DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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Note: **V-1**

DAΦNE VACUUM SYSTEM
The use of Titanium Sublimation Pumps (TSP)

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The vacuum chamber of the bending magnet.

Gas Load Q.

The adopted formula used to evaluate the total number of photons/second is:

$$N = 8.1\ 10^{20}\ E\ i\ \frac{\text{phot}}{\text{s}} \qquad \text{(E in GeV, i in Amp)}$$

By assuming a desorption coefficient $\eta = 2\ 10^{-6}$ molecules/photons, we get for a single dipole of the main ring:

$$N_D = \frac{N}{8}\ \eta = 5.7\ 10^{14}\ \frac{\text{mol}}{\text{s}}$$

for $i = 5.5$ Amp and $E = .51$ GeV.

From the law of ideal gases we have that the gas load Q_N, due to a single molecule, is:

$$Q_N = 3.7\ 10^{-20}\ \frac{\text{mbar}\cdot\text{liters}}{\text{s}} \qquad (T=293\ °K)$$

and the gas load in one dipole is

$$Q = N_D \cdot Q_N$$

(without taking into account the light from the Wiggler).

Therefore, in order to mantain a pressure of 10^{-9} mbar, a pumping speed of $2\ 10^4$ liters/sec is needed.

TSP.

The typical pumping speed S, per square centimeter, of a Titanium layer, for Carbon monoxide, at room temperature is:

$$S = 9 \ \frac{\text{liters}}{\text{sec}\cdot\text{cm}^2}$$

therefore $\frac{20000}{9}$ = 2200 square centimeters must be seen by the evaporator(s).

Titanium reacts with CO giving the compound TiCO (see, for ex.: D.J. Harra, Varian Associates, J. Vac. Sci. Technol., Vol.13, N.1, Jan./Feb. 1976). This means that 1 gram-atom (48 gr.) of Ti reacts with 1 gram-molecule (28 gr.) of CO.

Let us consider a 3 years life (1 year = $3.15\ 10^7$ sec) without maintenance for DAΦNE (i.e. without opening of the vacuum chamber). The integrated gas load Q' will be

$$Q' = Q\times 3\times 3.15\ 10^7 = 19\ 10^2 = 1900 \text{ mbar liters.}$$

But 1 gram-mol of gas => 22400 mbar liters, at room temperature, then

$$\frac{1}{22400} = \frac{X}{1900}\ , \quad X = Q' = 85\ 10^{-3} \text{ gr-mol of CO} = 85\ 10^{-3} \text{ gr-atoms of Ti.}$$

The total quantity of Titanium to be evaporated in three years, per bending magnet, will be:

$$85\ 10^{-3}\times 48 = 4.1 \text{ grams.}$$

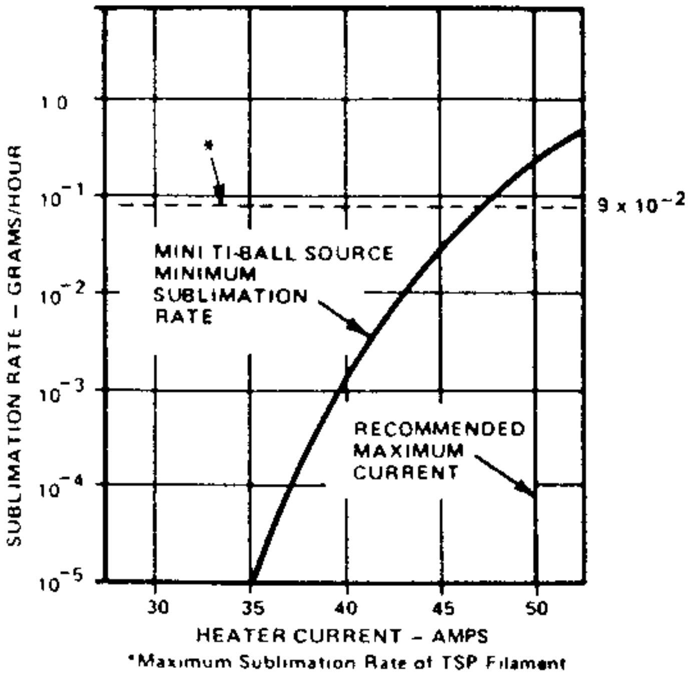
This means to use 4 standard commercial Titanium filaments or 1/3 in weight of a standard Varian Mini Ti Ball (15 grams usable Ti).

Let us consider now just the use of a Varian Mini Ti-Ball.

The necessary Ti sublimation rate TSR is (3 years = $2.63\ 10^4$ hours)

$$TSR = \frac{4.1}{2.63\ 10^4} = 1.6\ 10^{-4}\ \frac{\text{grams}}{\text{hour}}\ .$$

This value corresponds to a very small rate of evaporation for a Mini Ti-Ball: about 38 Amps of heater current are necessary (see figure). This means that risks of failure of the Ti-Ball itself are strongly reduced.



Mini Ti-Ball Source Minimum Sublimation Rate as a Function of Heater Current

How the vacuum chamber can be shaped to have the best performances by the sublimator.

If the sublimator has a concentrated Ti source (as the Mini Ti-Ball is) the best surface shape (on which to evaporate Ti) is a sphere, obviously, with the source at the center. The uniformity of the Titanium layer is essential if we want that all the Ti Atoms coming from the source react with the residual gas.

Naturally a sphere has not a practical shape; a cylinder or something like this could be the best solution.

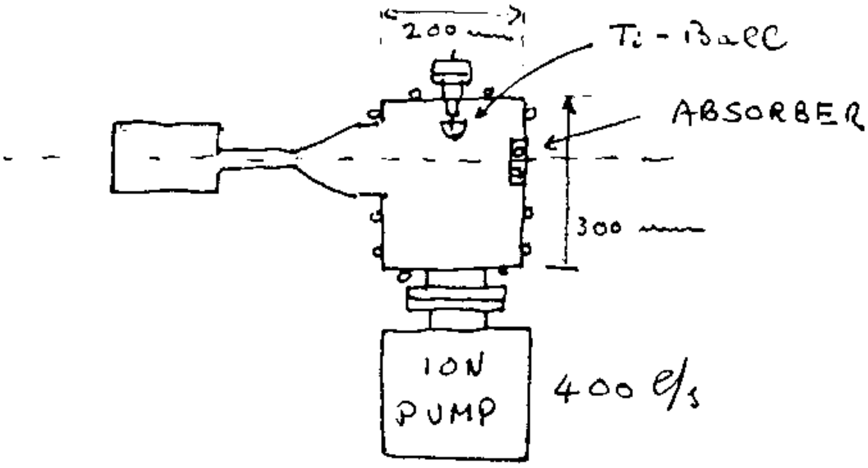
Here below some possible shapes are suggested, using two Mini Ti Ball per magnet, but let us remember that the use of standard Titanium filaments (8 or 12 per magnet) is not impossible.

The problem of the flakes.

The evaporated Titanium and its compounds form a layer on the inner walls of the vacuum chamber. At a certain thickness this layer can come off producing dust and small flakes that can reach the circulating beam.

Probably flakes have a dimension that makes impossible for them to move inside the vacuum chamber, at least when there are good vacuum conditions. On the contrary the dust could be a real problem if it is produced.

On the other hand on three years of work we will have 4.1 gr of Ti on 2200 cm^2; this gives a layer of about 20 microns and this seems not a dangerous thickness but for the following years the problem could become important.



If there are problems of buckling of the vacuum chamber due to the external pressure, we can consider the possibility to put a reinforcement behind the absorber; for the vacuum it sufficient to have a high conductance between the two regions separated by the absorber itself.