



## ***Influence of the $S(\alpha, \beta)$ Thermal Treatment on MCNPX Calculations Related to a Bonner Sphere Spectrometer***

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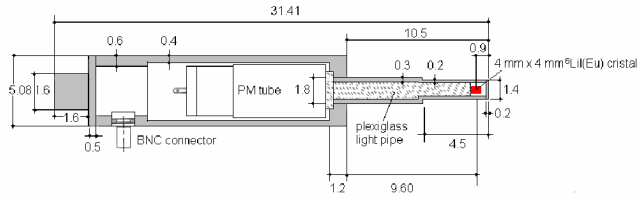
*AREVA NP GmbH - NEPR-G / Radiation Protection*

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- **Examination of a typical Bonner Sphere Spectrometer, diameters 2", 3", 5", 8", 10" and 12", polyethylene  $\rho = 0.95 \text{ g/cm}^3$**
- **Central detector, active scintillator  $^6\text{LiI}(\text{Eu})$ , 96 %  $^6\text{Li}$ , 4 mm diameter, 4 mm height**
- **Detection of thermal neutrons by  $^6\text{Li}(n, \alpha)^3\text{H}$**
- **Calculation with MCNPX™ 2.5.0**
- **Modelling of thermal neutron scattering due to chemical binding and crystalline effects in the PE with additional  $S(\alpha, \beta)$  cross section tables available for the cross section libraries used**
- **Calculation with and without consideration of the  $S(\alpha, \beta)$  thermal treatment**

Detector:



Energy Spectra:

$^{252}\text{Cf}$  and  $^{241}\text{Am-Be}$ , ISO 8529-1

Material Compositions:

Li Iodide	3.494 g/cm <sup>3</sup>	4.36% <sup>6</sup> Li, 0.18% <sup>7</sup> Li, 95.46% I (by weight)
PMMA	1.19	8% H, 60% C, 32% O
Al	2.7	100% Al
PE	0.95	85.7% C, 14.3% H
Pb	11.35	100% Pb

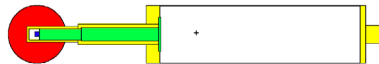
Calculation Approach (1)

- Code: **MCNPX™ 2.5.0**
- Geometry for the 2" sphere:

```

10/04/07 16:04:30
inp: conrad-ep4-p2-1.dat Response
of bonner spheres

probid = 10/04/07 16:02:53
basis: YZ
( 0.000000, 0.000000, 1.000000)
( 0.000000, 1.000000, 0.000000)
origin:
f = 0.00, 0.12, 14.02)
extent = ( 17.12, 17.12)
    
```

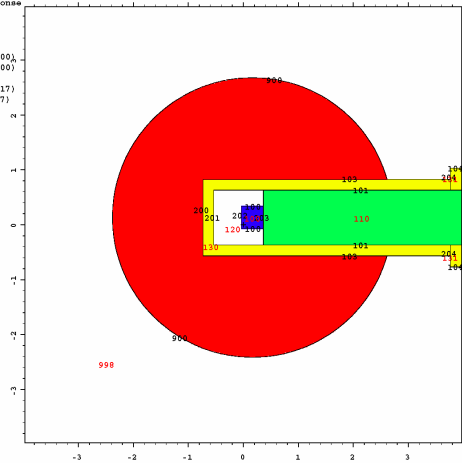


Geometry (outline of 2" sphere):

```

10/23/06 11:51:32
inp.conrad-wp4-p2-1.dat Response
of bonnez spheres

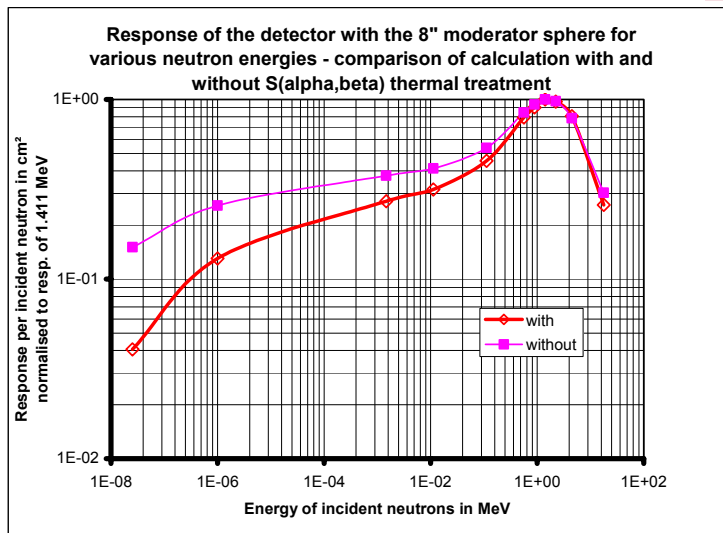
probid = 10/23/06 11:50:57
basis: XE
{ 0.000000, 0.000000, 1.000000}
{ 1.000000, 0.000000, 0.000000}
origin:
{ -0.13, 0.00, -0.17}
extent = ( 3.97, 3.97)
cell labels are
cell names
    
```



- **Response:**  
standard flux F4-tally modified by dose function  ${}^6\text{Li}(n,\alpha)^3\text{H}$  from JENDL 3.2
- **S(a,b) thermal treatment:**  
mt4 card in material specification of PE with entry poly.60t
- **Transport cross sections:**  
standard ENDF/BVI libraries in the MCNPX™ data package
- **Energy binning:**  
table II of description for problem 2 of CONRAD WP4

- **Source:**  
*1 n/s per source area, homogenous distributed, perpendicular emission*  
*source area plane disc, diameter as cross section area of sphere*  
*centre axis identical to center axis of detector arrangement*
  
- **Weighting factor composed of:**  
*cross section area of source, 2" example  $\pi/4 * (2 * 2.54\text{cm})^2 = 20.2683\text{cm}^2$*   
*volume of detector crystal =  $\pi * (0.2\text{cm})^2 * 0.4\text{cm} = 0.0502655\text{cm}^3$*
  
- **F4 tally:**  
*tally multiplier =  $\text{Li-atoms}/(\text{barn} * \text{cm}) = 3.494\text{g}/\text{cm}^3 * 0.0436 * 6.02\text{E}23/\text{mol} * 1\text{E}-24\text{cm}^2/\text{b} / 6\text{g}/\text{mol}$*   
*dose function = cross section for  $6\text{Li}(n,a)3\text{H}$ , JENDL-3.2 released June 1994, download from <http://t2.lanl.gov/data>*

8" Moderator Sphere for Various Neutron Energies

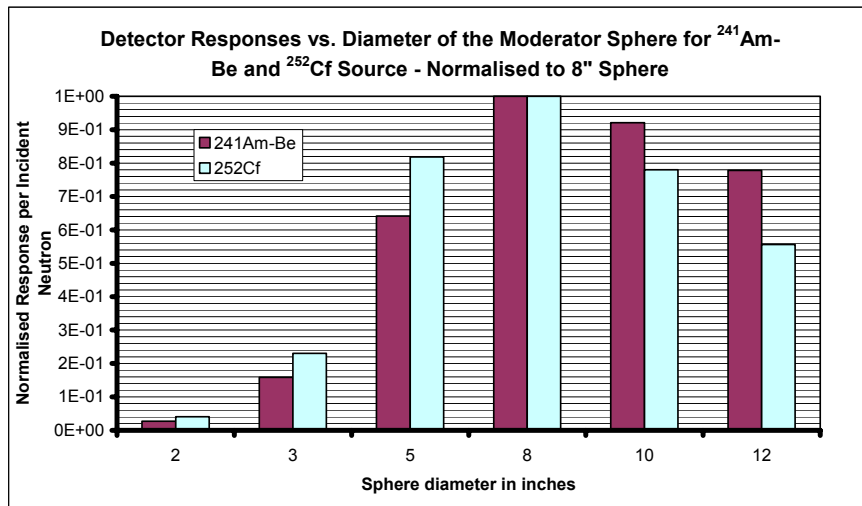


(all tally results of MCNPX have relative error < 1 %)

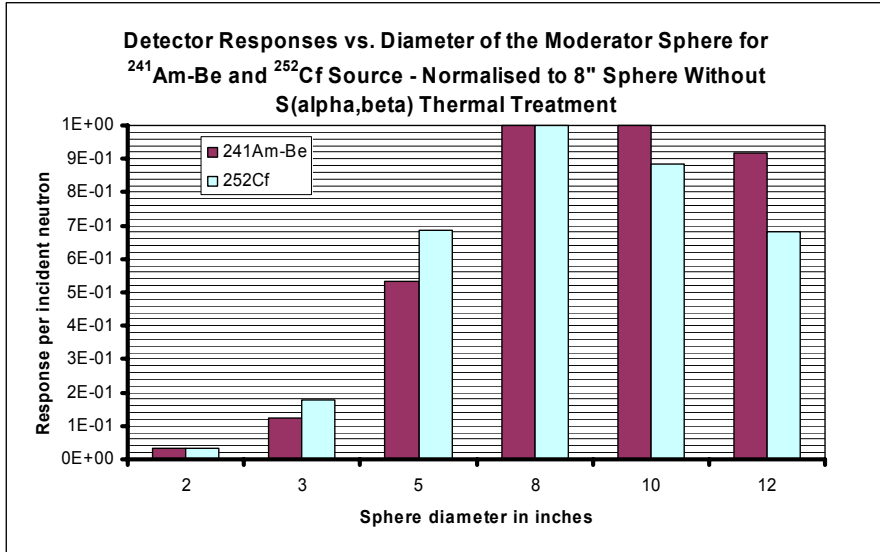
## Response for Various Sphere Diameters in case of <sup>241</sup>Am-Be and <sup>252</sup>Cf Source (Table)

Sphere diameter in inches	Response per incident neutron for			
	<sup>241</sup> Am-Be source		<sup>252</sup> Cf source	
	Absolute in cm <sup>2</sup>	Normalised to 8"	Absolute in cm <sup>2</sup>	Normalised to 8"
2	5.09881E-03	2.71771E-02	8.42033E-03	4.01954E-02
3	2.97003E-02	1.58305E-01	4.83356E-02	2.30735E-01
5	1.20390E-01	6.41689E-01	1.71451E-01	8.18442E-01
8	1.87614E-01	1.00000E+00	2.09485E-01	1.00000E+00
10	1.72778E-01	9.20926E-01	1.63370E-01	7.79865E-01
12	1.46016E-01	7.78282E-01	1.16519E-01	5.56216E-01
Without consideration of the S(α,β) thermal treatment:				
2	5.68959E-03	3.50683E-02	6.04401E-03	3.31377E-02
3	2.00962E-02	1.23865E-01	3.26436E-02	1.78976E-01
5	8.64557E-02	5.32878E-01	1.25104E-01	6.85911E-01
8	1.62243E-01	1.00000E+00	1.82391E-01	1.00000E+00
10	1.62016E-01	9.98601E-01	1.61083E-01	8.83174E-01
12	1.49054E-01	9.18708E-01	1.24290E-01	6.81451E-01

## Response in case of <sup>241</sup>Am-Be and <sup>252</sup>Cf Source, WITH Thermal Treatment



**Response in case of <sup>241</sup>Am-Be and <sup>252</sup>Cf Source, WITHOUT Thermal Treatment**

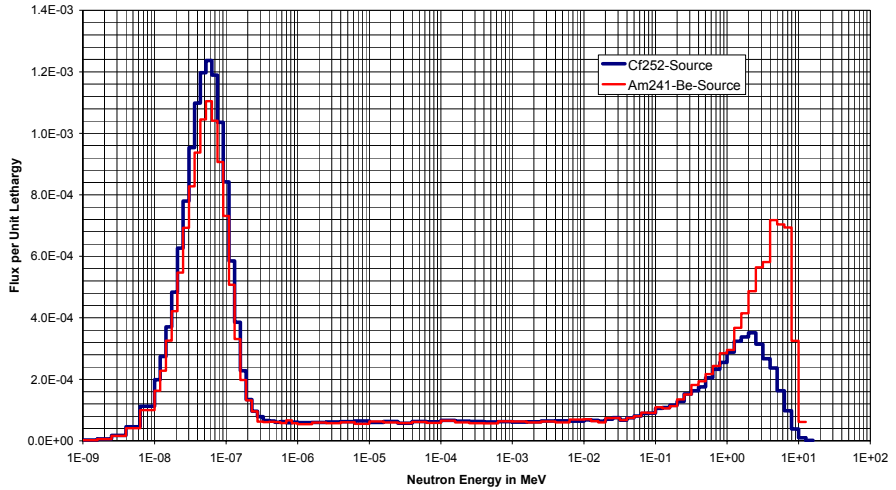


**8" Sphere, Neutron Flux Density per Incident Neutron in Inner 0.1mm Lenticular Layer on Crystal Front Side (1)**

<sup>241</sup> Am-Be-Source		<sup>252</sup> Cf-Source	
Neutron Flux Density			
in 1/cm <sup>2</sup> /s	Relative Error	in 1/cm <sup>2</sup> /s	Relative Error
4.36905E-03	0.0036	4.01306E-03	0.0017
Without Thermal Treatment:			
4.09499E-03	0.0040	3.67522E-03	0.0070

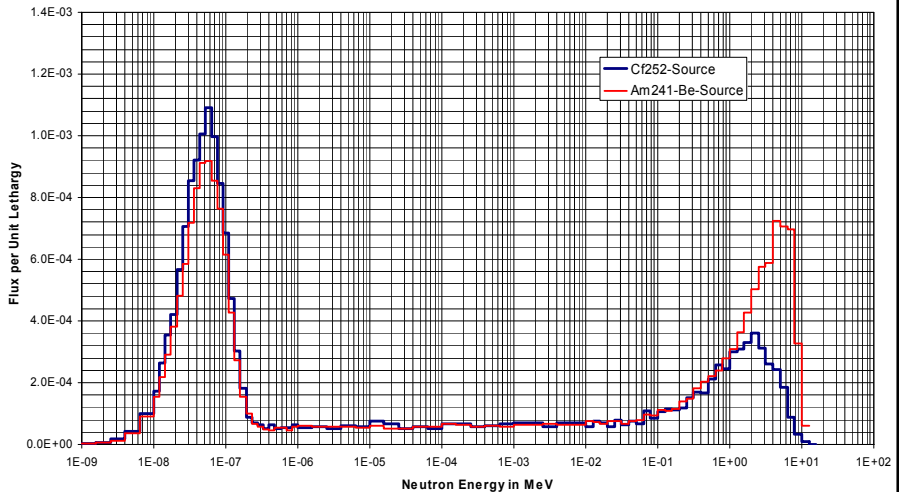
**8" Sphere, Neutron Flux Density per Incident Neutron in Inner 0.1mm Lenticular Layer on Crystal Front Side, WITH Thermal Treatment**

**Equilethargic Representation of the Neutron Spectra within the Inner 0.1 mm Lenticular Layer on the Crystal Front Side**



**8" Sphere, Neutron Flux Density per Incident Neutron in Inner 0.1mm Lenticular Layer on Crystal Front Side, WITHOUT Thermal Treatment**

**Equilethargic Representation of the Neutron Spectra within the Inner 0.1 mm Lenticular Layer on the Crystal Front Side**



***Don't forget the  
thermal treatment  
in case of Bonner  
spheres!***