«The Bragg ski-jump slope»

Illustrating the Bragg peak - Teaching the interference of heavy ions with cancer cells at certain depths.

WORK GROUP 3; MEDICAL APPLICATIONS:

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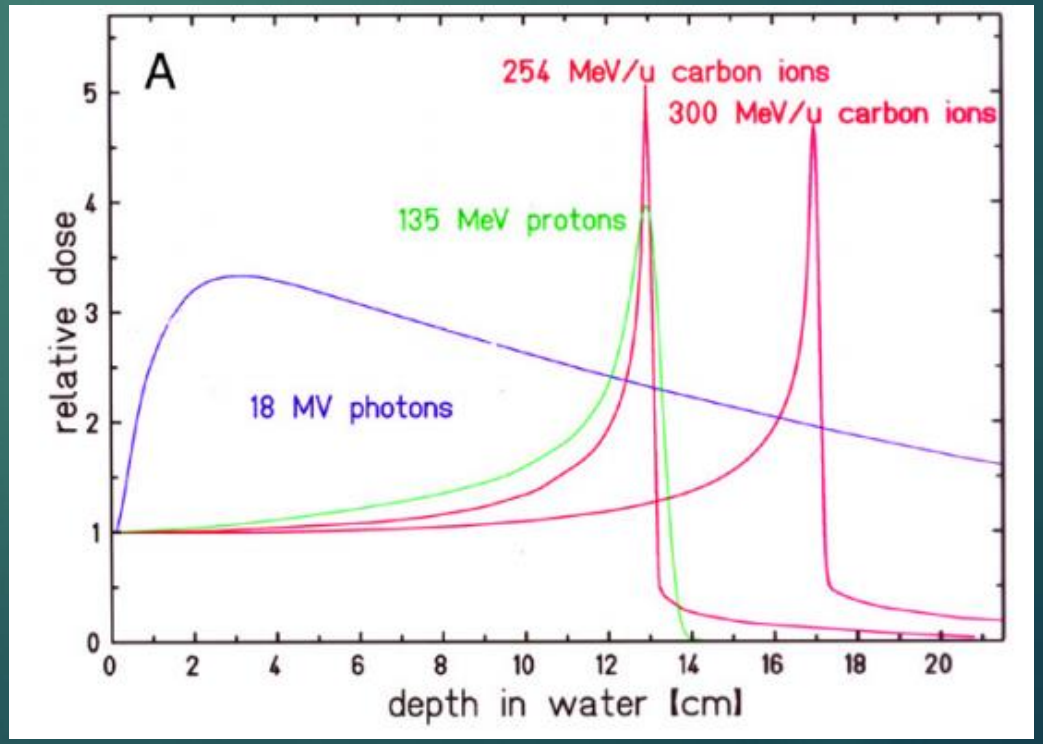
Bragg peak - Theory

- The main challenge in radiotherapy for cancer treatment is how to deliver high dosages of radiation to the tumor region, while minimizing the radiation affecting healthy tissue.
  - One of the most important new methods being developed for cancer therapy is irradiation with charged ions. Thanks to the characteristic dose deposition profile (the Bragg peak), charged particles offer the possibility to deposit dose much more locally than the photons, so dose in healthy tissue can be minimized
  - The quality of hadron therapy treatments is closely connected with the ability to predict and achieve a given beam range in the patient

Bragg peak model – the idea

- The idea was to make a simple model that would illustrate how proton treatmet differs from traditionally x-ray treatment with respect to how the energy is delivered to the area to be treated.



Bragg peak – comparison between our model and the real effect

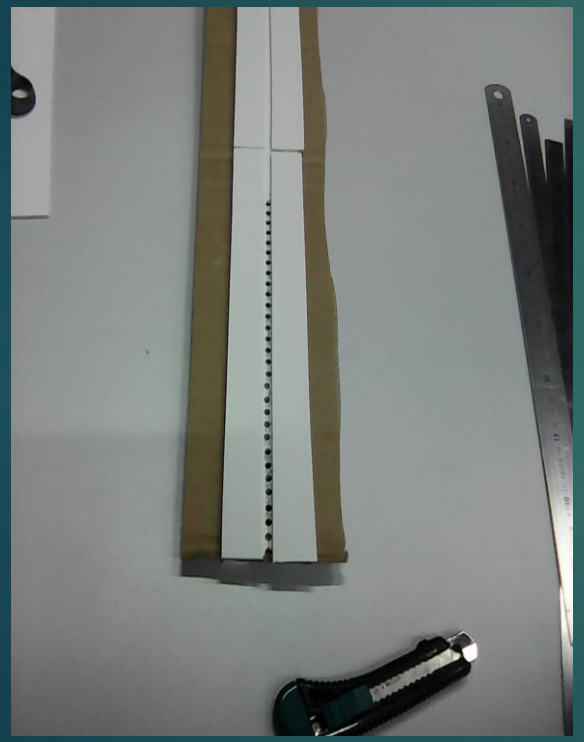
- The height of release point for the balls give the speed (energy) of the particles.
- The interference between the balls and the holes correspond to how the ions interfere with cells in our body
- The final drop in one of the holes illustrates the deposit of energy in a certain tumor cell.

Bragg Peak – teaching objectives

- Constructing – Using materials to build a model
- Adjusting – optimise the model to be functional
- Measuring – to represent the function
- Comparison with theory – find common parameters
- Improvement of model – try out different materials and settings

Bragg peak – building the model

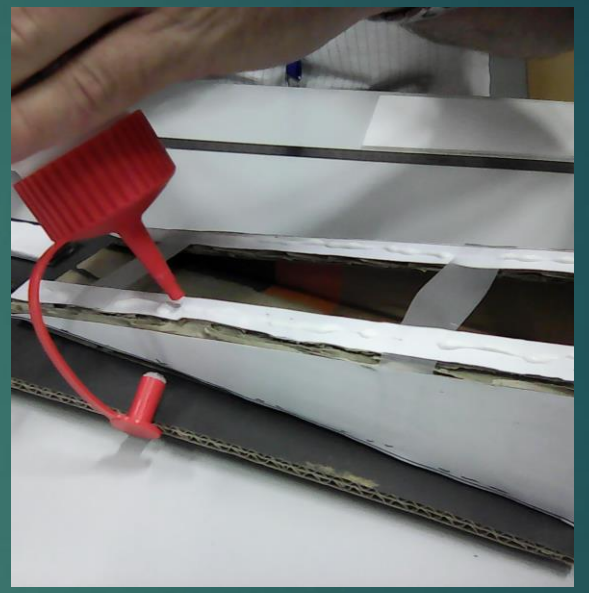
Make a paper strip with holes and glue it adding barriers



Make a narrow slot under the holes

Bragg peak – building the model

Make a cutting pattern of the slope angle



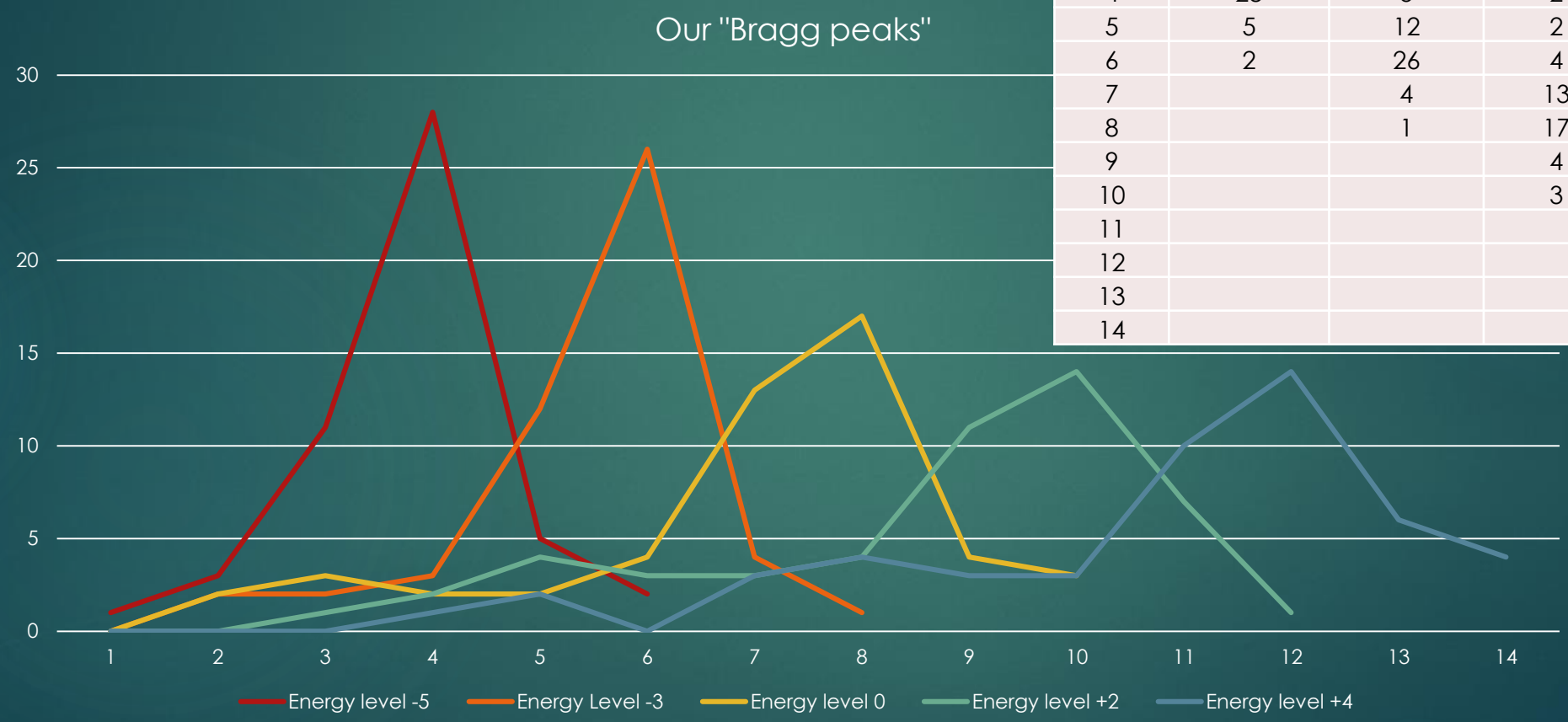
Adjust with strips and add glue

Bragg peak – description

- Mark the holes with numbers
- Mark different levels in the slope
- Select one level and discard 50 balls one by one from this level and register into which hole the balls drop.
- Make a table of the registrations and make a diagram of number of balls per hole.
- What do you observe?
- Change the level, and repeat the experiment.
- Is there any difference?

Bragg peak – Our results

Hole no.	Energy level -5	Energy Level -3	Energy level 0	Energy level +2	Energy level +4
1	1	0	0	0	0
2	3	2	2	0	0
3	11	2	3	1	0
4	28	3	2	2	1
5	5	12	2	4	2
6	2	26	4	3	0
7		4	13	3	3
8		1	17	4	4
9			4	11	3
10			3	14	3
11				7	10
12				1	14
13					6
14					4



Bragg peak – improvements of the model.

- Larger scale (larger holes and balls, longer slope and «target area»)
- More rigid material; i.e. plywood
- Be sure not to get glue on the steel balls!!

Bragg peak - Bibliography

- Range verification methods in particle therapy: Underlying physics and Monte Carlo modelin, Aafke Christine Kraan
- Nuclear physics in particle therapy: A Review, Marco Durante and Harald Paganetti