Fly and trajectory scans

Tim Mooney
2/27/2015
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 = $(scaler).CNT$
- $(scan).DnnPV = scaler.T$
- $(scan).P1SP = 0$
- $(scan).P1EP = 5$
- $(scan).NPTS = 10$
- $(scanner).TP = .5$

**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:**
  $(\text{scan}).P1PV = $(\text{motor}).VAL
  $(\text{scan}).P1SM = \text{FLY}
  $(\text{scan}).P1SP = 0
  $(\text{scan}).P1EP = 5
  $(\text{scan}).NPTS = 10
  $(\text{motor}).VELO = 1.0

  **Modified for hardware fly scan:**
  $(\text{scan}).ACQT = 1\text{D ARRAY}$
  $(\text{scan}).BSPV = $(\text{mcs}):\text{EraseStart}$
  $(\text{scan}).BSWAIT = \text{NoWait}$
  $(\text{scan}).A1PV = $(\text{mcs}):\text{StopAll}$
  $(\text{mcs}):\text{PresetReal} = 0$
  $(\text{mcs}):\text{ChannelAdvance} = \text{External}$
  $(\text{mcs}):\text{Channel1Source} = \text{Int. clock}$
  $(\text{scan}).D01PV = $(\text{mcs}):\text{mca1.VAL}$
  $(\text{mcs}):\text{Prescale} = 2500$
  $(\text{mcs}):\text{CountOnStart} = \text{Yes}$
  $(\text{mcs}):\text{NuseAll} = 1000$
  $(\text{scan}).R1PV = \text{not used}$
  $(\text{scan}).T1PV = \text{not used}$
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:
  \[
  \begin{align*}
  &$(scan).ACQT = \text{1D ARRAY} \\
  &$(mcs):\text{PresetReal} = 0 \\
  &$(mcs):\text{ChannelAdvance} = \text{External} \\
  &$(mcs):\text{Channel1Source} = \text{Int. clock} \\
  &$(scan).\text{NPTS} = 10 \\
  &$(scan).D01PV = $(mcs):\text{mca1.VAL} \\
  &$(mcs):\text{NuseAll} = 1000 \\
  &$(scan).R1PV = \text{not used}
  \end{align*}
  \]

  Modified for trajectory scan:
  \[
  \begin{align*}
  &$(scan).T1PV = $(traj):\text{Execute} \\
  &$(mcs):\text{Prescale} = 1 \\
  &$(scan).\text{BSWAIT} = \text{Wait} \\
  &$(scan).\text{BSPV} = \text{prepForTraj} \\
  &$(scan).\text{A1PV} = \text{prepData} \\
  &$(mcs):\text{CountOnStart} = \text{No} \\
  &$(traj):* = \text{many choices} \\
  &$(scan).\text{P1PV} = \text{not used} \\
  &$(motor).\text{VELO} = \text{not used} \\
  &$(scan).\text{P1SP} = \text{not used} \\
  &$(scan).\text{P1EP} = \text{not used} \\
  &$(scan).\text{P1SM} = \text{not used}
  \end{align*}
  \]
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**

1. **motor/encoder**
   - \( \div N \)
   - \( \div 1 \)
   - \( \div N(i) \)

   - e.g., step-motor hardware fly
   - e.g., trajectory, ensemblePSOFly
   - e.g., tableFly

2. **softGlue**
   - \( \div N(i) \)
   - \( \div 1 \)

   - detector
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