# First Lasing of the Third Stage of Novosibirsk FEL

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The 37th FEL Conference, 23 - 28 August 2015, Daejeon, Korea

# NovoFEL Team

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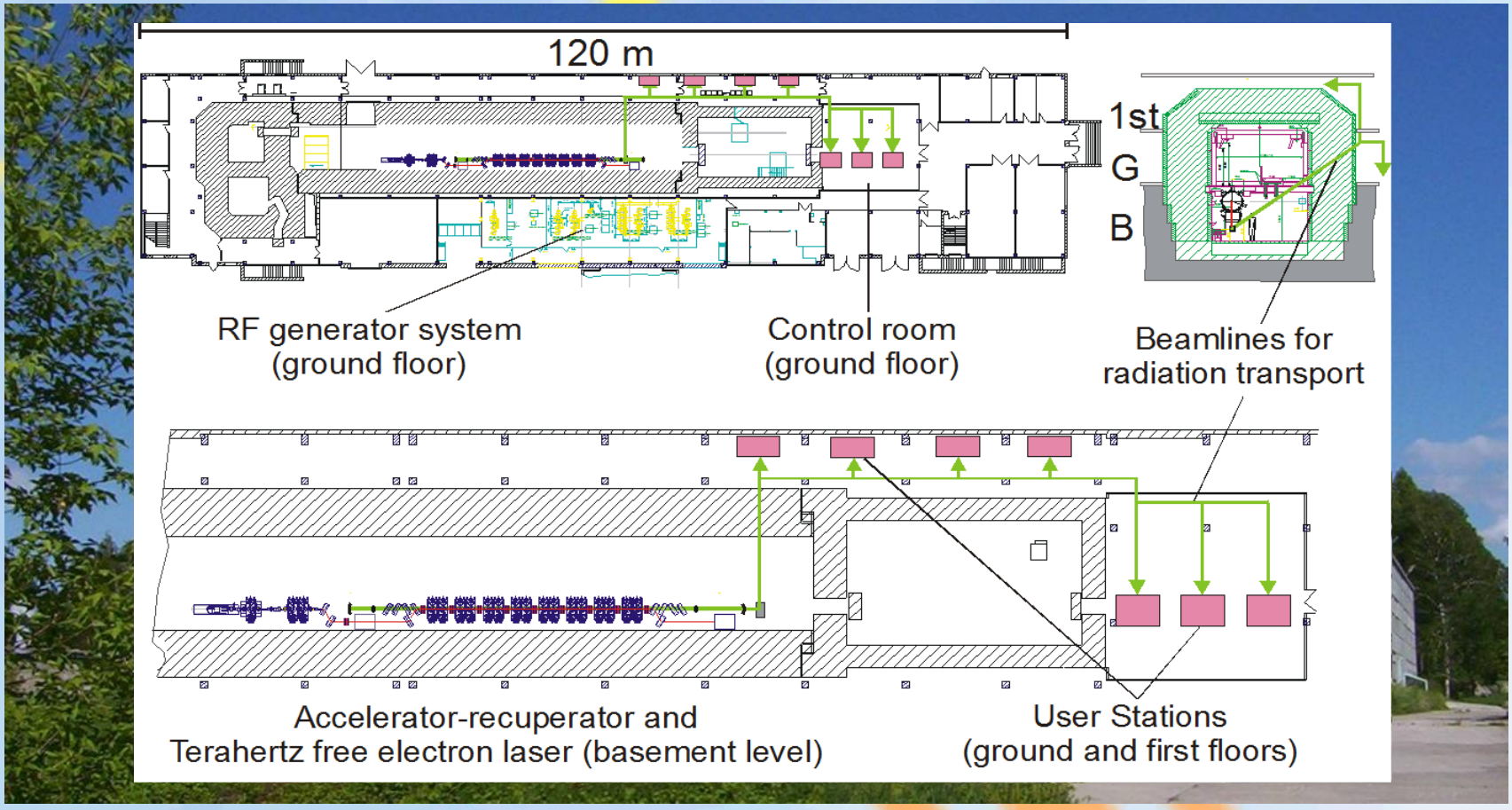
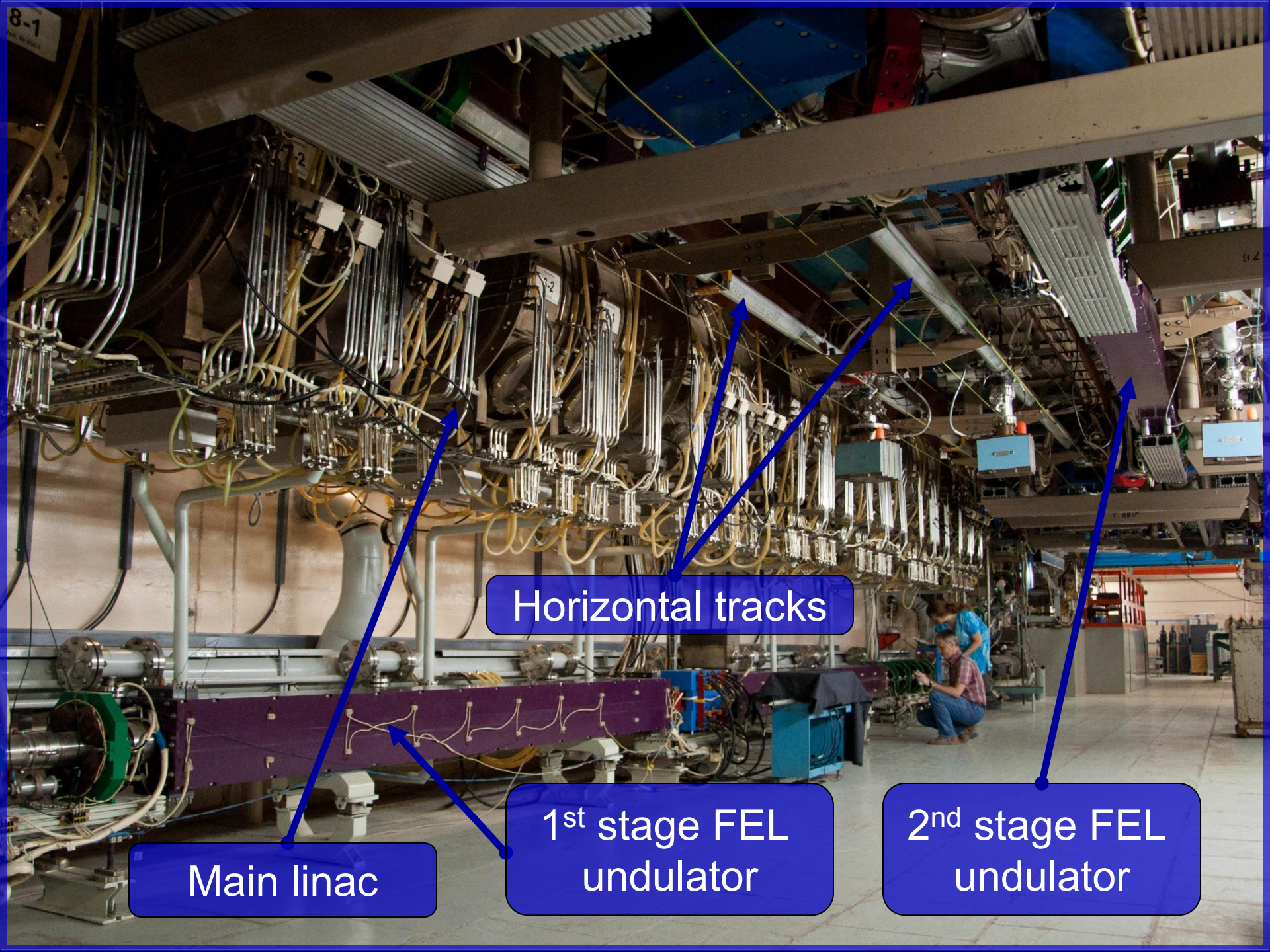
# Outline

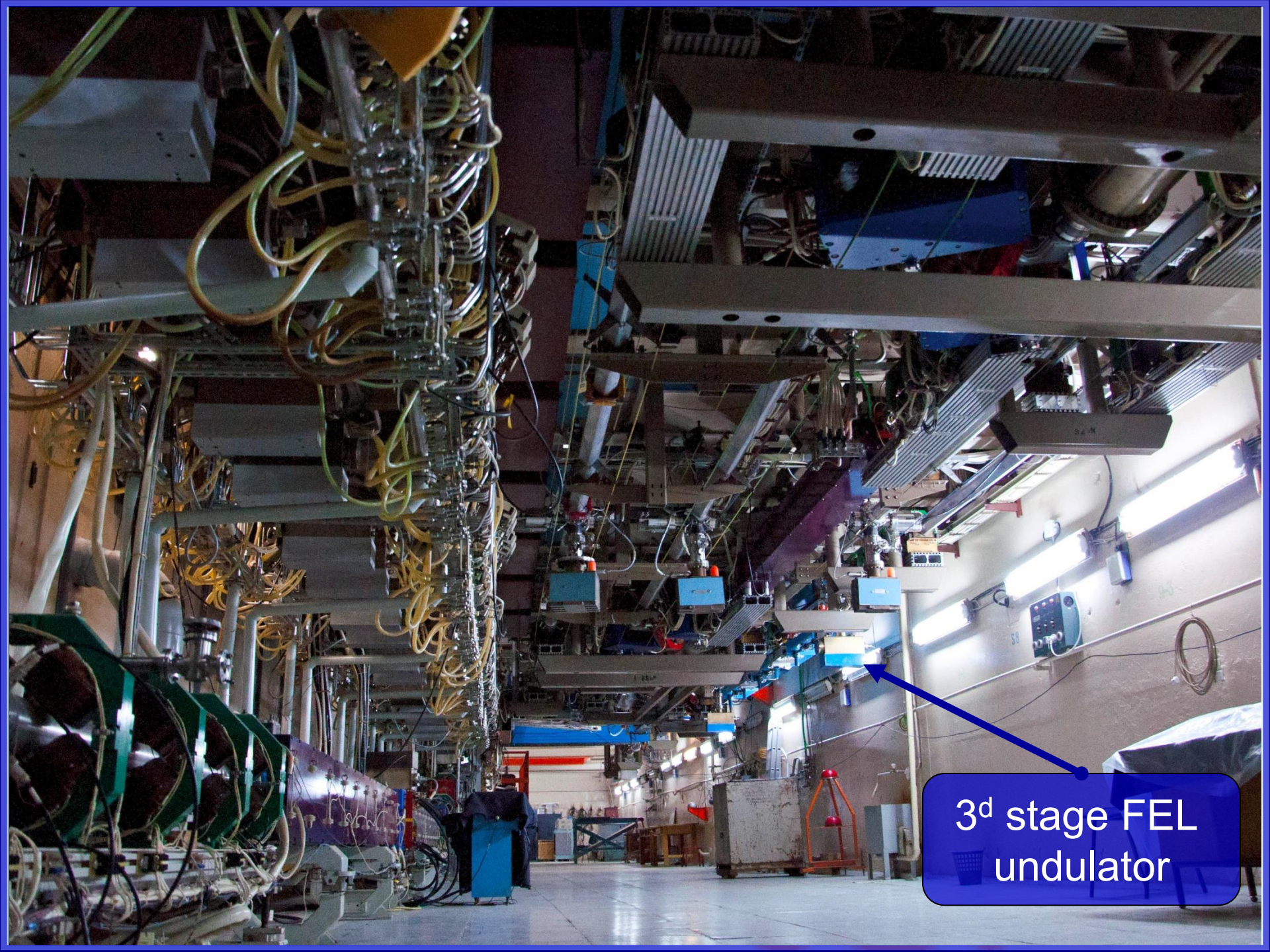
- Overview of the NovoFEL facility
- The third stage FEL design
- First lasing and first experiments
- Nearest plans

# Siberian Center of Photochemical Research

# Siberian Center of Photochemical Research

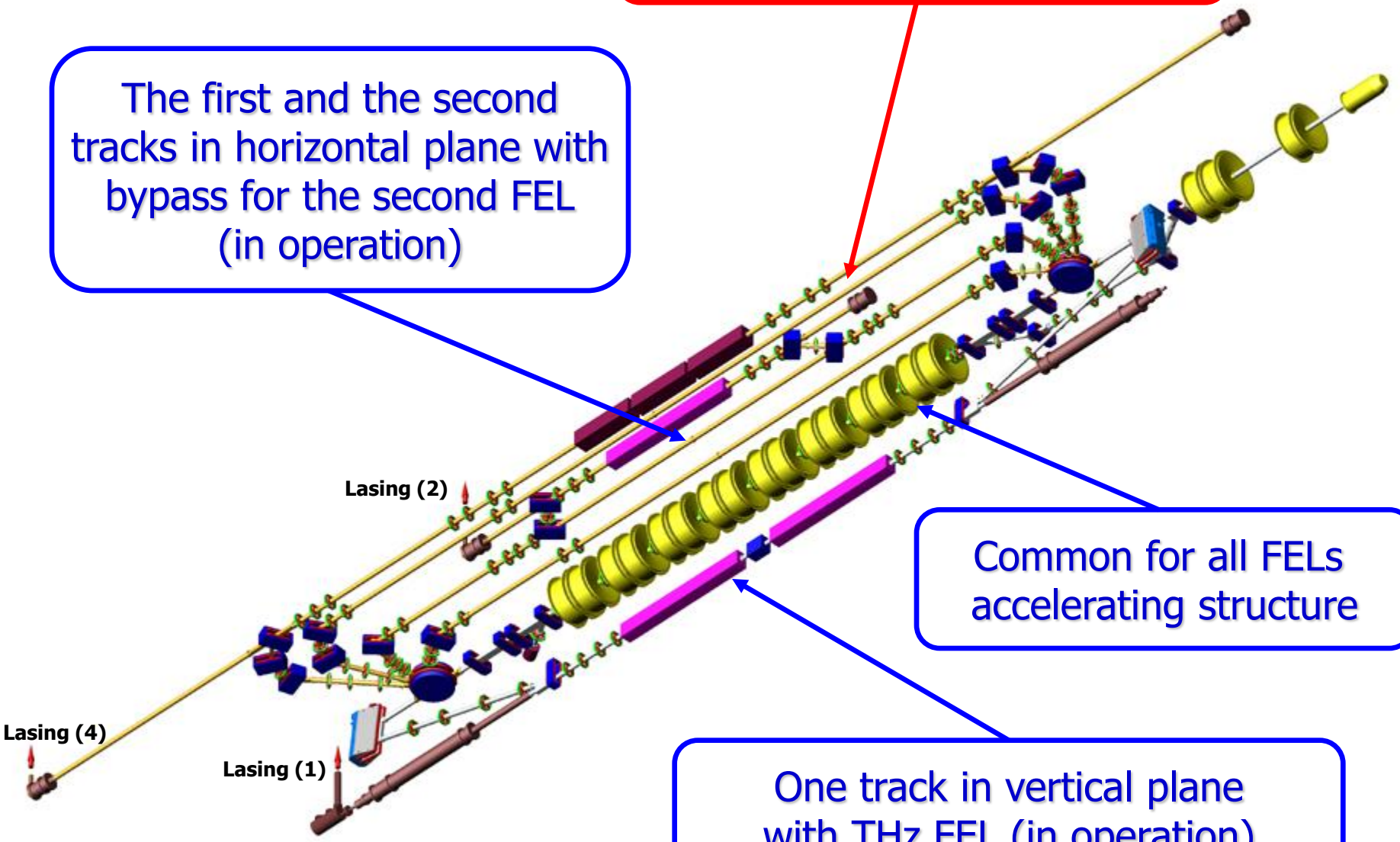



Horizontal tracks
Main linac
1st stage FEL undulator
2nd stage FEL undulator


3d stage FEL
undulator

The third and the fourth tracks with IR FEL (**first lasing**)

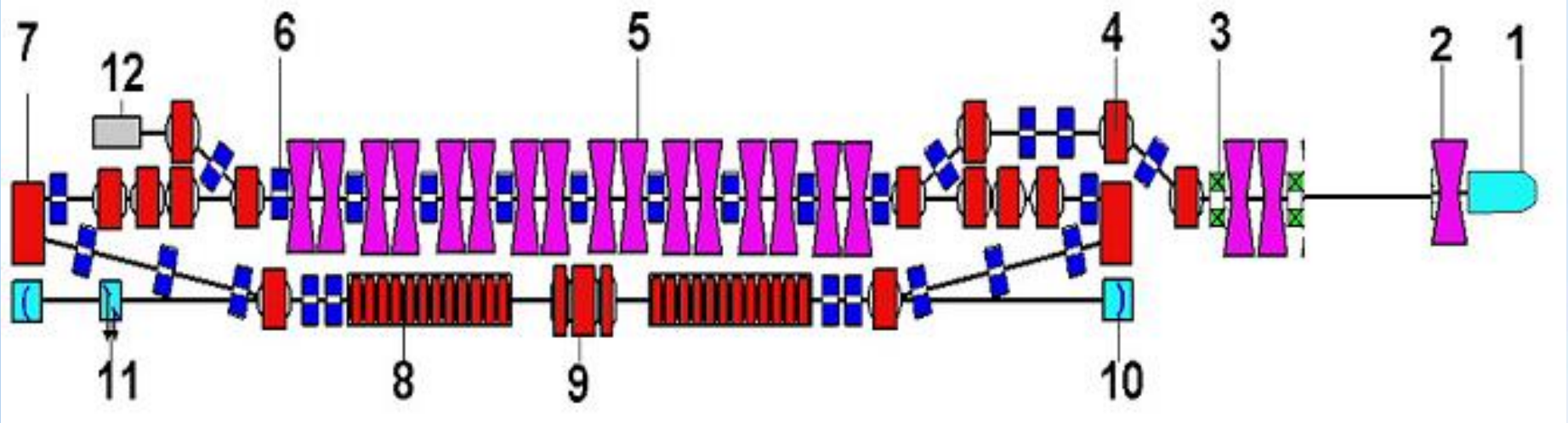
The first and the second tracks in horizontal plane with bypass for the second FEL (in operation)




Common for all FELs accelerating structure

One track in vertical plane with THz FEL (in operation)

# Injector, main linac and first stage beamlines

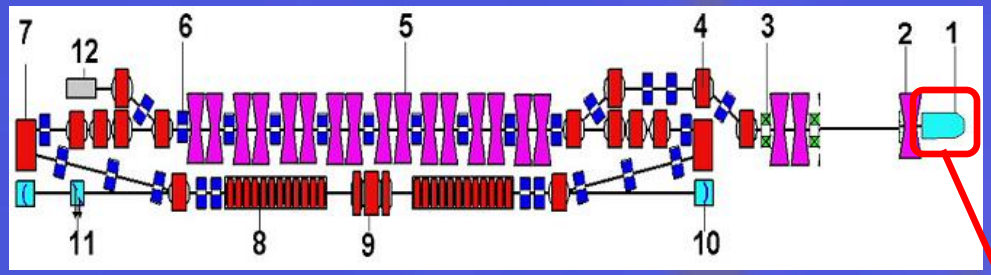


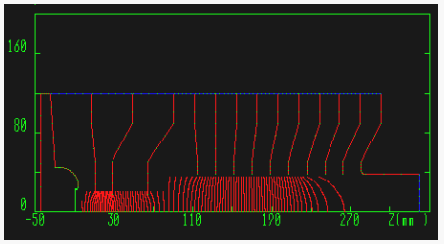

**1 – electron gun, 2 – bunching RF cavity, 3 – focusing solenoids, 4 – merger, 5 – main linac, 6 – quadrupoles, 7 – magnetic mirror, 8 - undulator, 9 - buncher, 10 – optical cavity mirror, 11 – calorimeter , 12 - dump.**

*Electron beam from the gun passes through the buncher (a bunching RF cavity), drift section, 2 MeV accelerating cavities and 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.*

# Electrostatic gun



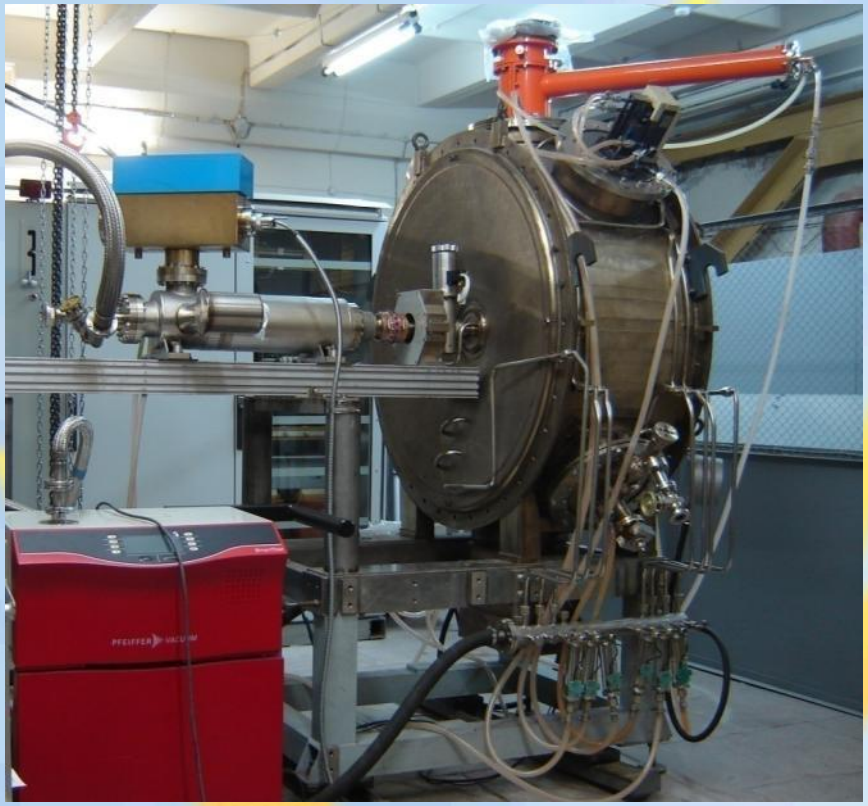



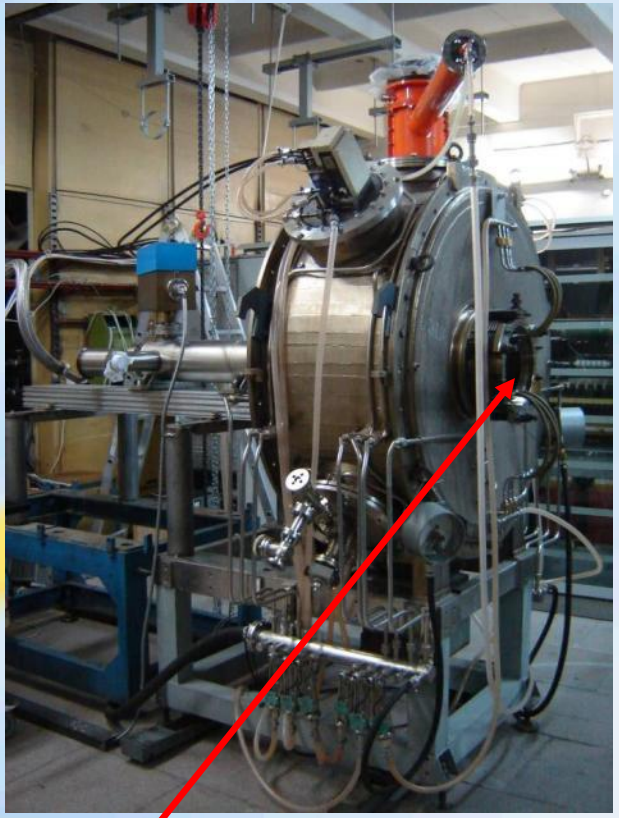

*Power supply:*

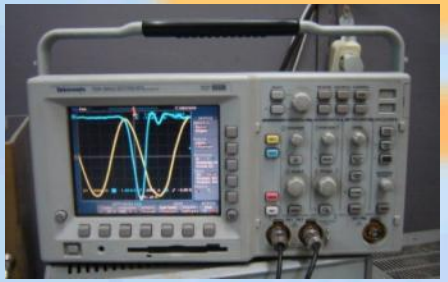
$U_{max}$ = 300 kV

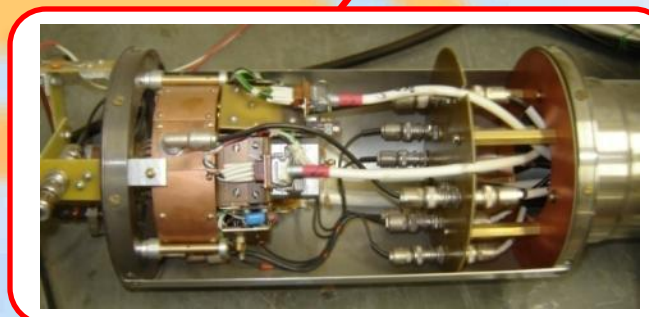
$I_{max}$ = 50 mA

# 90 MHz RF gun test setup

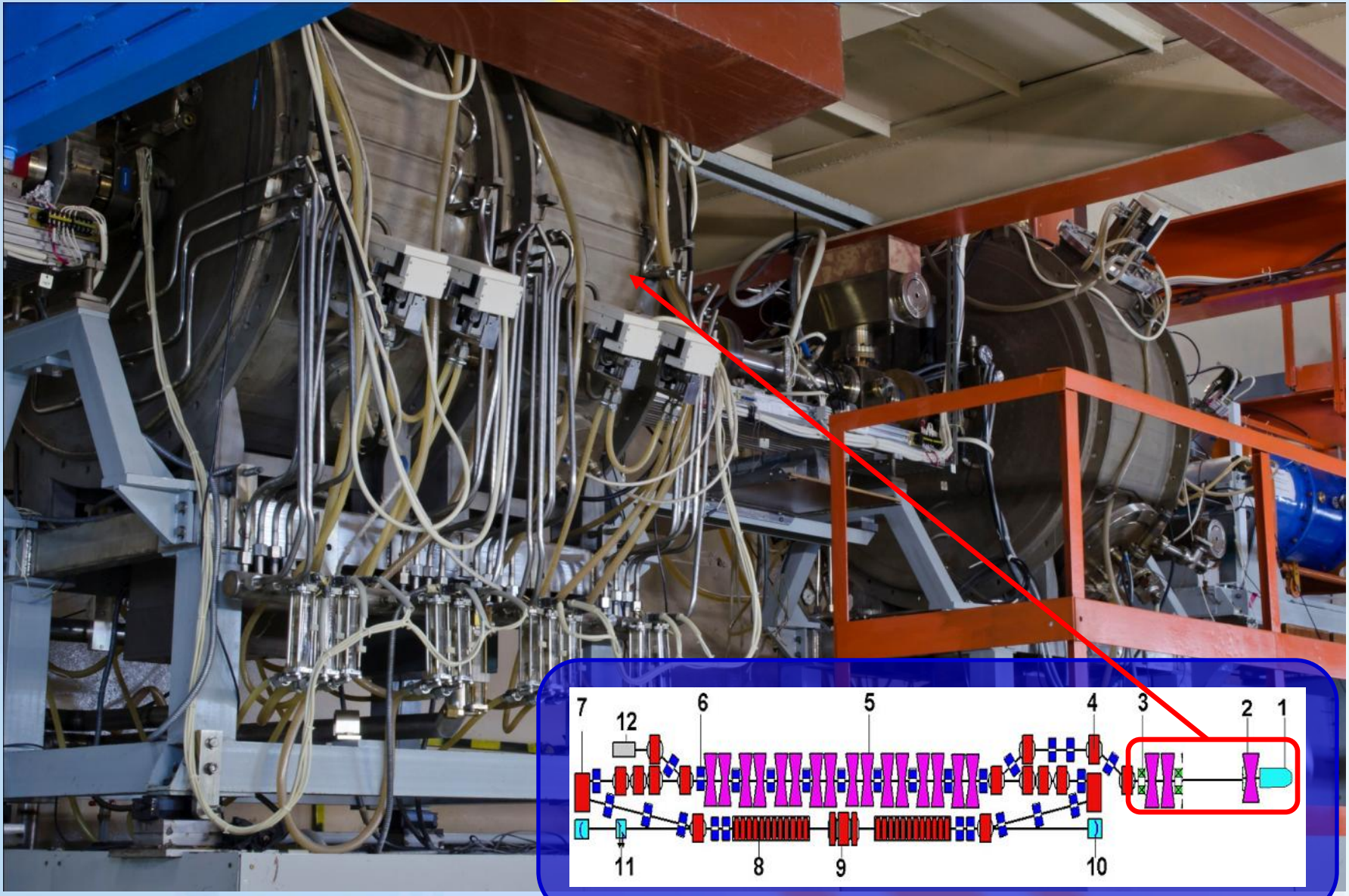








# Injector



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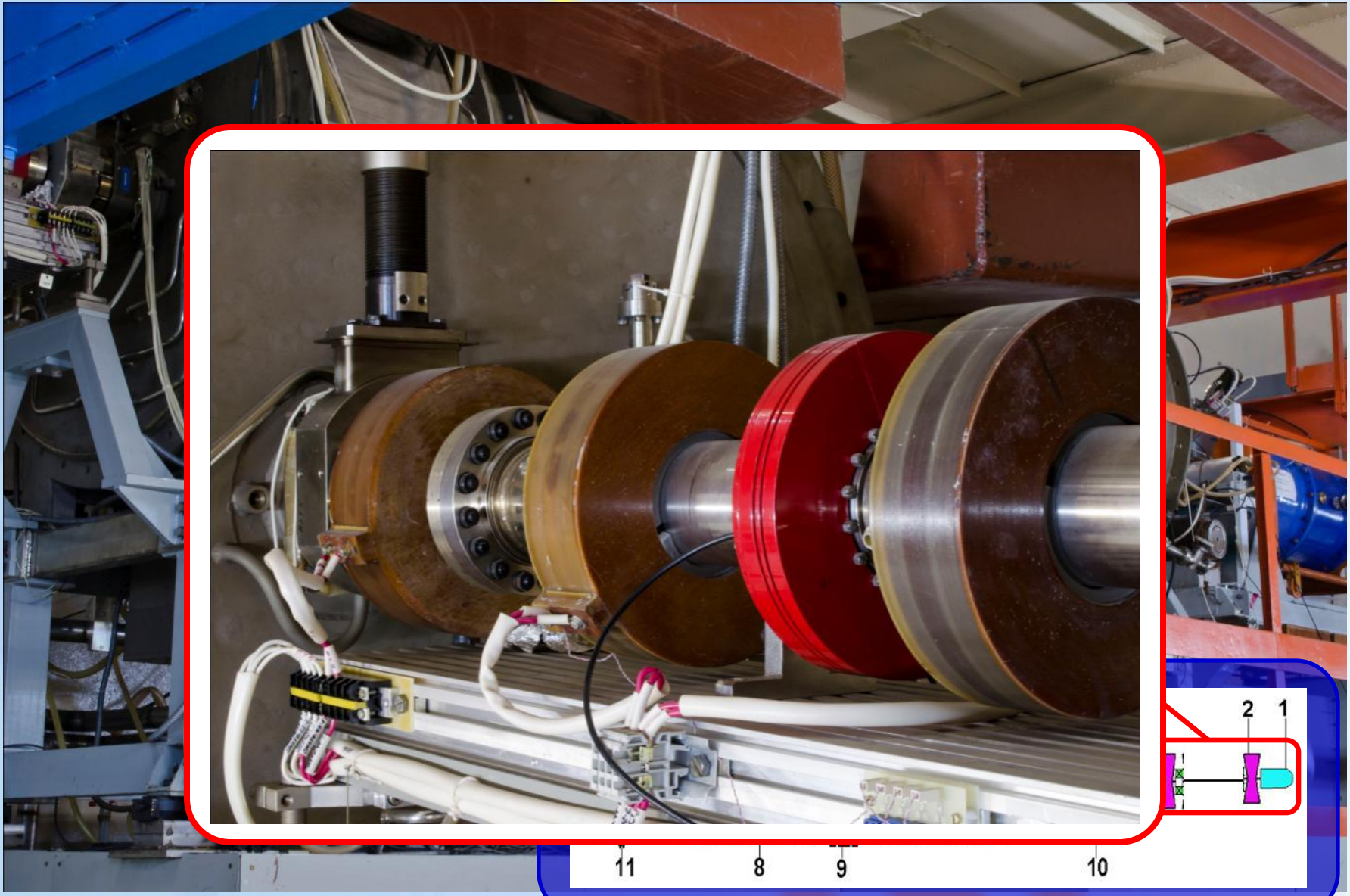
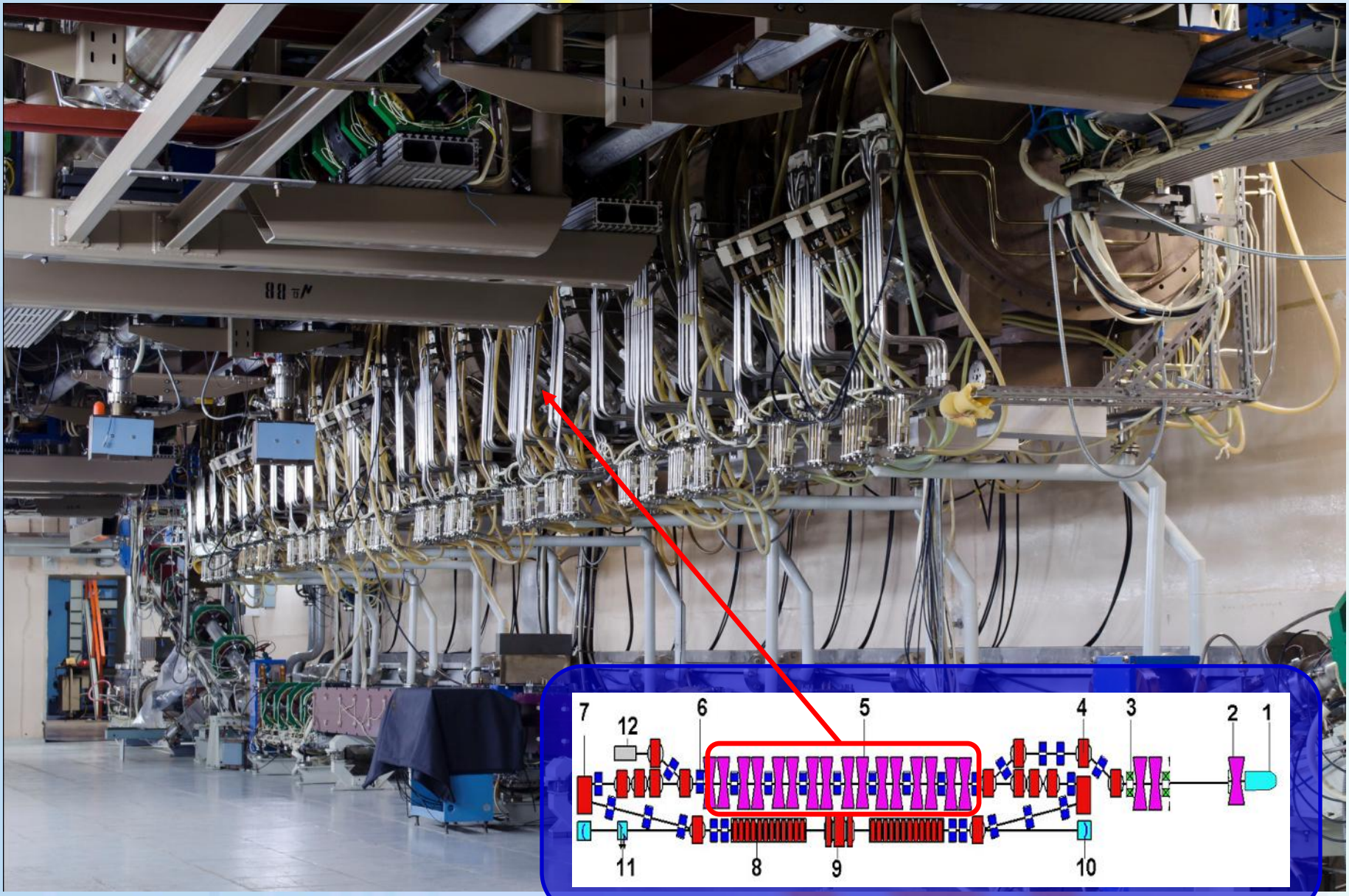


# Main linac



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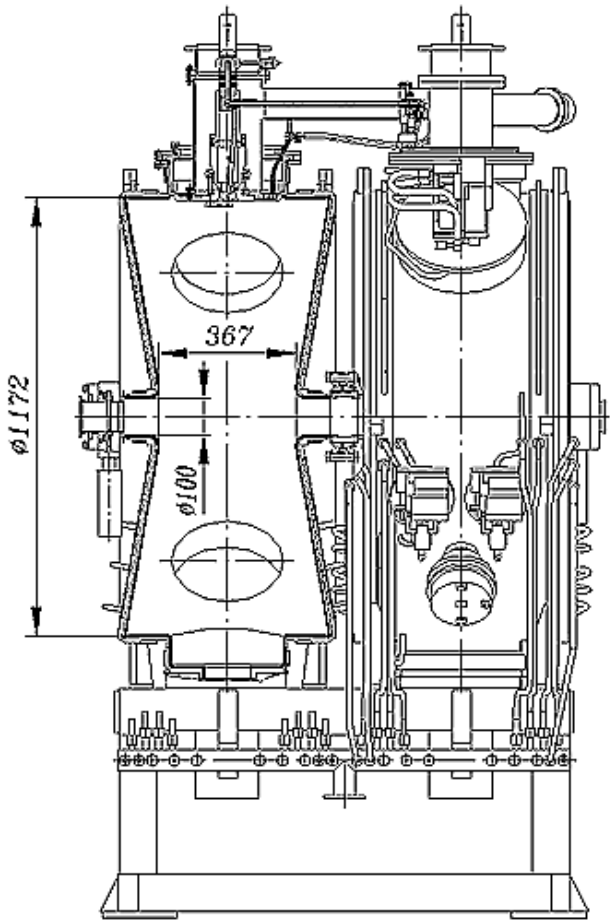
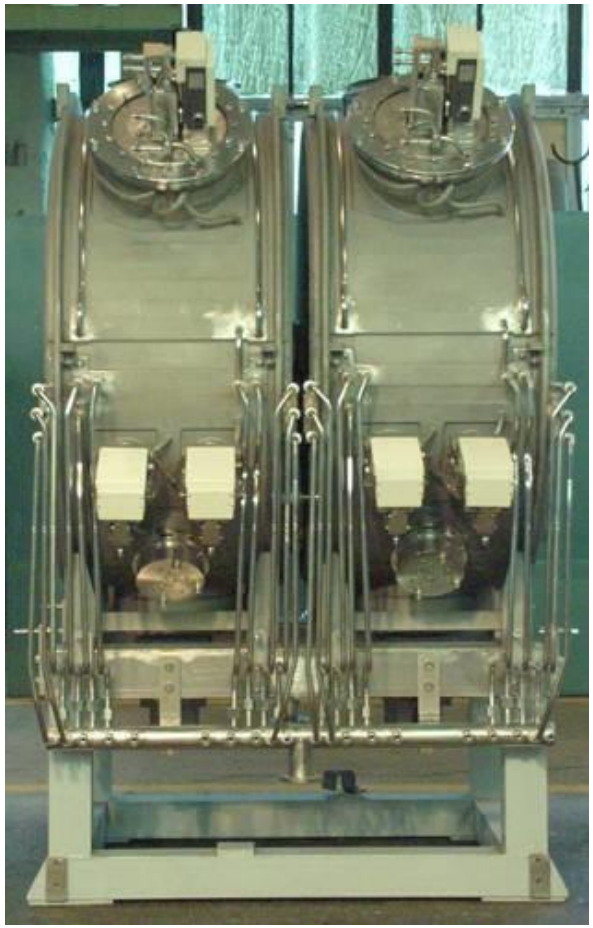
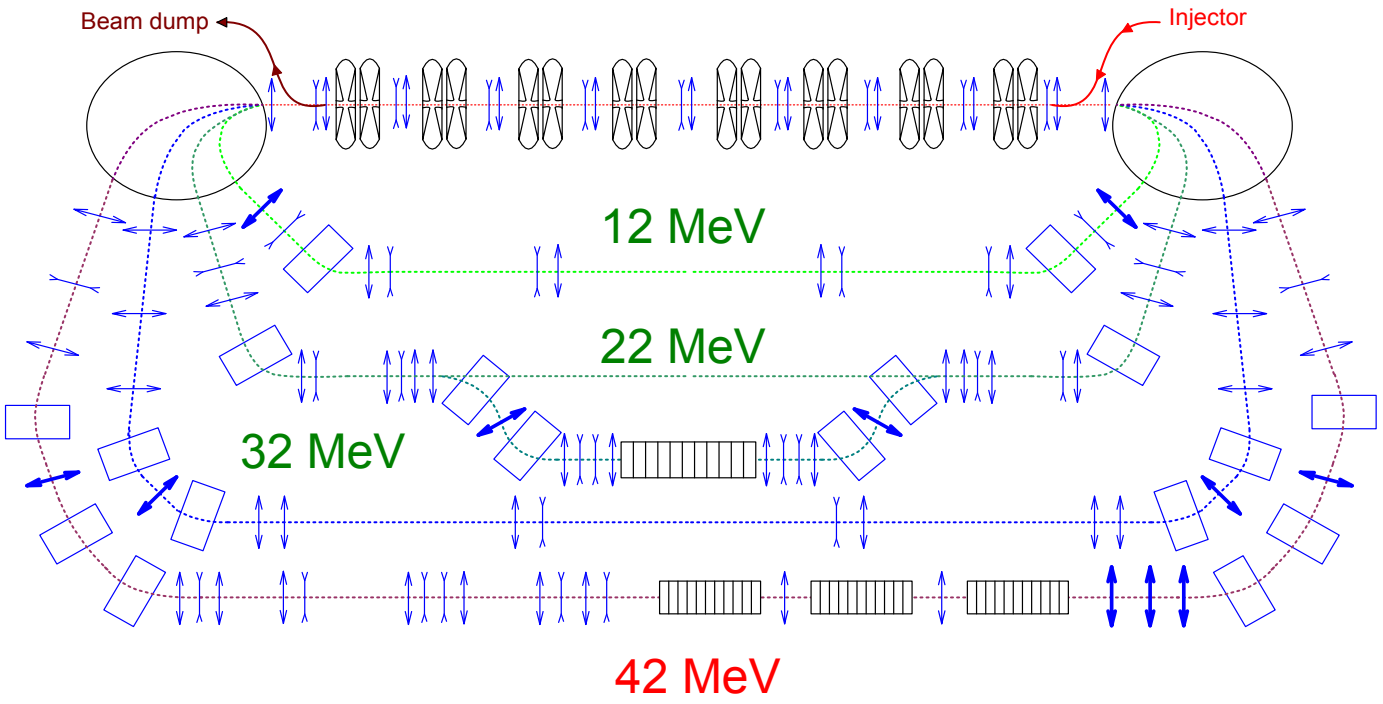


# Second and third stages beamlines



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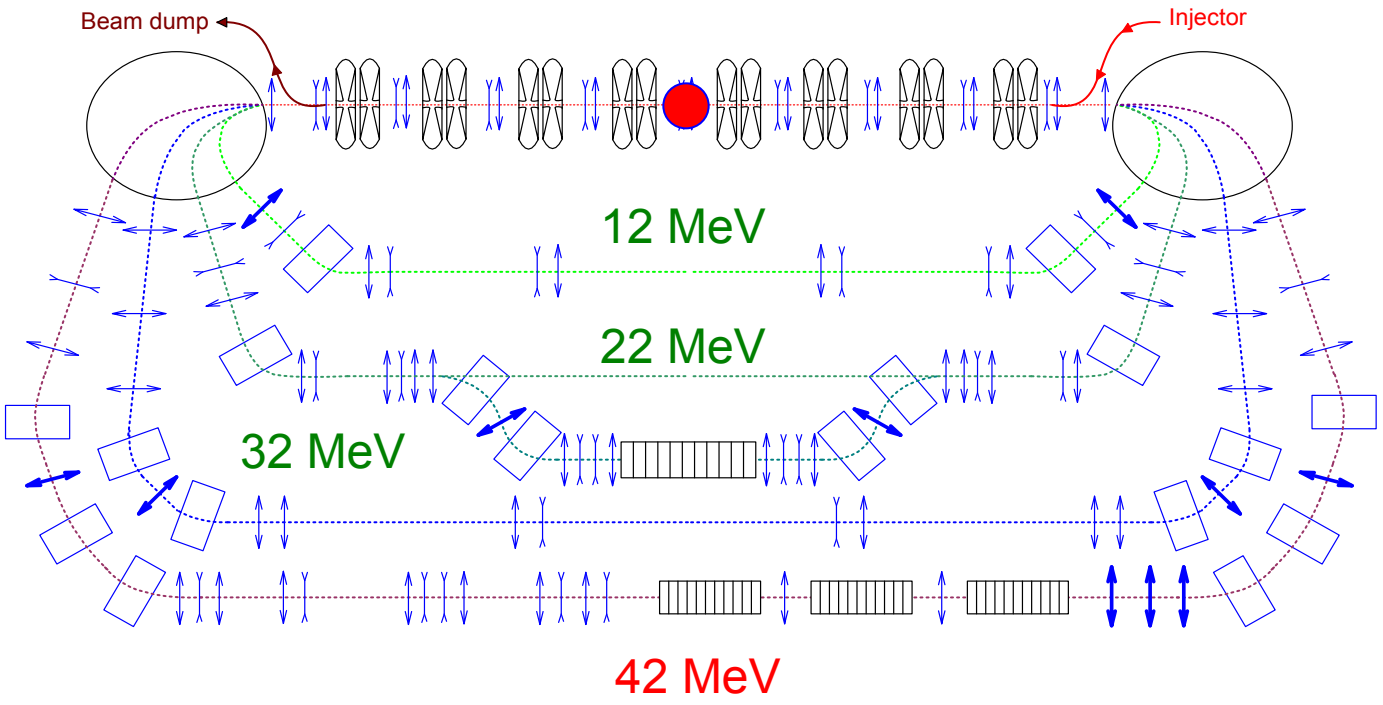

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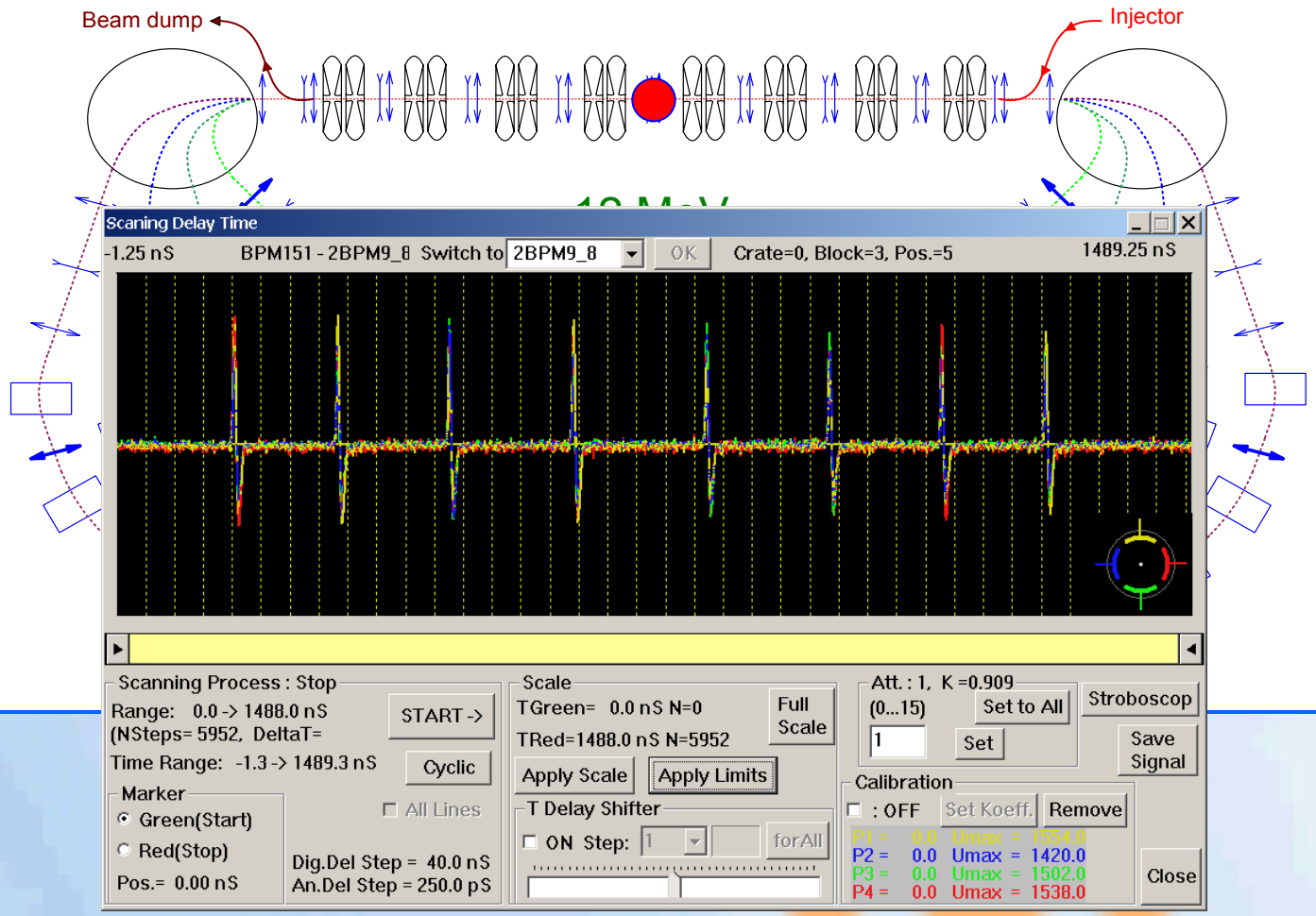
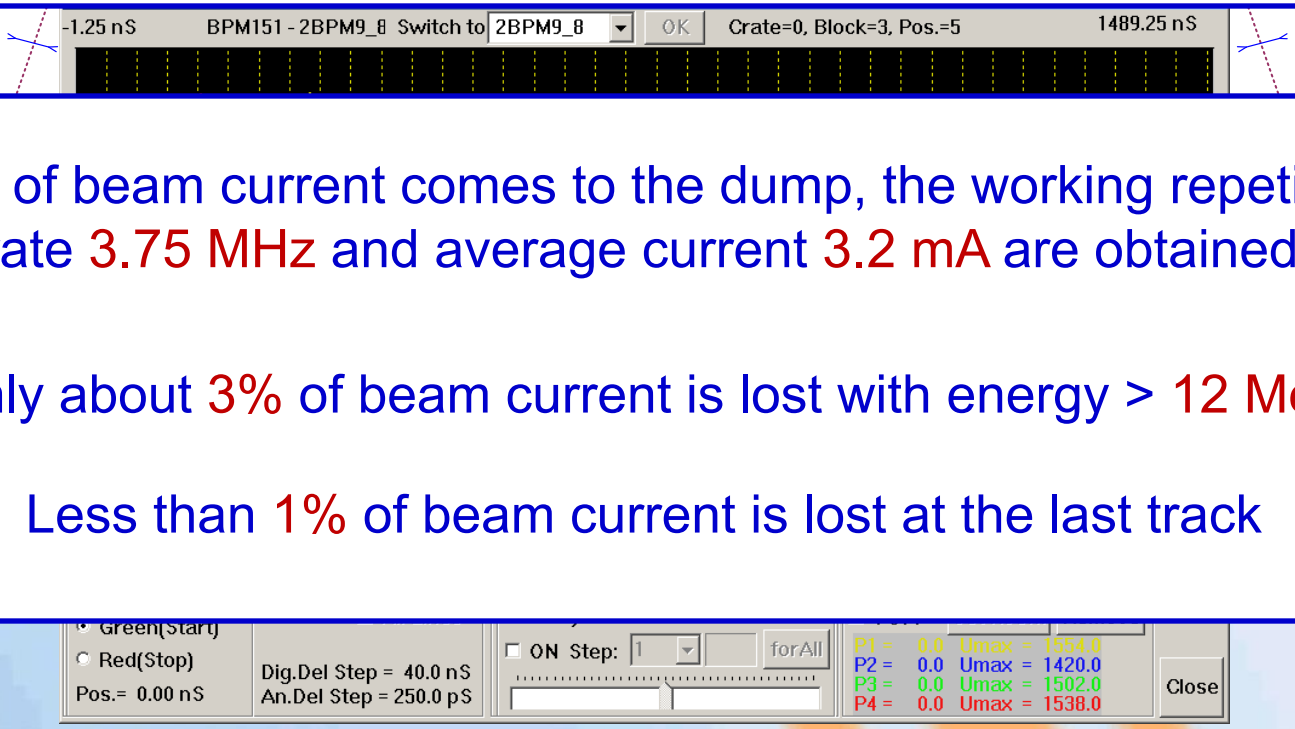


# Second and third stages beamlines

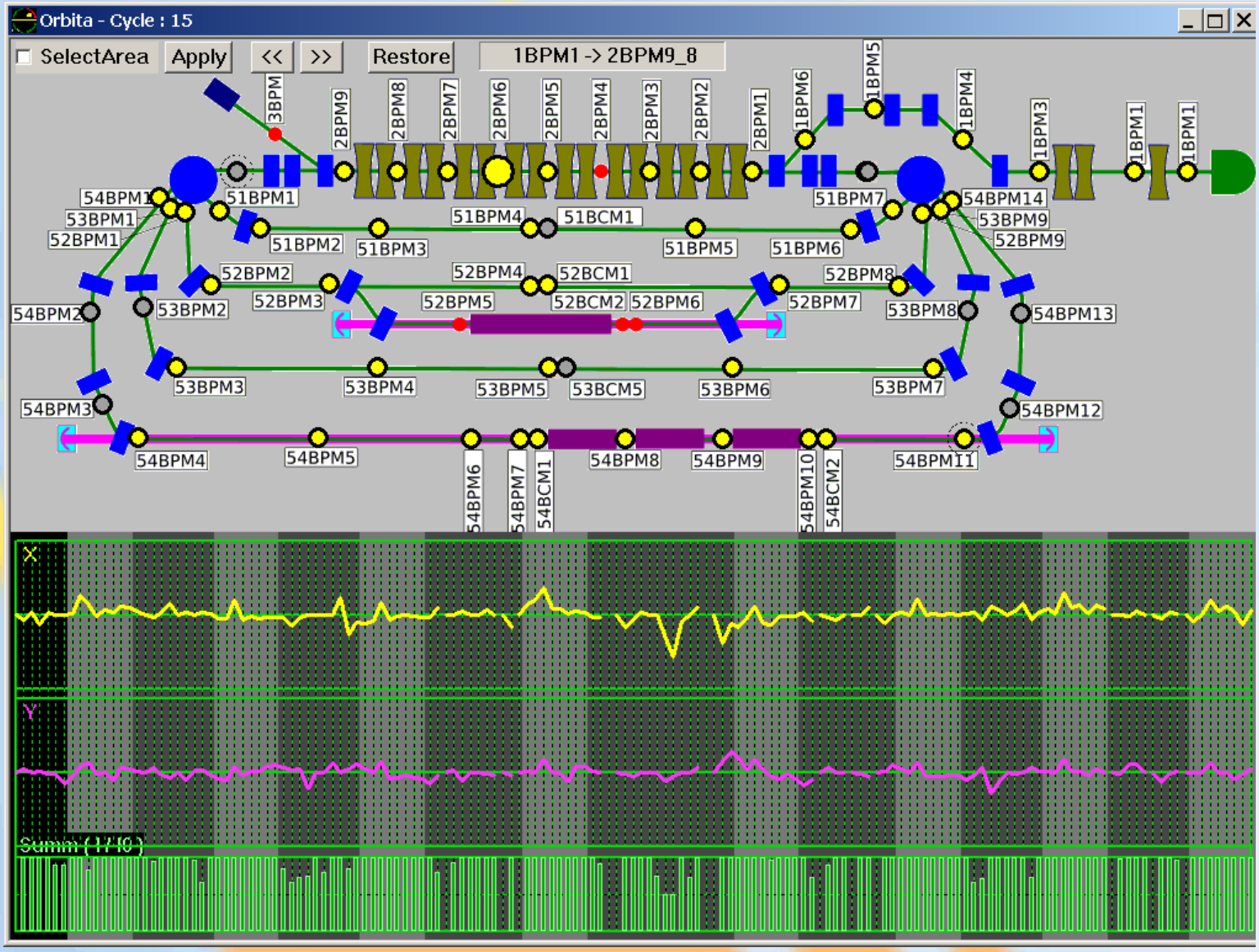
22 May 2012 – the first time the beam reached the dump after four accelerations and four decelerations




90% of beam current comes to the dump, the working repetition rate 3.75 MHz and average current 3.2 mA are obtained

Only about 3% of beam current is lost with energy > 12 MeV

Less than 1% of beam current is lost at the last track


Orbita - Cycle : 15
SelectArea
Apply
<<
>>
Restore
1BPM1 -> 2BPM9_8
3BPM
2BPM9
2BPM8
2BPM7
2BPM6
2BPM5
2BPM4
2BPM3
2BPM2
2BPM1
1BPM6
1BPM5
1BPM4
1BPM3
1BPM1
1BPM1
54BPM1
53BPM1
52BPM1
51BPM1
51BPM2
51BPM3
51BPM4
51BCM1
51BPM5
51BPM6
51BPM7
54BPM14
53BPM9
52BPM9
52BPM2
52BPM3
52BPM4
52BCM1
52BPM5
52BCM2
52BPM6
52BPM7
52BPM8
53BPM8
54BPM13
54BPM2
53BPM2
53BPM3
53BPM4
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53BCM5
53BPM6
53BPM7
54BPM3
54BPM12
54BPM4
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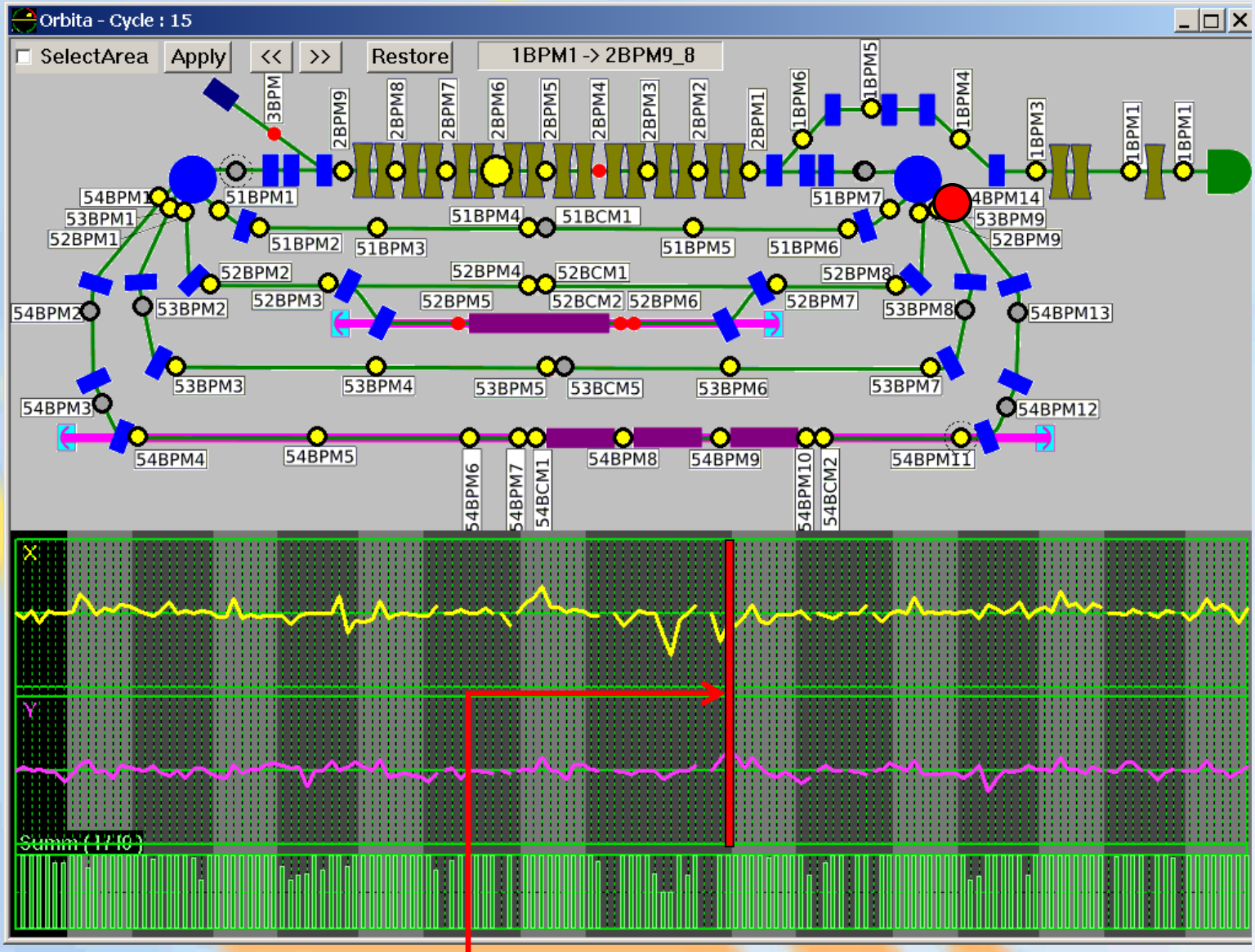
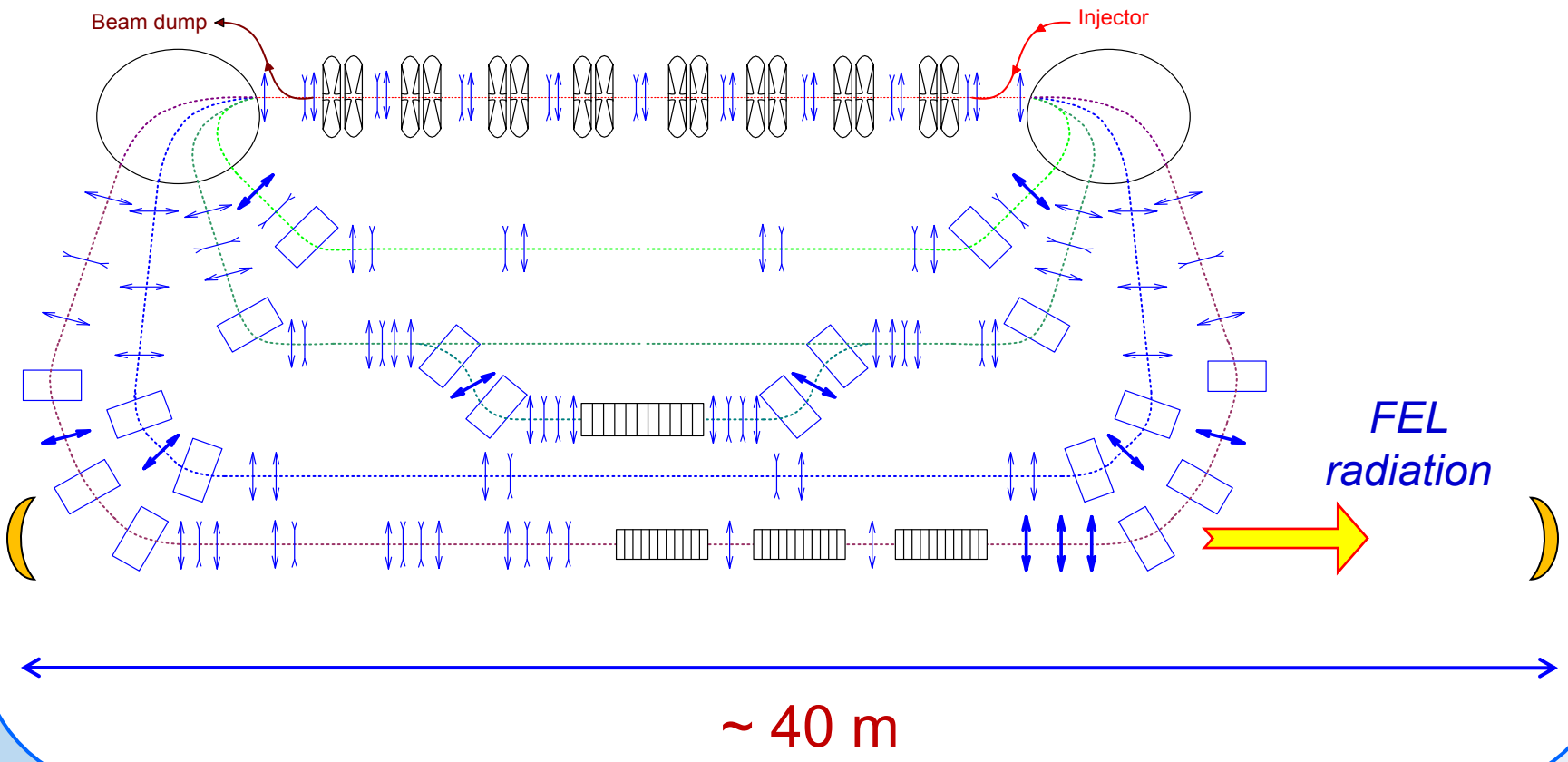
54BPM9
54BPM10
54BCM2
54BPM11
X
Y




Beam trajectory can be adjusted only before this point

# The third stage FEL



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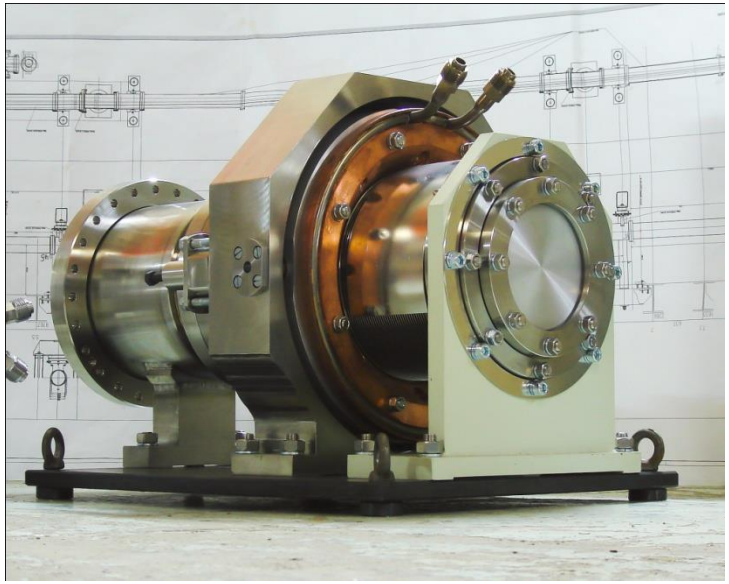

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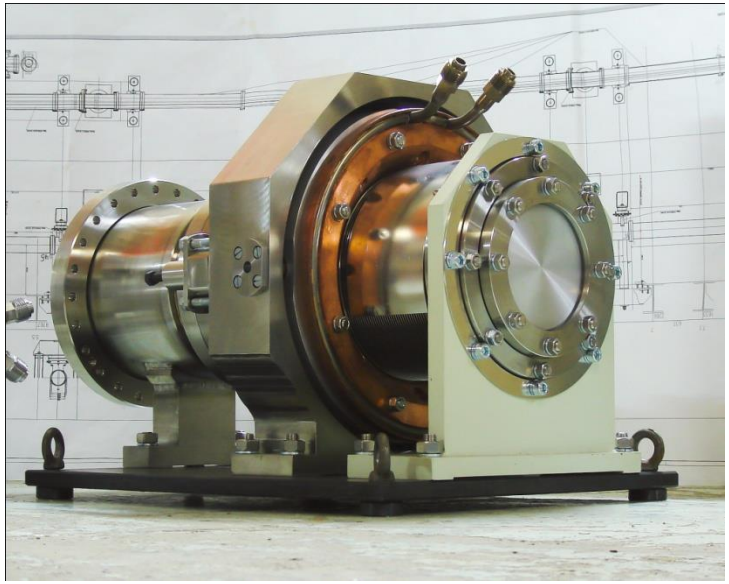




Electron outcoupling scheme may be used here

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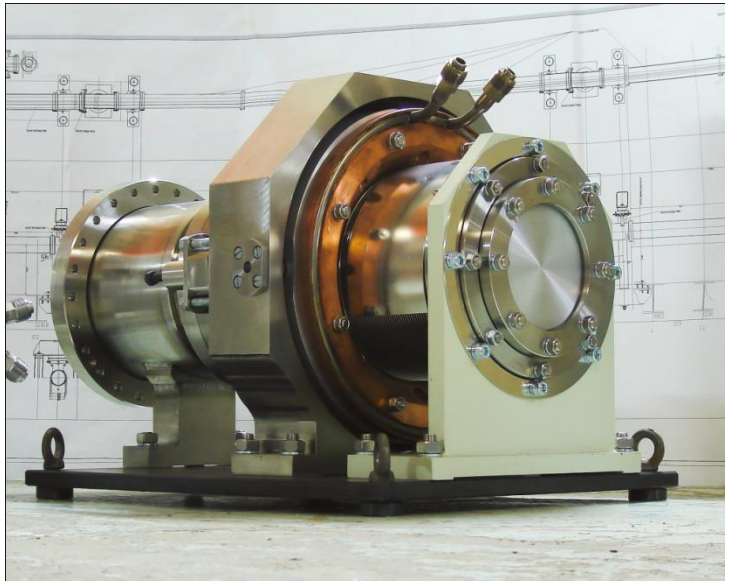




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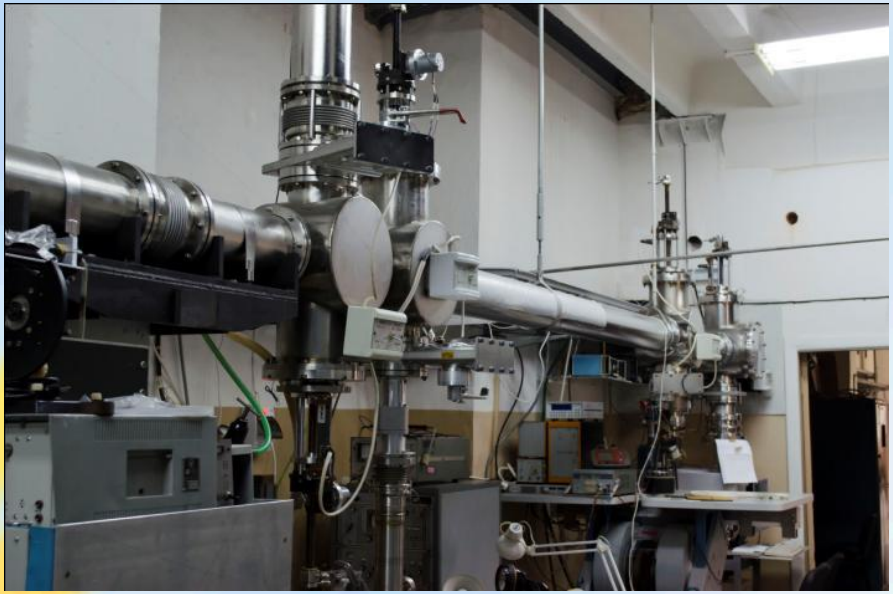
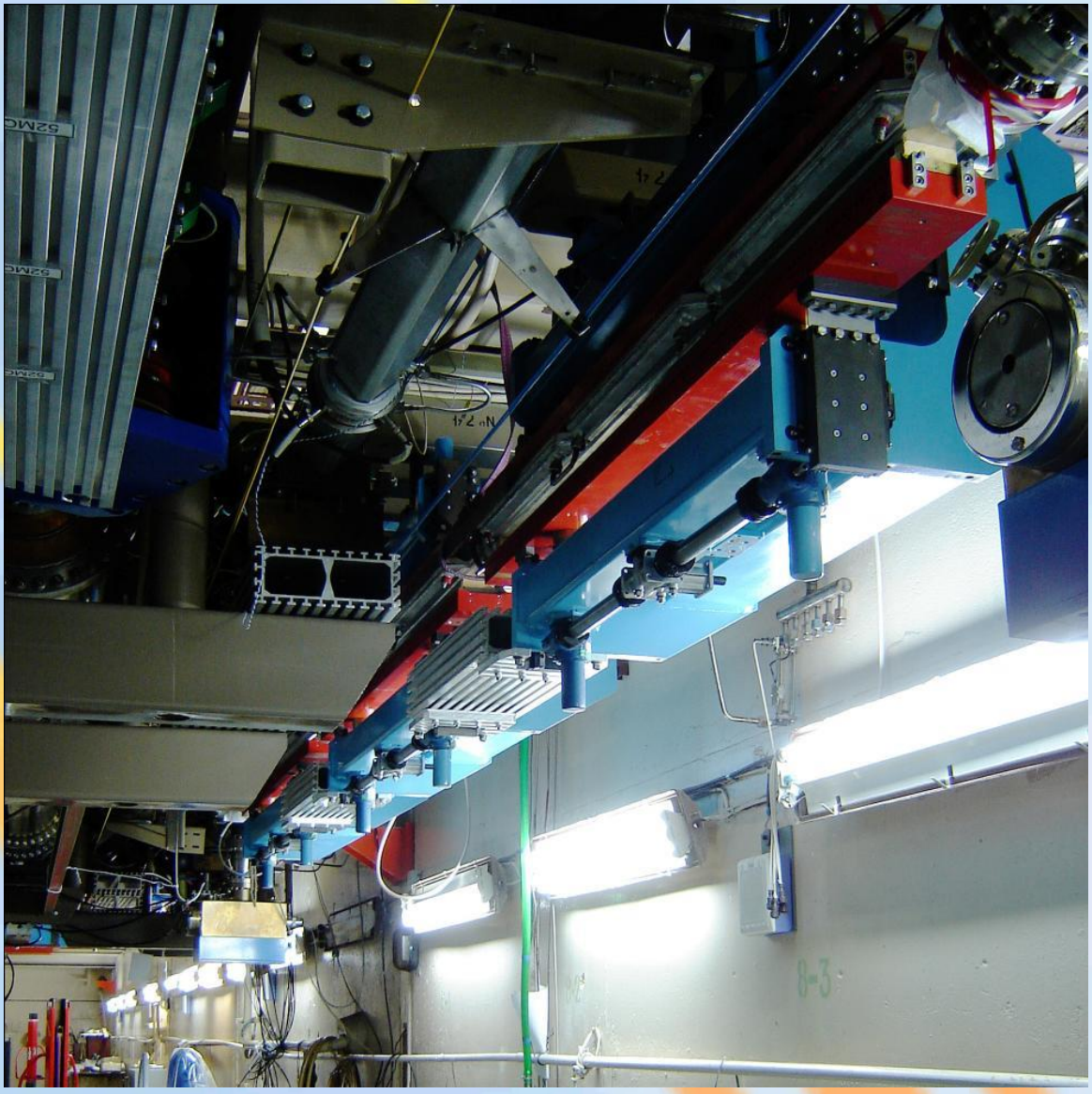
# *Optical beamlines*



In near future the third stage FEL radiation is planned to be delivered by existing optical beamlines to existing user stations.

# *The third stage FEL undulator*



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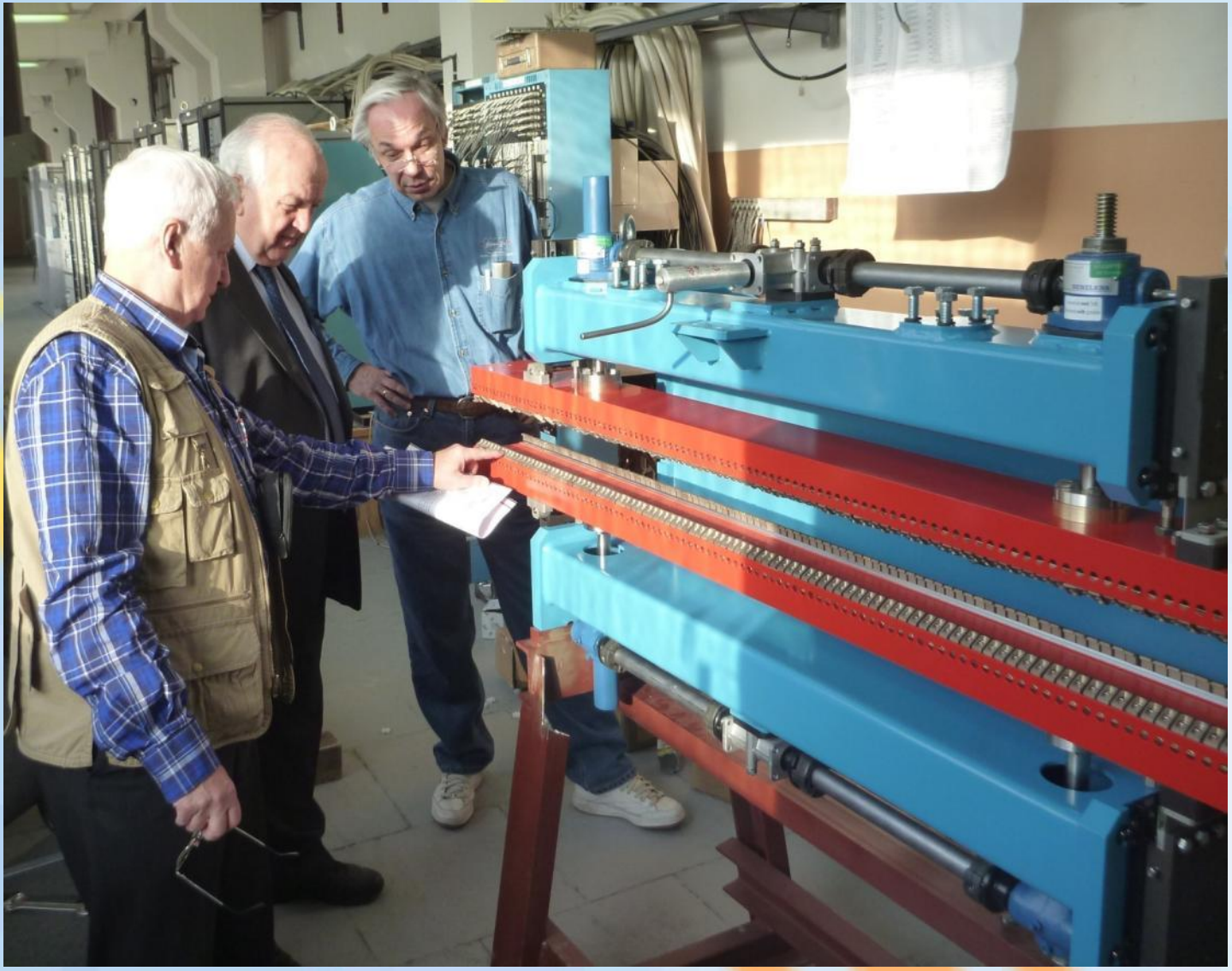

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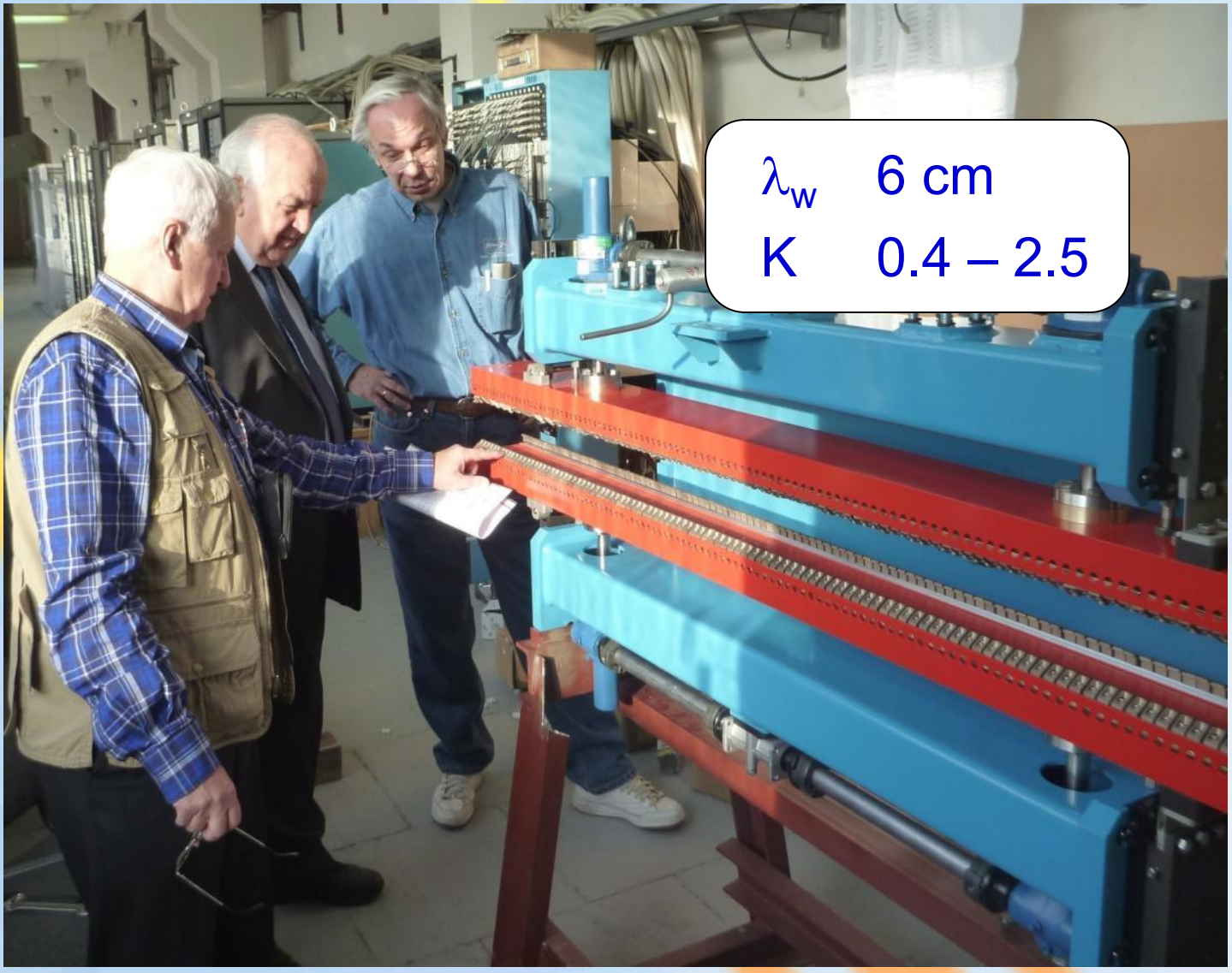

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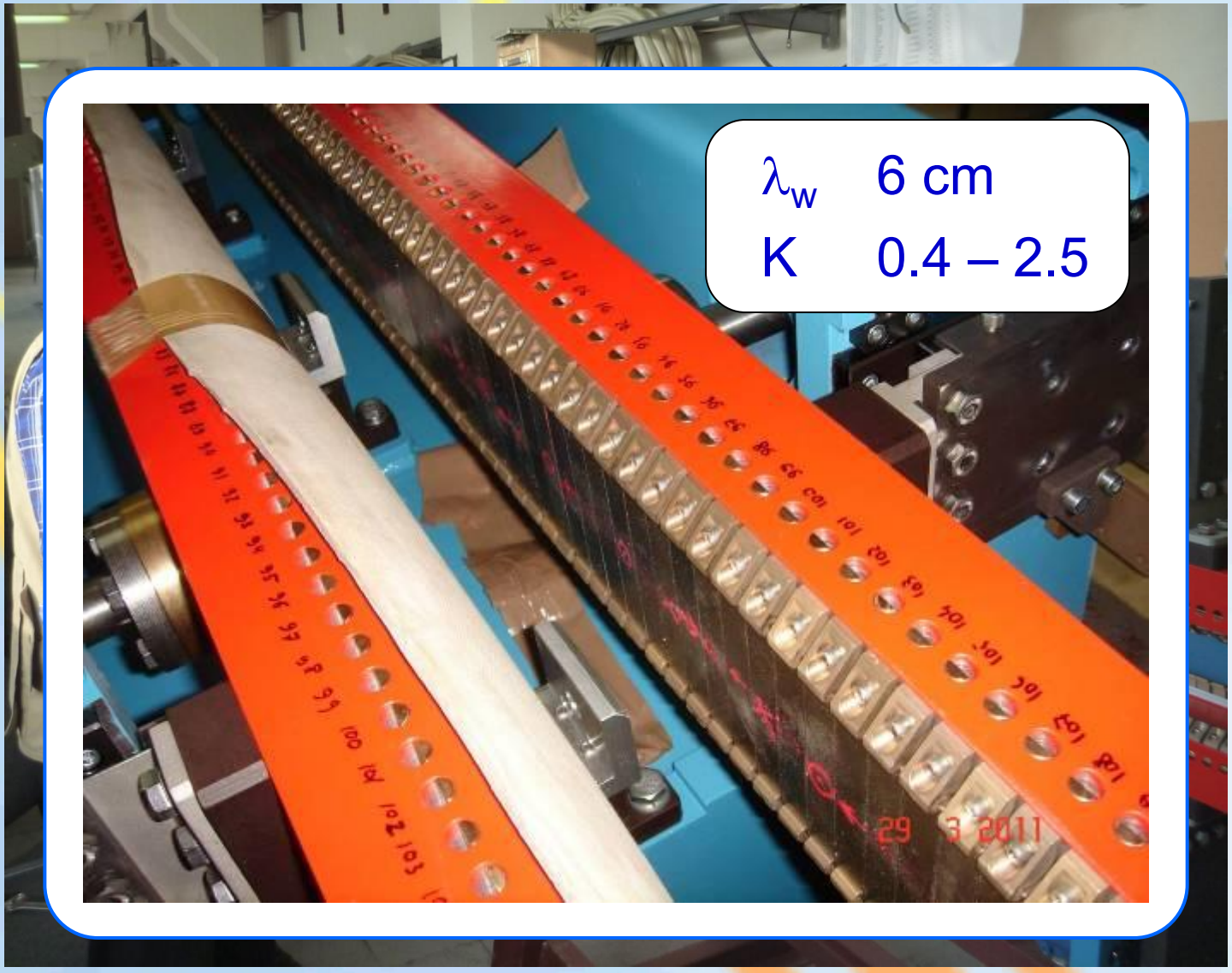


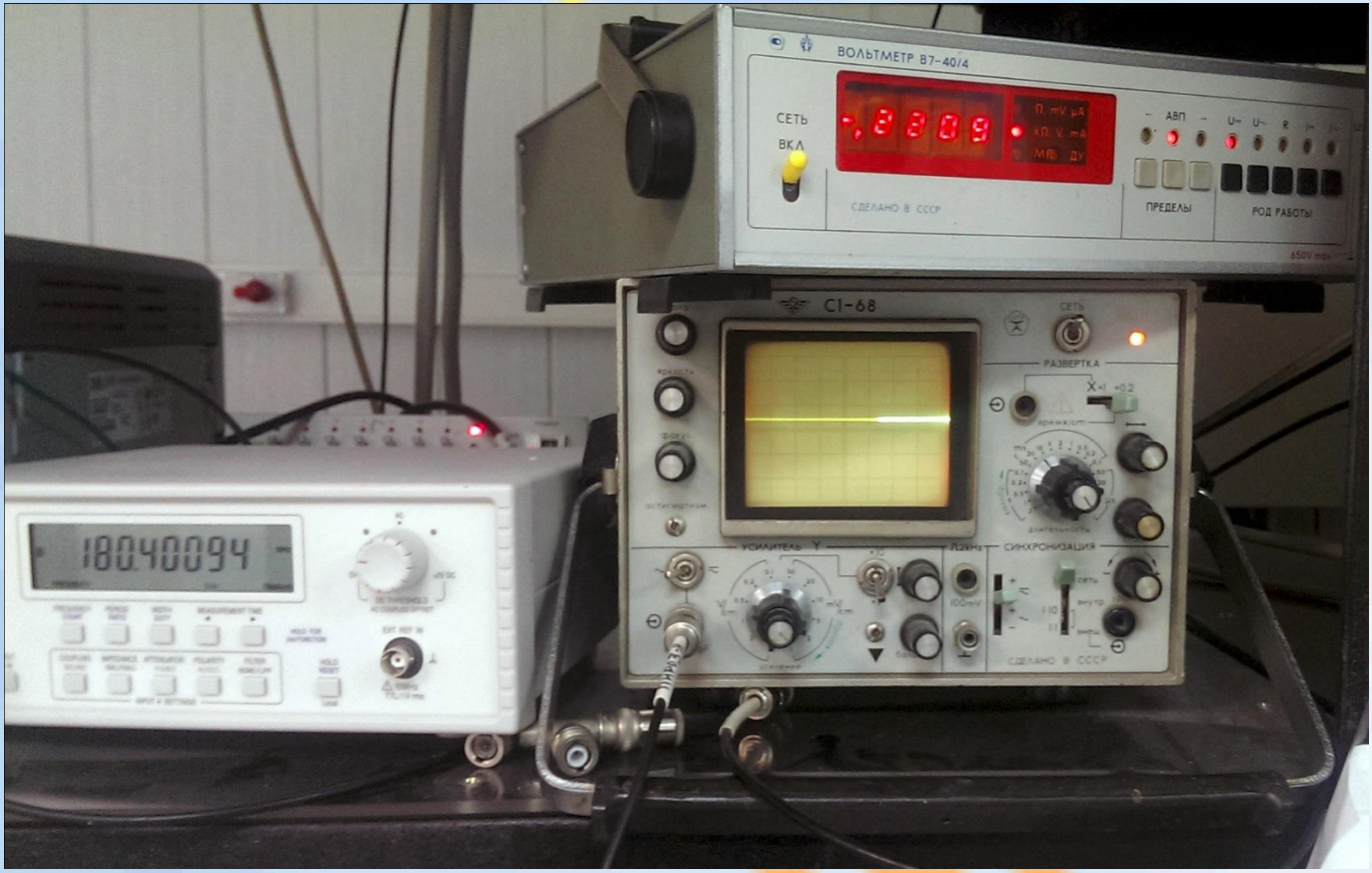
# First lasing

*Challenges*

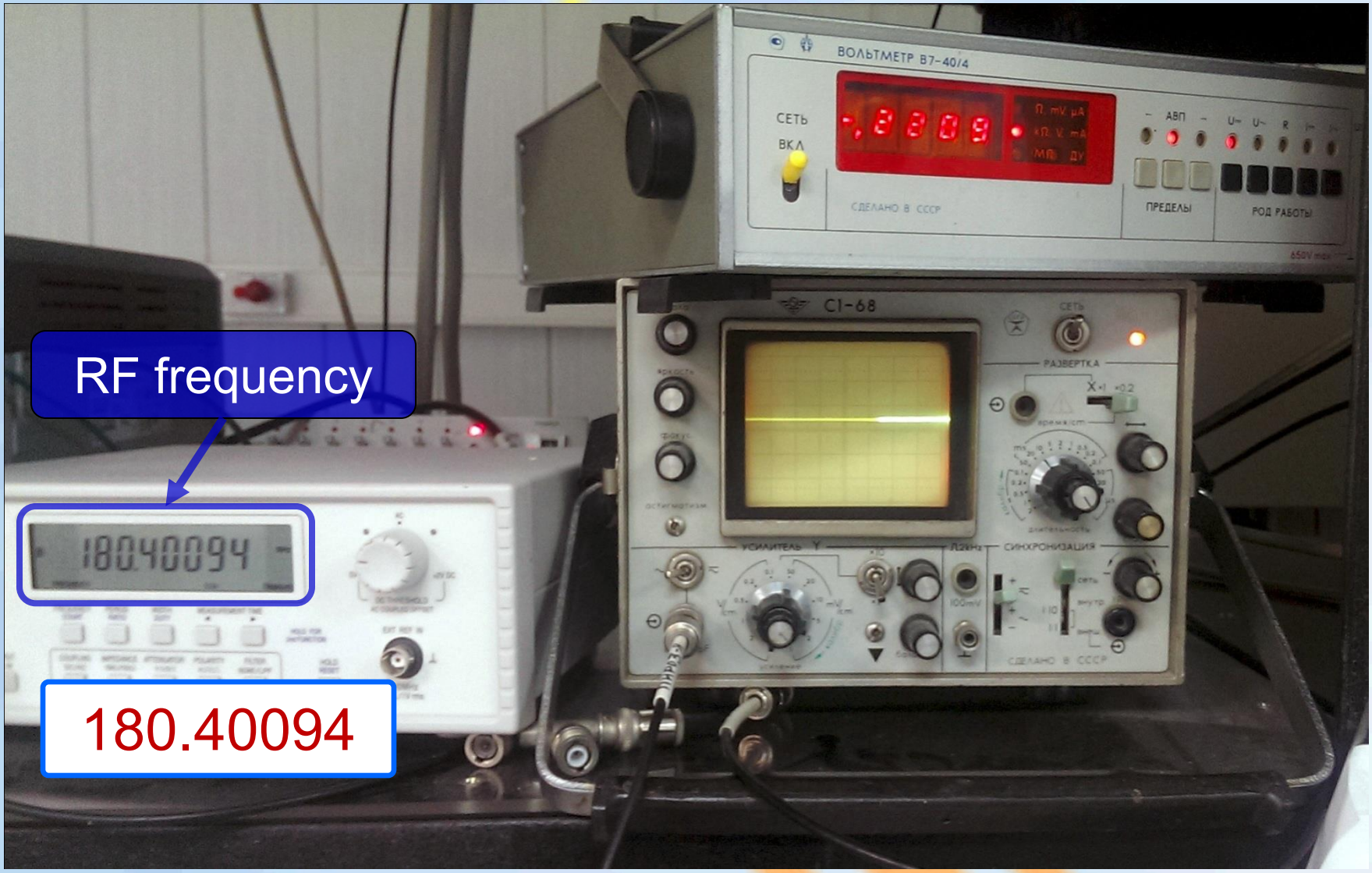
- Align mirrors of 40 meters long optical cavity and adjust the distance between them with accuracy better than 0.3 mm
- Obtain high recovery efficiency in multiturn ERL
- Adjust the beam trajectory in undulator with submillimetric accuracy

# First lasing

When it's done all that remains is to adjust RF frequency and watch carefully




# 6 July 2015 – the first lasing

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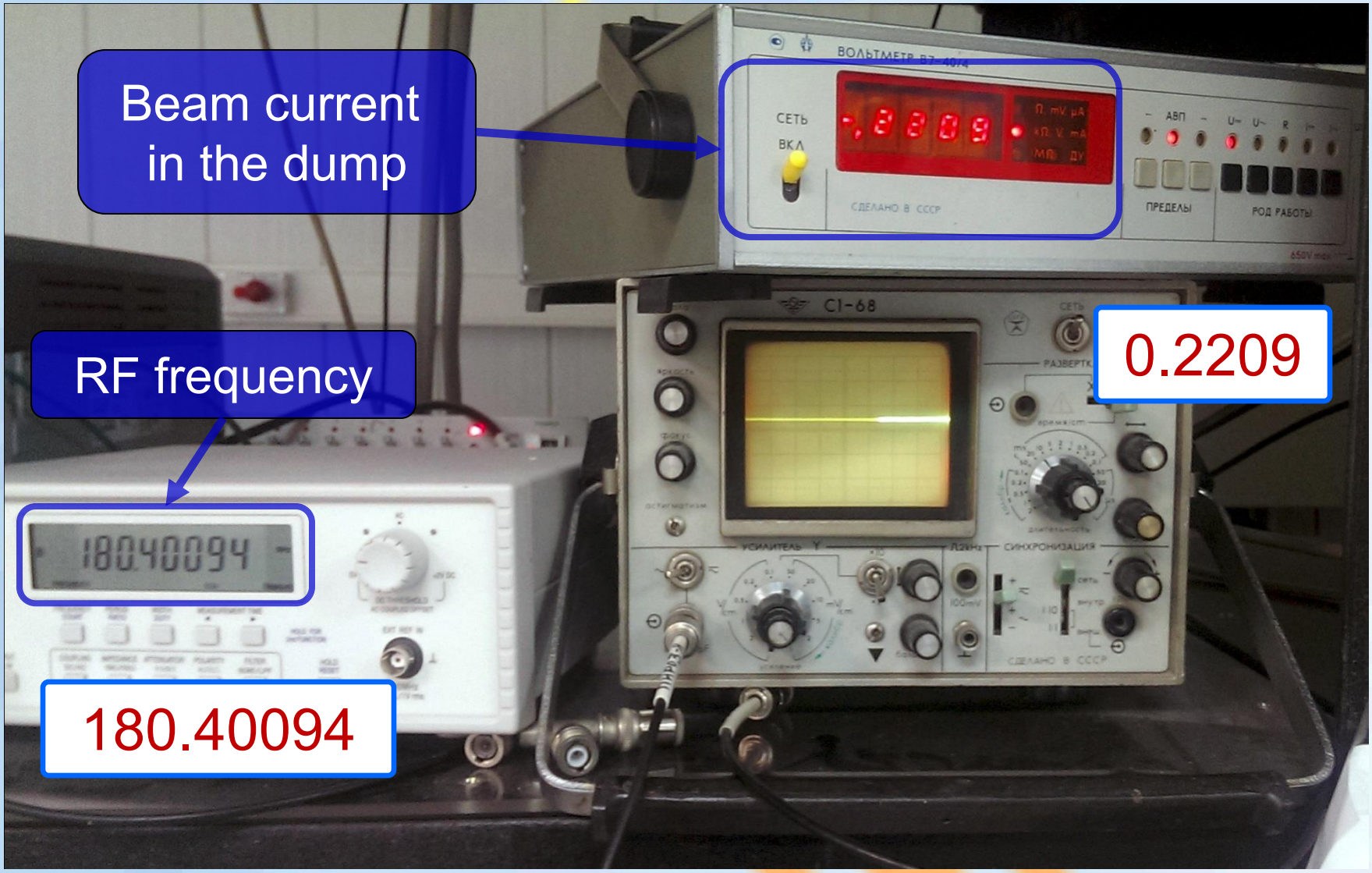


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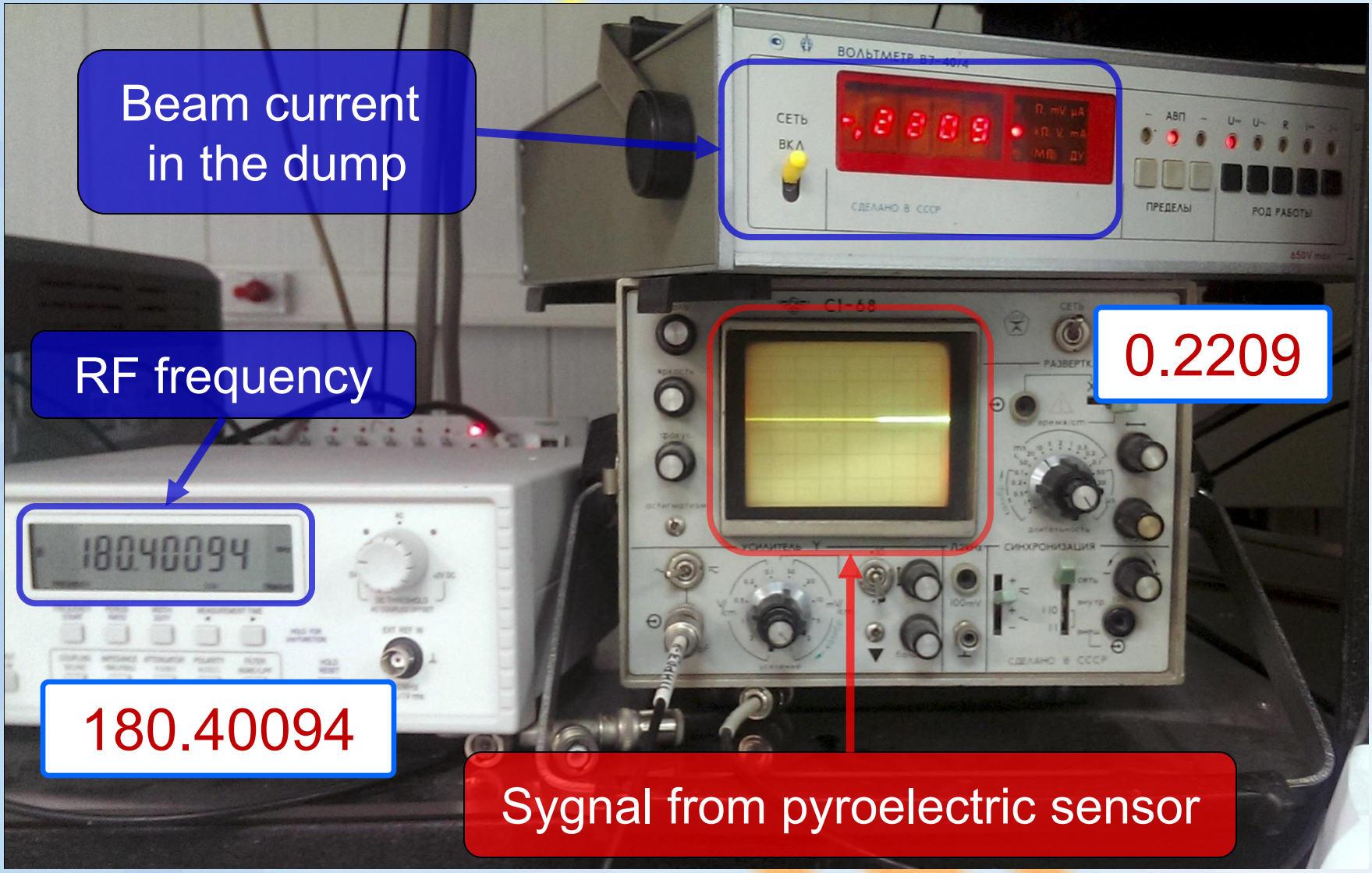


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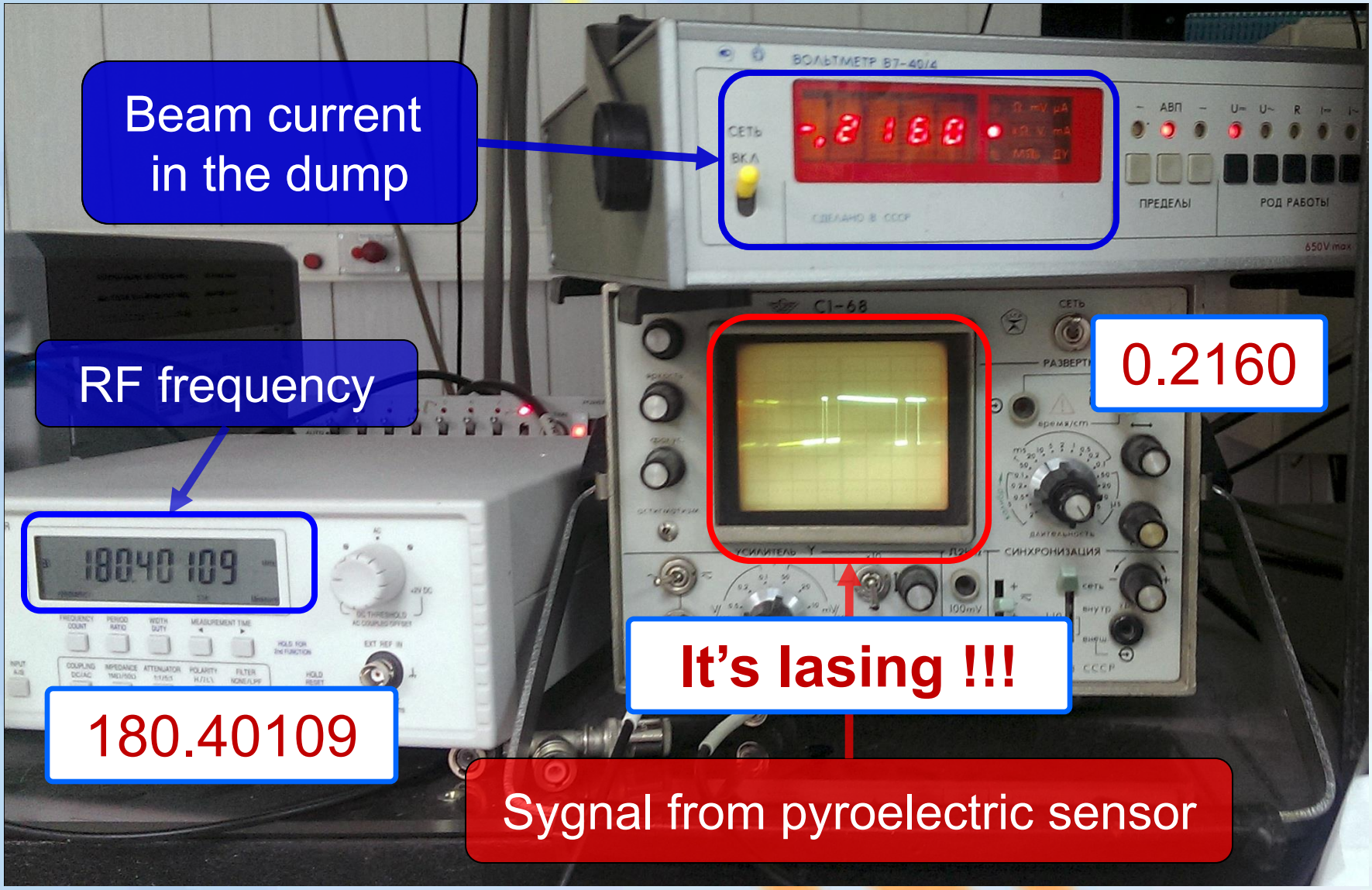
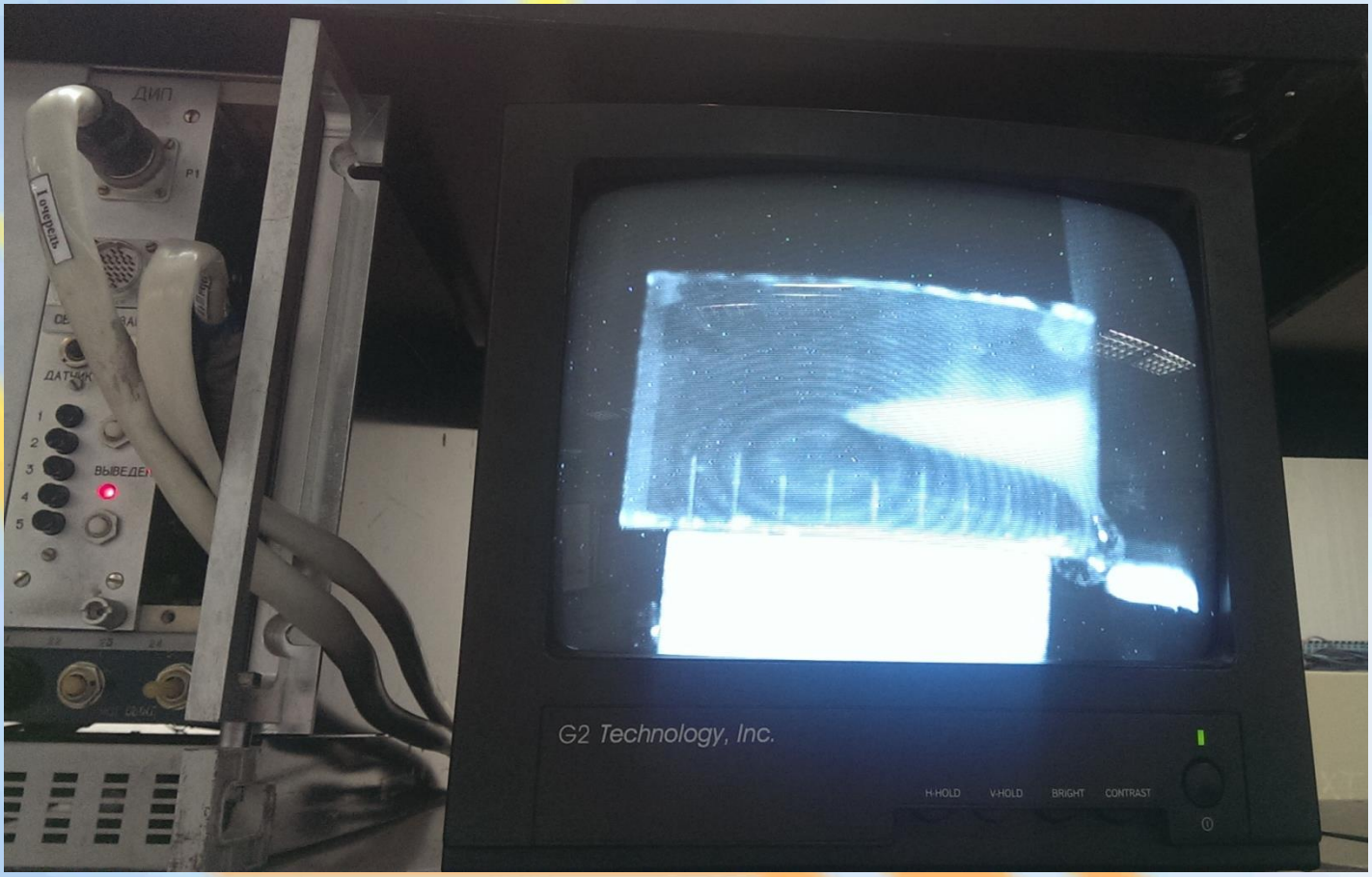



**6 July 2015 – the first lasing**

# First experiments with new FEL

*Drilling holes in plexiglass*




Radiation power was about 30 watts

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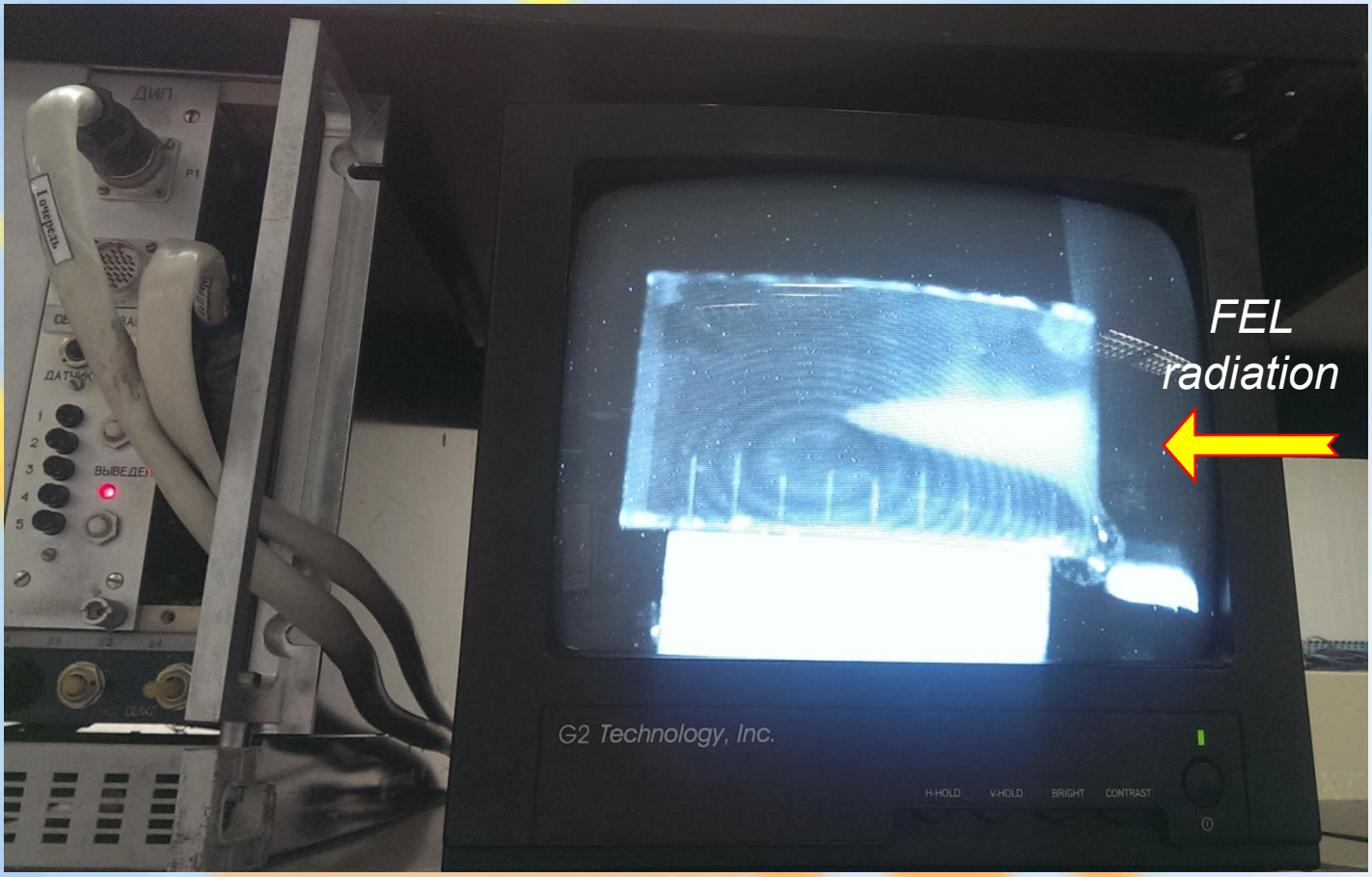


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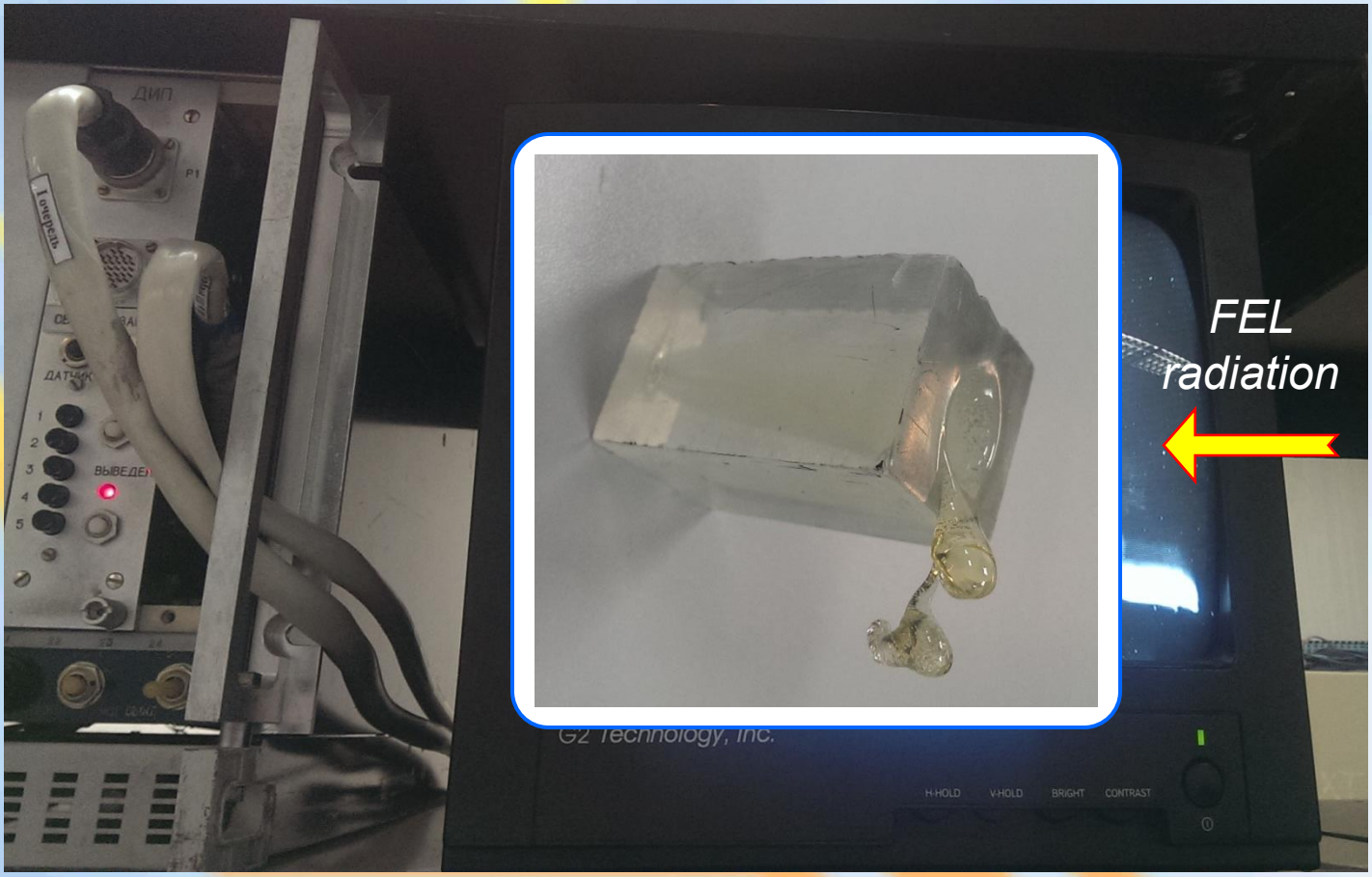
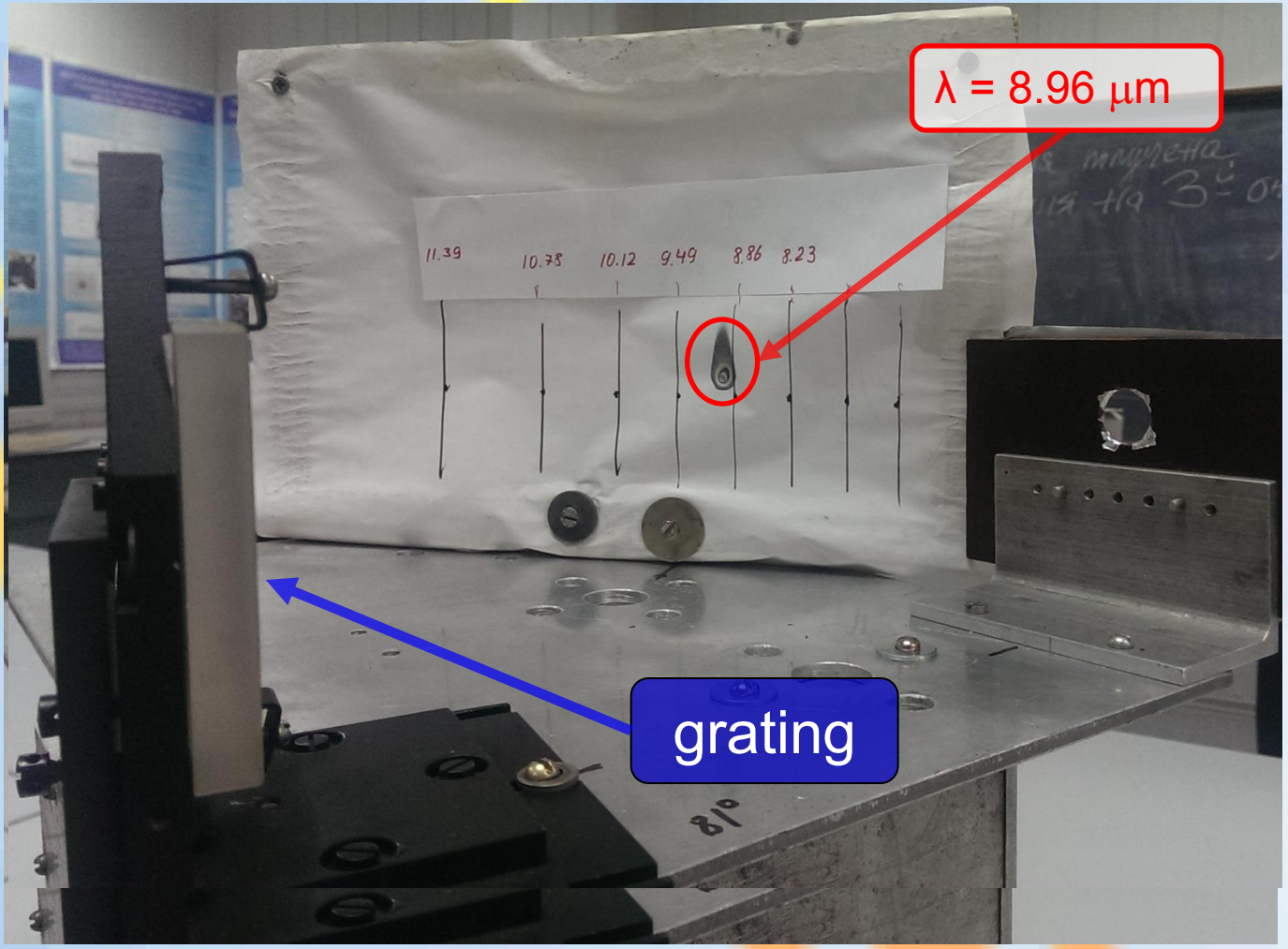



Radiation power was about 30 watts

# First experiments with new FEL

## *Measurement of the radiation wavelength*




Handmade monochromator

# Nearest and far future experiments

- Selective photochemical reactions
- Infrared laser catalysis
- Separation of isotopes
- …

# 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 |

# Nearest and far future plans

- Improve x-ray and neutron radiation shielding
- Install remote control units for undulator gap and optical cavity mirror angles
- Deliver FEL radiation to existing user stations
- Decrease beam losses and increase average current
- Increase DC gun voltage and improve beam quality in injector
- Optimize electron efficiency of FEL
- Install RF gun

**Thank you for your attention!**