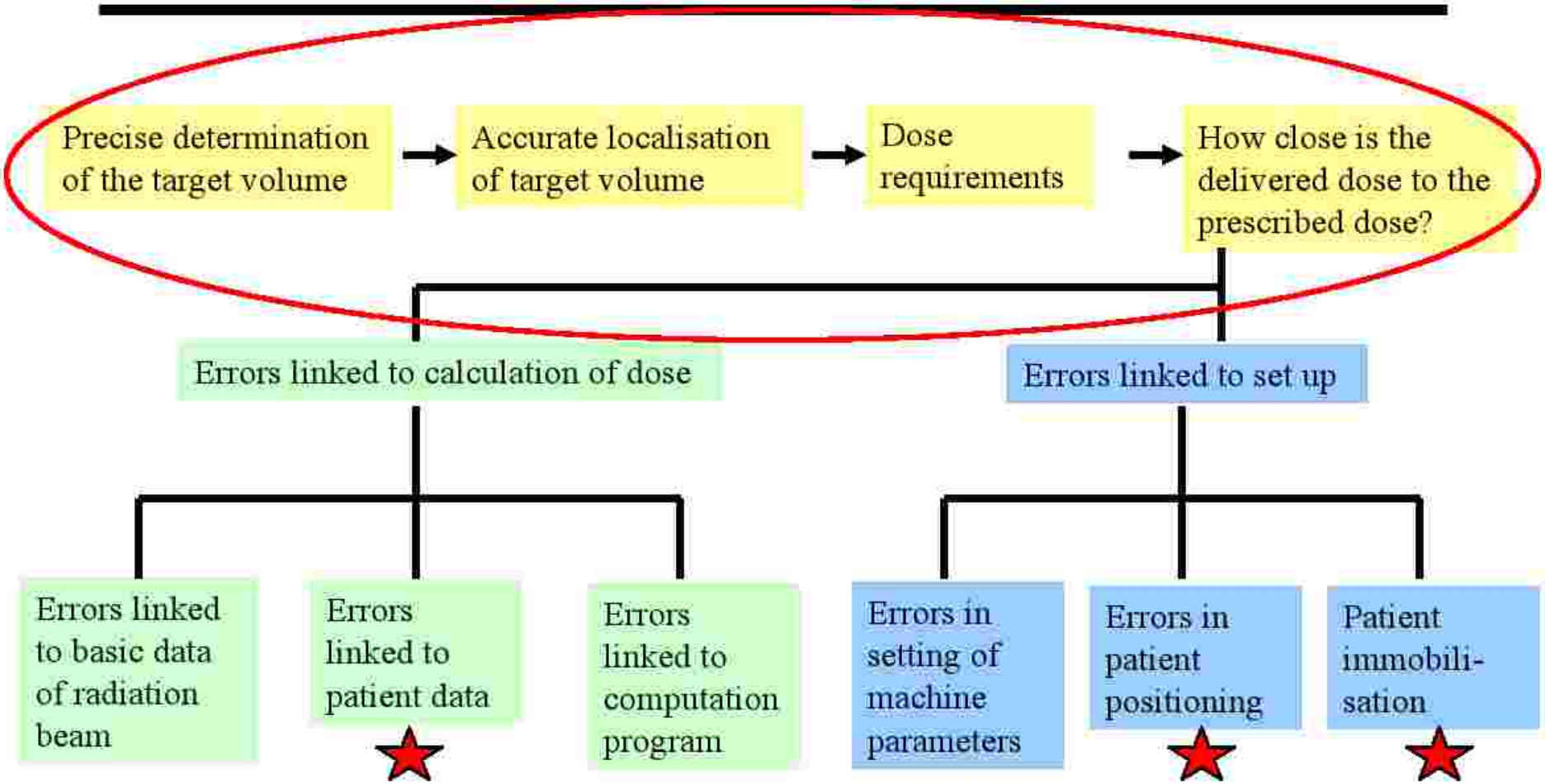
Errors in radiotherapy with a focus on brain tumors



Errors linked to basic data of radiation beam

- **The measurement of absorbed dose at a reference point in a phantom**
  - Depends upon accuracy of various parameters
  - Quality of dosimeters, determination of air temp and pressure (due to poor calibration)
  - Different for electrons and photons; uncertainty 1.5-3.5%

- **Measurement of dose distribution**
  - Uncertainty in measurement of dose due to error in detector (which depends upon radiation quality and dose rate) or nature of phantom
  - Must measure and not use ready made atlas (esp. for Linac)
  - Rather more important for electron profiles: depend upon energy adjustment of linac and mechanical and geometric properties of collimators

Errors linked to patient data

- Cross sectional anatomy is required to
  - determine relationship of tumor to surrounding tissues, body outline and landmarks
  - position and size of critical structures
  - attenuation information for photons and electrons
- CT scan position must replicate simulator / treatment couch
  - If not gated, image a breathing patient (relevant for non brain tumor sites!)
  - Window level and window width critical for all sites (for GTV/CTV determination)
- MR sequence, distortion errors, fusion of CT with MR for better target delineation
- PET more recently is fused (PET/CT)

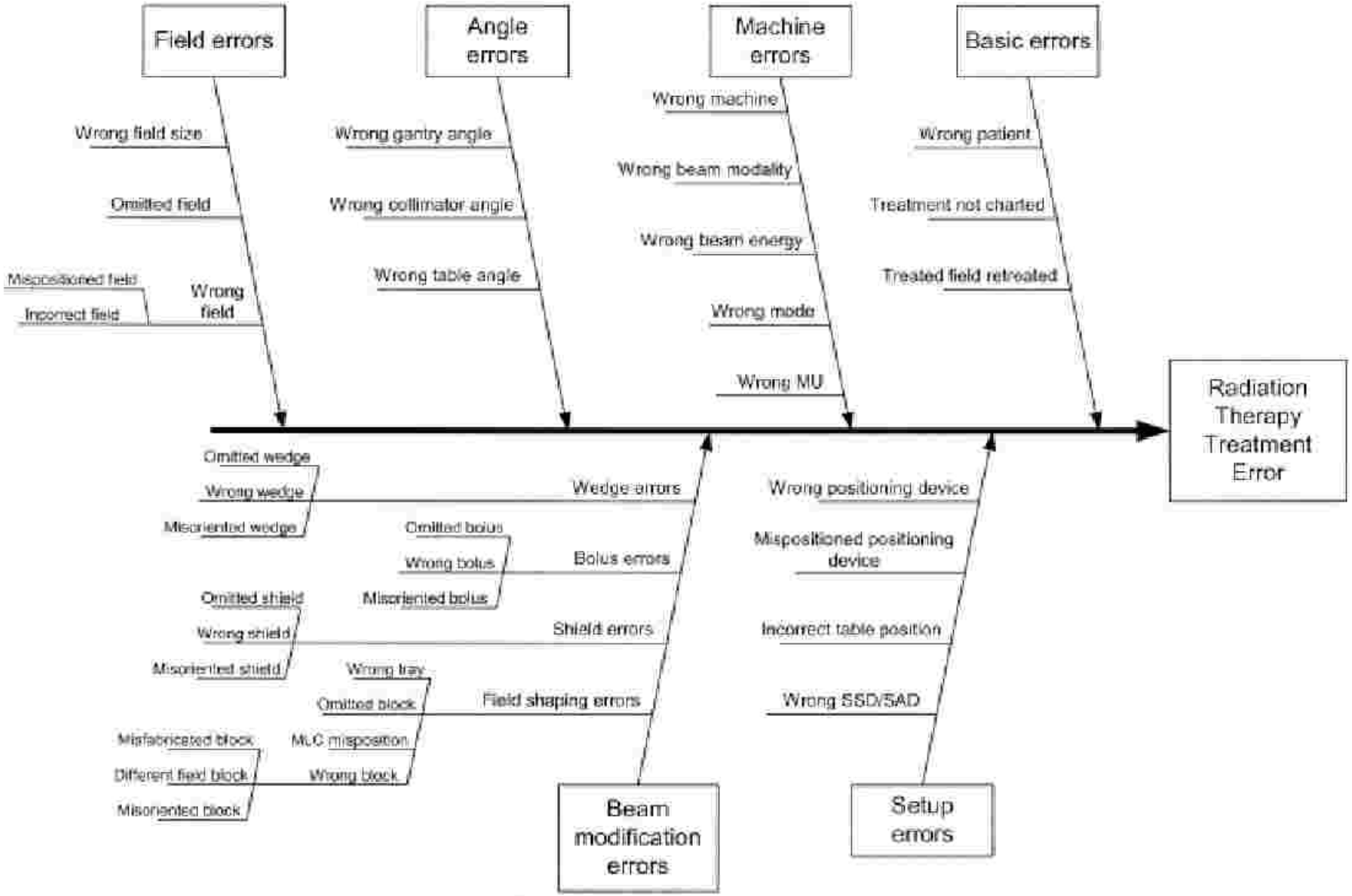
Errors linked to computation program

- Usually accurate, but errors result from misunderstanding of computation algorithms
- Tissues are generally assumed to be water equivalent, and these include fat and bone (if electron density information is not taken into consideration as for example in scanned images)

Errors in setting of machine parameters

- Optical, digital and mechanical devices have a tolerance
- Tolerance values published:
  - SSD indicator, 1-2 mm
  - Light and radiation field concordance, 1-3mm
  - Field size and indicator agreement, 1-3mm
  - Collimator rotation indicator, 1°
  - Couch height indicator, 2mm

Errors in setting of machine parameters...cont

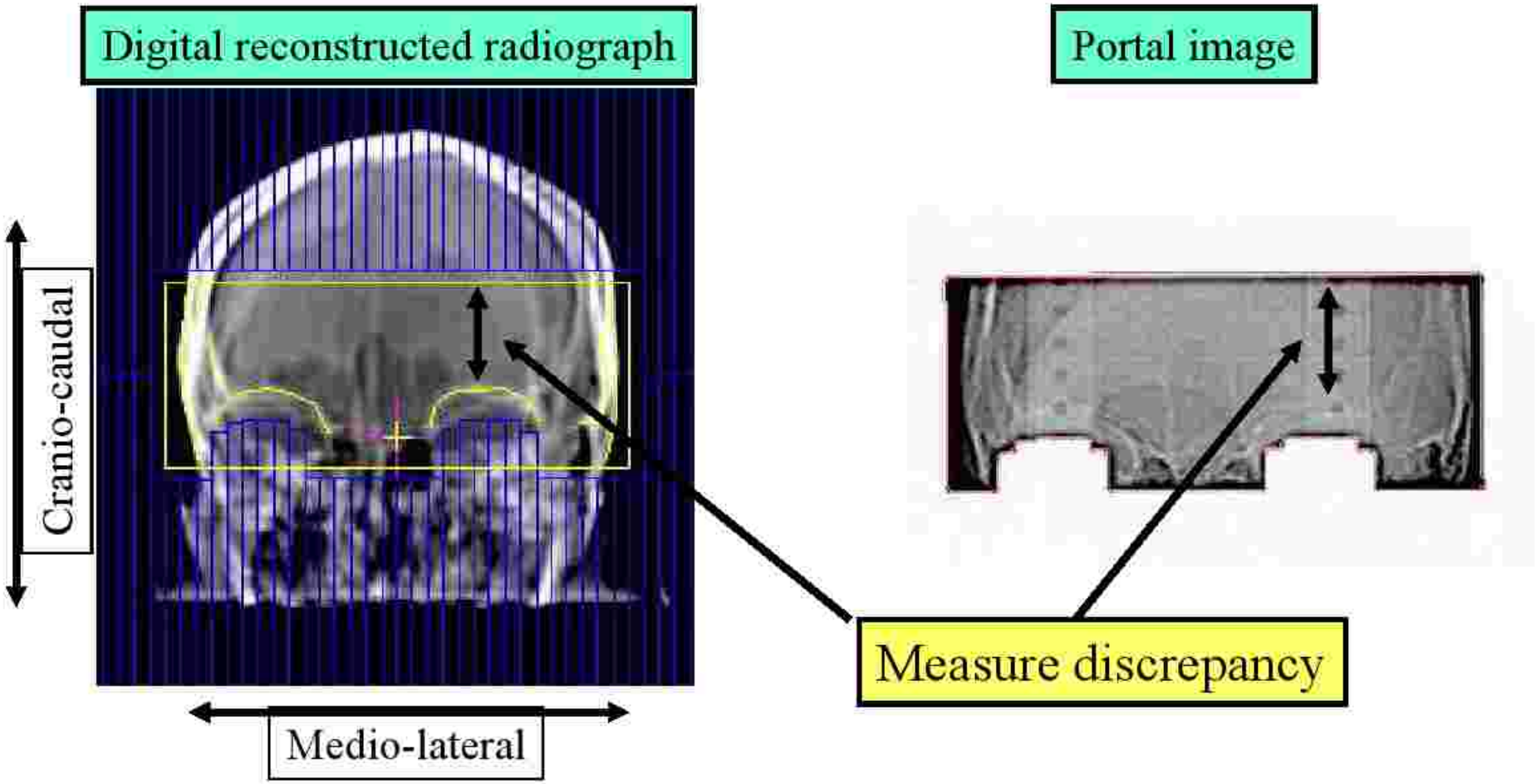


Errors in patient positioning and immobilisation

- Patient needs to be placed in a STABLE and REPRODUCIBLE position
- Ensured by using a thermoplastic mask
- Why? Because radiotherapy techniques are all about ACCURACY
  - Patient has a localisation CT scan (maybe an MRI), has a simulator verification of the treatment (planned on a TPS) and is treated on a machine for 5-6 weeks
- So how do we know what site got actually treated?
  - By comparing portal images on delivery to the treatment portal that we designed (say on a simulator image or by a digitally reconstructed radiograph)

How is reproducibility of immobilisation quantified?

Compare portal image and reference image



So how calculated?

- Lets say shift to right is **+** and shift to left is **–**
- So for 11 measurements we might get (in mm)

  Example A: +5, +4, +3, +2, +1, 0, -1, -2, -3, -4, -5

  Example B: +10, +8,+6,+4,+2, 0, -2, -4, -6, -8, -10

  - Q: What is the mean or average shift?

  Answer: 0 for both

- Any better way of quantifying discrepancy?

  How about standard deviation? 3.3mm vs. 6.6mm

- Another data set: Example C: +9,+8,+7,+6,+5,+4,+3,+2,+1,0,-1

  Mean =4, SD 3.3, compare with example A: same SD, different mean, so there is a **systematic shift** to right in example C, but the **random shift** is similar.

Systematic (Σ) and random errors (σ)