The Stanford-type Automated Mounting (SAM) system on the Canadian Macromolecular Crystallography Beamline (CMCF-2)

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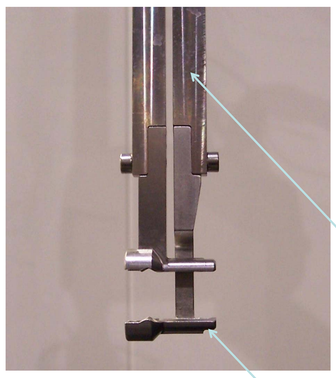
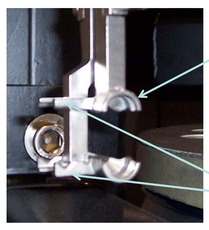
Abstract:
The Canadian Light Source (CLS) is currently implementing a Stanford-type Automated Mounting (SAM) system on the CMCF-2 (08B1-1) beamline. The Stanford robot is a high performance and reliable auto-mounter already used successfully at a number of facilities. The auto-mounter will be used in conjunction with Universal Puck (Uni-Puck), a single sample holding cassette, standard between ALS, APS SBC-CAT, and SSRL, which greatly reduces cost and effort for scientists using more than one facility in North America. The 4-axis industrial robot uses a pair of cryo-tongs to manipulate a magnetic tool which places samples in and removes samples from the sample holder within a 48L LN2 dewar. The cryo-tongs are coupled with a force/ torque sensor allowing the robot to evaluate its location and the presence of samples within a sample holder.

The ATI Gamma Force/ Torque sensor allows the robot to validate sample presence within the sample holders. It also enables the robot to sense key components during the calibration operation in order to reorient itself if components have been moved during maintenance.



Invar gripper bars minimize thermal expansion as the cryo-tongs move between LN2 and ambient environments.

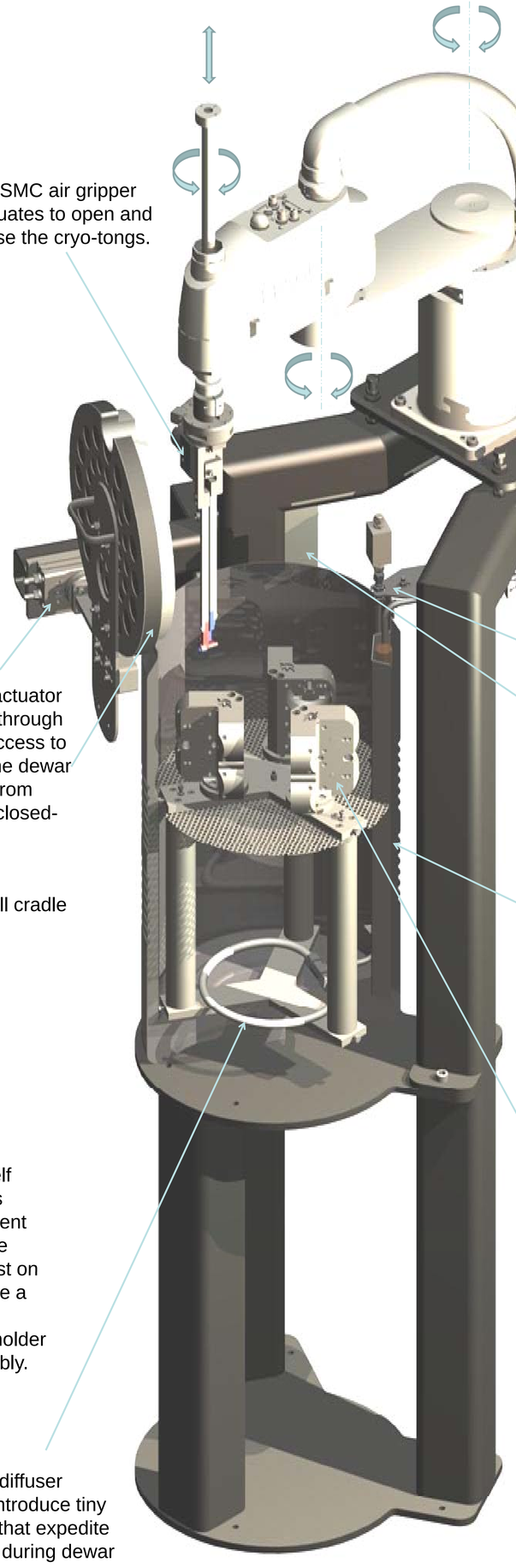
The cryo-tongs encapsulate the sample pin during transfer.



The cryo-tong fingers grasp the dumb-bell during dumb-bell manipulation.

An SMC air gripper actuates to open and close the cryo-tongs.

An SMC rotary actuator operates the lid through 90° to provide access to the samples. The dewar lid is fabricated from machinable PE closed-cell foam.

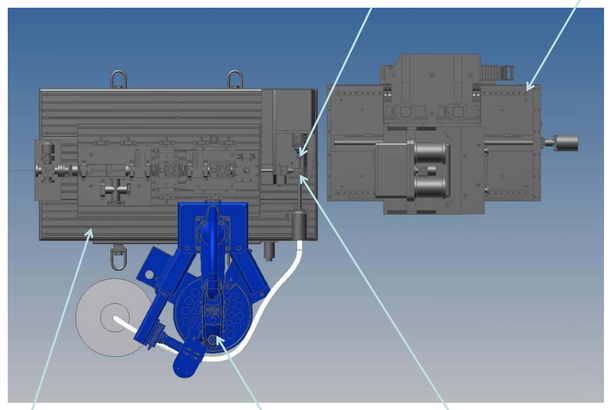


LN2 auto-fill / evac. system

The dewar is shown cross-sectioned for clarity.

20 micron porous diffuser tubing is used to introduce tiny bubbles of dry air that expedite the boil-off of LN2 during dewar evacuation.

CMCF-2 End-station model



Epson 4-Axis Pick and Place Robot
#E2S-553S-UL
Arm length: 550mm
Joint #3 stroke: 320mm

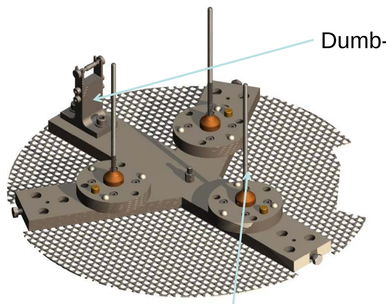
Cryo-tong Dryer / De-icer

Dry compressed air passes through an in-line electric heater and is dispersed through a cylindrical manifold with hundreds of small holes. The robot oscillates the cryo-tongs within the dryer to expose them to multiple jets of hot air.

Weak magnet end

Dumb-bell Magnet

Strong magnet end



Dumb-bell cradle

Alignment posts on the shelf assembly guide the various sample holders and alignment cassettes into position. The sample holders come to rest on three spheres which provide a three point contact thereby diminishing the risk of the holder freezing to the shelf assembly.

Unipuck Adapter with 4 Unipucks: Each Unipuck holds 16 sample pins.

Sample Cassette: Each cassette holds 96 sample pins.

Calibration Cassette: Precision faces on the cassette aid in re-orienting the robot when dewar internal components have moved.

Sample Mounting:

a) The dewar lid is opened and the tongs are moved from the dryer.
b) The robot cools the cryo-tongs in the liquid nitrogen within the dewar for ~20sec.
c) The robot picks up the dumb-bell magnet from the dumb-bell cradle with the fingers projecting from the cryo-tongs.
d) The robot positions the strong end of the dumb-bell magnet adjacent to the required sample pin.
e) The dumb-bell is moved away from the sample holder. The strong end of the dumb-bell magnet holds the pin more tightly than the ring magnet in the holder and the sample is removed from the port.
f) The dumb-bell magnet tool, with the sample pin still attached, is returned to the cradle and is released by the tongs.
g) The cryo-tongs, which are now fully cooled, move to surround the sample pin and are closed around it.
h) The tongs are rotated about a vertical axis to release the pin from the dumb-bell magnet; they are then moved swiftly out of the LN2 and towards the goniometer.
i) The base of the pin is positioned against the goniometer head permanent magnet.
j) The tongs are opened and moved away from the goniometer, leaving the sample centered in the nitrogen cryo-stream. The tongs return to the dryer.

Sample Dismounting:

a) The dewar lid is opened and the tongs are moved from the dryer.
b) The robot cools the cryo-tongs in the LN2 for ~30sec.
c) The tongs are closed and moved swiftly out of the LN2 and towards the sample position at the goniometer.
d) When the tongs are near the sample, they open, move to surround the pin, and then close.
e) The tongs are rotated about a vertical axis to release the pin from the goniometer magnet, and are rapidly transferred back to the dewar.
f) The sample pin is placed on the weak end of the dumb-bell magnet tool.
g) The tongs are opened to release the pin on to the dumb-bell magnet.
h) The robot picks up the dumb-bell magnet tool from the cradle.
i) The robot places the pin within the appropriate sample port.
j) The dumb-bell is moved rapidly away from the sample holder. The sample holder ring magnet holds the pin more strongly than the weak end of the dumb-bell magnet tool and the sample remains behind.
k) The dumb-bell magnet tool is returned to the cradle and is released by the tongs.
l) The tongs are removed from the dispensing dewar and the lid is closed. The tongs are then sent to the dryer in preparation for the next cycle.

Acknowledgements:

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Macromolecular Crystallography at SSRL

JCSG Joint Center for Structural Genomics
Developing high throughput methods for target selection, cloning, expression, crystallization, X-ray diffraction, and structure determination.

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