Memo for the PCHB Meeting at Mainz

Date and location: Mo, 05.08.2013, 10:00 to 16:00, Seminar room 2 Kernphysikalisches Institut JGU Mainz

Participants: K. Aulenbacher (JGU), M. Dehn (JGU), R. Xiang (HZDR), P. Murcek (HZDR), M. Schmeißer (HZB), J. Völker (HZB)
Video : T. Kamps (HZB)
Distribution: D. Böhlick (HZB), A. Büchel (HZB), S. Schubert (HZB), V. Shvedunov (MSU), J. Teichert (HZDR), R. Barday (HZB)

Agenda

- Status Report HZB, Thorsten Kamps
- Status Momentatron, Martin Schmeißer
- Introduction GunLab & Diagnostic Beamline, Jens Völker
- Status Inverted DC Gun, Monika Dehn
- Status Time Response Measurements & PCA, Eike Kirsch
- Status Transfer System, Petr Murcek
- Operation Experience with Transfer System, Cathode #2013.2, Rong Xiang
- Discussion Transfer System and Cathode Plug holding mechanism

Status of activities at HZB

PCHB Collaboration Meeting
JGU Mainz, 05.08.2013

T. Kamps | kamps@helmholtz-berlin.de

HZB Helmholtz Zentrum Berlin

SPONSORED BY THE
Federal Ministry of Education and Research
05K12CB2 – PCHB

JOHANNES GUTENBERG UNIVERSITÄT MAINZ
HZB Helmholtz Zentrum Berlin
HZDR

Status of activities at HZB

1. Overview (TK)
2. Status and outlook momentatron (Martin Schmeißer)
3. Introduction to GunLab (Jens Völker)

This talk

Status of work related to PCHB and SRF Gun development

Discussion with MSU

Official and administrative matters

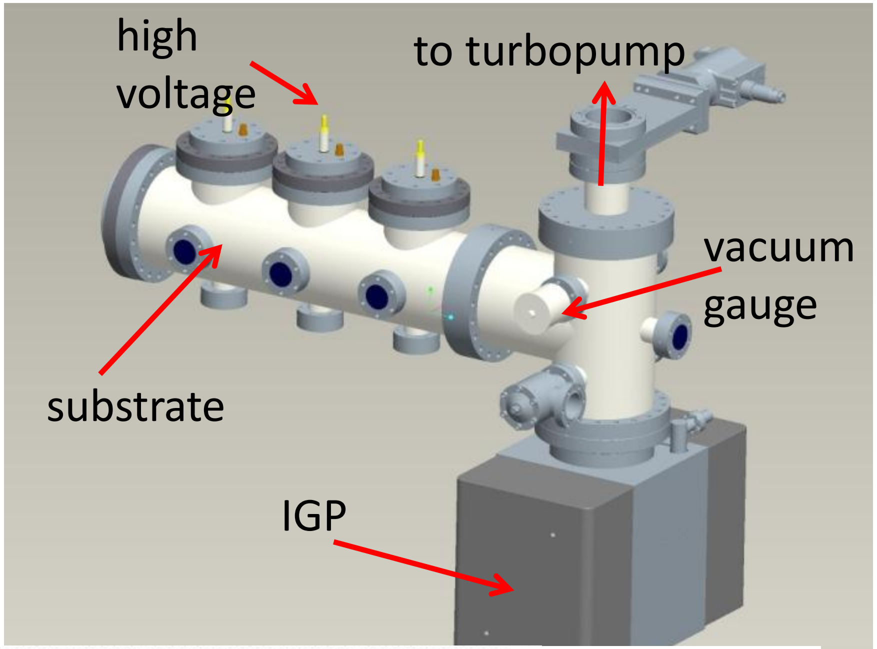
Workpackages of HZB inside PCHB

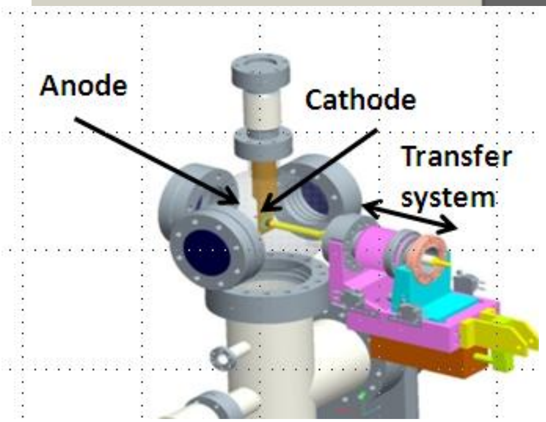
Task	Status	Next Steps
Setup of apparatus to study fieldemission from cathodes and cathode substrates → FE Setup	Physics and engineering design completed. All parts ordered.	Setup and commissioning with DFEA cathodes in autumn 2013.
Design of compact monitor to measure the transverse and longitudinal momentum distribution of photoelectrons → Momentatron	Physics design with simulation studies and error estimates finished.	Engineering design, construction and test.
Design of beam monitors for photoelectrons after acceleration in SRF photoinjector → GunLab	Discussed options for collaboration between HZB and MSU. Agreed on longitudinal phase space monitors, beam energy measurements	Physics design and writing of specs document

→ see presentation by Martin Schmeißer

→ see presentation by Jens Völker

FE Setup under construction at HZB: Test dark current emission from substrates and cathode films





Upgrade with UHV cathode transfer system

Courtesy: R. Barday

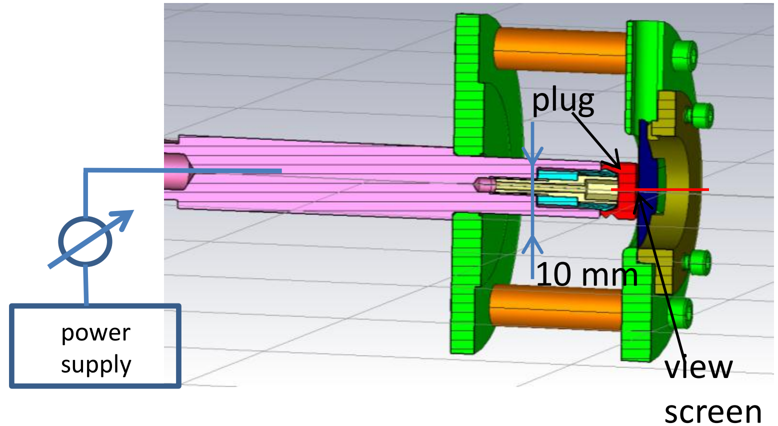
DC-setup for field emission study

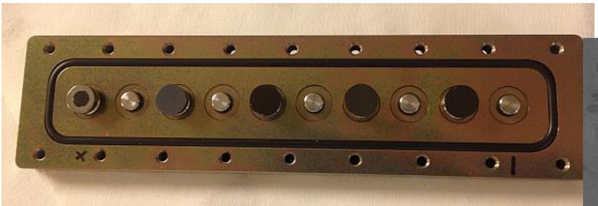
Current measurement and

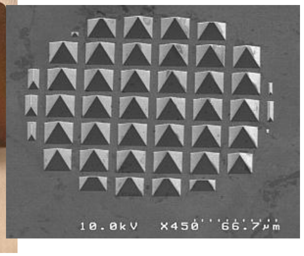
Image of the emitters on the view screen

Constant gap d=0.4 mm

Gradient can be changed by controlling bias voltage (U_{max}=10 kV)







Plugs covered with DFEA from B. Choi (U Vanderbildt)

Cavity design and beam dynamics

Engineering of cryomodule

GunLab location and discussion with MSU

Cathode preparation and analysis activity

Gun cavity design follows goals of low emittance, high average current and low beam losses

Low emittance → high launch field during electron beam emission, high peak field and high launch phase. Enable retractable cathode plug to obtain RF focusing during electron emission.

High average current → achieve good propagation of HOM to absorber, damping capabilities. Enable insert for normal-conducting, high QE cathode.

Avoid losses of unwanted beam, dark current generation from field emission → keep peak field in cathode surface within limits.

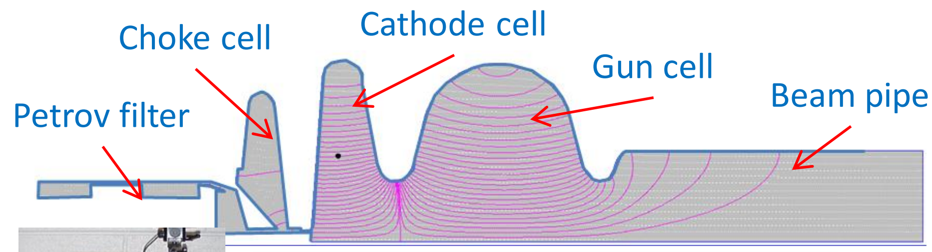
Table 1: Cavity field parameters relevant for beam dynamics studies for 2 MeV target exit energy.

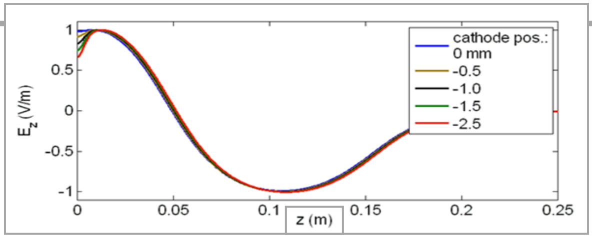
$$E_l = E_{max} \cdot G_{FF} \cdot \sin\phi_l$$

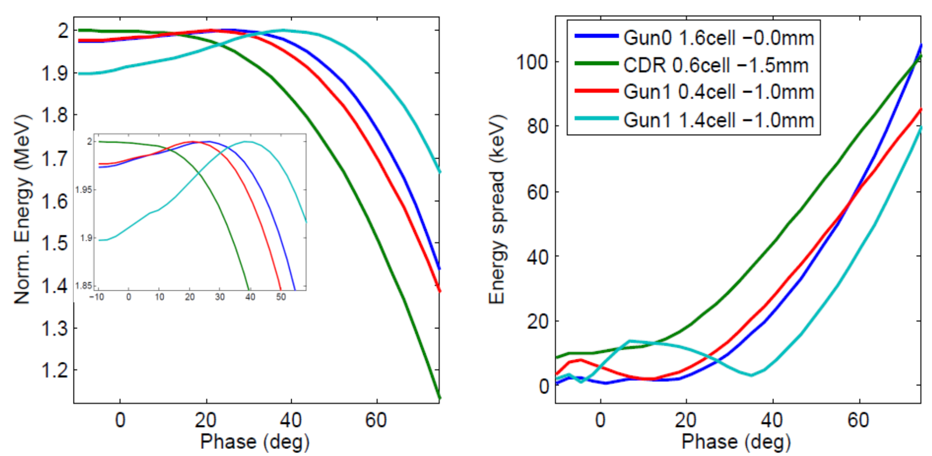
No.	Δz_{cath} mm	G_{FF}	E_{max} MV/m	ϕ_l degL	E_l MV/m
Gun0 1.6	0	0.99	21	27	9.4
CDR 0.6	-1.5	0.74	44	15	8.4
Gun1 0.4	-1.0	0.82	48	21	14.0
Gun1 1.4	-1.5	0.79	26	41	13.4
Gun1 1.4	-2.0	0.69	26	39	11.3

Elliptical 1.4 cell 1.3 GHz with Choke filter

A. Neumann, LINAC 2012

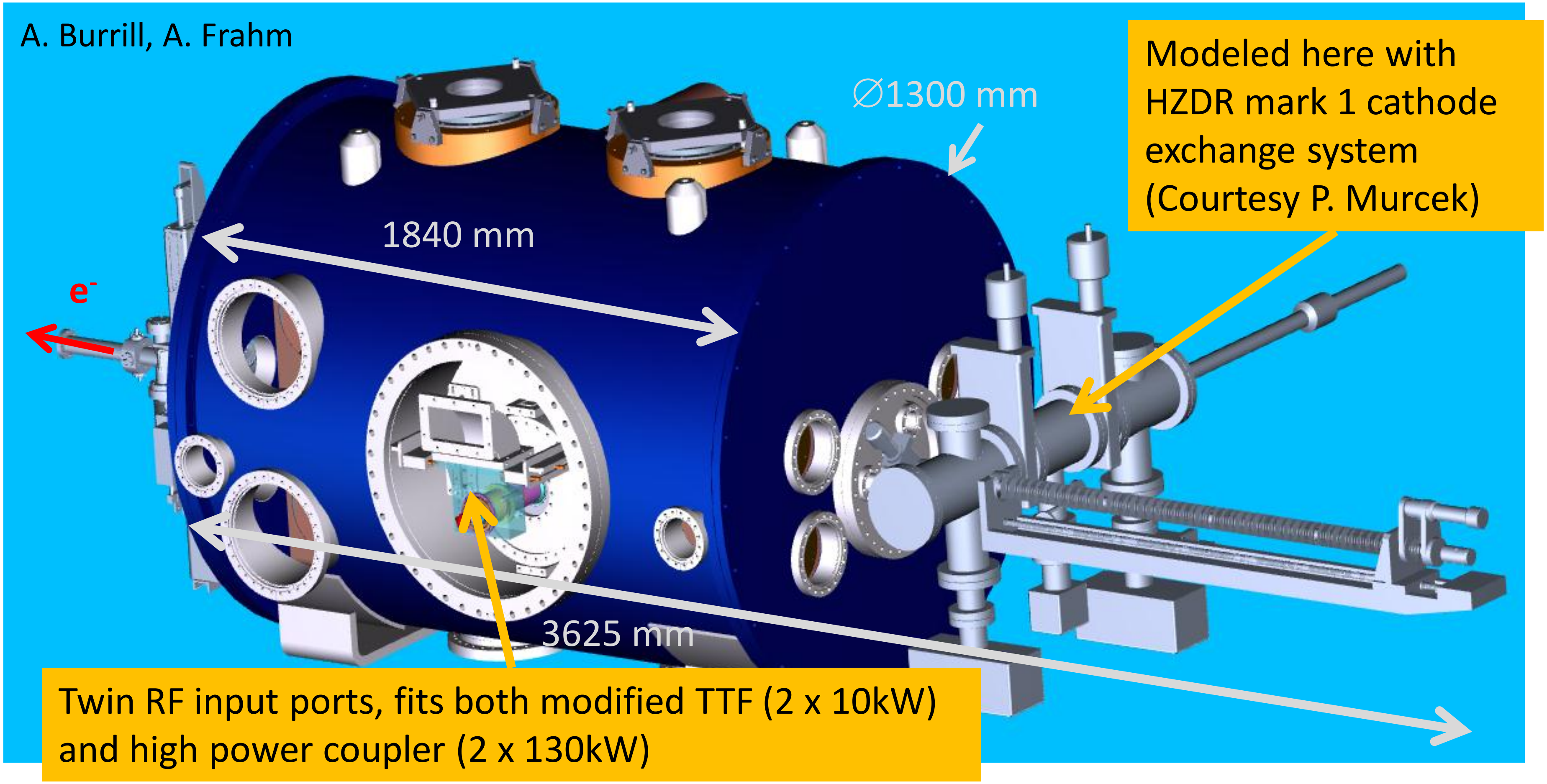






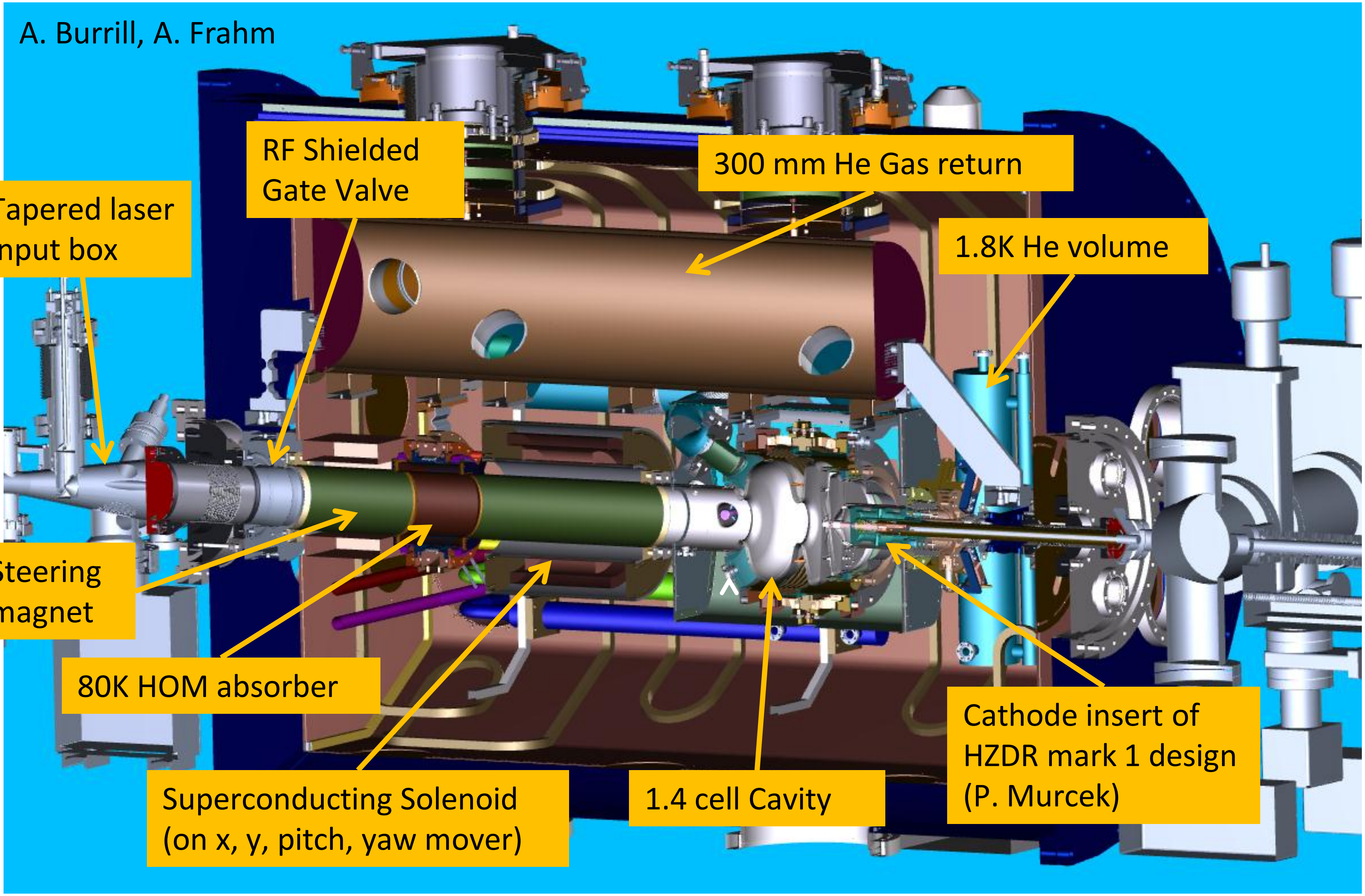
T. Kamps, LINAC 2012

Cryomodule design in line with staged approach towards BERLinPro goals (brightness, current)

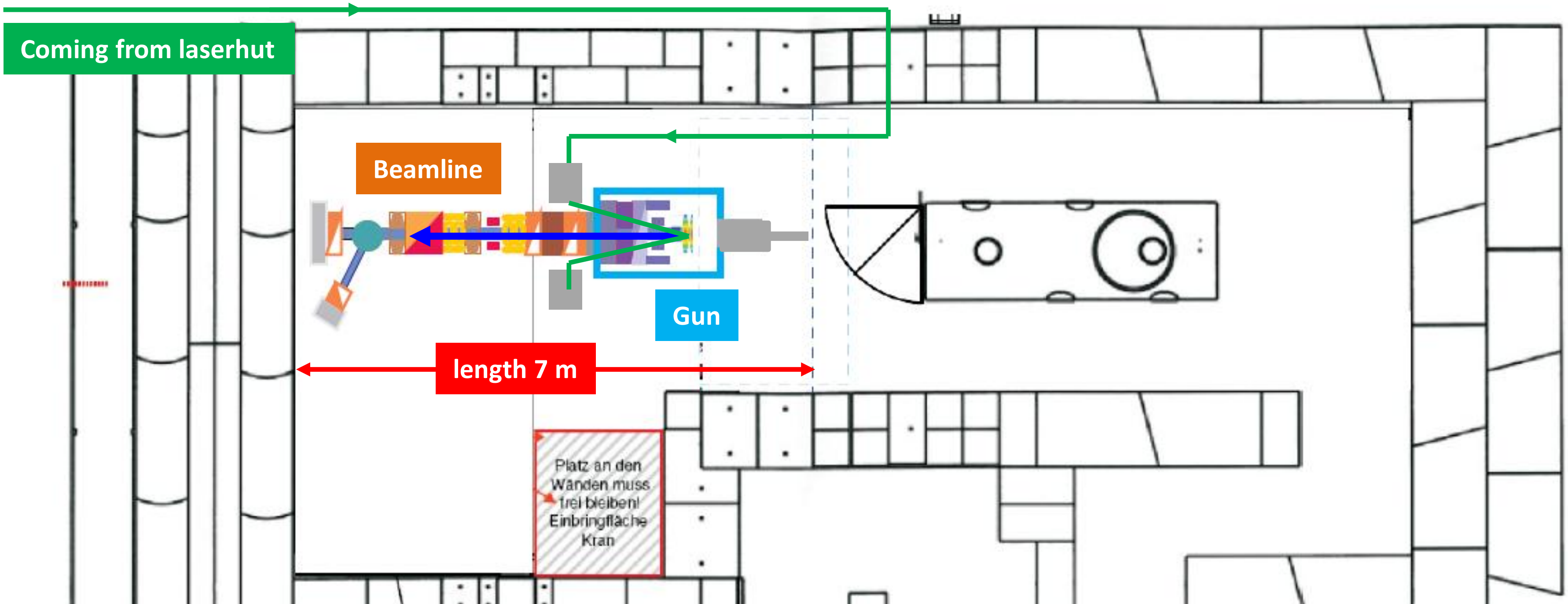


Houses one 1.4 cell 1.3 GHz gun cavity, SC solenoid, beamline HOM absorber, steerer package
Is completely LHe cooled

Inside the SRF gun cryomodule. Cold mass will assembled at JLAB and tested at HoBiCaT.



The focus is now on Gun1 for BERLinPro: Commissioning in GunLab starting 09/2014



The main goal is to commission and characterize the electron guns for BERLinPro prior to installation in the BERLinPro accelerator hall.

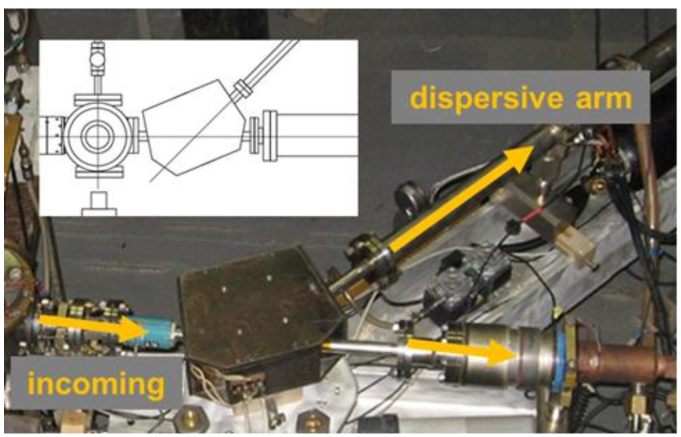
Gunlab is also a platform for collaborative research (Verbundforschung) on photocathodes (DE-RU PCHB), beam dynamics, instrumentation (TCAV with TU Dortmund, longitudinal phase space with MSU)

HZB Helmholtz Zentrum Berlin

Meeting with HZB and V. Shvedunov on 09.07.2013 → goal was to find area of collaboration, define tasks

HZB and MSU will collaborate on beam energy measurements and longitudinal phase space measurements.

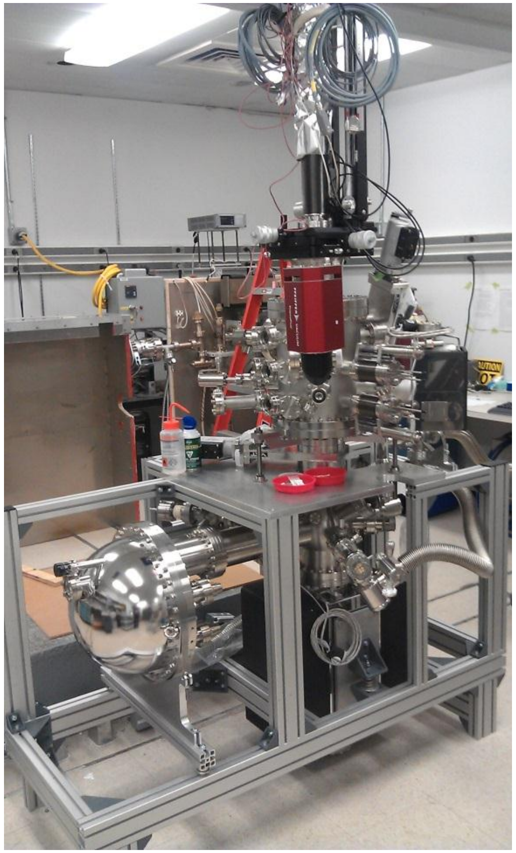
Next step: Write specs report together and produce call for tender.



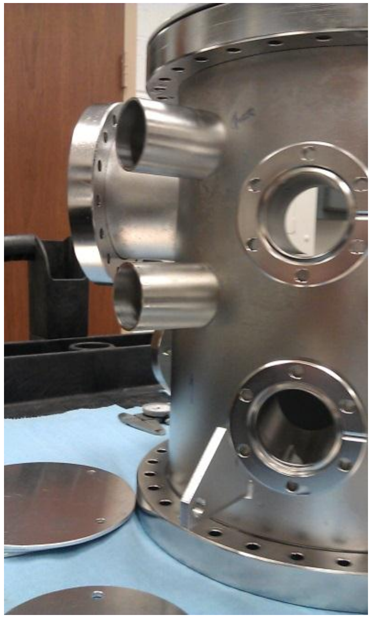
Tasks and timeline for the energy measurement project

Task	When?	Who?
Drafting of a MoU between HZB and MUS	As soon as possible	TK and VS
Physics design including simulations of all measurement scenarios.	Now to 01.11.2013	MSU and HZB (Jens Völker)
Call for tender for components	11/2013 to 01/2014	HZB
Production of components (from drawing room to test measurement s)	01/2014 to 07/2014	company
Shipment/ customs	07/2014 to 08/2014	company
Setup and checkout at Gunlab	08/2014 to 09/2014	HZB and MSU

Status of photocathode preparation system
S. Schubert (at BNL)



During commissioning detected leak in preparation chamber. After attempts with various sealants dismantled chamber. Cut off and replace leaking flange. Pumping down now (August 2013)



Preparation chamber shipped from HZB and setup at BNL (December 2012)

In the meantime find out correlations between growth, structure and QE with BNL depo system

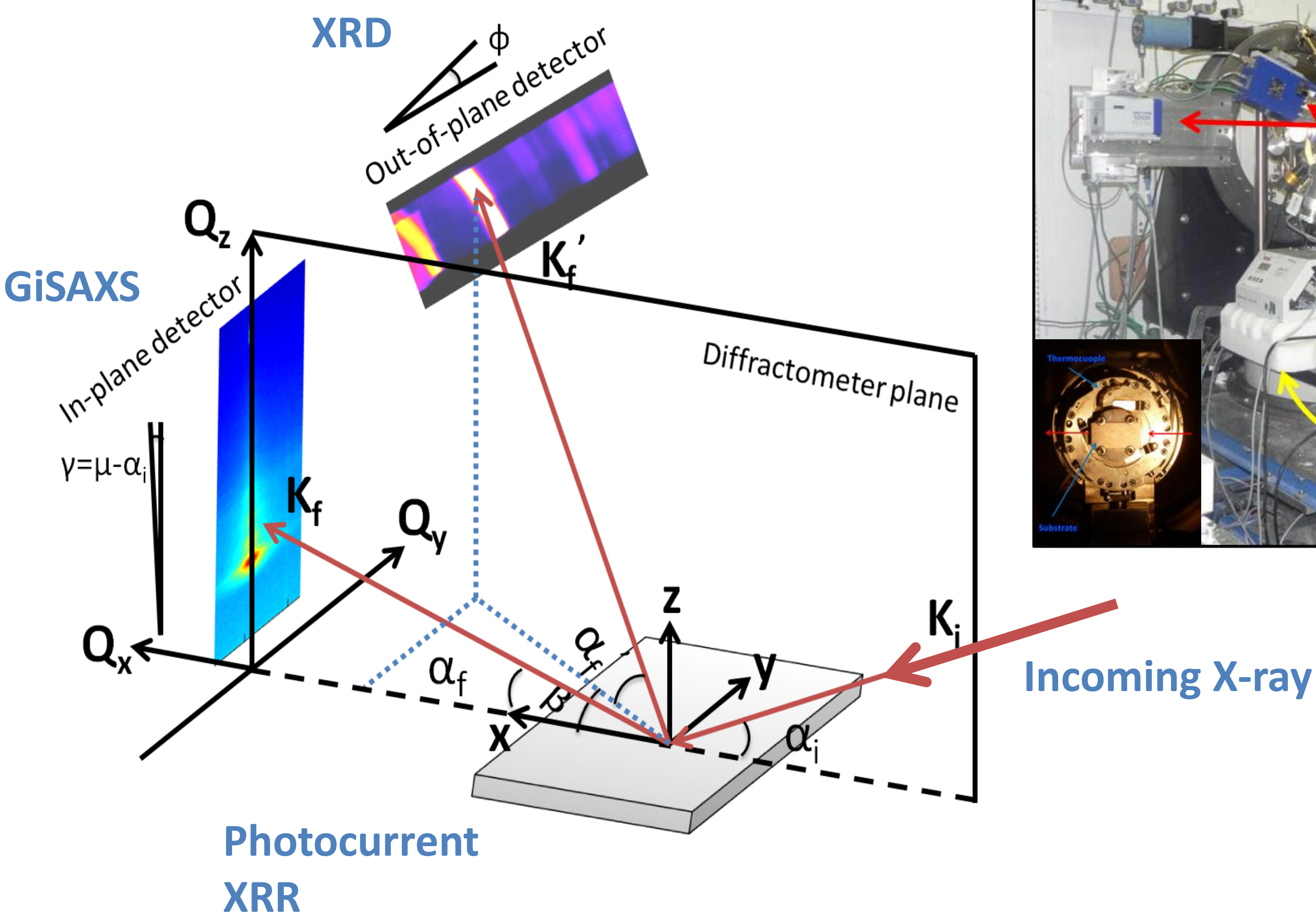
HZB Helmholtz Zentrum Berlin

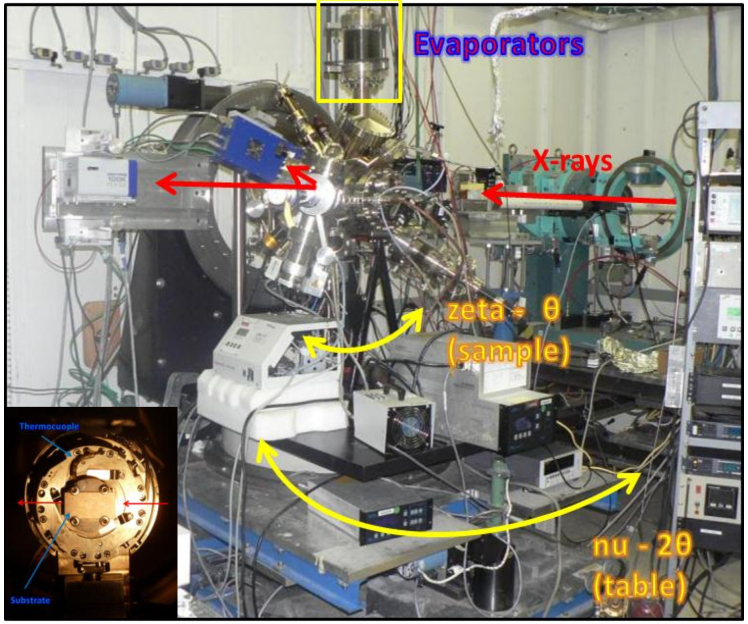
Method	Abbreviation	Which Information can be obtained?
Grazing incidence small angle x-ray scattering	GiSAXS	Thickness Morphology/Growth mechanism
X-ray reflectivity	XRR	Thickness Roughness
X-ray diffraction	XRD	Lattice information Preferred orientation
Core-level x-ray photoelectron spectroscopy	XPS	Chemical composition of surface layer (3-6 nm)
UHV- atomic force microscopy	UHV-AFM	Morphology Roughness

…combine these methods with in-situ measurement of photocurrent to uncover correlations between growth, structure and perfomance.

S. Schubert

X21 (NSLS) and G3 (CHESS) beamline experiments enable growth and GiSAXS, XRR and XRD



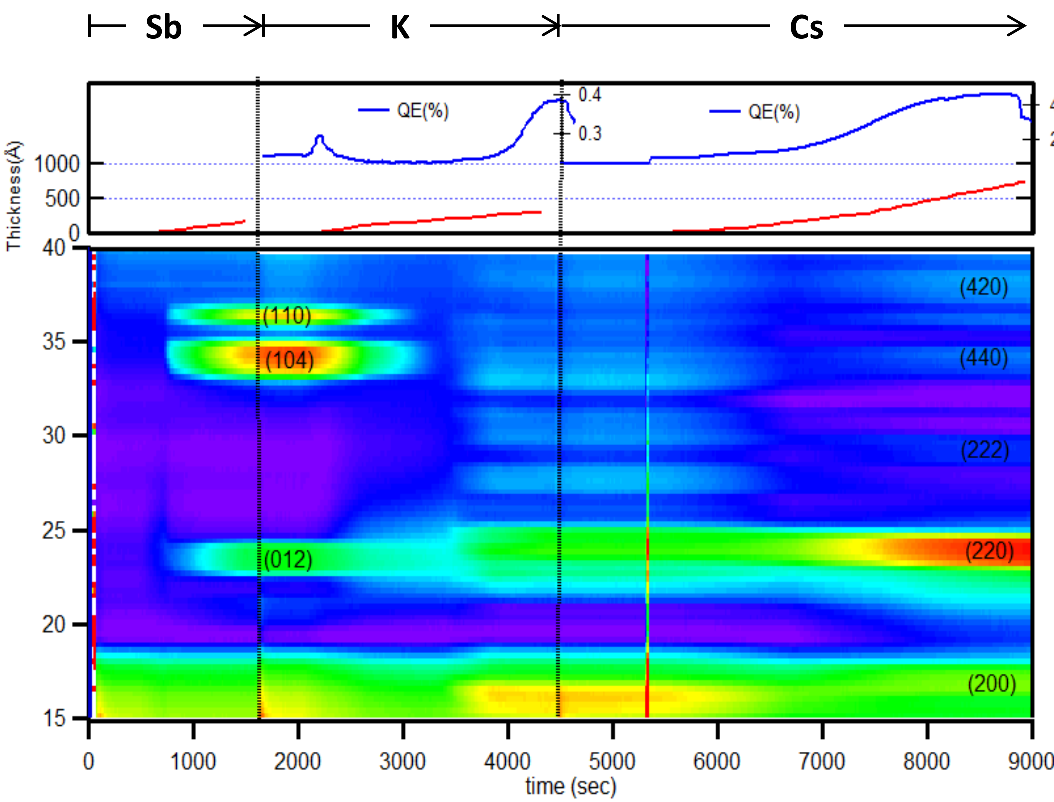


S. Schubert

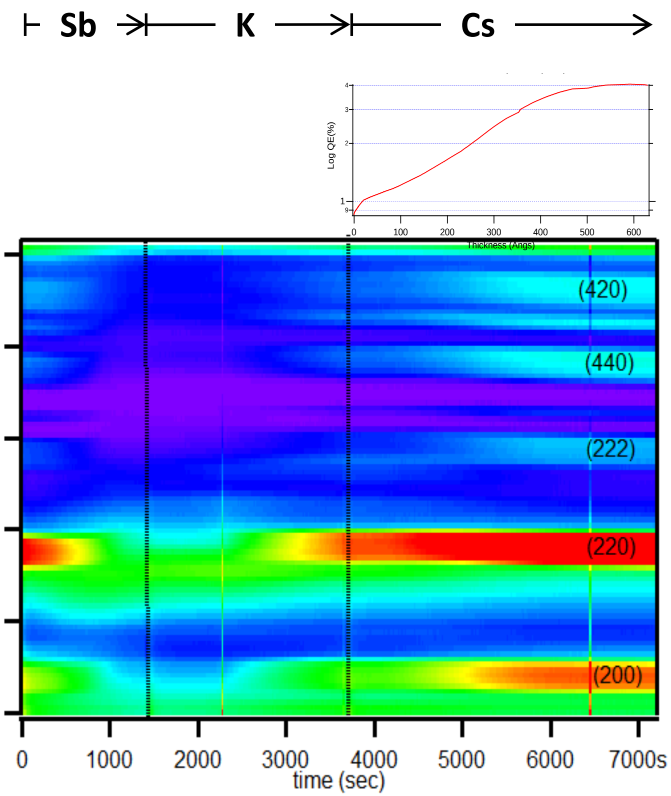
Prepare CsK2Sb and observe evolution of diffraction pattern, thickness and QE

HZB Helmholtz Zentrum Berlin

Growing of 1st cathode



Growing of 2nd on top of 1st



S. Schubert

PCHB administrative matters

Financials

Reporting duties

Webpage

HZB financials

Planung: **abrechnen:** **Plan (wird angepasst):**

	Gesamt	2012	2013	2014	2015
0813: Material	**3.000,00**		1.200,00	1.200,00	600,00
0837: Personal	**101.547,43**		40.000,00	40.000,00	21.547,43
GK (75%)	**76.160,57**	0,00	30.000,00	30.000,00	16.160,57
0847: Invest.	**176.000,00**	28.483,71	30.000,00	100.000,00	17.516,29
0838: Reisek.	**10.008,00**	2.517,94	5.000,00	1.000,00	1.490,06
0850: Sonstige	**35.000,00**	72,00	13.000,00	13.000,00	8.928,00
Summe	**401.716,00**	**31.073,65**	**119.200,00**	**185.200,00**	**66.242,35**

- In 2012 we spent all funds according to plan, invest into FE setup (30k) and travel costs to allow Martin participation at P3 workshop.
- In 2013 we want to invest into GunLab diagnostics (30k) → If possible shift part of GunLab to 2014 and invest into momentatron.
- In 2014 the invest is for GunLab diagnostics (100k).
- In 2015 the invest is for the momentatron (30k) → Move this to 2013.

Reporting: Info from PT-DESY

	A	B	C	D	E	F
1	**Förderkenn-zeichen**	**Zuwendungs-empfänger**	**Projektende**	**Zwischenberichte Vorlagefrist lt. Nebenbestimmung / Änderung durch Ergänzung im Zuwendungsbescheid**	**Schlussbericht Vorlagefrist lt. Neben-bestimmung**	**Nebenbestimmungen**
2	05K12CB2	Helmholtz-Zentrum Berlin	30.06.2015	jeweils 6 Wochen nach Ablauf des Kalenderhalbjahres (also zum 15.2. und 15.8. des Jahres) / ... Ihre Berichtspflichten für das abgelaufene Haushaltsjahr sehen wir dann erfüllt an, wenn uns ein Zwischenbericht als Teil des Zwischennachweises vorliegt (der Zwischennachweis ist zum 30.4. des Jahres fällig)	31.12.2015	s. NKBF98 Nr. 8 (wobei 8.3. von uns nicht benöitgt wird, einfach reicht.)
3	05K12CR1	Helmholtz-Zentrum Dresden - Rossendorf e. V.	30.06.2015	jeweils 6 Wochen nach Ablauf des Kalenderhalbjahres (also zum 15.2. und 15.8. des Jahres) / ... Ihre Berichtspflichten für das abgelaufene Haushaltsjahr sehen wir dann erfüllt an, wenn uns ein Zwischenbericht als Teil des Zwischennachweises vorliegt (der Zwischennachweis ist zum 30.4. des Jahres fällig)	31.12.2015	s. NKBF98 Nr. 8 (wobei 8.3. von uns nicht benöitgt wird, einfach reicht.)
4	05K12UM1	Johannes Gutenberg-Universität Mainz	30.06.2015	jeweils zum 30.4. des Jahres.	31.12.2015	s. BNBest-BMBF 98 Nr. 3 (wobei 3.3. nicht benötigt wird, einfach reicht.)

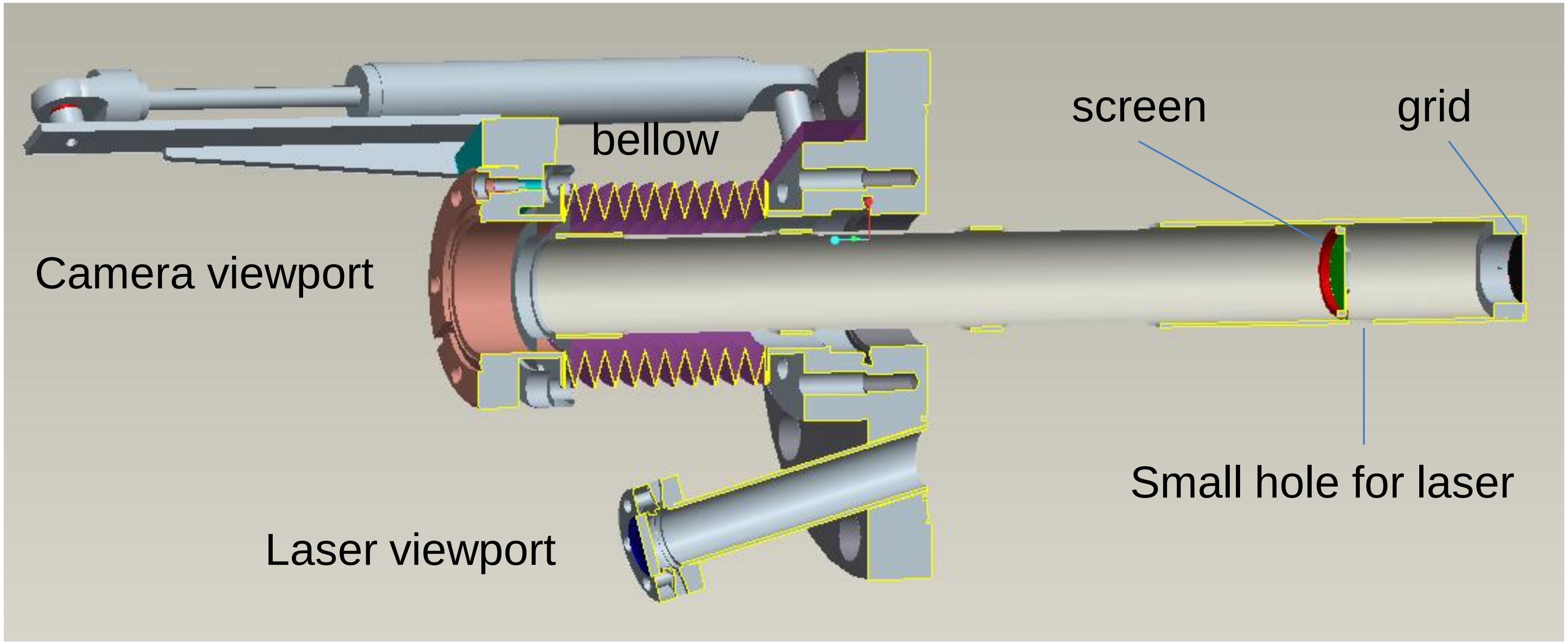
Webpage and Publications

- The webpage is live, could add
  - slides from collaboration meetings,
  - reports and publications,
  - photos and fancy logo.

Thank you

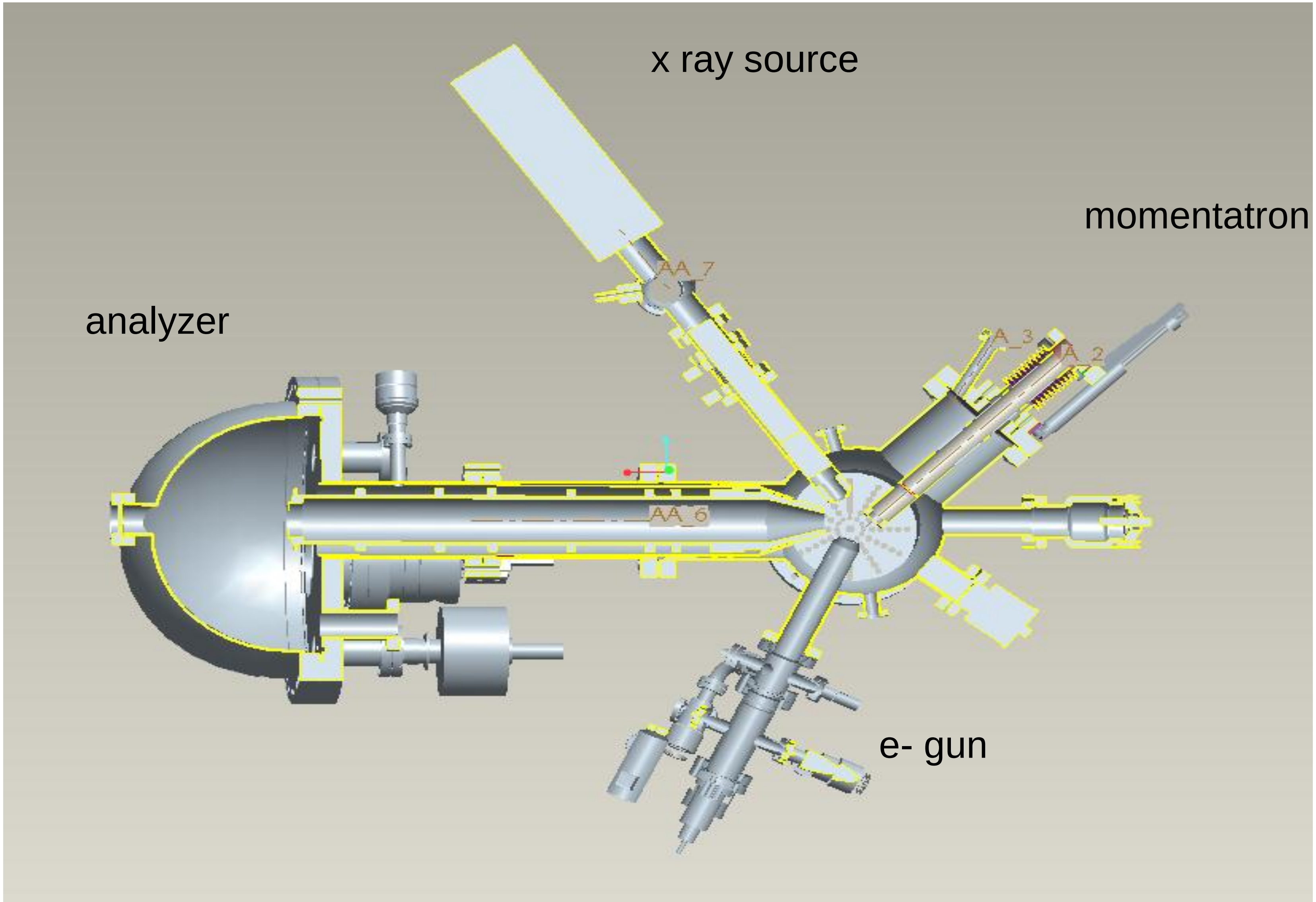
TECHNICAL DESIGN CONSIDERATIONS FOR THE MOMENTATRON

Martin Schmeißer

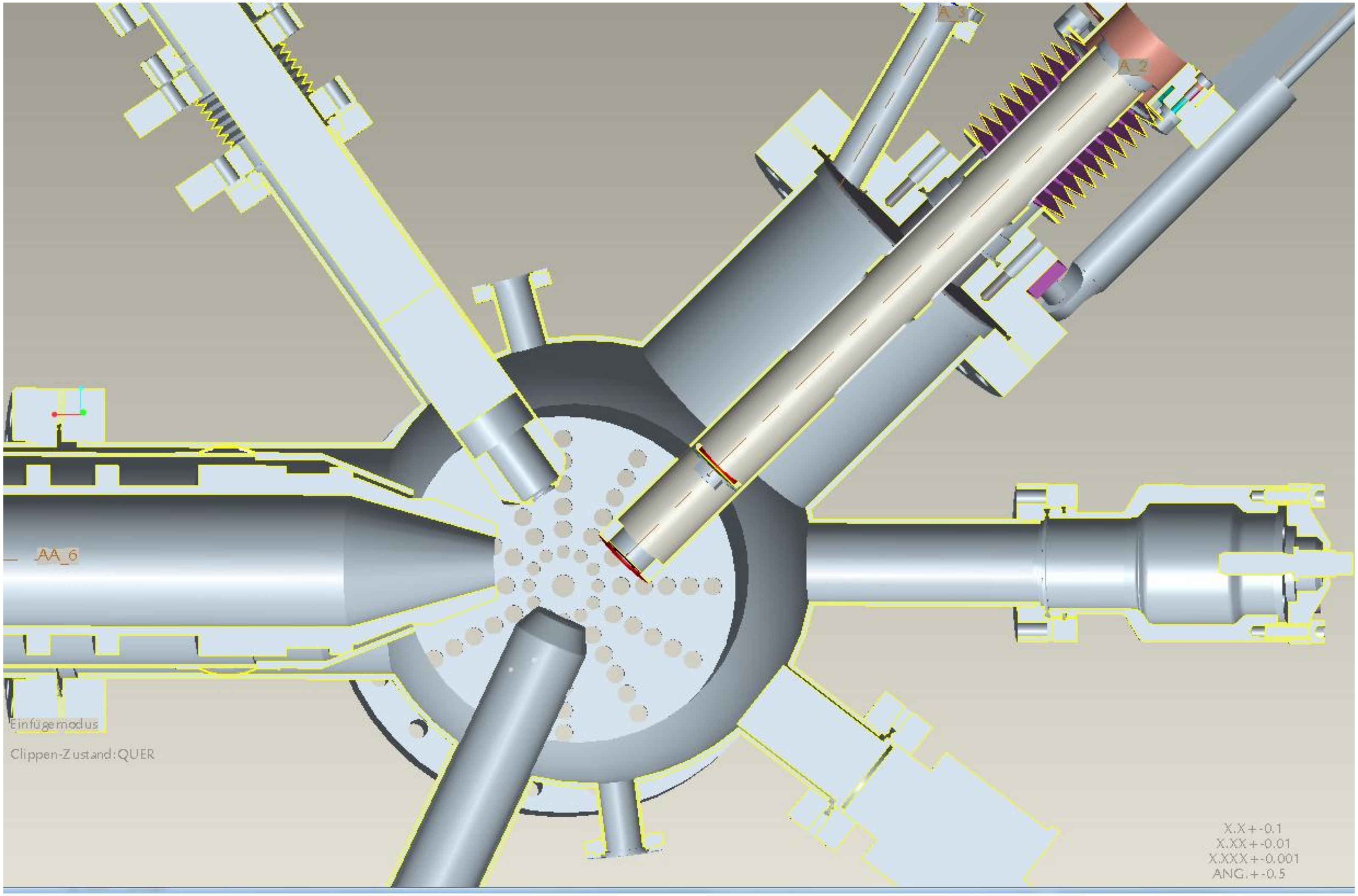


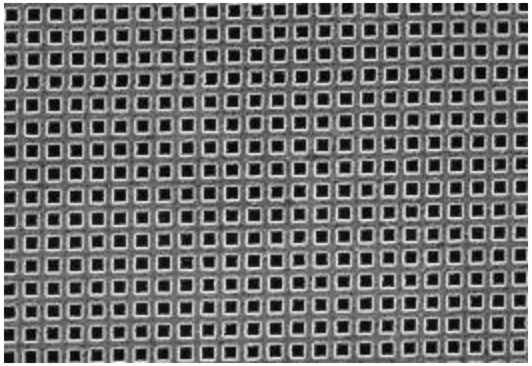
Linear dependence of radial screen coordinate on transverse momentum

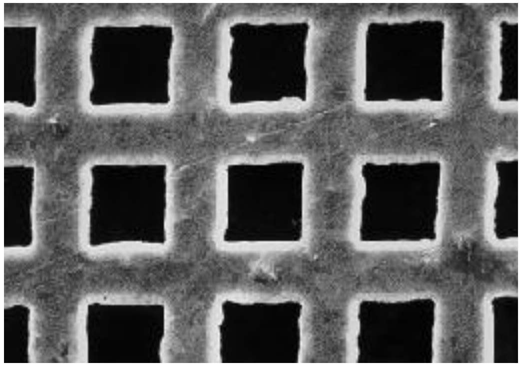
$$\frac{p_x}{mc} = \frac{r}{2g + d}\sqrt{\frac{2eV}{mc^2}}$$


x ray source
momentatron
analyzer
e- gun
AA_7
AA_6
A_3
A_2

HZB Helmholtz Zentrum Berlin





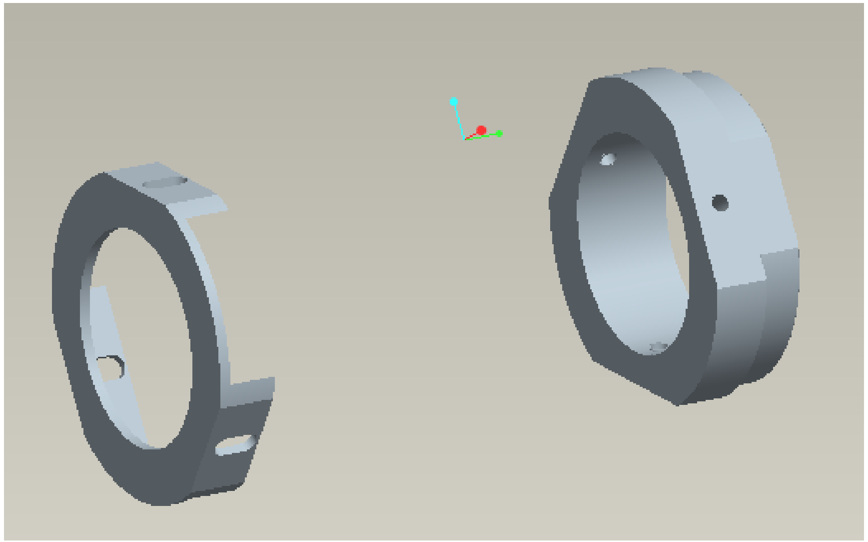


SEM images of electroformed grid from SPI

Grid:

1000 mesh made of Cu
50% open area
18µm hole size, 25.4µm pitch

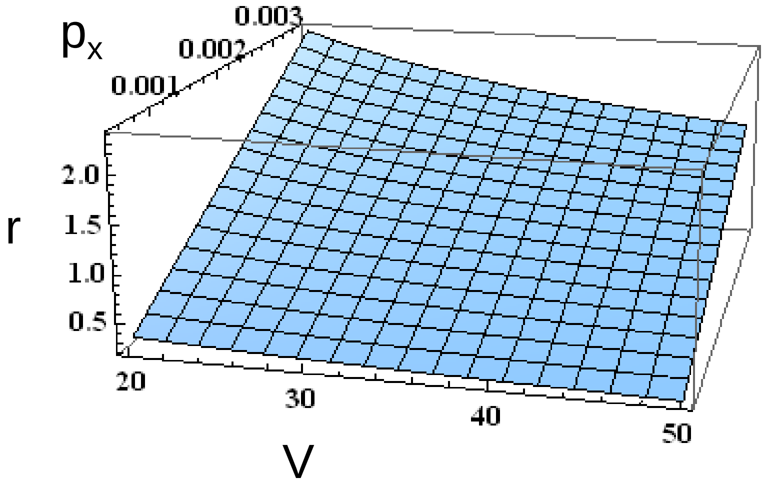
Clamped to drift tube with Al holder



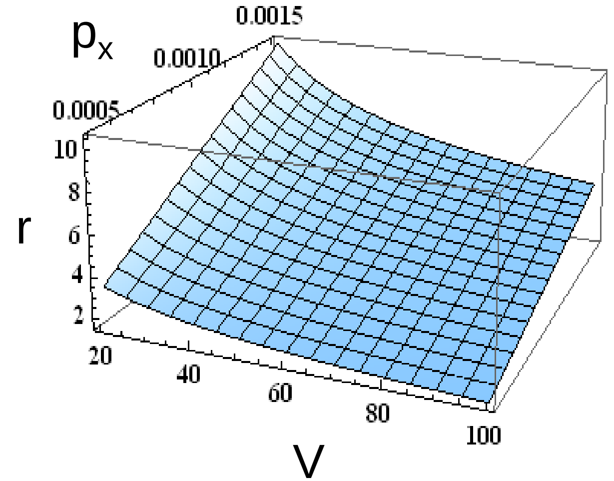
Gap	g	3mm
Drift Path	d	56mm
Potential	V	50V (maybe 100V)

$$\frac{p_x}{mc} = \frac{r}{2g+d}\sqrt{\frac{2eV}{mc^2}}$$

Radial coordinate at grid



at screen



Ratio 0.00025mc : 1mm

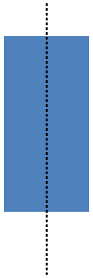
CAMERA

659 x 494 px
9,9 µm x 9,9 µm → about 4x4mm usable area
GigE Vision (use existing LabView code)
12 bit AD

Ratio screen : cam = 20 : 4
Ratio momentum:px = 0.0005mc : 40px

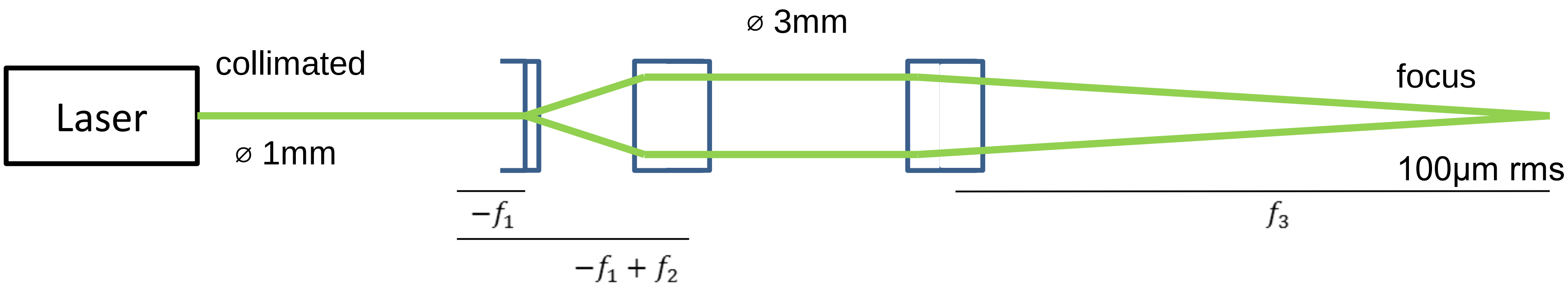
Expect 100-200px resolution for beam radius

b=60±5mm → f=50mm → g=300±100mm →



use existing lab laser with 1mW at 532nm (green)

Expand beam diameter with telescope, , mm
Focus with collimation lens mm



Will test setup in Berlin

Note : Laser goes through grid, expect diffraction

HZB Helmholtz Zentrum Berlin

Will a YAG:Ce screen work with 50eV electrons?

How much light will we see per e-?

Assume very low photon yield → need more current (maybe 100nA)
→ screen needs conductive coating

Laser power is sufficient to go up to µA at 1% QE

HZB Helmholtz Zentrum Berlin

Several sources of errors or reduced resolution:

1 Finite size of laser illuminated area, expect 100-150µm rms
- 100µm rms due to beam waist
- First order refraction minimum from one grid hole has 88µm diameter

2 Intensity modulation of electron beam due to grid
- Simulation shows strong modulation with 50µm grid (distinct peaks)
- Expect little modulation with fine grid (18µm holes)

3 Lens effect of the grid
- Resolution function $F = \frac{Da}{8g} = 2.3D$ would be 38µm

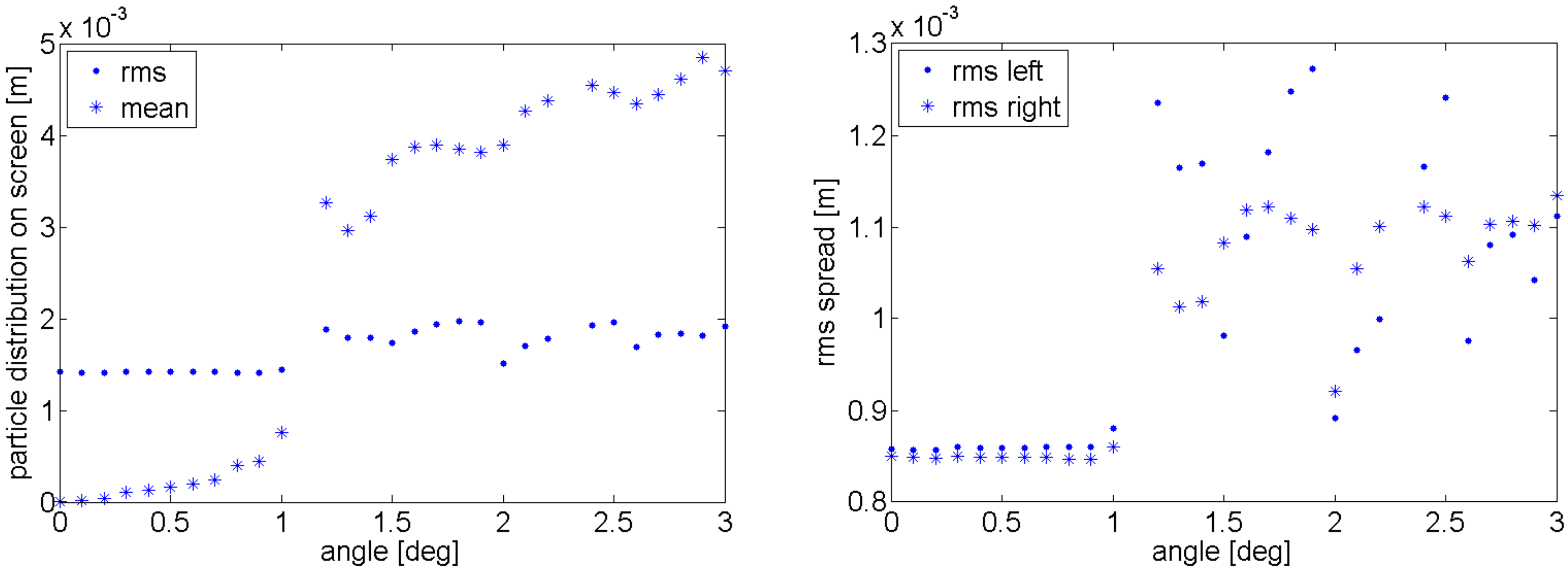
4 Magnetic field
- Earth field + pumps
- Shielded by µMetal in drift path

HZB Helmholtz Zentrum Berlin

5 Angle between cathode and grid

•Expect slight beam steering and no influence on distribution below 1deg angle

•Strong influence on distribution at larger angles



FEM Simulation mit CST: 50V, 3mm gap, hex. mesh, particle tracking in CST
similar results in ASTRA tracking with 3D field from CST tetragonal solver

HZB Helmholtz Zentrum Berlin

- Finalize design in week 32
- Get quotes for drift tube, screen, vacuum components in weeks 33, 34
- Expect 8 weeks delivery time → Mid October
    - Use this time for all sorts of testing:
    - Laser setup
    - Camera setup
    - Write sketches of analysis programs
- Setup at BNL end of October

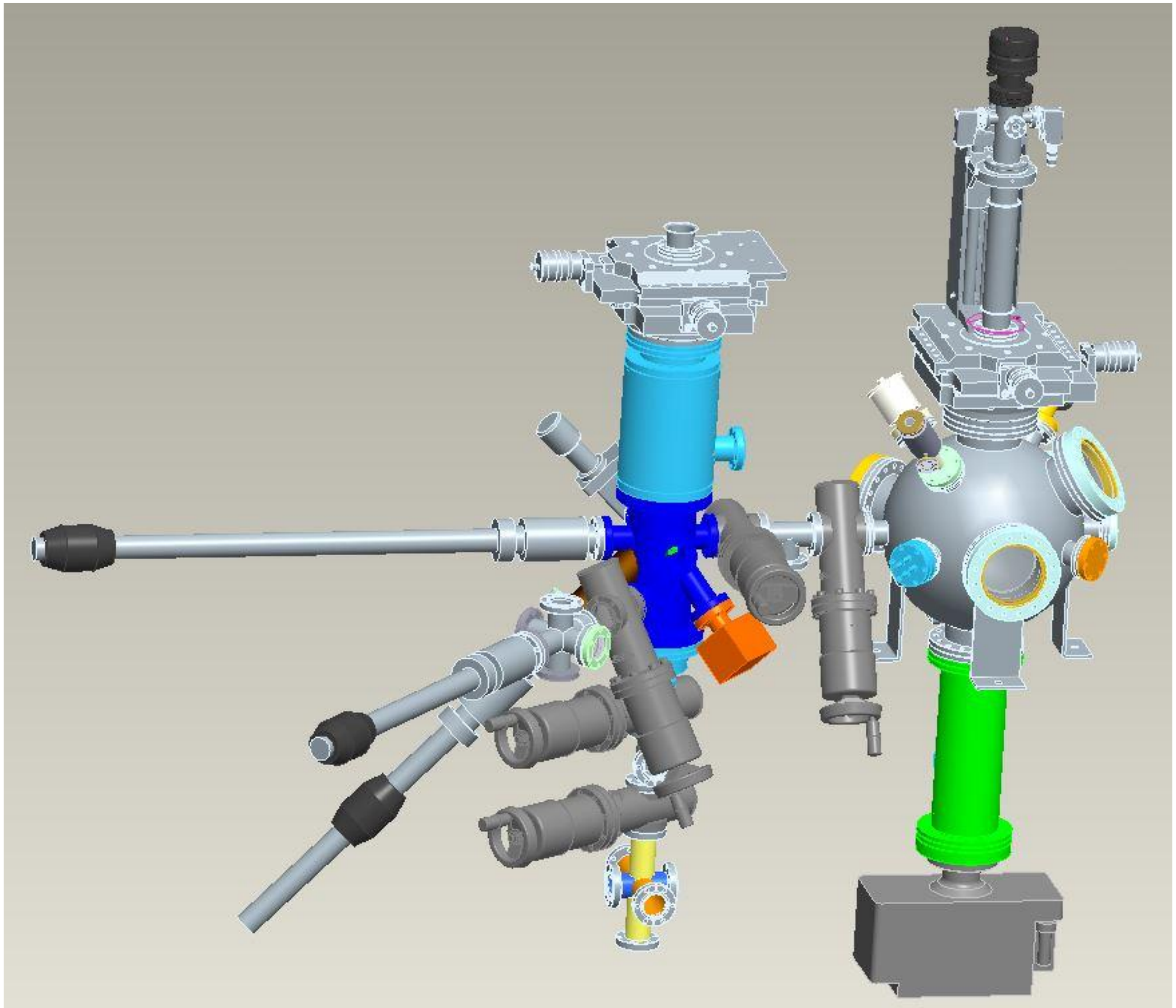
Thank you for your attention!

Transfersystem

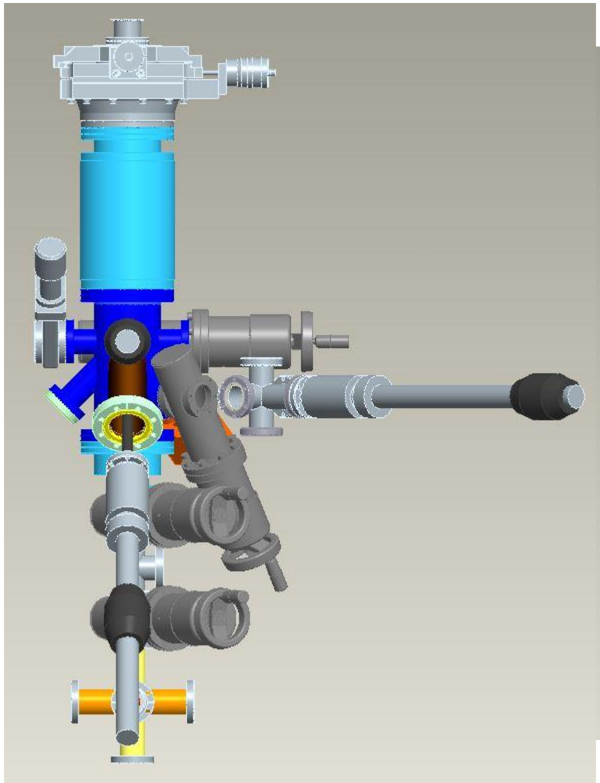
Status 05.08.2013

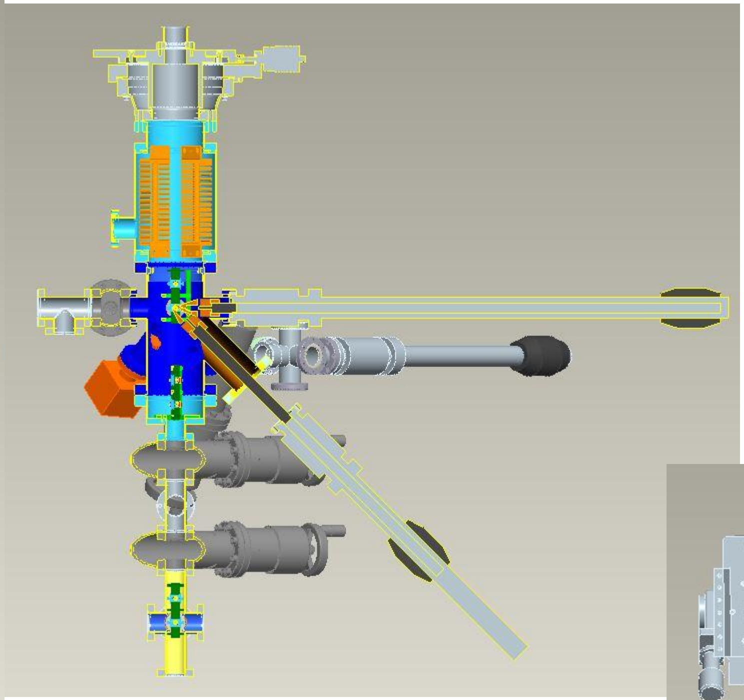
Petr Murcek I p.murcek@hzdr.de I www.hzdr.de

Rossendorfer Beschichtungskammer mit dem Transfersystem



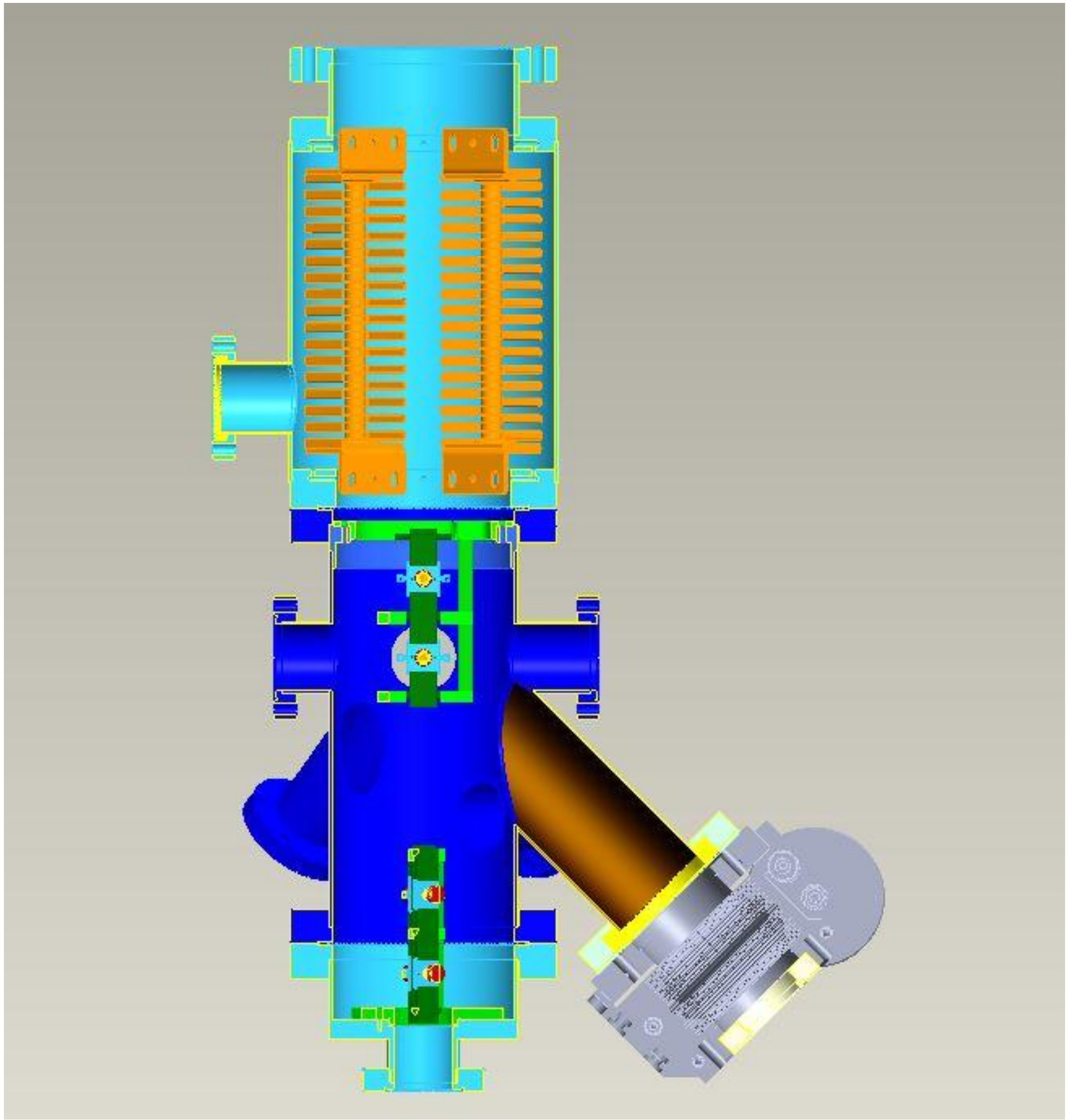
Petr Murcek I p.murcek@hzdr.de I www.hzdr.de





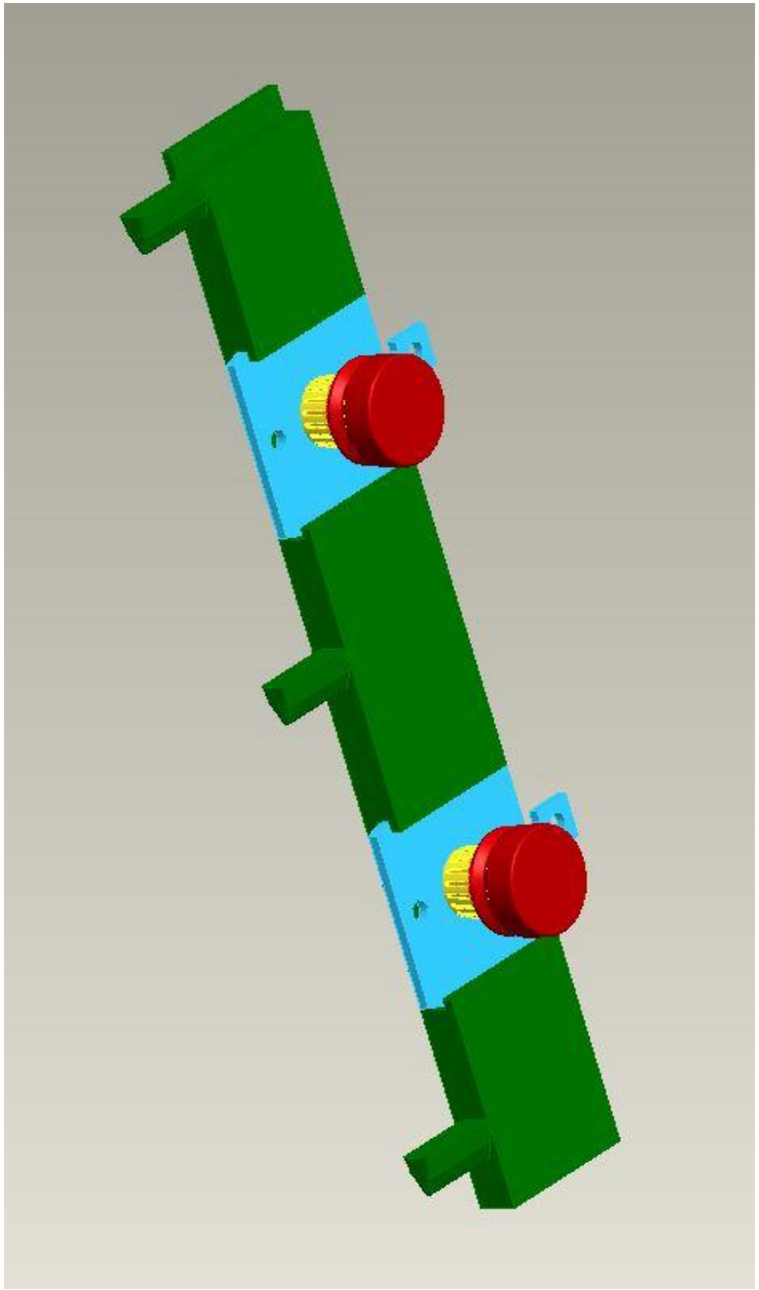
HZDR – Transferkammer

Member of the Helmholtz Association
Petr Murcek I p.murcek@hzdr.de I www.hzdr.de



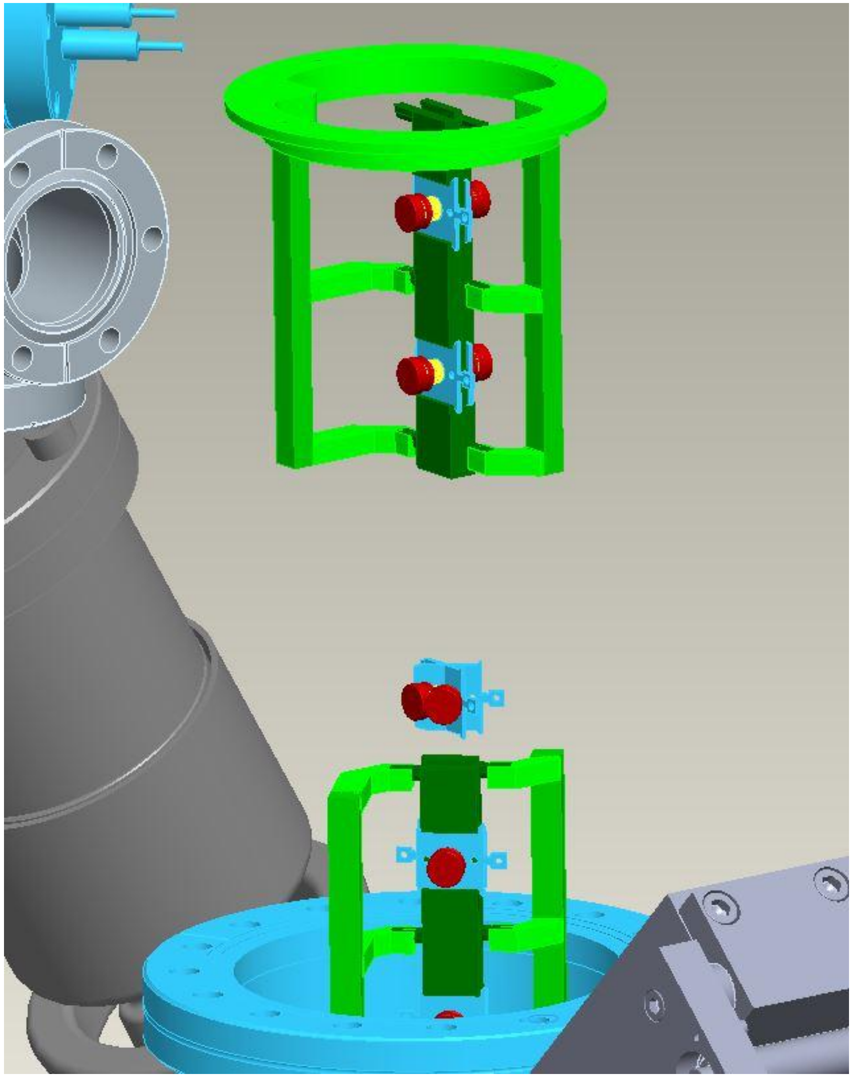
NEG Pumpe in der Transferkammer

Petr Murcek I p.murcek@hzdr.de I www.hzdr.de



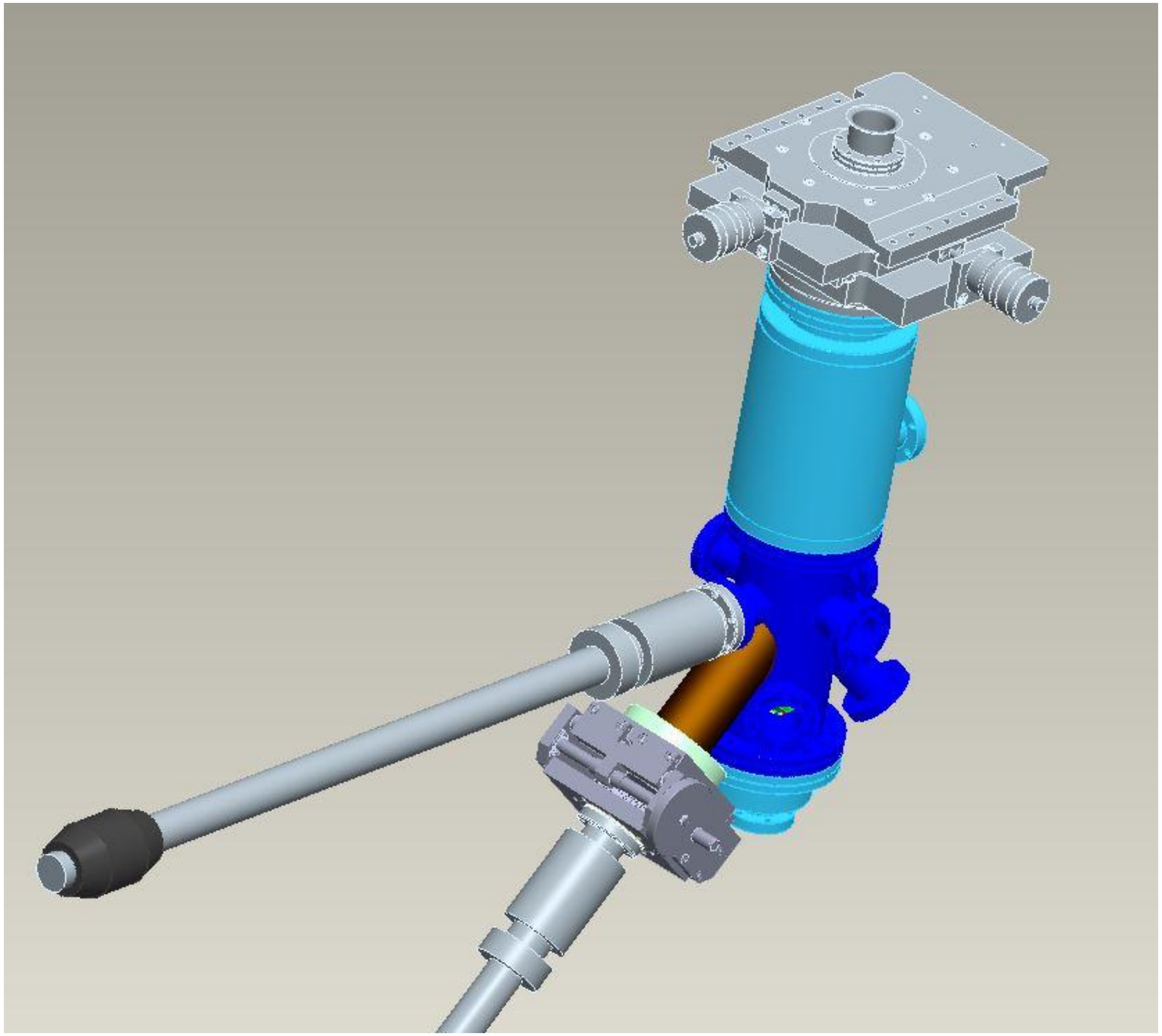
Wagen

Member of the Helmholtz Association
Petr Murcek I p.murcek@hzdr.de I www.hzdr.de



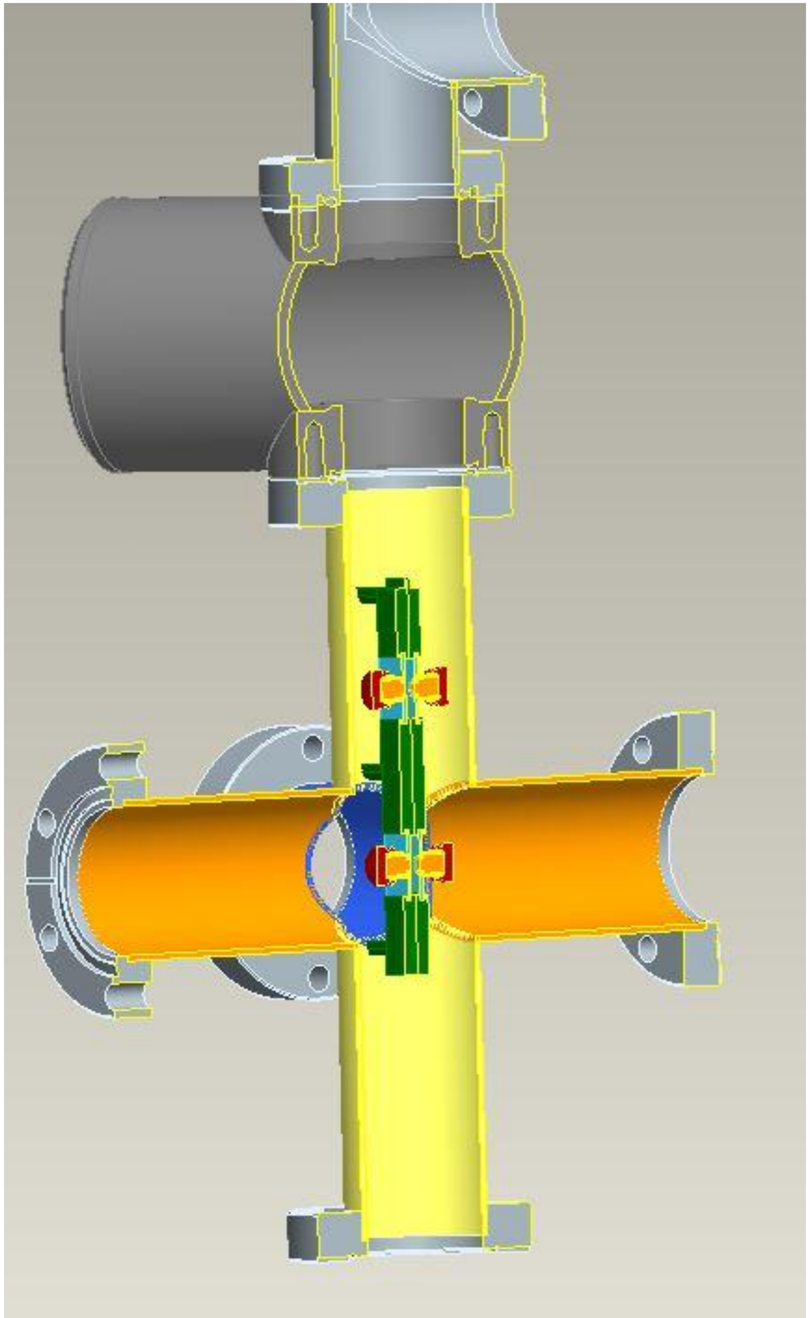
Halterung des Wagens in der Transferkammer

Petr Murcek I p.murcek@hzdr.de I www.hzdr.de



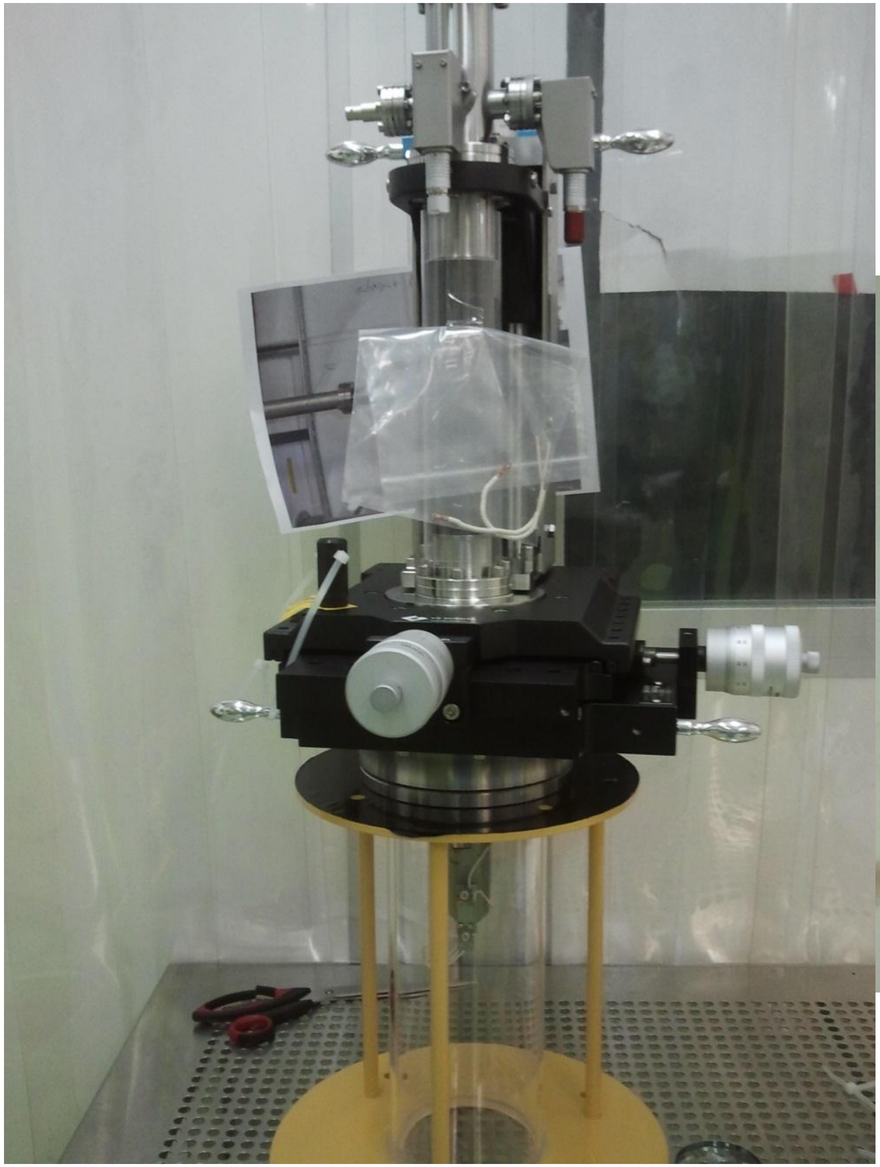
X-Tisch zur Kathodenbestückung

Petr Murcek I p.murcek@hzdr.de I www.hzdr.de

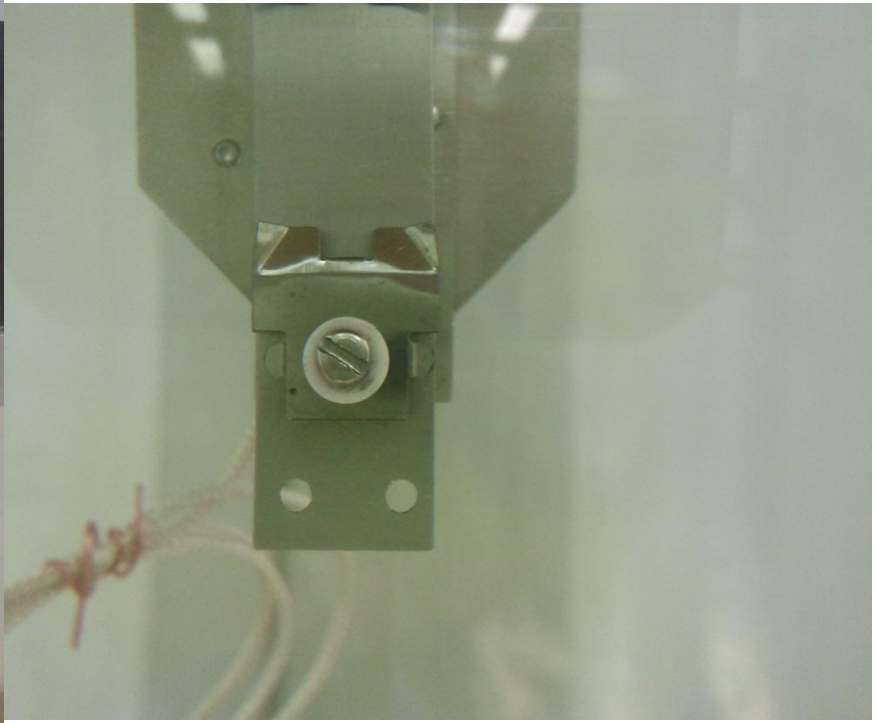


Position des Wagens
in der Transportkammer

Member of the Helmholtz Association
Petr Murcek I p.murcek@hzdr.de I www.hzdr.de

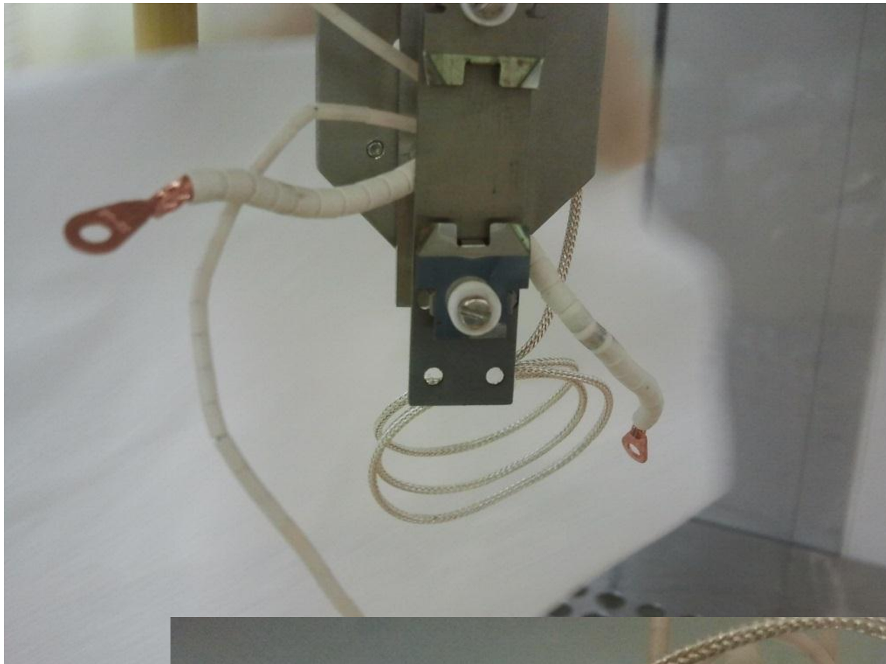


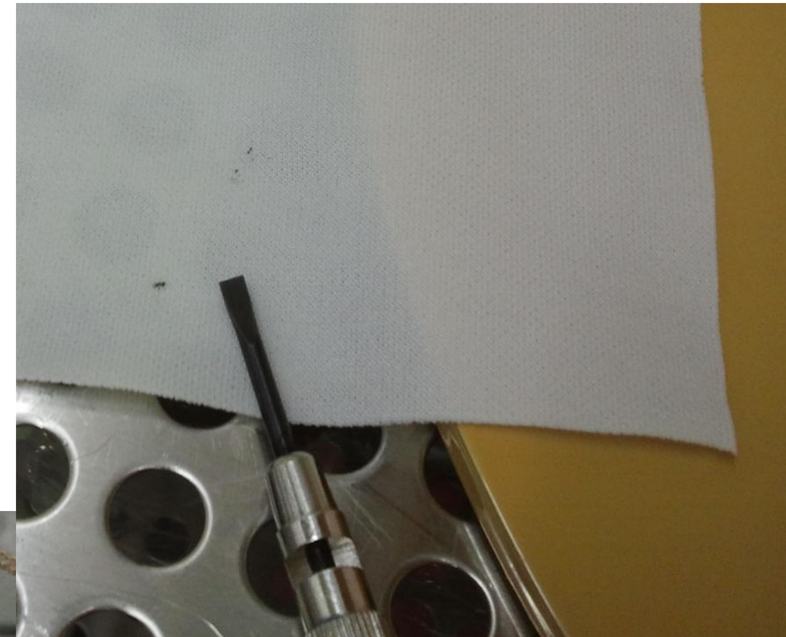
Probleme mit Manipulator

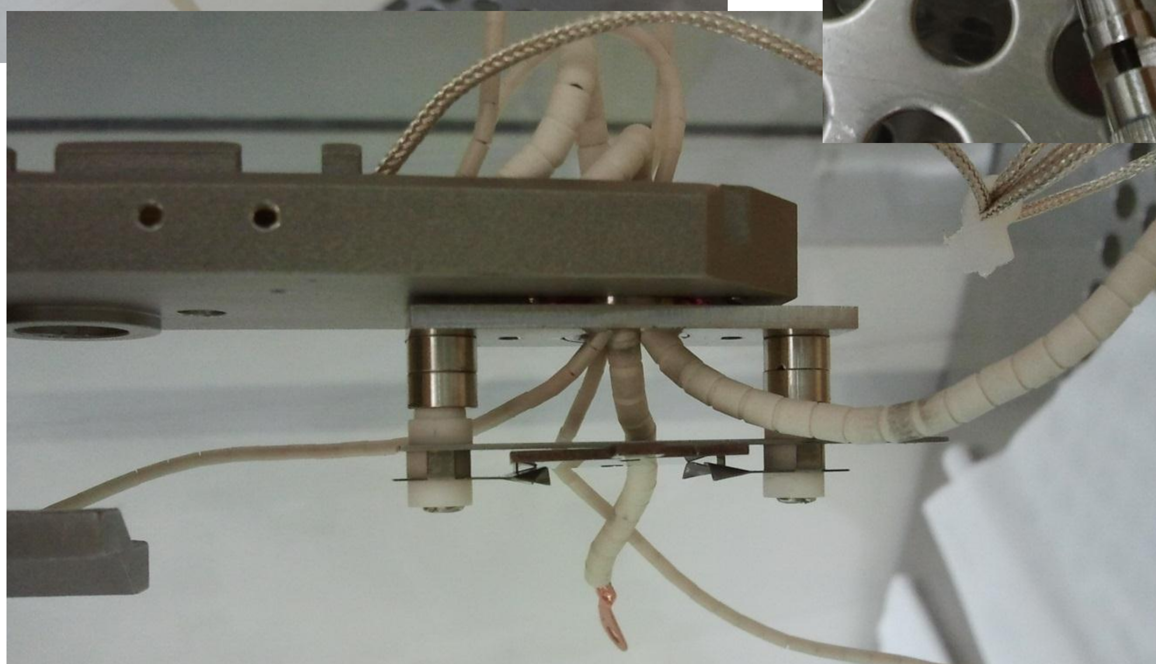


DRESDEN concept HZDR
Member of the Helmholtz Association
Petr Murcek I p.murcek@hzdr.de I www.hzdr.de

Probleme mit Manipulator



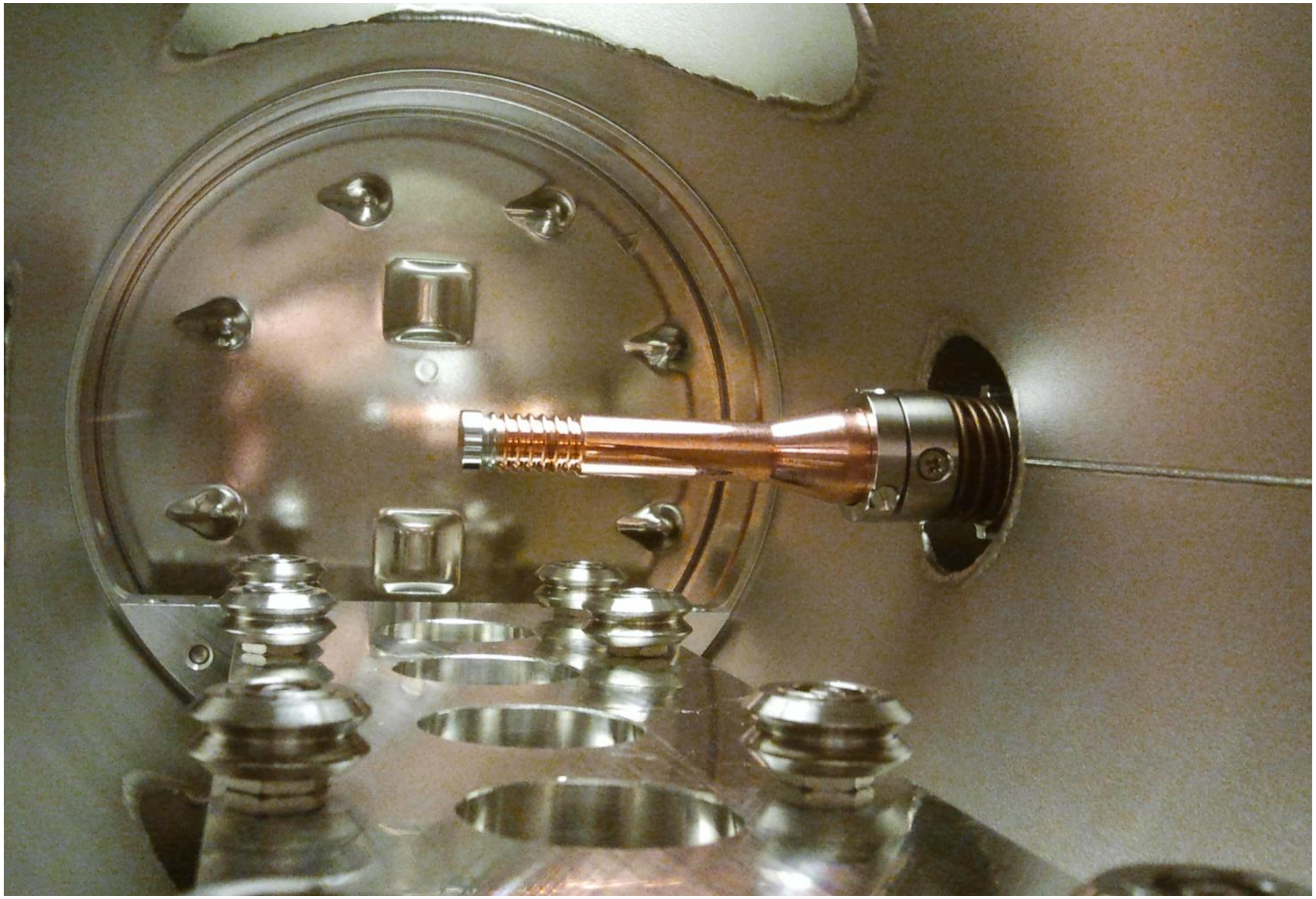




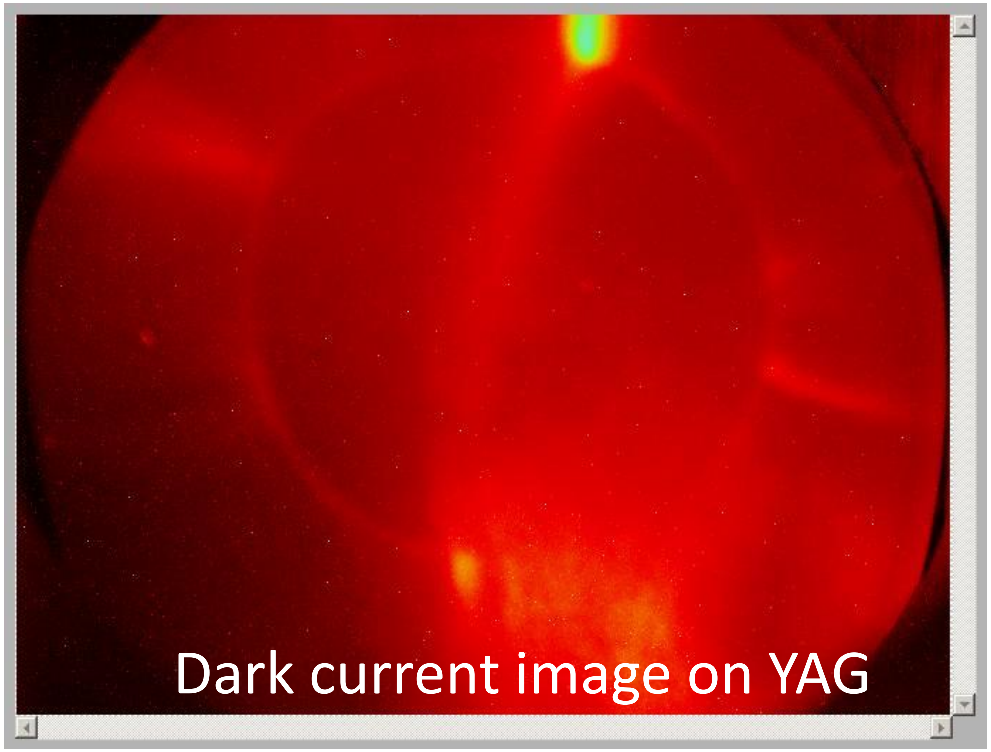
Petr Murcek I p.murcek@hzdr.de I www.hzdr.de

Cathode #2013.2.HZB

Before

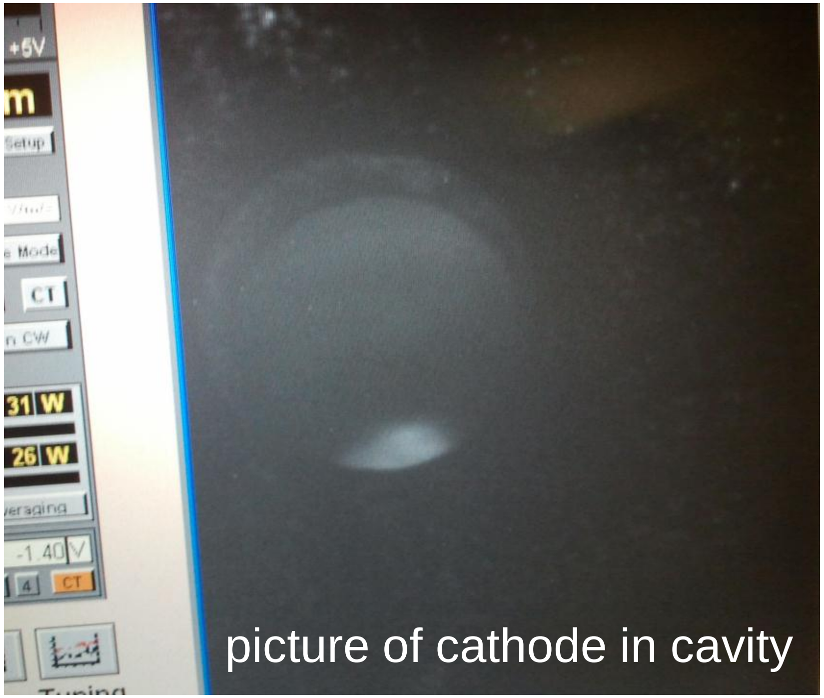


Rong Xiang I r.xiang@hzdr.de I www.hzdr.de



Laser on,
50 µA only with DC
100 µA with RF on
One RF breakdown happened, then we could achieve only 1 µA .

Rong Xiang I r.xiang@hzdr.de I www.hzdr.de



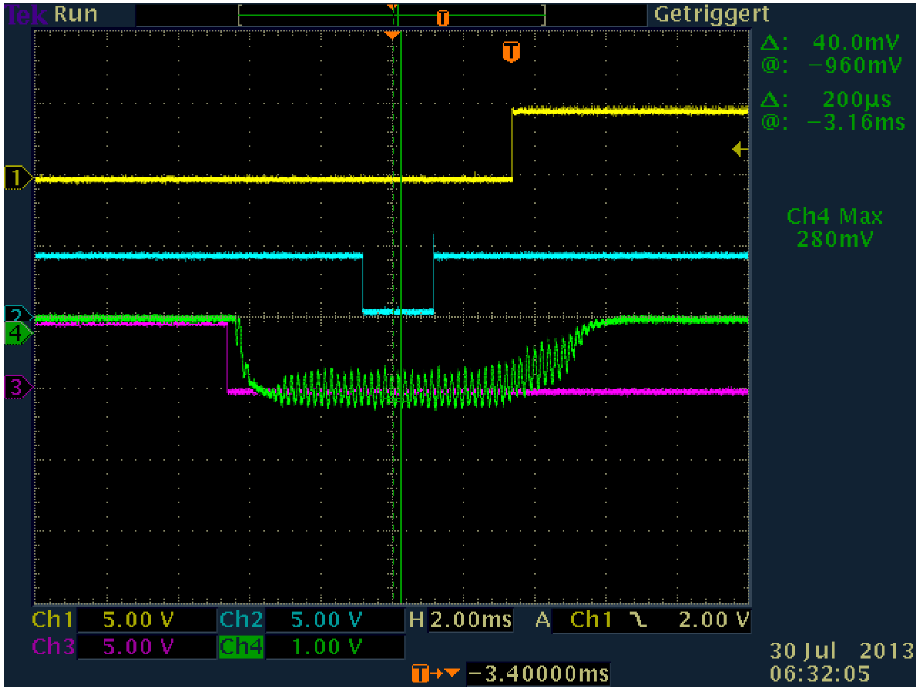
During the cathode being drawn out from cavity

Out from the cavity

HZDR

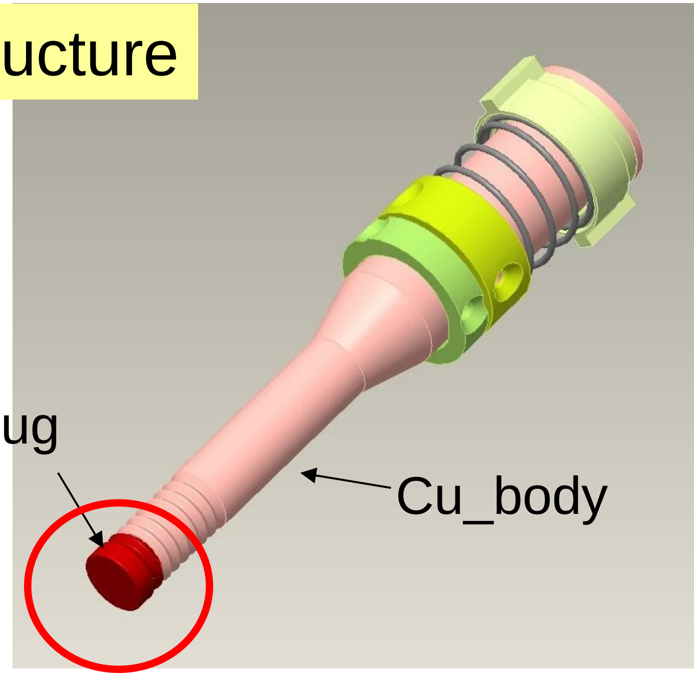
Rong Xiang I r.xiang@hzdr.de I www.hzdr.de

- Short cut between cavity and cathode – no DC
- No DC – multipacting problem

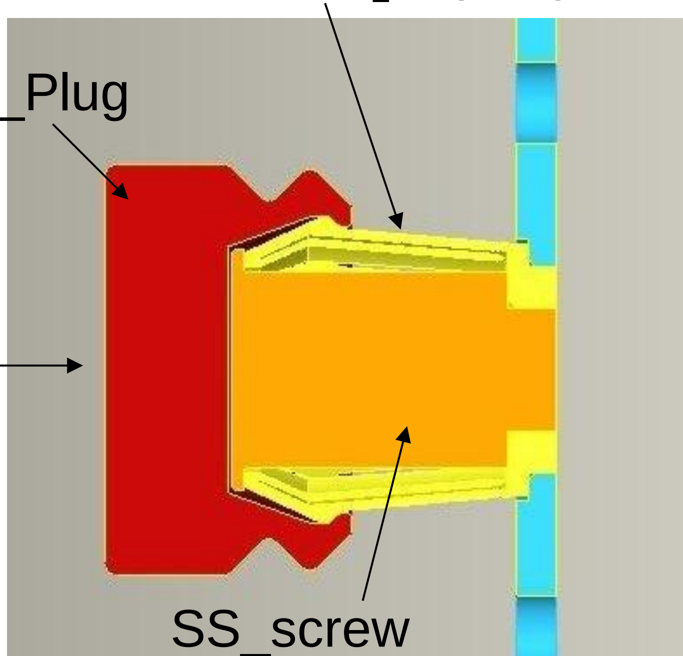


Rong Xiang I r.xiang@hzdr.de I www.hzdr.de

Cathode structure



Plug structure



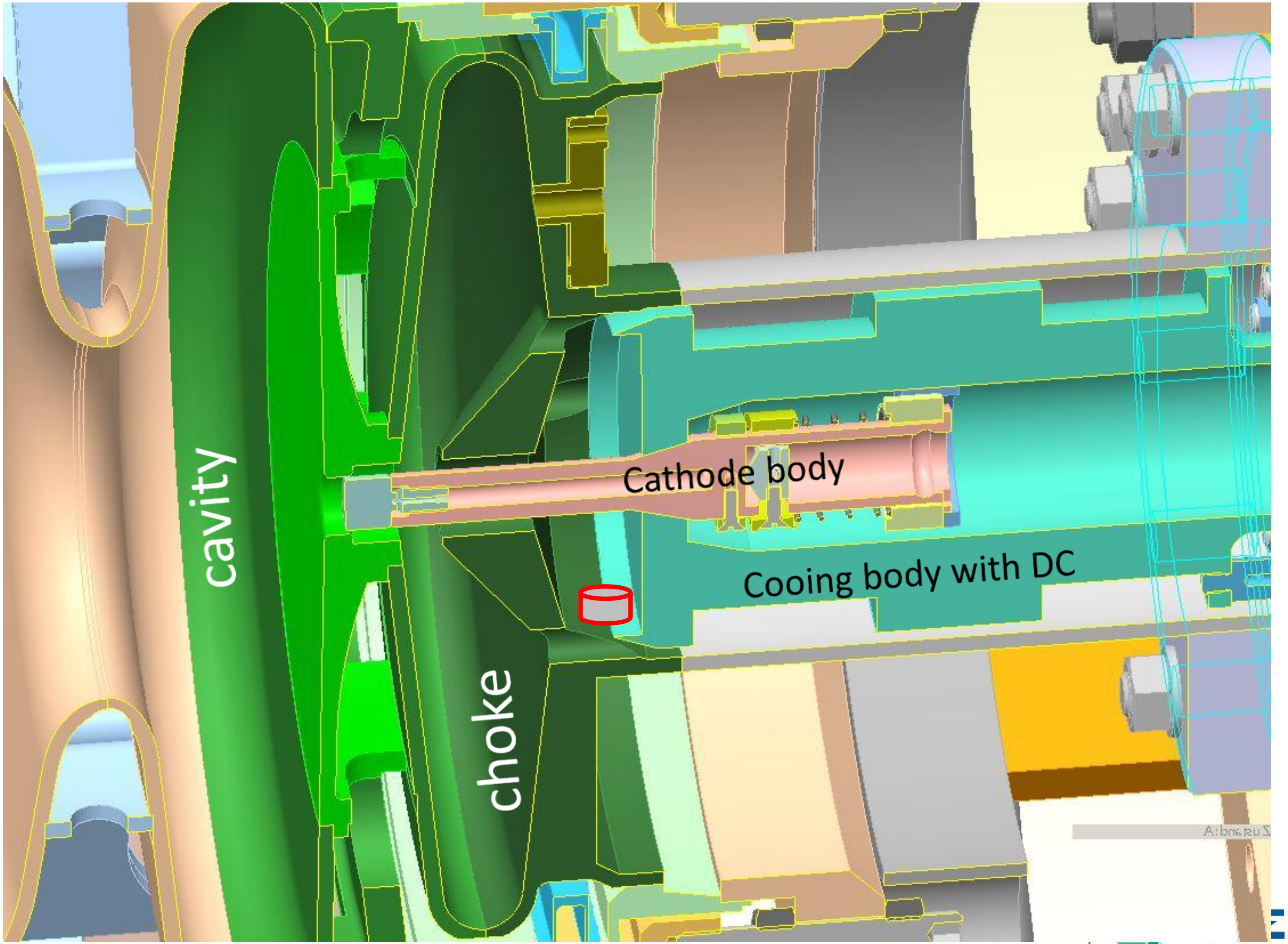
Δ T= 293K-77K

Thermal expansion ΔL/L (mm/mm)

Mo = - 87×10^{-5}
$CuBe_2$ = - 296×10^{-5}
SS316 = - 280×10^{-5}
Cu =- 330×10^{-5}
[http://cryogenics.nist.gov]

Ti = -185×10^{-5} [http://www.engineeringtoolbox.com]

cathode insert section



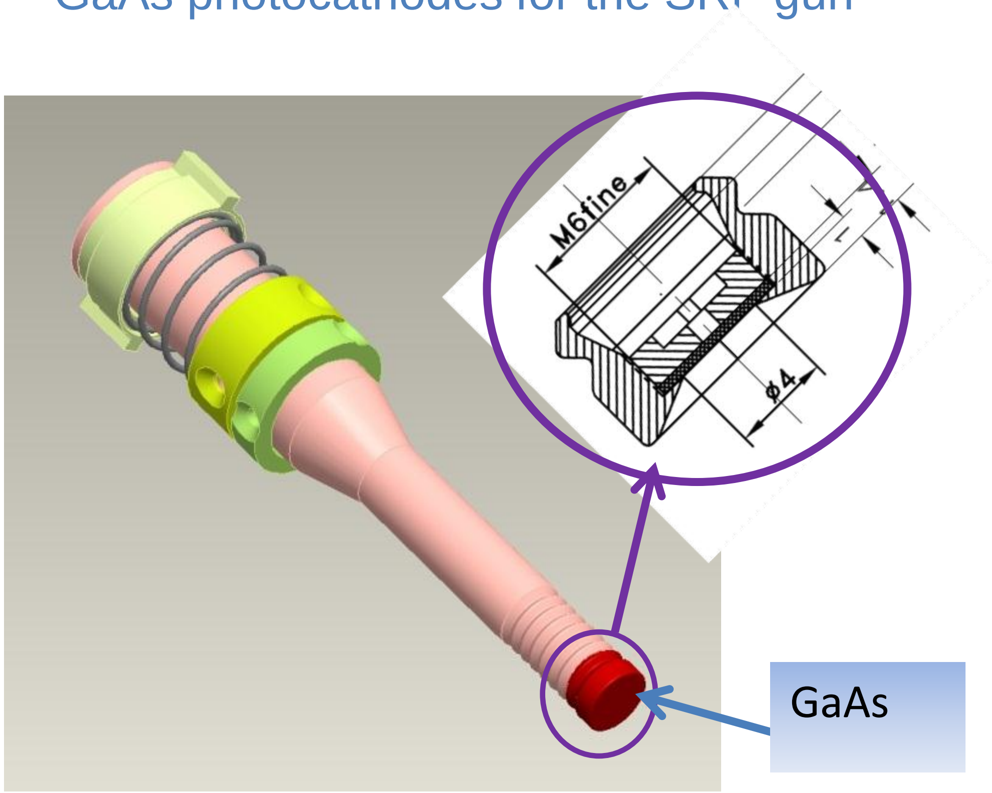
Rong Xiang I r.xiang@hzdr.de I www.hzdr.de

We need new ideas

- smaller plug→ RF properties?
- New plug with safety mechanism
- SS_screw → Titanium or Mo_plug→SS_plug
- Add indium in plug for better thermal contact
- ……

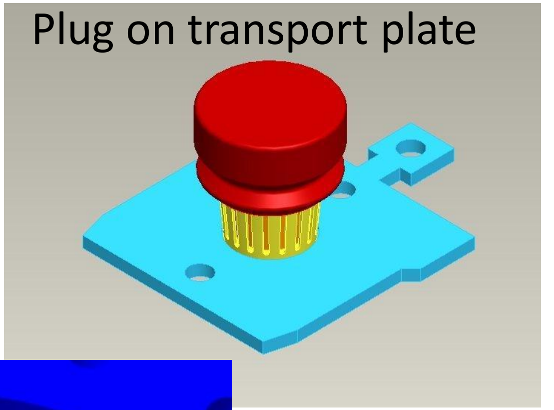
Rong Xiang I r.xiang@hzdr.de I www.hzdr.de

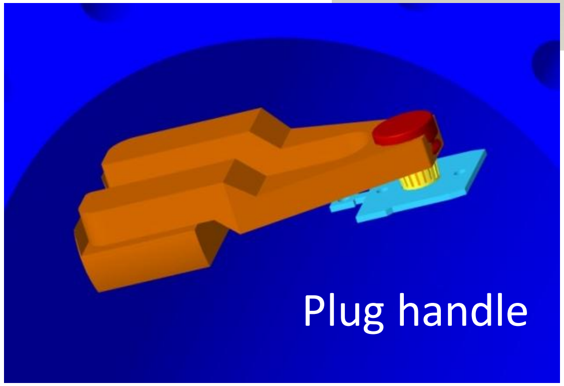
GaAs photocathodes for the SRF gun

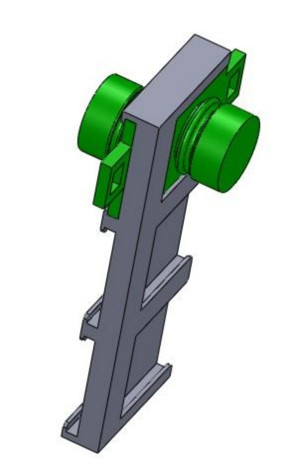


Cathode 106 mm long
plug ϕ10mm x 6mm (modified from HZB-plug)

- Easier for transport
- Easier for heat-cleaning







- Transport only small plugs
- HZB-carrier for storage and transport

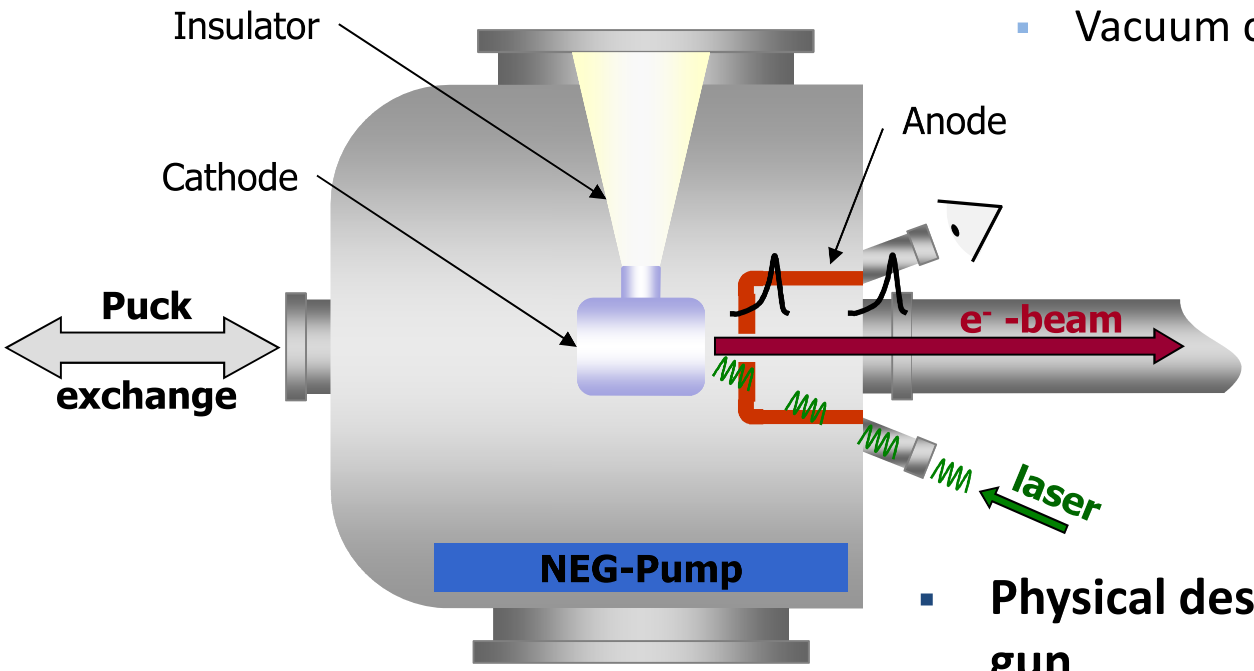
Time response measurements – Inverted gun

Status of the BMBF-Project | Mainz

Monika Dehn – 05.08.2013

Topics

- **High voltage for inverted gun**
  - Insulator
  - HV connector

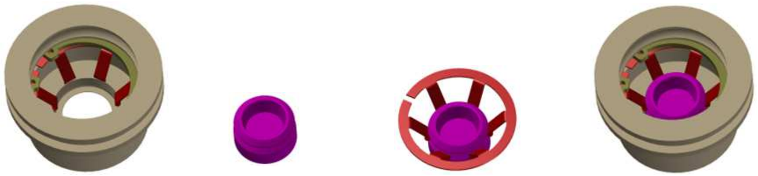


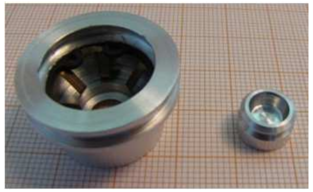
- **Mechanical construction of inverted gun**
  - Cathode manipulation
  - Laser beam path
  - Vacuum chamber

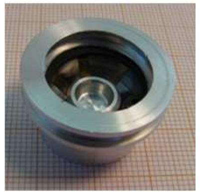
- **Physical design of inverted gun**
  - Cathode-anode design
  - Anode movement

Construction of inverted gun
Puck-adapter and manipulation

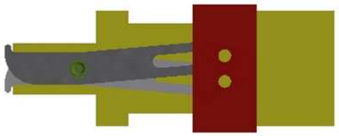
- **Adapter for different puck-Systems**
  - A spring inside KPH-puck is fixing the SRF-plug
  - A model is manufactured with easy fabricial materials
    - Puck: aluminium
    - Spring: bronze

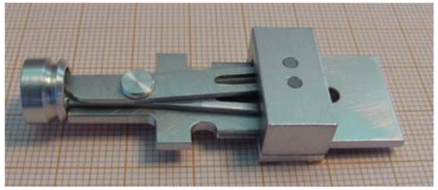


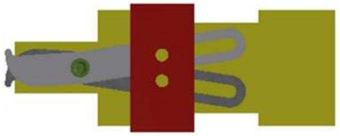




- **SRF-plug manipulation**
  - A grabber is picking up the SRF-plug from inside
  - A model is manufactured with easy materials
    - All elements: aluminium

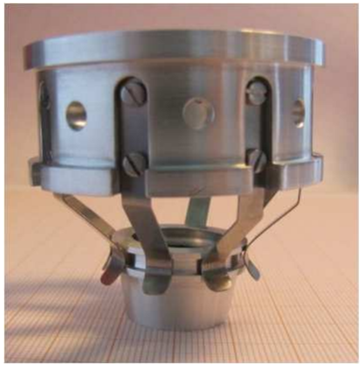






Construction of inverted gun
Model of cathode

Cathode:
Part of outer shape



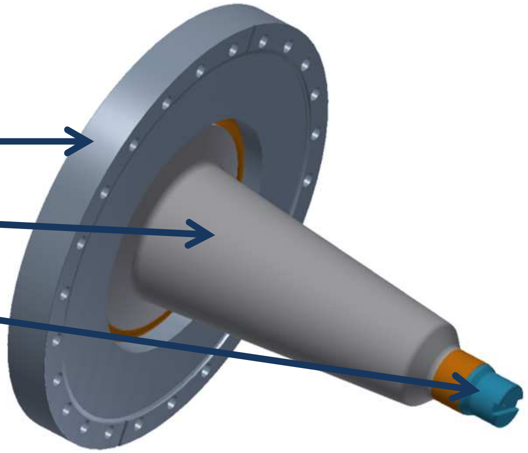
Puck assambling:
Puck is fixed by springs

Look inside:
Position of puck with photocathode

Spring:
Design will be modified again

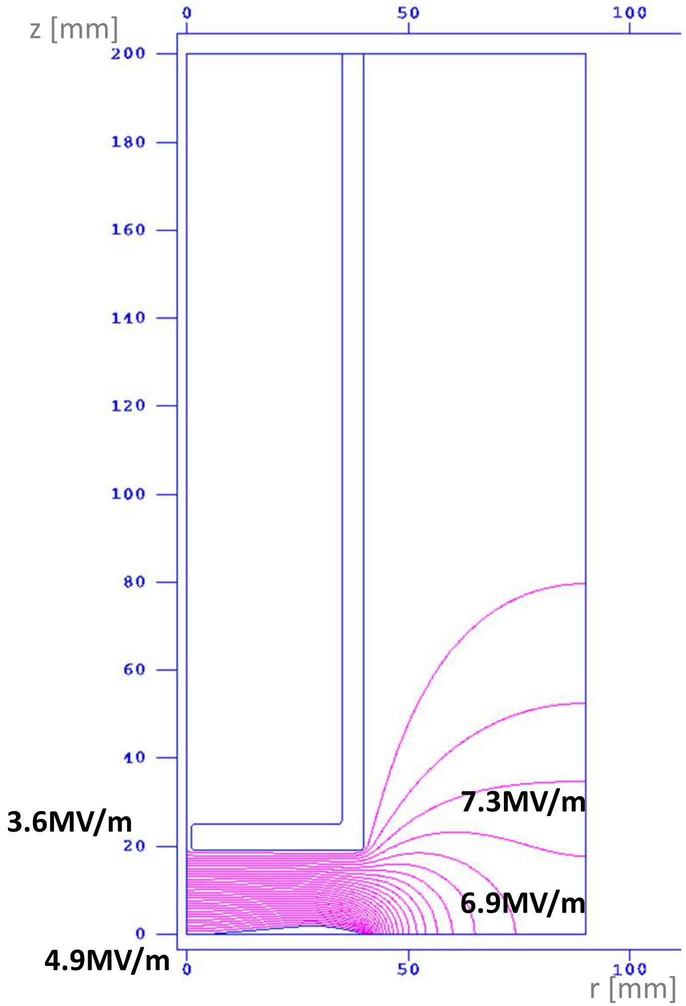
High voltage of inverted gun

- **Insulator**
  - CF-flange
  - Insulator: 99,7 FRIALIT (Al_2O_3)
  - Cathode connection: Mo



- **High voltage connector**
  - R30
  - U_{max} = 250kV

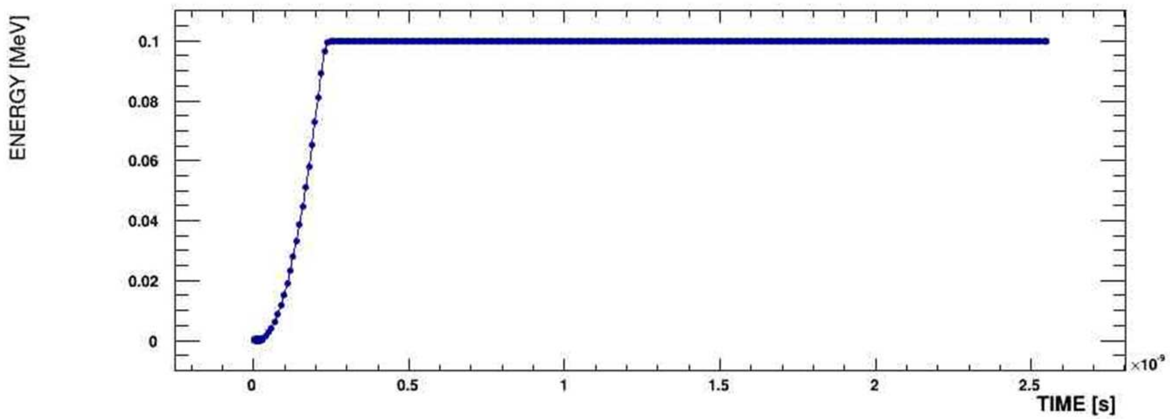
Physical design of inverted gun
Distance between cathode and anode: 20mm



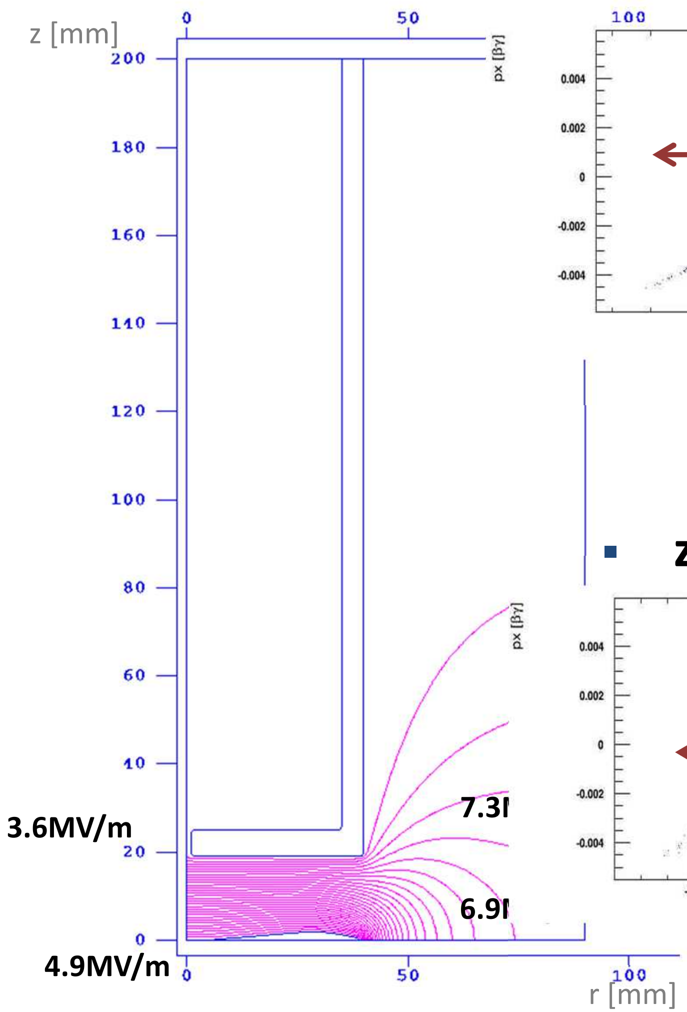
- **Particle tracking**
  - Beamsize of emission

    $\sigma_{emission}$ = 395µm
  - Time of emission

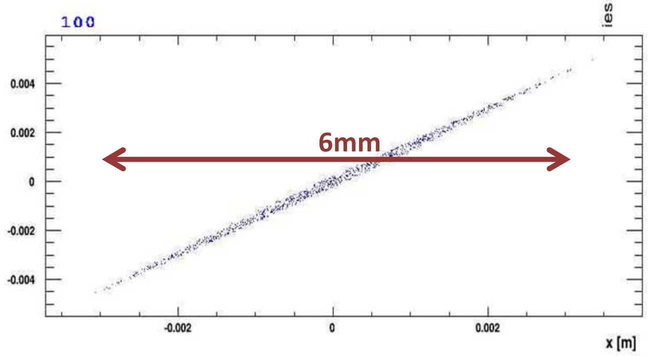
    t_{FWHM} = 10.4ps

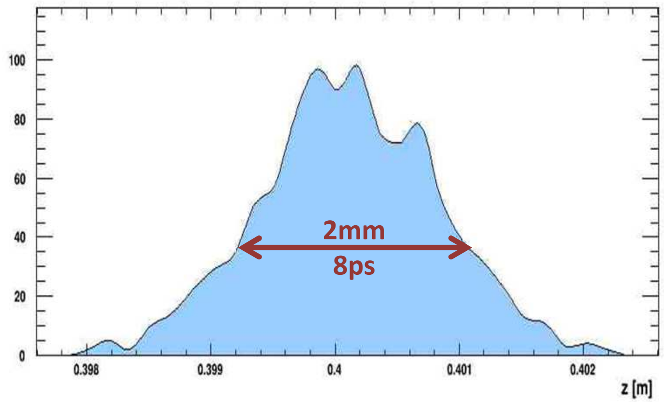


Physical design of inverted gun
Distance between cathode and anode: 20mm

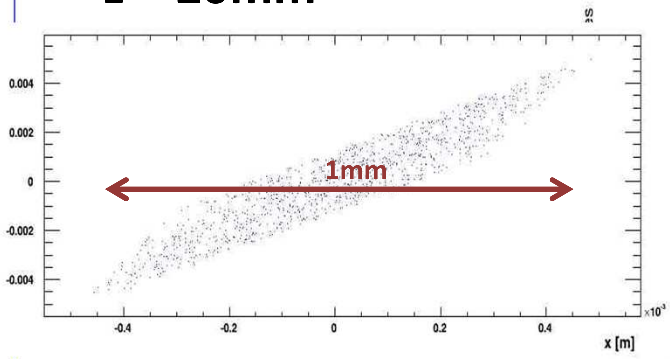


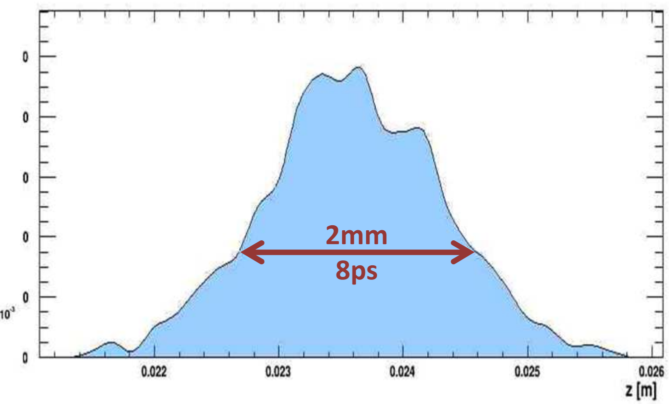
- **z = 400mm**



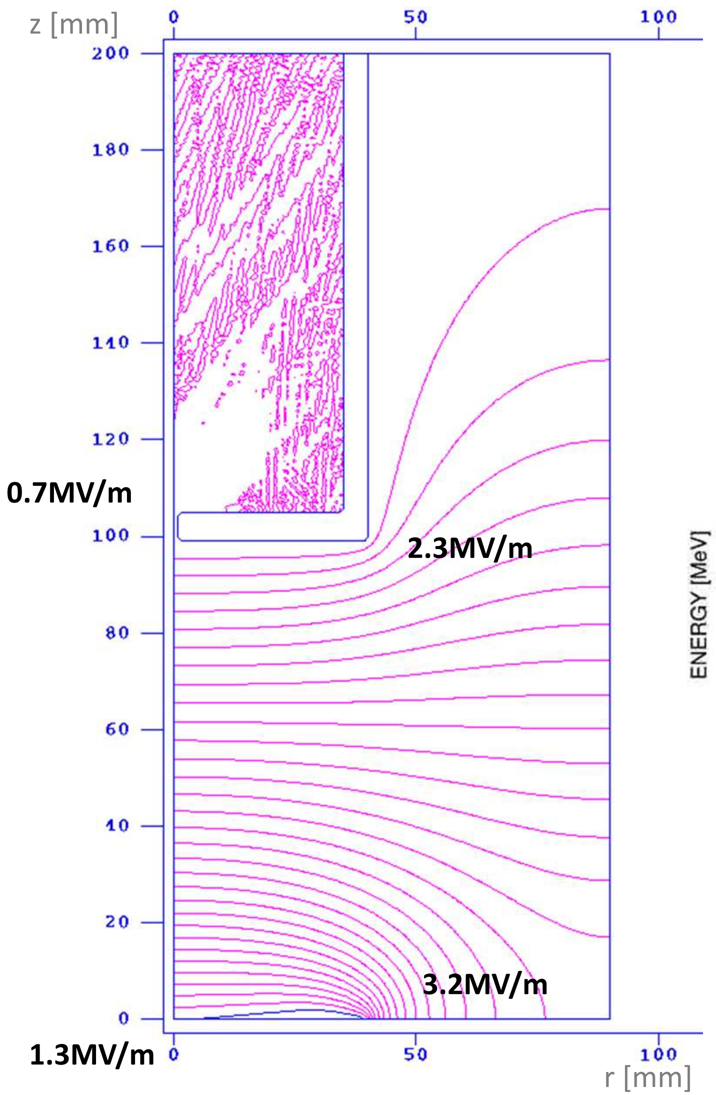


- **z = 20mm**





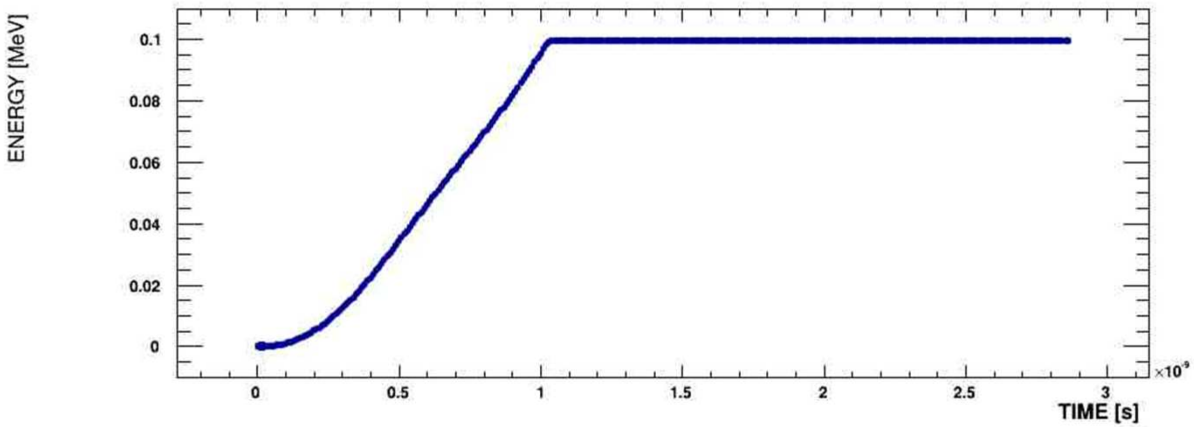
Physical design of inverted gun
Distance between cathode and anode: 100mm



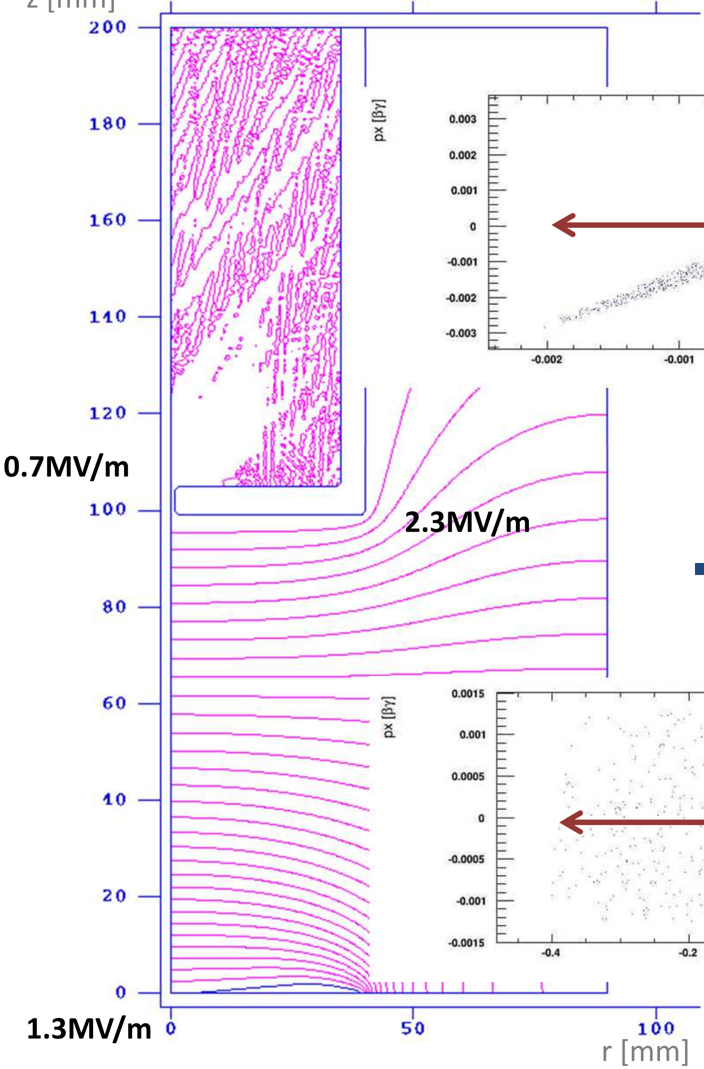
- **Particle tracking**
  - Beamsize of emission

    $\sigma_{emission}$ = 395µm
  - Time of emission

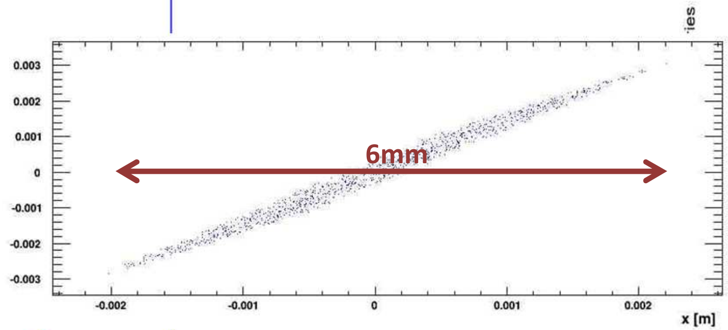
    t_{FWHM} = 10.4ps

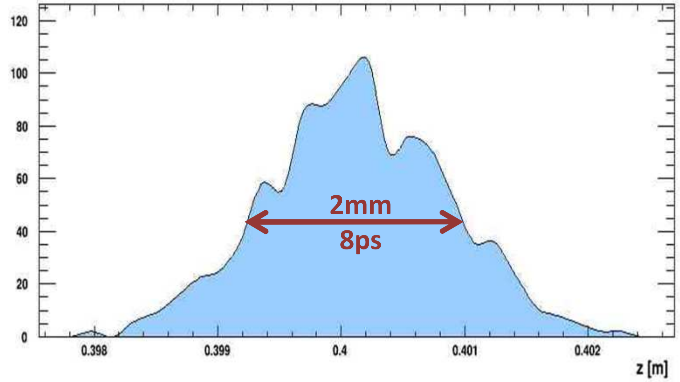


Physical design of inverted gun
Distance between cathode and anode: 100mm

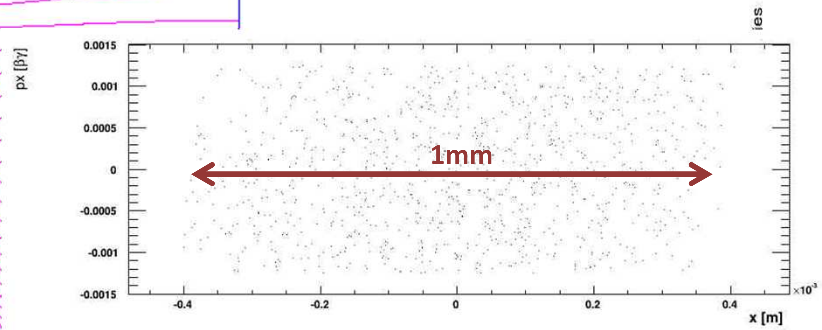


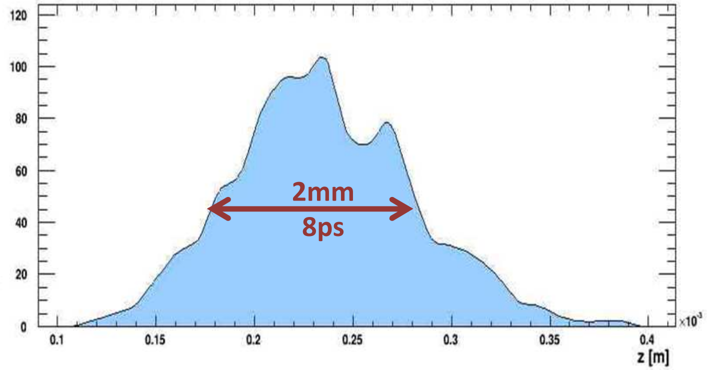
- **z = 400mm**

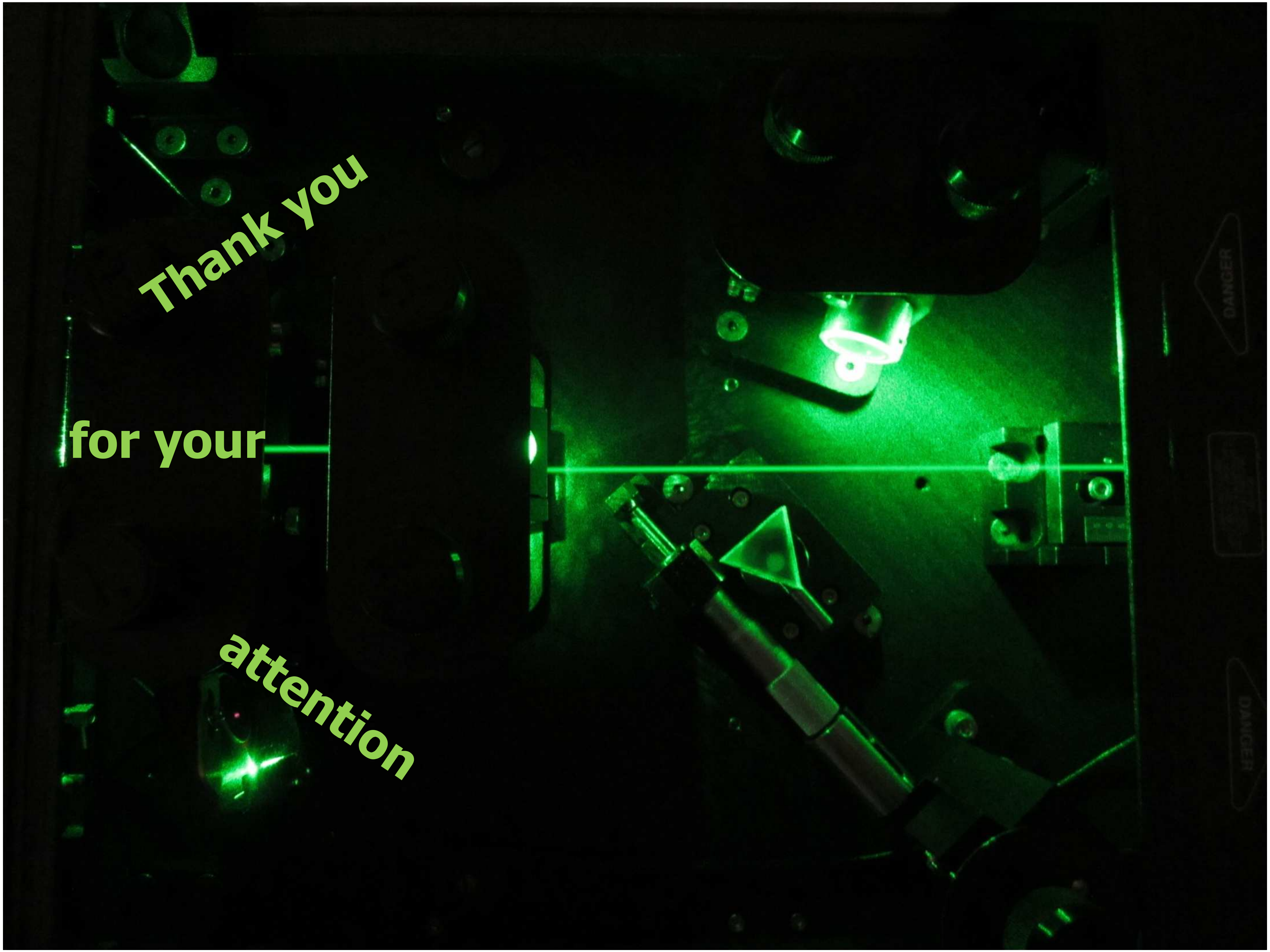




- **z = 100mm**






Thank you
for your
attention

Status diploma thesis: Time response measurement of GaAs and PCA (Potassium-Cesium-Antimonit)

Eike Kirsch – 05.08.2013
Johannes Gutenberg University Mainz

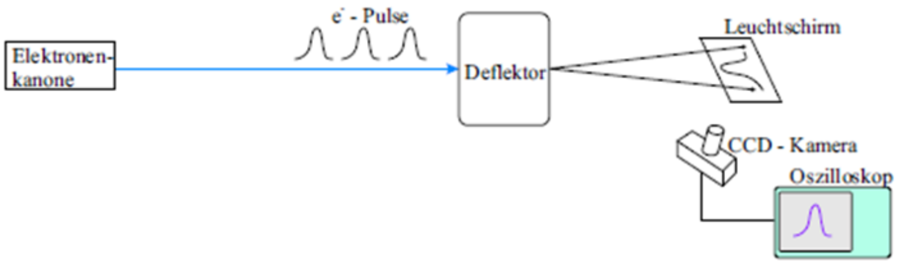
Outline

- **Motivation**
- **Experimental setup**
  - Laser
  - PKAT laboratory
  - Measurement
- **First results with bulk-GaAs**
  - Comparison of the time response @ λ = 400nm and λ = 800nm
  - Limitations for time response measurement
- **Outlook**

- **The energy distribution and the time structure have to be measured with high precision**
  - How long are the bunches?
  - Is a halo observable?

- **Time response measurement**
  - TM-110 deflector cavity transforms the longitudinal beam profile into a transversal beam profile
  - Electron bunches have to be synchronised to the RF
  - Transversal profile is observable as an intensity distribution on the luminescent screen

Schematic view:



Experimental setup
Laser

Verdi 10G
- Pump laser
- λ = 532nm
- P = 10W cw

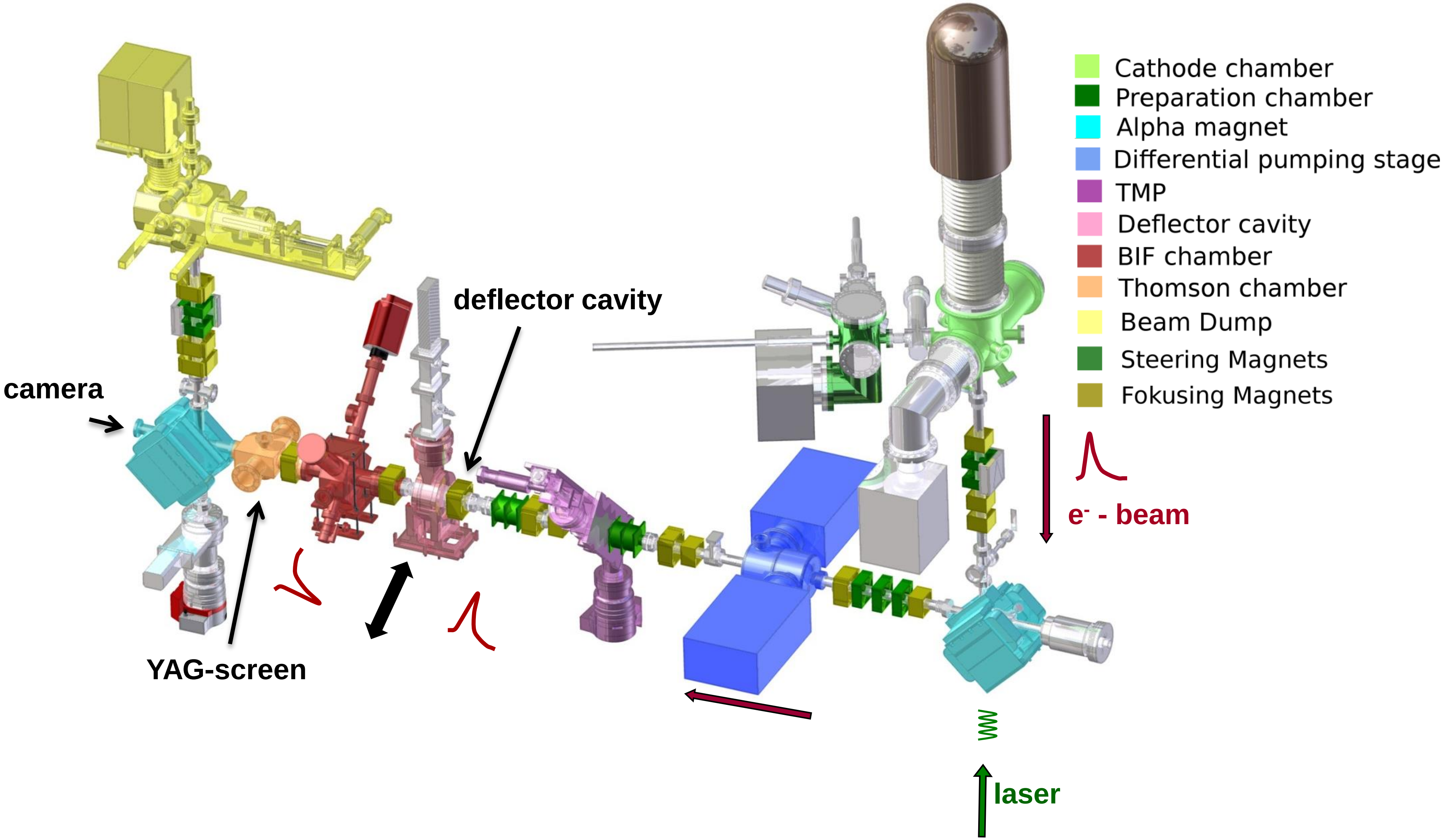
Modelocked Ti:Sapphire Laser (MIRA 900)
- Pulsed (~150fs) or cw
- λ = 755 – 890nm tuneable
- Repetition rate 76MHz
- P_{out} ~ 1,6W @ 800nm pulsed

SHG
- Since april 2013
- Frequency doubler
- λ = 400nm
- P_{out} ~ 500mW

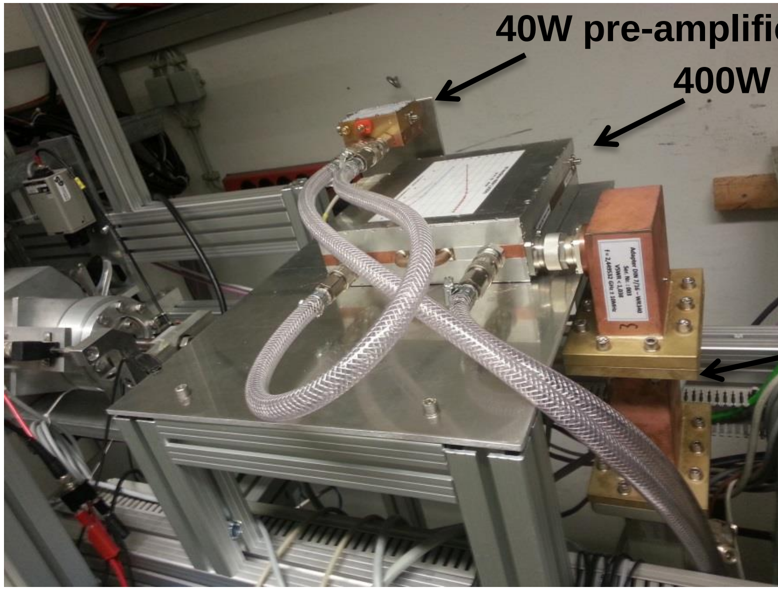
PKAT

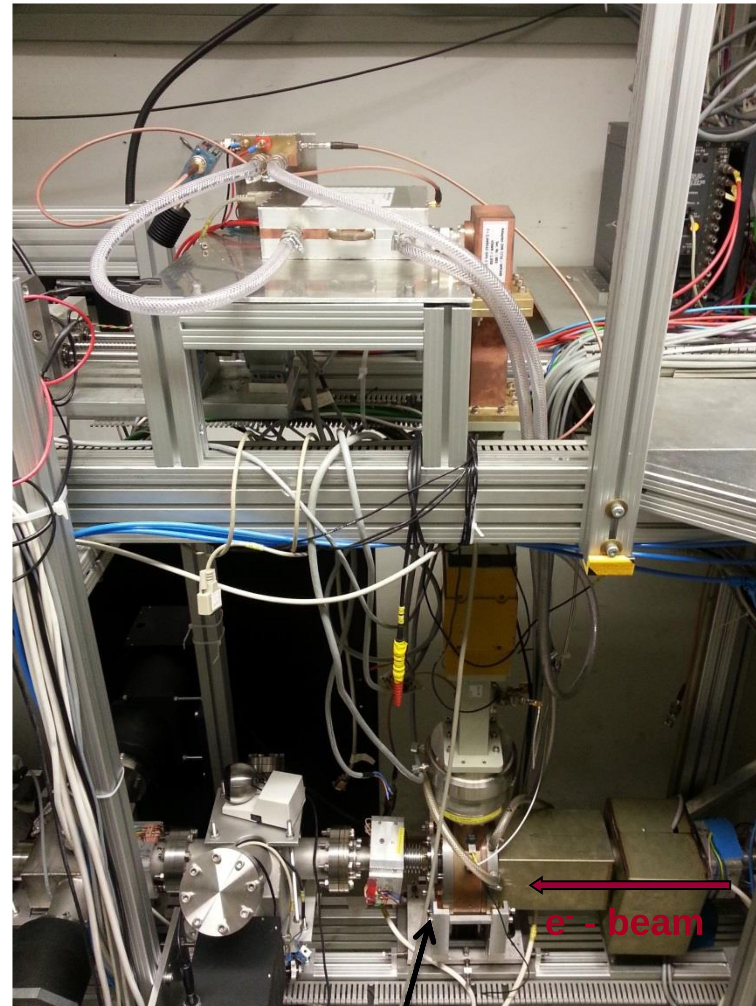
There is a possibility to bypass the SHG to measure at λ = 800nm

Experimental setup
PKAT



Experimental setup
Radio frequency

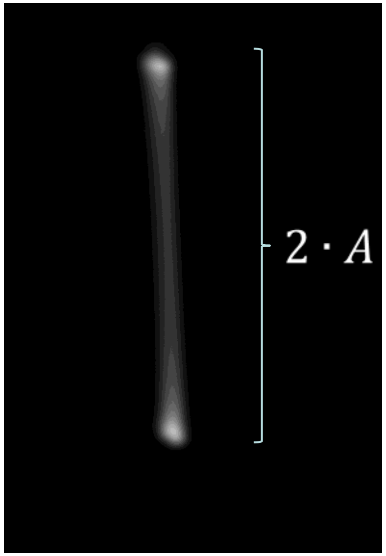




RF parameters:

- Semiconductor amplifier replaces old klystron (since april 2013)
- f = 2,45GHz (from MAMI Master)
- P_{out} = 400W (339W at the moment)
- Synchronisation with MIRA 900 laser via a phase detector

Measurement Calibration



Beam profile on the screen
@ P = 45W and λ = 400nm

RF and laser not synchronised

Position on the screen:

$$x(t) = A \cdot \sin(\underbrace{\varphi}_{\text{phase}}) = A \cdot \sin(\omega t)$$

$$\dot{x}(t) = \mathrm{A} \cdot \omega \cdot \underbrace{\cos(\omega t)}_{= 1\ @\ t=0}$$

$\mathrm{A} \sim \sqrt{P}$

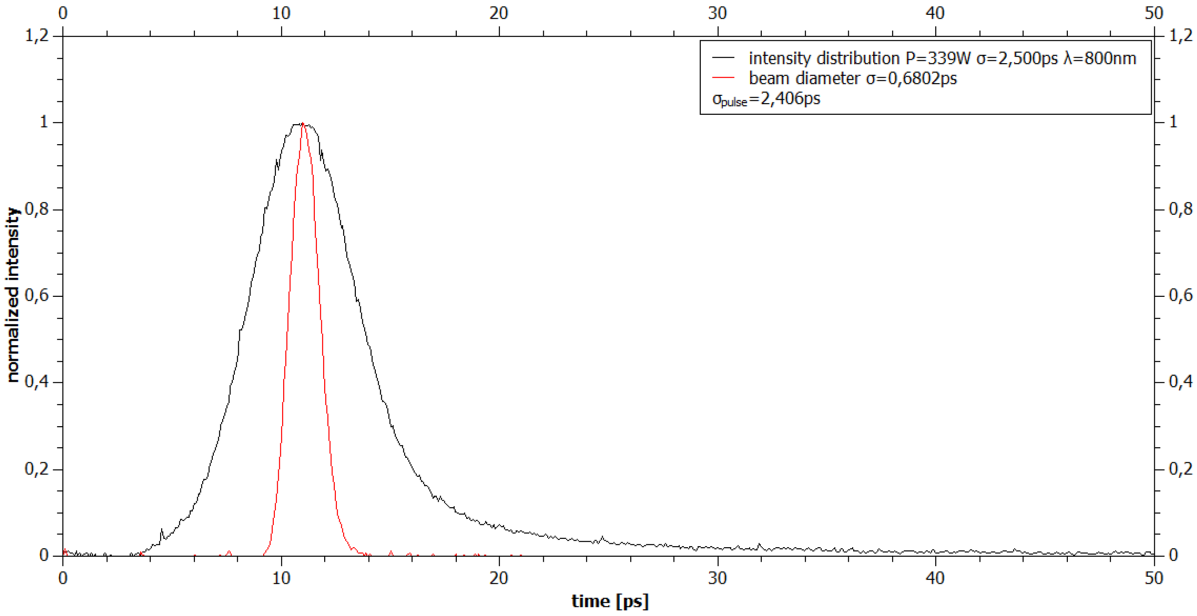
If A is measured, one can do a time <> distance calibration:

e.g. 1mm ≙ 6,6ps @ 45W
1mm ≙ 2,4ps @ 339W

First results with bulk-GaAs (I)

Beam profile on the screen
@ P = 339W and λ = 800nm

RF and Laser synchronised



Deconvolution formula (only for gaussian profiles):

$$\sigma_{distribution}{}^2 = \sigma_{pulse}{}^2 + \sigma_{diameter}{}^2$$

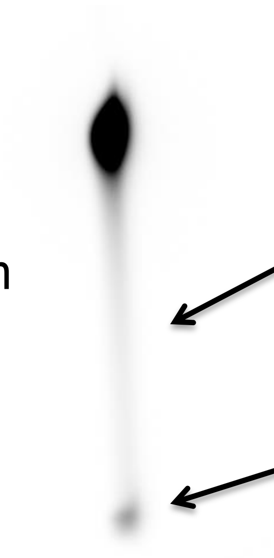
$$\sigma_{pulse} = \sqrt{\sigma_{distribution}{}^2 - \sigma_{diameter}{}^2}$$

time response

First results with bulk-GaAs (II)

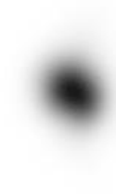
Comparison of the beam profiles (inverted) @ P=45W

λ = 800nm

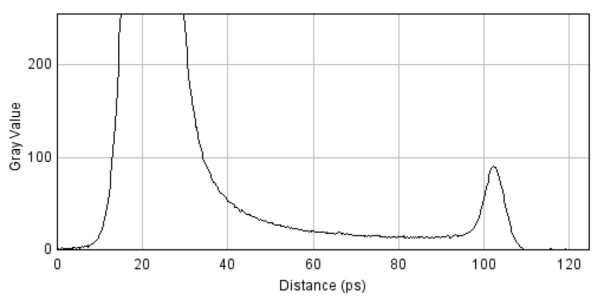


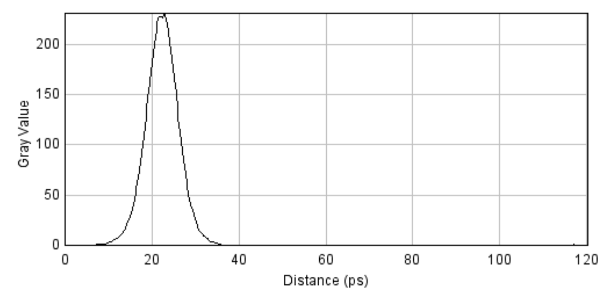
halo

reversal point of the RF deflection



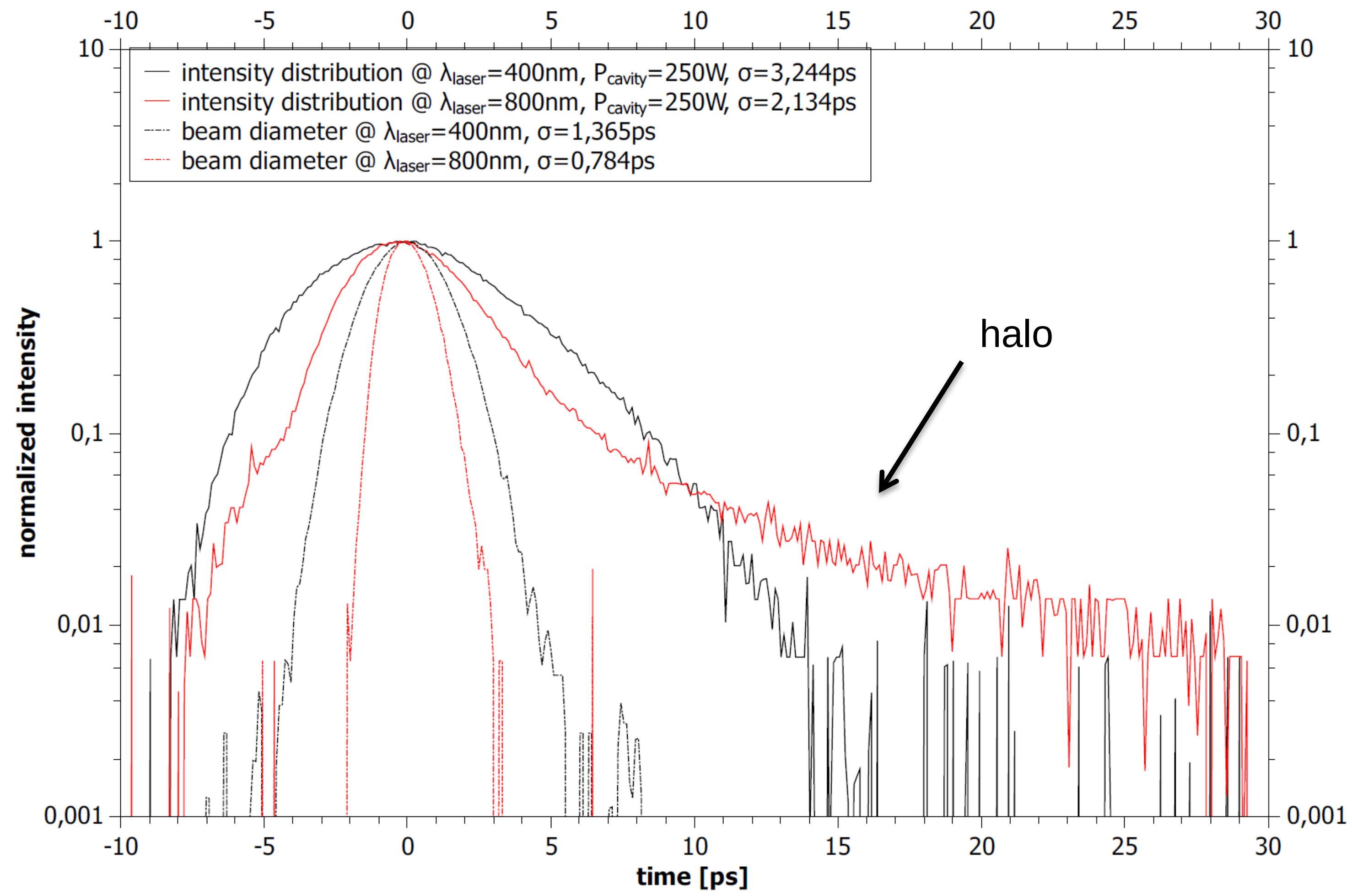
λ = 400nm





- Higher absorption coefficient @ 400nm

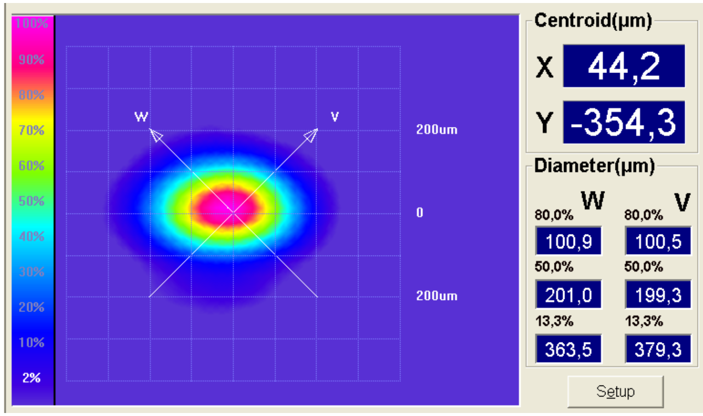
First results with bulk-GaAs (III)



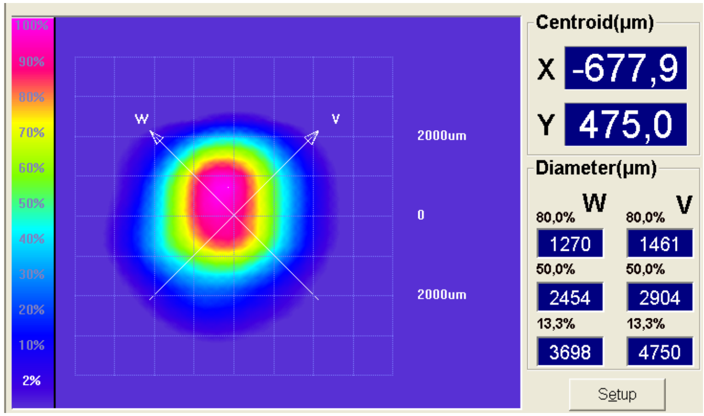
Limitations

- Transversal electron beam diameter (big influence)
- Laserspot seize
- Scatter effects in the fluorescent screen
- Resolution of the camera and pixelsize (z.Z.1 Megapixel)
- Resolution of the objective
- Wavelength (emittance-growth as a function of wavelength)

Laserspot measurement



Laserspot diameter @ λ = 800nm measured by a knife-edge-profiler



Laserspot diameter @ λ = 400nm measured by a knife-edge-profiler

$$\sqrt{d_{laserspot}} \sim d_{electron\ beam}$$

Reducing the transversal electron beam diameter means to reduce the laserspot diameter on the photocathode.

Outlook

- Installation of a 100 μm slit and a channeltron as an alternative measurement method (better resolution)
- Measurements with PCA (K_2SbCs) photocathodes
- Reduction of the laserspot diameter on the photocathode

channeltron

Thank you for your attention!