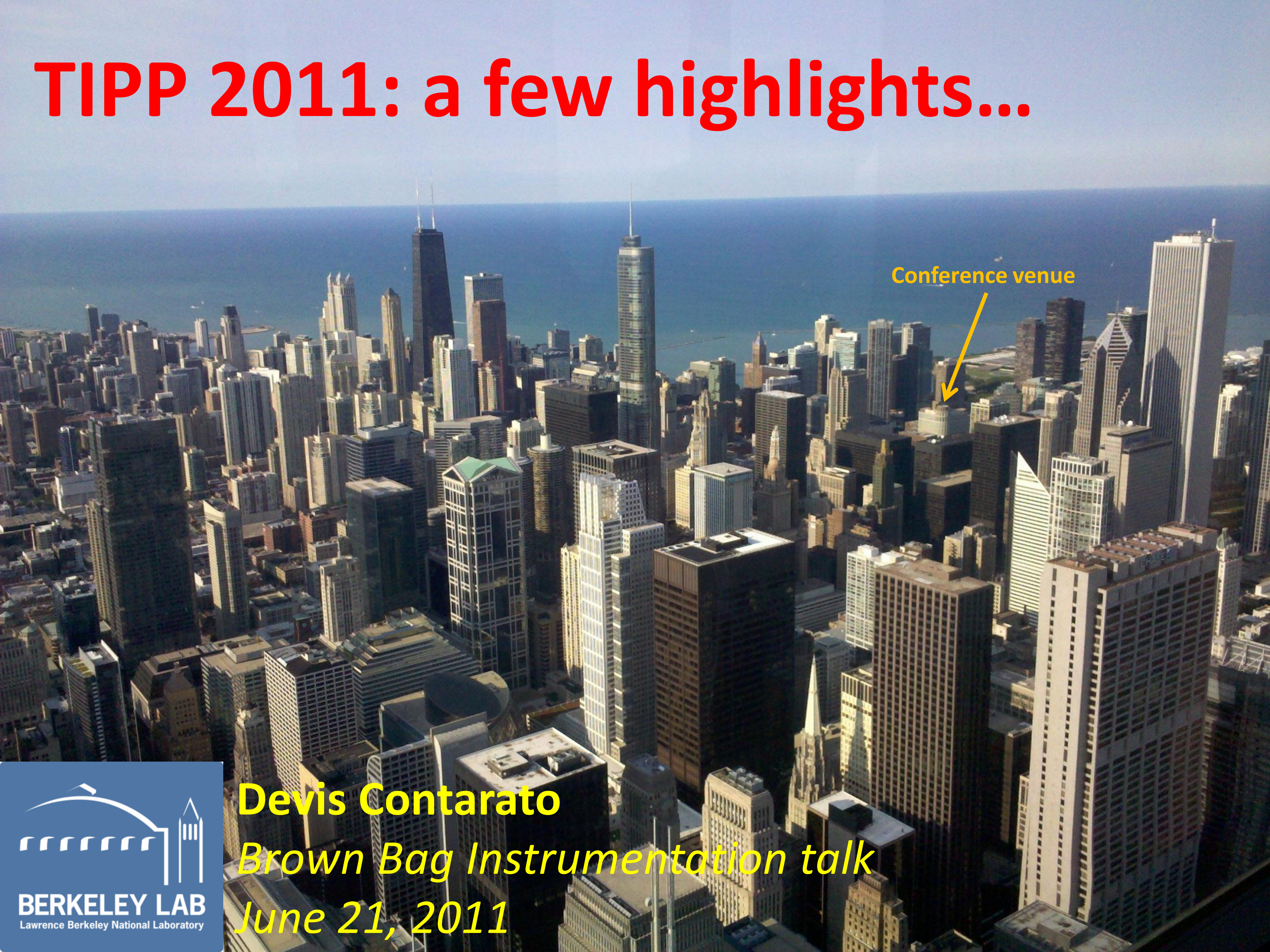
TIPP 2011: a few highlights…



BERKELEY LAB
Lawrence Berkeley National Laboratory

Devis Contarato

Brown Bag Instrumentation talk

June 21, 2011

Notes

- I attended only the first 3 days of the conference, therefore my take comes from a limited perspective…

- 9 parallel tracks at the conference, I hopped between:
  - Semiconductor detectors
  - Front-end electronics
  - Instrumentation for biological, medical and material research

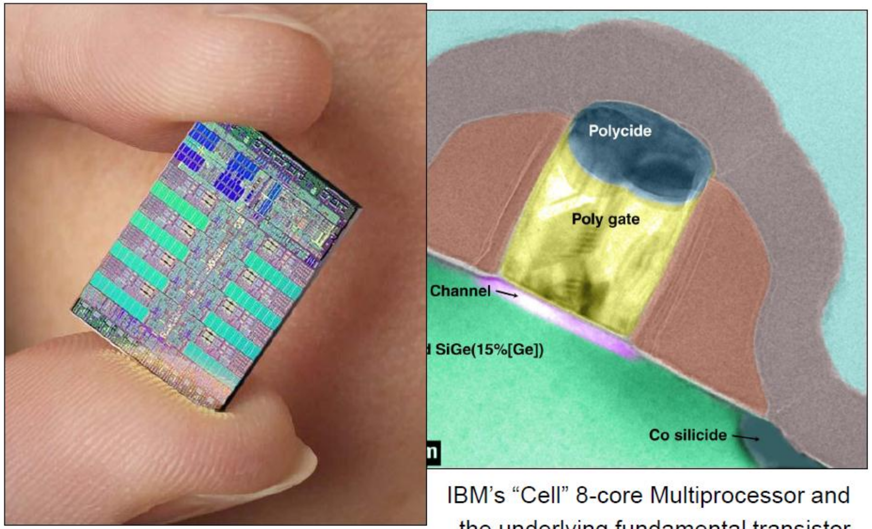
- My 5 picks, somehow exotic:
  - One plenary talk on the future of CMOS and High-Performance Computing
  - A couple technologies alternative to Si-planar sensors (3D sensors, diamond)
  - A couple examples of X-ray detectors (SOI, DEPFET for XFEL)

Beyond CMOS

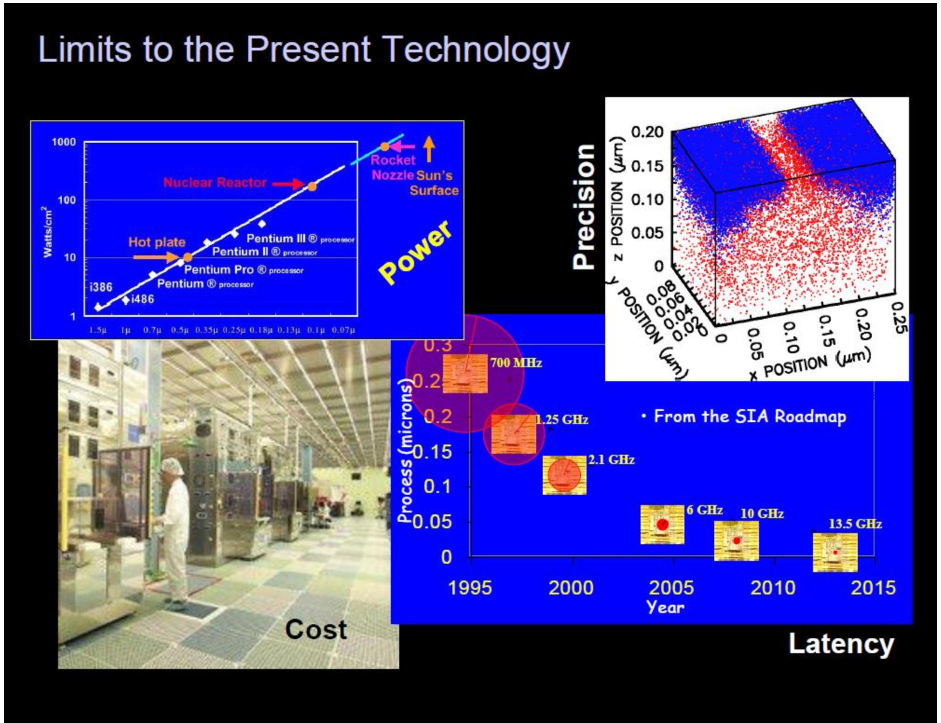
K. Bernstein- IBM TJ Watson Research Center
"The Evolution of CMOS and post-CMOS Electronics", plenary talk

- Despite the advances in technology and miniaturization, the basic building block of modern microprocessors is still… a binary switch!
- As the technology node scales down, CMOS processes are facing fundamental limitations, which will soon become quantum mechanical…

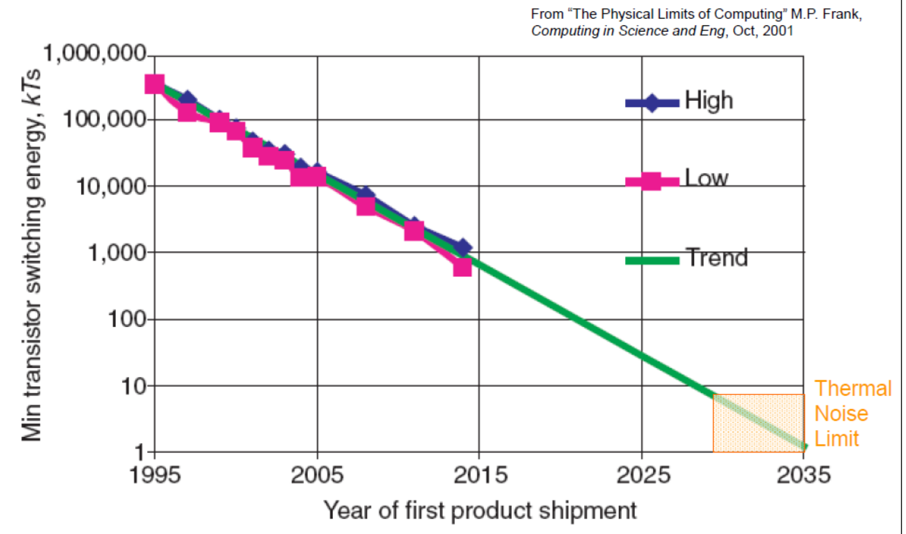
The Engine Driving The Digital Age



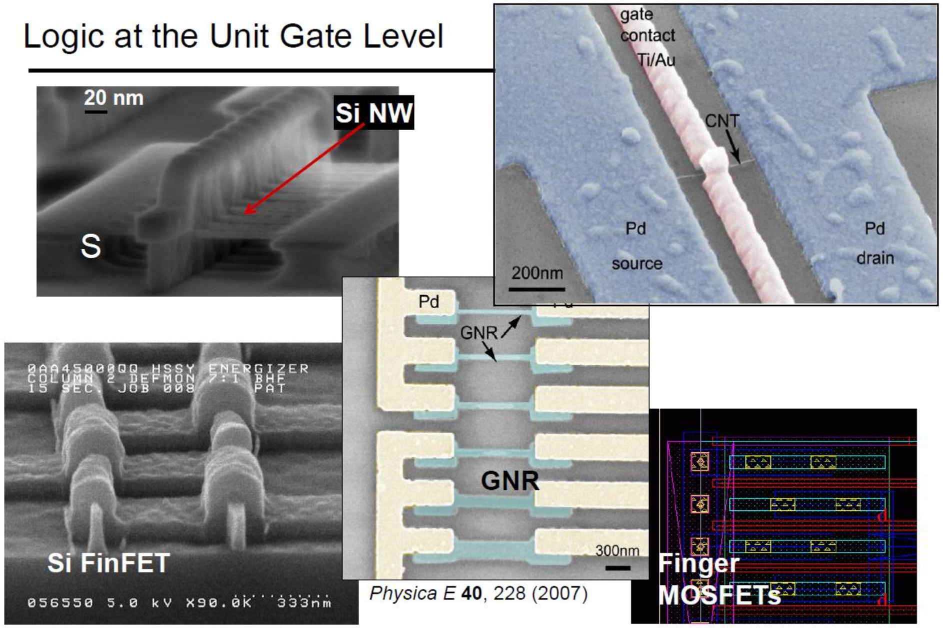
IBM's "Cell" 8-core Multiprocessor and the underlying fundamental transistor



Ultimate Boundaries: Minimum Switching Energy



Logic at the Unit Gate Level

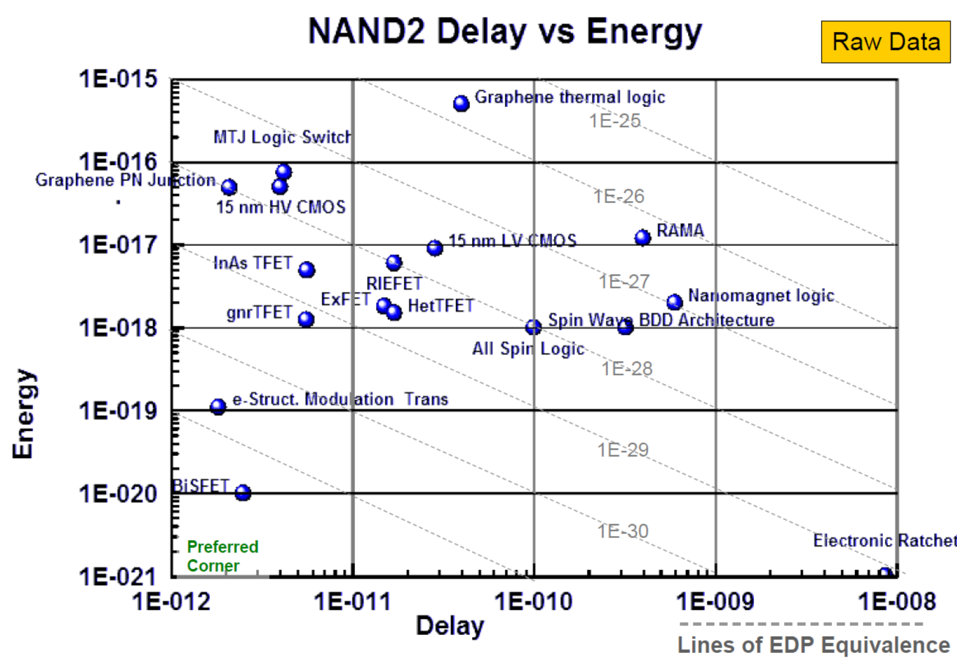


Physica E **40**, 228 (2007)

Switches going forward *naturally quantize their output* – can we exploit this in new architectures?

- There is a wealth of research towards the beyond-CMOS switch (not necessarily binary), involving nanotechnology and such…

- … but the challenge is still about keeping up with speed demands at low power consumption!

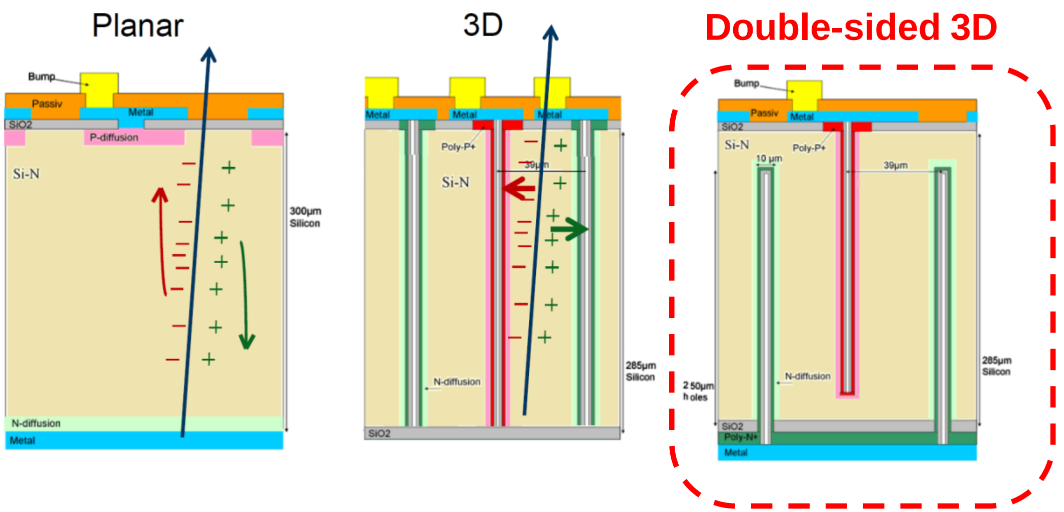


A potential Delay-Energy minima exists at approximately 1E-29

3D silicon sensors

A. Mac Raighne – University of Glasgow
"Characterisation of Glasgow/CNM double-sided 3D sensors"

- Electrodes are "pillars" implanted in sensor substrate: lateral depletion, lower depletion voltage, faster collection time → less trapping, more rad-hard…
- … but: complex process, yield issues, areas of inefficiency
- Double-sided approach has easier fabrication process (?), minimizes inefficiency regions
- Best performance in beam-test obtained with detector at an angle



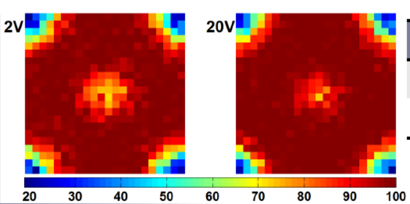
Beam test on 3D n-type pixel sensor, 55 µm pitch

University of Glasgow

Precision scans: Efficiency

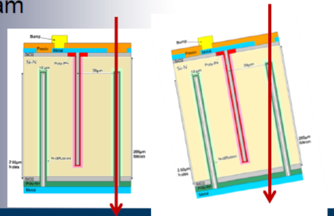
Timepix Telescope

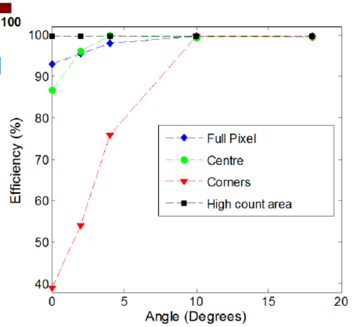
120 GeV π, w/ reference telescope

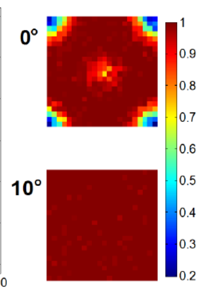


Voltage	Corner	Centre	Ring	Pixel
2V	35.6	79.1	99.1	91.2
20V	39.1	86.7	99.7	93.0

Full efficiency, **99.8±0.5%**, reached at an angle of **10°** to the incident beam







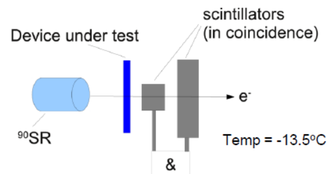
7

University of Glasgow

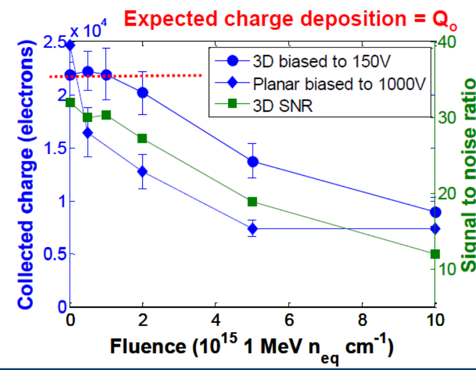
Charge collection efficiencies (150V)

Sr-90 electrons

^{90}Sr source, after 10^{16} n_{eq} cm^{-2}



- Large charge collection at high fluences and modest voltages
- 3D charge collection of 47% of Q_o @10^{16} fluence at 150V
- This has been simulated using TCAD without any high field effects present and shows very good agreement
- Noise is constant giving a signal to noise value of >10 @ 10^{16} fluence at 150V
- Compared to planar sensor higher charge collected
- Planar charge collection, 30% of Q_o @10^{16} fluence at 1000V



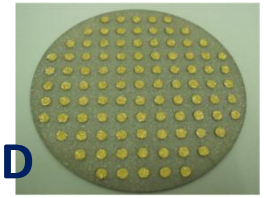
Charge collection studies and electrical measurements of heavily irradiated 3D Double-Sided sensors and comparison to planar strip detectors. R. Bates et al., submitted to IEEE

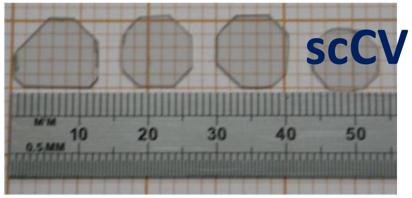
12

Diamond detectors

M. Mikuz – University of Ljubljana & Josef Stefan Institute
For the RD42 Collaboration
"Diamond Sensors for High Energy Radiation and Particle Detection"

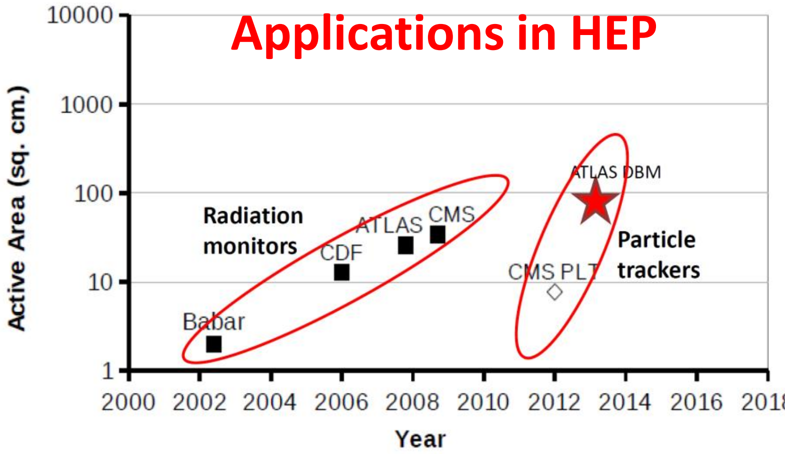
pCVD





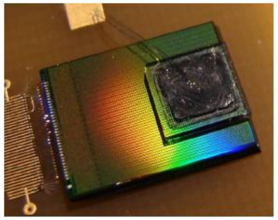
scCVD

- With respect to silicon, diamond shows lower leakage, higher mobility (faster signals), and is more radiation-hard
- Two sensor types:
  - ➢ polycristalline (pCVD), exists in 12 cm wafer
  - ➢ single crystal (scCVD), exists only in ~cm^2 pieces
- All LHC experiments use diamond as beam monitors
- Proposed trackers:
  - ➢ CMS Pixel Luminosity Telescope (PLT)
  - ➢ ATLAS Diamond Beam Monitor (DBM)

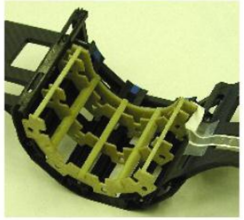


CMS Pixel Luminosity Telescope

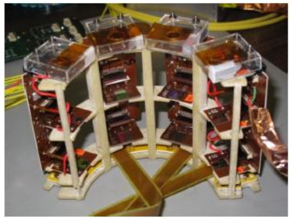
- Dedicated, stand–alone luminosity monitor
  - – Eight 3-plane telescopes each end of CMS
  - – 1.60° pointing angle r = 4.8 cm, z = 175 cm
- Diamond pixel sensors active area:
  - – 3.9 mm x 3.9 mm, scCVD diamond
- Count 3-fold coincidences fast-or signals (40 MHz)
- Full pixel readout pixel address, pulse height (1 kHz)
- ➢ Stable 1% precision on bunch-by-bunch relative luminosity



PLT plane



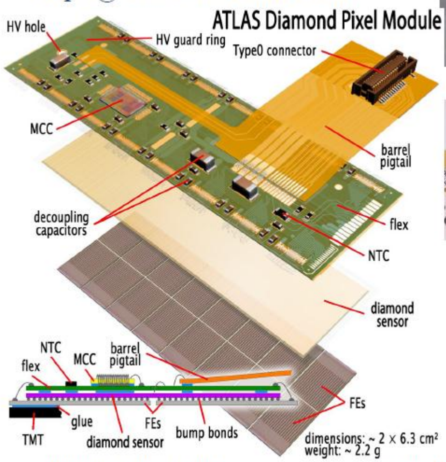
Cassette for 12 planes

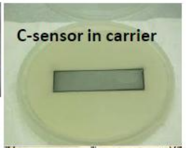


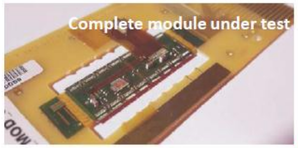
Full cassette in test-beam

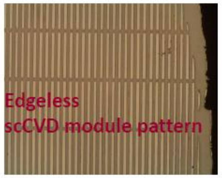
Diamond pixel modules

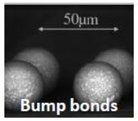
- Full modules built with I3 pixel chips @ OSU, IZM and Bonn



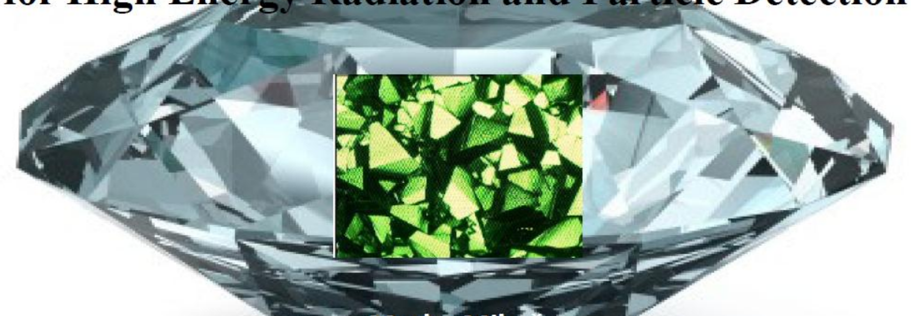








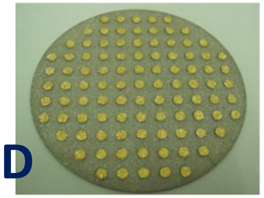
Diamond Sensors
for High Energy Radiation and Particle Detection



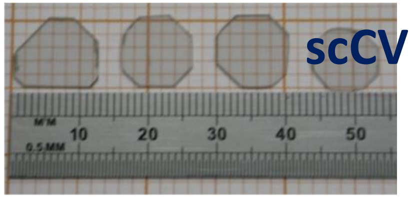
Marko Mikuž
University of Ljubljana & Jožef Stefan Institute
Ljubljana, Slovenia
for the CERN RD-42 Collaboration

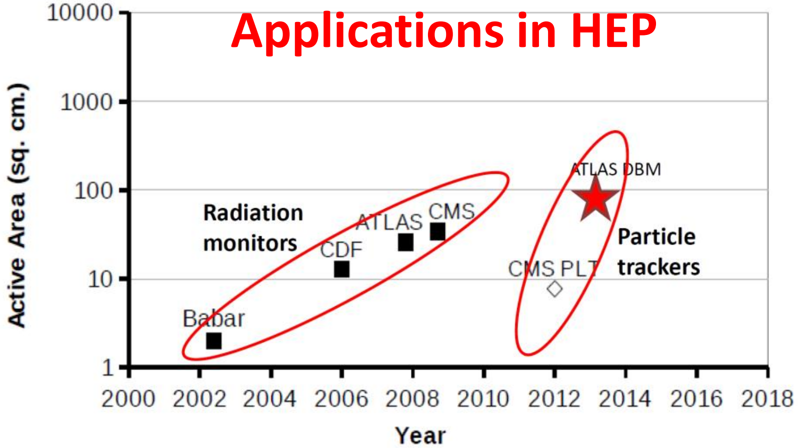
TIPP 2011
Chicago, IL, USA
June 9-14, 2011

pCVD



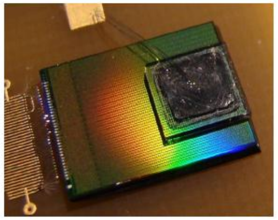
scCVD



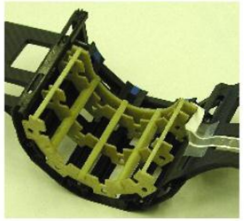


CMS Pixel Luminosity Telescope

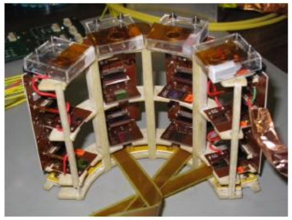
- Dedicated, stand–alone luminosity monitor
  - Eight 3-plane telescopes each end of CMS
  - 1.60° pointing angle r = 4.8 cm, z = 175 cm
- Diamond pixel sensors active area:
  - 3.9 mm x 3.9 mm, scCVD diamond
- Count 3-fold coincidences fast-or signals (40 MHz)
- Full pixel readout pixel address, pulse height (1 kHz)
- ➢ Stable 1% precision on bunch-by-bunch relative luminosity



PLT plane



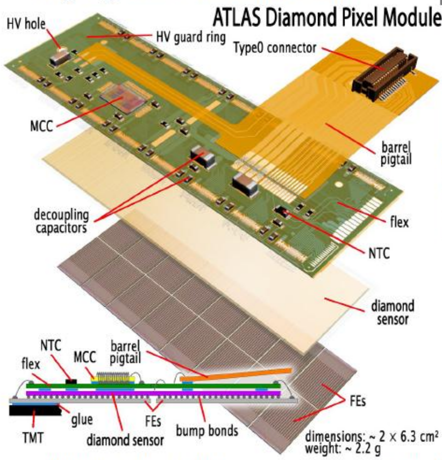
Cassette for 12 planes

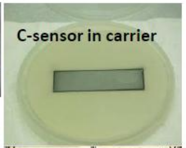


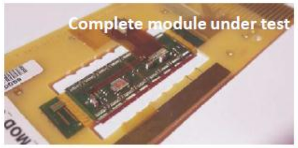
Full cassette in test-beam

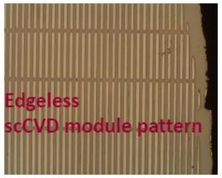
Diamond pixel modules

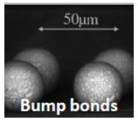
- Full modules built with I3 pixel chips @ OSU, IZM and Bonn





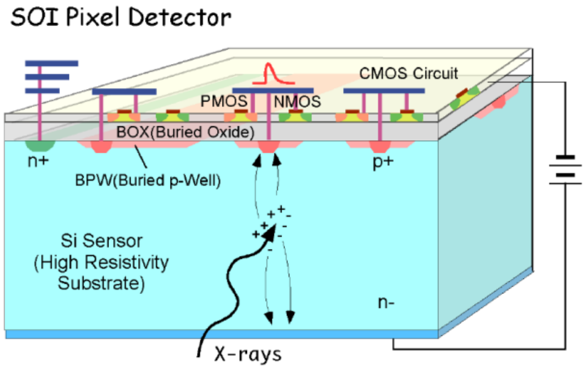


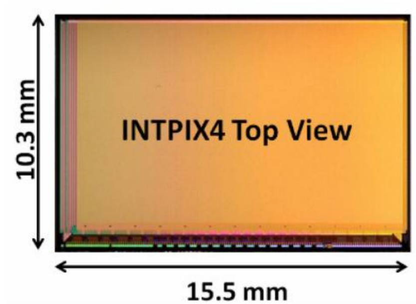




SOI pixels for X-rays

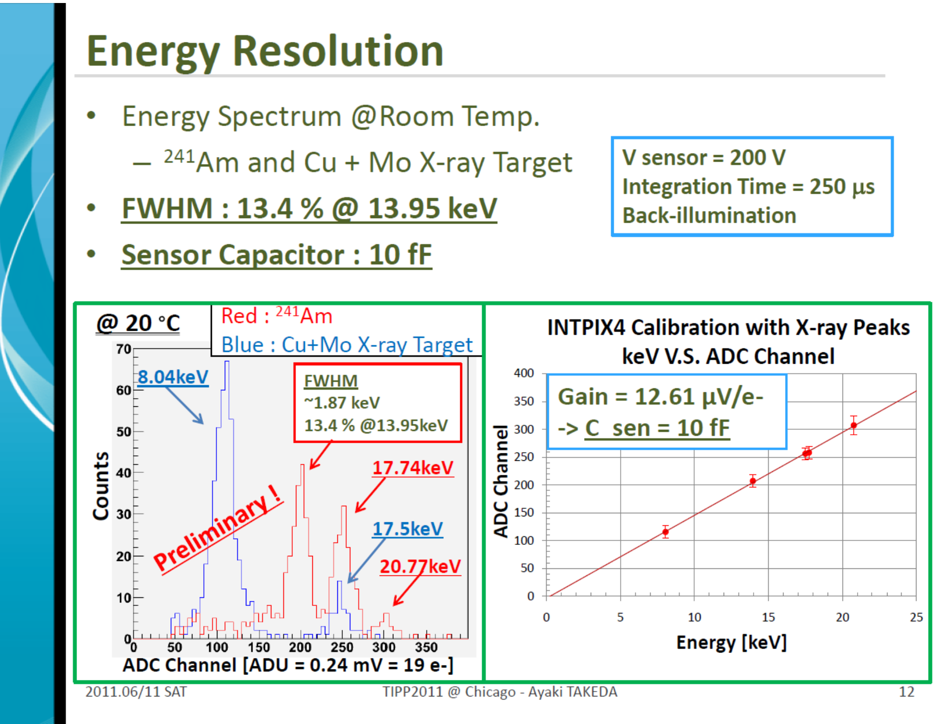
A. Takeda - KEK
"High resolution X-ray Imaging Sensor with SOI CMOS technology"

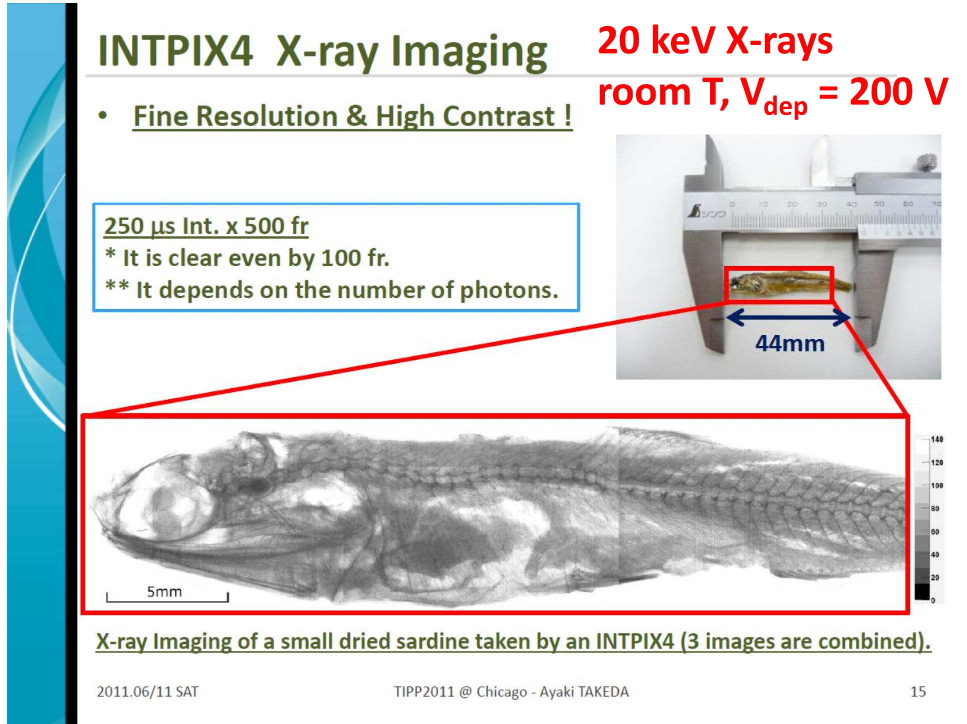




INTPIX4 Chip Photo

- Monolithic detector that integrates full CMOS electronics on a high-resistivity, fully-depleted substrate, no bump-bonding
- ½-reticle size imager, 17 μm pitch pixel with Correlated Double-Sampling (CDS)
- 260 μm thick, fully-depleted substrate, back-illuminated
- Test with X-rays at various energies, energy resolution improves with cooling
- … we are working on similar developments here at LBNL!

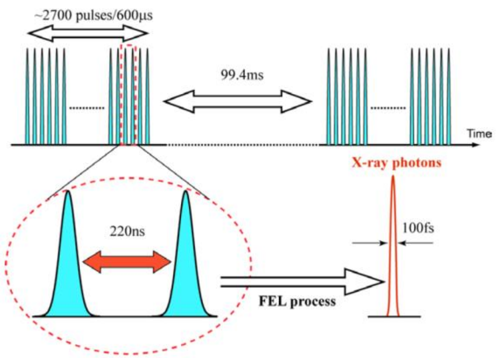




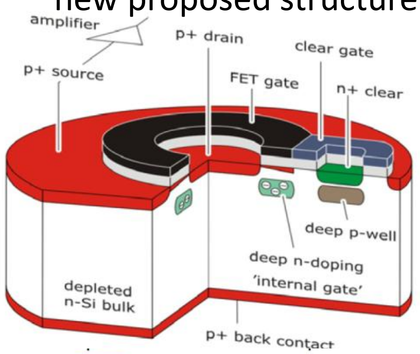
DEPFETs for EU-XFEL

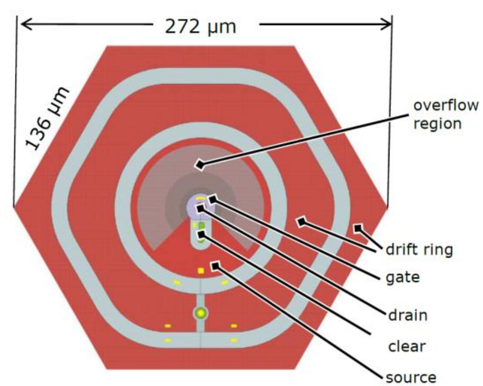
L. Andricek – MPI Halbleiterlabor, Munich
"DSSC – an X-ray Imager with Mega-Frame Readout Capabilities for the European XFEL"

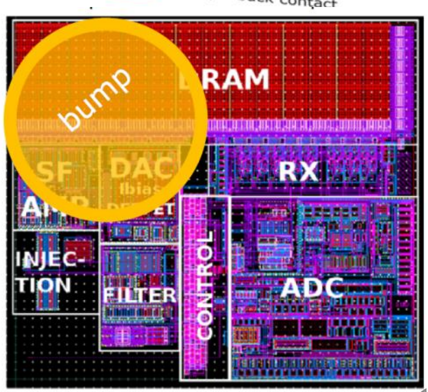
ILC-like beam structure:
10 Hz train, 2700 e^-/train,
bunch spacing 220 ns
→ need 5 MHz frame rate with storage of >500 frames/burst



- 1 Mpixel, 2D X-ray cameras at the end stations, energy range 0.5-25 keV, need to handle large dynamic range: new proposed structure with variable gain







- Hexagonal pixel, 204x236µm pitch
- 130nm readout ASIC with 8-bit ADC and SRAM in pixel