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Low Energy Beam Transport and Diagnostic

Status of the He^+ Test Injector

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Riezlern 2004

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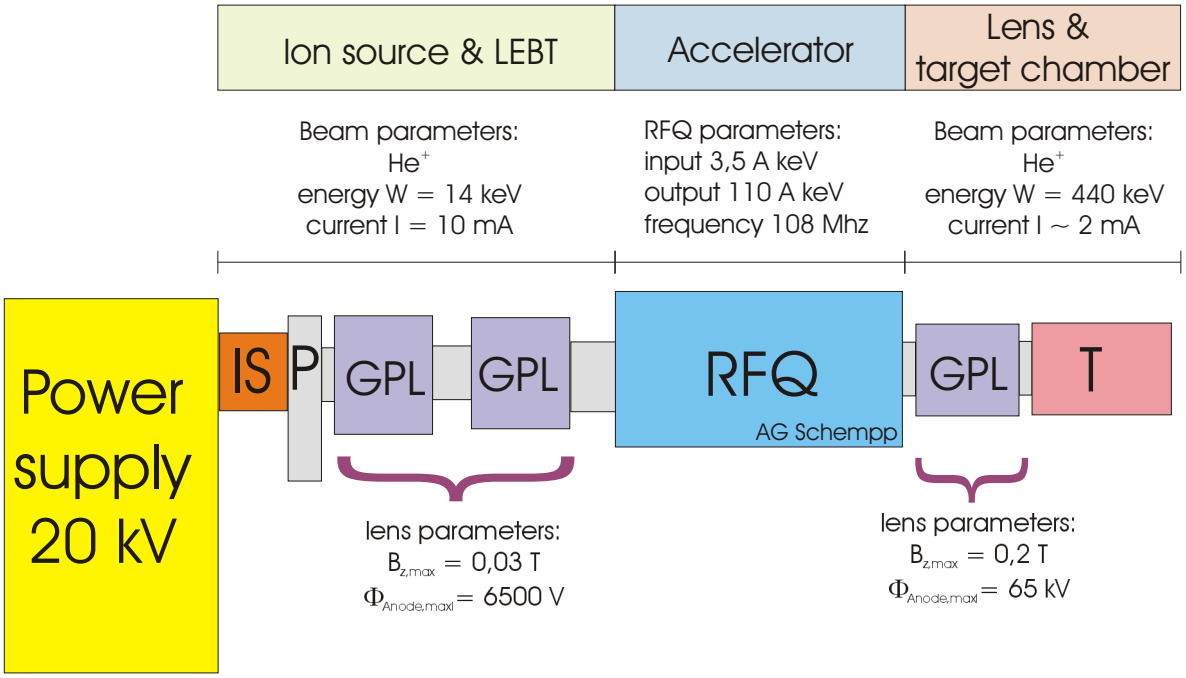
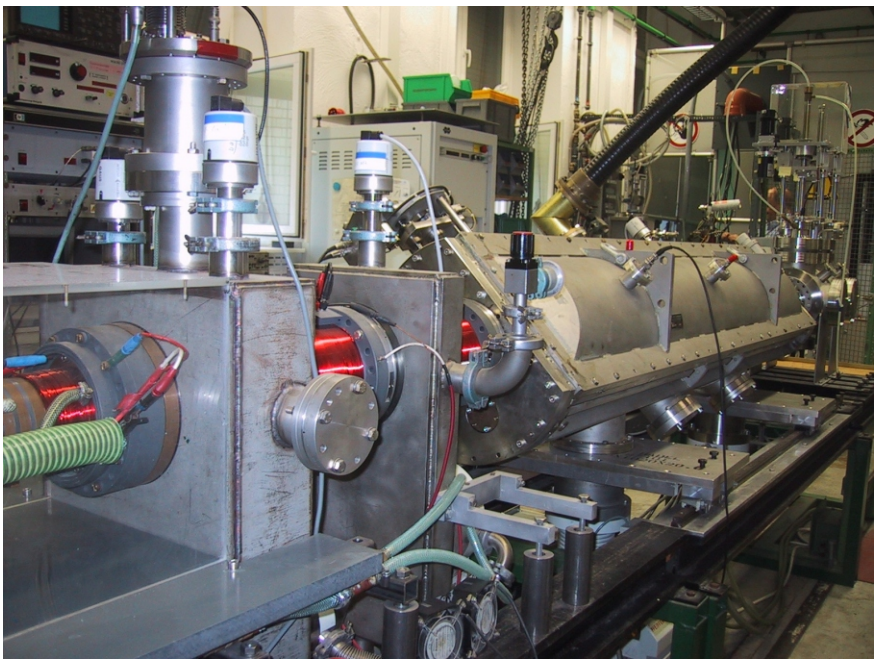
Layout of the He+ Test injector





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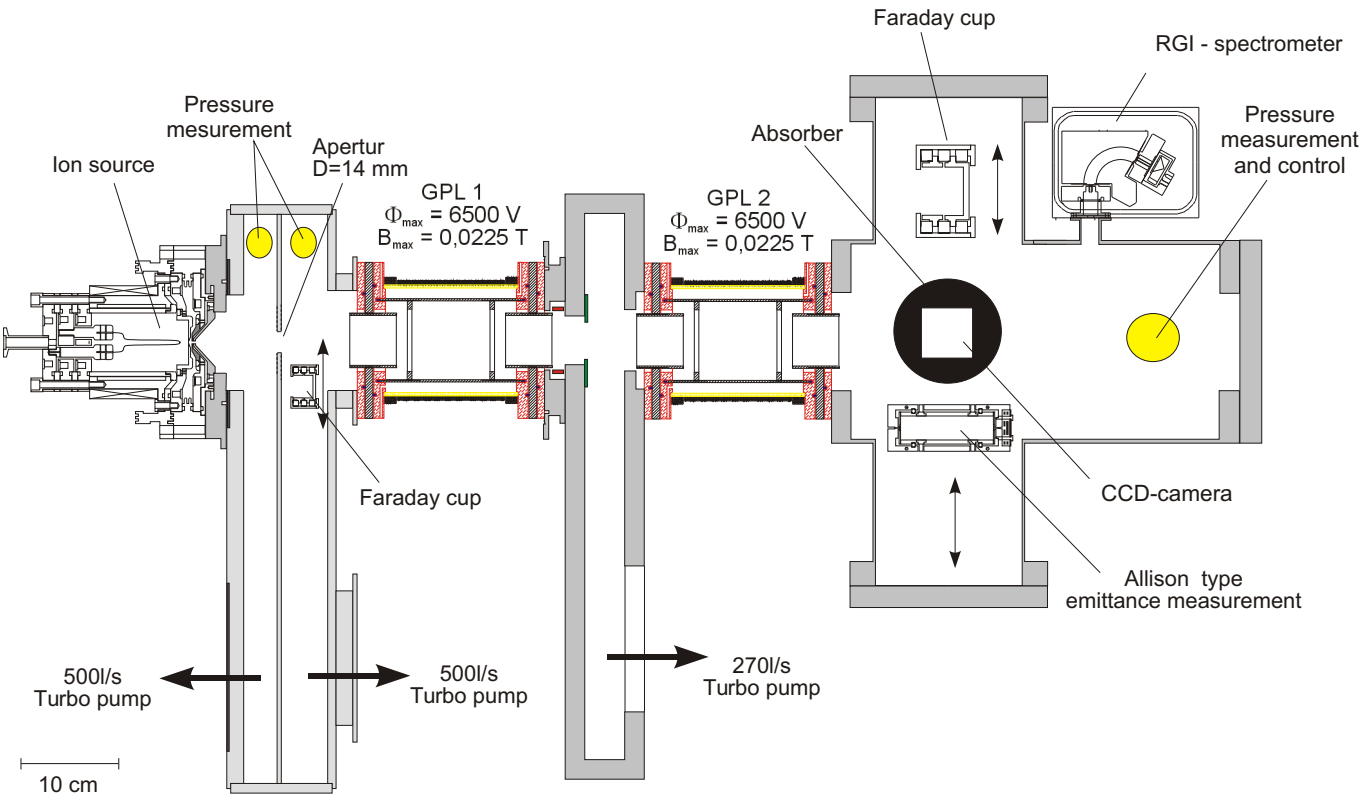
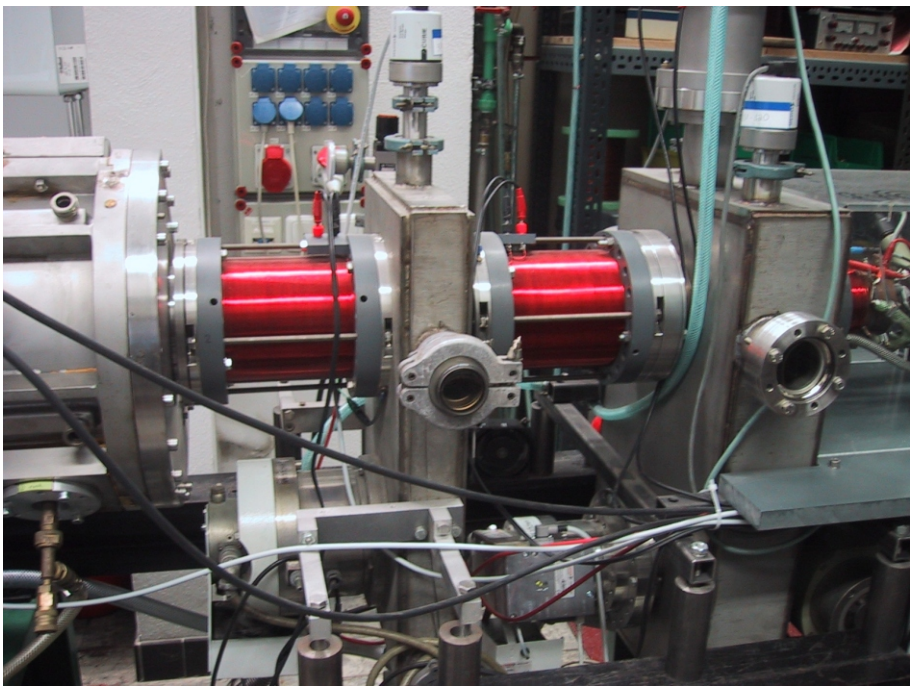
Layout of the LEBT - Section





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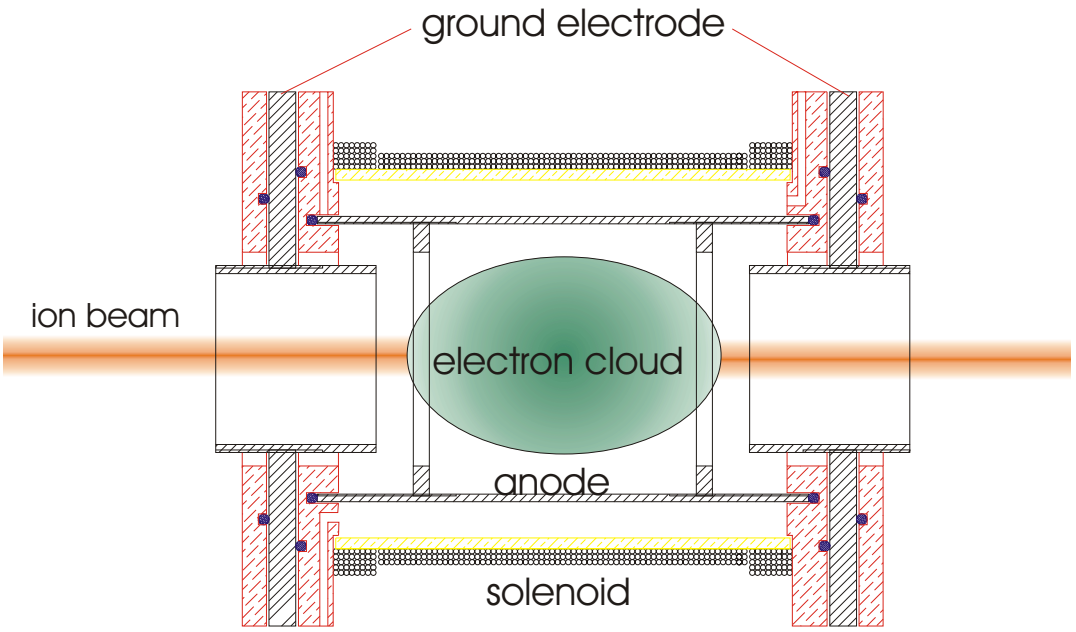
Gabor Lens: Space Charge Lens



radial enclosure condition

charge carrier in a magnetic field
equation of motion:

$$m_e \frac{dv}{dt} = -e \cdot (E_{space} + v \times B)$$

angular velocity

$$\Theta' = -\underbrace{\frac{eB_z}{2m_e}}_{\omega_l} + \frac{c}{r^2}$$

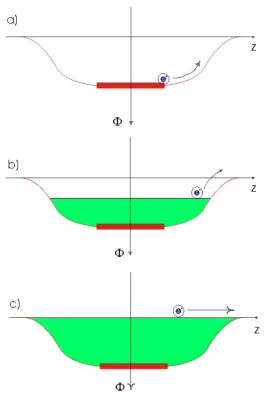
maximum density

$$E(r) = \frac{1}{\varepsilon_0 r} \int_0^r \rho_{\max}(r') r' dr$$

$$\rho_{e,\max,rad} = \frac{e\varepsilon_0 B_z^2}{2m_e}$$

e	elementary charge
B_z	magnetic field
ε_0	permittivity of free space
$\rho_{e,max,rad}$	electron density
m_e	electron mass

longitudinal enclosure condition



simple assumption

$$\Phi(r = 0) = 0$$

for homogeneous charge carrier distribution the maximum density is given by:

$$\rho_{e,\max,long} = \frac{4U_A \varepsilon_0}{r_A^2}$$

U_A	anode potential
ε_0	permittivity of free space
$\rho_{e,max,long}$	electron density
r_A	anode radius

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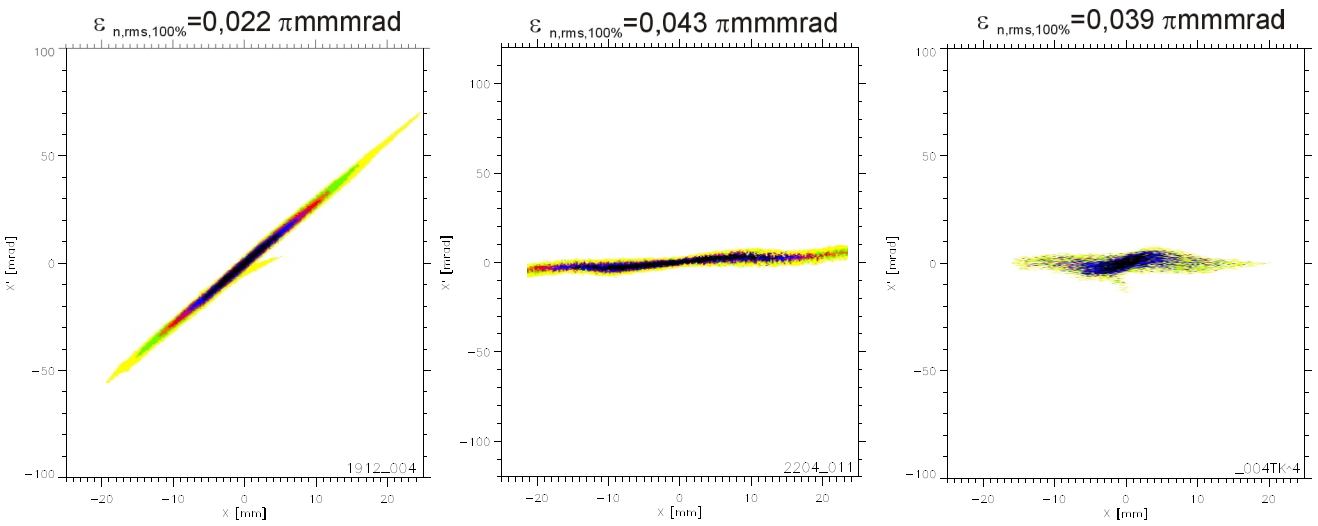
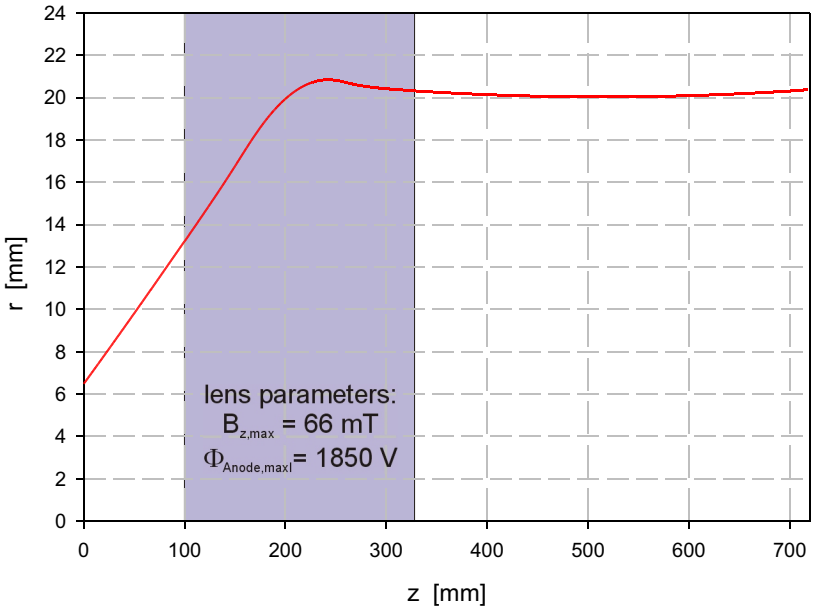
Beam Transport Measurement using Lens 1

W = 14 keV, I= 9 mA

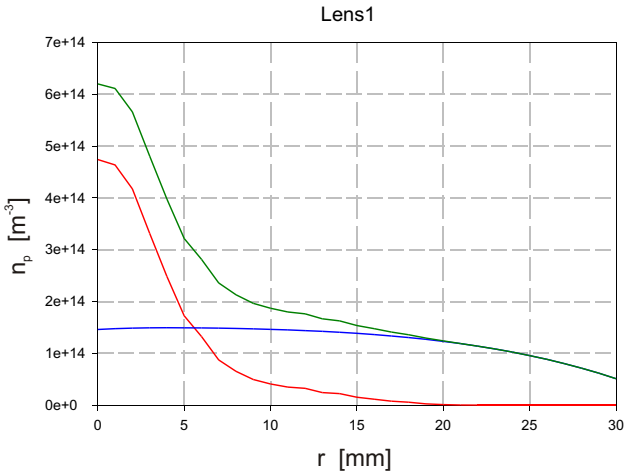




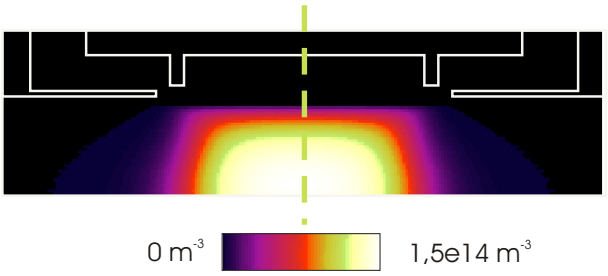
$$\frac{1}{f} = \frac{n_e \cdot e}{4 \cdot \varepsilon_0 \cdot U_B} \cdot l$$

$$\kappa_r = \frac{n_{exp}}{n_r} \qquad \kappa_l = \frac{n_{exp}}{n_l}$$

$$\kappa_r = 38\% \qquad \kappa_l = 49\%$$



Space charge density distribution



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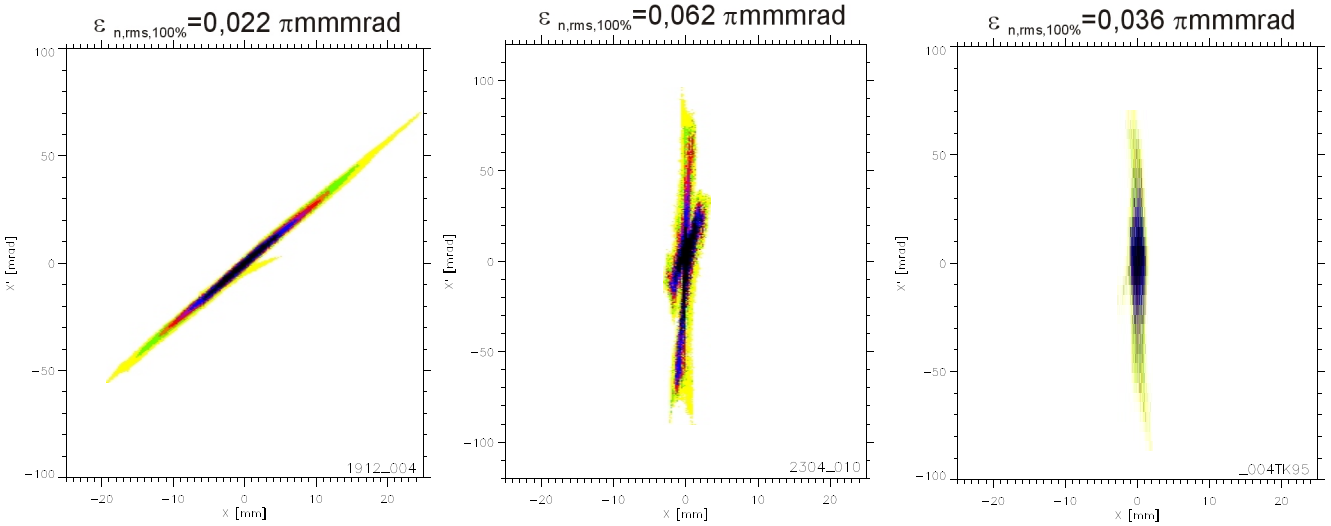
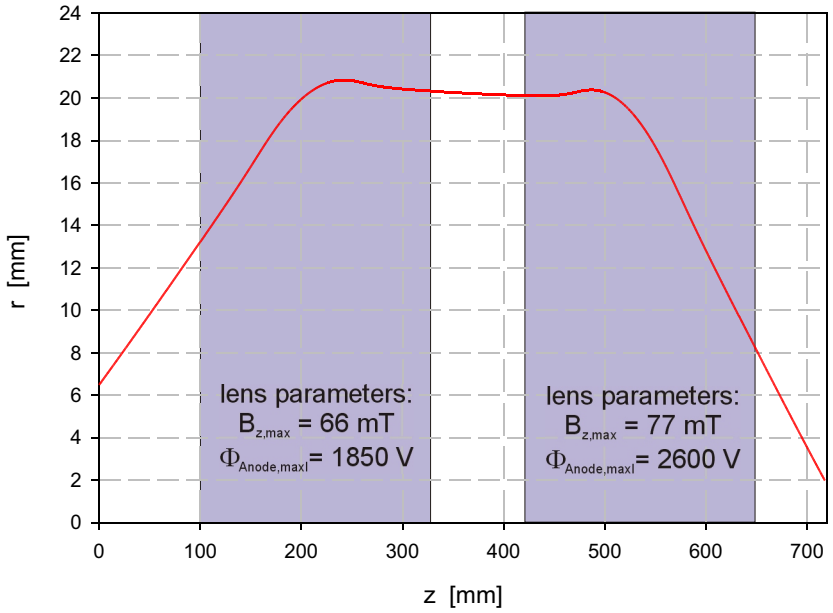
Beam Transport Measurement using Lens 1 & 2

W = 14 keV, I= 9 mA

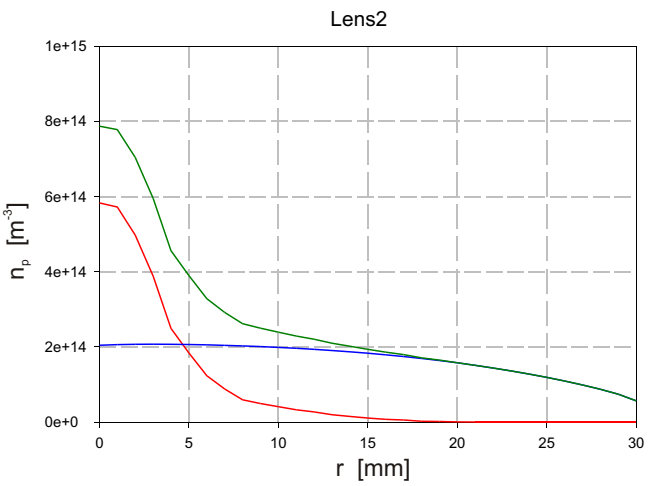




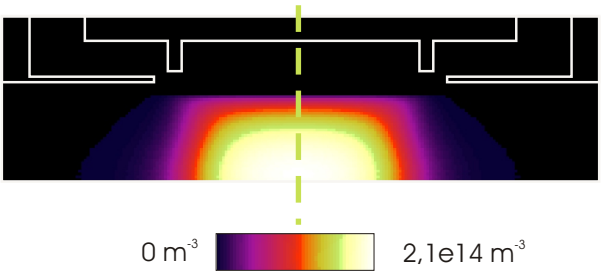
$$\frac{1}{f} = \frac{n_e \cdot e}{4 \cdot \varepsilon_0 \cdot U_B} \cdot l$$

$$\kappa_r = \frac{n_{exp}}{n_r} \qquad \kappa_l = \frac{n_{exp}}{n_l}$$

$$\kappa_r = 49\% \qquad \kappa_l = 61\%$$



Space charge density distribution



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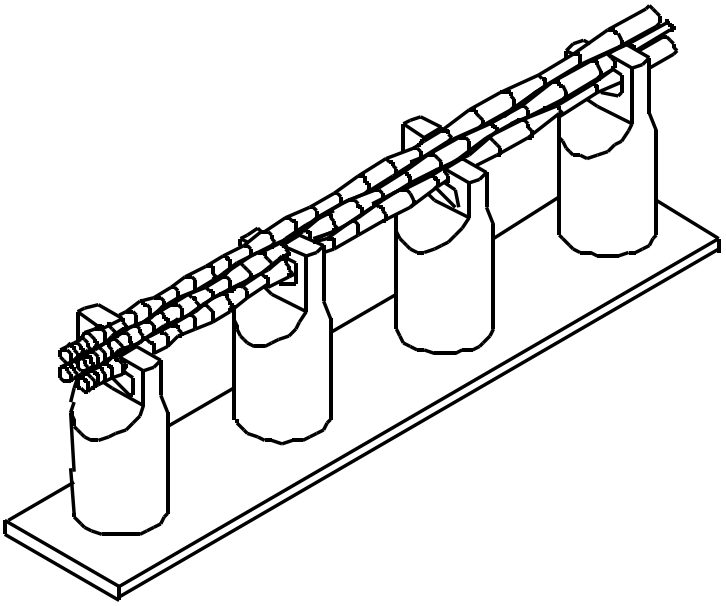
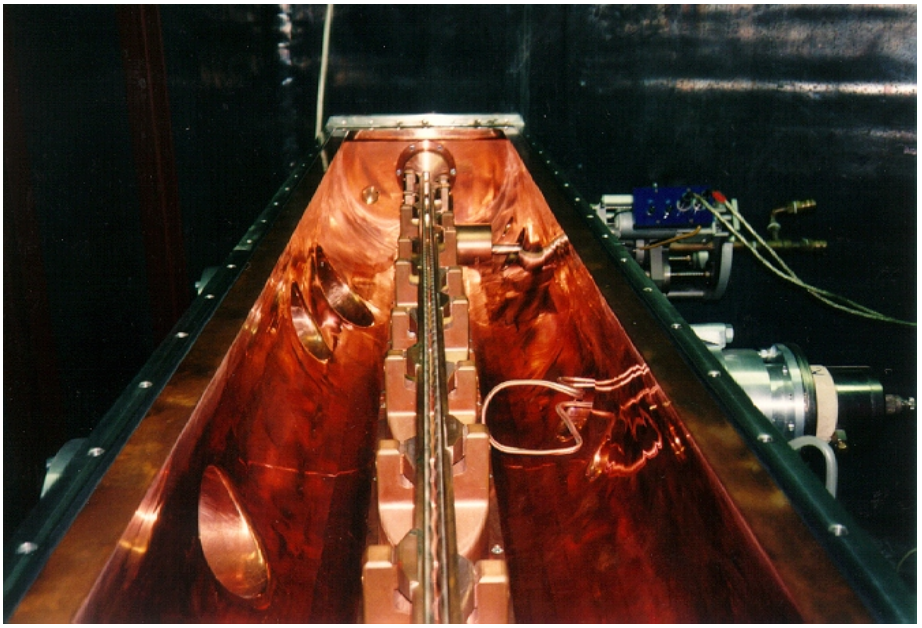
Low Energy Beam Transport and Diagnostic

in Zusammenarbeit mit der AG Schempp

Four - Rod - RFQ



Eingangsenergie:	3,5 keV/u
Ausgangsenergie:	110 keV/u
Elektrodenspannung:	80 kV
Strahlstrom:	0,7 mA A/q
Tastverhältnis:	33 %
Masse/Ladung:	16
Betriebsfrequenz:	108,48 MHz



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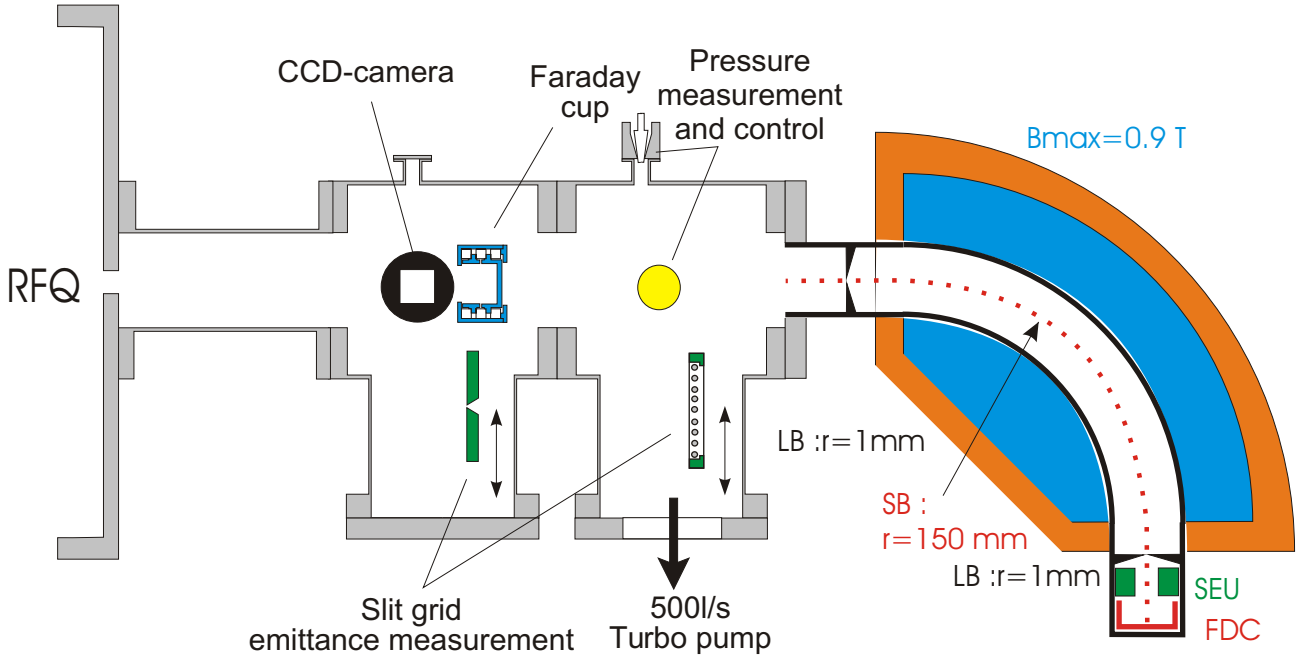
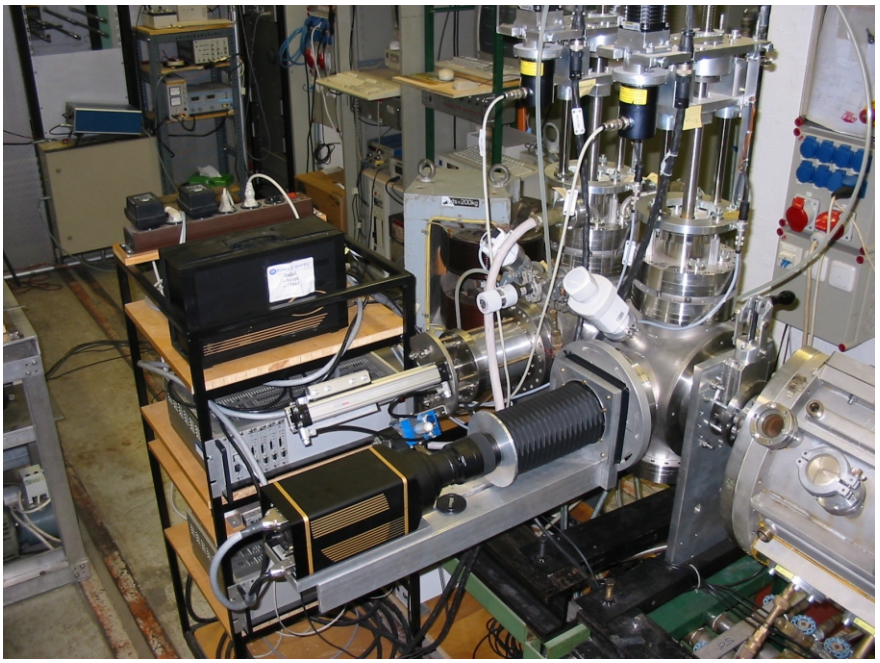
Beam Diagnostic behind the RFQ





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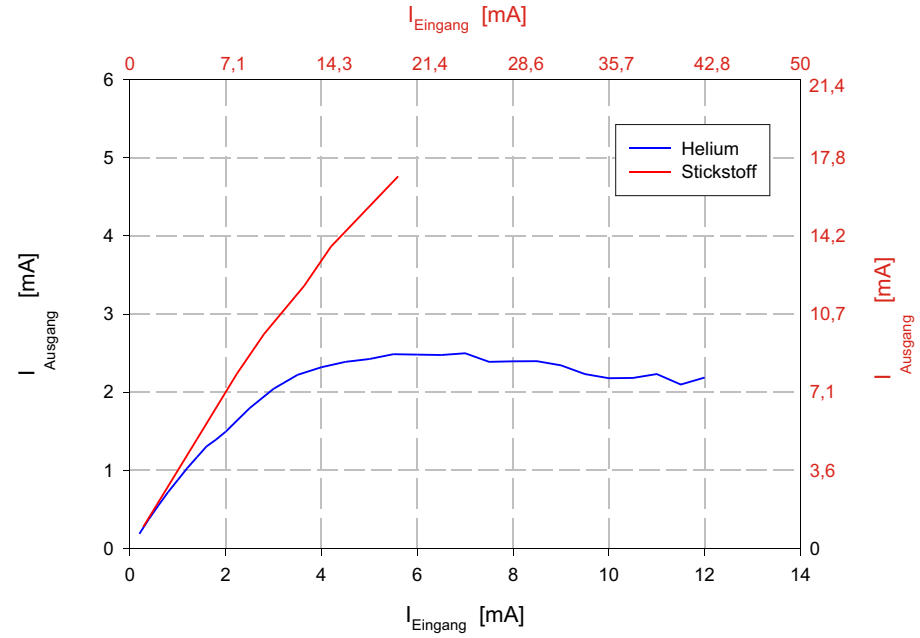
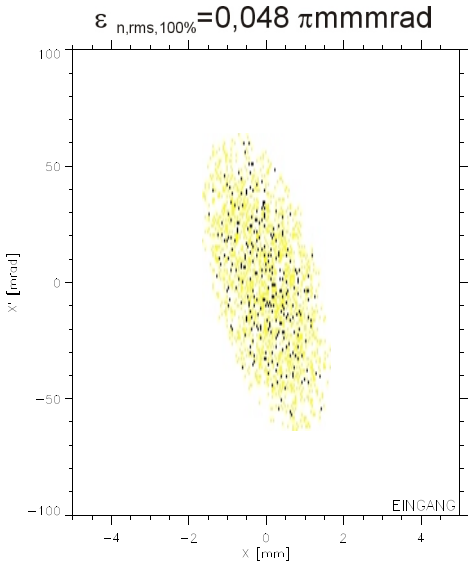
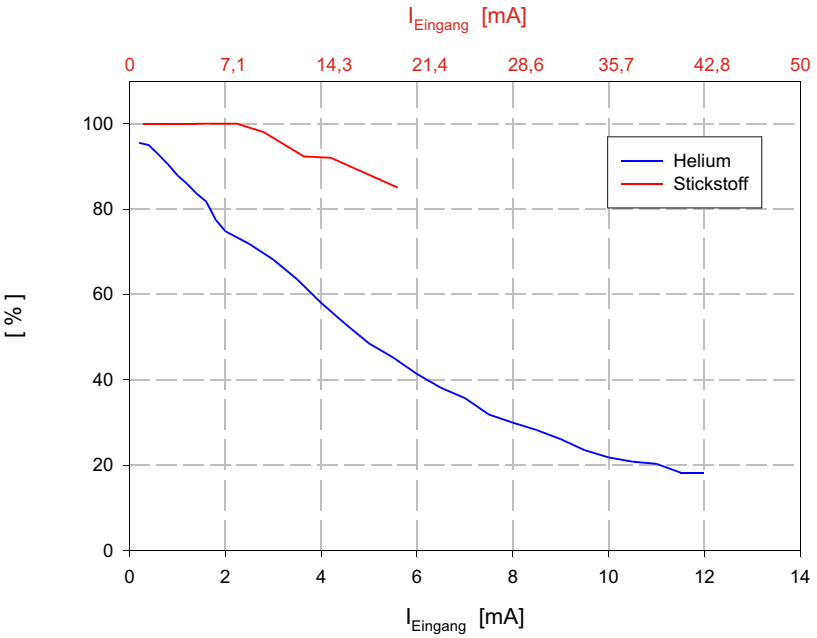
Beam Transport Simulations using PARMTEQ



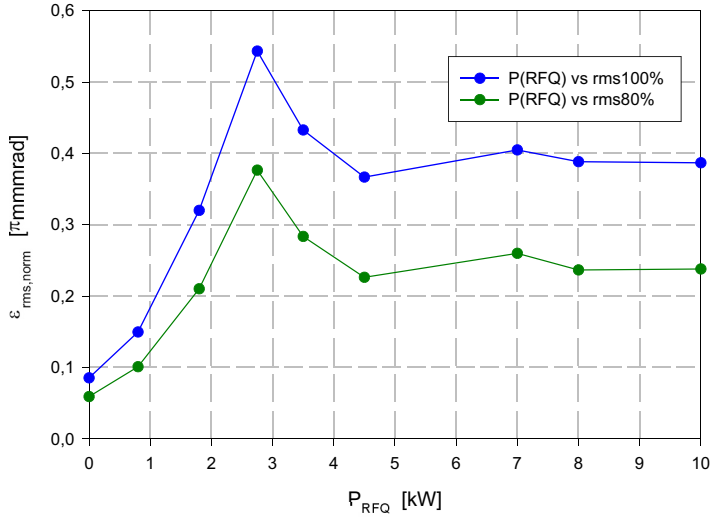
W_{input} = 3,5 A keV
W_{output} = 110 A keV
$U_{electrode}$ = 20 kV



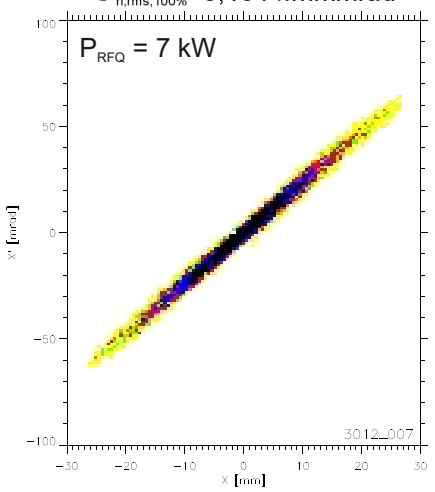


Emittance Measurement

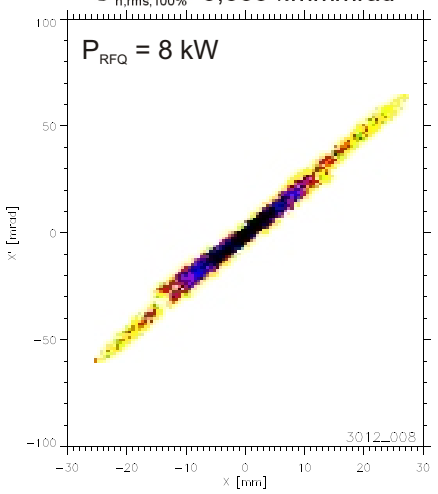
P_{RFQ} vs. Emittanz x - plane



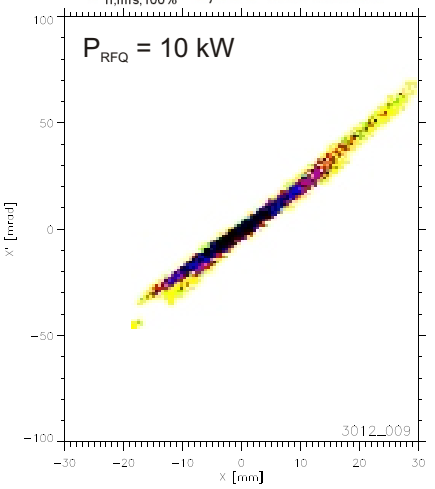
$\varepsilon_{n,rms,100\%}$=0,404 πmmmrad



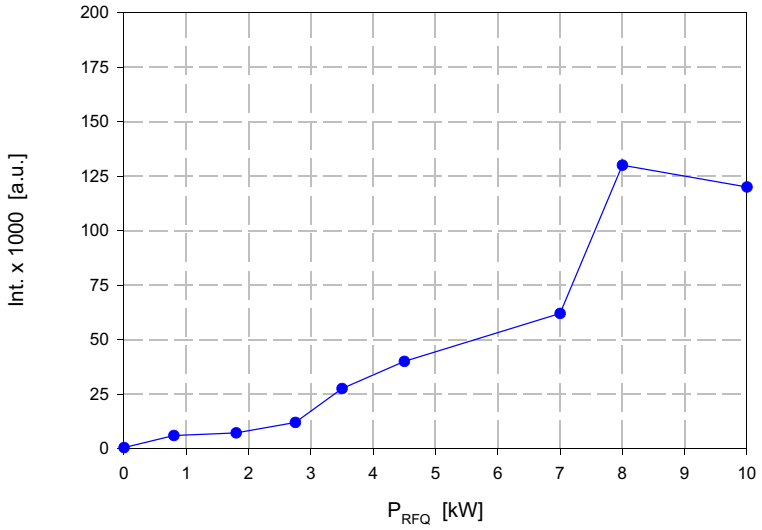
$\varepsilon_{n,rms,100\%}$=0,388 πmmmrad



$\varepsilon_{n,rms,100\%}$=0,386 πmmmrad



Max. Intensity (Profile Measurement)



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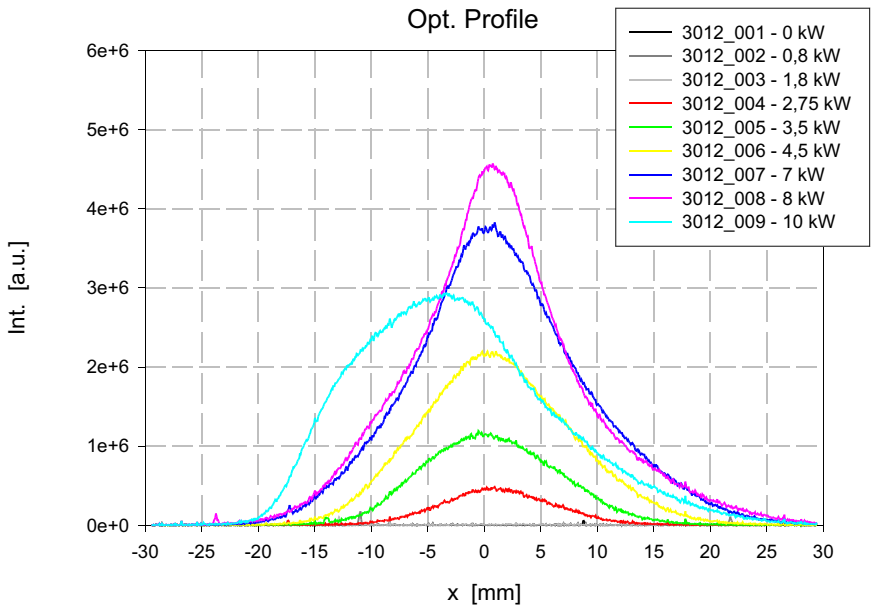
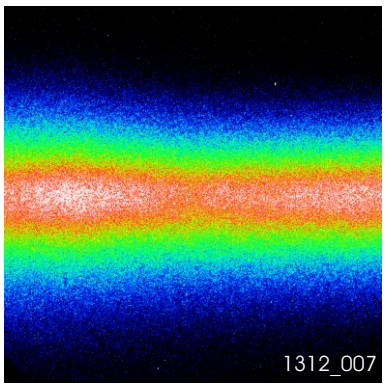
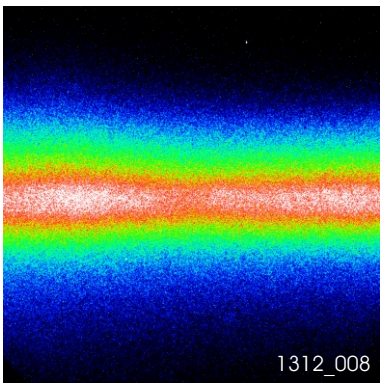
Optical Profile Measurement

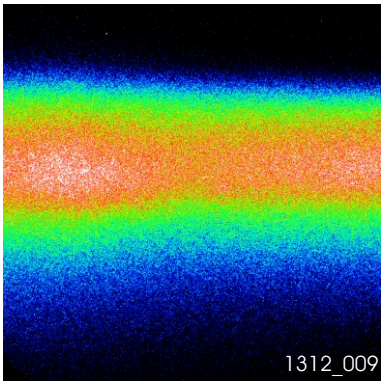




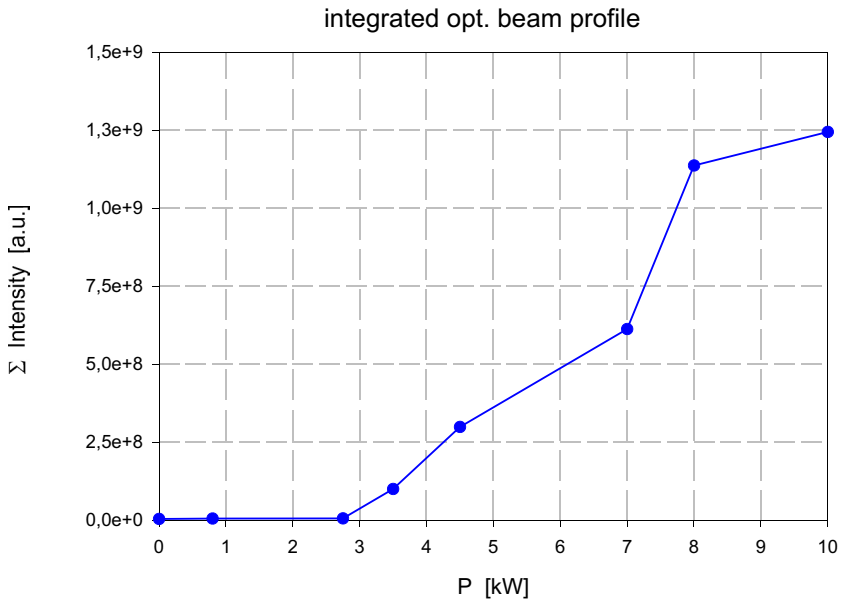
P=7kW



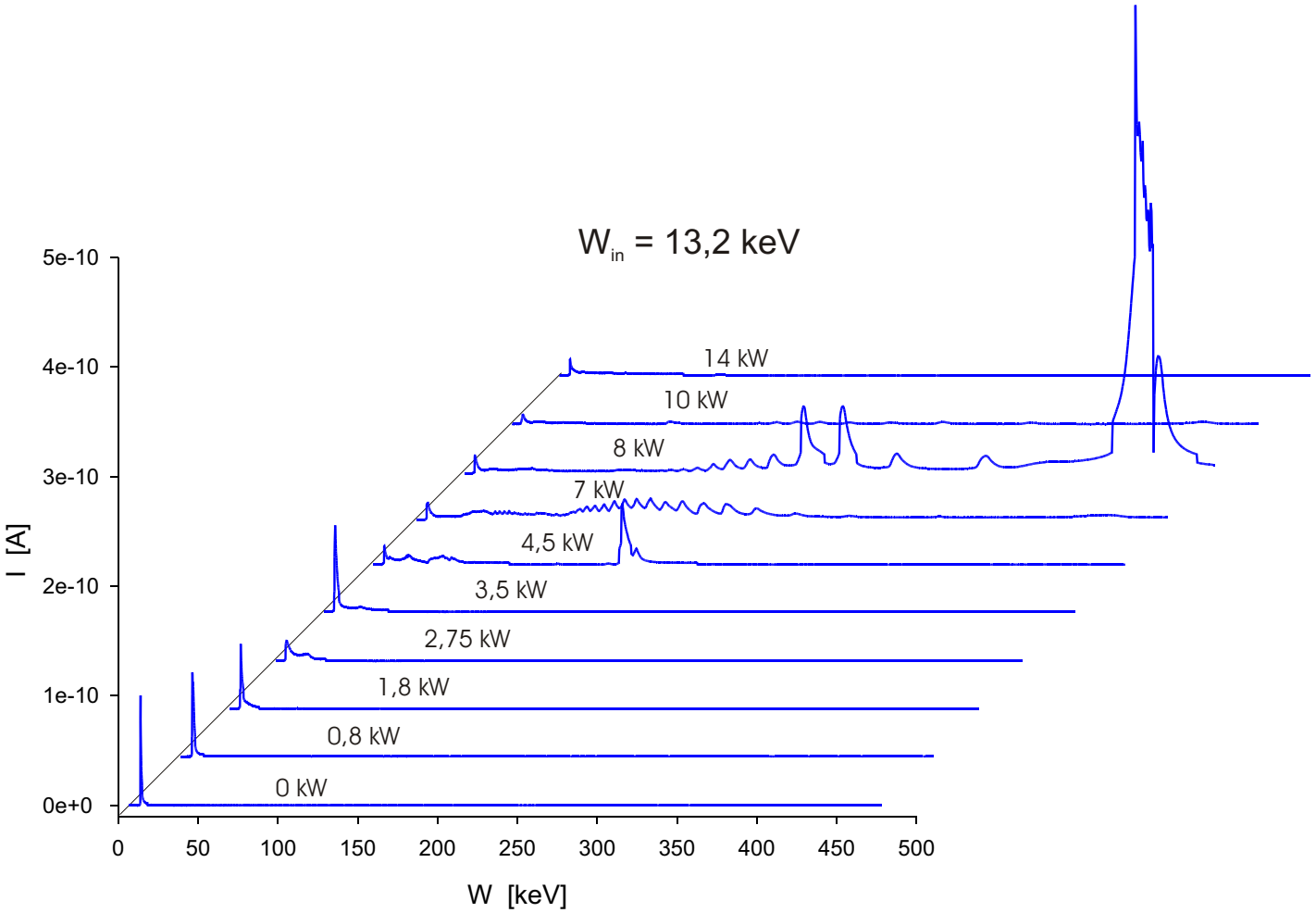
P=8kW



P=10kW

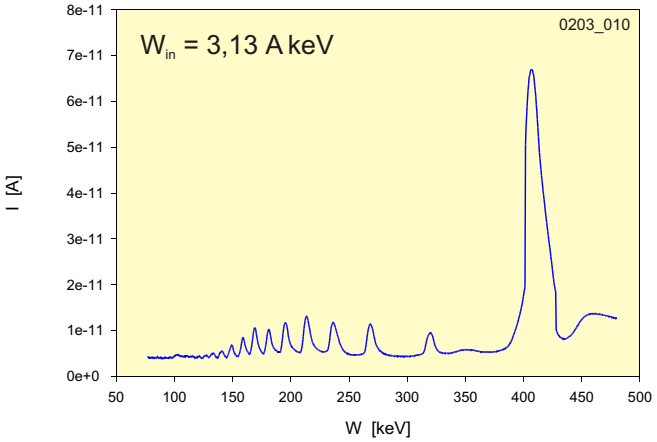


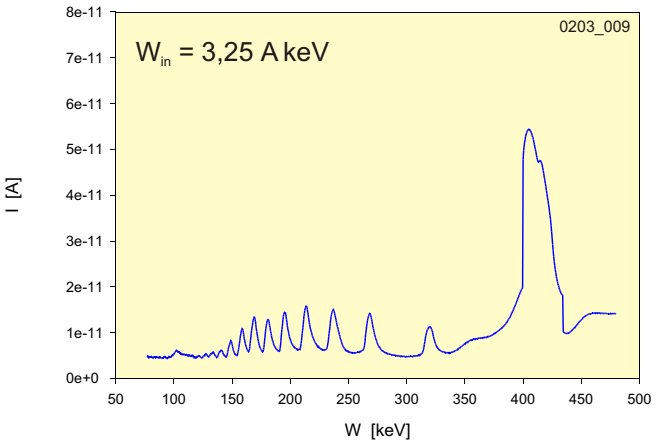
Energy Spectroscopy

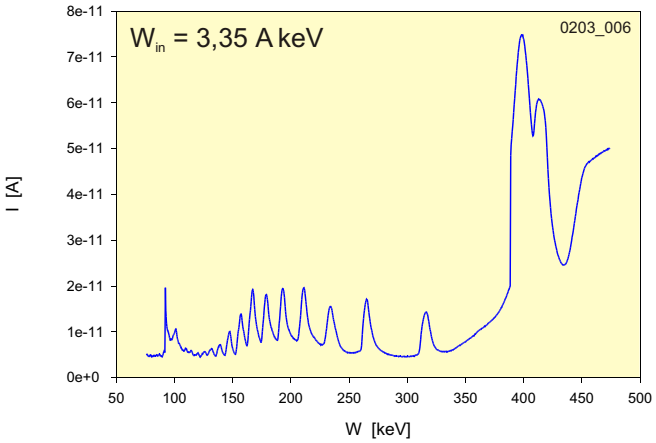


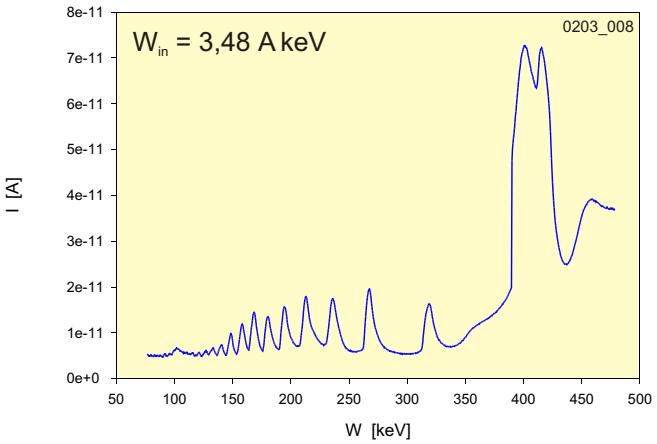
Energy Spectroscopy

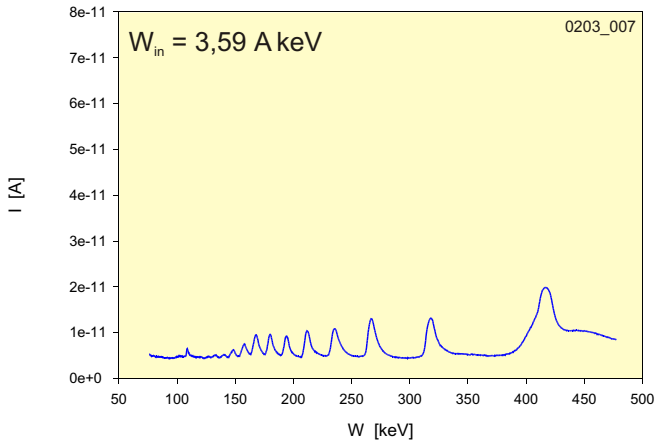
P_{RFQ} = 8 kW











Plan for the near future

- **Optimisation of the beam matching into the RFQ**
- **Measurement of the beam properties in y - plane**
- **Measurement of the time structure of the beam properties**
- **Installation of a large Gabor lens behind the RFQ**
- **Beam focussing into a target chamber**