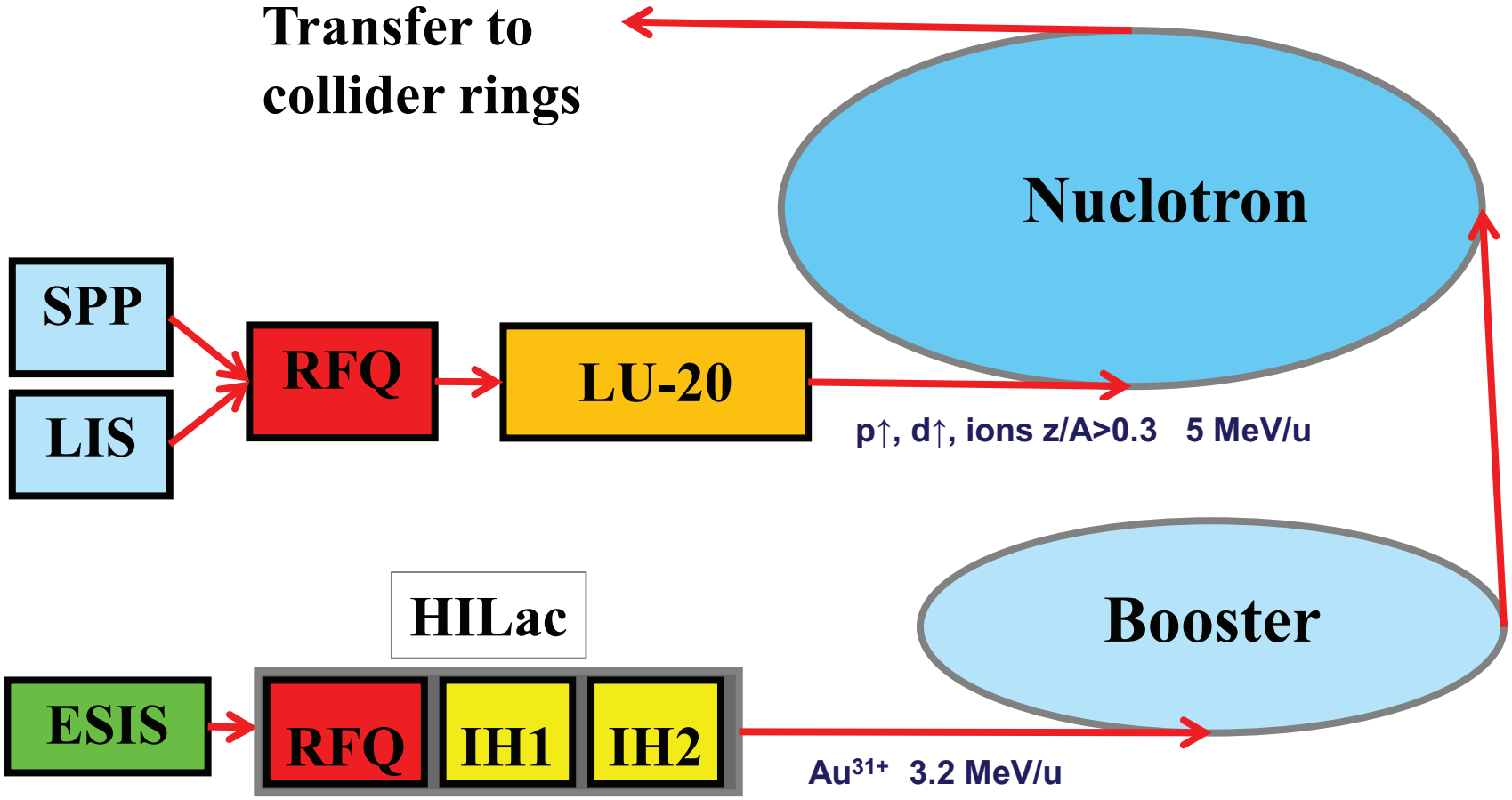
Commissioning of New Light Ion RFQ Linac and First Nuclotron Run with New Injector

A.Butenko, A.Sidorin on behalf of team
(JINR, Dubna)
RuPAC 2016

Structure of the injector complex



Polarized p↑ and d↑ beams, protons and light ions
are planned to be accelerated with existing Linac LU-20,
Heavy ions: HILac + Booster

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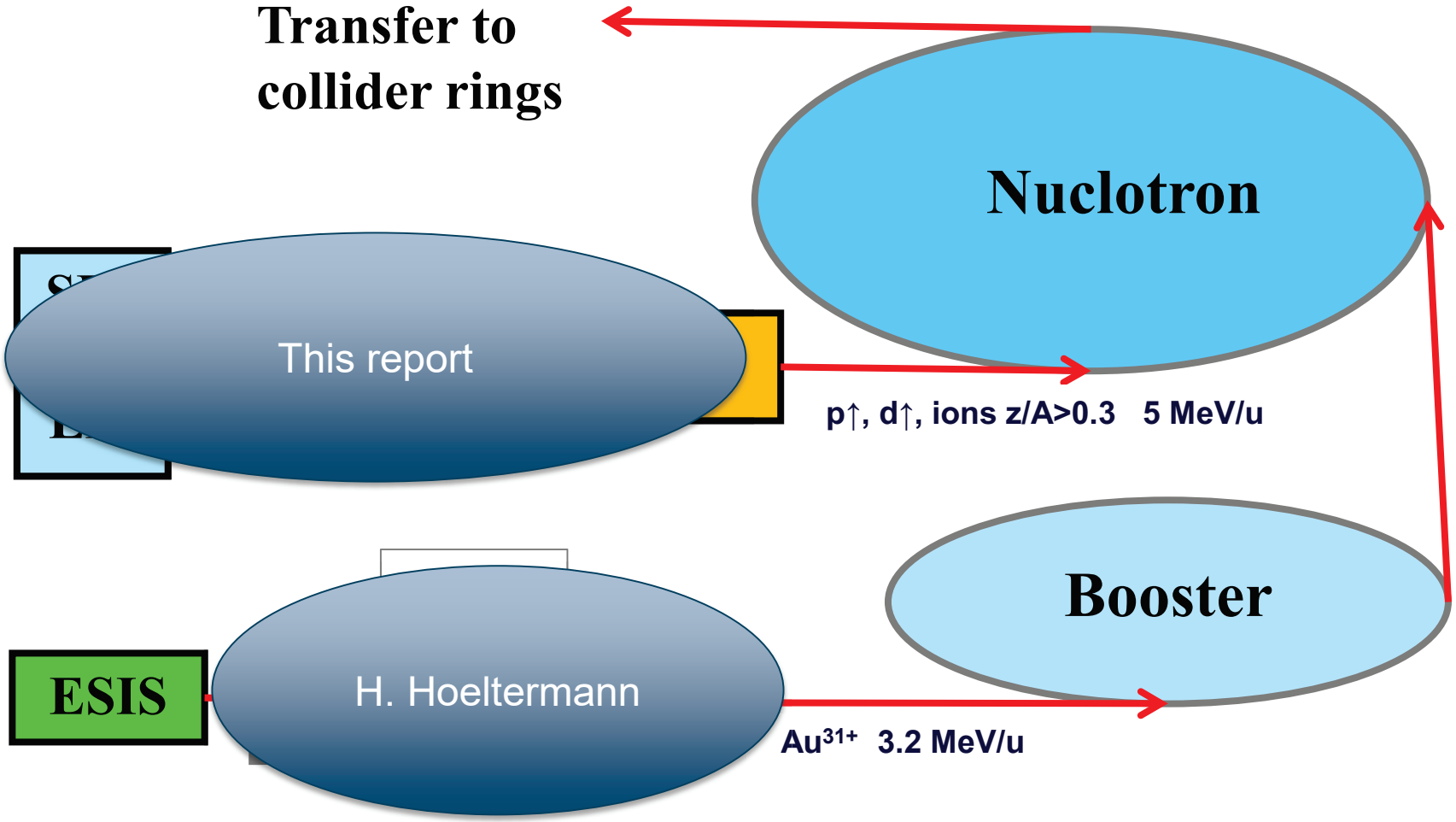

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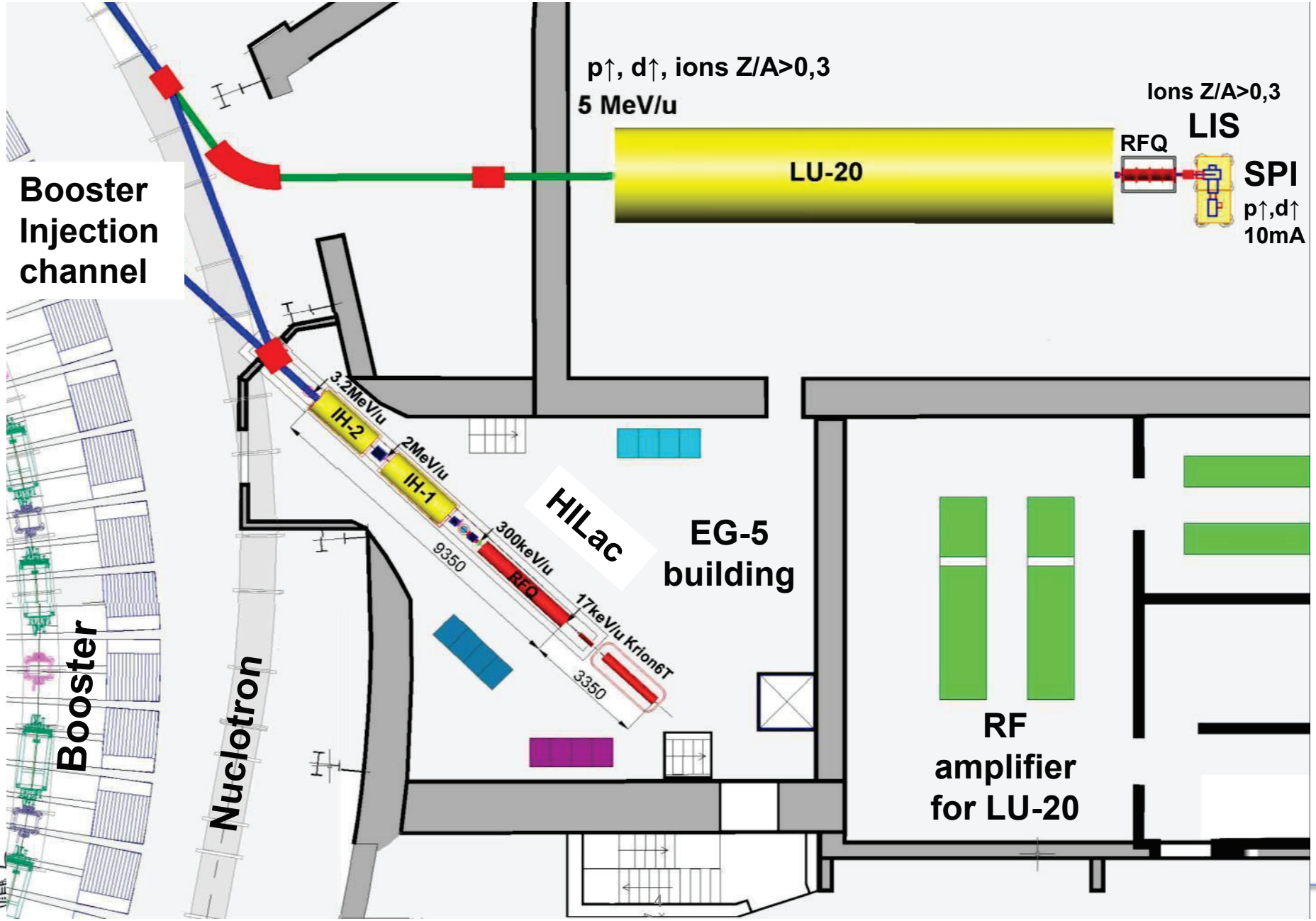
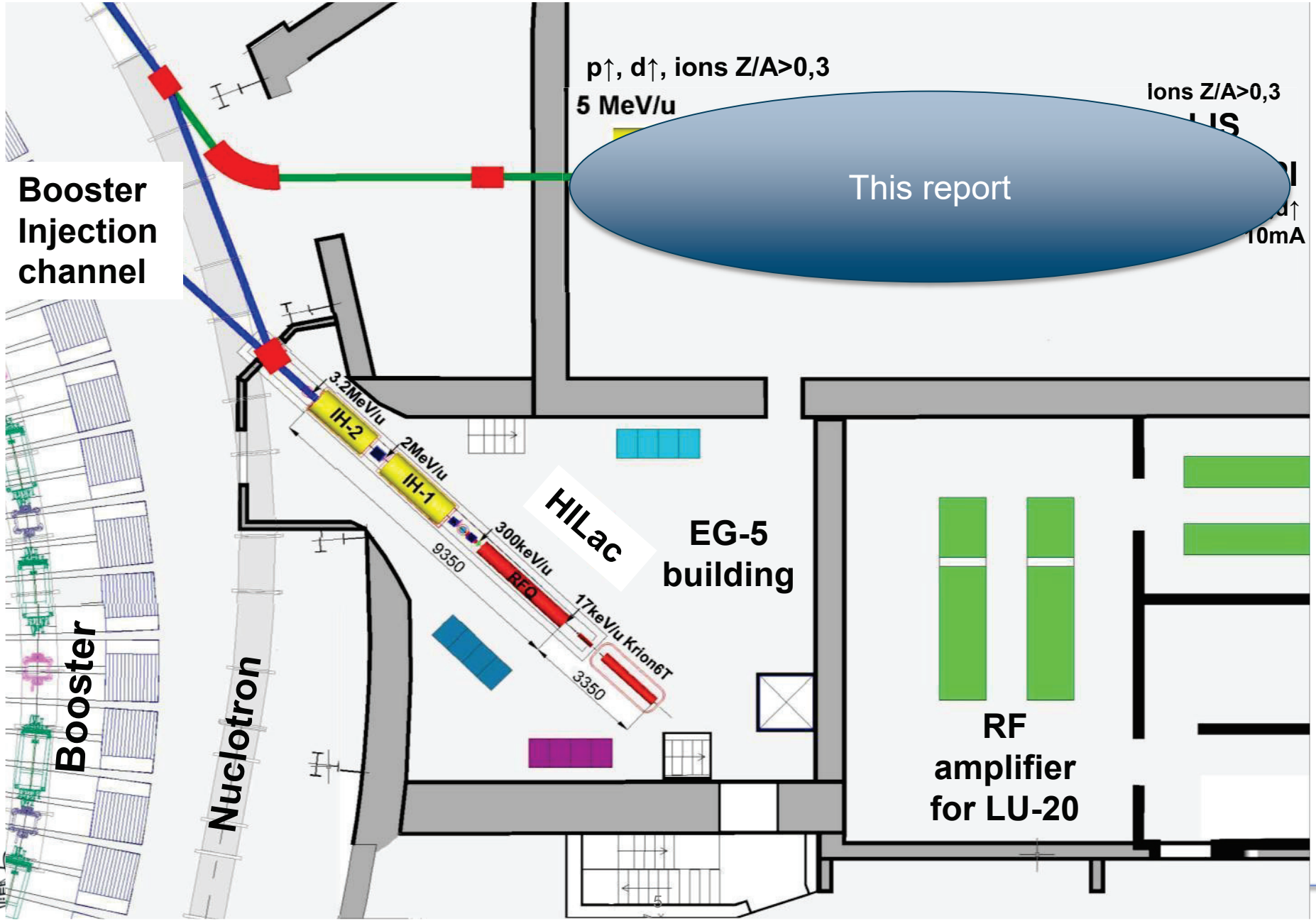
Injection complex layout



Injection complex layout



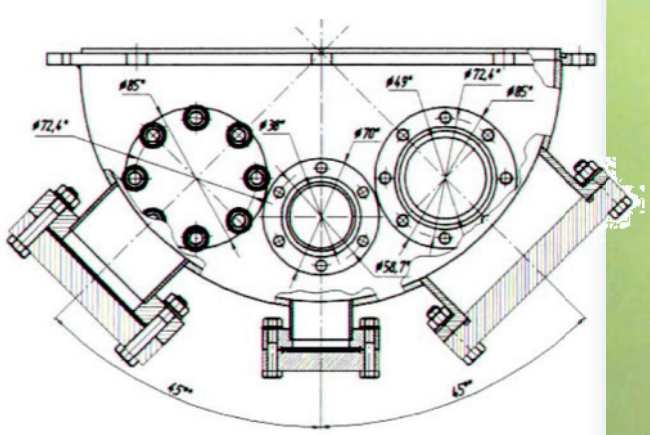
New laser ion source (LIS)

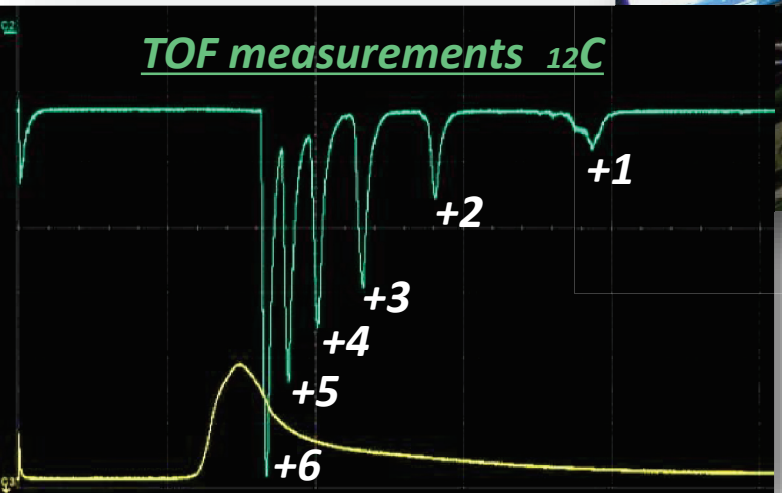
New Nd-YAG laser, instead of the old CO_2 laser

$E \geq 2$ J , $\tau \approx$ 7-8 ns, ~ $5 \cdot 10^{12}$ W/cm²

Acceleration of $_{12}C^{6+}$ without stripping after LU20

New LIS Test bench

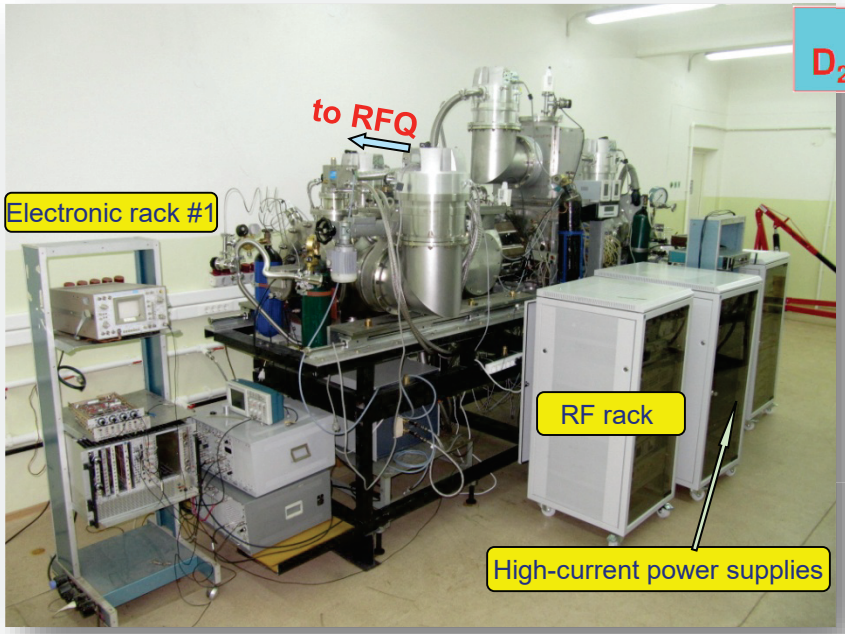


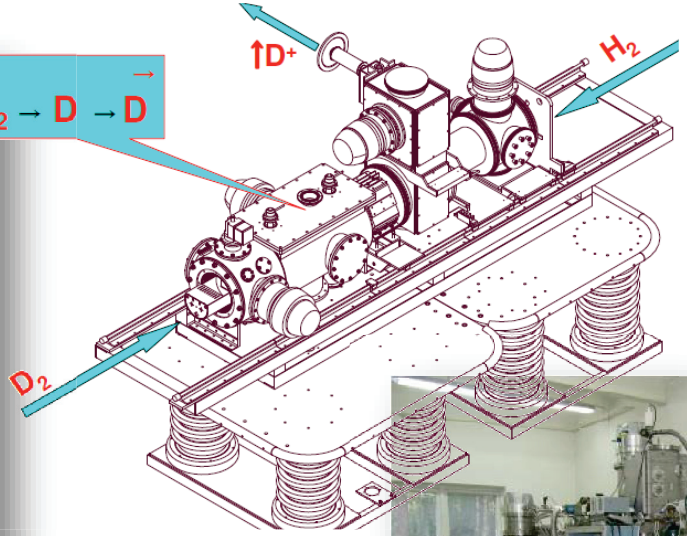


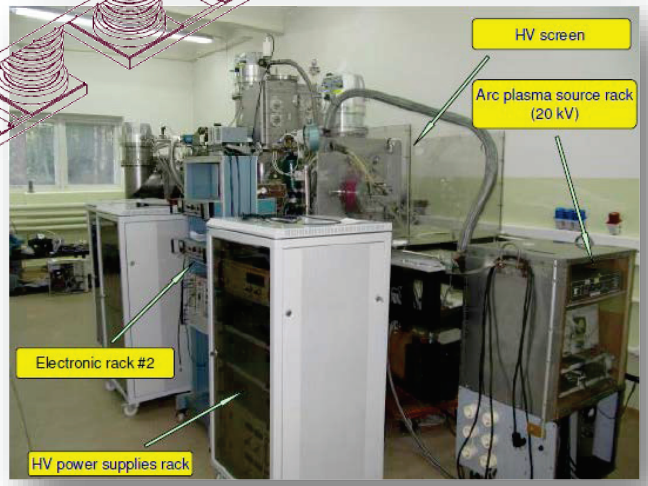
First run at Nuclotron: 2013 (C^{6+}, C^{5+})

Presently: Test of HILac

Source of polarized ions (p, d, H)
JINR+INR RAS







The main purpose of the SPI-project is to increase the intensity of the accelerated polarized beams (D+,H+) at the JINR Accelerator Complex up to **10^{10} p/pulse**

- Intensive work was carried out at INR of RAS (Moscow) and testing of the ABS systems was finished in July 2012
- In August 2012, the ABS was transported from the INR of RAS (Moscow) and assembled at JINR
- All-inclusive SPI-testing was carried out in 2013-2015 at JINR

Existed power generator provided only 5 kW to supply ion sources (to the HV terminal 700kV)

Source of Polarized Ions (SPI) power consumption up to 25 kW

Solution:

To decrease HV voltage at the source terminal down to 150 kV
and to use insulating (to 150 kV) transformer on power 30 kVA

Electrostatic accelerator has to be replaced by RFQ

Foreinjector for LINAC LU-20

Before June 2016

Ion Source
power consumption
≤ 5kW

↓

Accelerating tube
625 kV- protons,
312.5 kV - Z/A=1/2,
470 kV - Z/A=1/3.

↓

LU-20

Today

Ion Source
power consumption
≤ 30kW

↓

Accelerating tube
(LEBT)
31 keV/u - p↑,d↑,
ions Z/A>1/3

↓

RFQ

↓

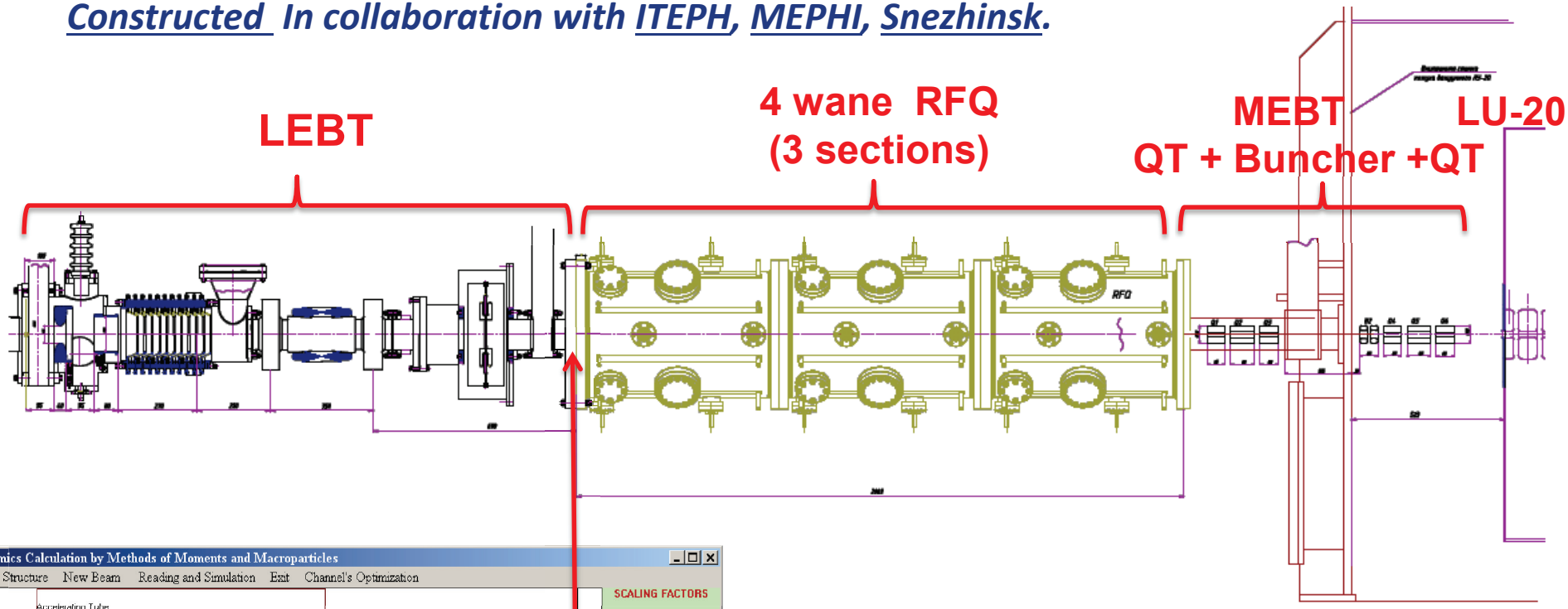
MEBT

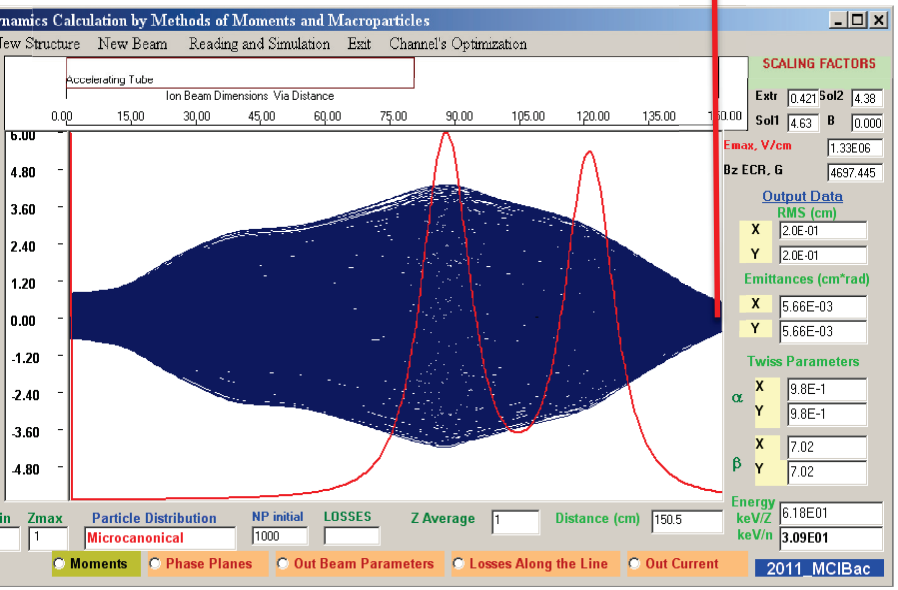
↓

LU-20

New foreinjector for LU-20

Constructed In collaboration with ITEPH, MEPHI, Snezhinsk.





LEBT parameters for polarized d+ from SPI source

SPP ions	Z/A	Current mA	ε_n(4rms) π sm mrad	Beam energy keV/u	
				From SPI	LEBT exit
$^2D^+$	0,5	10	0.2	10	45

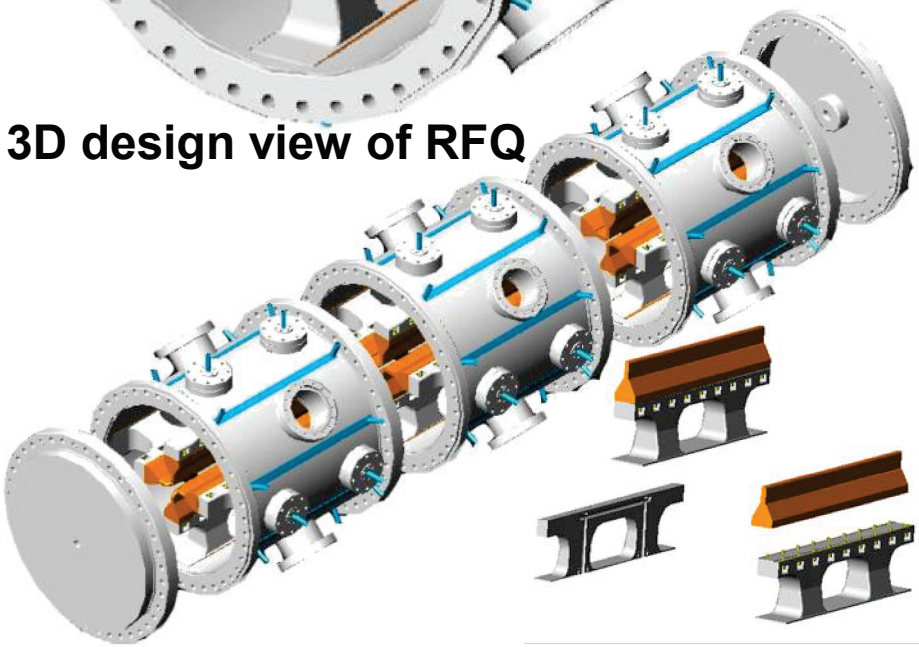
New foreinjector for LU-20

RFQ main parameters

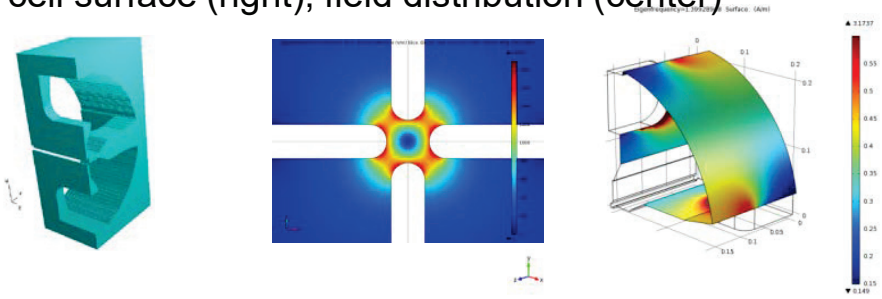
q/A	1.0	0.5	≥ 0.3
Injection energy, [keV]	31	61.8	103
Max current, [mA]	10	20	10
Output energy [MeV/u]	0.156		
Norm emittance (output) [π·cm·mrad]	≤ 0.5		
RFQ length, [m]	2.2		
Transmition, %	> 85%	> 89%	> 93%
In LU-20 acceptance	70 %	71 %	80 %

RFQ design has been started in September 2011 (ITEP&MEPhI, Moscow)

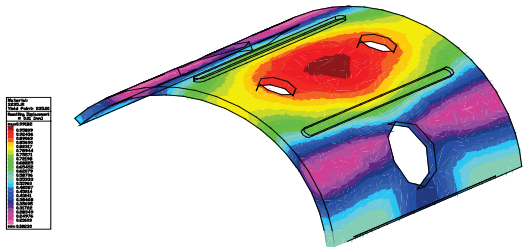
3D design view of RFQ



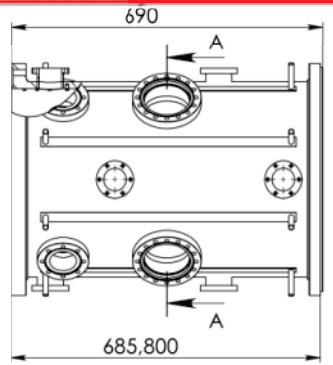
View of the resonant cell (left), distribution of current on the cell surface (right), field distribution (center)

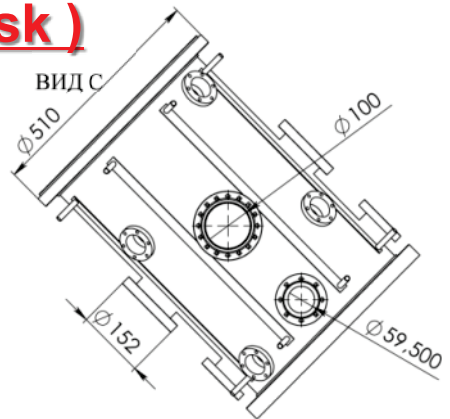


Results of hardness simulation for resonator cell



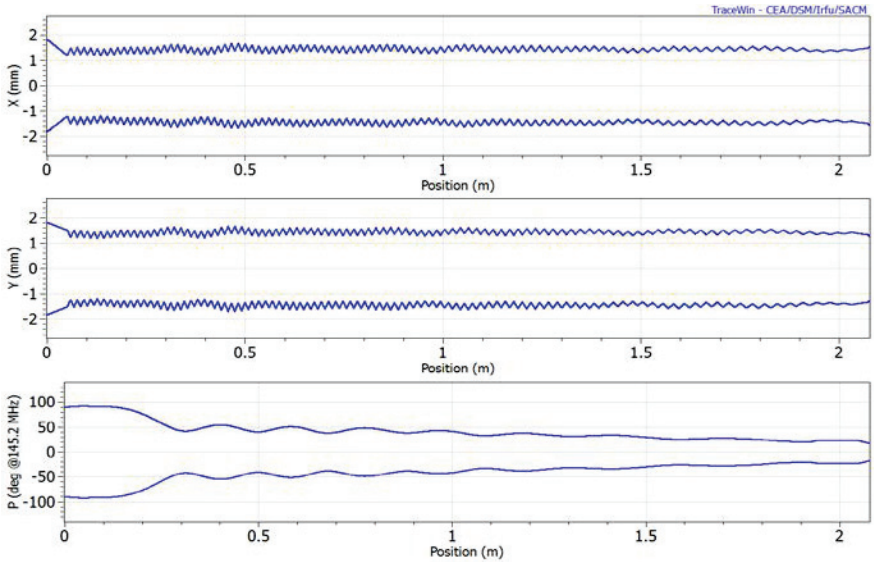
Fabrication of the RFQ resonator started in August 2013, Completed 2015 (VNIITP, Snezhinsk)

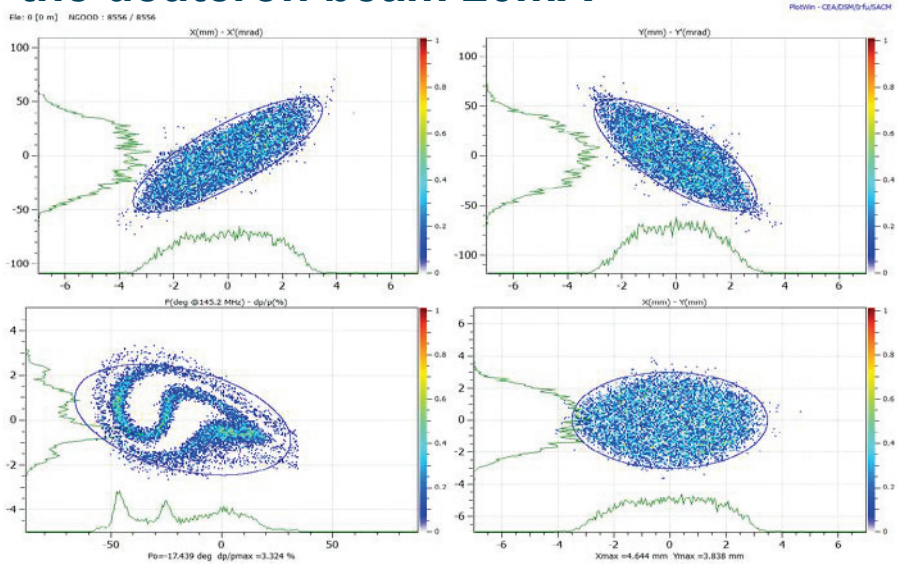




RFQ section (2.2 m for z/A=0.3÷1)

Simulations results for the deuteron beam 20mA

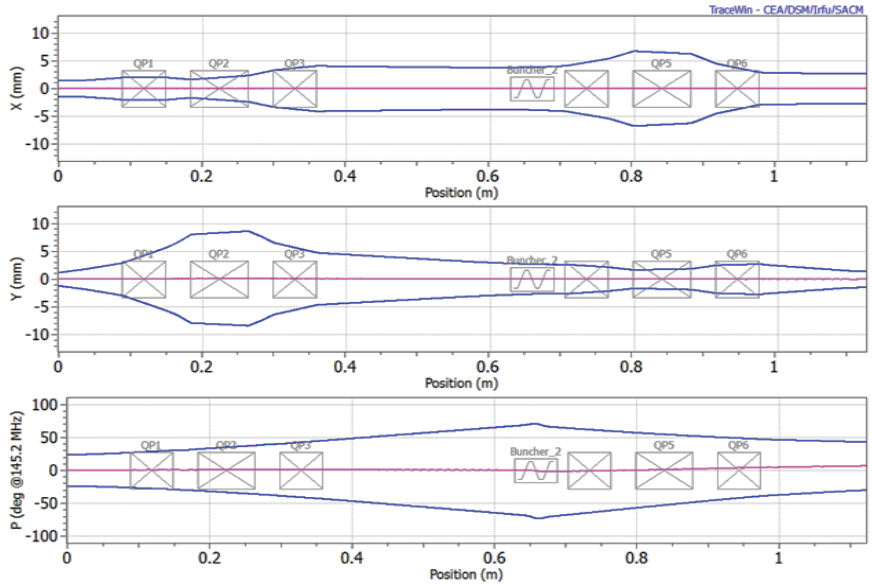


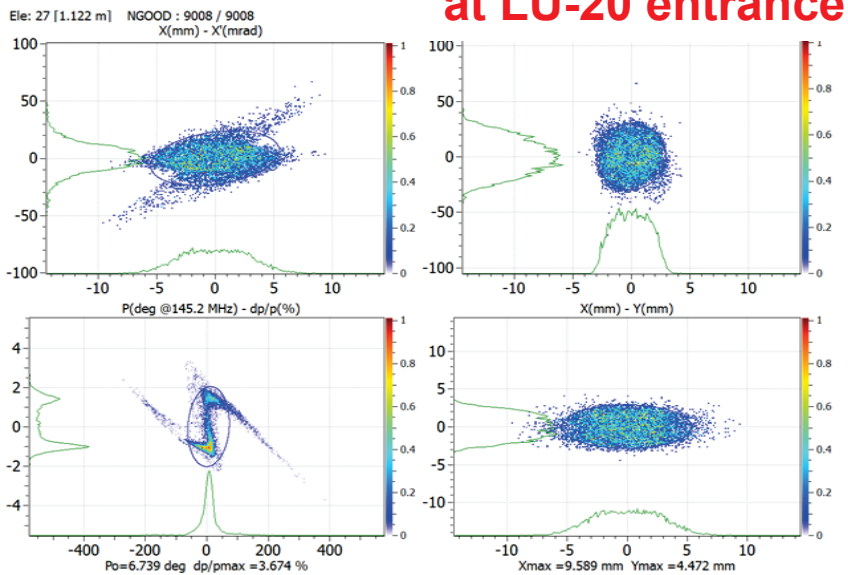


MEBT section

(Q triplet + buncher + Q triplet)

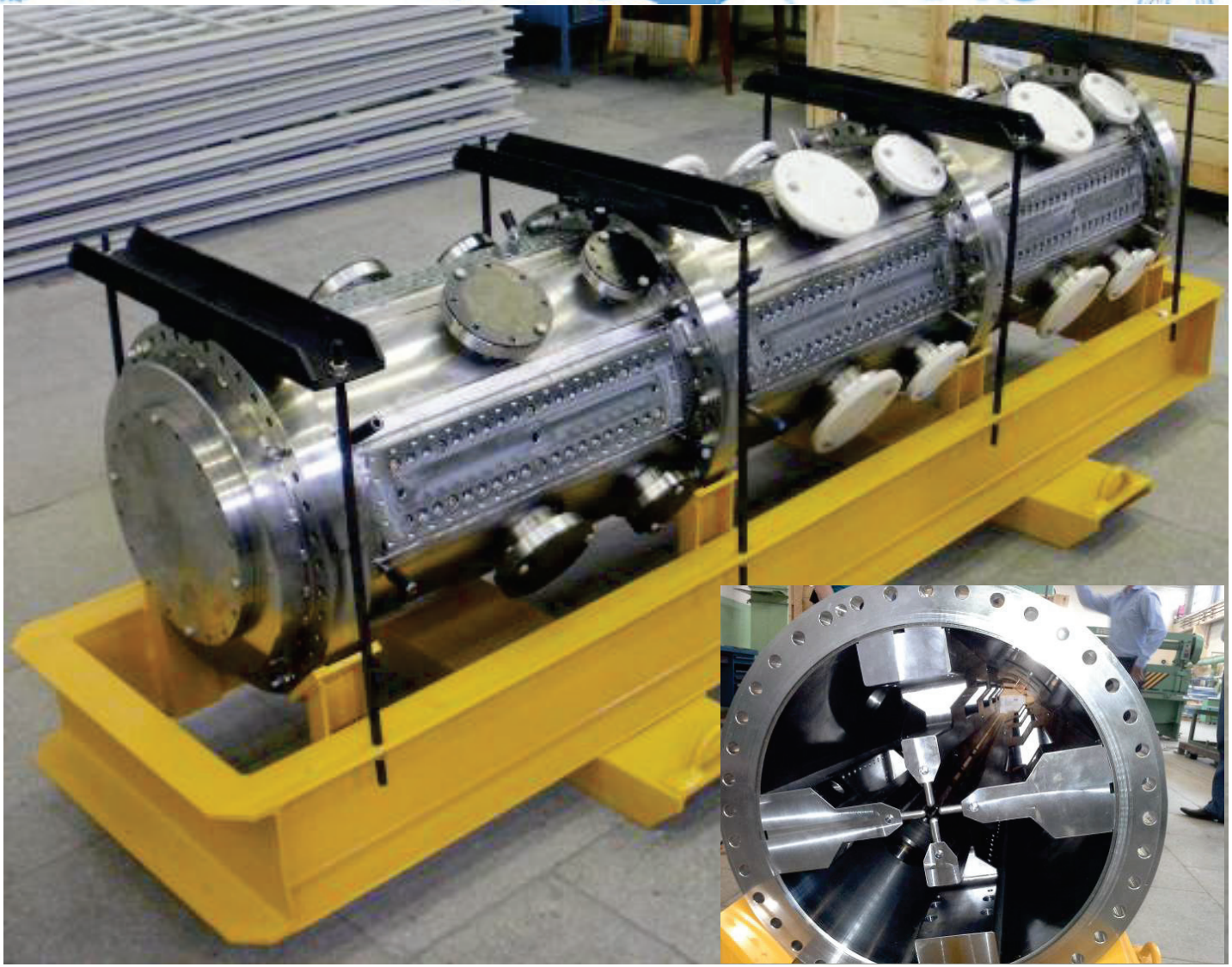
at LU-20 entrance





The resonator fabrication

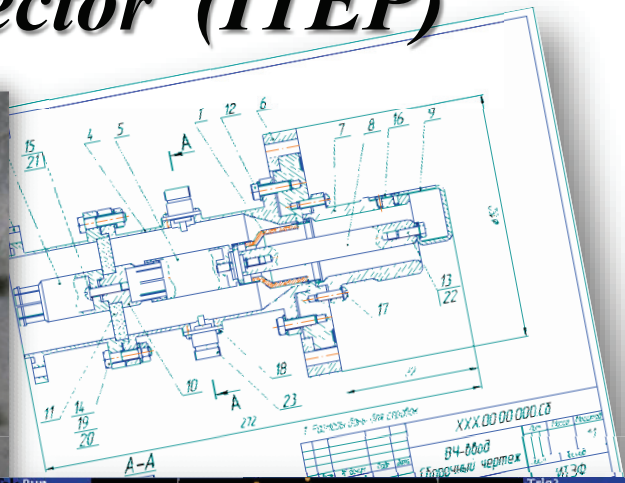
VNIITP, Snezhinsk

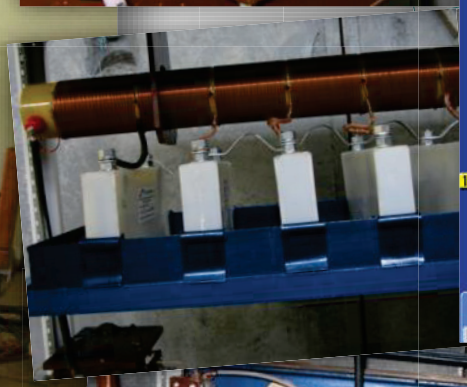


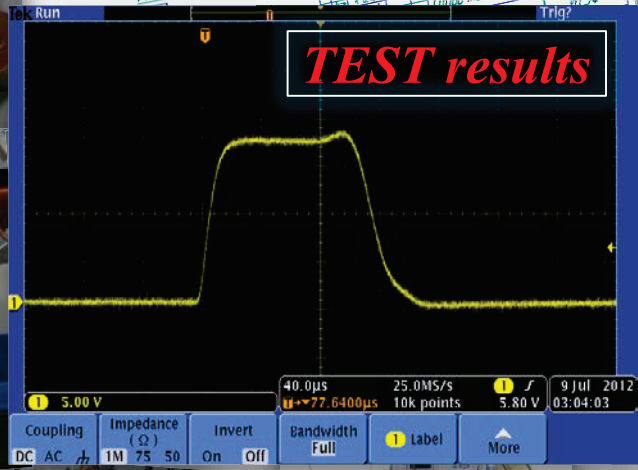
March 2015, before the cupper coating

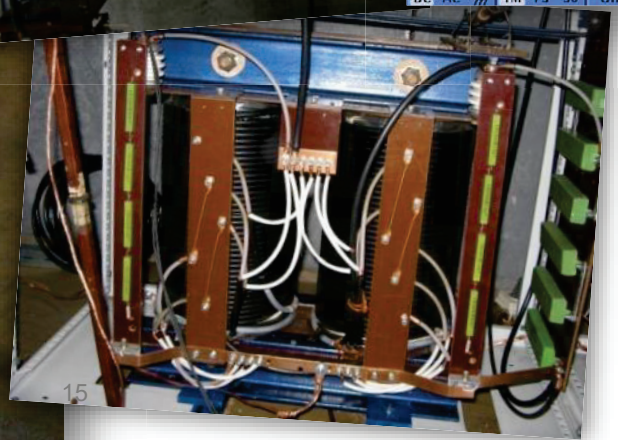
RF amplifier for the new foreinjector (ITEP)

RF amplifier
145 MHz
for RFQ

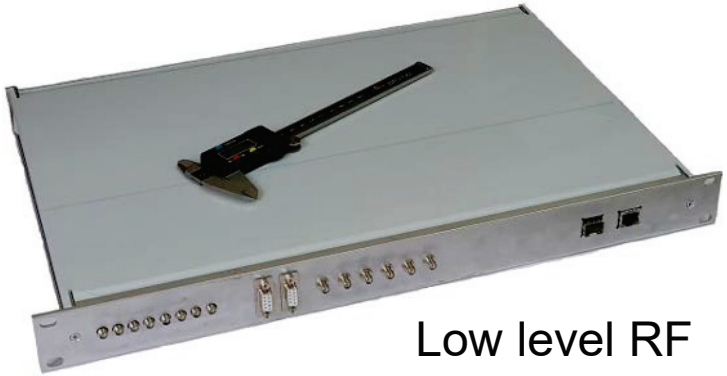






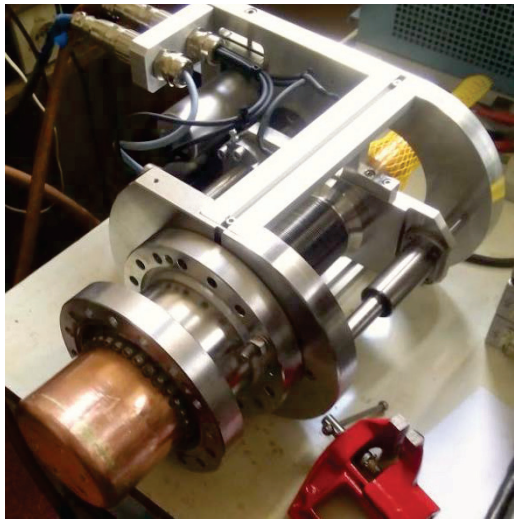


RF system construction (ITEP)



Low level RF

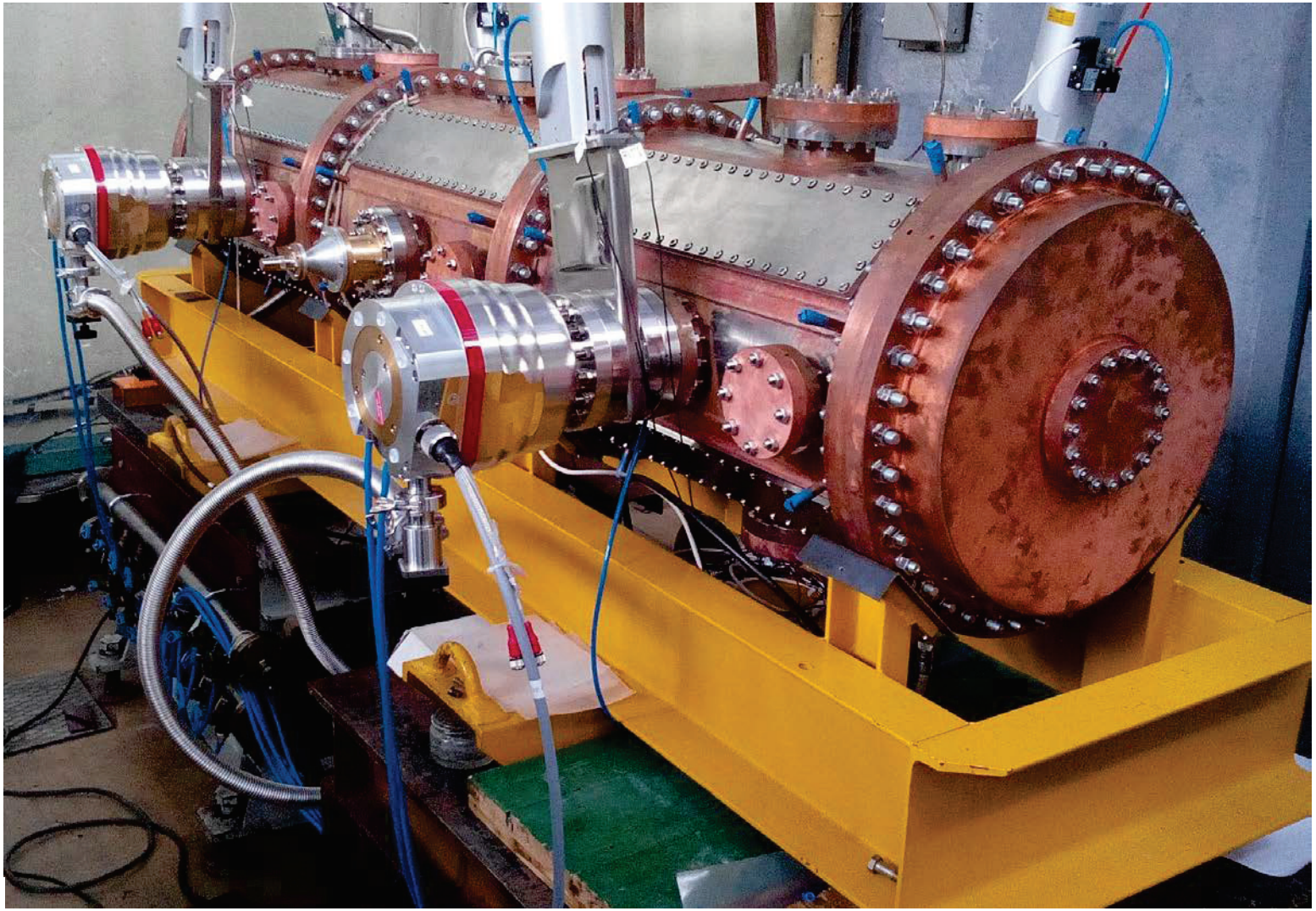
Power input



Automatic frequency control

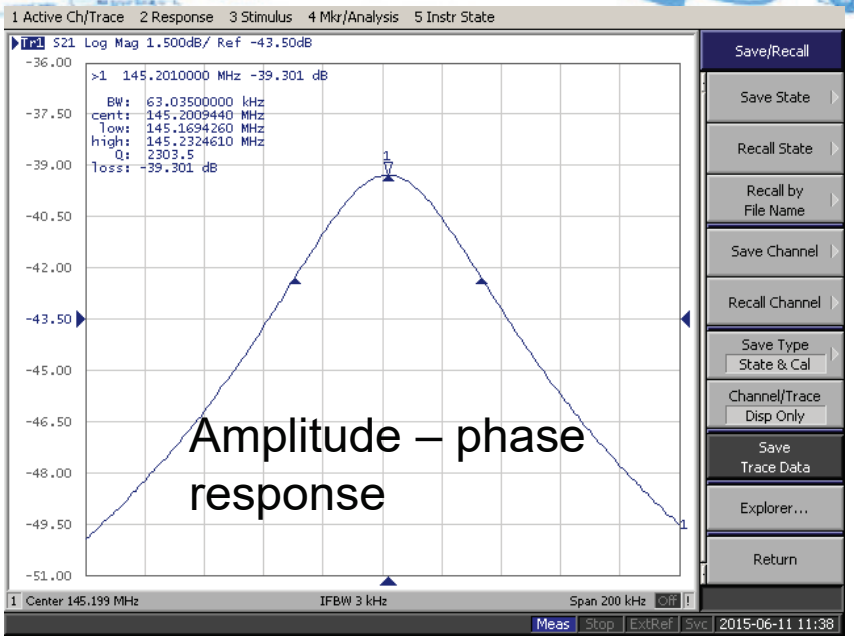
ITEP, Moscow

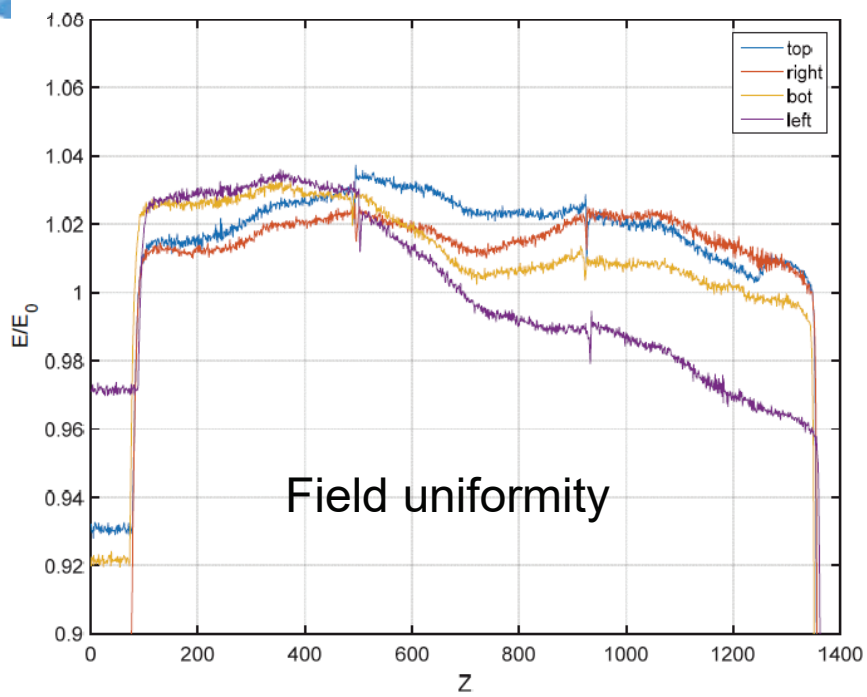
Vacuum and RF tests, RF training (ITEP)



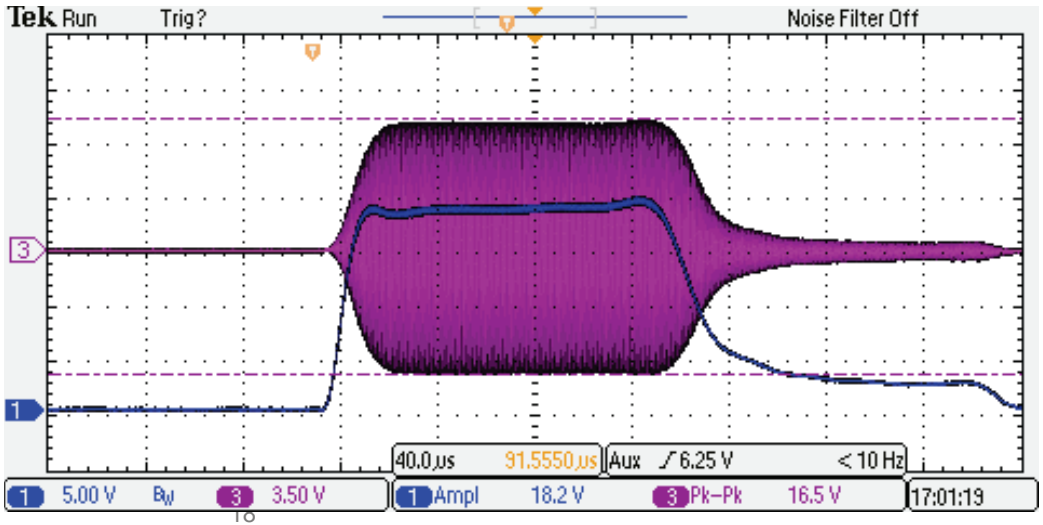
May – September 2015 ITEP, Moscow

Results of the RF tests (ITEP)





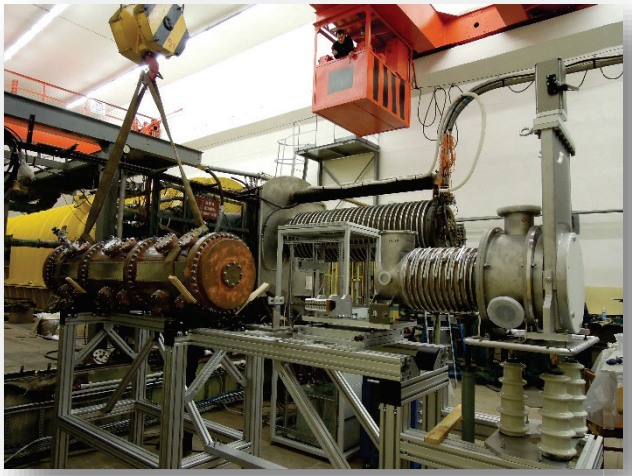
Design power level ~ 340 kW in the resonator

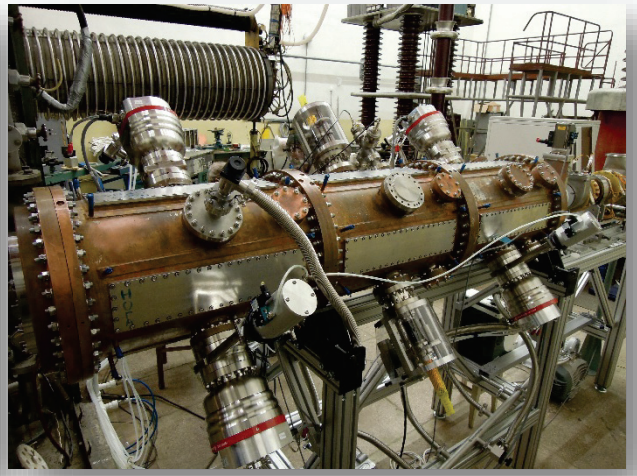


RFQ & RF amplifier shipment to JINR

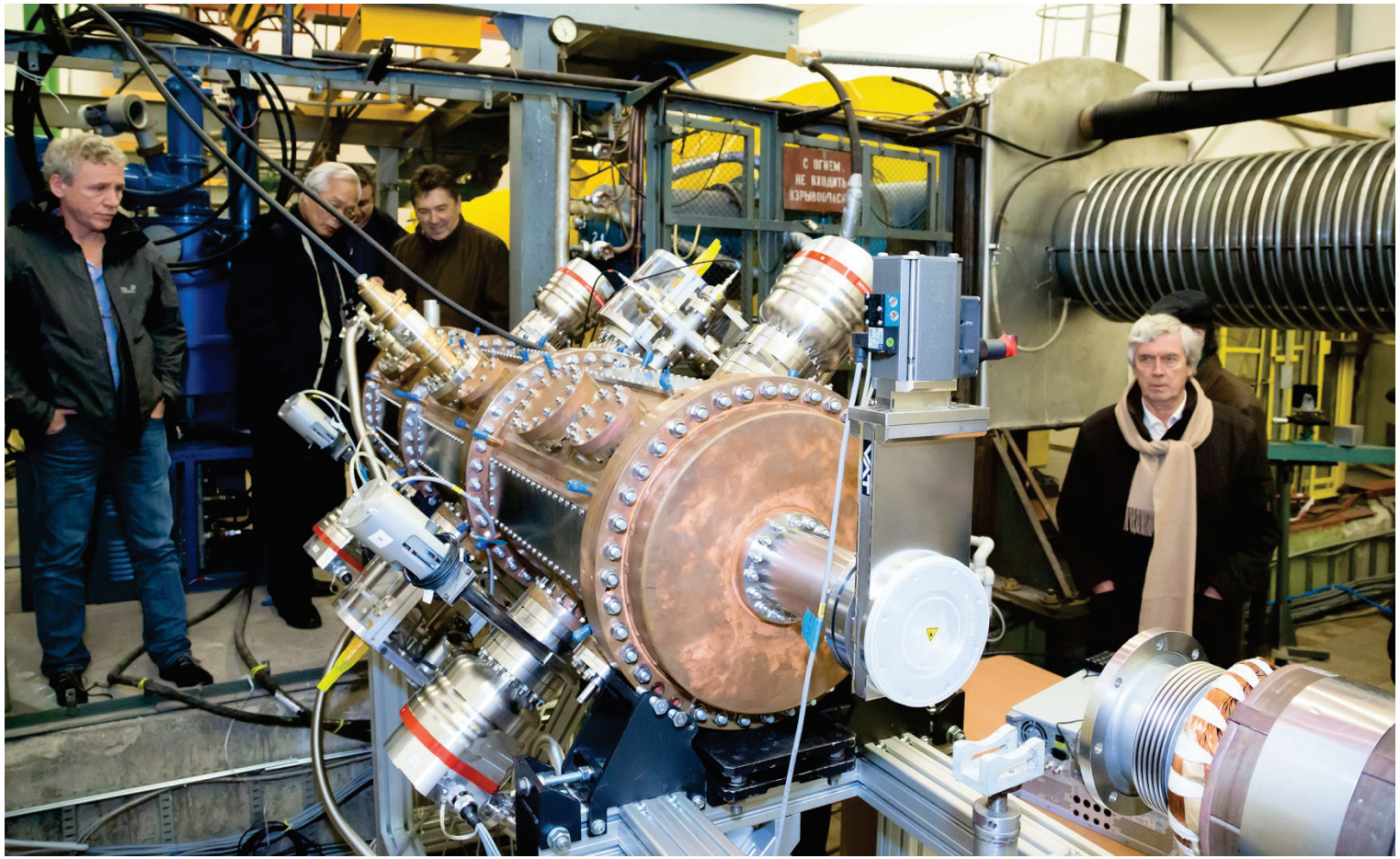
06 Oct. 2015

Equipment mounted & assembled on test bench 16 Oct. 2015



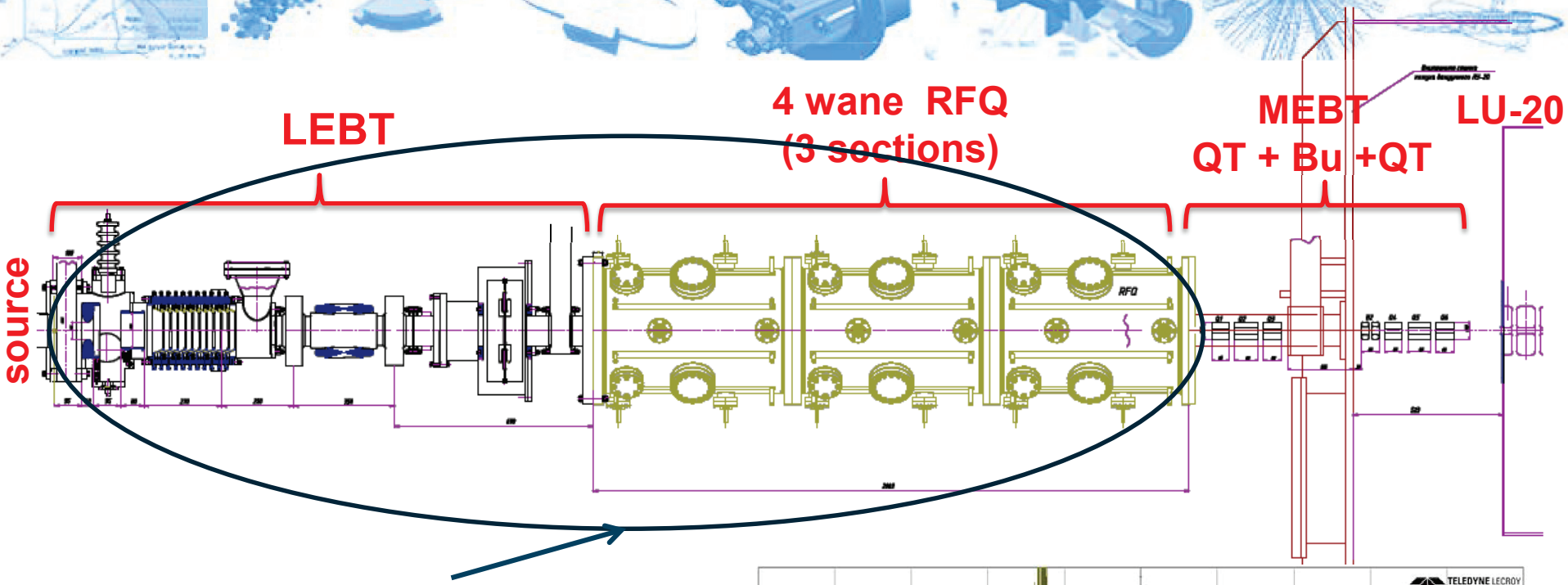


Assembly of the LEBT and ion source

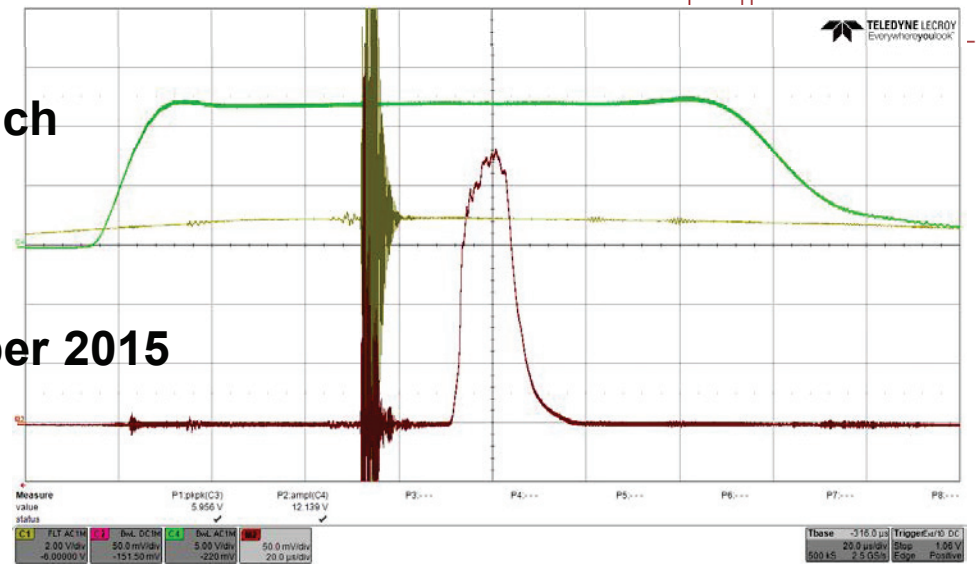


JINR, October 2015

Test-bench operation



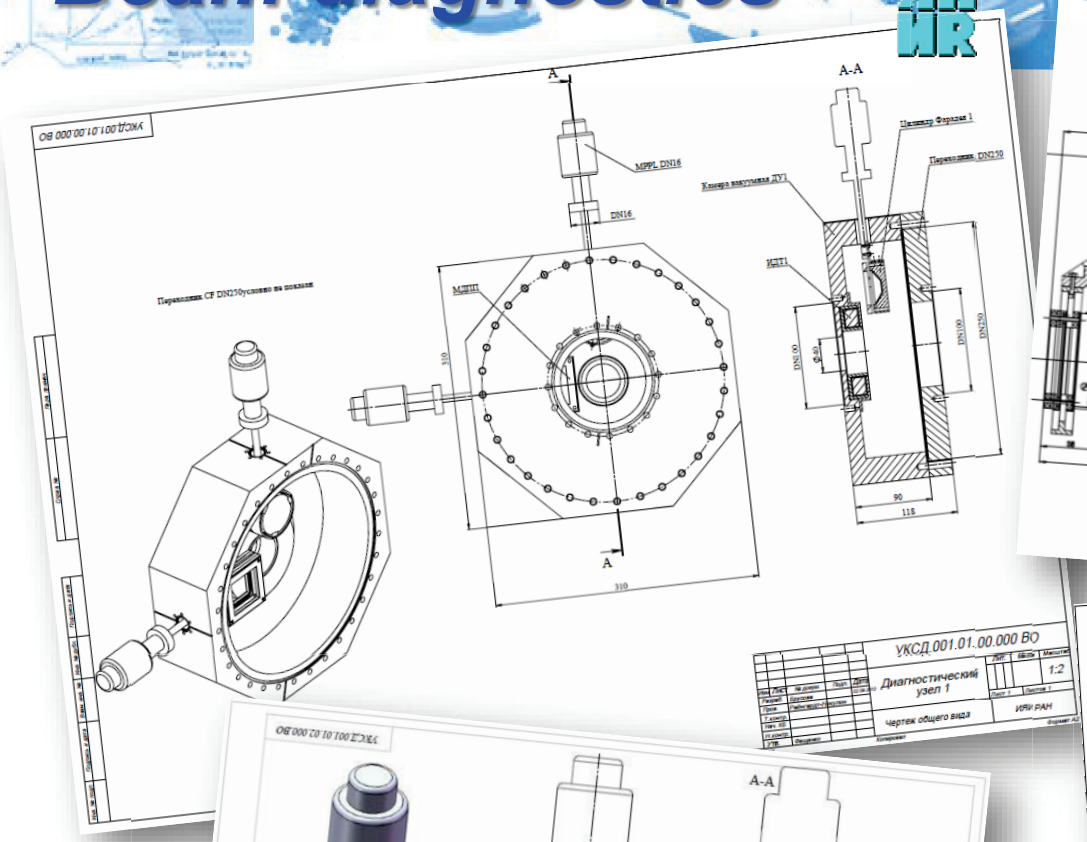
Low energy beam transport (LEBT) and RFQ were commissioned **at test bench** with the laser source:

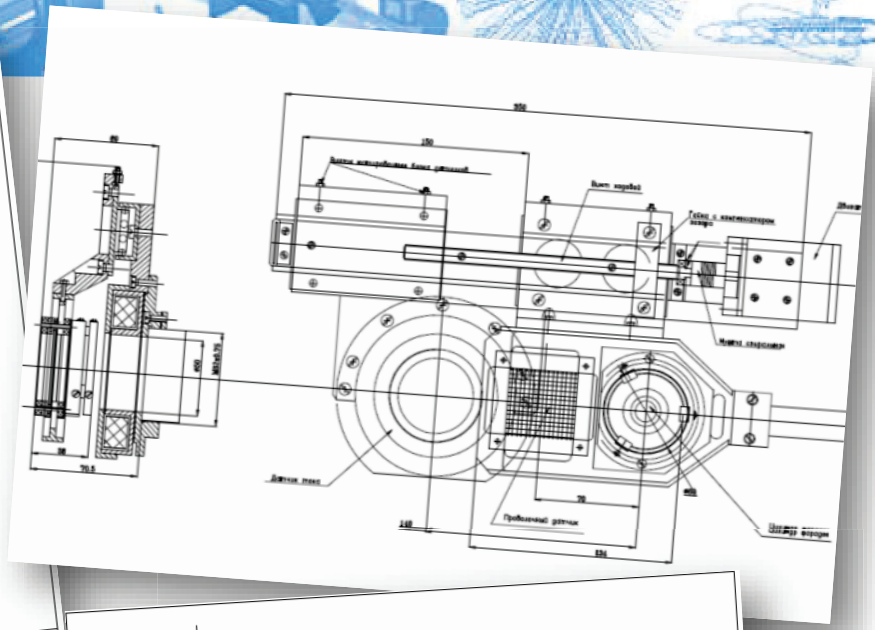


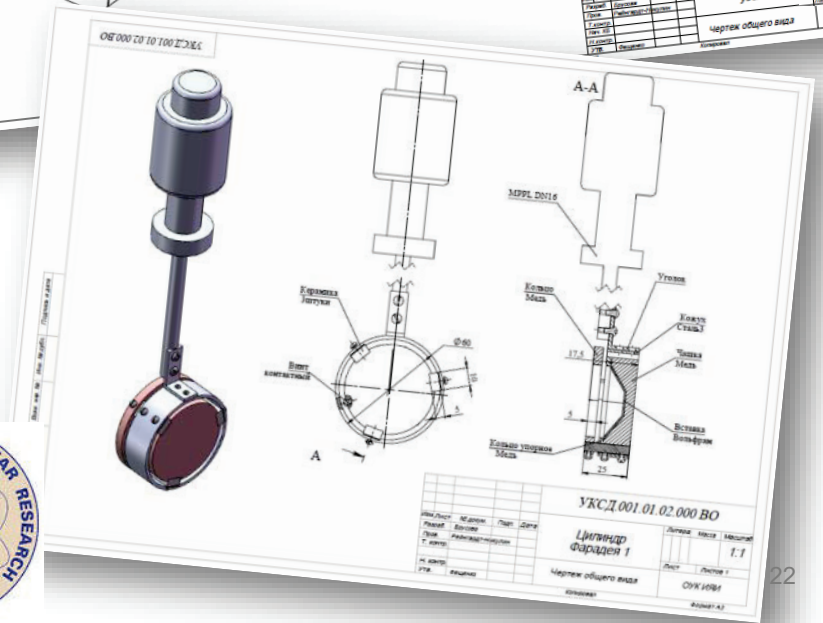
First beam acceleration10 - 12 November 2015

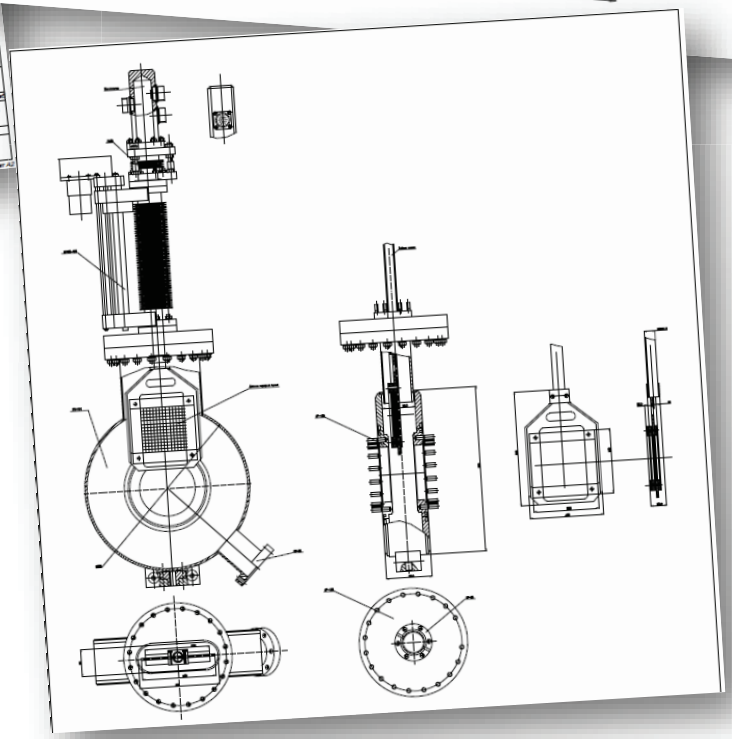
Beam diagnostics

In cooperation with INR RAS

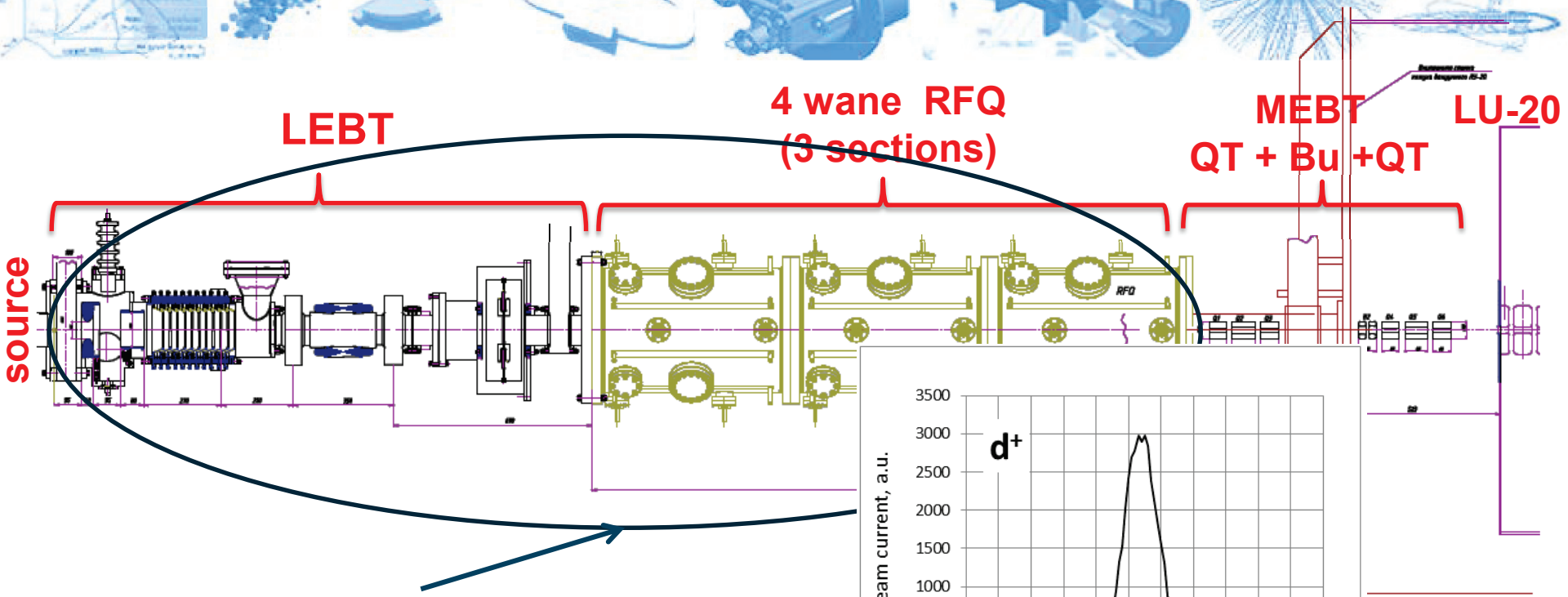






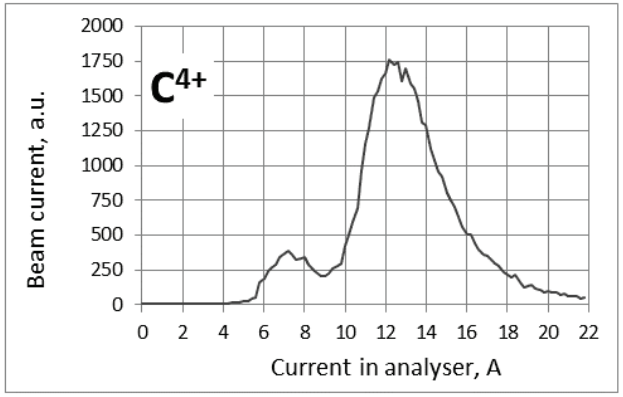


Test-bench investigations



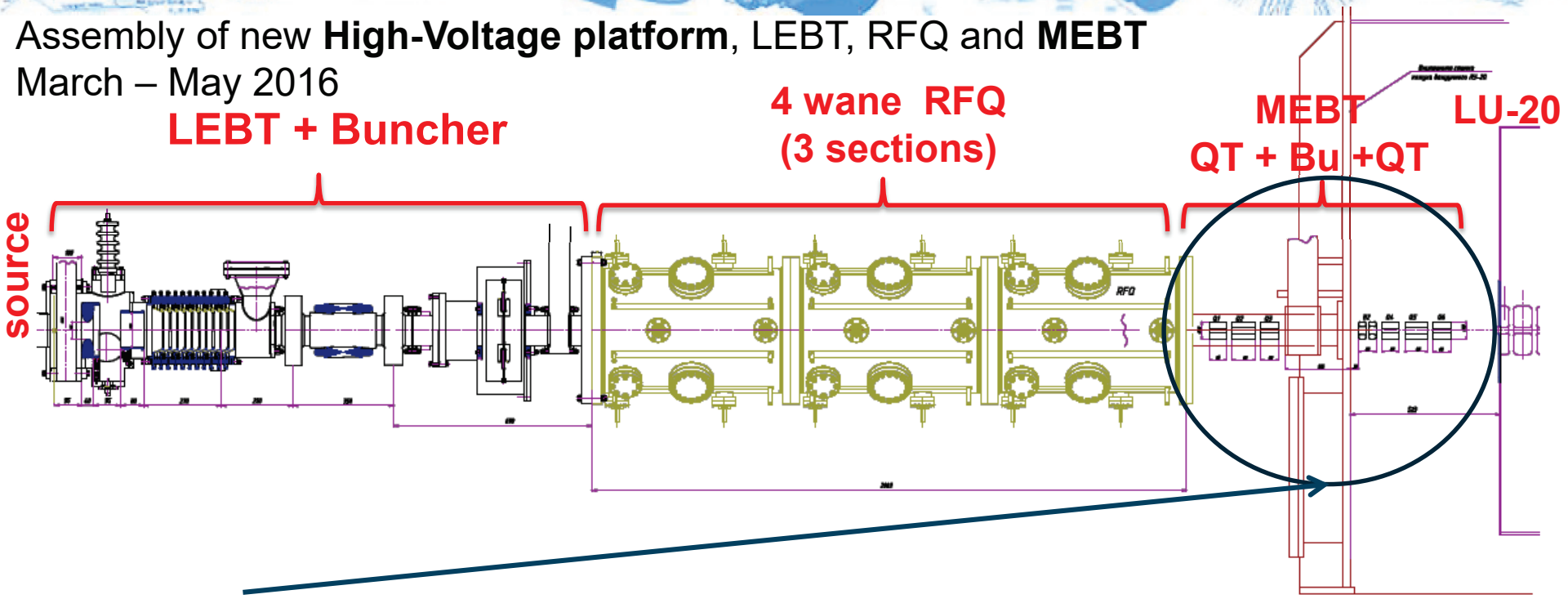
Investigations of parameters at the test-bench

January – February 2016



Assembly at LU-20

Assembly of new **High-Voltage platform**, LEBT, RFQ and **MEBT**
March – May 2016



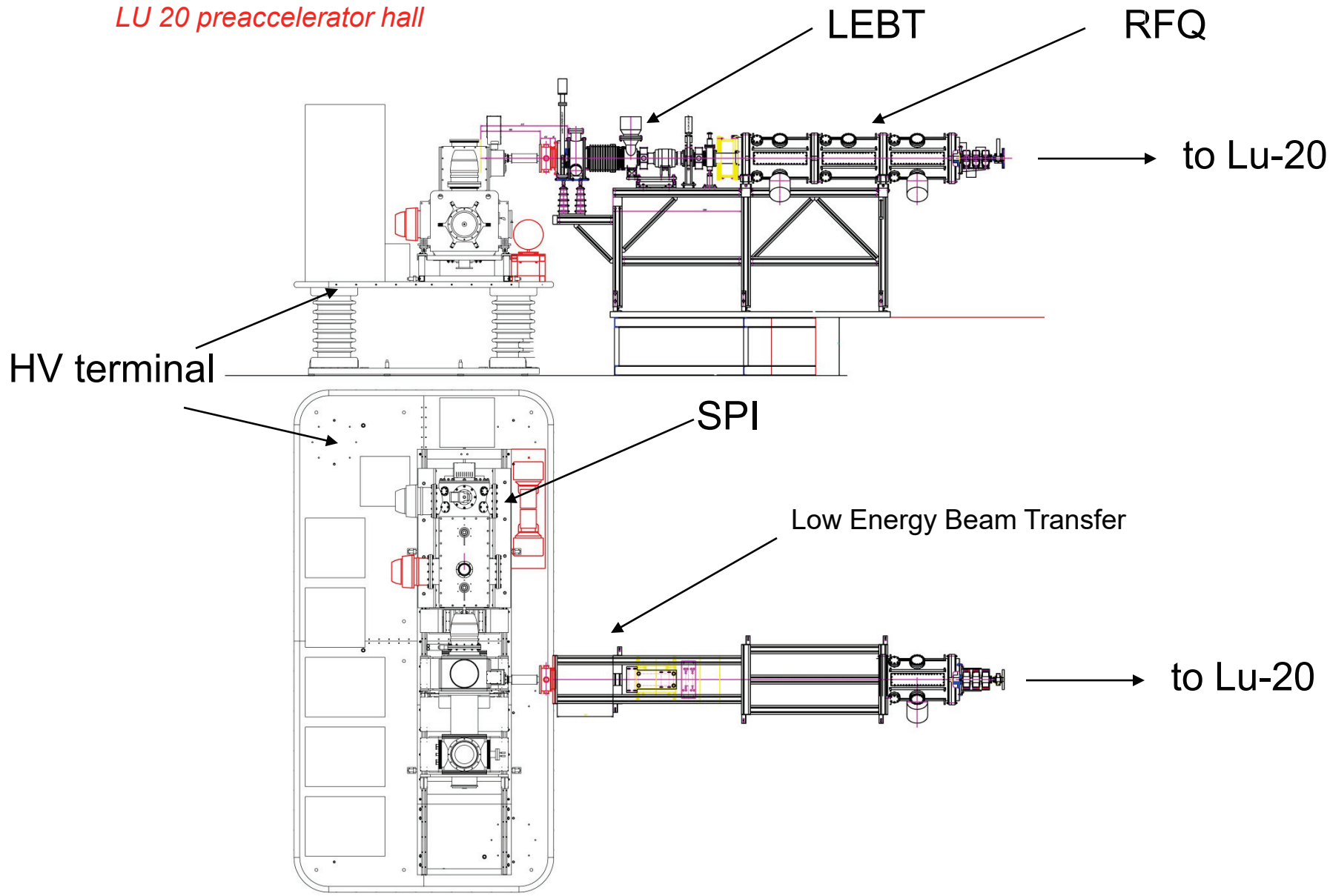
The MEBT includes two triplets of quadrupole lenses and Buncher

In the current configuration the Buncher is absent (Transmission ~ 20%)

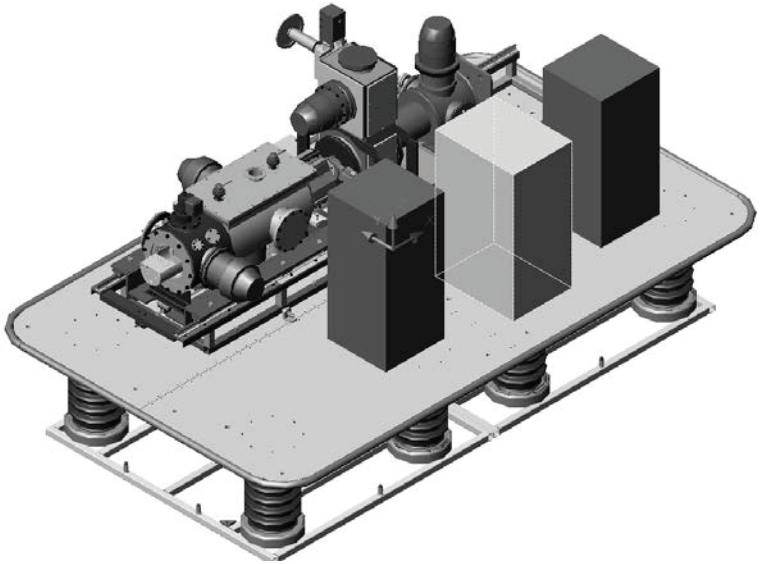
(The Buncher is constructed and under test at ITEP, will be installed in 2017)

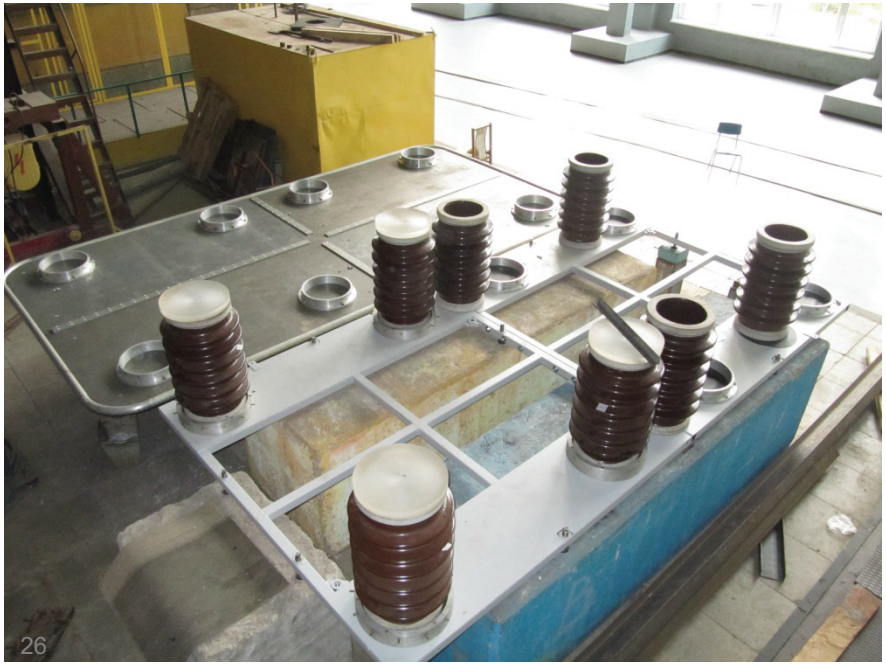
SPI & LEBT & RFQ layout at linac Lu 20

LU 20 preaccelerator hall

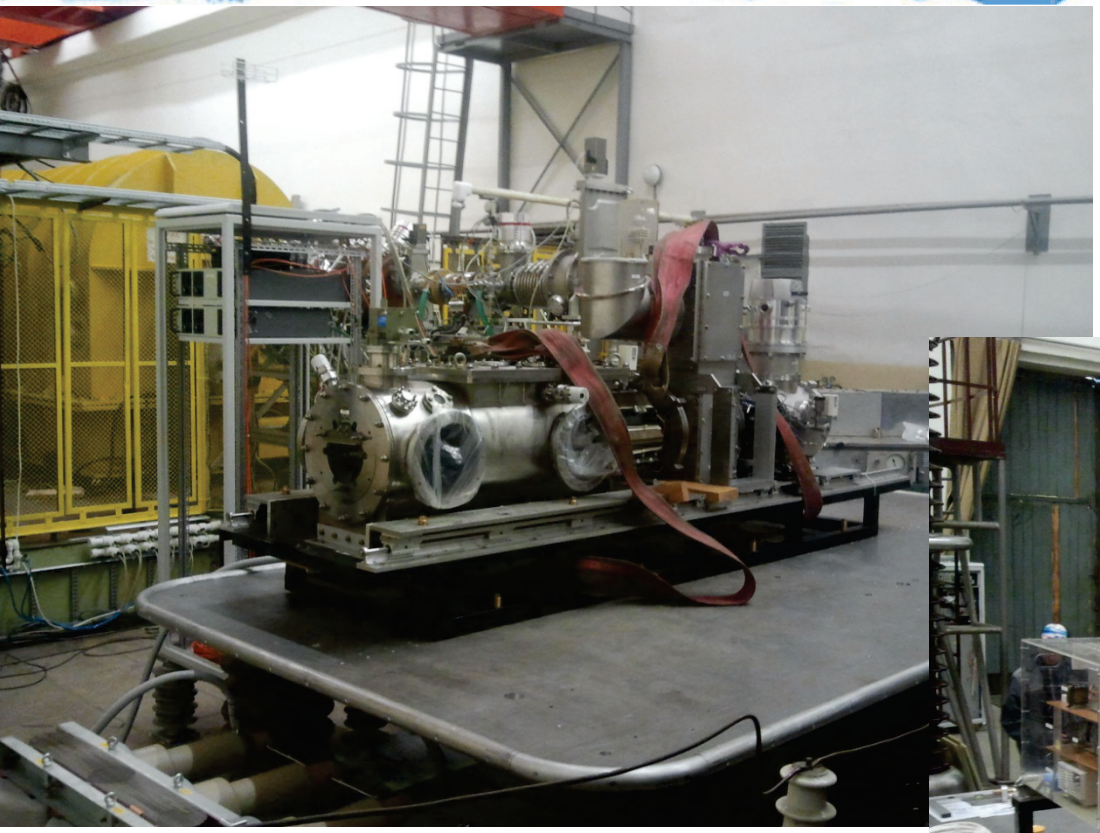


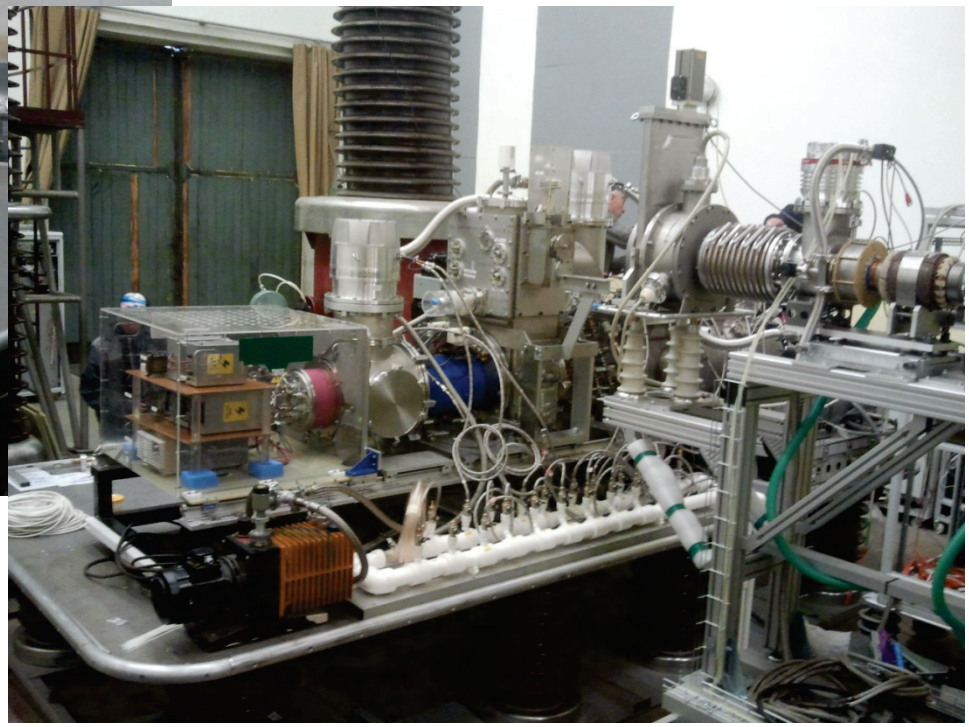
HV-terminal production (2015)





SPI assembly at LU-20

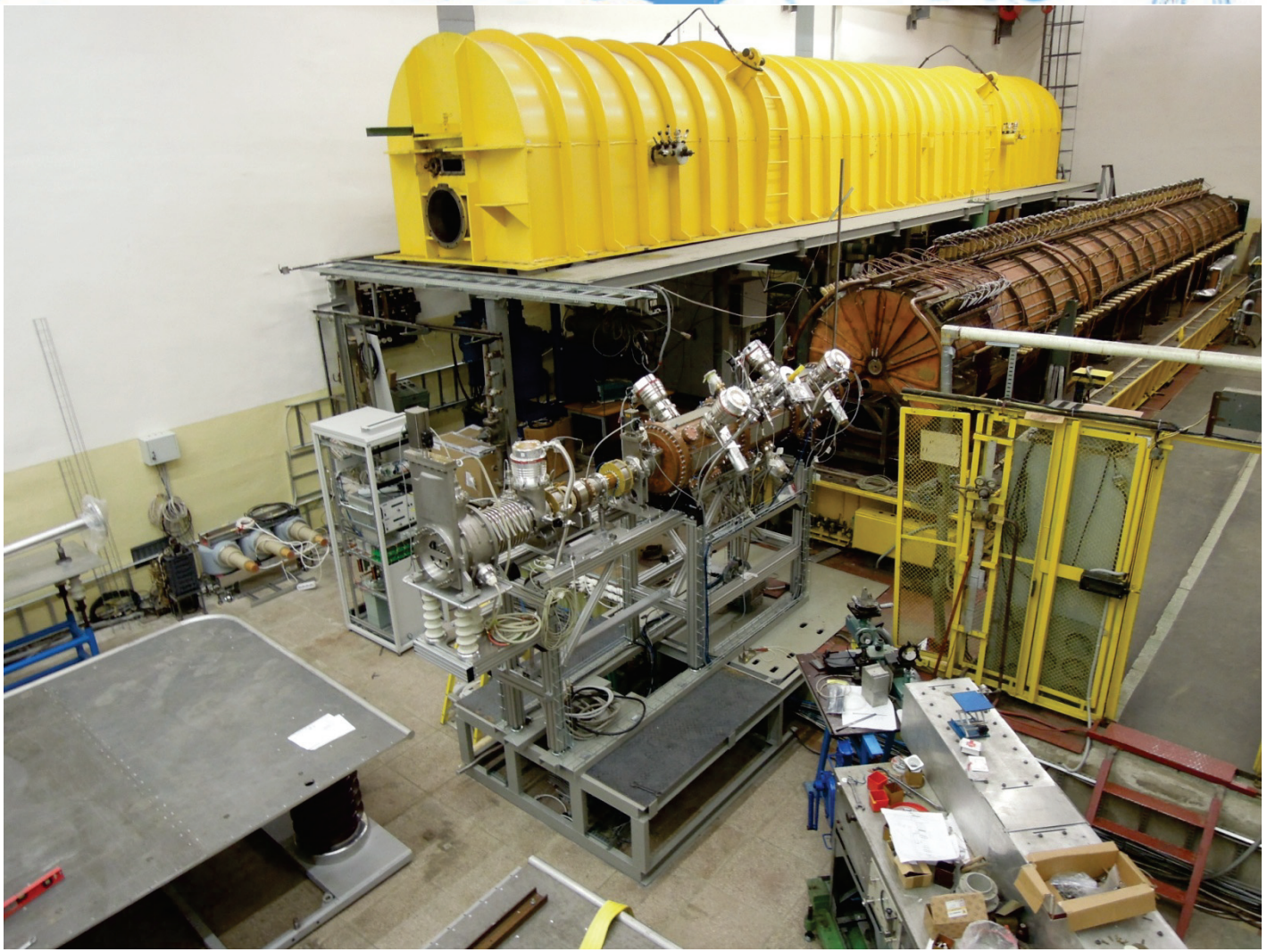




SPI transportation and assembly at LU-20

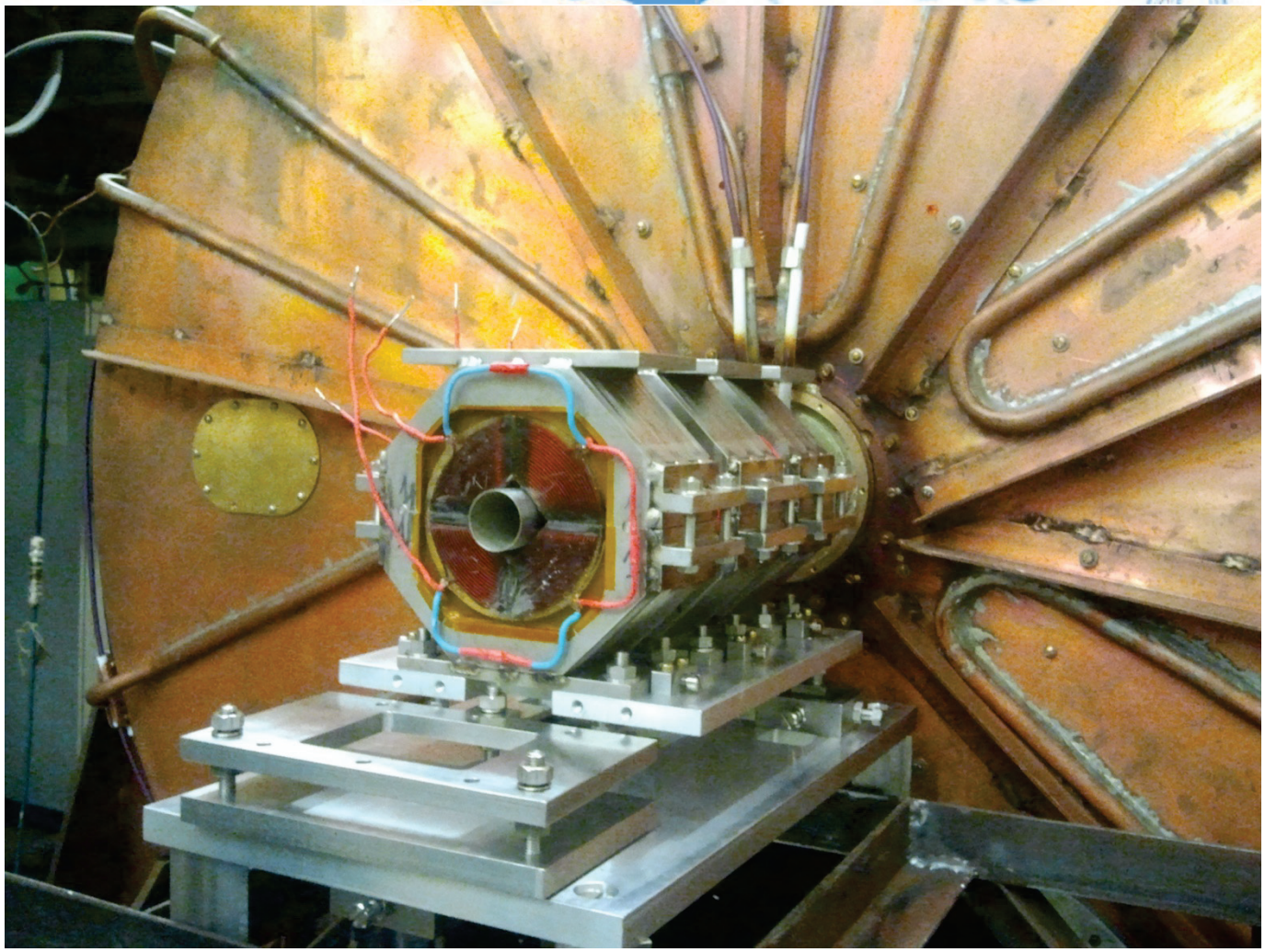
Control system of the **SPI** under the high voltage

Assembly at LU-20



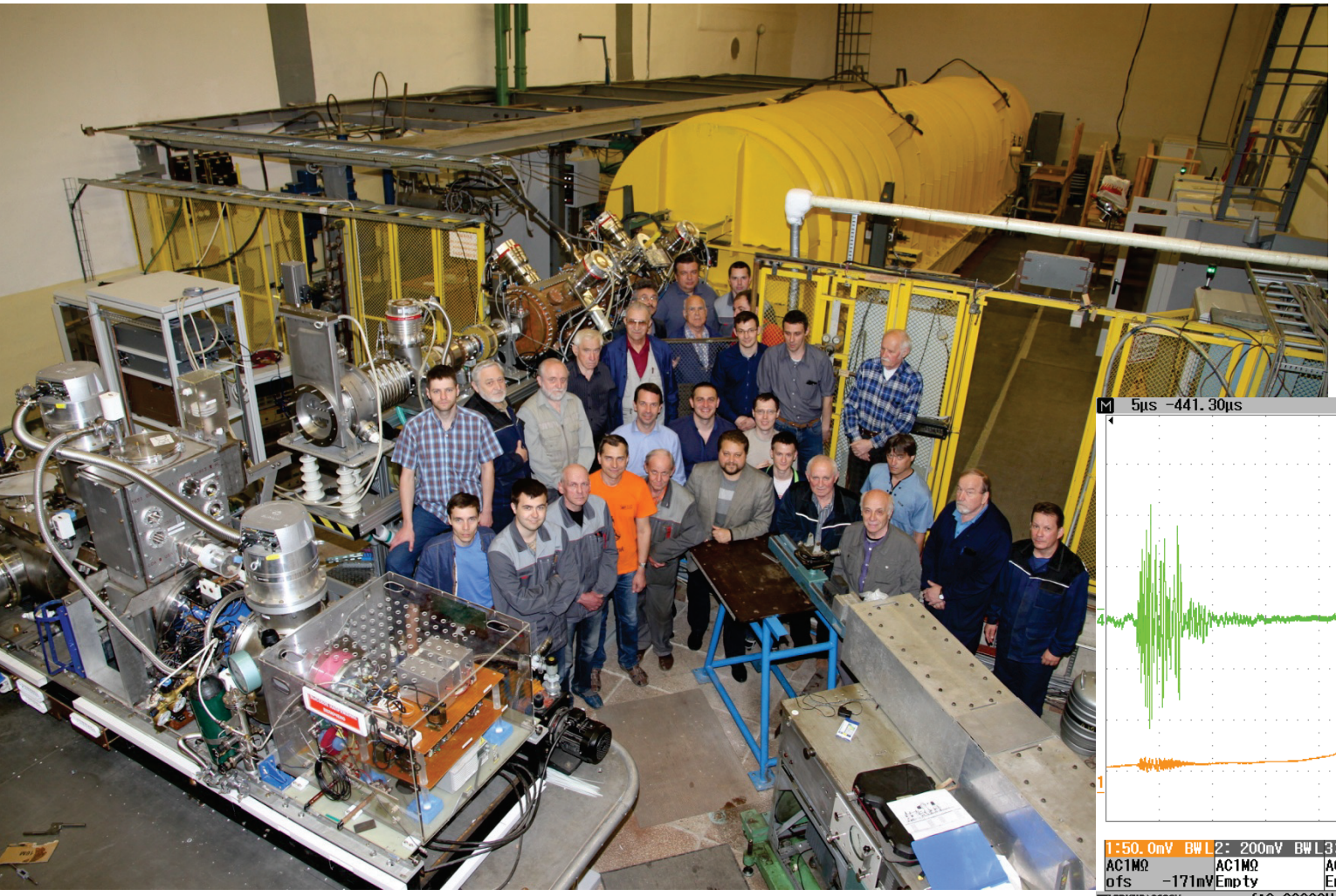
Assembly and adjustment of LEBT and RFQ

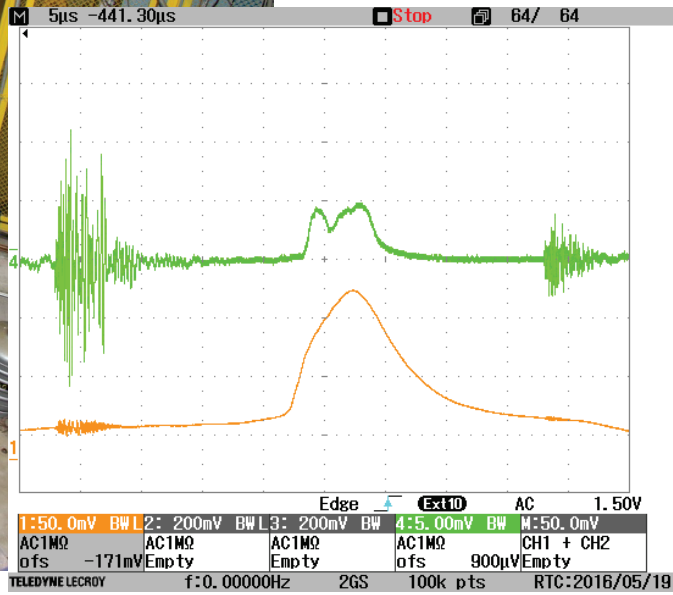
Assembly at LU-20



Triplet inside LU-20 vacuum vessel

Test at LU-20

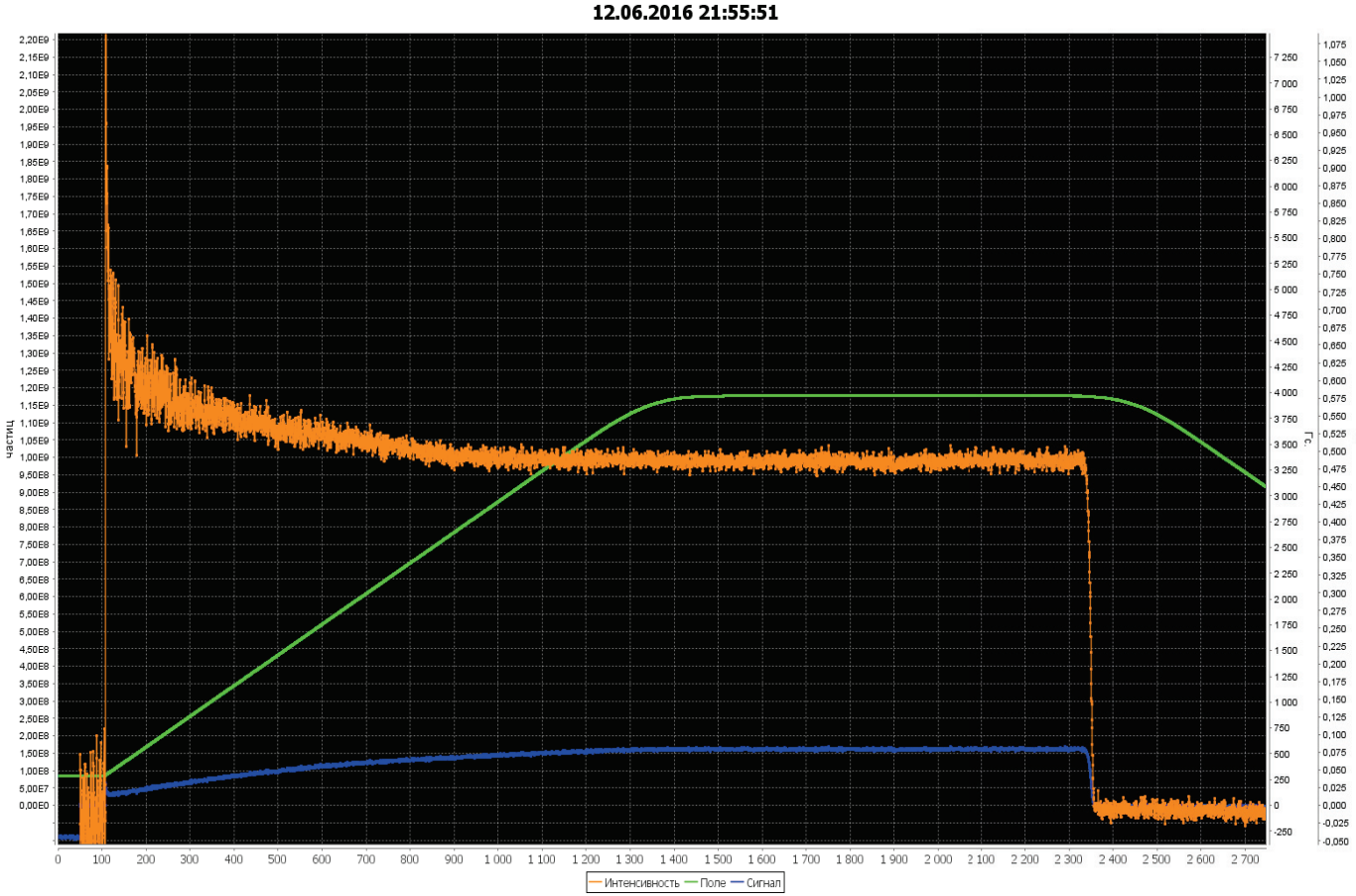




16 of May – beam from the laser source was accelerated in the new foreinjector and LU-20

Commissioning at Nuclotron

12 of June the unpolarized deuteron beam from SPI was accelerated in the Nuclotron



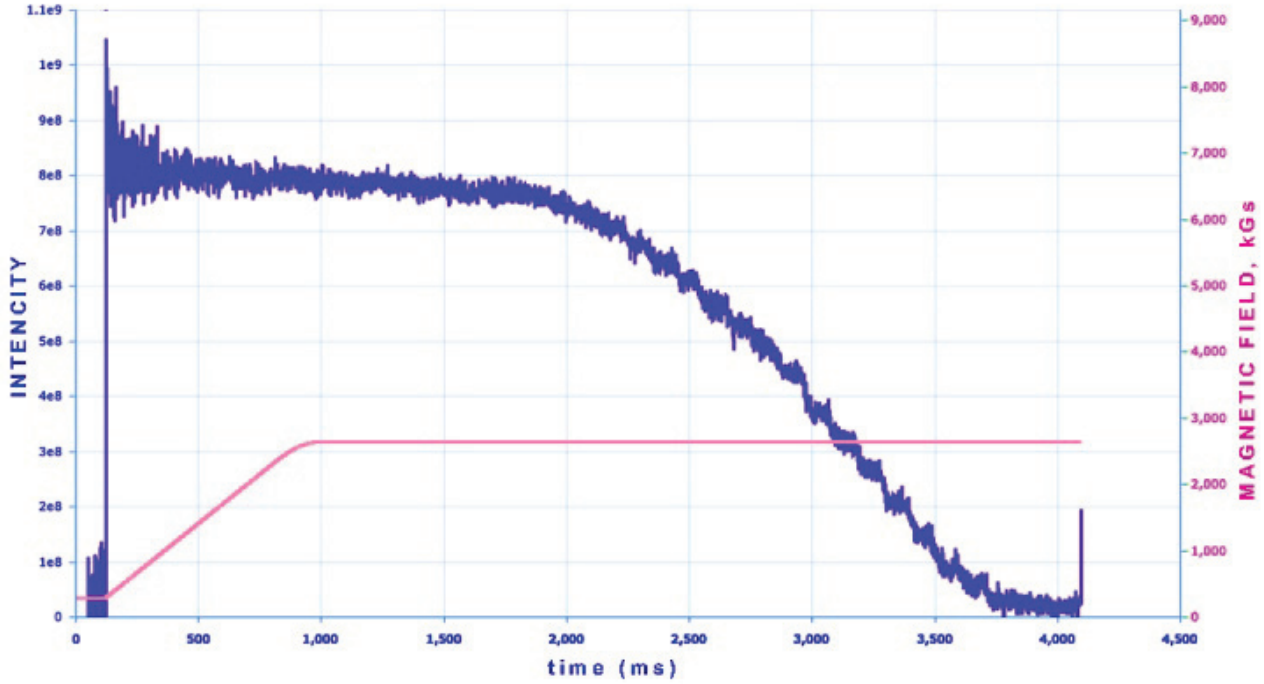
Energy 750 MeV/u, intensity 10^9

Run #53, started 26.10.2016

Routine operation of SPI and new foreinjector

Polarized deuteron acceleration:

Intensity $2 \div 5 * 10^8$, Vector polarization ~ 70% (preliminary)



Deuteron Spin Structure experiment, internal target

Thank you for attention