Recuperation electron beam in the coolers with electrostatic bending

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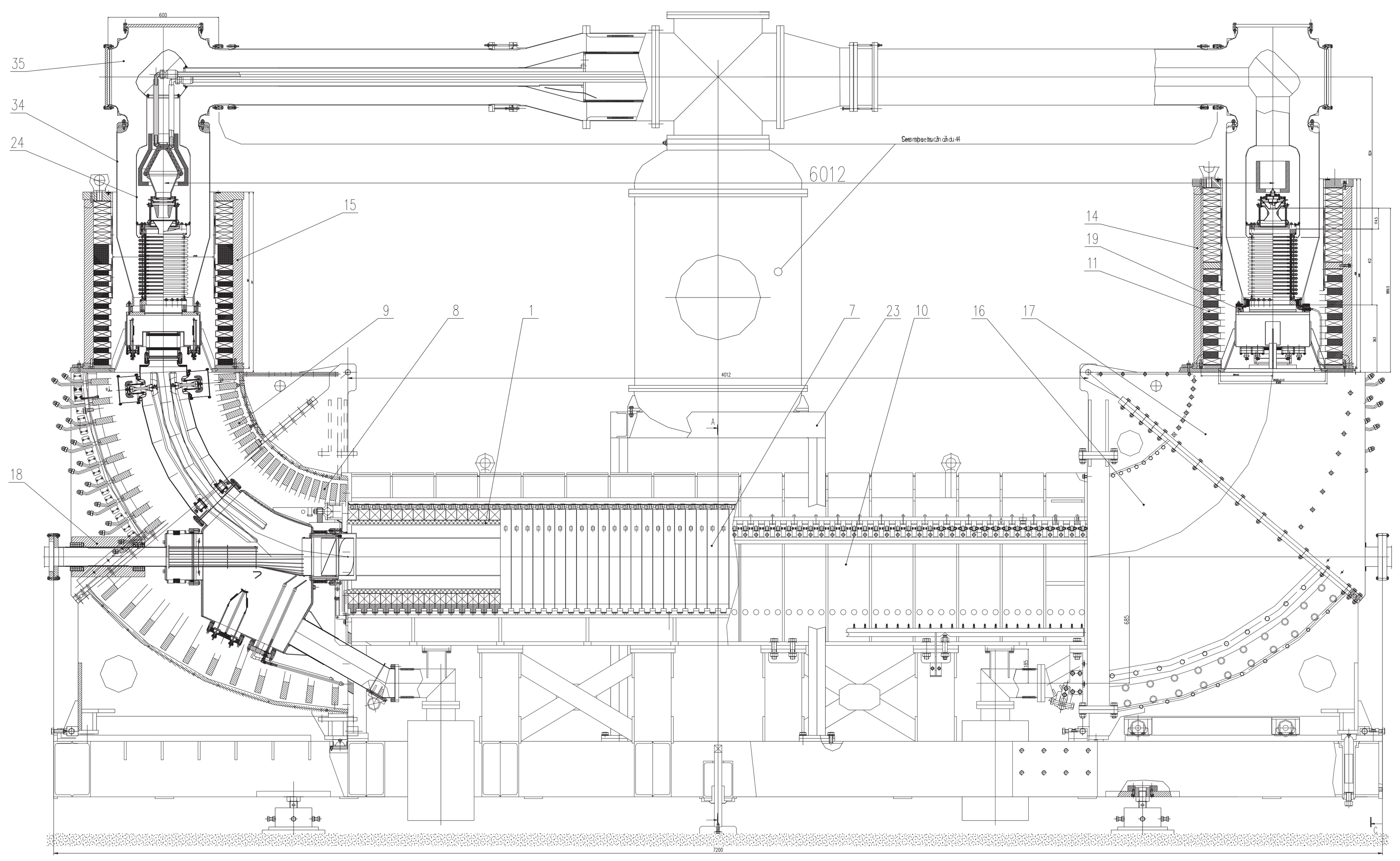
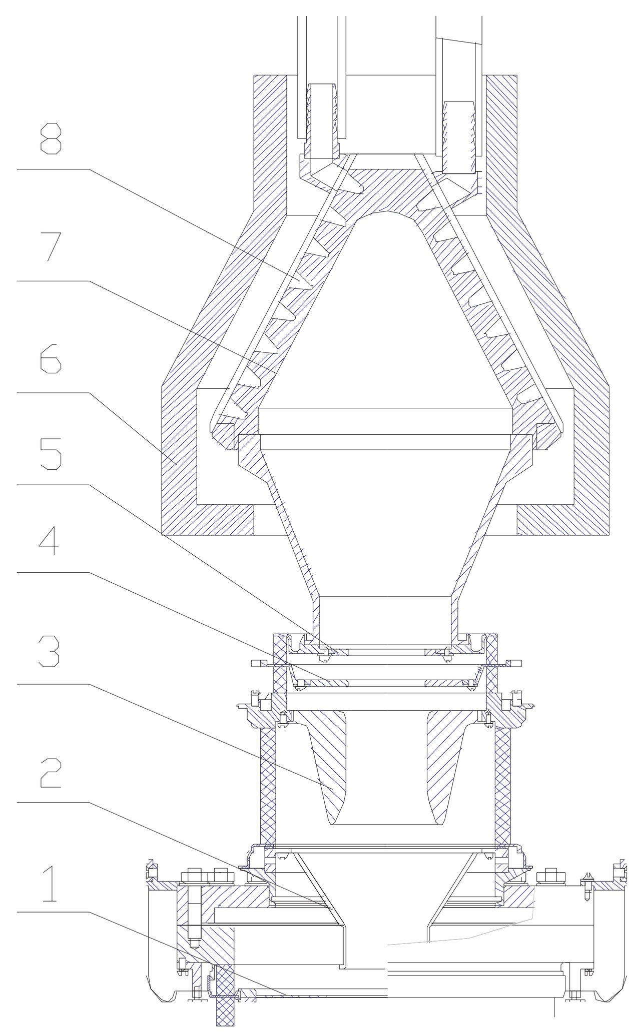
EC-300



Electron cooler EC-300 with the electrostatic bending

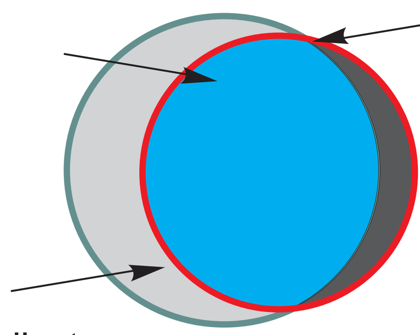
Collector

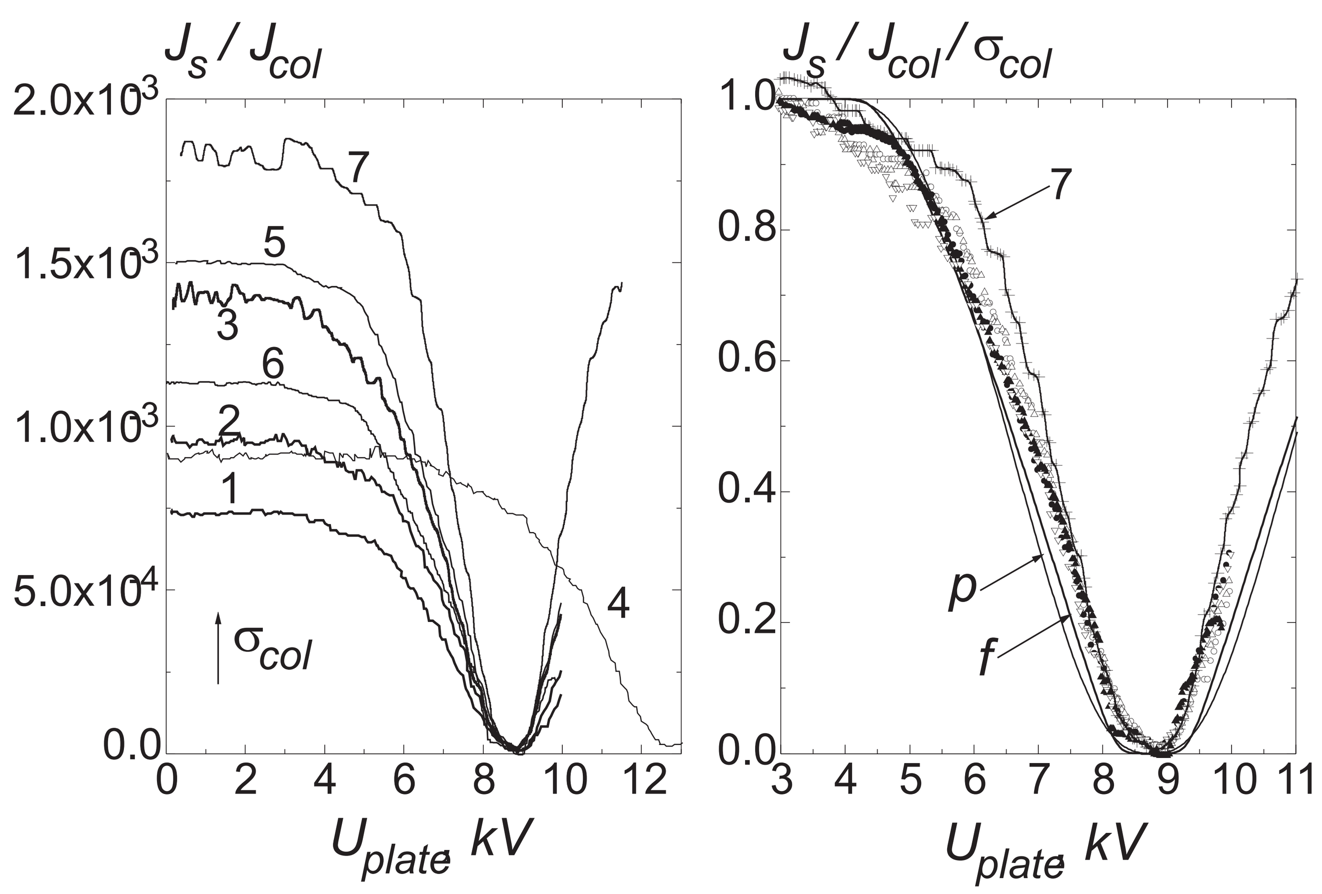


1. Last deaccelerator electrode
2. Collector input
3. Input collector electrode
4. Suppressor
5. Collector apperture plate
6. Magnetic flux concentrator
7. Collector surface
8. Cooling system

Profile of the secondary beam flux

The radial profile of the flux of the secondary electron was estimated in the experiment when centrifugal force is produced by combination of the magnetic and electric fields. Combir magnetic and electrostatic bending the primary electron beam is aimed to the collector. ' secondary electron is shifted in the horizontal direction depending on ratio between the electr field on electrostatic plates and magnetic field in the correction coils. At pure magnetic bending secondary electrons has the maximal displacement so the large leakage current is observed. electrostatic bending the both beams don't drift and the leakage current is minimal.

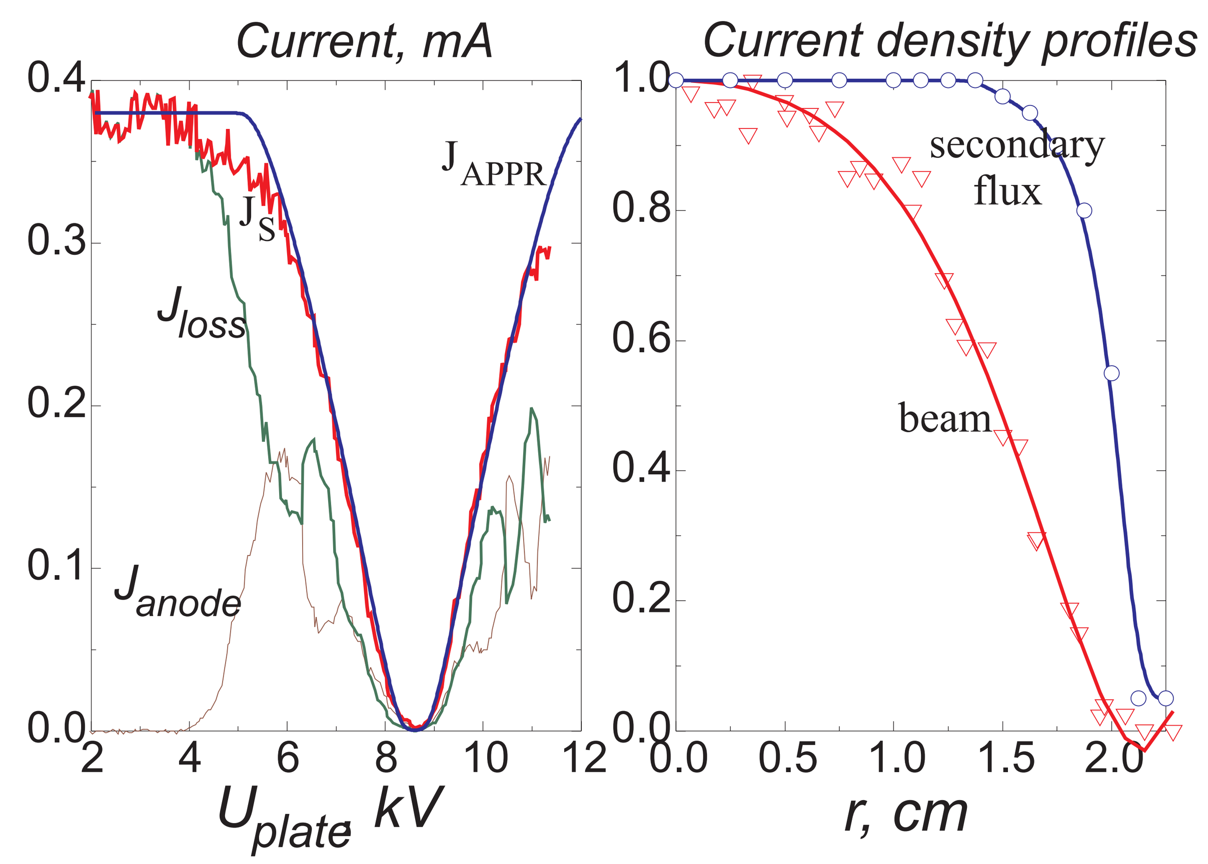




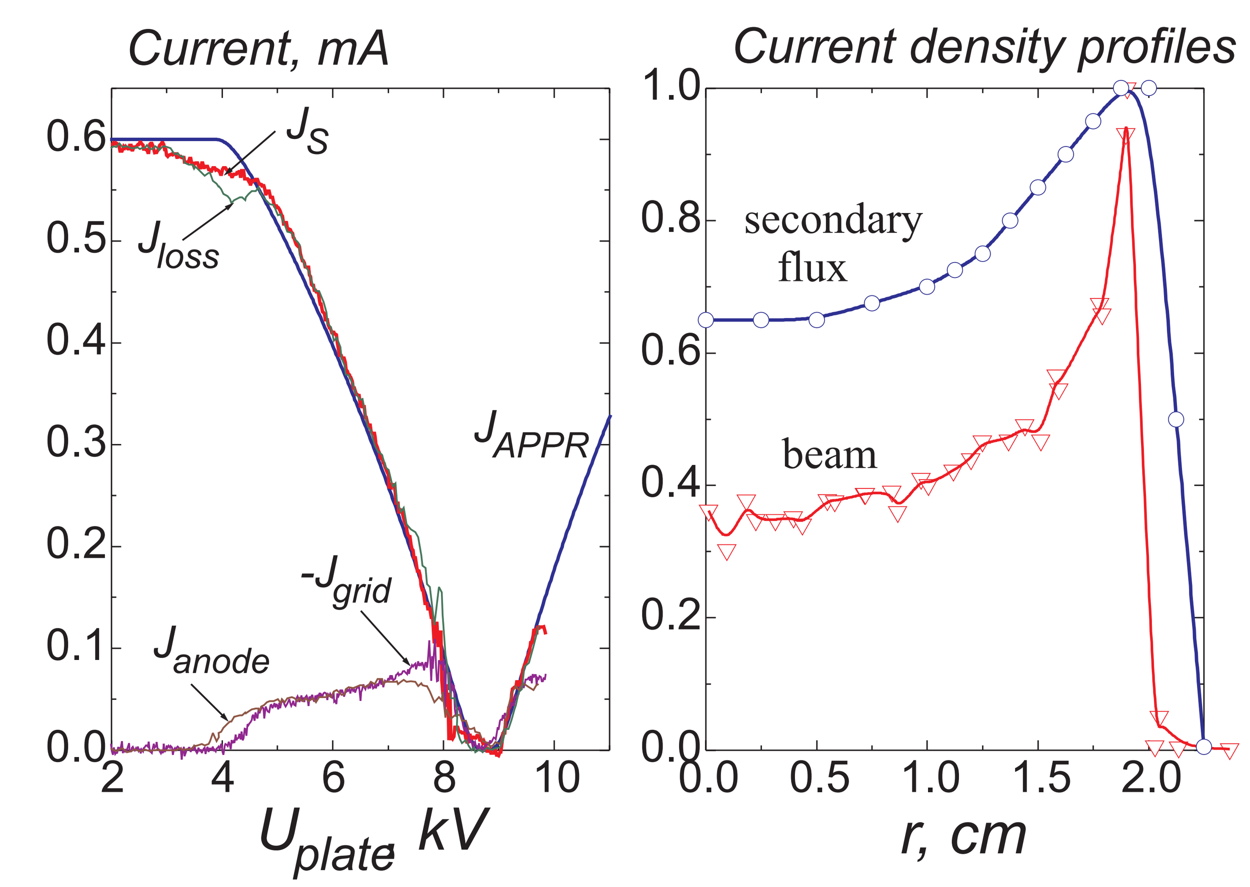
Leakge current versus the electrostatic plates voltage for the different regimes. The left picture is the same but it is normalized on the collector efficiency (the collector loss at U_{plate}=0). The curves p and f are constructed with a parabolic and flat profiles of the secondary electrons. The model of "moon-phase" is used for leakage current estimation.

Table 1. Parameters of measurements.

metering number	U_{anode} kV	U_{grid} kV	U_{supp} kV	U_{coll} kV	J_{coll} A	$U_{cathode}$ kV	ó$_{coll}$	U_{grid}/ U_{anode}	Character of current density profile
1	3.03	0.038	0.04	1.4	0.192	-100.9	7.4?10^{-4}	0.013	negative-going parabolic
2	3.03	0.048	0.04	1.99	0.200	-100.95	9.6?10^{-4}	0.016	negative-going parabolic
3	3.03	0.051	0.04	3.93	0.197	-100.9	1.4?10^{-3}	0.017	negative-going parabolic
4	3.03	0.08	0.04	1.92	0.210	-150.2	9?10^{-4}	0.026	negative-going parabolic
5	3.03	0.25	0.41	1.95	0.317	-100.9	1.5?10^{-3}	0.083	flat
6	3.03	0.54	0.4	1.88	0.524	-100.7	1.1?10^{-3}	0.178	flat + positive-going parabolic
7	3.03	0.056	0.44	2.41	0.207	-100.8	1.8?10^{-3}	0.018	negative-going parabolic



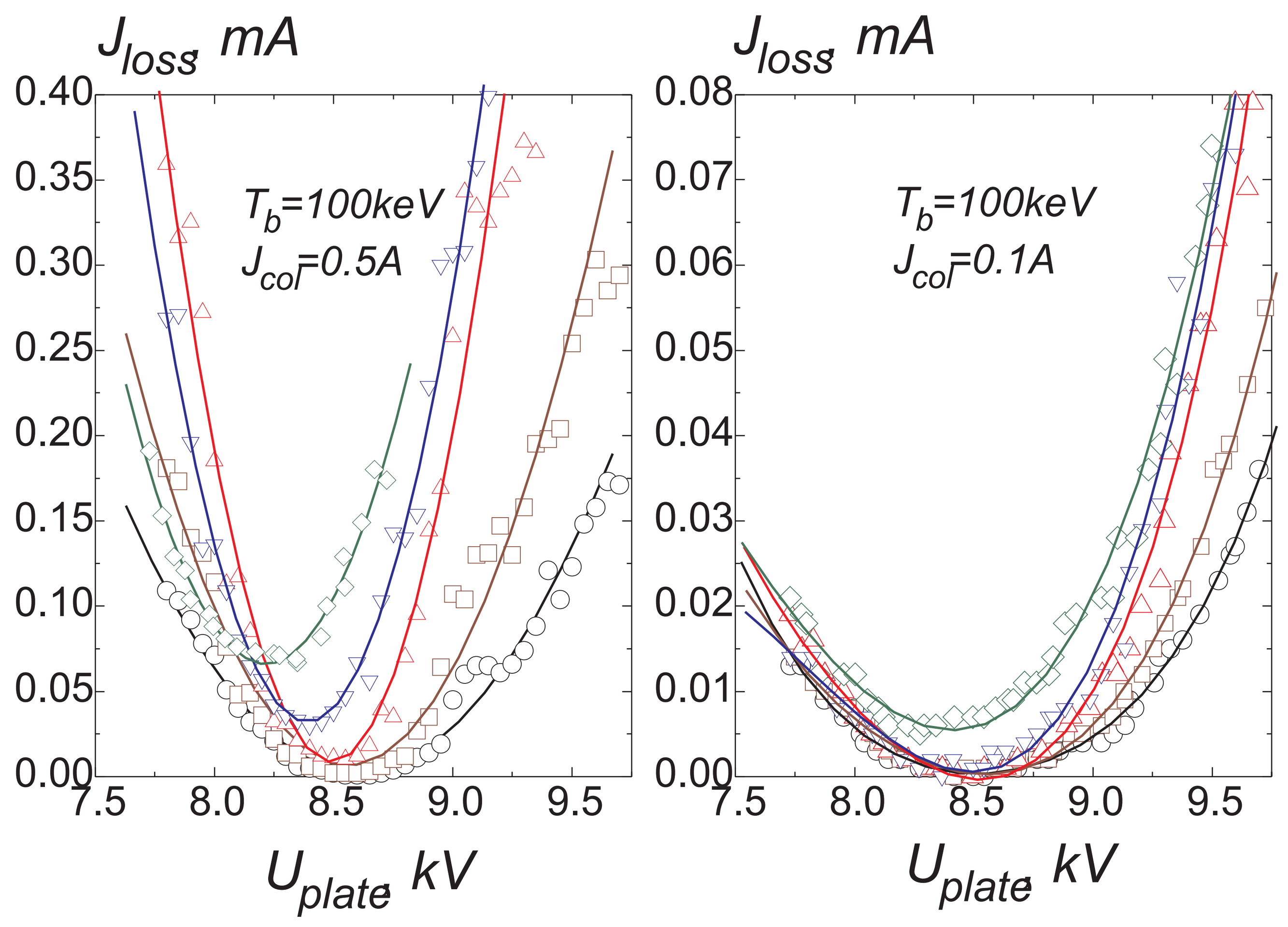
Metering 7 in Table



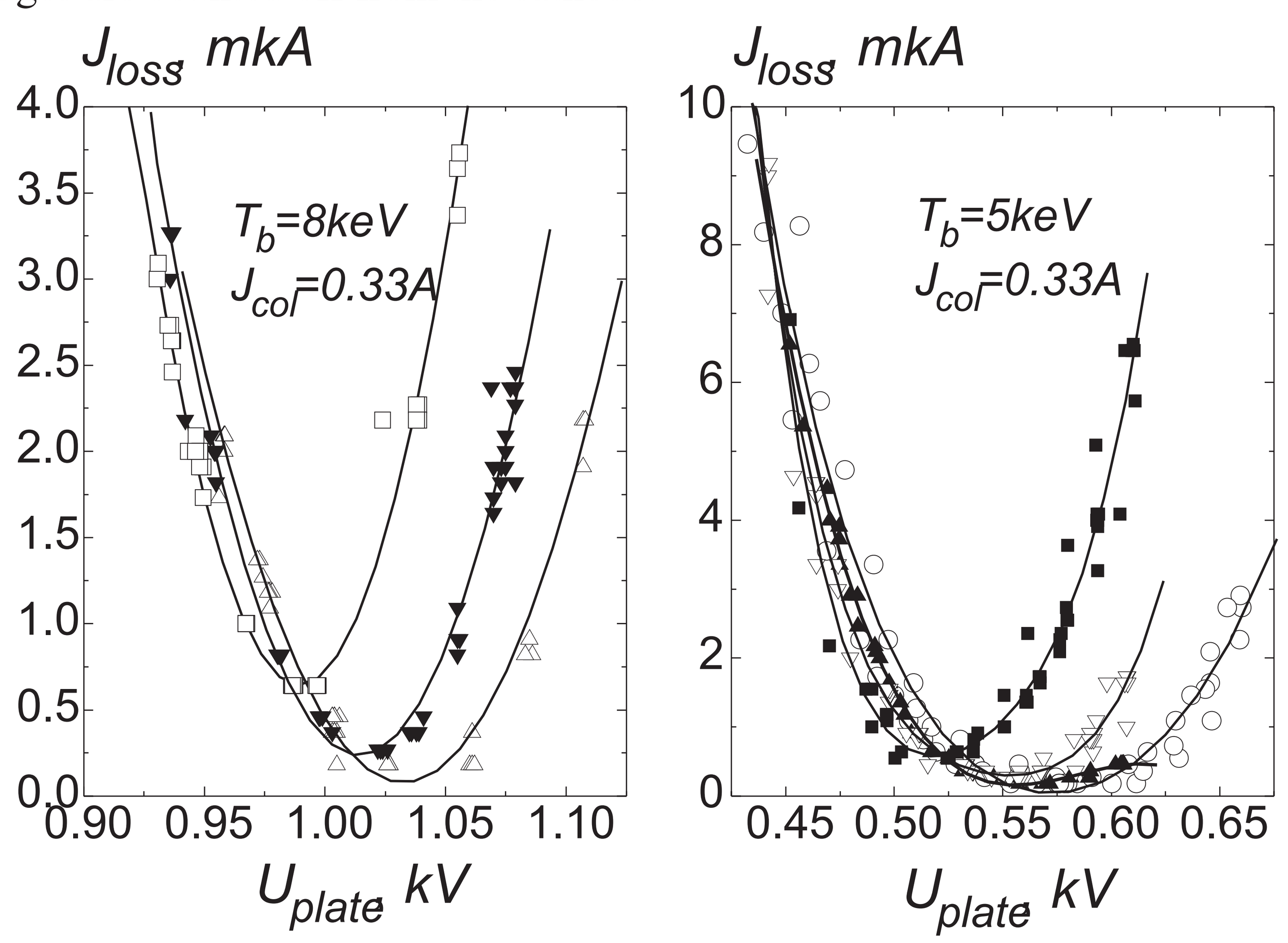
Metering 6 in Table

Optimal voltage on the electrostatic plates

Suppressor voltage

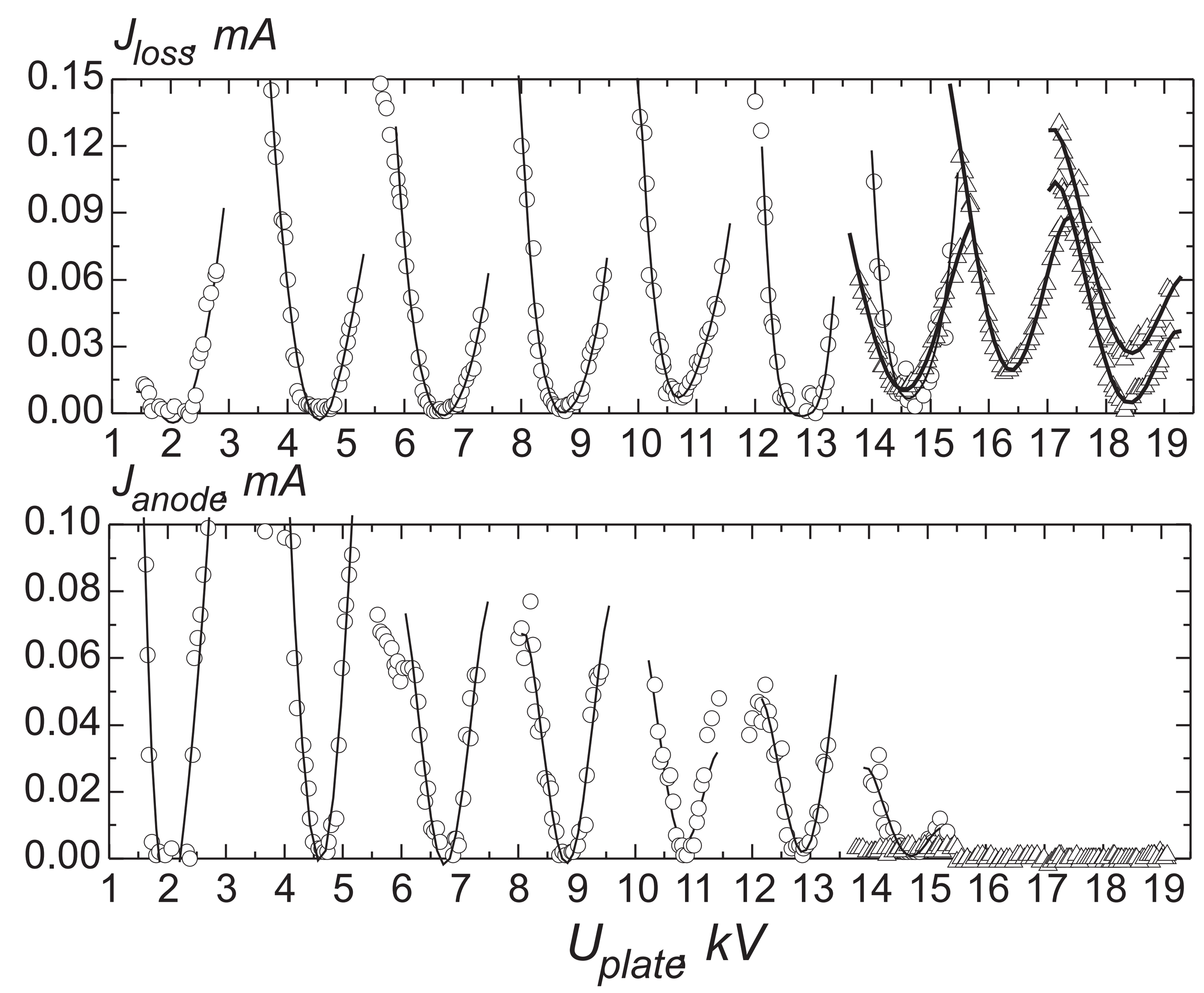


EC-300. Leakage current versus the voltage of electrostatic plates for the different value of the suppressor voltage. The electron beam parameters: $U_{an}=3$ kV, $U_{grid}=0.5$ kV, $U_{cath}=-100$ kV, $U_{sup}=0.42$, 1.0, 2.1, 3.0 and 4.5 kV (from right to left), $U_{col}=4.1$ kV, $J_{col}=0.5$ A (left picture); $U_{an}=3$ kV, $U_{grid}=-0.2$ kV, $U_{cath}=-100$ kV, $U_{sup}=0.42$, 1.0, 2.1, 3.0 and 4.5 kV (from right to left), $U_{col}=4.1$ kV, $J_{col}=0.1$ A (right picture). All voltages are counted off from the cathode.



EC-30. Leakage current versus the voltage of electrostatic plates for the different value of the suppressor voltage. The magnetics fields in the cooer: $B_{TOR}=0.5kG$, $B_{COL}=0.8kG$. The electron beam parameters for left picture $U_{coll}=2.55kV$, $U_{anode}=2kV$, $U_{cath}=-8kV$, $U_{grid}/U_{anode}=0.077$ and $J_{coll}=0.33A$. The shape of the beam is nearly flat The suppressor voltage is $U_{sup}=0.017$, 0.52 and $1kV$. The electron beam parameters for right picture $U_{coll}=2.55$ kV, $U_{anode}=2$ kV., e $U_{cath}=-5$ kV, $U_{grid}/U_{anode}=0.077$ and $J_{coll}=0.33A$. The shape of beam is nearly flat. The suppressor voltage is (U_{plate}) at $U_{sup}=0.02$, 0.22, 0.52 and $1kV$.

Electron energy



Accuracy is enough for determination of optimal plate voltage. Optimal plate voltages are dependent as ãâ^2 (1) but measured values U_{opt} correspond to electron energy T_b - (2±0.5)keV. Probably such difference results from energy loss of leaving electrons.

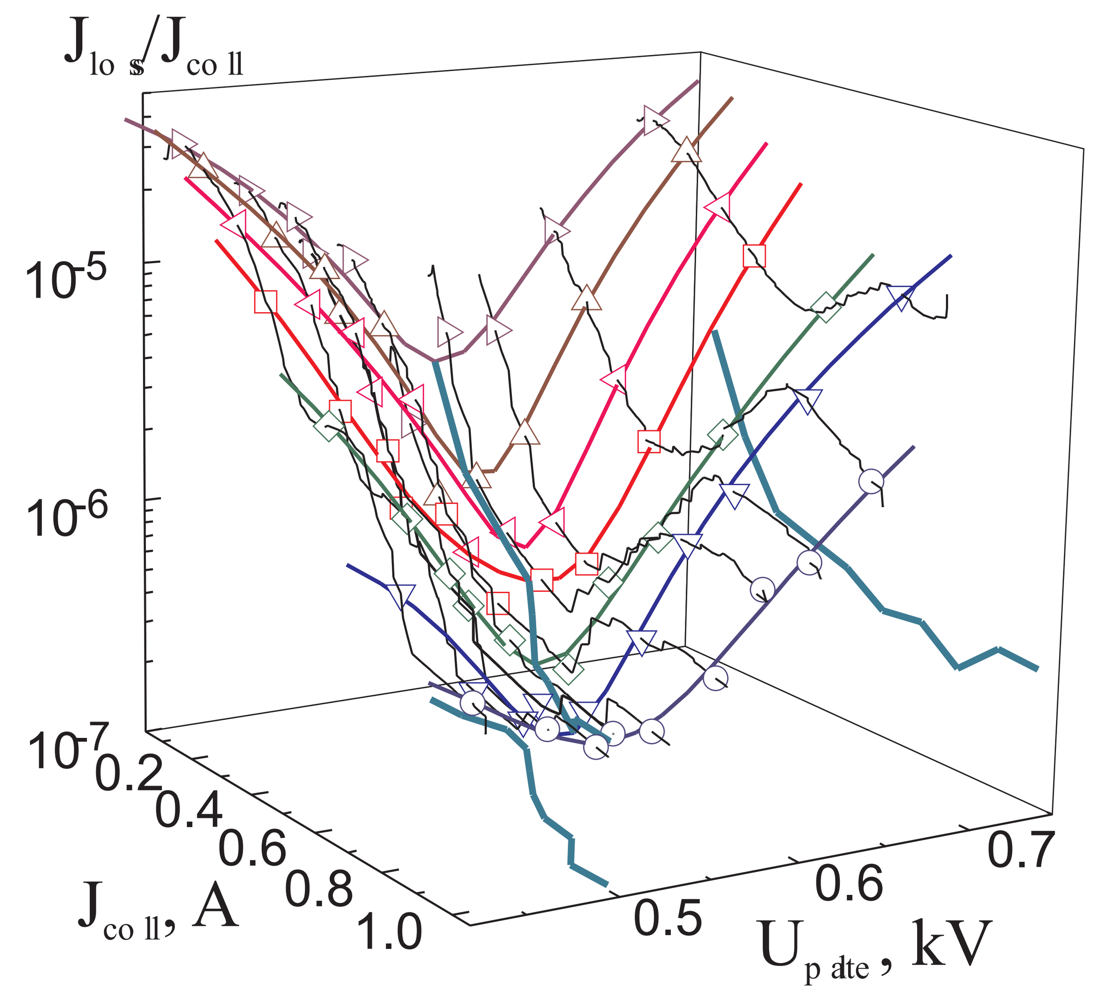
Summary

The collector can be reused at some optimal plate voltages U_{opt}. The main part of the secondary electrons is returning into the collector and the recuperation level can be done (~10^{-6}) that is much less than degree of collector efficiency (~10^{-3}). The density profile of secondary electron flux depends on beam density profile weakly. The flux density in outer layer is equal or some larger than inside. The important detail is presence of outputting secondary electrons in small gap (0.25cm) between the collector aperture and the beam.

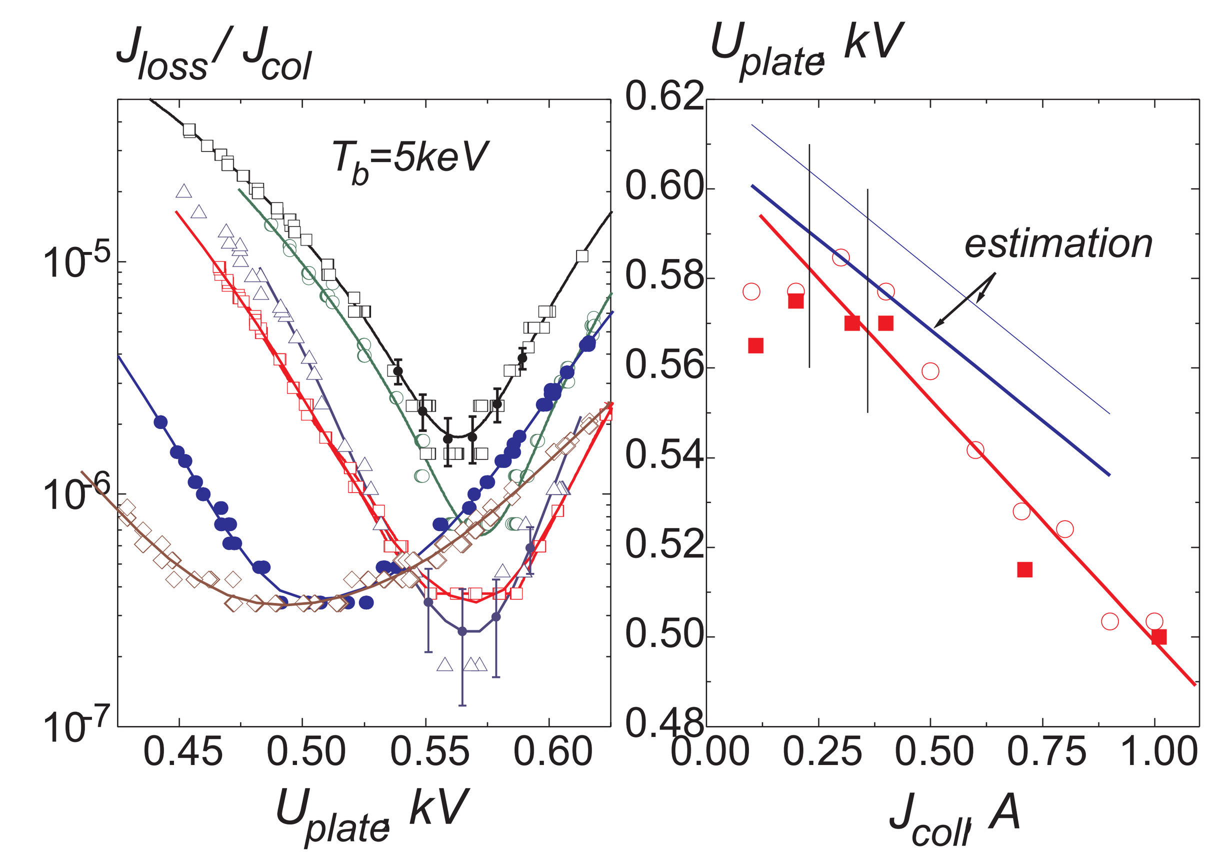
The optimal plate voltages U_{opt} for leakage current minimization are proportional to ã·â but the measured values U_{opt} correspond to energy of leaving electrons which some less than the beam energy T_b. The observed energy shift may be explained by energy spectrum of secondary electrons.

Measured recuperation levels at U_{plate} ?U_{opt} change inversely proportional to J_{coll}, i.e. inversely proportional to space charge potential into collector. Recuperation levels appreciably depend on suppressor voltage. Optimal voltages U_{opt} is independent of beam current J_{coll} at T_b ? 24 keV.

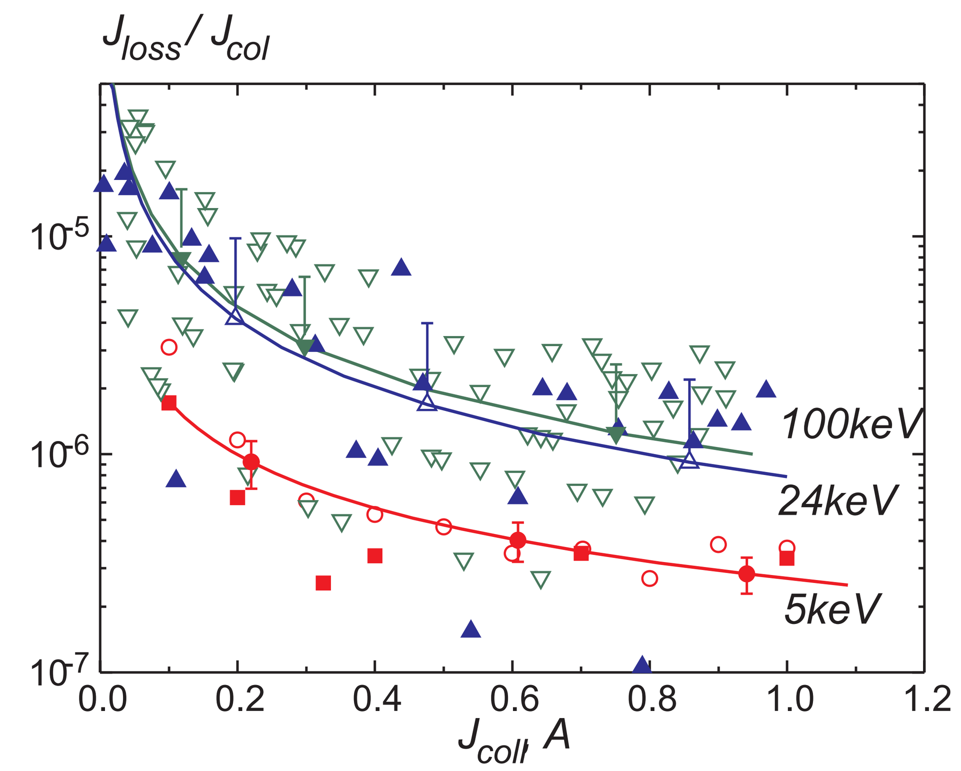
Current



Loss current versus the electrostatic plates voltage and the electron current. **EC-40.** Measurements was done at $B_{TOR}=0.5$kG, $B_{COL}=0.8$kG, $U_{coll}=2.6$ – 2.8kV, $U_{anode}=2$kV, $U_{sup}=0.23$ kV and $U_{cath}=-5$ kV.



Leakage current versus at the different electron current $J_{coll}=0.2$, 0.325, 0.4, 0.7 and 1A (left picture).



Recuperation level as function beam current at different beam energies