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Solutions for the storage and handling of SPINE standard pucks

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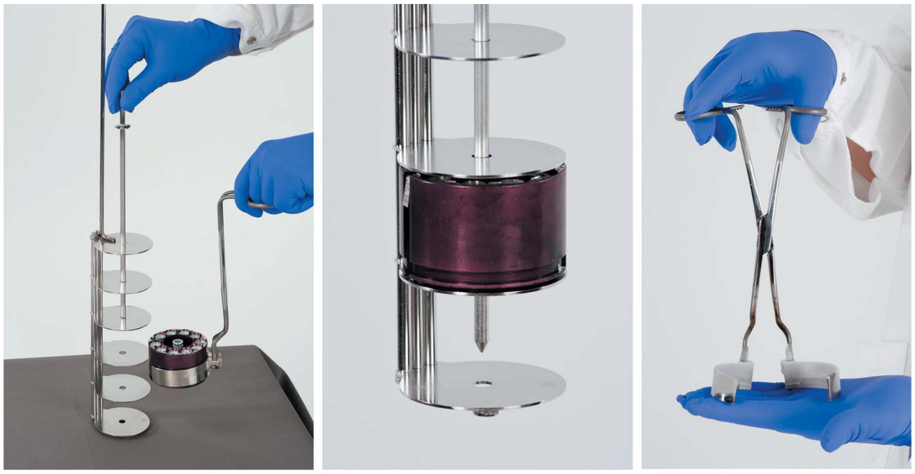
Currently there is no rack system for the long-term storage of SPINE pucks in spite of their commercial availability and heavy usage at the ESRF. The only way to store pucks is in transport dewar canisters which presents a number of limitations and drawbacks. Here a simple affordable rack for storing SPINE pucks is described, which we believe is accessible to not only synchrotrons but also both academic and industrial research laboratories.

Keywords: puck; basket; rack; holder; storage; dewar; vial; loop; crystallography; X-ray; crystal; SPINE; ESRF.

Our high-throughput structural biology laboratory has two in-house X-ray generators equipped with ACTOR robotics (Rigaku, UK). Long-term storage of SPINE pucks (Cipriani *et al.*, 2006) became necessary when the robots were converted to accept these pucks, to enhance compatibility with the European Synchrotron Radiation Facility (ESRF, Grenoble, France). A rack for both ACTOR pucks and Uni-pucks suitable for the larger storage dewars, *e.g.* HC35 (Taylor-Wharton, USA), are available from Rigaku and Crystal Positioning Systems, respectively. However, there is no such rack for SPINE pucks in spite of their commercial availability (Molecular Dimensions, UK) and heavy usage at the ESRF. The only way to store the pucks is in transport dewar canisters from Molecular Dimensions (Cipriani *et al.*, 2006). This is undesirable for several reasons: (i) with multiple users, each with multiple projects, many transport canisters and CX100 transport dewars (Taylor-Wharton, USA) would be required to accommodate the work load; (ii) when using the canisters the pucks cannot be taken out individually without removing all the pucks above, and finally, (iii) transport dewars are not the preferred long-term storage method compared with the larger variants (Owen *et al.*, 2004). Such a solution would be cumbersome and introduce extra handling of the pucks that could potentially put the crystals at risk.

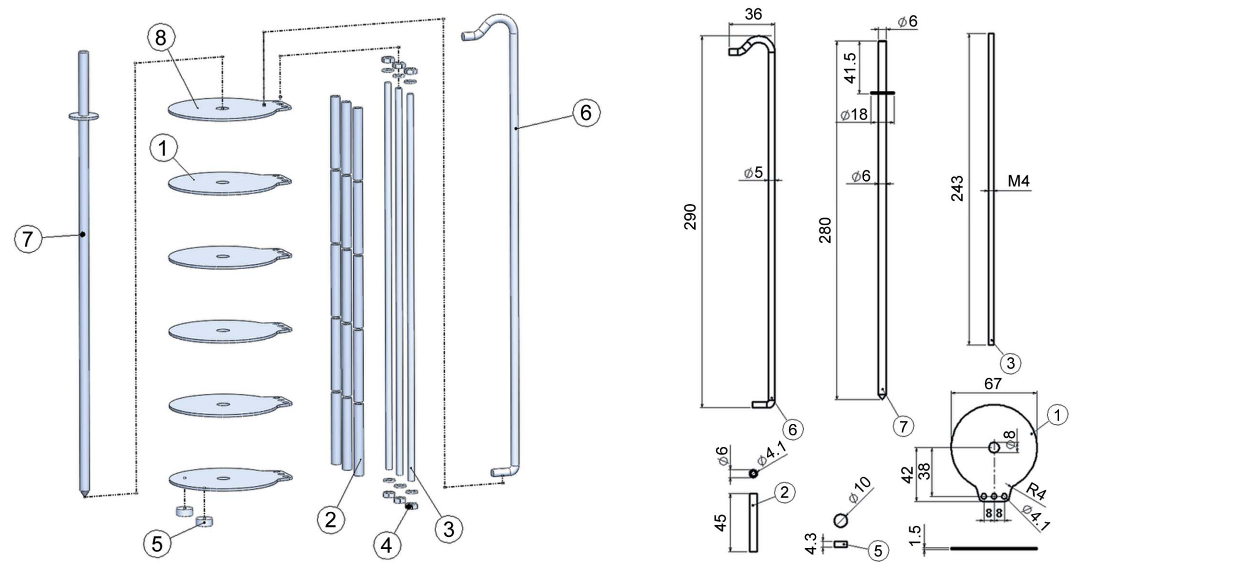
Here we present a simple affordable rack for storing SPINE pucks. Instead of stacking pucks on top of each other as in the commercially available canister, the pucks sit on individual shelves [Figs. 1(*a*) and 1(*b*)] in a similar fashion to the ACTOR storage rack. As a consequence, pucks can be removed and replaced individually without having to remove the pucks above. The rack consists of six plates: five shelves and a cover plate for the uppermost puck (Fig. 2). Serving as backbone are three threaded rods that pass through each shelf. The height of the shelves is determined by thin spacer tubes passed over the threaded rods. Nuts and washers (M4) at either end of the threaded rods secure the construction. A removable locking pin is inserted through all shelves, and pucks, along the axis of the pucks to secure them in place. A handle is welded to the cover plate to hang the rack in the storage dewar and a pair of feet is welded to the bottom shelf to keep the rack stable while standing. All parts are made of stainless steel (1.4404) and are graded after cutting and electrically polished to give a smooth durable surface except for the threaded rods, nuts and washers. Manufacturing is by JA Precisionsteknik AB (Sweden), and blueprints including CAD files are available on request. To handle the pucks into and out of the rack (Fig. 1*a*) we modified a pair of ACTOR puck tongs by incorporating callipers to grip the puck (Fig. 1*c*).

To address any concerns that crystals remained frozen during the transfer of pucks into and out of the rack outside of liquid nitrogen



(*a*) (*b*) (*c*)

Figure 1
Photographs of the puck rack. (*a*) An overview of the rack showing placement of a puck. (*b*) Close-up view showing a puck in position, secured by the locking pin. (*c*) Specially modified tongs with callipers to handle the pucks.



(*a*) (*b*)

Figure 2
Blueprints showing all components of the puck rack in exploded view (*a*) and with all dimensions (*b*). All parts are numbered as follows: (1) shelves, (2) spacer tubes, (3) M4 threaded rods, (4) M4 nuts and washers, (5) feet, (6) handle, (7) locking pin, (8) cover plate. All dimensions are given in millimetres.

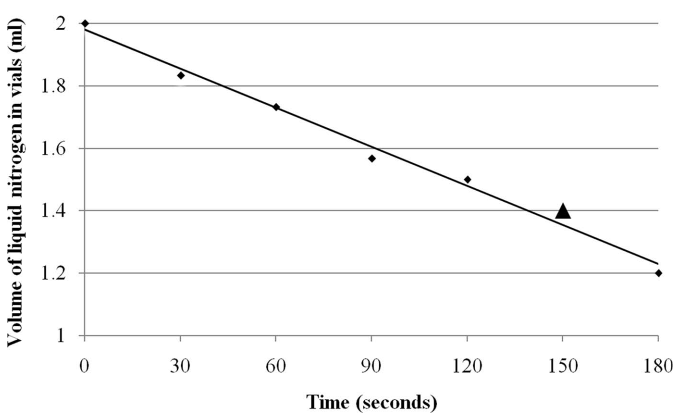


Figure 3
Graph displaying the time taken for liquid-nitrogen levels to go down in the tubes placed in a cooled puck (diamonds). The critical level at which the liquid nitrogen passes the crystal is highlighted (triangle).

we tested the time taken for liquid nitrogen to disappear. Pucks with ten CrystalCap HT vials (Hampton) were put into liquid nitrogen to flood the vials (2 ml total volume). CrystalCaps with pre-mounted loops (22 mm from base to loop) were added to each vial and left to equilibrate. The pucks were then transferred to room temperature and the level of liquid nitrogen in several vials checked every 30 s (Fig. 3). When the level reached approximately 1.4 ml (shown by the triangle in Fig. 3) the crystal was no longer submerged and could presumably start thawing. It took more than 2 min to reach this level which allows plenty of time to transfer all pucks into or out of one rack, which took approximately 40 s in total.

The rack was designed to be as simple and cheap as possible but remain robust. In fact, the 20 racks that we use on a regular basis have given almost two years of trouble-free use. There are some areas where modifications and enhancements could improve the rack, such as non-heat-conducting material in several places. However, such a simple and cheap solution for storing SPINE pucks makes a viable option to not just synchrotrons but also to academic and industrial research laboratories alike in the absence of a commercial source.

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