Electron-positron collider VEPP-2000 commissioning

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on behalf of VEPP-2000 team,

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VEPP-2M \rightarrow VEPP-2000

Physics at VEPP-2000

Round beams - a way to increase luminosity.

VEPP-2000 systems

First beam

Round beam

Beam-beam study

Conclusion
**VEPP-2M collider complex**  
(1974-2000)

- Luminosity: $L=5\times10^{30}\text{cm}^{-2}\text{s}^{-1}$
- Radiative polarization
- Spin precession frequency measurements
  - $\rho, \omega, \varphi, K^\pm, K^0$ mass measurements
- $e^+e^-$ anomalous magnetic moment comparison ($10^{-11}$)
Overview of VEPP-2M results

\[ \int L dt \geq 100 \, (\text{pbarn})^{-1} \]
1. Precise measurement of the quantity
   \( R = \frac{\sigma(e^+e^- \to \text{hadrons})}{\sigma(e^+e^- \to \mu^+\mu^-)} \)
2. Study of hadronic channels:
   \( e^+e^- \to 2h, 3h, 4h ..., h = \pi, K, \eta \)
3. Study of ‘excited’ vector mesons: \( \rho', \rho'', \omega', \phi', \ldots \)
4. CVC tests: comparison of \( e^+e^- \to \text{hadr.} \) (T=1) cross section with \( \tau \)-decay spectra
5. Study of nucleon-antinucleon pair production - nucleon electromagnetic form factors, search for NNbar resonances, ..
6. Hadron production in ‘radiative return’ (ISR) processes
7. Two photon physics
8. Test of the QED high order processes 2->4,5
VEPP-2M \rightarrow VEPP-2000

(2000-2007)

- E \approx 1 \text{ GeV} \hspace{1cm} \text{(per beam)}
- L \approx 1 \times 10^{32} \text{ cm}^{-2} \text{ sec}^{-1} \hspace{1cm} \text{(1×1 bunch)}
Increasing of Luminosity

- Number of bunches (i.e. collision frequency)
- Bunch-by-bunch luminosity

\[ L = \frac{\pi \gamma^2 \xi_x \xi_y \epsilon_x f}{r_e^2 \beta^*} \left(1 + \frac{\sigma_y}{\sigma_x}\right)^2 \]

- Geometric factor (gain=4)
- Beam-beam limit enhancement
- IBS for low energy? worth life time!

\[ \xi_{x,y} \geq 0.1 \]
Angular momentum conservation!\[ M_z = x'y - xy' \]

Small and equal $\beta$-functions at IP: \[ \beta_x = \beta_y \]

Equal beam emittances: \[ \varepsilon_x = \varepsilon_y \]

Equal betatron tunes:\[ \nu_x = \nu_y \]

Small and positive fractional tunes

(V.V. Danilov et al., EPAC’96, Barcelona, p.1149, (1996))
Vertical size dependence on beam-beam parameter $\xi$

"Weak-Strong" Beam-Beam Simulations

$$\xi = \frac{N r_e \beta^*}{4 \pi \gamma (\sigma^*)^2}$$

Flat beams, fit on VEPP-2M experimental data

Round beams, simulation
“Strong-Strong” Beam-Beam Simulations
Practical Realization of Round Beams Options for VEPP-2000
Practical Realization of Round Beams
Options for VEPP-2000
Solenoid 13.0 T
Solenoid Test

![Graph showing magnetic field (B, T) vs. distance (S, mm)]
Solenoids- “off”

\[ \nu_z = 1.38; \quad \nu_x = 2.44 \]
Beam’s CCD pictures

- regular
- kicked
- tune mes.
CO and Beam Sizes  (solenoids “off”)

E = 508 MeV
Pick-up diagnostics
Beam currents

Synchrotron B-3M

Booste Booster BEP

VEPP-2000

\[ \tau(150\ mA) \approx 500\ sec \]

\[ \tau(1\ mA) \geq 10\ hours \]
Round beam operation

\[ E = 508 \text{ MeV} \]

E = 508 MeV

\[ \beta^* = 4.5 \text{ cm}, \quad \nu_1 = 2.12, \quad \nu_2 = 4.15 \]

Orbit response matrices on dipole and quadrupole corrections + Singular Values Decomposition
Round beams (solenoid field 10 T)

positron beam

#1 (1M2)  #2 (2M2)  #3 (2M1)
Round beam lattice

#1 (1M2)
#2 (2M2)
#3 (2M1)
#4 (3M1)
“Weak-strong” beam-beam study

\[ \xi = 0.08 \]
Tune chromaticity measurements.
Sextupoles “on”.

Revolution frequency, kHz
Measurement of damping time

\[ \tau(\text{theory}) = 21.4 \text{ s} \]

\[ \tau(\text{measured}) = 21.0 \text{ s} \]
Dynamic aperture scan
Threshold current dependence on tune

![Graph showing threshold current dependence on tune](image.png)
### Best luminosity run

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<table>
<thead>
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<td>L</td>
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<td>dL</td>
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<td><strong>IEAVG</strong></td>
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<td><strong>IPROD AVG</strong></td>
<td><strong>365.86 mA^2</strong></td>
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VEPP-2000 Luminosity

Center of Mass Energy, GeV
VEPP–2000 is working

«Round beams» – not a bad idea!

Max. Lumi. achieved $1 \times 10^{31} \text{ cm}^{-2}\text{s}^{-1}$ at φ-meson energy

Potentially $2 \times 10^{31} \text{ cm}^{-2}\text{s}^{-1}$ possible at φ

and $1.6 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$ at 2 GeV

More positrons required!