# VEPP-4M COLLIDER: STATUS AND PLANS.

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## Abstract

A start has been made on the performance of physical experiments with the new detector KEDR at the modified $e^+$, $e^-$ collider VEPP-4M. The first experimental observation of photon splitting in the strong Coulomb field of nuclei has been carried out on the ROKK-1M facility using the Compton back scattering of laser photons on the high energy electron beam. Now we are looking for possibility of measurements of the total cross section of annihilation $e^+ e^-$ into hadrons in the energy range of 0.7 GeV to 1.8 GeV. This energy range is same special one for the VEPP-4M, so here additional investigations are being conducted to achieve reasonable luminosity. In this connection, some peculiarities of usage of the wigglers and influence of Touschek effect while lowering energy are discussed. Due to large dispersion at the interaction point (IP), the horizontal beam size at it is determined mainly by synchrotron motion. We have scanned the betatron tunes with the different values of monochromatization parameter, and observed how it affects the various synchro-betatron resonances induced by beam-beam interaction.

## 1 INTRODUCTION

A modernized VEPP-4M magnetic structure has mirror symmetry about the axis passed through the middle points of experimental and technical straight sections (figure 1).

To operate with two bunches per each beam, special N and S insertions are made in the ring with setting additional vertical separators. Wigglers for generation of intense X-ray beams will be installed here too. Two pair of dipole magnets placed at the experimental area and lenses near the IP form high-resolution strong focussing spectrometer-tagging system. Two dipole wigglers to control beam properties are located on opposite sides of experimental area. To control the decrements, two dipole-quadrupole wigglers are installed in the technical area in places with non zero dispersion. Expected maximum luminosity at 5 GeV is $2 \cdot 10^{31}$ with existing magnetic system.
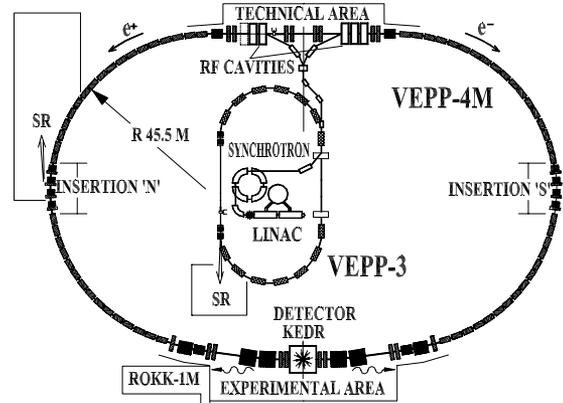


Figure 1: Layout of VEPP4-M complex.

| Parameters | Values | Units |
|---|---|---|
| Circumferens | 366 | m |
| Bending radius | 34,5 | m |
| Tunes Qx/Qz | 8,54/7,58 | |
| Mom. compaction | 0,017 | |
| Max. energy | 6 | GeV |
| Nat. chromaticities $C_X/C_Z$ | -13/-20 | |
| RF-frequency | 181,8 | MHz |
| Harmonic number | 222 | |
| RF power | 0,3 | MW |
| RF voltage | 5 | MV |
| Number of bunches per beam | 2 | |
| Interaction point | | |
| $\beta_Z$ function | 0,05 | m |
| $\beta_X$ function | 0,75 | m |
| $D_X$ function | 0,80 | m |

Table 1: Main Parameters of the VEPP-4M.

## 2 CURRENT ACTIVITY

### 2.1 Detector KEDR

KEDR is a general purpose detector experiments at the VEPP-4. The program of

experiments for KEDR detector is aimed to studying physics of J/Ψ, Y-mesons and two-photon processes. The main components of the KEDR detector are:

- vertex detector;
- drift chamber;
- aerogel cherenkov counters;
- scintillation time-of-flight counters;
- CsI end-cap calorimeter;
- LKr barrel calorimeter;
- superconducting solenoid;
- muon identification system;
- magnet yoke;
- system for detection of scattered electrons (tagging system).

By now, almost all KEDR subsystems are installed at VEPP-4M collider (excepting LKr calorimeter and aerogel counters). During December 97- February 98, the detector was put into operation and some work on background optimisation was done. During March-April 98, the first experiments were carried-out. The goal was to scan the energy range near the J/Ψ meson. The J/Ψ meson has been observed. During June-December 1998, the KEDR detector will be assembled completely.

## 2.2 The ROKK-1M facility

The ROKK-1M facility generates high energy polarized γ-ray beams by backscattering of laser light against the high energy electron and positron beams of the VEPP-4M collider. The facility design allows to obtain backscattering of the laser beam photons on electron and positron beams separately or simultaneously. Tagging and/or collimation are used to select a narrow energy band from the γ-quanta spectrum. Operating in a laser polarimeter mode, the ROKK-1M facility is able to measure transverse and longitudinal polarization of the electron and positron beams. The following experiments had been performed at the ROKK-1M facility since 1993:

- photonuclear physics experiments [1];
- investigation of non-linear QED effects: first experimental observation of the photon splitting process in the Coulomb field of nuclei and the Delbrük scattering cross section measurement in the 150÷450 MeV energy range [2];
- precise calibration of the energy response and space resolution of different detectors, including the KEDR detector Tagging System [3], the KEDR detector liquid krypton calorimeter prototype [4], the BELLE detector cesium iodate calorimeter prototype [5].

At present, the ROKK-1M facility γ-ray beam has the following parameters:

- γ-quantum energies up to 1600 MeV for an electron (positron) beam energy E up to 6 GeV;
- Total γ-ray flux up to $10^6$ photons/s;

- Tagging range for γ-quanta is 2÷61 % of the electron (positron) beam energy;
- Tagging energy resolution (1÷3) % of the γ-quantum energy in the whole tagging range;
- The γ-ray beam energy bandwidth, obtained by collimation, the FWHM is 2.35 – 10 %.

## 2.3 Synchrotron radiation

About 40 groups from Russia and foreign countries carry out scientific research and development of new technologies using SR from the storage rings VEPP-3 and VEPP-4M. There are 12 experimental stations in operating status at the VEPP-3. The work subjects are of a great variety. Construction of a radiation-protected experimental hall with a total area of about 1200 $m^2$ near the tunnel of the VEPP-4M northern semi-ring comes to completion. Fourteen SR beamlines and about 20 experimental stations and special laboratory rooms for experimental teams will be housed in this hall. Five SR channels have been traced by SR beam and fist experiments were started.

# 3 LUMINOSITY AT LOW ENERGY

Interest of our physicists to the energy range between ϕ-meson and J/Ψ-particle initiated in 1997 the experimental studies of possibilities to obtain a reasonable luminosity with lowering energy from 1.8 to 1 GeV. In this range we have run into certain difficulties. Some elements of the VEPP-4M magnetic structure are significantly different in a field level from the main bending magnets. Such an inhomogeneity leads to the fact that the residual fields have a sufficient adverse effect on stability and reproducibility of operation regimes on changing energy. Besides, the additional problems occur here due to a decrease of the radiation damping decrements and due to an enhancement of role of Touschek processes (beam sizes and "life" time). The latter is illustrated in Fig.2 where the energy spread-versus- energy curves measured and calculated are shown. Experimental
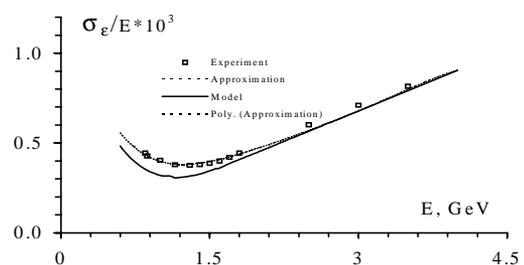


Figure 2: Energy dependence of energy spread (the beam current is 0,1mA).

data have been obtained from the observations of a longitudinal beam size by the special optical system at a synchrotron frequency kept constant. They can be

approximated by the dependence $\sigma_\varepsilon/E=(A/E^2+B\cdot E^2)^{1/2}$. Another curve presents a results of self-consistent multiple Touschek processes model calculation. To provide conditions for obtaining acceptable luminosity we controlled the beam parameters using two dipole wigglers with the field up to 2 Tesla and total length about 2 m placed in the straight sections with non zero dispersion. On Fig.3, a result of radial beam size measurement versus the wiggler current is given for
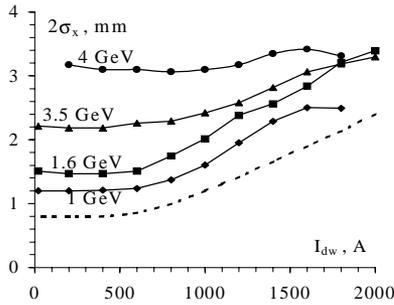


Figure 3: Manipulation of the radial size with the help of dipole wigglers.

some set of values of energy (the current 2 kA corresponds to the field about of 1.8 Tesla). The dotted curve on the plot is the result of calculation for the case of energy E=1 GeV. Luminosity experiments were carried out for a set of energy values with a maximal beam current achievable for that energy values. Theoretical behaviour of maximum luminosity with energy in the regime of 2×2 beams is constructed in Fig.4 under assumption that the magnetic structure is kept constant including a relative field of dipole wigglers (with an absolute value 1.8 Tesla at 1.8 GeV). In experiments the wigglers field was optimized. Generalised experimental data are close to the $E^4$-dependence in Fig.4 except the 1 GeV point
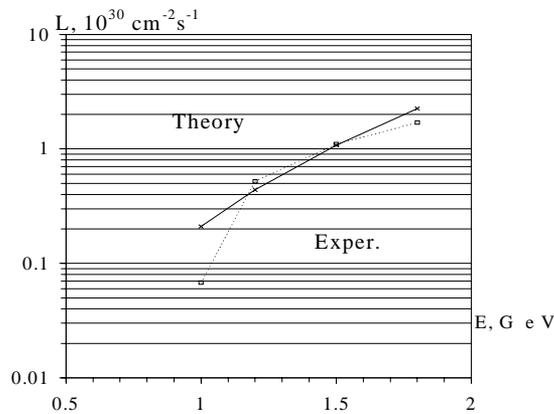


Figure 4: Luminosity versus energy.

where the conditions seem to be not optimal, and so the study at this energy shout be re-carried out.

## 4 LARGE DISPERSION AT THE IP

The magnet structure near the IP has an additional function to be a magnet spectrometer for electrons scattered in two-photon reactions. Due to this, the dispersion function at the IP has a big value (0,8 m), which generally may be considered as a disadvantage from the beam-beam interaction point of view. Actually, analytical estimation shows that in some special case, the big value brings a positive effect in getting luminosity. That case is, when the synchrotron beam size at the IP becomes much more than the betatron one, and the influence of the horizontal betatron motion on the particle's trajectory decreases significantly. As it was shown in [6] for flat beams, the width $\Delta A_Z$ of the resonance $M\cdot Q_X+L\cdot Q_Y+N\cdot Q_Z=K$ depends upon the monochromatization parameter $\lambda$ (which is defined as the ratio of synchrotron and betatron beam sizes at the IP) as: $\Delta A_Z\sim\lambda^{-M/2}$.

The VEPP-4M brings the opportunity to study experimentally the beam-beam interaction with a big dispersion value at the IP. The dipole-gradient wiggler allows us to redistribute the decrements of synchrotron and betatron motions and to change in this way the monochromatization parameter $\lambda$. In particular, on the energy of injection (1.8 GeV), $\lambda$ can be varied in the range from 2 to 4.

We performed a few two-dimensional scans (which differ by the synchrotron tune and $\lambda$) of the betatron tunes in trapeze area near our customary working point above the main coupling resonance. In each point of the scan's sequence we measured the beam sizes for both weak $(e^+)$ and strong $(e^-)$ beams, angular spread for the weak beam, and the luminosity. As a result we will get a diagram of synchro-betatron resonances and hope to identify them and estimate how their strengths depend on the $\lambda$. At the present time, the obtained data are under processing,

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