Summary - Problem P7: Energy Response Characteristics of a MOSFET Radiation Detector

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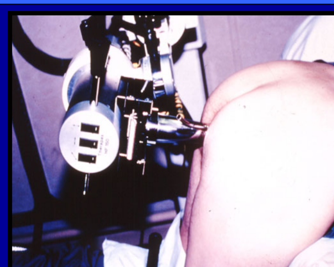
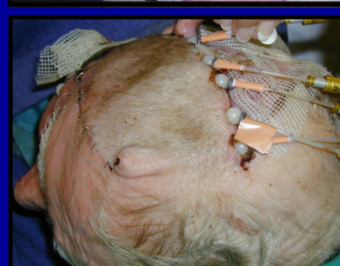
- National requirements to perform *in vivo* patient dosimetry (*eg Council Directive 97/43/euratom, UK cancer standards, etc*)
- Should form part of QA procedures of an oncology department

➢ Ergo a need for simple high-fidelity system

- Reality: - no system exists for brachytherapy QA





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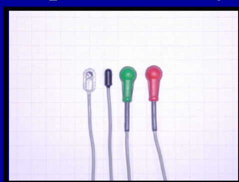
- Typical *in vivo* dosimetry uses:
- Diodes and or TLDs placed on the patient's body



- TLDs can't provide time resolution and require post processing

- True *in vivo* dosimetry
- Spatial and temporal resolution : stepped brachytherapy
- Integrated response
- Fit inside 1.5 mm ID tube
- Integrated software and hardware design methodology
- Permit repeated post Tx readout without data corruption

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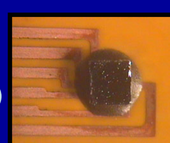
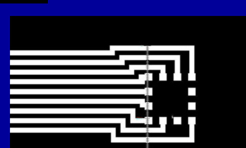
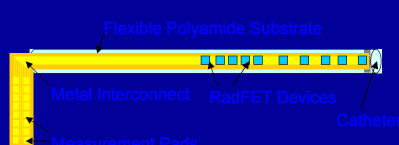
- Develop non-encapsulated semiconductors (MOSFETs)



- Use micro-electronics fabrication processes

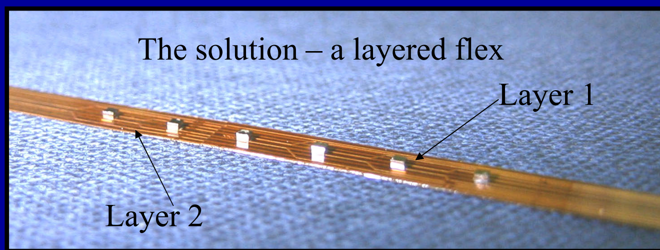


- Mount detectors on flexible polyamide to produce array



We need four interconnects for each RadFet – we also have an onboard diode so we need an extra line for this

➤ a total of 51 interconnects!



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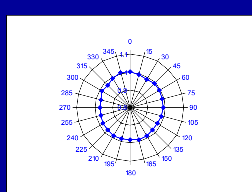
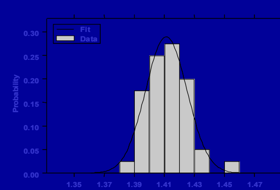
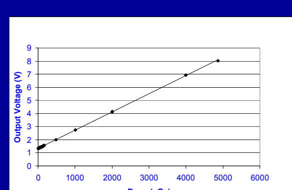


Anisotropy



Inter-device sensitivity



Energy response

Linearity

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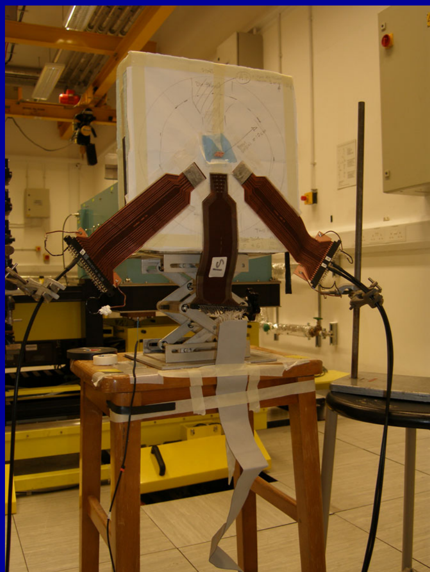

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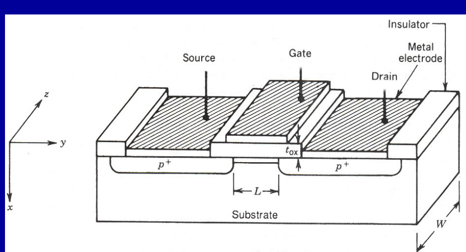

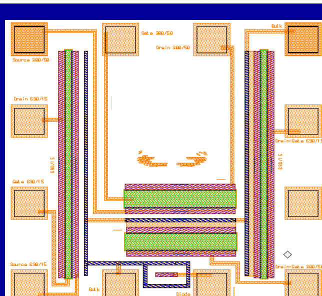

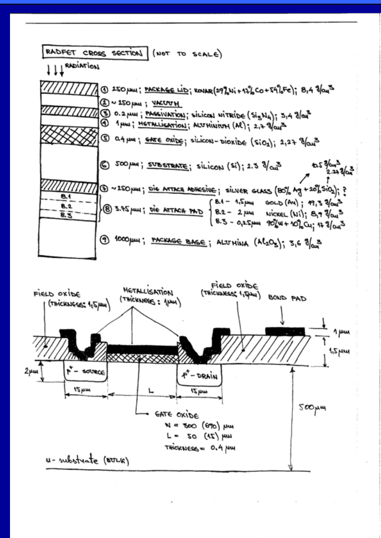

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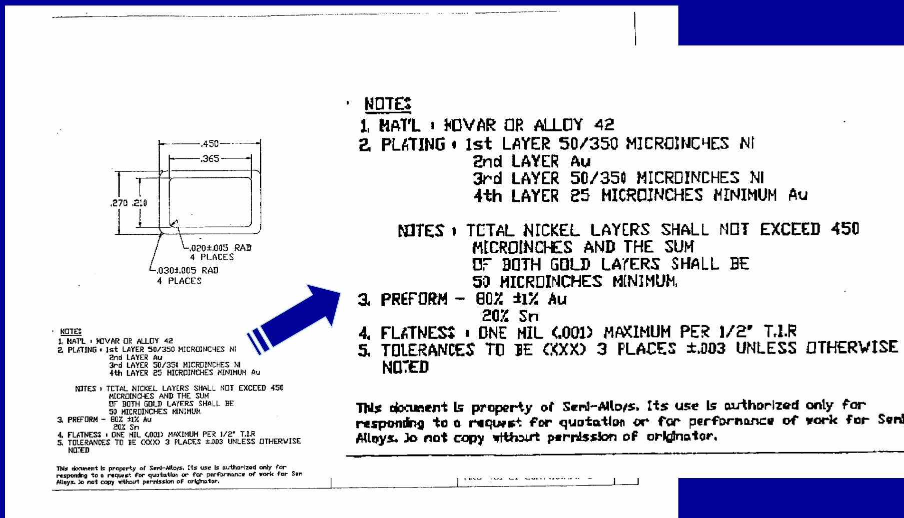

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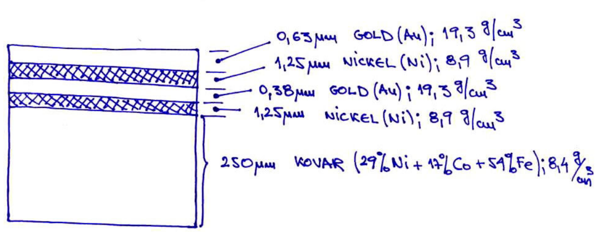
LAYER ① (PACKAGE LID) – MORE DETAILED DESCRIPTION



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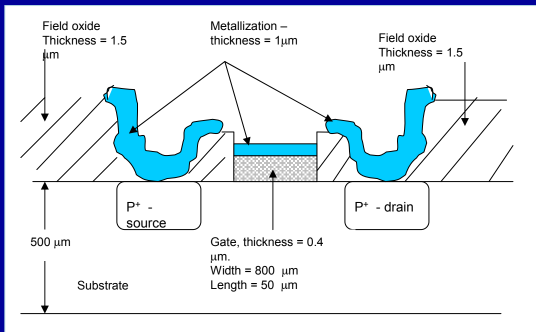

Region 1: 250 µm lid – 29% Ni, 17% C0, 54% Fe
Region 2: 250 µm vacuum
Region 3: 0.2 µm thick passivation – Si_3N_4
Region 4: 1 µm thick aluminium contact
Region 5: 0.4 µm thick gate oxide – SiO_2
Region 6: 500 µm thick silicon substrate - Si
Region 7: 250 µm adhesive – 80% Ag, 20% SiO_2
Region 8: 1.5 µm Au attach pad A
Region 9: 2 µm Ni attach pad B
Region 10: 0.2 mm attach pad C - 90% W, 10% Cu
Region 11: 1000 µm Al_2O_3, base

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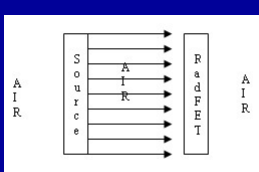
The problems:

1 Calculate the energy response function (for capped and uncapped systems)



2 Consider the effects of uncertainties in the composition of the device:

a) 20% in thickness of region 1
b) 20 % in Ni proportion of region 1
c) 20% in Ag in region 7
d) 200% underestimate of region 8 thickness
e) sensitivity to lateral extent

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	Participant A	Participant B	Participant C	Participant D
MCNPX		X	X	
PENELOPE				X
GEANT 4	X			
FLUKA	X			
FOTELP		X		

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	Participant A	Participant B	Participant C	Participant D
Q1a	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$
Q1b	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$
Q2a	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$
Q2b	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$
Q2c	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$
Q2d	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$
Q2e	$X \pm \sigma_{rand}$	$X \pm \sigma_{rand}$	NO	NO

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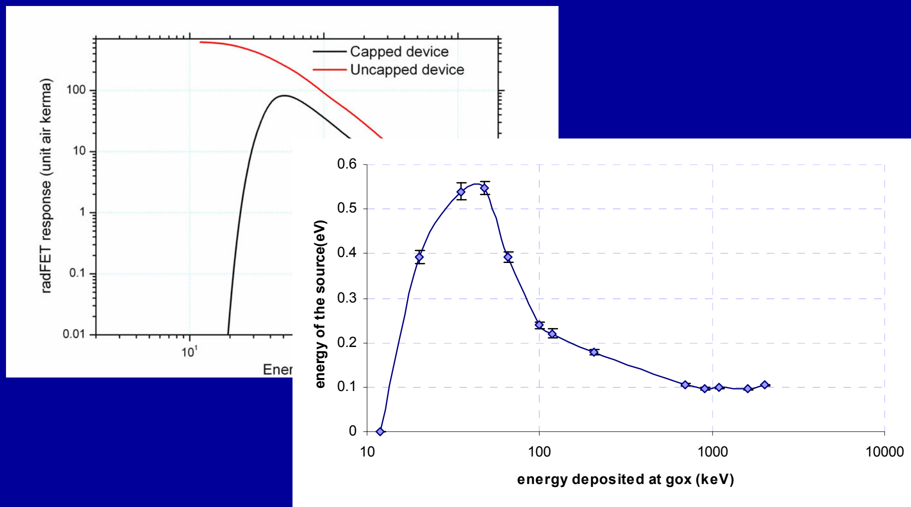

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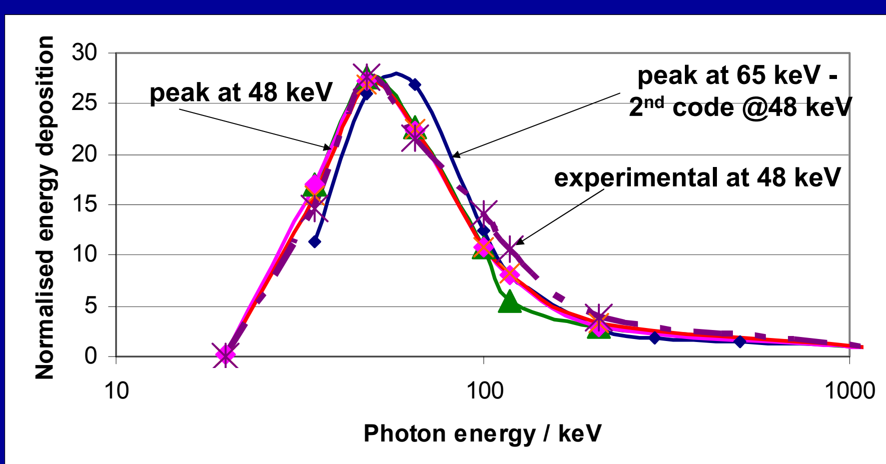

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	Participant A	Participant B	Participant C	Participant D
MCNPX		48 keV	48 keV	
PENELOPE				48 keV
GEANT 4	48 keV			
FLUKA	65 keV			
FOTELP		48 keV		

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	Participant A	Participant B	Participant C	Participant D
MCNPX		**27.65$\pm$0.06**	**27.23$\pm$1.17**	
PENELOPE				**26.81$\pm$2.17**
GEANT 4	**26.74$\pm$1.65**			
FLUKA	**26.82$\pm$1.37**			
FOTELP		**26..9$\pm$0.11**		

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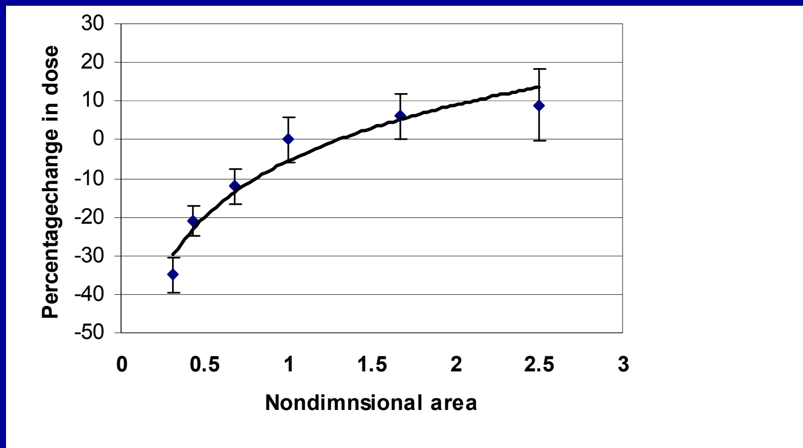

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	Participant A	Participant B	Participant C	Participant D
Uncertainty budget	Yes	No	No	No

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Components of uncertainty budget from problem specification

- Code statistics
- Uncertainty in layer thickness
- Uncertainty in composition
- Uncertainty in kerma calculation
- Uncertainty in energy of maximum
- Uncertainty in iso energy
- Geometrical truncation
- Cross-sections
- Code space

etc

Simple assumption - independent

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Components of uncertainty budget from problem specification

	Variation
Stats	3 % @ conv.
Lid thickness	7% @10% change
Ni fraction	1% < stats
Ag fraction	nil
Geom trunc.	10 %
X-sections	assume 5%
Codes	4%

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Mean value @ peak 48 keV

27.42±14%

Much higher than the 1 - 3% statistical uncertainty usually reported !

If we ignore all but lid and geometric truncation - 12 %