Cherwell and OverMOS Projects

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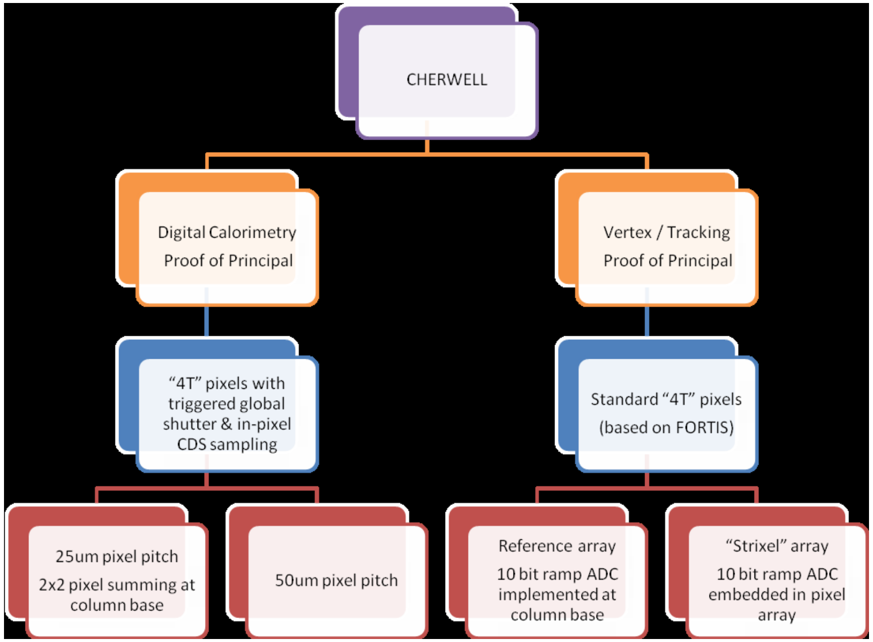
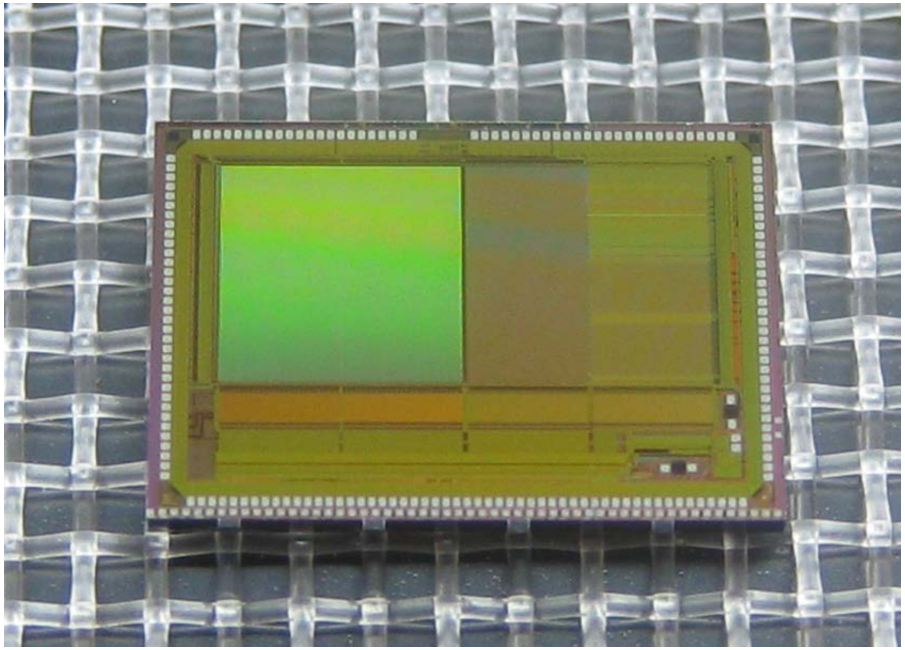
Arachnid and OverMOS collaboration
plus ATLAS CMOS upgrade groups

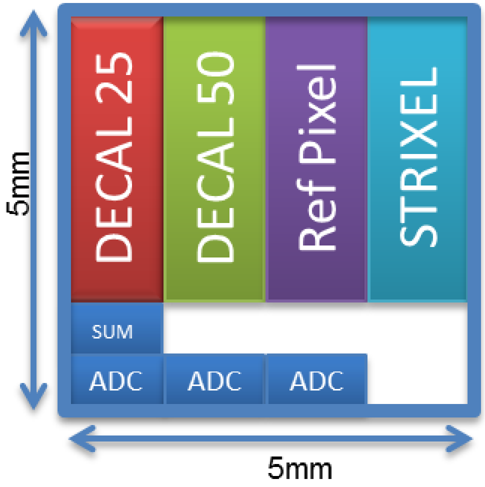
Cherwell

- Sensor produced more than five years ago but funding cut (SpiDer collaboration) so not tested.
- Designed for testing vertexing, tracking and digital calorimetry at Linear Collider.
- Uses ideas from FORTIS (tracking) and TPAC (calorimetry) sensors.
- MAPS 180µm TowerJazz
- Secured funding from PRD in 2011 to test sensors (Arachnid Collaboration: QMUL, Bristol, Birmingham, RAL, Daresbury).
- Test beams at CERN in 2012 and 2014.
- Paper currently being written (slowly).

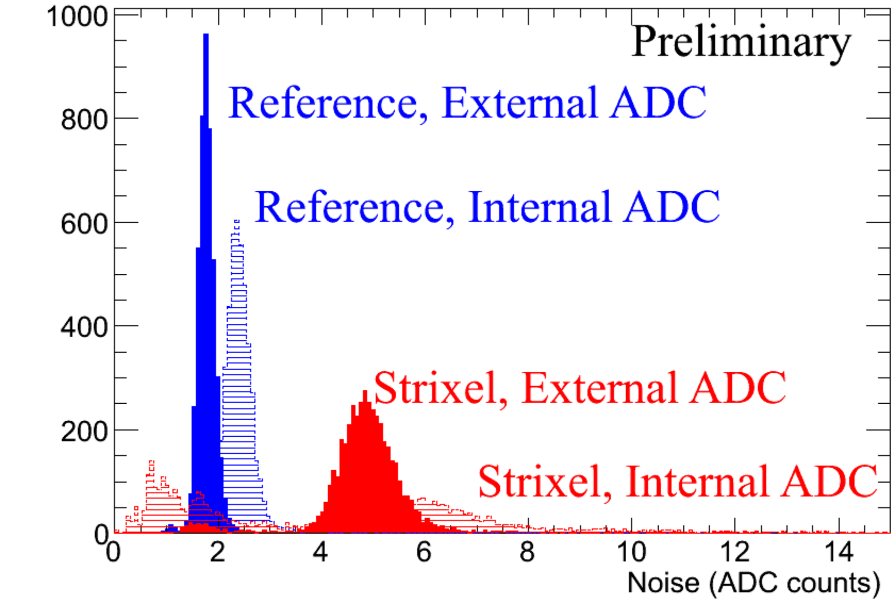
What is Cherwell?

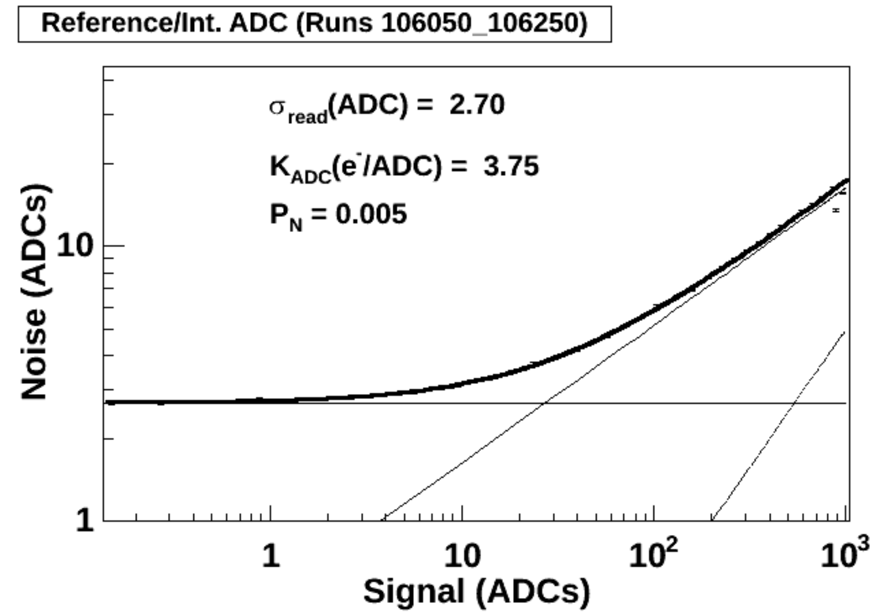


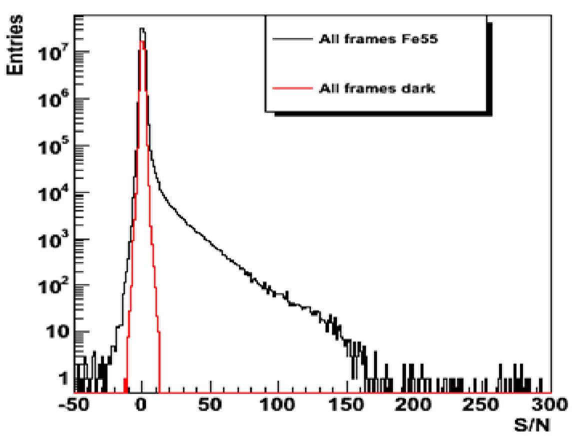


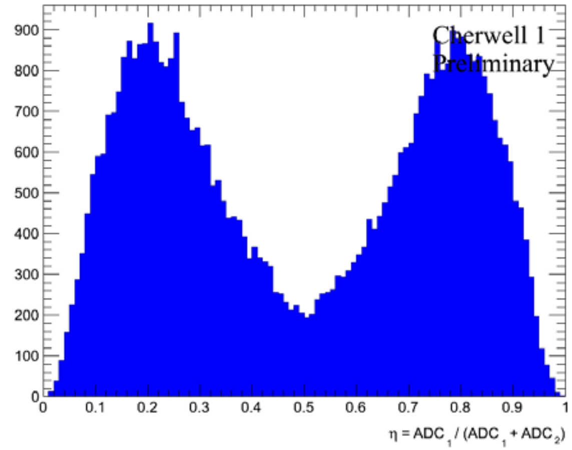


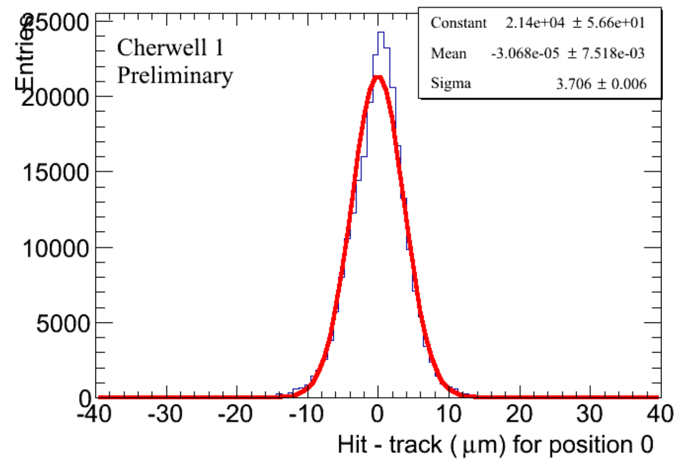
Some preliminary results









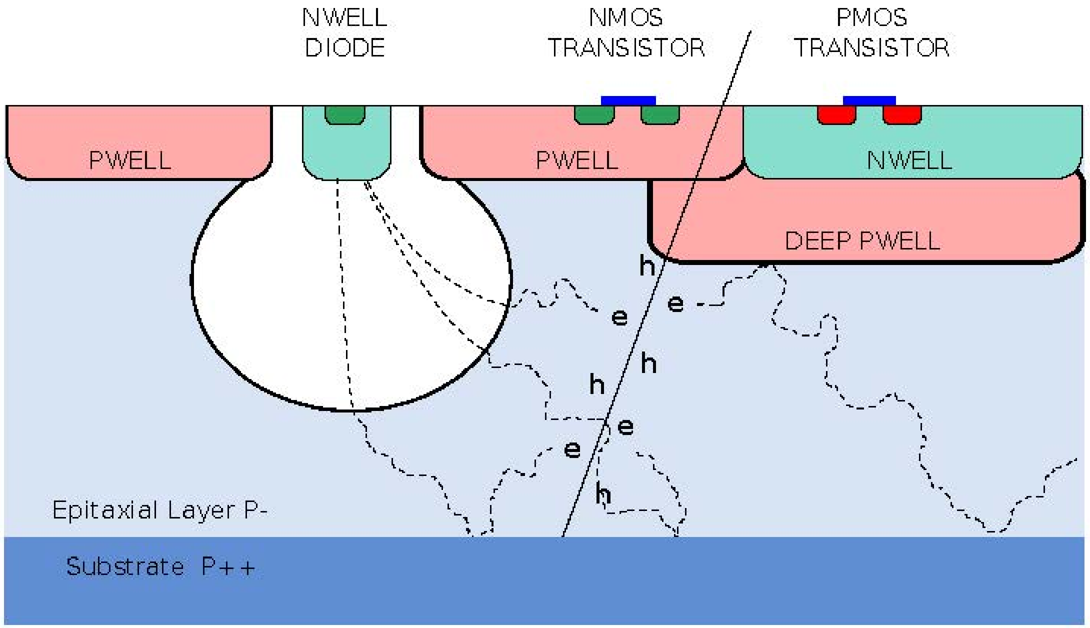


Summary

- Results summary
  - Signal to noise > 100
  - Noise ~8 e^-.
  - Hit efficiency > 99.7%.
  - Hit resolution ~3.7 µm.
  - Pedestals and noise consistent across pixels.
  - In-pixel electronics results still to be done.
- Tests that were never done:
  - Speed (DAQ very slow by today's standards).
  - Power output (never measured).
  - Radiation tolerance (expected to be ~250 kRad).
  - Ganging of pixels together (noise levels).
  - Power-pulsing.

Charged Particle Detection

Deep p-well: enhances charge collection, allows enhanced pixel structures



Thin epitaxial layer: shorter collection times, less multiple scattering, less chance of charge capture

High-resistivity epitaxial layer: improved signal to noise.

Guard rings: improve resistance to radiation damage.

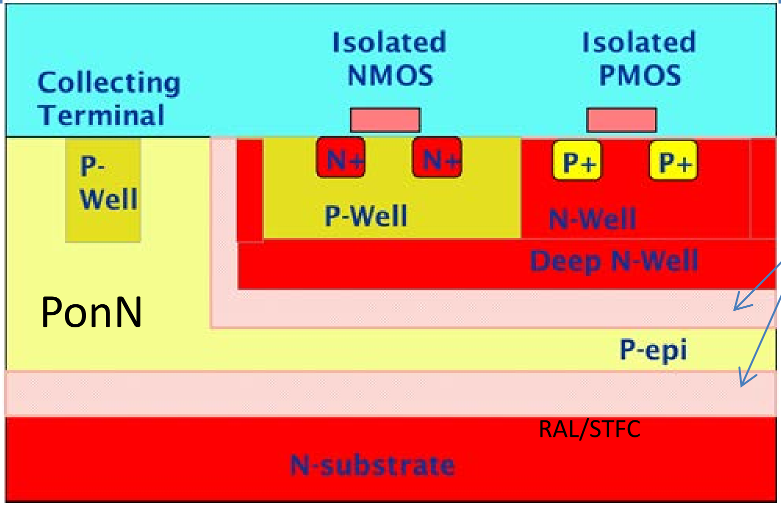
High-resistivity epitaxial layer + low voltage bias (HR-CMOS): charge collection by drift, faster, radiation hardness

High voltage bias (HV-CMOS): charge collection by drift, faster, radiation hardness

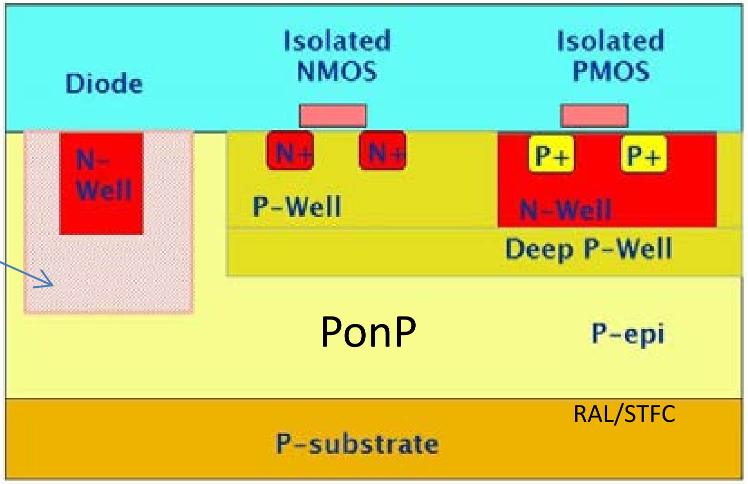
OverMOS 1 Project

- OverMOS Collaboration. Design: R. Turchetta, D. Das, F. Wilson, S. Worm, G. Villani, S. McMahon; Simulation: RAL+Glasgow; Testing: open to all.
- An over-depleted epitaxial layer to induce charge transport by drift rather than diffusion.
  - p-epi on n-type substrate (PonN)
  - p-epi on p-type substrate (PonP). TJ standard.
- Aims are high-radiation tolerance (>~100 Mrad) and high speed (90% of charge in <~20ns).
- Possible to bias using low voltage levels (~10-20 V) rather than HV-CMOS levels (80-150 V).
- Piggy-backs on ATLAS CMOS upgrade project. Shared DAQ and testing.
- Secured funding from Centre for Instrumentation (CfI) in 2014 and 2015.
- Some test structures have been designed in a MPW run and are being manufactured. Many variants and epitaxial thicknesses:
  - 40 x 40, 80, 200, 400, 800 µm pixels
  - Different epitaxial layer resistivities.
- Just test the pixel response (minimal ancillary logic).
- Due: ~20 April 2015. Then will be diced, bonded and tested.

OverMOS 1 Project

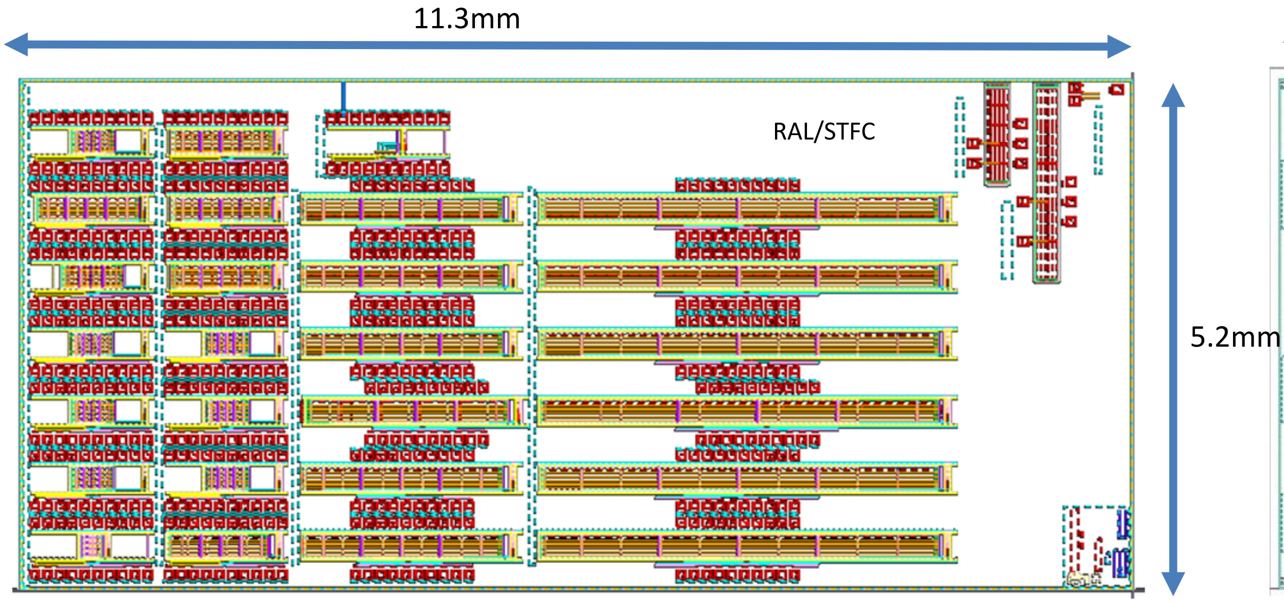


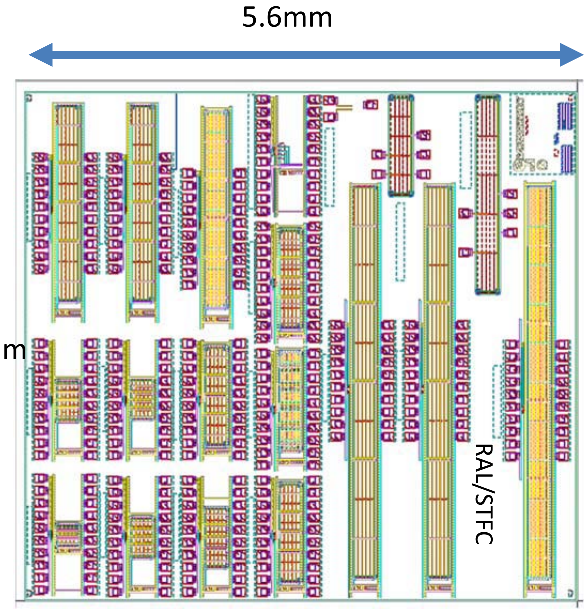
Depleted regions



30 variants

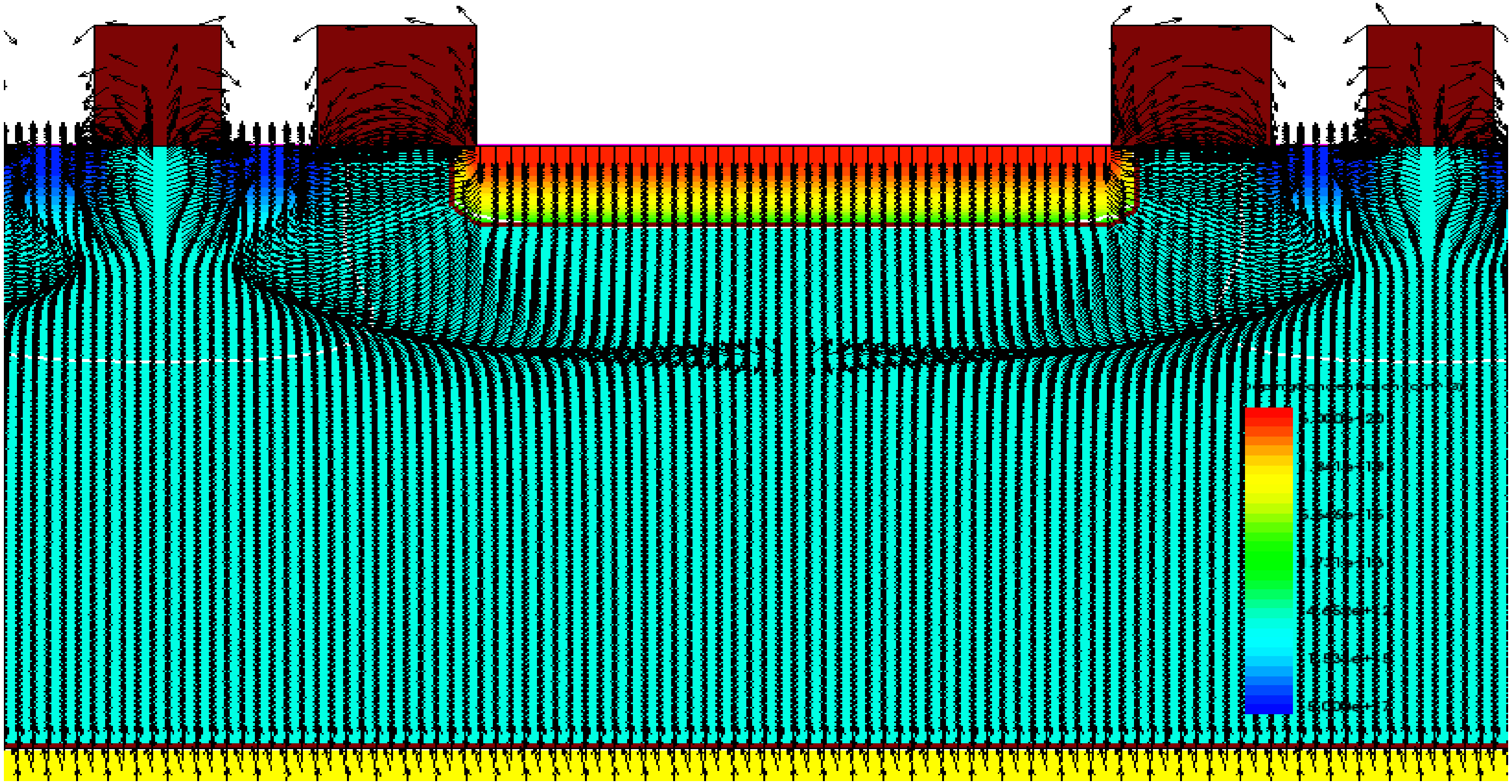
19 variants





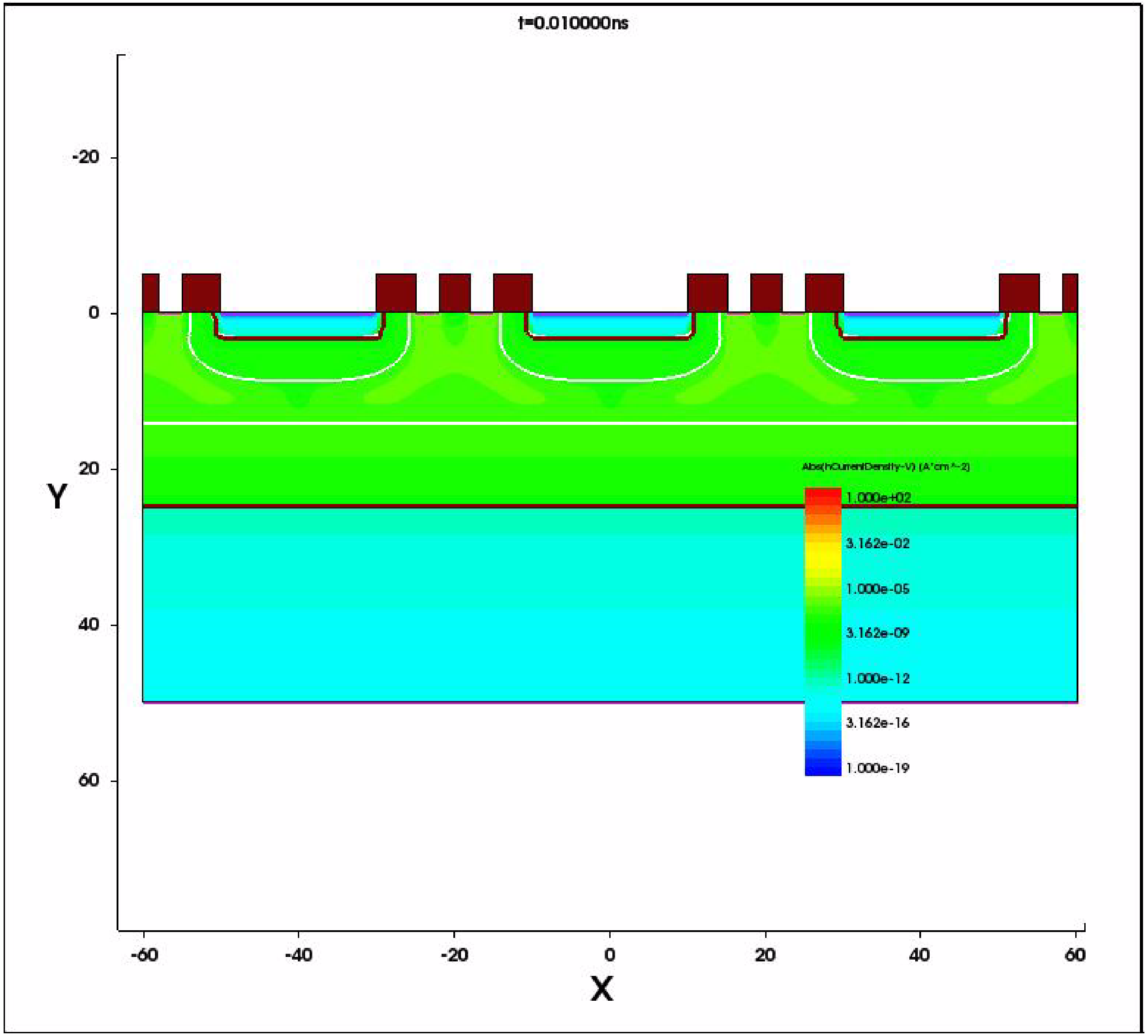
OverMos 1 Project: E-Field

- Too soon for results.



- Charge doesn't get stuck under pixel

OverMos 1 Project: Charge drift



Perpendicular track through middle of sensor

Shows current density distribution between 0-27 ns.

Majority of charge arrives within <15ns.

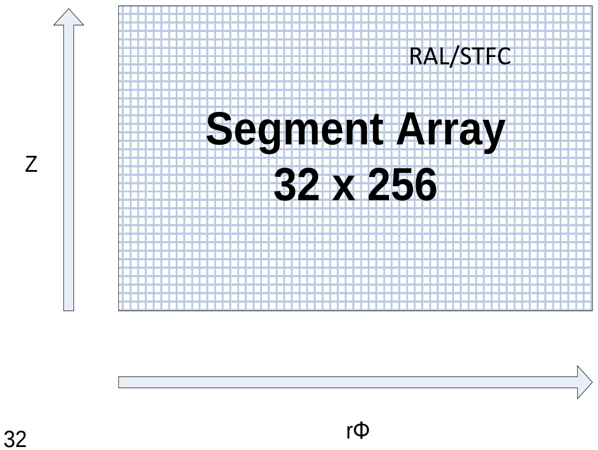
Charge does not get trapped under pixel

OverMOS 2 Project: Engineering run (?)

	Needs
Segment size	800 um x 40 um
Array	32 segments x 256 strips
Sensor size	25.6 mm x 10.24 mm
Hits to be readout	8 hits@40MHz per 128 strip (max 8 hits/cm^2/25ns) 4.16 Gbits/sec
Signal (e- per MIP)	2000 (25 µm thickness)
Noise in e- rms	< 30
Radiation Hardness	100Mrad TID; 10^{15} n_{eq}/cm^2
Power Budget	0.02 W/cm^2 (6 µW/pixel)

Max. Chip area limited by reticle size: 23.5mm x 31.5mm

Size of sensing area:
10.24mm x 25.6mm



No. of Strips: 256
32 segments arranged in 256 strips

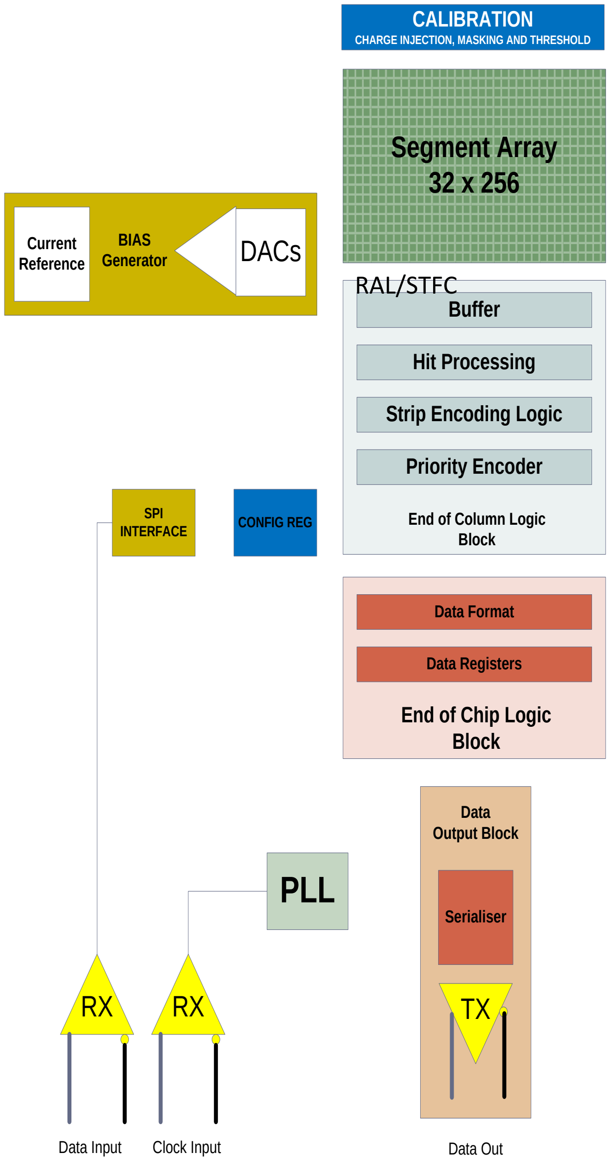
Segment: 40µm x 800µm

No. of segments in Z direction: 32

No. of strips in X direction: 256

No. of bits per segment:
M (X position) = 7
N (Z position) = 5
Flag/Overflow = 1
Total = 14

Read 8 hits for 128 strips
Each hit contains 8 bits
8 hits contain 13 x 8 = 104 bits



Future

- Cherwell
  - Complete paper.
  - Some untested features may be characterised if have time.
- OverMOS 1
  - Due ~20 Apr 2015.
  - Dice and bond.
  - Spend the summer irradiating with x-rays, neutrons, protons, …
  - TCT edge scanning laser tests.
- OverMOS 2
  - Aim for a full engineering run design (2.5 x 2.5 cm).
  - Compatible with ATLAS DAQ.
  - Design by Aug/Sep 2015.
  - But… don't have the money to go to production yet.
- Technology Review
  - Update Jamie Crook's chart.
- Linear Collider
  - Perhaps use ideas in simulation of detectors.
  - Use TCAD simulations to estimate power and speed in a LC design.