Fly and trajectory scans

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Fly-scan choices

- Software fly scan
  - Data acquired while positioners move at constant speed
  - Detectors triggered by software
    - Periodically, or at user-specified time intervals
  - Positions acquired by software along with detector data
  - Few-ms dead time between data points
  - No cabling required

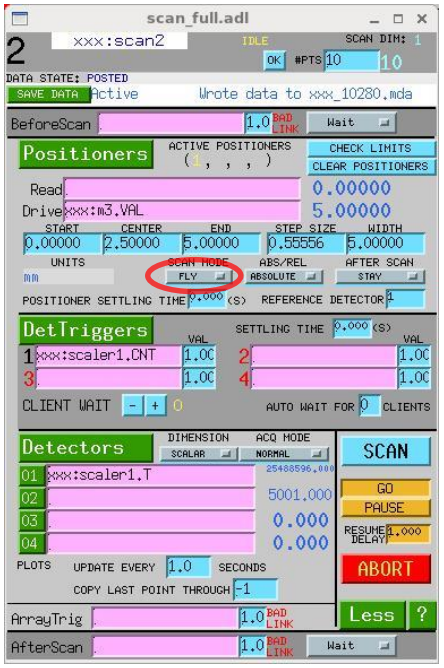
- Hardware fly scan
  - Data acquired while positioners move
  - Detectors triggered by pulses from positioner
    - Periodically
    - At user-specified positions
  - Positions implied or acquired by multichannel scaler
    - Arraycalc “cum” function reconstructs motor positions from scaler data
  - No dead time between points
  - Need cable from selected motor to selected detector(s)

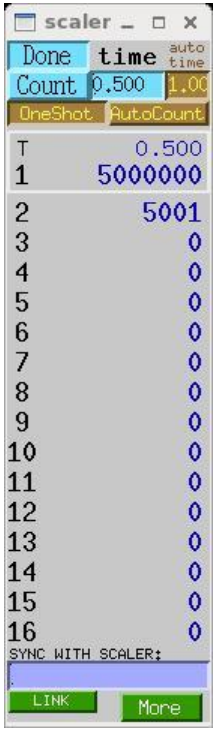
Hardware fly choices

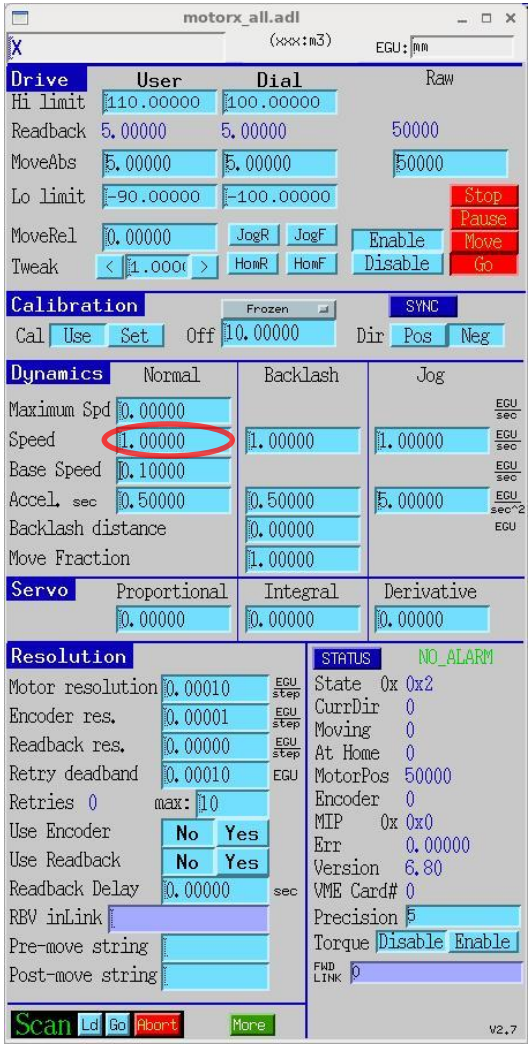
- Constant speed (from now on, "*Hardware fly scan*")
  - Positioner moves at constant speed
  - Positioner can be moved by motor record
  - Specify StartPos, EndPos, NPTS, and Speed
  - May be able to specify data-acquisition positions
    - Requires supported motor or external hardware
- Trajectory (from now on, "*Trajectory scan*")
  - Motor moves along specified trajectory
  - Use trajectory controls
  - Specify trajectory positions and times
  - Specify data-acquisition positions
    - Details depend on controller
  - Requires supported motor

Software fly scan

- Requirements:
  - positioner speed can be set
  - position updates periodically or on demand
  - scan manager (e.g., sscan record)
- User interface:
  - Differences from step scan







Software fly scan

- Remarks:
  - Positioner speed and detector-dwell time must be set
  - Imprecise synchronization between data and *recorded* positions
  - Limited to <~ 10 Hz

- PVs: (values in green: user's choice)

Same as for step scan:

$(scan).ACQT = SCALAR
$(scan).P1PV = $(motor).VAL
$(scan).R1PV = $(motor).RBV
$(scan).T1PV = $(scaler).CNT
$(scan).D*nn*PV = scaler.T
$(scan).P1SP = 0
$(scan).P1EP = 5
$(scan).NPTS = 10
$(scaler).TP = .5

Modified for software fly scan:

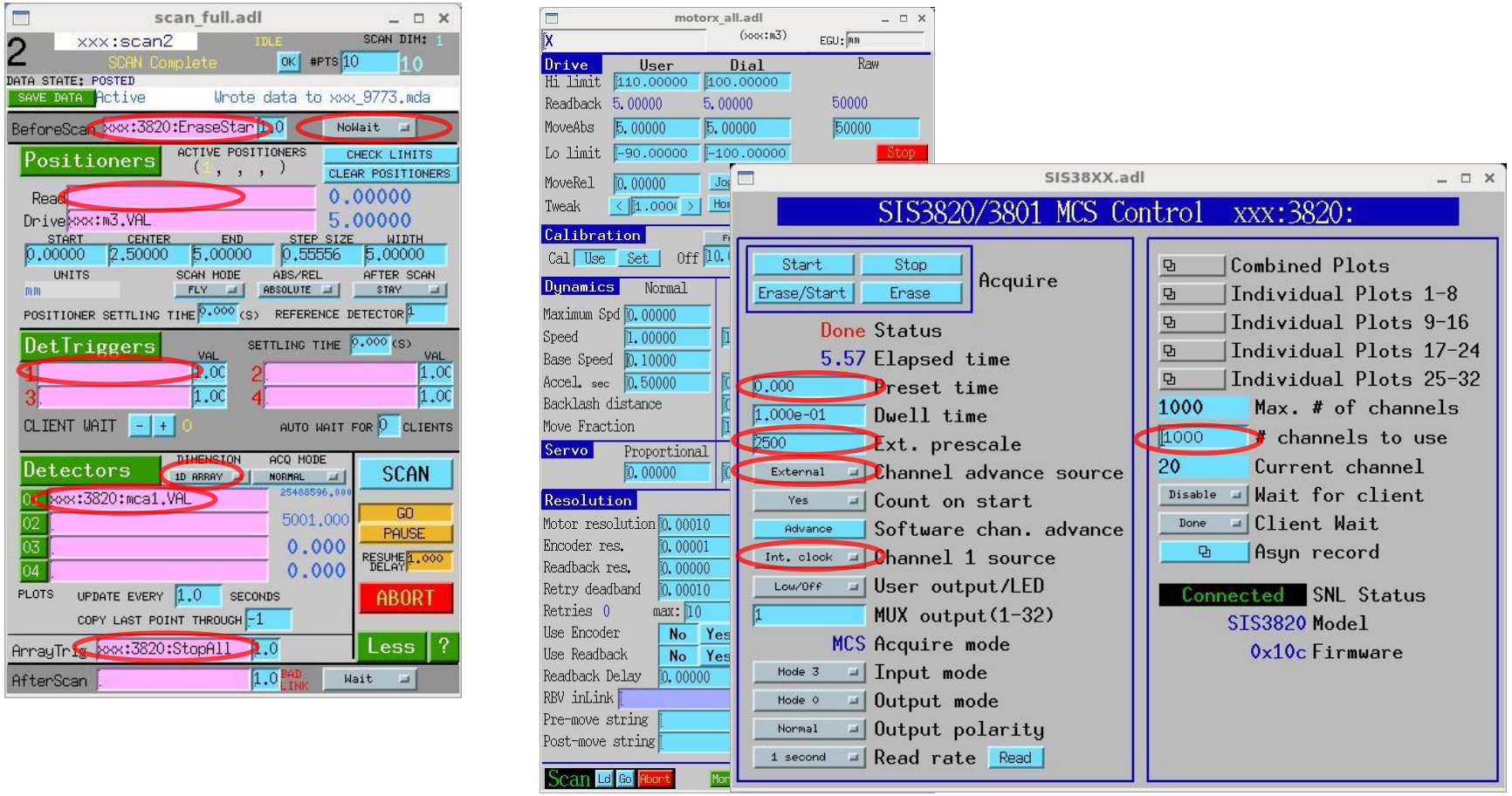
$(scan).P1SM = FLY
$(motor).VELO = 1.0

Hardware fly scan requirements

- Positioner can output pulses during nontrajectory move
  - Any stepper motor (with external divide-by-N)
  - Aerotech Ensemble with EnsemblePSOFly database
  - Probably other servo motors can do this
- Hardware-triggered detector can cache or stream scan data
  - MCS (*Struck* multichannel scaler)
  - XIA DXP
  - Some cameras
- Data-storage client
  - sscan record (saveData)
  - spec
  - areaDetector plugin

Hardware fly scan

- User interface:
  - Differences from software fly scan:



Hardware fly scan

- Remarks:
  - positioner speed must be set
  - detector must be prepared and started before motor moves
- PVs:

Same as for software fly scan:

$(scan).P1PV = $(motor).VAL
$(scan).P1SM = FLY

$(scan).P1SP = 0
$(scan).P1EP = 5
$(scan).NPTS = 10
$(motor).VELO = 1.0

Modified for hardware fly scan:

$(scan).ACQT = 1D ARRAY
$(scan).BSPV = $(mcs):EraseStart
$(scan).BSWAIT = NoWait
$(scan).A1PV = $(mcs):StopAll
$(mcs):PresetReal = 0
$(mcs):ChannelAdvance = External
$(mcs):Channel1Source = Int. clock

$(scan).D01PV = $(mcs):mca1.VAL
$(mcs):Prescale = 2500
$(mcs):CountOnStart = Yes
$(mcs):NuseAll = 1000

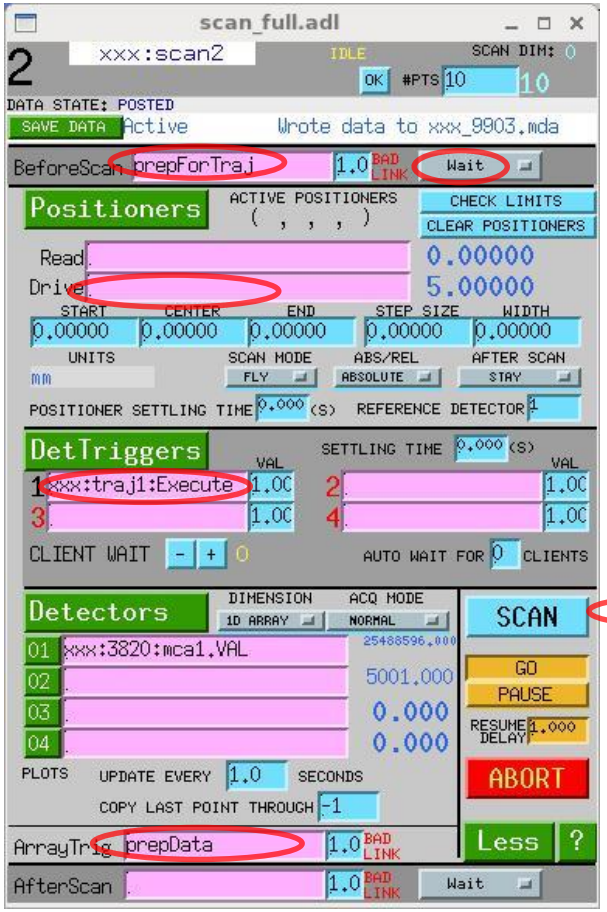
$(scan).R1PV = *not used*
$(scan).T1PV = *not used*

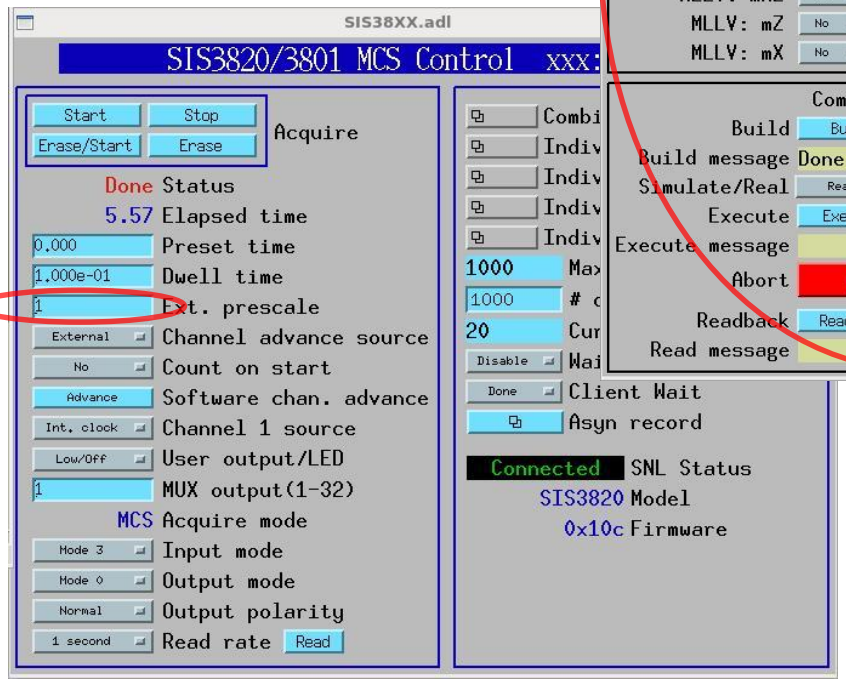
Trajectory scan requirements

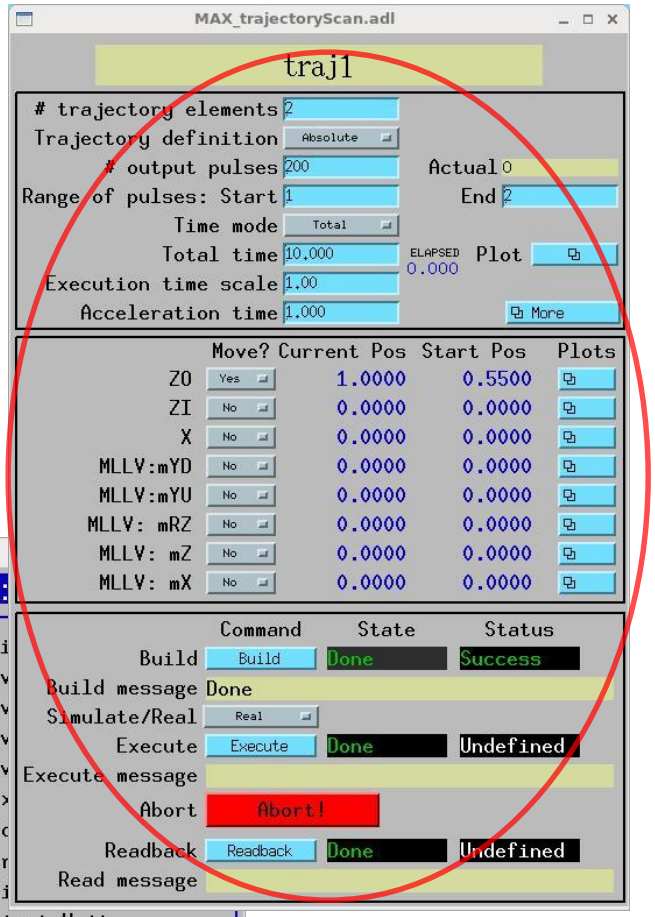
- Controller can move motor along trajectory
  - Newport MM4005 or XPS
  - In motor R6-9, Aerotech Ensemble or Pro-Dex (OMS) MAXv
- Controller can generate position-synchronized pulses
- Position-table generator
  - E.g., spec, arraycalc, python, etc.
- Hardware-triggered detector can cache or stream scan data
  - Same as hardware fly scan
- Data-storage client
  - Same as hardware fly scan

Trajectory scan

- User interface:
  - Differences from hardware fly scan:







Trajectory scan

- Remarks:
  - Trajectory must be loaded
  - Detector must be prepared and started before motor moves
- PVs:

Same as for hardware fly scan:

$(scan).ACQT = 1D ARRAY
$(mcs):PresetReal = 0
$(mcs):ChannelAdvance = External
$(mcs):Channel1Source = Int. clock

$(scan).NPTS = 10
$(scan).D01PV = $(mcs):mca1.VAL
$(mcs):NuseAll = 1000

$(scan).R1PV = *not used*

Modified for trajectory scan:

$(scan).T1PV = $(traj):Execute
$(mcs):Prescale = 1
$(scan).BSWAIT = Wait

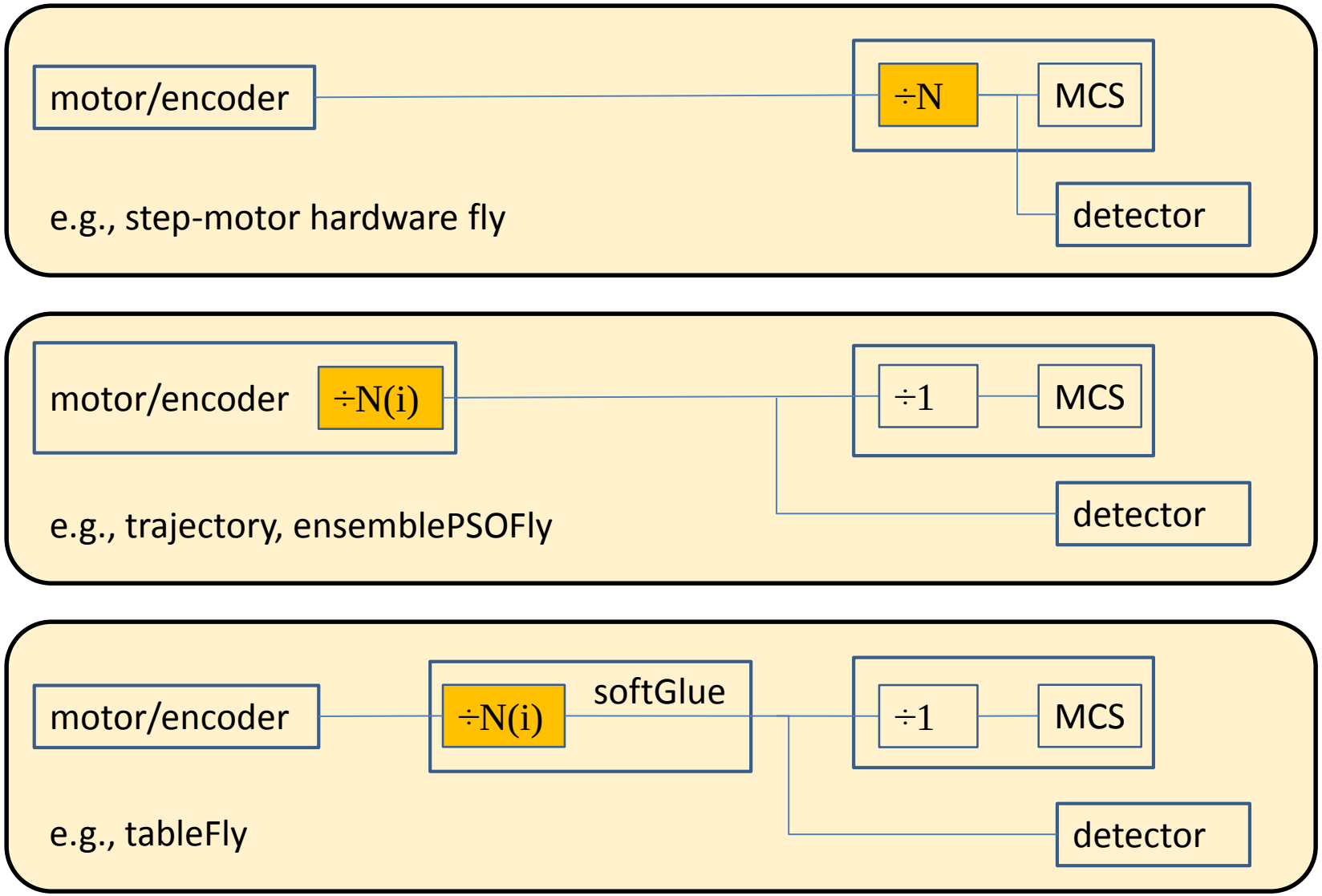
$(scan).BSPV = prepForTraj
$(scan).A1PV = prepData
$(mcs):CountOnStart = No
$(traj):* = many choices

$(scan).P1PV = *not used*
$(motor).VELO = *not used*
$(scan).P1SP = *not used*
$(scan).P1EP = *not used*
$(scan).P1SM = *not used*

Trajectory definition

- Number of trajectory elements
- Array of positions for each motor
  - Ensemble: only one motor
- Array of times
  - Can be specified as total time
- Number of output pulses, start/end element
  - MM4005: pulses evenly spaced in distance along trajectory
  - XPS: pulses evenly spaced in time
  - Ensemble: pulses evenly spaced in distance, or at trajectory points
    - Under development: at user-specified positions
  - For MAXv: pulses only at trajectory points
- Absolute/Relative/Hybrid position mode
  - Currently, Ensemble and MAXv don't support Hybrid mode
- MAXv has timing problems in very slow motion

Detector-trigger options



Examples

- 1ide hexFly (hard fly scan)
  - EnsemblePSOfly.db with evenly spaced data-gate signals
- 2bmb, 32idc tomography fly (hard fly scan)
  - EnsemblePSOfly.db with evenly spaced data-trigger signals
- 2bmb interlace fly (hard fly scan)
  - EnsemblePSOfly.db with user-specified data-trigger signals
    - tableFly.db uses softGlue to generate triggers from motor pulses
    - interlaceFly.db programs tableFly
  - Acquire at ~100 Hz for ~30 minutes
- 15idd USAXS fly (trajectory scan)
  - Ensemble and MAXv trajectories with user-specified data-trigger signals
  - Rotation stage (Ensemble) executes exponential trajectory
  - Translation stages (MAXv) execute commensurate trajectories
- Gradient mirror deposition system (trajectory motion)
  - Ensemble trajectory
  - support installed, but not connected to higher-level software

Plans, possibilities

- Database support for “automatic” soft fly scans
- Database/softGlue support for “automatic” hard fly scans
- Ensemble multiple-motor trajectory support
- ID/monochromator fly scan
- Relax ensemblePSOFly motor-config constraints
- Implement *Hybrid* mode for Ensemble/MAXv trajectory
- Implement Ensemble and MAXv trajectory in model-3 driver