A Year of Contemporary Physics at West High School

WEST
HIGH SCHOOL™
EST. 1890

2022-23 Starts and Ends at CERN

August 2022

- CERN ITW (and the Anitmatter Factory)
- Meet up at CERN with BL4S student, Thatcher

Panther Peak: Beamline for Schools Competition Team

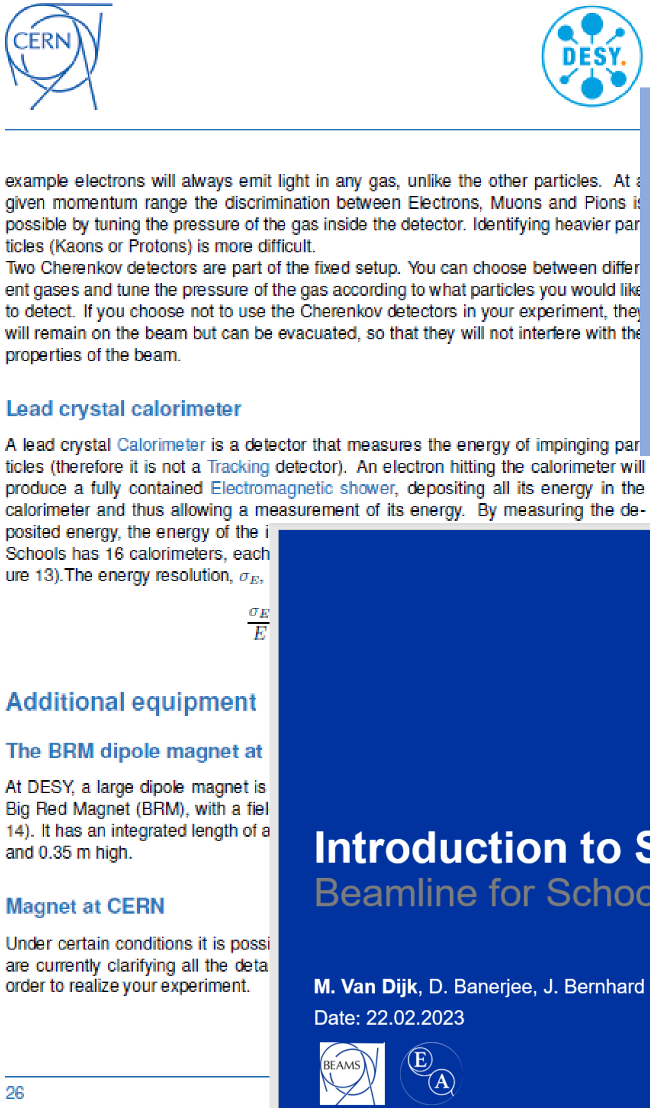
- “Particle Camp” Fall 2022
- Introduction to Contemporary Physics
- Cloud Chambers
- Introduction to BL4S Competition for new teammates

Huntsman Cancer Institute

Fall, 2023

- HCI Proton Therapy Facility
- "real life" physics in our neighborhood
- Medical Physics Inspiration
- (potential) physicist mentors

Research and Writing


CERN DESY.

example electrons will always emit light in any gas, unlike the other particles. At a given momentum range the discrimination between Electrons, Muons and Pions is possible by tuning the pressure of the gas inside the detector. Identifying heavier particles (Kaons or Protons) is more difficult.
Two Cherenkov detectors are part of the fixed setup. You can choose between different gases and tune the pressure of the gas according to what particles you would like to detect. If you choose not to use the Cherenkov detectors in your experiment, they will remain on the beam but can be evacuated, so that they will not interfere with the properties of the beam.

Lead crystal calorimeter

A lead crystal Calorimeter is a detector that measures the energy of impinging particles (therefore it is not a Tracking detector). An electron hitting the calorimeter will produce a fully contained Electromagnetic shower, depositing all its energy in the calorimeter and thus allowing a measurement of its energy. By measuring the deposited energy, the energy of the i
Schools has 16 calorimeters, each
ure 13).The energy resolution, σ_E,

$\frac{\sigma_E}{E}$

Additional equipment

The BRM dipole magnet at

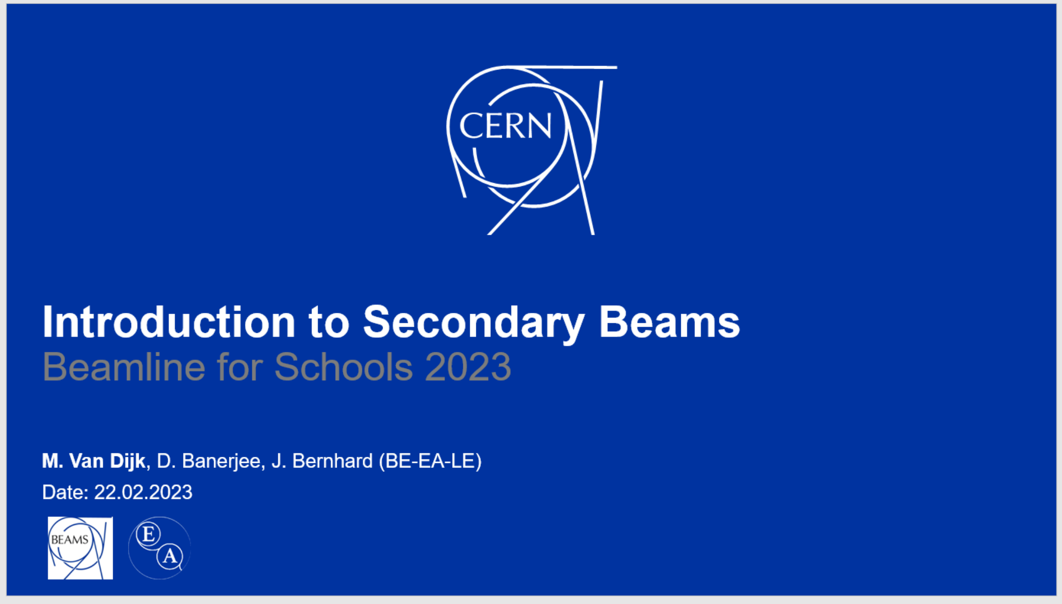
At DESY, a large dipole magnet is
Big Red Magnet (BRM), with a fiel
14). It has an integrated length of a
and 0.35 m high.

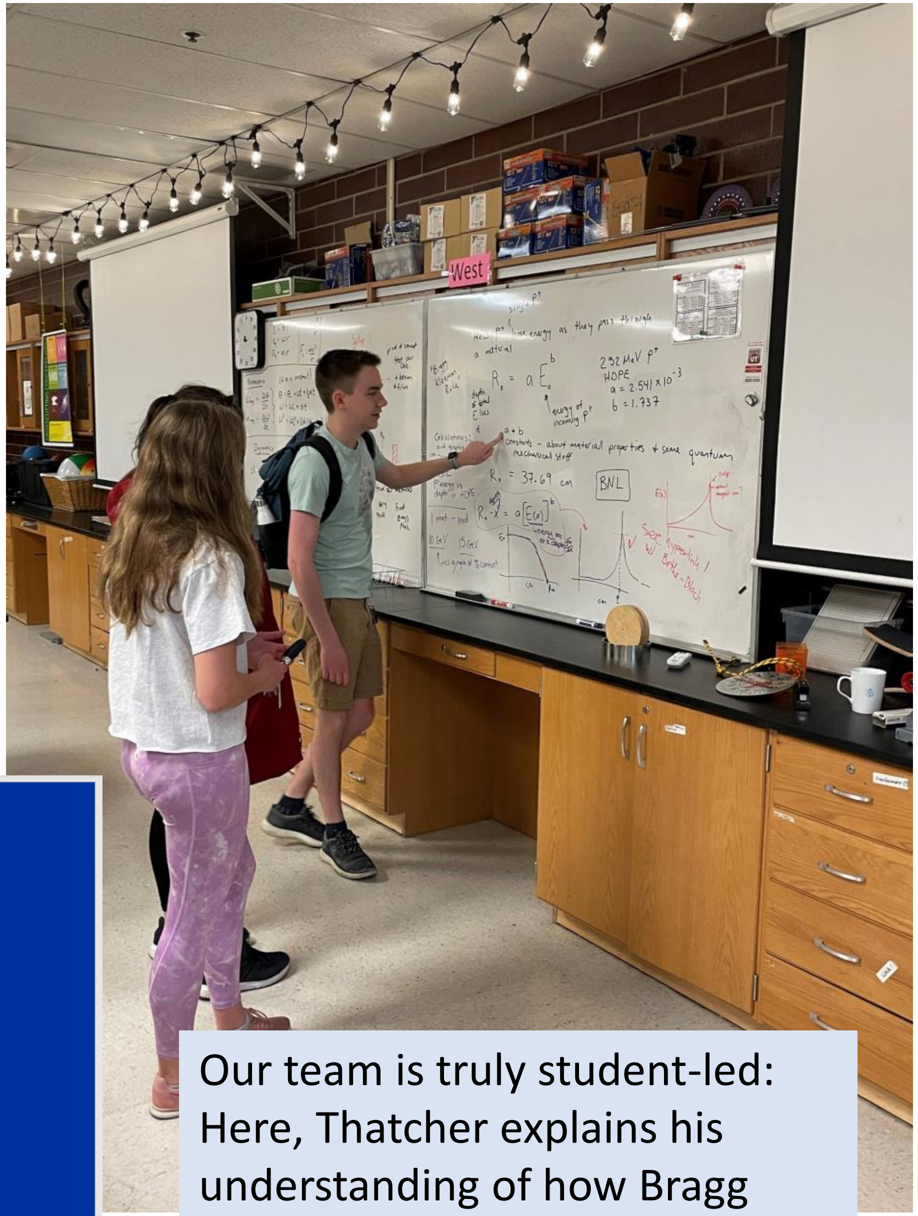
Magnet at CERN

Under certain conditions it is possi
are currently clarifying all the deta
order to realize your experiment.

26

BL4S Coordinators have provided documents and a variety of Zoom presentations with valuable background information.





Our team is truly student-led: Here, Thatcher explains his understanding of how Bragg peaks work to Natalie and Sanskriti

Utilizing Proton-Sensitive Film to Visualize Bragg Peaks

Cole Chu, Natalie Germanov, Thatcher Goff, Marriane Liu, Sanskriti Negi,
Christopher Pankow, Hanxiao Shi, Fiona Zara, Tony Zhang

2023 April 12

1 Motivation

On a visit to the Huntsman Cancer Institute Proton Therapy Department, we became intrigued about how high energy hadrons deposit ionizing energy as they travel through matter: Bragg peaks. Approximately one third of the world's population will be diagnosed with cancer in their lifetime — many of whom will choose to use proton therapy as a form of treatment. Bragg peaks can precisely target tumors and minimize collateral tissue damage, making this form of therapy especially preferable for more prevalent cases. However, the invisible, high-energy beam can be extremely disconcerting to the patient due to a lack of understanding of the technology. By harnessing proton-sensitive materials to create visualizations of a particle beam exhibiting Bragg peak behavior, we can not only assuage cancer patients' worries, but also combine art with science to provide valuable insight into the behavior of particle beams through different materials. While this behavior can theoretically be predicted with equations, a physical visualization can help expand our understanding.

2 Experimental Setup

Our experimental setup contains two phases: the first is to gather quantitative information to support theore

In our first phase

rule[7,9]. We first plac

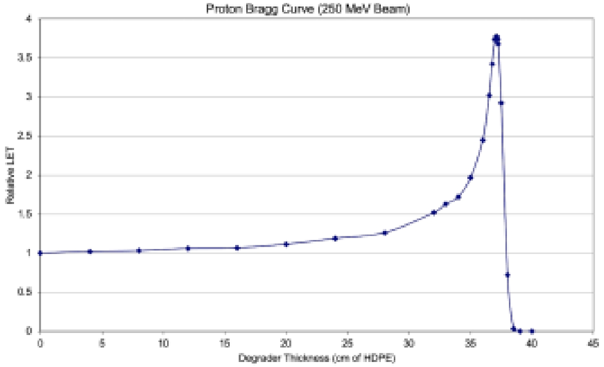
and radiochromic film

correspondent uses E

quantitative and visu

amount of uncertainty

Figure 4:
Graph created using data from BNL. 250 MeV.



We found a close correlation between the measured Bragg peak depth (26.1 cm at 205 MeV and 37.1 cm at 250 MeV) and our calculated values (26.33 cm and 34.67 cm, respectively).

In these graphs, the peak of the curve represents the Bragg peak. The inverse Bragg-Kleeman rule equation graphs a vertical asymptote, representing the mean position of the highest energy loss. However, the Bragg-Kleeman rule is an approximation because it does not account for all relativistic effects and other complex physics [7, 9]. For an in-depth explanation of our understanding of the more precise formulae, see: https://docs.google.com/document/d/1bxGBXjTn7FdMJ15IeN$_X$nA3MsyxLYD$_Q$JBWJ274Pz10/edit?usp=sharing.

Once we confirm our understanding of the Bragg-Kleeman rule, we can use it to predict the position of our experiment's Bragg peaks. For example calculations, we will use stainless steel and lead at 1 GeV. Values for α and p of stainless steel and lead were found in Table 2 of "The Physics of Proton Therapy[7]." Example calculations:

1. St... Steel:

$$\alpha = 5.659 \times 10^{-4}, p = 1.706$$

$$R_0 = 5.659 \times 10^{-4}(1000)^{1.706} \approx 74.257\text{cm}$$

$$\alpha = 6.505 \times 10^{-4}, p = 1.676$$

$$\alpha = 6.505 \times 10^{-4}(1000)^{1.676} \approx 69.382\text{cm}$$

...at a proton beam at 1 GeV will respectively have an approximate Bragg ...inless steel and lead of 74 cm and 69 cm, respectively

Win or not, every year the students and I find value in the endeavor of producing a proposal. We learn physics content, practice technical writing, make connections with the physics community, and work collaboratively.

Win or not, every year I am proud of the students' final product.

Contemporary Physics in the General Physics Classroom

- Good
  - High student interest (as always)
  - Incorporated CRMD Time of Flight study this year, data discussion
  - Lots of discussion about statistical methods, thanks to Derek's interest
  - Fun projects – ATLAS coloring books, particle models
- Bad
  - End of year, student- and teacher burnout
  - Not enough time
  - Not enough background for students in rotation, EM
- To try 2023-24
  - Cram all of mechanics into Semester 1
  - Start Contemporary physics early spring
  - Incorporate a Master Class again (maybe not ATLAS, if we still have to use Hypatia)
  - CRMDs running all. of. the. time. We have 3 CRMDs now!
  - AP Phys 1: get ahead of the content enough to include contemporary physics a couple of times before the exam (?)

ID Quarknet Summer Camp, 2023

- Plateau counters for 2 detectors
- Performance Study for 6780
- Attempt to do a 2-detector shower study with Enrique
  - (zero events in 1 hour)
- Proper single detector shower study
  - (22 potential events in 40-ish hours)
- Thoughts for implementation 2023-24
  - 3 detectors at WHS!
  - “Steve Method”
  - More multi-detector studies
  - Altitude vs. Flux (Snowbird Octoberfest?)

July 2023

- CERN and the Antimatter Factory
- with another BL4S student, Topher