P7 – Energy Response Characteristics of a RadFET Radiation Detector

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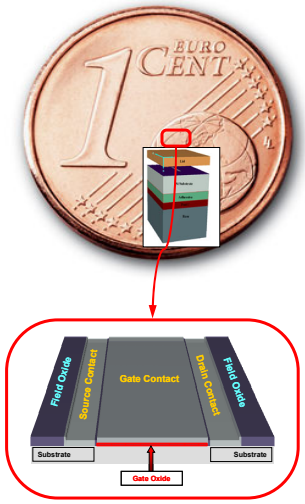
Outline

- Solution to Problem P7
  - Geometry Modifications of the Problem
- Used are the Monte Carlo codes
  - FLUKA; full solution to the problem
  - Geant4; partial solution of the problem
- Uncertainty Budget



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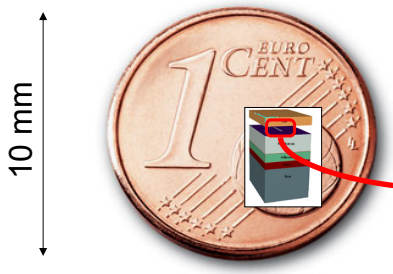
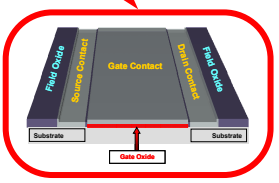


What sizes are we simulating?



50 µm

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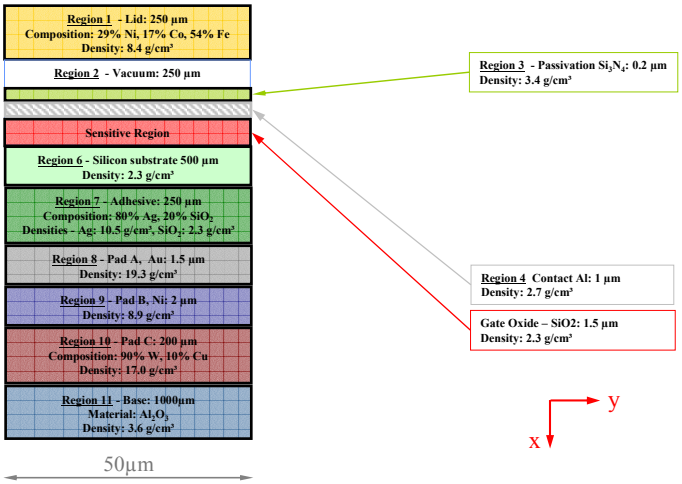
The given Geometry and Modifications



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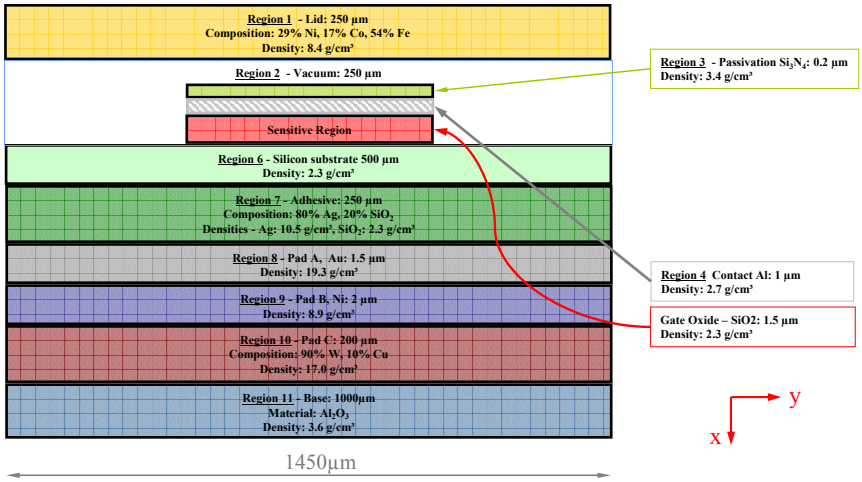

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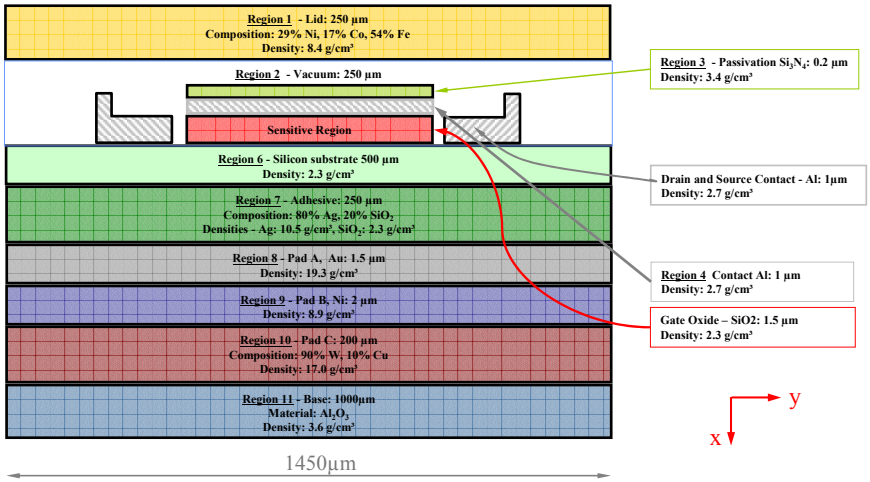

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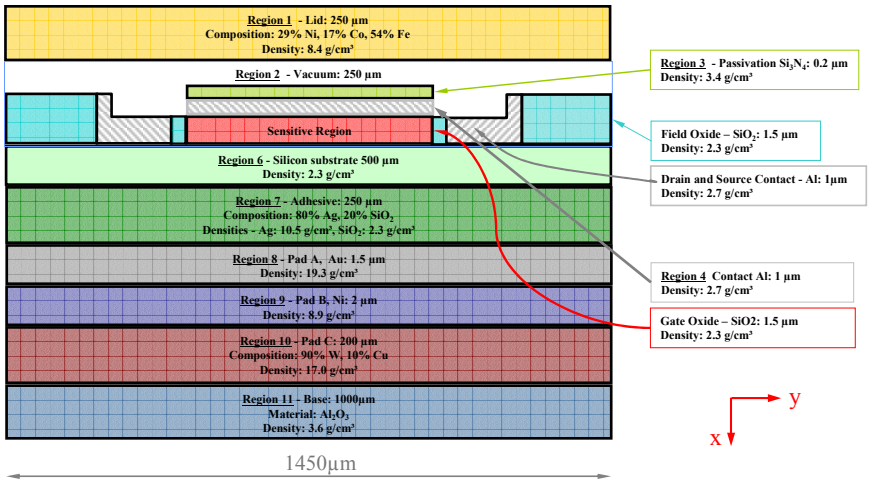

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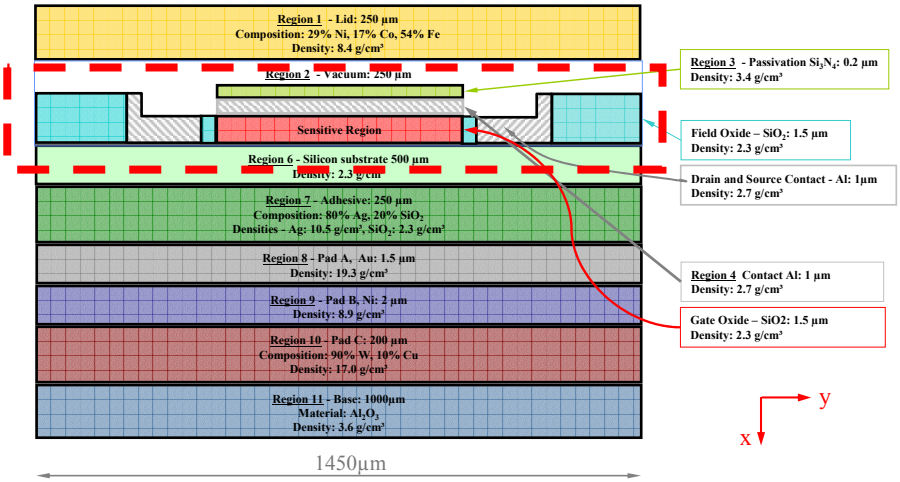

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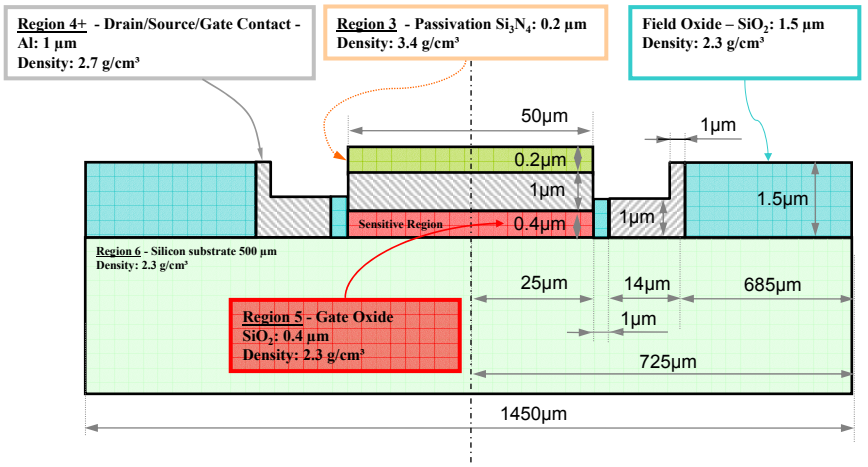

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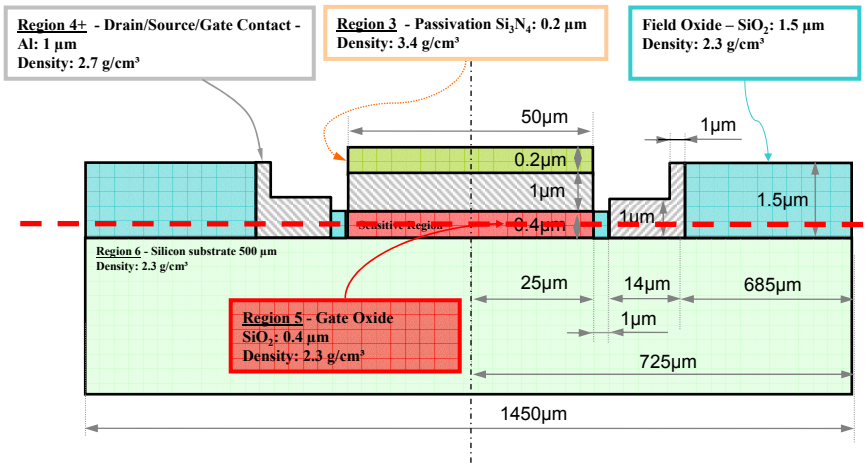

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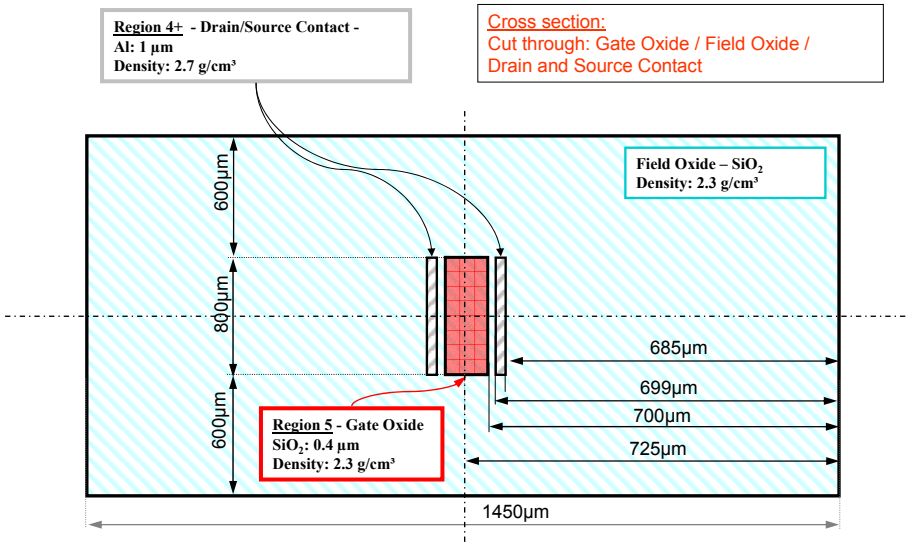

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Monte Carlo Simulation with FLUKA & GEANT4

MC Codes used

- FLUKA 2006 / Geant4.7.1
- Transport of
  - electromagnetic particles
  - hadronic particles
  - heavy ions
- Energy: 20 TeV to …
  - 10keV (all particles)
  - thermal neutrons
  - 1 keV (ph, e^-)
  - 250eV (ph, e^-) / GEANT4 (LEEM)

Hardware

- PC, Intel Pentium4, 2.4 GHz
- SGI/Altix, 64 bit Intel Itanium2, 1.4 GHz
- maximum number of starting photons: NPS = 10^9
- stat. uncertainties: ~ < 3%
- average simulation time per setup:
  - 7 - 9 days

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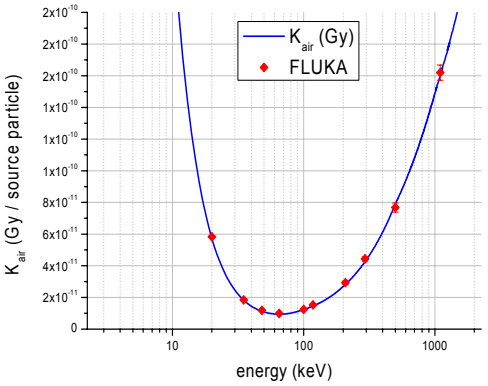
Air Kerma calculation

- All materials are replaced by air
- Air Kerma can be calculated in two ways
  - using literature data
  - using FLUKA

$$K_{air} = \int_0^\infty dE \cdot \Psi(E) \cdot (\frac{\mu_{tr}}{\rho})_{E,Z}$$
$$\Psi(E) = \Psi_{E_0} \delta(E - E_0)$$
$$K_{air} = \int_0^\infty dE \cdot \Psi_{E_0} \delta(E - E_0)(\frac{\mu_{tr}}{\rho})_{E,Z} = \Psi_{E_0}(\frac{\mu_{tr}}{\rho})_{E_0,Z}$$



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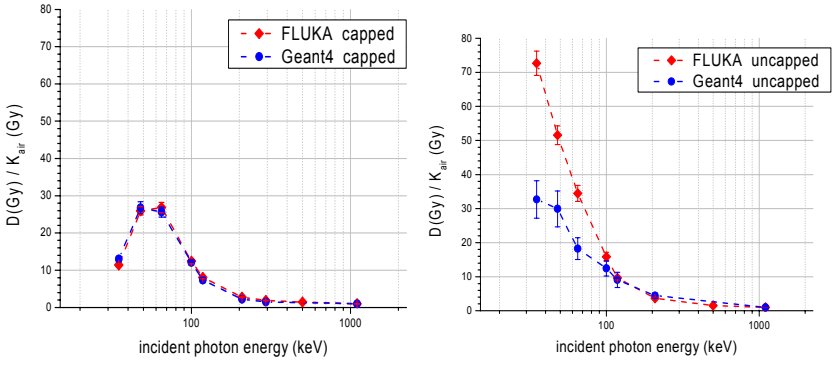
Energy response function of the capped and uncapped RadFET



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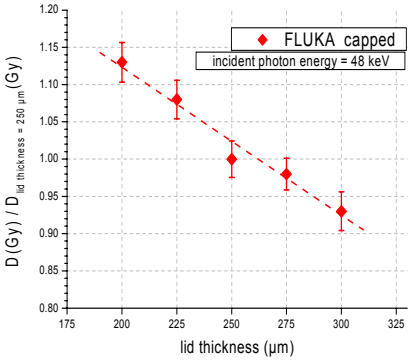
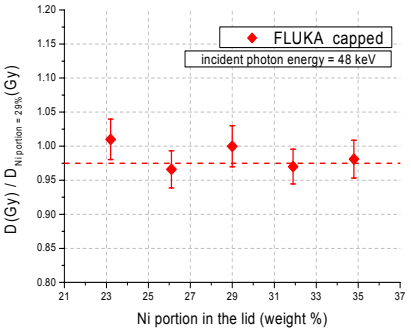
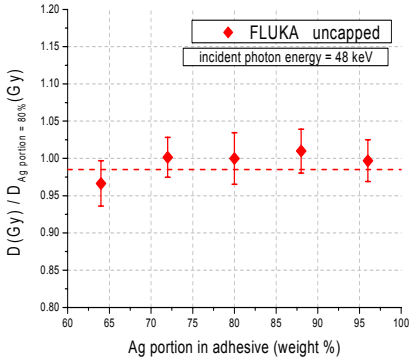
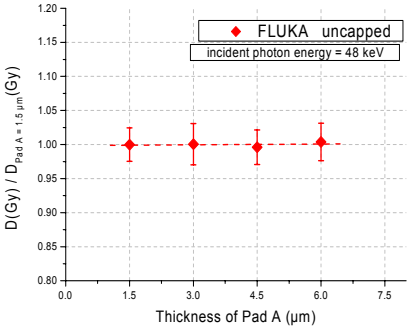
Variation of Lid Thickness and Ni Portion



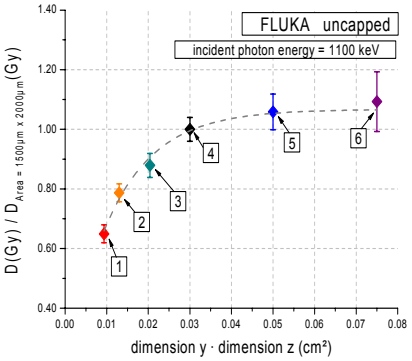


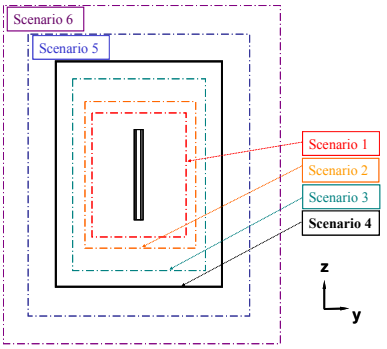
Variation of Ag portion in the Adhesive and Underestimation of the thickness of Attach Pad A (uncapped device)





Sensitivity of the solutions to the extent of the model in y- and z-directions





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Uncertainty Budget (FLUKA)

	capped	uncapped	
		$E_{ph} \geq 100$ keV	35 keV $\leq E_{ph} <$ 100 keV
Statistical uncertainty	5 %	5 %	5 %
Cross sections data	5 %	5 %	5 %
Model geometry	7 %	7 %	7 %
Mean code deviations	9 %	12 %	62 %
Simulation uncertainty	**13.5 %**	**15.6 %**	**63 %**
Lid thickness	13 %	--	--
Ni portion of the lid	3 %	--	--
Ag portion of adhesive	3 %	3 %	3 %
Thickness of attach pad A	3 %	3 %	3 %
RadFET related uncertainty	**14 %**	**4.5 %**	**4.5 %**
Total simulation uncertainty	**19.5 %**	**16.5 %**	**63.5 %**

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Conclusions

- The choice of the geometry has considerable influence on the result
- Response of “capped” and “uncapped” device differ most significantly incident for photon energies below 100 keV
- Comparison of FLUKA and Geant4
  - “capped” RadFET
    - good agreement
  - “uncapped” RadFET
    - incident photon energies ≥ 100 keV: reasonable agreement
    - incident photon energies < 100 keV; significant disagreement
- Variation of RadFET Parameters
  - Increase of the lid thickness by 20% decreases the response in the gate oxide by 13%
  - No effect was found for the variation of
    - Lid composition
    - Composition of adhesive
    - Thickness of Pad A

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Thanks for your Attention !!!

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Spatial Electron Fluence in capped RadFET due to 48keV incident photon irradiation