Dose optimization techniques and methods in MDCT

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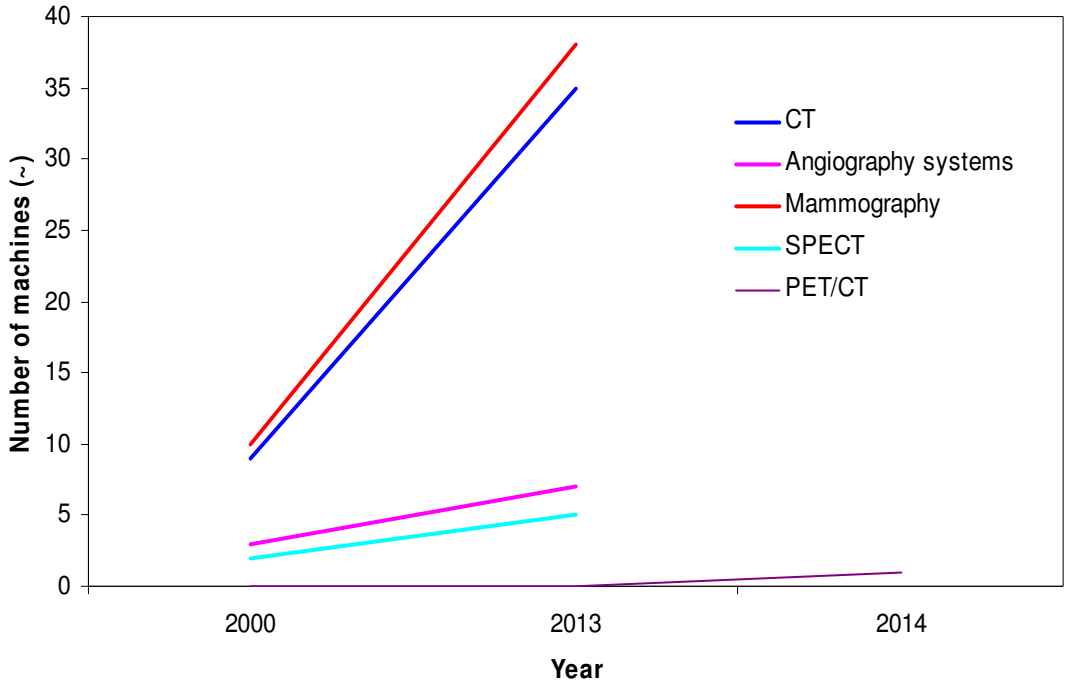
Disclosures

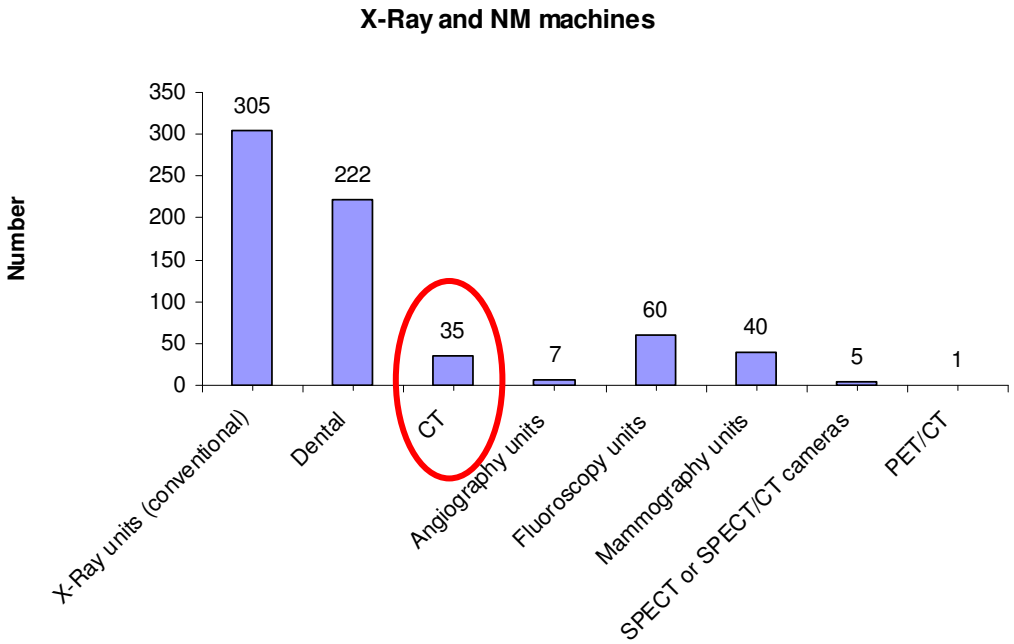
Author has no research or any type of financial support form the manufacture representatives mentioned in the presentation

Number of x-ray machines in clinical use over last 10-15 years in MK



More examinations → Higher dose population

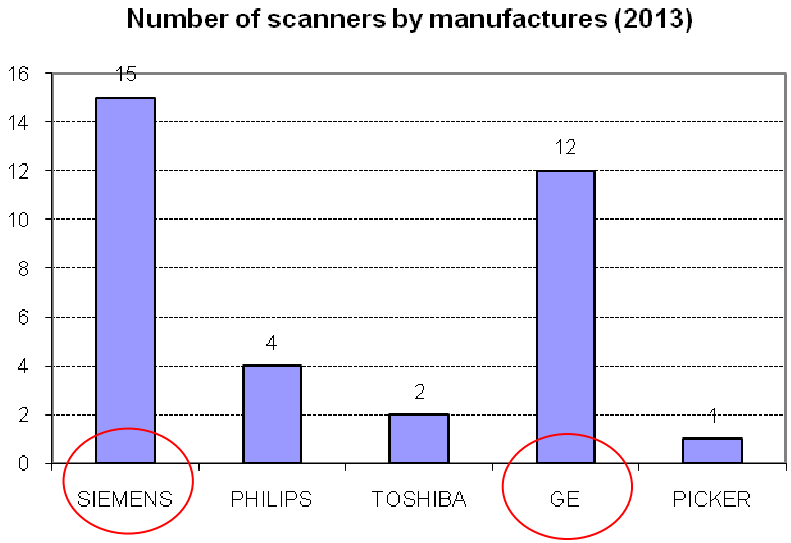
Number X-ray machines and cameras by imaging modalities



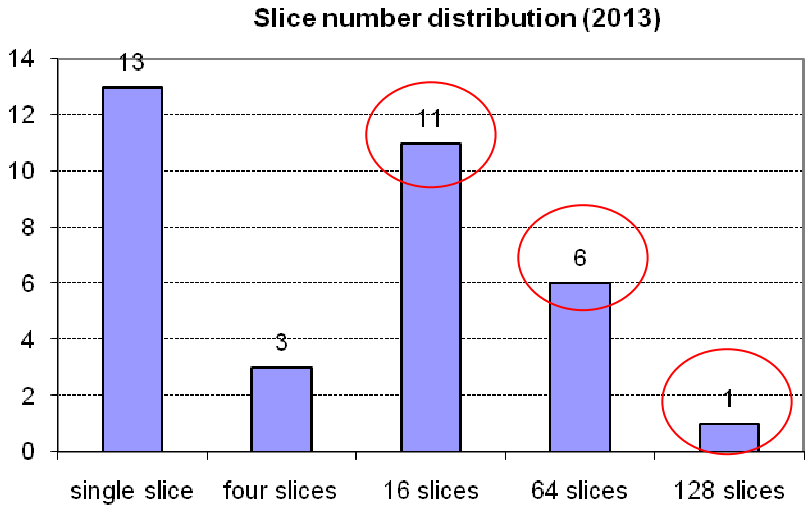
In Macedonia, there are more CT scanners per million population than UK or Slovenia (*)

* Data from project DDM2 2011-2012

Type of CT scanners in Macedonia

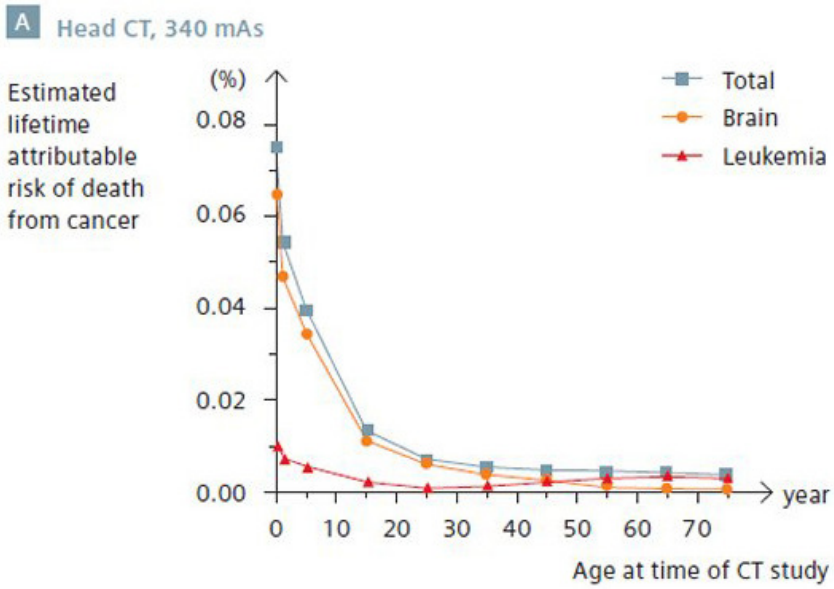


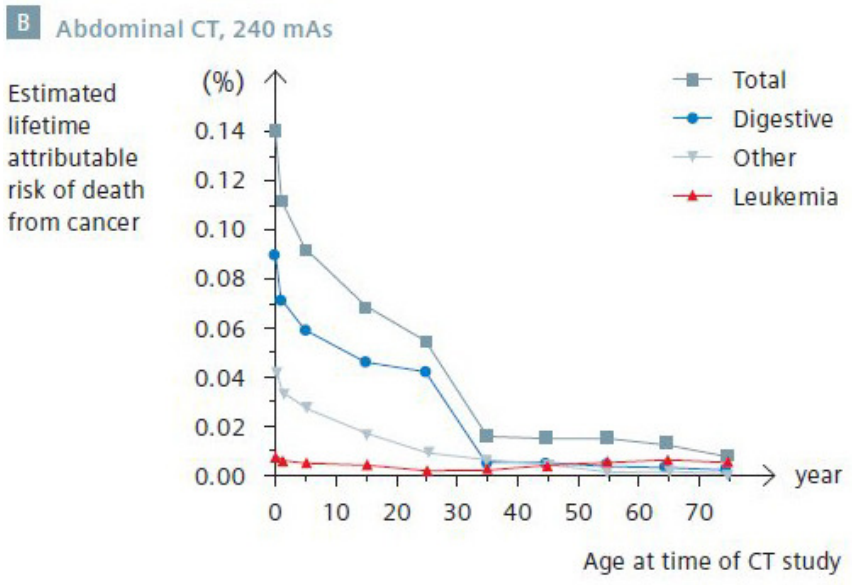
SIEMENS and GE are the most represented manufacturers



Dose modulation features in 16 or more slices scanners

Estimated risk of death by cancer attributable to a CT scan (LNT model)





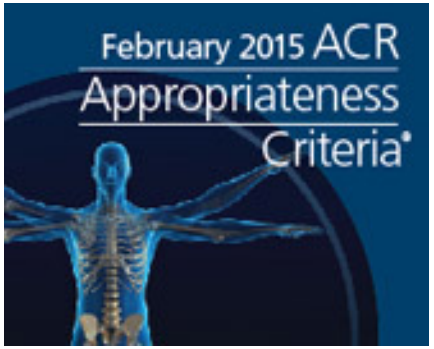
- Higher risk in abdominal examinations
- Higher risk in pediatric patients

* Data from Guide to Right Dose SIEMENS Medical

DOSE OPTIMIZATION TECHNIQUES and METHODS in MDCT

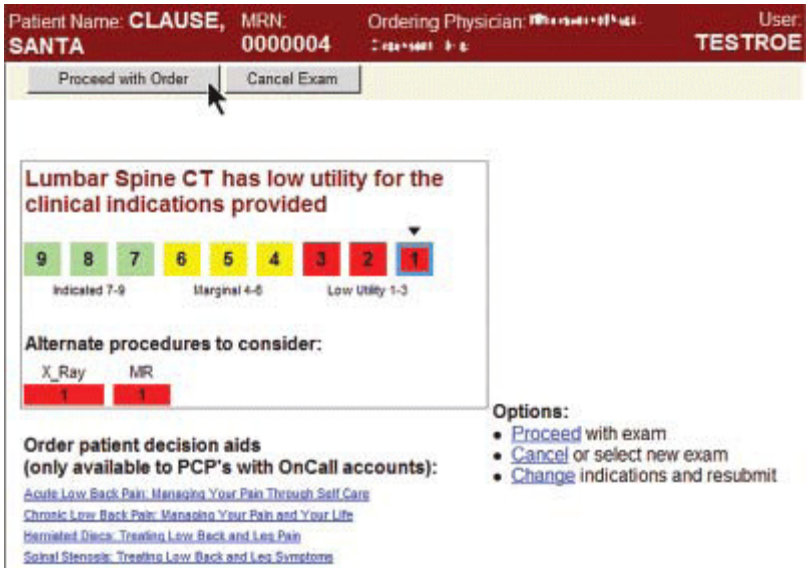
- Justification of examinations
- Dose optimization techniques in CT
  - AEC systems
  - Reconstruction techniques
  - Beam energies, etc
- Role of the medical personnel
  - Technologist, Radiologist, Medical physicist
  - Appropriate protocols and image quality
- Implementation of patient dosimetry tools (DRLs, dose tracking, dose card, etc)

JUSTIFICATION



Evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging

Decision Support Tools



JUSTIFICATION (local circumstances)

24.09.2014, Minister N. Todorov – press conf

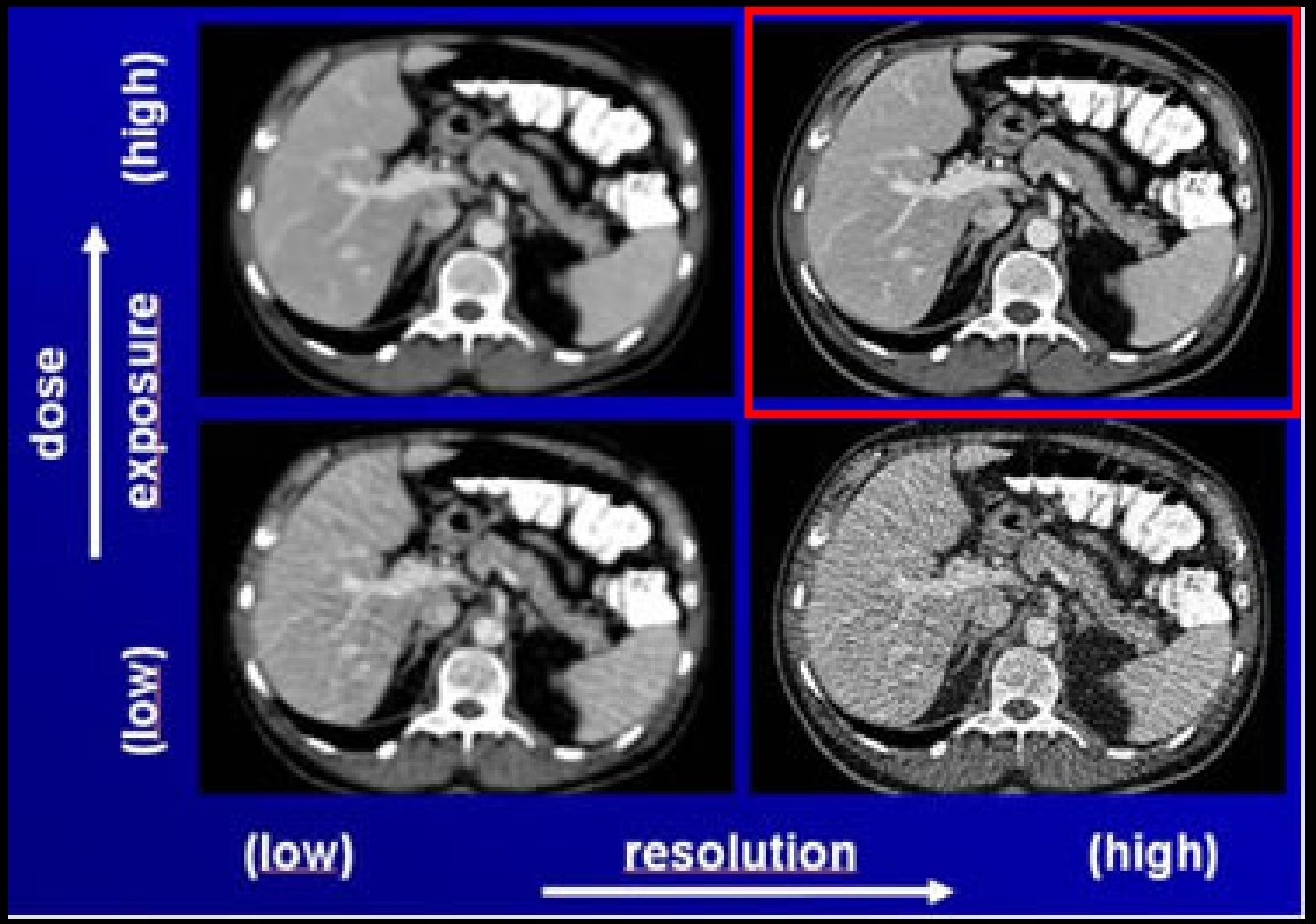
- 12 CT exams in some patients, although "standards" allow max 3 CT examinations per year?!

- 41% of 15 500 CT exams with no pathological findings?!

Approximately ~ 50% of CT examinations are unjustified !

Not because of "lack of pathological findings",

BUT because of not respecting of appropriateness of CT examination for particular clinical needs



(*)

Relation between spatial resolution, image noise and dose

(*) http://www.imp.uni-erlangen.de/forschung/dose/dose.htm

Technology developments in CT

SIEMENS Healthcare

1994 CARE Dose4D	1997 Ultra Fast Ceramic (UFC)	1999 Adaptive ECG-Pulsing	1999 HandCARE	2002 Pediatric 80 kV Protocols	2005 DSCT
2007 Adaptive Cardio Sequence	2007 Adaptive Dose Shield	2008 Flash Spiral	2008 Selective Photon Shield	2008 4D Noise Reduction	2008 X-CARE
2009 IRIS	2010 CARE kV	2010 SAFIRE	2010 CARE Child	2011 Stellar Detector	2013 ADMIRE

Technology developments in CT

SIEMENS Healthcare

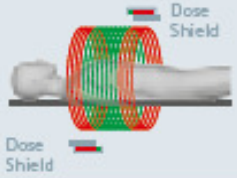
1994

CARE Dose4D

2002

Pediatric 80 kV Protocols

2007



Adaptive Dose Shield

2008

X-CARE

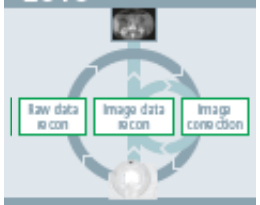
2009

IRIS

2010

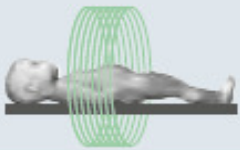
CARE kV

2010



SAFIRE

2010



CARE Child

2013

ADMIRE

Technology developments in CT

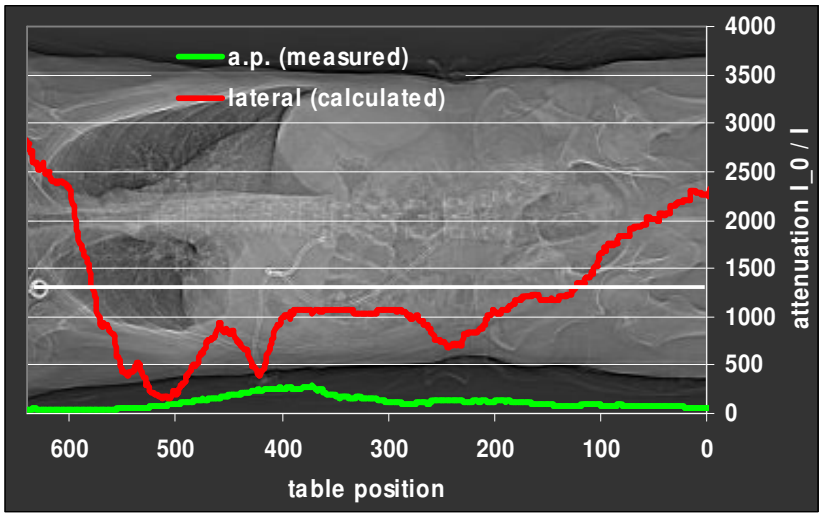
SIEMENS Healthcare

Tube current adjustment according to patient attenuation characteristics

Dose reduction circa 20-40 %

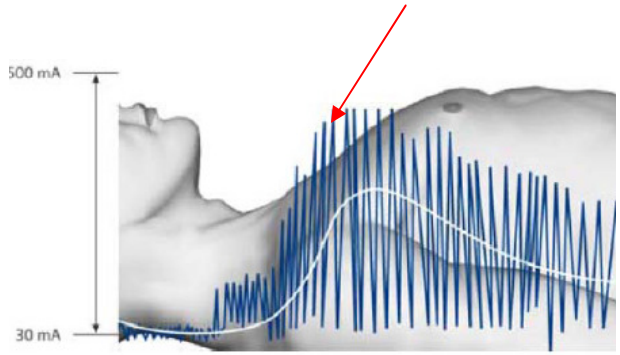
"Real time" exposure control

AP topogram



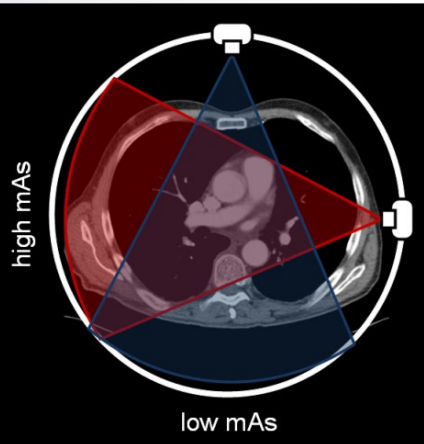
AP & LR attenuation profile across z-axis

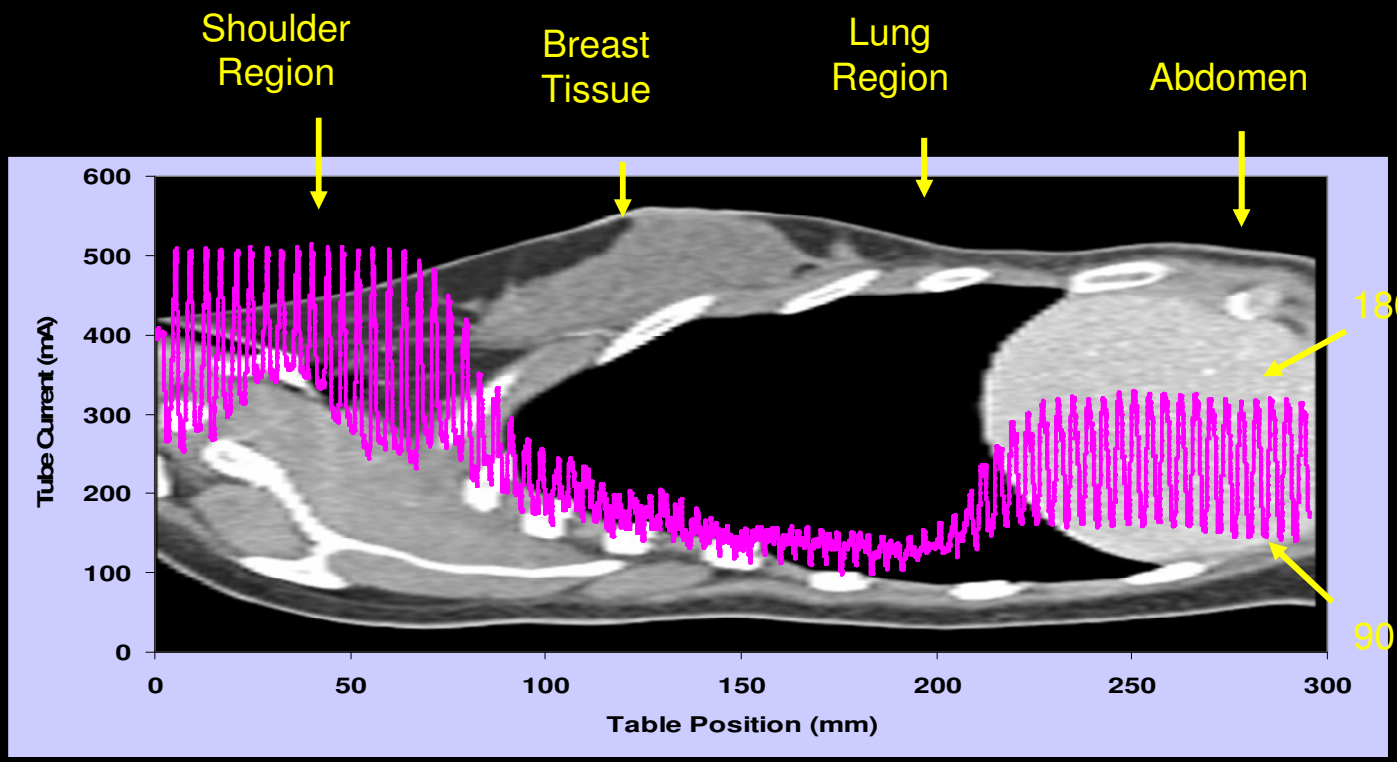
Angular modulation



Based on the attenuation profiles, the system performs TCM during each tube rotation (ANGULAR MODULATION)

DOSE OPTIMIZATION TECHNIQUES in MDCT

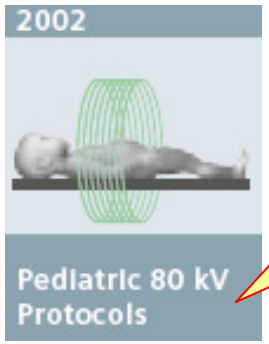




Long Axis TC Modulation

Technology developments in CT

SIEMENS Healthcare



Available of 80 kV in pediatric protocols;

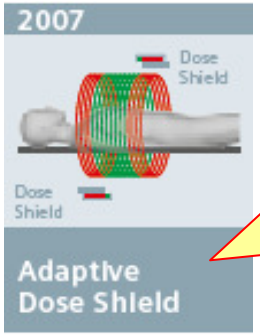
Lower dose than 120 kV, and better image contrast.

Up to 50% dose savings

80 kV	0,5 mSv	
100 kV	1 mSv	
120 kV	1,6 mSv	IAEA
140 kV	2,3 mSv	

Technology developments in CT

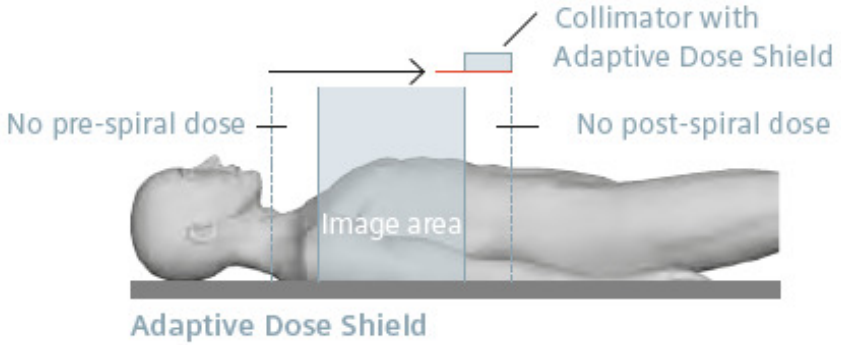
SIEMENS Healthcare

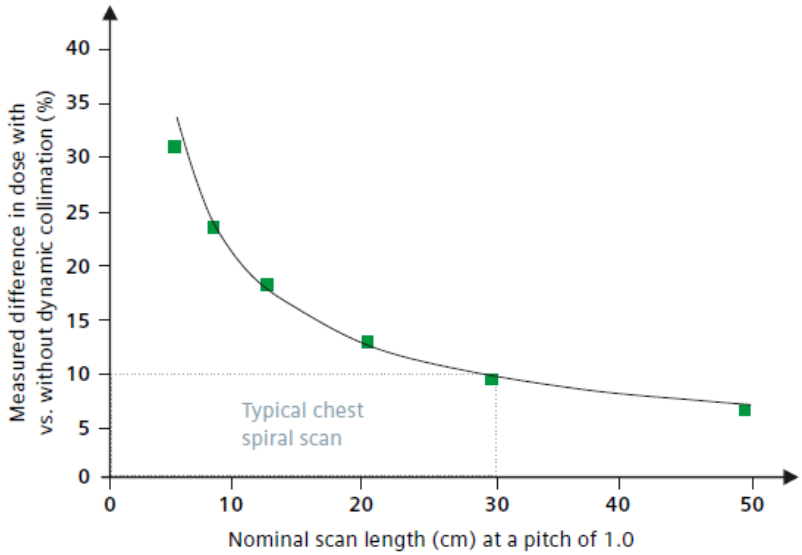


Dynamic Collimator control -

Movement of collimator blades limits over-ranging

Reduction patient dose – up to 35%





In spiral CT, it is routine to do an extra half-rotation of the gantry before and after each scan;

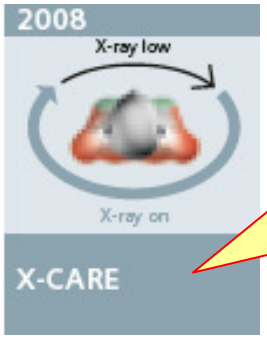
BUT, only part of these acquired data is necessary for image reconstruction

- In shorter scans, and wider detectors → more dose reduction

- Higher pitch factor → more dose reduction

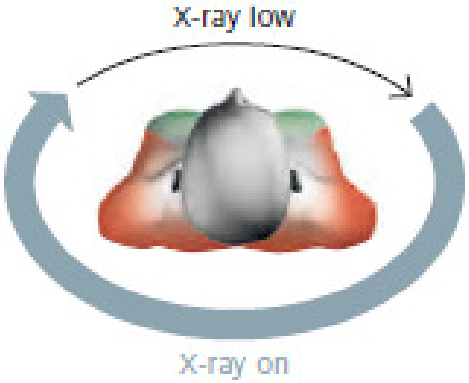
Technology developments in CT

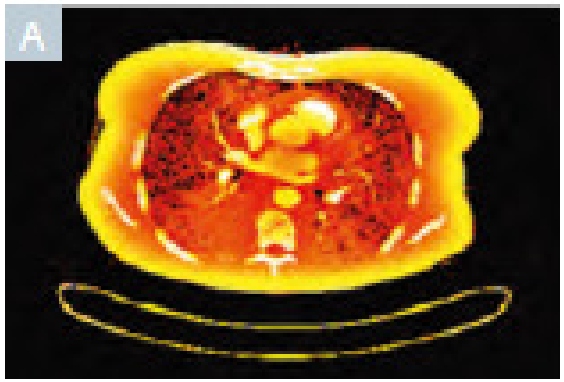
SIEMENS Healthcare



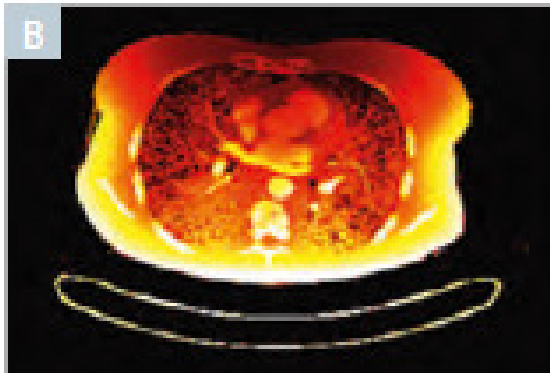
Organ- Based Dose Modulation –

Selectively limit the radiation exposure of sensitive organs





Radiation doses without X-CARE



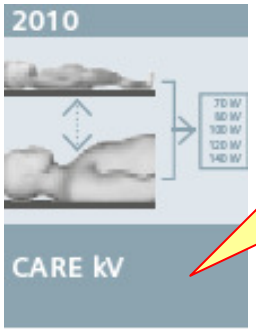
Radiation doses with X-CARE

(*)

(*) Dose organ map calculation

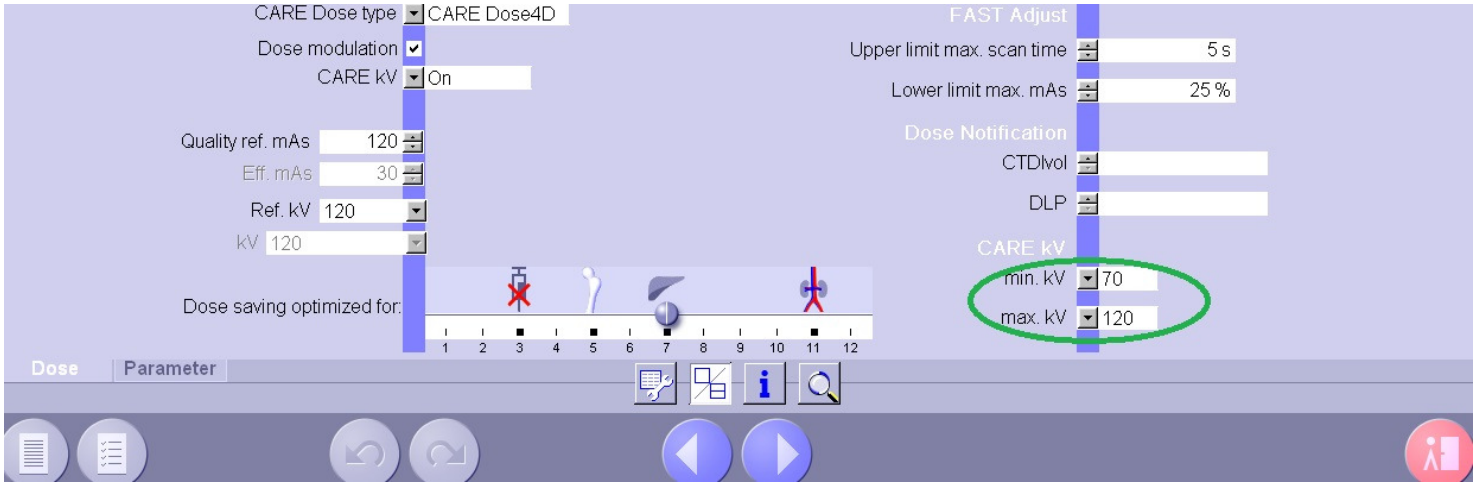
Technology developments in CT

SIEMENS Healthcare



"Fully automated" adjustment of tube voltage;

Followed by CARE Dose 4D (TCM)



CARE kV option – active;

Selection of type of examination (non contrast, skeleton, abdomen or IV contrast)

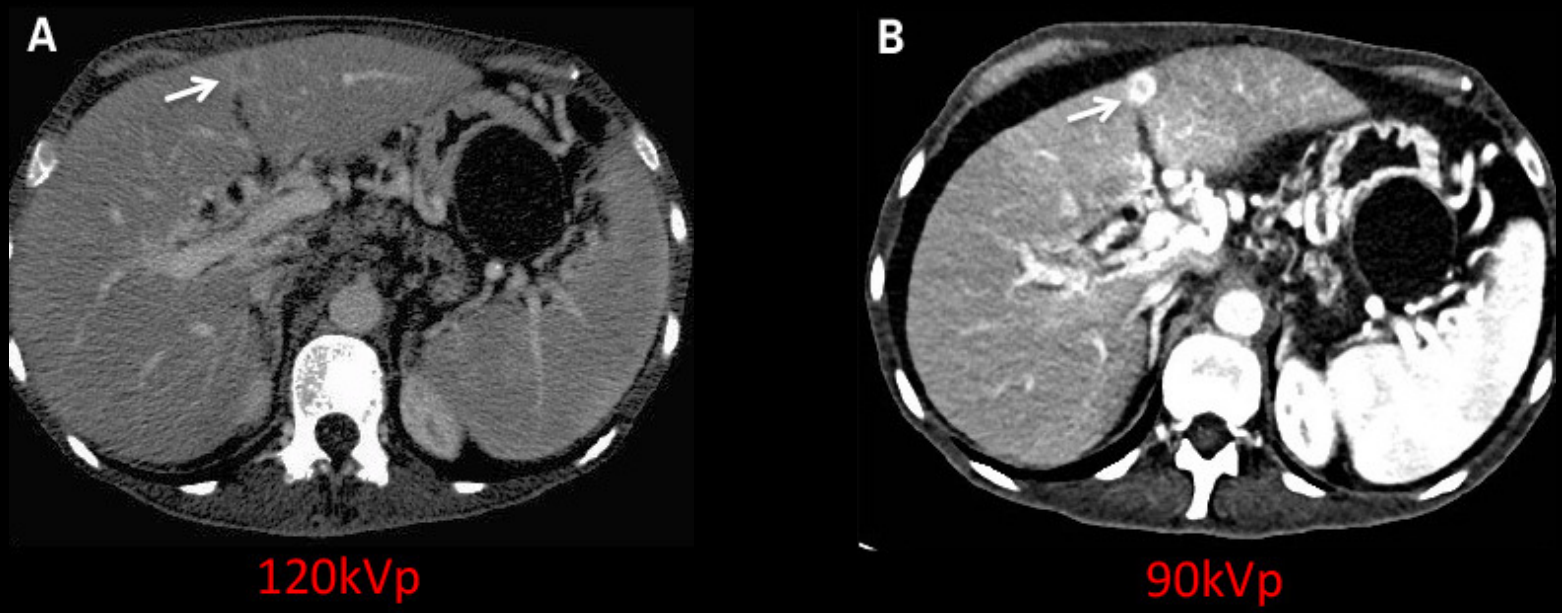
Scanner identify optimal kV

Topogram is performing (to adjust TCM)

CARE kV

The same image quality

CARE kV



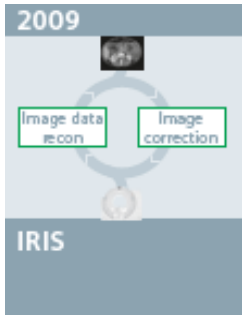
NOT dose reduction technique only

Improved image quality (contrast)

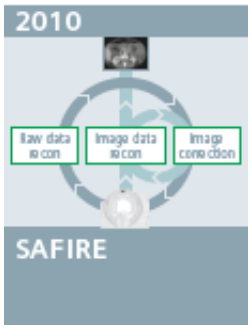
Technology developments in CT

SIEMENS Healthcare

Reconstruction techniques which reduce noise at low dose level (dose reduction up to 60%)

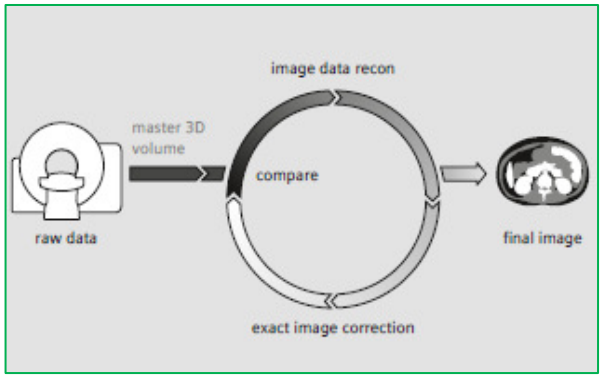


IRIS –
Iterative Reconstruction in Image Space

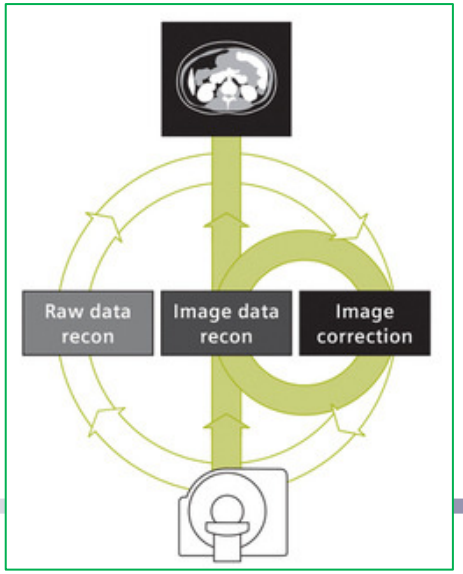


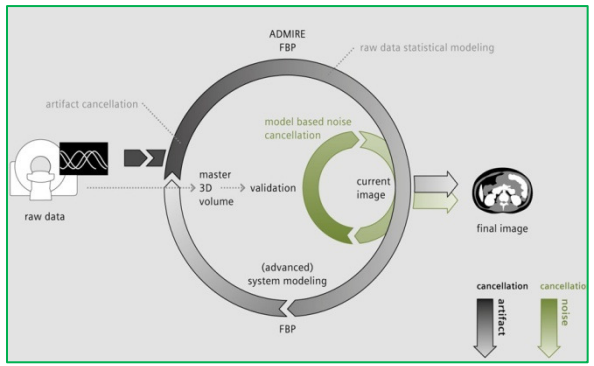
SAFIRE –
Sinogram Affirmative Iterative Reconstruction

ADMIRE –
Advanced Modeled Iterative Reconstructior

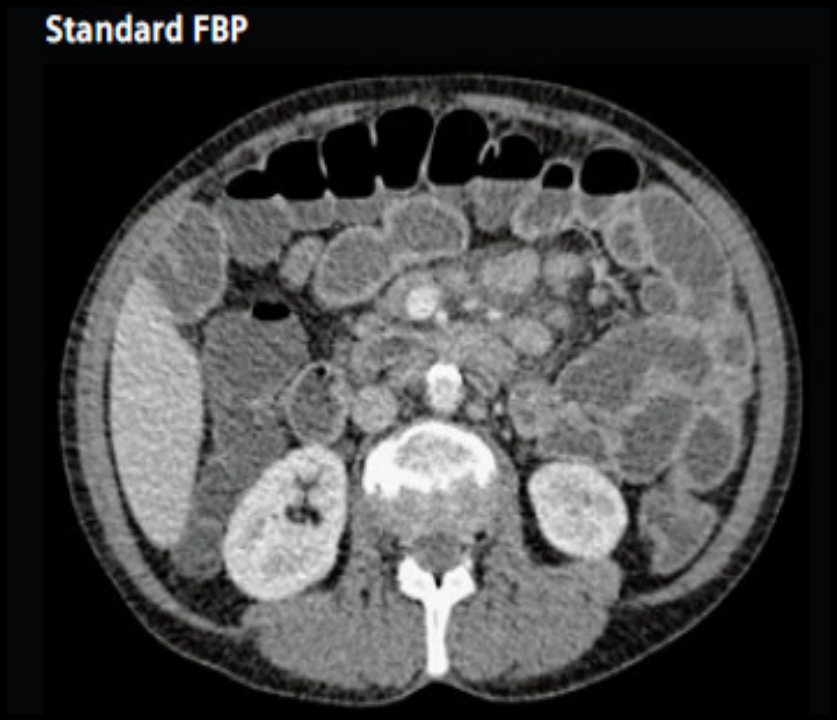


Row data recon only once;
Corrections and removing noise performed in image space

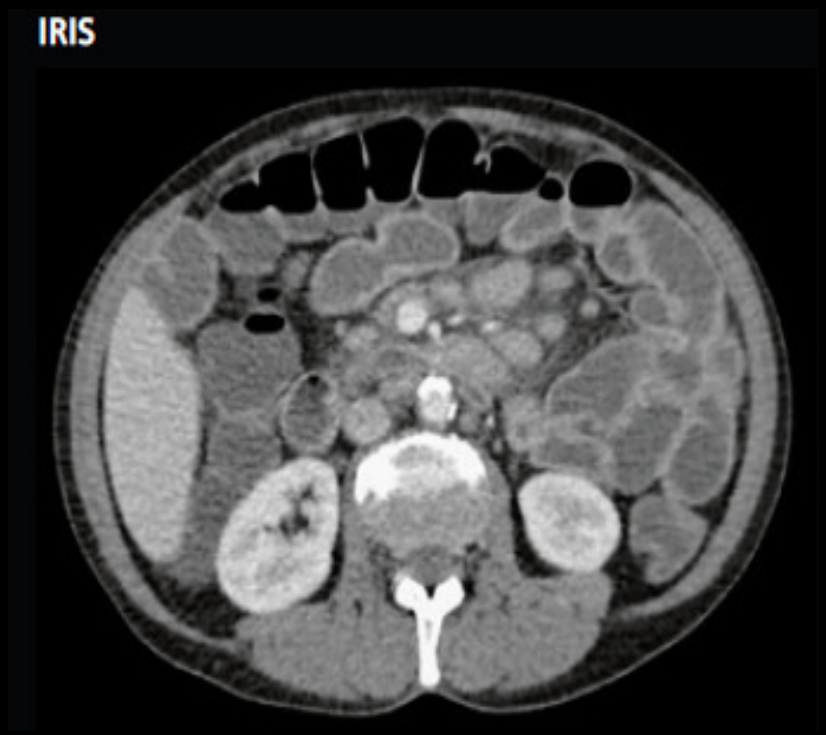




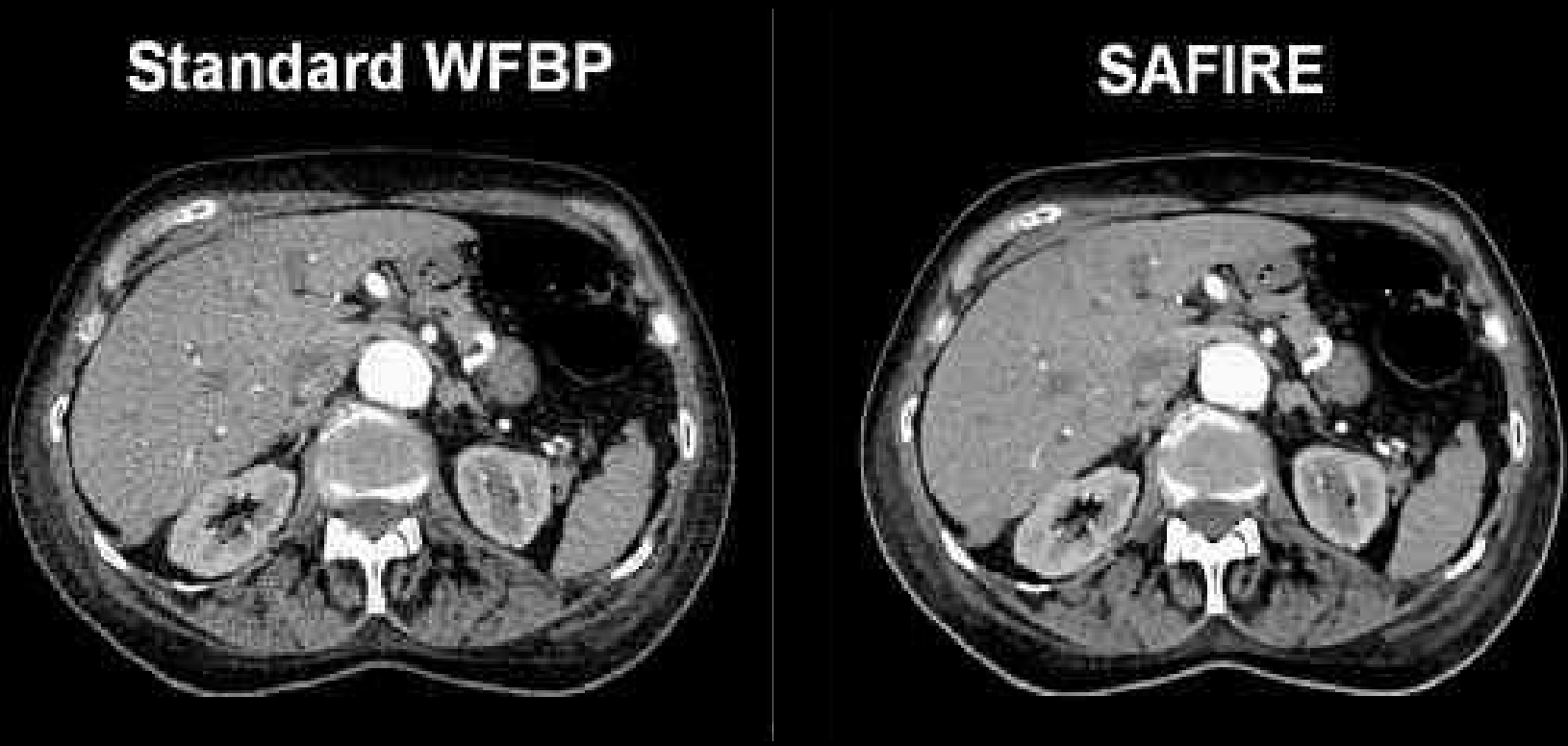
DOSE OPTIMIZATION ECHNIQUES in MDCT

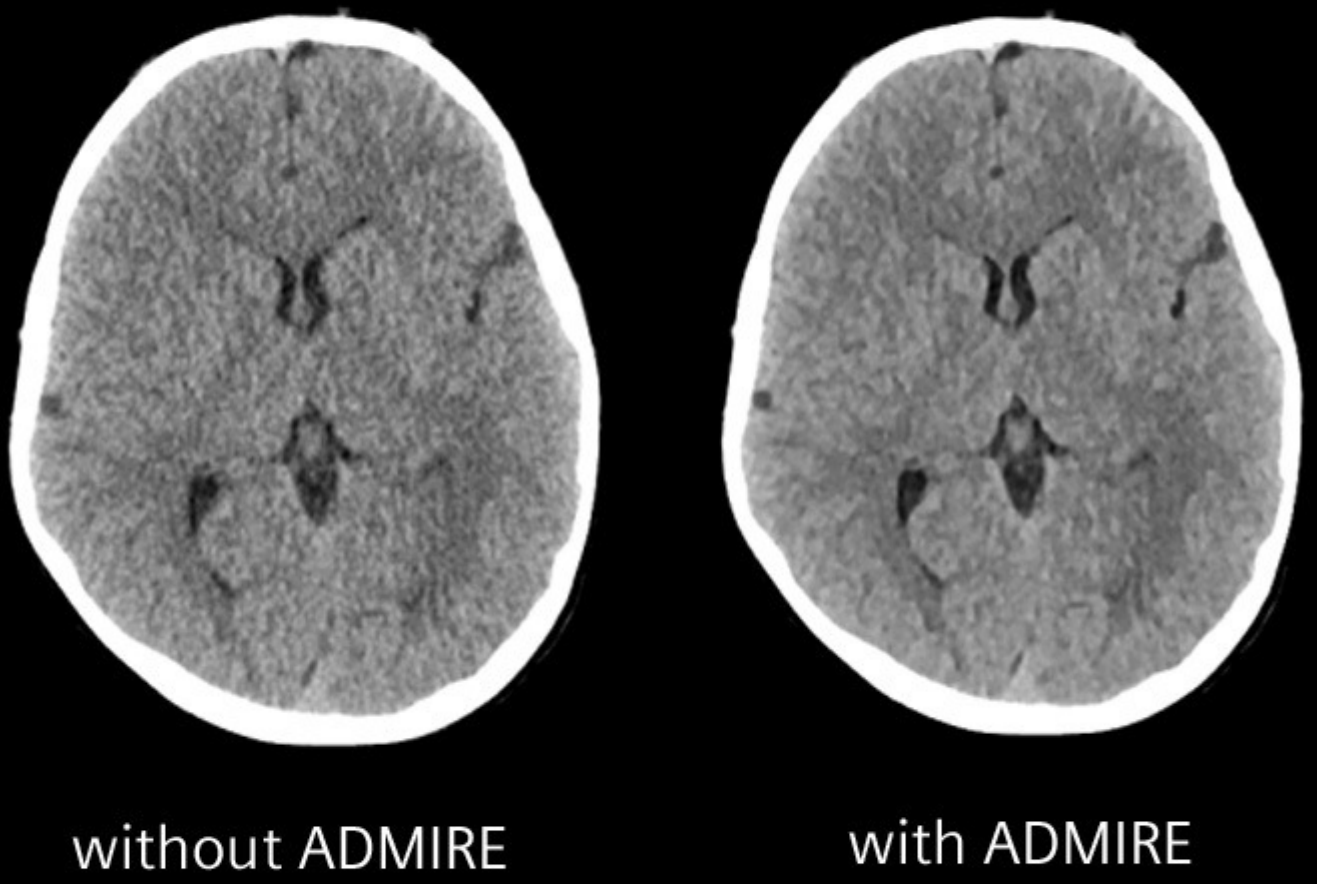


Scanned at 50% of normal dose



Scanned at 50% of normal dose


Standard WFBP
SAFIRE

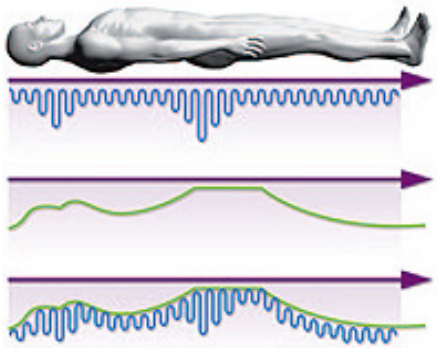


without ADMIRE

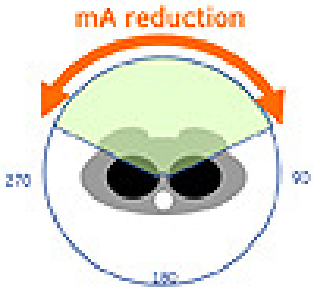
with ADMIRE

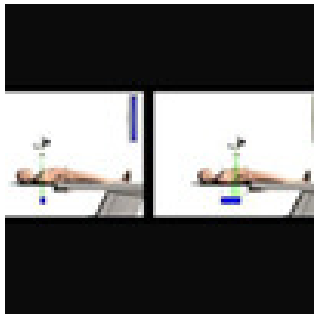
Technology developments in CT

GE Healthcare



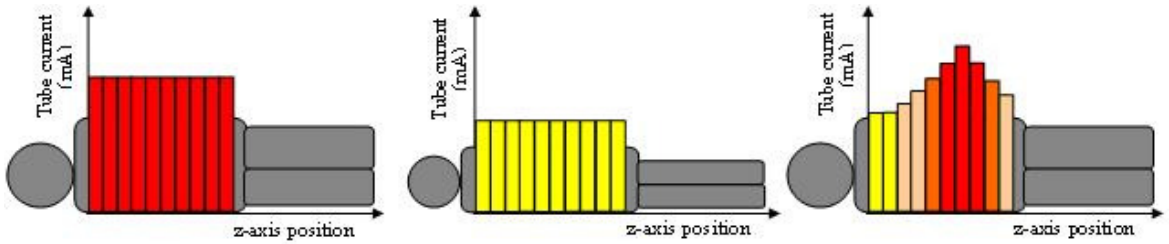
TCM modes





Dynamic Z-axis collimation

ASIR, VEO RECONs



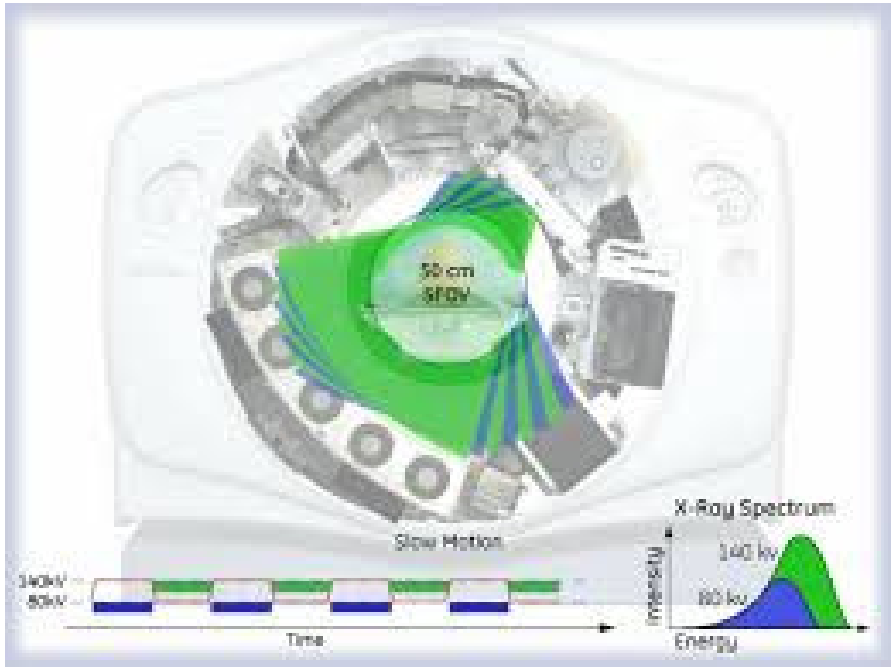
(*)

Building scanning protocols - more option are available

(*) V. Gershan, Assessment of AEC system response in GE 16 slices scanner, Contributions, MANU, June 2014

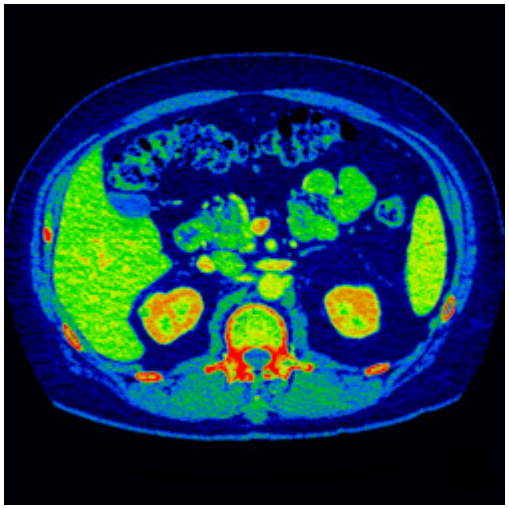
Technology developments in CT

GE Healthcare

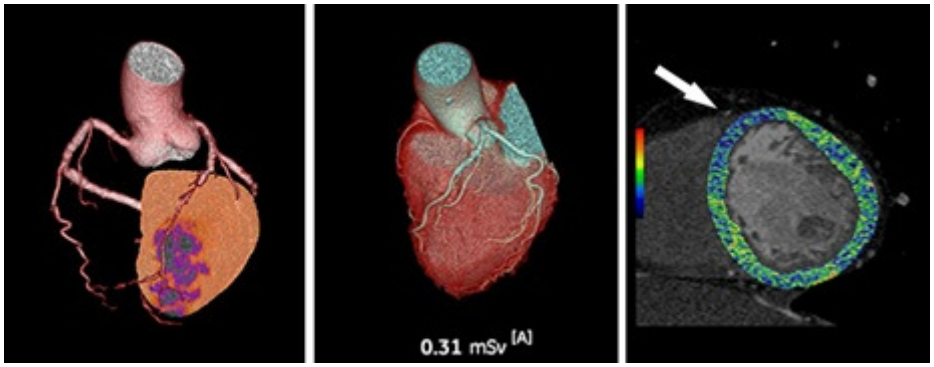


Gemstone Spectral Imaging

Rapid kV switching (140 and 80kV)
Gemstone Detector technology

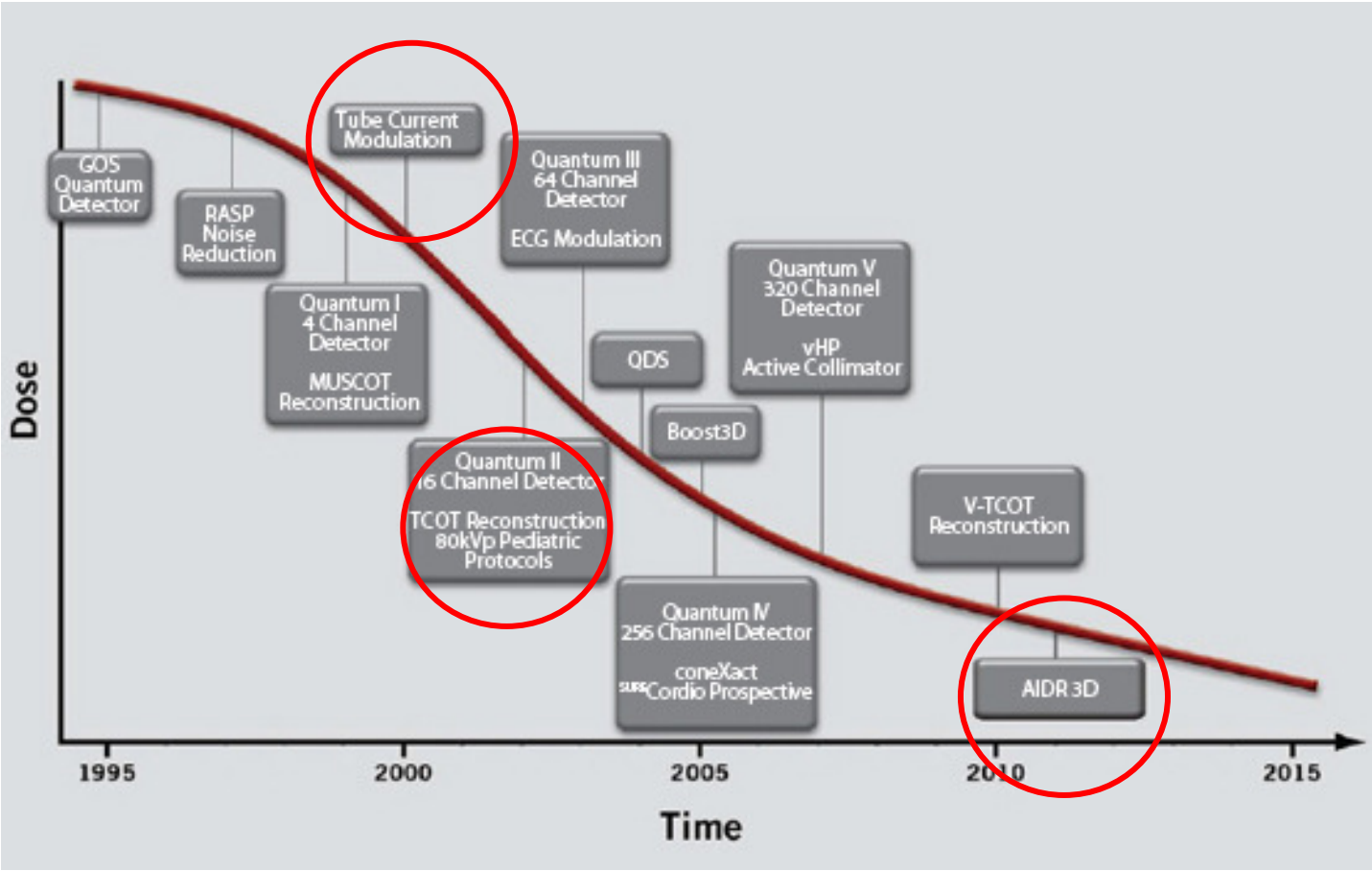


The same tissue, different HU at different energy = color



Technology developments in CT

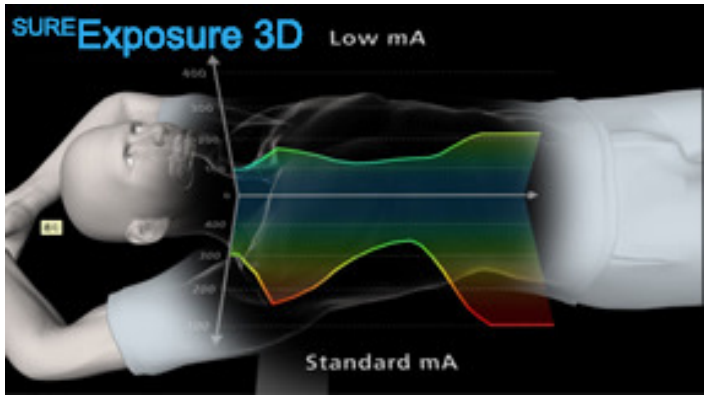
TOSHIBA



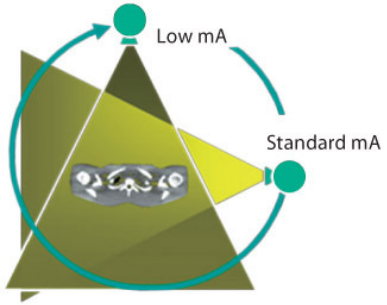
Significant dose reduction in TOSHIBA scanners

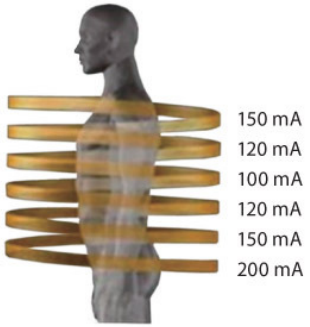
Technology developments in CT

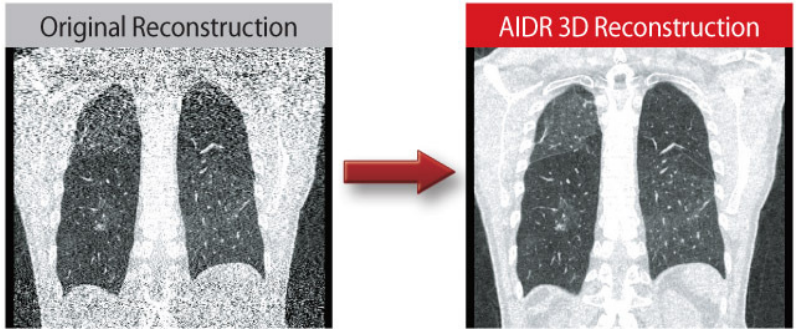
TOSHIBA



TCM modes





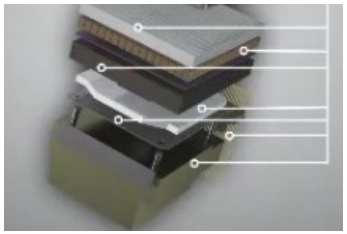


Toshiba AIDR3D

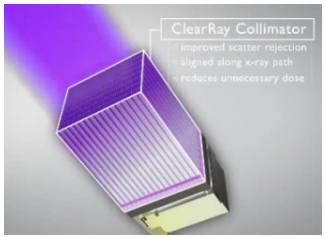
Variable pitch factor across scanning
(unique feature)

Technology developments in CT

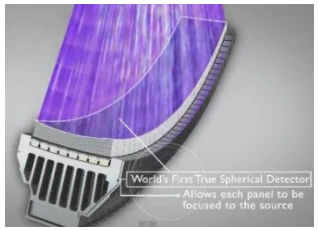
PHILIPS



NanoPanel 3D Detector



ClearRay Collimator



Spherical Detector

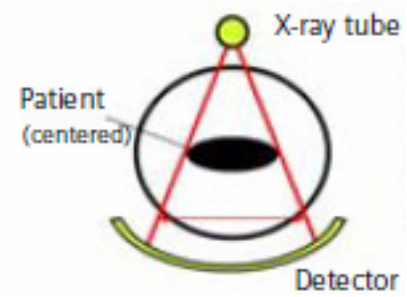
Tube Current Modulation

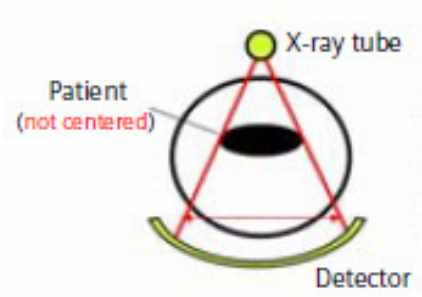
ACS, Z-DOM, D-DOM

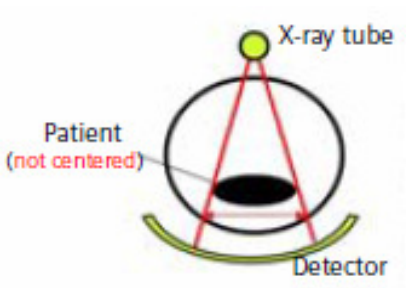
Philips IMR

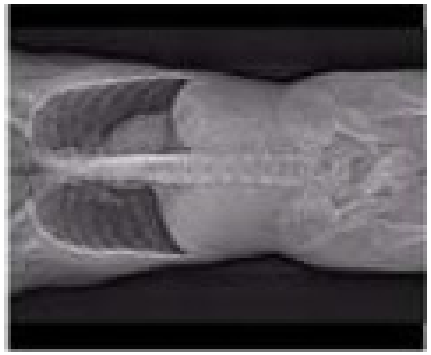
Philips iDOSE4

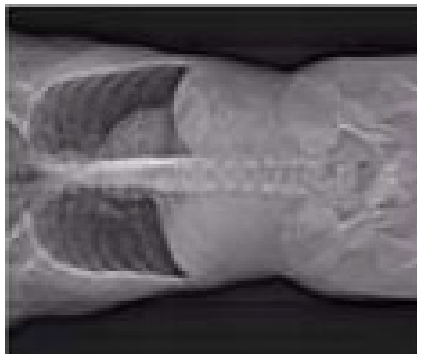
Relevance of proper patient positioning(1/2)

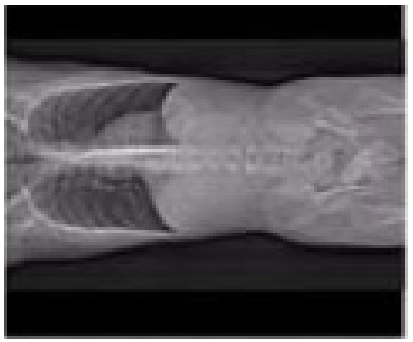












Positioning in isocenter,

Optimal dose,

Optimal image quality

Higher positioning,

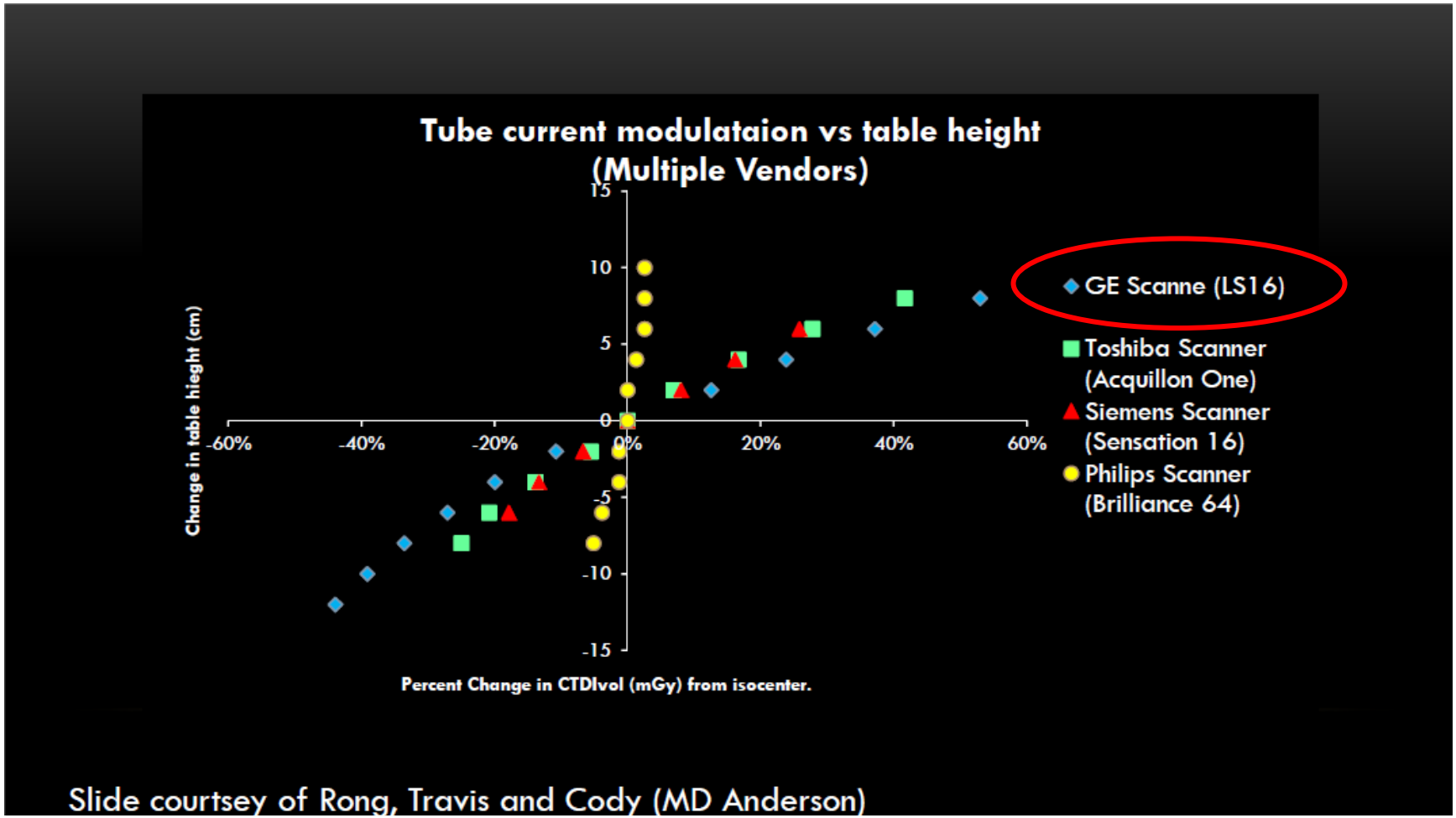
Scanner estimates a big patent and chose higher dose settings

Lower positioning,

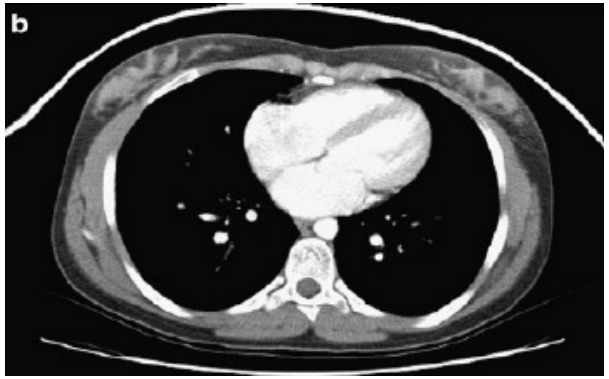
Scanner estimates a smaller patient

Lower dose, but higher image noise

Relevance of proper patient positioning(2/2)



Using of protective tools



(*)

Using of protective tools may reduce dose in some organs, but its change image quality and may cause error in HU or artifacts.

Protocol optimization and using a new scanner features are preferable options.

(*) Kim et al., Radiatr Radiol 2010; 40:1739

Different examinations → different image quality;

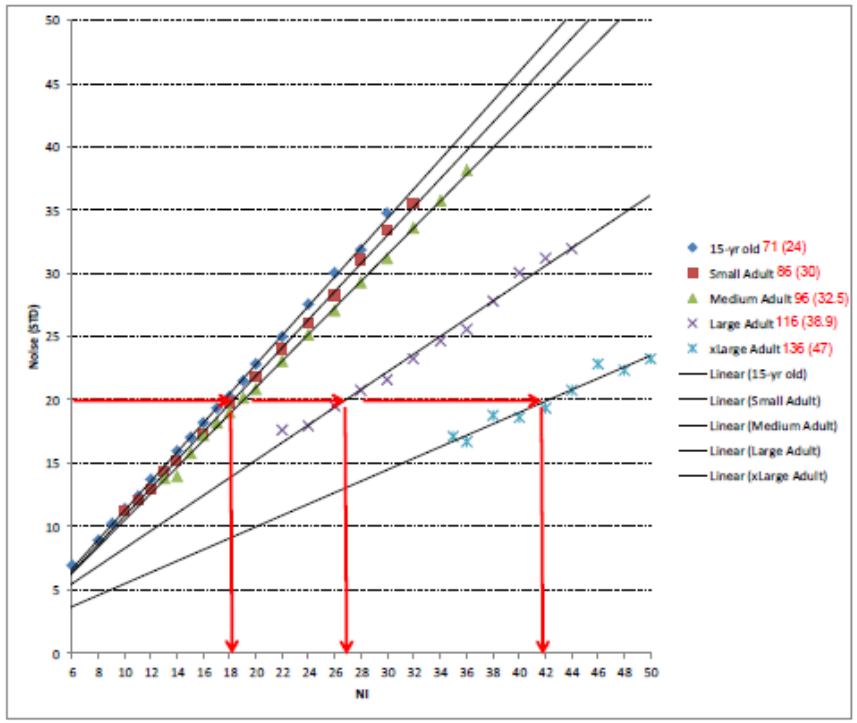
Each CT unit (even radiologist) → different image quality

	25% Increase in Image Quality Reference Parameter	Change in $CTDI_{vol}$
GE	NI from 10 to 12.5	Decrease ~ 10 %
Hitachi	SD from 10 to 12.5	Decrease ~ 10%
Neusoft	DoseSave Level from 20 to 25	Increase ~ 25%
Philips Newer Software	DoseRight Index from 20 to 25	Increase ~ 25%
Philips Older Software	mAs/slice from 400 to 500	Increase ~ 25%
Siemens	Reference mAs from 200 to 250	Increase ~ 25%
Toshiba	SD from 10 to 12.5	Decrease ~ 10%

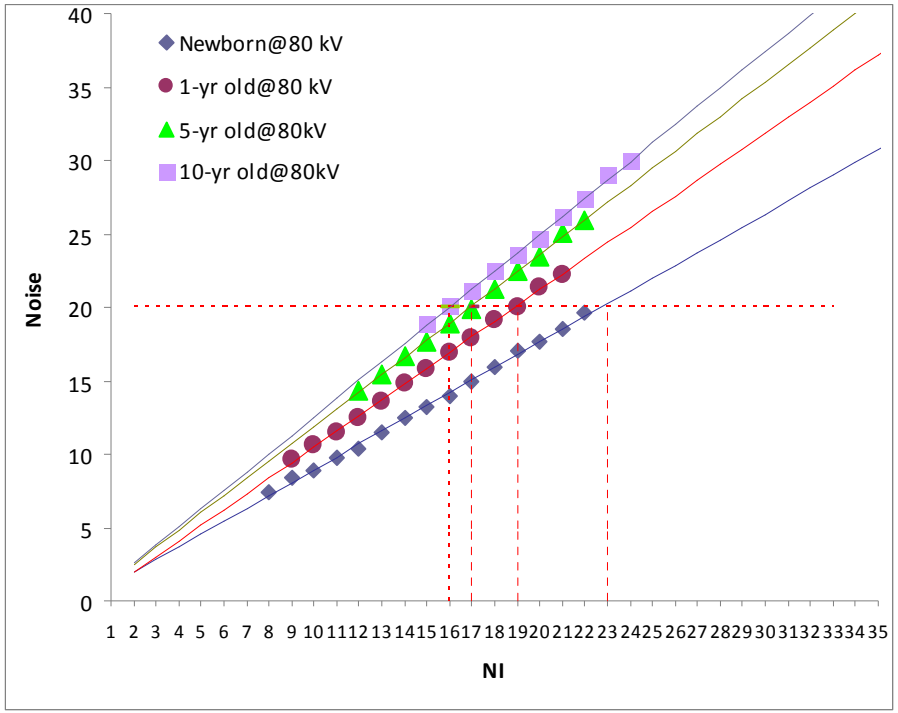
(*)

(*) M. Supanich, Henry Ford Health System, 3dt CT Dose Summit, 2013, Phoenix, Arizona

Complex relationship between selected and produced image quality



(*)



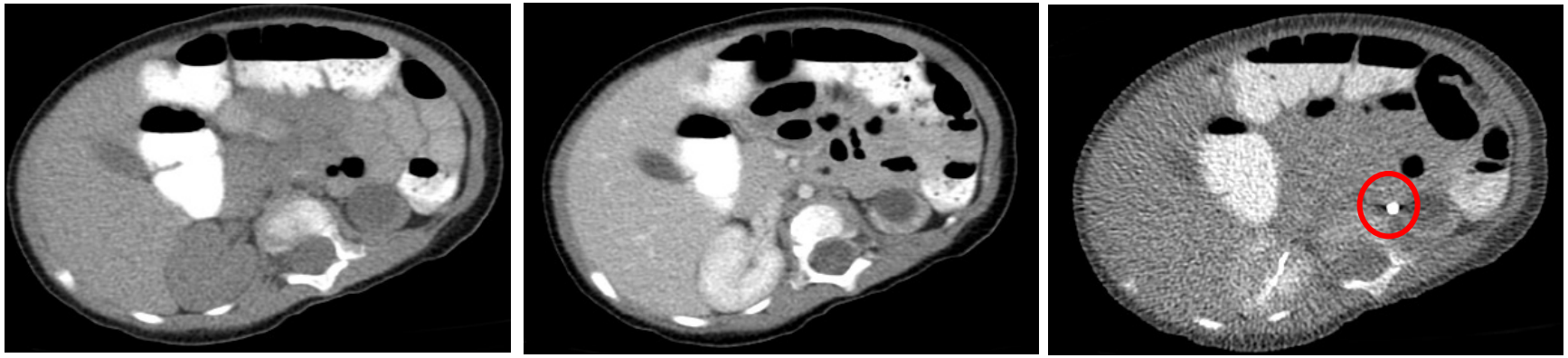
(**)

The same NI does not produce the same noise level for different patient sizes ?!

(*) CT Jensen, XJ Rong, V Gershan et al., RSNA 2013, Chicago

(**) V Gershan and J Rong, RPM 2014, Varna

Lower dose in contrast series

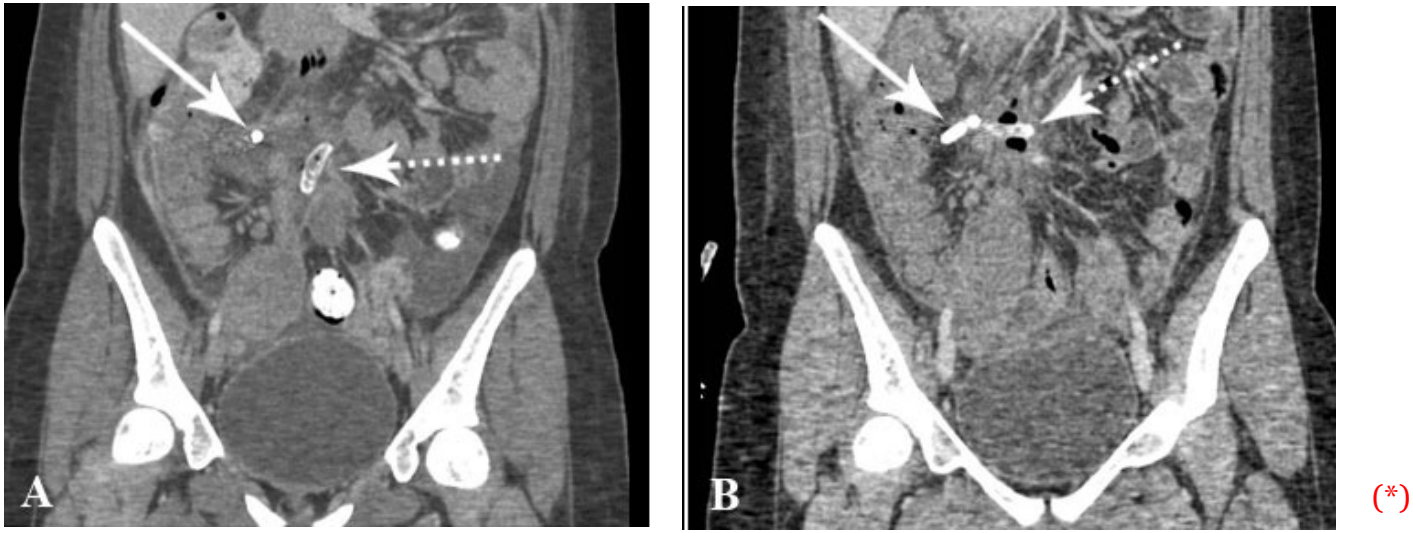


(*)

GE:	NI	↑
TOSHIBA:	SD	↑
SIEMENS:	ref mAs	↓
PHILIPS:	mAs/slice or DoseRight Index	↓

(*) D. Frush, Duke University, 3dt CT Dose Summit, 2013, Phoenix, Arizona

Lower dose in follow-up examinations



(*)

Perforated appendix

Standard protocol - 10.9 mGy

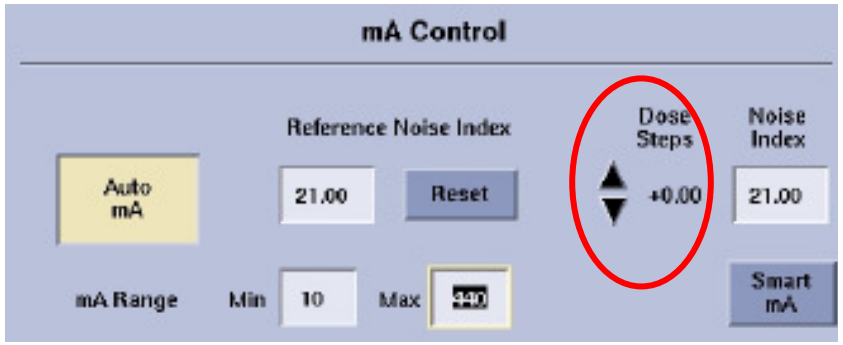
Follow-up scan in 8 days,

Reduced dose protocol - 4.8 mGy

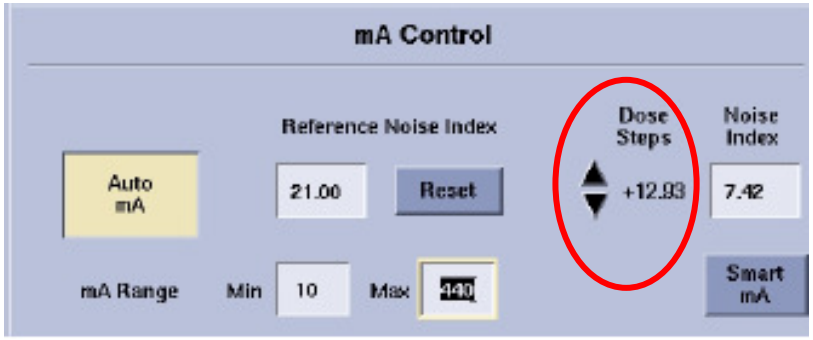
(*) J. Cochrane Miller, Radiology Rounds, Massachusetts General Hospital, Feb 2008

Particular attention on slice thickness

Slice thickness 5 mm



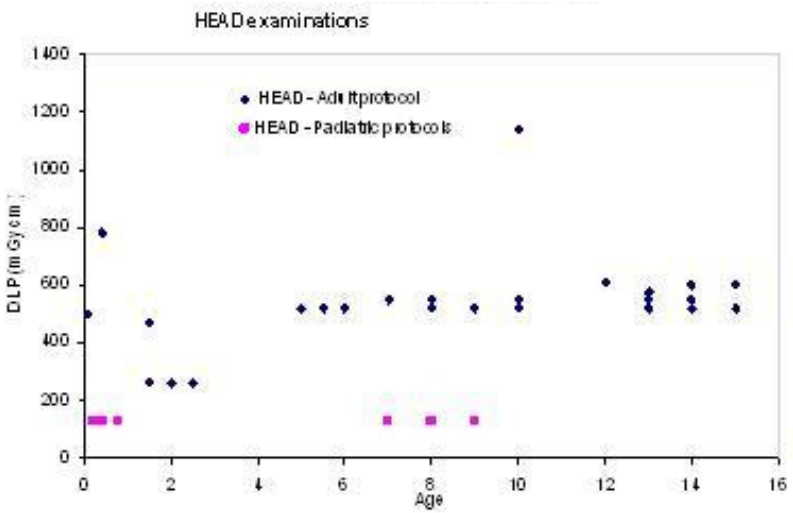
Slice thickness 0.625 mm



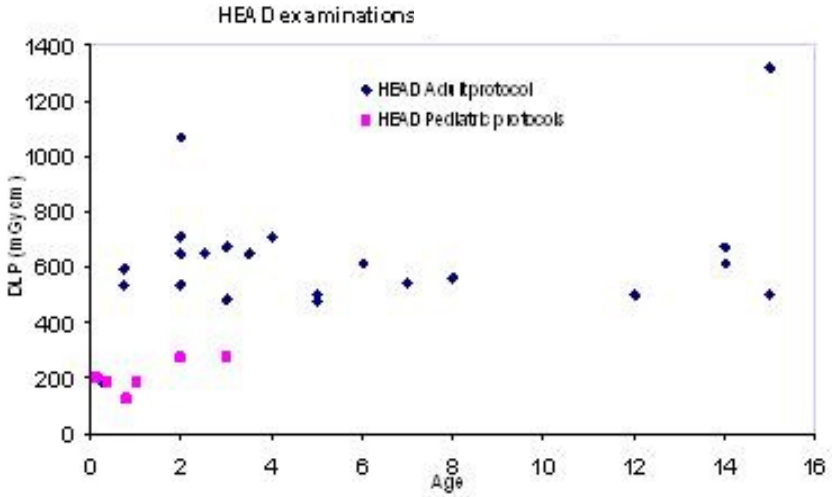
Much higher dose in thinner slices!

CLINICAL PRACTICE IN MACEDONIA - Hospital A

Pediatric and newborn head scanning by using of adult head protocol



4.11 times higher dose!

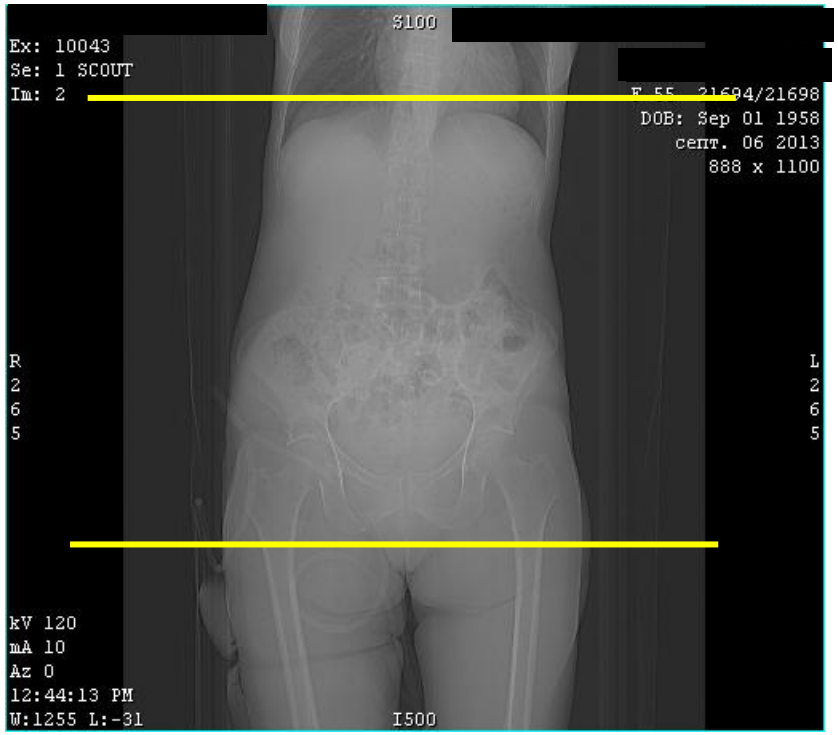


2.57 times higher dose!

* V.Gershan, ECR 2014, Vienna (Euro Safe Imaging campaign)

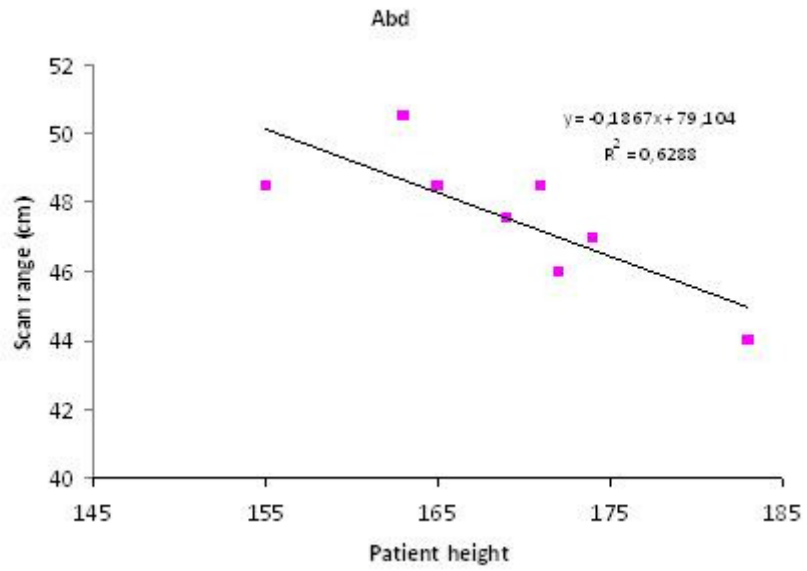
CLINICAL PRACTICE IN MACEDONIA - Hospital B

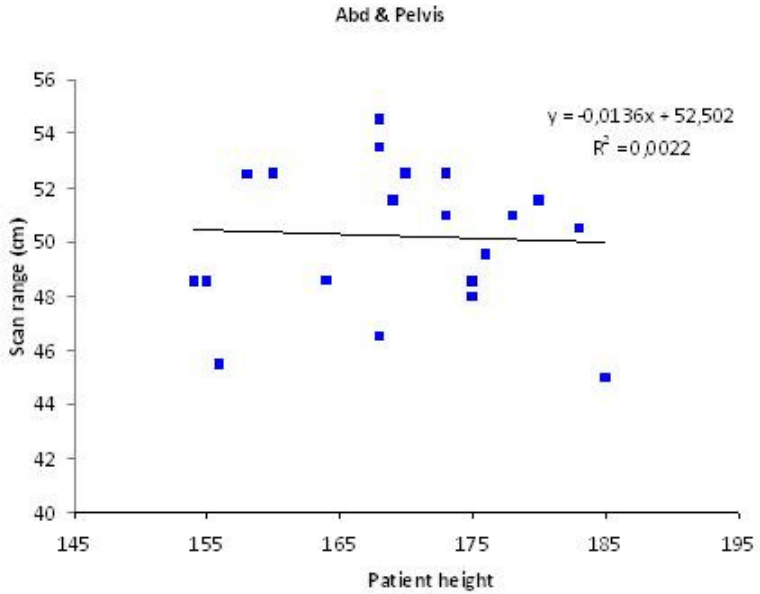
Scan range



Abdomen ≠ **Abdomen & Pelvis**

CLINICAL PRACTICE IN MACEDONIA - Hospital B





Higher patient, shorter scan length ?!

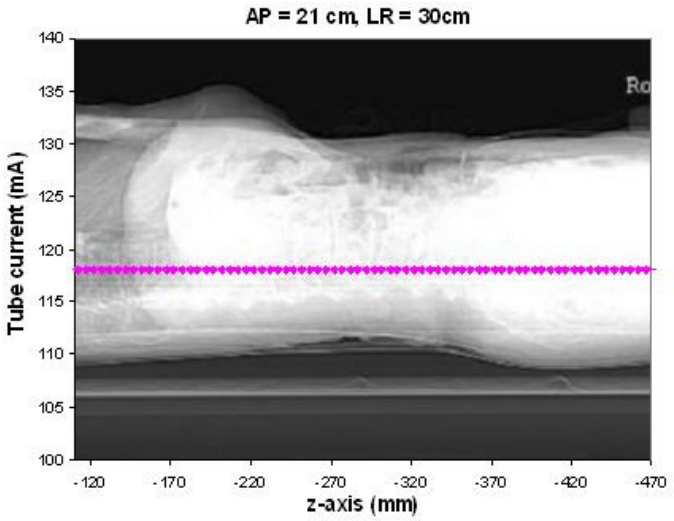
Scan length in patients with the same hight ?!

Unpropriate and unconsitent length scan is practice against all radiation protection principles

* V.Gershan & K.Andonovska, ECR 2014, Vienna (Poster session)

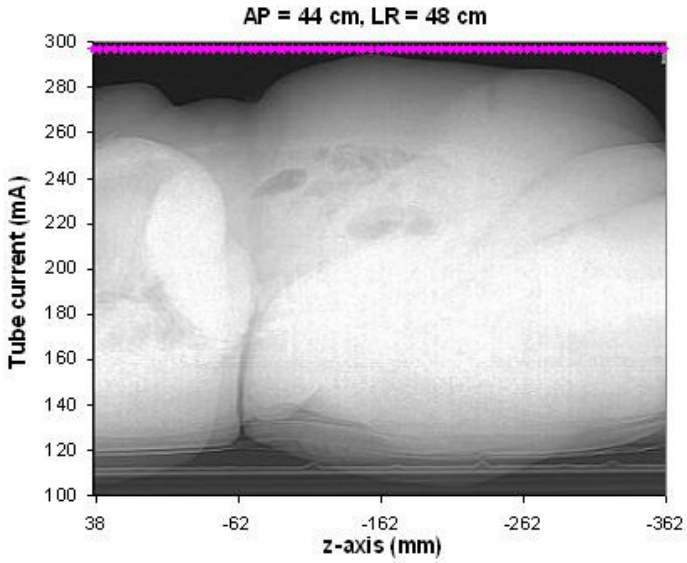
CLINICAL PRACTICE IN MACEDONIA - Hospital B

Using of the same protocol parameters, regardless of patient size



54 kg

NI=14, mA =110 - 300



110 kg

NI=14, mA =110 - 300

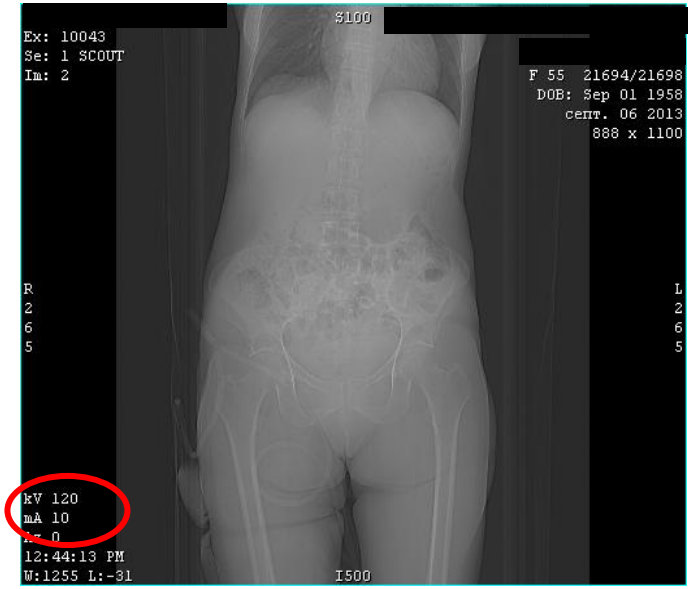
Scanner can not degrease tube current < 110 mA, although this patient can be scanned at lower dose

Scanner can not increase tube current > 300mA, High noise level, compromised image quality

(*) V. Gershan, Assessment of AEC system response in GE 16 slices scanner, Contributions, MANU, June 2014

CLINICAL PRACTICE IN MACEDONIA - Hospital B

Changing kV after scout?!



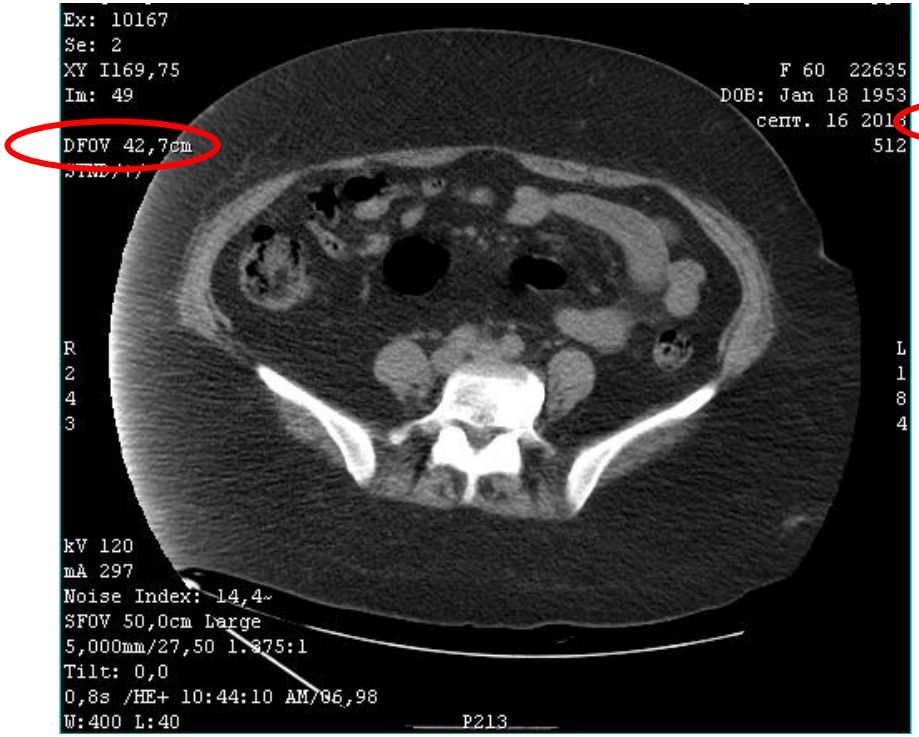
Scout at 120 kV,

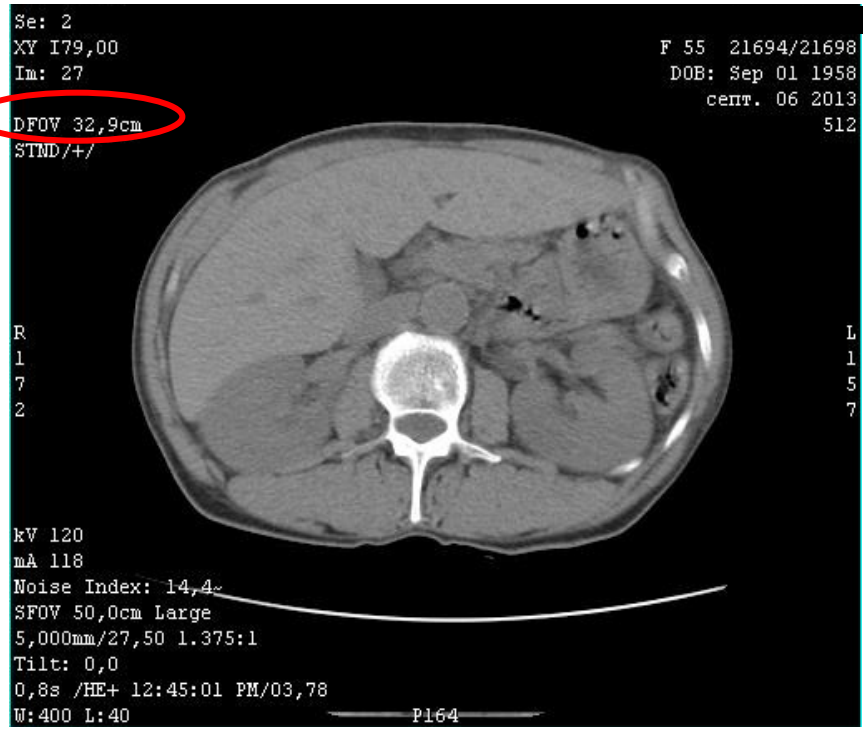
Sscanning at 100 kV? (to reduce dose)

Compromised of AEC system, increased image noise

CLINICAL PRACTICE IN MACEDONIA - Hospital B

Non-using of excising scanner options for non standard patients

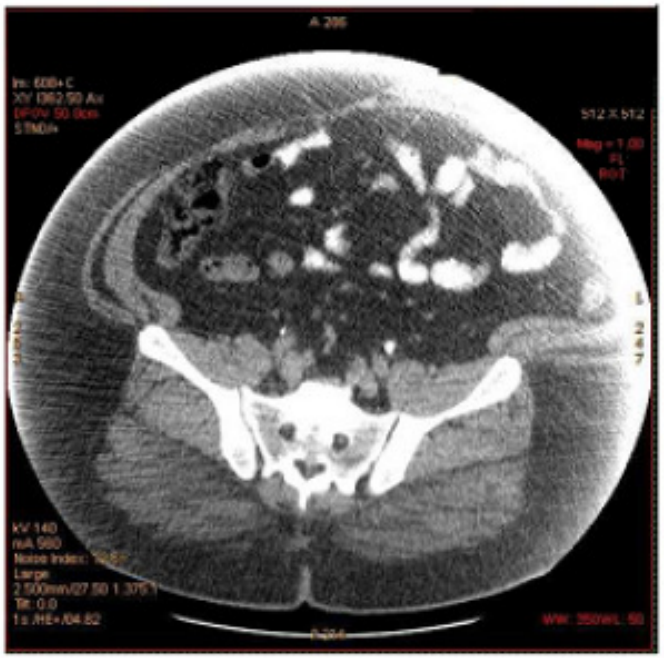




DFOV in the largest patient 43 cm, in the smallest 33 cm

"WideView"™ option during image reconstruction

(TM) GE Healthcare – WideView, SIEMENS – Extended Field of View, stc.



DFOV 50 cm

Reconstruction without “WideView” option

DFOV 53 cm

Reconstruction with “WideView” option

CLINICAL PRACTICE IN MACEDONIA - Hospital C

The same number of series, regardless of clinical indications

Exam Description: ABDOMEN

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Helical	S22.250-I382.750	11.60	504.20	Body 32
200	Axial	S72.750-S72.750	16.67	16.67	Body 32
3	Helical	S182.250-I392.750	10.59	644.56	Body 32
5	Helical	S22.250-I382.750	11.88	520.90	Body 32
		Total Exam DLP:		1686.33	

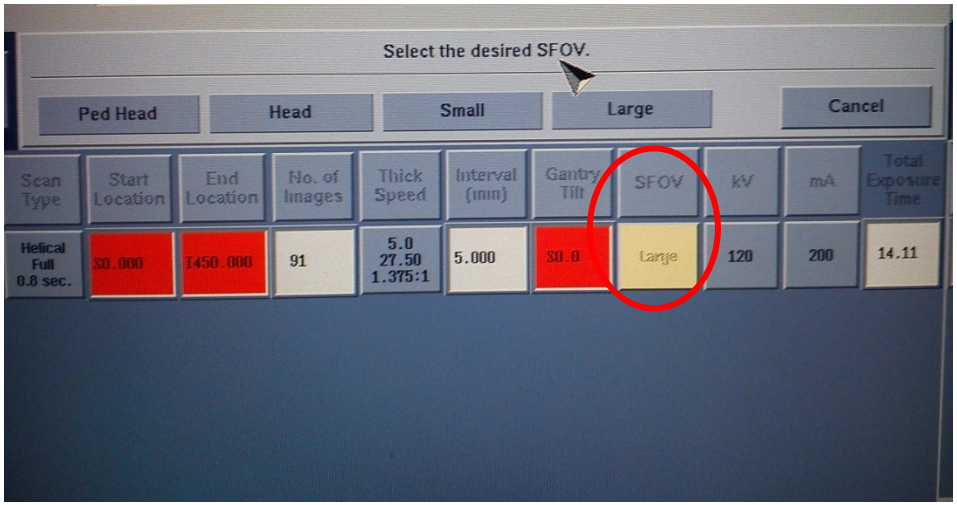
1/1

24.08.2012

Late phase contrast series for echinoccocus?

CLINICAL PRACTICE IN MACEDONIA - Hospital C

Using of default protocol, even it is wrong



Large SFOV in the protocol for head scanning ?!

SUMMARY

1. Education and training of medical personal who work with MDCT should improve; medical staff HAVE TO KNOW scanner performances

2. It is myth that DEFAULT protocols are the best adjusted

3. DRLs should be developed at local and national level

4. National Clinical protocols with number of series, time and amount of IVU contrast, should be developed

5. CT exposure protocols should be adjusted in terms of patient size, target organ of examination, the first or follow up examination, etc

THANK YOU!