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ANALYSIS OF STACK-TAIL $\frac{\Delta p}{p}$ INTERFERENCE WITH CORE COOLING

1. Cooling

An effort was made to understand the results of the experiment (see ME/Note 16) to study the interaction of the stack-tail $\left(\frac{\Delta p}{p}\right)$ and (HF) stack-core systems. The computer program of S. van der Meer was used with the following parameters:

(i) System 1 and system 2 gain set to give the observed thermal power of 200 Watts.

(ii) System 3 gain set to give the observed thermal power of 1 Watt.

(iii) System 3 pick-ups centered on 11.5 MeV (about 1855.3 kHz). This was the observed centroid of the distribution with the stack-tail off.

Unfortunately, these parameters are not well known, at least not to me, so they should be considered educated (?) guesses.

The filter response was left as it was found in the data file. Fig. 1 shows a comparison of the calculated and measured response. The errors in the measurements are probably $\sim$ 3 dB ($\sqrt{2}$ in voltage gain), so the agreement is fairly good. The measurements do seem to be somewhat higher than the calculations, but it would be better to make a more careful measurement of the filter response before drawing a firm conclusion.

The initial and final distributions for the first phase of the experiment (stack tail $\Delta p/p$ system gain reduced to a power level of 200 W) are shown in Figure 2. Comparison with Figure 1 shows that the beam distribution is centered around 11 MeV (1855.3 kHz) instead of the nominal 18 MeV (1855.0 kHz). Under these circumstances one would expect, for sufficiently high power levels in the stack-tail system, a diffusion of particles towards higher energy, where there is a relative maximum in the filter response.

The results of the computer calculation, shown in Fig. 3,agree with this expectation. A broad shoulder in the distribution develops at $\sim$ 15 MeV, where the thermal noise is large. The actual distribution observed (Fig. 2), however, agrees poorly with calculations. The cooling is much better than expected on the high energy side; much worse on the low energy side. In fact, the most surprising feature in Fig. 2 is the large shift in the mean of the distribution. The 3 curves in Fig. 3 are an attempt to simulate the behaviour seen in Fig. 2, by changing the delay in system 3. Curves are given were the synchronous particle has energies 11.5 (corresponding to the zero in gain from the pick-up), 25 and 40 MeV. While the curve with the large phase shift does create a distribution with larger densities on the low energy side, it does not convincingly reproduce the observed experimental behaviour. The large phase shifts are not entirely unreasonable since the HF system delays had not been adjusted at this time.

2. Unresolved Questions

1. The shift in the distribution to lower energies when the stack-tail system is turned on is not explained by the model. Why?

2. The gain of the HF system appears to be lower in practice than is normally assumed in the computer model. Has the gain been set to a lower value to improve the stacking rate? Is there some beam feedback effect which is reduced with a lower gain in the core? Note: most of the core blow-up observed with this stack would go away if the gain of the HF system were doubled.

What to do?

It would be nice to be able to make some conclusion as to whether the thermal noise in the stack-tail system is the major culprit in the blow-up of the core. I don't think it is possible to make any firm conclusions, but I find the data to be suggestive that the blow-up is caused, at least in parts, through this mechanism. I believe that it would be possible to make the filters slightly deeper (say 5 dB) without seriously compromising the phase characteristics on the stack-tail.

However, as long as the SPS luminosity lifetime is 16 hours, there will be little need to reduce the core blow-up which is a limitation only for dense stacks (say $\sim 10^{12}$ particles). Probably the most useful improvement would be to increase the $\bar{p}$ flux - both at production and accepted into the stack-tail.

3. More Experiments?

It would be interesting to repeat this experiment with more (say 10^{11}) $\bar{p}$'s and a system which has been properly tuned to give the proper phases and pick-up positions.

It would also be interesting to see how the cooling (heating) behaves as a function of gain in both the HF and LF systems.

Reported by: J. Marriner

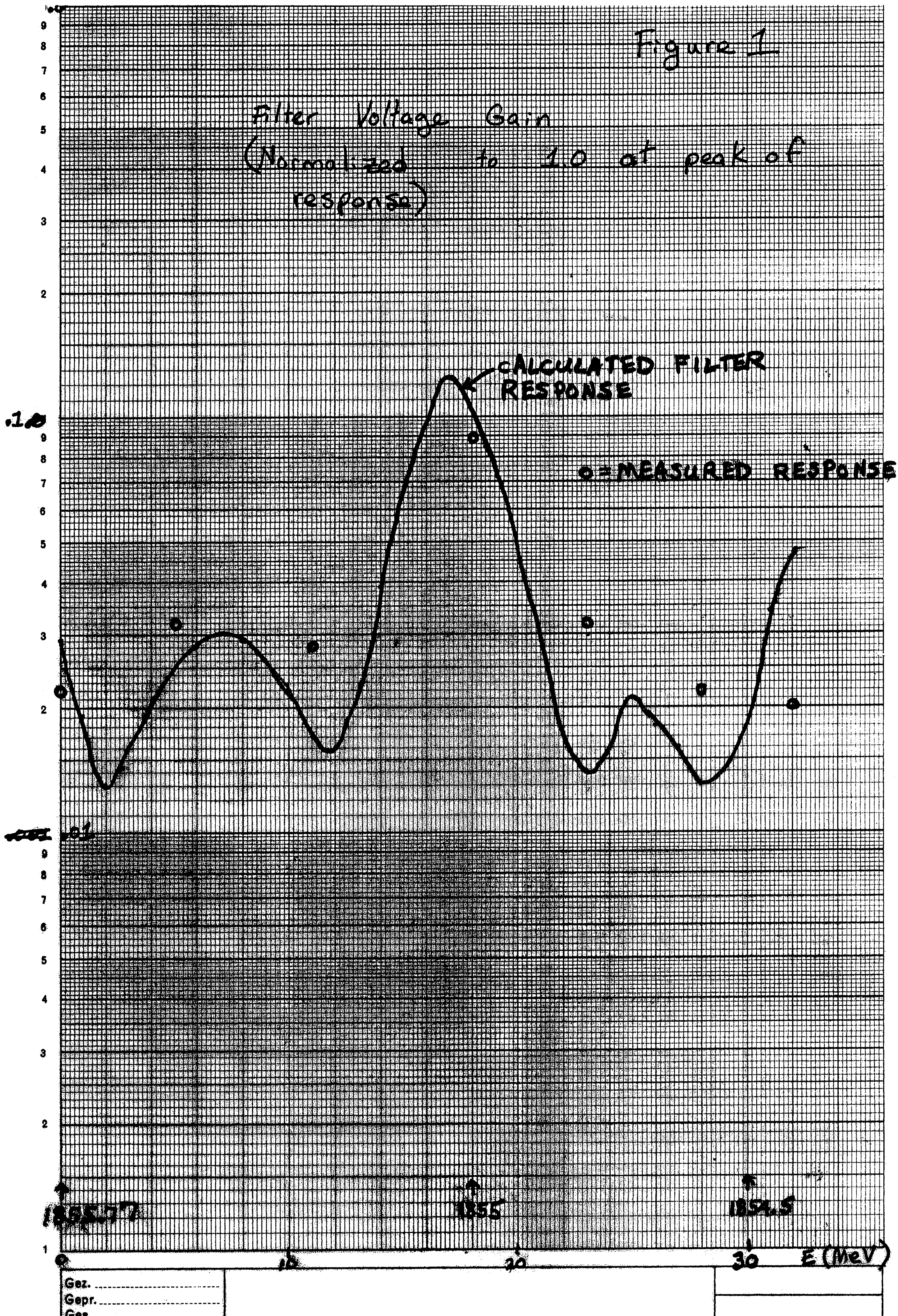
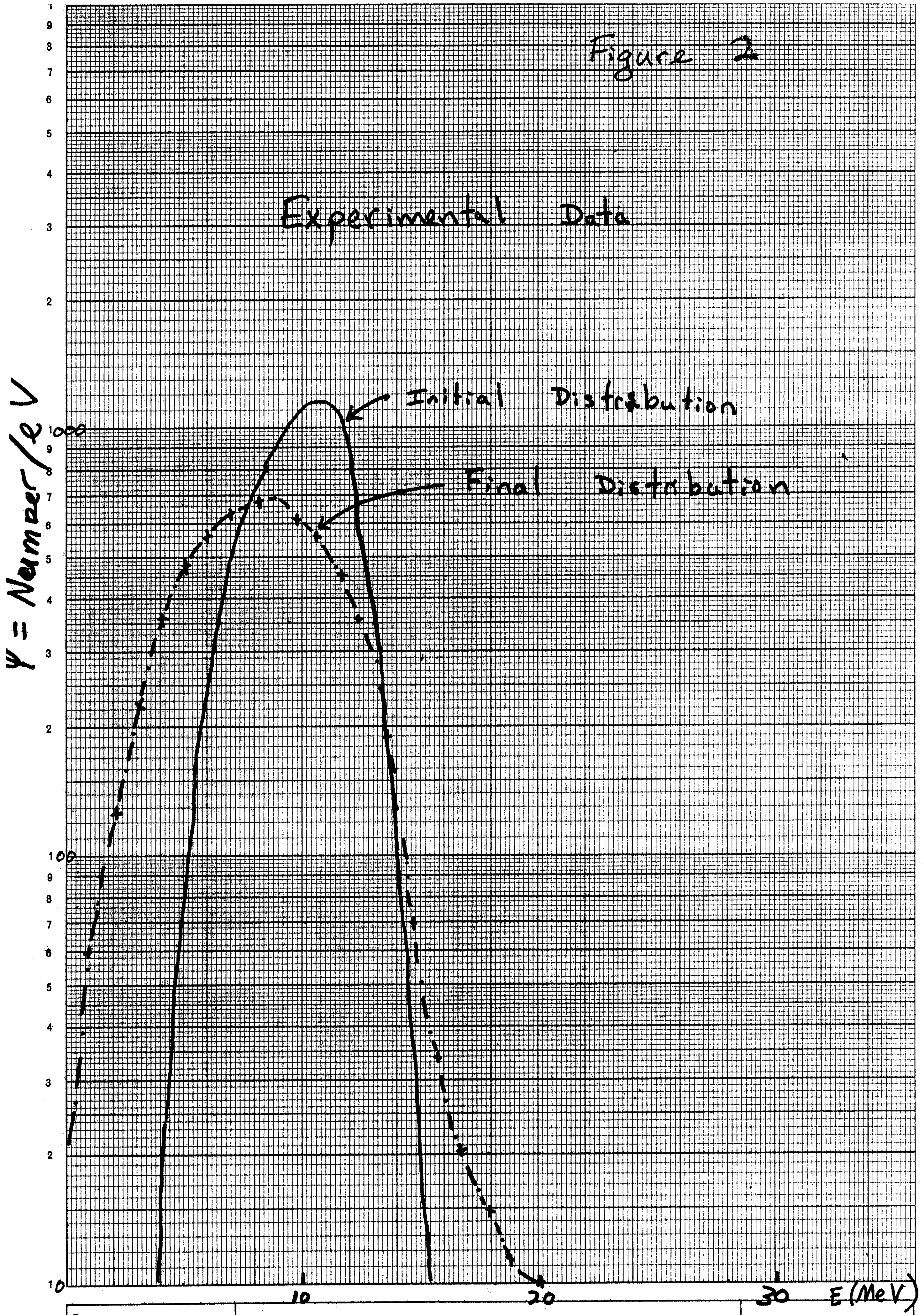


Figure 1
Filter Voltage Gain (Normalized to 1.0 at peak of response)
CALCULATED FILTER RESPONSE
o = MEASURED RESPONSE
1855.77
1855
1854.5
E (MeV)
Gez.
Gepr.
Ges.

Figure 2



Gez.
Gepr.
Ges.

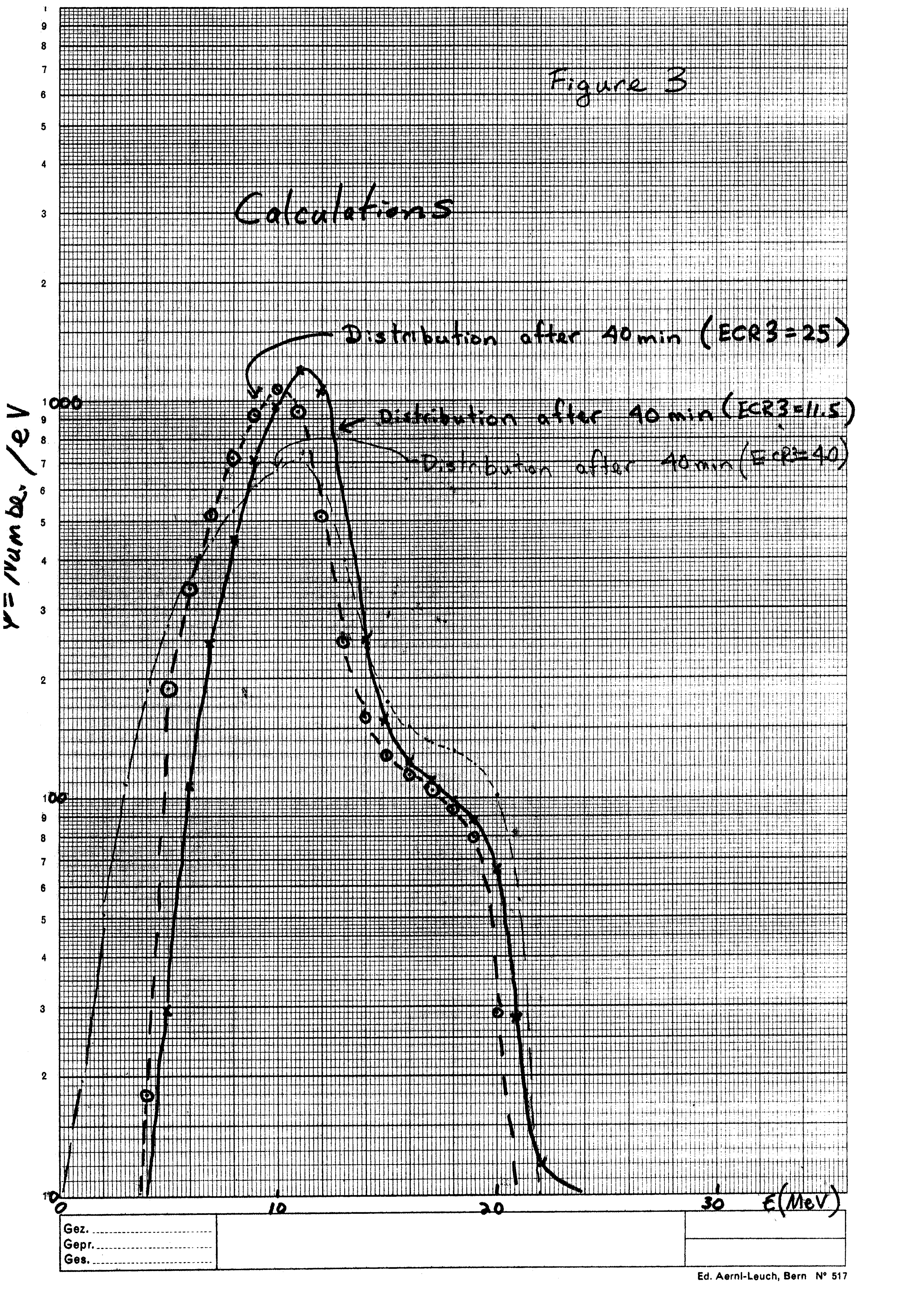


Figure 3
Calculations
Distribution after 40 min (ECR3 = 25)
Distribution after 40 min (ECR3 = 11.5)
Distribution after 40 min (ECR3 = 40)
Y = Number / eV
E (MeV)
0
10
20
30
100
1000
Gez.
Gepr.
Ges.
Ed. Aerni-Leuch, Bern N° 517