35

# И Н С Т И Т У Т

# ЯДЕРНОЙ ФИЗИКИ СОАН СССР

ПРЕПРИНТ И Я Ф 75 - 65

V.M.Aulchenko, G.I.Budker, I.V.Vasserman, I.A.Koop,
L.M.Kurdadze, V.P.Kutovoy, A.P.Lisenko, S.I.Mishnev,
E.V.Pakhtusova, S.I.Serednyakov, V.A.Sidorov, A.N.Skrinsky,
G.M.Tumaikin, A.G.Khabakhpashev, A.G.Chilingarov,
Yu.M.Shatunov, B.A.Shwartz, S.I.Eidelman

## BEGINNING OF THE EXPERIMENTS WITH ELECTRON-POSITRON STORAGE RING VEPP-2M

Новосибирск

1975

V.M.Aulchenko, G.I.Budker, I.V.Vasserman, I.A.Koop,
L.M.Kurdadze, V.P.Kutovoy, A.P.Lisenko, S.I.Mishnev,
E.V.Pakhtusova, S.I.Serednyakov, V.A.Sidorov, A.N.Skrinsky,
G.M.Tumaikin, A.G.Khabakhpashev, A.G.Chilingarov,
Yu.M.Shatunov, B.A.Shwartz, S.I.Eidelman

# BEGINNING OF THE EXPERIMENTS WITH ELECTRON-POSITRON STORAGE RING VEPP-2M

## ABSTRACT

Experiments on high energy physics have begun in the Novosibirsk Institute of Nuclear Physics using the new electron-positron colliding beam machine VEPP-2M. Maximum machine energy is 2E = 1340 Mev. The attained luminosity is $10^{30} cm^{-2} sec^{-1}$.

In February - May VEPP-2M has been used for search of narrow resonances in the energy range 770 -1340 Mev with the help of the "OLYA" detector covering a solid angle of 0.65 x $4\pi$ steradian. Data processing is not yet completed, however the first results prove that in this energy range no resonances in a system "$\pi^+\pi^-$ + neutrals" exist with a cross-section larger than 0,1 of that for a corresponding mode of the $\omega$ - or $\varphi$ -meson.

Besides that the storage ring was used to study the process of beam polarization and develop the method of absolute energy calibration with the help of resonance depolarization.

New electron-positron colliding beam machine VEPP-2M with the energy up to 2E = 1340 Mev came into operation in Novosibirsk Institute of Nuclear Physics of the Siberian Division of the USSR Academy of Sciences. The decision to construct a new storage ring with higher luminosity was made in November 1970 after the end of experimental runs with VEPP-2 whose average luminosity was $10^{28}cm^{-2}sec^{-1}$. In spring of 1973 the storage ring mounting has been completed and in August the luminosity $10^{28}cm^{-2}sec^{-1}$ was obtained. In May 1974 the level $10^{29}cm^{-2}sec^{-1}$ was achieved and to the beginning of experiments in December 1974 the maximum luminosity slightly differed from $10^{30}cm^{-2}sec^{-1}$.

Besides the high luminosity the new storage ring VEPP-2M possesses 2 more advantages if compared to the old one: three (instead of one) interaction regions are suited for experiments and detection systems with higher solid angle can be used. The lay-out of VEPP-2M complex is shown in Fig.1. The pulsed accelerator ILU with the energy 3 Mev is used as injector. The synchrotron B-3M accelerates electrons up to 250 Mev. The beam current ejected from the synchrotron is 1 amp (about $10^{11}$ particles), the repetition rate - 1 Hz. The old storage ring VEPP - 2 - a weak focusing large aperture racetrack - is used as a booster in which electrons and positrons are stored in turn. To store positrons a convertor is introduced into the synchrotron-booster channel. Storing of electrons and positrons occurs at 120 Mev, the rate of positron storing being 0.6 mamp/min. After a sufficient number of positrons or electrons is stored in the booster their energy is increased up to the VEPP-2M energy and then a well formed (thin) beam is transferred into the VEPP-2M ring by a one-turn extraction-injection system.

VEPP-2M is an alternating-gradient machine its ring consisting of 8 sections of the magnetic system, 4 short and 4 long (85 cm) straight sections. 200 MHz rf cavity (the 12-th harmonic of the revolution frequency) is installed in one of the long straight sections. The average radius of an equilibrium orbit is 2.84 m, frequency of betatron oscillations 3.1;



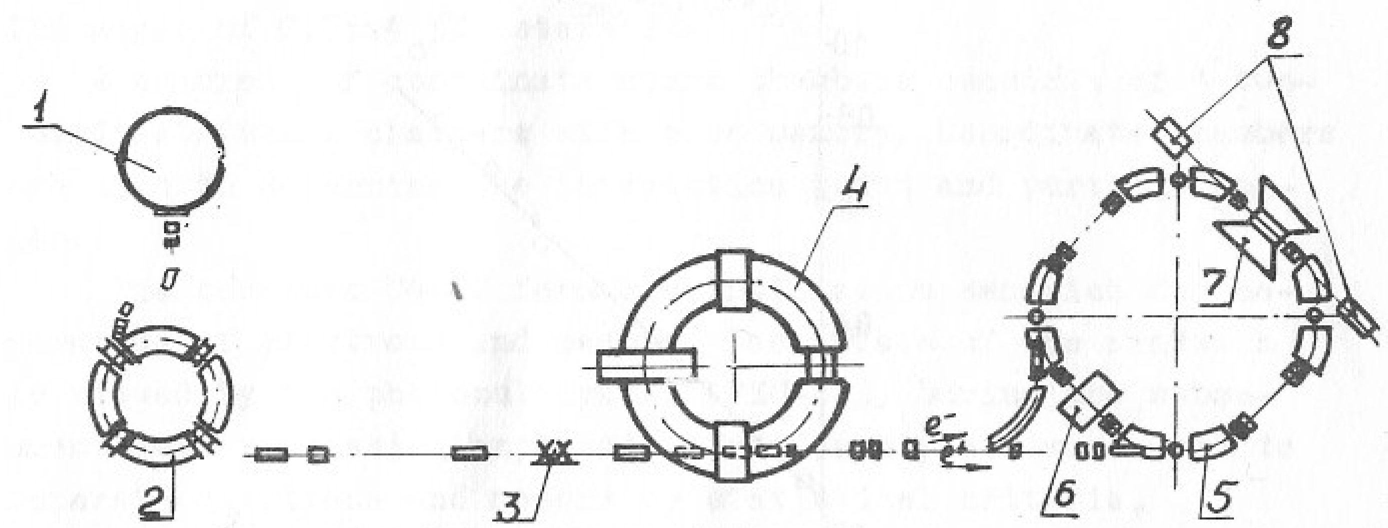


Fig.1 Lay-out of VEPP-2M complex: 1 - injector ILU; 2 - synchrotron B-3M; 3 - parabolic lenses and convertor; 4 - booster; 5 - VEPP-2M ring; 6 - rf cavity; 7 - "OLYA" detector; 8 - total absorption counters of the 2 -monitor.

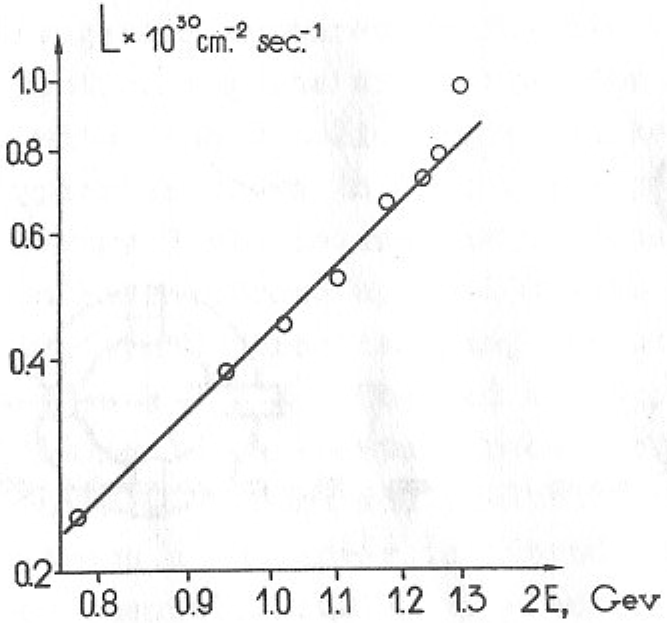


Fig.2 Energy dependence of luminosity.

Experimental values are taken from scanning.



compaction coefficient $\alpha$ =0.18; $\beta$ - function in the interaction point $\beta_r$ = 45 cm, $\beta_z$ = 6.5 cm.

Average vacuum in the ring chamber is about $1\cdot10^{-9}$torr, however at the currents 0.1 mA the lifetime is already determined by Touschek effect.

The record luminosity $9\cdot10^{29}cm^{-2}sec^{-1}$ was obtained at the energy E=625 Mev. Fig.2 presents energy dependence of the luminosity during February-May 1975. It should be noted that in the absence of faults the average luminosity is close to the maximum one. Works on increasing luminosity are in progress.

In autumn 1974 the first detection system was mounted in VEPP-2M - the "OLYA" detector (On-LIne). The general view of the detector is shown in Fig.3. "OLYA" consists of 32 scintillation counters (40 photomultipliers) and 16 coordinate wire spark chambers (10.000 wires) grouped in 4 identical quadrants surrounding the interaction region. The detector covers a solid angle of 0.65x4 $\pi$ steradian.

A quadrant of coordinate spark chambers consists of 4 two-coordinate spark chambers with core memory. Coordinate chambers are used to determine the interaction point and particle angles.

The counters C4-C7 form a scintillation sandwich for separation of electrons and mesons. Each plate of the sandwich is viewed by its photomultiplier (FEU-82). During the subsequent data processing amplitudes from each plate were used to separate electrons and mesons by statistical criteria.

The choice of definite geometry for a detected event was performed by triggering scintillation counters C1, C2, C3-1 and C3-2.

To suppress background due to cosmic particles time of flight between the C3 counters of the opposite quadrants was measured. For the events of the effect this time should be equal to zero, while for cosmic events - 2 nsec. The C3 counters have the sizes 225x725x10 $mm^3$. Each counter was viewed by 2 photomultipliers PM-56 DVP from opposite small sides. A signal from these photomultipliers enters the geometry compensation circuit providing the independence of the triggering moment of the point in which a particle hits a counter. Time re-

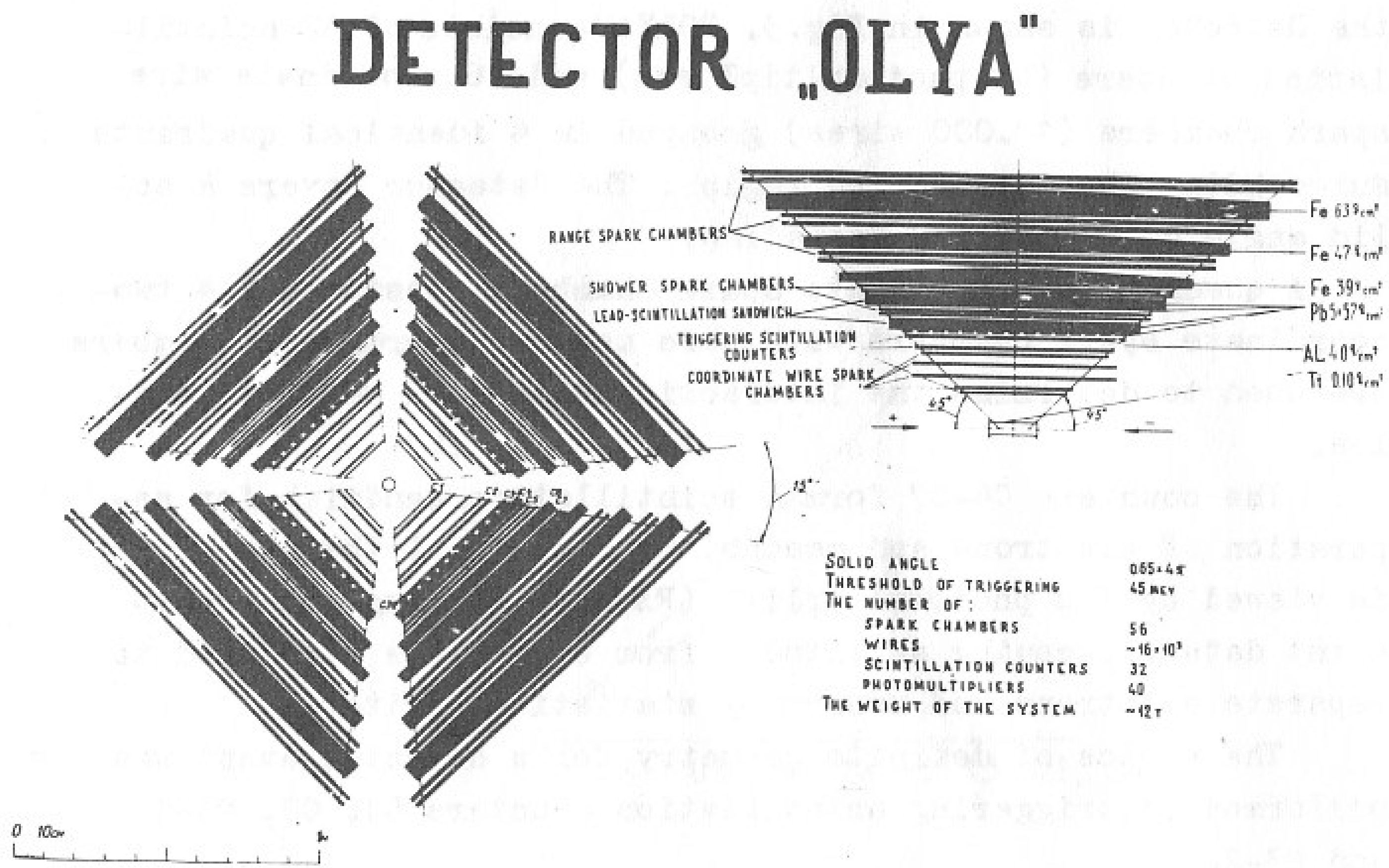


Fig.3 "OLYA" detector: C1, C2, C3-1 and C3-2 - triggering scintillation counters; C4-C7 - sandwich scintillation counters.



solution (width at half-maximum) of the time-of-flight system is 0.7 nsec. Time-of-flight selection allows to decrease a number of triggerings due to cosmic particles by a factor greater than 100.

Additional suppression of cosmic background by a factor of 10 was provided by synchronization of detector triggerings with the phase of a revolution frequency.

The described apparatus composes the first part of the "OLYA" detector. The second part will include shower and range chambers (6.000 wires).

The luminosity monitoring was performed by detecting the process of double Bremsstrahlung by 2 total absorption NaI(Tl) counters. The counters were mounted from the opposite sides of the interaction region along the beams. At the luminosity $10^{29}$ cm$^{-2}$sec$^{-1}$ the counting rate of $\gamma\gamma$ - events is 1 Hz, effect-to-background ratio is about 1.

Detector control, accumulation and primary data processing are performed by a minicomputer M-6000 in the detection control room. M-6000 is in turn connected with an universal computer "Minsk-32" whose magnetic tapes record the data.

In February-May 1975 the detector "OLYA" was used to perform the experiment in search of sharp resonances by scanning the energy range $770 < 2E < 1340$ Mev.

In each energy point a luminosity integral 200 or 300 mcbarn$^{-1}$ was obtained. During the experiment background measurements were periodically performed when the beams collided in the neighbouring straight section. Quantitative characteristics of the experiment are shown in Table.

During the first stage of data processing two-track non-collinear events ($|\Delta\varphi|>15^{\circ}$) were selected in which at least one particle had a range more than 23 g/cm$^2$.

The preliminary results of data processing show that in the energy range 770 - 1340 Mev no resonances in the "$\pi^+\pi^-$ + neutrals" system exist with a cross-section greater than 0.2 of that for a corresponding decay mode of the $\omega$ - or $\phi$ -meson. Fig.4 illustrates the situation in the energy range 770 - 1026 Mev.

Separation of other reaction channels is in progress.

Besides the described experiment VEPP-2M was used to study radiative polarization of the beams in a storage ring /1/.

TABLE

| Energy 2E, MeV | 770 - 1026 | | 1026 - 1300 | | 1300 - 1340 | |
|---|---|---|---|---|---|---|
| Type of measurements | Effect | Back-ground | Effect | Back-ground | Effect | Back-ground |
| Scanning step (2E), MeV | 0.5 | 5.0 | 0.66 | 6.6 | 1.0 | 10 |
| Integrated luminosity per point, $10^{30}$ cm$^{-2}$ | 200 | - | 300 | - | 200 | - |
| Measurement time, $10^3$ sec | 716 | 74 | 381 | 43 | 26 | 2.6 |
| Number of detector triggerings, $10^3$ | 700 | 82 | 477 | 60 | 31 | 3.8 |
| Number of selected events | 2262 | 5 | 2319 | 6 | 141 | 1 |



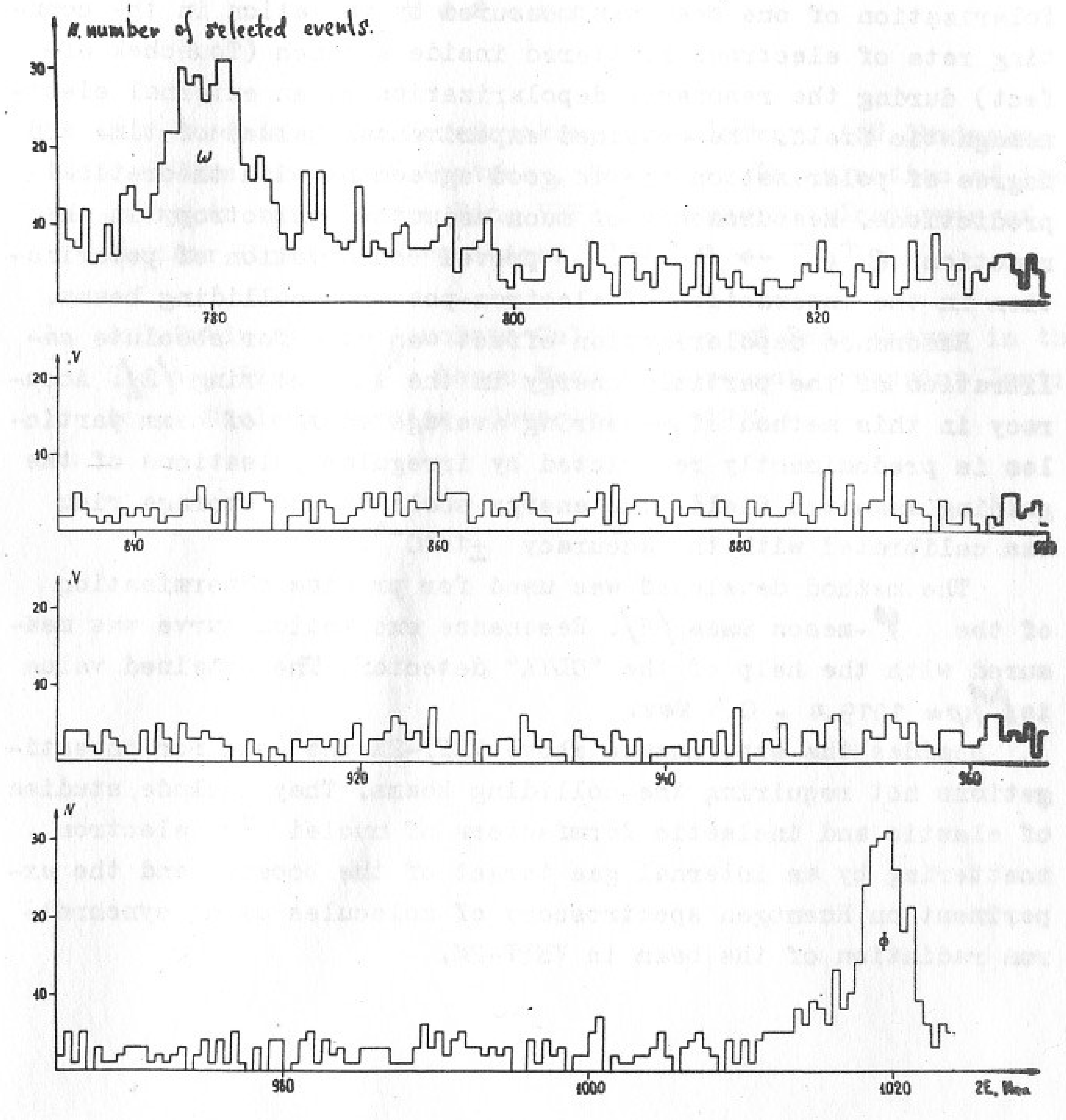


**Fig.4 Preliminary results of scanning.**

Polarization of one beam was measured by variation in the counting rate of electrons scattered inside a bunch (Touschek effect) during the resonance depolarizarion by an external electromagnetic field. The obtained experimental values of time and degree of polarization are in good agreement with theoretical predictions. Measurements of muon azimuthal anisotropy in the reaction $e^+e^- \rightarrow \mu^+\mu^-$ proved conservation of polarization in the interaction of electron-positron colliding beams.

Resonance depolarization effect was used for absolute calibration of the particle energy in the storage ring /2/. Accuracy in this method of measuring average energy of beam particles is predominantly restricted by irregular pulsations of the guiding magnetic field. The energy scale of the storage ring was calibrated with the accuracy $\pm 1 \cdot 10^{-4}$.

The method developed was used for precise determination of the $\varphi$-meson mass /2/. Resonance excitation curve was measured with the help of the "OLYA" detector. The obtained value is $M_\varphi = 1019.4 \pm 0.3$ Mev.

Besides the experiments above VEPP-2M was used for investigations not requiring the colliding beams. They include studies of elastic and inelastic formfactors of nuclei in electron scattering by an internal gas target of the booster and the experiment on Roentgen spectroscopy of molecules using synchrotron radiation of the beam in VEPP-2M.



R e f e r e n c e s

1. L.M.Kurdadze, S.I.Serednyakov, V.A.Sidorov, A.N.Skrinsky, G.M.Tumaikin, Yu.M.Shatunov. Radiative Polarization of the Beams in the Storage Ring VEPP-2M. Preprint Institute of Nuclear Physics, Novosibirsk, 1975.

2. A.D.Bukin et al. Absolute Calibration of Beam Energy in the Storage Ring. $\varphi$ -Meson Mass Measurement. Preprint Institute of Nuclear Physics, Novosibirsk, 1975.

Поступила 10 июля 1975г.

Ответственный за выпуск Г.А.СПИРИДОНОВ
Подписано к печати 13.8.75г. МН 07425
Усл. 0,8 печ.л., тираж 250 экз. Бесплатно
Заказ № 65

Отпечатано на ротапринте в ИЯФ СО АН СССР