

# Progress with the MX Control System Toolkit

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<http://mx.iit.edu/>

# What is MX?

- A portable beamline control toolkit: *BSD, Cygwin, DJGPP, eCos, HP/UX, Irix, Linux, MacOS X, QNX, RTEMS, Solaris, Tru64, VMS, VxWorks, Windows.*
- Written in C, with Python and Tcl interfaces available.
- Designed as middleware.
- Comes with a set of servers and clients so that it can run standalone.
- Has an extensive set of over 440 device drivers (*motors, scalers, MCAs, MCSs, area detectors, ...*).
- Not tied to one specific network protocol.
- MX servers and clients share the same set of drivers.
- Servers can act as clients and clients can act as servers.
- Easy to interface to other people's drivers.
- Easy to embed in other applications and servers.

# Recent Changes to MX

- Debian Packages are now available for MX and EPICS Base. They can be found at:

`deb` <http://fermi.phys.iit.edu/debian/sarge> `binary/`  
`deb-src` <http://fermi.phys.iit.edu/debian/sarge> `source/`

We plan to submit these packages for inclusion in the main Debian distribution.

- MX now runs on 64-bit architectures: tested on Alpha, AMD64, Itanium, MIPS, PARISC, and SPARC.
- Cross platform threading and synchronization primitives were added for use in enhanced multi-protocol event support.
- Moving to embedded computers for MX servers.

# MX for Physical Sciences Applications

## Deep X-ray Lithography

A graphical user interface has been developed by Ken McIvor for lithography measurements at MR-CAT (APS Sector 10).

Exposure

^ Lithography

Over-scan by:  mm

X center:  < mm

Backoff by:  mm

Y center:  < mm

Motor speed:  mm/s

Mask length:  mm

^ Dosage:  mA\*m

∨ Basic Motion

∨ Number of scans:  ↗

Start position:  mm

■ Email notification: @vtext.com

End position:  mm

■ Monitor APS status

X Position: 50.011

Y Position: 147.310

Ring current: 102.36

Shutter: open

Time: 04:08 / 8:40:40

Dose: 347.09 / 43848.05

Scans: 48 / 6048

Moving to end point.



# SERGUI – Macromolecular Crystallography for MX

Jim Fait (U. Georgia) has developed a user interface for crystallography experiments at SER-CAT (APS Sector 22)

The screenshot displays the SER-CAT Control Program interface, which is used for managing macromolecular crystallography experiments. The interface is divided into several functional areas:

- Wavelength:** Controls for Energy (Current: 12749.999 eV, Desired: 12750 eV), Wavelength (Current: 0.97243 Å, Desired: 0.97242 Å), and Gap Energy (5569.430 eV).
- Attenuation:** Controls for Transmission (Current: 100.000 %, Desired: %).
- Slits:** Controls for Horizontal and Vertical slits (Current: 80.070 μm, Desired: μm), with a **Drive** button.
- Detector:** Controls for Distance (Current: 900.000 mm, Desired: mm), Offset (Current: 0.000 mm, Desired: mm), and Two-Theta (Current: -0.000 deg, Desired: deg).
- Optimize:** Buttons for **Optimize Tune**, **Optimize Horizontal Slits**, and **Optimize Vertical Slits**, along with a **Feedback Off** button.
- View:** A live video feed of the experimental setup.
- Focus:** Buttons for **Near**, **Auto**, and **Far**.
- Zoom:** Buttons for **In** and **Out**, along with directional arrow buttons.
- Shutter:** Radio buttons for **Open** and **Closed**, with a green **Closed** button highlighted.

At the bottom of the interface, there is a status bar with the following information:

Peak	12660.73	-8.0	5.0	
Wavelengths:	Peak	Edge	Low	High
Wavelength:	0.97928 Å	0.97945 Å	0.98257 Å	0.97177 Å
Energy:	12660.73 eV	12658.61 eV	12618.33 eV	12758.60 eV
f':	-7.97 e-	-9.86 e-	-5.21 e-	-3.98 e-
f'':	5.05 e-	3.13 e-	0.47 e-	3.67 e-

Buttons for **Idle** and **Exit** are also present. The bottom status bar shows: Energy: 12749.999, Transmission: 100.000, Ring Current: 0.006, Beam Status: On A, Searched C, Searched D, Searched.

# Sample Alignment with SERGUI

The screenshot displays the SER-CAT Control Program interface. The main window shows a central image of a sample with a red crosshair. The interface includes a menu bar (File, Setup, Help) and a toolbar (Logbook, Hutch, Sample, MAD, Collect). The left panel contains alignment controls: Phi (0.000), +X, -X, +Y, -Y buttons; Select Camera (Top, bottom); Fine Adjustment (Up, Down, Left, Right); Top Camera Zoom (1 X, 2 X); AutoAlign, Save Image, Lights buttons; and an Align button. The bottom panel shows a table of peak data and a status bar.

Alignment  
Phi 0.000  
+X -X  
+Y -Y  
Select Camera  
 Top  bottom  
Fine Adjustment  
Up  
Left Right  
Down  
Top Camera Zoom  
 1 X  2 X  
AutoAlign Save Image Lights  
Align Snap On

x: -104.030um y: 835.686um z: -2837.237um

Peak	12660.73	-8.0	5.0
Wavelengths:			
Wavelength:	0.97928 Å	0.97945 Å	0.98257 Å
Energy:	12660.73 eV	12658.61 eV	12618.33 eV
f' :	-7.97 e-	-9.86 e-	-5.21 e-
f'' :	5.05 e-	3.13 e-	0.47 e-

Energy: 12749.999 Transmission: 100.000 Ring Current: 0.007 Beam Status: On A Searched C Searched D Searched



# AVIEX CCD Detector (PCCD-170170)



*The PCCD-170170 will be similar in appearance to the PCCD-16080 shown in this picture.*

- This will be the first commercial application for MX.
- 4096 by 4096 pixel CCD detector.
- 2 by 2 module design with 16 taps and fiber-optic coupling.
- Can be used both as an area detector and as a streak camera.
- High dynamic range:  $\sim 30,000$
- High sensitivity: Single X-ray photon signal is above the read-noise floor.
- Very fast readout.
- Can operate in a vacuum.
- Supports ROIs to reduce the amount of data transferred.
- First installation will be at SOLEIL.

# MX as a CCD Control System

- The main components controlled by MX are:
  - EPIX PIXCI E4 imaging board controlled via PCI-Express.
  - AVIEX CCD detector electronics controlled via Camera Link.
- The high-level object seen by application programs is an MX *area\_detector* record.
- The area detector record controls the imaging board through an MX *video\_input* record and the CCD detector electronics through an MX *camera\_link* record.
- The modularity of the design allows one to easily switch imaging boards or detector electronics without requiring large changes to the rest of the software.
- Network transparency for MX clients is implemented via the MX *network\_area\_detector* driver.
- Both Linux and Windows are supported for the detector computer.
- Future plans include support for EPICS and Blu-Ice clients.
- SOLEIL plans to write their own Tango-based wrapper for MX.



# Near Term Plans

- Finish enhancements of the event and callback system for MX.  
*(Winter 2006-2007)*
- Finish the full implementation of an MX-based Portable Channel Access Server for EPICS clients.
- Implement an MX-based Blu-Ice Device Hardware Server.
- Implement loadable device drivers and extensions.

# Supported Devices

## Motor Controllers

ACS MCU-2  
Aerotech Unidex 500  
Am9513  
Animatics SmartMotor  
APS insertion device  
Blu-Ice motor  
Bruker D8  
Compumotor 6K  
Compumotor 6000  
Cryostream 600 temp ctrl  
DAC output  
Delta Tau PMAC  
DSP E500  
EPICS motor record  
IMS IM483  
IMS MDrive  
IMS Panther  
Joerger SMC24  
Kohzu SC-series motor  
LakeShore 330 temp ctrl  
MarDTB motor  
McLennan PM304  
McLennan PM600  
MX network motor  
NI ValueMotion  
New Focus Picomotor  
Newport MM3000  
Newport MM4000  
Newport ESP  
NSLS MMC32  
OMS VME58  
OSS BCW  $\mu$ -GLIDE  
Oxford Inst. ITC503 temp ctrl  
Pan/Tilt/Zoom motor  
Phidget stepper motor  
Physik Instrumente E-662  
Pontech STP100  
Prairie Digital Model 40  
Precision Microcontrol MCAPI  
Radix Databox motor  
SCIPE motor  
SI 9650 temp ctrl  
Software emulated motor  
spec motor  
Velmex VP9000  
XIA HSC-1

## Pseudomotors

ALS dewar positioner  
APS 18-ID monochromator  
CCD detector A-Frame  
Compumotor linear interp.  
CrystalLogic 20  
Delta  
Elapsed time  
Gated backlash  
Linear function  
Monochromator  
MX record field  
PMAC coordinate system  
Q (momentum transfer)  
Segmented move  
Sine arm  
Slit center/width  
Table rotation/translation  
Tangent arm  
 $\theta$ -20  
Translation  
X-ray energy  
X-ray wavelength  
X-ray wavenumber  
XAFS wavenumber

## Amplifiers

APS QuadEM  
Keithley 428  
MX network amplifier  
Oxford Danfysik IC PLUS  
Oxford Danfysik QBPM  
SCIPE amplifier  
Software emulated amp  
Stanford Res. Syst. SR570  
UDT Tramp

## Multichannel Analyzer

EPICS MCA record  
MX network MCA  
Ortec Trump  
Roentec RCL  
Software emulated MCA  
XIA DXP-2X  
XIA Saturn

## Counter/Timers

Am9513  
Black Cat Systems GM series  
Blu-Ice timer  
DSP QS-450 scaler  
DSP RTC-018 timer  
EPICS scaler record  
Joerger VSC-16  
Kinetic Systems 3610 scaler  
MCS scaler/timer  
MX network scaler/timer  
Ortec 974  
Prairie Digital Model 45  
Radix Databox  
SCIPE scaler/timer  
Software emulated scaler/timer  
spec scaler/timer  
XIA Handel/Xerxes timers  
XIA PFCU shutter timer

## Pseudocounter/timers

Autoscale scaler  
Gain tracking scaler  
Interval timer  
MCA alternate time  
MCA channel  
MCA ROI integral  
Scaler function  
Timer fanout

## Multichannel Encoder

MCS encoder  
MCS time MCE  
MX network MCE  
PMAC MCE  
Radix Databox encoder

## Multichannel Scaler

EPICS MCA record (as an MCS)  
MX network MCS  
Radix Databox MCS  
Scaler function MCS  
Software emulated MCS  
Struck SIS3801

## Analog and Digital I/O

Animatics SmartMotor I/O  
Bit manipulation  
Blu-Ice ion chamber  
Compumotor I/O  
Crossbow CXTILT02  
Data Track Tracker  
Delta Tau PMAC I/O  
EPICS I/O  
General PC I/O port  
IMS MDrive I/O  
Intel 8255  
Keithley 2000 series  
Keithley 2400 series  
Keithley 2700 series  
Kinetic Systems 3063  
Kinetic Systems 3112  
Kinetic Systems 3512  
MarDTB status  
MCAI function  
MCA value  
McLennan PM600 I/O  
MODBUS I/O  
Motorola 6821  
MX network I/O  
New Focus Picomotor I/O  
Newport Elec. P6000A  
Omega iSeries  
PC parallel port  
Pfeiffer TPG 261/262  
Prairie Digital Model 45  
Precision Microcontrol I/O  
SCIPE I/O  
Software emulated I/O  
Stanford Res. Syst. SR630  
VME I/O  
Wago 750-specific MODBUS  
X10 CM17A  
XIA PFCU filter summary

## Pulse Generators

MX network pulser  
Prairie Digital Model 45  
Struck SIS3801  
Struck SIS3807

## Area Detectors

AVIEX PCCD-170170  
MarCCD  
MX network AD  
Software emulated AD

## Video Input

EPIX PIXCI  
MX network video  
Software test pattern  
Video4Linux 2

## Pan/Tilt/Zoom

Hitachi KP-D20A/B  
MX network PTZ  
Panasonic KX-DP702  
Software emulated PTZ  
Sony VISCA

## Relays

Blind relay  
Blu-Ice shutter  
Generic relay  
MarCCD shutter  
MarDTB shutter  
MX network relay  
Pulsed relay  
XIA PFCU filter  
XIA PFCU shutter

## Single Channel Analyzers

MX network SCA  
Oxford Danfysik Cyberstar X1000  
Software emulated SCA

## Multichannel Analog Input

Oxford Danfysik QBPM

## Encoders

Kinetic Systems 3640

## **Serial ports**

Camera Link  
DOS COM  
DOS Fossil  
EPICS RS-232  
Linux/Unix tty  
Kinetic Systems 3344  
MX network RS-232  
spec command  
TCP socket  
VMS RS-232  
VxWorks RS-232  
Wago 750 serial  
Win32 COM

## **GPIB**

EPICS GPIB  
Iotech Micro488EX  
Keithley K500  
Linux GPIB  
MX network GPIB  
NI 488

## **CAMAC**

DSP 6001  
ESONE CAMAC  
Software emulated CAMAC

## **USB**

libusb

## **Port I/O**

DOS port I/O  
DriverLINX for Win32  
Linux iopl/ioperm  
MX portio for Linux  
VxWorks port I/O

## **VME I/O**

EPICS VME record  
mmap() VME I/O  
NI VXI MEMACC  
RTEMS VME I/O  
Struck SIS1100/3100  
VxWorks VME I/O

## **MODBUS**

MODBUS/TCP  
MODBUS Serial RTU

## **Goniostat Tables**

ADC table

## **Sample Changers**

MX network sample changer  
SER-CAT robot  
Software emulated sample changer

## **Autoscale**

Amplifier autoscale  
Filter autoscale  
Filter/amp autoscale  
MX network autoscale

## **Servers**

TCP/IP MX servers  
Unix domain socket MX servers

## **Scans**

File list step scan  
Input device step scan  
MCS quick/fast/slew scan  
Motor step scan  
Pseudomotor step scan  
 $\theta$ - $2\theta$  step scan  
XAFS step scan

## **Variables**

APS topup/time to inject  
Blu-Ice variables  
EPICS variables  
Inline variables  
Mathop calc  
MX network variables  
PMAC variables  
Position select calc  
spec variables