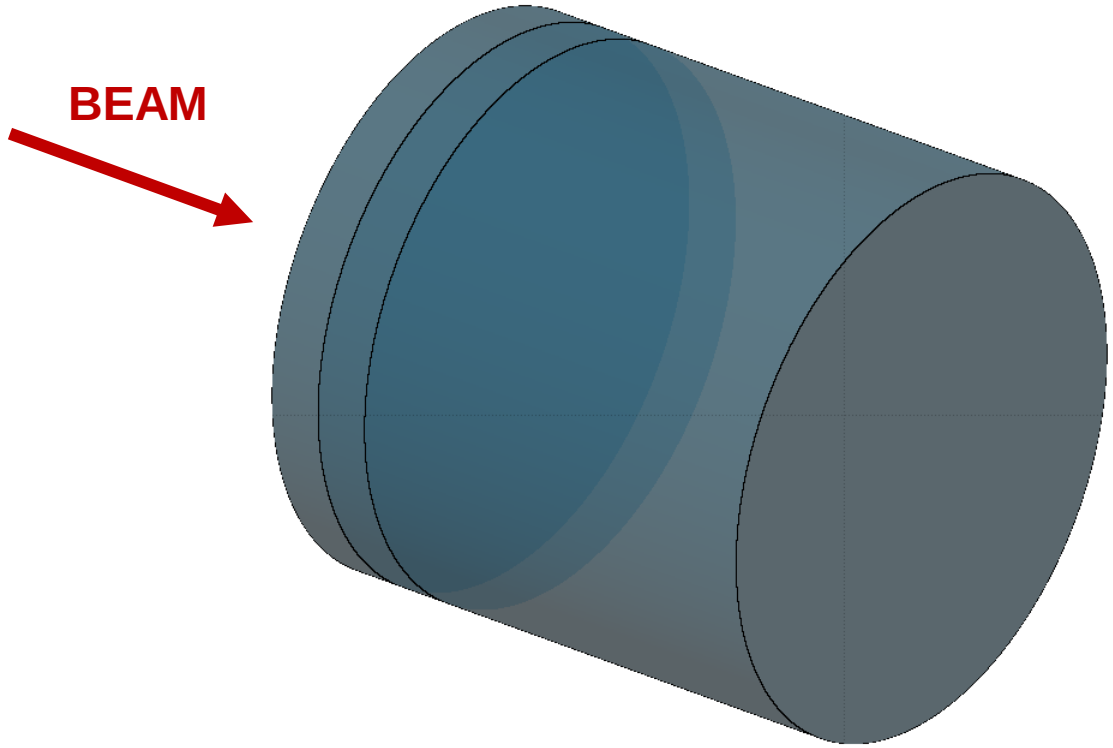
Exercise: Scoring I

Exercise objectives

- Learn how to use **USRBIN** scoring cards
- Learn how to look at simulation results in different ways
- Plot a Bragg peak
- See that bin size matters
- Compare scoring by region vs. scoring on a 3D grid

The input file

- Geometry
  - Cylindrical water target, centered on and parallel to z-axis
  - L = 10 cm, R = 5 cm
  - Split into 3 parts along z-axis (1-1-8 cm) for scoring purposes
- Beam
  - 100 MeV protons (zero beam size and divergence) hitting centre of front face



Implement these scorings and run

- Add a **USRBIN** covering the target to score ENERGY with 0.1-cm R-bins, 1 Φ-bin, 0.1-cm z-bins
- Add a **USRBIN** covering the target to score ENERGY with 0.2-cm R-bins, 1 Φ-bin, 0.1-cm z-bins
- Add a **USRBIN** to score ENERGY by region
- Add a **USRBIN** covering the target to score ENERGY with 1 R-bin, 1 Φ-bin, 10 z-bins (1-cm)
- Run 5 cycles with 1000 primaries each (should be quite fast)

Processing and plotting results

- Process the results and make the following plots:

1. Plot the Bragg peak in terms of stopping power [MeV/cm]
   - Think about what you need to plot: 1D Projection or 1D Max?

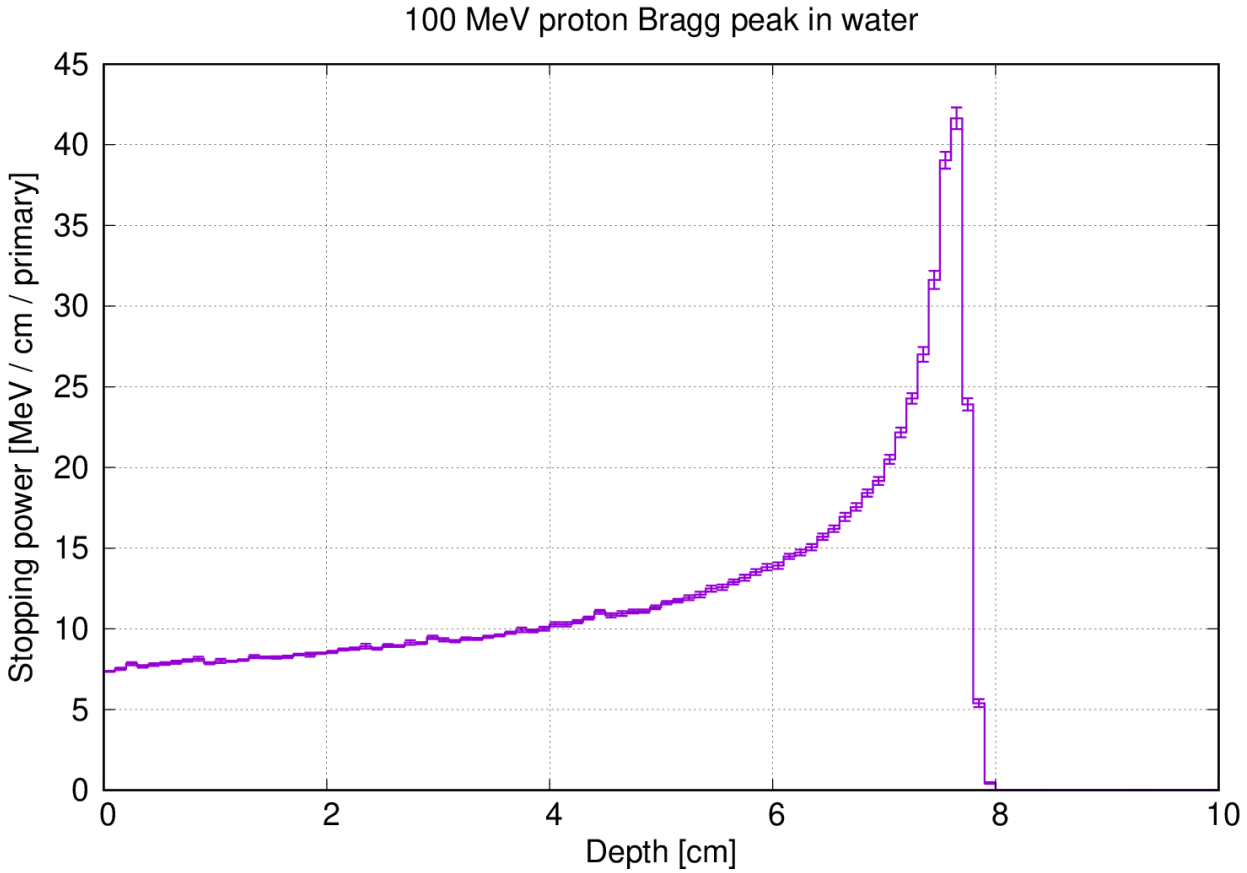
2. Plot and compare the peak energy deposition density along the z-axis using the scorings with the smaller and larger radial bin size
   - You can plot both scorings independently and then combine them in a single USR-1D plot

3. Plot and compare energy deposition values obtained via **`USRBIN`** per region and **`USRBIN`** on a grid

Results

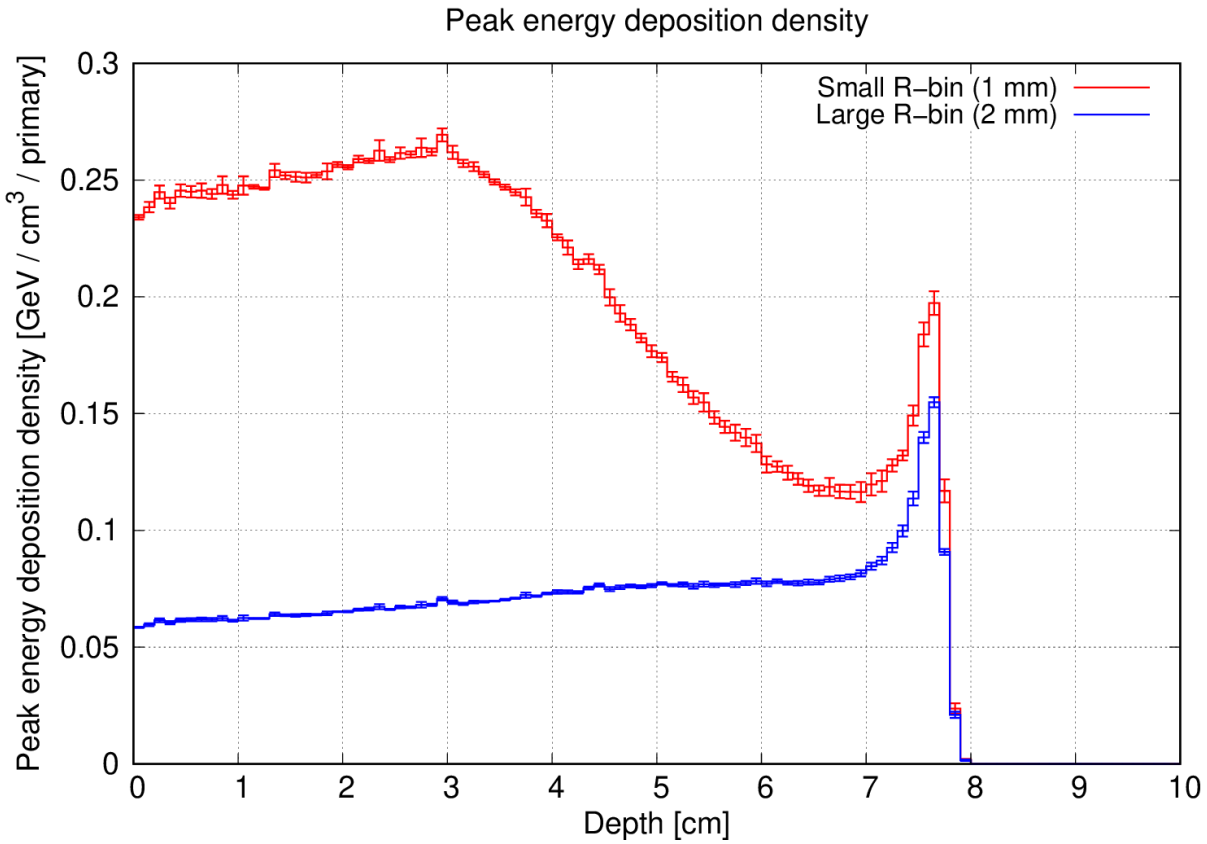
1: Plotting the Bragg peak

- Use either of the first two **USRBIN** scorings, and plot a 1D Projection (Z)
- How to get stopping power [MeV/cm] starting from energy deposition density [GeV/cm^3]?
  - You will need to multiply by the transverse scoring area and convert GeV to MeV



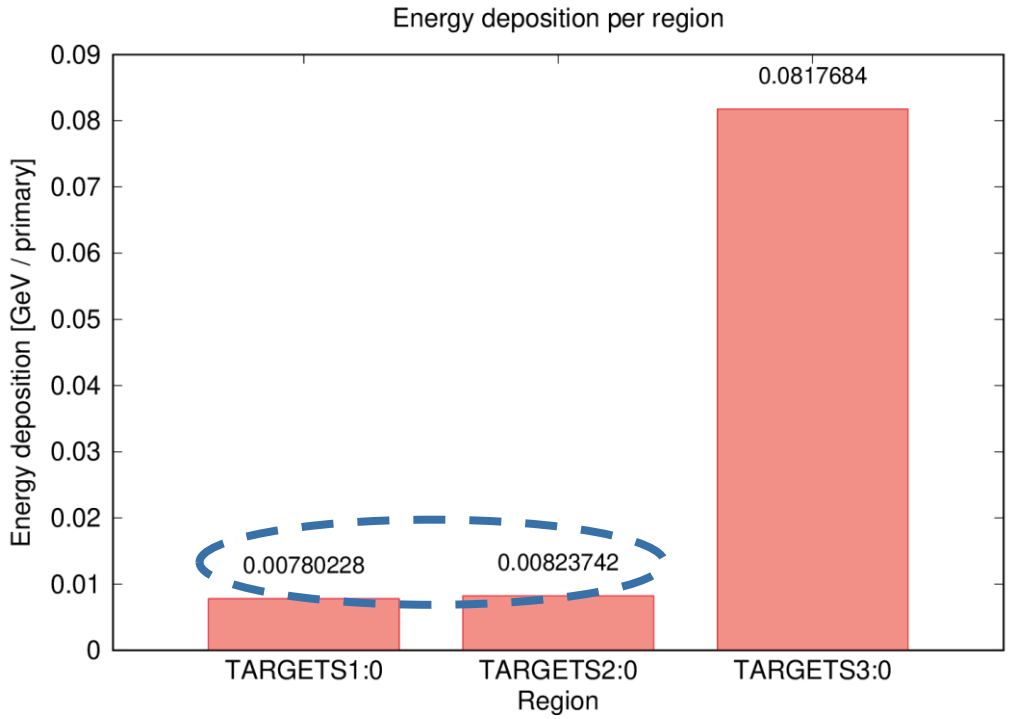
2: Comparing results with different R-bin sizes

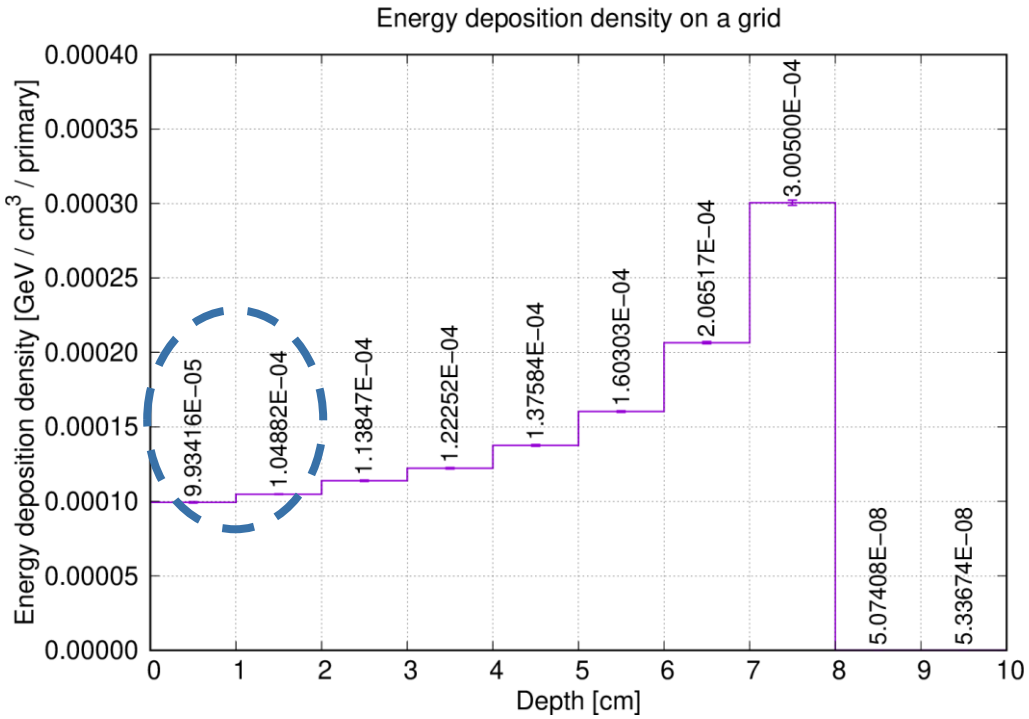
- For each of the first two **USRBIN** scorings, plot a 1D Max curve (Z) to obtain the peak energy deposition density
- Compare the two results in a single plot using the USR-1D plot option in Flair (Add → USR-1D); use the *histerror* option to plot statistical errors
- Note that:
  - The 2-mm binning gives a lower peak value: be careful with bin size, without exaggerations. The choice depends on beam, geometry, thresholds
  - The 1-mm binning has larger statistical errors: too small bins can cause slow convergence, and might be meaningless



3: Comparing scoring by regions and by grid

- Plot the 3rd **USRBIN** scoring (energy deposition per region, left) and the 4th **USRBIN** scoring (energy deposition density with a single radial bin, right)
- The first two bins of the grid scoring correspond to the regions TARGETS1 and TARGETS2, respectively
  - Why are the values different? Hint: the difference is a factor of ~78.54…



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