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From: Bhaskar Sur <SURB@crl.aecl.ca>  
Subject: Re: answers  
To: henry@mips2.Phy.QueensU.CA  
Message-Id: <01H0LSB51SN691Y1JU@crl.aecl.ca>  
X-Vms-To: IN%"henry@mips2.Phy.QueensU.CA"  
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SNO-STR-93-031

Dear Henry:

Here is the text of the initial gas-jet proposal. The rest of this letter follows this text, so read on to the end please ! [Also, from somewhere deep within the bowels of CRL, your FAX of yesterday morning appeared on my desk just about quitting time yesterday ! ]

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INITIAL MEMO ON A GAS TRANSPORT SYSTEM FOR SNO CALIBRATION

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February 1993.

From: Bhaskar Sur,  
A.E.C.L. Research, Chalk River Laboratory.

Dear Bill (Frati):

In reply to your enquiry about gas transport thoughts, here is a hastily written "proposal". It should in no way be treated as formal, and the names on the author list are put there without permission and with the intent of coercing these people to work on the project. I think a real yield calculation is very difficult, so [if the collaboration wishes for this idea to proceed], the thing to do would be a test.

The advantages of a gas transport system are that:

- 1) It is cheap [no separate water system, no acrylic piping to install, no neutron generator to buy]. It is also very fast.
- 2) It looks like it may be possible to get by without a high intensity neutron generator { and as I understand it, the associated cost and hassle }
- 3) Gas transportation by laminar flow in a capillary is well understood technically; there is a vast amount of experience with it here (and elsewhere).
- 4) The system is versatile: it looks like it can be used for at least 2 sources (16N and 8Li) and possibly more. The source decay chamber can be designed as desired and (in reply to the issue of 16N betas raised in your letter) in particular can be internally lined with a (say, metal) beta absorber. [I assume this chamber which will be positioned inside the D2O will be externally all acrylic.]
- 5) The option of a permanent source flow arrangement remains. One need now only install a capillary (flexible, very very little mass ...) inside the

etc. etc. etc. ...

My phone number here is (613) 584-1807 ext. 3980

Unfortunately, due to a previous engagement at Notre-Dame U., I can't make the meeting in Kingston next week. Is it possible to make a late entry into the Penn meeting ?

Regards

Sur.

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A PRELIMINARY PROPOSAL FOR USING A GAS-CAPILLARY TRANSPORT SYSTEM FOR SNO CALIBRATION SOURCES.

B.Sur, D.Earle (in absentia), E.Bonvin (without permission), R.Deal, E.Gaudet

I. The 6.13 MeV gamma from  $^{160}\text{Gd}$  .

Method: Produce  $^{16}\text{N}$  ( $t(1/2)=7.13$  s) via the  $^{19}\text{F}(n,\alpha)$  reaction.

Target: Teflon =  $(\text{CF}_2)$ polymer; density= upto 2.3

Neutron source: Pu-Be or Am-Be completely sealed source of modest strength ( $\sim 5 \times 10^5$  neutrons/sec).  
<Average Neutron Energy>  $\sim 6$  MeV (?) .

A small D-T generator could also be envisaged.

Transport: Collect  $^{16}\text{N}$  recoils and transport to a "decay chamber" inside SNO via a  $\text{N}_2$  gas capillary.

Calculation of Activity:

Effective target thickness for collecting recoils  
= Range of recoil ions in target.

For  $E_{\text{neutron}}=6$  MeV, Max recoil energy of  $^{16}\text{N}$  = 1.97 MeV.  
(at  $\Theta_{\text{lab}}=0$  deg, {  $Q = -1.53$  MeV } )

Let us take average recoil energy = 1 MeV.

Range of 1 MeV  $^{16}\text{N}$  ions in teflon = effective target thickness  
=  $0.62 \text{ mg cm}^{-2}$

(n,alpha) cross-section at { $E_{\text{neutron}} = < 6 \text{ MeV } >$ } = 200 milli barn

Therefore for each 6 MeV neutron hitting a teflon target, we can extract

$$\frac{0.62\text{E-}03 \text{ [g/cm}^2\text{]} \times N_{\text{avogadro}} \times 2 \times 2\text{E-}25 \text{ [cm}^2\text{]}}{\text{gram mol. wt. of teflon}} = 2.8\text{E-}06 \text{ atoms of } ^{16}\text{N}$$

Note: 1) I have used  $\text{CF}_2$  as the molecule of teflon. I don't know if this should be the case in a polymer.

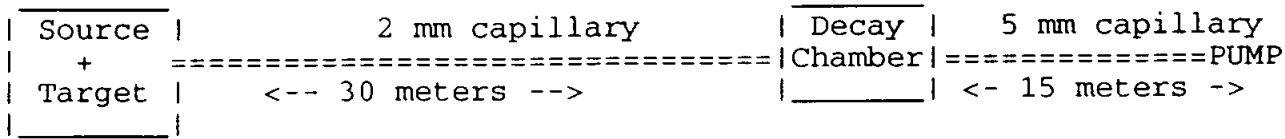
2) The actual calculation of yield is very ! convoluted !  
 One should fold the neutron yield from the source at each energy with the cross-section AND with the effective target thickness computed using the angular distribution of the recoils. However, I expect this very rough calc. is good within an order of magnitude at worst.

3

Therefore, with say 10 teflon foils surrounding completely a say  $5 \times 10^5$  n/sec source, we should get a yield (and therefore an activity) of roughly  $15 \text{ sec}^{-1}$ . I assume this more than enough for SNO.

Calculation of gas transport parameters.

I used a viscous flow code (GASFLOW) used by the ISOL group here at Chalk River. They have extensive experience with gas transport systems (one of the reasons I thought this idea would be feasible) and they assure me that the results from the code are reasonable. I only tried some 10-15 variations on my own before hitting the following workable solution. The ISOL group here assures me that there are several variations and tricks by which flow rates, pressures transport time can be adjusted. The solution I hit is :

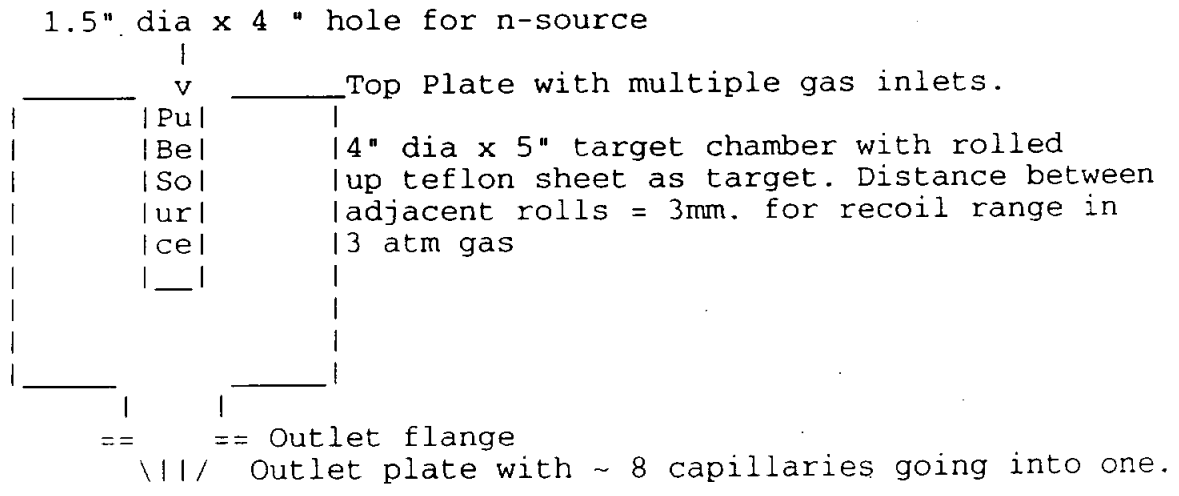


$3 \text{ atmospheres}$  P=0  
 <-- t\_xport = 0.55 sec ---> -< t = 0.19 sec ->

Gas flow rate = 379 STP cc/sec. (~ 23 liters/min)

The gas would of-course be nitrogen, either from the cover gas system or from a bottle+LN2 trap.

The source + target configuration that we are getting built for a test looks like:



When we do the test, we will find out if the 16N likes to come with the nitrogen stream without an aerosol. We have made arrangements to use the ISOL group's gas flow system and can also use their NaCl oven to

get an aerosol.

Of-course we can also invert the above set-up, fill it with water, and sweep out the  $^{16}\text{N}$  from the  $^{16}\text{O}(n,p)$  reaction with the nitrogen bubbles. I don't know if the  $^{16}\text{N}$  ions will behave like a gas and preferentially come out in the gas phase.

## II. $^8\text{Li}$ .

Here the reaction to be used is  $^7\text{Li}(n,\gamma)$ . A low energy neutron source is preferred, or  $^7\text{Li}$  foils in the target chamber can produce some thermalization. The recoil range however is miniscule. So the idea is to use a Li salt as the aerosol+target. We are looking for an appropriate salt (there appear to be several). The calculations are straightforward. One writes down a differential equation for the gas flow and obtains a yield as a function of chamber dimensions (average area and volume), flow rate, pressure, and rate of Li salt take-up in the gas stream. For a salt with  $M=50\text{g}$ , take-up rate = 10 microgram/sec, gas flow rate = 300 STP cc/sec, chamber pressure = 3 atm, average chamber (ie. target) area =  $38\text{ cm}^2$ , and volume = 235 cc, neutron source =  $10^5$  THERMAL neutrons/sec I get a delivery rate of 7.4  $^8\text{Li}$  per second at the chamber output. With a transport time of 0.55 sec, a little less than half this yield will reach the "decay chamber" deep inside SNO.

Again the proof of the pudding is in the eating. The ISOL group tells us we are welcome to contaminate their oven tube with a Lithium salt if we so desire. They think the scheme will work if our production numbers are right.

Any other sources ?

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Back to the letter:

I have just about finished writing a much more formal report on the N-1 we did. You'll be getting it soon.

Michal's point:

The pancake part's volume is 400 cc. not 200. But I think that indeed about 200 cc of it will be "dead" volume as far as Ra extraction is concerned. So 20% of the beads are inactive. This was basically a compromise to get BOTH extraction and emanation geometries into a single column without making the column complicated to machine, have moving parts, or have to be opened for transfer from one geometry to the other.

Fins might work, and I'll think about what they do to the emanation. Basically you don't want too much of a path length through beads for the Rn to have to go through before it hits free space. A variation on that was suggested by Emmanuel: Block out the central part of the pancake. Either way, I would think of doing this as a retrofit (attached perhaps to the frit retainer assembly).

Transferring the beads from a tube to a separate pancake between water flow and counting is of-course the obvious thing to do and is avoided here on the "principle" of sealed transfer. It requires either (a) exposing the beads to air and the possible resultant contamination; or (b) having some sort of valve between the two volumes with (i) resultant moving parts (hard to design and machine) and more importantly (ii) making a gas tight seal in the presence of small beads, grit and fines which may be impossible to do.

Thank you for pursuing the column issues. Let me know if anything else

+C. Desires