Moving Forward – What does this mean for the Medical Physicist and the Imaging Community?

John M. Boone, Ph.D., FAAPM, FACR
Professor and Vice Chairman of Radiology
University of California Davis Medical Center
Chairman, AAPM Science Council
Chairman, ICRU* committee on CT Image Quality & Dose

*International Commission on Radiological Units and Measurement

Moving Forward:

- National / International Activities
- Education and Training
- Clinical: What can we really do?
- Regulations, Accreditation, Certification

Moving Forward:

- National / International Activities
- Education and Training
- Clinical: What can we really do?
- Regulations, Accreditation, Certification

Science Council

Imaging Physics Committee

CT subcommittee

TG-111

TG-200

TG-xxx

Therapy Physics Committee

Research Committee

Technology Assessment Committee

AAPM REPORT NO. 111

Comprehensive Methodology for the Evaluation of Radiation Dose in X-Ray Computed Tomography

A New Measurement Paradigm Based on a Unified Theory for Axial, Helical, Fan-Beam, and Cone-Beam Scanning With or Without Longitudinal Translation of the Patient Table

Report of AAPM Task Group 111: The Future of CT Dosimetry

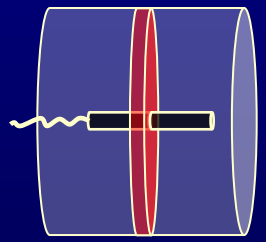
February 2010

Robert L. Dixon, Ph.D., Chair of TG-111

Robert L. Dixon, Chairman
Dept. of Radiology, Wake Forest University School of Medicine
Jon A. Anderson
Dept. of Radiology, UT Southwestern Medical Center at Dallas
Donovan M. Bakalyar
Dept. of Radiology, Henry Ford Hospital
industry **Kirsten Boedeker**
Toshiba Medical Systems
John M. Boone
Dept. of Radiology, University of California Davis
Dianna D. Cody
The University of Texas M.D. Anderson Cancer Center
Rebecca Fahrig
Dept. of Radiology, Stanford University
David A. Jaffray
Princess Margaret Hospital, Toronto
FDA **Iacovos S. Kyprianou**
U.S. Food and Drug Administration
Cynthia H. McCollough
Dept. of Radiation, Mayo Clinic Rochester
Michael F. McNitt-Gray
Dept. of Radiology, University of California Los Angeles
industry **Hugh T. Morgan**
Philips Healthcare
Richard L. Morin
Dept. of Radiology, Mayo Clinic Florida
Keith D. Nakonechny
CancerCare Manitoba
Thomas J. Payne
Abbott Northwestern Hospital
Robert J. Pizzutiello
Upstate Medical Physics
industry **Bernhard T. Schmidt**
Siemens AG
Anthony J. Seibert
Dept. of Radiology, UC Davis Medical Center
William E. Simon
Sun Nuclear Corp.
Thomas W. Slowey
K&S Associates, Inc.
FDA **Stanley H. Stern**
U.S. Food and Drug Administration
Paul Sunde
Radcal Inc.
industry **Thomas L. Toth**
GE Healthcare
industry consortium **Stephen Vastagh**
MITA

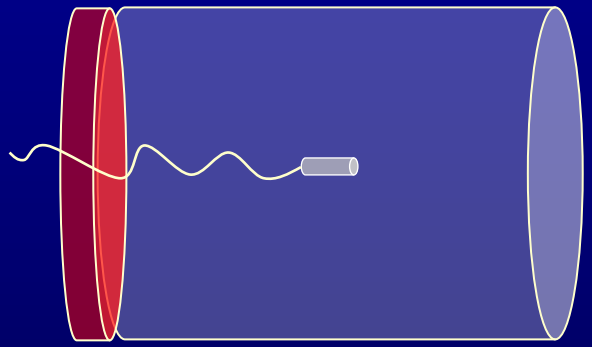
CT dose measurement techniques have not kept pace with CT technology

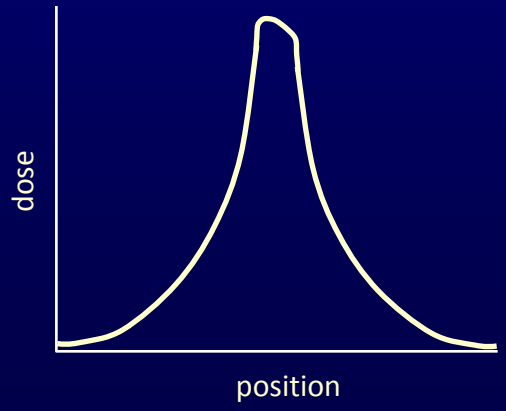
TG-111



$$CTDI_{100} = \frac{1}{nT} \int_{-50mm}^{50mm} D(z) \; dz$$

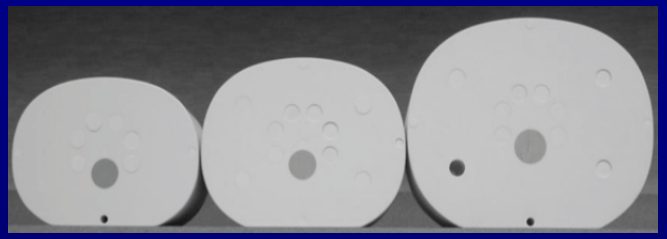
old | new



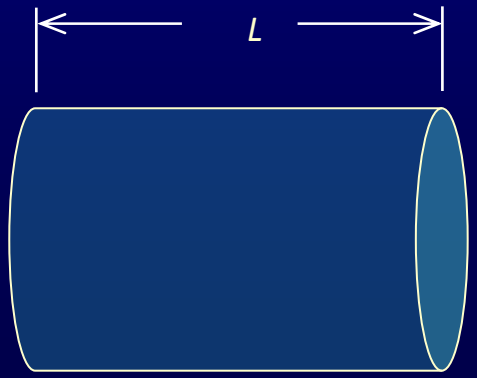


CT phantoms have not kept pace with CT applications or acquisition modes

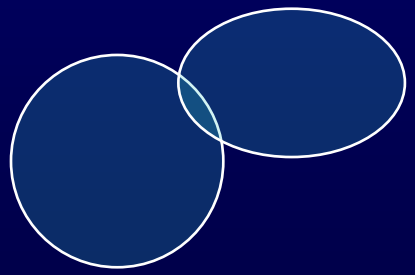
TG-200 Phantoms for CT


Phantom images courtesy of various web sites, Dr. Cynthia McCollough, and Dr. Robert Dixon



Length



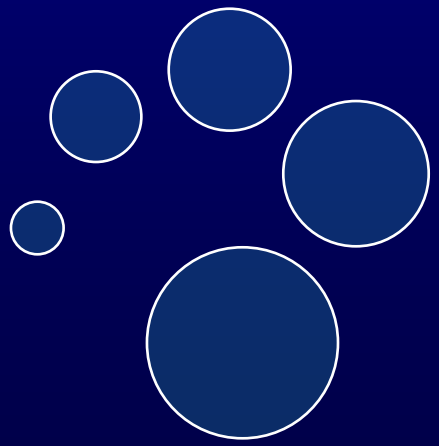
Shape

$(C_5O_2H_8)_n$

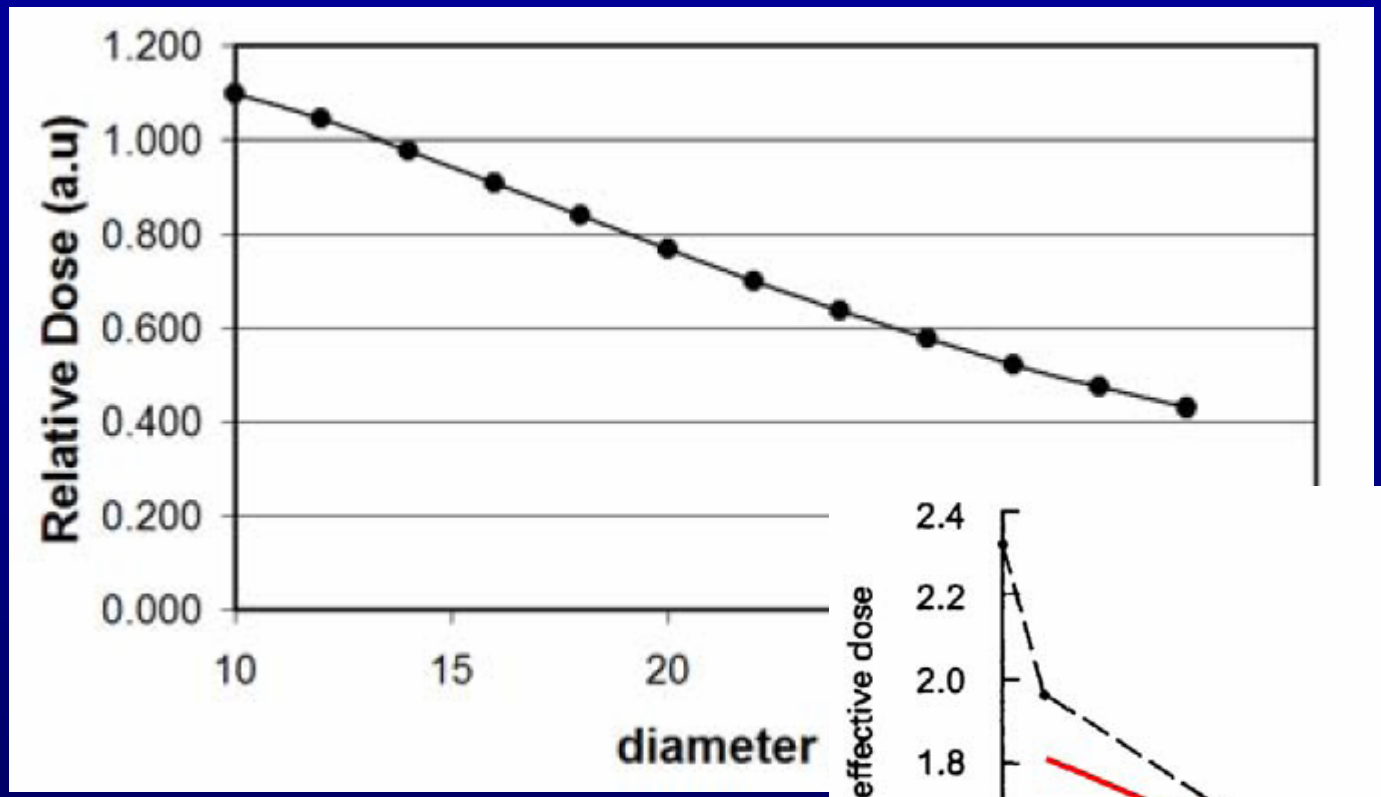
$(C_2H_4)_n$

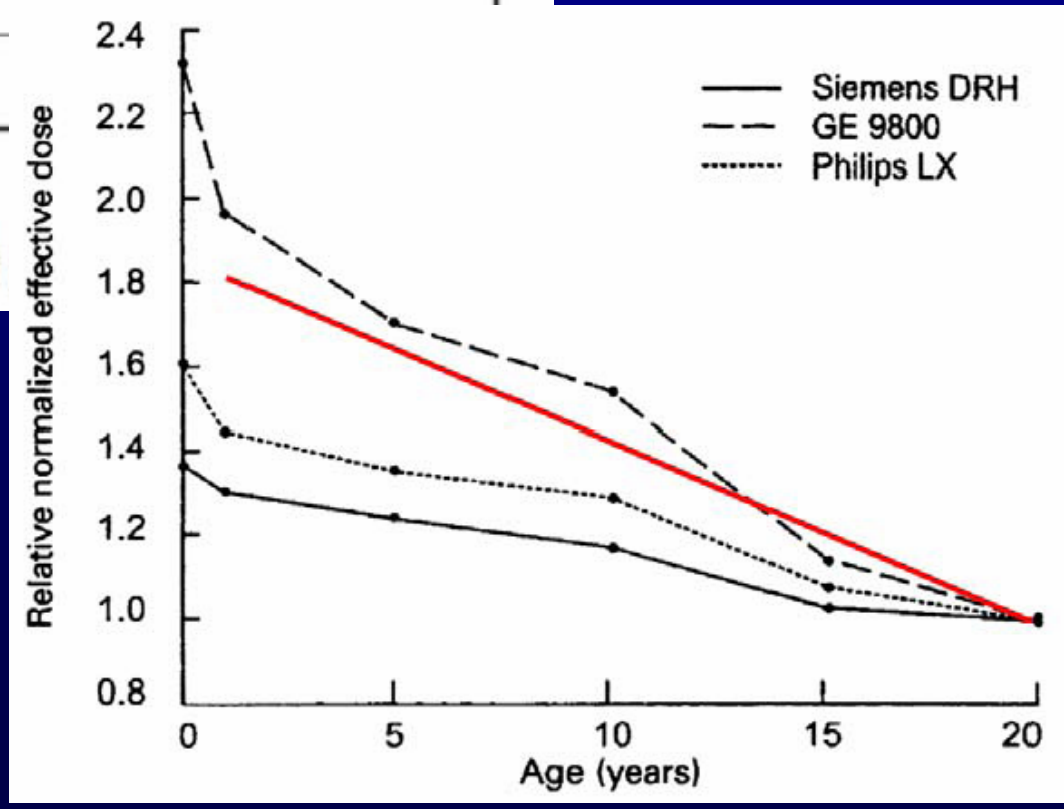
H_2O

Composition



Diameter





TG-xxx

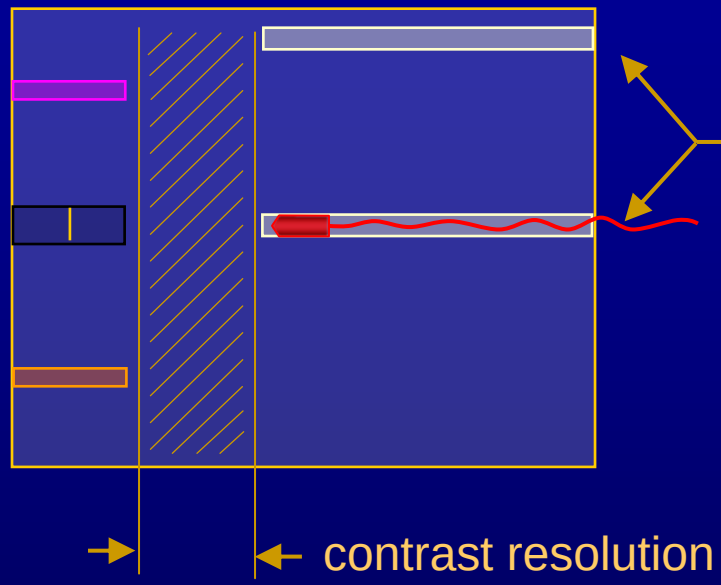
Pediatric $CTDI_w$

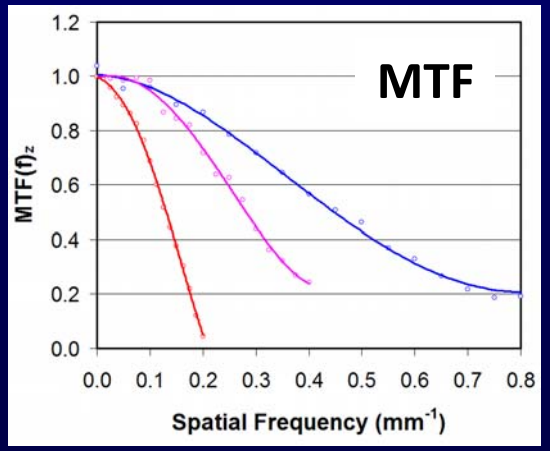
ICRU

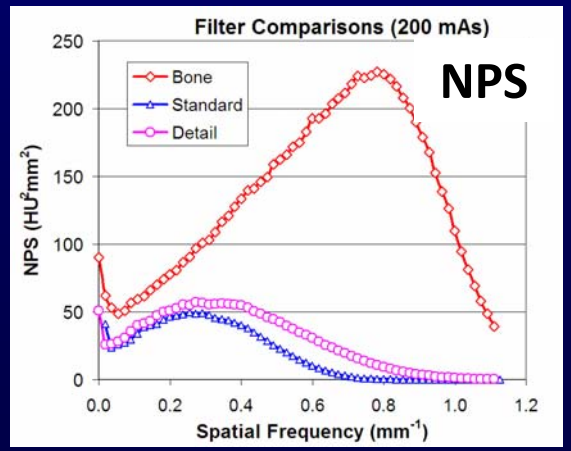
International Commission on Radiation Units and Measurements, Inc.

Patient Dose Assessment and Image Quality in Computed Tomography

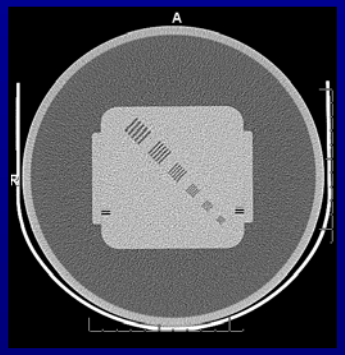
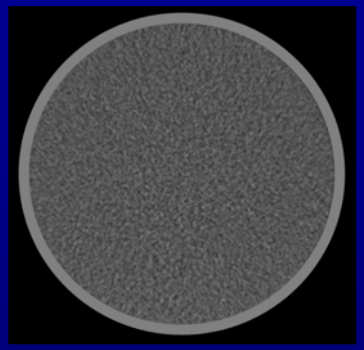
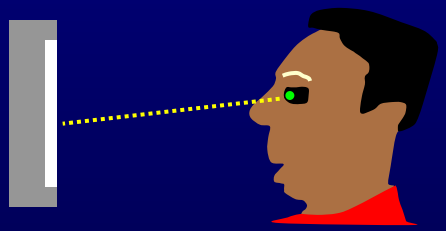
ICRU CT phantom and analyses



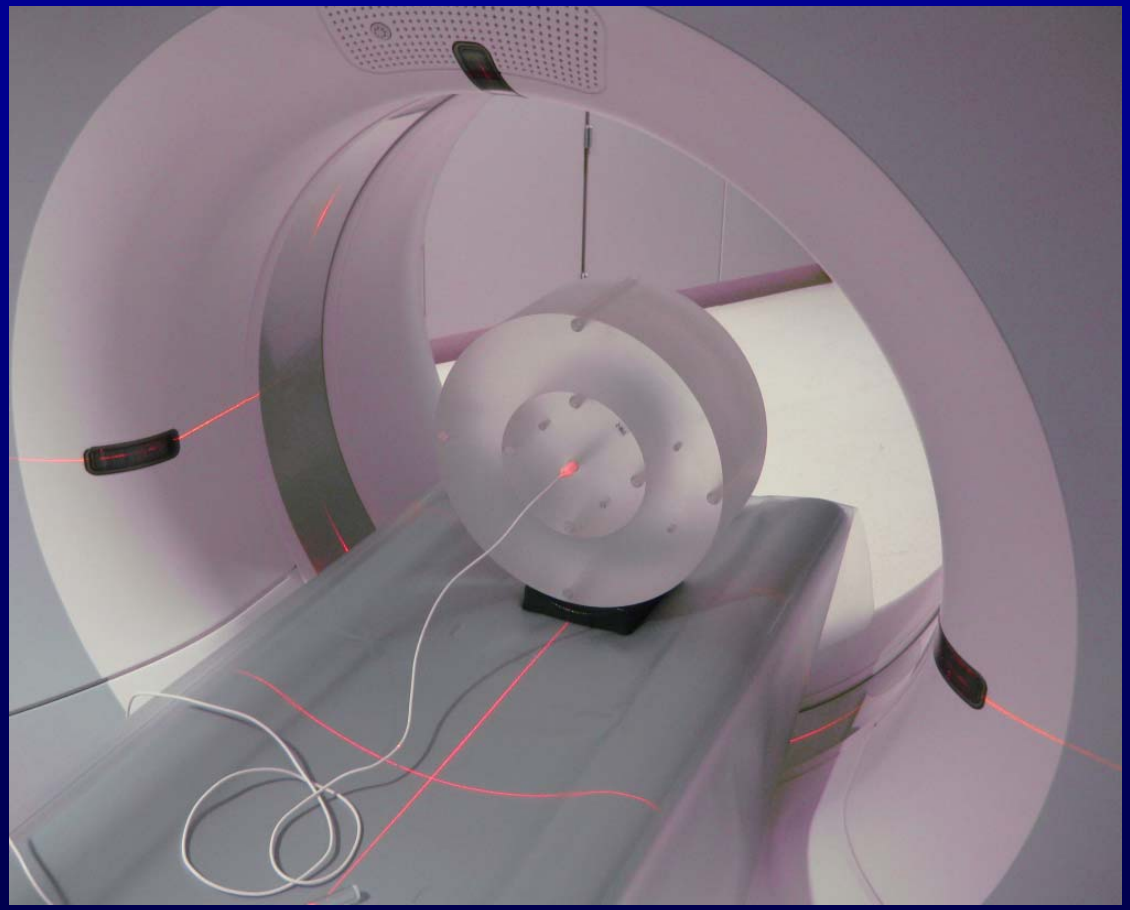


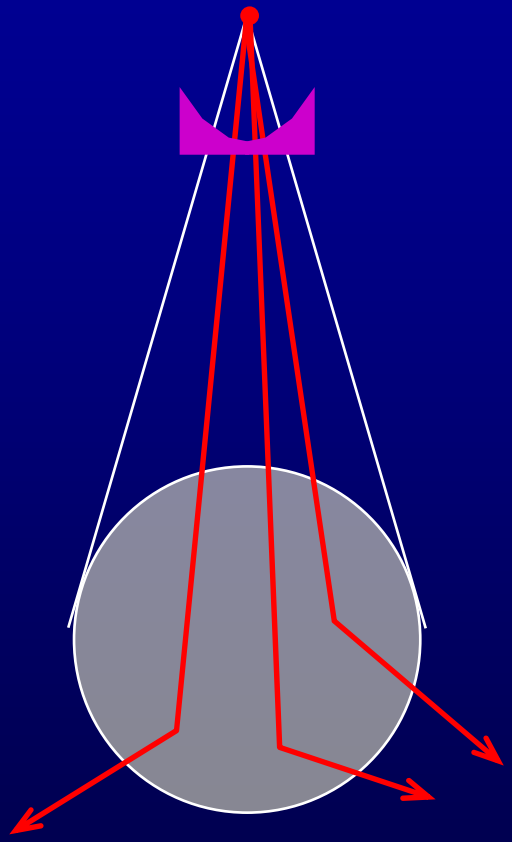


ICRU CT phantom evaluation

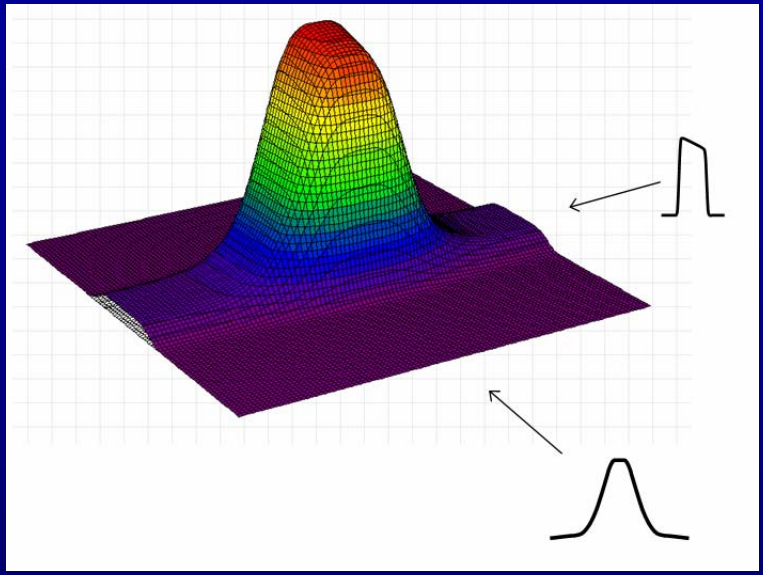
	Old Era	New Era
phantom	 complicated	 simple
analysis	 simple	$MTF(f) = \frac{\int_{-\infty}^{\infty} LSF(x) \quad e^{-2\pi i f x} \quad dx}{\int_{-\infty}^{\infty} LSF(x) \quad dx}$ complicated
results	perfunctory	useful & quantitative

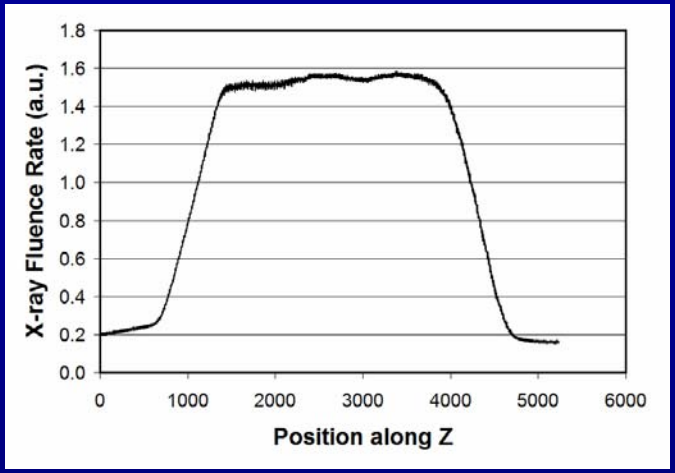
Historical CT dose evaluation

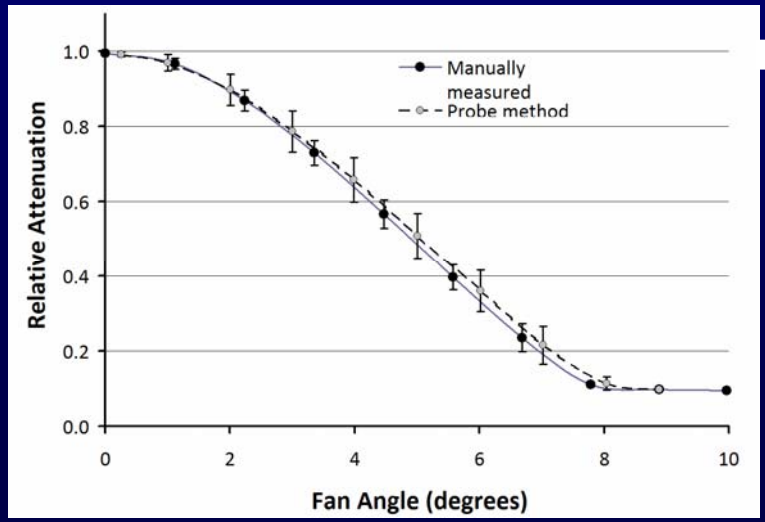


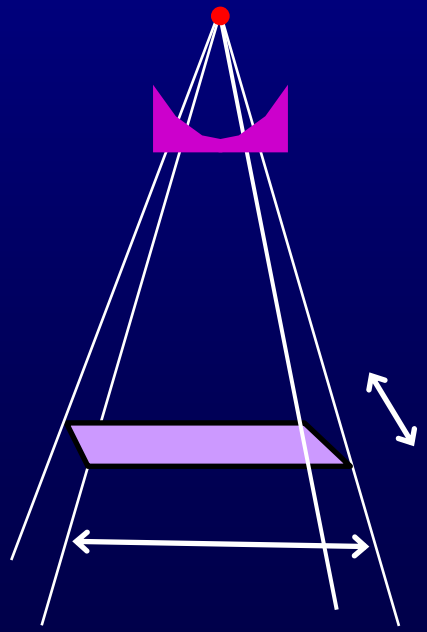


ICRU CT beam evaluation









National / International Activities

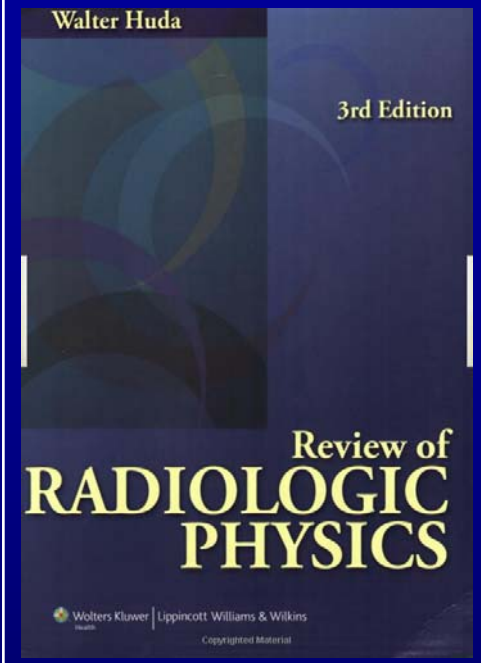
Dose Reporting (ACR, etc)

Reference Doses (NCRP)

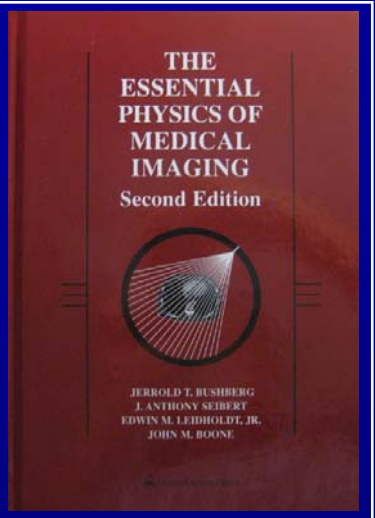
Dose Information in DICOM header

Moving Forward:

- National / International Activities
- Education and Training
- Clinical: What can we really do?
- Regulations, Accreditation, Certification

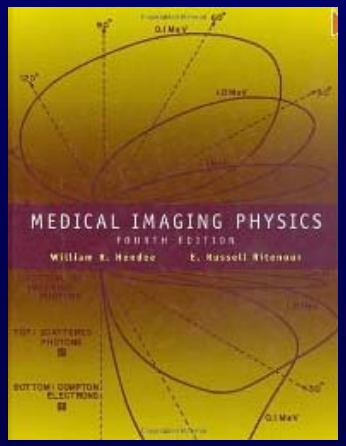


Walter Huda



Leidholdt Bushberg Seibert Boone

Traditional Books



Bill Hendee

Russ Ritenour

RSNA 2010
PERSONALIZED MEDICINE:
In Pursuit of Excellence
NOVEMBER 28 – DECEMBER 3
McCORMICK PLACE, CHICAGO

52nd Annual Meeting
July 18-22, 2010
Pennsylvania Convention Center
Philadelphia, Pennsylvania

MTMI
Medical Technology Management Institute

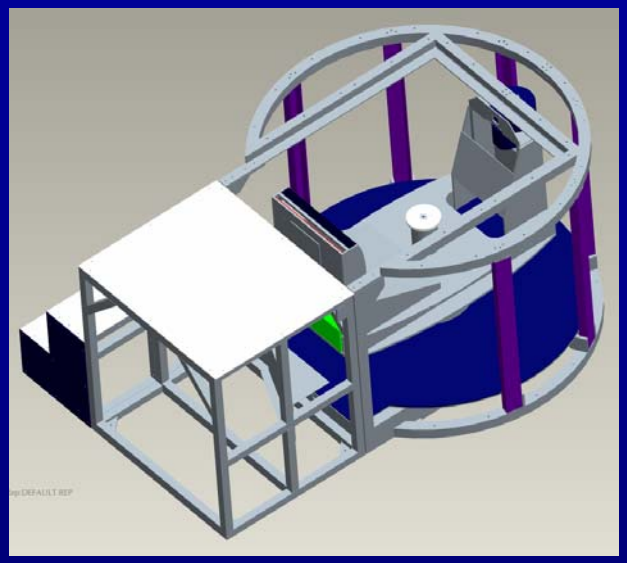
A Review of CT Imaging
8 Hours ARRT Category A Credit
CHRISTINE ECKENROD, RT(R)(CT)(MR)

CTguru.org
Computed Tomography Education & Registry Review

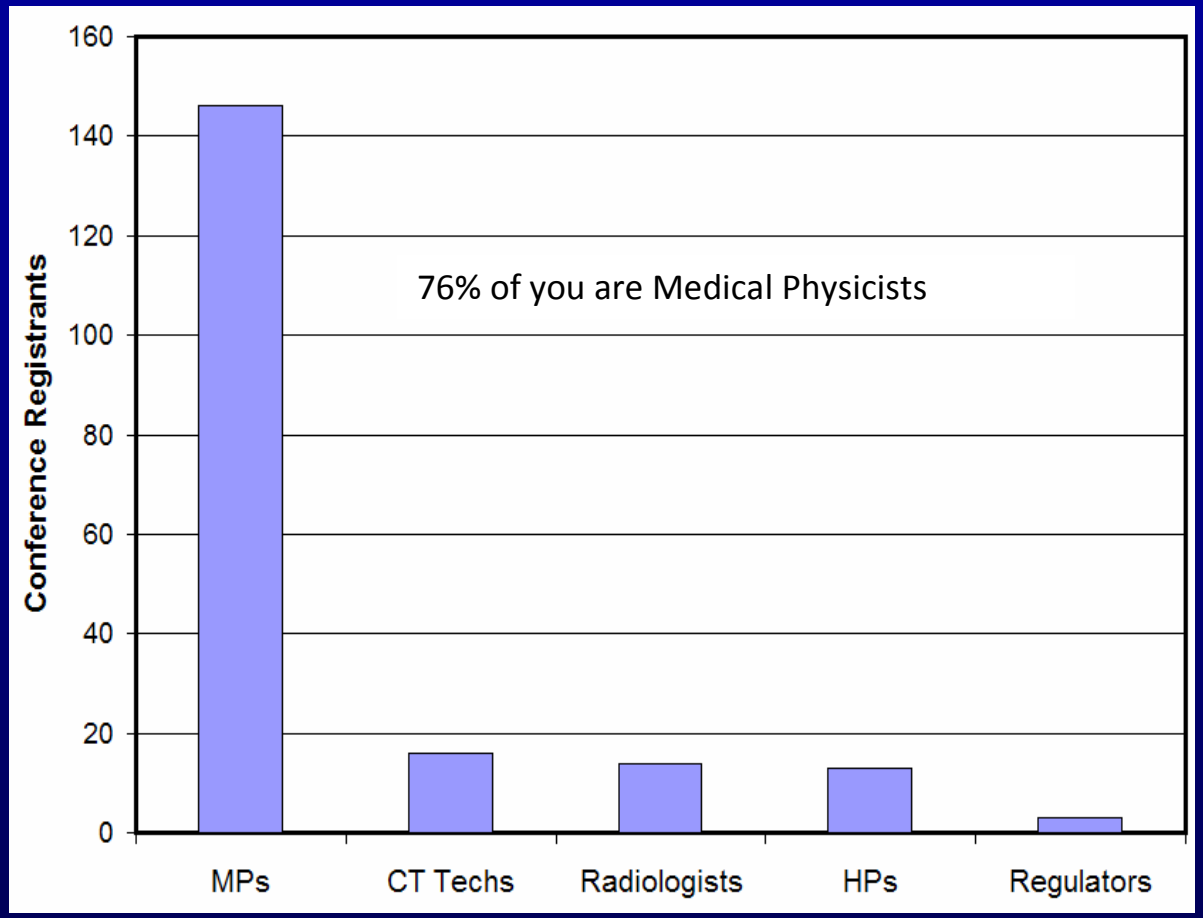
Annual Meetings in Radiology Societies and Focused Courses

The First International Meeting on Image Formation in X-Ray Computed Tomography
June 6-9, 2010
Fort Douglas/Olympic Village, Salt Lake City, Utah, USA

ISCT International Society for Computed Tomography

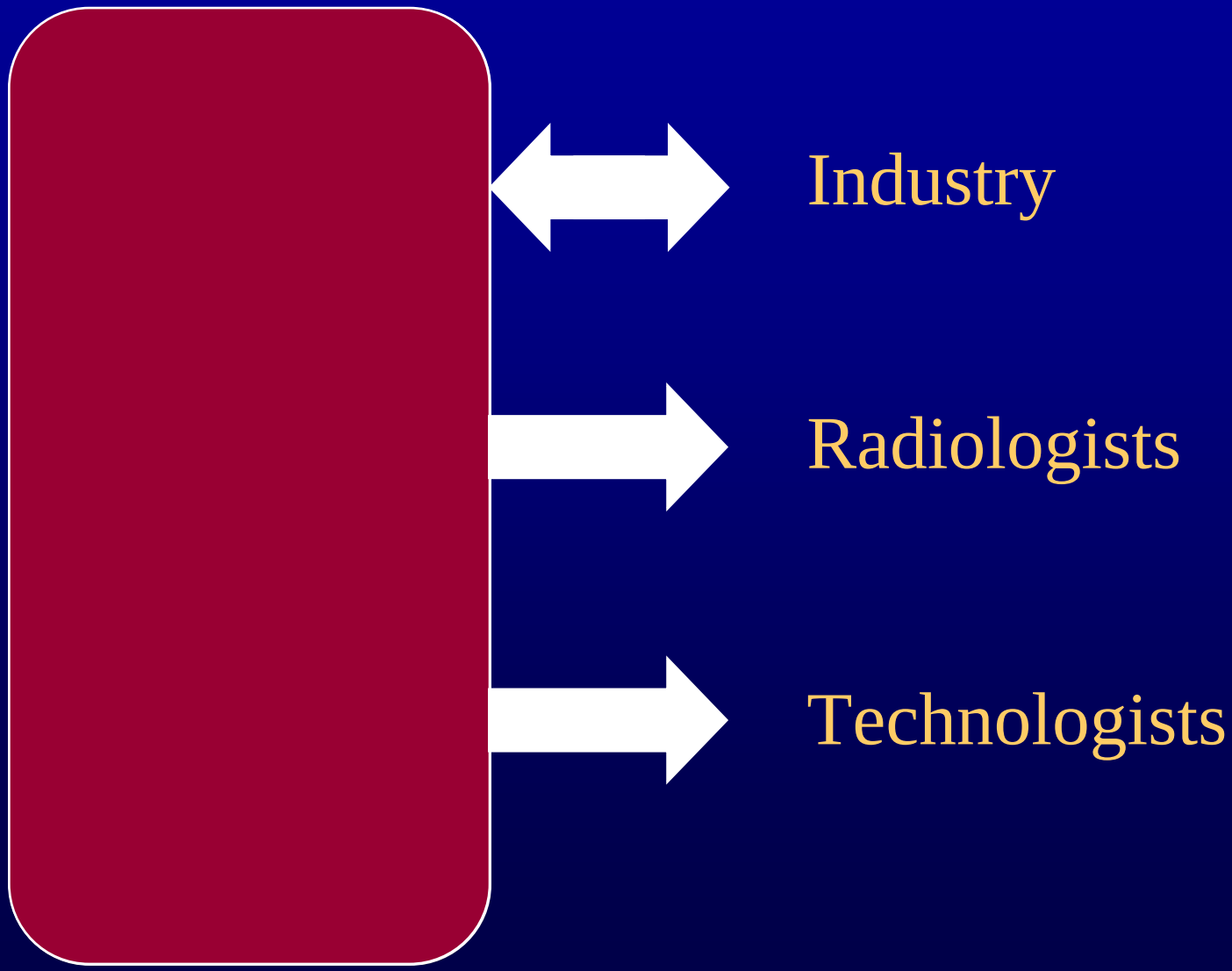


Radiologists and Technologists don't design CT scanners, MP's do



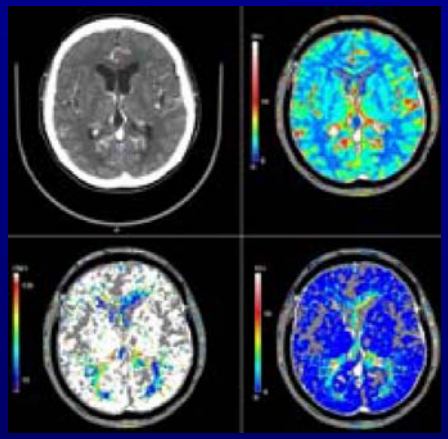
Medical Physicists must take the lead in CT and CT Dose Education

Medical Physics



Radiation-induced temporary hair loss as a radiation damage only occurring in patients who had the combination of MDCT and DSA

Eur Radiol (2005) 15:41–46



U.S. Department of Health & Human Services www.hhs.gov

U.S. Food and Drug Administration

Home | Food | Drugs | Medical Devices | Vaccines, Blood & Biologics | Animal & Veterinary | Cosmetics Radiation-Emitting Products | Tobacco Products

Medical Devices

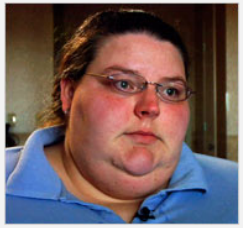
Home > Medical Devices > Medical Device Safety > Alerts and Notices (Medical Devices)

Safety Investigation of CT Brain Perfusion Scans: Update 12/8/2009

Radiation Overdoses Point Up Dangers of CT Scans

Written by Humboldt Online Editor on 16 October 2009

New York Times Raven Knickerbocker, then an X-ray technologist at Mad River Community Hospital in Arcata, Calif., activated a CT scan 151 times on the same area of the head of 2 ½-year-old Jacoby Roth, investigators concluded.



The dose information was there on the CT scanner

GE VCT (1)

GE VCT (2)

GE Lightspeed 16

Toshiba Aquilion

Siemens Definition

GE Discovery

Ceretom

UC Davis Medical Center Main Hospital

Siemens Sensation 64

Placer Center for Health

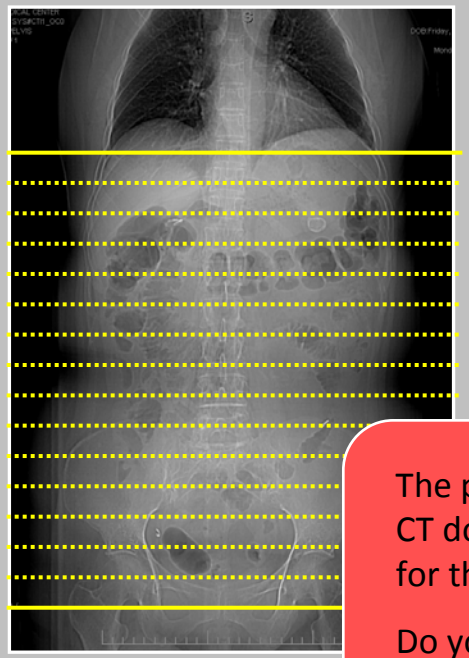
Siemens AS+

Ellison Ambulatory Care Center

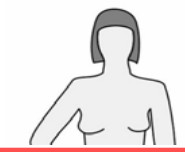
9 CT scanners

only two are the same model

Patient: Ann Smith
DOB: 4-29-1940
Accession Number: ABCDEF
Referring Physician: Dr. Alan Jones
Technologist: Alison Omega-Hansley

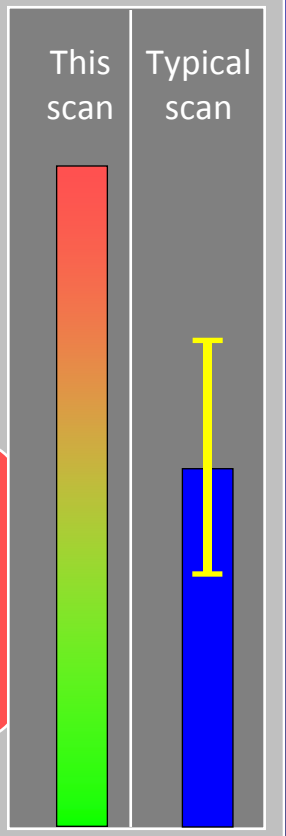


Abdomen-Pelvis



The parameters selected will result in a CT dose that is above the 75 percentile for this examination

Do you want to proceed?



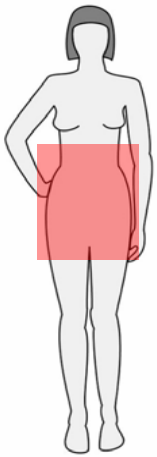
kVp: 120
mA: 600
Rotation time: 0.50 sec
Pitch: 0.95
CTDIvol: 33 mGy
Length: 32.5 cm
DLP: 1072 mGy-cm

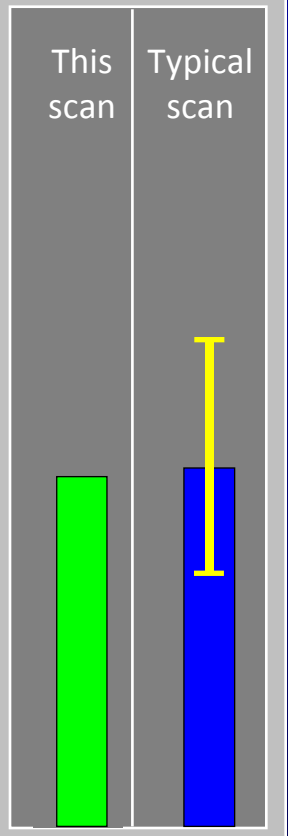
RECON FILTER: xxx
64 x 1.00 mm
Delivery: PACS-1

SCAN

Patient: Ann Smith
DOB: 4-29-1940
Accession Number: ABCDEF
Referring Physician: Dr. Alan Jones
Technologist: Alison Omega-Hansley

Abdomen-Pelvis





kVp: 120
mA: 600
Rotation time: 0.50 sec
Pitch: 0.95
CTDIvol: 23 mGy
Length: 32.5 cm
DLP: 1052 mGy-cm

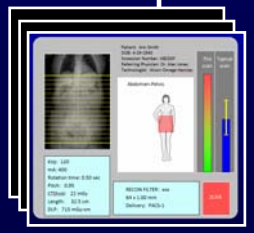
RECON FILTER: xxx
64 x 1.00 mm
Delivery: PACS-1

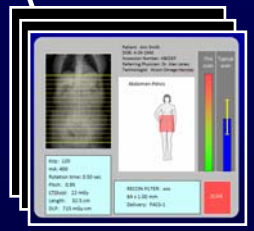
SCAN

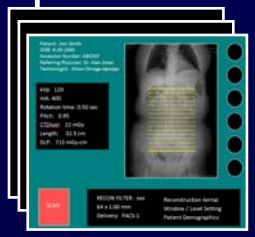
Training Modules: MITA

Medical Imaging and Technology Alliance

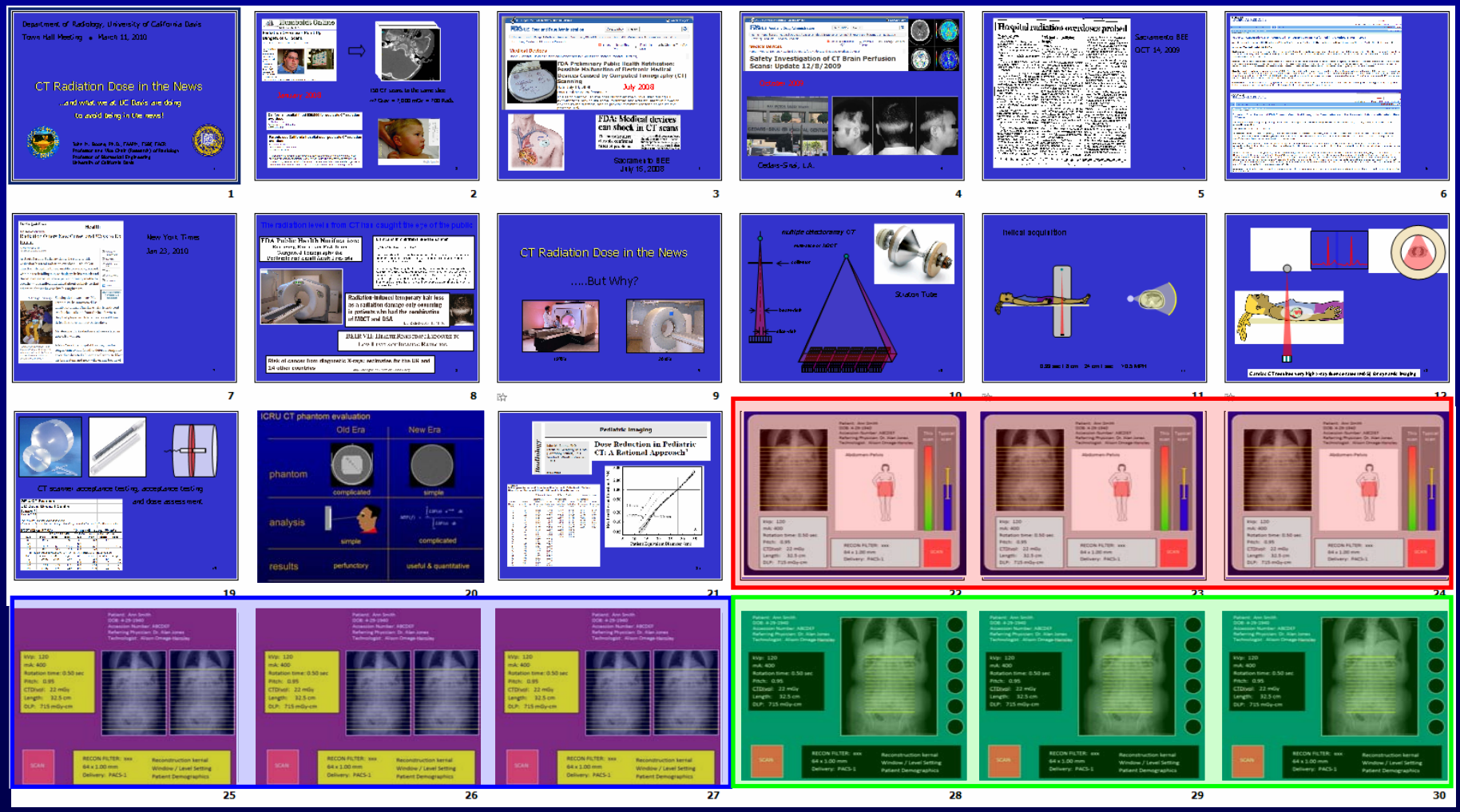
VENDOR 1	VENDOR 2	VENDOR 3	VENDOR 4
MODEL A	MODEL A	MODEL A	MODEL A
MODEL B	MODEL B	MODEL B	MODEL B
MODEL C	MODEL C	MODEL C	MODEL C
MODEL D	MODEL D	MODEL D	MODEL D
MODEL E	MODEL E	MODEL E	MODEL E







AAPM ⟷ MITA


Department of Radiology, University of California Davis
Town Hall Meeting • March 11, 2010
CT Radiation Dose in the News
...and what we at UC Davis are doing to avoid being in the news!
FDA: Medical devices can shock in CT scans
Sacramento BEE July 15, 2008
Safety Investigation of CT Brain Perfusion Scans: Update 12/8/2009
Cedars-Sinai, L.A.
Hospital radiation overdoses probed
Sacramento BEE OCT 14, 2009
New York Times Jan 23, 2010
The radiation level from CT has caught the eye of the public
CT Radiation Dose in the News
.....But Why?
multide detectorarray CT
Skeleton Tube
helical acquisition
CT scanner acceptance testing, acceptance testing and dose assessment.
ICRU CT phantom evaluation
Old Era
New Era
phantom
complicated
simple
analysis
simple
complicated
results
perfunctory
useful & quantitative
Pediatric Imaging
Dose Reduction in Pediatric CT: A Rational Approach
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Moving Forward:

- National / International Activities
- Education and Training
- Clinical: What can we really do?
- Regulations, Accreditation, Certification

Cynthia McCollough, Ph.D.

Mayo Clinic

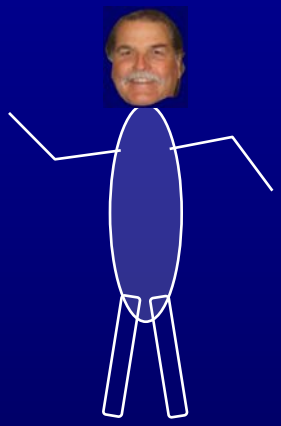
Rochester, Minnesota (N=28)

Dianna Cody, Ph.D.

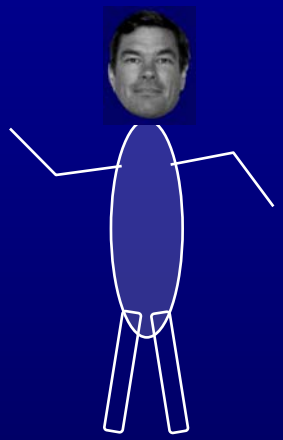
MD Anderson Cancer Center

Houston, Texas (N=36)

University of California Davis Medical Center, Department of Radiology, Sacramento, California



John M. Boone, Ph.D.



J. Anthony Seibert, Ph.D.

Dr. Ramit Lamba – CT doc

Chief of Computed Tomography

CT Protocol Development at UC Davis

(on limited budget with few participants)

Department of Radiology

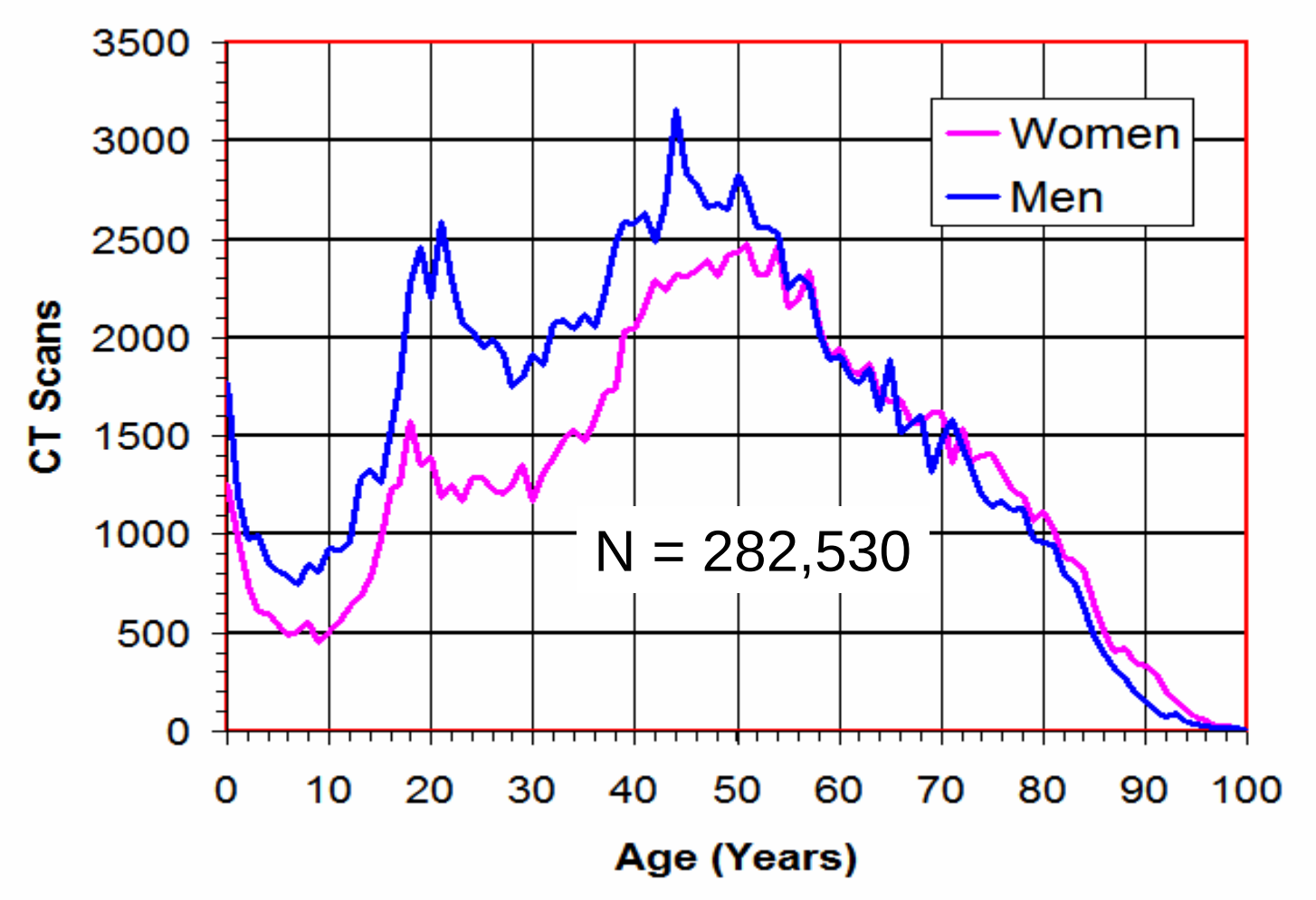
Radiation Use Committee

Health Physics Program

UCDAVIS
UNIVERSITY OF CALIFORNIA

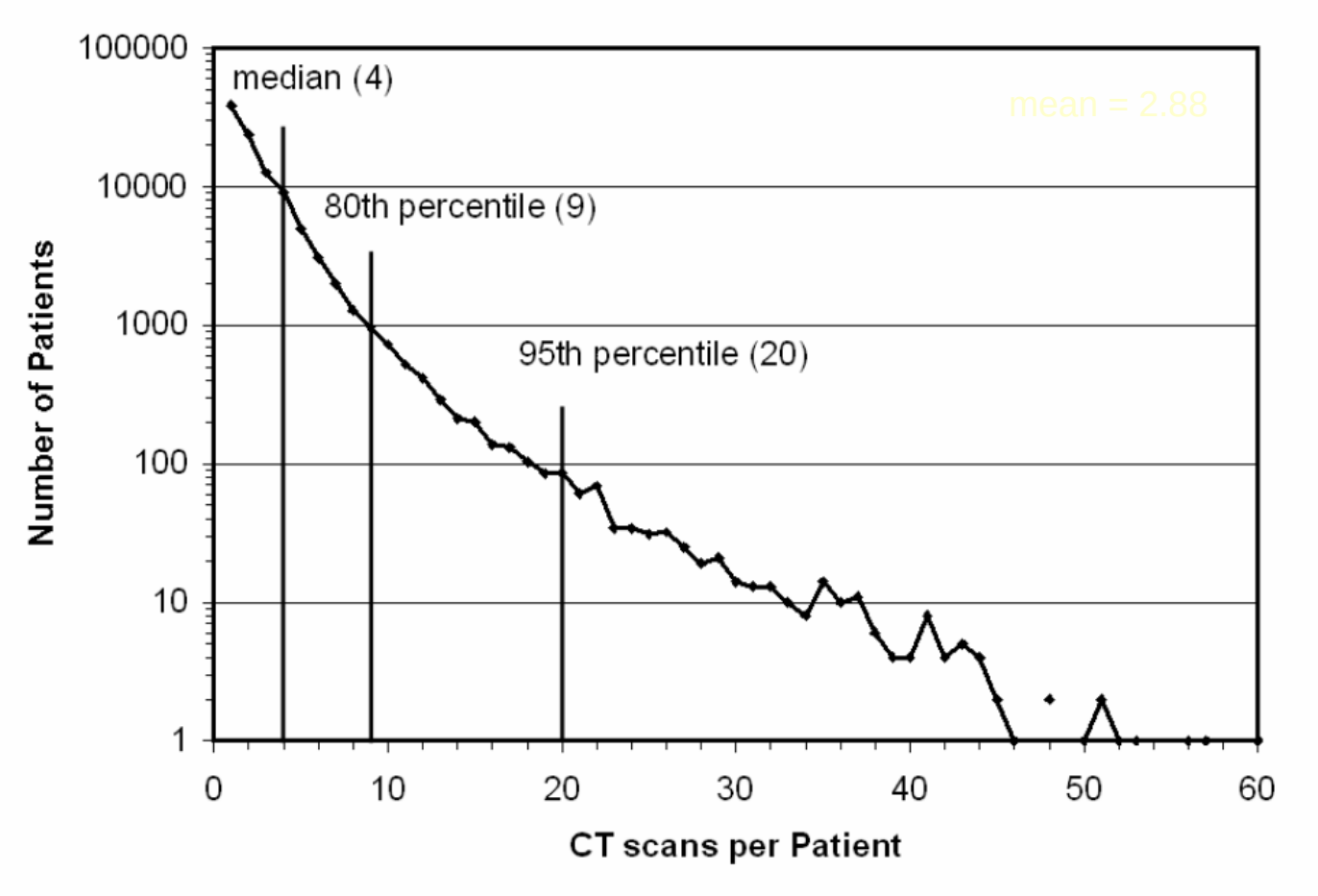
Monitoring local CT utilization

CT use 1997-2005
by age and gender



UCDAVIS
UNIVERSITY OF CALIFORNIA

Monitor CT scans *per patient*



Physicist Evaluation of CT Perfusion Protocols

1. Meet with Neuroradiologists – techs – administrators
2. Identify all scanners used for CT perfusion
3. Check CT perfusion protocols and evaluate dose (<500 mGy)
4. Lock down scanner security (passwords)
5. Heighten awareness of high dose CT techniques to techs
6. Scrutinize all CT Angiography protocols
7. Evaluate CT technologist training / CT certification (52% CT)

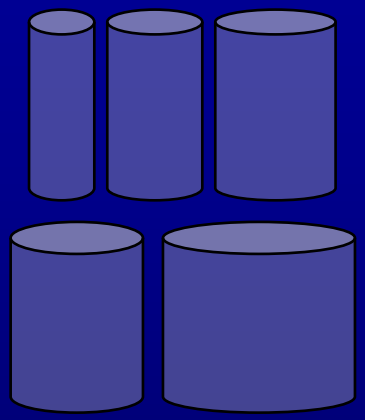
Physicist Evaluation of Pediatric Protocols

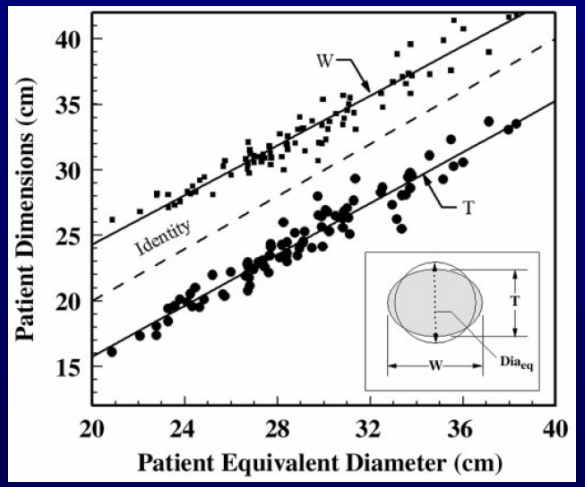
Radiology

2003 Pediatric Imaging

John M. Boone, PhD
Estella M. Geraghty, MD, MS
J. Anthony Selbert, PhD
Sandra L. Wootton-Gorges, MD

Dose Reduction in Pediatric CT: A Rational Approach[1]





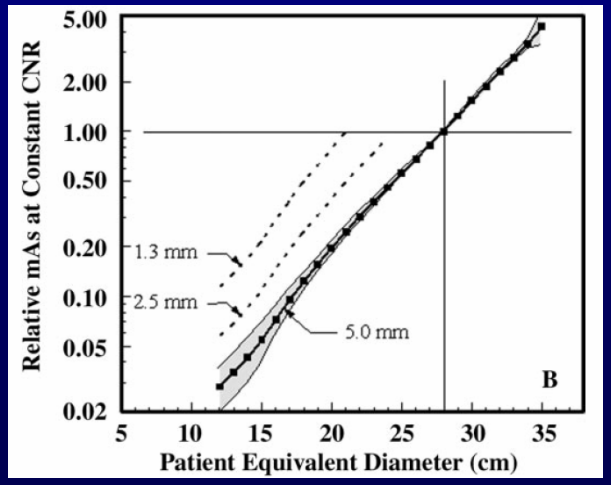


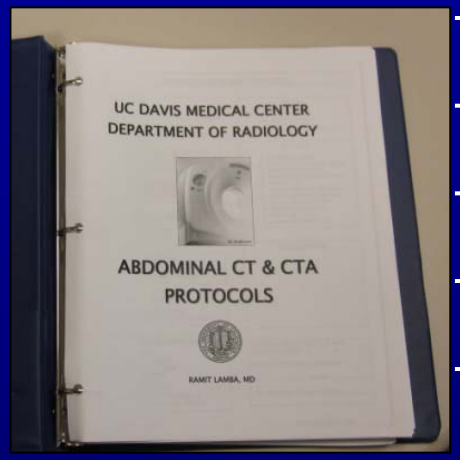
TABLE 1
Milliampere Second and Dose Reduction Factors in Patients with Various Diameters at Abdominal CT with Different Section Thicknesses

		5.0-mm Sections		2.5-mm Sections		1.3-mm Sections	
Patient Diameter (cm)	Patient Circumference (cm)	Milliampere Second Reduction Factor	Dose Reduction Factor	Milliampere Second Reduction Factor	Dose Reduction Factor	Milliampere Second Reduction Factor	Dose Reduction Factor
12	38	0.028	0.050	0.057	0.100	0.113	0.199
13	41	0.035	0.060	0.070	0.120	0.139	0.241
14	44	0.043	0.072	0.085	0.145	0.171	0.289
15	47	0.054	0.090	0.109	0.181	0.217	0.361
16	50	0.072	0.118	0.144	0.236	0.289	0.471
17	53	0.095	0.152	0.190	0.303	0.380	0.607
18	57	0.124	0.193	0.248	0.385	0.496	0.771
19	60	0.157	0.236	0.313	0.473	0.626	0.945
20	63	0.196	0.287	0.393	0.573		
21	66	0.245	0.344	0.490	0.688		
22	69	0.304	0.408	0.609	0.816		
23	72	0.374	0.478	0.749	0.956		
24	75	0.457	0.555				
25	79	0.557	0.642				
26	82	0.678	0.742				
27	85	0.824	0.860				
28	88	1.000	1.000				
29	91	1.239	1.195				
30	94	1.532	1.428				
31	97	1.883	1.702				
32	101	2.297	2.023				
33	104	2.792	2.410				
34	107	3.409	2.911				
35	110	4.323	3.544				

1. Verify that CT techs are using the pediatric dose protocols (manual protocols)

Optimize CT protocols for all scanners

CT protocol book
(Lightspeed 16)



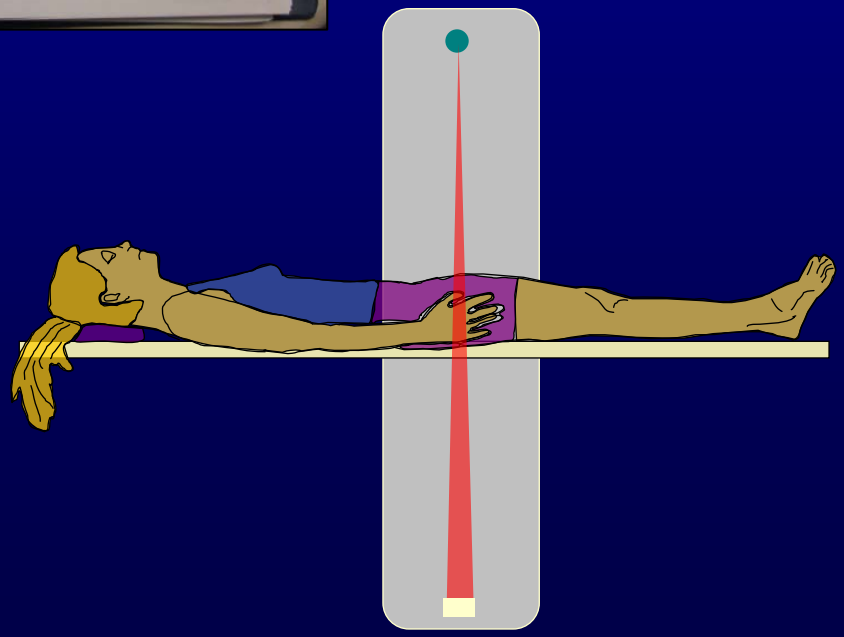
→ GE VCT

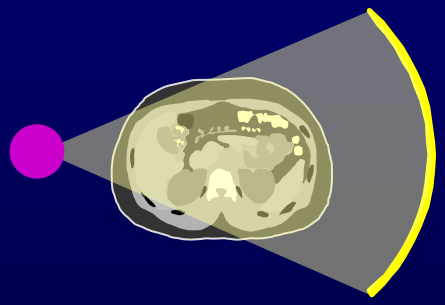
→ Siemens Definition

→ Siemens Sensation 64

→ Siemens AS+

→ Toshiba Aquilion



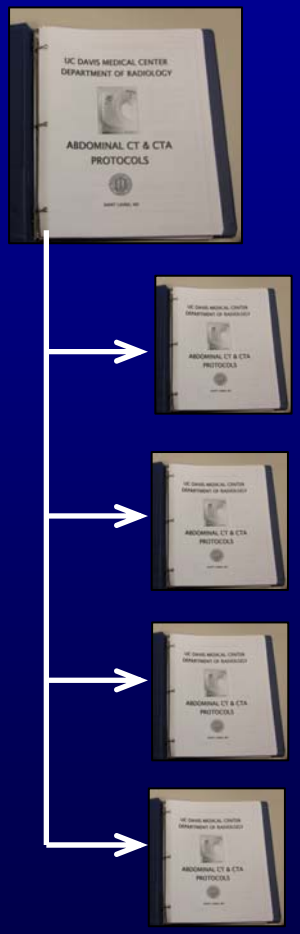


ImPACTscan.org

kVp	Sub-group	Scanner	CTDI (Head, mGy/100mAs) Air	Centre	Perip	CTDI (Body, mGy/100mAs) Air	Centre	Perip
80	.080	GE LightSpeed 16	13.0	7.1	7.6	10.7	1.7	3.8
100	.100	GE LightSpeed 16	21.9	13.4	13.6	19.9	4.2	8.1
120	.120	GE LightSpeed 16	32.2	21.1	20.8	29.3	7.2	13.8
140	.140	GE LightSpeed 16	43.9	29.7	29.0	40.0	10.8	18.6
80	.080	GE LightSpeed VCT	14.8	8.3	10.0	14.8	1.9	4.9
100	.100	GE LightSpeed VCT	24.2	15.3	17.4	24.2	4.0	8.8
120	.120	GE LightSpeed VCT	35.0	23.7	26.1	35.0	6.7	13.3
140	.140	GE LightSpeed VCT	46.9	33.1	35.5	46.9	9.9	18.3
80	.080	Siemens Sensation 64	4.9	3.3	3.5	4.9	0.9	1.8
100	.100	Siemens Sensation 64	9.9	7.0	7.3	9.9	2.1	4.0
120	.120	Siemens Sensation 64	16.1	11.7	12.1	16.1	3.8	6.8
140	.140	Siemens Sensation 64				24.6	6.1	11.0
80	Sl.s.080	Siemens Definition AS	5.7	3.3	3.6	5.7	0.9	2.0
100	Sl.s.100	Siemens Definition AS	10.5	6.7	7.1	10.4	1.9	3.9
120	Sl.s.120	Siemens Definition AS	16.9	11.3	11.8	16.9	3.5	6.6
140	Sl.s.140	Siemens Definition AS	24.3	16.6	17.3	24.3	5.5	9.7
80	.080	Toshiba Aquilion Multi / 4	14.7	7.6	8.9	20.3	2.2	5.6
100	.100	Toshiba Aquilion Multi / 4	23.5	13.8	15.5	30.8	4.3	9.7
120	.120	Toshiba Aquilion Multi / 4	33.8	21.5	23.3	42.5	7.1	14.8
135	.135	Toshiba Aquilion Multi / 4	43.6	28.7	30.1	52.1	9.8	19.7

$$CTDI_w = 0.333 \; CTDI_{100}^{CENTER} + 0.666 \; CTDI_{100}^{EDGE}$$

CT protocol book
(Lightspeed 16)



mAs values to match $CTDI_w$ of GE 16 at 100 mAs

Scanner	kVp	CTDIw HEAD	CTDIw BODY	Norm mAs HEAD	Norm mAs BODY
GE LightSpeed 16	80	7.4	3.1	100	100
GE LightSpeed 16	100	13.6	6.8	100	100
GE LightSpeed 16	120	20.9	11.6	100	100
GE LightSpeed 16	140	29.2	16.0	100	100
GE LightSpeed VCT	80	9.4	3.9	79	79
GE LightSpeed VCT	100	16.7	7.2	81	95
GE LightSpeed VCT	120	25.2	11.1	83	104
GE LightSpeed VCT	140	34.7	15.5	84	103
Siemens Sensation 64	80	3.4	1.5	219	208
Siemens Sensation 64	100	7.2	3.4	189	202
Siemens Sensation 64	120	11.9	5.8	175	199
Siemens Sensation 64	140		9.4		171
Siemens Definition AS	80	3.5	1.6	211	194
Siemens Definition AS	100	6.9	3.3	196	209
Siemens Definition AS	120	11.7	5.6	179	207
Siemens Definition AS	140	17.0	8.3	171	193
Toshiba Aquilion Multi / 4	80	8.5	4.5	87	70
Toshiba Aquilion Multi / 4	100	14.9	7.9	91	86
Toshiba Aquilion Multi / 4	120	22.7	12.2	92	95
Toshiba Aquilion Multi / 4	135	29.6	16.4	99	98

Other Considerations:

Collimation Width

Gantry Rotation Time

Table Speed (ie. Pitch)

Timing for Contrast Bolus

Reconstruction Filters

Window / Level Settings

Moving Forward:

- National / International Activities
- Education and Training
- Clinical: What can we really do?
- Regulations, Accreditation, Certification

CRS
CALIFORNIA RADIOLOGICAL SOCIETY

CRS Update

Update from Sacramento

New Bill on Radiation Exposure Prevention

Over the past year there have been several incidents in California hospitals where patients receiv
(Padilla) is new legislation sponsored by the Consumer Attorneys of California which attempts to
SB 1237 would require that on all imaging procedures involving ionizing radiation the provider wou
patient's film.

The CRS has met with the author and sponsor to indicate concerns with the bill as drafted since
many cases the specific radiation dose is a range that varies based upon the physical aspects o
hearings and pronouncements by the FDA on possible new requirements for manufacturers of im
more information be available to the operator to indicate specific patient dose.

The bill will be heard this week in Senate Health Committee and major amendments are likely to
advocated the inclusion of a delayed mandate for accreditation of CT units in both hospital and fr
beginning in 2012. We will keep you informed of the progress of this legislation.

U.S. Department of Health & Human Services www.hhs.gov

FDA U.S. Food and Drug Administration A-Z Index Search go

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Medical Devices

Home > Medical Devices > Medical Device Safety > Alerts and Notices (Medical Devices)

- Medical Device Safety
  - Alerts and Notices (Medical Devices)
  - Public Health Notifications (Medical Devices)
  - Archived Safety Alerts, Public Health Advisories and Notices

FDA Preliminary Public Health Notification: Possible Malfunction of Electronic Medical Devices Caused by Computed Tomography (CT) Scanning

Date July 14, 2008

Dear Healthcare Professional:

This is to alert you to the possibility that the x-rays used during CT examinations may cause some implanted and external electronic medical devices to malfunction, and to provide recommendations to reduce the potential risk.

Regulations

FDA U.S. Food and Drug Administration A-Z Index Search go

Home | Food | Drugs | Medical Devices | Vaccines, Blood & Biologics | Animal & Veterinary | Cosmetics | Radiation-Emitting Products | Tobacco Products

Medical Devices

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Home > Medical Devices > Medical Device Safety > Alerts and Notices (Medical Devices)

- Medical Device Safety
  - Alerts and Notices (Medical Devices)

Safety Investigation of CT Brain Perfusion Scans: Update 12/8/2009

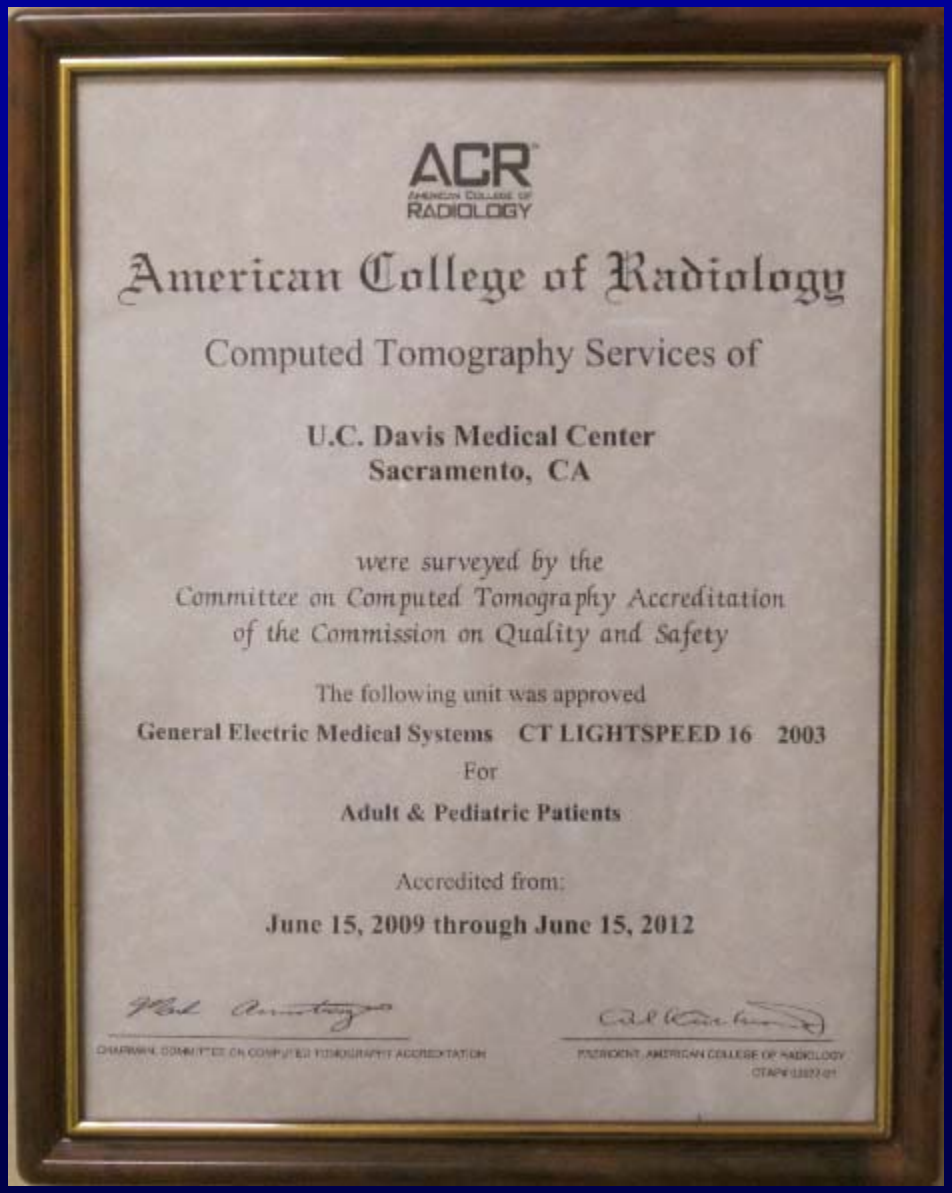
Date Issued: December 8, 2009

SB 1237

"…would require that on all imaging procedures involving ionizing radiation the provider would be required to indicate or note the specific radiation dose on the patient's film."

"CRS has also advocated the inclusion of a delayed mandate for accreditation of CT units in both hospital and freestanding settings that would parallel the Medicare requirement beginning in 2012."

Regulations



ACR
AMERICAN COLLEGE OF RADIOLOGY

American College of Radiology

Computed Tomography Services of

U.C. Davis Medical Center
Sacramento, CA

were surveyed by the
Committee on Computed Tomography Accreditation
of the Commission on Quality and Safety

The following unit was approved

General Electric Medical Systems CT LIGHTSPEED 16 2003

For

Adult & Pediatric Patients

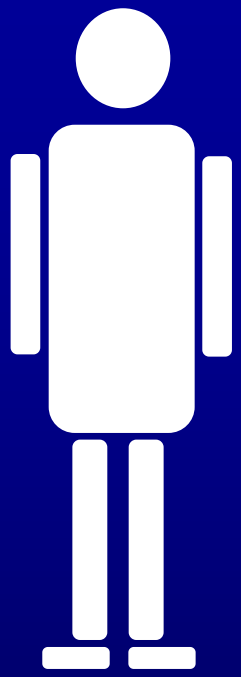
Accredited from:

June 15, 2009 through June 15, 2012

CHAIRMAN, COMMITTEE ON COMPUTED TOMOGRAPHY ACCREDITATION

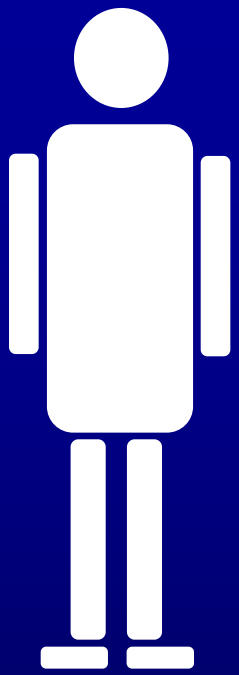
PRESIDENT, AMERICAN COLLEGE OF RADIOLOGY

Accreditation



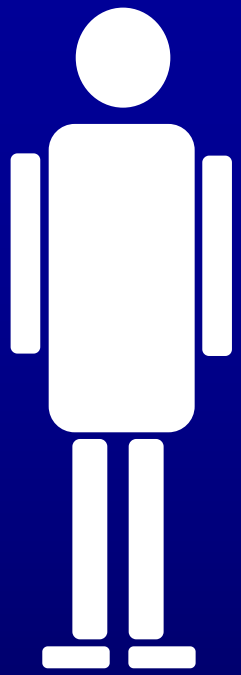
Radiologist

ABR Certified



Medical Physicist

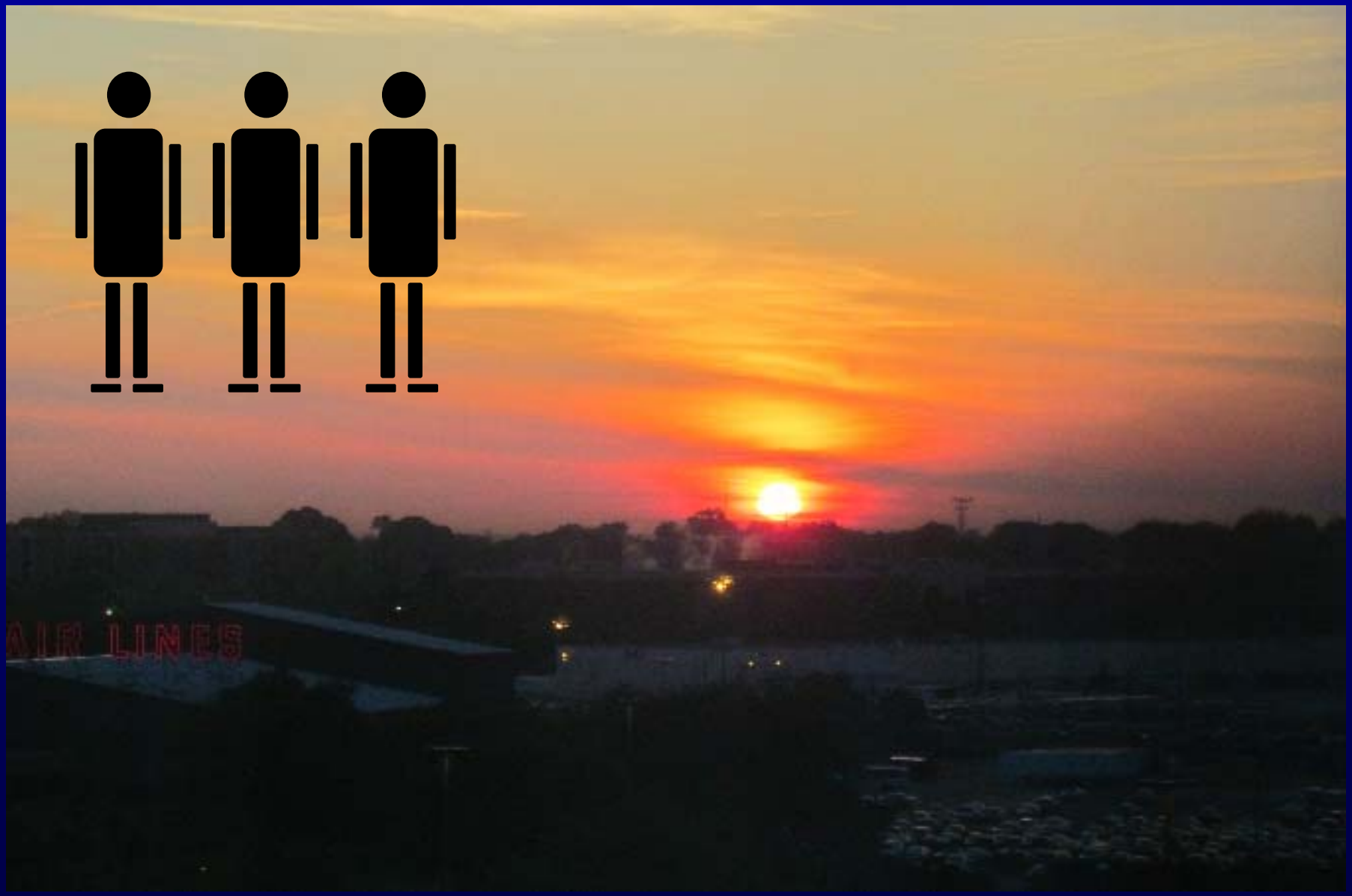
ABR Certified



CT Technologist

ARRT (CT) Certified

Certification


AIR LINES

Moving Forward – What does this mean for the Medical Physicist and the Imaging Community?

John M. Boone, Ph.D.
Professor and Vice Chairman of Radiology
University of California Davis Medical Center