Available online at www.sciencedirect.com
SciVerse ScienceDirect
Physics Procedia 32 (2012) 753 – 756
Physics Procedia

18th International Vacuum Congress (IVC-18)

Vacuum chamber for the measurement system of the beam energy

Abakumova[1] E., Achasov[1] M., HaiYi Dong[2], HuaMin Qu[2], Krasnov[1] A., Kosarev[1] A., Muchnoi[1] N., Pyata E. [1]*, Qiong Xiao[2], XiaoHu Mo[2], YiFang Wang[2], Zhukov[1] A..

[1] *Budker Institute of Nuclear Physics SB RAS, Novosibirsk, 630090, Russian Federation*
[2] *Institute of High Energy Physics Chinese Academy of Sciences, Beijing 100039, PRC*

Abstract

Vacuum chamber for the beam energy measurement system based on the Compton backscattering method is presented. The main elements of the chamber are GaAs entrance viewport and a copper mirror. The viewport design provides baking out of the vacuum chamber up to 250 ˚C. To produce the viewport, an original technology based on brazing GaAs plate by lead has been developed. The vacuum chambers were installed at the BEPC-II and VEPP-4M colliders. After installation the residual gas pressure is about 10^{-10} Torr.

PACS: 07.30.-t; 07.30.kf;
Keywords: High vacuum GaAs viewport

Introduction

In experiments at e^+e^- colliders the accurate beam energy determination is important for cross section and particle mass measurements. The energy can be measured with relative accuracy of $10^{-4}\div10^{-5}$ by the method based on Compton backscattering of monochromatic laser radiation on the beam [1].

The general idea of method is as following. The maximal energy of the scattered photon ω_{max} is related with the electron energy ε by the kinematics of Compton scattering:

$$\omega_{\max} = \frac{\varepsilon^2}{\varepsilon + m^2{}_e / 4\omega_0}, \tag{1}$$

Where ω_0 is the laser photon energy, m_e is electron mass. If one measures ω_{max}, then the electron energy can be calculated:

$$\varepsilon = \frac{\omega_{\max}}{2}\left(1 + \sqrt{1 + \frac{m^2{}_e}{\omega_0 \omega_{\max}}}\right) \tag{2}$$

* Corresponding author. Tel.: +7-383-329-45-94; fax: +7-383-330-71-63.
E-mail address: e.e.pyata@inp.nsk.su.

 doi:10.1016/j.phpro.2012.03.630

As a source of initial photons the monochromatic laser radiation with ω_0 ~ 0.12 eV is used. The laser light is put in collision with the electron or positron beams, and the energy of the backscattered photons is precisely measured using the High Purity Germanium (HPGe) detector. The maximal energy of the scattered photons is determined by fitting of the abrupt edge in the energy spectrum. The system based on this approach was designed and constructed for Beijing electron-positron collider (BEPC-II) (Figure 1) [2].

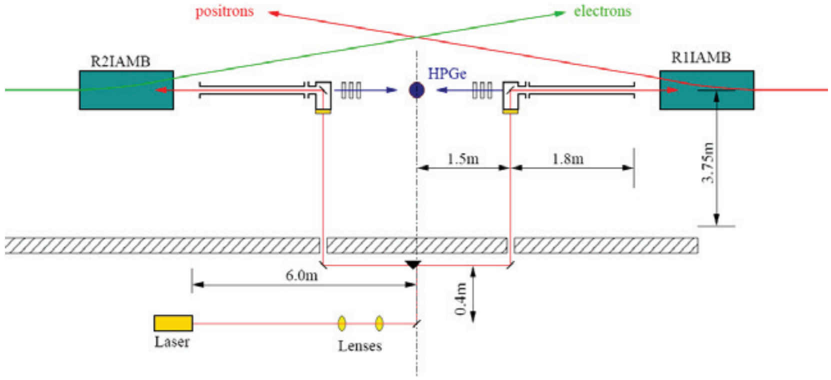

Figure 1. The beam energy measurement system layout

1. Beam energy measurement system

The system includes the CO_2 laser which beam is focused using a doublet of lenses, reflected through an angle 90° using a 45° mirror, and then reflected either to the right or left by means of a movable prism. The beam is again reflected by 90° through a hole in the wall of the collider tunnel and then is incident on a viewport in a vacuum pipe extension of the beam pipe.

The insertion of the laser beam into the vacuum chamber is performed using the laser-to-vacuum insertion system. The system is the special vacuum chamber with the GaAs entrance viewport [3] and water cooled copper mirror. In the vacuum chamber the laser beam is reflected through an angle of 90° by a copper mirror. After backscattering the photons return to the mirror, pass through it, leave the vacuum chamber, and are detected by HPGe detector. Note, the copper mirror protects the view port against high power synchrotron radiation due to low reflectivity of high energy photons (less than 1%) from a metallic surface.

2. GaAs entrance viewport

The viewport based on the GaAs monocrystal provides:

1) transmission spectrum from 0.9 up to 18 μm
2) baking out of a vacuum system up to 250 °C
3) using for extra high vacuum system

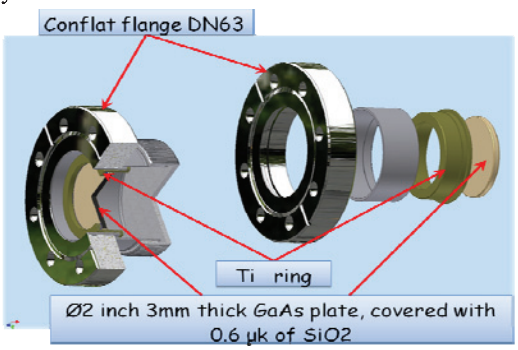

Figure 2. The GaAs viewport.

The viewport design is shown in Figure 2. It includes 304 L steel DN63 flange of conflate type and GaAs crystal plate with diameter of 50.8 mm and thickness of 3 mm. In order to compensate mechanically the difference of the GaAs and stainless steel thermal expansion coefficients, GaAs plate is brazing with pure quite soft lead to titanium ring, which in it turn is brazing with AgCu alloy to the stainless steel ring. The stainless steel ring is weld to the flange. To avoid the GaAs plate decomposition during brazing it is covered with 0.6 µm SiO_2 film using gas-phase deposition method. The transmission spectra of the plate before and after covering are shown in Figure 3. The transmission of the plate increases from 55 to 60 % at the CO_2 laser wavelength λ=10.6 µm and from 20 to 35% at λ =1 µm.

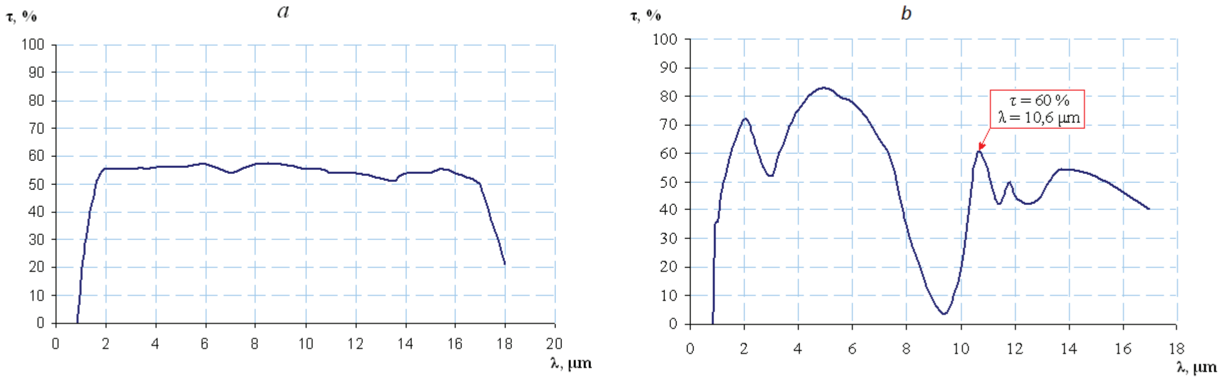

Figure. 3. The transmission spectra of GaAs are shown for a) original plate, the thickness of the plate is 3 mm; b) plate covered by SiO_2 film with thickness of 0,6 µm.

3. Copper mirror

The copper mirror layout is shown in Figure 4. The mirror is mounted to the support. This support can be turned by bending the vacuum flexible bellow, so the angle between the mirror and the laser can be adjusted as necessary. Synchrotron radiation (SR) photons heat the mirror. In order to reduce the heating of the mirror, it is placed 1.8 m from the BEPC-II vacuum chamber flange. The SR power absorbed by the mirror approximately is about 200 W. The extraction of heat is provided by the water cooling system. To prevent the adsorption of the residual gas molecules on the mirror surface it was covered with 0.5 µm thickness gold layer.

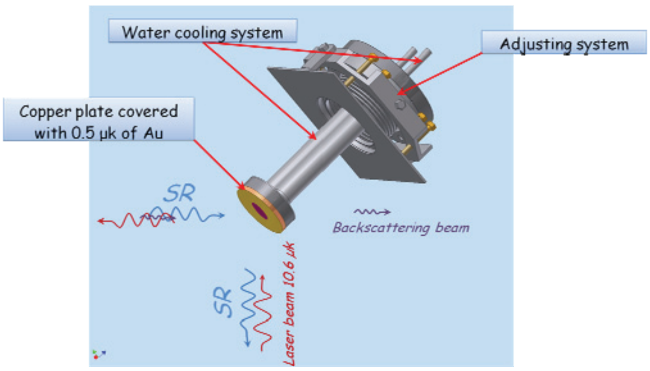

Fig.4. Copper mirror

4. Vacuum systems performance

The vacuum chamber was installed at VEPP-4M collider (Novosibirsk) and tested in experiment. Then such chambers were installed at BEPC-II collider. After backing out at 250 °C during 24 hours the pressure $2 \bullet 10^{-10}$ Torr was obtained. The residual gas spectrum is shown in Figure 5.

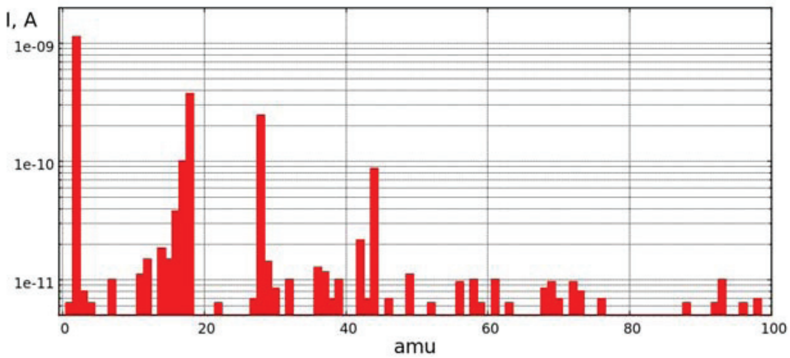

Fig.5. Residual gas spectrum

Conclusion

The vacuum chambers were installed at VEPP-4M and BEPC-II colliders. After installation the residual gas pressure is about 10^{-10} mbar. To produce the viewport, an original technology based on brazing GaAs plate with lead has been developed.

Acknowledgements

The work is supported in part by grants RFBR 08-02-00328-a, 08-02-00251-a, 08-02-92200-NSFC-a, Research and Development Project of Important Scientific Equipment of CAS (H7292330S7).

References

1. R. Klein et al., Nucl. Instr. Meth. A 384 (1997) 293; J. Synchrotron Rad. 5 (1998) 392; N. Muchnoi et al., In Proc. of the EPAC, Scotland, Eidenburgh,June 26-30, 2006, EPAC 1181; V.E. Blinov et al, in Proc. of International Conference on instrumentation for colliding beam physics, Novosibirsk, Russia February 28 - March 5, 2008, Nucl. Instr. and Meth. A 598 (2009) 23
2. M.N. Achasov et al., BINP Preprint 2008-4 (2008); ArXiv:0804.0159 (2008); M.N. Achasov et al., Nucl. Phys. Proc. Suppl. (2009) 189, 366-370; MO Xiao-Hu et al., Proc. of the Int. Workshop on e+e- collisions from φ to ψ, October 13 - 16, 2009, Beijing, China (2010) Chin. Phys. C 34(6), 912-917.
3. E.V. Abakumova et al., VTT 20(2) (2010) 77 (in Russian)