Dose Build-Up effect in Proton Therapy

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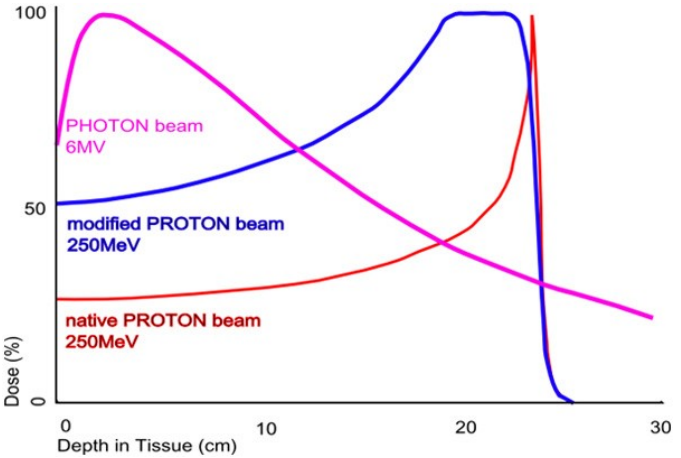
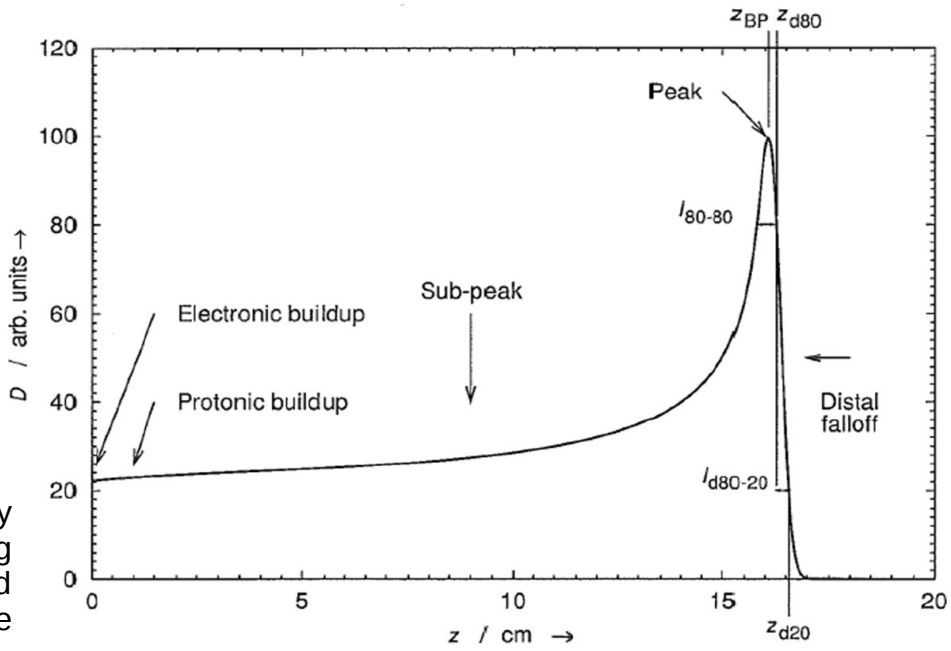
What it is

- Protons loose energy by ionisation i.e. liberation of electrons
- Propagating electrons do electromagnetic showering
- Those showers peak in beam direction
- This causes a build-up of the dose in the tissue
- Well known from conventional radiotherapy:
- Also expected in proton therapy
  but much smaller because produced
  electrons have lower energy
- Additional contribution from secondary
  protons expected (nuclear reactions)
- Benjamin Tham (UCL, Medical Physics)
  investigated this in his Master project
  in MC simulation

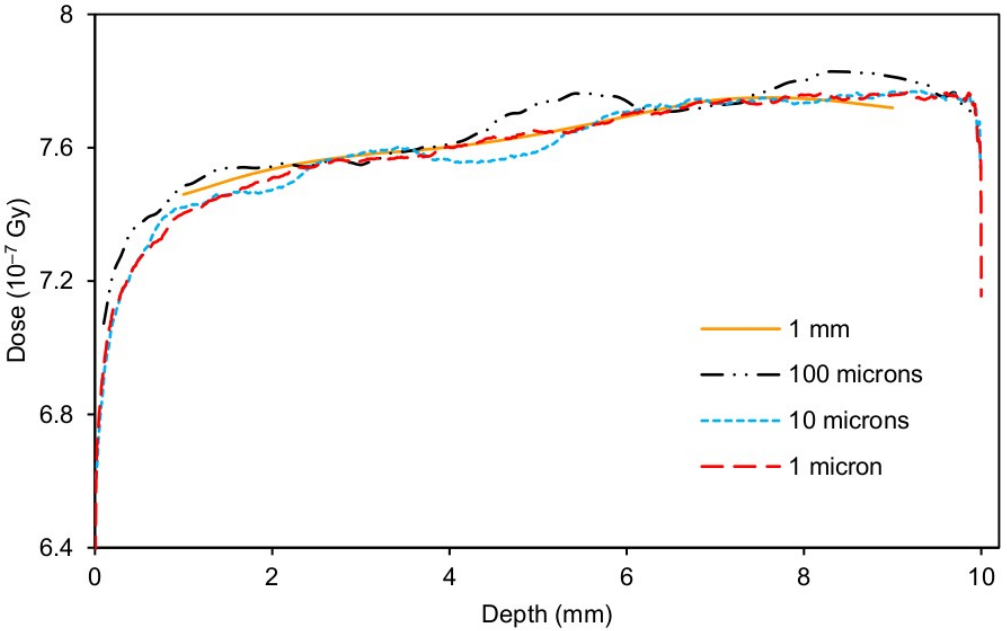




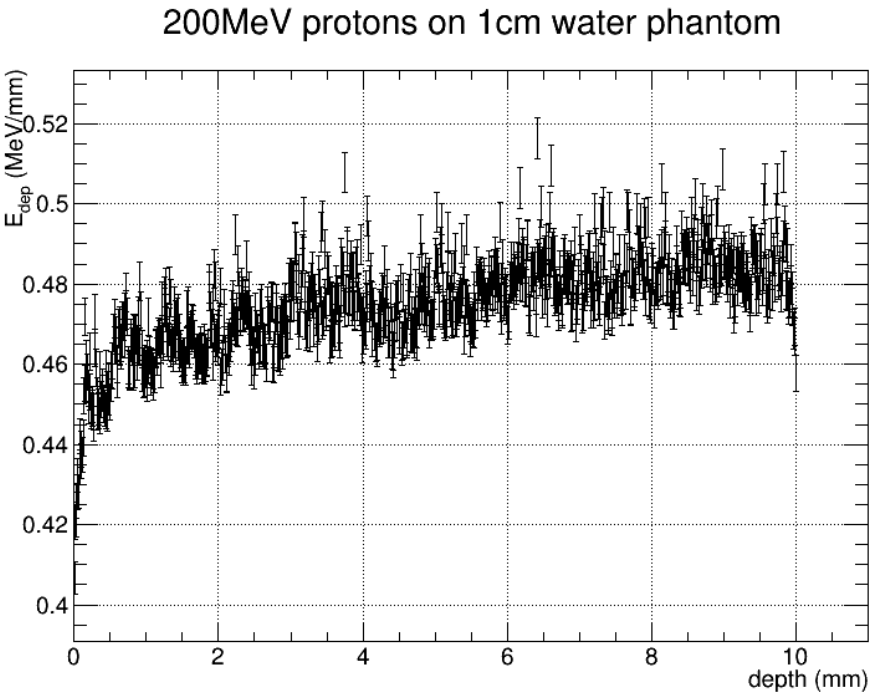
The physics of proton therapy
Wayne D Newhauser and Rui Zhang
Published 24 March 2015 • © 2015 Institute of Physics and Engineering in Medicine

Ben's Master project

- I think I can reproduce Benjamin's results
- Plots show the same features



Ben's simulation

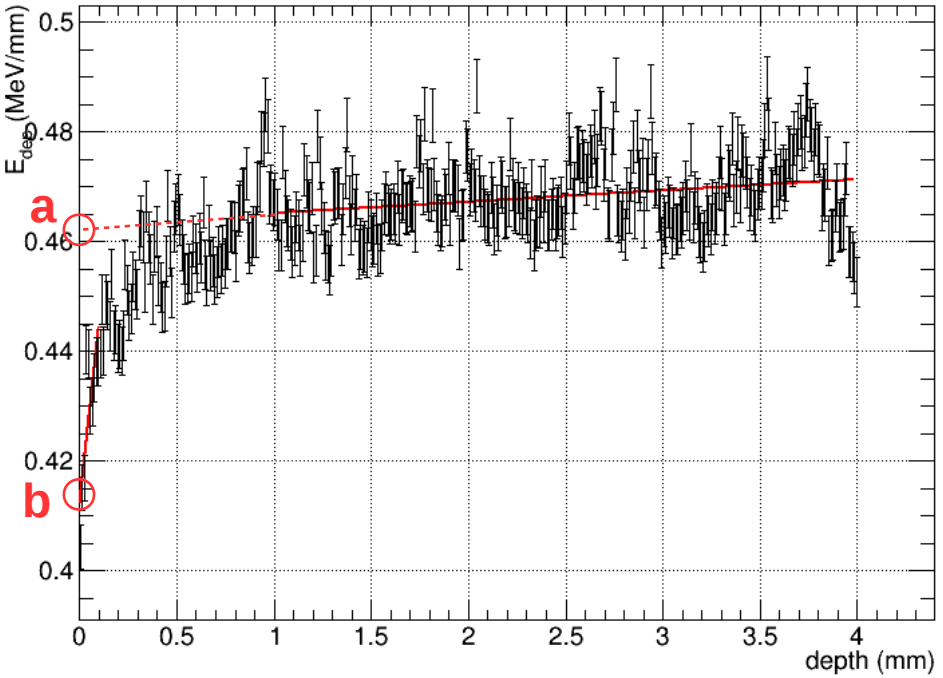


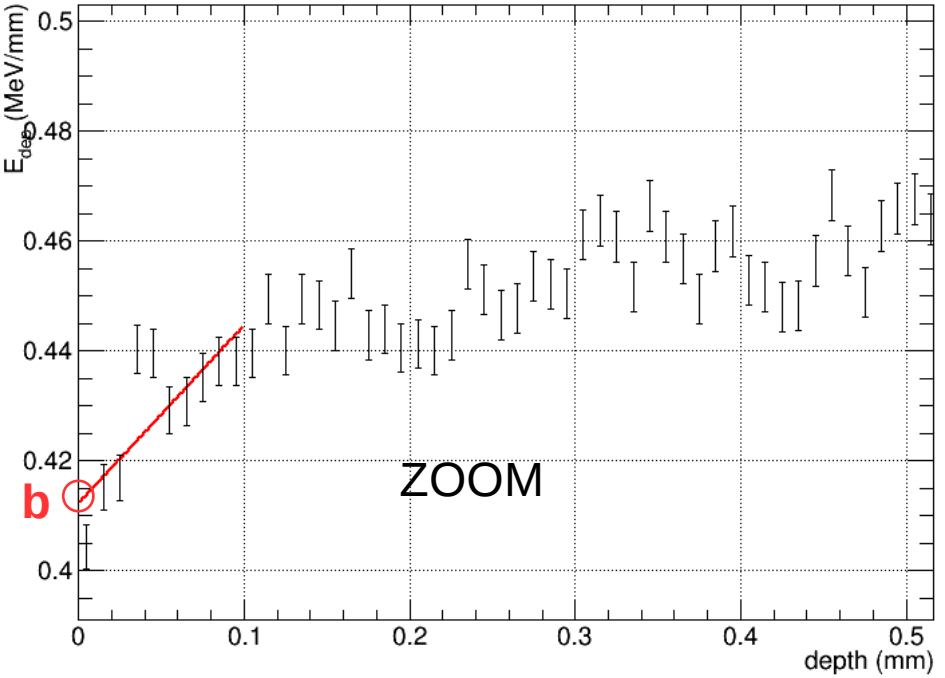
My reproduction using his code

Quantization and Clinical Relevance

BU = (a-b)/a

- My first try of quantization of the **electron** build-up effect:
  It happens on a scale of **1mm** and is of the order of **BU=10%**
- Contribution from secondary protons happens at bigger scale (next slide)
- Is that clinically relevant? Is it worth to prove irrelevance?

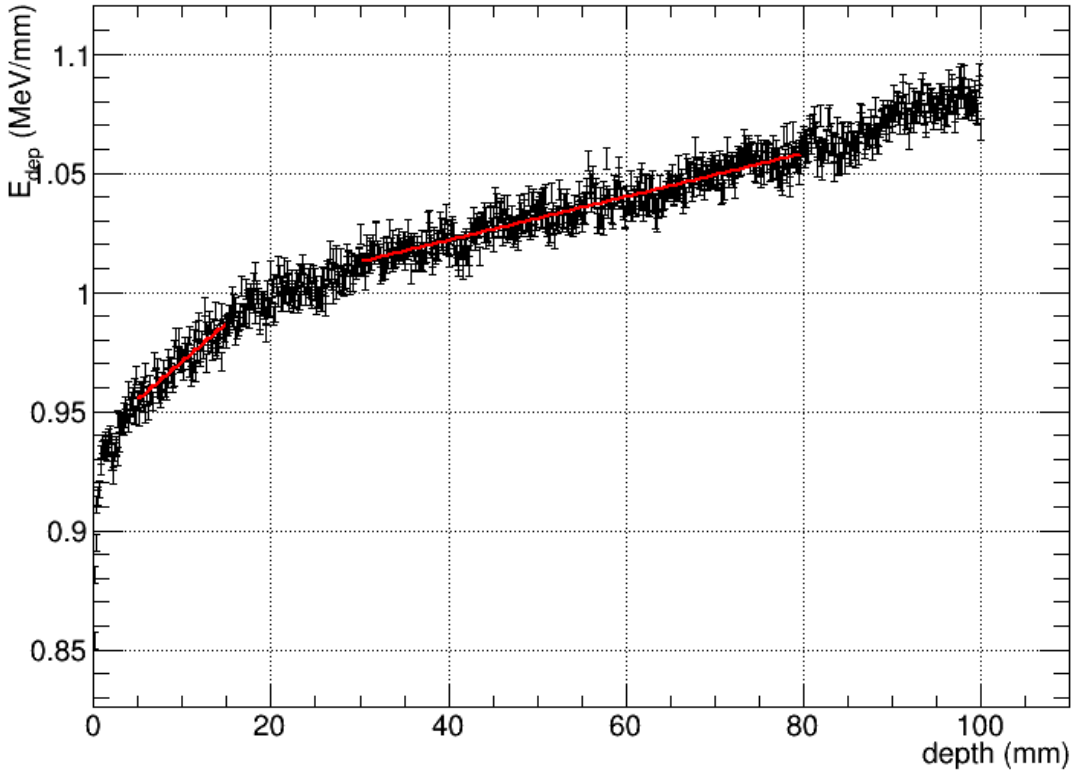




200MeV proton beam

Quantization and Clinical Relevance

- Quantization of the **secondary hadrons** (mostly protons?) build-up effect: It happens on a scale of **20mm** and is of the order of **5%**
- Is that clinically relevant? Is it worth to prove irrelevance?
- How reliable is Geant4 in simulation of nuclear reactions?



200MeV proton beam

Range cut issue

- Particles unable to travel at least the range cut value are not “produced” in Geant4
- Every energy loss by those (virtual) particles is attributed to the mother particle
- When you choose the range cut to be too large, you cut out all low energetic (low range) electrons generated by the ionizing proton
- This yields a very low simulated dose contribution from electrons (what happened in Ben's thesis)