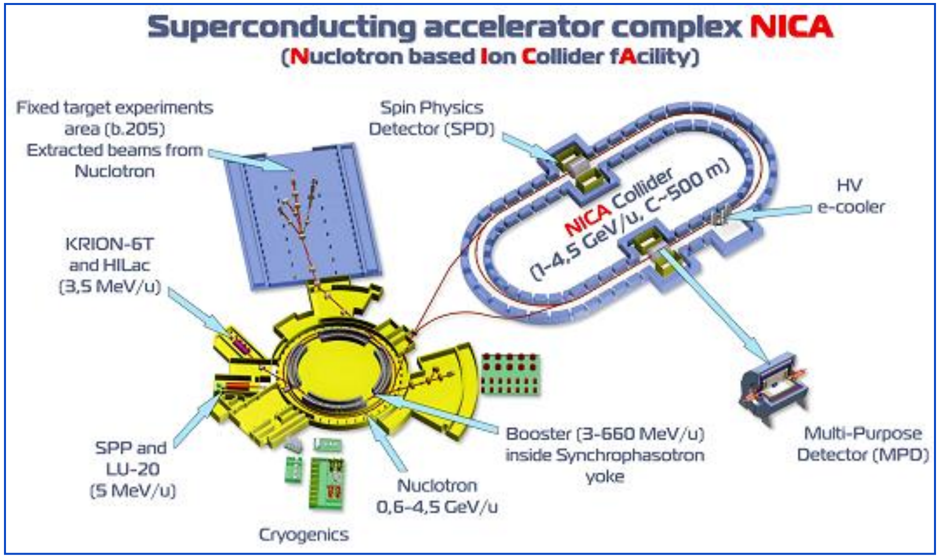
THE NEW OPTION OF FRONT END OF ION LINAC

A. Kovalenko, JINR, Dubna, Russia
A. Kolomiets, ITEP, Moscow, Russia

NICA Project at JINR

The two injectors intended:

- Heavy ions 0.16< Z/A <0.33
- Protons/light ions (0.33 ≤ Z/A ≤ 1) (including polarized p- and d- beams)

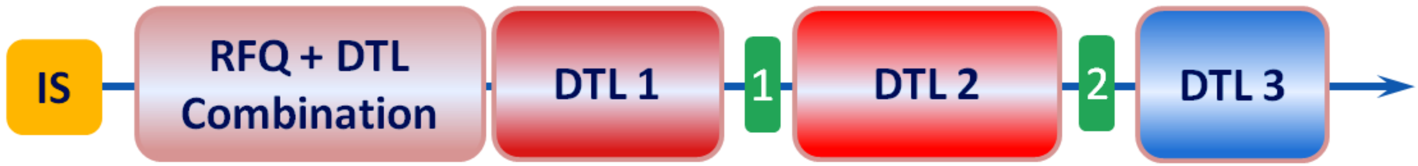


The two accelerator chains are realized:

- Heavy Ion Source KRION-6T → Heavy Ion Linac → Booster → Nuclotron → Collider;
- The sources (p, d (including polarized), light ions) → modernized existing linac LU-20 → Nuclotron → Collider.

The main goal of the work is design of compact and efficient linac that can be considered as light ion injector option for NICA project and also for other applications (say, medical synchrotrons).

Layout of Injector



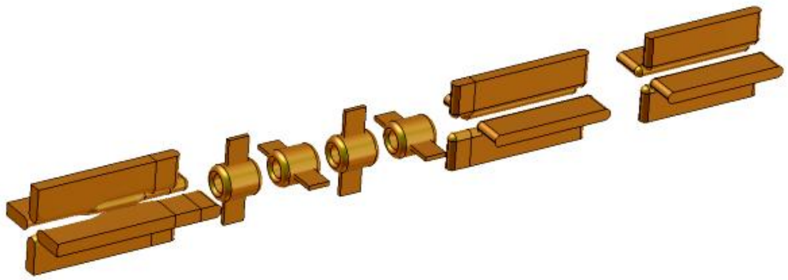
RFQ Parameters

Parameter	Value
Accelerating frequency, MHz	109.0
Voltage between the vanes and tubes, kV	132.0
Average radius, mm	7.50
Thickness of the electrodes, mm	5.25
Maximum modulation coefficient	2.0
Betatron phase advance at the focusing period (minimum), deg.	36
Transverse acceptance (normalized), cm·mrad	0.42
Regular RFQ length, m	3.0
Total combination length, m	3.55
Output beam energy, MeV/u	0.82
Injection energy, MeV/u	0.03
Beam transmission @ I = 10 mA	95%
Maximum electric field at the electrodes surface, kV/cm	227

Parameters of DTL Cavities

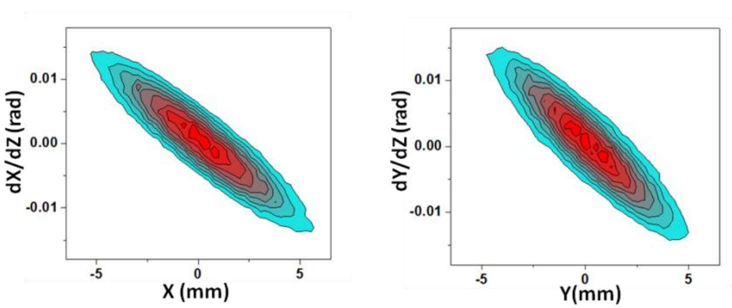
Parameter	DTL 1	DTL 2	DTL 3
Frequency, MHz	109	109	218
Aperture, mm	10.0	10.0	10.0
Number of acceleration gaps	10	13	11
Electric field at the drift tube surface, kV/cm	230	230	230
Gap length, mm	30.0	50.0	50.0
Gap voltage, kV	600.0	700.0	700.0
Cavity length, mm	830	1605	1200
Output energy, MeV/u	2.58	5.06	10.72

RFQ Output



The main feature of the RFQ is the new approach to the beam formation at the RFQ output that provides converging beam in both transverse planes as well as in longitudinal one. It is achieved by adding after regular RFQ vanes several drift tubes and RF quadrupoles that act as triplet. RFQ output beam can be directly injected into DTL cavity.

Calculated Emittances at RFQ Output

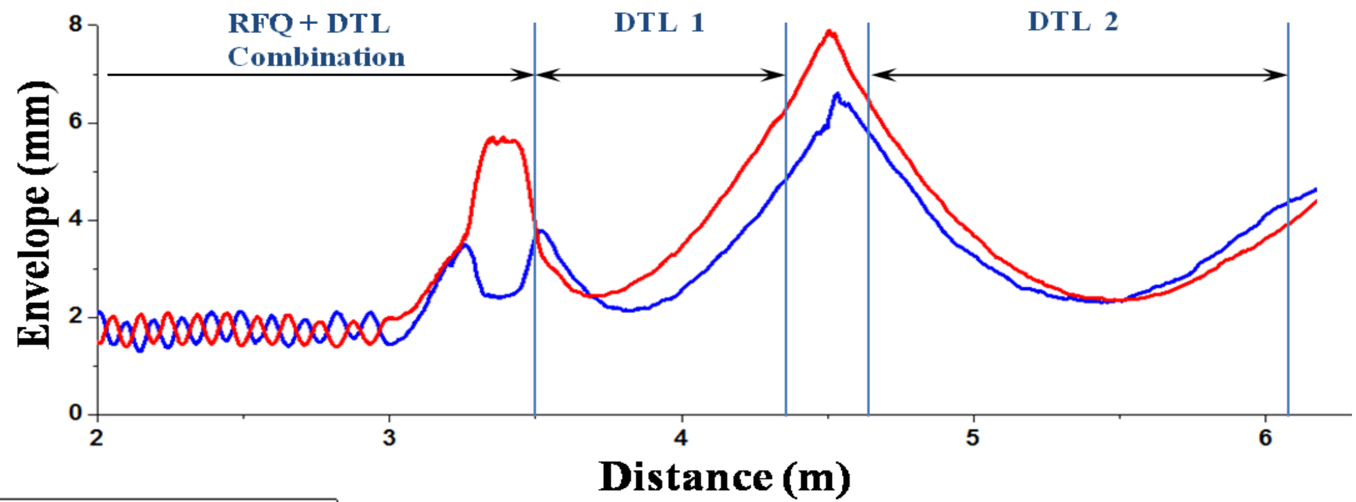


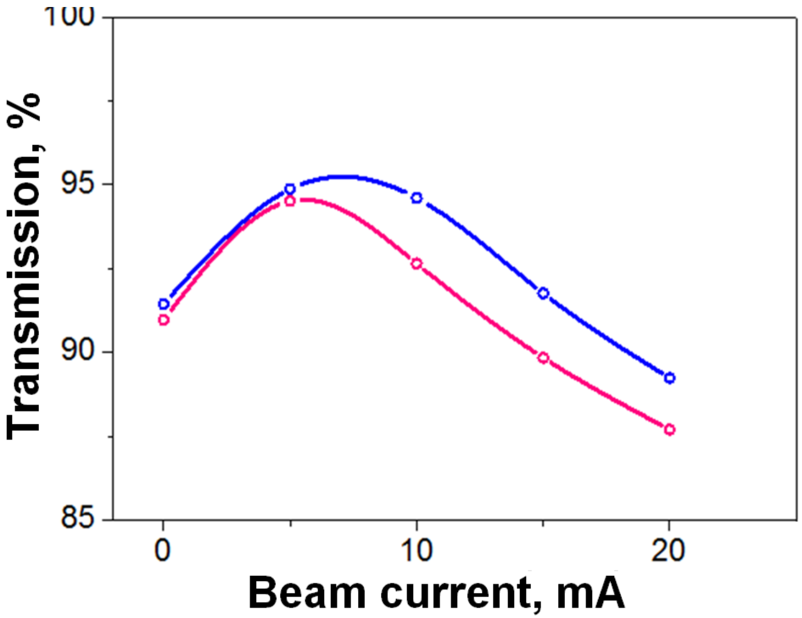
Twiss Parameters at RFQ Output

Beam current, mA	α_x	α_y	β_x m/rad	β_y m/rad
0	1.82	1.95	0.468	0.656
5	2.04	2.40	0.494	0.767
10	2.00	2.63	0.484	0.833
15	1.96	2.04	0.477	0.650

Beam Simulation Results

Calculated Transverse Envelopes





Transmission vs Beam Current

Blue – RFQ output

Red – injector output

Summary

Results of development and computer study of light ion injector for NICA project show that proposed combination of RFQ and Hybrid structure provides beam with parameters required for direct injection into following DTL cavity.

Injector with total length L_{tot} = 6 m accelerates ions with Z/A = 0.33 up to an energy of W = 5 MeV/u. Accelerating structures are designed for conservative surface field $E_s \leq$ 230 kV/cm to guarantee reliable operation.

This approach allows designing injector front end without MEBT with additional focusing and rf elements. It can be useful option for designing of new ion linacs including carbon ions and protons injector of medical synchrotron as well.