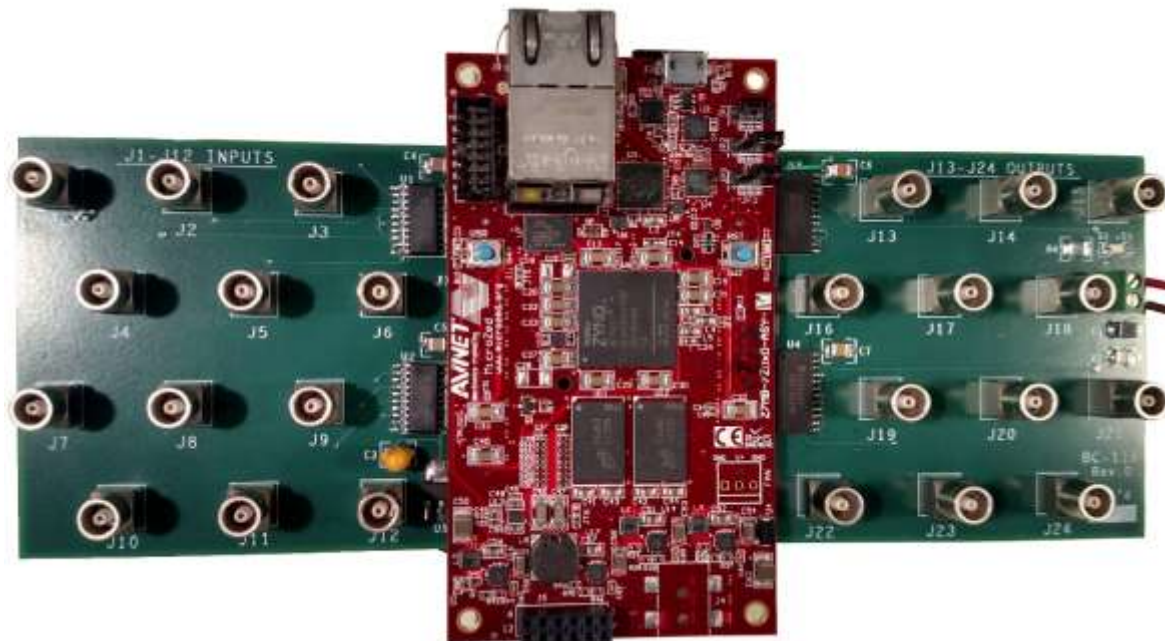
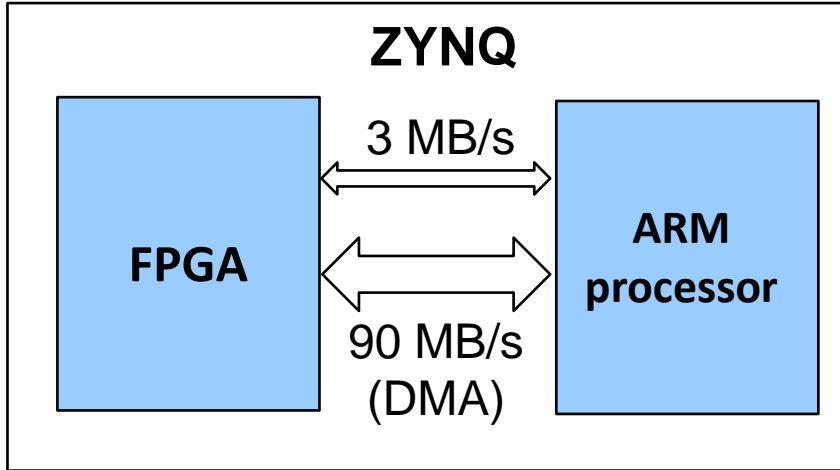


EPICS and Custom Beamline Electronics on the MicroZed

Tim Mooney, Kurt Goetze
EPICS-collaboration meeting – June 15, 2018



Overview



softGlueZynq

Rewrite of softGlue for the Xilinx Zynq chip

EPICS IOC

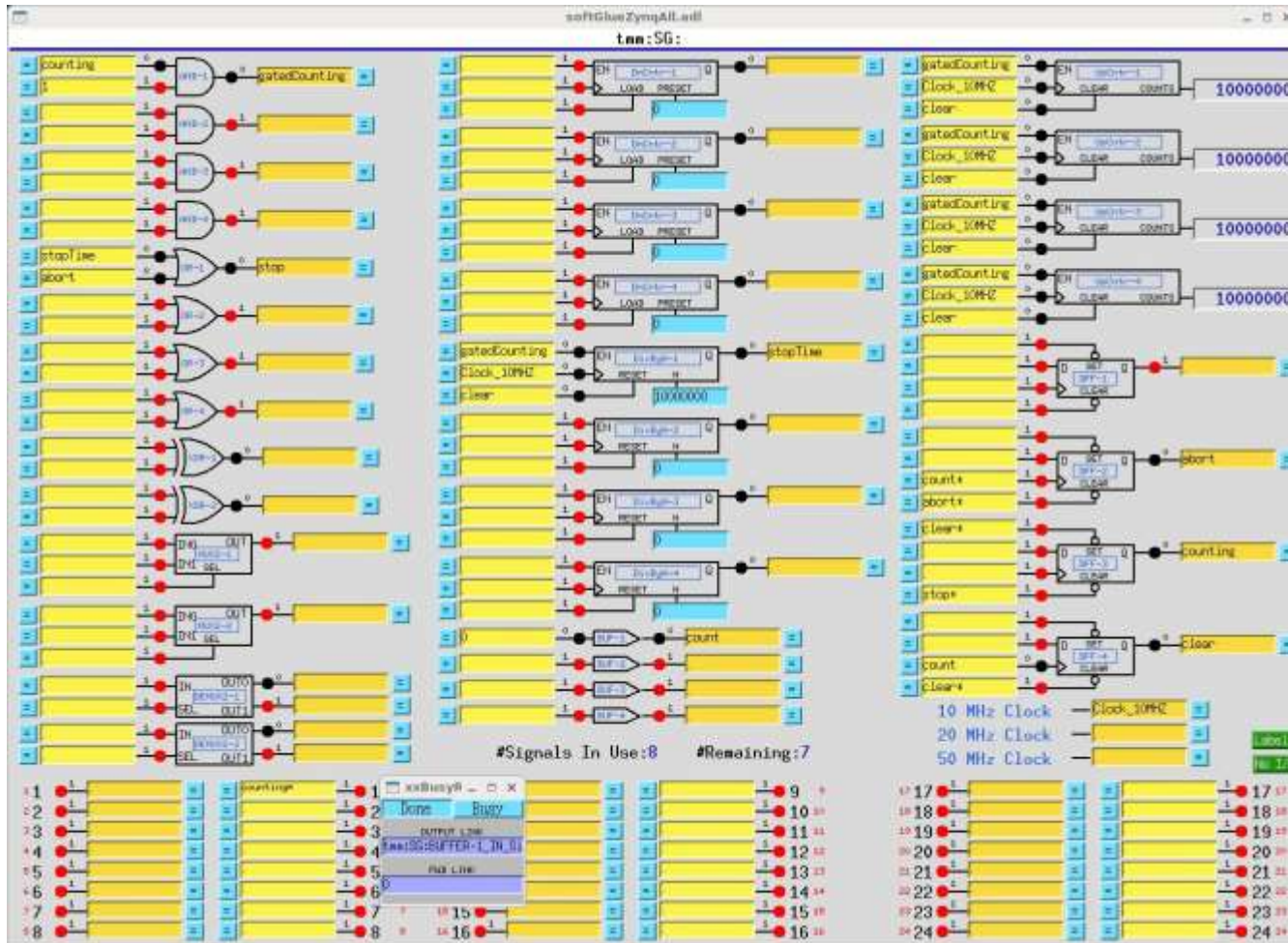
Runs everything in synApps that doesn't need VME hardware

Deployed and maintained in much the same way as a VME IOC (cross compiler, NFS mount, procServ)

Overview

- **softGlueZynq enables beamline users to construct simple digital electronic circuits, and connect those circuits to field wiring, by writing to EPICS process variables (PVs).**
- **softGlueZynq also provides user control over how hardware interrupts are generated by field I/O signals, and dispatched to cause EPICS processing.**
- **softGlueZynq circuits can be autosaved and restored, saved as text files, emailed to another user, and managed by *configMenu*.**
- **softGlueZynq does this by loading an Xilinx Zynq FPGA with a predefined collection of circuit elements (logic gates, counters, flip-flops, etc.), whose inputs and outputs are connected to switches controlled by EPICS PVs.**

MEDM display



configMenu.adl

configMenu: SG

NAME: **gatedScaler**
 DESC: four channel scaler
 STATUS: **Success**

config Name

Load	accelDece1Gate	Save
Load	clear	Save
Load	encoderTest	Save
Load	fourPulses	Save
Load	gatedScaler	Save
Load	pulseFromEdge	Save
Load	shutterDetTrig	Save
Load	pulse_stretcher	Save
Load	toMrandTest	Save
Load		Save

Page:

Done

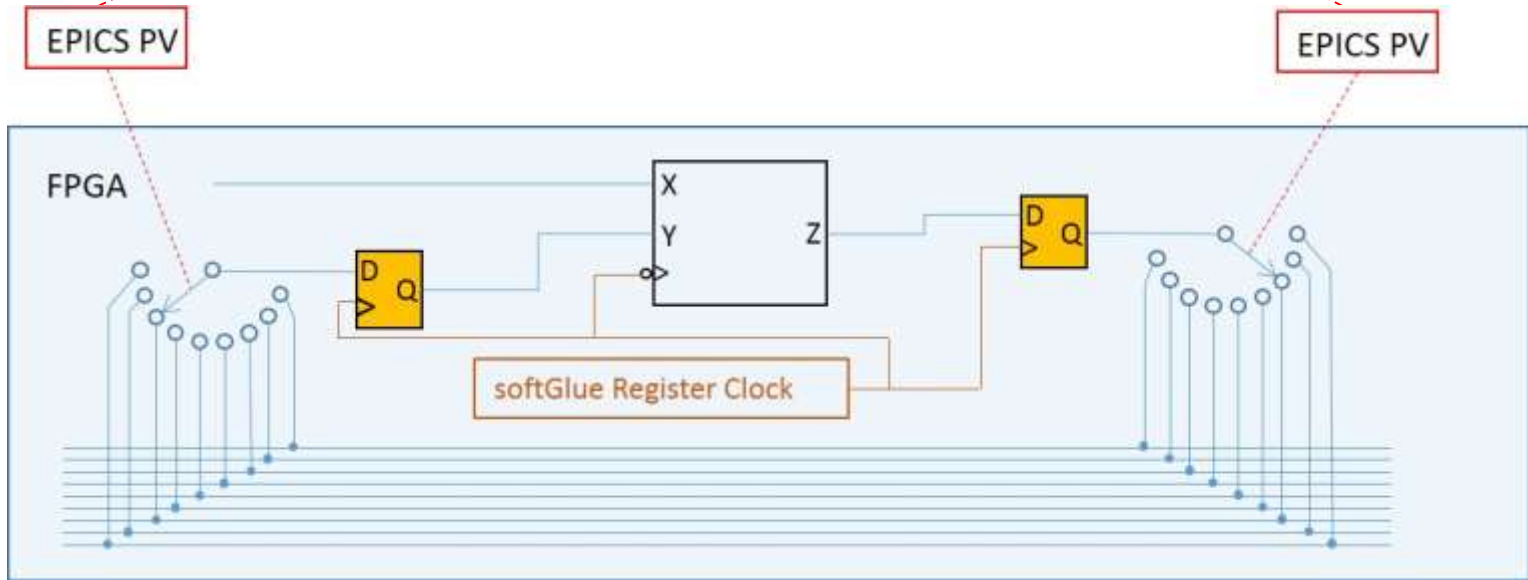
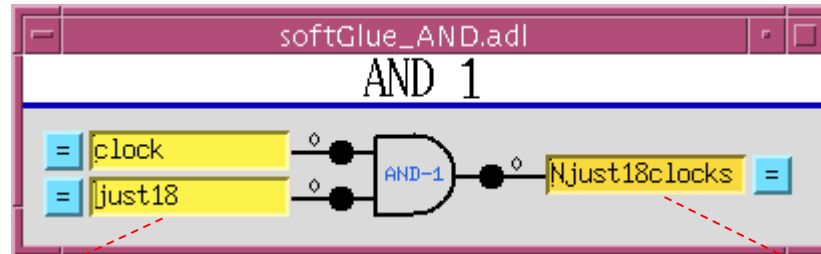
xxBusyR

OUTPUT LINK

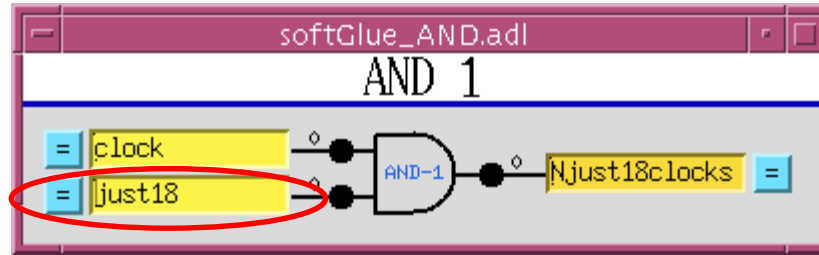
yyy:softGlue:BUFFER-1

FWD LINK

How it works, conceptually



Circuit-element inputs



option	example	result	comment
empty		1	
number	1	1	
	0	0	
	1!	Positive-going pulse	~3 μ s
	0!	Negative-going pulse	~3 μ s
	0.499	0	
name	mySignal	Connected to all other inputs and output named "mySignal"	

Field I/O

- Connected just as are circuit elements
- Interrupt can drive EPICS record on rising edge.

softGlueZynqFieldIO_Intxx.adl
tmm:SG:

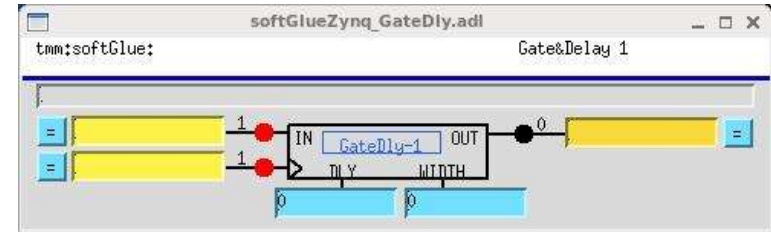
Field Input Bit		Interrupt-driven record		Field Output Bit		Interrupt-driven record	
		INTERRUPT ON RISING EDGE	WRITE SIGNAL VALUE VIA THIS LINK			INTERRUPT ON RISING EDGE	WRITE SIGNAL VALUE VIA THIS LINK
1	1	<input type="checkbox"/>	None	<input type="checkbox"/>	1	<input type="checkbox"/>	None
2	2	<input type="checkbox"/>	None	<input type="checkbox"/>	2	<input type="checkbox"/>	None
3	3	<input type="checkbox"/>	None	<input type="checkbox"/>	3	<input type="checkbox"/>	None
4	4	<input type="checkbox"/>	None	<input type="checkbox"/>	4	<input type="checkbox"/>	None
5	5	<input type="checkbox"/>	None	<input type="checkbox"/>	5	<input type="checkbox"/>	None
6	6	<input type="checkbox"/>	None	<input type="checkbox"/>	6	<input type="checkbox"/>	None
7	7	<input type="checkbox"/>	None	<input type="checkbox"/>	7	<input type="checkbox"/>	None
8	8	<input type="checkbox"/>	None	<input type="checkbox"/>	8	<input type="checkbox"/>	None
9	9	<input type="checkbox"/>	None	<input type="checkbox"/>	9	<input type="checkbox"/>	None
10	10	<input type="checkbox"/>	None	<input type="checkbox"/>	10	<input type="checkbox"/>	None
11	11	<input type="checkbox"/>	None	<input type="checkbox"/>	11	<input type="checkbox"/>	None
12	12	<input type="checkbox"/>	None	<input type="checkbox"/>	12	<input type="checkbox"/>	None
13	13	<input type="checkbox"/>	None	<input type="checkbox"/>	13	<input type="checkbox"/>	None
14	14	<input type="checkbox"/>	None	<input type="checkbox"/>	14	<input type="checkbox"/>	None
15	15	<input type="checkbox"/>	None	<input type="checkbox"/>	15	<input type="checkbox"/>	None
16	16	<input type="checkbox"/>	None	<input type="checkbox"/>	16	<input checked="" type="checkbox"/>	Rising

CONNECTOR # Less CONNECTOR #

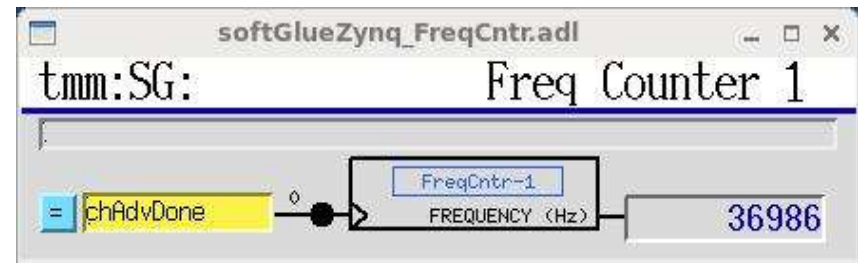
Additional circuit elements

- **Gate&Delay Generator**

- Delay a signal.
- Optionally, specify output pulse width.
- 20 ns time resolution (fast version has 4 ns time resolution.)



- **Frequency Counter**



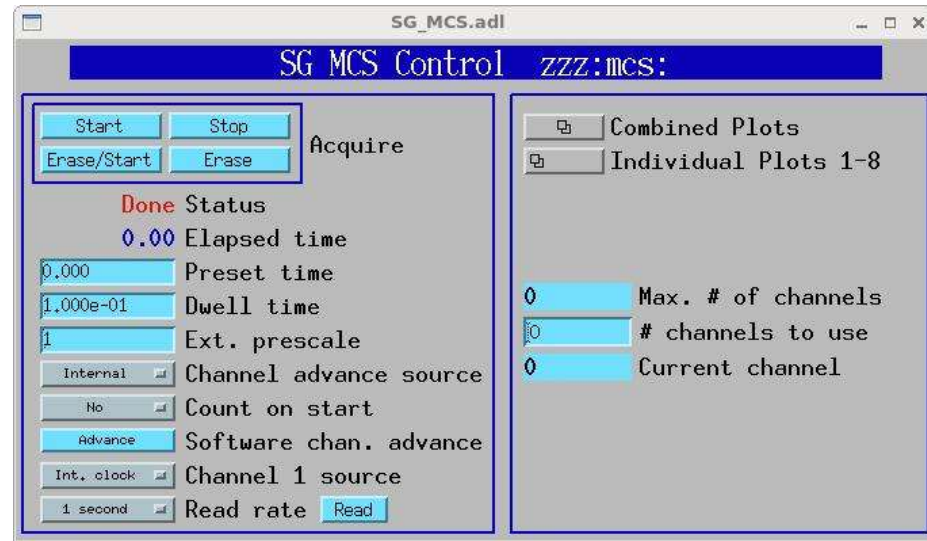
Additional circuit elements

- 16 input scaler



Done	Done/stop	Count time	Elapsed time	
Count	Prescaler	1.000	1.000	
#	Description	Gate?	Preset count	Actual count
1			10000000	10000000
2			0	0
3			0	0
4			0	1004011
5			0	0
6			0	0
7			0	0
8			0	0
9			0	0
10			0	0
11			0	0
12			0	0
13			0	0
14			0	0
15			0	0
16			0	0

- 8 input multichannel scaler (in progress)



SG MCS Control zzz:mcs:

Start Stop
Erase/Start Erase Acquire

Done Status
0.00 Elapsed time
0.000 Preset time
1.000e-01 Dwell time
1 Ext. prescale

Internal Channel advance source
No Count on start
Advance Software chan. advance
Int. clock Channel 1 source
1 second Read rate Read

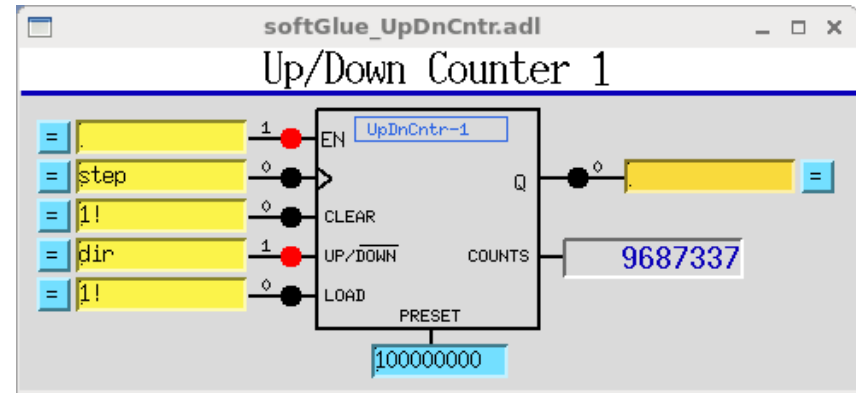
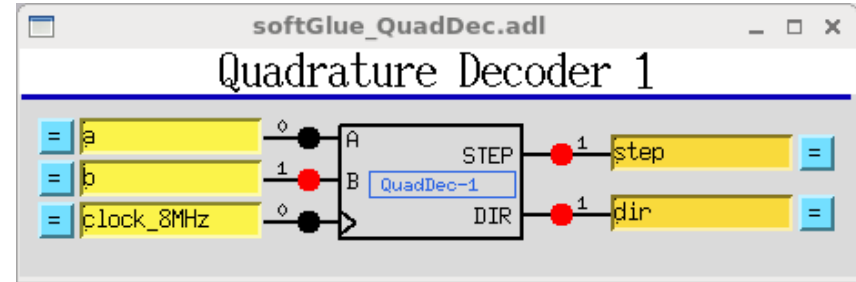
Combined Plots
Individual Plots 1-8

0 Max. # of channels
0 # channels to use
0 Current channel

Additional circuit elements

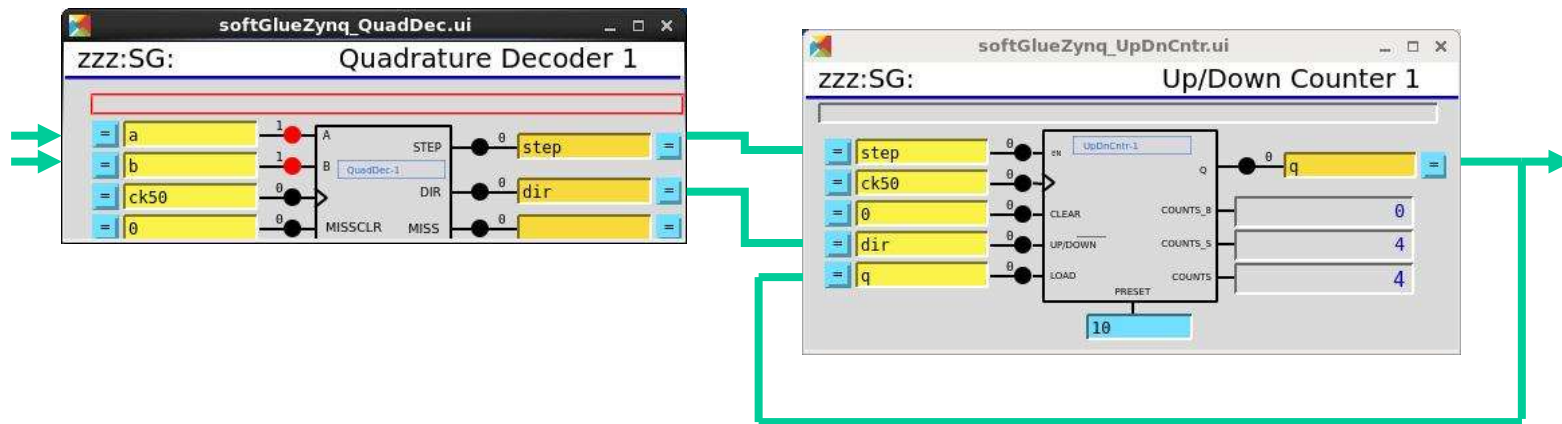
- **Quadrature decoder**
 - Read encoder or interferometer

- **Up/Dn Counter**

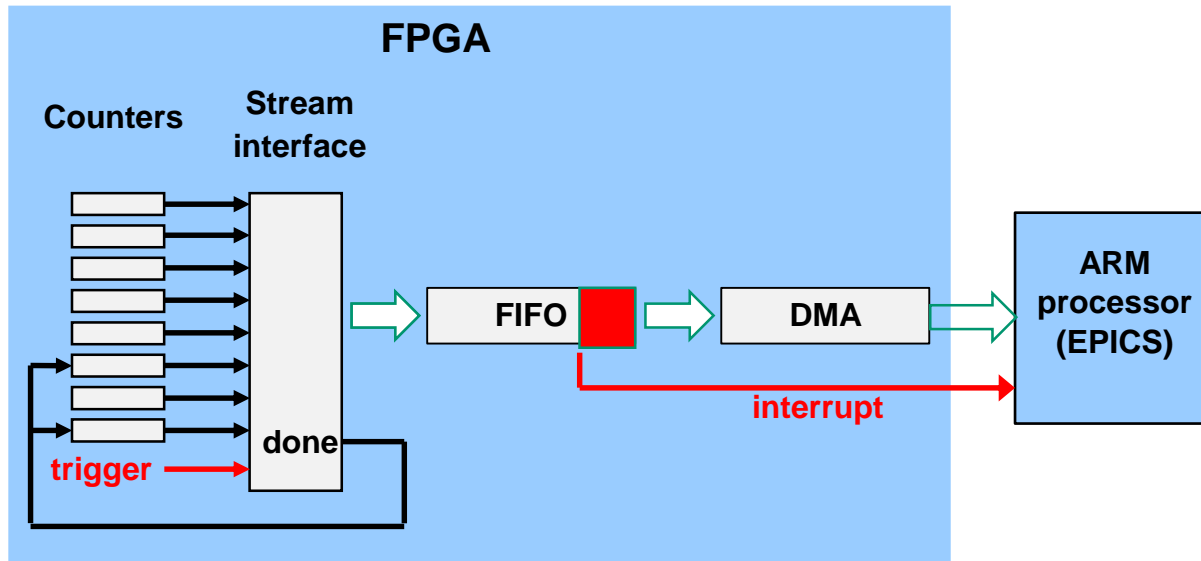


Track encoder or interferometer

Generate triggers



Data-acquisition infrastructure

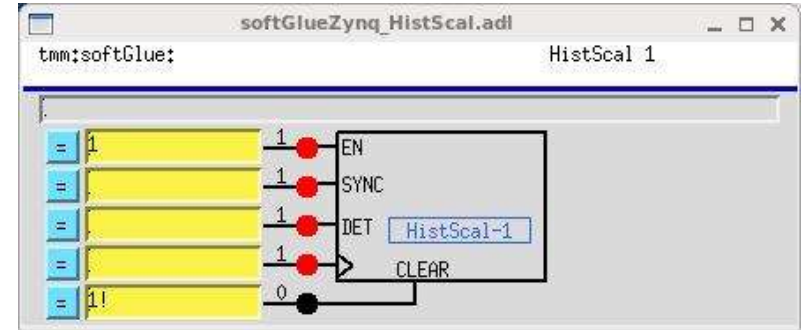


Used for interferometer recorder, pixelTrigger, multichannel scaler, and histogramming scaler

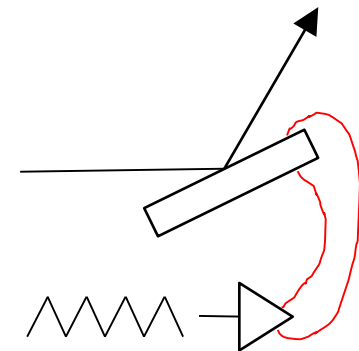
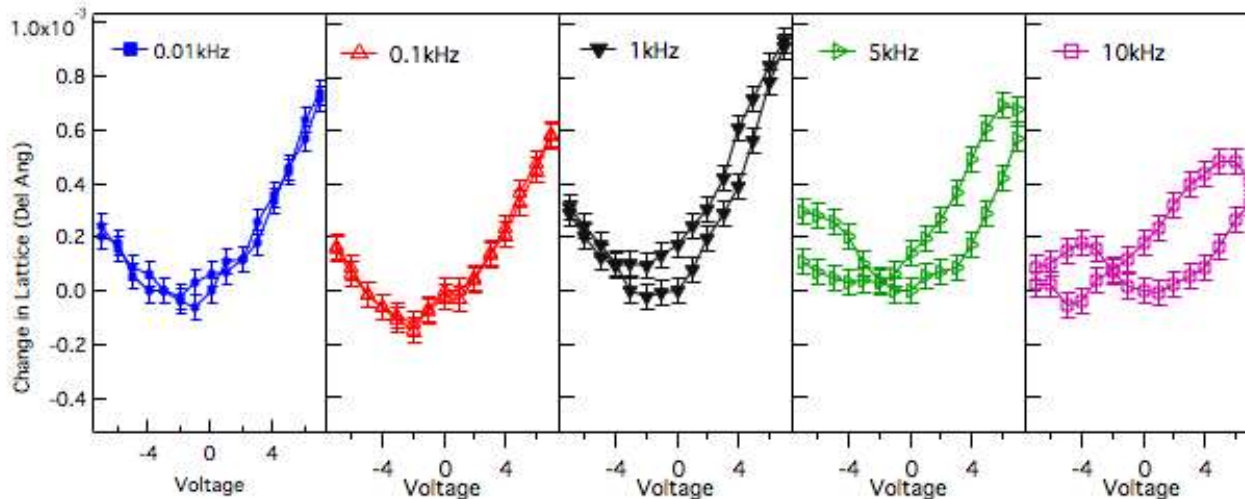
Additional circuit elements

- **Histogramming Scaler**

- Like a MCS, but SYNC sets current channel to 0
- 64 time bins, channel advance at up to 50 MHz (fast version up to 250 MHz)

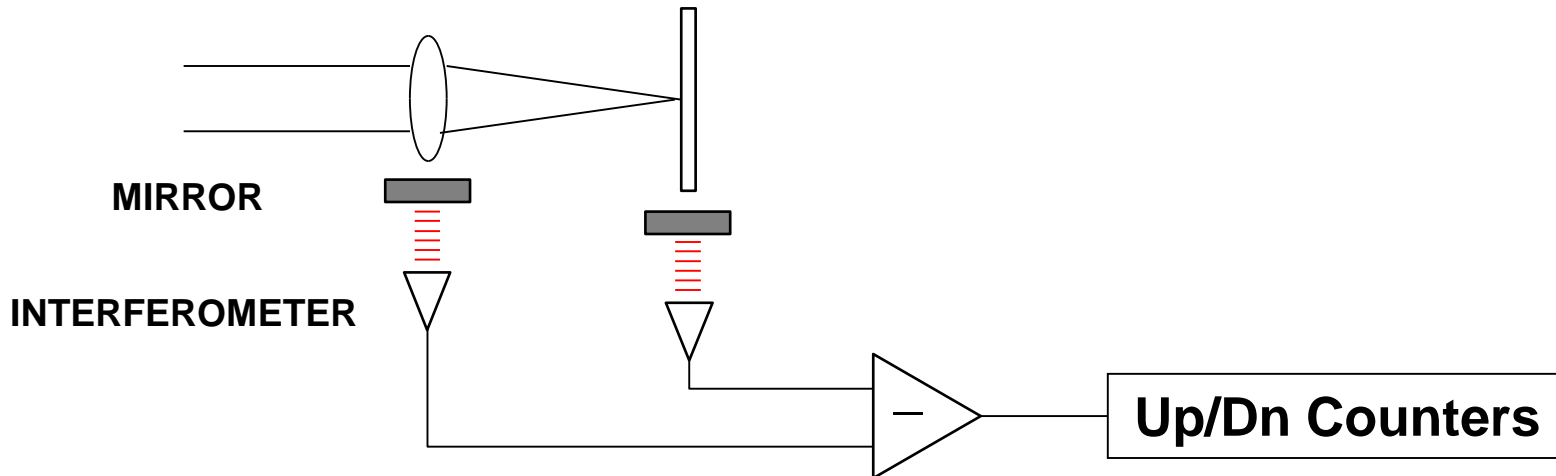
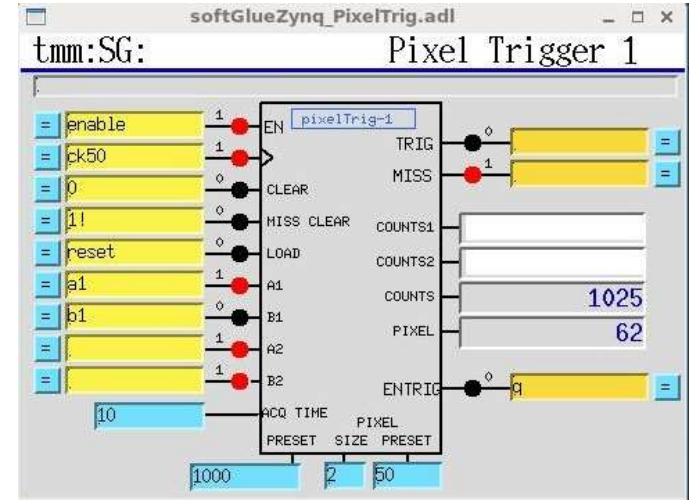


- **piezoDiffraction data (Phil Ryan - 6idb)**



Additional circuit elements

- pixelTrigger (1D fly scan)**
 - Track location of focal spot on sample ($X_{ZP} - X_{SAMPLE}$)
 - Generate triggers from focal spot motion.
 - User specifies pixel size in interferometer ticks.

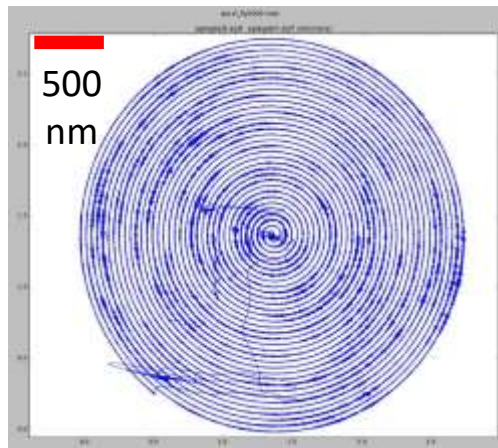


Interferometer recorder

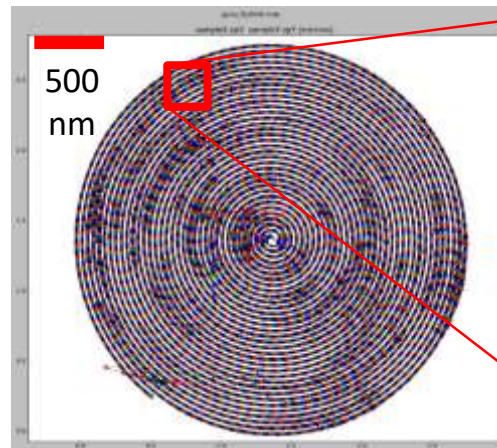
Ptychotomography measurement:

- Spiral generated by waveform generator driving piezos
- Recorded (X_{ZP} , X_{SAMPLE} , Y_{ZP} , Y_{SAMPLE} , Image number, Time)
- Interferometer at 500 Hz, camera at 20 Hz

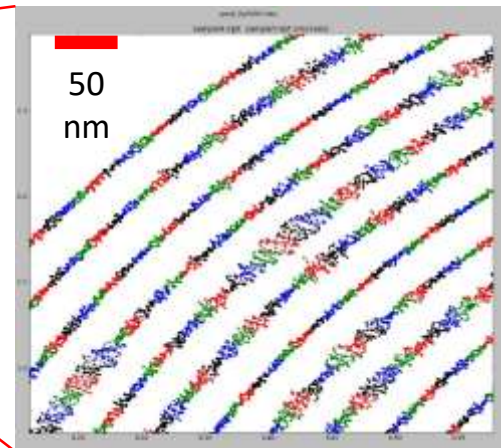
Focal spot trajectory



Readings coded by image number



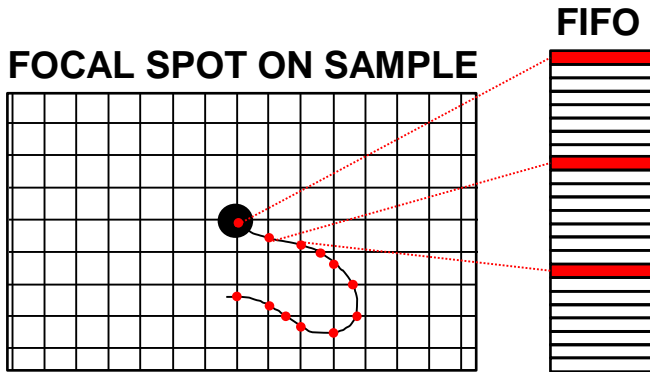
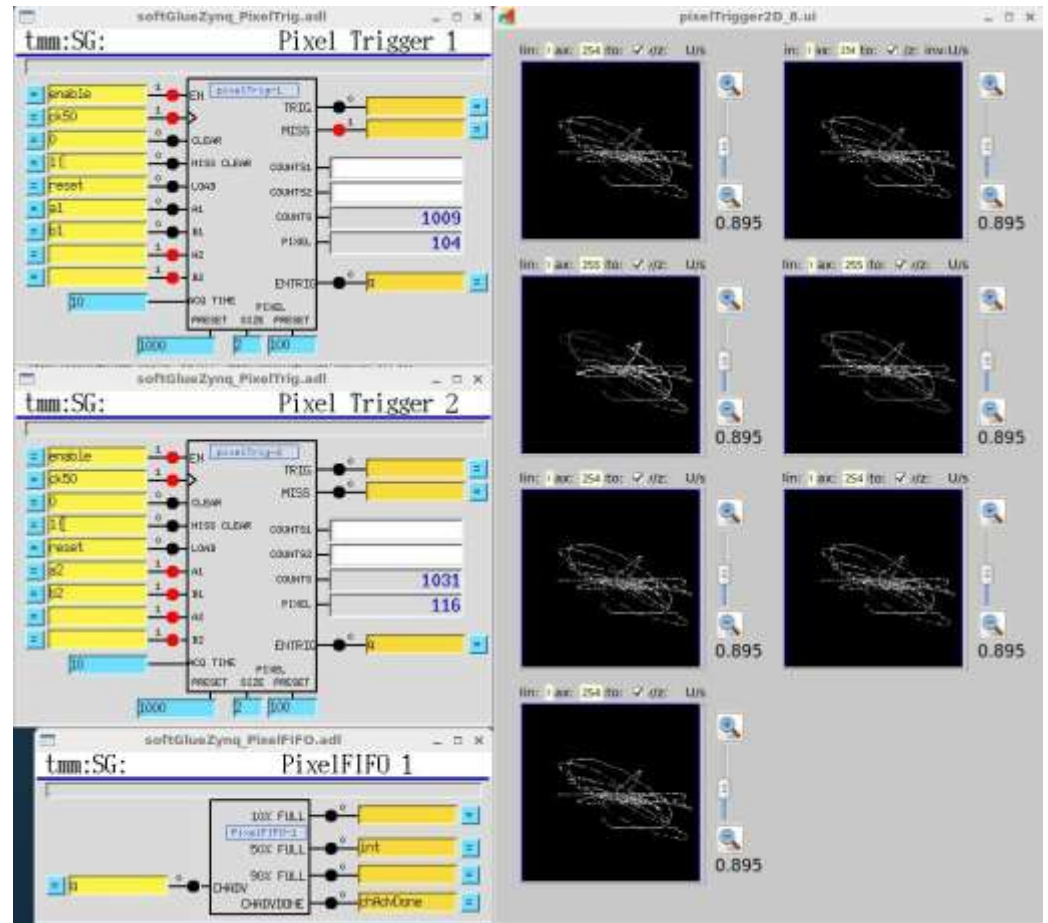
Closeup of the trajectory



Application

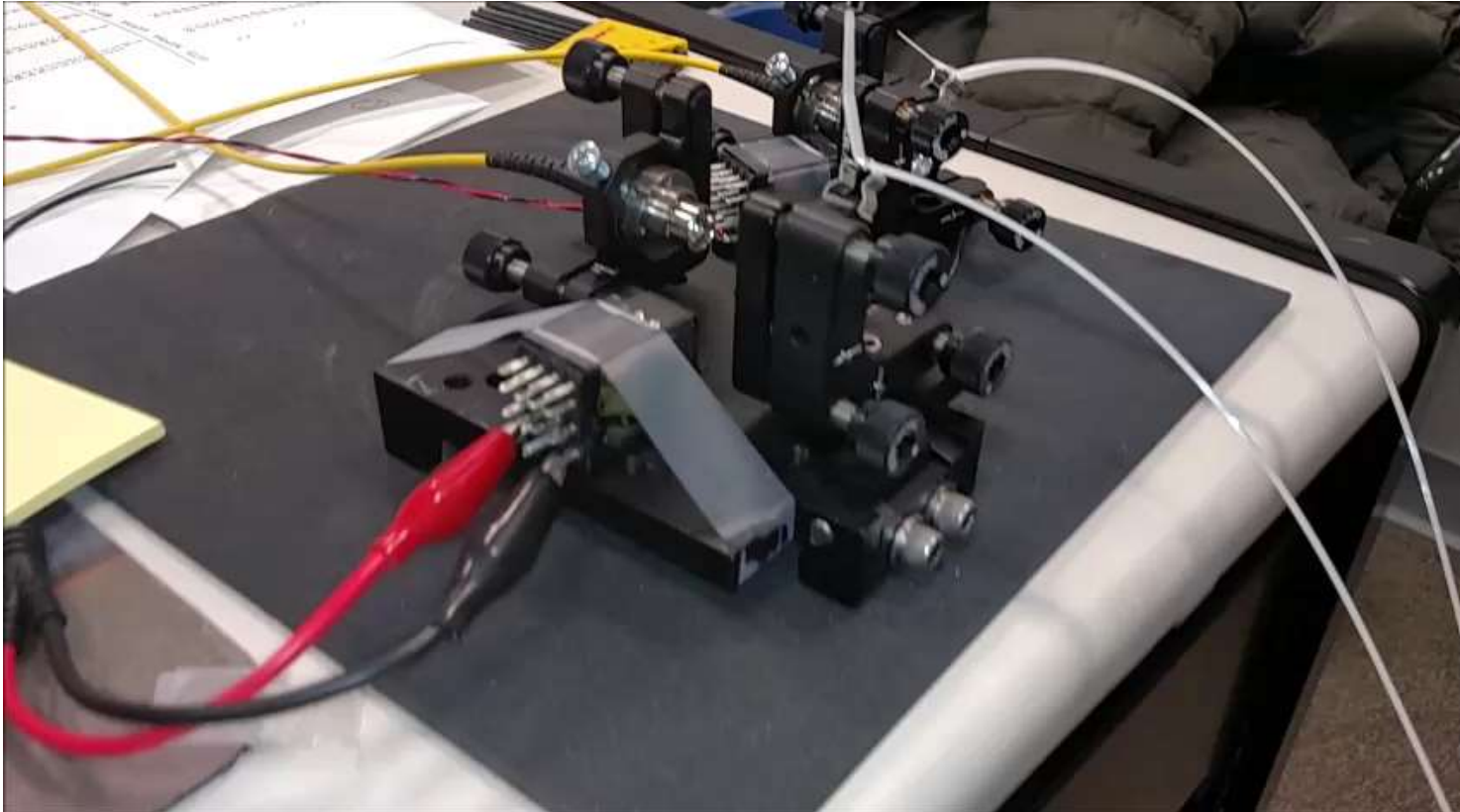
- **X-ray microscope data-acquisition system (2D fly scan)**

- Trigger when focal spot leaves a pixel
- Event data:
 - (x,y)
 - 7 counters
- Events at <400 kHz

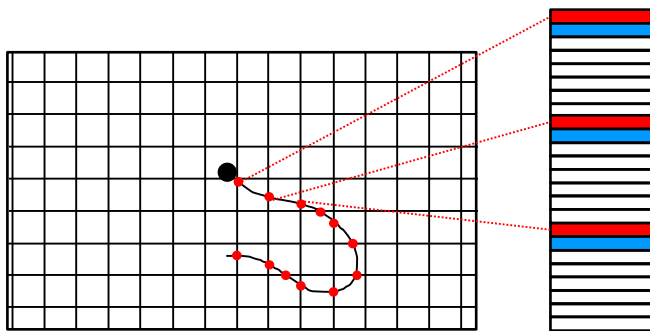
Application

- **pixelTrigger Demo: response to impulse**



Application

- Time resolved data acquisition (3D fly scan)
 - Trigger on pixel OR time boundary
 - Event data:
 - (x,y)
 - ΔT since sync
 - 6 counters
 - $dT > 2 \mu s$ (20 ns?)



Application

- Time resolved data-acquisition (3D fly)
 - dT 5 μ s

