EVALUATION OF n + 16O CROSS SECTIONS FOR THE ENERGY RANGE 1.0E-11 to 150 MeV

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This evaluation provides a complete representation of the nuclear data needed for transport, damage, heating, radioactivity, and shielding applications over the incident neutron energy range from 1.0E-11 to 150 MeV. The discussion here is divided into the region below and above 20 MeV.

INCIDENT NEUTRON ENERGIES < 20 MeV

Below 20 MeV the evaluation is based completely on the ENDF/B-VI.0 (Release 0) evaluation by Ha(92). The following minor modifications were made to the ENDF/B-VI.0 evaluation:

2. The (n,p) [and nonelastic] cross section from 19 to 20 MeV was varied slightly to join smoothly with the higher energy values at 20 MeV.

INCIDENT NEUTRON ENERGIES > 20 MeV

The evaluation above 20 MeV utilizes MF=6, MT=5 to represent all reaction data. Production cross sections and emission spectra are given for neutrons, protons, deuterons, alpha particles, gamma rays, and all residual nuclides produced (A>5) in the reaction chains. To summarize, the ENDF sections with non-zero data above En = 20 MeV are:

MF=3	MT= 1	Total Cross Section
	MT= 2	Elastic Scattering Cross Section
	MT= 3	Nonelastic Cross Section
	MT= 5	Sum of Binary (n,n') and (n,x) Reactions
	MT=102	Radiative Capture Cross Section (Estimate Only)
MF=4	MT= 2	Elastic Angular Distributions
MF=6	MT= 5	Production Cross Sections and Energy-Angle Distributions for Emission Neutrons, Protons, Deuterons, and Alphas; and Angle-Integrated Spectra for Gamma Rays and Residual Nuclei That Are Stable Against Particle Emission

The evaluation is based on nuclear model calculations that have been benchmarked to experimental data, especially for n + O16 and p + O16 reactions (Ch96a). We use the GNASH code system (Yo92), which utilizes Hauser-Feshbach statistical, preequilibrium and direct-reaction theories. Coupled-channel and spherical optical model calculations are used to obtain particle transmission coefficients for the Hauser-Feshbach calculations, as well as for the elastic neutron angular distributions.

Cross sections and spectra for producing individual residual nuclei are included for reactions that exceed a cross section of approximately 1 nb at any energy. The energy-angle-correlations for all outgoing particles are based on Kalbach systematics (Ka88).

A model was developed to calculate the energy distributions of all recoil nuclei in the GNASH calculations (Ch96b). The recoil energy distributions are represented in the laboratory system in MT=5, MF=6, and are given as isotropic in the lab system. Note that all other data in MT=5,MF=6 are given in the center-of-mass system. This method of representation requires a modification of the original ENDF-6 format.

Preequilibrium corrections were performed in the course of the GNASH calculations using either Feshbach, Kerman, Koonin (FKK) theory [Ch93] or the exciton model of Kalbach (Ka77, Ka85). Discrete level data from nuclear data sheets were matched to continuum level densities using the formulation of Ignatyuk (Ig75) and pairing and shell parameters from the Cook (Co67) analysis. Neutron and charged-particle transmission coefficients were obtained from the optical potentials, as discussed below. Gamma-ray transmission coefficients were calculated using the Kopecky-Uhl model (Ko90).

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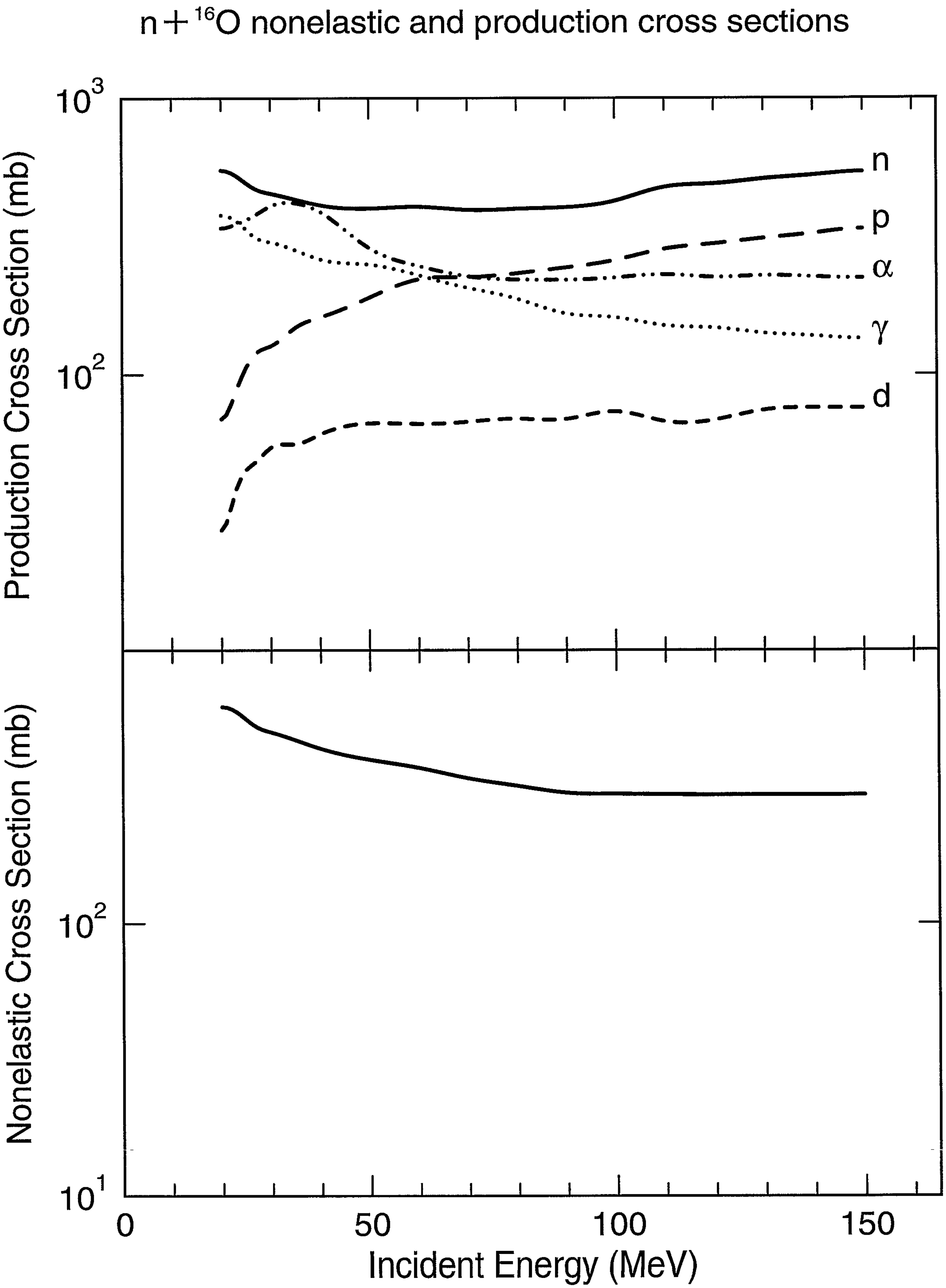
8016 = TARGET 1000Z+A (if A=0 then elemental)
1 = PROJECTILE 1000Z+A
Nonelastic, elastic, and Production cross sections for A<5 ejectiles in barns:

Energy	nonelas	elastic	neutron	proton	deuteron	triton	helium3	alpha	gamma
2.000E+01	6.200E-01	1.020E+00	5.486E-01	6.899E-02	2.735E-02	0.000E+00	0.000E+00	3.406E-01	3.787E-01
2.300E+01	5.920E-01	1.054E+00	5.252E-01	8.761E-02	3.848E-02	0.000E+00	0.000E+00	3.517E-01	3.634E-01
2.700E+01	5.230E-01	1.071E+00	4.699E-01	1.195E-01	4.842E-02	0.000E+00	0.000E+00	3.801E-01	3.148E-01
3.000E+01	5.000E-01	1.059E+00	4.532E-01	1.269E-01	5.441E-02	0.000E+00	0.000E+00	4.086E-01	3.028E-01
3.500E+01	4.670E-01	1.012E+00	4.319E-01	1.481E-01	5.595E-02	0.000E+00	0.000E+00	4.193E-01	2.834E-01
4.000E+01	4.350E-01	9.670E-01	4.119E-01	1.614E-01	6.073E-02	0.000E+00	0.000E+00	3.905E-01	2.626E-01
5.000E+01	3.960E-01	8.150E-01	4.003E-01	1.905E-01	6.656E-02	0.000E+00	0.000E+00	2.887E-01	2.511E-01
6.000E+01	3.700E-01	6.800E-01	4.063E-01	2.221E-01	6.624E-02	0.000E+00	0.000E+00	2.484E-01	2.301E-01
7.000E+01	3.390E-01	5.730E-01	3.956E-01	2.263E-01	6.739E-02	0.000E+00	0.000E+00	2.276E-01	2.069E-01
8.000E+01	3.180E-01	4.890E-01	3.989E-01	2.331E-01	6.910E-02	0.000E+00	0.000E+00	2.216E-01	1.887E-01
9.000E+01	3.000E-01	4.210E-01	4.041E-01	2.446E-01	6.888E-02	0.000E+00	0.000E+00	2.210E-01	1.664E-01
1.000E+02	2.970E-01	3.400E-01	4.257E-01	2.599E-01	7.339E-02	0.000E+00	0.000E+00	2.247E-01	1.609E-01
1.100E+02	2.957E-01	2.800E-01	4.767E-01	2.850E-01	6.751E-02	0.000E+00	0.000E+00	2.305E-01	1.504E-01
1.200E+02	2.950E-01	2.380E-01	4.906E-01	2.982E-01	6.821E-02	0.000E+00	0.000E+00	2.257E-01	1.475E-01
1.300E+02	2.950E-01	2.050E-01	5.105E-01	3.122E-01	7.417E-02	0.000E+00	0.000E+00	2.286E-01	1.411E-01
1.400E+02	2.950E-01	1.760E-01	5.261E-01	3.251E-01	7.574E-02	0.000E+00	0.000E+00	2.263E-01	1.379E-01
1.500E+02	2.950E-01	1.480E-01	5.411E-01	3.377E-01	7.558E-02	0.000E+00	0.000E+00	2.240E-01	1.347E-01

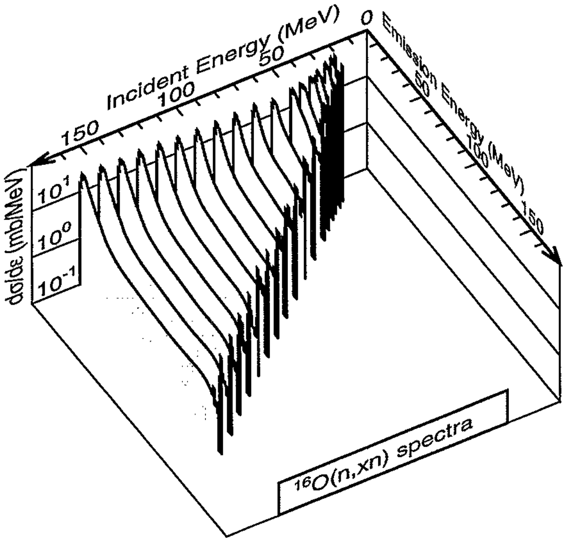
8016 = TARGET 1000Z+A (if A=0 then elemental)
1 = PROJECTILE 1000Z+A
Kerma coefficients in units of f.Gy.m^2:

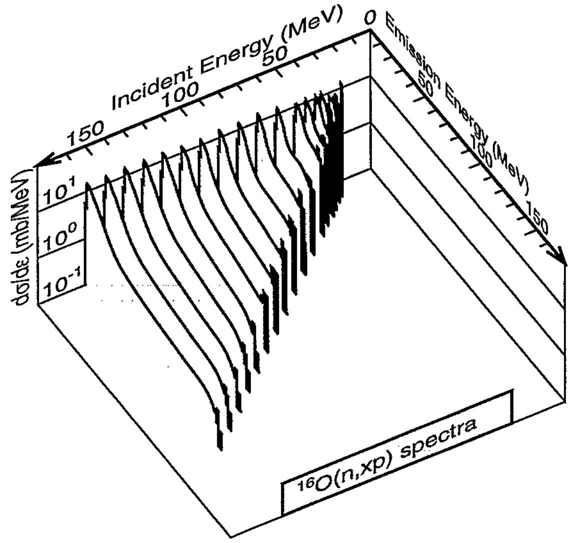
Energy	proton	deuteron	triton	helium3	alpha	non-rec	elas-rec	TOTAL
2.000E+01	2.059E-01	8.326E-02	0.000E+00	0.000E+00	9.067E-01	6.713E-01	2.693E-01	2.136E+00
2.300E+01	3.068E-01	1.401E-01	0.000E+00	0.000E+00	1.018E+00	6.790E-01	2.696E-01	2.413E+00
2.700E+01	4.823E-01	2.145E-01	0.000E+00	0.000E+00	1.010E+00	6.032E-01	2.639E-01	2.574E+00
3.000E+01	5.800E-01	3.121E-01	0.000E+00	0.000E+00	1.046E+00	5.635E-01	2.553E-01	2.757E+00
3.500E+01	8.160E-01	4.444E-01	0.000E+00	0.000E+00	1.080E+00	5.277E-01	2.382E-01	3.107E+00
4.000E+01	1.008E+00	6.006E-01	0.000E+00	0.000E+00	1.088E+00	5.265E-01	2.251E-01	3.448E+00
5.000E+01	1.478E+00	8.029E-01	0.000E+00	0.000E+00	9.045E-01	5.736E-01	1.850E-01	3.943E+00
6.000E+01	2.082E+00	8.752E-01	0.000E+00	0.000E+00	8.724E-01	6.180E-01	1.448E-01	4.592E+00
7.000E+01	2.474E+00	1.019E+00	0.000E+00	0.000E+00	8.713E-01	6.059E-01	1.172E-01	5.087E+00
8.000E+01	2.728E+00	1.138E+00	0.000E+00	0.000E+00	9.032E-01	5.923E-01	9.740E-02	5.459E+00
9.000E+01	3.153E+00	1.141E+00	0.000E+00	0.000E+00	9.483E-01	5.669E-01	8.233E-02	5.892E+00
1.000E+02	3.574E+00	1.239E+00	0.000E+00	0.000E+00	9.985E-01	5.659E-01	6.559E-02	6.442E+00
1.100E+02	4.018E+00	1.120E+00	0.000E+00	0.000E+00	1.093E+00	5.706E-01	5.343E-02	6.855E+00
1.200E+02	4.620E+00	1.148E+00	0.000E+00	0.000E+00	1.095E+00	5.641E-01	4.497E-02	7.472E+00
1.300E+02	5.157E+00	1.188E+00	0.000E+00	0.000E+00	1.179E+00	5.671E-01	3.837E-02	8.129E+00
1.400E+02	5.777E+00	1.171E+00	0.000E+00	0.000E+00	1.206E+00	5.860E-01	3.262E-02	8.773E+00
1.500E+02	6.423E+00	9.620E-01	0.000E+00	0.000E+00	1.234E+00	6.053E-01	2.712E-02	9.251E+00

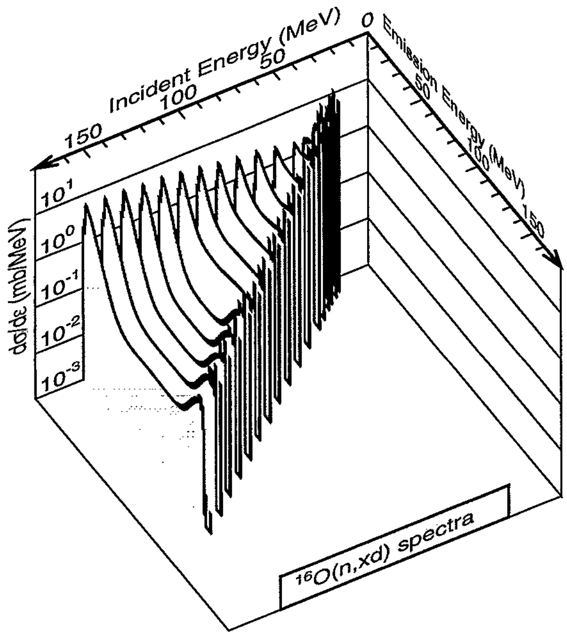


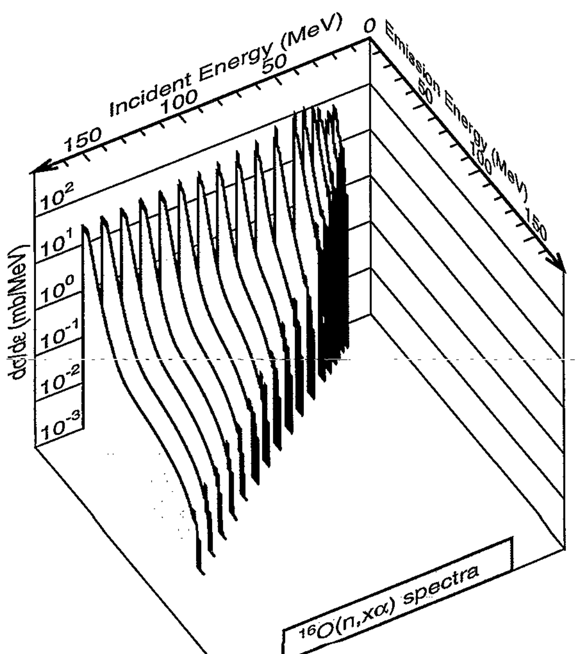
n + ¹⁶O nonelastic and production cross sections
Production Cross Section (mb)
Nonelastic Cross Section (mb)
Incident Energy (MeV)
10³
10²
10²
10¹
0
50
100
150
n
p
α
γ
d

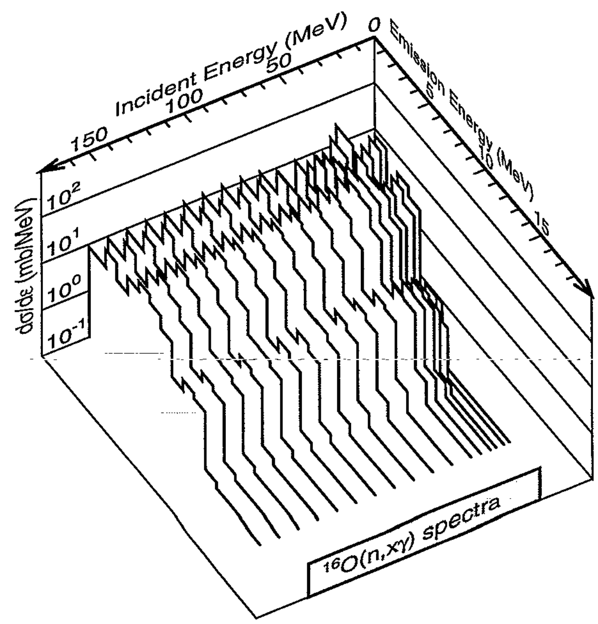
n + ^{16}O angle-integrated emission spectra



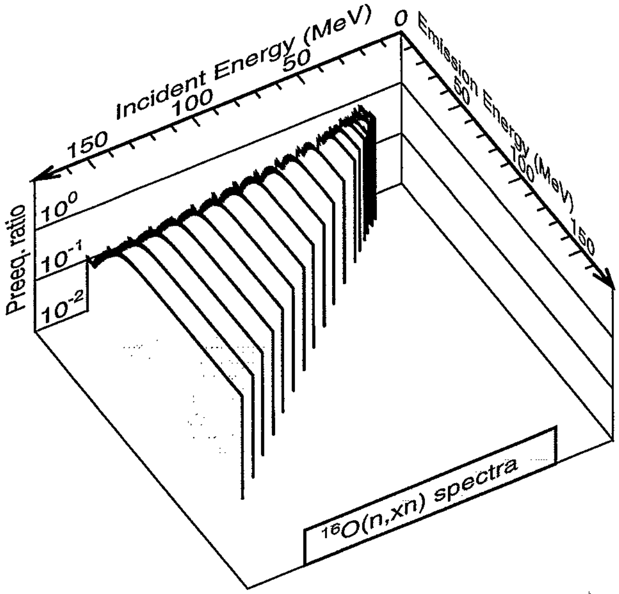


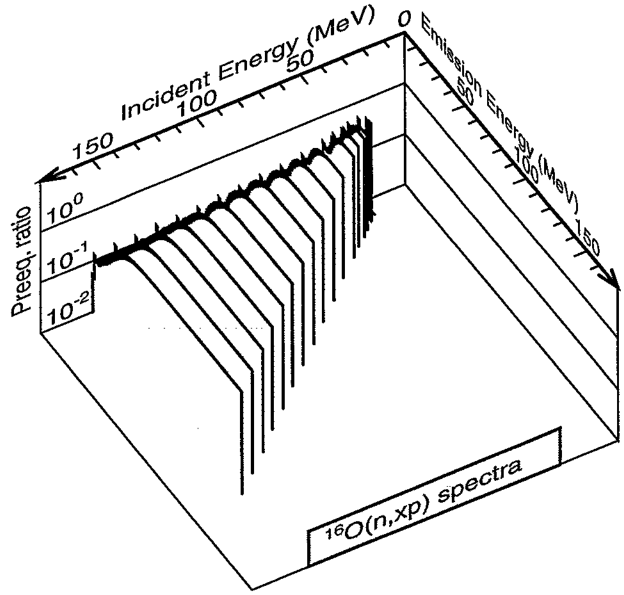


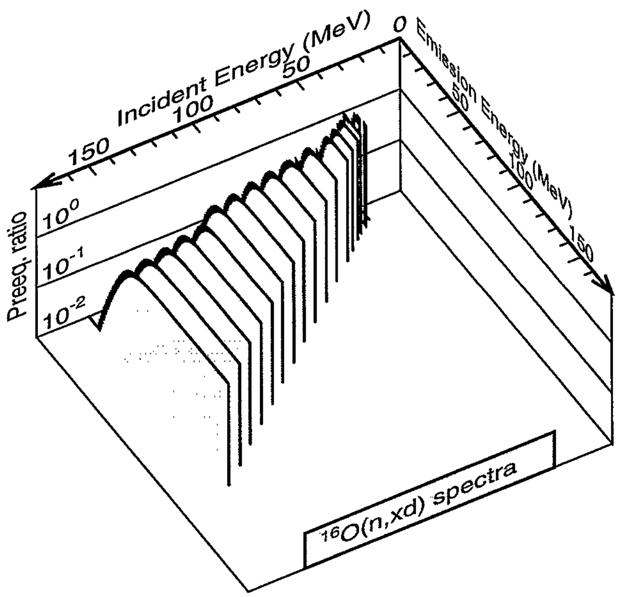


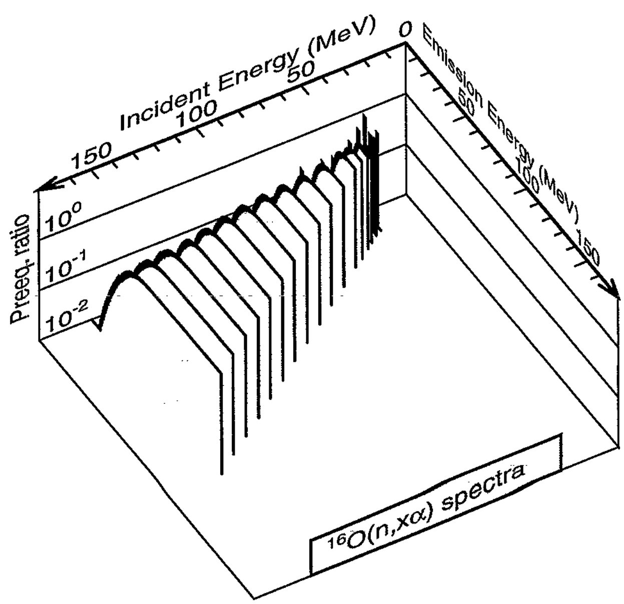


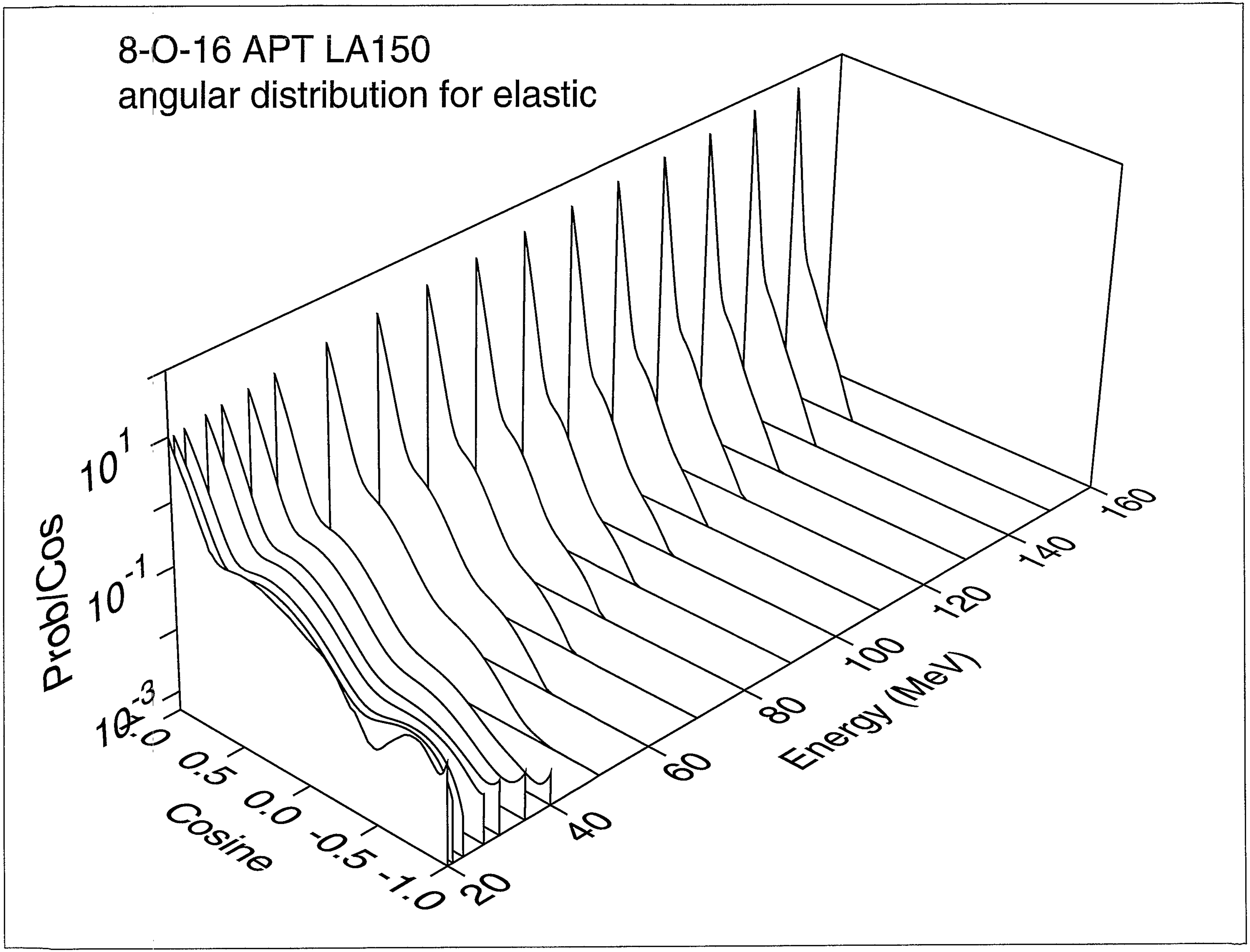
n + ^{16}O Kalbach preequilibrium ratios

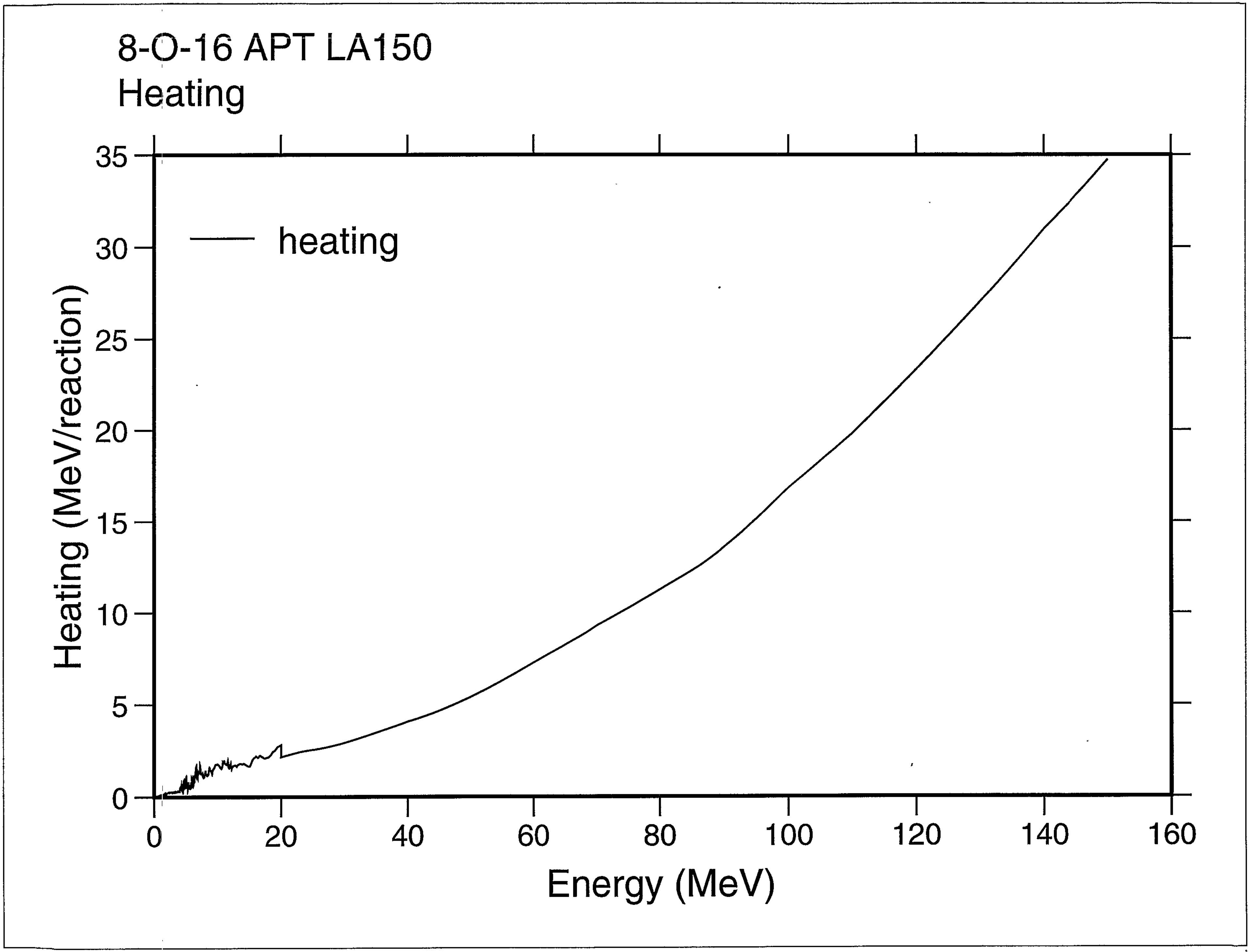


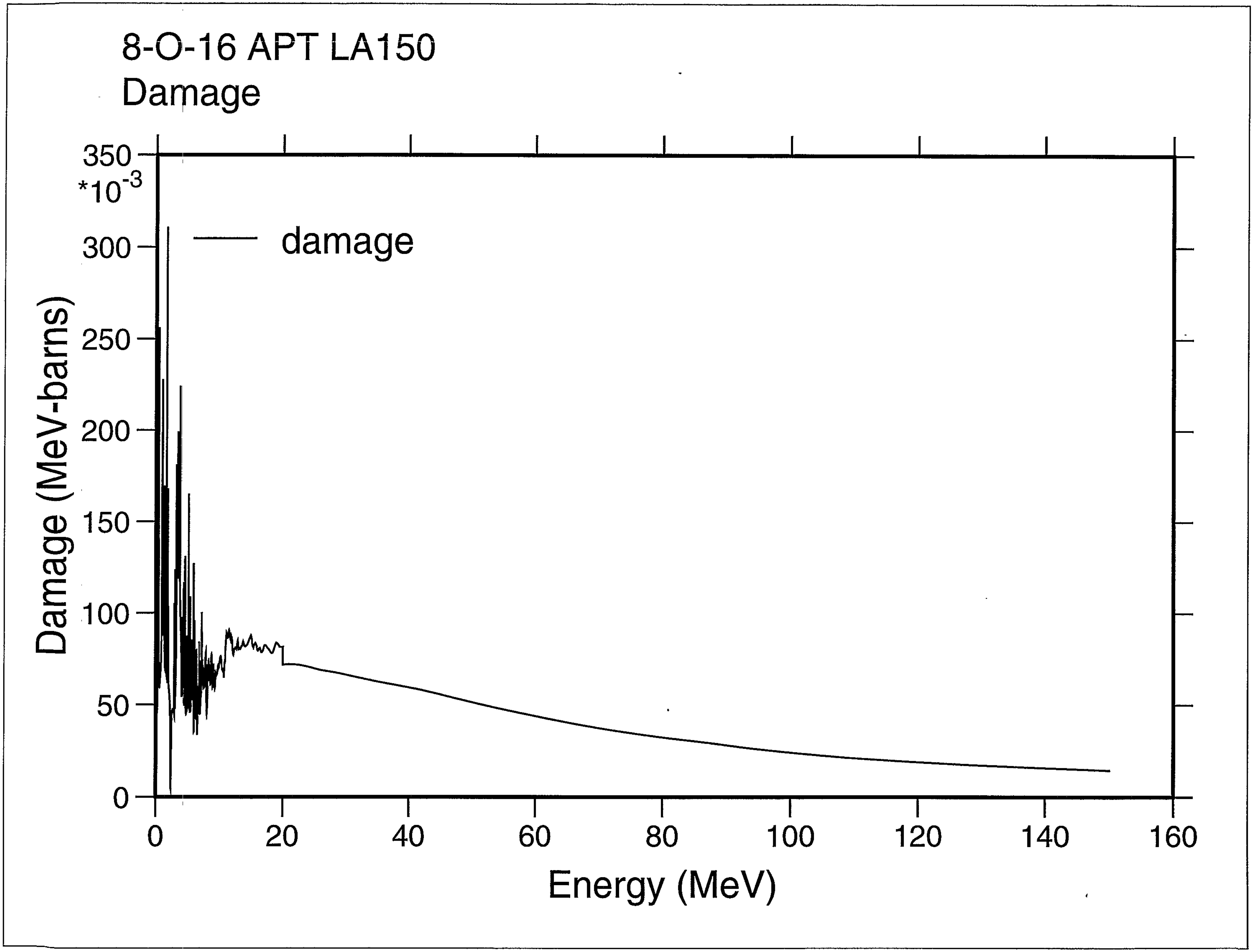







8-O-16 APT LA150
angular distribution for elastic
Prob/Cos
10^1
10^{-1}
10^{-3}
Cosine
1.0
0.5
0.0
-0.5
-1.0
Energy (MeV)
20
40
60
80
100
120
140
160


8-O-16 APT LA150
Heating
heating
Heating (MeV/reaction)
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160
Energy (MeV)


8-O-16 APT LA150
Damage
damage
Damage (MeV-barns)
*10^-3
350
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160
Energy (MeV)