DarkLight Non-standard Optics

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August 2024

1 Goal Scenarios

1 μm tantalum	10, 15, **20**, 25 MeV
1 μm carbon	10, 15, **20**, 25, 30 MeV
2 μm carbon	10, 15, **20**, 25, 30 MeV

2 Scattering Angles

Note: constant cut distance of 10 cm and constant number of incidents 1.0×10^7.

2.1 1 μm Carbon Target

Energy [MeV]	**Cut Radius [cm]**	**# of Cuts**	**IQR x**	**IQR y**	**$\times$ IQR**
10	7.6	287	0.001855826	0.002127924	16.7
15	8.1	275	0.00127664	0.001643191	25.5
20	8.1	263	0.000986447	0.001424472	31.0
25	8.1	258	0.000814125	0.001304853	35.7
30	8.1	251	0.000701297	0.001231513	39.5

Table 1: Cut details for the 1 μm Carbon target scenarios.

Energy [MeV]	**RMS x [rad]**	**RMS y [rad]**
10	0.0026546	0.00269968
15	0.0020913	0.00212844
20	0.00180008	0.00187091
25	0.00165725	0.00171639
30	0.00154835	0.00163349

Table 2: RMS values for the 1 μm Carbon target Scenarios.

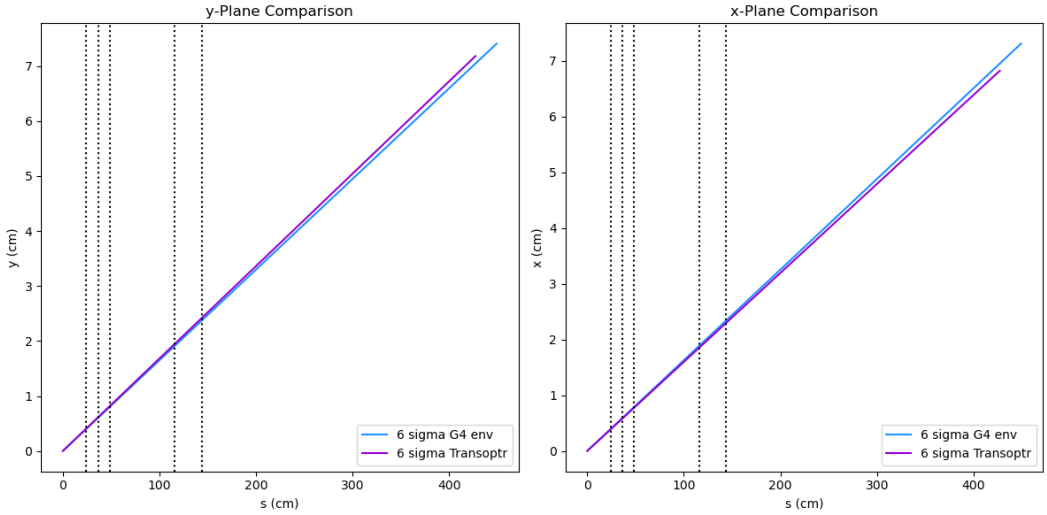


Figure 1: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Carbon target at 10 MeV case.

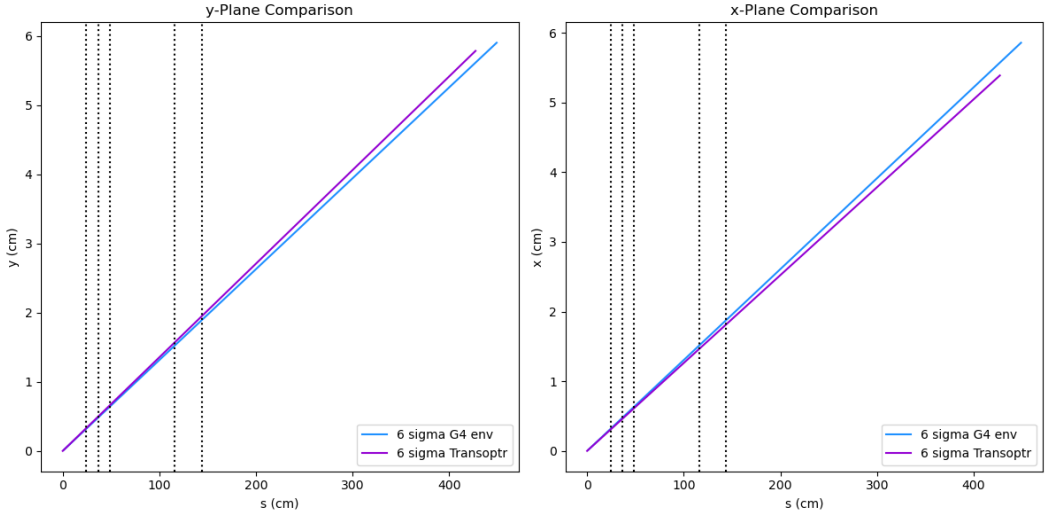


Figure 2: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Carbon target at 15 MeV case.

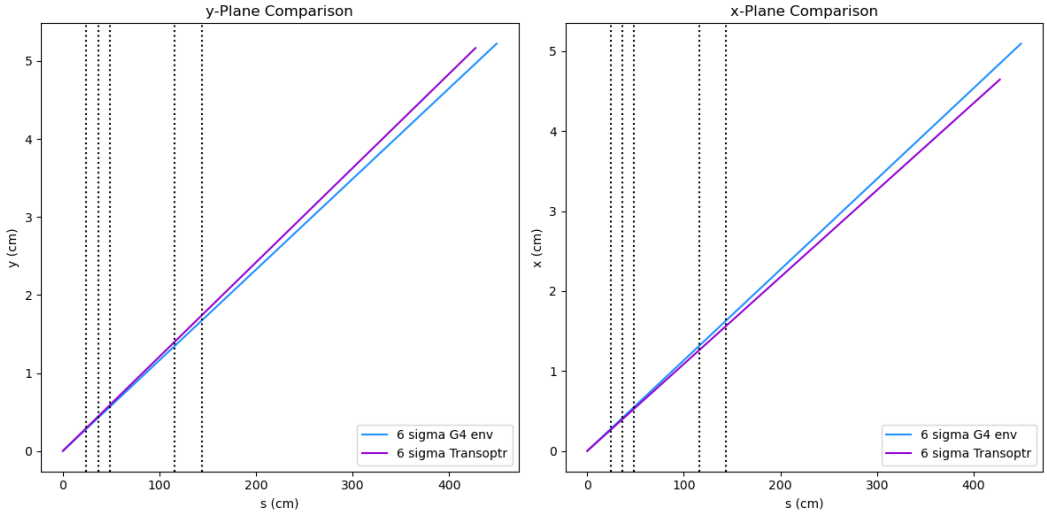


Figure 3: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Carbon target at 20 MeV case.

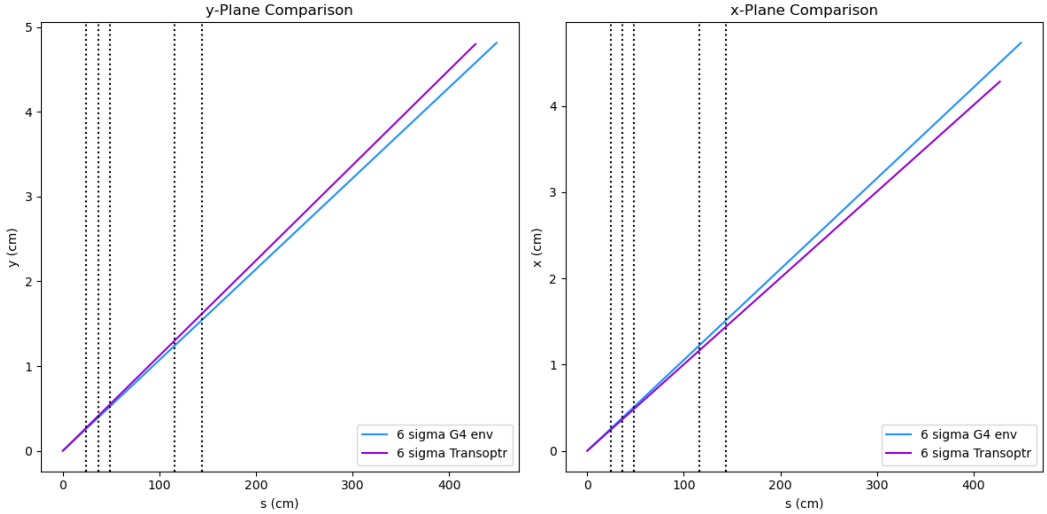


Figure 4: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Carbon target at 25 MeV case.

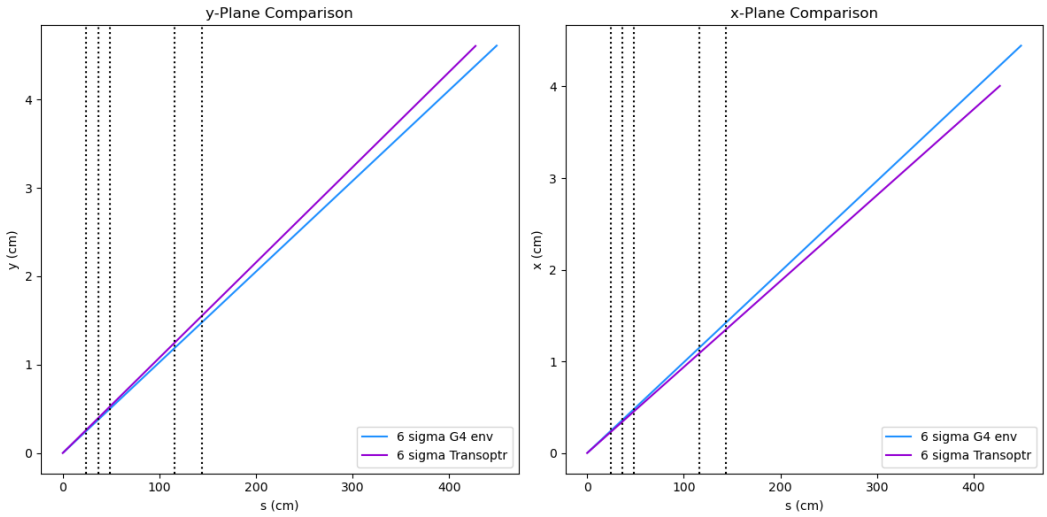


Figure 5: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Carbon target at 30 MeV case.

2.2 1 μm Tantalum Target

Energy [MeV]	**Cut Radius [cm]**	**# of Cuts**	**IQR x**	**IQR y**	**$\times$ IQR**
10	11.5	764	0.017286548	0.017325753	4.5
15	7.0	743	0.011694377	0.011739494	2.5
20	6.0	731	0.008829538	0.008890784	2.7
25	5.6	652	0.007096777	0.007172676	3
30	5.7	533	0.005933889	0.006022083	3.5
50	5.3	475	0.00358367	0.00373285	5.60
55	5.4	434	0.00326115	0.003424652	6.3

Table 3: Cut details for the 1 μm Tantalum target scenarios.

Energy [MeV]	**RMS x [rad]**	**RMS y [rad]**
10	0.02044531	0.02046903
15	0.01389478	0.01390443
20	0.01061946	0.01059647
25	0.00859129	0.00860689
30	0.00727964	0.00730866
50	0.00454417	0.00459381
55	0.0042011	0.00424967

Table 4: RMS values for the 1 μm Tantalum target Scenarios.

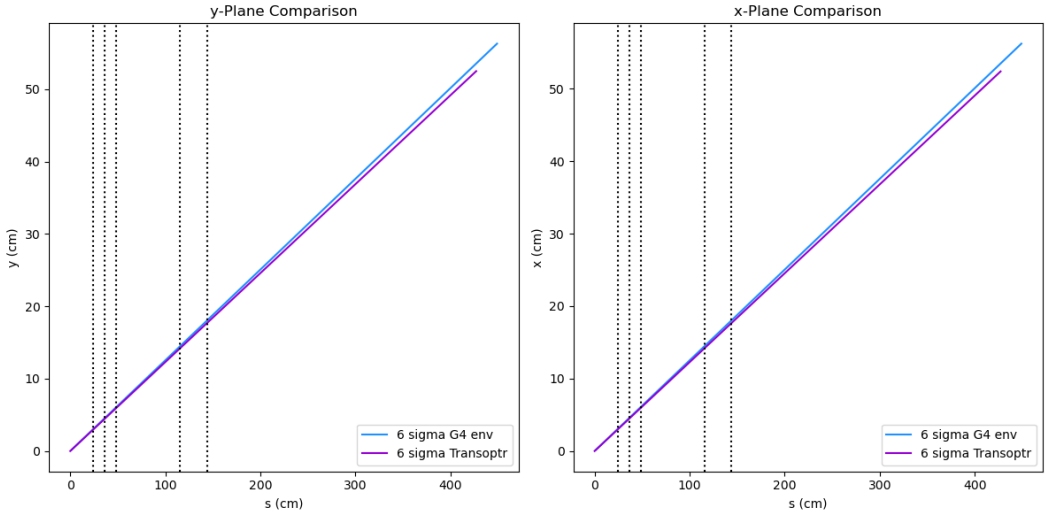


Figure 6: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Tantalum target at 10 MeV case.

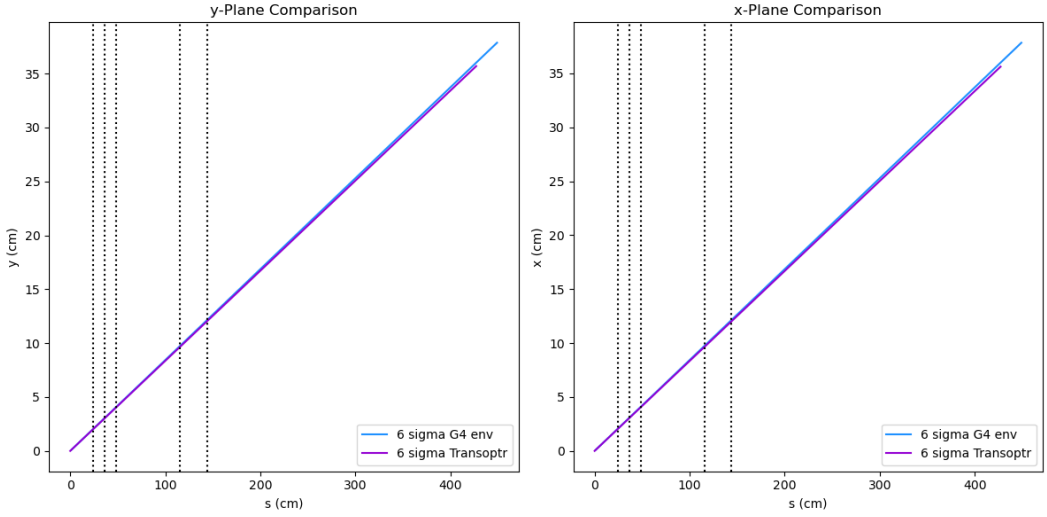


Figure 7: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Tantalum target at 15 MeV case.

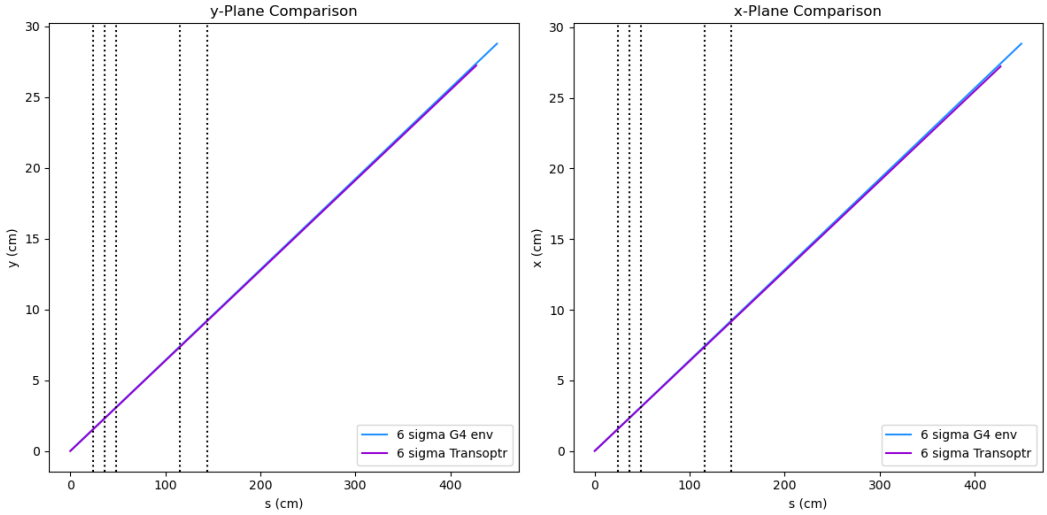


Figure 8: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Tantalum target at 20 MeV case.

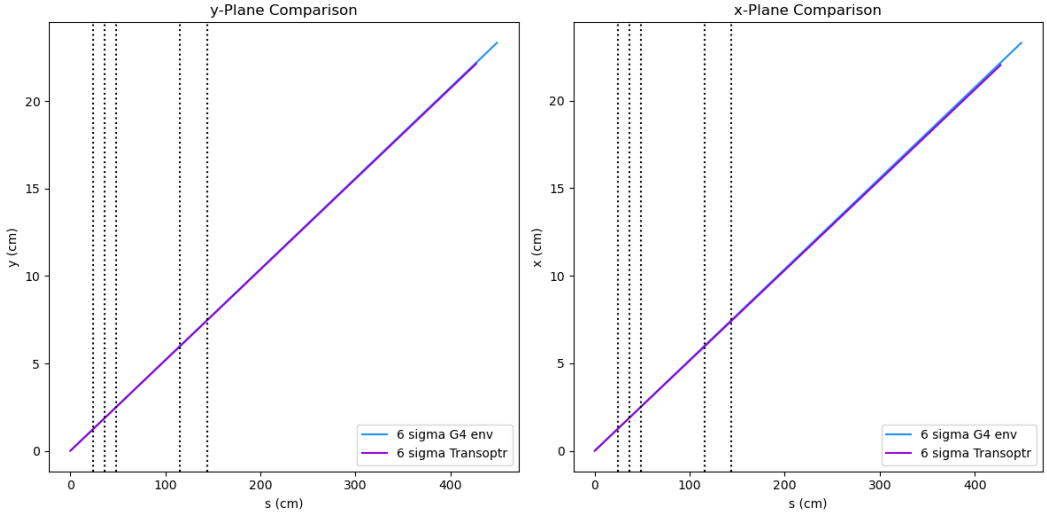


Figure 9: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Tantalum target at 25 MeV case.

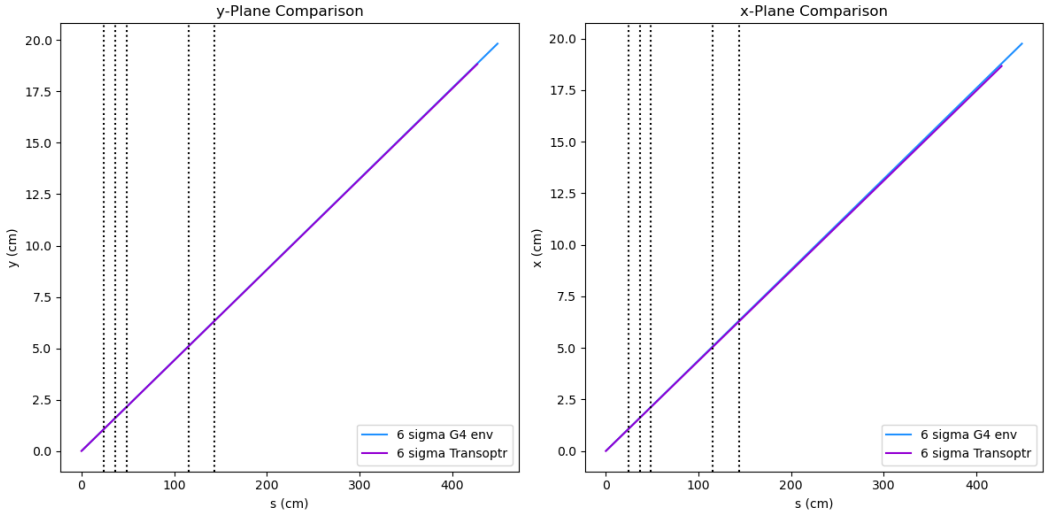


Figure 10: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Tantalum target at 30 MeV case.

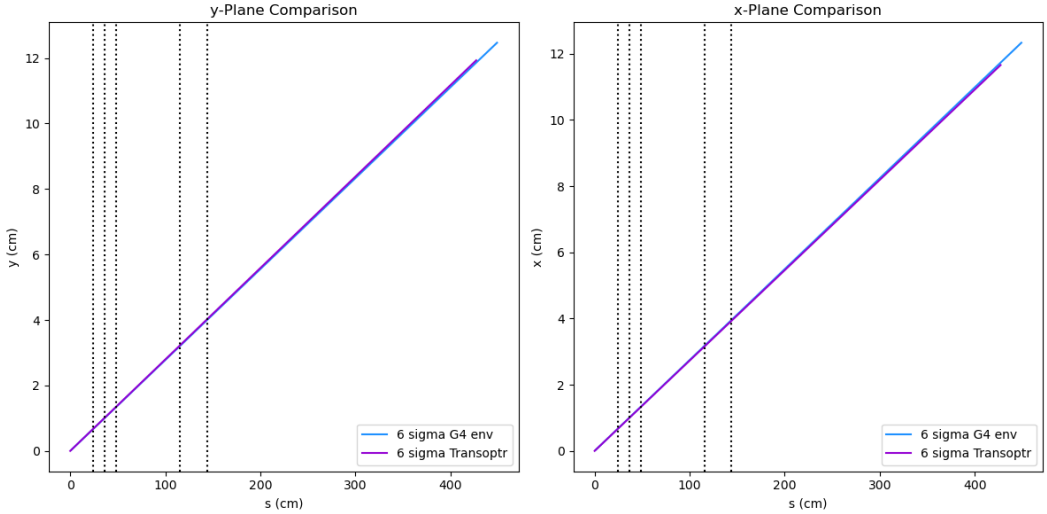


Figure 11: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Tantalum target at 50 MeV case.

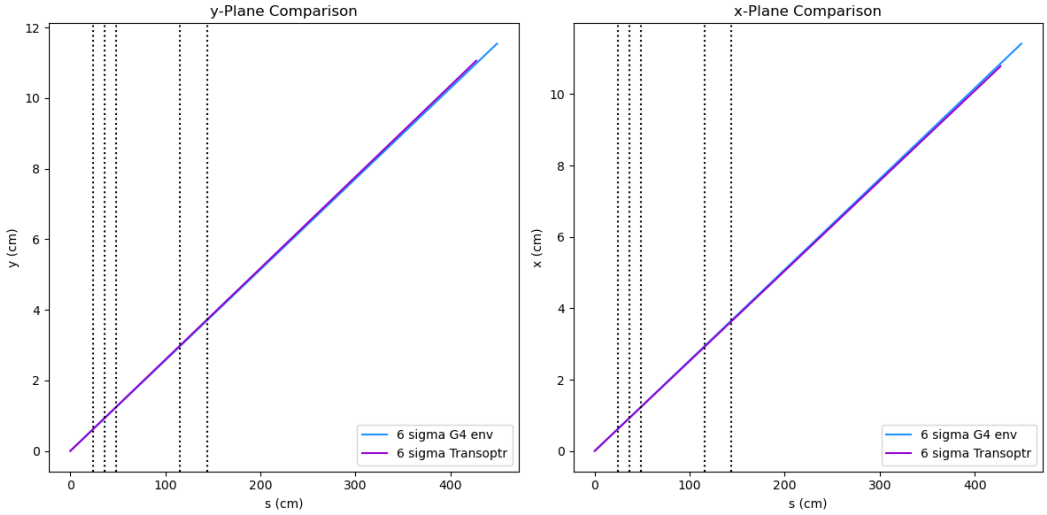


Figure 12: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 1 μm Tantalum target at 55 MeV case.

2.3 2 μm Carbon Target

Energy [MeV]	**Cut Radius [cm]**	**# of Cuts**	**IQR x**	**IQR y**	**$\times$ IQR**
10	6.5	570	0.002748405	0.002939609	9.5
15	7.0	542	0.001875365	0.002143438	14.7
20	7.1	531	0.001431975	0.001767149	19
25	7.1	549	0.001165897	0.001555584	22.5
30	7.1	559	0.000989465	0.001424273	25

Table 5: Cut details for the 2 μm Carbon target scenarios.

Energy [MeV]	**RMS x [rad]**	**RMS y [rad]**
10	0.00350856	0.00360906
15	0.00263758	0.00275591
20	0.00220452	0.00232561
25	0.00193944	0.00207667
30	0.00177951	0.00192483

Table 6: RMS values for the 2 μm Carbon target Scenarios.

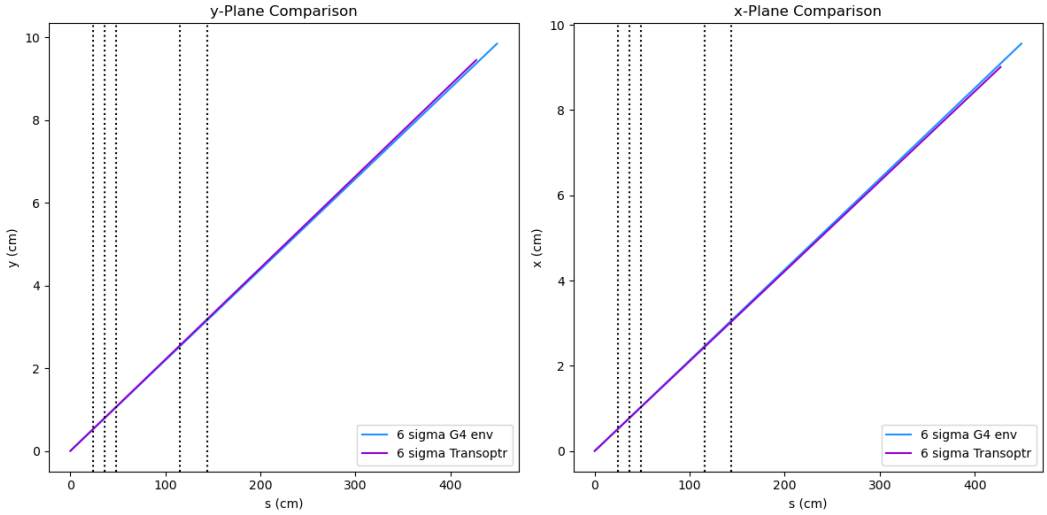


Figure 13: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 2 μm Carbon target at 10 MeV case.

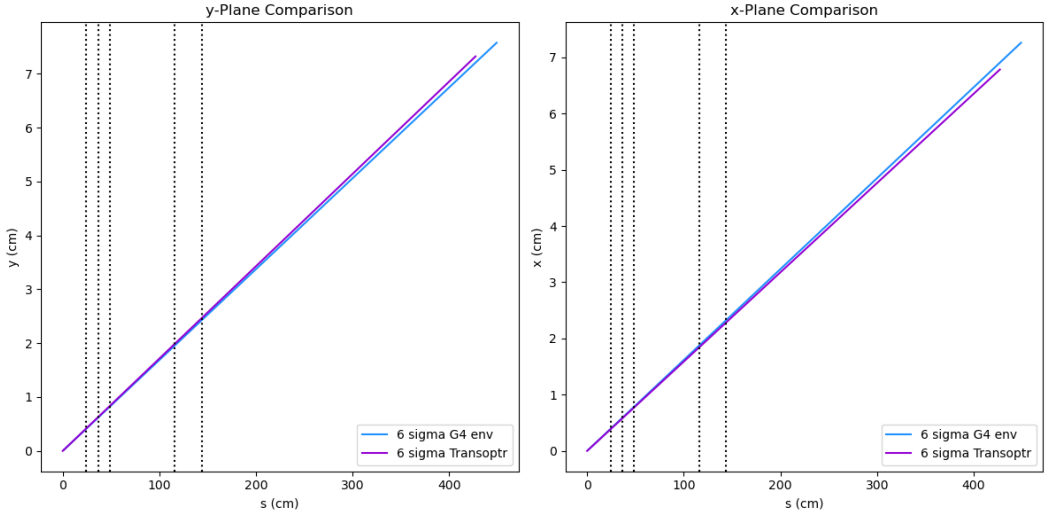


Figure 14: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 2 μm Carbon target at 15 MeV case.

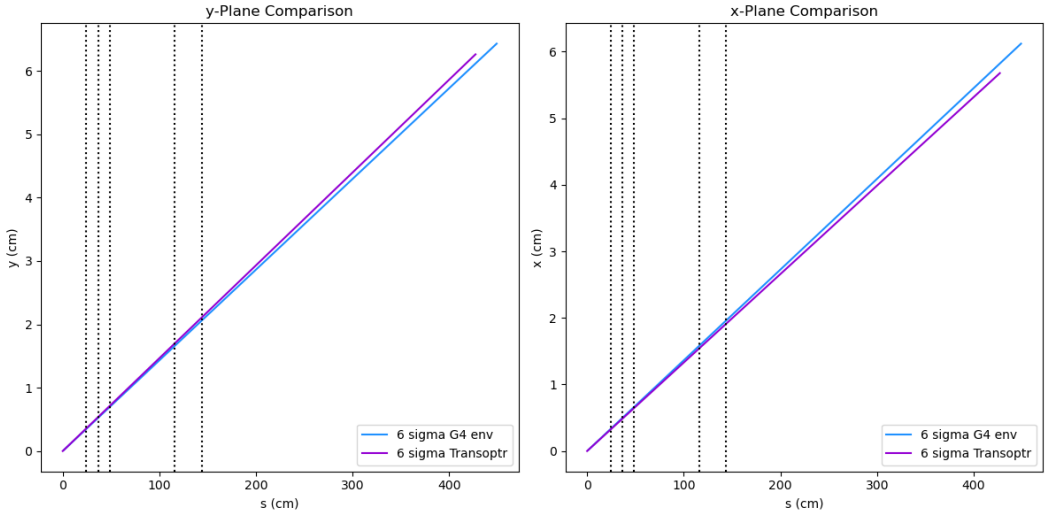


Figure 15: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 2 μm Carbon target at 20 MeV case.

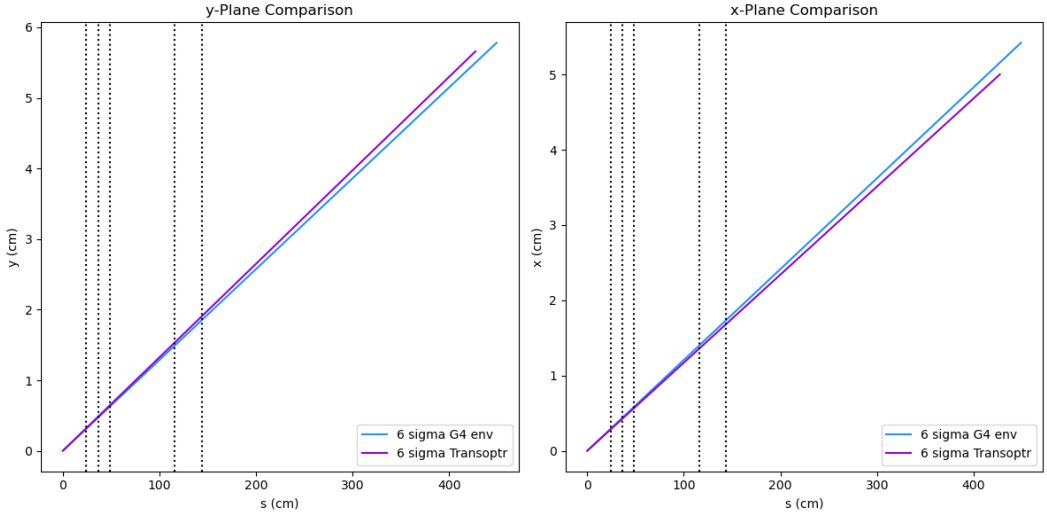


Figure 16: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 2 μm Carbon target at 25 MeV case.

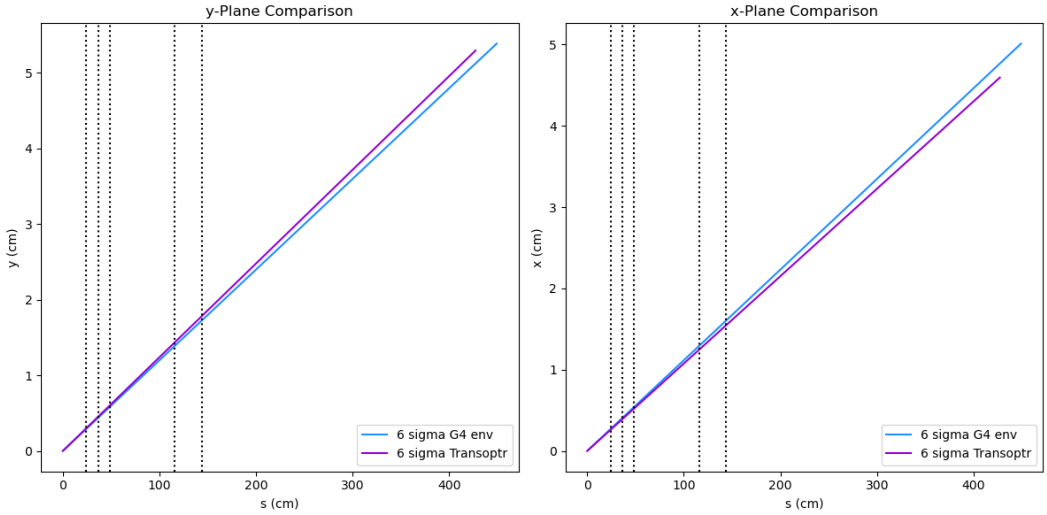


Figure 17: Shows the comparisons between 6σ envelopes produced using Geant4 and Transoptr in both the x and y planes for the 2 μm Carbon target at 30 MeV case.

3 1μm Carbon Target

3.1 No Magnets Scattering Visual

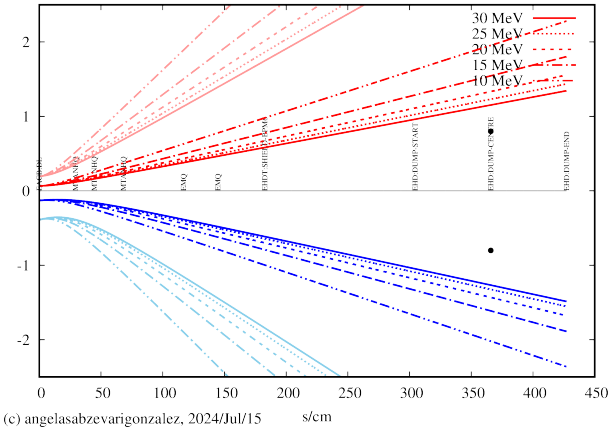


Figure 18: Carbon scattering at all desired energies with no magnets.

3.2 10 MeV

code numbers: 4.43, 6.17, 14.47, 5.72, 18.0

PMQ1 [T]	PMQ2 [T]	PMQ3 [T]	EMQ1 [T]	EMQ2 [T]	xP1 [cm]	xP2 [cm]	xP3 [cm]	xE1 [cm]	xE2 [cm]
-0.3	0.3	-0.3	0.09	-0.15	29.4369	44.6209	68.1042	116.717	144.716

Table 7: One magnet set up for 1 μm Carbon target at 10 MeV.

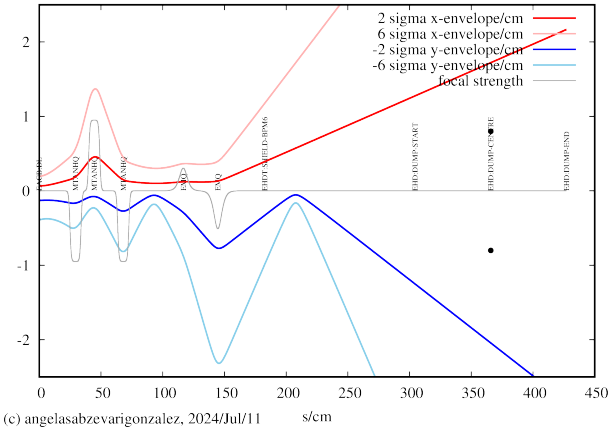


Figure 19: Envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths and positions for the 10 MeV case.

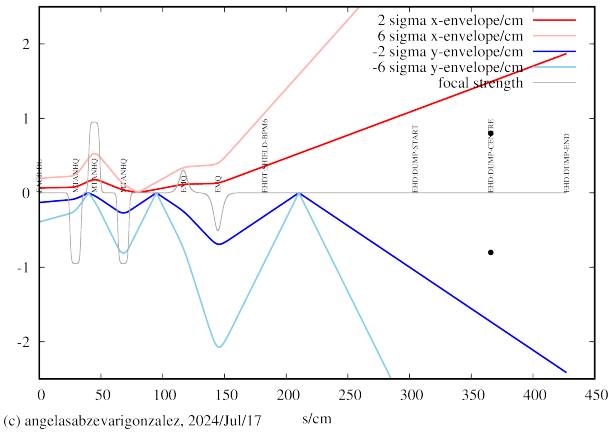


Figure 20: Envelope plots with no target to ensure the magnetic set up for 10 MeV case using the 0.3 T PMQs is still valid. No changes were made.

3.3 15 MeV

code numbers: 4.43, 6.17, 14.47, 5.72, 18.0

PMQ1 [T]	PMQ2 [T]	PMQ3 [T]	EMQ1 [T]	EMQ2 [T]	xP1 [cm]	xP2 [cm]	xP3 [cm]	xE1 [cm]	xE2 [cm]
-0.3	0.3	-0.3	0.19	-0.09	29.4369	44.6209	68.1042	116.717	144.716

Table 8: One magnet set up for 1 μm Carbon target at 15 MeV.

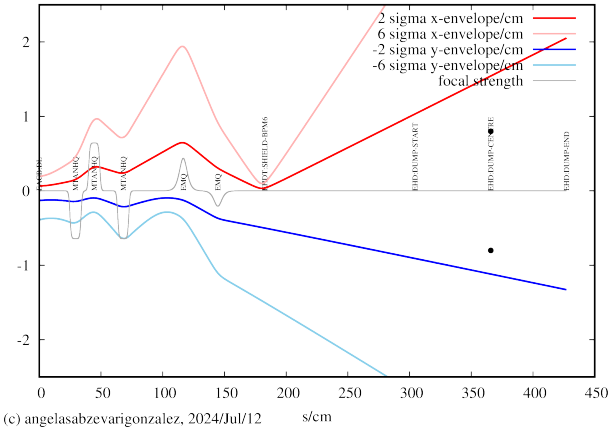


Figure 21: Envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths such that the magnet positions do not have to change from the 10 MeV case to the 15 MeV case.

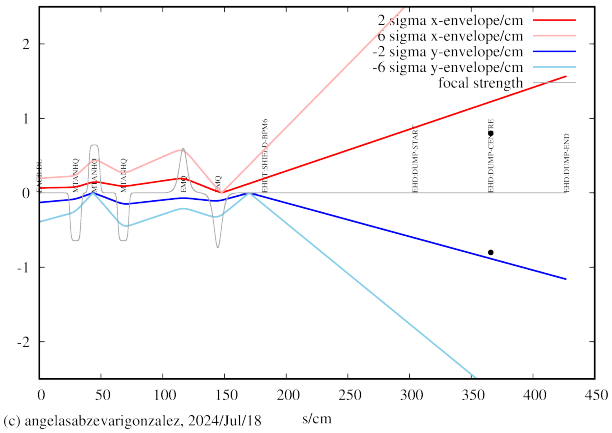


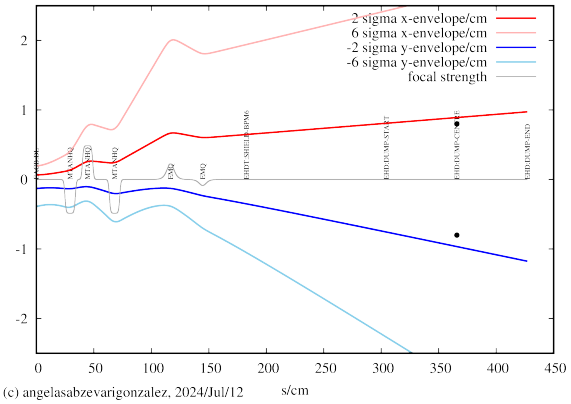
Figure 22: Envelope plots with no target to ensure the magnetic set up for 15 MeV case using the 0.3 T PMQs is still valid.
EMQ1 = 0.26 T and EMQ2 = -0.32 T.

3.4 20 MeV

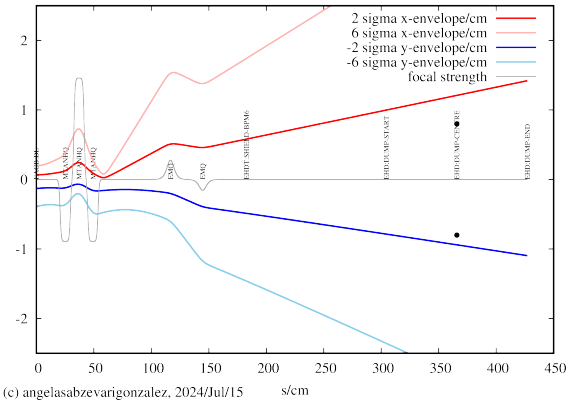
code numbers:
4.43, 6.17, 14.47, 5.72, 18.0
0, 3, 3, 5.72, 18

PMQ1 [T]	**PMQ2 [T]**	**PMQ3 [T]**	**EMQ1 [T]**	**EMQ2 [T]**	**xP1 [cm]**	**xP2 [cm]**	**xP3 [cm]**	**xE1 [cm]**	**xE2 [cm]**
-0.3	0.3	-0.3	0.13	-0.05	29.4369	44.6209	68.1042	116.717	144.716
-0.55	0.9	-0.55	0.16	-0.09	25.1869	37.2007	49.2146	116.724	144.723

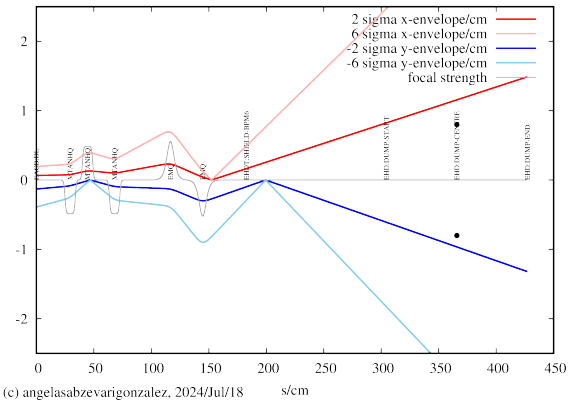
Table 9: Magnet set ups for 1 μm Carbon target at 20 MeV.



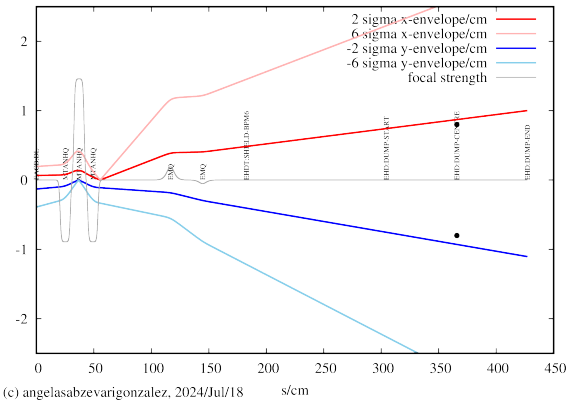
(a) Transoptr envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths such that the magnet positions do not have to change from the 10 MeV case to the 20 MeV case.



(b) Transoptr envelope plots using two 0.55 T PMQs, one 0.9 T PMQ, and two EMQs set to optimized strengths such that the magnet positions do not have to change from the Tantalum scenarios to the nominal Tantalum cases.



(c) Envelope plots with no target to ensure the magnetic set up for 20 MeV using the 0.3 T PMQs is still valid. EMQ1 = 0.32 T and EMQ2 = -0.30 T.



(d) Envelope plots with no target to ensure the magnetic set up for 20 MeV using the nominal PMQs is still valid. EMQ1 = 0.11 T and EMQ2 = -0.03 T.

3.5 25 MeV

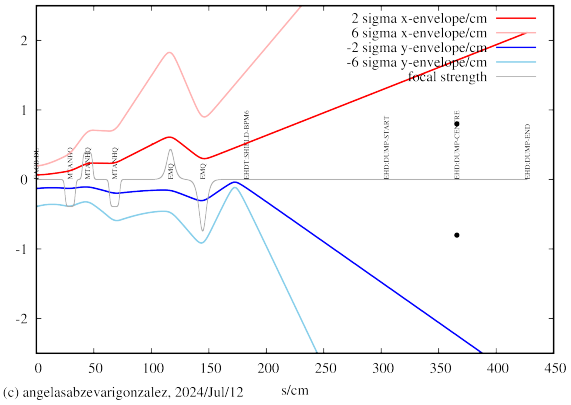
code numbers:

4.43, 6.17, 14.47, 5.72, 18.0

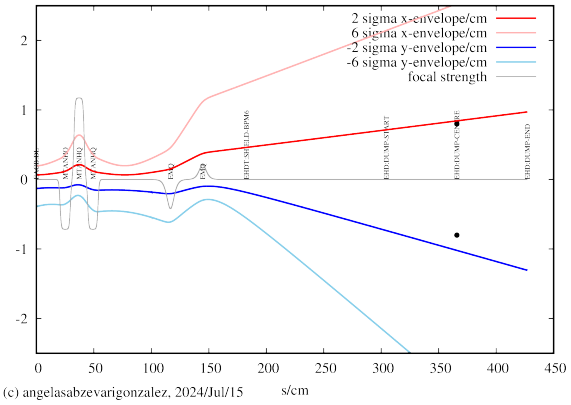
0, 3, 3, 5.72, 18

PMQ1 [T]	PMQ2 [T]	PMQ3 [T]	EMQ1 [T]	EMQ2 [T]	xP1 [cm]	xP2 [cm]	xP3 [cm]	xE1 [cm]	xE2 [cm]
-0.3	0.3	-0.3	0.31	-0.53	29.4369	44.6209	68.1042	116.717	144.716
-0.55	0.9	-0.55	-0.30	0.15	25.1869	37.2007	49.2146	116.724	144.723

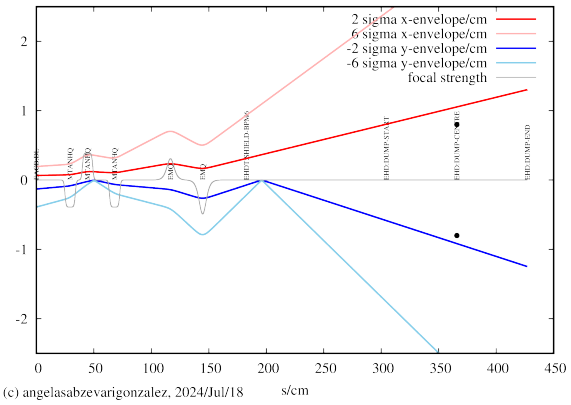
Table 10: Magnet set ups for 1 μm Carbon target at 25 MeV.



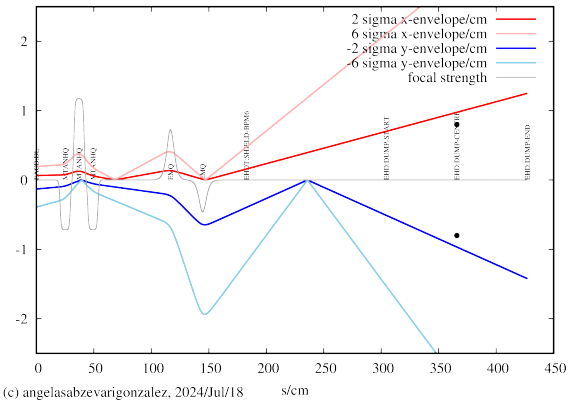
(e) Transoptr envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths such that the magnet positions do not have to change from the 10 MeV case to the 25 MeV case.



(f) Transoptr envelope plots using two 0.55 T PMQs, one 0.9 T PMQ, and two EMQs set to optimized strengths such that the magnet positions do not have to change from the nominal Tantalum cases.



(g) Envelope plots with no target to ensure the magnetic set up for 25 MeV using the 0.3 T PMQs is still valid. EMQ1 = 0.22 T and EMQ2 = -0.35 T.



(h) Envelope plots with no target to ensure the magnetic set up for 25 MeV using the nominal PMQs is still valid. EMQ1 = 0.52 T and EMQ2 = -0.33 T.

3.6 30 MeV

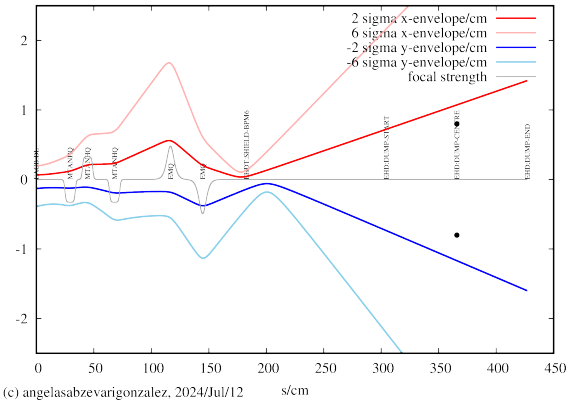
code numbers:

4.43, 6.17, 14.47, 5.72, 18.0

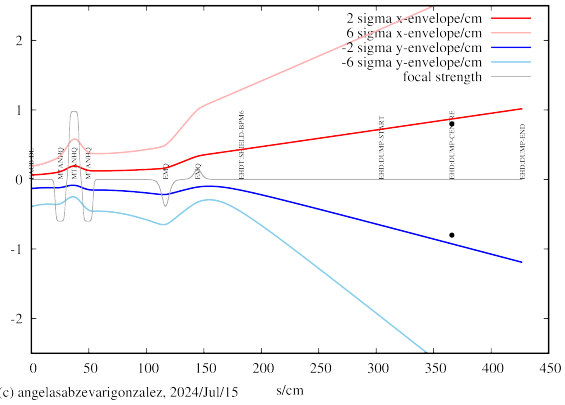
0, 3, 3, 5.72, 18

PMQ1 [T]	**PMQ2 [T]**	**PMQ3 [T]**	**EMQ1 [T]**	**EMQ2 [T]**	**xP1 [cm]**	**xP2 [cm]**	**xP3 [cm]**	**xE1 [cm]**	**xE2 [cm]**
-0.3	0.3	-0.3	0.41	-0.42	29.4369	44.6209	68.1042	116.717	144.716
-0.55	0.9	-0.55	-0.33	0.13	25.1869	37.2007	49.2146	116.724	144.723

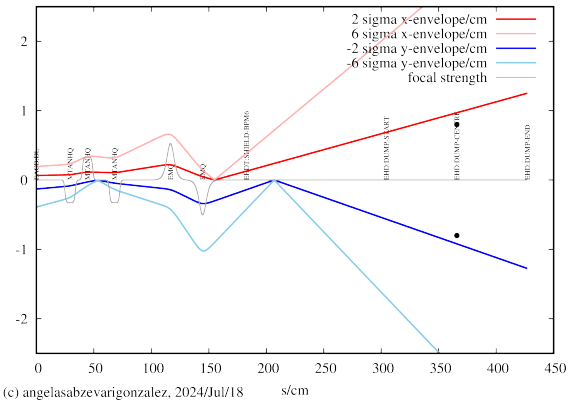
Table 11: Magnet set ups for 1 μm Carbon target at 30 MeV.



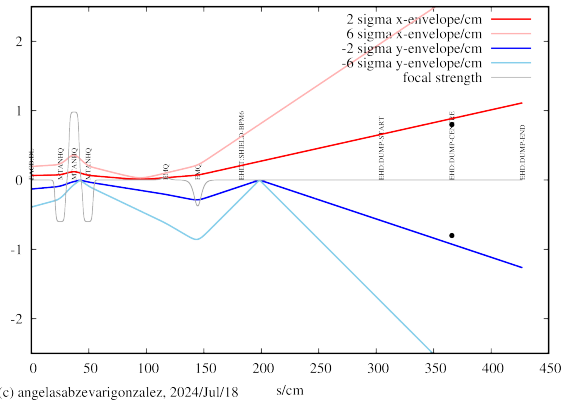
(i) Transoptr envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths such that the magnet positions do not have to change from the 10 MeV case to the 30 MeV case.



(j) Transoptr envelope plots using two 0.55 T PMQs, one 0.9 T PMQ, and two EMQs set to optimized strengths such that the magnet positions do not have to change from the nominal Tantalum.

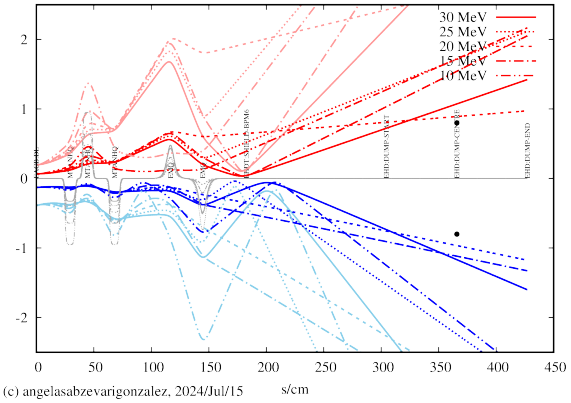


(k) Envelope plots with no target to ensure the magnetic set up for 30 MeV using the 0.3 T PMQs is still valid. EMQ1 = 0.45 T and EMQ2 = -0.43 T.

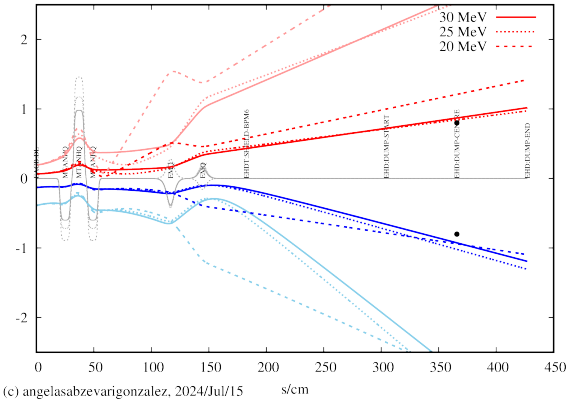


(l) Envelope plots with no target to ensure the magnetic set up for 30 MeV using the nominal PMQs is still valid. EMQ1 = 0.03 T and EMQ2 = -0.32 T.

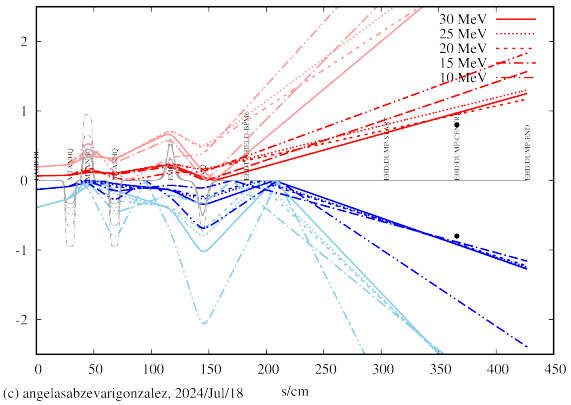
3.7 Carbon Summary



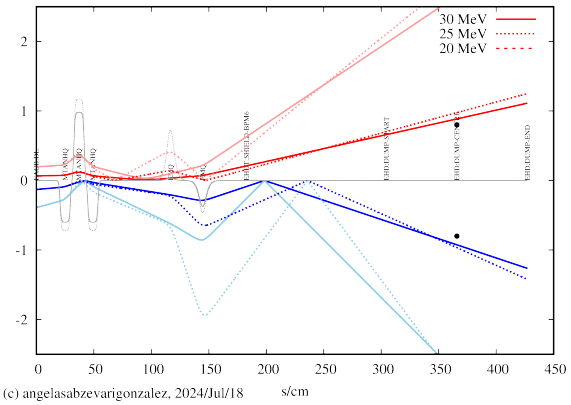
(m) All energy 2 and 6 σ envelope plots using three 0.3T PMQs and two EMQs set to specific strengths to accommodate the new magnet positions.



(n) All energy 2 and 6 σ envelope plots using nominal PMQs and two EMQs set to specific strengths to accommodate the nominal magnet positions.



(o) All energy 2 and 6 σ envelope plots using the 0.3 T PMQs without a target to show the set ups are still valid given different EMQ strengths.

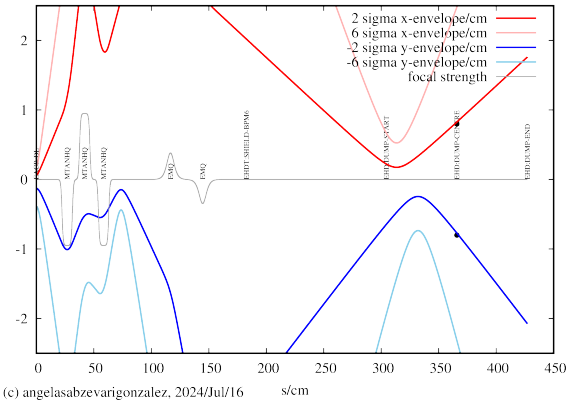


(p) All energy 2 and 6 σ envelope plots using the nominal PMQs without a target to show the set ups are still valid given different EMQ strengths.

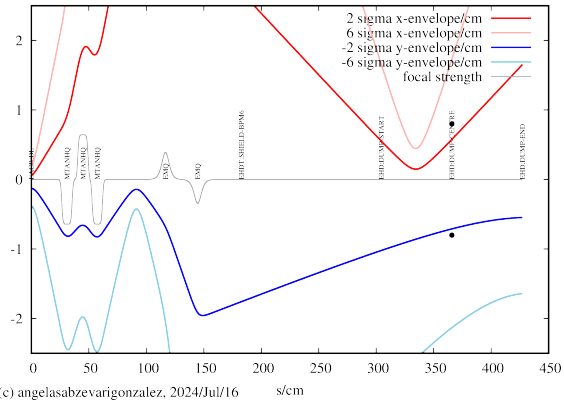
4 1 μm Tantalum Target

4.1 10-25 MeV

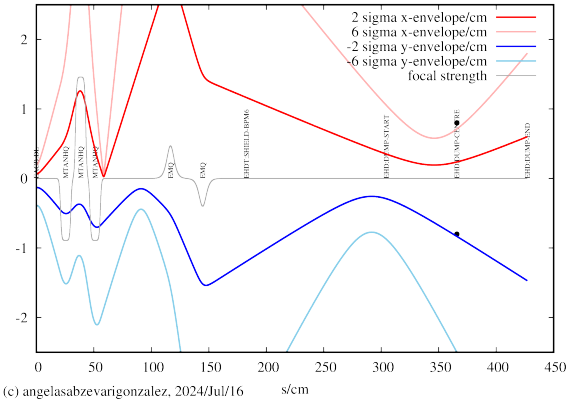
Tried finding solutions for lower energy cases including 10, 15, 20, and 25 MeV. Unable to find any magnet set ups that allow for these energies given the nominal and 0.3 T PMQs.



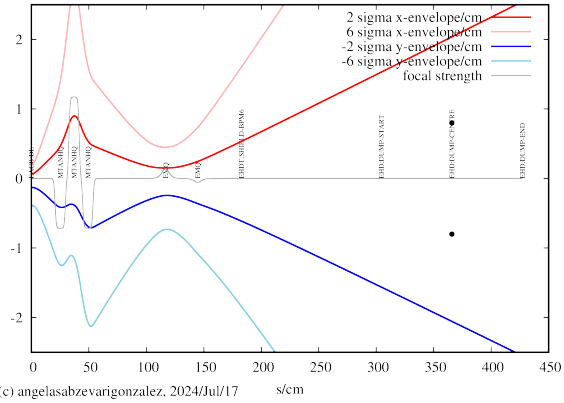
(q) The best I could find for 10 MeV Ta. (code values: -0.3, 0.3, -0.3, 0.11, -0.10, 1.89, 6.22, 7.41)



(r) The best I could find for 15 MeV Ta. (code values: -0.3, 0.3, -0.3, 0.17, -0.15, 6.0, 4.9, 3.5)



(s) The best I could find for 15 MeV Ta. (code values: -0.55, 0.9, -0.55, 0.27, -0.23, 0.56, 4.0, 3.6)



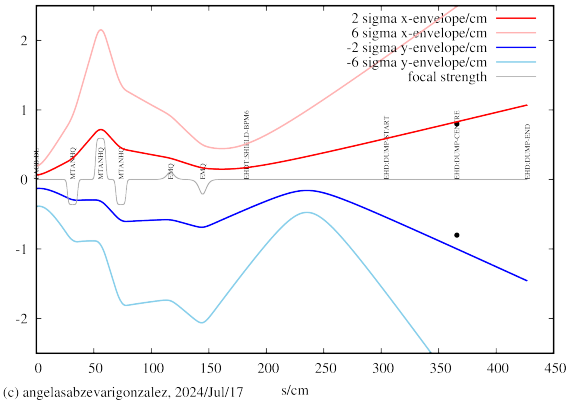
(t) The best I could find for 25 MeV Ta. (code values: -0.55, 0.9, -0.55, 0.410, -0.04, 0.15, 3.0, 3.0)

4.2 50 MeV

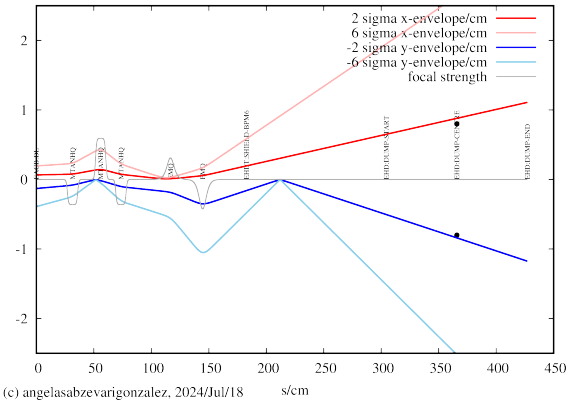
code numbers: 6.54, 15.45, 8.62, 5.72, 18.0

PMQ1 [T]	**PMQ2 [T]**	**PMQ3 [T]**	**EMQ1 [T]**	**EMQ2 [T]**	**xP1 [cm]**	**xP2 [cm]**	**xP3 [cm]**	**xE1 [cm]**	**xE2 [cm]**
-0.55	0.9	-0.55	0.15	-0.30	31.5468	56.0104	73.6446	116.718	144.717

Table 12: One magnet set up for 1 μm Tantalum target at 50 MeV.



(u) Envelope plots using the nominal PMQs and two EMQs set to optimized strengths and positions for the 50 MeV case.



(v) Envelope plots with no target to ensure the magnetic set up for 50 MeV is still valid.
EMQ1 = 0.44 T and EMQ2 = -0.60 T.

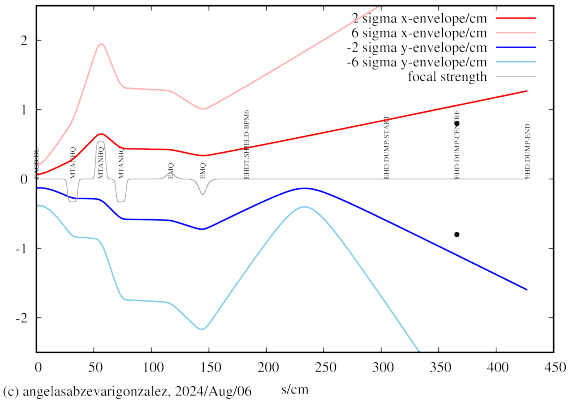
Figure 23: Transoptr envelope plots for the 50 MeV 1μm Tantalum case for when the target is in and out of the beam line.

4.3 55 MeV

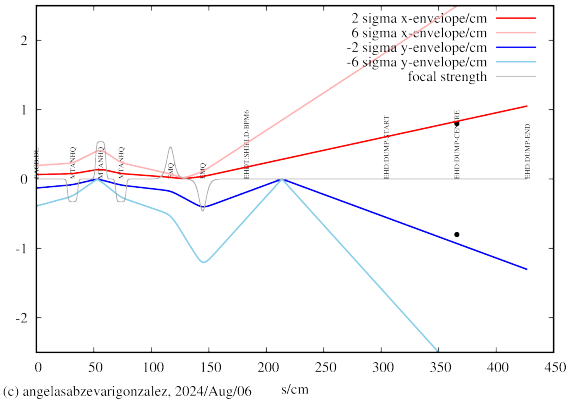
code numbers: 6.54, 15.45, 8.62, 5.72, 18.0

PMQ1 [T]	**PMQ2 [T]**	**PMQ3 [T]**	**EMQ1 [T]**	**EMQ2 [T]**	**xP1 [cm]**	**xP2 [cm]**	**xP3 [cm]**	**xE1 [cm]**	**xE2 [cm]**
-0.55	0.9	-0.55	0.15	-0.35	31.5468	56.0104	73.6446	116.718	144.717

Table 13: One magnet set up for 1 μm Tantalum target at 55 MeV, keeping the magnet positions the same as 50 MeV.



(a) Envelope plots using the nominal PMQs and two EMQs set to optimized strengths and positions for the 55 MeV case.



(b) Envelope plots with no target to ensure the magnetic set up for 55 MeV is still valid.
EMQ1 = 0.72 T and EMQ2 = -0.72 T.

Figure 24: Transoptr envelope plots for the 55 MeV 1μm Tantalum case for when the target is in and out of the beam line.

5 2μm Carbon Target

5.1 No Magnets Scattering Visual

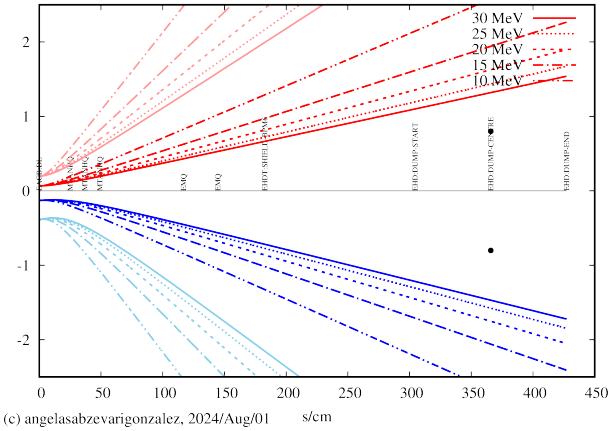


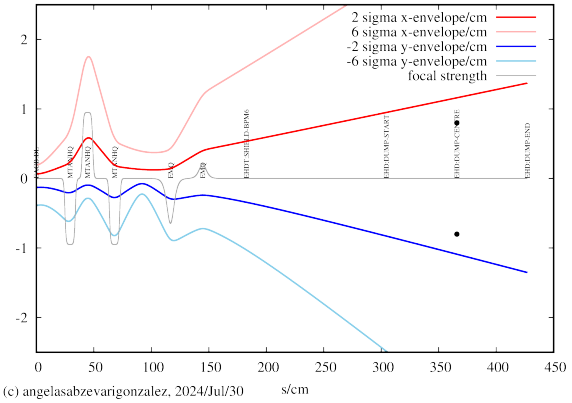
Figure 25: Carbon scattering at all desired energies with no magnets.

5.2 10 MeV

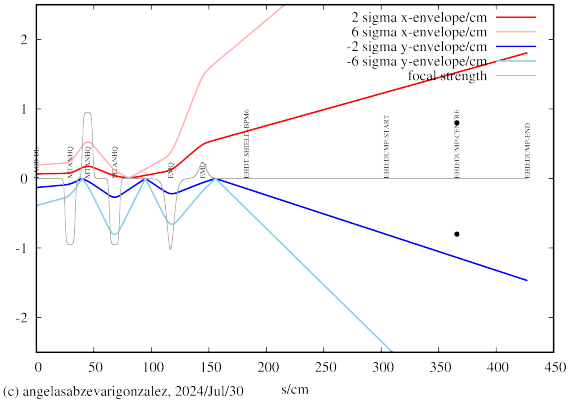
code numbers: 4.43, 6.17, 14.47, 5.72, 18.0

PMQ1 [T]	PMQ2 [T]	PMQ3 [T]	EMQ1 [T]	EMQ2 [T]	xP1 [cm]	xP2 [cm]	xP3 [cm]	xE1 [cm]	xE2 [cm]
-0.3	0.3	-0.3	-0.19	0.06	29.4369	44.6209	68.1042	116.717	144.716

Table 14: One magnet set up for 2 μm Carbon target at 10 MeV.



(a) Envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths and positions for the 10 MeV case.



(b) Envelope plots with no target to ensure the magnetic set up for 10 MeV case using the 0.3 T PMQs is still valid. EMQ1 = -0.3 T and EMQ2 = 0.07 T.

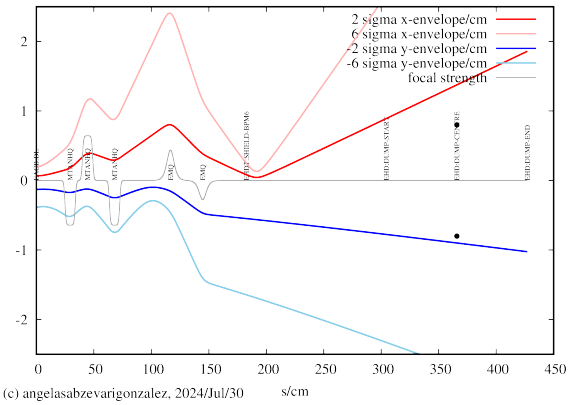
Figure 26: Transoptr envelope plots for the 10 MeV 1μm Carbon case for when the target is in and out of the beam line.

5.3 15 MeV

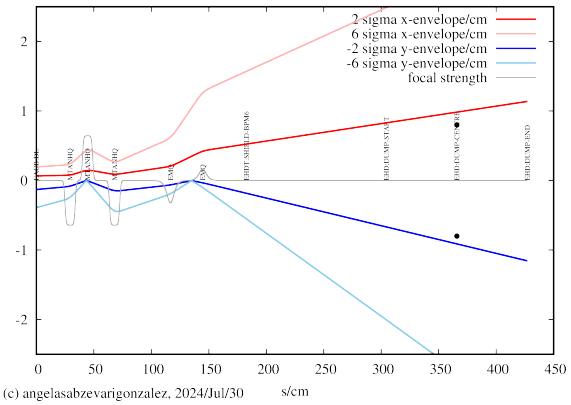
code numbers: 4.43, 6.17, 14.47, 5.72, 18.0

PMQ1 [T]	PMQ2 [T]	PMQ3 [T]	EMQ1 [T]	EMQ2 [T]	xP1 [cm]	xP2 [cm]	xP3 [cm]	xE1 [cm]	xE2 [cm]
-0.3	0.3	-0.3	0.19	-0.12	29.4369	44.6209	68.1042	116.717	144.716

Table 15: One magnet set up for 2 μm Carbon target at 15 MeV.



(a) Envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths such that the magnet positions do not have to change from the 10 MeV case to the 15 MeV case.



(b) Envelope plots with no target to ensure the magnetic set up for 15 MeV case using the 0.3 T PMQs is still valid. EMQ1 = -0.14 T and EMQ2 = 0.07 T.

Figure 27: Transoptr envelope plots for the 15 MeV 1μm Carbon case for when the target is in and out of the beam line.

5.4 20 MeV

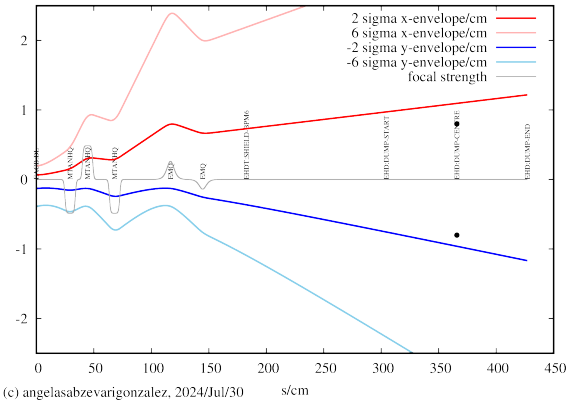
code numbers:

4.43, 6.17, 14.47, 5.72, 18.0

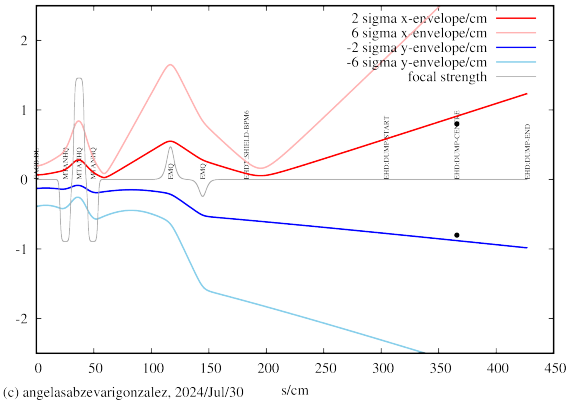
0, 3, 3, 5.72, 18

PMQ1 [T]	PMQ2 [T]	PMQ3 [T]	EMQ1 [T]	EMQ2 [T]	xP1 [cm]	xP2 [cm]	xP3 [cm]	xE1 [cm]	xE2 [cm]
-0.3	0.3	-0.3	0.15	-0.08	29.4369	44.6209	68.1042	116.717	144.716
-0.55	0.9	-0.55	0.27	-0.14	25.1869	37.2007	49.2146	116.724	144.723

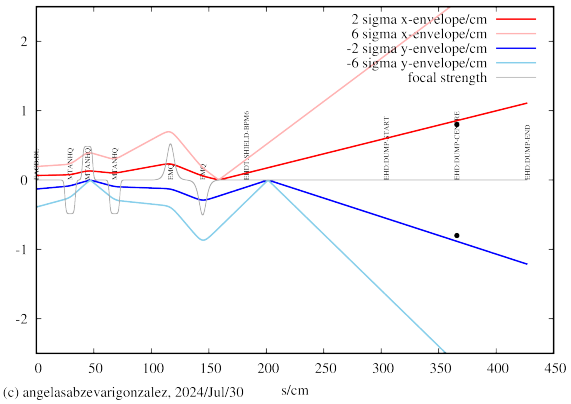
Table 16: Magnet set ups for 2 μm Carbon target at 20 MeV.



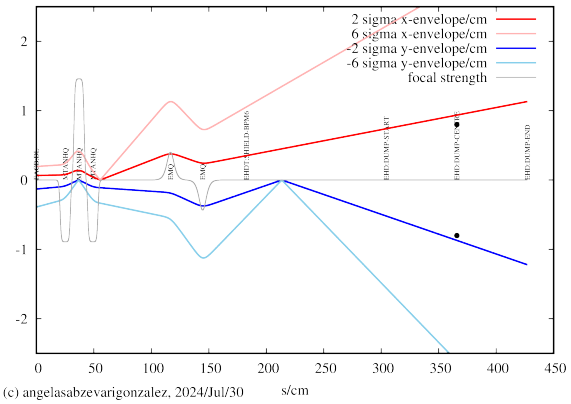
(a) Transoptr envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths such that the magnet positions do not have to change from the 10 MeV case to the 20 MeV case.



(b) Transoptr envelope plots using two 0.55 T PMQs, one 0.9 T PMQ, and two EMQs set to optimized strengths such that the magnet positions do not have to change from the Tantalum scenarios to the nominal Tantalum cases.



(c) Envelope plots with no target to ensure the magnetic set up for 20 MeV using the 0.3 T PMQs is still valid. EMQ1 = 0.30 T and EMQ2 = -0.29 T.



(d) Envelope plots with no target to ensure the magnetic set up for 20 MeV using the nominal PMQs is still valid. EMQ1 = 0.23 T and EMQ2 = -0.25 T.

5.5 25 MeV

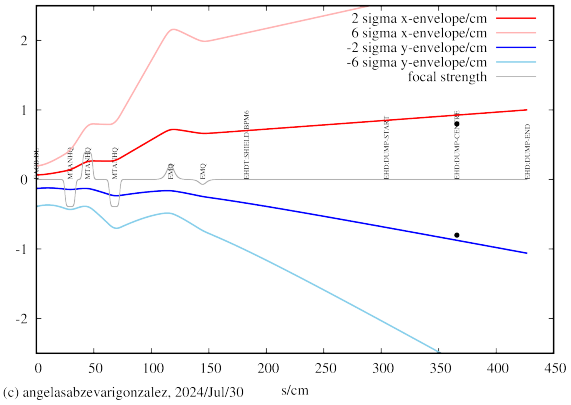
code numbers:

4.43, 6.17, 14.47, 5.72, 18.0

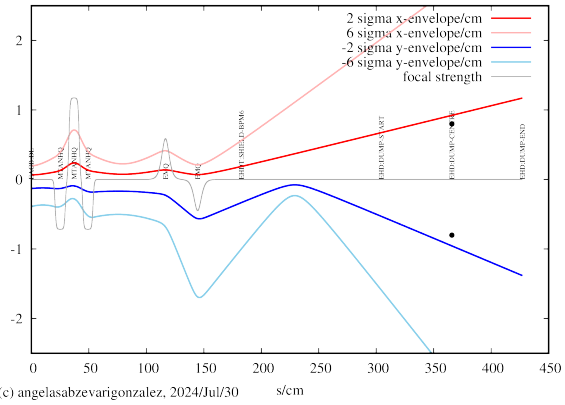
0, 3, 3, 5.72, 18

PMQ1 [T]	PMQ2 [T]	PMQ3 [T]	EMQ1 [T]	EMQ2 [T]	xP1 [cm]	xP2 [cm]	xP3 [cm]	xE1 [cm]	xE2 [cm]
-0.3	0.3	-0.3	0.15	-0.05	29.4369	44.6209	68.1042	116.717	144.716
-0.55	0.9	-0.55	0.42	-0.32	25.1869	37.2007	49.2146	116.724	144.723

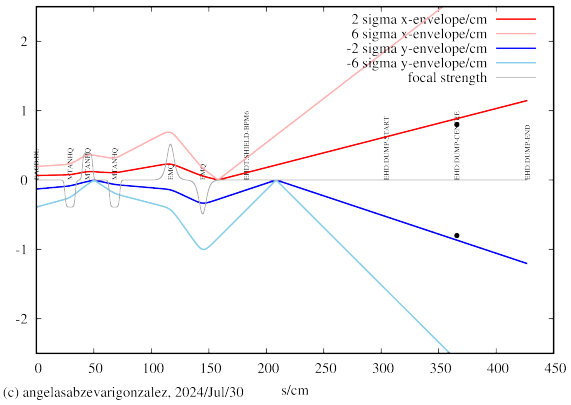
Table 17: Magnet set ups for 2 μm Carbon target at 25 MeV.



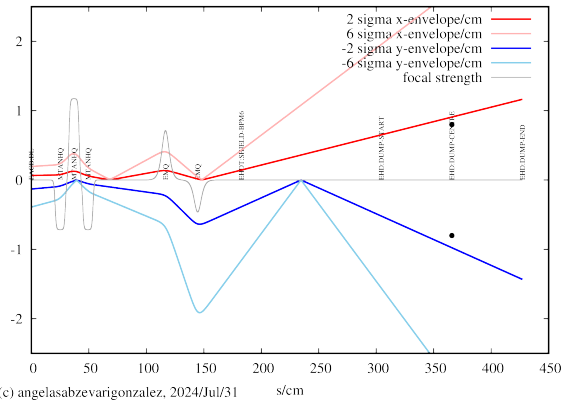
(e) Transoptr envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths such that the magnet positions do not have to change from the 10 MeV case to the 25 MeV case.



(f) Transoptr envelope plots using two 0.55 T PMQs, one 0.9 T PMQ, and two EMQs set to optimized strengths such that the magnet positions do not have to change from the nominal Tantalum cases.



(g) Envelope plots with no target to ensure the magnetic set up for 25 MeV using the 0.3 T PMQs is still valid. EMQ1 = 0.37 T and EMQ2 = -0.35 T.



(h) Envelope plots with no target to ensure the magnetic set up for 25 MeV using the nominal PMQs is still valid. EMQ1 = 0.51 T and EMQ2 = -0.33 T.

5.6 30 MeV

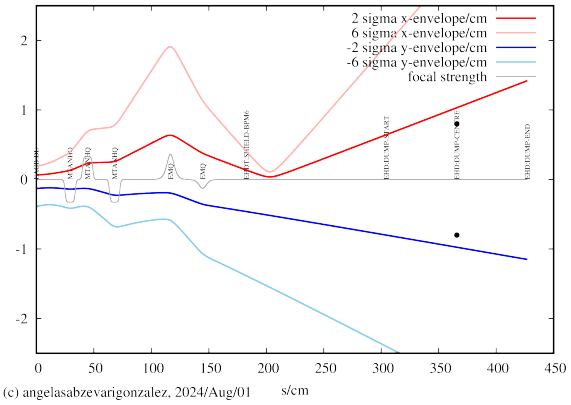
code numbers:

4.43, 6.17, 14.47, 5.72, 18.0

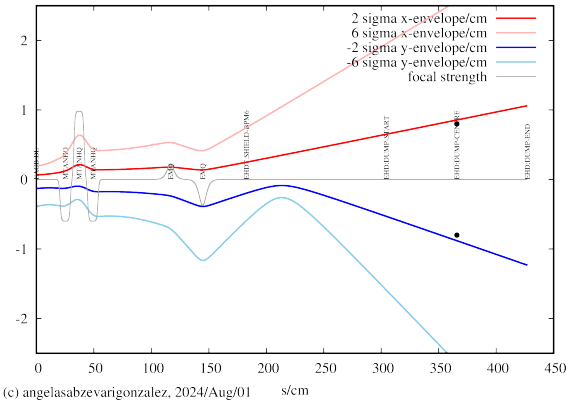
0, 3, 3, 5.72, 18

PMQ1 [T]	**PMQ2 [T]**	**PMQ3 [T]**	**EMQ1 [T]**	**EMQ2 [T]**	**xP1 [cm]**	**xP2 [cm]**	**xP3 [cm]**	**xE1 [cm]**	**xE2 [cm]**
-0.3	0.3	-0.3	0.31	-0.11	29.4369	44.6209	68.1042	116.717	144.716
-0.55	0.9	-0.55	0.18	-0.32	25.1869	37.2007	49.2146	116.724	144.723

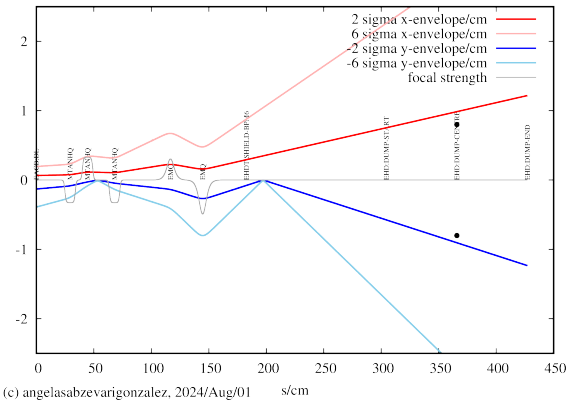
Table 18: Magnet set ups for 2 μm Carbon target at 30 MeV.



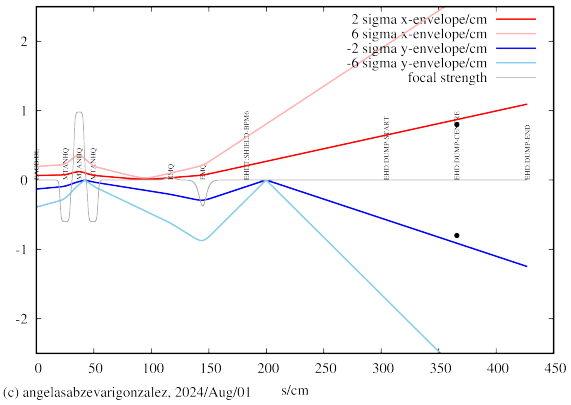
(i) Transoptr envelope plots using three 0.3 T PMQs and two EMQs set to optimized strengths such that the magnet positions do not have to change from the 10 MeV case to the 30 MeV case.



(j) Transoptr envelope plots using two 0.55 T PMQs, one 0.9 T PMQ, and two EMQs set to optimized strengths such that the magnet positions do not have to change from the nominal Tantalum.

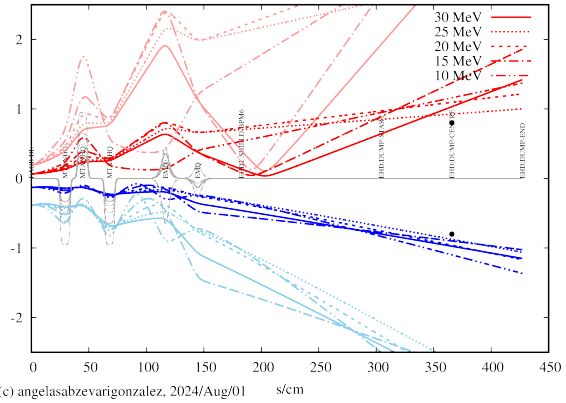


(k) Envelope plots with no target to ensure the magnetic set up for 30 MeV using the 0.3 T PMQs is still valid. EMQ1 = 0.26 T and EMQ2 = -0.42 T.

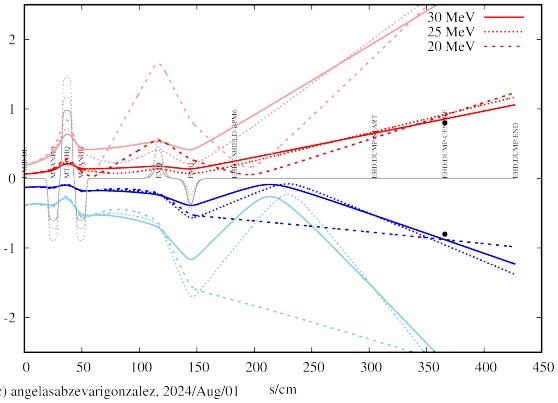


(l) Envelope plots with no target to ensure the magnetic set up for 30 MeV using the nominal PMQs is still valid. EMQ1 = 0.04 T and EMQ2 = -0.32 T.

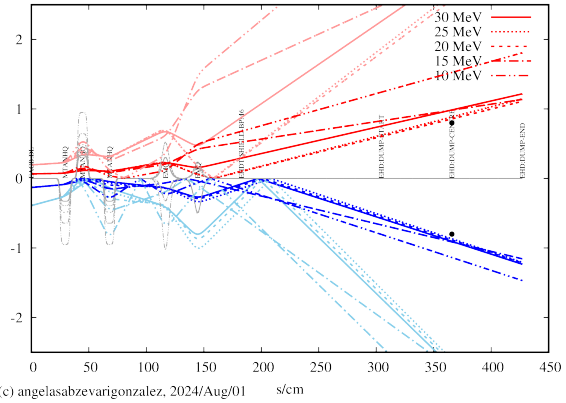
5.7 Carbon Summary



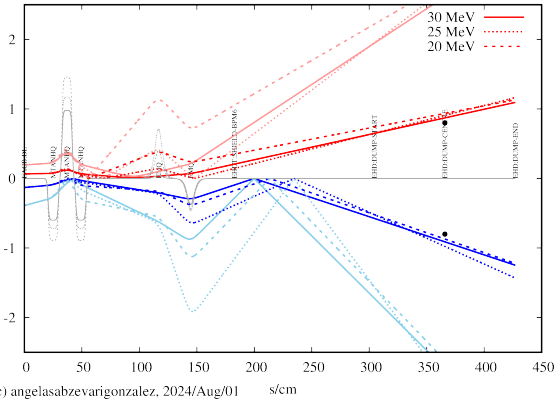
(m) All energy 2 and 6 σ envelope plots using three 0.3T PMQs and two EMQs set to specific strengths to accommodate the new magnet positions.



(n) All energy 2 and 6 σ envelope plots using nominal PMQs and two EMQs set to specific strengths to accommodate the nominal magnet positions.



(o) All energy 2 and 6 σ envelope plots using the 0.3 T PMQs without a target to show the set ups are still valid given different EMQ strengths.



(p) All energy 2 and 6 σ envelope plots using the nominal PMQs without a target to show the set ups are still valid given different EMQ strengths.

6 The Master Tables

6.1 Scattering Angles

Material	Width [μm]	Energy [MeV]	RMS x [rad]	RMS y [rad]
Carbon	1.0	10	0.0026546	0.00269968
Carbon	1.0	15	0.0020913	0.00212844
Carbon	1.0	20	0.00180008	0.00187091
Carbon	1.0	25	0.00165725	0.00171639
Carbon	1.0	30	0.00154835	0.00163349
Tantalum	1.0	10	0.02044531	0.02046903
Tantalum	1.0	15	0.01389478	0.01390443
Tantalum	1.0	20	0.01061946	0.01059647
Tantalum	1.0	25	0.00859129	0.00860689
Tantalum	1.0	30	0.00727964	0.00730866
Tantalum	1.0	50	0.00454417	0.00459381
Tantalum	1.0	55	0.0042011	0.00424967
Carbon	2.0	10	0.00350856	0.00360906
Carbon	2.0	15	0.00263758	0.00275591
Carbon	2.0	20	0.00220452	0.00232561
Carbon	2.0	25	0.00193944	0.00207667
Carbon	2.0	30	0.00177951	0.00192483

Table 19: Table of RMS values for all of the desired energies and targets.

6.2 Magnet Positions

Scenario	PMQ1 [cm]	PMQ2 [cm]	PMQ3 [cm]	EMQ1 [cm]	EMQ2 [cm]
0.3T (New) PMQs	29.4369	44.6209	68.1042	116.717	144.716
Nominal PMQs	25.1869	37.2007	49.2146	116.724	144.723
50MeV+ PMQs	31.5468	56.0104	73.6446	116.718	144.717

Table 20: Magnet positions.

6.3 What Works

Energy [MeV]	Material	0.3T PMQs	Nominal PMQs
10	C	✓	✗
10	Ta	✗	✗
15	C	✓	✗
15	Ta	✗	✗
20	C	✓	✓
20	Ta	✗	✗
25	C	✓	✓
25	Ta	✗	✗
30	C	✓	✓
30	Ta	✗	✓
50	Ta	✗	✓
55	Ta	✗	✓

Table 21: Summary table of magnet set ups that work and don't work at various energies for 1μm Carbon, 2μm Carbon, and 1μm Tantalum targets.

6.4 EMQ Strengths

Material	Width [μm]	Energy [MeV]	PMQ Set Up	EMQ1 [T]	EMQ2 [T]	EMQ1 [T] (TO)	EMQ2 [T] (TO)
Carbon	1.0	10	new	0.09	-0.15	0.09	-0.15
Carbon	1.0	15	new	0.19	-0.09	0.26	-0.32
Carbon	1.0	20	new	0.13	-0.05	0.32	-0.30
Carbon	1.0	20	nominal	0.16	-0.09	0.11	-0.03
Carbon	1.0	25	new	0.31	-0.53	0.22	-0.35
Carbon	1.0	25	nominal	-0.30	0.15	0.52	-0.33
Carbon	1.0	30	new	0.41	-0.42	0.45	-0.43
Carbon	1.0	30	nominal	-0.33	0.13	0.03	-0.32
Tantalum	1.0	50	50MeV+	0.15	-0.30	0.44	-0.60
Tantalum	1.0	55	50MeV+	0.15	-0.35	0.72	-0.72
Carbon	2.0	10	new	-0.19	0.06	-0.30	0.07
Carbon	2.0	15	new	0.19	-0.12	-0.14	0.07
Carbon	2.0	20	new	0.15	-0.08	0.30	-0.29
Carbon	2.0	20	nominal	0.27	-0.14	0.23	-0.25
Carbon	2.0	25	new	0.15	-0.05	0.37	-0.35
Carbon	2.0	25	nominal	0.42	-0.32	0.51	-0.33
Carbon	2.0	30	new	0.31	-0.11	0.26	-0.42
Carbon	2.0	30	nominal	0.18	-0.32	0.04	-0.32

Table 22: Master table of all of the required EMQ strengths for every desired scenario.
Note (TO) refers to 'Target Out' therefore is the required EMQ strengths when the target is out.