

Crystal Undulator Radiation

Proposed by Accelerating Africa

Introduction

We are a collaboration of grade 11 students from St John's College and Barnato Park High School. Science is a deeply-rooted passion of ours. We realise that we can make a significant impact in Science education in South Africa if we are able to carry out our experiment at CERN. South Africa is a developing country, and scientific research is vital to our sustainability and socio-economic growth. We firmly believe that the impact that we could make would not only benefit the world, but also create a strong scientific culture in South Africa. With the Square Kilometer Array (SKA) coming to South Africa, we believe our country has huge potential to be a scientific hub in Africa and students in South Africa need to be the future scientists.

2015 is the International Year of Light. We have been fascinated by the history of synchrotrons from the first accidental observation of synchrotron radiation to the recent development of 3rd generation synchrotrons and Free Electron Lasers. We therefore propose an experiment that could be the next step in the production of brilliant light sources. Electromagnetic radiation has and continues to form the basis of modern technology, and we have, therefore, proposed an experiment to produce high energy gamma rays using a crystalline undulator which we would love to conduct at CERN.

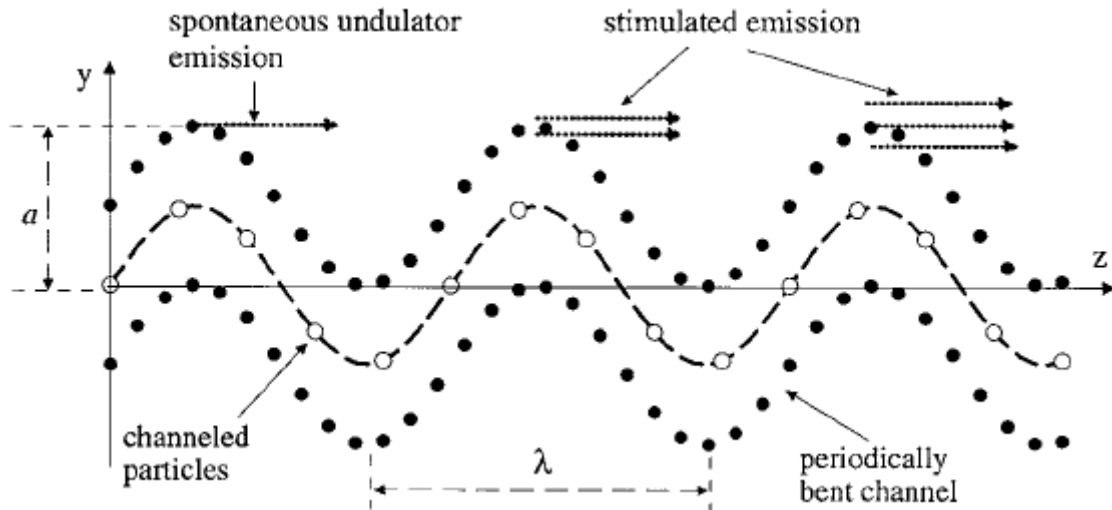
Background

The acceleration of subatomic charged particles causes radiation. Acceleration can be achieved by means of curved motion. Initially this was achieved using bending magnets, but as the need for higher intensity sources became apparent, magnetic undulators were used to produce very narrow beams of near-coherent light. It has been realised that a crystalline undulator with a small amplitude and a short period would be able to achieve coherent beams of radiation whose brightness would be several orders of magnitude greater still. The size of a crystal undulator is very space efficient compared to magnetic undulators currently used, but yet able to achieve significant magnetic fields when relativistic beams of particles are used. A crystalline undualtor could produce "light" in the gamma-ray regime.

Our Experiment

The University of Johannesburg collaborates with many institutions. As a result, we would be able to bring to CERN a crystal undulator to conduct our experiment. The crystal is specifically grown using either carbon with boronated layers or silicon with germanium laden layers

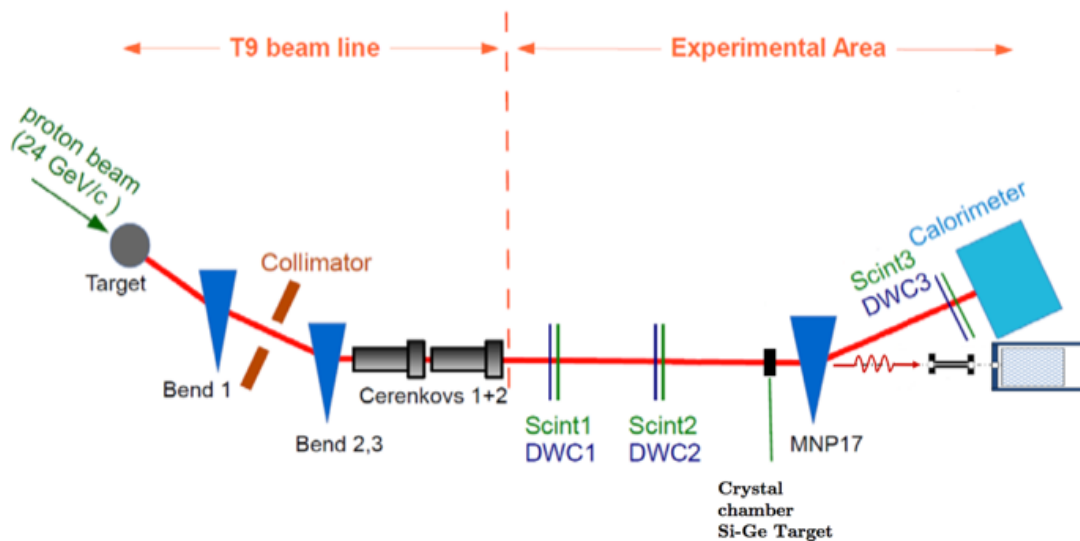
incorporated. The boron or germanium atoms cause the crystal lattice to swell and thus graded doping creates a tiny undulating channel through which the subatomic particles (electrons, positrons or muons) can be fired. As the particles accelerate as a result of the undulation, we will detect and measure the resulting radiation.



By controlling the incident beam, we should be able to tune the resulting gamma ray radiation. A gamma ray source, that could potentially be made into a gamma ray laser, has huge potential.

Experimental setup

We propose to use the beam line at CERN to initially produce a positron beam to fire through our crystal. We intend to measure the effects of a positron beam passing through the crystal and later repeat the experiment to obtain results for an electron beam.



The secondary beam produced by the proton beam colliding with the target will contain a huge variety of particles. We will select the particles that are required. The collimator and the

first two bend magnets will allow us to select only the positively charged particles within a particular momentum range (0.5-10 GeV). We will use the Cerenkov detectors to identify the particles that remain. These tagged particles will then progress to be incident on the crystal. The delay wire chambers will allow us to find the positions of the particles while the scintillators will provide a timestamp for the particles. In this way we will know the trajectory and identity of the particles that are arriving at the crystal chamber. The MNP17 magnet will sweep away all charged particles and allow all the electromagnetic radiation to proceed to the photon calorimeter. The third delay wire chamber and the MNP17 magnet will allow us to establish the momentum of the particles that passed through the crystal, while the third scintillator and the calorimeter will allow a redundant study of the particle energy. In this way we should be able to determine the kinematic properties of the particle responsible for the undulator radiation that we detect.

A lot of analysis will be required as we realise not all the radiation detected at the photon calorimeter will be the radiation from the crystal undulator. All the data collected, that the setup allows us to measure, will allow this undulator radiation to be identified and measured separately.

Gamma radiation has huge applications in nuclear research and holds the promise of getting rid of nuclear waste. The possibilities of further science exploration due to the success of the experiment are endless. How many doors will our intriguing project open for science?

Conclusion

We realise that doing the experiment at CERN is only the first step, but we are enthusiastic about all the analysis, hard work and learning that will follow. If we are successful in being able to conduct our experiment at CERN, we will work not only on the Science, but also on spreading the benefits and brilliance of Science to our fellow students and communities around South Africa. We will explicitly state the vast fascination of science while advertising its wonder. Being able to carry out our experiment at CERN will inspire many students from many schools to take part in science expos, to investigate science further and to take this incredible subject at school and at university.

Acknowledgements

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