Phoswich Unfolding

A Development of the Gamma-ray Unfolding Algorithm
for the Phoswich Detector

,   ,   *

*

17

150

Phoswich   Unfolding   . Unfolding

Response   MCNP4C   Unfolding

PV-WAVE   . Unfolding   2   ANSI X-ray Beam

Series   18   Unfolding   ,   1%

. ANSI X-ray Beam Series   M150   H150

Unfolding   RMS   0.57%   0.84%   .   ,   18

Random Sampling   4

Unfolding   .   RMS

0.05%, 0.12%, 0.08%,   0.03%   .

ABSTRACT

A gamma-ray unfolding program has been developed to unfold the measured spectra of the Phoswich detector. MCNP4C and PV-WAVE were used to construct the gamma-ray response profile and unfolding algorithm, respectively. ANSI X-ray beam series and the random-sampled gamma-ray sources, which consist of 18 gamma-ray sources, were used to review the unfolding program for the Phoswich Detector. The unfolded gamma-ray sources obtained by this program well agreed with the original gamma-ray sources. Energy spectra

produced by M150 and H150 among ANSI X-ray Beam Series were unfolded through the unfolding program. Their RMS errors were 0.57% and 0.84%, respectively. The spectra obtained by random-sampled gamma-ray sources were also unfolded and their RMS errors were found to be 0.05%, 0.12%, 0.08%, and 0.03%, respectively.

1.

Photoelectric Effect, Compton Scattering, Pair Production

. 1.02MeV Pair Production

Single Escape Peak

Double Escape Peak . , Photoelectric Effect

X-ray

K-fluorescence Peak .[1]

.

Unfolding Response Unfolding

. Response

(Monoenergetic Gamma-ray)

(Pulse Height Spectra) Unfolding

. Response

Unfolding

.

Phoswich PMT(Photo Multiplier Tube)

, , .[2]

CsI(Tl) Plastic Scintillator

Phoswich Unfolding . , ANSI X-ray Beam Series 18 Random Sampling

Unfolding .

2.

2.1 Response

Response Phoswich Unfolding

Unfolding

. Response

　　　　　　　　　　　　　　　　　　　MCNP4C　　　　　　　　　　　　　.

Phoswich　　　　　　　　　　　　　　　　　1m　　　　　　　　　　　　　　　　　　　　　.
　　Response　　　　　　0　　2.5MeV　　5keV　　　　　　　　　　　　　Phoswich
　　　　　　　　　　　　　　　　　　　　Response　　　　　　　　　.　　　　Phoswich
　　　　　1　　　　. Phoswich　　　　　　　Response　CsI(Tl)　　Plastic Scintillator
　　　MCNP4C　　　F8 Tally　　　　　　　　　　　　　.

　　　Response

　　　　　　　(Housing)

　　　　　　　　　　　　　　　　　　　　　　　　　　　　Response
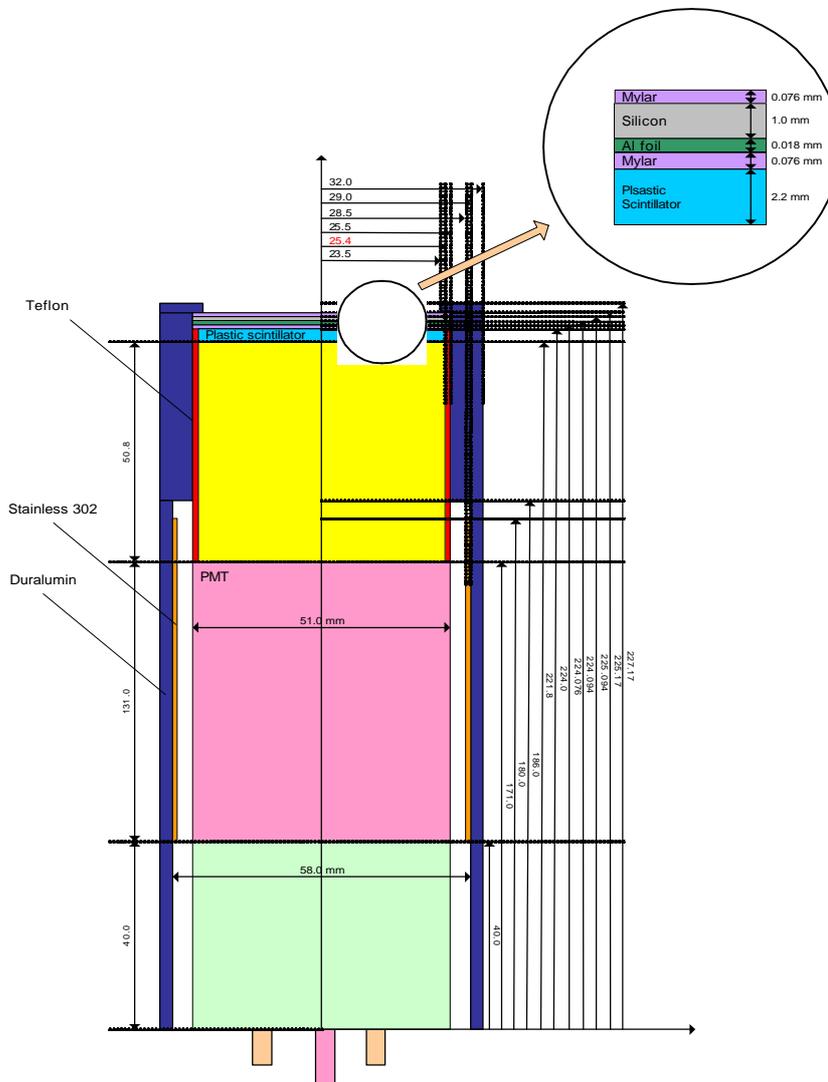
　　　　Unfolding　　　　　　　　.

1. Phoswich

Phoswich   CsI(Tl)   Plastic Scintillator

CsI(Tl)   Plastic Scintillator

PMT   .   2   Phoswich

CsI(Tl)   Plastic Scintillator   Response   .

Response   Plastic Scintillator   CsI(Tl)

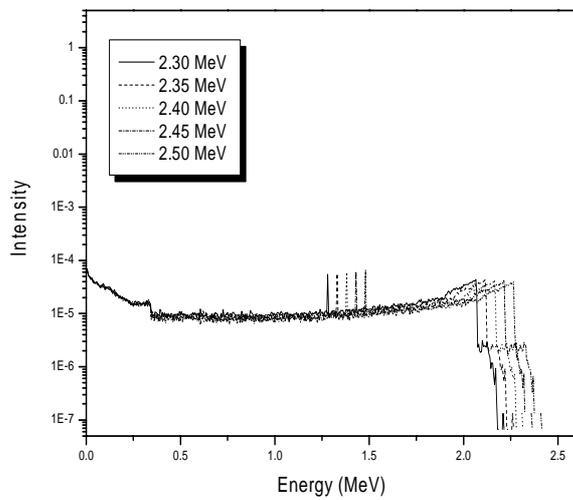.   2   Plastic Scintillator

CsI(Tl)   1/80   Unfolding

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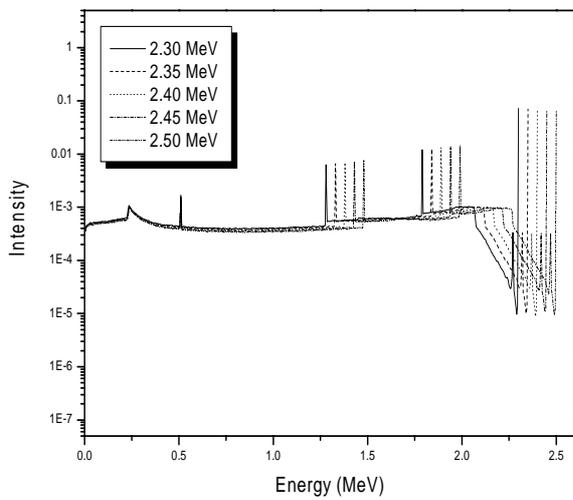
2. Phoswich   CsI(Tl)( )   Plastic   ( )   Response

2.2 Unfolding

Unfolding   Response Matrix

Inverse Matrix Method, Stripping Method,   Folding Iteration Method   .

Neural Network   Unfolding

.   Stripping Method

Unfolding

Unfolding   .[3, 4]

Unfolding   Compton Scattering

Stripping Method   Phoswich   Unfolding

.

Unfolding

Photopeak Efficiency   .

K-fluorescence, Single Escape Peak, Double Escape Peak   Compton Scattering   .

Unfolding

                                    . $(E_{max}-E_K < E \leq E_{max})$ Unfolding

(1)   .

$$S(E) = \frac{M(E)}{P(E)} \quad \text{for} \ E_{max} - E_K < E \leq E_{max} \tag{1}$$

, $S(E)$ $M(E)$
. $P(E)$ Photopeak Efficiency   . E_{max} E_K
K-fluorescence   .

                              $(E_{Cmax} < E \leq E_{max}-E_K)$ Unfolding $P(E)$

K-fluorescence   Unfolding

                                                            (2)   .

$$S(E) = \frac{M(E) - S(E + E_K)K(E + E_K)}{P(E)} \quad \text{for} \ E_{C\max} < E \leq E_{max} - E_K \tag{2}$$

                    $(E \leq E_{Cmax})$

                    Compton Scattering, Single Escape   Double Escape   .
E_{Cmax} Compton Edge   . E_X
Compton Scattering   Compton Scattering
                              (E_{max}) E_{Cmax} Compton Scattering
                    $(E_0(E))$.
          , Compton Gap   Compton Edge
                                                            0.256MeV   .

          Single Escape   Double Escape   Compton Gap   Compton
Scattering   (3)   .

$$S(E) = \frac{1}{P(E)} \left\{ \left[M(E) - S(E + E_K)K(E + E_K) - \sum_{E_x = E_0(E)}^{E_{max}} S(E_X)C(E_X) \right] \right\} \quad \text{for} \ E \leq E_{C\max} \tag{3}$$

3.

2   ANSI X-ray Beam Series   18   Unfolding

                                .   CsI(Tl)

Plastic Scintillator   Response   Unfolding

                                          .

          ANSI X-ray Beam Series   30keV   150keV   M150   H150
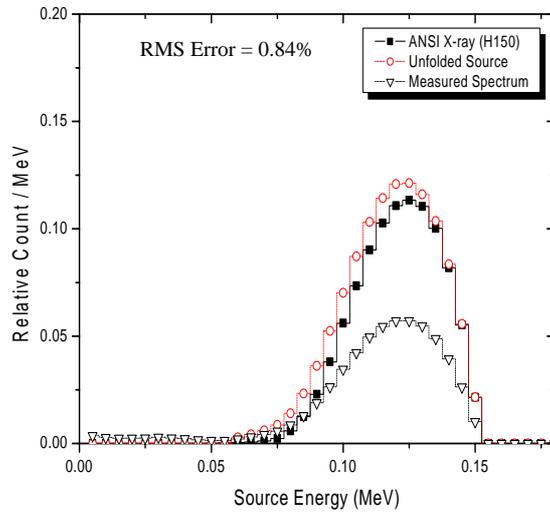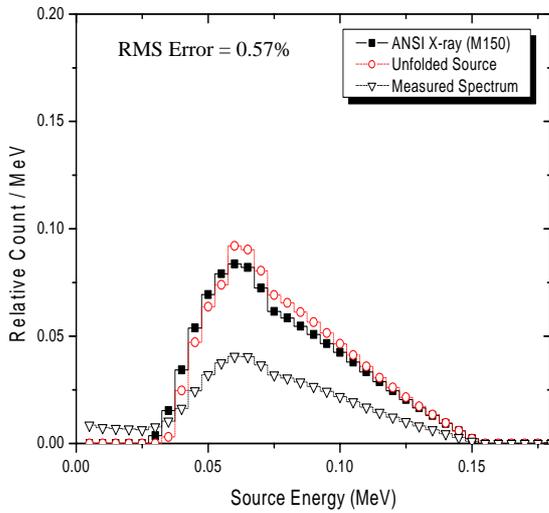
                Phoswich   Response   .   Response

                Unfolding   M150   H150   .   3

    M150   H150   Unfolding   .

3. ANSI X-ray Beam Series   M150   H150   Unfolding

          Unfolding   (4)

RMS(Root Mean Square)   .

$$RMS = \left[\frac{1}{N} \sum_{i=1}^{N} (S_i - U_i)^2 \right]^{1/2} \tag{4}$$

          S_i i U_i Unfolding   i

                    .   M150   H150   Unfolding   RMS

          M150   0.57%, H150   0.84%   .

                              18   Phoswich   Response

          Unfolding   .   Co-60   Sc-46

2   1:1   20   .

Random Sampling   18   , Co-60

Sc-46

.

Random Sampling   20

Response   Unfolding   .   1   4

. 4   Unfolding   RMS

0.05%, 0.12%, 0.08%   0.03%   .

, 20   Unfolding

Response

Unfolding   .

.   ,   Unfolding

RMS   .

1. Random Sampling   Unfolding

Source	Beam Energy (MeV)	Case #1		Case #2		Case #3		Case #4	
		Input Source	**Unfolded Source**	**Input Source**	**Unfolded Source**	**Input Source**	**Unfolded Source**	**Input Source**	**Unfolded Source**
Sn-113	0.0241	0.03558	0.03351	0.09660	0.09159	0.06610	0.06251	0.00676	0.00701
Am-241	0.0595	0.02382	0.02356	0.08422	0.08334	0.04975	0.04926	0.05631	0.05568
Co-57	0.1221	0.08882	0.08990	0.06408	0.06491	0.00971	0.00985	0.07674	0.07773
Ce-141	0.1455	0.04390	0.04388	0.05477	0.05488	0.02790	0.02780	0.04012	0.04008
Ce-139	0.1658	0.04951	0.04968	0.04877	0.04889	0.08889	0.08911	0.07729	0.07746
Hg-203	0.2792	0.05786	0.05791	0.08445	0.08435	0.04705	0.04709	0.06582	0.06580
I-131	0.3645	0.04012	0.04011	0.01181	0.01176	0.07383	0.07391	0.08442	0.08450
Au-198	0.4118	0.04044	0.04038	0.05269	0.05255	0.07551	0.07521	0.08659	0.08623
Sr-85	0.514	0.06564	0.06558	0.01087	0.01095	0.04112	0.04113	0.08430	0.08451
Cs-134	0.6046	0.04463	0.04461	0.02174	0.02180	0.04917	0.04928	0.05984	0.05993
Cs-137	0.6616	0.05454	0.05447	0.03372	0.03361	0.06837	0.06822	0.07279	0.07270
Nb-95	0.7658	0.04668	0.04659	0.02569	0.02561	0.05246	0.05250	0.03438	0.03433
Mn-54	0.8348	0.02889	0.02893	0.09828	0.09835	0.03963	0.03958	0.05609	0.05612
Sc-46(A)	0.8892	0.06586	0.06587	0.07537	0.07542	0.05562	0.05558	0.05799	0.05797
Sc-46(B)	1.1205	0.06586	0.06570	0.07537	0.07526	0.05562	0.05559	0.05799	0.05802
Co-60(A)	1.1732	0.02871	0.02884	0.03682	0.03691	0.00633	0.00632	0.00587	0.00586
Na-22	1.2745	0.06594	0.06620	0.04860	0.04869	0.05434	0.05435	0.01139	0.01143
Co-60(B)	1.3325	0.02871	0.02869	0.03682	0.03688	0.00633	0.00628	0.00587	0.00589
La-140	1.5966	0.06550	0.06546	0.02110	0.02106	0.06454	0.06429	0.05912	0.05901
Y-88	1.8361	0.05899	0.05879	0.01824	0.01821	0.06776	0.06760	0.00032	0.00034
RMS Error		0.05%		0.12%		0.08%		0.03%	

4. Random Sampling **20** **Unfolding**

ANSI X-ray Beam Series   Unfolding

RMS   Phoswich   Unfolding   M150   H150 X-ray

.   Response

Peak   Response

Unfolding   .

Response   K-fluorescence   Compton

Scattering   .

4.

Phoswich   Unfolding   Response   Unfolding

.   , ANSI X-ray Beam Series   18   Phoswich

Response   Unfolding   Unfolding

Response   . Phoswich   Unfolding

Response

Unfolding   5keV   .

Unfolding

     Unfolding   .

Response   Unfolding   .

     .

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