PAUL SCHERRER INSTITUT

PSI

A. Zandonella :: Vacuum :: Paul Scherrer Institut

Load-lock systems and cathode holder at PSI

EWPAA 2019:

European Workshop on Photocathodes for Particle Applications

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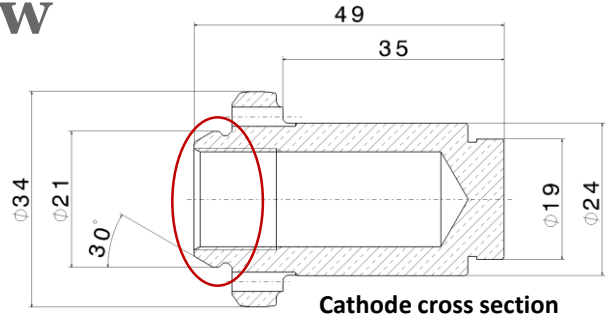
Cathode Systems Overview

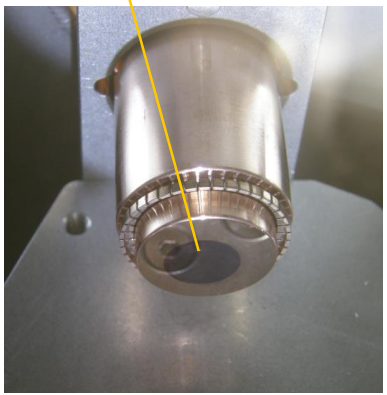
Cathode

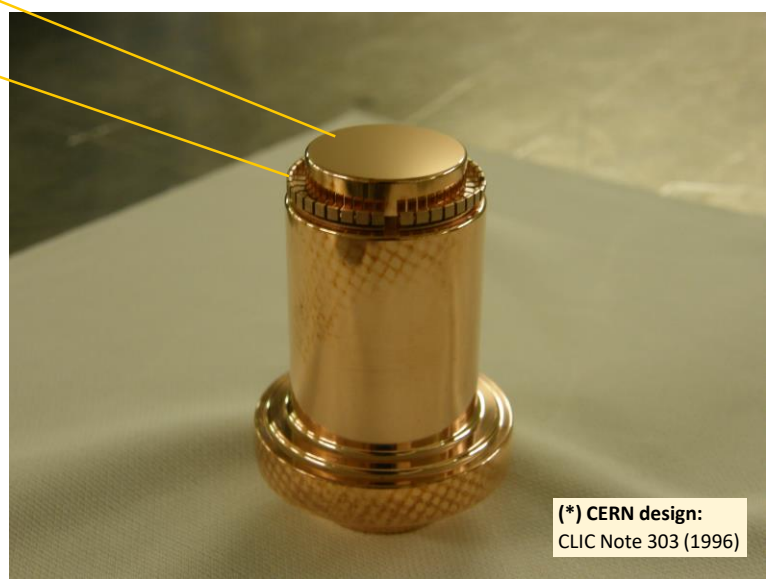
- Design with challenging interface for cathode grabbing *
- Cathode material: Cu-OFE
- Surface roughness Ra 0.1
- RF-contact spring
  Material: CuBe2 (annealed)

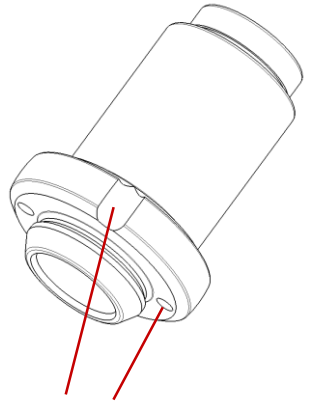


Cathode cross section

Cathode with coating
Cs2Te layer (ø=1cm; 40 nm)







Grooves (2) and bore holes (2) for cathode grabbing

Cathode Systems Overview

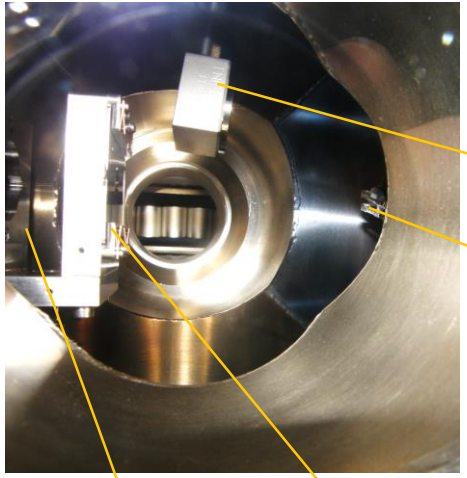
Cathode preparation system

Microscope camera
Inspection of Cs2Te coating through window port mounted on the linking chamber

Cathode annealing and QE measuring chamber (p<5x10^{-10}mbar)

Linking chamber (p=5x10^{-9}mbar)
With rotating carousel holding 4 cathodes
- Introduction of new cathodes in the system
- Exchange of the cathodes between chambers
- NexTorr vacuum pump (NEG/SIP)
- Separable vacuum chambers by gate valves

Cs2Te Evaporation chamber (p<5x10^{-10}mbar)
- Blind deposition: 15nm Te / 25nm Cs

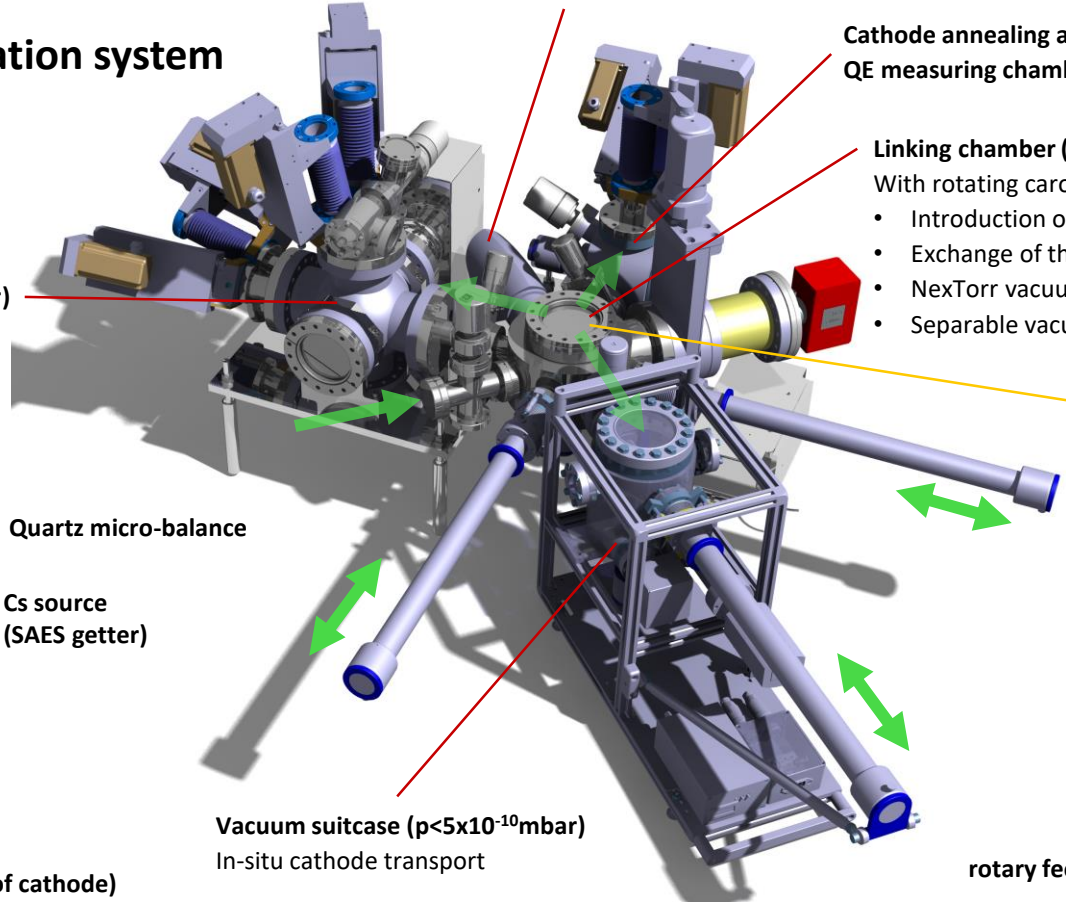


Quartz micro-balance

Cs source (SAES getter)

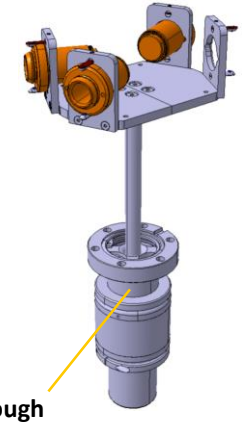
Cathode holder

Aperture (in front of cathode)



Vacuum suitcase (p<5x10^{-10}mbar)
In-situ cathode transport

Carousel for storage of 4 cathodes



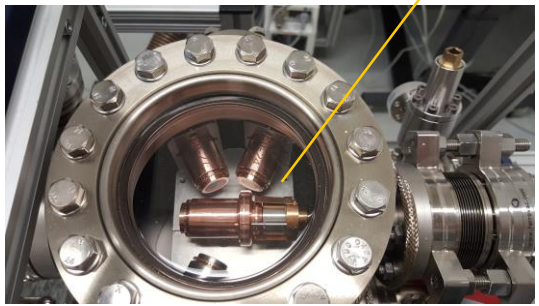
rotary feedthrough

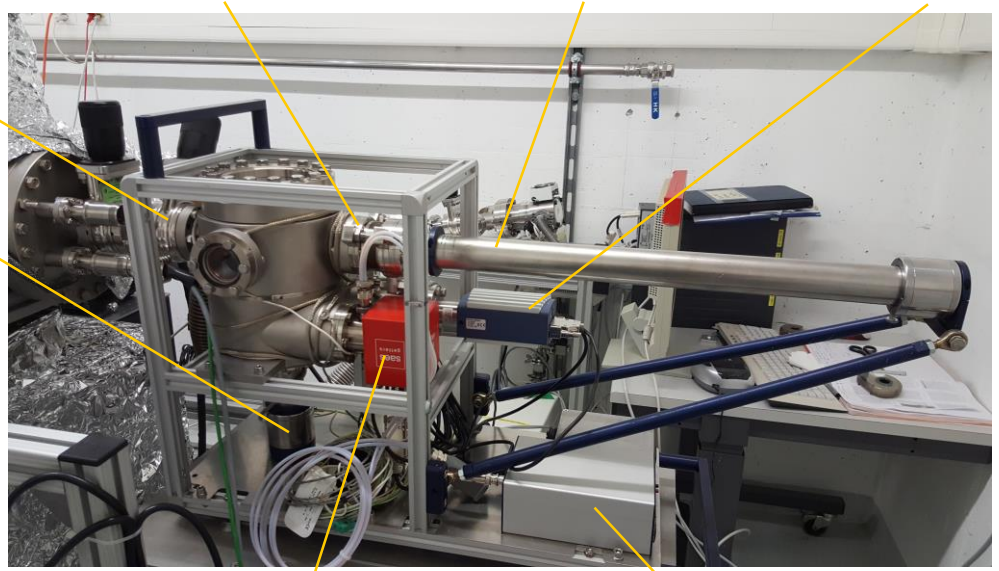
Cathode Systems Overview

In-situ cathode transport

To avoid contamination of the Cs2Te cathode surface at atmosphere the cathodes are transported in a so called **"vacuum suitcase"** from the preparation system to the photo injector

- Designed by Ferrovac GmbH
- Pressure < $5x10^{-10}$mbar
- Weight: 10kg





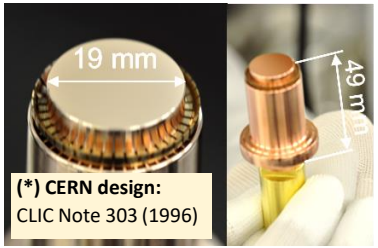
Cathode Systems Overview

Cathode load-lock system (Photo injector)

To reach a stable resonant frequency in the gun the RF-contact spring on the cathode has to be pushed with a force of ~500N into the cathode plug reception of the photo injector (gun).

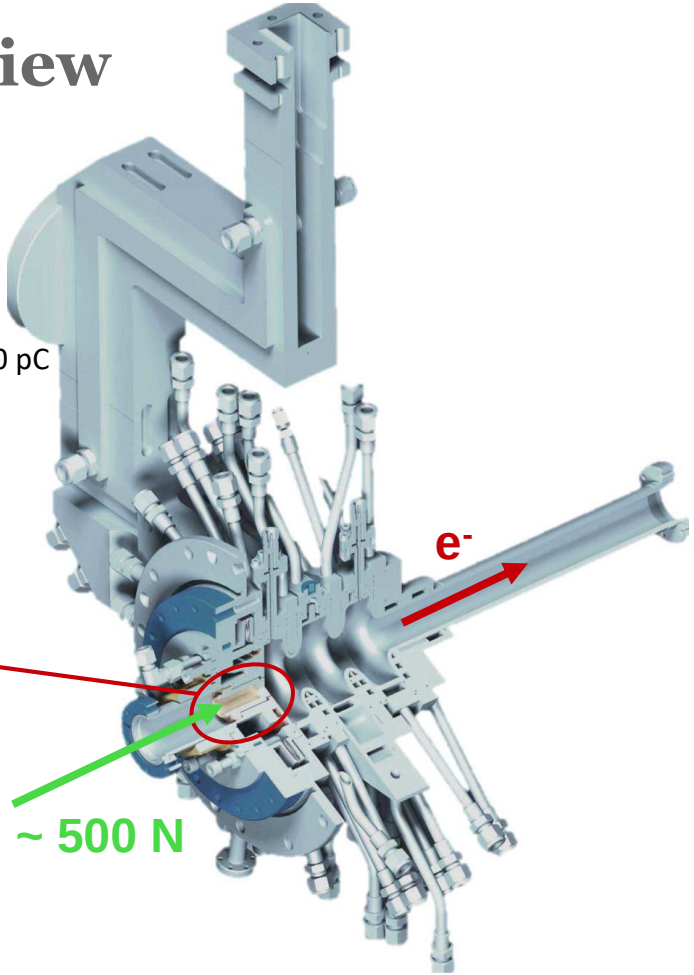
SwissFEL RF Photo injector:

- S band, 2.5 Cell; 7 MeV;
- 100 MV/m; 100 Hz; 10 - 200 pC



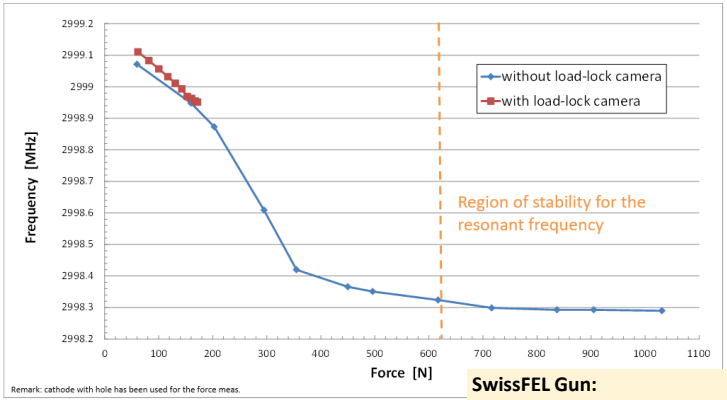
(*) CERN design:
CLIC Note 303 (1996)

Exchangeable cathode plug *



Example of a force vs. frequency measurement at PSI:

Positioning of the cathode (2): measurement of the force



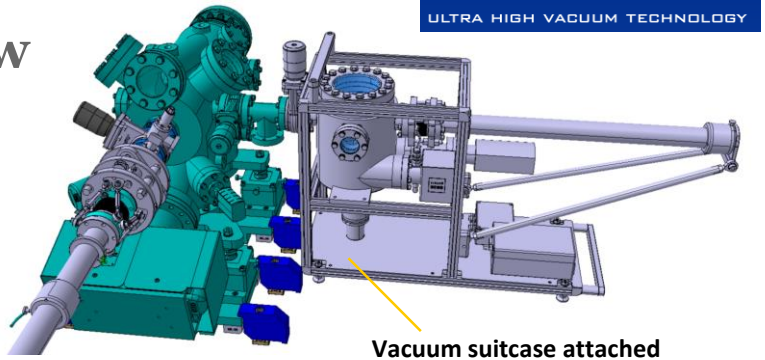
SwissFEL Gun:
low-power measurements in WLHA 9/5/14
A.Citterio, M.Bopp, L.Stingelin, D.Bieri, N.Gaiffi

Cathode Systems Overview

Cathode load-lock system (Photo injector)

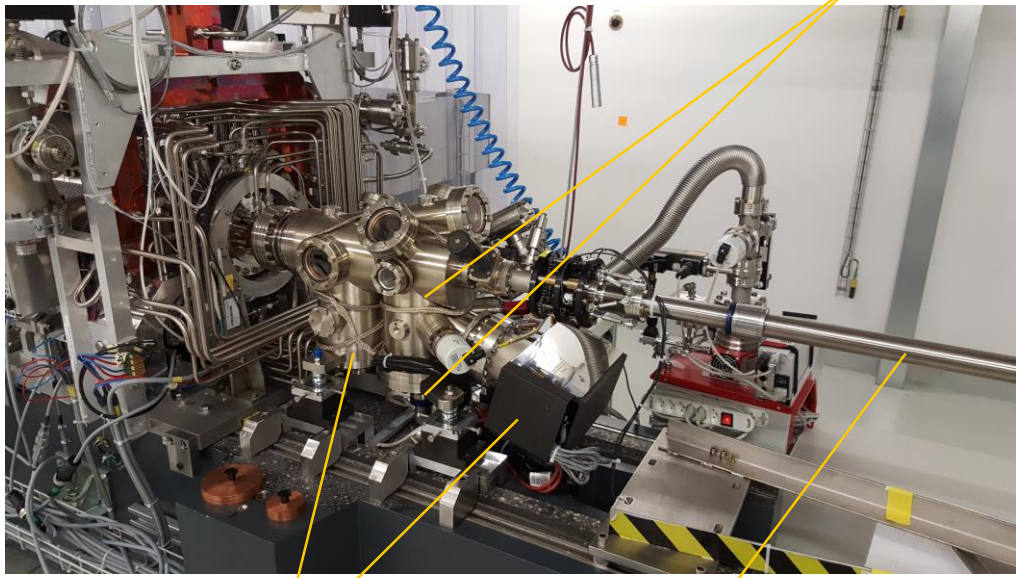
Through a short load lock with discreet pumping the cathodes can be transferred in-situ from the vacuum suitcase to the load lock chamber.

- Designed by Ferrovac GmbH
- Pressure < $5x10^{-11}$mbar



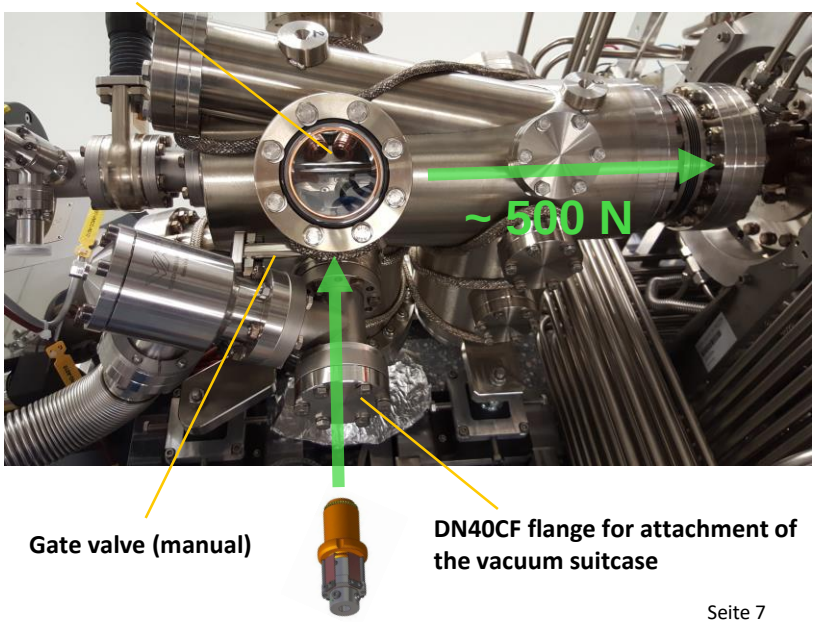
Vacuum suitcase attached to the load-lock chamber

Rotary feedthrough with carousel holding 4 cathodes



vacuum pumps (NEG/SIP)

Linear rotary feedthrough



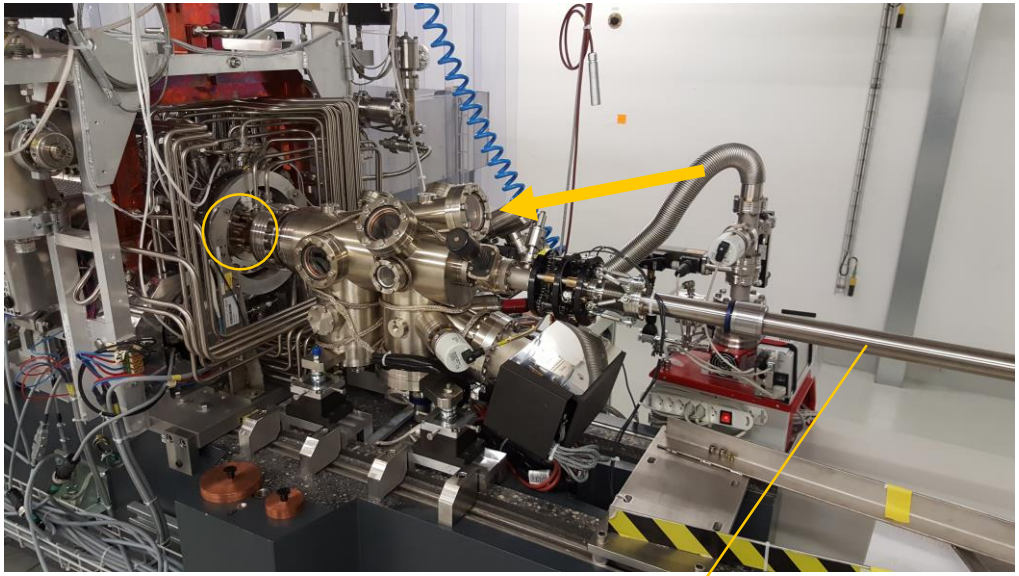
Gate valve (manual)

DN40CF flange for attachment of the vacuum suitcase

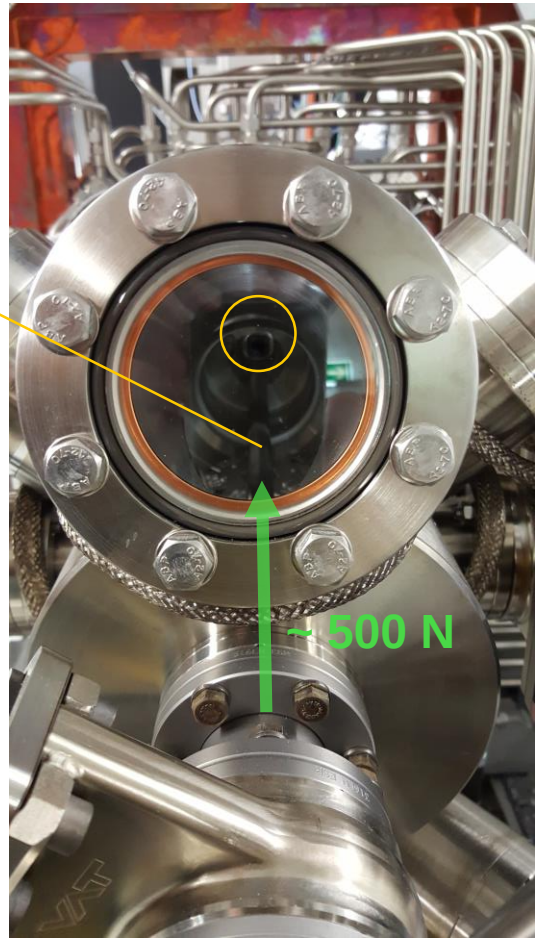
Cathode Systems Overview

Cathode load-lock system (Photo injector)

The linear rotary feedthrough grabs a cathode from the carousel. Shaft, grabber and cathode are then pushed into the cathode plug reception of the photo injector



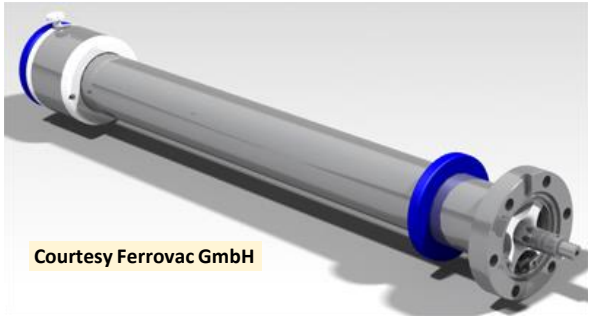
Linear rotary feedthrough



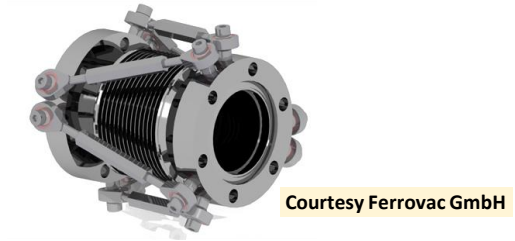
Manipulation of the cathode

Cathode transfer in between chambers, storage and grabbing

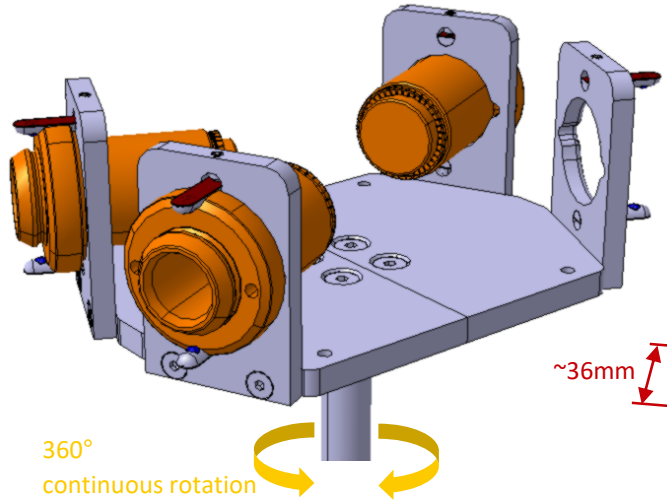
The transfer of the cathodes in between the UHV chambers is done with magnetically driven linear rotary feedthroughs.



Each feedthrough is equipped with a **port-aligner** to adjust the transfer level

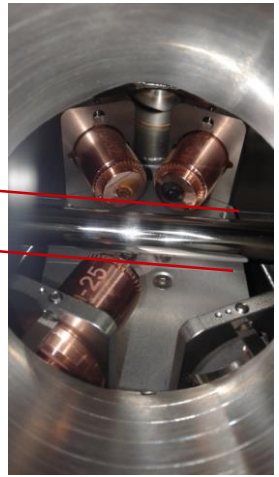


The cathodes are **stored** on stainless steel plates with a bore hole, mounted vertically on a base plate. The two grooves on the outside diameter of the cathodes collar are used to hold them in position.



Carousel with storage for 4 cathodes, mounted on magnetically driven rotary feedthrough

Clearance for cathode transfer

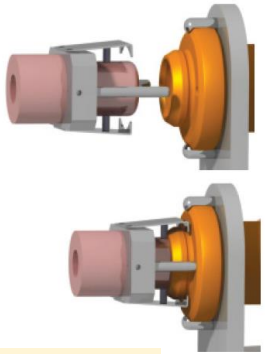


Manipulation of the cathode

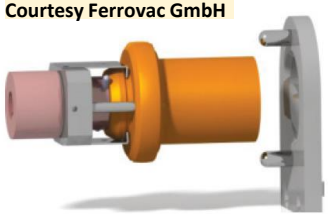
Cathode transfer in between chambers, storage and grabbing

Issues with the 1st grabber type

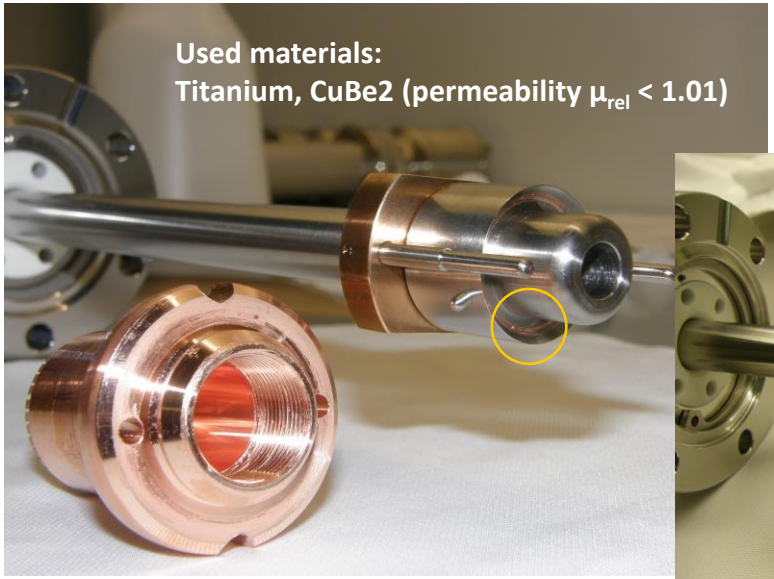
- The cathode get stuck in the grabber due to vacuum erosion
- The cathode was not in line with the manipulator shaft ("hang down")

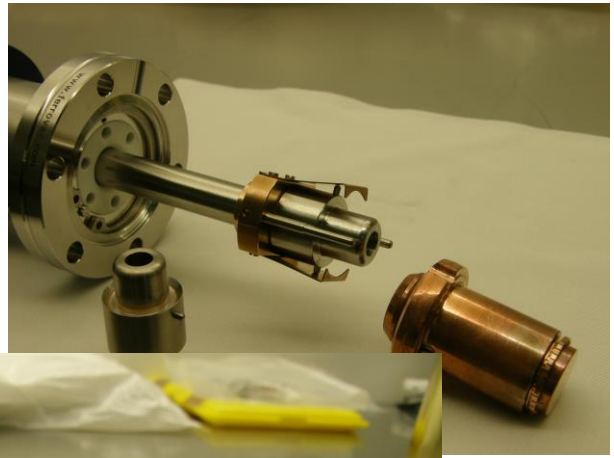


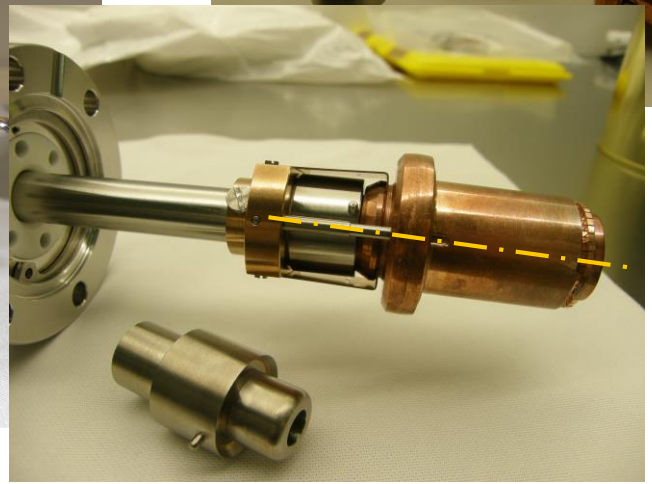
Courtesy Ferrovac GmbH



Concept of the cathode grabbing mechanism





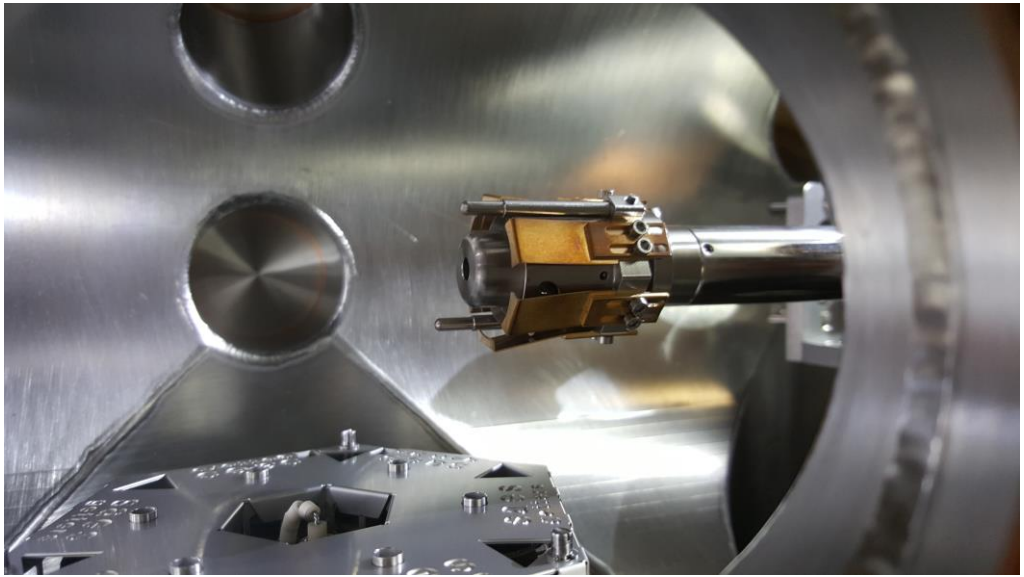


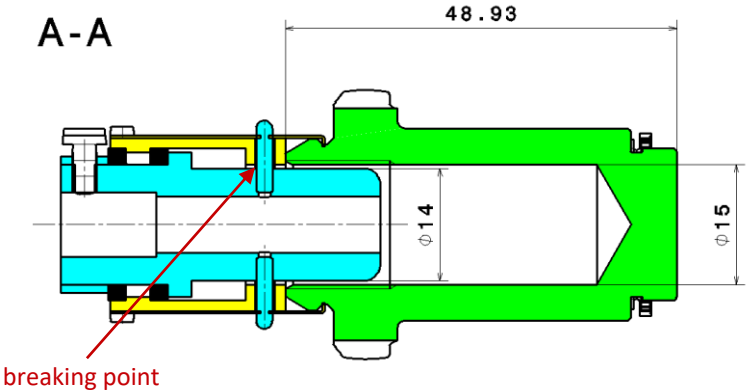
Manipulation of the cathode

Cathode transfer in between chambers, storage and grabbing

1st improvements of the cathode grabbing mechanism

- New concept without friction between cathode and grabber
- 6 adjustable leaf springs to avoid “hang down” of the cathode





Result with the 2nd grabber type

- The cathode didn’t get stuck anymore
- The problem with the “hang down” was improved

Issues with the 2nd grabber type

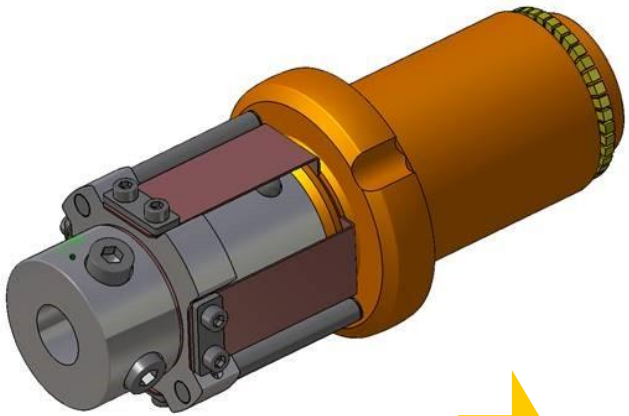
- The opening pins were to thin and broke
- The leaf springs started to fatigue after a while

Manipulation of the cathode

Cathode transfer in between chambers, storage and grabbing

3rd improvements of the grabber

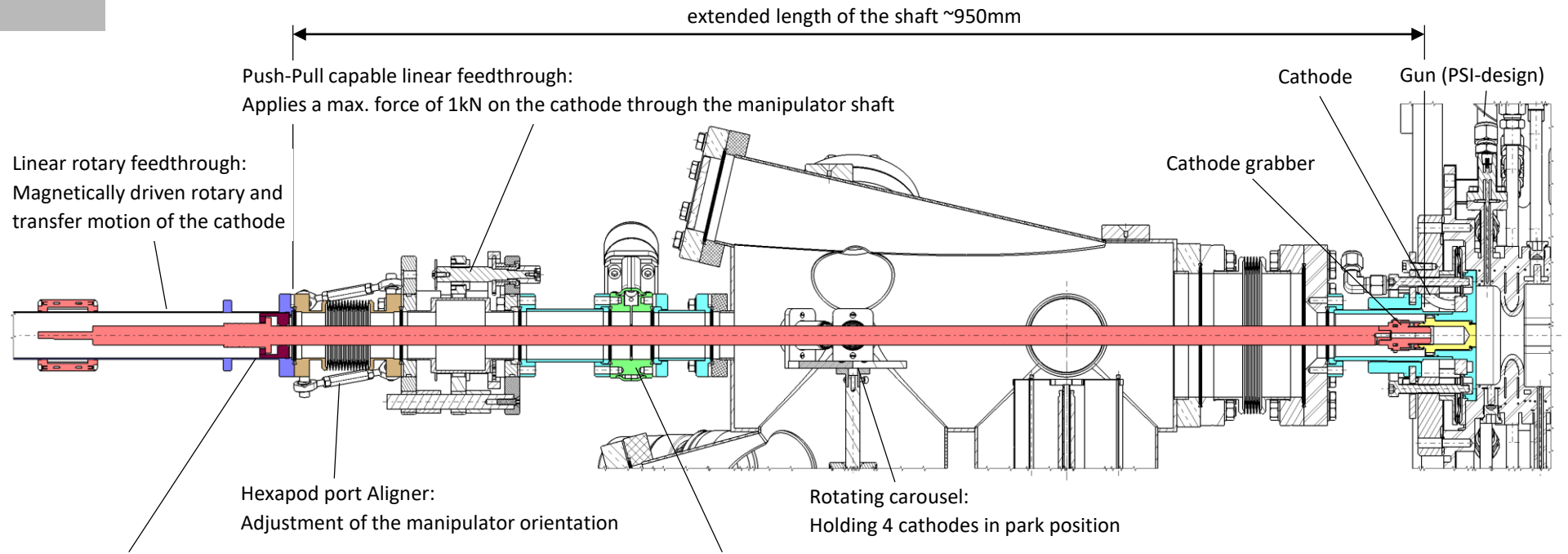
- Thicker opening pins
- Thicker leaf springs (but reduced amount of springs for a reasonable opening torque)
- Spring material: CuBe2 (annealed)



This last version of the grabber is currently built-in the cathode preparation system for test purpose

Manipulation of the cathode

Cathode pushing mechanism in the load-lock system



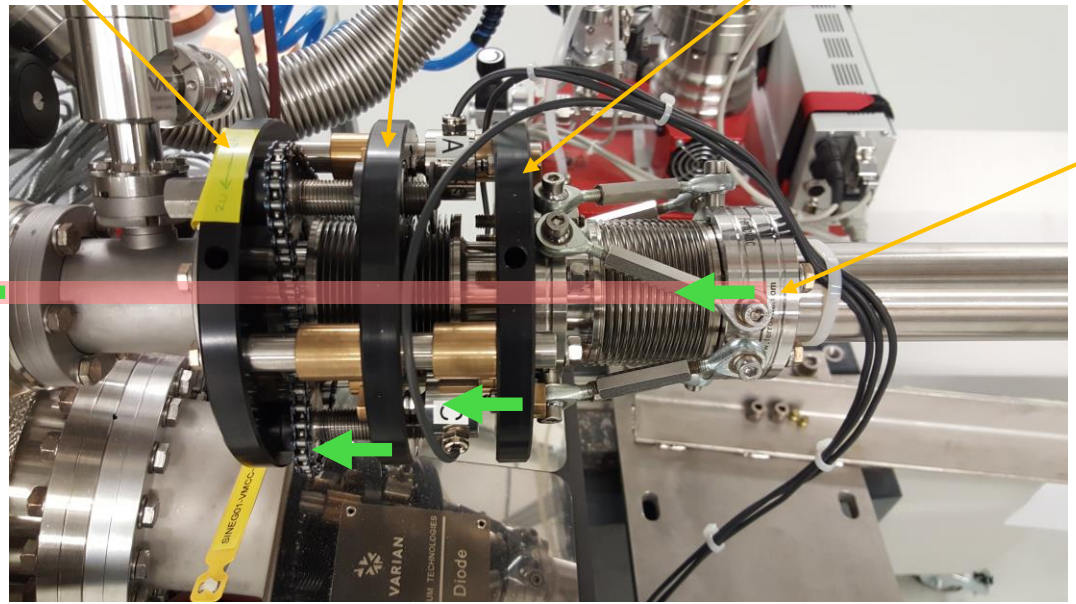
Manipulation of the cathode

Push-Pull capable linear feedthrough with force measurement

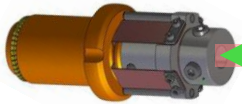
fixed base plate
connected to CF40 flange of the bellows
and the load lock chamber

moveable intermediate plate
actuated by 3 threaded spindles
mounted on the base plate

moveable pulling and pushing plate
connected to the intermediate plate with 3 force transducers
and the 2nd flange of the bellows



bayonet coupling inside the manipulator
to guarantee force closure from the linear
feedthrough to the manipulator shaft



~ 500 N

Manipulation of the cathode

Ideas for improvements on the load-lock system

Issues:

- The pushing force measurement is not accurate enough due to…
  - the own weight of the manipulator
  - The elasticity of the long manipulator shaft
  - Deformation of the photo injector, which is slightly deformed when applying force

For a future design of the load-lock the concept must consider…

- The shortest possible manipulator shaft length
- A force measurement in the direct line of force
- A force closure with the photo injector, to avoid any deformation when pushing (decoupling must still be guaranteed)

Wir schaffen Wissen – heute für morgen

Many thanks to:

- Romain Ganter
- SLS vacuum team
- Ferrovac GmbH