The LHe Coolable Precision Manipulator

Warning!

Cooling fluids (liquid nitrogen or helium) may cause acrohypothermia! Always wear gloves and glasses when handling them.
Be careful when turning or moving the mechanicals parts of the manipulator to prevent the clamping of any body parts.
Never attempt to connect / disconnect any live electrical connections! Always de-energize them before.
Refer to the general safety regulations for further details.

Specifications:

XY-Motion: ±25mm (on a radius)
Z-Motion: 400mm
Rotation: infinite
Bake out: < 230°C (except differentially pumped rotary motion feedthrough: < 130°C)
Cooling: possible with LN2 or LHe
Heating: possible by heating the complete manipulator head

Differentially Pumped Rotary Motion Feedthrough (DDF63)

The DDF63 has 2 pumping stages: The outer one should have a vacuum of about 1mbar the inner one about 10^{-4}mbar. Both are connected by valves and pipes to the load lock chamber.
Both stages need to be pumped before and after a system bake out. The inner stage should be pumped after / during every rotation to maintain a good vacuum in the preparation chamber.
One should pump the DDF63 if the vacuum in the preparation chamber gets worse than usual.
If not operated a good DDF63 needs to be pumped once a week only.
The **maximum bake out temperature** for the DDF63 is **130°C**. Therefore it's recommended to keep it **outside the bake out panel**.

Supporting Prop

The horizontal mounting of the manipulator requires a prop to support the weight of the manipulator underneath its centre of mass. Make sure this support is properly working at any time. Otherwise the micrometer screws might get damaged.
By default the manipulator is supported by a gas piston (not bake able) just outside the bake out oven. A fully bake able version is available too

Sample Preparation and Manipulation

The manipulator can be used to transport the samples to the appropriate places for sample preparation and analysis. It's also possible to prepare samples by heating and cooling when they are clamped to the manipulator.
If you heat a sample for a longer time, you should make sure that the temperature of the manipulator head stays well below 100°C (measure with the temperature diode). Otherwise you will have some heavy outgassing and melt the contacts (221°C).

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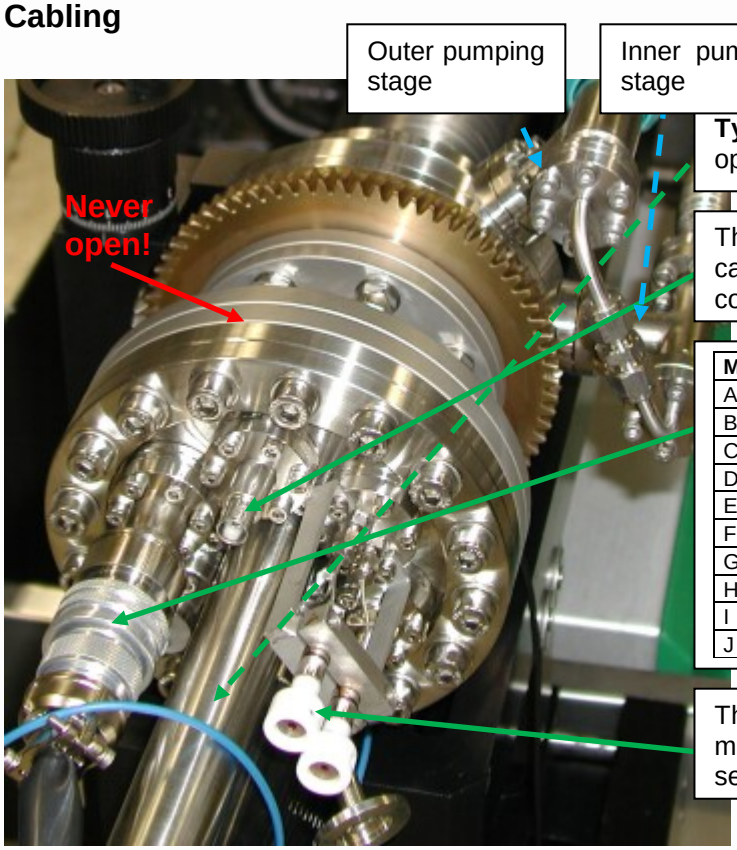
Cabling



Type K thermocouple (not shown here: opposite side).

This BNC connector is not used. But it is cabled to the manipulators head using coaxial wire. **Vmax=500V**

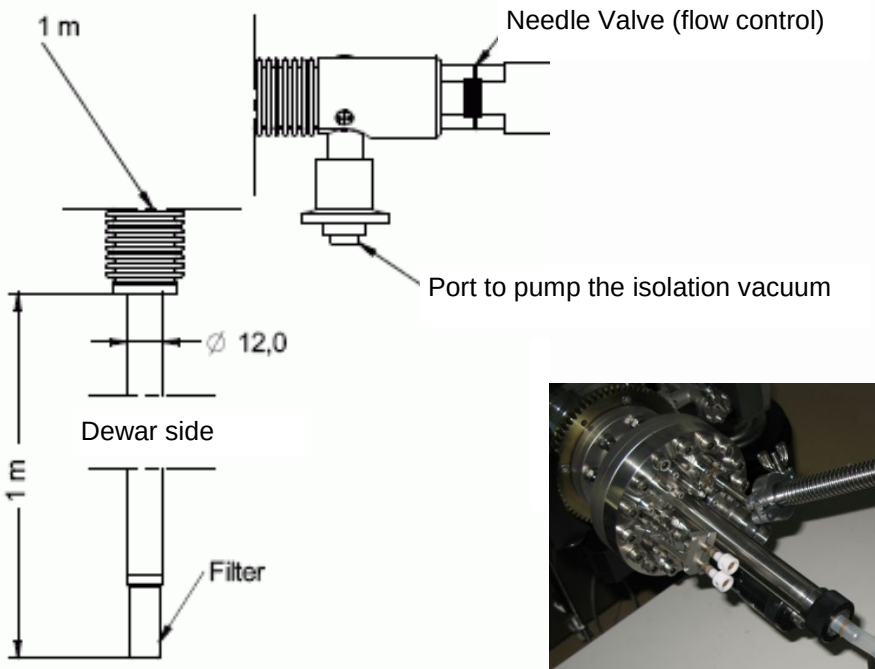
Manipulator	Use	
A	Diode +	Ø0.3mm Cu
B	n.c.	Ø0.3mm Cu
C	Pin2	Ø0.3mm Cu
D	Pin3 (CrNi)	Ø0.3mm Cu
E	Pin4 (Ni)	Ø0.3mm Cu
F	Pin5	Ø0.3mm Cu
G	n.c.	Ø0.3mm Cu
H	Diode -	Ø0.3mm Cu
I	Pin1	Ø0.6mm Cu
J	Pin6	Ø0.6mm Cu

These connectors allow you to heat up the manipulators head (e.g. during the cooling) to set a precise temperature. **Imax=2A**

The wires connected to pin I and J allow 5A permanent current (10A short term). The other wires A-H allow 3A permanent current.
The temperature diode (DT-470-12A) needs 10µA supply current. The voltage reading across the sensor can be transformed into a temperature using the standard curve 10 table from Lake Shore (http://www.lakeshore.com/temp/sen/sd400_ts.html#curve10).

Sample Cooling

The manipulator head may be cooled by a continuous flow of liquid nitrogen (LN2) or liquid helium (LHe).
To cool with LHe the supplied LHe transfer tool has to be inserted into a LHe dewar with a ø12mm quick fit connection. Slightly open the needle valve of the LHe transfer tool to check the gas flow.
Insert the other side into the port of the manipulator.
Now you may open the needle valve completely and increase the overpressure of the LHe dewar to get good flux. It is usually not necessary to pump the other side (KF16) with the He gas outlet. To recycle the He gas one may connect the gas line at the outlet, while making sure that it does not hinder the motion of the manipulator, if you attempt to move the cold manipulator at a later stage. The gas outlet will be frozen hard if a rubber / silicone based pipe is used.



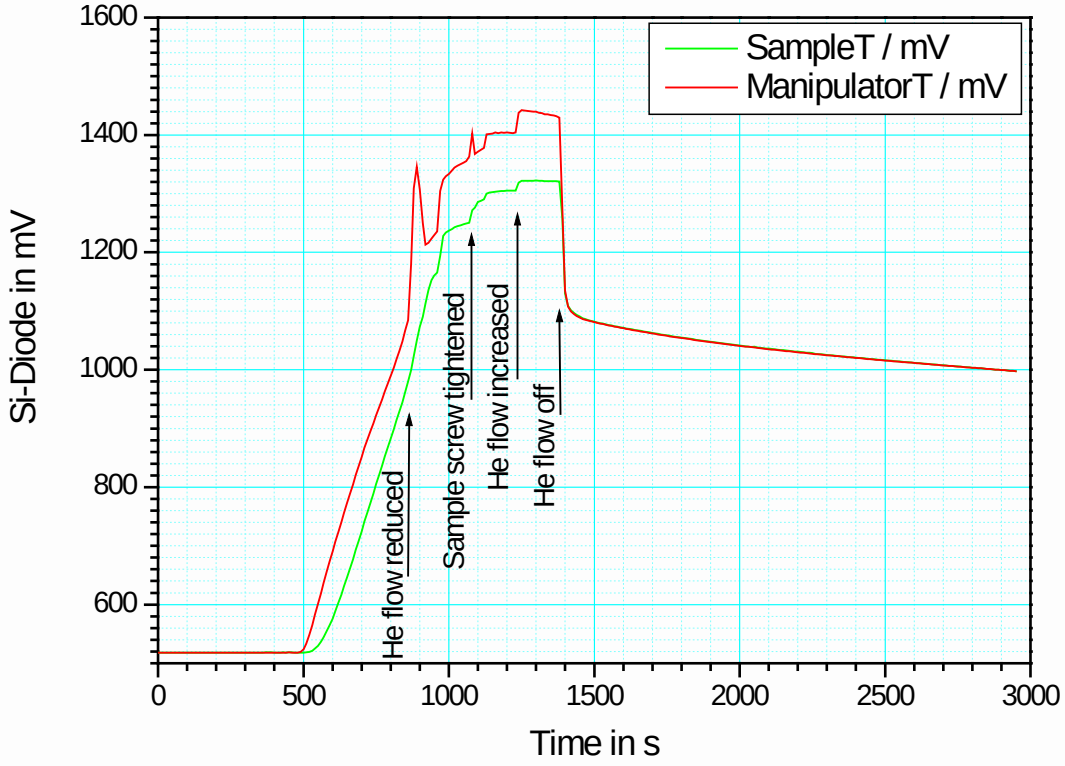
A pump (>2m^3/h) is needed to cool down the manipulator with LN2. It's recommended to use this simple setup (image on the right) instead of the LHe transfer tool. Due to the small cross section of the LHe transfer tool, cooling with LN2 takes significantly longer than cooling with LHe. Using the LN2 adapter and a small pipe reaching into a dewar containing ~1.5 liters LN2 leads to a cool down time of <20min.

Please keep in mind that the sample is always warmer than the temperature reading of the temperature diode from the head of the manipulator. If the sample is in good thermal contact to the sample holder and the sample holder is clamped well to the manipulator head, the temperature difference is less than 5K at the minimum temperature (less elsewhere). The thermocouple reading is faulty at low temperature as the sample transfer mechanism does not allow the direct cabling of the thermocouple.

Using LN2 before cooling with LHe does save you some LHe, but it's not worth the hassle. You would save about 0.5 to 1 liter of LHe if you pre-cool with LN2 first. Of cause this implies the risk of freezing out some of the remaining LN2 or air when changing from LN2 to LHe. It works, but it's not recommended.

Using LHe only it takes about 20 min to cool the sample holder to <20K. The actual sample temperature depends strongly on the clamping of the sample holder to the manipulator head and on the clamping of the sample to the oven. So the chart only gives the general idea.

One also sees that an increased LHe flow reduces the temperature only very little. Cooling the sample to < 20K takes about 2-3 liters of LHe. But when cooling to the minimum temperature (~5K at the manipulator head, ~10K at the sample), the LHe consumption increases to about 30 liters / hour (max. flow)!



Heating the Manipulator Head

To control the exact temperature of the manipulator head one may counter heat while cooling. This may be done by passing a current (max. 2A) through the heater incorporated into the head of the manipulator. It requires 2 cables with 2mm pins and a standard laboratory power supply (30V, 2A). Be aware that the Si-diode only measures the temperature of the manipulator head – not the sample temperature.

Service and Maintenance

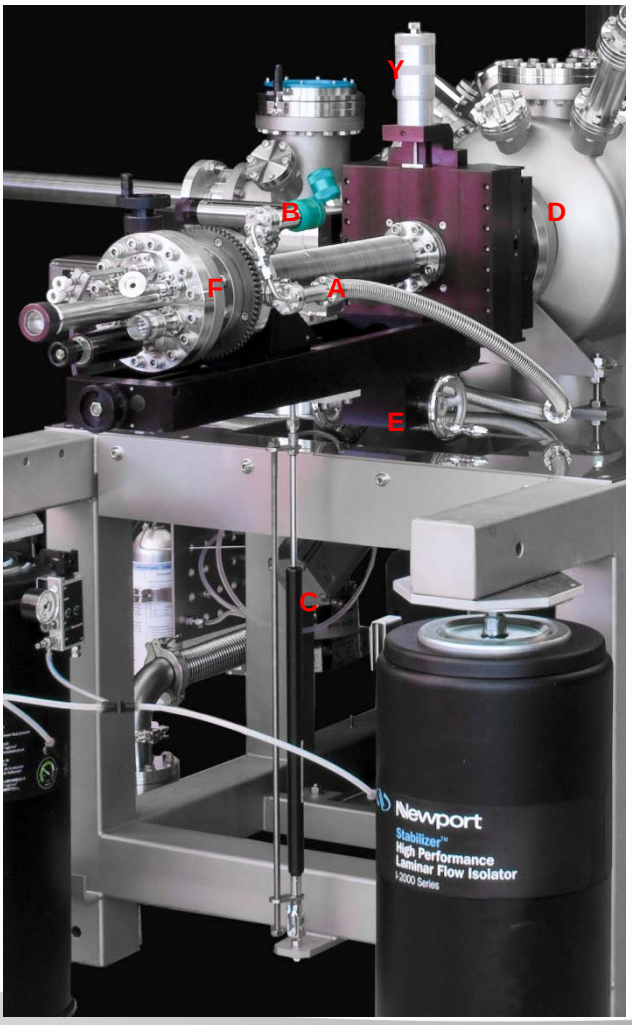
If there is ice freezing out at the flexible part of the LHe transfer tool of the manipulator, the vacuum isolation is probably broken, i.e. it degraded over time. In that case, you may re-establish it by pumping at the side port for the isolation vacuum. Opening and closing this port has to be done with an appropriate tool e.g. SV16 available at CreaTec. If the vacuum can't be re-established, the transfer tool has to be send in for repair.

The weight of the manipulator (>25kg) needs to be balanced by a supporting prop (~300N). If it does not work correctly, the micrometer screw for changing the height of the manipulator is prone to break. Therefore you have to check that the supporting prop is always working correctly. In case you experience any difficulties while using this micrometer screw: Try to support the manipulator by lifting if slightly with your hand. If it works better now, you have to exchange or lubricate the prop.

The worm gears for rotation and translation as well as the micrometer screws have to be lubricated with bake able oil or grease. Check every 6 month.
To lubricate the micrometer screws one has to remove the little screw (Z) holing the outer cylinder of the micrometer screw.
If the force to operate a micrometer screw increases, you have to disassemble it completely. Clean off any particles from the threads. First wash off the old lubricant (e.g. with acetone), than lubricate with a small amount of bake able oil or grease.

How to Remove the Manipulator off the UHV-System

1. Set the manipulator to X= 25, Y=5, Z=400 (fully retracted).
2. Remove the bellow from the differentially pumped feedthrough: Disconnect the bellow from the DN16CF T at the manipulator (A).
3. Fix the supporting prop (C) with the some nuts and the threaded rod. Remove the connection (4 screws M6x20) to the manipulator.
4. Lift up the manipulator Y=25 (15 ... 45) while supporting it with your hands. No force is allowed on the micrometer screw while lifting!
5. Remove the prop from underneath the manipulator (tilt it sidewards).
6. Open the DN150CF flange (D) to the UHV-chamber.
7. Remove the manipulator off the chamber with 2 people: One holds the end of the manipulator at the DN150CF flange (F), the other slowly navigates the manipulators head out off the UHV-chamber grabbing the X,Y table.
8. Never attempt to do this alone! Don't lift at the bellow or any of the

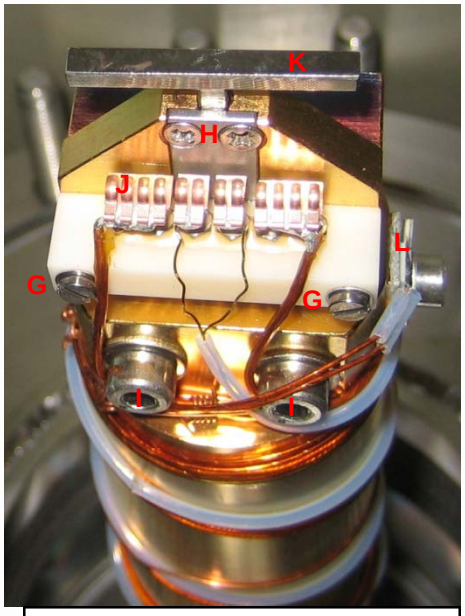


smaller flanges!

9. Watch out for the axis of the Z-handle (E)! It sticks out and might interfere with the system frame.
10. Lay down the manipulator on a flat surface and put a piece of wood or Styrofoam underneath to level the manipulator.

Repair the manipulator and put it back into the chamber in reverse order. Use new copper seals. Make sure to check that the **supporting prop (C) is unlocked** after finishing the repair!

Repair / Exchange the Head of the Manipulator



To remove the complete head of the manipulator, please take the following steps:

1. Remove the manipulator off the UHV-chamber.
2. Dis-solder all cables from the contact pins (J) and the temperature diode (L).
3. Remove the manipulator contacts: 2 screws M2x10 (G).
4. Remove the cover of the T-bar: 2 screws M2x3 countersunk (H).
5. Remove the manipulator head: 2 screws M4 Allen head (I).
6. Remove the T-bar (K).

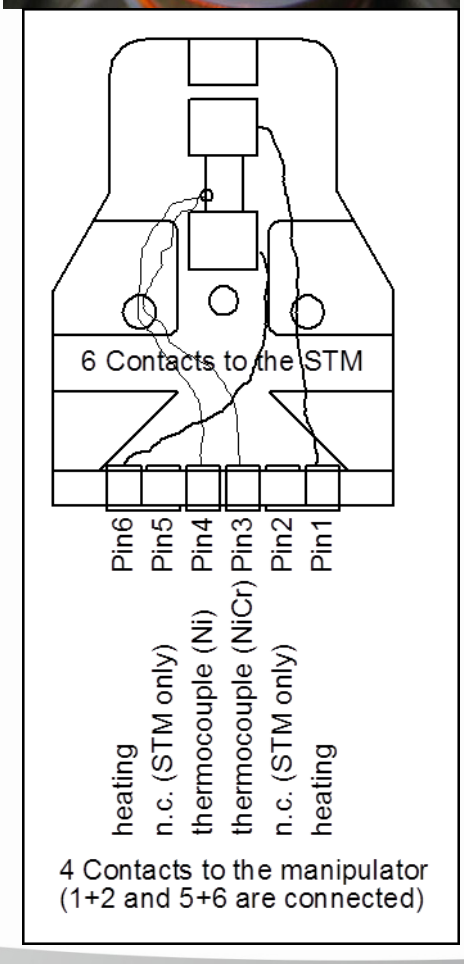
The assembly has to be done in reverse order.

To exchange the T-bar only, step 2 can be dropped.

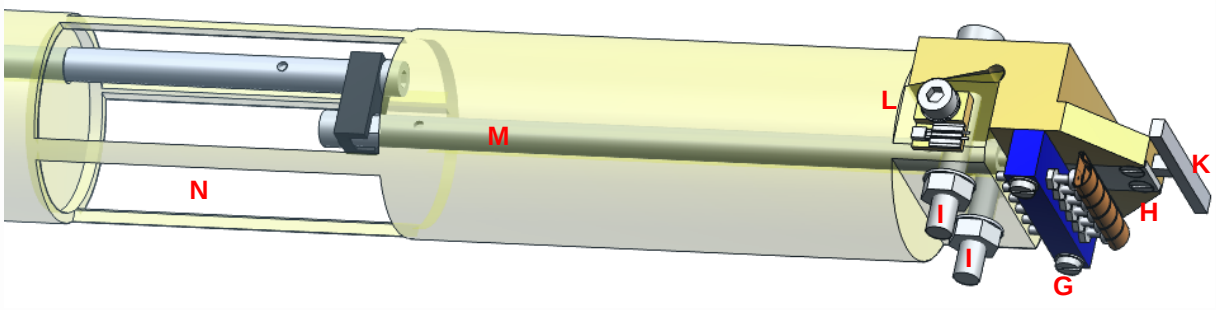
To exchange some of **the CuBe contacts** only:

1. Cut the new CuBe springs in shape using small scissors.
2. Dis-solder the broken CuBe springs (J) and re-solder the new ones. Make sure not to wet the round corners of the springs with the solder flux or the tin. Otherwise the tin would go into these corners and the springs get stiff!
3. Solder the wires in the corner between the screws and the CuBe springs without (!) dis-soldering the CuBe springs again. (You have to play with the temperature of the solder pen to achieve this. Otherwise 2 people are necessary: one is soldering the wire the other holds the CuBe spring. Doing it alone is easier!)
4. Remove the manipulator contacts: 2 screws M2x10 (G).
5. Remove the solder fluid with water and alcohol. Dry blow with nitrogen.
6. Re-mount the manipulator contacts: 2 screws M2x10 (G).
7. Check the contacts with a sample holder.

We use Castolin 157 (Sn96Ag4, melting point 221°C), but there are others too.



Top view onto the sample holder



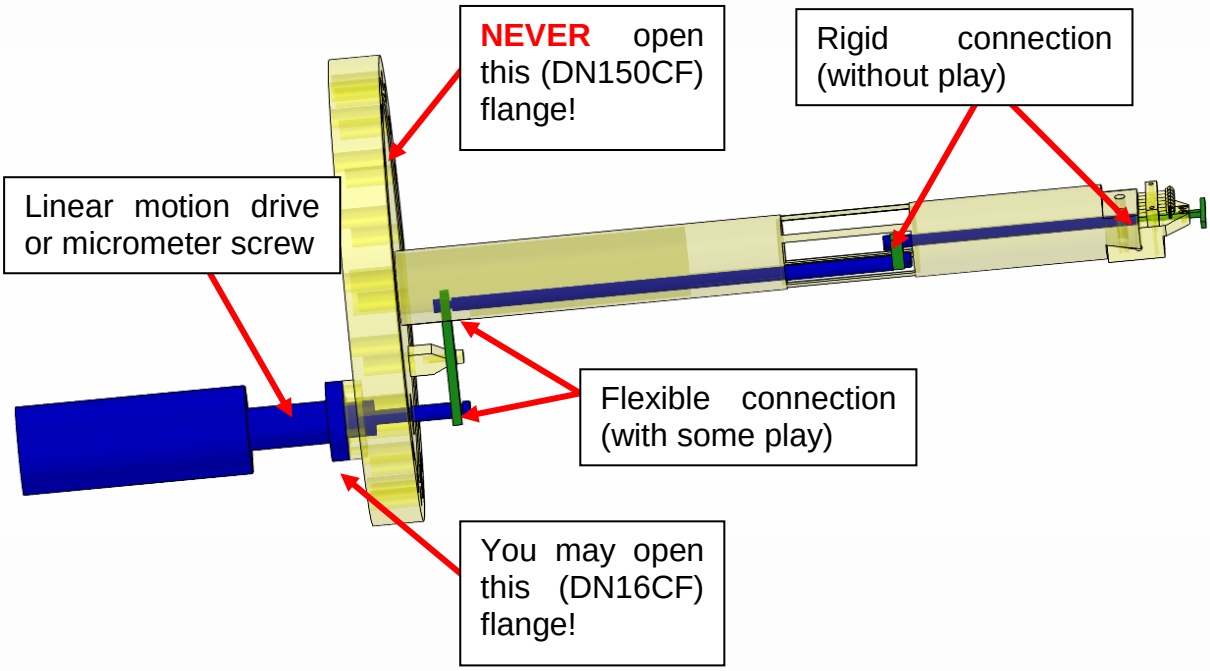
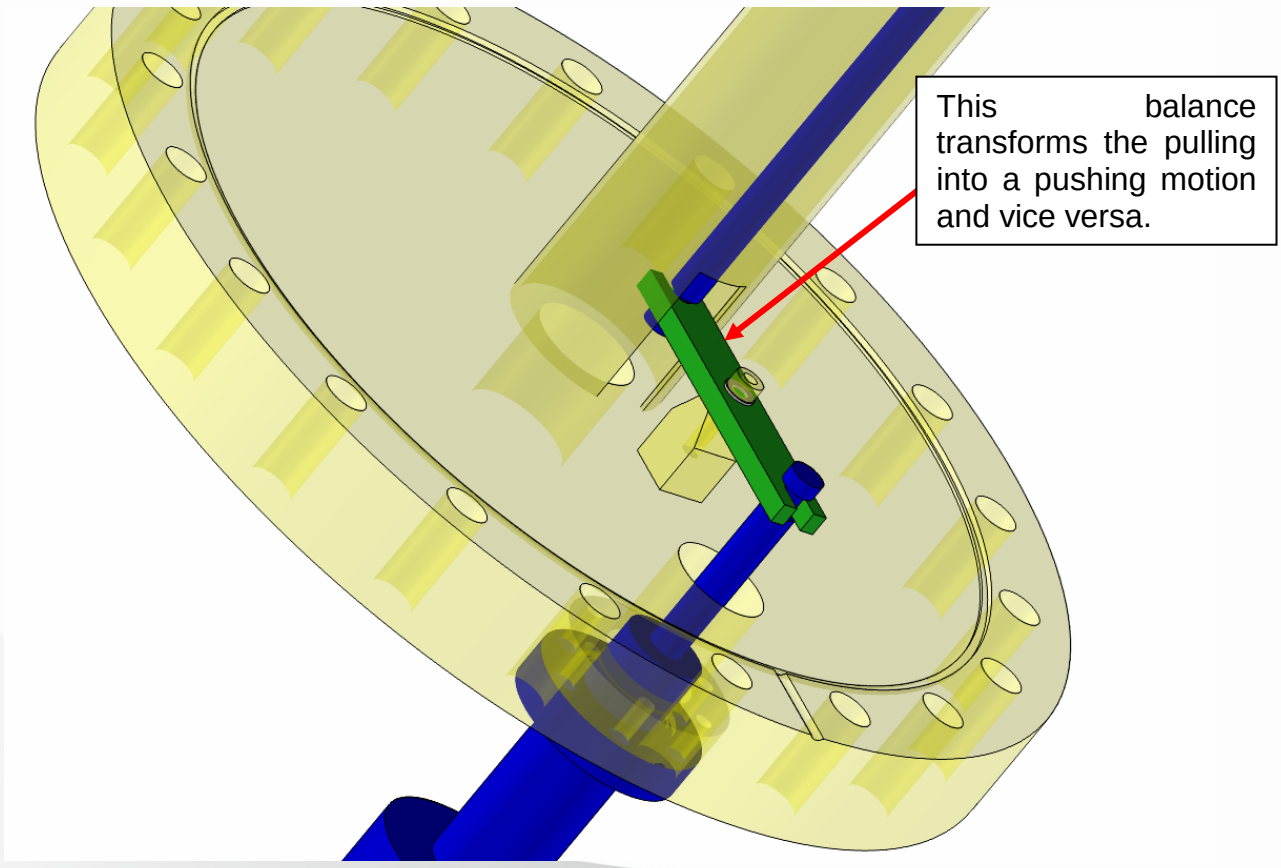
How to Remove the LHe-Cryostat off the Manipulator

1. Remove the manipulator off the UHV-chamber.
2. Remove head of the manipulator.
3. Remove the temperature diode (L).
4. Remove the rod (M) that connects to the T-bar (1 screw M3x20) to get more space in the cage just before the manipulator head.
5. Put all cables inside the cage (N) - only the outer diameter of the head fits through the bearings. You may also feed the cables through the hole for the rod (M).
6. Go to Z=400 (completely retracted). Remove the circlip (retainer) from the bearing using long pliers.
7. With the help of 3 threaded bolts (M4x250mm) remove the bearing from its bed. It usually sits tight. It might help to move the manipulator forward/backwards.
8. Go to Z=0…100 so that you can disassemble the bearing using an Allen key. Remove the disassembled parts.
9. Use some cardboard or something similar to form a tube that covers the bellow of the manipulator and holds it firmly in place when the LHe cryostat is removed.
10. Open the DN63CF flange behind the rotary feedthrough. Don't attempt to open the DN150CF at the end of the manipulator or any other flange!
11. Slowly remove the LHe cryostat off the manipulator. Keep the LHe insert parallel to the bellow, so you don't damage it – avoid squeaking sounds!
12. Exchange the broken part of the manipulator (e.g. bellow or DDF63).
13. Re-assemble the bearing and put it back in place only using minor forces – don't use a hammer!
14. Mount the circlip (retainer) in front of the bearing.
15. Slide the new LHe cryostat in. The front end will slide through the mounted bearing – but only in this direction!
16. Align the new insert with the scale of the rotary feedthrough, so that the sample will point to either 0° or 180° - whatever you are used to.
17. Remount the manipulator's head and wires. Make sure that the T-bar is tight and parallel to the manipulator's head.

Make sure to reconnect the pumping stages of the DDF63 in the correct order. The 2nd stage goes deeper into the DDF63.
Never attempt to open the DN150CF flange (F) next to the DDF63! It's not possible to change this copper seal.

How the linear motion to clamp the sample works:

(The LHe insert of the manipulator is drawn shorter to increase visibility.)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