Prof.dr Simon Nikolić
opšta medicina

Kompjuterizovana tomografija



MMXV

Istorijat

1917 

J. Radon (1887 - 1956) Austrian Academy of Sciences (OAW)

fizički principi - ideja o rešenje za rekonstrukciji unutrašnjosti objekta na osnovu linijskih integrala

1958 Korenblyum (UKR) razvio X-ray skener i isprobao izgraditi tanak slajs kroz pacijenta sa analognom rekonstrukcijom slike

1963 A.M. Cormack prvi izveo matematičku primenu za tomografsku rekonstrukciju.

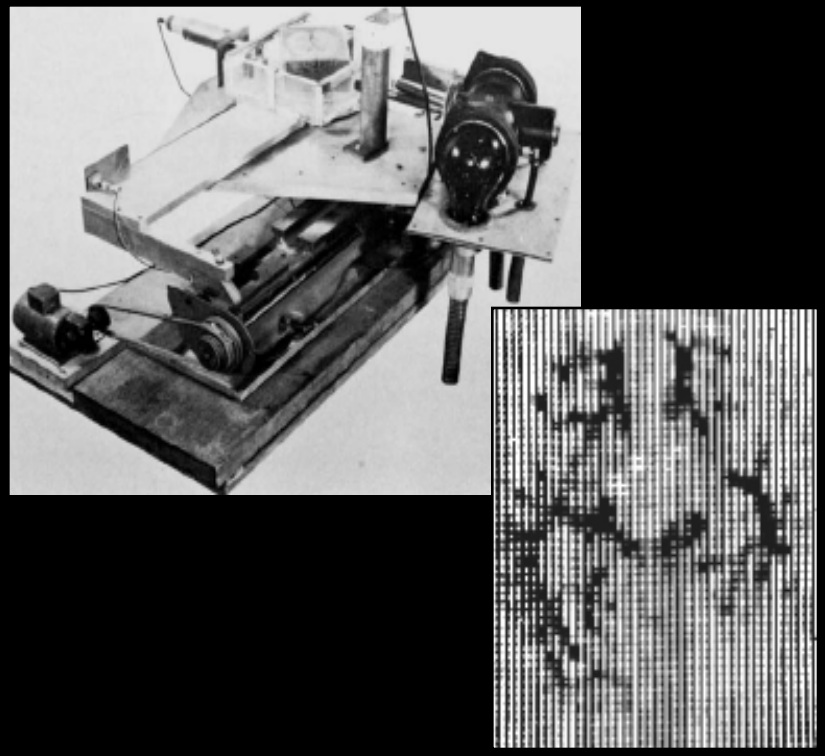
Rešenje je doneo na osnovu predhodnih istraživanja holandskog fizičara H.A. Lorentz-a koji je spmenut u radu Backwinkel iz 1906 g.

Na svoju nesreću Lorentz nije publikovao svoje rezultate i tako je njegov rad ostao nepoznanica do danas.

Istorijat

1969 G.N. Hounsfield pružio dokaz za načelo prvog CT skenera baziranog na radioaktivnom izvoru u EMI istraživačkoj laboratoriji.

1972 Hounsfield i Ambrose objavili prvu klinički sken glave.







1979 Nobel prize in physiology or medicine





Allan M. Cormack

b. 1924 Johannesburg, S.Africa
d. 1998

Tufts Un., Medford, MA, USA

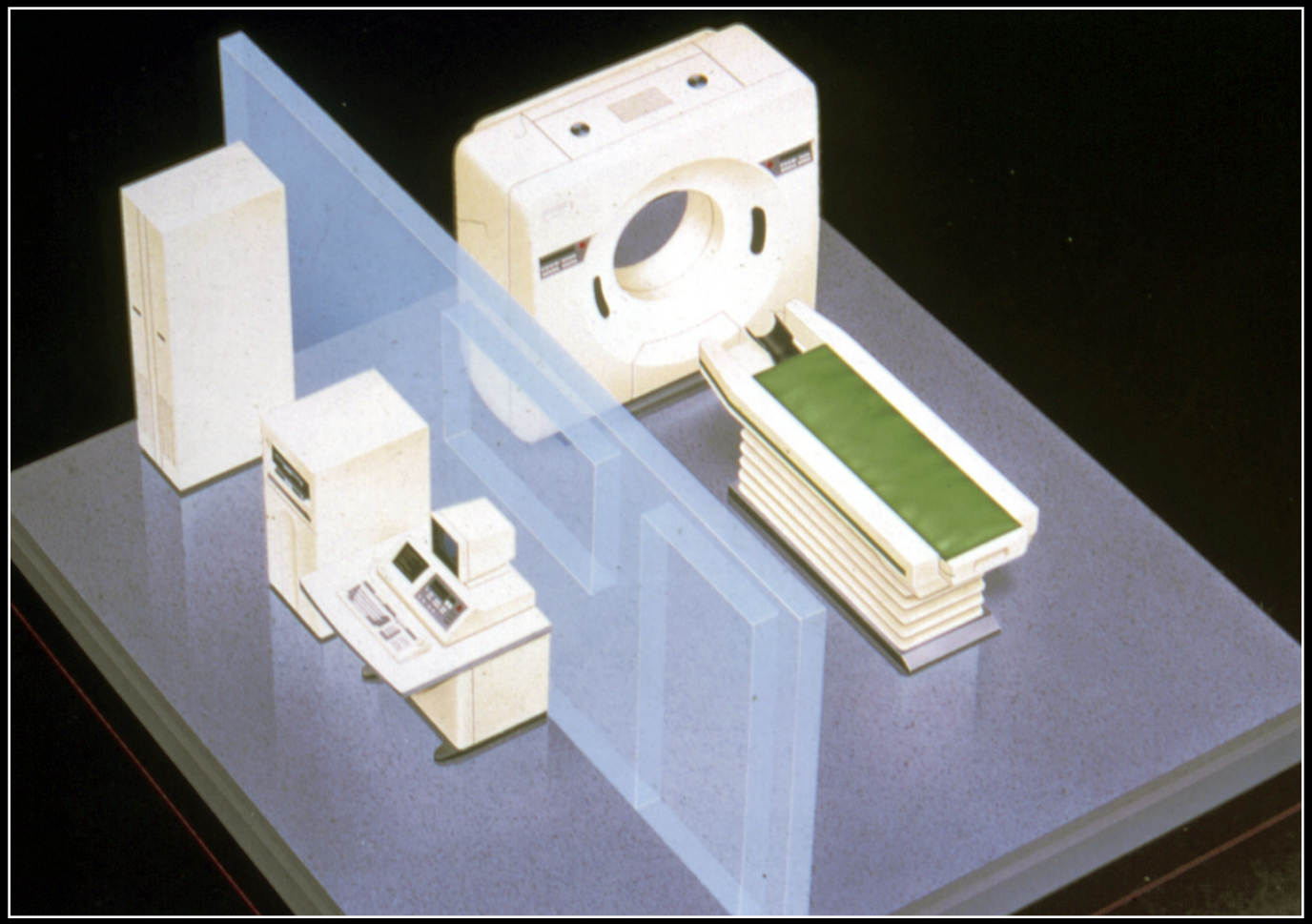
Godfrey N. Hounsfield

b. 1919 Newark, UK
d. 2004

Central Research Laboratories, EMI, London, UK

"for the development of computer assisted tomography"

CT kabinet



1. Gantry

pokretno postolje

<u>Rendgenska cev</u>:

Zbog matrixa 512x512

120 kV 1000 mA

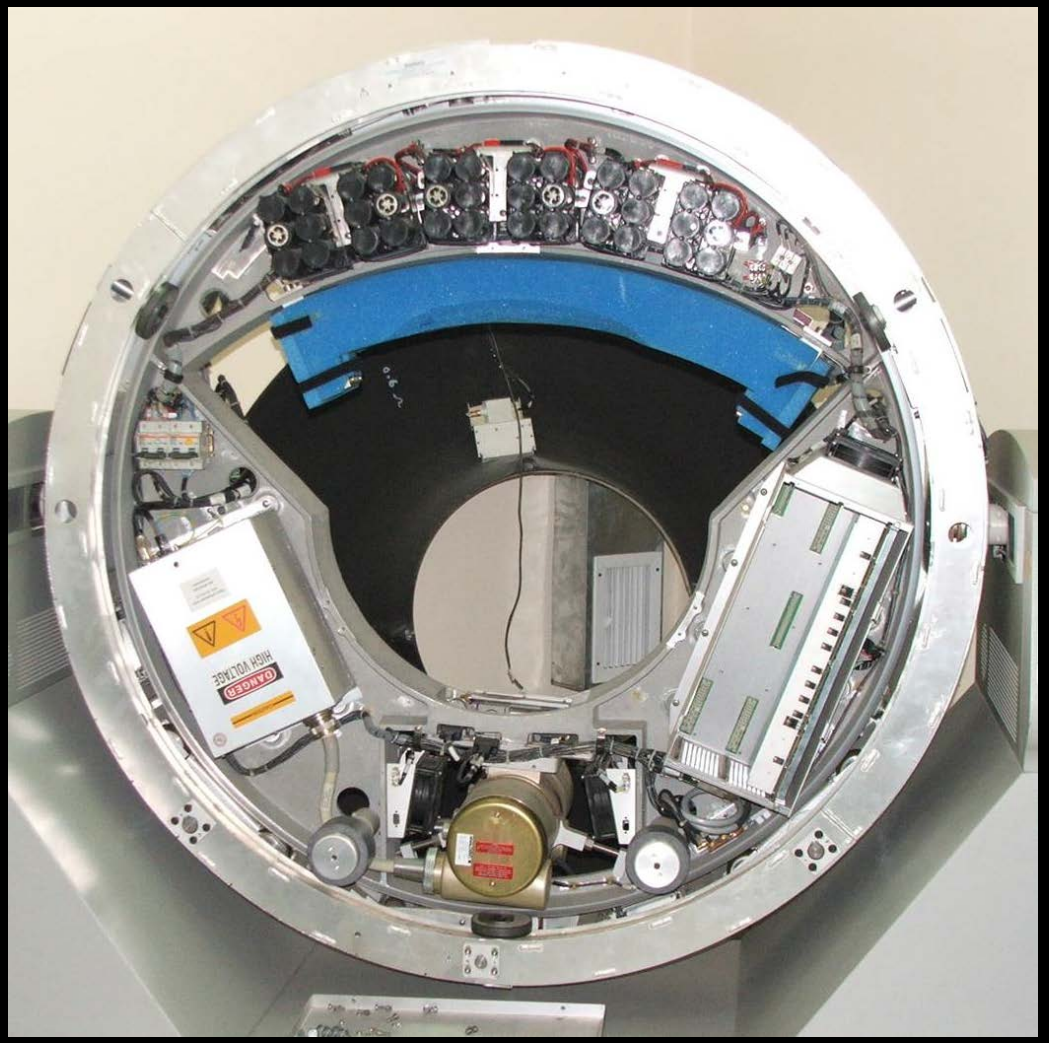
Fokus 0,6 x 1,2 mm

Rasterećenje cevi

impulsnim radom 1-5 ms

Direktno hlađenje anode

izvođenjem osovine anode van cevi



Detektori

Kristalni emituju svetlost koja se preko fotomultiplikatora prevodi u elektični impuls.

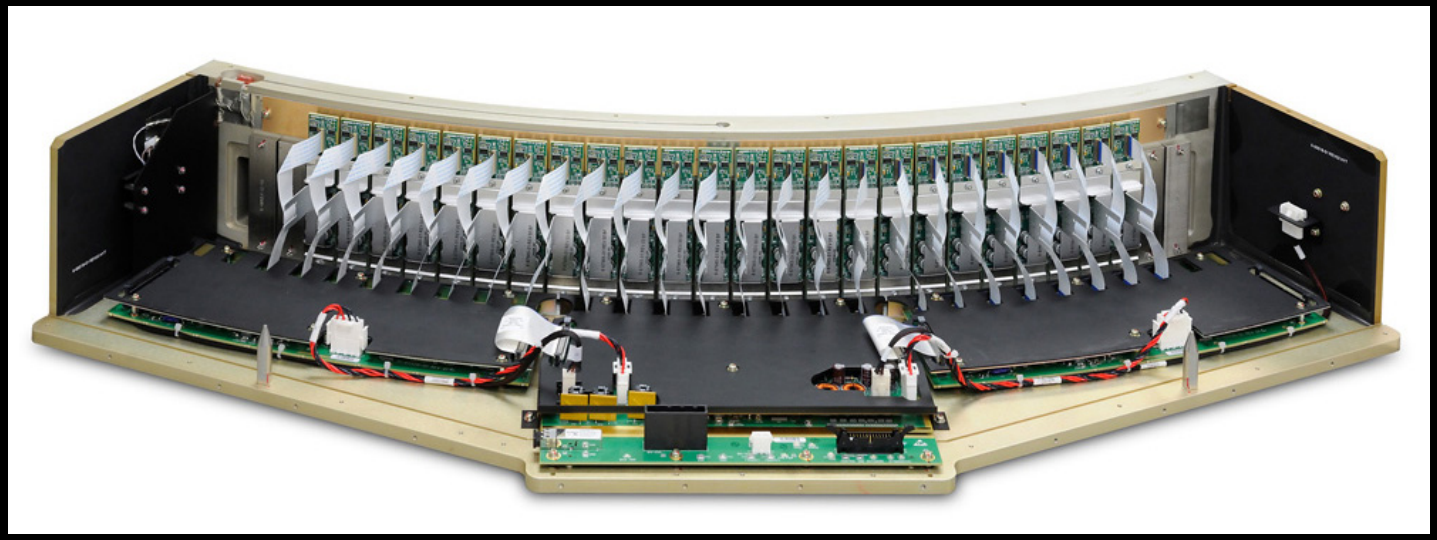
Ranije se koristio NaJ. Danas CaF_2, $Bi_4Ge_3O_{12}$, CsJ.

Gasni funkcionišu kao jonizacione komore u kojima dolazi do jonizacije gasa i stvaranja električnog impulsa.

Xe, Cr pod pritiskom (20-30 atm) čime se povećava efikasnost.

Keramički velika osetljivost, minimalna tromost, velika rezoluciju.

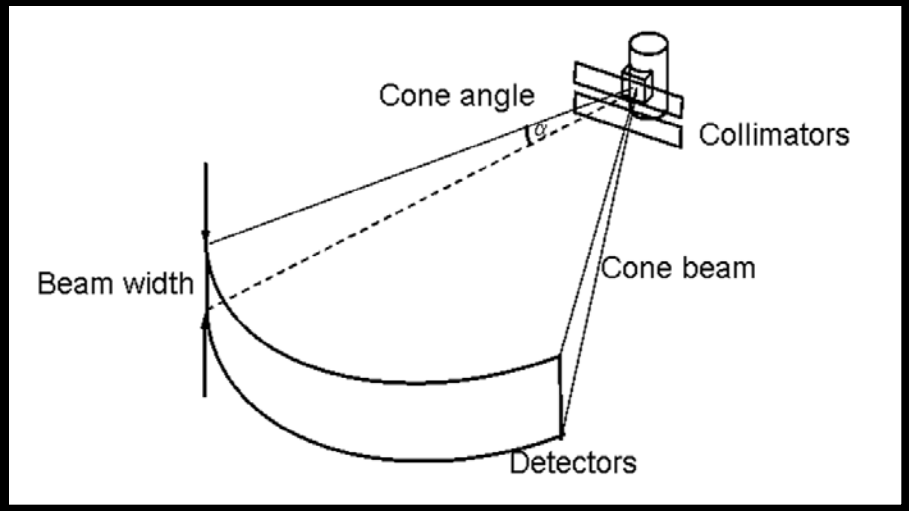
Ispod scintilacionog sloja (Ga - gadolinijum, S i drugi aditivi) je sloj fotodioda.

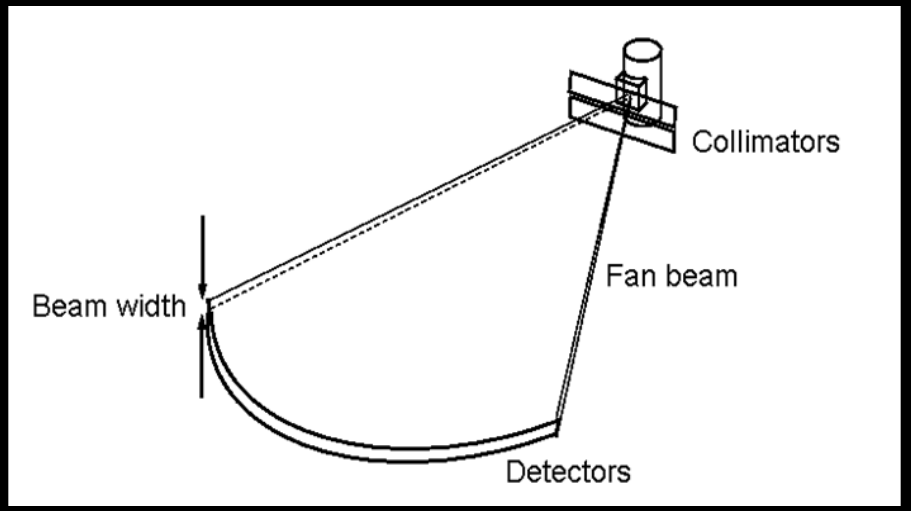




	+	−
Kristalni	velika efikasnost mogućnost rada pri pokretnoj cevi	veličina, ne mogu da se blisko naslože u detektorski niz tromost uzrokuje smanjenu rezoluciju
Gasni	bolja rezolucija slike mala tromost manja zapremina, mogu se naslagati blisko što povećava efikasnost	manja efikasnost za 60-90% kod kretanja cevi još manja, pa se tu i ne koriste
Keramički		

Slice thickness (section): **Collimators**





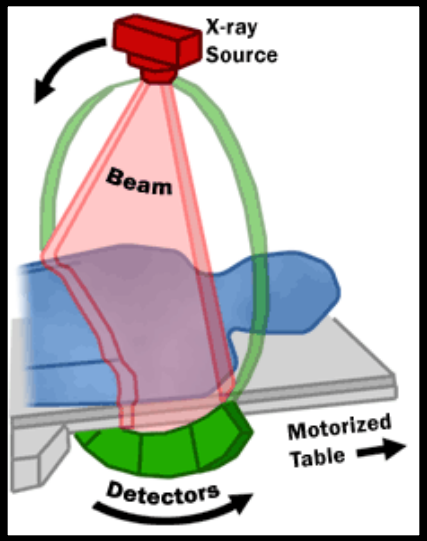


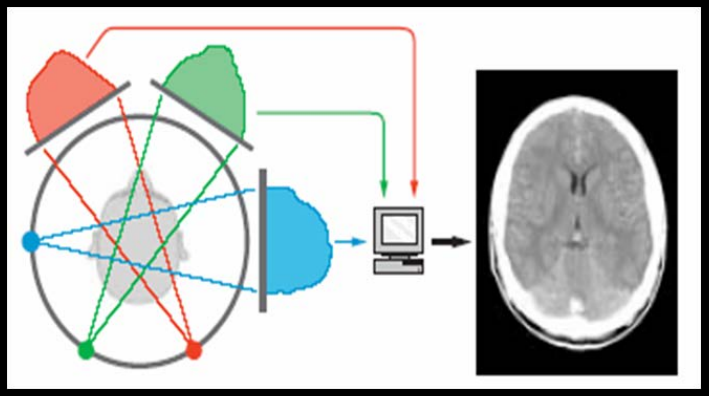
Dvostruka kolimacija:

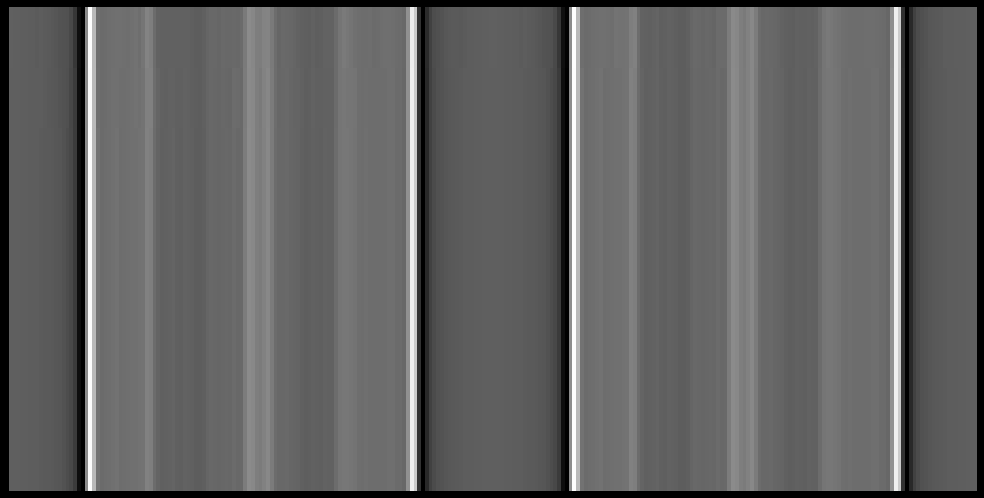
na rtg cevi (0,5 - 12 mm)

ispred detektora radi smanjenja rasutog zračenja

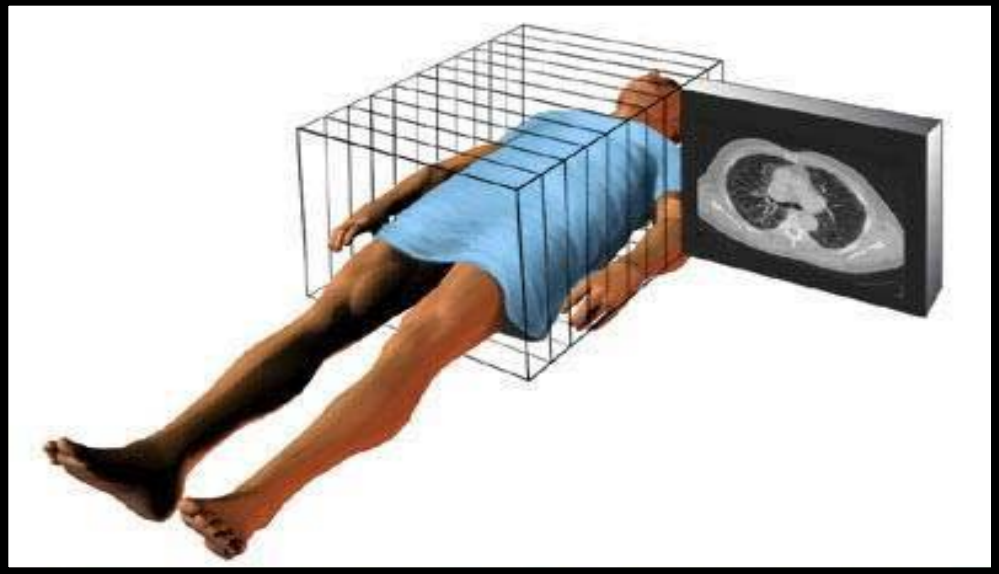
Princip dobijanja slike





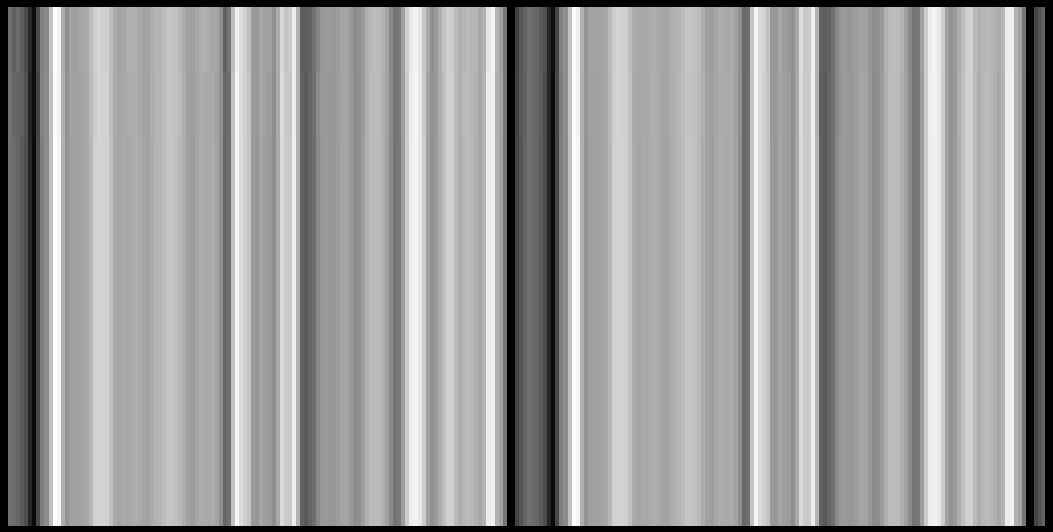


CT slika je mapa linearnih koeficijenata slabljenja snopa u pojedinim tačkama snimanog sloja.



VOXEL - volumska informacija

PIXEL - površinska informacija



2. Generator

Monotank

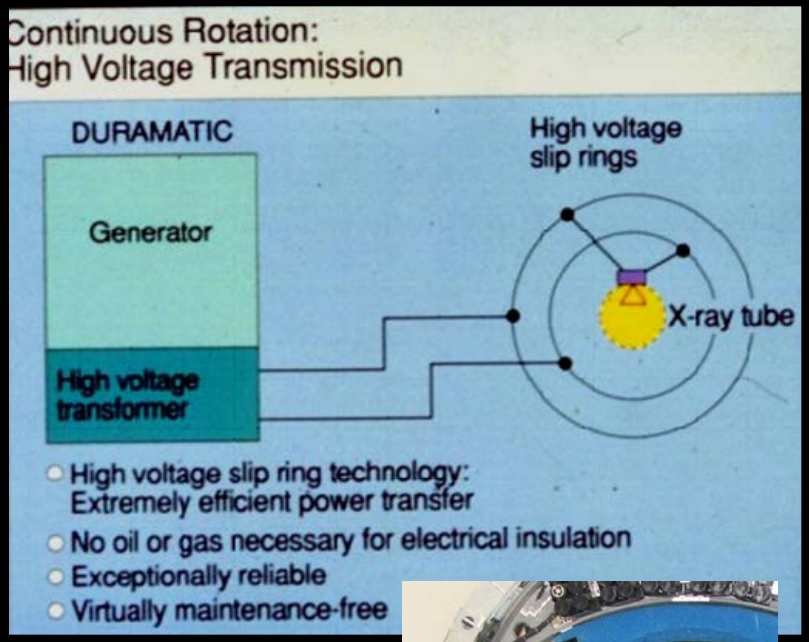
Povećavanjem frekvence

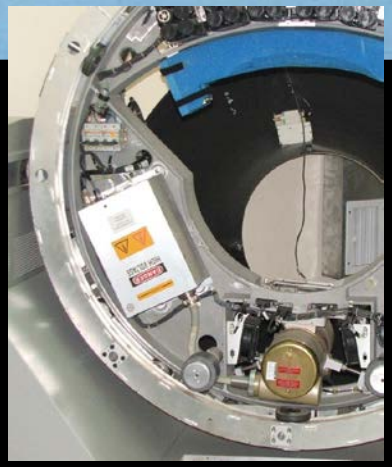
sa 50 na 5000 Hz smanjuje se

površina preseka jezgra

transformatora sa 400 na 4 cm^2.

U istom kućištu nalaze se Tr, visokonaponski ispravljački element i rtg cev.





Napon je rigorozno konstantan (manja talasnost) čime se smanjuje doza koju pacijent prima.

Specijalno priključivanje visokonaponskih kablova na rtg cev, da ne bi došlo do uvrtanja.

3. Sto za pacijenta



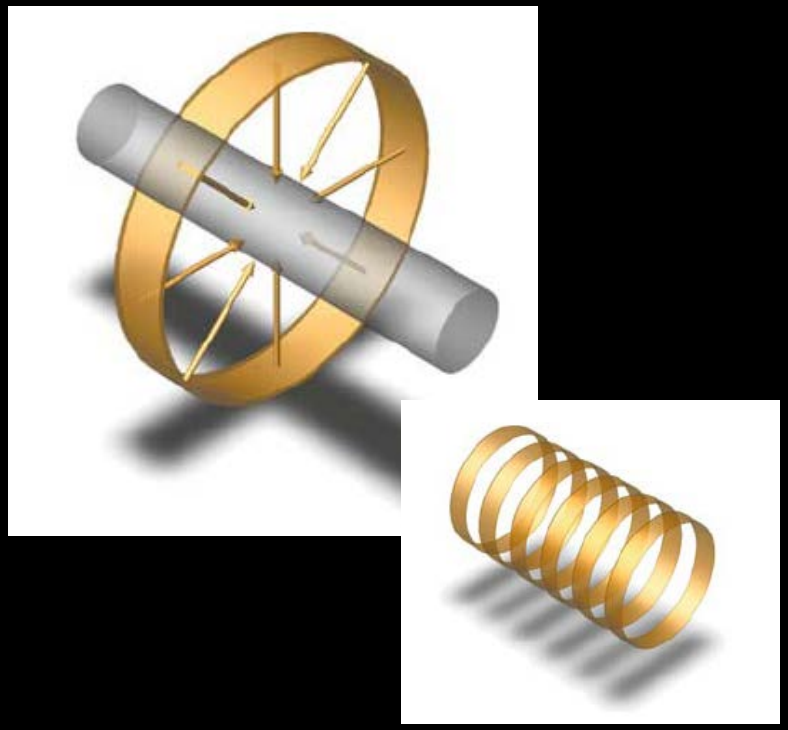




Sinhrono kretanje, karbonska vlakna (manja apsorpcija)

Sekvencijalni

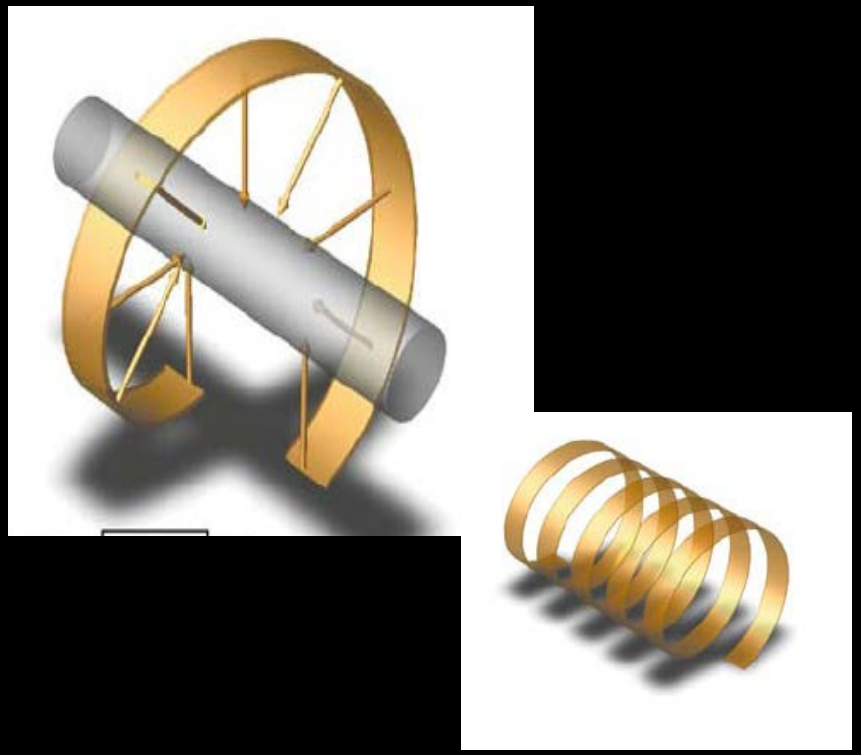
Očekivano pomeranje stola i posebno prstenasta merenja.



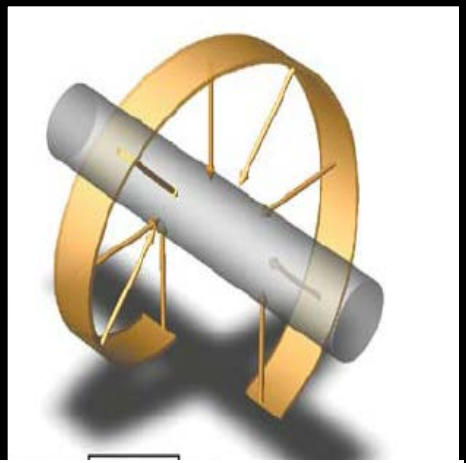
Spiralni

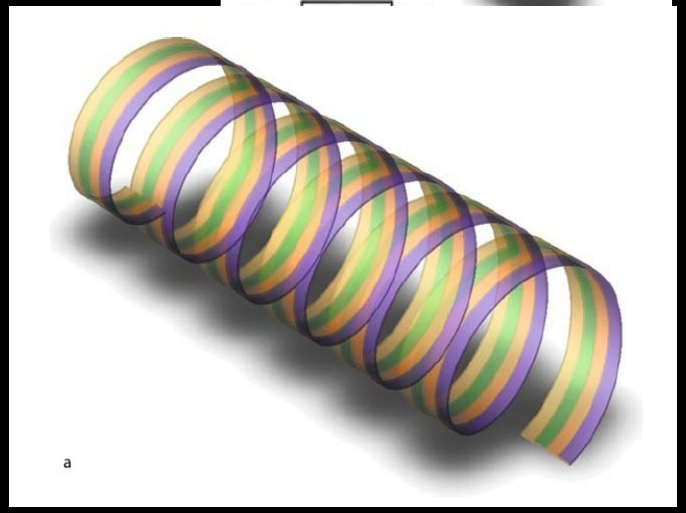
Kombinacija pomeranja stola i kontinuirane rotacije akvizicione jedinice

Rezultat spiralna projekcija objekta.



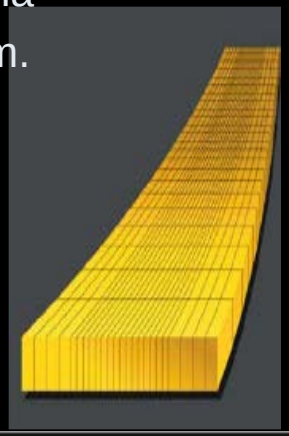
Multislajsni

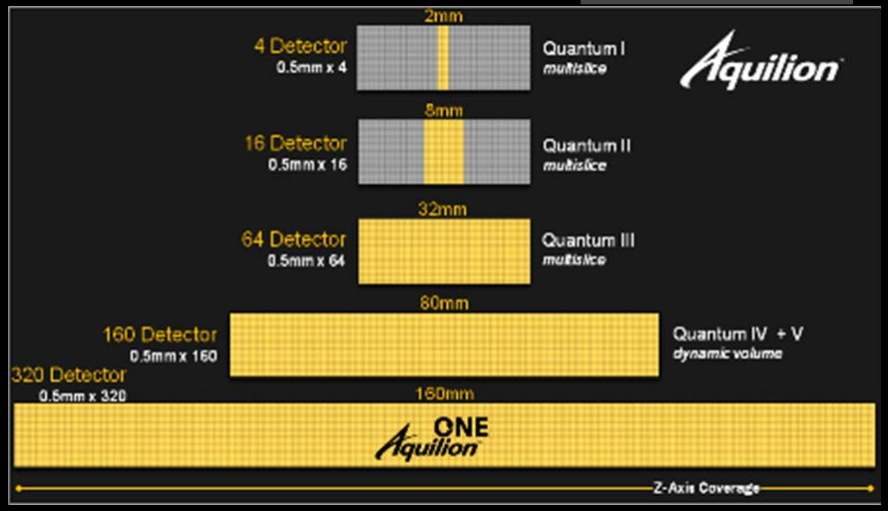




Multidetektorski

Detektorska jedinica podeljena unutar kojih su mere 0,75 mm.

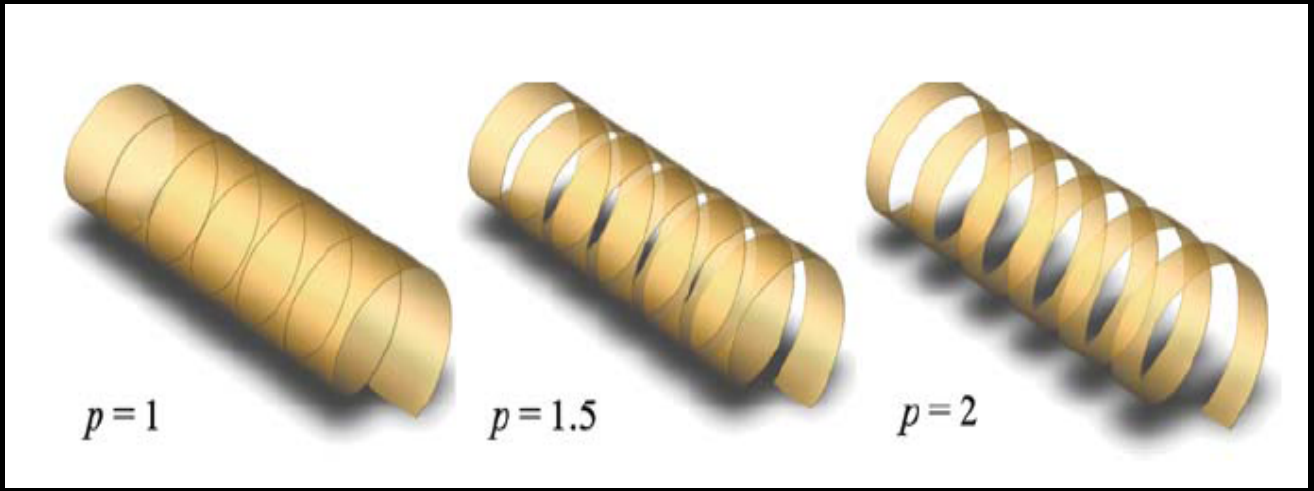




- **Pitch** odnos kretanja stola i debljine sloja $P = d / S$

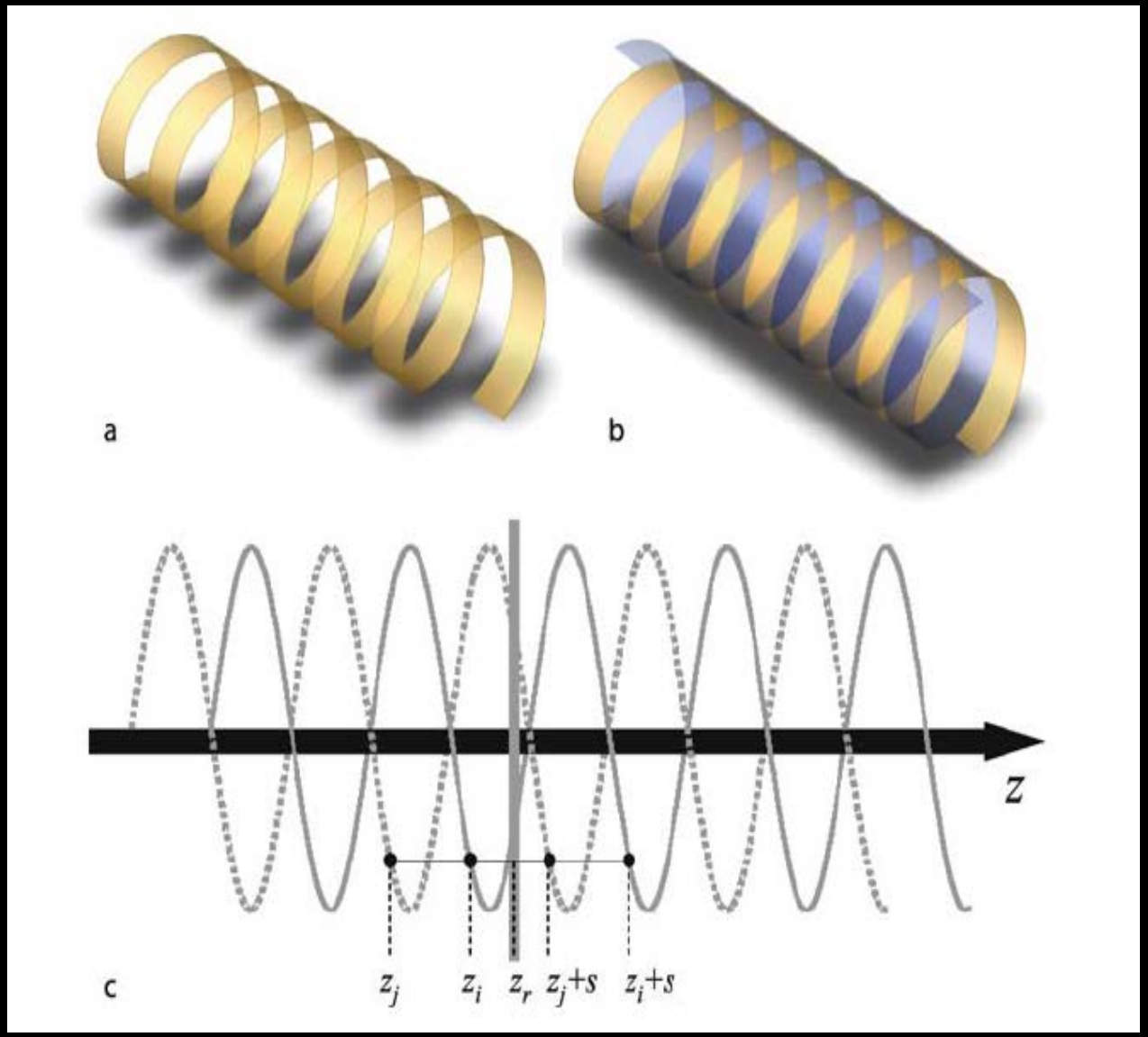
  Broj koji pokazuje razvučenost ili zgusnutost spirale

  P = 1 (10 mm/10 mm)

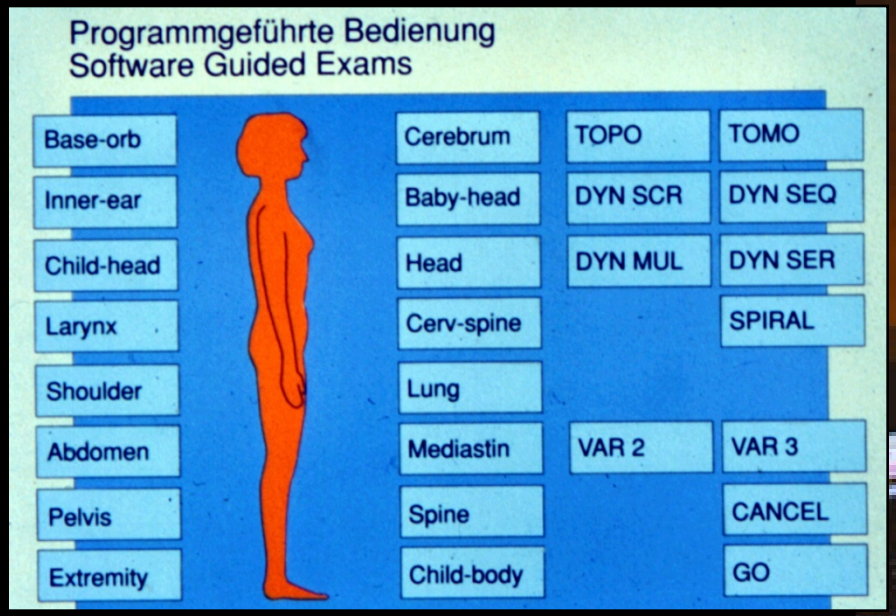


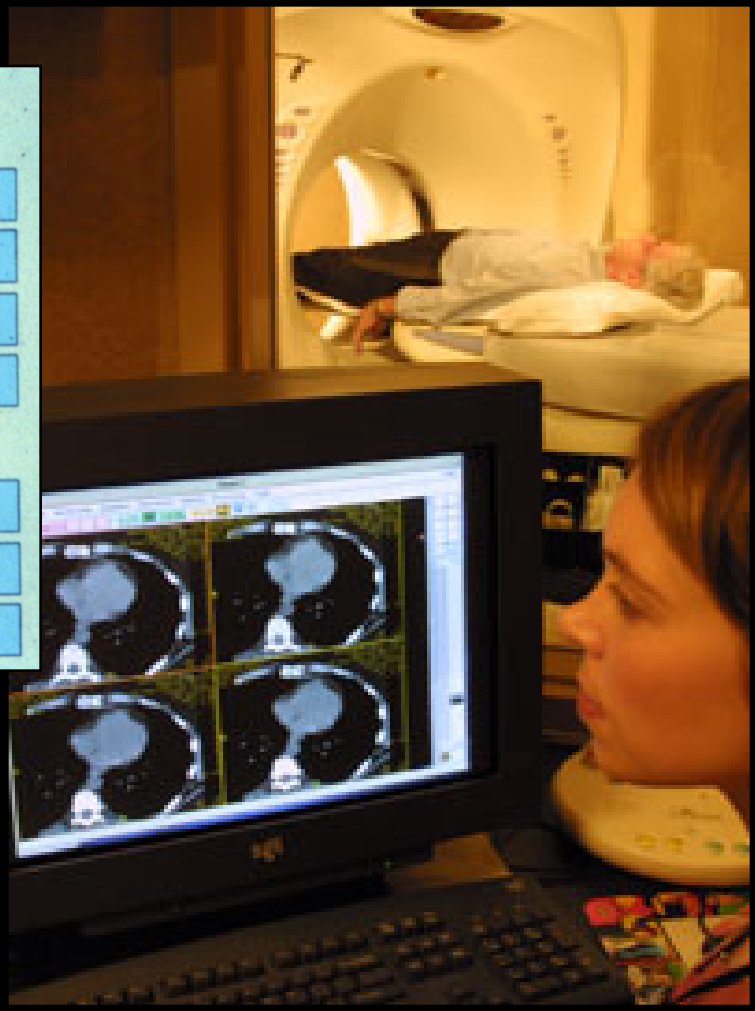
Ako je P>1 imamo

- veći volumen
- redukciju akvizicionog vremena
- manju debljinu slice
- doza je manja (kod P2)


a
b
z
c
z_j
z_i
z_r
z_j+s
z_i+s

4. Komandna konzola



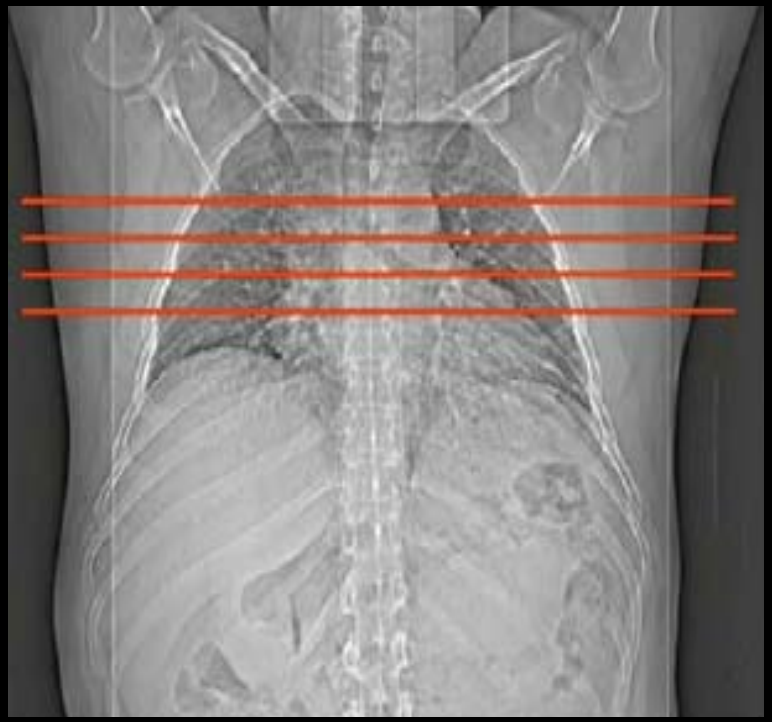


Komande za upravljanje sisitemom

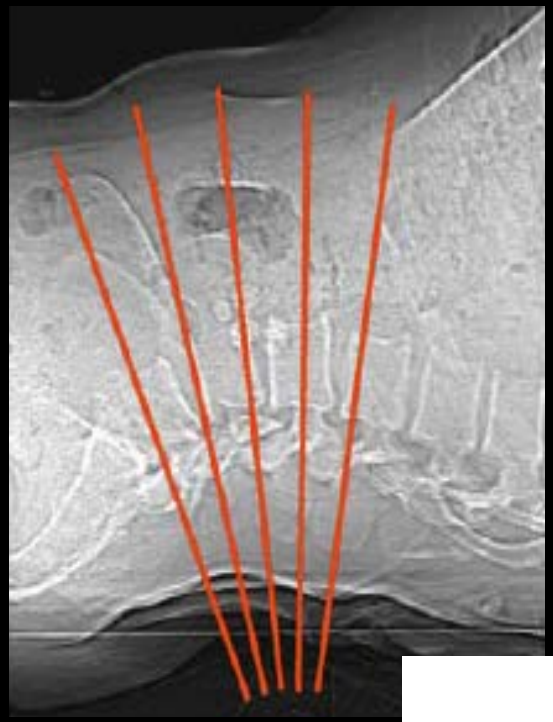
Rekonstrukcija slike sa displejom

Scout view:

topogram
scanogram
pilot scan



frontalni



lateralni

Ravan preseka direktno kroz strukture.

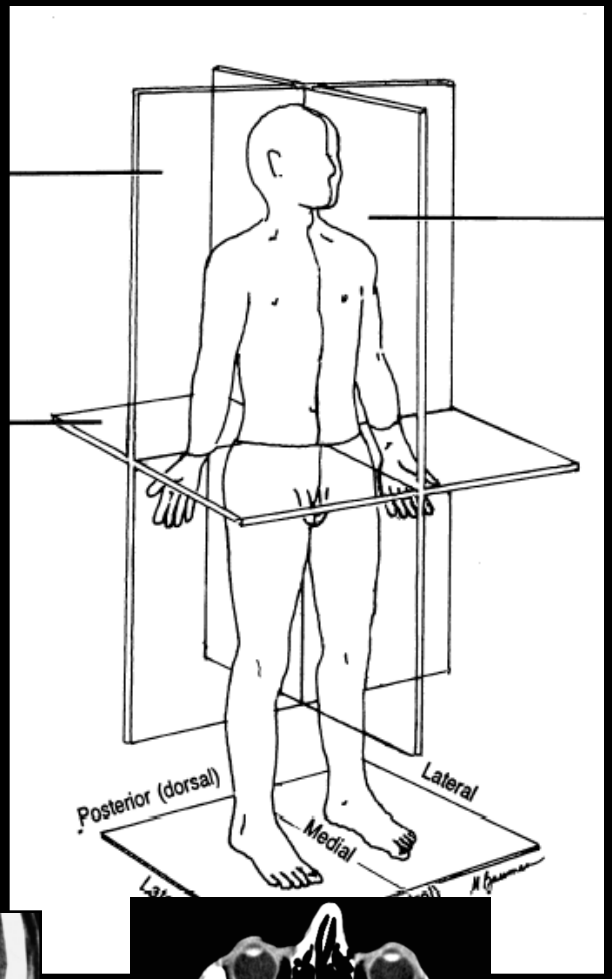
Slika velikog dinamičkog opsega

ali male prostorne rezolucije.



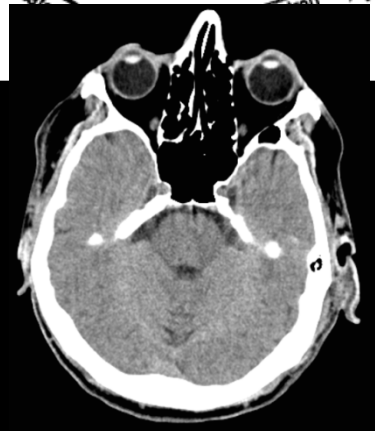
Coronar
frontal project.

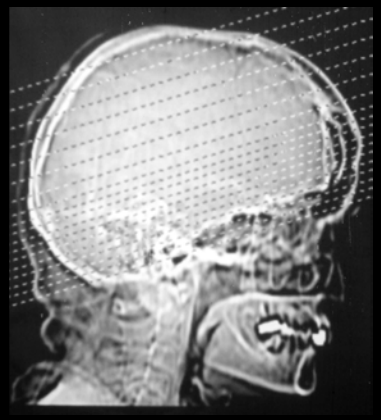
Transversal
axial project.



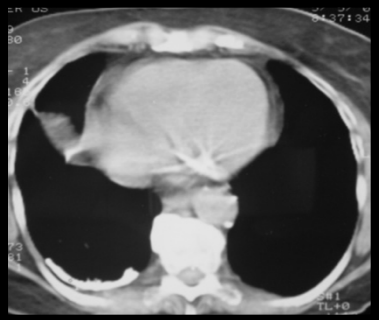
Sagital
profil project.

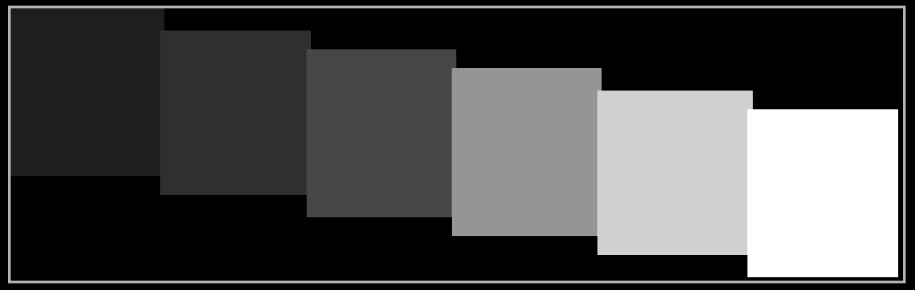






DENZITET Hounsfield Units - **HU**





-1000 **0** **+1000**

vazduh voda kost

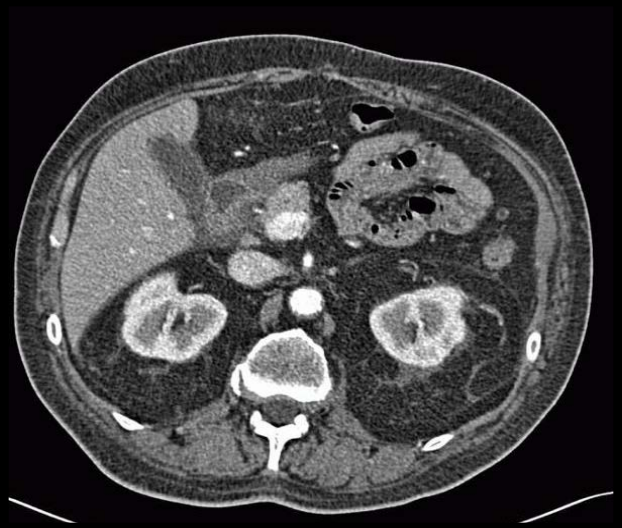
Obrada slike

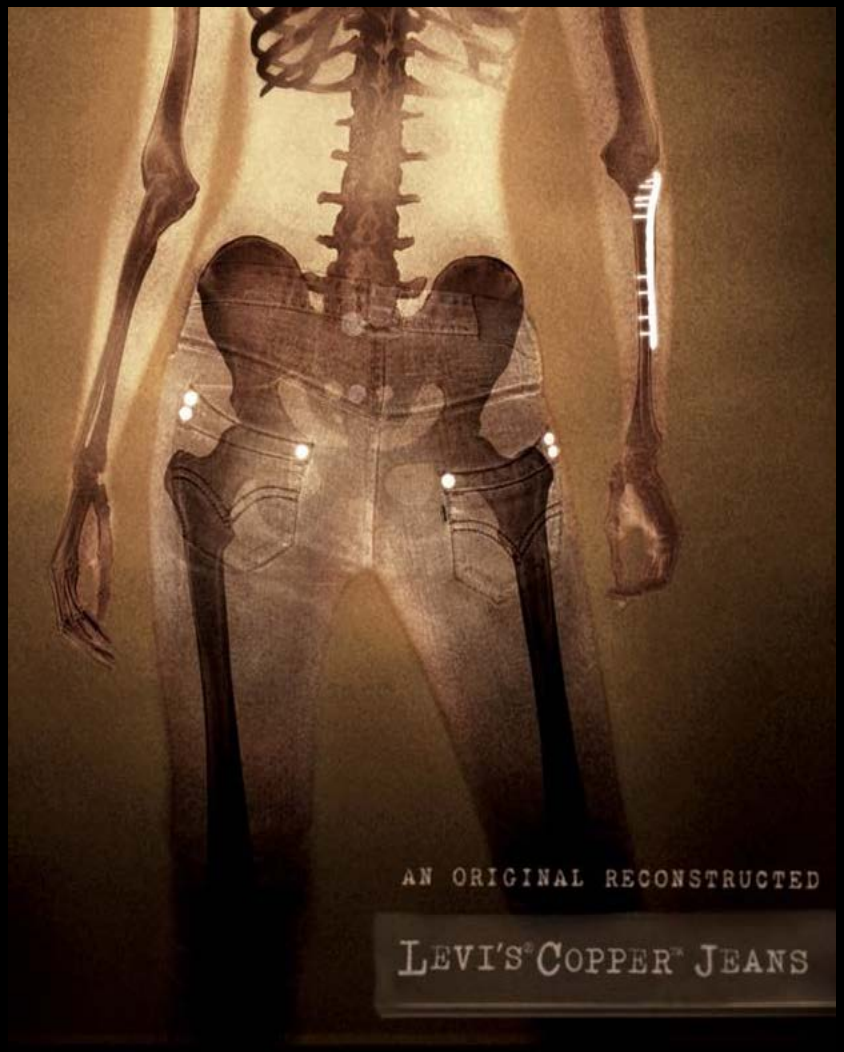
KOST:	+600 +1000
VODA:	0
PLUĆA:	-300 - 950
VAZDUH:	-1000



Jetra:	65
Krv:	50
Bubreg:	30
Exudat:	20
Mast:	-90



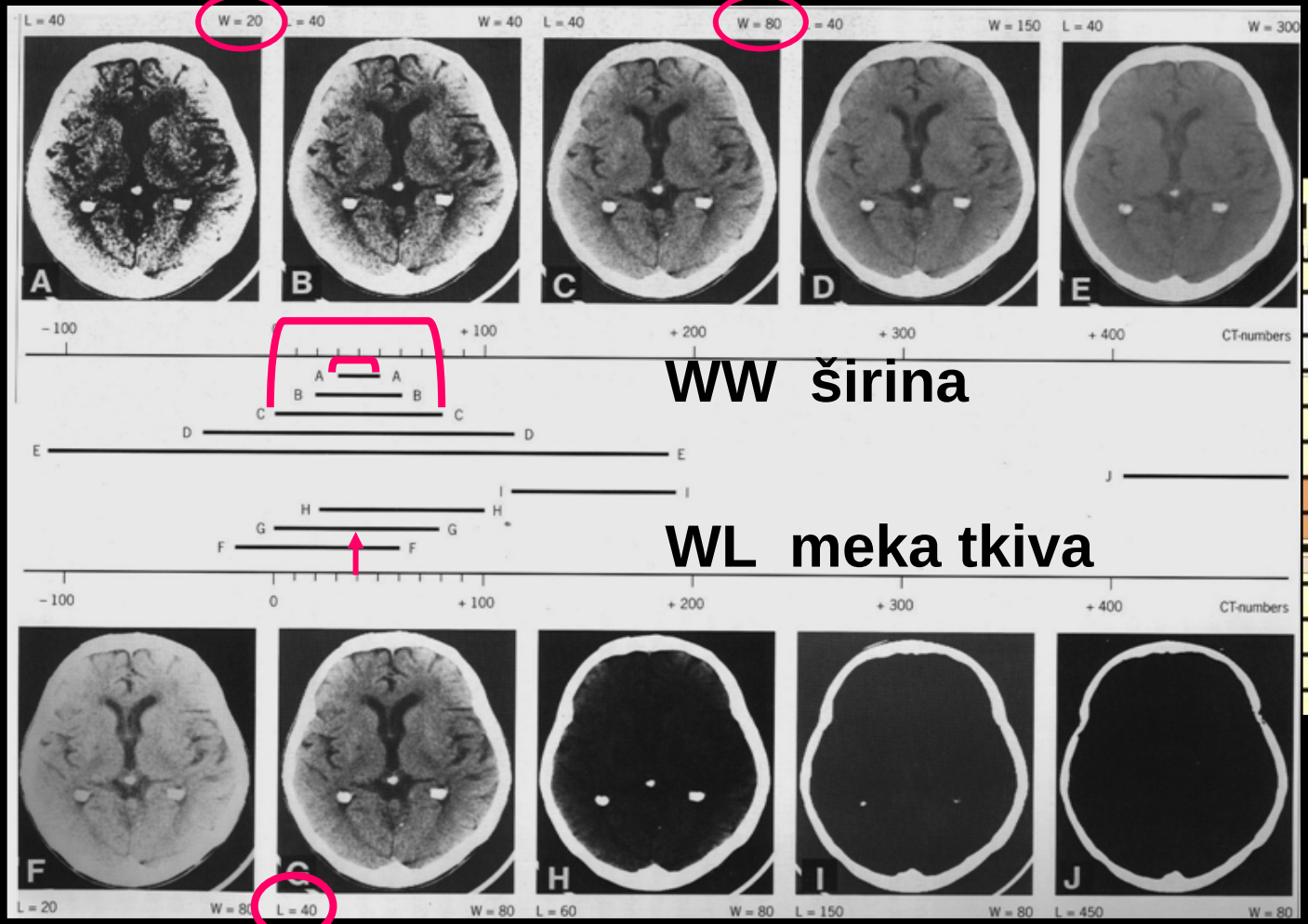


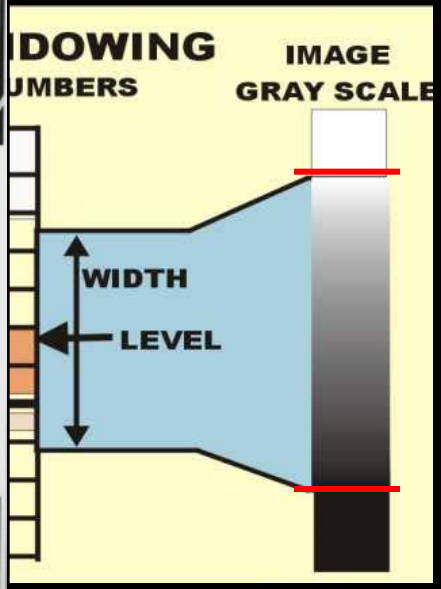


Da bi smo dobili sve detalje podešavamo prozor (window) kroz koji gledamo sliku.

- **WW** (window width) - širina prozora
- **WL** (window level) - nivo prozora

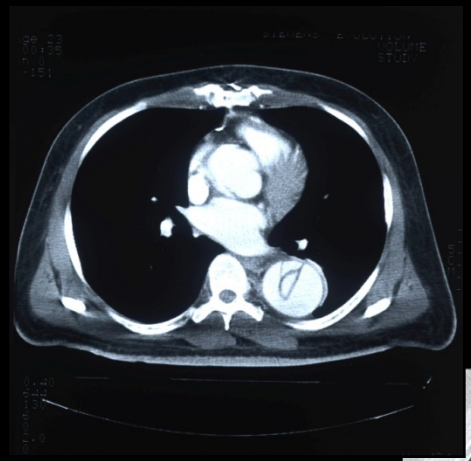
WC (window centar)


L = 40
W = 20
W = 40
L = 40
W = 80
W = 150
L = 40
W = 300
A
B
C
D
E
– 100
+ 100
+ 200
+ 300
+ 400
CT-numbers
WW širina
WL meka tkiva
0
F
G
H
I
J
L = 20
L = 40
L = 60
L = 150
L = 450

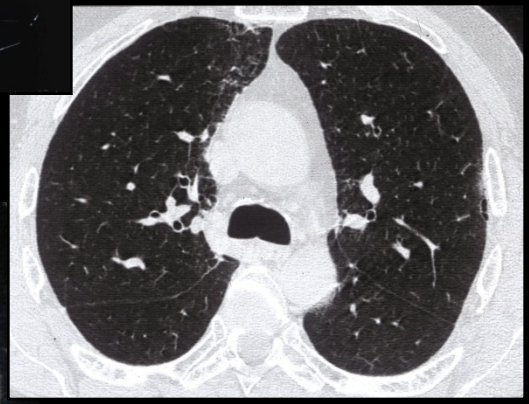

IDOWING
UMBERS
IMAGE
GRAY SCALE
WIDTH
LEVEL

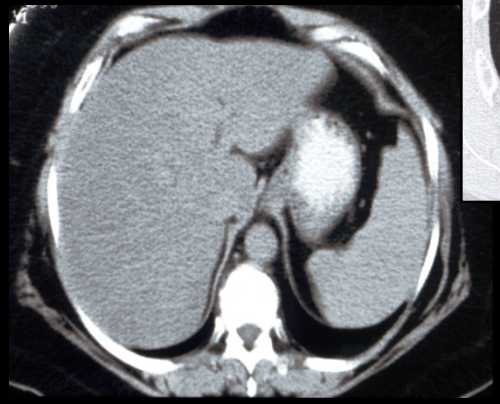
Predefinide windoving

Cerebrum	35/80
Lung	- 600/1200
Mediastinum	40/400
Abdomen	40/300
Liver	40/200
Pelvis	50/350
Bone	450/1500



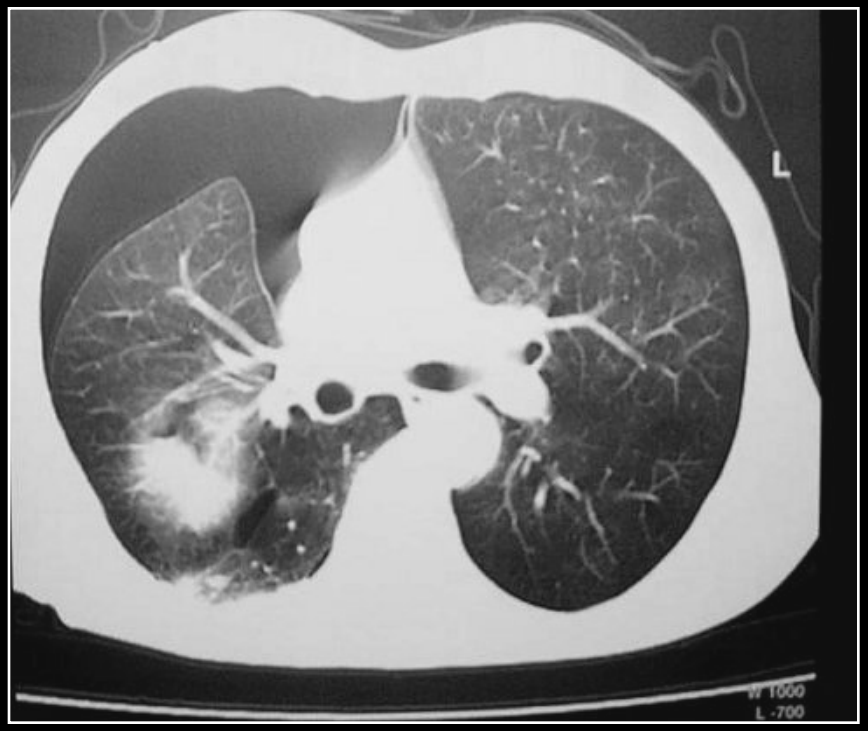




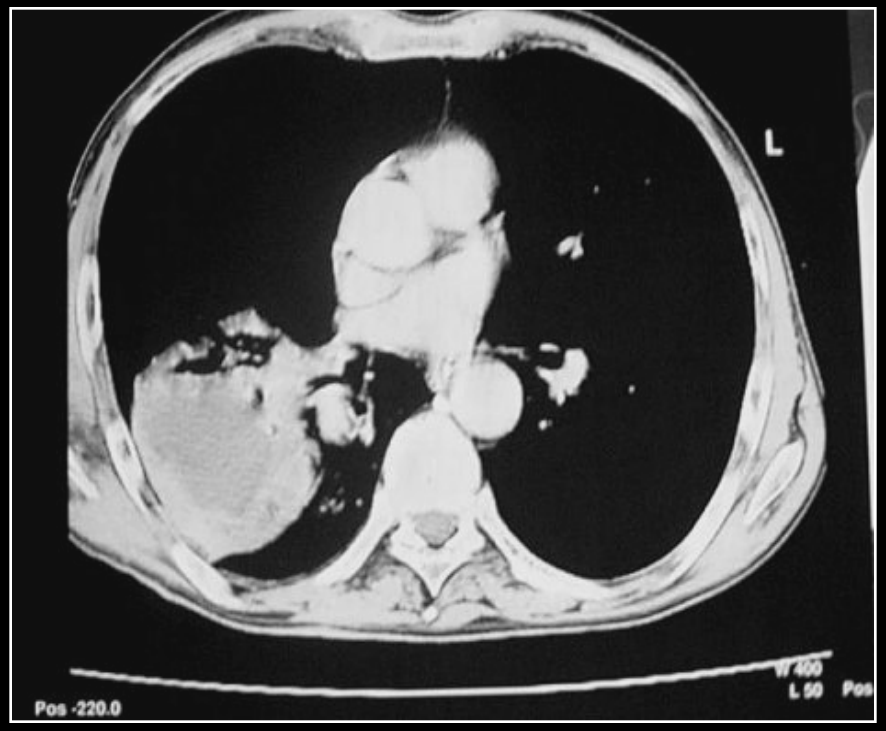


WW (window width) - širina prozora

broj nijansi sivog koje se prikazuju na slici.



Prozor za pluća

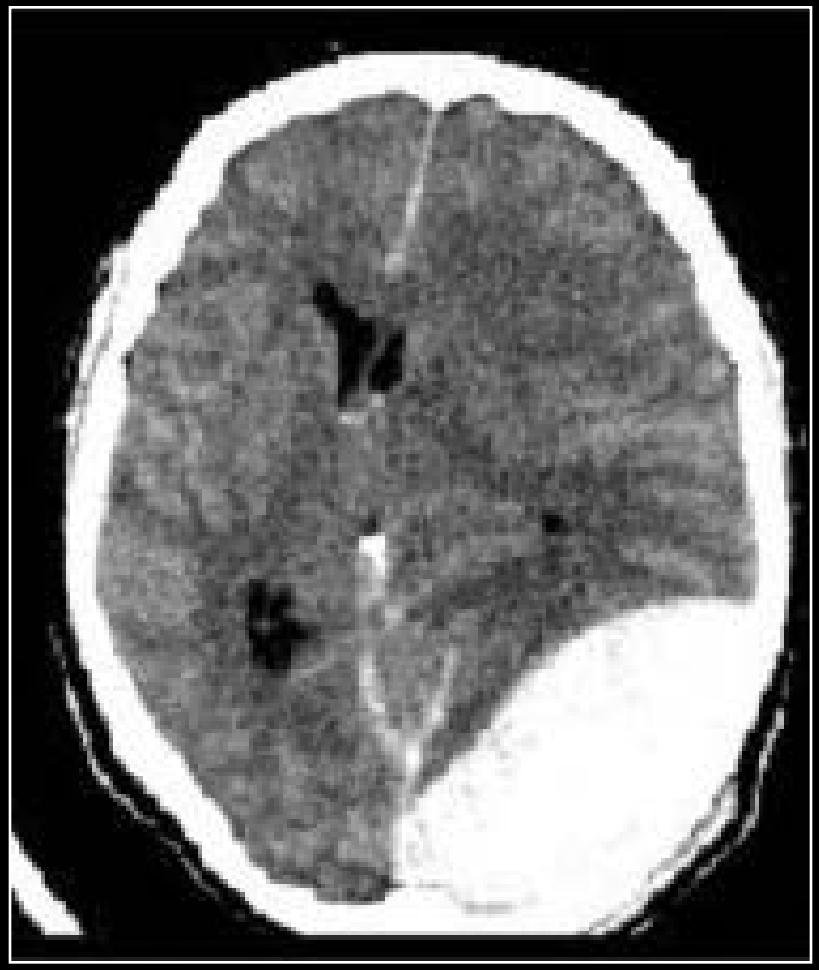


Prozor za medijastinum

Skala sivog na slici ne pređe broj koji možemo da razlikujemo

WL (window level) - nivo prozora
u skali sivog sa koga se analizira slika.





kost visoku a meka tkiva nisku apsorpcionu vrednost ne možemo istovremeno da analiziramo

Prednost digitalne slike



- Prostorna rezolucija <1 mm
  manja od rtg filma zbog gustine matriksa
- Kontrastna rezolucija ±2 HU
  na slojevima tanjim od 2 mm rezolucija je manja zbog artefakata
  a može se poboljšati ukoliko se produži vreme skeniranja

- Mogućnost prilagođavanja i uočavanja
  dijagnostički važnih detalja koji su naizgled "skriveni"

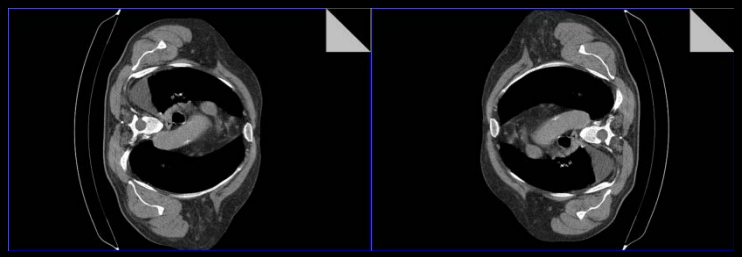
Post-procesing



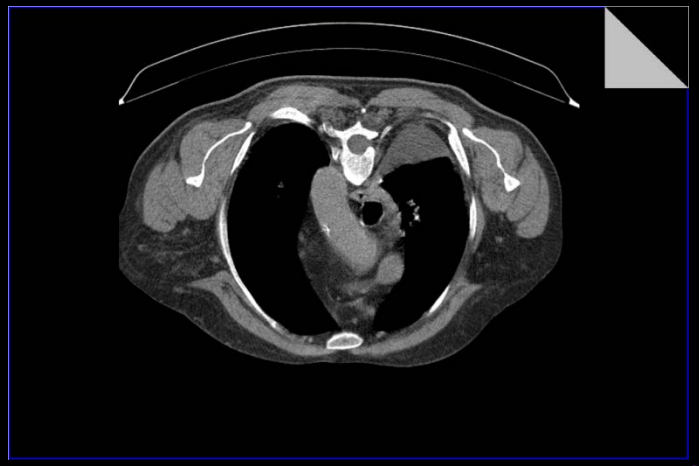
Image - home view



Mirror



Rotate ± 90^0



Flip



Magnify



Pan

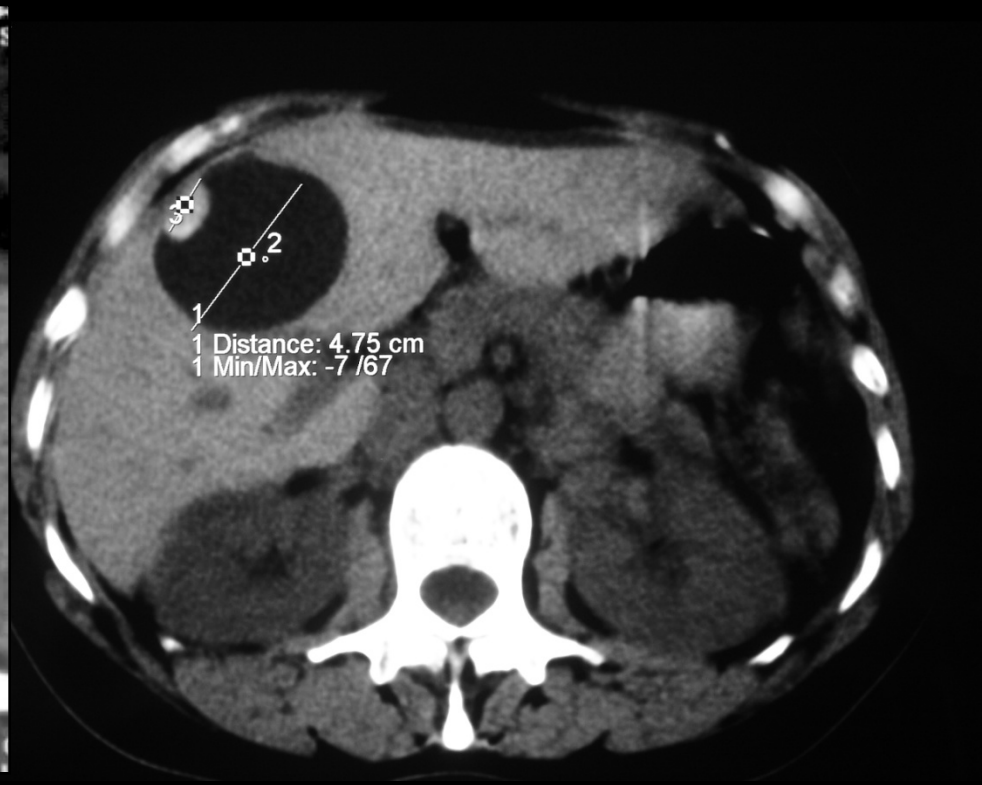


Minify



Invert





Distance

Zoom

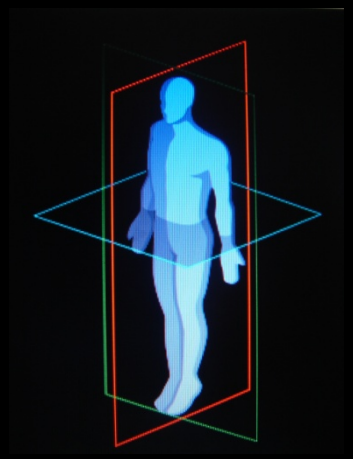
analog - smanjuje rezoluciju

hardware (field of view) - isti broj piksela matrice na smanjenu veličinu polja koje se rekonstruiše što daje manju efektivnu veličinu pikselima ali sa više detalja.

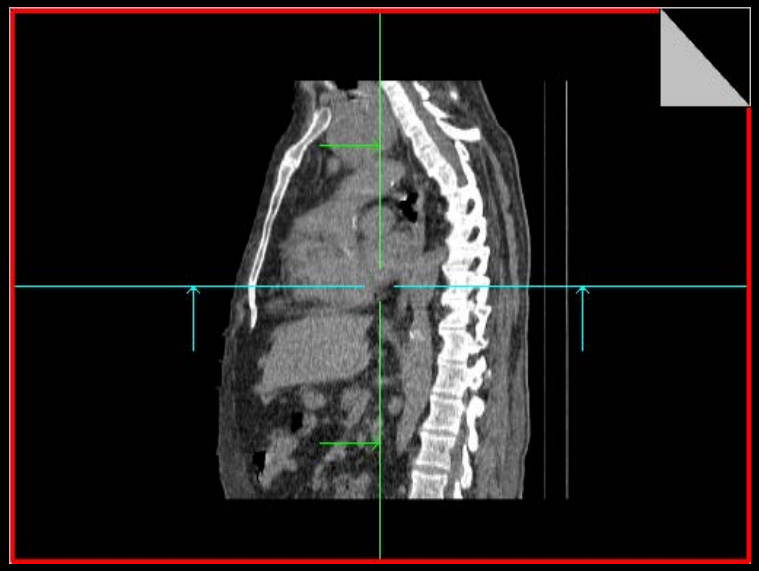
Cine viewing

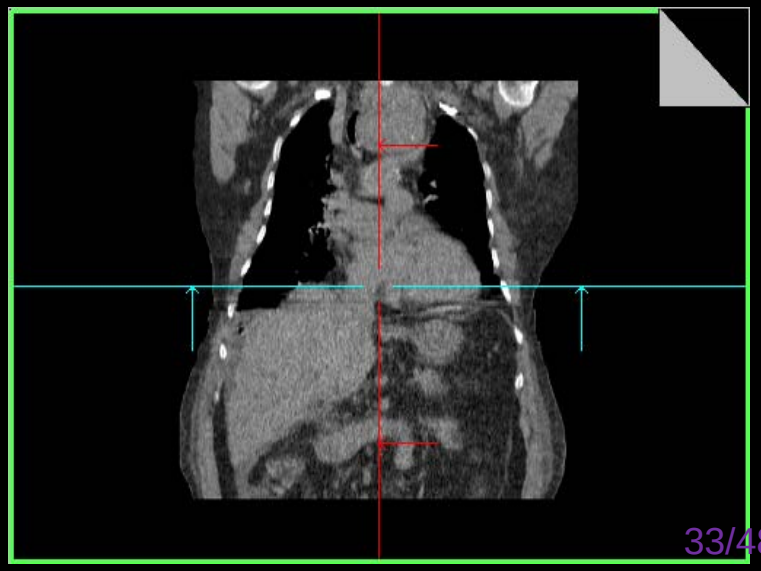


Prikaz image u 3D tehnici





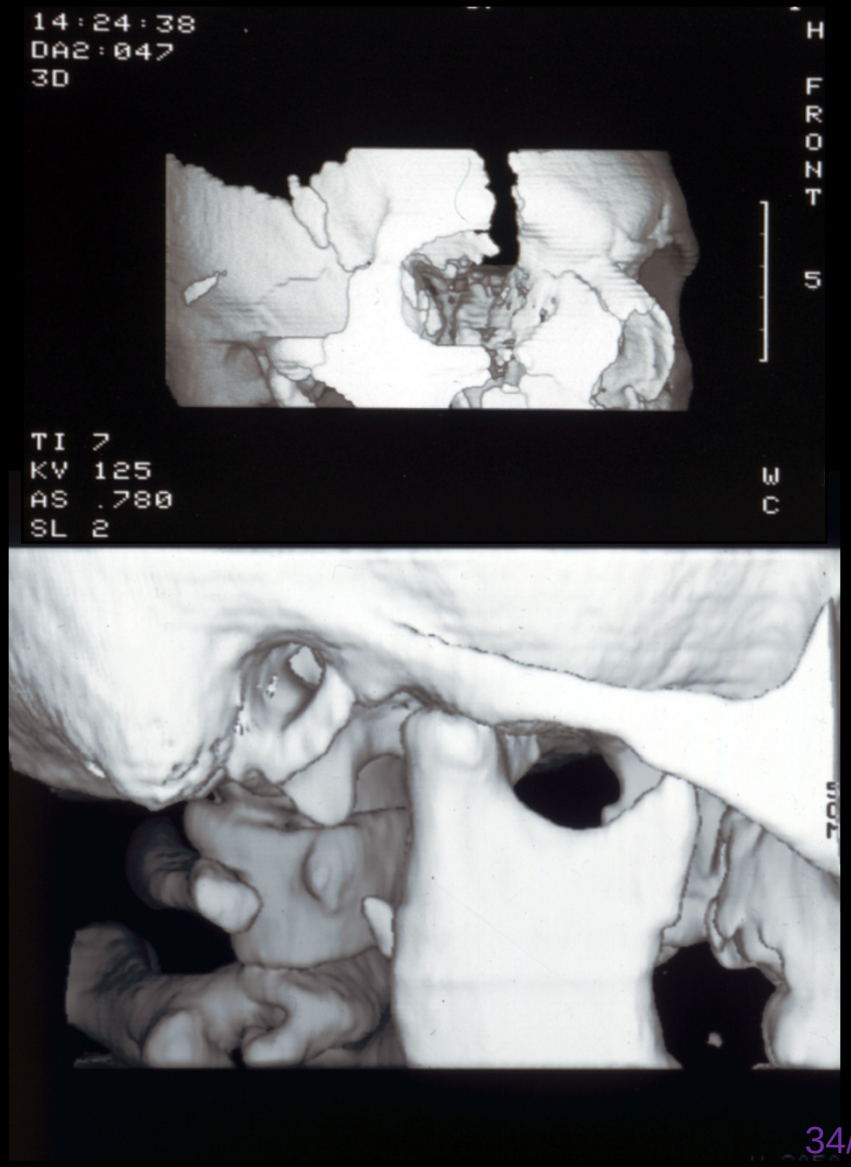




- MPR (multy plane reconstruction)

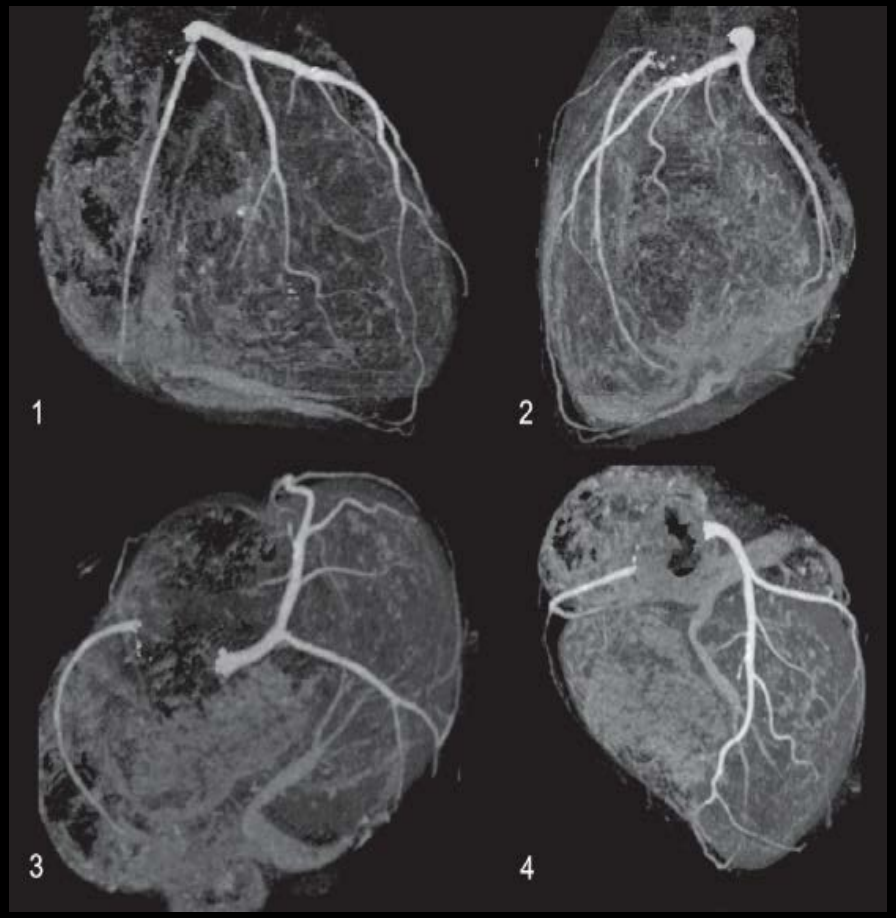
rekonsrtukcija 2D slike u bilo kojoj ravni.





- MIP (max. intensity projection)

Naglašavanje objekata najveće svetline u odnosu na struktture iz neposredne okoline.



- mIP (min. intensity projectiontect)

Naglašava male kontrastne strukture u odnosu na svoju okolinu.





- VRT (volume rendering technique)

Zapreminsko izvođenje, jasniji prikaz kontura objekta sa semitransparentnim prikazom pojedinih tkiva.

0 -100% odabranih HU zasenčenje varira.



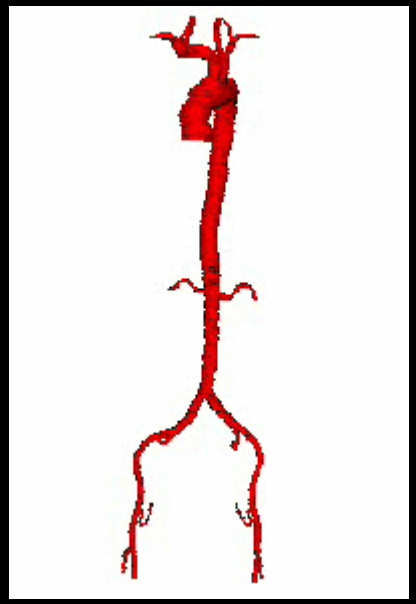


+ MIP + MPR

- SSD (shaded surface display)

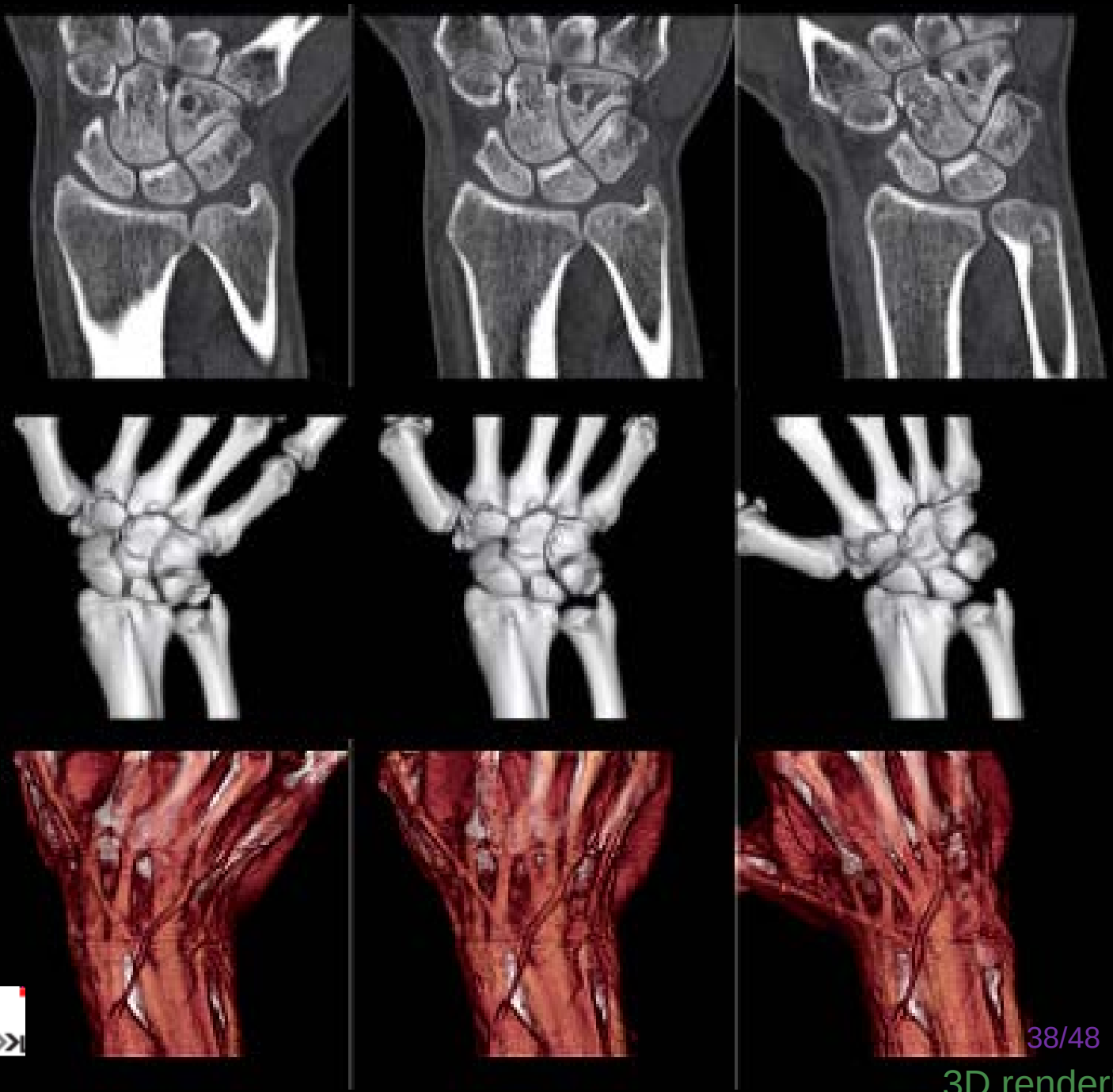
Postupak odvajanja objekta od okoline. prikazuje samo površina a vrednosti - prag denziteta bira operater (kost, mišići, hrskavica, ...)

Sve vrednosti izvan raspona 0 -100% odabranih HU prikazuje kao 0.



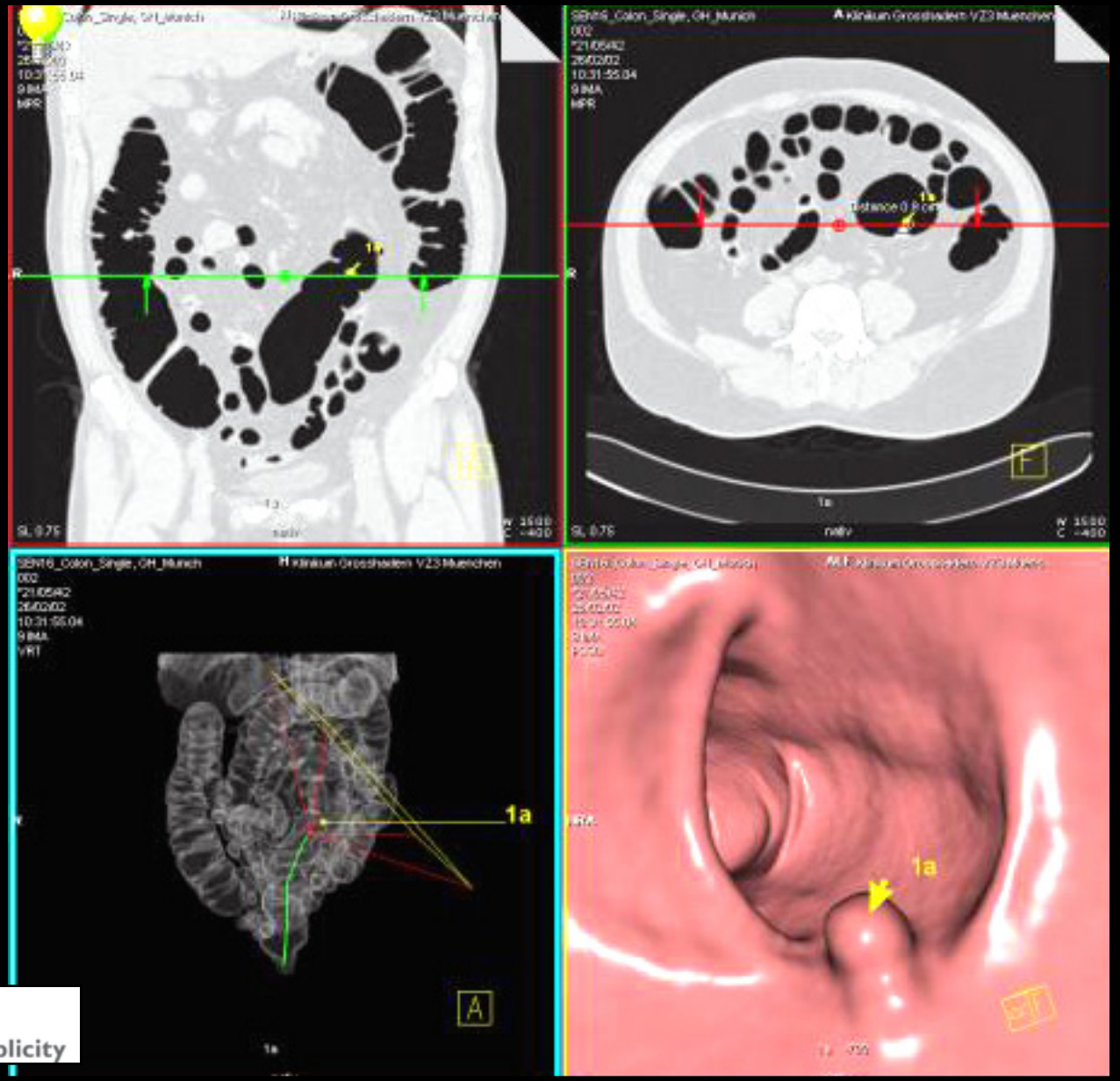


Spiral CT
MPR
VTR



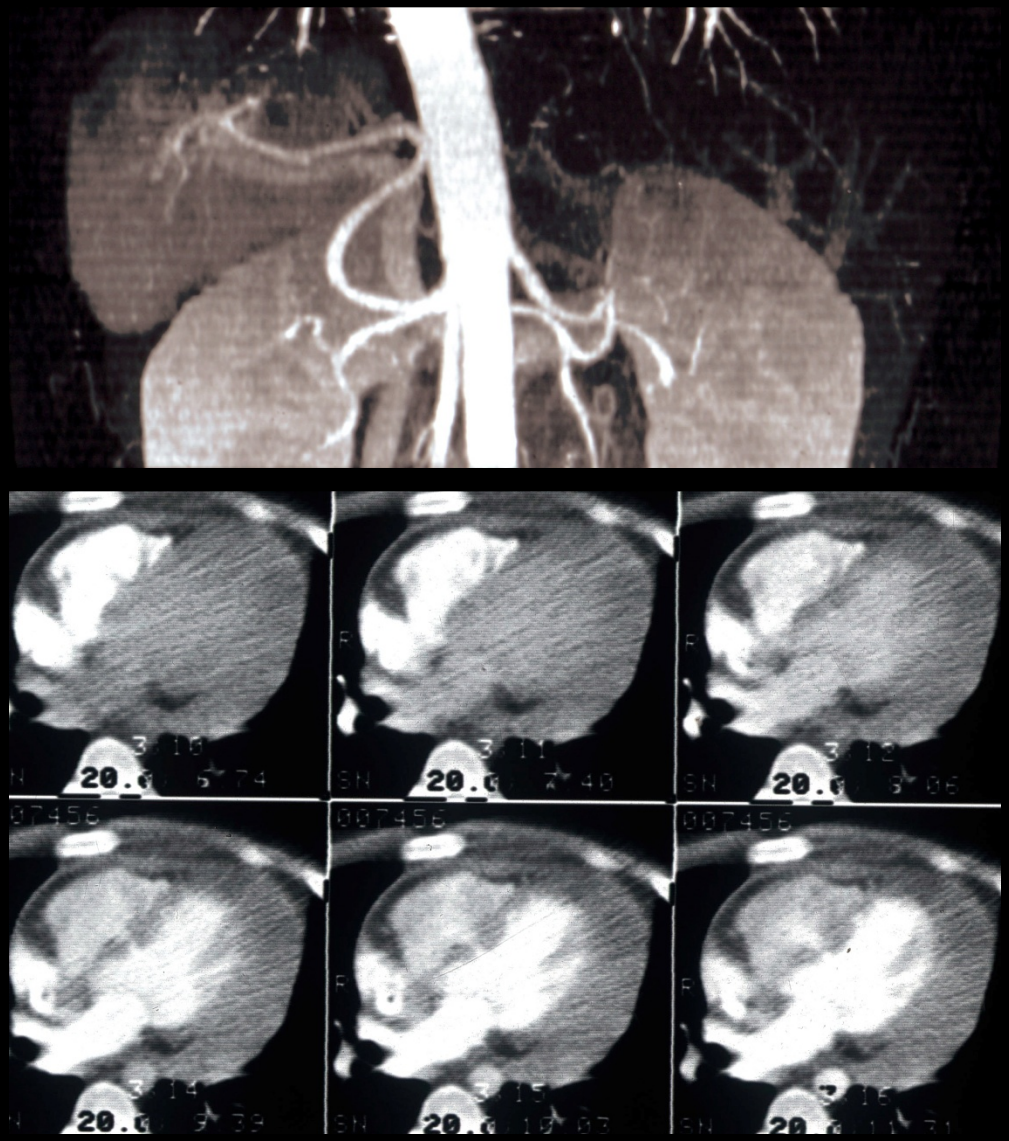
TOSHIBA
Leading Innovation

- Fly through
  Virtual endoscopia
  Traktografija



PHILIPS
sense and simplicity

- Angio CT
  Kardio CT



CT opis

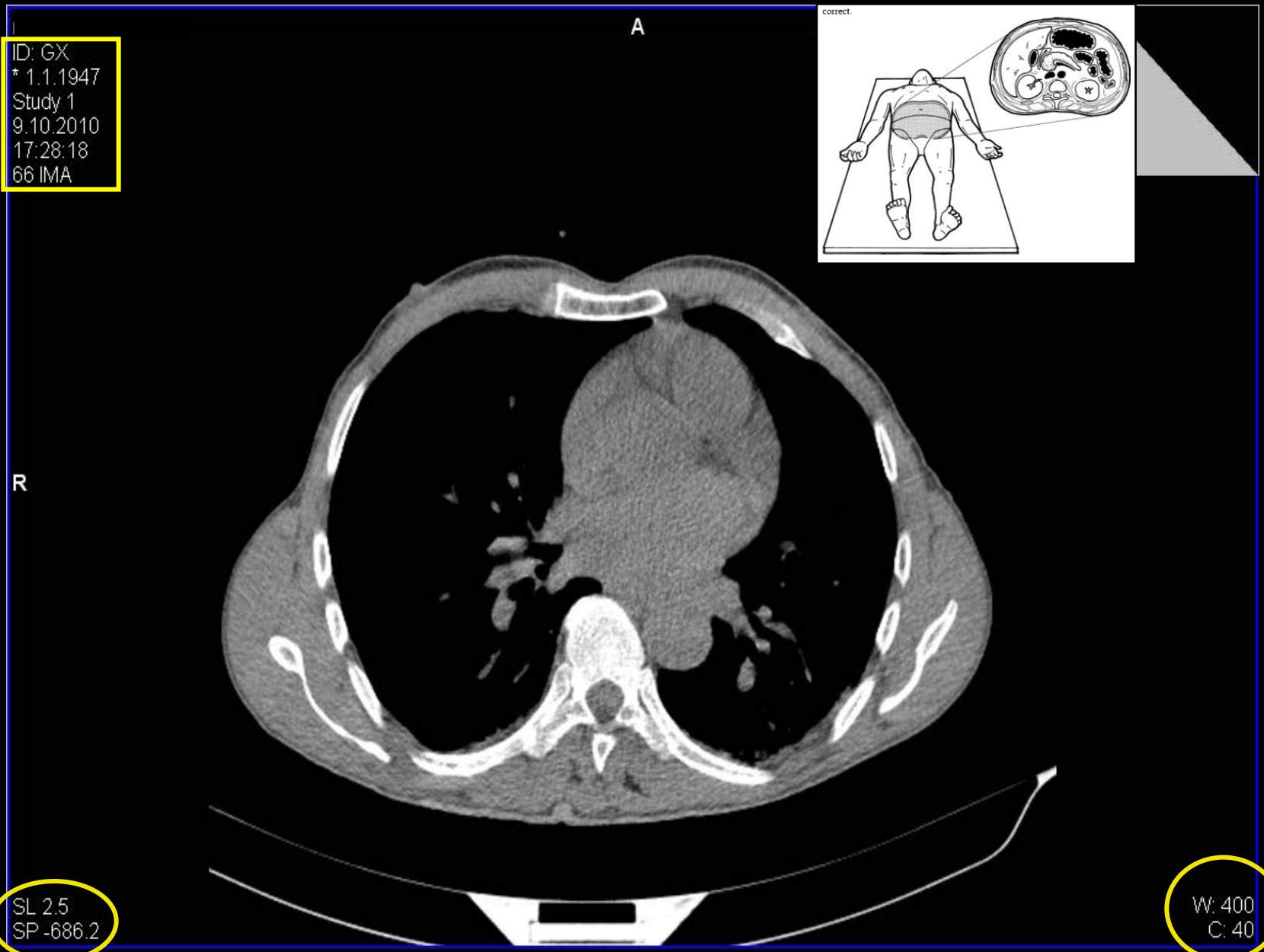
ORGANA

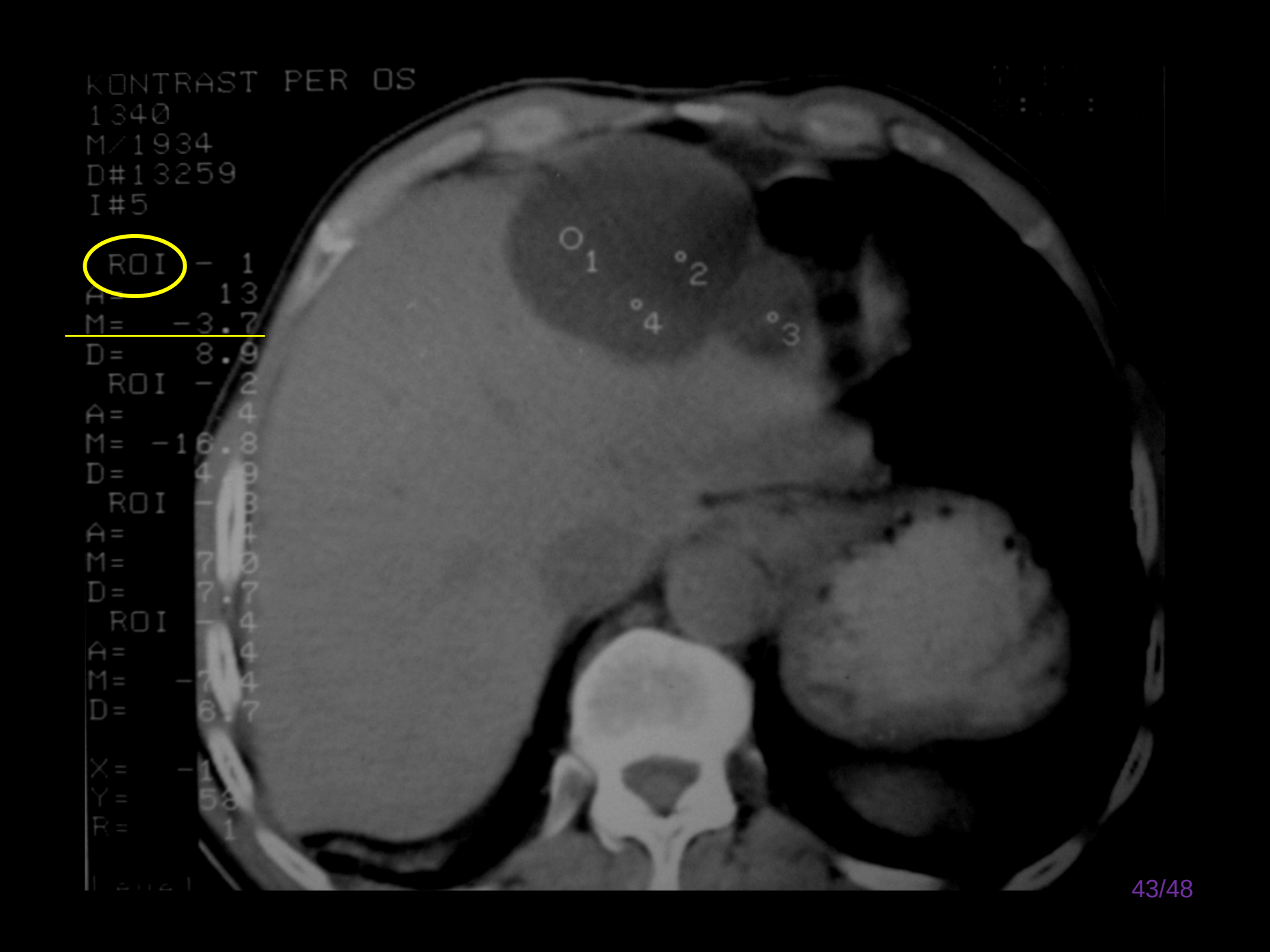
- L okalizacija
- O blik
- V eličina
- D enzitet

PROMENE

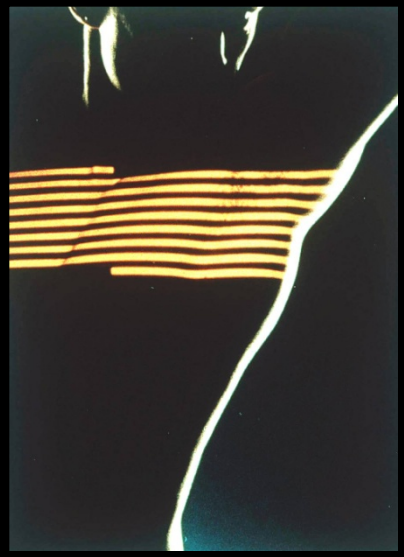
- L okalizacija
- O blik
- V eličina
- D enzitet
- H omogenost
- O graničenost




ID: GX
* 1.1.1947
Study 1
9.10.2010
17:28:18
66 IMA
A
R
correct.
SL 2.5
SP -686.2
W: 400
C: 40


KONTRAST PER OS
1340
M/1934
D#13259
I#5
ROI - 1
A= 13
M= -3.7
D= 8.9
ROI - 2
A= 4
M= -16.8
D= 4.9
ROI - 3
A= 11
M= 7.0
D= 7.7
ROI - 4
A= 4
M= -7.4
D= 8.7
X= -1
Y= 58
R= 1
1
2
3
4

Brief protocol
abdomen and pelvis



Region: above diaphragm to pubic symphysis

Contrast media: iv: 120 ml - 2,5ml/sec

oral: 1000 ml over 1h.

ctal: 500 ml immediately before skan.

Scan delay time: 50 sec after start of bolus

CT technique: 120 kV, 175-300 mA, 512 matrix,

inspiration, bottom to top, 10/10/8

(colimacija, pomeranje stola, reconstrukcioni interval)

Pitch 1:1

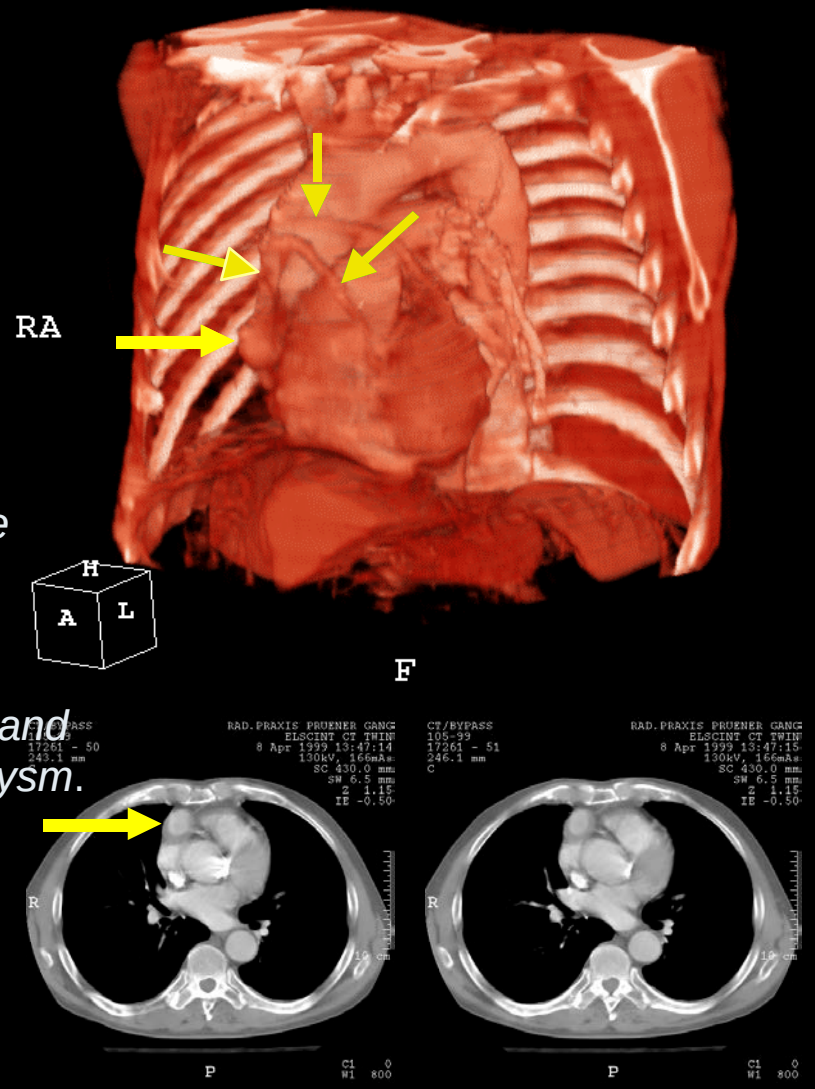
(pomeranje stola tokom 1 rotacije 1,25:1 1,4:1)

RogelaP., Mutzes S., Hamm B. Body CT: state-of-the-Art. Protocols for long-spiral CT, short-spiral CT, incremental CT. München; Bern; Wien; New York: Zuckschwerdt Verlag, 1996.

- 04.08.99.
- Patient: N.N. DOB: 09.07.48.
  Sex: M
  Patient Loc: IN20
  Patient Status: O
  Physician: DR. J.B. PIERCE
  Wa17261-51 4.8.99 10:05AM
  Requested by: DR. WALLACE
- CT Thorax/Abdomen
  Diagnosis: H.A.
  History: H.A.

- **FINDINGS:** *Aortocoronar venous bypasses to the right and the left coronary artery, and the ramus circumflexus.*

- **IMPRESSION:** *The bypass connecting the aorta and the right coronary artery has developed an aneurysm*.

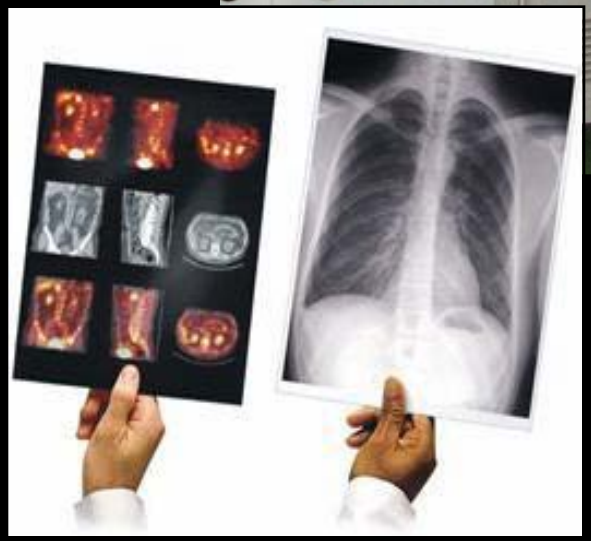


Radiologists: J.B. Pierce , M.D
Transcribed on: 4.8.99 at 10:30AM by

5. Printer slike









Diagnostic procedure	Typical effective dose (mSv)	Equivalent no. of chest X-rays	Approx. equivalent period of natural background radiation
Radiographical examinations			
Limbs and joints (except hip)	<0.01	<0.5	< 1.5 days
Chest (single PA film)	0.02	1	3 days
Skull	0.06	3	9 days
Thoracic spine	0.7	35	4 months
Lumbar spine	1	50	5 months
Hip	0.4	20	2 months
Pelvis	0.7	35	4 months
Abdomen	0.7	35	4 months
IVU	2.4	120	14 months
Barium swallow	1.5	75	8 months
Barium meal	2.6	130	15 months
Barium follow-through	3	150	16 months
Barium enema	7.2	360	3.2 years
CT head	2	100	10 months
CT chest	8	400	3.6 years
CT abdomen or pelvis	10	500	4.5 years
Radionuclide studies			
Lung ventilation (^{133}Xe)	0.3	15	7 weeks
Lung perfusion (^{99m}Tc)	1	50	6 months
Bone (^{99m}Tc)	4	200	1.8 years



- http:// www.med.pr.ac/katedra/interna-medicina.php