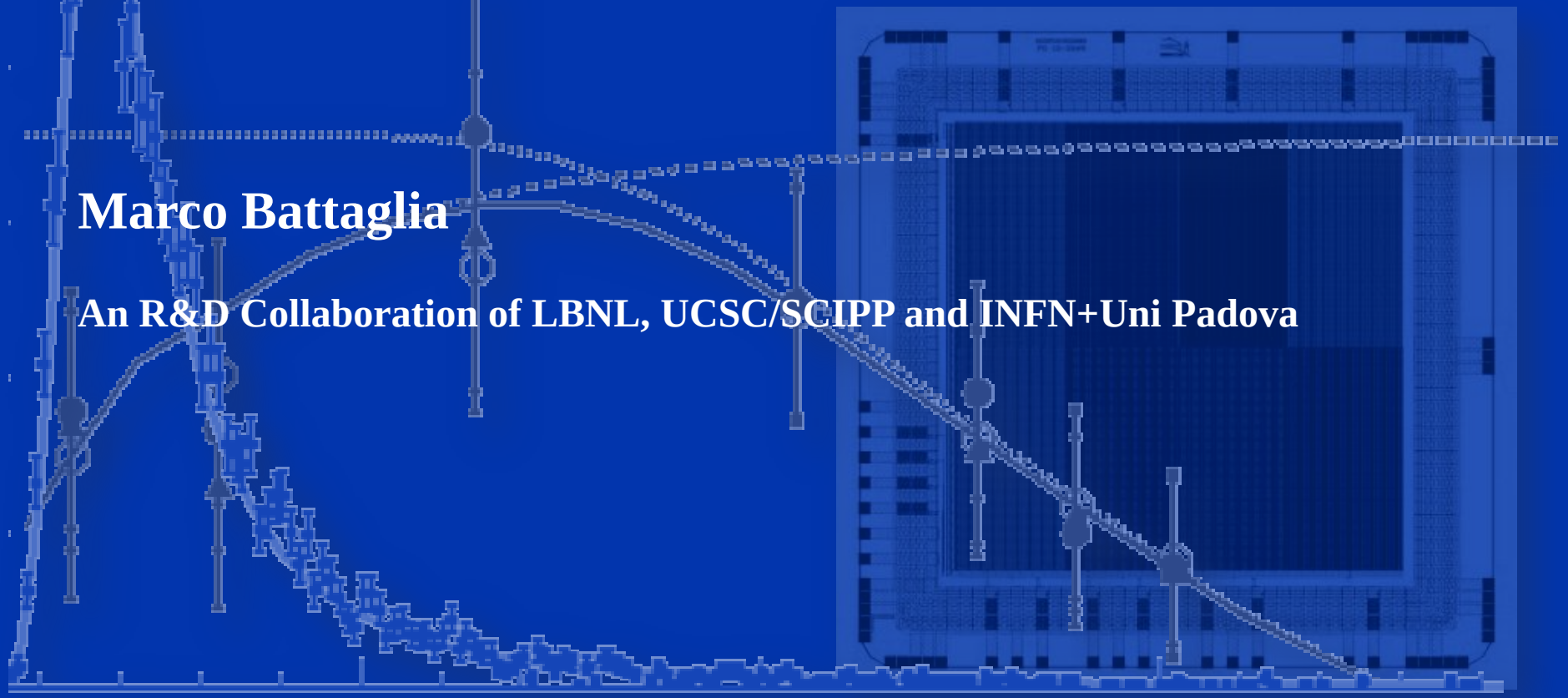
R&D on Detectors for CLIC Beam Monitoring at LBNL and UCSC/SCIPP

Marco Battaglia

An R&D Collaboration of LBNL, UCSC/SCIPP and INFN+Uni Padova



CLIC Collaboration Working Meeting: 2012-2016 Work packages

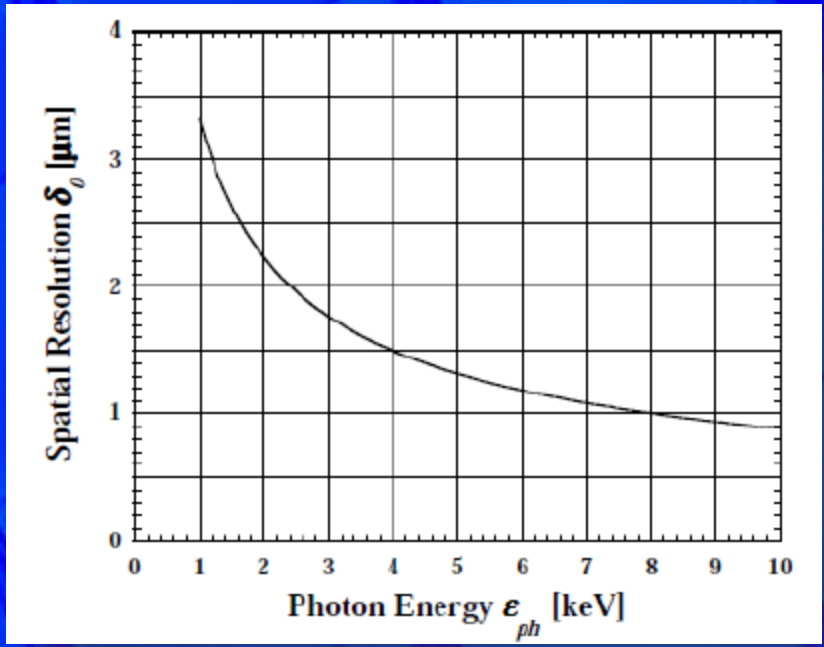
LAWRENCE BERKELEY NATIONAL LABORATORY **November 3, 2011**

Beam monitor system with non-destructive measurements of transverse bunch profile and time structure, down to very small sizes and bunch length essential.

X-ray imaging essential to achieve mm resolution using Diffraction Radiation or optics based on Fresnel Zone Plates

Beam monitoring can be coupled with sensor giving high-frame rate, low point spread function, energy-resolved efficient X-ray detection.

Tests at Spring8 have given proof of concept but showed CCD limitations from slow frame rate (10 f/s) and moderate PSF (4 μm).



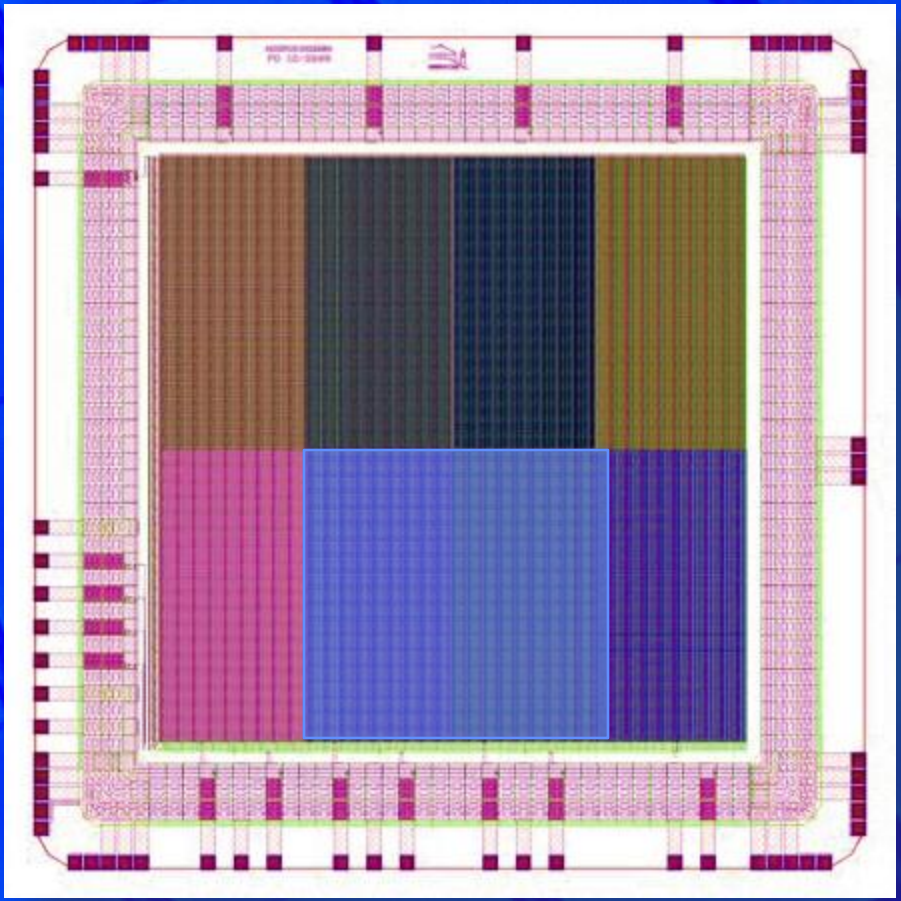
SOI Sensors

R&D on emerging Silicon-On-Insulator technology pioneered at Berkeley in collaboration with KEK, Rohm/OKI Inc, INFN and now SCIPP/UCSC; New sensors tested with m.i.p and X rays

4 parallel output arrays
r/o clock up to 50 MHz;

260μm-thick device from foundry tested with V_d up 70 V in beam test corresponding to depletion of ~110μm (700 Ω–cm);

Tested with 200 GeV pion beam at CERN SPS in Sep. 2010: <S/N>=52;
m.i.p. hit efficiency > 0.99;
$\sigma_{point} = (1.12 \pm 0.03)\mu m$



MB et al.
NIM A654 (2011)

Chip back-processing

Tests on chip thinning and back-processing for:

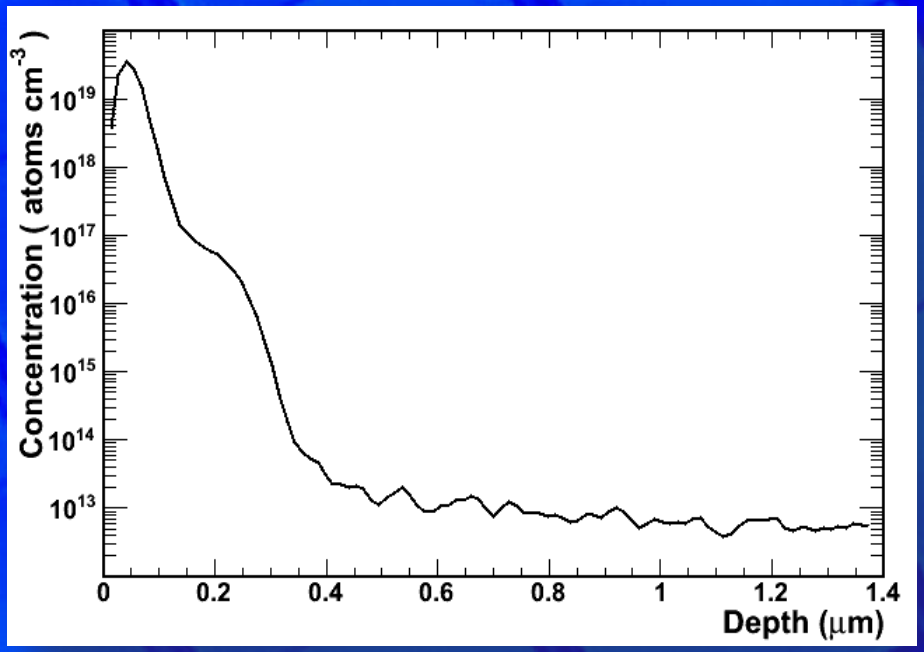
- fully depleted sensor;
- sensor with thin entrance window for low-energy X-ray and e^- imaging;
- thin sensors for low-material tracking and vertexing in accelerator HEP

Sensor thinned to 70μm using grinding at Aptek Inc.
Back-plane post-processing to create thin entrance window and anneal crystal damage at LBNL:

Thin phosphor layer implant at 33keV using cold process at -130 C;

After implant, chip annealing at 500 C in nitrogen atmosphere;

Spread Resistance Analysis of chip:
P layer extends to depth of 0.4μm with highest concentration within 0.2μm:

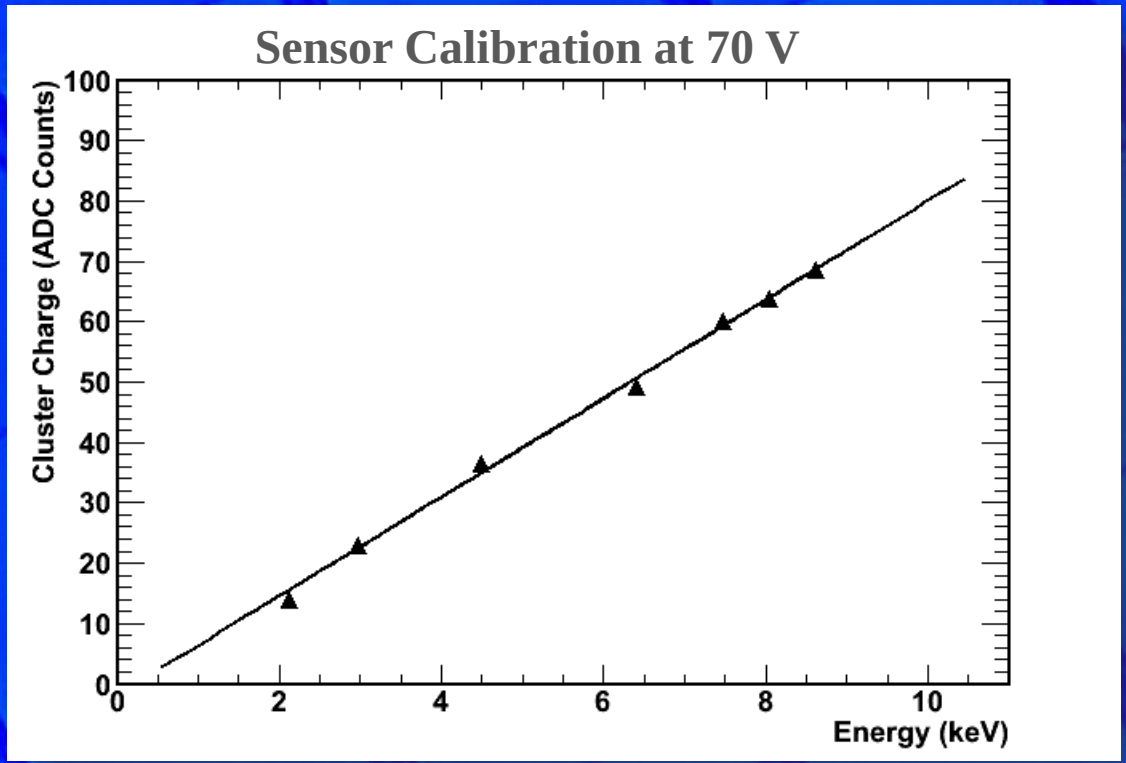


X-ray Tests

Test at LBNL ALS 5.3.1 beamline with 12 keV X-ray beam on metal foil;

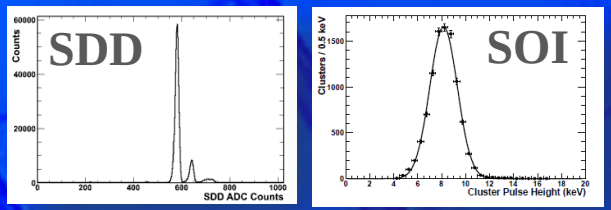
Detect XRF on back-illuminated thin SOI and monitor flux and energy with SDD sensor.

Element	E (keV)
Au	2.12
Ag	2.98
Ti	4.50
Fe	6.40
Ni	7.47
Cu	8.05
Zn	8.60

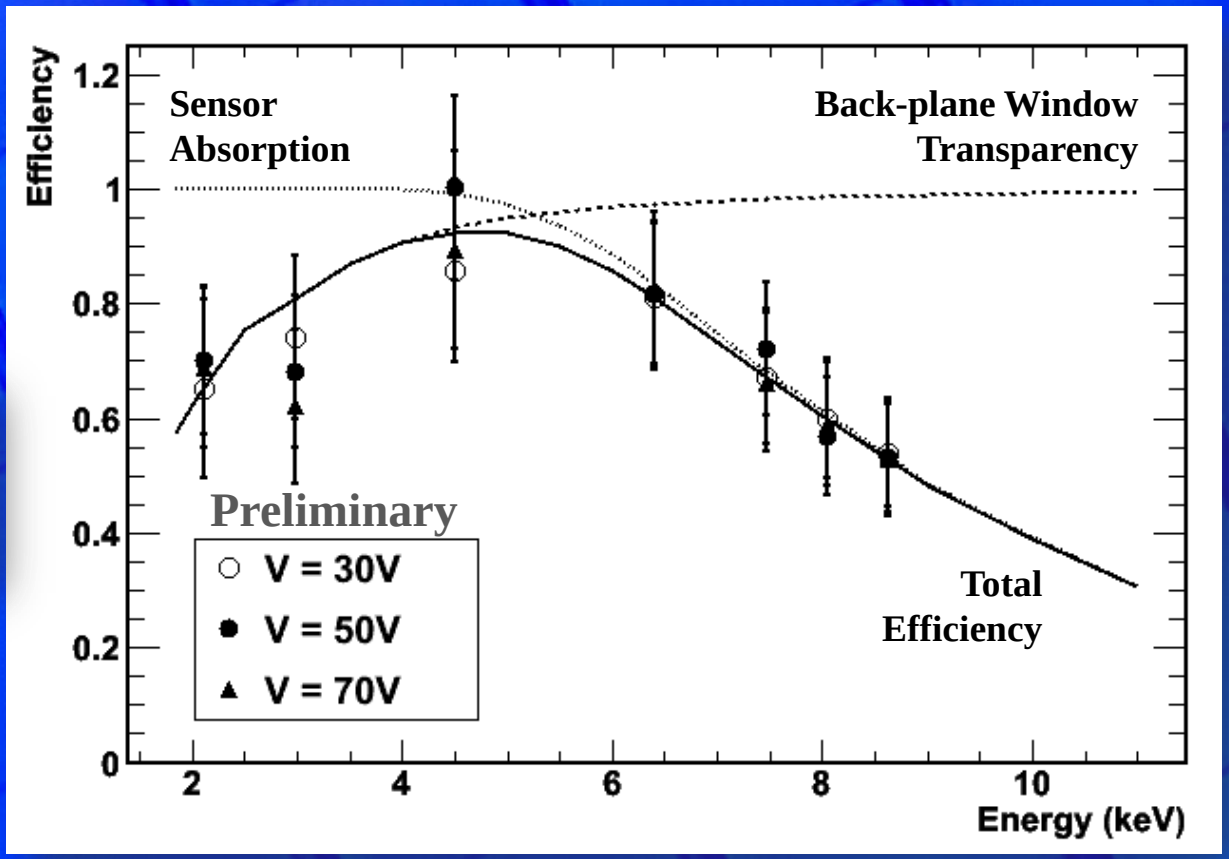


X-ray Tests: Quantum Eff. vs. En.

Extract efficiency from recorded rates for various foils normalised to rate on SDD spectrometer;



Uncertainties on geometry accounted as (correlated) systematics:



Extract equivalent thickness of backplane entrance window by 1-par χ^2 fit to measured efficiency curve: $(0.6 \pm 0.2)\mu m$ of equivalent Si thickness, in agreement with result of SRA analysis.

MB et al.
IEEE-NSS 2011

Successful thinning and back-plane post-processing of prototype SOI sensor;

Full charge collection in fully depleted sensor, comparable pixel noise;

Quantum efficiency for X-rays exceeds 0.60 for $2 < E < 8$ keV;

Entrance window with ~0.5mm equivalent Si inactive thickness;

Availability of thin pixellated sensor with thin entrance window opens broad field of imaging applications;

Committed to pursue application to X-ray diffraction radiation and syncrotron radiation imaging system for CLIC.

UC SANTA CRUZ

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Proposed next steps for CLIC Work Package

2012

New SOI chip with 5 x 8 mm^2 active surface designed and submitted;

Molecular Beam Epitaxy equipment being installed at LBNL for sensor back-plane δ doping;

Prototype for tests with X-rays and UV at LBNL ALS;

Proposed contribution to design, simulation, optimisation and mechanics;

Participate to tests with CERN and Cornell groups at CESR-TA (UV, optical) δ doping tests of SOI sensors

2013-2014

Design and manufacture reticle size SOI sensor (sensor stitching if needed);

Upgrade r/o electronics for larger sensor and test at SCIPP/UCSC

Develop mechanics at LBNL, integration at CERN

Tests at CESR-TA