NTNU

Norwegian University of Science and Technology

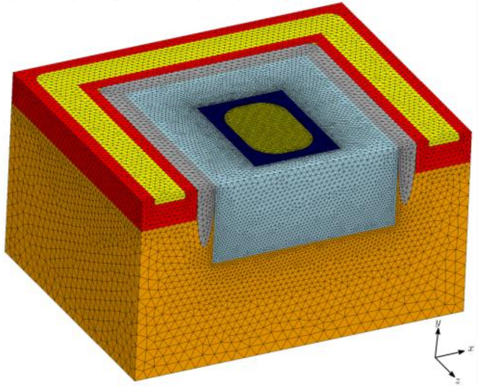
Simulation of a Three-Dimensional Mercury Cadmium Telluride-Based Avalanche Photodiode

Using a Particle-Based Self-Consistent Monte Carlo simulator (FFI-MCS)

Julius Mihkkal Eriksen Lindi

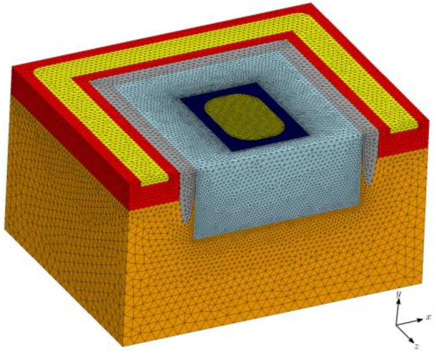
Supervisor @ FFI: Trond Brudevoll

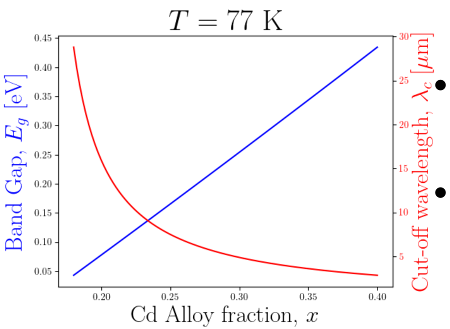
Supervisor @ NTNU: Jon Andreas Støvneng

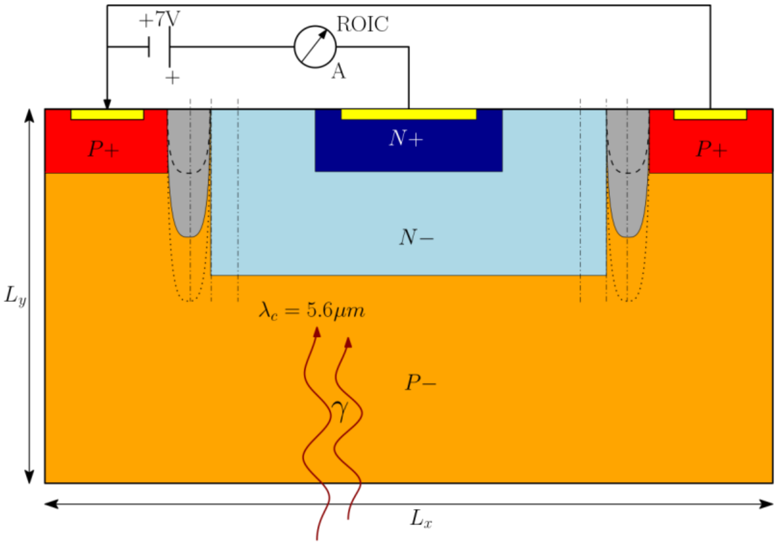


$Hg_{1-x}Cd_xTe$ e-APD

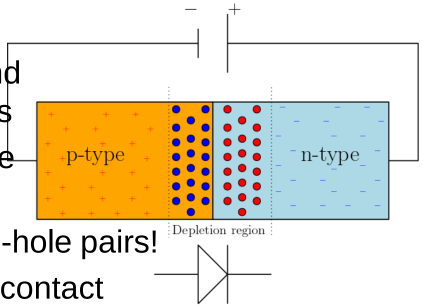
$Hg_{0.28}Cd_{0.72}Te$ Avalanche Photodiode







- Dimensions: $5.4\mu m \times 3.0\mu m \times 4.2\mu m$
  - Very small device! (convenient for computing time)
- High **reverse bias** voltage of $7V$ applied at $N+$ contact
  - Creates a larger **pn-junction** and multiplication region for electrons
  - **Photogenerated** electrons in the absorption layer (lower P-)
  - **Impact** and **ionize** new electron-hole pairs!
  - Electrons continue upward to N-contact



- A read-out device (**ROIC**) detects the signal
- Applications: **Infrared**/Thermal imaging, night-vision devices

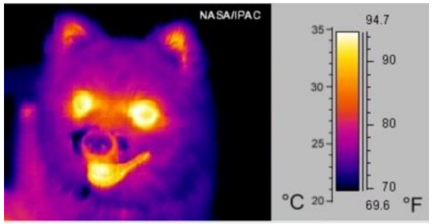
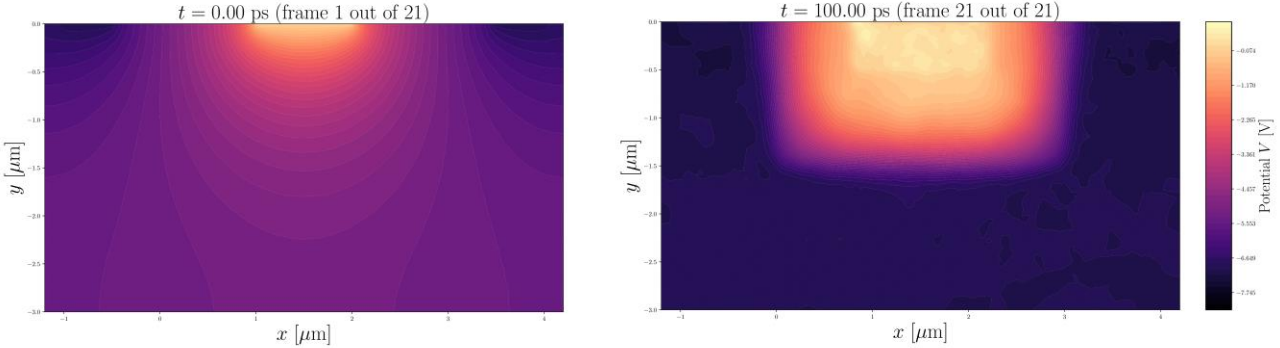
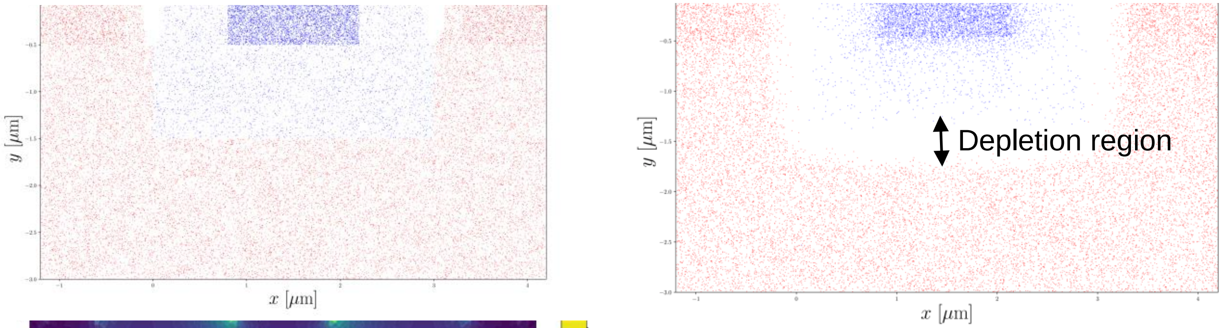


Figure 4. A dog as seen in the infrared spectrum.[8]

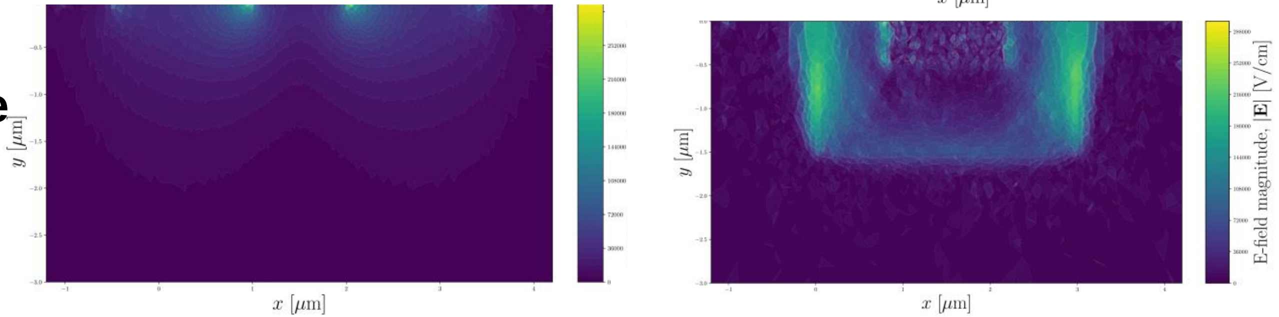
- **Potential plots**



- **Particle density plots**



- **Electric field magnitude**



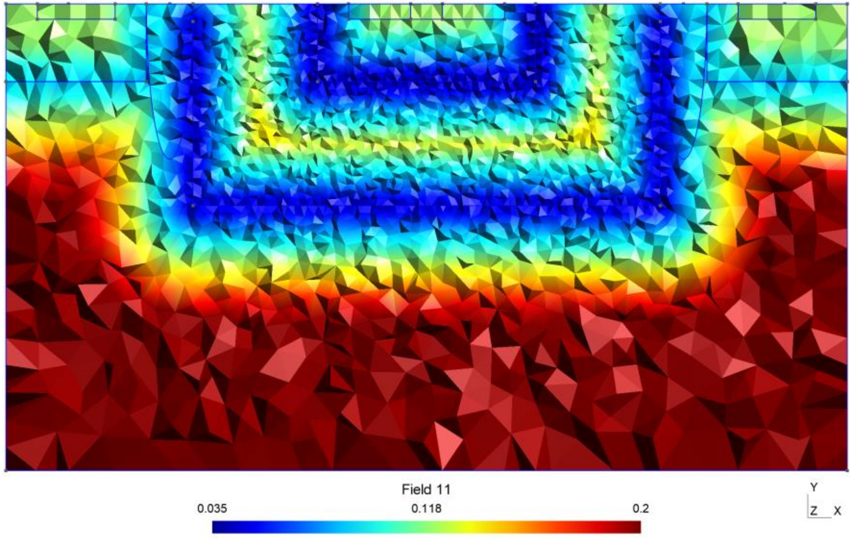
Summary of the project

- Only 2D devices have been extensively studied before
- Recent developments to FFI-MCS have paved way for simulating things easier and faster in 3D

  <u>Objectives:</u>

  – Construct a device with **complex 3D geometry**
  – **Optimize mesh** & find **suitable parameters** that are reasonable to use in 3D simulation
    - E.g. simulation doesn't take too long and the results are physical & accurate
    - **Time resolution, mesh refinement, # of superparticles**, etc.
  – Investigate geometry-dependent effects of **Guard Rings** (isolating groves)
  – Further work (master thesis): Study guard rings in a realistic device and optimize their geometry such that noise resulting from **dark currents** <u>is minimized</u>.

Mesh optimization



Node/element density