THE PROTOTYPE OF NEW VARIABLE PERIOD UNDULATOR FOR NOVOSIBIRSK FREE ELECTRON LASER

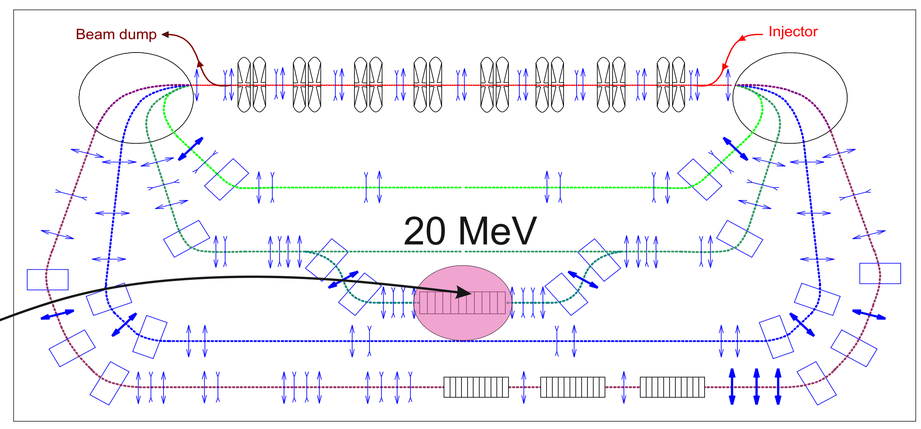
I.V. Davidyuk , O.A. Shevchenko, V.G. Tcheskidov, N.A. Vinokurov

Budker Institute of Nuclear Physics, Novosibirsk, Russia

Novosibirsk FEL is a powerful source of terahertz radiation.

Permanent magnet variable-period undulator was developed to replace existing EM one of the second stage.

Bypass of the second stage with undulator is here

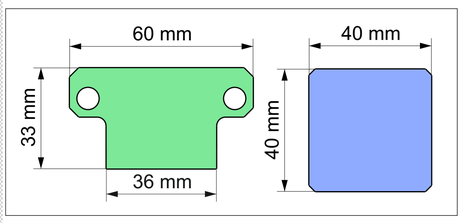


What is the benefit?

	Existing EM undulator	VPU
Undulator period (mm)	120	48 - 96
Field amplitude (kGs)	0 - 1.3	0.93 - 2
Radiation wavelength (μm)	37 - 80	14 - 75
Number of periods	30	40 - 80

What does it look like?

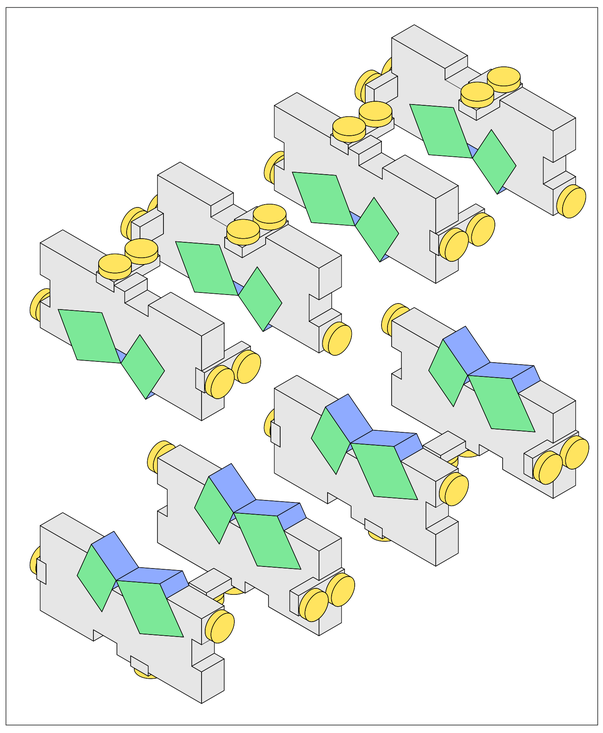
Our VPU looks like hybrid undulator with splitted poles.



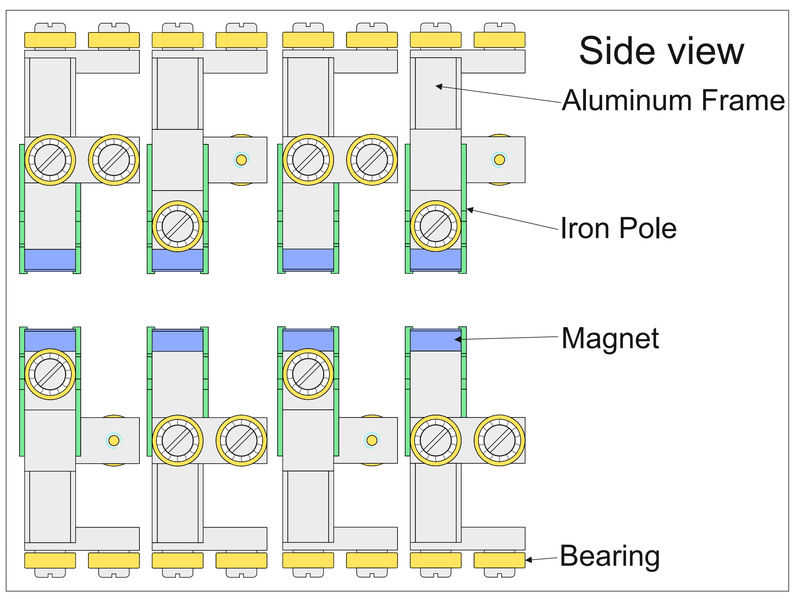
Magnet block thickness is 10 mm.

Pole thicness is 4 mm.

Life-size iron pole and magnet block



Two magnets are combined in one movable unit.
The top and bottom units are not connected.
Blocks in one unit are tilted relative to each other, therefore the free aperture is a rhomb.
This configuration provides field amplitude growth with distance from the central axis in all directions.

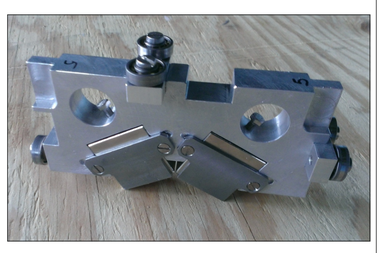


The mass of one unit block is about 1 kg, and the vertical magnetic force acting on the unit is about 20 N at undulator period 5 cm and 50 N at period 9 cm. Therefore,to avoid the problem with the systematic shift it is necessary to provide a friction coefficient value less than 5*10^-3 with help of *bearings*.

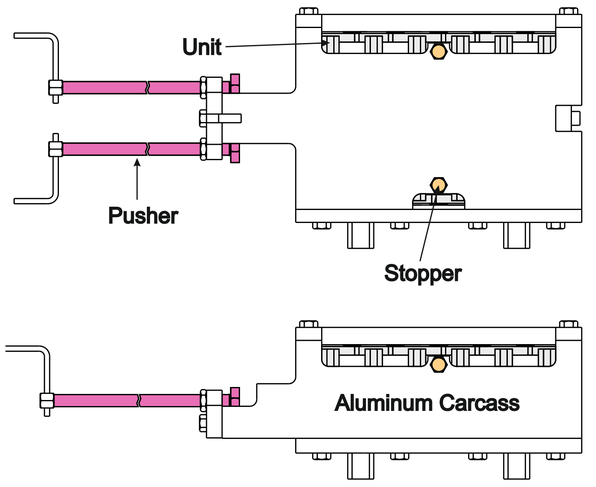
Prototype mechanical design

Carcasses of undulators are made of aluminum and allow installing up to 8 units in row.

Units consist of two magnets, four metal plates, aluminum frame and set of bearings.
Bearings positions are optimized to avoid tilts of the unit.



This one has both upper and lower arrays of units and it is suitable for magnetic measurements.

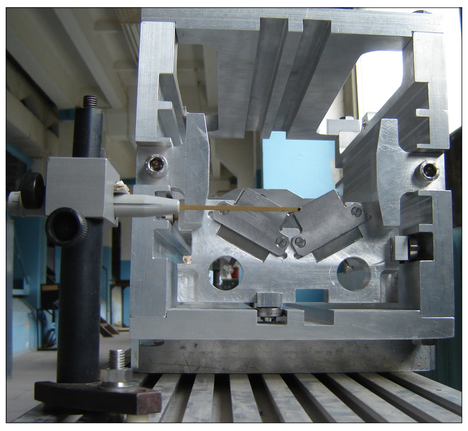


This one has upper array and a metal plate in the horizontal symmetry plane that provides proper boundary conditions. It is convenient to conduct mechanical measurements.

Measurements

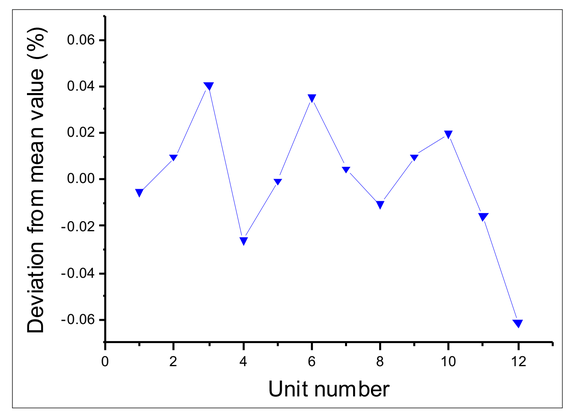
Finally, we can check results of computer simulations.

We placed a **Hall sensor** at the 90 mm distance from the unit.



We compared data from the detector for all the units. The mean value is 97.8 Gs, while the magnetic field calculated in CST Studio software in the same scheme is 97.3 Gs. It means that magnetizations of manufactured magnets are very close to project value 1.3 T

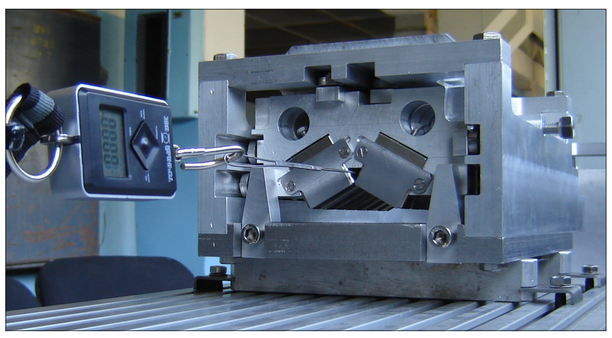
One can see here deviation from the mean value of magnetization for all units in the drawing on the right

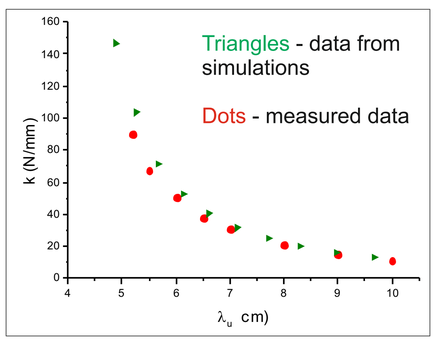


Using magnetic field distribution from simulations we can find **the vertical attraction force** between two units and compare it to the measured one!

Lower unit was fixed and upper unit could be moved only vertically.
The measured force was 60.42 N and the weight of the unit was 9.92 N, thus, attraction force is 50.5 N.
The force obtained from numerical calculation of simulated field is 50.85 N.

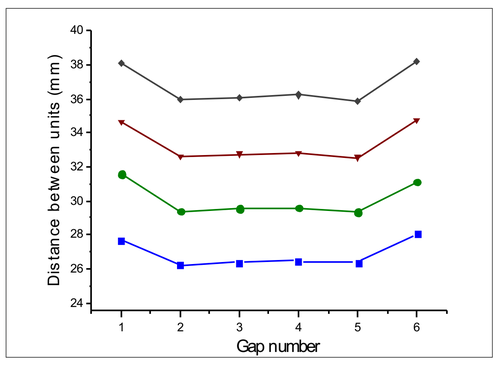
We also measured **horizontal repulsive force** between units in three-unit scheme: two fixed in the ends and one that we can shift in the middle.

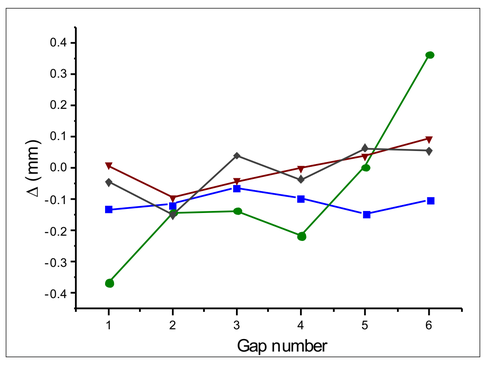




In such a scheme behavior of the force is almost linear with growing shift. But, as the period of undulator changes, the repulsive longitudinal force on shifted unit changes too. The figure above shows the dependence of three-unit system rigidity k (repulsive force normalized on shift) on the period of undulator.

Then we checked the **repeatability of the units distribution**.
We measured distances between units at different periods, changing the undulator period back and forth.
Distributions of the units are shown in the figure on the left. Displacements of the magnet after the period change are shown in the right figure.





Davidyuk Igor
daveduke@outlook.com
http://www.inp.nsk.su/