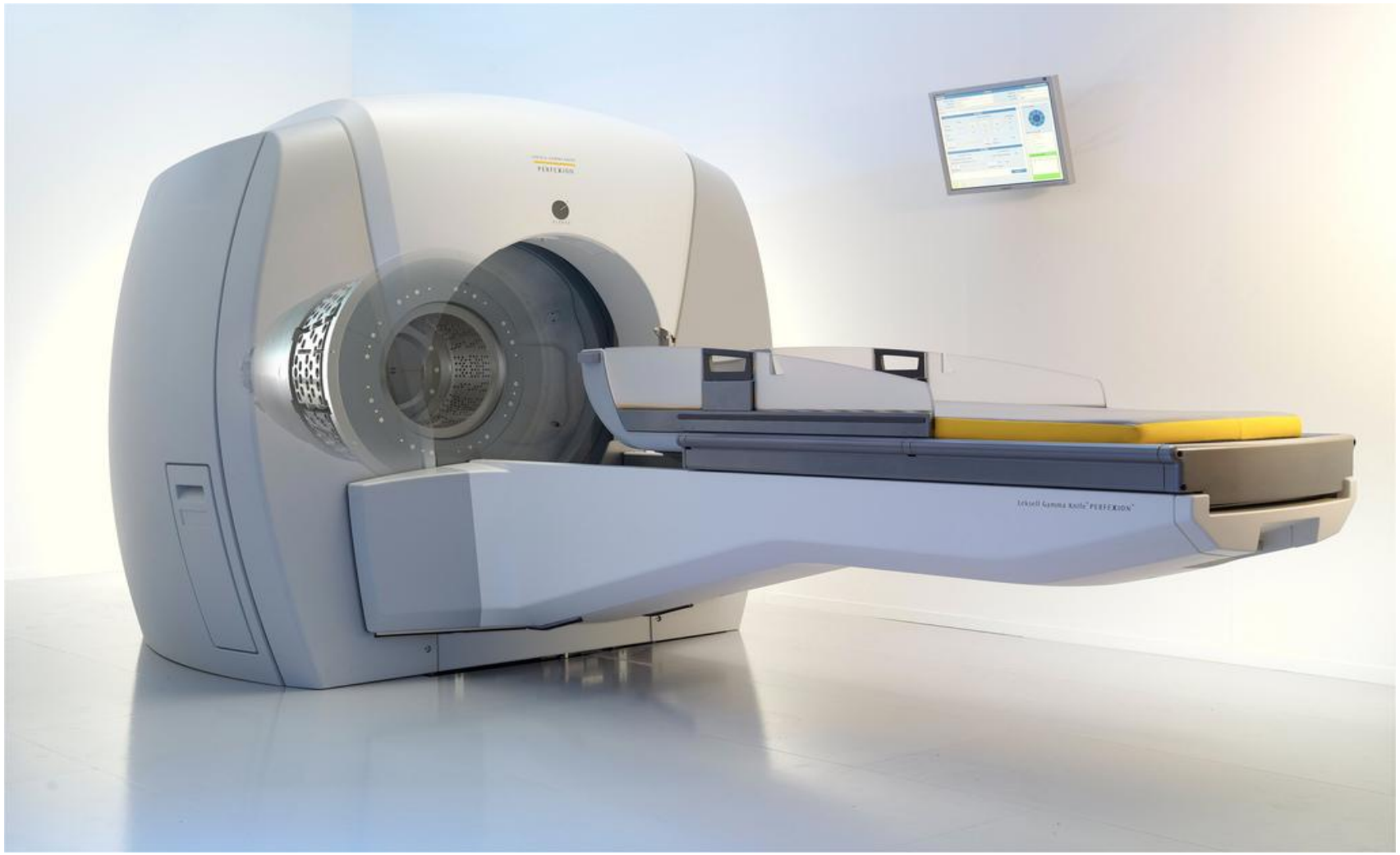
STEREOTAKSA

Stereotaktički tretman je primena spoljašnjeg snopa zračenja kroz stereotaktičke vodjice za preciznu isporuku doze definisanom volumenu mete

Istorija

- 1908 – Prva stereotaktička metoda, London, Victor Horsley iRobert H. Clarke ("Horsley-Clarke apparatus")
- 1930 – poboljšanje H-C aparata
- 1947-1949 – 2 uredjaja za hirurgiju mozga
  - Henry T. Wycis i Ernest A. Spiegel's uredjaj (USA)
  - Lars Lekselov uredjaj (Švedski neurohirurg, kasnije osnivač ELEKTA
- 1978 –Russell A. Brown primenio CT u radiohirurgiji (USA)
  - Osnova za današnje uredjaje

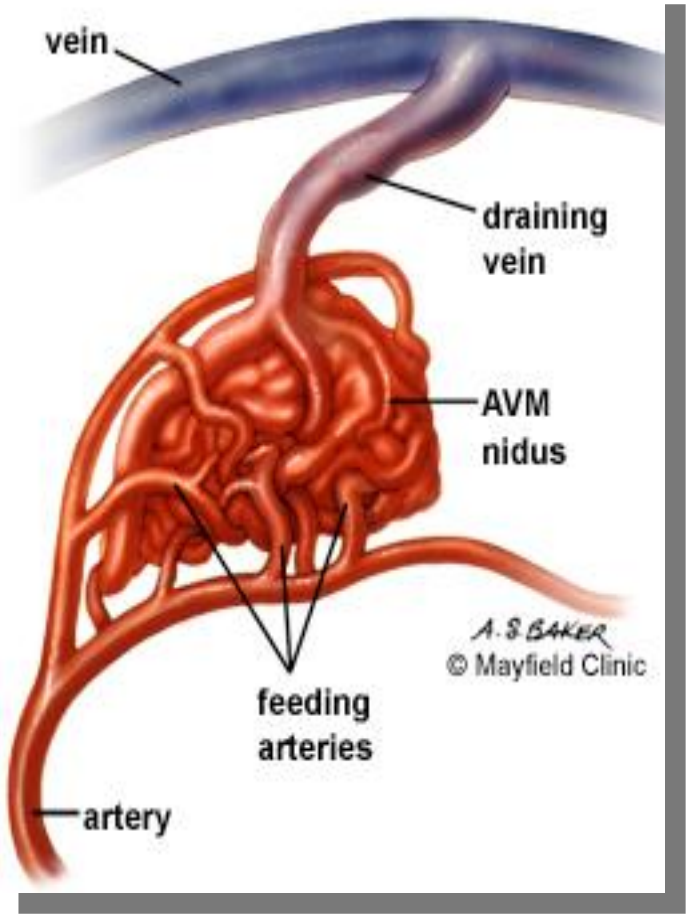
Elekta Gamma Knife®



Primena

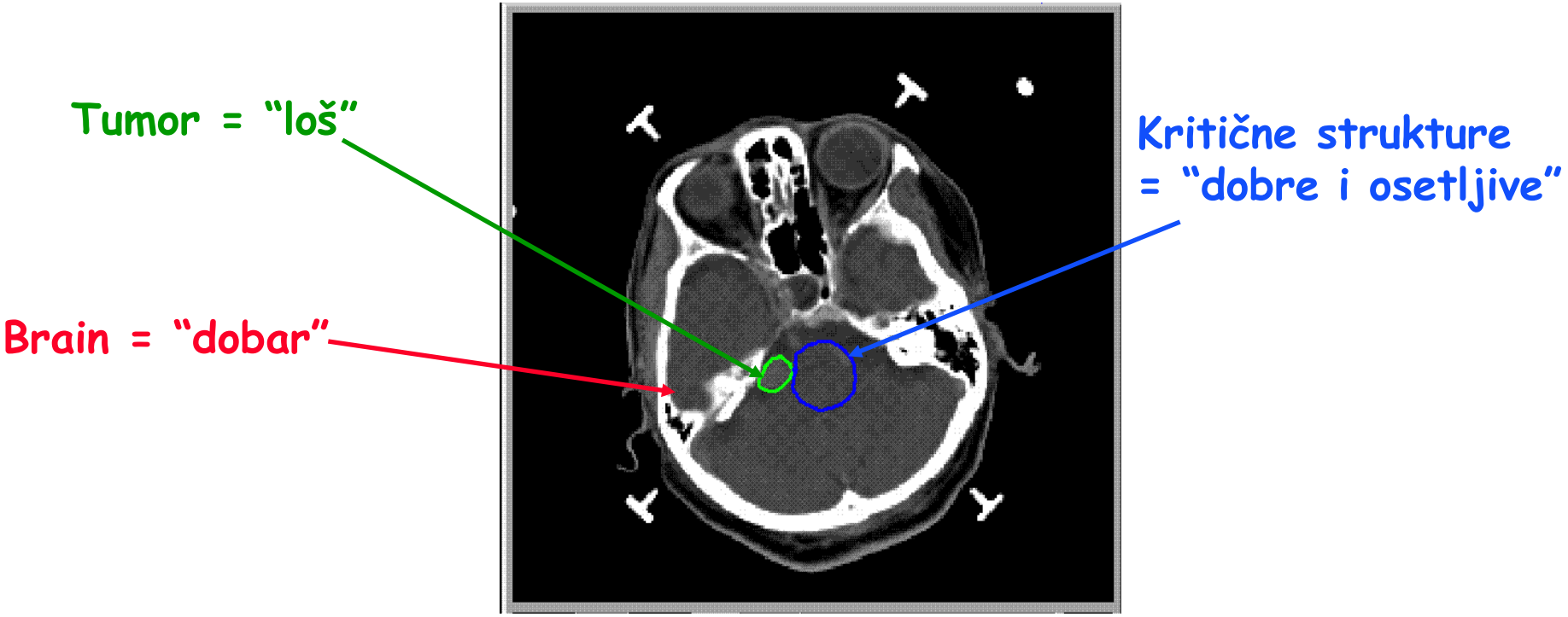
- Tumori mozga
  - Maligni i nemaligni
  - Primarni i metastaze
- Arteriovenozne malformacije (AVMs)

- Neuralgije
  - Poremećaj facijalnih nerava
- Parkinson'ova bolest
- Tremori
- Epilepsija
- .....



Radiohirurgija

Minimalno invazivna procedura koja koristi fokusirani snop zračenja visokog intenziteta kao ablativni hirurški instrument za uništenje tumora



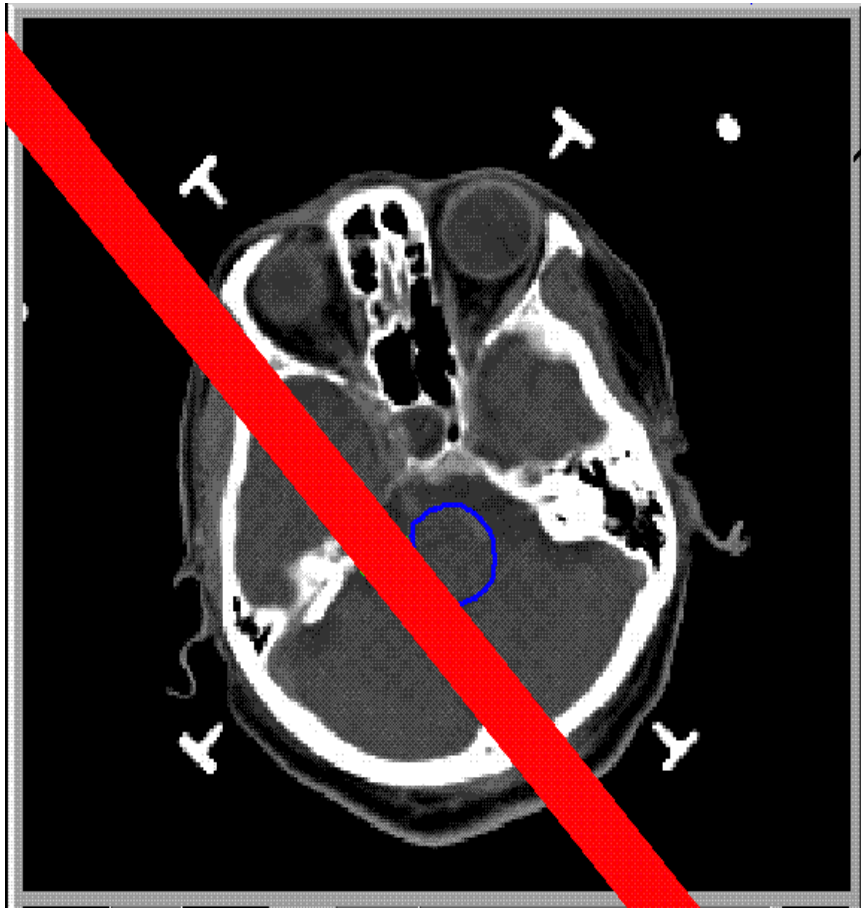
Radiohirurgija

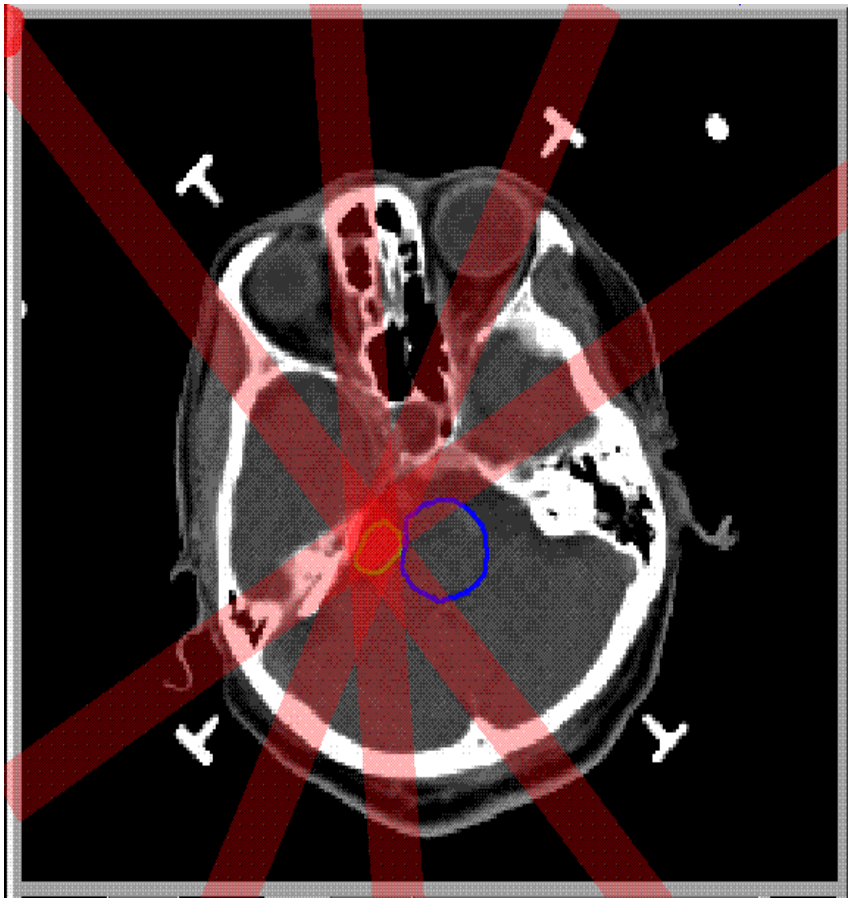
- Pojedinačna doza (14-34) Gy
- Koristi se ako je adenom bar (3-5) mm od optičkog nerva ili hijazme u mozgu
- Tolerancija mesta ukrštanja optičkih nerava u mozgu na dozu iznad 8 Gy je mala i dovodi do rizika pojave slepila na oba oka
- Kod 97 % pacijenata dolazi do stabilizacije ili smanjenja tumora
- U 17-96 %, dolazi do remisije (popuštaju i simptomi bolesti)
- Srednje vreme remisije je 29,8 meseci

Komplikacije u radiohirurgiji

- Pojava hipopituiarizma (smanjenje lučenja jednog ili više hormona proizvedenih pituitarnom žlezdom u bazi mozga, prednji režanj hipofize): (2-47)%
- Poremećaj vida: (1-11)%
- Oštećenje kranijalnog nerva: retko
- Privremena epilepsija
- Radijacione nekroze
- Stenoze karotidne arterije
- The larger the volume of tumour and the closer it is to the optic nerves the greater

Problem radiohirurgije (Inverzna dozimetrija)

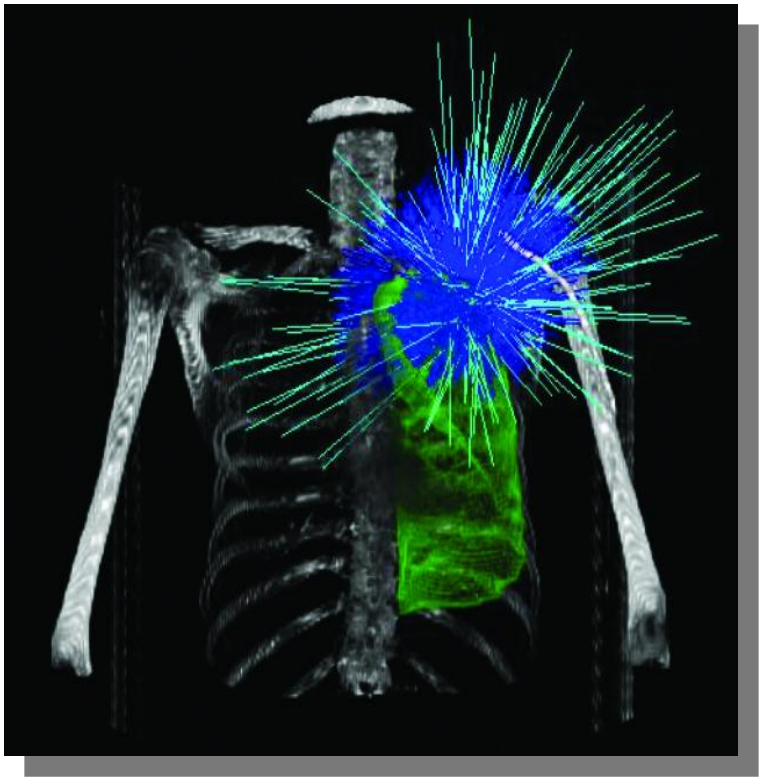




Doza iz višestrukog snopa je aditivna (sabira se)

Prednosti

- Tretman tumora nedostupnih konvencionalnom hirurgijom
  - Zaustavlja rast menjanjem DNK
- Neinvazivna (nema fizičkog reza)
- Ekstremno precizna
- Kraće traje od ma kog tretmana, hirurškog, hemo ili radioterapije: (30-60) minuta
- Efikasnija
- Kompletne troškove pokriva zdravstveno osiguranje
- Manje propratnih efekata

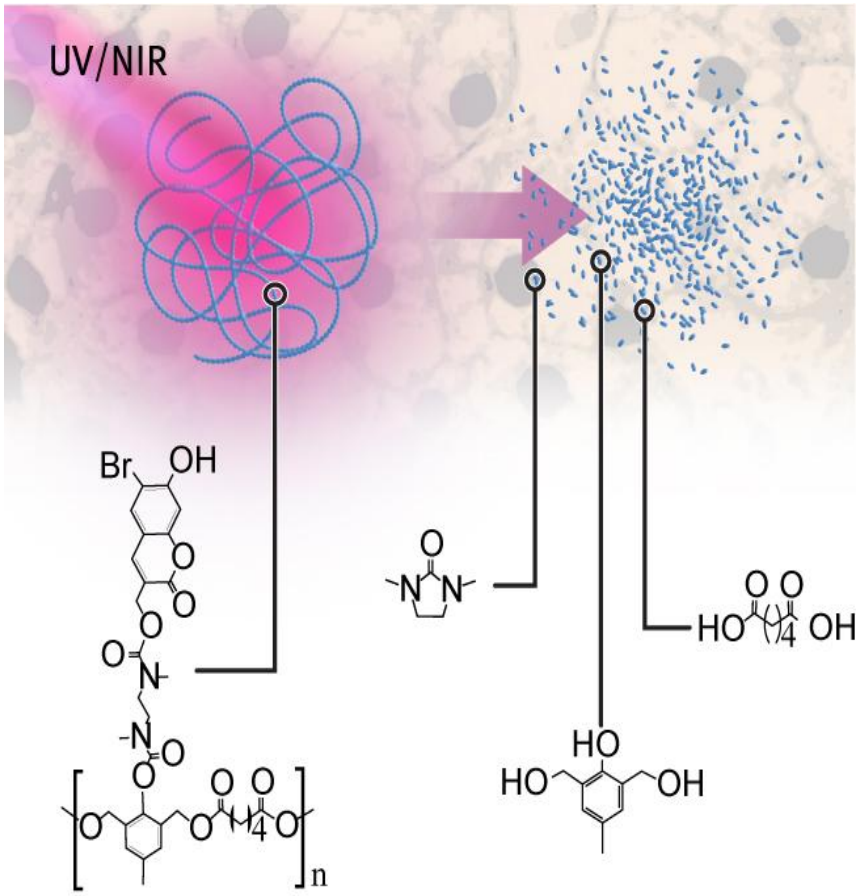


Nedostaci

- Postoje propratne pojave
  - Problemi sa kožom
  - umor
  - Gubitak kose
  - glavobolje
  - Okot mozga
  - Oštećenje tkiva
  - I još…
- Ne može da potpuno uništi tumor
  - Samo zaustavlja rast
- Skupa metoda
  - Oko $12,000 za 1 tretman
  - Oko $55,000 za 5 tretmana
- Rezultat zahteva vreme
  - Od 1 meseca do 2 godine

Buduće tehnologije

- Ekstremno jak snop koji dezintegriše tumor
  - menja DNK tako da se biološki razgradi
- Veća preciznost
  - Nema oštećenja okolnog tkiva
- Manje propratnih pojava
- Jeftinija terapija
- 4-Dimenziono mapiranje
- Brži rezultati
- Brža procedura



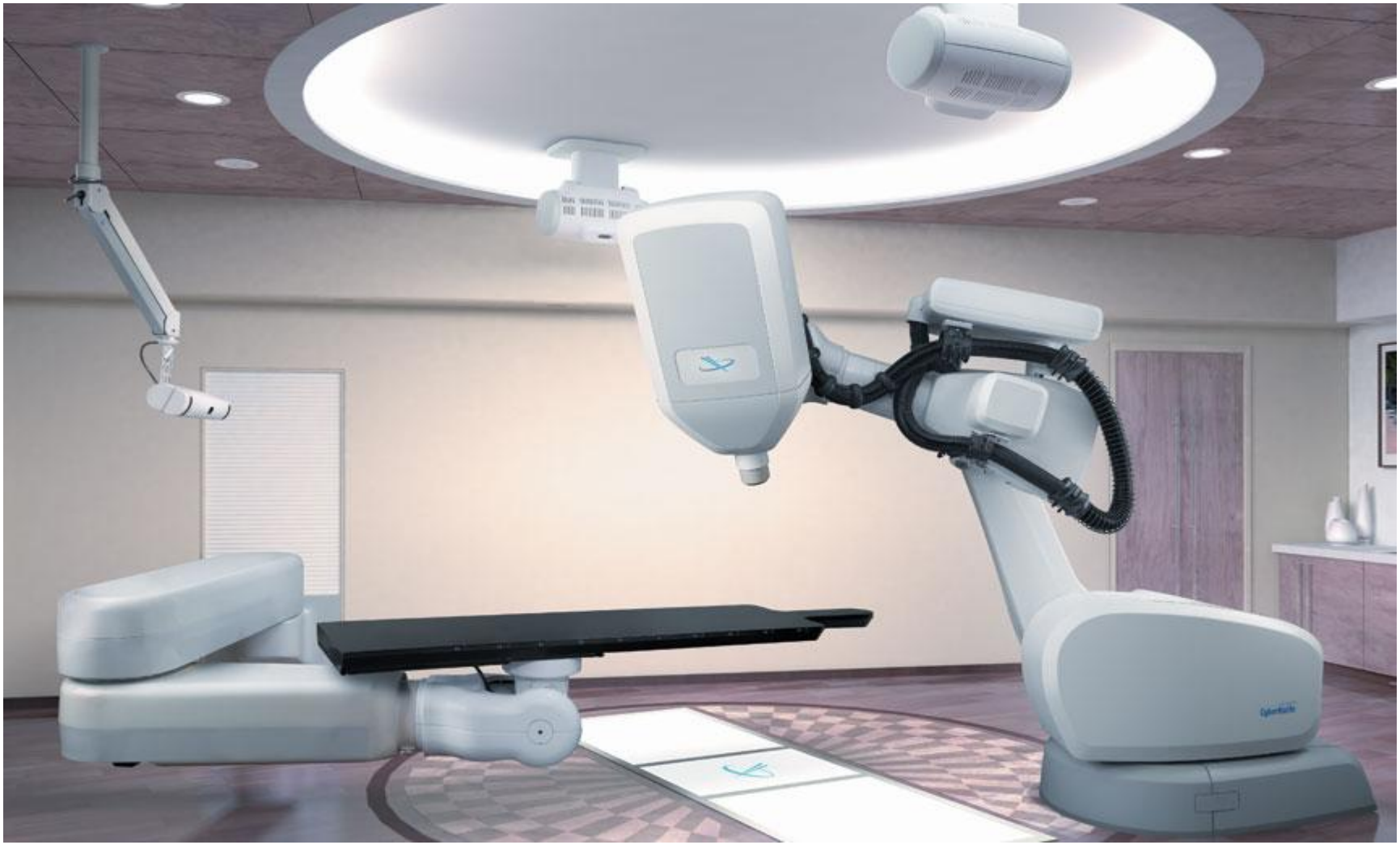
PROCEDURE STEREOTAKSE

Gama nož (radiohirurgija) (Stereotactic Radio surgery, SRS)

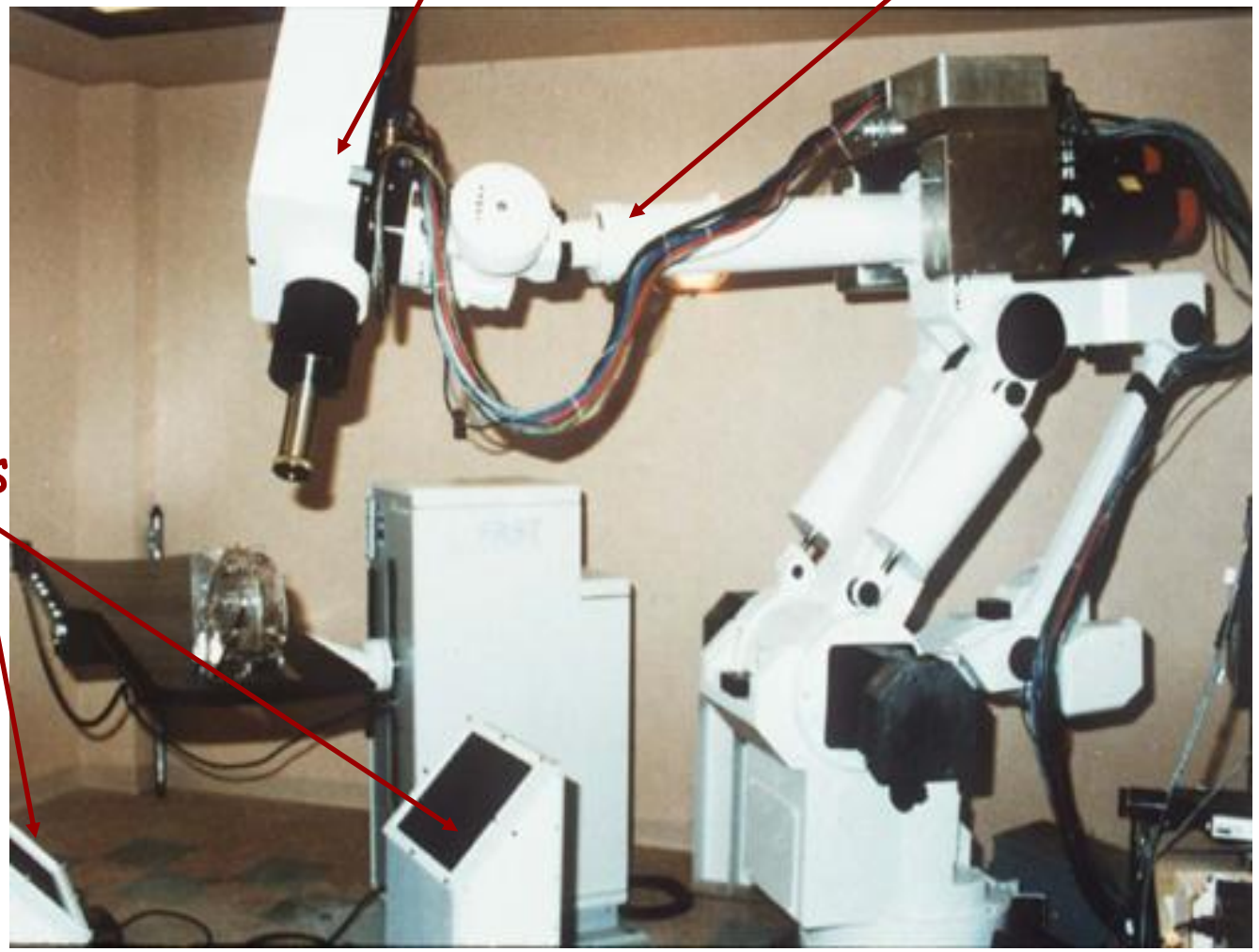
Cyber nož (SRS)

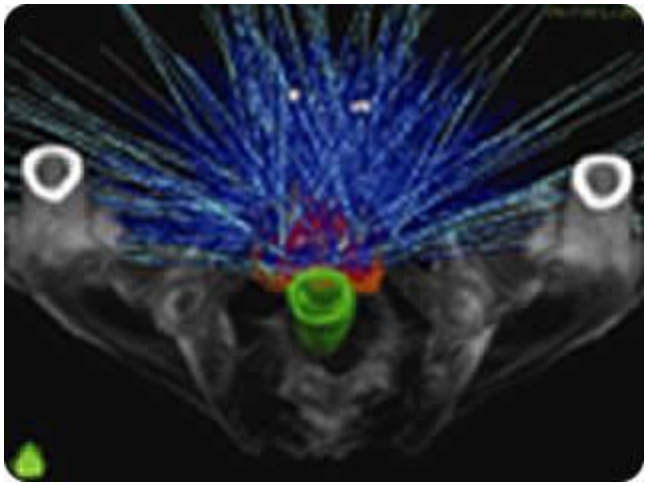
Protonska terapija (SRS)

Sajber nož

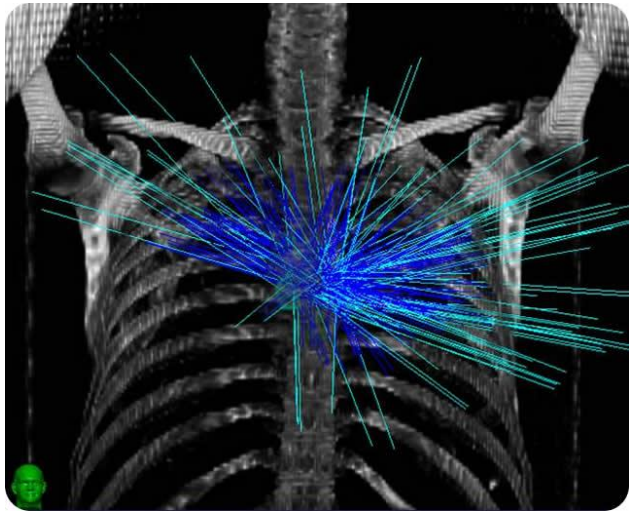


Sajber nož (CyberKnife)

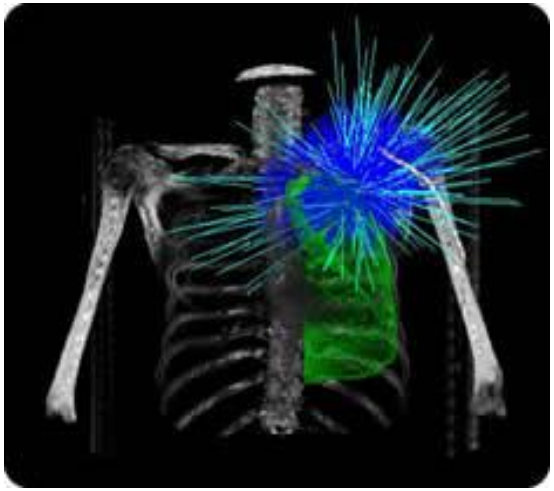




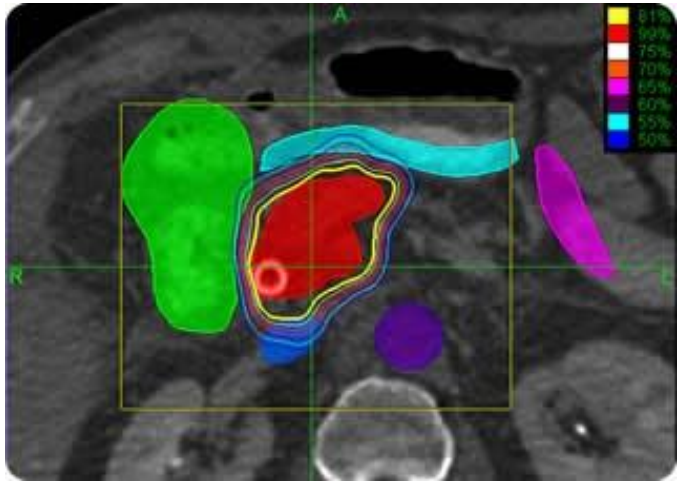
Prostata



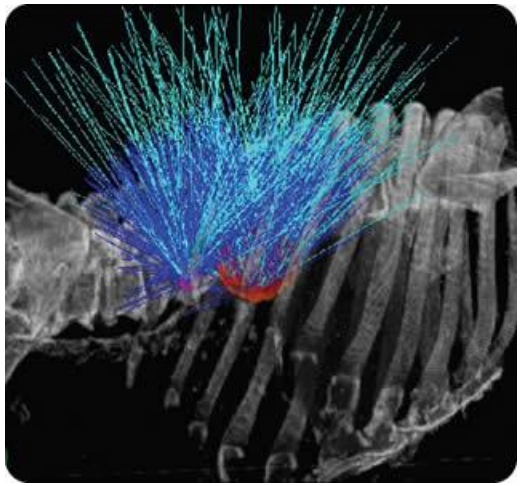
kičma



pluća



Pankreas



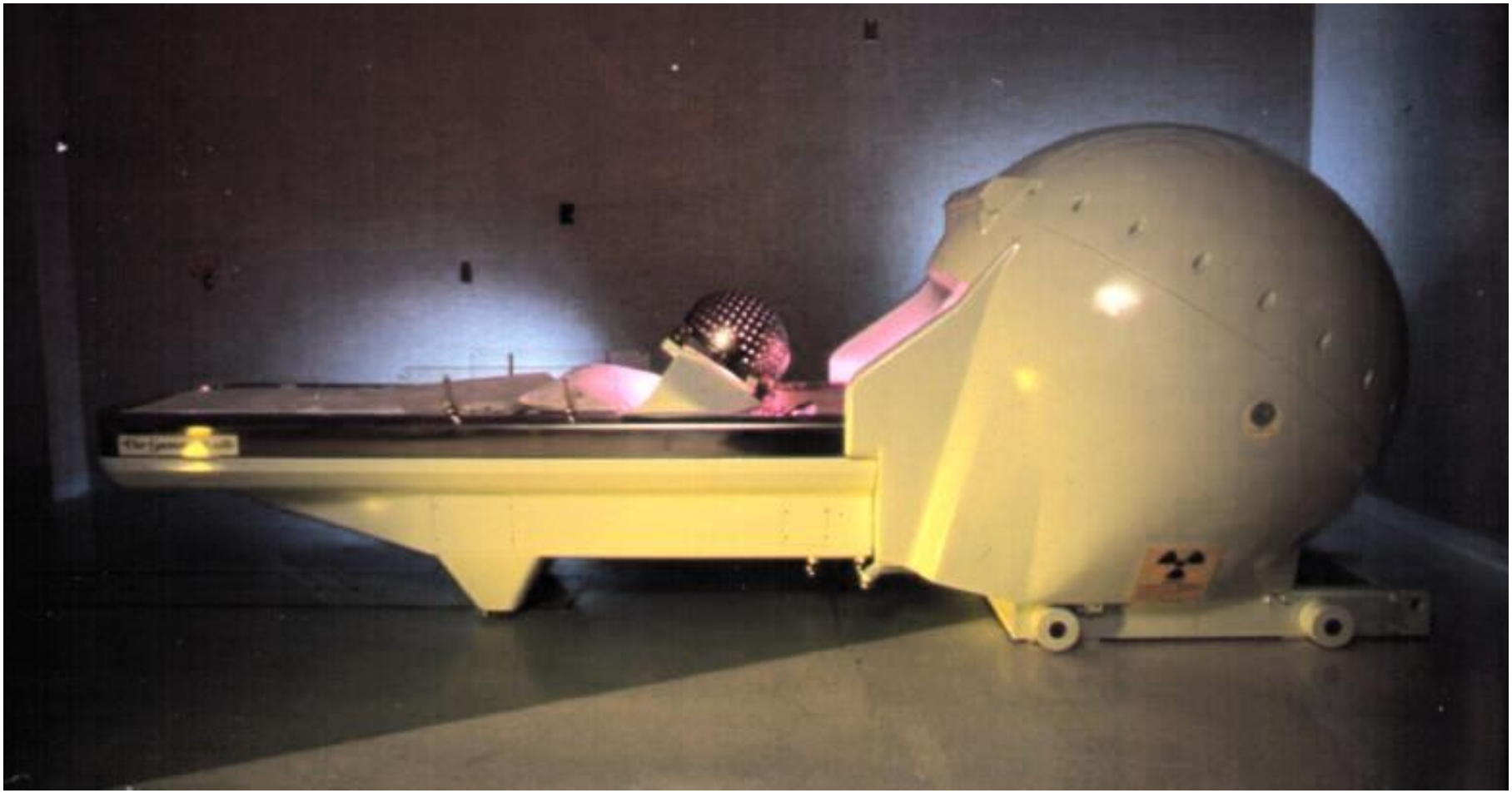
bubrezi

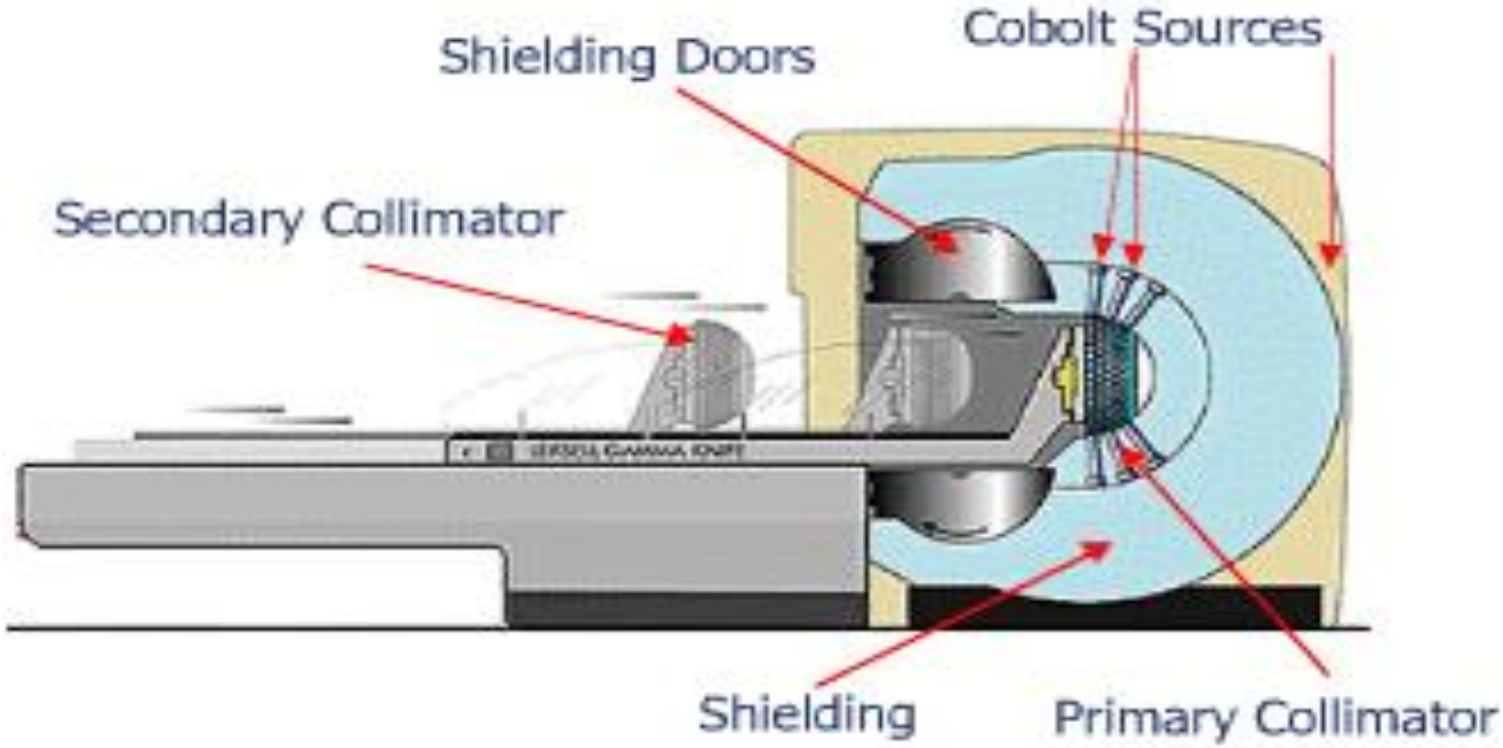
Diverzitet primene sajber noža

Šta je Gama nož?

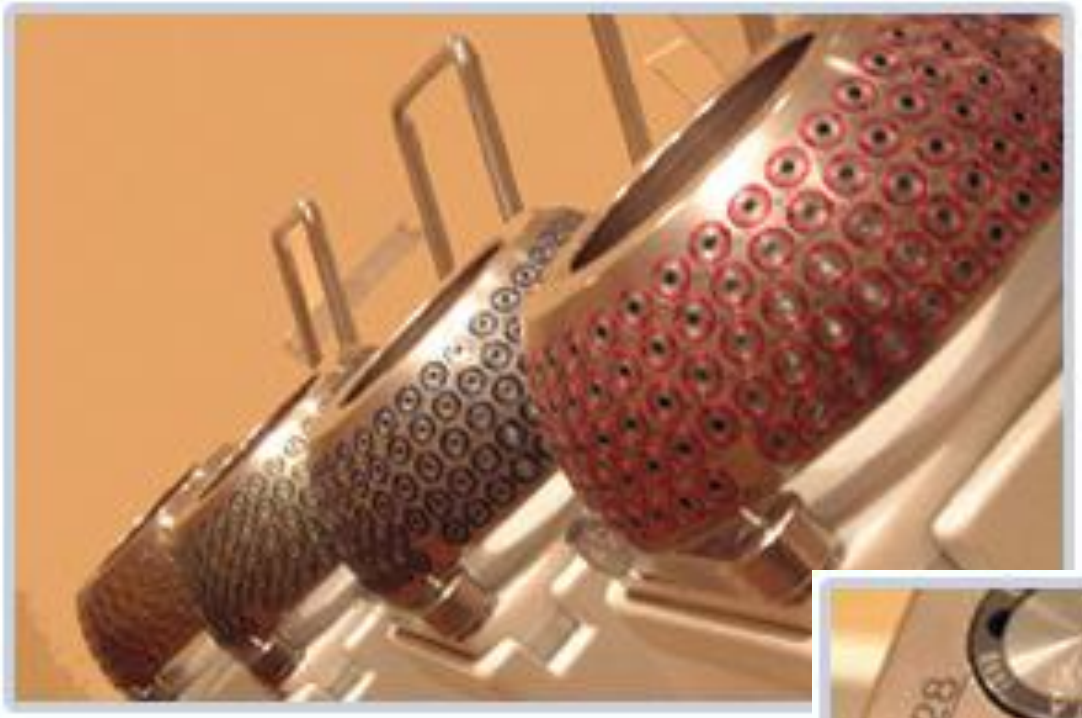
- Neinvazivni tretman karcinoma
- Usmereno gama zračenje
- "šotovi" zračenja različitih prečnika (2, 4, 7, 9,....) mm

Gama nož




Shielding Doors
Cobolt Sources
Secondary Collimator
Shielding
Primary Collimator

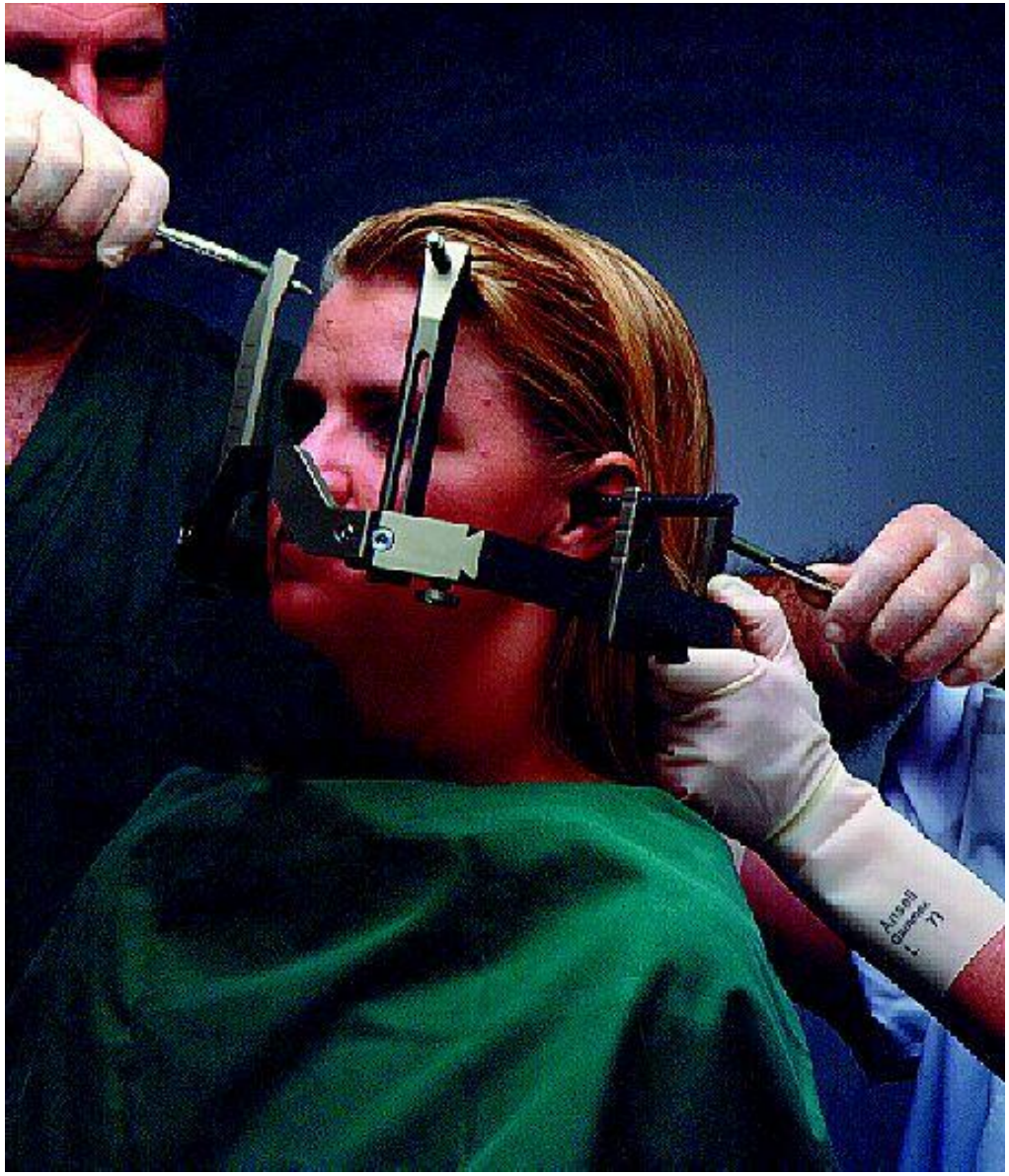
Gama nož



A 28
B 26
C 23
A 29
B 27
C 24
D 24

201 izvora gama zračenja Co-60 smešteni u hemisferi i ciljani kroz kolimator do fokalne tačke.

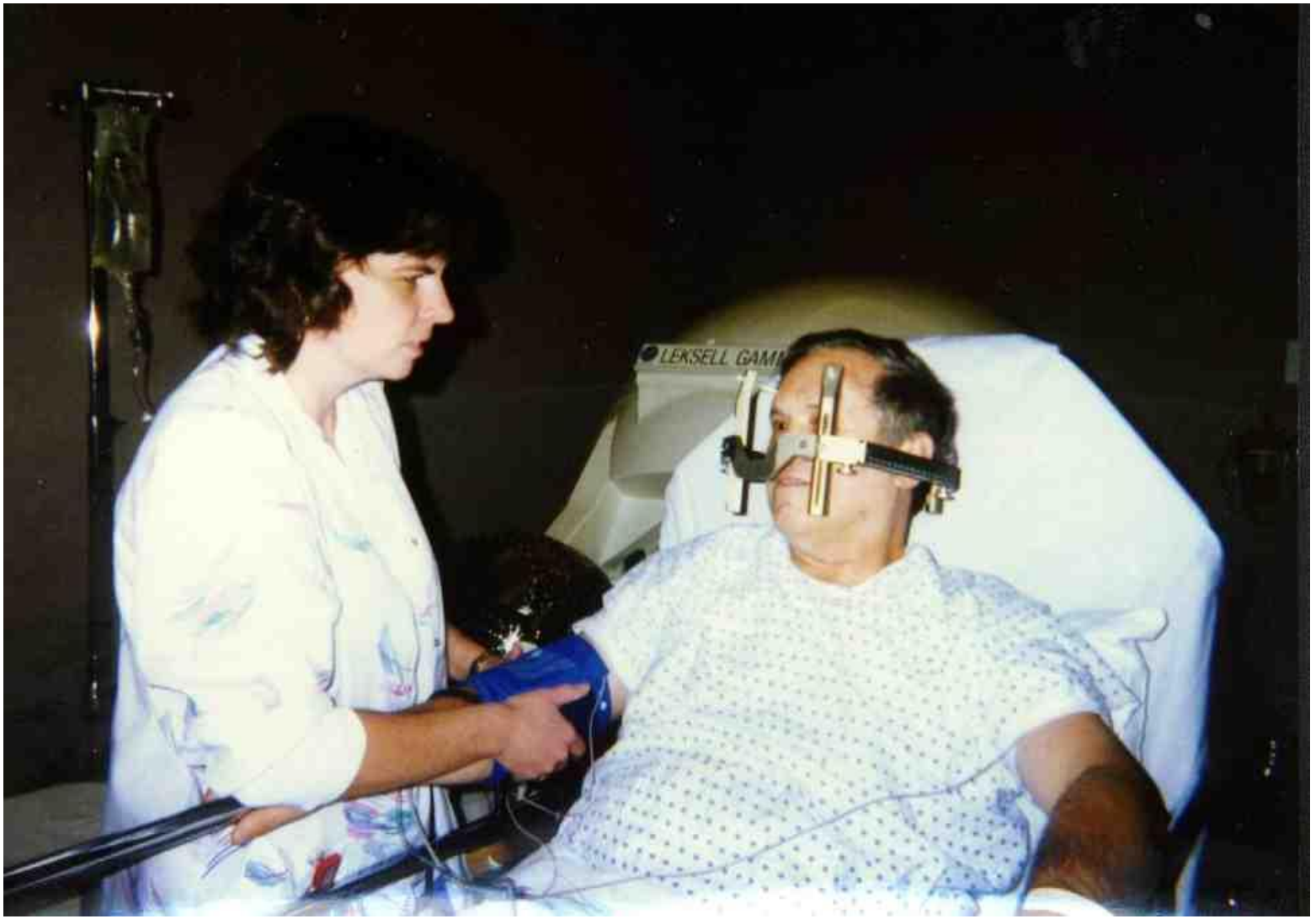
Glava pacijenta je tako pozicionirana da tumor bude u fokalnoj tačku snopa gama zračenja.

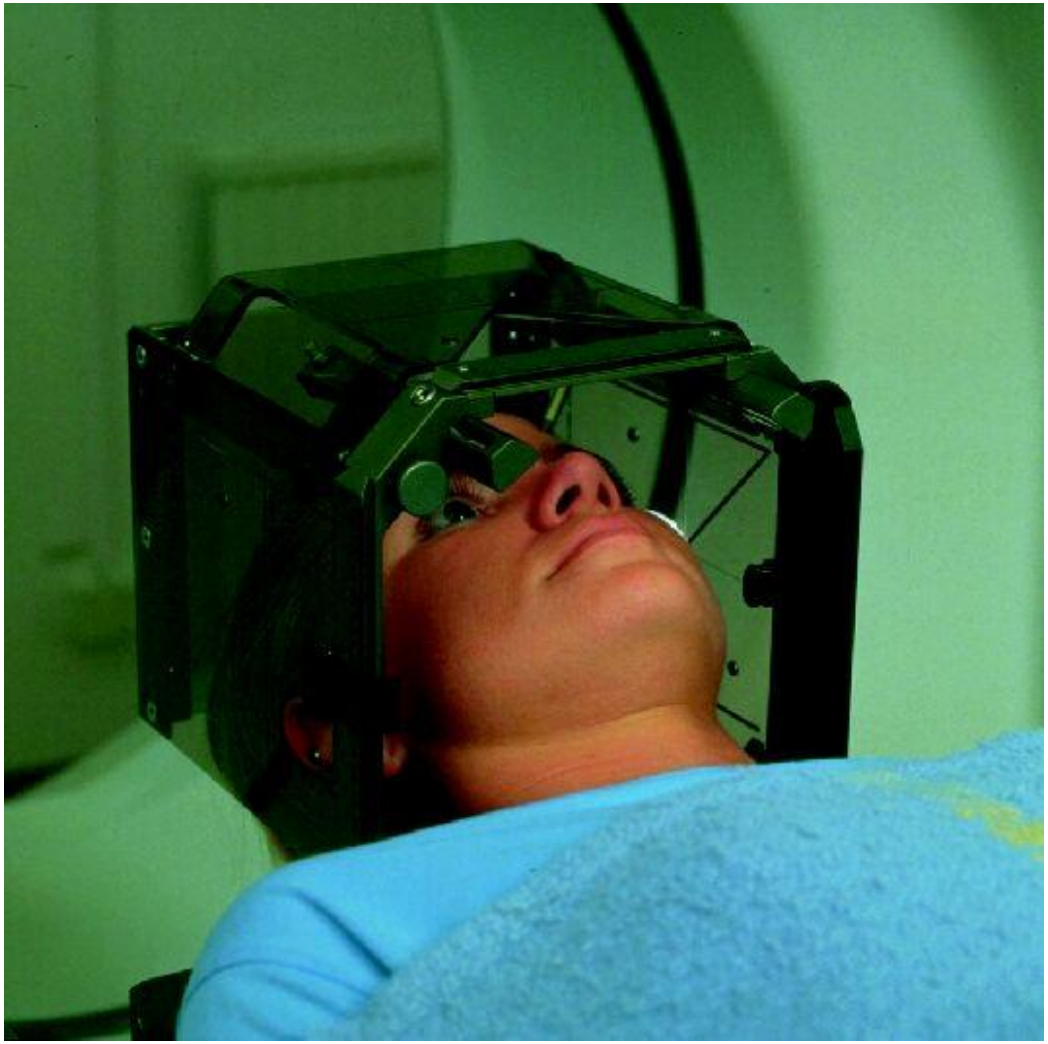


Kako funkcioniše Gamanož?

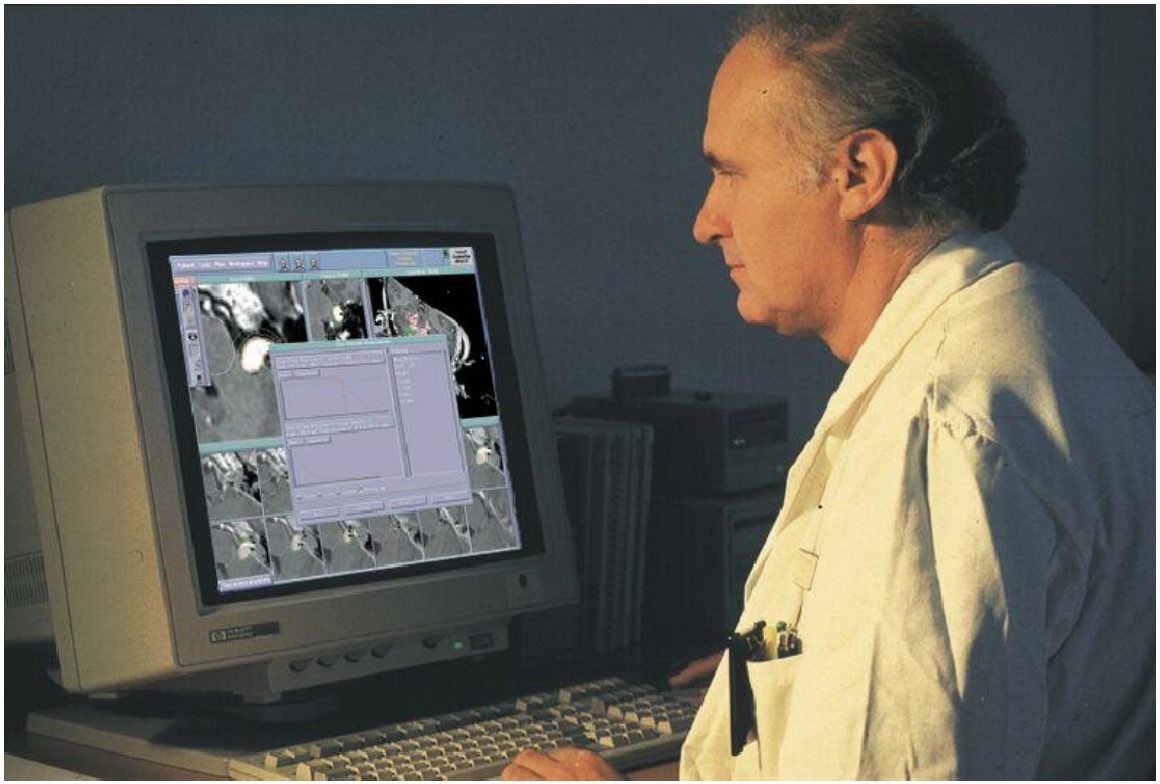
Korak 1: Stereotaktički okvir se postavi na glavu pod lokalnom anestezijom.

Okvir za Gama nož

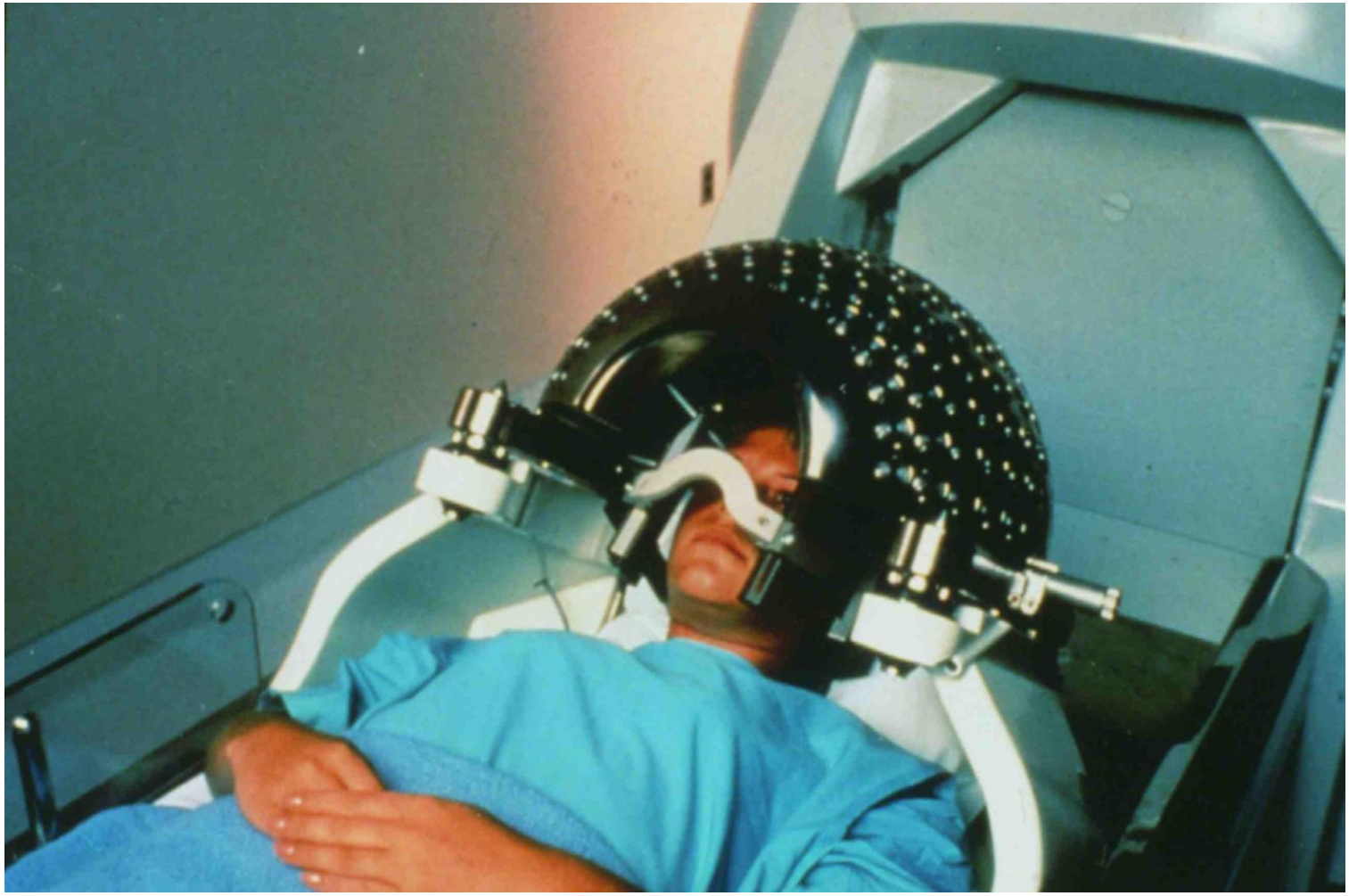

LEKSELL GAM



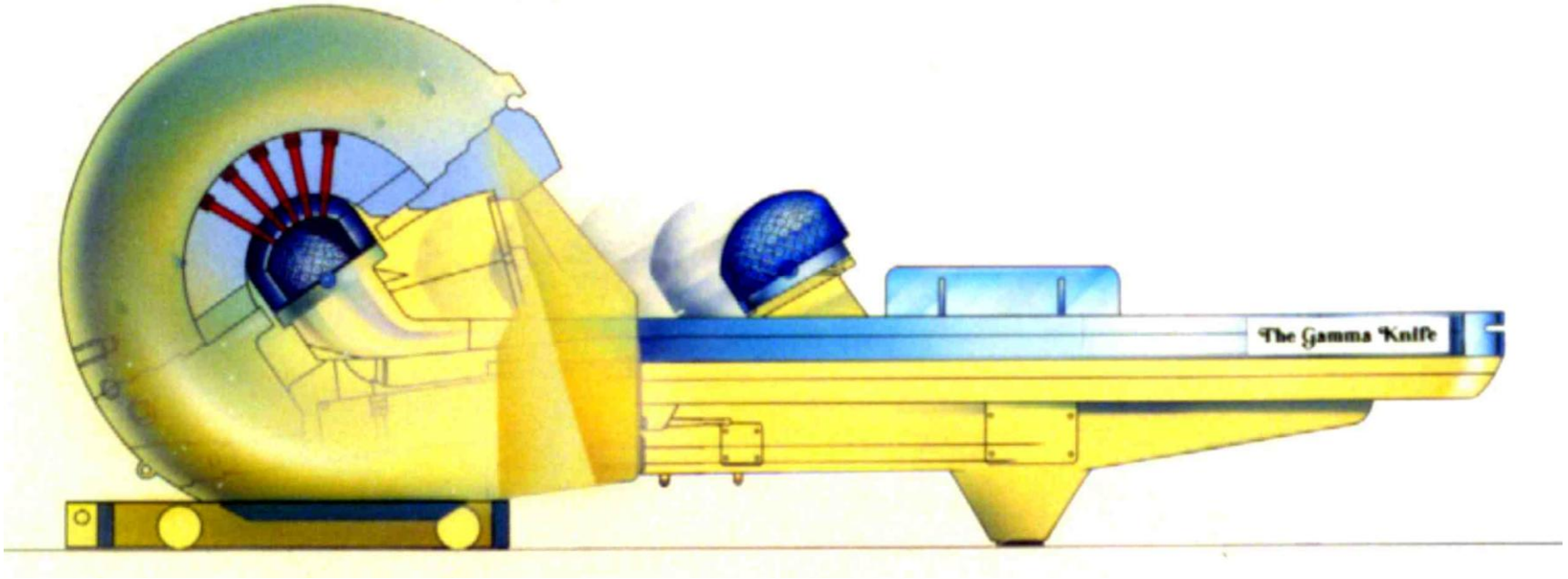
Korak 2: Napravi se MRI ili CT slika dok pacijent nosi okvir



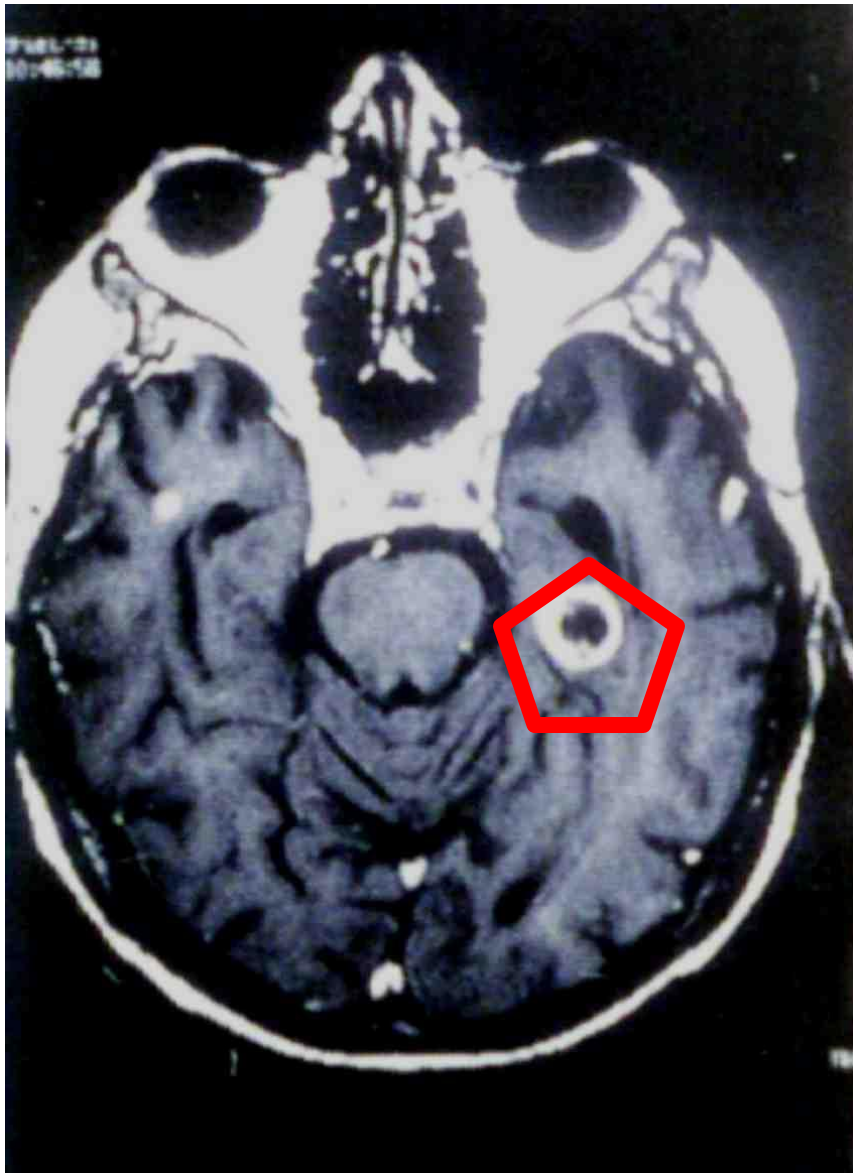
Korak3: Na osnovu slika pravi se plan tretmana.
Ključna tačka: vrlo precizna isporuka doze.

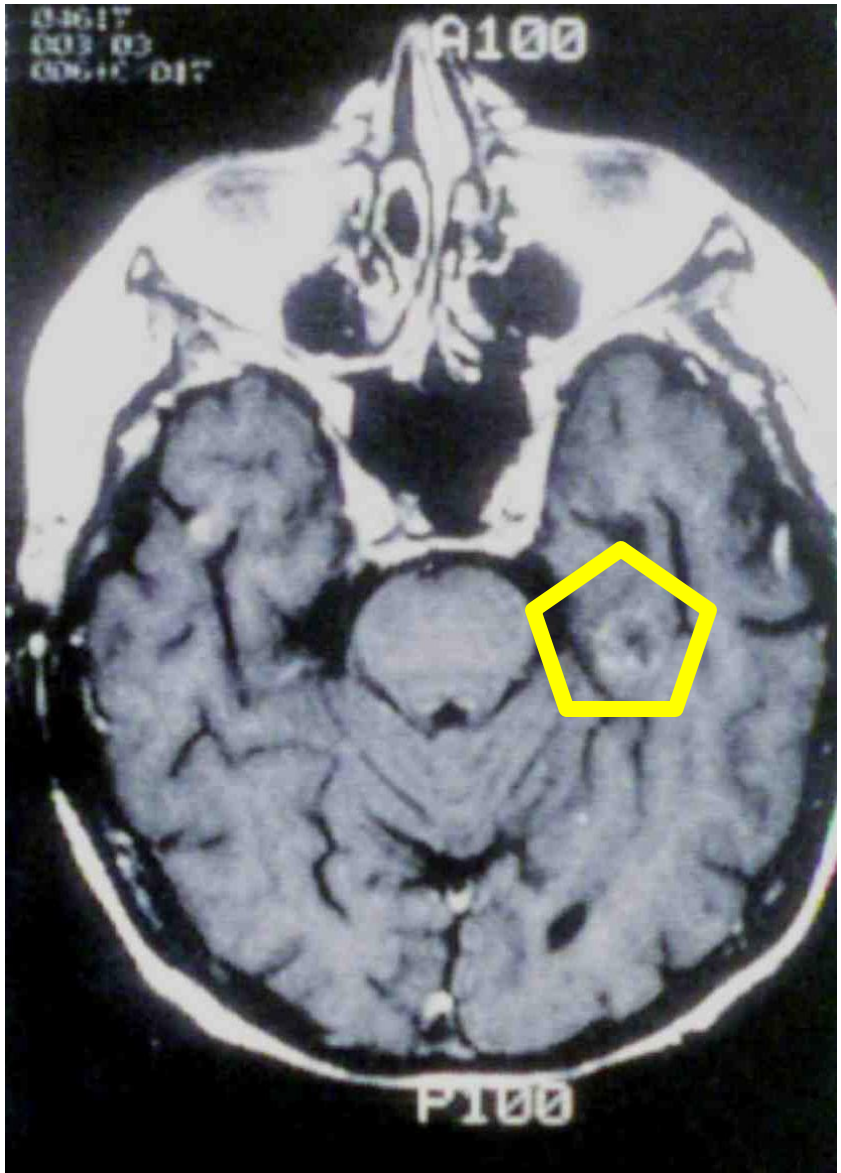


Korak 4: Pacijent leži na tretmanskom stolu gama noža dok je okvir fiksiran na odgovarajući kolimator



Korak 5: Vrata tretmanske jedinice se otvaraju. Pacijent je smešten u oklopljenom bunkeru pošto je zona zračenja visokog intenziteta.



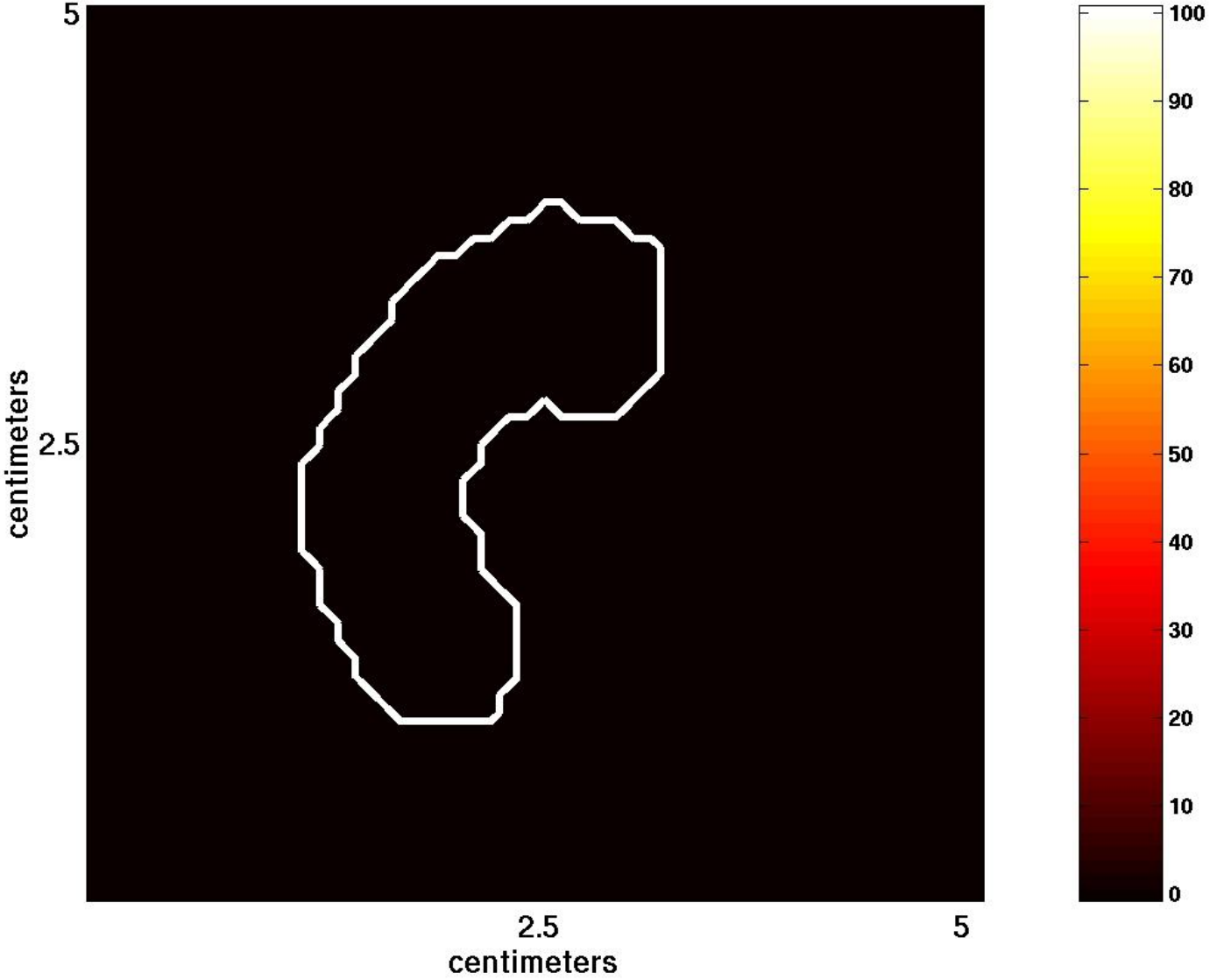

A100
P100

4
4
8
8
4
4

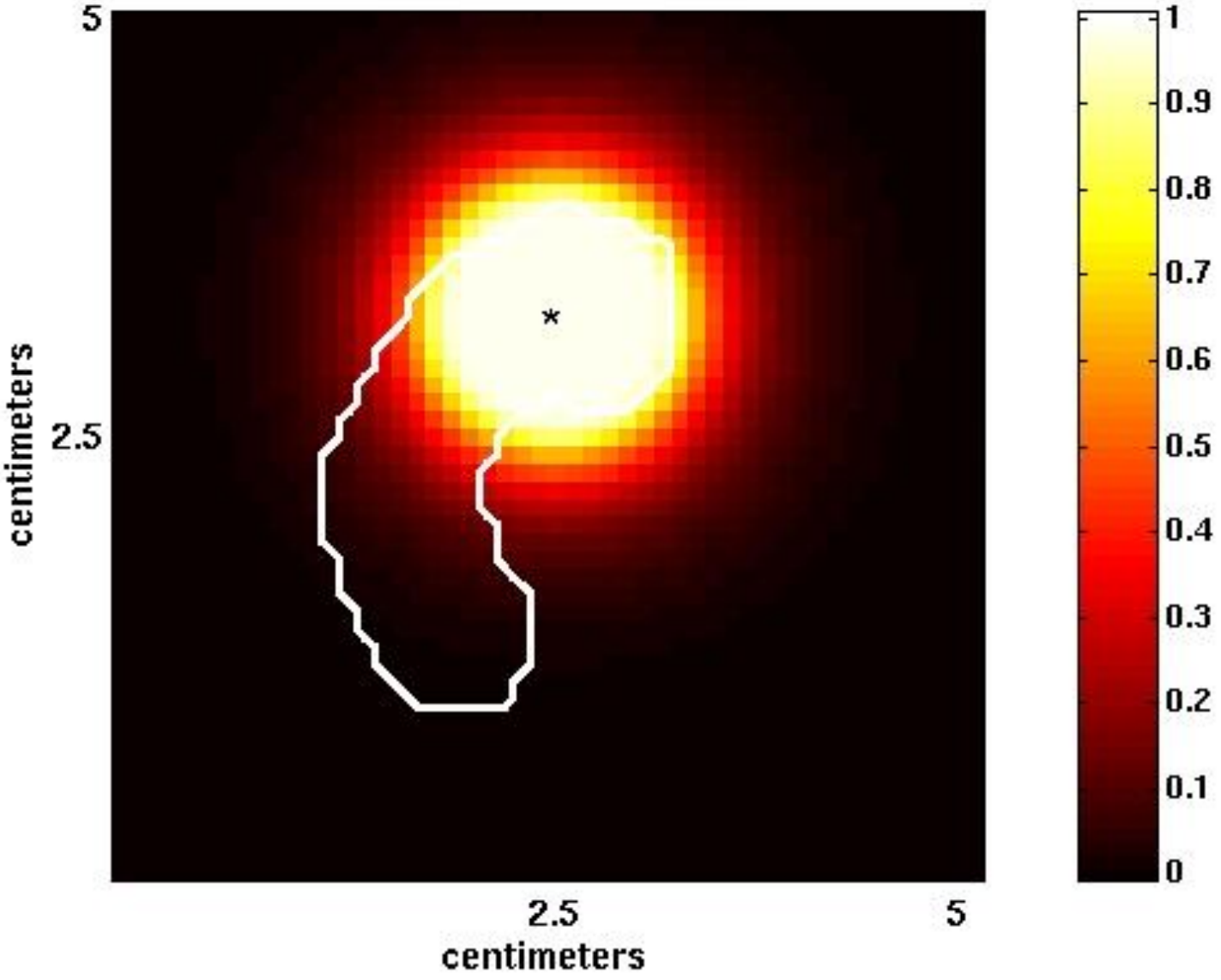
Planiranje tretmana

- Planira se:
  - Broj snopova ("šotova")
  - Veličina šota
  - Lokacija šota
  - Intenzitet
- Kvalitet plana zavisi od pacijenta i iskustva medicinskog tima

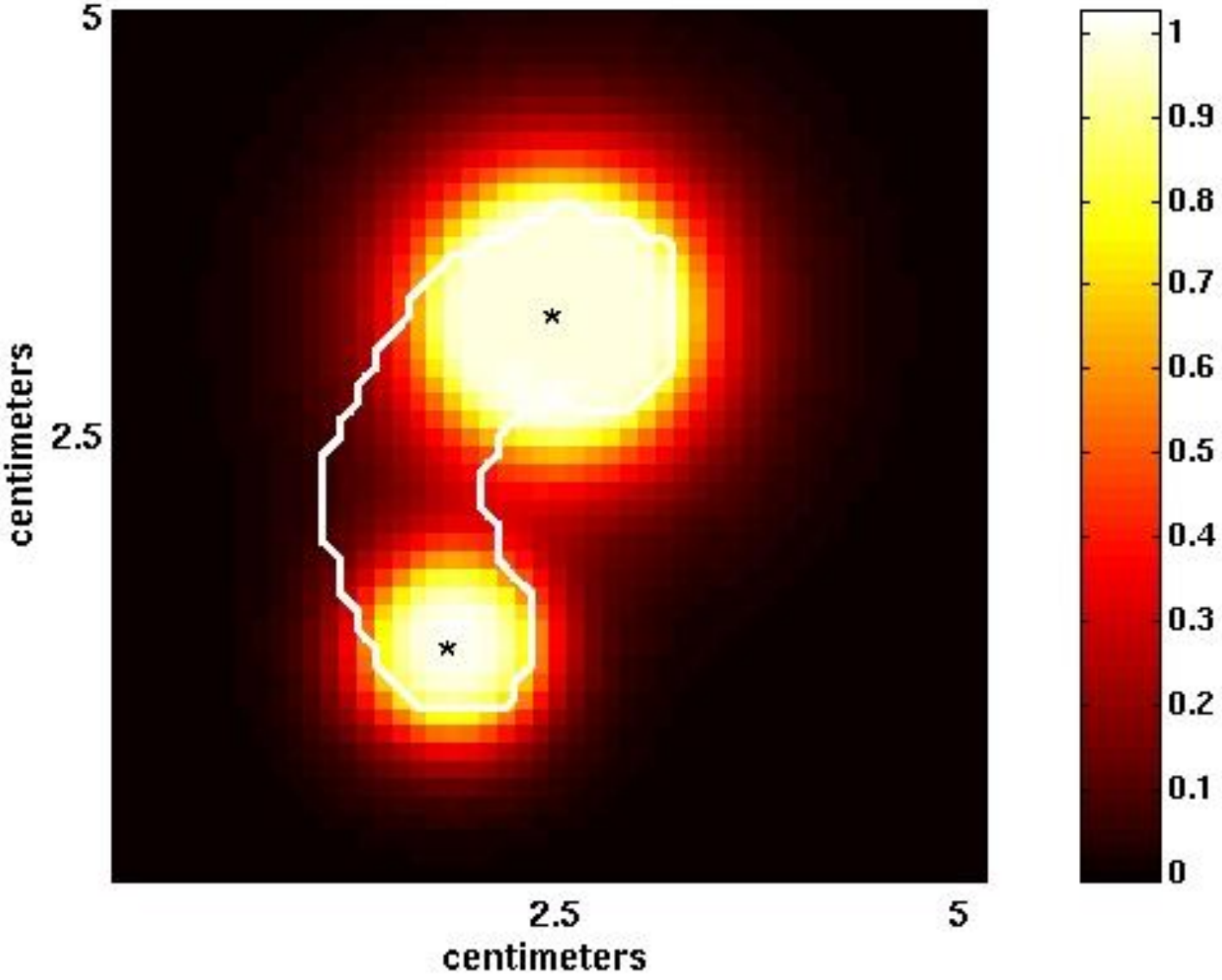
Meta


5
2.5
centimeters
2.5
5
centimeters
100
90
80
70
60
50
40
30
20
10
0

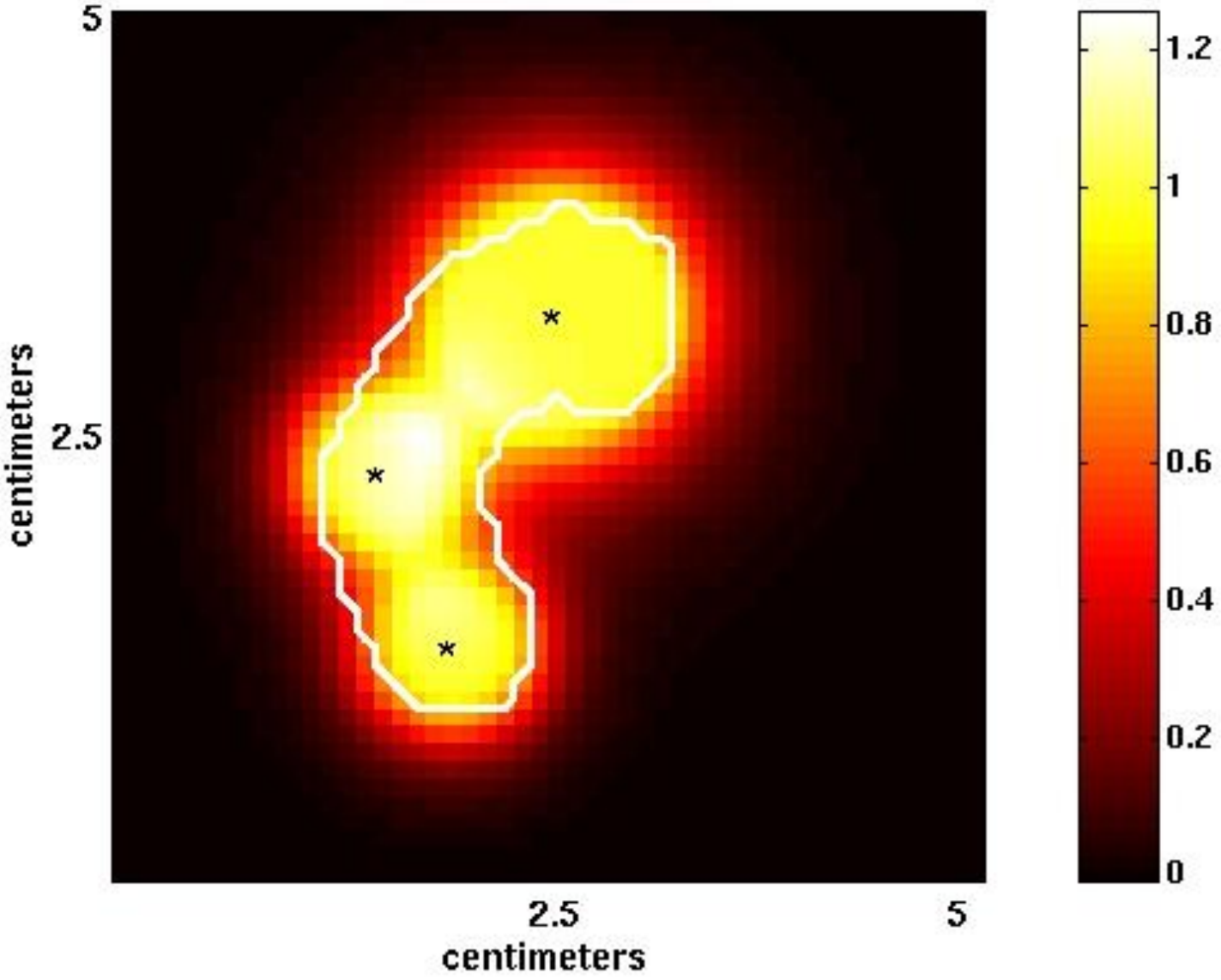
1 šot



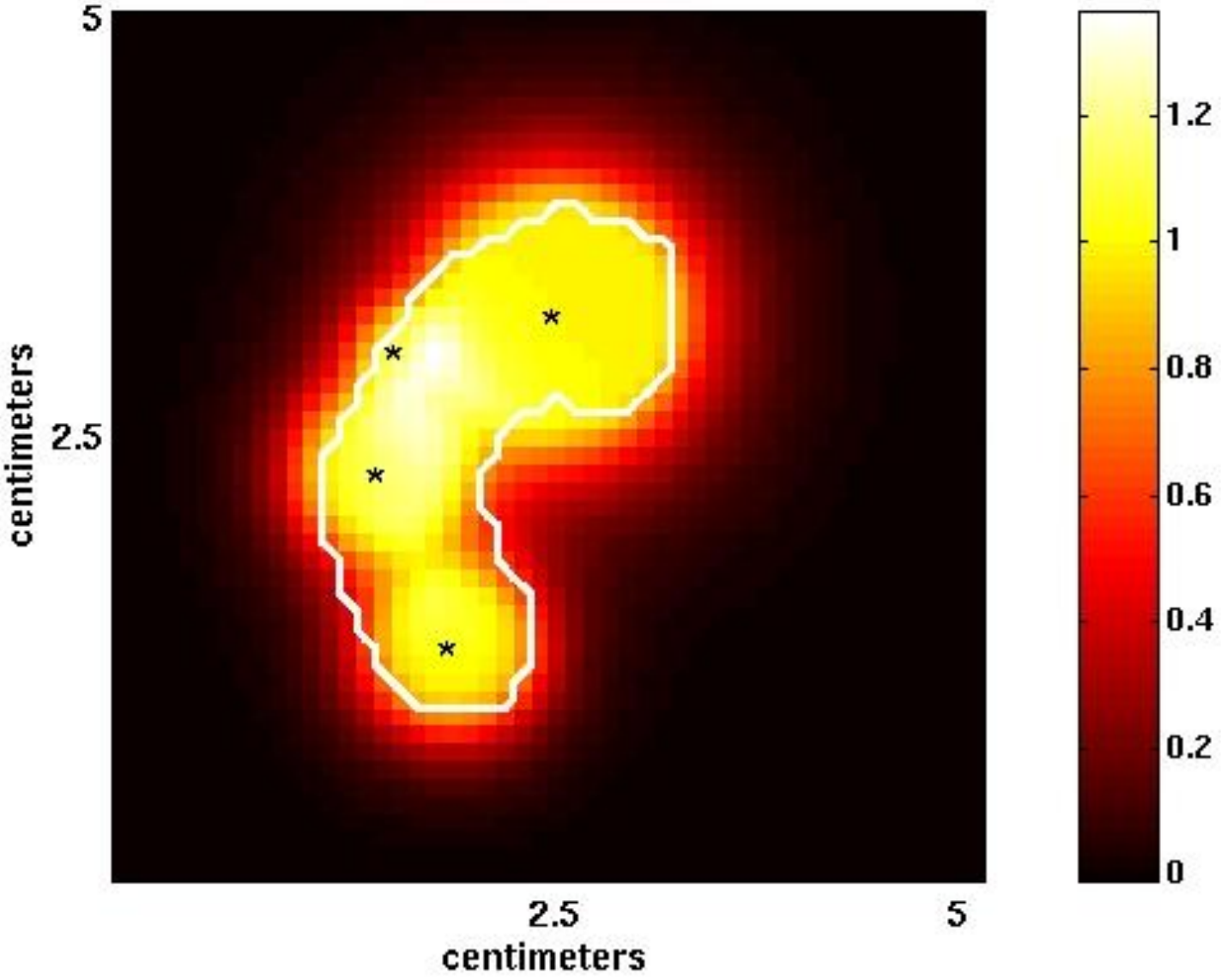
2 šota



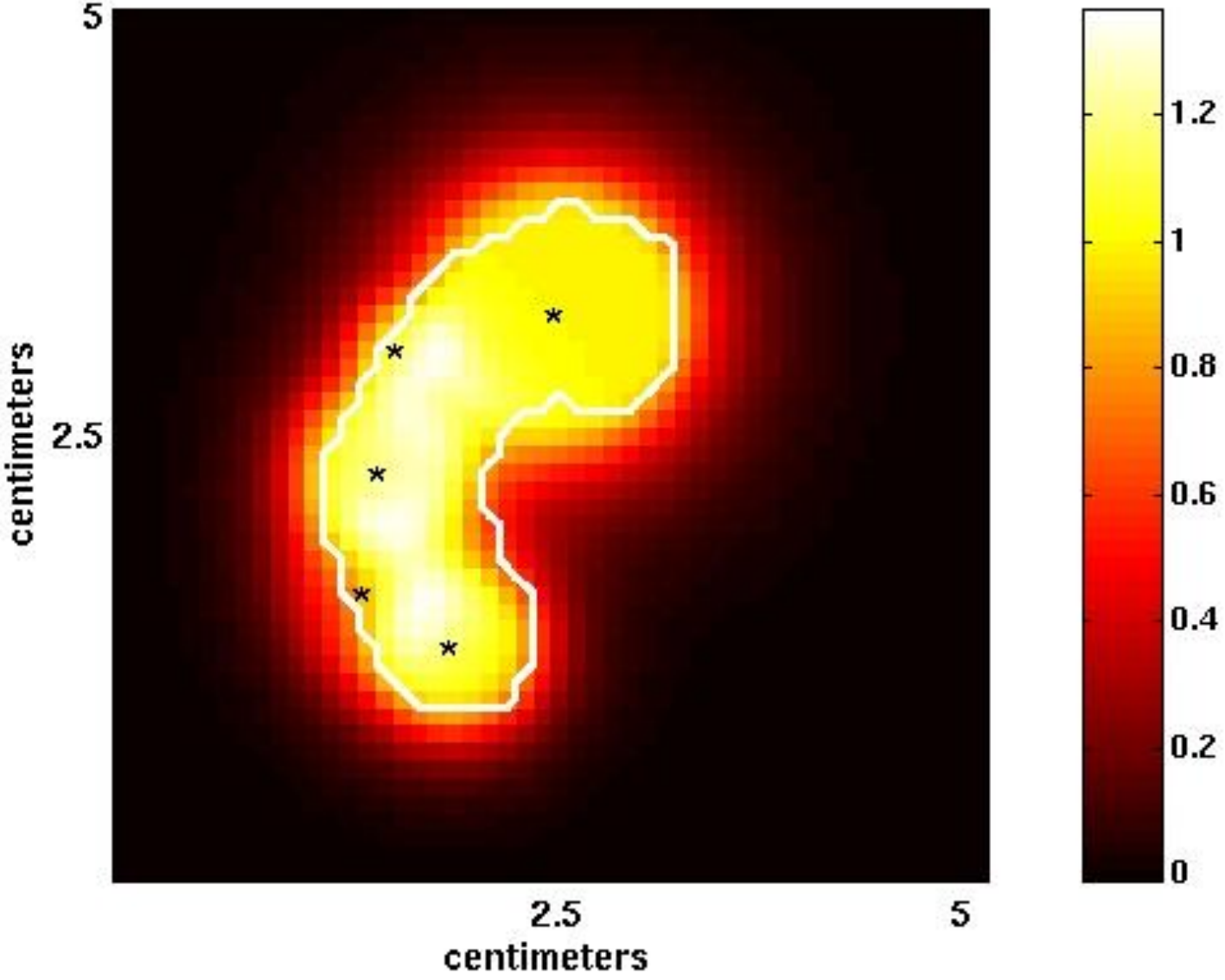
3 šota



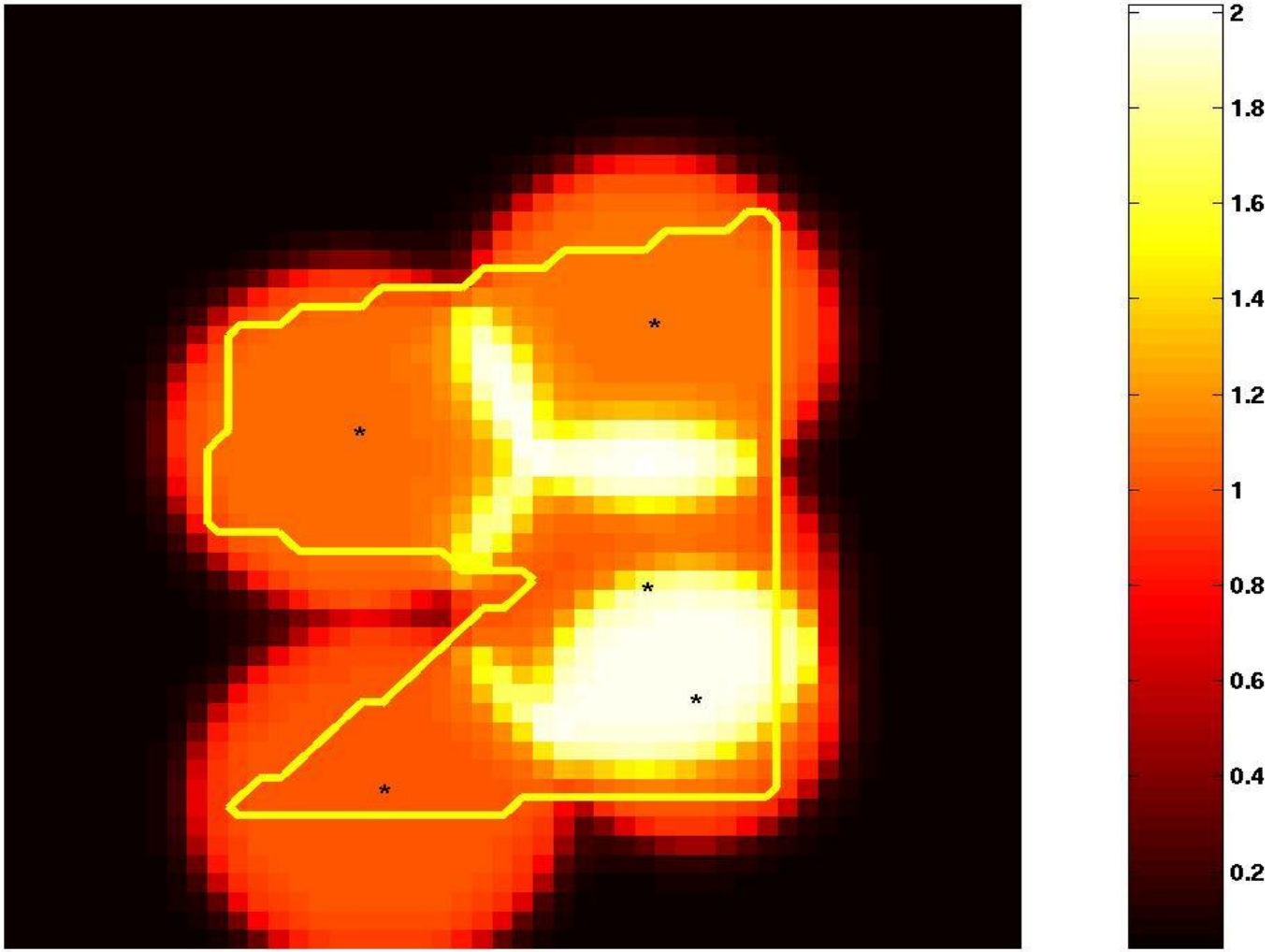
4 šota



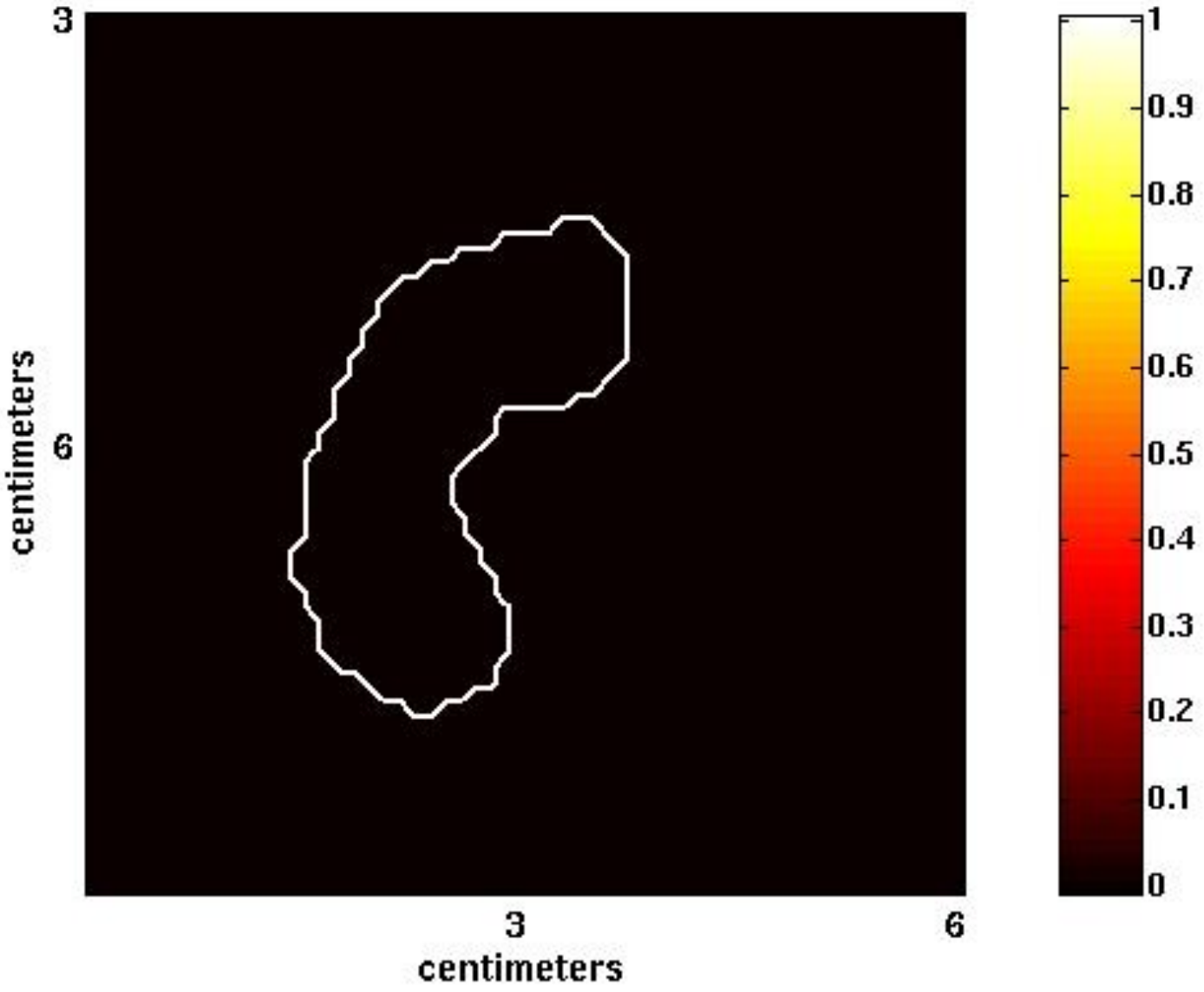
5 šotova



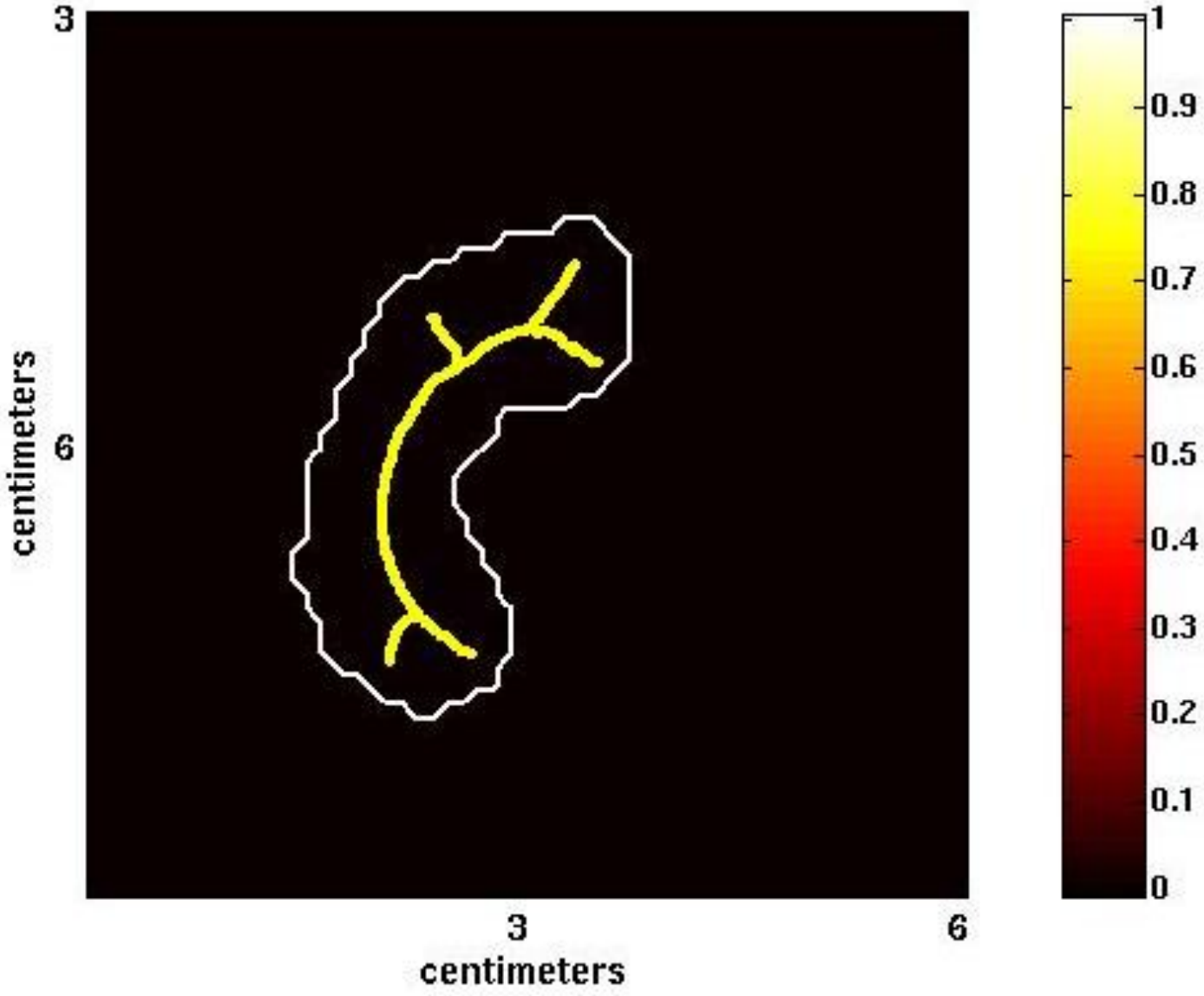
Dvodimenzionalni primer



Meta

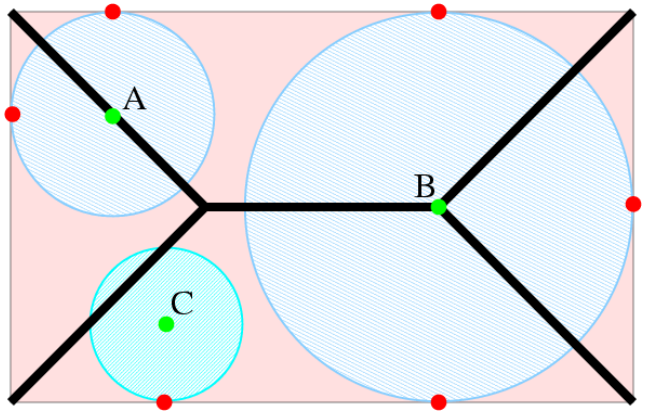


Odredjivanje skeleta mete

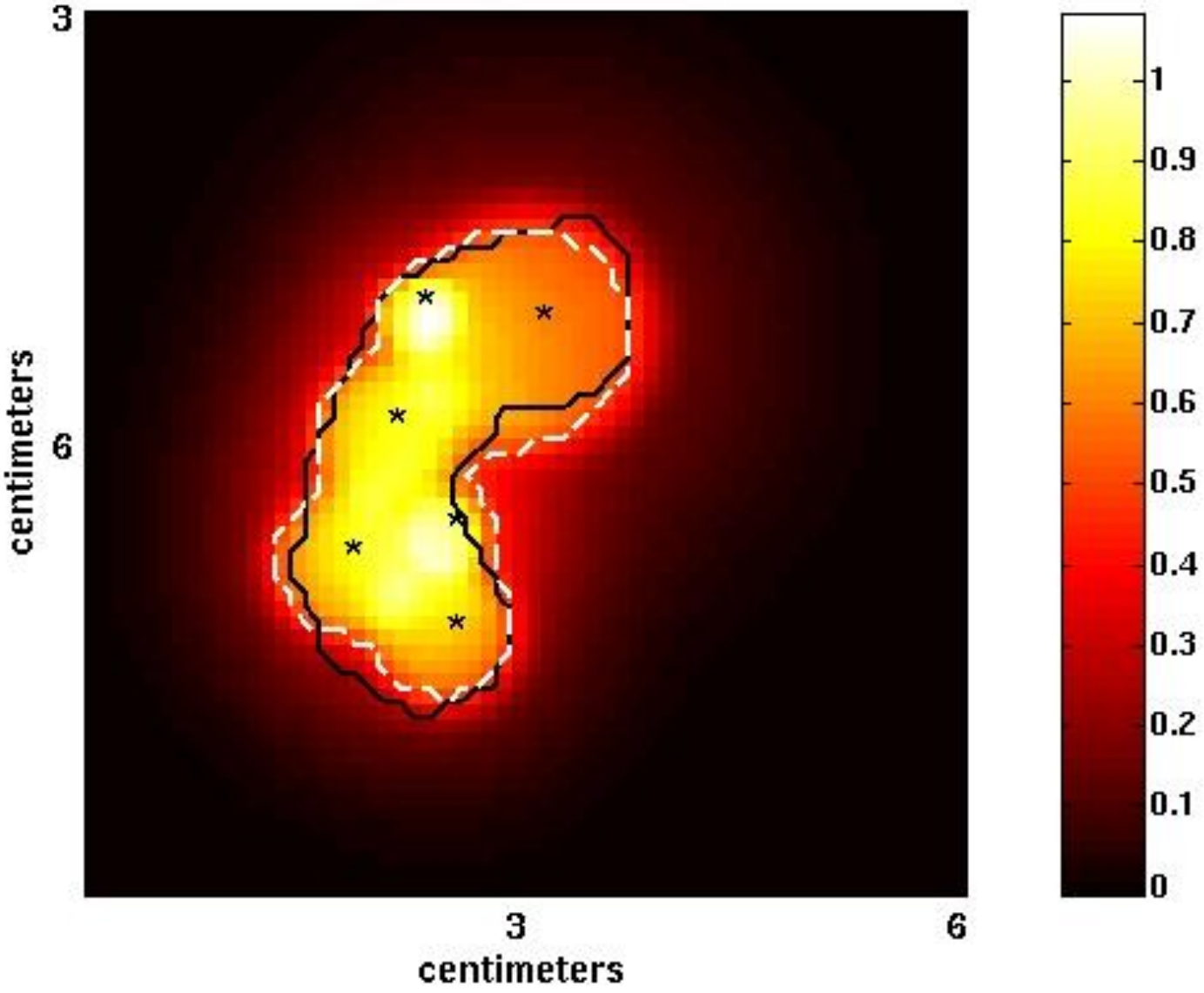


Skeletonizacija

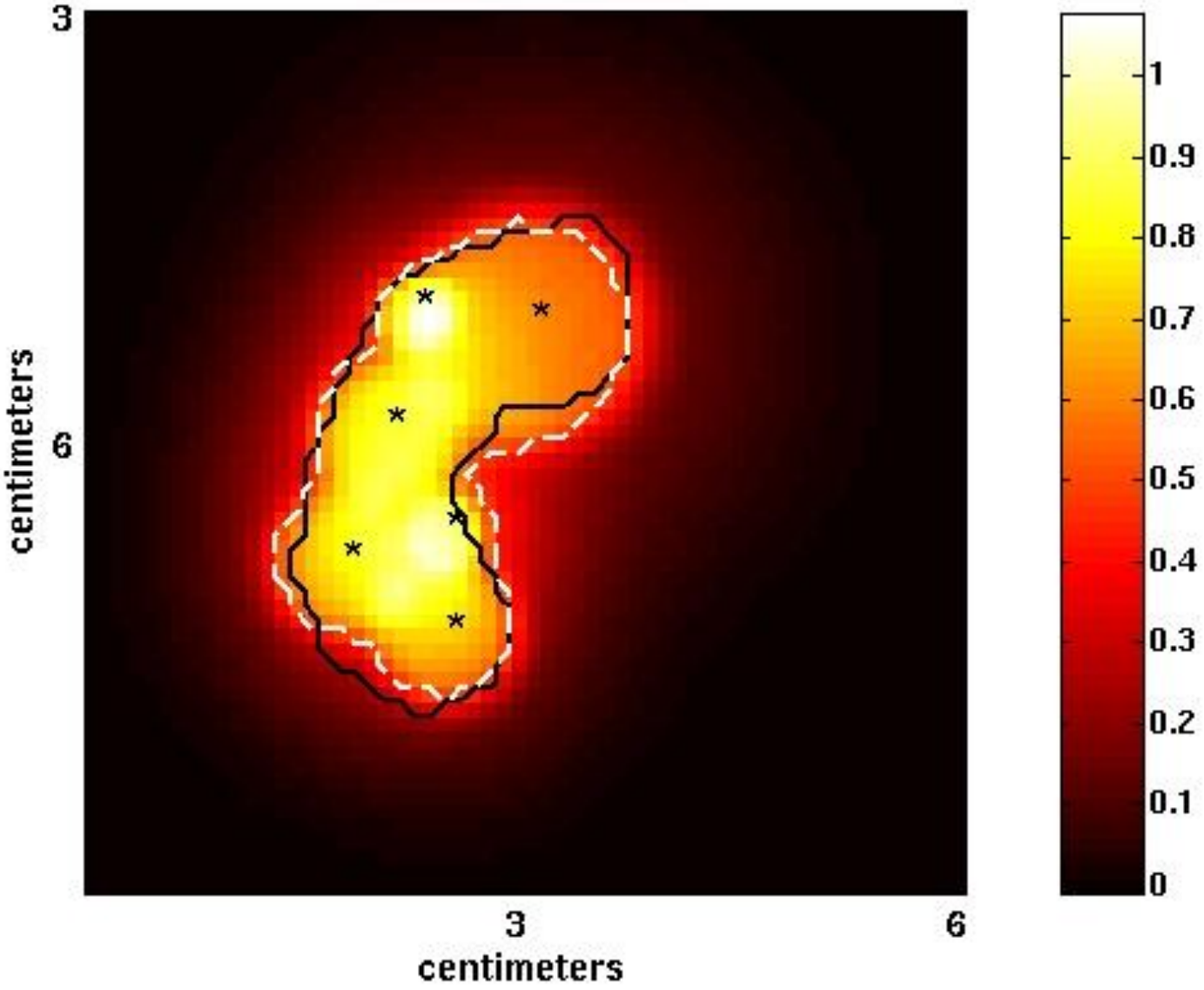
- Skelet slike: : lokusi centara svih krugova dodiruju se u najmanje 2 granice i svi se nalaze u regiji od interesa
- Za nalaženje skeleta koriste se različiti algoritmi



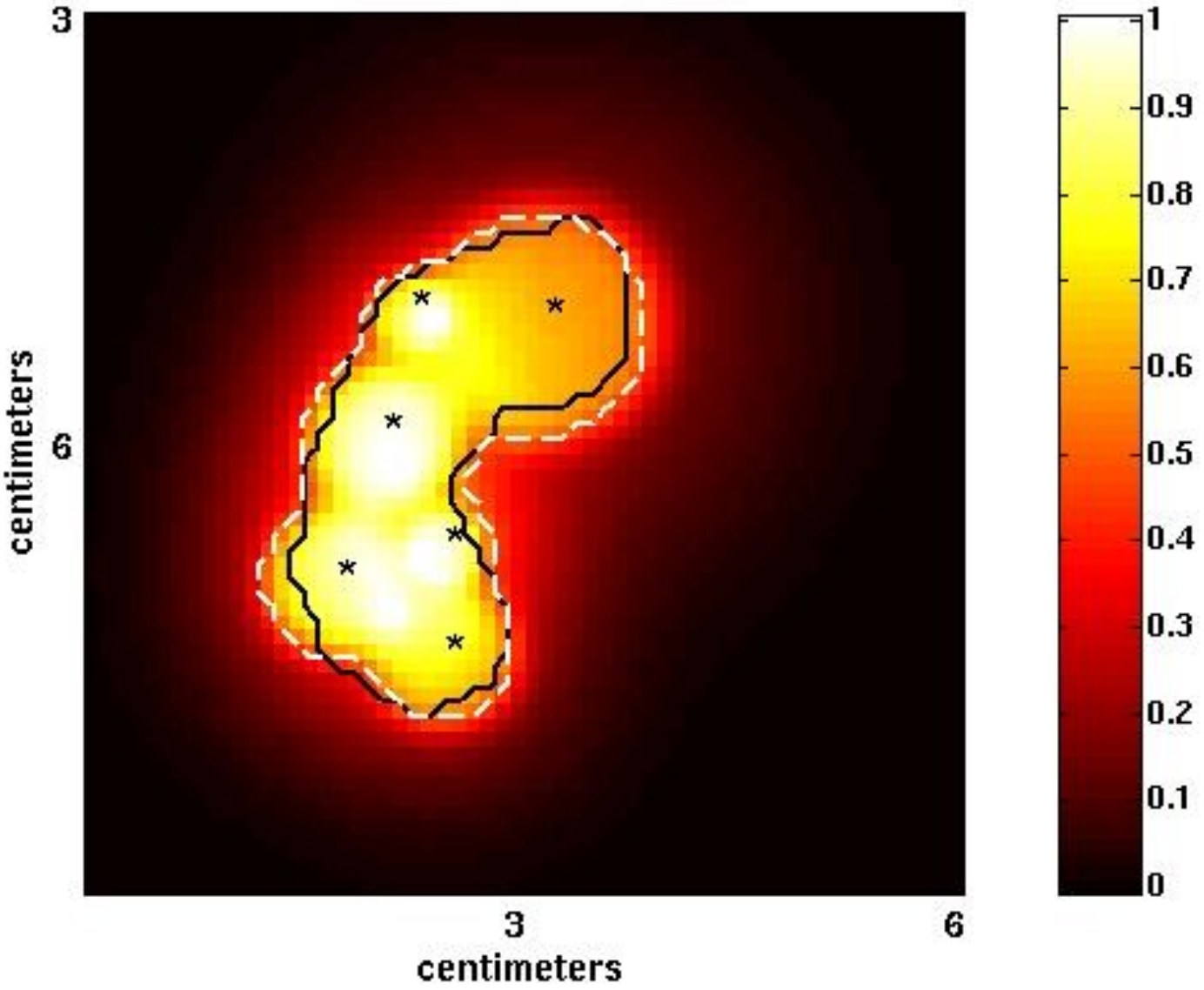
Rezultat pakovanja "u sferu"



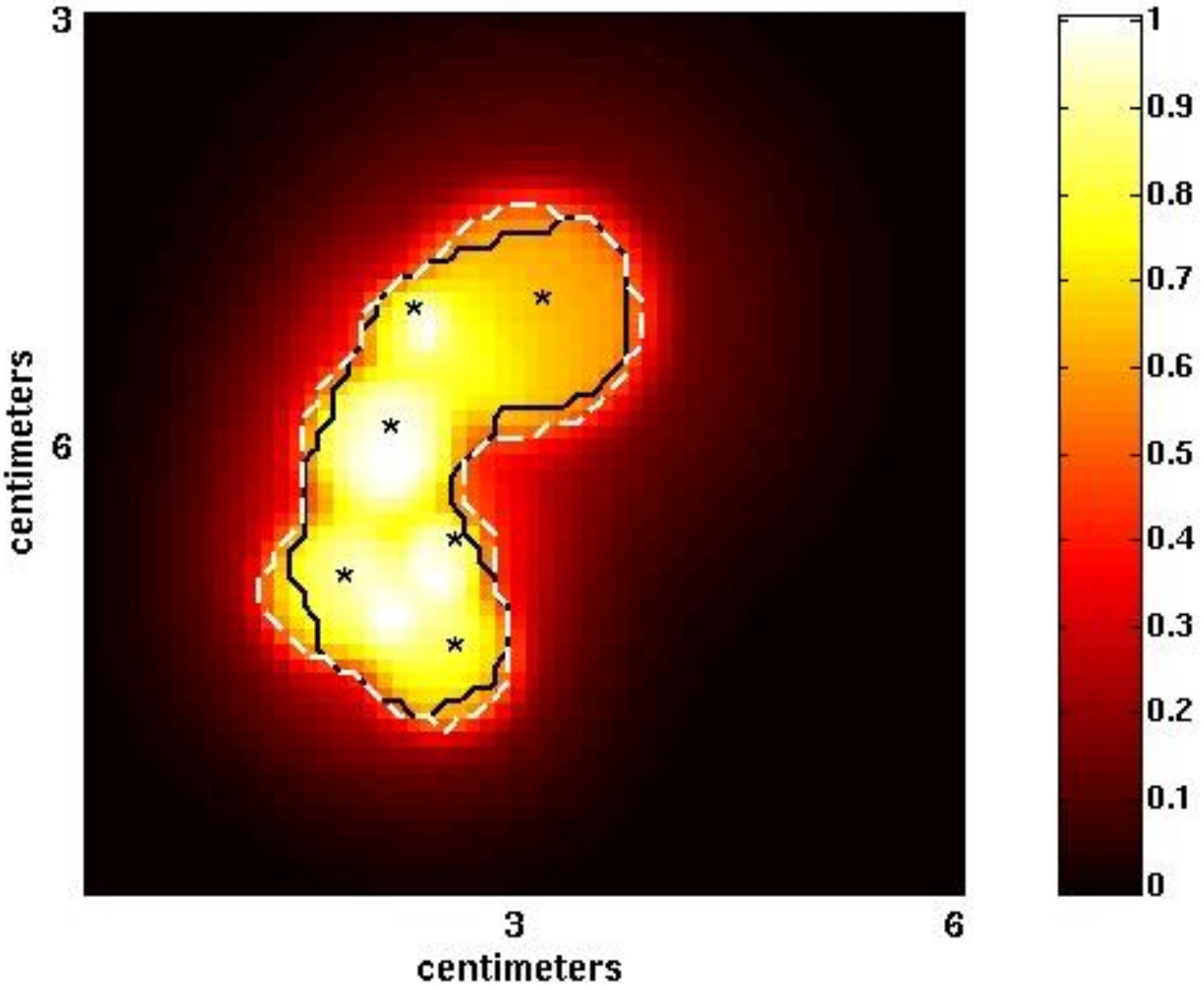
10 Iteracija



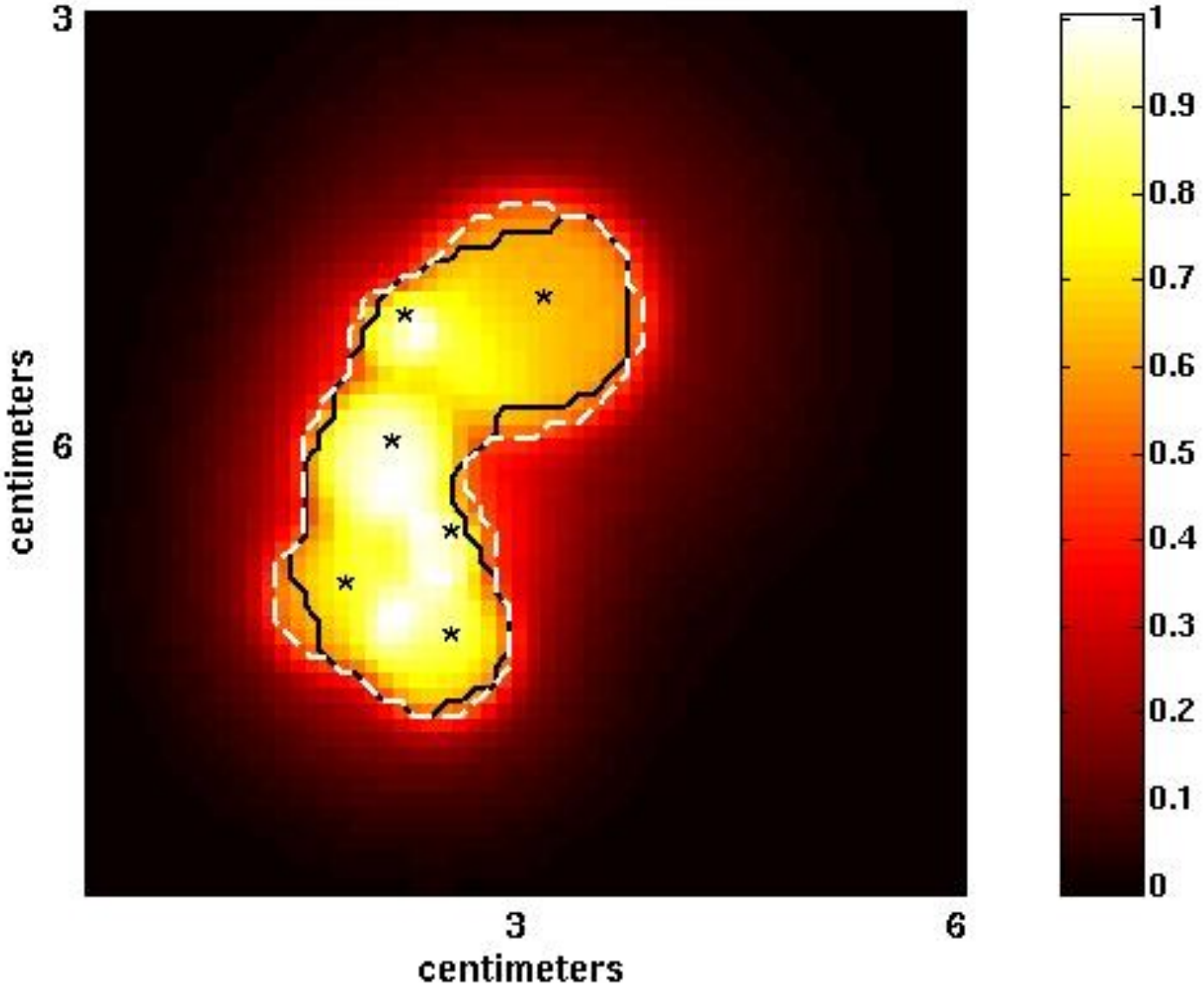
20 Iteracija



30 Iteracija



40 Iteracija



Poredjenje vremena egzekucije

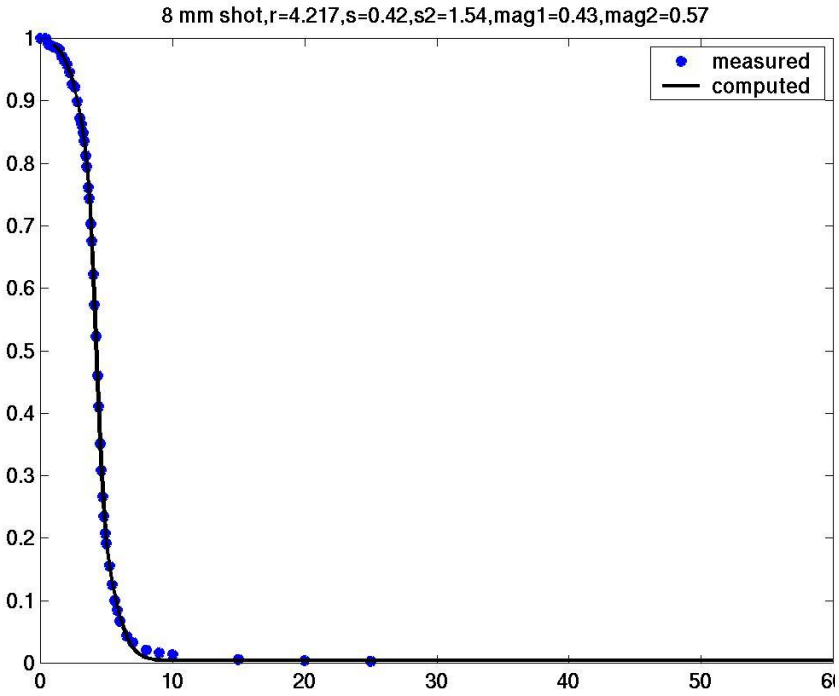
Srednje vreme	Veličina tumora		
	mali	srednji	veliki
slučajni (Std. Dev)	2 min 33 sec (40 sec)	17 min 20 sec (3 min 48 sec)	373 min 2 sec (90 min 8 sec)
numerički (Std. Dev)	1 min 2 sec (17 sec)	15 min 57 sec (3 min 12 sec)	23 min 54 sec (4 min 54 sec)

Procenjeni broj šotova

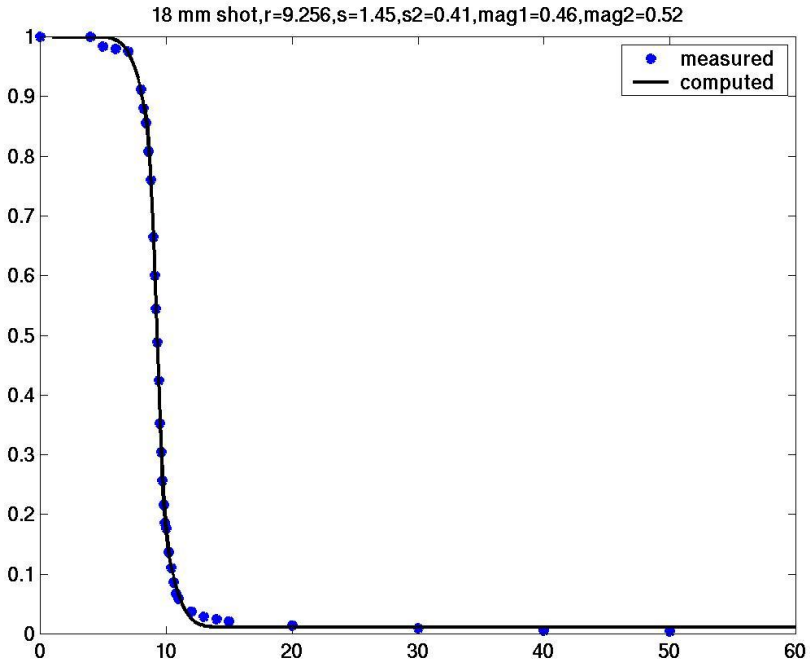
Raspoložive veličine šotova:4mm, 8mm, 14mm, and 18mm

Veličina šlema(mm)	4 & 8	4 & 14	4 & 18	8 & 14	8 & 18	14 & 18
Broj šotova	25	10	9	7	7	7

8mm shot

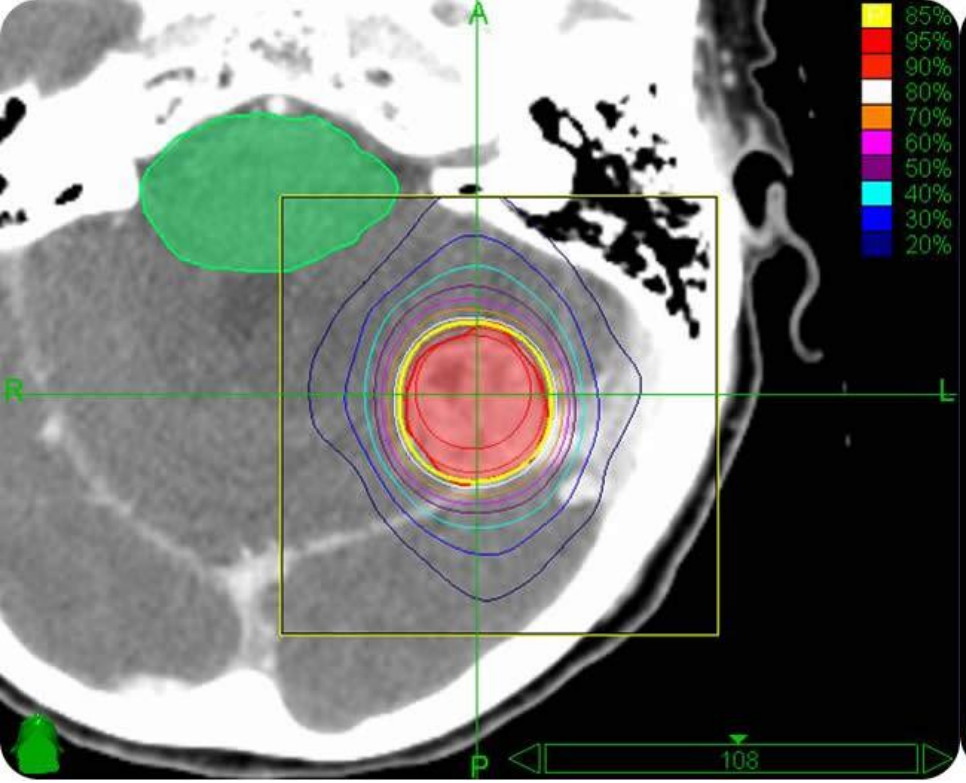


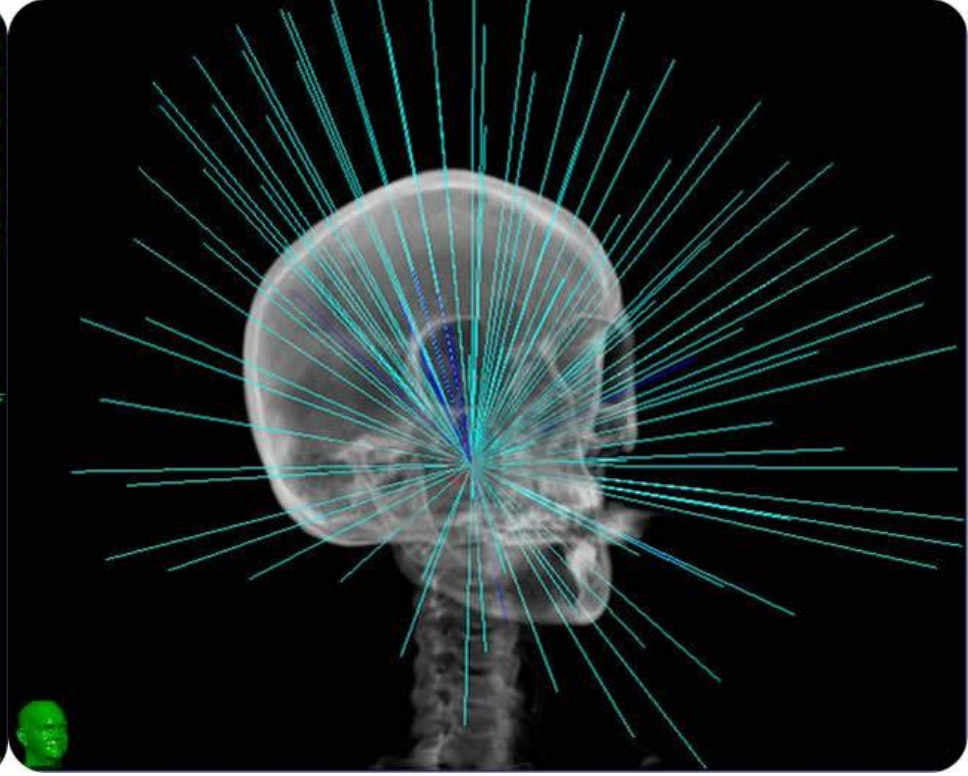
18mm shot

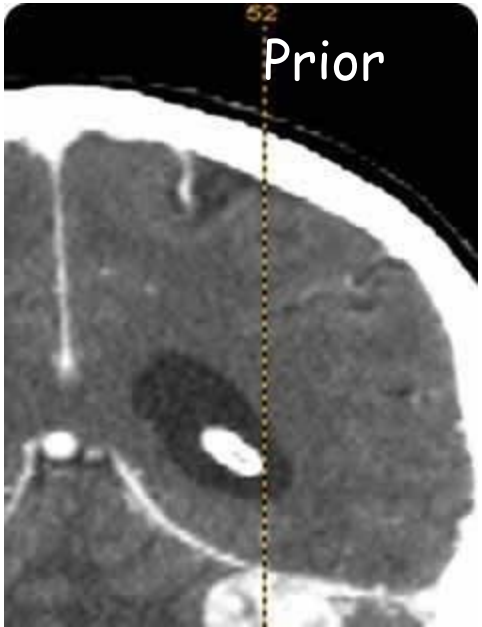


Planiranje tretmana

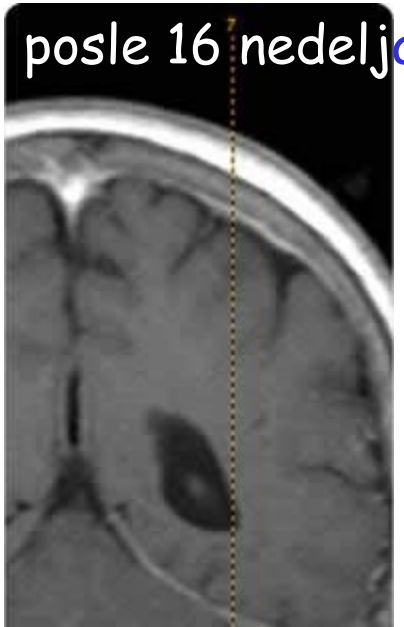
- Odrediti niz konfiguracija snopa koji će uništiti tumor
- Ograničenja:
  - Željena raspodela doze
  - Fizičke karakteristike snopa zračenja
  - Ograničenja uredjaja za isporuku doze
  - Trajanje/frakcionisanje tretmana


A
85%
95%
90%
80%
70%
60%
50%
40%
30%
20%
R
L
P
108



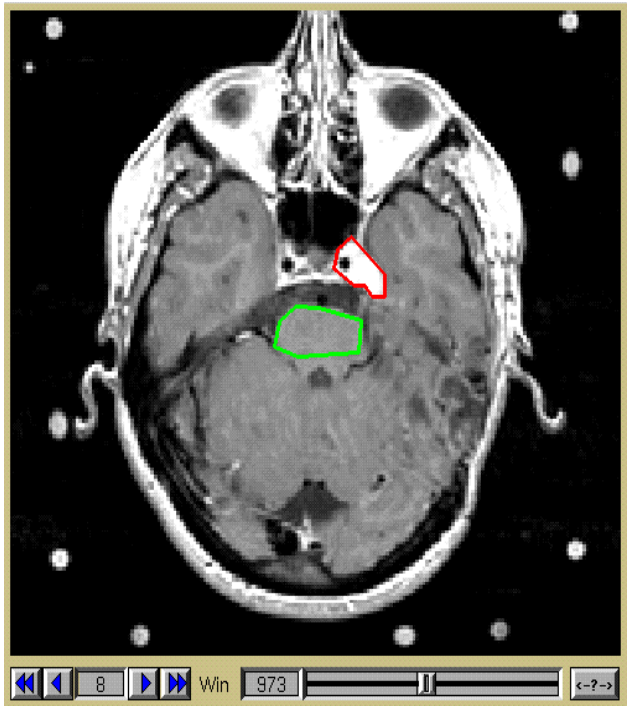

Prior

posle 10 nedelja

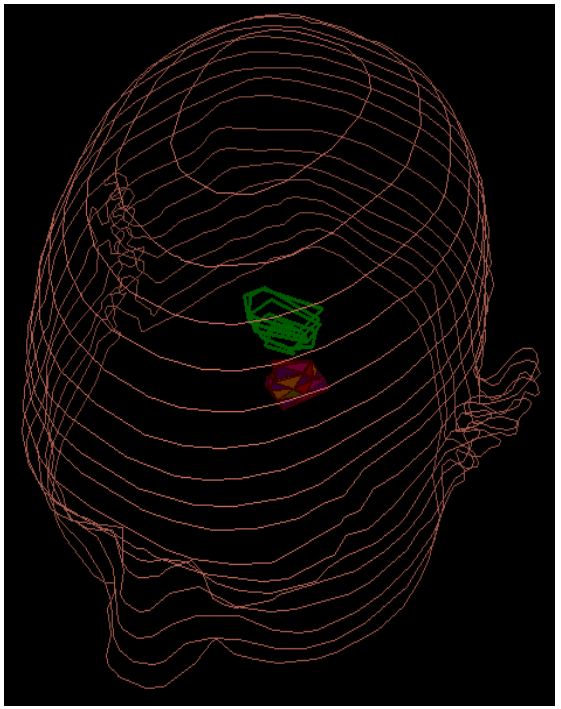

posle 16 nedelja

Planiranje tretmana

(1) Region od interesa



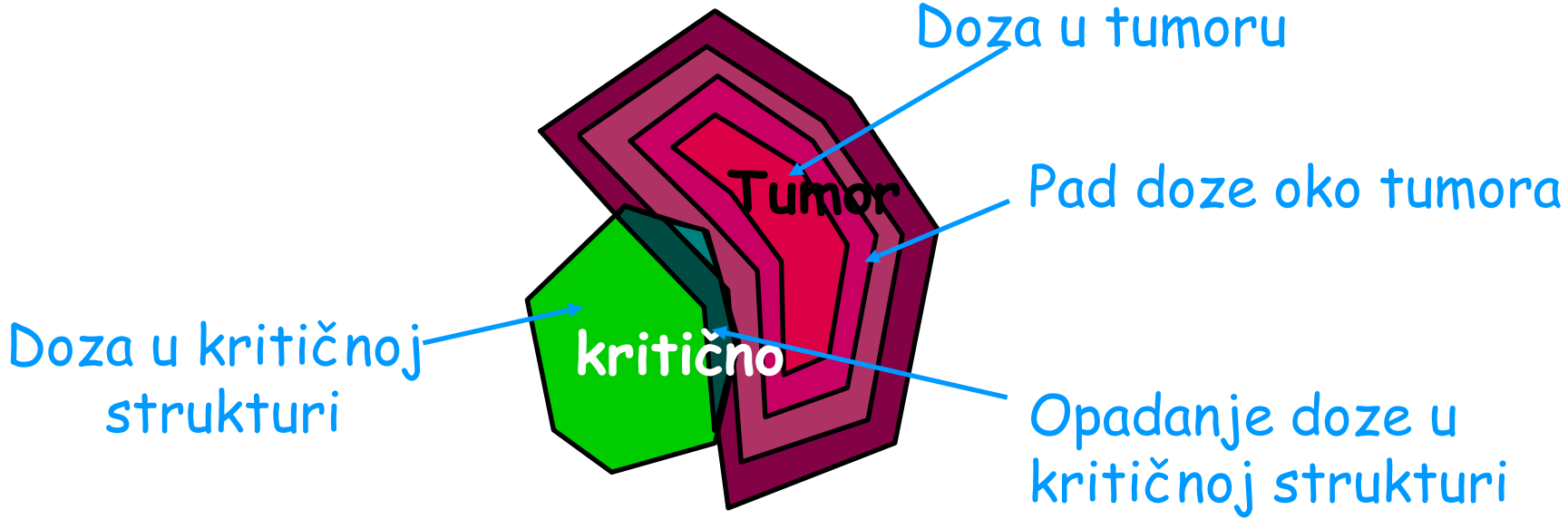
Hirurg označi region od interesa



Planiranjem se kreira 3D region

Planiranje terapije

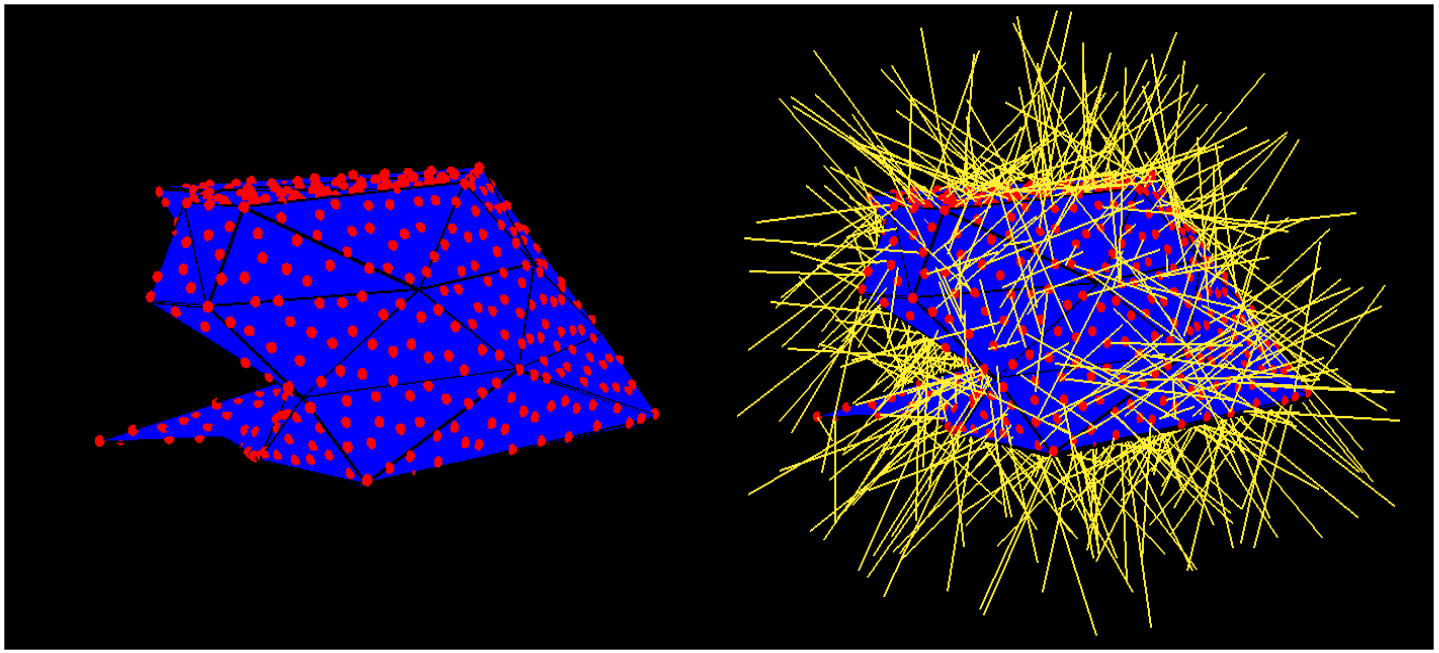
(2) Ograničenja doze:



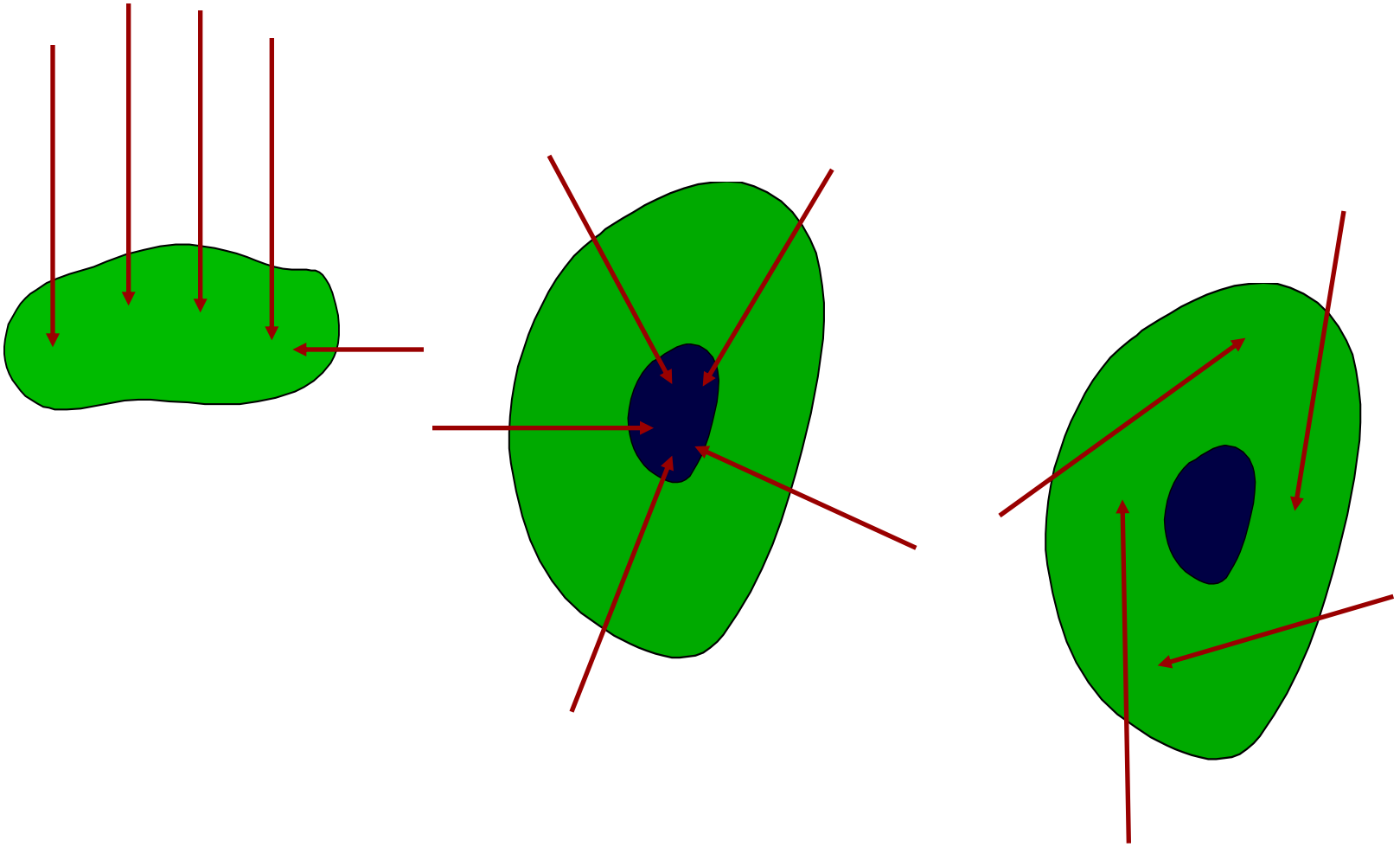
(3) Maksimalni broj snopova

Inicijalno uzorkovanje snopa

- Generisanje distribucije tačaka (šotova) na površinu tumora
- Definisati snopove slučajne orijentacije kroz te tačke

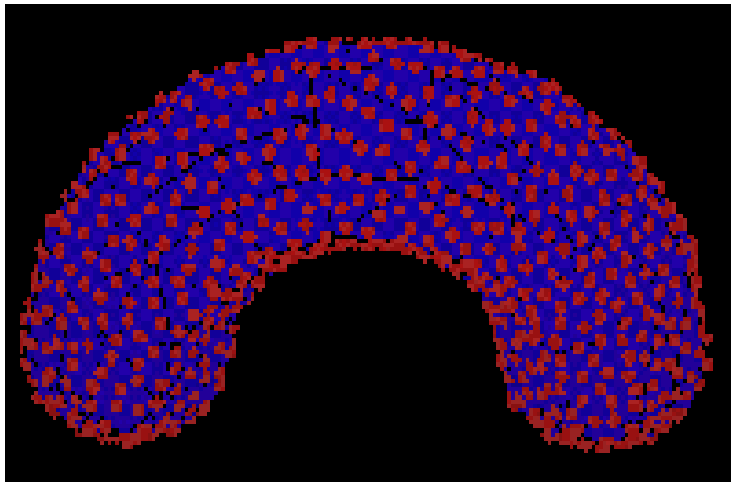


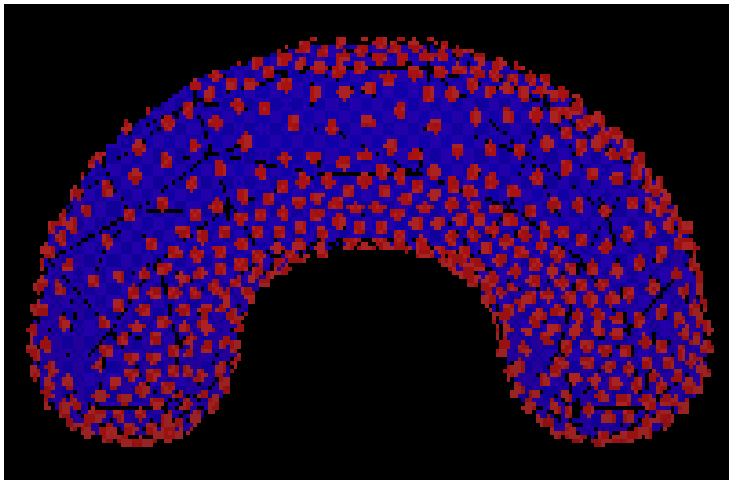
Deterministička selekcija snopa



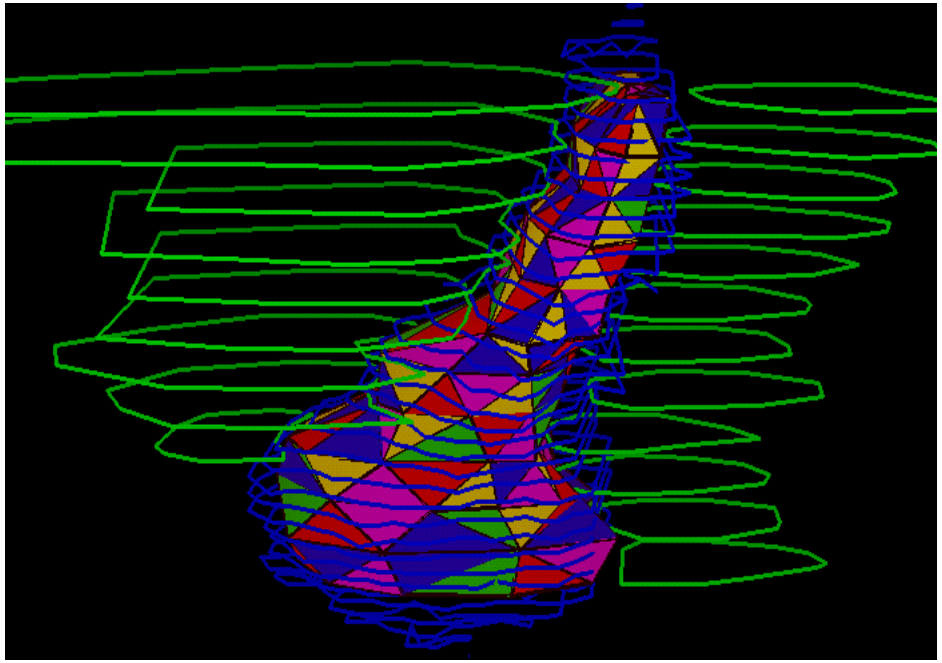
Kurvatura snopa

- Postaviti što više tačaka u regionu tumora u oblasti visoke zakrivljenosti

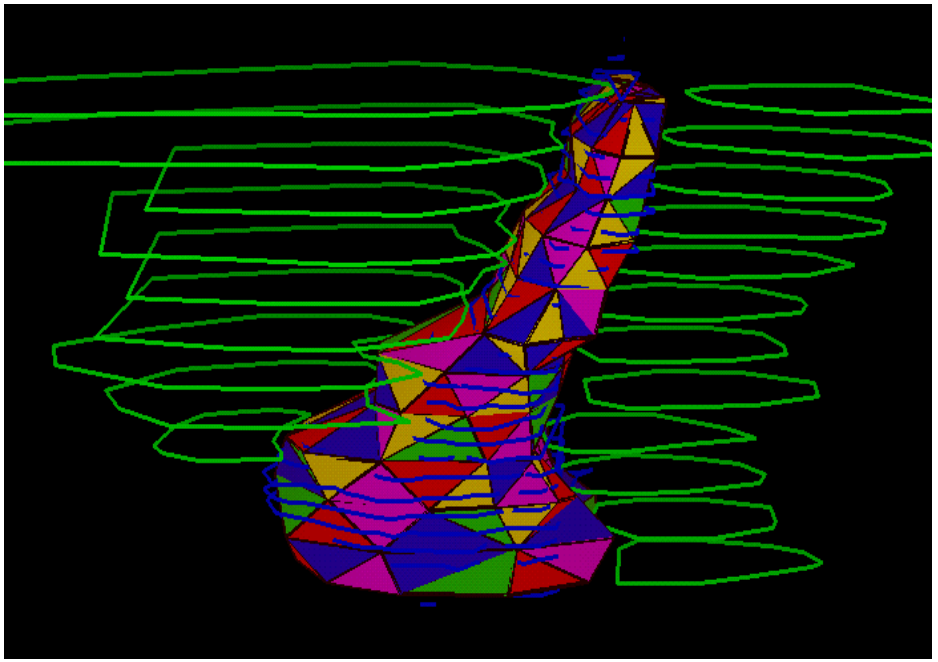




Evaluacija za slučaj prostate

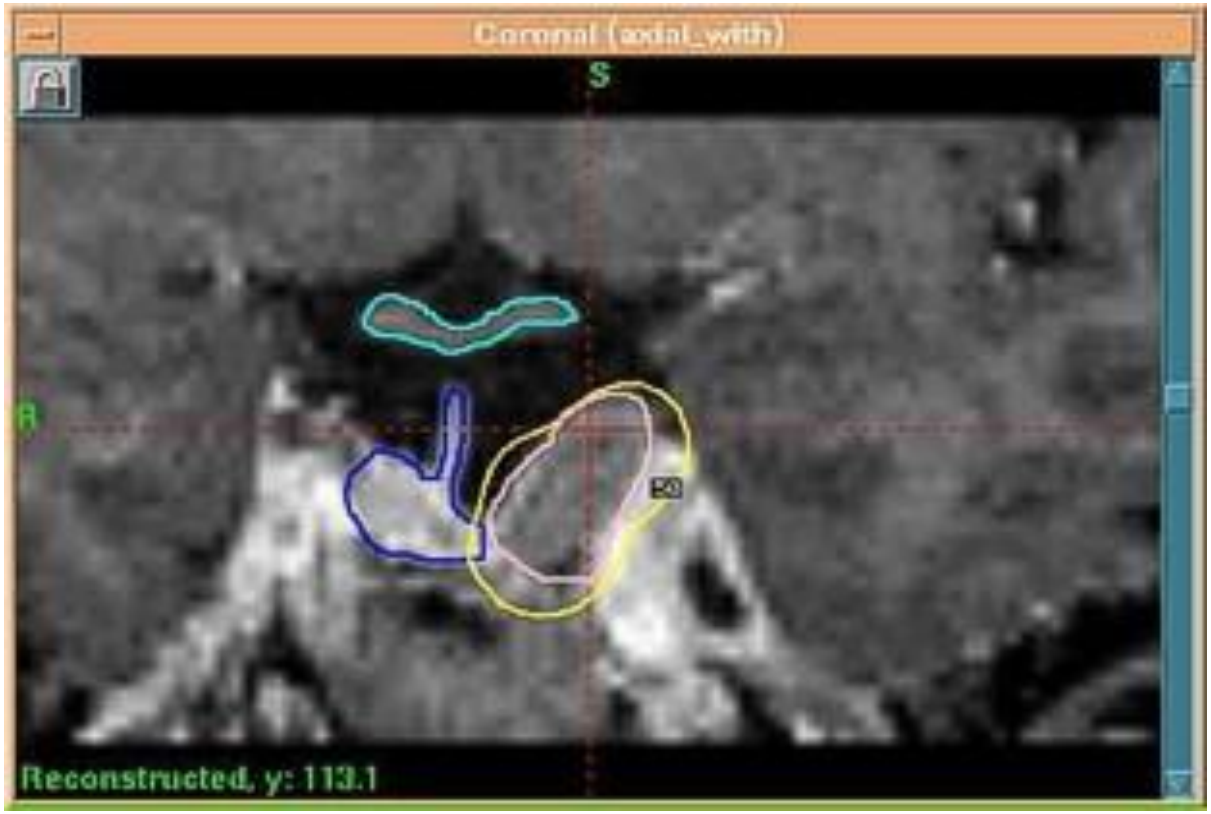


50% Isodose Curve

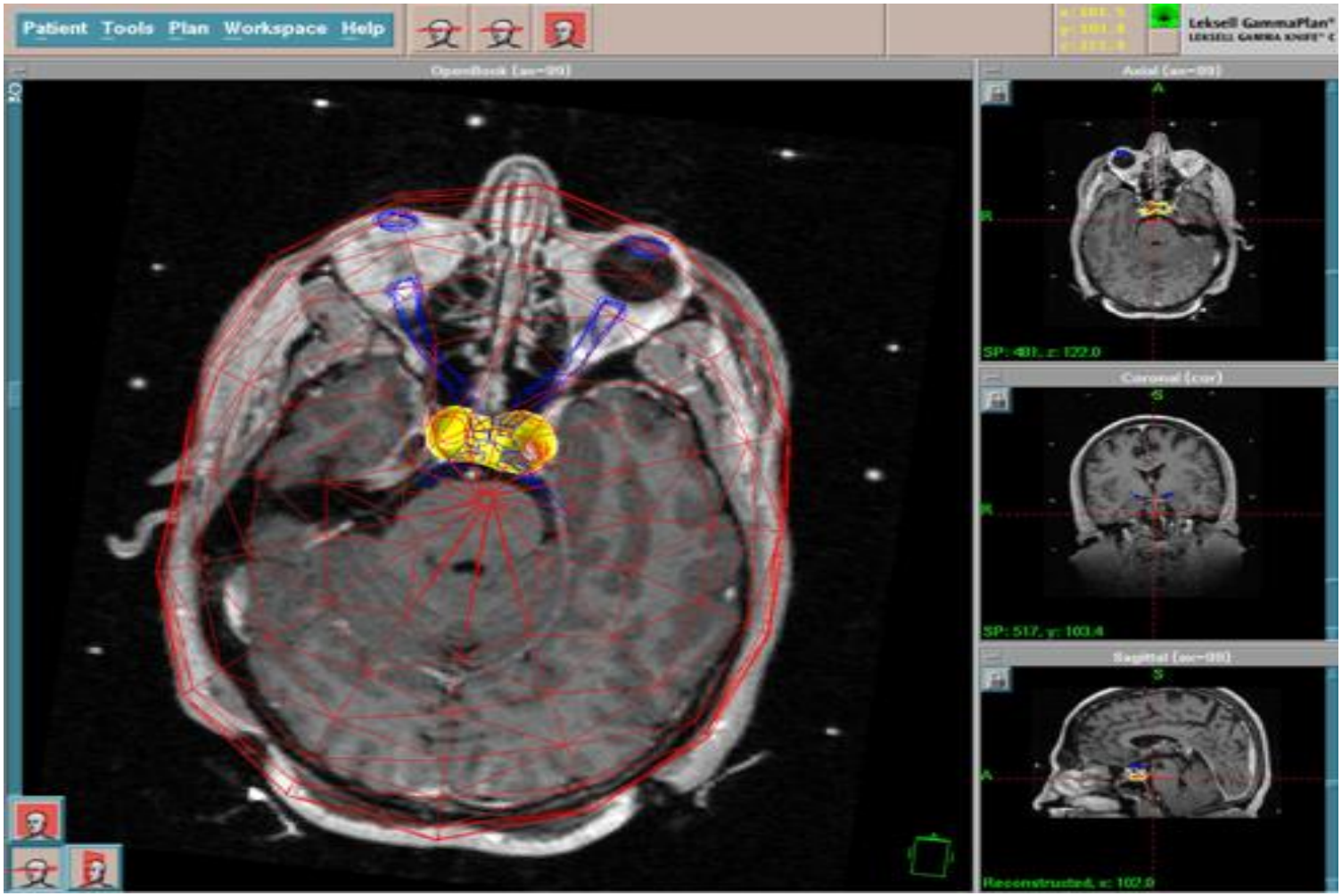


70% Isodose Curve

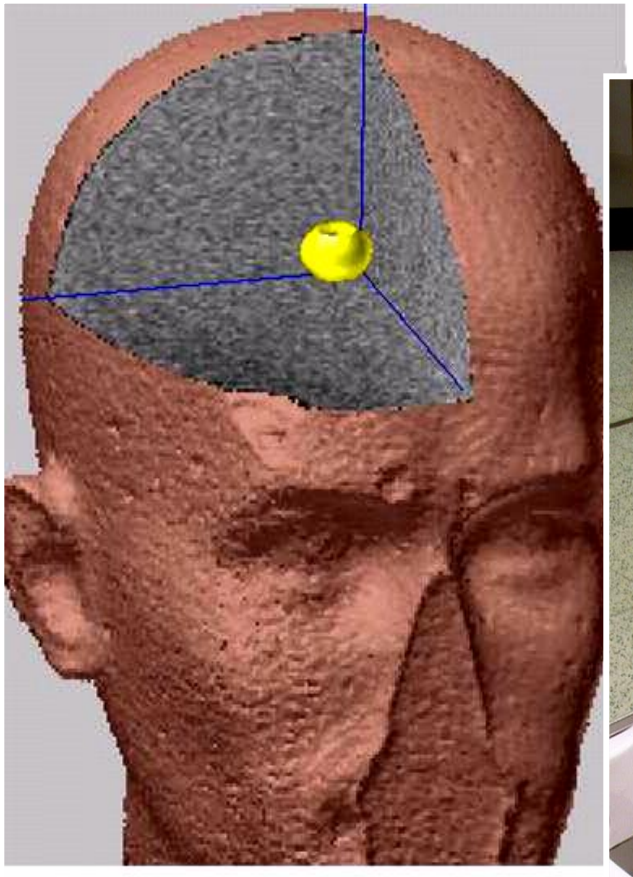
Koronalna sekcija na planu tretmana

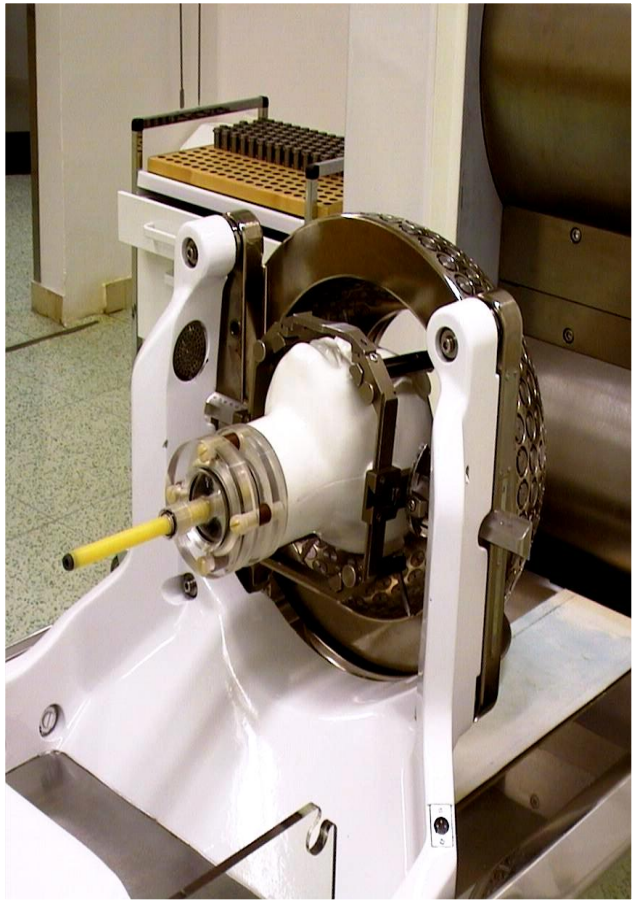


Gamma Plan



Verifikacija plana zračenja pacijenta

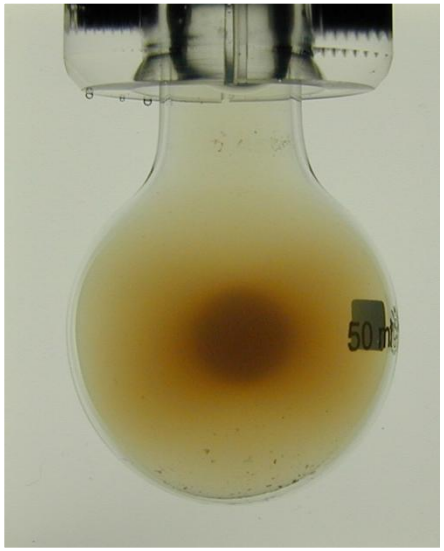




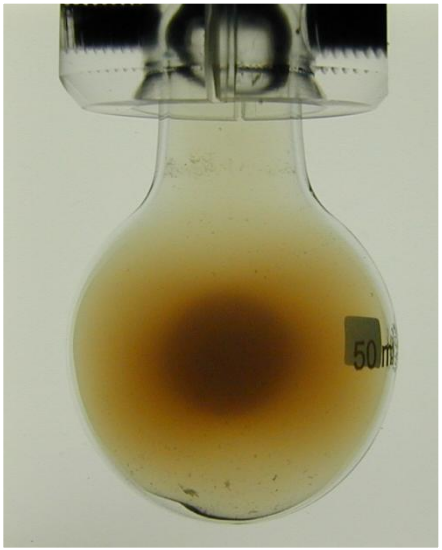
Ekspozicija gel dozimetra gama nožem sa kolimatorom različitih prečnika

4 mm

8 mm



14 mm

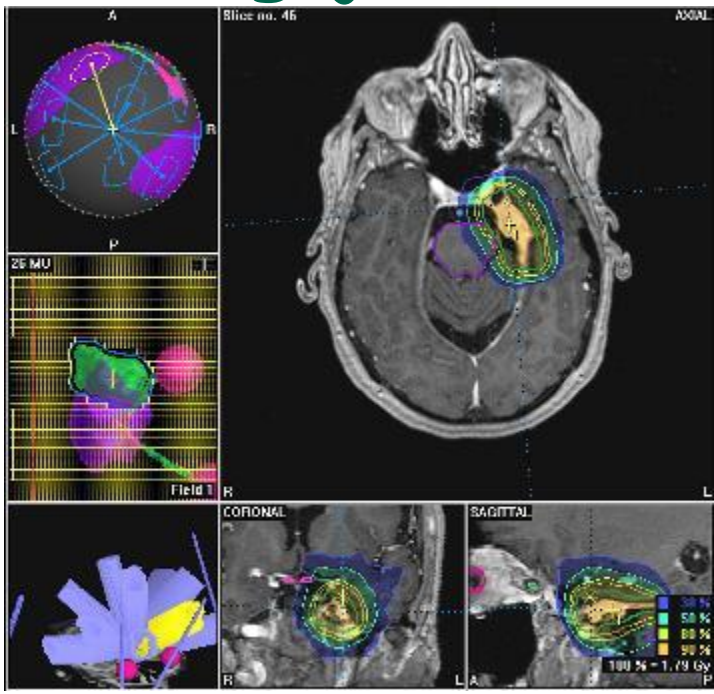


18 mm

Kontrola kvaliteta ozračivanja mozga laboratorijskih pacova- FANTOM

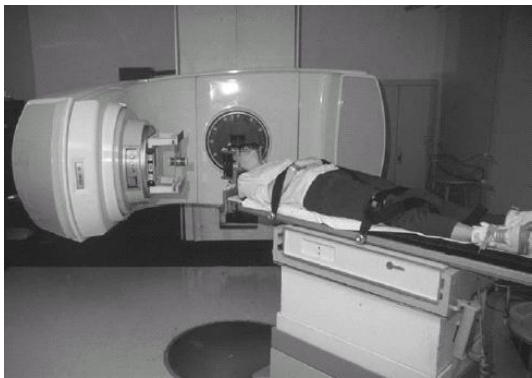
stakleni fantom punjen gel dozimetrima

Stereotaktička radiohirurgija

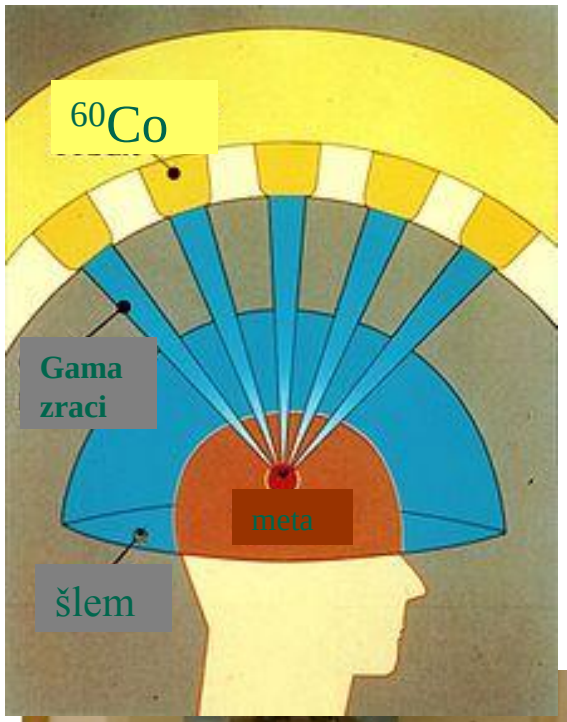


Gama nož (Gamma Knife, gamma unit)

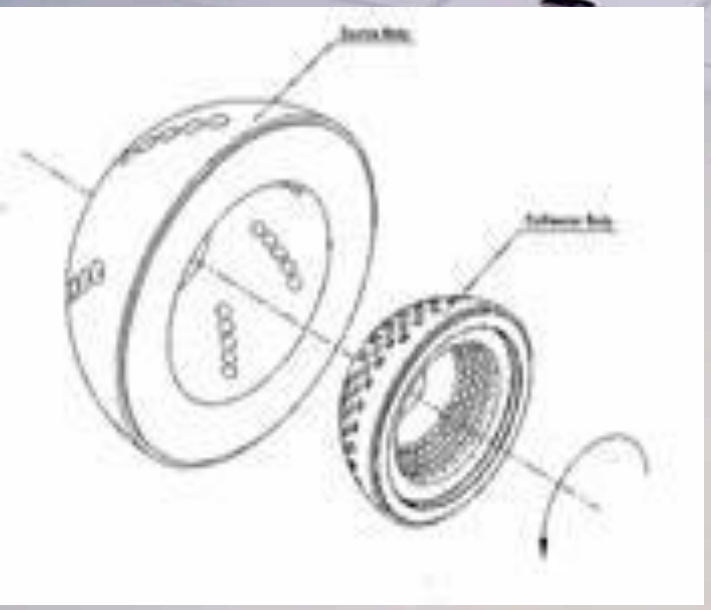
Obično 201 ^{60}Co: 201 kolimisani snop usmeren na fokus na rastojanju 40 cm
Kružno polje: prečnik(4; 8; 14; 18) mm



Stereotaktička radiohirurgija

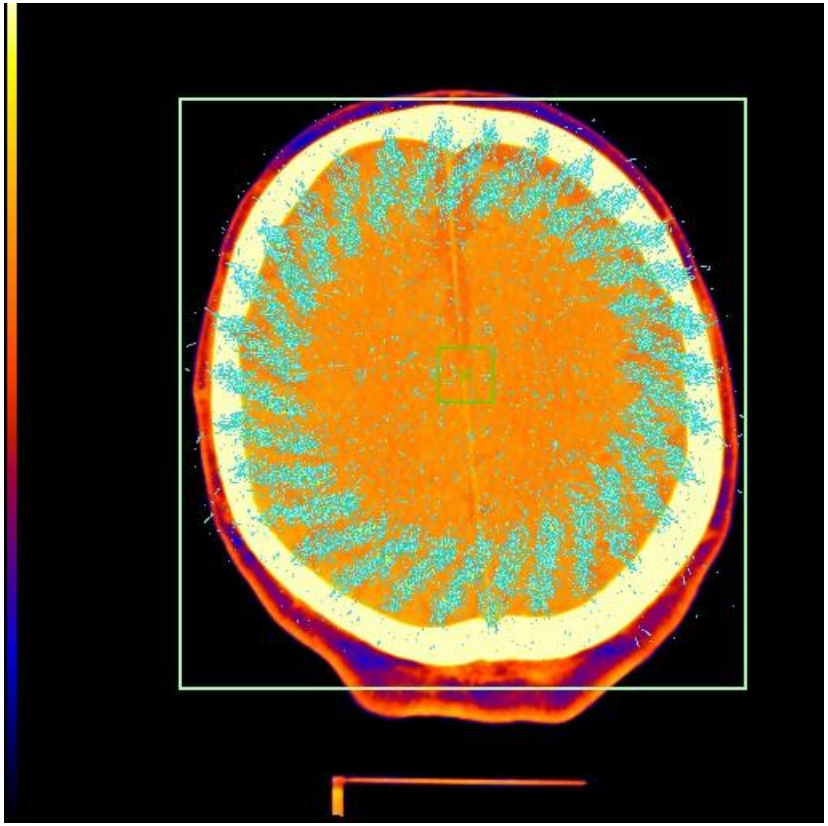


ROTATING GAMMA SYSTEM *ART6000*

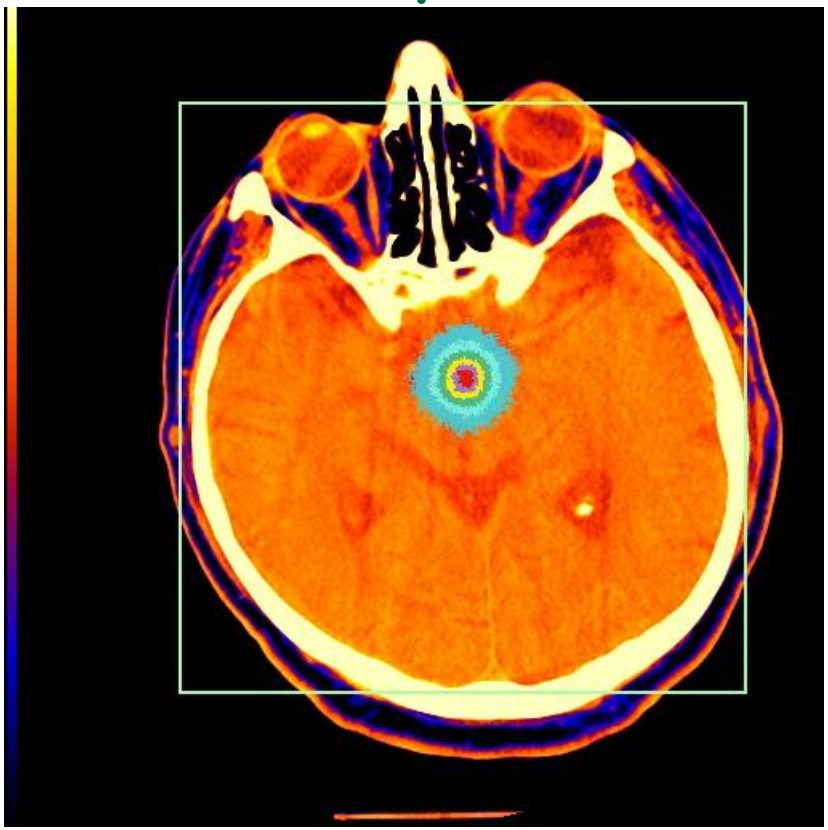


American Radiosurgery Inc, San Diego, CA

Nož sa 150 izvora
Slike dobijene programom FOTART
za ART6000 instalciju
(Dr Radovan D. Ilić, Prof.dr.Vesna Spasić Jokić)



Doza u temenu



Doza u tumoru