Minutes of the PCHB Meeting 13.10.2014 at JGU
Memo: Victor Bechthold, 14.10.2014
Comments: TK, MAHS, 17.10.2014

Topics

Status reports from HZDR, HZB, JGU and MSU.

Attendance

JGU: Kurt Aulenbacher , Victor Bechthold, Valery Tyukin, Igor Alexander, Simon Friederich
HZB: Roman Barday, Martin Schmeißer, Thorsten Kamps
HZDR: Jochen Teichert, Rong Xiang
MSU: Ivan Vladimirov

Agenda

See distributed agenda & slides

Discussions

Status of photocathode R&D in Dresden (presentation by Jochen and Rong):

- Explanations for the crated landscape on the Cs2Te photocathode so far not clear.
- Rong did ex-situ SEM measurements and is on the waiting list for EDX measurements.
- The use of a halogen lamp with glass bulb filled with noble gas as heater in the preparation system may be risky due to the gas volume inside the bulb. Another issue is the actual temperature which can be reached on the substrate.
- New prep system for GaAs will be setup and stay next to the SRF gun.
- Concerning the transfer system at HZDR: Is the current pump distribution with 4 x 750l necessary?

Concerning the prep/analysis and transfer systems at HZB (presentation by Martin)

- Who produces good magnetic manipulators? Mixed experience at the labs with produces from Lesker and VG Scienta.
- HZB and HZDR both want an additional view window for the insertion load lock.
- The insertion load lock can be taken off. New samples are placed in the insertion load lock in a clean room, there is no need to vent the suitcase or insert samples in a dusty lab.
- HZB will not have the custom NEG pump on the transfer system, due to space (height) constraints. HZB's vertical manipulator will be shorter.

On the spectrometer design (presentation by Ivan)

- Resolution of the spectrometer system is 0.1% at 1 MeV.

Regarding field emission measurements (presentation by Roman):

- The vacuum conditions in the FE setup are excellent, and all without baking. Setup of the system under clean conditions proved to be useful.

- Performance is limited by local vacuum pressure in the gap between cathode film and viewscreen.
- The functionality of the setup is discussed to be moved to the activation-chamber or transfer koffer of the K2CsSb apparatus. Vacuum conditions and particulates in the respective chambers could be an issue.

Regarding K2CsSb apparatus at JGU (presentation by Victor):

- Possible improvements have been collected and discussed and will be carried out

Organizational discussions

Next and closing meeting will be held May 2015 in Moscow, organized by MSU. We thank Vasiliy and Ivan for the proposal.

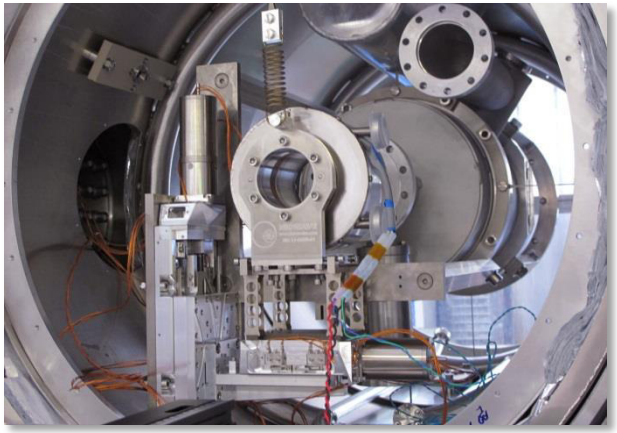
PCHB Collaboration Meeting

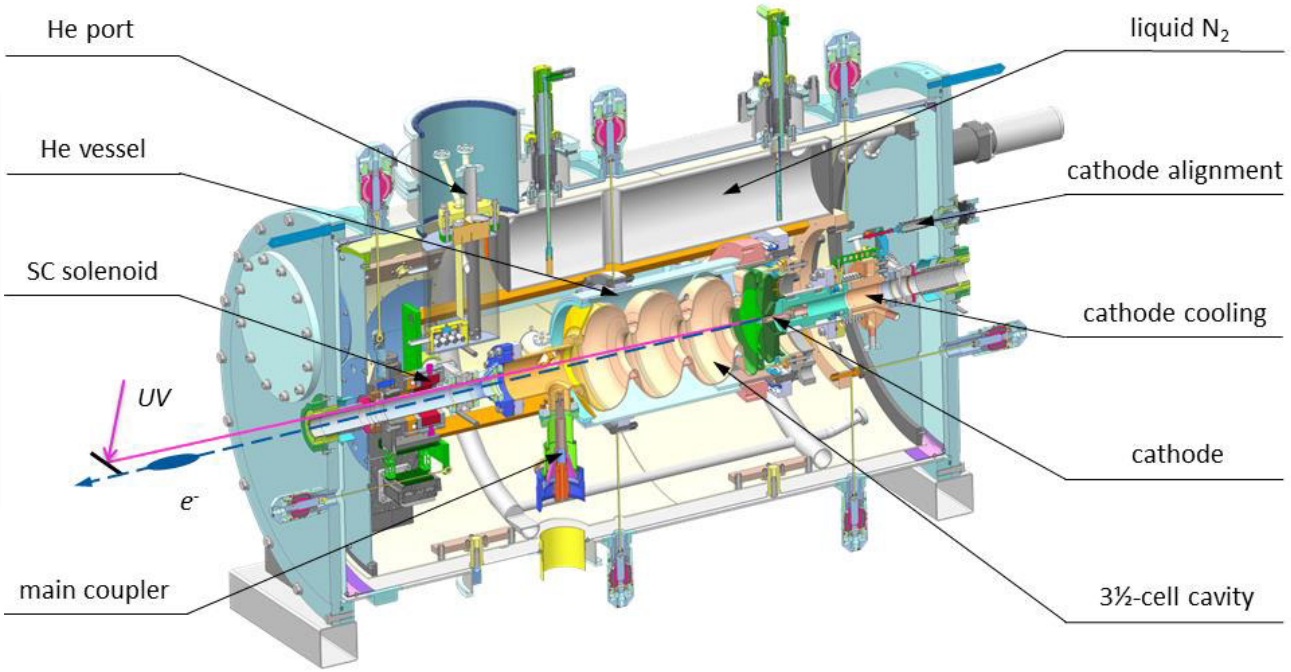
J. Teichert for the HZDR SRF Gun Group

Mainz 13.10.2014

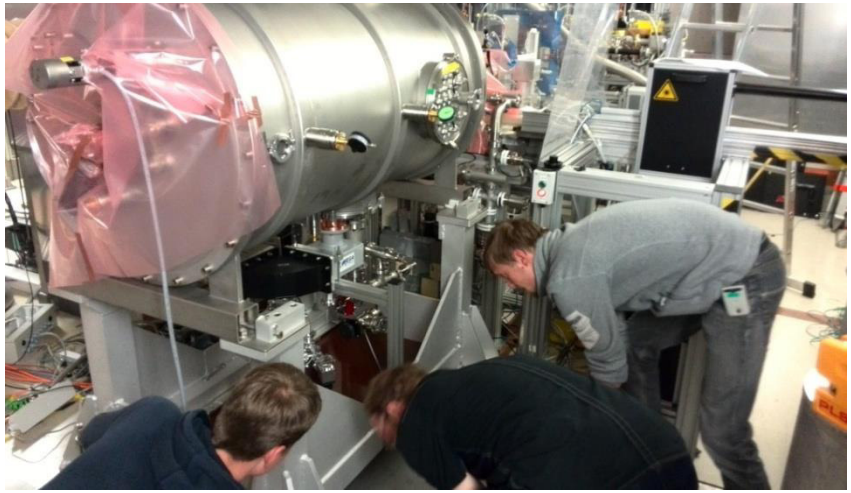
Overview

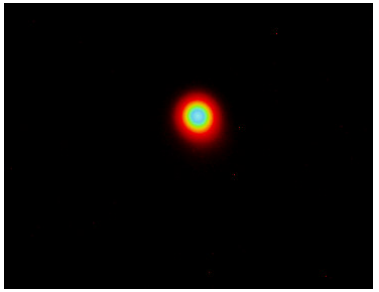
- Commissioning of SRF Gun II
- “Old” Cathode Transfer System & Cs_2Te PC
- “New” Transfer System & GaAs see Rong´s talk
- Prelimary Results
- Outlook





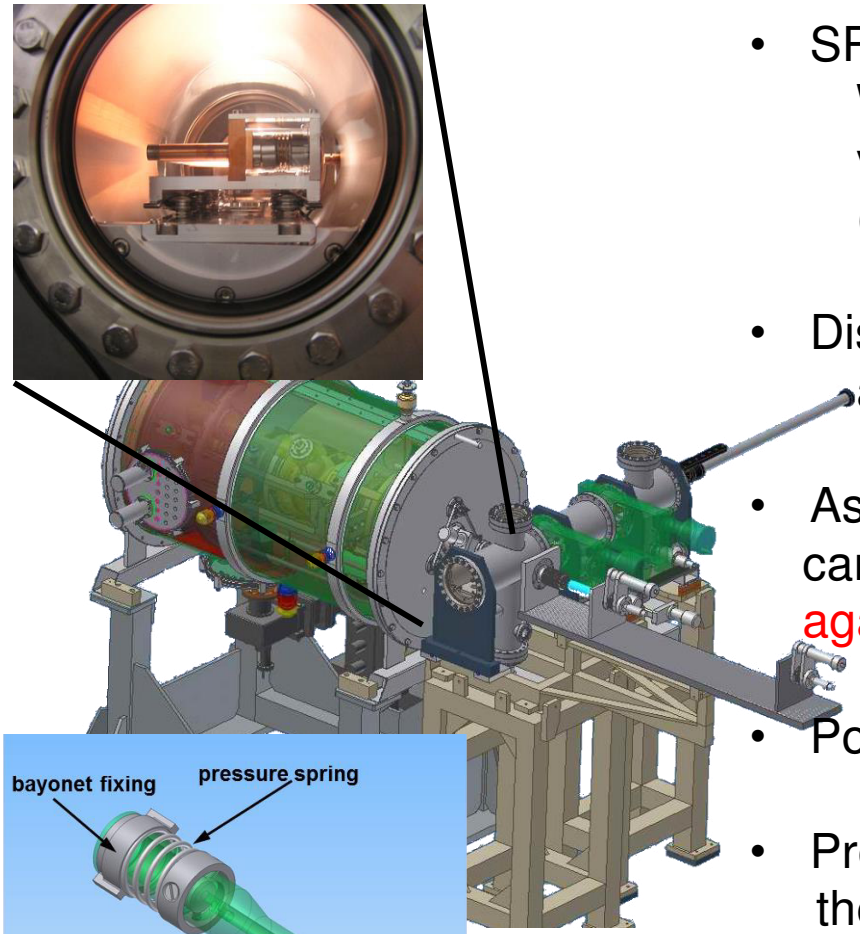
- New cavity - fine grain Nb, produced, treated and tested at Jlab
- New cryomodule – 10 cm longer, fabricated and assembled at HZDR
- Integration of a superconducting solenoid (NbTi wire) on a x-y table with cold motors (70 K)





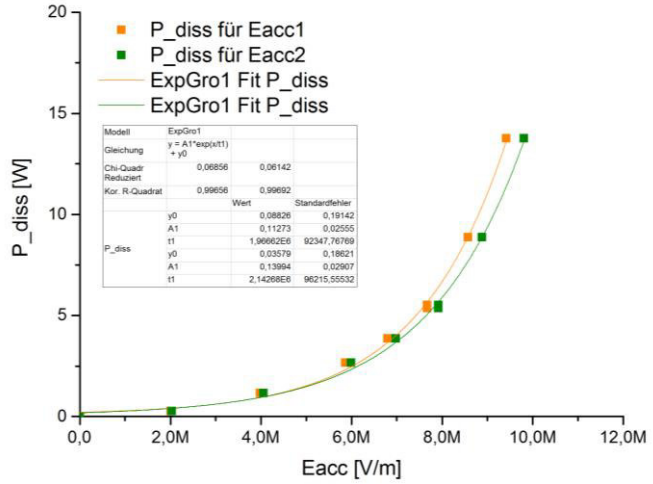
- Gun installation finished on May 16, 2014
  without PC transfer system
- First beam with Gun II on June 10, 2014
  with Cu photo cathode
- First beam in ELBE on August 12, 2014
  20 nA CW
- Installation of PC transfer system postponed to Jan. 2015
- Beam with Cs_2Te PC will start in Feb. 2015

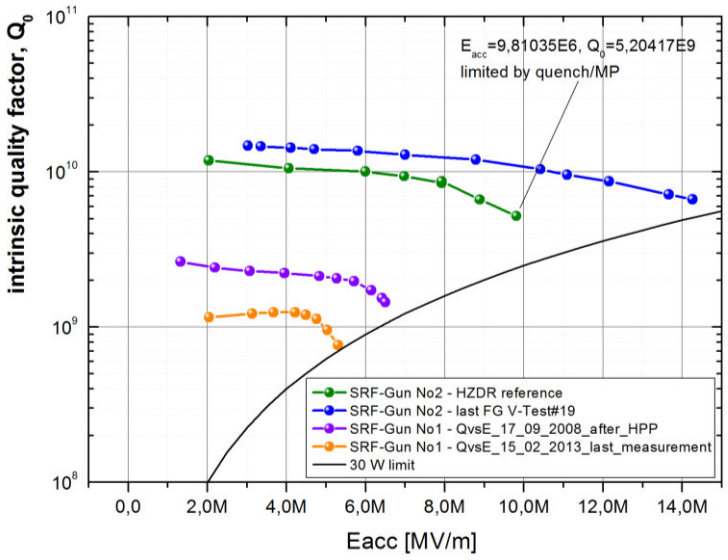
Cs_2Te Cathode Transfer System



- SRF gun I:
  We found (turbo pump?) oil in transfer system vacuum leak in one DN160 full metal valve (to valve housing if valve closed)
- Disassembly and cleaning of all components at companies VACOM, VAT, DREEBIT
- Assembly with new pumps, alignment of PC carrier, vacuum check, backing
  again oil in the vacuum chambers!
- Postpone installation from Oct. 14 to Jan. 15
- Presently, part by part check in order to find the oil source (perhaps the again leaking full metal valve?)

RF – Measurements





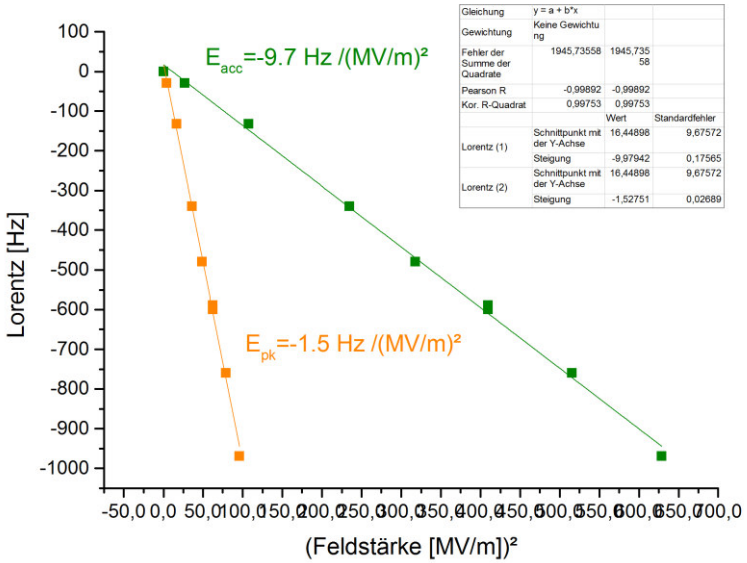
Q_0 still > 10^{10} in gun
much less field emission
two time higher gradient
than SRF Gun I

present results
peak fields
vertical test: 38 MV/m
gun pulsed: 32 MV/m
gun CW: 27 MV/m

(corresponds to E_{acc}= 10 MV/m)

RF – Measurements

Lorentz Force Detuning

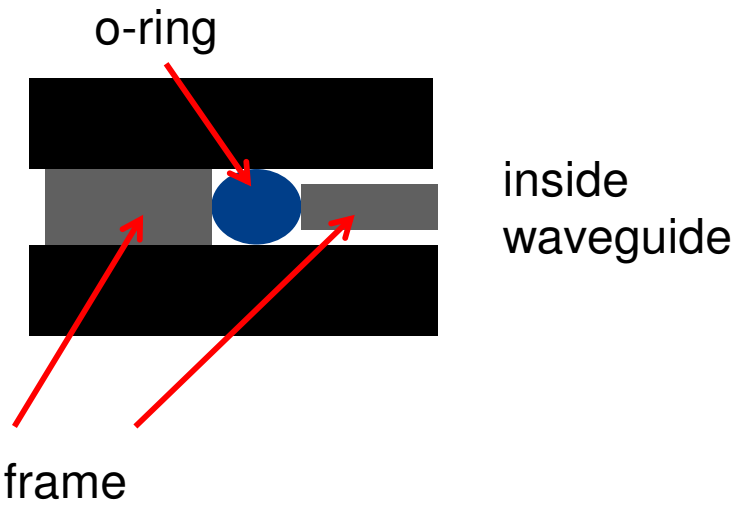


$$\Delta f = -k_{peak} E_{peak}^2$$

comparison with	SRF gun I	TESLA cavity
k_{peak} [Hz/(MV/m)²]	0.69	0.25

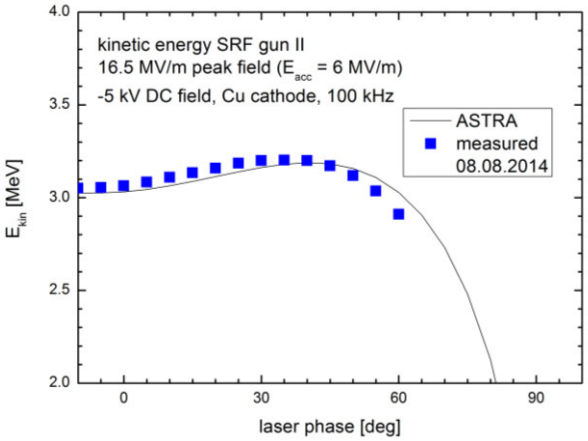
Coupler Warm Window Temperature

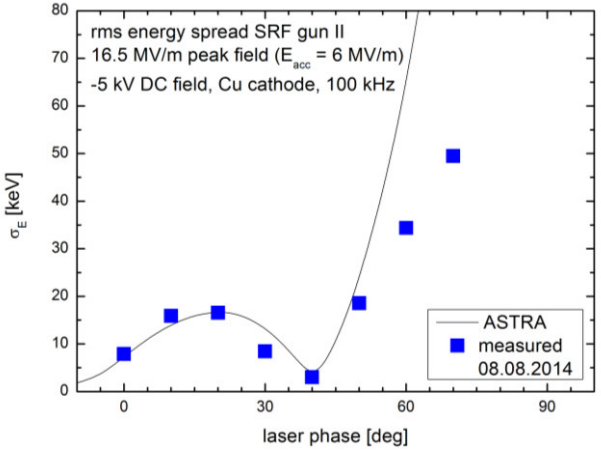
- higher than in ELBE modules
- new window didn´t help
- coupler test bench:
  foulty o-ring frame

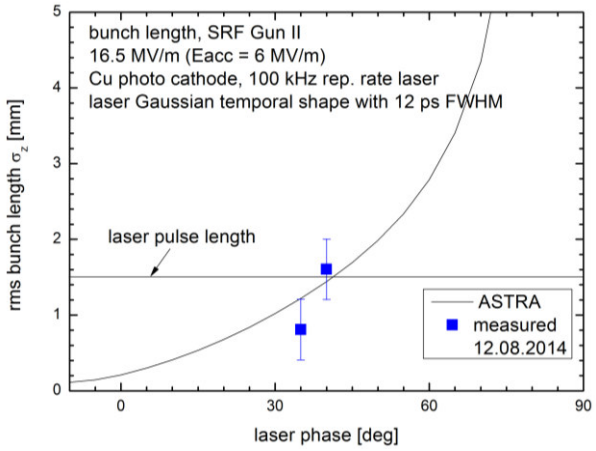


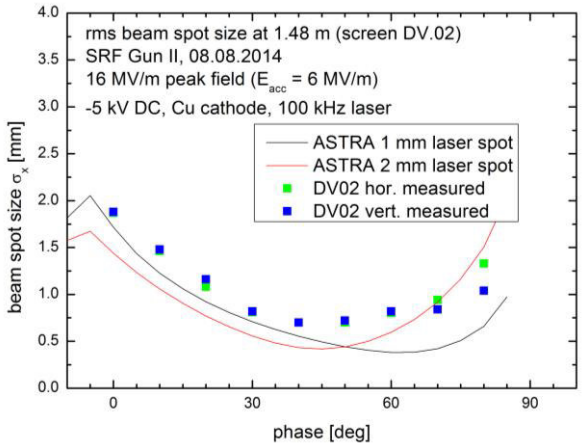
Beam Characterization

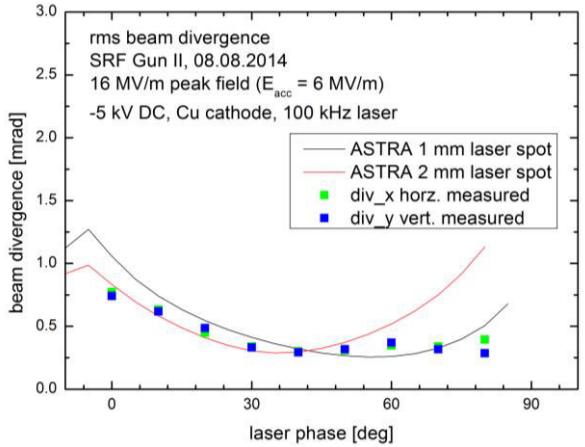
E_{acc}= 6 MV/m (16 MV/m peak), cathode position z_{cath} = -2.1 mm

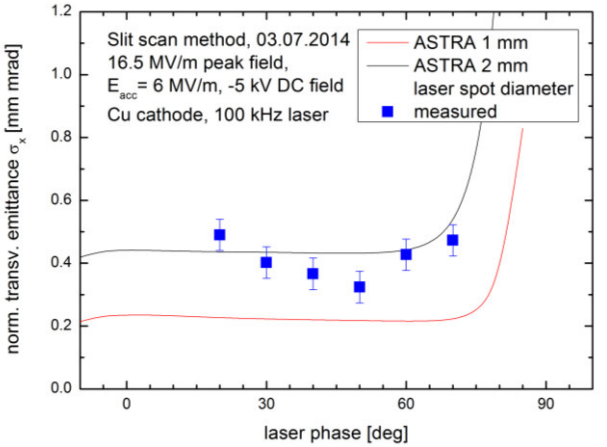






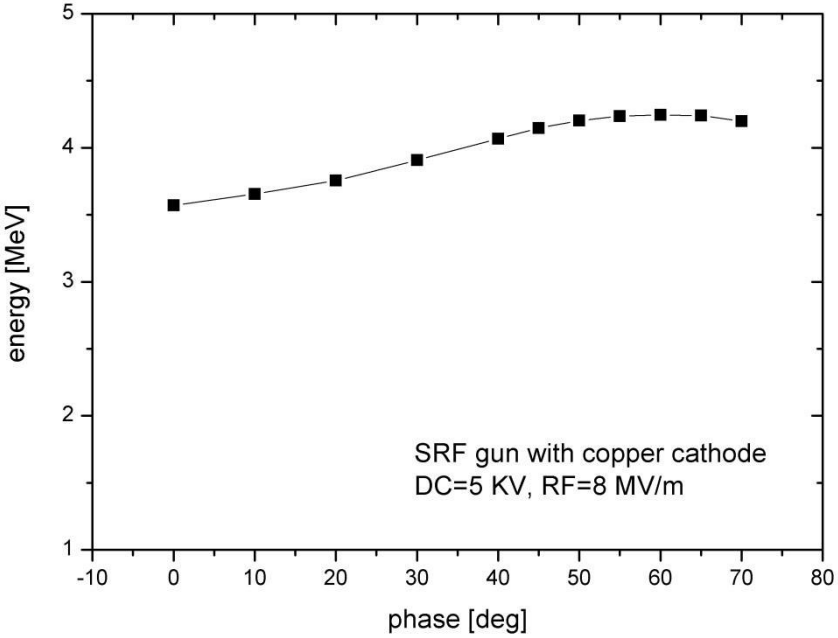


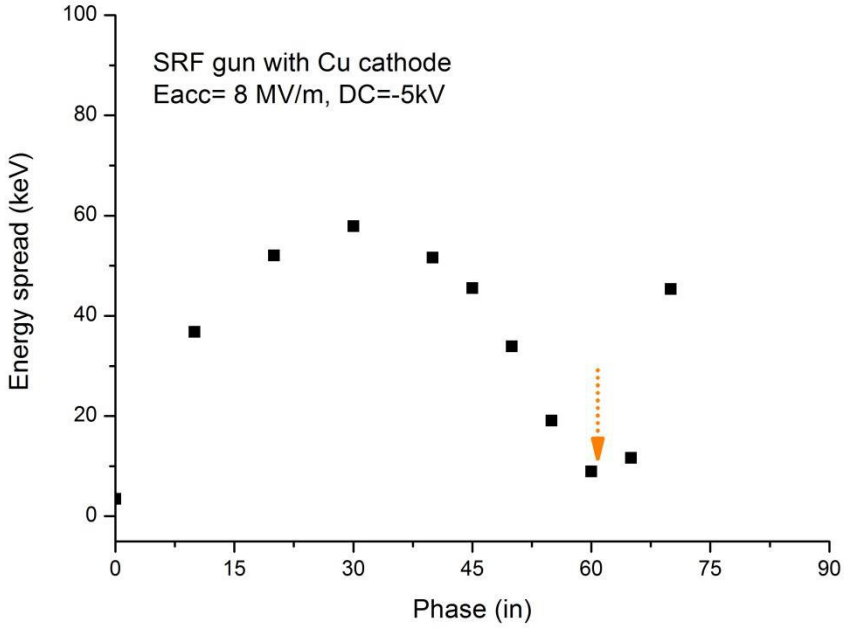




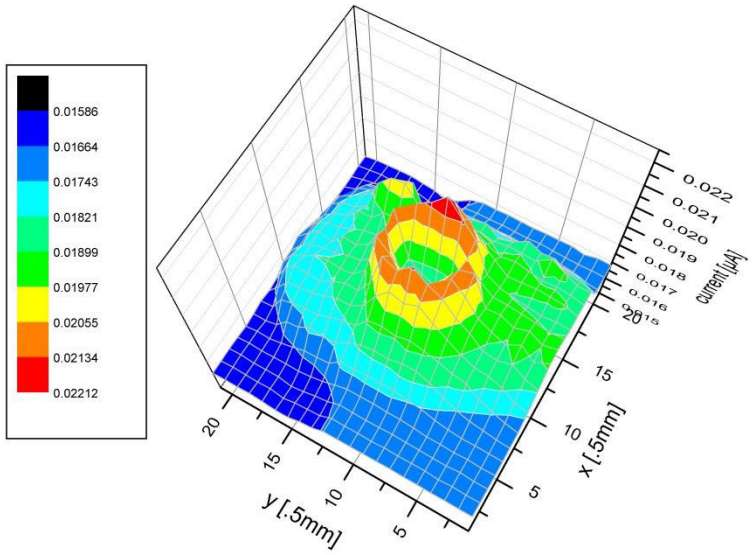
Beam Characterization

E_{acc}= 8 MV/m (21.6 MV/m peak) cathode position z_{cath} = -2.1 mm

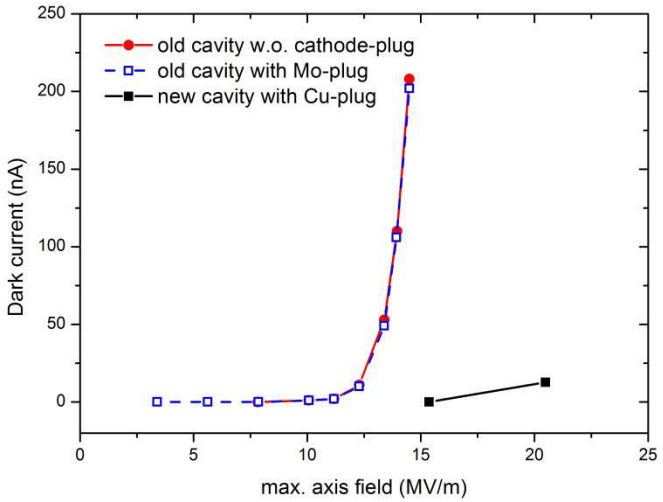




Cu Cathode Properties & Dark Current

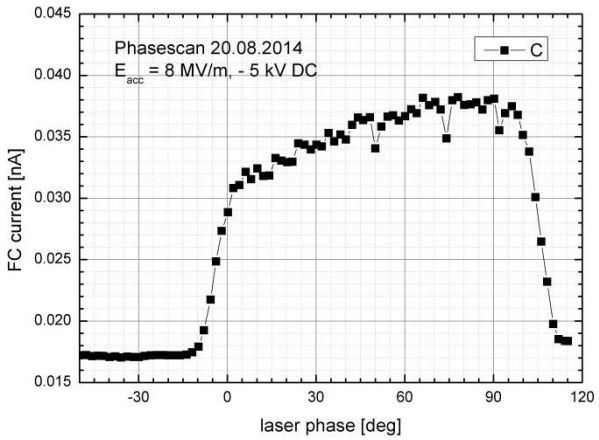


cathode scan (26.08.2014)

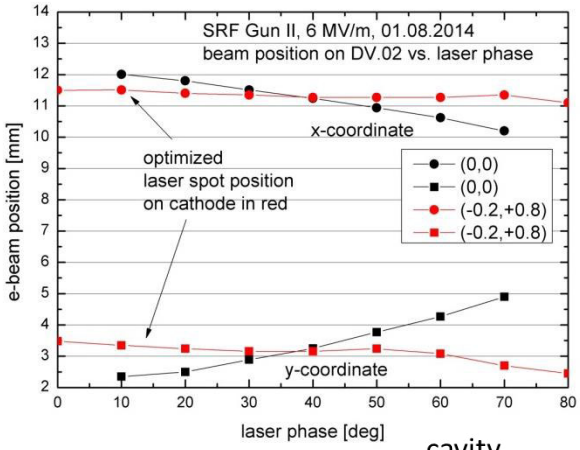


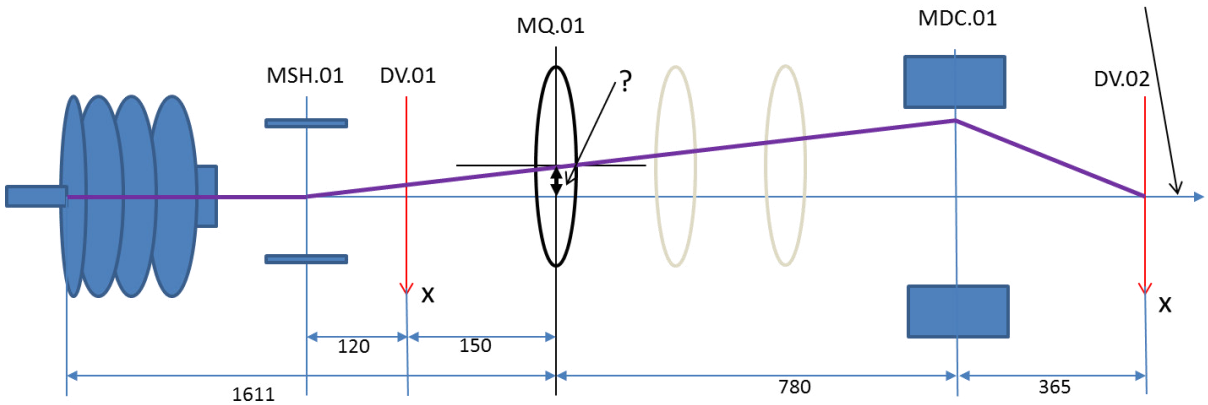
Beam Based Alignment

laser phase scan



laser spot positioning





misalignment between „electric“ cavity axis and beamline

*) defined by phase scan alignment

Elbe run 4/2014 Oct. – Dec. 2014

- Beam measurements with Cu cathode at 8 MV/m + 10 MV/m
- Solving the PC transfer system problem
- Preparation of Cs_2Te PC

Shut-down Dec. 2014 – Jan. 2015

- Instalation of the PC transfer system
- Coupler repair

Elbe run 1/2015 Jan. – April. 2015

- Beam with Cs_2Te cathodes at 8 MV/m + 10 MV/m
- Demonstration of avarage current of 1mA in CW
- Proposal for ELBE beamtime (Accelerator Science)

PCHB Collaboration Meeting

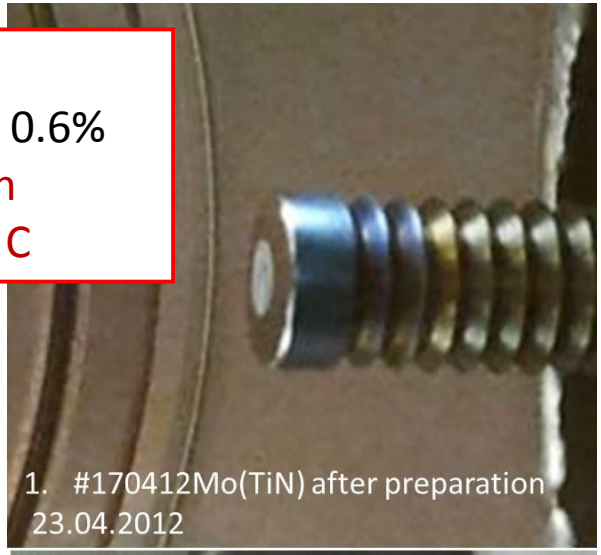
Photocathode at HZDR

R. Xiang in name of SRF gun group

13.10.2014

Cs_2Te photocathodes

170412Mo
- fresh QE 8.5%, in gun 0.6%
- total beam time 600 h
- extracted charge 265 C

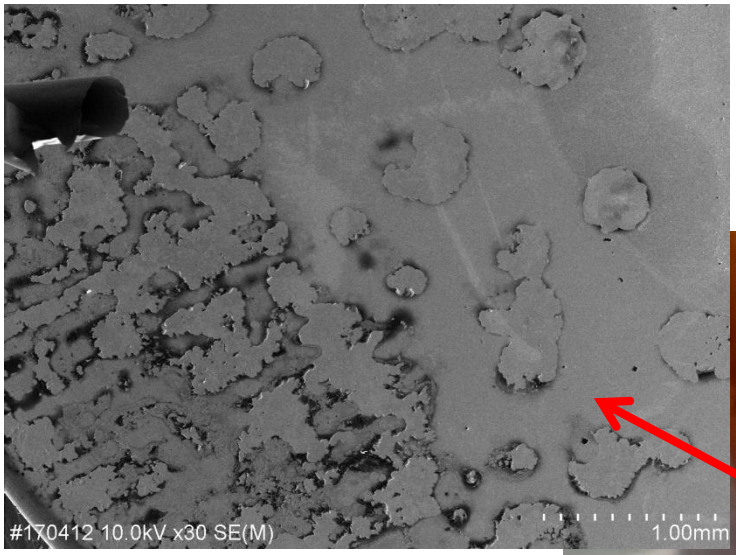

1. #170412Mo(TiN) after preparation 23.04.2012

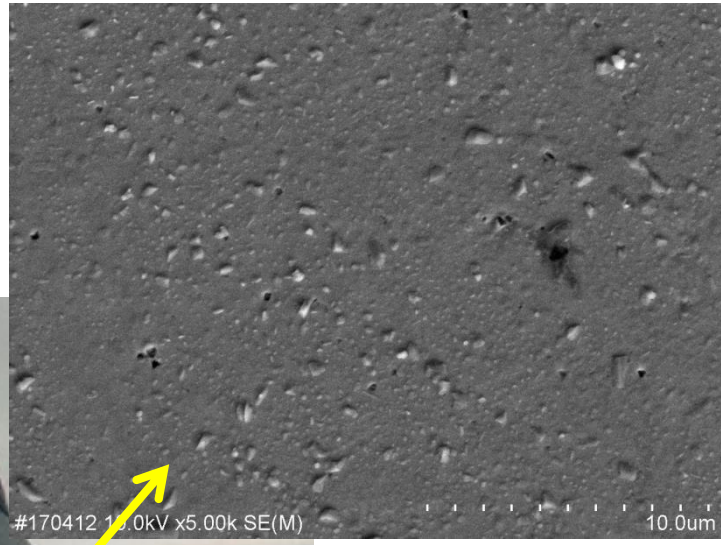

2. #170412Mo(TiN) in cavity, 07.06.2012

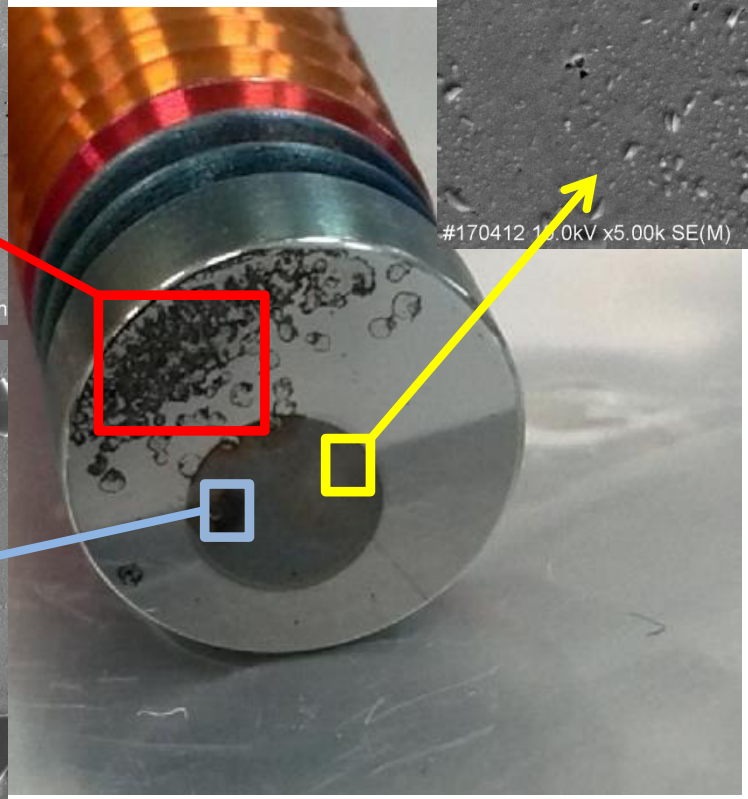

3. #170412Mo(TiN) in cavity, 23.08.2012

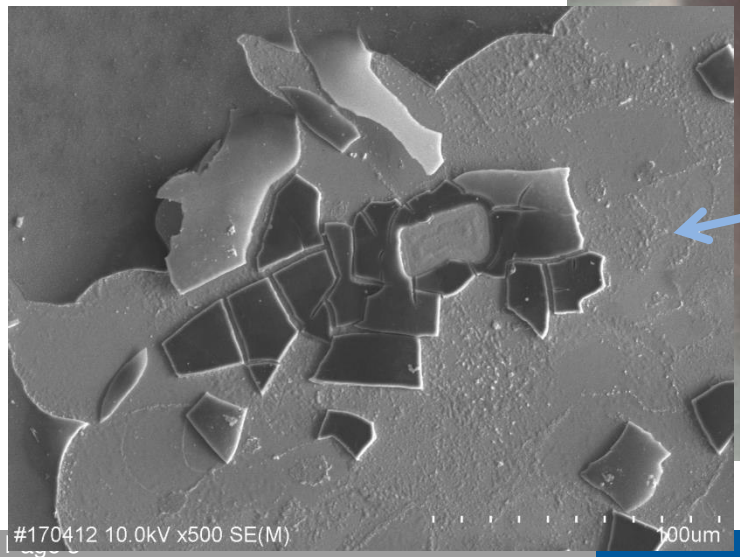

4. Explosion in air 24.06.2014

Cs_2Te photocathode

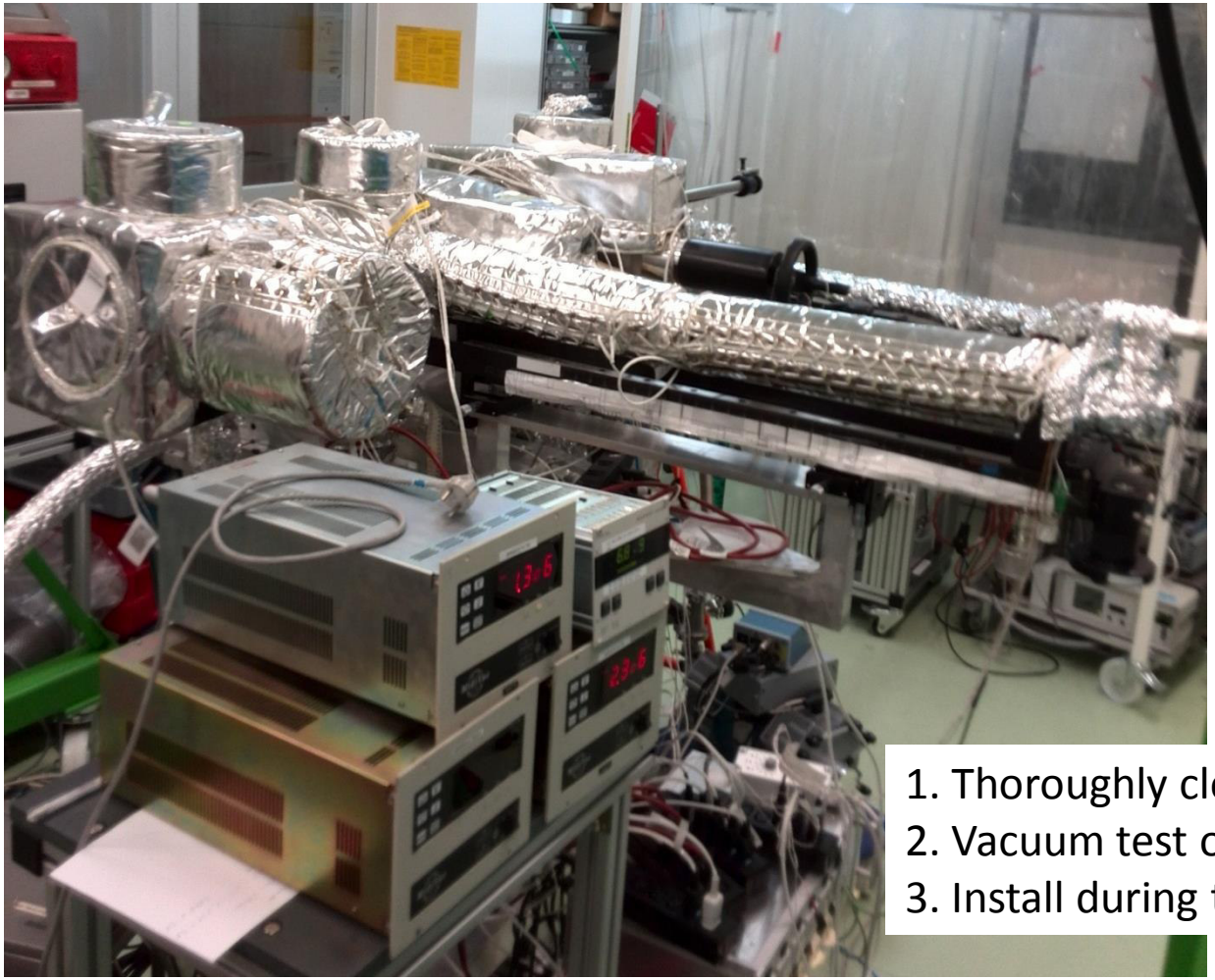








Cs_2Te cathode TPK



1. Thoroughly cleaned
2. Vacuum test out of accelerator hall
3. Install during the winter shut down

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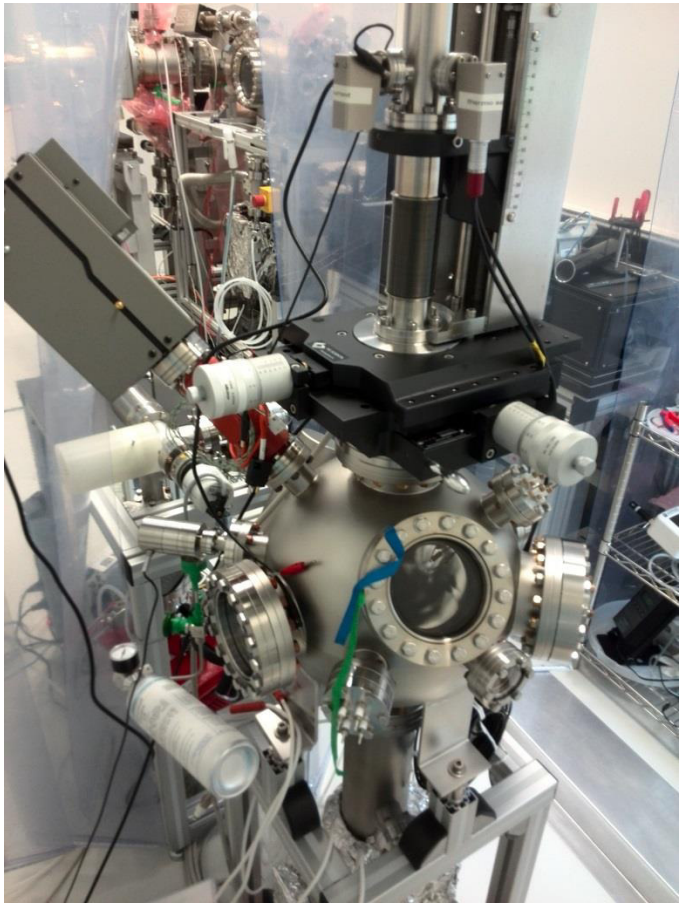
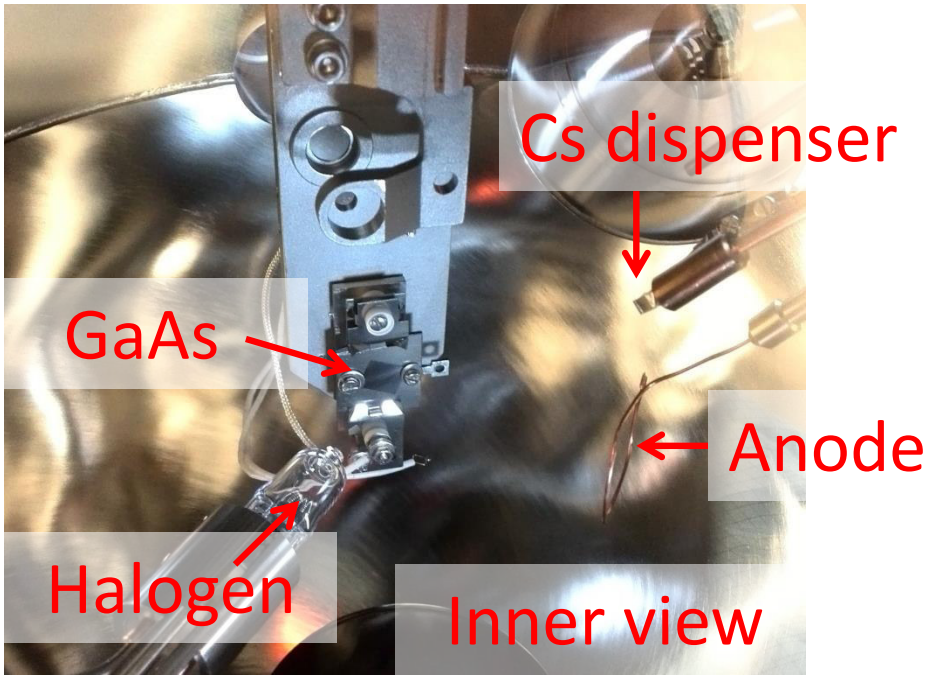
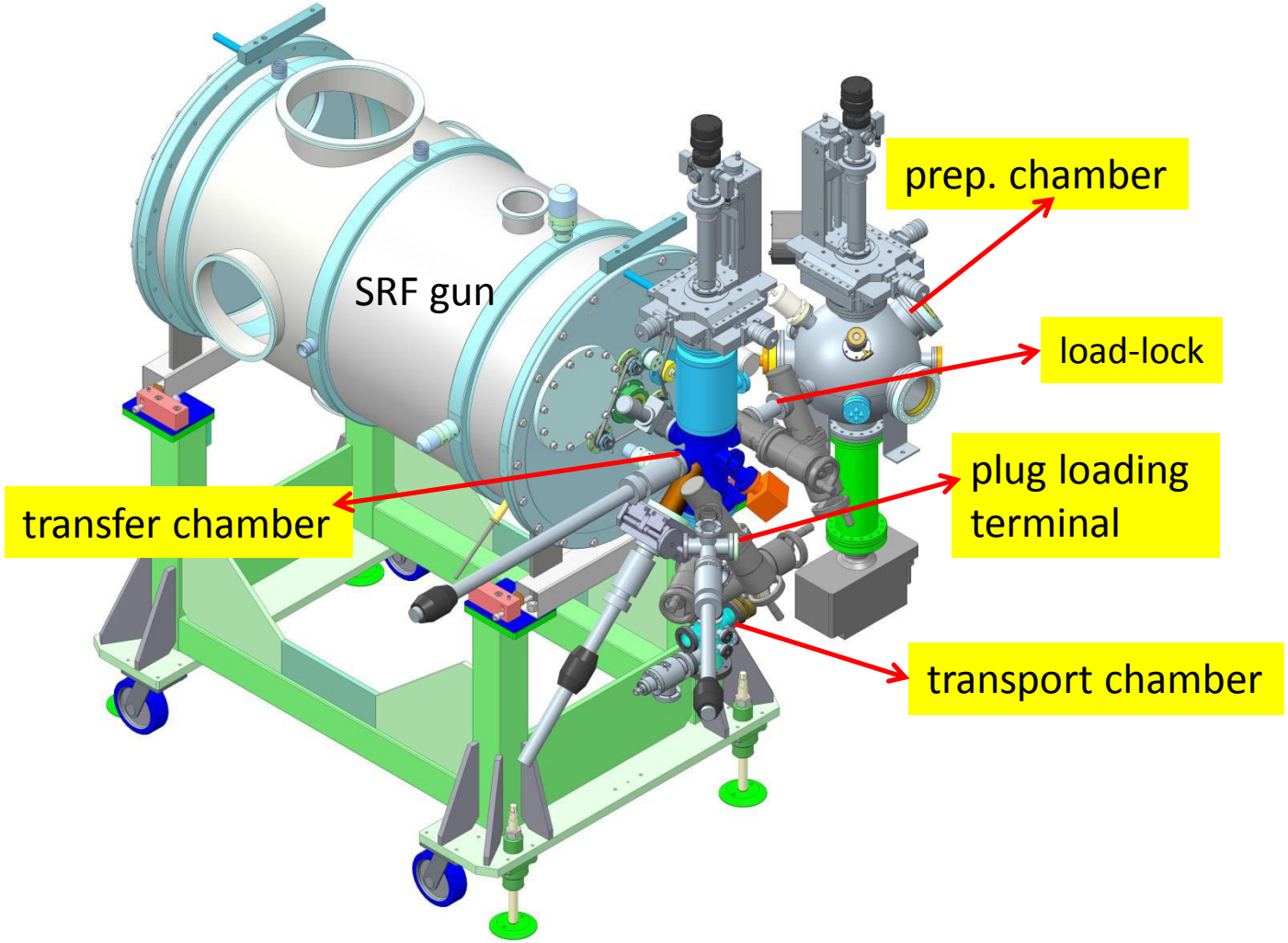
GaAs photocathode status

Vacuum 4×10^{-11}mbar. Temperature of GaAs chip ?

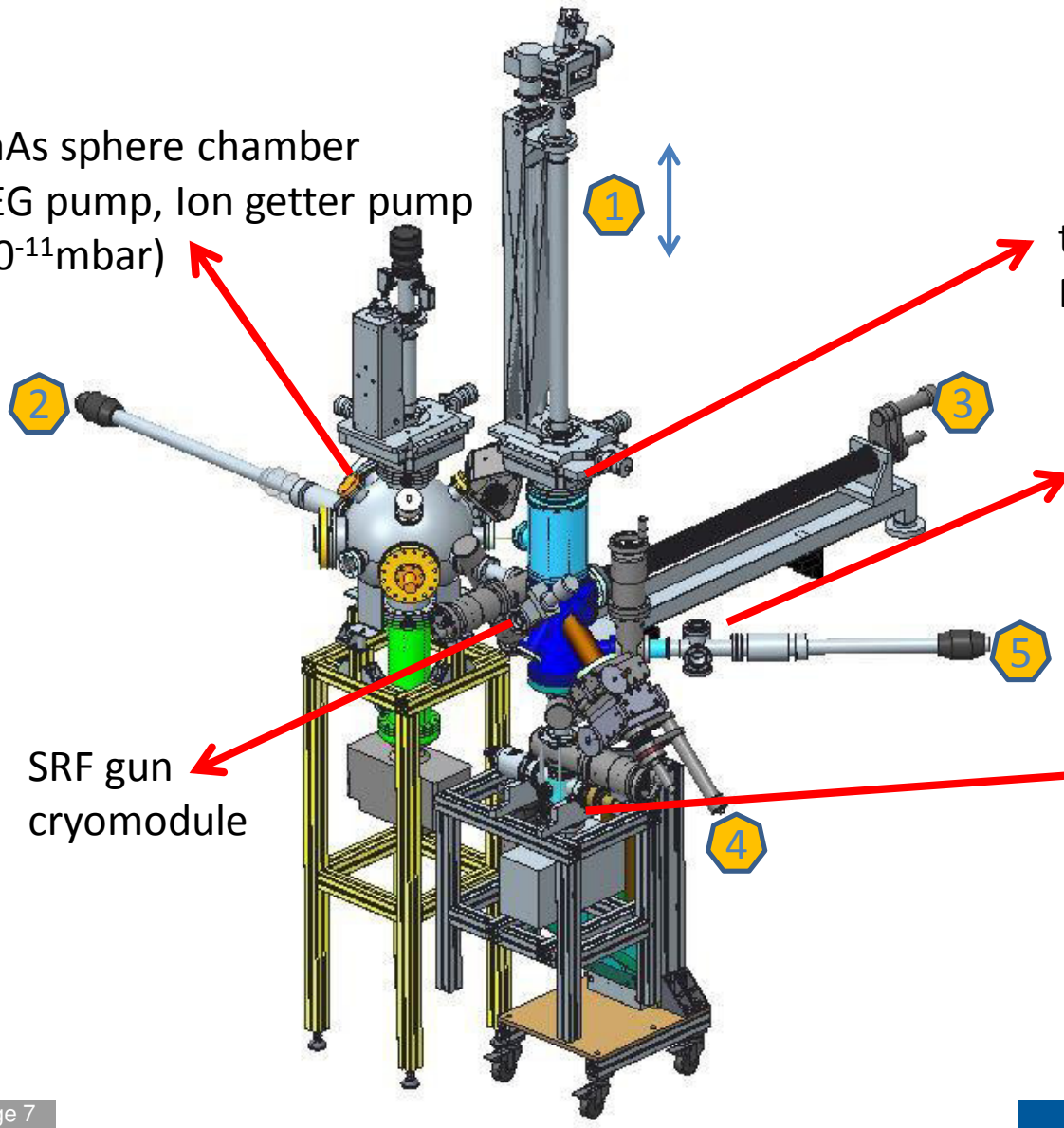




Transfer system in 2013



Transfer system status 2014.10



GaAs sphere chamber
NEG pump, Ion getter pump
(10^{-11}mbar)

transfer chamber (10^{-11}mbar)
Nextorr, NEG module

plug loading terminal
Turbo-pump set (10^{-8}mbar)

SRF gun
cryomodule

transport chamber(10^{-11}mbar)
Nextorr, Ion getter pump

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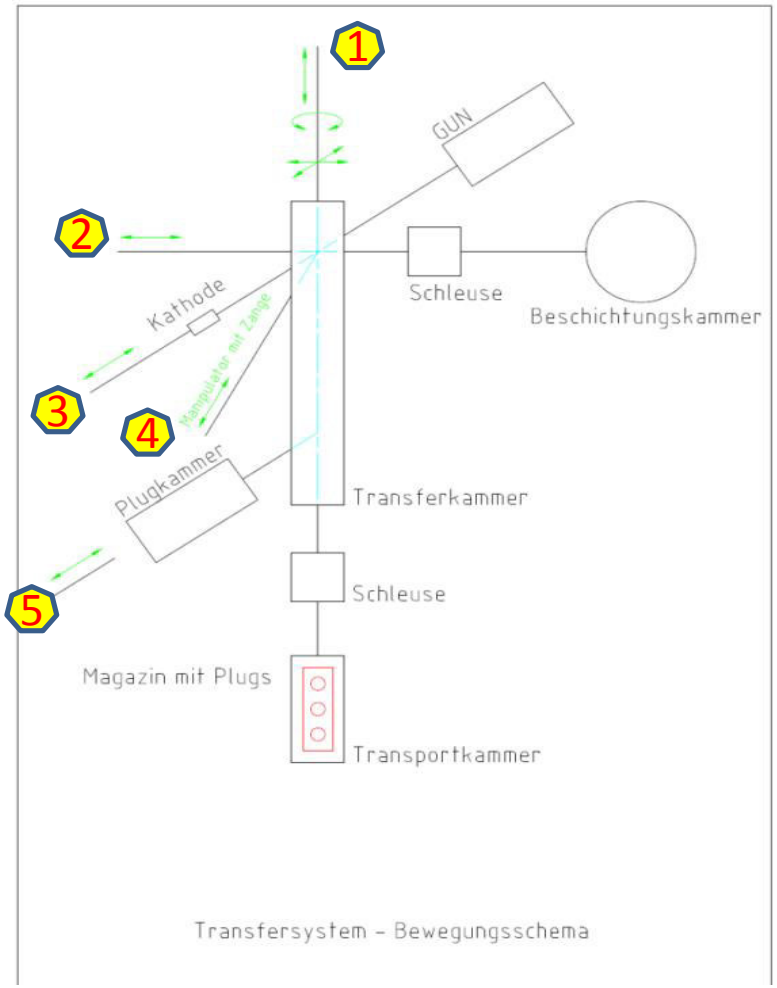
Manipulator quotation



1. move wagen with jaws

z =610mm movement
360° Rotation
X,Y table ± 12.5 mm
2nd inner-Z movement 12mm

2. (Magnetic) move one chip with jaws

Movement 600mm **(√)**

3. move cathode body into gun

original ELBE SRF Gun manipulator **(√)**

4. (Magnetic) move puck (plug) with finger

300 mm movement
X-Y table ± 7.5 mm **(√)**

5. (Magnetic) move one chip with jaws

Movement 330 mm **(√)**

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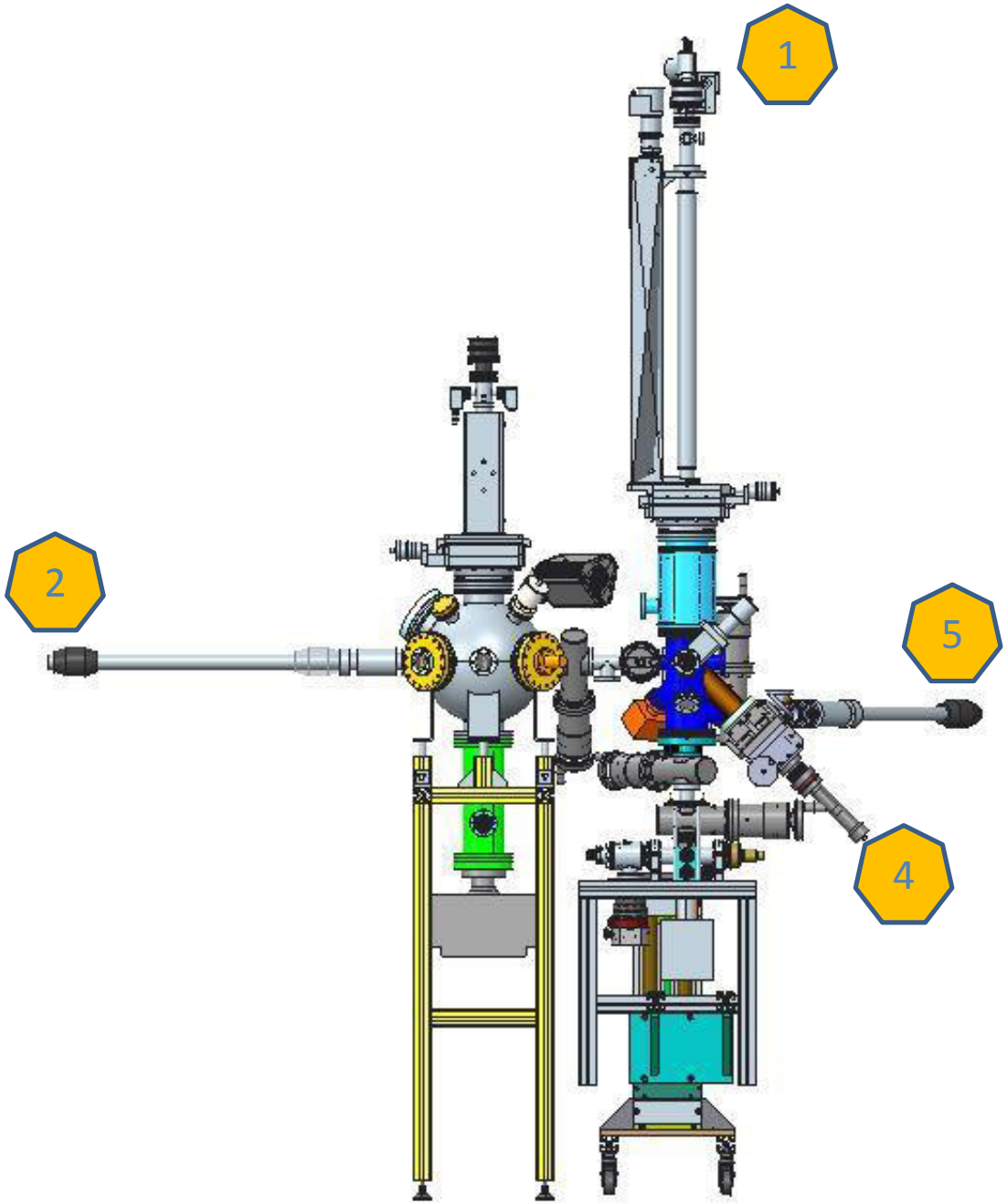
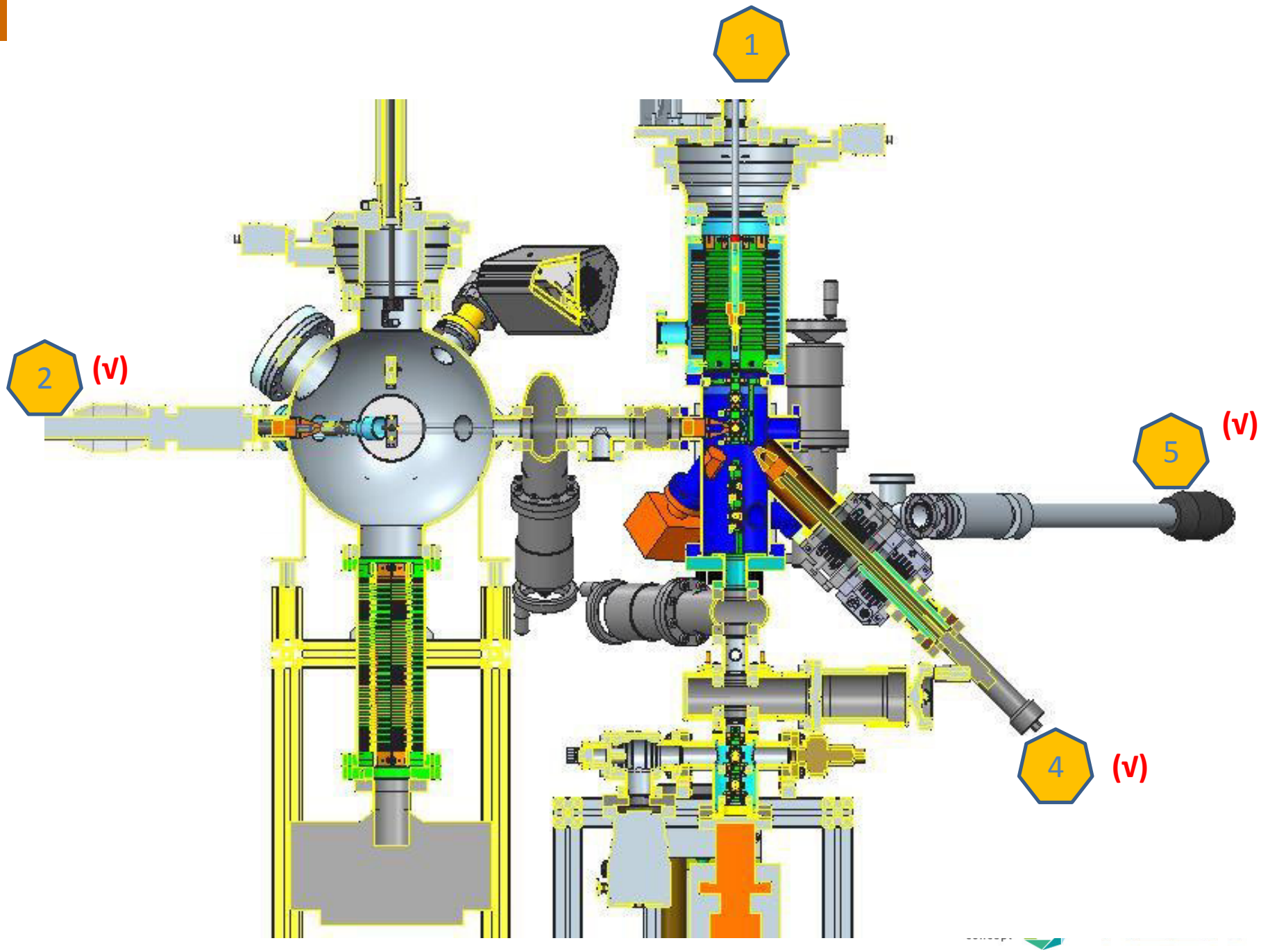

1
2
5
4

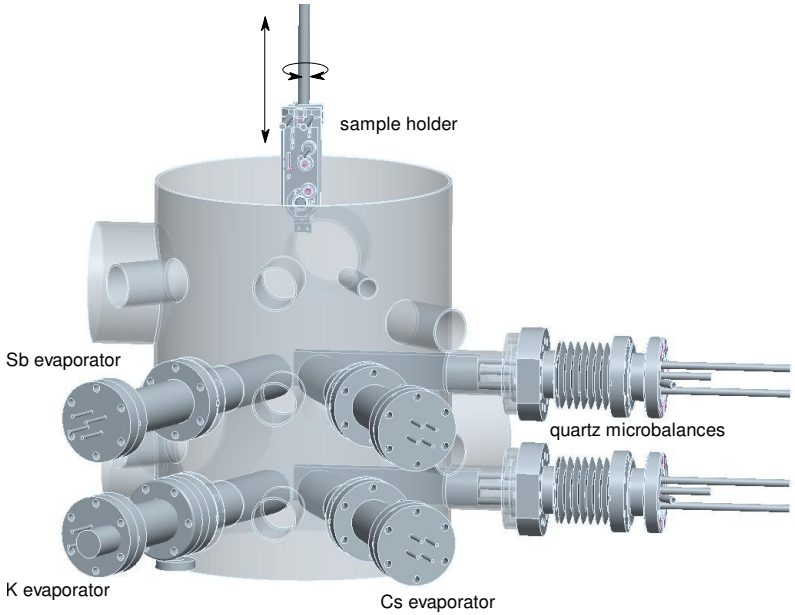

1
2
(V)
5
(V)
4
(V)

FIRST LIGHT MOMENTATRON

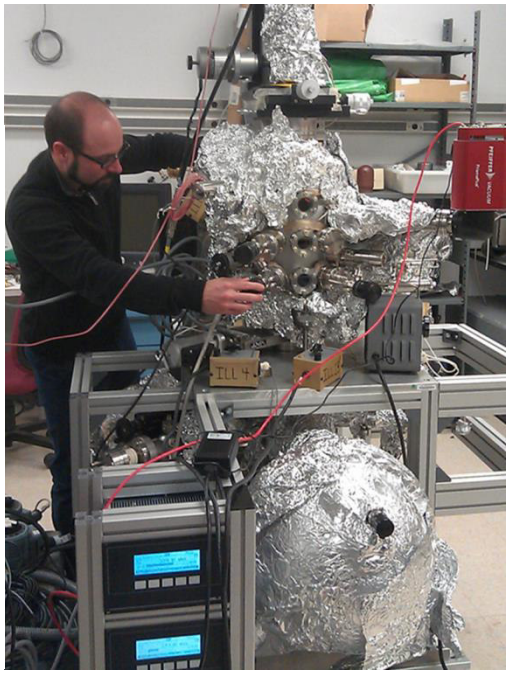
STATUS PREP SYTEM HZB

STATUS TRANSFER SYSTEM HZB

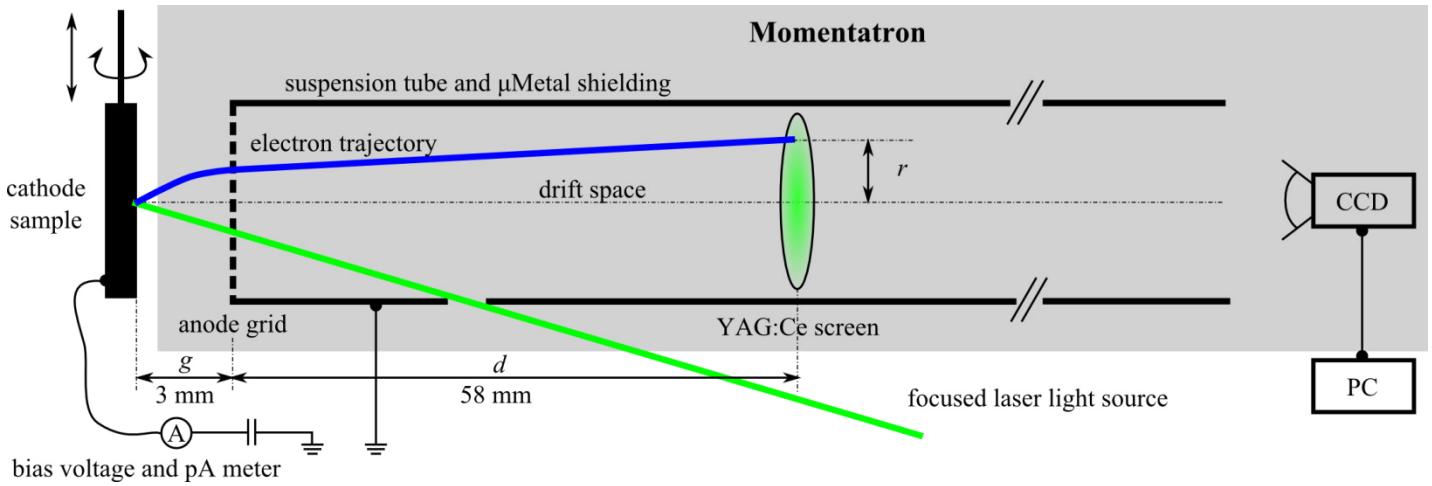
PHOTOKATHODE PREPARATION AT BNL

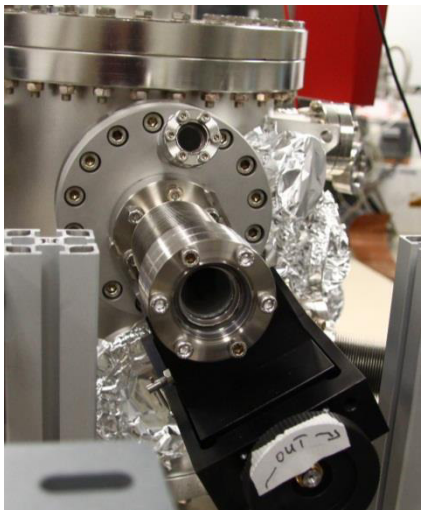


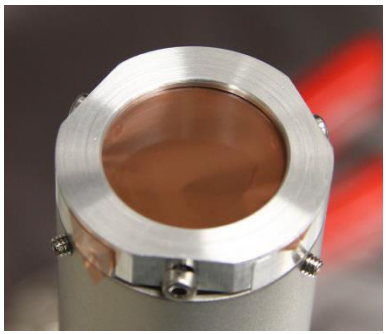
- $P = 1*10^{-9}$ mbar
- $P_{H_2O} = 4.5*10^{-11}$ mbar
- Sb evaporated from PtSb beads
- Alkali metals from alvasources
- First time we could use the Momentatron
- Mounted in prepchamber



- Preparation of 10nm Sb at room temp (heater failed) on Mo substrate
- Sequential growth following Sommers recipe
- slow K deposition (2h at RT)
- K_3Sb had ~ 0.35% QE at 532nm
- Cs deposition, second Cs source activated
- Possibly over cesiated the surface
- CsK_2Sb had ~ 0.09% QE
- Surface recovers over night, ~ 0.45% QE





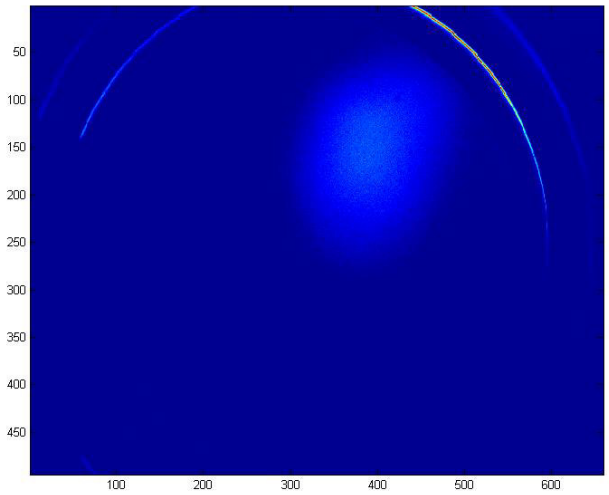


Linearer Zusammenhang zwischen Radius am Schirm und transversalem Impuls erlaubt Rekonstruktion der Impulsverteilung

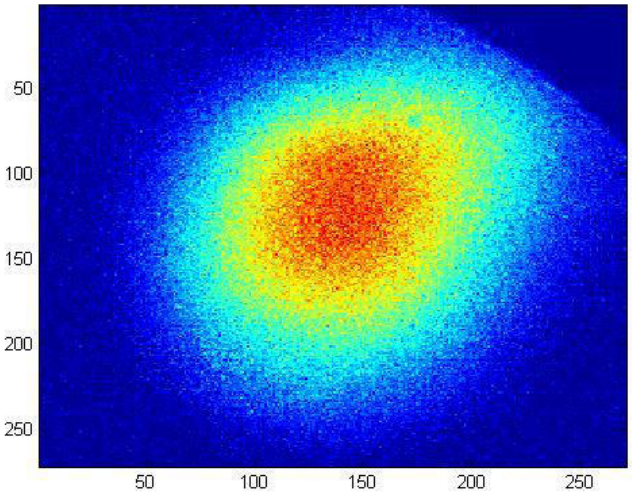
$$\frac{p_x}{mc} = \frac{r}{2g + d}\sqrt{\frac{2eU}{mc^2}}$$

HZB Helmholtz Zentrum Berlin

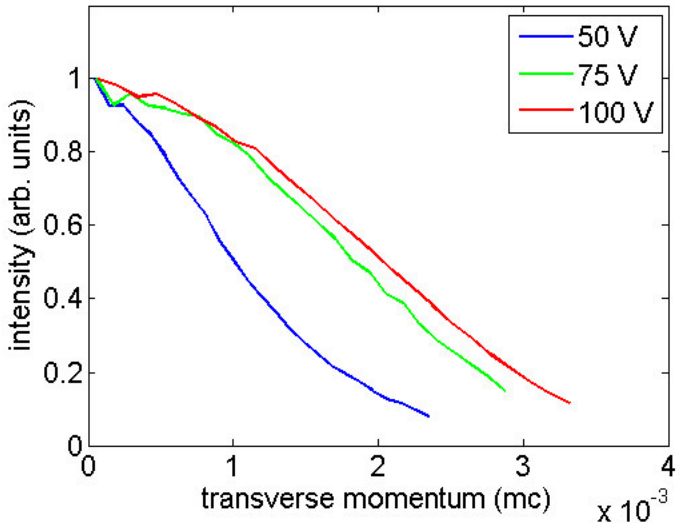
Rohbild



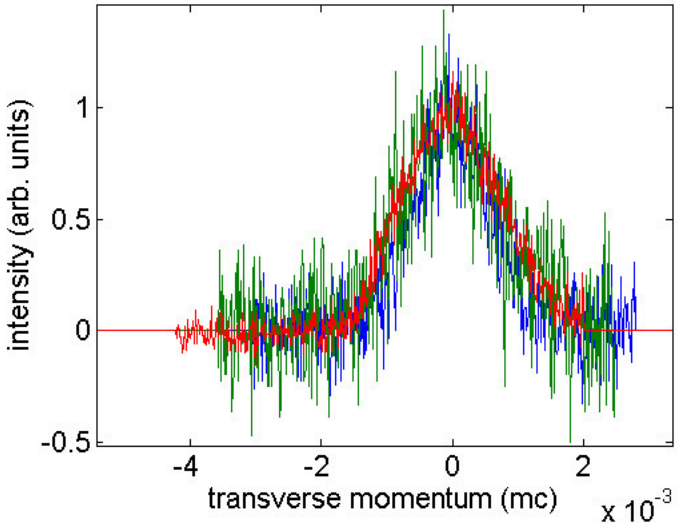
Region of interest



Radiales Intensitätsprofil



Lineares Profil



- Proof of principle
- 50eV are sufficient to generate measurable intensity on screen, but dynamic range of scintillator and optics are too low at 50eV

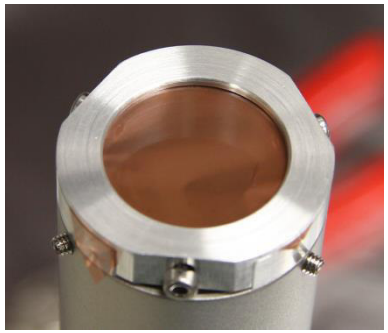
- No space charge issues (for now)

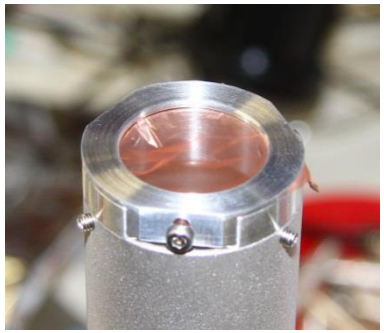
- Beam was off-center, deformed and the width of the intensity distribution was higher than anticipated

→ Probably due to deformed anode and large laser spot size

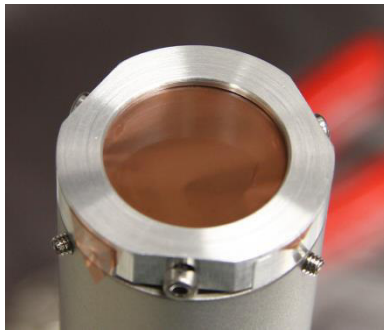
- SNR is about 10dB → camera cooling, higher bias voltage

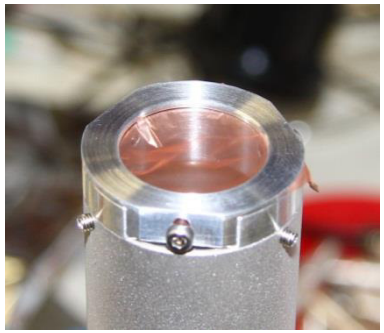
- Laser spot size ca. 1mm rms, intensity distribution on the screen ca. 3mm rms





- Verbesserungen am Momentatron
  - Reparatur Anode
  - Fokussierter Laserstrahl, Notch Filter für 532nm, stabiler blauer Laser
  - Spektral aufgelöste Messungen (QE und Emittanz) mit Weisslichtquelle





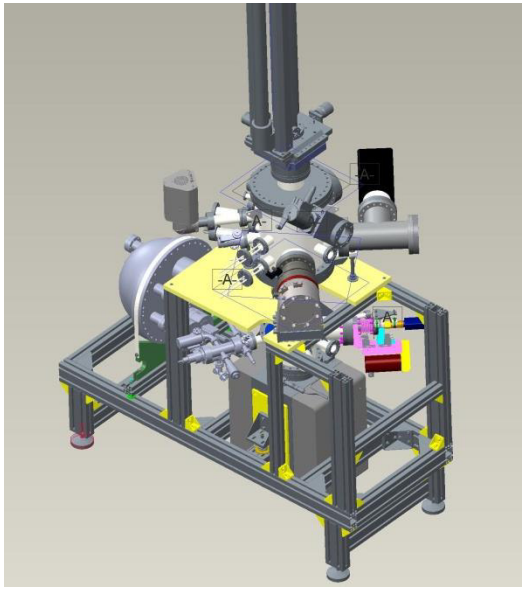
STATUS PREP-SYSTEM

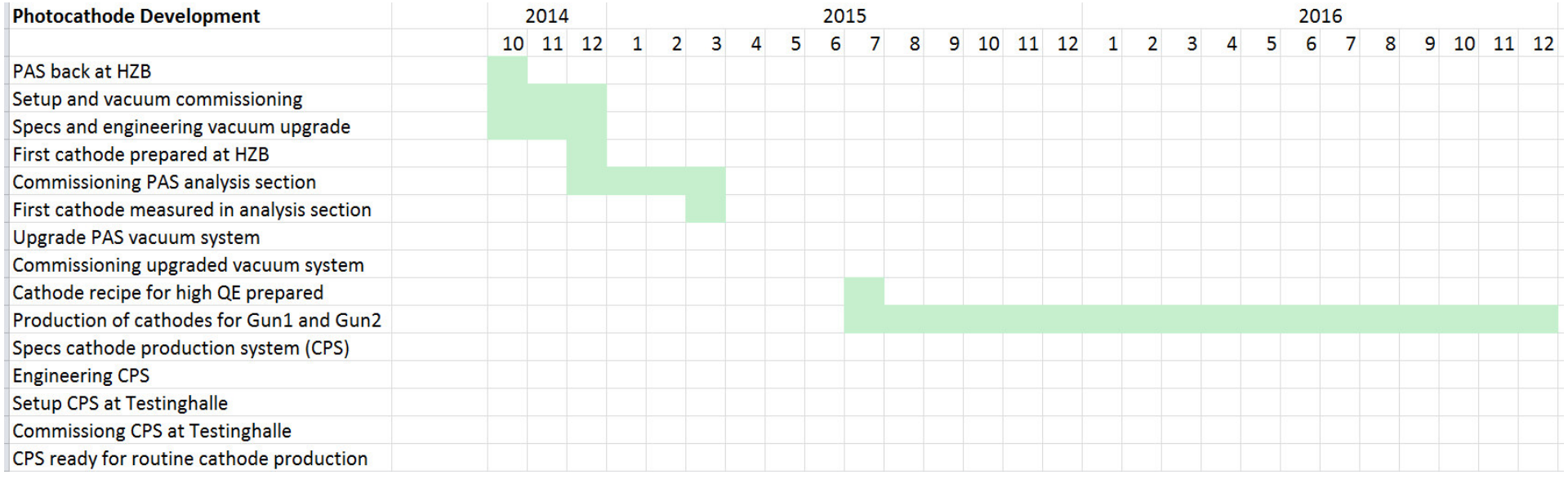
Julius Kühn is now in charge, engineering Daniel Böhlick

Chamber, equipment and momentatron are back in Berlin
We have new lab space in Adlershof, dedicated for prep system

Vacuum upgrade
- new 400l/s turbo
- Replaces one of the getter pumps
- New tsp

Commissioning of analytic equipment
- First use of X-Ray source, XPS analyzer, and LEIS





STATUS TRANSFER SYSTEM

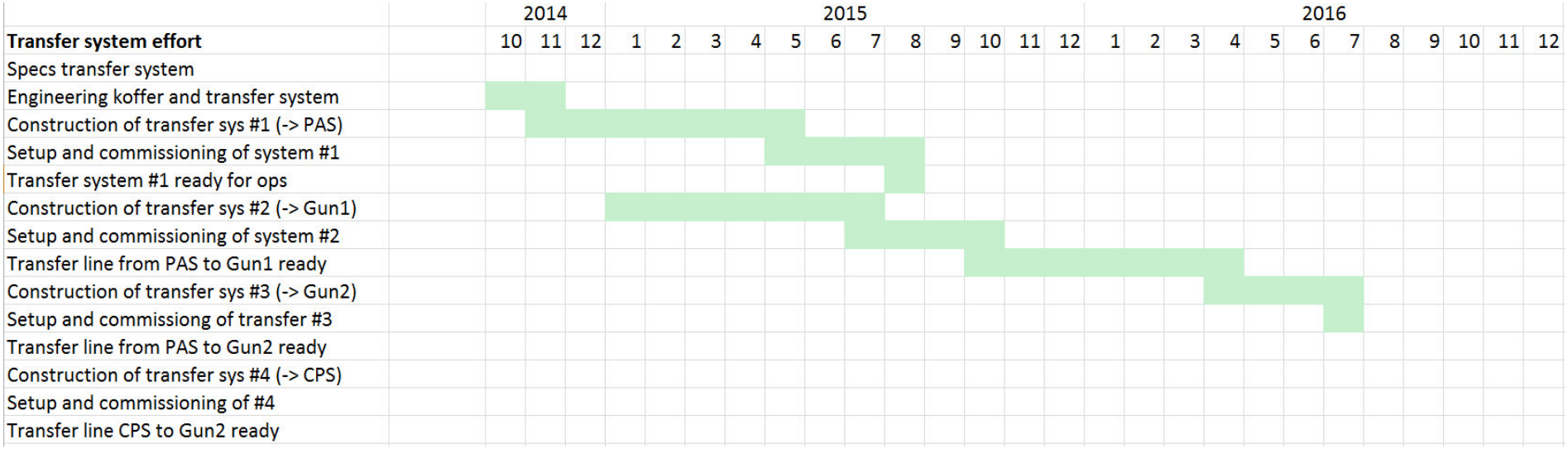
Julius Kühn is now in charge, Kerstin Martin engineering

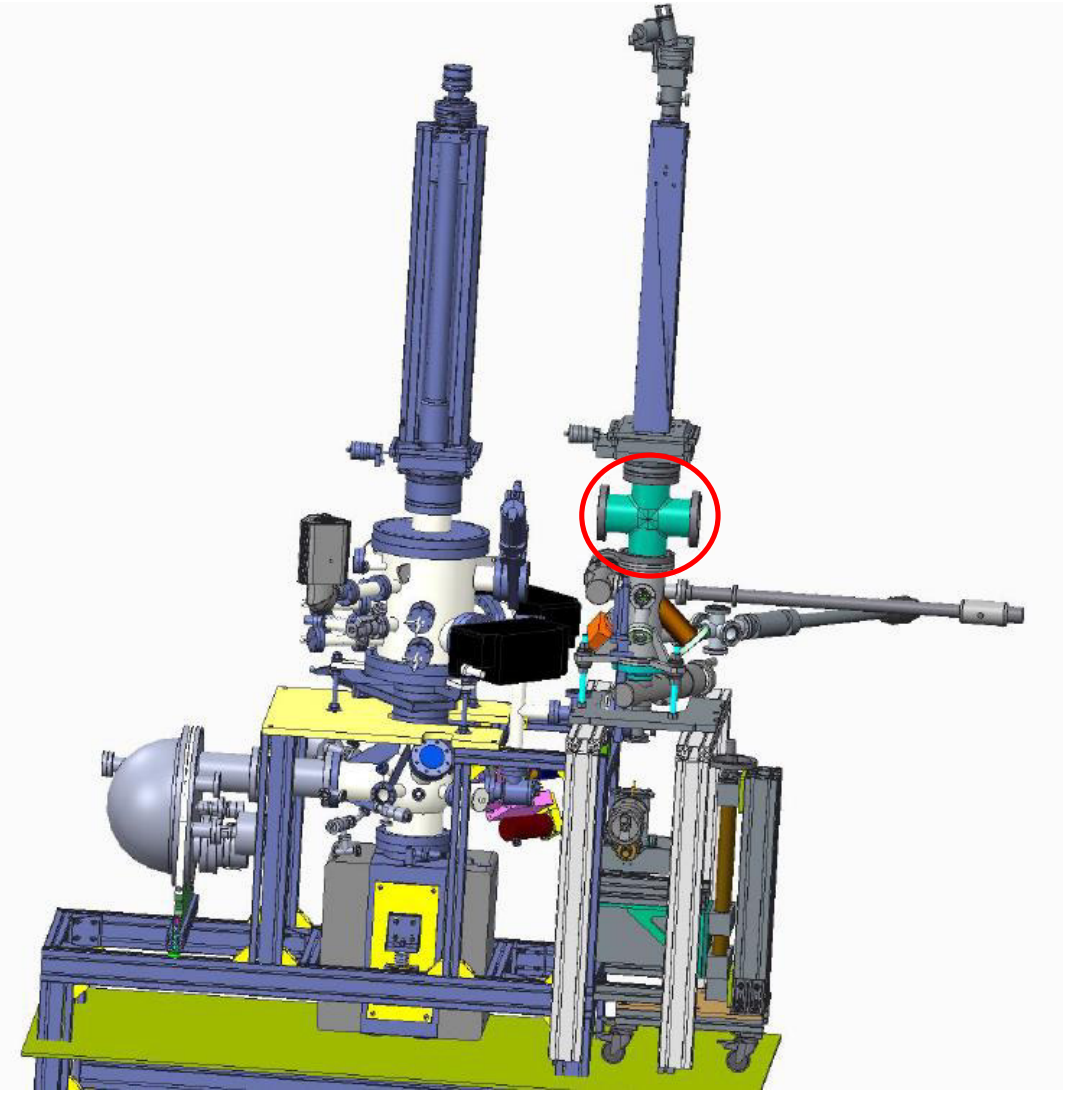
We need separate transfer systems for the prep chamber and gun, which are in different buildings

TS1 for transfer to/from prep chamber

- will have load lock

TS2 for transfer into gun

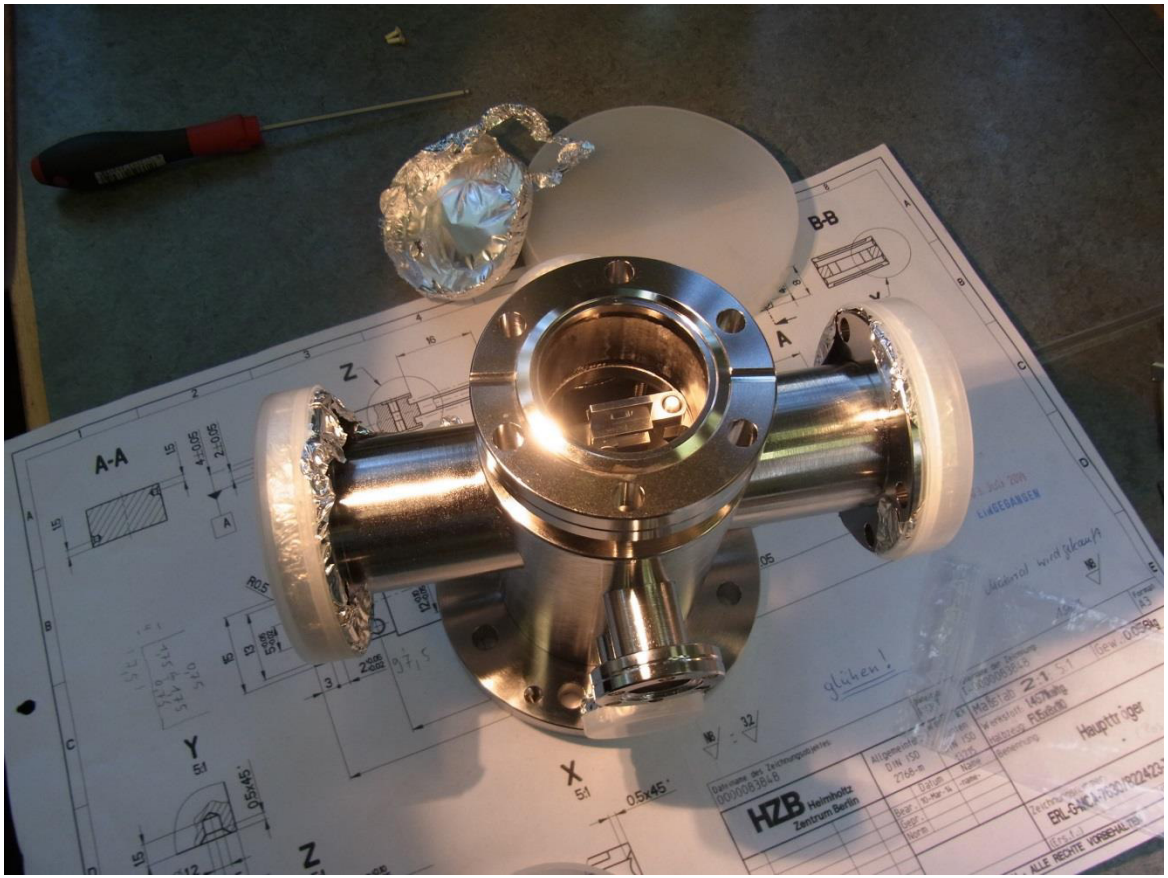


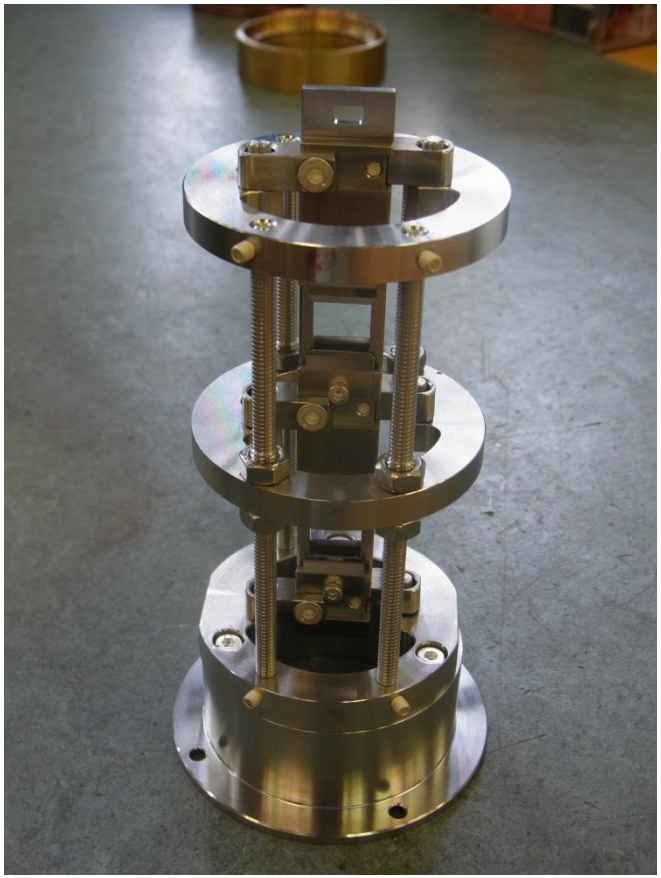


KM will place orders for chamber and manipluators soon

The pumping cross and HZDR custom pump do not fit into our lab (height)

Koffer + Wagen were manufactured, Vacuum testing & 400°C bake pending





Diskussion Fenster für Load-Lock

Diskussion Vakuum im Transfersystem

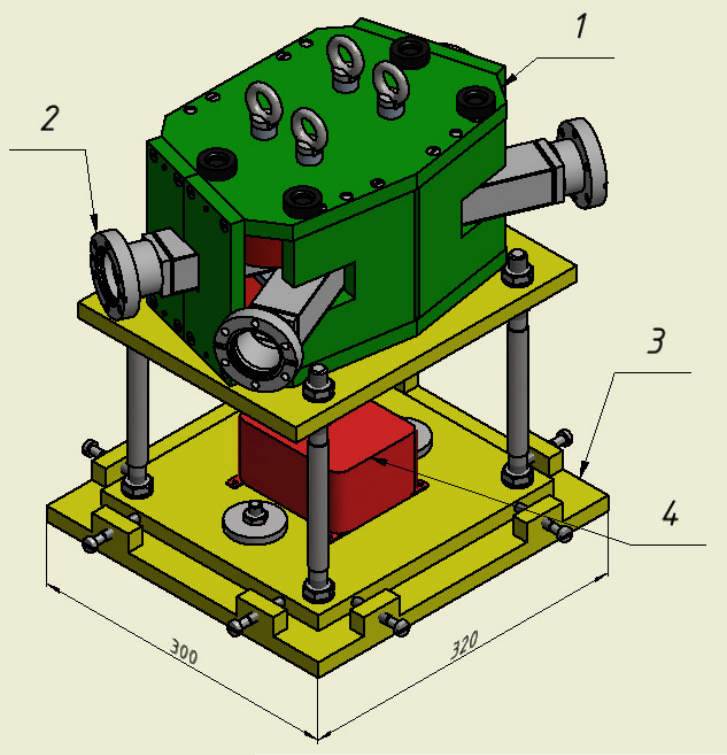
2 Pfade für Plugs

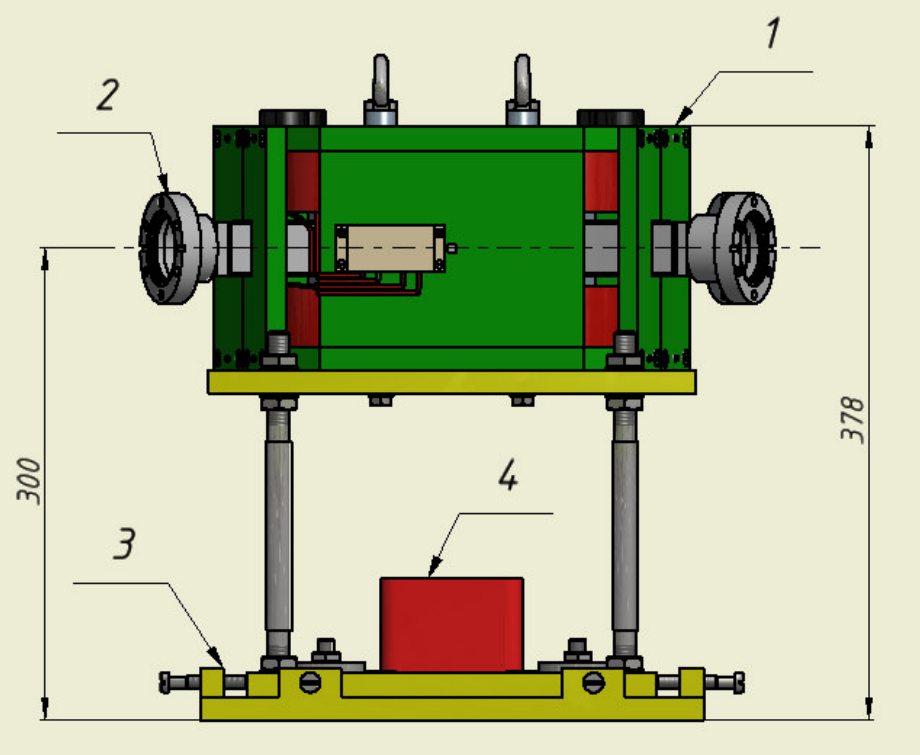
- Füllen des Koffers im Reinraum : Koffer sieht Luft, Plugs sind sauber
- Oder : leerer Koffer wird ausgeheizt und sieht nie Luft, Proben einschleusen über Load Lock am Transfersystem

SPECTROMETER DESIGN

13.10.2014

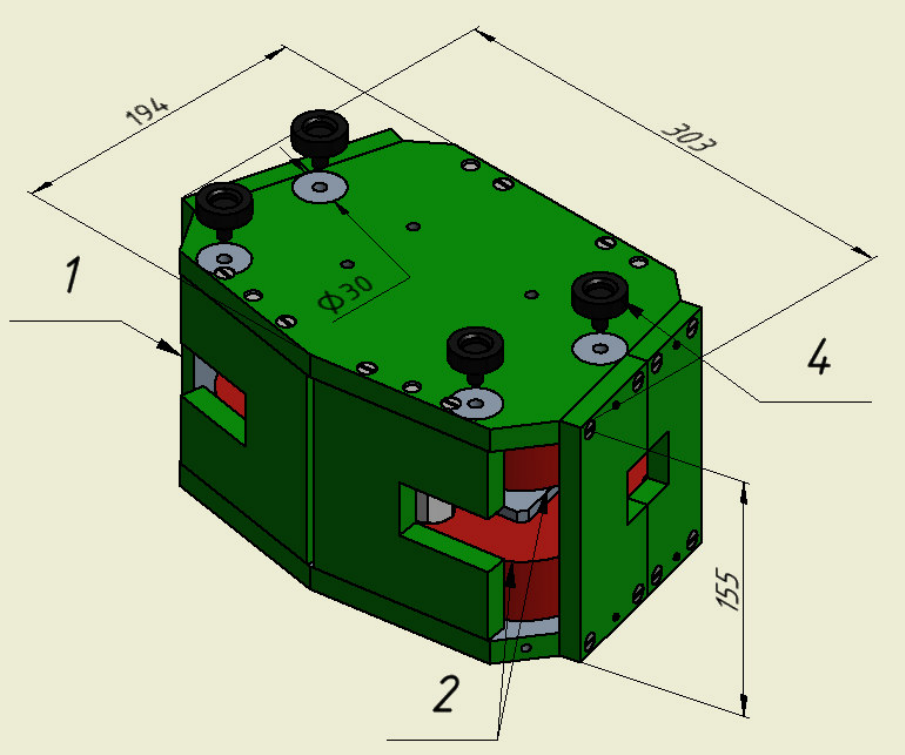
Design review

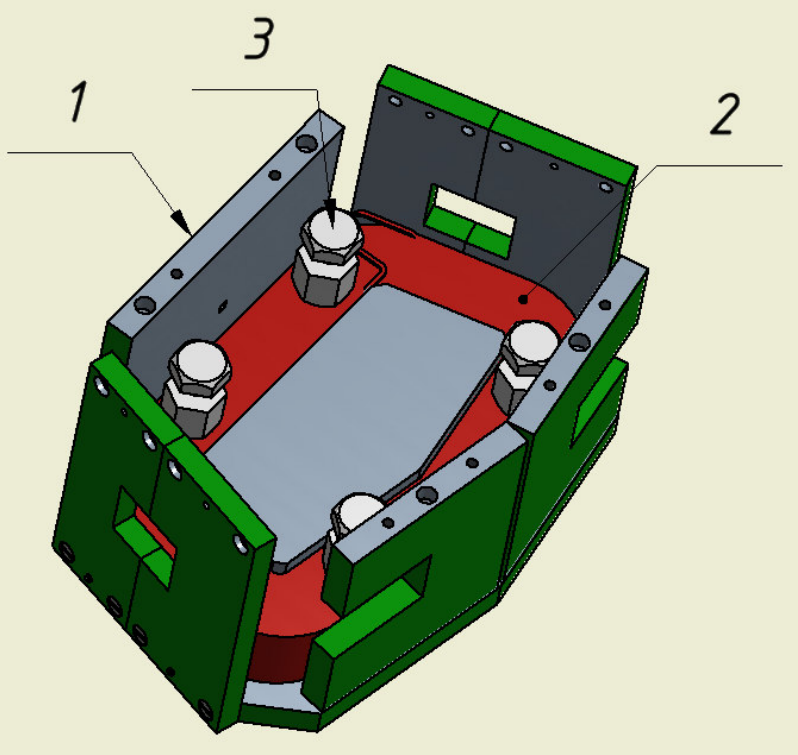




1 – dipole magnet, 2 – vacuum chamber, 3 – pedestal, 4 – controller corps.
Mass ≈ 56 kg, overall sizes = 300×320×378 mm.

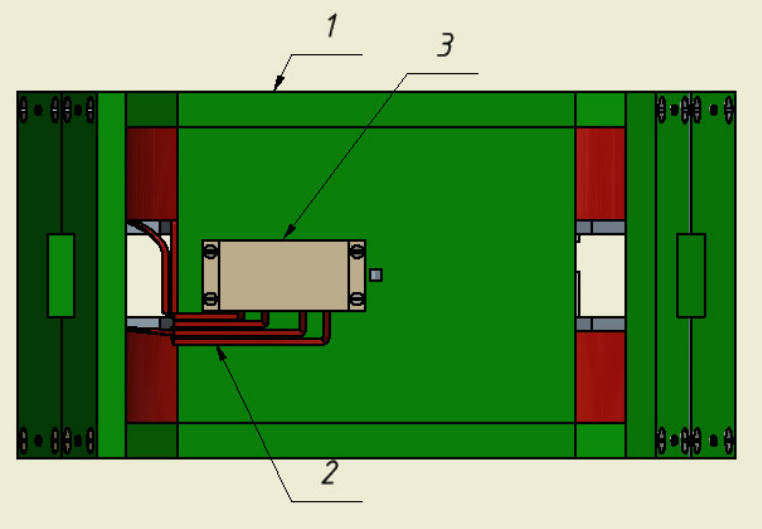
Dipole magnet

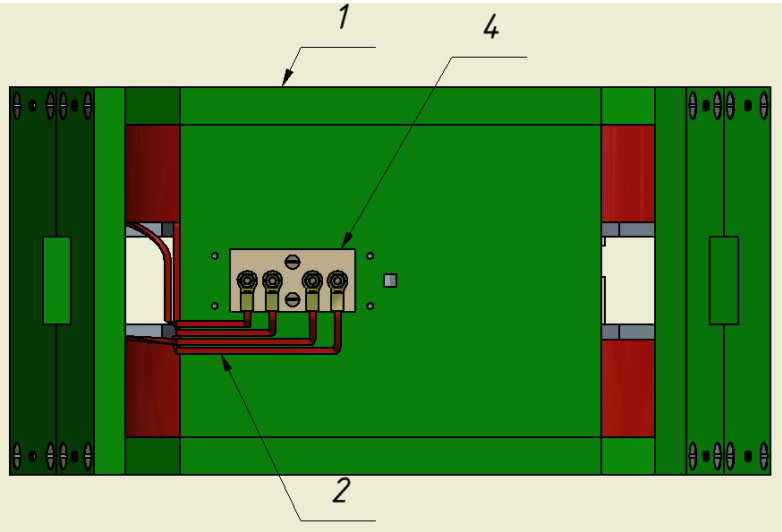




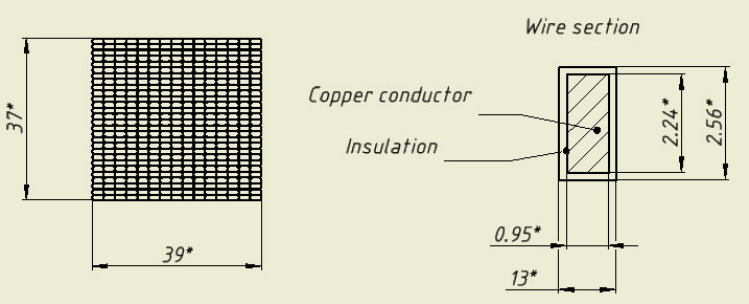
1 – dipole magnet yoke, 2 – coils, 3 – spacers, 4 – laser tracker sphere holders. Yoke mass ≈ 29 kg, overall yoke sizes = 194×303×155 mm. Outer yoke surfaces will be painted in color RAL 6018.

Dipole magnet

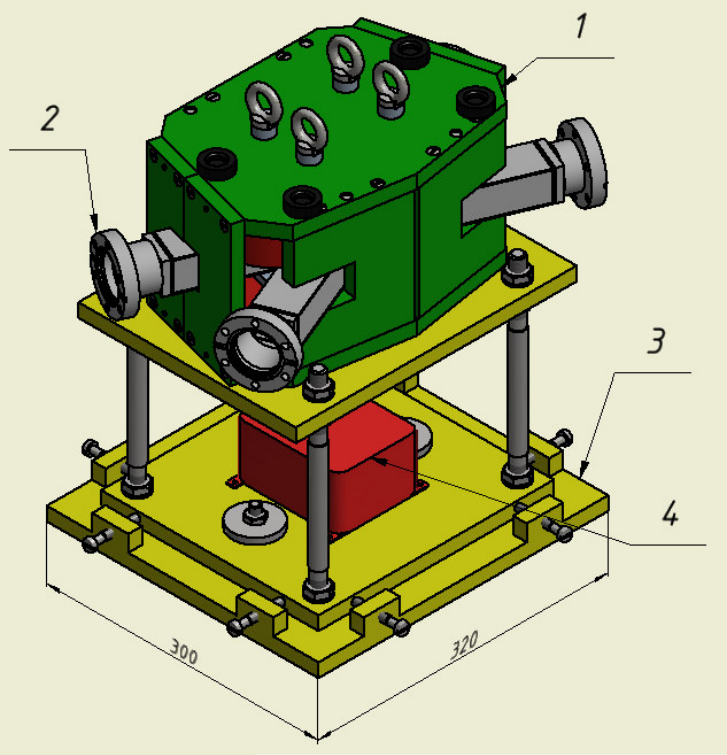


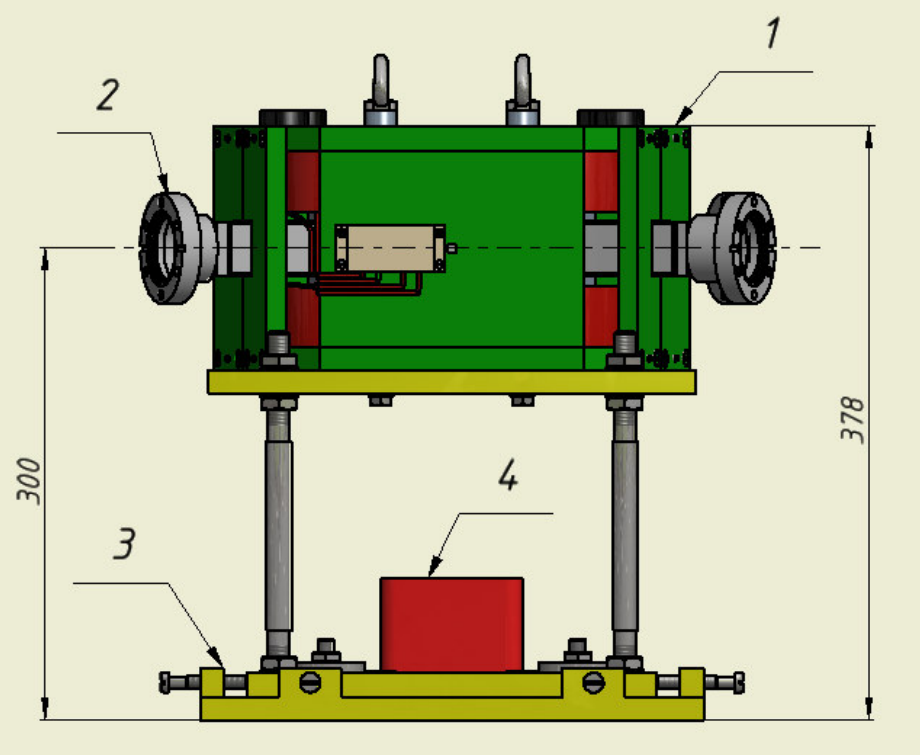


1 – dipole magnet yoke, 2 – wires, 3 – protective hood, 4 – electrical manifold. Coil mass ≈ 8 kg, resistance ≈ 2 Ohm. The power supply must provide maximum voltage ≈ 22 V and power ≈ 98 W.



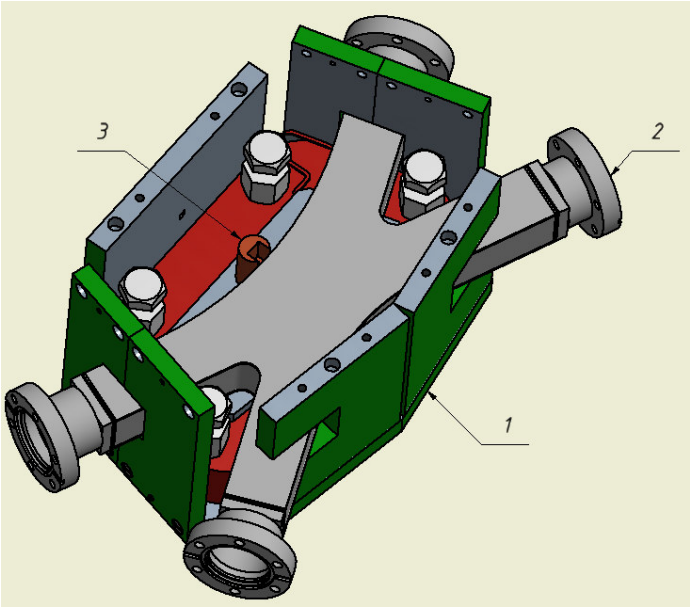
Field measurement controller

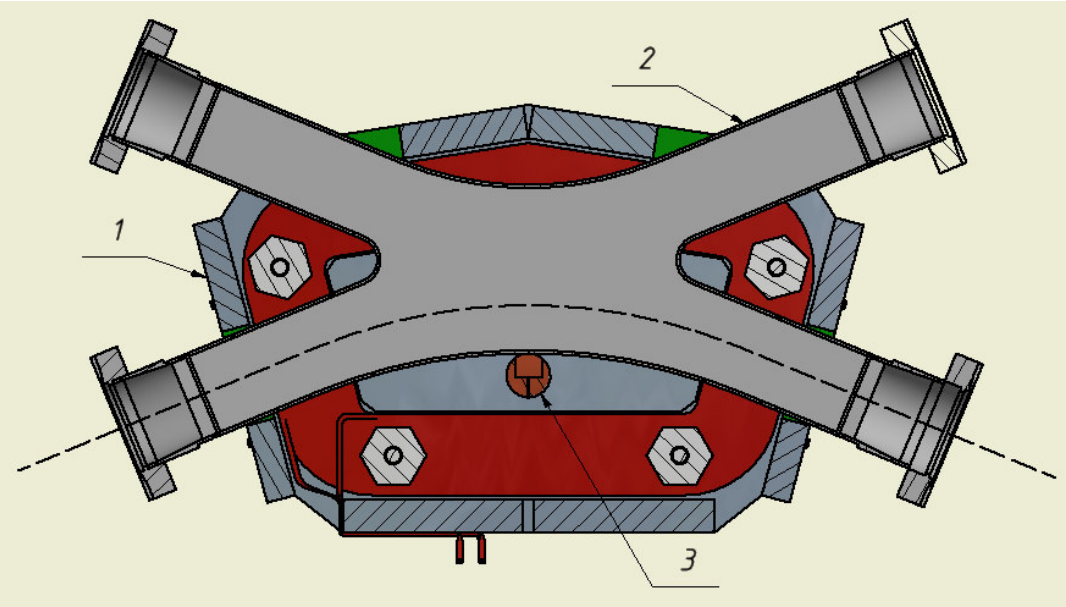




1 – dipole magnet, 2 – vacuum chamber, 3 – pedestal, 4 – controller corps.

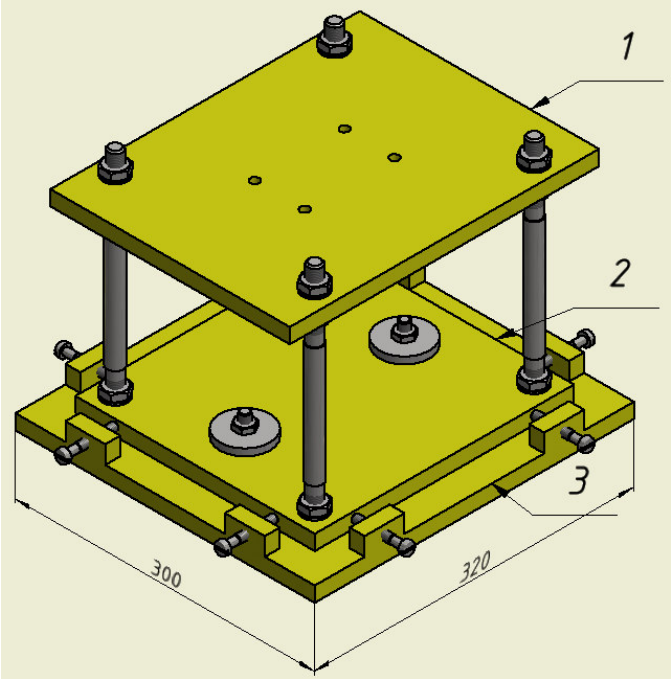
Field measurement controller

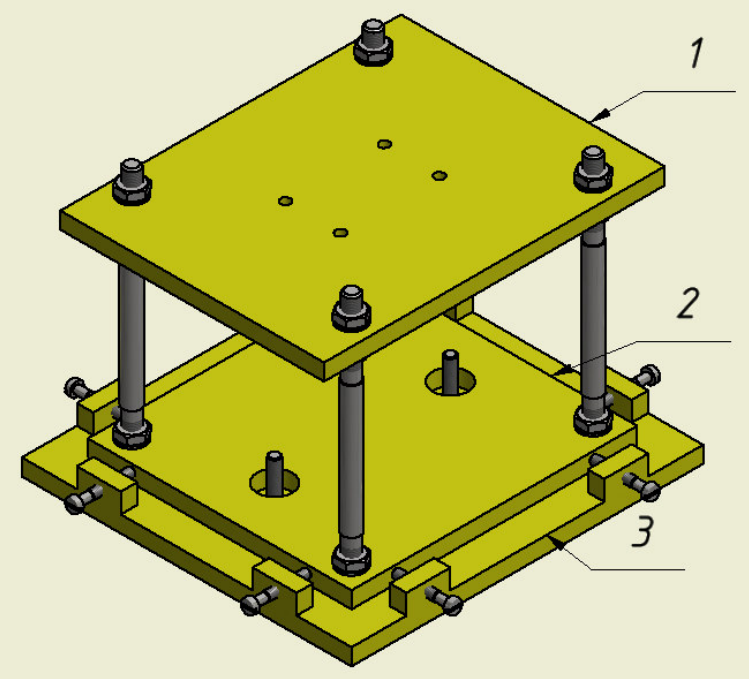




1 – dipole magnet yoke, 2 – vacuum chamber, 3 – stand for Hall probe.

Pedestal for dipole magnet





1 – plate 1, 2 – plate 2, 3 – plate 3.
Mass ≈ 12 kg, overall sizes = 300×320×223 mm.

Thank you for your attention!

Current state of FE-setup

Roman Barday
13.10.2014

DC-Setup for FE Study

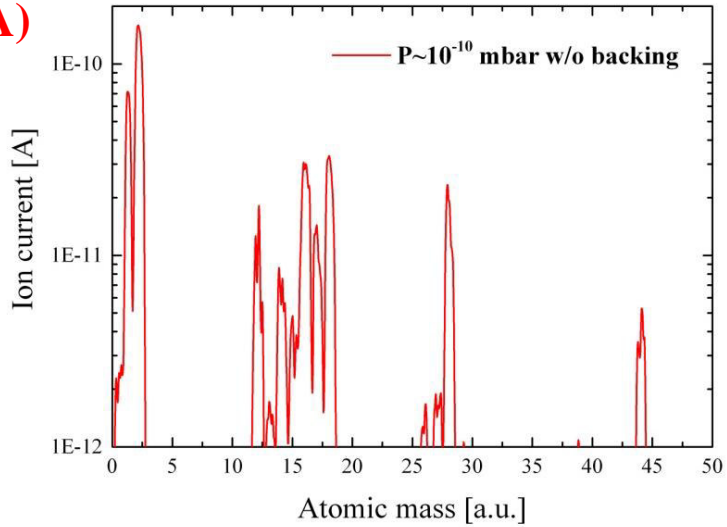
- **Image of the emitters on the view screen (50 pA)**
- **Current measurement over the entire surface**
- **Local measurements* I=I(E)→β, A_e**

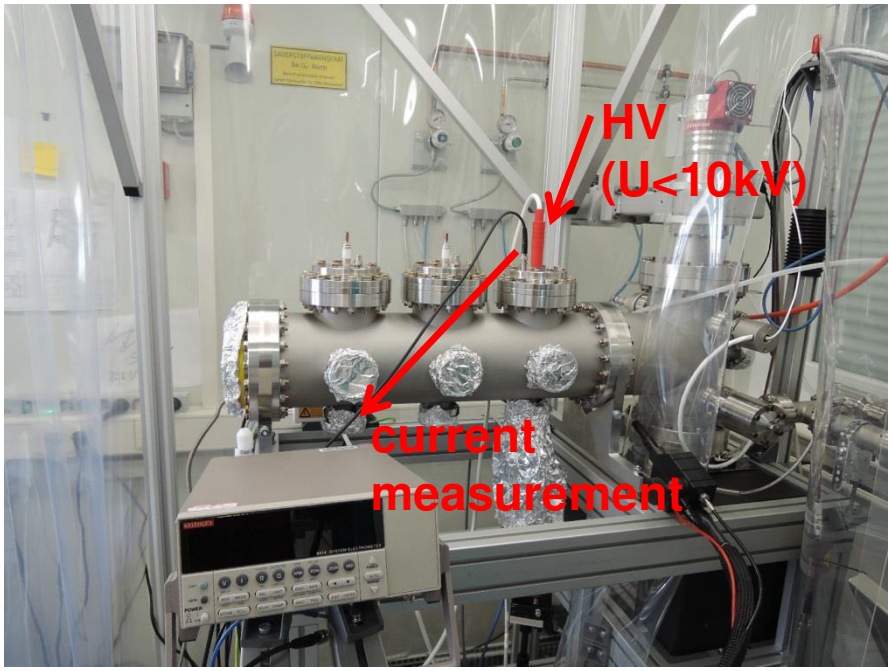
  Large surface with d=10 mm: immediately

  Pressure ~10^{-10} mbar w/o backing

  Flow Box: Loemat ISO class 5

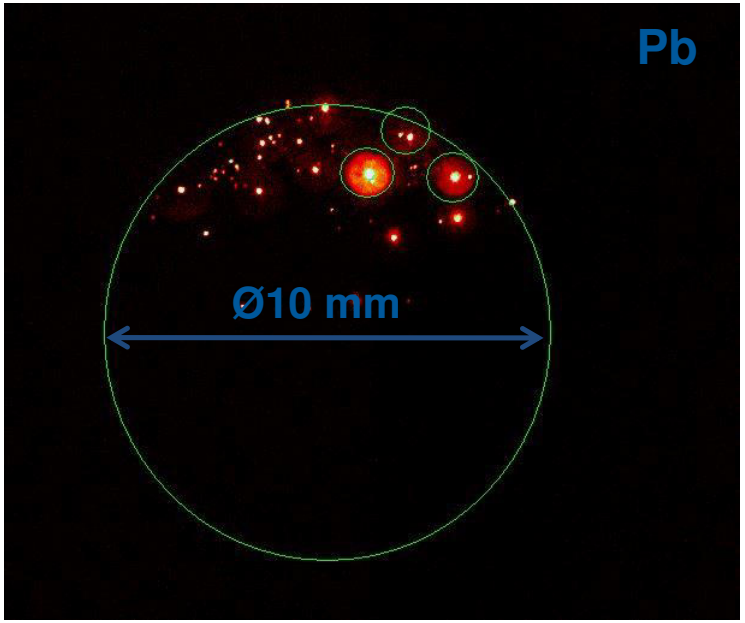
  Dry Ice Cleaning (Cry Snow SJ-10)

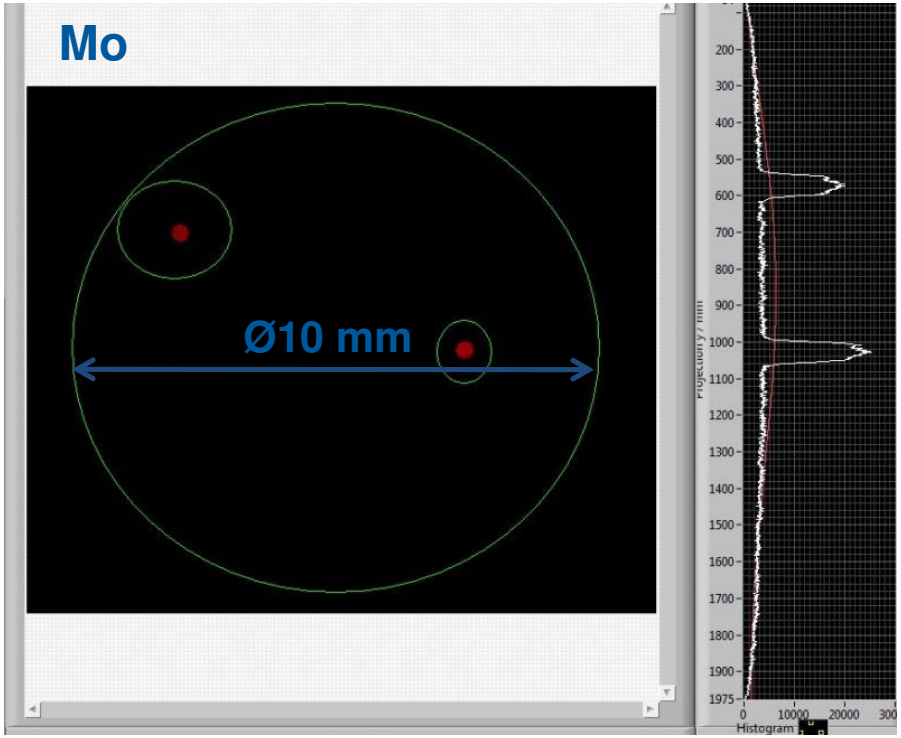


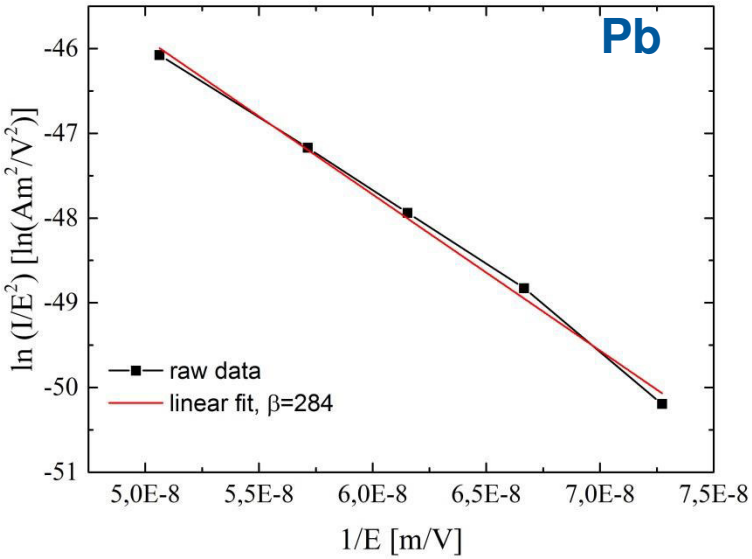


DC-Setup for FE Study

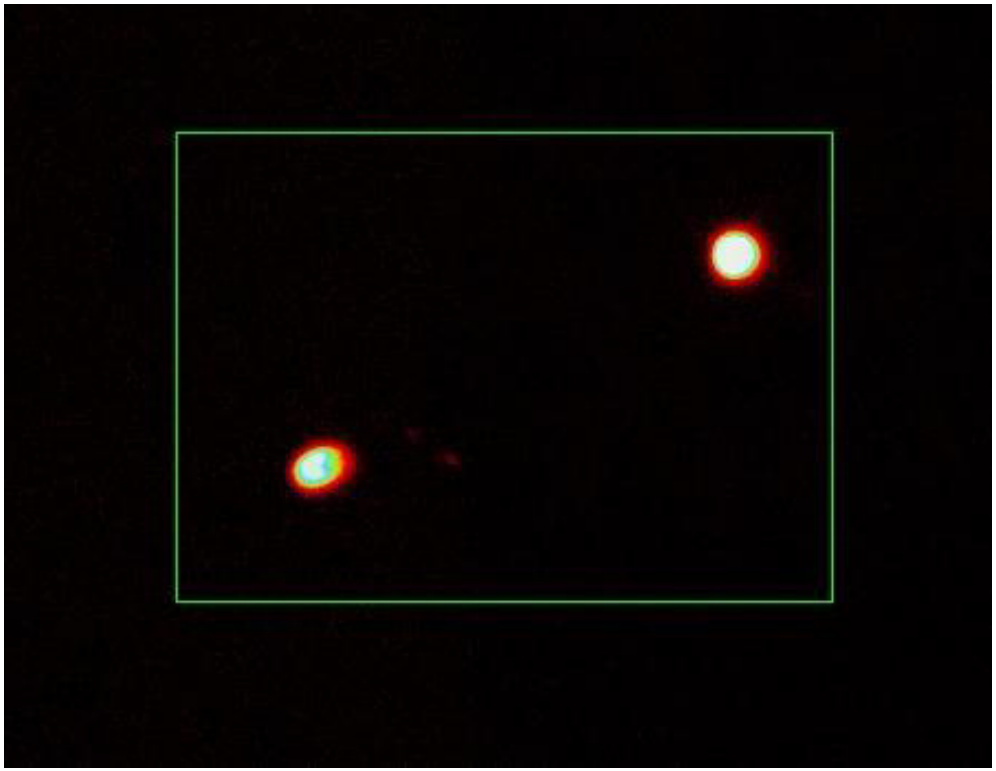
Mo sample: two emitters, I=15 nA @ 16.3 MV/m
No FE at 30 MV/m for Mo samples
I=4 µA @ 20 MV/m for Pb coated on Nb, β=284
I<50 pA @ 25 MV/m for Pb coated on Nb

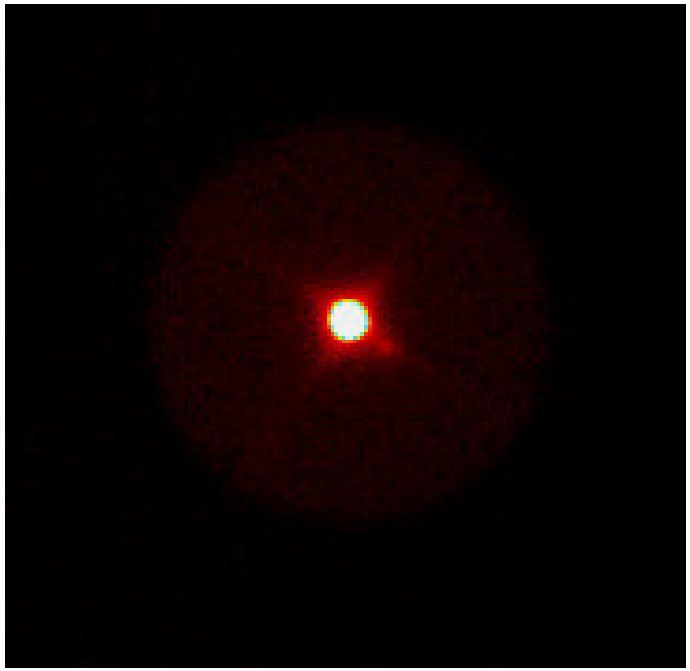


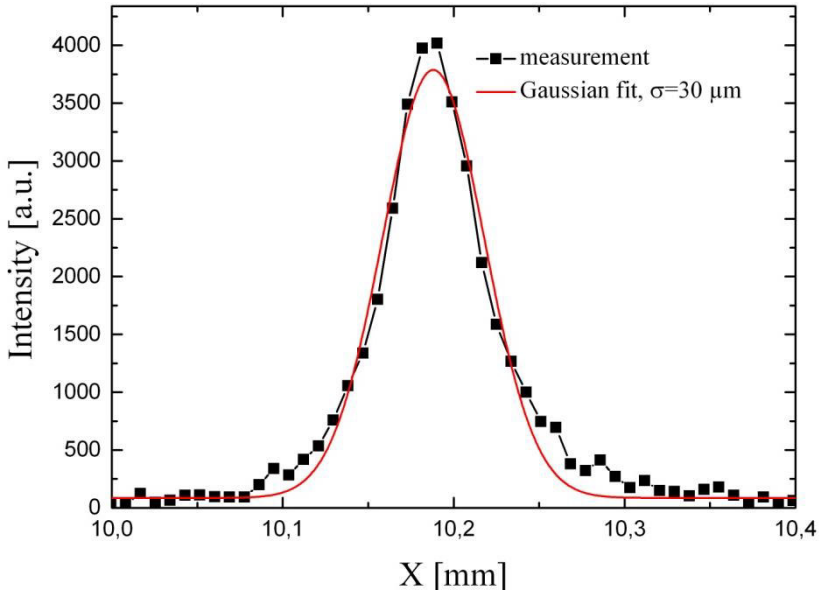




Resolution of individual emitters







Federal Ministry of Education and Research

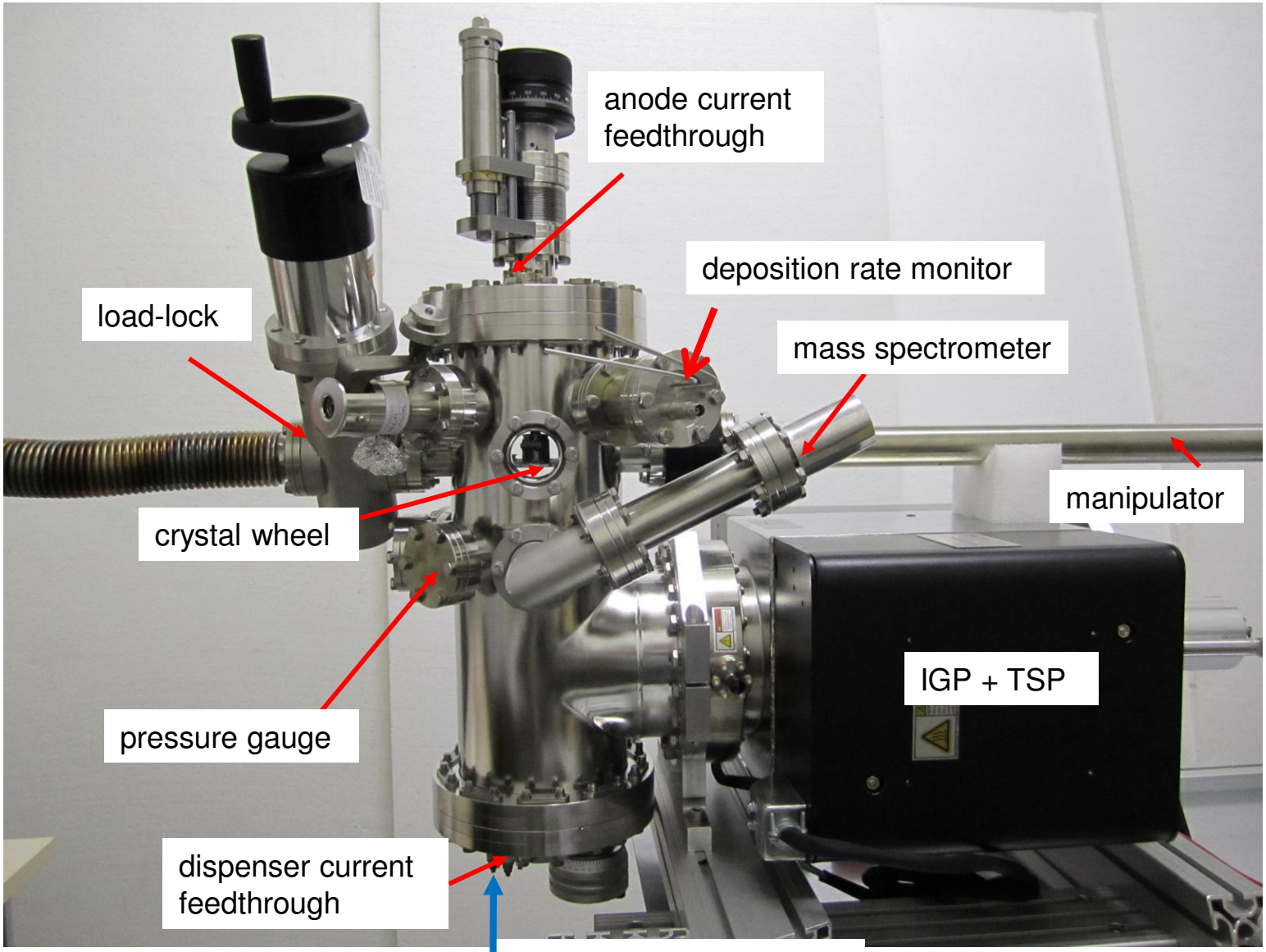
05K12CB2 – PCHB

Status K_2CsSb cathodes and time response measurements

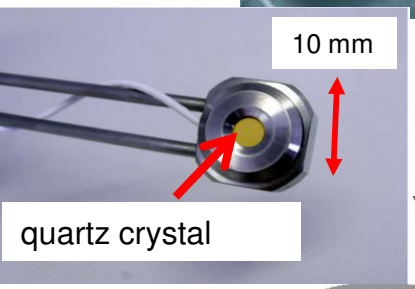
Victor Bechthold – 13.10.2014

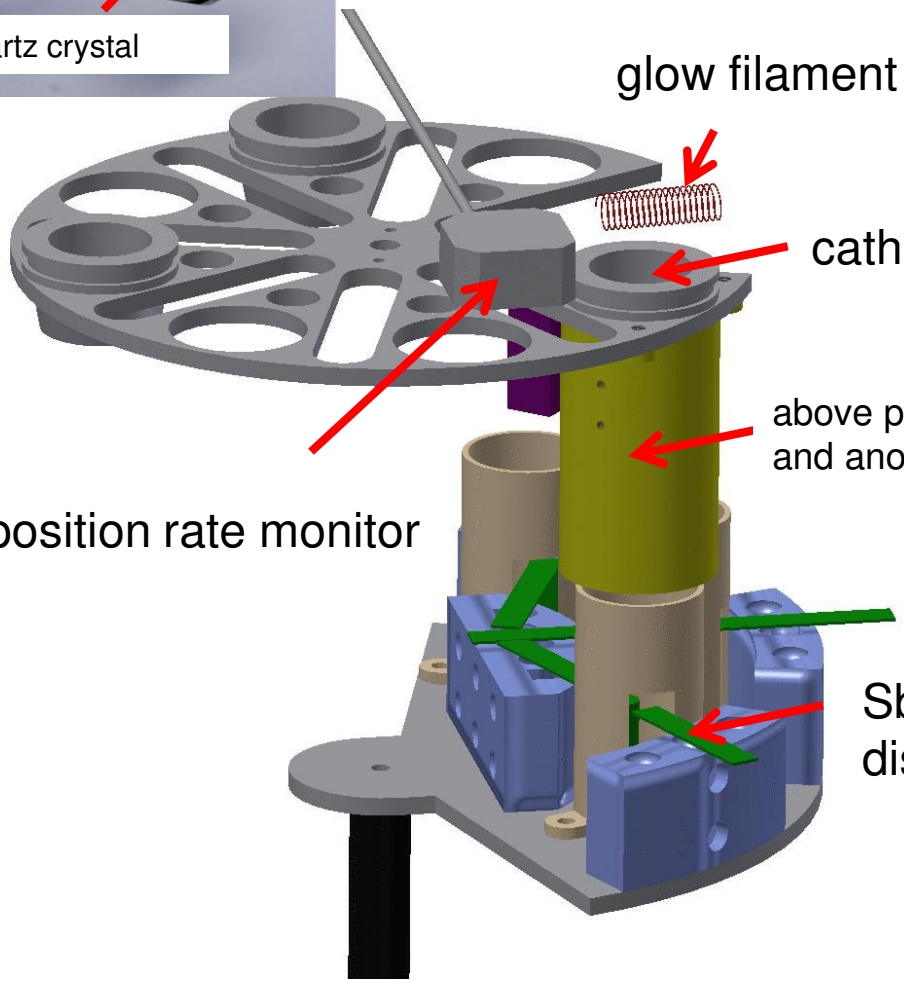
Johannes Gutenberg-Universität Mainz – Institut für Kernphysik

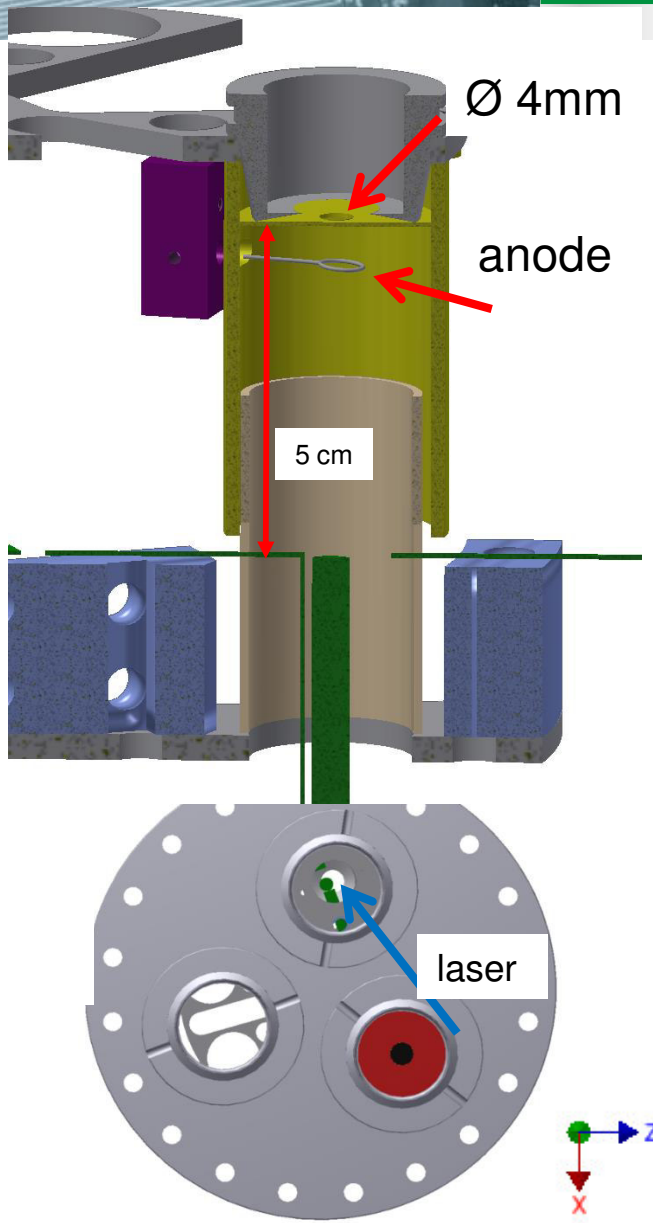
(PCA=K_2CsSb) cathode kitchen



system principle







recipes and procedure

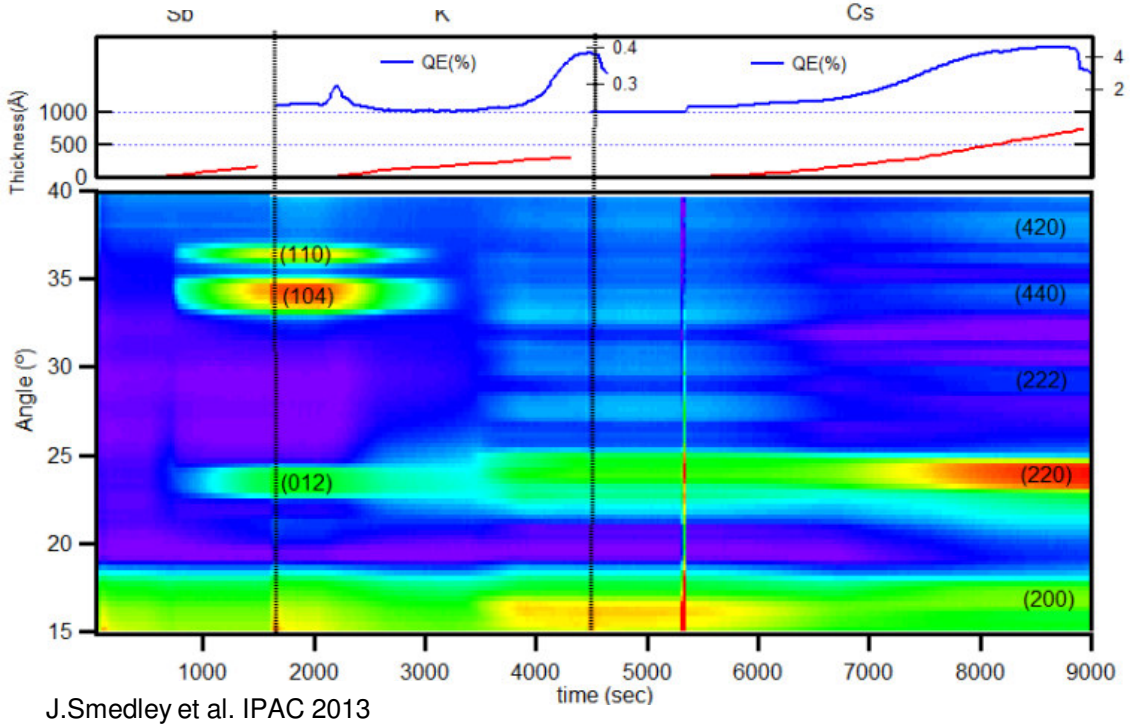
Dowell [NIM A 356 (1995)]

1. cleaning: 600°C (30min-8h)			
metal	**temperature / C°**	**depostion rate/ nm/s**	**thickness /nm**
***2.* Sb**	150	0,1-0,2	10
3. K	140-135	0,5	20
4. Cs	135-110	1	100-150

BNL [APL Mater. 1, 032119 (2013)]

1. cleaning: 600°C (30min-8h), cool down to RT, K with 0,02 nm/s for 5min			
metal	**temperature / C°**	**depostion rate/ nm/s**	**thickness /nm**
***2.* Sb**	100 /RT	0,02	8-15
3. K	135-140	0,02	- q.e.-plateau
4. Cs	135-140	0,02	- q.e.-plateau

***In-situ* X-ray diffraction (XRD) monitoring @ BNL**:



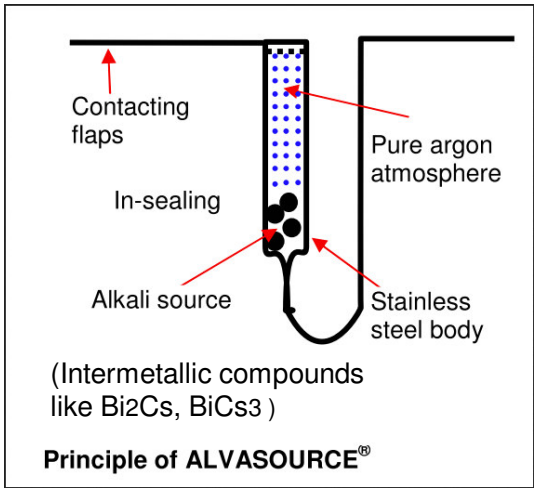
J.Smedley et al. IPAC 2013

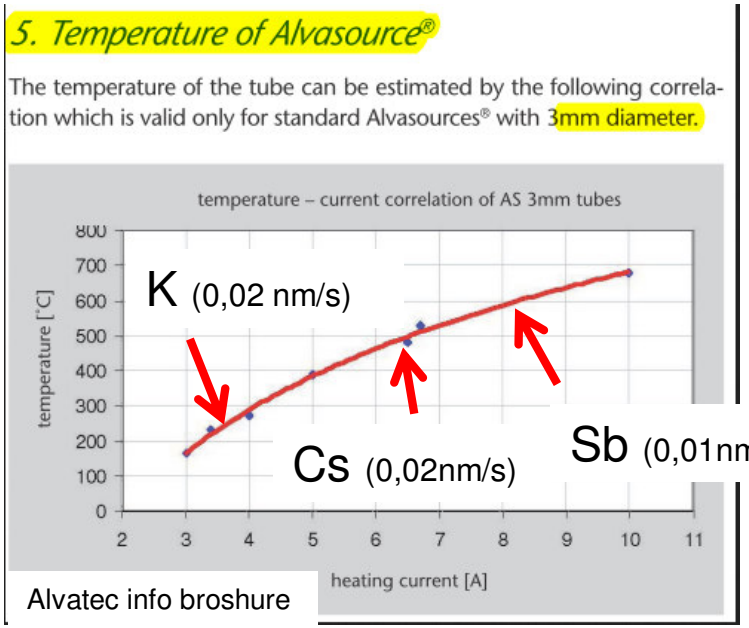
What happens?

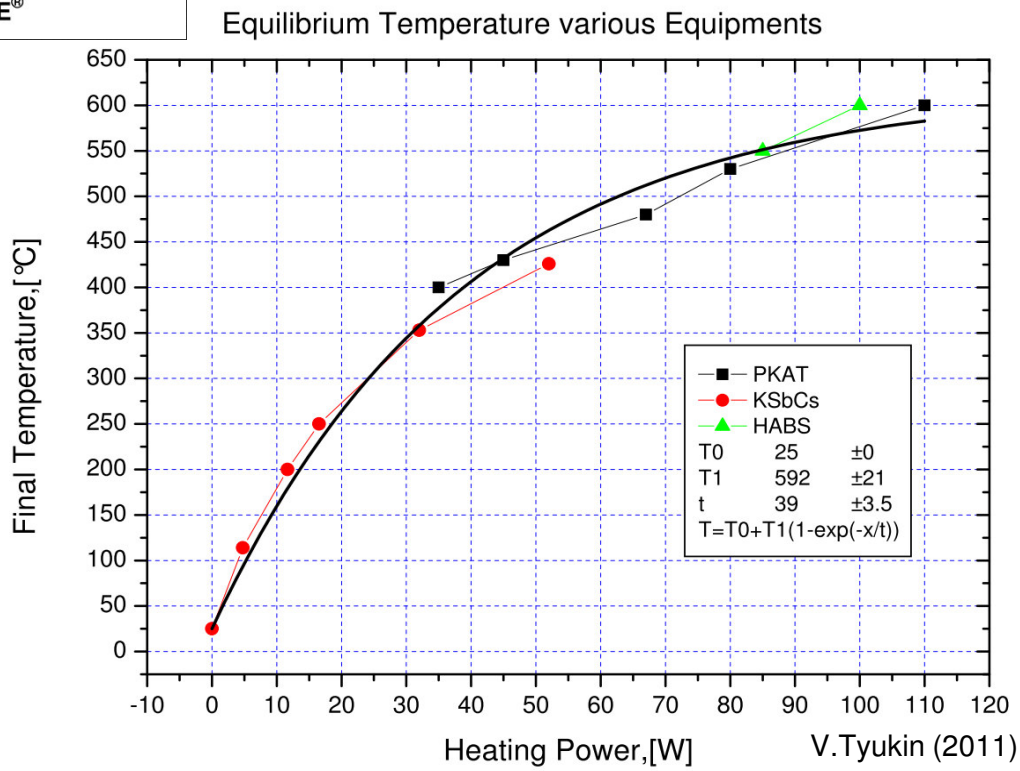
- Sb film is amorphous for the first 4nm (t=700s), then forms a clear crystal pattern [003]
- When K deposition reaches 20 nm (t=3000s) the Sb crystall begins to dissolve, K_3Sb begins to form
- A step rise in QE while Cs depostion
- While progressively cubic K_2CsSb is build QE rises exponnentially in time
- Cs catalyzes the formation of good crystals, i.e. cathode achieves defined texture [220]

Alvatec V-source:

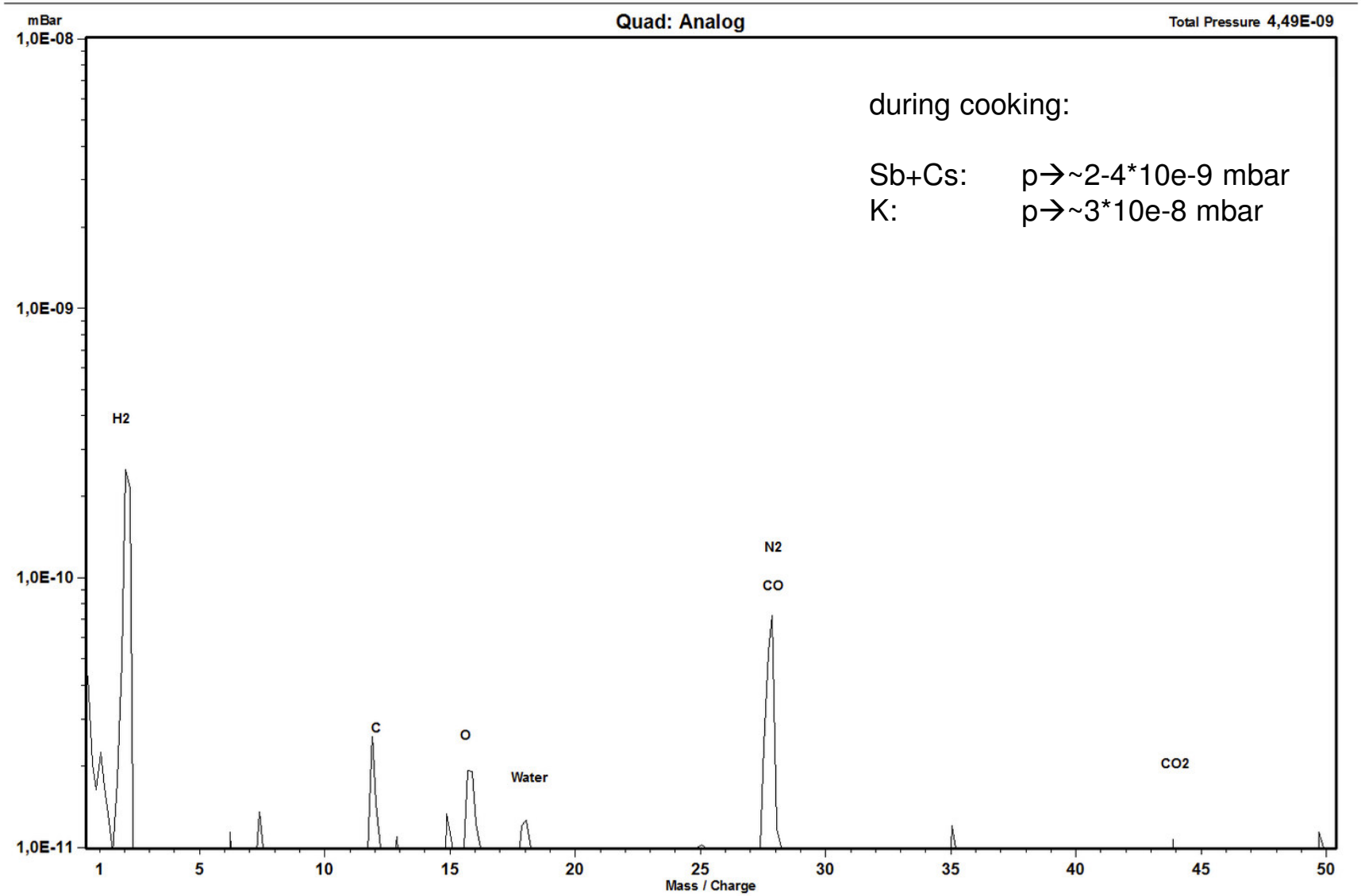
metal	content [mg]
Sb	400
K	65
Cs	250







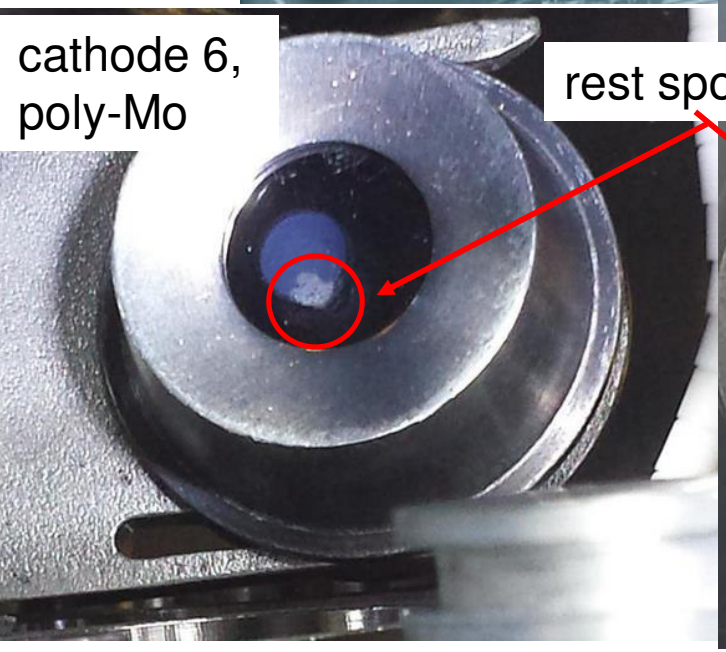
residual gas analysis

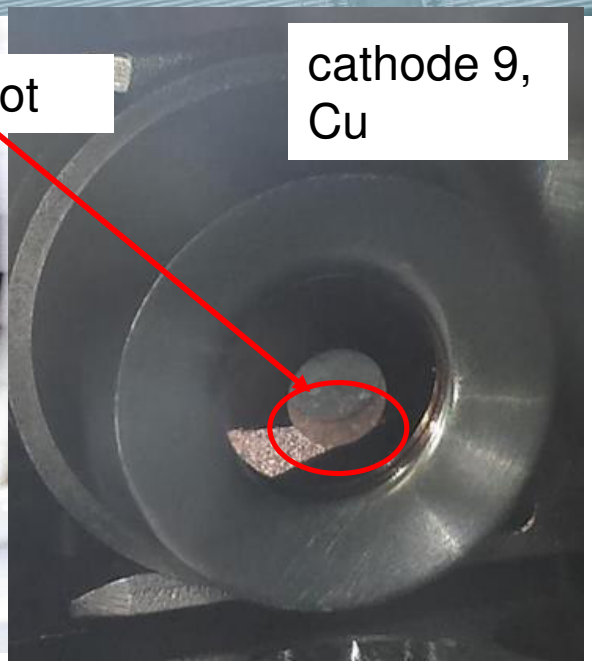


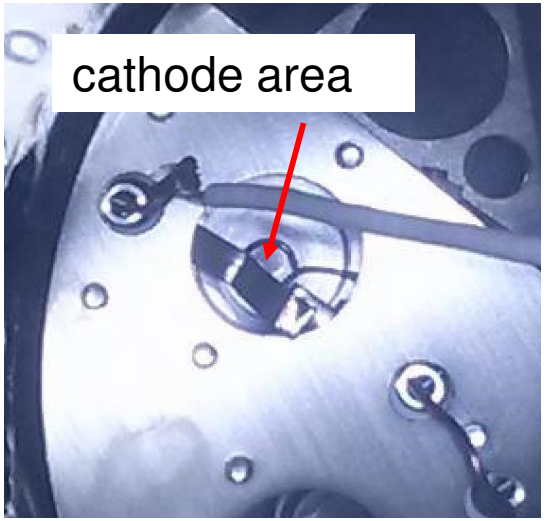
during cooking:

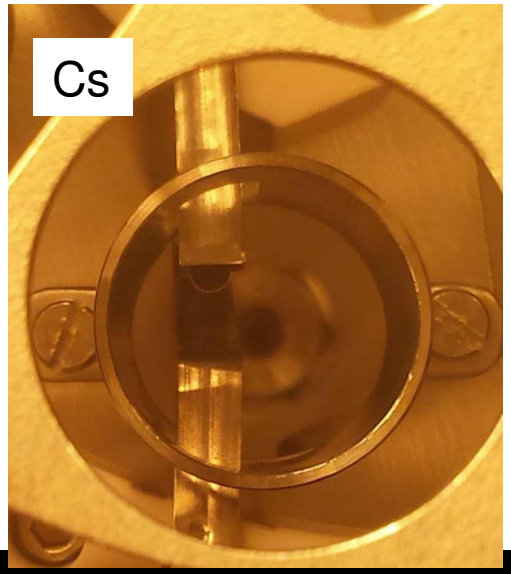
Sb+Cs: p→~2-4*10e-9 mbar
K: p→~3*10e-8 mbar

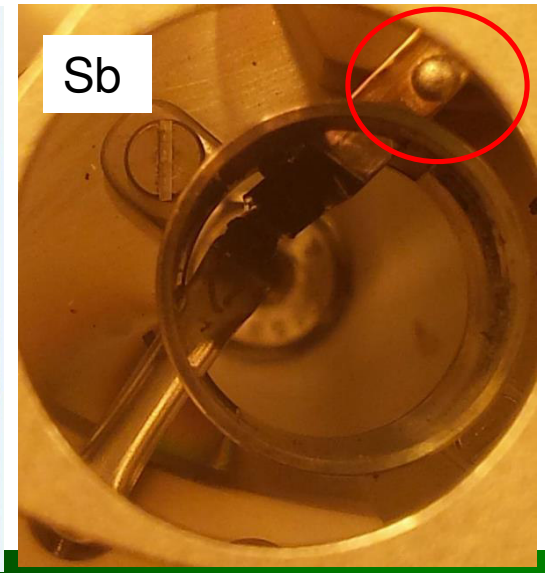
impressions











first results

#cathode / recipe	substrate	QE [%]	comment
2014-07-29 **1** Dowell	glass	0,9	(substrate not heated)
2014-08-07 **2** Dowell	Cu	(K: 0,45) 0,1	q.e. plateau reached
2014-08-28 **3** Dowell	Cu	0,05	Cs: 4 min. q.e. dicrease, 8 min increase und final dicrease till the end
2014-08-29 **4** BNL	Poly-Mo	(K: 0,6) 0,05	Cs: continuous q.e. dicrease. short (2min) and small increase after 2 and 8 min
2014-09-01 **5** BNL	Poly-Mo	0,05	Cs: continuous q.e. dicrease, short (2min) and small increase after 2 min
2014-09-04 **6** BNL	Poly-Mo	0,03	Cs: continuous q.e. dicrease for 75min (~30nm)
2014-09-05 **7** BNL	Poly-Mo	-	*CsSb* cathode, no q.e. increase with Cs
2014-09-05 **8** BNL	Poly-Mo	0,14	*KSb* cathode, expeted behaviour
2014-09-10 **9** BNL	Cu	(K: 0,7) 0,05	Cs: continuous q.e. dicrease, also with varying dispenser current
2014-09-16 **10** BNL	Poly-Mo	(K: 0,7) 1,8@edge	without above pot, i.e. without online measurement of q.e., 60-70 nm Cs

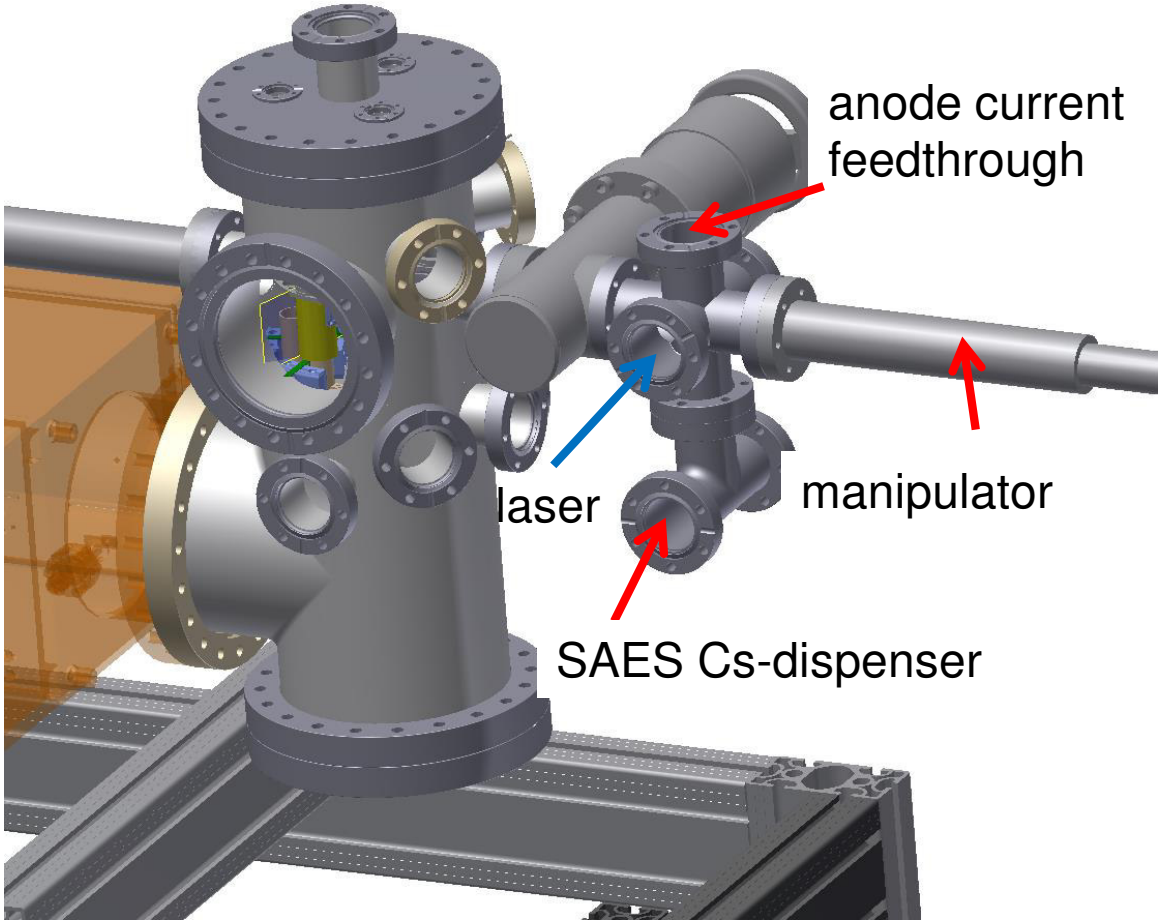
Results:

appears to function (almost), but…

Issues:

- with Sb/Cs-dispenser ?
- with „clean“ q.e. measurement
- no complete substrate cleaning possible through heating @ >600°C for many hours

ideas & possible improvements



Before opening & changing all dispensers:

- try another Cs dispenser (SAES)
- (no substrate heating)
- another position for q.e. measurement

Further possible improvements:

- new position for anode
- larger mask and anode
- new position for mass spectrometer (higher)
- more substrates, e.g. Si (100)
- TSP not yet used→better vacuum
- direct temperature measurement

- baking out the chamber below melting temperature of In (max.150°C)

#cathode / recipe	substrate	QE [%]	Comment
2014-10-10 **11** Dowell/BNL	Poly-Mo	(K:0,3)	Cs: continuous q.e. dicrease, main issue seems to be Sb dispenser

time response measurements @ PKAT

principle of electron pulse generation

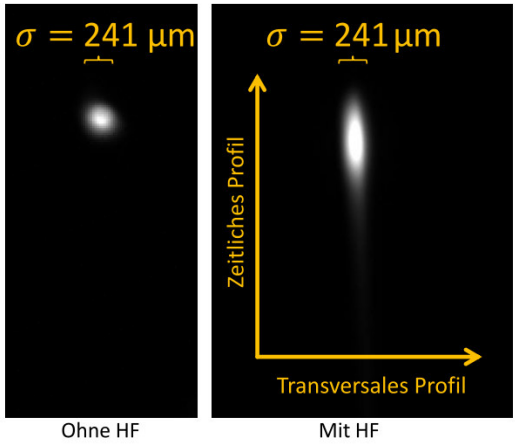
laser pulses (red) generate electron pulses (green) synchron to RF

- TM_{110} cavity transforms longitudinal beam profile into a transversal one
- synchronization of electron bunches and RF cavity needed for observation
- resulting intensity disturbation represents the time dependency of electrons in one bunch
- measured by YAG-screen and channeltron

preliminary results

Beam profile on YAG-screen

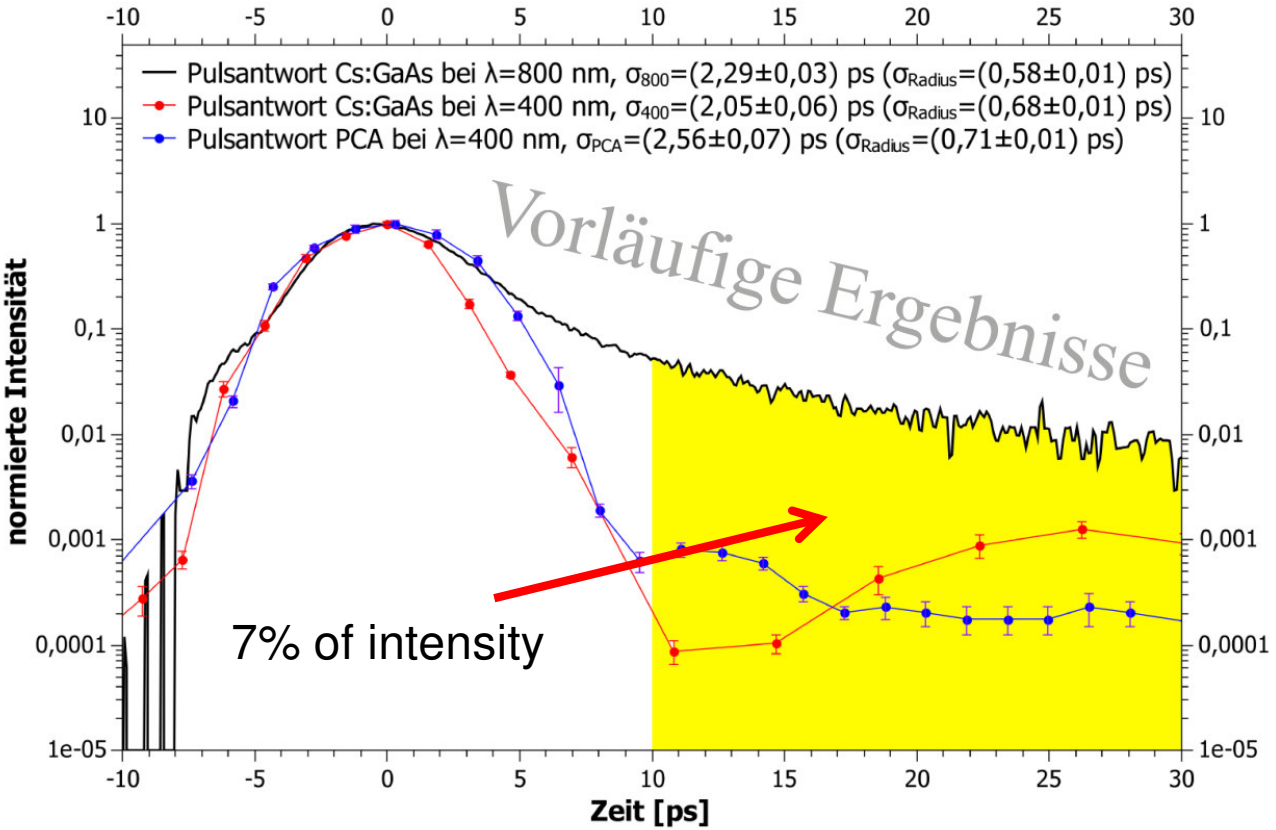
Intesity disturbation is convolution of transversal beam diameter and pulse response



[E. Kirsch, diploma thesis, JGU Mainz 2014]

time response:

→beam halo measurement



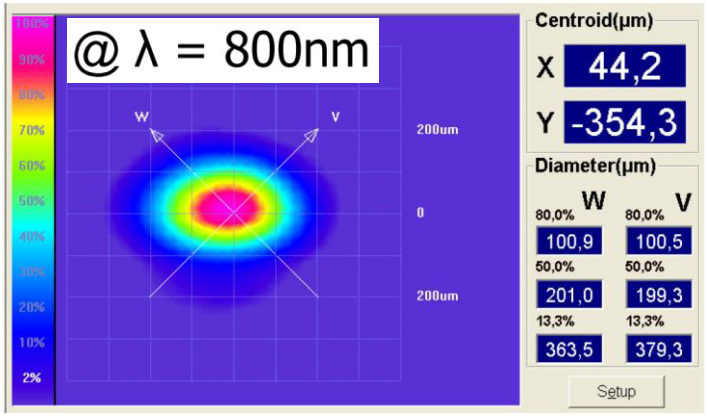
[E. Kirsch. diploma thesis, JGU Mainz 2014]

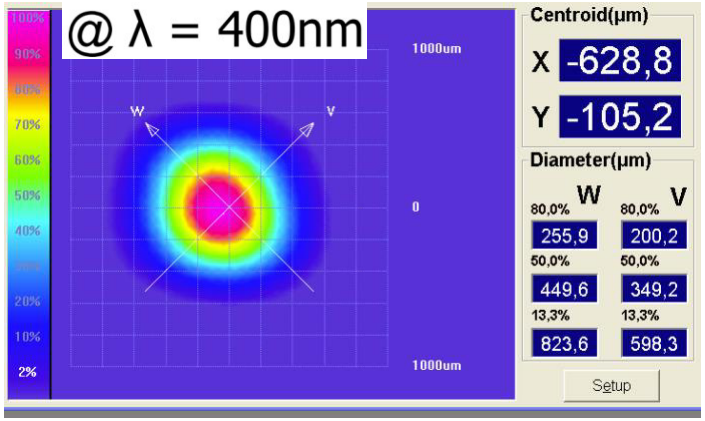
further challenges

- time resolution mainly depends on beam size:

→minimize laser spot

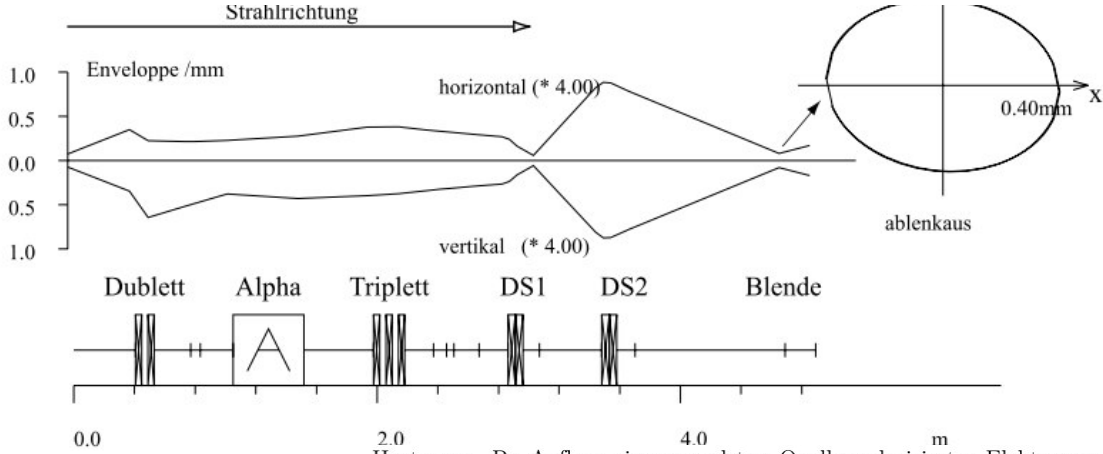
$\sqrt{d_{laser\ spot}} \sim d_{electron\ beam}$



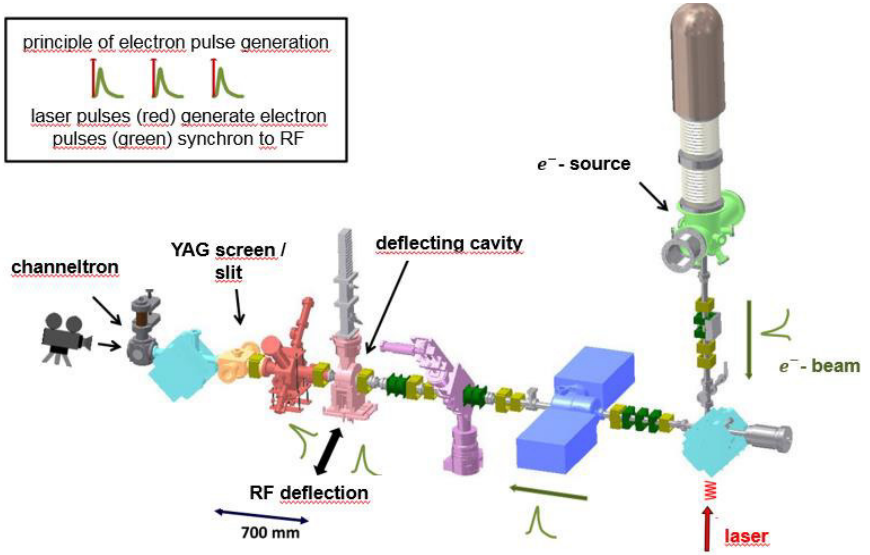


[E. Kirsch, diploma thesis, JGU Mainz 2014]

→minimize beam spot @ slit (new position!), new focusing system?



Hartmann, P.: Aufbau einer gepulsten Quelle polarisierter Elektronen. Johannes Gutenberg Universität Mainz, Dissertation, 1997



outlook

PCA-cathodes

- carry out possible improvements @ PCA-kitchen
- measurements of time response, lifetime, q.e. chart., spectral analysis etc.

time response / PKAT:

- reinstall and repeat measurements done by E.Kirsch (2013)
- improve time resolution to t= 2σ< 1ps
- analysis of beam halo at a level of $<10^{-6}$ of max. energy after excitation

PCHB-Projekt Overview

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- PCHB
  Photo**C**athodes for **H**igh **B**rightness, high average current electron beams
- Kollaboration verschiedener Institute
  - Helmholtz-Zentrum Berlin (HZB mit ERL bei BerLinPro), Helmholtz-Zentrum Dresden Rossendorf (HZDR mit ELBE), Johannes Gutenberg-Universität Mainz (JGU), Saint-Petersburg State Polytechnic University (SPSPU), Skobeltsyn Institute of Nuclear Physics Lomonosow Moscow State University (MSU)
- Aufgabenbereich der JGU
  - Messungen der Impulsantworten verschiedener Photokathoden bei 800nm und 400nm anregender Laserwellenlänge
    - K_2CsSb (PCA)
      Sowohl aus eigener Herstellung als auch im Rahmen der Kollaboration mit HZB und HZDR aus deren Herstellung
    - Cs:GaAs
      Verschiedene Typen
  - Ziele
    - Zeitauflösung von 0,5ps
    - Dynamikbereich in der Intensitätsauflösung von 5 Größenordnungen
  - Entwicklung und Inbetriebnahme einer neuen 100keV-Photoemissions-Elektronenquelle
    - Variabler Extraktionsgradient : 1 - 5MV/m
    - Inverses Design

PCHB-Projekt Overview

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- STATUS
- What can be done until summer 2015
- What will we do after summer 2015

PCHB-Projekt Status

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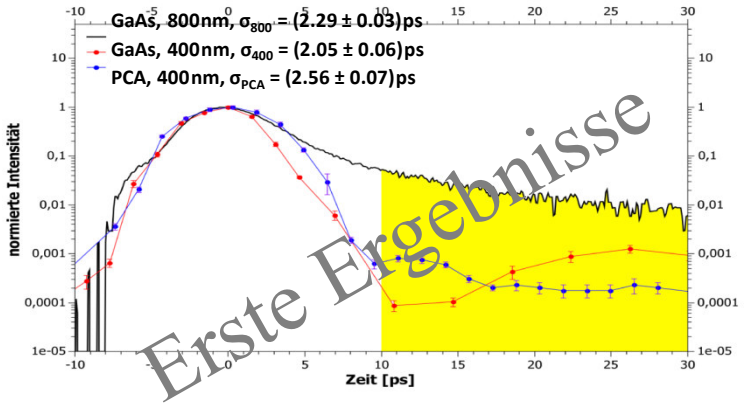

Summertime sadness….

- May:source broken, (vented)
- June: repaired, but broken again (vented)
- August : Repaired but…
- Now:Manipulator broken
  (vent activation chamber)
- expected to work againg in November

- Measurements promising, objectives for the apparative parameters almost reached
- Measurements neither reproduced nor completed, let alone being published
- PCA cathodes may become available, at least Kalium cathode is almost certain.
- minimum Goal: Monika,Victor do experiment with K (?:KCsSb,GaAs) and publish.
- →Variable gradient source must be deprioritized to allow for measurements
- → probably not be available before end of project in summer 2015.

Additional logistic problem: TLS experiment not yet finished.

Whats next?

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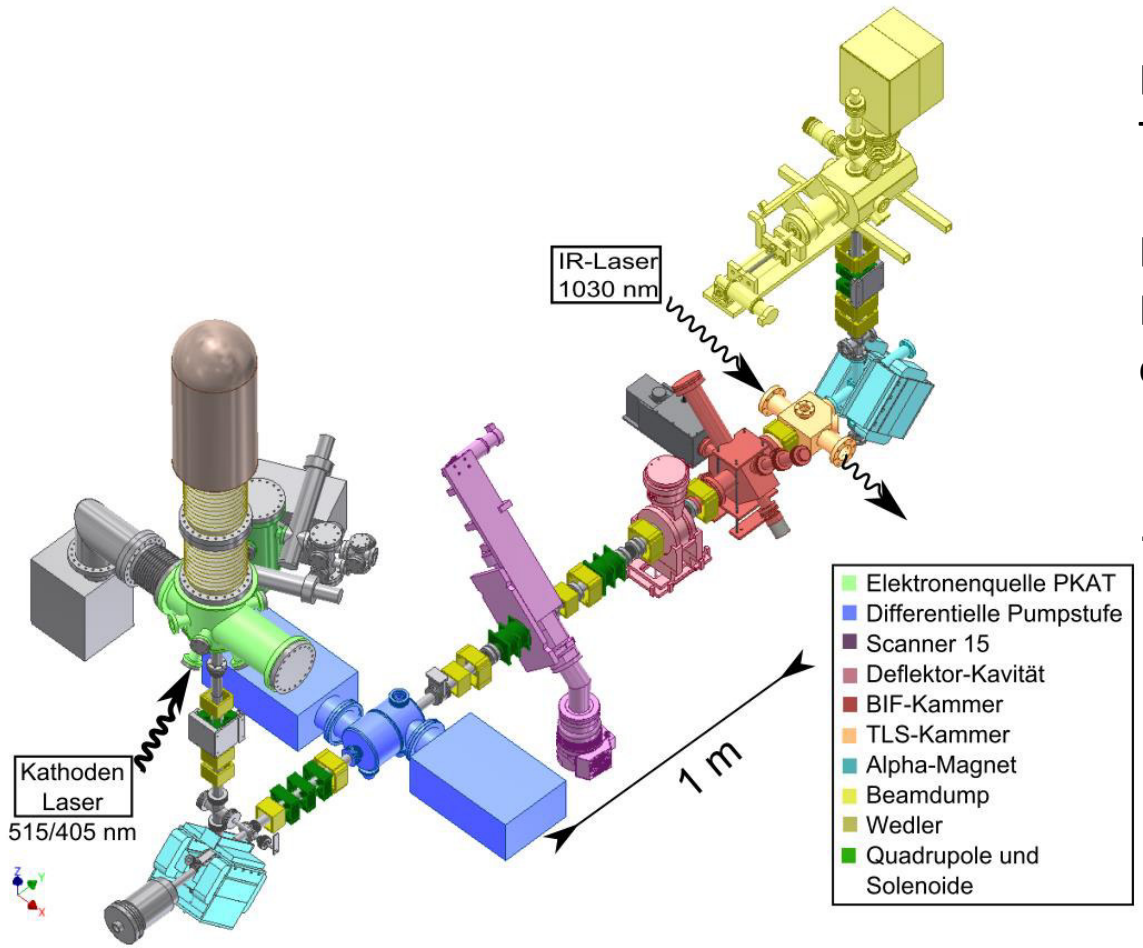

Further complication:

Laboratory is too crowded, because Tobias‘ project is ongoining (TLS)

LOTOS-project:
Move TLS to set-up
of the „HOPE“-source in hall MESA-2!

→ Frees space for
Nahid & Monika,

LOngitudinal
ThOmson
Scanner

..promises ultra high time resolution ! ..but we plan only Demonstation experiment

LOTOS

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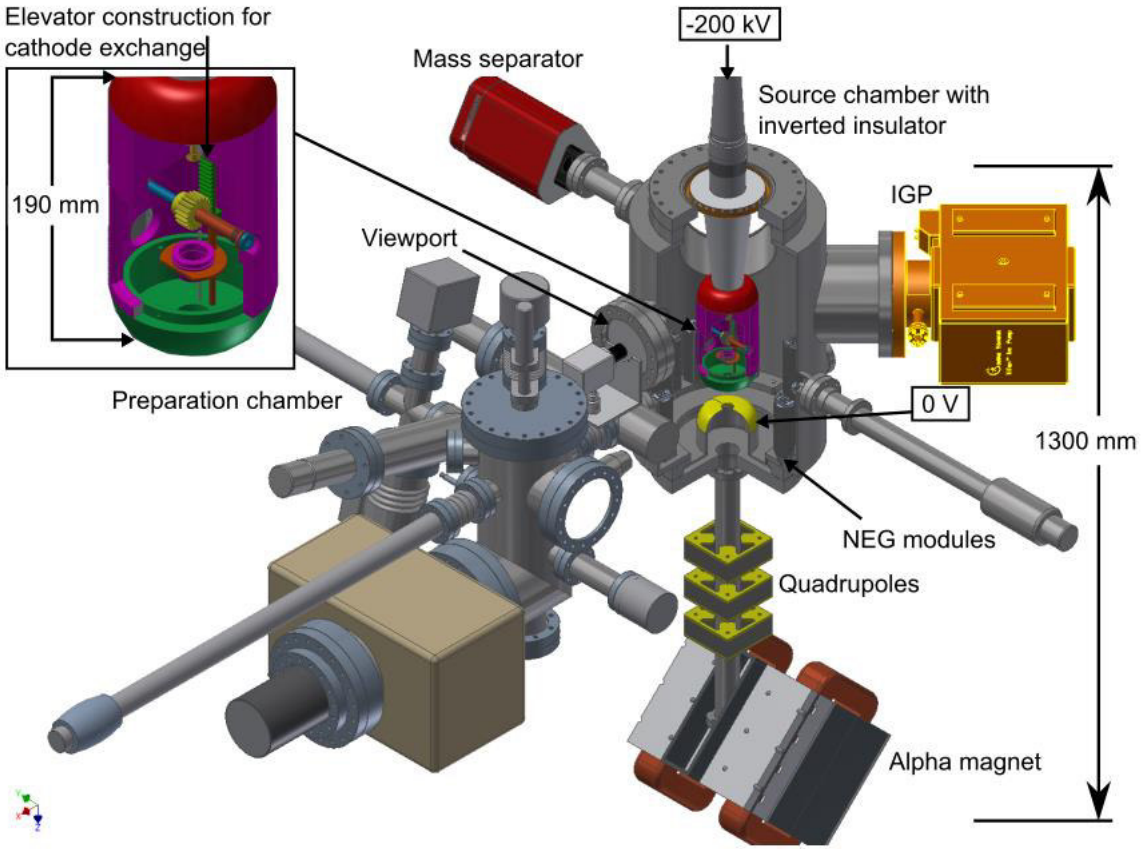

The problem for TLS is the low peak current in the 20 ns long pulse of Tobias Experiment (~50-100mA). The new ‚HOPE' source should give up to five Amperes. High peak current allows for longitudinal TLS

100ps LOTOS

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TDC Histograming

Rek. Signal (limited by Resolution of detection)

PMT-Pulse

Experiment requires „only“ to build (in Hall MESA-2) beamline &buncher
→ Victor
+ Optical detection system (additional Phd student)

Fast PMT

Thomson Photons

Unbunched el: 20ns

1,3 GHz buncher

Photocathode In 100-200keV source

bunched el: ~26 pulses ~70ps, 700ps Period

20ns

Laser 1050nm

timing

Laser 525nm

Sub ps LTLS

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