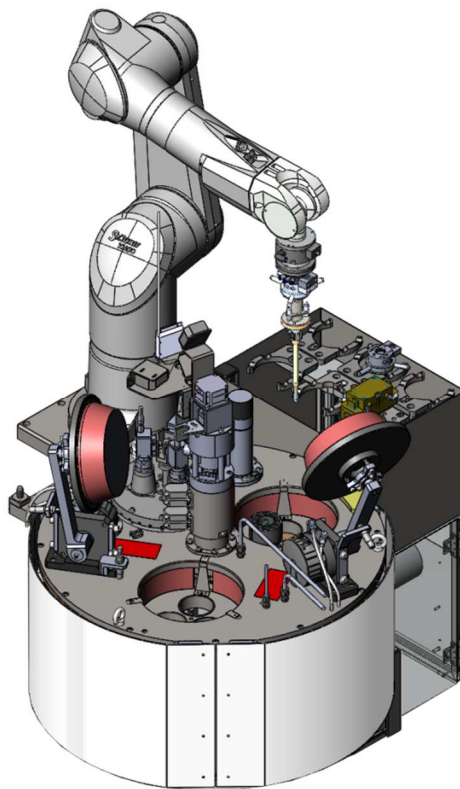


FlexHCD Documentation Volume I

User Manual



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PLEASE KEEP THIS MANUAL AT ID30B CONTROL CABIN

PLEASE READ THIS MANUAL BEFORE USING THE SAMPLE CHANGER

Table of Contents

1	INTRODUCTION.....	2
1.1	Contents of the CE declaration	2
1.2	Detail of the different volumes.....	3
1.3	Operating conditions	3
1.4	Definitions and terminology	3
2	SAFETY.....	5
2.1	Pictograms.....	5
2.1.1	Warning.....	5
2.1.2	Information	5
2.1.3	Obligations	5
2.1.4	Interdictions	5
2.1.5	Residual risks.....	6
3	USE	7
3.1	Working modes	7
3.2	Dewar loading	7
3.3	Initializing the robot.....	Error! Bookmark not defined.
3.4	Parking the robot	16

1 INTRODUCTION

The goal of this manual is to provide information concerning the operation and use of **Flex High Capacity Dewar** sample changer (FlexHCD). **It is addressed to beamline users.**

- Please read through the complete instruction manual before using the machine.
- Keep this instruction manual at ID30B control cabin, in a safe place, for later use.

FlexHCD is a versatile, high performance, sample changer system designed to be used in automatized synchrotron beamlines to handle biological crystallized samples at cryogenic temperatures. It allows the users to automatically transfer samples from a stocking High Capacity Dewar to the diffractometer and back.

It is based on a 6-axes robotic arm and a high capacity cryogenic stocking system.

FlexHCD has been developed by **EMBL Diffraction Instrumentation Group**, in collaboration with **ESRF**.

1.1 Contents of the CE declaration

CE Declaration can be found on **Volume III of FlexHCD Documentation**. It contains the following information:

Designation of the equipment: **FlexHCD Sample Changer**

The equipment manufacturer is:

ESRF – European Synchrotron Radiation Facility
71, avenue des Martyrs
38000 GRENOBLE- FRANCE

Authorized representative:

Paul BERKVENS – Head of the Safety Group
ESRF – European Synchrotron Radiation Facility
71, avenue des Martyrs
38000 GRENOBLE- FRANCE

The equipment is in conformity with:

2006/42/EC Machinery

2006/95/EC Low voltage

2004/108/EC Electromagnetic compatibility

1.2 Detail of the different volumes

The technical documentation for FlexHCD is divided on five volumes:

- **Volume I: User instruction (this one)**
- Volume II: Maintenance Manual
- Volume III: Technical information
- Volume IV: Risk assessment
- Volume V: Annexes

1.3 Operating conditions

Operation conditions are listed below:

Temperature	18 to 25°C
Acceptable location	Indoors only
Maximum humidity for non-condensation conditions	Hygrometry < 20% and temperature < 25 °C

1.4 Definitions and terminology

- User: People interacting with FlexHCD machine.
- Beamline technician: People in charge of the technical problems occurring on the beamline
- Pin: small, slender, metallic tube or needle with mounted crystal support holding the sample to be exposed to x-rays.
- Cap: support/base of the pin.
- Sample holder: Cap + pin.
- Vial: sample holder reservoir and protecting device.
- Puck: Device that stocks several sample holders in order to ease their transport.
- Gripper: Electromechanical device attached to the wrist of the robotic arm intended to pick up/release samples holder and hold them when the robot is moving.
- Robot controller: Unit holding control electronics and power supply for robotic arm movements.
- Dewar: Liquid nitrogen vessel in which samples are stored
- Tool bank: Mechanical support for the storing of robot grippers
- De-freezing station: Gripper drying device mounted on the tool bank.
- Main rack: Closed cabinet containing electrical & pneumatic devices of the machine.
- Front end rack: Closed cabinet containing electrical & pneumatic devices of the machine installed under the tool bank
- Touchscreen: Screen of the control computer installed on the marble of the experimental hut. It's used to interact with the FlexHCD during Puck Transfer Mode and Maintenance mode
- GUI: graphical user interface of the FlexHCD control software


- Goniometer: MD2S goniometer installed in the experimental hutch. The FlexHCD main purpose is to mount and unmount samples to and from the goniometer.
- X-ray Detector: Detector installed in the experimental hutch permitting to image diffraction patterns resulting from a data collection.

2 SAFETY


To prevent damage to the equipment or personal injury it is mandatory to read the following safety precautions before use. Make sure that this manual is available to any user of the machine.

2.1 Pictograms

2.1.1 Warning

	<p>WARNING: This icon marks warnings. To prevent possible injury, read all warnings before using this equipment.</p>
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2.1.2 Information

	<p>INFORMATION: Notes of the "information" type provide very important information to help the reader to understand a description or a procedure.</p>
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2.1.3 Obligations

Below are listed all the signs concerning security obligations during machine use. Each sign will be inserted into the documentation where it corresponds.

	<p>Wear cryogenic gloves</p>
	<p>Wear face shield</p>



2.1.4 Interdictions

Below are listed all the signs concerning security interdictions during machine use. Each sign will be inserted into the documentation where it corresponds.

	<p>Interdiction</p>
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2.1.5 Residual risks

Below are listed all the signs concerning residual risk during machine use. Each sign will be inserted into the documentation where it corresponds.

	Cold part. Burn hazard.
	Warning against moving part. Risk of crushing.

3 USE

The FlexHCD normal use is described in this chapter.

	WARNING: Any use of the machine not described in this manual is considered as non-compliant.
	INTERDICTION: It is strictly forbidden to access inside the electrical cabinet or the front end rack during normal machine use. It is strictly forbidden to electrically disconnect any of the elements
	INTERDICTION: Do not open the experimental hutch doors while mounting or unmounting a sample. Do not move the detector while mounting or unmounting a sample.





3.1 Working modes

Two working modes are available for beamline users:

- **Puck Transfer Mode:** It must be active to load and unload the High Capacity Dewar with your samples.
- **Sample Transfer Mode:** Active only with hutch interlocked, allows you to mount and unmount samples on goniometer from MXCube interface.

3.2 Loading High Capacity Dewar

To load the High Capacity Dewar (from now on, HCD) with your samples, follow the steps described down below.

	OBLIGATION: Wear cryogenic gloves when loading HCD with your samples.
	OBLIGATION: Wear face shield when loading HCD with your samples
	RESIDUAL RISK: Residual risk of nitrogen burns when loading and unloading HCD
	RESIDUAL RISK Warning against moving part. Risk of hitting or crushing when opening and closing HCD User Port.

When you enter the experimental hutch, you must press the green button on the pendant near the High Capacity Dewar (Figure 1) to put the machine on *Puck Transfer Mode*. The green button will light up and the touchscreen will be enabled.



Figure 1: Puck Transfer Mode button and Emergency Stop button

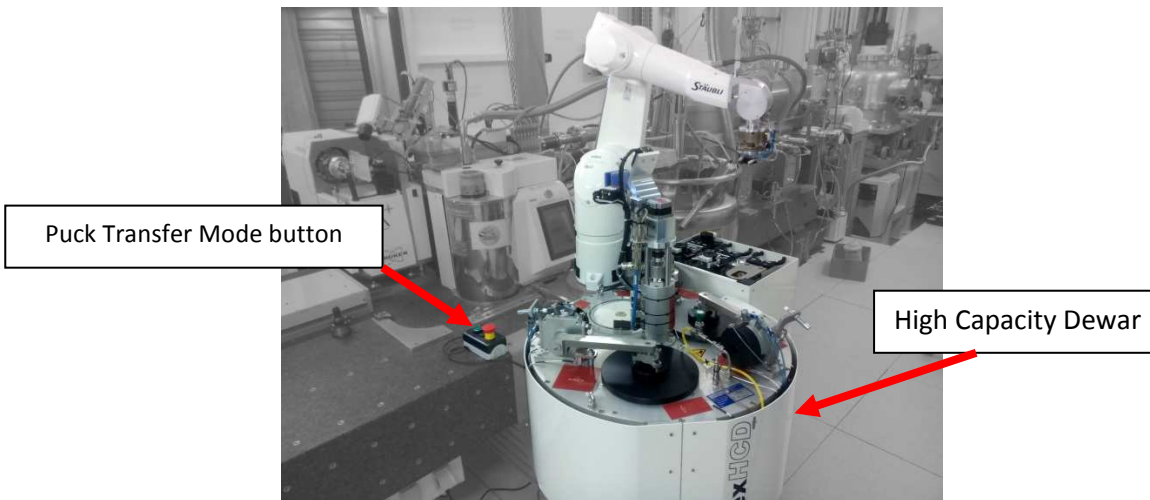


Figure 2: Puck Transfer Mode button and High Capacity Dewar emplacement.

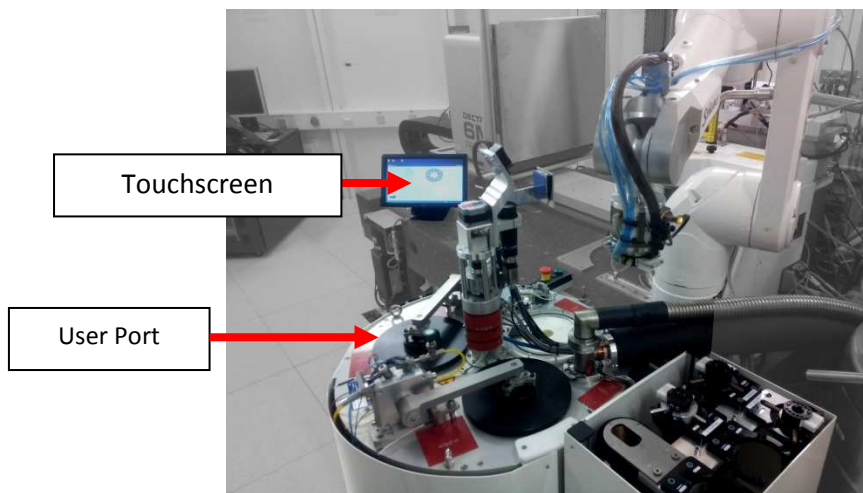


Figure 3: Touchscreen emplacement and User Port location.

Once *Puck Transfer Mode* is active, the touchscreen will show the following Graphical User Interface (GUI).

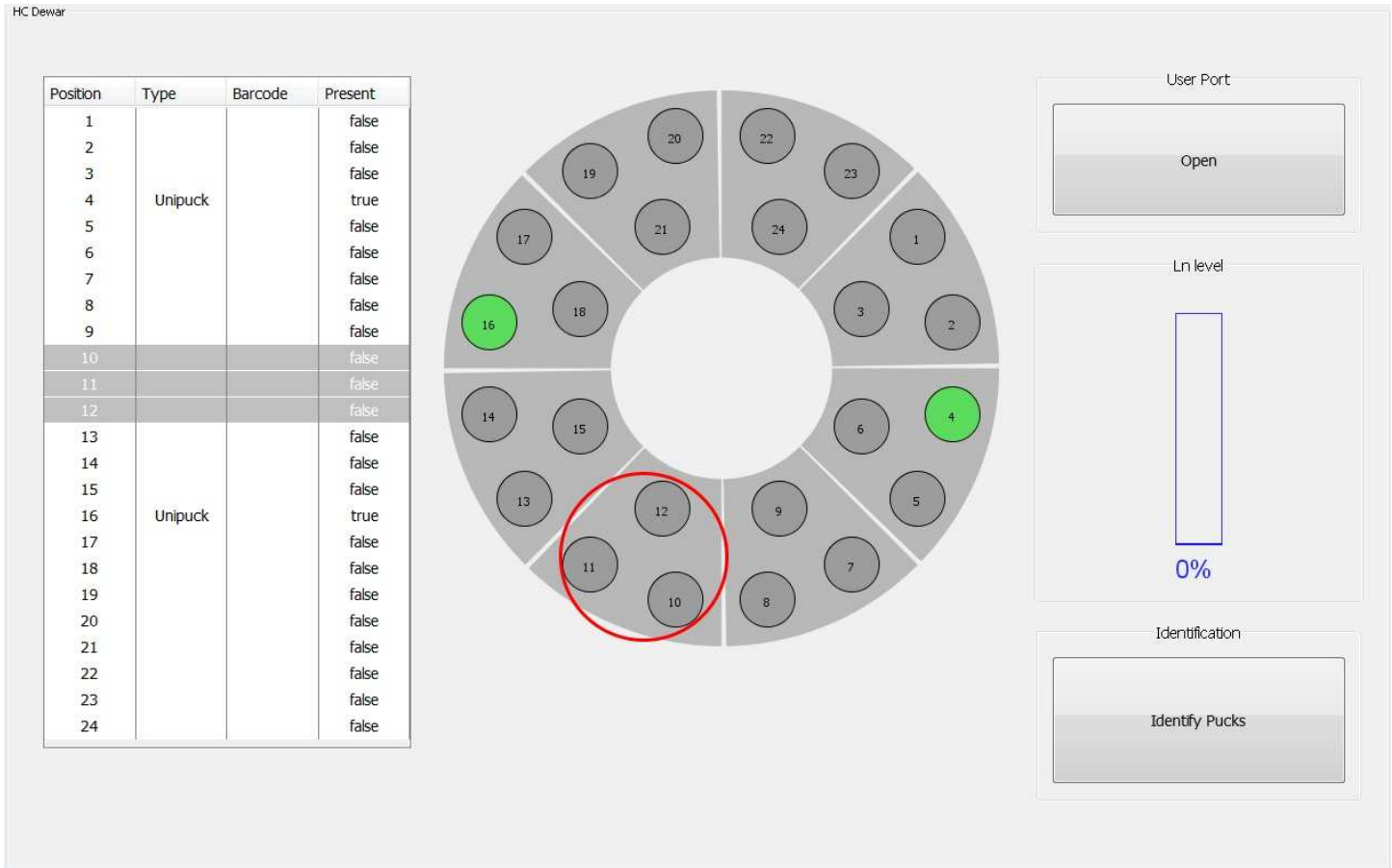




Figure 4: Puck Transfer Mode GUI.

You can touch one segment of the plate on the touchscreen, so the machine will automatically present this plate segment under the HCD User Port (Figure 3), represented in the graphical interface by a red circle.

The button placed in the upper right area of the GUI allows you to open and close HCD User Port.

	<p>WARNING: Do not lean over HCD when opening User Port to avoid hitting. Keep your hands away from HCD when closing User Port to avoid finger crushing.</p>
	<p>INTERDICTION: Only the person performing the loading or unloading process is authorized in the proximities of HCD.</p>

In the HCD, there are two types of segments: **SC3 puck footprint segments** (Figure 5) and **Unipuck footprint segments** (Figure 6). On each segment you have three puck slots. The placement of these segments is represented in the following table:

Plate number	Segment Numbers	Segment type
1	1,2,3	SC3
2	4,5,6	Unipuck
3	7,8,9	SC3
4	10,11,12	Unipuck
5	13,14,15	SC3
6	16,17,18	Unipuck
7	19,20,21	SC3
8	22,23,24	Unipuck



Figure 5: SC3 segment

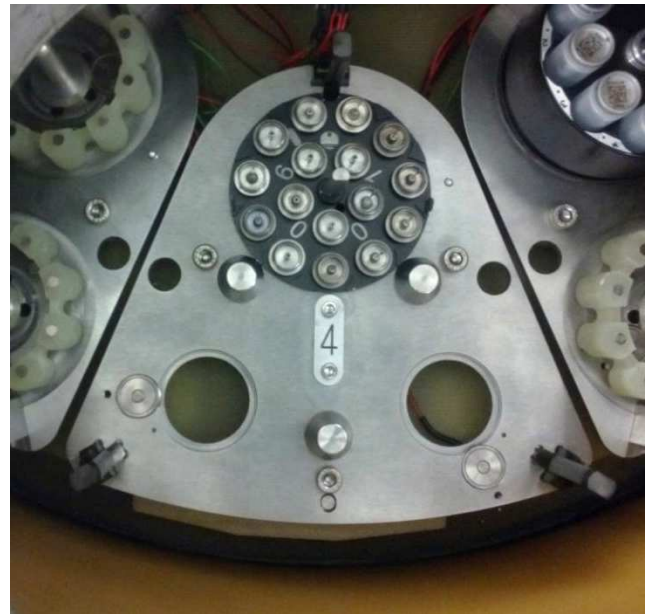


Figure 6: Unipuck segment

During the loading process, every time you place a puck correctly in its slot, FlexHCD will detect its presence. On the GUI, the corresponding HCD slot will change color from **grey** to **red**. In the GUI shown at Figure 4, a liquid nitrogen level indicator is also shown, as well as a table containing a summary of puck presence and type.




	<p>WARNING:</p> <p>To avoid collisions, please make sure you load each of your pucks in a compatible segment and that they are correctly placed and detected by the control system.</p>
	<p>INFORMATION:</p> <p>Every puck has a guiding groove that must be aligned with the guiding finger on the puck slot inside HCD to warrantee the correct emplacement.</p>
	<p>INFORMATION:</p> <p>Samples in non-detected pucks will not be mounted by the robot.</p>

Figure 7 shows the sequence of loading an SC3 puck and a Unipuck puck.

SC3 puck loading in HCD



Unipuck loading in HCD

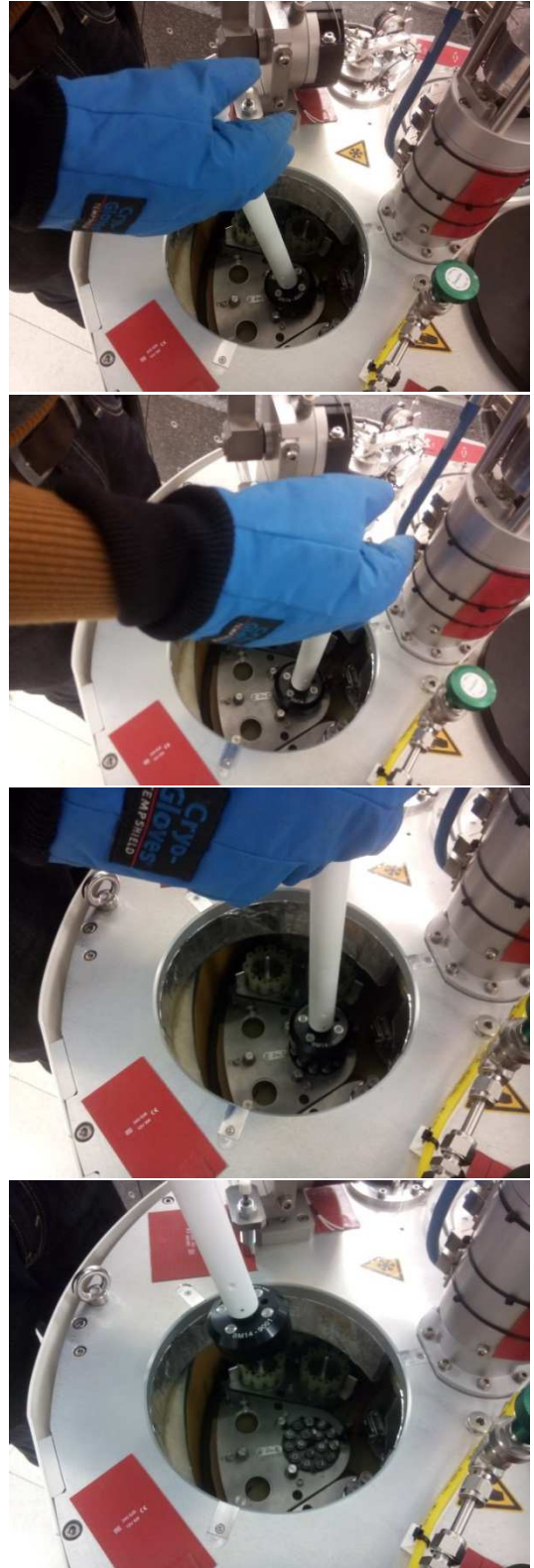




Figure 7: Pucks loading

Once you have loaded all your pucks you have to make the system identify these pucks. For that you have to push the button “Identify pucks” on the touchscreen. This action can take several seconds. Once it’s finished, all identified pucks will change color from **red** to **green**. Pucks that haven’t been identified will remain red. In this case you have to verify the good positioning of the pucks in their slots. Once you have adjusted their positions, you can relaunch a new “Identify pucks” action.

When all your pucks are correctly identified you can close the User Port using the corresponding button on the touchscreen, interlock the hutch and proceed to the control cabin to begin data collection.

The Sample Changer will automatically switch to *Sample Transfer Mode* when hutch interlock is done.

Remember that you must not open the hutch, nor move the detector, while mounting or unmounting a sample.

	<p>INFORMATION: At any time during HCD loading or unloading, if an emergency situation arrives, you can press the Emergency Stop button (Figure 1) to cut machine power. If this happens, get in touch with local contact to reset the machine.</p>
	<p>INTERDICTION: Do not try to do any intervention or manipulate the Sample Changer in a way that is not described in this manual. If you find any problem or detect a malfunctioning of the Sample Changer, please get in touch with local contact.</p>

3.3 MXCube interface

The FlexHCD is fully integrated into MxCube. The beamline users are therefore able to command loading/unloading actions directly from the common beamline control interface.

3.3.1 Loading - unloading actions

Loading and unloading actions are accessible by right clicking on a sample in the sample list on the left side of the MxCube GUI (see: Figure 8). Some additional information and actions concerning the robot are also available on the dedicated Sample Changer tab. To accede to this tab you have to click on the **Show SC details** button (see: Figure 9).

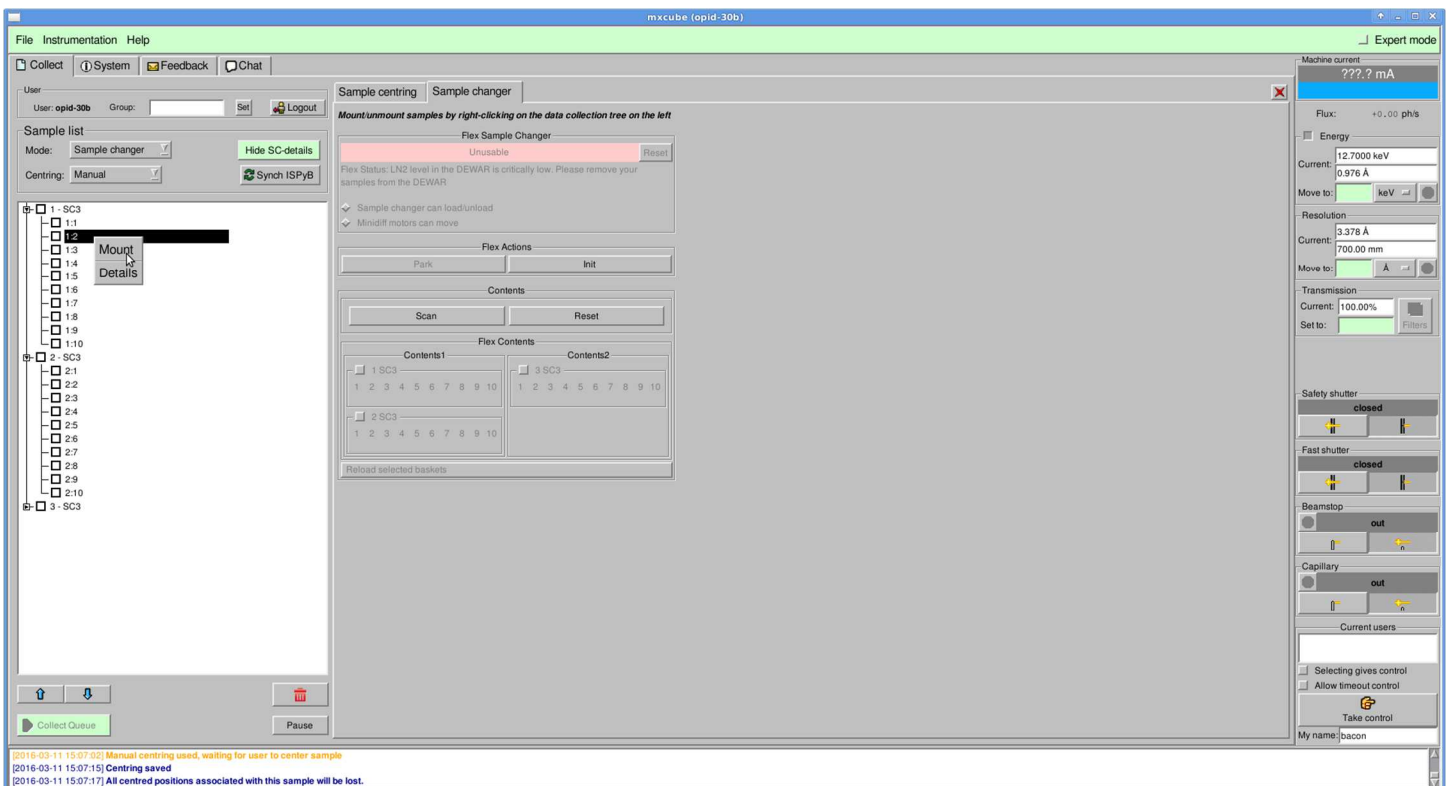


Figure 8 : mounting a sample

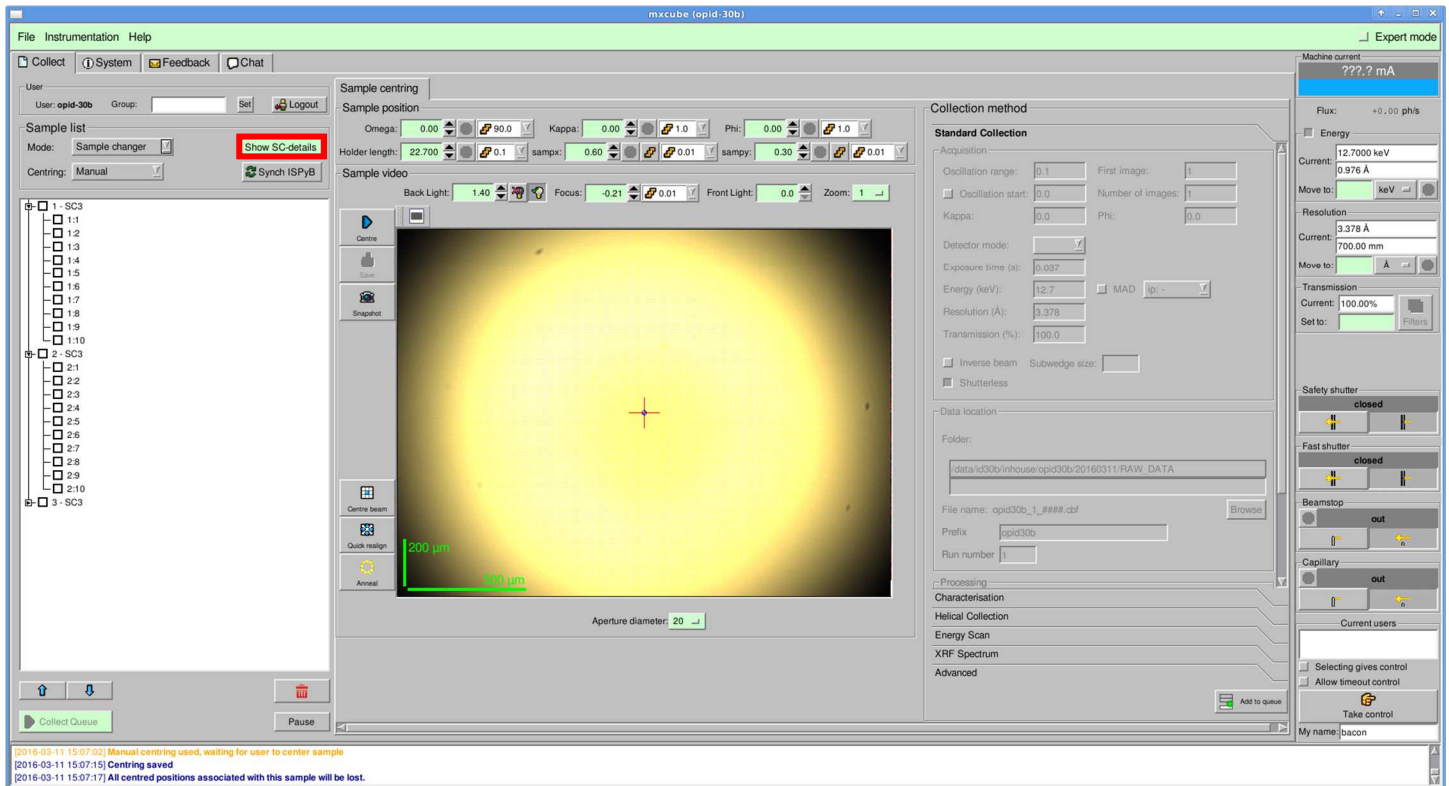


Figure 9 : SC details button

3.3.2 Detailed SC interface in MxCube

The dedicated SC tab is shown on Figure 10. On this tab you have various useful information and commands. On the upper part of the tab you have a colored text label displaying the current state of the robot.

Color codes are:

- Red: robot in error or in an alarm state
- Yellow: robot is executing a task
- Green: robot is ready for operation

Under the state label you find a verbose status description. This text label displays additional information about the robot's current state.

On the upper center part of the tab you can find the "Flex Actions" panel. In this panel you have two buttons: "Park" and "Init". Please refer to sections 3.3.3 and 3.3.4.

In the bottom center part of the Flex tab you find the "Contents" panel with two buttons:

- Scan: button permitting to rescan pucks in the HCD
- Reset: permit to reset your sample list in mxCube.



WARNING:

If you reset your sample list, it means that if you had a mounted sample on the goniometer, it will lose its state in MxCube when you will proceed to the next scan. This can lead to a desynchronization of robot and MxCube sample states resulting in the blocking of the robot.

On the bottom part of the tab you can find a graphical representation of the present pucks and samples in the sample changer.

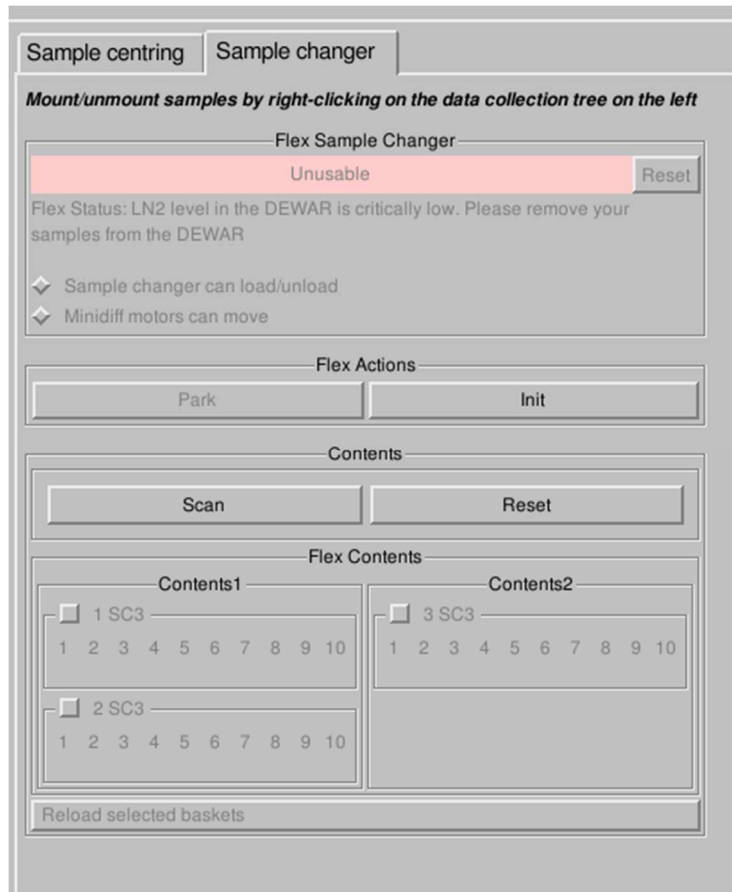


Figure 10: SC details tab

3.3.3 Initializing the robot

When all your pucks are loaded in the HCD, you can proceed to the initialization of the robot. For that you have to click on the button “Init”. It will defreeze the gripper and put the robot in the correct standby position. Once this action is done, the robot is ready for normal operation.



INFORMATION:

If an emergency stop occurs or if the robot is blocked in an unusual position, you can also push the “Init” button in order to put back the robot into a normal state. **If there is a sample in movement (in the robot gripper) it will be trashed into the de-freezing station.**

3.3.4 Parking the robot

Once you have finished working with the FlexHCD it's recommended to park the robot, in order to clear the space in front of the goniometer. For that you have to click on the “Park” button.