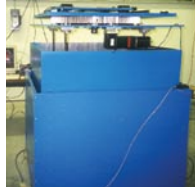
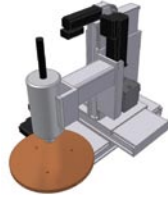




**Spectrometer for Inelastic X-ray Measurements at Spring-8**  
pg. 2-2



**SMARTS Translator for LANL Neutron Facility**  
pg. 2-3



**Five Axis Positioning System for NASA**  
pg. 2-4



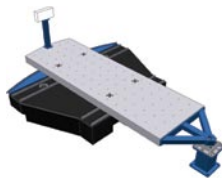
**Compact Precision Translator for LANL Neutron Facility**  
pg. 2-4



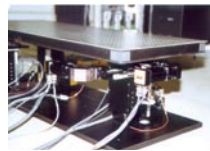
**Upright Cryostat Holder**  
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**MAX-Lab Precision Positioning System (Optical Table)**  
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pg. 2-8



**Brookhaven Nat'l Laboratory Precision Optical Table**  
pg. 2-9



**Kappa Six-Circle Goniometer for Cornell University**  
pg. 2-10

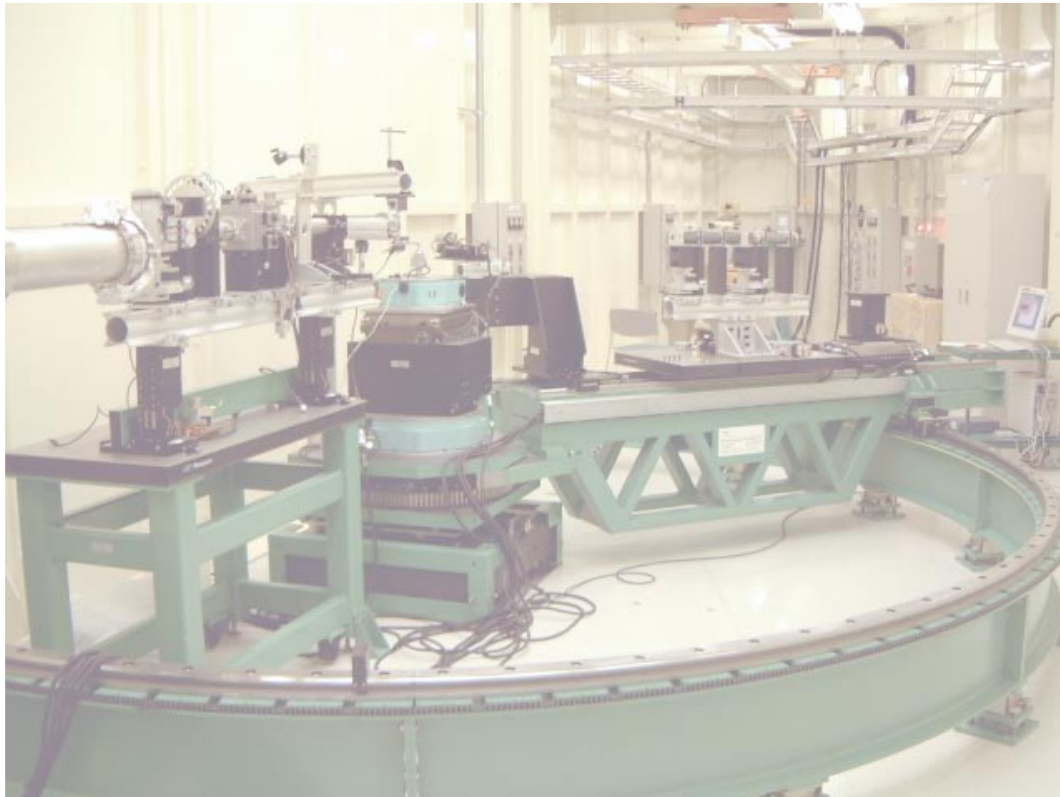


**Goniometer for the Canadian Neutron Beam Centre**  
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## High Precision Systems

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## Spectrometer for Inelastic X-ray Measurements at Spring-8



This spectrometer is operating at the Spring-8 synchrotron in Japan as part of a dedicated inelastic beamline (BL12XU). The system is used for investigating electronic excitations with milli-electron volt resolution; therefore many of the specifications require high precision, and accuracy on the micron level. The 3-meter analyzer arm on the spectrometer needs to have an angular stability measured in arc seconds over a long range of travel, under vacuum conditions.

The spectrometer is designed for several types of inelastic X-ray measurements, such as performing non-resonant inelastic X-ray scattering, which directly measures the dynamical structure factor,  $S(\mathbf{q}, \omega)$ , of the sample. The scientific focus is to study the single-particle and collective electronic excitations in many-body systems. The incident table allows for diagnostics, attenuation of the highly monochromatic beam, and reduction of parasitic scattering. In addition to the standard capability of orienting the sample, the spectrometer will be used with large magnets, furnaces, or a specially designed cryostat with a fine-positioning carrier, for measurement of samples in extreme environments.

In the initial phase, the spectrometer will have a one-, two-, or three- meter radius spherically bent silicon analyzing crystal, allowing for a range of energy resolutions of around 100 meV to 1 eV. The spectrometer has the custom designed versatile capability of positioning a shielded detector in the backscattering geometry for use with various sample chambers, which will allow optimizing the energy resolution.

The second purpose of the spectrometer is for Resonant Raman scattering, to capitalize on the large resonant enhancement of the inelastic scattering cross sections. The incident X-ray energy will be widely tunable to excite core electron absorption edges of samples ranging from the copper to vanadium. For large-q scattering, the instrument can also be used to do high- resolution Compton scattering.

### Final Acceptance Tests of the Phase I IXS Spectrometer at BL12XU, SPring-8 (15-30 Apr. 2002)

TEST	ITEMS	SPECIFICATION	MEASUREMENT	NOTE	
Functional Performance	Sphere of confusion of spectrometer tower and 3-m arm	$\theta/2\theta/\phi/\chi$ < 50 microns	Phi circle < $\pm 0.5$ mm Chi arc < $\pm 3$ mm Theta circle < $\pm 3$ mm 2Theta circle (0-50°) < $\pm 0.5$ mm 2Theta circle (50-90°) < 30 mm Needs to be done	Measure with steel ball on Huber goniometer 1003 and a dial gauge	
	Analyzer $\theta/\chi$ axes intersection	within 50 microns		Measure with steel ball on Huber goniometer 1003 and a dial gauge	
	Angular stability of analyzer stage against arm and analyzer stage motion	within 2 arcsec or 10 microrad or 30 microns deviation at 3 meters from sample			Measure with digital levels
	Static stability of simulated measurements	within autocollimator's resolution 0.5 arcsec measured overnight		Overnight drift less than 2 arcsec.	Measure with autocollimator

**Publication:** 2nd Internat'l Workshop on Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation (MEDSI02) September 5-6, 2002 – Advanced Photon Source, Argonne National Laboratory, Argonne, Illinois U.S.A.  
Development of a Spectrometer for Inelastic X-ray Measurements  
8th International Conference on Synchrotron Radiation Instrumentation (SRI) meeting in San Francisco, California, August 25th 2003, Optical design and performance of the Taiwan Inelastic X-Ray scattering beamline (BL12XU) at Spring-8

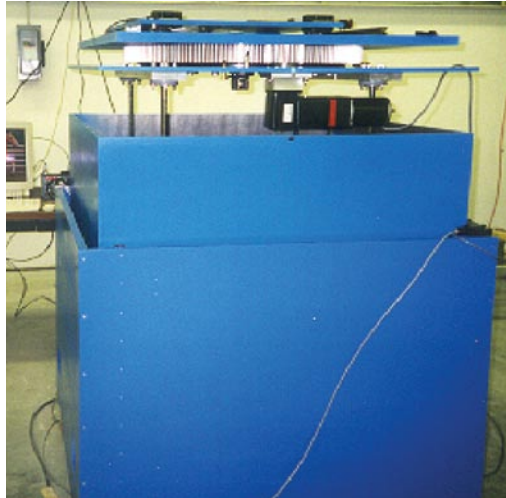


## SMARTS Translator for LANL Neutron Facility

This system was designed and built for a new spectrometer called SMARTS (spectrometer for materials research at temperature and stress) at the LANSCE facility at Los Alamos National Laboratory. SMARTS is used for measurements of residual macrostrain in engineering components and in-situ loading. This translator is the central component of SMARTS. It is used to position plates or tube specimens 10's of centimeters in dimension with a mass of a few kg as well as ancillary equipment (load frame, furnaces, eulerian cradle with a mass of as much as 1000 kg) relative to a fixed neutron beam and two detectors in permanent locations on either side of the translation table.



Verifying load capacity with  
3000 lb milling machine



Partially completed final assembly



Pre-paint trial assembly

### Specifications

#### Motions:

Vertical translation (Z): 600 mm; Rotation (R): 380 degrees; Horizontal translations (X, Y; normal to one another in a horizontal plane): 300 mm each.

#### Capacity:

The maximum mass to be placed on the table is 1500 kg.

#### Precision:

X, Y, Z: For a 100 kg load the accuracy is better than 50 micrometers on each motion over any 100 mm of motion and it does not exceed 0.5 mm over the whole range of motion.

For a 1500 kg load the accuracy is better than 100 micrometers on each motion over any 100 mm range of motion. X, Y, and Z axes are equipped with linear encoders.

R: accuracy is better than 0.1 degree and is equipped with a rotary encoder.

All four axes include a coarse (1 mm, 1 degree) visual scale to indicate position.

#### Speed of Travel:

Z maximum speed is 5 mm/s, R maximum speed is 10°/s, X, Y maximum speed is 5 mm/s

#### Control:

This translator is a complete standalone system. In addition to control from a PC with windows 9x or NT system, a hand-held joystick and position display are provided. The control uses the "Compumotor 6K" indexer. All four motions are equipped with limit switches.

**Publication:** *Appl. Phys. A 75,1-3 (2002) SMARTS-a spectrometer for strain measurement in engineering materials*



## Compact Precision Translator for LANL Neutron Facility

This system was designed and built for the Los Alamos National Laboratory. Although highly customized, it uses several of our standard slides, both motorized and non-motorized.

Motions: Vertical (Z): 50 mm max, Rotation (R):  $\pm 5^\circ$  max, Horizontal (X, Y; normal to one another in the horizontal plane): 100 mm max. each, Tilt:  $\pm 5^\circ$  max. parallel to beam.

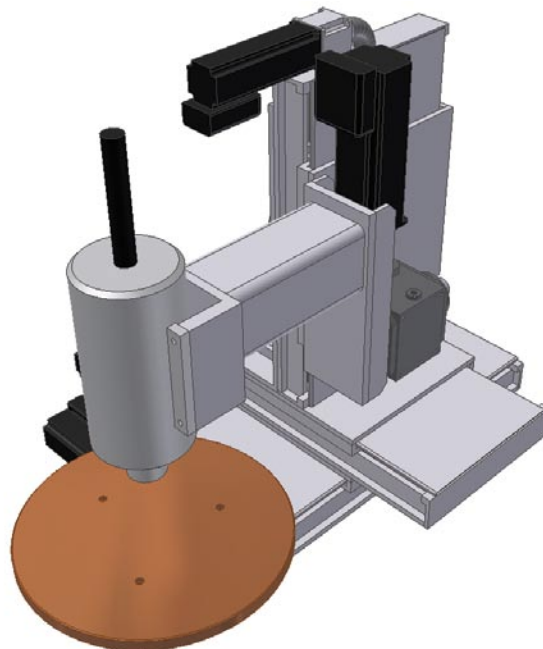
Capacity: The maximum mass to be placed on the table is 680 kg.



## Five Axis Positioning System for NASA



ADC is developing a 5 axis positioning system device to facilitate research in the area of electron beam free form fabrication in microgravity. This process will be used to create replacement components for isolated equipment from raw material in wire form. Possible applications range from military equipment, to the ISS, to manned exploration of space.



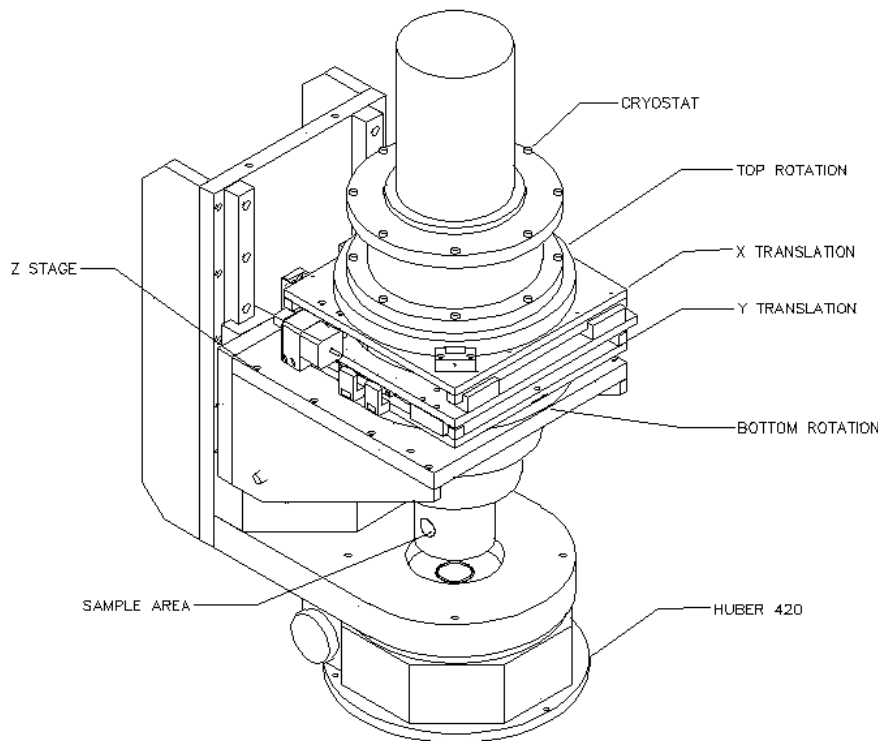
This system will provide a high precision manipulation system with both position and velocity control of the electron gun and substrate. Other requirements for this system include operation in vacuum as well as capacity for dealing with large heat loads from the welding process.



## Upright Cryostat Holder

ADC has developed a precise positioning system to attach a Huber 420 (phi circle) to a dispex style cryostat. This system provides fine, precise, reproducible positioning of the sample and holds its position despite vibration, tension, and torque from the helium and vacuum lines.

The design incorporates X, Y and Z motorized adjustments and manual rotations. Fine adjustments can be made very easily in order to keep the sample in the beam while the system is being cooled. The area around the sample is kept open for the use of a detector and sample slits. The manual lockable 360-rotation adjustments allow the carrier to be moved out of the way of the incoming and scattered beam, while maintaining orientation of the sample. All motorized translation motions have limit switches. The system can be used with small modification for different cryostat manufacturers including Suzuki-Shokan, Janis, Iwatani, Lakeshore, and Advanced Research Systems.



### Specifications:

#### X & Y translation:

Range of motion:	± 15 mm
Absolute Accuracy:	2 µm
Bi-directional repeatability (precision):	2 µm
Minimum incremental motion:	1 µm
Positioning stability:	Rock solid, no movement, very stable
Load Capacity:	50 Kg

#### Z translation:

Range of motion:	± 85 mm
Absolute Accuracy:	2 µm
Bi-directional repeatability (precision):	2 µm
Minimum incremental motion:	1 µm
Positioning stability:	Rock solid, no movement, very stable
Load Capacity:	50 Kg

#### Rotation:

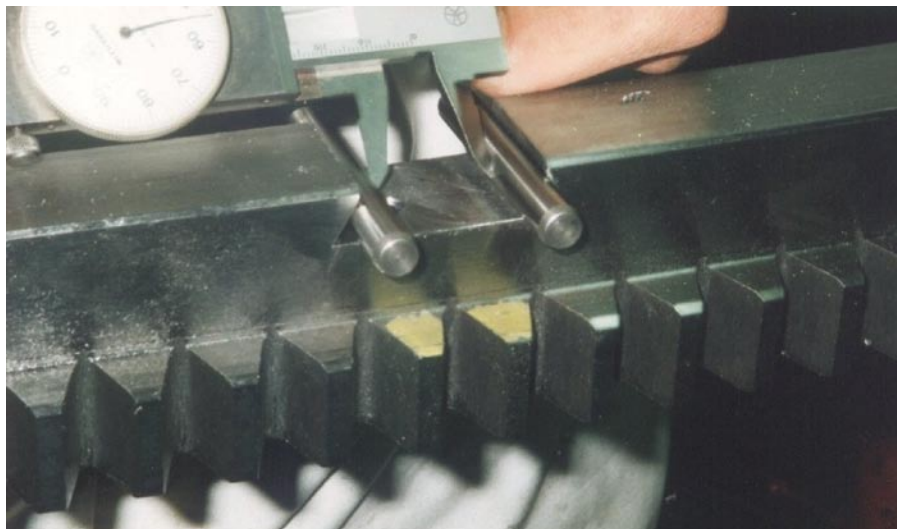
Two manual lockable 360-rotation adjustments



## Arecibo Observatory Upgrade

Advanced Design Consulting designed a large turntable, capable of positioning the receiver heads to within .5 mm (taking into consideration the weight budget and achieving the required velocity). ADC also designed the positioning systems for the tertiary sub-reflector and the eight new receiver heads. This project was part of a \$25 million upgrade to the Arecibo facility. A Gregorian reflector system now hangs from the main detector area 137 meters (450 feet) above the main reflector dish. The Gregorian dome contains two reflector dishes, a radar transmitter, and microwave receivers. The secondary and tertiary reflectors channel the signal from the main reflector into the receivers.

The CH and Gregorian drive systems met their tracking specifications with no problems, and in fact the carriage house exceeded its specifications by a large factor. More information about the observatory and its facilities is available at <http://www.astro.cornell.edu/facilities/arecibo.shtml>.

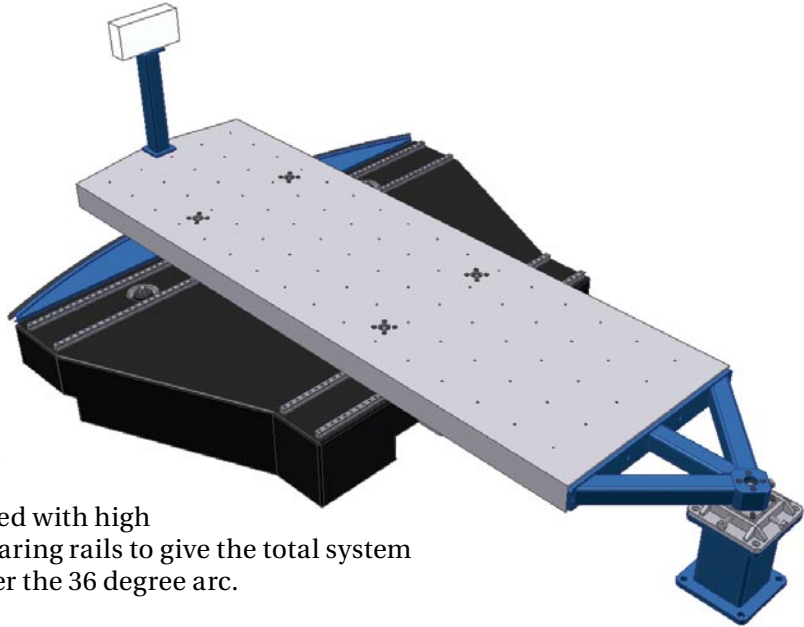




## Rotational Platform for NSRRC/Spring-8

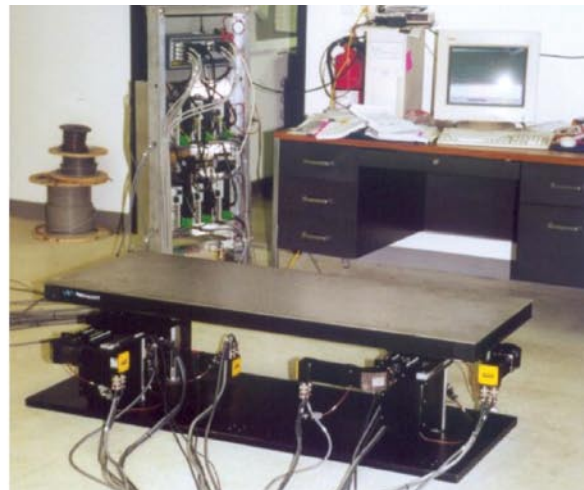
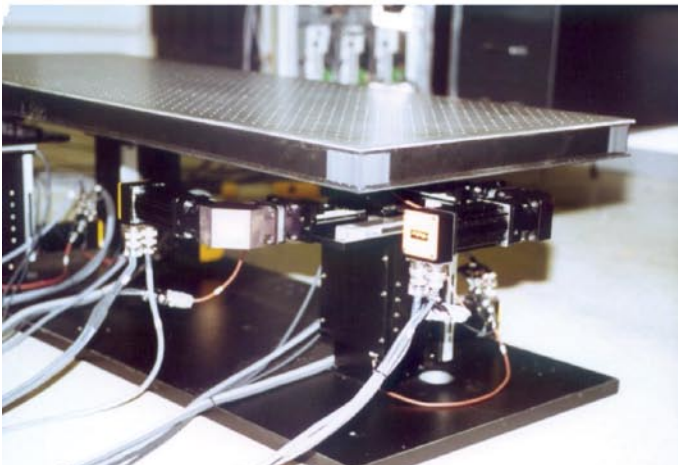
The rotational platform was designed for use at Spring8 to allow for the rotation of the beamline components following a diamond monochromator to maintain system alignment over the range of beam energies.

A 5-phase stepper motor drives the platform with an effective open loop resolution of .002 degrees through a chain drive. A rotary encoder can be used both as a digital readout of the position and to close the positioning loop for a system accuracy of up to .0005 degrees. The machine base is composed of polymer concrete with mounting surfaces ground to  $\pm 20\mu\text{m}$  and combined with high precision crossed linear recirculating bearing rails to give the total system straightness of trajectory of  $\pm 50\mu\text{m}$  over the 36 degree arc.



## MAX-Lab Precision Positioning System (Optical Table)

This positioning system's worksurface can move precisely vertically and horizontally, tilt along any axis, and rotate. These movements are accomplished by a triangular arrangement of three assemblies of stepper-motor-actuated slides to which the worksurface is attached via spherical bearings. Each horizontal and vertical motion stepper motor is independently controlled and is equipped with limit switches. The size of this table is 600 mm wide, 1500 mm long, and 500 mm tall. The system has an accuracy of  $5\mu\text{m}$  and it was supplied with linear incremental optical encoders on all jacks and all motorized slides. The control uses the "Compumotor 6K" indexer.

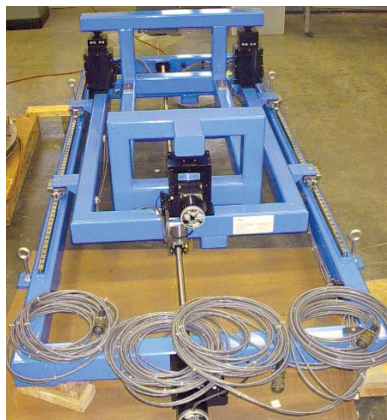




## Custom Precision Optical Table

These custom precision positioning systems were designed to provide high precision X-, Y-, Z-axis motion using high load capacity positioning stages arranged in 3-point kinematic fashion. Both systems can be precisely moved vertically and horizontally, tilted along any axis, and rotated. These movements are accomplished by a triangular arrangement of three assemblies of stepper-motor-actuated jacks and slides to which the instrument (breadboard) is attached via spherical bearings. Each horizontal and vertical motion stepper motor is independently controlled and is equipped with limit switches.

The system shown on the left was designed to hold a large diffractometer and can be moved precisely in and out of x-ray beam path. The system shown on the right was specifically designed to hold a six-circle diffractometer.



ADC builds standard optical tables (see page 1-16). The following chart lists our standard optical tables:

Series	Model	Vertical Travel (mm)**	Transverse Travel (mm)**	Longitudinal Travel (mm)**	Pitch (+/-degrees)**	Roll (+/-degrees)**	Yaw (+/-degrees)**	Dynamic Load Capacity (N)*	Breadboard Tapped Holes	Breadboard Hole Spacing (mm)	A (mm) Contracted Height	A (mm) Extended Height	B (mm) Table Width	C (mm) Table Length	D (mm) Center to Center Longitudinal Spacing	E (mm) Center to Center Transverse Spacing	F (mm) Table Thickness	G (mm) Pivot Point Location	Motion Repeatability (with & without encoder)	
OPT																			w	w/o
	100-1	100	100	50	5	5	5	4000	M6	25X25	673	773	609.6	914.4	#	#	112	#	<4μm	<10μm
	100-2	100	100	50	5	5	5	4000	M6	25X25	673	773	914.4	1524	1025	525	112	134.85	<4μm	<10μm
	100-3	100	100	50	5	5	5	4000	M6	25X25	673	773	1219.2	1828.8	#	#	112	#	<4μm	<10μm
	250-1	250	100	50	5	5	5	4000	M6	25X25	762	1012	609.6	914.4	#	#	112	#	<4μm	<10μm
	250-2	250	100	50	5	5	5	4000	M6	25X25	762	1012	914.4	1524	#	#	112	#	<4μm	<10μm
	250-3	250	100	50	5	5	5	4000	M6	25X25	762	1012	1219.2	1828.8	1100	711.2	112	141.2	<4μm	<10μm

# Contact ADC for details.

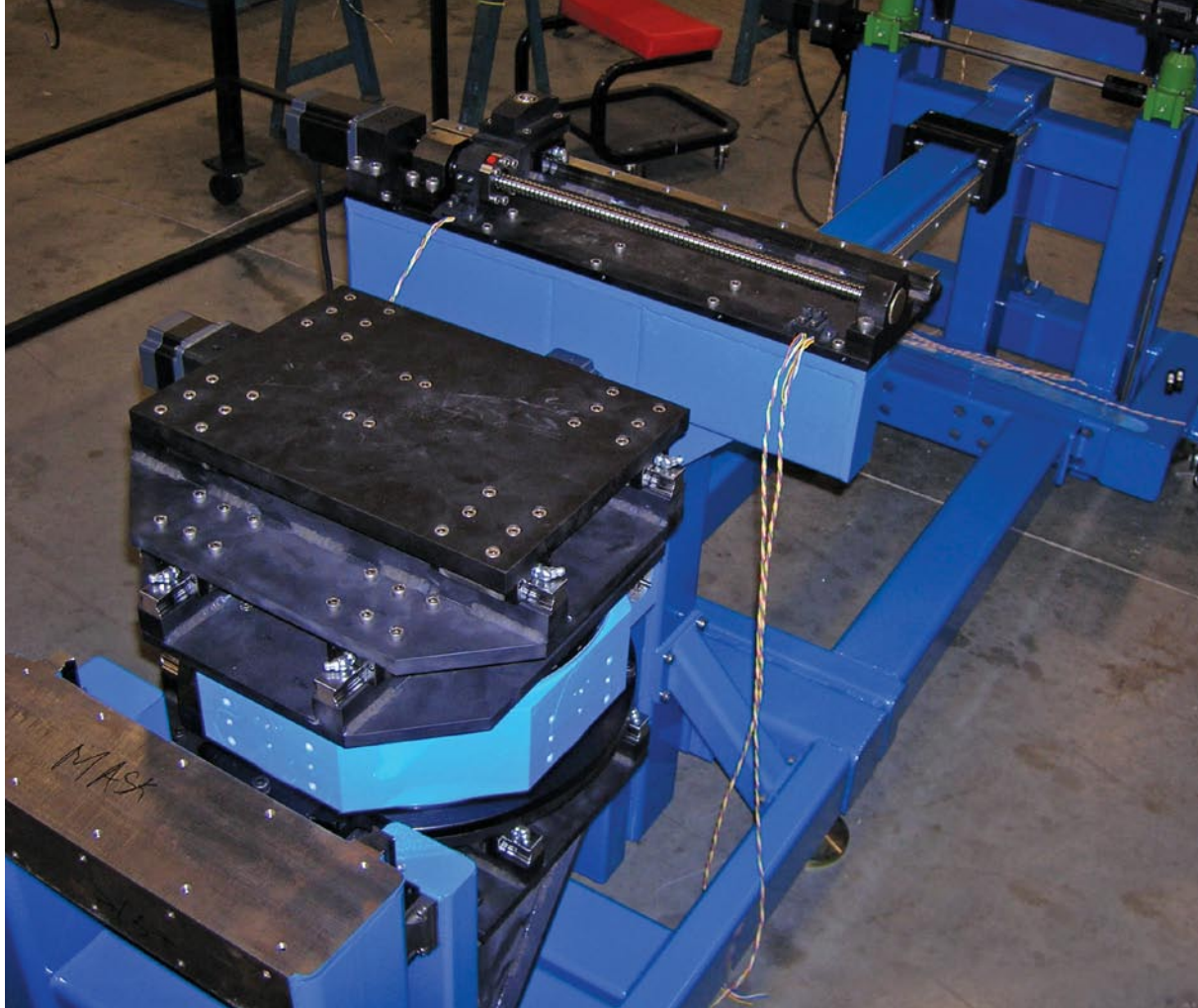
\* Centered on table. Load must be derated as it is moved off center.

\*\* Care must be taken to prevent binding of free actuators in combined translations and rotations

For connector and pin out information see page 3-33



## **Brookhaven National Laboratory Precision Optical Table**



HIGH PRECISION SYSTEM

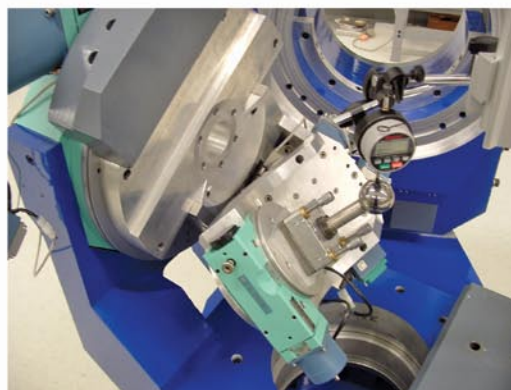
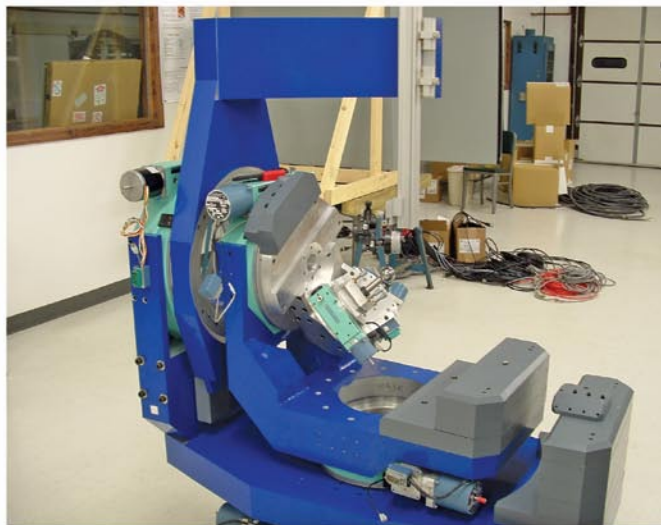
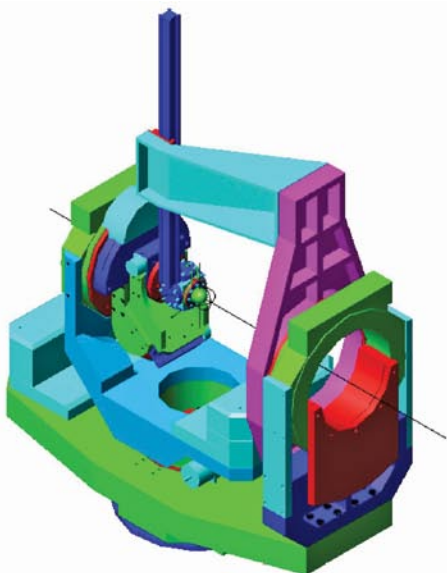
This optical table was designed to position both the sample and a MAR345 detector for use in an experiment at Brookhaven National Labs. 5 degrees of freedom of the detector were used to align the detector with the incoming beam. A 6th, high precision translation was used to position the detector along the beam path while maintaining a vertical position of  $\pm 20\mu\text{m}$ . The sample was positioned with a 4 DOF (degrees of freedom) stack up of stages including an X,Y,Z and a rotation. The entire structure is contained on a large welded steel tubing base with locking casters to create a unique, portable experiment station.



## Kappa Six-Circle Goniometer for Cornell University

ADC custom designed and built a six circle kappa Goniometer for G2 line at CHESS. Cornell had six rotation from Huber and wanted to utilize those for this application. They had very stringent requirements and Huber standard six circle Goniometer could not meet the requirements. There had to be significant custom design, finite element analysis, and calculations done for this project.

All axes were perfectly counterbalanced to provide the very high accuracies at any accessible angular position. Our design incorporated advanced material and construction techniques resulting in lightweight yet rigid systems to improve dynamic performance with larger loads and higher velocities at extremely high precisions. The six-circle Kappa Goniometer was designed to handle heavy loads. It included collimator and detector arms with adjustable holders for collimators, slits, various size cryostats, heat chambers and vacuum chambers.



Publication: *REVIEW OF SCIENTIFIC INSTRUMENTS* 77, 113301 \_2006\_

0034-6748/2006/77\_11\_/113301/9/\$23.00 © 2006 American Institute of Physics 77, 113301-1

Six-circle diffractometer with atmosphere- and temperature-controlled sample stage and area and line detectors for use in the G2 experimental station at CHESS



## Goniometer for the Canadian Neutron Beam Centre

HIGH PRECISION SYSTEM

### Double axis goniometer

Distance from platform top to arc center = 152.4 mm (6 inches)

Minimum Rotational Travel = +/- 7.5 degrees

Rotational Accuracy = +/- 0.001 degrees (closed loop, microstepping mode)

The rotary axis motorized with feedback (stepper motor, encoder, limit switches)

Load Capacity: 1600 pounds

### Linear Stages

Linear Travel Range = Minimum 25 mm total

Linear Travel Accuracy = +/- 0.005 mm (open loop)

Linear Travel Accuracy = +/- 0.0005 mm (closed loop, microstepping mode)

The linear stage motorized with feedback (stepper motor, encoder, limit switches)

Load Capacity: 1600 pounds

Motion Repeatability: < 0.5 micron (limited by typical controller)

Motion Resolution: < 0.2 micron (encoder)

