ACCELERATOR DEPARTMENT
Internal Report

AWM-2

BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, L.I., N.Y.

Facsimile Price \$ 11.00
 Microfilm Price \$ 80
 Available from the
 Office of Technical Services
 Department of Commerce
 Washington 25, D. C.

TARGET EFFICIENCY MEASUREMENTS AT THE AGS**MASTER**

A.W. Maschke

June 6, 1962

A standard method for measuring target efficiency is the radio-chemical method, from which is determined the number of protons N which traverse the target. In order to obtain a figure for the mean number of traversals $\bar{T}$, one has the relation $\bar{T} = N/I_0$, where I_0 is the beam monitor estimate (an integrated signal from a pick-up electrode, externally calibrated) of the number of circulating protons. Whereas N is determined to within a few percent, the beam monitor has a probable error of $\sim 20\%$. Furthermore, since targeting efficiency is in general a critical function of machine parameters, RBD* settings, etc., it is useful to have an alternate method which does not entail stopping the machine to insert target foil etc. Counter measurements, taken simultaneously with the pick-up electrode signals enable one to determine $\bar{T}$ in a manner independent of the calibration of the beam monitor.

Consider a signal $S(t)$ from a spill counter looking at the target. $S(t) = K\alpha(t)I(t)$, where $I(t)$ is the beam intensity as measured from a pick-up electrode, $\alpha(t)$ is the fraction of the beam which is intercepting the target at any given time, and K is a constant for a fixed measurement. K can be determined by making a plot of $K\alpha(t) = S/I$. If one knows that at sometime $\alpha(t) = 1$, then K may be determined. One method for doing this is to give the beam a large deflection with the RBD. A plot of $K\alpha$ will show a plateau at $\alpha = 1$.

*Rapid Beam Reflector giving $\sim 1''$ deflection with a rise time of $\sim 20 \mu\text{sec}$.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

If targeting starts at t_0 , we can write the following relation:

$$\bar{T} = \frac{\frac{1}{\tau} \int_{t_0}^{\infty} S(t) dt}{KI_0}$$

where $I_0 = I(t_0)$, and τ is the period of a single revolution. There are several methods of measuring the integral. For long spills (> 5 ms) it is necessary to use an integrating network, since the broadening of the bunches give rise to a nonlinear response in the spill and pick-up electrode signals. For shorter spills, the amount of debunching is small, and the envelope gives a good indication of S and I . For very fast spills ~ 20 - 30 μ sec, the individual bunches can be distinguished. In this case it is useful to trace the history of a single bunch through the targets. Our formula then becomes simply:

$$\bar{T} = \frac{\sum S_i}{KI_0}$$

One source of difficulty in making these measurements is the fact that the intensity of the radiation varies by a factor of 1000 between very short and very long spills. This necessitates considerable change in the gain of the scintillation counter in order to avoid saturation effects. We can unite $K = cgf$, where g is the gain of the phototube and scope preamp, and f is the fraction of the beam lost in making a single traversal through the target. This is in general dependent upon the thickness T of the target. We have in fact: $f = 1 - e^{-T/L}$, where L is the nuclear interaction length for that particular target material.

Another method for measuring the target efficiency which is most useful for slow spills is an adaptation of a method used at CERN. Strictly speaking it puts an upper bound on the efficiency. Whereas with the previous methods, one determined η from the relation $\eta = \bar{T}f$, this method determines η directly. One makes the assumption that the targeting efficiency is highest at the commencement of the spill.

For instance, suppose that at time t_1 , $I(t_1) = .9I_0$. Then we can write:

$$\eta(t_1) = \frac{\int_{t_0}^{t_1} S(t)dt}{\int_{t_0}^{\infty} S(t)dt} \cdot \frac{I_0 - I(t_1)}{I_0}$$

We have the relation here then that $\eta \leq \eta(t_1)$, since the efficiency may not be 100 % even at the commencement of targeting. If we allow t_1 to approach t_0 , we get:

$$\eta(t_0) = \frac{\int_{t_0}^{\infty} S(t)dt}{I_0} \cdot \left(\frac{dI}{dt}\right)_0 \cdot \frac{1}{\left(\frac{dv}{dt}\right)_0}$$

where

$$V(t) \equiv \int_{t_0}^t S(t')dt'$$

Several interesting by-products of these measurements came out. For instance, one can determine the horizontal density distribution of the bunches by observing the spill as α increases. Also the details of the dynamic behavior of the beam during targeting can be studied. In fact one can observe the "instantaneous" efficiency, and see exactly where the loss is occurring. Measurements made to date have agreed to within about 10 % to those made by radio-chemical means. Further studies will be needed to determine the energy dependence of the c factor.

AWM:ab

6/6/62

Distribution: B1, B2, B3.