SOURCES4 Validation

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The SOURCES4 Code

- The SOURCES 4A code is capable of calculating neutron production rates for four different problem configurations : interface, homogeneous, beam, three regions.

- A homogeneous mixture problem is one in which the a-emitting material and spontaneous fission sources are intimately mixed with the low-Z target material (i.e., at&ns of cx-emittingmaterial are directly adjacent to the target aA beam problem is one in which a monoenergetic et-beam is incident upon a slab containing low-Z target material (see Fig. 3).

Interface problem

Interface problems exist when a slab of a-emitting material (such as Pu, Po, or Am) is in close contact with a low-Z target material (such as Be, C, or Al). In these problems, cx-particles are emitted from the Region I materials and travel across the interface junction into the Region II materials. In Region II, the et-particles can interact through (a,n) reactions and generate a neutron source. It is necessary to assume that in all interface problems the thickness of each region is significantly larger than the range of the et-particles within it. Also, it will be assumed that all cx-particles travel in a straight-line trajectory from their point of emission (generally an excellent assumption).

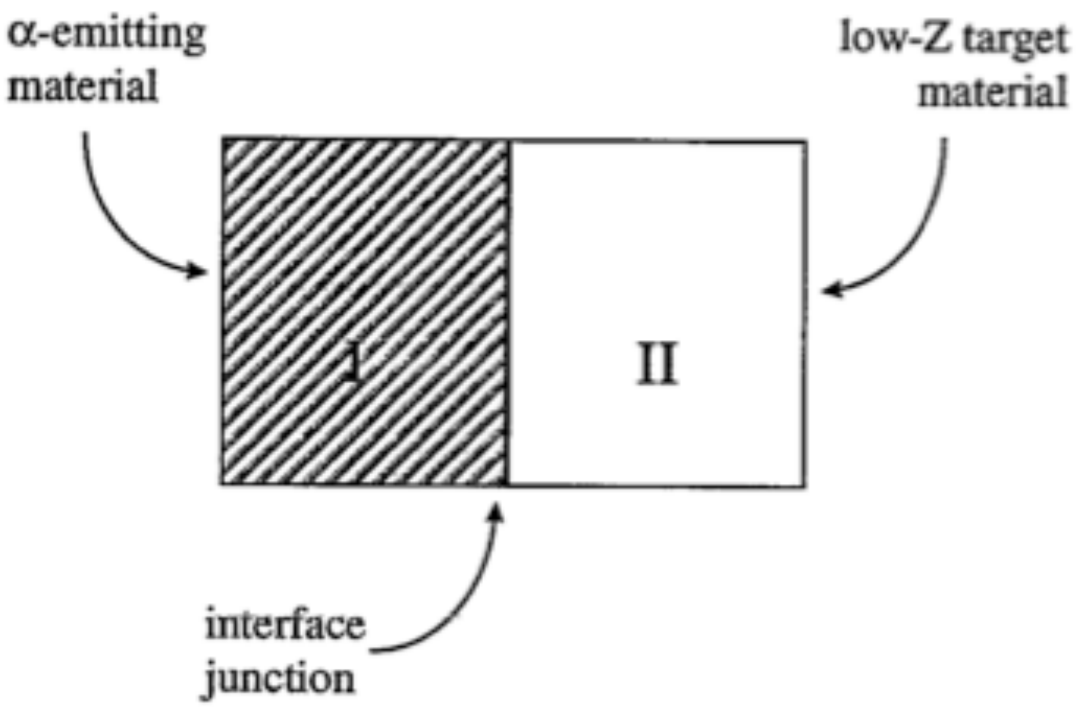

Fig. 4. General Schematic for Interface Problems.

Beam problem

A beam problem is one in which a monoenergetic et-beam is incident upon a slab containing low-Z target material. It is a necessary condition that the thickness of the slab of target material (t) be significantly larger than the range of the cx-particles in the beam (i.e., that all c+particles come to rest within the target slab).

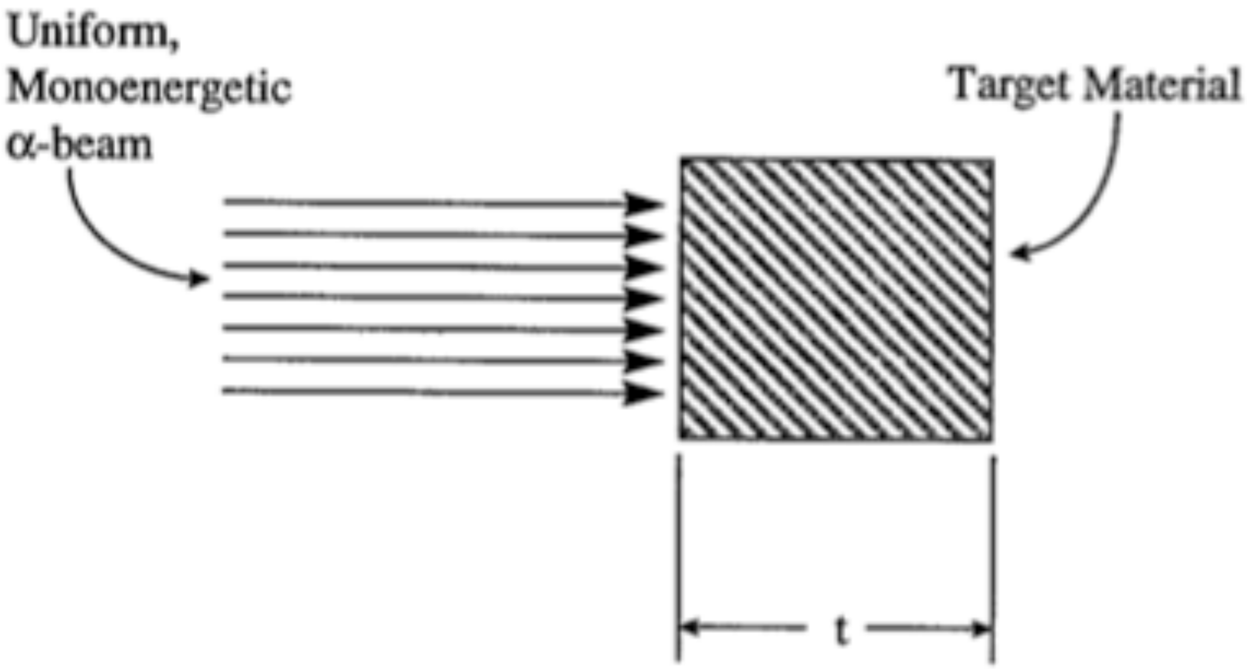

Fig. 3. General Schematic for Beam Problems.

Three region problem

A three-region (cx,n) problem consists of an u-emitting slab (such as Pu, Po, or Am) in direct contact with a thin slab of low-Z target material (such as Be, C, or Al) which is itself in contact with a thick (a,n) target. In this particular problem, u-particles born in region A, can slow through region A to interface ab, slow through region B to interface bc, and slow to a stop in region C. Thus, neutrons can be produced in both region B and region C due to the slowing cx-particles.

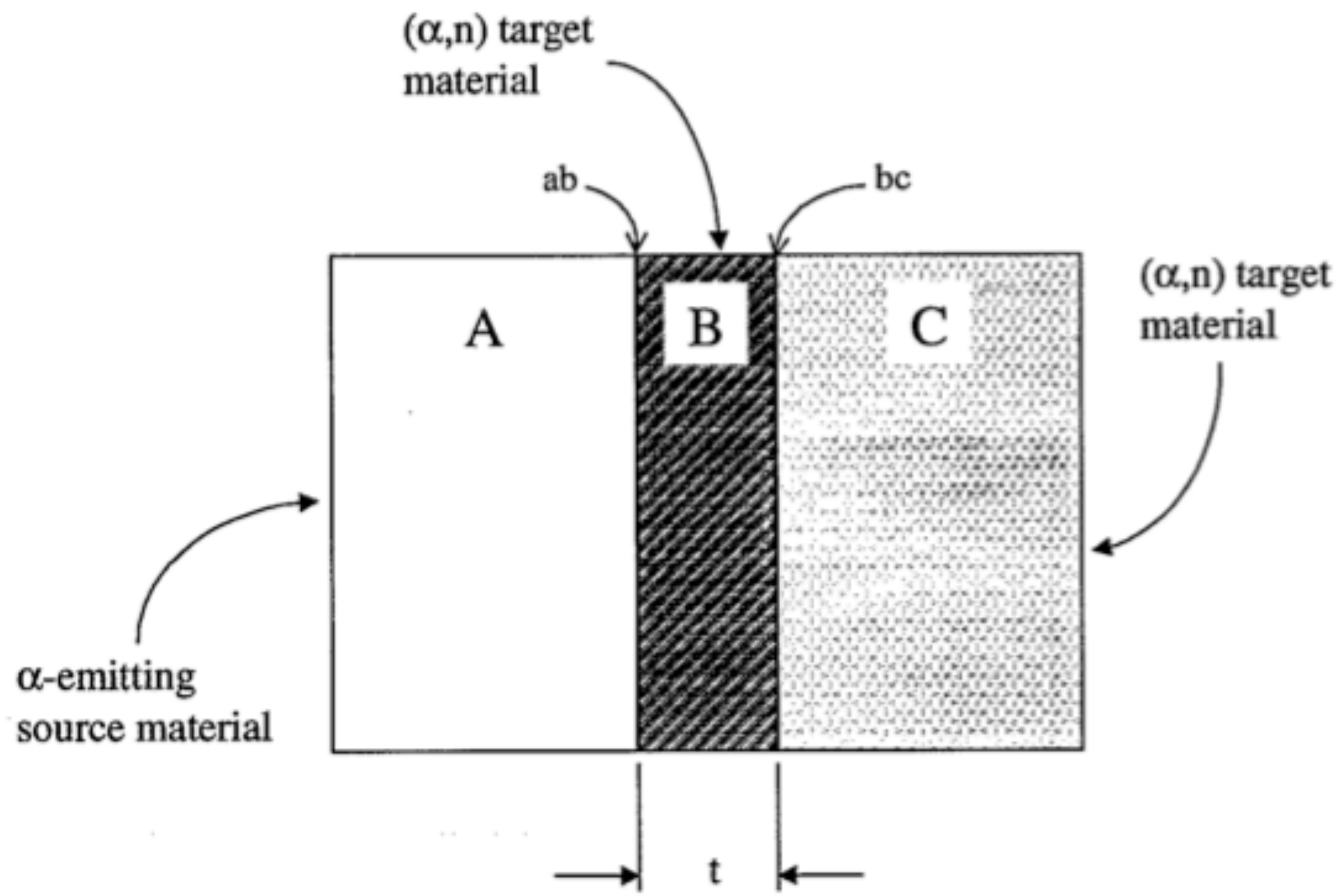

Fig. 6. General Schematic for Three-Region Interface Problem.

Homogenous mixture

PuBe13 Source (Stewart, 1953)

This problem illustrates the neutron source magnitudes and spectra from a PuBel3 source (elemental constituents are 13/14 Be and l/14 Pu) with six isotopes of Pu (Pu-237, Pu-238, Pu-239, Pu-240, Pu-241, and Pu-242) and one isotope of Be (Be-9) present. The example solves for the magnitude and spectra and uses a 48 group neutron energy structure) which is linearly interpolated between 12.0 and 0.0 MeV. The six Pu isotopes are used as sources, and the one beryllium isotope is the target.This input deck is an appropriate model of the experimental measurement performed by L, Stewart (STEWART, “Determination of the Neutron Spectrum and Absolute Yield of a Plutonium-Beryllium Source,” Master’s Thesis, University of Texas (1953).)

A comparison of the data measured by the experimenters and the SOURCES 4A calculation is shown in the next slide. Reasonable agreement between the SOURCES 4A spectrum calculation and the measured values is found. The calculation neglected any source contaminants (esp., Am- 241), because they were not specified in the published experiment.

The total neutron source magnitude calculated by SOURCES 4A was 2.69x10^5 neutrons/s-cm3, whereas the experimenters reported a total neutron source rate of 2.28x10^5 neutrons/s-cm3.

This magnitude of agreement (17%) is standard for a SOURCES 4A calculation.

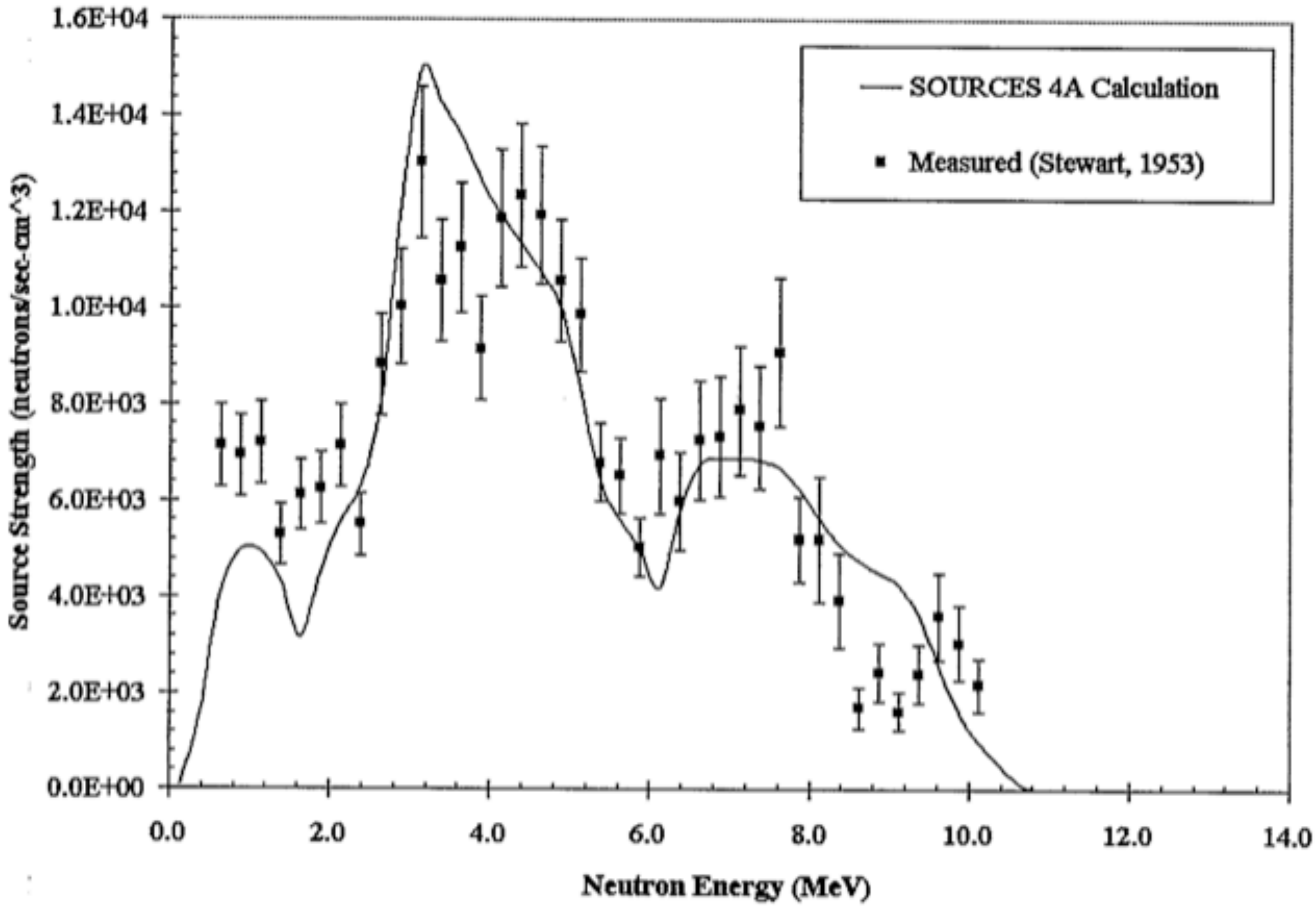

Fig. 9. Energy-Dependent Neutron Source Strength in $PuBe_{13}$ Homogeneous Problem as Calculated by SOURCES 4A and Compared with Measured Data.

Po-Be (1)
Homogenous source problem

Using the photographic emulsion method, researchers at Los Alamos National Laboratory measured the neutron energy spectrum from a Po-Be source.

The source was a mixture of Po and Be metals in the shape of a cylinder 3/8” in diameter and 1/4” in height.

The total source activity was reported by the researchers as 100 mCi.

This source configuration was modeled as a homogeneous source problem using SOURCES 4A.
The problem was executed to acquire the neutron source energy spectrum plotted in Fig. 12 next slide.

The SOURCES 4A calculation appears to overestimate the average neutron energy produced tiom the sample. On further analysis, it can be found that a Po-Be source, though a mixture of ot-ernitting material and (ct,n) target material, is composed of grains of Po and grains of Be. These grains have an average diameter significantly larger than the cx-particlerange. Thus, it is postulated that a Po-Be source is more properly modeled as an interface problem of Po and Be. This theory is supported by the calculations showed in next slides

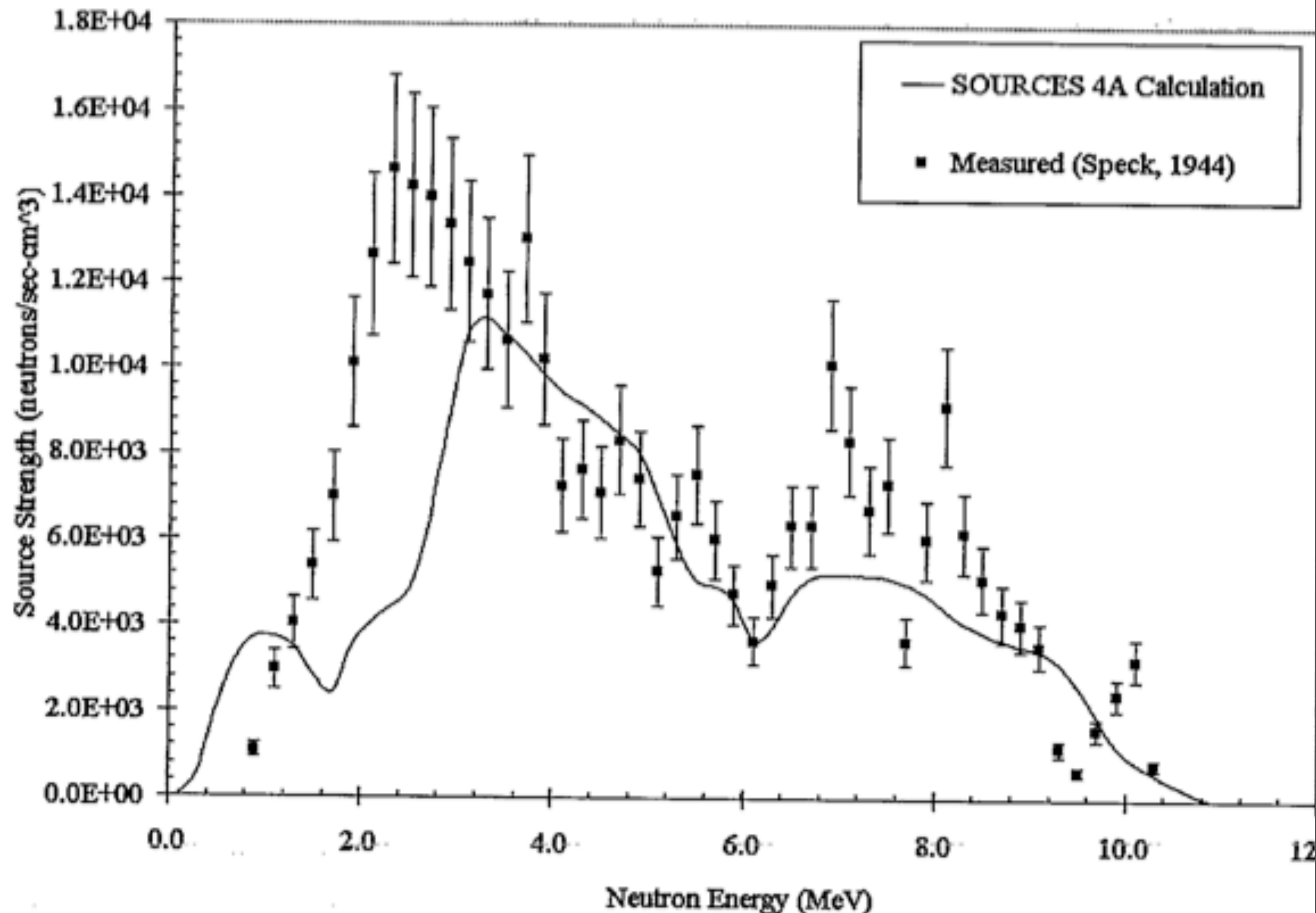

Fig. 12. Energy-Dependent Neutron Source Strength in Po-Be Homogeneo Problem as Calculated by SOURCES 4A and Compared to Measured Data.

Po-Be (II) Interface problem

The SOURCES 4A calculation and the measured value appear to agree within a good degree of accuracy. This yields confirmation that a Po-Be (a,n) source is affected by the grain structure of its metal components.

It is important that any SOURCES 4A users consider this type of problem when modeling any realistic (a,n) sources.

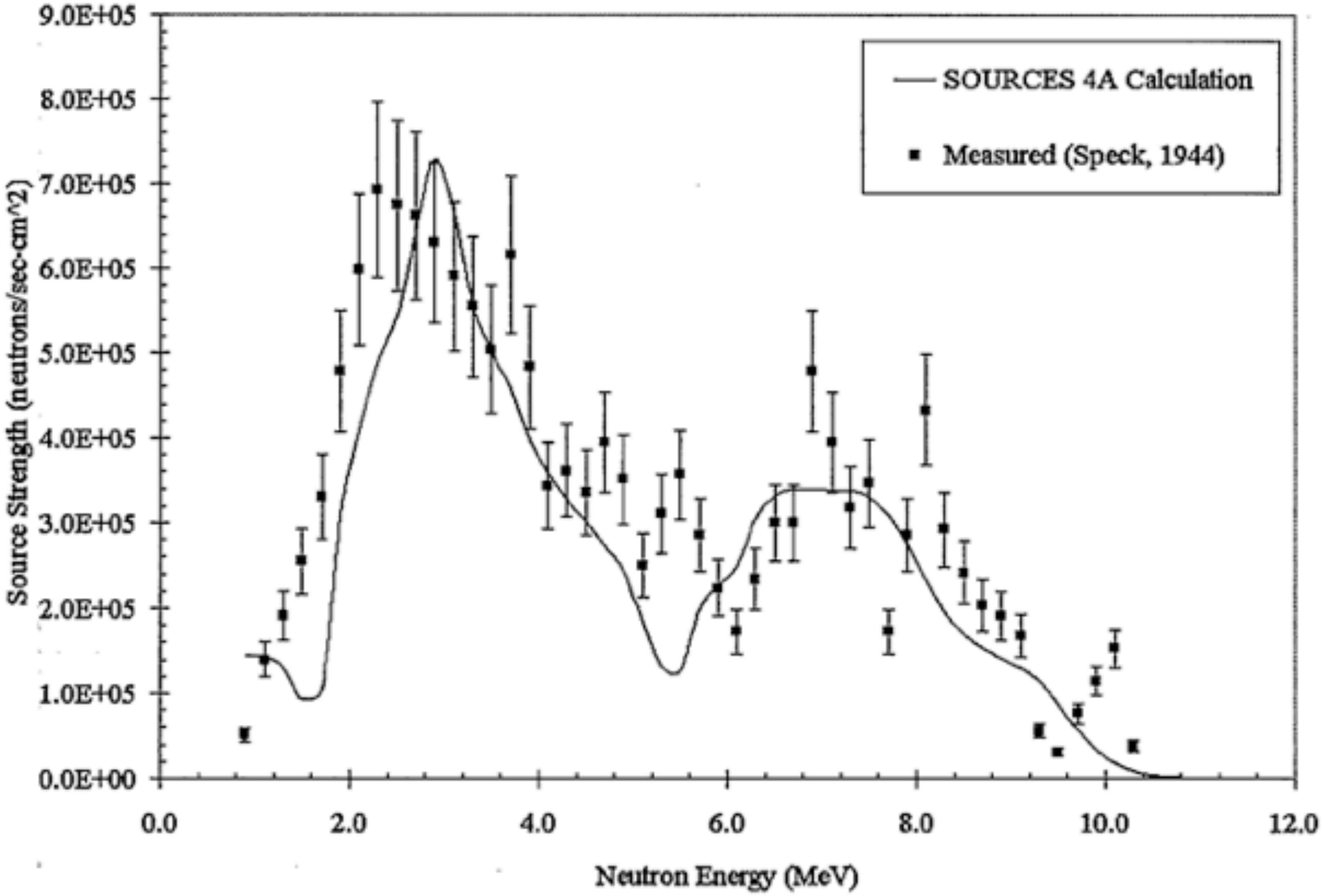

Fig. 17. Energy-Dependent Neutron Source Strength in Po-Be Interface Problem as Calculated by SOURCES 4A and Compared to Measured Data.

Beam problem

Alpha Beam of 5.5 MeV on magnesium. The magnesium sample contains two naturally occurring isotopes (Mg-25 and Mg-26) as (a,n)target nuclides. The isotope Mg-24 was neglected due to its negligible (a,n) cross section. The neutron energy group structure consisted of 81 energy groups in 0.1 MeV bins.

The total neutron yield per incident a-particle was reported by the experimenters to be 1.33x104 neutrons/a-particle.
The SOURCES 4A calculation output a value of 1.27x104 neutrons/a-particle.
The measured average neutron energy was 2.85 & 0.12
MeV, where as SOURCES 4A reported an average energy of 3.04 MeV. The total neutron yields agree to within 5%.

The measured and calculated neutron energy spectra have excellent agreement (within experimental error).

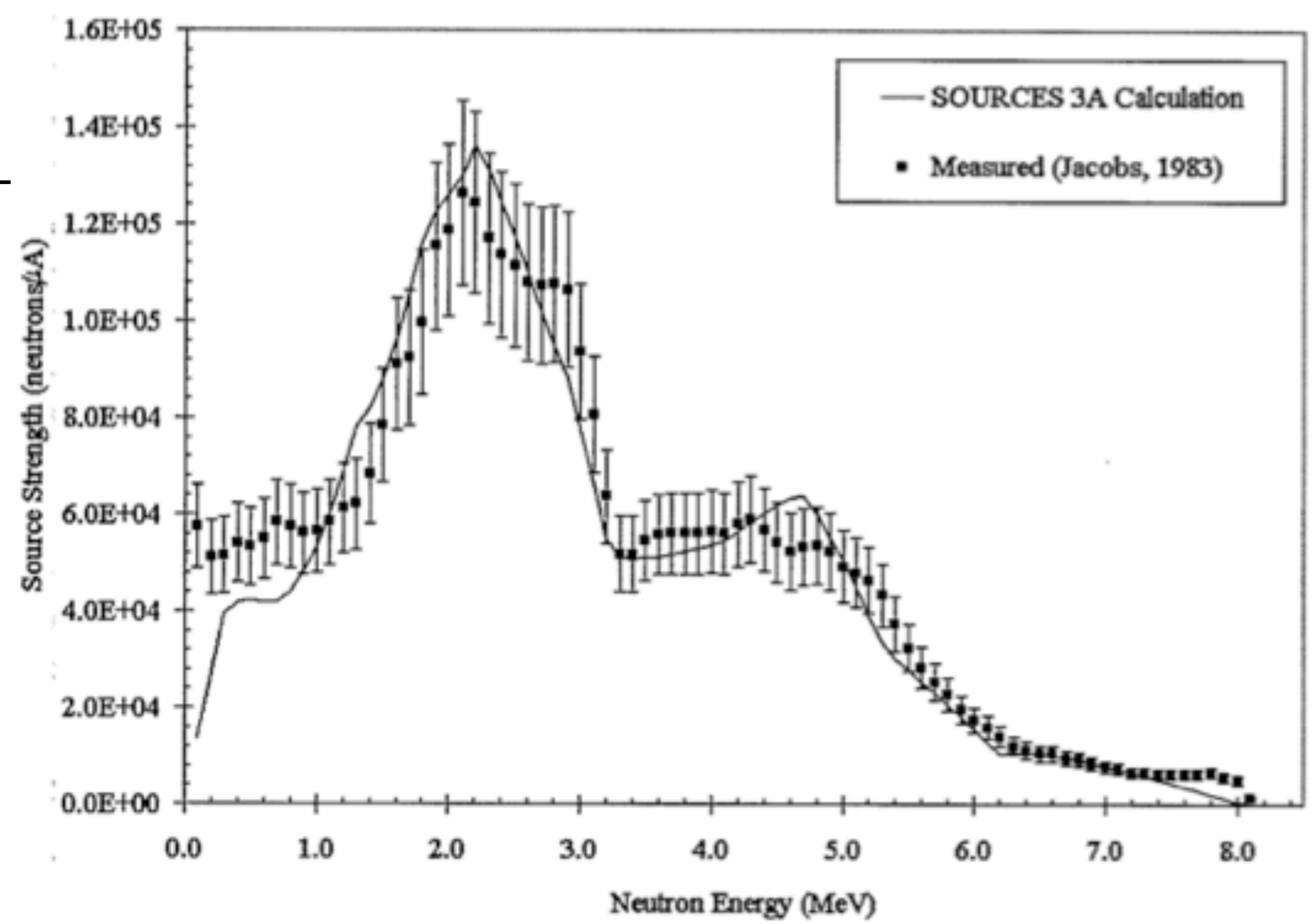

Fig. 21. Energy-Dependent Neutron Source Strength from 5.5 MeV α-Particles Incident on Magnesium Slab as Calculated by SOURCES 4A and Compared to Measured Data.

I showed validation of SOURCES4 code within the problem configuration (homogenous and interface) I used for calculating radiogenic neutron spectra

A validation for the beam problem is also provided