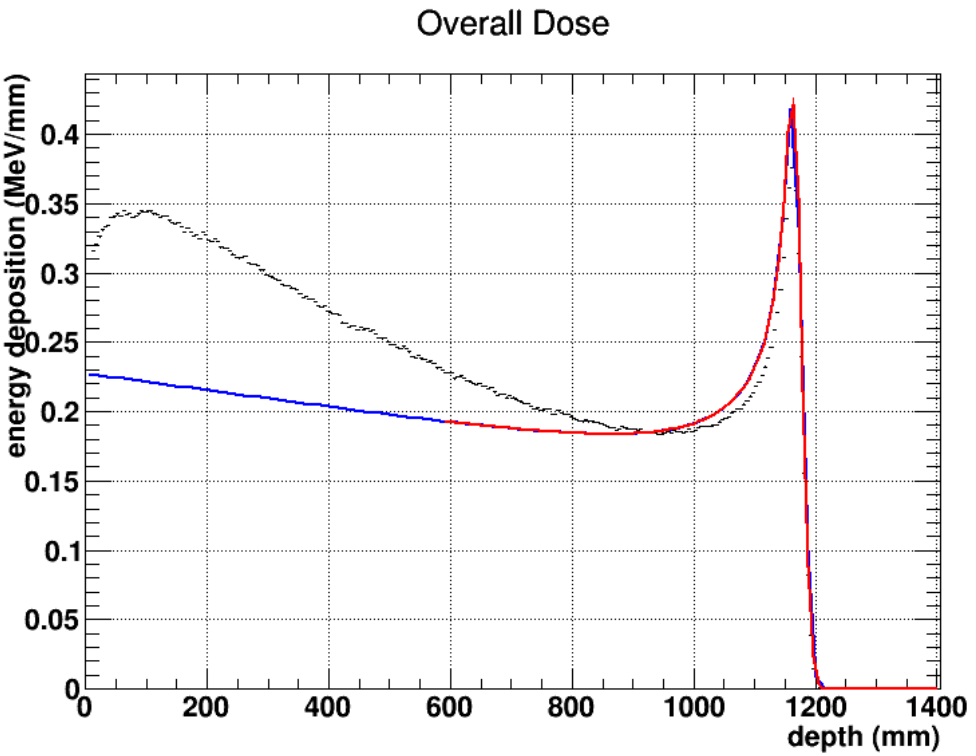
Build-up redefinition
& liquid Hydrogen simulation

Laurent Kelleter
16/08/2017

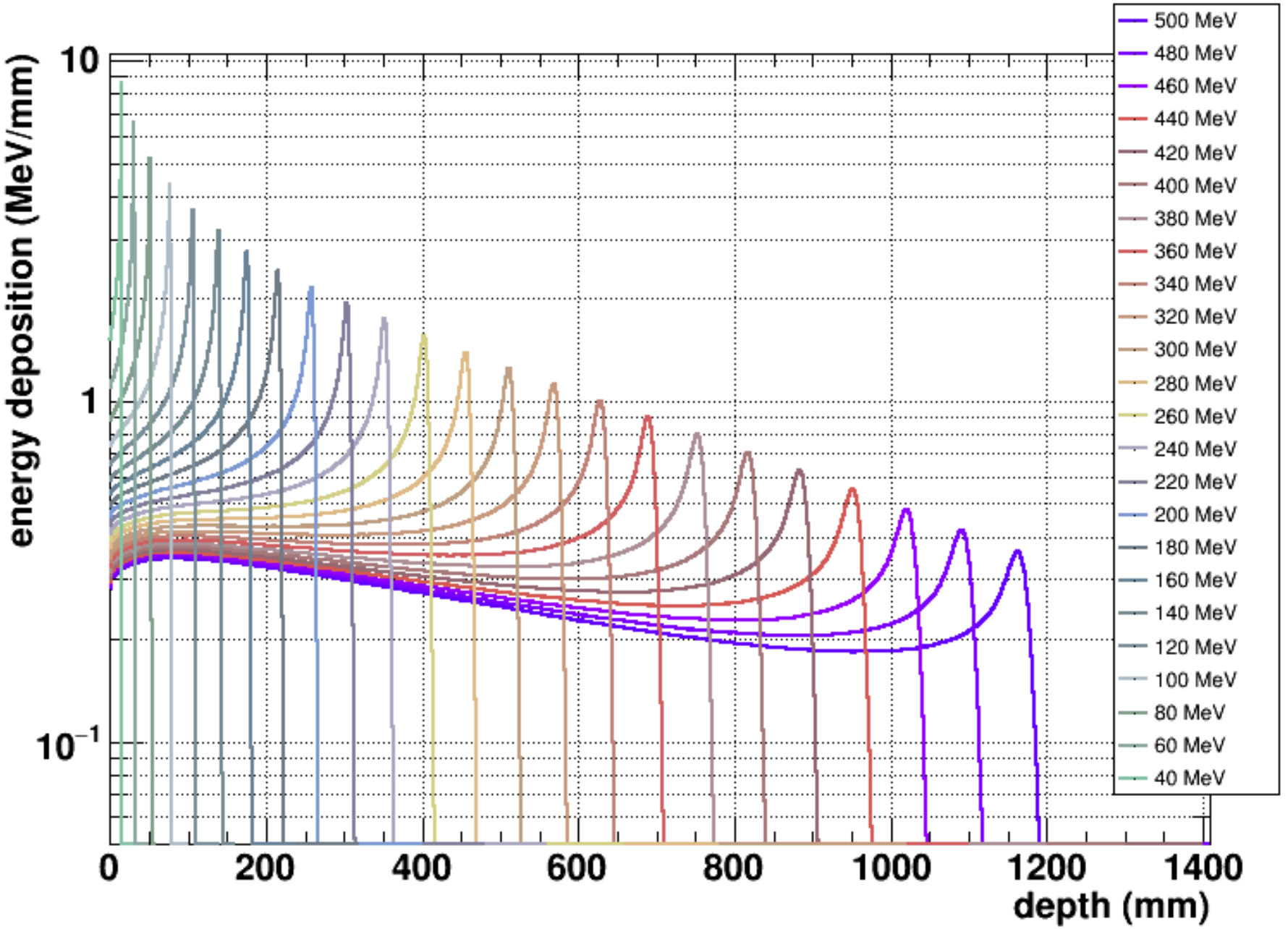
Old definition

- Old build-up definition based on Bragg fit to curve
- With the extension of energies up to 500MeV, this model breaks down completely
- To keep a consistent model, it has to be changed

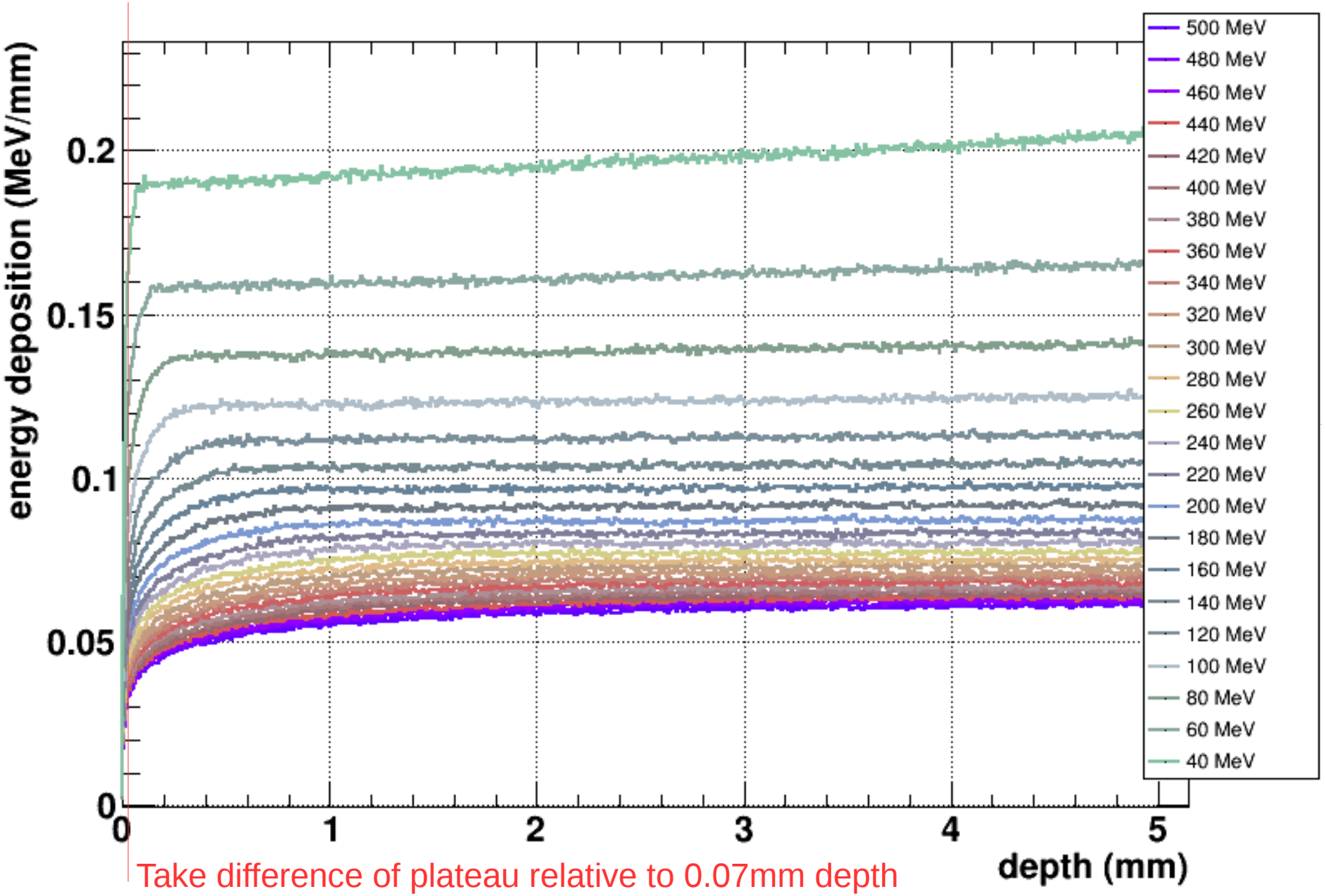


500 MeV

Bragg peak evolution with beam energy

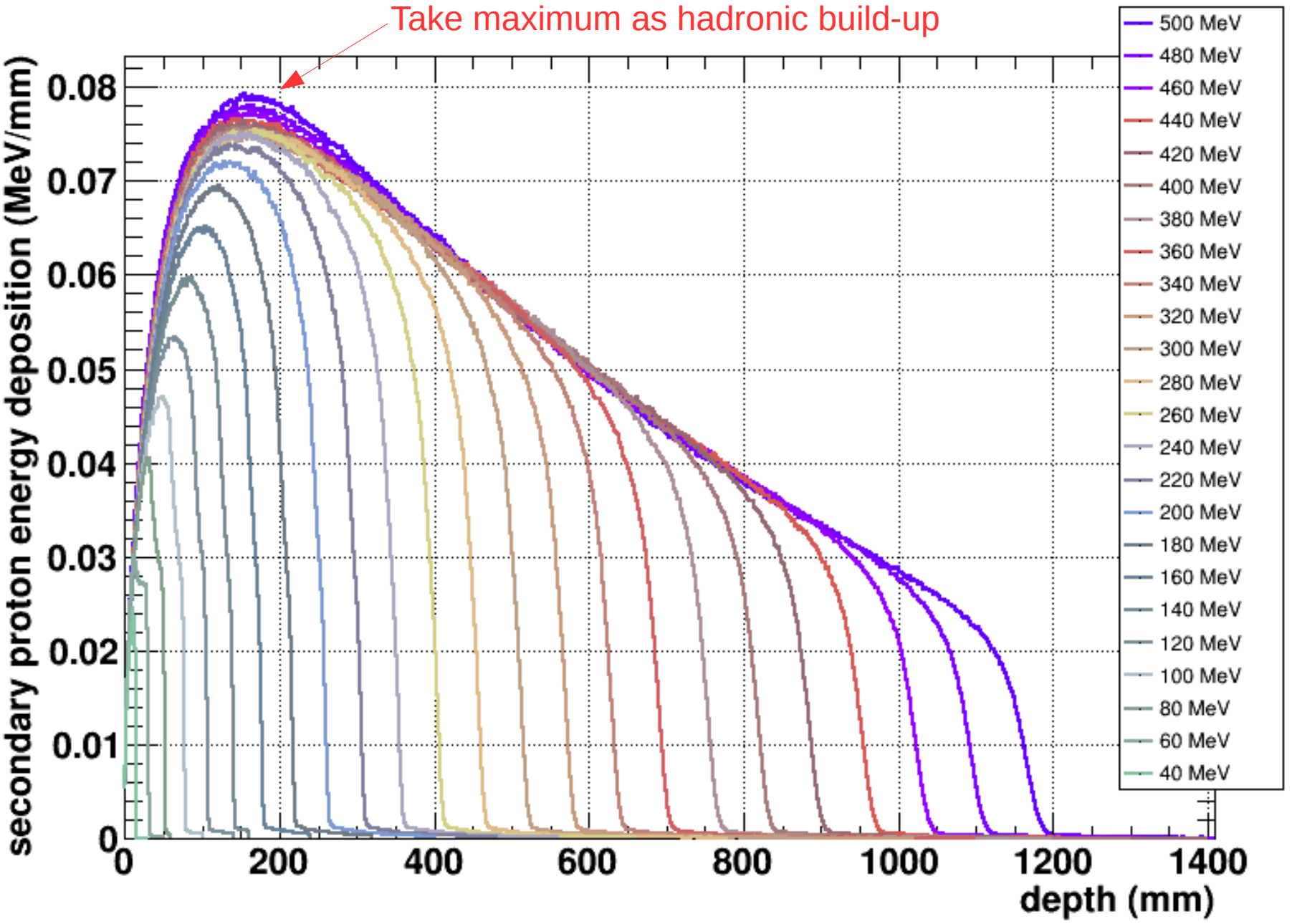


Electron dose evolution with beam energy



Take difference of plateau relative to 0.07mm depth

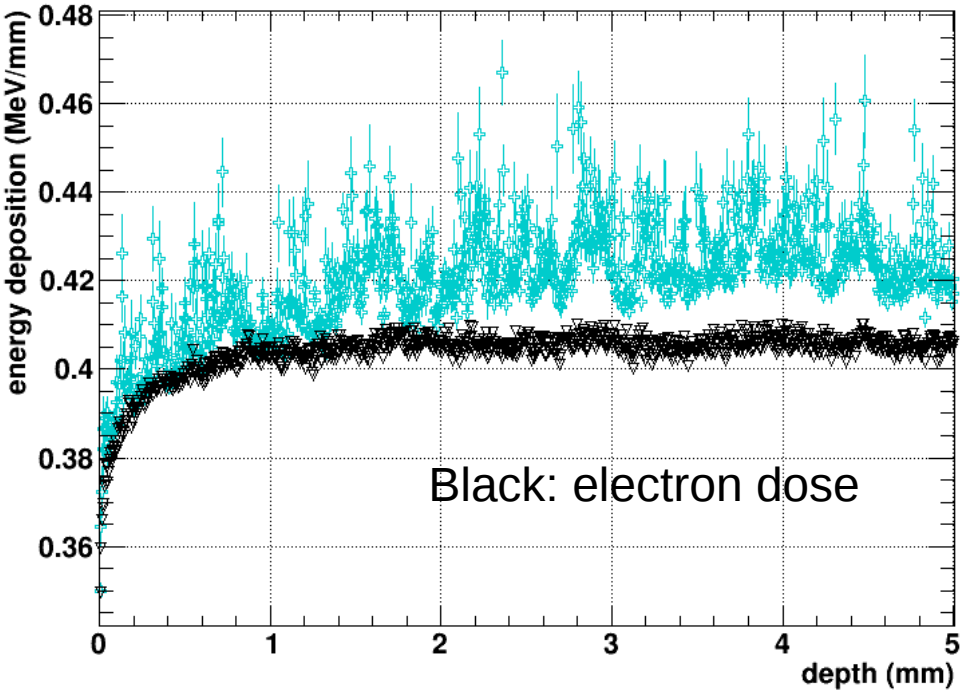
Sec. Proton dose evolution with beam energy



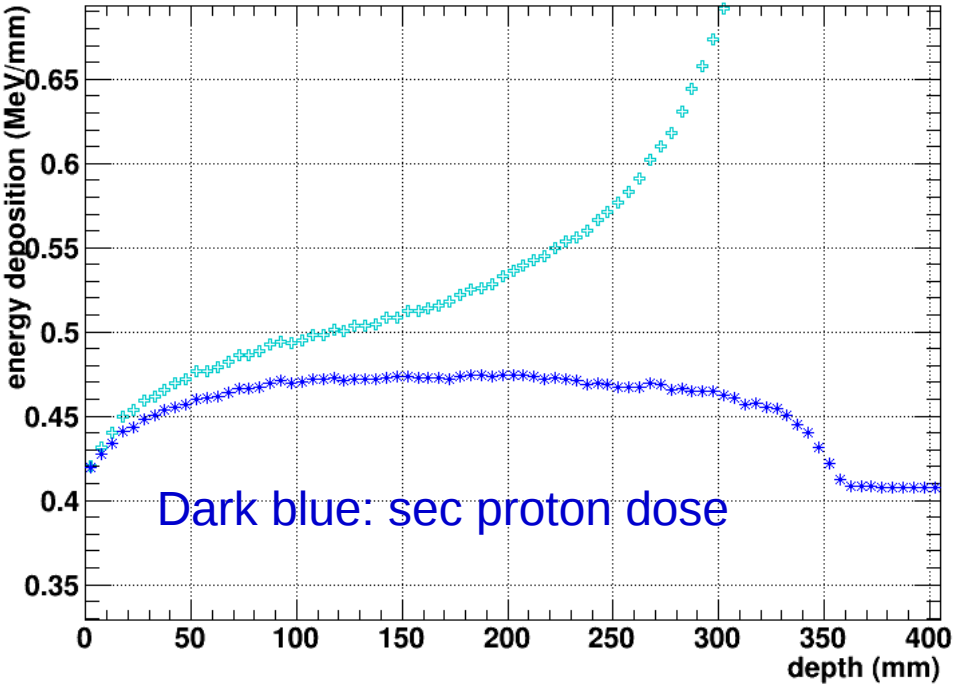
New definition

- Define build-up as difference between the dose in entrance region and the dose at the plateau (immediately following build-up region)
- In order to get a cleaner signal, use energy deposition distribution of secondary particles (electrons/protons)
- Define build-up with respect to depth at 0.07 mm (clinical relevance)

Comp electron dose+const. – total dose



Comp sec prot dose+const. – total dose

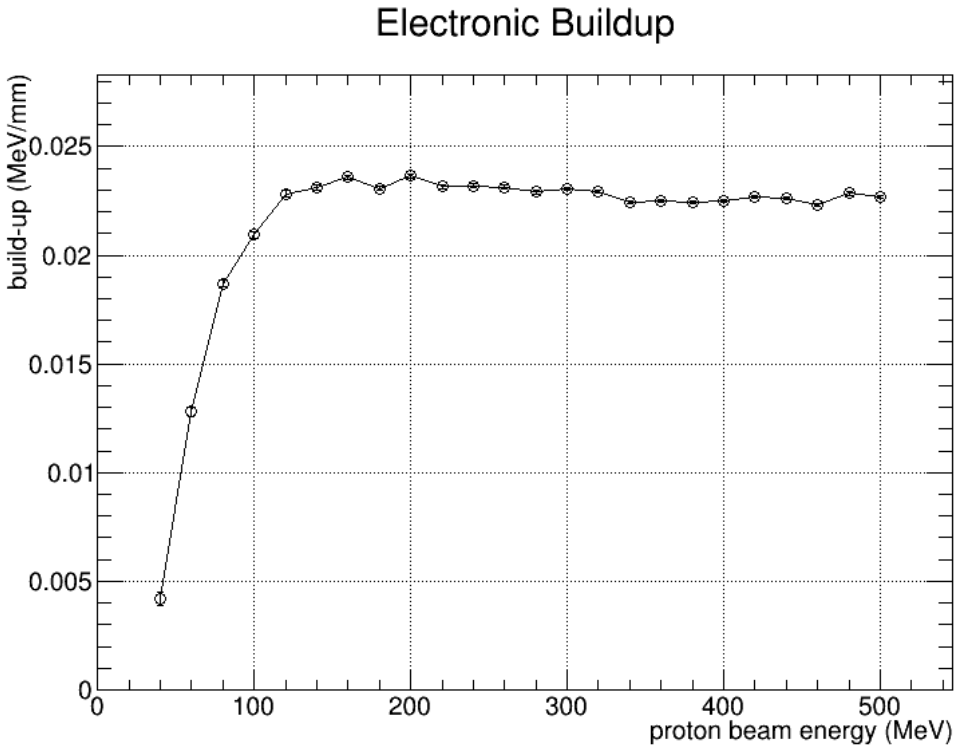


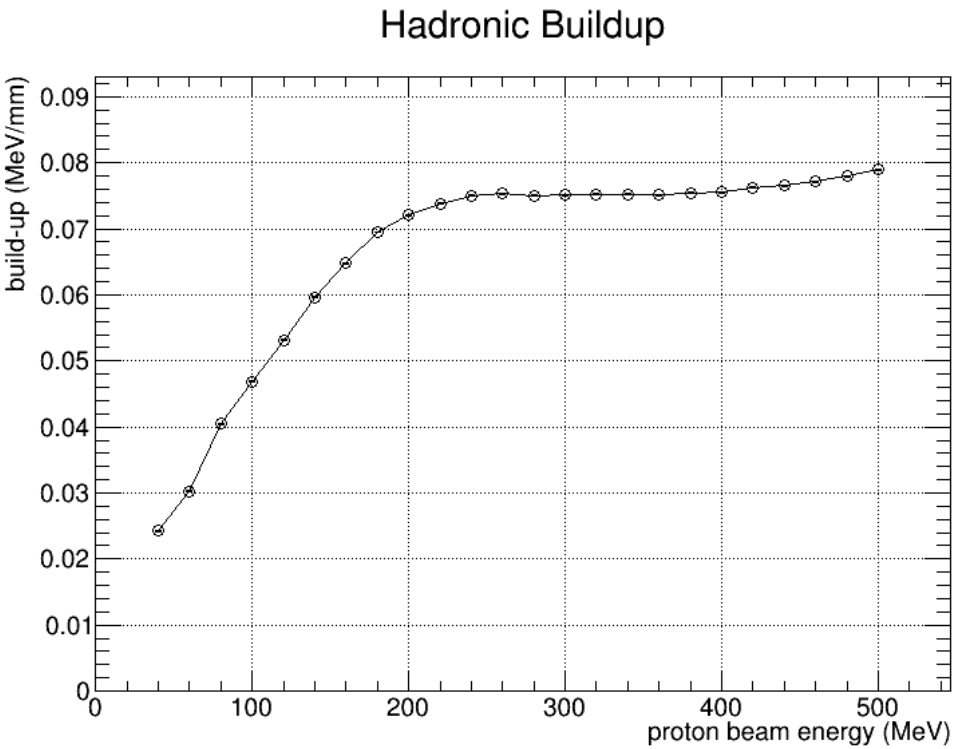
Normalisation

Then there are three options to normalise the build-up:

- Don't normalise the build-up (so build-up is in units of energy deposition)
  - Advantage: Absolute value of build-up
  - Disadvantage: Lack of context
- **Normalise to dose in entrance region**
  - **Advantage: Like old definition, giving the percentage of the missing energy deposition compared to situation with no build-up effect**
  - **Disadvantage: Reference dose not clearly defined**
- Normalise to dose at Bragg peak
  - Advantage: Provides context with respect to dose that one wants to deliver to the tumour
  - Disadvantage: makes build-up look bigger than it is as it scales with the longitudinal smearing of the Bragg peak

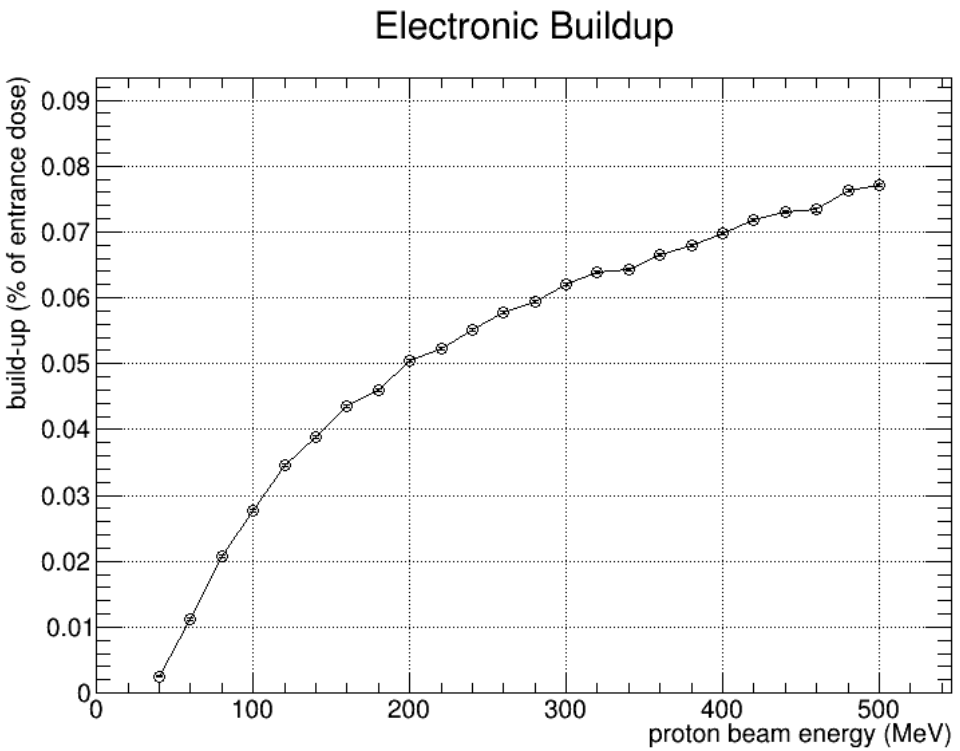
Build-up (absolute value)

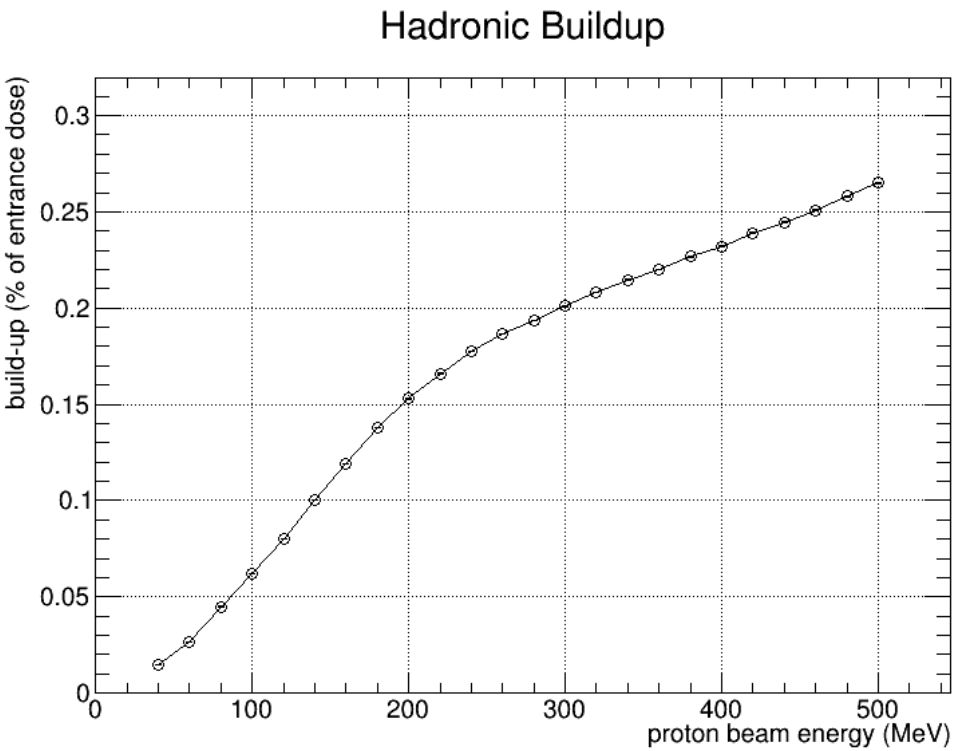




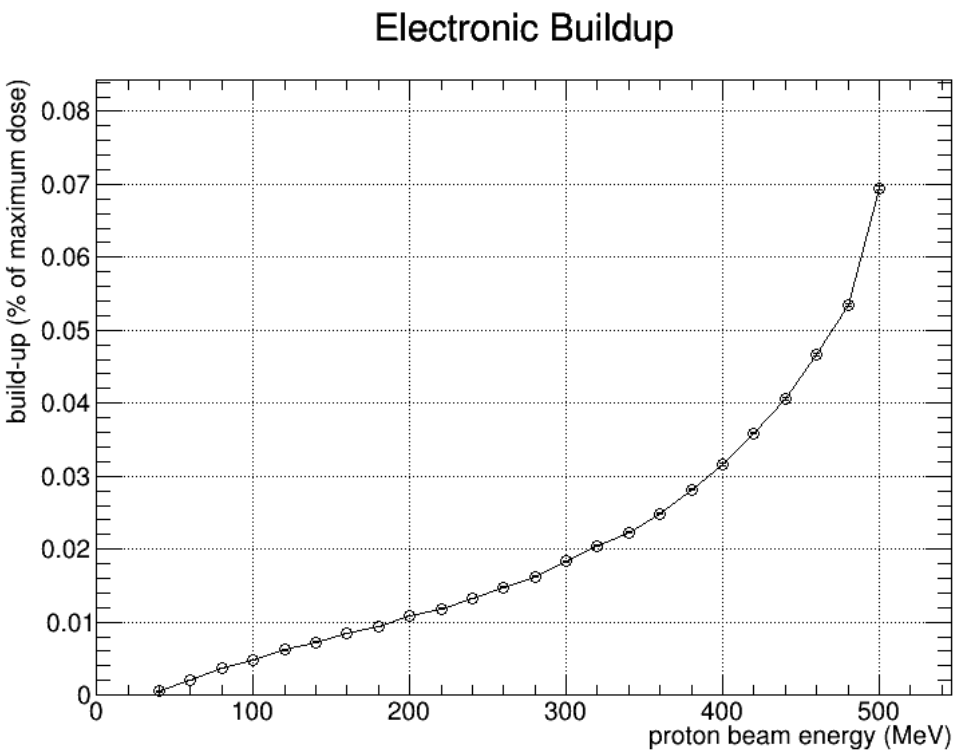
Build-up (reference to entrance dose)

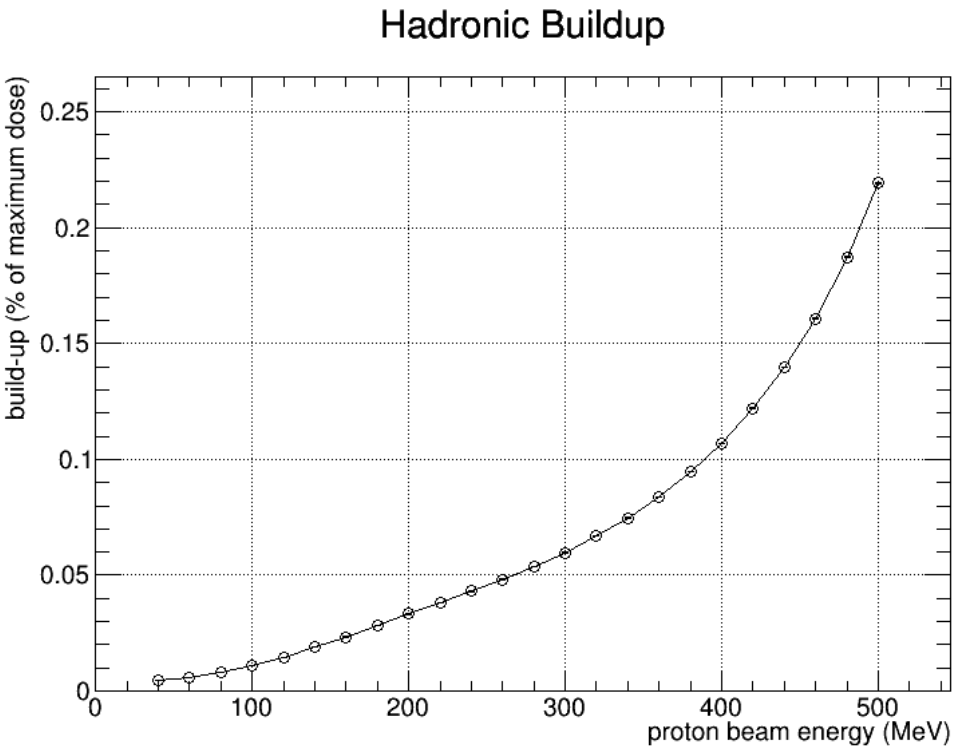
! this is probably the most meaningful definition





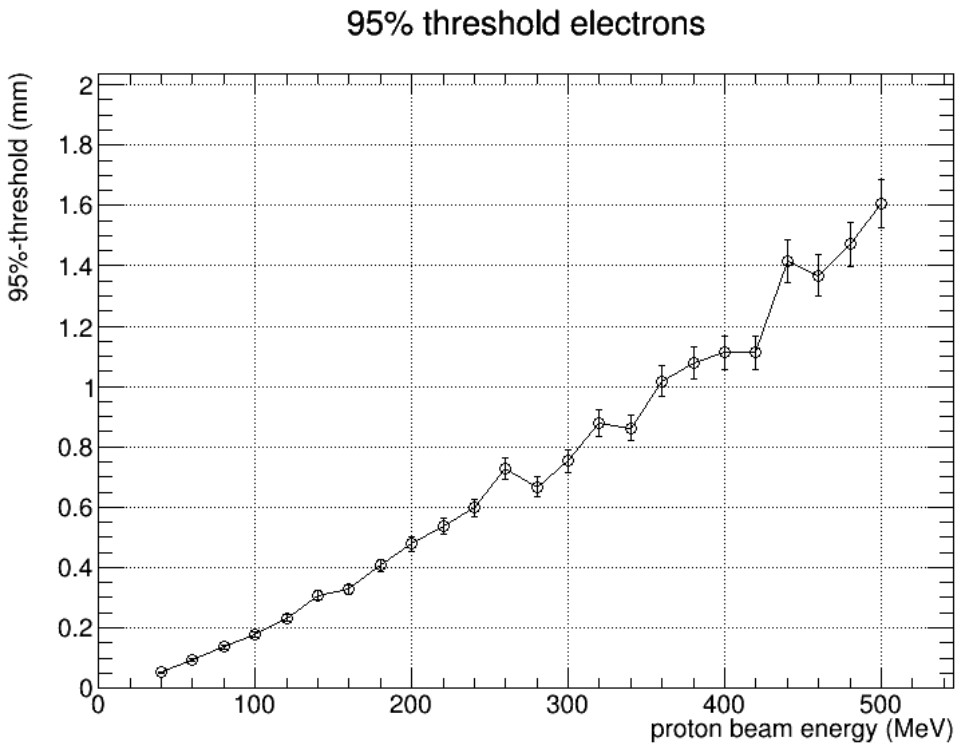
Build-up (reference to maximum dose)

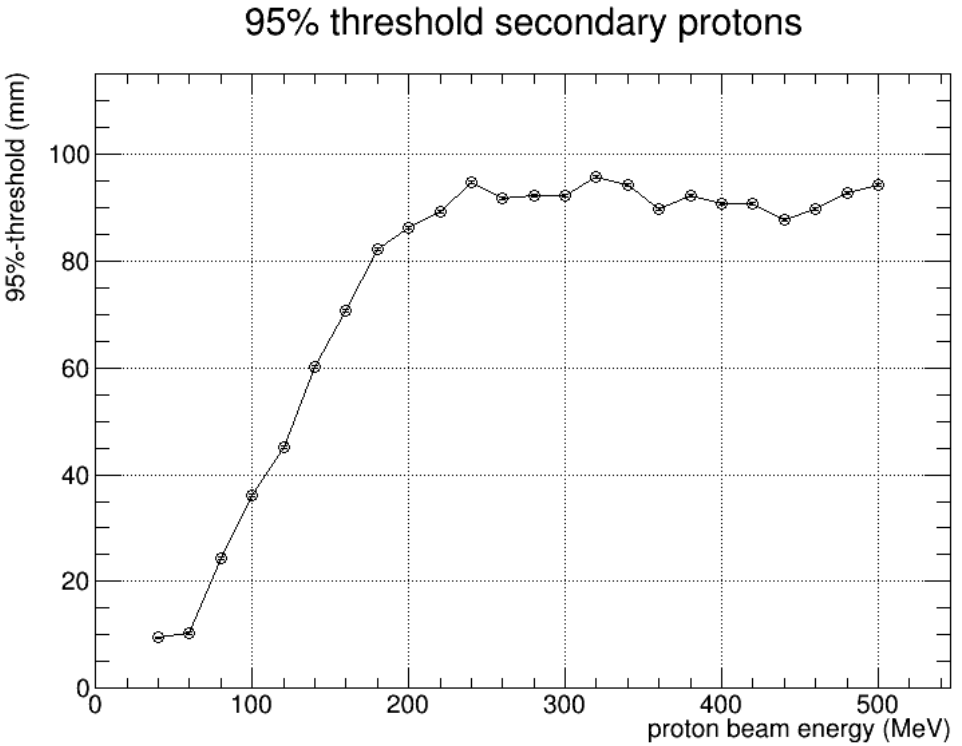




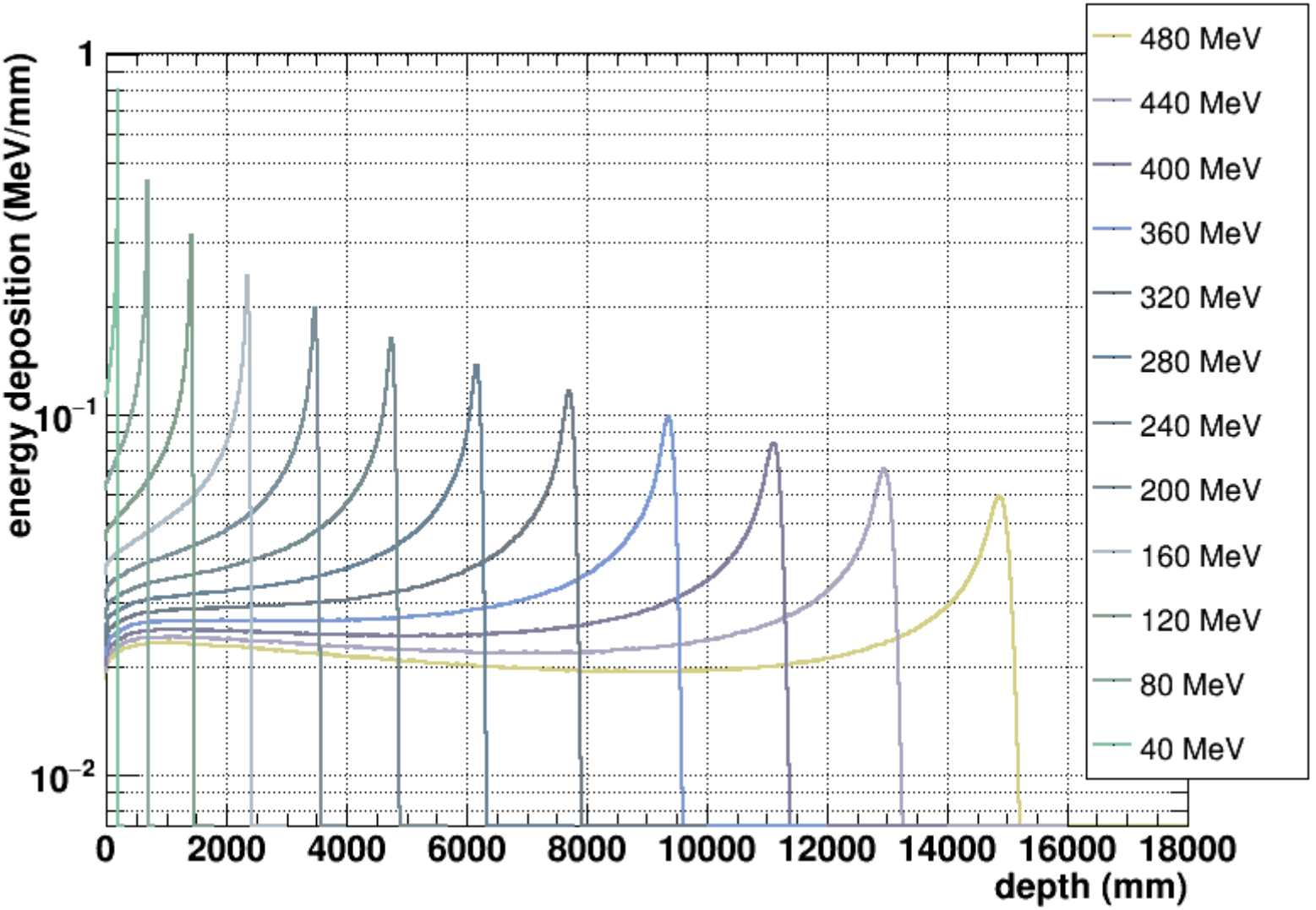
95%-threshold

- Attempt to quantify the extent of the build-up region in function of beam energy
- As reference dose use
  - Plateau of electron dose for electron threshold
  - Maximum of sec. proton dose for hadronic threshold

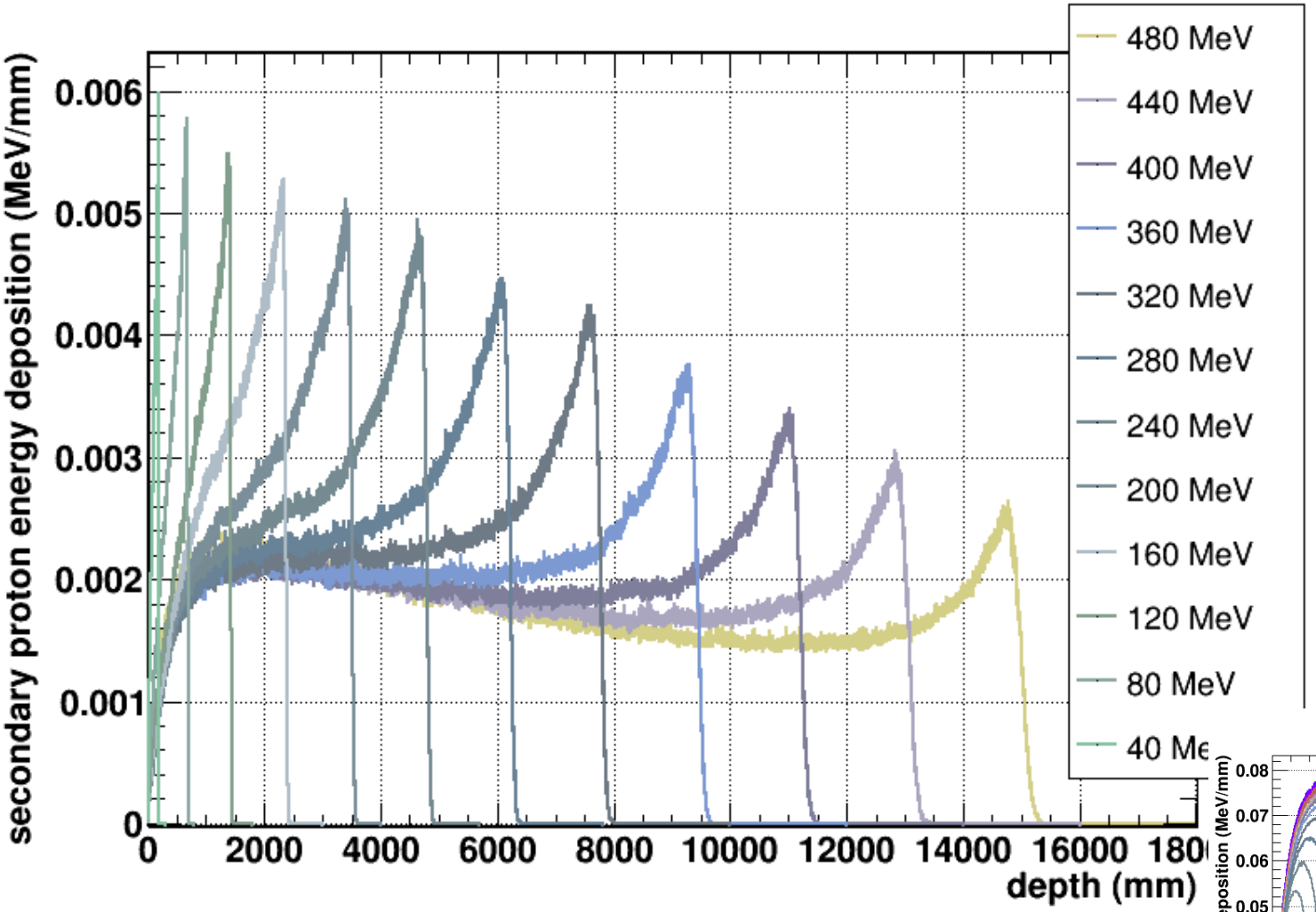


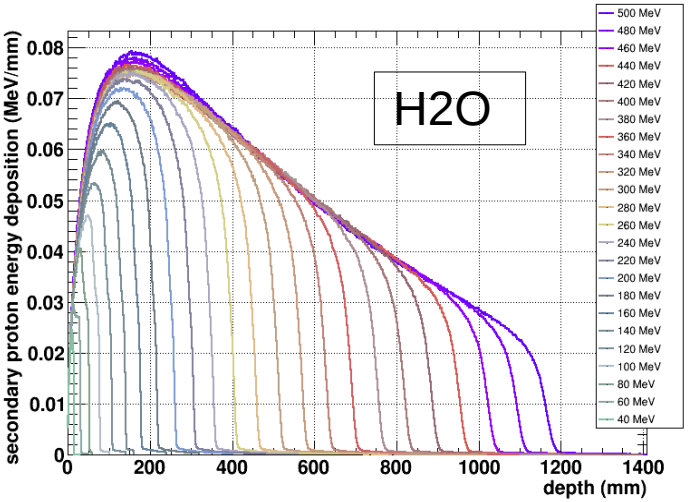


Liquid hydrogen: Bragg peak



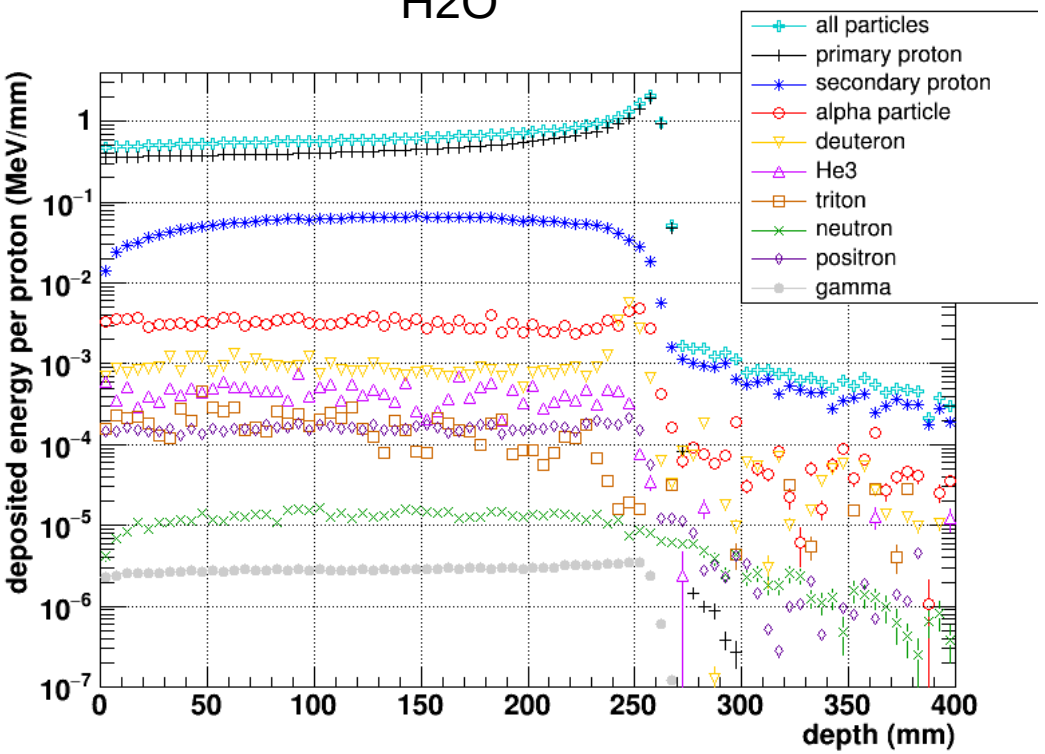
Liquid hydrogen: Secondary protons



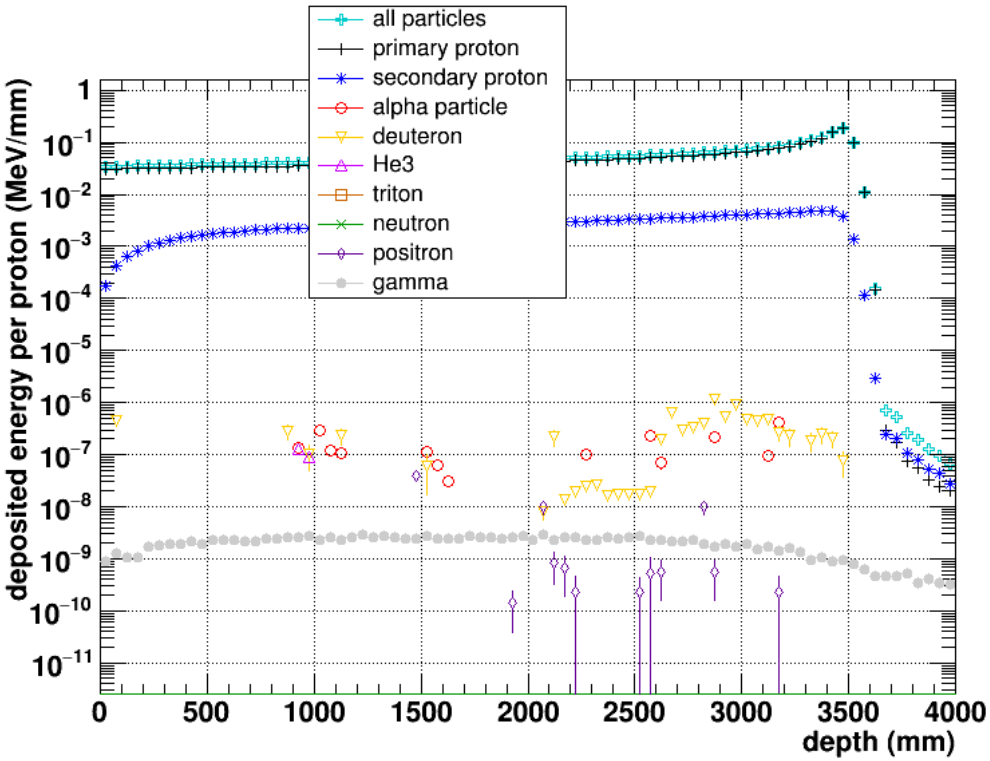


Liquid hydrogen: Energy deposition

H2O

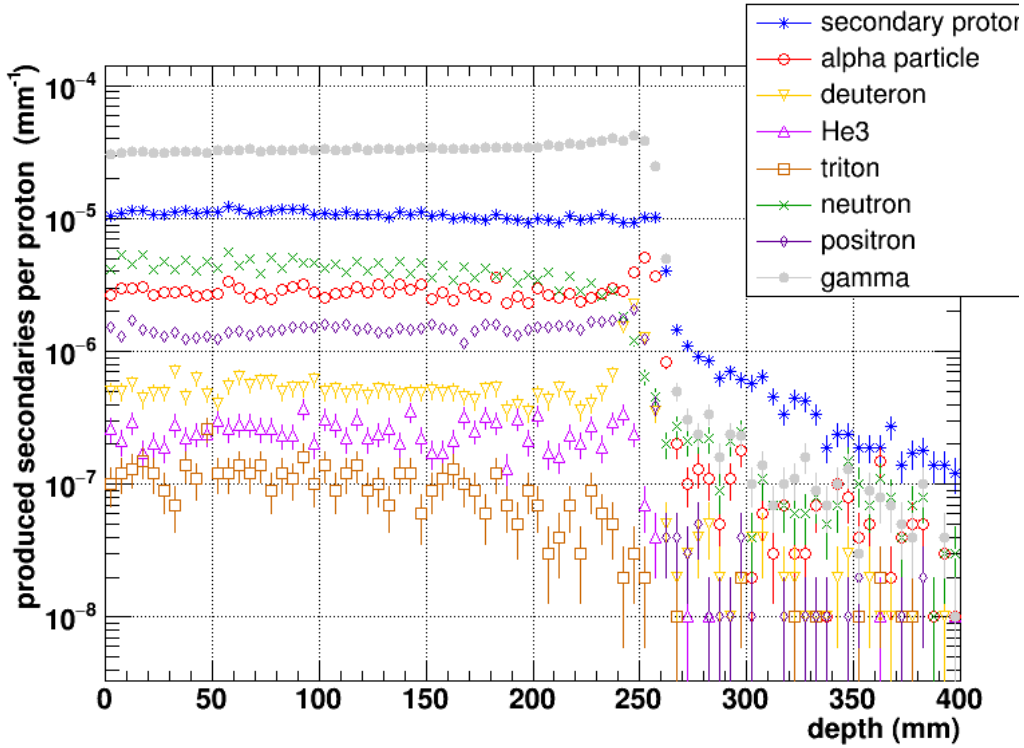


Liquid Hydrogen

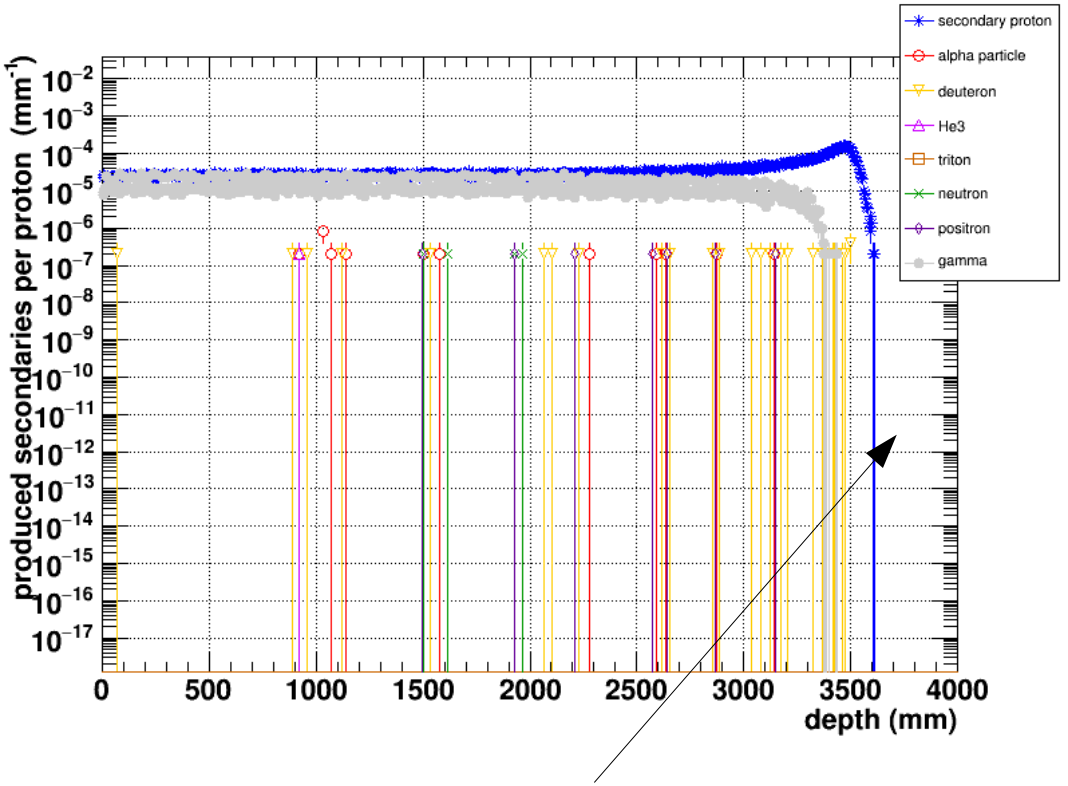


Liquid hydrogen: Particle production

H2O



Liquid Hydrogen



No particle production behind
Bragg peak due to lack of neutrons