FARADAY CUP ARRAY MEASUREMENTS OF ION-BEAM PROFILE CHARACTERISTICS

ECRIS10 Grenoble

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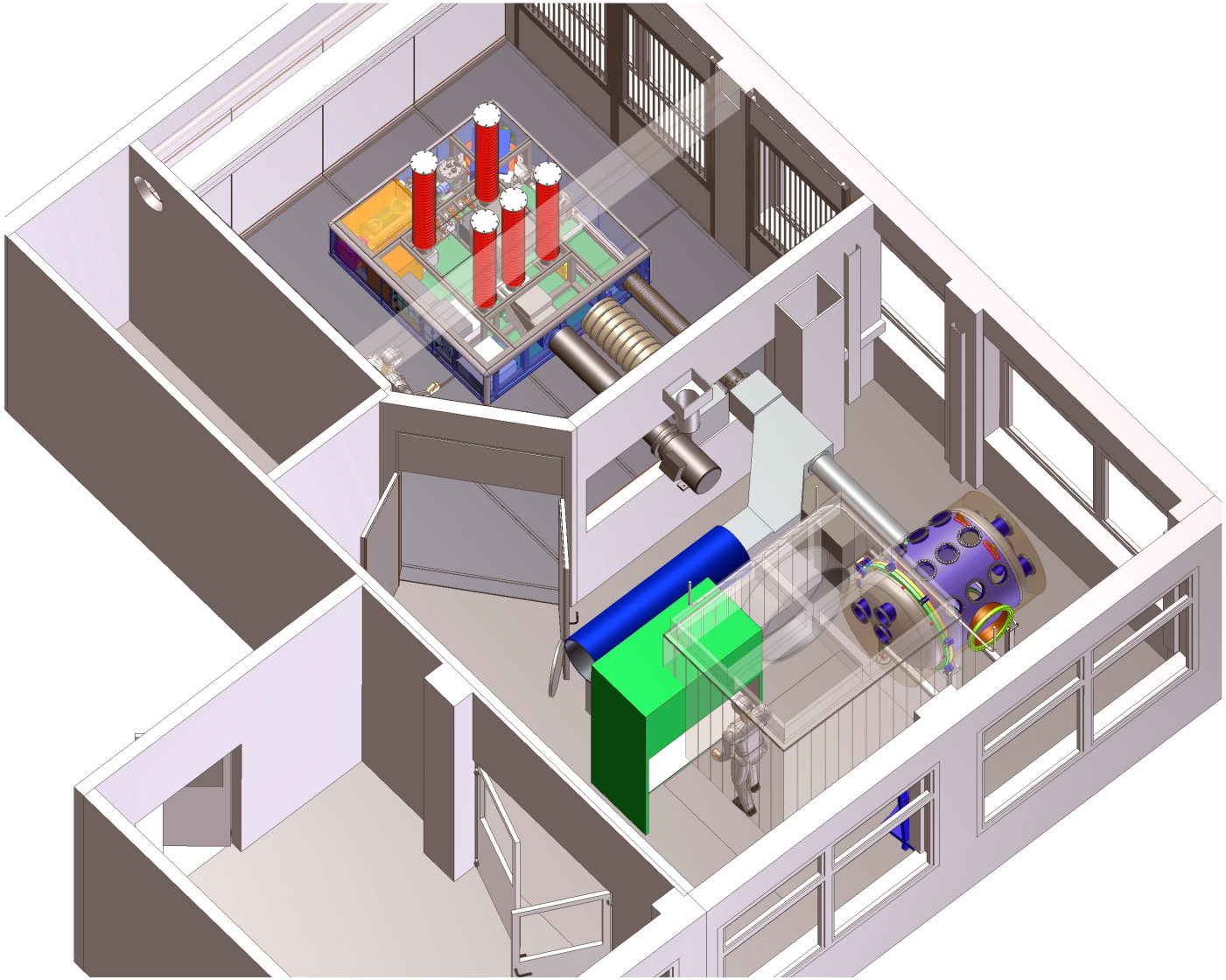
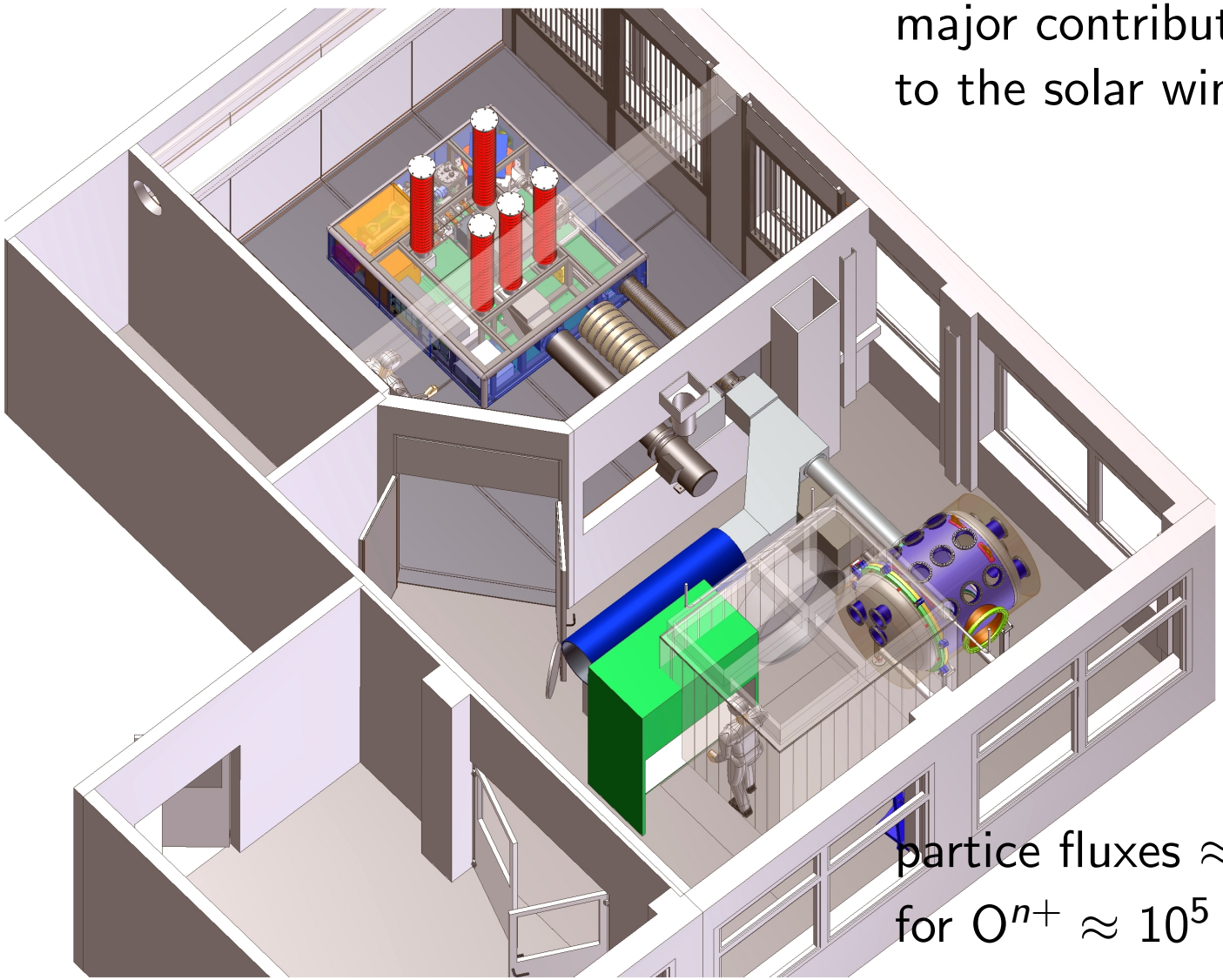
Outline

Solar Wind Calibration Laboratory



Solar Wind Calibration Laboratory



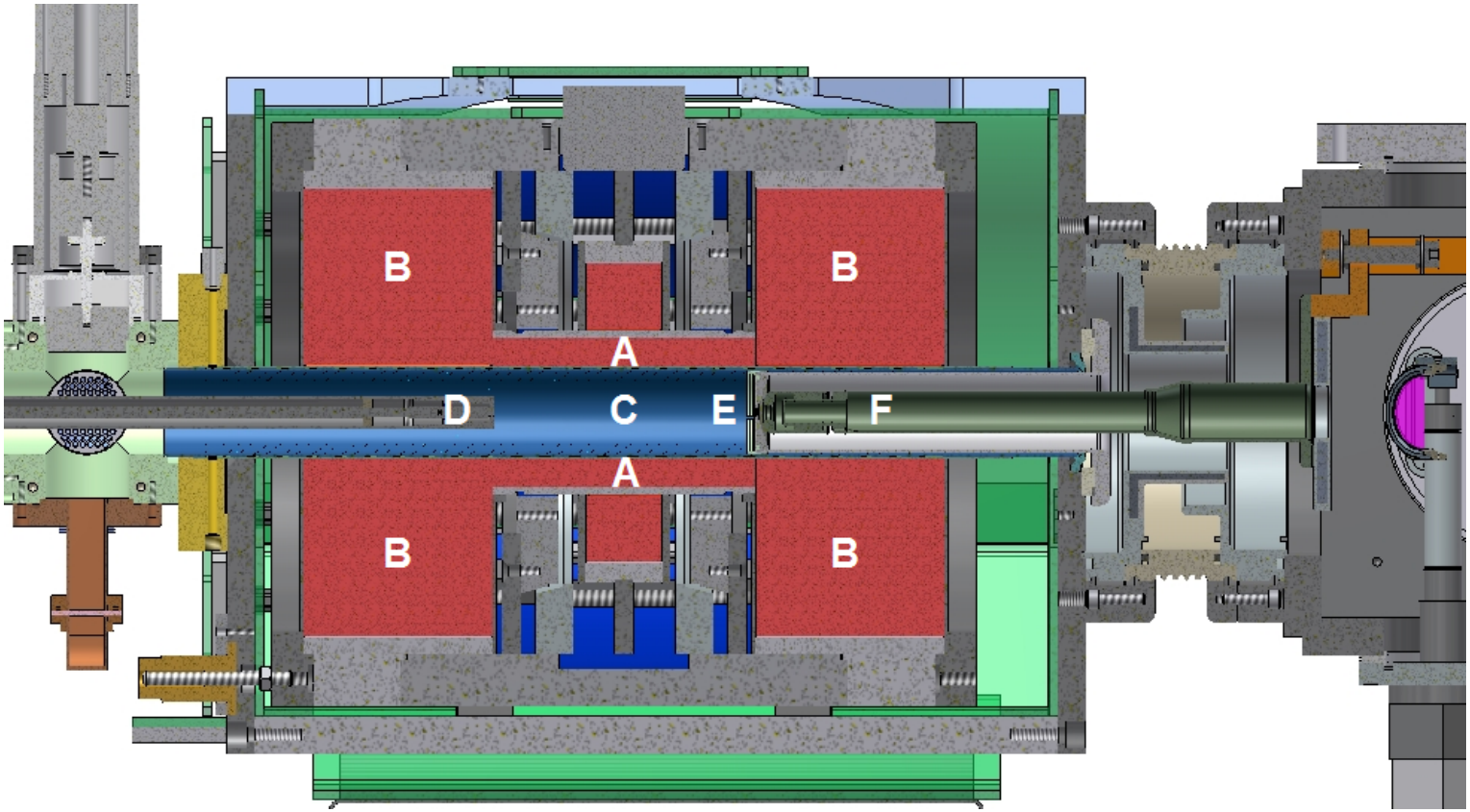
major contributions of ion species to the solar wind:

- H^+
- He^+ - He^{2+}
- C^{4+} - C^{6+}
- O^{6+} - O^{8+}
- Ne^{8+}
- Mg^{10+}
- Si^{8+} - Si^{9+}
- Fe^{6+} - Fe^{16+}

partice fluxes $\approx 10^8 \frac{particles}{cm^2 \cdot s}$ (H^+)

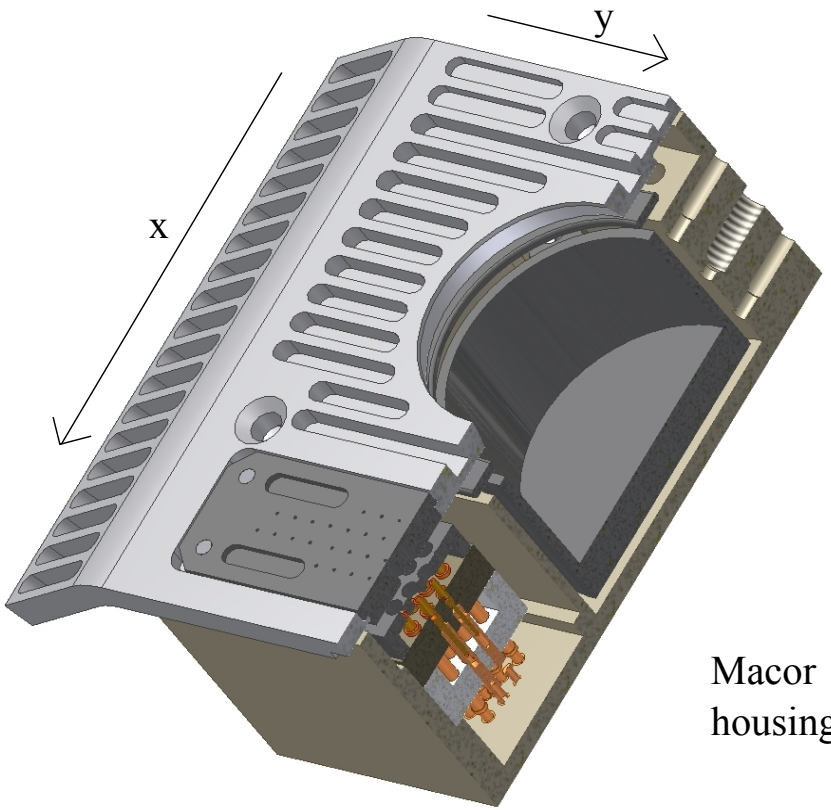
for $O^{n+} \approx 10^5 \frac{particles}{cm^2 \cdot s}$ $\rightarrow$ restriction!

Ion Source and Extraction

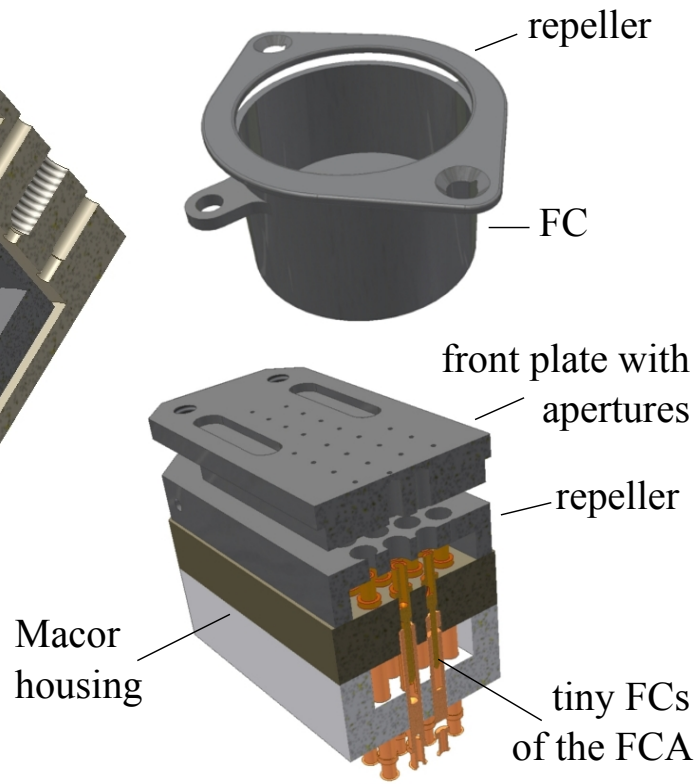


A	hexapole for radial confinement
B	magnetic rings for axial confinement
C	plasma chamber
D	biasable microwave antenna
E	plasma electrode
F	3D-movable extraction

Faraday Cup Array (FCA)



cut view of the detector
with mounted front cover



detection hardware in detail

[Panitzsch et al., 2009, Rev.Sci.Instrum.]
doi:10.1063/1.3246787

Faraday Cup Array (FCA)

Characteristics:

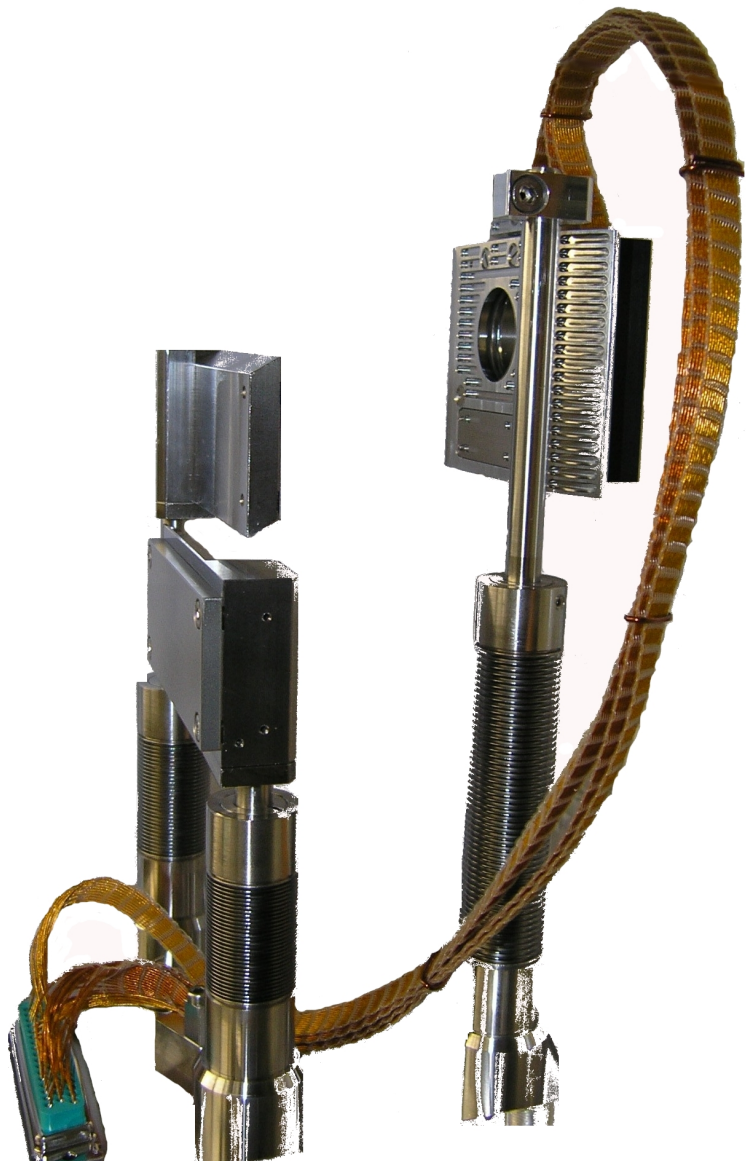
- FC & FCA in one detector
  $\rightarrow$ profile & total current measurable
- direct measurement with secondary electron escape suppression
- high durability: up to 40 W of beam power
- fast system: 10 s per profile scan

Detector hardware:

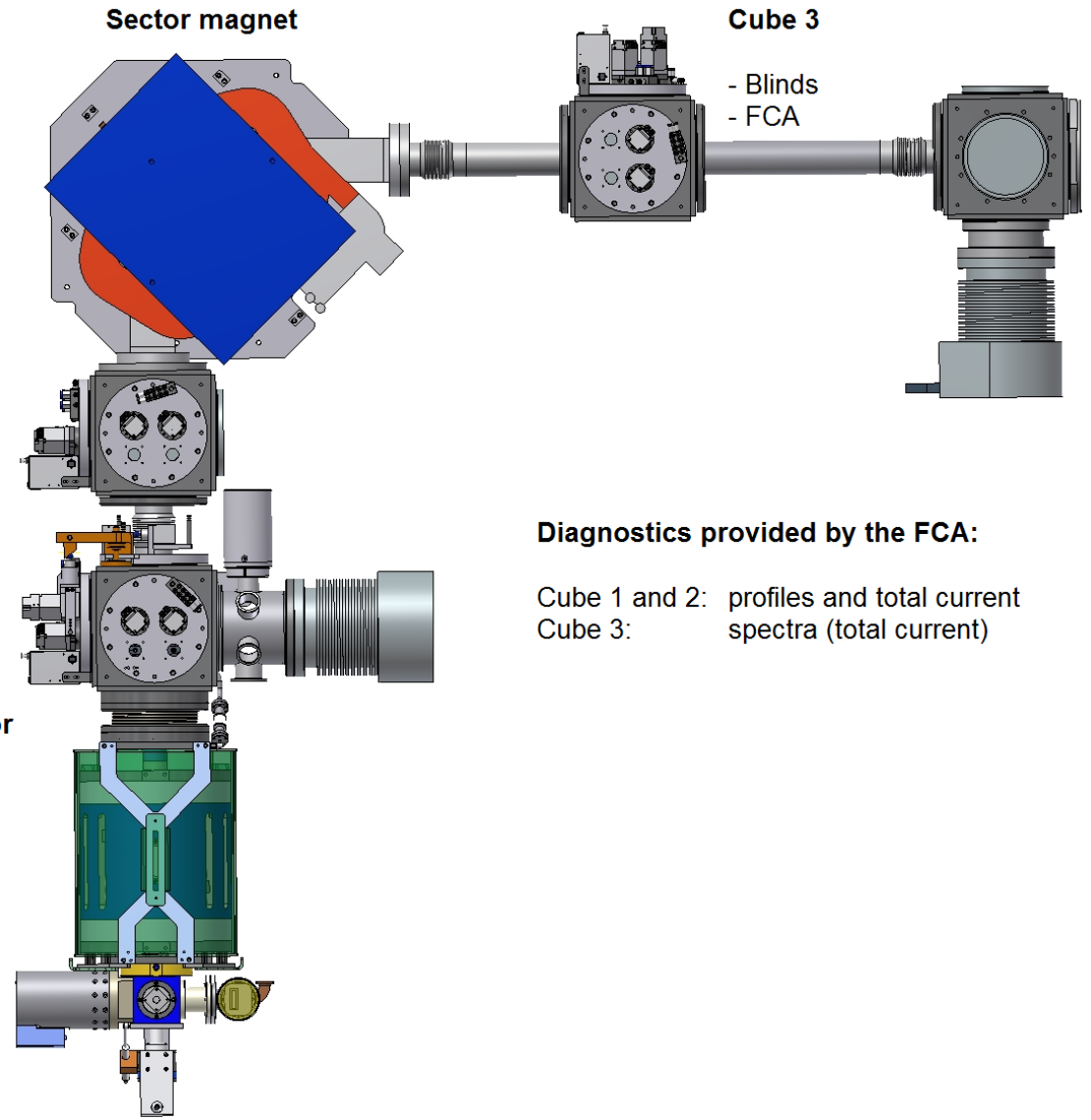
- spatial resolution: 58 dpi x 51 dpi
- scanned area: 45 x 30 mm^2
- detection of structures on mm-scale

Detector electronics (present configuration):

- large dynamic range: 50 pA $\rightarrow$ 50 μA
  $\rightarrow$ high sensivity at absoulte current values
- ranges from 200 nA/cm^2 to 20 mA/cm^2 (if $P_{beam} < 40\,W$)



Placements of the FCAs (and Beam Line)

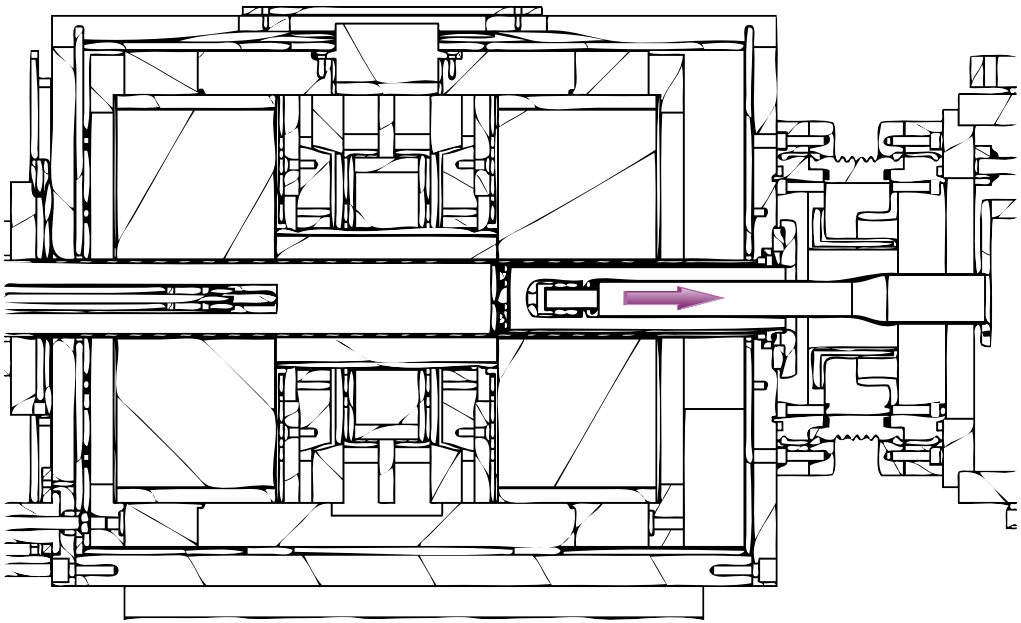


Diagnostics provided by the FCA:

Cube 1 and 2: profiles and total current
Cube 3: spectra (total current)

Ion Beam Focussing

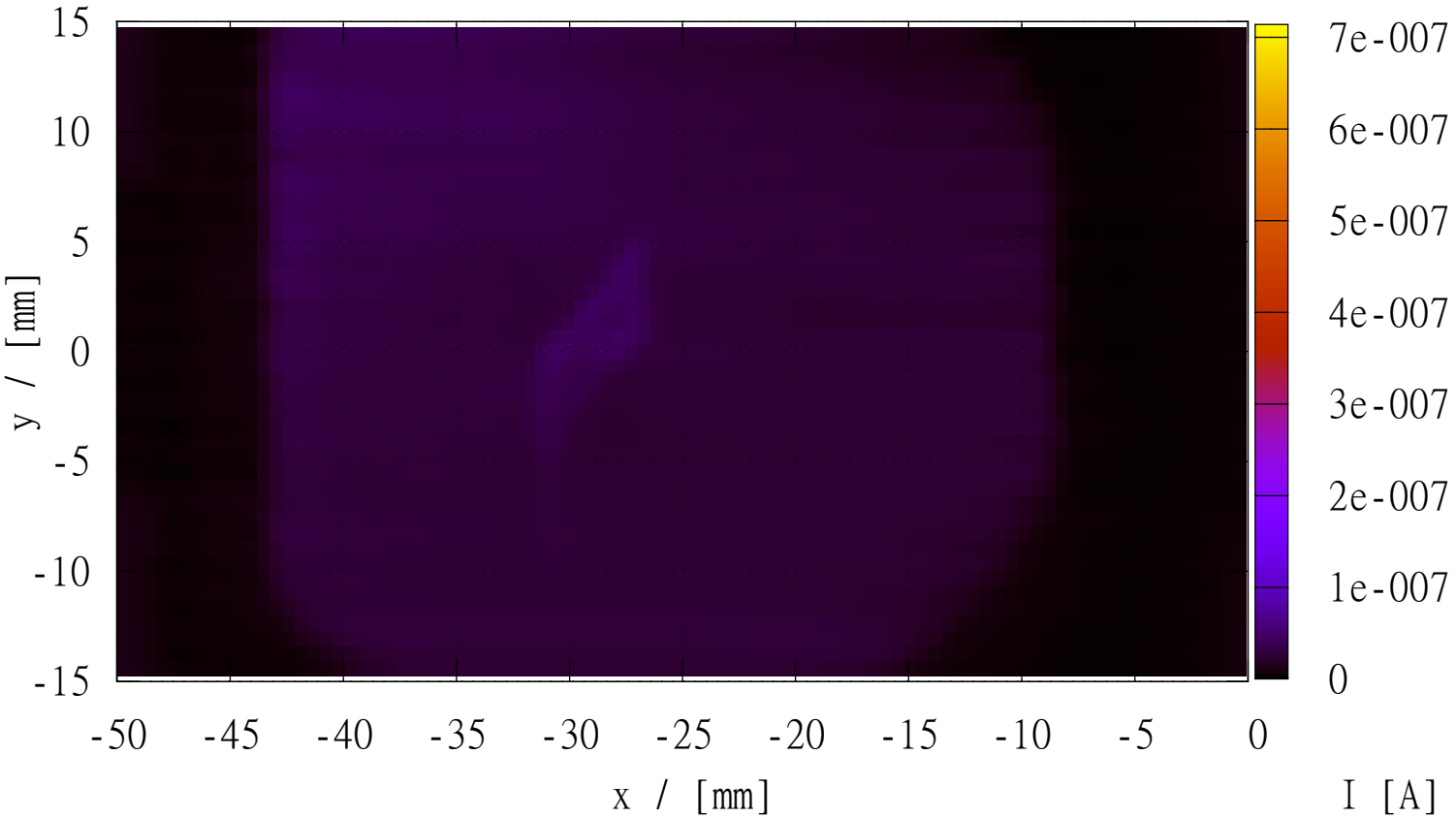
Procedure



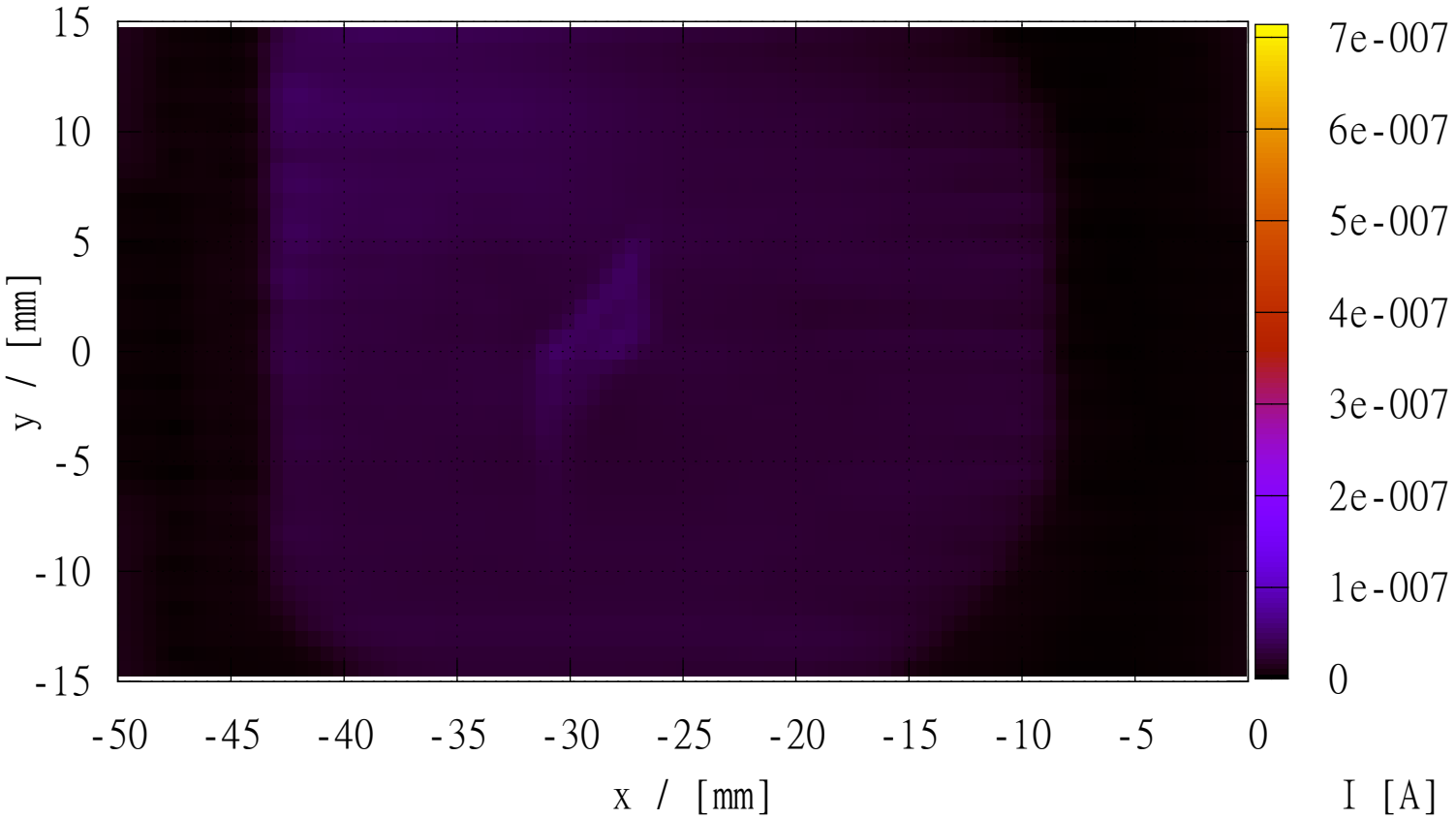
Source Settings

pressure inside plasma chamber	p_{ECR}	1.0×10^{-5} mbar
microwave power	$P_{\mu w}$	50 W
microwave frequency	$f_{\mu w}$	11 GHz
extraction voltage	U_E	15 kV (test 1)
		from 13 to 2 kV (test 2)
extraction position perpend. to beam line	d_{Ep}	central
extraction position along beam line	d_{Ea}	from 5 to 25 mm (test 1)
		25 mm (test 2)

Ion Beam Focussing by Moving the Extraction



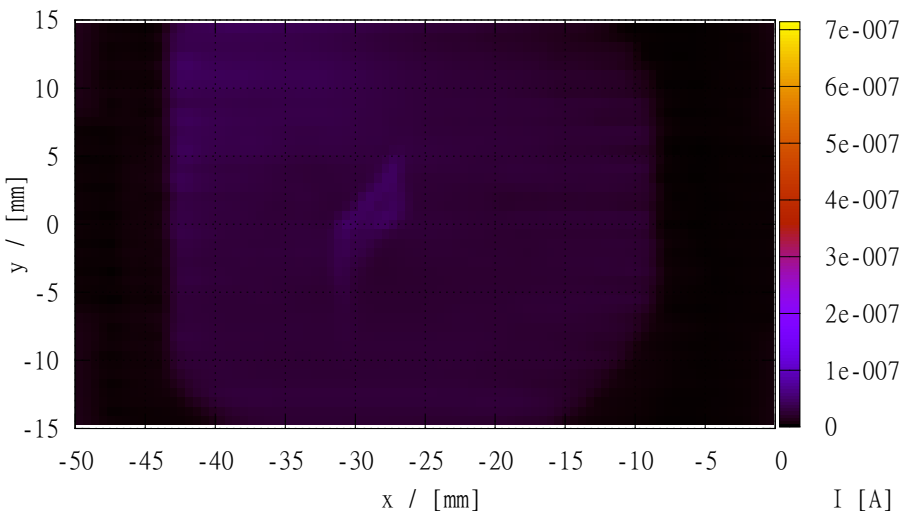
Ion Beam Focussing by Moving the Extraction



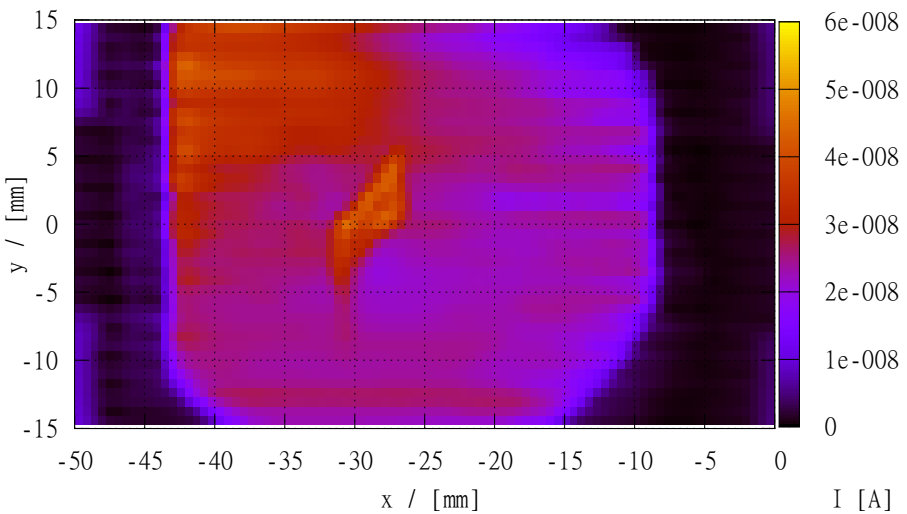
Ion Beam Focussing by Moving the Extraction

The extraction is moved im mm-steps starting at a distance of 5 mm to the plasma electrode ending at a distance of 25 mm.

same scale:



full scale:



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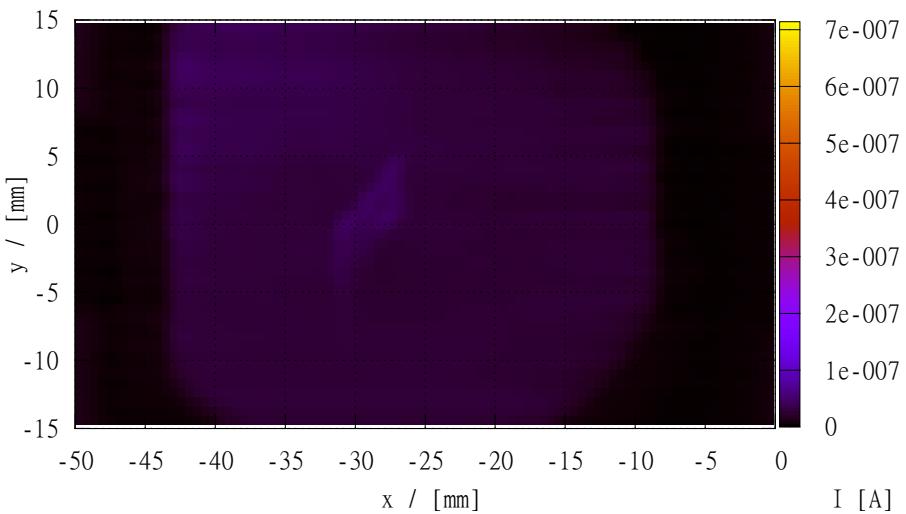

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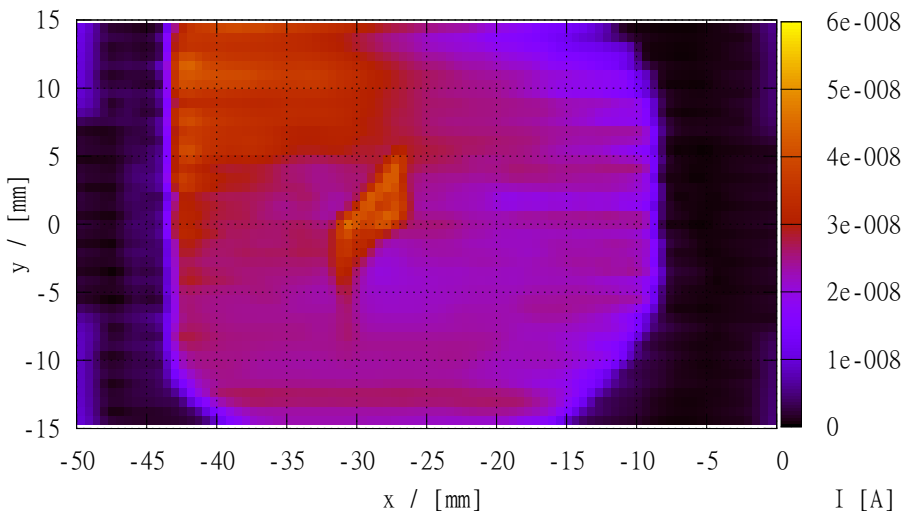
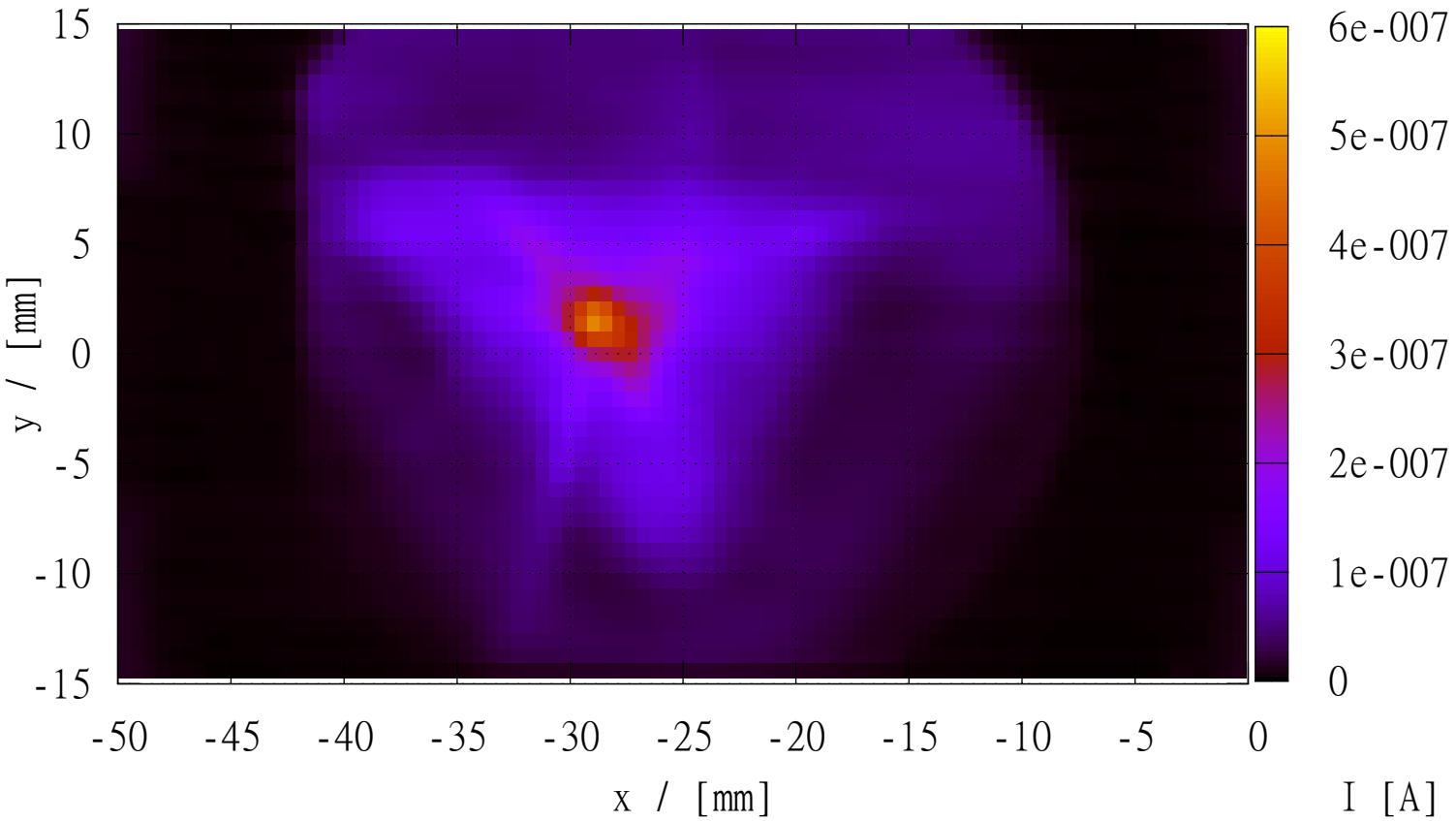


Ion Beam Focussing by Lowering the Extraction Voltage



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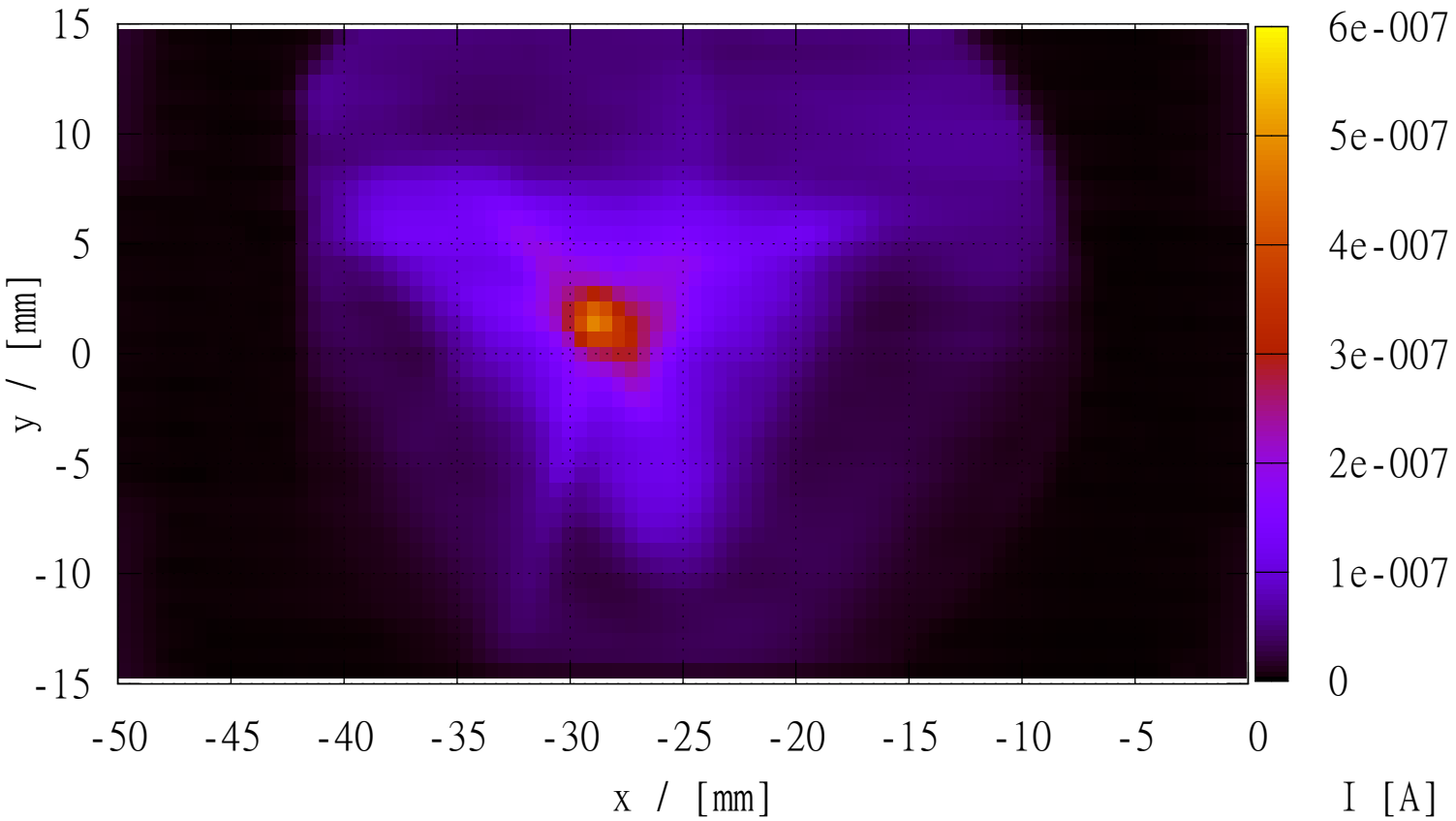
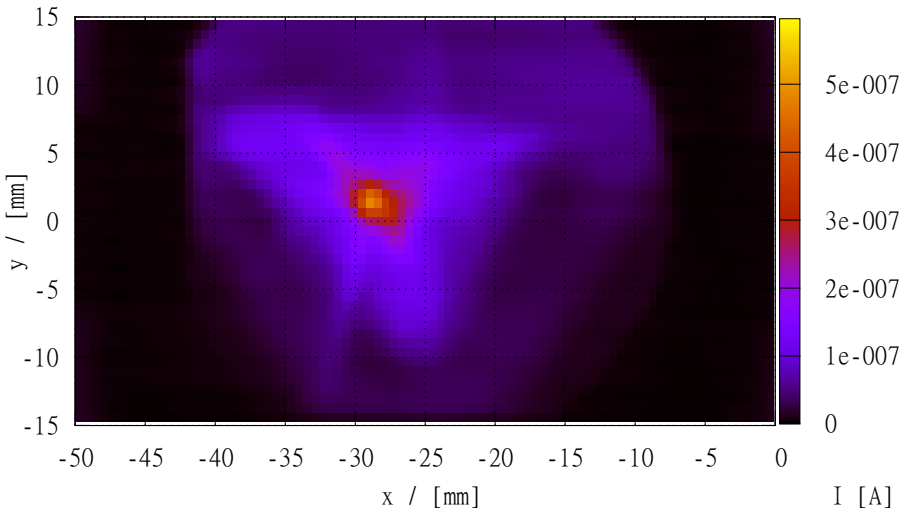


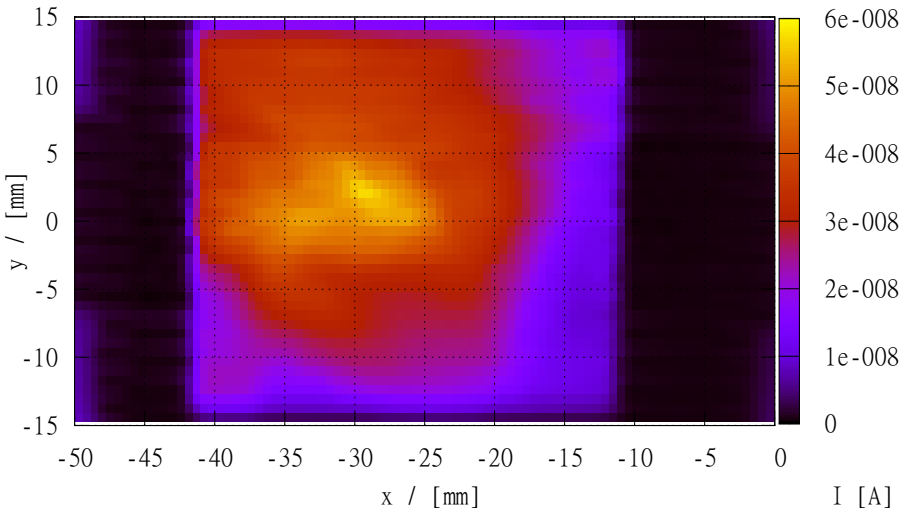
Ion Beam Focussing by Lowering the Extraction Voltage

The extraction voltage is lowered in 1 kV-steps starting at a voltage of 13 kV, ending at 2 kV.

cube 1:



cube 2:



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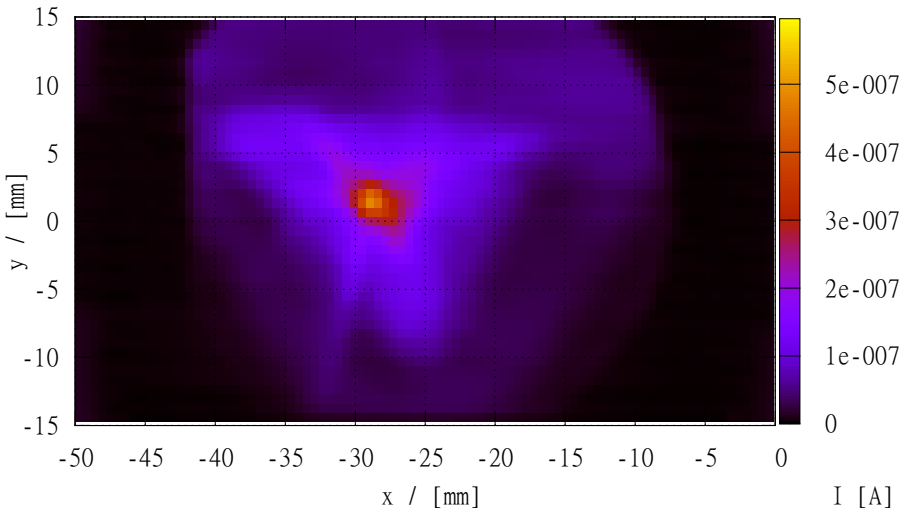
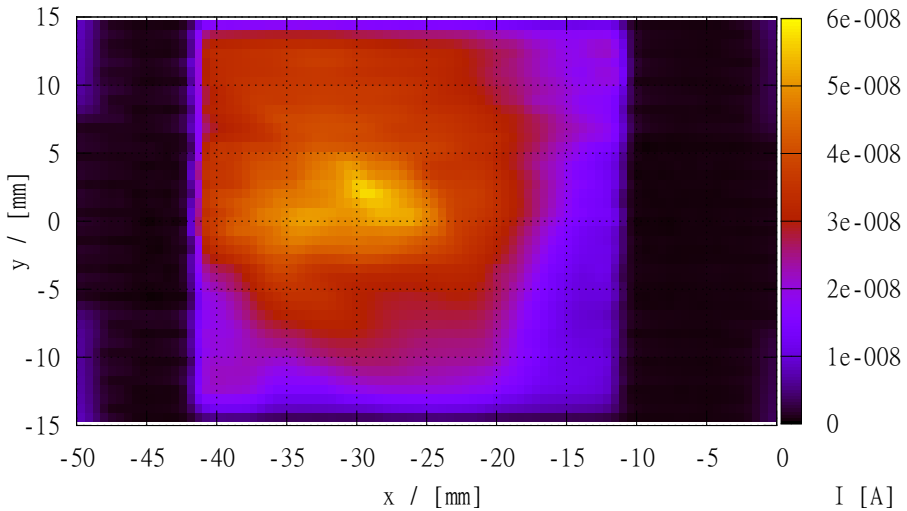
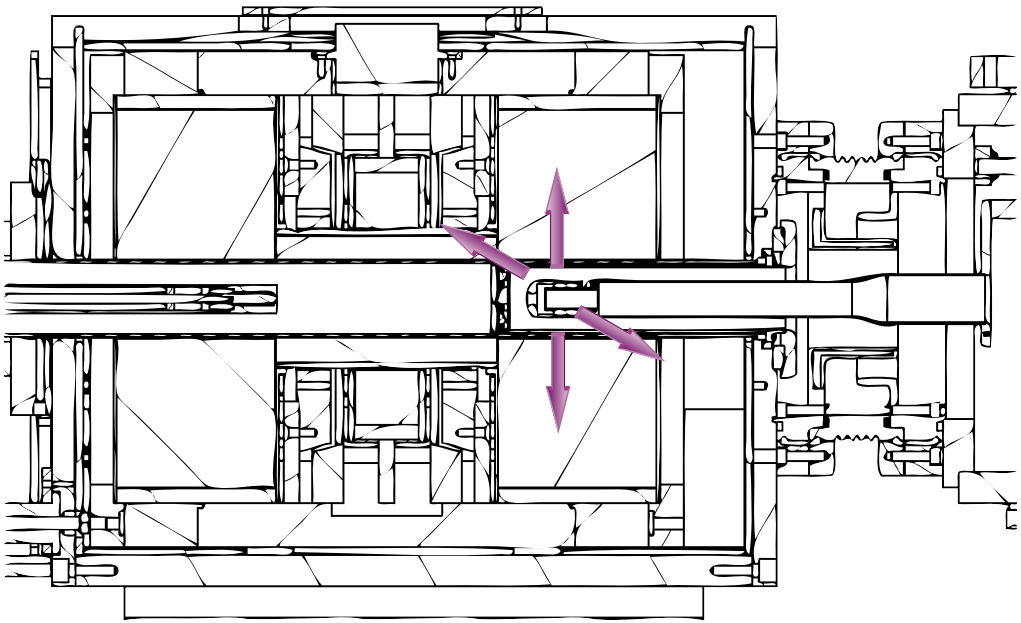


cube 2:



Ion Beam Steering

Procedure



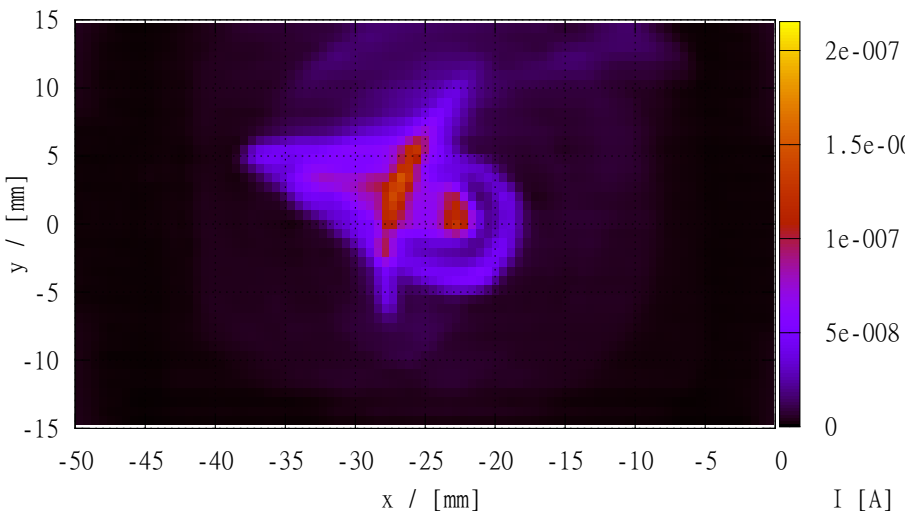
Source Settings

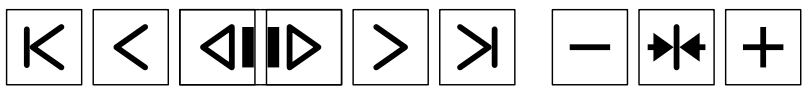
pressure inside plasma chamber	p_{ECR}	1.0×10^{-5} mbar
microwave power	$P_{\mu w}$	50 W
microwave frequency	$f_{\mu w}$	11 GHz
extraction voltage	U_E	6 kV
extraction position perpend. to beam line	d_{Ep}	variable
extraction position along beam line	d_{Ea}	25 mm

Ion Beam Steering

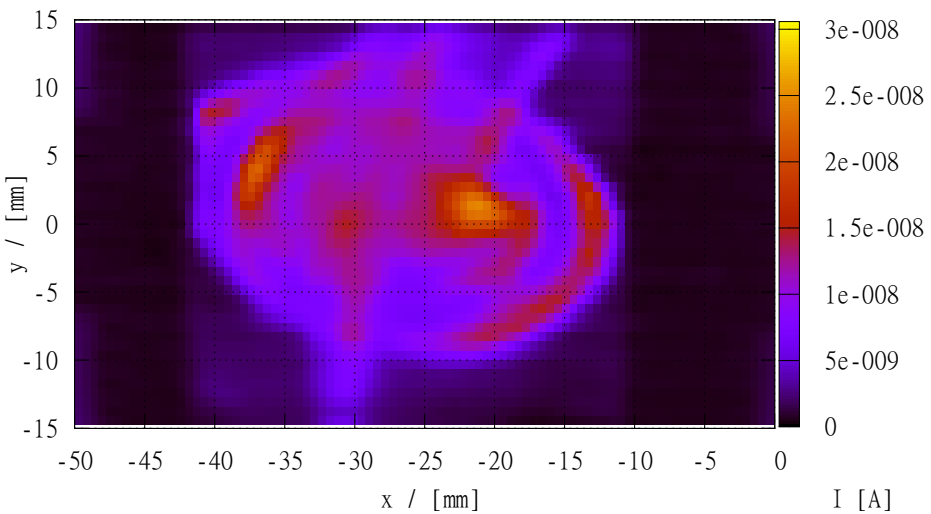
extraction moving from left to right (horizontally)
0.5 mm per step

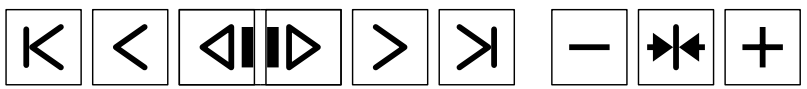
cube 1:





cube 2:





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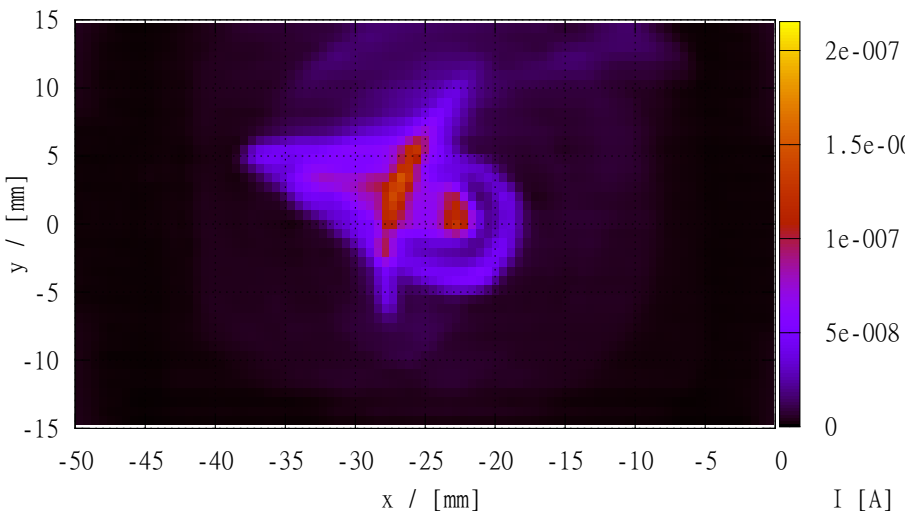

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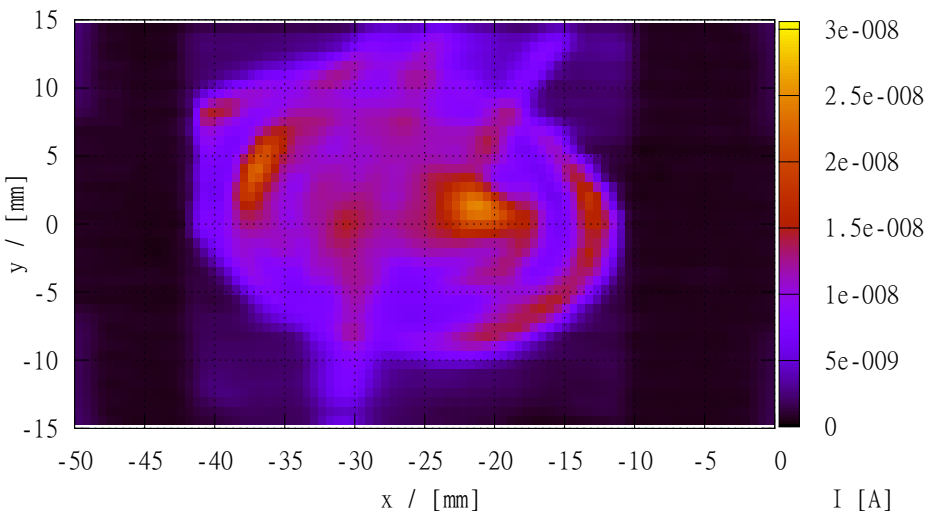
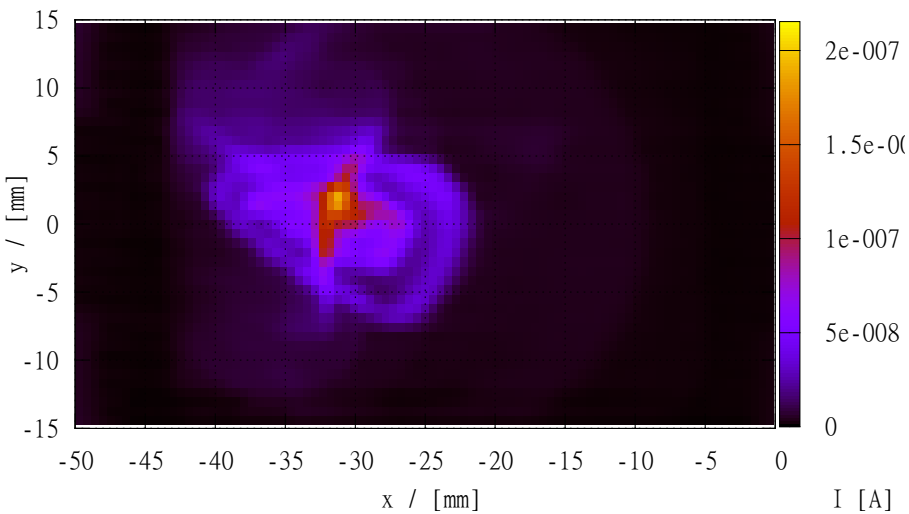


Ion Beam Steering

extraction moving upwards (vertically)
0.5 mm per step

cube 1:



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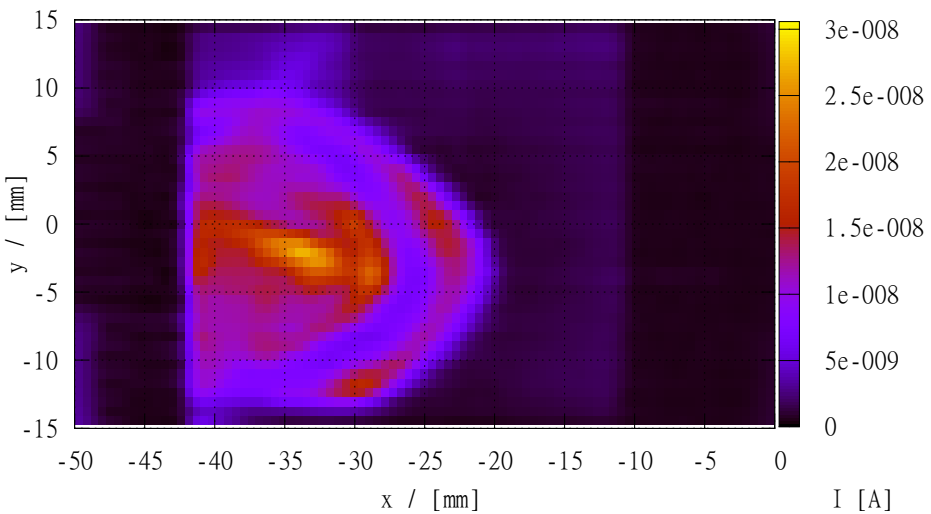

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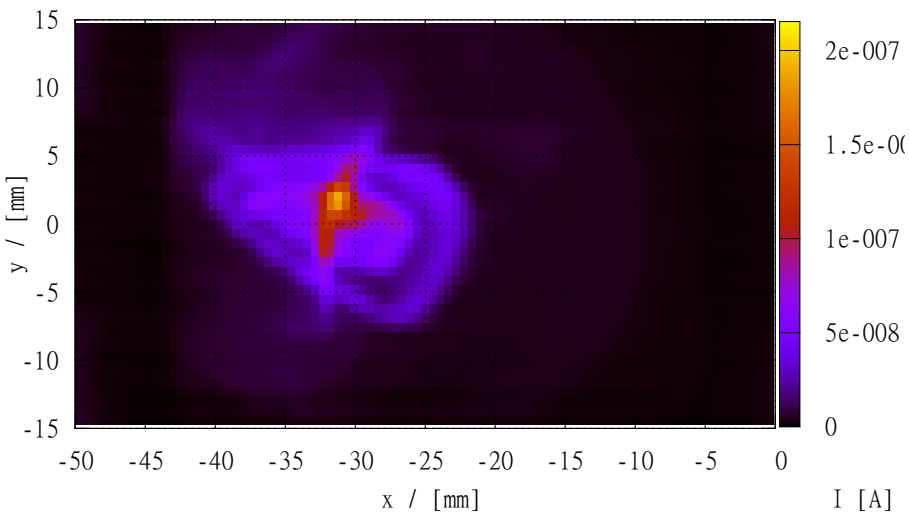

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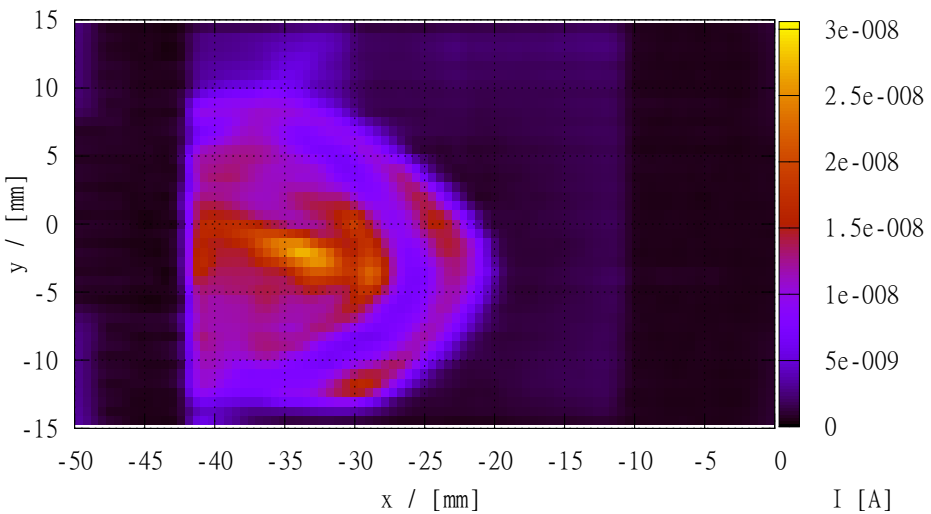

Ion Beam Steering

conclusion for the beam steering:

$\rightarrow \quad \approx \frac{\pi}{2}$ rotation from extraction to cube 1!

the rotation of charged particles induced by a magnetic lens is defined as:

$$\Theta_{tot} = \sqrt{\frac{q}{8mU_{extr}}} \cdot \int B_z dz \qquad [Glaser]$$

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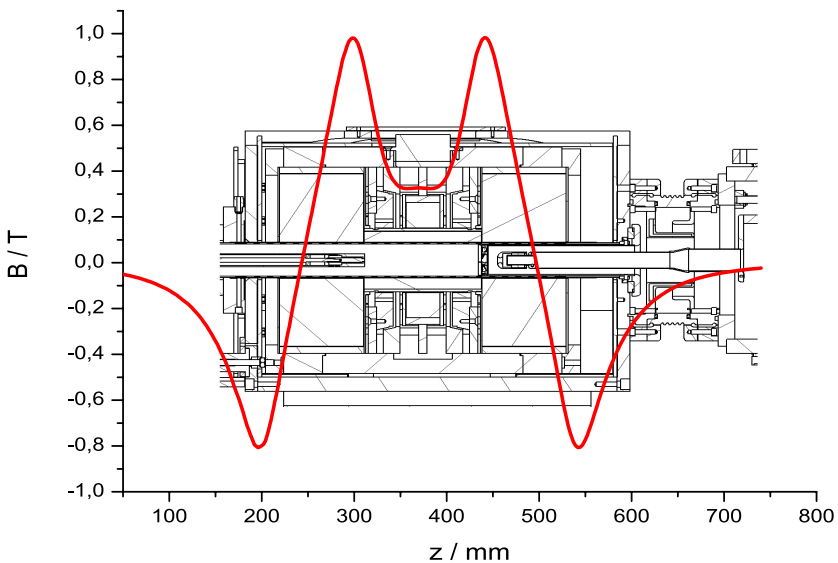

$\int B_z dz \approx 0.03\ Tm$

$U_{extr} = 7\ kV$

beam dominated by: O^{2+} & N^{2+}

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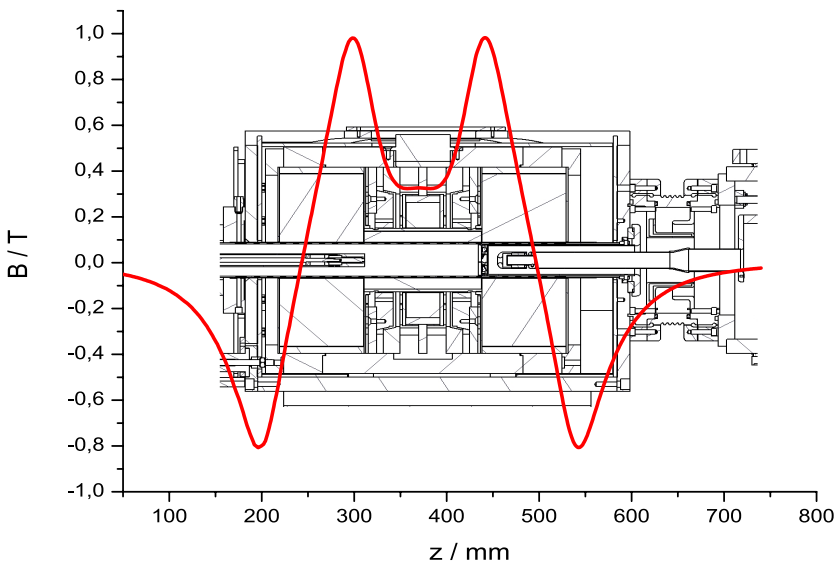

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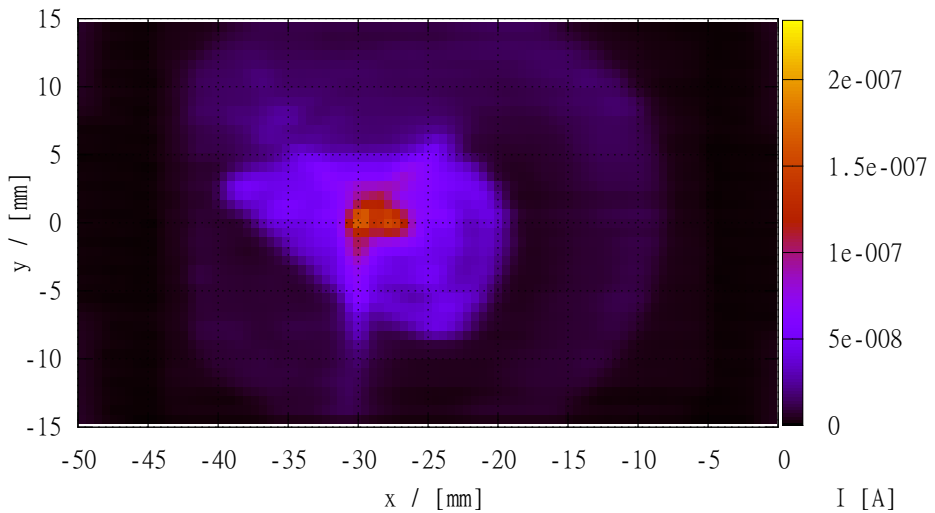
$\rightarrow$ rotation amounts to $\approx \frac{\pi}{2}$!

Ion Distribution of a Strongly Focussed Beam Profile

Source Settings

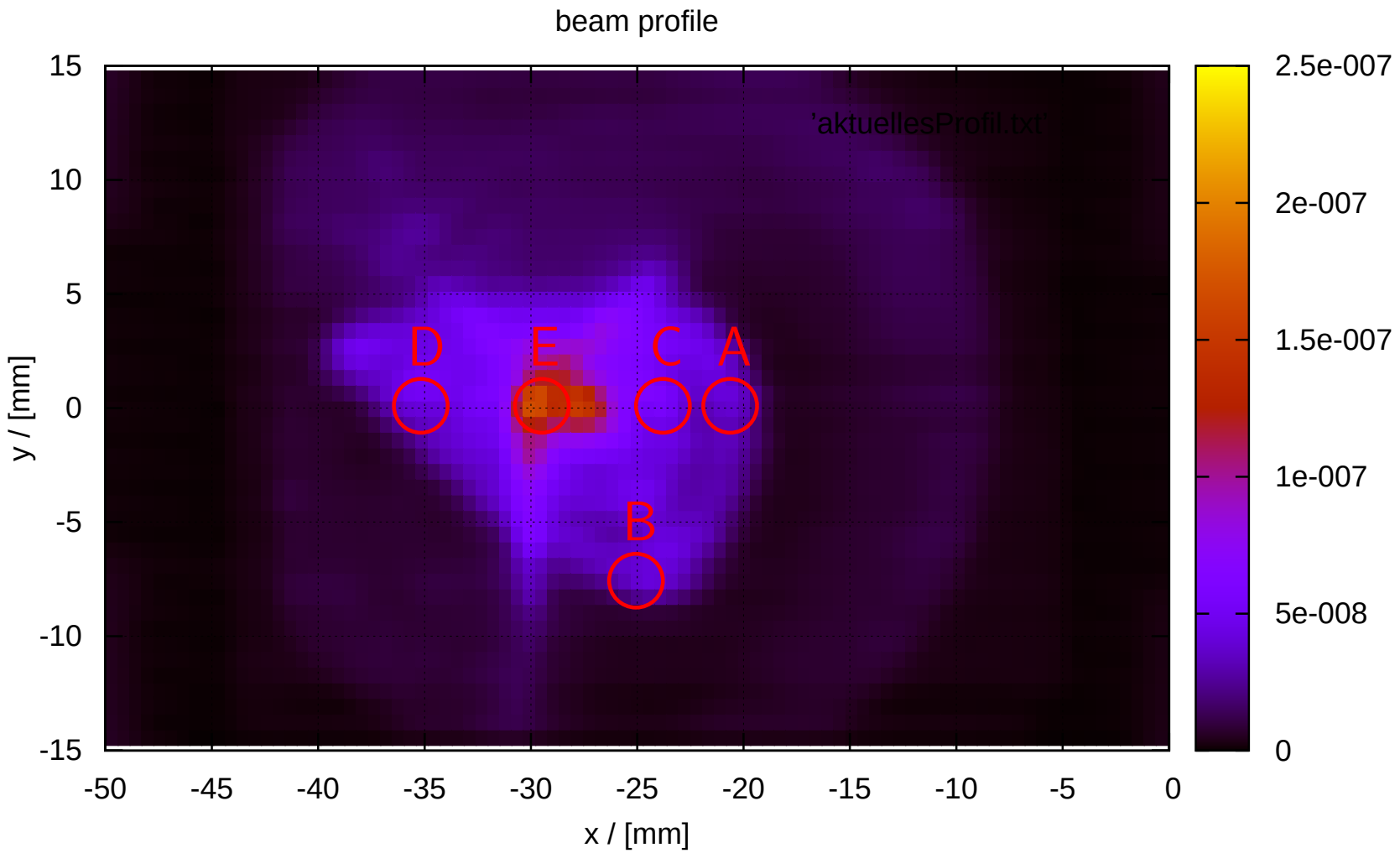
pressure inside plasma chamber	p_{ECR}	1.0×10^{-5} mbar
microwave power	$P_{\mu w}$	50 W
microwave frequency	$f_{\mu w}$	11 GHz
extraction voltage	U_E	7 kV
extraction position perpend. to beam line	d_{Ep}	central
extraction position along beam line	d_{Ea}	25 mm

lead to the following profile in cube 1:



Ion Distribution of a Strongly Focussed Beam Profile

positions of the beam profile where spectra have been measured:



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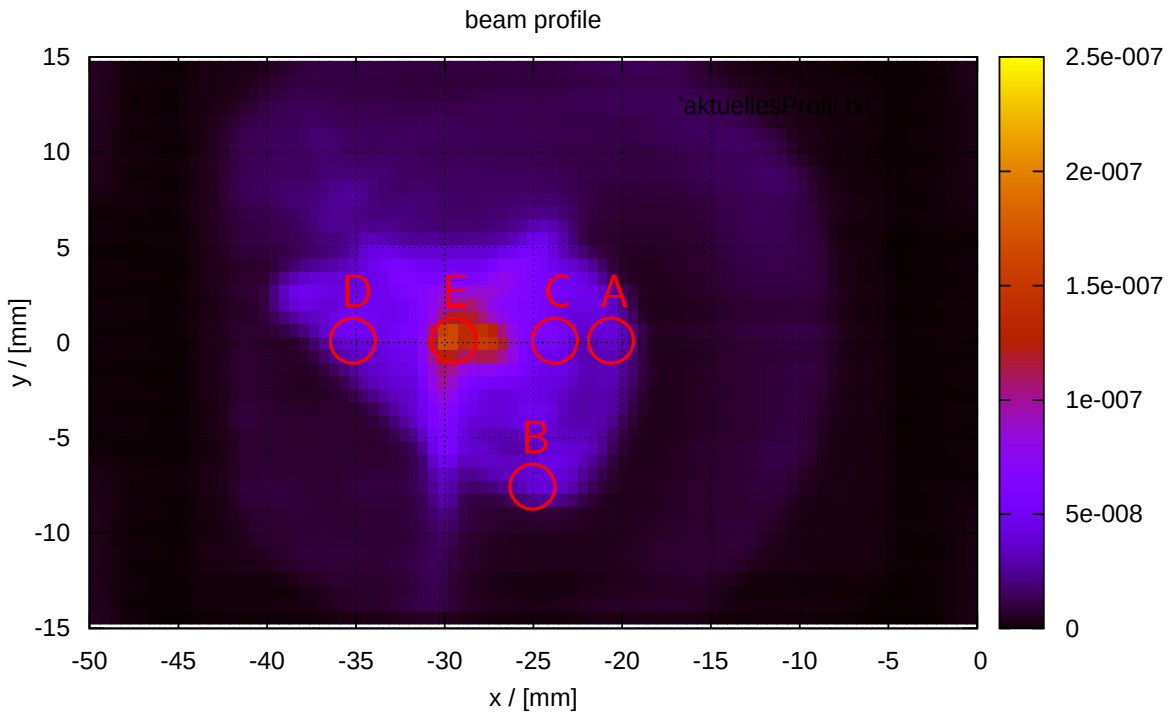
overview of the profile:



dominating ion species:

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C	N^{2+} O^{2+}
D	N^{2+} O^{2+}
E	$O^{1+\rightarrow 4+}$ $N^{1+\rightarrow 4+}$ H_2O^+, OH^+, H^+

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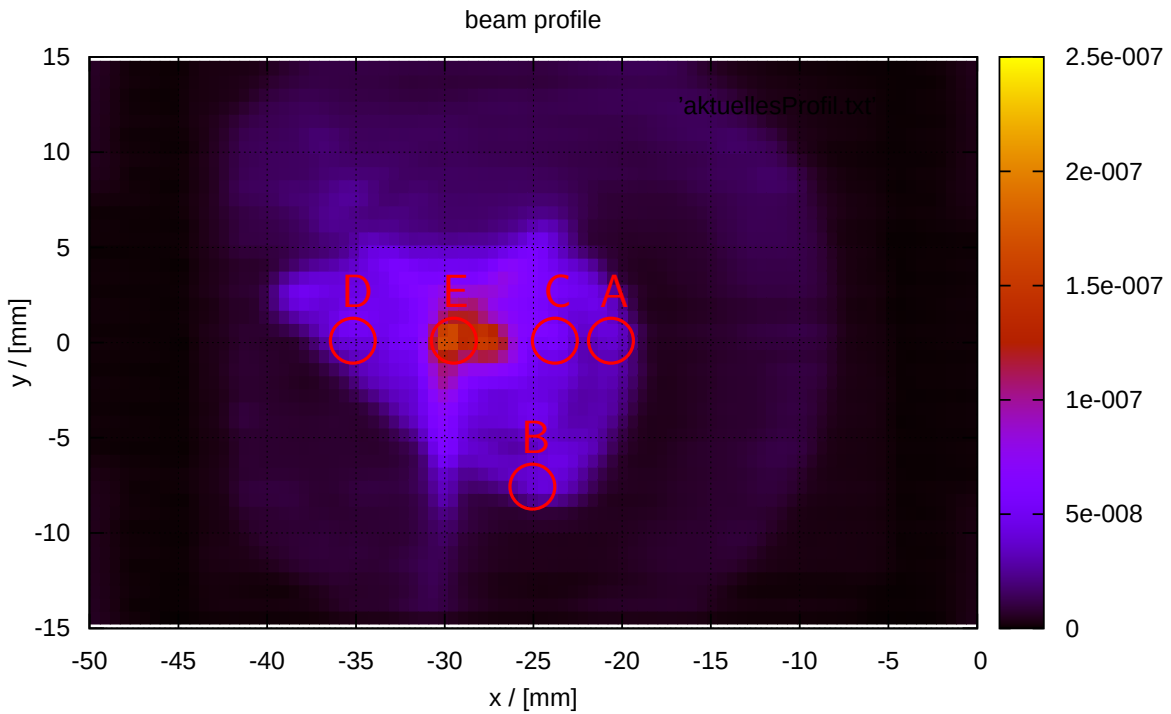

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assuming a slight misadjustment of the blinds at position C:

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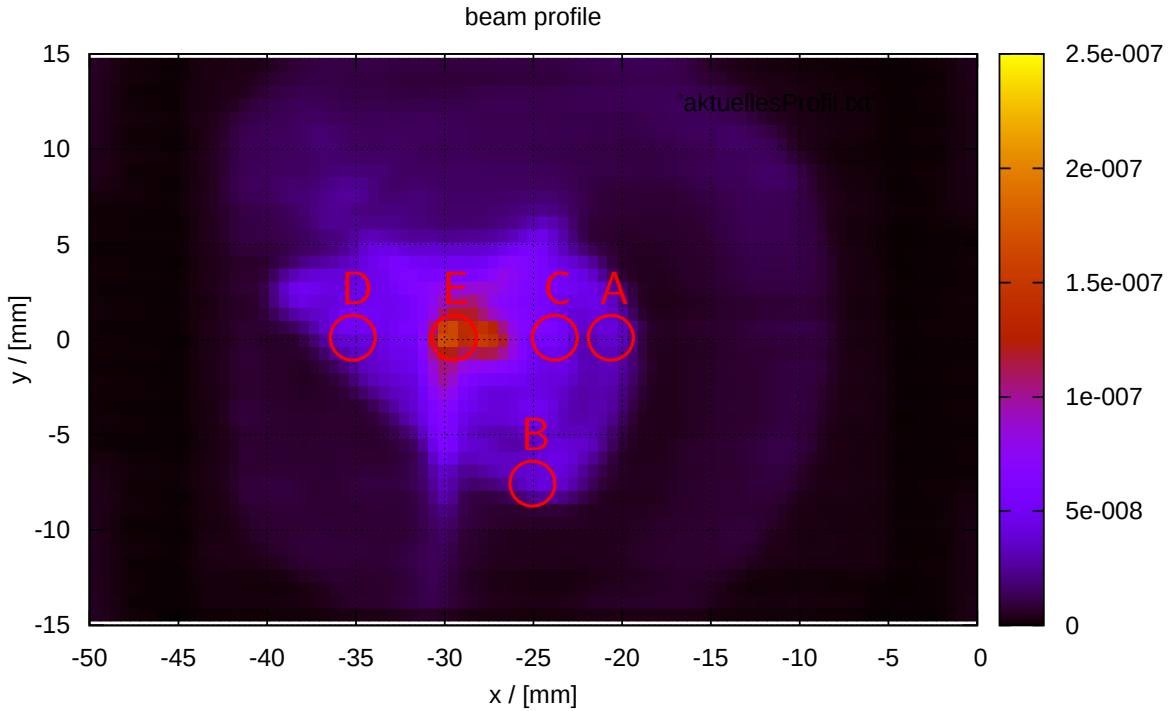

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assuming a slight misadjustment of the blinds at position C:

$\rightarrow$ each ring is dominated by a specific m/q ratio!

Summary

Beam focussing:

- both techniques work

(moving the extraction and changing the extraction voltage)

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Detector:

- high resolution (in current and location)
- works well as our primary beam diagnostic
- more sensitive version under development