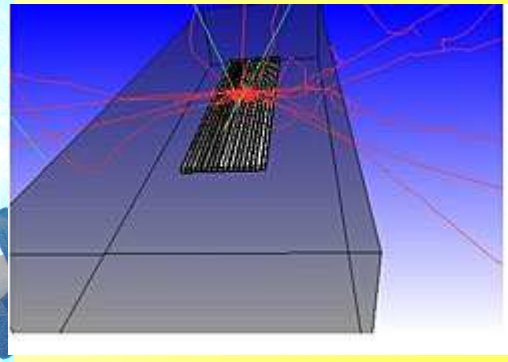
Fundamental Physics and Basic Research In Brachytherapy With Geant4

Hampton University - Hampton, VA
http://www.jlab.org/~gueye/CAMI/cami_web
Jefferson Lab - Newport News, VA
http://www.jlab.org/glab

- Source Uniformity
- 3D In-vivo Measurements
- Energy Dependence
- Biomedical with Ultrafast Lasers
- G4NAMU
  - Elementary Cross Sections
  - Energy Loss
- Polarization Dependence
- Convolution Product in Imaging

Beta Detector

(Coll: NIST, Varian)



→ Uniformity/non-uniformity of sources

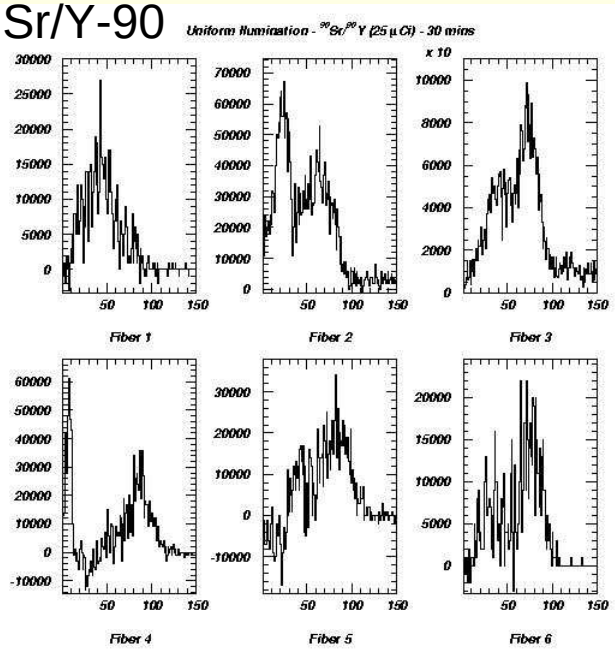
→ Absolute calibration of Brachytherapy sources

→ Removed transfer: films ↔ ionization chambers

→ Accuracy better than 100 μm (possibly: 50 μm)

PhD Thesis: Lawrence Tynes

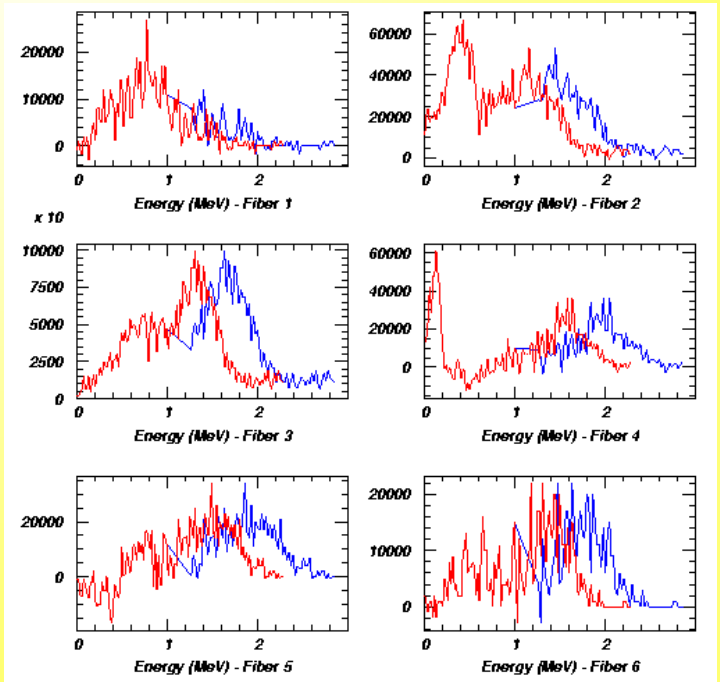
Sr/Y-90



Preliminary

Deconvolve

Physics Processes

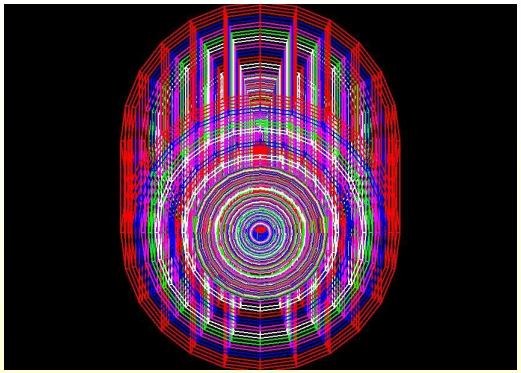


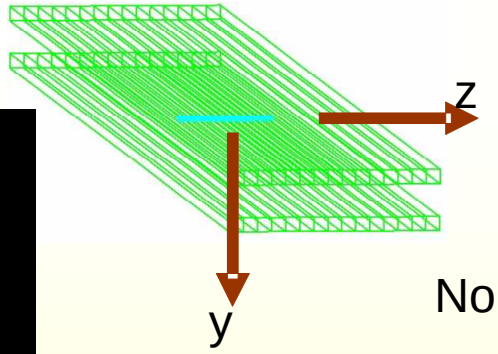
Before

After

GESiB

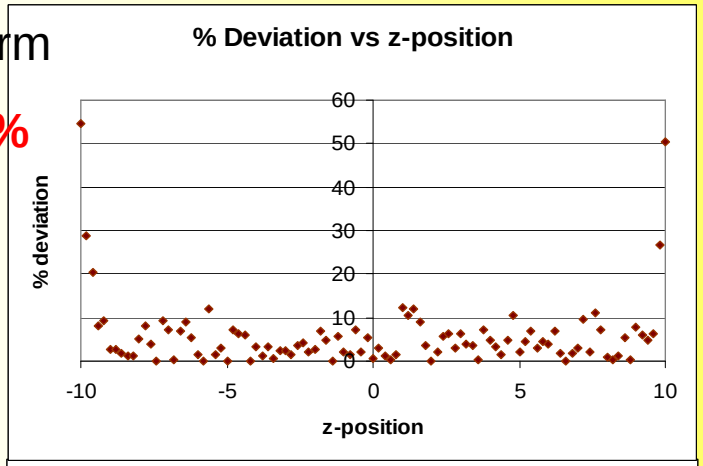
(Coll: MGH, Laval, McGill, Varian)





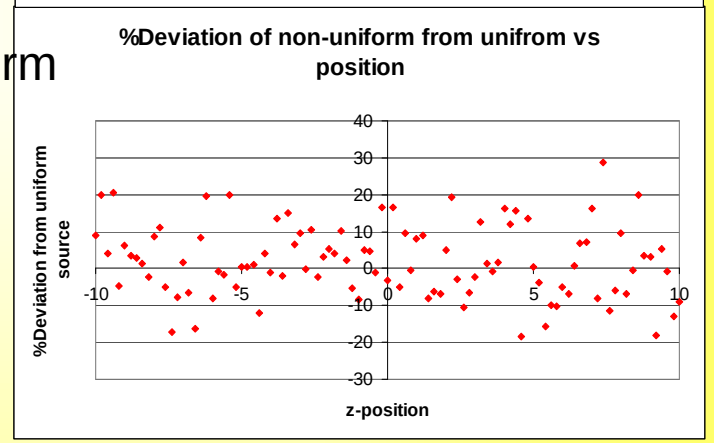
Uniform

<10%



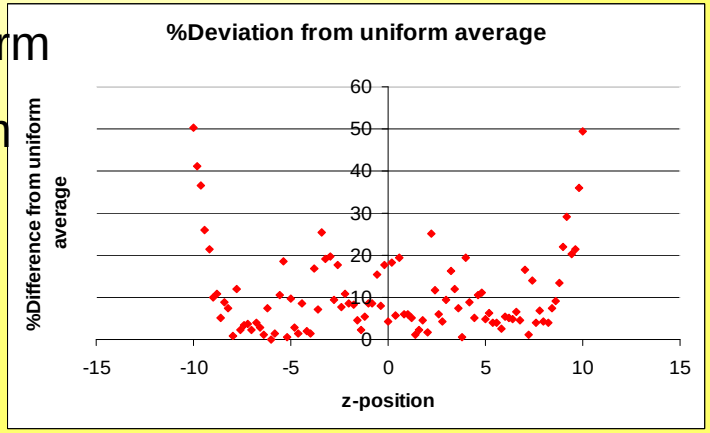
Non-Uniform

<20%



Non-Uniform / Uniform

>20%



Uniformity/non uniformity of Brachytherapy Sources

P-32: Φ = 0.21 mm x L = 20 mm

Cylinders: number = 100,wall = 0.2 mm

AAPM: TG43, Dose rate @ surface & 2 mm

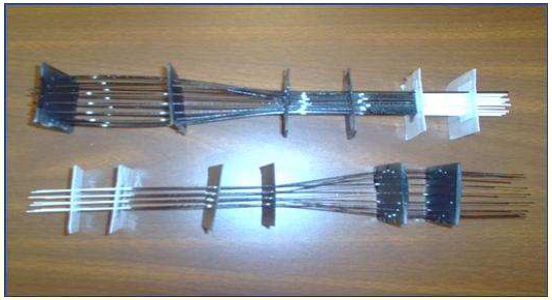
IAEA: %deviation from average **(Req: <20%)**

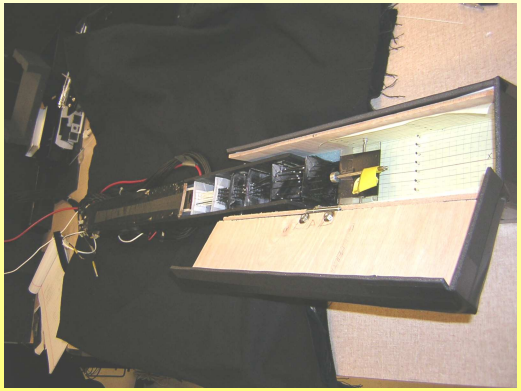
w/o & w/ 80 μm bubble, 150k events

PhD Thesis: Nnenna Onumah

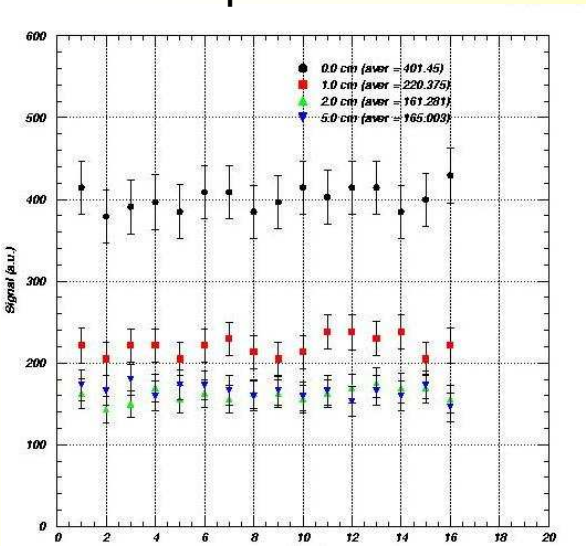
In-vivo Dose Measurements

(Coll: DePaul Hospital, Varian)

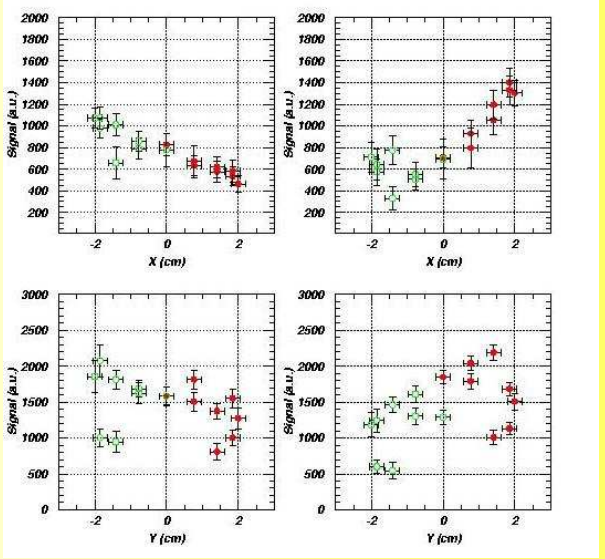




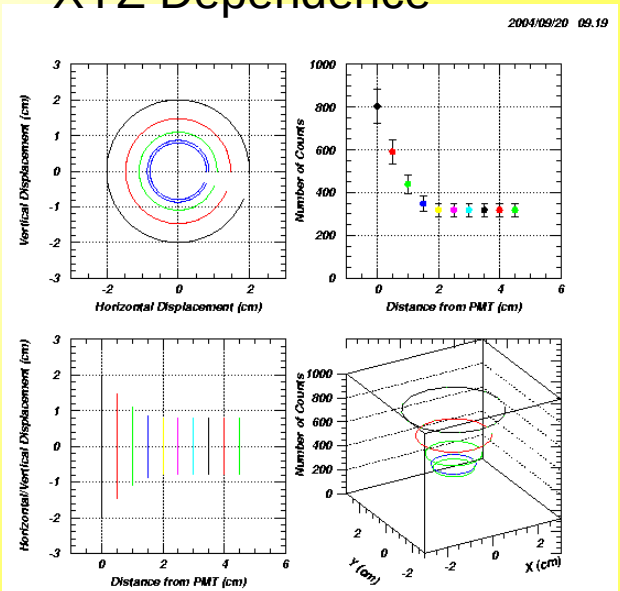
Z Dependence



XY Dependence



XYZ Dependence



→ Real Time Measurements

→ Position, dose distribution

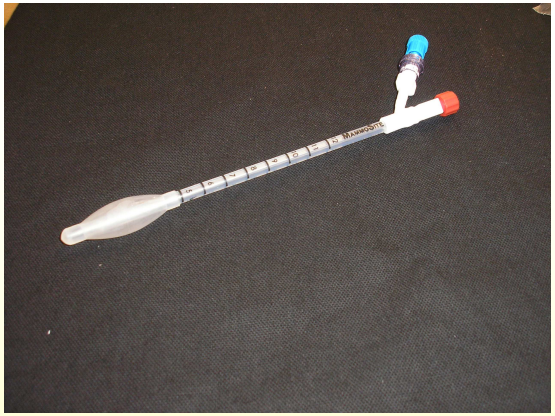
→ Treatment Plans:

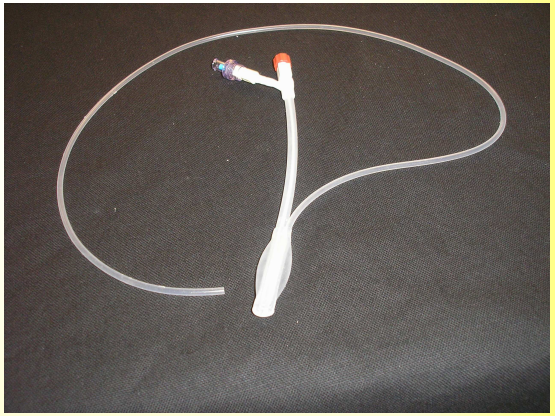
Verification, Adjustments

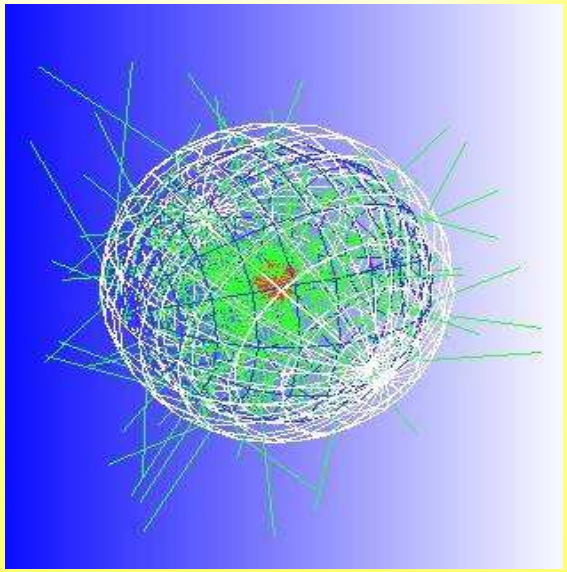
PhD Thesis: Carlos Velasco

Active Mammosite

(Coll: Proxima Therapeutics, dePaul Hospital)







→ Real time measurements

→ Absolute position (≤ ±1 mm)

→ Absolute dose distribution

BSc (MSU): Jacquelyn Winston

BSc (HU): Thomas Cudjoe

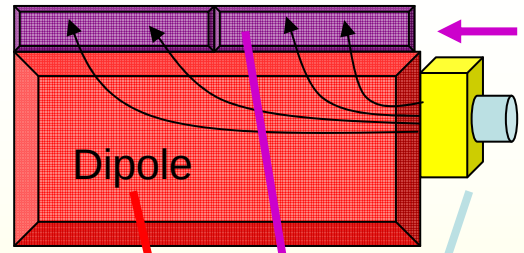
Mono Energetic Brachytherapy Sources

(Coll: Jefferson Lab, EVMS, ODU)

→ Energy dependence of cancer cells

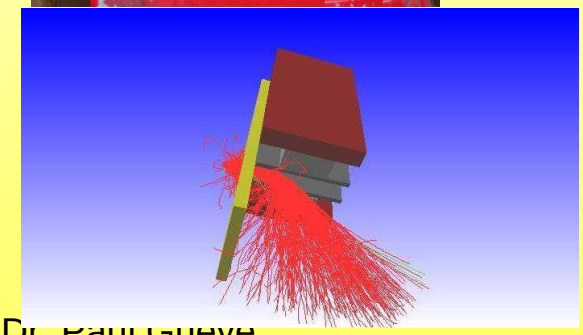
Master Thesis: Ariano Munden

PhD Thesis: Rachel Black

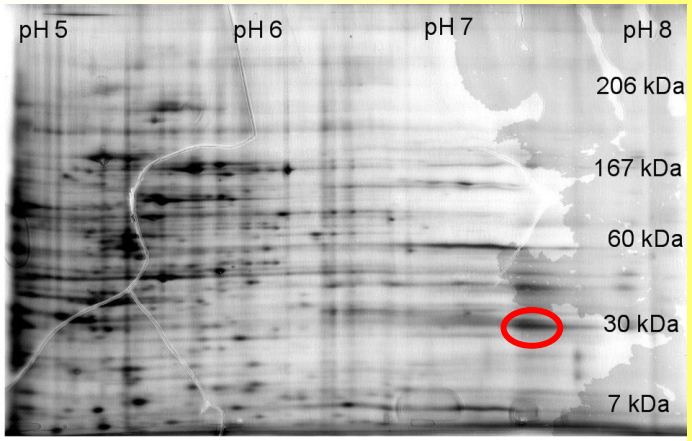


Breast cancer cells

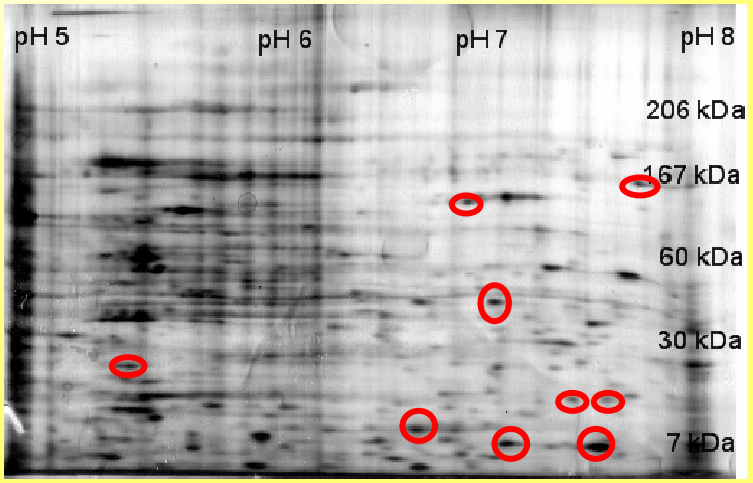
Collimator & source (Sr-90)



1-2 MeV



0.3-1 MeV

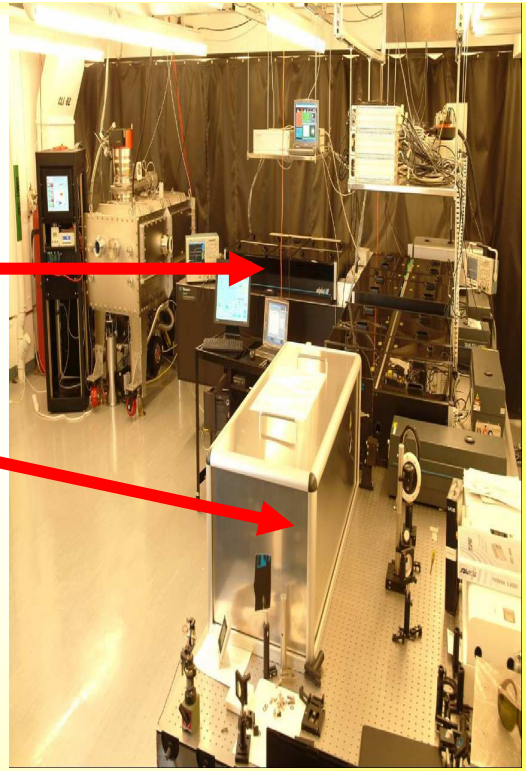


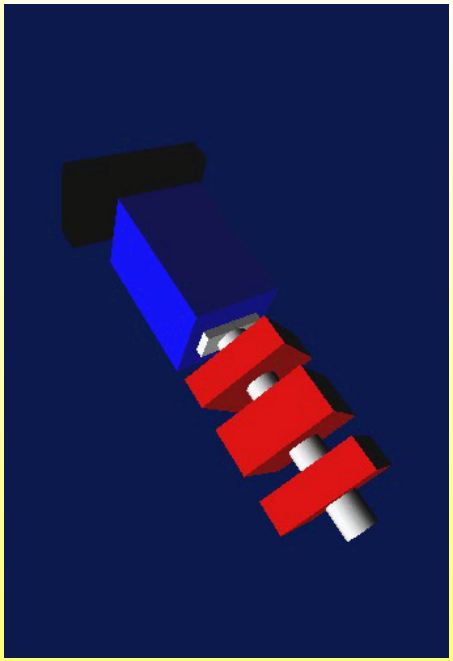
Advanced Laser Light Source
Ultrafast & Interface Biology/Medecine

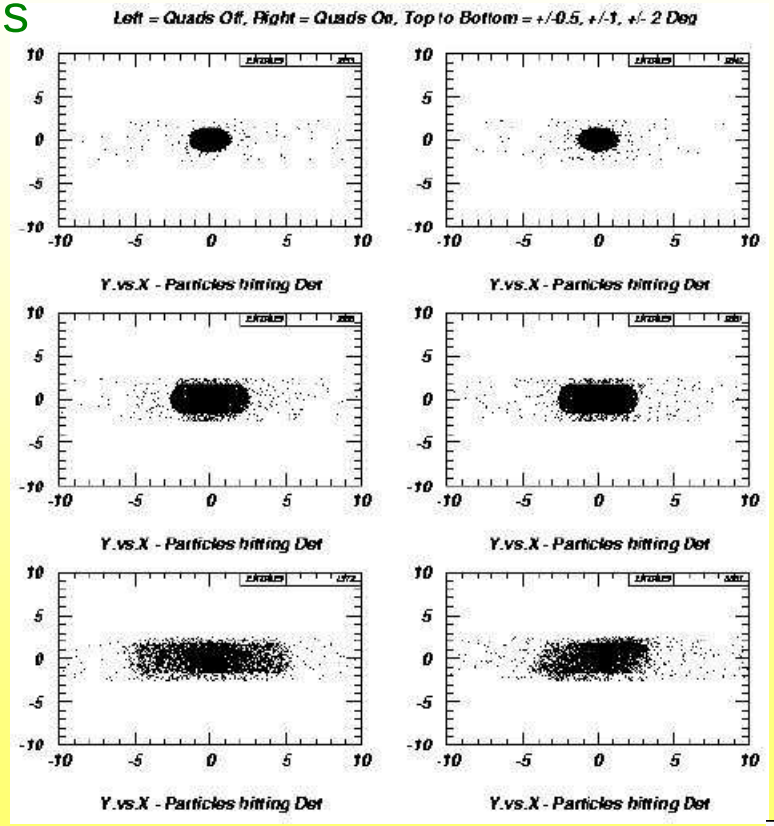
- Varennes, Canada
- Dynamic of biological processes
- Radiation safety (monitoring program)
- Charged beams characterization
- Medical Applications

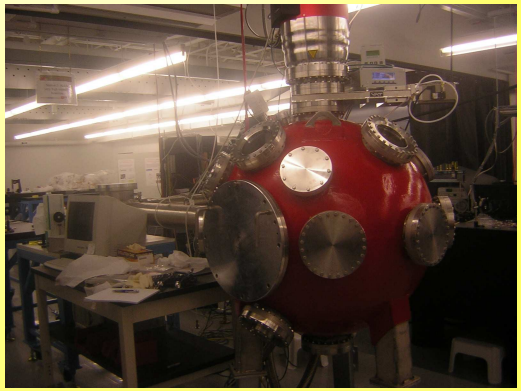
10 Hz, 300 mJ, 25 fs

100 Hz, 100 mJ, 25 fs







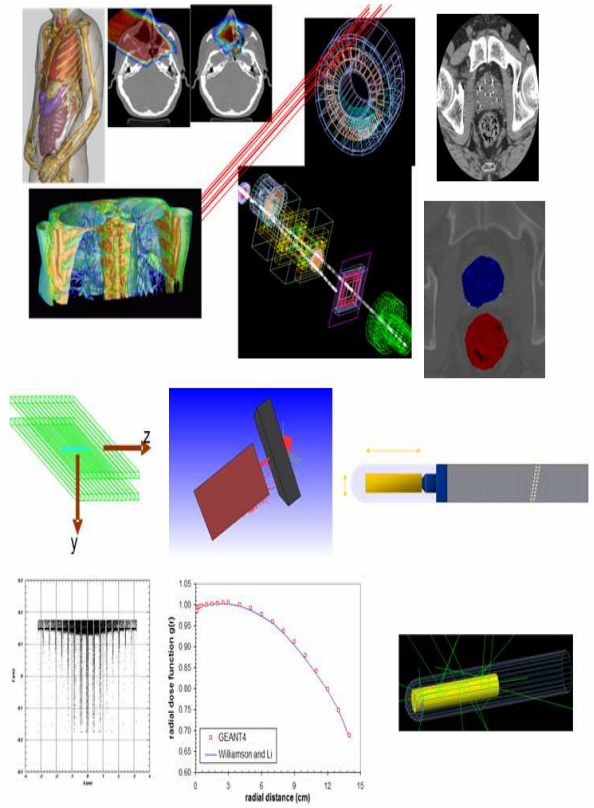


G4NAMU

http://geant4.slac.stanford.edu/g4namu/index.html

G4NAMU

- Coherent working groups in US & Canada
- Three Groups
  - Brachytherapy
  - Proton therapy
  - PET/SPECT (GATE)
- Head of Brachytherapy section

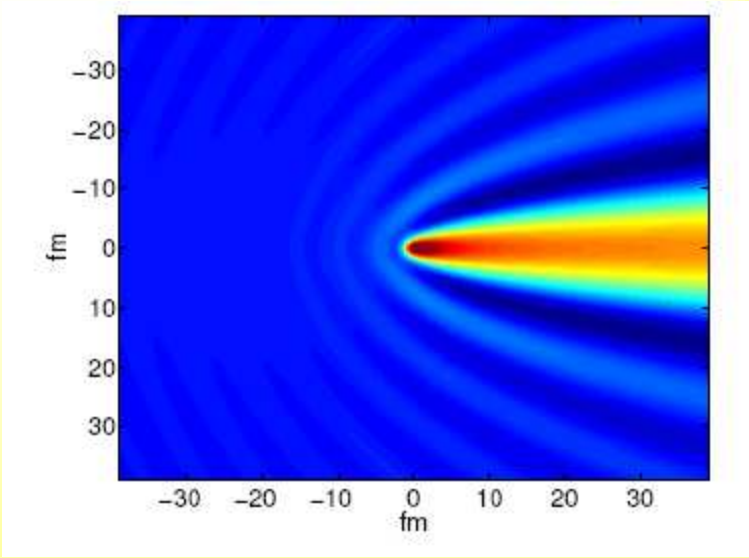


G4NAMU, Ctnd.

208Pb(e,e')

E = 100 MeV

~40% effect!



Physics Issues (<50 MeV)

- Electromagnetic physics
- Low energy neutrons
- Multiple scattering
- Coulomb corrections
- Experimental cross sections
- Theoretical understanding
- Start: March/April 2006
- Groups: HU, JLab, Laval, McGill, Switzerland, NIST, Saclay, INFN, CERN, SLAC…

Futures Directions

- Accelerator Physics (JLab/EVMS)
  - Proton therapy
    - New center at Hampton University
    - Collaboration with MGH, Saclay & Orsay
  - Polarized beams in cancer treatments

  PhD Thesis: Michael Epps & Solomon Sahle

- Convolution Product & Lyapunov stability in Medical Physics (Switzerland/France/Italy/Armenia)
  - Nuclear Physics form factors (validation)

    $\sigma(Q^2, W, t) = f(Q^2) \otimes g(W) \otimes h(t)$
  - Implementation in medical physics

  Bachelor degree: Lesly Upton

! Questions !