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A PROPOSAL TO INCREASE THE PRECISION OF THE 25-FOOT BUBBLE CHAMBER

R. Palmer
Brookhaven National Laboratory

ABSTRACT

In addition to the 3 main cameras, 2 fiducial volume cameras are proposed that would photograph a limited volume at higher magnification, higher resolution, and smaller bubble-growth time.

In addition to the 3 main cameras it is proposed here to provide two fiducial volume cameras to take high-resolution, high-precision photographs of a limited fiducial volume. The fiducial volume proposed would be 5 m long, 2 m wide, and about 30 cm deep in the beam plane, situated at the upstream end of the chamber. This volume would be photographed by two special lenses with a demagnification of 30 times. The image would then be 65 mm wide, 160 mm long, and would thus be similar to that for the main cameras. The resolution of these lenses would, as in the main lenses, be limited by consideration of the depth of focus required. We have

$$\delta \approx 1/2\sqrt{D\lambda} \ ,$$

where D = full depth of focus, λ is the wave length of light, and δ is the full width at half height of an image of an infinitesimal source. For the main lenses $D \approx 300$ cm, $\lambda = 5\ 10^{-5}$ cm, and $\delta = 0.6$ mm. In contrast for the fiducial cameras we have $D = 30$ cm and $\delta = 0.2$ mm. The images on the film would then be 7μ which is essentially the same as for the main lenses. The f number of the fiducial volume lenses would also be approximately the same as for the main lenses, only the focal length and field angle are different, i.e., 67 mm and 100° instead of 27 mm and 140°. The smaller field required of the fiducial lenses assures that they will have a performance superior to the main lenses.

It should be noted here that when Scotchlite is used for illumination, as is the proposal for the 25-foot, then each lens has its own flash lamp. Only light from a particular camera's lamp illuminates its film. It follows that the light delay used by different lenses may be different. The light delay required by any lens is related to its resolution since for good contrast it is required that the bubble diameter be of the same order of size as the resolution. Thus the high-resolution fiducial cameras would in general use a shorter bubble-growth time than the main cameras. The tracks they would see would be only 200μ wide instead of 600μ for the main cameras. The bubble growth time used would be only 1/9 as long, because the bubble size grows as $\sqrt{\text{time}}$.

Some doubt might be expressed as to the ability to photograph with such high resolution through such a long path of hydrogen. The present experience with the 7 foot is encouraging since 200μ wide fiducials were seen through 10 feet of hydrogen even when the chamber was near sensitivity. However, if this did prove to be a problem, the fiducial cameras could be inserted into the chamber on tubes so that the distance of hydrogen through which they photograph is less.

At this point we see that the present proposal can be compared with W. D. Walker's suggestion.[1] Indeed, many fiducial cameras could be inserted which would result in photographing through a reduced thickness without giving up the advantage of the large volume for γ conversion, trapping, and neutrino physics. This author is not here proposing more than 2 such cameras for reasons of analysis complication, but the similarity with Walker's proposal is still there.

It is further proposed that there be 10 parallel laser beams in the beam plane spaced at 20-cm intervals across the width of the fiducial volume. The laser beams would be observed in the photographs by the light that is scattered by the liquid from the beam. Such beams have been used at CERN and are known to be visible. The beams would provide a reference against which angles and curvatures could be compared. They could be easily measured by machines like the HPD and would not be confused with tracks since they would be lighter instead of darker than the background.

Let us now consider the possible causes of low precision in a large chamber and see how the proposed fiducial lenses would help.

1. Distortion due to liquid flow between the time the tracks pass and the cameras photograph. The fiducial lenses will have 3 times higher resolution than the main lenses and will therefore be able to photograph 3 times smaller bubbles. Since the bubble diameter is known to grow as $\sqrt{\text{time}}$, this means that the fiducial cameras can photograph bubbles after a growth time 1/9 of that for the main cameras. Thus the liquid flow distortion should be reduced by 1/9.

2. Optical distortion due to temperature gradients between the lens and tracks. Such distortion can have various mean lengths. If the mean length is small compared with 10 cm then such distortion will have little effect on the determination of angle and curvature of an average 1-meter long track. If, however, the distortion has a mean length long compared with 1 meter, then it can be observed by measuring the laser beams and corrections can be made.

3. Lens distortion and distortion due to misalignment of the shield and chamber windows can all be removed by measurements on the laser beams.

4. Film and measurement errors are reduced by a factor of 2.5 because the magnification is 2.5 times higher. The fiducial volume camera pictures will look very like 80-in. bubble-chamber pictures and will be measurable by conventional automatic devices such as PEPR, POLLY, spiral reader, etc.

Tracks in the fiducial volume should then be 200μ wide and the precision should be ~ 50μ or better, i.e., similar to the 80-in. bubble chamber. The high resolution volume will in fact be much larger than the 80-in. although much smaller than the whole chamber. The fiducial volume will allow precision measurements of all tracks associated with any primary strong interaction vertex and will enable proton recoils from deuterium to be seen down to a length comparable to what is possible in the 80-in. The rest of the chamber can be regarded as a secondary interaction detector where tracks are stopped or interact or where γ's are converted. The proposal, therefore, combines the advantages of a small high-precision bubble chamber with those of a large trapping chamber. It puts the high-precision chamber inside the large chamber.

REFERENCE

[1] W. D. Walker, Difficulties with Large Bubble Chambers, National Accelerator Laboratory 1969 Summer Study Report SS-10, Vol. II.