Status of the VEPP-2000 Collider Project

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Layout of the VEPP(-2M)-2000 collider complex

- **E ≈ 1 GeV** (per beam)
- **L ≈ 1×10^{32} cm^{-2} sec^{-1}** (1×1 bunch)
ВЭПП-2000

**TASKS for VEPP-2000:**

1. To study “peculiarities” above 1.4 GeV (total).

2. To measure with good enough precision total hadron cross-section in 1.4 - 2 GeV (total) - for hadron contribution to muon g-2.

3. To measure form-factors (in time-like region) for protons and neutrons

\[ e^+ + e^- \rightarrow p + \text{anti-p} ; \quad e^+ + e^- \rightarrow n + \text{anti-n} . \]

4. For accelerator physics: “Round Beams”!
Increasing the Luminosity

- Number of bunches
- Bunch-by-bunch luminosity

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

Round Beam:

- Geometric factor
- Beam-beam limit enhancement
Concept of Round Beams

Conservation of the z-component of angular momentum

\[ M_z = y p_x - x p_y \]

Requirements:

✓ Round cross-section of beams at IP
✓ Machine optics has rotational symmetry

4×4 transfer matrix

\[
T = \begin{pmatrix}
A & -B \\
B & A
\end{pmatrix}
\]

Motion in central field with additional integral of motion reduces the transverse oscillations from 2D to 1D!

Practical Realization of Round Beams: Options for VEPP-2000

\[ \int_{0}^{l} H_{sol} \, ds = \frac{1}{2} \int_{0}^{l} H_{z} \, ds \]
Practical Realization of Round Beams

Conversion of conventional machine using beam adapters

Touschek problem for low energy:
  worse life time!

(A.Burov, S.Nagaitsev, Ya.Derbenev, FERMILAB-Pub-01/060-T)
View of the Collider
Lattice

![Graph showing Lattice characteristics with Betas Z and X, and Dispersion over S (cm).](image-url)
Weak-Strong Beam-Beam Simulation

Emittance of the weak beam vs. the beam-beam parameter. Sextupoles off. 1,2 – two codes.
Weak-Strong Beam-Beam Simulation

Emittance of the weak beam vs. the beam-beam parameter. Sextupoles on. 1,2 – two codes.
Strong-Strong Beam-Beam Simulation

Macroparticles/bunch $N_p = 50000$, transverse mesh $128\times128$;
Field calculated via FFT
Strong-Strong Beam-Beam Simulation

Beam size and luminosity vs. the nominal beam-beam parameter (PAC’2003)
Comparison of the sextupoles on and off options.
# Main Parameters of VEPP-2000

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circumference</td>
<td>24.38 m</td>
</tr>
<tr>
<td>RF frequency</td>
<td>172 MHz</td>
</tr>
<tr>
<td>RF voltage</td>
<td>100 kV</td>
</tr>
<tr>
<td>RF harmonic</td>
<td>14</td>
</tr>
<tr>
<td>Momentum compaction</td>
<td>0.036</td>
</tr>
<tr>
<td>Synchrotron tune</td>
<td>0.0035</td>
</tr>
<tr>
<td>Energy spread</td>
<td>$6.4 \times 10^{-4}$</td>
</tr>
<tr>
<td>Beam emittances (x,y)</td>
<td>$1.29 \times 10^{-7}$ m rad</td>
</tr>
<tr>
<td>Dimensionless damping decrements (x,y,z)</td>
<td>$2.19 \times 10^{-5}$, $2.19 \times 10^{-5}$, $4.83 \times 10^{-5}$</td>
</tr>
<tr>
<td>Betatron tunes</td>
<td>4.05, 2.05</td>
</tr>
<tr>
<td>Betatron functions @ IP</td>
<td>10 cm</td>
</tr>
<tr>
<td>Particles per bunch</td>
<td>$1 \times 10^{11}$</td>
</tr>
<tr>
<td>Beam-beam parameter (x,y)</td>
<td>0.075, 0.075</td>
</tr>
<tr>
<td>Luminosity per IP (at 1GeV)</td>
<td>$1 \times 10^{32}$ cm$^{-2}$ s$^{-1}$</td>
</tr>
</tbody>
</table>
Dipole Magnet (2.4 T)
Dipole: Magnetic Measurements

\[ B(I, \text{Gs}) \]

\[ I, \text{A} \]
Dipole: Magnetic Measurements

Guiding field 0.6 T

Guiding field 2.38 T
Quadrupole
Quadrupole: Magnetic Measurements
Vacuum Chamber
Single-Mode RF Cavity (172 MHz)
Calculated main mode & HOM
RF cavity parts
Solenoid 13.0 T
Solenoid: Coils

Nb-Sn

Nb-Ti
Assembly of the Nb-Ti and Nb-Sn coils
VEPP-2000 Luminosity

\[
\begin{align*}
L_V & = \frac{L_{\text{cm}^{-2} \text{s}^{-1}}}{10^{33}} \\
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L_V & = \frac{L_{\text{cm}^{-2} \text{s}^{-1}}}{10^{30}} \\
L_V & = \frac{L_{\text{cm}^{-2} \text{s}^{-1}}}{10^{29}}
\end{align*}
\]

\[E, \text{ GeV} \]

- \text{E}^2
- \text{E}^4
- \text{Work}
POSITRON SOURCE

- Debuncher
- Damping ring
- To VEPP-2000
- Electron gun
- Subharmonic
- Target
- Photo-gun
- 300 MeV linac
- Linac
- 510 MeV
- To VEPP-4
hall of 300 @500 MeV linacs
510 MeV damping ring
Summary


♦ Dipole, quads, sextupoles, skew-quads, steering coils, 6 from 8 vacuum chamber are ready, tested and installed

♦ 13 T field is achieved in solenoid prototype

♦ Weak-strong and strong-strong simulation show high $\xi$ for the round beams

♦ Construction of transfer line from e$^+$ source is going on

♦ Beam $\rightarrow$ at the end of 2004