

# *Problems and Shortcomings of the RPC Remote Monitoring Program of Institutions Dosimetry Data*

J. A. Bencomo, N. Hernandez, and W.F. Hanson

University of Texas

M.D. Anderson Cancer Center

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# Abstract

Through the years the Radiological Physics Center (RPC) has harvested its database and experience on quality assurance at institutions participating in the NCI sponsored cooperative study groups. The RPC's vast collection of measurements on a variety of accelerator models has allowed the development of dosimetry data sets that represent the parameters that characterize similar machine models used in radiotherapy. These "Standard Data" sets have been used as the basis for a pilot project "Remote Monitoring of Institutions' Dosimetry Data." This program complements the RPC's mailed TLD program, and on-site dosimetry review visits. Details of the program have been presented elsewhere. This poster addresses several shortcoming and problems with the program implementation. Results of the analysis of 20 visited institutions (74 photon beams), which also have been reviewed by the remote program, are presented. The analysis shows that after pooling all data items independently of the category to which they belong, 1270/1414 items that were found to be within the RPC acceptance criteria were confirmed by on-site measurements, 30/1414 items that did not agree with the RPC's criteria were also confirmed by measurements. 78/1414 items that were found to be out of criteria were not confirmed by on-site measurements, and 36/1414 items found within the RPC's criteria were found to be out of criteria by the on-site measurements. This poster will discuss what data to review, the adequacy of criteria for data acceptance, the necessary level of review, review accuracy, and the efficacy of the program in identifying potential problems on the institution data sets.

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# Introduction

The Radiological Physics Center (RPC) has provided radiotherapy quality assurance (QA) to institutions participating in NCI-Funded cooperative Clinical trials since 1972. The RPC is presently monitoring more than 1,240 megavoltage therapy facilities (i.e., approximately 3,900 photon beams, and 1514 machines with electron beams), which are actively participating in one or more cooperative groups. Traditionally the RPC audits are performed on-site by a qualified RPC-Physicist and by a TLD program to monitor machine output calibrations. The on-site dosimetry review is a labor-intensive component of the QA program; therefore, the large number of institutions monitored precludes frequent on-site visits. The RPC has a priority-score schema for on-site visits based on several monitored problem-indicators and the number of protocols patients treated by the institution. Since 1997, the RPC has been implementing an off-site audit program to review dosimetry data and dose calculation for all institutions it monitors. The main objectives of the off-site audit program are:

- To provide a baseline quality audit to all institutions participating in NCI cooperative trials
- To identify, evaluate, and resolve systematic errors in an institution's dosimetry data.
- To complement the RPC priority-score scheme based on unresolved discrepancies and by identifying Machine make and models for which RPC have limited on-site measurement data.

The off-site dosimetry data review includes photon beams and electron beams parameters, Brachytherapy parameters, and reference cases review.

# Materials and Methods

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**The following tools are used to evaluate institution's photon Beams:**

- TLD history for output
- TG-21 Calculations
- Dosimetry data (Compare with RPC “standard” Data)
  - Relative output factors (OPF)
  - Percentage Depth Dose (%DD)
  - Wedge Transmission Factors (WTF)
  - Off-Axis Factors (OAF)

## **Evaluation Criteria**

**The following criteria is used to evaluate the comparison of institution's dosimetry data against the RPC ‘Standard Data’**

*±2 % of RPC “standard data” for OPF, %DD, WTF, and OAF*

# Materials and Methods

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## Standard Data

Institution's photon dosimetry data were compared against "standard data" for a given make and model accelerator.

The RPC database contains photon beams characteristics obtained during on-site review visits for more than 3900 linear accelerator's photon beams. Analysis of these data suggests that machines of the same make and model have nearly identical photon beam dosimetry properties. The RPC has identified "Standard" dosimetry data for 45 different make, model, and energy of linear accelerator photon beams. The methodology for the measurements and comparison between the RPC standard data and the institution's data has been previously presented.

The RPC has developed tables of photon beams standard data for relative output factors, wedge factors, and off-axis factors, percent-depth-dose data, for different energies and megavoltage machine makes and models.

# Materials and Methods

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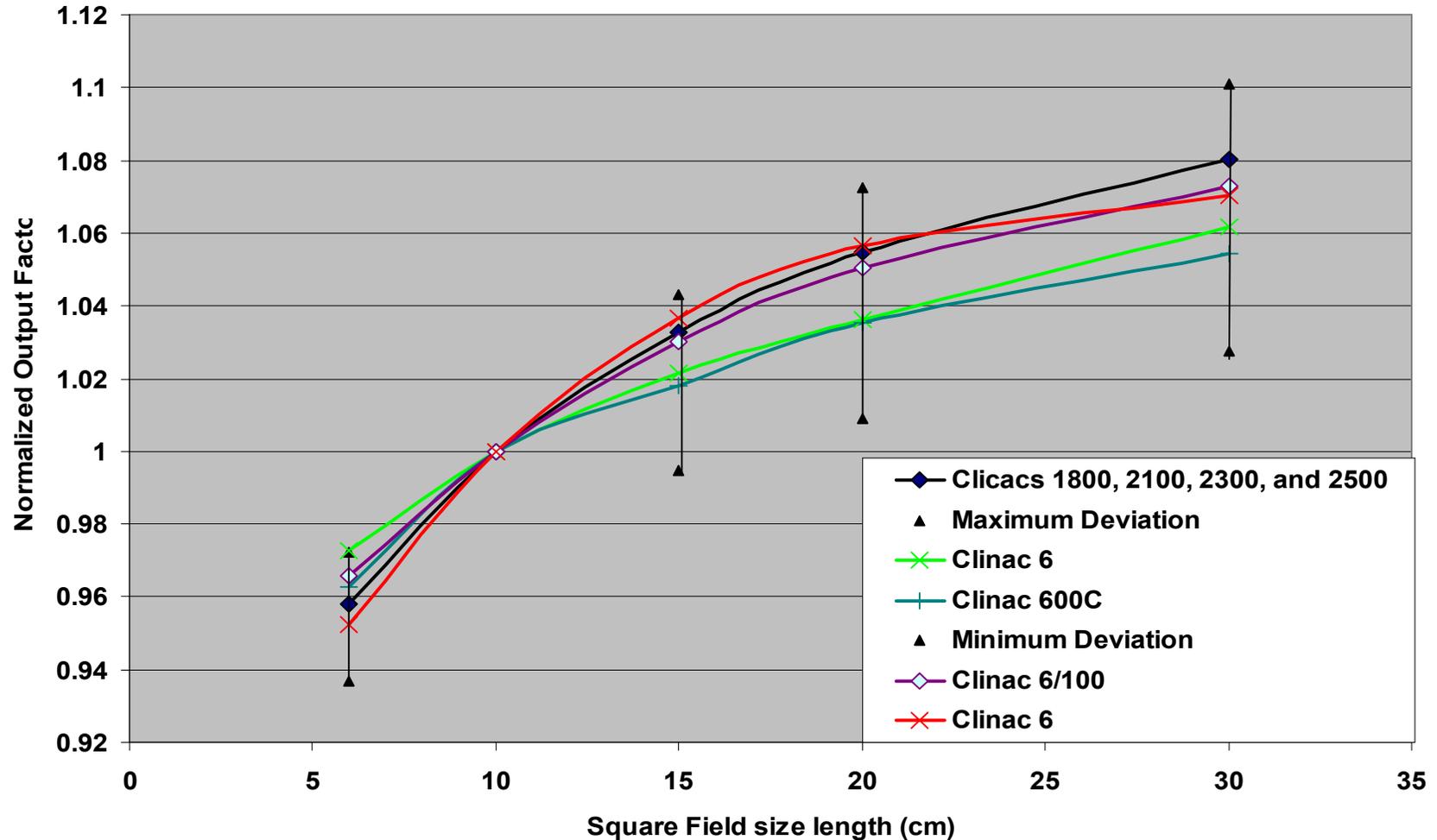
## *RPC “Standard Data”*

### **Standard Data for Photon Beams Include:**

- Output factors (RPC’s Internal Report)
- In-air OA profile (RPC’s Internal Report)
- Depth dose data (Ref. 1 to 12)
- WTF and TF (Ref. 13, 15)
- WTF field size and depth dose (Ref. 14)
- The next few graphs show some of the “Standard data” used by the RPC.

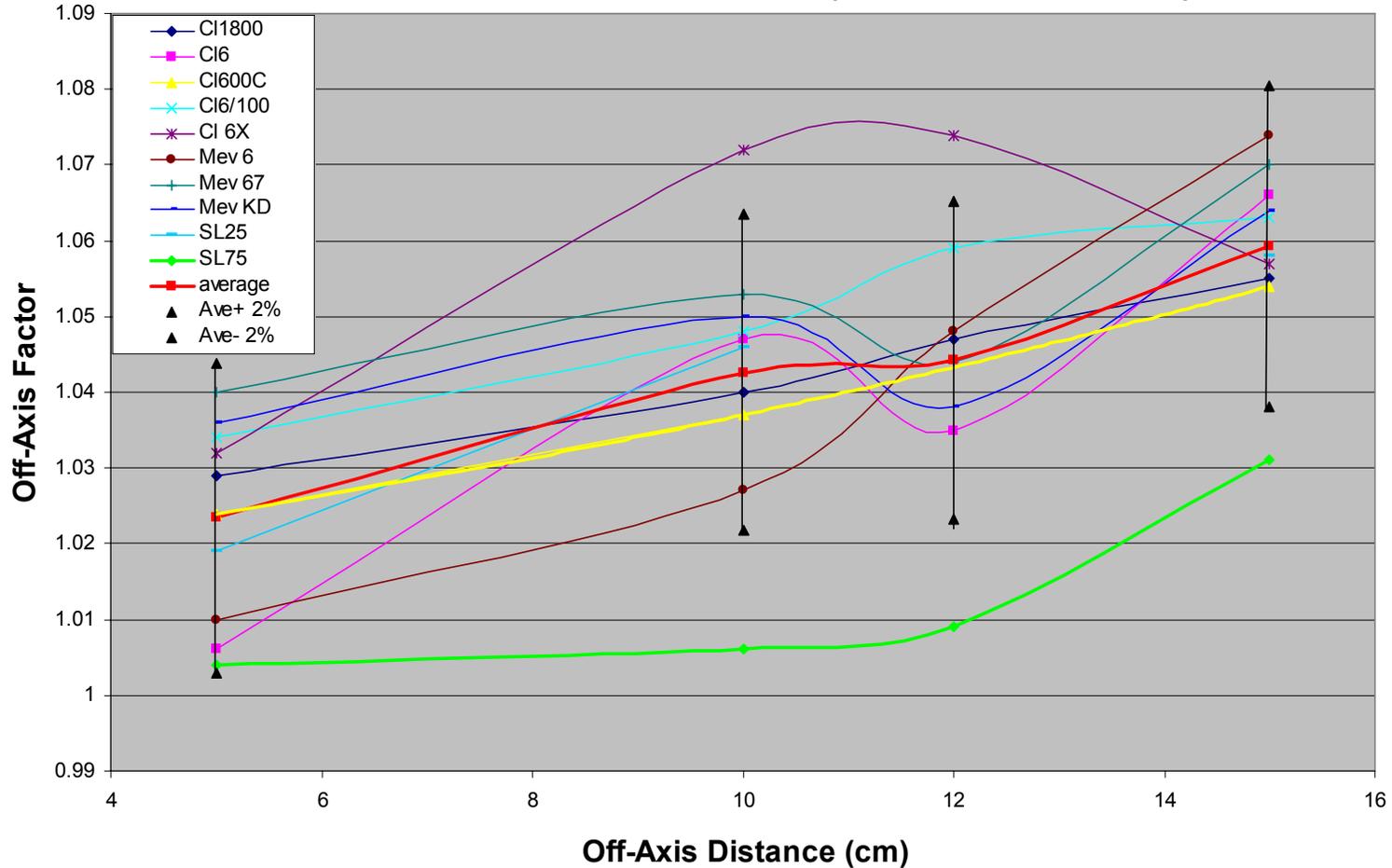
# Materials and Methods

RPC "Standard Data" for the OPF of Several  
Varian Linear Accelerators (6 MV Photon Beams)



# Materials and Methods

RPC "Standard Data" for OAF Measured in Air for Several Manufacturers Linear Accelerators (10 MV Photon Beams)



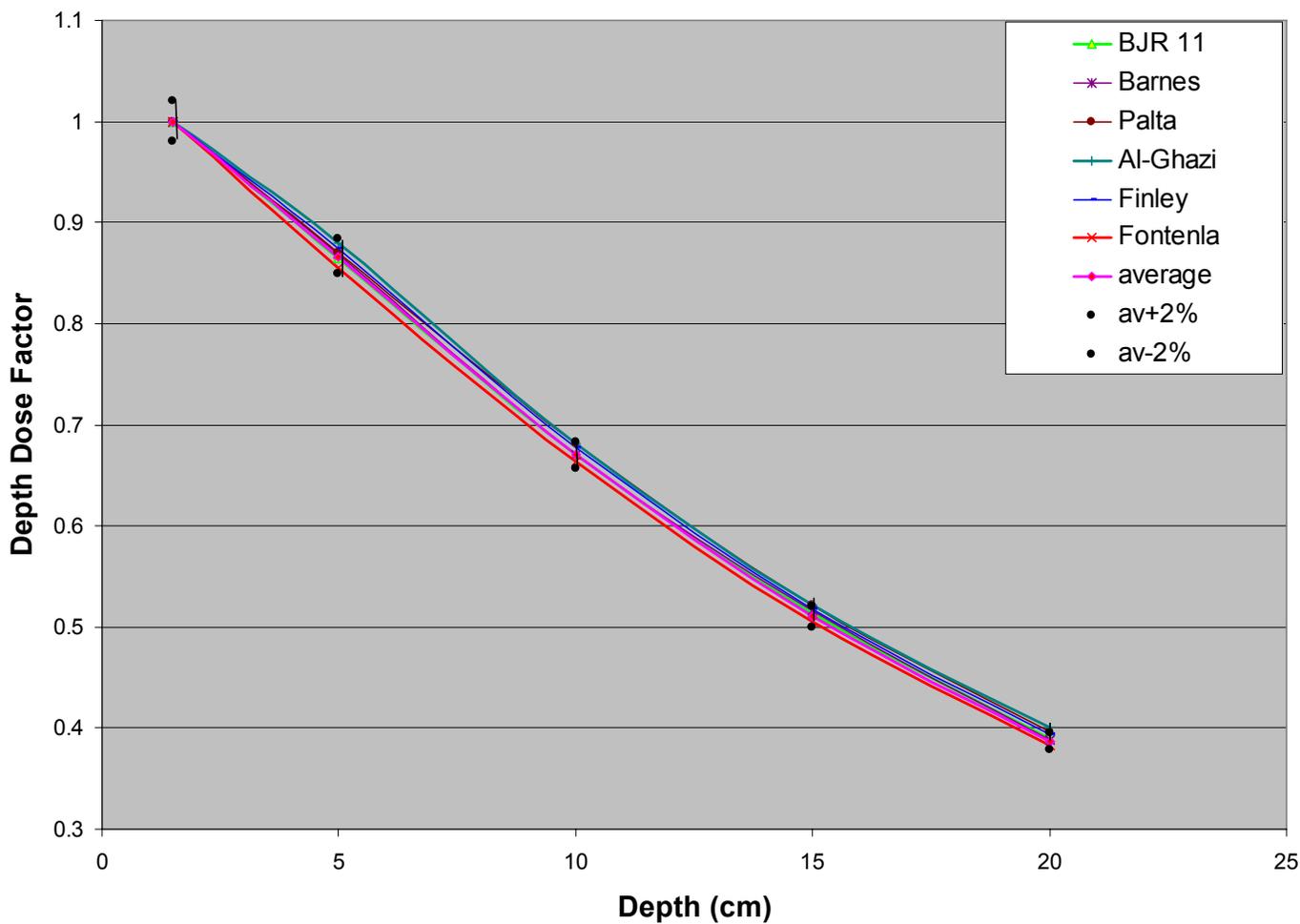
# Materials and Methods

***RPC "Standard Data" recommended for %DD Data for 14 models of Linear Accelerators.***

Machine	Energy(MV)	Data Sets	"Best Fit"*	Min(%)	Max(%)
Clinac 4/100	4	19	Biggs <sup>5</sup>	-1.1	0.5
SHM 4	4	17	BJR #11 4 MV) <sup>6</sup>	-1.5	1.5
Clinac 2100	6	17	Barnes <sup>2</sup>	-0.5	0.6
Clinac 6/100	6	79	Coffey <sup>8</sup>	-0.6	1.2
Clinac 6	6	34	Fontenla <sup>7</sup>	-0.7	0.6
Mevatron 6	6	22	BJR #11 (6 MV) <sup>6</sup>	-1.3	0.2
Mevatron KD	6	15	Al-Ghazi <sup>12</sup>	-0.9	0.4
SL75	8	16	BJR #17 (8 MV) <sup>6</sup>	0	1.9
Clinac 1	10	69	Purdy <sup>3</sup>	-0.4	-0.1
Mevatron 74	10	16	Keller <sup>9</sup>	-0.8	0.6
Mevatron 77	15	7	BJR #17 (16 MV) <sup>6</sup>	-0.4	1.5
Clinac 1800	18	16	BJR #17 (21 MV) <sup>6</sup>	-0.4	0.7
Mevatron KD	18-23	10	Al-Gazi <sup>12</sup>	0.1	0.5
Sagittaire	25	7	BJR #17 (25 MV) <sup>6</sup>	-0.3	0.8

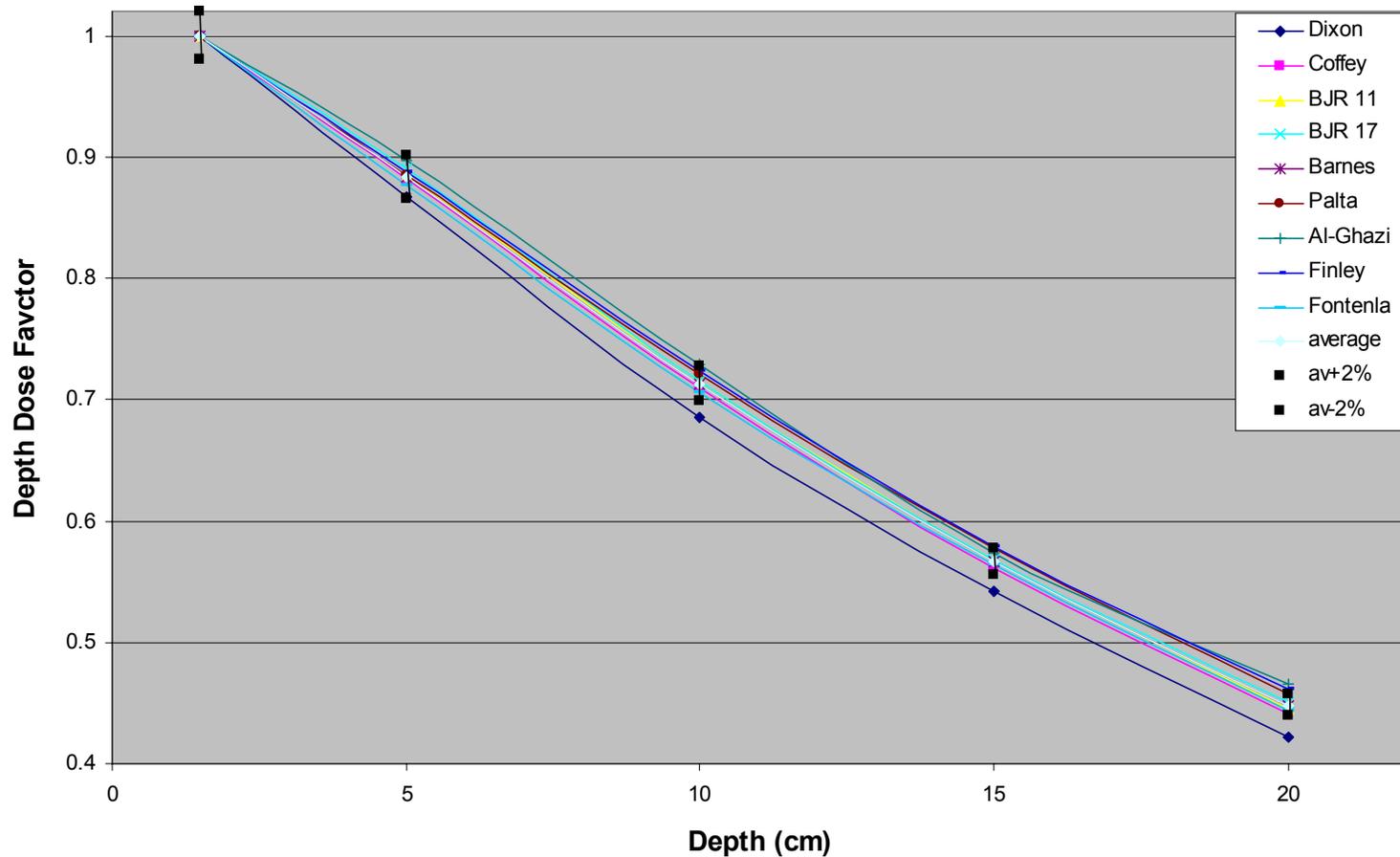
# Materials and Methods

RPC "Standard Data" for %DD data for 6 MV Photon Beams  
(10 cm x 10 cm Field Size)



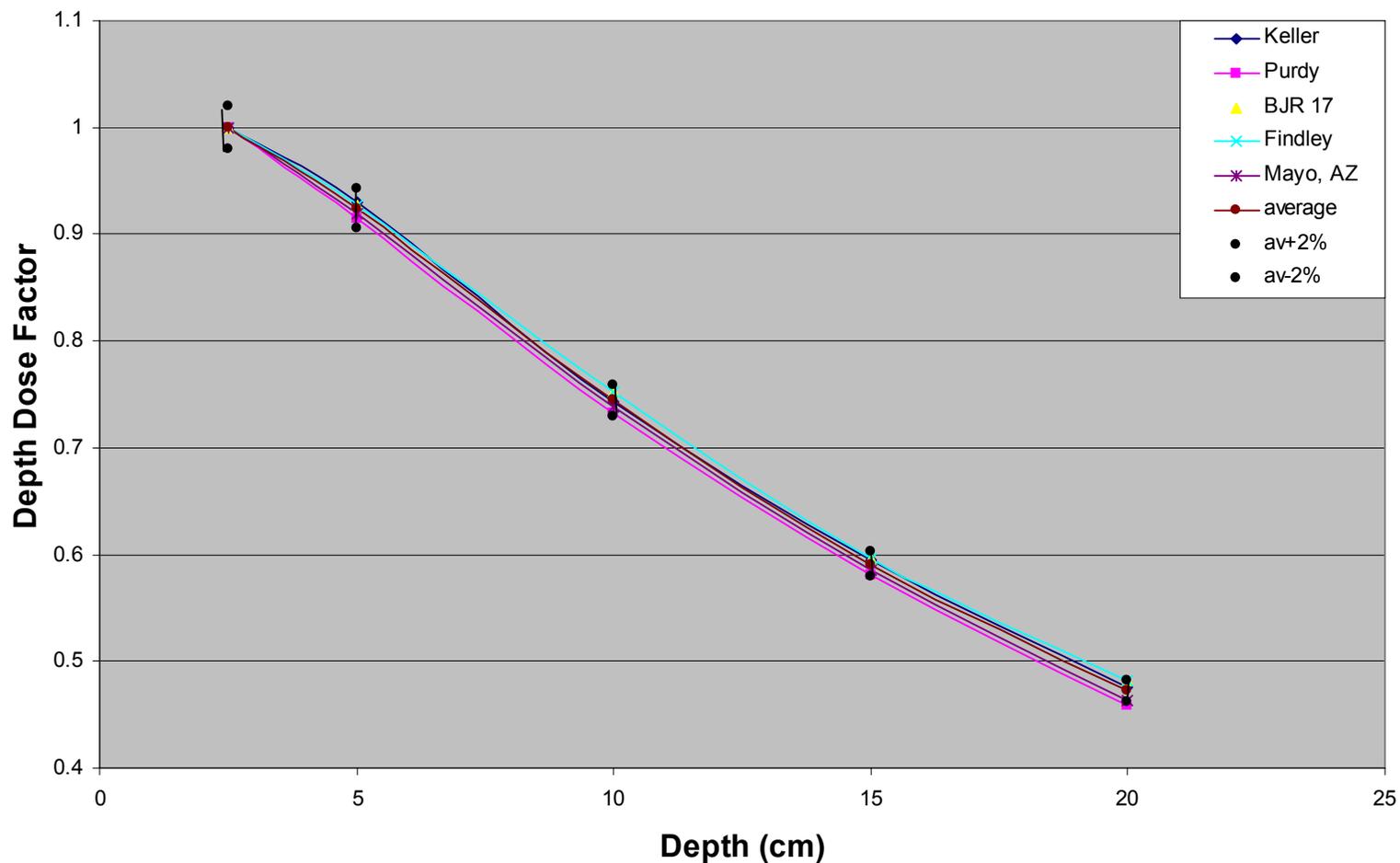
# Materials and Methods

Percentage Depth Dose for 30 cm x 30 cm Field Size for Different  
Published Data for 6 MV Photon Beams of Linear Accelerators



# Materials and Methods

RPC "Standard data" for %DD for 10 MV Photon Beams  
(10 cm x 10 cm Field Size)



# Materials and Methods

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## Analysis of Data

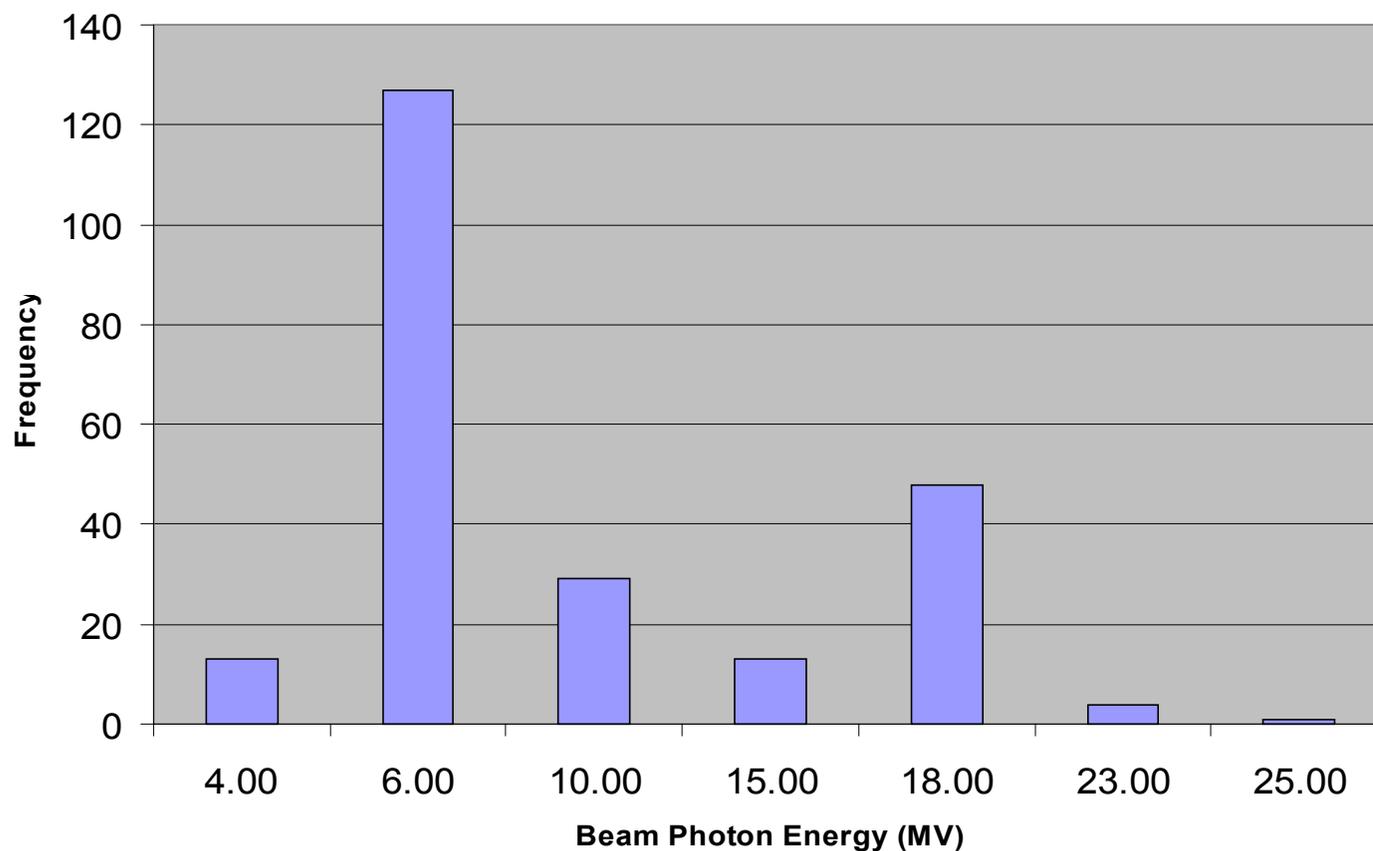
The RPC has received dosimetry data for 218 photon beams from 78 institutions. After a preliminary analysis of these 218 photon beams, several institutions were prioritized for an on-site dosimetry review based on the results of the comparison of institution's dosimetry data to the RPC "standard data". Other institutions were prioritized for on-site review for other reasons.

To date 20 institutions (74 photon beams) have received both on-site and off-site dosimetry review.

The following is the comparison of the parameters measured on-site with the values submitted by the institution.

# Demographics

*Data collected from 78 institutions show the following distribution of Photon Beams energies regardless of machine model and make.*



# Demographics

*Data collected from 78 institutions show the following distribution of Photon Beams by manufacturer and single or multi modality LINACS.*

<b>Machine</b>	<b>Modality</b>	<b># of Machines</b>	<b># of Models</b>	<b># of Beams</b>
Cobalt-60	Single	3	3	5
Varian	Single	9	8	47
	Multi	14	3	121
Seamens	Single	4	4	6
	Multi	8	2	46
Philips	Multi	2	2	3
Mitsubishi	Single	1	1	2
GE	Multi	3	3	4
Dynaray	Single	1	1	1

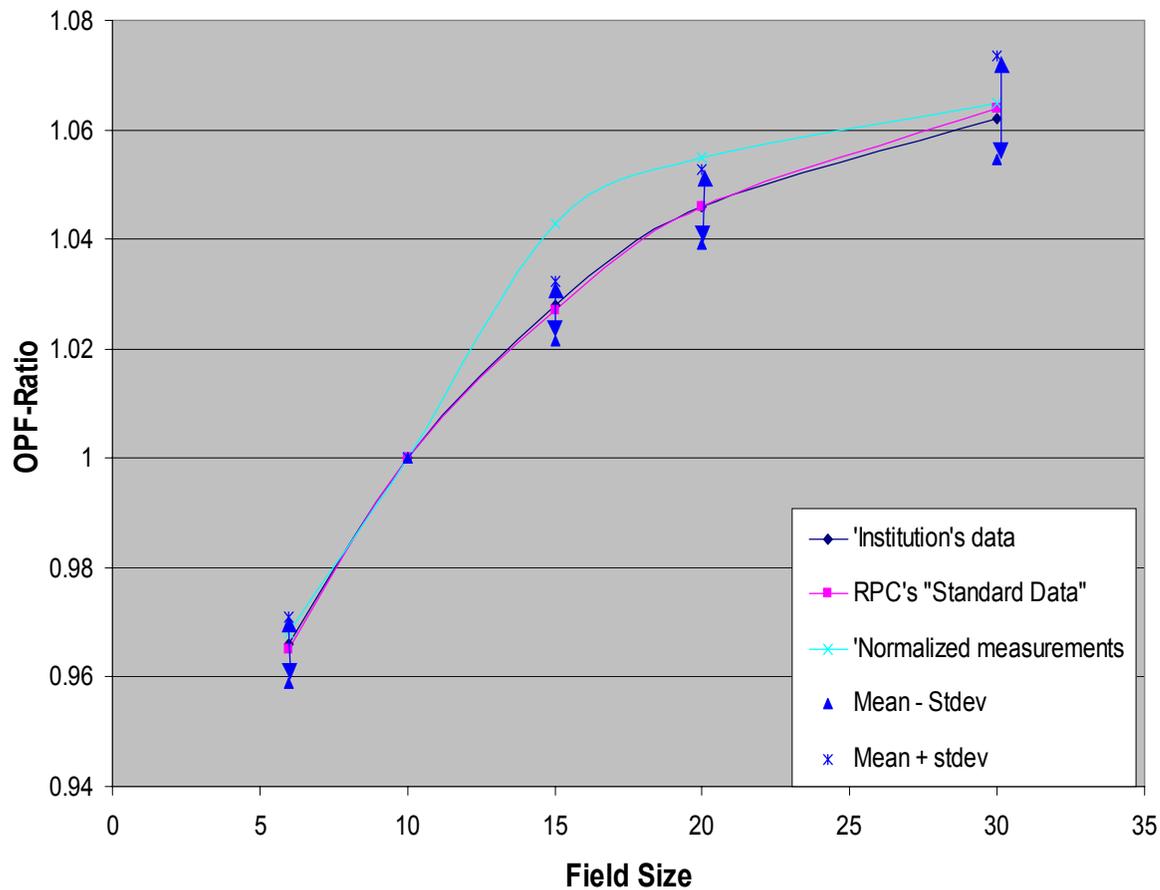
# Results

Evaluation of data sampled from the 20 institutions have identified the following causes of discrepancies between the on-site and off-site reviews.

- An Institution which has multiple sets of data one set was submitted for off-site review, and another for on-site review.
- Incomplete data sets were submitted for the off-site review. This is most significant for wedge transmission, and off-axis data.
- Institutions' %DD and off-axis factors agree with RPC's "Standard Data" but measurements on-site disagree by more than 2% with the RPC's acceptance criteria.
- Institutions with not wedge transmission's factors field size and depth dependence are found to be out off criteria for most institutions visited.
- Institutions that identified beams as 15 MV but it ionization ratio and on-site measurements identified it as 18 MV.
- RPC does not have well defined "Standard Data" for unusual machine models, make, and beam energy combinations.
- Variability on beam parameters and wedge factors among the same machine make and model from the same manufacturer

# Results

Example of Output Factor measured for a Clinac 4 (4 MV ) machine with Institution's data and with the RPC's "Standard Data"



# Results (Output Factors)

The output factors (OPF) for each of the 74 photon beams analyzed were compared with the appropriate RPC' "Standard data" for 6, 10, 15, 20, and 30 cm<sup>2</sup> field sizes. Crosstables for the results were tabulated into two by two tables. There were 249 intercomparisons made.

Crosstable of OPF data pooled by Field Size

On-site Visit Meas. witin criteria	Standard to inst Ratio within criteria	
	Yes	No
Yes	246/249	1/249
No	2/249	0/249

Table shows that:

- (246+0)/249 or 98.8% of the items intercompared were confirmed by measurements.
- No disagreements with standard data were confirmed by measurements.
- There was a prediction error of (1/249) or 0.4% of OPF that were not confirmed by the visit.
- (2/249) disagreements were not detected by the intercomparison with the standard before the visit. (0.8%)

# Results (Off-Axis Factors)

Off-center ratios (OCF) for each of the 74 beams analyzed were compared with the appropriate RPC' standard off-axis factors (OAF) measured in air at 5, 10, and 15 cm off-axis distances. Crosstables for the results were tabulated into two by two tables.

There were 186 intercomparisons made.

Crosstable of OAF data pooled by distance off-axis

On-site Visit Meas. within criteria	Standard to inst Ratio within criteria	
	Yes	No
Yes	159/186	14/186
No	4/186	9/186

The table shows that:

**Note:** The institution's values are OCR measured at  $d_{max}$ . The RPC's OAF "Standard Data" should not exceed the OCR by more than 1-1.5% for large distances from the central axis.

- (159+9)/249 or 98.8% of the OAF intercompared were confirmed by measurements.
- (9/186) or 4.8% of the OAF disagreeing with the RPC "Standard Data" were confirmed by measurements.
- There was an prediction error of (14/186) or 7.5% of the OAF that were not confirmed by the visit.
- (4//186) OAF disagreements were not detected by the intercomparison with the RPC's "Standard Data' before the visit. (2.2%)

# Results (Wedge Factors)

Wedge factors (WF) for each of the 74 photon beams analyzed were compared with the appropriate RPC' wedge factor "Standard Data" for 15, 30, 45, and 60 degree wedges. Crosstables for the results were tabulated into two by two tables.

There were 166 intercomparisons made.

Crosstable of WF data pooled by wedge degree angle

On-site Visit Meas. within criteria	Standard to inst. Ratio within criteria	
	Yes	No
Yes	131/166	31/166
No	2/166	4/166

The table shows that:

**Note:** Institutions which use a single transmission factor, irrespective of field size and depth may incur in significant discrepancies with RPC's On-site measurements.

- (131+4)/166 or 81.3% of the WF intercompared were confirmed by measurements.
- (4/166) items or 2.4% of WF disagreeing with the RPC' "Standard DATA" were confirmed by measurements.
- There was an prediction error of (31/166) or 18.7% of WF that were not confirmed by the On-site Review.
- (2/166)(1.2%) WF disagreements were not detected by the intercomparison with the RPC's WF "Standard Data" before the on-site review.

# Results (% Depth-Dose Factors)

%Depth-Dose factors (%DDF) for each of the 74 beams analyzed were compared with the appropriate RPC' %DDF "Standard Data" for each beam energy, field size, and depth. Crosstables for the results were tabulated into two by two tables for each field size and depth. These tables were combined by pooling data for all the field sizes, depths and energies. There were 797 intercomparisons made.

Crosstable of %DDF data pooled by field size, depth, and beam energy

On-site Visit Meas. within criteria	Standard to inst. Ratio within criteria	
	Yes	No
Yes	134/797	34/797
No	12/797	17/797

The table shows that:

- (134+17)/797 or 94.2% of the %DDF intercompared were confirmed by measurements.
- (17/797) or 2.1% of %DDF disagreeing with the RPC's "Standard Data" were confirmed by measurements.
- There was an prediction error of (34/797) or 4.3% of %DDF intercompared that were not confirmed by the on-site review.
- (12/797)(1.5%) %DDF disagreements were not detected by the intercomparison with the RPC's "Standard Data" before the on-site review.

# Results (Overall Agreement)

The OPF, %DDF, WF, and OAF data for each of the 74 beams analyzed were pooled into a single Crosstable. This table combines the data for all the field sizes, depths and energies. The table gives an overall index of agreement.. There were 1414 intercomparisons made.

Crosstable of all data pooled

On-site Visit Meas. within criteria	Standard to inst. Ratio within criteria	
	Yes	No
Yes	1270/1414	78/1414
No	36/1414	30/1414

The table shows that:

- (1300+30)/1414 or 91.9% of the items intercompared were confirmed by measurements.
- (30/1414) or 2.1% of the items intercompared disagreeing with the RPC's "Standard Data" were confirmed by measurements.
- There was an prediction error of (78/1414) or 5.5% of items intercompared that were not confirmed by the visit.
- (36/1414)(2.5%) of disagreements found by the on-site review were not detected by the intercomparison with the RPC's "Standard Data" before the on-site review.

# Results (Pooled by Beams)

Number of photon beams in each category for each dosimetry parameter compared.

Total Number of Photon Beams Analyzed	OPF	PDD	OAF	WF
	68	74	62	69
Number of Photon Beams, Off-site review found a parameter out of criteria	1	9	7	22
Number of Photon Beams Off-site review found a parameter out of criteria and Confirmed by on-site review	0	8	7	3
No. of Photon Beams Off-site review found a parameter out of criteria but not Confirmed by on-site review	1	9	2	22
Number of Photon Beams with a parameter within criteria that were found out of criteria by on-site review	3	3	3	2
Total number of photon beams with a parameter found out of criteria by either review	4	12	10	24

# Conclusions

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- (10/20) or 50% of institutions institutions visited due to discrepancies suggested by the off-site review were verified by on-site review.
- (16/20) or 80% of the discrepancies predicted by the off-site review were not confirmed by the on-site review.
- (8/20) or 40% of the institutions discrepancies found during the on-site review were not predicted by the off-site review.

Off-site evaluation failed to identify wedge transmission problems in a significant number of cases.

- Wedge transmission continue to be a major concern identified by both the off-site and on-site reviews.

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