ELECTRONIC VS PASSIVE DOSIMETRY

CAN'T WE ALL JUST GET ALONG?

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Introduction

- Passive dosimeter (TLD, OSLD, film) typically provides the dose of legal record (DLR)
- Electronic dosimeter (ED, DRD, SRD) used as secondary dosimeter
- Problems arise when we expect them to be identical
- Expectations need to be reasonable

Passive Dosimeter

- Used as primary dosimeter
  - No immediate readout, no alarms
  - Processed by accredited laboratory, must satisfy QA requirements of ISO 17025
  - Used to **document** doses, establishes dose of legal record (DLR)

Electronic Dosimeter

Used most commonly as secondary dosimeter

- Immediate read out
- Alarm options, data logging, data upload, access control
- Most commonly used for photon DDE
- No specific, *issued*, ANSI std, but incorporated into N13.11 since 2001
- Use to **control** doses

Expectations

- Copy from promotional info on popular electronic dosimeter:
  - *Operational dosimetry for personnel working with ionizing radiations sources. X-Ray and gamma: 20 keV to 6 Mev HP (10) deep dose equivalent Accuracy: <+-5% (Cs 137, 0.2 mSv/hr; 20mRem/hr)*
- What's it saying?
  - +/- 5% for ^{137}Cs at a dose rate of 20 mrem/h

From summary of IAEA study (2007)

- "… the general dosimetric performance of the tested APDs is comparable to the performance of standard passive dosimetric systems [2, 4], (except for beta and low photon energy radiation and pulsed radiation fields). The accuracy at reference photon radiation, the reproducibility and repeatability of measurements are even better than for most passive dosimeters."
- "However, the study highlights that not all the devices have been designed for any radiation field and that the end-user should take into account at least information about the dose equivalent rate and energy ranges before using the dosimeter. It is also shown that two different APD can measure simultaneously $H_p(10)$ and $H_p(0,07)$ for low and high penetrating radiation with satisfactory results."

Emphasis added

Problems/challenges

- Worker sees ED result, seems more “real”
- RP gets to tally cumulative man-rem from ED
- What if they are different
  - TLD problem
  - ED problem
  - No problem, just different
    - Background
    - Energy response
    - MRD

Comparing Doses

- Generally accepted rule is +/-25% for doses > 100 mrem

  "Most of the groups felt that further investigations were not required when dosimetry results compared within 25 % above 100 mrem."

  - From 1998 Electronic Dosimetry Workshop

- Limit to > 100 mrem reduces impact of background subtraction differences
- +/- 25% accommodates energy response differences

Possible Causes of Differences

- Background subtraction
- Photon energy dependence
- Effect of phantom
- Site “calibration” factor
- Dose rate dependence
- Penetrating beta radiation
- Environmental conditions (temp, humidity, RF interference)

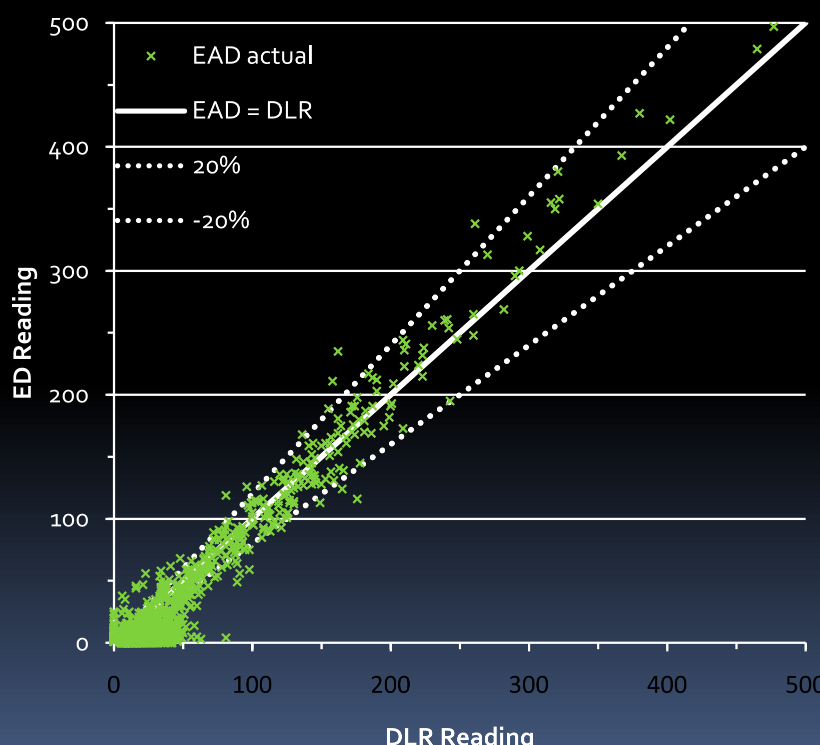
Background Subtraction

- DLR typically is accumulating around the clock, including background. Inaccurate background subtraction will affect the comparison.
- Example:
  - 1500 paired DLR/ED results
  - EOY analysis showed ED -20% compared to DLR, comparing all doses.
  - Limiting comparison to 153 pairs with DLR > 100 mrem brought difference to < 2%.

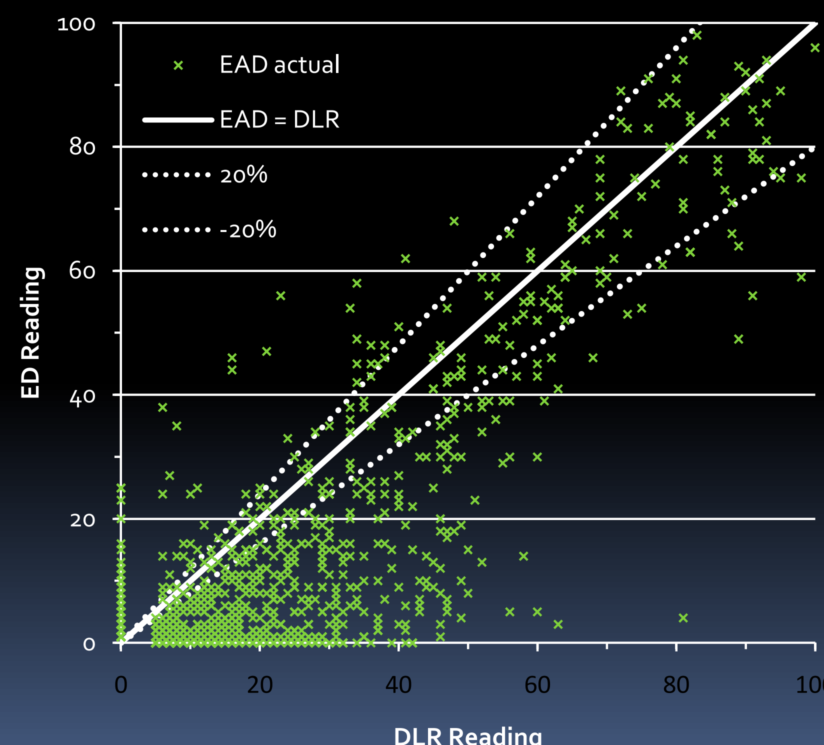
DLR Range	# DLRs	Sum DLR	Sum ED	%diff
0-49	1196	17799	7577	57%
50-99	130	9321	8176	12%
>= 100	153	27217	27626	-2%
total	1497	54337	43379	20%

Background Subtraction example (ctd)

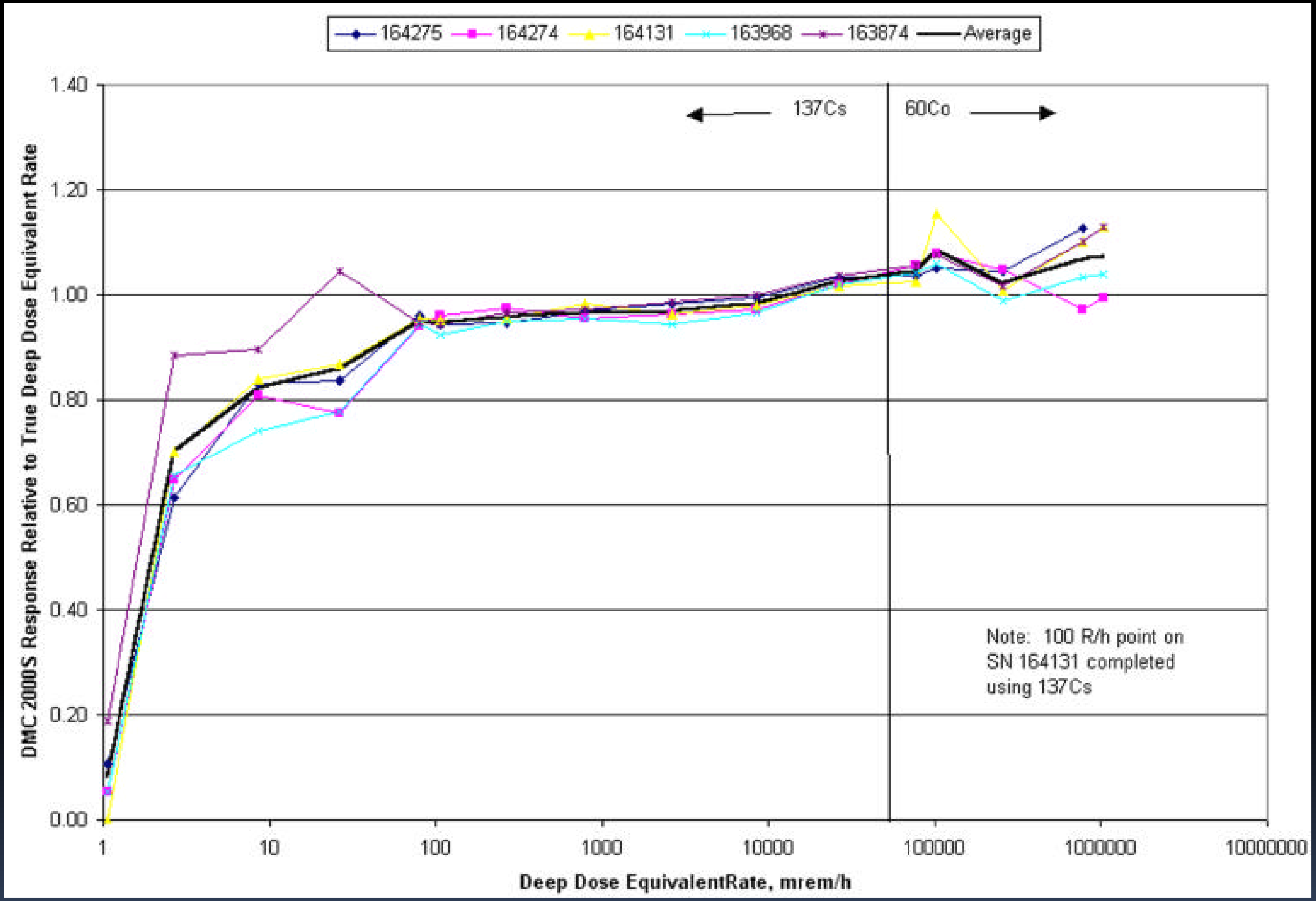
All results



Zoom in on <100 mrem



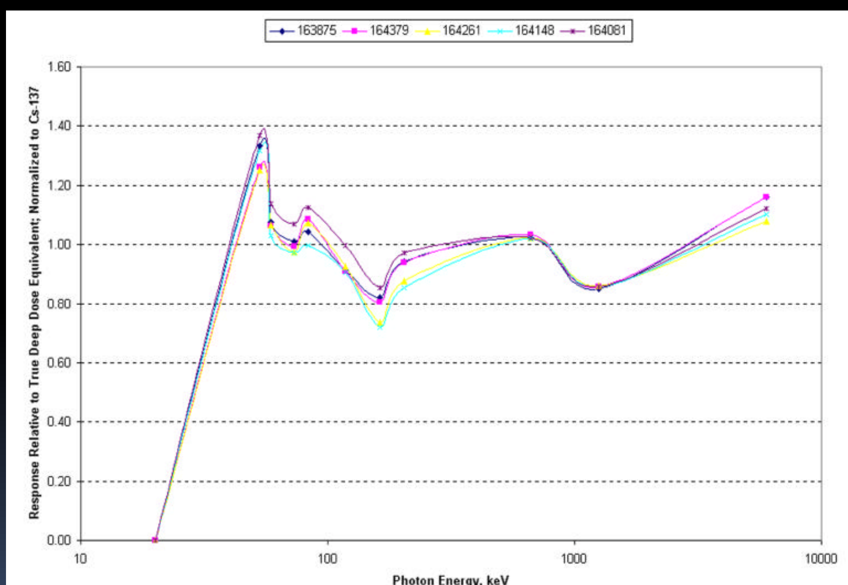
Dose Rate?



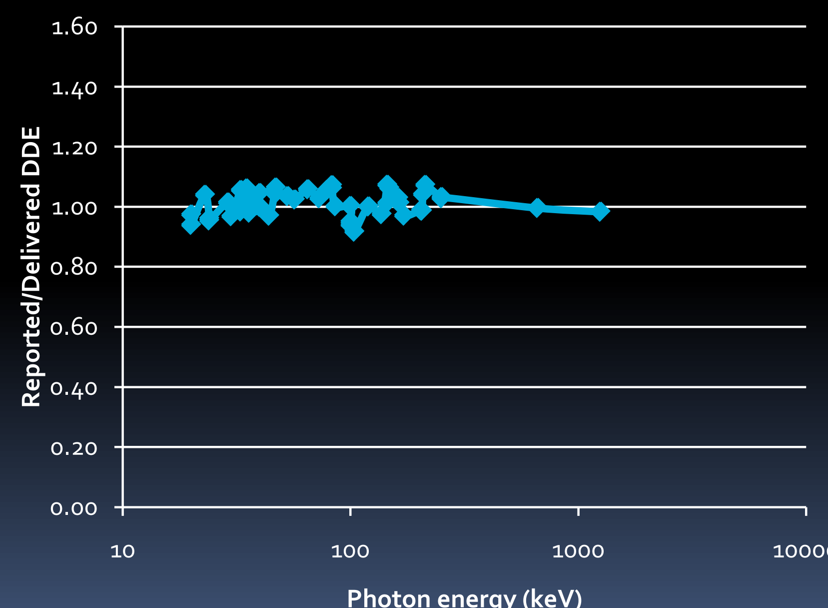
From Reference 6

Energy Dependence?

ED (from reference 6)



Panasonic UD-802



Conclusions/Recommendations

- Only one dosimeter provides the dose of legal record
  - Educate the workforce and management about uses
  - Secondary dosimeter is for dose control and backup
- Differences at low doses are often due to background subtraction
  - Expect better agreement at higher doses
- Differences at higher doses (>100 mrem) are due to systematic bias such as energy response
  - Understand radiation fields
  - Understand dosimeter energy response characteristics
  - Perform side by side test to document differences

Conclusions/Recommendations (cont.)

- Establish adjustments to help ED be a better predictor of DLR results:
  - Add some background/general area component to ED sum
  - Adjust ED calibration to agree with DLR for typical work fields or for some well known field (^{137}Cs)

References

1. **IAEA-TECDOC-1564**; *Intercomparison of Personal Dose Equivalent Measurements by Active Personal Dosimeters*, November 2007
2. **ANSI/HPS N13.11-2009**; *American National Standard for Dosimetry - Personnel Dosimetry Performance - Criteria for Testing*, January 2009
3. **ANSI/HPS N13.11-2001**; *Personnel Dosimetry Performance –Criteria for Testing*, July 2001
4. **RadSafe archives**; http://www.radlab.nl/radsafe/archives/
5. NIST; *Conference report: Electronic Dosimetry Workshop Gaithersburg, MD October 14-16, 1998;* J. Shobe and K.L. Swinth
6. Battelle Memorial Institute, *Evaluation of the MGP Instruments Model DMC 2000s Electronic Dosimeter;* January 2001; http://www.arrowtechinc.com/mgp/PNWD-3040.pdf