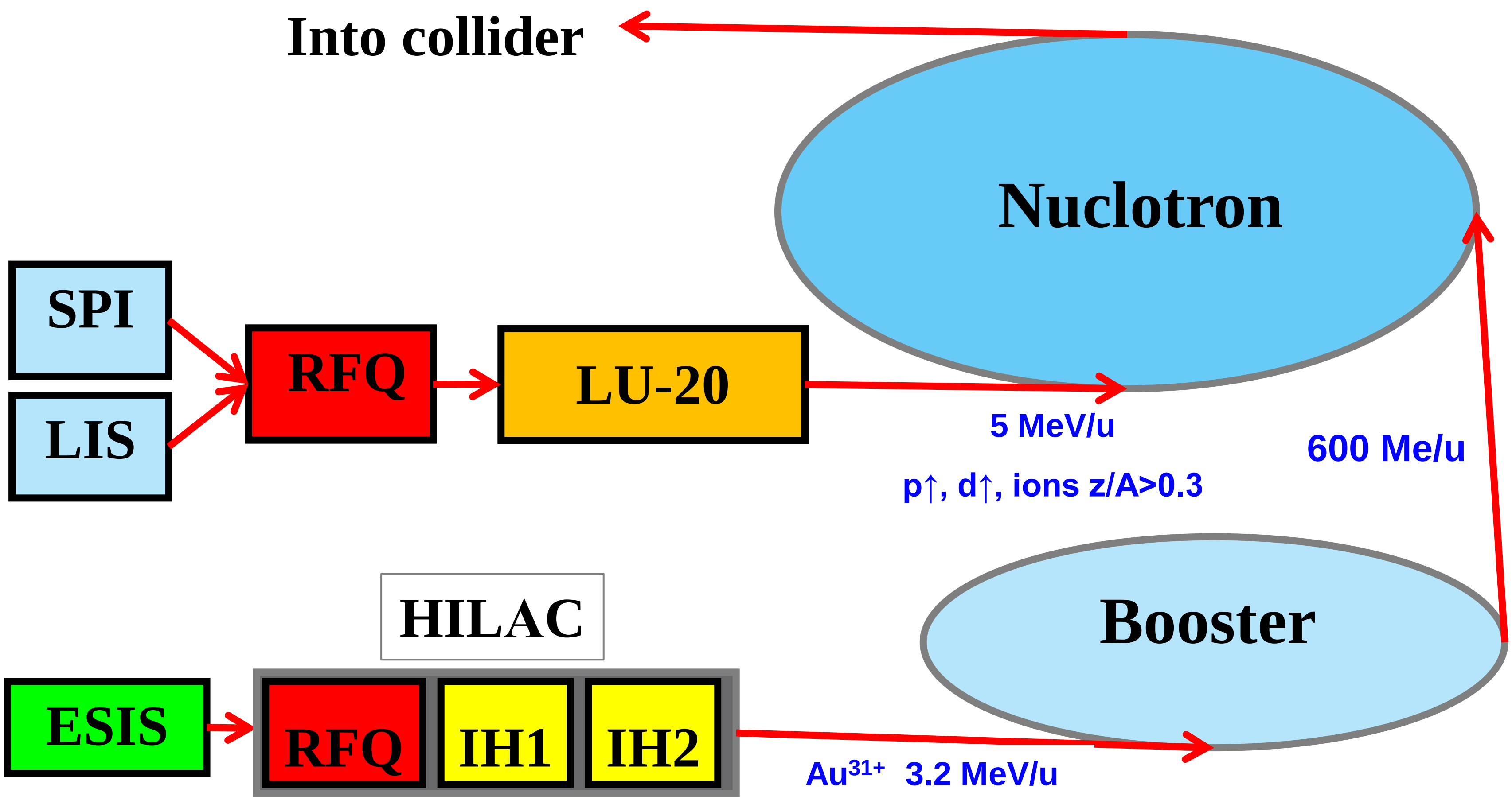
Injection facility of NICA

Levterov K. on behalf of Acceleration group

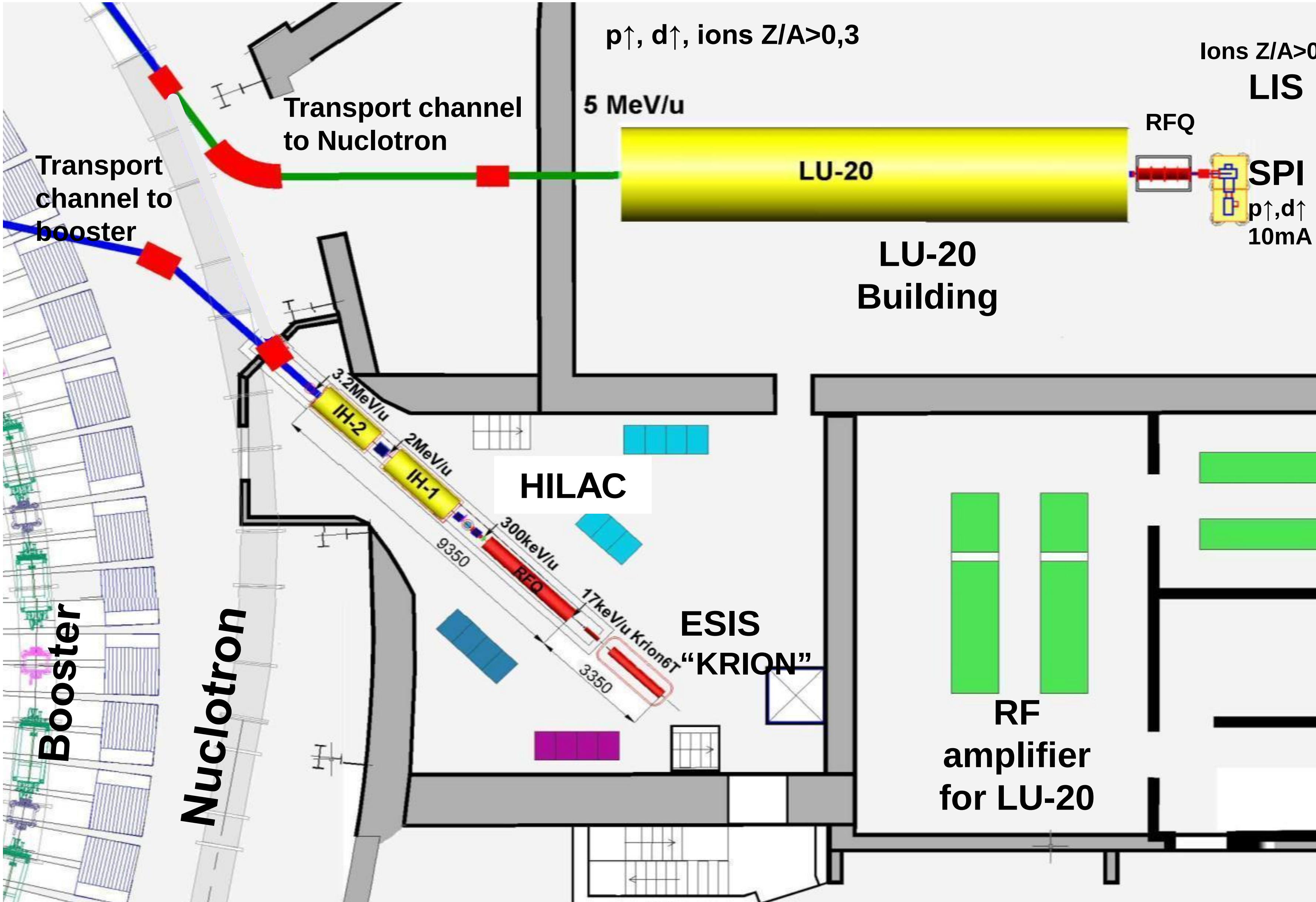
HILAC & LU-20 – two injectors for NICA



Beams of polarized protons and deutrons p↑ и d↑ and light ions will be accelerated by LU-20, then by Nuclotron

Heavy ions : HILAC + Booster + Nuclotron

Injection Facility arrangement



TOPICS

- **Commissioning of new injector HILAC.**
- **Upgrade of Alvarez based injector that's already done.**
- **Alvarez based injector upgrade that is coming up.**

Commissioning of new injector HILAC.

HILAC

Heavy Ions Linear accelerator

NICA Injector for Au^{31+} 3.2 MeV/u to Booster&Nuclotron

In collaboration with
“BEVATECH OHG”(Germany),
JINR, INR(Russia).

BEVATECH REUTER TECHNOLOGIE Kreß GmbH Sondermaschinenbau Diagnostics: NTG

Tasks

1. **Assemble HILAC itself including MEBT and intertank section.**
2. **Install vacuum system.** (JINR, “Bevatech”)
3. **Install RF amplifiers and fiders.** (JINR, “TOMCO”)
4. **Development and production 10 pulsed power supplies for doublets, triplets and solenoids.** (JINR, INR)
5. **Development and production Low Energy Beam Transfer channel (LEBT) for matching beam from ion source to RFQ including pulse transformer.** (JINR)
6. **Timing system.** (JINR)
7. **Low Level RF control system (LLRF)** (“Bevatech”, JINR, ITEP)
8. **Software.** (JINR, ITEP)
9. **Beam analysis at the HILAC output.**

RF AMPLIFIERS

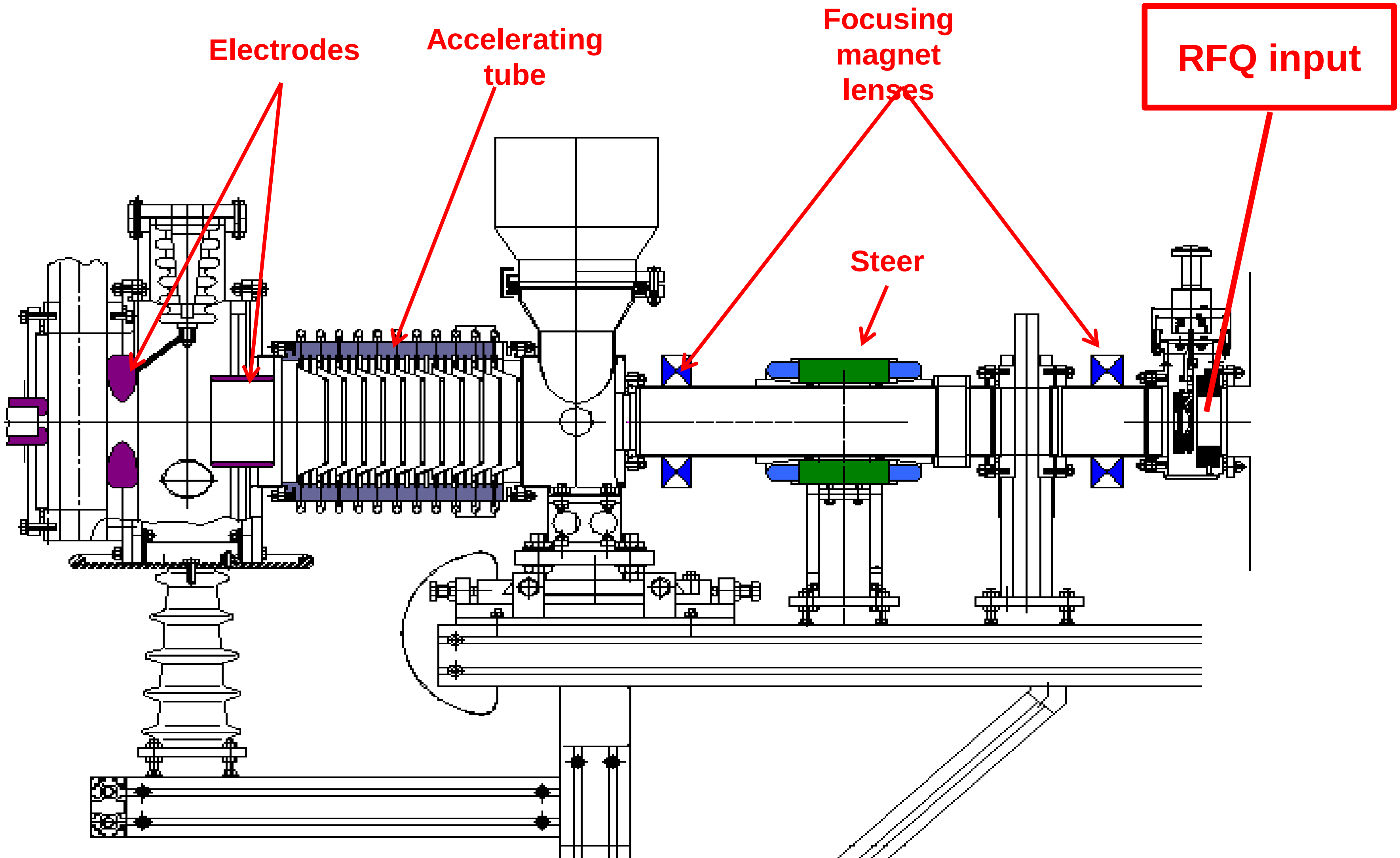
A.Buteko, K.Levterov, V. Kobets

Three amplifiers,100MHz, 10Hz rate:
140 kW, 340 kW, 340 kW

BEVATECH JINR TOMCO

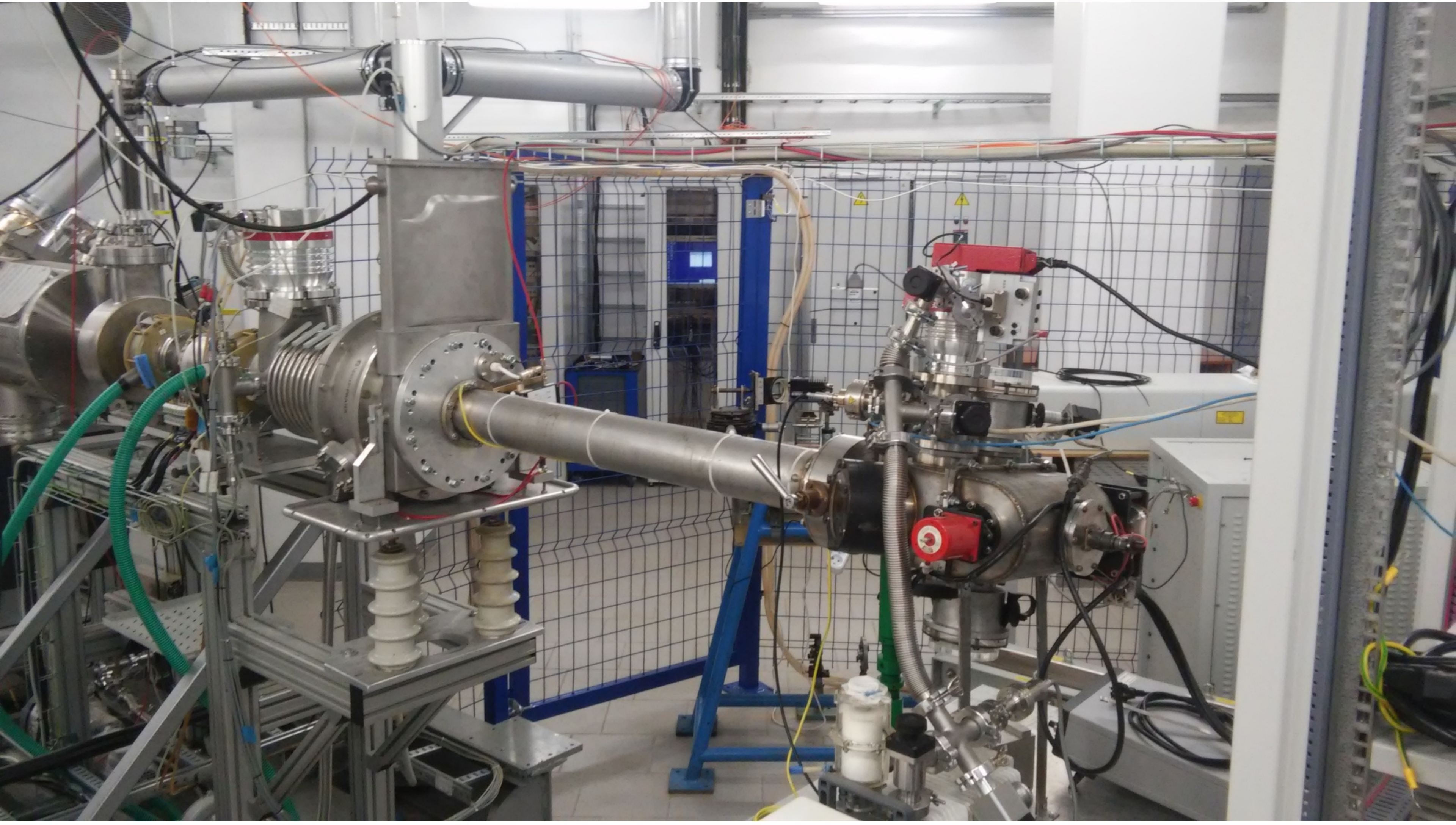
NICA

LEBT
Low Energy Beam Transfer
E_{in}=3 keV/u E_{out}=17 keV/u



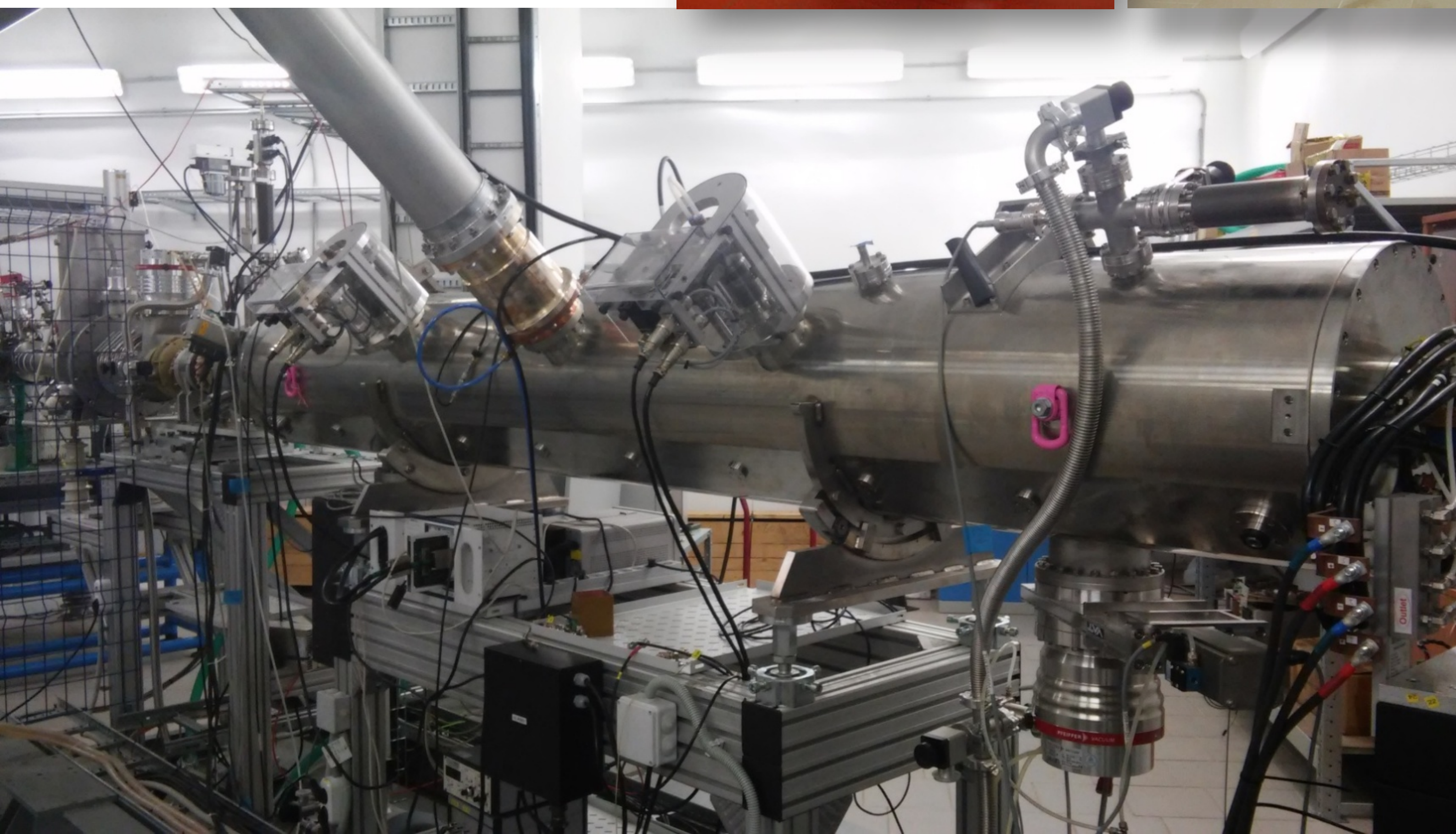
JINR, RUSSIA

LIS + LEBT
Low Energy Beam Transfer
E_{out}=17 keV/u



BEVATECH, GERMANY

4-rod RFQ
Ein= 17 keV/u
Eout= 300 keV/u

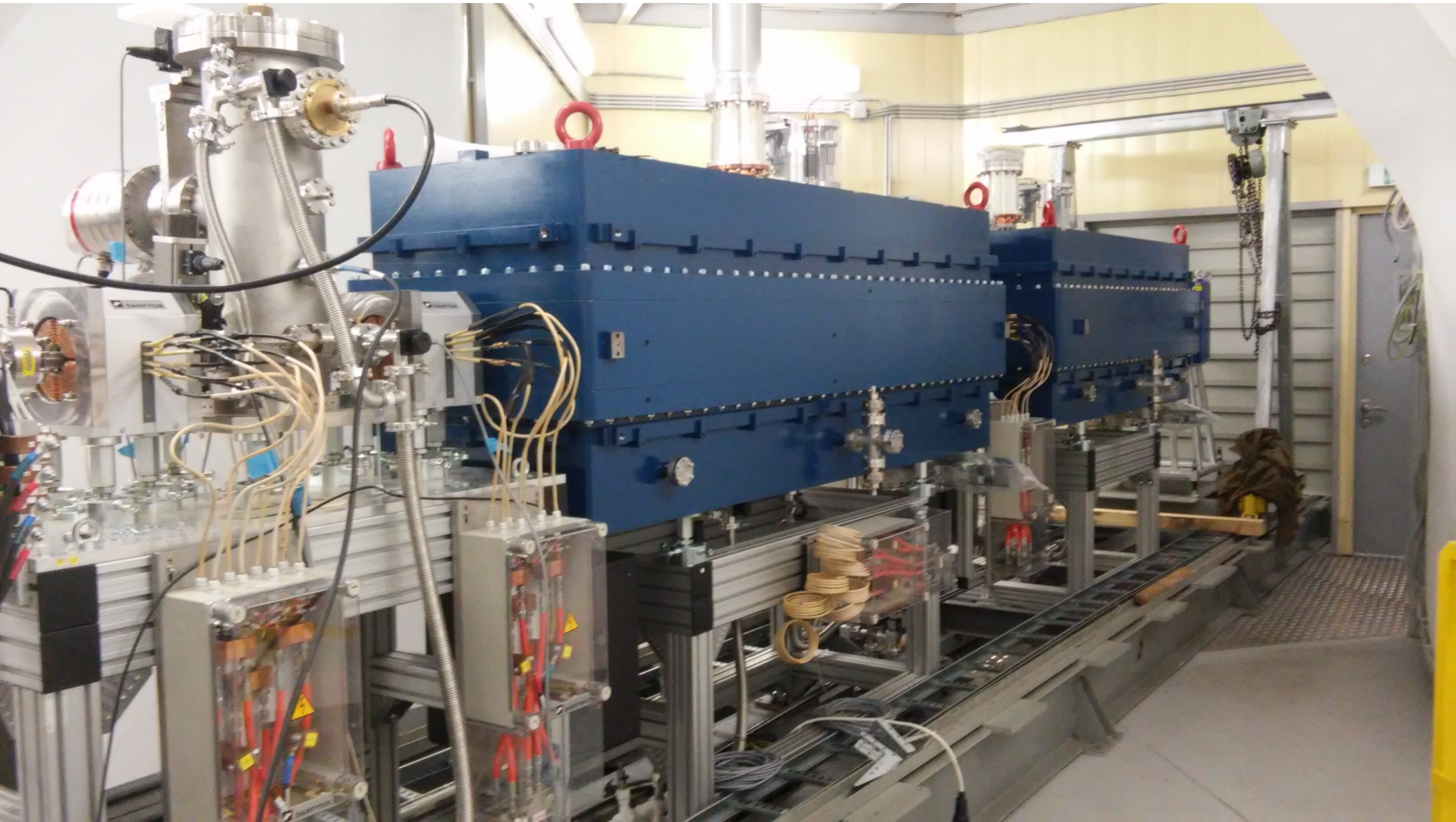


BEVATECH, GERMANY

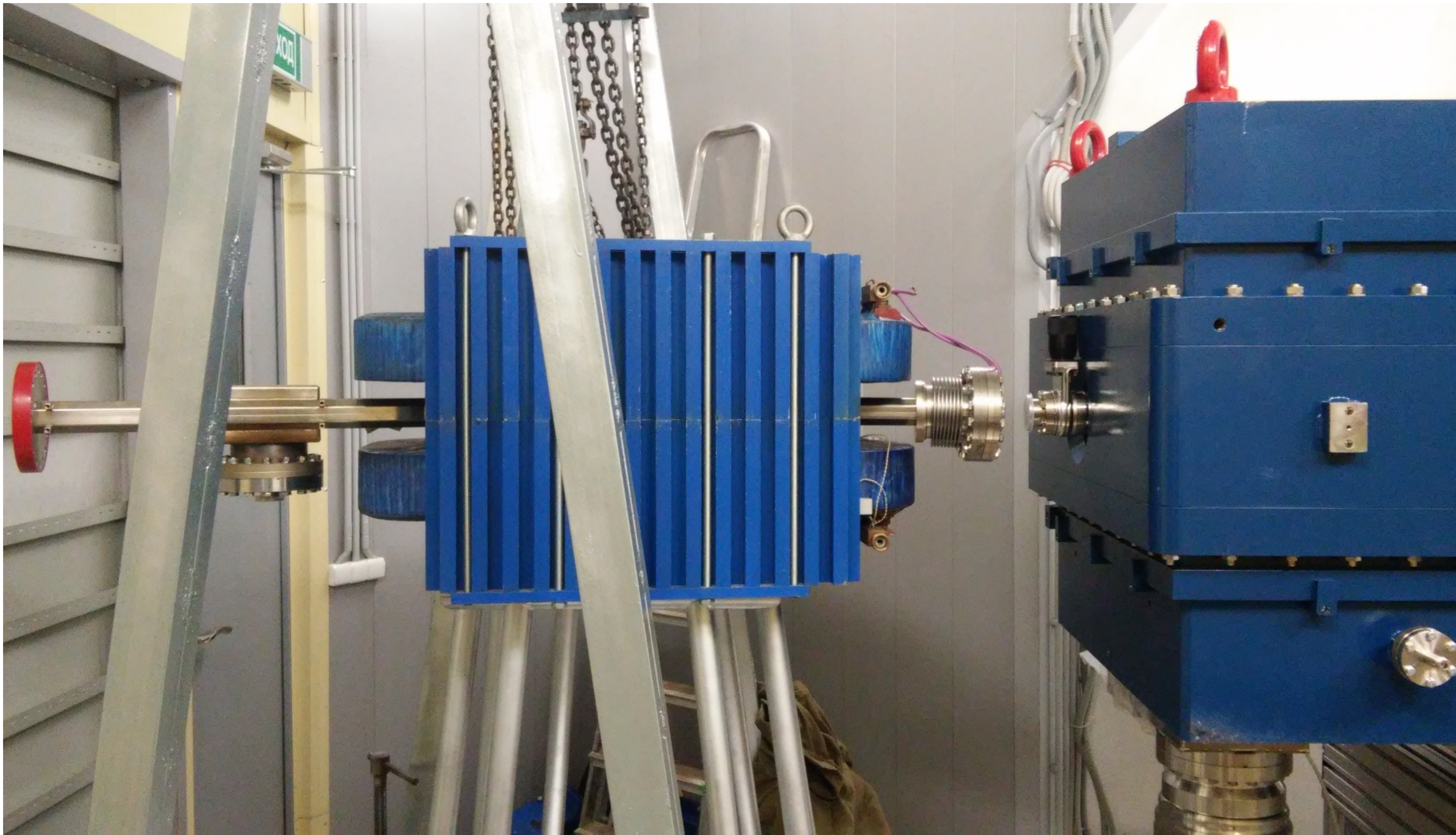
Buncher+IH1+IH2

Ein=300 keV/u   Eout=3.2 MeV/u

DTL structure «KONUS» (KOmbinierte NUll grad Struktur) – combined structure with zero synchronus phase.



Analyzing magnet at the HILAC output

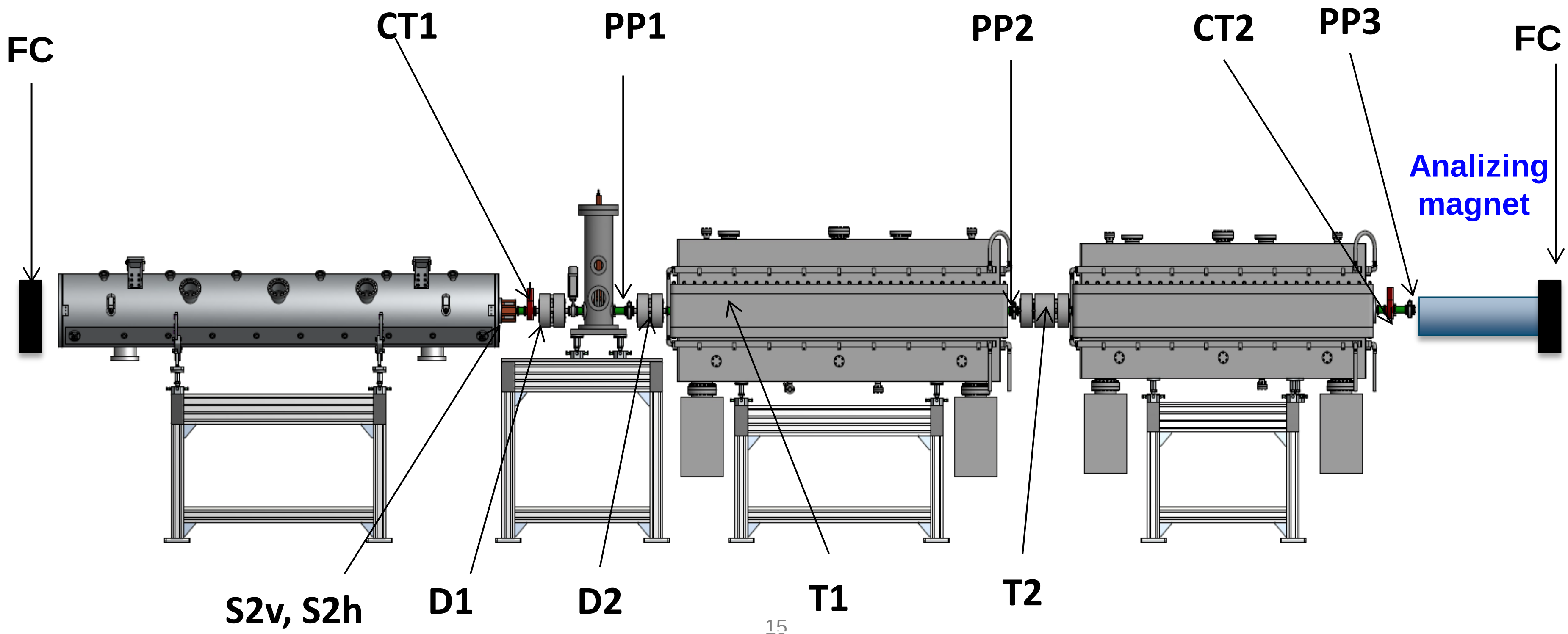


Pulsed power supply for doublets, triplets, and solenoids up to 1.2 kA, t=3 ms

Experimental setup

S- steerer, CT-current transformer, PP-phase probe, D- doublet, T- triplet, FC- Faraday cup

Experimental E_{out}= 3.2 MeV

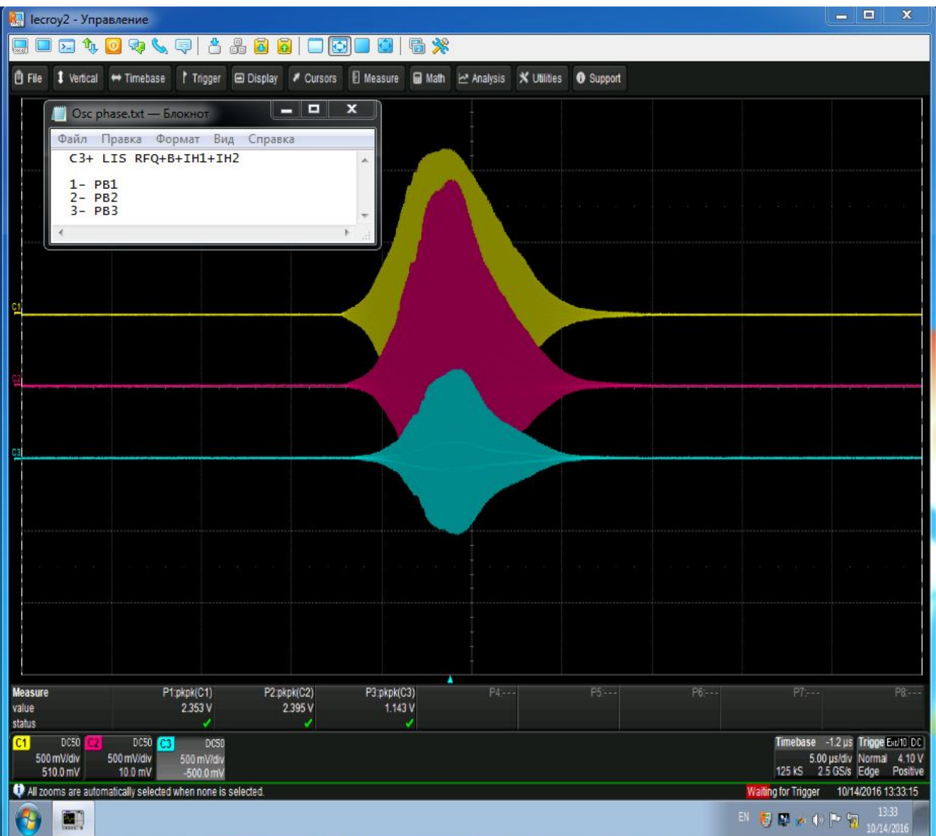


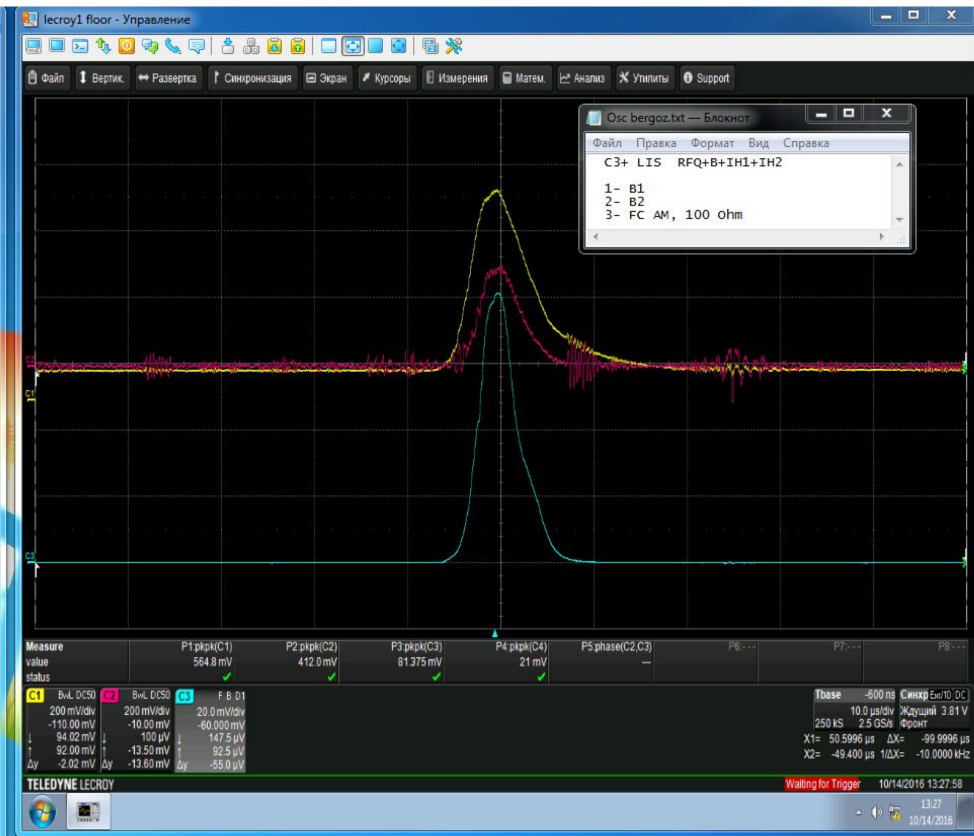
Experimentally found energy ≈ 3.2 MeV

C3+ ions from Laser Ion Source

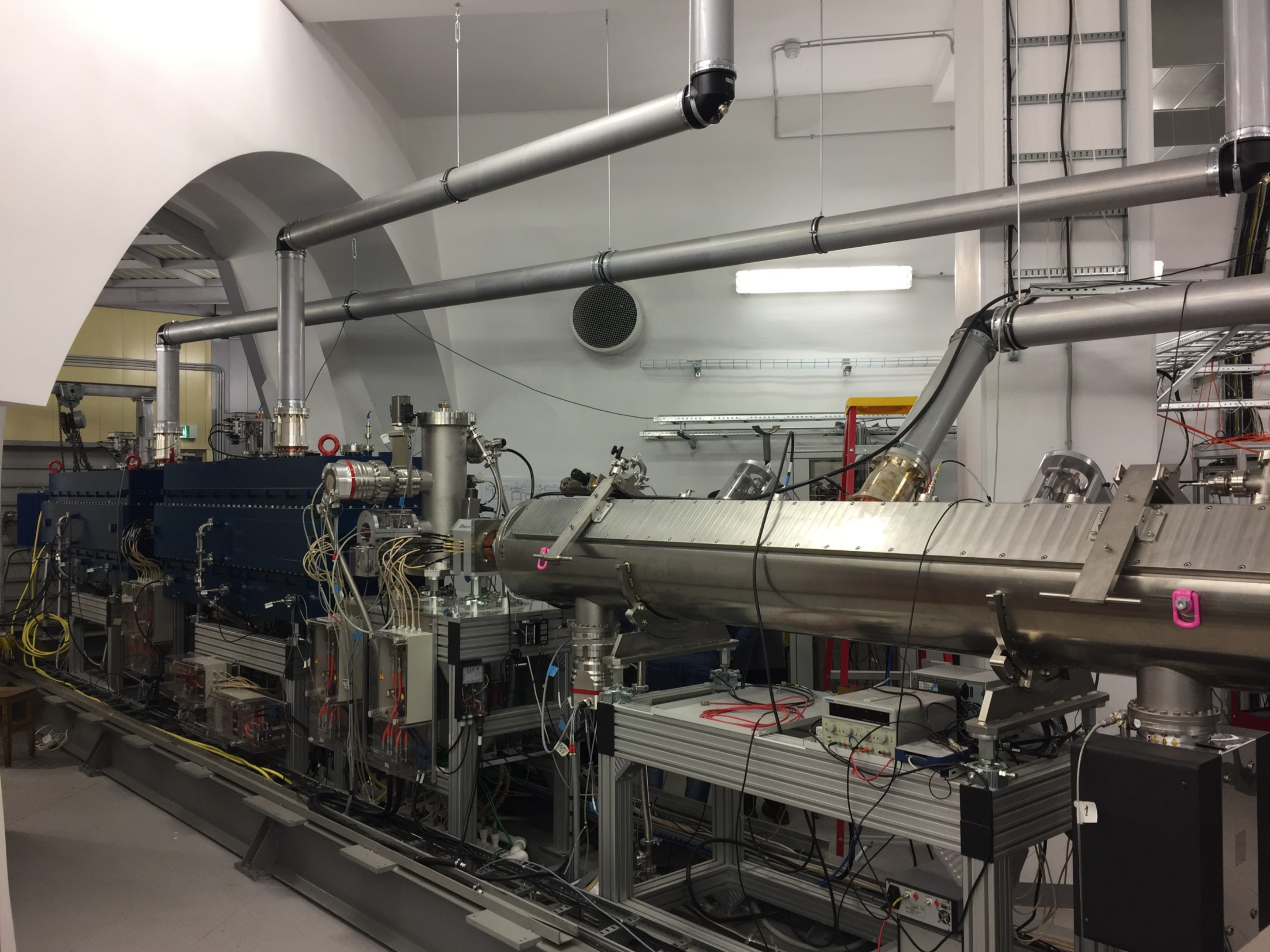
Phase probe's signals

Current transformer's and Faraday cup signals





HILAC commissioning team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Krion-6T ESIS

Theoretical и achieved parameter:

1) **Magnetic field up to B= 6.0 T, (5.0 T, 2015)**
2) **Energy of electron string $E_e \le 25$keV ($E_e \le 12$keV, 2015)**

Working element/charge state	Au^{31+} (Au^{51+})
Expected ion int. *N_i*	1÷4 x 10^9 ppp Au^{31+} (5x10^8, 2015) (1÷3 x 10^8 ppp for Tm^{41+} ~Au^{51+})
Repetition rate	50 Hz (for Au^{31+}) 50÷100 Hz, 2015 3÷5 Hz for Tm^{41+} -Au^{51+}, 2015
Extraction time form the ESIS	8 ÷ 30 x 10^{-6} s
RMS emittance	0.6 π mm mrad (for 8 x 10^{-6} s extraction time); 0.15 π mm mrad (for 30 x 10^{-6} s extraction time).
Peak current in pulse	up to 10 mA

Plans:

1) Improvement of internal Au injection.
2) Experiments in Au production in в magnetic field upto 6T

WHAT WE HAVE TO DO

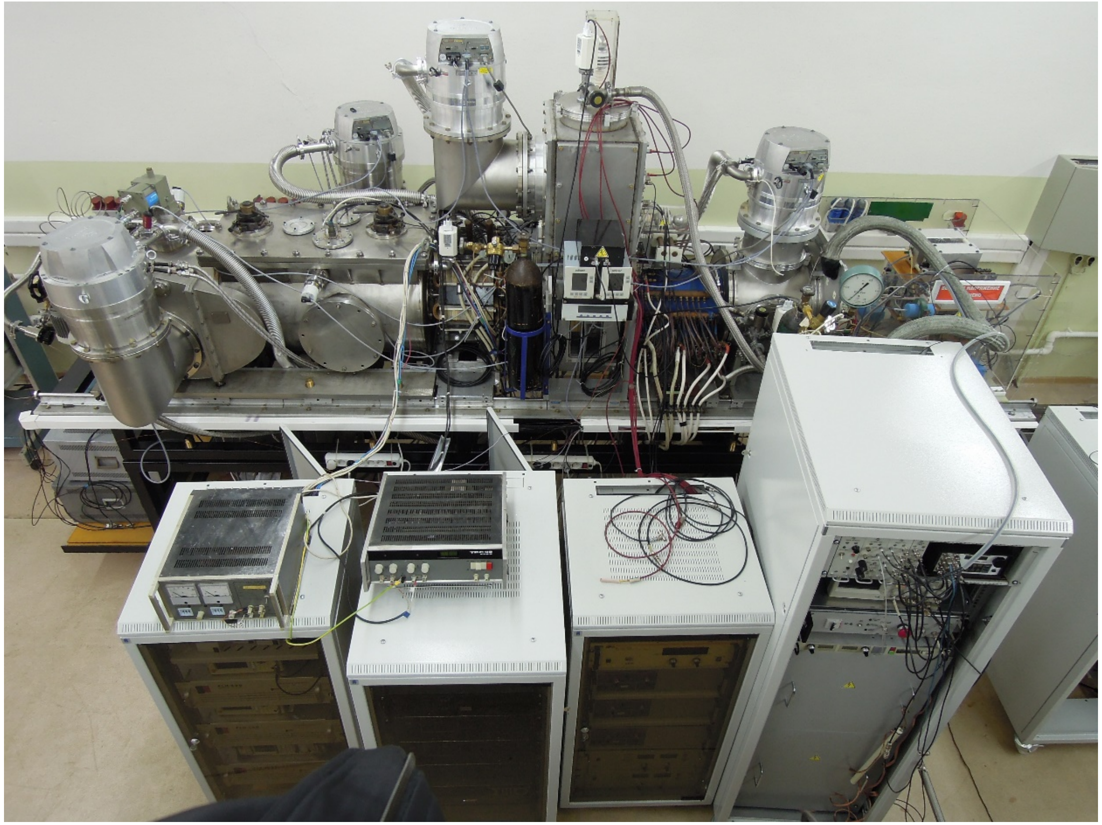
- **Measurement of transmission.**
- **Analysis of the beam from ESIS KRION 6T at the HILAC output.**
- **To build High Energy Beam Transport channel (HEBT).**
- **Beam analysis at the HEBT output.**
- **Researching for the modes of operation.**

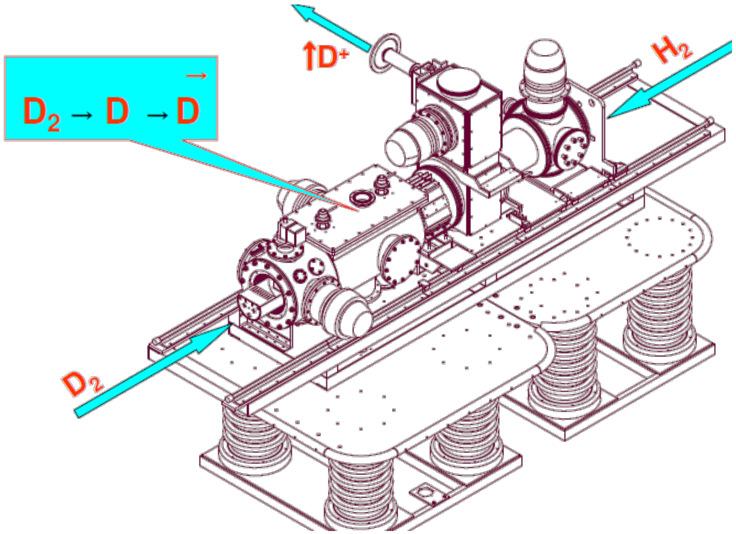
ALVAREZ BASED INJECTOR UPGRADE

Source of Polarised Ions (SPIon)

V. V. Fimushkin,
A. S. Belov

JINR + INR

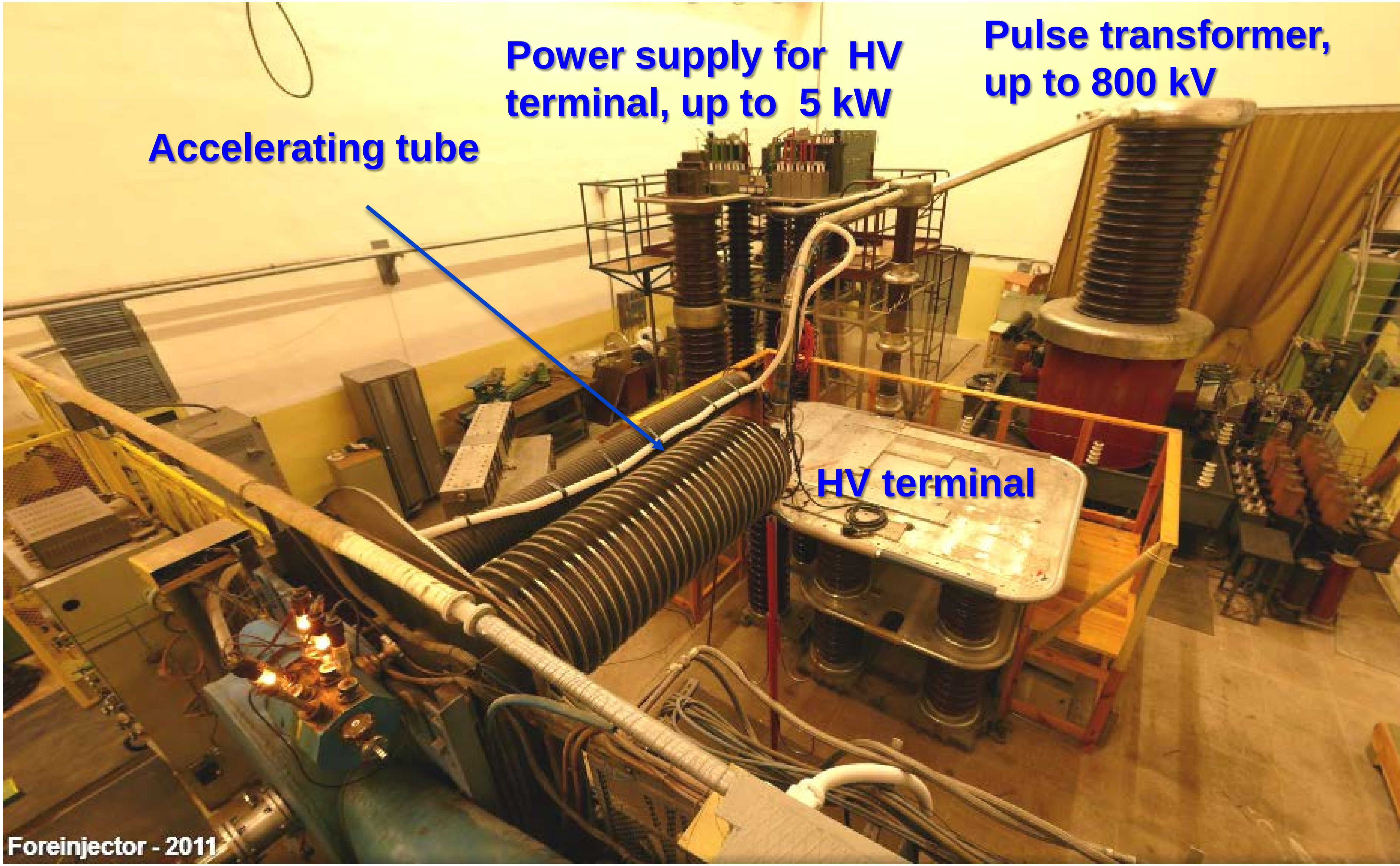




The main goal is the beams of high intensity (d+,p+) at the Accelerating Facility of LHEP JINR up to **10^{10} p/pulse**

25 kW is needed

Forinjector for Alvarez LU-20 before upgrade



Forinjector for ALVAREZ LU-20

Before upgrade

Ion Source

P_{max} = 5 kW

HV TERMINAL

$U_{HV\ terminal} \geq 300$ kV

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

LINAC

After upgrade

Ion Source

P_{max} = 35 kW

HV TERMINAL

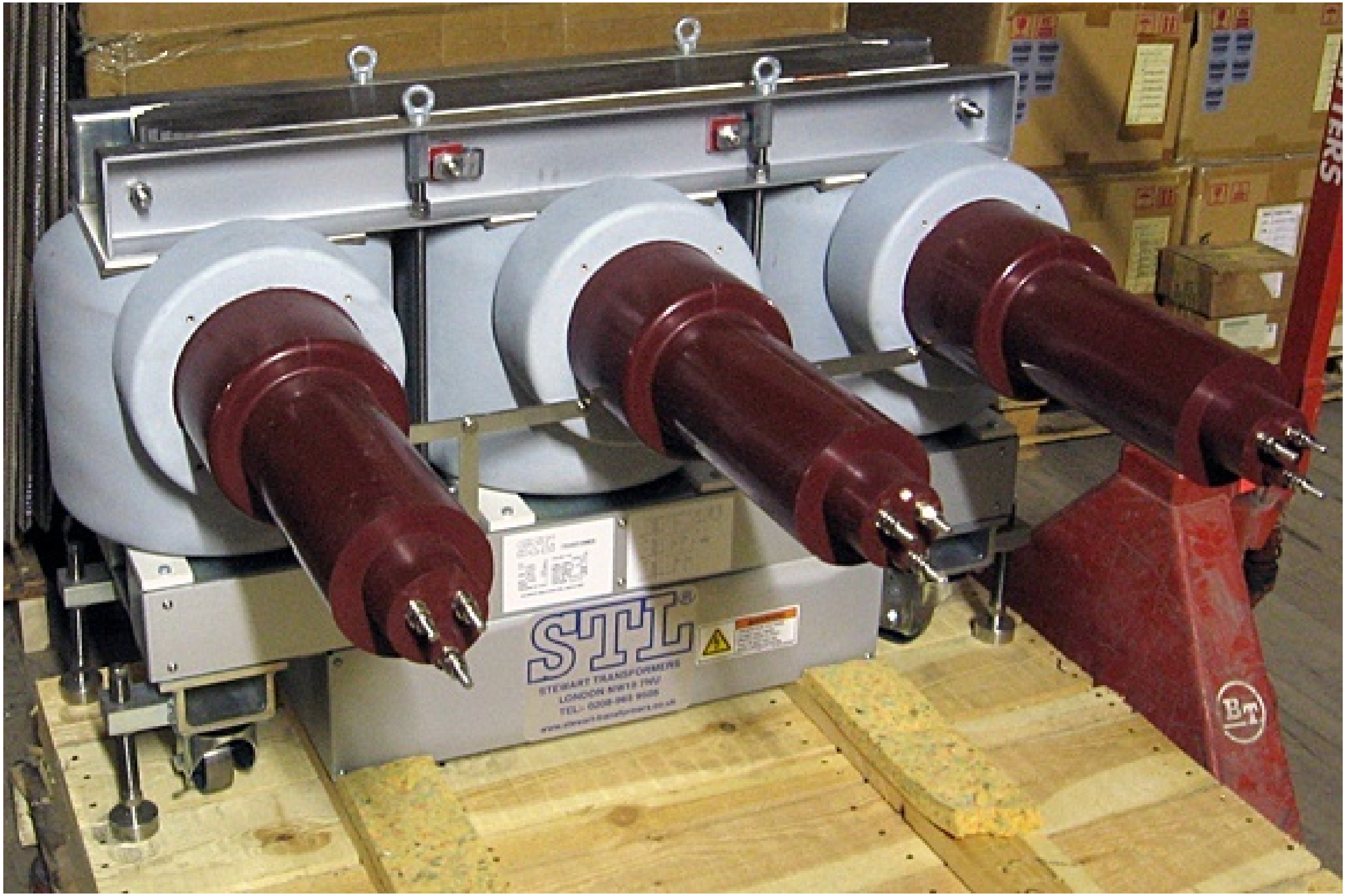
$U_{HV\ terminal} \leq 100$ kV

45 kV- protons,
62 kV - Z/A=1/2,
103 kV - Z/A=1/3.

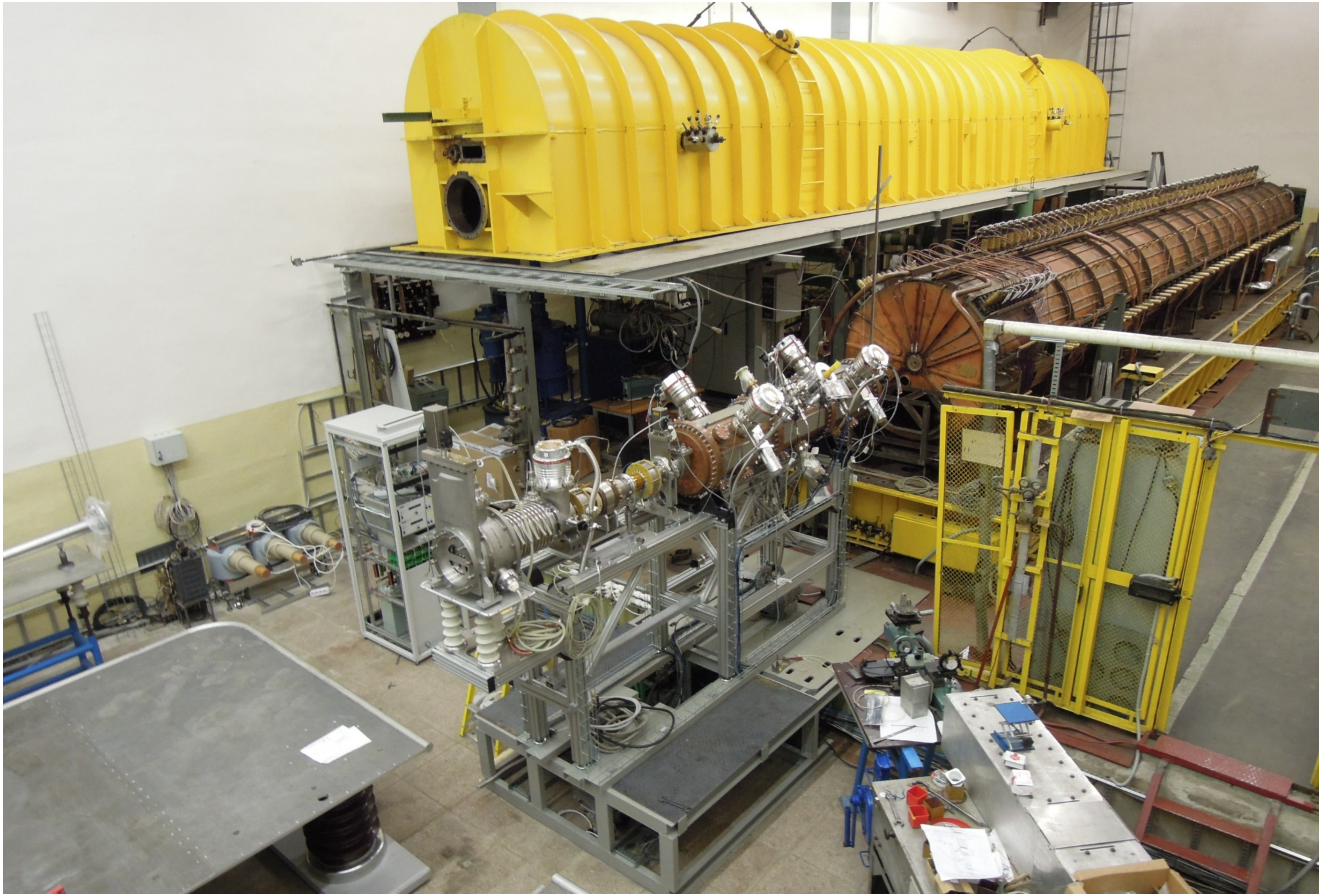
RFQ

LINAC

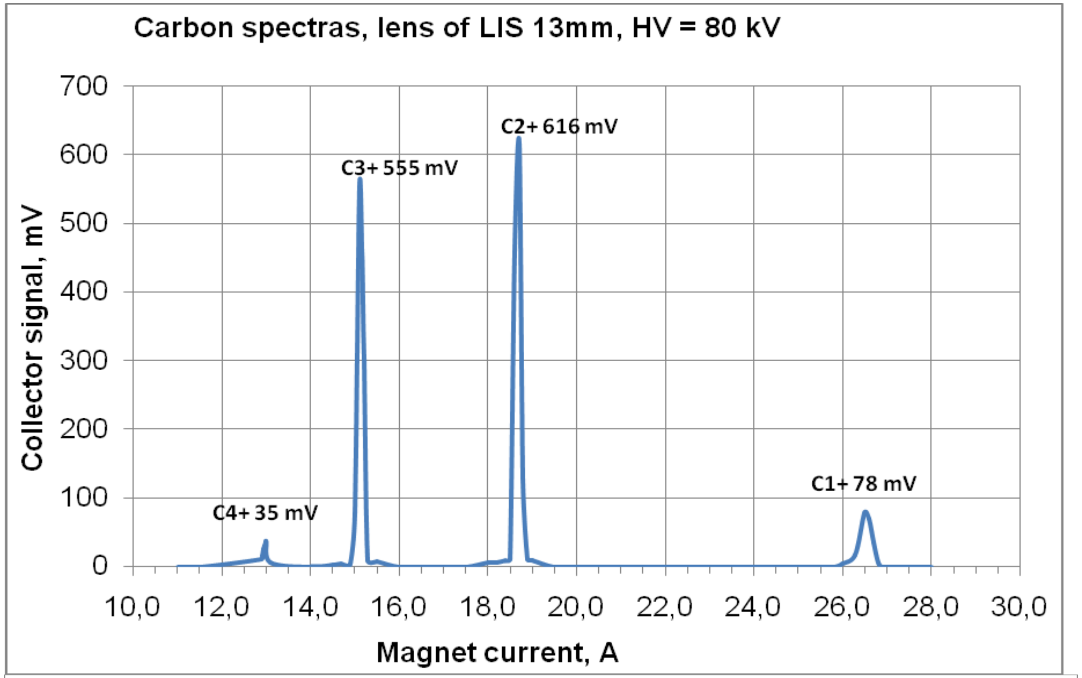
Isolation transformer, 160 kV, 35 kWA

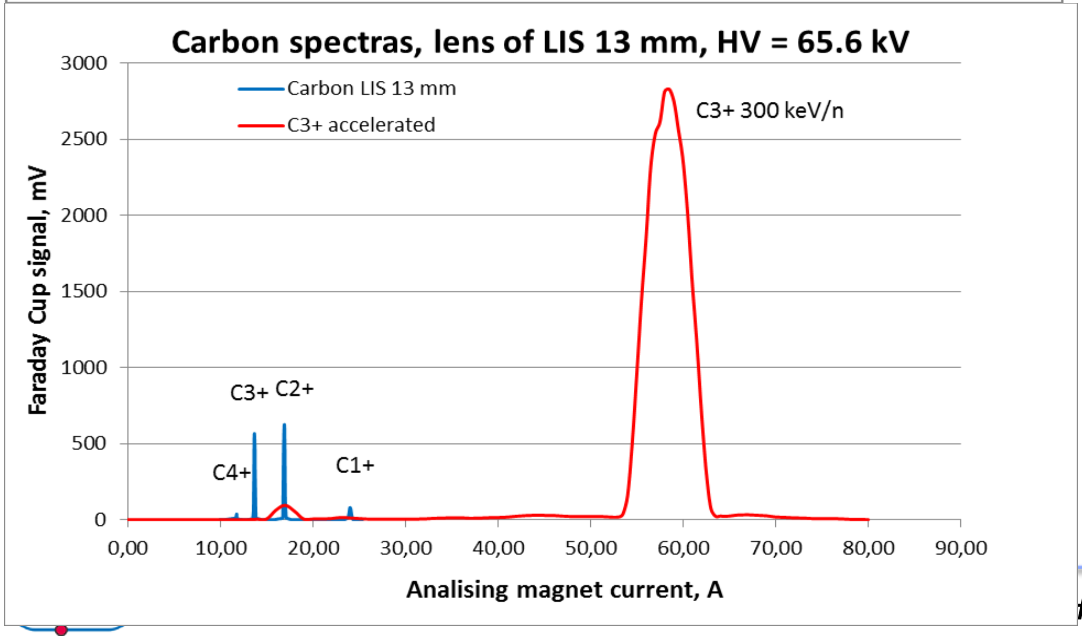


Upgraded forinjector for Alvarez LU-20.



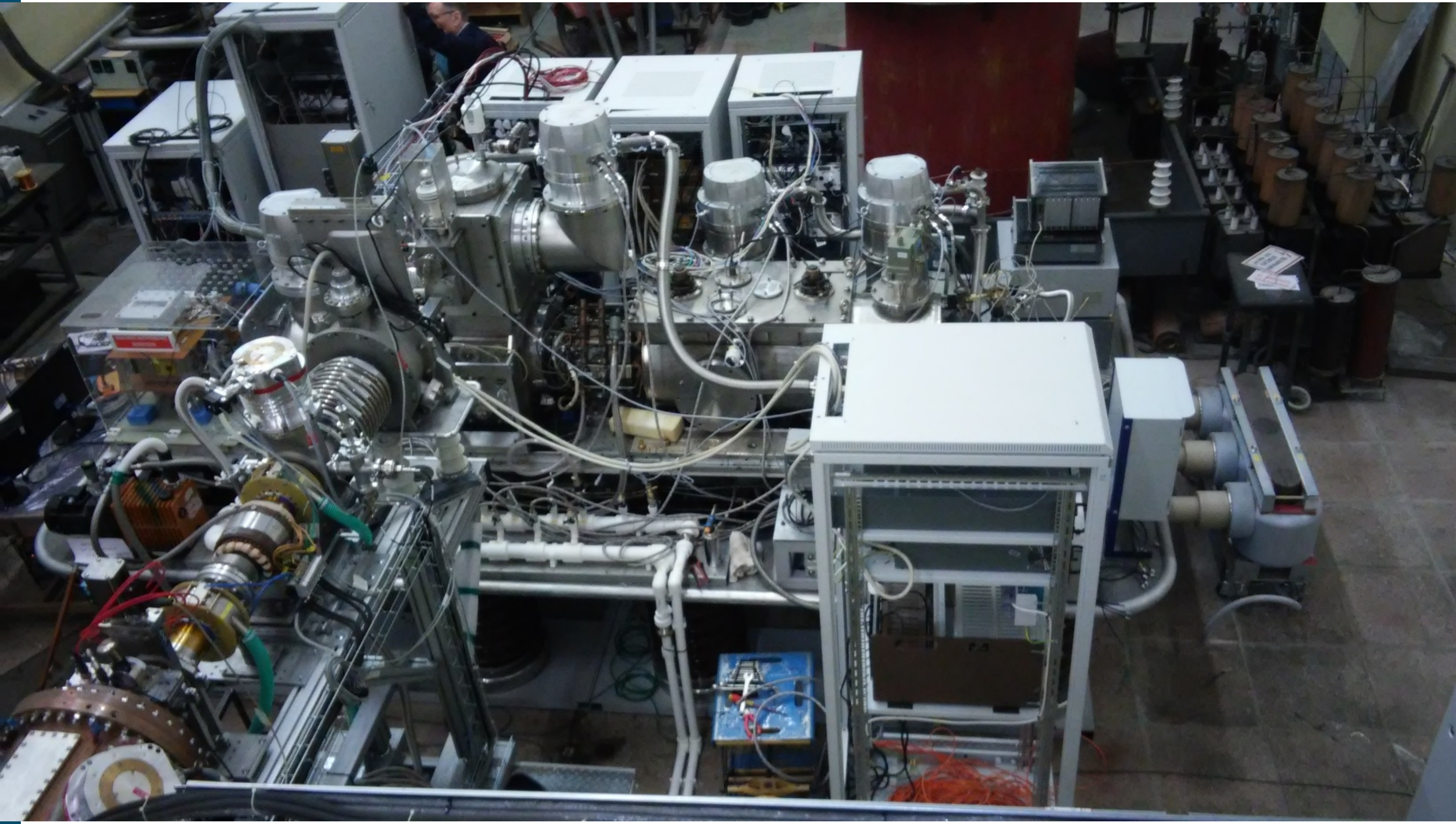
Acceleration in ITEP RFQ





4-vane RFQ
Ein= 31 keV/u
Eout=156 keV/u

Upgraded forinjector, RFQ, SPIon.



Upgraded forinjector, SPIon.

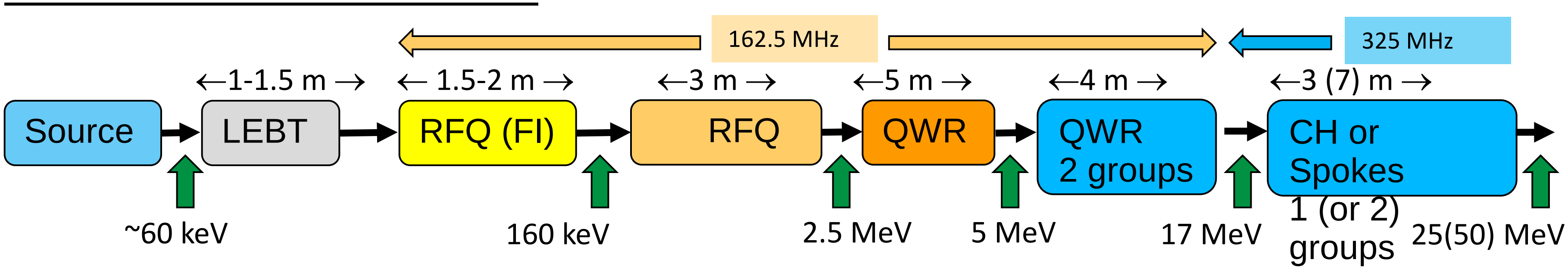
Alvarez based injector upgrade that is coming up.

Joint collaboration of JINR, NRNU, MEPhI, INP, BSU, PTI NASB,BSUIR, SPMRC NASB.

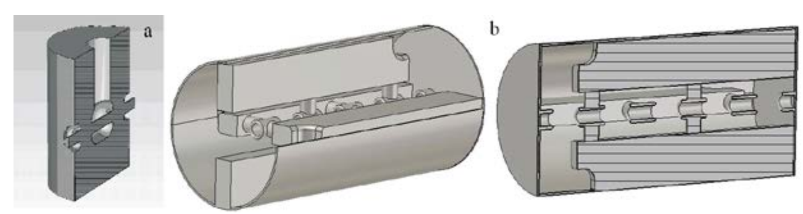
Parameters of SC linac

Cavities group	1	2	3	4
β_g	0.07	0.141	0.225	0.314
W_{in}, MeV	1.0	4.1	17.2	34.3
β_{in}	0.046	0.093	0.189	0.263
W_{out}, MeV	4.1	17.2	34.3	50
β_{out}	0.093	0.189	0.263	0.314
T, %	17.5	17.5	17.5	17.5
K_T, %	100	100	100	100
f, MHz	162	162	324	324
N_{gap}	2	4	4	4
φ, deg	−20	−20	−20	−20
L_{res}, m	0.13	0.26	0.416	0.58
E, MV/m	3.08	10	12	11.21
U_{res}, MV	0.4	2.6	5	6.5
B, T	1.6	2	2.6	2.8
L_{sol}, m	0.2	0.2	0.2	0.2
L_{gap}, m	0.1	0.1	0.1	0.1
L_{per}, m	0.53	0.66	0.816	0.98
N_{per}	8	6	4	4
L, m	4.24	3.96	3.264	3.92

Protons up to 25 MeV (50 Mev after upgrade), Light ions up to 7.5 MeV/u.



Electrodynamics models of QWR cavities were designed for β =0.07, 0.105, 0.12 (and 0.150 as reserve) and resonant frequency of *f*=162 MHz. As an example, optimal QWR characteristics for *f*=162 MHz and β =0.07 are the following: cavity height 480 mm, central conductor length 439 mm, central conductor radius 18 mm, cavity internal radius 67 mm, central drift tube length 118 mm, gaps length 24 mm



THANKS