A New Algorithm for the Panasonic UD-802

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Abstract

In response to the revised standard for whole body dosimeter testing, HPS N13.11-2001, a function style algorithm has been designed for the Panasonic UD-802 dosimeter. This new algorithm, to be implemented at the Callaway Plant, successfully meets the challenges of the new test fields, including mixtures of beta or neutron with low energy photons, as well as accommodating the expanded range of photon energies. The development of the new algorithm and the standard Panasonic algorithm that it replaces are discussed with respect to the revised standard.

Today's Presentation

- Background
  - Panasonic UD-802 design
  - ANSI N13.11-1983
  - Standard Panasonic algorithm
  - HPS N13.11-2001
- Challenges and solutions
- New algorithm design
- Test results
- Cautions

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Panasonic UD-802 Dosimeter

Phosphor	Filtration (approx.)	Use
E1 $Li_2B_4O_7$	20 mg cm^{-2} plastic	Beta
E2 $Li_2B_4O_7$	300 mg cm^{-2} plastic	Beta/photon
E3 $CaSO_4$	300 mg cm^{-2} plastic	Photon
E4 $CaSO_4$	900 mg cm^{-2} lead	Photon

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Response matrix of the UD-802

Field	Energy	E1	E2	E3	E4
M30	20	0.765	0.637	10.405	0.378
NS-25(prelim)	20	0.821	0.762	13.198	0.545
H50	39	0.817	0.793	11.903	1.302
NS-80	65	0.772	0.764	7.056	1.424
H100	83	0.770	0.761	4.572	1.274
NS-120	100	0.750	0.747	3.364	0.956
H150	118	0.788	0.775	2.524	0.906
H300	251	0.905	0.895	1.581	0.914
Cs	662	0.956	1.000	1.000	1.067
Co	1250	0.950	0.977	0.901	0.880

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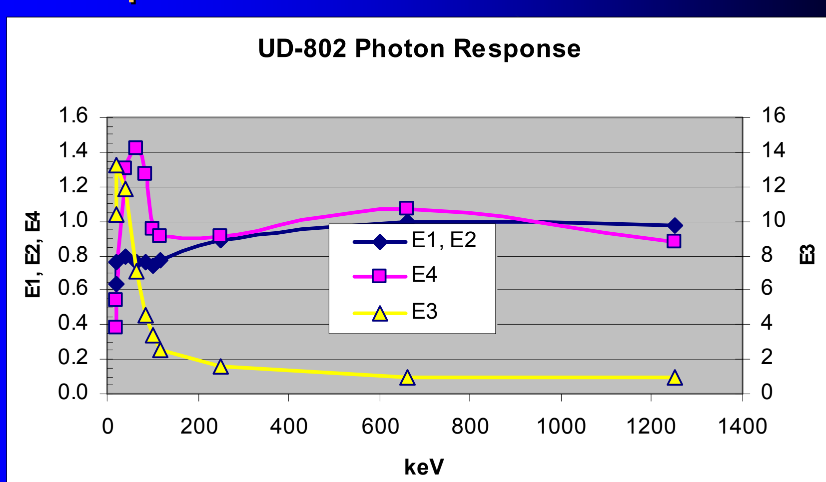
Response curves for the UD-802



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ANSI N13.11-1983

- Pure fields
  - Photons (5 fields from 20-70 keV)
  - Gamma (^{137}Cs)
  - Beta (^{90}Sr/Y)
  - Neutron
- Mixtures
  - Photons and gamma
  - Beta and gamma
  - Neutrons and gamma

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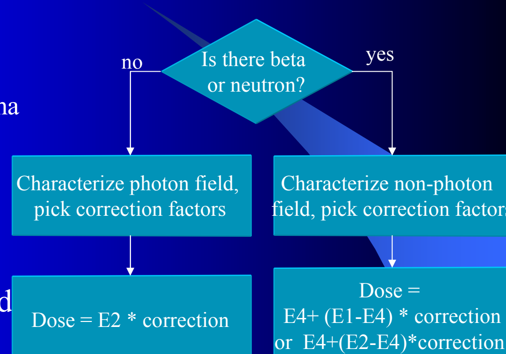
Standard Panasonic algorithm

- Decision style
  - low E photon and gamma
  - **or** beta/neutron and gamma
- Beta signal = E1-E4
- Neutron signal =E2-E4
- Photon correction based on discrete points



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HPS N13.11-2001 test fields

- Pure fields
  - Low energy photons – over 50 fields from 20 – 200 keV
  - High energy photons - ^{137}Cs and ^{60}Co
  - Betas – 800keV and 2MeV E_{max}
  - Neutron – hard or moderated
- Mixtures
  - High and low photons
  - Any photon plus beta
  - Any photon plus neutron

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Challenges for standard algorithm

- Photon/beta and photon/neutron mixtures
  - Non-photon response (beta or neutron) not accurately estimated with E1-E4 or E2-E4 (see the response graph)
  - E4 subtracts too little for the very low photon fields, and too much for the others
- Additional photon fields
  - Discrete correction factors not as accurate between points

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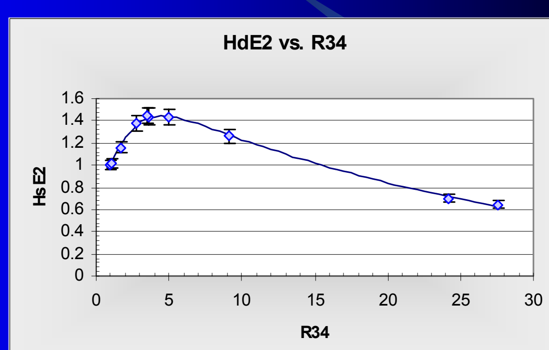
Solution – a new design

- Function based correction factor to determine photon contribution to E1, E2
  - Use a function that predicts the ratios E1/E4 and E2/E4 based on photon field
  - The fraction of E4 response subtracted from E1, E2 depends on photon energy
- Function based correction factors for photon doses
  - Smooth fit to full range of photon energies

Example Function HdE2

Deep dose correction factor for E2.

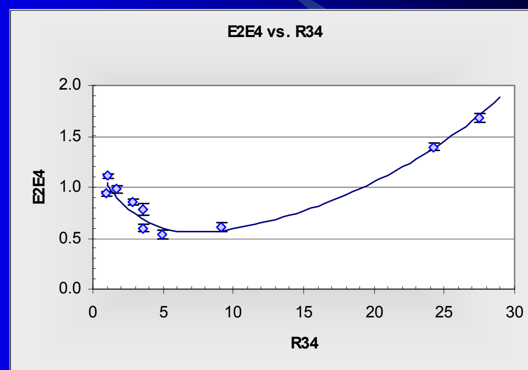
Within 2% from 20keV to ^{60}Co



Example function E2E4

Ratio of E2 to E4 photon response.

Within 15% from 20keV to ^{60}Co



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New algorithm general flow

- Photon field calculations
  1. Characterize photon field (E3/E4)
  2. Calculate photon correction factors
  3. Calculate photon dose estimates using E2 and E4 with correction factors
  4. Calculate estimated photon interference on E1 and E2 using E4 with correction factors

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New algorithm general flow (ctd.)

- Non-photon calculations
  1. Calculate non-photon signals, NetE1 and NetE2, by subtracting estimated photon contribution
  2. Characterize field using ratio of NetE1/NetE2
  3. Calculate appropriate correction factor from characterization
  4. Calculate non-photon dose using net responses and correction factors
  5. Test non-photon dose for significance

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New algorithm general flow (ctd.)

- Calculate total doses
  1. If non-photon component is significant <u>and</u> interferes with E2, use only E4 for photon dose. Otherwise use combination of E2 and E4 for photon dose.
  2. If non-photon component is not significant, set equal to zero (and use combination of photon dose estimates based on both E2 and E4)
  3. Sum photon dose with any significant non-photon dose.

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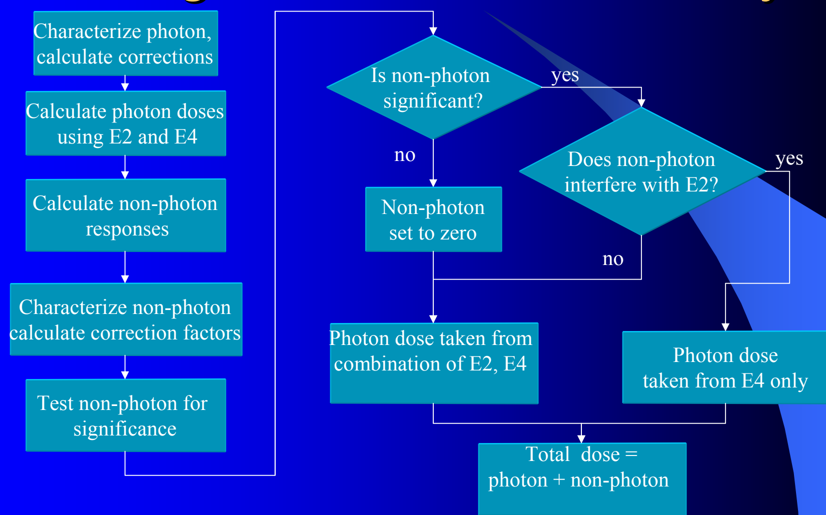
New algorithm flow - summary



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Testing

- Photon of the month
  - 4 groups of 5 new energies
  - 90% < 10% bias, all < 20%
- Synthetic testing
  - Use calculated element responses to test to a wide range of mixtures without the time and cost of irradiations

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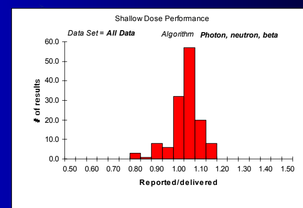
Synthetic testing results

- Synthetic testing to over 130 pure and mixed fields: ^{137}Cs, ^{60}Co, $^{90}Sr/Y$, ^{204}Tl, D_2O mod ^{252}Cf, 8 x ray fields from 20-250 keV
- Ratios of 1:3, 1:1 and 3:1 for mixtures of high and low energy photons, photons and beta, and photons and neutron.
- Single algorithm



Results of synthetic testing
bias=observed/delivered

Min	0.760
Max	1.144
Average	1.005
+/- 10%=	85%
+/-20%=	98%

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Cautions

- The Panasonic UD-802 cannot be relied on to accurately measure neutron and beta in the same issue cycle.
  - There are neutron and beta mixtures that show the same exact responses as photon and beta, but require very different correction factors.
  - Best approach is to use separate badges, one insensitive to either beta or neutron, when in mixed field conditions.
- Different Panasonic systems show different response matrices even for the same dosimeter model. For best results **generate your own system-specific matrix**.

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Dosimetry program support since 1988

- Algorithm development and revision
- Program assessment
- Troubleshooting
- Training
- Program documentation
- System testing

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