DUMAND – Deep Underwater Muon and Neutrino Detection

February 22, 1980
Hawaii DUMAND Note 80-5

MEMORANDUM

TO: DUMAND Group

FROM: John Learned

SUBJECT: A New Type of Module

A new approach to making a light trap has (somewhat) crystallized in my thinking and I want to share it with you for comments, refinement and criticism. I'll write it up more formally later. The idea is simple but was arrived at in a somewhat roundabout way. It is simply to use an inflatable (with perhaps fresh water) bag which is gathered together and attached to the phototube. The bag is the light collecting surface with photons trapped in it (not in the volume which it surrounds). Here are some dimension:

PMT area = 125 cm^2 (∿a 5" tube)

Bag thickness = 1 mm

Bag diameter = 4 m

Gross collection area = 12.8 m^2

Collection fraction (with $n_1 = \frac{4}{3}$ and $n_2 = \frac{3}{2}$) = .46

Art's unit 17 g/m^2 Vic's unit: s=59

Sensitivity = .59 P.E./Quanta/m^2 = 1 P.E./1.7 Q/m^2 = 59 P.E./100 Q/m^2

K^{40} noise = 880 kHz (at 1 P.E.)

Effective collection area = 5.85 m^2

Collection area gain = 468

(Compared to <25 for the UNI = Urchin)

Volume of material in bag = .05 m^3

(Compared to ∿2 m^3 in UNI)

Cost of plastic ≈ \$100 (at \$1/pound?)

Surrounded volume of water = 33.5 m^3/module

(Total surrounded volume in array ≈ 800 K tons ≈
A super tanker of nice mountain spring water)

The above suggests to me that we fill the modules from the surface via the drill stem with fresh water. This accomplishes:

a) Modules go down with minimum mass when being installed

b) Provides the string bouyancy (maybe too much at nearly one ton per module). But large cross sections will need large bouyancy - same problem, maybe worse, for UNI.

c) No growth inside bags

d) Keeps high n_{pe} counts from contained K^{40} decays down (probably not a big deal though)

e) One can put a little wavelength shifter inside (e.g., quinine (tonic) water) and save some central PMT area to catch the inner light. Perhaps the inner surface of the bag can be aluminized and made white inside to optimize internal light collection. Notice that we thereby get a nearly 10^6 ton, super, low energy neutrino detector ∿ free!!

It may be that filling from the surface is too much bother and (as George Wilkins suggested when I tried the idea out on him) one could use shore power and a bottom located pump for inflation. Details...

A slight variation, with substantial merit: put two phototube modules on a bag and use local fast coincidences to keep the noise rate down. Notice that this scheme whips the long-tail-of-K^{40} noise and after-pulse problems and that one set of (digitization and control) electronics could be shared. There's no reason not to sum the amplitudes while keeping seperate high level, coincidence-seeking discriminators. Because phase space is mixed up, one can use an arbitrary number of detectors viewing the same spatial region. Note that by using a 20 ns coincidence, with two tubes sharing the signal from the bag size as above, the individual noise rates of 440 kHz go down to ∿4kHz coincidence with each at the 1 P.E. level. Even adding a little threshold to each to cover long (but independent) tails on the noise distribution, doesn't bother us. The sensitivity of this detector is 5 to 10 times better than heretofore assumed.

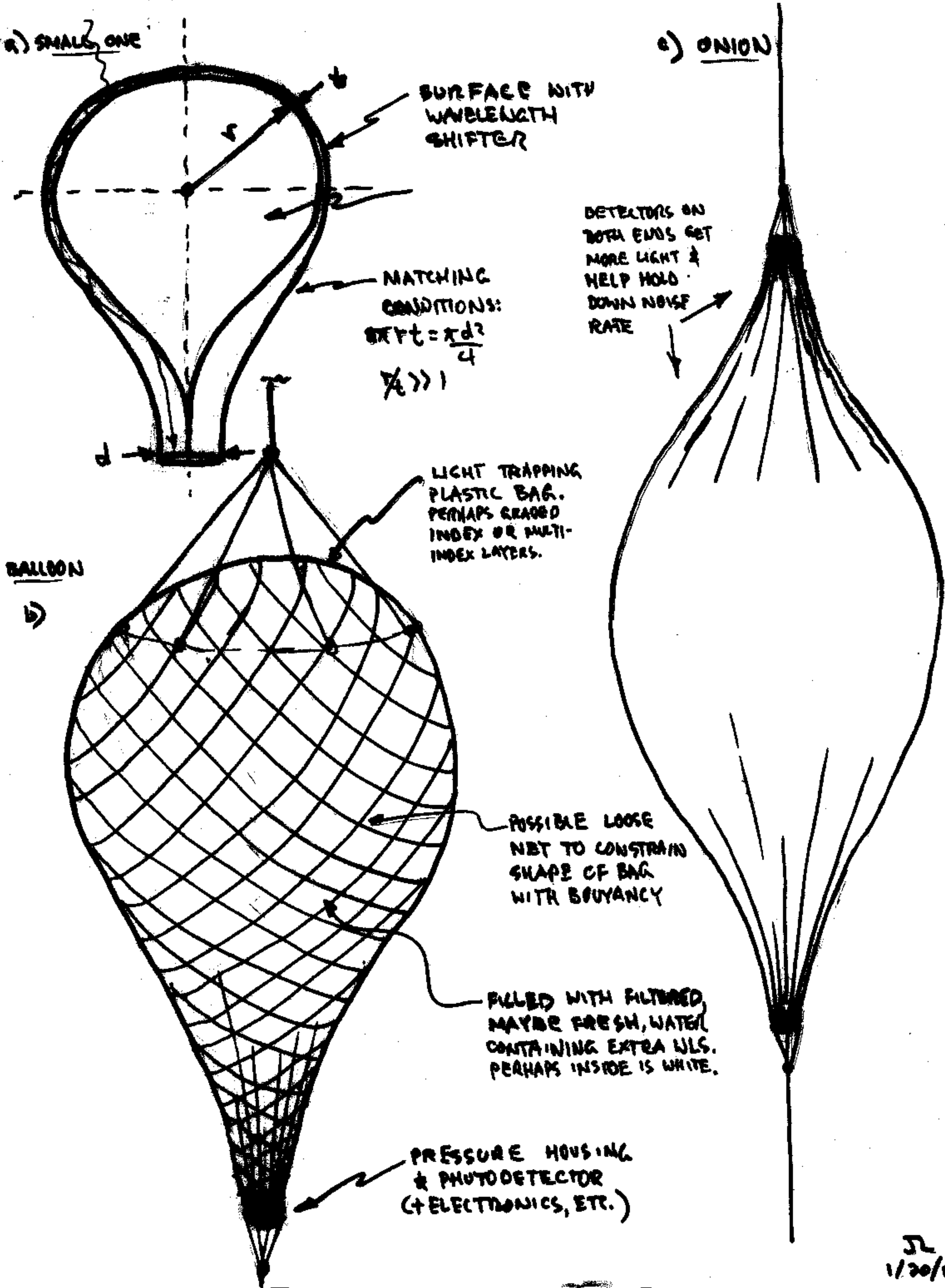
Questions: is this right? Can one make such bags that will trap light with reasonably good efficiency over several meters while only 1mm thick? (They could be somewhat thicker I suppose but would get stiff - if this turns out to be the big hassle, how about inner and outer bags with liquid+wls in between?...Nasty) Can one make the transitions sufficiently adiabatic to provide full trapping gain? Long term plastics in the ocean? Why didn't I think of this before? (same question of you)? Tonight I'm full of enthusiasm and believe it to be the coalescence of ideas we've needed. I hope it looks this good tomorrow after you get your hands on it!

P.S. How about a catchy name?

P.P.S. Just realized I forgot the "theory" such as it is. I believe I can argue that this is a nearly optimal light trap for the given amount of high index of refraction material. It collects phase space better than UNI and it has higher inherent (parallel surface) trapping. UNI, as did the 1978 sausage, has much wasted volume of material (which is expensive).

P.P.P.S. Could we use osmotic pressure pumps to inflate the bags? I've discussed the idea with several folks and have heard no objections in principle. Is it practical though?

SKETCHES OF LIGHT TRAPS



JL
1/30/80