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STUDY OF RECENT PROBLEMS WITH THE STACK TAIL COOLING SYSTEM

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Abstract

Recently the stack tail gain profile in the Accumulator has been measured. This measurement is here used as input for theoretical computation of the stochastic cooling system. The conclusion of this calculation is that the change of sign of the real part of stack tail gain is the main culprit for the recent problems with the stochastic cooling. With the correct gain profile the expected improvement of the stacking rate is theoretically about a factor of two.

An analysis is presented of the recent stochastic cooling problems in the Accumulator based on the measurements of the stack tail integrated gain[1], shown in Fig. 1. From the observed stack profile, Fig. 2, it is evident that the problems are in the stack tail system. As we shall see, the main cause of the problems with the stack tail cooling system is the fact that the real part of ST gain changes sign at the revolution frequency 628,900 Hz.

One might think that the effect of this will be quite small, however, one has to consider the entire cooling system which consists of the ST *and* the core cooling systems. The maximal wrong-sign gain is some 13 dB smaller than the maximal right-sign gain, however, the real part of ST gain changes sign some 30 MeV/c above the core momentum, where the core cooling gain is some 10 dB smaller than its maximal value. Thus the weak core cooling and the stack tail system are interfering destructively at these momenta. The result is a barrier in the momentum space which causes the beam to pile up there and to have smaller than optimal flux toward the core.

These effects have been extensively studied in the computer simulation reported here and some of the results are shown below.

In Fig. 3 I show the design values of the real part of the gain in both systems. Since the log scale is used, what is shown is the absolute value of the real part, the change of sign being clear from the notches. The result of the computer calculation of 10 hour of stacking is shown in Fig. 4.

The stochastic stacking code[2] has been modified for this calculation such that an arbitrary gain profile can be used. Since the measured data exist for the stack tail system, but not for the core cooling system, we can at this point only do a hybrid calculation, *i.e.* use the **design core gain** combined with the **measured stack tail gain**. It would be desirable to obtain measurements of the core system as well, such that the simulation of the complete momentum cooling system may be done.

Let us now look at the data. The real part of the gain of both systems is shown in Fig. 5. The core gain is again as in Fig. 3, however, the stack tail gain is obtained from the measured values, Fig. 1. The indicated notch is at the position where the stack tail gain crosses zero. This significantly decreases the total gain, also shown in the figure. The corresponding stack profile after 10 hr is shown in Fig. 6. Notice the significant dip between the tail and the core. This actually looks worse than in reality, the reason most likely being that the real core gain is higher than the one used used in the computation and, as a result of that, the minimum in the total gain is less prominent.

Let us now remove the negative real part by replacing it with very small but positive gain, as shown in Fig. 7. The corresponding stack profile after 8 hrs. of stacking is shown in Fig. 8. The stack is more than twice the size of the one from Fig. 6, yet the only difference is that the real part of ST gain is now strictly positive.

The conclusion of this computation are:

1. It is imperative to measure the core gain profile, such that the complete simulation of the present system can be done. At present, we can only do the hybrid calculation described above, which evaluates the stack tail system *under the assumption that the core system has more or less its design profile.*

2. If this assumption is true, the conclusion of this study is that the local minimum in the total gain at 30 MeV/c above the core momentum is the cause of the present problems.

How much improvement in stacking rate can we expect if we change the gain profile from the one in Fig. 5 to something like that in Fig. 7? As mentioned, in this calculation the improvement is about a factor of two. This is most certainly an overestimate, but it is the best number we can give based on the present data.

REFERENCES

[1] R. Pasquinelli and S. Werkema, private communication.

[2] J. Marriner and V. Visnjic, Fermilab Stochastic Cooling Code, User's Guide, **PBAR Note # 498**, 1991.

-1 MeV: att: 0 dB, delay: 0 ps, phase: 90 deg
16 MeV: att: 0 dB, delay: 0 ps, phase: 90 deg

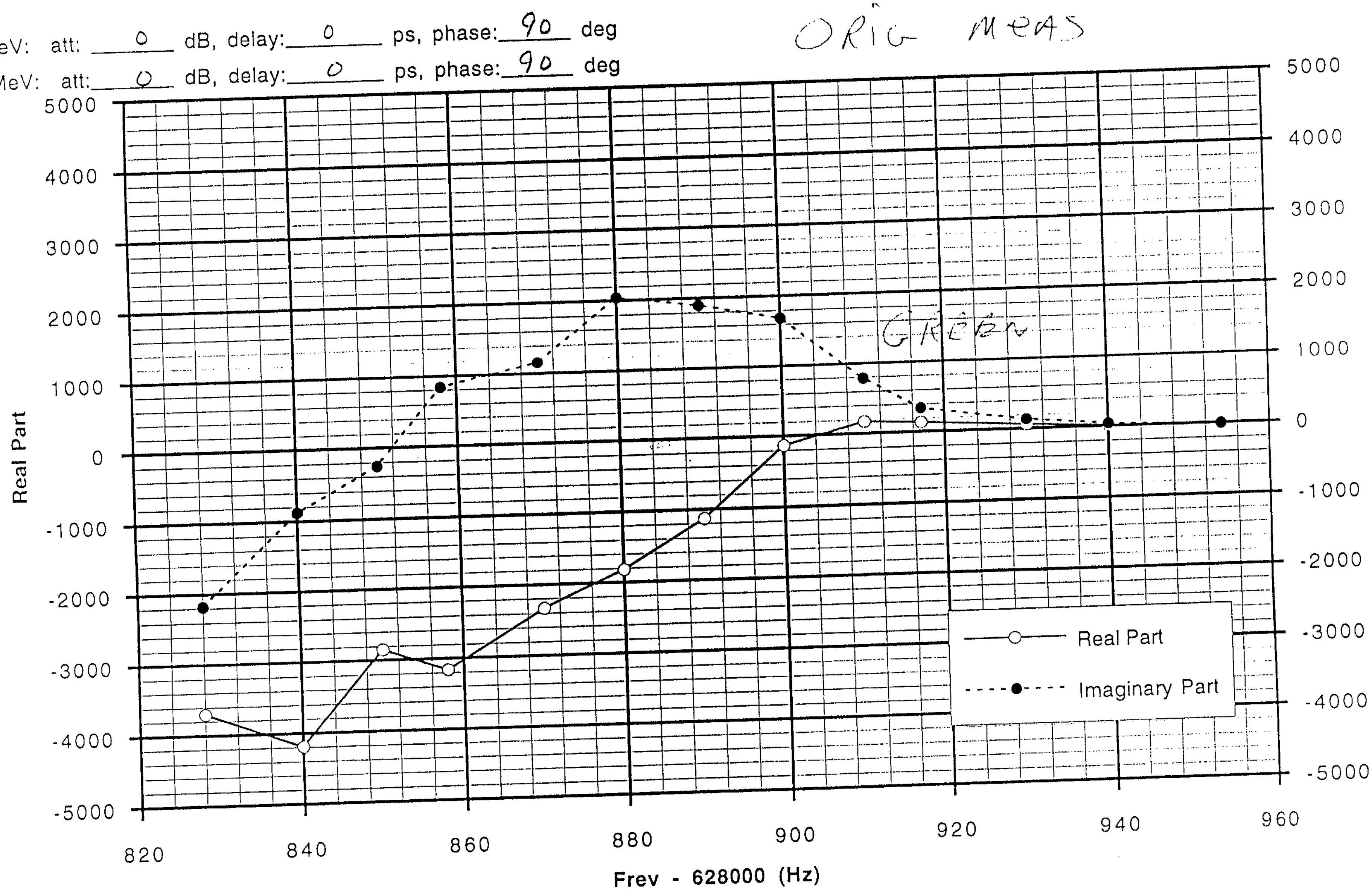


Fig. 1

S. Werkema

2/16/94 17:53

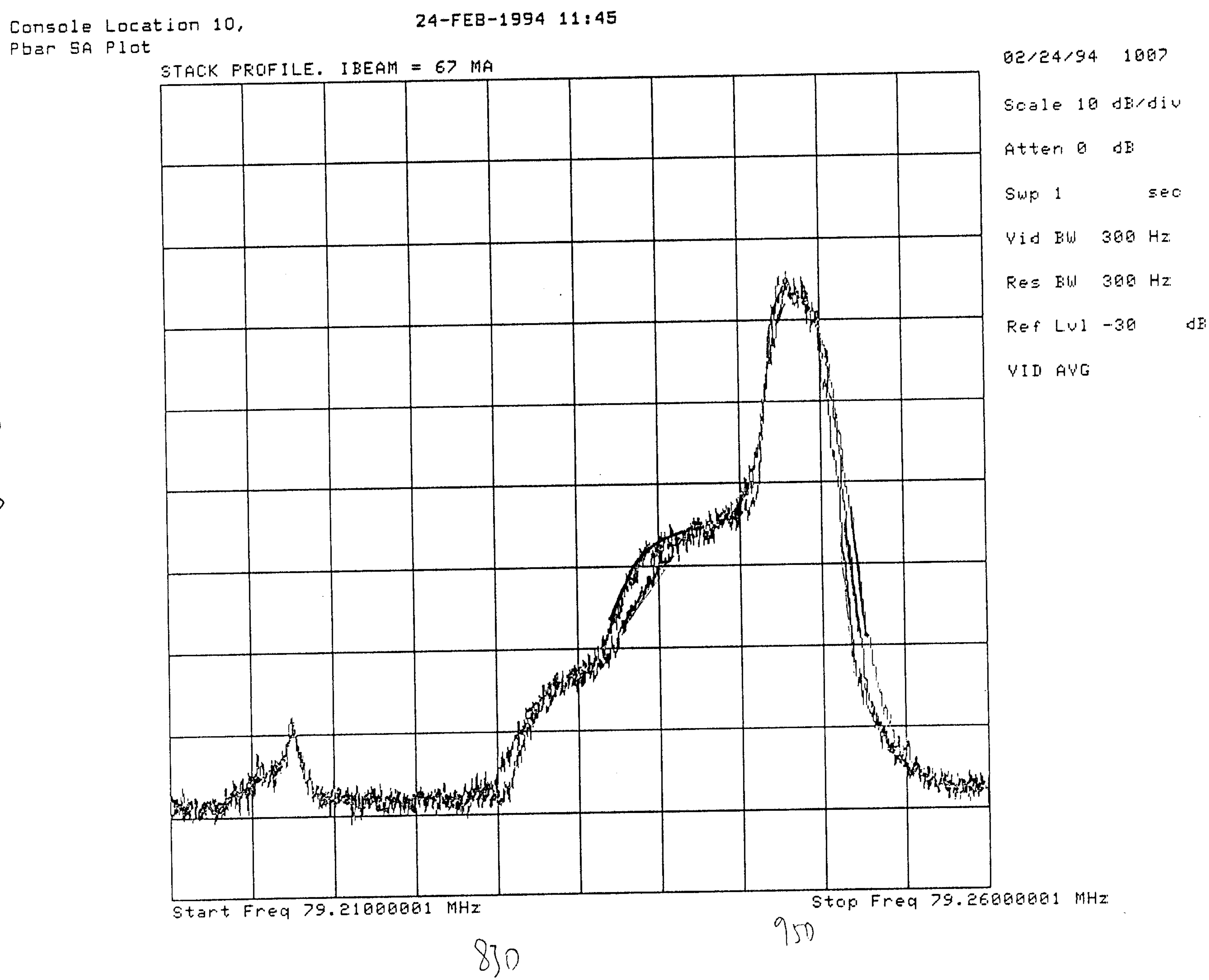
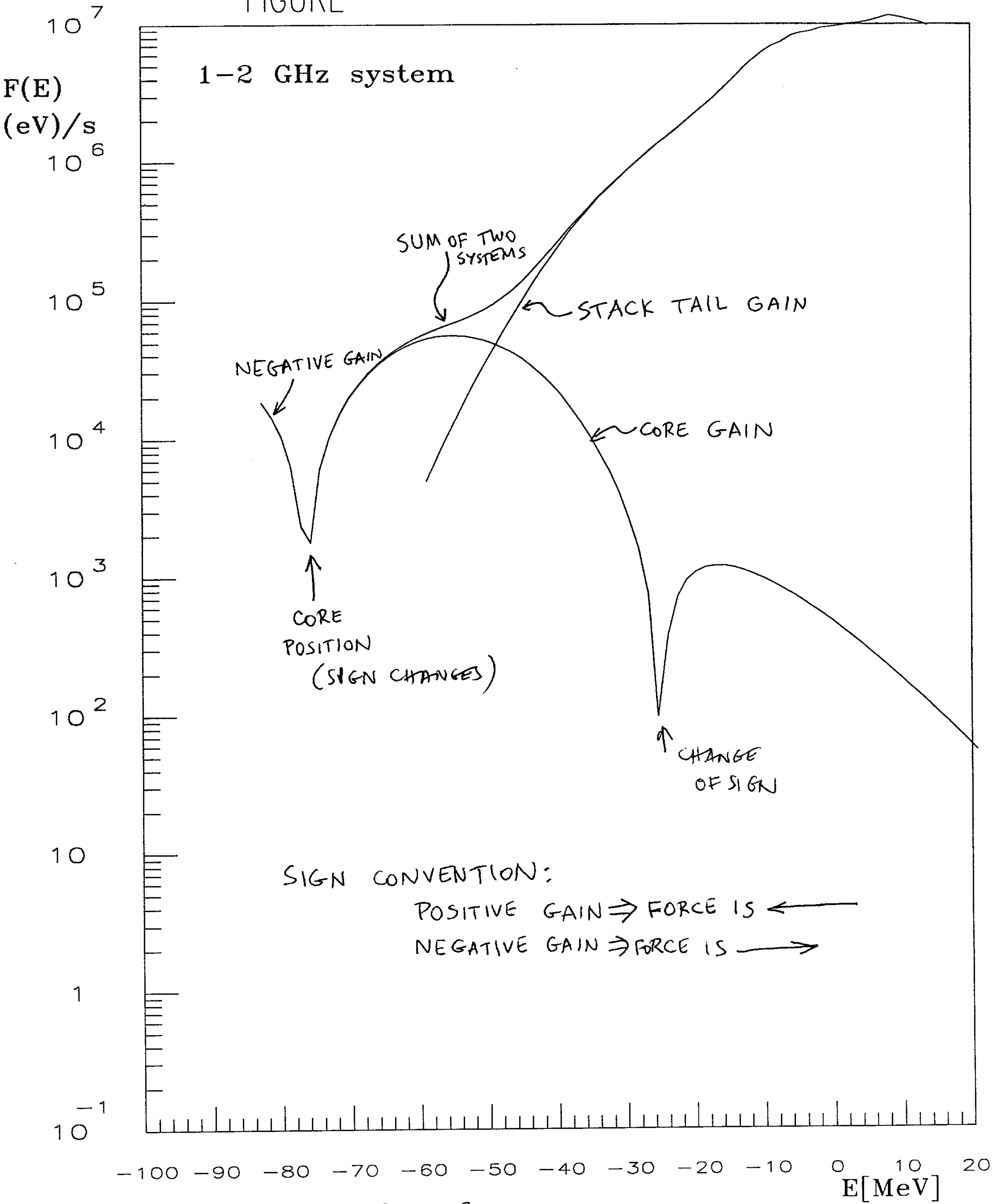

Console Location 10,
Pbar SA Plot
24-FEB-1994 11:45
STACK PROFILE. IBEAM = 67 MA
02/24/94 1007
Scale 10 dB/div
Atten 0 dB
Swp 1 sec
Vid BW 300 Hz
Res BW 300 Hz
Ref Lvl -30 dB
VID AVG
Start Freq 79.21000001 MHz
Stop Freq 79.26000001 MHz
830
950

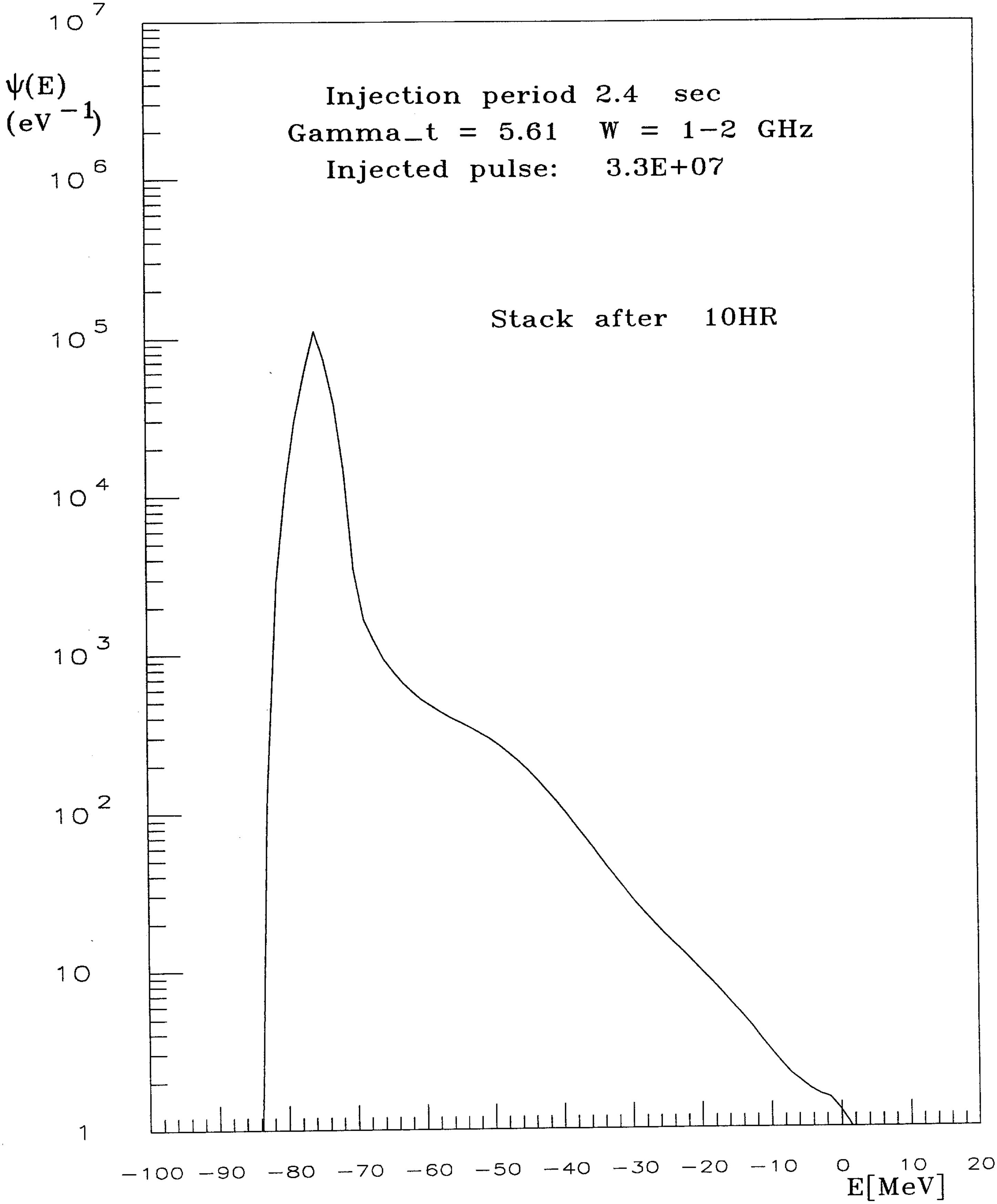
Fig. 2

FIGURE



1–2 GHz system
F(E) (eV)/s
10^7
10^6
10^5
10^4
10^3
10^2
10
1
10^{-1}
SUM OF TWO SYSTEMS
STACK TAIL GAIN
NEGATIVE GAIN
CORE GAIN
CORE POSITION (SIGN CHANGES)
CHANGE OF SIGN
SIGN CONVENTION:
POSITIVE GAIN ⇒ FORCE IS ←
NEGATIVE GAIN ⇒ FORCE IS →
−100 −90 −80 −70 −60 −50 −40 −30 −20 −10 0 10 20
E[MeV]

Fig. 3



ψ(E)
(eV^{-1})
Injection period 2.4 sec
Gamma_t = 5.61 W = 1-2 GHz
Injected pulse: 3.3E+07
Stack after 10HR
10^7
10^6
10^5
10^4
10^3
10^2
10
1
-100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20
E[MeV]

Fig. 4

FIGURE 3

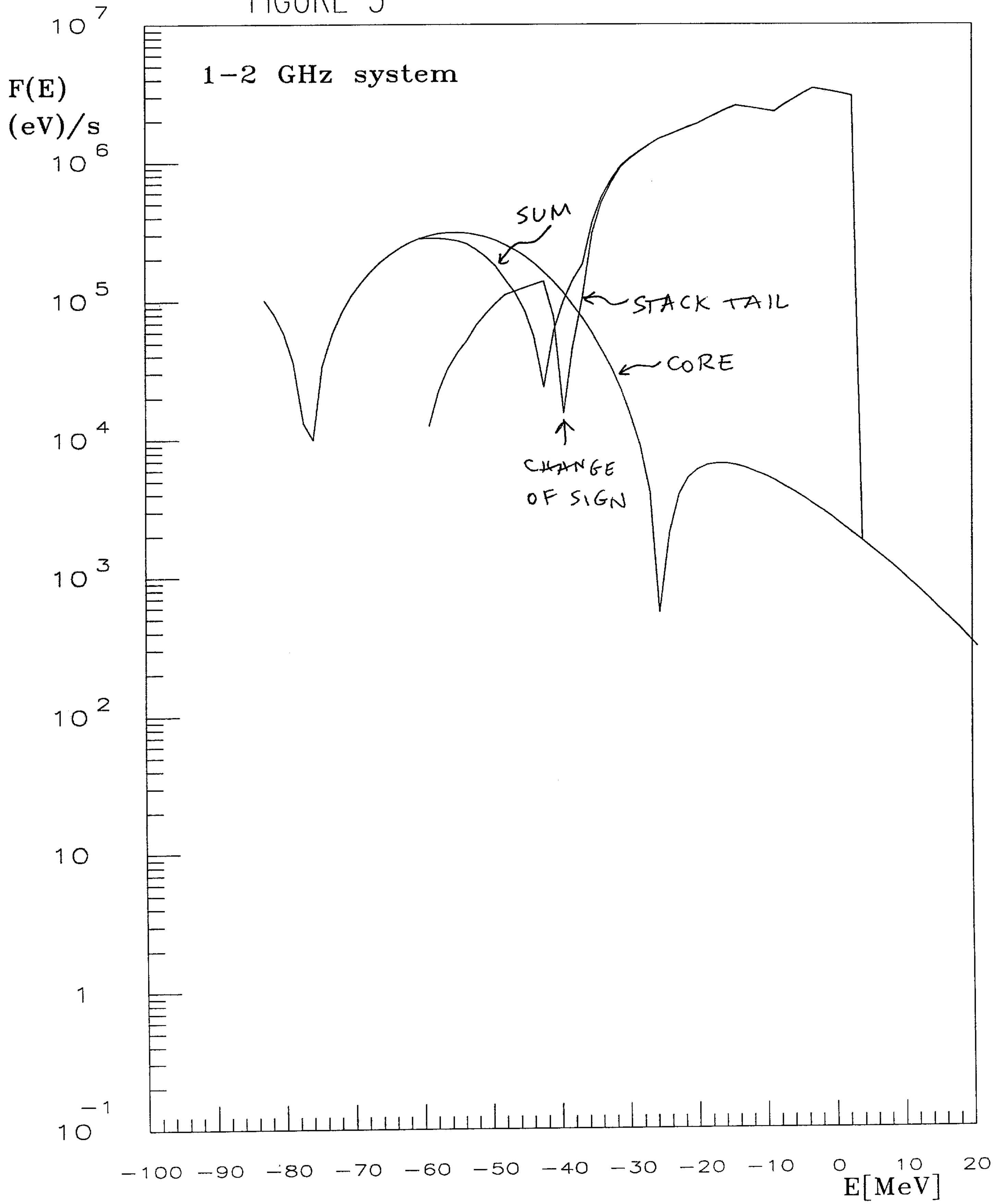
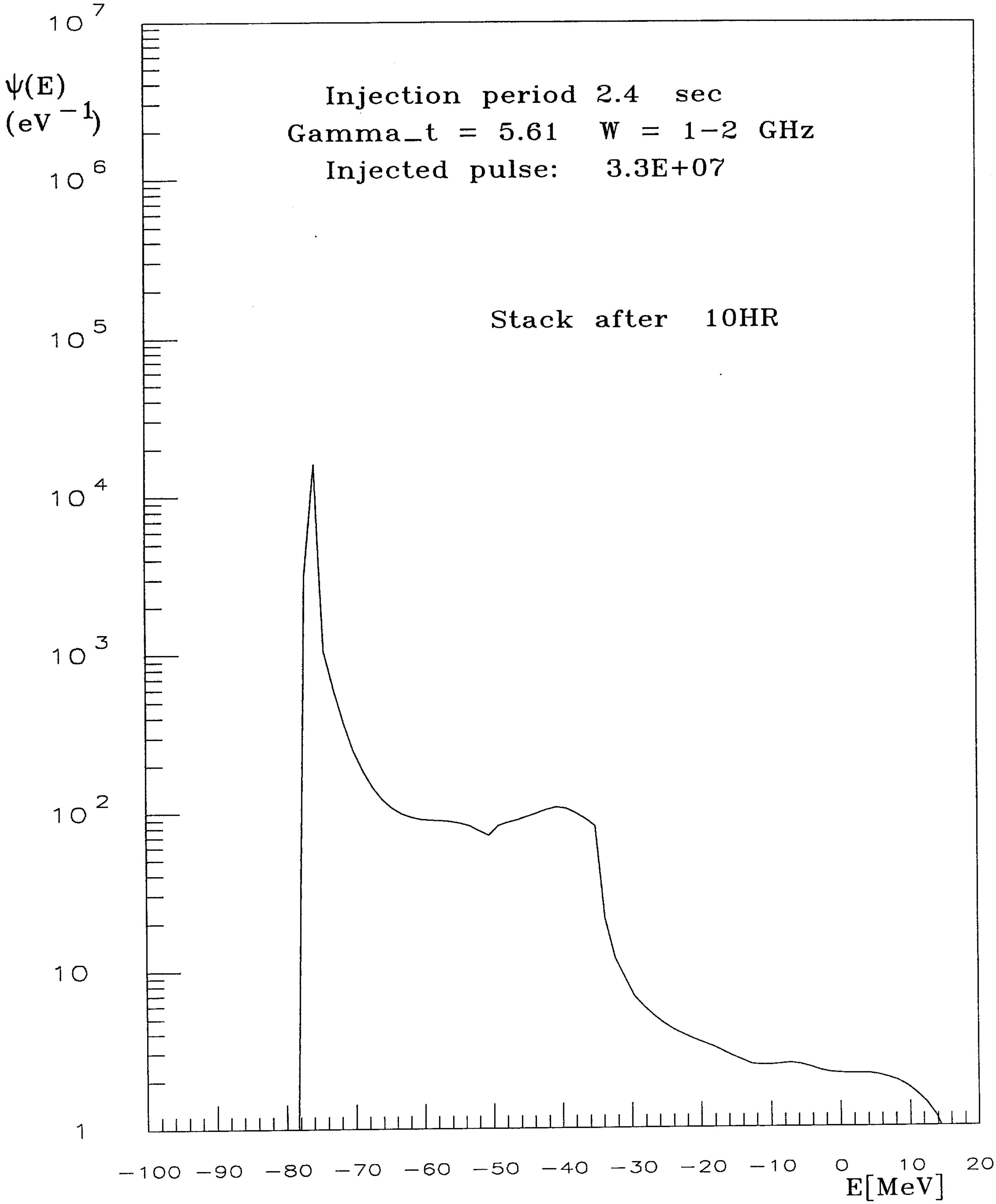


Fig. 5



Injection period 2.4 sec
Gamma_t = 5.61 W = 1-2 GHz
Injected pulse: 3.3E+07
Stack after 10HR
ψ(E) (eV⁻¹)
10⁷
10⁶
10⁵
10⁴
10³
10²
10
1
-100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20
E[MeV]

Fig. 6

FIGURE 3

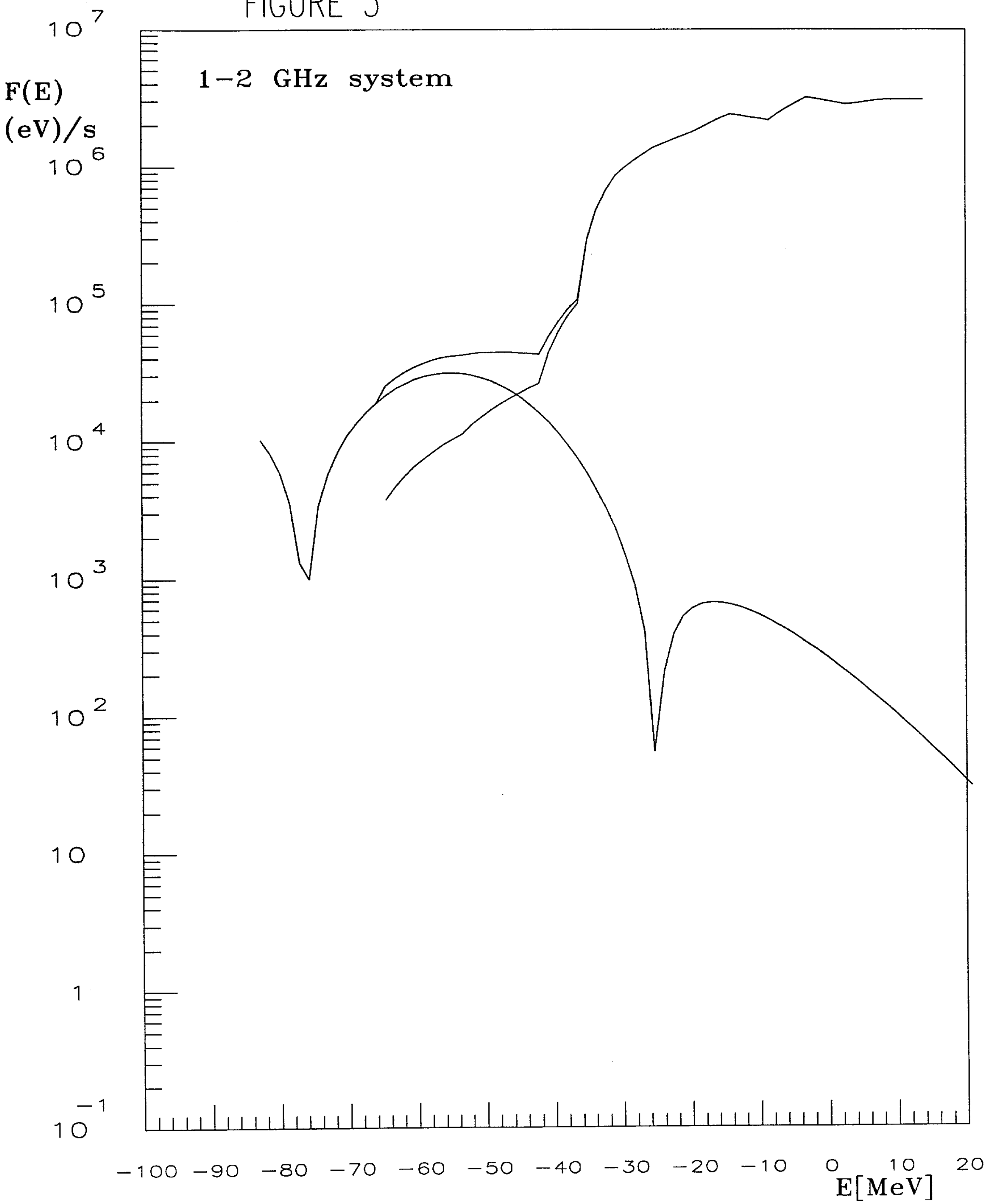
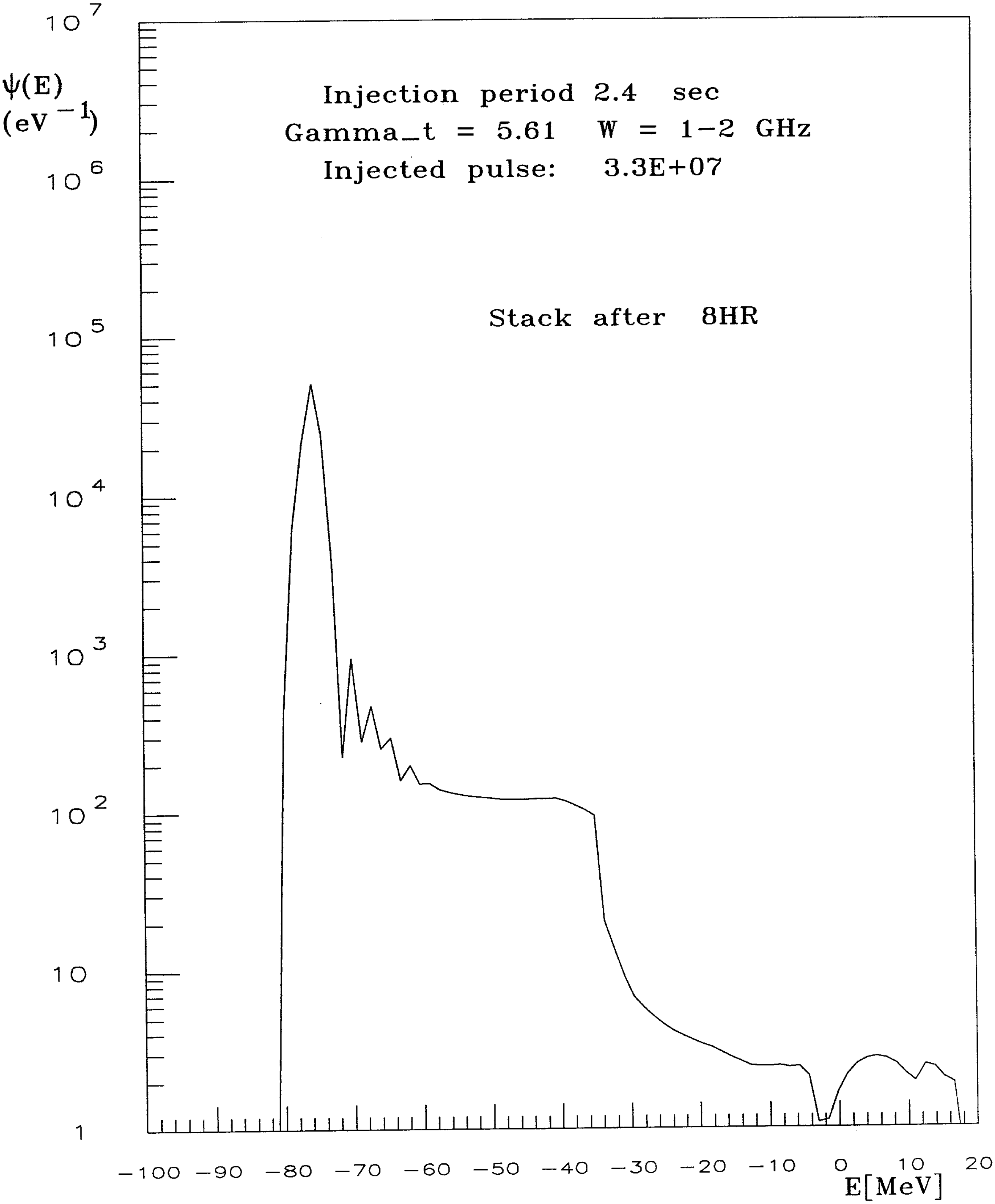


Fig. 7



10 7
ψ(E)
(eV −1)
10 6
10 5
10 4
10 3
10 2
10
1
Injection period 2.4 sec
Gamma_t = 5.61 W = 1−2 GHz
Injected pulse: 3.3E+07
Stack after 8HR
−100 −90 −80 −70 −60 −50 −40 −30 −20 −10 0 10 20
E[MeV]

Fig. 8