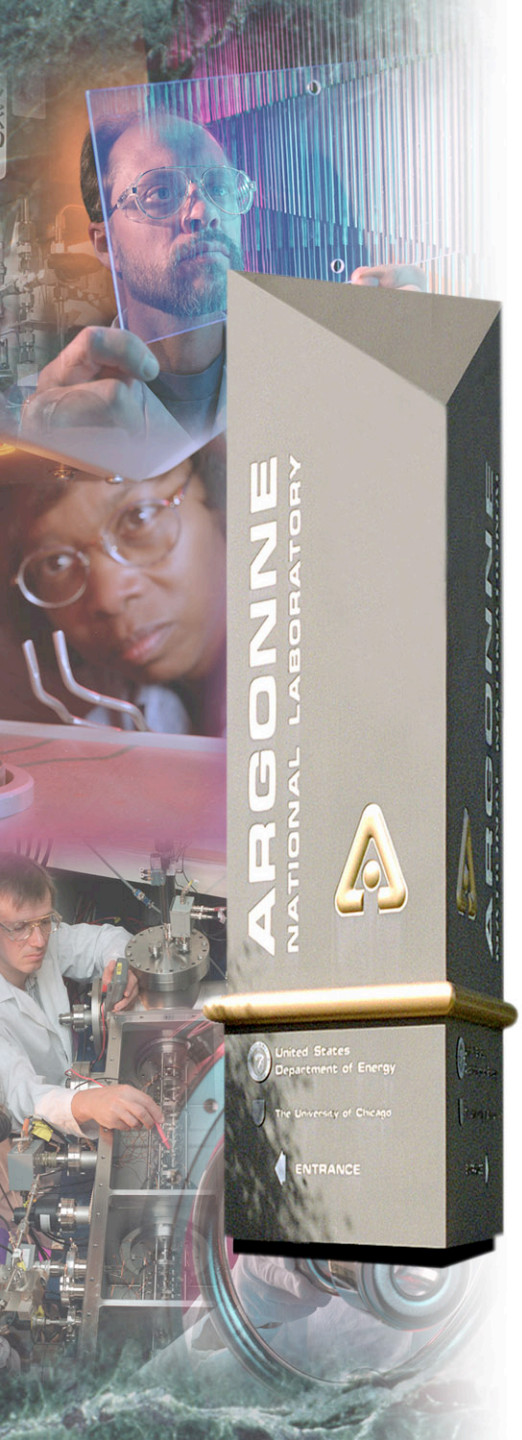

synApps 5.8

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What is synApps?

- **A collection of EPICS *modules* for synchrotron-beamline users**
  - Web page:
    http://www.aps.anl.gov/bcda/synApps
  - Subversion repository:
    https://subversion.xray.aps.anl.gov/synApps

- **EPICS modules:**
  - alive, autosave, busy, calc, camac, caputRecorder, dac128V, delaygen, dxp, ip, ip330, ipUnidig, love, mca, measComp, modbus, motor, optics, quadEM, softGlue, sscan, std, vac, vme, xxx

- **Support directories:**
  - documentation, configure, utils

synApps modules

- **Modules contain the following kinds of support:**
  - Compiled code; libraries, for examples:
    - *record and device support*
    - *SNL (State Notation Language) programs*
    - *string-calc, array-calc engines*
  - EPICS databases and autosave-request files
    - *A database is a program written in a high-level language.*
    - *One or more copies of a database can be run, each with its own private process variables (PV's).*
    - *The database designer recommends PV's to be autosaved by naming them in a .req file.*
  - Display files for MEDM, caQtDM, and CSS-BOY
    - *The default user interface*
  - Documentation
  - Some modules contain iocBoot directories, mostly for testing.

Other EPICS modules included with synApps

- areaDetector (ADCore and ADBinaries) (*Mark Rivers*)
- Asyn (*Mark Rivers, Eric Norum*)
- lpac (*Andrew Johnson*)
- Seq (*Ben Franksen*)
- Stream (*Dirk Zimoch*)
- devlocStats (*Stephanie Allison*)
- allenBradley (*Marty Kraimer*)

alive

- **Sends operational status of an IOC to a server.**
  - Environment variables
  - vxWorks boot parameters
  - Boot time
- **Collected information is available at** http://bcda.xray.aps.anl.gov/cgi-bin/ioc_alive.cgi

autosave

- **Records latest values of selected EPICS PVs; restores those values when the ioc restarts.**
  - Not an archiver; only the latest value is saved
  - Don't confuse this with saveData, which writes scan data
  - When a list list of PV's is saved, the entire list is written, even if only one PV has changed.
- **Can save/restore any scalar or array-valued PV (synApps 5.1)**
  - Array-valued PV must be hosted by the ioc that does the restore operation. (Normally, ioc's save/restore only their own PV's.)
  - DBF_MENU, DBF_ENUM PV's are handled by number.
- **Save operation uses channel access for scalars.**
- **Restore operation uses static database access for scalars.**
- **Arrays are saved and restored with database access.**

…autosave

- **Three restore options for save files:**
  1) before record/device initialization
     - Motor positions must be restored at this time.
     - Arrays cannot be restored at this time. *
     - PV's that are DBF_NOACCESS before record init (e.g., genSub variable-type fields) cannot be restored at this time. *
  2) after record/device initialization
     - to override record-initialization values
     - Link fields cannot be restored at this time. *
  3) both before and after record initialization
     - The 'auto_settings.sav' file is restored at both times.
     - It's not an error to attempt to restore a PV at the wrong time.
     - If you restore a motor position at this time, you override the value read from hardware, without writing to hardware.

* Not illegal, just doesn't work

...autosave

- **PV lists can use include files (e.g., <database_name>.req), include path.**
  - Database developer can supply default include file with database.
  - User can override with custom include file.
- **Save triggers:**
  - on change of any PV in the list
  - periodically
  - on change of a trigger PV
  - manual
- **User can reload save sets.**
- **Autosave can recover from file-server reboot.**
  - Currently, only on vxWorks
- **User can choose to save redundant files.**
- **Autosave reports status via EPICS PV's.**

...autosave

- Sample request file

```
xxx:my_PV.VAL
xxx:my_array_PV.VAL

file  motor_settings.req  P=$(P),M=m1
...
<END><lf>
```

PV names

Keyword

Macro replacements

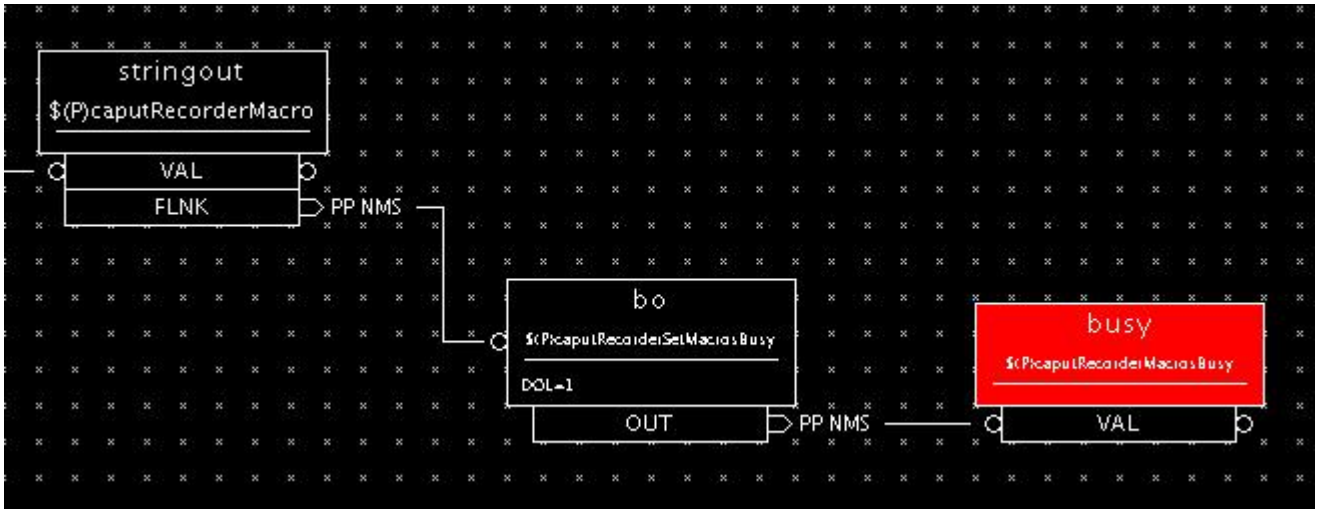
Name of include file

- Sample save file

```
# save/restore V4.4 Automatically generated…
xxx:my_PV.VAL 1.0
xxx:my_array_PV.VAL @array@ { "0" "0.1" … "10.2" }
xxx:m1.DIR 0
xxx:m1.DHLM 100
xxx:m1.DLLM -100
...
```

busy

- **Allows channel-access clients and asyn drivers to participate in EPICS' completion reporting**
- **Records**
  - **busy** – like *bo* record, but forward link is executed only if VAL==0.
  - Example of use:



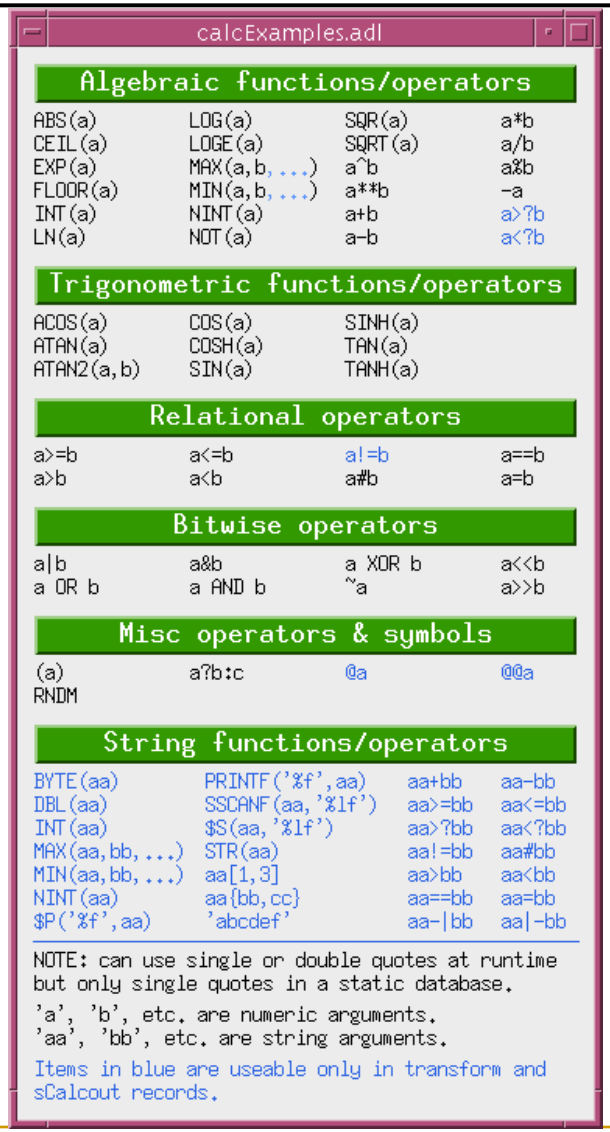
calc

Support for evaluating expressions entered at run time

- **Records**
  - **acalcout** – like *calcout*, but also supports array expressions; user can specify wait-for-completion.
  - **scalcout** – like *calcout*, but also supports string expressions; user can specify wait-for-completion.
  - **swait** – like *calcout*, but uses recDynLink (no “PP MS” link attributes), and waits for completion.
  - **transform** – like 16 *calcout* records that share a PV data pool
  - **sseq** – like *seq*, in base, but can get and put strings; user can specify wait-for-completion.
- **Other code**
  - interpolation routines for *aSub* record
  - averaging routines for *sub* record
  - *sseq*-record editor

...calc

- **Databases, display files for run-time programming**
  - userCalc, userCalcout
  - userStringCalc
  - userArrayCalc
  - userTransform
  - userStringSeq
  - userAve
  - interpolation
- **Examples of ALL calc expressions can be found in synApps MEDM help displays**

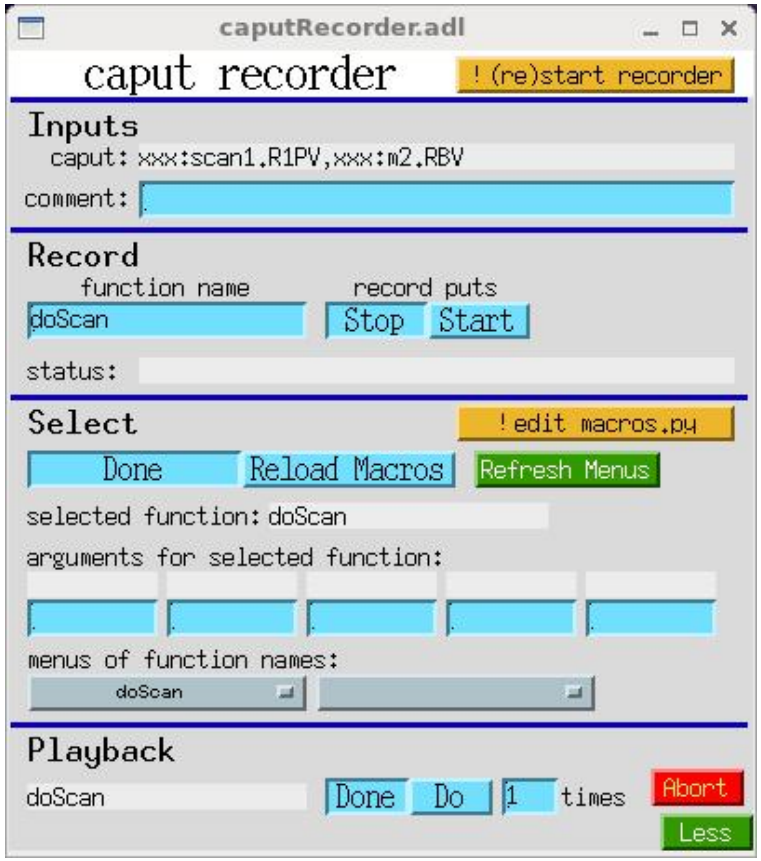


camac

- **Communication with CAMAC crate/modules**
- **Records**
  - camac – generic BCNAF/data for run-time camac control
- **Devices supported**
  - VME bus adapter
  - CAMAC crate controller
  - E500 motor controller
  - RTC-018 real-time clock
  - QS-450 quad scaler

caputRecorder

- **Support for recording and playing back sequences of channel-access puts.**
- **User interface for executing python functions**



configure

- **Configures all modules in or used by synApps**

- **RELEASE**
  - specifies version number and file path to EPICS base, and to every module synApps/support

- **makeReleaseConsistent.pl**
  - Edits <module>/configure/RELEASE for every module in synApps/support, to agree with synApps/support/configure/RELEASE
  - “make release” in synApps/support causes this to run.

dac128V

- **device support, database, and display files for dac128V IndustryPack module**
  - 8-channel, 12-bit DAC
  - Support exists to run a DAC channel manually, or according to an algorithm written at run time, or as a *scan* positioner, or as part of a PID feedback loop at up to ~10 Hz, or as part of a fast PID feedback loop at up to ~10 kHz.

delaygen

- **device support, database, and display files for delay generators**
  - *Stanford Research Systems* DG535 and DG645 digital delay generators.
  - *Colby Instruments* PDL100A programmable delay line
  - *Coherent* synchronization delay generator
  - *Berkeley Nucleonics* 505 pulse/delay generator

documentation

- ***TOP-level synApps documentation***
  - What synApps is
  - How to deploy it
  - How to build it
  - How to make a user application from the ‘xxx’ sample module
  - How to fit the user application to a particular set of hardware

- **This presentation**

dxp

- record, device support, databases, and display files for XIA DXP and Saturn spectroscopy systems
- dxp record for setting DXP parameters
- device support for the mca record

ip

- **device support, SNL code, databases, and display files for *many* message-based devices**
  - originally, for devices supported via IndustryPack hardware
  - Note some of this support will inevitably be out of date, or pending access to hardware for testing.

- **deviceCmdReply**
  - Used to write support at run time for one command/reply message
  - *scalcout* to format output string
  - *asyn* record to write/read device
  - *scalcout* record to parse reply

- **devXxStrParm device support**
  - New support should use stream/asyn

ip330

- **device support, databases, and display files for the IP330 ADC IndustryPack module**

- **16/32 channel, 16-bit ADC**

  - ip330Scan for periodic, averaged reads of ADC channels
  - ip330Sweep, with the MCA record, for using ip330 as a waveform-digitizer, or to record analog data during a fly scan
  - ip330PID for using the ip330 in a fast-feedback loop

ipUnidig

- device support, databases, and display files for the IPUnidig digital I/O IndustryPack module
- IP-UD-I 24-channel input/output/interrupt module
- DIO316I 48-bit digital I/O module

love

- **Support for Love controllers**
  - Uses RS485 Octal Serial IndustryPack module, or RS232 module with 232/485 converter
  - Asyn device support for the ao, ai, bo, bi, and mbbi records
  - Asyn Interpose interface for Lovelink
  - Sample application, database, and display files
    - *vxWorks and Linux only*
  - Startup scripts for vxWorks and Linux are provided to configure Ipac, Asyn, and the Interpose interface

mca

- **Support for multichannel analyzers, multichannel scalers, and other array-valued detectors**
- **mca record**
- **device support**
  - Canberra 556 AIM module (MCA and ICB controller)
  - DSA-2000 Ethernet MCA
  - various Canberra-ICB modules for spectroscopy
  - SIS 3801 (Struck STR7201) and 3820 multichannel scalers
  - (DXP support in dxp module)
  - (IP330 support in ip330 module)
  - (quadEM support in quadEM module)

measComp

- **Support for *Measurement Computing USB* devices**
  - USB-CTR08 8-channel counter/timer module
  - USB-1608GX-2AO analog I/O module
  - USB-4303 (obsolete) counter/timer module

modbus

- **Support for Modbus Protocol**
  - Programmable Logic Controllers (PLCs)
  - Other modbus devices, such as temperature controllers
- **Uses asyn to support various communication links**
  - TCP/IP
  - Serial RTU
  - Serial ASCII

motor

- **Motor record and device support**
  - stepper and servo motors
  - soft-motor support
    - *Put motor "face" on, e.g., a DAC channel*
    - *Drive a hard motor through a nonlinear transform*
  - user/dial/raw coordinates
  - backlash-takeout algorithm
  - pre/post move commands
  - many more features

…motor

- **Supported motor types**
  - Oregon Micro Systems, Inc. (OMS) models; VME8, VME44, VME58, VS4, VX2, MAXv, PC68 and PC78.
  - Newport models MM3000, MM4000/5/6, PM500, ESP300/301/100 and XPSC8.
  - Schneider Electric (formally IMS) models IM483, MDrive and MForce.
  - Advanced Control Systems, Corp. model MCB-4B.
  - Mclennan models PM304 and PM600.
  - Physik Instrumente (PI) GmbH & Co. model C-630, C-844, C-848, C-862/863, E-662, E-710 and E-816.
  - MicroMo model MVP 2001 B02.
  - Micos model MoCo dc controller, SMC hydra controller.
  - Delta Tau PMAC2-VME controller.
  - Faulhaber MCDC2805 servo controller.
  - Parker Hannifin, Compumotor Division, 6K Series controllers.
  - New Focus, models; 8750 and 8752.
  - ACS Motion Control, SPiiPlus model.
  - Spectra-Physics, Encoder Mike Controller, Model 18011.
  - Thorlabs, Piezo Controller, Model MDT695.
  - Animatics Corporation SmartMotor.
  - piezosystem jena GmbH EDS data interface module.
  - Kohzu SC-200, SC-400, SC-800 stepper motor controllers.
  - attocube systems AG ANC150 Piezo Step Controller.
  - Aerotech Soloist single-axis servo controller, Ensemble multi-axis digital servo controller.
  - Hytec 8601 Industry Pack based 4-channel Stepper Motor Controller.

optics

- ***Slits and mirrors***
  - *Four virtual positioners; two real motors*
  - *Automatic sync to motor positions*
  - *Completion reporting*
- ***Monochromators***
  - *Nondispersive double-crystal*
    - Geometries: (Y1, Z2), (Y2, Z2)
    - Crystal species: Si, Ge, Diamond, Si (77K)
    - Miller indices, allowed reflections
    - Operational modes:
      - *Use/Set*
      - *Manual/Auto*
    - Managing the vertical beam offset
    - Automatic sync to motor positions

…optics

- ***…Monochromators***
  - *Spherical grating*
    - Geometrical variables:
      - *1) Grating line density; radius*
      - *2) Tangent-arm length*
      - *3) Diffraction order*
      - *4) Input/output slit distances*
    - Operational modes:
      - *Use/Set*
      - *Manual/Auto*
    - Grating-stripe list
    - Manual sync to motor positions

…optics

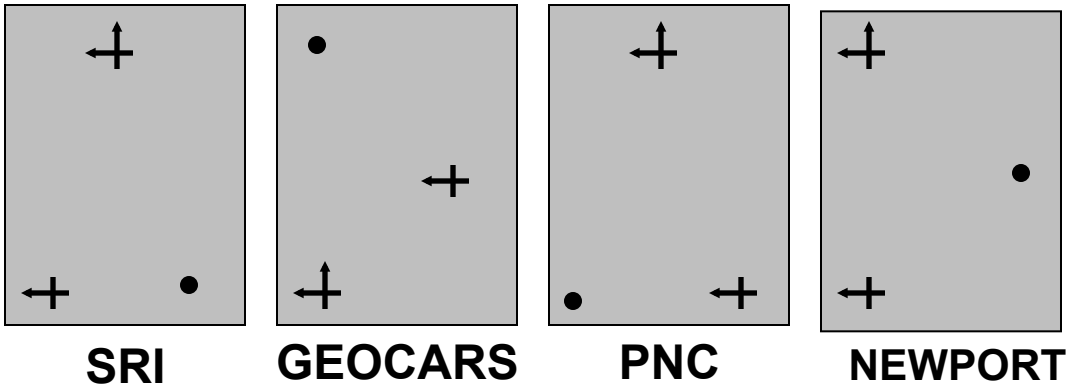
- ***…Monochromators***
  - *Dispersive double-crystal*
    - Geometries: nested, symmetric
    - Crystal species: Si, Ge, Diamond, Si (77K)
    - Miller indices, allowed reflections
    - Operational modes:
      - *Use/Set*
      - *Manual/Auto*
      - *Theta1 / Theta1&2 / Rock Theta2*
    - Accommodate incident-beam angle shift (“world offset”)
    - Automatic sync to motor positions

…optics

- **Optical table**
  - ***Table*** record supports a six-degree-of-freedom optical table.
  - Four geometries: SRI, GEOCARS, NEWPORT, and PNC
  - User/client can write either to (x, y, z, θ_X, θ_Y, θ_Z), or to underlying motor records.
  - Table rotates about user-specified point.
  - Table database includes a list of rotation points, selected by menu.
  - Can recover table position from motor positions
  - Partial support for fewer than six degrees of freedom

…optics

- **…Optical table**
  - Geometries
    - SRI
    - GeoCARS
    - Newport
    - PNC



- Calibration/sync
  - Use/Set – changes to [X, Y, ..]. move table / change calibration
  - Zero – redefine current [X, Y, …] as zero
  - Sync – update [X, Y, …] from motors, honoring calibration
  - Init – clear calibration and sync to motors

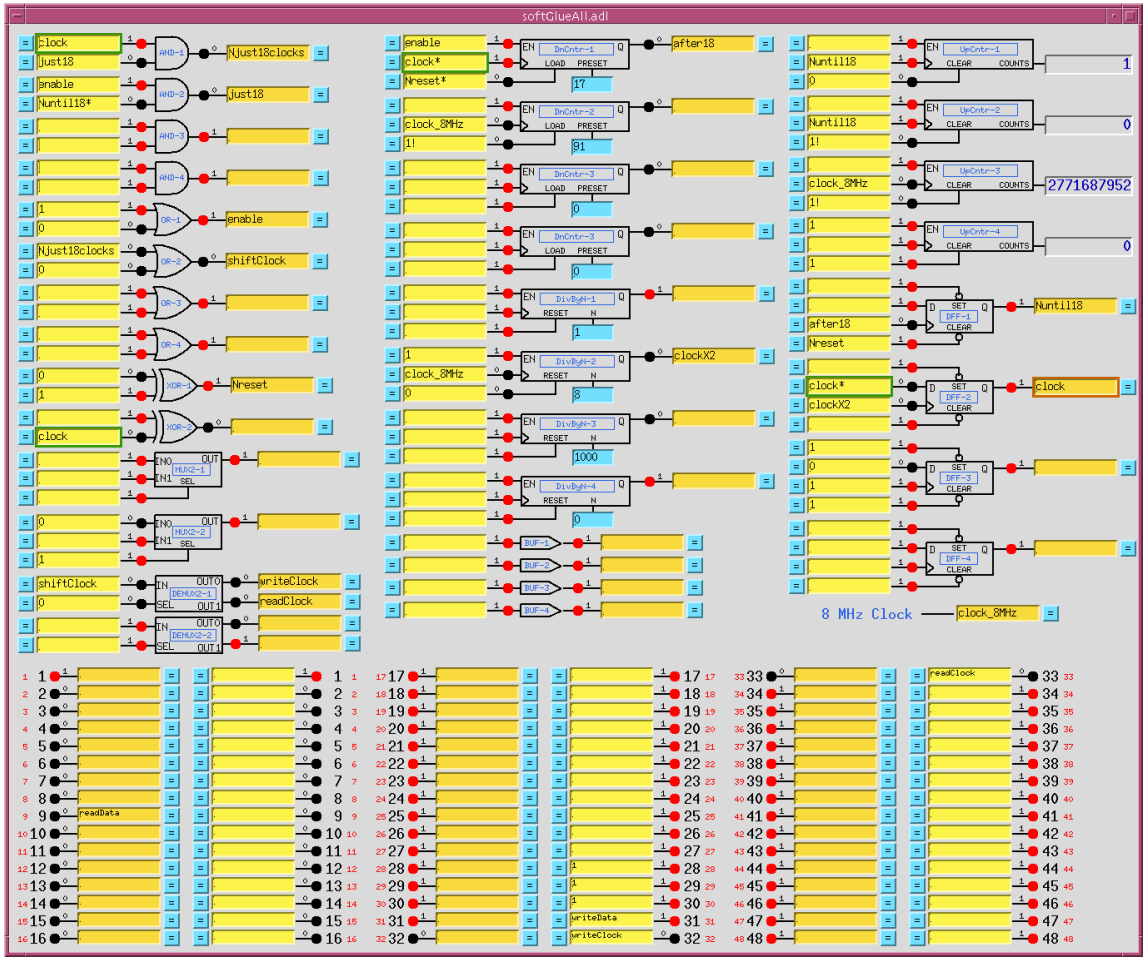
- Table record sets motor speeds so that motors start/stop together.

quadEM

- **Support for four-input electrometers.**
  - *CAENels* AH401B, AH401D, AH501, AH501C, and AH501D picoammeters
  - APS quad electrometer

softGlue

- Support for FPGA-based digital electronics.



sscan

- **Support for user-programmable data-acquisition**
  - **sscan** record executes scans
  - saveData saved data to a file
  - recDynLink implements sscanRecord links
- **A one-dimensional scan:**
  - Do NPTS times:
    - Set conditions — e.g., move motors; wait for completion
    - Trigger detectors — e.g., start scaler; wait for completion
    - Acquire data — read detector signals; store in arrays
  - Write data to NFS file
- **Multidimensional scan:**
  - Same as a 1-D, but detector trigger executes inner-loop scan.
  - saveData monitors a set of **sscan** records, determines scan dimension when scan starts, and writes data as it is acquired.

...sscan

- **scan features:**
  - Three 1-D scan types: constant-step-size, table-driven, fly
  - Unlimited number of data points, scan dimensions
  - 0-4 positioners, 0-4 detector triggers, 0-70 detector signals
  - Acquisition from scalar and 1-D-array-valued PV's
  - Detector/client wait, data-storage wait
  - Pause/resume, abort
  - Double buffered: can write 1-D acquired data during next 1-D scan
  - *saveData* writes self-describing XDR-format (".mda") files to NFS-mounted disk (vxWorks only, at present).
  - A positioner can have private scan parameters (scanparm record).
  - After-scan actions include move to peak, valley, and edge.
  - scanparm record + after-scan action = automated 1-D alignment, so you can easily implement an "Align" button.

…sscan

- **The sscan record**
  - performs 1-D scan
  - before-scan link – optional completion callback
  - positioner: any writable, numeric, scalar PV (menus, enums are ok)
  - detector trigger: any writable, numeric, scalar PV
  - detector signal: any readable, numeric, scalar or 1D array PV
  - array detectors: exactly <scanRecord>.NPTS elements are acquired
  - array trigger: callback indicates array data are ready to read
  - after-scan link – optional completion callback
  - pause/resume
  - abort (<scanRecord>.EXSC -> 0) wait for callbacks, cleanup
  - kill (two aborts in a row) abandon callbacks
  - handshake with multiple display / data-acquisition clients
  - handshake with data-storage client

Other data-acquisition-related software

- **Data-visualization tools for use with the sscan record**
  - scanSee (*Ben-chin Cha, John Hammonds*)
  - dview, sview (*Dohn Arms*)
  - utils/mdautils (*Dohn Arms*)
  - utils/mdaExplorer (*Tim Mooney*)
  - utils/mdaPythonUtils (*Tim Mooney*)

std

- **Epid record**
  - Extended PID record
- **Scaler record**
  - Controls a set of counters with a common clock, gate, and trigger
- **Soft-motor database**
  - *Run-time programmable* soft-motor/transform/hard-motor database
  - Quick solution for driving a motor through a nonlinear transform
- **4-step database**
  - Up to four steps of (set condition; read data) with an end calculation
  - Originally developed for dichroism experiments
- **PID control**
- **Femto current-amplifier support**
- **genTweak, ramp_tweak**
- **selector**
- **pvHistory**
- **Alarm clock, countdown timer**

utils

- **changePrefix**
  - Change EPICS prefix throughout a copy of the xxx module
- **changePrefixIoc**
  - Change EPICS prefix for all files in an ioc directory
- **copyAdl**
  - Find MEDM-display files; copy to specified directory.
- **mdaExplorer, mdaPythonUtils, mdautils-src**
  - Display, manipulate scan-data (MDA) files
- **snapDb**
  - “Freeze” a collection of userCalcs into a custom database, display
- **Subversion utilities:**
  - logModuleFromTag, releaseNotesFromTag, makeTar

vac

- **Support for vacuum measurement and control**
  - vs, digitel records
  - Granville-Phillips GP307, GP350
  - Televac MM200, CC10
  - Digitel 500/1500
  - Gamma MPC, MPCe, LPC, SPC

vme

- **VME record**
  - Provides run-time access to VME bus
  - Great for testing hardware
  - Run-time programmed control of an unsupported VME board

- **Device support for VME hardware**
  - Joerger scaler
  - APS bunch-clock generator
  - APS machine-status interface
  - Heidenhain encoder interpolator
  - Generic A32 VME interface
  - HP Laser interferometer
  - VMI4116 16-bit DAC
  - Acromag 9440 16-bit digital input

XXX

- **Prototype user directory**
  - Builds everything in synApps into a load module
  - Contains command files to load/configure ~everything in synApps
  - Contains sample top-level display files
  - Contains sample script to set environment variables and start up the sample user interface
  - Contains table of recommended address/interrupt configuration for selected VME and IndustryPack hardware

- **Two ways to use this module**
  1) Make copies; run changePrefix; build; customize; run a beamline
     - *this is the recommended use*
     - *detailed instructions in support/documentation*
  2) Reference/grab bag

For developers: features of synApps

- **extended-processing records**
  - records that are neither synchronous nor asynchronous, as these terms are described in the *EPICS Application Developer's Guide*
- **completion reporting**
  - All databases behave correctly when written to by ca_put_callback().
- **recDynLink links**
  - Similar to standard EPICS links, but no "PP NMS" attributes
- **GUI standards**
  - Default colors for menus, PV values, links, etc.
- **coordinated motions**
  - Many of the databases in synApps (especially in 'optics') involve coordinated motion of several motors.
- **initialization of complex databases**
  - Some common EPICS initialization problems are handled in various synApps databases.

Coordinated motions

- **Simple cases: database (transform records)**
  - Slits, mirrors, spherical-grating monochromator
- **More complicated cases: SNL code**
  - Multiple-crystal monochromators
- **Very complicated cases: custom record**
  - Optical table, scan
- **Criteria a useful coordination should meet:**
  - Report completion to ca_put_callback()
  - Share control of base positioners with CA clients
  - Recover state from the states of base positioners

Completion reporting

- **Simple prescription for databases contained within a single ioc:**
  - Use only PP links and forward links in execution chain.

- **Database operations spanning more than one ioc:**
  - Use records with put_callback links to span iocs:
    - ***calcout*** *with asynchronous device support*
    - ***sscan***, ***swait***
    - ***sseq*** *or* ***sCalcout*** *(with .WAIT* = "Wait")*

- **Cases in which a CA client performs part of the operation:**
  1) Database sets a **busy** record via PP or put_callback link.
  2) CA client clears the **busy** record when operation is done.
- **Cases in which part of the operation is driven by a CP link:**
  - Not different from above; a CP link is a CA client

Initialization of complex databases

- **Initial values: .VAL vs. .DOL**
  - Most records allow .VAL field to be set in the database.
  - Note that .DOL cannot be used for constant strings.

- **Save-restore and interaction with record/device initialization**
  1) save-restore pass 0
  2) record/device initialization → *device support can use pass-0 value*
  3) save-restore pass 1 → *pass-1 overrides record/device-init value*

- **.PINI (Process at INIt) uses and limitations**
  - This is the normal mechanism for database initialization.
  - What if you need a value from some other .PINI-initialized record, and that record hasn't processed yet?
  - Note .PHAS is not considered in .PINI processing.

...Initialization of complex databases

- **Contending with link alarms**
  - If you have an input link to a record with .UDF=1, you get a link alarm.
  - .UDF=1 until a record processes. (In 3.14.1+, database can specify .UDF)
  - ➢ The transform record can abort execution on a link alarm (or not).
- **Initialization problems with CP links**
  - You have a CP link to a field that is a calculation result.
  - If the calc result is the same as the field's initial value, you'll have the right value, but you won't *know* that you have the right value, and you won't know for how long to wait to be sure.
  - ➢ The transform record *always* posts its initial calculation result.
- **Programmatically initializing link fields**
  - Link field must be written with a CA link (because lock-set recalc).
  - .PINI processing occurs *before* CA is running (EPICS 3.13.5+).
  - ➢ Can't use .PINI; Drive init from a scan task; set init record to "Passive" when init is done.

synApps in use at APS

- **Deployed/released on APSshare**
  - New minor releases (e.g., what would be synApps 5.7.x, if minor releases were numbered) are done by adding new versions of modules to the synApps *support* directory.
  - Beamline iocs select module versions with their *RELEASE* files.
    - There are 256 versions of synApps 5.7 installed on APSshare.
    - There are ~130,000 versions of synApps 5.6.
  - A new major release is done when it becomes impractical to upgrade the previous release - for example, because:
    - a new version of EPICS base is needed, or
    - a new non-backward-compatible version of *asyn*, *seq*, *etc*. is needed.