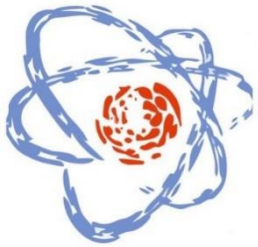


Development of the Electron string ion sources thermometry systems

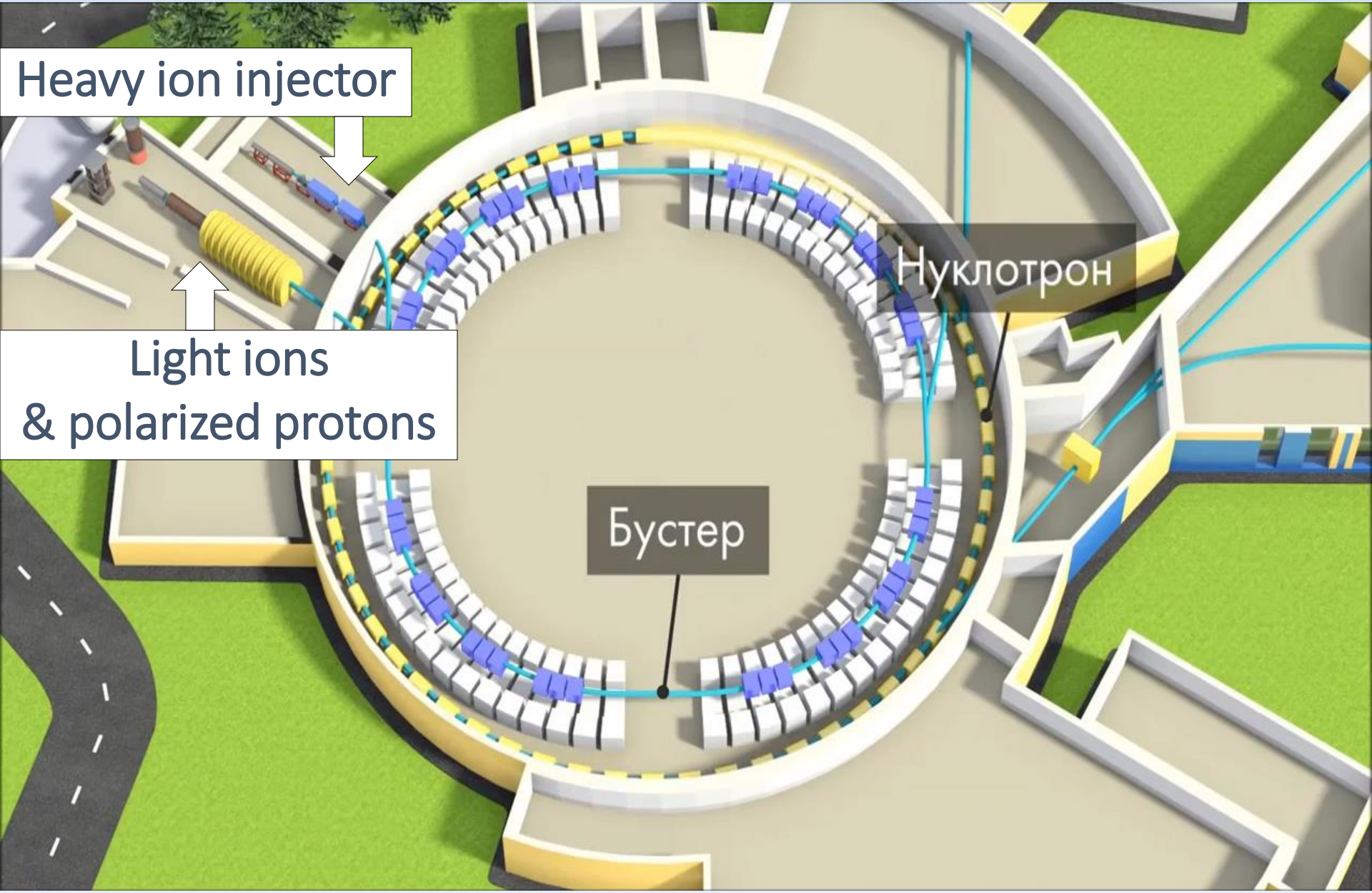
Ponkin Dmitry

LHEP JINR senior engineer

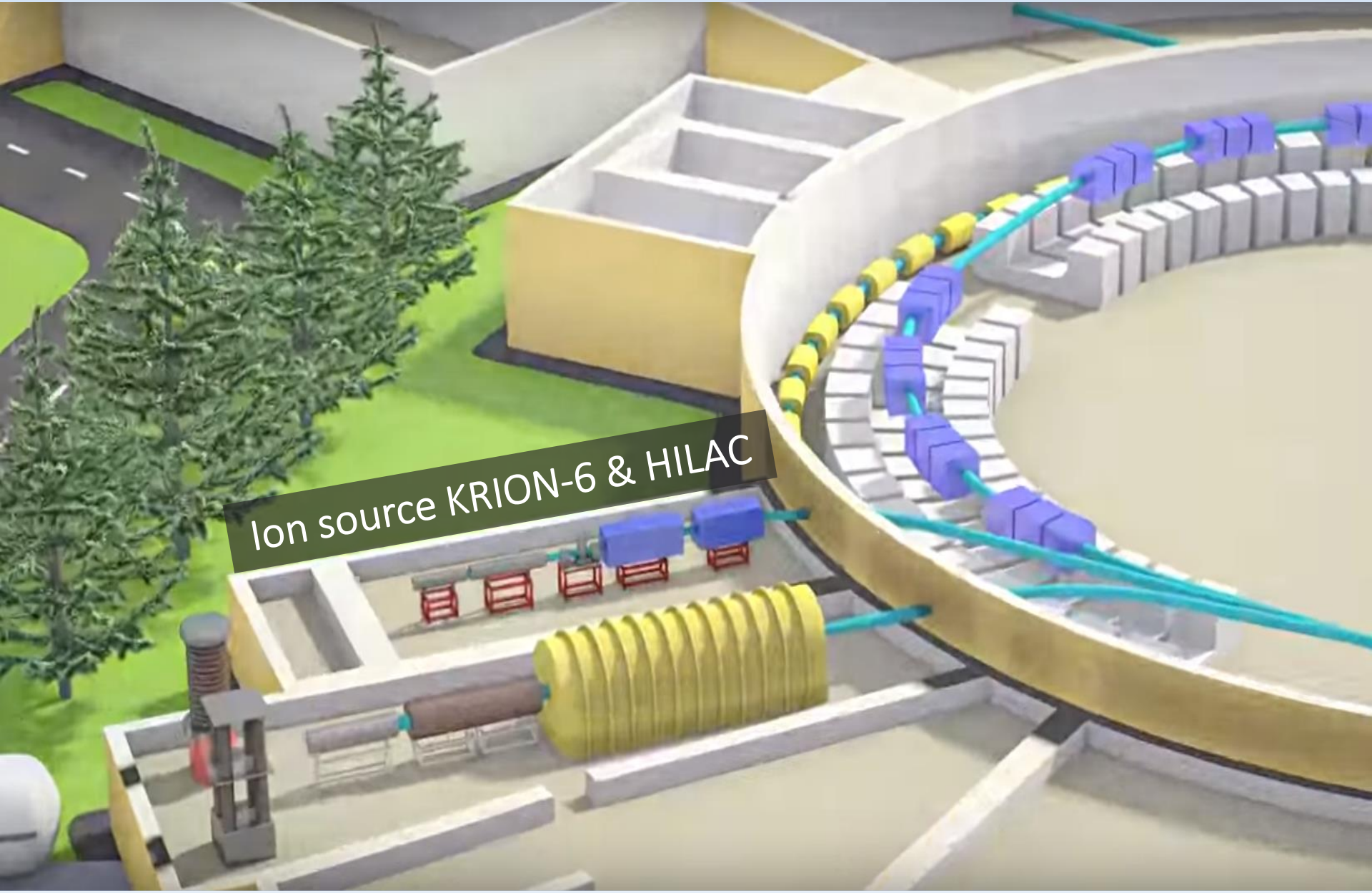
on behalf of the NICA acceleration division

Dubna, 9-13 November 2020

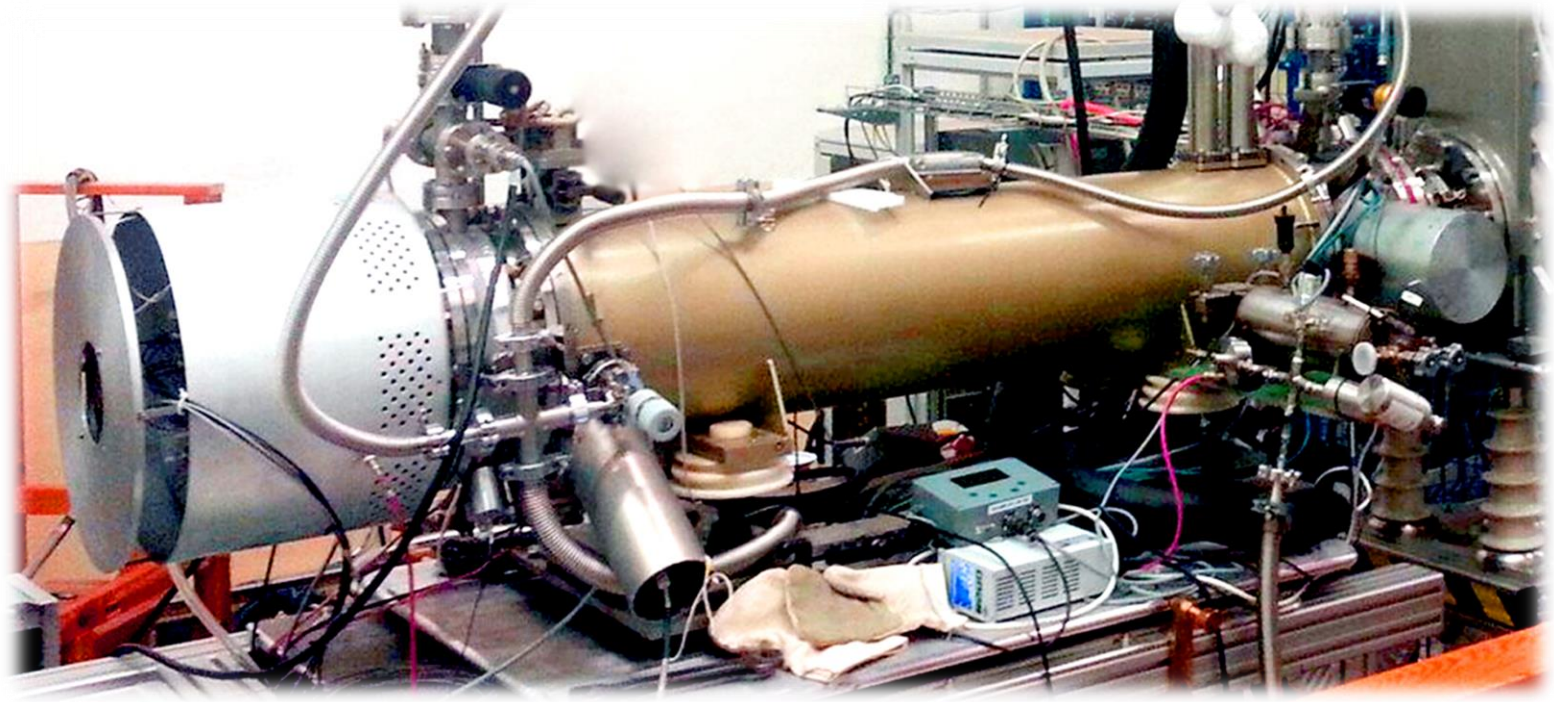
NICA injection complex



Heavy ion injection



Heavy ion source KRION 6T



Ions produced and injected: $^{78}Kr^{17+}$ $^{124}Xe^{41+}$ $^{40}Ar^{16+}$ $^{12}C^{6+}$

- 5.4 T SC solenoid
- E inj. up to 25 kV
- electron string
- cryogenic
- highly charged ions
- unique technology

EBIS = Electron Beam Ion Source

History

•Invented by E.D. Donets at JINR,Dubna in 1968. Au^{19+} beam in 1969.

•1970-1985, in Dubna, cryogenic version of EBIS KRION-I,2, bare ions C, N, O, Ne, Ar, Kr, Xe. HCI physics begins.

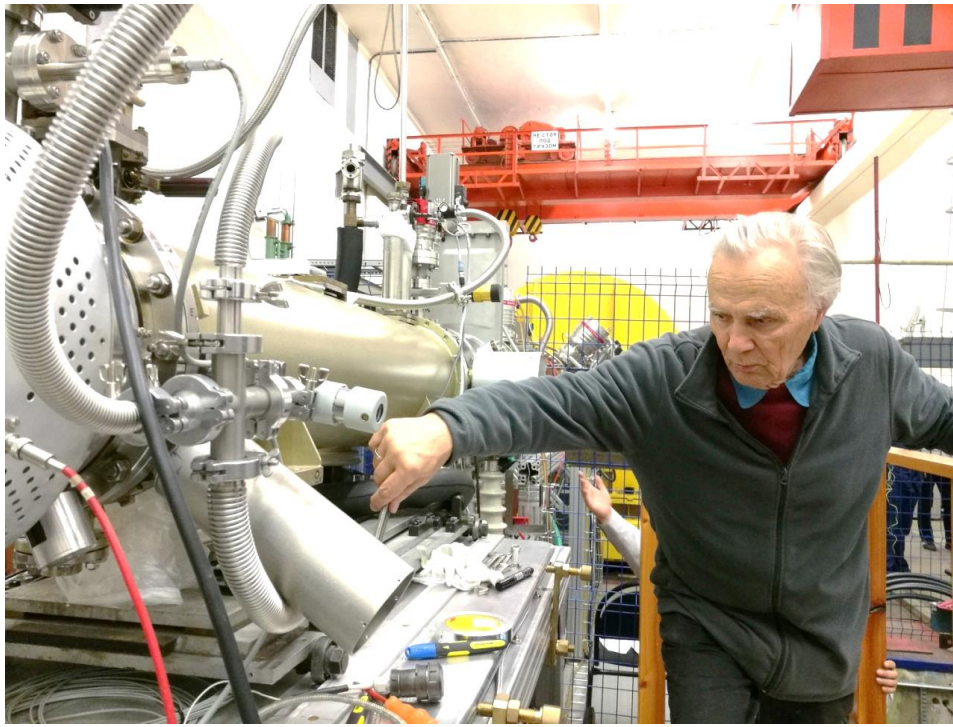
•1970-1985, Europe, US, Japan, a lot of EBIS (*EBIS time*), **U^{90+} !**

•1982, at Bekerley, EBIT, from EBIS, 1990s, SuperEBIT, U^{92+} !

•Since 1985, in accelerator fields, ECRIS time

•2001-2005, breakthrough of EBIS at JINR, new idea of ESIS, and high current EBIS at BNL.

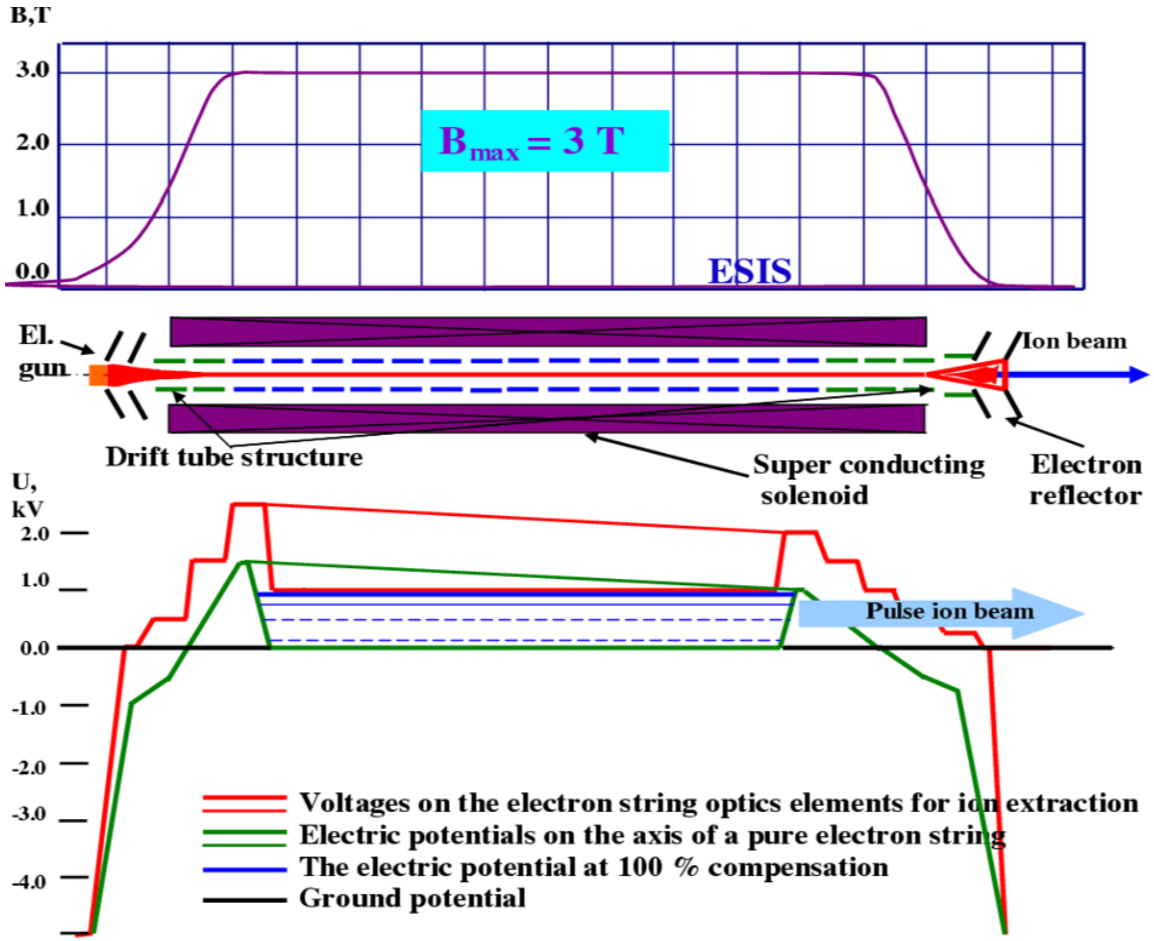
•In China, Shanghai EBIT



Prof. E.D. Donets near Krion-6T ESIS during Nuclotron run #55, JINR, Dubna, February 2018

• **ESIS Krion 6T and Krion N1 for NICA JINR**

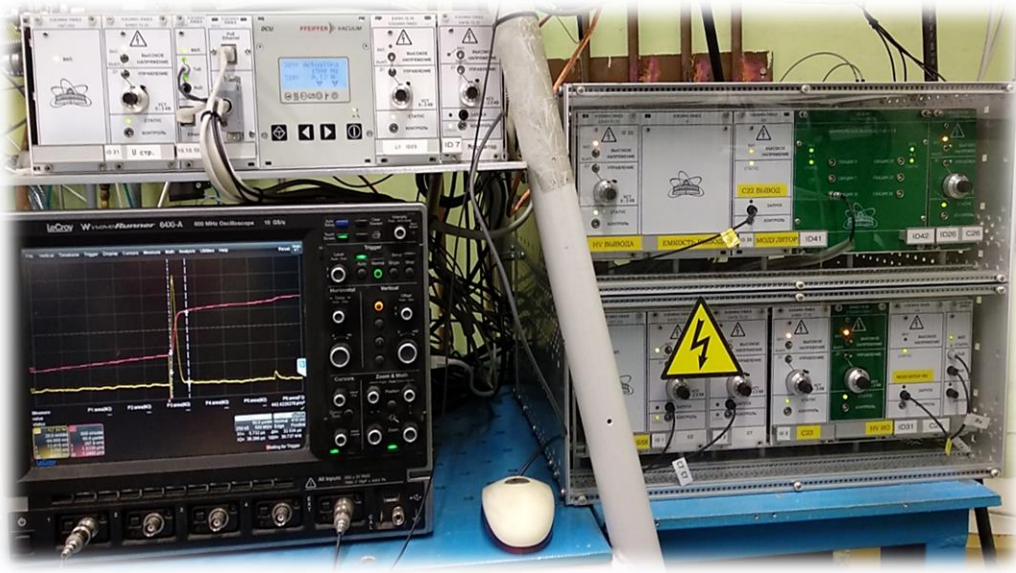
ESIS = EBIS in electron reflex mode of operation



ESIS KRION 6T electronics

Slow control

- vacuum
- ion optics supply
- HV electrodes
- electron gun supply
- Synchronization
- thermometry



Ion motion control system

- DC barrier modules
- pulsed barriers modules
- extraction modules
- interface modules
- drift structure divider

Beam diagnostics

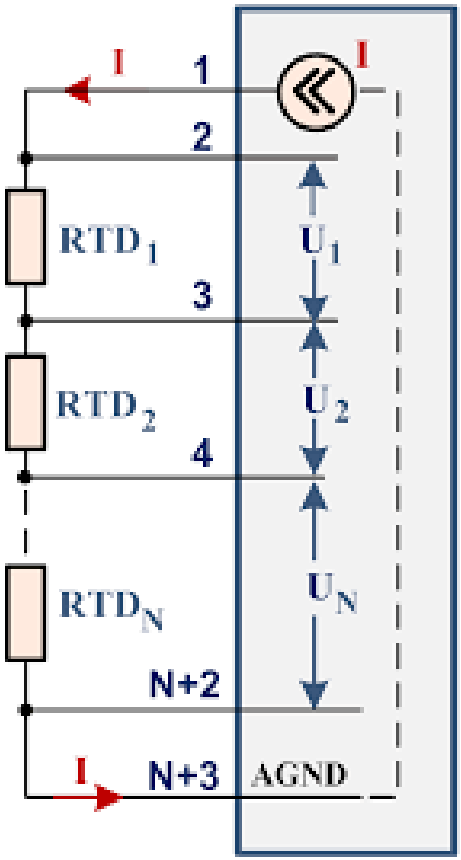
- beam profile monitor
- oscilloscopes
- ion collectors
- ToF system
- indused signals

Cryogenic measurements:

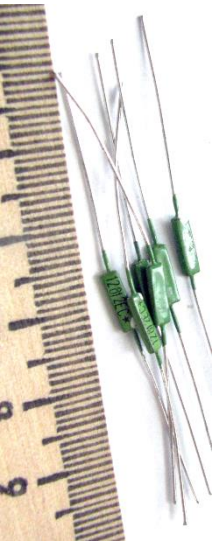
- cryogenic sensors (precision, stability)
- sensor wiring and connection

- meas. electronics
- current source
- signal shielding

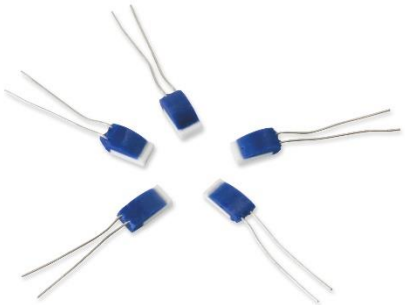
4-wire



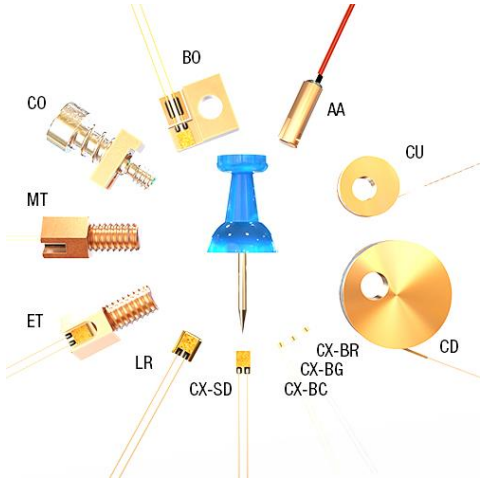
U = IR, R = U/I



TBO

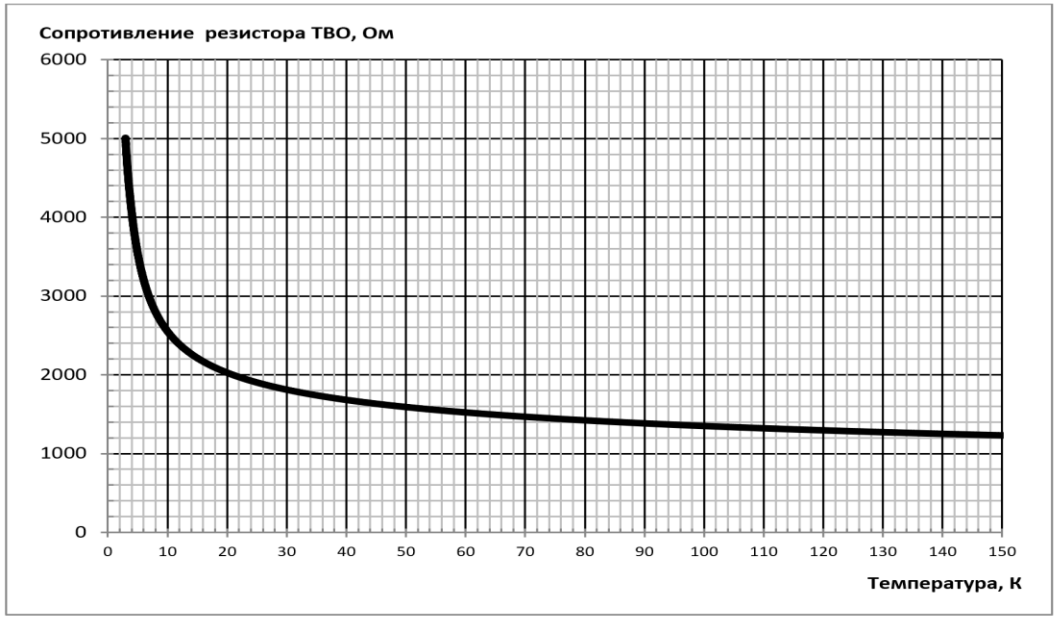


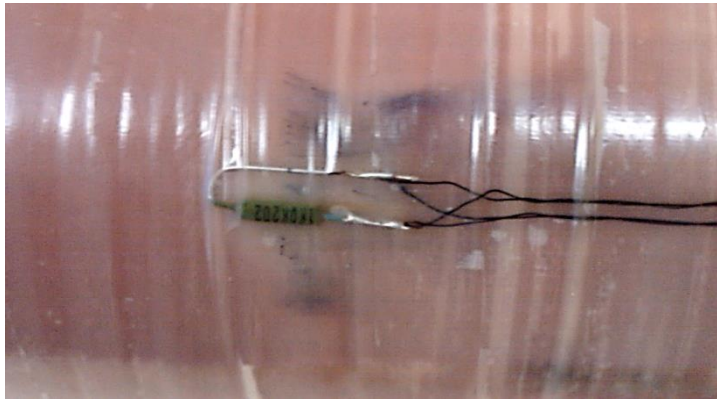
PT sensors

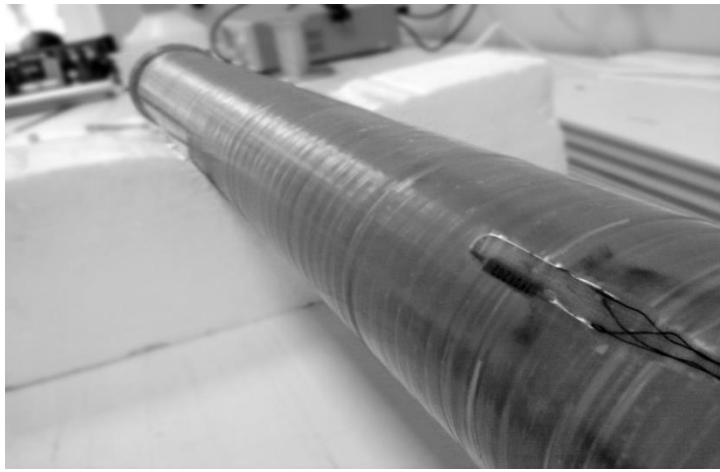


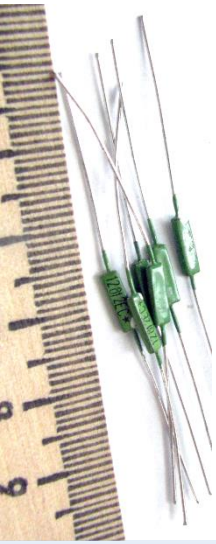
Cernox

Thermometry => superconducting solenoid







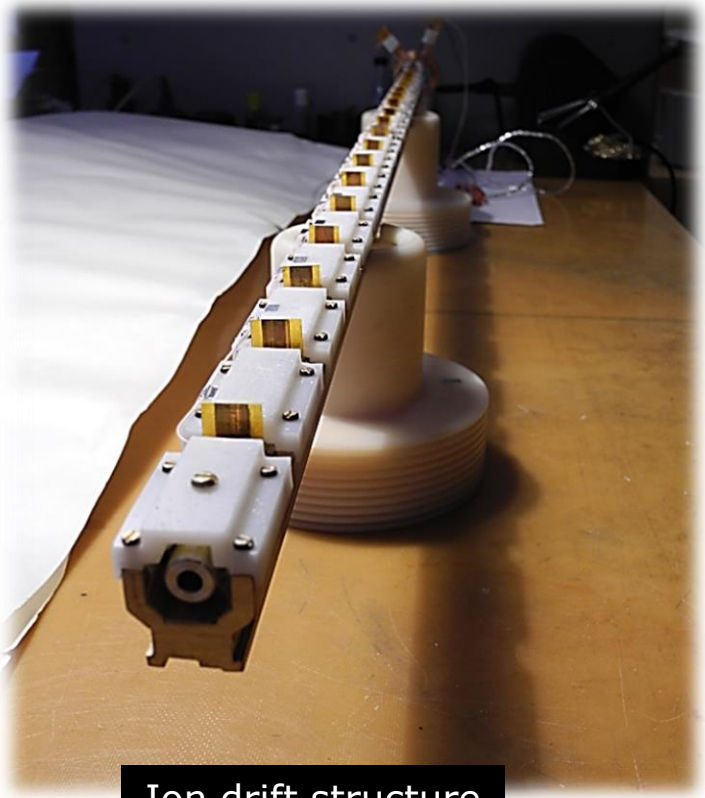


TBO* resistor:

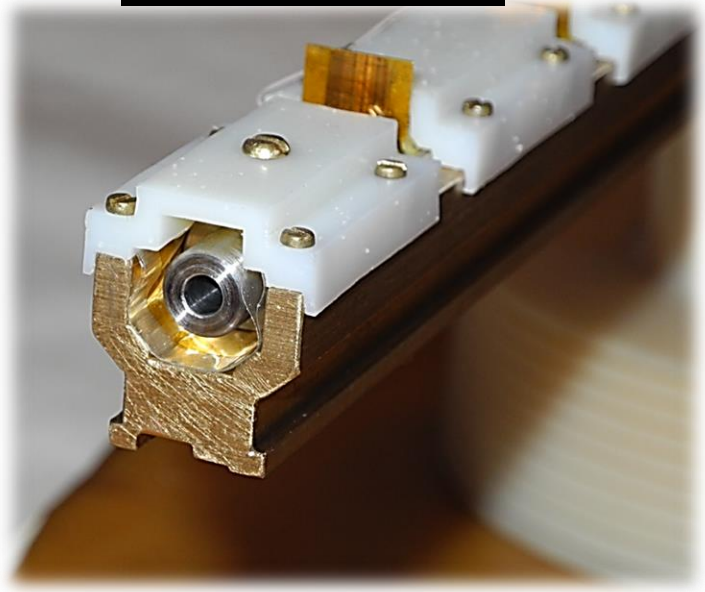
- heat resistant
- moisture resistant
- volume

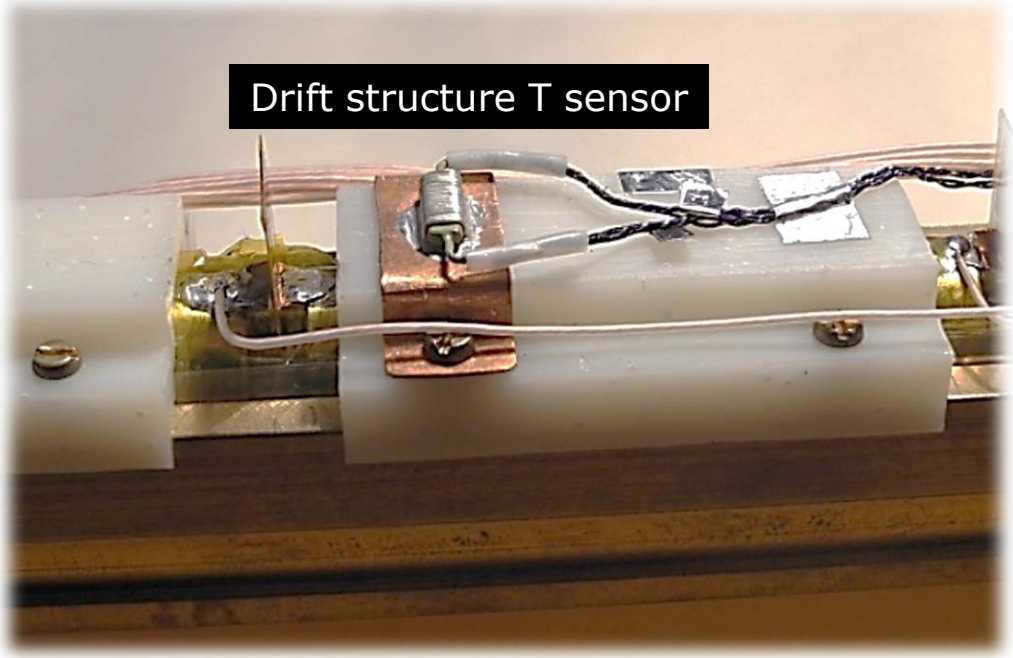
$$T = \sum_{n=1}^{m} K_n \cdot \left(\frac{R_0}{R_t} \right)^{n-1}$$

KRION 6T
superconducting solenoid
T sensor



Ion drift structure

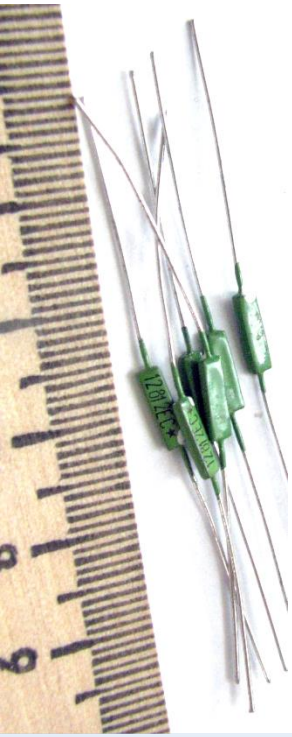




Slow control => thermometry

TBO* resistor:

- heat resistant
- moisture resistant
- volume

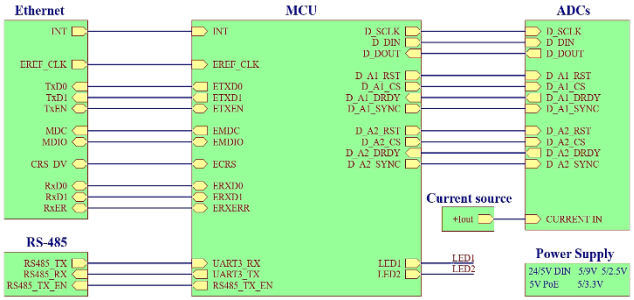


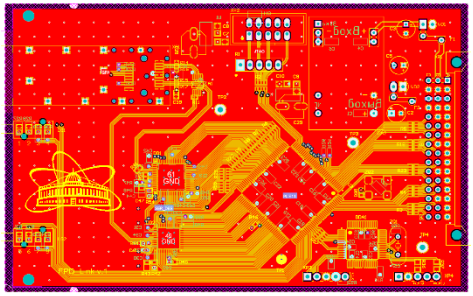
Measurement scale	4 - 300 K
Accuracy	± 0,3* % in 30 K range
Channels	N * 8
ADC resolution	24 bit
Current source	10/100/1000 uA

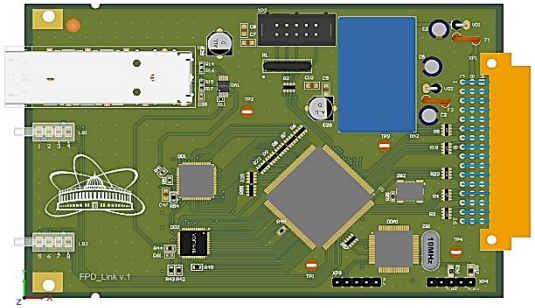
Advantages

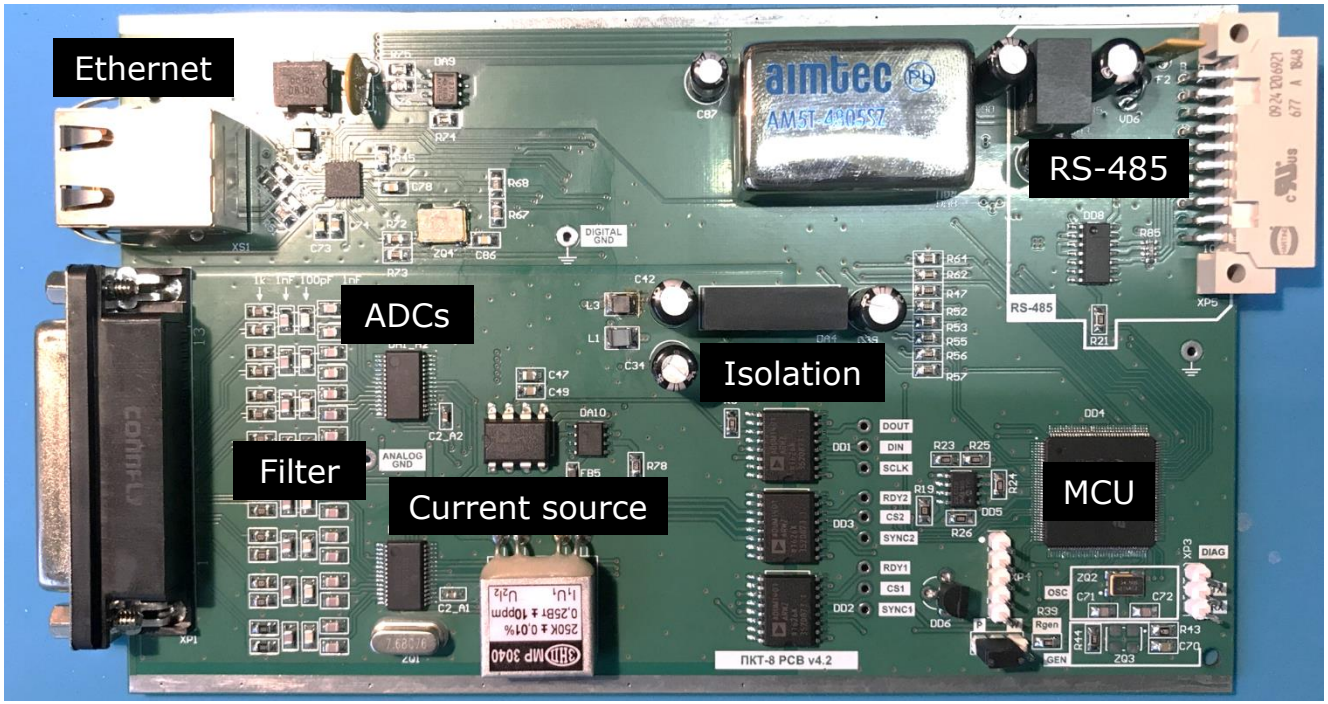
- PoE: less wires needed
- precision
- Modbus RTU/over TCP
- modular (3U case)
- robust & cost-effective
- on-board current source

The design process



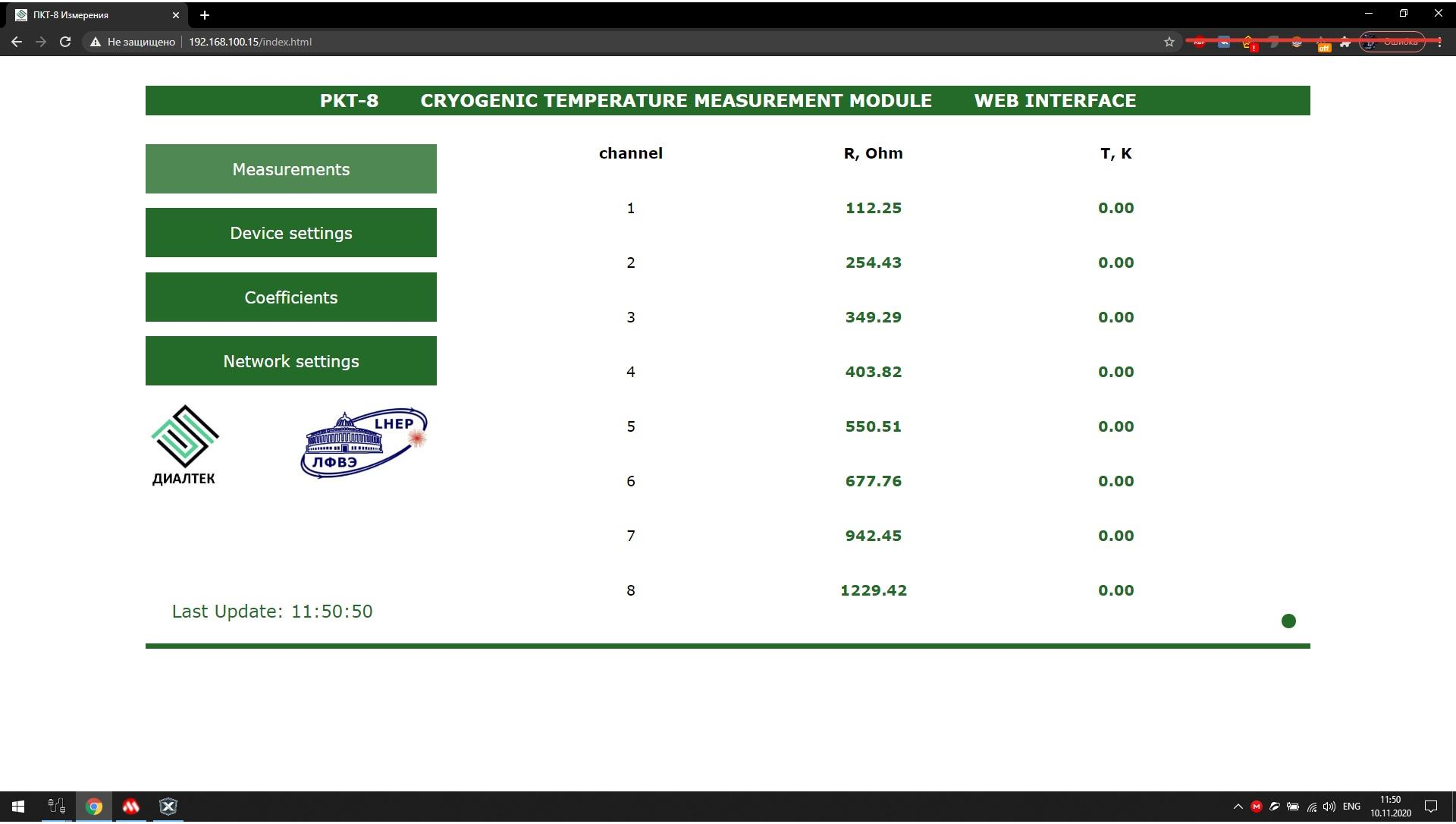


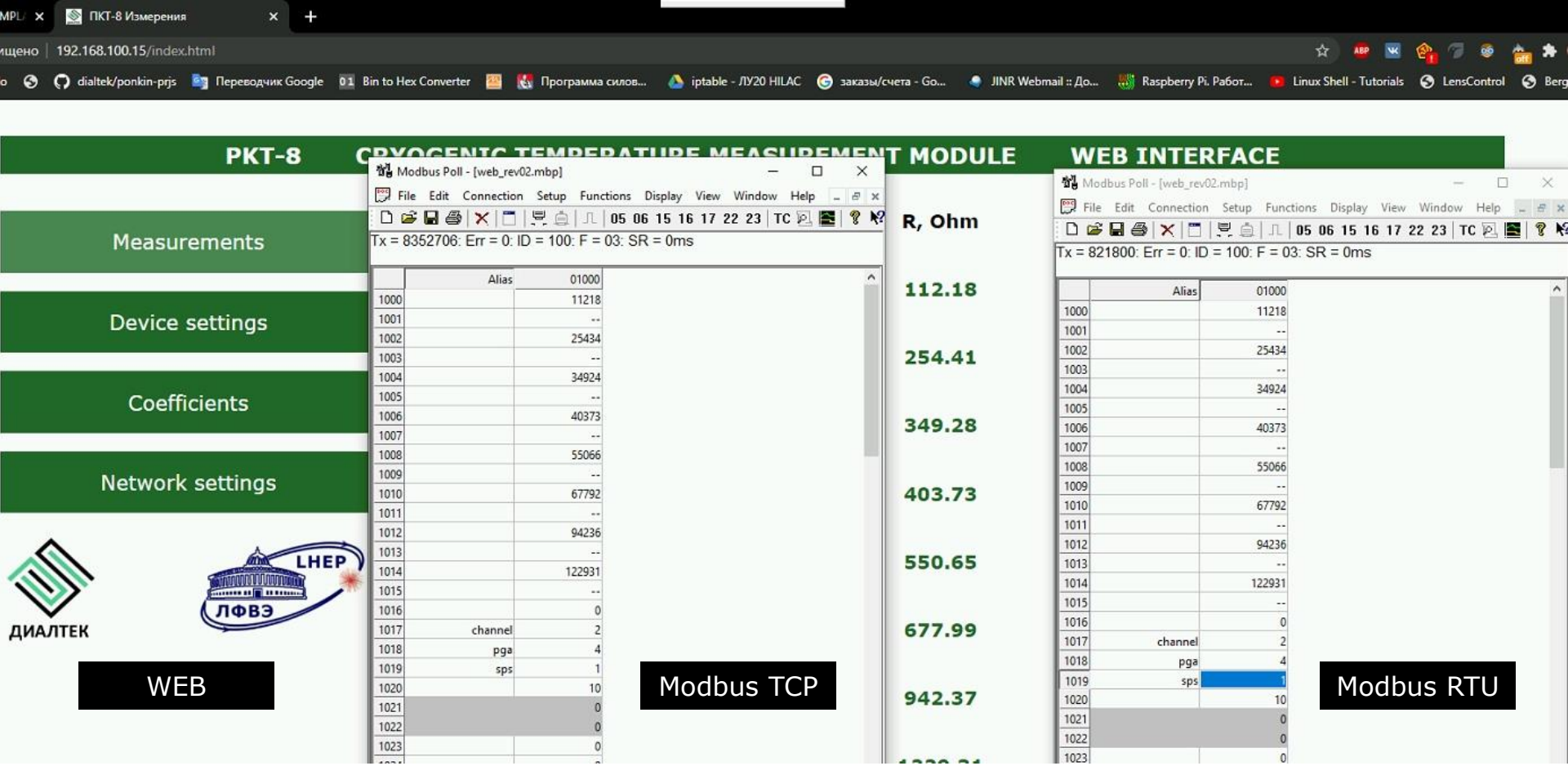




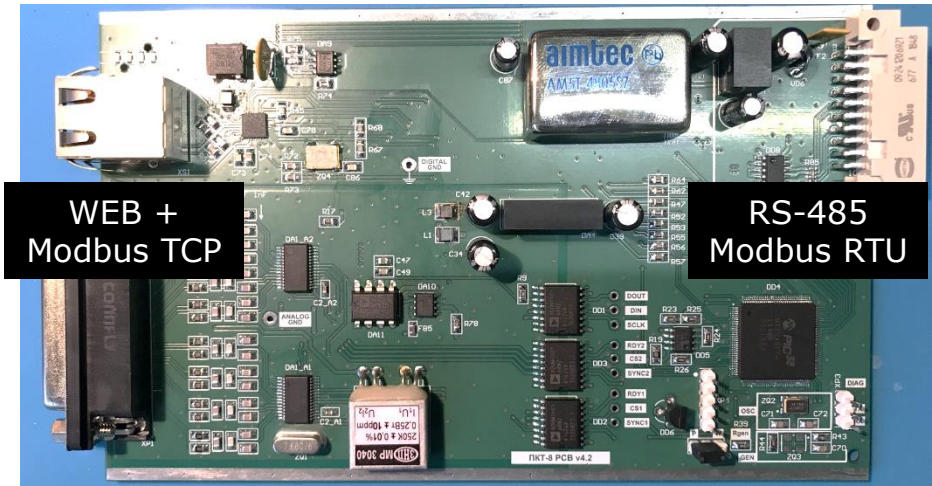
«Cool» resistor

The embedded system **web interface**



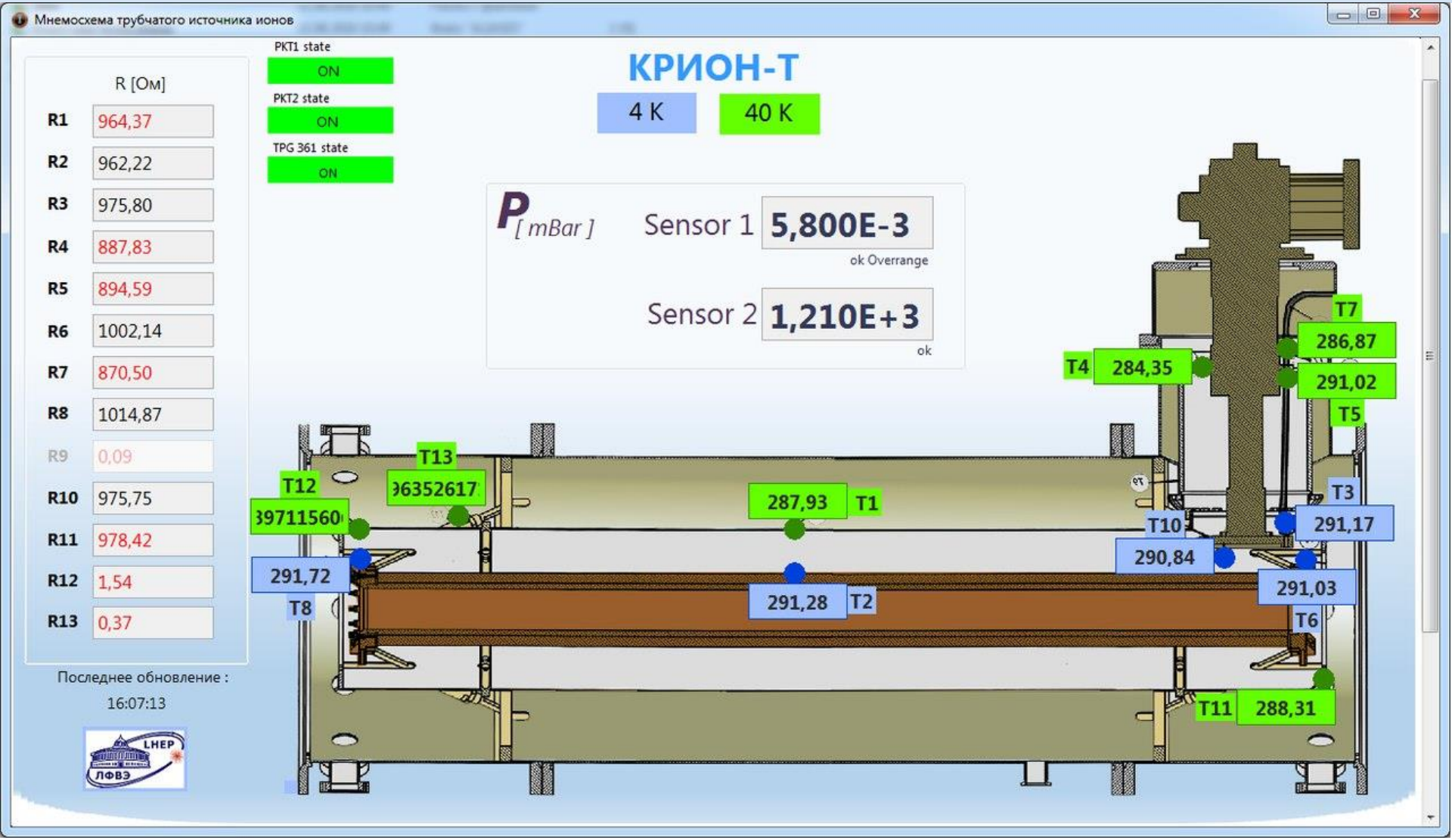


Web interface + Modbus



Slow control => thermometry

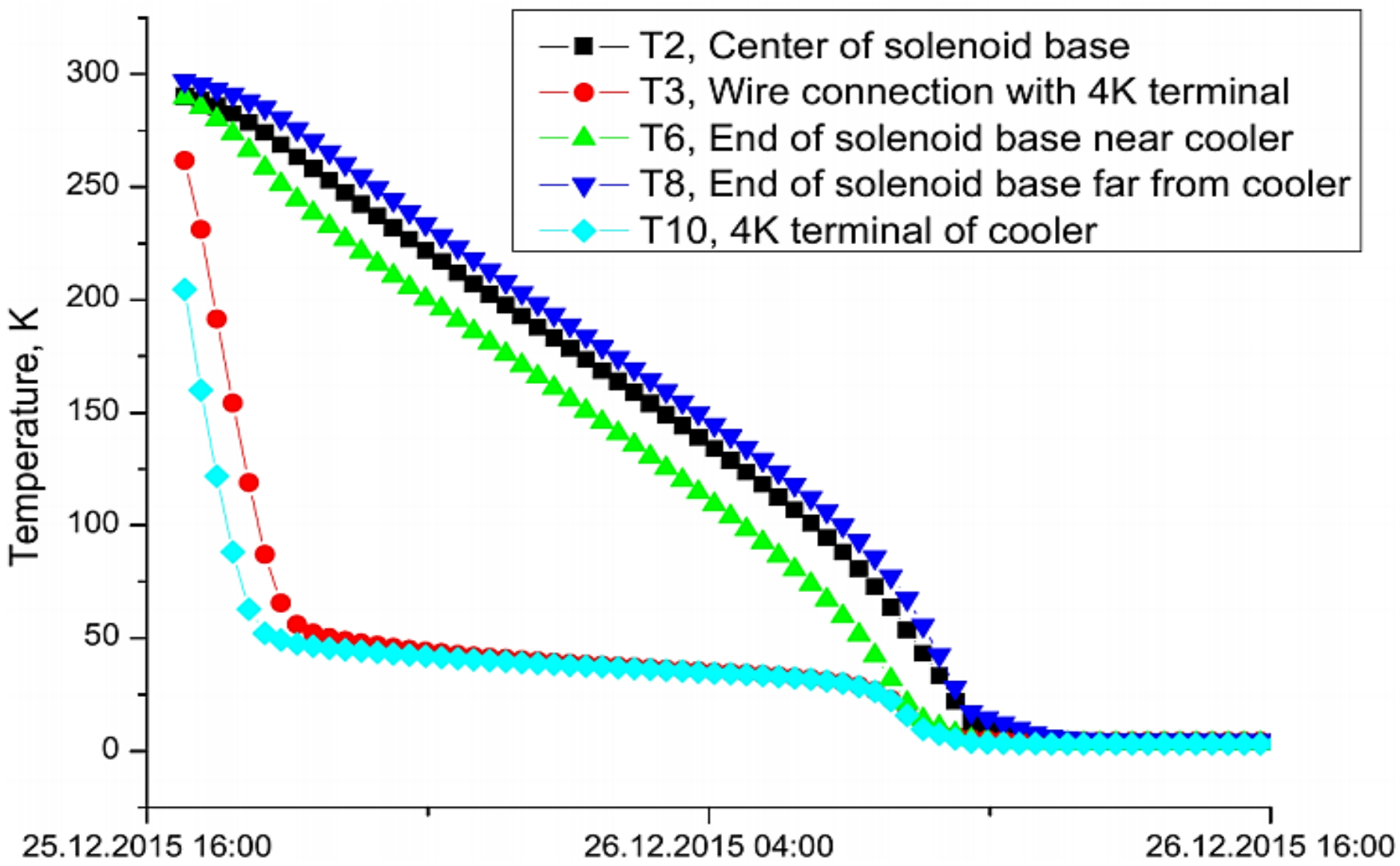
Slow control => thermometry



TANGO

https://www.tango-controls.org/

Slow control => thermometry

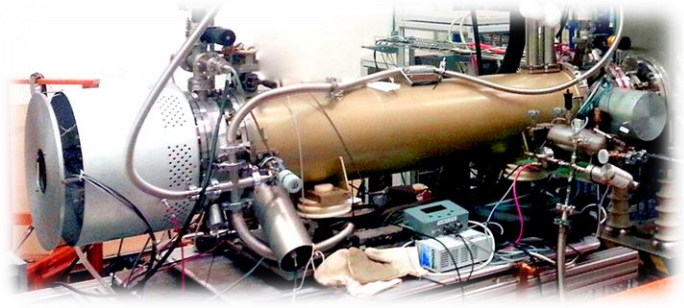


Summary

- ESIS Krion 6T successfully produced beams for the Nuclotron runs in 2014 and 2018, all the electronic systems were developed and works fine
- The thermometry system including electronics, sensors, wiring etc is a complicated system. It is complex and interesting
- The designed electronics is a powerful device with, can be used in other parts of the accelerator complex
- The design is done by a young engineers group, it has 2 diploma work and several study practices
- We are ready for the new designs
- We can offer the device for your cryogenic or precision meas.

problem:

unique facilities => unique electronics*



JINR

We are ready for collaboration in any technical questions

email: **ponkin@jinr.ru**

Thank you!