

# EPICS at APS Beamlines

Tim Mooney

Advanced Photon Source

Argonne National Laboratory

# EPICS applications for synchrotron beamlines (synApps)

- Standard EPICS base & extensions
- Standard EPICS modules (e.g., MPF)
- synApps modules (std, motor, MCA)
- synApps-compatible clients

# synApps

- Custom EPICS records
- Custom EPICS device-support modules
- Other custom infrastructure (e.g., autosave, recDynLink, saveData)
- Custom EPICS databases, MEDM displays
- Custom clients (e.g., scanSee)
- Matched to a version of EPICS base

## Just to clarify...

- We didn't write everything in synApps
- One function of synApps is to bundle compatible versions of selected EPICS software – wherever developed – into a single tar file that can run a beamline

# Basic record/device support

- Motors
- Encoders
- Scalers
- Optical table
- Multichannel analyzer
- String calc, sequence
- Multichannel scaler
- Complex expressions
- Serial (RS-232)
- Enhanced PID
- GPIB
- Scan
- ADC's
- Scan parameter
- DAC's
- Generic VME

# Layered devices, techniques

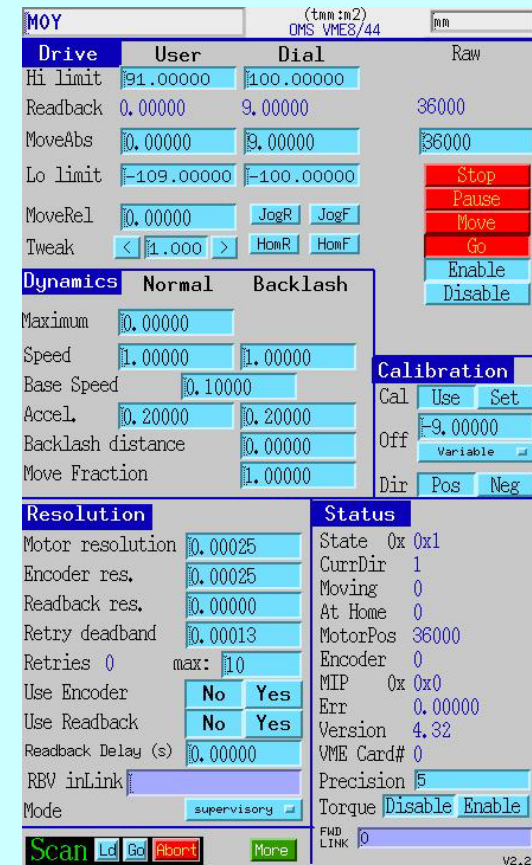
- Optical tables
- Slits
- Mirrors
- Monochromators
- Piezo controller
- Digital Multimeter
- Current preamplifier
- Interpolation
- N-step measurement
- Serial I/O block
- GPIB I/O block
- Autocollimator
- Temperature controller
- X-ray microscope
- Insertion device
- Filter/shutter

# Other support

- Autosave (save parameters through reboot)
- saveData (store scan data to disk)
- Clients to display scan/MCA data
- Programs to handle MDA, NeXus data files
- recDynLink (adds notify-when-done link)

# Motors

- Stepper, servo
- Oregon Microsystems
- Newport
- Intelligent Motion Systems
- McClellan
- Soft support





# Scalers

- Multiple preset scalers
- Background count interrupted by data-acquisition count
- User-programmable end calculations

Done	OneShot	time	Count time	Elapsed time	Counts
Count	AutoCount	5.00	0.100	0.000	Cts/sec
#	Description	Gate?	Preset count	Actual count	Calc result
1		N Y	1000000	0	0.000
2		N Y	100000	0	0.000
3		N Y	0	0	0.000
4		N Y	0	0	0.000
5		N Y	0	0	0.000
6		N Y	0	0	0.000
7		N Y	0	0	0.000
8		N Y	0	0	0.000

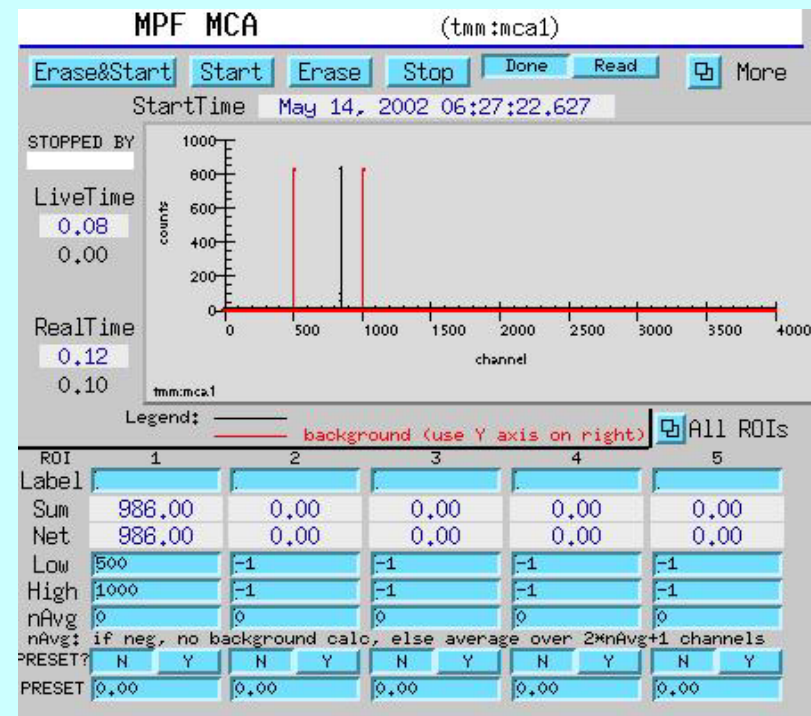
Card 0 Delay 0.000 (s) Clock 1.000e+007 Hz DisplayFreq 5.000 Hz  
 AutoCount: Delay 0.000 (s) DisplayFreq 5.000 Hz  
 Calculations ENABLE SYNC WITH SCALER: Less More

Done	OneShot	auto time	Count time	Elapsed time	Var	User calculations	
Count	AutoCount	5.00	0.100	0.000	I	Expression	Result
#	Description	Gate?	Preset count	Actual count			
1		N Y	1000000	0	A	A	
2		N Y	100000	0	B	B	
3		N Y	0	0	C	B*1.5	
4		N Y	0	0	D	B*2	
5		N Y	0	0	E	B*2.5	
6		N Y	0	0	F	B*3	
7		N Y	0	0	G	B*3.5	
8		N Y	0	0	H	B*4	

Card 0 Delay 0.000 (s) Clock 1.000e+007 Hz DisplayFreq 5.000 Hz Calcs: ENABLE  
 AutoCount: Delay 0.000 (s) DisplayFreq 5.000 Hz Less

# Multichannel analyzer

- Canberra AIM
- XIA DXP
- 32 regions of interest
- Halt acquisition on ROI preset
- Background subtraction for ROI sums
- Also supports sampling ADC (Acromag IP-330)



# Serial O/I Block

- Combination of string calc to construct output message, serial record to send and/or receive, and string calc to parse reply
- Intended for run-time programming
- Similar GPIB support

The screenshot displays the 'Serial O/I block 0\_1' interface. It is divided into three main sections:

- Make output string:** This section includes a 'MORE' button. It has three rows: 'DOUBLE VARIABLES' with 'PV NAME' 'A' and 'NUMBER' '0.00000'; 'STRING VARIABLES' with 'PV NAME' 'AA' and 'STRING' '0'; and a 'HELP' row with a yellow warning icon, 'CALC EXPRESSION', and 'RESULT' '0.00000'. A 'STRING RESULT:' field is at the bottom.
- Send and/or Receive:** This section has a 'Write/Read' dropdown menu. It includes 'Output' and 'Input' fields, both with 'TERM' '13'. Below these are 'Length:' fields for 'Requested:0' and 'Actual:0'. At the bottom, it shows 'Timeout: 500 (ms)' and 'Status: Timeout'.
- Parse reply string:** This section has a 'MORE' button. It includes a 'AA<REPLY STRING>' field. Below it is a 'HELP' row with a yellow warning icon, 'CALC EXPRESSION', and 'RESULT' '0.00000'. A 'STRING RESULT:' field is at the bottom.





# Monochromators

- Double crystal (dispersive, nondispersive)
- Spherical grating

The schematic shows a beam entering from the left, passing through a PZT1 stage, then reflecting off a crystal (Theta2), and finally reflecting off a second crystal (Theta1) before reaching the detector. The control panel includes a table of parameters:

H1	K1	L1	E (keV)	lambda (Å)	TH (deg.)
a	5.43102		113.2819	6.27025	89.00000
2d	6.27120		3.2478	3.81750	37.49807

Buttons include Manual, Auto, Move, and All Stop. A 'Done' button is also present.

E (keV)	Lambda (Å)	H1 K1 L1	TH1 (deg.)	H2 K2 L2	TH2 (deg.)
14.3997726	0.86875820	9 7 5	84.7200928	9 7 5	81.8372040
14.3367748	0.86479871	a 5.43102	82.4013678	a 5.43102	82.4013678
14.3997726	0.86101526	2d 0.87246	84.7200928	2d 0.87246	81.8372040
14.2714329	0.86101526	Silicon	80.7093887	Silicon	69.8050919

Phi 1	Phi 2	Calibration	world unad
3idd:m44	3idd:m43	Use Set	2.000
72.781	2292.636	Theta1 only	< 1.000 >
1270266.811	40014038.282	Theta1 and 2	All Stop
82.3973124	241.2507444	Rock Theta2	Done
155.1781249	2533.8861446		

### Spherical Grating Monochromator

Energy (eV)	Wavelen (Å)	Phi (deg)
0.000	50.000000	2.18963
1744.687	7.106388	0.311133
0.000	-50.000000	-2.18963

Buttons: Manual, Auto, Move, Sync, Stop, Use

SCM Motors:

r (mm)	x (mm)	r' (mm)
tmm:m6	tmm:m7	tmm:m8
3.50025	2.00000	5.57575
3.50025	2.00000	5.57566
2.000000	7357	5.575664
7357		TRACK

Stop button is highlighted in red.

Gratings: grating 1

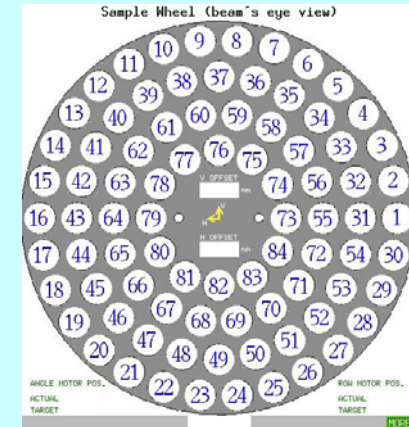
Debug, More buttons are present.

Description: 600 gr/mm, R diffraction order: 1

- grating line density: 600.000 1/mm
- radius of curvature: 114,600 m
- tangent-arm length: 0.3683 m
- included angle: 175.5000 degrees

# Miscellaneous

- Slit
- Sample Wheel
- 4-step measurement



### Four-step measurement

DO MEASUREMENT

DETECTOR 1 TRIGGER NAME VALUE DETECTOR 2 TRIGGER NAME VALUE  
 tmm:scaler1.CNT 1

	Signal 1	Signal 2	Signal 3	Signal 4
DESC	signal 1	signal 2	signal 3	signal 4
LINK				
<b>MEASURED VALUES</b>				
A	0.000000	0.000000	0.000000	0.000000
B	0.000000	0.000000	0.000000	0.000000
C	0.000000	0.000000	0.000000	0.000000
D	0.000000	0.000000	0.000000	0.000000
<b>CALCULATED VALUES</b>				
E	0.000000	0.000000	0.000000	0.000000
F	0.000000	0.000000	0.000000	0.000000
G	0.000000	0.000000	0.000000	0.000000
H	0.000000	0.000000	0.000000	0.000000

TRIGGER END CALCS:

### Slit\_1 (Looking upstream)

H SIZE 96.500  
 -7.250  
 -103.700  
 -|0.000| +  
 Scan

Sync H  
 97.000  
 0.000  
 -103.000  
 DN |0.000| UP  
 Scan

H CENTER 51.850  
 -0.125  
 -48.250  
 <|0.000|>  
 Scan

3.700  
 3.500  
 3.500  
 <|0.000|>  
 Scan

100.000  
 -3.750  
 -100.000  
 <|0.000|>  
 Scan

V SIZE 197.000  
 0.000  
 0.000  
 -203.000  
 -|0.000| +  
 Scan

100.000  
 0.000  
 0.000  
 -100.000  
 DN |0.000| UP  
 Scan

V CENTER 98.500  
 0.000  
 -101.500  
 DN |0.000| UP  
 Scan

Sync V

# String Expressions

- Extends CALC record to combine string and numeric expressions
- Useful for run-time programming of serial devices
- EPICS links are *programmable* at run time

The screenshot displays the 'userStringCalc2' interface. It features two main tables for variable management:

DOUBLE VARIABLES		PV NAME	VALUE
A			233.52000
B			0.00000
C			0.00000
D			0.00000
E			0.00000
F			0.00000
G			0.00000
H			0.00000
I			0.00000
J			0.00000
K			0.00000
L			0.00000

STRING VARIABLES		PV NAME	VALUE
AA			
BB			
CC		tm:m7.RBV	
DD			
EE			
FF			
GG			
HH			
II			
JJ			
KK			
LL			

Below the tables is a 'CALC (CALCULATION)' window showing a calculation: `CC("RBV", "VAL")` resulting in `0.00000`. The 'STRING RESULT' is also `0.00000`. The 'DELAY' is set to `1.000` and the 'EVENT#' is `0`. The 'OUTPUT PV NAME' is `tm:m8.VAL PP NMS`.

The right-hand panel, titled 'Example string expressions', lists various functions:

- AA+BB**: CONCATENATE STRINGS
- AA-BB**: E.G., 'A:B.VAL' - 'VAL' =
- AA>BB**: (<, >=, etc.)
- LEXICAL COMPARE, LOGICAL RESULT**
- PRINTF('abc%f', A)**: ONLY ONE ARGUMENT, RESULT IS STRING
- \$P('abc%f', A)**: \$P MEANS PRINTF
- SSCANF(AA, '%1f')**: ONLY ONE ARGUMENT, RESULT TYPE DEPENDS ON FORMAT STRING
- \$S(AA, '%1f')**: \$S MEANS SSCANF
- MAX(AA, BB)**: LEXICAL COMPARE, STRING RESULT
- AA-'VAL'+'EGU'**: M.VAL -> M.EGU
- 'yyy:' + AA - 'xxx:'**: xxx:M -> yyy:M
- DBL(AA)**: FIND FIRST NUMBER IN STRING, CONVERT TO DOUBLE
- INT(AA)**: FIND FIRST NUMBER; CVT TO INT
- STR(A)**: CONVERT TO STRING
- AA[1,3]**: EXTRACT SUBSTRING 'ABC'[1,3] = 'B'
- AA['ab', 'yz']**: EXTRACT SUBSTRING 'ABC'['A','C'] = 'B'
- AA[1,4][2,3]**: 'ABCDEF'[3,5][1,1] = 'E'
- AA('old', 'new')**: REPLACE 'OLD' WITH 'NEW' (ONCE)

A note states: "NOTE: You can use either single or double quotes for string literals. Using one allows you to include the other in the string."

The bottom right panel, titled 'Example array expressions', lists: **@0** (GET VARIABLE 0), **@A+3** (GET VARIABLE A; ADD 3 TO IT), **@(A+3)** (GET VARIABLE A+3), and **@@0** (GET STRING VAR 0).



# Scans

- Multidimensional
- 4 positioners, 4 detector triggers, 70 signals
- saveData client writes data to NFS-mounted disk
- Can acquire arrays (e.g., MCA spectra)
- ~300 Hz on MV162
- Start/end, table, on-the-fly
- Also for 1-dimensional automated alignment

The screenshot displays a control interface for a scan. At the top, it shows '1 tmm:scan1' in 'IDLE' state with 'PROC' and 'SCAN DIM: 0'. Below this, there are fields for '#PTS' (10) and '0'. A 'SAVE DATA: Active' indicator and 'saveData OK' button are visible. The 'Positioners' section shows 'Read' and 'Drive' values for 'tmm:userCalc3.B'. A table of scan parameters is provided:

START	CENTER	END	STEP SIZE	WIDTH
0.00000	0.00000	999.00000	111.00000	0.00000

Below the table, 'SCAN MODE' is set to 'LINEAR', 'ABS/REL' to 'ABSOLUTE', and 'AFTER SCAN' to 'PRIOR POS'. 'POSITIONER SETTLING TIME' is 0.000 (s) and 'REFERENCE DETECTOR' is 1. The 'Detector triggers' section lists four triggers with 'VAL' values of 1.00. 'DET. SETTLING TIME' is 0.000 (s) and 'CLIENT WAIT' is 0. The 'Detectors' section shows four detectors with 'ACQ MODE' set to 'NORMAL' and 'CHECK LIMITS' checked. A 'SCAN' button is prominent. A plot in the bottom right shows a signal vs. position for 'tmm:userCalc3.B' with a y-axis from 0 to 10400 and an x-axis from 0 to 1000. The plot shows a noisy signal with several peaks. At the bottom, a 'motor 9' control panel shows 'Start' and 'End' positions, '#Pts' (11), and 'StepSize' (0.000000). 'Acquis Time' is 1.000000. 'TrgPV' is 'tmm:scaler1.CNT' and 'DetPV' is 'tmm:userCalc1.VAL'.



# Clients

- MCA display (IDL program)
- scanSee (IDL program for 1D, 2D, 3D data)
- Plot\_data (Python demonstration)
- PVMail (send email when PV value violates boundary)
- Misc. experiment-specific user interfaces in tcl/tk, python/tk, Igor, IDL, java
- Channel Archiver
- **BackUp/Restore Tool**
- StripTool (strip chart)
- ...

# Autosave/restore

- Saves PV values (e.g., motor positions, scan config) through reboot
- Defends against crash during save operation
- Typically 80 values saved every 5 s, 3000 values every 30 s
- New features:
- Include files
- Macro substitution
- Dated backups (reboot history)
- Choose save/restore directories

# CCD support

- CA server on CCD's native platform
- Calls vendor-supplied software
- Stores images to local disk (HDF format)
- Some simple image analysis
- Hosts EPICS PV's for control

# For more information

- EPICS

`www.aps.anl.gov/epics`

- synApps

[www.aps.anl.gov/xfd/bcda](http://www.aps.anl.gov/xfd/bcda)

`cars9.uchicago.edu/gsecars/index.html`