Radiation Dose Monitoring in Pediatrics:

Experience at Boston Children's Hospital

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Disclosures

Outline

1. Technical Implementation
   - Decisions: Data Format and Communication
   - Building a team and role of the physicist
2. Size-Specific and Indication-Based Diagnostic Reference
   - Regulatory
   - Protocol Optimization
3. Educating Users

Outline

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Decisions – Data Format

1. RDSR: Event level data, allows for optimization
2. Secondary Capture/OCR
3. Image meta-data: OK for DX, NOT for CT, XA
4. MPPS and Custom Reports: The Last resort

Radiation Dose Structured Report

Patient:
Referring Physician:
Study: Pediatric^Pediatric Cardiac Catheterization
Manufacturer: Siemens
Completion Flag: PARTIAL
Verification Flag: UNVERIFIED
Content Date/Time:

X-Ray Radiation Dose Report

Procedure reported
Projection X-Ray (113704, DCM)
HAS CONCEPT MOD
Has Intent:
Combined Diagnostic and Therapeutic Procedure (R-002E9, SRT)
Observer Type
Device (121007, DCM)
Device Observer UID

Device Observer Name
ARTIS123031
Device Observer Manufacturer
Siemens
Device Observer Model Name
AXIOM-Artis
Device Observer Serial Number
123031
Scope of Accumulation
Study (113014, DCM)
HAS PROPERTIES
Study Instance UID:

Accumulated X-Ray Dose Data

Acquisition Plane:
Plane A (113620, DCM)
Calibration:
Dose Measurement Device:
Dosimeter (A-2C090, SRT)
Calibration Date:
02-11-2015 21:05:23.000

Calibration Factor:
1
Calibration Uncertainty:
5 Percent
Calibration Responsible Party:
Siemens
Dose Area Product Total:
0.00152384 Gy.m2
Dose (RP) Total:
0.16296 Gy
Fluoro Dose Area Product Total:
0.00075835 Gy.m2
Fluoro Dose (RP) Total:
0.06333 Gy
Total Fluoro Time:
828 s
Acquisition Dose Area Product Total:
0.00076549 Gy.m2
Acquisition Dose (RP) Total:
0.09963 Gy
Total Acquisition Time:
75 s
Reference Point Definition:
15cm from Isocenter toward Source (113860, DCM)

Accumulated X-Ray Dose Data

Acquisition Plane:
Plane B (113621, DCM)
Calibration:
Dose Measurement Device:
Dosimeter (A-2C090, SRT)
Calibration Date:
02-11-2015 21:41:18.000
Calibration Factor:
1
Calibration Uncertainty:
5 Percent
Calibration Responsible Party:
Siemens
Dose Area Product Total:
0.00327012 Gy.m2
Dose (RP) Total:
0.36952 Gy
Fluoro Dose Area Product Total:
0.00189613 Gy.m2
Fluoro Dose (RP) Total:

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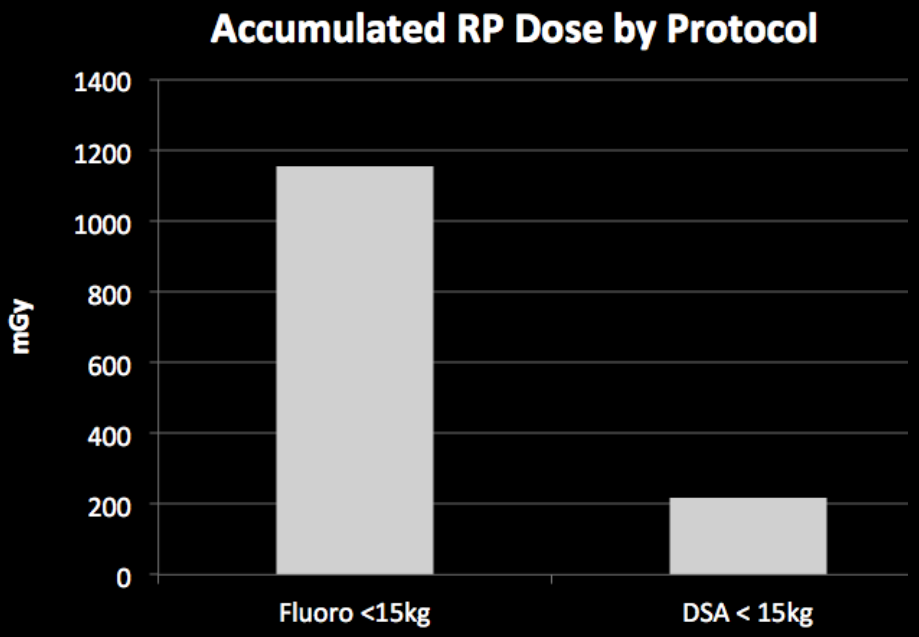
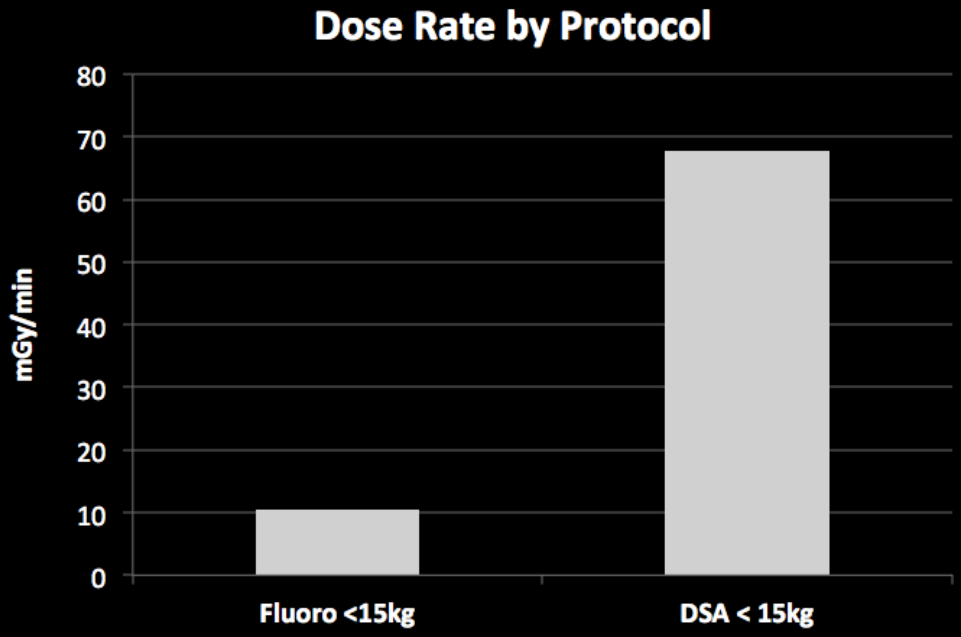
Radiation Dose Structured Report

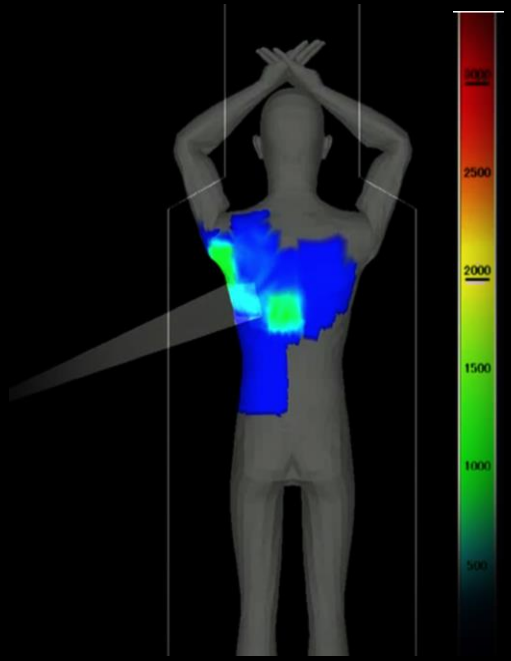
Type	Protocol	DAP [mGy-cm2]	Reference Point	Reference Point Dose [mGy]	Beam On Time [r	kVp	mA	mAs	Start Time	Primary Angle [deg]	Secondary Angle [deg]	Fluoro Mode	Pulses per Secor	Number of Pulses
Fluoroscopy	FL <30kg 7.5	170.1	15cm from Isocei	1.97	442	67	233.9	103.383	2016-07-26 14:5	91.2	-0.2	Pulsed	7.5	130
Fluoroscopy	FL <30kg 7.5	46.2	15cm from Isocei	0.54	122.4	67	231.9	28.384	2016-07-26 14:5	91.2	-0.2	Pulsed	7.5	36
Fluoroscopy	FL <30kg 7.5	7.8	15cm from Isocei	0.090000	22.8	67	208.8	4.76	2016-07-26 14:5	91.2	-0.2	Pulsed	7.5	6
Fluoroscopy	FL <30kg 7.5	417.9	15cm from Isocei	4.83	1084.6	67	234.7	254.555	2016-07-26 14:5	91.2	-0.2	Pulsed	7.5	319
Fluoroscopy	FL <30kg 7.5	246.7	15cm from Isocei	2.06	1084.6	64	176.2	191.106	2016-07-26 14:5	0.6	-0.3	Pulsed	7.5	319
Fluoroscopy	FL <30kg 7.5	113	15cm from Isocei	1.31	272	69	233.3	63.457	2016-07-26 14:5	91.2	-0.2	Pulsed	7.5	80
Fluoroscopy	FL <30kg 7.5	635.3	15cm from Isocei	7.59	966	69	237.8	229.714	2016-07-26 14:5	91.2	-0.2	Pulsed	7.5	210
Fluoroscopy	FL <30kg 7.5	382.5	15cm from Isocei	4.62	927	69	237.1	219.791	2016-07-26 15:0	91.2	-0.2	Pulsed	7.5	206
Fluoroscopy	FL <30kg 7.5	28.3	15cm from Isocei	0.34	68.4	70	228.5	15.629	2016-07-26 15:01	91.2	-0.2	Pulsed	7.5	18
Fluoroscopy	FL <30kg 7.5	83.3	15cm from Isocei	1.01	205.2	69	234.1	48.037	2016-07-26 15:01	91.2	-0.2	Pulsed	7.5	57
Stationary Acquis	Card <30kg	314.9	15cm from Isocei	3.8	346.8	70	319.5	110.802	2016-07-26 15:01	91.2	-0.2		30	102
Stationary Acquis	Card <30kg	170	15cm from Isocei	1.44	346.8	66	323.2	112.085	2016-07-26 15:01	0.6	-0.3		30	102
Fluoroscopy	FL <30kg 7.5	376.9	15cm from Isocei	4.55	927.5	69	235.1	218.055	2016-07-26 15:02	91.2	-0.2	Pulsed	7.5	265
Stationary Acquis	Card <30kg	944	15cm from Isocei	11.41	914.6	70	367.4	336.024	2016-07-26 15:02	91.2	-0.2		30	269
Stationary Acquis	Card <30kg	472.2	15cm from Isocei	4	911.2	66	341.6	311.265	2016-07-26 15:02	0.6	-0.3		30	269
Fluoroscopy	FL <30kg 7.5	10.1	15cm from Isocei	0.090000	39.6	64	192.6	7.626	2016-07-26 15:03	0.6	-0.3	Pulsed	7.5	11
Fluoroscopy	FL <30kg 7.5	146	15cm from Isocei	1.76	360.5	69	233.6	84.212	2016-07-26 15:03	91.2	-0.2	Pulsed	7.5	103
Fluoroscopy	FL <30kg 7.5	471	15cm from Isocei	5.69	1172.5	69	234.9	275.42	2016-07-26 15:03	91.2	-0.2	Pulsed	7.5	335
Stationary Acquis	Card <30kg	3.9	15cm from Isocei	0.050000	4.6	70	288.1	1.325	2016-07-26 15:04	91.2	-0.2		30	1
Stationary Acquis	Card <30kg	1.5	15cm from Isocei	0.010000	4.2	66	297.9	1.251	2016-07-26 15:04	0.6	-0.3		30	1
Stationary Acquis	Card <30kg	428.3	15cm from Isocei	5.17	387.6	70	395.9	153.45	2016-07-26 15:04	91.2	-0.2		30	116

Radiation Dose Structured Report

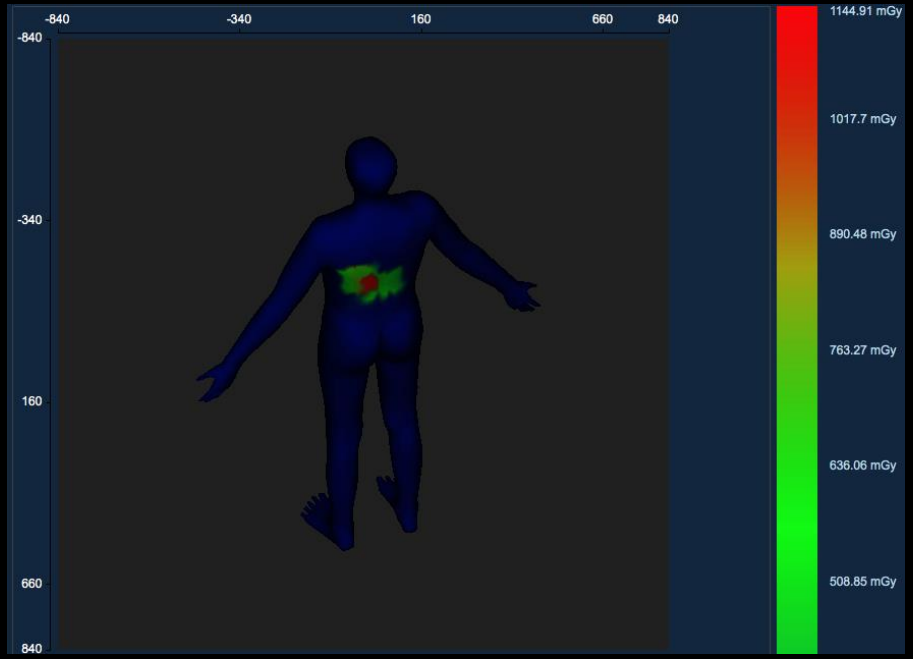




Peak Skin Dose Mapping

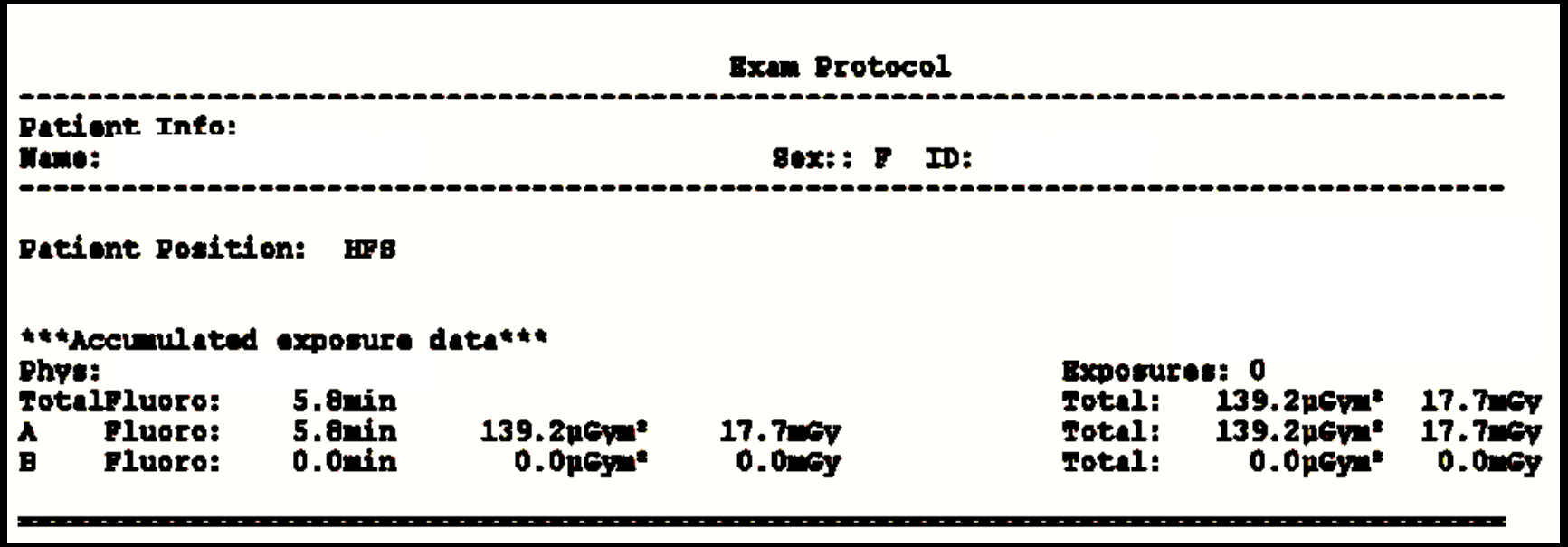


Toshiba (Real-time)



Radimetrics (Retrospective)

Secondary Capture: Requires OCR



Exam Protocol

Patient Info:
Name: Sex:: F ID:

Patient Position: HFS

Accumulated exposure data

Phys:				Exposures: 0	
TotalFluoro:	5.8min			Total: 139.2μGym²	17.7mGy
A Fluoro:	5.8min	139.2μGym²	17.7mGy	Total: 139.2μGym²	17.7mGy
B Fluoro:	0.0min	0.0μGym²	0.0mGy	Total: 0.0μGym²	0.0mGy

DICOM Image Meta-Data

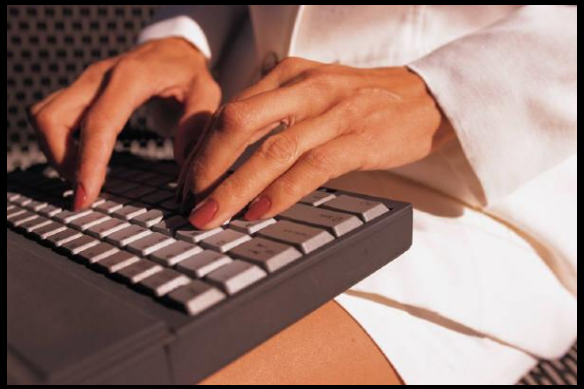
KVP	i	>	1514	0018,0060	DS	4 B	125
DeviceSerialNumber	i	>	1526	0018,1000	LO	14 B	72567767433727
SoftwareVersions	i	>	1548	0018,1020	LO	8 B	4.1.3.2
ProtocolName	i	>	1564	0018,1030	LO	6 B	Chest
SpatialResolution	i	>	1578	0018,1050	DS	6 B	0.148
DistanceSourceToDetector	i	>	1592	0018,1110	DS	4 B	1752
DistanceSourceToPatient	i	>	1604	0018,1111	DS	4 B	1698
EstimatedRadiographicMagnificationFactor	i	>	1616	0018,1114	DS	16 B	0.99376063528071
ExposureTime	i	>	1640	0018,1150	IS	2 B	2
Exposure	i	>	1650	0018,1152	IS	2 B	1
ExposureInuAs	i	>	1660	0018,1153	IS	4 B	1400
ImageAndFluoroscopyAreaDoseProduct	i	>	1672	0018,115e	DS	6 B	0.409
▶ ImagerPixelSpacing	i	>	1686	0018,1164	DS	12 B	0.148\0.148
Grid	i	>	1706	0018,1166	CS	2 B	IN
AcquisitionDeviceProcessingDescription	i	>	1716	0018,1400	LO	64 B	UNIQUE: S:200 L:4.0 FC d:
RelativeXRayExposure	i	>	1788	0018,1405	IS	4 B	372
ExposureIndex	i	>	1800	0018,1411	DS	4 B	372
PositionerType	i	>	1812	0018,1508	CS	4 B	NONE
CollimatorShape	i	>	1824	0018,1700	CS	12 B	RECTANGULAR
CollimatorLeftVerticalEdge	i	>	1844	0018,1702	IS	2 B	0
CollimatorRightVerticalEdge	i	>	1854	0018,1704	IS	4 B	2321
CollimatorUpperHorizontalEdge	i	>	1866	0018,1706	IS	2 B	0
CollimatorLowerHorizontalEdge	i	>	1876	0018,1708	IS	4 B	2520
ViewPosition	i	>	1888	0018,5101	CS	2 B	PA
DetectorTemperature	i	>	1898	0018,7001	DS	4 B	29.2
DetectorType	i	>	1910	0018,7004	CS	12 B	SCINTILLATOR

DICOM Image Meta-Data

- Use with CR/DX
- Does not contain accumulated information or info on rejected studies

MPPS and Custom Solutions

- MPPS typically used for scheduling with appended messages
- Contain very limited Radiation Dose module (time, DAP) based on archived images
- Manual Entry is more reliable



MPPS and Custom Solutions

- Other solution: OCR from printed report to virtual printer

Decisions – Data Transfer

- Send from Modality
  - Fast, reduce burden on PACS

- Send from PACS
  - Maintains complete database (# studies, etc)
  - Can retrieve data through query or sync

Role	Responsibility

Role	Responsibility
PACS Administrator	Maintain server, coordinate upgrades, configure PACS forwarding and sync

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Radiologist Division Head	Review data, approve protocol changes
Department Administrator	Dedicate time, resources, $$$
RSO	Ensure compliance with regulations
Medical Physicist	All of the above

Actual Responsibility:

Configuration, interpretation, education, developer(?)

Examination Dose Notifications

Patient ID	Accession Number	Details
		VOI: Reference Point Dose Value: 1131.1 [mGy] Threshold: 1000.0 [mGy] Dose Source: Scanner Output Criteria: gender Study: Pediatric Biopsy/Coronary Angio Modality: XA Model: Station: Date/Time: Institution: Action Level:

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   - Decisions: Data Format and Communication
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2. Size-Specific DRR's - CT

Joint Commission: "The [critical access] hospital establishes or adopts diagnostic computed tomography (CT) imaging protocols based on current standards of practice, which address key criteria including clinical indication, contrast administration, age (to indicate whether the patient is pediatric or an adult), patient size and body habitus, and the expected radiation dose index range"

2. Size-Specific DRR's - CT

Joint Commission: "The [critical access] hospital reviews and analyzes incidents where the radiation dose index (CTDIvol, DLP, or size specific dose estimate [SSDE]) from diagnostic CT examinations exceeded expected dose index ranges identified in imaging protocols"

DRR MAX SETTINGS (Boston Children's Hospital)

Date: 07-05-2016

ANATOMIC REGION	PATIENT SIZE	$CTDI_{vol}$ (mGy, 32)	$CTDI_{vol}$ (mGy, 16)
HEAD (Class 1)	PEDIATRIC	-	40
	ADULT	-	75
HEAD (Class 2)	PEDIATRIC	-	20
	ADULT	-	40
HEAD (Class 3)	PEDIATRIC	-	10
	ADULT	-	20
ABDOMEN (Class 1)	PEDIATRIC	10	15
	ADULT	25	-
ABDOMEN (Class 2)	PEDIATRIC	5	8
	ADULT	16	-
ABDOMEN (Class 3)	PEDIATRIC	3	4
	ADULT	8	-
CHEST (Class 1)	PEDIATRIC	7	11
	ADULT	18	-
CHEST (Class 2)	PEDIATRIC	4	6
	ADULT	9	-

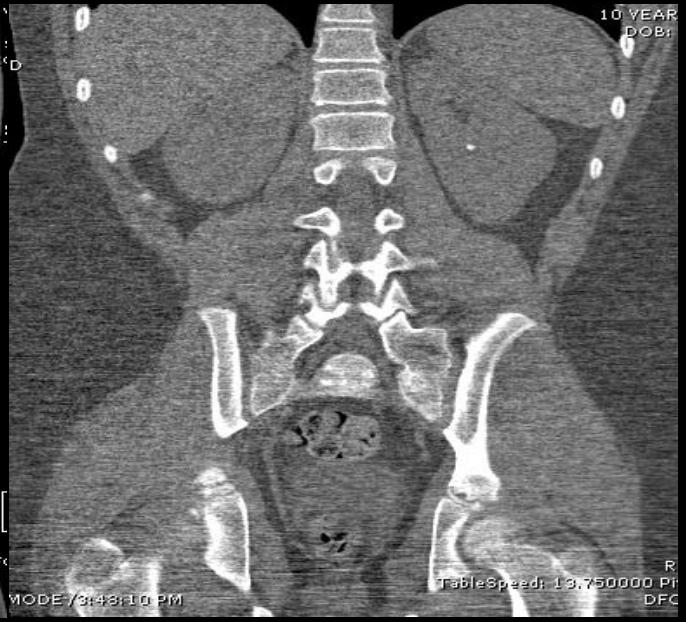
DC I

Relative Dose = 100%

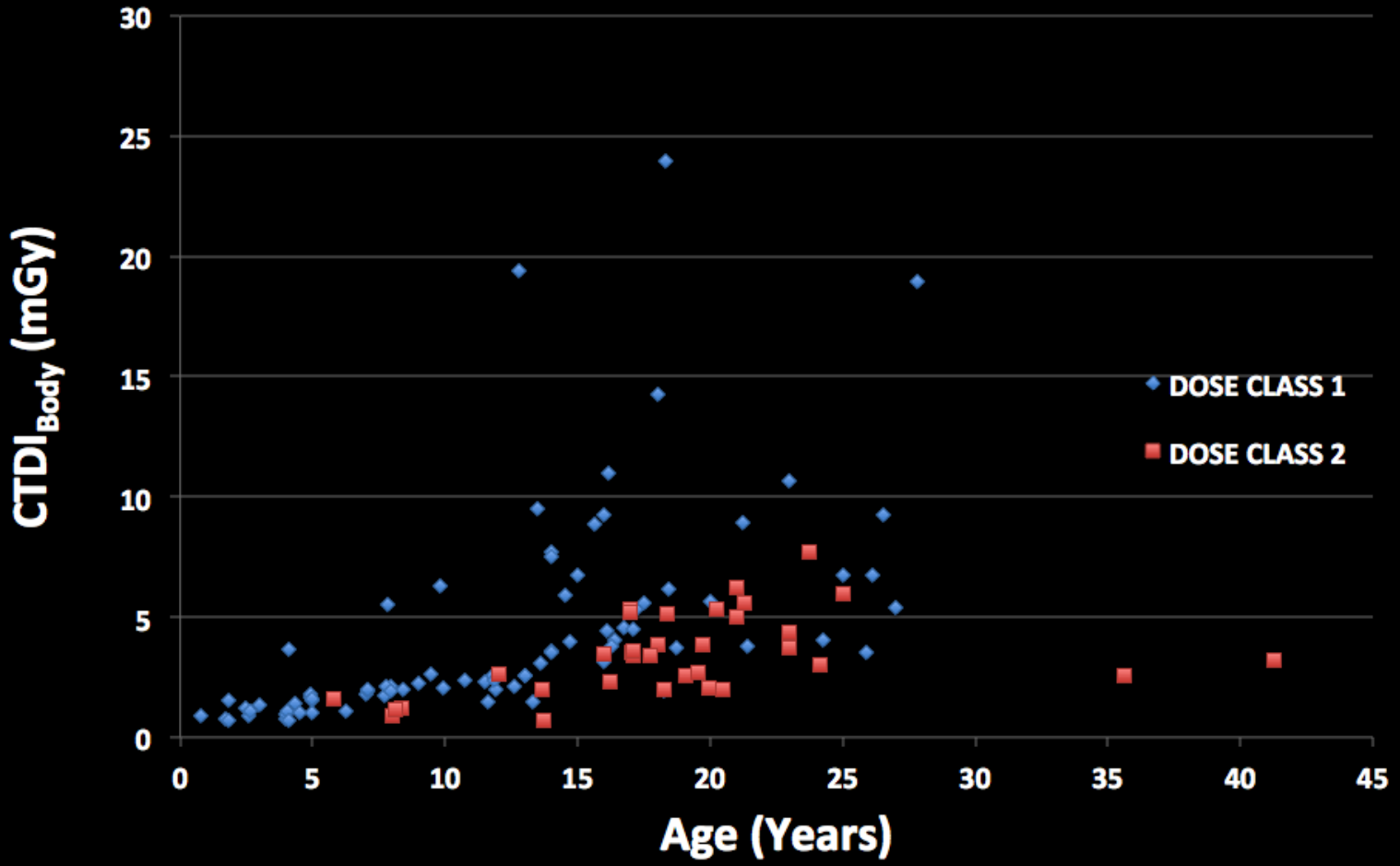
DC II

Relative Dose = 50%

DC III



Relative Dose = 25%



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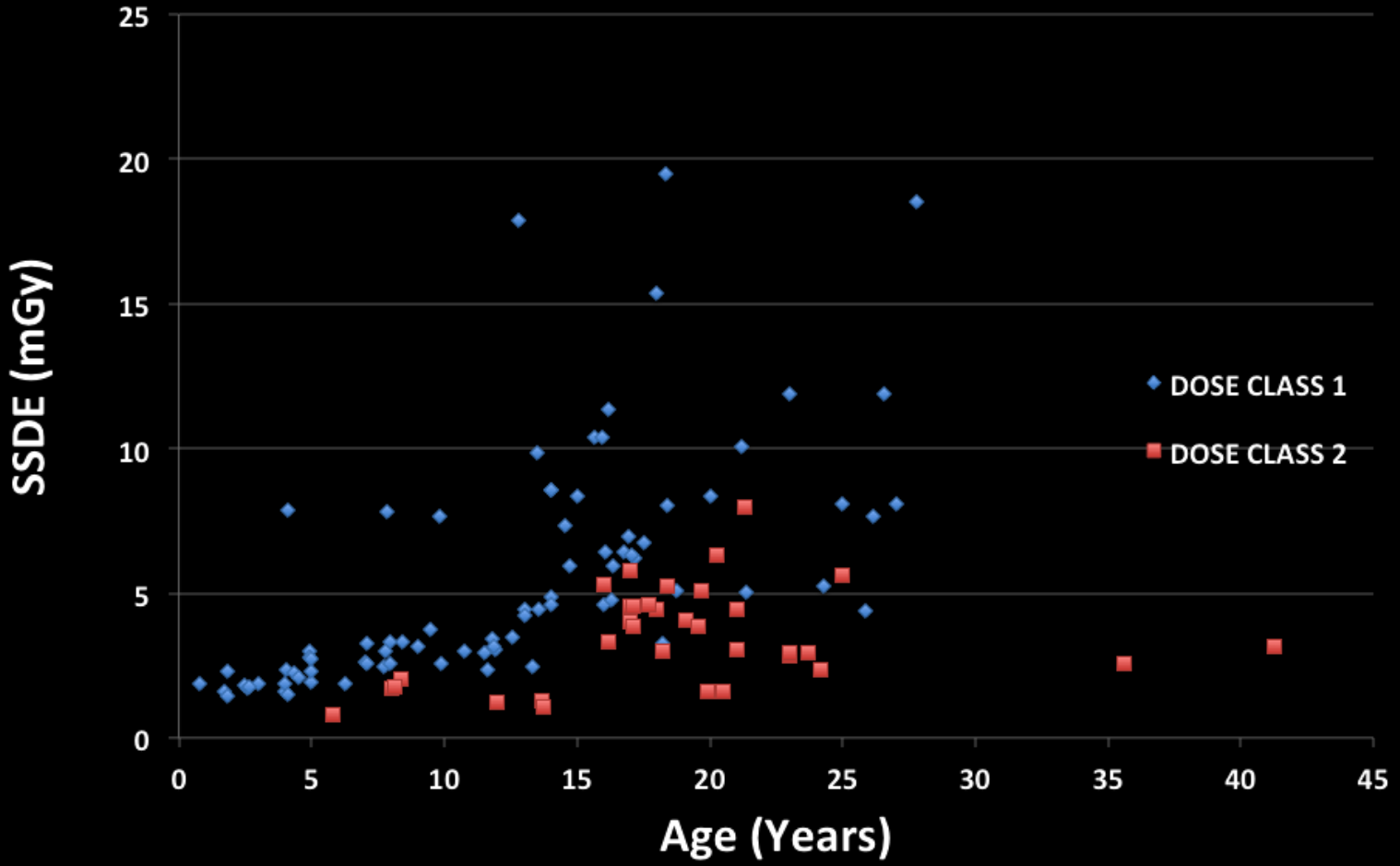

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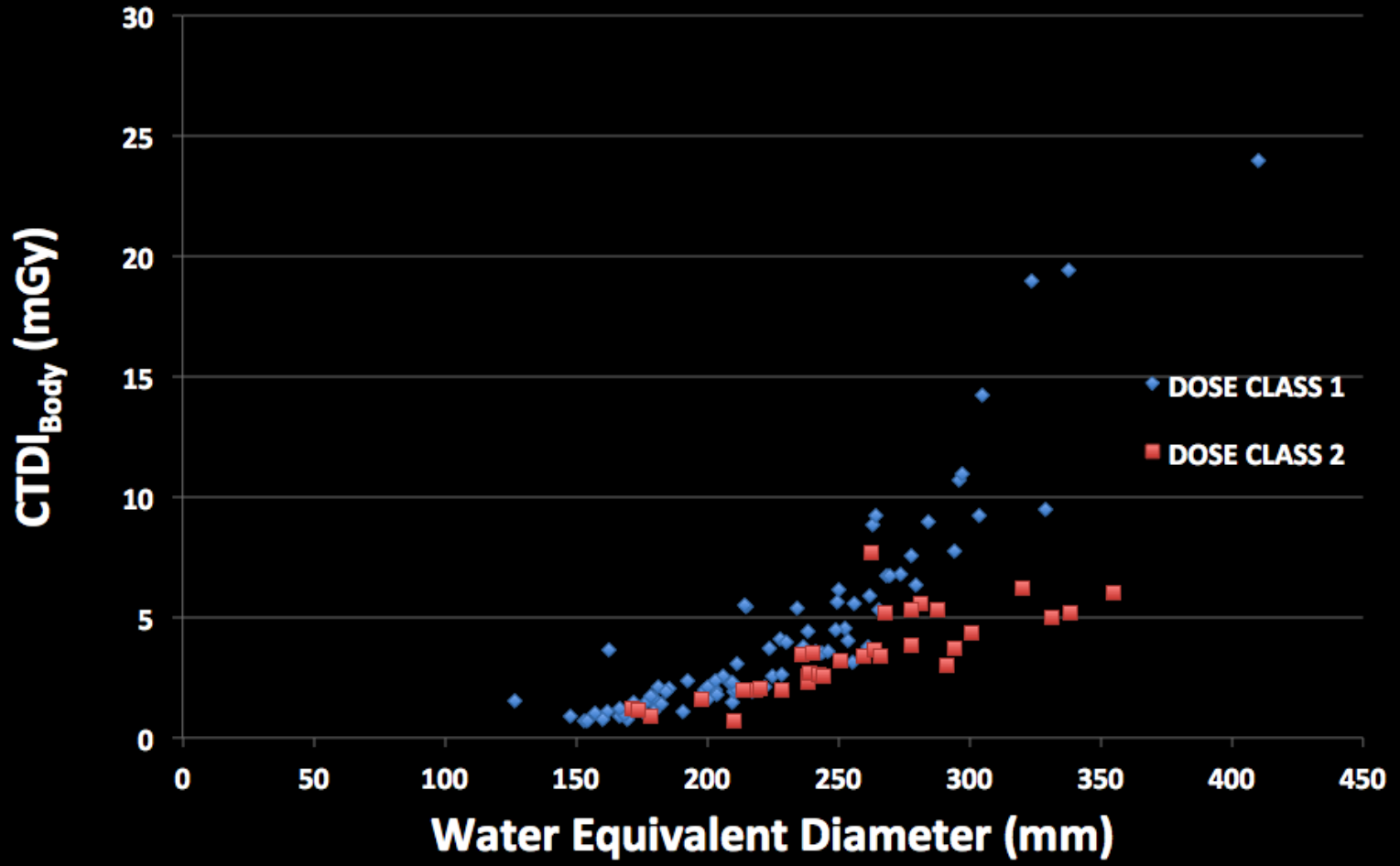

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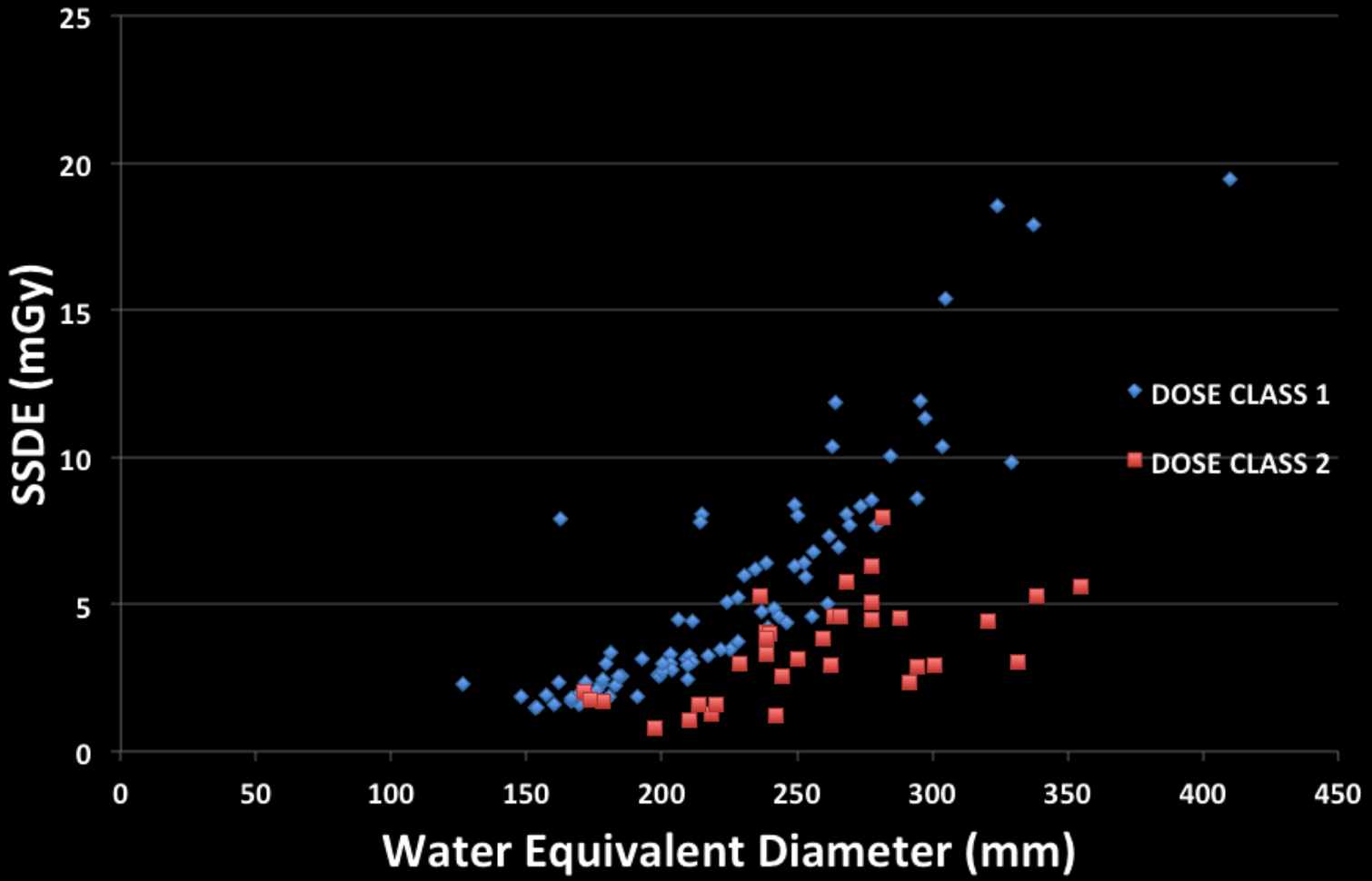

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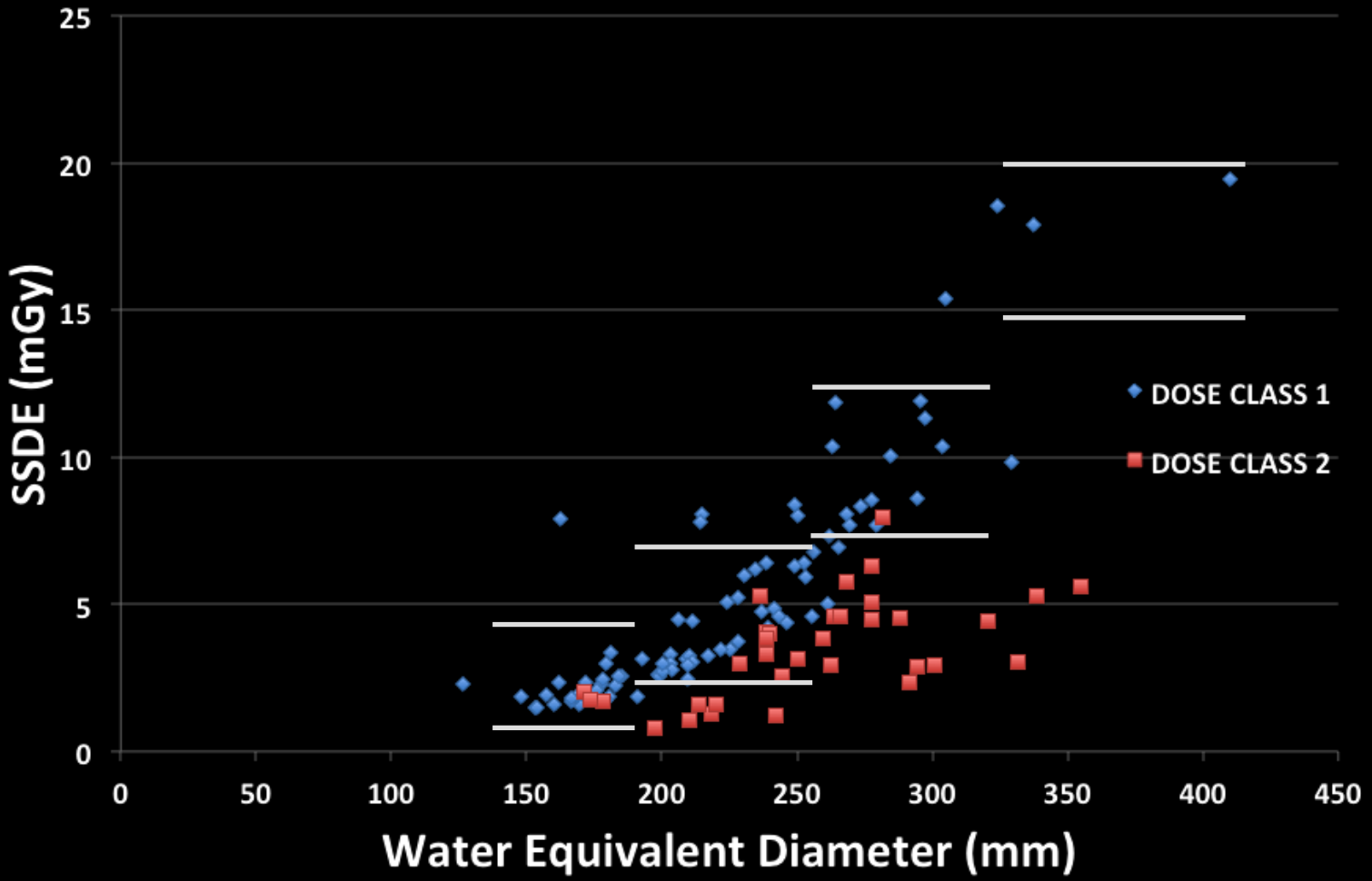

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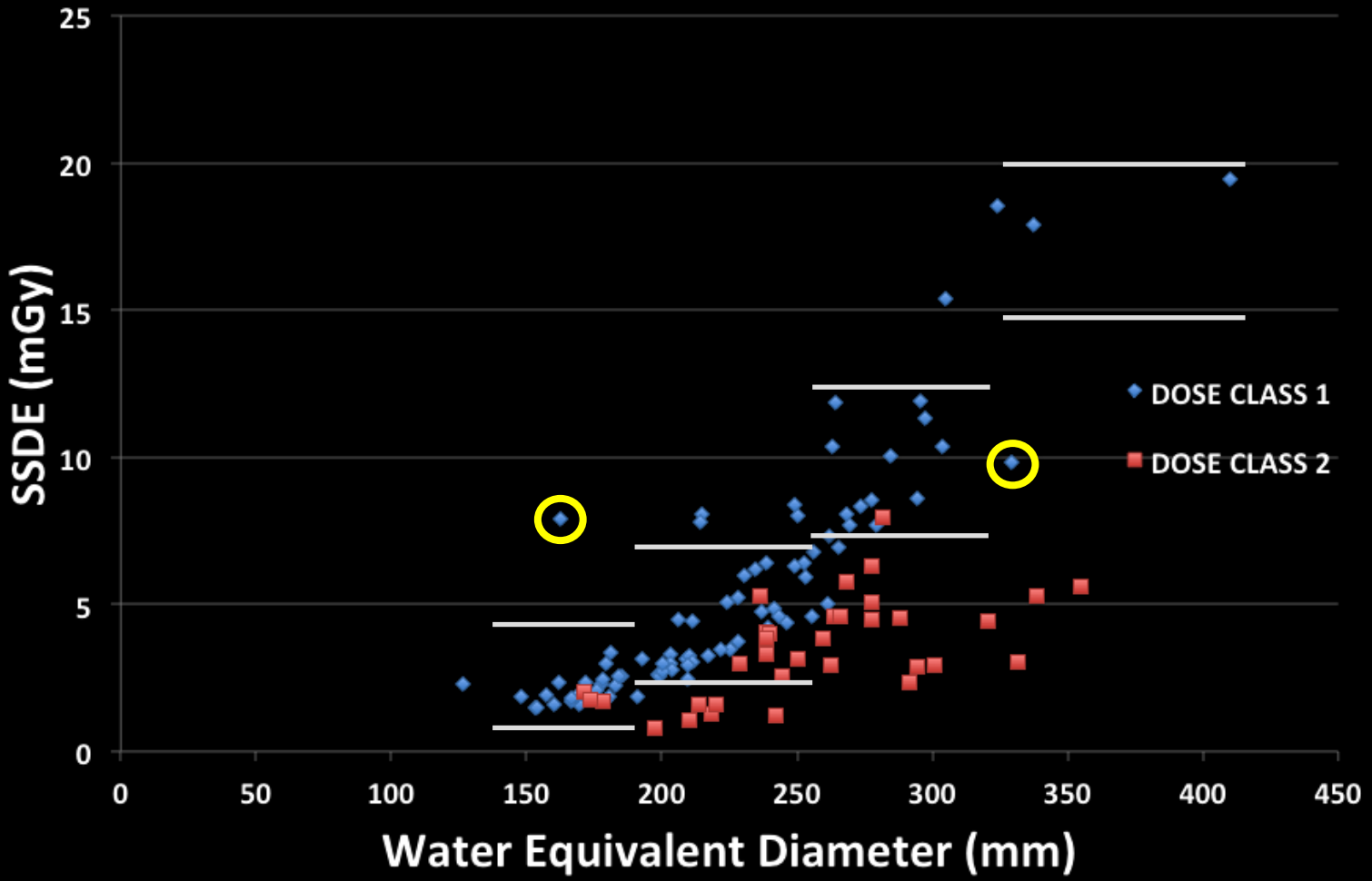

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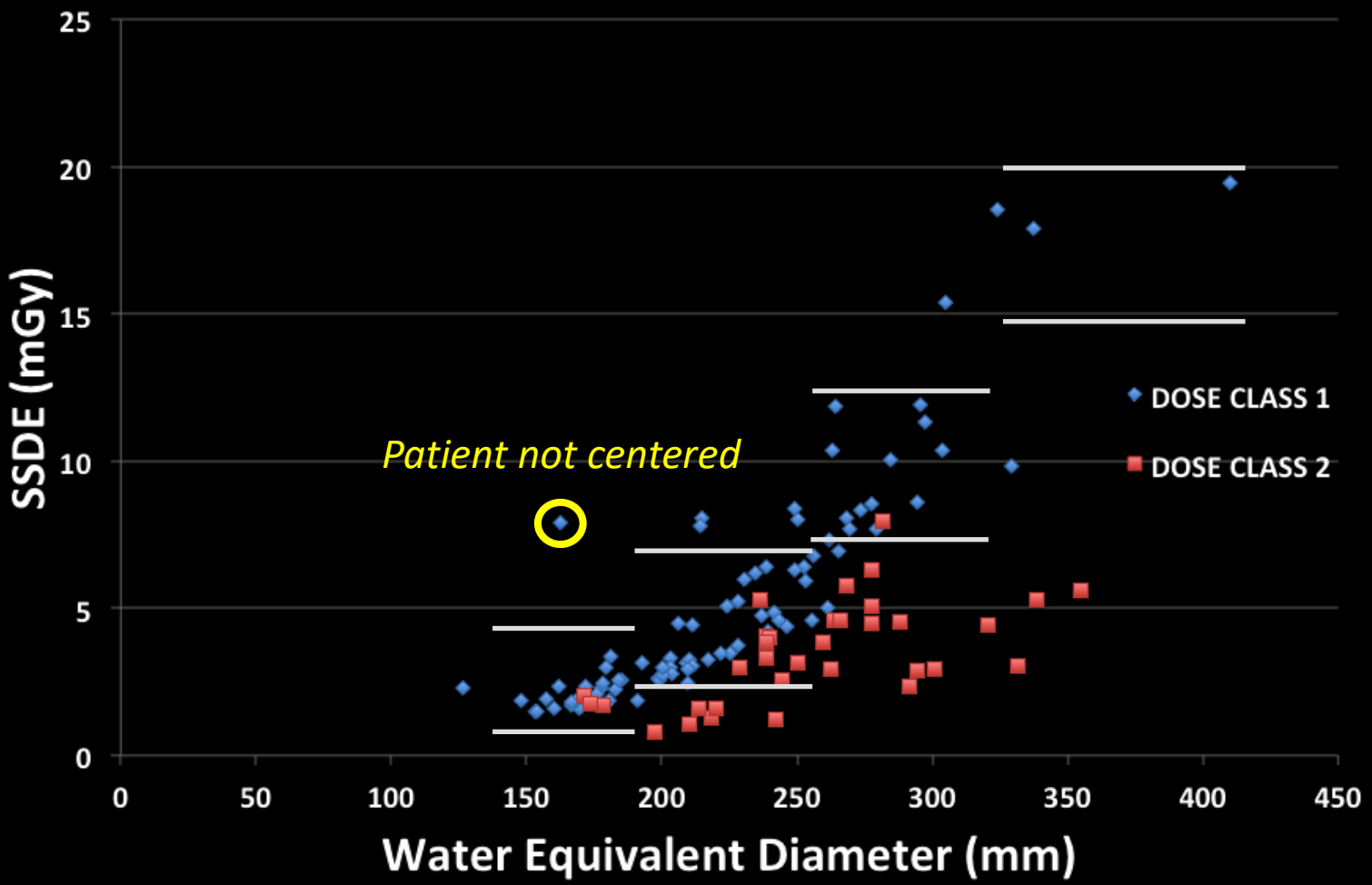

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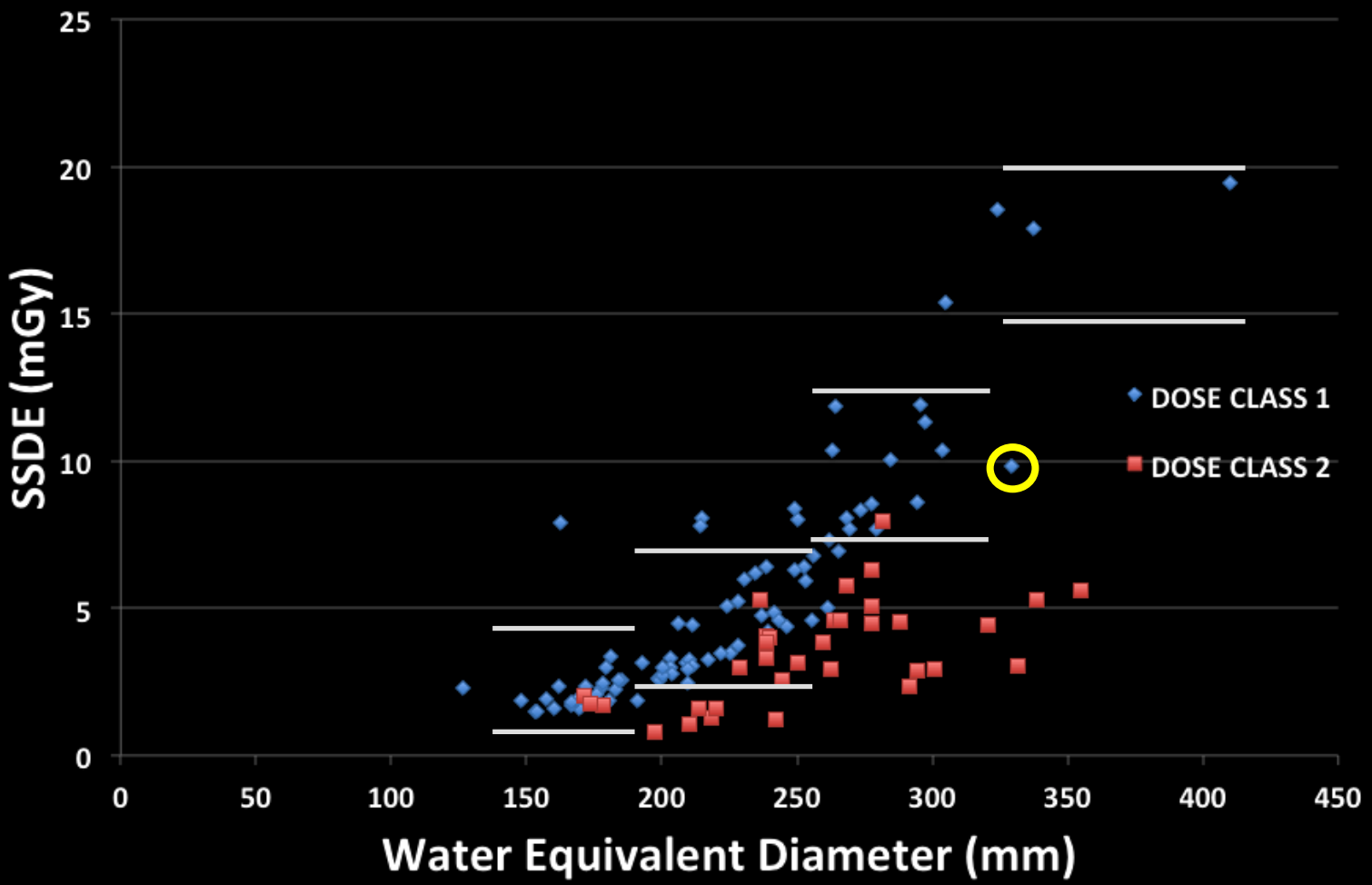

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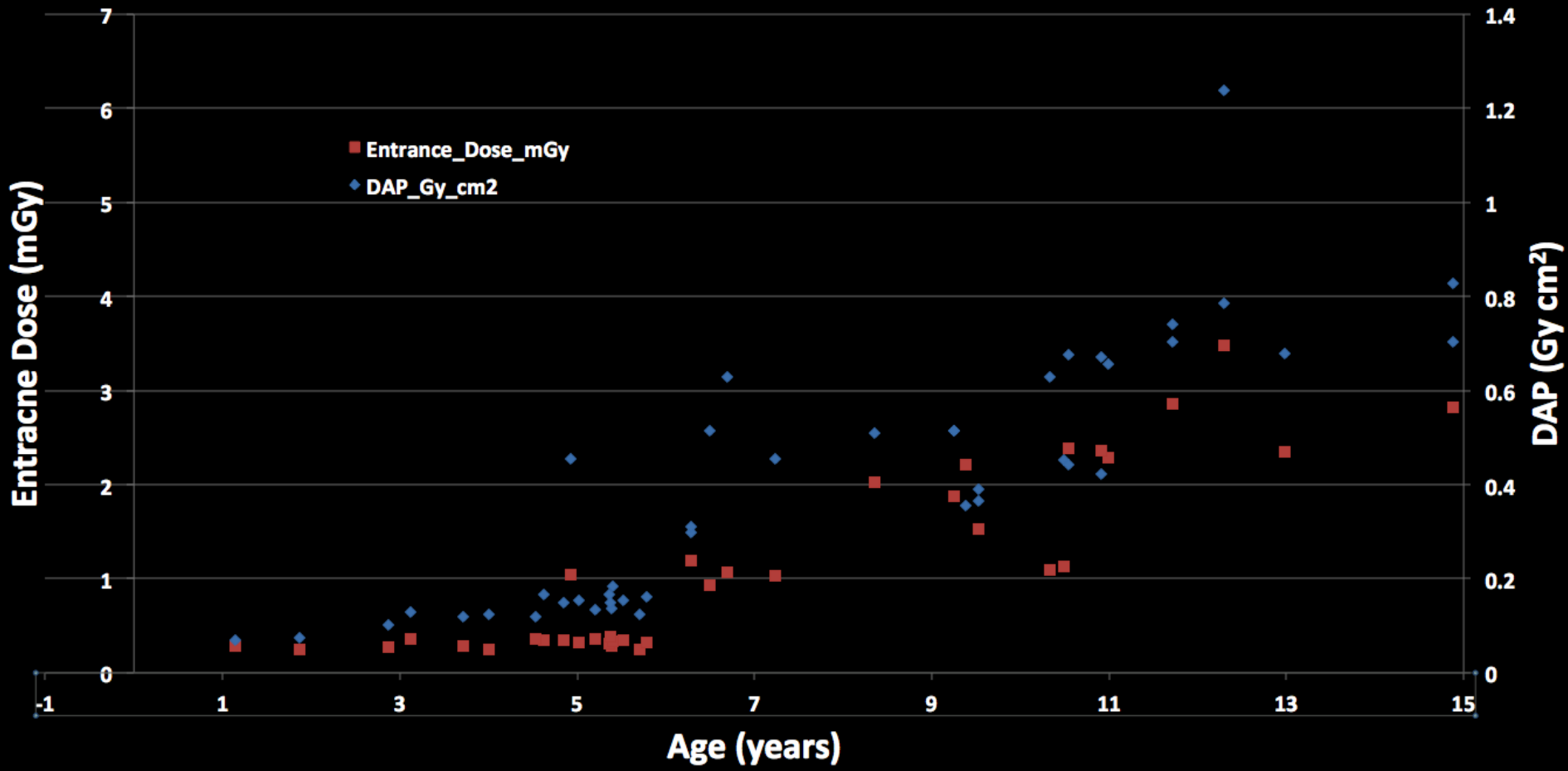
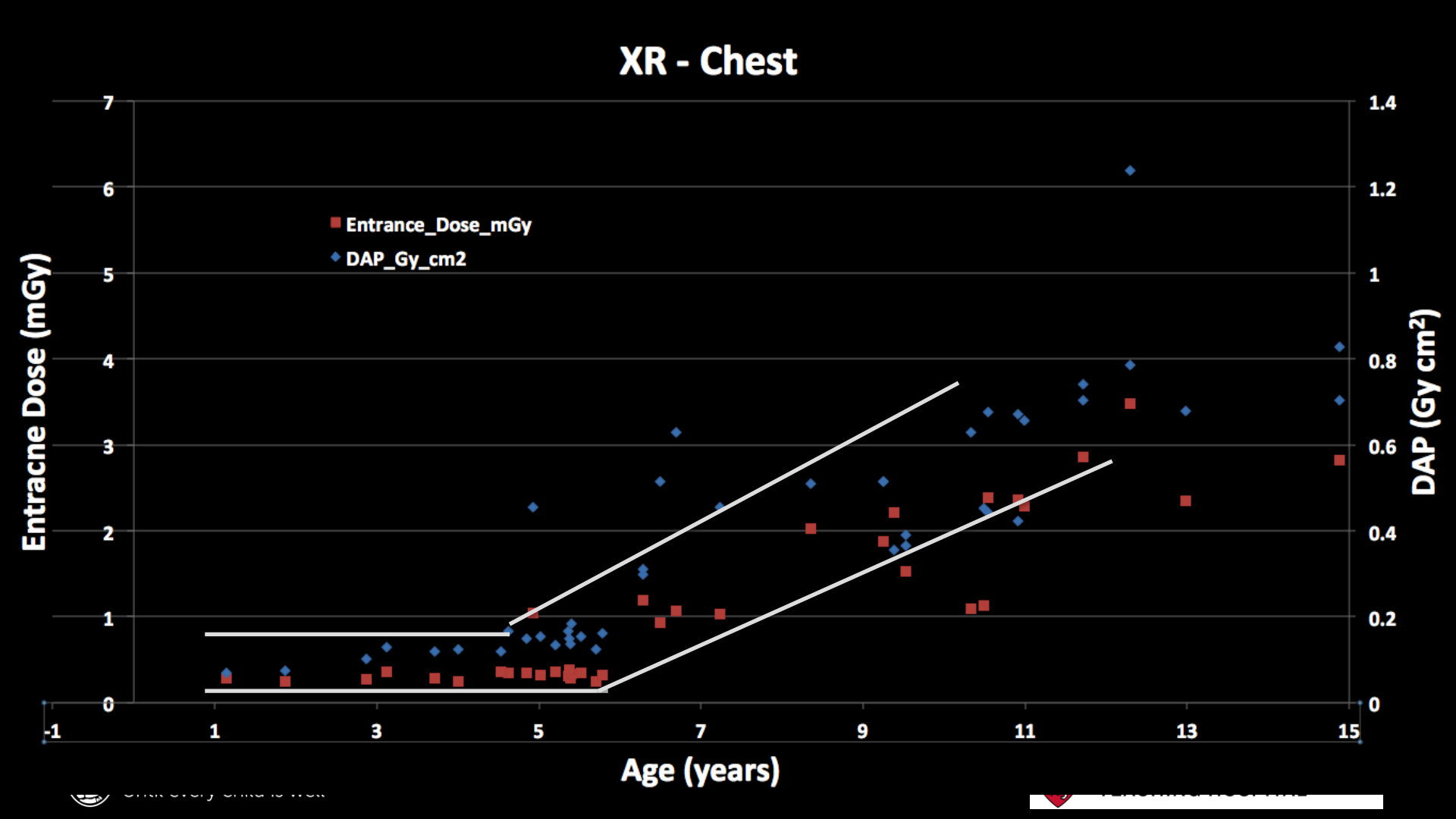
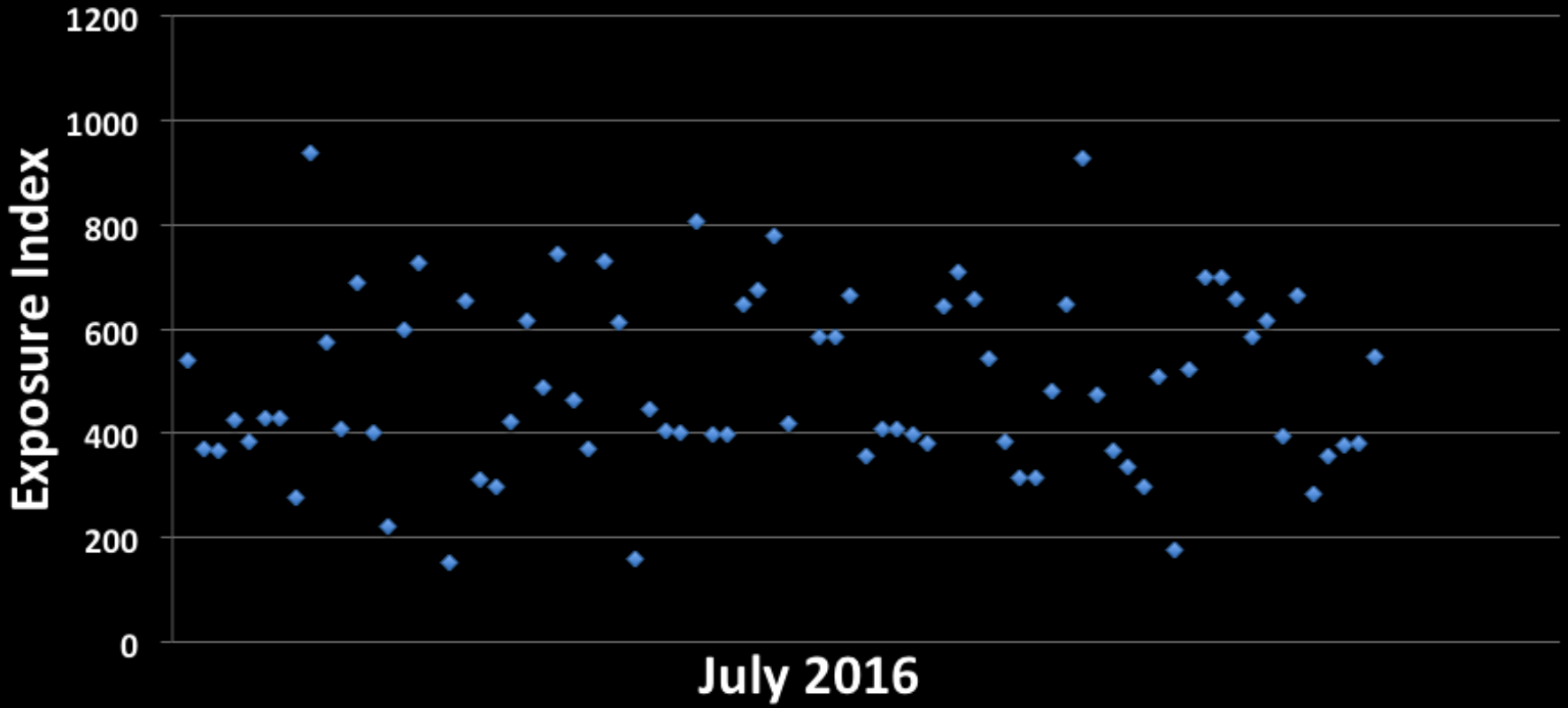
Max mA too low

XR - Chest


Entrance_Dose_mGy
DAP_Gy_cm2
Entracne Dose (mGy)
DAP (Gy cm²)
Age (years)
0
1
2
3
4
5
6
7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
-1
1
3
5
7
9
11
13
15


XR - Chest
Entrance_Dose_mGy
DAP_Gy_cm2
Entracne Dose (mGy)
DAP (Gy cm²)
Age (years)
0
1
2
3
4
5
6
7
0
0.2
0.4
0.6
0.8
1
1.2
1.4
-1
1
3
5
7
9
11
13
15

XR-Abdomen



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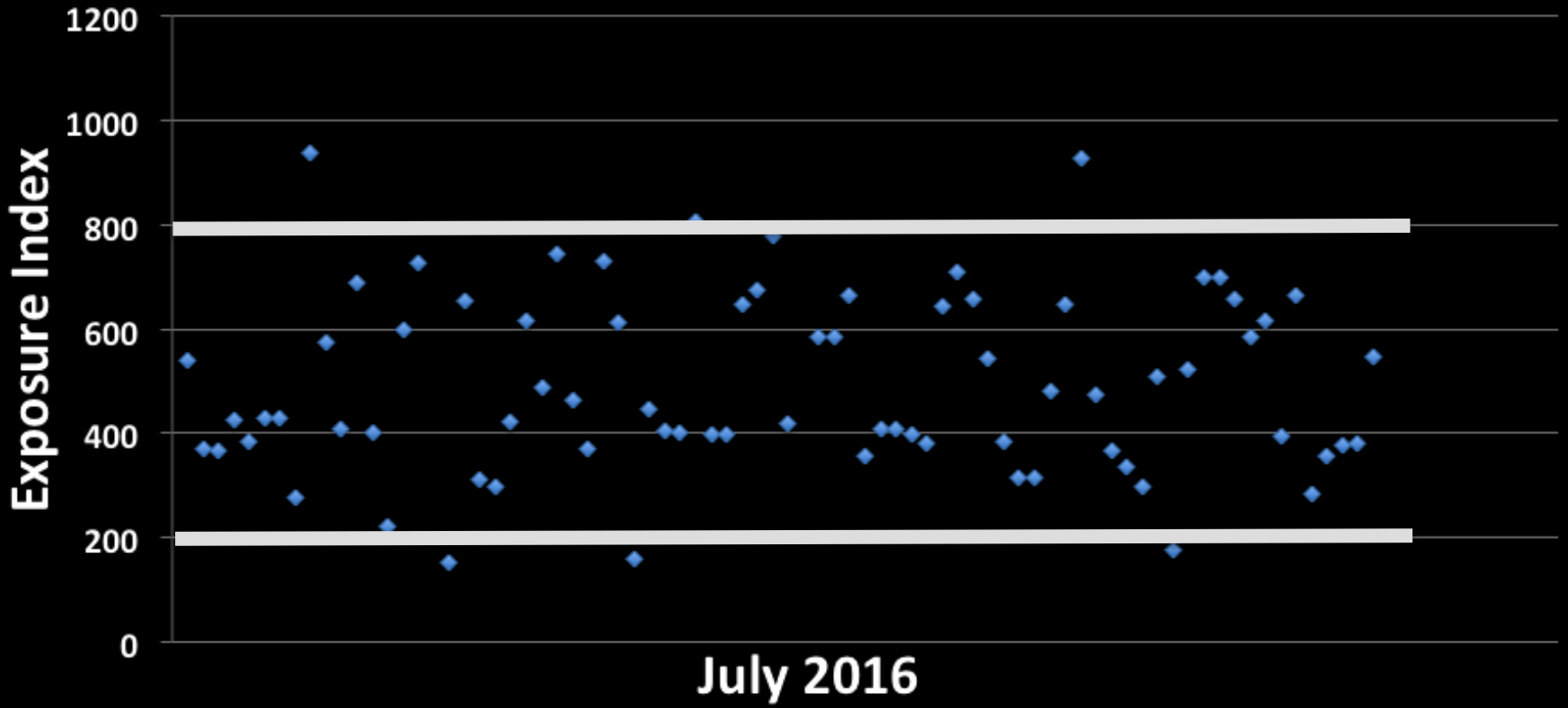
XR-Abdomen



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3. Educating Users - Technologists

- Work together to prepare “standing” dashboards
- Set up email reports (e.g. monthly)
- Develop QA loop defining when to escalate events and recommended action

3. Educating Users - Administrators

- Demonstrate compliance with regulatory/accreditation standards

- What to show if JC shows up…

3. Educating Users - Radiologists

- Potential dangers of dose history and the gambler's fallacy
- QI tool (MOC, etc)
- Justification for re-training of best practices

Thank You

Questions?