DAΦNE TECHNICAL NOTE
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Note: **V-5**

MAIN RING VACUUM SYSTEM

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I. INTRODUCTION

In this note we will consider the vacuum system excluding RF cavities and long straight sections which are isolated by sector valves (Fig. 1). In particular we will determine the pumping speed and the location of pumping elements as well as the need for cooling of various parts of the machine in order to speed up the design of the vacuum chamber - absorber system which will no doubt represent a long lead item due to its complexity.

Almost the entire photon flux strikes water cooled copper absorbers at almost normal incidence except a small fraction downstream of each dipole which strikes Al chamber. The exact amount will be determined by the position of the absorber and will result in

$$\Delta P \geq 50 \text{ W/degree}$$

$$\Delta\Phi \approx 6.5 \times 10^{18} \text{ photons/s degree}$$

for full current of 5.5 A.

Another small amount will strike the slot in the dipole chamber downstream from the wiggler (Fig. 2). The worst case is in the “long bending section” and for 1 cm opening $\Delta p \approx 30$ W and $\Delta\Phi \approx 2.5 \times 10^{18}$ photons/s with Δy and $\Delta y' = 0$.

Besides the above power dissipated in the vacuum chamber, three additional sources should be taken into account:

a) power due to RF image currents especially in higher electrical resistivity components;

b) power in higher order modes;

c) heat transferred from the yokes of the wiggles to the chamber.

FIG. 1

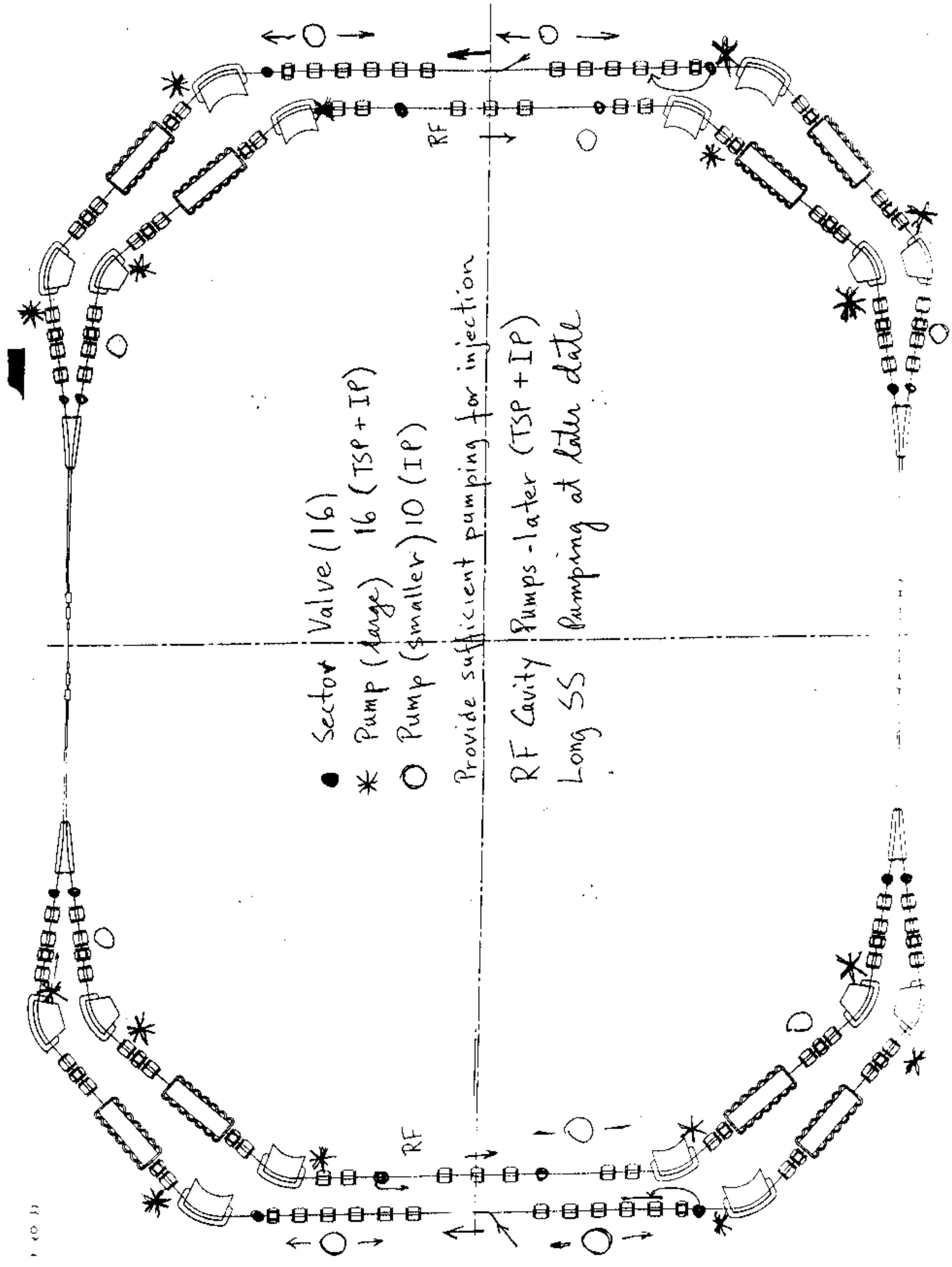
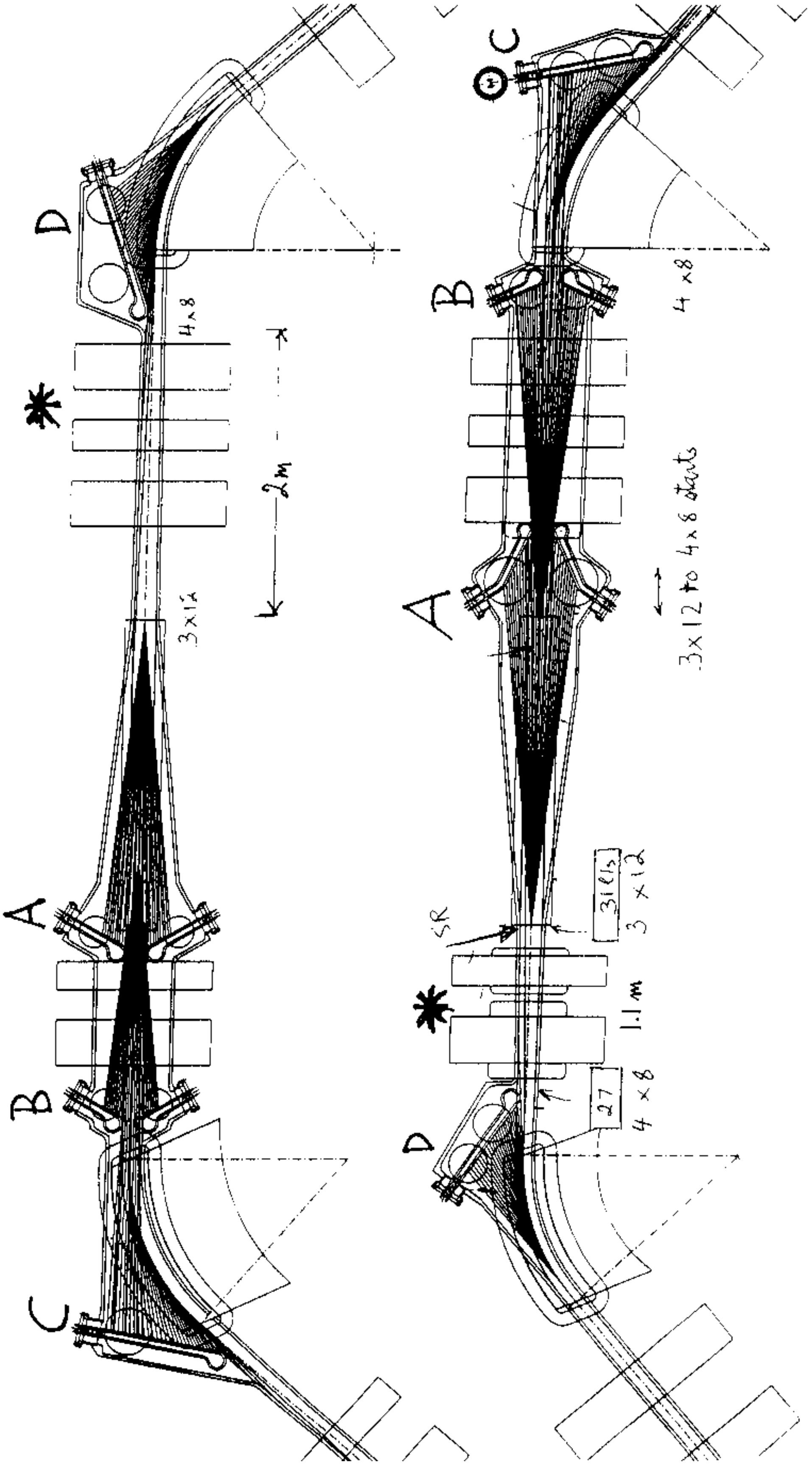

● Sector Valve (16)
✱ Pump (large) 16 (TSP + IP)
○ Pump (smaller) 10 (IP)
Provide sufficient pumping for injection
RF Cavity Pumps - later (TSP + IP)
Long SS Pumping at later date
RF
RF

FIG. 2


D
*
4x8
2m
3x12
A
B
C
C
B
A
4x8
3x12 to 4x8 starts
31 cells
3 x 12
SR
*
1.1 m
27
4 x 8
D

Some photons will be reflected from the Al chamber but the reflected flux from the absorbers should be negligible (~ 1%) compared to photoelectrons.

II. PUMPING SPEED

A. Cu Absorbers

The pumping speed necessary to maintain the ring at ~ 10^{-9} Torr was calculated from:

1) PSD yields, η_s, obtained at the NSLS using Al 6063-T5 extrusions (Fig. 4 in Ref. 2),

2) photoelectron production in copper at normal incidence[1],

3) only photons with energy >10 eV are considered in photoelectron production[2, 3].

Furthermore we assumed that the Cu absorbers would be scrubed in a short time compared with the time to reach $\eta \approx 1 \times 10^{-6}$ for Al (good assumption[3]). The desorbed gases will be liberated by photoelectrons, originating in absorbers, which strike the adjacent Al surfaces. We can therefore consider this machine as an aluminum system cleaned not by photons but primarily by photoelectrons originating in Cu absorbers.

Using Ref. 1 and 2, we obtain the following coefficients after a dose less than 1×10^{25} photons:

H_2	5×10^{-6}	molecules per photon
CO	1×10^{-6}	"
CO_2	$< 5 \times 10^{-8}$	"
CH_4	$< 5 \times 10^{-8}$	"

To reach the design goal of 1×10^{-9} Torr for CO and 5×10^{-5} Torr for H_2, the pertinent data for 5.5 A operation at 4 locations (A, B, C and D in Fig. 2) are listed in Table I, indicating required bending section pumping speed of ~ 3×10^4 l/s for CO and H_2. Pumping speed for CH_4 and other inert gases is less than 1000 l/s.

Upper and lower walls of the antechambers will be equipped with 20 cm i.d. holes terminated with 25 cm conflat flanges (Table I, Fig. 2) resulting in the conductance of 3.5×10^3 l/s and 13×10^4 l/s per hole for CO and H_2 respectively. All pumping units connected to these flanges will contain TSP, but only bottom units will contain 200 l/s ion pumps.

A 40 cm long cylinder will have CO and H_2 pumping speeds of $> 2 \times 10^{4}$ and $> 5 \times 10^{3}$ l/s respectively. A plate DIP will be mounted in each dipole (BNL design[4]).

It is instructive to check the pumping speed obtained above by calculating photoelectron production from copper absorbers and using electron desorption to arrive at the gas load from Al chambers. We therefore integrate the product of DAΦNE photon spectrum above 10 eV and the quantum efficiency of Cu[5] and obtain 6×10^{-21} A per photon. This yields 1.8 A for 3×10^{20} photon/s of dipole radiation. Using the results from BNL experiment[1] at U10B beam line ($\varepsilon_c = 500$ eV):

a) 55% of photoelectrons produced in a grounded copper absorber at normal incidence strike the surrounding chamber surfaces;

b) 95% of electron produced have an energy lower than 30 eV,

we estimate DAΦNE average photoelectron energy lower than 20 eV. Scaling down the CO electron desorption coefficient for 150 °C baked Al samples[6] from 600 eV to 20 eV we obtain a value of ~ 0.02 which results in $\sim 1 \times 10^{17}$ molecules/s or $\sim 3 \times 10^{-7}$ Torr at the beginning of the commissioning. A factor of 300 will be achieved with a dose of $< 5 \times 10^{24}$ photons[2].

TABLE I

Bending Section Pumping Requirements

Absorber - Fig. 2	**A (2x)**	**B (2x)**	**C**	**D**
Photon flux/s	9×10^{19}	6×10^{19}	3.3×10^{20}	3×10^{20}
CO gas load Tl/s	$< 3 \times 10^{-6}$	2×10^{-6}	1×10^{-5}	$< 1 \times 10^{-5}$
H_2 gas load Tl/s	1.5×10^{-5}	$1. \times 10^{-5}$	5×10^{-5}	5×10^{-5}
S CO l/s	$< 3 \times 10^{3}$	2×10^{3}	1×10^{4}	$< 1 \times 10^{4}$
S H_2 l/s	$< 3 \times 10^{3}$	2×10^{3}	1×10^{4}	$< 1 \times 10^{4}$
CH_4 gas load Tl/s	$< 2 \times 10^{-7}$	1×10^{-7}	$< 5 \times 10^{-7}$	$< 5 \times 10^{-7}$
S CH_4 l/s	100	100	250	250
Number of holes	one up one down	one down	one up two down	one up two down

B. Aluminium Chamber

As was mentioned before, some radiation will strike the chamber downstream of every dipole and the desorption will depend on the position of the beam and the Cu absorber. In the magnet sections (Fig. 2), depending on the distance between the dipole and the wiggler, some photons will be intercepted by the absorbers. Due to the low conductance of the 4 x 8 cm vacuum chamber of 27 l m s^{-1} we cannot rely on the large pumping speed of the absorber chamber, In addition, the gas load will be initially much higher due to “direct” interaction of photons with aluminum. Due to the presence of the electron beam, the pumping holes in the chamber have to be covered with slots which further decreases their conductance. In addition their location will be restricted by quadrupoles and other elements.

Once the position of the absorber has been determined a careful calculation of photons incident on the chamber should be made for the worst case and the necessary pumping speed implemented using a combination of TSP, and ion pumps.

Calculated photon fluxes, power dissipations and pumping speeds are listed in Table II.

Approximate location of the pumps is marked ∗ in Fig. 1 which also contains the location of sector valves ● and smaller pumps ○ in areas of no direct synchrotron radiation.

TABLE II

Pumps downstream of dipole magnets

Location	Length (m)	% of 5 °*	Flux (photon/s)	Power (W)	Pumping Speed (l/s)
Long Bending Section “D”	2	66	2×10^{19}	180	600
Short Bending Section “D”	1.1	37	1×10^{19}	100	300
All other pumps at	1 2 3	77 + 11 + 4	2.5×10^{19} + 3×10^{18}	208 + 32	750 + 100

* At present absorber location , 5° (11%) of total dipole radiation will strike the chamber.

III. IMPROVEMENTS AND TESTS

There are 2 ways to improve η_s:

1) In situ glow discharge. In BNL experiments[1] an improvement up to a factor of 10 has been realized using various absorbers in a stainless steel chamber. We plan therefore to install GDC electrodes in all antechambers, which is very easy.

2) Biasing the absorber positively (~ 30 V) to prevent photoelectrons from reaching the surrounding Al chamber and thus preventing them from desorbing surface gases. Due to normal photon incidence, the number of reflected photons is negligible. The fact that the absorbers would have to be isolated might introduce some problems. In any case positive bias could be applied only after the antechamber has been reasonably well cleaned. Conversely, negative bias could be used to increase the energy of photoelectrons to speed up the clean-up.

Both methods will be tested on an aluminum chamber with a Cu absorber at U10B beam line. A set-up[1] working at 100 mrad can be readily modified. A system at normal incidence could be build if desired.

ACKNOWLEDGMENTS

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Things to do

1) Experiments at U10B NSLS*
2) Calculate and draw "photon profile" downstream from all dipole (including Δx variations) to size the required pumps for the vacuum chamber $\ast$ in Fig, 1.
3) Calculate beam heating for all components with higher electrical resistivity.
4) Ti ball life test as a function of on/off cycles (turn on through a series resistor).
5) Work on clearing problems. Long SS due to e^+ beam may not require CE's.

A note including all necessary information for a proposal will be written before I leave INFN.