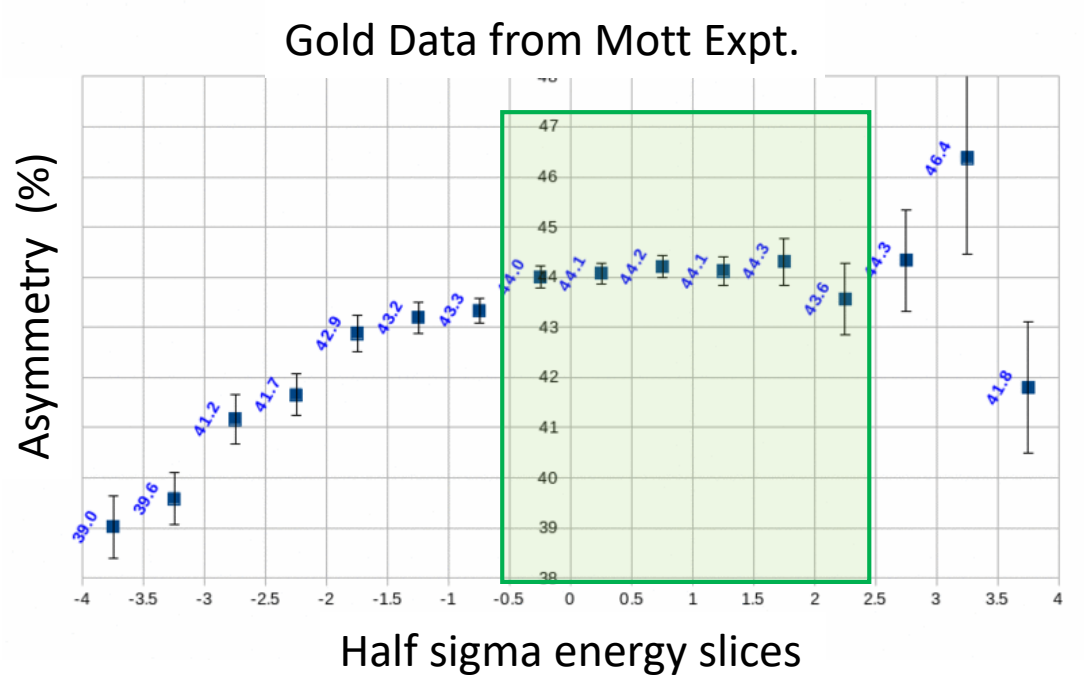
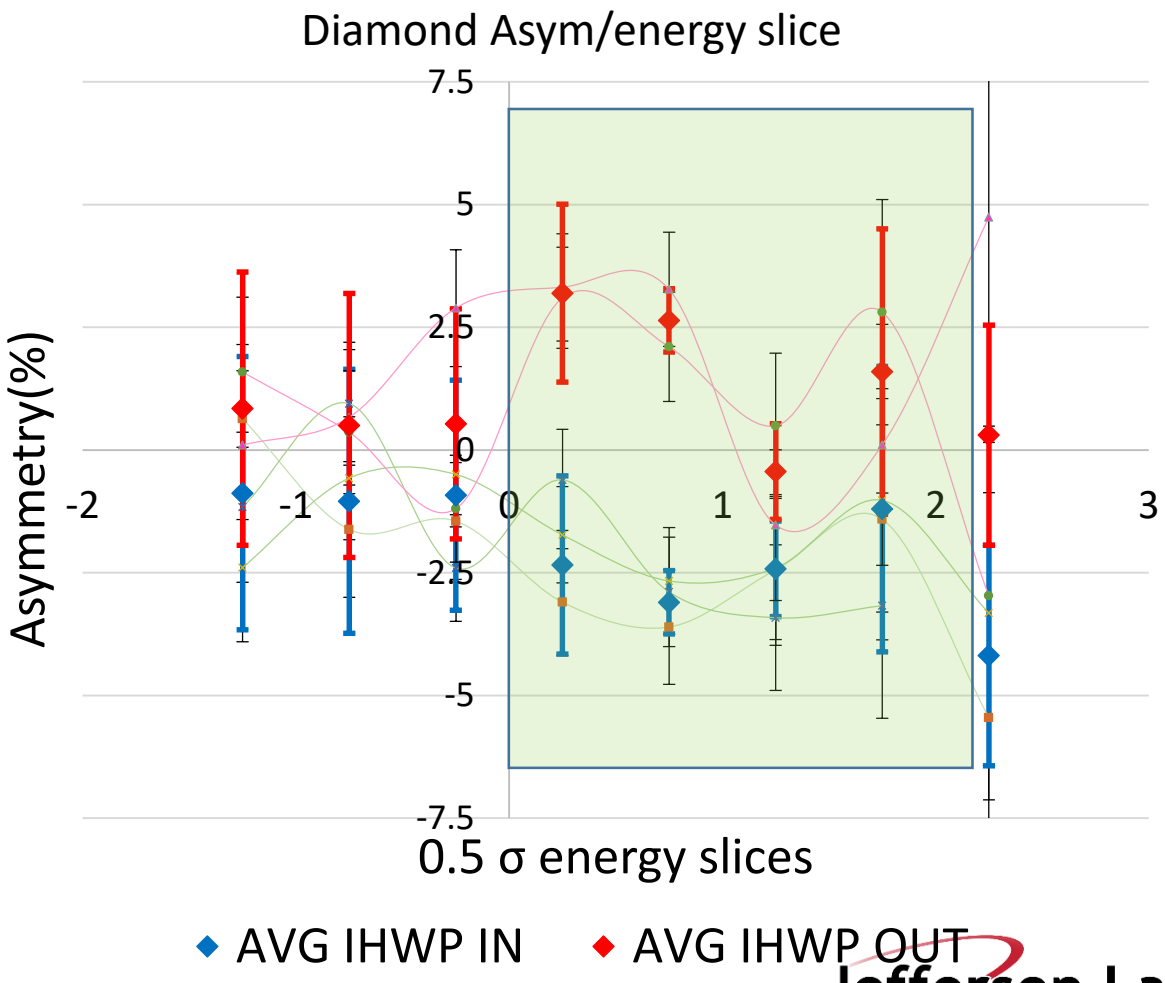
Energy Analysis for Gold Targets



- Many data sets (same cuts all thickness)
- great statistics
- high asymmetry
- years of analysis

Energy Analysis for Diamond 6.3 MeV, 77 µm



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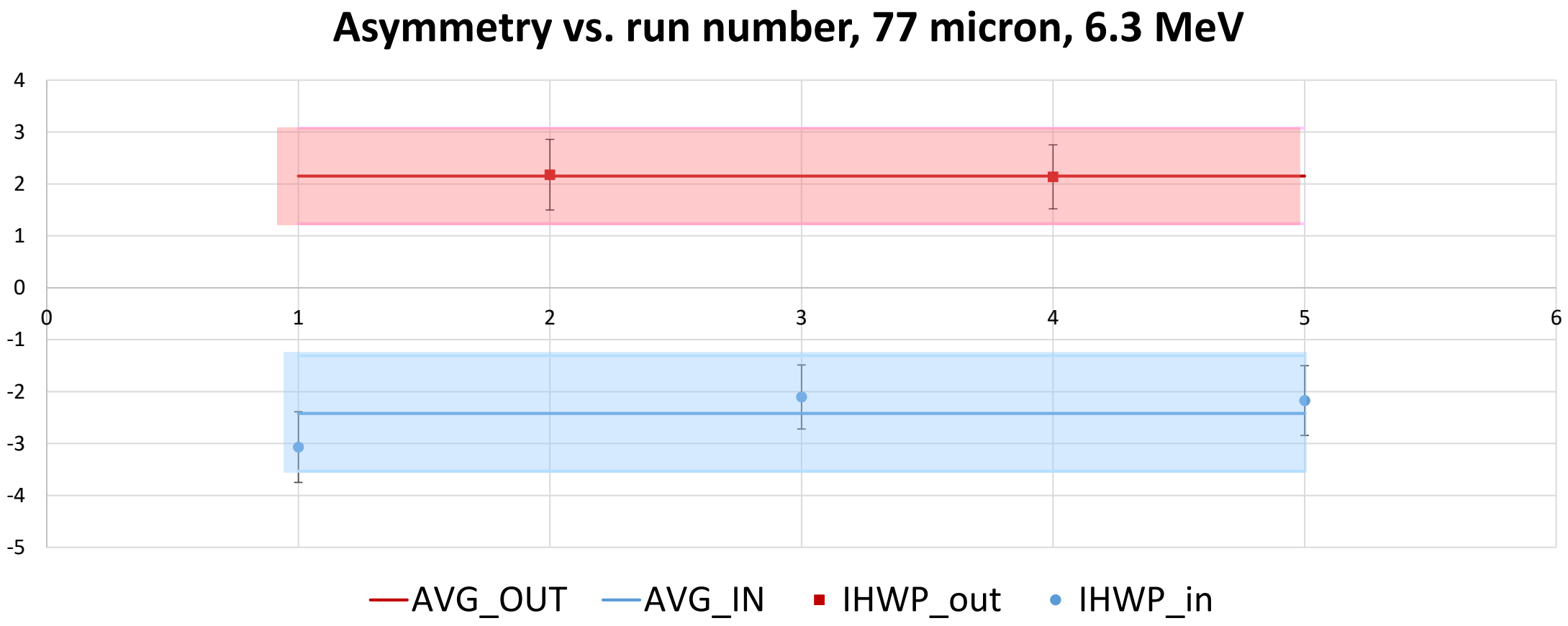
Asymmetry for 77 micron 6.3 MeV



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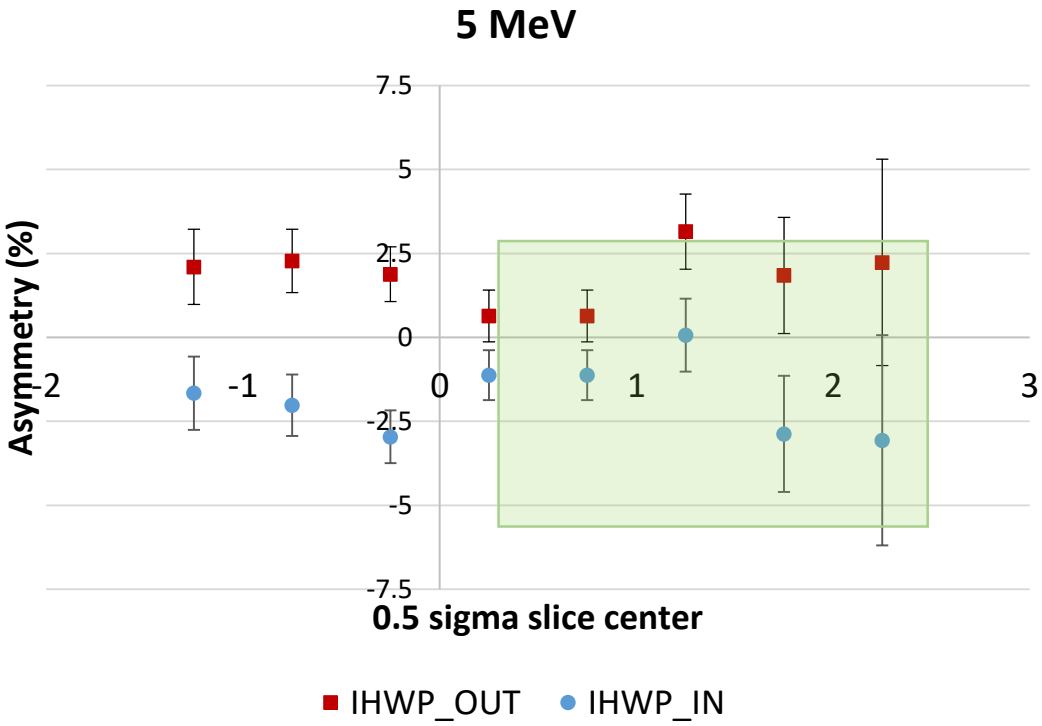
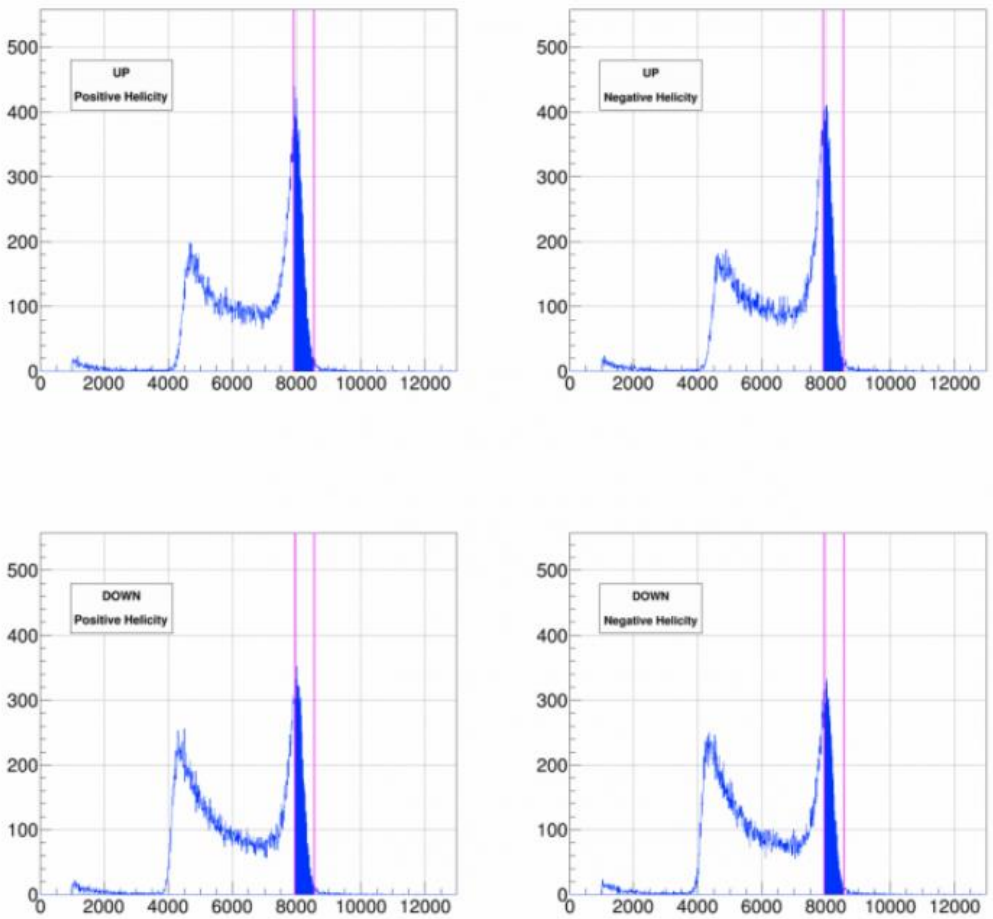
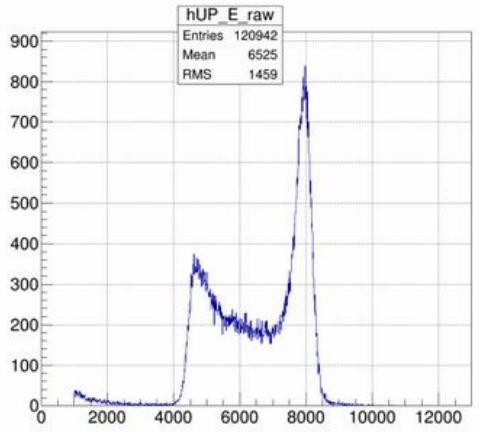
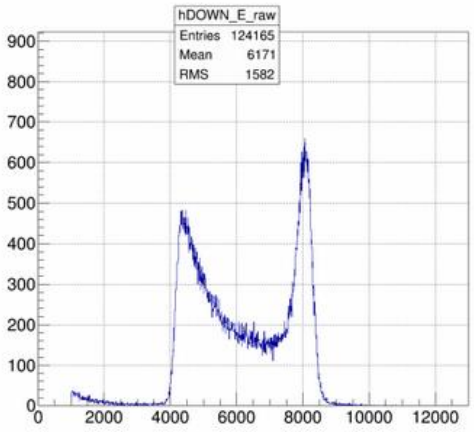
77 micron Diamond 5 MeV

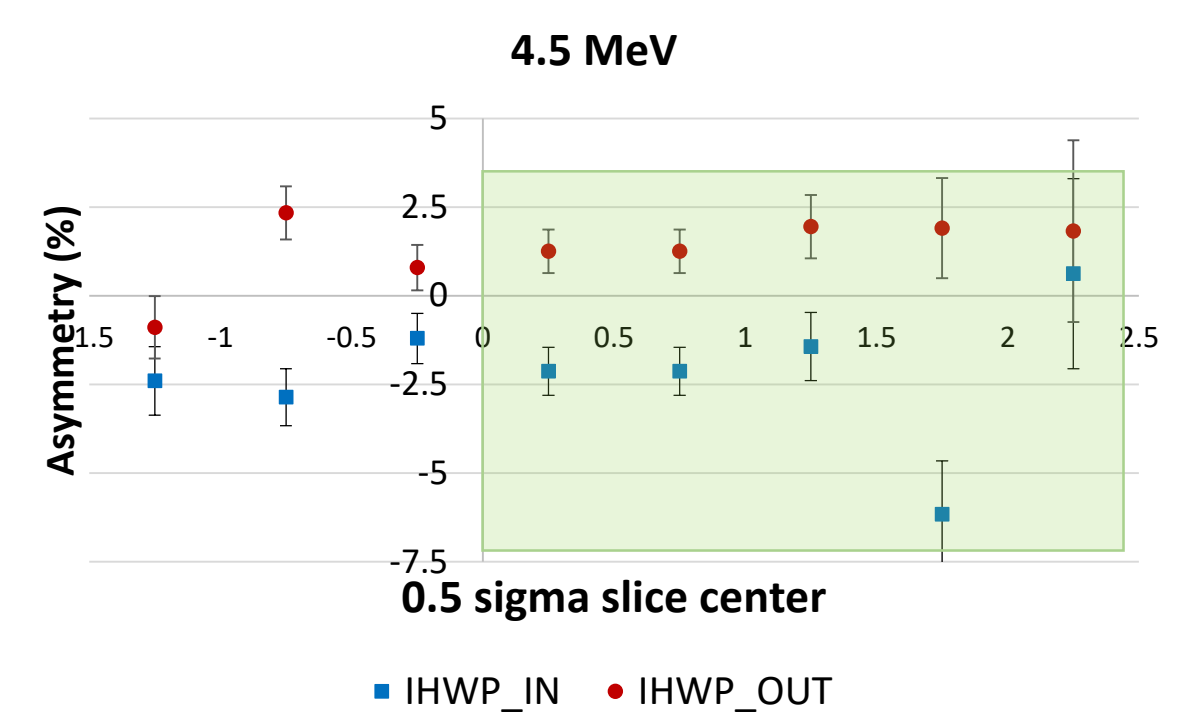


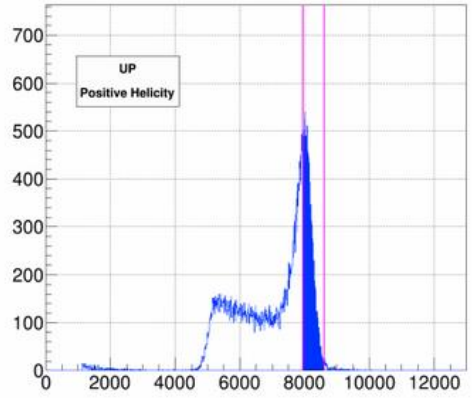


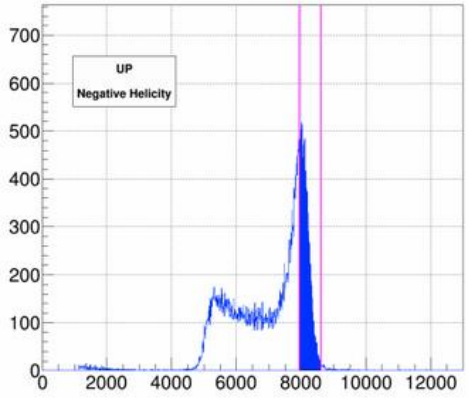


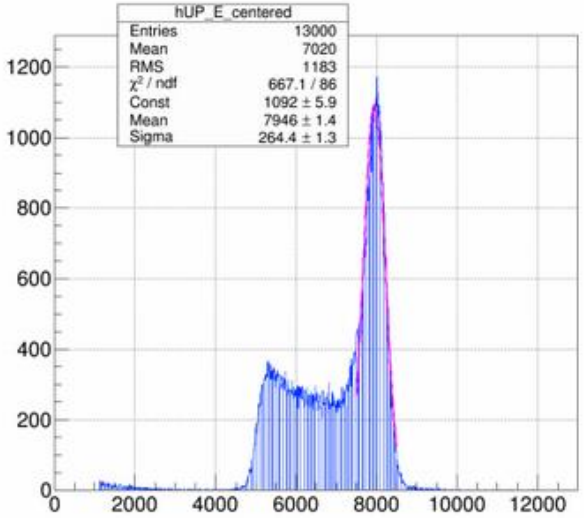


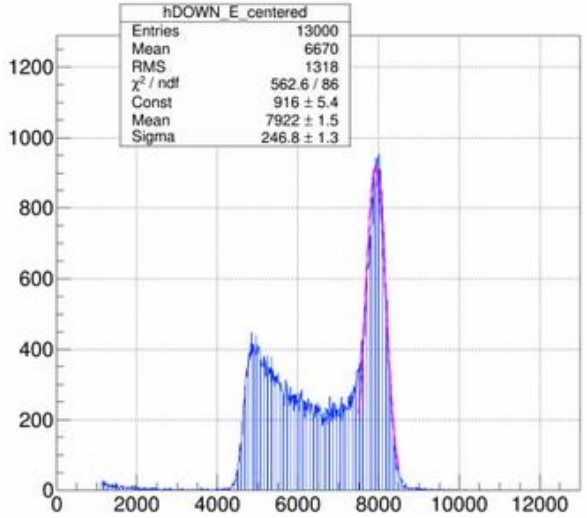
77 micron Diamond 4.5 MeV

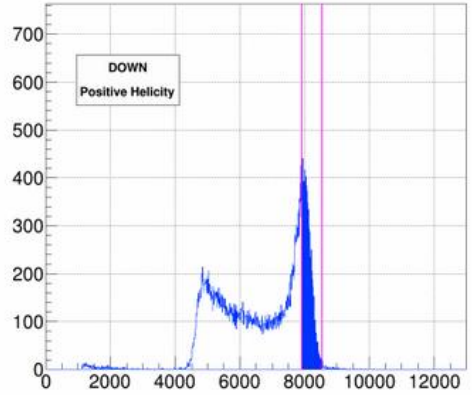


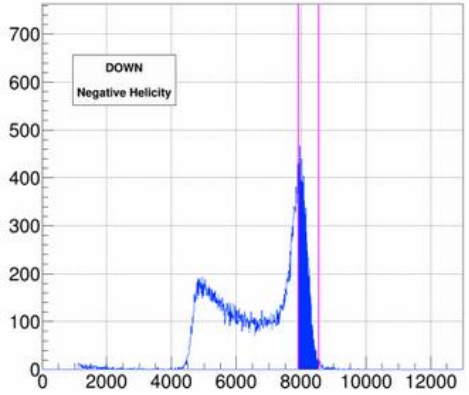












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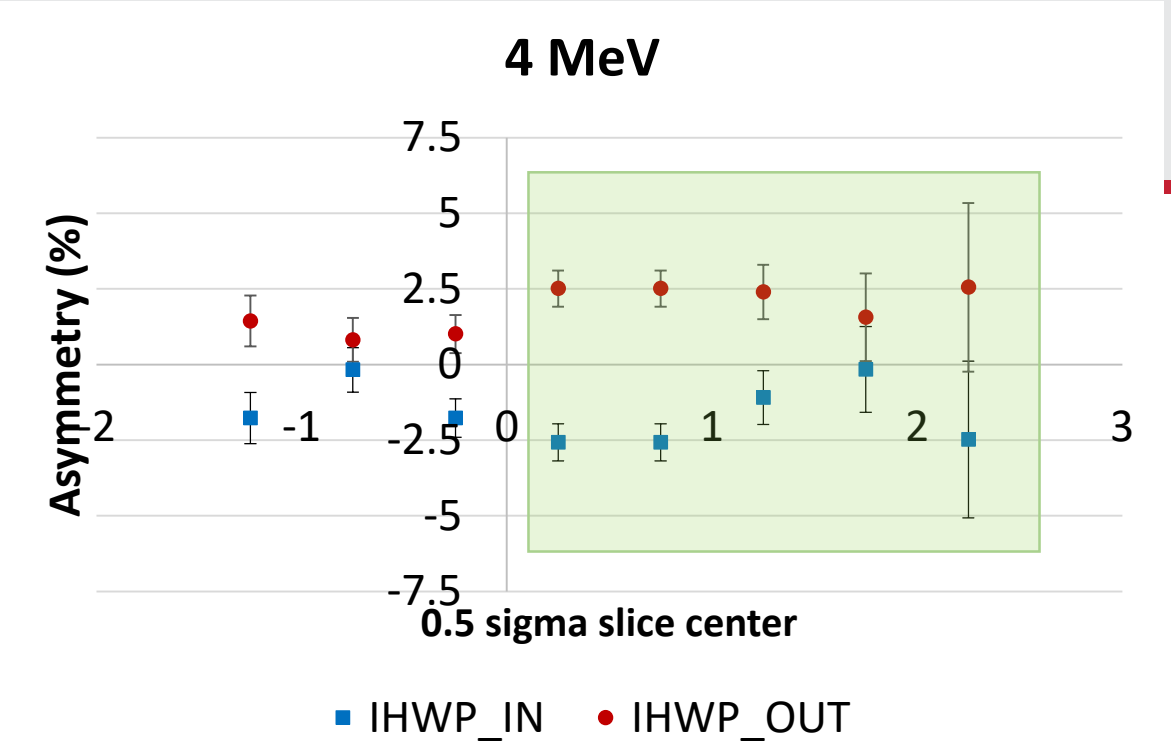
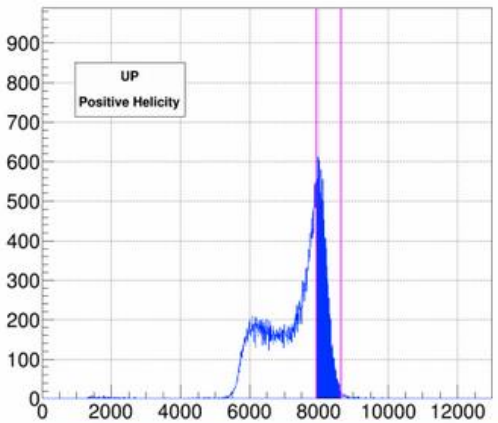
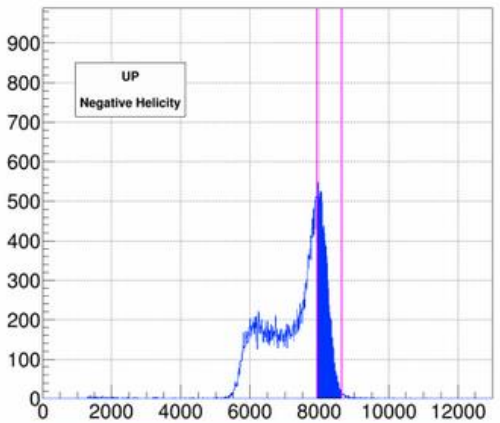
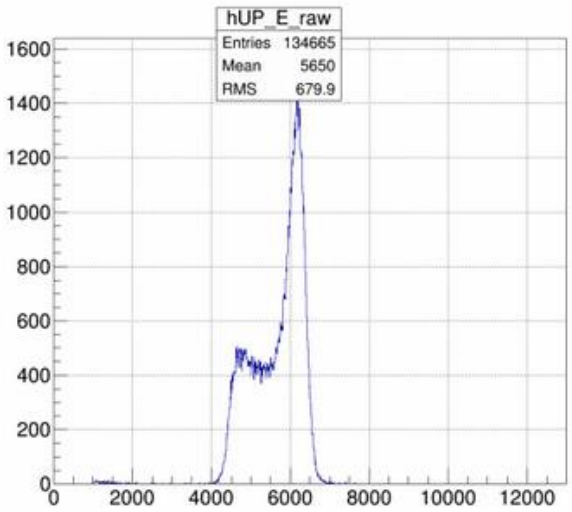
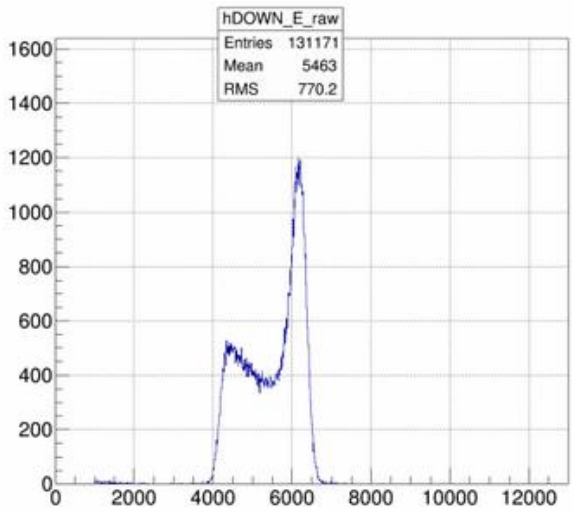
77 micron Diamond 4.0 MeV

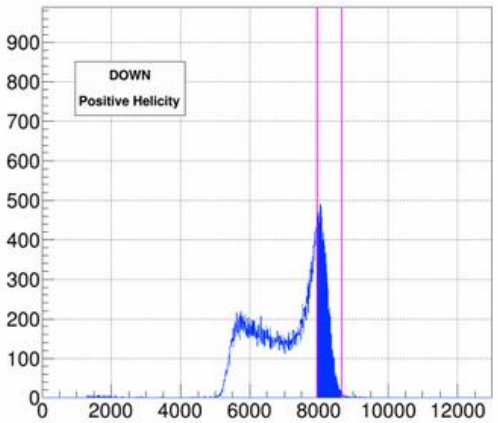


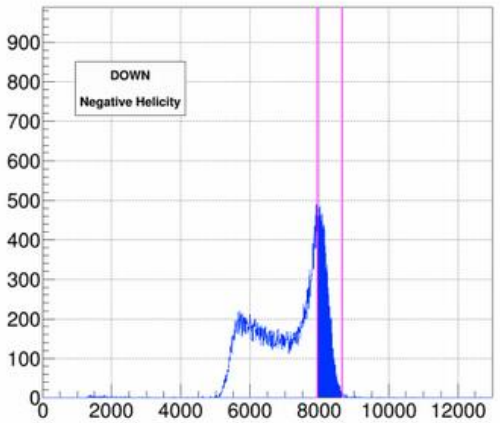




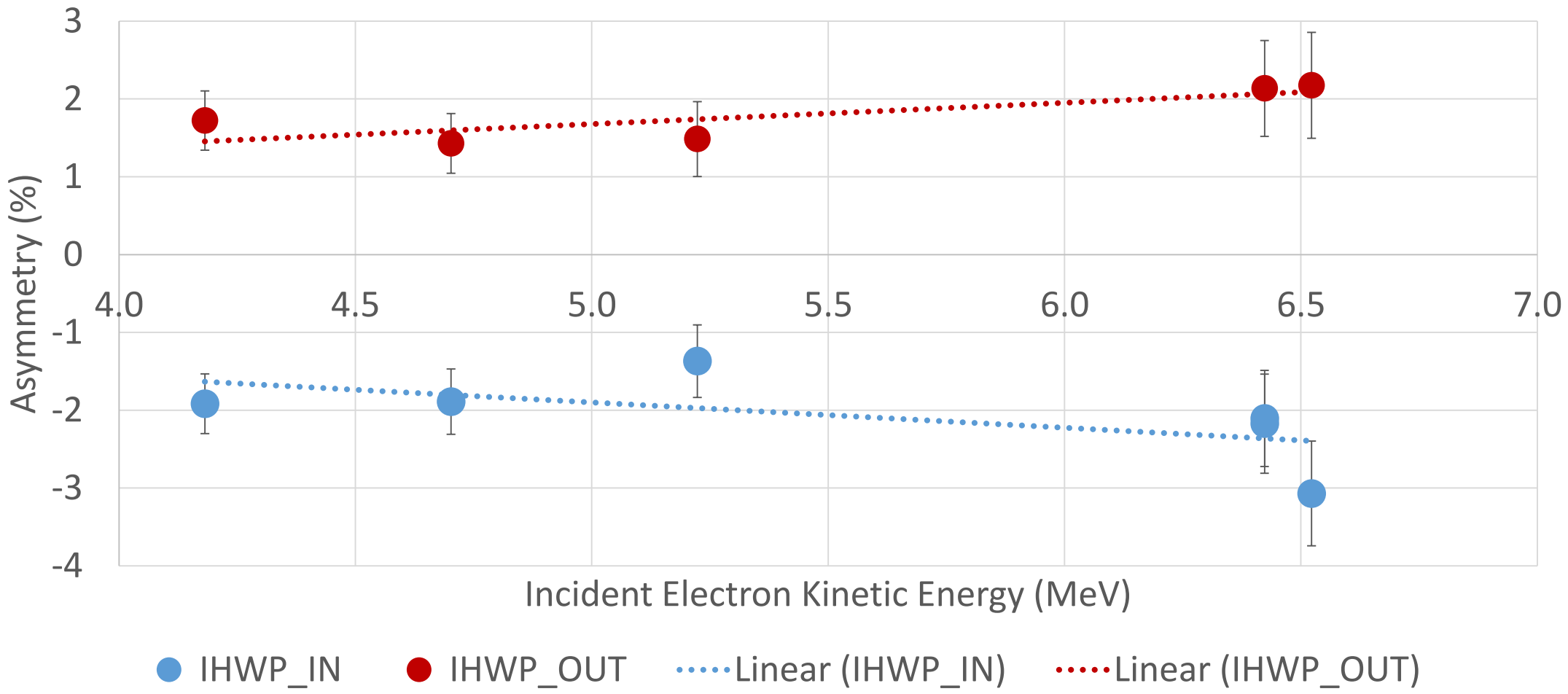








77 micron Diamond Asymmetry Summary



Potential trend in asymmetry with Energy?

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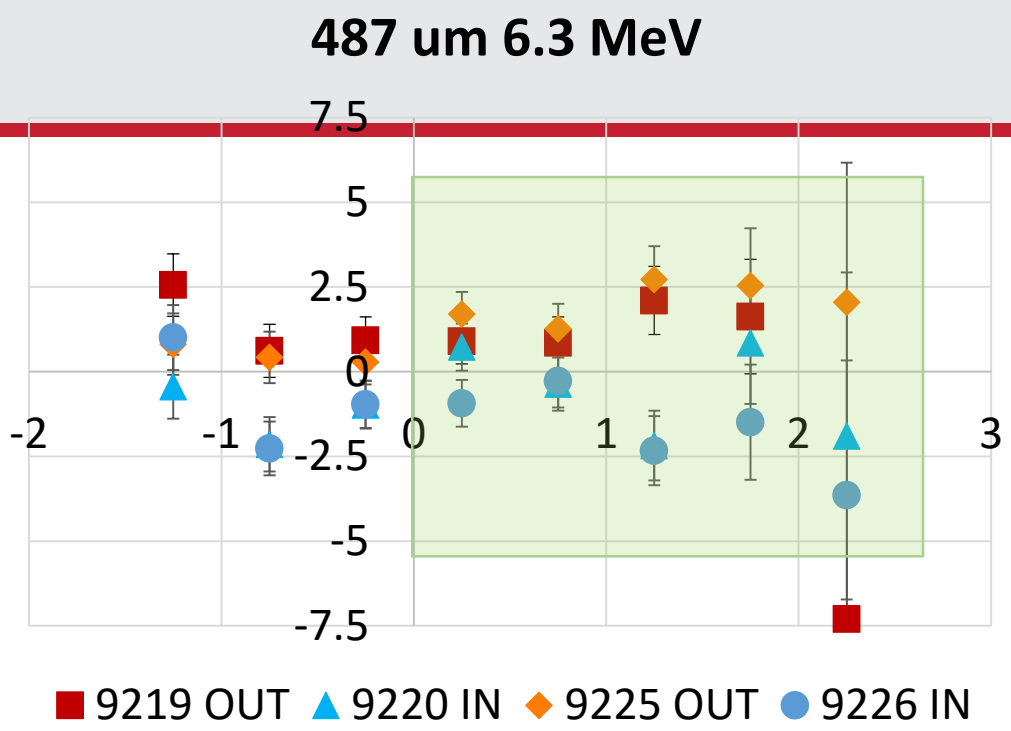
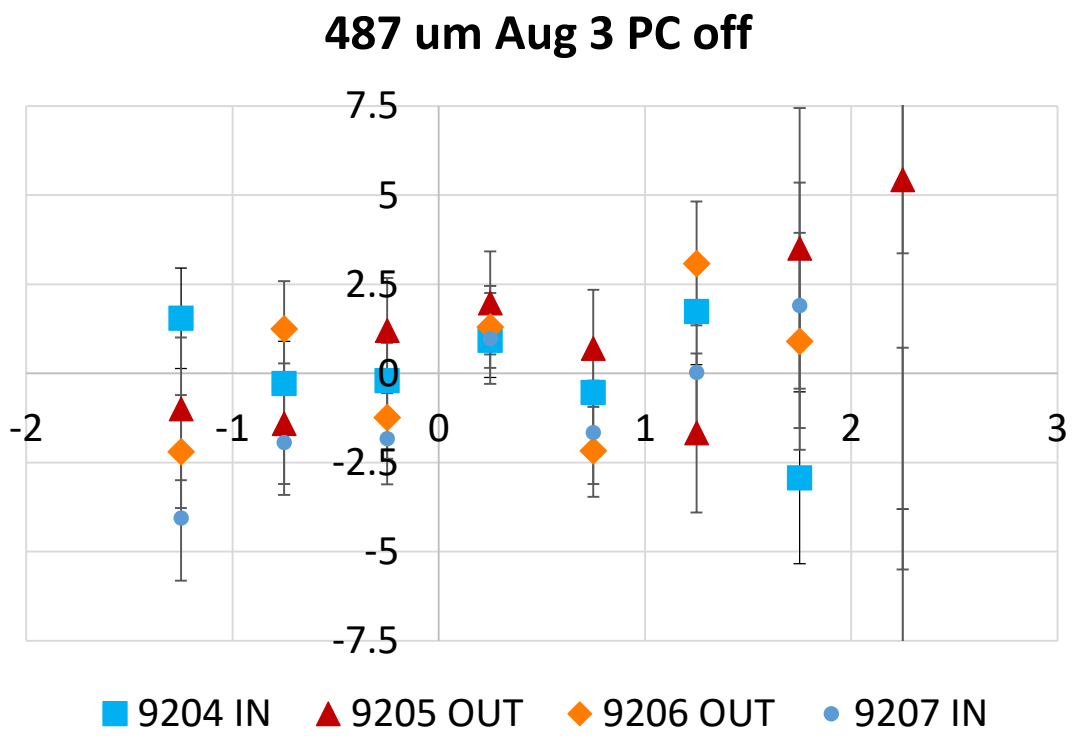
Energy slices
487 micron Diamond
6.3 MeV



Energy cuts 0 through 2.5 sigma look ok here too



Data with Pockles Cell off: data consistent with zero

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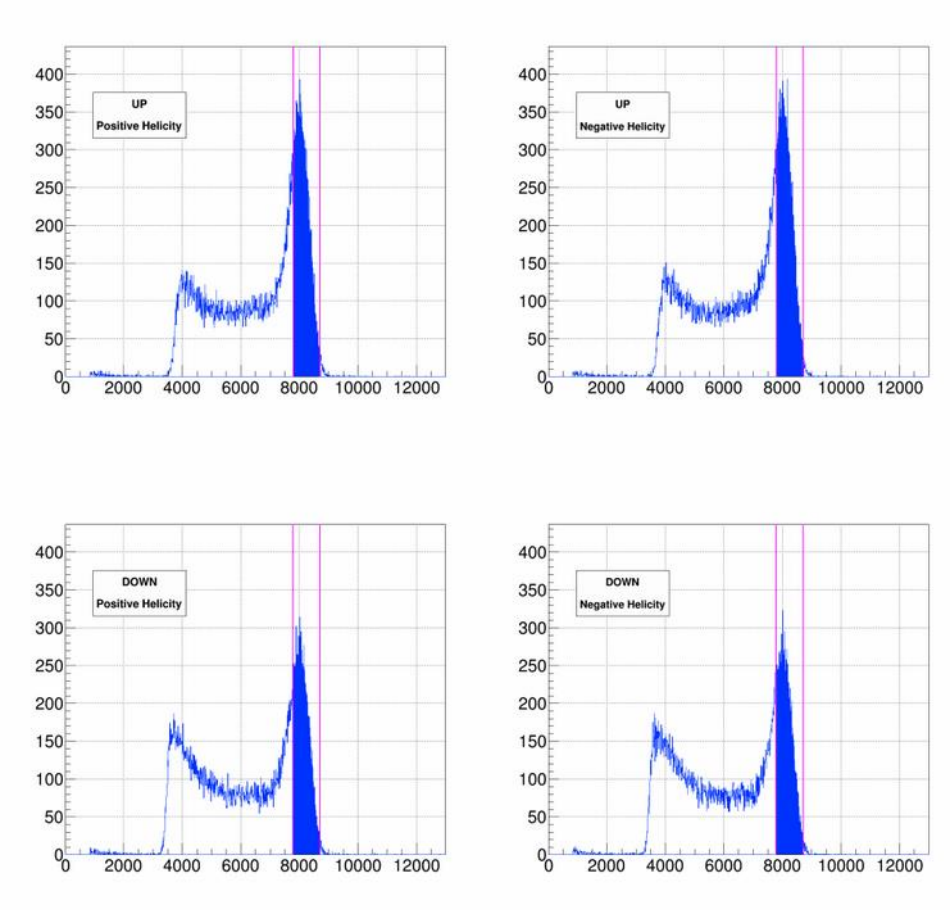
6.3 MeV

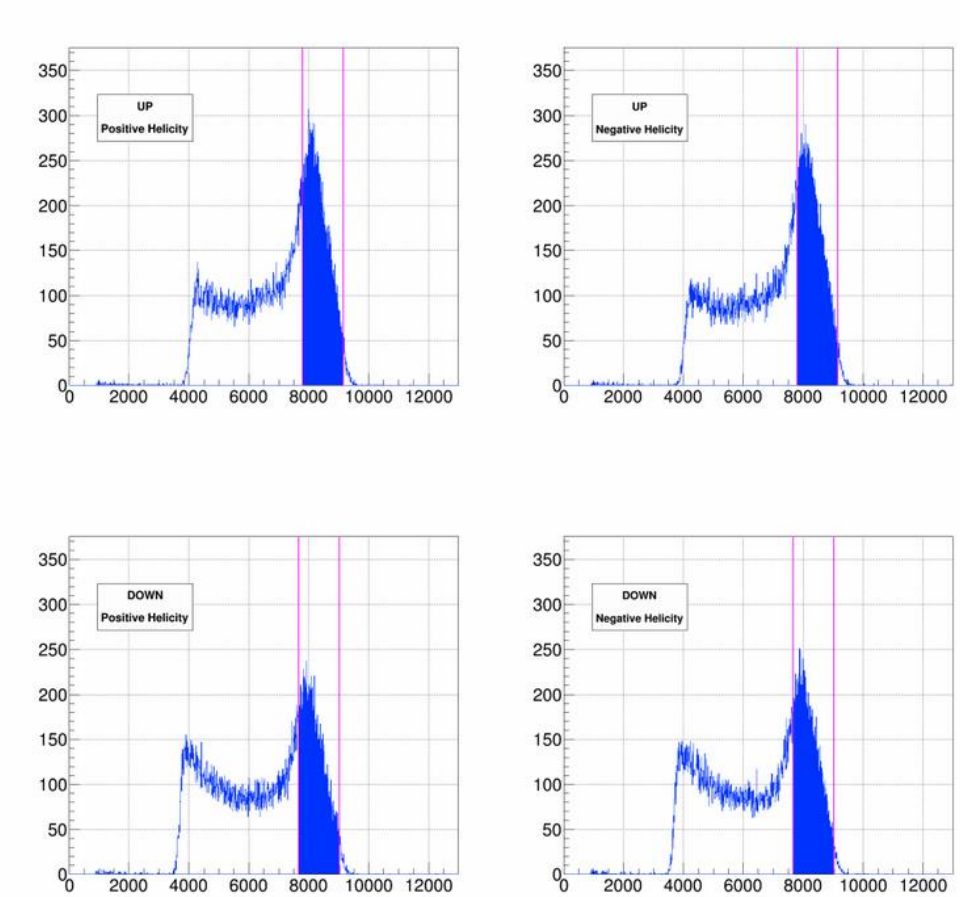
487 micron

Run 9219



847 micron

Run 9222



Peaks broadening in energy, asymmetry diluted

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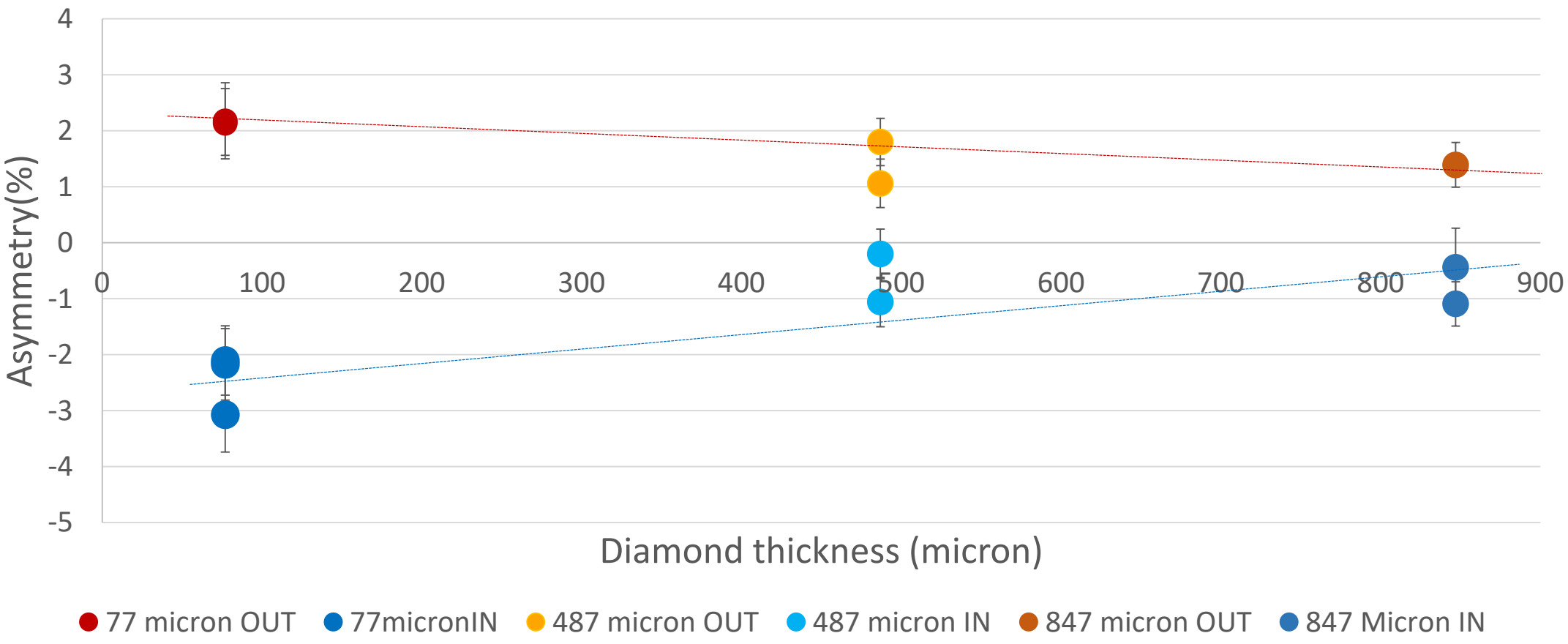
Asymmetry vs. Thickness, 6.3 MeV



Trend toward decreased asymmetry with thickness

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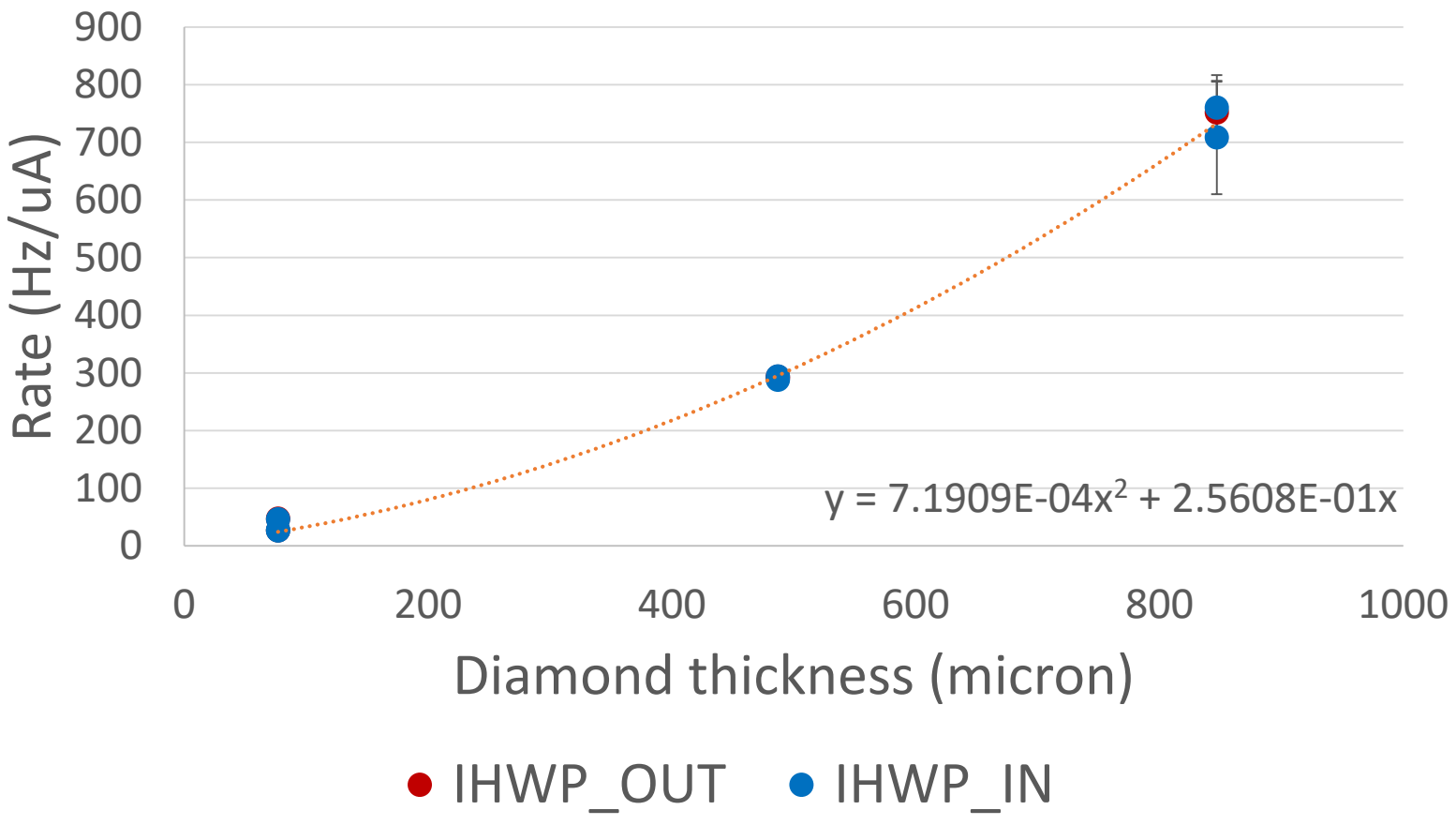
Averaged Rate/detector vs. Thickness, 6.3 MeV



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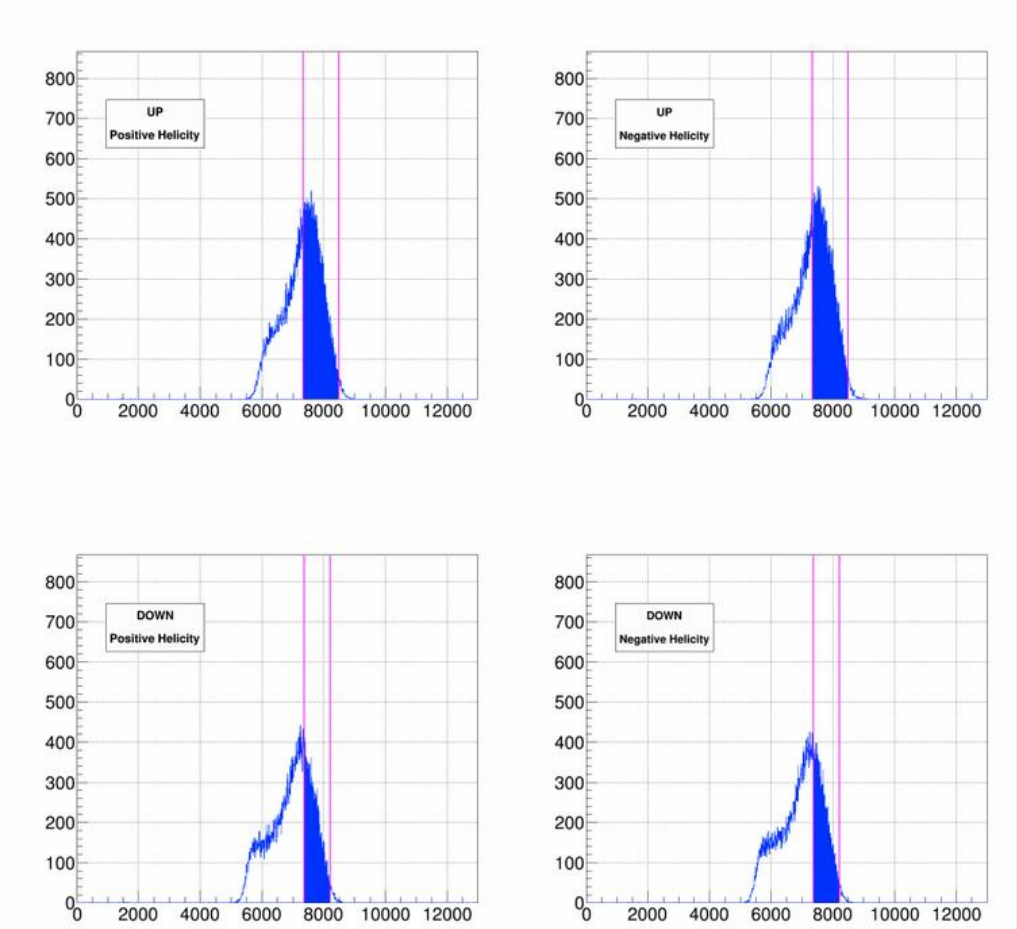
4 MeV

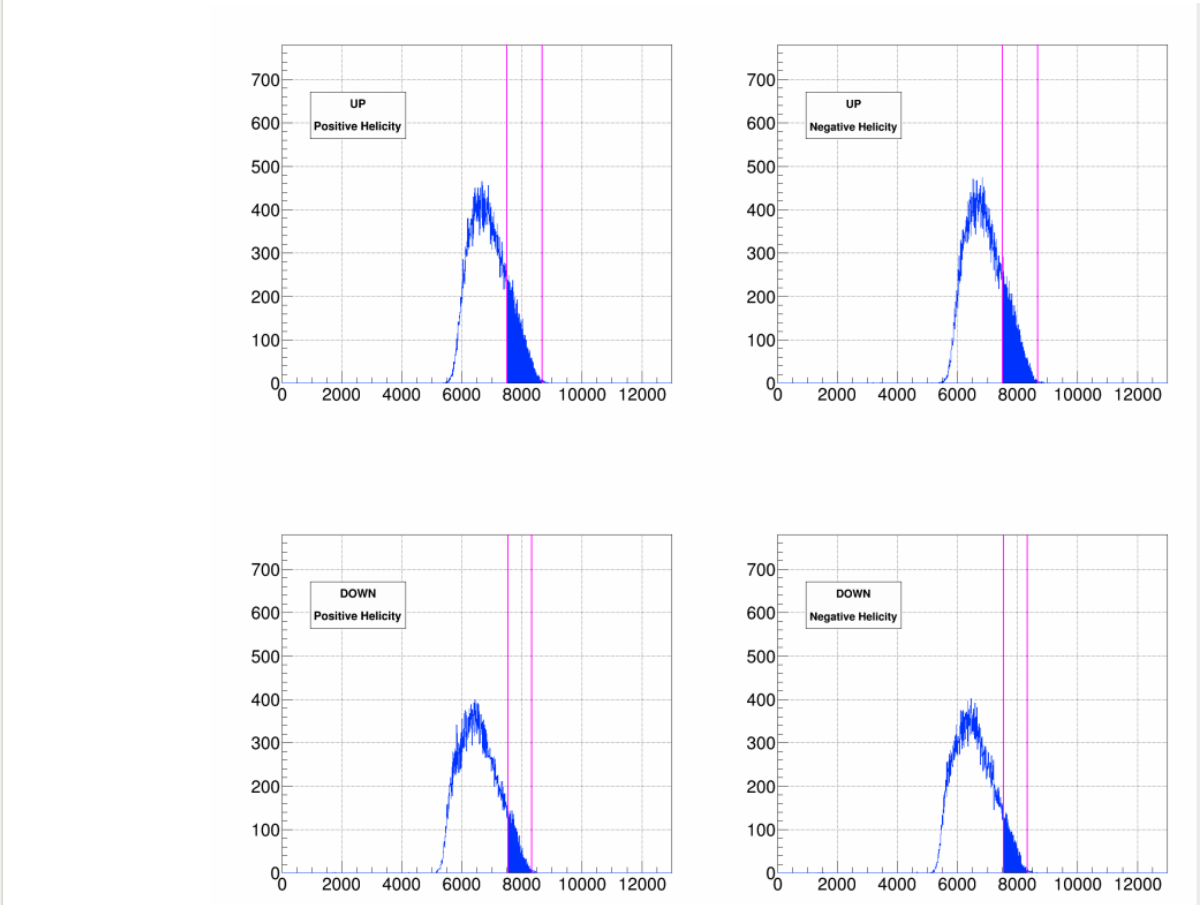
487 micron

Run 9244



847 micron

Run 9246



Background Dominates for thick targets, 4 MeV

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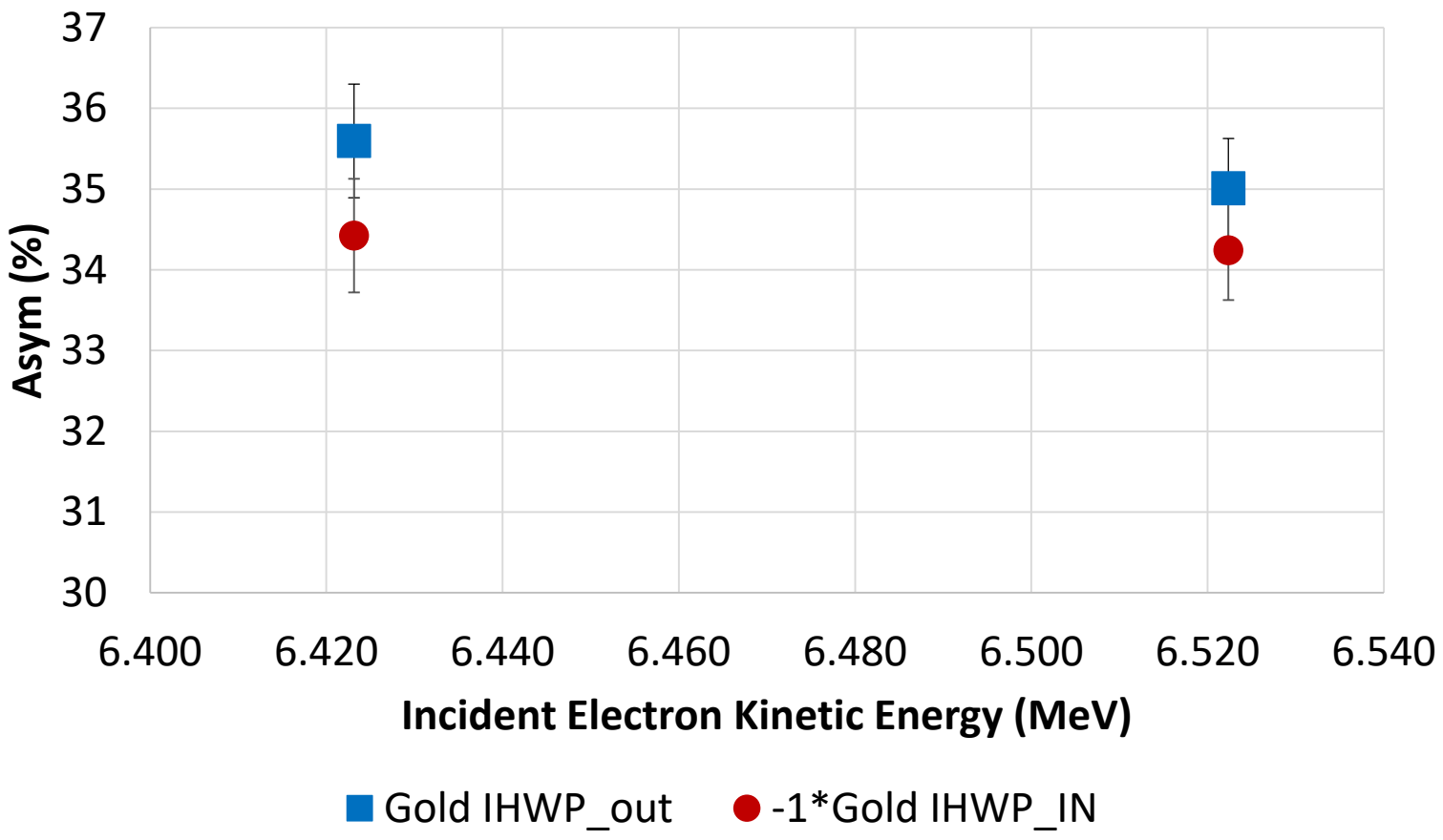
Asymmetry for Gold foil, 0.750 µm



For reference from prior ladder:

Run 9192, HWien = Foil #4 (0.750 um):
Mott Asym UD (%) =
35.3261 +/- 0.419984

Run 9193, Foil #4 (0.750 um):
Mott Asym UD (%) =
-35.4031 +/- 0.41833

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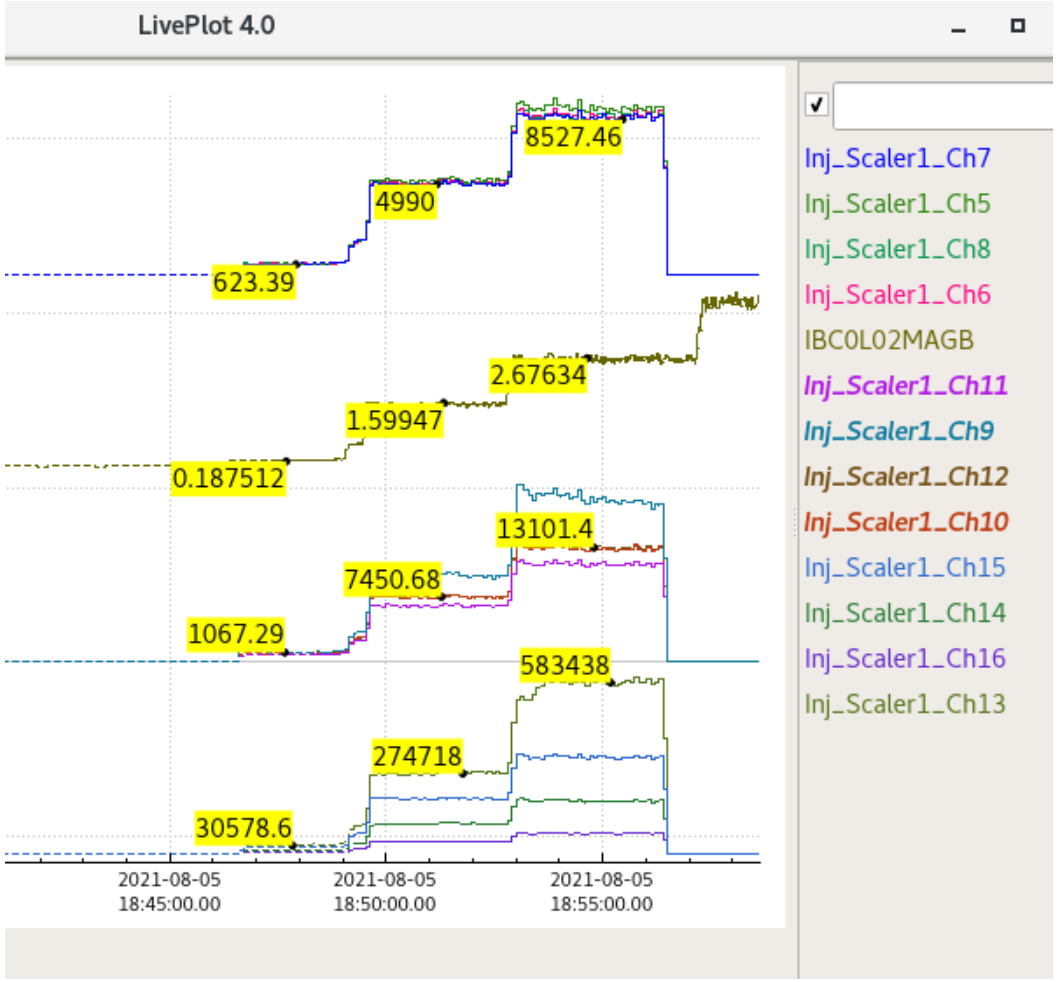
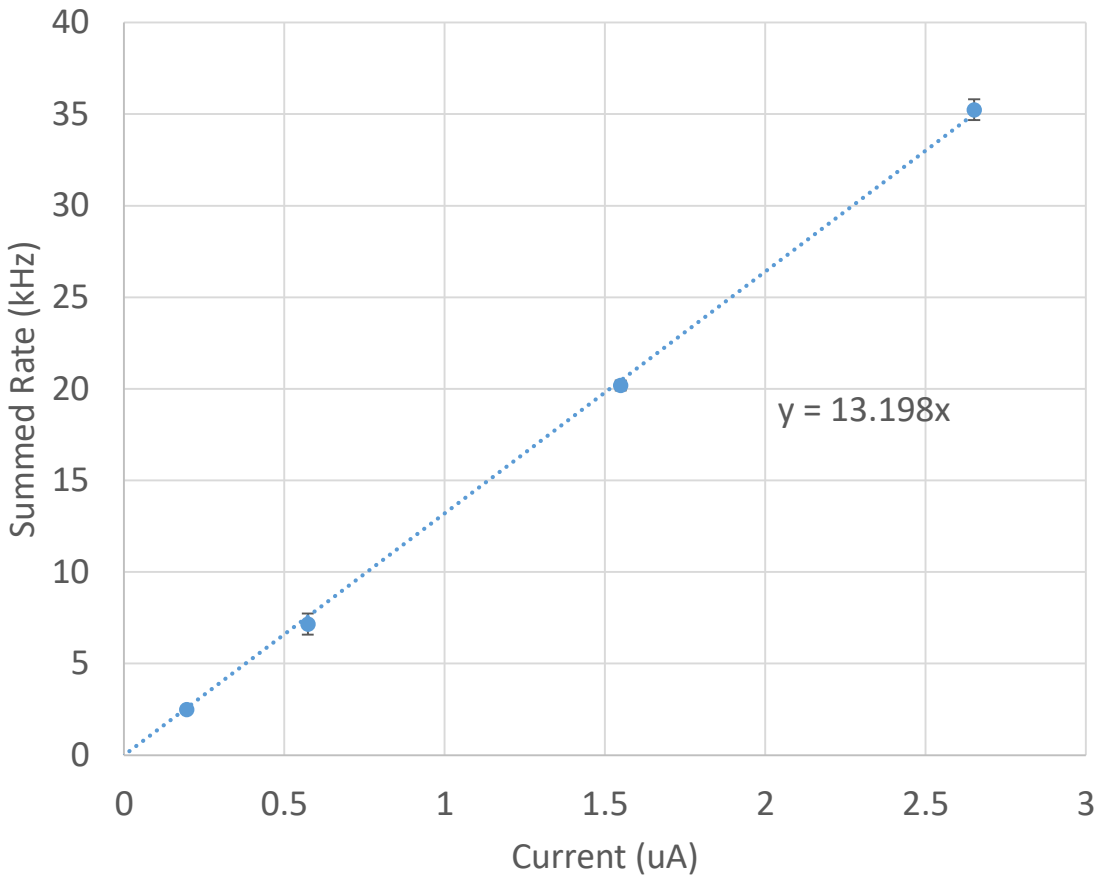
Rate vs. Current





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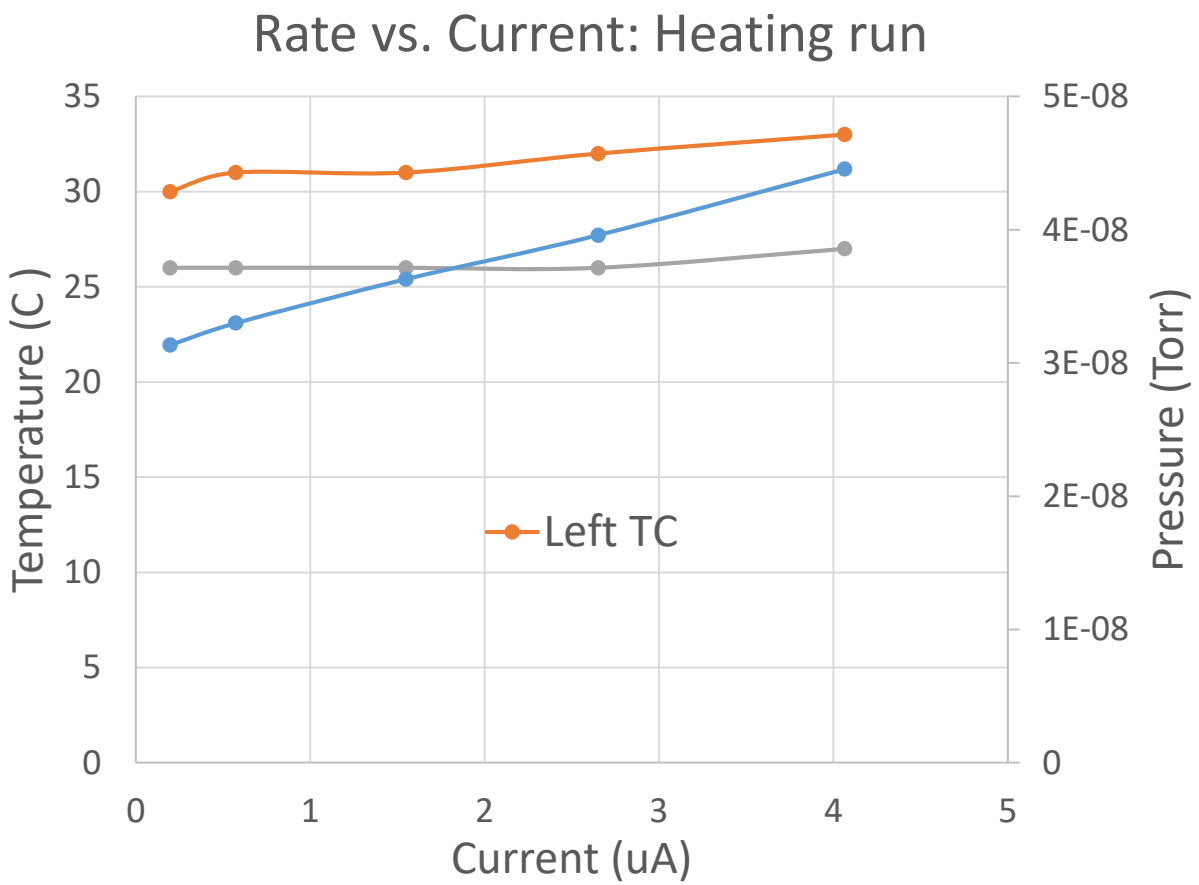
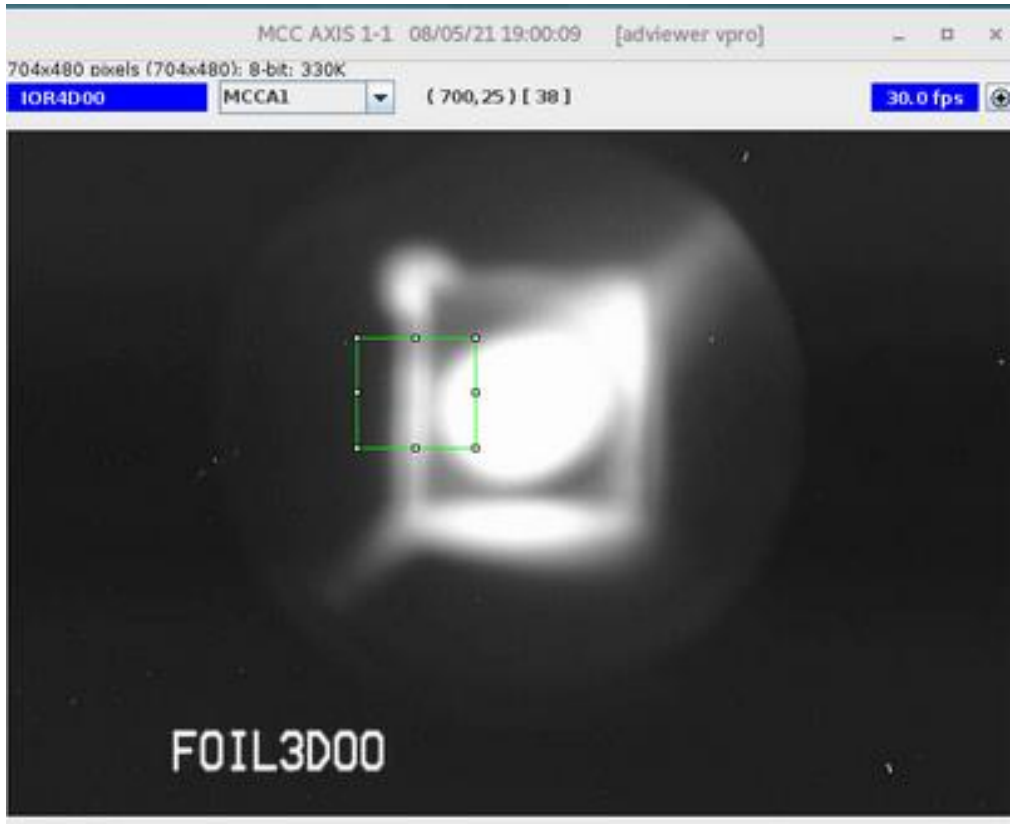
Target Heating: 847 micron





Total higher current run time ~20 minutes

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Data: 77 micron vs. Energy

run	Energy (MeV)	AsymUD	AsymUD_err	IHWP	RunTime (sec)	Scal_Current (uA)
9239	4.2	-1.92	0.38	IN	540.649	0.704353
9249	4.7	-1.89	0.42	IN	519.593	0.90174
9252	5.2	-1.37	0.47	IN	565.333	0.906287
9231	6.4	-2.11	0.62	IN	518.202	1.00152
9233	6.4	-2.17	0.64	IN	504.494	0.985318
9216	6.5	-3.07	0.67	IN	488.296	0.763048
9240	4.2	1.72	0.38	OUT	531.662	0.719951
9250	4.7	1.43	0.38	OUT	598.845	0.92628
9251	5.2	1.48	0.48	OUT	523.094	0.92579
9232	6.4	2.14	0.62	OUT	522.068	1.01233
9217	6.5	2.18	0.68	OUT	467.363	0.77382

Data: A vs T at 6.3 MeV

run	Target um	K.E. MeV	IHWP	AsymUD	AsymUD_err	RunTime	Scal_Current
9217	77	6.522	OUT	2.17638	0.680779	467.363	0.77382
9232	77	6.423	OUT	2.13505	0.616853	522.068	1.01233
9216	77	6.522	IN	-3.0707	0.672327	488.296	0.763048
9231	77	6.423	IN	-2.10512	0.61752	518.202	1.00152
9233	77	6.423	IN	-2.17309	0.637546	504.494	0.985318
9219	487	6.522	OUT	1.06008	0.434162	463.633	0.213155
9225	487	6.522	OUT	1.79828	0.422362	531.443	0.192775
9220	487	6.522	IN	-0.200794	0.445094	459.644	0.204677
9226	487	6.522	IN	-1.06012	0.441041	489.438	0.190475
9223	847	6.522	OUT	1.39071	0.400472	390.321	0.116877
9221	847	6.522	IN	-0.440191	0.698999	246.366	0.0599072
9222	847	6.522	IN	-1.09362	0.395809	407.796	0.111879

Conclusions

- First Run with diamond targets complete
  - Non-zero asymmetry measured
  - Asymmetry changes sign with insertable waveplate insertion
- Asymmetry decreases with increasing thickness as expected
- Potential trend toward higher asymmetry with increasing energy
- Minimal heating observed