Beam diagnostic for the injection beam line at MESA

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  - Motivation
  - Emittance
  - Photo cathodes
  - Space charge
- Components
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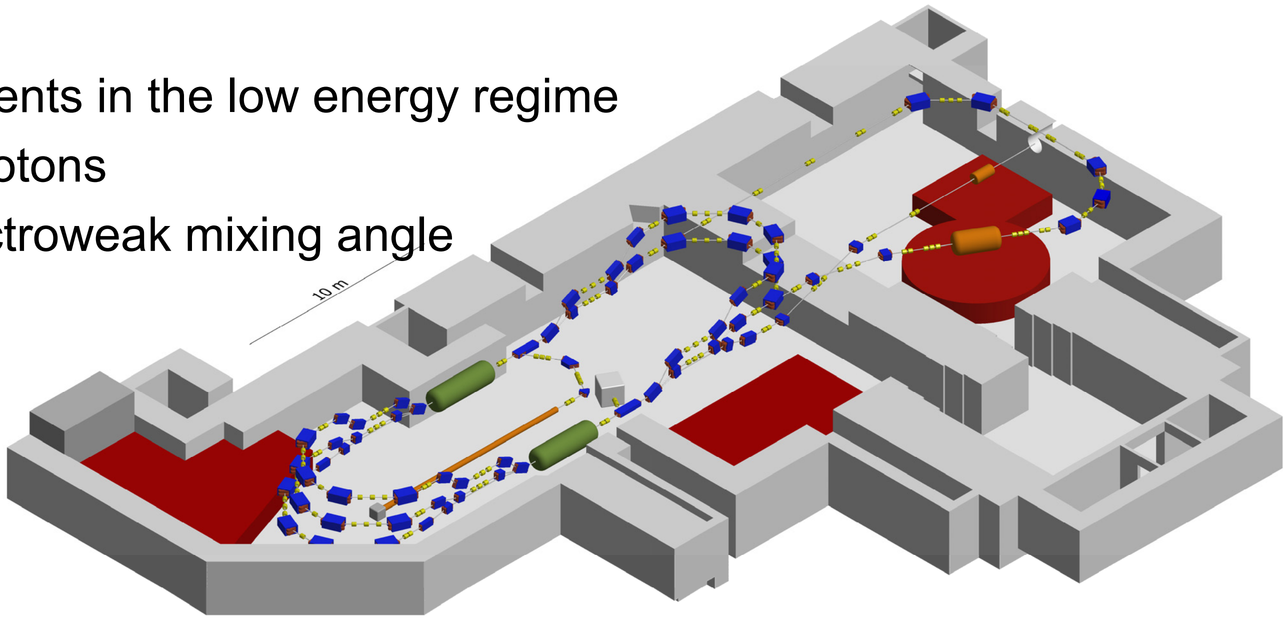
- Summary & outlook

Introduction - Motivation

- beam diagnostics for MESA
- 100 kV or 200 kV dc-electron gun
- normal conducting injector up to 5 MeV
- 1,3 GHz cw electron beam
- 155 MeV, 150µA polarized beam
- 105 MeV, 1 mA (10 mA @ stage 2) ERL-Mode
- bunch charge up to 8 pC (10 mA @ 1,3 GHz)

- Precision measurements in the low energy regime
- Search after dark photons
- Measurement of electroweak mixing angle



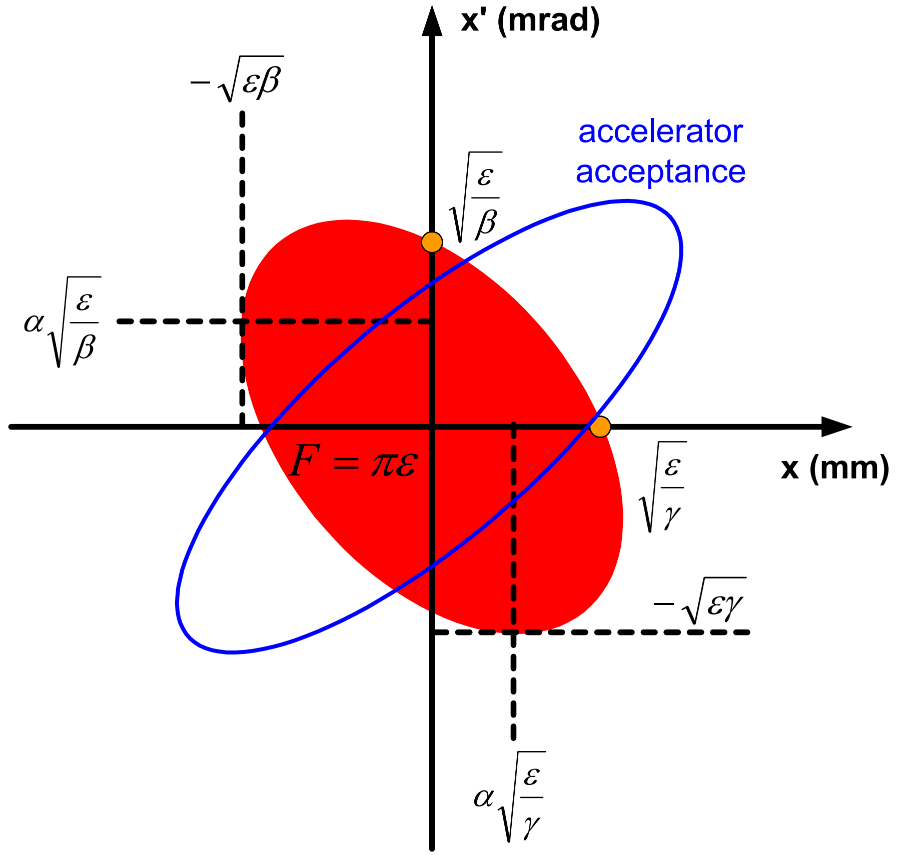
Important properties of the source/injector

- emittance must be smaller than the acceptance of the accelerator
- high extractable current
- long life time → stable photo emission
- reliable

Introduction - Emittance

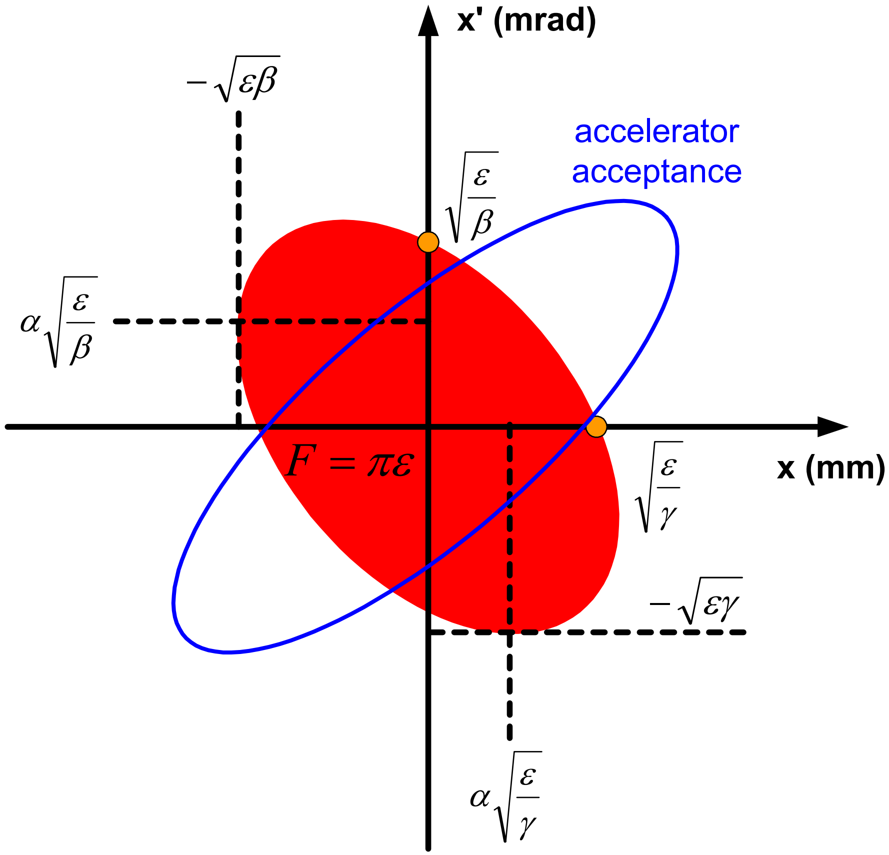
Emittance-ellipse $\gamma x^2 + 2\alpha x x' + \beta x'^2 = \varepsilon$

- 6 dimensional phase space
- transversal:
  - displacement and divergence
- longitudinal:
  - phase and energy spread
- TWISS-Parameters:
  - α, β und γ



Introduction - Emittance

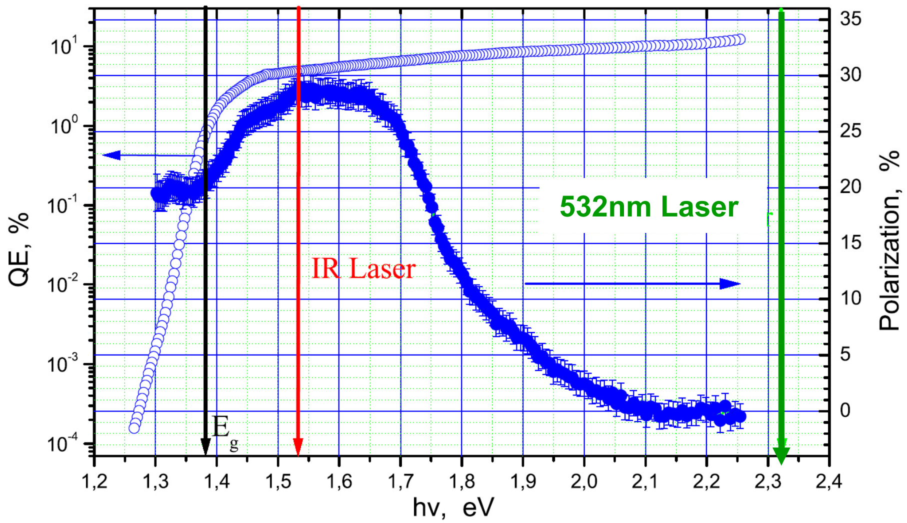
Emittance-ellipse $\gamma x^2 + 2\alpha x x' + \beta x'^2 = \varepsilon$



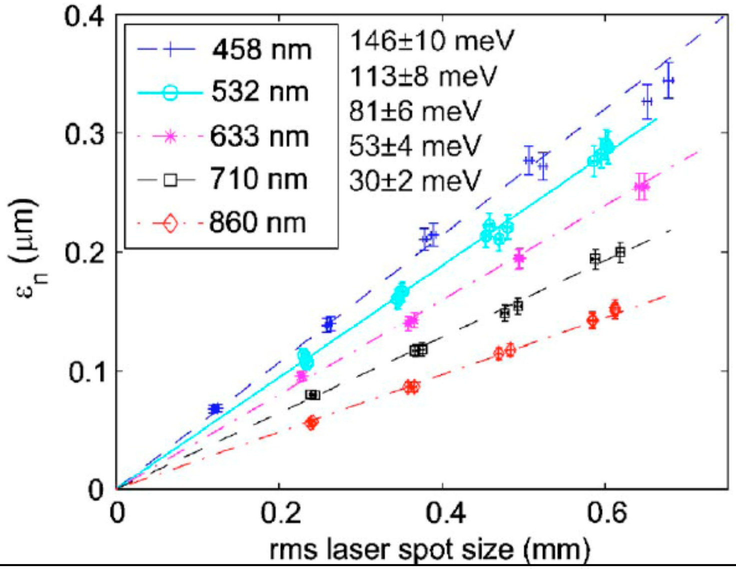
possibilities to measure the emittance

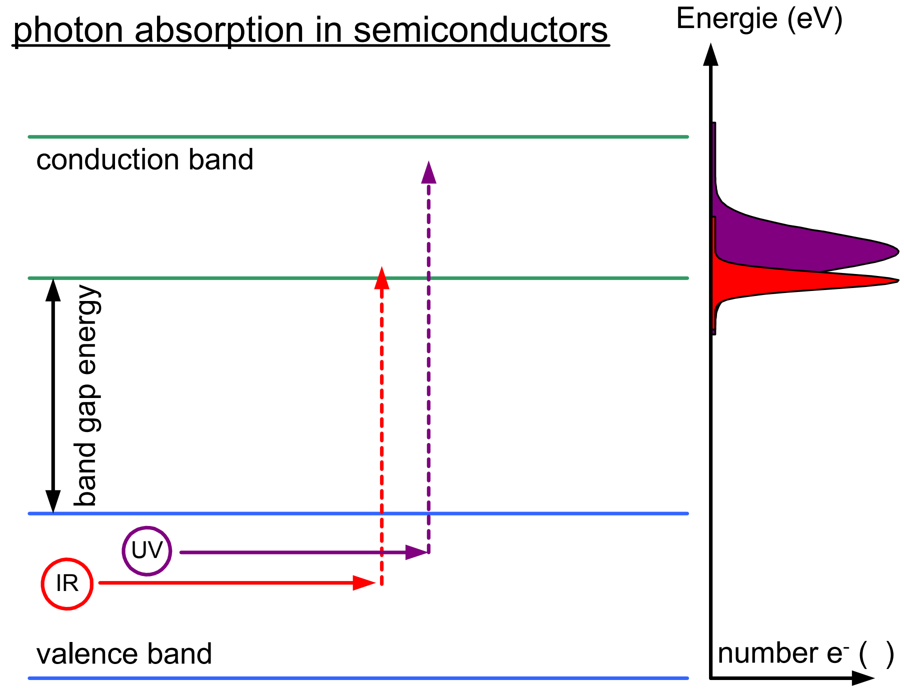
- quadrupole scan (std. technique)
  - measure the beam profiles for different focus strength
- slit or hole mask (new technique in IKPH)
  - measure the position displacement & width of divergence distribution

Introduction – Photo cathodes



PhD thesis R. Barday, JoGu University 2007





Thermal emittance and response time measurements of negative electron affinity photocathodes
JOURNAL OF APPLIED PHYSICS 103, 054901 2008 – **I.V. Bazarov**

Introduction – Photo cathodes

- charge life time of photo cathode $Q \cong 700\ C$
- aver. electron current for experiment $I = 1\ (10)\ mA \rightarrow \dot{Q} = 3{,}6\ (36)\ C/h$
- phase acceptance of the accelerator $\varphi_{acc.accept.} = 36°$

  → with dc electron source 90% of the charge get wasted

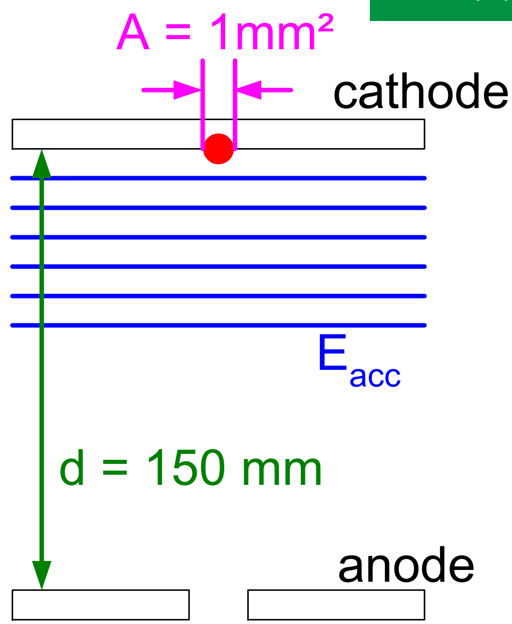
  → experimental time $t_{\exp} \leq 20\ (2)\ h$

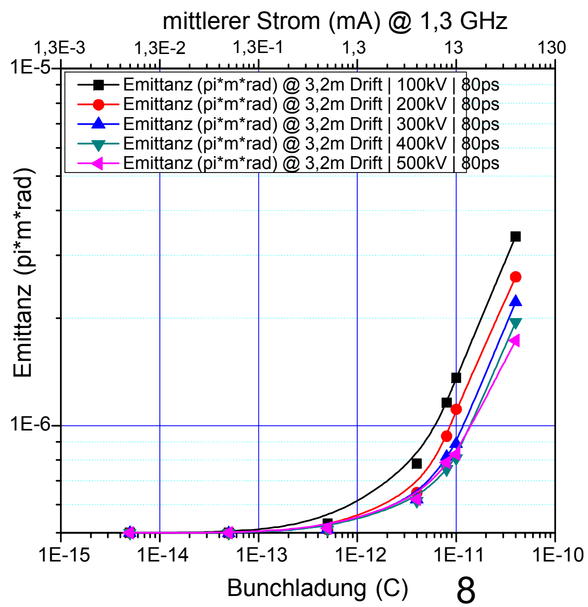
- with dc electron source 90% of the charge get wasted → **pulsed source increase the operational time by a factor 10**

MESA would need pulses with a length of 70 ps and a repitition rate of 1,3 GHz

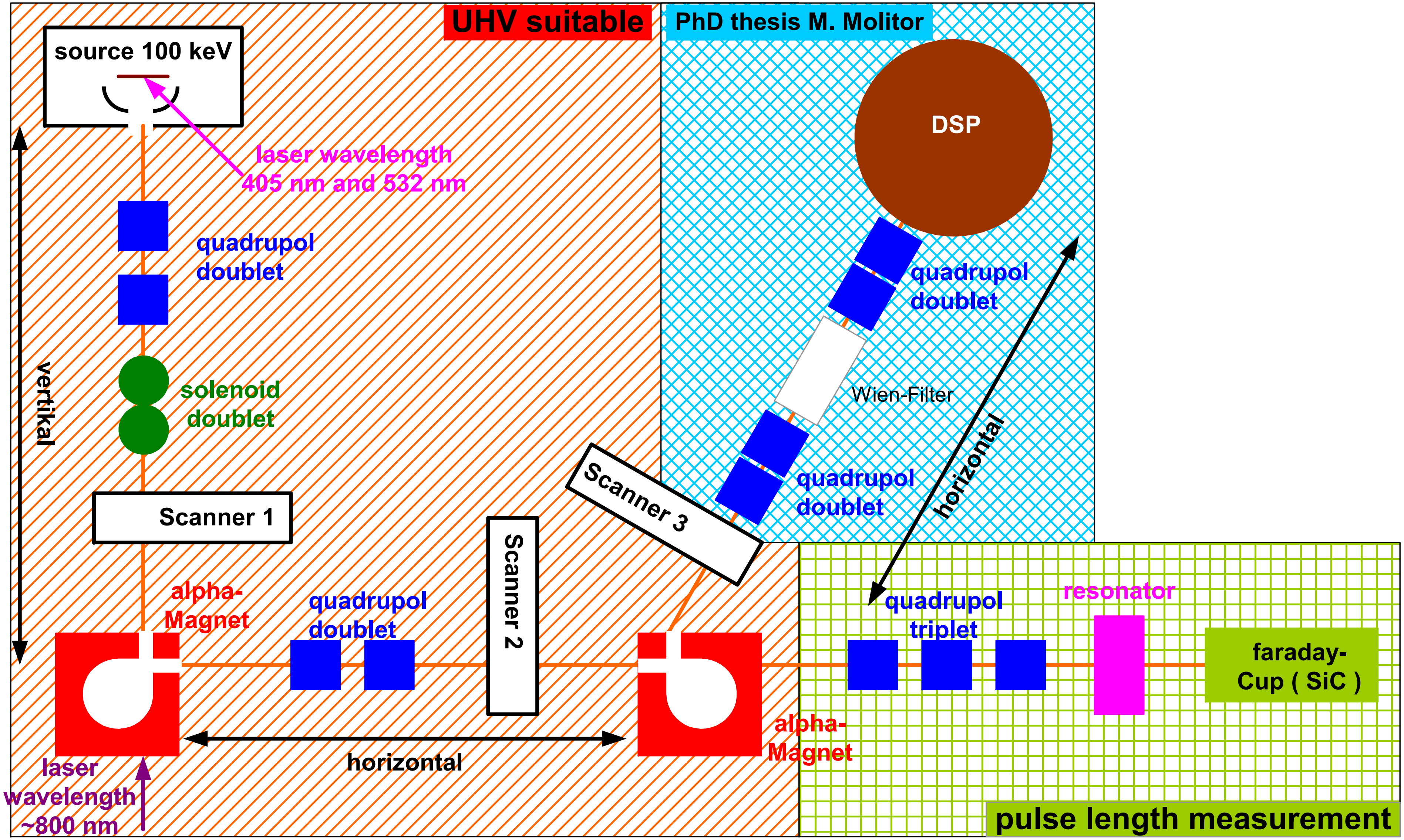
Introduction – Space charge

- current limit $$I_{sc,\lim} = p_0 \frac{A}{d^2} U^{3/2}$$
- acceleration voltage $$U = 100\ kV$$
- perveance $$p_0 = 2{,}33 \cdot 10^{-6} \frac{A}{V^{3/2}}$$
- current limit with source parameters $$I_{sc,\lim} \cong 3\ mA$$

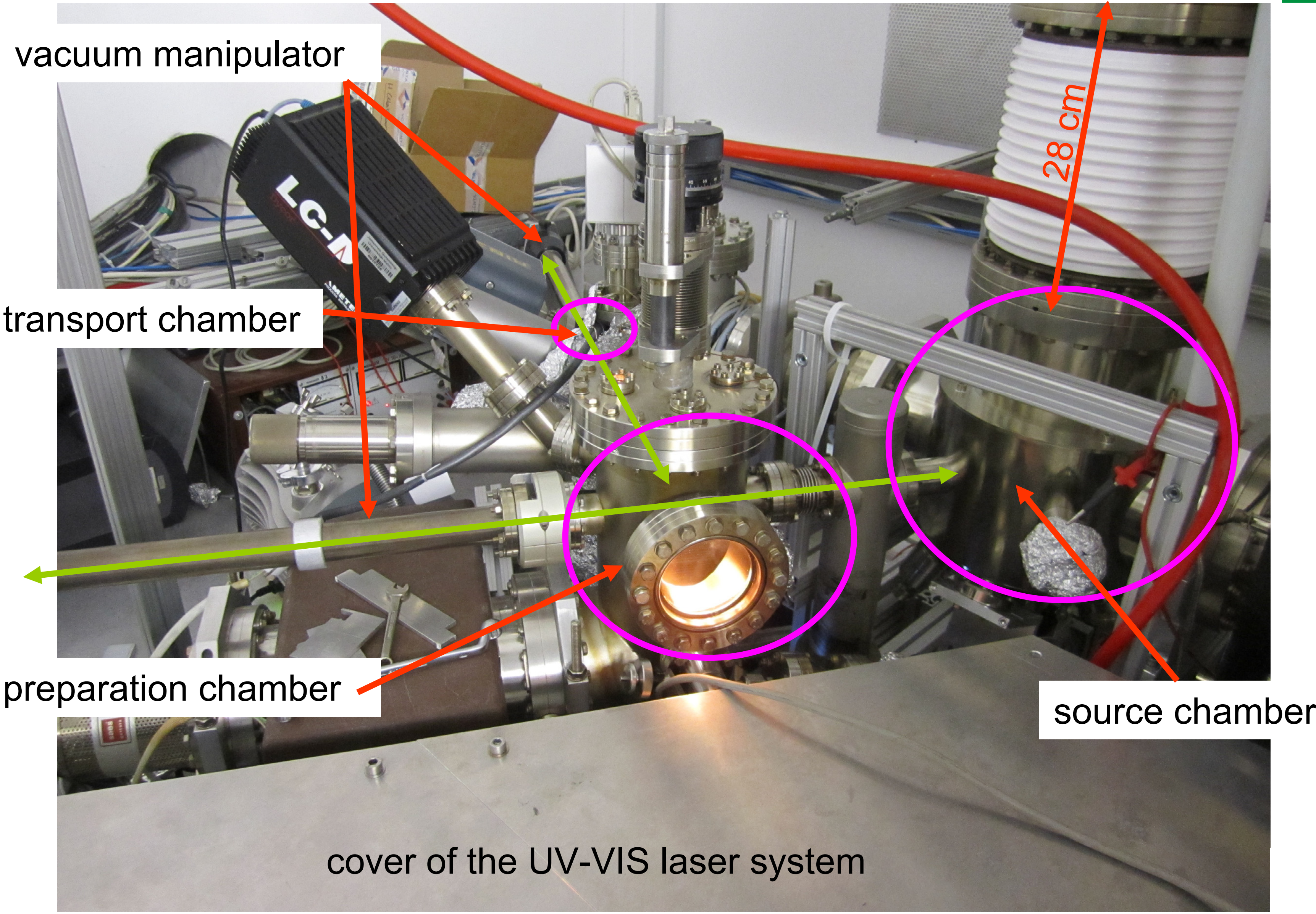




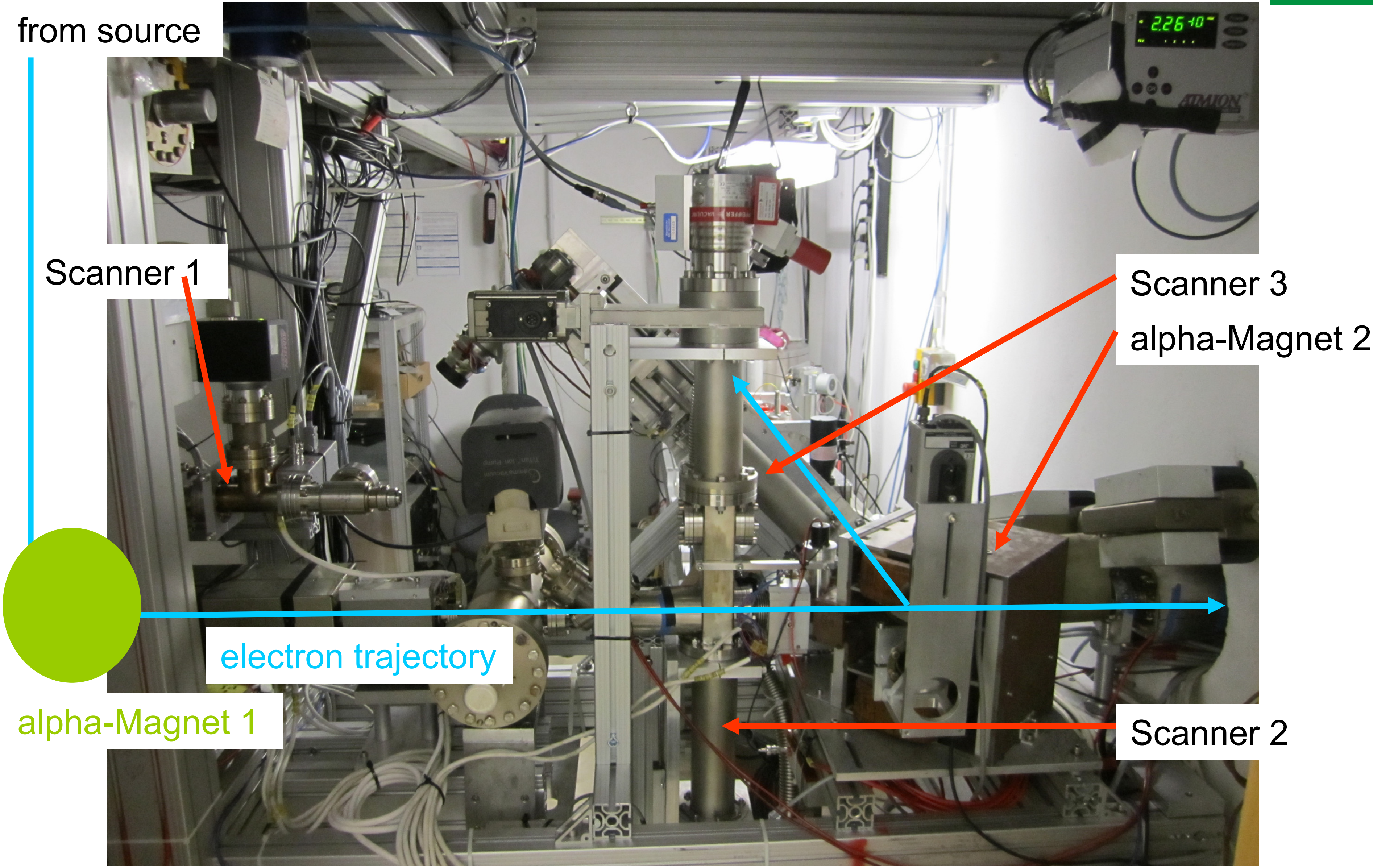
Components
Overview of PKA2



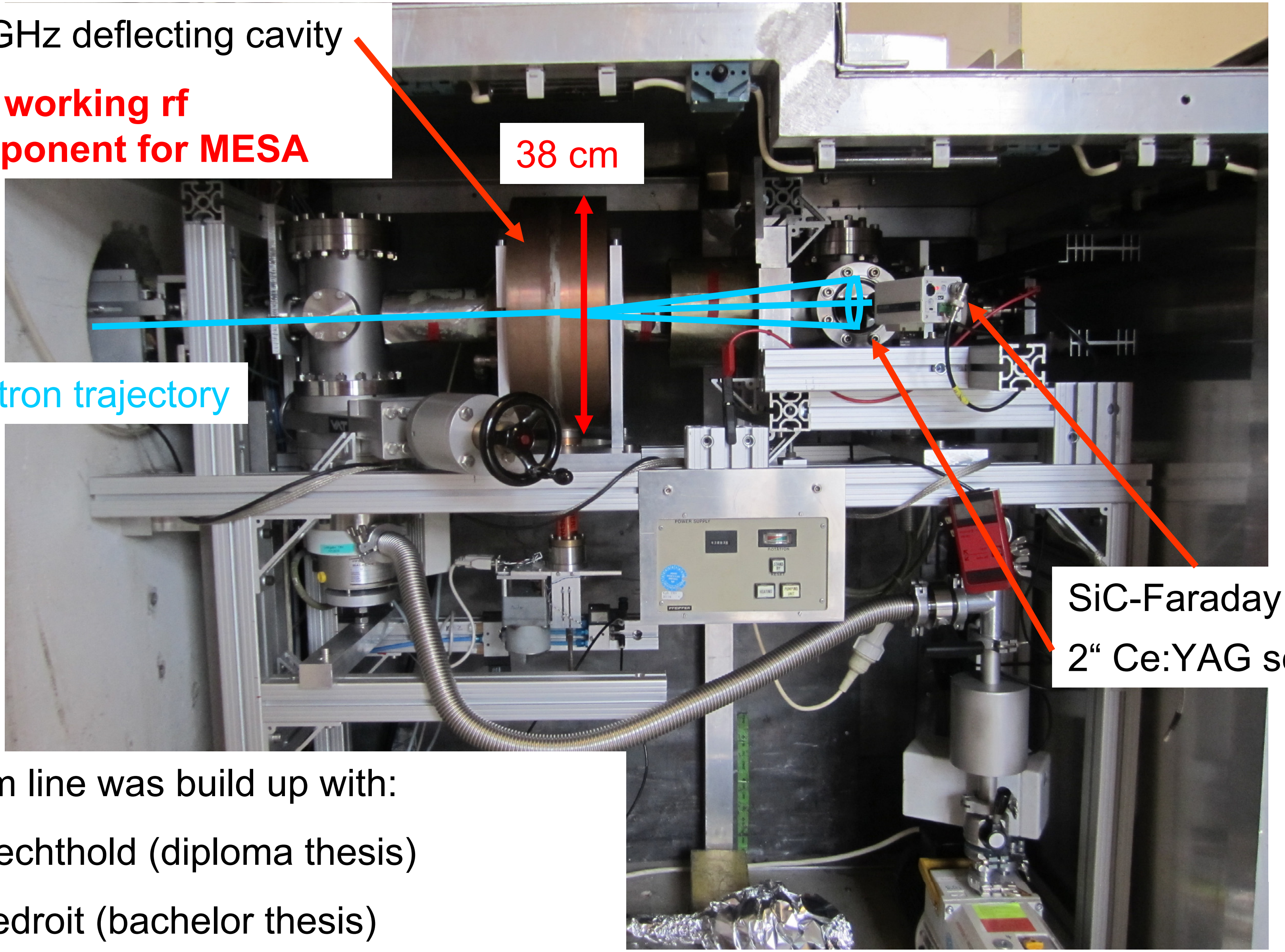
Components - Source



Components - Source



Components – Deflecting cavity

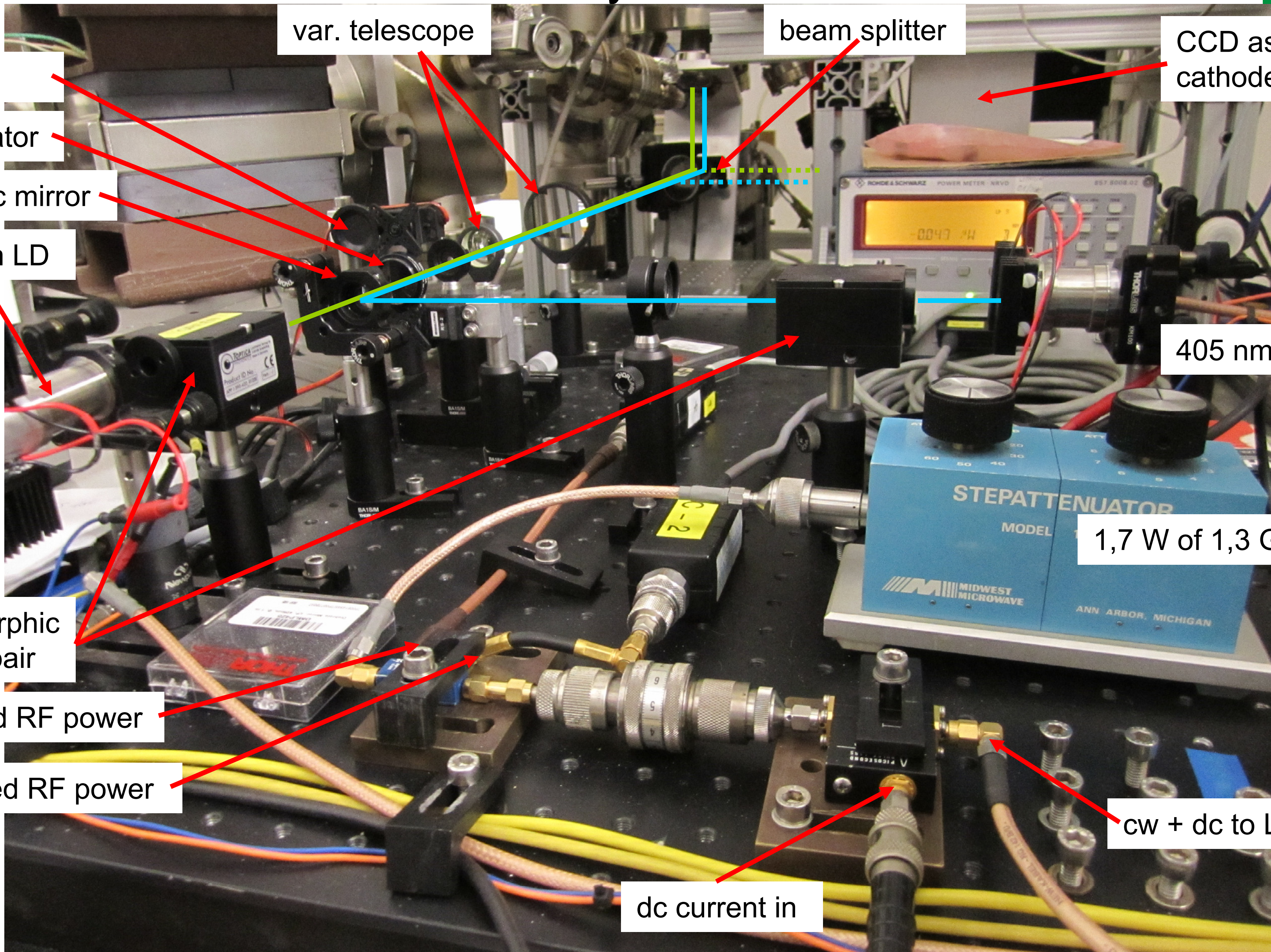


beam line was build up with:

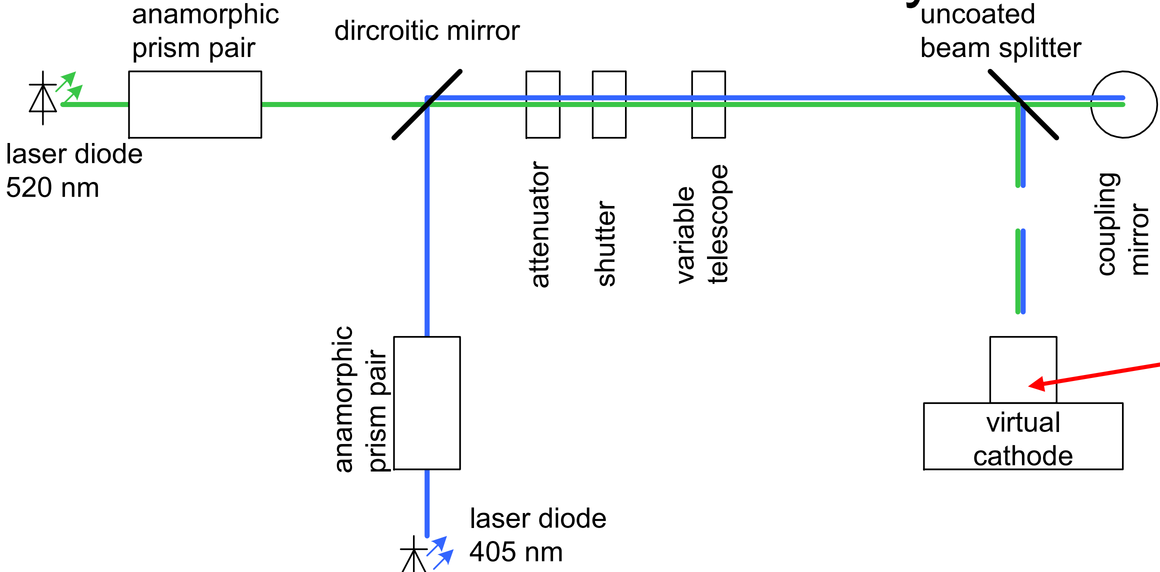
V. Bechthold (diploma thesis)

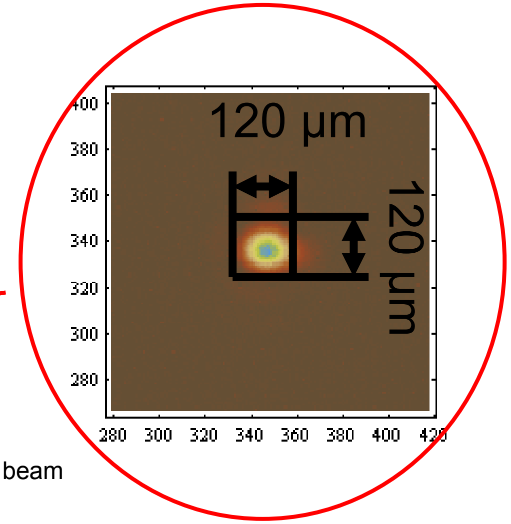
B. Ledroit (bachelor thesis)

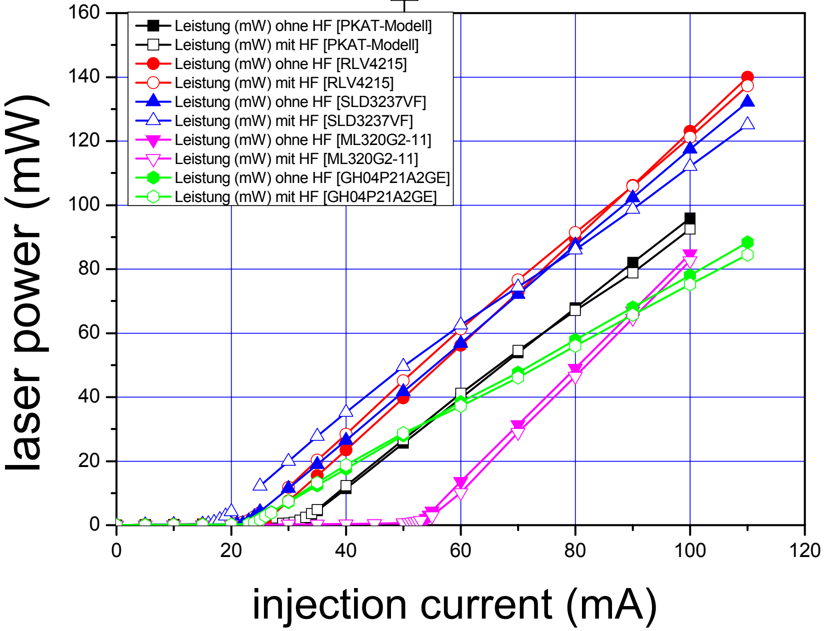
Components
UV-VIS laser system



Components
UV-VIS laser system







wave length : 405nm

dc-beam: P_{max} < 300 mW

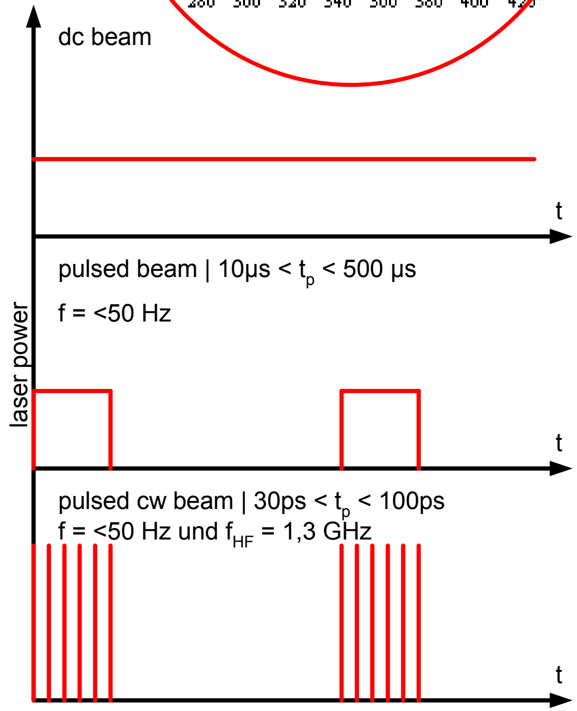
P_{mittel} < 300 mW

pulsed-beam: P_{max} < 300 mW

P_{mittel} < 3 mW

pulsed cw-beam: P_{max} < 3000 mW

P_{mittel} < 3 mW



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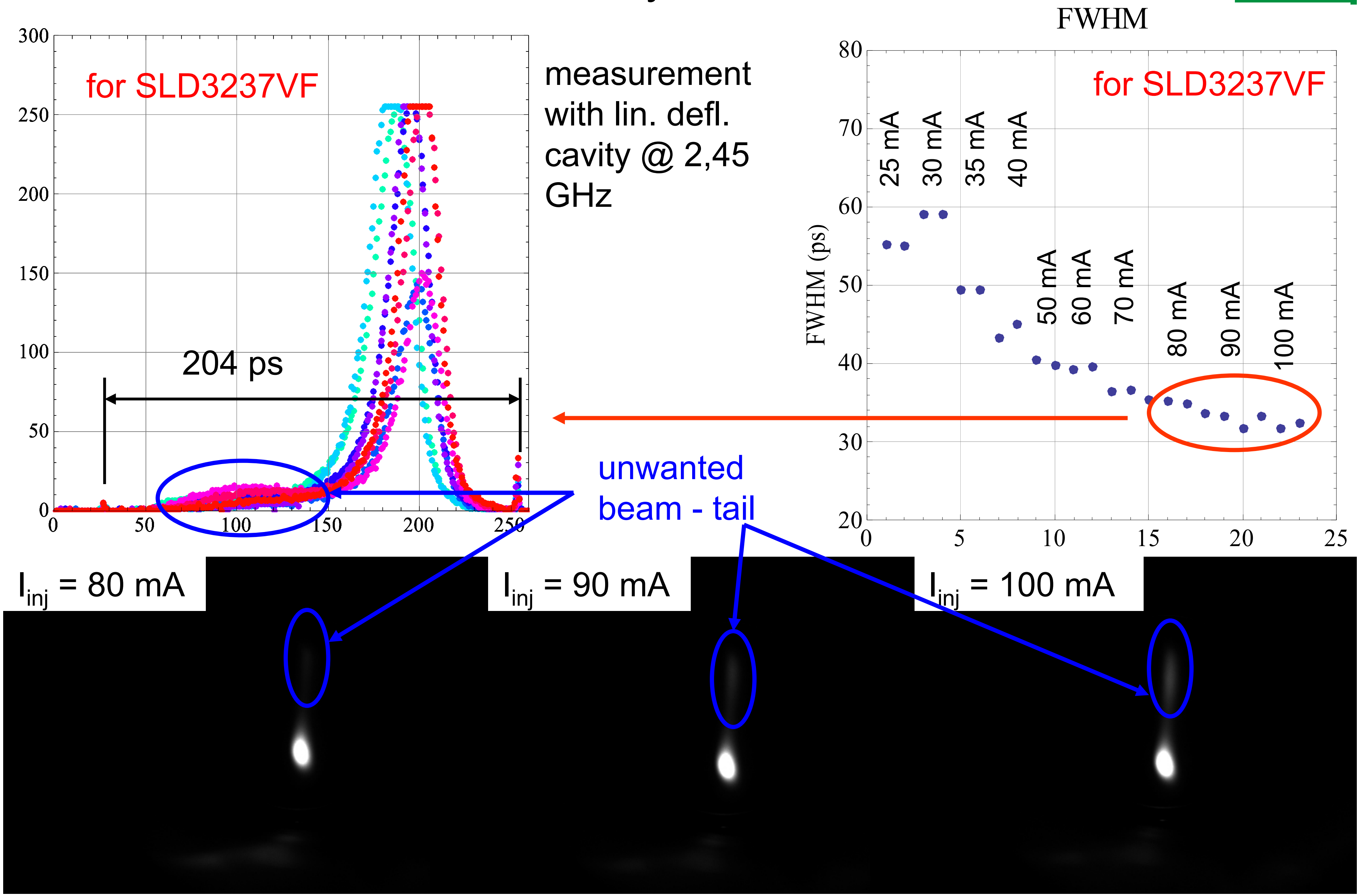
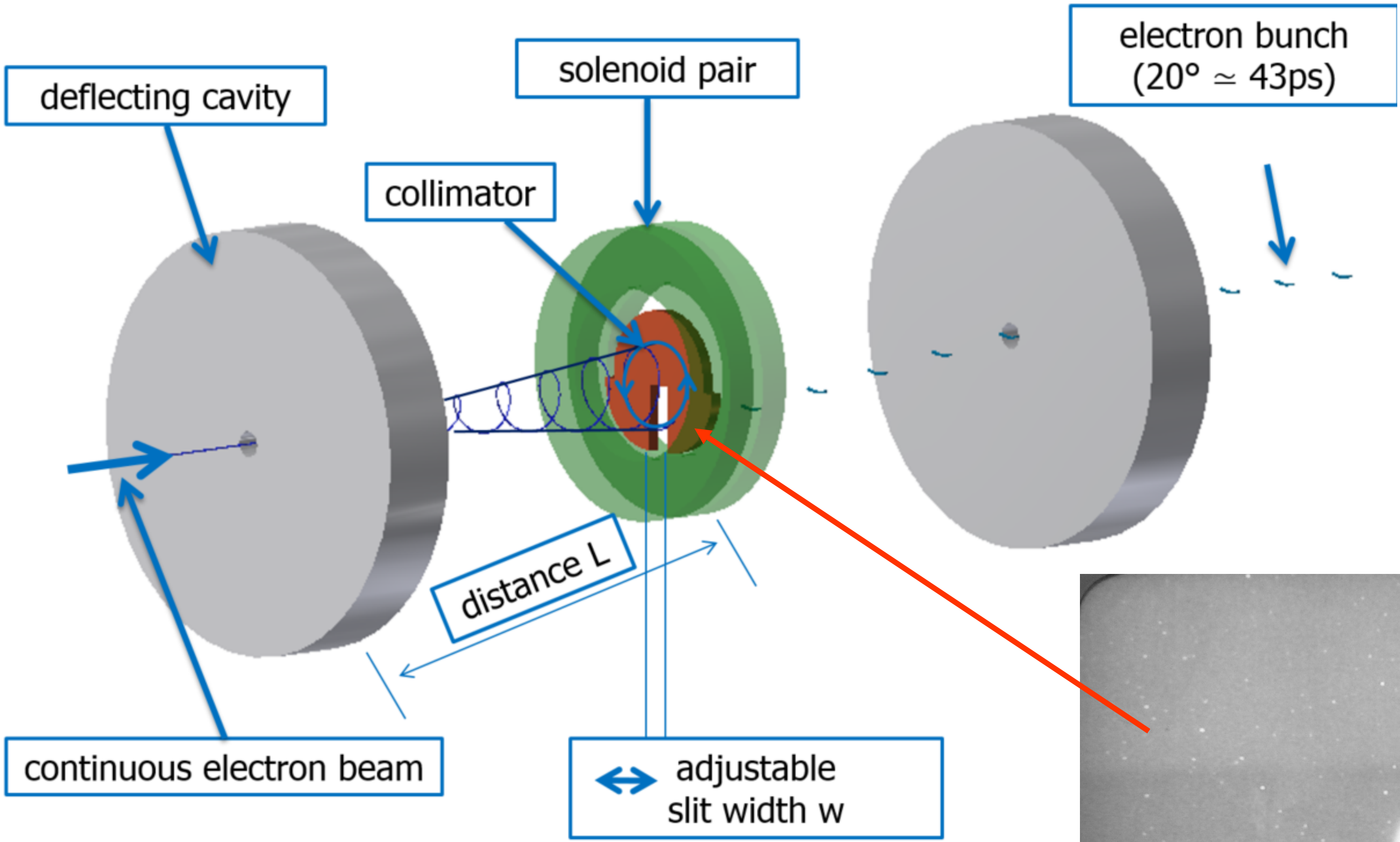
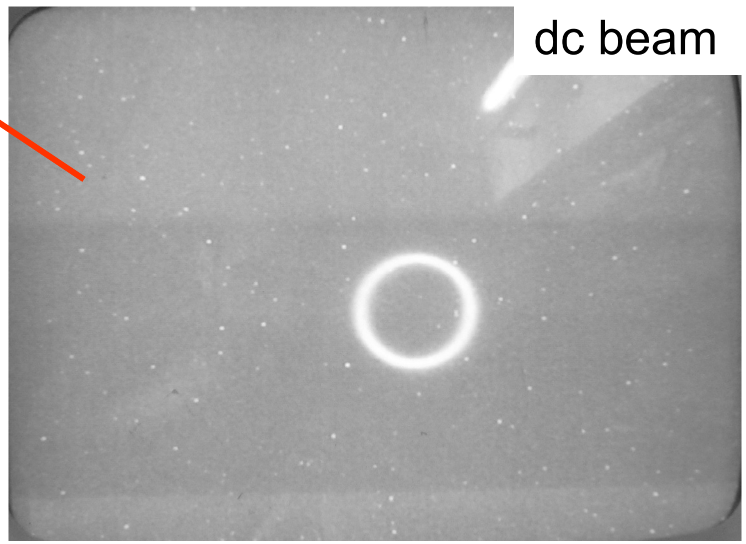


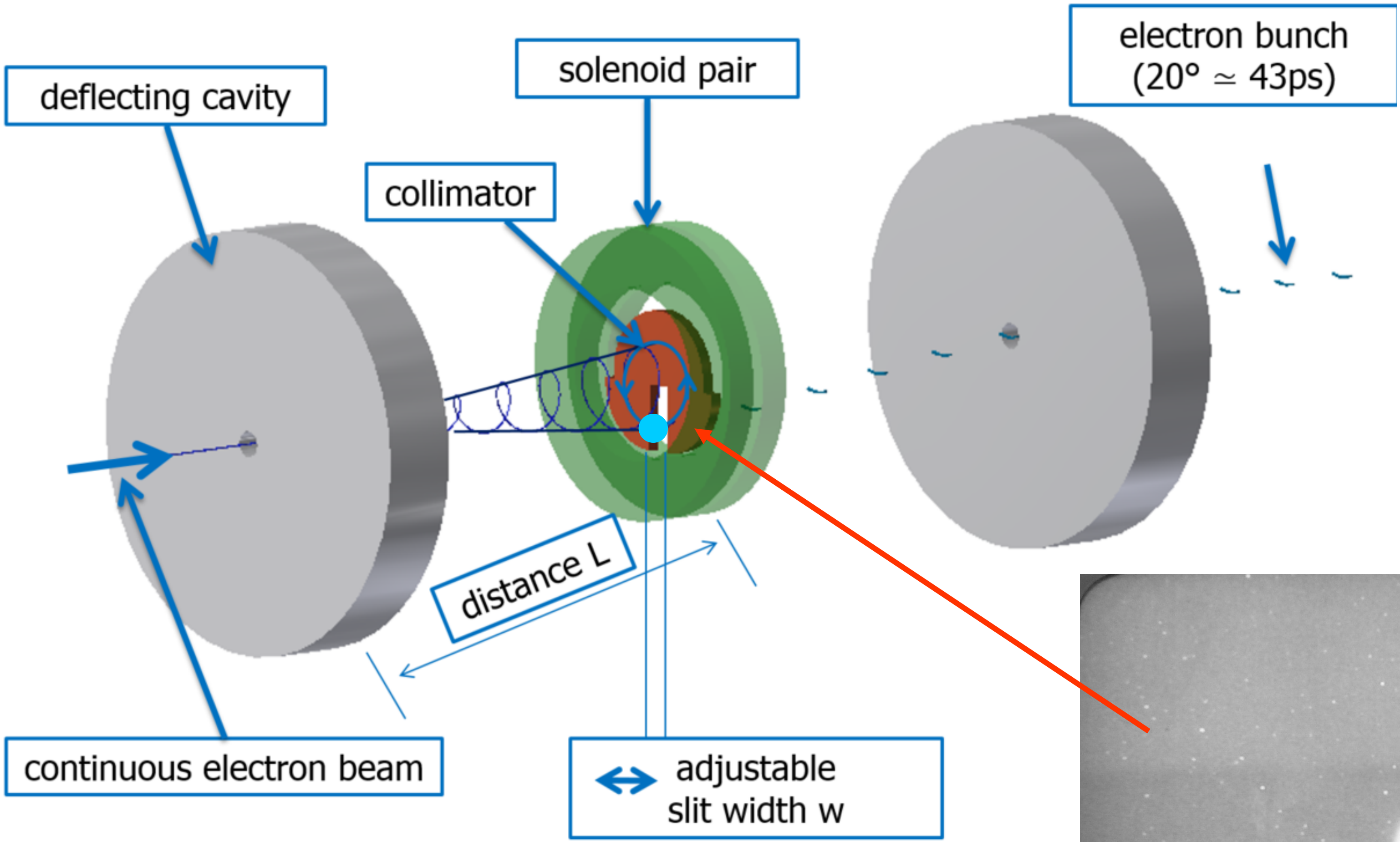
Components – Deflecting cavity





Diploma thesis: V. Bechthold

Components – Deflecting cavity

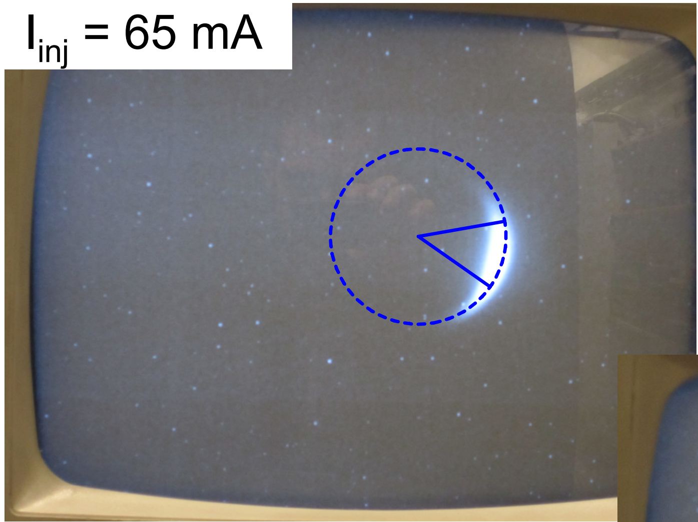


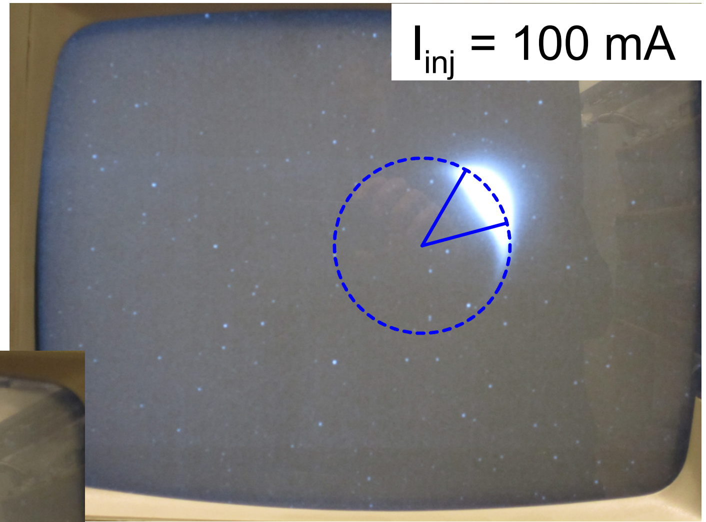
Diploma thesis: V. Bechthold

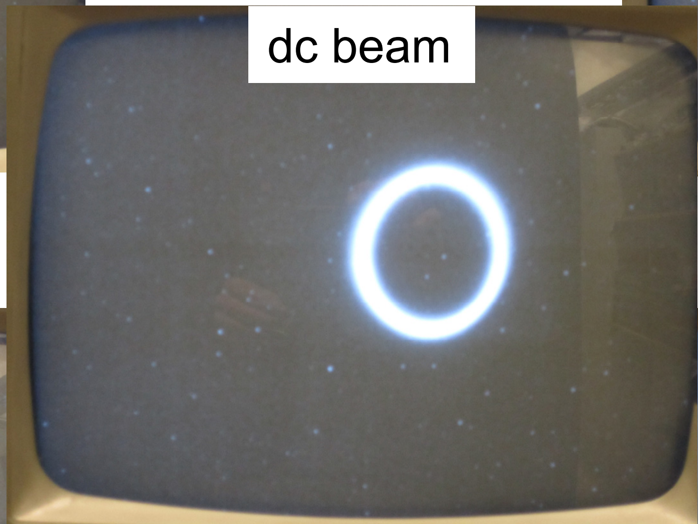
Components – Deflecting cavity

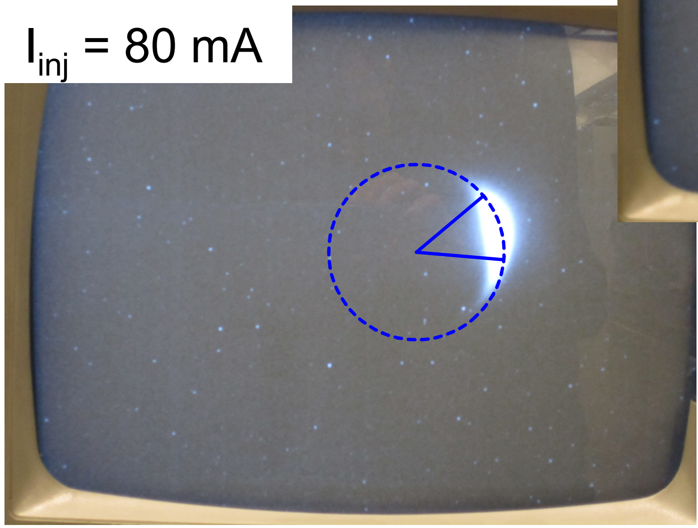
from Monday
19.Jan.2015

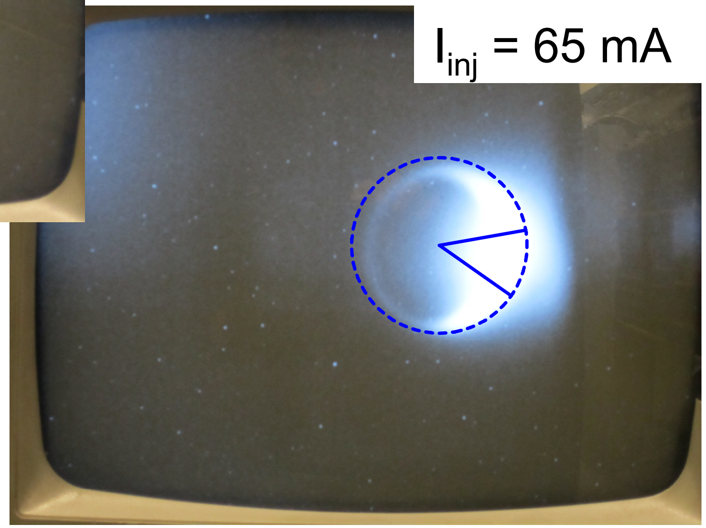
acceptance = 45°











Components - Scanner

- Scanner 1
  - Ce:YAG Ø = 25 mm
  - wire (W Ø = 40μm)
  - 21 hori. & 21 verti. slits (w = 25 μm / 250 μm)
- Scanner 2
  - Ce:YAG Ø = 25 mm
  - wire (W Ø = 40μm)
  - 21 x 21 holes (Ø = 25 μm / 250 μm)
- Scanner 3
  - Ce:YAG Ø = 25 mm
  - Ce:YAG Ø = 25 mm with hole Ø 2 mm
  - Ce:YAG Ø = 25 mm with hole Ø 3 mm

quadrupolscan
quadrupolscan
emittance measurement

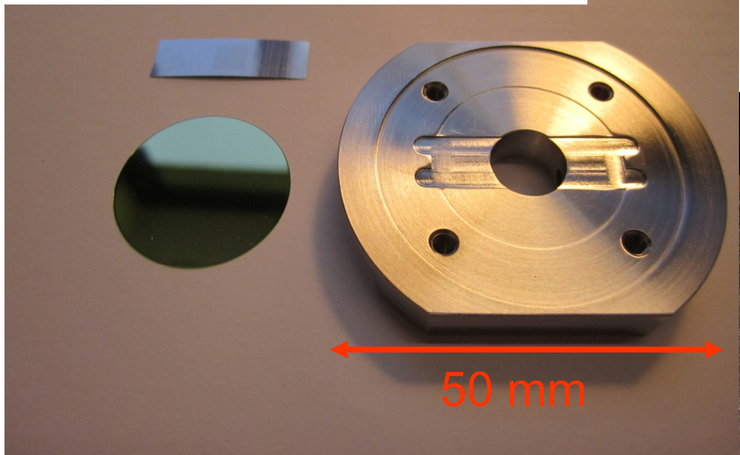
quadrupolscan
quadrupolscan
emittance measurement

screen
heli.correlated asym.
heli.correlated asym.

Ce:YAG – Yttrium-Aluminium-Granat

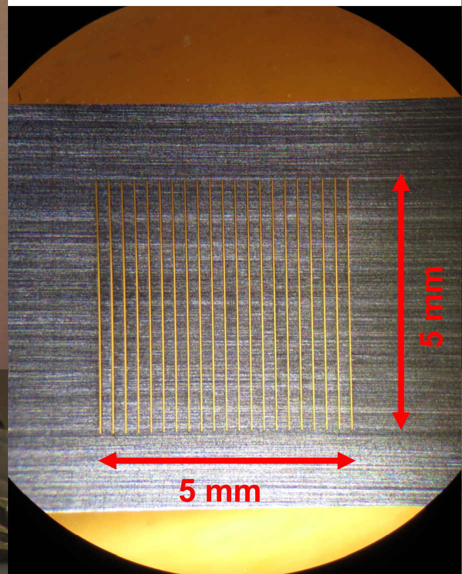
Components - Scanner

holder for investigations of the electron scattering in YAG



carriage of Scanner 3

slit mask



slit width 25 µm

slit distance 250 µm

number of slits 21

area 5x5 mm²

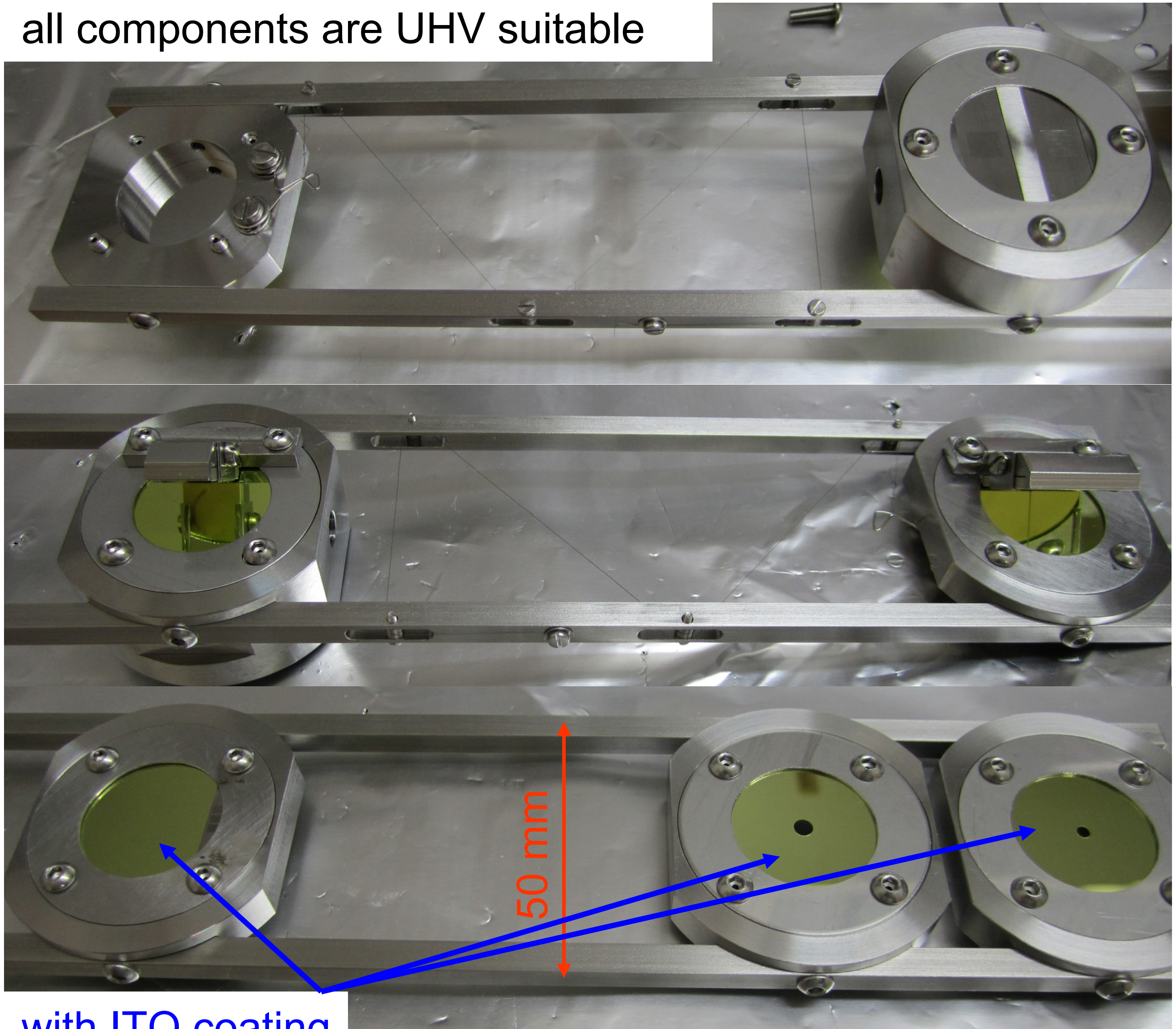
50 µm stainless steel

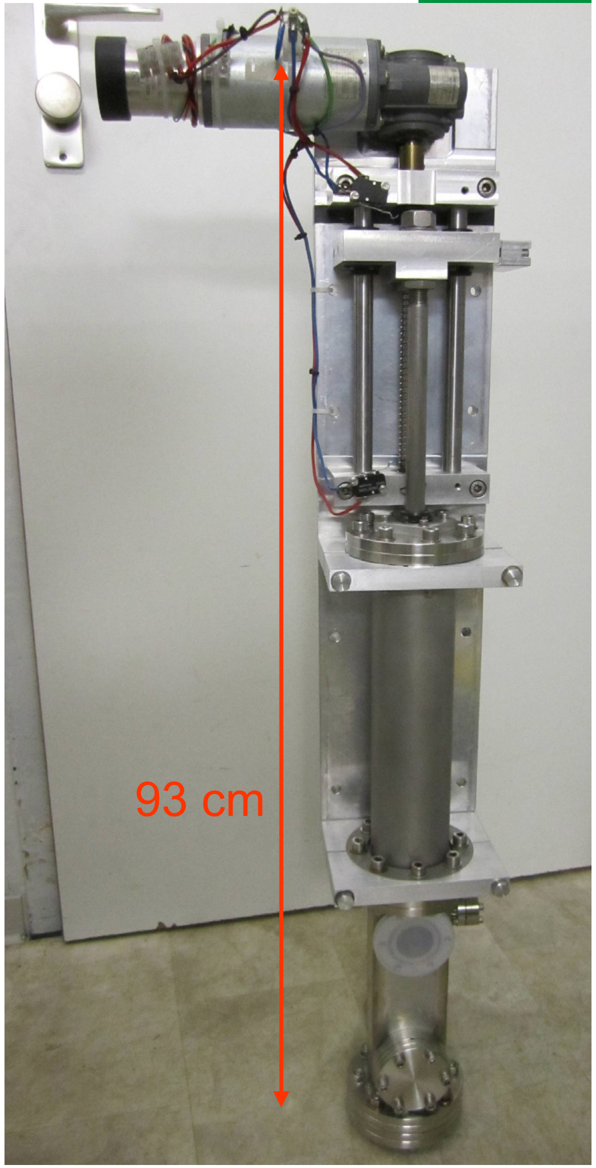
holder for YAG-screens

mounted YAG-sceens

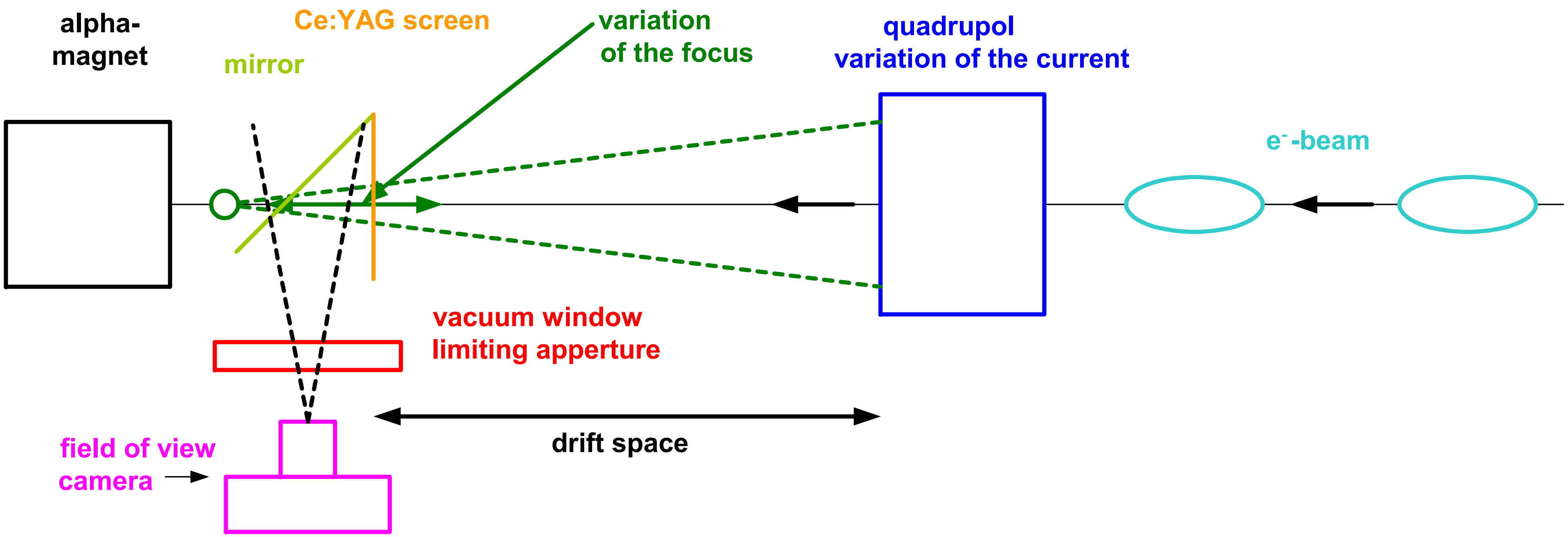
Components - Scanner

all components are UHV suitable





Results – Quadrupol-Scan

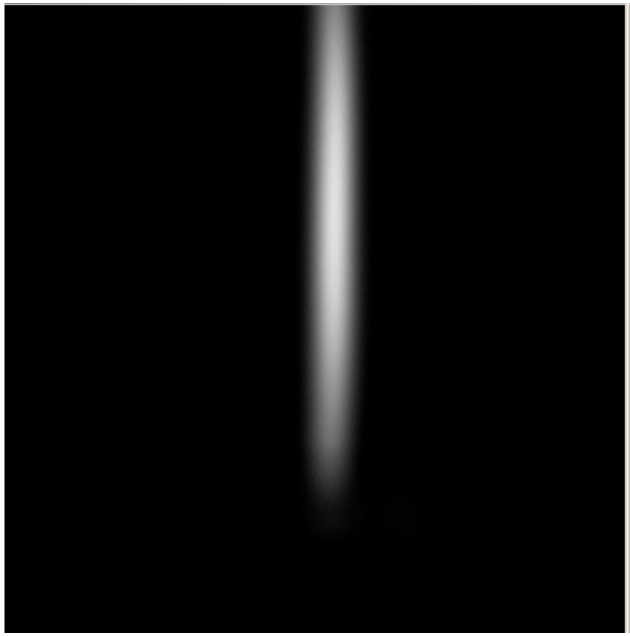


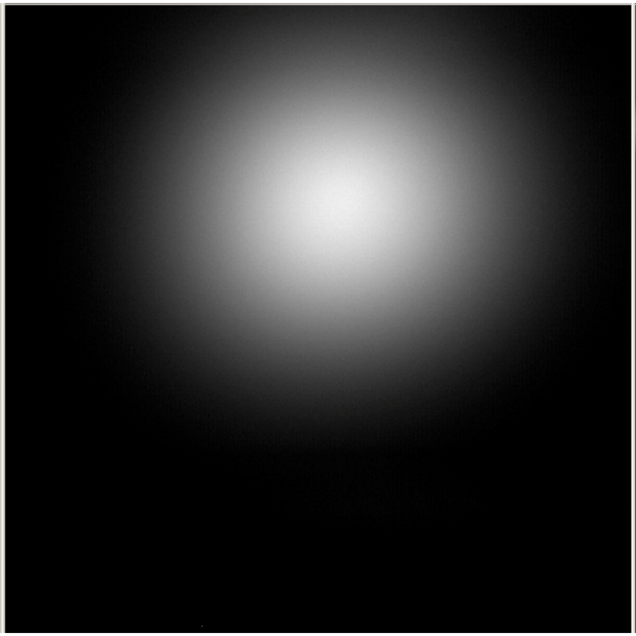
Results – Quadrupol-Scan

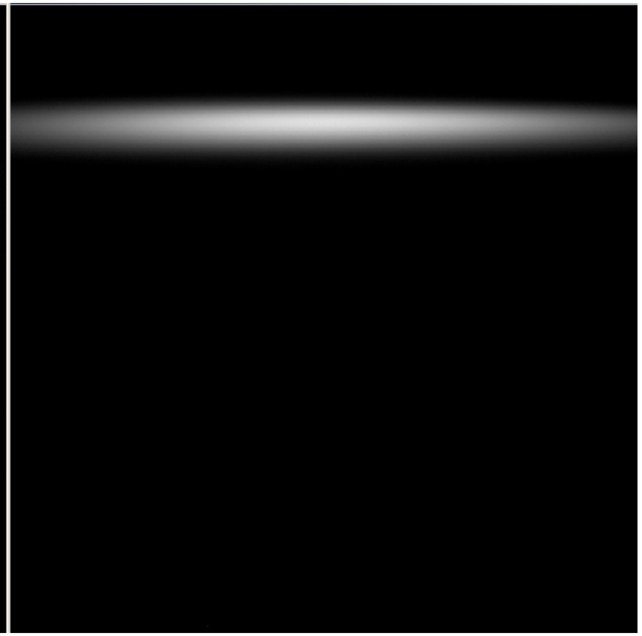
focus stregth: 2,75 diopter

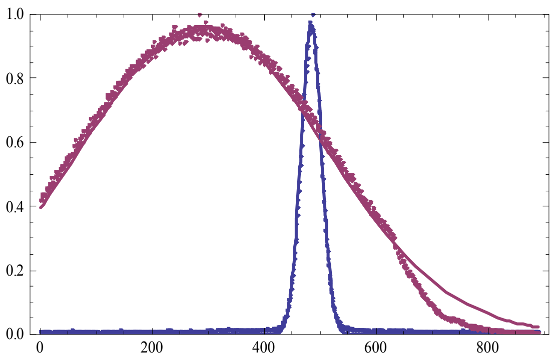
focus stregth: 0 diopter

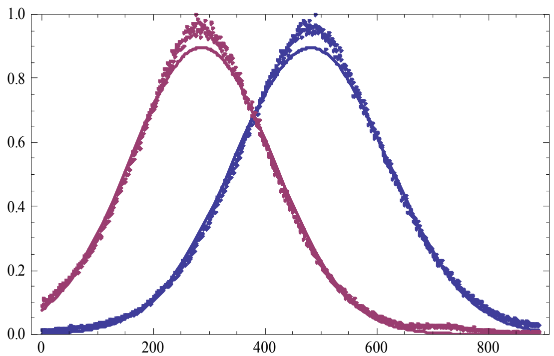
focus stregth: -2,75 diopter

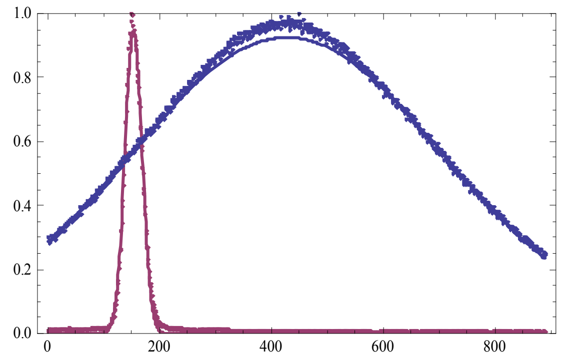












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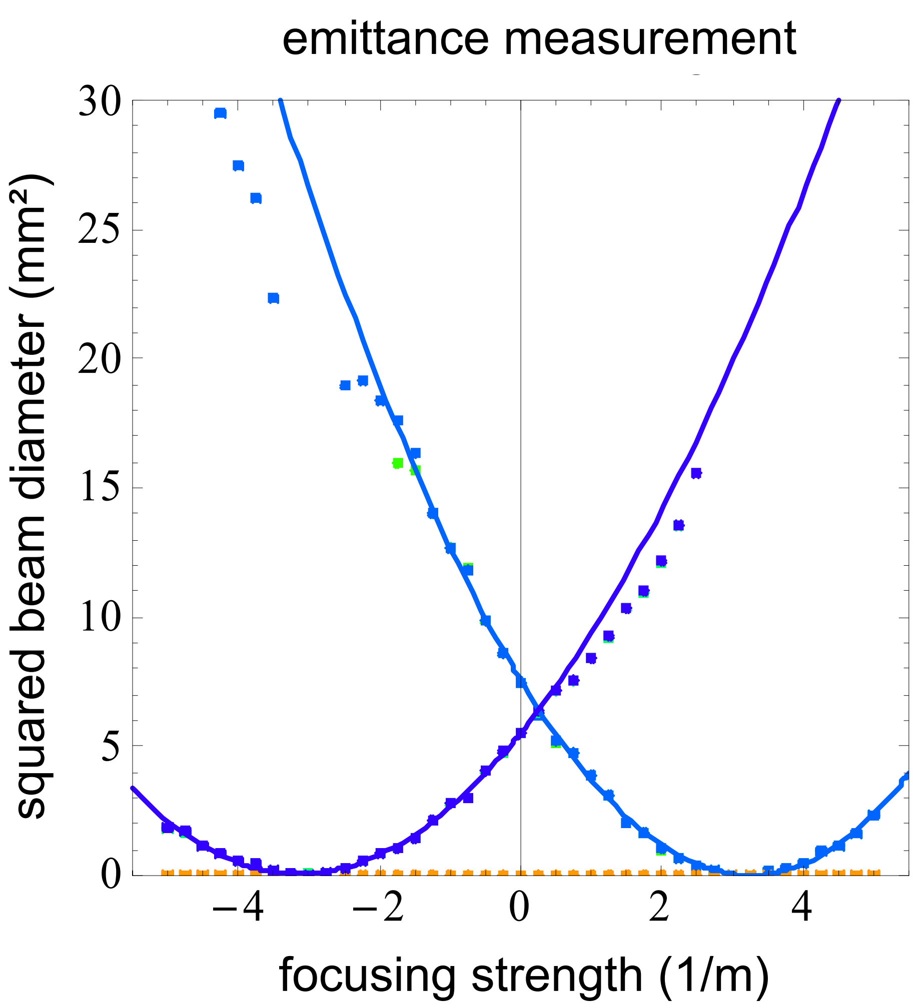
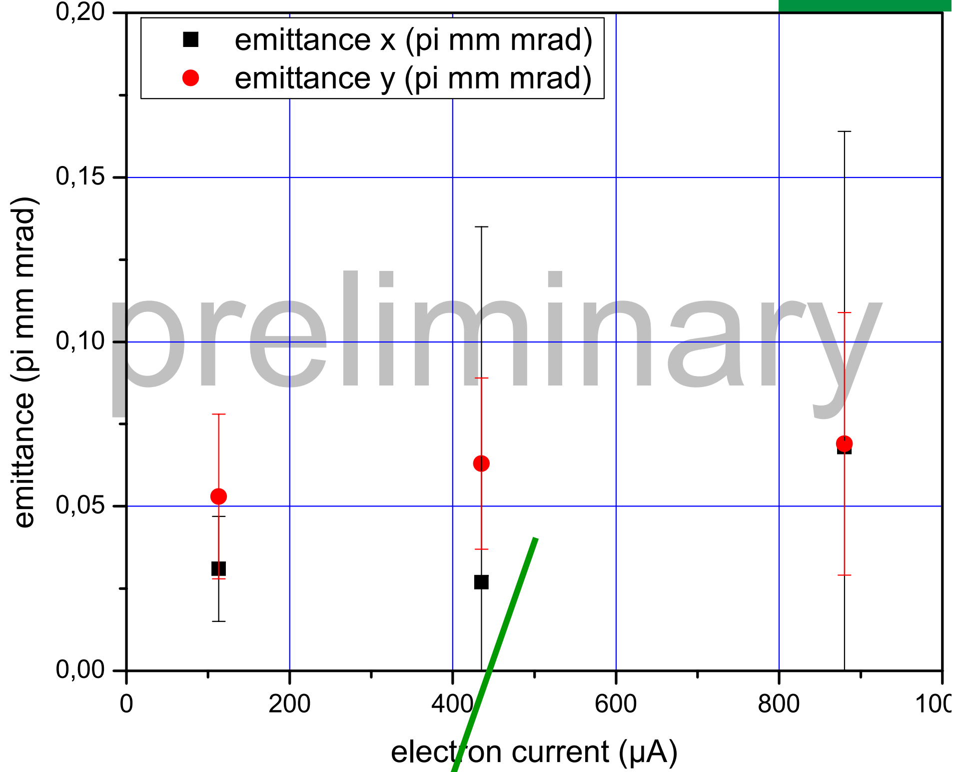
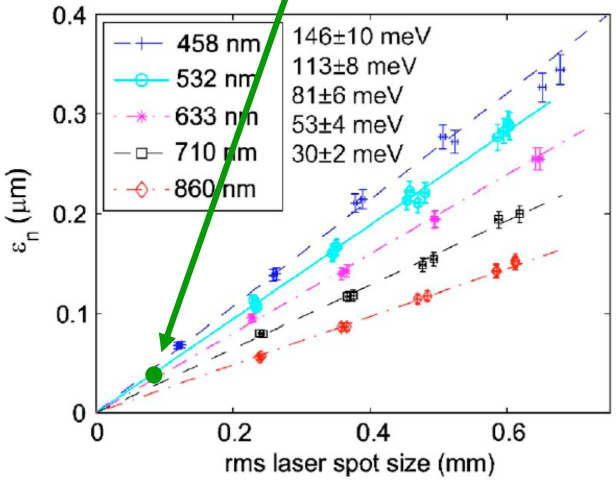
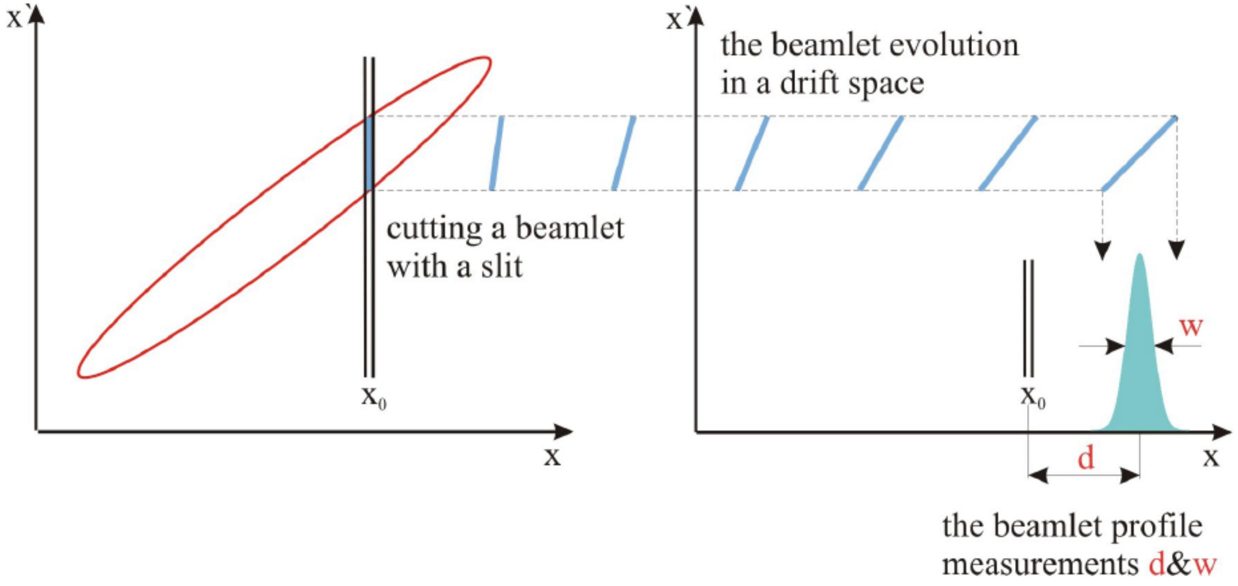


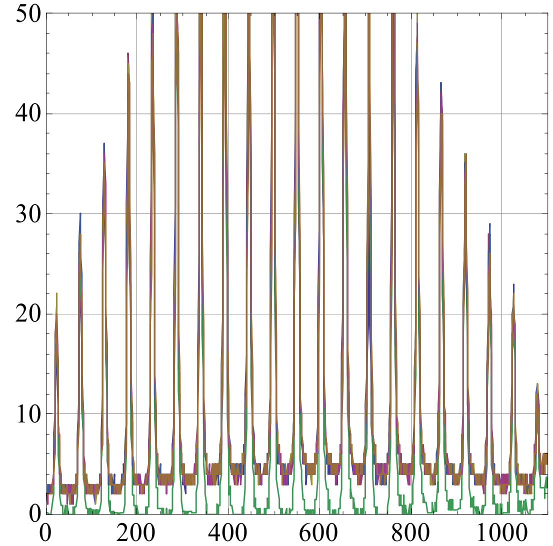


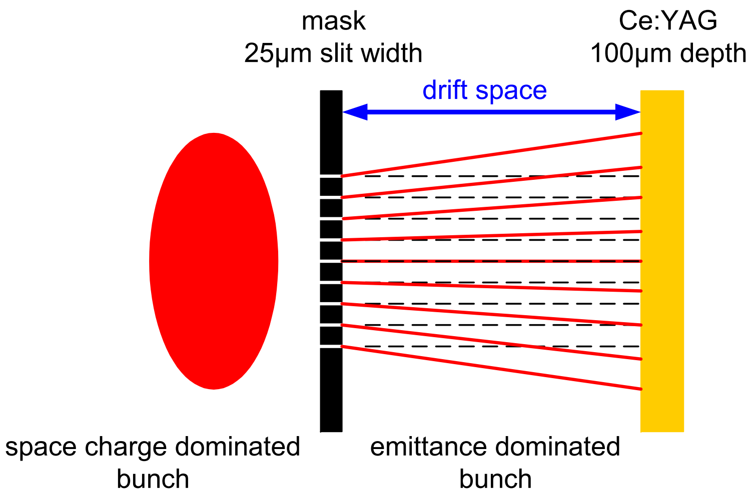


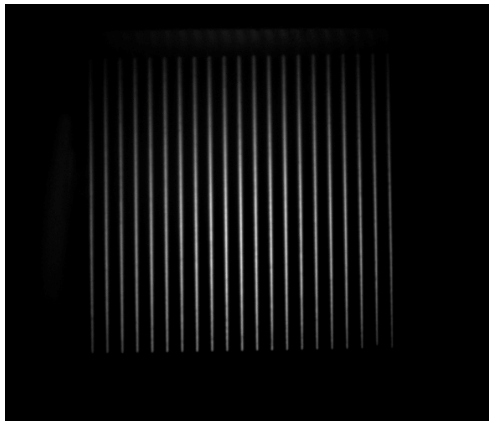
Results – Slit mask



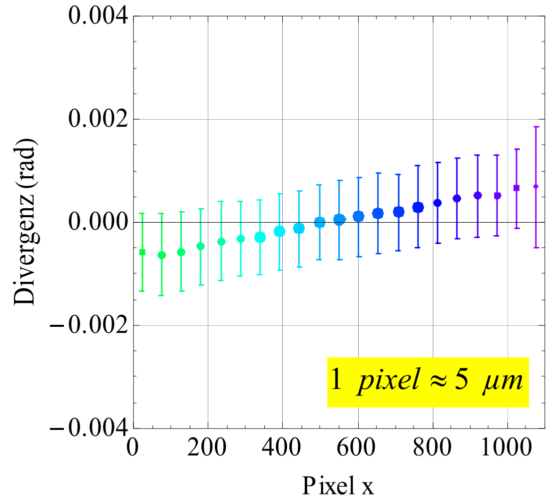
measured slit mask







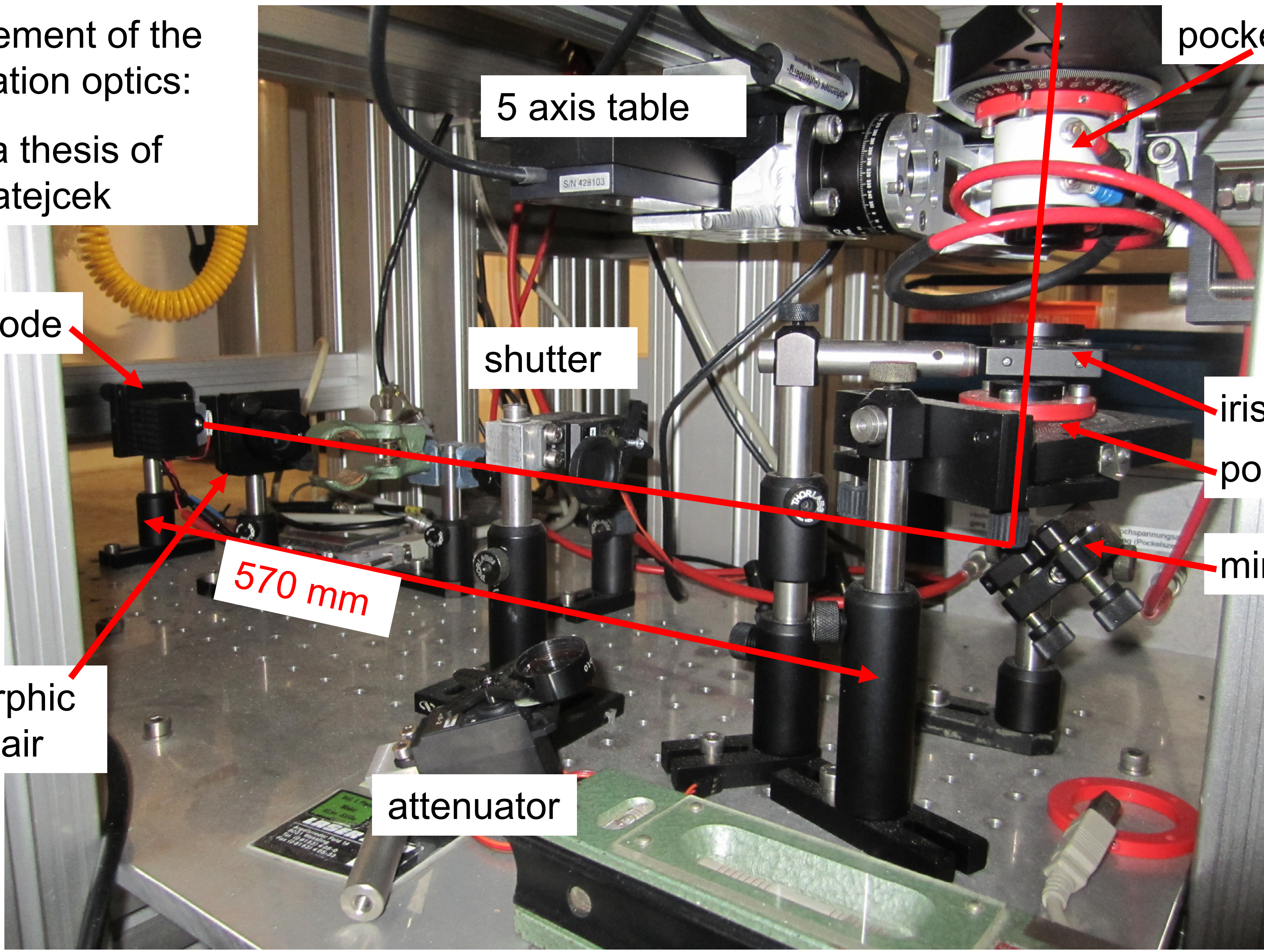
reconstructed phase space



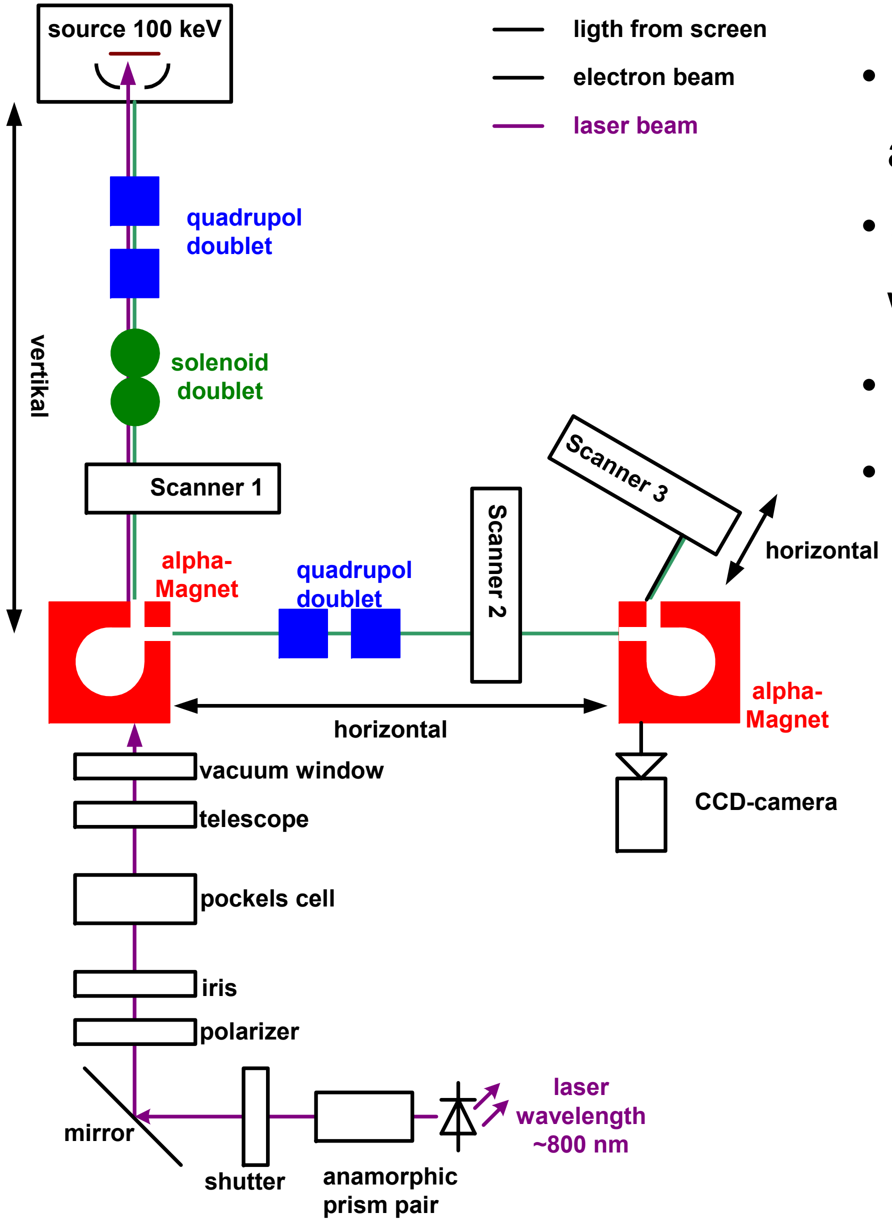
Components – IR laser system

improvement of the polarization optics:

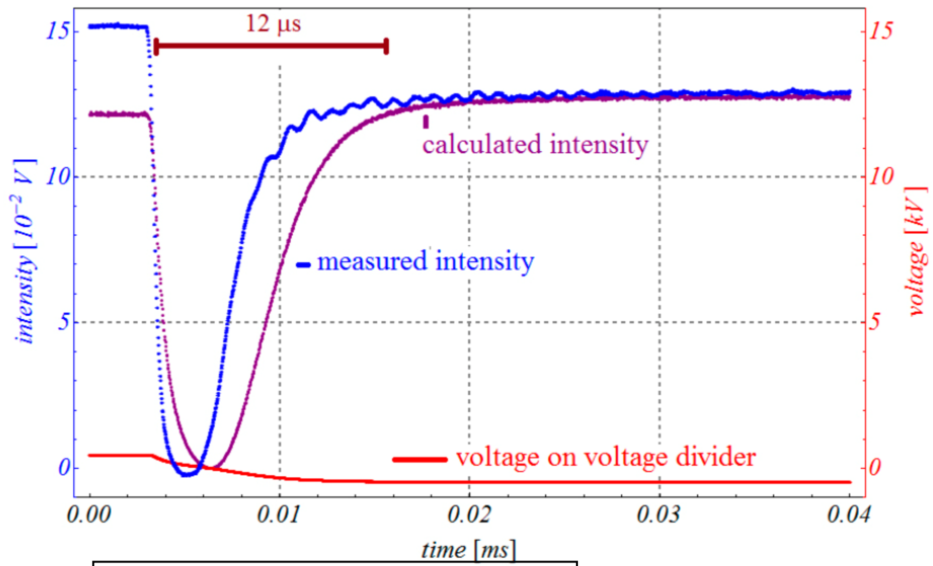
diploma thesis of Chr. Matejcek



Results – IR laser system



- Investigations on helicity correlated asymmetries for P2 experiment
- switching helicity with 1 kHz instead of 50 Hz with RTP pockels cell
- circular polarisation of 99,99%
- loss 1,2% of measurement periode



Diploma thesis: Chr. Matejcek

RTP: rubidium titanyl phosphate - RbTiOPO4

summary & outlook

- diagnostic beam line is build up and ready to get used
- possibility to measure the two trans. phase spaces an the temporal distribution for different currents and beam diameter
- cross check between screen, wire and mask measurements
- three available laser wave lengths
- investigations of the beam halo with wires and perforated screens

- get more experience with the beam line
- commissioning of the 1,3 GHz system (laser + cavity)
- get final results for all laser wavelength
- closer look to helicity correlated asymmetries
- characerization if the bunches are suitable for 1 mA / 1 pC (stage 1)

Thanks for your attention!