External beam radiotherapy

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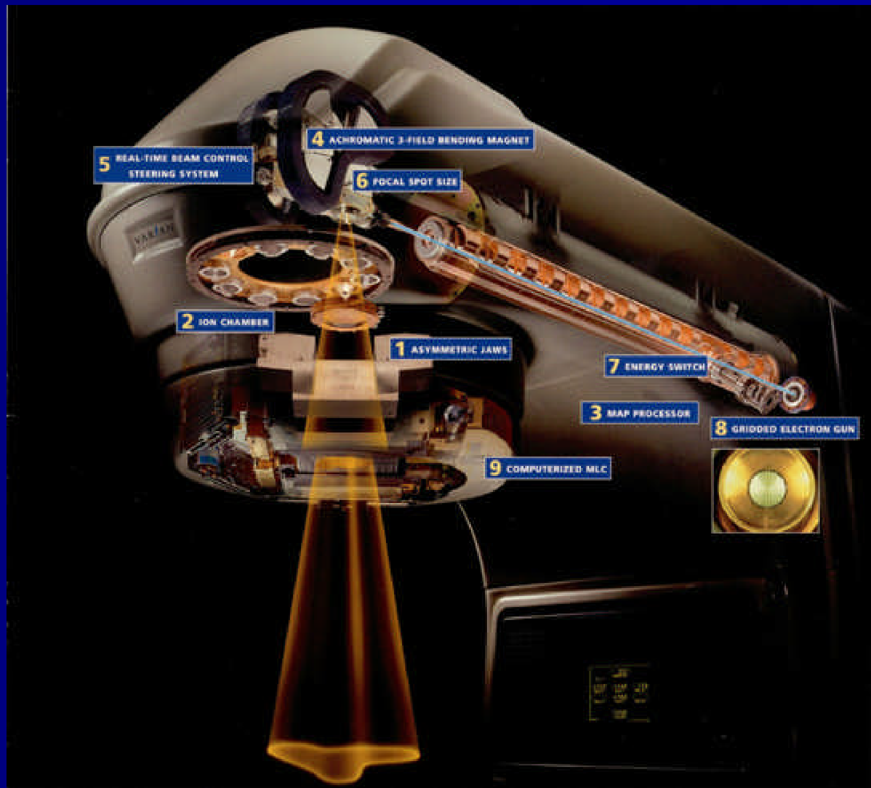
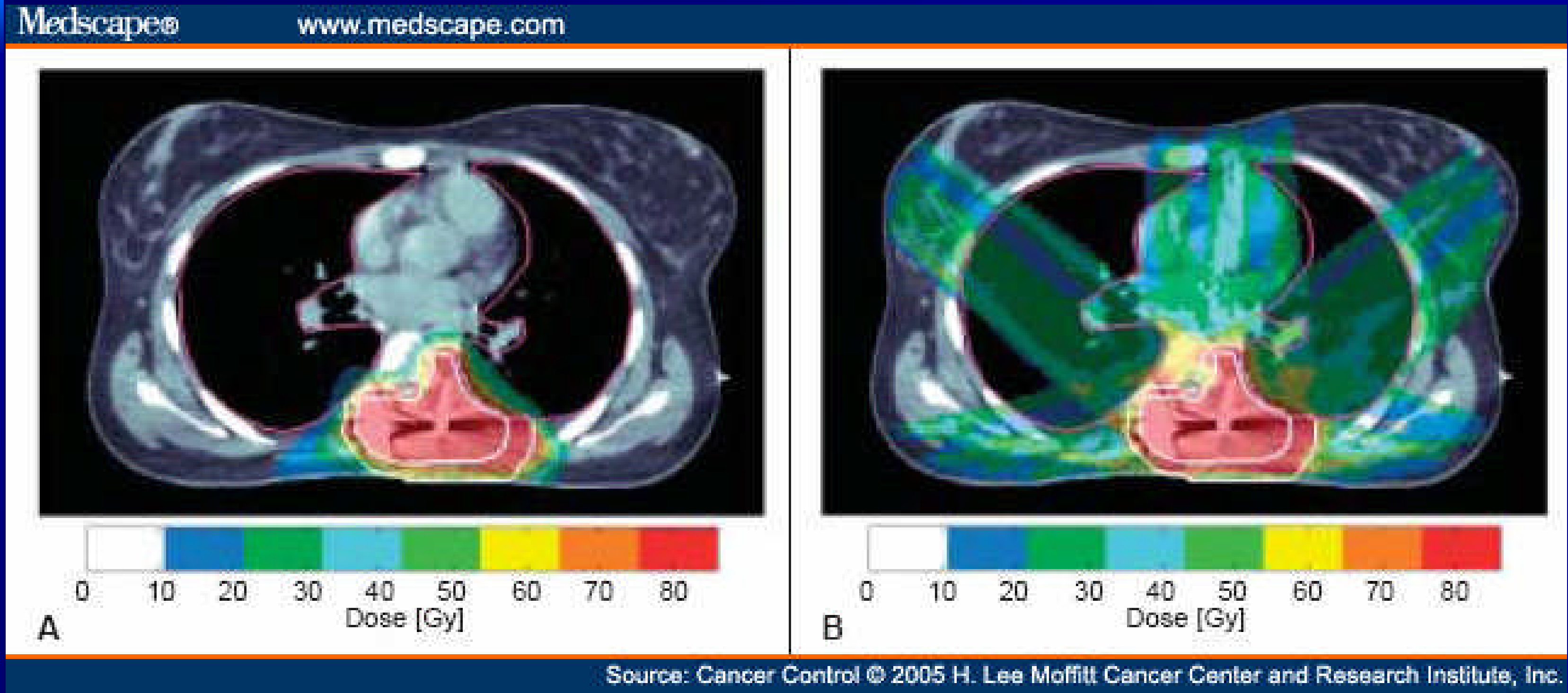
Tools for external beam radiation therapy



Dose distributions in external beam radiation therapy



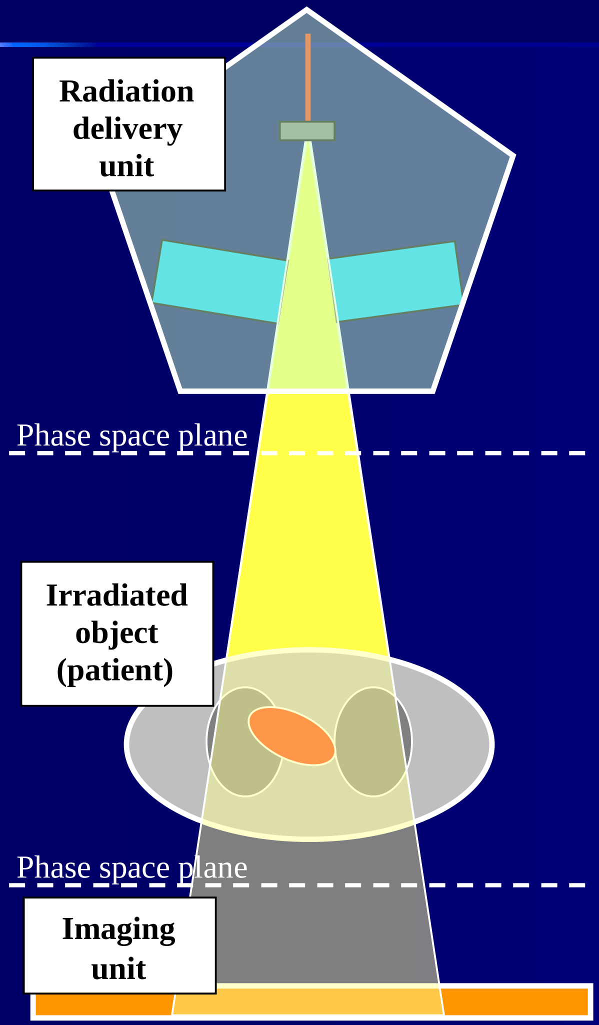
What is external beam radiation therapy?

- The largest application of medical physics (~80-90%)
- Most versatile part of medical physics (merging of all basic disciplines)
- Extensive use of computers in radiotherapy with CT-based therapy and convolution/superposition dose calculation
- Since then various applications ranging from dosimetry through imaging science
- More and more dependent on computers

Main applications

- Conventional radiation therapy
  - Dose calculation of open fields
  - Dose calculation of blocked fields
  - Large field dosimetry
- Intensity modulated radiation therapy
  - Dose calculation of narrow fields
  - Small field dosimetry
  - Optimization
- Image-guided radiation therapy
  - Imaging systems
  - Off- and on-line adaptation

Typical computational simulation

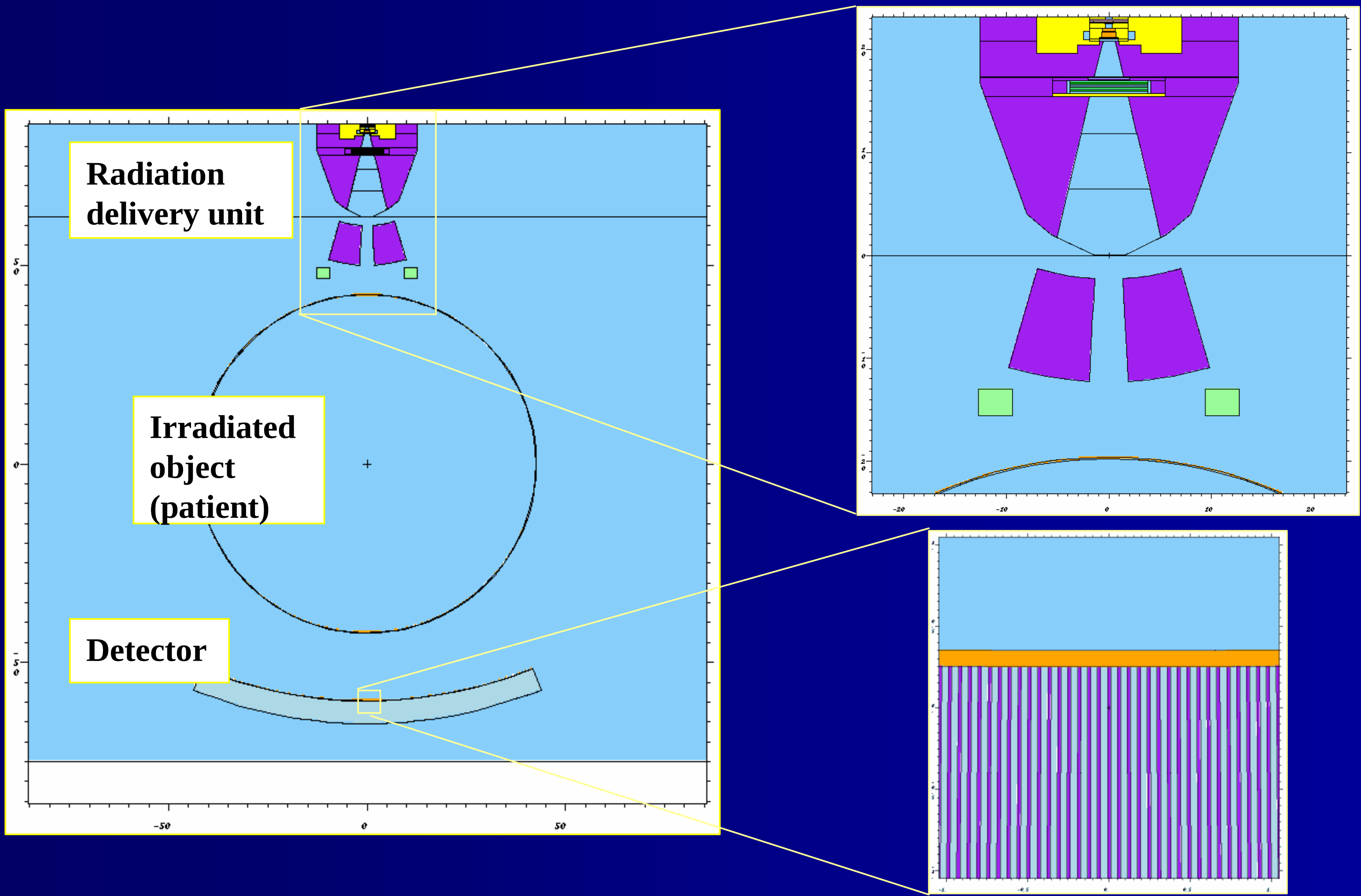


Three main units:

- radiation delivery unit
- radiation detection unit (imaging)
- irradiated object

Phase spaces between different units are the main communication interface. If needed, phase space models can be made based on these phase spaces to input into MC or deterministic codes.

Example (tomotherapy)



Most common applications

- Linac simulations
  - Beam production (target simulations, spectra)
  - Beam modifiers
  - IMRT applications
- Dose calculation
  - Homogeneous and heterogeneous phantoms
  - Clinical applications
- Dosimetry
  - Ionization chamber correction factors
- Imaging systems
  - Portal images

Main problems with benchmarks

- Very few "benchmark-orientated" experiments
- Mostly clinical experiments
- Many inter-code comparisons
- Many simple calculations
- Lots of literature, little useful for benchmarking

Software tools

- Benchmarks (radiotherapy) = Monte Carlo dose calculation
- Most commonly used MC codes
  - EGS (~60-70%)
  - MCNP (~20-25%)
  - PENELOPE (~5-10%)
  - GEANT (~2-5%)
  - Other (<5%)

What is missing?

- Rigorous benchmarking (together with other applications in Med Phys)
- Dose calculation is not a problem
- Main focusing areas should be
  - Imaging
  - Treatment adaptation
  - Perhaps time-dependence (4D)

Parallel computing

- University of Wisconsin – Madison $1.2M from NSF + $0.7 internal funds – Grid Laboratory Of Wisconsin (GLOW) with ~400 dual processor systems under Condor environment
- Medical Physics is 1/6 of the project
- Need, but problems with distributing vs parallel code architectures (e.g., MC codes, optimization)

Conclusions

- Lots of literature
- Few high quality benchmarks
- Need for more rigorous benchmarks
- Need for more benchmark-oriented experiments
- Strong connection with other medical physics disciplines