DAΦNE TECHNICAL NOTE
INFN - LNF, Accelerator Division

Frascati, Aug. 30, 1991
Note: **RF-3**

DAΦNE RF SYSTEM PARAMETERS

R. Boni, A. Gallo

INTRODUCTION

The main parameters of the DAΦNE complex have been frozen(1), therefore it is possible to define the characteristics of the Radiofrequency System (RFS).

In RF-1 we have already considered some important aspects like the power source's type and the cavity technology (room temperature or superconducting) which has to be used. It is our intention to feed the cavities by individual klystron to have better reliability, separated feedback, and electronic controls. In this paper we report the RFS parameters needed for the final version of DAΦNE, and the booster. The main ring cavities are still under development and here we assume a conservative value of their shunt impedance.

MAIN RING RFS PARAMETERS

The synchrotron radiation and parasitic beam losses have been estimated(1) to be respectively 9.3 keV/turn and 7 keV/Ω/turn with $\approx 9*10^{10}$ particles per bunch and a bunch length $\sigma_l \approx 3$ cm.

Then, for a vacuum chamber broadband impedance $(Z/n)_o \sim 2\ \Omega$, the required RF peak voltage is:

$$V \approx 260 \text{ kV},$$

and the beam power, for a constant number of particle/bunch :

$$P_b = (9.3 + 2*7) = 23.3 \text{ kW/Amp}$$

We propose a RFS with the following parameters:

RF frequency, F_{RF} [MHz]	368.256
Harmonic number, h	120
Number of cavity/ring	1
Max gap cavity voltage, V_c [kV]	400
Cavity shunt impedance, $R_c = V^2/2P$ [MΩ]	2.25
Unloaded cavity Q	30,000
Max cavity wall loss, P_c [kW]	35
Number of klystron/ring	1
Max klystron power [kW]	150

The above listed features ensure sufficient flexibility to store up to about 2.5 Amps distributed in 60 bunches filled with $\approx 9{*}10^{10}$ particles each, if the machine impedance $(Z/n)_o$ will result ≈ 2Ω, or full beam current (≈ 5 Amps) in 120 bunches for $(Z/n)_o \approx 1\Omega$.

Table I shows the most significant data for a cavity voltage V_c = 260 kV and $(Z/n)_o$ = 1 or 2 Ω.

TABLE I

	$Z_{BB} \approx 1\Omega$	$Z_{BB} \approx 2\Omega$
P_c	15 kW	15 kW
U_b	16.3 keV	23.3 kV
I_b	5 Amps	2.5 Amps
P_b	81.5 kW	58.25 kW
P_{in}	96.5 kW	73.25 kW
ΔP	53.5 kW	76.75 kW
β	6.4	4.9

As reported in RF-1 the factor β is the generator-cavity coupling needed to match the power amplifier at full beam.

The large power margin ΔP guaranties the possibility to increase the cavity voltage if requested, or to dissipate more power if the cavity shunt impedance were lower. Moreover, the cavity detuning, usually applied to fight the Robinson instability(2), overloads the power amplifier. The waveguide losses and the necessity of some overrated power supply must also be taken into account.

To separate the amplifier from the cavity and to protect the klystron against high reverse power, a ferrite circulator, commercially available in this frequency and power range, will be installed. The choice to use either waveguides or coaxial lines to feed the cavities has still to be done, since it depends on the needed length, being the location of the klystrons not yet decided.

With reference to RF-1 we have, for $Z_{BB} = 2\Omega$ and $I_b = 2.5$ Amps:

$$\sin \Phi_S = \frac{23.3\,keV}{260\,kV} = 0.09 \qquad \textit{synchronous phase}$$

$$\Phi_S = (5.14)^0$$

$$R_b = \frac{V_C^2}{2P_b} = 0.58\,M\Omega \qquad \textit{beam loading}$$

$$R_L = \frac{R_C R_b}{R_C + R_b} = 0.46\,M\Omega \qquad \textit{generator load}$$

$$R_S = \frac{R_g R_C}{R_g + R_C} = 0.38\,M\Omega < R_b \qquad \textit{source impedance}$$

with $R_g = R_L$.

The value of R_S satisfies the first Robinson criterion(3).

ACCUMULATOR RFS PARAMETERS

To provide large margin in RF acceptance, the accumulator RFS will be designed to achieve the maximum RF peak voltage of 200 kV.

The shape and the main characteristics of the resonator have already been carried out and they will be presented shortly, in a dedicated report.

RF frequency, F_{RF} [MHz]	73.651
Harmonic number, h	8
Number of cavities	1
Max gap cavity voltage, V_c [kV]	200
Cavity shunt impedance, $R_s = V^2/2P$ [MΩ]	1.0
Unloaded cavity Q,	15,000
Cavity wall loss, P_c [kW]	20
Synchrotron losses, U [keV]	5.44
Max beam power, P_b [kW]	0.7
Tetrode power [kW]	50
Synchrotron frequency, f [kHz]	50.15

Even in this case we need a suitable power margin of the tetrode amplifier. A circulator has been recently developed in this frequency range and installed in Bessy, Berlin. Even though it is not strictly necessary to protect the tetrode, we will use it to reduce the interactions, at the operating frequency, between cavity and RF source. The RF feeding line will be a coaxial 6-1/8" standard type.

REFERENCES

(1) DAΦNE Design Book : Parameter List.

(2) K. Robinson: “Stability of Beam in Radiofrequency Systems”, Cambridge Electron Accelerator, CEAL 1010, Febr. 1964.

(3) M. Sands: “Beam-Cavity Interaction 1”, Laboratoire de l'Accelerateur Lineaire, Orsay, 1976.