# DESIGN OF THE VEPP-2000 VACUUM SYSTEM

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*Abstract*

The Budker Institute of Nuclear Physics (BINP) project of the VEPP2000 electron-positron Round Colliding Beams in the energy range 2*(0.2 - 1.0)GeV will have an average synchrotron radiation (SR) power of up to 1000W per meter, a very tight packing magnetic elements and beam diagnostic devices. The high photon stimulated desorption rate in the beginning of operation makes the use of the non-evaporated getter (NEG) coating and the cold surface of the cryogenic optics as an effective molecular pumping quite reasonable. The aim of this work is the vacuum system design and estimation of residual gas pressure time profile during conditioning period of the VEPP-2000 operation. The description of manufacturing, cleaning and proposed bake-out procedures for the beam vacuum chambers are presented.

## INTRODUCTION

A decision to upgrade the VEPP-2M complex by replacing the existing collider with a new one in order to improve the luminosity and at the same time to increase the maximum attainable energy up to 2 GeV will significantly broaden the potential of experiments performed at the collider. The new project is called "VEPP-2000" based on the center-of-mass energy and year when the project has been approved.

Figure 1 shows the layout of the VEPP-2000 complex. It consists of a 2.5 MeV linac, 250 MeV synchrotron, booster ring and the VEPP-2000 storage ring. The booster can change polarity to store subsequently electrons and positrons and is capable of accelerating beams up to the energy of 900 MeV. Above this level, the energy of the collider will be ramped to the energy of experiment. The injector is kept unchanged from the VEPP-2M collider.

The design luminosity of the VEPP-2000 $1\times10^{32} cm^{-2}s^{-1}$ at 1 GeV could be available due to the Round Colliding Beams concept [1]. In order to realise the round transverse section beams, four special superconducting solenoids with magnetic field 13T will be applied close to Interaction Points (IP) at both sides of the Spherical Neutral Detector (SND) and the Cryogenic Magnetic Detector (CMD).

Note, that perimeter of VEPP-2000 is 24.4m only and the average density of SR flux is $1.2*10^{19}$ photon/s per meter and SR power is 1000W per meter at maximum design currents Ie-=Ie+=200mA. Special SR absorbers will be used along the total length of the ring except interaction regions and RF cavity. An intense gas load due to photon stimulated desorption should be compensated by high enough molecular pumping speed. But, even in case, the use of solenoid cold surfaces as the efficient pump, there is no enough room along the ring to arrange an effective molecular pumping speed over 1500 litre/s. Numerical simulations show that at this pumping, the maximum currents Ie-=Ie+=200mA could be available (from vacuum point of view) after a half a year continuous conditioning. To decrease conditioning duration, a getter molecular pump was approved for application in the straight beam vacuum chambers.

This paper contains numerical simulations of the residual gas pressure dynamic with/without getter application and concepts of the bending magnet and straight vacuum chambers design.

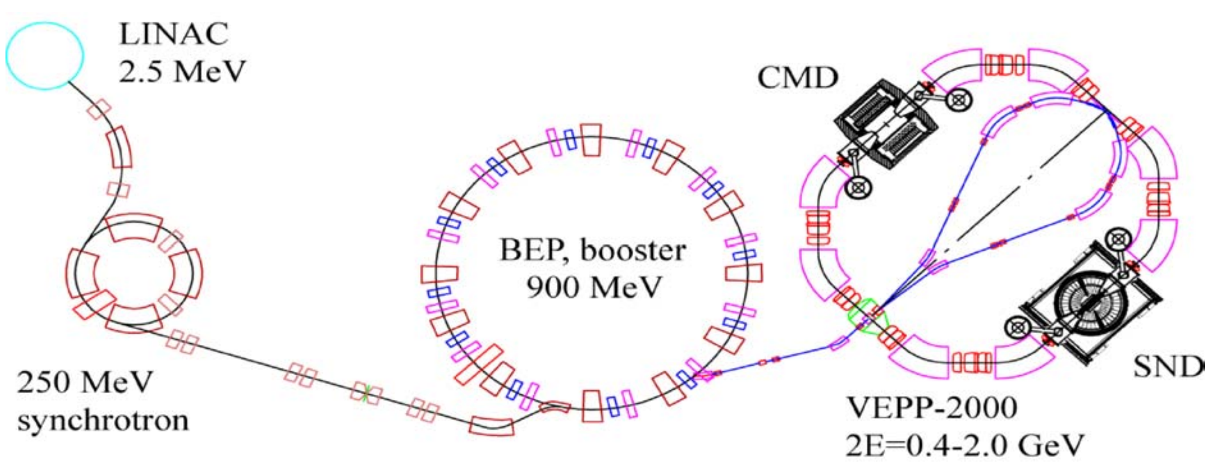


Figure 1: Layout of the VEPP-2000 complex.

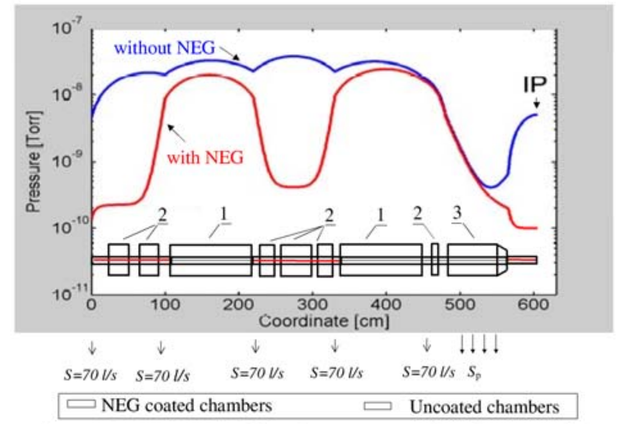


Figure 2: Pressure profile along quota of perimeter with and without NEG coating in the straight sections. 1 – bending magnet, 2 – quadrupole, sextupole lens, 3 – superconducting solenoid.

## PUMPING SYSTEM AND PRESSURE ESTIMATION

The pumping system contains the following elements: 16 combined pumping units "PVIG-100" (i.e. ion pump + titanium sublimation pump) placed at the ends of vacuum chambers in the bending magnets; the pump "PVIG-250" connected to RF cavity; 4 cryopumps forms from cold surface of the solenoid. It is planned to use a perforated liner cooled by liquid nitrogen to prevent SR exposure of the surface at 4.2 K. The linear pumping speed of the slots should be 3 $litre{\cdot}s^{-1}cm^{-1}$ in $N_2$ equivalent. The cold 4.2 K surface is an ideal pump for all gases except for $H_2$, since after accumulation more than 1 monolayer of cryosorbing $H_2$ its equilibrium vapour pressure is $5{\cdot}10^{-7}$ Torr at this temperature. Never the less, the calculation shows that the beam lifetime is mainly determined by residual pressure of CO. The numerical simulation of the pressure profile (Figure 2) was carried out under the following conditions: *Ie-*=*Ie+*=200 mA; S – lumped pumping units with 70 l/s pumping speed; Sp=3 $litre{\cdot}s^{-1}cm^{-1}$ – distribution cryopumping; molecular conductivity of the bending magnet and straight vacuum chambers are ~ 14 litre/s and ~ 5 litre/s respectively; photon flux – $3{\cdot}10^{20}$ *photons/s* per ring; photodesorption yield (for CO after accumulated dose 100 A·h): $3{\cdot}10^{-6}$ *molecule/photon*. In case of application of the non-evaporated getter (NEG) in straight chambers (see Figure 2), the sticking probability 0.5 for CO is taken into account.

Numerical simulation of conditioning (Figure 3) takes into account that maximum available current is limited by residual gas pressure (lifetime) and the power of injection system. The VEPP-2M (the predecessor of VEPP-2000) experience has shown that during conditioning the following relation between maximum available current and average residual gas pressure is valid:

$$I(mA)\cdot\hat{P}(Torr)\approx 10^{-6}$$

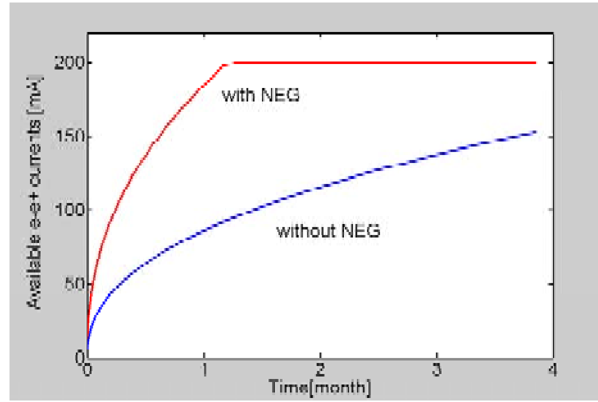


Figure 3. Available currents during conditioning.

A decrease in the photodesorbtion yield with accumulated dose is taken into account according to the following empirical expression [2]:

$$\eta=\eta_0\left(\frac{\Gamma}{\Gamma_0}\right)^{-0.6}$$

where $\eta$ (*molecule/photon*) – photodesorbtion yield, $\Gamma$ (*photon/m*) is accumulated photon dose, $\eta_0$ – photodesorbtion yield at the accumulated dose $\Gamma_0$. Here, the volumes $\eta_0 = 2{\cdot}10^{-4}$ , $\Gamma_0 = 10^{21}$ are used for calculation.

## VACUUM CHAMBERS DESIGN AND TECHNOLOGY

### Conceptual design

The conceptual design of the *bending magnet vacuum chamber* is shown in Fig. 2. The pumping slots (2) connect the chamber with ion pumps. The estimated pumping speed is 70 litre/s at the each end. The double sites morrow (3) is used for monitoring both e- and e+ beams profile and positioning. The design of the SR absorbers (1) is the same as that in the *strait vacuum chambers* (Fig. 5). The copper strip is brazed to the specially designed stainless steel cooling tube welded to the beam chamber. The stainless steel thickness between copper and water is 1mm only. This design allows to avoid water–welding seam–vacuum transitions and provides the necessary cooling capacity.

Main material for vacuum chamber production is stainless steel sheets 316LN. The cleaning procedure of the vacuum chambers follows several steps:

– degrease in perchloroethylene;
– ultrasonic cleaning in alkaline detergent (pH=9.7) at 60°C for 30 minutes;
– degrease in perchloroethylene;
– ultrasonic cleaning in alkaline detergent (pH=9.7) at 60°C for 30 minutes;
– immediate rinsing with demineralised water jet;
– immediate rinsing in demineralised water by immersion;

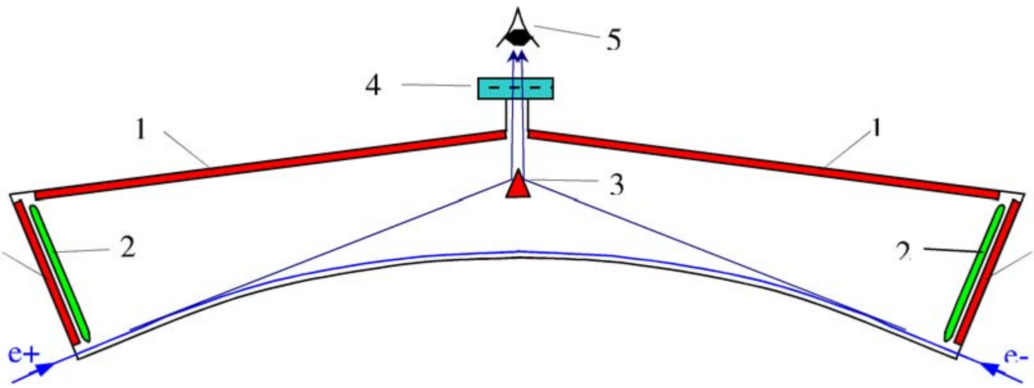


Figure 4. Bending magnet vacuum chamber. 1- Copper SR absorbers; 2- pumping holes to ion pumps; 3 - double sites morrow: 4 –window; 5 - beam profile monitor.

- drying in the air oven at 150°C.
- pre-bakeout under vacuum at 300C.
- deposition of 3mkm getter TiZrV film inside straight vacuum chamber using magnetron discharge in Kr atmosphere.

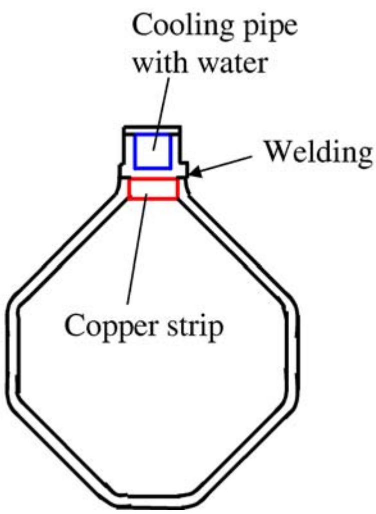


Figure 5. Cross-section of the straight vacuum chamber.

The TiZrV NEG was developed at CERN [3]. The decision to apply TiZrV coating in the VEPP-2000 was done due to its following properties:

- comparative low temperature of activation (180°C);
- quite large number of reactivation cycles (more than 20) without drastically losing the sorption properties;
- low photodesorption yields at bombardment by high energy photon [3];
- the coverage is cleaned by irradiation as a result of molecular dissociation and diffusion of atoms into the bulk of material [3]. This is very important because NEG will have large gas load from uncoated part during VEPP-2000 conditioning.

### *Bakeout procedure*

The proposed bakeout is two step procedure: a) the uncoated part of vacuum system is baked to 300°C during 24 hours whilst the TiZrV coated part is held at 80°C; b) for NEG activation the uncoated part is maintained at 150°C whilst the TiZrV coated chamber is activated at 190 ± 5°C for 24 hours [4].

## CONCLUSION

The numerical estimations of the pressure profile and reachable Ie- Ie+ current during conditioning were done. Results show that NEG coating applied even in straight vacuum chamber significantly decreases conditioning duration (cost) of VEPP-2000. The conceptual design of vacuum chamber is presented.

## ACKNOWLEDGMENTS

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