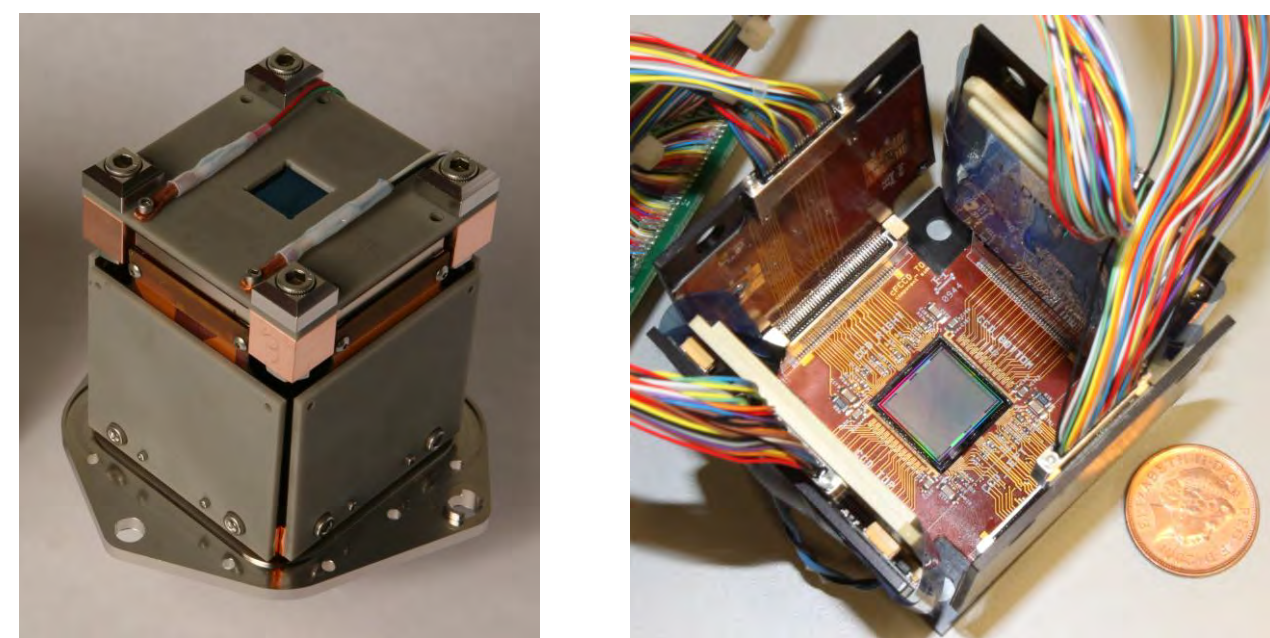


# Detector R&D at LBNL

P. Denes, N. Andresen, D. Contarato, D. Doering, D. Gnani, C. Grace, B. Krieger, J. Joseph, H. von der Lippe, P. McVittie, H. Padmore, C. Tindall, JP Walder, B. Zheng

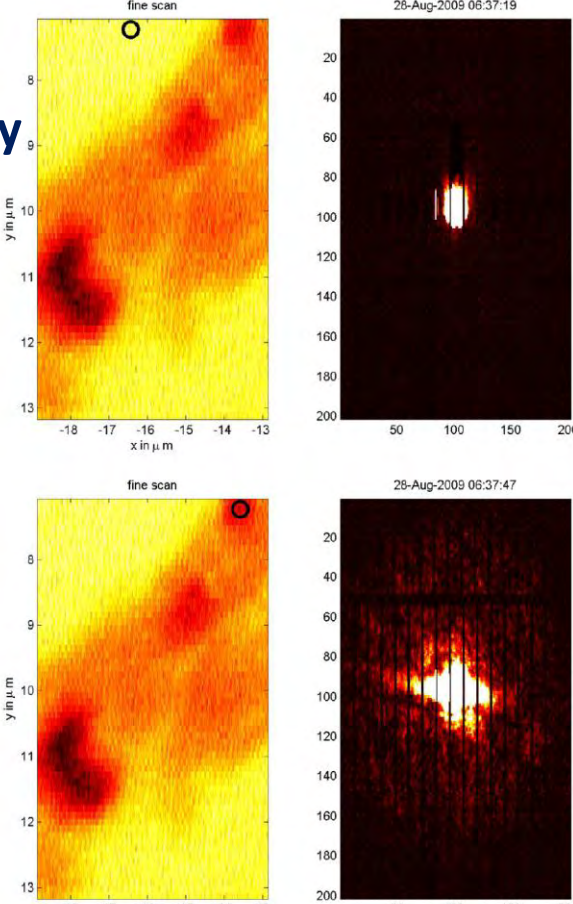
## Fast CCD



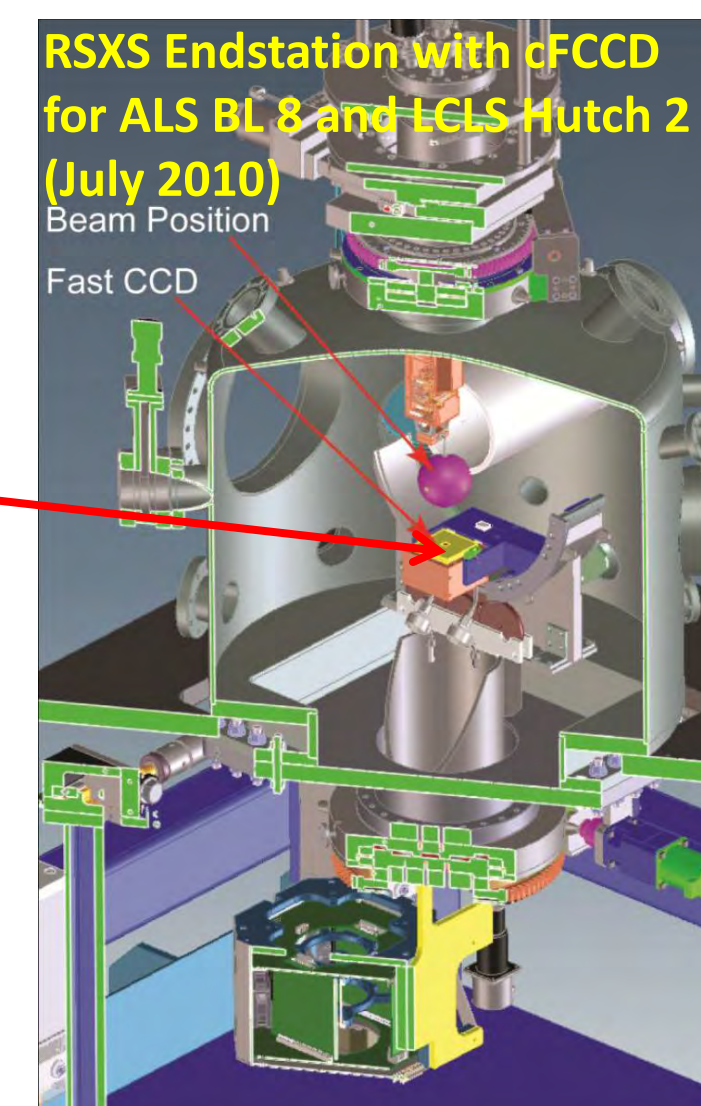
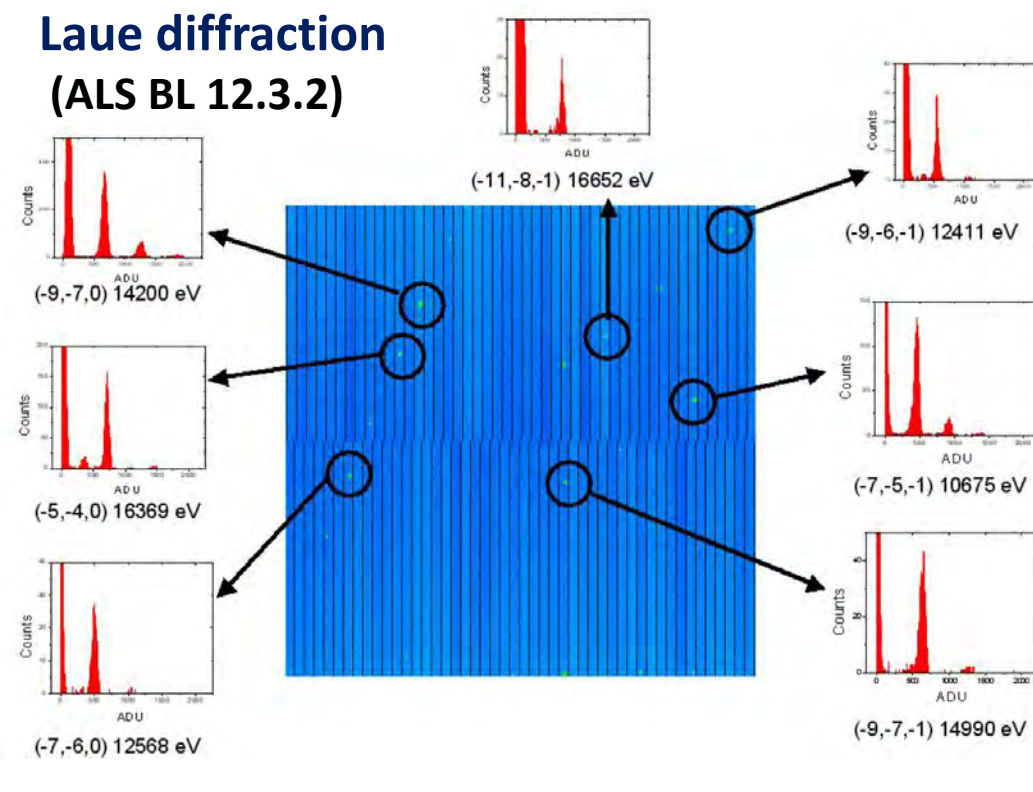
- Direct detection
- Fully-depleted, back-illuminated CCD
- 200  $\mu\text{m}$  thick, 480 $\times$ 480 pixels, 30 $\times$ 30  $\mu\text{m}^2$
- 96 outputs, (almost) column parallel
- 200 frame/s readout rate
- Custom 0.25  $\mu\text{m}$  CMOS readout ASIC
- Developed in collaboration with ANL/APS
- Performance:

- 15-bit dynamic range
- 250-300 eV FWHM
- PSF < 1 pixel
- Several uses at Advanced Light Source beamlines:
  - ✓ Microdiffraction
  - ✓ Ptychography / STXM
  - ✓ Resonant Soft X-ray Scattering
  - ✓ Tomography
  - ✓ High-pressure

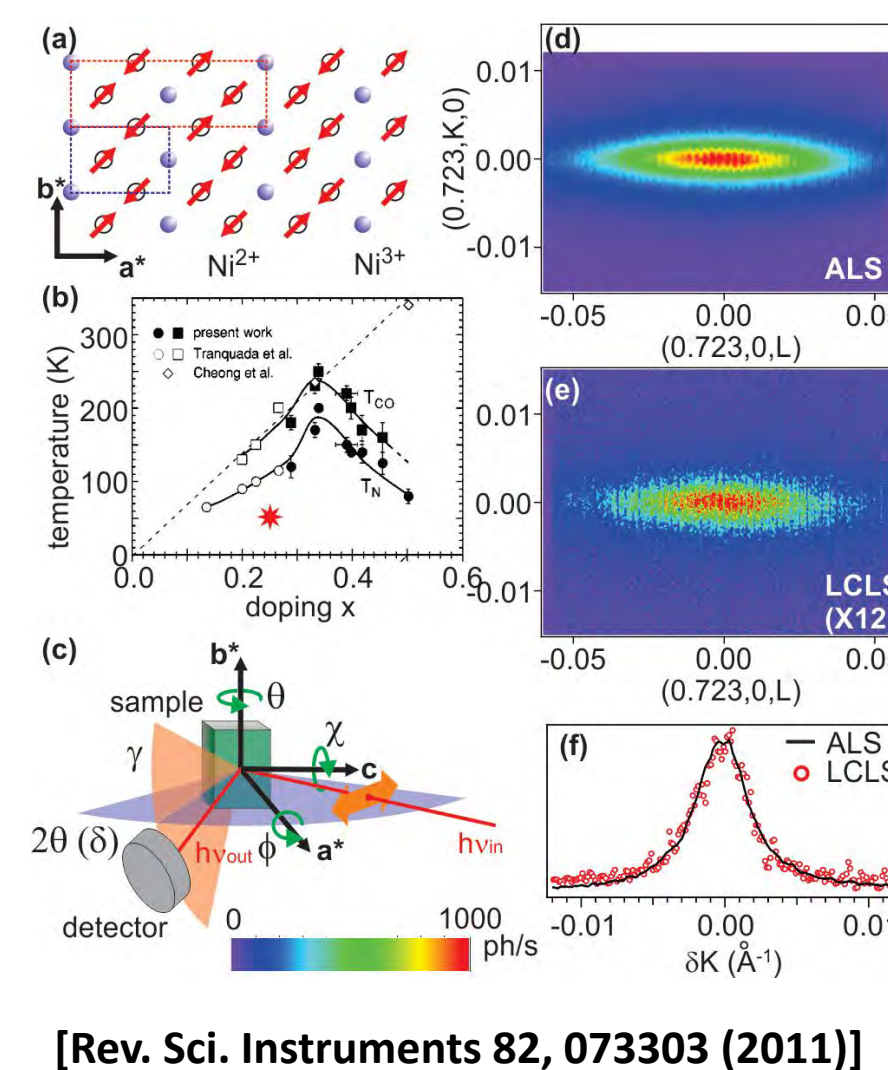
Soft X-ray Ptychography (ALS BL 9.0.3)



Fast, energy resolved Laue diffraction (ALS BL 12.3.2)

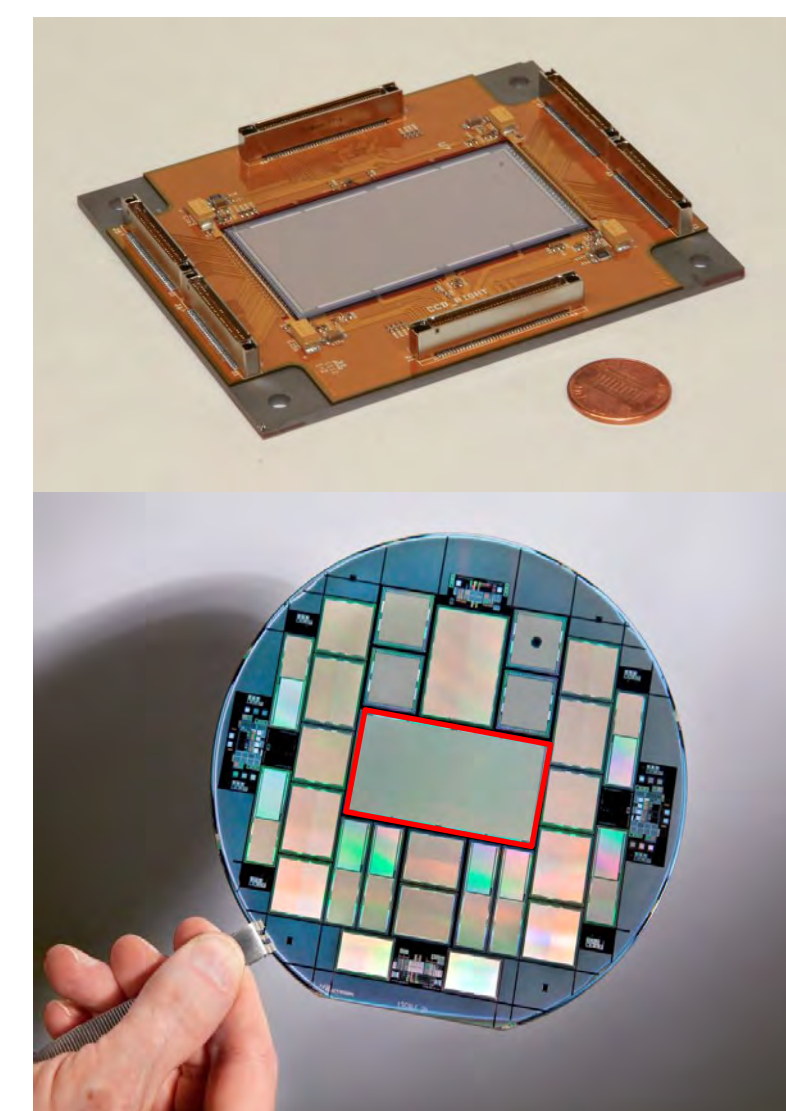


RSXS Endstation with a Fast CCD for ALS BL 8 and LCLS Hutch 2 (July 2010) Beam Position Fast CCD

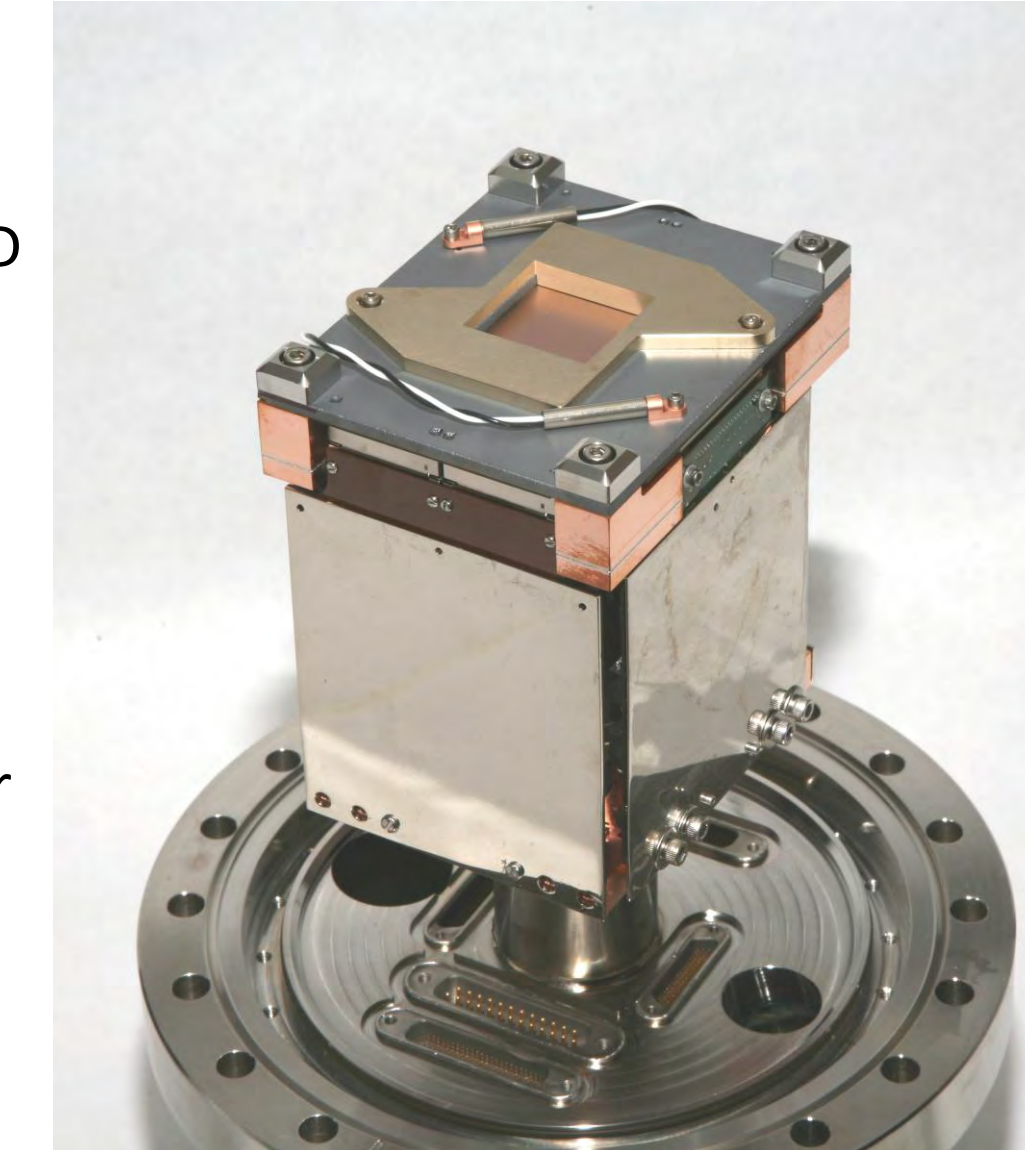


[Rev. Sci. Instruments 82, 073303 (2011)]

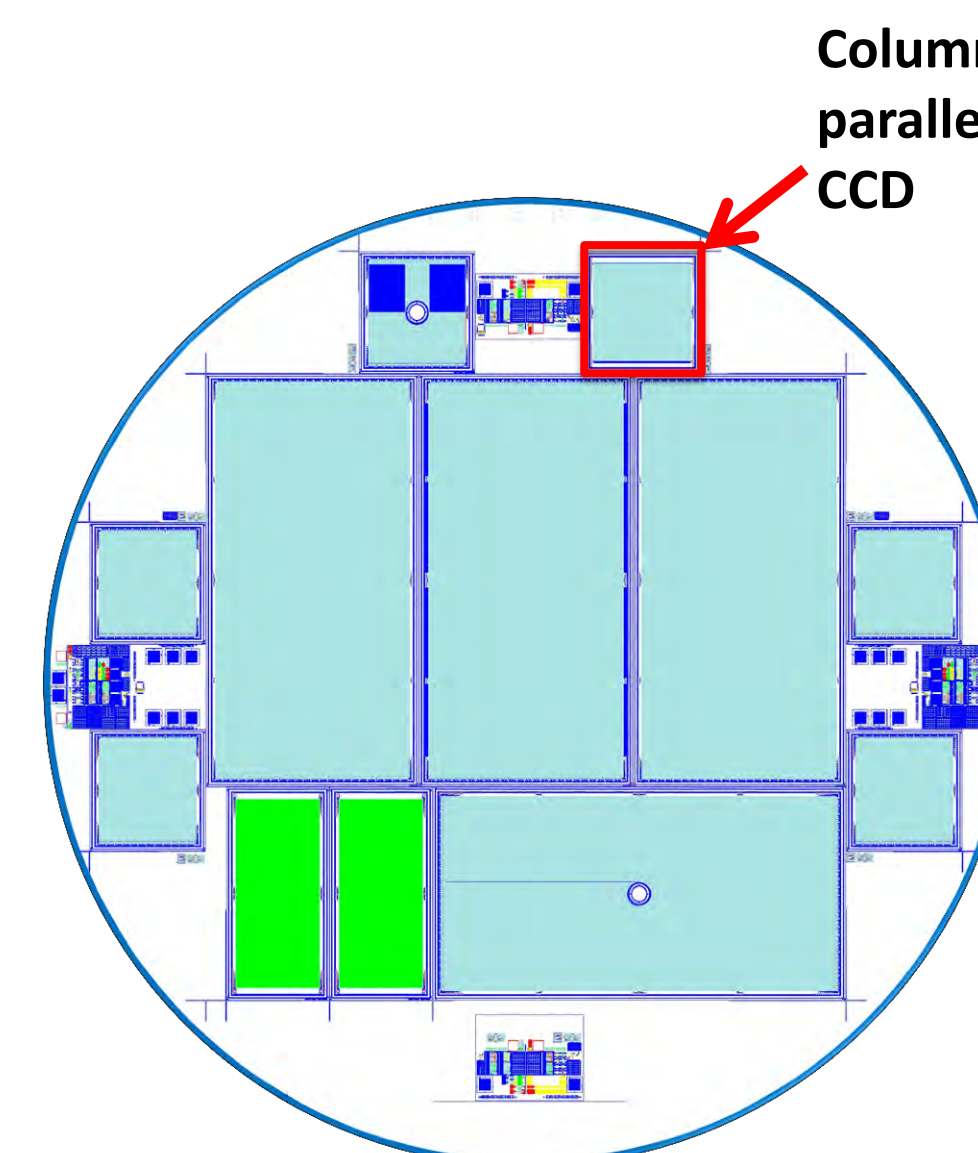
## 1k Frame Store CCD



- 1920 $\times$ 960 pixels, two operation modes:
  - 2k  $\times$  1k, 100 frame/s direct detection CCD
  - 1k  $\times$  1k, 200 frame/s CCD with electronic shutter (Frame Store CCD)
- 192 outputs
- 200 frame/s
- Speed-enhancing buffer ASIC
- Full detector systems being developed under Recovery Act funding, to be delivered to ALS and APS in late 2011

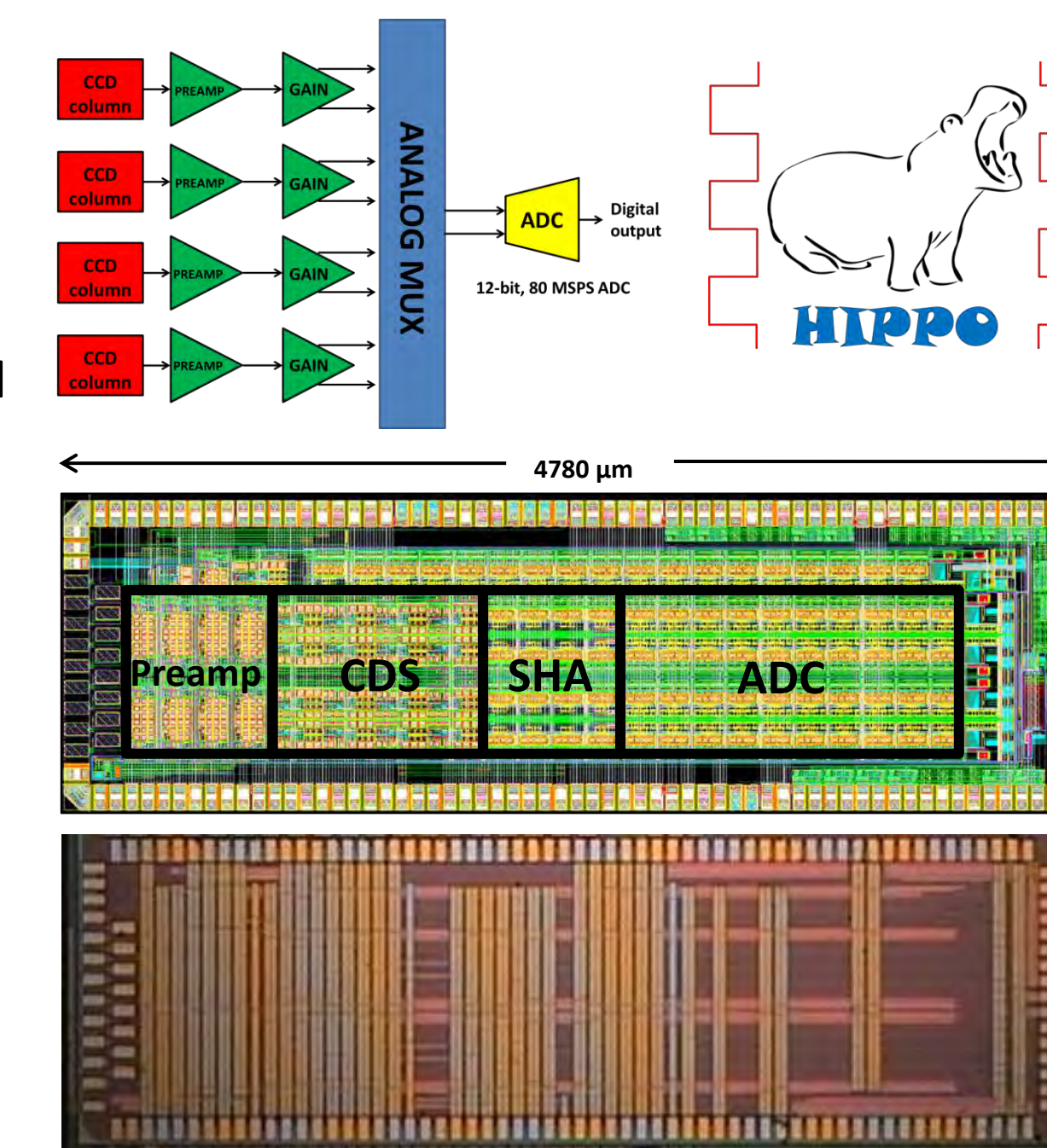


## Very Fast Column Parallel CCD

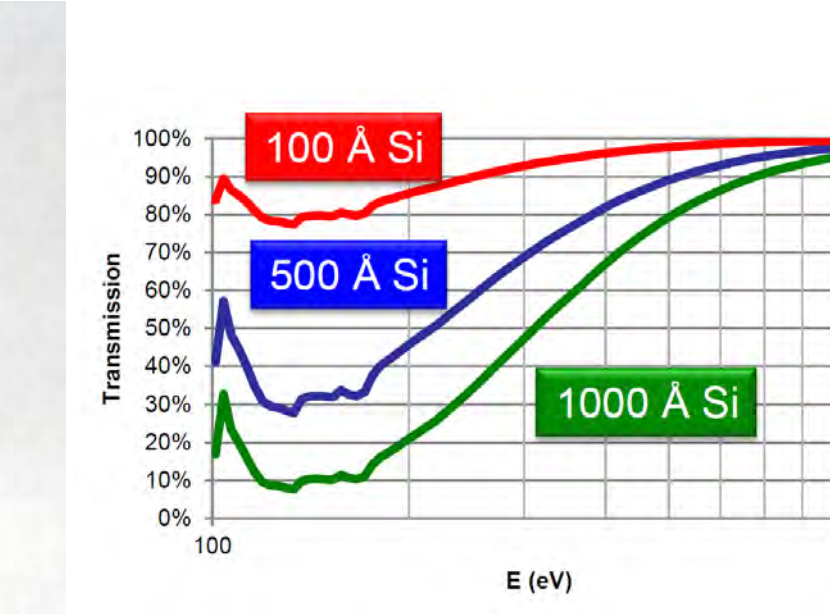


Column parallel CCD

- Prototype CCD with fully column-parallel readout in production
- 288 $\times$ 288 pixels, 50  $\mu\text{m}$  pitch
- **HIPPO: custom multi-channel readout ASIC in 65 nm CMOS technology:**
  - 80 MHz, 12-bit ADC on 50  $\mu\text{m}$  pitch
  - Multiplex 4 inputs
  - Frame rate up to 10,000 Megapixels/s
  - R&D on high data rates
  - Compression algorithms



## Thin window R&D

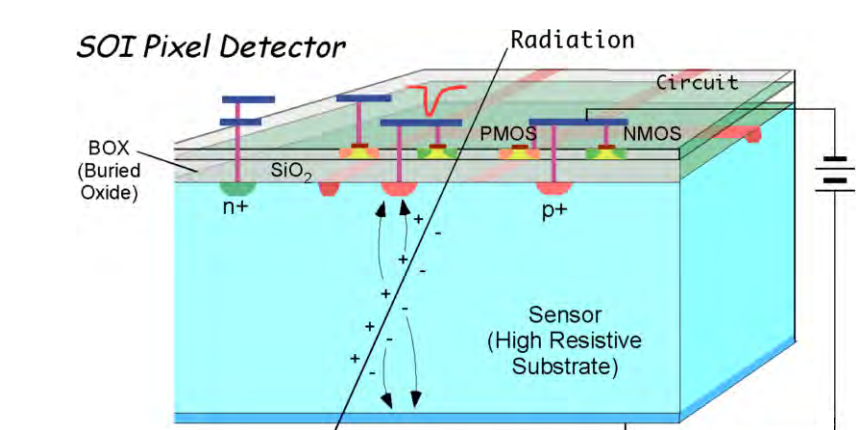


- R&D on low temperature (< 500°C) processes to avoid damage to sensor metallization
- Need 100 Å window thickness for O(100 eV) X-ray sensitivity
- Several processes under test, including in-house developments (cold implantation, a-Si)

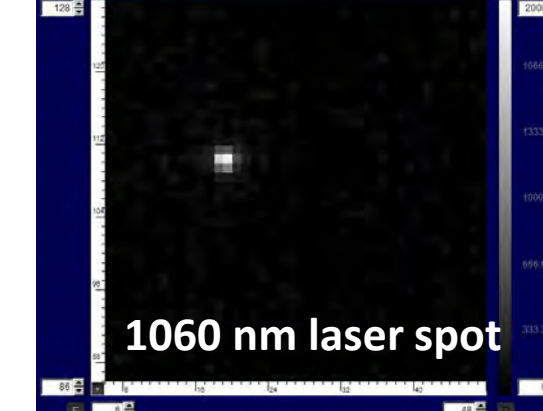
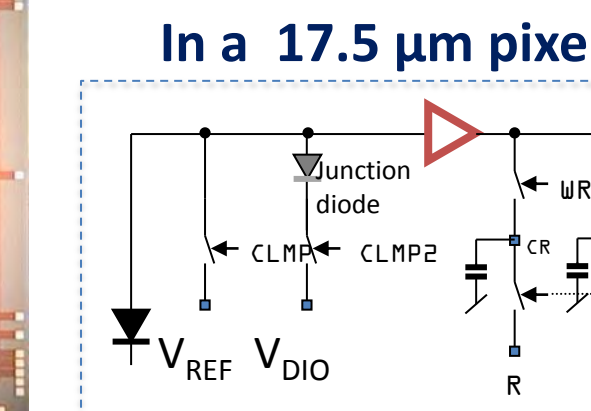
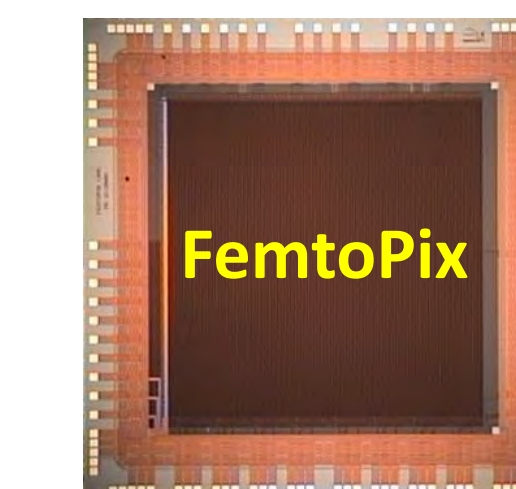
Process	Window thickness	Status
Low energy implantation + 500°C annealing	1000-2000 Å	Process dependent, several SOI prototypes functional
Low energy implantation + laser annealing	400-700 Å	Several SOI prototypes functional
a-Si contact deposition by sputtering	300 Å	Prototypes functional after processing, high leakage
Molecular Beam Epitaxy	50-75 Å	Building in-house capability

## SOI pixel R&D

- Integration of CMOS electronic and high-resistivity substrate: possibility for small pitch pixel sensors with high density, full CMOS readout



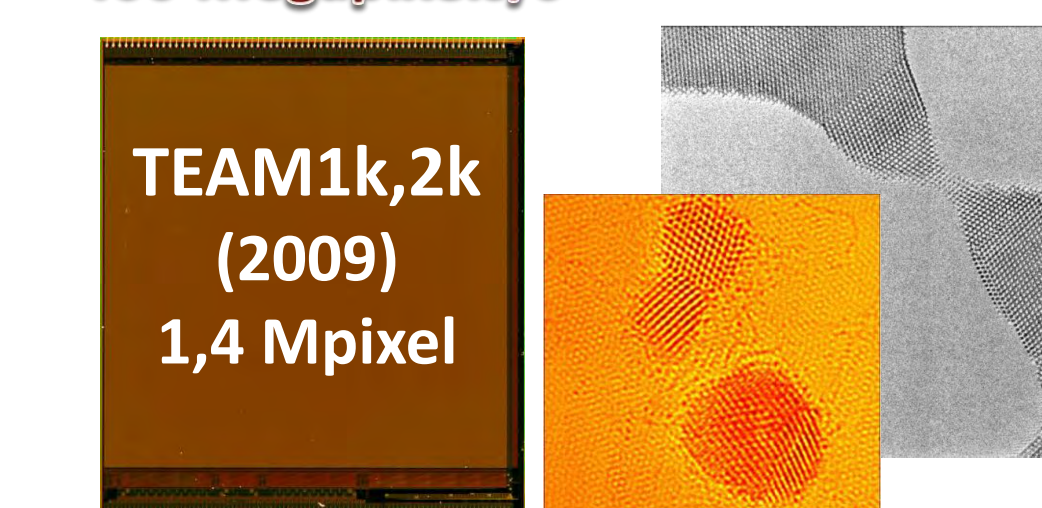
- **FemtoPix chip:** gated soft X-ray SOI detector for ALS femtoslicing BL
  - 0.20  $\mu\text{m}$  SOI-CMOS process
  - 192 $\times$ 192 pixels, 17.5  $\mu\text{m}$  pitch
  - In-pixel CDS
  - 4,000 frame/s readout



## Other synergistic activities

- Development of fast, high-resolution, radiation hardened pixels for Transmission Electron Microscopy

400 Megapixels/s



6,400 Megapixels/s

