Outline

- Historic remarks
- Round beams concept
- VEPP-2000 overview
- Lattice options
- Dynamic aperture
- Beam-beam study
- Round beam luminosity
- First experimental runs 2010-2011
- Energy calibration
- Conclusion
Layout of VEPP-2000 complex

ILU
2.5 MeV Linac

B-3M
250 MeV synchro-betatron

e\textsuperscript{−}e\textsuperscript{+} convertor

BEP
\textit{e}^-, \textit{e}^+
booster
825 MeV

CMD-3

SND

VEPP-2000

2 m

RF
Collider overview

L = 24.39 m
f_{acc} = 172 MHz
V_{acc} = 120 kV
E = 0.2 – 1 GeV
B_{bend} = 2.4 T
B_{sol} = 13 T
\beta^* = 2 – 10 cm
\sigma_s = 3 cm
\epsilon = 1.4 \cdot 10^{-7}\text{mrad}
\nu_{x,z} = 2.1; 4.1
\alpha = 0.036
\xi = 0.15
N^\pm = 1 \cdot 10^{11}
L = 1 \cdot 10^{32}\text{cm}^{-2}\text{s}^{-1}
VEPP-2000 lattice
The Concept of Round Colliding Beams

Angular momentum conservation:
\[ M_y = x'z - xz' \]

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

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

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

Small and positive fractional tunes

(V.V. Danilov et al., EPAC’96, Barcelona, p.1149, 1996)
Round beam options

- "Flat"
- "Normal Round"
- "Single möbius"
- "Double möbius"
Machine tuning

Closed Orbit corrections
Pick-ups Orbit Response Matrix to focusing offsets (4×32)
SVD analysis → steering coil corrections
2-3 iterations + minimizing of $\sum I_{\text{cor}}$ → correctors setting
$\Delta x; \Delta z \approx \pm 0.2$ mm

Lattice corrections
BPMs ORM to steering coils modulations (20×36)
SVD analysis → focusing corrections (quads + solenoids)
3–4 iterations → lattice setting
$\beta^*; \text{zero dispersion outside achromats;}

Coupling compensation
1.5 Tm field of CMD detector + solenoids compensating coils
3 families of skew quads → $v_1 - v_2 < 0.003$
Lattice corrections

\[ \beta_x, \beta_z \ (\text{cm}) \]

\[ \beta_x, \beta_z \ (\text{cm}) \]

\[ \beta_x, \beta_z \ (\text{cm}) \]

\[ D_x \ (\text{cm}) \]

Dispersion

After 3 iterations

After 4 iterations
Lattice and beam sizes
(I\(\pm\) <1mA)

\(\nu_1 = 2.15; \ \nu_2 = 4.15\)
Positron beam lifetime
($I^+ = 20$ mA)
“Week-strong” beam-beam
(“dynamic beta and emittance”)

$I^+ = 3$ mA; $I^- = 48$ mA
Threshold current vs. tune
("week-strong")

$E = 500 \text{MeV}$
$\beta^* = 4.5 \text{cm}$

$\xi = 0.1$
"Strong-strong" beam-beam
(“dynamic beta and emittance”)

$I^+ = 61.8 \text{ mA}; \quad I^- = 53.2 \text{ mA}$
Luminosity measurements

Bhabha scattering in the SND and CMD detectors

\[ \theta_{\text{scatt}} \geq 0.5 \]

Main disadvantage \( \Rightarrow \) low counting rate

\[ \dot{n} \approx 10 \text{ Hz at } L=1 \cdot 10^{31} \text{ cm}^{-2}\text{s}^{-1} \]

Basic formulae of the luminosity:

\[ L = \frac{f_0 \cdot N^+ \cdot N^-}{4 \pi \cdot \Sigma^* \cdot \Sigma^*} \]

Beam profile measurements at 16 points \( \Rightarrow \)

\[ \Sigma^* = \sqrt{(\sigma^*_x)^2 + (\sigma^*_z)^2} \]

with dynamic \( \beta \)-functions and beam emittance, but under assumption: no other lattice distortions besides counter beam.

Time of measurement \( \approx 1 \text{ s at any energy.} \)
Luminosity measurements

(E = 837 MeV; Run 2011)
Luminosity at run 2011
(CMD data)

\[ \int L dt \approx 22 \ (pb)^{-1} \]
$6\ \pi$-mesons production

(preliminary)
Luminosity vs. $\xi$

$L, 10^{30} \text{cm}^{-2} \text{s}^{-1}$

$E=537.5 \text{MeV}$
$\beta^* = 8 \text{cm}$

$\xi = \frac{N^- r_e}{4\pi\gamma\varepsilon}$
Specific luminosity vs. $\xi$
Radiative polarization

\[ \frac{\Delta B_s}{B_s} = 10^{-3} \]

\[ \frac{\Delta B_s}{B_s} = 10^{-2} \]
Beam energy calibration

\[ E = 750.67 \pm 0.03 \text{ MeV} \]

\[ \dot{f}_d = -10 (\text{Hz/sec}) \]

\[ \ddot{f}_d = -10 (\text{Hz/sec}) \]

\[ f_d = 1 (\text{Hz/sec}) \]

\[ f_d = \left( \frac{E(\text{MeV})}{440.6484} - 1 \right) f_0 \]
BEP upgrade (1GeV)
BEP upgrade (1GeV)

- Magnetic field strength: 26.0 kGs
- Current: 9.5 kA

Dimensions:
- Length: 73 cm
- Width: 40.2 cm
- Height: 39 mm
Conclusion

Round beams give a serious luminosity enhancement. The beam-beam parameter achieves a value $\xi = 0.15$. VEPP-2000 started up for data taking with 2 detectors. Precise beam energy calibration is in progress. To reach the target luminosity, more positrons are needed. Booster BEP upgrade for beam transfer at 1GeV is being prepared.
Thanks for your attention!

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