Robotics and Navigation in Medicine

Summer term 2015

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Robotics & Navigation in Medicine

Robotics	Navigation	Clinical Examples
basic principles	calibration	serial kinematics
kinematics	localization	parallel kinematics
paths & trajectories	image guidance	special robots

Robotics and Navigation in Medicine

IMAGE GUIDANCE

Image guidance

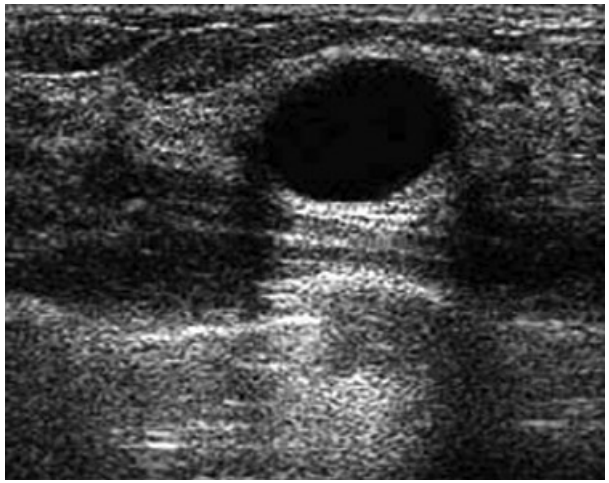
- So far we have considered tracking artificial markers
- Images of the patient (anatomy) can serve as a means for localization and visualization
  - Identify the target region (radiology, tumors, vessels, …)
  - Identify natural landmarks (bones, skull, vertebrae, …)
  - Measure motion and deformation

Image guidance

- A patient is no rigid object with a natural coordinate frame
- While we can easily scan / sense the outer perimeter of a patient, the true regions of interest are often inside
- We need to relate the robot to images of the patient
- Motion and deformation of the patient and the organs is still a challenge!

Image guidance

- Image modalities
  - Ultrasound (US): well established, realtime, 2D(+3D), non-ionizing, medium to high resolution
  - 3D by motorized transducer, 2D array, or tracking



Peters 2008

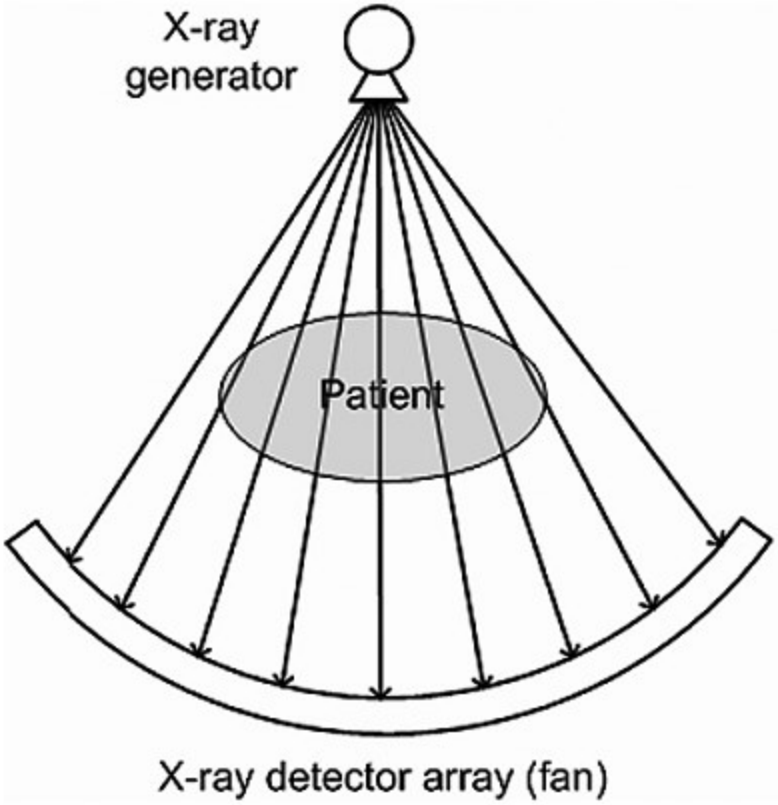
Image guidance

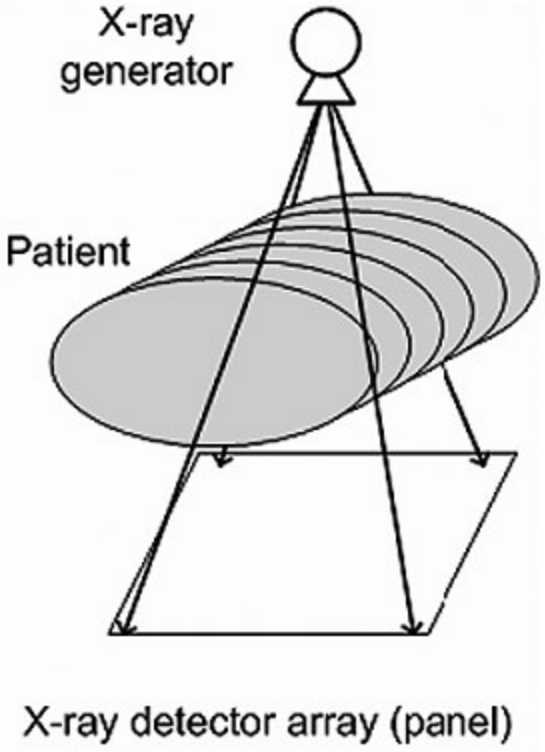
- Image modalities
  - X-ray: well established, realtime, 2D, ionizing, medium to high resolution, available in (almost) every OR

Peters 2008

Image guidance

- Image modalities
  - Computed Tomography (CT) : not-realtime, 3D, ionizing, medium to high resolution, typically available before treatment, sometimes in OR





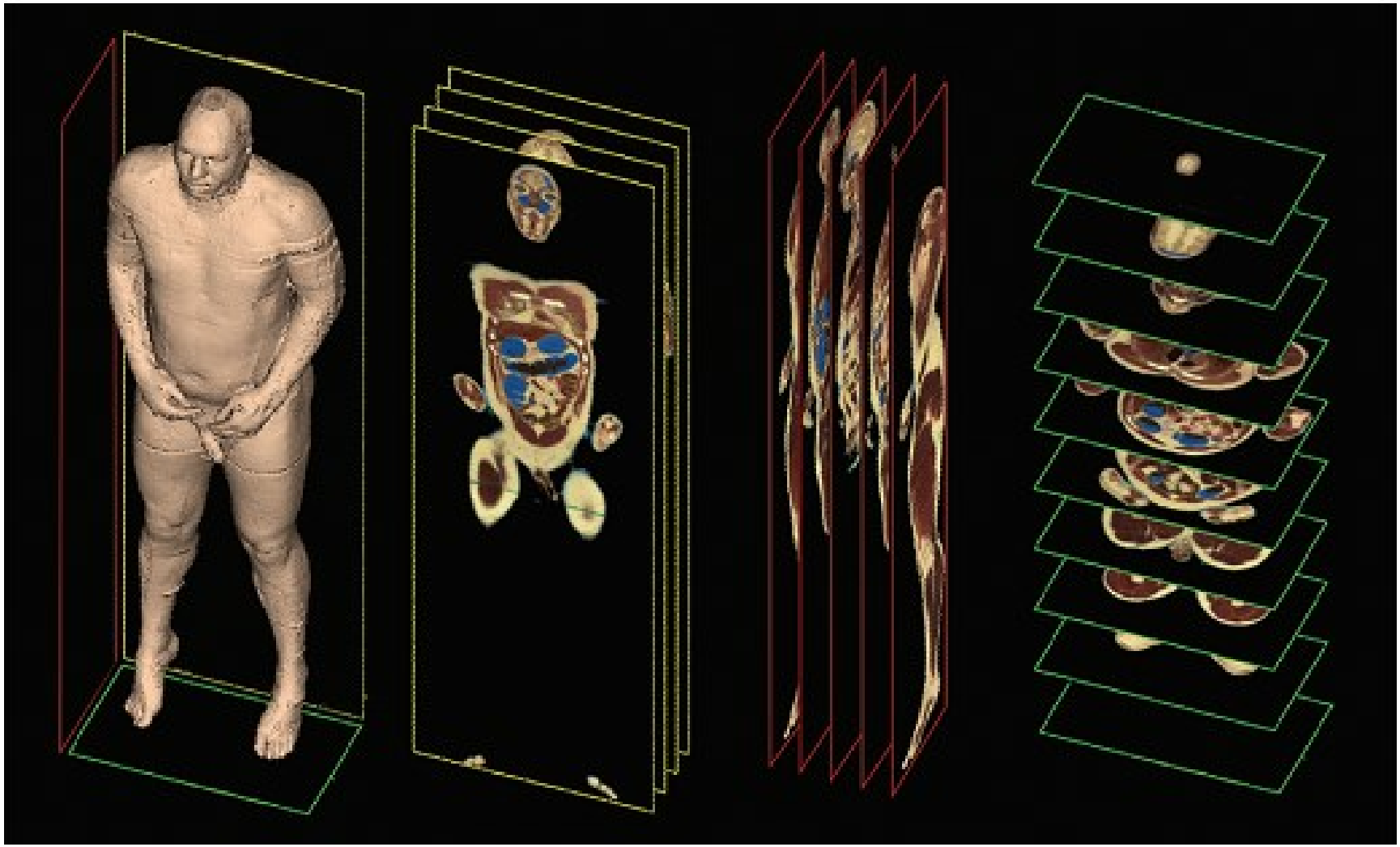
Peters 2008

Image guidance

- Image modalities
  - Magnetic resonance imaging (MRI): limited-realtime, 3D, non-ionizing, medium to high resolution, typically available before treatment, sometimes in OR

Wikipedia

Image guidance



Views onto a patient

Peters 2008

Image guidance

- Fiducial Localization Error (FLE)

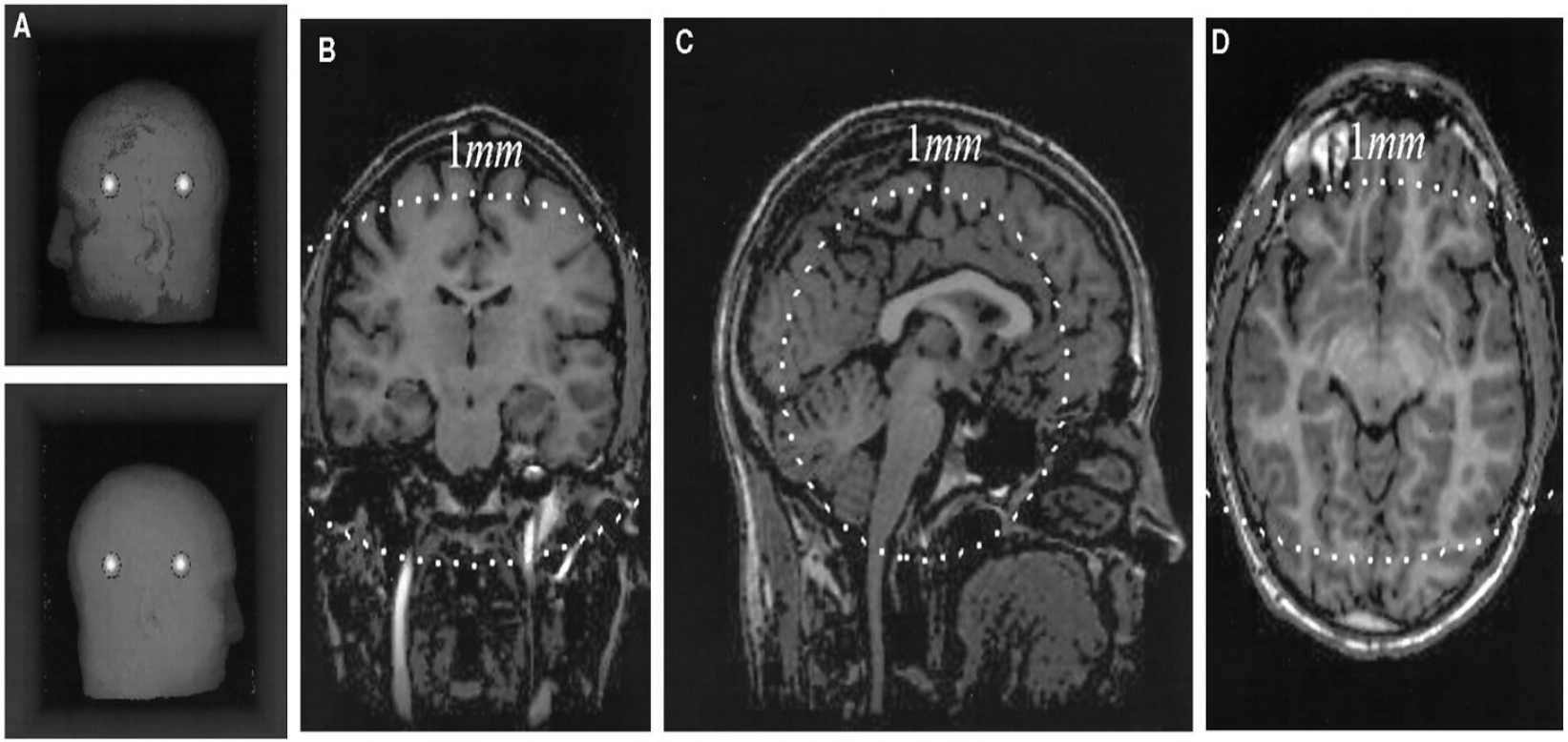
Image guidance

- Fiducial Registration Error (FRE)

Image guidance

- Target Registration Error (TRE)

Image guidance



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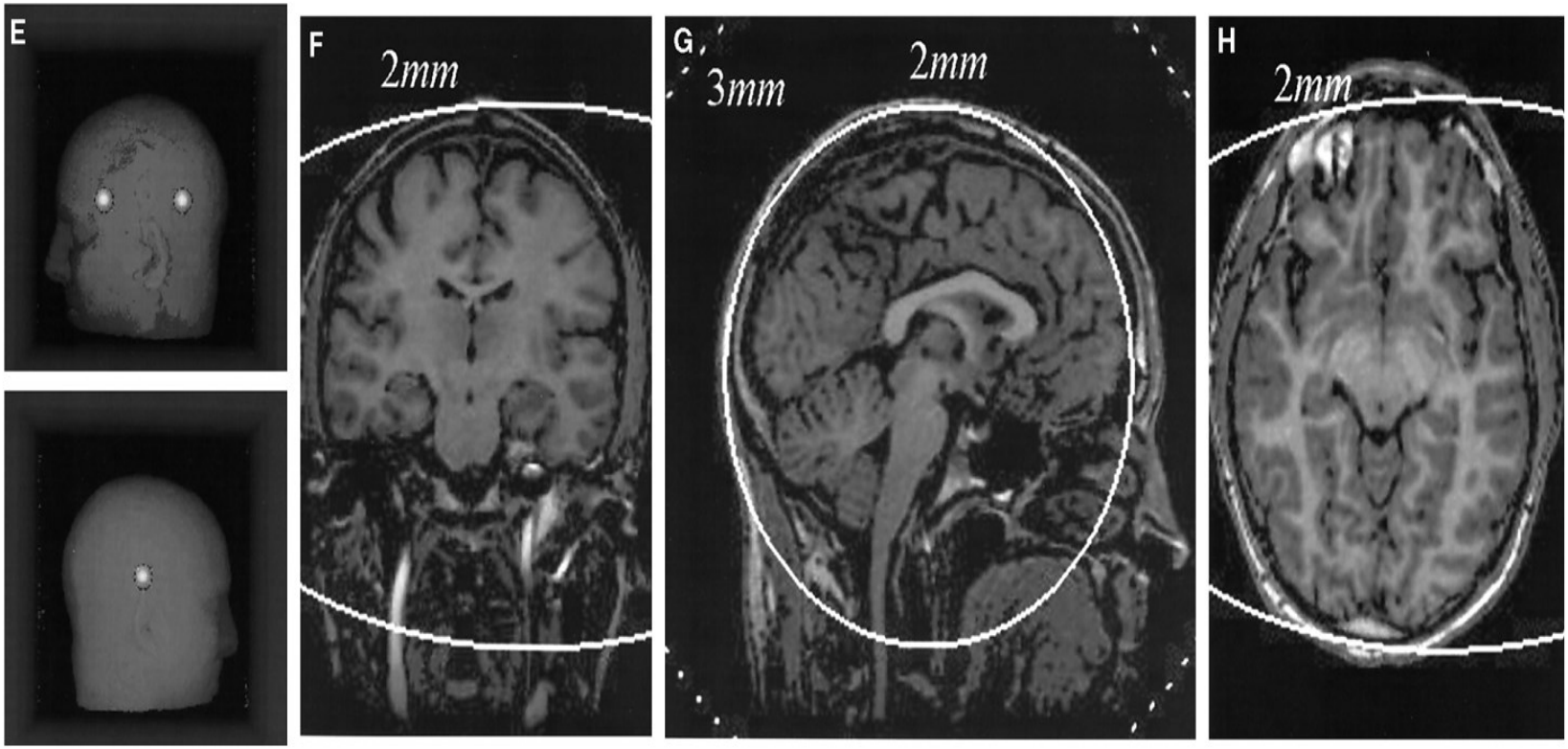

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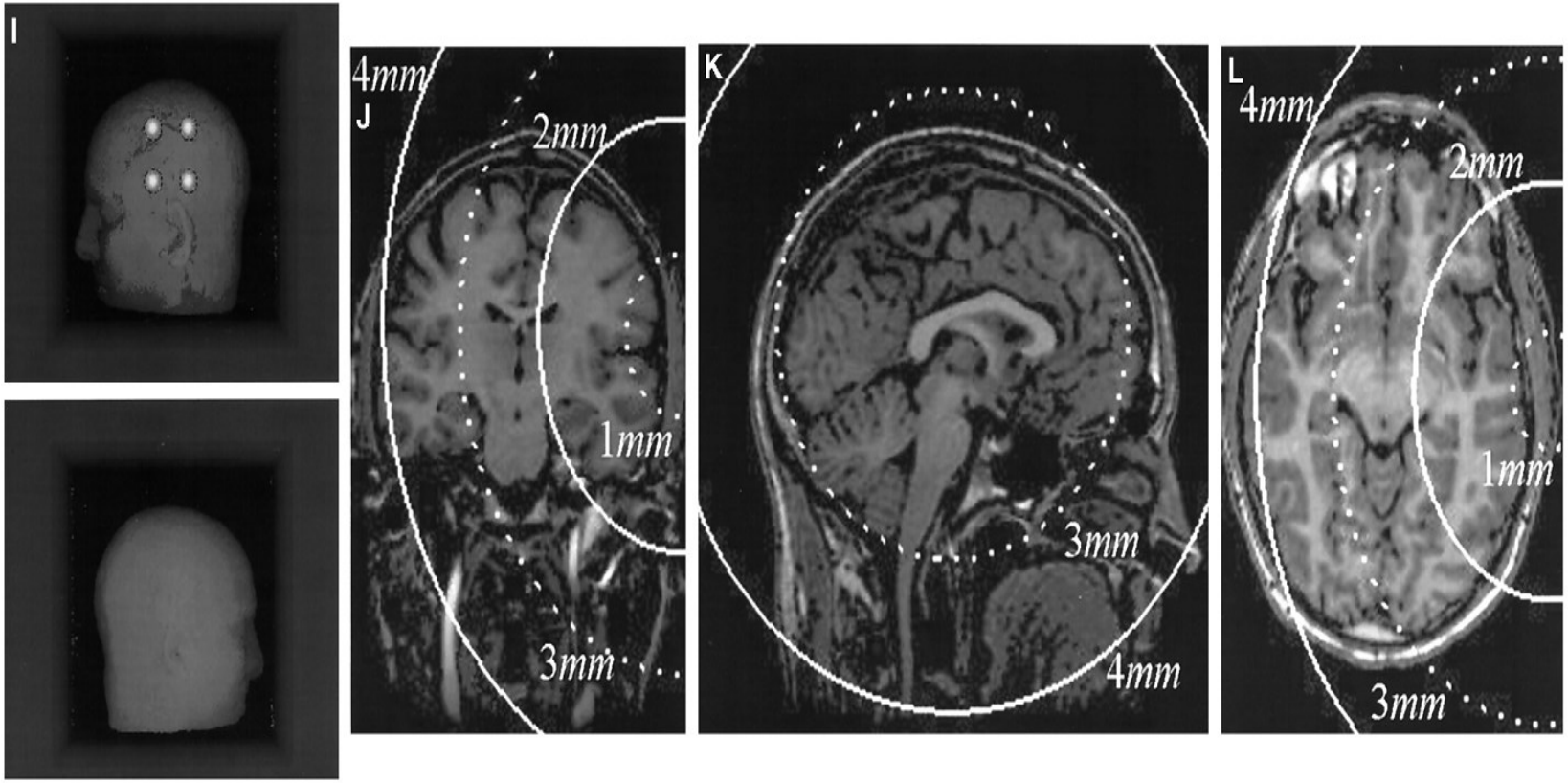

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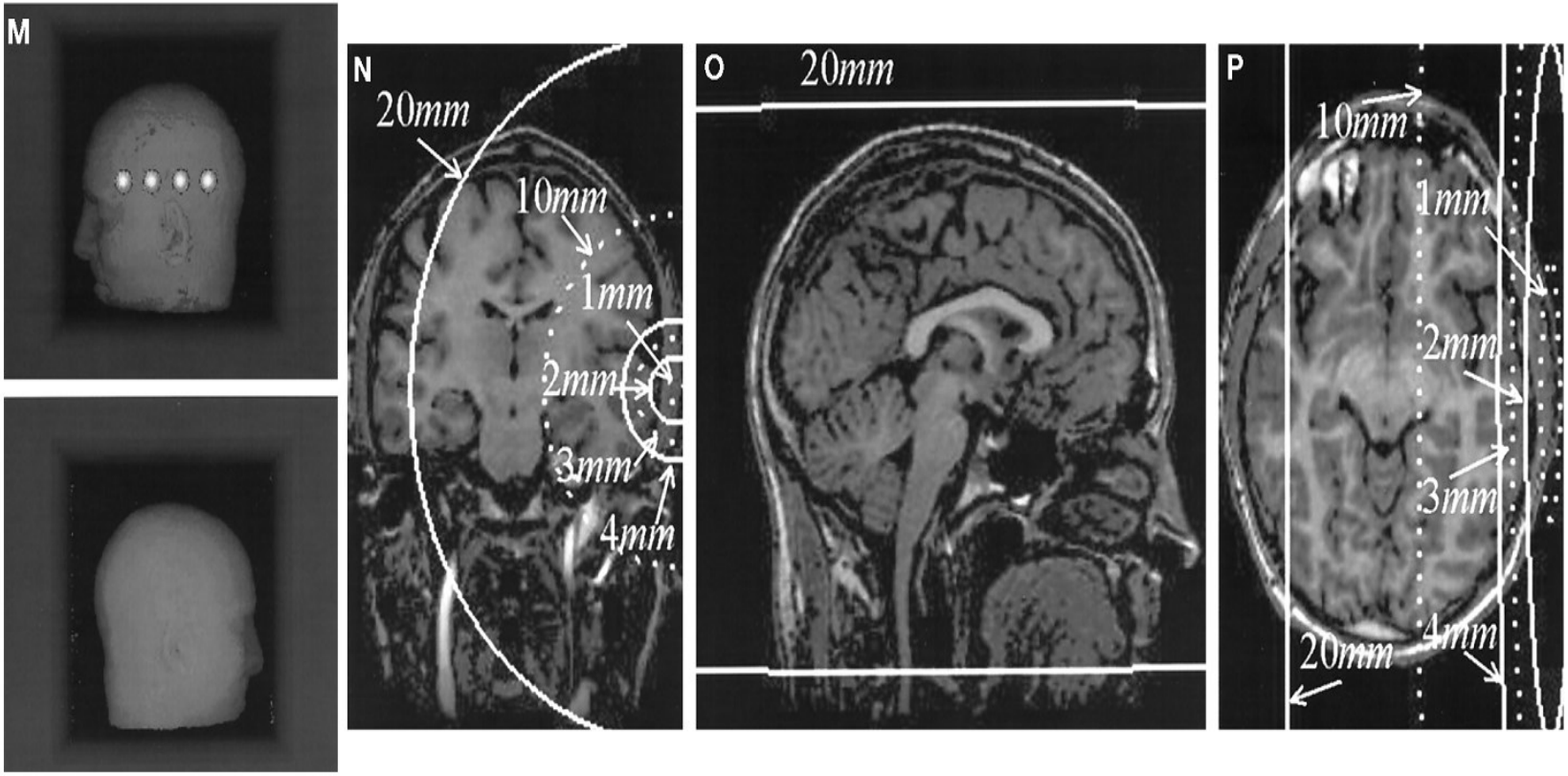


Image guidance

Image guidance

Image guidance (why?)

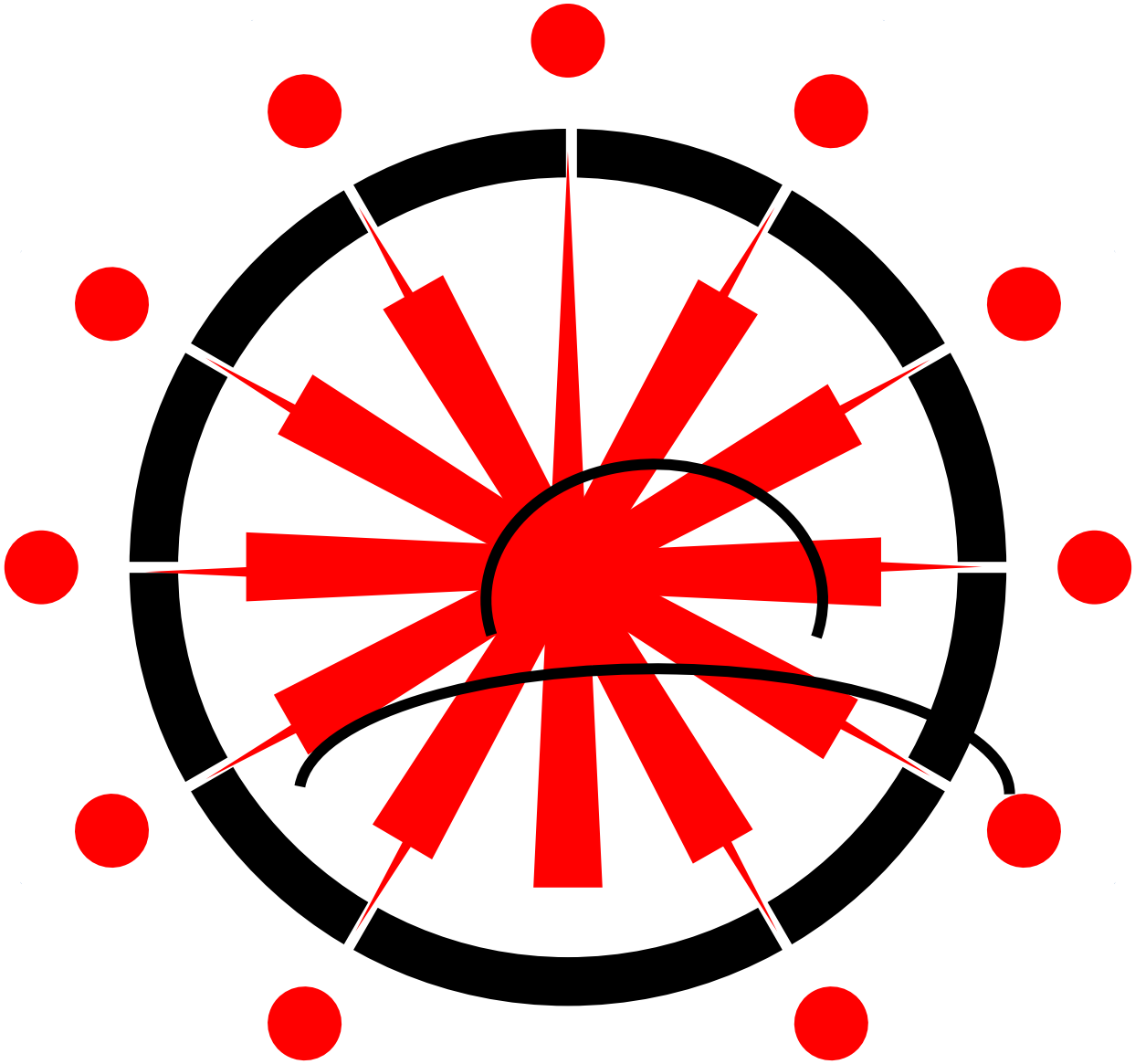
Gamma knife

Non-invasive radiation

Fixation with stereotactic frame

http://images.elektagallery.com

Image guidance (why?)



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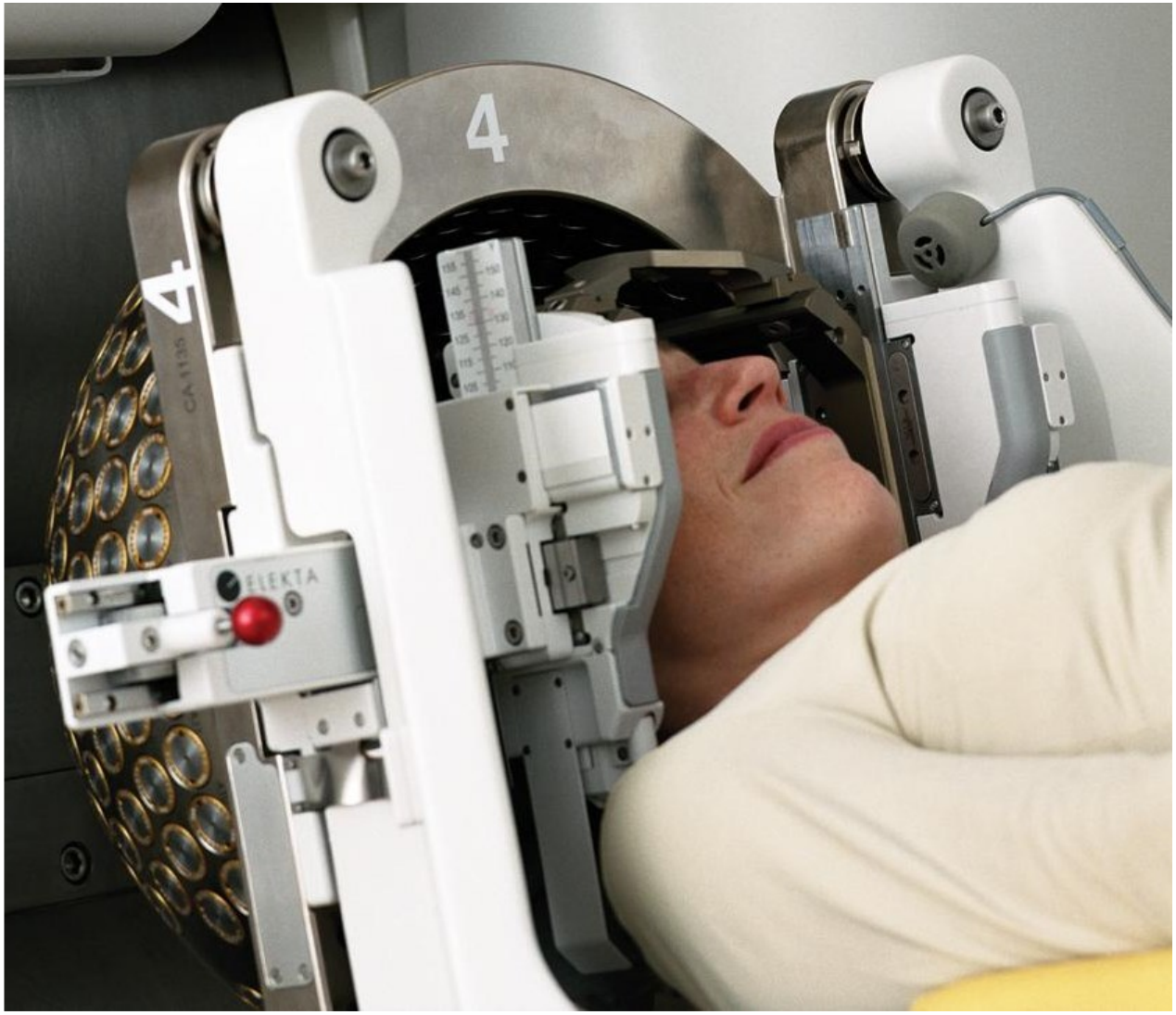

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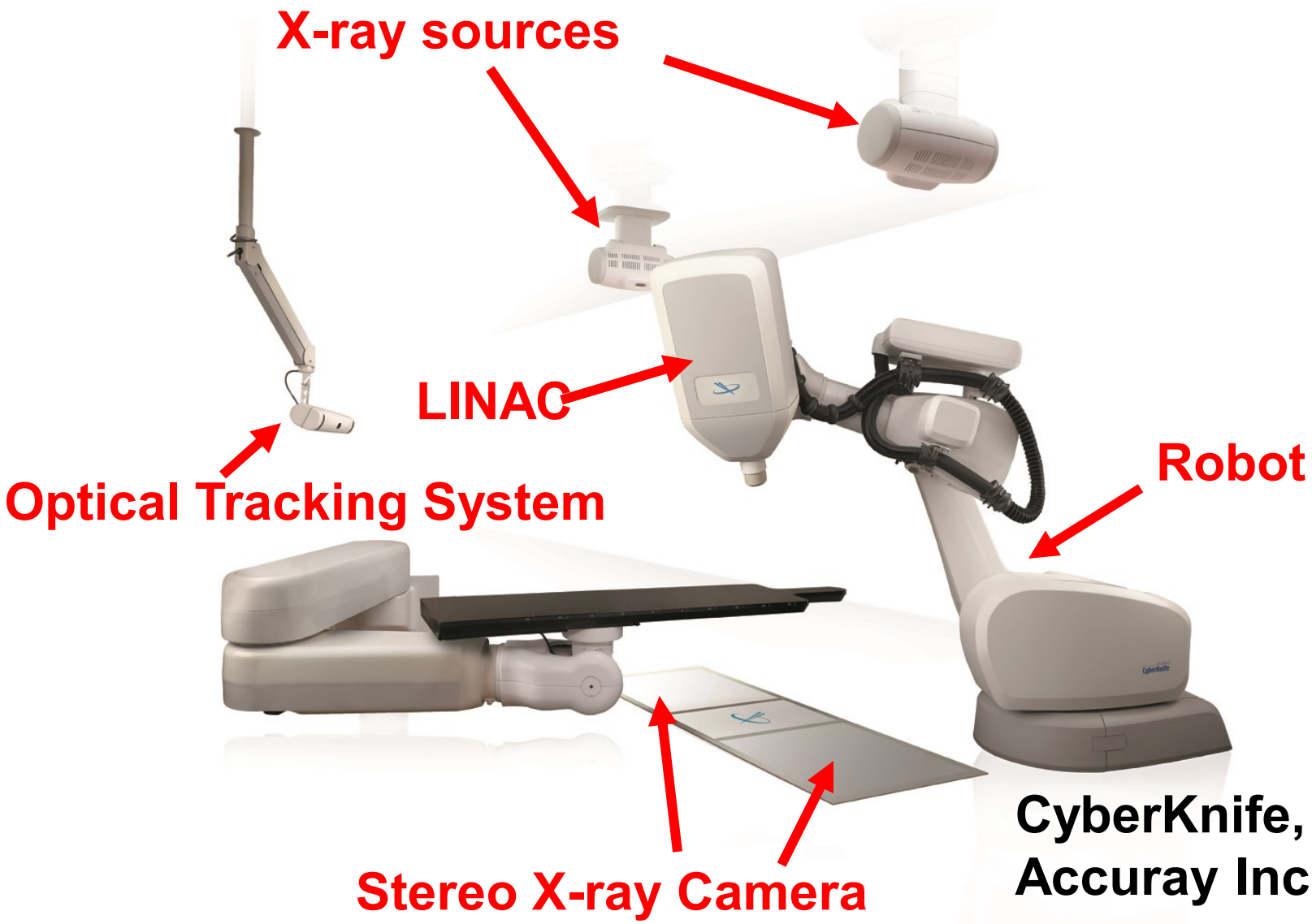
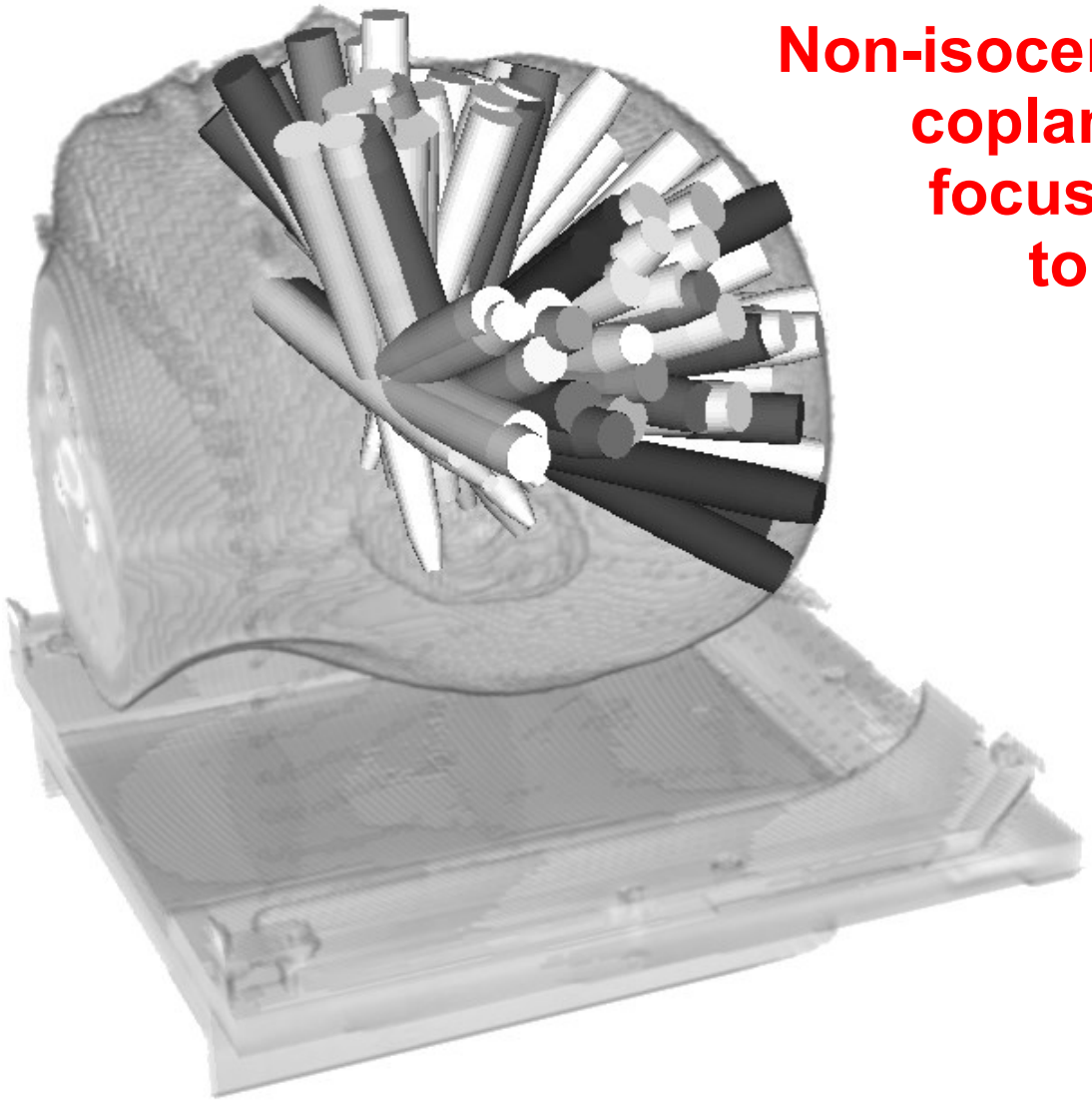


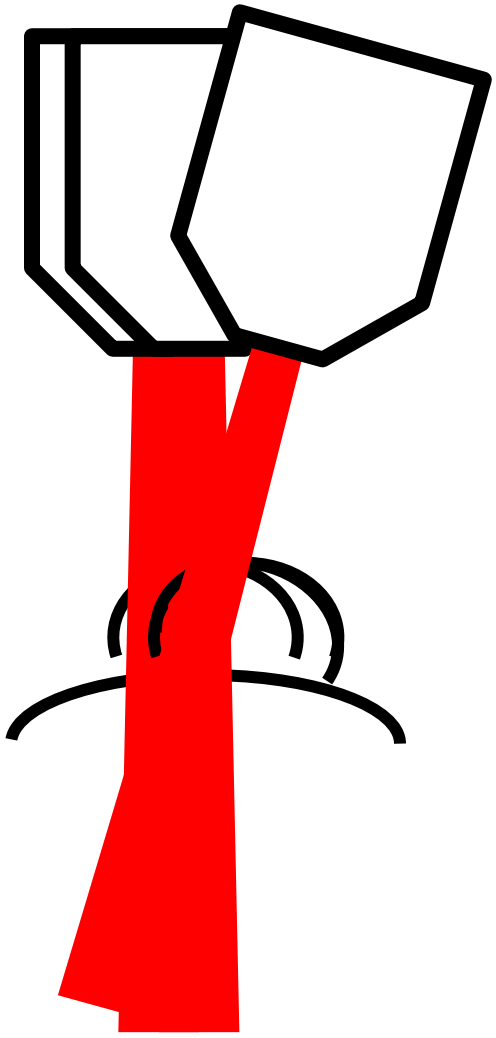
T. Viulet, F. Ernst, A.Schweikard, Accuray Inc.

Image guidance (why?)



Non-isocentric, non-coplanar beams focussing dose to the target

Image guidance (why?)



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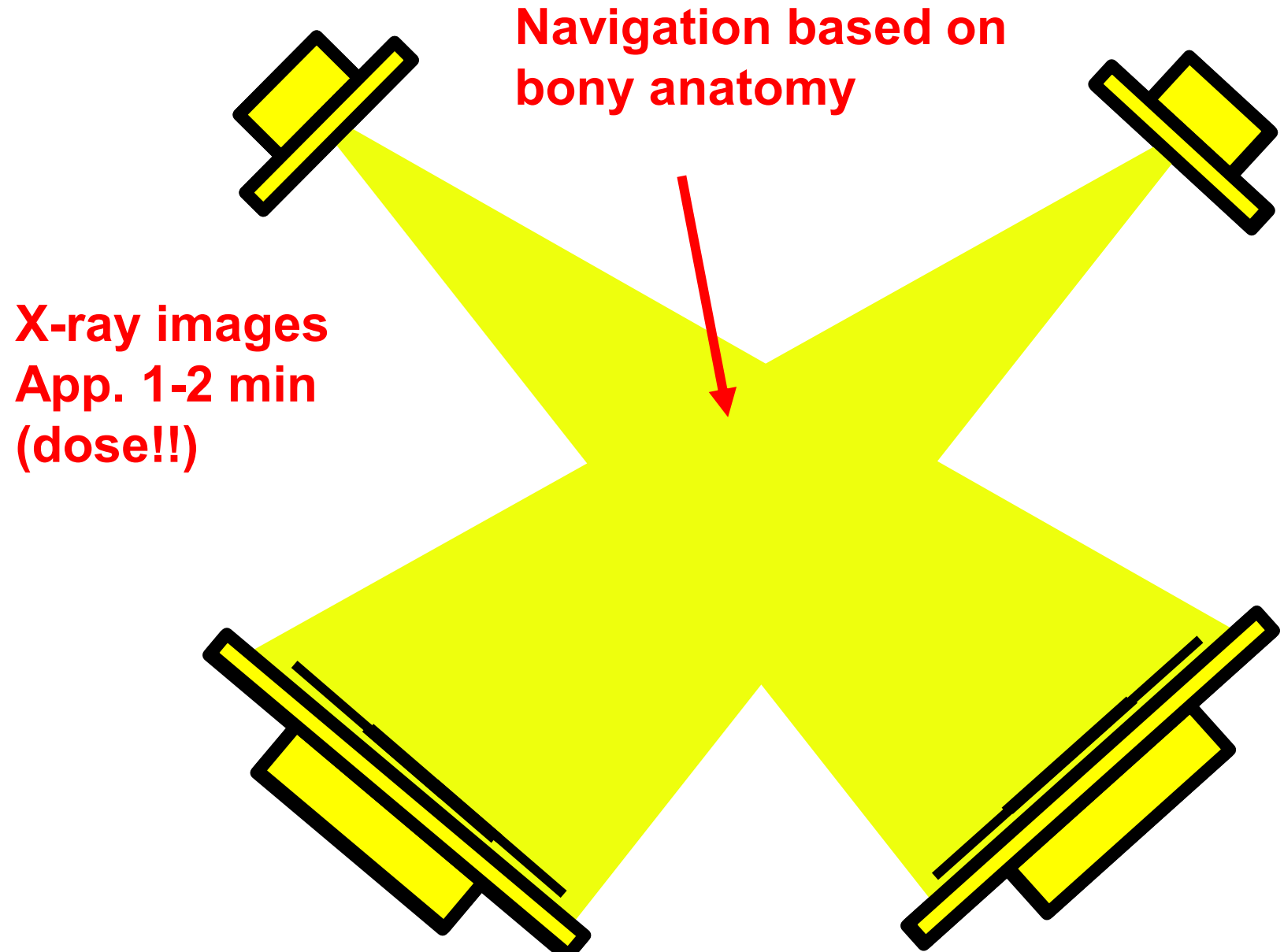

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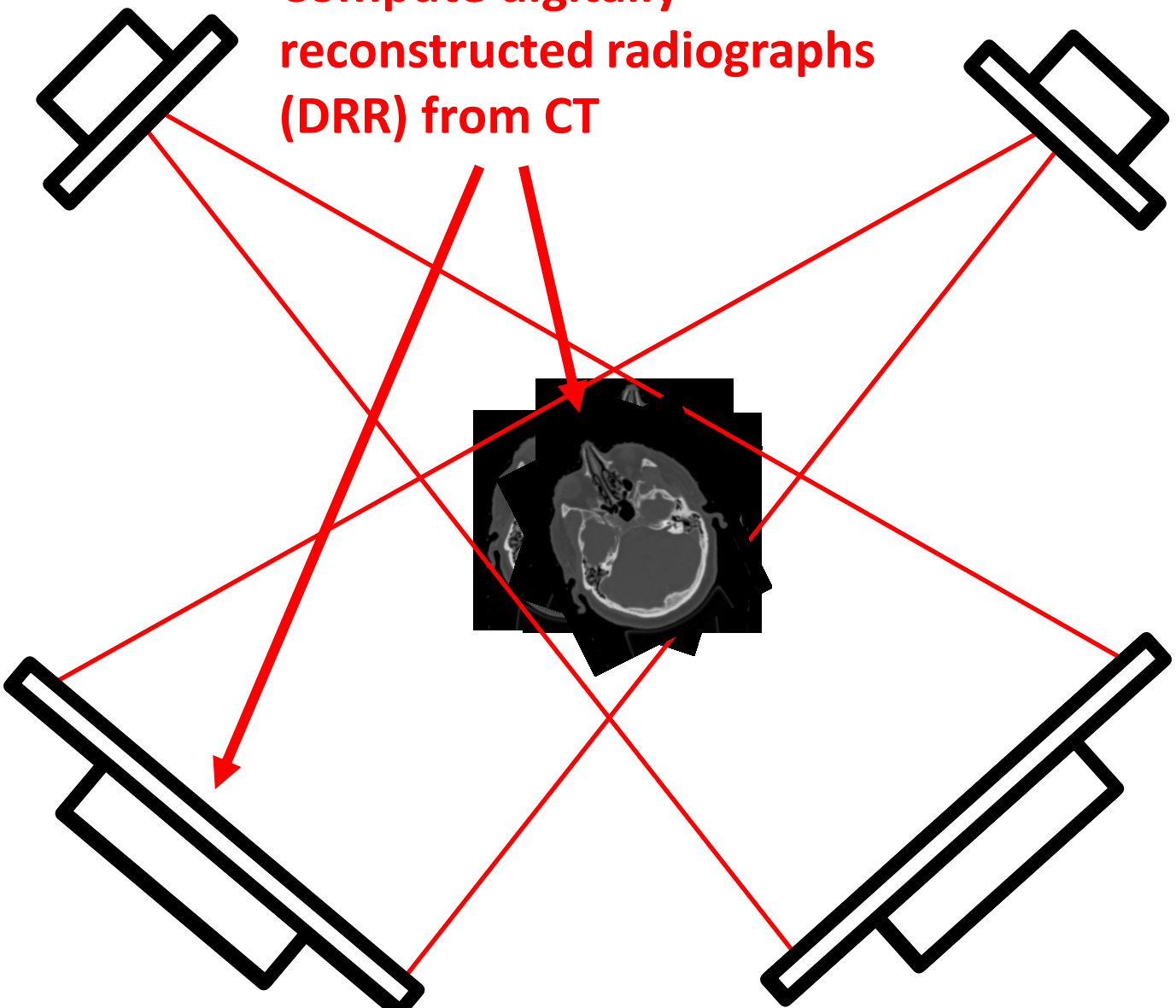

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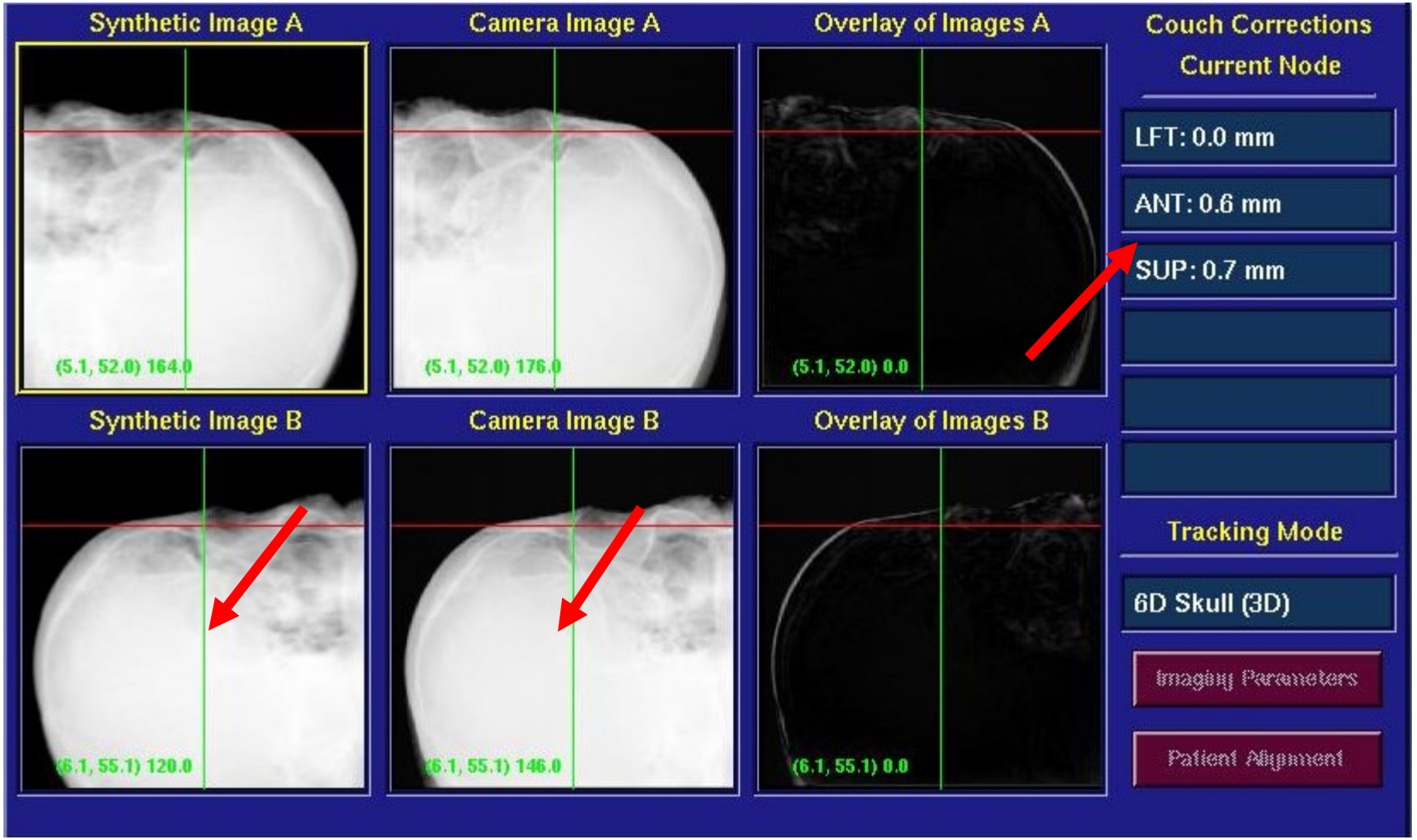

Compare DRRs for fifferent rotation / translation with actuaX-ray images: best fitting DRR yields offset angle / vector

Wikipedia

- Intro
  - X-ray
  - CT
  - MRI
  - US
  - OCT
- Patient models
  - Voxels
  - Surfaces
  - Splines (NURBS)