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Electret Ion Chamber System for Measurement of Pulsed Radiography X-Ray Units

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INTRODUCTION

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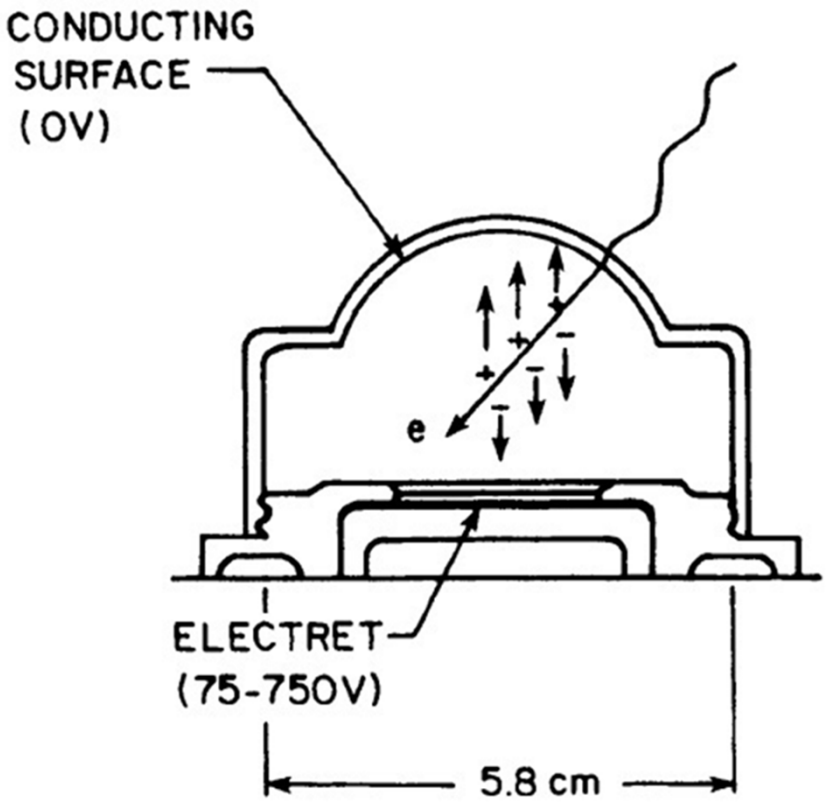
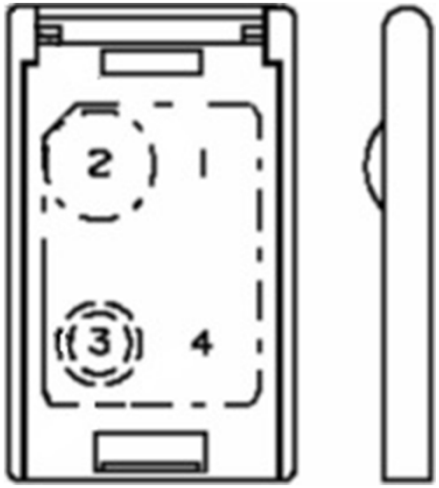
- Research may involve Radiation-Generating Devices (RGD)
  - Ionizing Radiation Field
    - Pulsed
    - Continuous
- Pulsed field measurements problematic
  - Instrumentation may grossly under-respond
- Considering use of Electret Ion Chambers (EICs)
  - In conjunction with; OR
  - Replacement for Thermoluminescent Dosimeters (TLDs)

EIC - Concept of Operation

- Passive integrating ionization chamber
  - Permanently-charged Teflon disc (electret)
  - Conducting plastic chamber
- Ions produced reduce surface charge on the electret
  - Reduction in charge corresponds to quantity of exposure



TLD: Harshaw Model 8825



	Position 1		Position 2		Position 3		Position 4	
	Material	**Thickness**	**Material**	**Thickness**	**Material**	**Thickness**	**Material**	**Thickness**
Chip	TLD-700	0.38 mm	TLD-700	0.38 mm	TLD-700	0.15 mm	TLD-600	0.38 mm
Filter	ABS + Cu	333 mg·cm^{-2}	ABS + PTFE	1,000 mg·cm^{-2}	Mylar	17 mg·cm^{-2}	ABS + Sn	703 mg·cm^{-2}

MATERIALS and EQUIPMENT

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- E-PERM® Electret Ion Chambers:
  - "S" type chamber (58 mL)
  - Short-term (1.542 mm thick) electret
- SPER-1E portable electret voltage reader
  - Voltage measurements were verified with reference electrets
  - Exposure calculated from initial and final voltage measurements
  - Manufacturer's Gamma Radiation Calibration Factor
- Placed in close proximity Harshaw 8825 TLD
  - Read by Radiation Protection Dosimetry Program
- RADCAL Model 9015 with 10X5-6 or 10X5-0.6 probes
  - Measured integrated exposure
  - Chamber varied depending upon expected exposure rate
  - Placed in location with expected elevated dose

METHODS - EVALUATION

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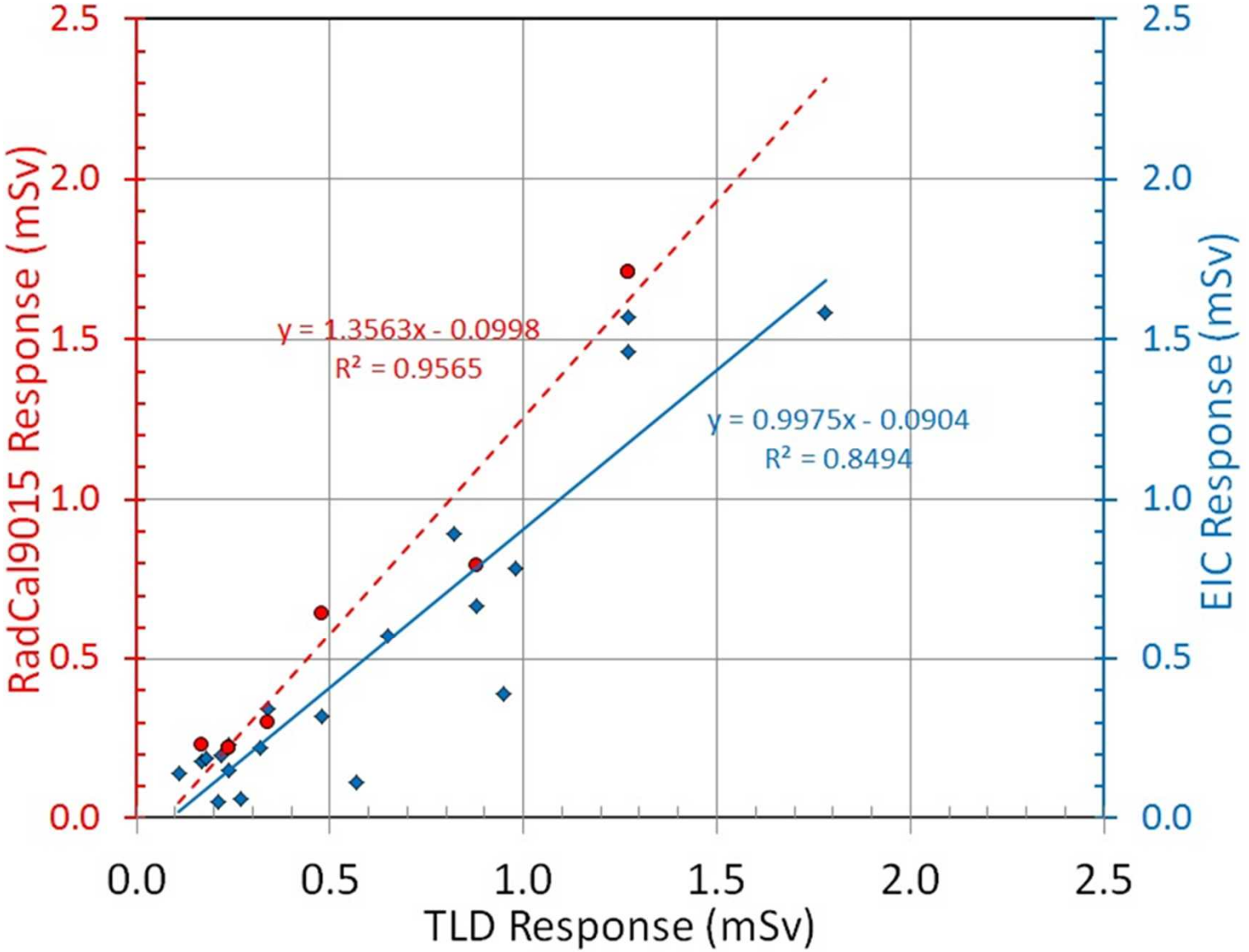
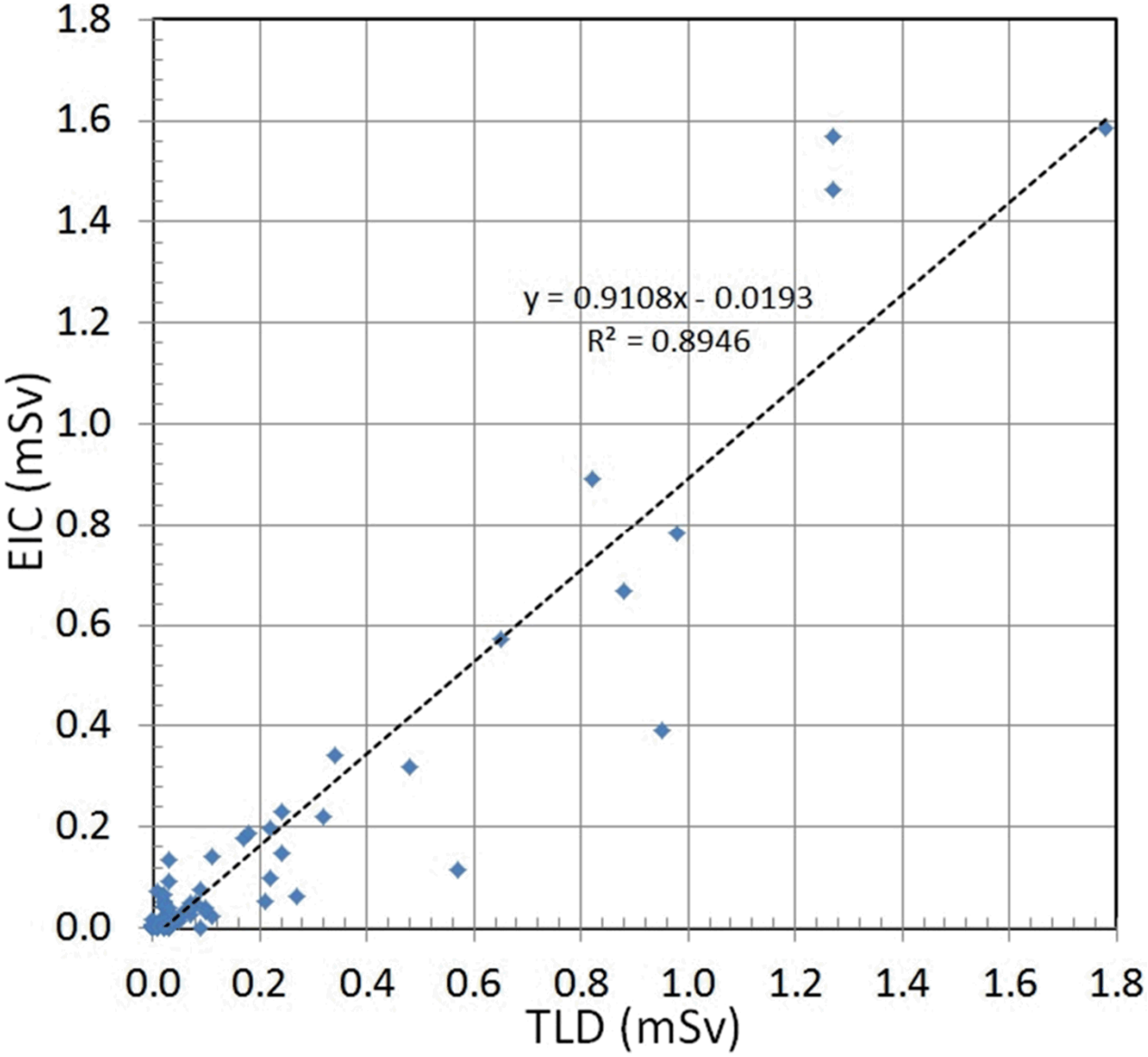
- 10 RGD Surveys:
  - Portable Radiography Units
  - Flash X-ray Units
  - Pulsed LINAC
- 76 Co-Located Measurements:
  - 12 Positive TLD Measurements (>0.1 mSv)
  - 39 Positive EIC Measurements (>4 µSv)
  - 7 Positive Rad Cal 9015 Measurements

EIC (mSv)	TLD (mSv)	RadCal (mSv)	Relative Difference (wrt TLD)	Relative Difference (with respect to RadCal)
0.67	0.88	0.80	-24.3%	-16.3%
0.32	0.48	0.64	-33.8%	-50.6%
0.78	0.98	-	-20.1%	-
0.18	0.17	0.23	4.2%	-22.4%
0.34	0.34	0.30	0.4%	13.3%
1.46	1.27	1.71	15.2%	-14.5%
1.57	1.27	1.71	23.6%	-8.2%
0.23	0.24	0.22	-4.2%	3.8%
0.15	0.24	0.22	-38.2%	-33.1%
0.05	<LLD	0.05	<LLD	5.6%
0.04	<LLD	0.05	<LLD	-14.8%
0.89	0.82	-	8.6%	-
0.05	0.21	-	-74.8%	-
0.39	0.95	-	-58.7%	-
0.11	0.57	-	-79.9%	-
0.57	0.65	-	-11.8%	-
0.06	0.27	-	-77.2%	-
1.58	1.78	-	-11.0%	-
0.22	0.32	-	-31.3%	-
0.20	0.22	-	-10.5%	-
0.14	0.11	-	29.0%	-
0.19	0.18	-	4.6%	-
		Mean:	**-19.5%**	**-13.7%**
		Standard Deviation:	**32.8%**	**19.0%**
		Median:	**-11.4%**	**-14.6%**
		Number of co-located measurements:	**20**	**10**

EIC vs RADCAL vs TLD



EIC vs TLD


y = 0.9108x - 0.0193
R² = 0.8946
EIC (mSv)
TLD (mSv)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8

POTENTIAL ISSUES

- Logistics
  - Electret voltage measurement (pre- and post survey)
  - RCT responsible for QA/QC
- Maximum Exposure Measurement of 2 mSv (200 mrem)
  - Assuming an initial voltage of 750 V and a final voltage of 250 V
- May not meet immediate survey needs for portable radiography units
  - Posting/Boundary verification
  - Changes in radiological conditions

CONCLUSION

- Variability with respect to TLD and RADCAL 9015
  - Likely due to variations in geometry
    - Narrow beam
    - Potentially poor beam characterization
- Adequate for verifying dose rates at posted area boundaries
  - Pulsed portable devices
- Electret voltage reader
  - Portable
  - Easy-to-use under field conditions
  - Conversion of voltage difference to dose challenging for many RCTs

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