Making Cancer History®

APBI using Proton Therapy

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AAPM 2022

SAM Joint Imaging Therapy Educational Course:

Advances in Breast Cancer Diagnosis and Treatment: Mammography, Breast Biopsy, SBRT, APBI

Outline

1) Background

2) CT Simulation

3) Planning Technique

4) Discussion

Background

- RTOG 0413 trail: accelerated partial breast irradiation (APBI) compared to whole breast irradiation (WBI) for early-stage breast cancer.
  - similar 10 year recurrence rate: 4.6% vs 3.9%[‡]
- WBI late effects: fibrosis, shrinkage, edema and skin thickening
- APBI has the potential of improved cosmesis
- APBI delivers radiation directly to the tumor resected cavity that is at highest risk for recurrence and limits the dose to the surrounding healthy breast tissue
- APBI is more convenient for the patient due to the shorter treatment course of 5 to 8 days

‡ *Vicini etal Lancet. 2019 Dec 14; 394(10215): 2155–2164.*

Background

- Forms of APBI:
  - Brachytherapy
  - 3D conformal radiotherapy (3DCRT) (non-invasive and higher dose homogenity)
  - Proton (e.g. passive scattering)

More challenging planning technique over PBS

Background

Comparing Proton APBI vs Photon 3DCRT

Pros

- less normal breast tissue irradiated
- less lung and heart dose

Cons

- More acute skin toxicity
- More rib pain and fractures

Improving planning technique

RTOG 2009-0818

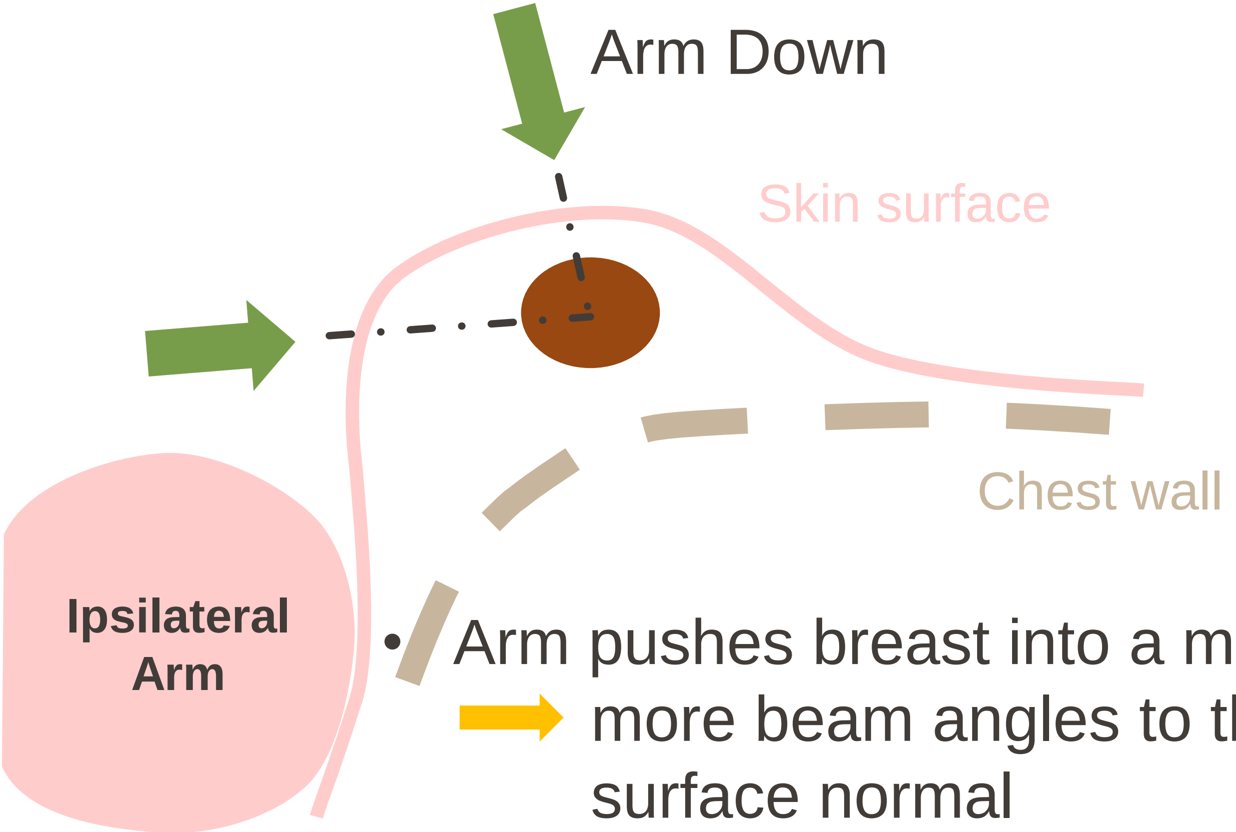
- Primary Objective:
  - assessing the cosmesis and toxicity of partial breast irradiation using proton beam irradiation
- Eligibility:
  - stage 0, I, II with < 3cm
  - negative surgical margins
  - lumpectomy cavity must be clearly delineated
  - cavity volume <30% of whole breast
- Prescription:
  34 Gy in 10 fraction BID, > 6 hours apart

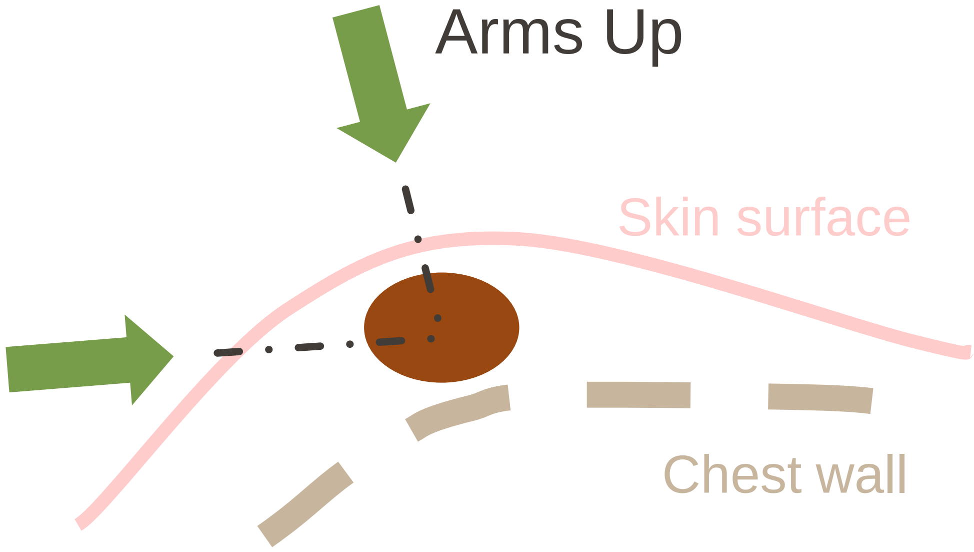
Simulation: Arm position

- Patient in supine position
- Vaclok on acrylic board with variable slant (0, 5, 10, or 15 deg)

Arm Up	Arm Down
	

Simulation: Arm position



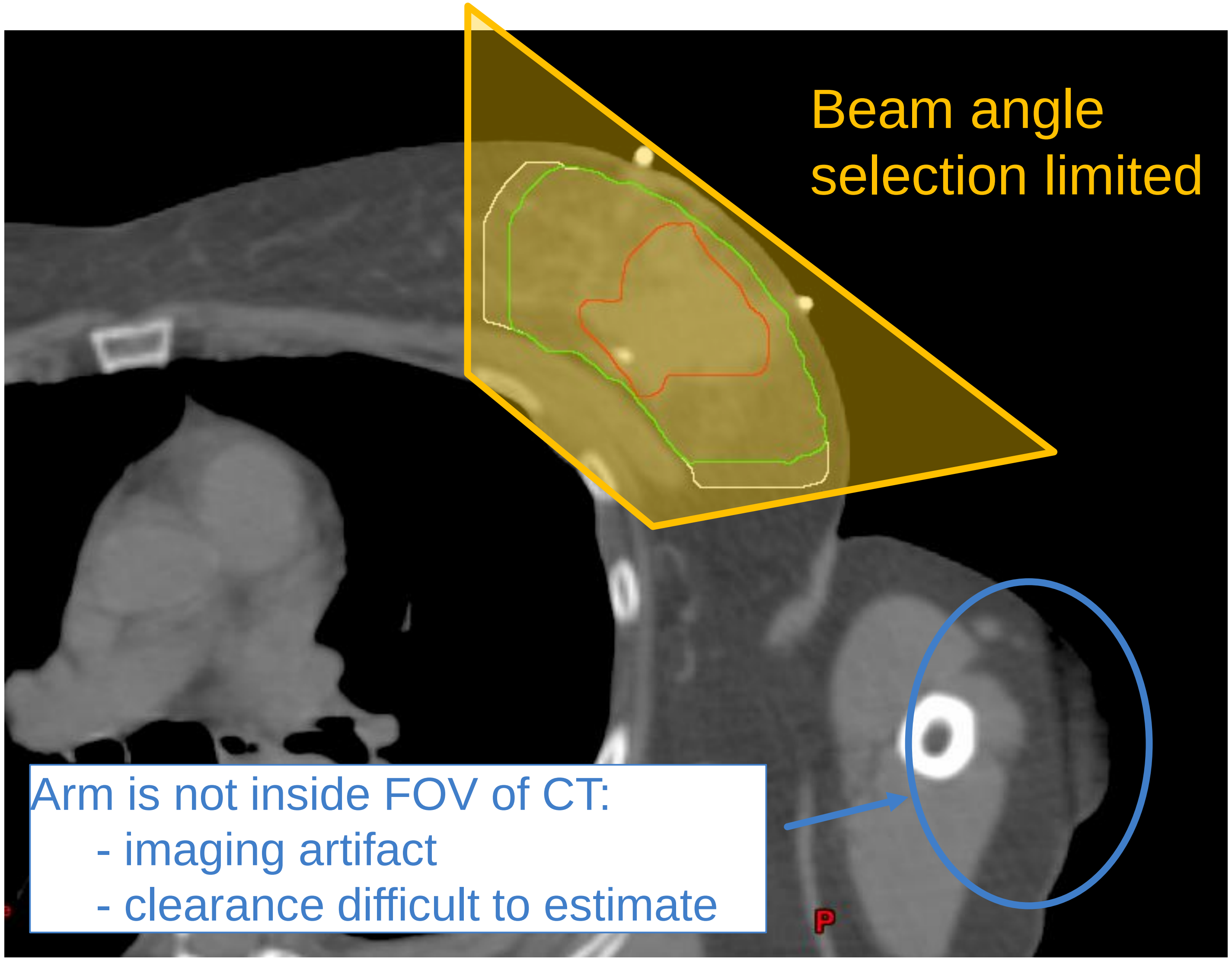


- Arm pushes breast into a mound → more beam angles to the surface normal
- Breast tissue not very stable → relies on good IGRT (e.g. X-ray; fids and surg. clips)
- Not working for lateral tumors

- Breast tissue stretched out across chest wall → more tangential beam
- May reduce distance between tumor and chestwall
- Stable and reproducible setup

Simulation: Arm position

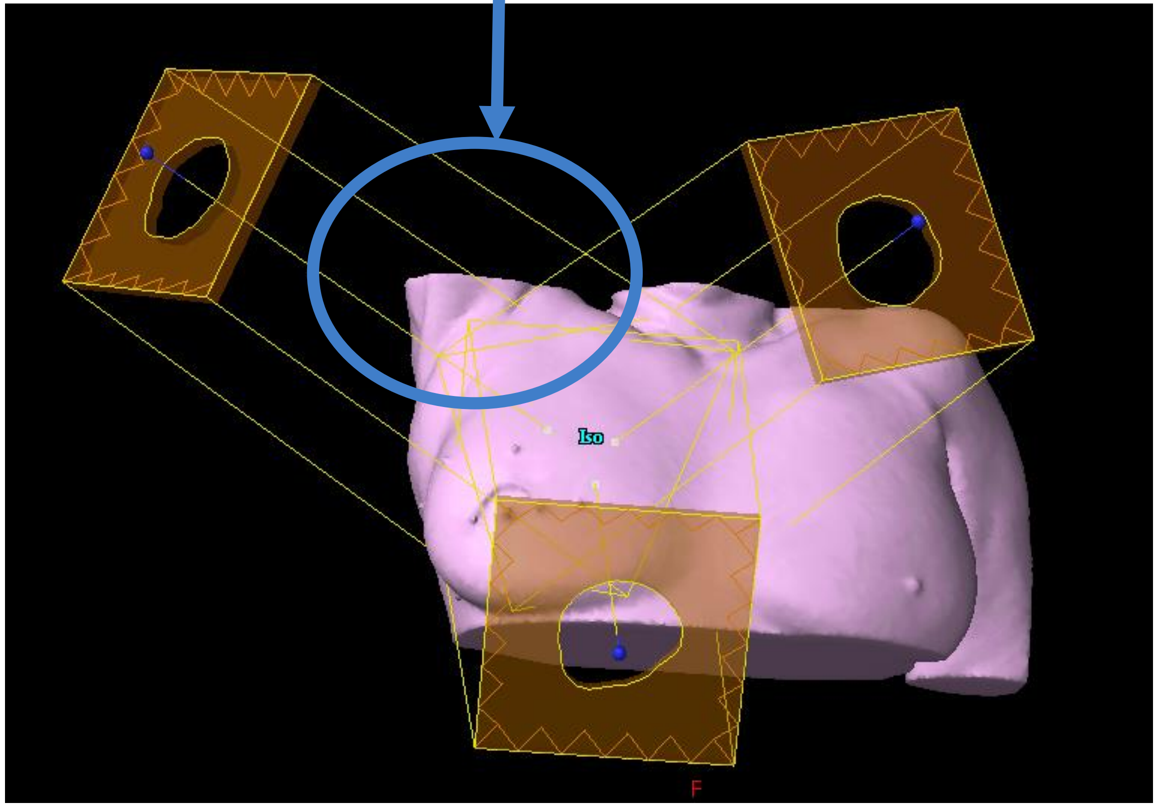
Arm Down



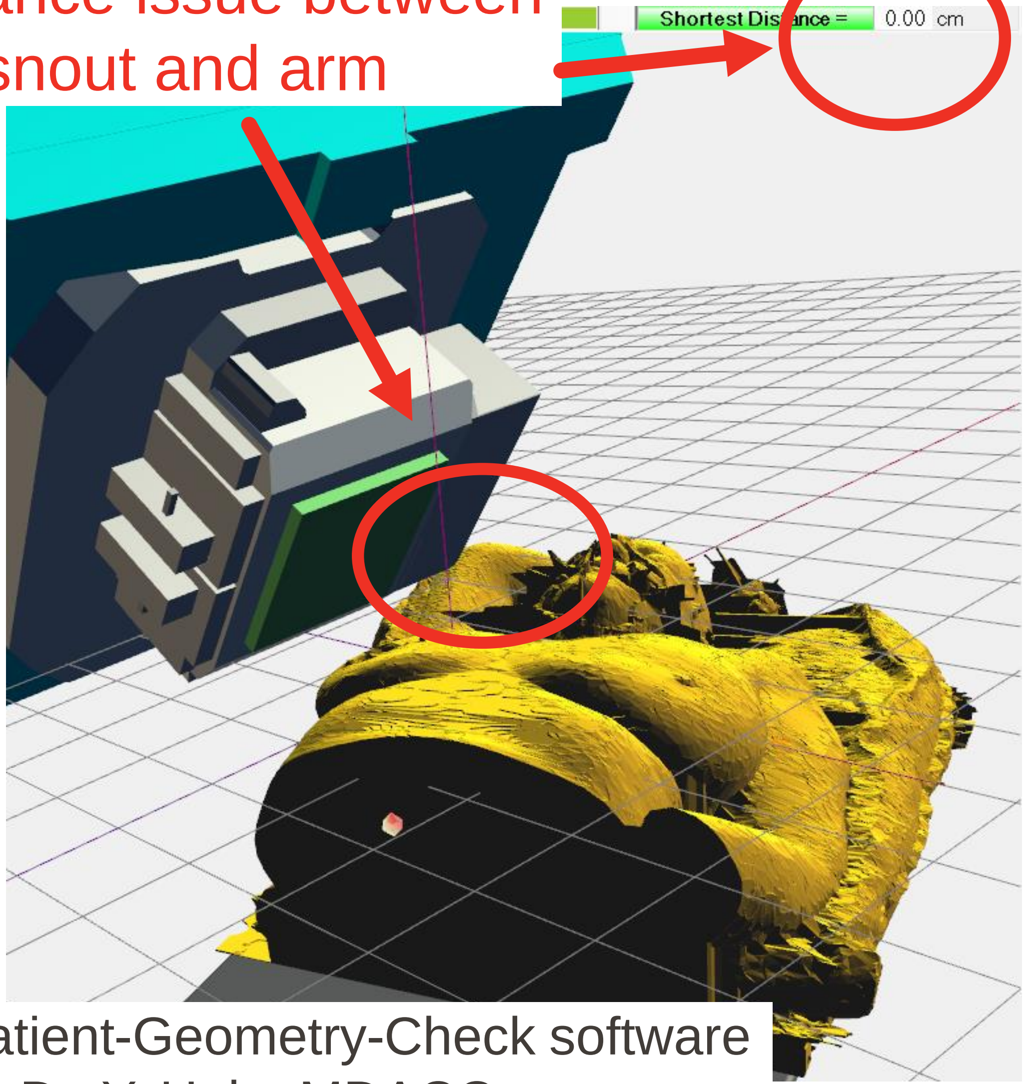
Simulation: Arm position

Arm Up

Arm and vacloc are not in CT scan



Clearance issue between snout and arm



Patient-Geometry-Check software by Dr. Y. Hojo, MDACC

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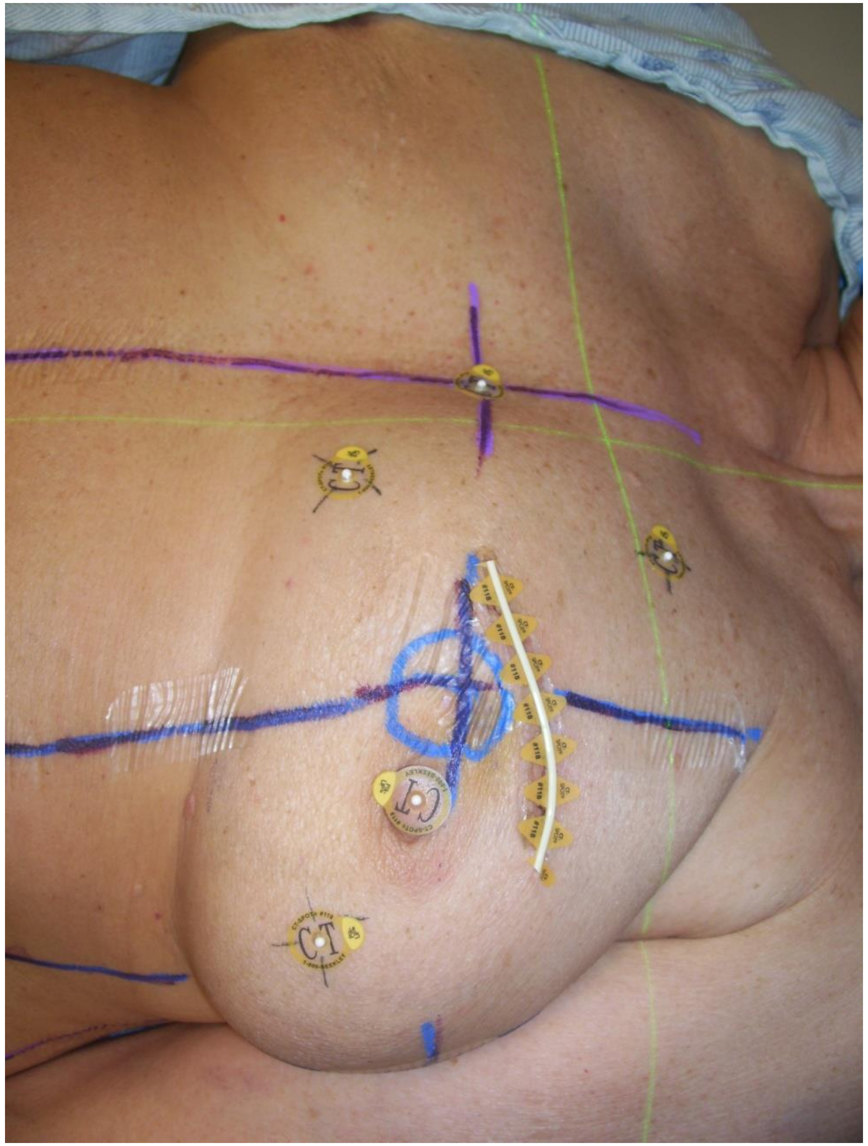
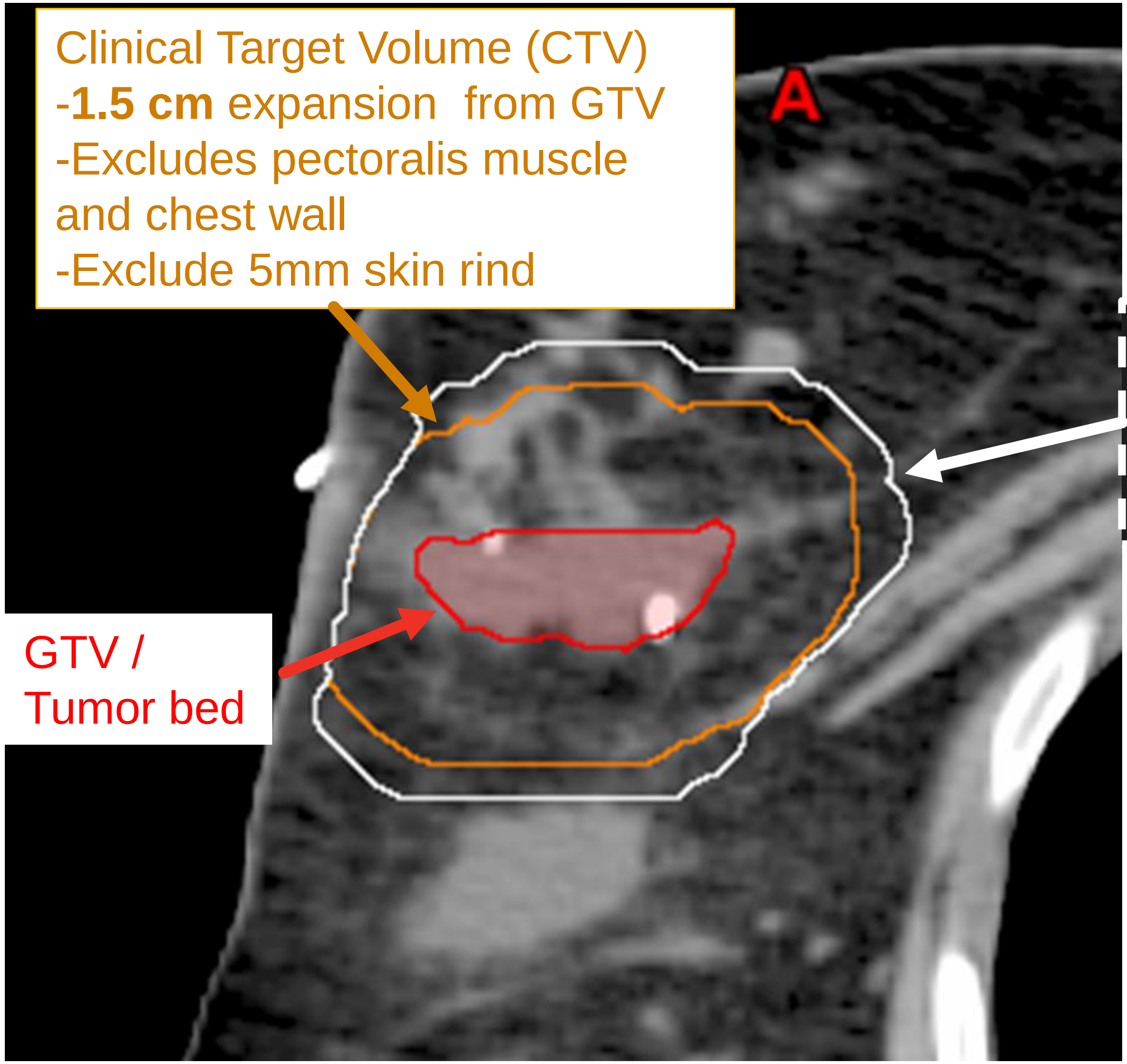
Simulation: Marking

- Midline (red)
- Marked Isocenter (blue)
- Surgical scar (wire)
- BBs on skin pigments (Beekley non-metalic)
- BBs on nipple (Beekley non-metalic)
- Surgical clips (if present, e.g. Biozorb)



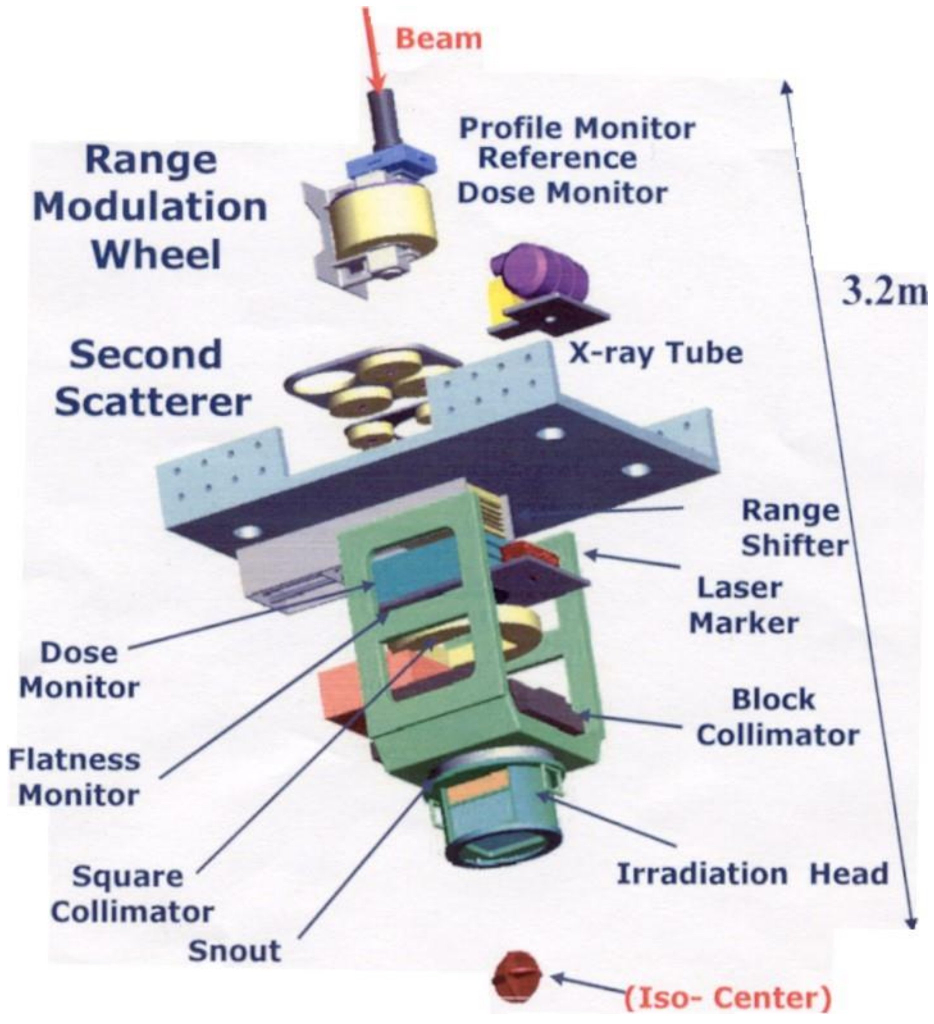
RTOG 2009-0818



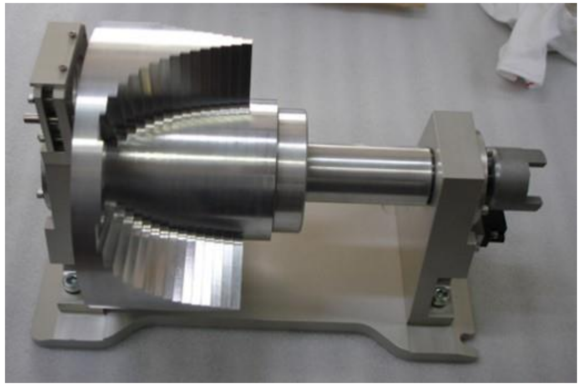
RTOG 2009-0818

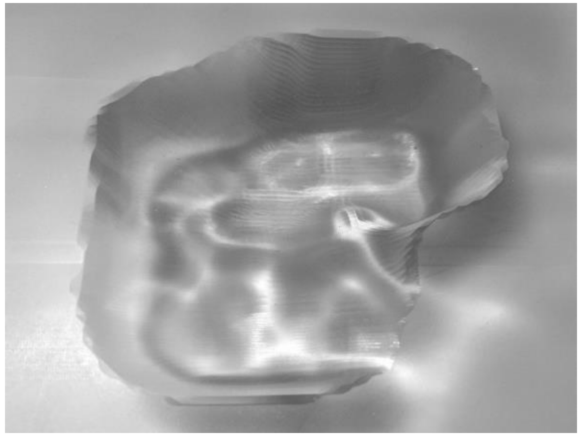
- Normal Breast (Ipsilateral Breast)
- Uninvolved Breast (Normal Breast – CTV)
- Heart
- Ipsilateral Lung
- Contralateral Lung
- Contralateral Breast
- Skin 2mm
- Skin 5mm

Passive Scattering Devices



Courtesy: A. Smith, UTMDACC





Range Modulator Wheel

(function of energy, field size)

Aperture collimator:

- brass,
- 3 sizes (e.g. 18x18 cm)
- Thickness: 2cm
- Number, typical 2 pieces

Compensator

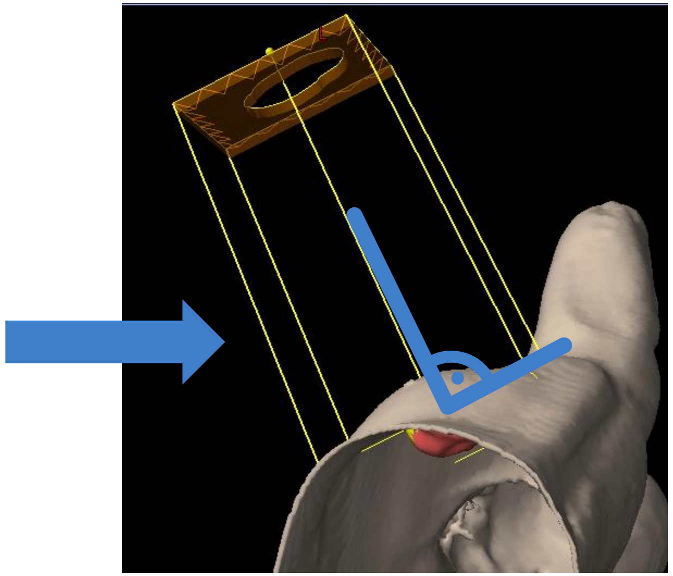
- Acrylic plastic
- Smooth surface
- Thickness variable 2-15 cm

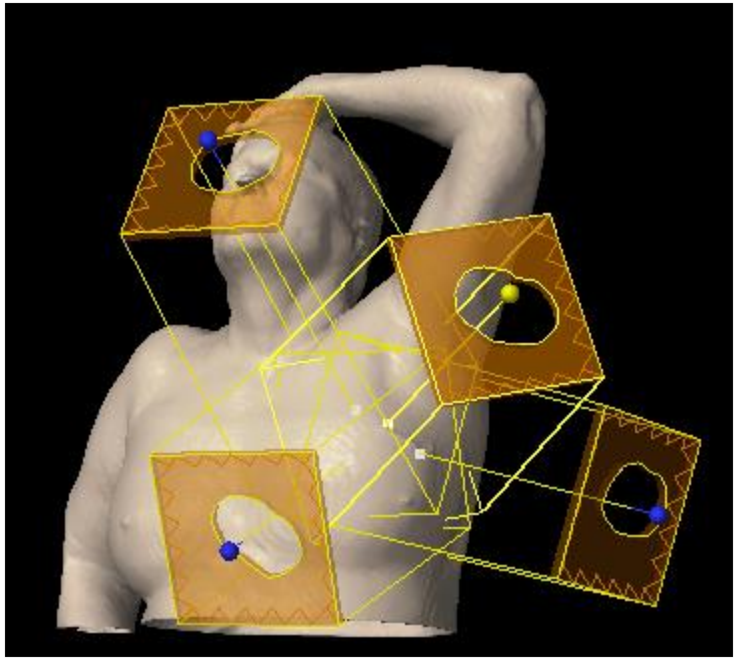
Planning: Beam Angle Selection

- Contradicting goals: skin sparing vs robust plan
- Maximize hinge angle → tangential beams
- Robust plan has en-face beam (but there is only 1 angle)
- Compromise between skin sparing and robustness.

Planning: Beam Angle Selection

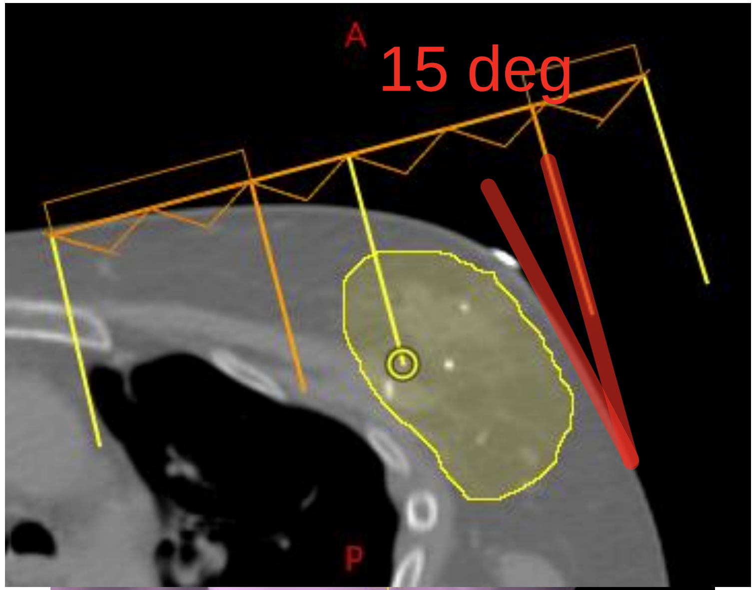
- Use 3 fields!
- First, create en-face beam (in 3D) (couch kick required)



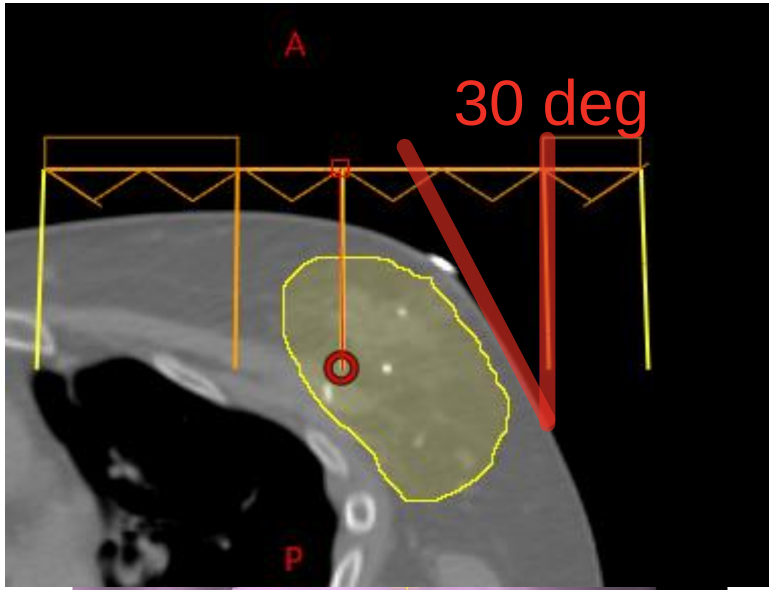


- add 3 more beams surrounding the en-face-beam and “maximize” hinge angle while maintaining the following limits:

Planning: Beam Angle Selection - Limits



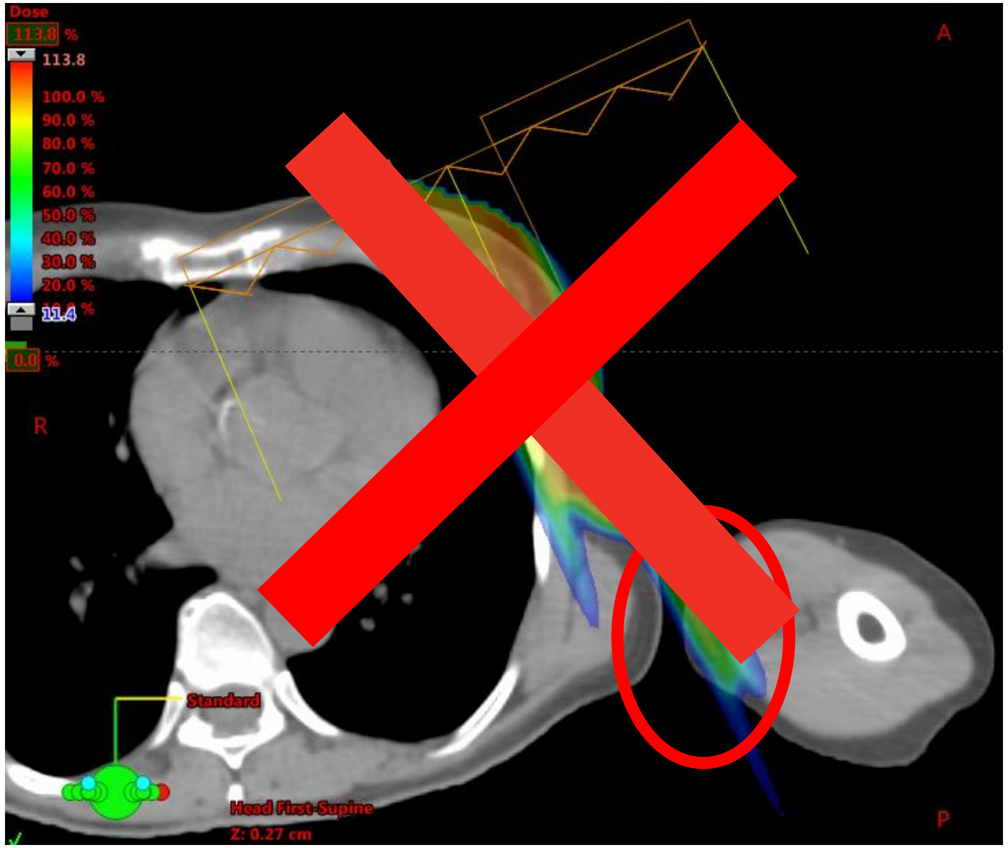
1. Grazing angle >~30 deg

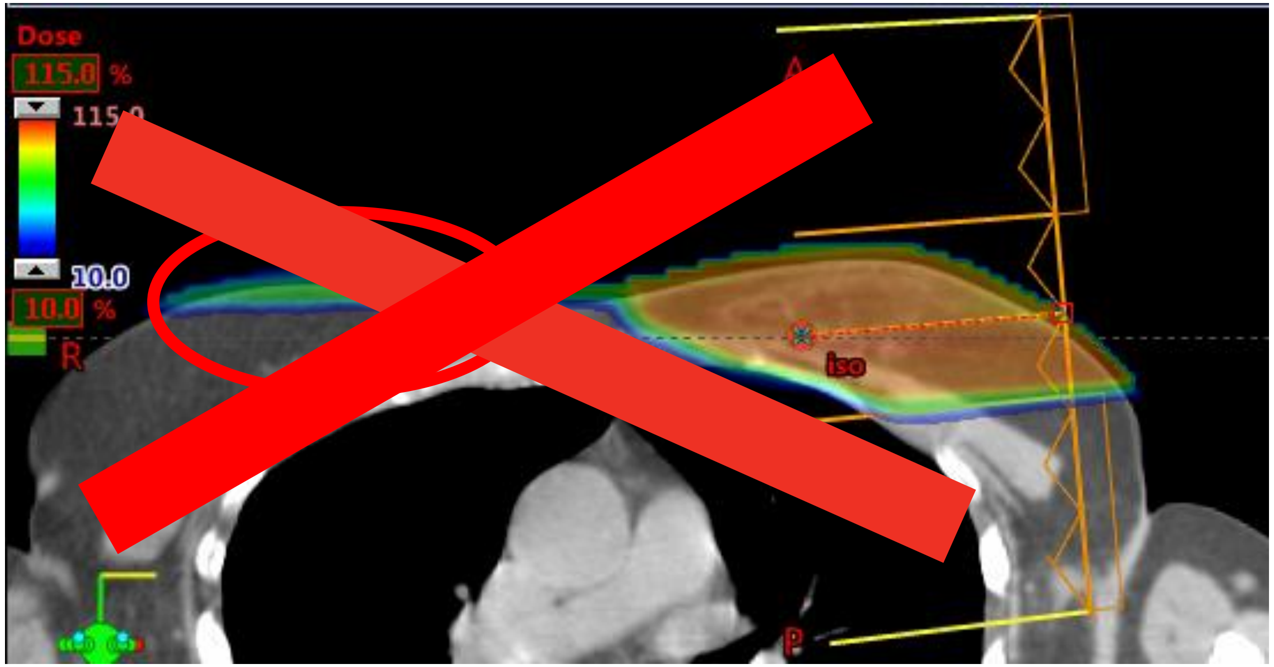


Visualize in Eclipse:

Planning: Beam Angle Selection - Limits

2. Avoid flash to arm or contralateral side

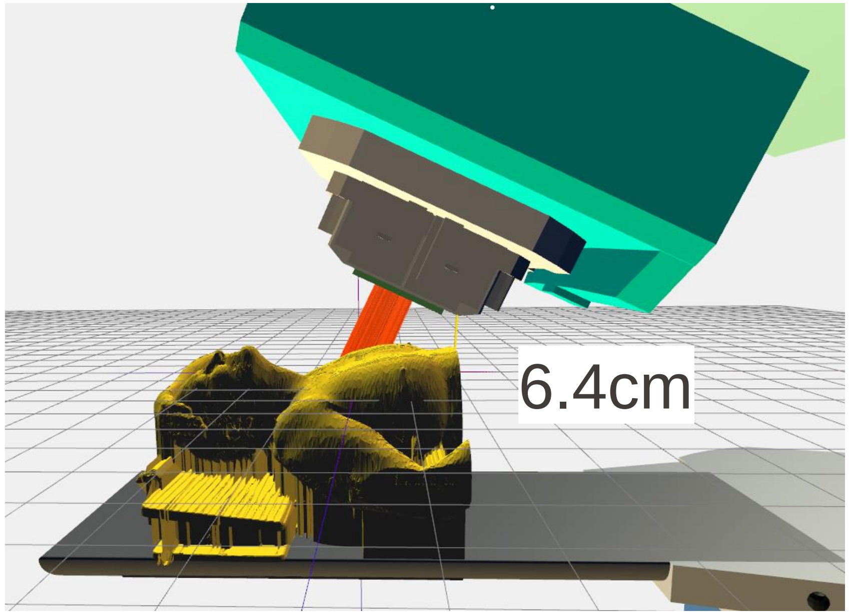


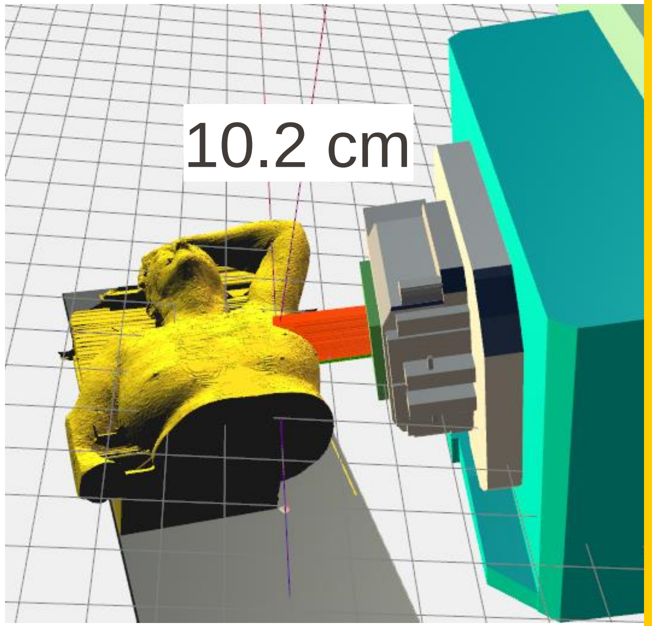


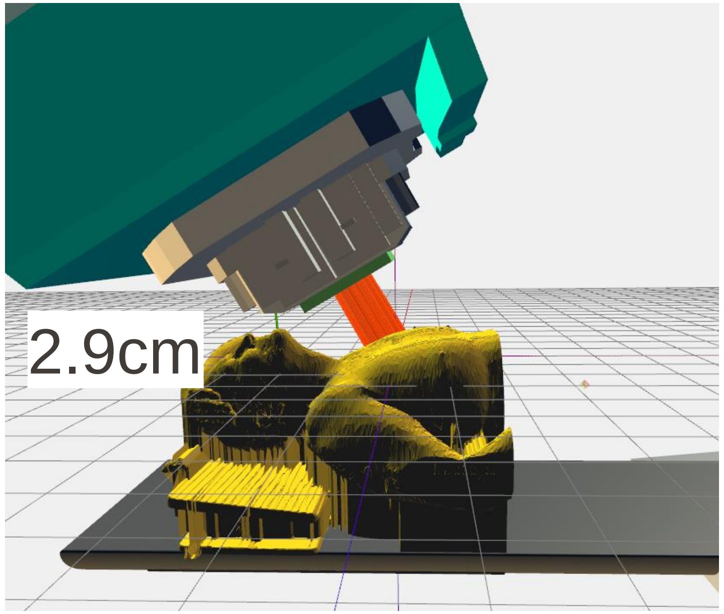
Planning: Beam Angle Selection - Limits

3) Snout position in TPS < 20 cm → Airgap < 15 cm (ensures lateral target coverage)

4) Patient-Geometry-Check-software, clearance: 6-10 cm







adjust gantry angle if needed.

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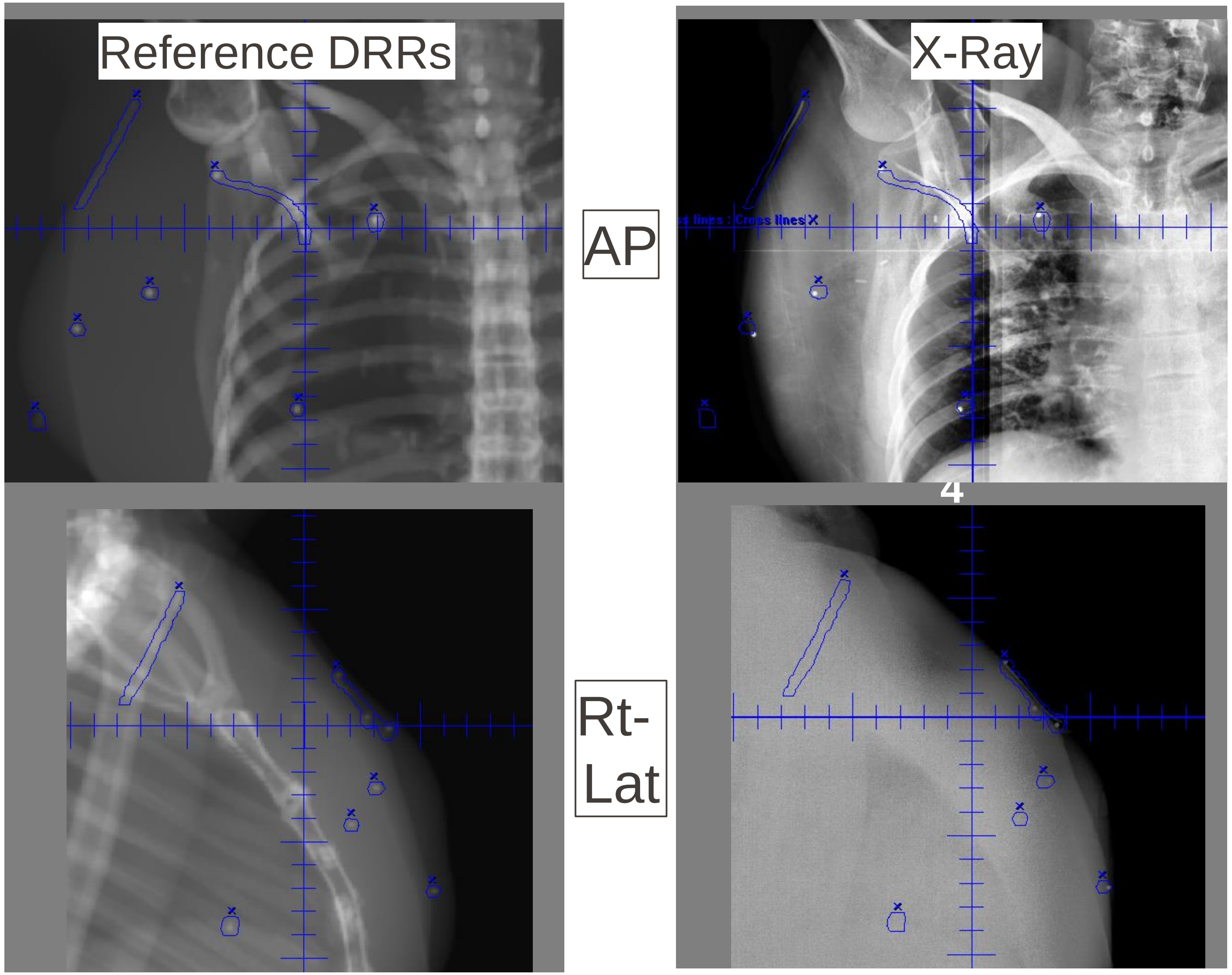
Planning: Beam Line Parameter

- No proximal margin (to limit skin dose)
- Distal margin‡: DM = Range x 3.5% + 0.1 cm
- Compensator smear (to account for setup uncertainties):
  1.0 cm for arms down (higher variability) and 0.7 cm for arms up
- Aperture margin are between 0.7 and 1.0 cm depending on how much coverage to the PTV is wanted

‡Moyer et al. IJROBP 49(5) 2001

IGRT

- Orthogonal X-ray
- BBs & wires placed on skin, but removed for treatment
- A 10 patient study ‡ average deviation over 100 Tx: 0.3-0.5 cm (1σ=0.2 cm)



‡Strom *et al.* Practical Radiation Oncology (2015) 5

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Patient Outcome

Clinical outcome of the first 100 patients‡

- No acute or late grade 3 skin toxicity
- Acute dermatitis (week 6): 58% grade 1, 11% grade 2
- Hyperpigmentation (week 6): 45% grade 1 (<10% area), 2& (>10% area)
- Physicians and patient cosmesis 83% and 93%
- Late skin effect (>18 month); spider veins ~35%

  → - dosimetric threshold 3525 cGy to 1 cm^3 of “2-mm” skin ≡ 2.5 cm^2

  - at least 3 fields
- No patient experienced fat necrosis, fibrosis, infection or breast shrinkage

‡ Pasalic *et al.* IJROBP 109(2) 2021

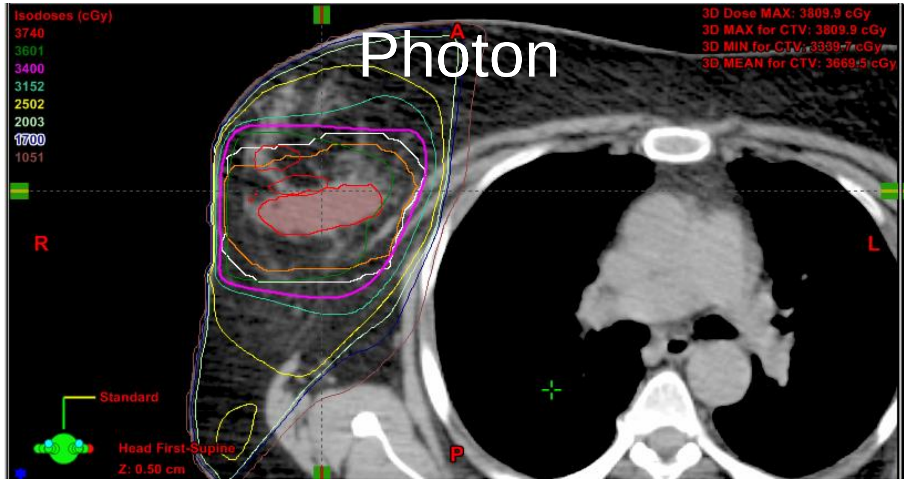
Patient Outcome

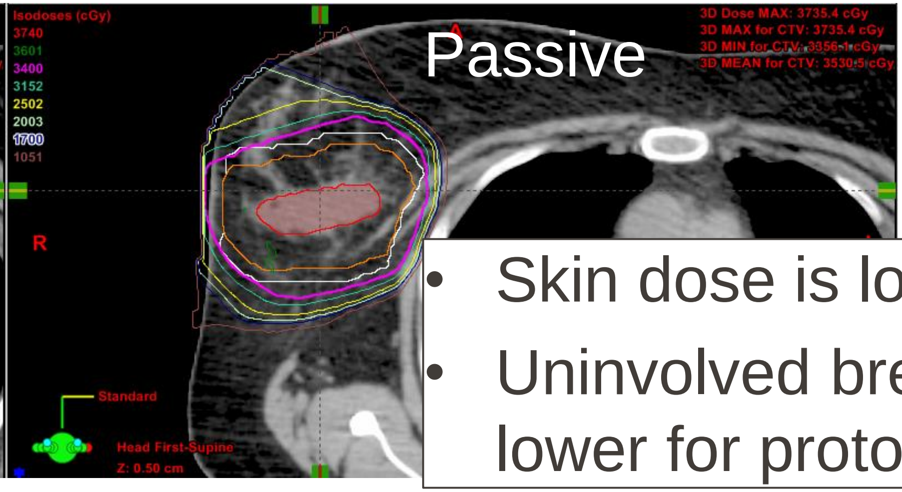
Cosmesis outcome selected patients after 1 year‡

- Hyperpigmentation in the irradiated field

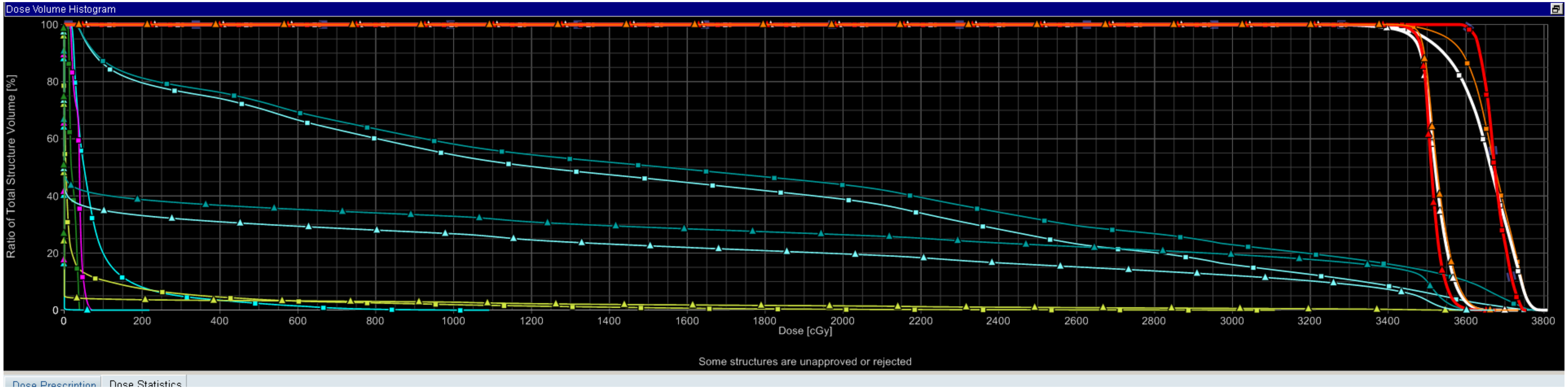
‡ Strom *et al.* Practical Radiation Oncology (2015) 5, e283-e290

Photon vs Proton

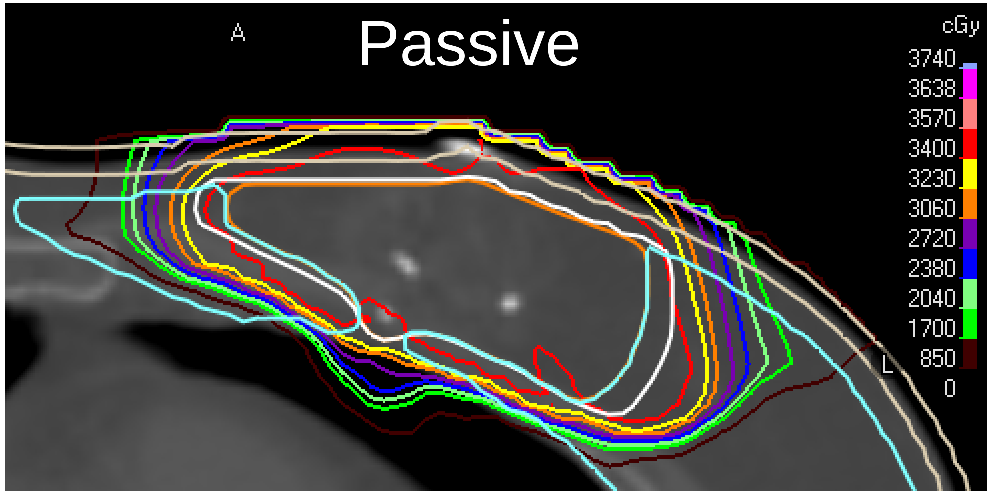


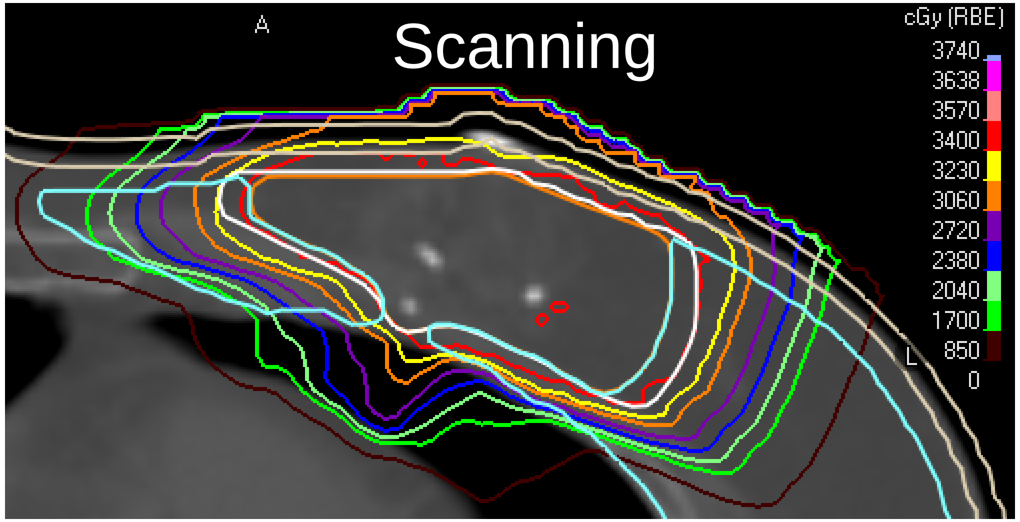


- Skin dose is lower for photon plan
- Uninvolved breast dose is much lower for proton plan

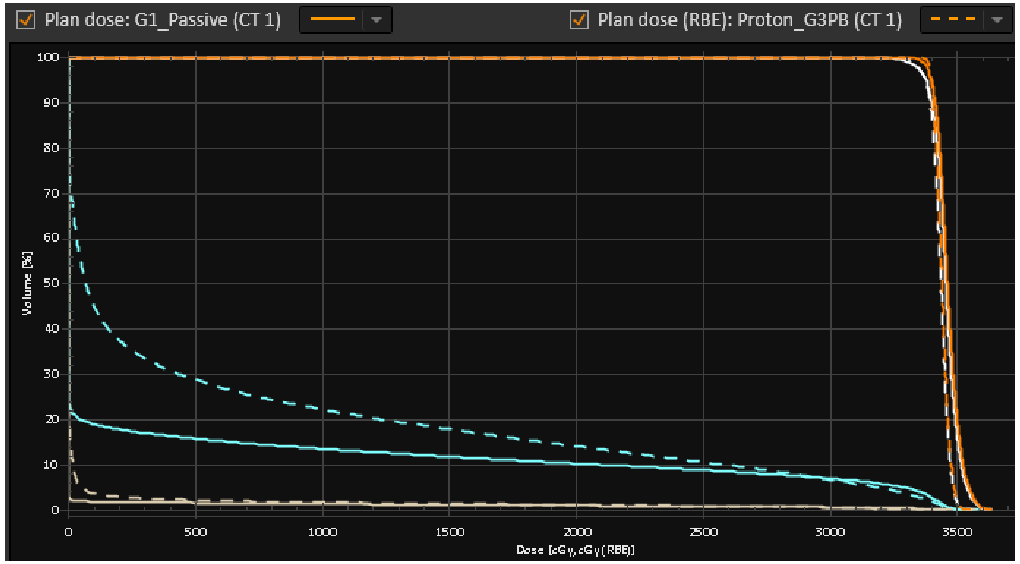


Passive (3 fld) vs Scanning (1 fld)



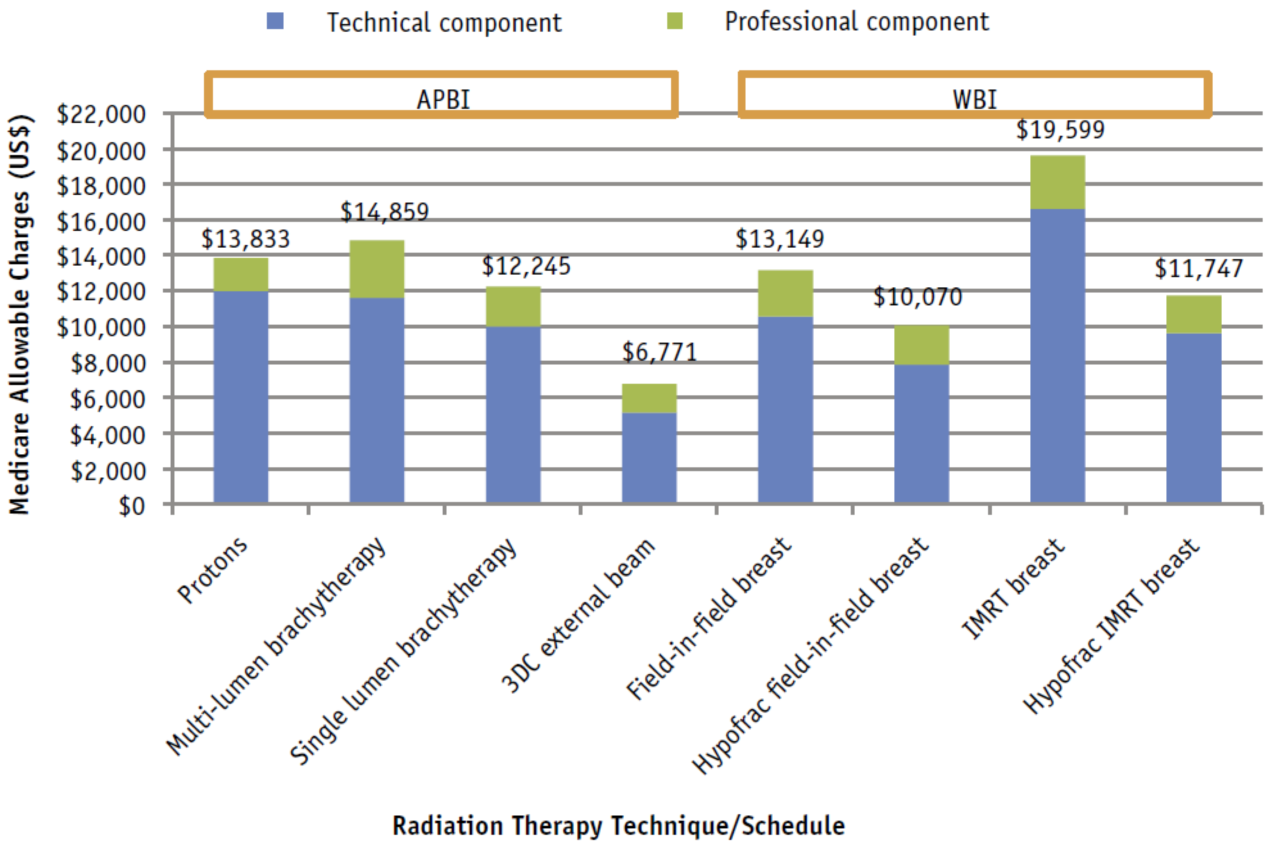


- Skin dose is lower for scanning beam plan
- Uninvolved breast dose is lower for passive plan



Costs of Proton Partial breast

- There has been many publication regarding cost effectiveness advocating the use for proton treatment, e.g. Ovalle ‡
- It was found that the costs of proton treatment is competitive with brachytherapy and standard FiF treatment
- The most expensive method was WBI IMRT



‡ Ovalle et al. IJROBP 95 (1), (2016)

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THE UNIVERSITY OF TEXAS
MDAnderson
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Thank you very much for listening.

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