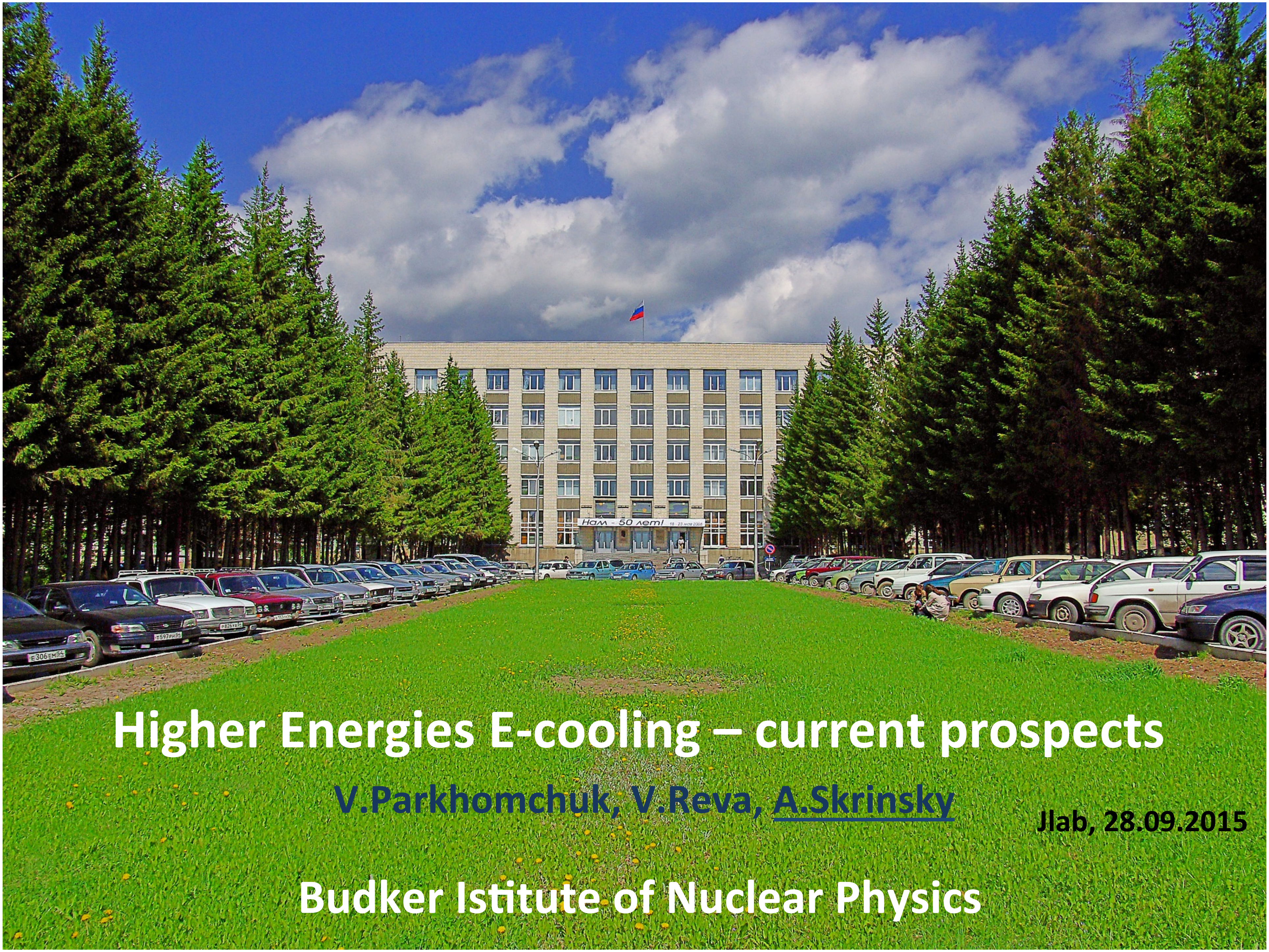


Higher Energies E-cooling – current prospects

V.Parkhomchuk, V.Reva, A.Skrinsky

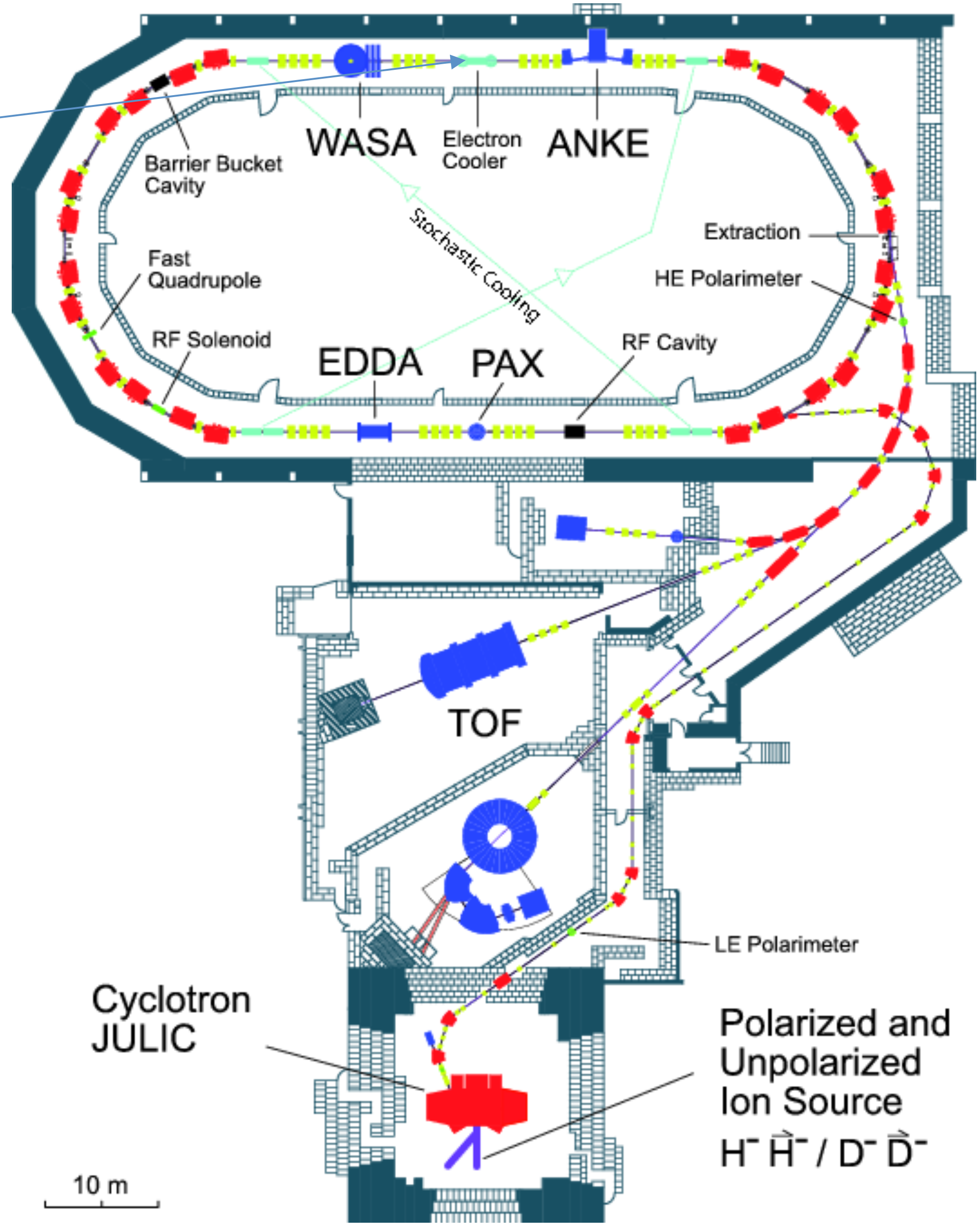
Jlab, 28.09.2015

Budker Istitute of Nuclear Physics

For fast cooling:

- **electron energy up to 2-4 MeV – electrostatic acceleration;**
- **higher energies – RF accelerator-recuperator.**

Cooling section

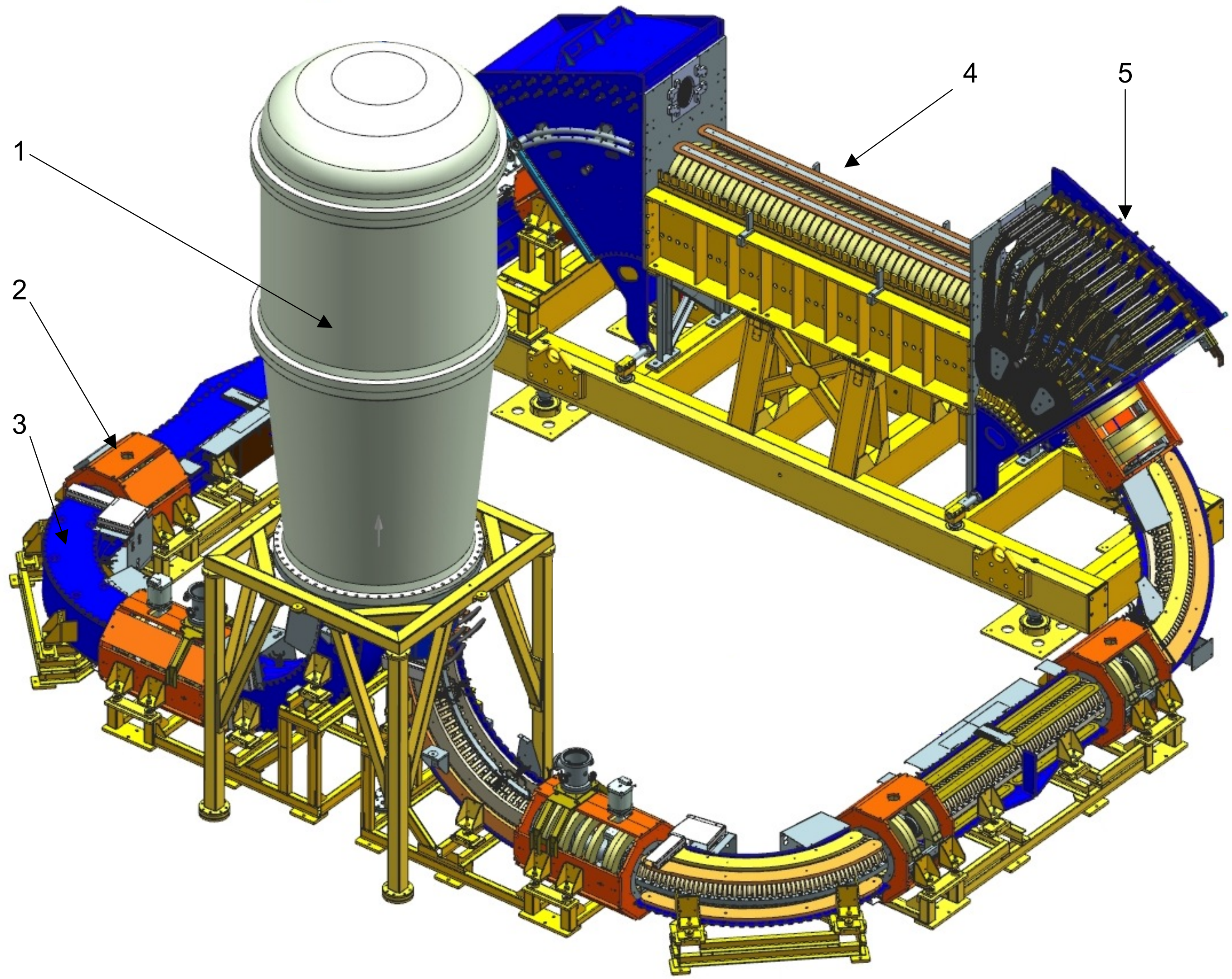


COSY – 2MeV (e)

(general view)

@ Julich

1 – HV vessel
2 – line element of the transport channel
3 – bend element
4 – cooling section
5 – toroid section



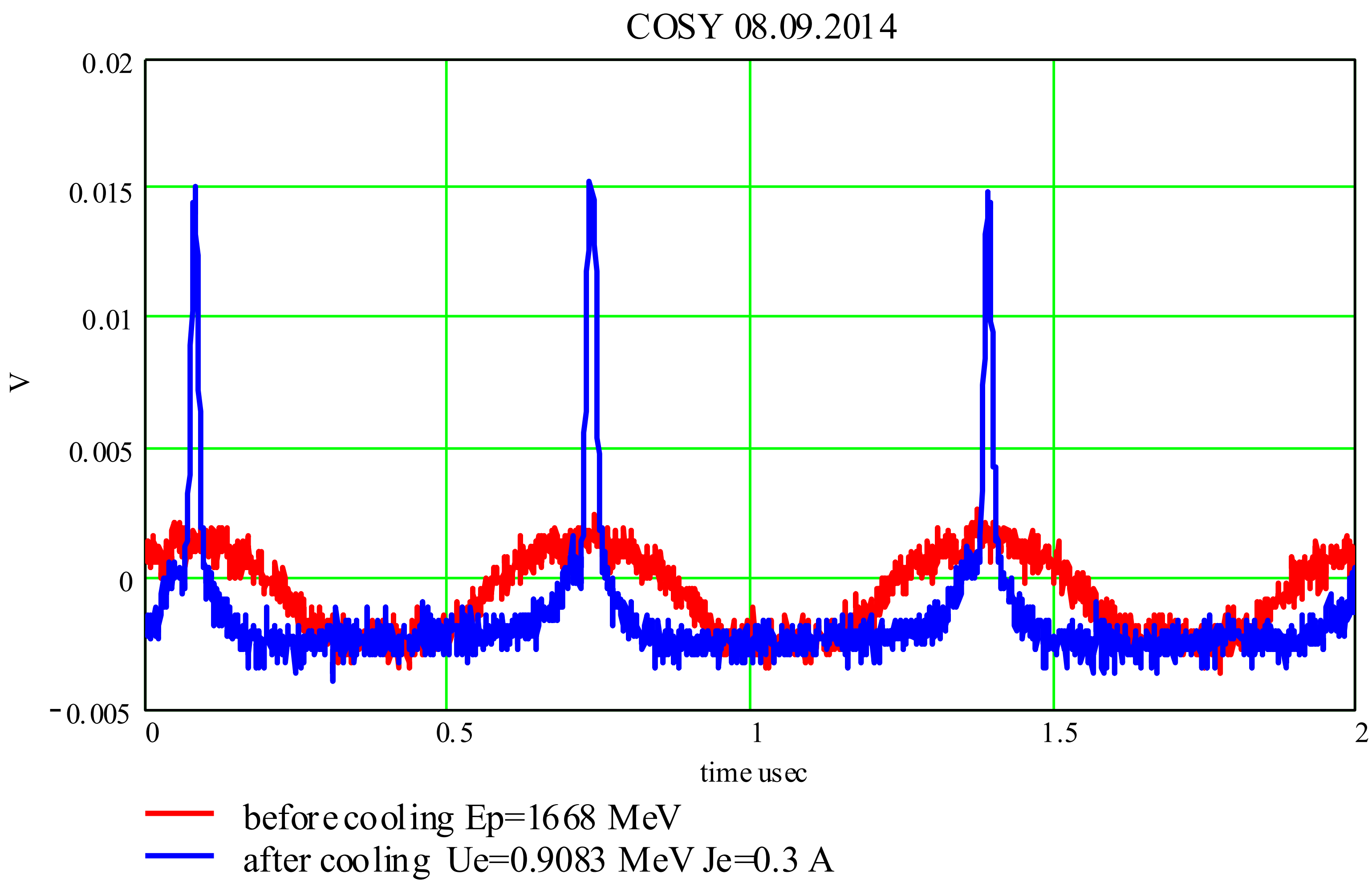
COSY cooling system (general view)

2 MeV cooler arriving at COSY (2012)

(BINP: design, construction, start of operation)

Main parameters
of COSY cooling system.

Energy range	0.025 ÷ 2 MeV
Maximal electron current	1-3 A
Cathode diameter	30 mm
Cooling section	2.69 m
Bending radii	1.00 m
Magnetic field in cooling section	0.5 ÷ 2 kG
Vacuum in cooling section	10^{-9} mbar
Full length of electron beam (cathode-collector)	27 m

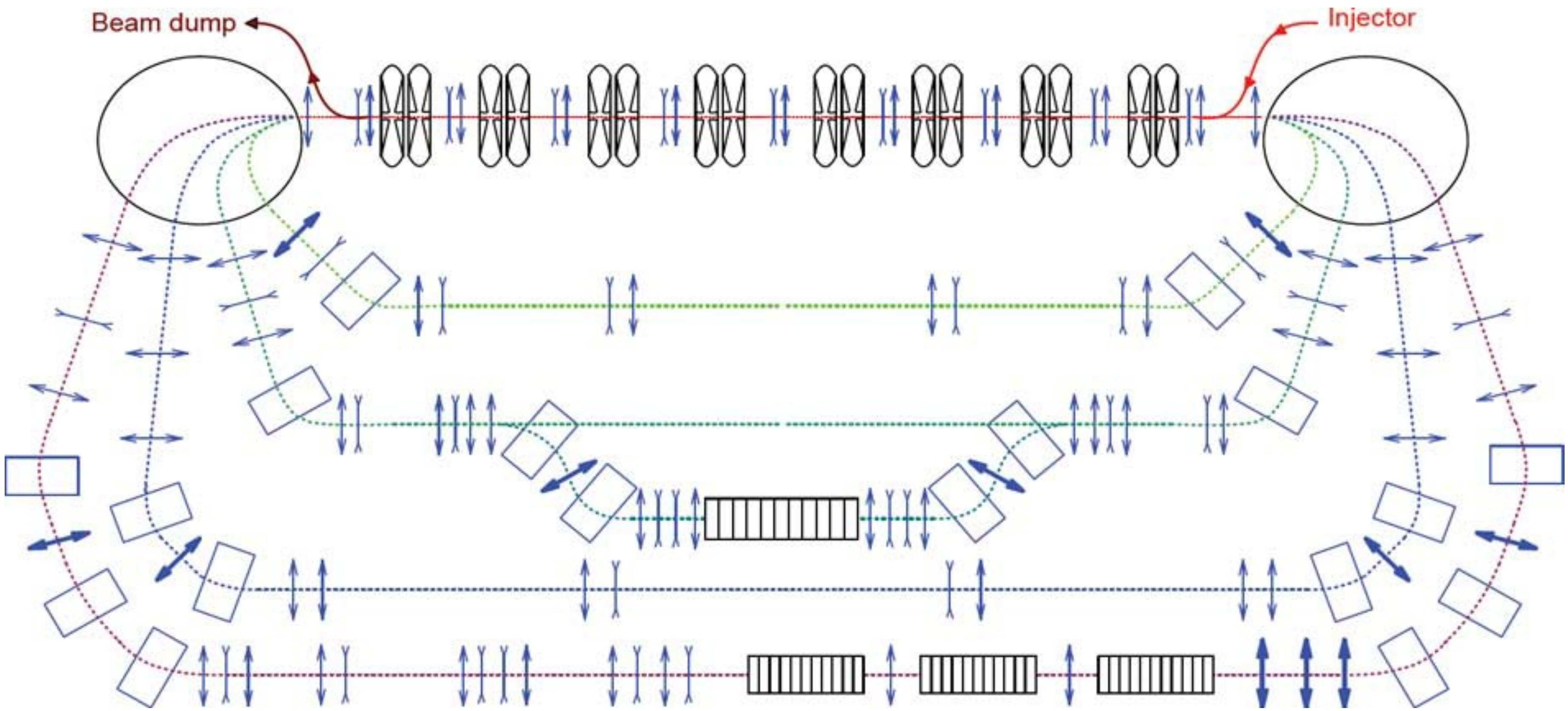


Long-to-short proton bunches using electron cooling @ COSY.

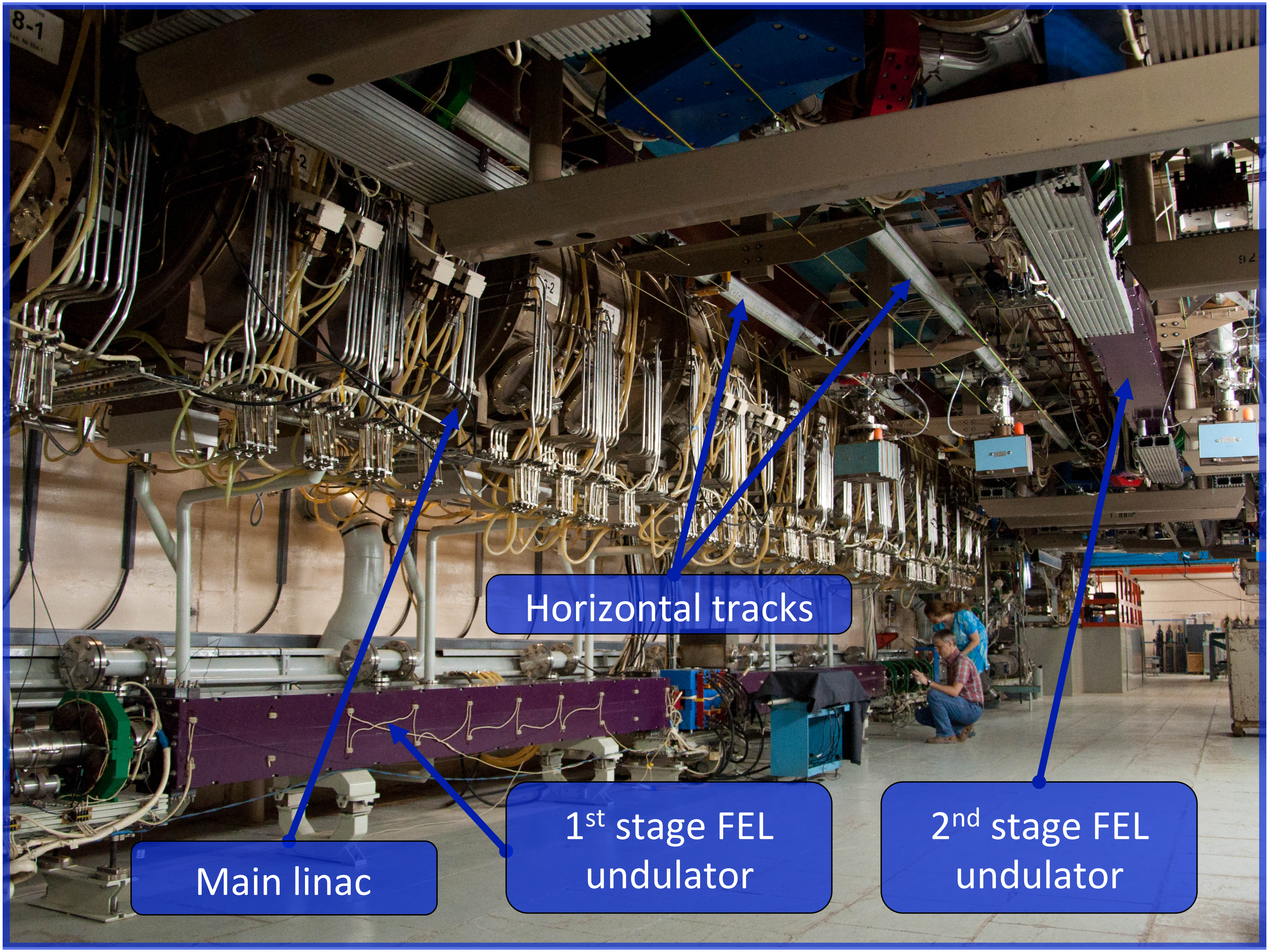
Higher energies could be useful to enhance luminosity of Ion-ion end electron-ion colliders at ion energies

10–100 GeV per nucleon.

The Novosibirsk FEL as prototyping electron beams for higher energies electron cooling.



Novosibirsk Free Electron Lasers – based on multi-turn accelerator-recuperator



Horizontal tracks
Main linac
1st stage FEL undulator
2nd stage FEL undulator


3d stage FEL undulator

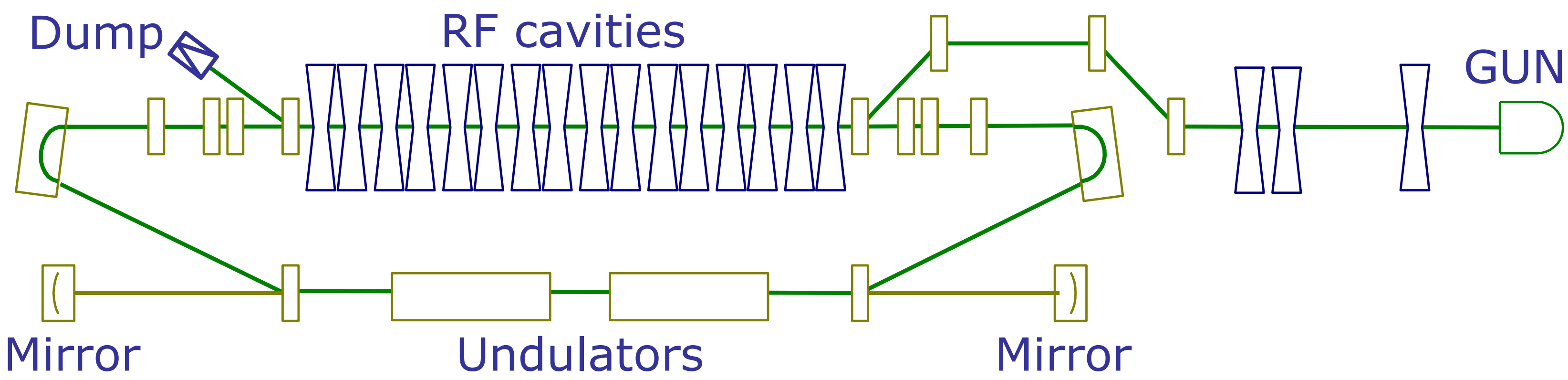
Electron beam and radiation parameters

	1st	2nd	3d	
Energy, MeV	12	22	**42**	46
Current, mA	30	10	**3**	50
Wavelength, μm	90-240	37-80	**9**	5-20
Radiation power, kW	0.5	0.5	**0.1**	5
Electron efficiency, %	0.6	0.3	**0.2**	0.5

Parameters of Novosibirsk FEL – important for cooling:

Injection energy, MeV	2
Main linac energy gain, MeV	10
Charge per bunch, nC	1.5
Normalized emittance, mm·mrad	20
RF frequency, MHz	180.4
Maximum repetition rate, MHz	90.2
Pulsed current, A	**15**
Mean current, mA	**150**
Maximal energy, MeV	**42 (50)**

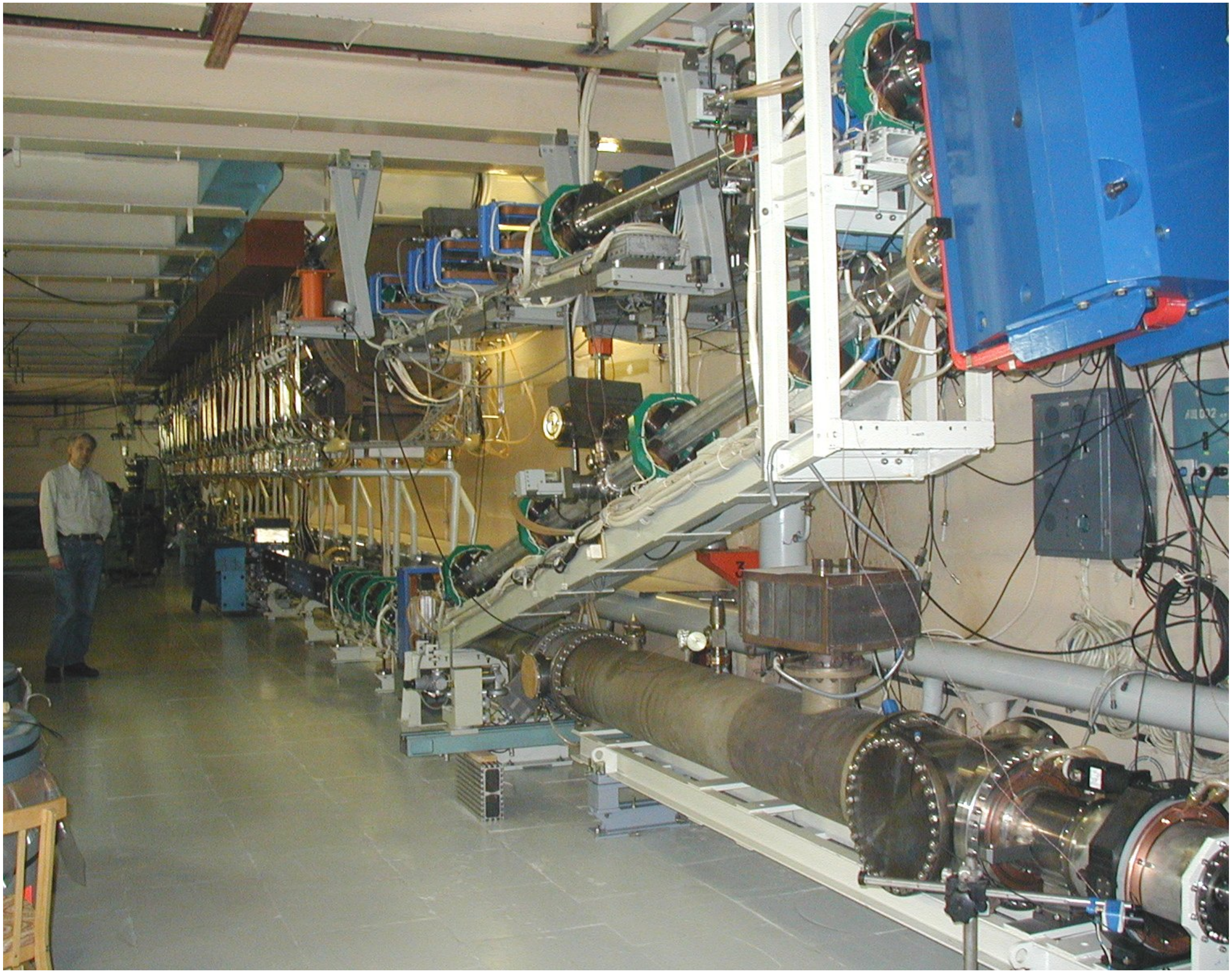
First stage: submillimeter (THz) FEL



Electron beam from the gun passes through the bunching RF cavity, drift section, two accelerating cavities, the main accelerating structure and the undulator, where a fraction of its energy is converted to radiation.

After that, the beam returns to the main accelerating structure in a decelerating RF phase, decreases its energy to its injection value (2 MeV) and is absorbed in the beam dump.

THz FEL (old)



Main improvement needed.

To reach fast and deep enough cooling we need:

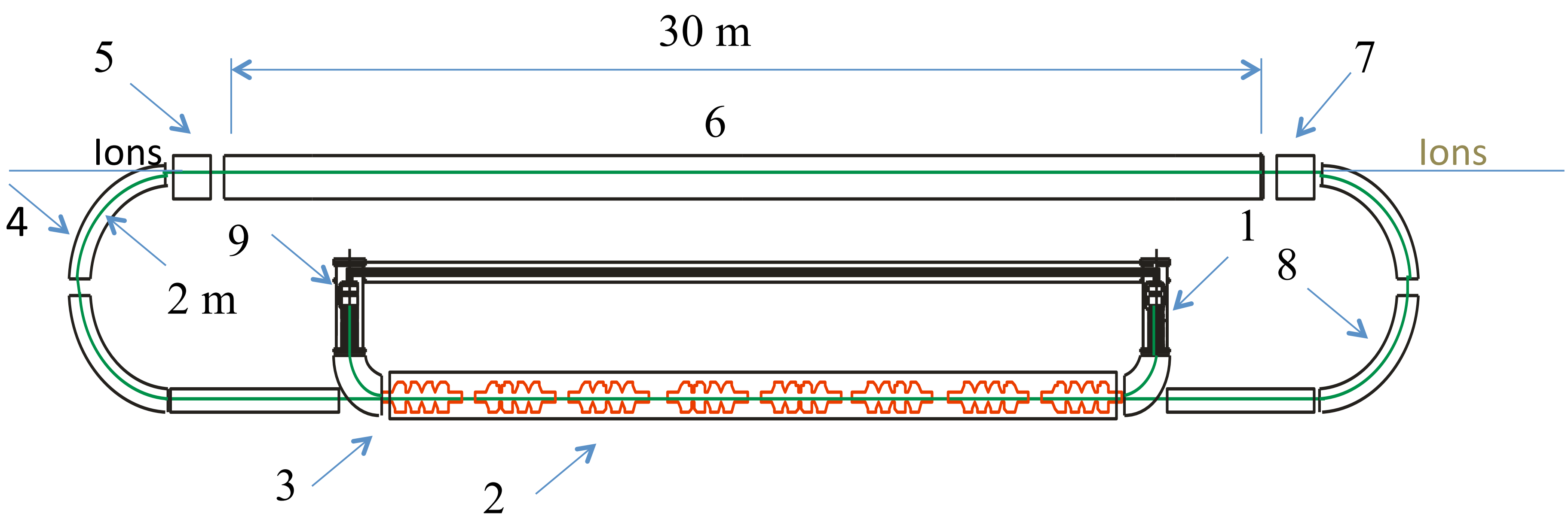
electron beam immersed

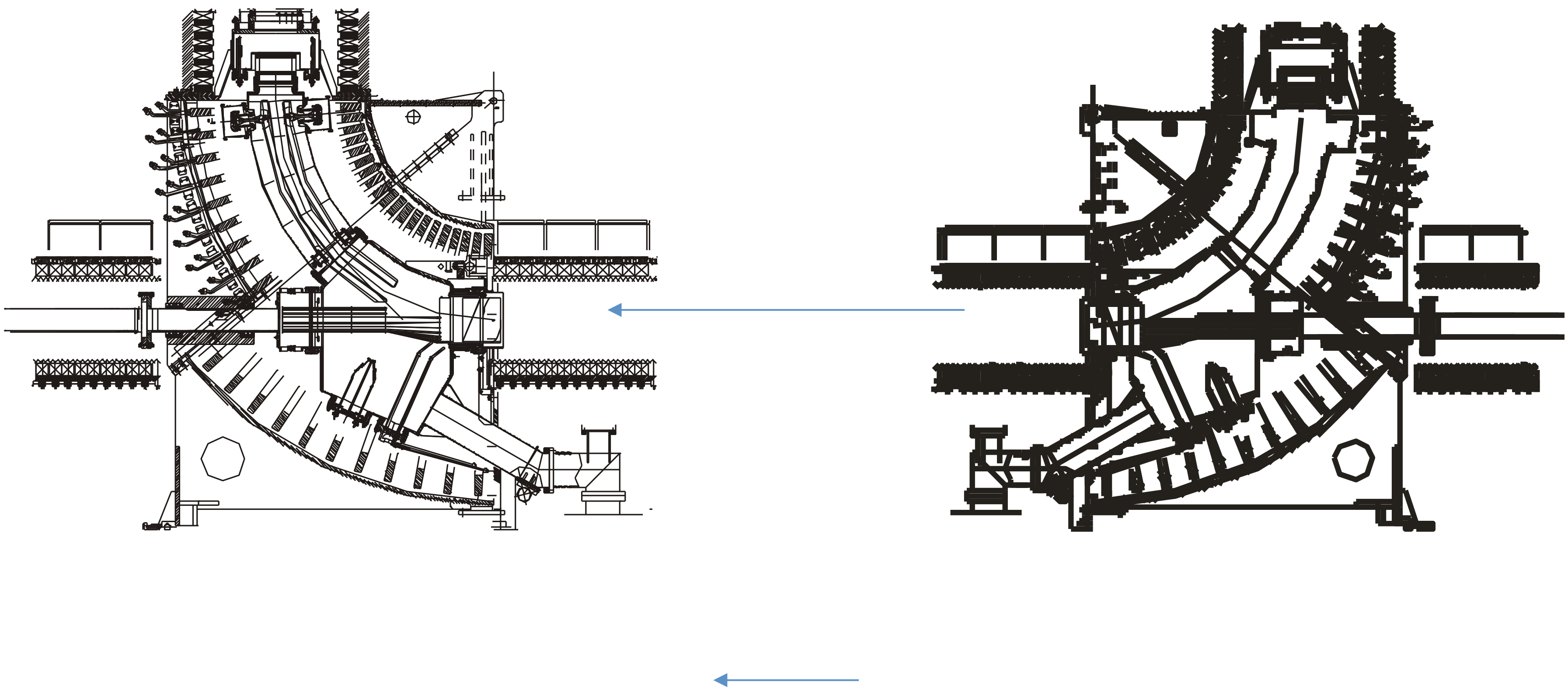
in "perfect" longitudinal magnetic field

from emitter (gun) to collector!

Plus, If necessary, – stochastic precooling!

1 – accelerator column (2 MeV)
2 – RF structure (50 MeV)
3 – toroid section
4 – bend element
5 – beam transformer element
6 – cooling section
7 – beam transformer element
8 – bend element
9 – decelerator column

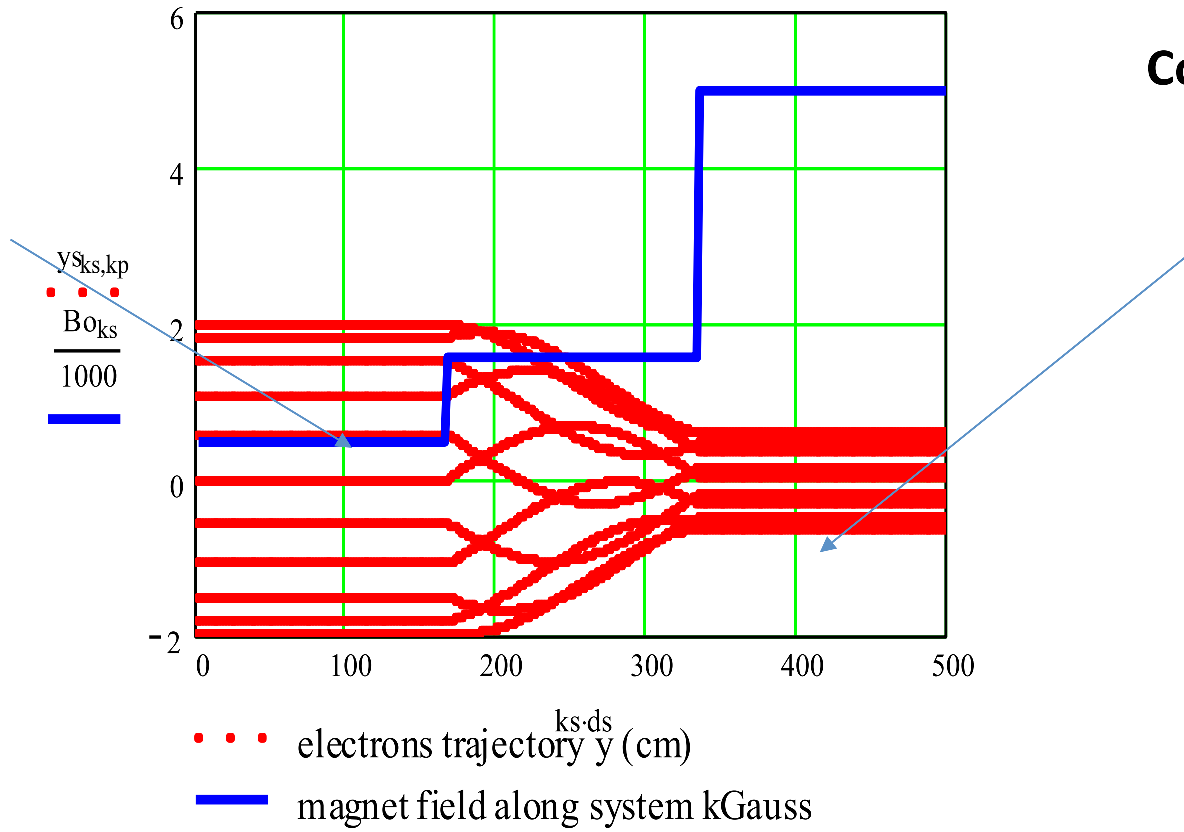




E-Beam

Transfer path

Cooling section



Transfer section: low longitudinal field, wider E-beam ➔ to higher field compressed E-beam

Such e-beam compression makes transvers electron velocities higher – hence, suppresses electron-ion radiative recombination and ion beam life-time longer almost without harm for cooling rate.

The presented option is just preliminary sketch.
The other roads to higher energies e-Cooling
are proposed and under development by Ya.Derbenev &
V.Litvinenko (“coherent electron cooling”) and Ya.Derbenev
(transformations of round to flat beams).

In any case, it is lot of work to design high luminosity
Ion-ion and electron-ion beams colliders
In 10-100 GeV ion energy range.