Low-Energy ^{7}Be Analysis Using EDA

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Chi-squared Expression and Search Method in EDA

$$\chi^2_{\mathrm{EDA}} = \sum_i \left[\frac{nX_i(\mathbf{p}) - R_i}{\Delta R_i}\right]^2 + \left[\frac{nS-1}{\Delta S/S}\right]^2$$

$$\rightarrow \chi^2_0 + (\mathbf{p}-\mathbf{p}_0)^{\mathrm{T}}\cancelto{0}{\mathbf{g}_0} + \tfrac{1}{2}(\mathbf{p}-\mathbf{p}_0)^{\mathrm{T}}\mathbf{G}_0(\mathbf{p}-\mathbf{p}_0)$$

$$g_i = \frac{\partial \chi^2}{\partial p_i},$$

$$G_{ij} = \frac{\partial^2 \chi^2}{\partial p_i \partial p_j} = H^{-1}_{ij}$$

Search method is the rank-1 variable metric algorithm of Davidon, Broyden, as modified by Wolfe:

$$\mathbf{\Delta p} = -\mathbf{Hg}$$

$$\mathbf{r} = \mathbf{\Delta p} - \mathbf{H\Delta g},$$

$$\mathbf{H}_{n+1} = \mathbf{H}_n + \frac{\mathbf{rr^T}}{\mathbf{r^T\Delta g}}$$

Summary of ^{7}Be Analysis

channel	a_c (fm)	l_{max}
^{3}He+^{4}He	4.43	4
p+^{6}Li	3.13	1
γ+^{7}Be	50.	1

Reaction	Energies (MeV)	# data points	Types of data	χ^2
^{4}He(^{3}He,^{3}He)^{4}He	E_{3He}=1.2 - 10.8	1519	$\sigma(\theta)$, $A_y(^3$He)	1381
^{4}He(^{3}He,p)^{6}Li	E_{3He}= 8.2 - 10.8	129	$\sigma(\theta)$	123
^{6}Li(p,^{3}He)^{4}He	E_p= 0.025 - 3.0	773	$\sigma_{int}(E)$, $\sigma(\theta)$, $A_y(p)$	1203
^{6}Li(p,p)^{6}Li	E_p= 0.50 - 2.6	190	$\sigma(\theta)$	240
^{4}He(^{3}He,γ)^{7}Be	E_{3He}= 8.2 - 10.8	40	$\sigma_{int}(E)$	53
^{6}Li(p, γ)^{7}Be	E_p= 0.16 – 1.174	26	$\sigma_{int}(E)$	23
Free norms.				135
Total		2677		3158

(χ^2/pt.=1.18, χ^2/d.o.f.=1.20)

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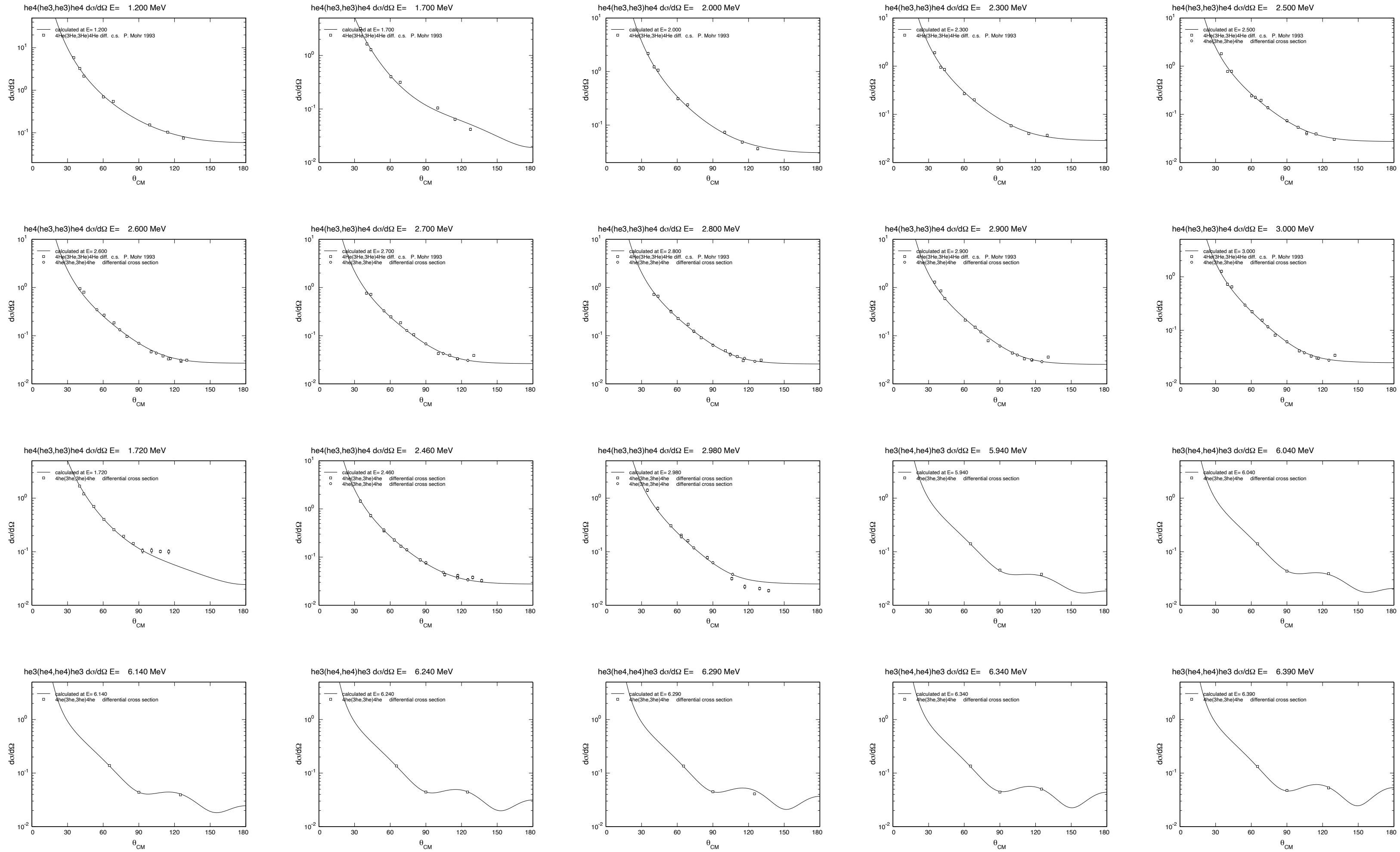
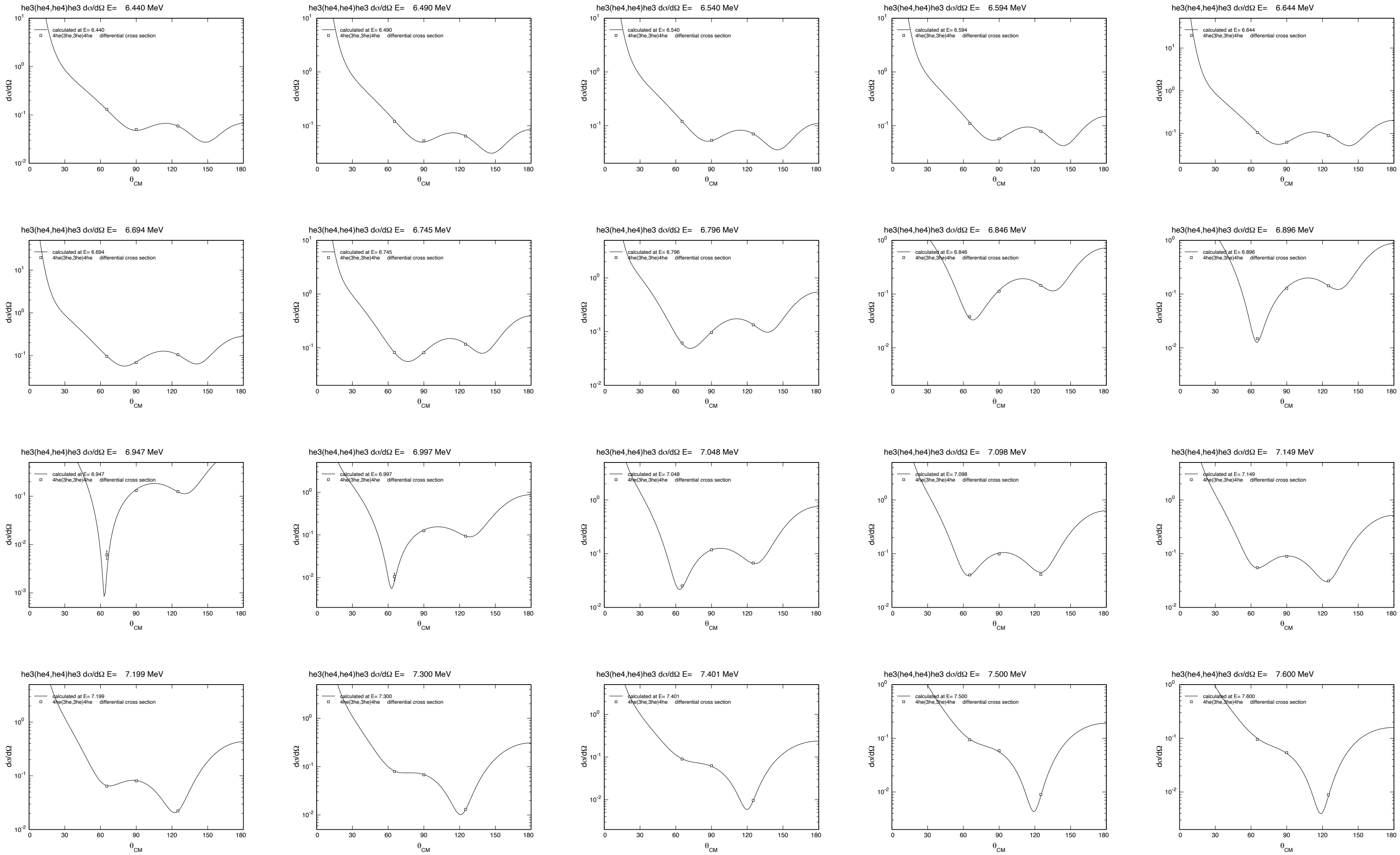
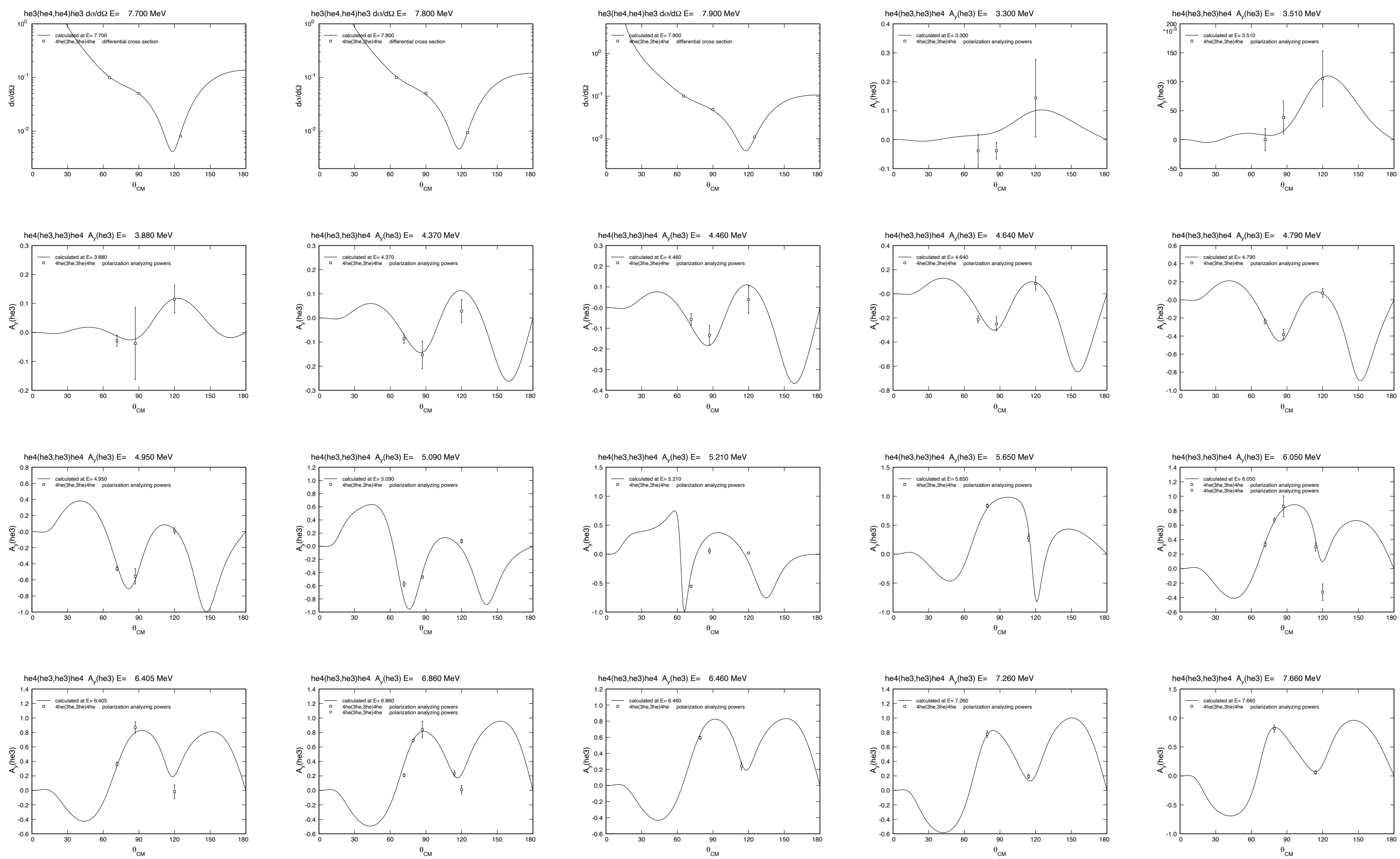
^{4}He(^{3}He,^{3}He)^{4}He Differential Cross Sections



$^4He(^3He,^3He)^4He$ Differential Cross Sections, cont.



^{4}He(^{3}He,^{3}He)^{4}He Analyzing Powers



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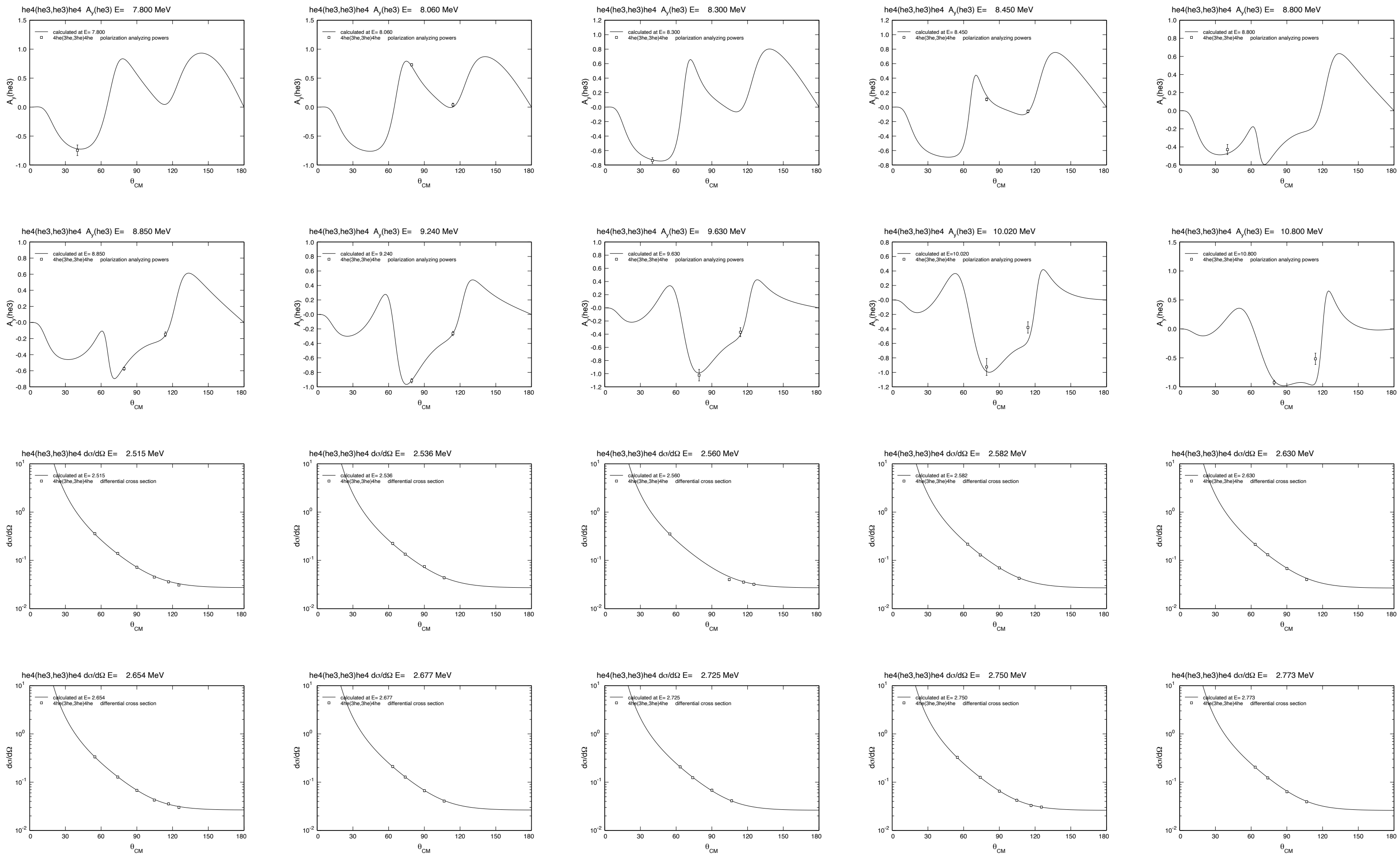
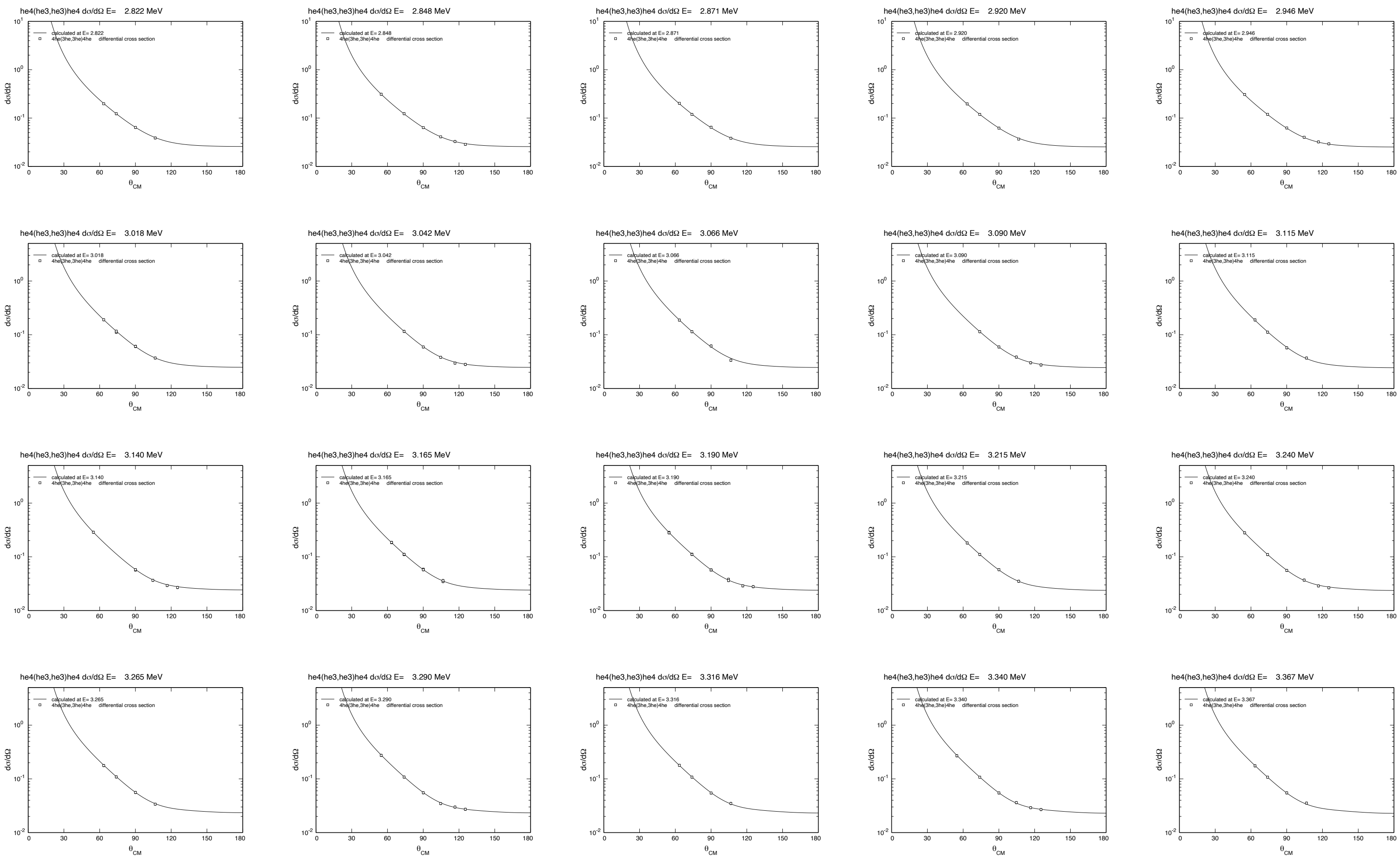
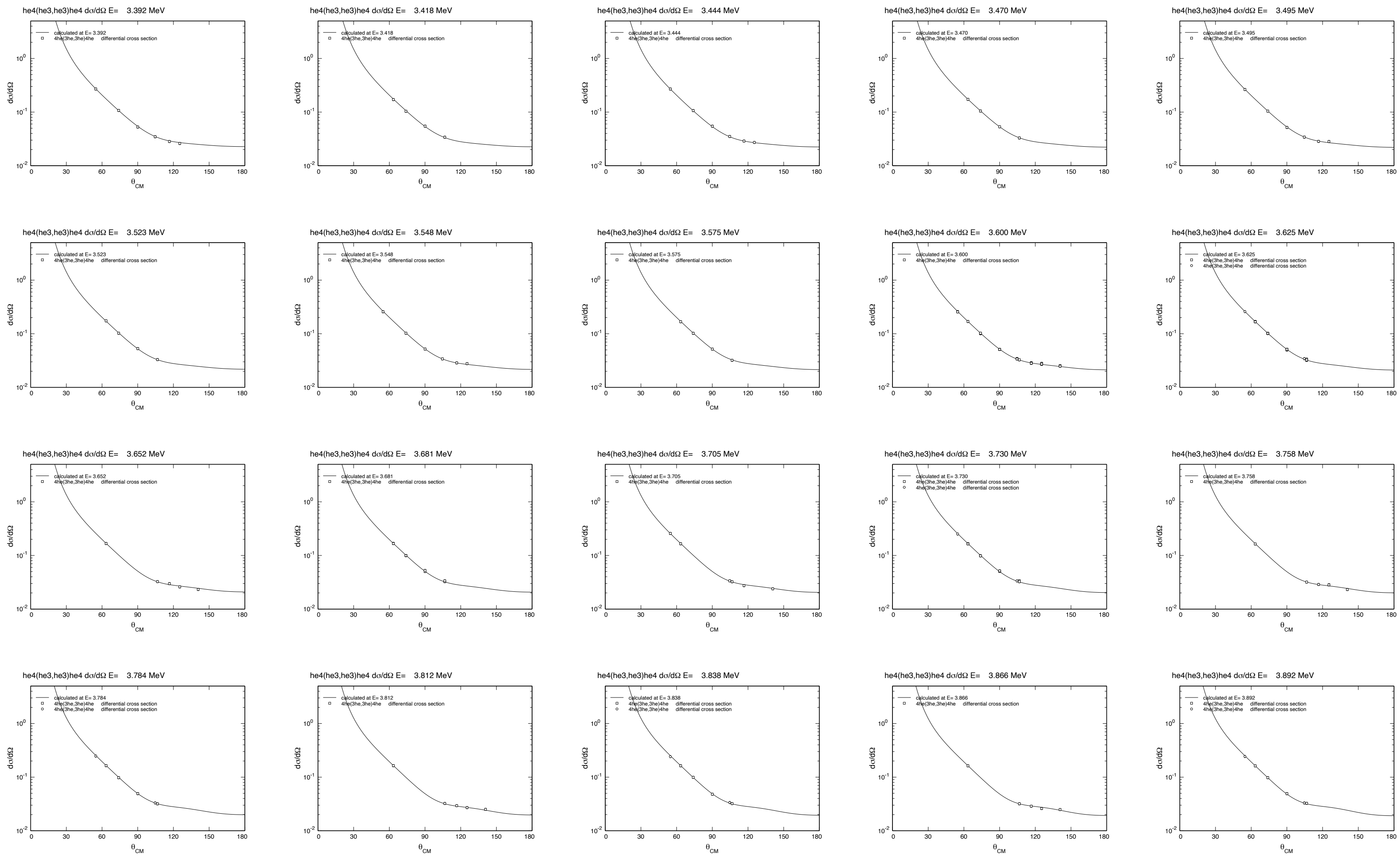
$^4He(^3He,^3He)^4He$ Analyzing Powers



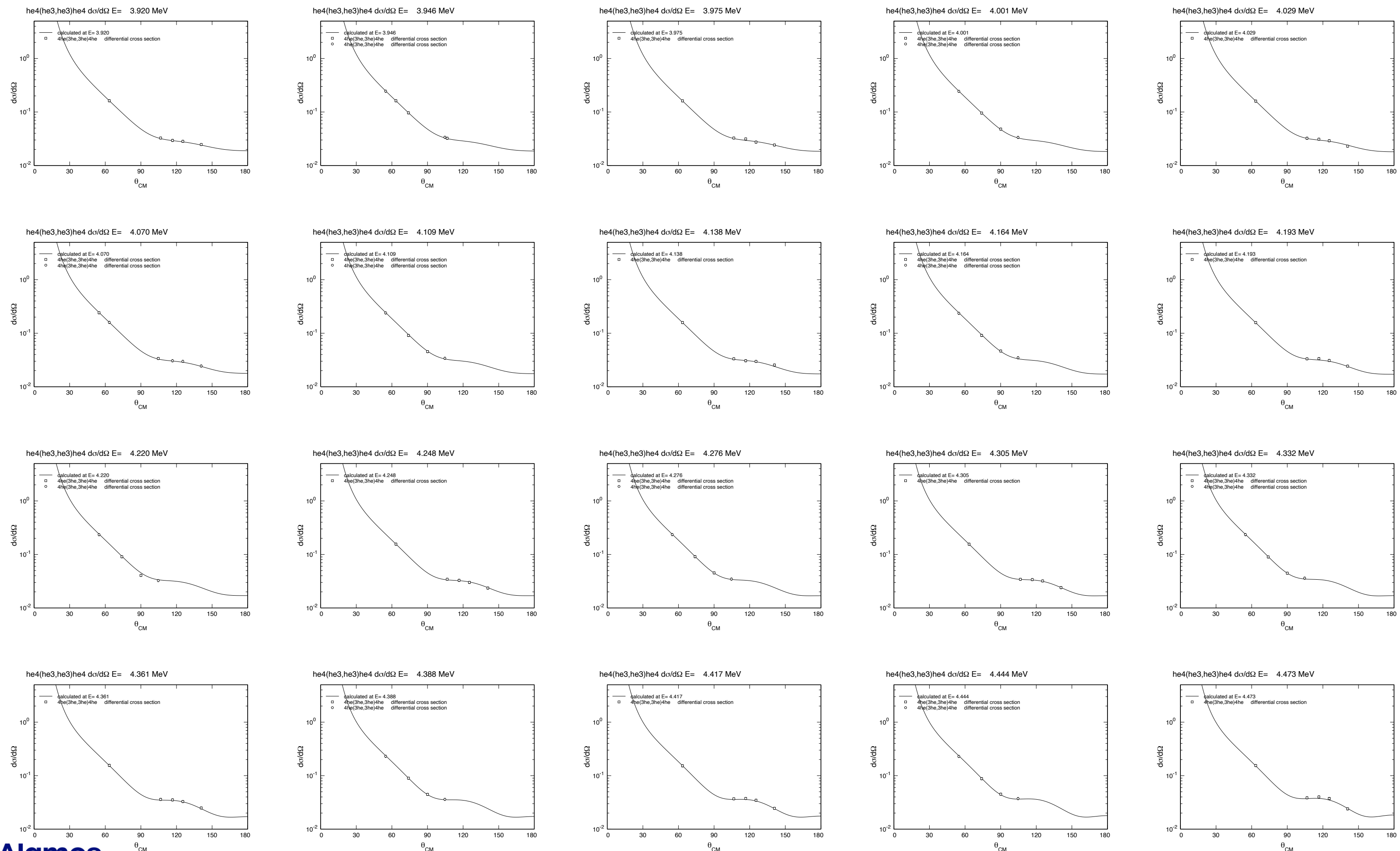
$^{4}He(^{3}He,^{3}He)^{4}He$ Differential Cross Sections



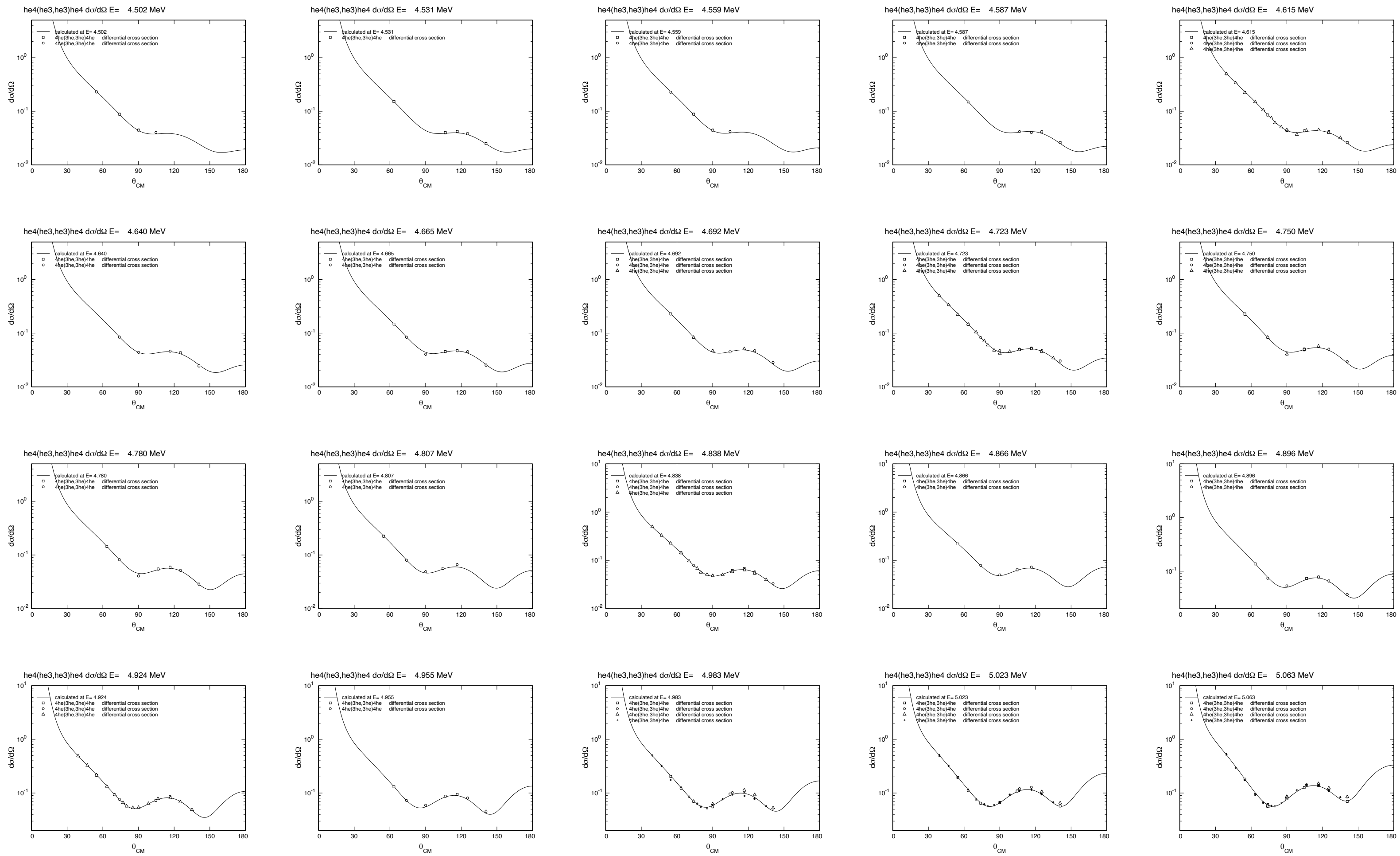
$^4He(^3He,^3He)^4He$ Differential Cross Sections, cont.



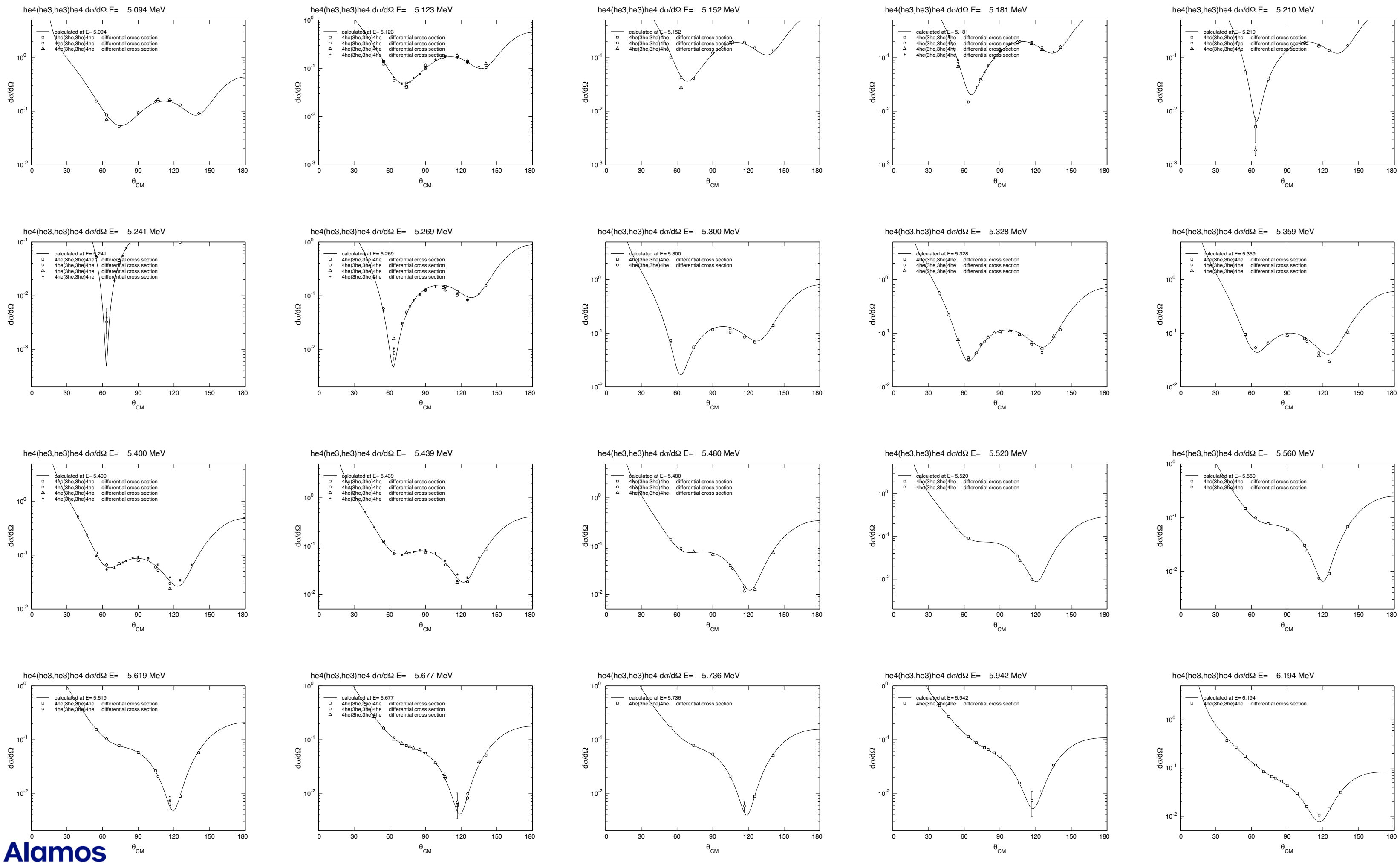
$^{4}He(^{3}He,^{3}He)^{4}He$ Differential Cross Sections, cont.



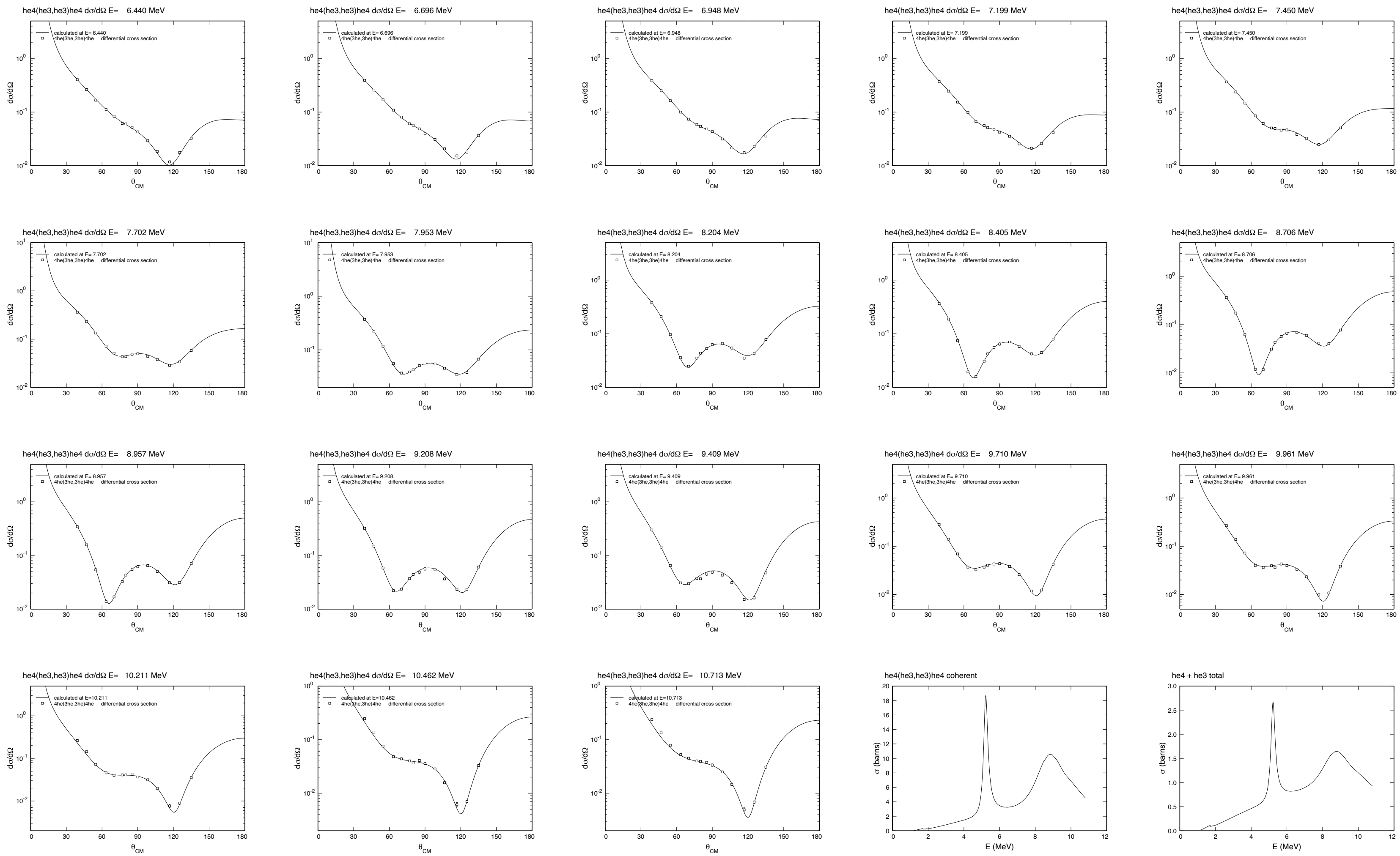
^{4}He(^{3}He,^{3}He)^{4}He Differential Cross Sections, cont.



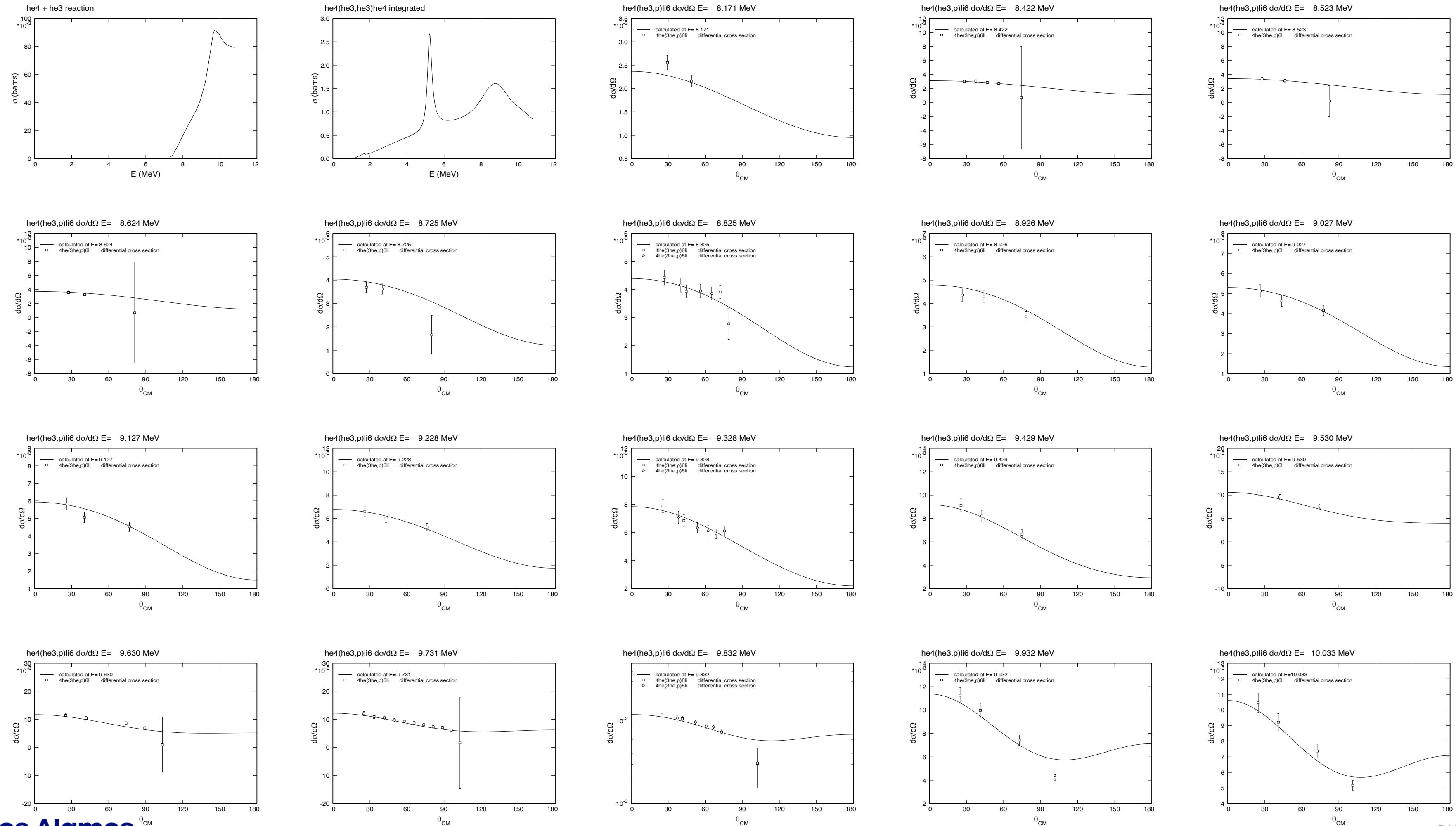
$^4He(^3He,^3He)^4He$ Differential Cross Sections, cont.



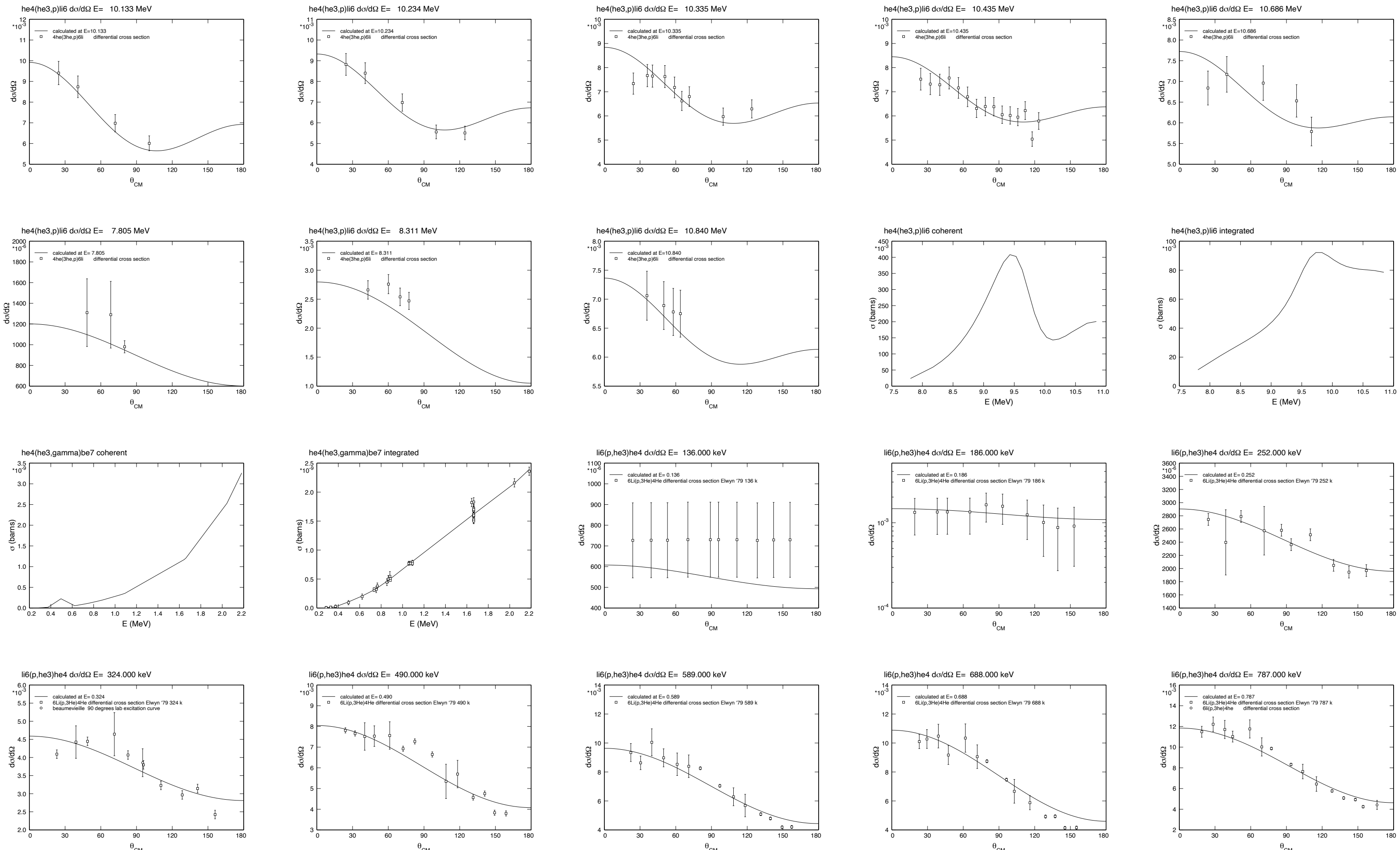
^{4}He(^{3}He,^{3}He)^{4}He Differential Cross Sections, cont.



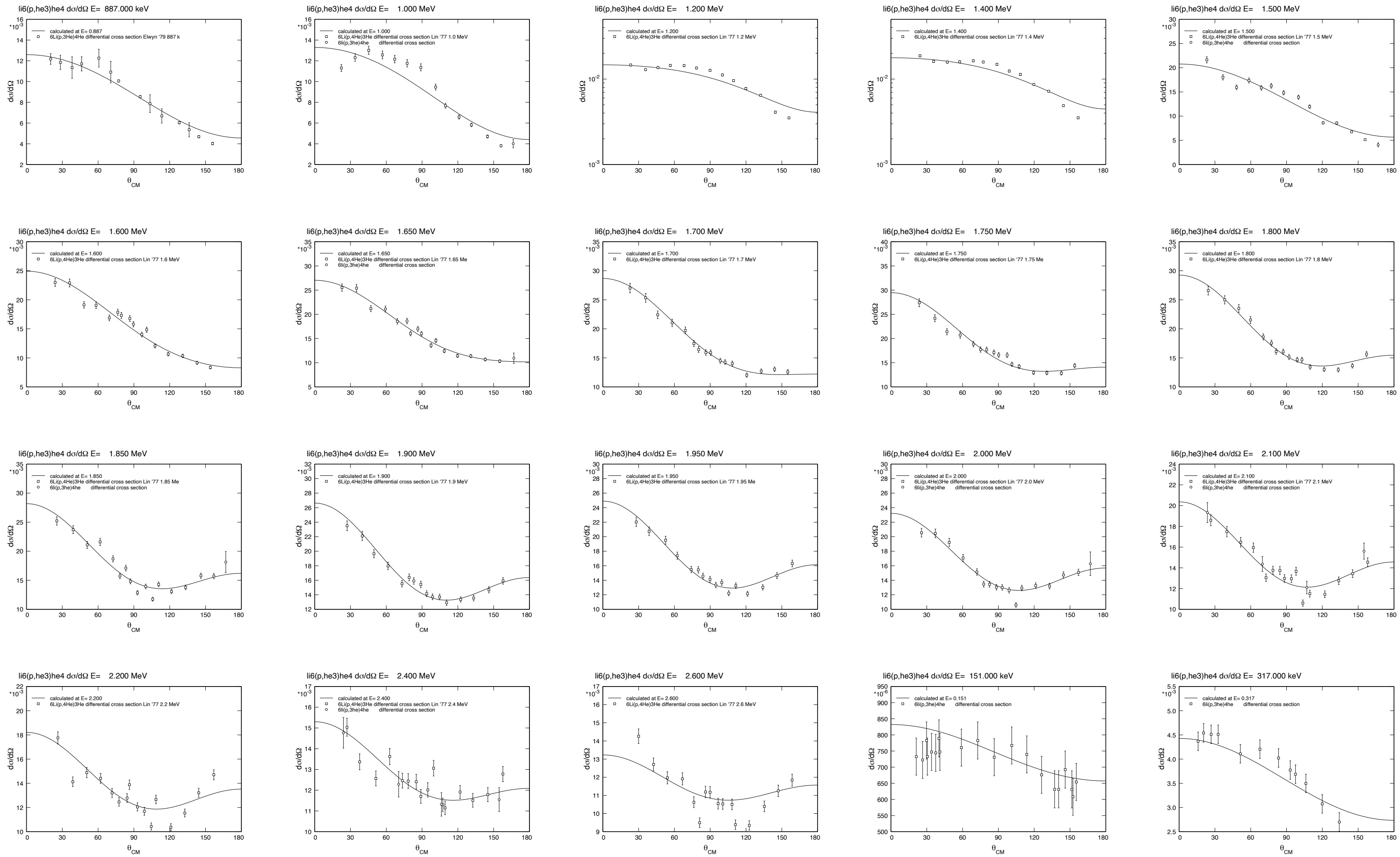
^{4}He(^{3}He,p)^{6}Li Differential Cross Sections



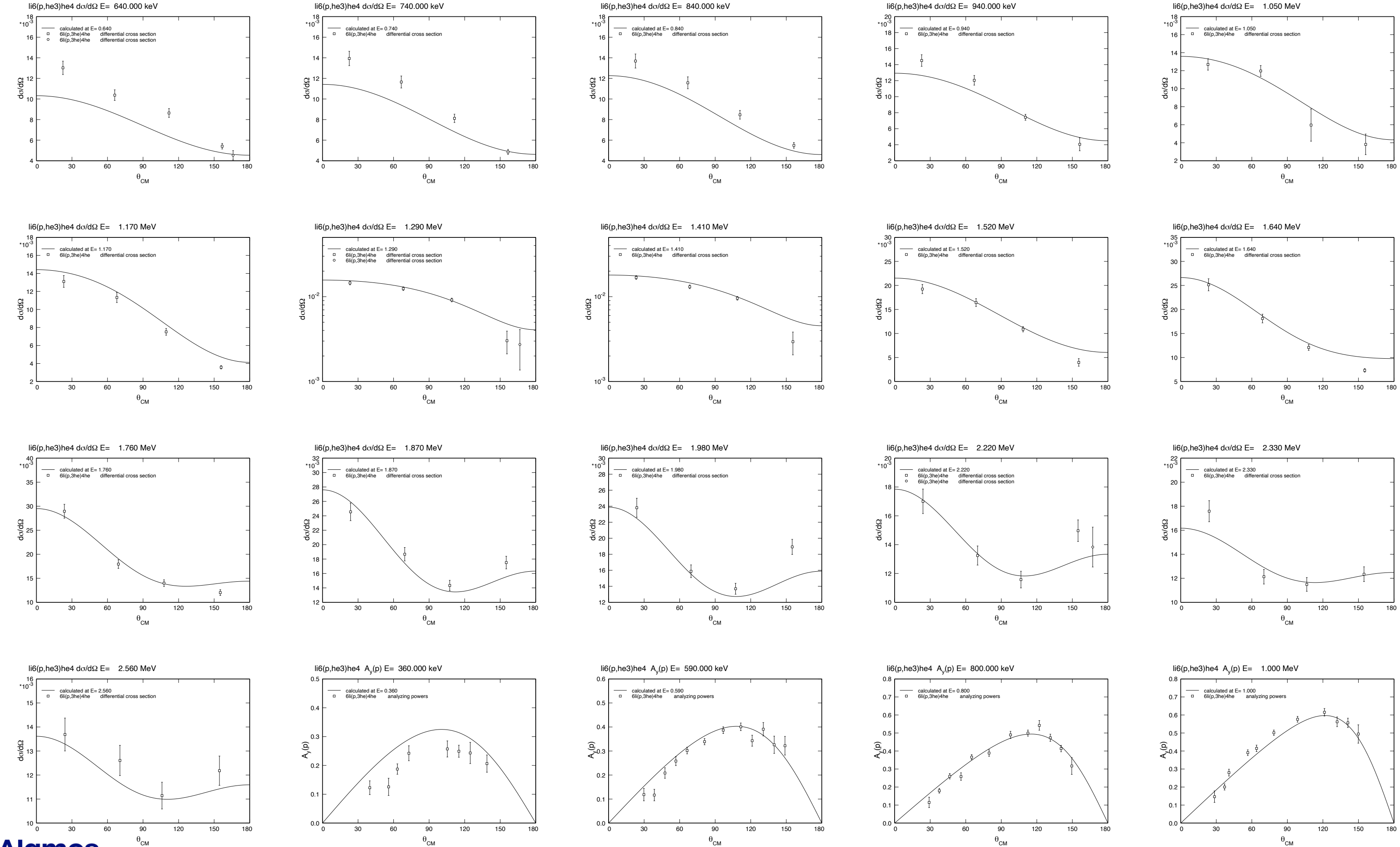
$^4He(^3He,p)^6Li$ and $^6Li(p,^3He)^4He$ Differential Cross Sections



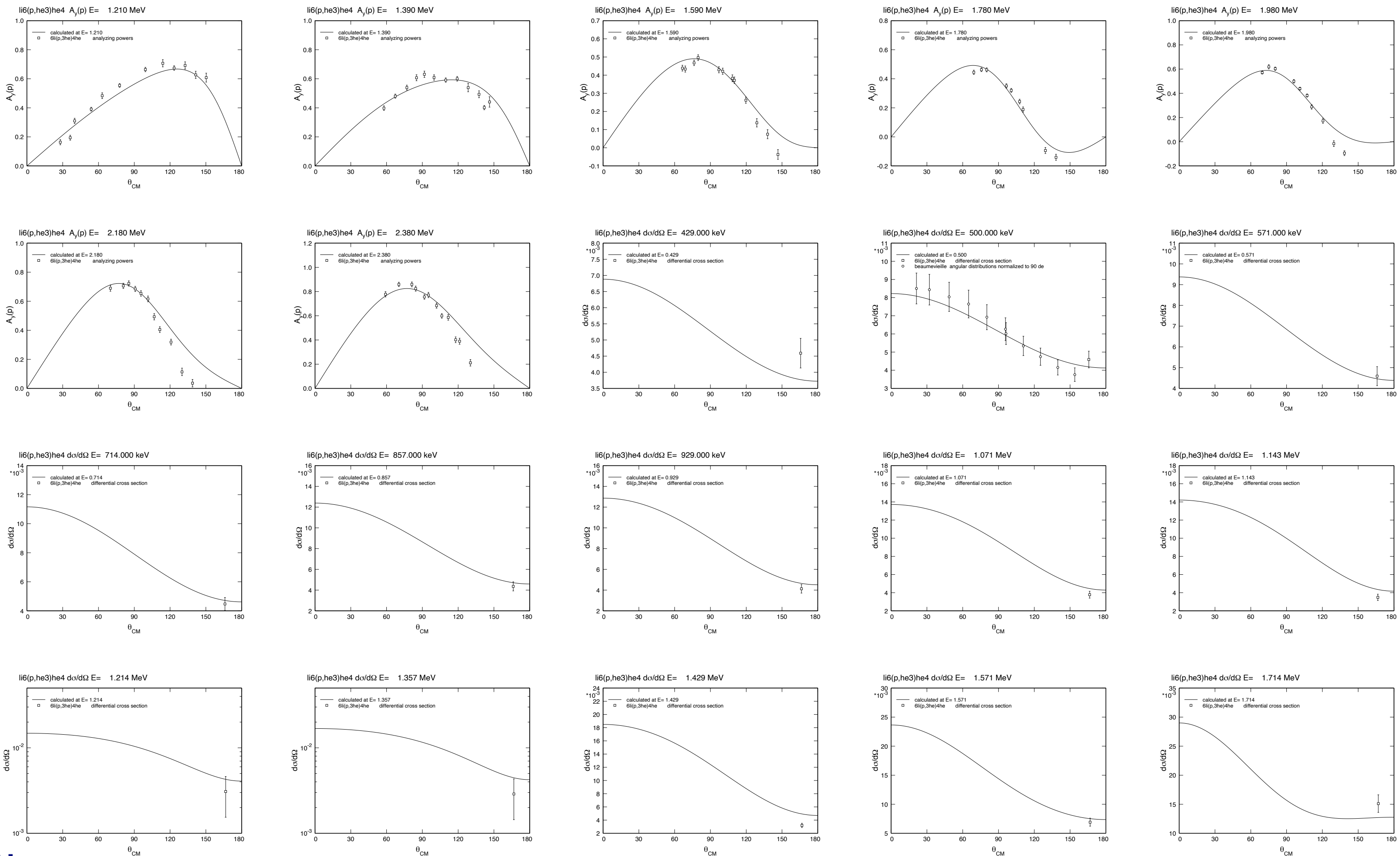
$^{6}Li(p,^{3}He)^{4}He$ Differential Cross Sections



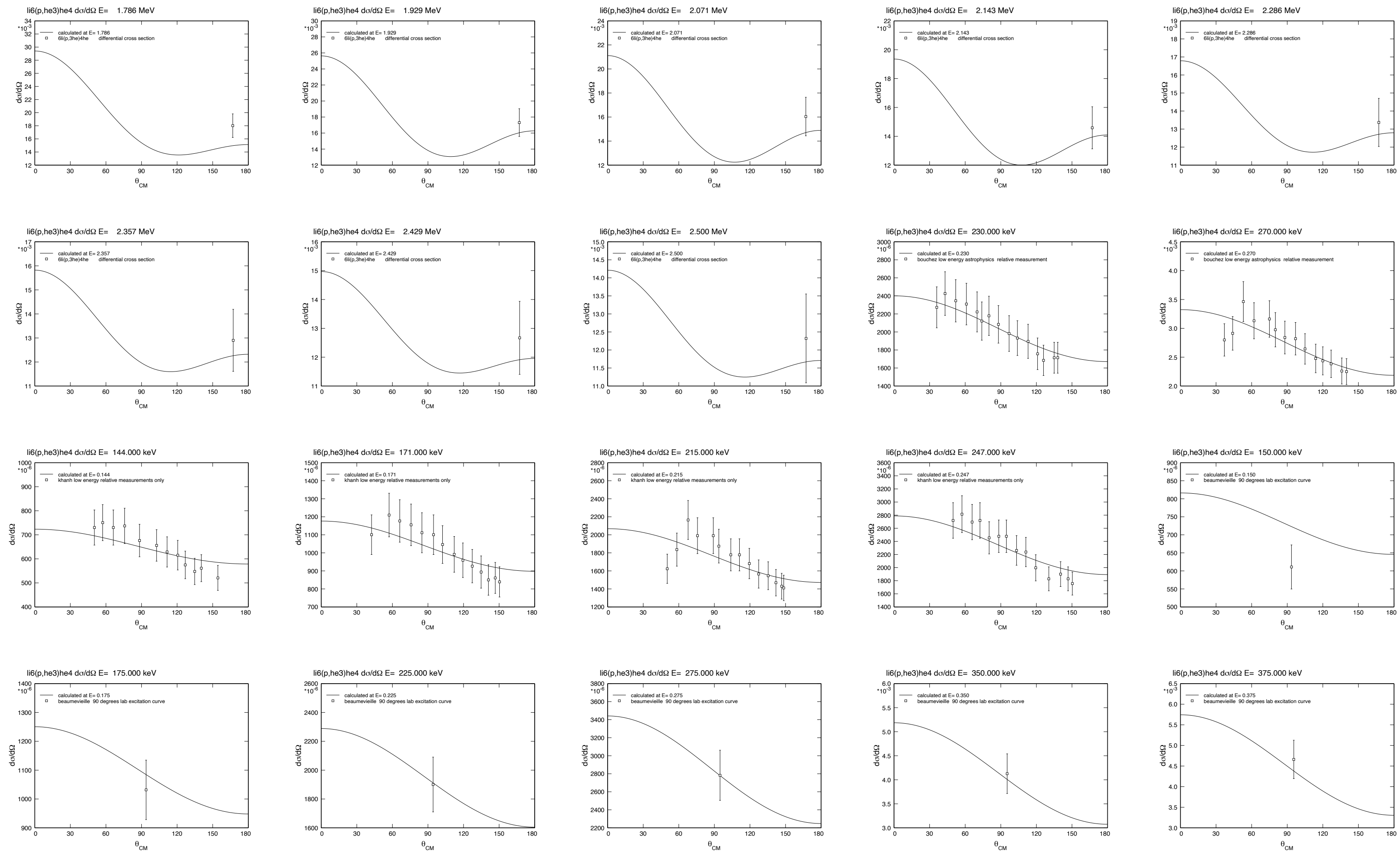
$^{6}Li(p,^{3}He)^{4}He$ Differential Cross Sections and Analyzing Powers



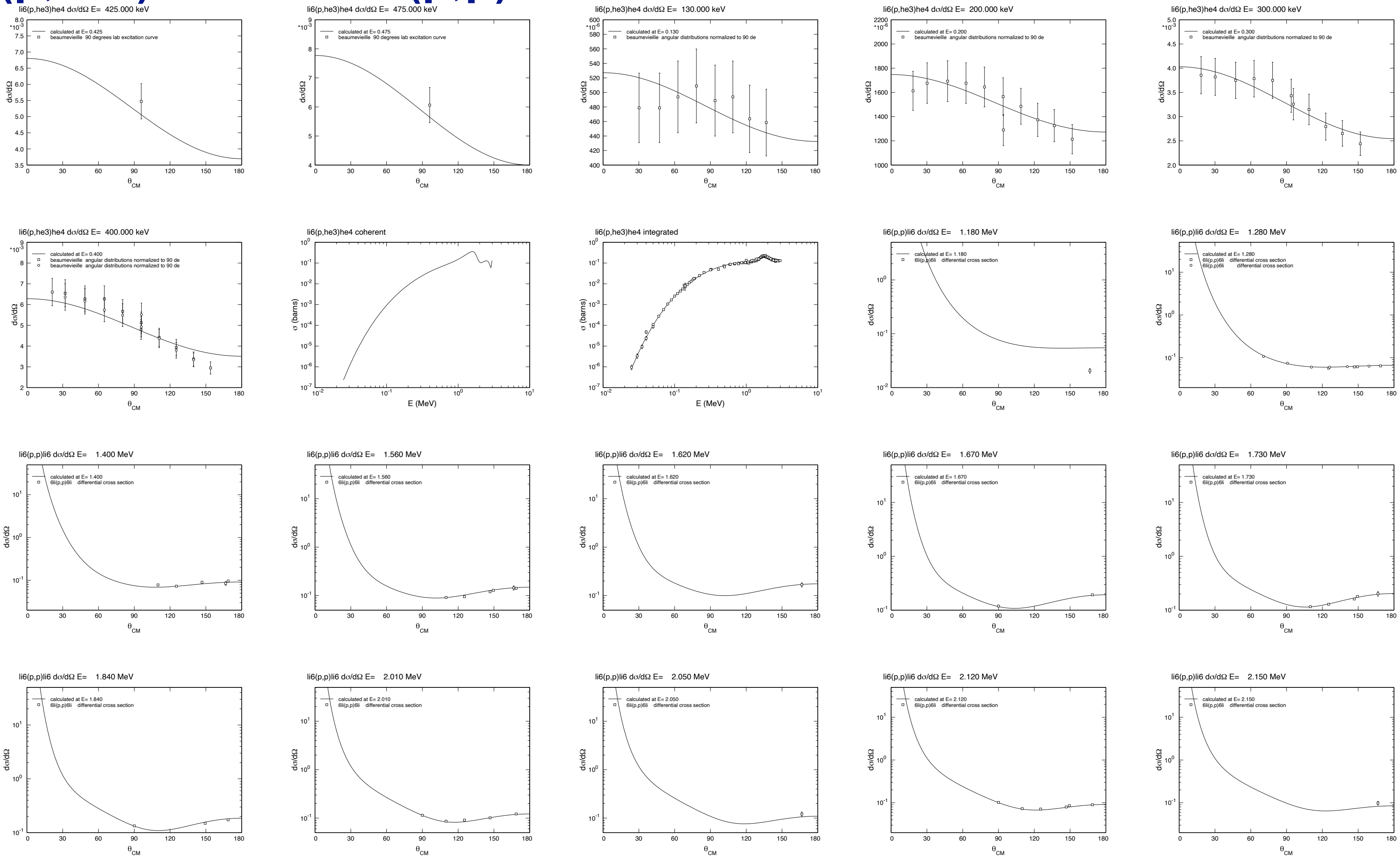
$^{6}Li(p,^{3}He)^{4}He$ Analyzing Powers and Differential Cross Sections



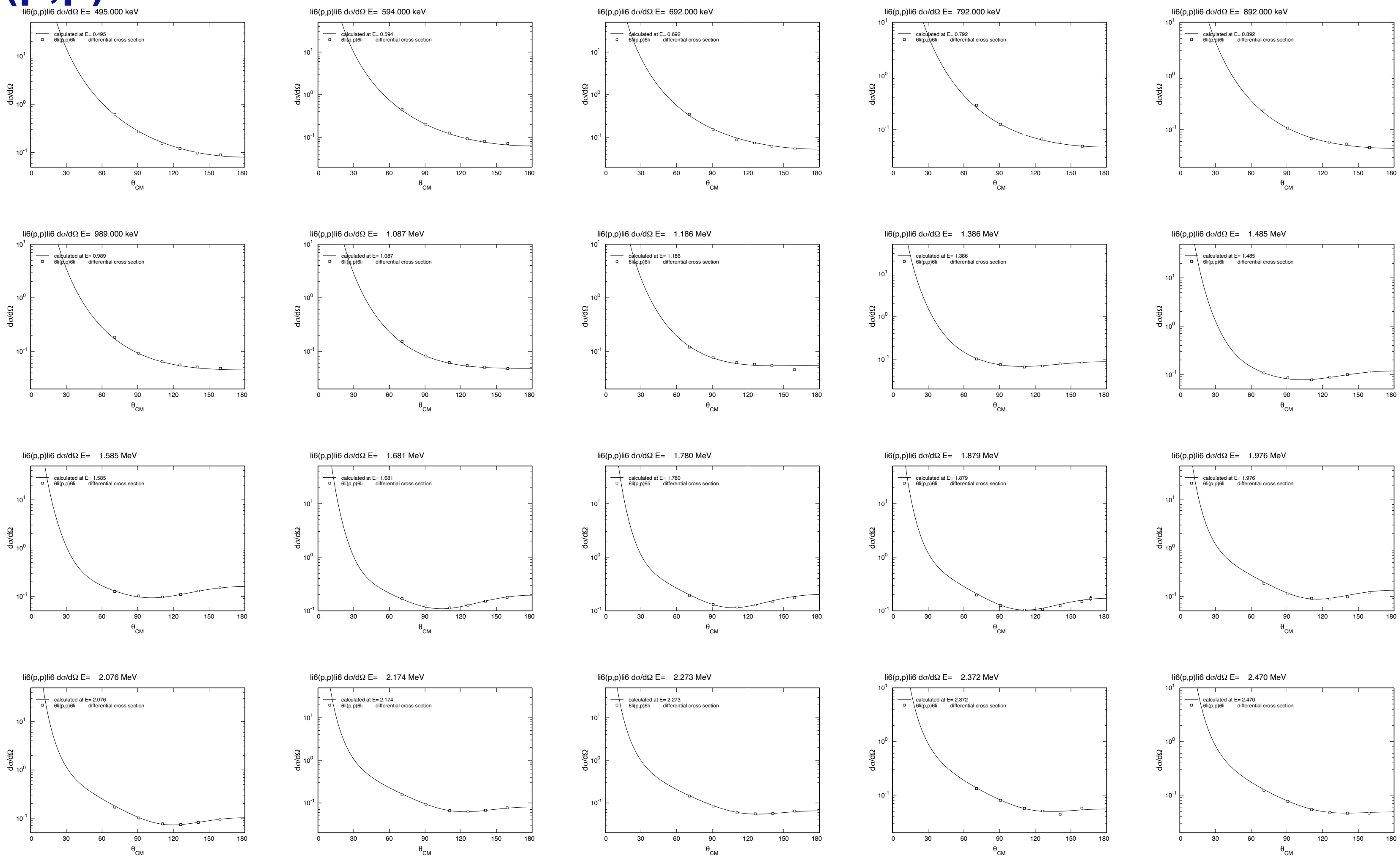
$^{6}Li(p,^{3}He)^{4}He$ Differential Cross Sections



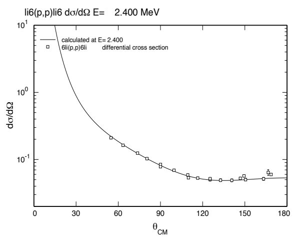
^{6}Li(p,^{3}He)^{4}He and ^{6}Li(p,p)^{6}Li Differential Cross Sections

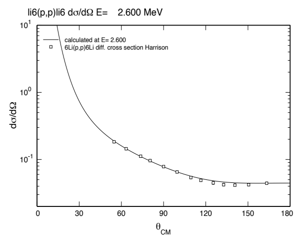


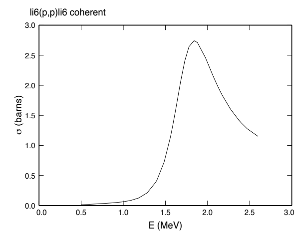
^{6}Li(p,p)^{6}Li Differential Cross Sections

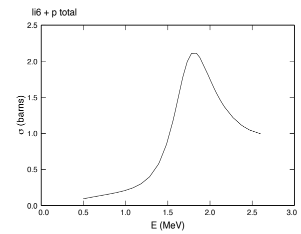


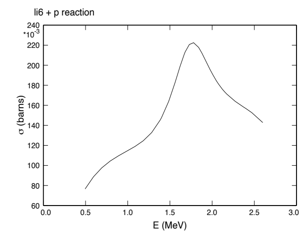
^{6}Li(p,p)^{6}Li Differential Cross Sections

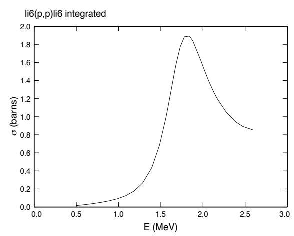


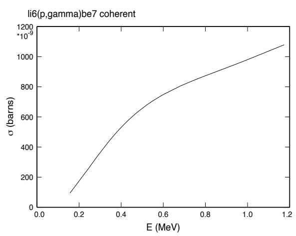


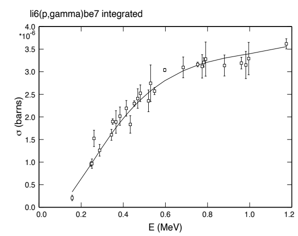




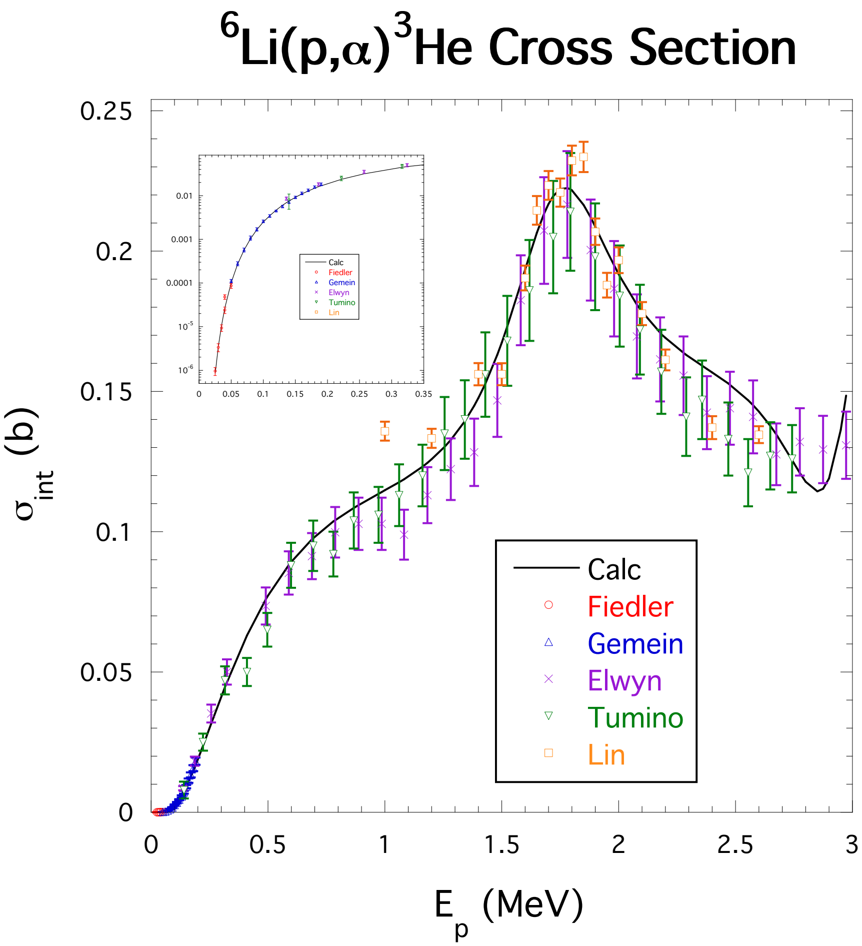




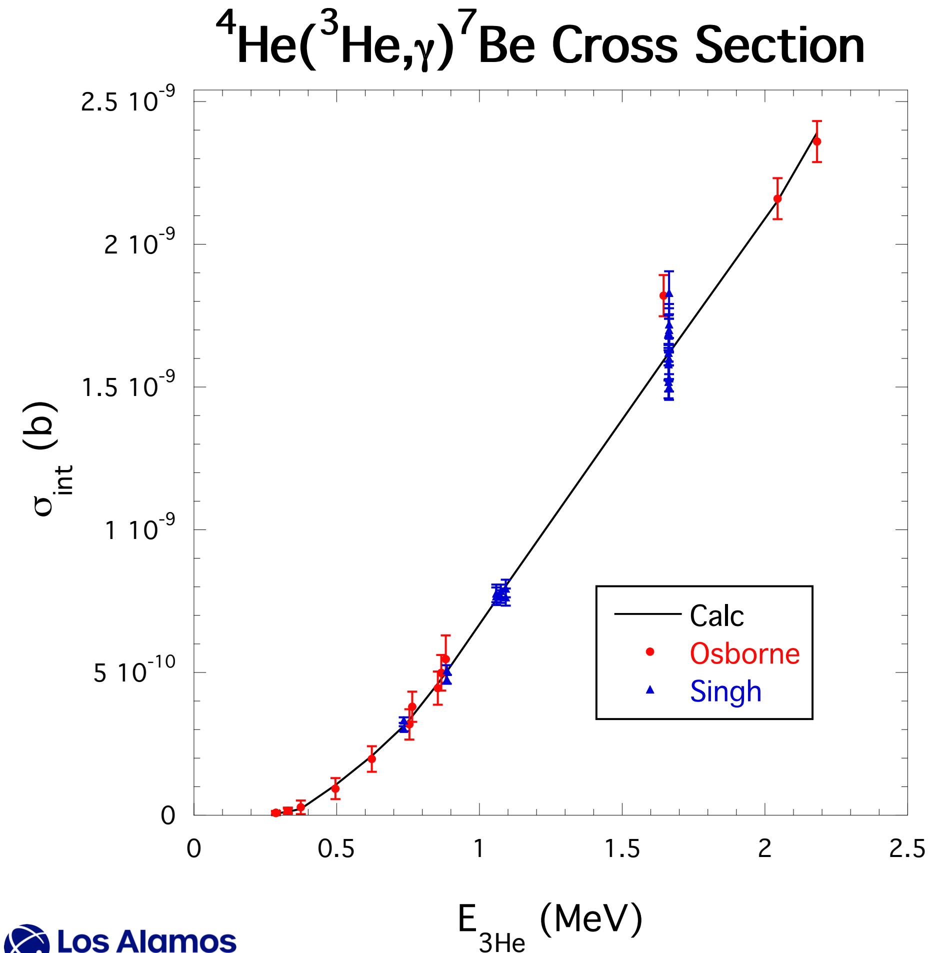


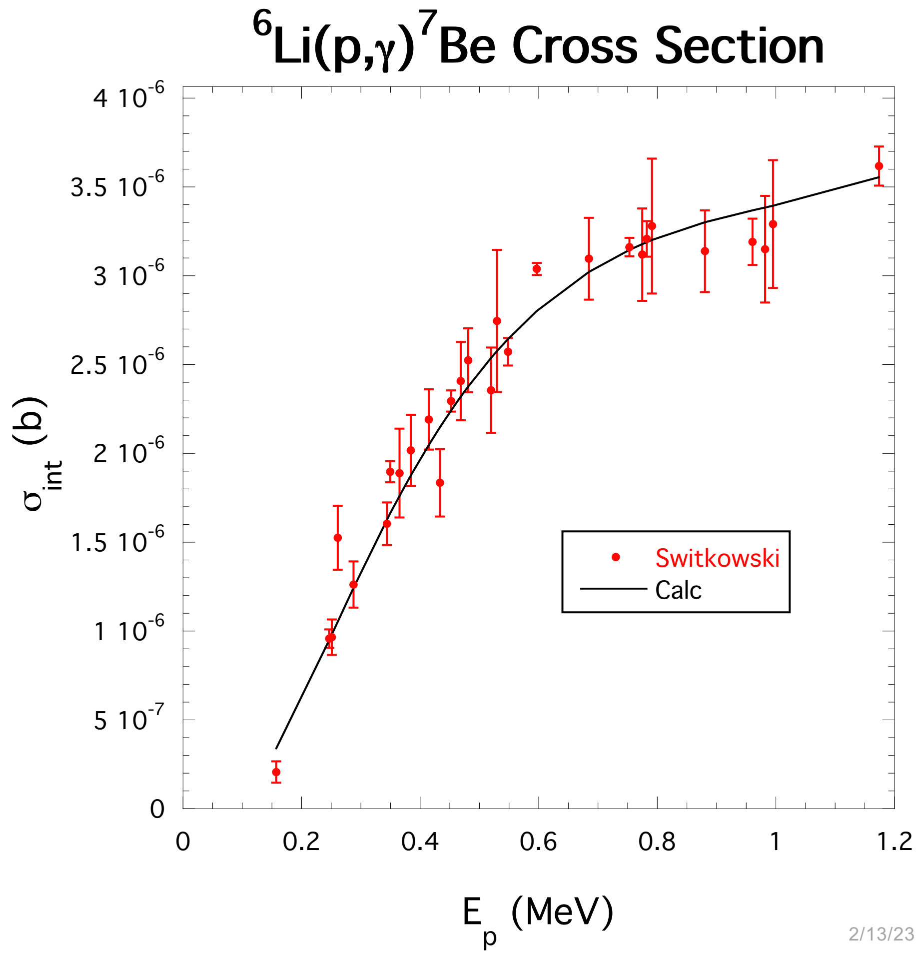


Integrated Reaction Cross Section



Integrated Capture Cross Sections





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Summary/Conclusions

- The EDA analysis of reactions in the ^{7}Be system at excitation energies up to 8.15 MeV gives a good representation of the experimental data included (χ^2/d.o.f.=1.2), including capture. Our prescription for photon channels, based on R.G. Newton's semi-classical treatment of EM scattering, is quite different from the the standard (e.g.,L&T) one, so parameter comparisons would be difficult.
- The narrow $3/2^+$ resonance seen in the previous version of this analysis appears to have been spurious, and it is no longer present.
- A recent measurement of ^{3}He+^{4}He scattering in the range $0.676 \leq E_{3He} \leq 5.48$ MeV from Paneru *et al*. is an important addition to the experimental data base. Som was kind enough to send us his laboratory data late last week, but we have not yet converted it to a form that can be used by EDA. However, the ^{3}He+^{4}He *S*-wave scattering length from our analysis, a_0 = 45.8 fm, is closer to the value obtained from his halo EFT analysis (42±1) fm than to the R-matrix value, 33.1±0.13(stat.)(+7.5,-3, analysis) fm.