NOVOSIBIRSK FREE ELECTRON LASER FACILITY: TWO-ORBIT ERL WITH TWO FELS

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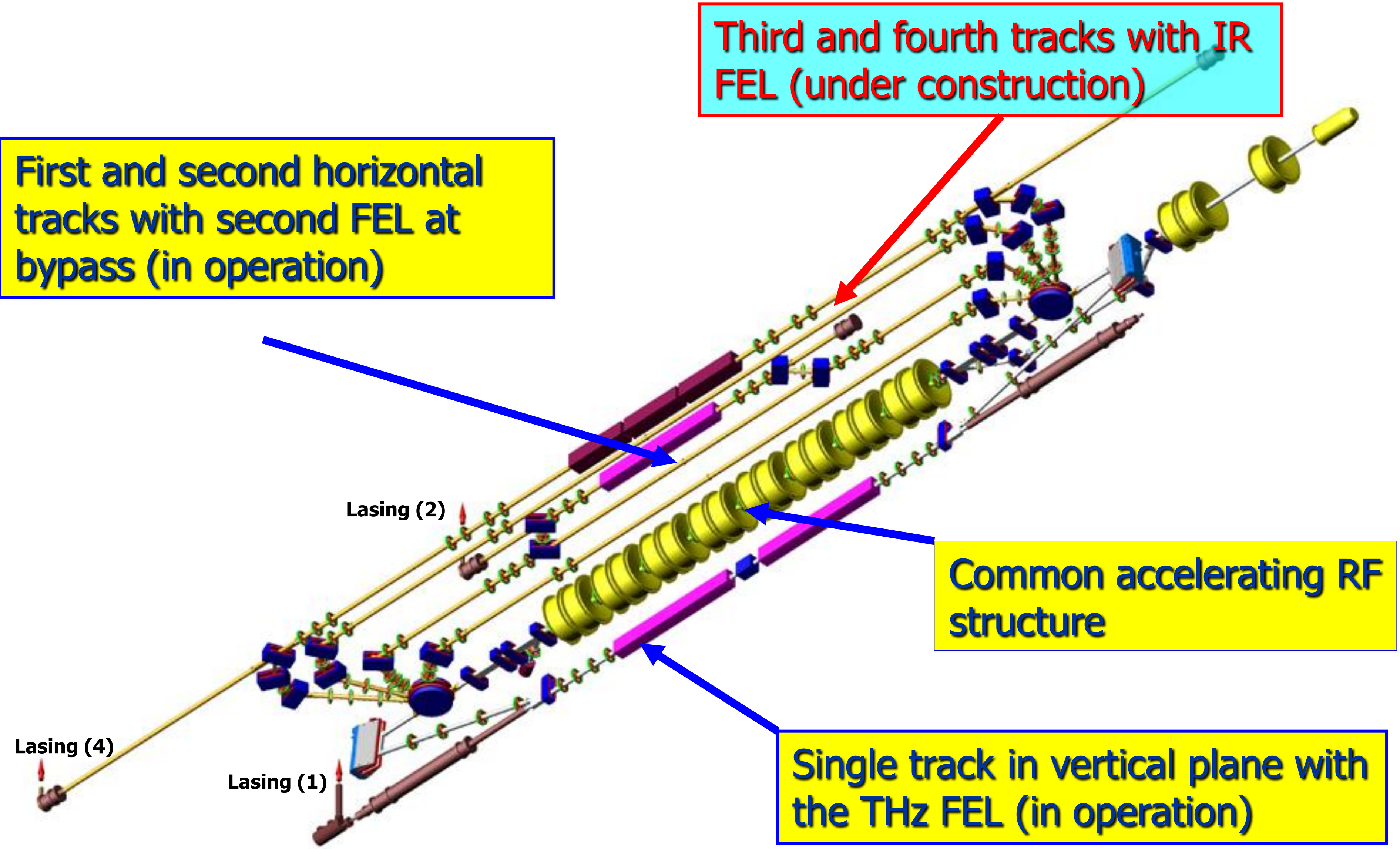
Electron efficiency of FEL is rather low (~1%), therefore energy recovery is necessary for a high power FEL.

Energy recovery

- **decreases radiation hazard and**
- **makes possible operation at high average current.**

Novosibirsk ERL with 3 FELs



Features of the RF system

- Low frequency (180 MHz)
- Normal-conducting uncoupled RF cavities
- CW operation

First Stage Accelerator-Recuperator Parameters

♦ Bunch repetition rate, MHz	22.5
♦ Average electron current, mA	30
♦ Maximum energy, MeV	12
♦ Bunch length, ps	100
♦ Normalized emittance, mm*mrad	30

Free Electron Laser Parameters

♦ Wavelength, mm	0.12-0.24
♦ Pulse duration, FWHM, ps	~50
♦ Pulse energy, mJ	0.04
♦ Repetition rate, MHz	11.2
♦ Average power, kW	0.5
♦ Peak power, MW	1
♦ Minimum relative linewidth, FWHM	$3 \cdot 10^{-3}$

User stations at NovoFEL

Introscopy and spectroscopy

Gas dynamics

Metrology

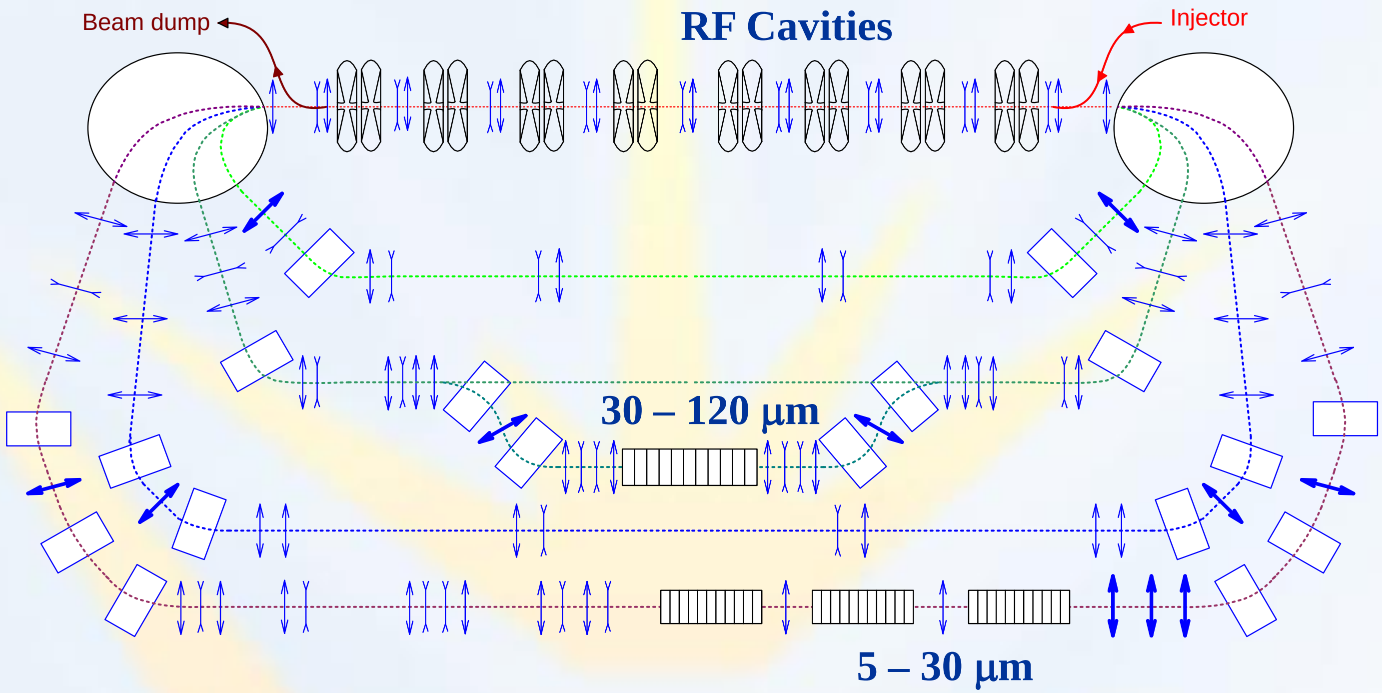
Molecular spectroscopy

Biology

Status

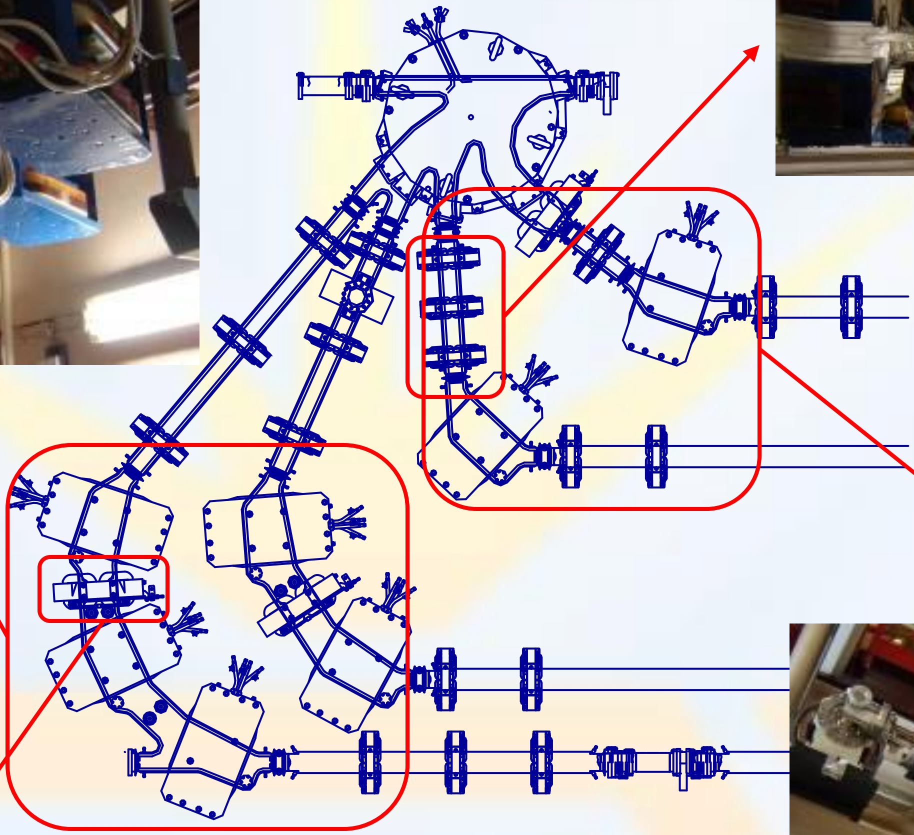
- ERL works at 12 MeV and up to 30 mA average current (world record for ERLs).
- Up to 500 W of average power at 110 – 240 micron wavelength range is delivered to users. Linewidth is less than 1%, maximum peak power is about 1 MW.
- Five user stations are in operation.
- Second stage of ERL and FEL was commissioned last year.

2-nd stage Novosibirsk FEL (in horizontal plane)



Radiation wavelength	**5 – 240 μm**
Average power	**Up to 10 kW**
E-beam energy	**up to 40 MeV**
Maximum repetition rate	**90 MHz**
Maximum mean current	**150 mA**

Magnets and vacuum chamber of bends

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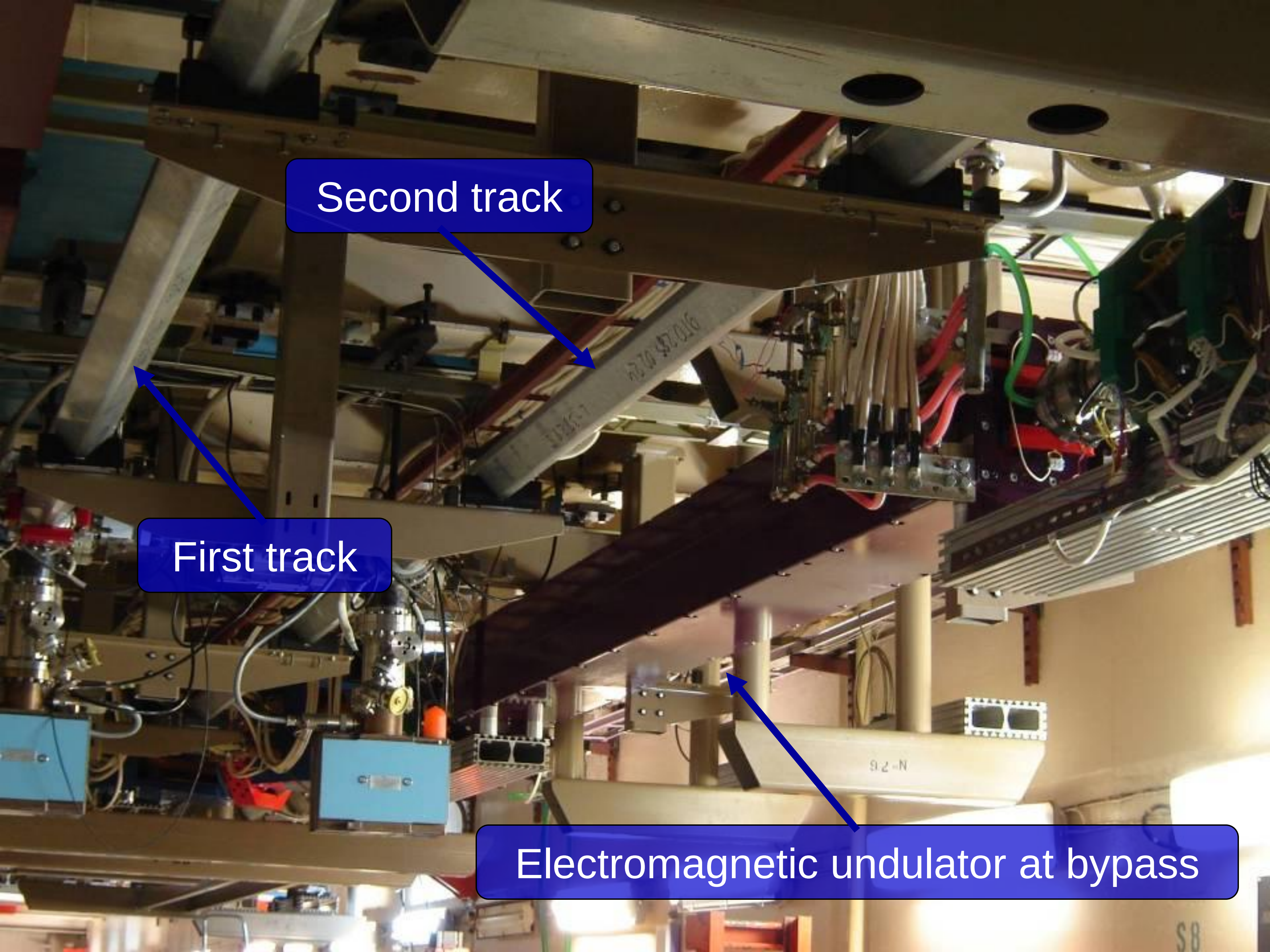
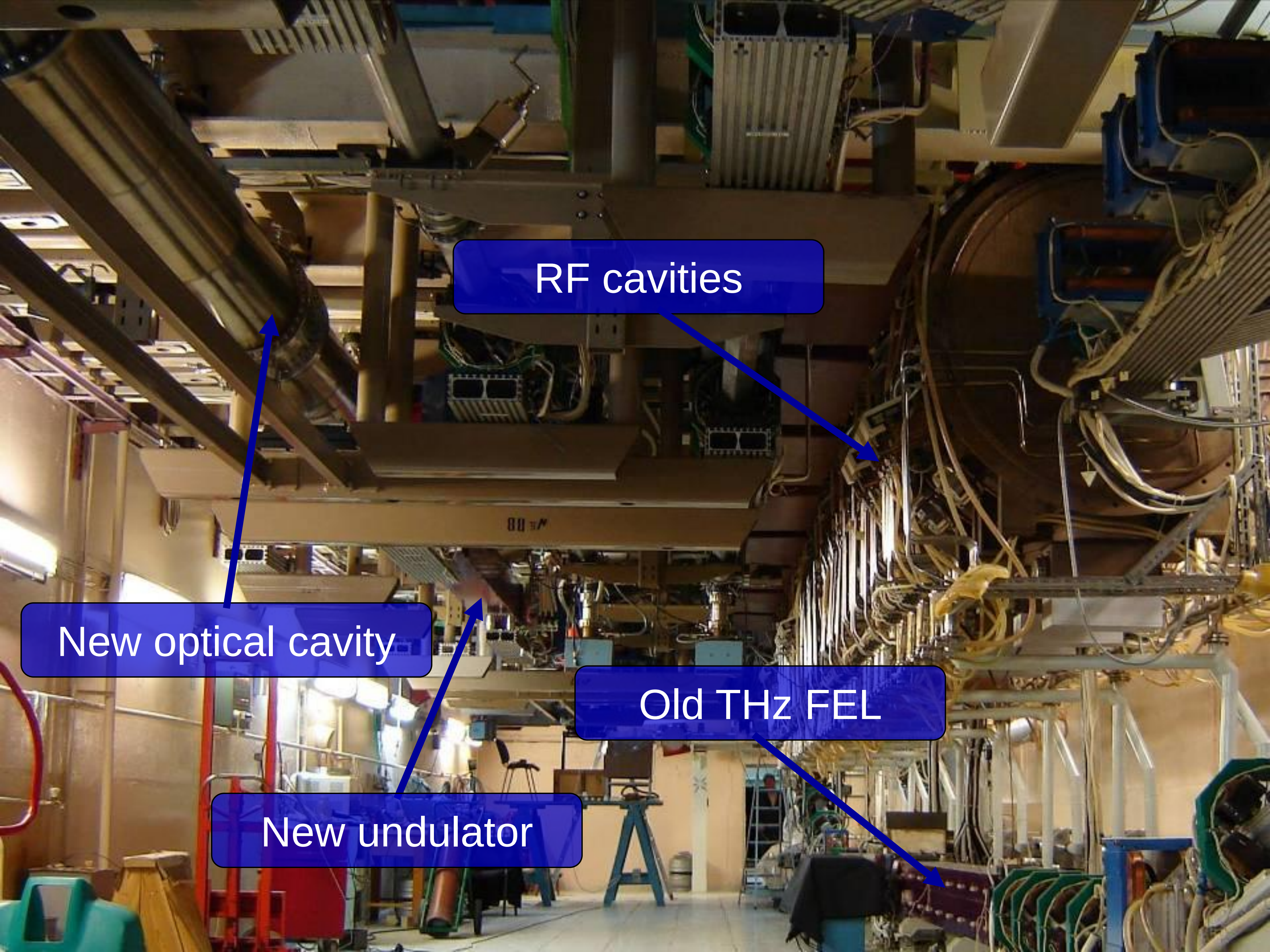
The bends are hanged on the ceiling.

Round magnet is at the top left corner, the old THz FEL magnetic system is at down-left.

Elements of the optical resonator for the second-turn FEL are yet at the floor (down-right corner).


Second track
First track
Electromagnetic undulator at bypass


RF cavities
New optical cavity
Old THz FEL
New undulator

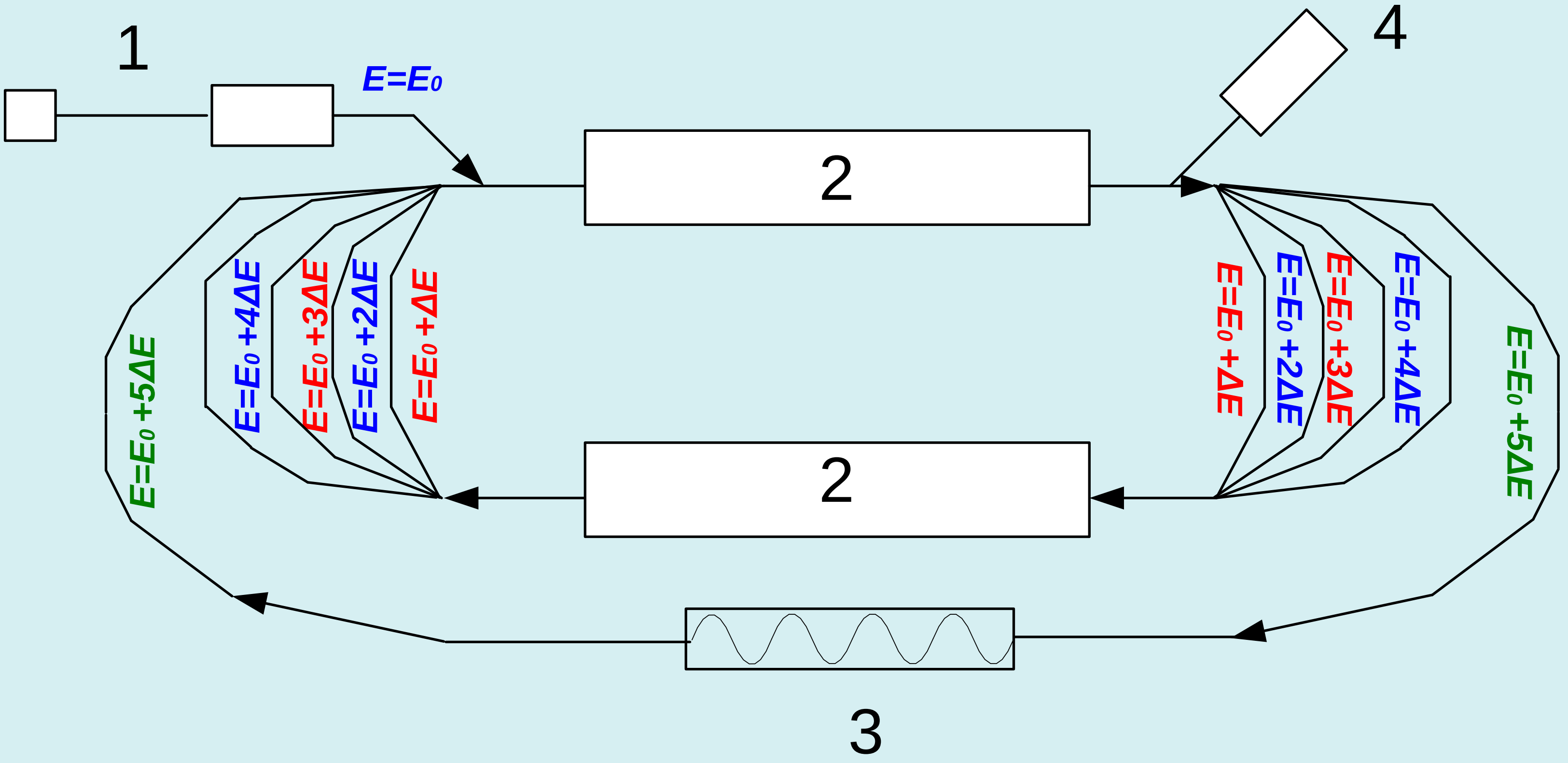
Status of the second stage ERL and FEL

First in the world multi-turn ERL is in operation now. First lasing took place on February 2, 2009, at the 50 micron wavelength. Maximum gain is more than 40%. Radiation of new FEL delivered to the existing experimental stations. Average power is 0.5 kW yet.

Problems

1. Large energy spread after FEL leads to the beam loss increase. – Solution: sextupole corrections were inserted in some quadrupoles to make second order achromat.
2. Complicated focusing and trajectory correcion at common tracks (with two beams).

Multiturn ERL with separation of accelerated and decelerated beams



1 – injector, 2 – RF accelerating cavities, 3 - undulator or other “user” device, 4 – beam dump.

Advantage of new ERL scheme

1. One can adjust each arc length, optics, and trajectory steering independently.
2. It is easy to meet very different optical requirements for accelerating and decelerating beams.
3. Beam diagnostics is simplified.
4. Splitting of RF system decreases the length of section with unseparated beams, making easy the focusing problem.

Thank you