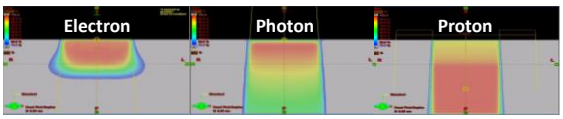
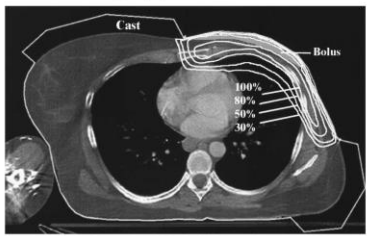
Introduction: *e* vs. γ vs. *p*



- Depth dose and lateral profiles
  - Suitable for superficial tumors
  - Requires collimation close to skin
- Clinical *e* unchanged for decades and underutilized in cancer radiotherapy
- ~ 15% utilization

EAT – *Electron Arc Therapy*

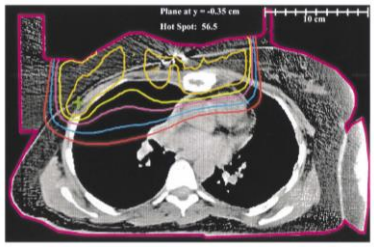
- Electron beam delivered in partial arc
- Modifications to linac/cone and TPS
  - Shortened cone
  - Different PDDs
  - Cutout shape
- Patient-specific cast/shield and bolus
- Primarily for chest wall irradiation
- Univ. of Utah



Leavitt 1985 Electron ARC therapy: physical measurement and treatment planning techniques IJROBP 11
McNeely 1988 Electron arc therapy: chest wall irradiation of breast cancer patients IJROBP 14(6)

ECT – *Electron Conformal Therapy*

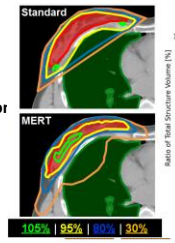
- One or a few electron beams
- Bolus electron conformal therapy
  - Tissue equivalent
  - Modulate electron energ
  - Keep PTV within 90% isodose volume
  - Minimize dose to distal/underlying critical structures and normal tissue

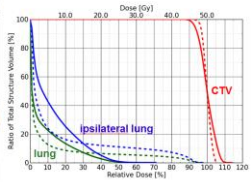


Perkins 2001 A custom three-dimensional electron bolus technique for optimization of postmastectomy irradiation IJROBP51

MERT – *Modulated Electron Radiotherapy*

- Multiple electron beams
- Energy modulation
  - Bolus or energy selection
- Intensity modulatior
  - Cutout
  - eMLC
  - pMLC
  - Scanning beam





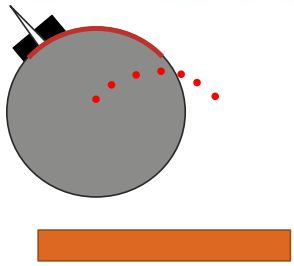
Henzen et al 2014 Beamlet based direct aperture optimization for MERT using a photon MLC. Med Phys, 41
Henzen et al 2014 Monte Carlo based beam model using photon MLC for modulated electron radiotherapy. Med Phys, 41

DEAR – *Dynamic Electron Arc Radiotherapy*

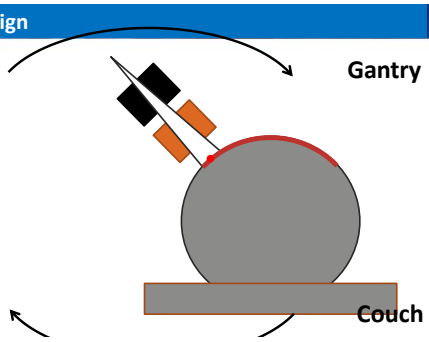
- Electron radiation is delivered in ARC mode
- Electron applicator and cut-out are kept to provide lateral beam constriction
- Treatment couch is in simultaneous motion with gantry rotation to prevent collision. Beam always normal to skin and SSD = 100 cm
- Couch motion, gantry rotation, and dose rate are modulated to produce desirable dose distributions

Rodrigues, Yin, and Wu. "Dynamic Electron Arc Radiotherapy (DEAR): a feasibility study", *Phys Med Biol*, 2014. 59(2)

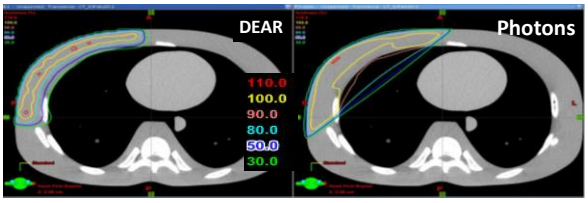
DEAR design



DEAR design



Plan comparison: chest wall phantom

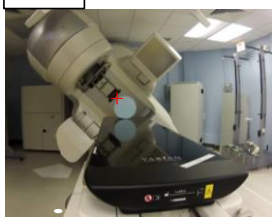


- DEAR: 6, 9, 12 MeV.
- Photons: 6X, tangent, no wedge

DEAR delivery

DEAR delivery demo

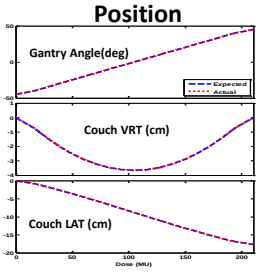
Room View



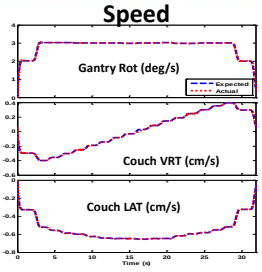
Patient View

Gantry and couch motion

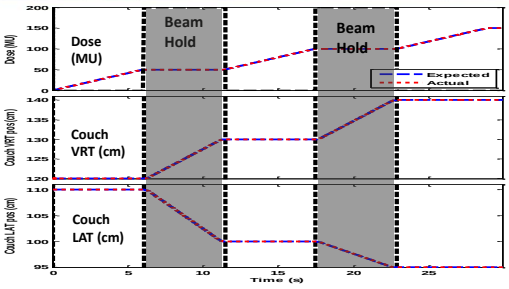
Position



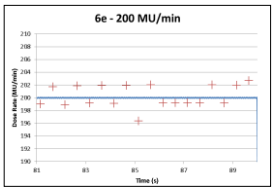
Speed



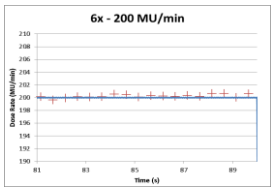
Beam hold



Dose rate modulation

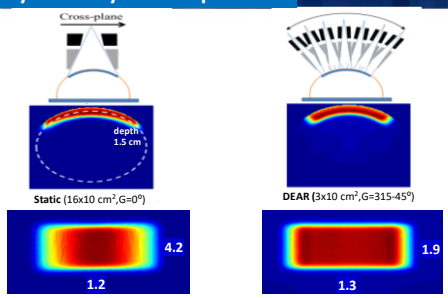


stdev = 1.6 MU/min



stdev = 0.2 MU/min

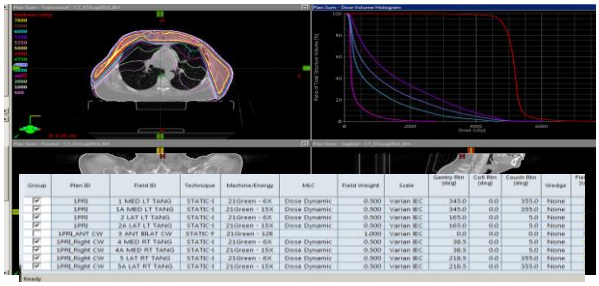
Dosimetry: 6*e* on cylindrical phantom



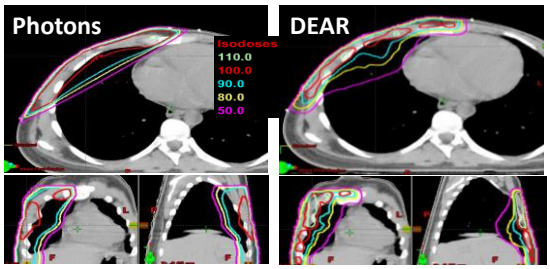
Virtual scanning mode

- 6 MeV electron
- D=1cm cutout
- CR film
- 148 CP (7MU/CP)
- Beam hold (D->e)

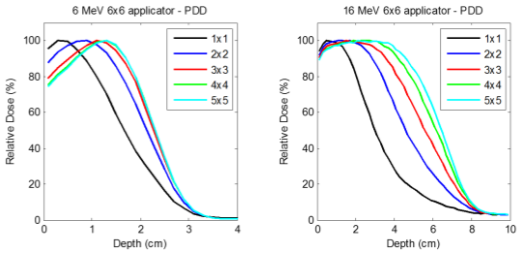
Potential DEAR case



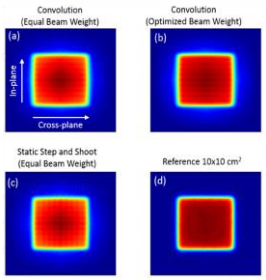
Need for fine energy resolution



Small field electron beam dosimetry

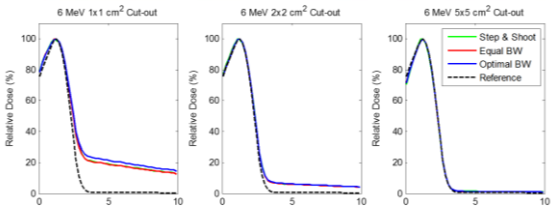


Small field electron beam dosimetry



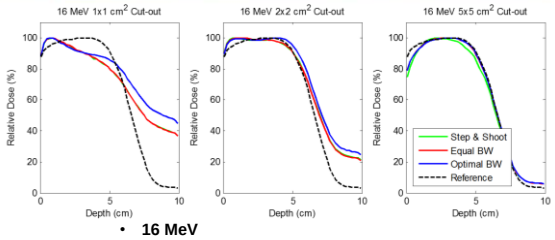
- **Composite dose map**
- **6 MeV**
- **1x1 cm² kernel**

Small field dosimetry



- **6 MeV**
- **10x10 cm²**
- **PDD**

Small field dosimetry



- 16 MeV
- 10x10 cm²
- PDD

DEAR Summary

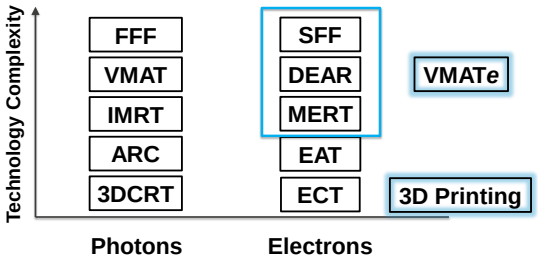
Advantages

- Uniform dose distributions over large and curved targets while maintaining narrow penumbra
  - Treated area > cone size
- DEAR delivery
  - Fixed cone/cutout
- DEAR delivery has high accuracy
  - Expected and actual plans agree very well
  - Trajectory log file can be used as a QC tool
  - Dosimetry

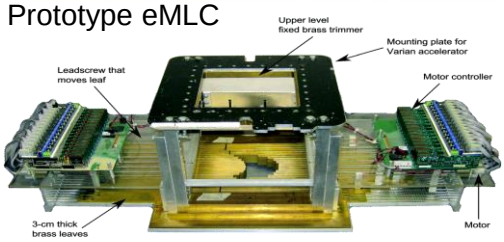
Challenges

- Small field dosimetry
- Not ready in clinical operation
  - Couch motion
- Coarse energy selection
  - Bolus
- Planning tools
  - Forward and inverse optimization
- Dynamic delivery collimators
  - Motorized electron collimator (MEC)
  - Electron MLC (eMLC)
- QA Tools

Summary: *e* vs. γ



Prototype eMLC



Eley, J. G., K. R. Hogstrom, et al. (2011). "Potential of discrete Gaussian edge feathering method for improving abutment dosimetry in eMLC-delivered segmented-field electron conformal therapy." Medical Physics 38(12): 6610-6622.

Looking to the Future

Antolak

Commercial eMLC

Gauer, T., D. Albers, et al. (2006). "Design of a computer-controlled multileaf collimator for advanced electron radiotherapy." Physics in medicine and biology 51(23): 5987-6003.

http://euromechanics.com/e_emlc.html

https://www.youtube.com/watch?t=66&v=F0BBbHRrjBg

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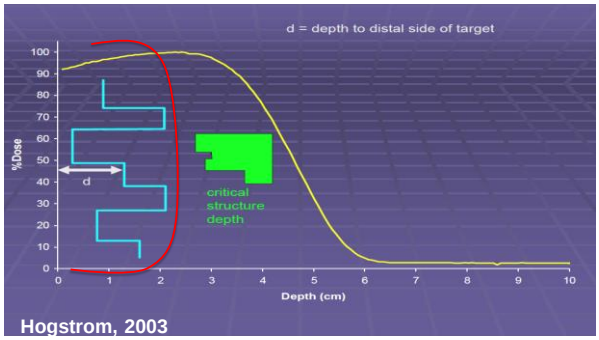
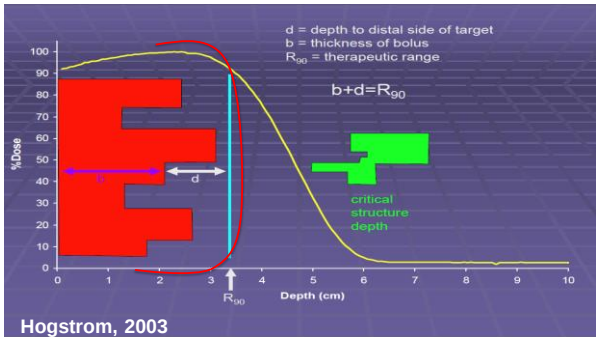


Hogstrom, 2003



Hogstrom, 2003