Introduction
Part 3.a)

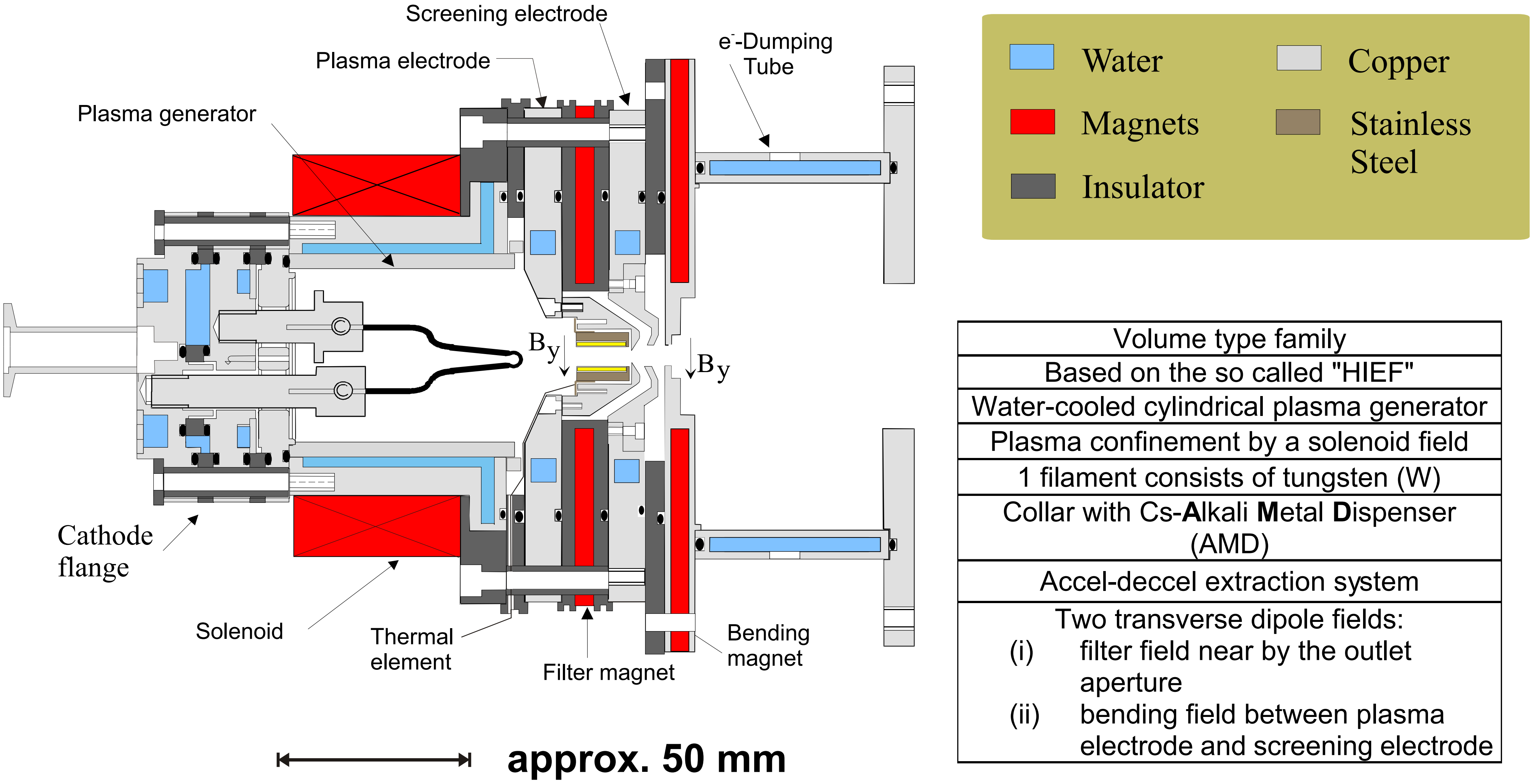
Investigations of a small volume typed H^--ion source introducing a collar with Cs dispenser

Overview

~ Overview of the ion source
~ Collar
~ Current measurements

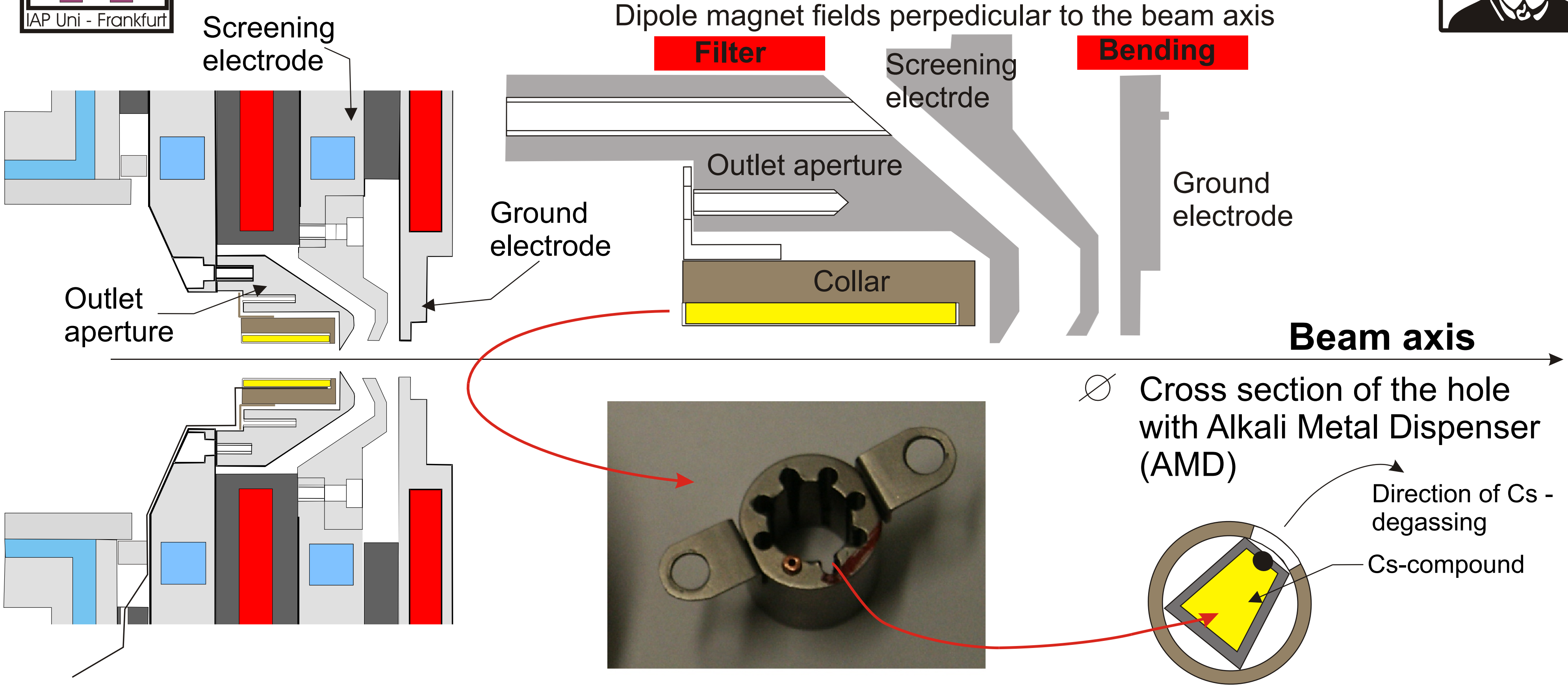
Under cooperation of:
Rainer Thomae
Working group:
C. Gabor, A. Jakob, O. Meusel, J. Pozimski (group leader), F. Santic, J. Schäfer
Prof. Dr. U. Ratzinger, Prof. Dr. H. Klein

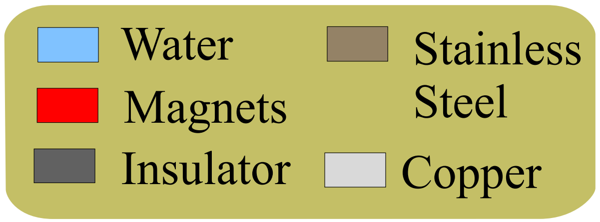
Schematic drawing of the H⁻-ion source



Volume type family
Based on the so called "HIEF"
Water-cooled cylindrical plasma generator
Plasma confinement by a solenoid field
1 filament consists of tungsten (W)
Collar with Cs-**A**lkali **M**etal **D**ispenser (AMD)
Accel-deccel extraction system
Two transverse dipole fields: (i) filter field near by the outlet aperture (ii) bending field between plasma electrode and screening electrode

Extraction region





~ Collar heating due to plasma
~ Temperature control with different duty cycle
~ Mounting with 2 small stainless steel plates

Drawing NOT in scale !

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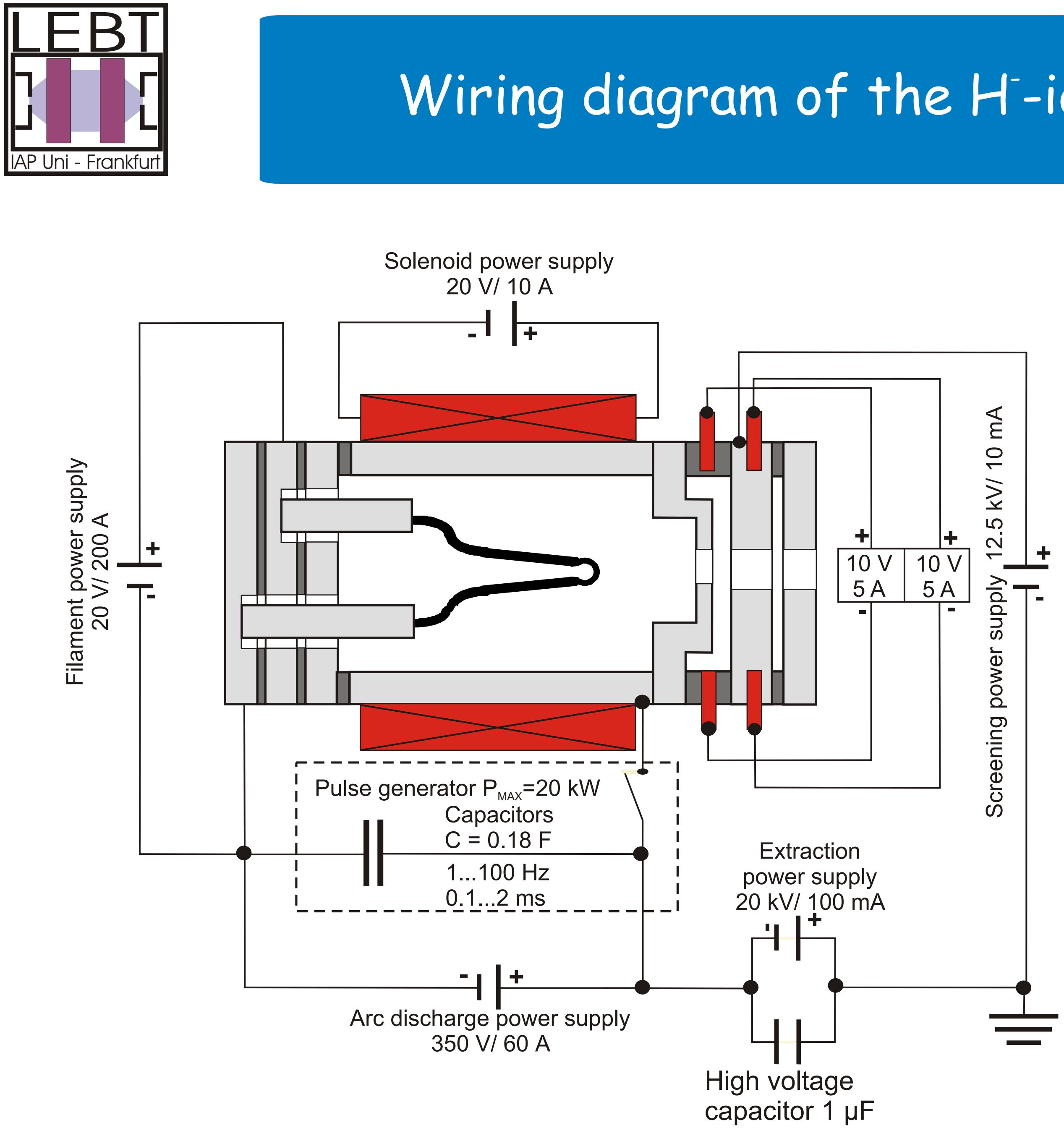
Wiring diagram of the H^--ion source



Main parameters:

Arc voltage	60...110 V
Arc current	10...100 A
Frequency	10...100 Hz
Pulse length	100 µs...1 ms
Arc power	< 10 kW
Filament current	< 130 A
Cathode length	104...130 mm
Cathode diameter	1.6 mm
Solenoid field	< 30 mT
Filter & bending	< 15 mT
Operation gas	Hydrogen
Pressure at the gas inlet	7...14 Pa
Extraction radius	1.5...3 mm
Gap	2...8 mm
Screening hole	1.0...3.5 mm
Neg. extraction voltage	1.5...9.0 kV

Magnets
Copper
Insulator

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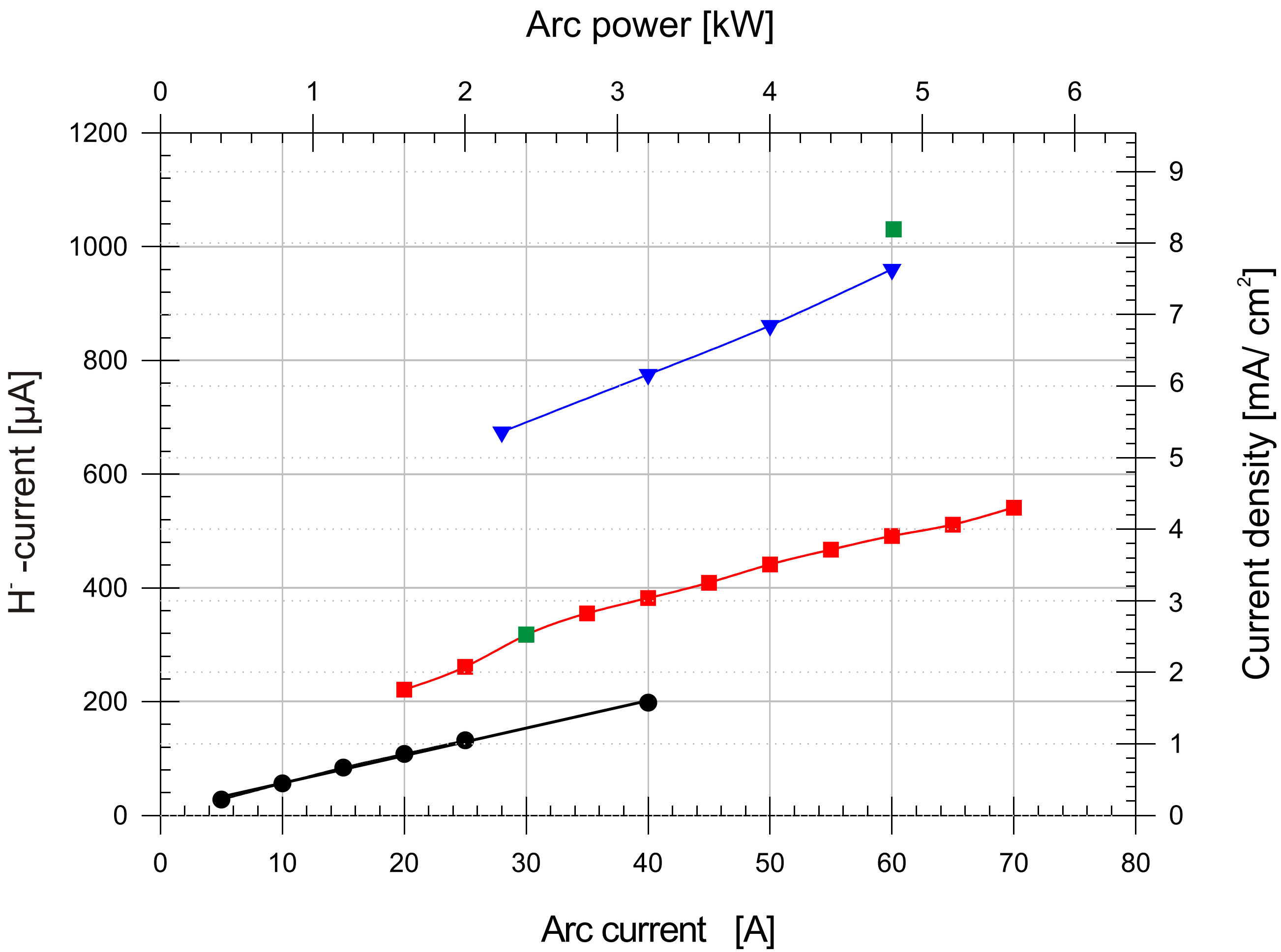
H^--current as a function of the arc power with collar



Extraction radius: 2 mm
Arc voltage: 80 V
Pressure: 10 Pa

Operation without Cs

- Pulse length: 500 µs
  Repetion rate: 17 Hz

Operation with Cs

- Pulse length: 300 - 500 µs
  Repetion rate: 20 - 50 Hz
  T ~ 410 - 430°C
- pulse length: 300 µs
  Repetion rate: 20 Hz
  T ~ 410 - 430°C

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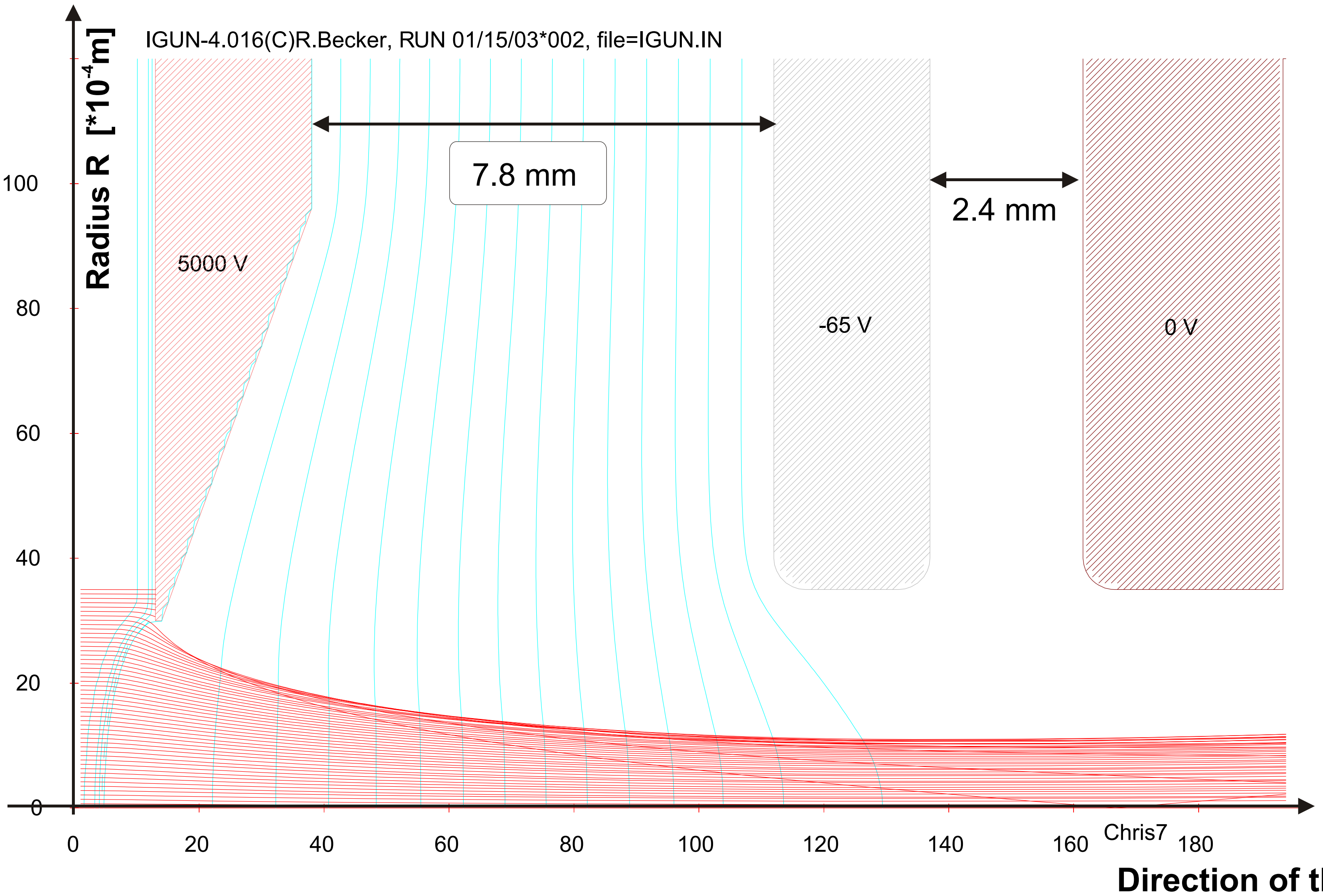
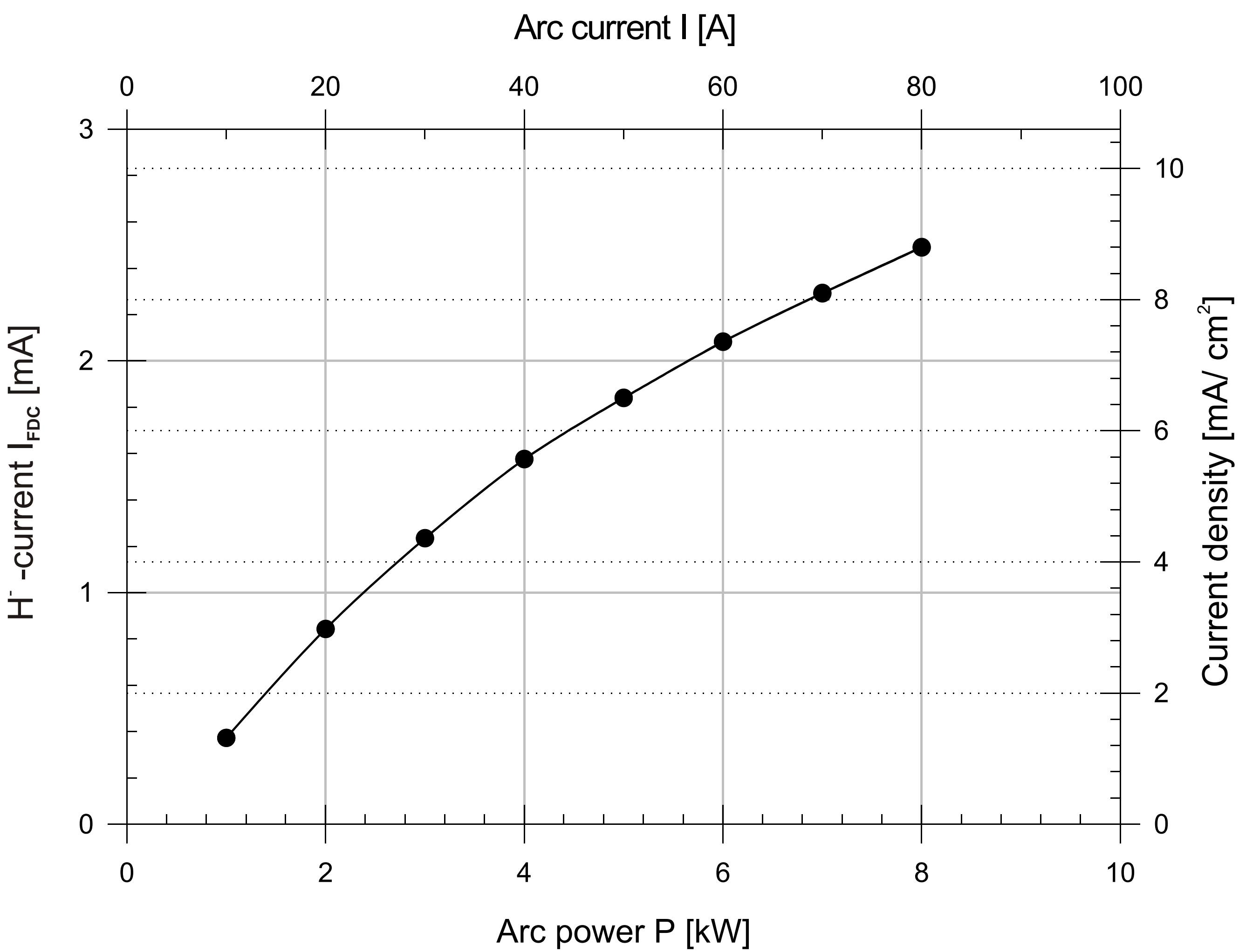
Beam trajectory plot simulated with IGUN



R = 3 mm
d = 7.8 mm
S = R/d = 0.38
A = 0.283 cm^2
Current density:
10.6 (app.8) mA/cm^2
Electric field strength:
0.6 kV/ mm
Total current:
2 mA H^--ions
1 mA e^--electrons
=> e/H^--ratio: ~10 - 20
(with Caesium!)

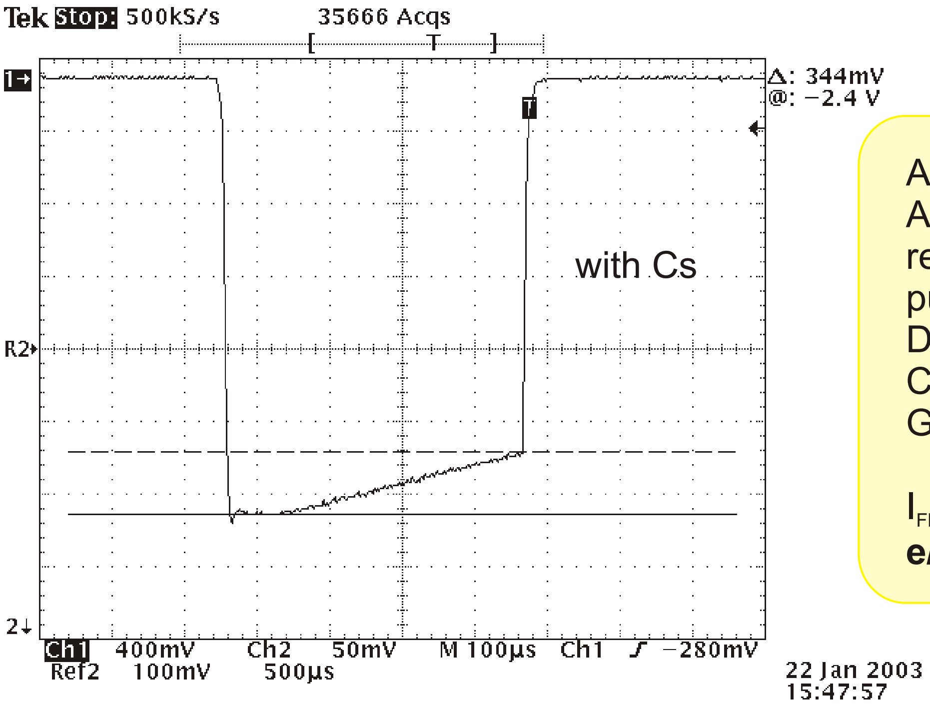
H^- -current vs. arc power without collar



Arc voltage:	100 V
Repetion rate:	50 Hz
Pulse length	400 µs
Duty cycle:	2.0 %
Gas pressure:	0.14 mbar

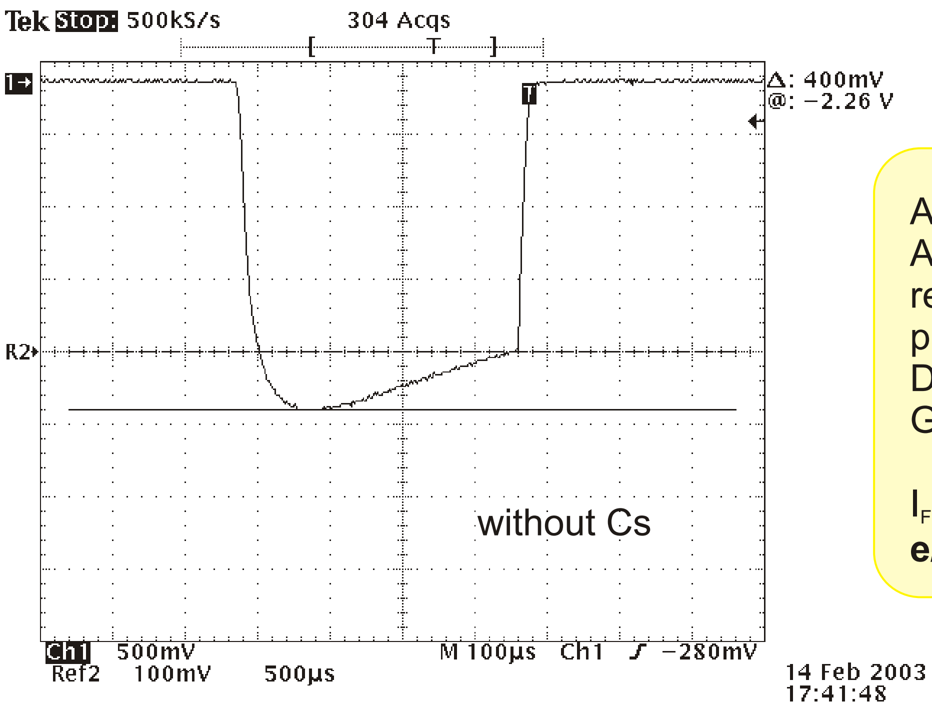
Matched case:
Extraction Voltage: -7.7...-2.8 kV
e/H ratio: ~70 (!)

Pulse shape of the H^--beam



Arc current: 80 A
Arc voltage: 100 V
repetion rate: 70 Hz
pulse length 400µs
Duty cycle: 2.8%
Collar temperature: 340°C
Gas pressure: 0.14 mbar

I_{FDC} = 2,6 mA
e/H proportion: ~10



Arc current: 80 A
Arc voltage: 100 V
repetion rate: 50 Hz
pulse length 400 µs
Duty cycle: 2.0 %
Gas pressure: 0.14 mbar

I_{FDC} = 2,5 mA
e/H ratio: ~70 (!)

Summary

For planned (diagnostic) experiments should be the achieved current high enough

It is possible to work with/ without collar
=> Research into Cs influence on beam transport, ...

Further investigations
(beam profile, CCD camera, emittance measuerment)
to the ion beam shift due to magnetic filter& bending field are necessary.

Introduction
Part 3.b)

Preparation for non-destructive beam diagnostic via laser electron detachment

Overview

~ Motivation & Principle

~ Important Laser Parameters

~ Ion beam transport simulation

Working group
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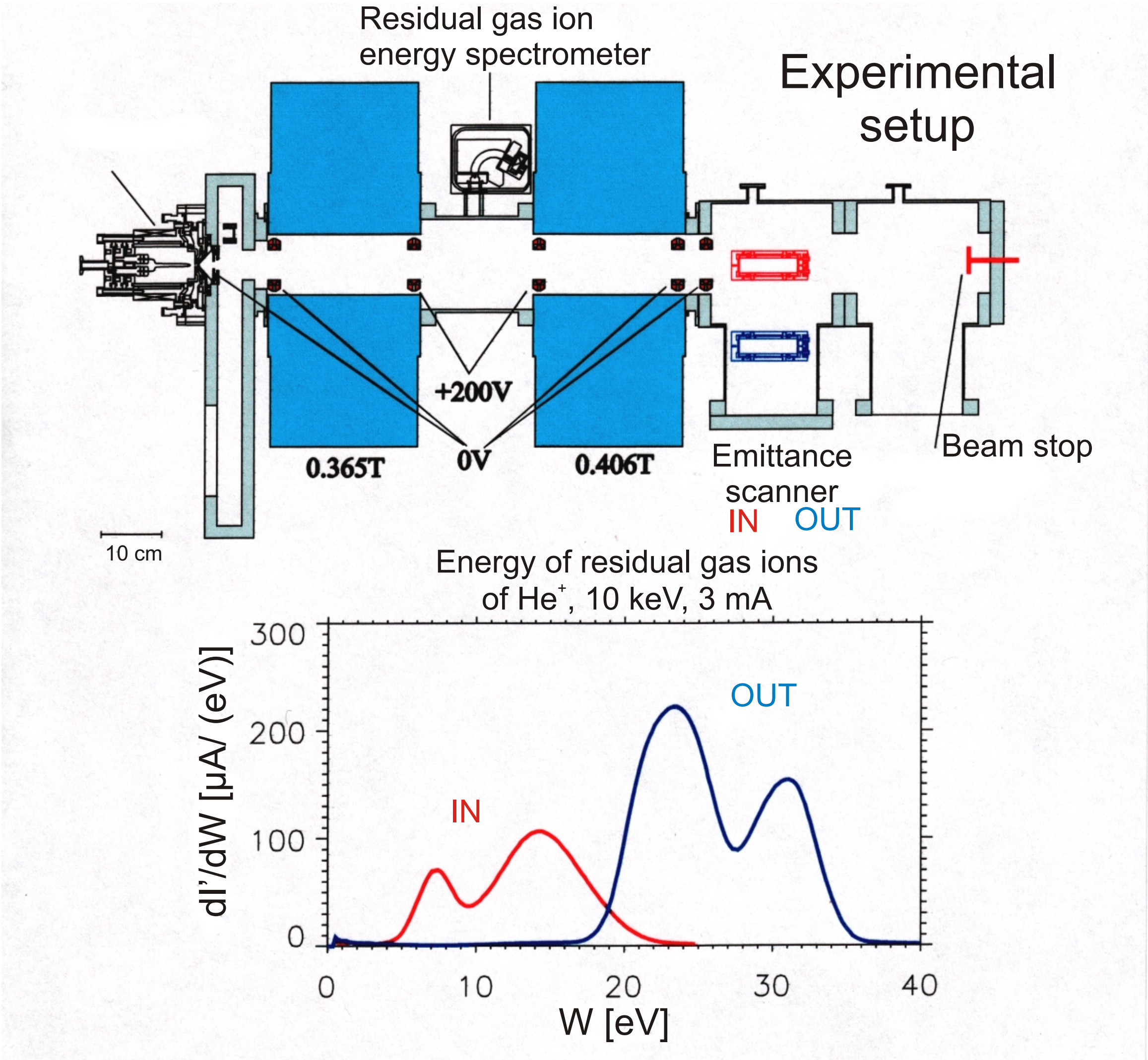
Problems with destructive measurement devices



Vaporise the metall
Deformations
Melting
Plasma

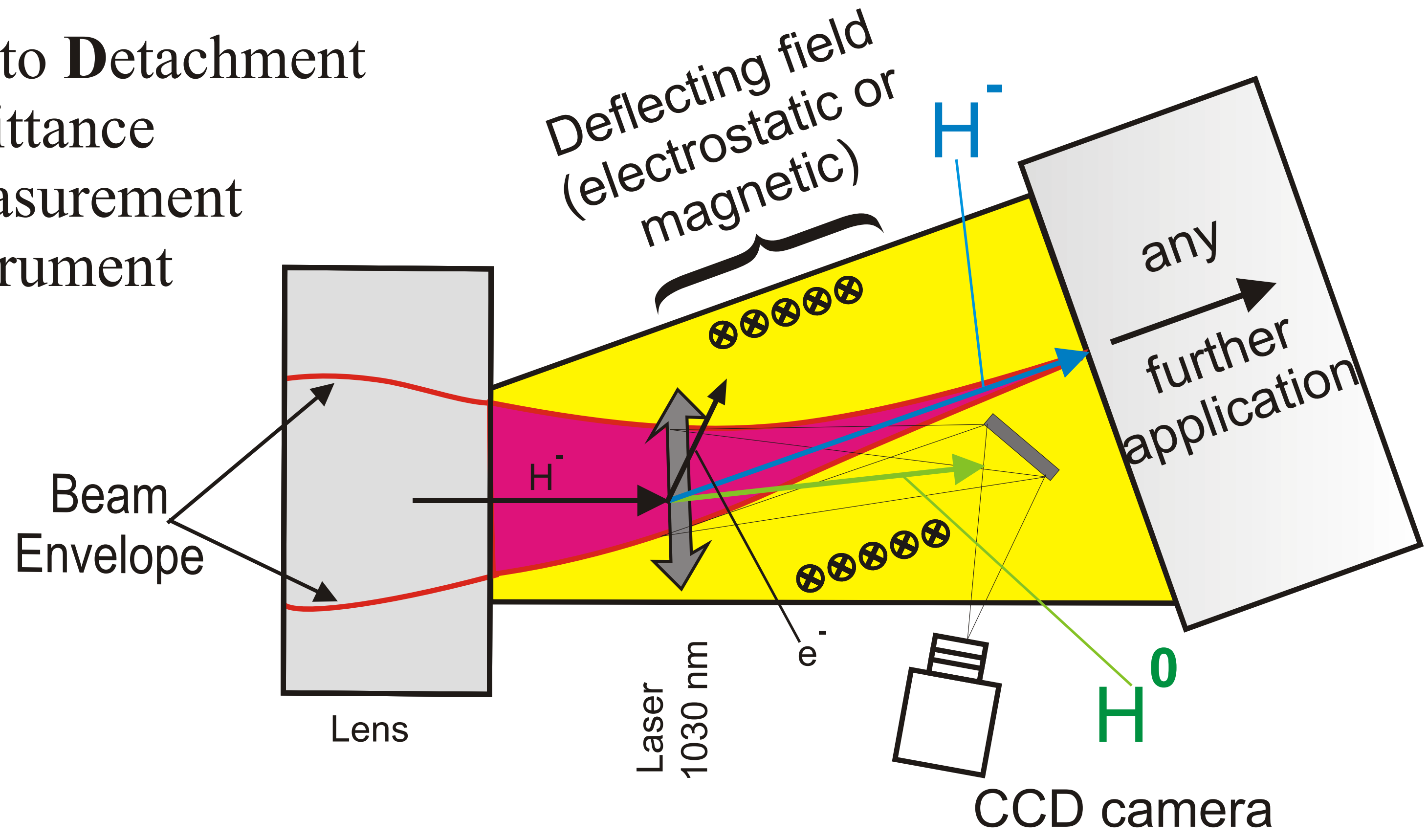
(i) It is difficult to determine the influence on degree of space charge and beam potential.

(ii) Secondary electrons produced by the interaction of the ions and the harp.

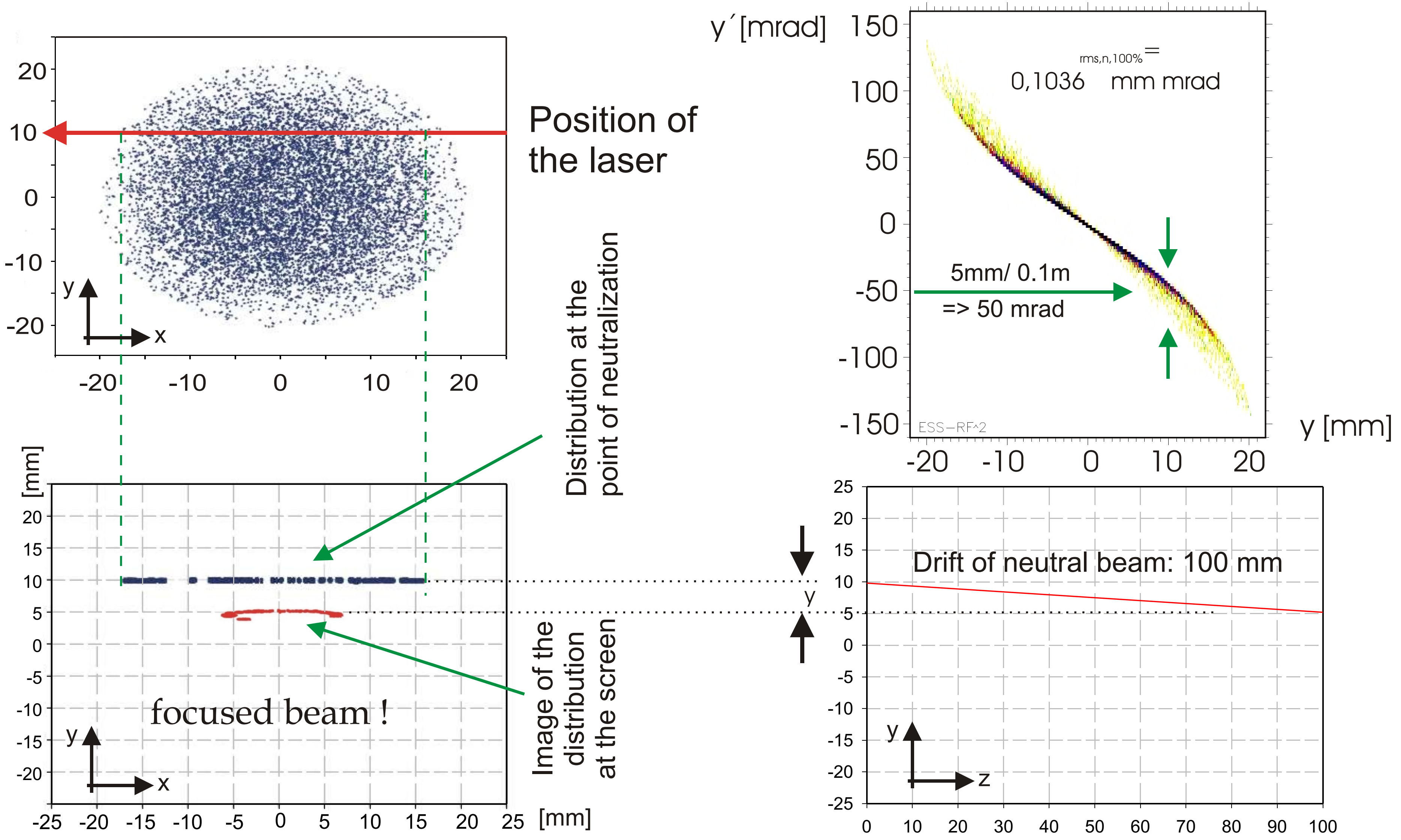
Non-destuctive H⁻-Beam Emittance Measurement

- Due to the low binding energy of the additional electron photons with appropriate energy (W~1.5 eV) can be neutralise the negative ions
- Peak cross section s=4.0*10^{-17} at a wave length of 830 nm

Photo **D**etachment
Emittance
Measurement
Instrument



Beam drift and image of the neutrals due to photodetachment



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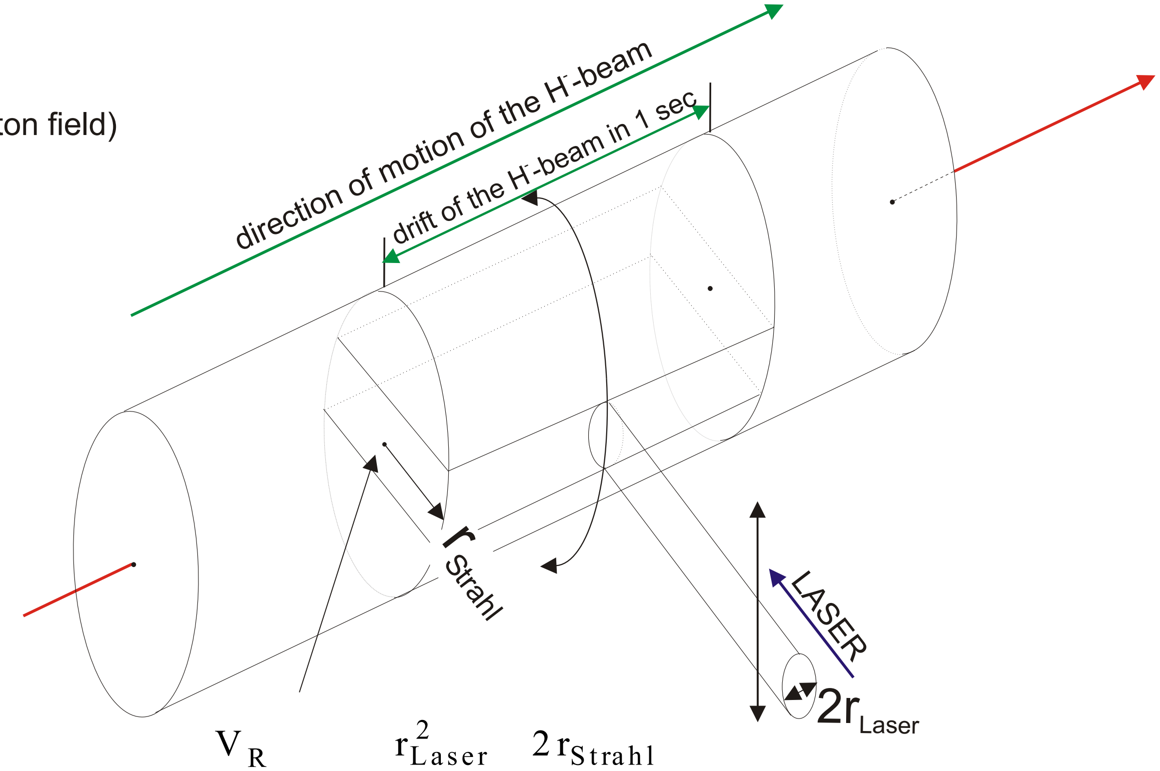
Production rate due to photo detachment

<u>Suppositions :</u>

(i) $r_{Laser} < r_{Strahl}$ (t_i= time that the ion spends in the photon field)

(ii) $t_i << t$ (= laser puls duration)

(iii) n_{H^-}= const. (small laser puls energy => linear. approach)



Production rate:

$$\frac{d}{dt}n_0 \qquad n_H \qquad n \qquad v$$

Total number of neutrals:

$$N_{H^0} \qquad \frac{d}{dt}n_0 \qquad V_R$$

I	2 mA	U	6 kV
P	15 W	$r_{ion\ beam}$	5 mm
	300 µs	r_{laser}	200 µm

=> $N^0 = 1.21*10^{+8}$ neutrals

Features of the Lasersystem

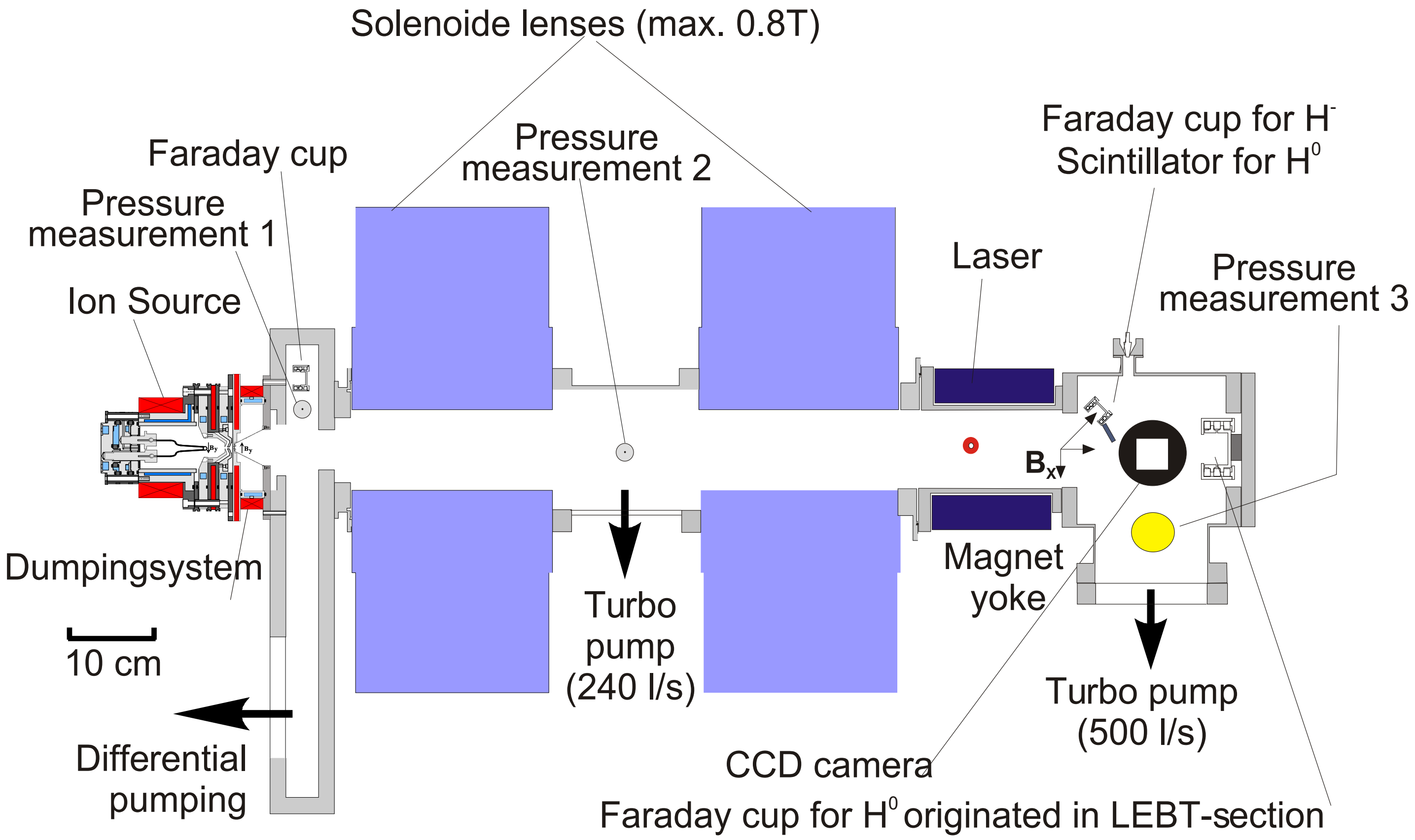
Versa Disk Laser Yb:YAG Laser	
Wave length	1030 nm
Max. power output P	20 W
Beam diameter	~ 1.5mm
Beam divergence (full angel)	<0.5 mrad
Mode Structur TEM_{00}	measured
Power Stability	measured
Power consumption (240V/ 50Hz)	<600W
Interface	RS - 232
Special water cooling	

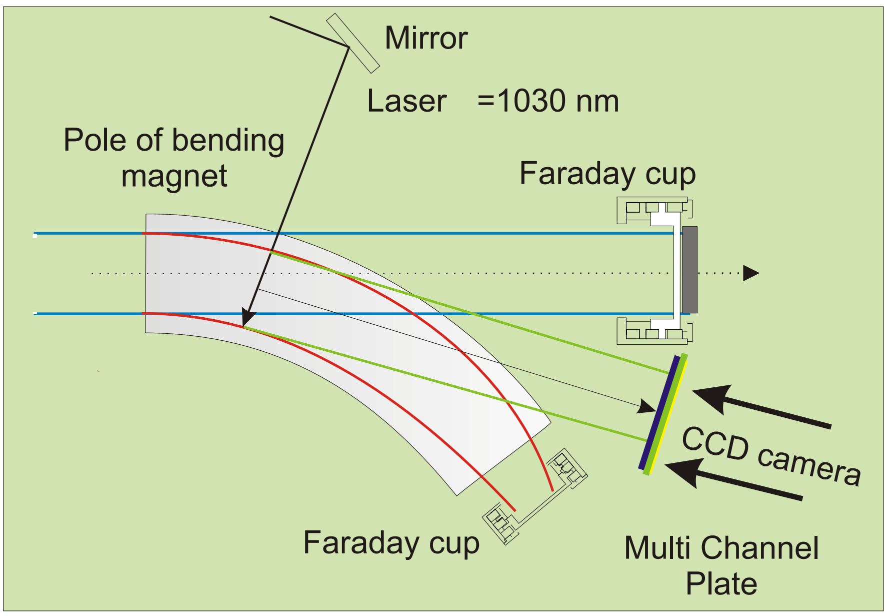
Laser Head:
Length: 700 mm
Width: 120 mm
Height: 80 mm

Achieved results

Current [A]	Power [W]	Power Stability [%]	M²
12,0	1,51	0,79	1,01
20,0	9,44	1,08	1,06
25,0	14,8	0,73	1,02
30,0	20,2	0,31	1,01

Low Energy Beam Transport line





Bending magnet 56.9°
Radius 179 mm°
B = 1.2 kG @ 10 keV H^--ions
Length = 150mm

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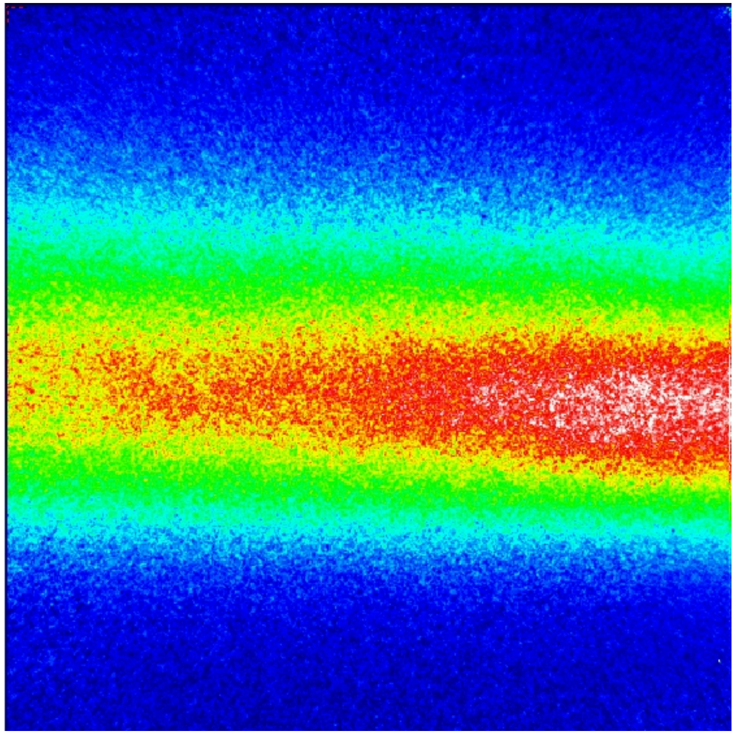
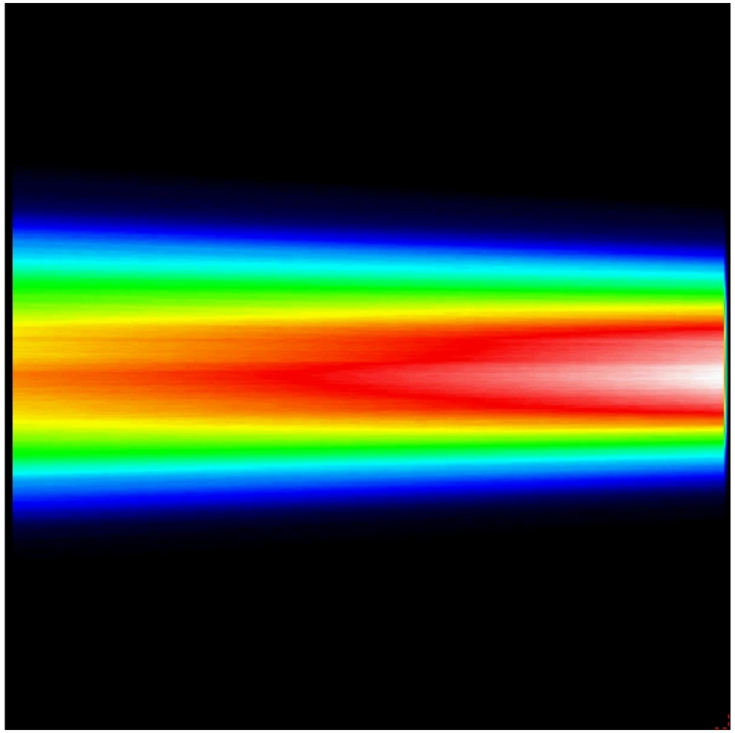
Preliminary CCD camera measurement

Measurement



Simulation



120 mm behind ground electrode

(i) same scale

(ii) miscoloured

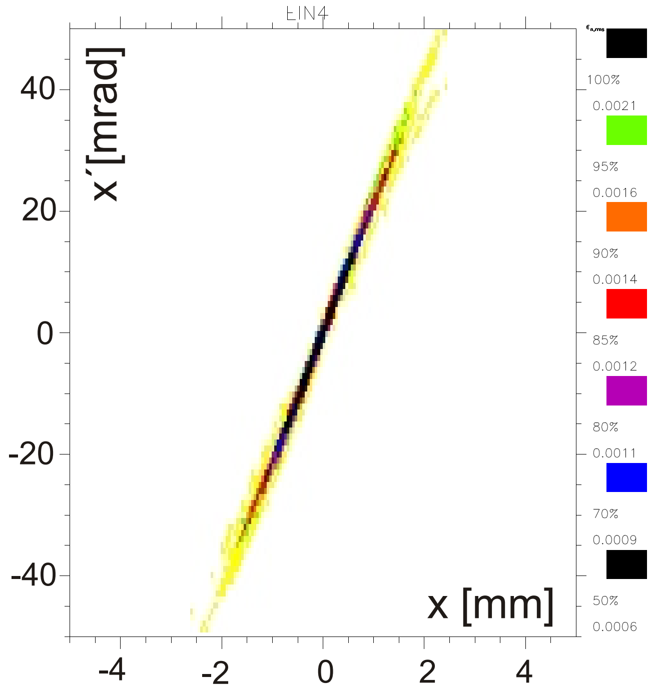
Divergence angle ~ 68 mrad

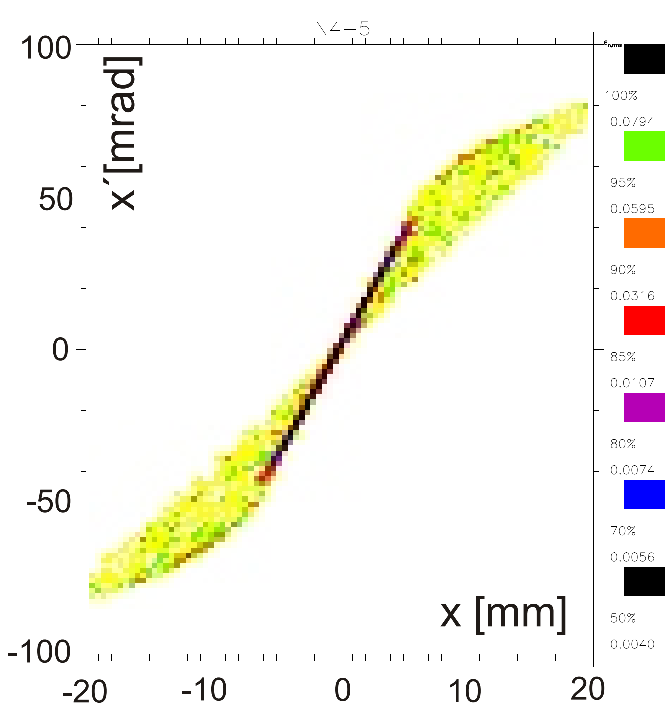
Compensation degree: 80 %
Entrance distribution based on IGUN
(r=2.5mm and r`=40..50 mrad)
Divergence angle: 82 mrad

=> either the compensation degree might be higher
or the div. angle might be smaller ......

..... but measurement and simulation are in the same oder of magnitude!

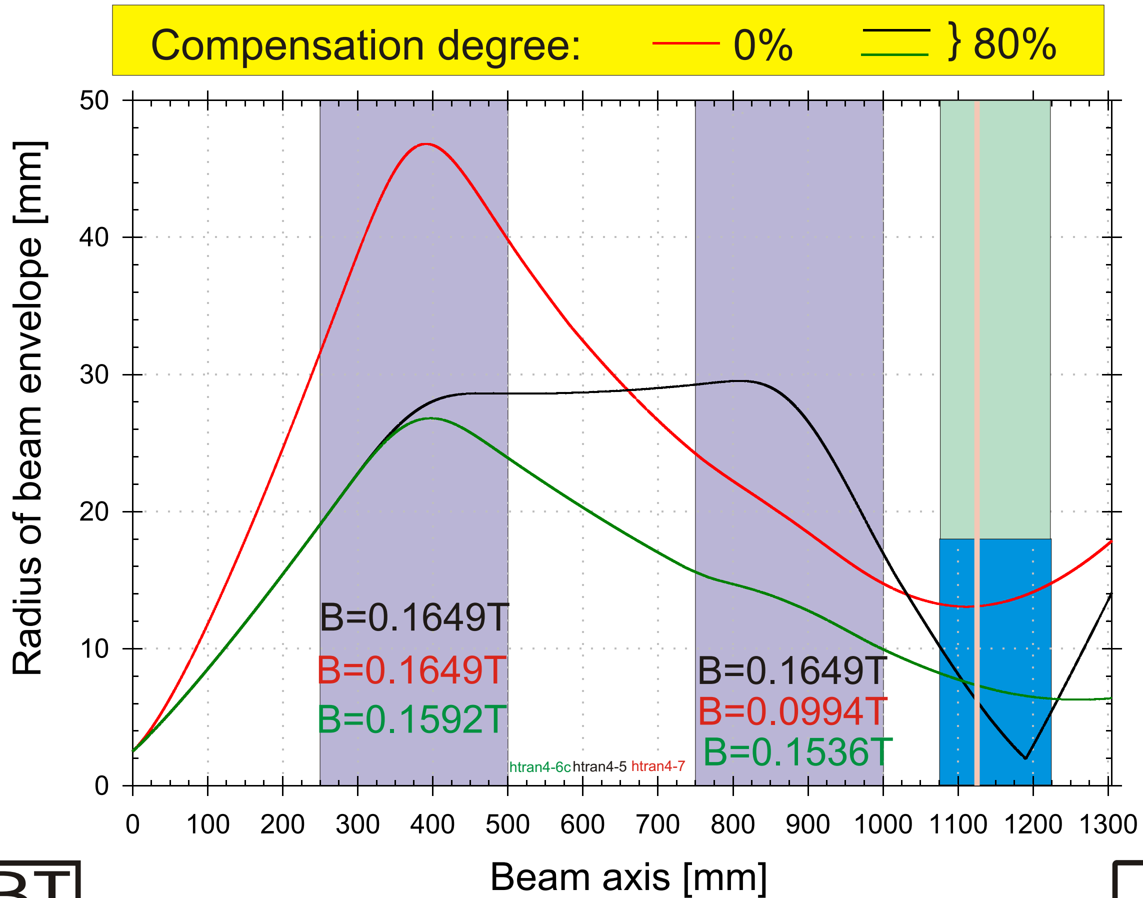
Multiparticle Siumlations (with LINTRA)





100%, norm.= 0.0025 mmmrad

r=2.5mm; r`=50mrad



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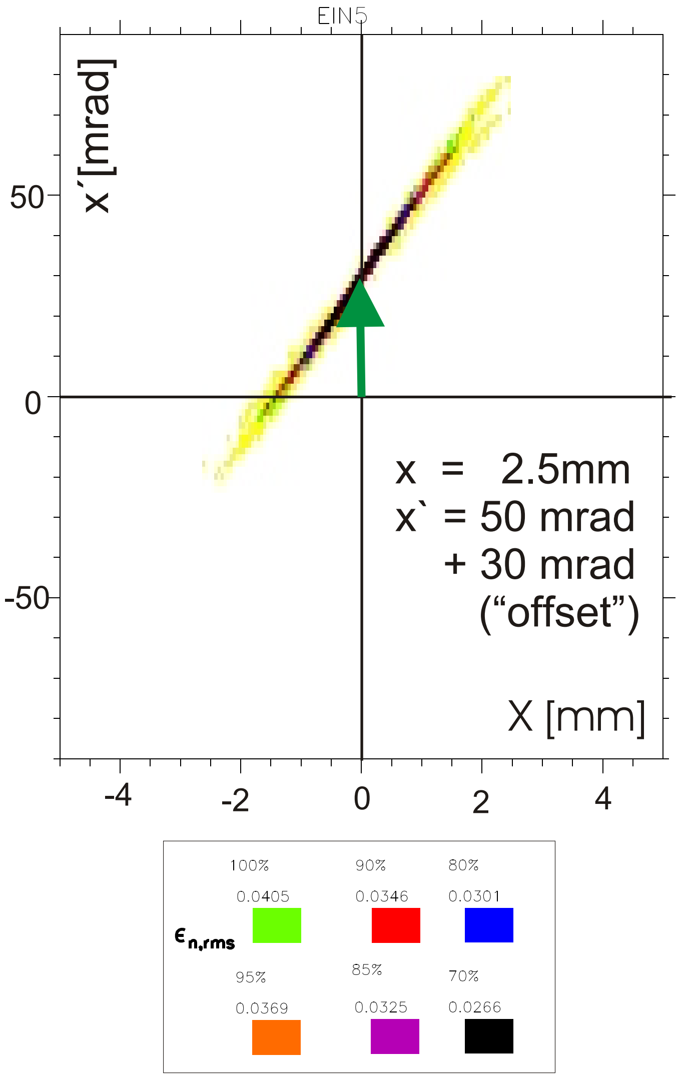
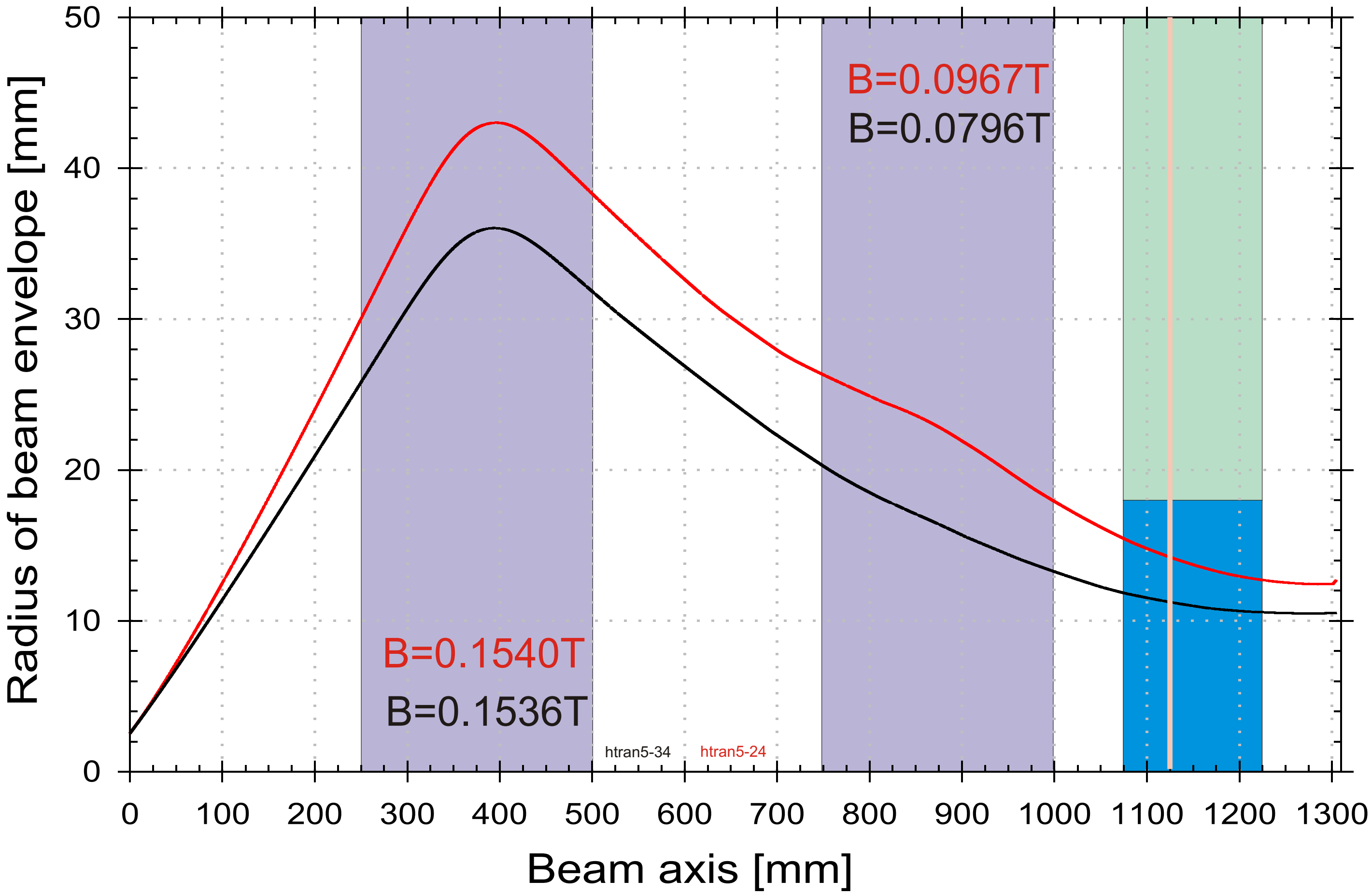
Simulations with an "of-axis" beam





Compensation degree: —— 50% —— 80%

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Conclusion & Outlook

Photodetachment emittance measurement

-> approximatly non-destructive
(only a small portion of H^-- will be neutralized)

-> no mechanical parts

-> no secondary electrons produced by
interaction of H^--ions (e.g.) with slit

Simulations has been shown

-> Solenoids will achieve quite good transmission
if the div. angle < 50..80 mrad

-> 2 solenoids have the advantage of different beam
angle.

Outlook

The test bench will be completed in the near future :

~ matching of the ion beam to the transport line

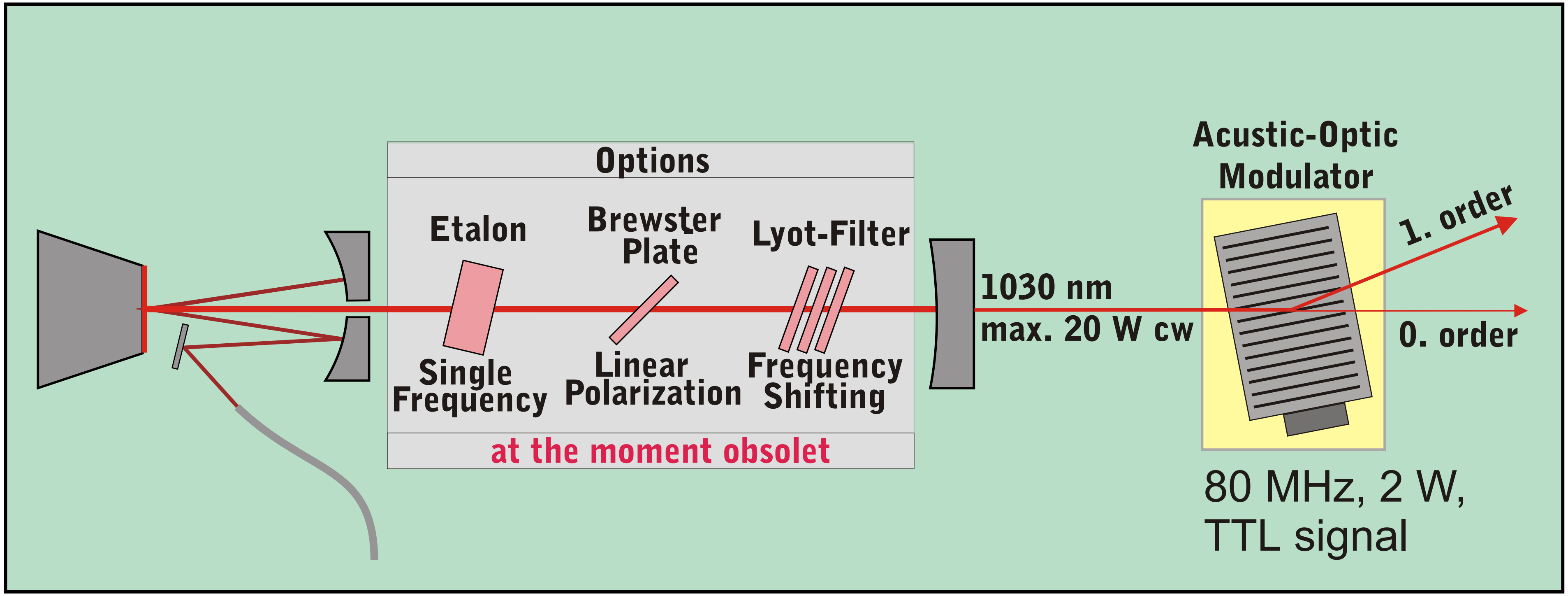
~ differentiell pumping tank

~ diagnostic (magnetic) chamber

~ Laser & optical beam path require more investigations about the influence of lense to the focus, ...

~ Important object of investigation is the influence of the deflecting field

Design Principle of Optical Cavity

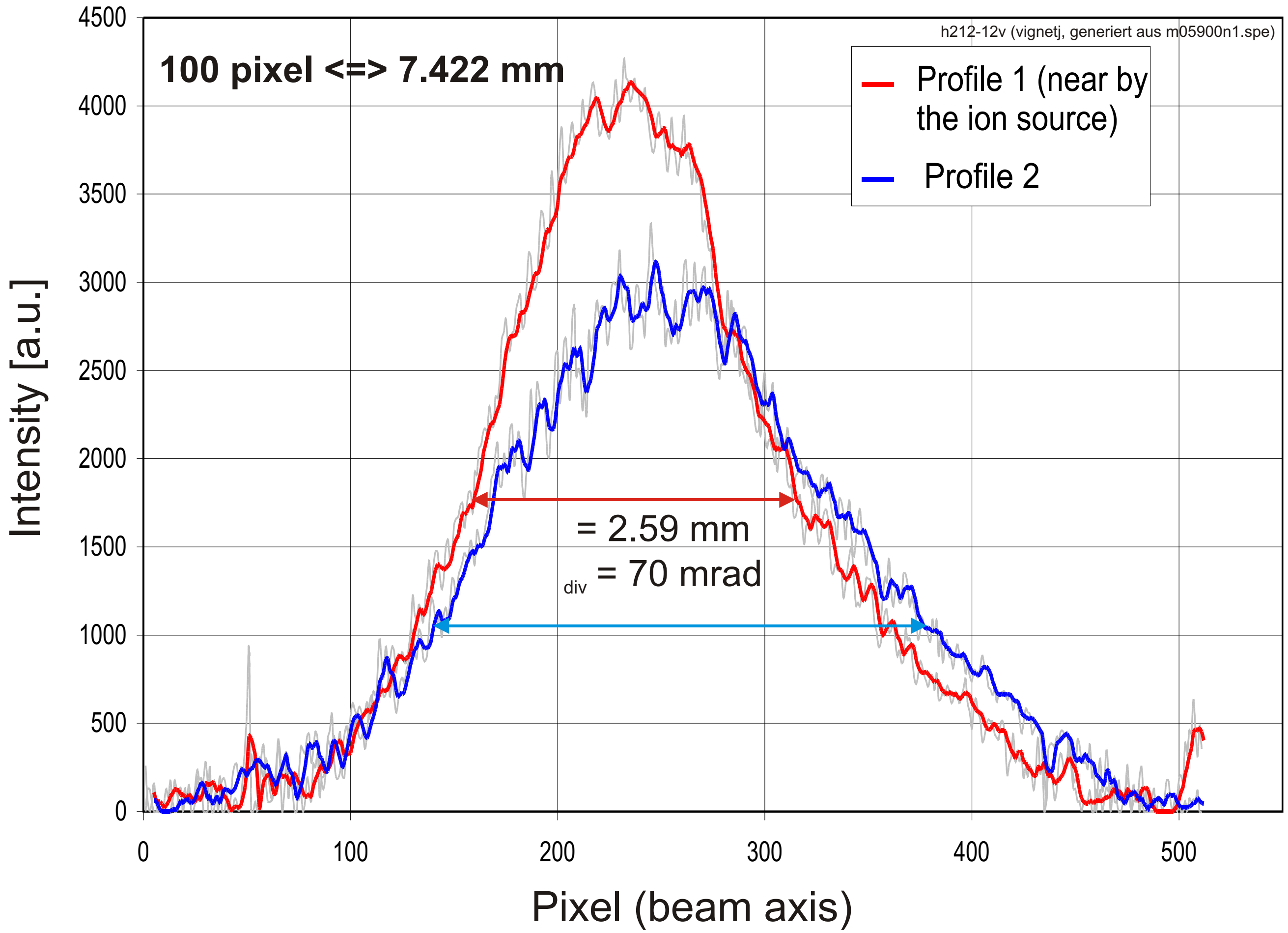


<u>For emittance measurements :</u>

(i) recommended to use the cavity without additional optic elements

(ii) The AOM will deflect the laser beam in 0.order into a beamdump and in 1.order to the ion beam.

CCD camera Beam profile



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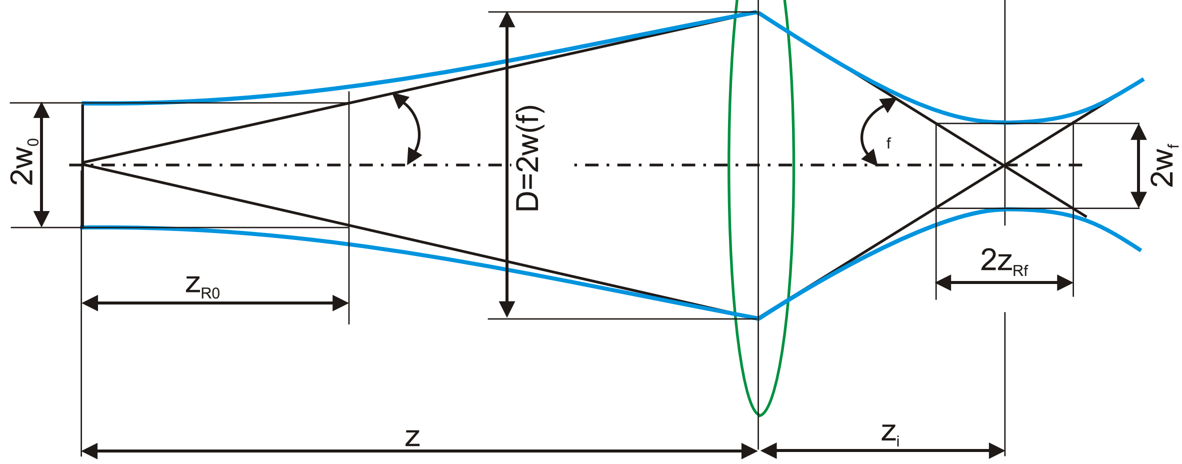
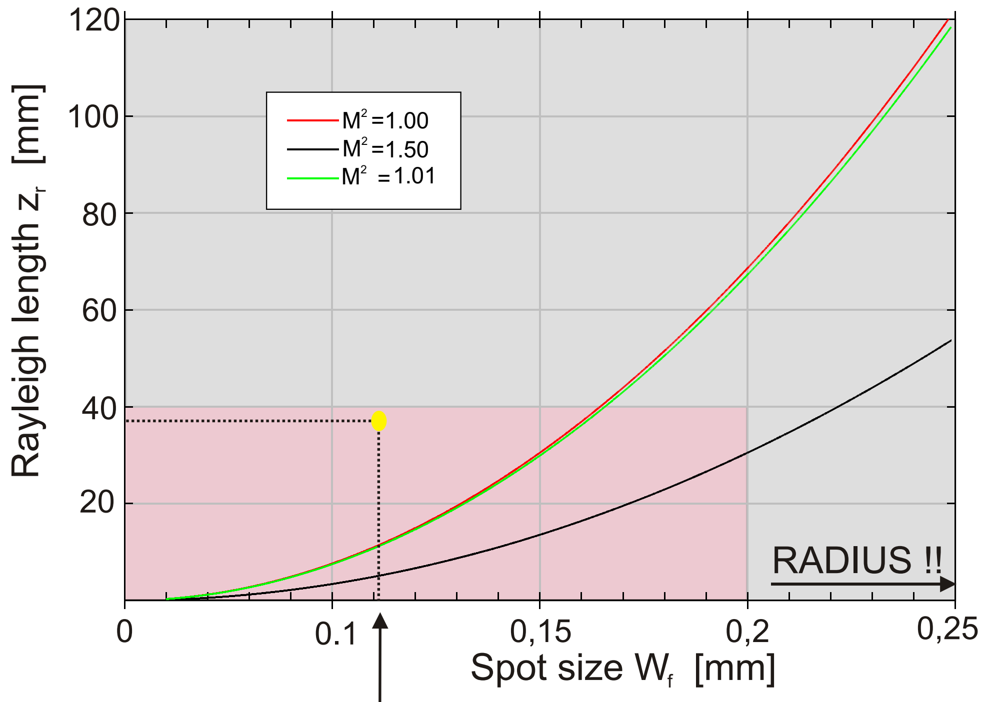
Laser beam propagation

$_0$; w_0; z_0	Chracterization of a radialsym. Laserbeam
$_0 w_0 \quad _f w_f$	Space beamwidth product
$M^2 \quad - \quad \frac{_0 w_0}{2}$	Time diffraction limit *"how close to a diffration limited (gaussian) laser beam"*





$$z_{Rf} \quad - \quad \frac{w_f}{M^2}$$

"propagation behind z_{Rf} is like the far-field angle $_f$"

$$w_f \quad \frac{w * f}{\sqrt{(z \quad f)^2 \quad \left(\frac{w_0^2}{\;}\right)^2}}$$

f = 0.4 m
w = 0.5 mm
z = 2 m

=>

w_f = 128 µm

z_{Rf} = 38 mm

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