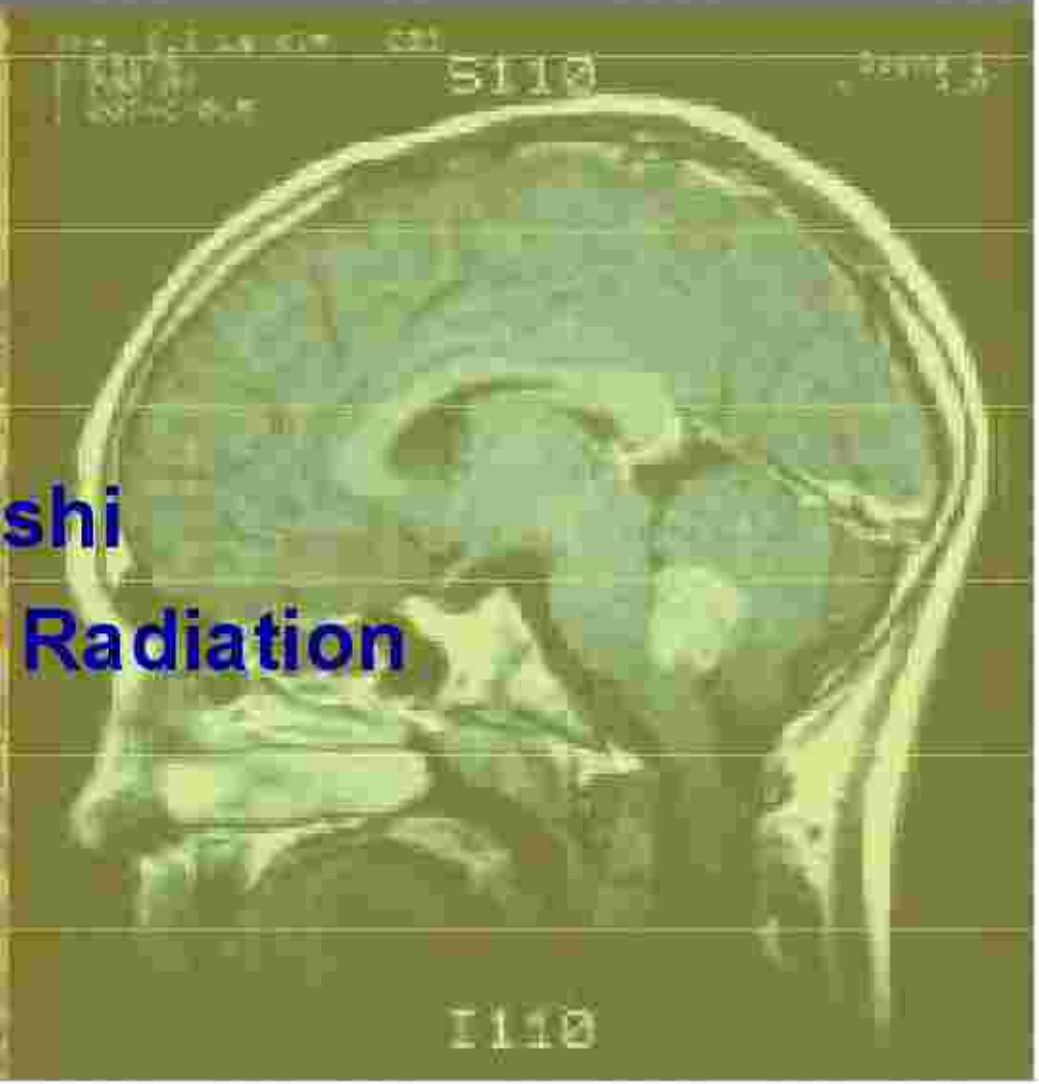
RT techniques in medulloblastoma



Anusheel Munshi

Department of Radiation Oncology

TMH

Rationale for Craniospinal irradiation(CSI) in medulloblastoma

- CSF dissemination is known in 16-46% of cases
- Posterior fossa, spinal cord, ventricular walls & supratentorial region including the cribriform plate form the main sites of relapse.
- Being radiosensitive, RT is curative in up to 70% of standard risk patients.

Target volume for CSI

- Whole brain with its meninges
- Spinal cord down to the caudal end of the thecal sac(usually S2 but should be verified by saggital MRI)
- Primary tumour site/posterior fossa(for boost)


CSI is challenging and demands precision……

Challenges in planning CSI

- Immobilization & positioning of a large target area
- Large & irregular shape of the clinical target volume (CTV)
- Multiplicity of fields
- Inhomogeneity at the junctions between the brain and spinal fields
- Large number of critical normal structures having direct bearing on the late effects in these pediatric long term survivors.

Planning steps

- Positioning
- Immobilization
- Simulation
- Verification
- Treatment
- Junction shift

Positioning

PRONE:

- It provides direct visualization of the field junctions on the patient.
- Good alignment of the spine.

SUPINE

- Comfortable.
- Useful in anesthesia(in < 7yr age gp)

Immobilization

- Prone position of patient
- Arms by the side on a CSI board CSI board
- Lucite base plate with a sliding semicircular Lucite structure for head-rest & chin-rest.
- Slots from A to E to allow various degrees of extension of neck

Immobilization

- Thermocol wedge for supporting the chest wall
- Alignment of the thoracic & lumbar spine parallel to the couch (to confirm under fluoroscopy)
- Thermoplastic mold for Immobilization of the head,cervical spine & shoulders.

Radiotherapy Planning

Phase I

- Two lateral cranial fields
- 1 or 2 spinal fields

Phase II: Posterior fossa boost

- Two lateral cranial fields
- Conformal technique in low risk cases.

Critical issues in CSI fields

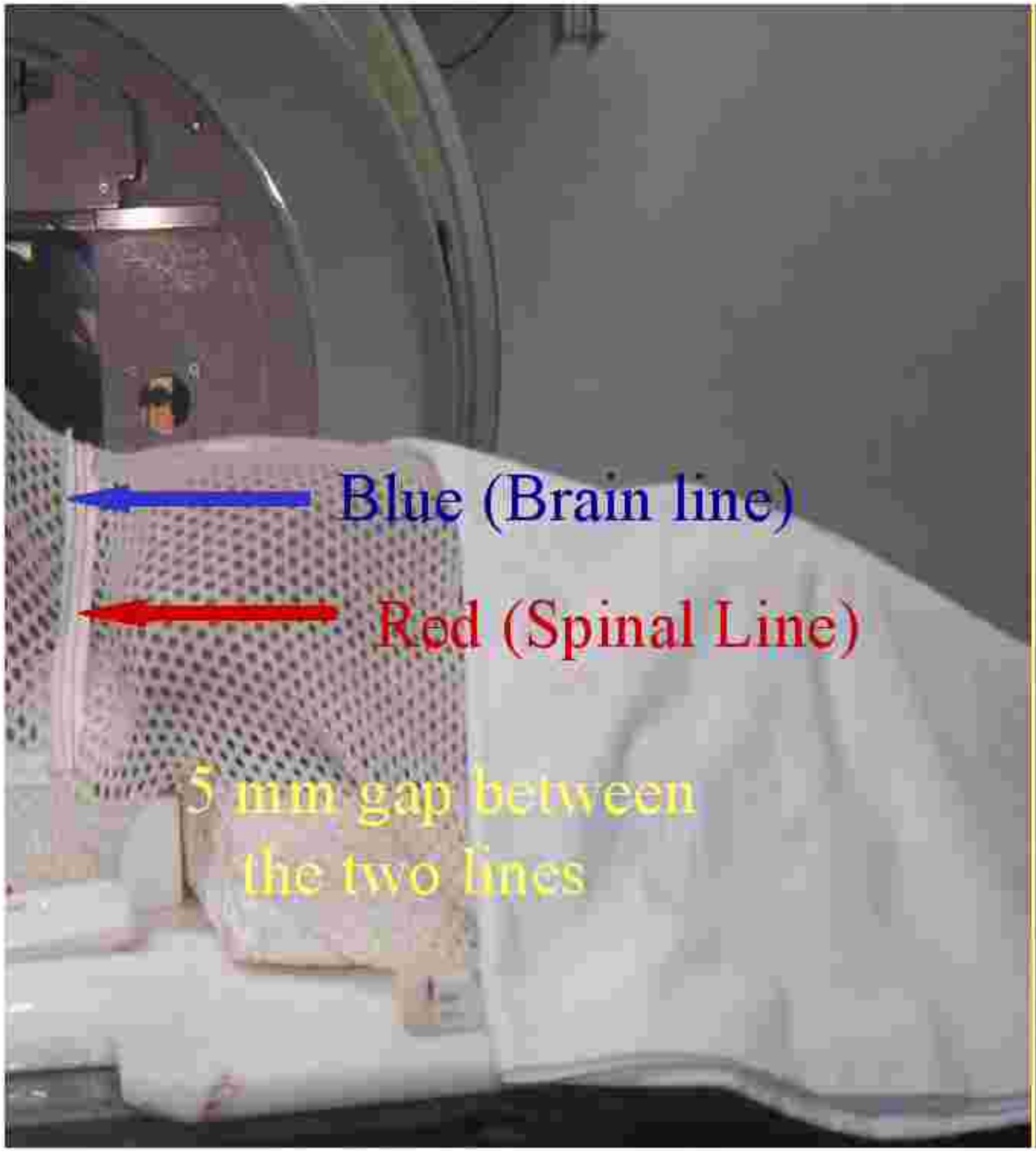
- Concern 1

Divergence of the upper border of the spinal field in case of single spinal field(and interdivergence of spinal fields in case of 2 spinal fields)

- Concern 2

Divergence of both cranial fields

- Spinal field simulated first (get to know the divergence of the spinal field)
- SSD technique
- 2 spinal fields if the length is > 36 cm
- Upper border at low neck
- Lower border at termination of thecal sac or S2 whichever is lower
- In case of 2 spinal fields , junction at L2/L3



Spinal field

(Upper border)

Craniospinal junction

Possible causes of overdose at the neck

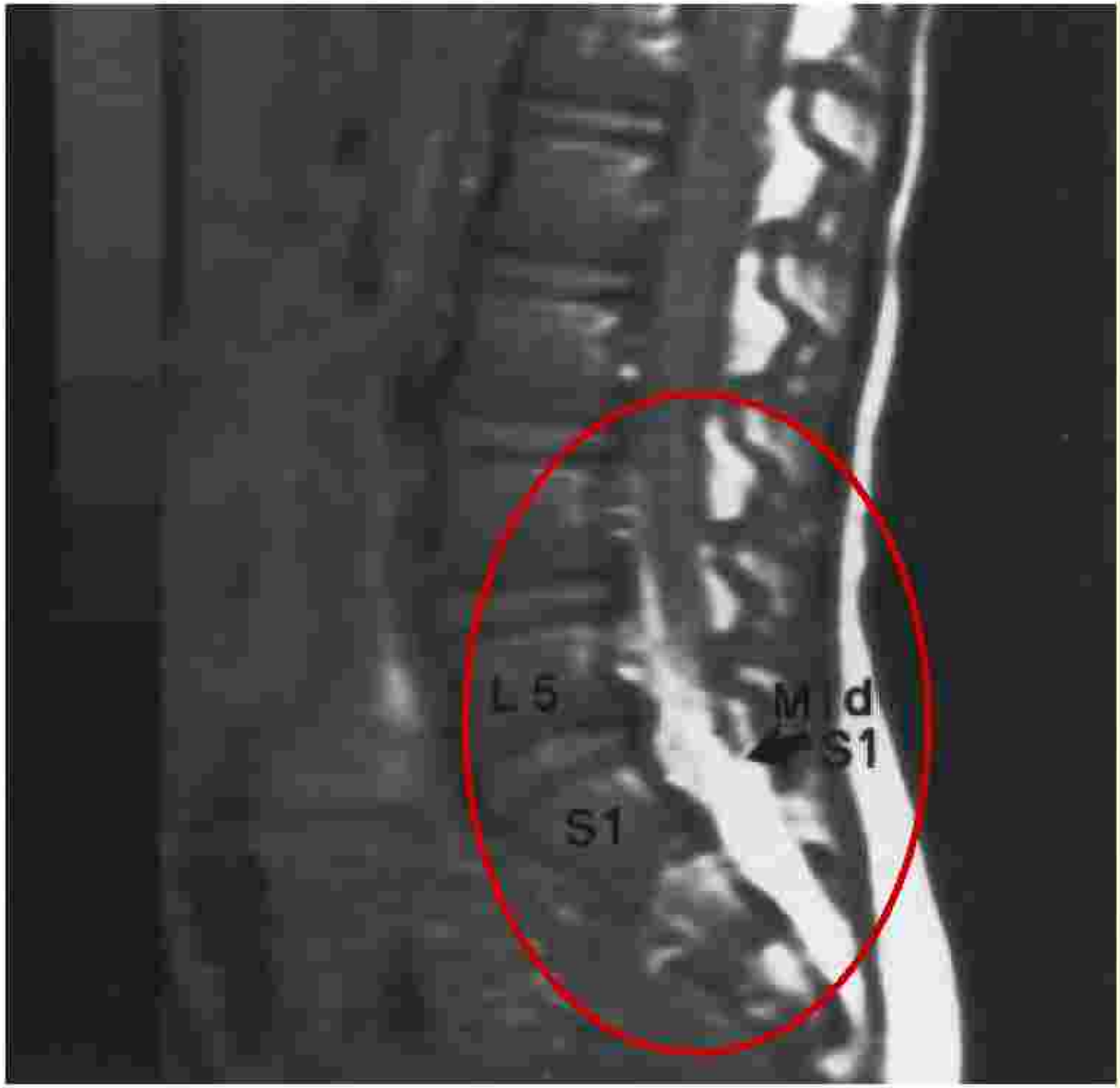
- Narrow neck separation than cranium
- Couch rotation towards gantry decreased treatment distance(and > dose).
- Horns at the lateral aspect of the beam secondary to overflattening of the LA beam.

Halperin IJROBP 1996

Termination of thecal sac

- Traditional recommendation for lower border of spinal field is inferior edge of S2 (myelogram & autopsy studies).
- 8.7% patients have termination below S2-S3 interspace.
- MRI accurately determines the level of termination of the thecal sac & the extent of neuraxial disease if present.

IJROBP, 1998, vol 41


L 5
M i d
S1
S1

Gap or no gap-spinal fields

- Proponents of no gap

  Concerned over possible lower dose to part of target volume. (Tinkler, 1995).

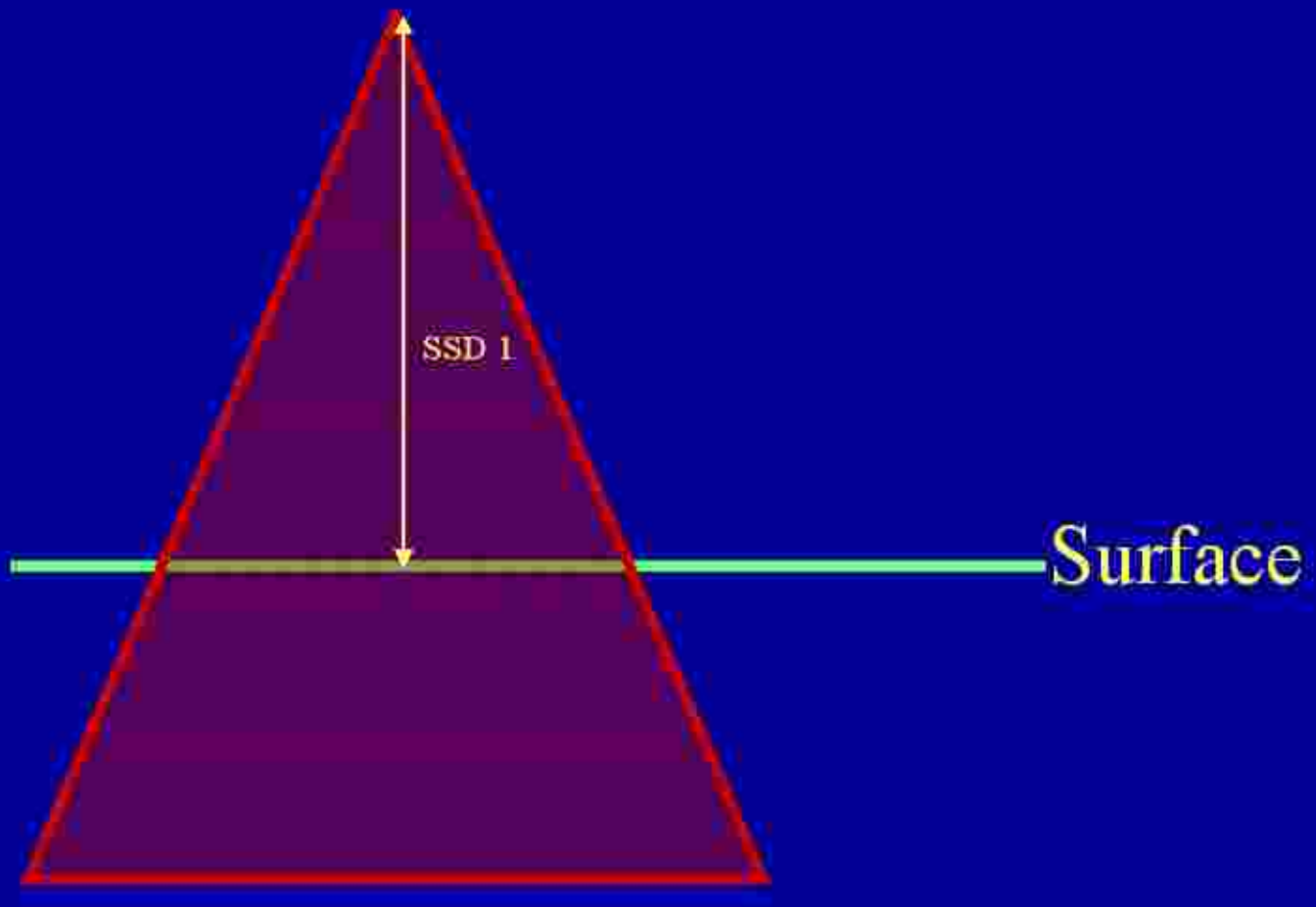
- Proponents of gap

  Overdose at the junction & cervical spine & may result in disabling late toxicity.

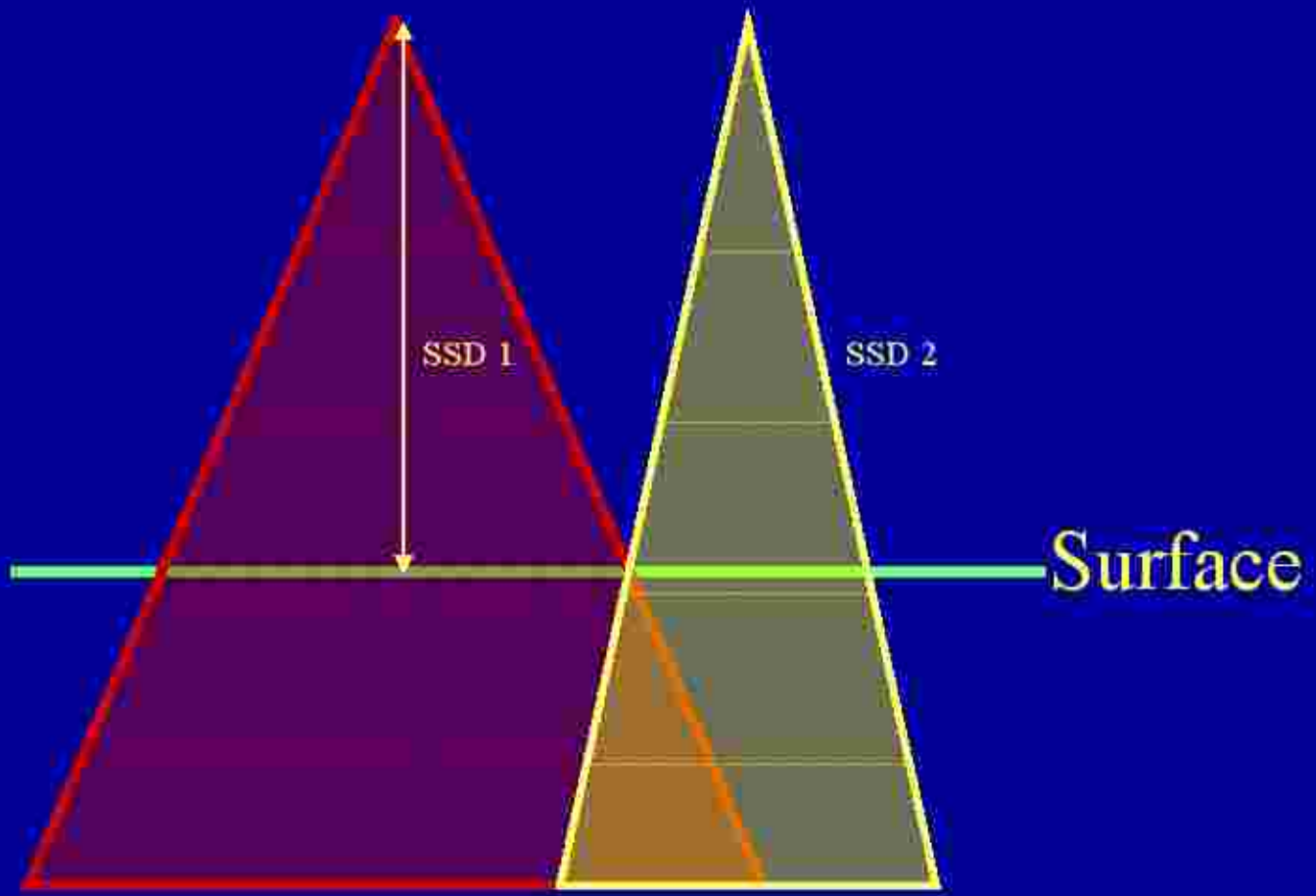
Fixed or calculated gap spinal fields

- Use of fixed gap ranging from < 5 mm to 10mm between fields OR
- Customised gap for each patient depending on the field length & depth of prescription, may be more appropriate
- Spinal fields are simulated after gap calculation.
- Width - vertebral body + 1 cm to include the intervertebral foramina, usually 5 to 7 cm.

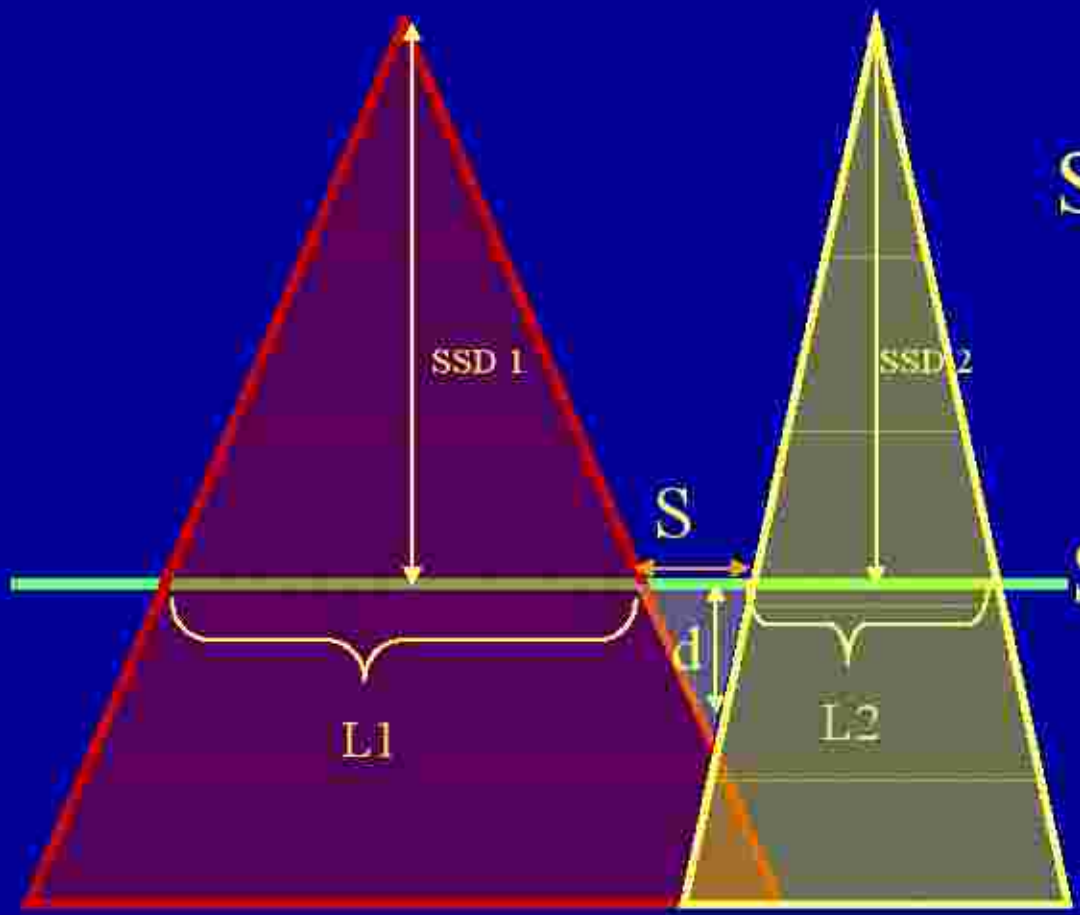
Gap calculation-formula



Gap calculation-formula

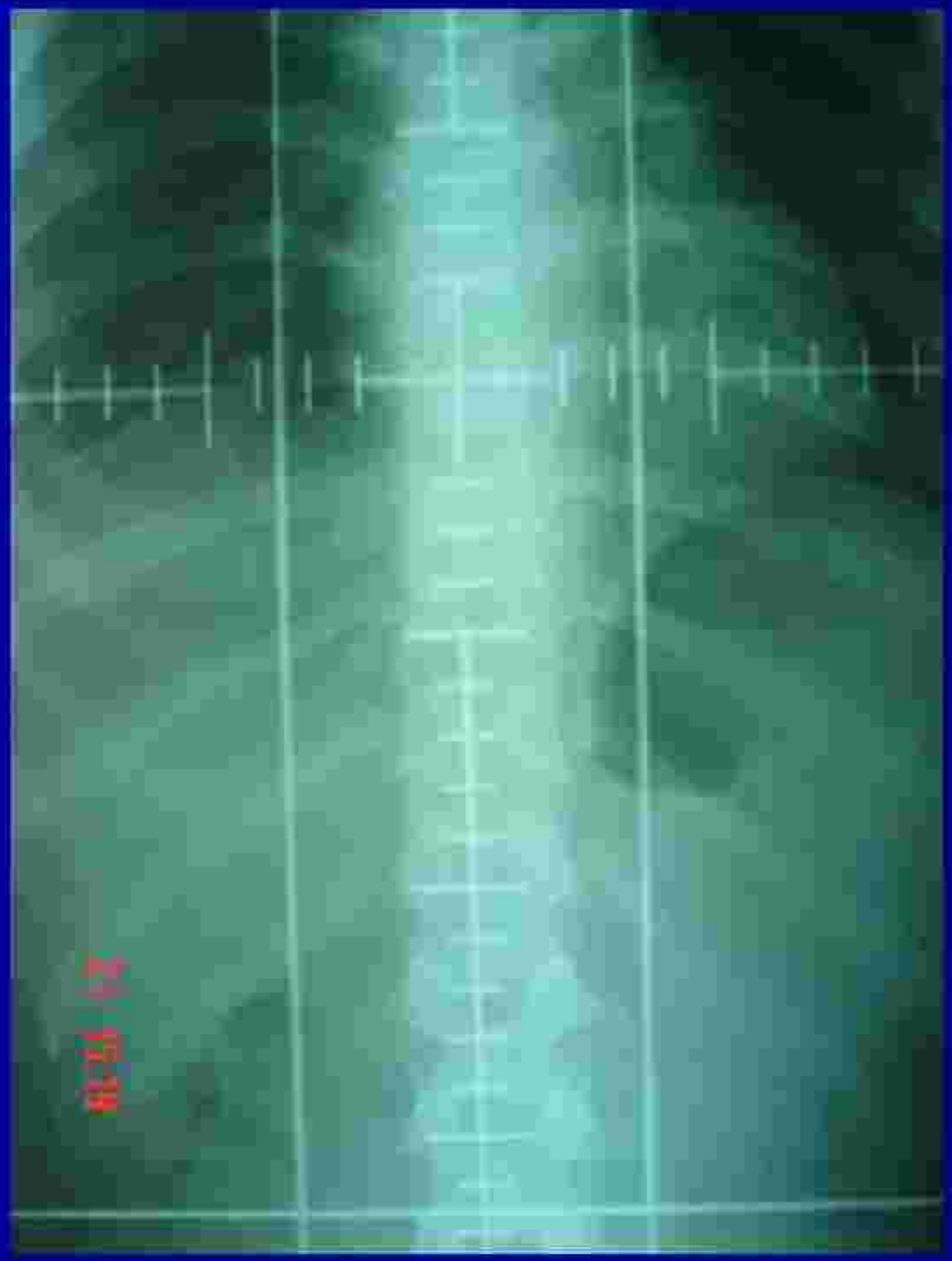


Gap calculation-formula



$$S = \tfrac{1}{2} L1(d/SSD1)$$

$$+ \tfrac{1}{2} L2(d/SSD2)$$



Extended SSD technique

- Advantage

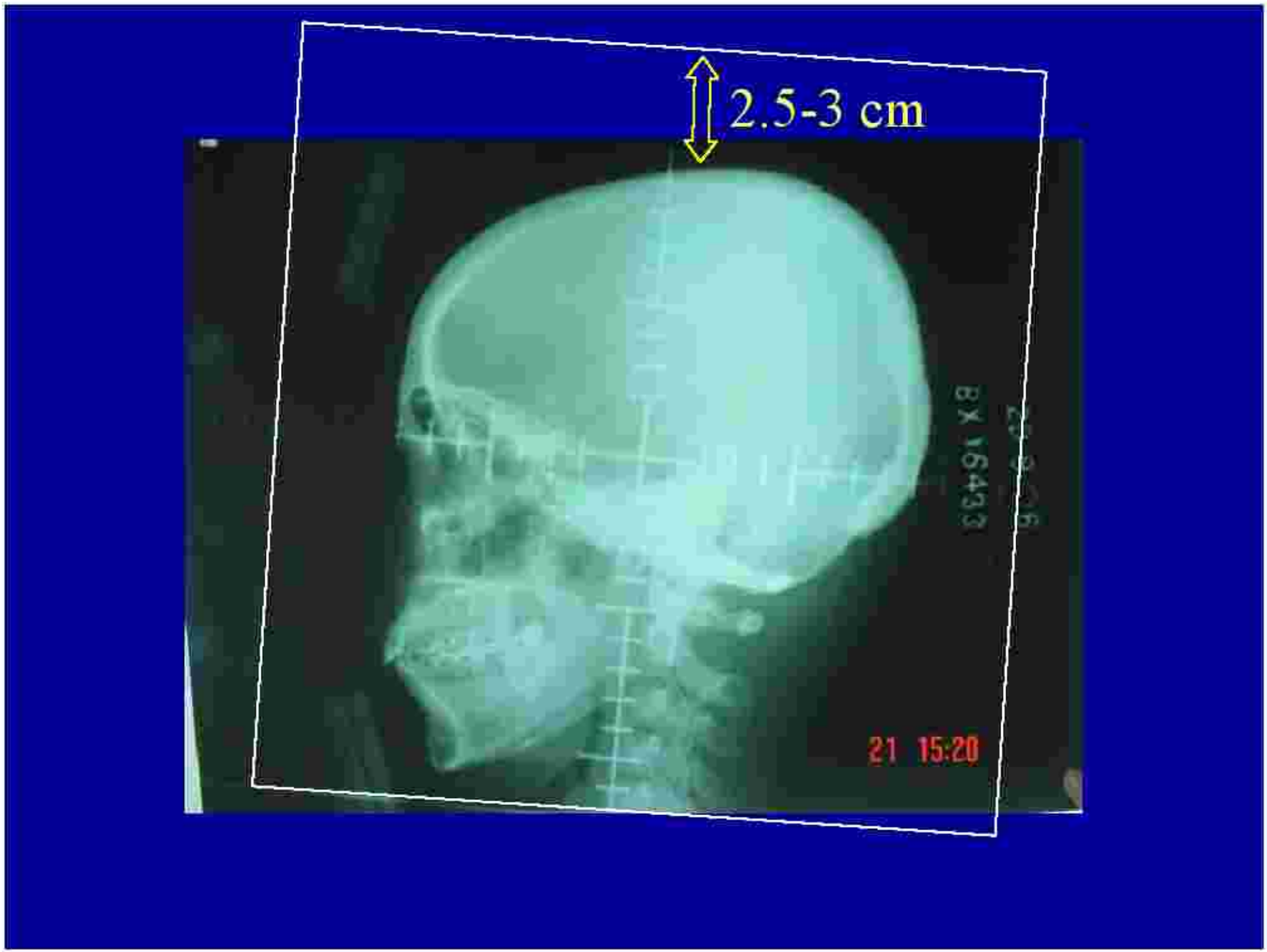
  Single spinal field and circumventing the issue of junction between two spinal fields

- Disadvantage

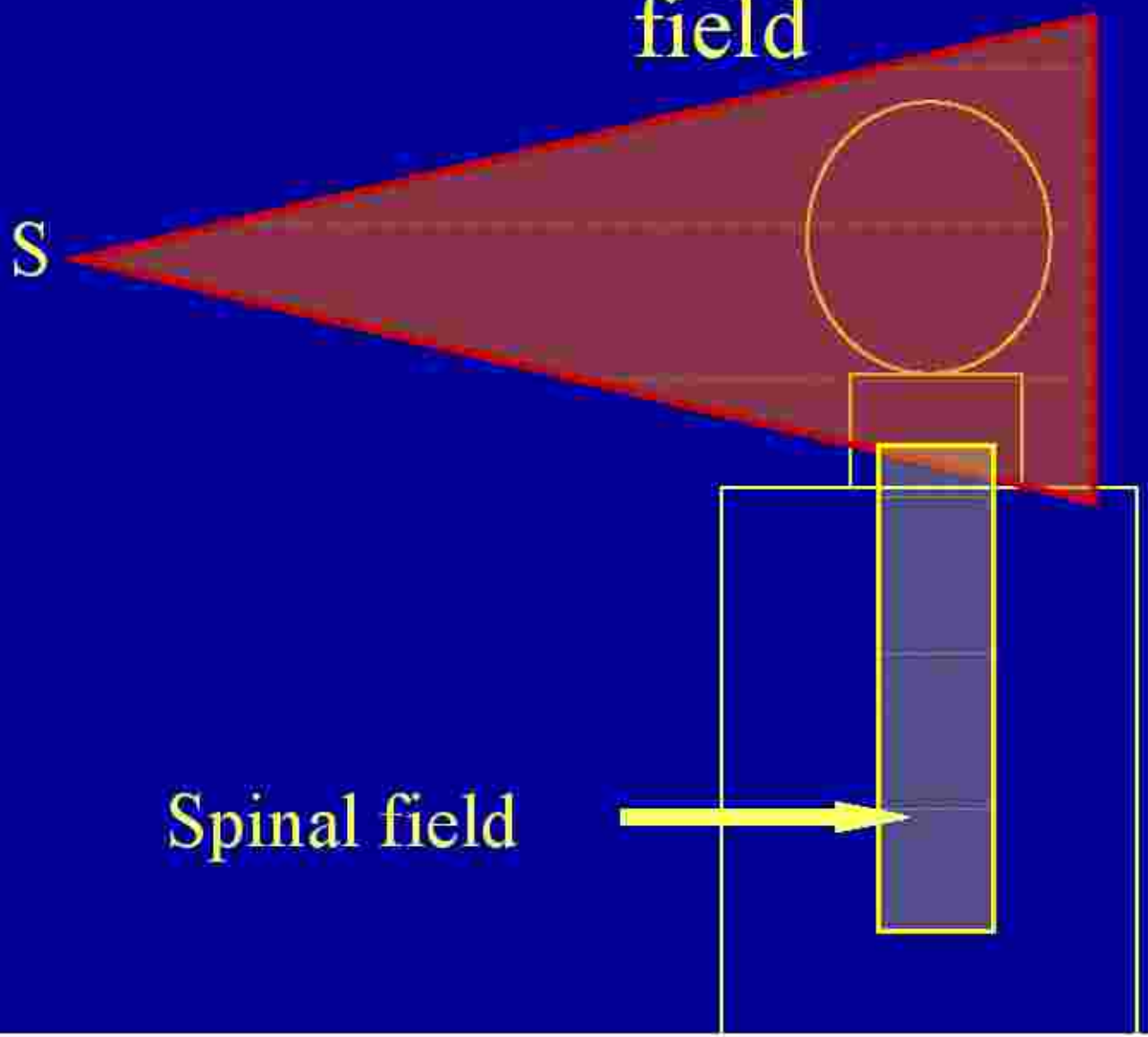
  Higher percentage depth dose and greater penumbra results in higher mean doses to all anterior normal structures,(mandible, esophagus, liver, lungs, heart, gonads and thyroid gland)

Simulation-cranial field

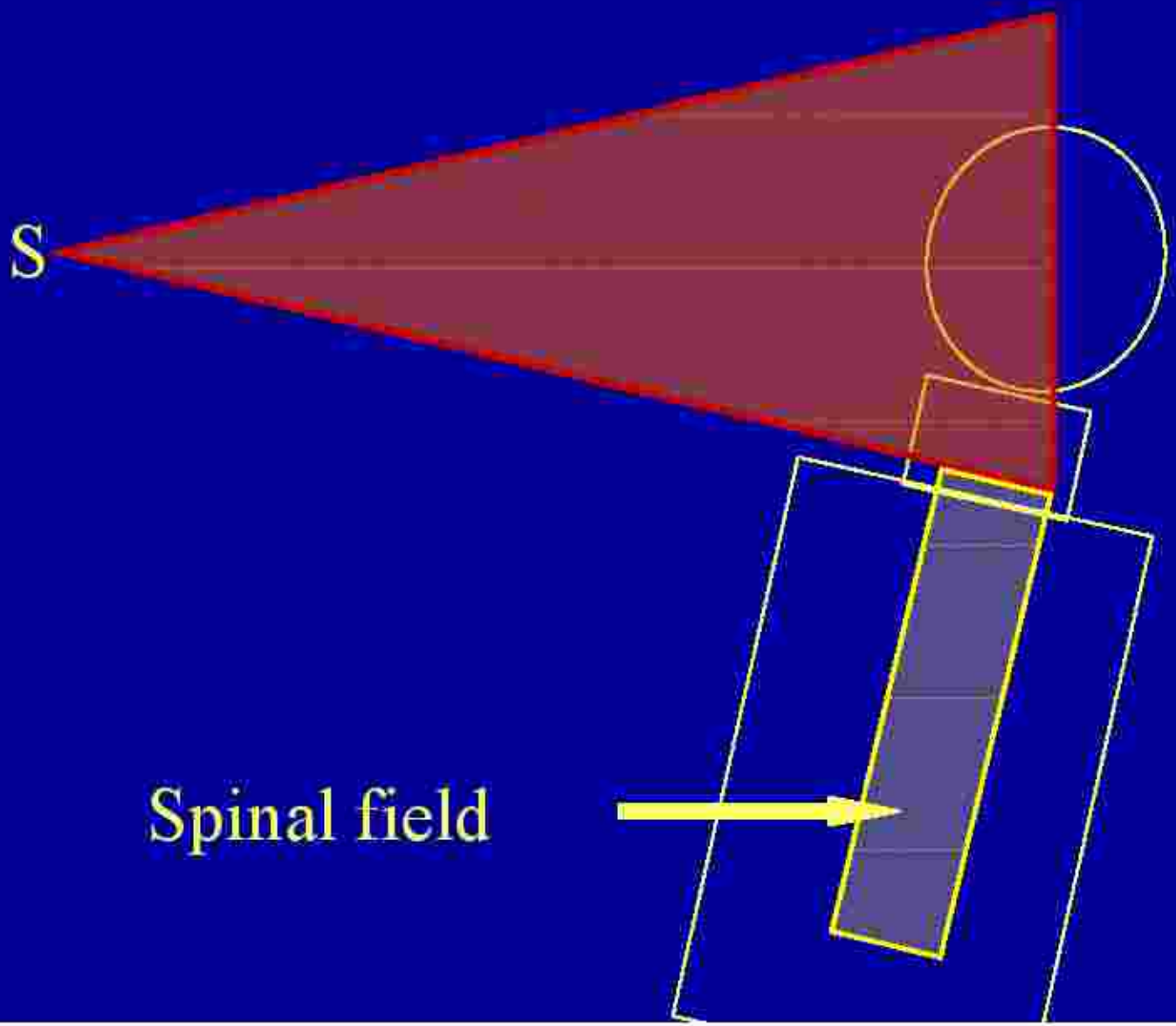
- Whole brain field is simulated & lower border is matched with the superior border of spinal field.
- AP width & superior border include the entire skull with 2 cm clearance.
- Techniques for matching craniospinal fields.
  - **Collimator/couch rotation**
  - **Half beam block**
  - **Asymmetric jaws**
  - Penumbra generators
  - Wedge
  - Tissue compensator


2.5-3 cm
21 15:20

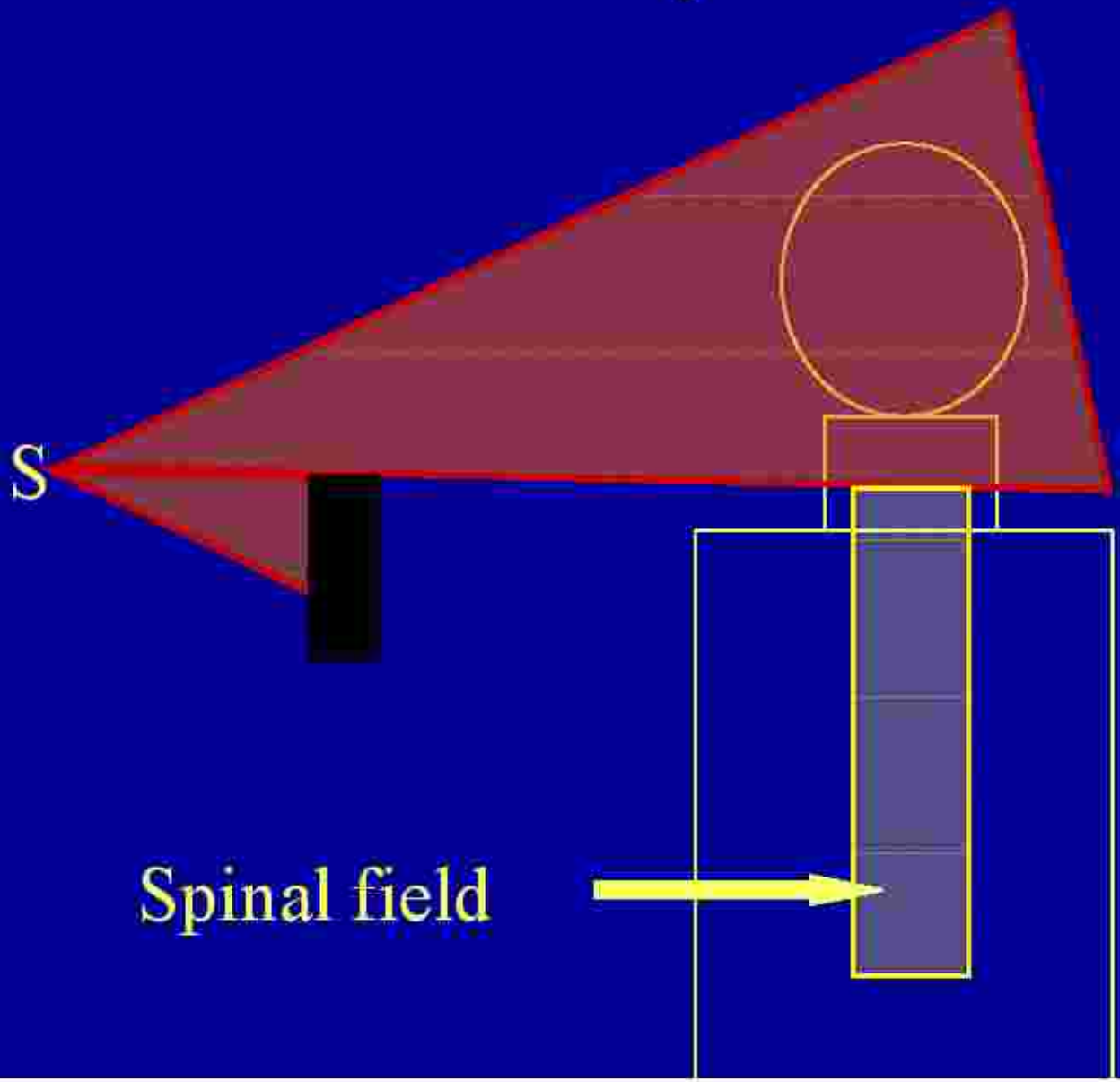
Problem 1: Divergence of cranial field



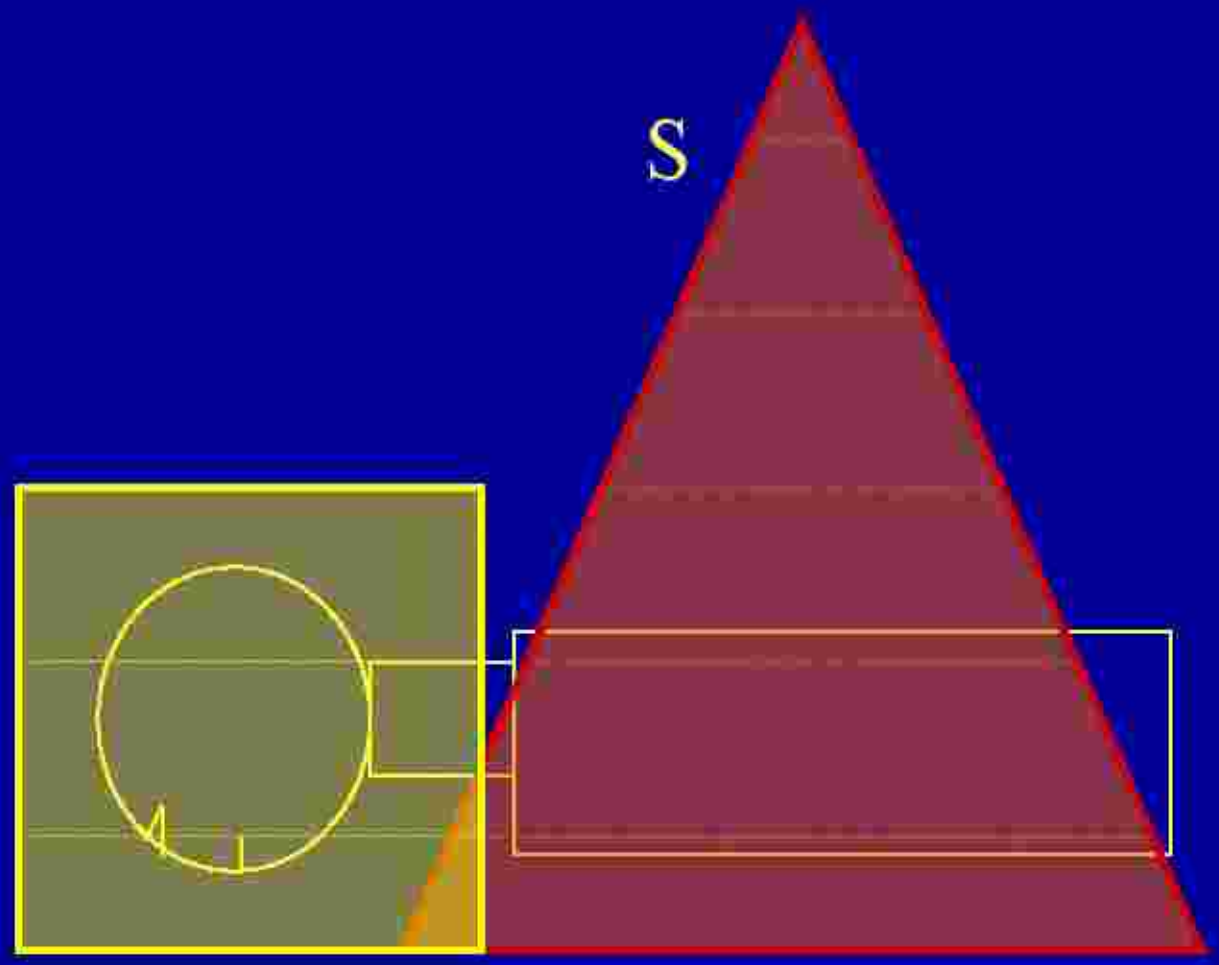
Solution A: Rotate the couch



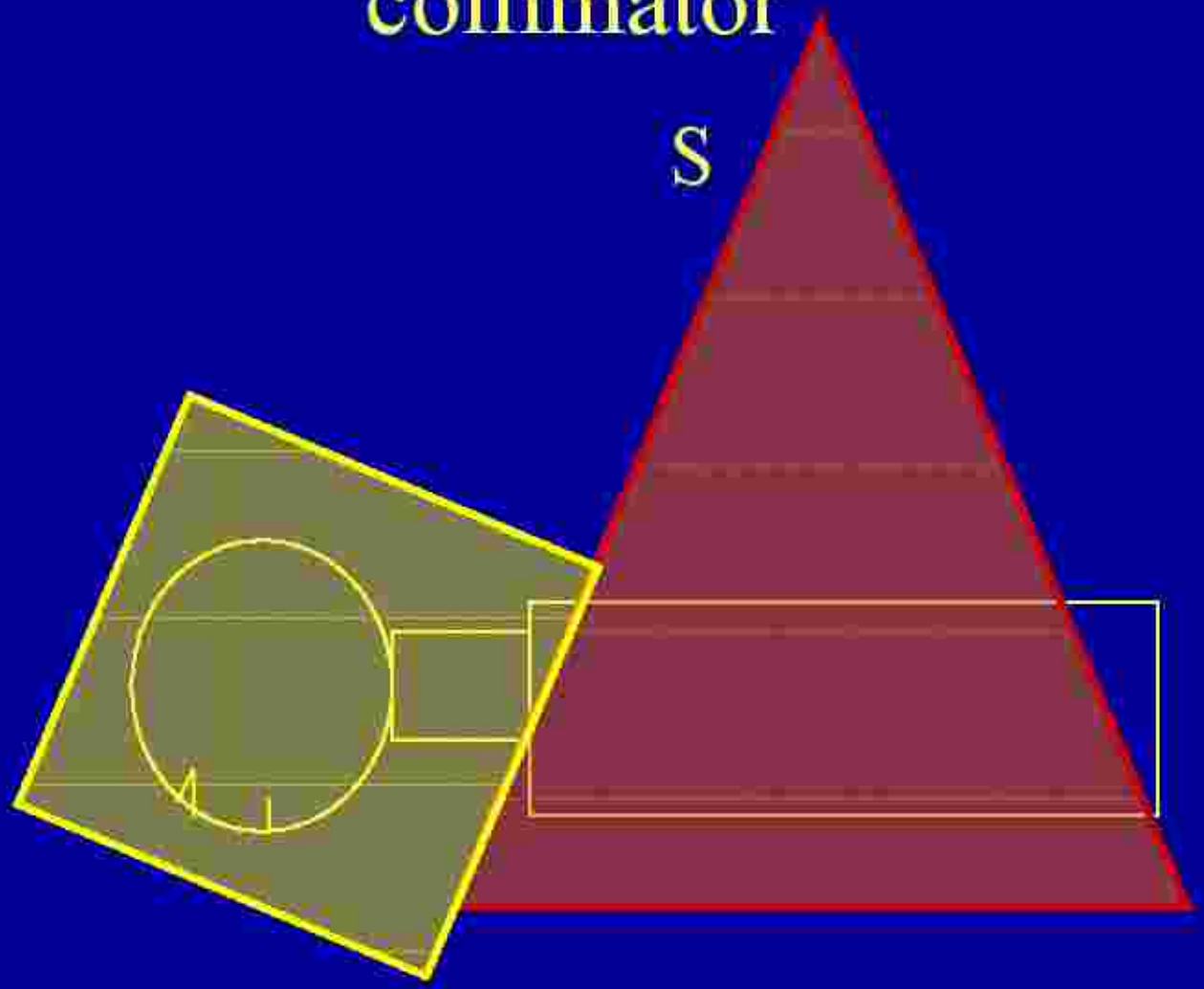
Solution B: Asymmetric block



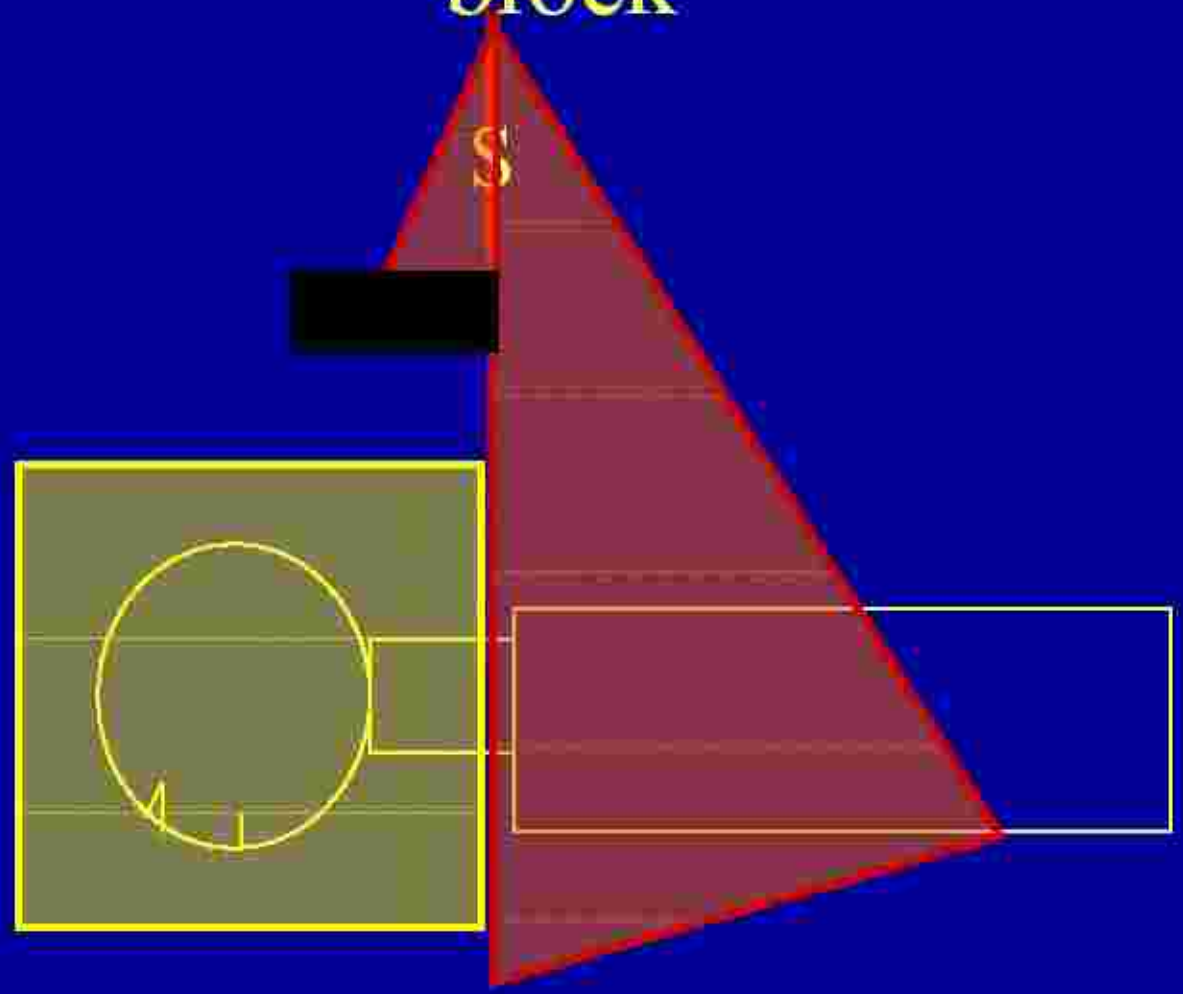
Problem 2 Divergence of spinal field



Solution A: Rotate the cranial field collimator



Solution B: Use asymmetric spinal block



Simulation-cranial field

- In practice 5 mm gap left in the cranial and spinal fields.
- Cranial field Collimator angle = $\tan^{-1}\{ \frac{1}{2} L_1/SSD\}$ L_1 is spinal field length.
- Couch angle = $\tan^{-1}\{ \frac{1}{2} L_2/SAD\}$

  L_2 is cranial field length.
- Use of asymmetric collimator jaws precludes the need of couch rotation.

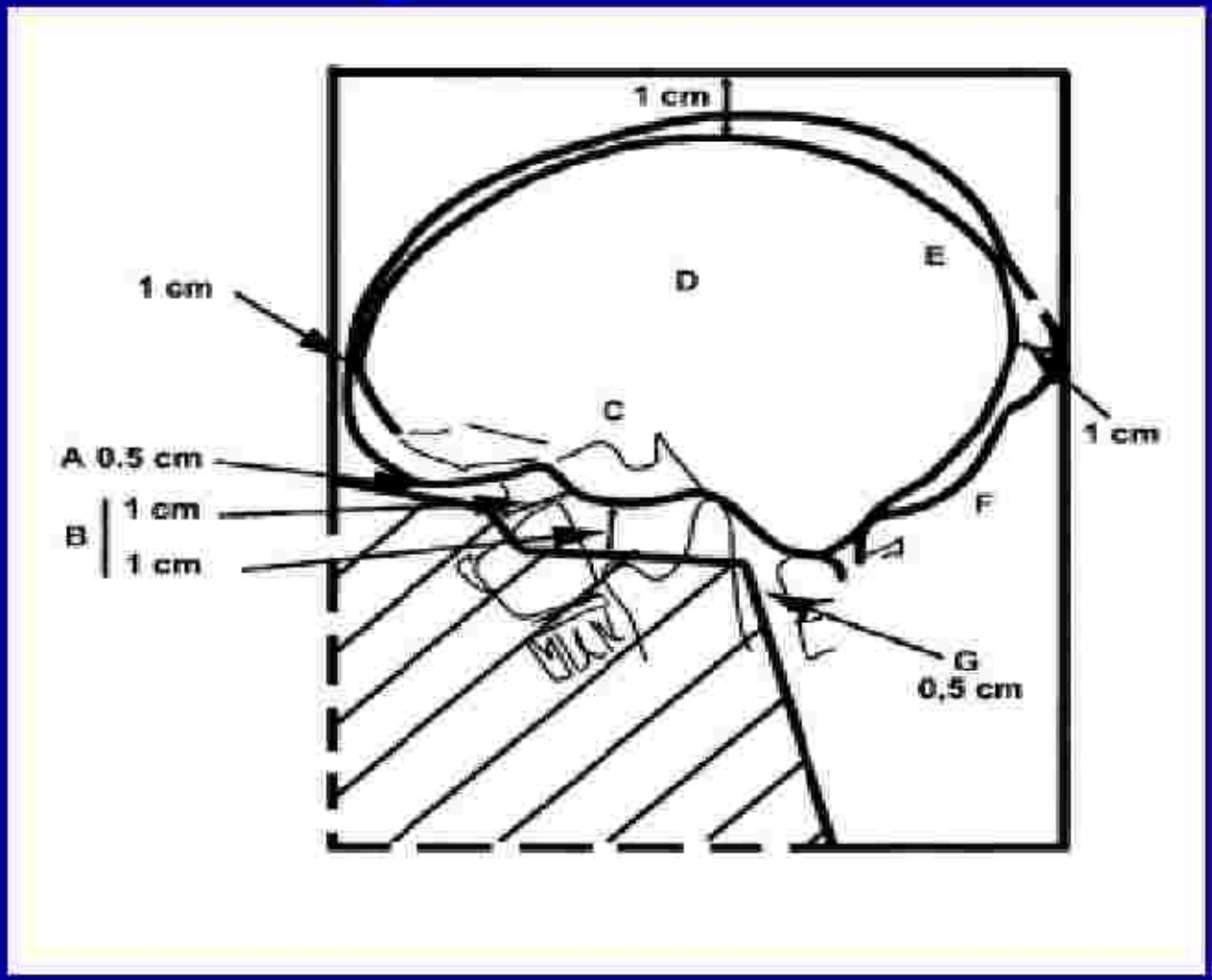
Shielding

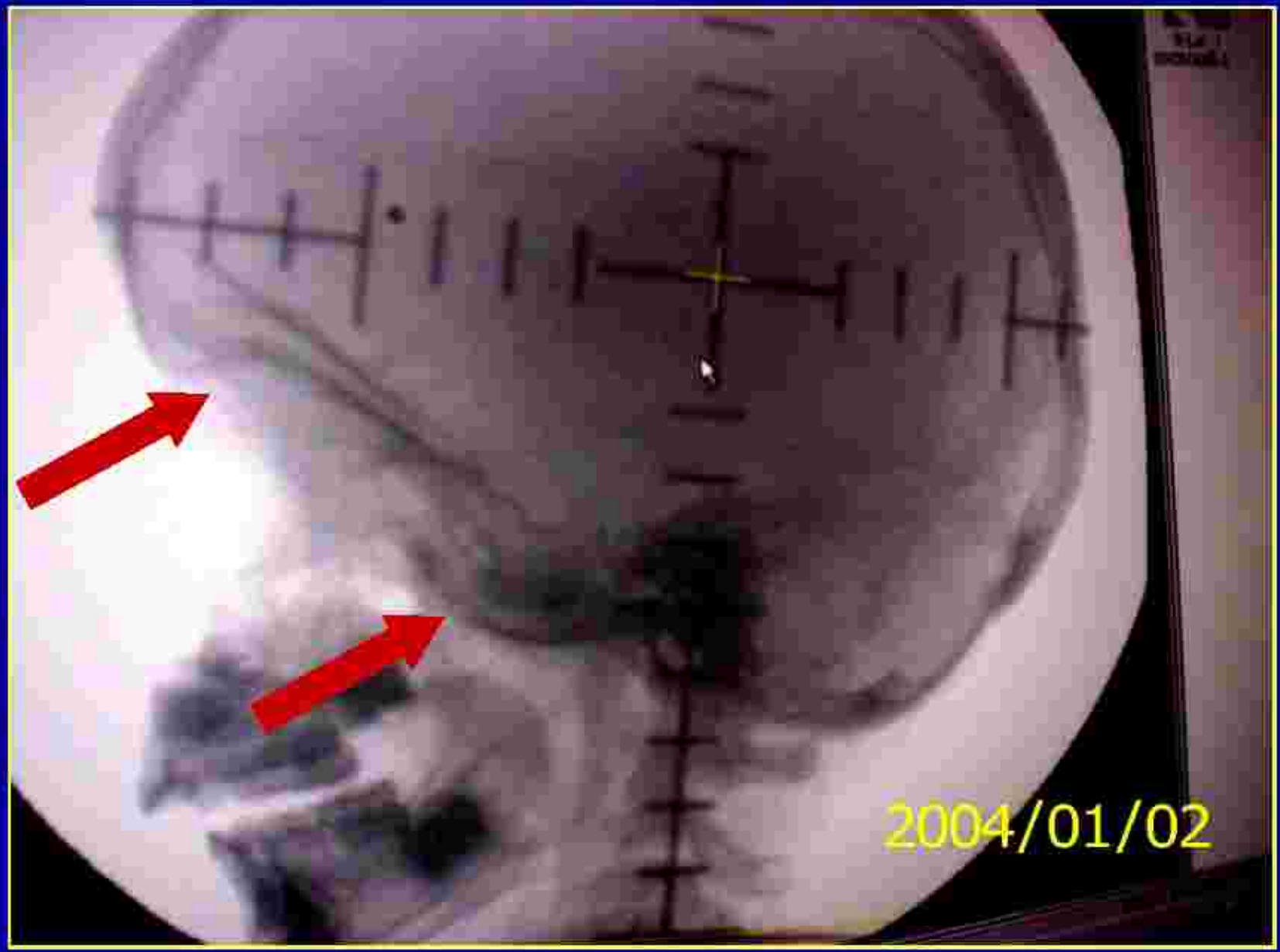
More important is what not to shield !

DO NOT SHIELD

- Frontal (cribriform plate)
- Temporal region

SFOP (French society Paediatric Oncology) guidelines

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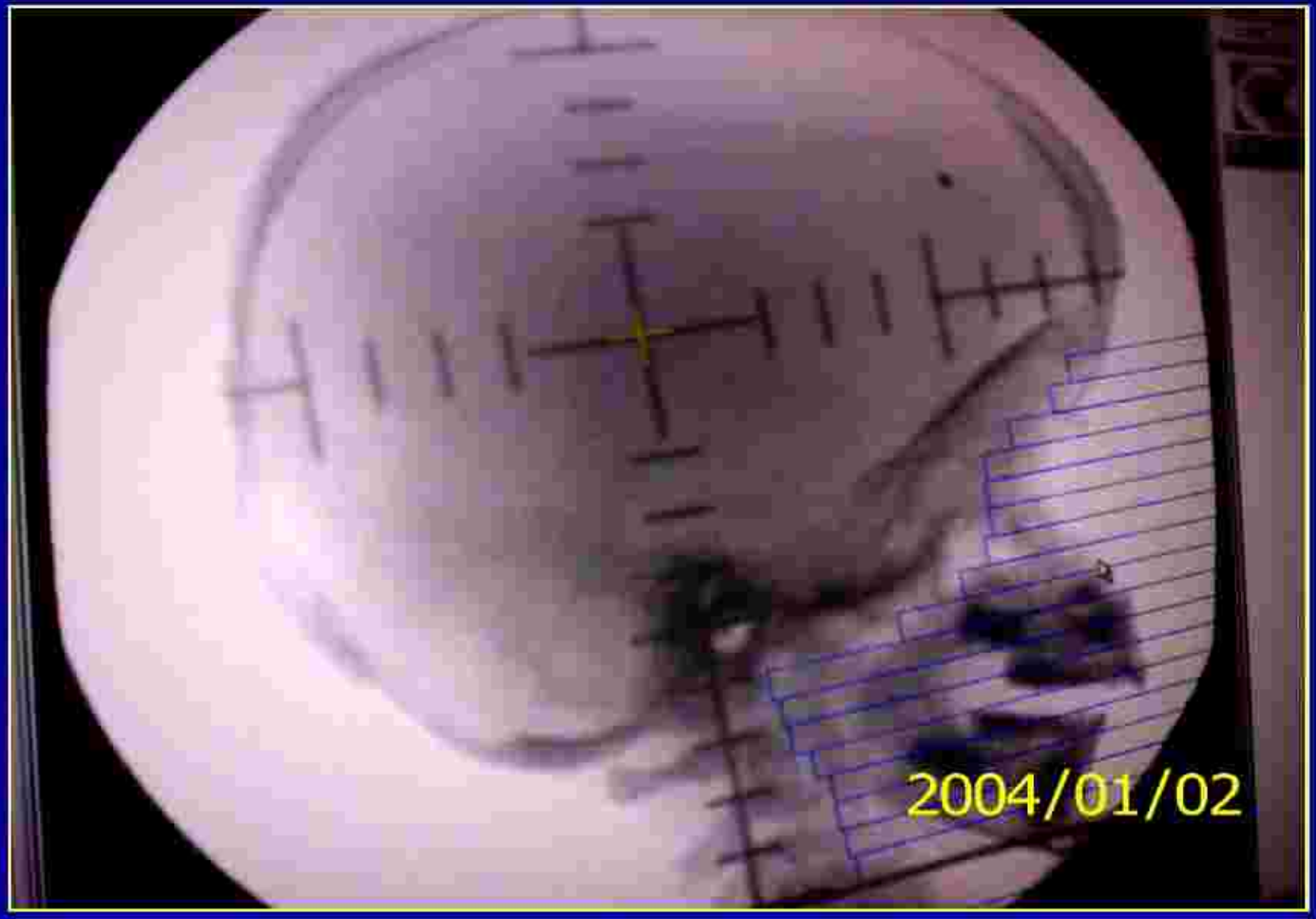

2004/01/02

Treatment & verification

- Port films after placing radio-opaque markers on the inferior border of cranial field can be used to verify craniospinal field matching.
- Electronic portal imaging has also played important role in verification & correction of set up errors.

Moving Junction in CSI

- 5mm overlap at 4mv photons 30 to 40% overdose(14Gy for 36Gy prescribed dose) which may exceed cord tolerance

  (Hopulka, 1993, IJROBP).

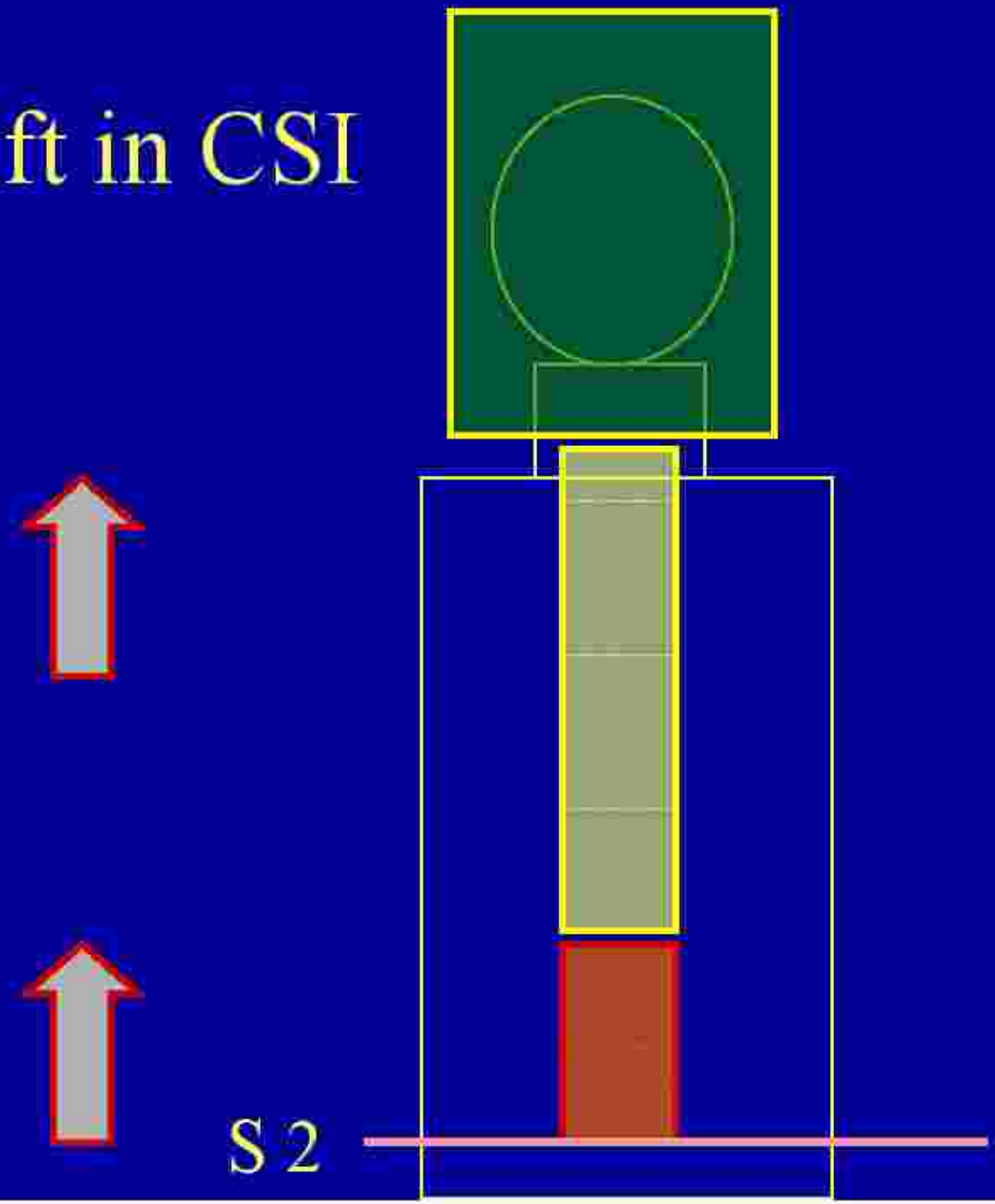
- Systematic error during radiotherapy delivery could further lead to an overlap or gap.
- Feathering after every 5 to 7 fraction smoothesout any overdose or underdose over a longer segment of cord

Moving junction/feathering

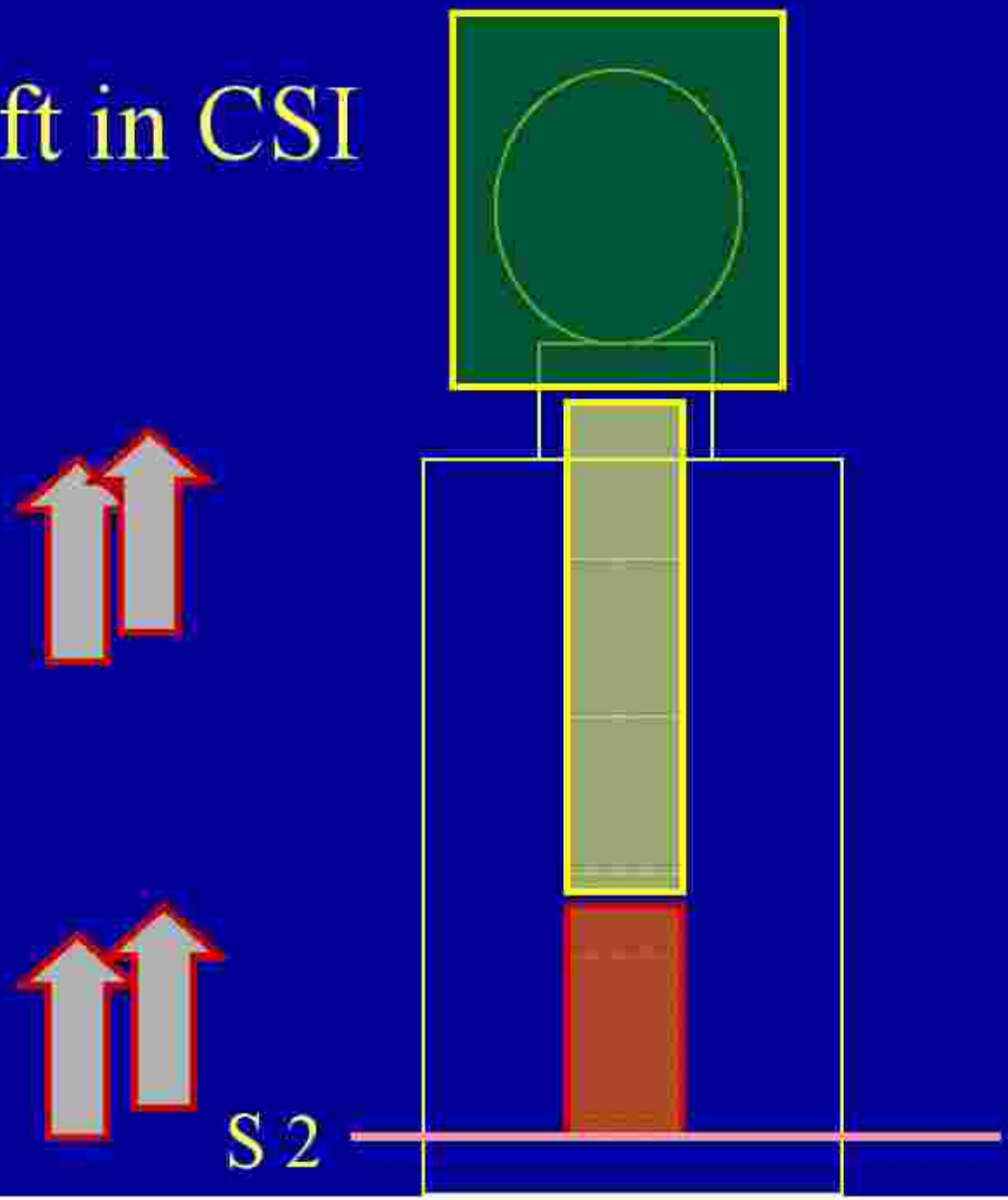
Advantage:

Feathering after every 5 to 7 fraction smoothes out any overdose or underdose over a longer segment of cord.

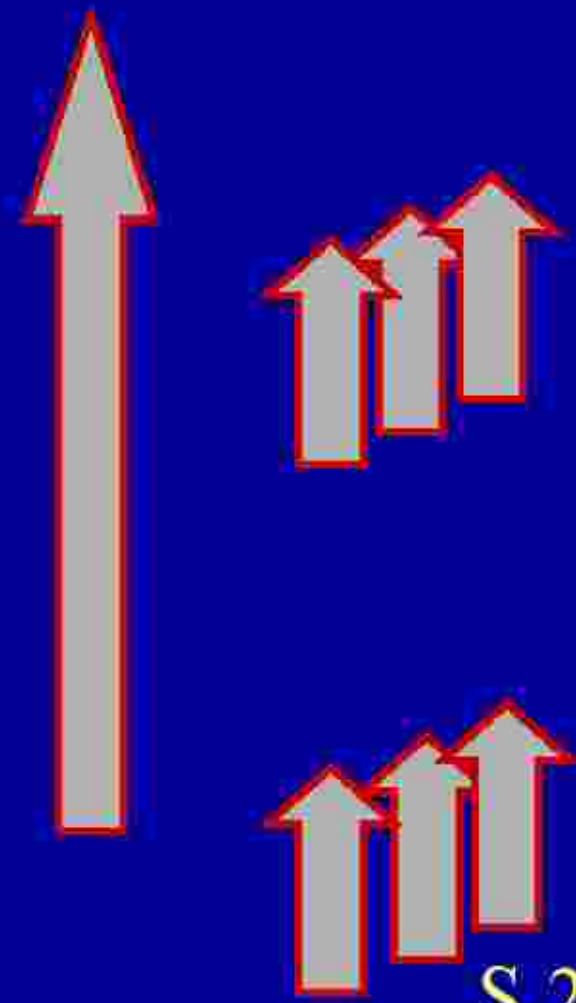
Junction shift in CSI

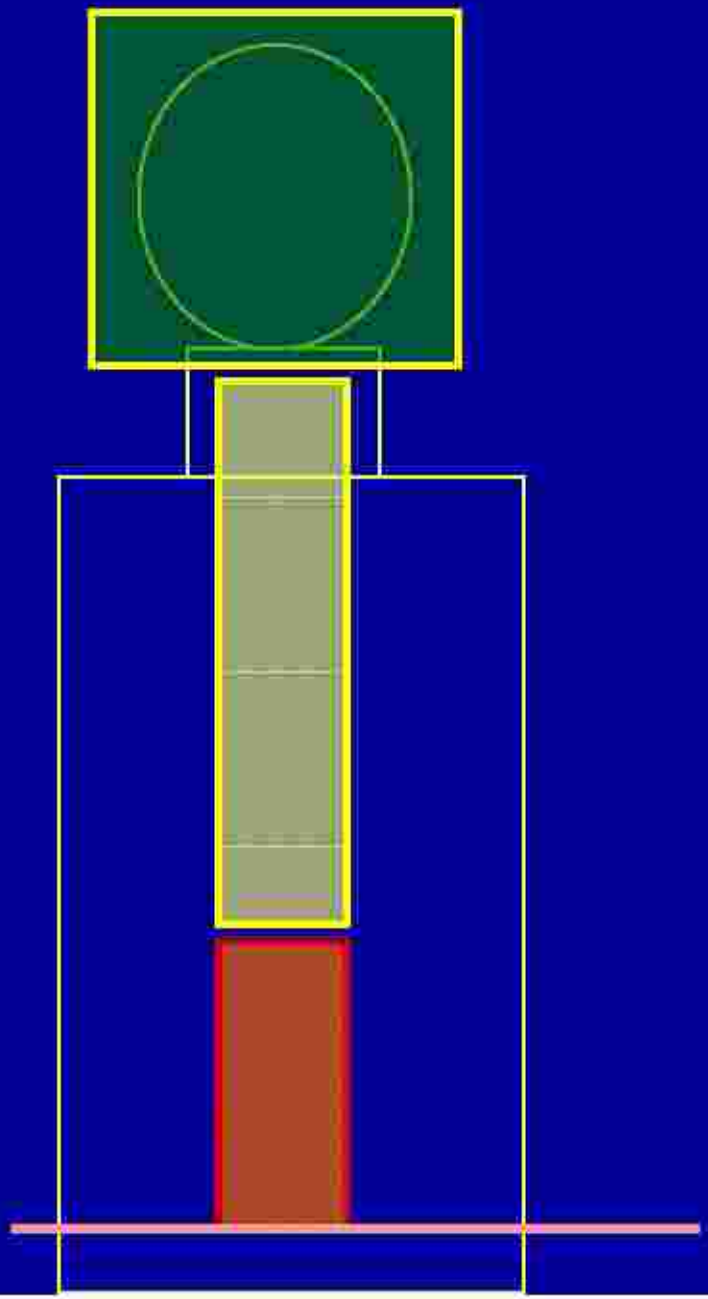


Junction shift in CSI



Junction shift in CSI





S 2

Junction shift

- Usually shifted by 1 to 2 cm at each shift
- Done every few fractions(every 7# at our center).
- Either in cranially or caudal direction.
- Cranial inferior collimator is closed & spinal superior collimator is advanced by the same distance superiorly (if junction to be shifted cranially).
- Similarly, lower border of superior spinal field & superior border of inferior spinal field are also shifted superiorly, maintaining the calculated gap between them.

Posterior fossa boost

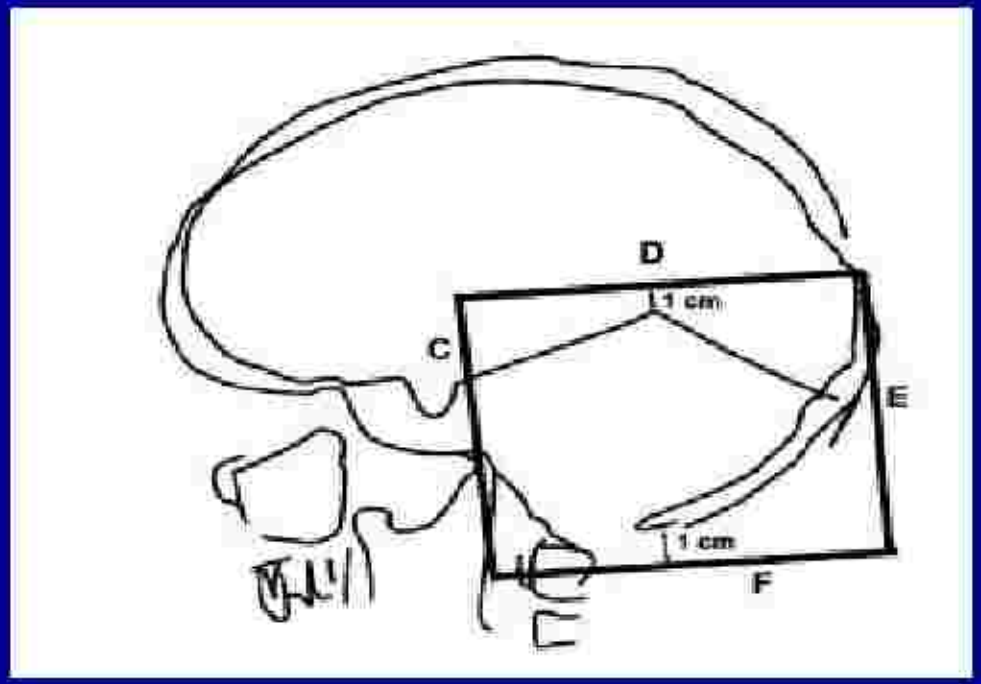
Borders

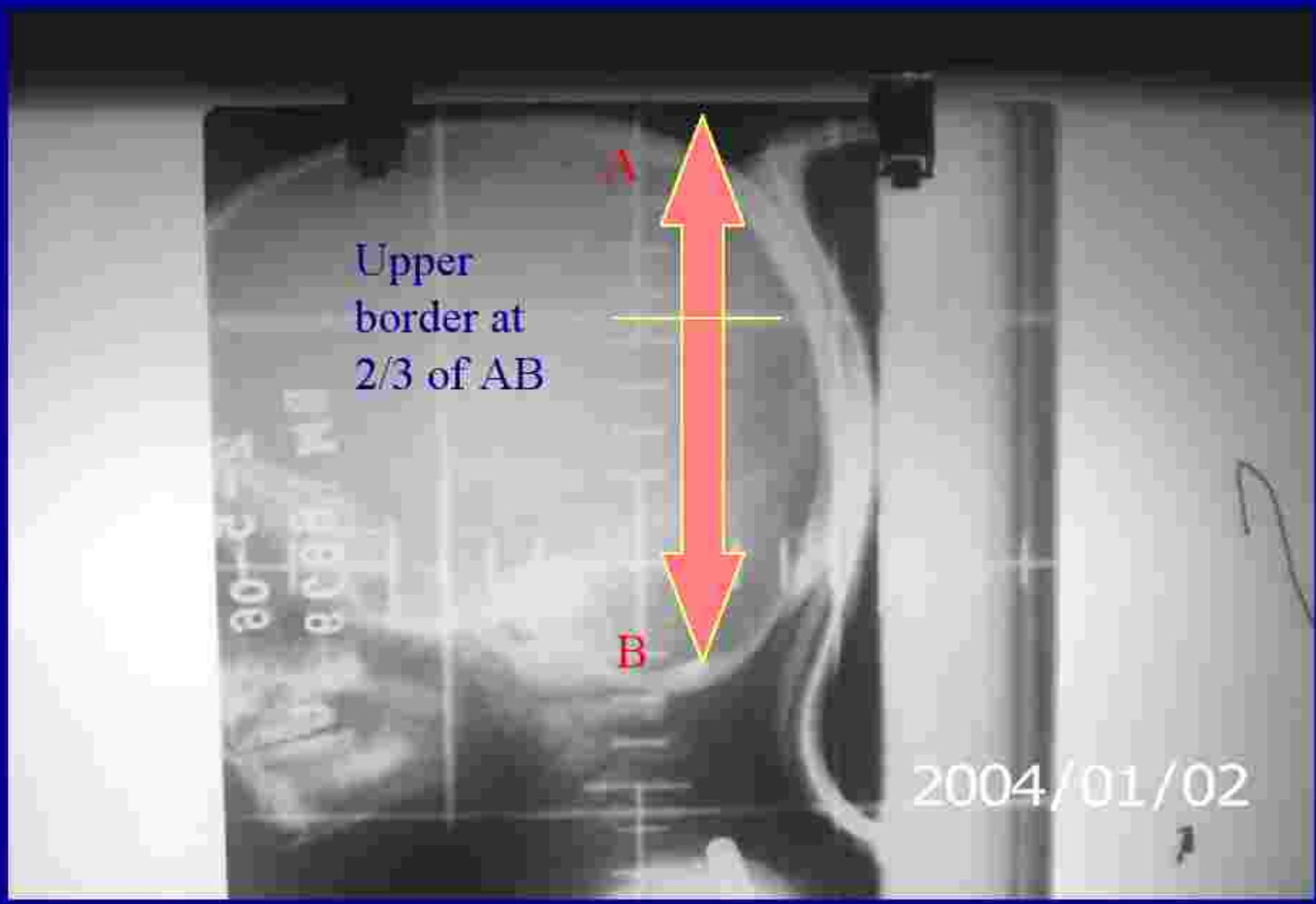
- Anterior: Posterior clinoid process.
- Posterior: Internal occipital protuberance.
- Inferior: C2-C3 interspace.
- Superior: Midpoint of foramen magnum & vertex or 1 cm above the tentorium (as seen on MRI).

Field arrangement

- Two lateral opposing fields.
- 3DCRT boost to the preop tumor bed with appropriate margins is being studied.

SFOP guidelines




A
Upper
border at
2/3 of AB
B
2004/01/02

Dose prescription

Dose	Medulloblastoma
CSI	35Gy/21#
PF boost	19.8Gy/11#

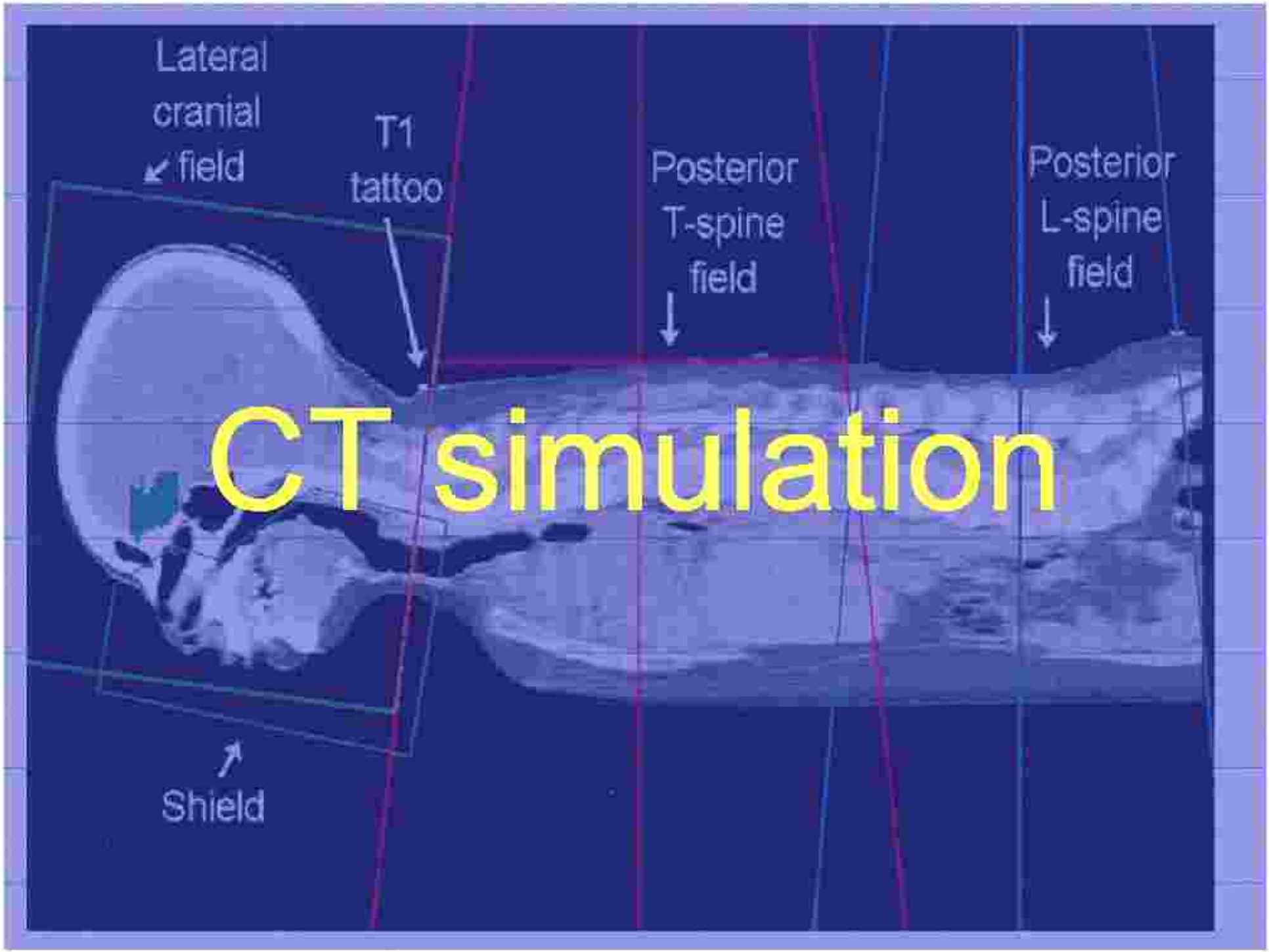
Dose prescibed at mid separation for the cranial fields

Determined by the MRI for the spinal fields

Junction shift every 7 fractions

Technical beam parameters

- Photons: 4 to 6mv produce good dose homogeneity
- Cranial field - prescribed at midplane SSD
- Spinal field - 5 to 6cm along central axis depending on depth of spinal cord at SSD (posterior vertebral body seen on Lateral X rays / CT scan / MRI).


Lateral cranial field
T1 tattoo
Posterior T-spine field
Posterior L-spine field
CT simulation
Shield

CT simulation

- Ability to virtually simulate, thereby minimizing the time a patient must remain immobilized.
- Better definition of critical organs (spinal cord) and target volume (cribriform plate)
- Graphical overlays of anatomic CT data onto digitally reconstructed radiographs (DRRs) - improves field placement, shielding accuracy & direct calculation of gap between the fields.

Steps in CT simulation

- Patient positioned using all ancillary devices and the spinal columns aligned with the sagittal external laser.
- Three-point reference marks drawn on the mask in a transverse plane at the center of the head with the aid of the external lasers.
- Two or three reference marks were placed on the posterior skin surface along the spinal column
- Spiral CT images of 3-5 mm thickness are acquired.
- Following image acquisition, all spinal reference marks are tattooed and the patient permitted to leave.
- A total of 130–170 images are reconstructed depending on the patient's height.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*13-Sep-1997
13-Sep-2006
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H-SP
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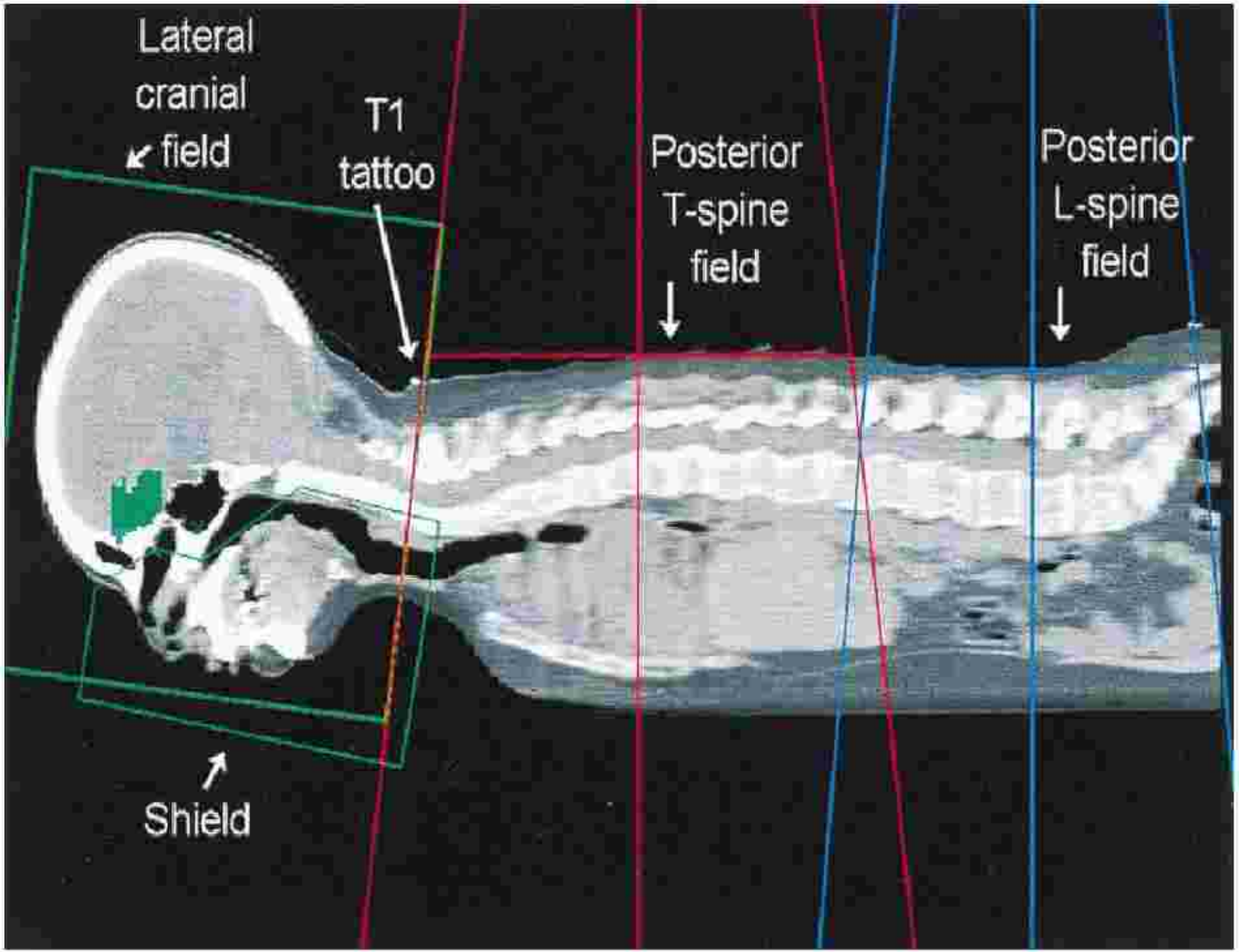
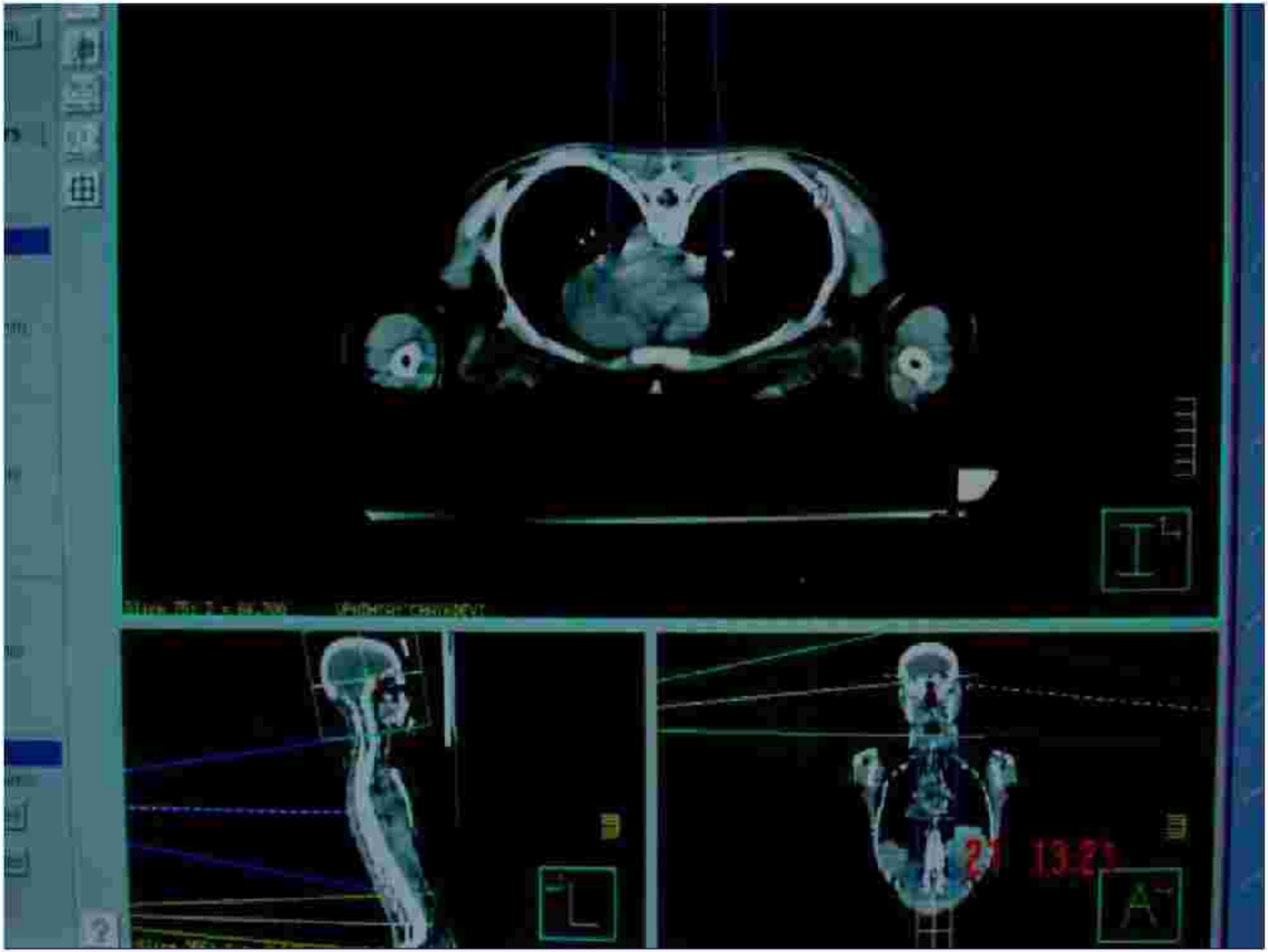
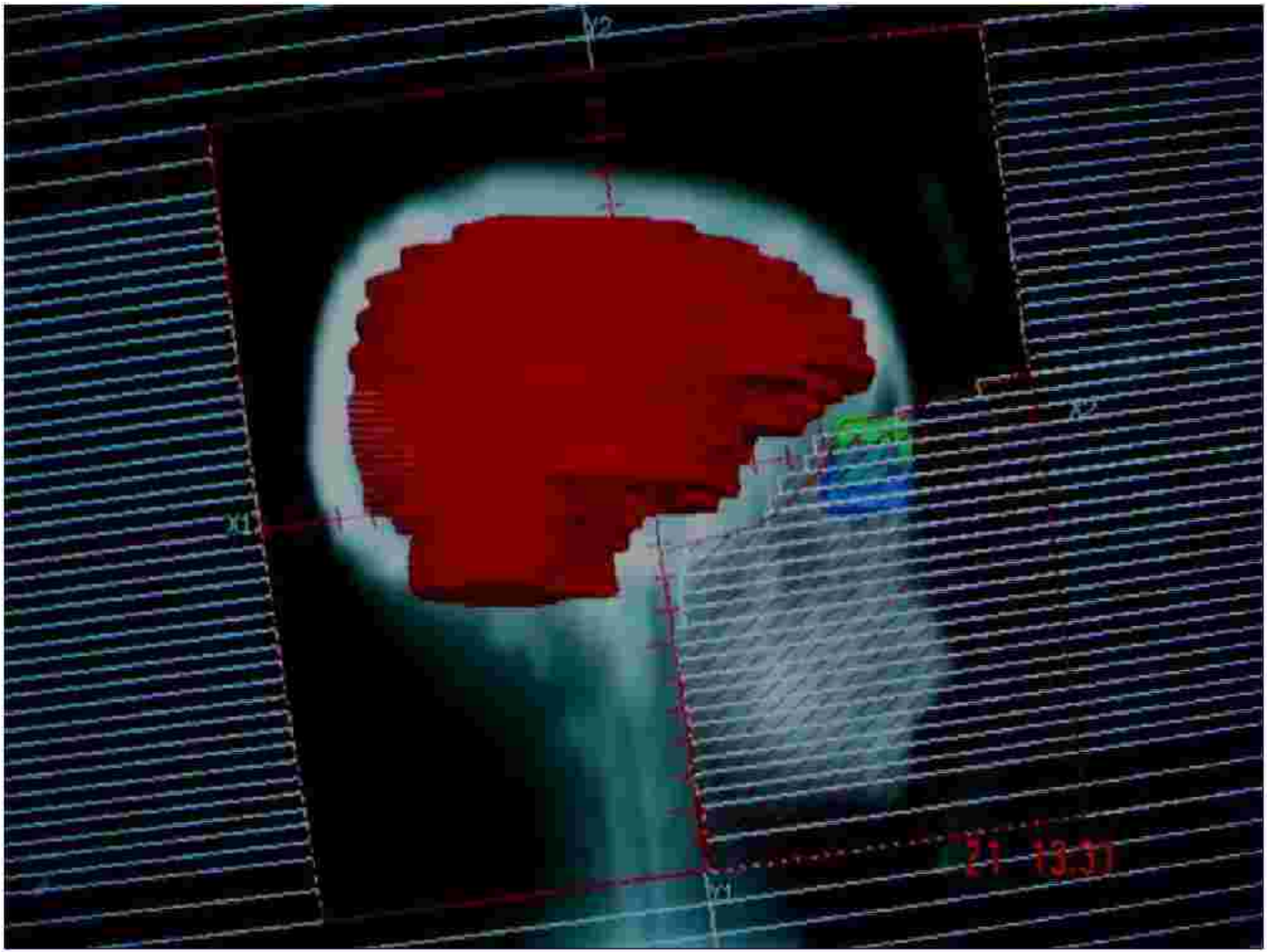
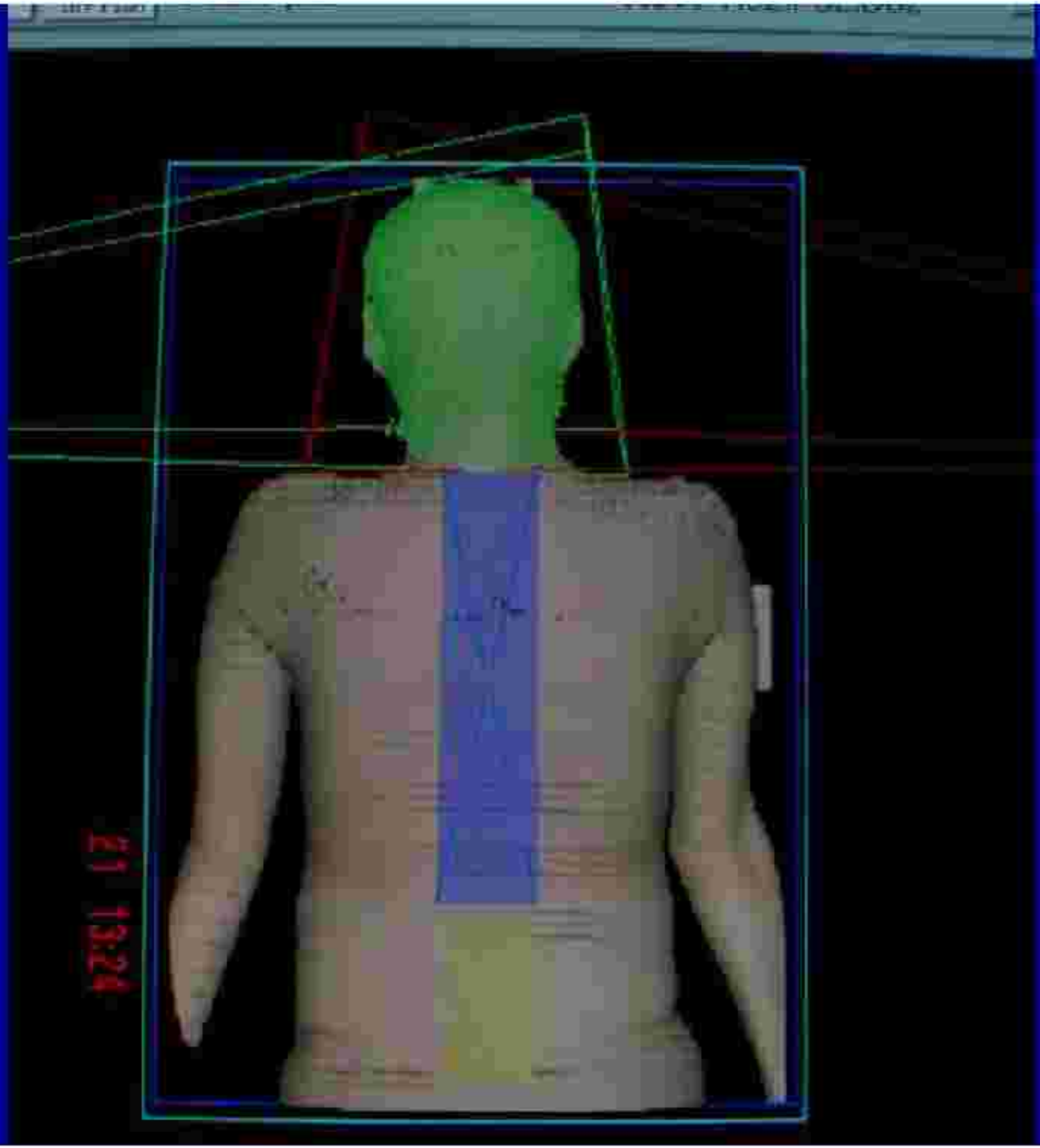
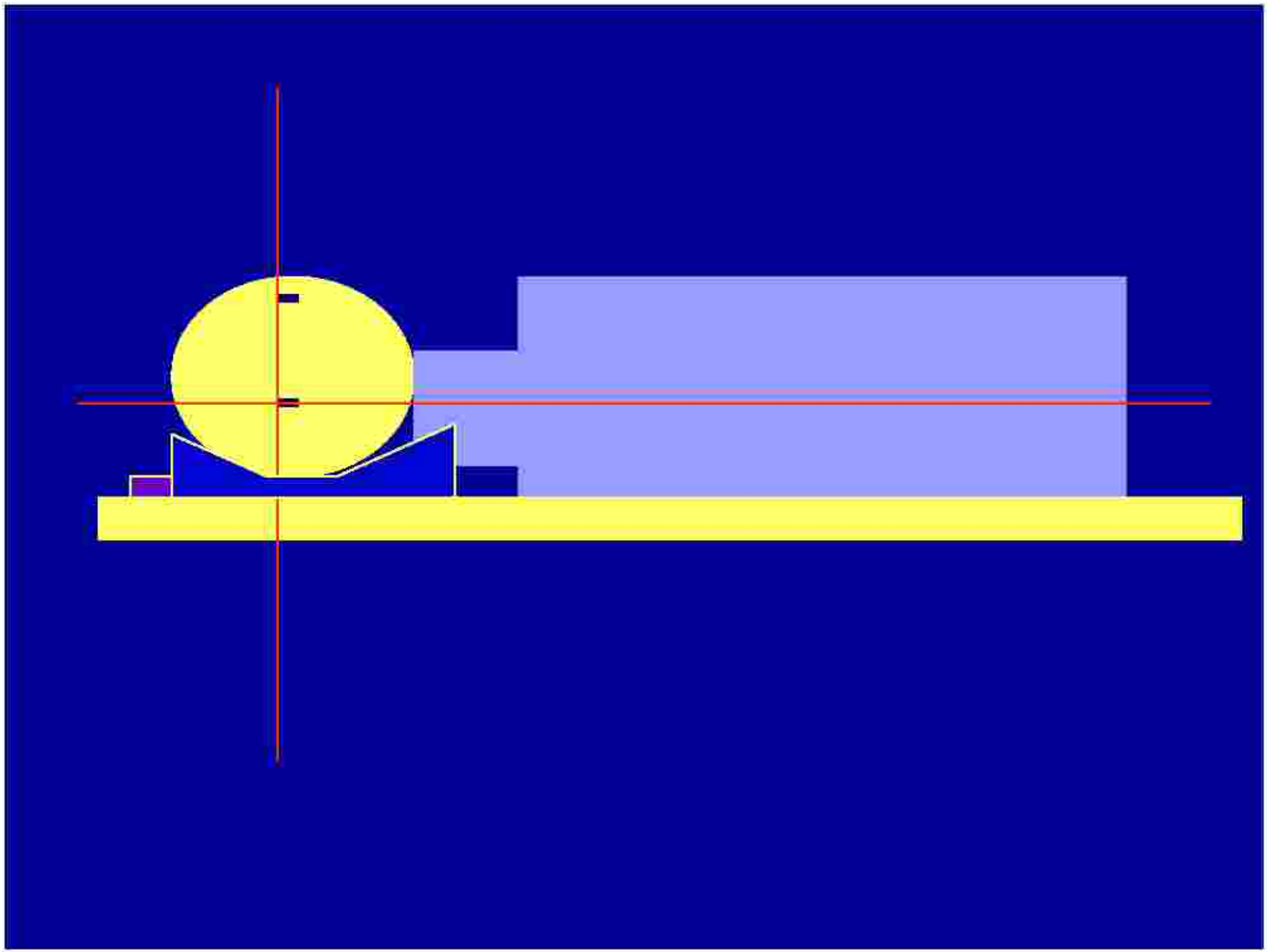
21 13:19

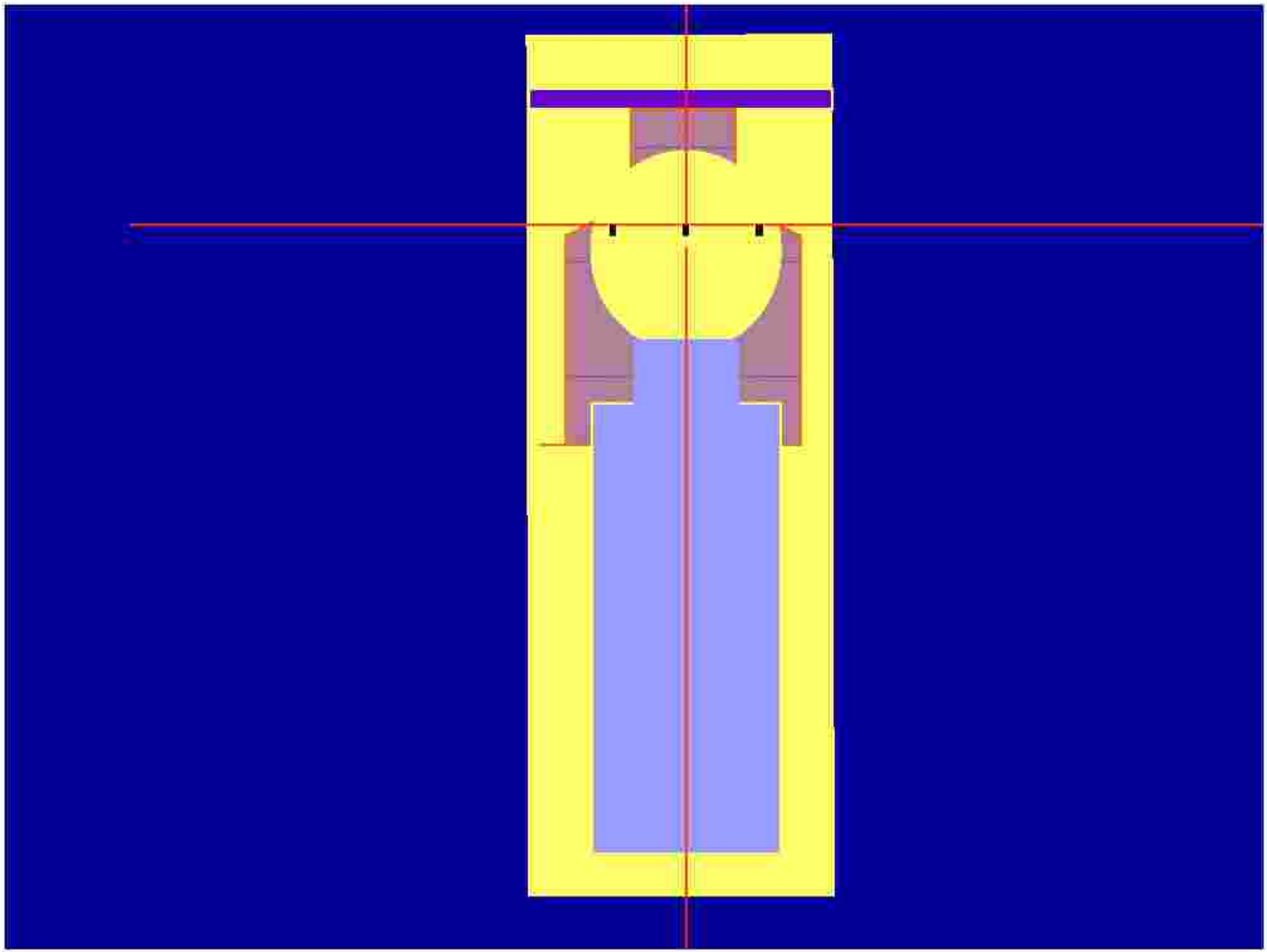

Lateral
cranial
field
T1
tattoo
Posterior
T-spine
field
Posterior
L-spine
field
Shield

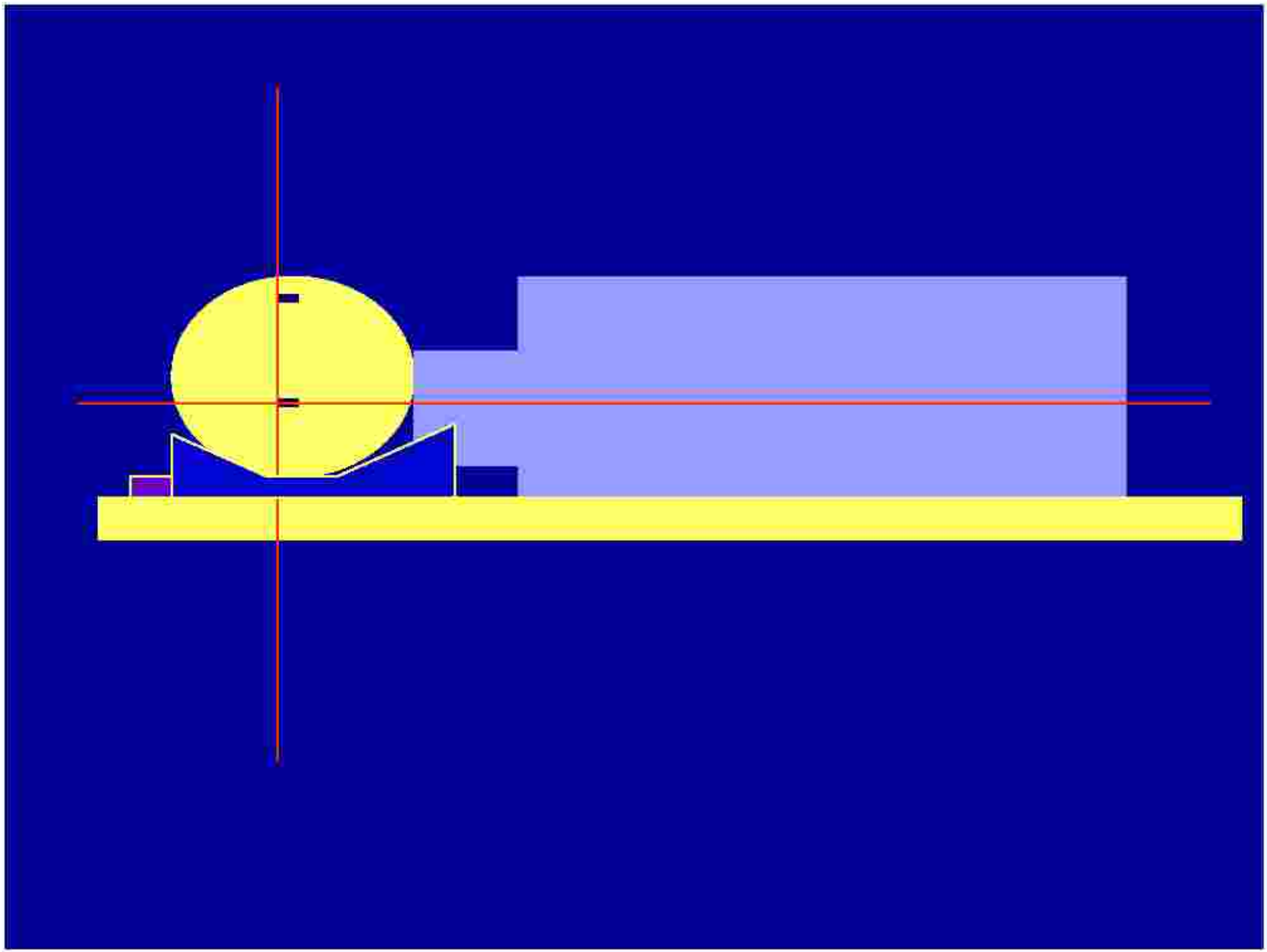


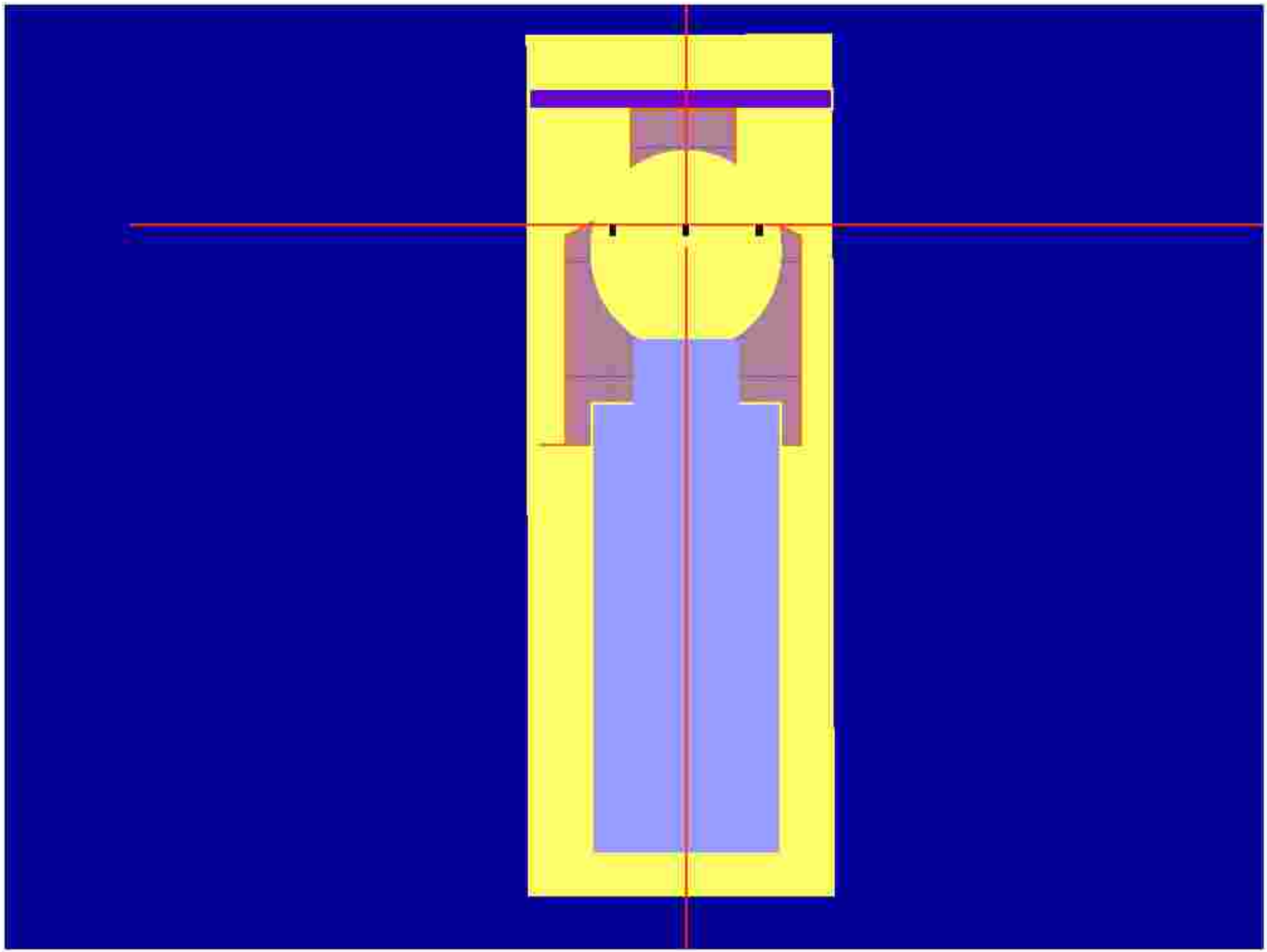



AD 1524









Supine CSI planning
CT based

Individualized CT planning

- Method analogous to conventional simulation but with use of asymmetric collimator jaws for matching beam divergence.
- Field junctions can be visually verified.
- The distance between the two isocenters (three if two spine fields are required) can be calculated once the beams have been set.
- This distance can then be used as the digital longitudinal table distance shift.

CT simulation – fixed field geometry

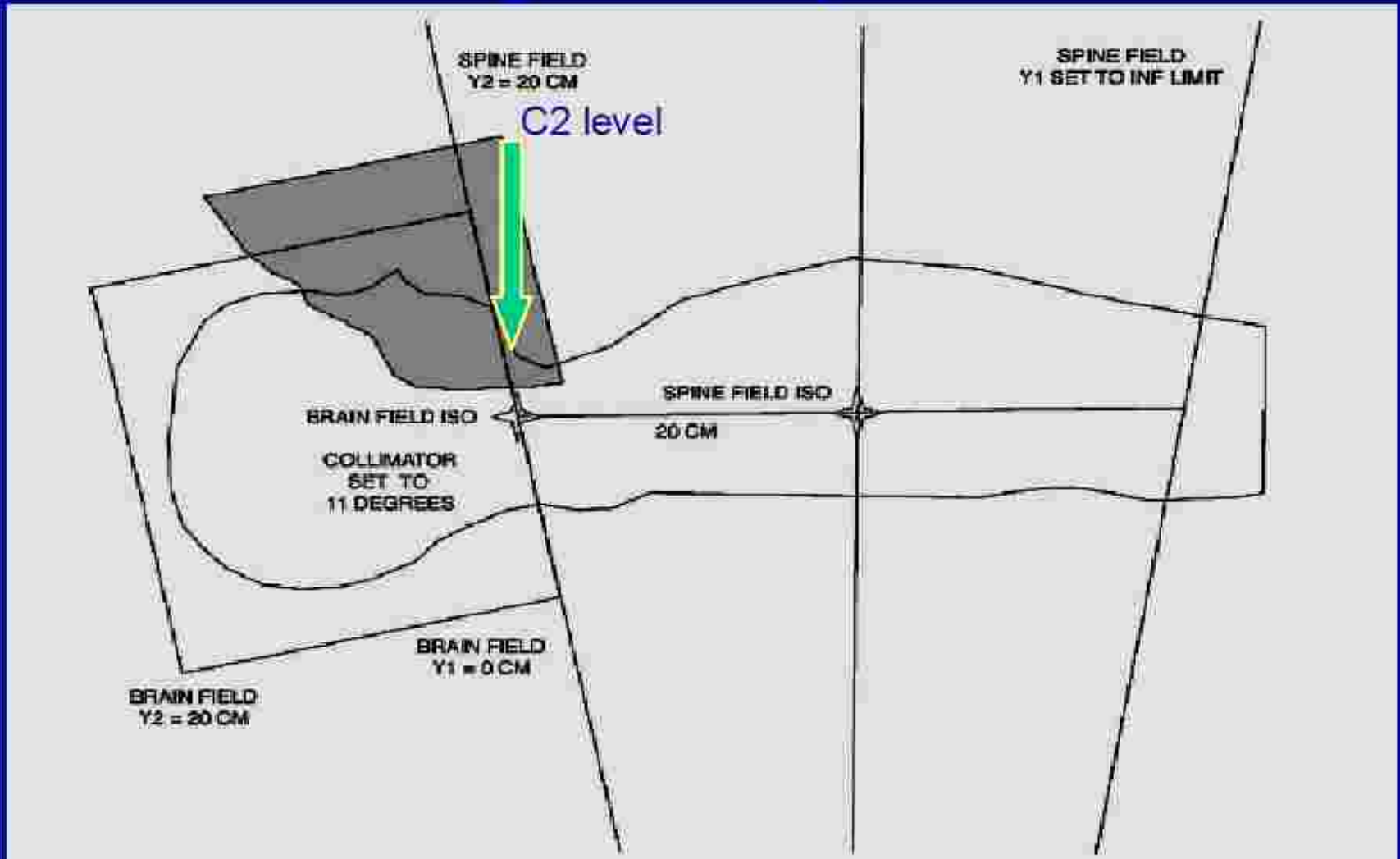
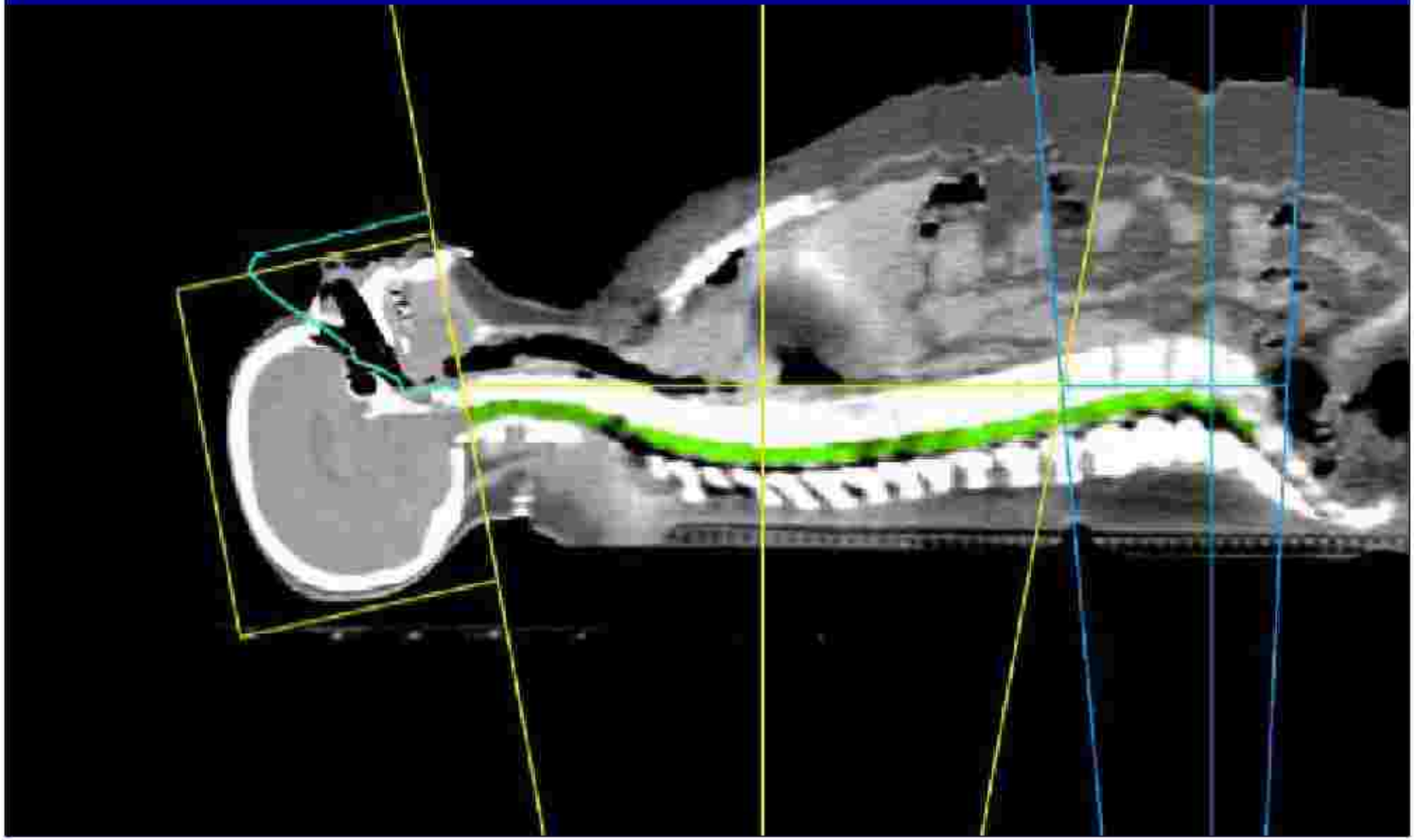


Fig. 1. Schematic diagram of the CSI technique as applied to a supine patient.

Saggital MPR of patient in supine CSI



Supine CSI by conventional simulation-

The TMH technique

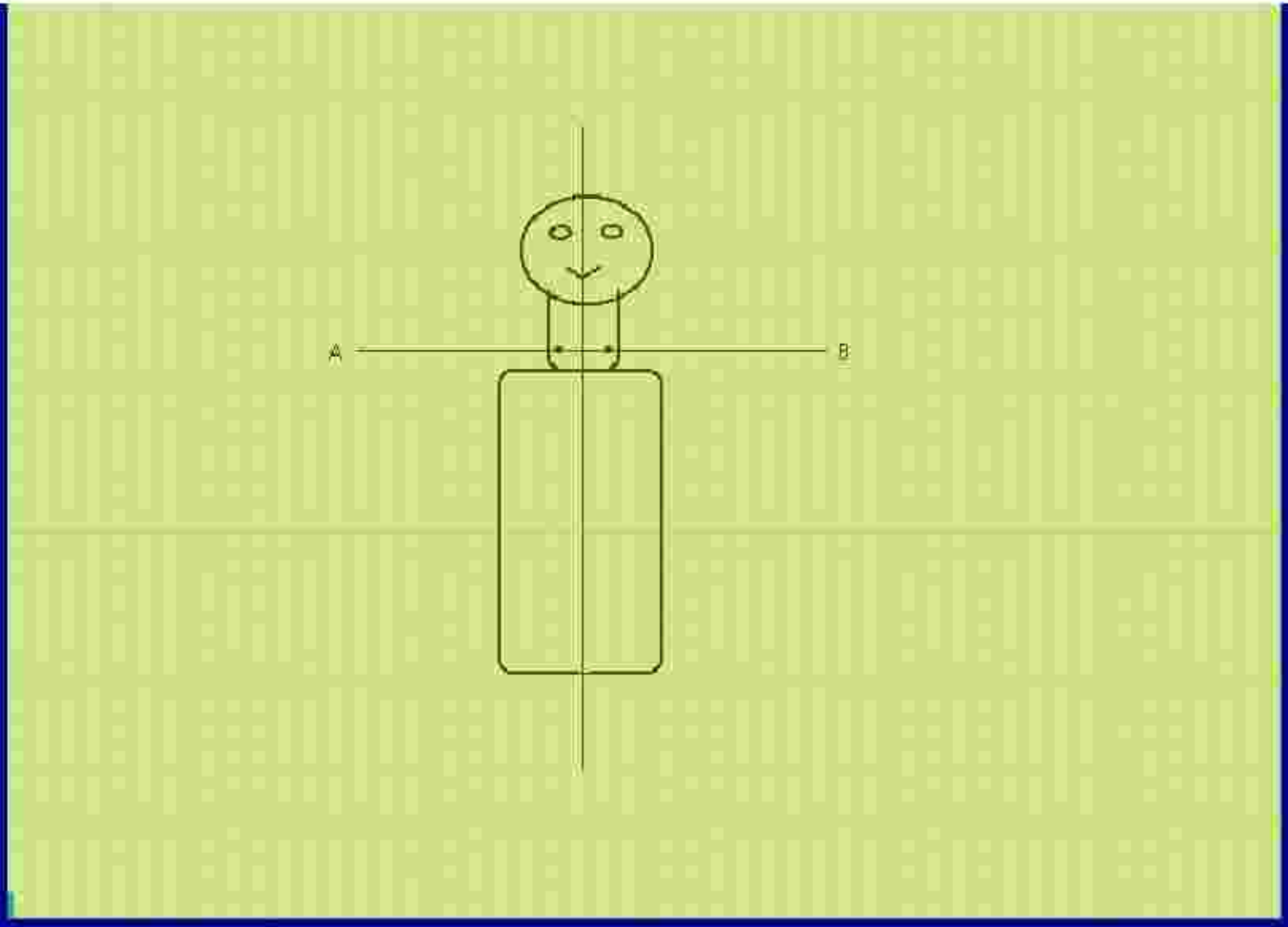
Supine CSI planning - conventional

Positioning:

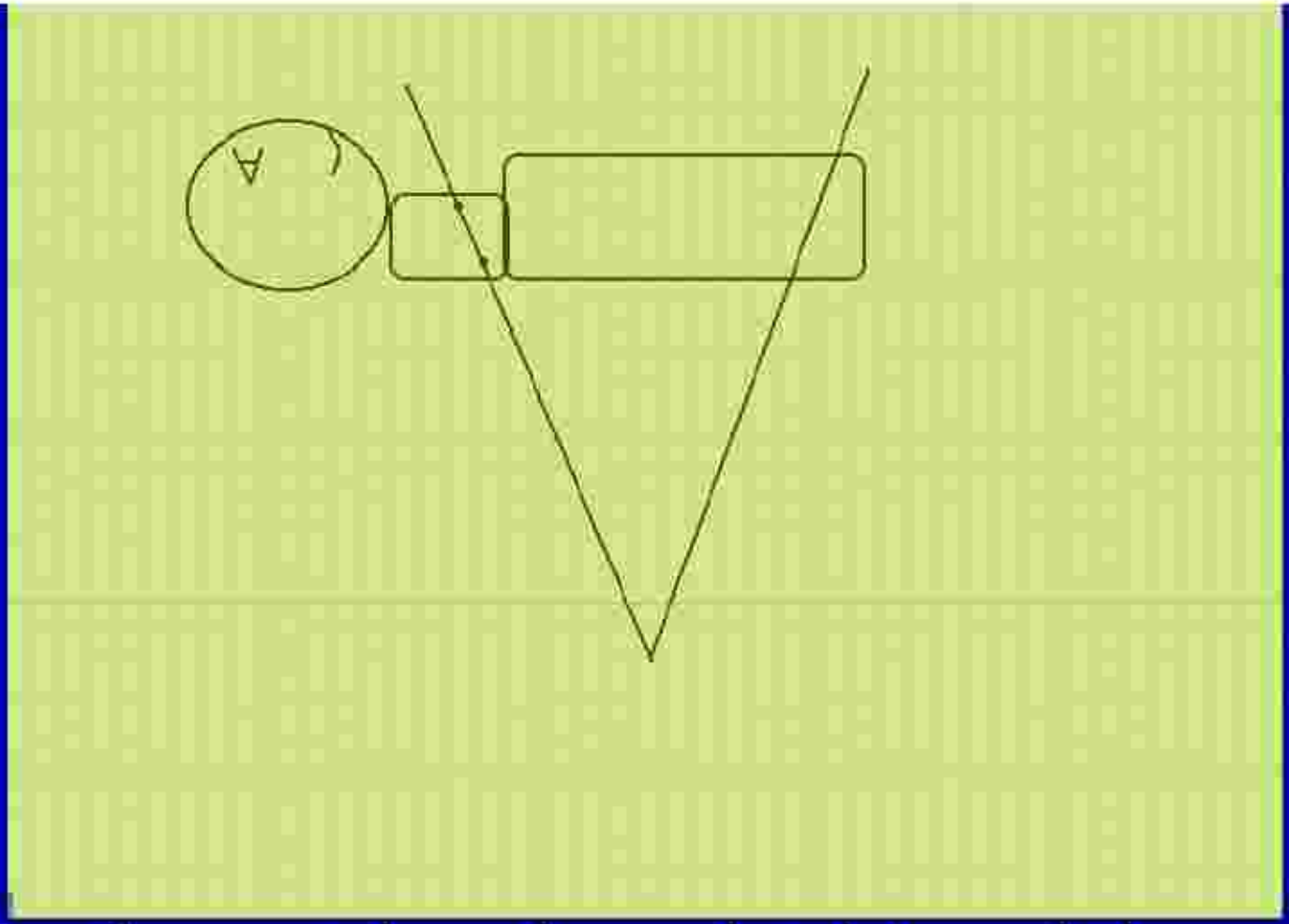
- Supine on NNR with arms by the side of body.
- Check spinal column alignment on fluoroscopy.
- Neck in near neutral position but slightly extended.

Immobilisation:

- Thermoplastic mold for immobilization of face & neck.
- Close fit at the nasion.
- Any constraint for the jaw is removed to facilitate anesthetic maneuvers.

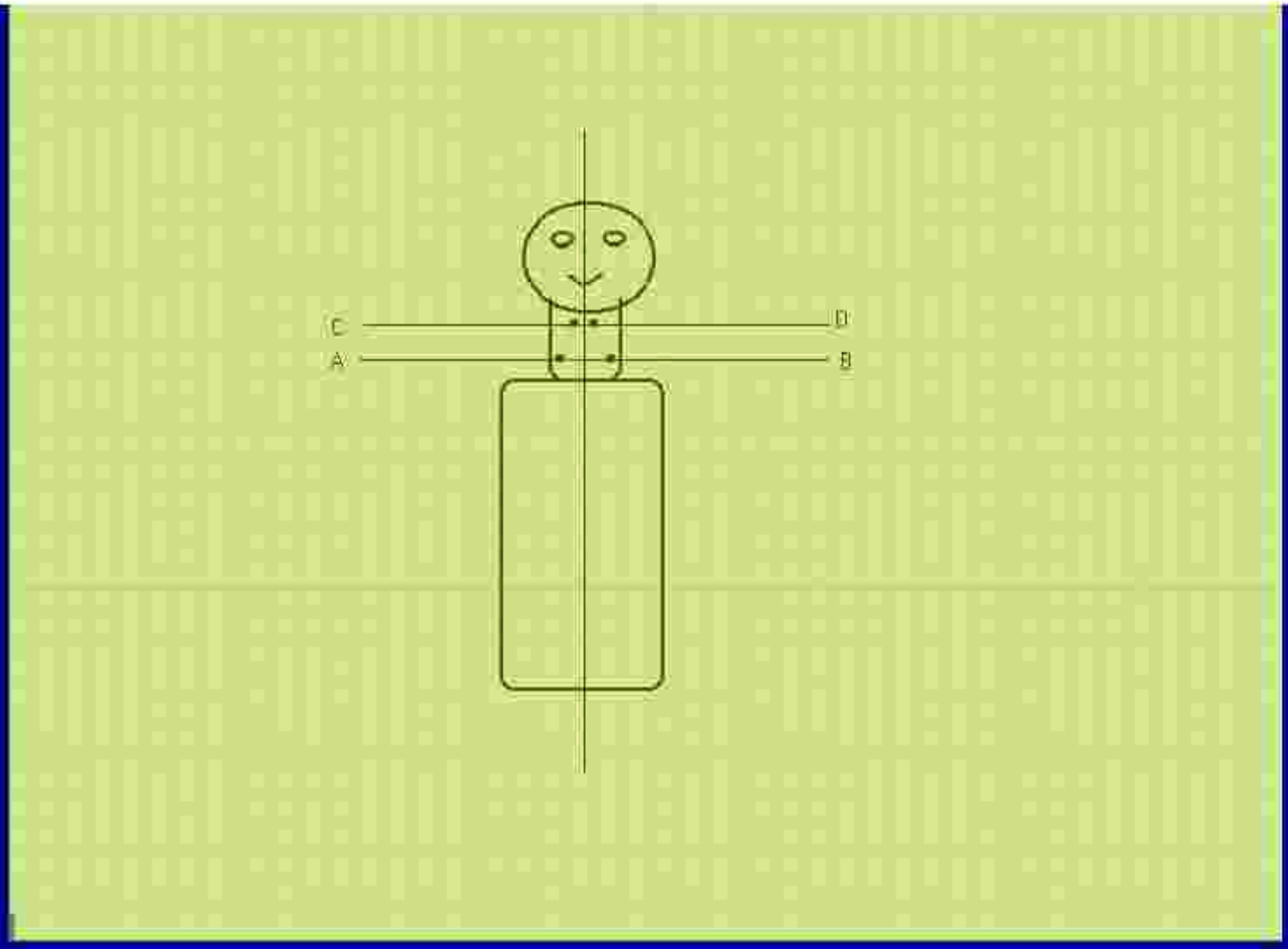


Step 1: Two lead markers by the side of the neck at the same laser level

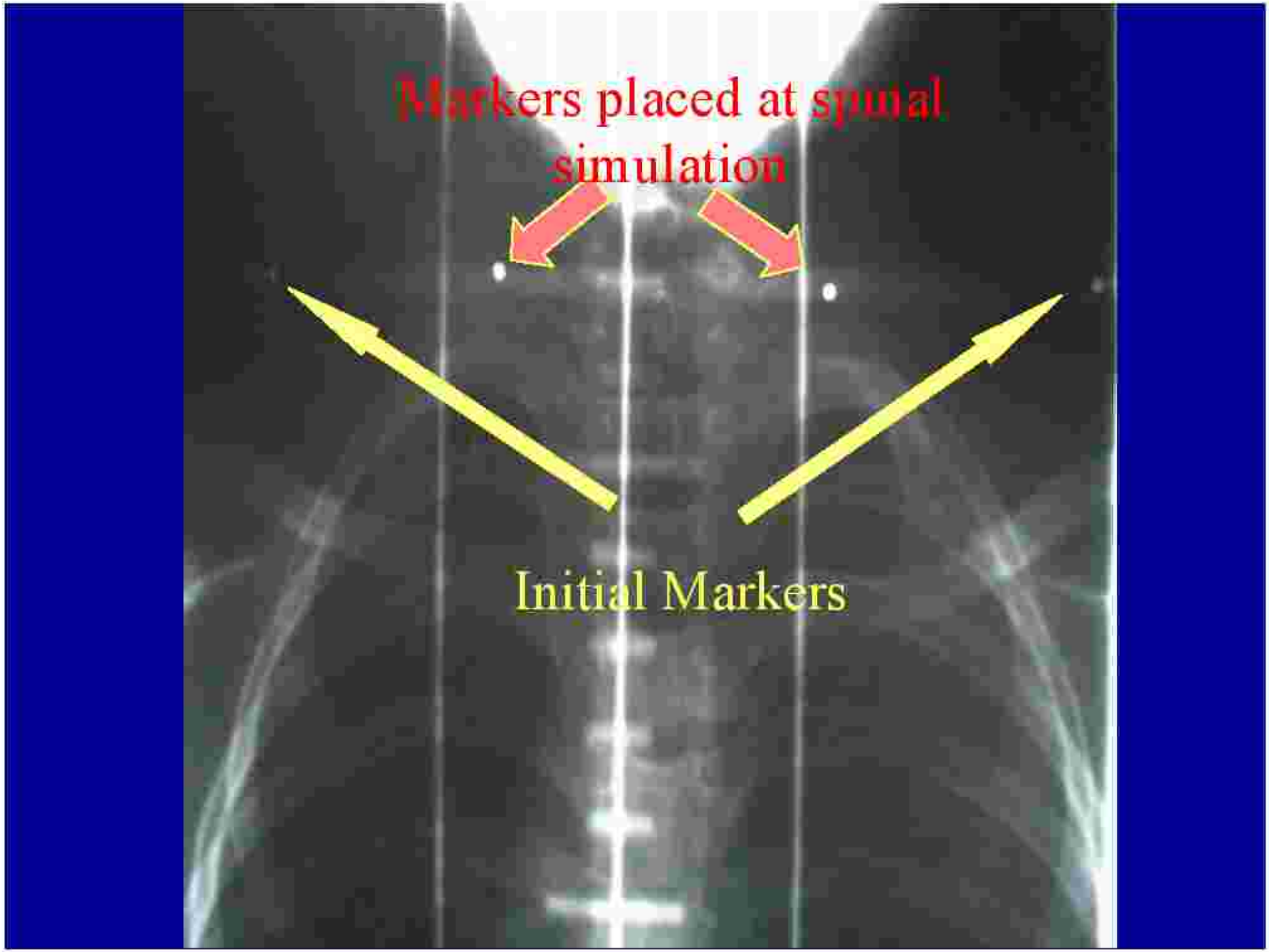


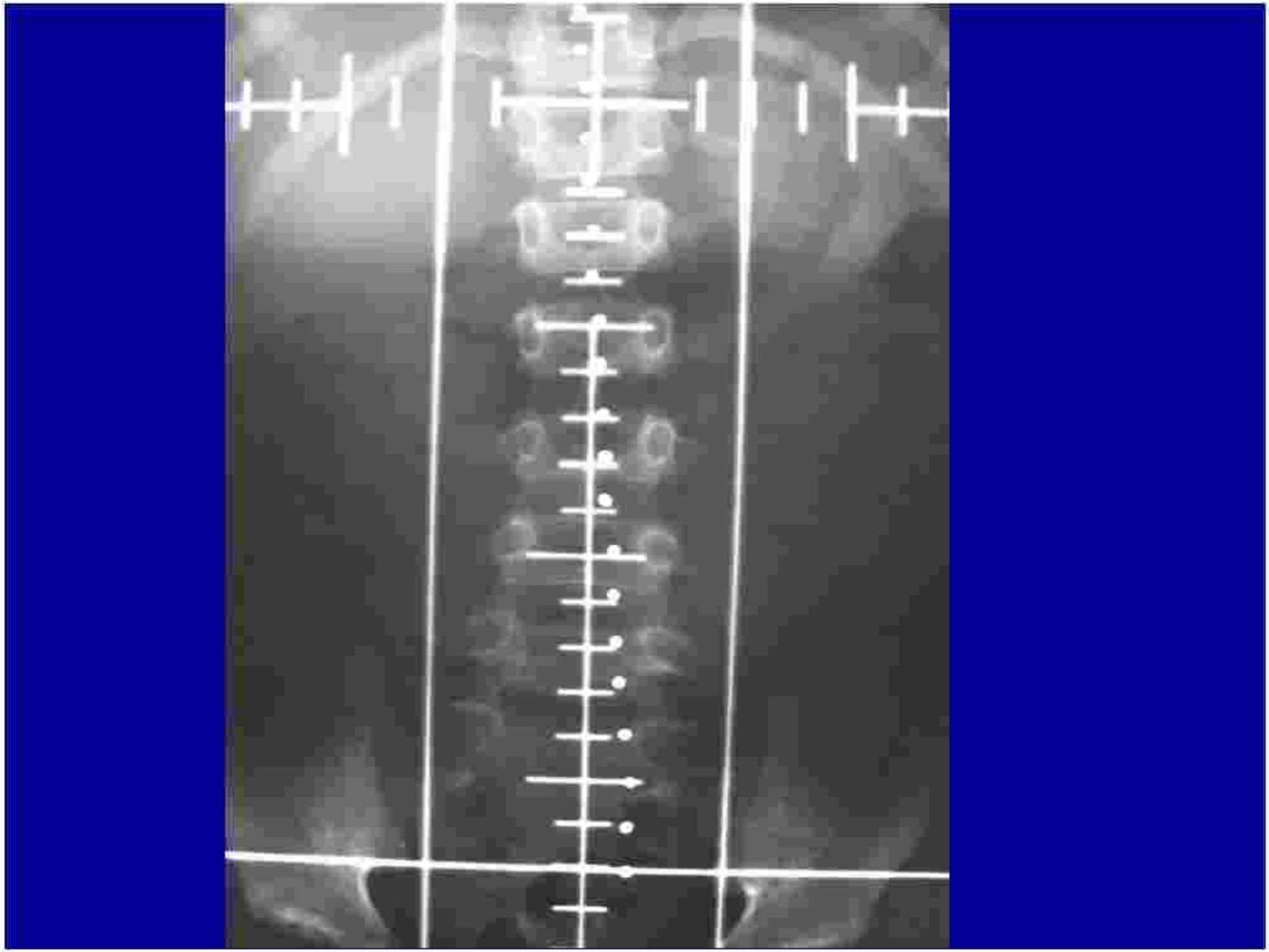
Step 2 : Gantry taken through table and the upper border of spinal field matched with the markers.

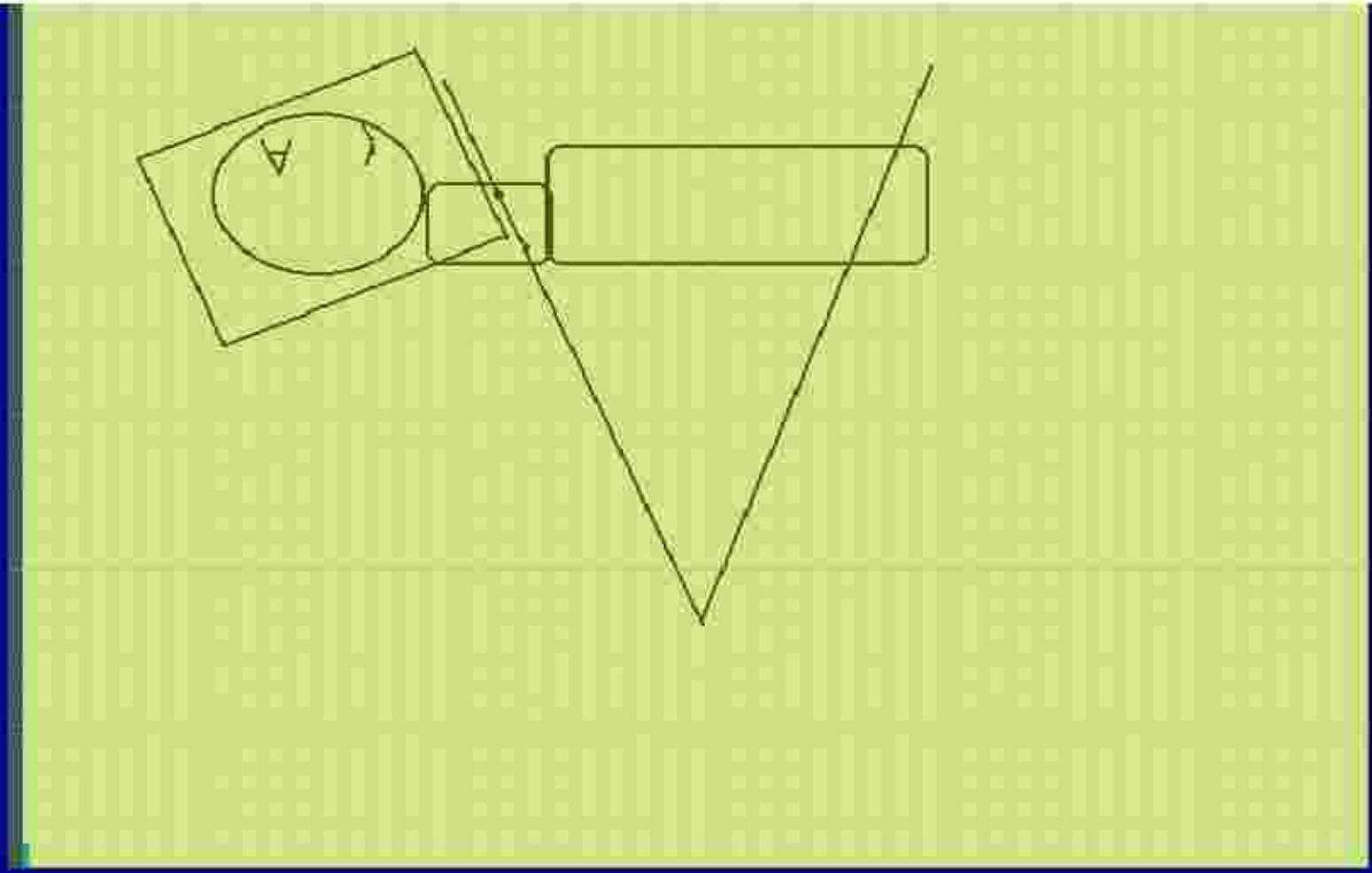
Step 3: Two additional markers placed in the line of upper border



Anterior view of the placement of the markers


Markers placed at spinal simulation
Initial Markers





Step 4: Collimation of the cranial field adjusted according to the line joining the two markers on one side of the neck(which is the divergence of the spinal field)

Thank you