MPS/Int./VA 61-9
14.7.1961.

SOME EXPERIENCES CONCERNING INTERNAL PS TARGET EFFICIENCY MEASUREMENTS

About two months ago the target group started with a programme for relative and abolute efficiency measurements of standard and other target heads.

Experiments have been made with some methods of measurements and although the progress made is not very important, (especially due to more urgent target experiments during the rather short effective development time) it seems worth noting these experiments together with our future programme.

General experimental conditions

The target efficiency is defined as :

$$\eta = \frac{\text{number of protons absorbed and scattered out of the machine at target position}}{\text{number of accelerated protons}}$$

The number of secondary particles ($\div$ number of protons absorbed and scattered in the target) can be measured either by Čerenkov counters or by an ionization chamber.

The number of protons are measured either by Hereward's current transformer or by (Fischer's) digital voltmeter.

Some basic requirements for reliable efficiency measurements with Čerenkov counters are :

a the linearity of the counters; this was checked with integrated burst output at different monitor voltages and beam intensities. Reliable conditions for all monitors with a linearity within 2 °/o and at beam intensities up to $2{,}5 \times 10^{11}$ protons were found at counter voltages lower than 1600 V and counter output voltages lower than 0,2 V.

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b for short bursts ($<$ some ms) a 2 μF integrator on the counter output is sufficient; for longer bursts ($>$ 100ms) the integrator has to be increased to 20 or 50 μF

c differences in burst shapes between our counters and one of Cocconi's placed in the Berne beam behind the concrete wall are not detectable; also the Cocconi counter showed the same accuracy in linearity as mentioned in a.

Another apparatus, which can be used very well for these measurements, is an ionization chamber made by D. Harting et al., counting secondary particles. Recently (during the γ-run of 2/5 June) the linearity of this apparatus was checked at different beam intensities observing target 05 under an angle of 5°. The first check gave a linearity within 3% (on the sensitivity of approximately $\frac{10^8 \text{ particles}}{\text{sec.}}$ of the counter).

Relative efficiency measurements.

The relation between integrated burst outputs (divided by the beam intensity) from different target heads (e.g. mounted on the six-head target system) and measured with equal counter conditions should be identical with the relation between their efficiencies.

The same relation should be found between the integrated counter outputs of the ionization chamber.

No systematic measurements have been made up to now. Only the efficiencies of several beam-target operations ("cuts-through" with and without beam steering) with a 15 mm Be target in s.s. 05 have been compared. Within the accuracy of the method, no differences in efficiency were found. Increasing the thickness of the target (2 targets flipping at the same time) did not influence the efficiency.

Moving this target 05 radially from -25 mm to +25 mm and observing the integrated background current from the counters in s.s. 01 and 61 this background output changed 40% (see fig. 1).

At the same time H. Bingham measured with the ionization chamber the ratio $\frac{\text{total number of counts}}{\text{proton beam intensity}}$ looking at target 05 in an angle of 5^o. An output increase of about 10% was found varying the position of target from $\Delta r = 0$ to +25mm. This increase can be expected due to less influence of the fringing field of magnet 6.

It is perhaps interesting, that this measurement will be repeated with the ionization chamber placed in a much larger angle with the target ($60 - 90^o$) and with the Čerenkov counter above the target.

Absolute efficiency measurements.

Method 1. Comparing the fall off in proton current with the integrated burst shape.

This method is based on the fact that at the start of the long burst (say 10 ms) the loss of particles due to multiple scattering can be neglected.

Note : if we suppose that scattered protons smaller than 1,5 mrad (mean value) will remain in the machine than the necessary time for building up this angle for e.g. 50 µAl will be about 12 ms and for 50 µBe about 34 ms.

In practice the slopes of the integrated burst shape and of the signal of the Hereward transformer are made identical during the first 10 ms (see fig. 2). The efficiency η becomes the ratio $^a/b$.

A measurement on April 8th, 1961 with a 50 µ Be target gave an efficiency of 80%. Some measurements on a later date (during normal machine running) showed, however, that errors of 10% can be made easily. The reason is that small differences in slope during the first 10-20 ms are hardly noticeable on the scope.

A variation of this method is to absorb part of the beam by a fast target before the long burst starts. Now the integrated short burst trace has to be made equal to the current fall in the Hereward signal (see fig. 3). The ratio of the integrated long burst (a) and the intensity decrease during this burst (b) is the efficiency of the long burst target.

Note : if the burst length of the fast target is, say 700 μs, theoretically no important loss of particles by multiple scattering can be expected neither with 0,1 mm Cu Be nor with a 0,5 mm Al fast target.

The disadvantage of this method is the same as mentioned before : critical adjustment of the two fast target traces on the scope.

Method 2 : Using the absolute value of efficiency of a large foil target (J.A. Geibel) a comparison of the bursts from a normal and the large foil target eliminates the efficiency of the normal target.
A comparison has to be made both with a Čerenkov monitor and with an ionization chamber.

Conclusion.

The method of comparing integrated burst outputs with the target monitor seems adequate for measuring relative target efficiency measurements.

More accurate values for absolute target efficiencies seem to be obtained from a comparison between the bursts from the large foil target and a standard one. It is advisable to use the ionization chamber at these measurements.

Programme.

1. Comparing burst outputs from a 50 μ Be target (long burst production)

and a 15 mm Be target (short burst production). The ionization chamber has to be used as counter.

2. Comparing burst outputs from a 50 μ Be target and the 5 μ Al large foil target. The ionization chamber has to be used as a counter.

3. Comparison of burst outputs from :

a	50 μ Be foil	)	
b	50 μ Al foil	)	
c	∅ 0,5 Al rod	)	long burst production.
d	∅ 0,5 Be rod	)	
e	∅ 3 Al point source	)	

All these targets are fixed on the six-head target. The Čerenkov monitor can be used as a counter.

4. The same as (3), but with the following targets :

a	∅ 3 Al point source	)	long burst production.
b	∅ 3 Be point source	)	
c	∅ 3 Be point source	)	short burst production.
d	∅ 1 Be point source	)	

The ionization chamber has to be used as a counter.

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Distribution : (open)

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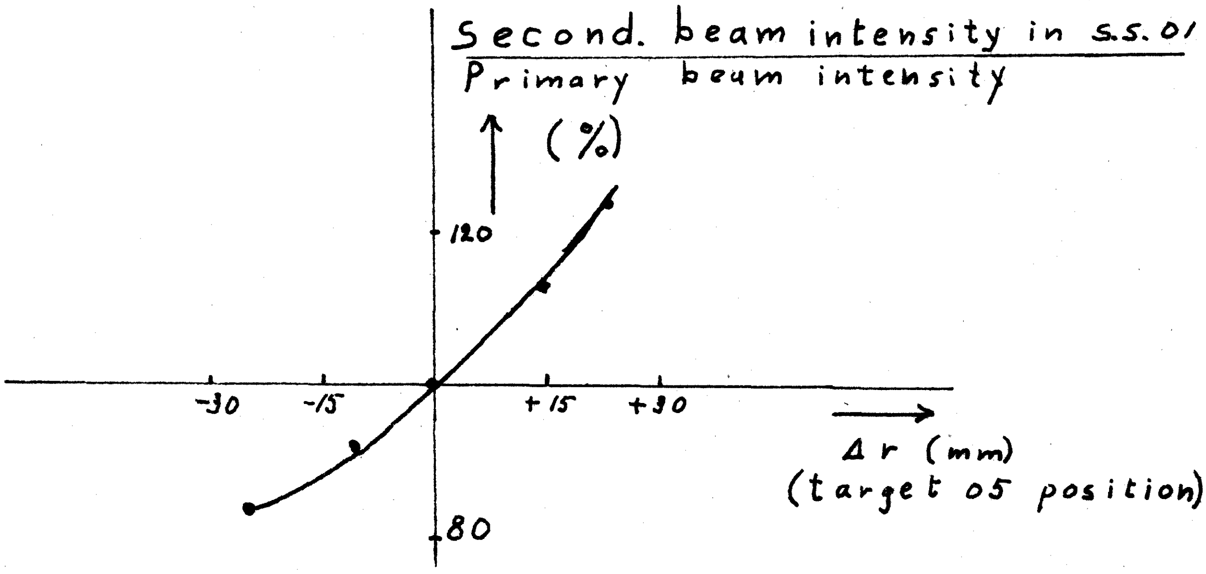

Fig. 1 A background measurement in s.s.01 with a 15 mm Be target in s.s.05 in operation. (4/6/61)

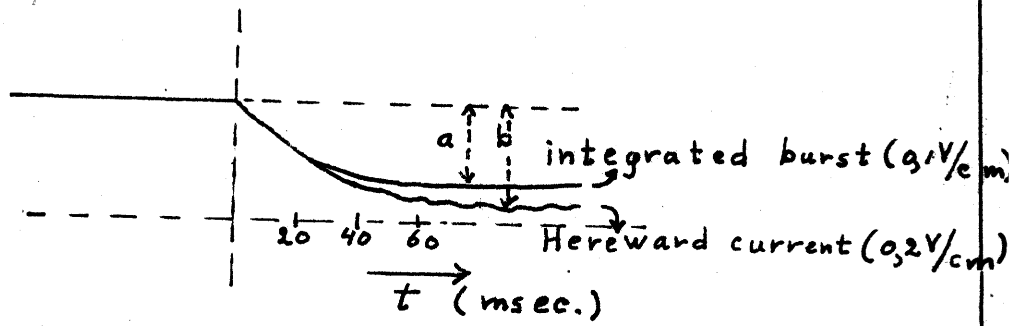

Fig. 2 An absolute efficiency measurement of ~~with~~ a 50μ Be target (8/4/61)

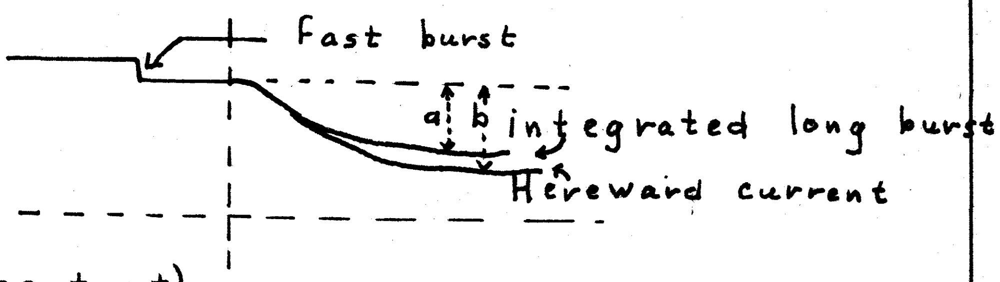

Fig. 3 (See text)

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10/6/61