Developments at SLAC

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Extensive collaborations with other institutions

Gratefully acknowledge support by DOE and NIH

SRI 2010, Argonne

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CS-PAD Camera

Successful collaboration with Cornell University

110 mm by 110 mm by 500 mm thick pixels

Array of 758 by 758 pixels

Readout at 120 Hz using RCE-based DAQ

High and Low Gain modes

Bump-bonded, hybrid architecture

Cornell Team
Darol Chamberlain (2), Sol M. Gruner (1,2), Marianne S. Hromalik (1,3), Lucas J. Koerner (1,4), Hugh T. Philipp (1), Mark W. Tate (1)(1) Department of Physics, Cornell University(2) Cornell High Energy Synchrotron Source (CHESS) (3) presently SUNY Oswego(4) presently Applied Physics Lab of Johns Hopkins University

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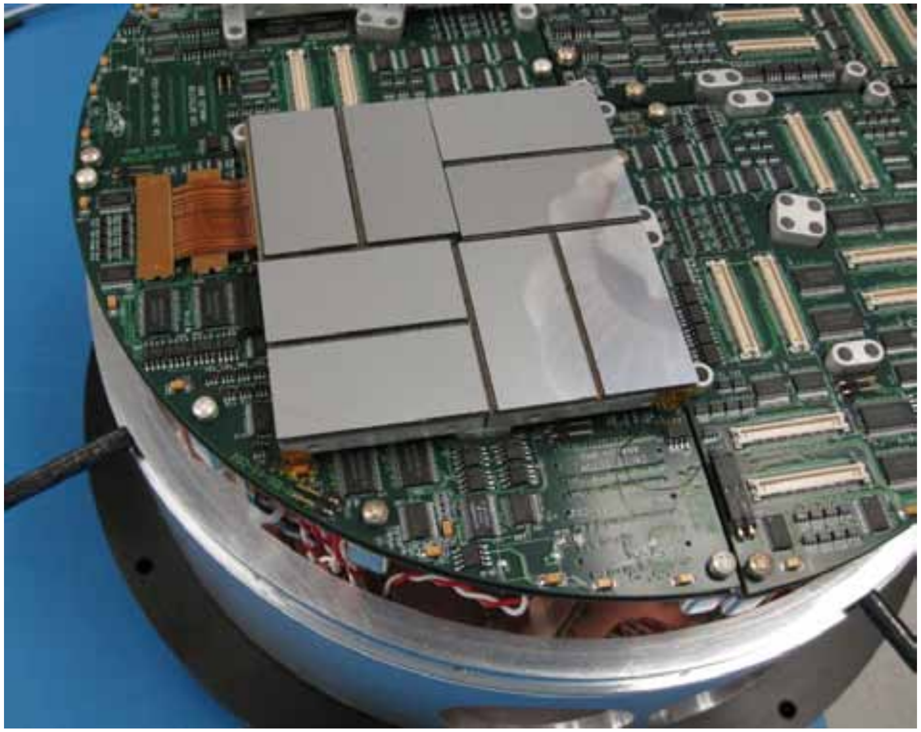
XPP Hutch

Only quarter of possible modules mounted

Partially due to bump bond yield



Being installed on XPP robot arm by Ryan Herbst

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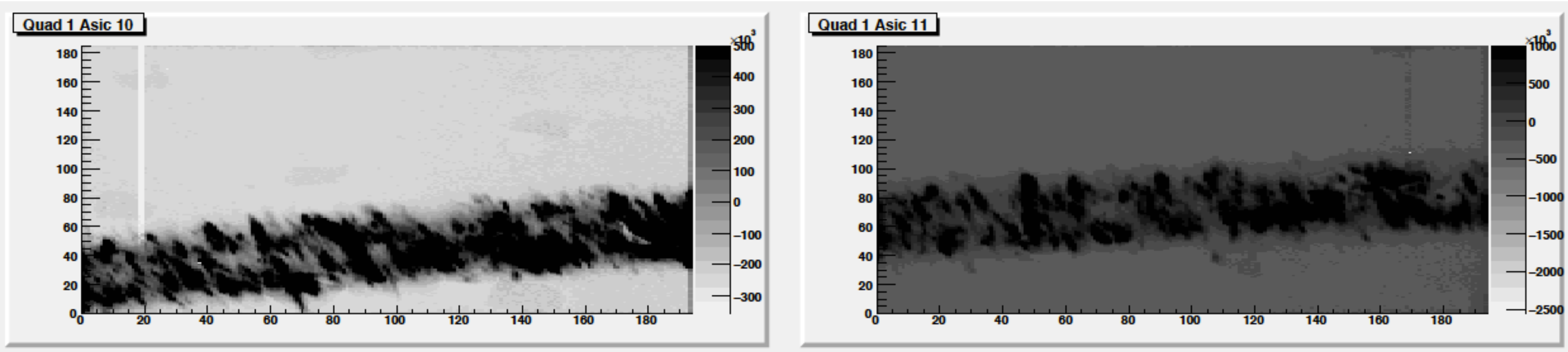
CS-PAD Sees First LCLS Light



August 26

Beryllium window target

~ 9 keV photons

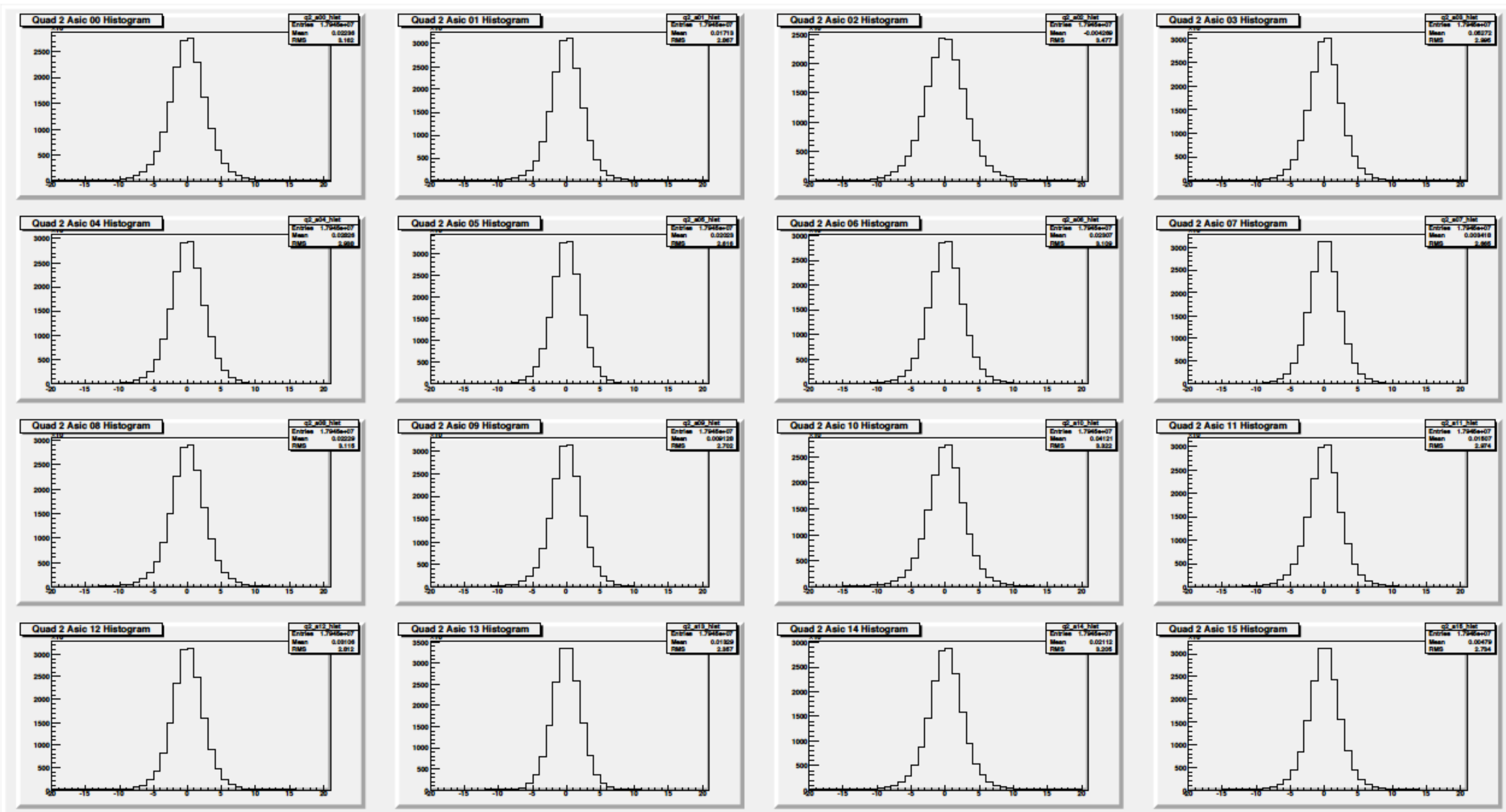
~ 1 mJ per pulse

Operated under-biased at 40 V
for safety reasons

CS-PAD Noise

Noise distributions for each of the 16 ASICs as measured in the XPP hutch on the robot arm

Typical RMS of 3 ADUs



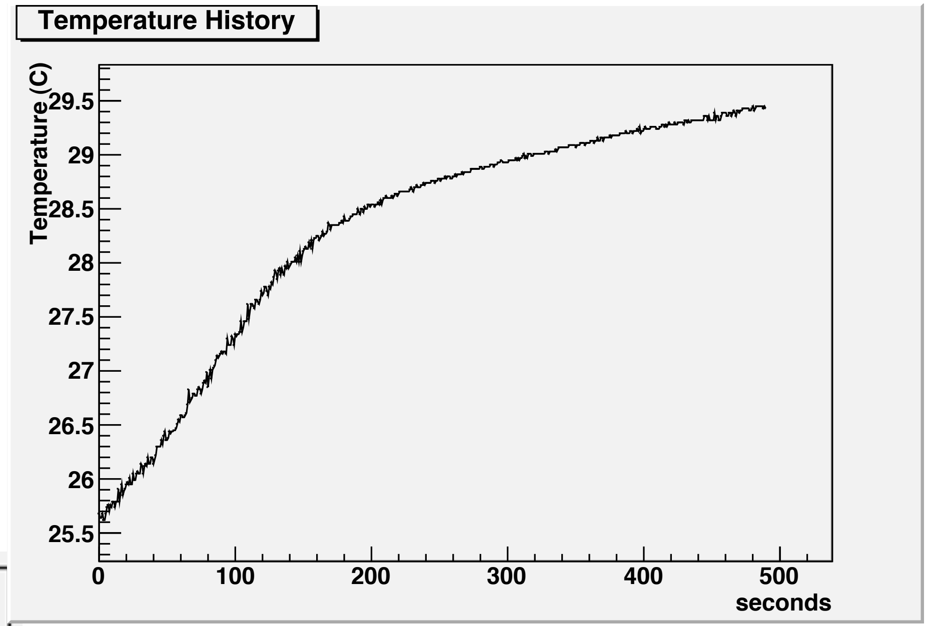
CS-PAD in XPP Thermal

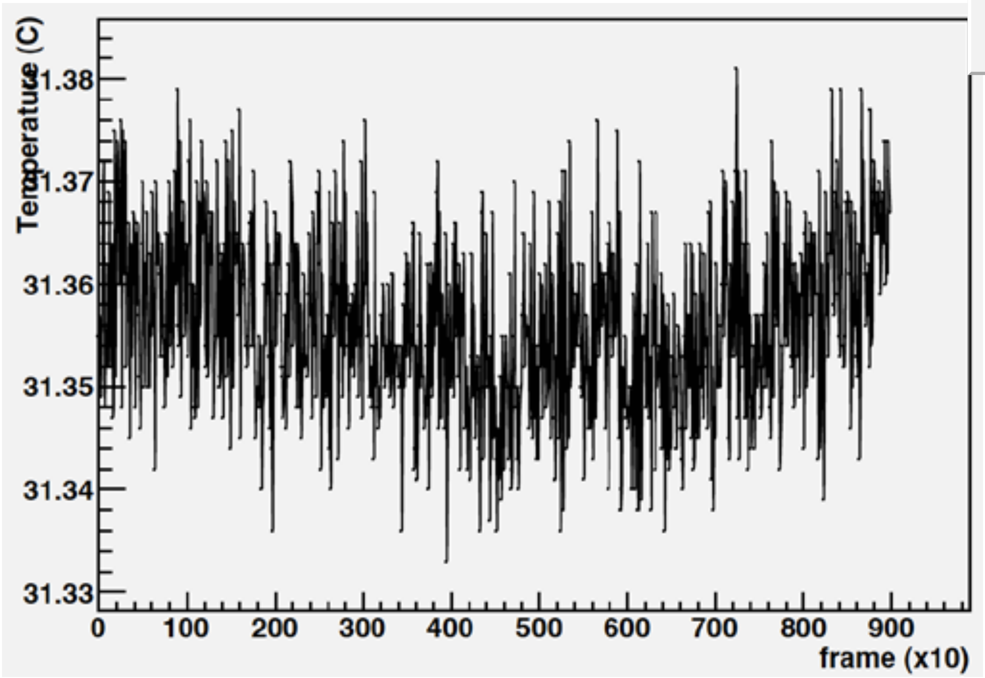
In air

Water cooled

Equilibrates in 30 minutes

Stable to within +/- 10 mK over 15 minutes





Solid copper cold straps

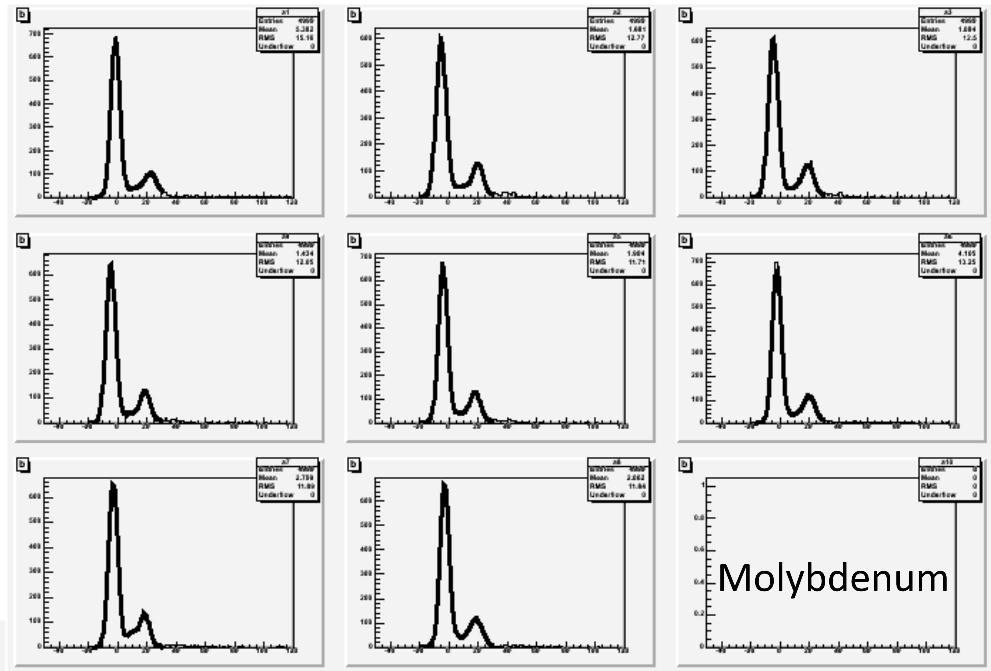
Sensor around 37 C

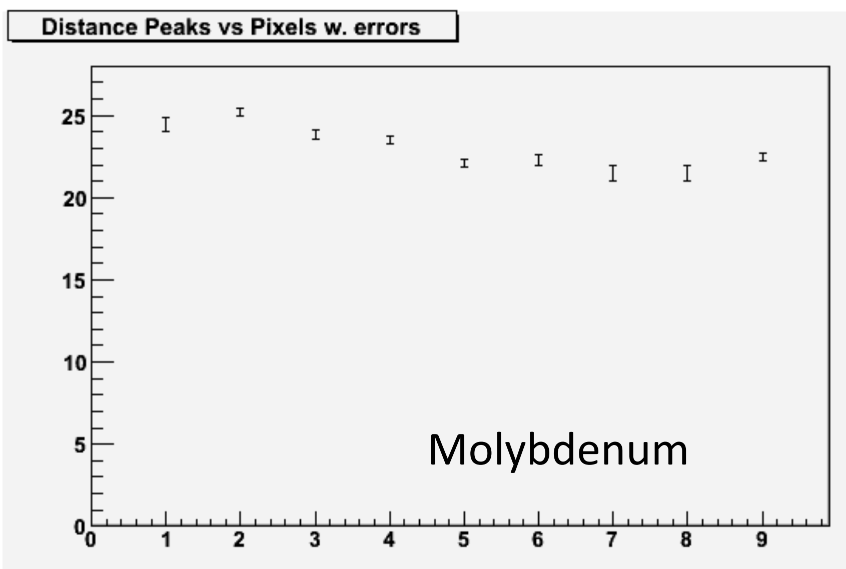
CS-PAD Spectra/Gain

X-ray fluorescence spectra: Cu, Se, Mo

Taken at ALS

Used to provide pixel-by pixel gain correction





On average 8 keV photon equals 10.5 ADUs

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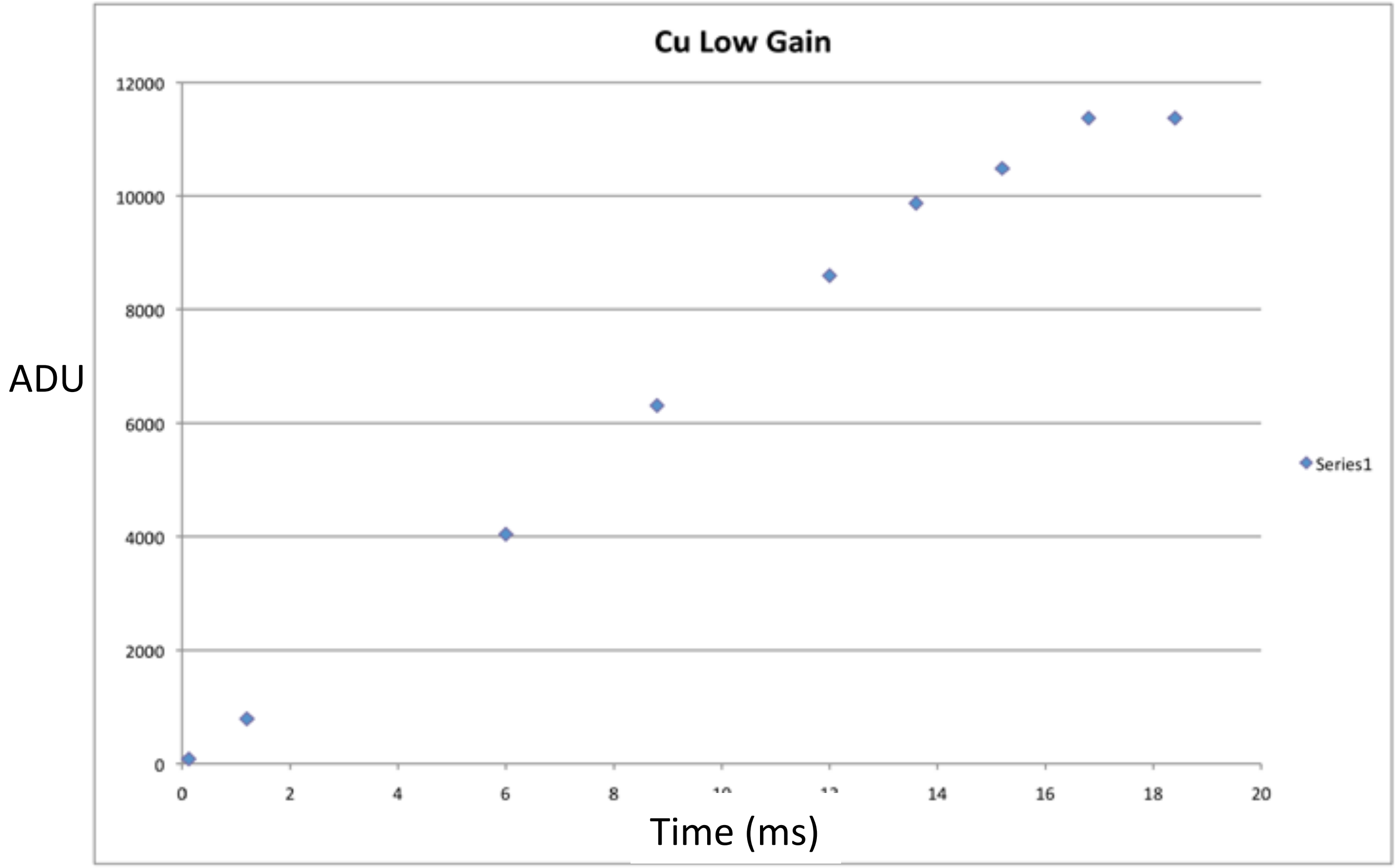
CS-PAD Dynamic Range



Full capacity in low gain mode is over 7,000 8 keV photons

Taken at ALS 10.3.1

CS-PAD Frame Noise

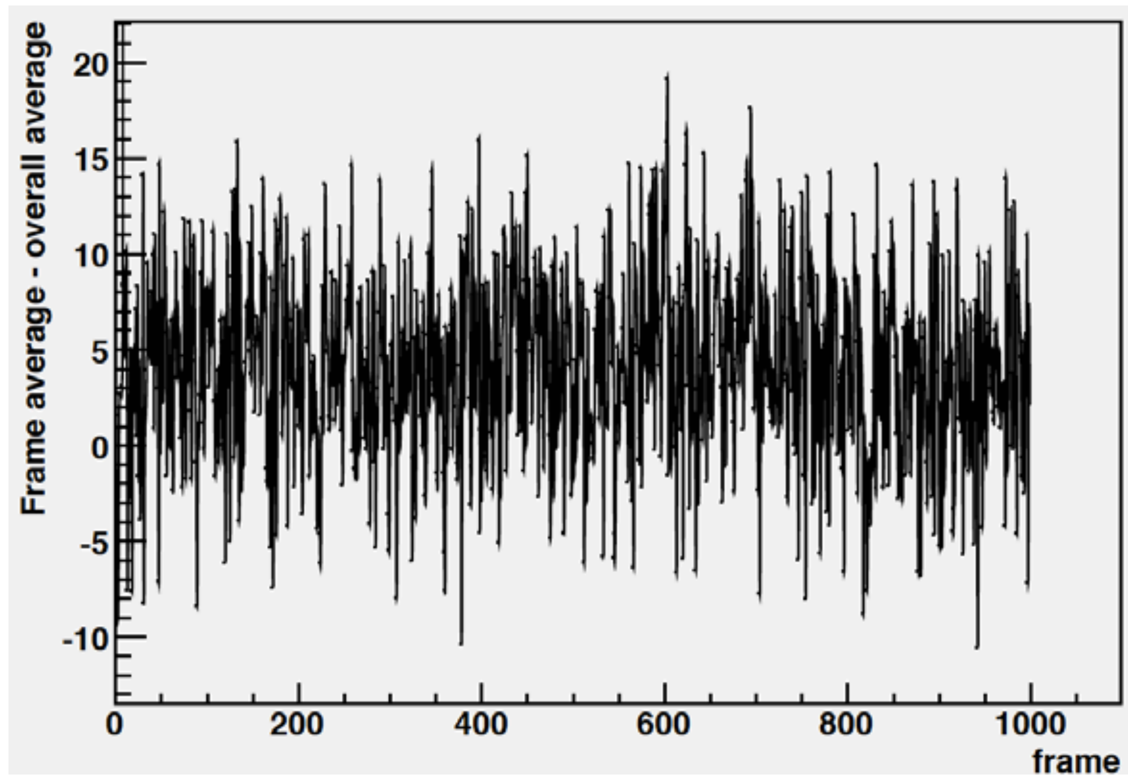
Correlated across one ASIC

Varies frame-to-frame

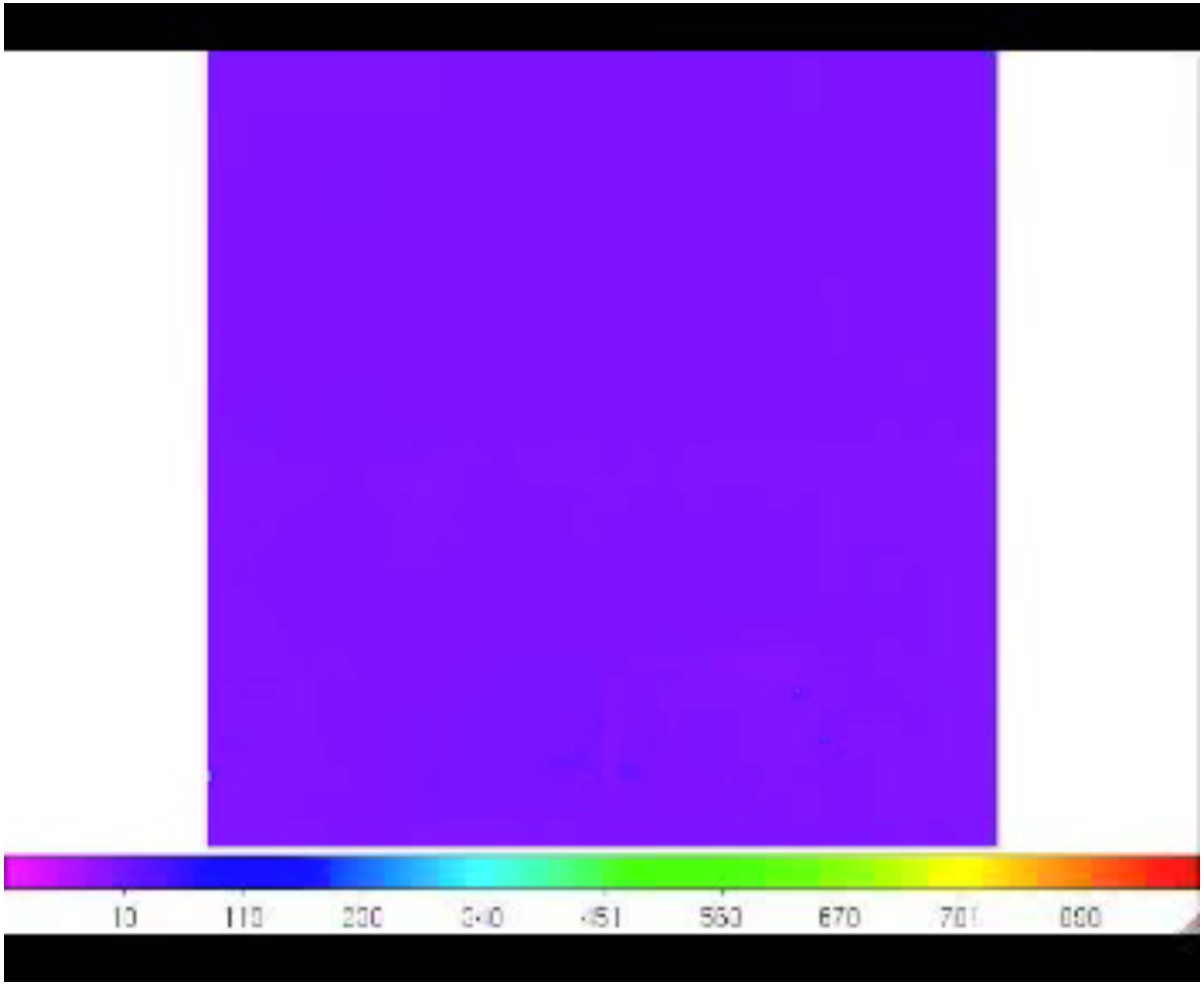
Low occupancy – correctable

Very high occupancy – insignificant

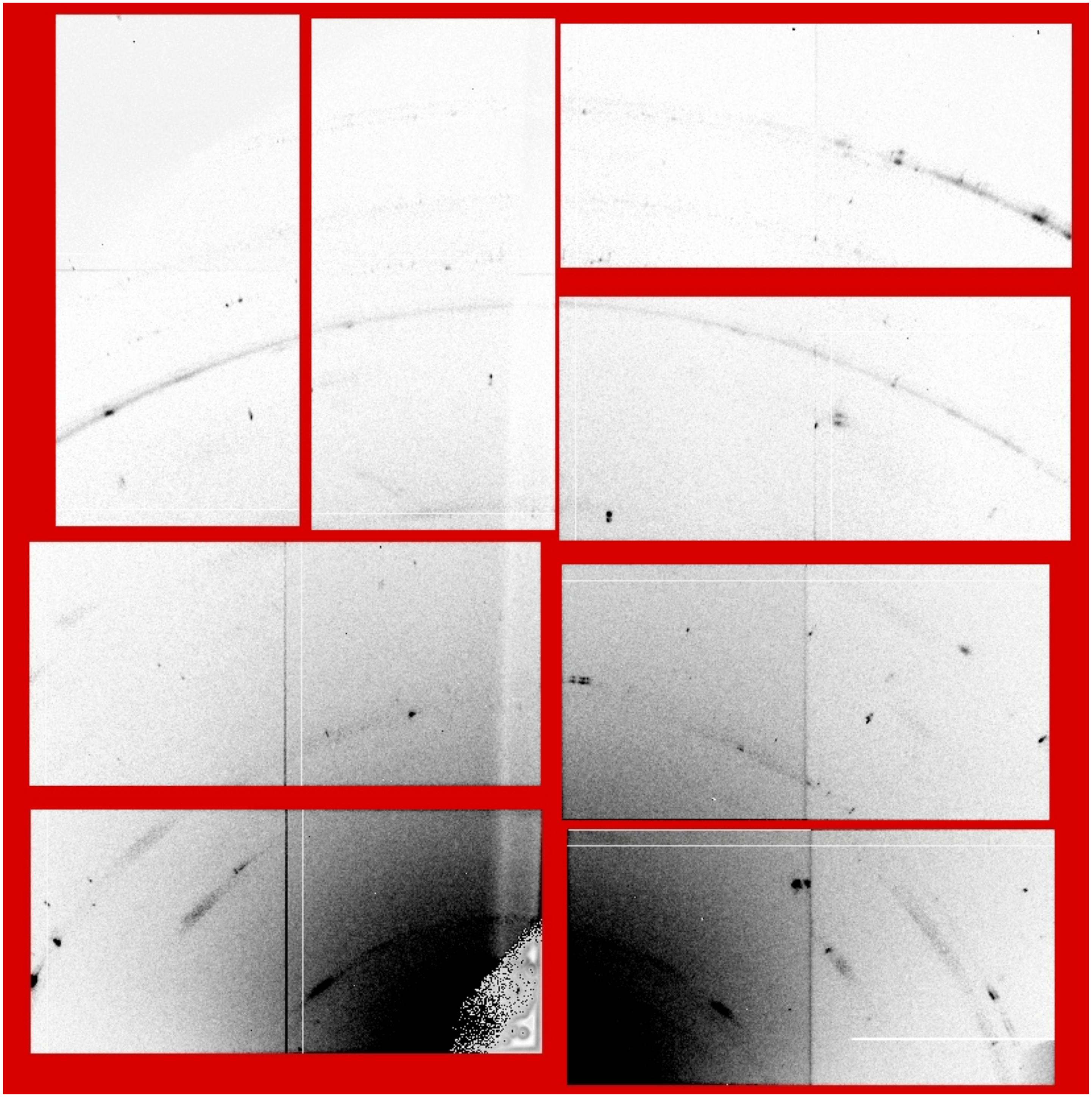
Disconnect 20 pixels to provide references (i.e. no bump between circuit cell and sensor cell



LCLS Silver Behenate



Silver Behenate powder



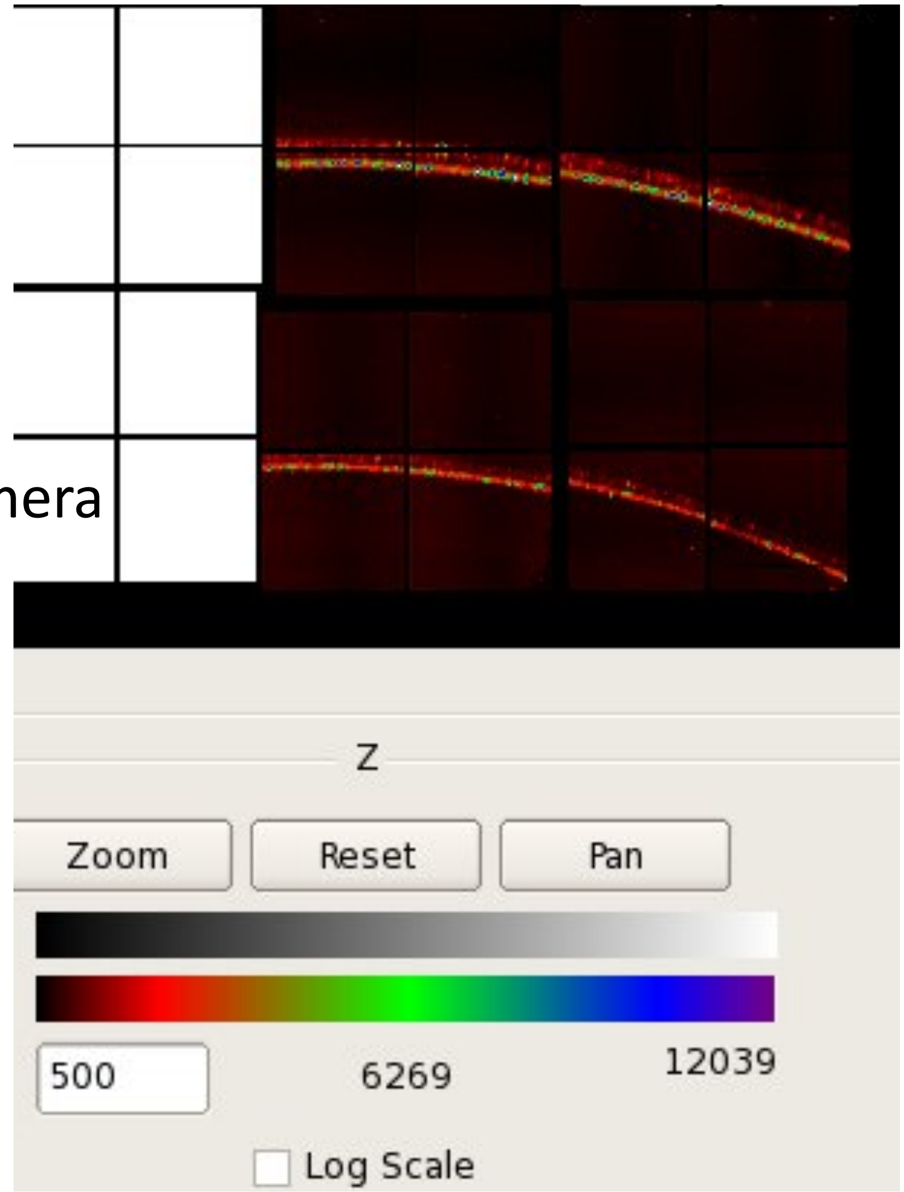
CS-PAD in XPP

Much work left to do:

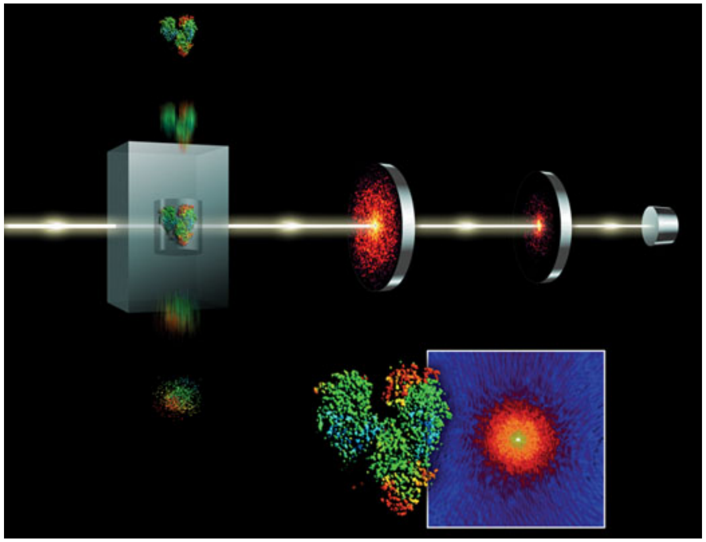
Calibration software

Modules for remainder of camera

- Beryllium window
- 9 keV
- ~1 mJ/pulse
- High gain mode
- Raw data



CXI Hutch



Same modules as used in XPP hutch

Operate in vacuum

Two full cameras needed

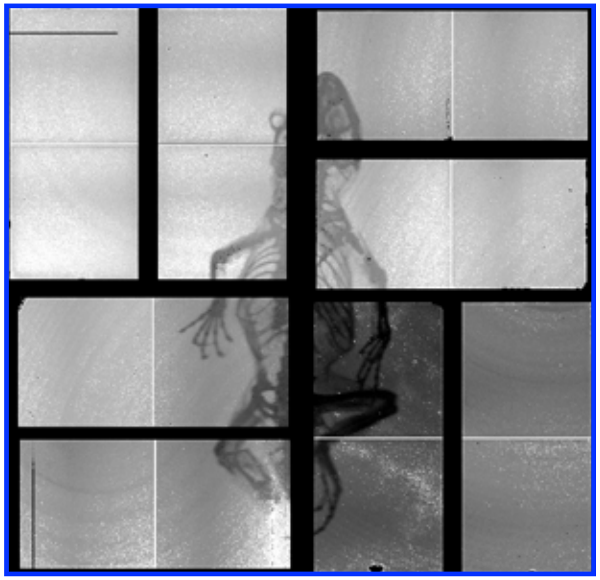
Variable aperture

Second camera mechanical assembly nearly complete

Progress being made in design of the flexible cold straps

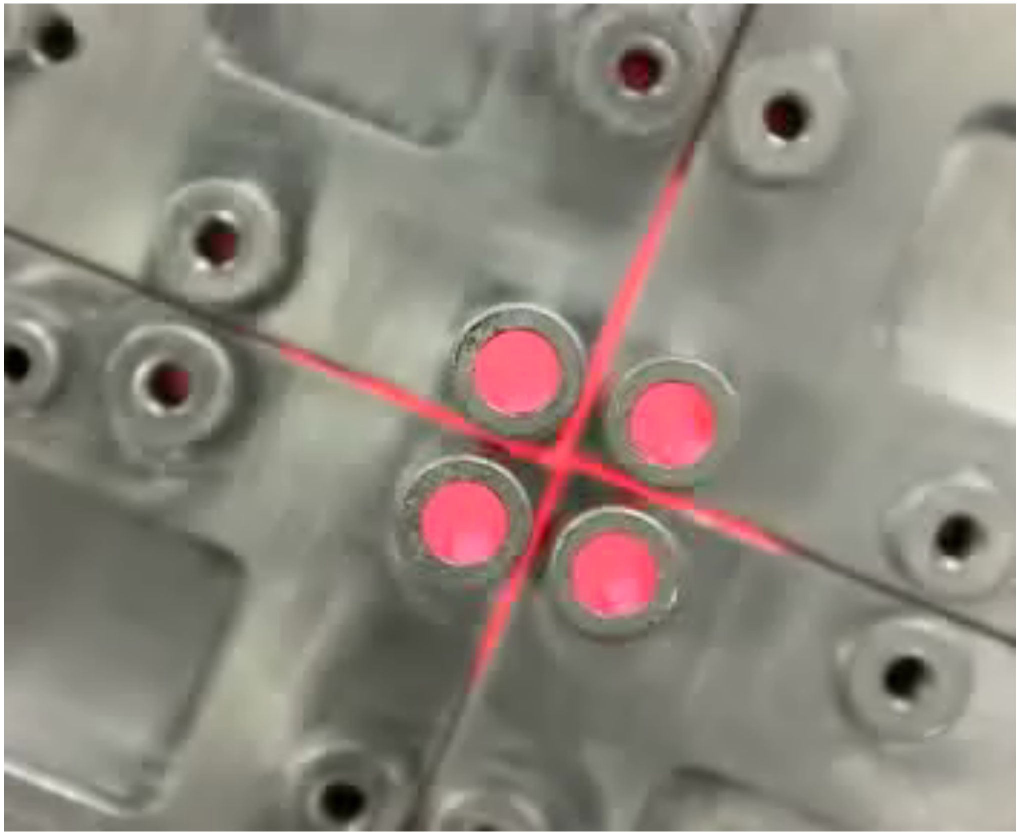
Sufficient ASICs and sensors either on hand or on order

Challenges: bump bonding, assembly, testing, cold straps



CXI Variable Aperture

B. Duda
T. Nieland



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BNL XCS Sensor Concept

BNL:
Pavel Rehak
Gabriella Carini
Wei Chen
Pete Siddons

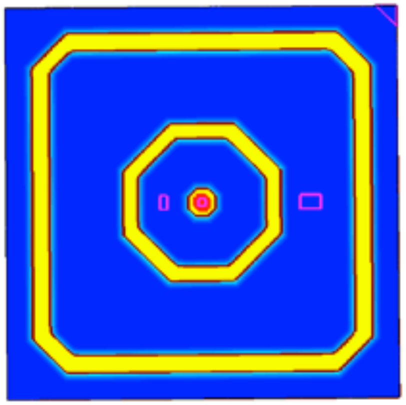
Small pixel (< 60 mm)

Low noise (< 100 electrons)

Modest full well capacity (100 x 8 keV)

Charge pump design is proposed

Central anode surrounded by three rings

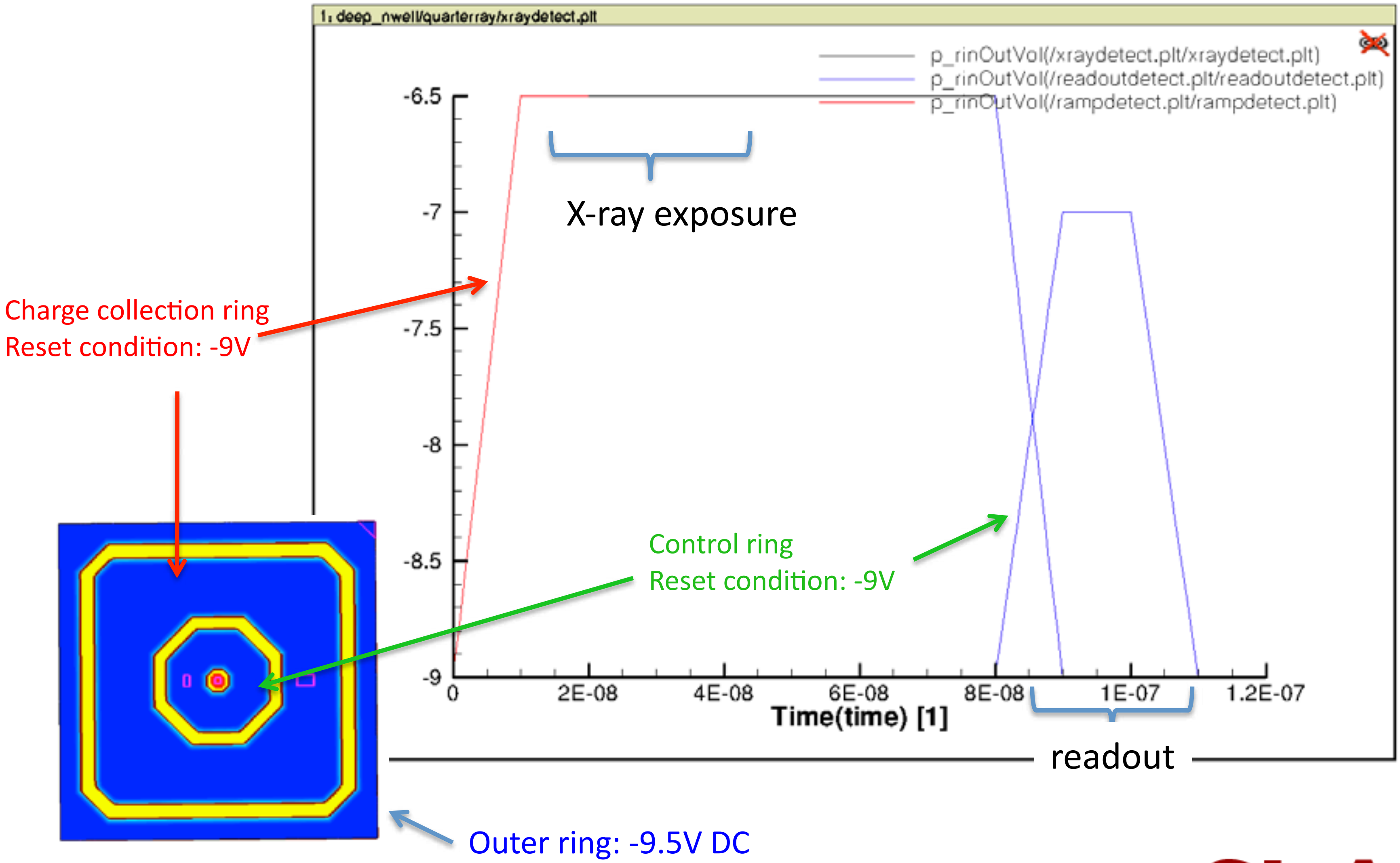


Modulate the potentials on the 4 electrodes so that:

Signal charge is collected on the middle P-ring during the sensing stage

Signal charge is transferred to the anode during the readout stage

Pixel Bias Sequence



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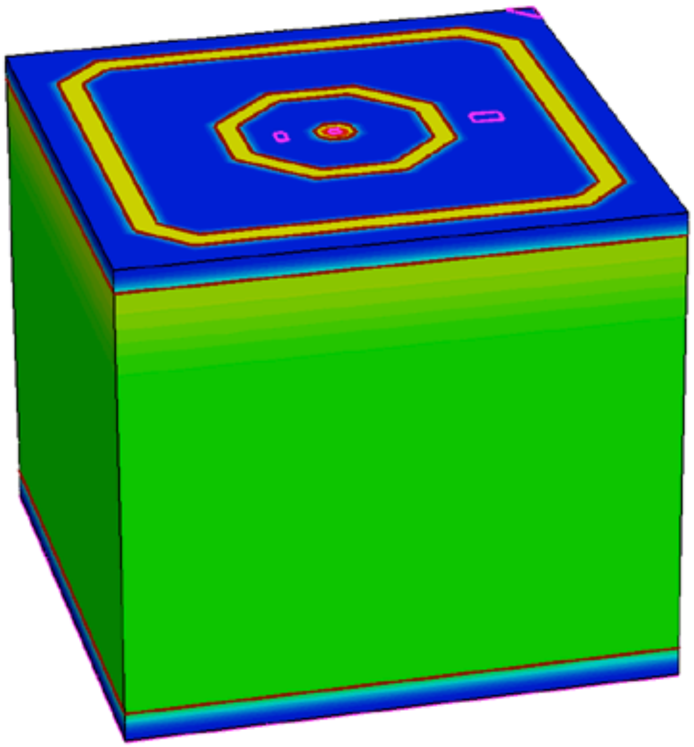
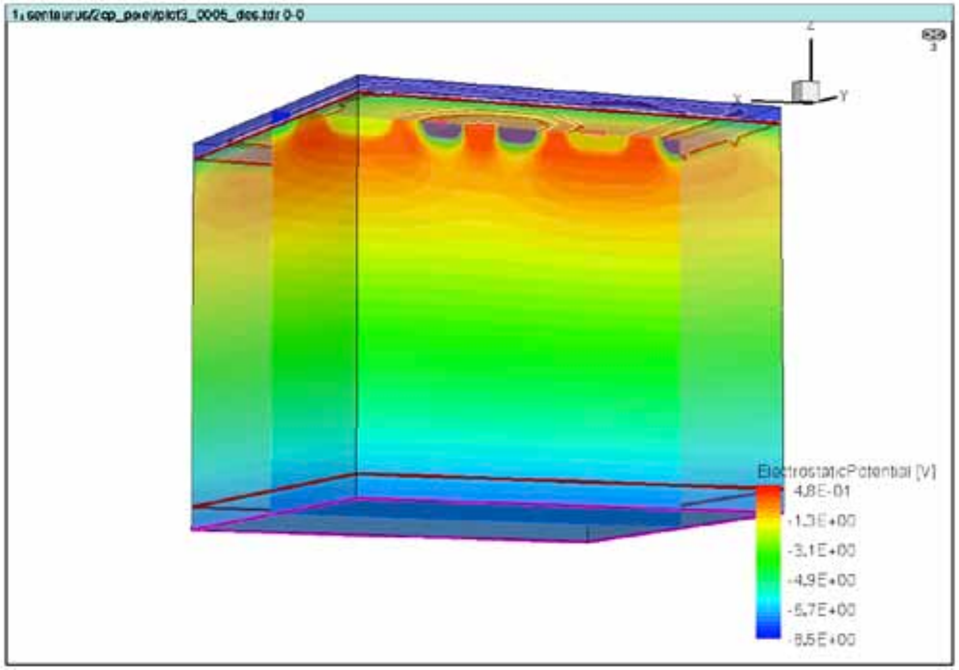
3D Simulations



Julie Segal
Synopsys TCAD



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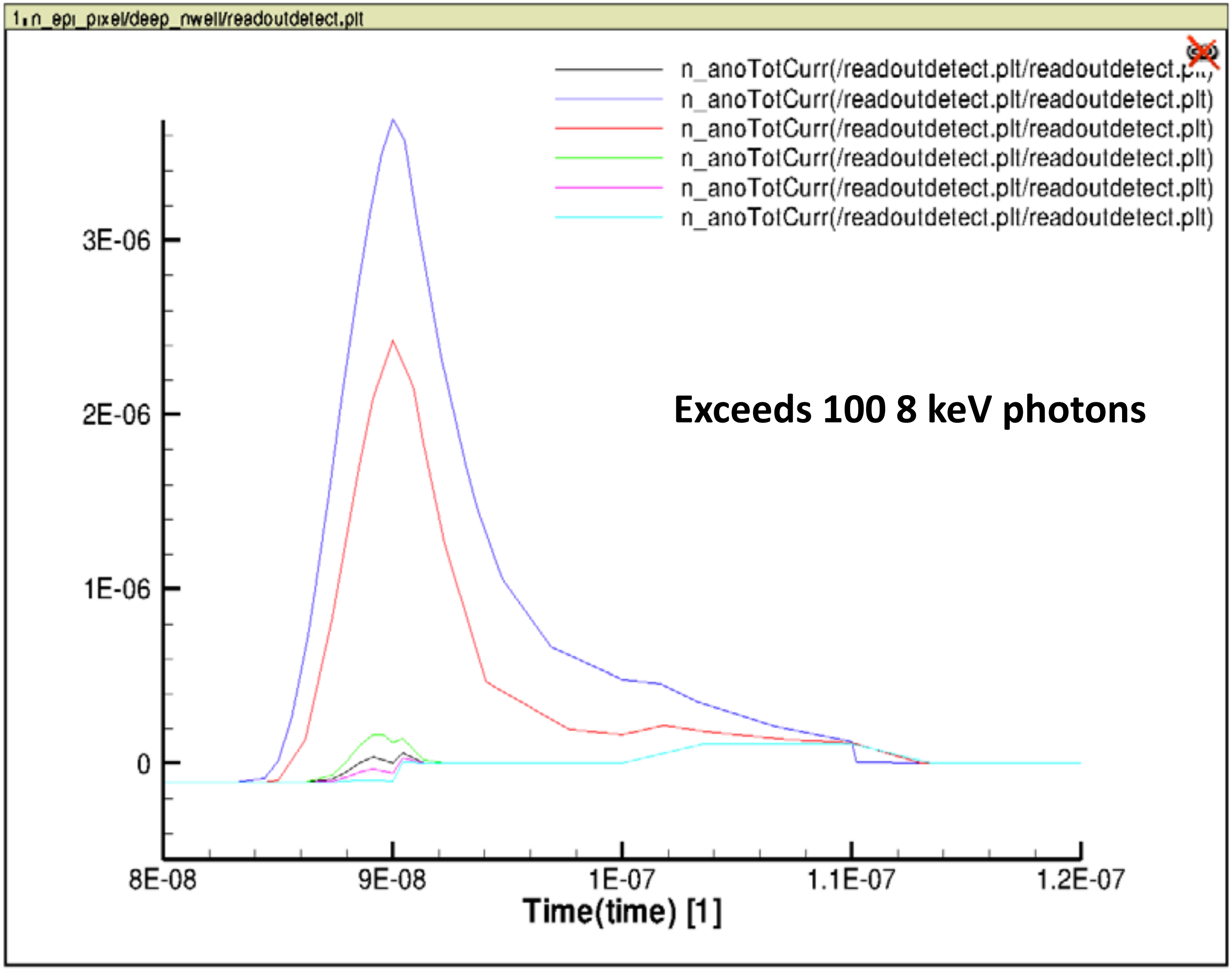
XCS Sensor Full Capacity

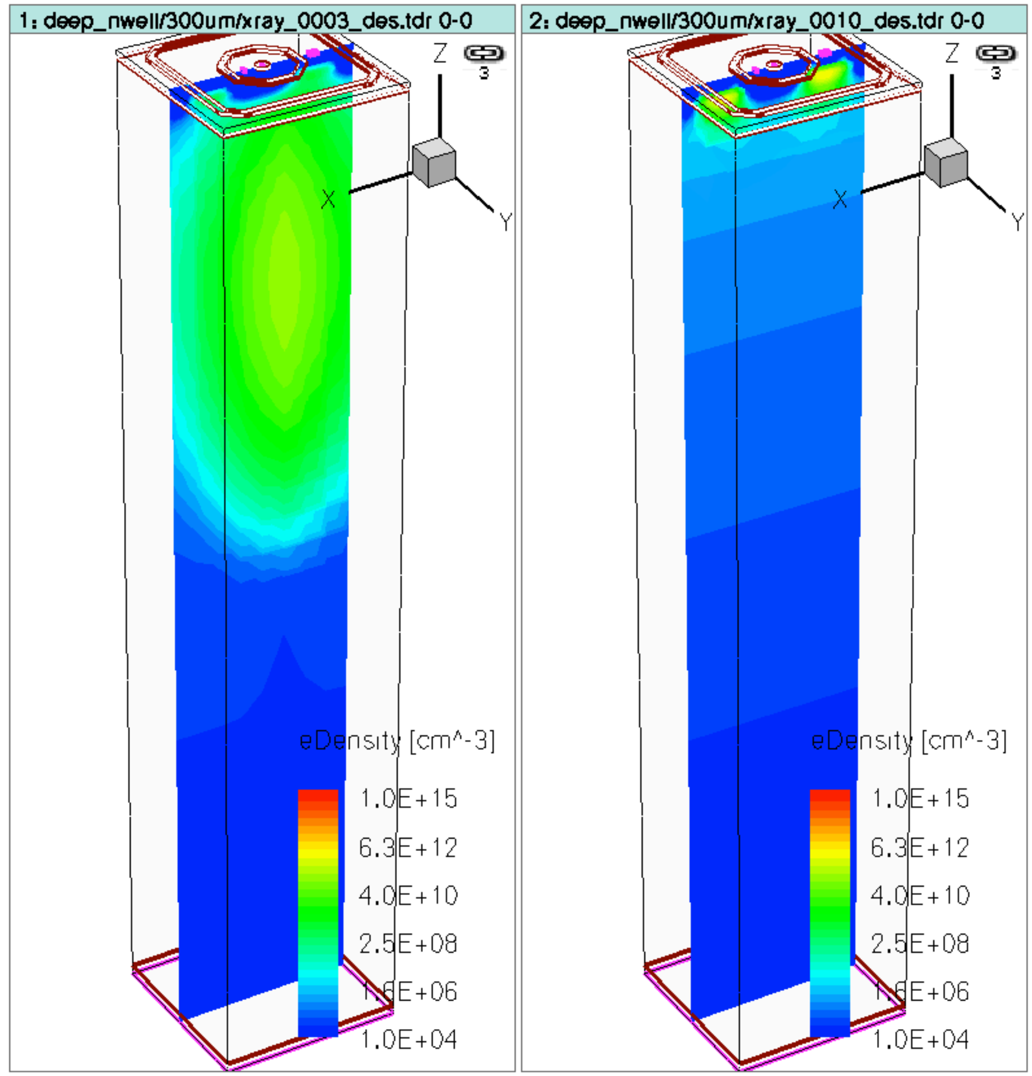


Signal Collection

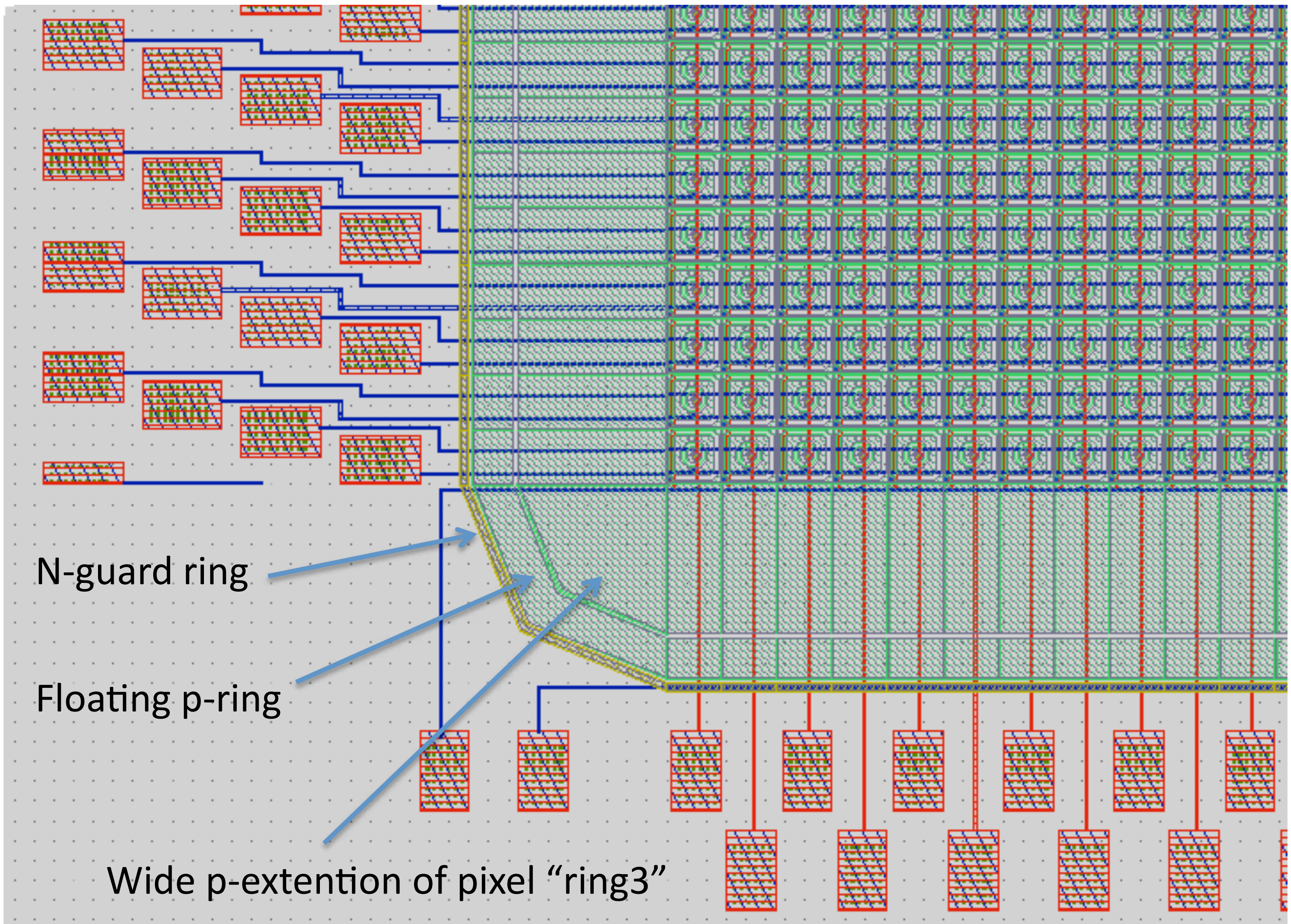
8 keV photon

Charge 5 ns and 50 ns after x-ray absorbed

Electrons are collected under middle P ring



XCS Sensor Layout



ASML Stepper

PAS-5500/60
I Line (365 nm)

Overlay accuracy is 20 nm

Features down to 400 nm

Maintained by ASML engineers on a daily basis

Can program sensor array sizes on the fly – no need to purchase new stepper masks

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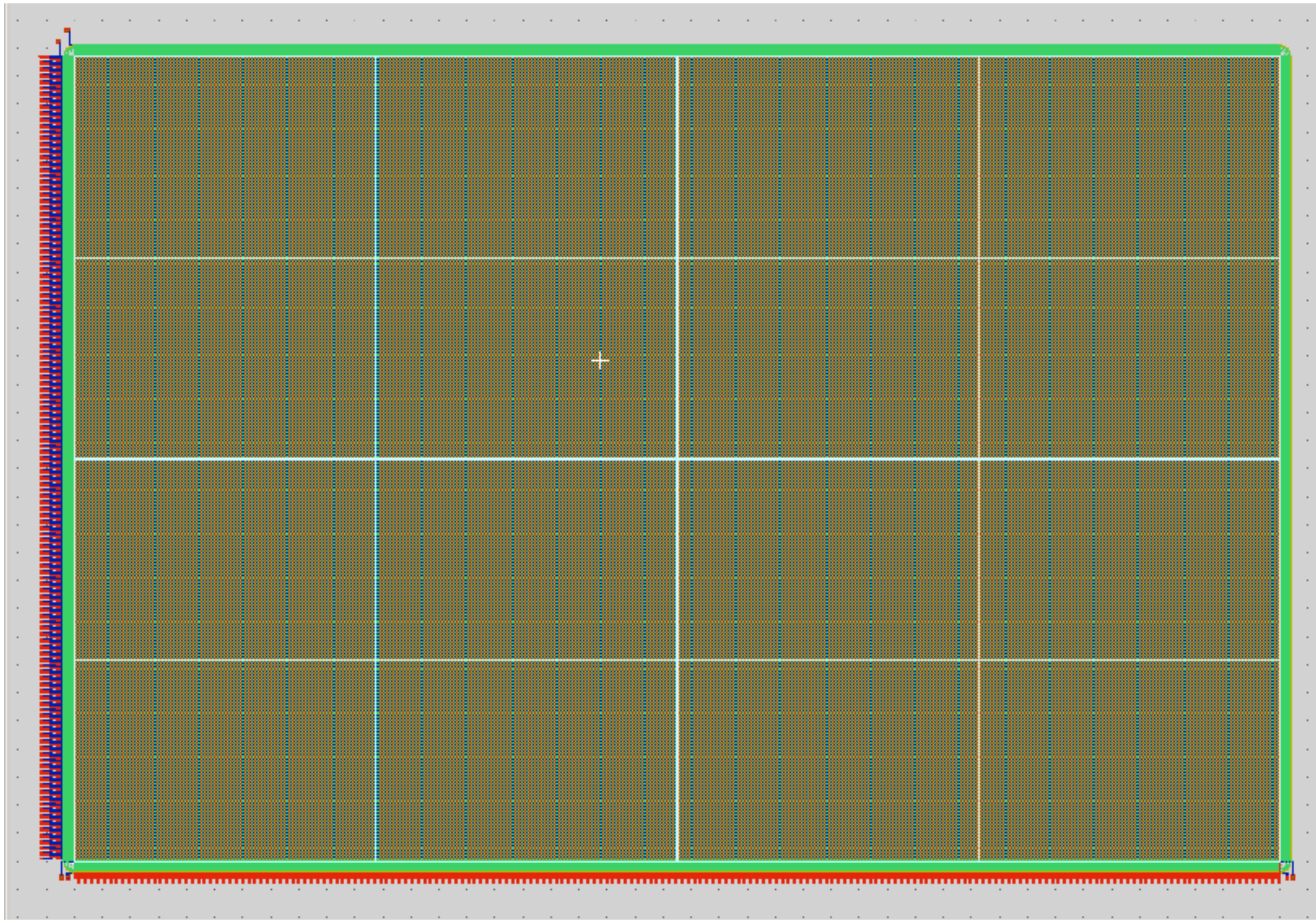
XCS 384 x 256 Sensor



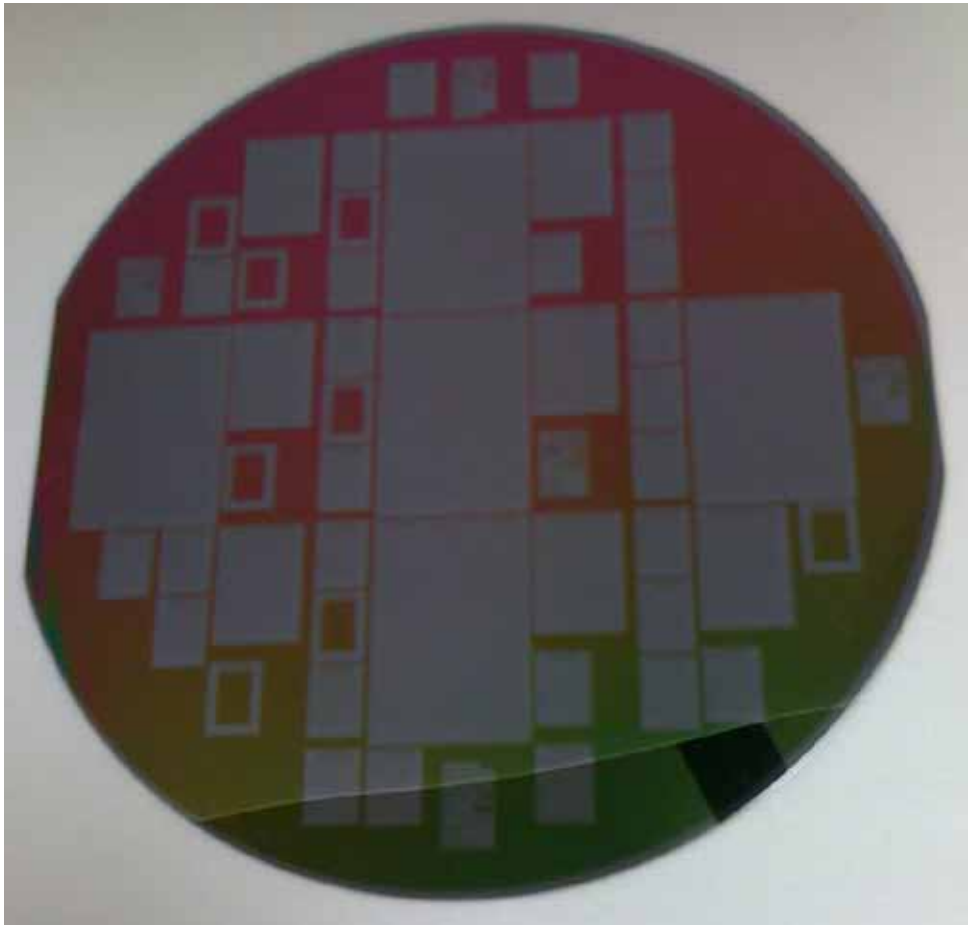
28 Exposures

XCS Manufacture

Full process simulation complete

Wafer fabrication has begun
Ten 300 mm thick wafers
Five 500 mm thick wafers

Mask design finished
Masks in hand



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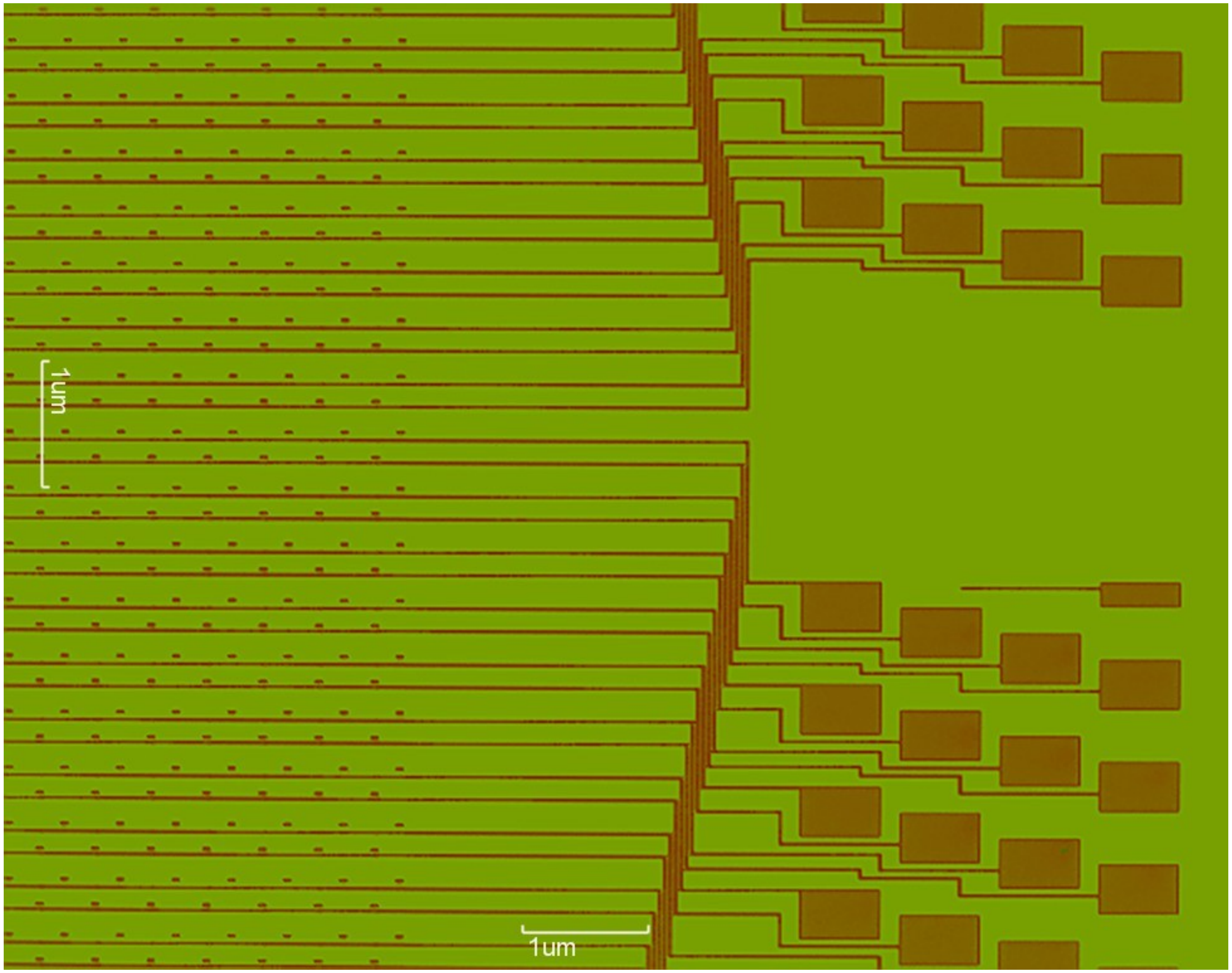
XCS Switcher Pads

Stitched field

2 micron lines

Can you locate the stitching seam?



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XCS Switcher

A. Dragone[1],G. Haller[1], and P. Caragiulo[2]
[1]SLAC National Accelerator Laboratory
[2]DEE Polytechnic Institute of Bari

Monitor for the first and last 4 channels

Output 128 dual channels
56 um pitch

Token bidirectional
(redundant – top and bottom for daisy chain)

Drives the P rings
Swings from -30V to +30V

Supplies (redundant pads)

Control Lines

Technology: TSMC 0.18um HV LDD-MOS

Average Power Consumption with the expected settings ~ 100mW/per chip

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XCS System

Modular

Operate at -40 C

Minimize insensitive gaps

As large an area as possible

Mechanical design in early stages

Expect to operate complete prototype in early 2011

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MEC Hutch

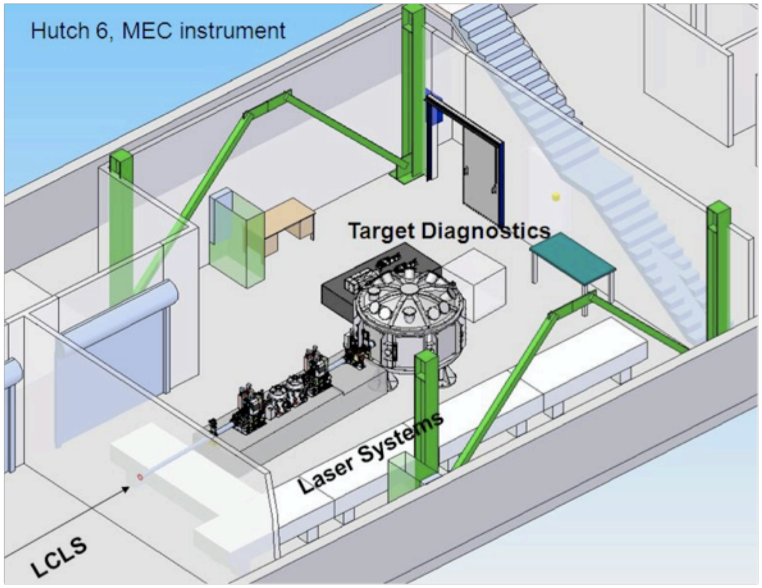
Small camera

Core is CS-PAD

Two 2x2 modules

Thinner aluminum entrance window

Needed late 2011



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FEXAMPS for XCS Beamfinder

Requirements similar to those of the XPP camera:

Large dynamic range ~14 bits

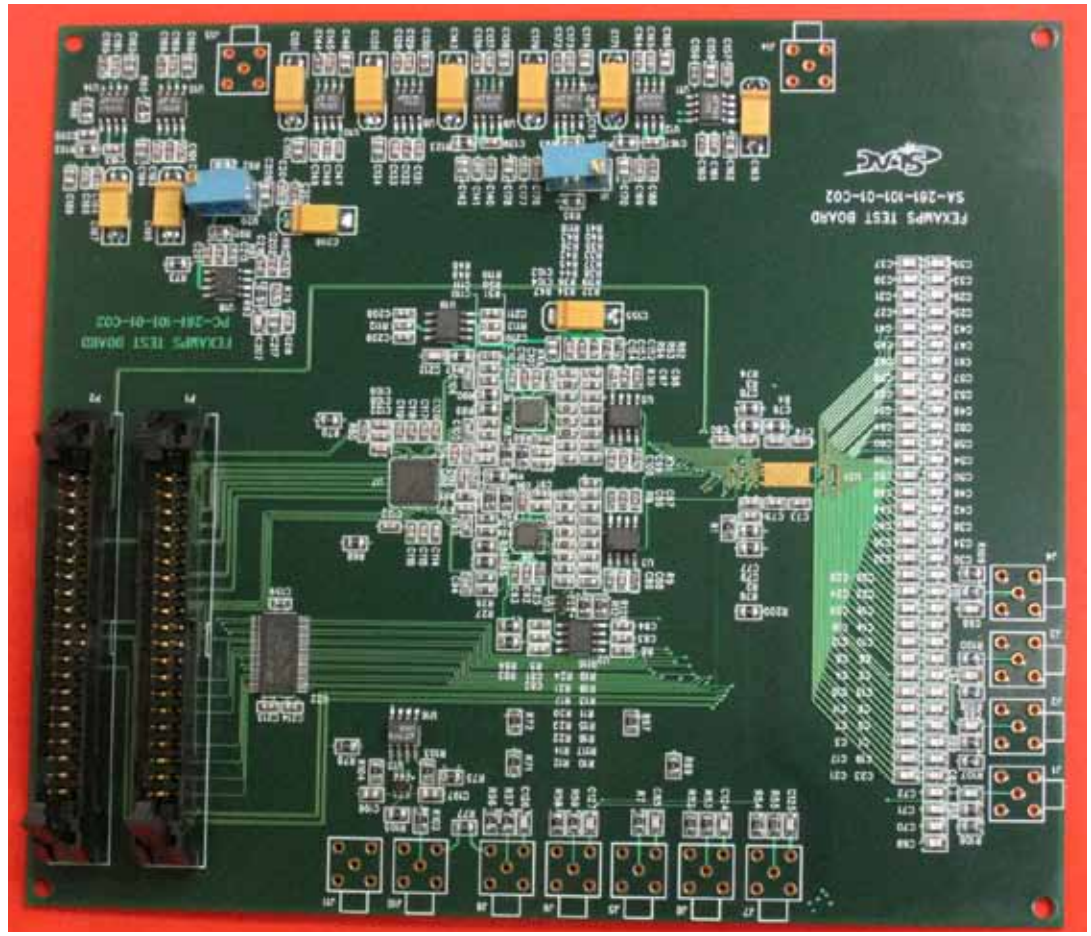
Noise < single photon

Area ~ 1 mm2

Low channel count = strips …

Efficient for 6 – 25 keV photons

Working on new DAQ board



SLAC: A. Dragone
BNL: P. O'Connor

Molecular Biology Consortium:
E. Westbrook and A. Thompson

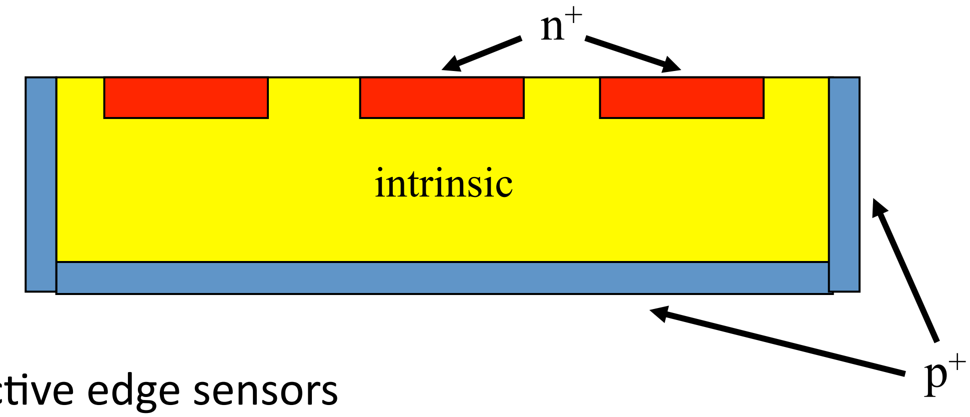
University of Hawaii: S. Parker

LBNL:
E. Mandelli, G. Meddeler, D. Gnani

Stanford University:
N. Jaffari, B. Wooley

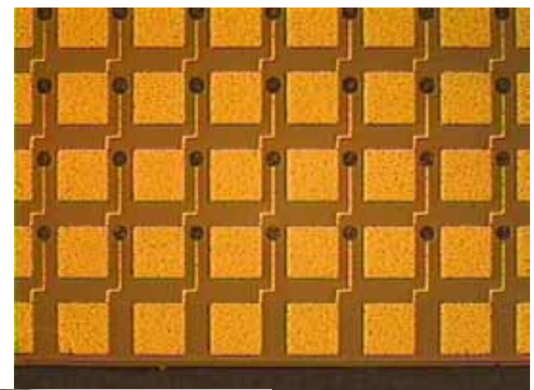
ESRF: J. Morse

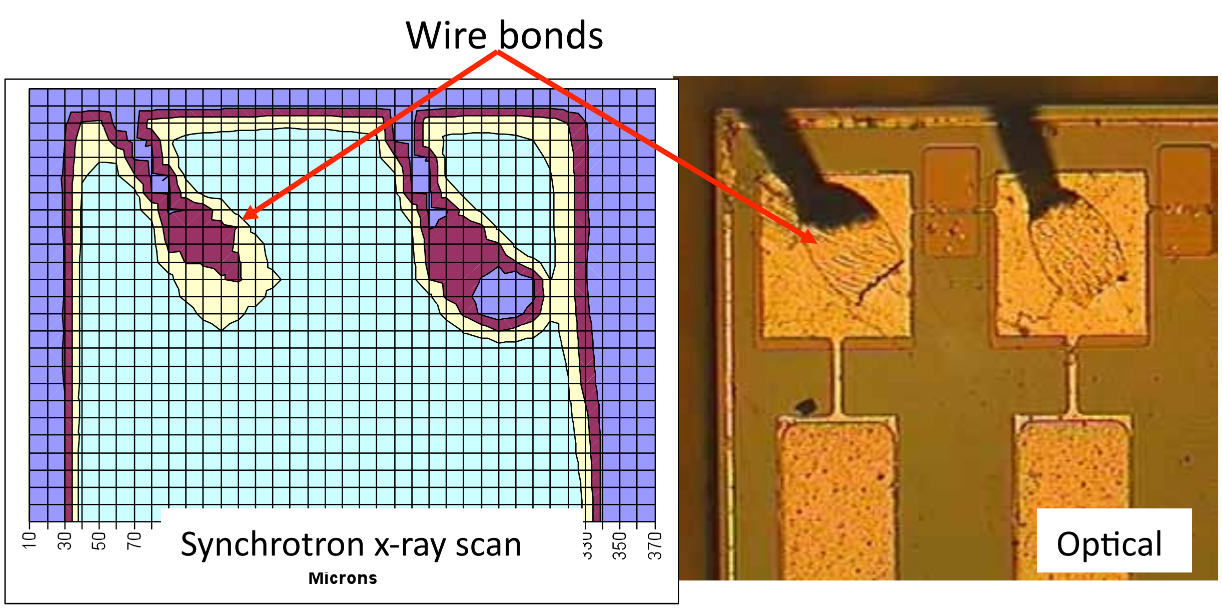
3DX

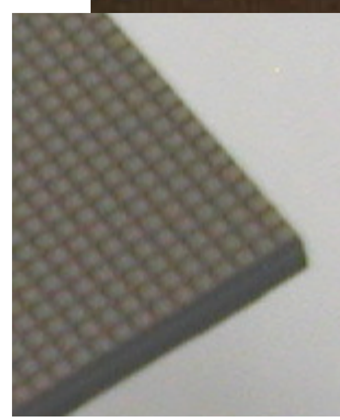


Active edge sensors

150 mm square pixels

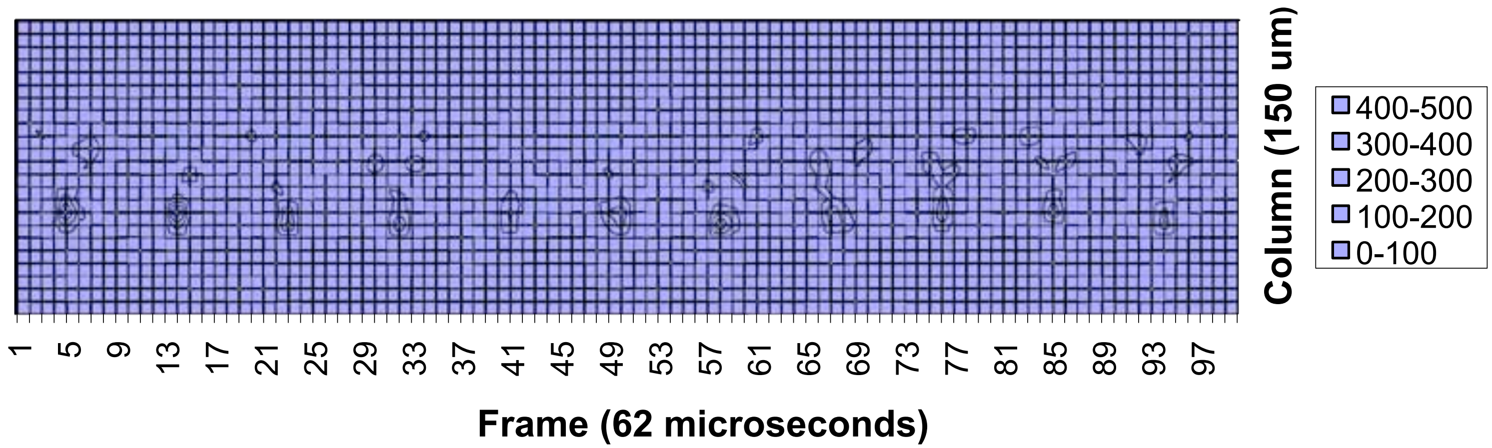






Bump Bonded at Stanford

3DX Timing

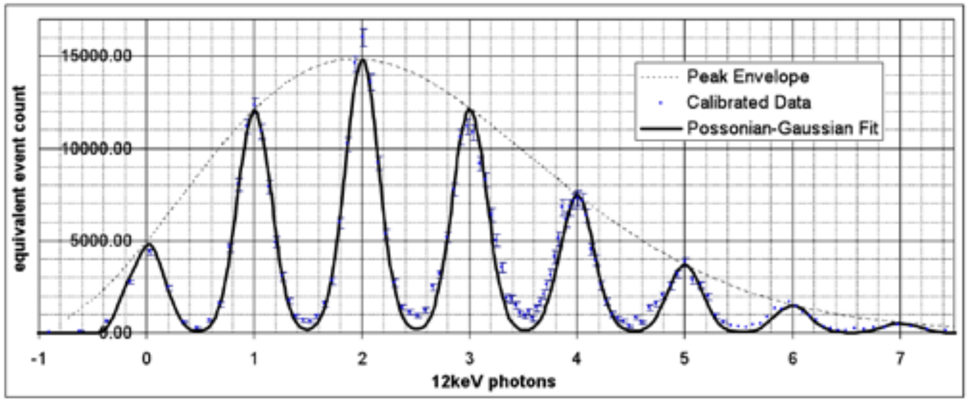


Beam mechanically chopped at 2,000 Hz

16 kHz frame rate

3DX Linearity

Photon Counting

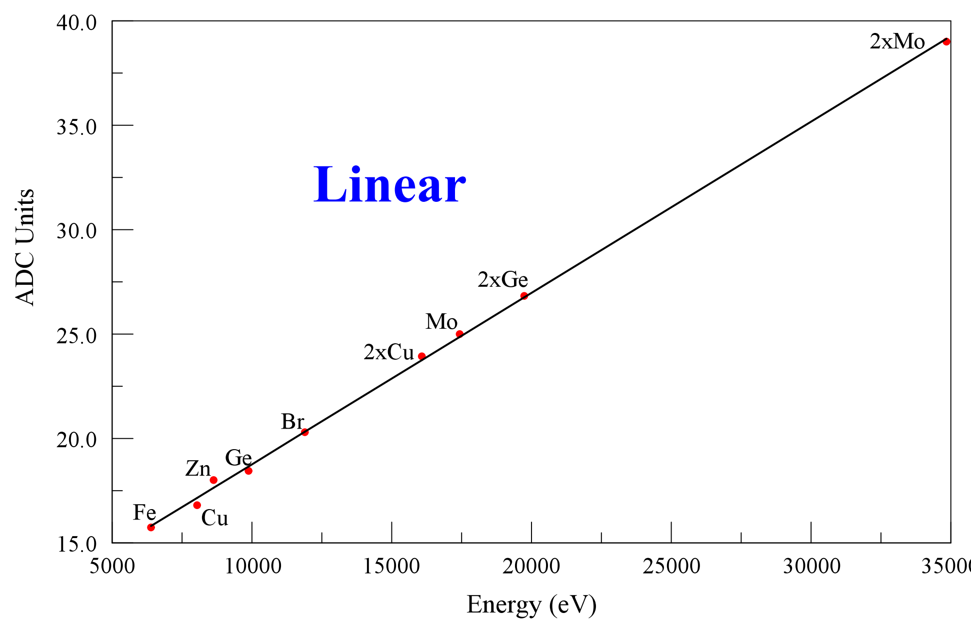


Pixel-level high/low gain bit

Oh-chip frame noise correction circuit

On-chip pedestal trimming

Second generation ready for testing



Summary

- CS-PAD camera #1 successfully operating in LCLS-XPP hutch
- Two more CS-PAD detectors will be made and installed in the LCLS-CXI hutch in early 2011
- Small area CS-PAD system planned for use in the LCLS-MEC
- Developing low-channel-count detectors based on the FEXAMPS chip for XPP and XCS hutches
- BNL detector system to be installed in the LCLS-XPP hutch in early 2011
- Developing and fabricating sensor for the LCLS-XCS hutch based on novel sensor concept proposed by Pavel Rehak of BNL
- Switcher and front-end circuit chips for the XCS sensor have been designed and are in fabrication

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