Theory and simulations of highly charged ion beam emittance, extracted from EBIS\ESIS ion source: influence of the magnetic field, the dip of the electron beam\string potential and the ion beam space charge.

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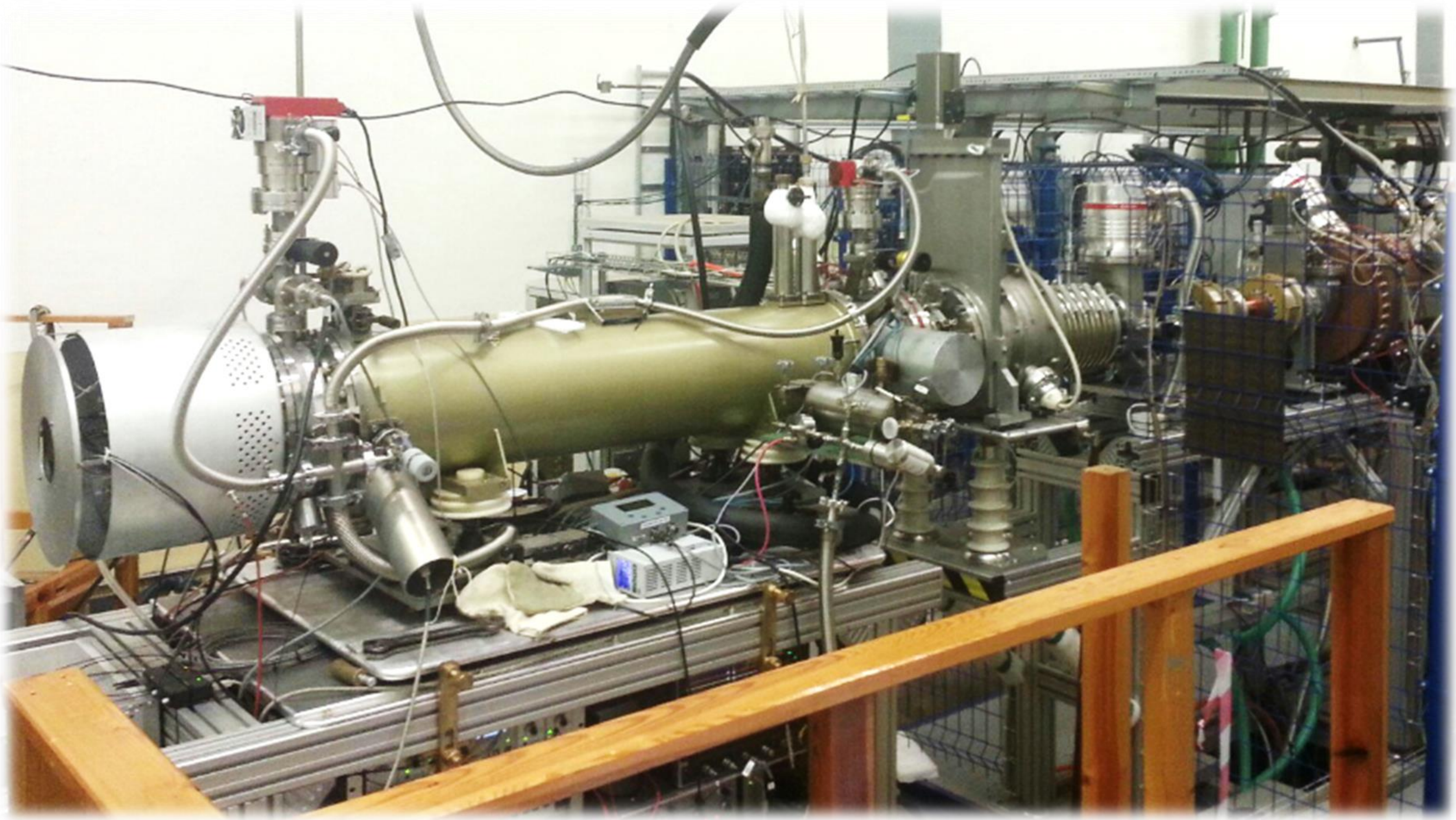
KRION-6T



Contribution into transverse ion beam emittance:

- crossing of ESIS solenoid magnetic flux by the ion beam extracted from ESIS paraxially
- ions temperature prior their extraction from ESIS ion trap
- ion beam space charge

Crossing magnetic flux factor

$$\varepsilon_{mag} = \frac{qB}{8m_{ion}c} r_{e^-}^2$$

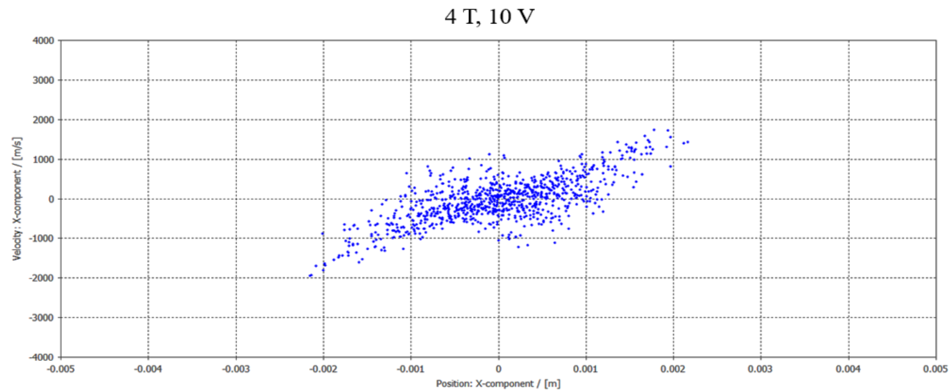
q – the ion's charge

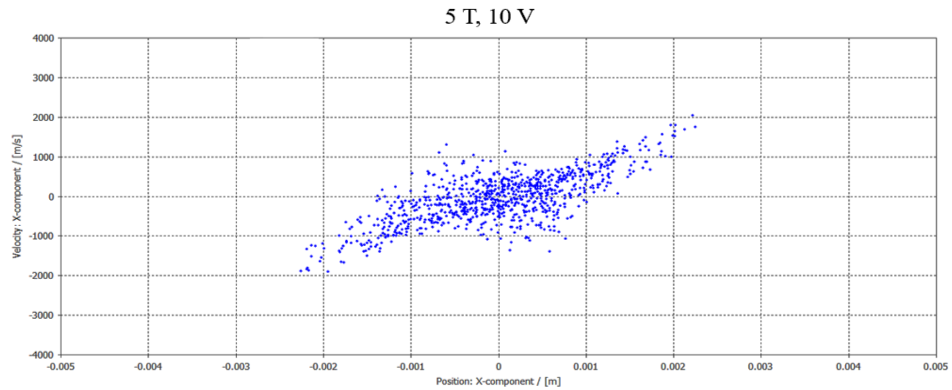
m_{ion} – the ion's mass

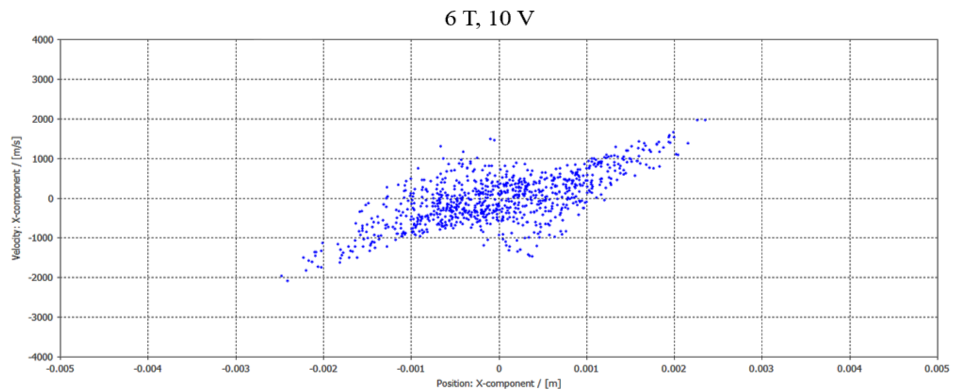
B – strength of magnetic field in solenoid

r_{e^-} – an electron beam radius

$B\ (T)$	4	5	6
$\varepsilon_{n_{mag}}\ (\mu m)$	0.0004	0.0005	0.0006

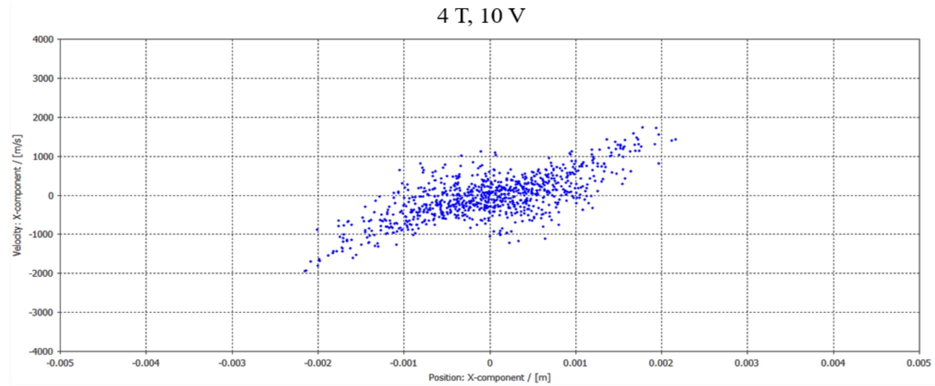






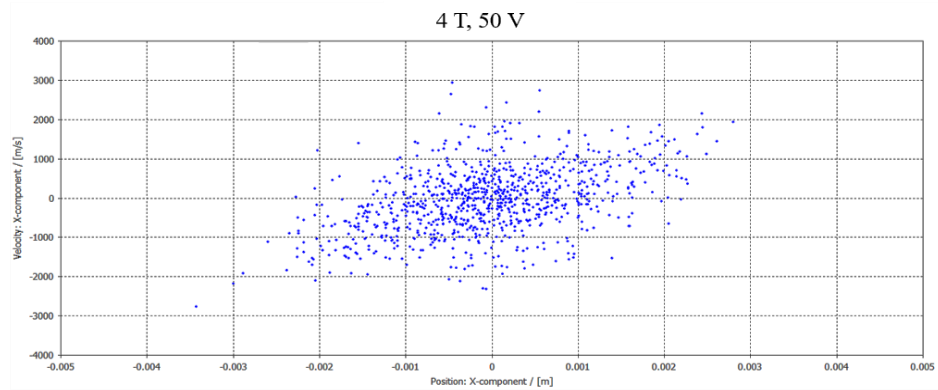
Ions temperature factor

$$\varepsilon_T = \frac{r_{e^-}}{2}\sqrt{\frac{kT_{ion}}{m_{ion}c^2}}$$

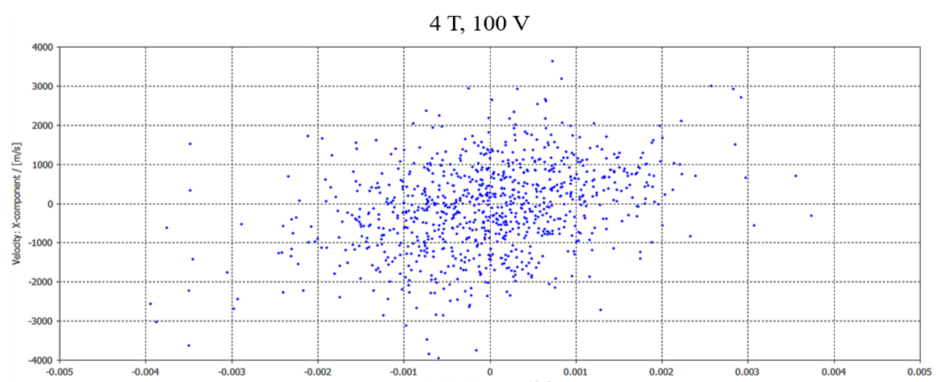


c – speed of light

kT_{ion} is determined by the dip of the electron string potential



ΔV (V)	ε_T (μm)
10	0.00098
50	0.0022
100	0.003

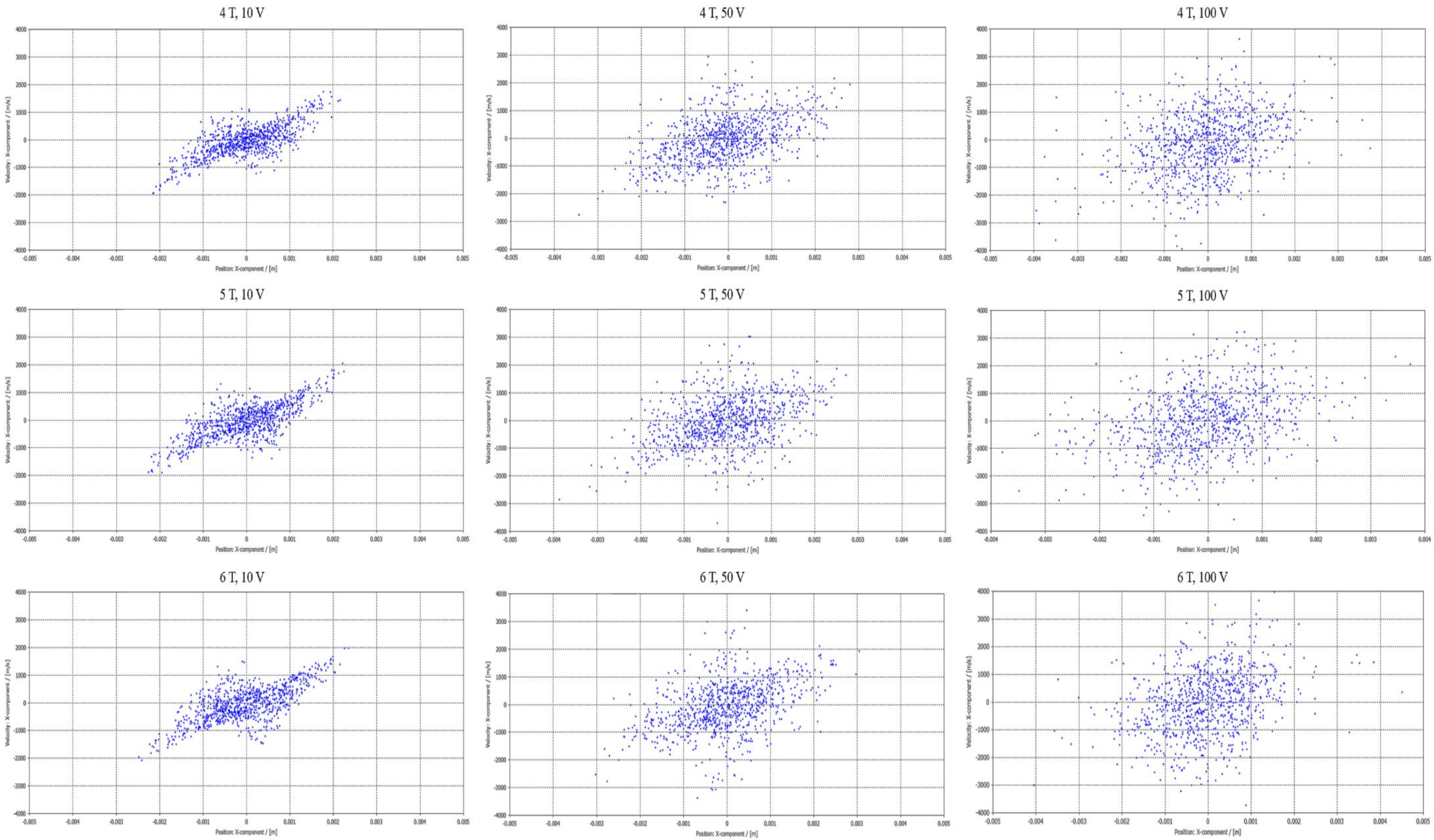


Correspondence between the analytical estimates and simulation

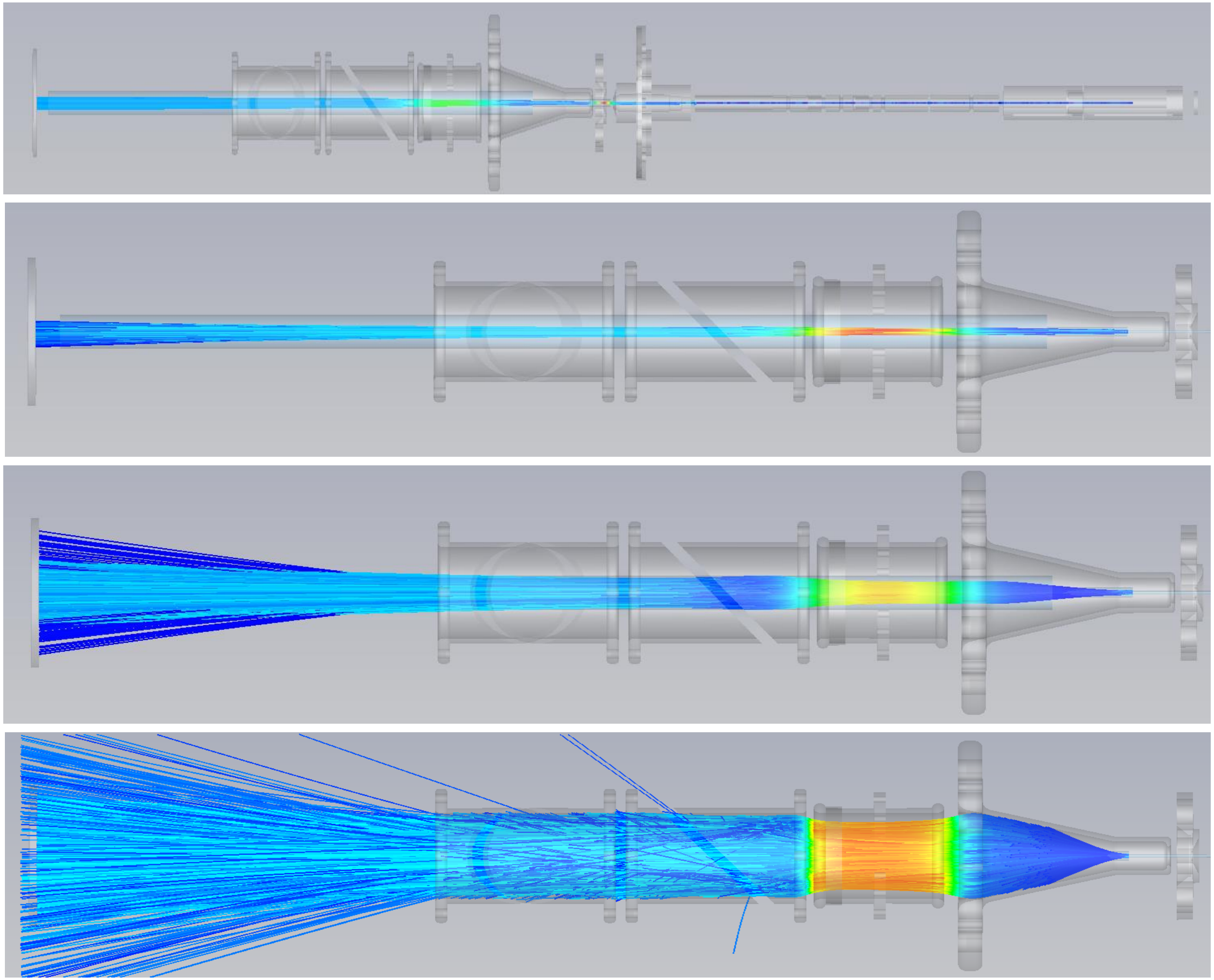
$$\varepsilon = \sqrt{\varepsilon_T^2 + \varepsilon_{mag}^2}$$

$B\ (T)$	$\Delta V\ (V)$	$\varepsilon_{analytic}\ (\mu m)$	$\varepsilon_{CST}\ (\mu m)$
4	10	0.00106	0.00072
	50	0.0022	0.00226
	100	0.0031	0.00314
5	10	0.0011	0.00087
	50	0.00222	0.00212
	100	0.00311	0.00313
6	10	0.00115	0.00101
	50	0.00224	0.00225
	100	0.00313	0.00329

Correspondence between the analytical estimates and simulation



Space-charge factor



No space charge

Current: 10 µA

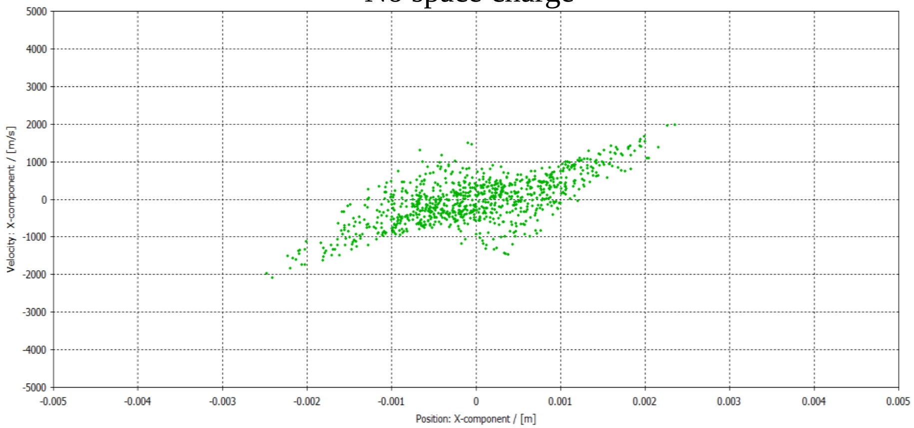
Current: 0.1 mA

Current: 1mA

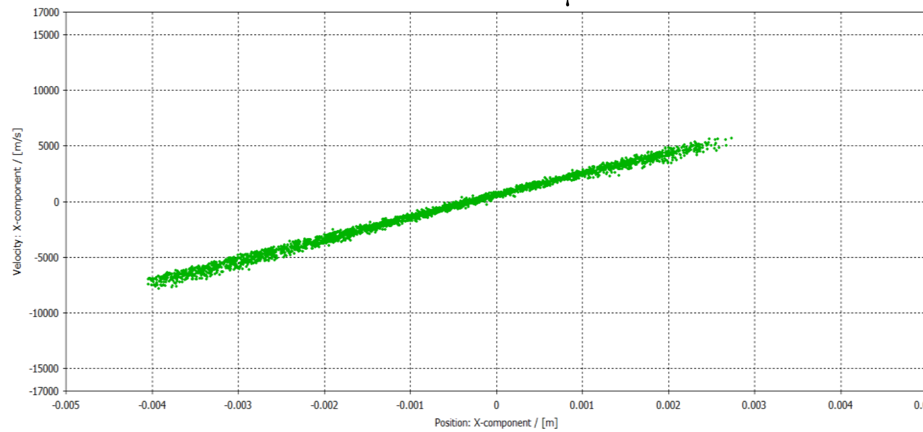
Space-charge factor

$B\ (T)$	$\Delta V\ (V)$	$Current\ (mA)$	$\varepsilon(\mu m)$, without space charge	$\varepsilon(\mu m)$, with space charge
6	10	0.01	0.00115	0.00301
		0.1		0.007
		1		0.035

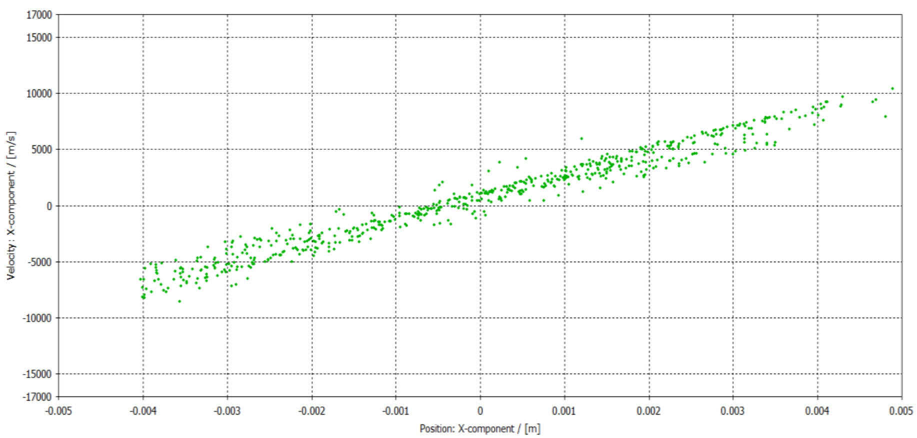
No space charge



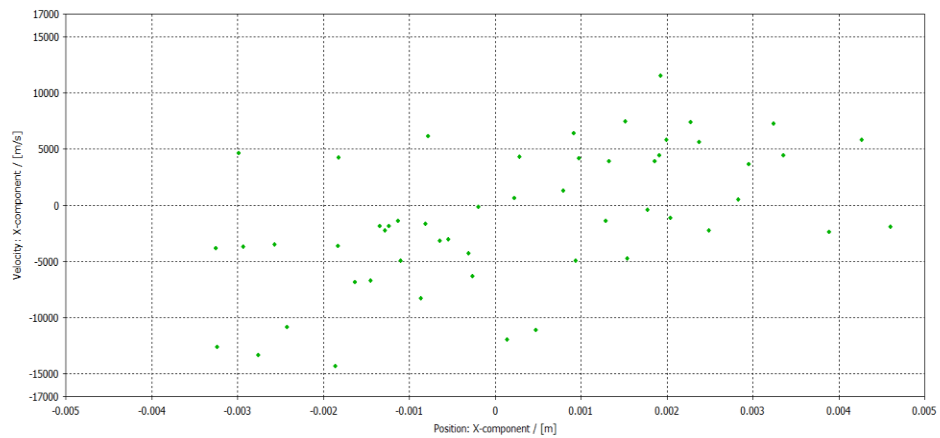
Current: 10 μA



Current: 0.1 mA



Current: 1 mA



Conclusion

- The influence of the magnetic field, ion temperature and space charge on the emittance of the beam formed in the ESIS KRION was studied
- Space charge factor – the largest contribution, need to use lenses;
- Thermal and magnetic emittance makes smaller effect
- Analytical calculations are consistent with numerical simulations of CST

Final results will be discussed in framework of injection efficiency estimation for the present configuration of NICA injection complex

Thank you for attention!