Proposal – Japan /Argentina / Mexico

1. Team name: Cancer STOP

2. Country: Japan/Argentina/Mexico

3. Name and email address of the team coach:

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Miki Ohtsuka - m_ohtsuka@waseda.jp – Japan

4. Names, dates of birth and gender of each student team member (minimum of five students).

Name (Students)	**Date of birth**	**Gender**	**School(s)/Organization(s)**
Marianela Pepe	February 8, 2002	Female	Huechulafquen Science Club - Argentina
Juan Francisco Wehinger	October 2, 2002	Male	Huechulafquen Science Club - Argentina
Lucio Daniel Martínez	March 7, 2002	Male	Huechulafquen Science Club - Argentina
Sofía Ezcurra	February 24, 2002	Female	Huechulafquen Science Club - Argentina
Huascar Miguel Azurduy Hernández	March 19, 2003	Male	Huechulafquen Science Club – Argentina *(Guest)*
Wakana Yanagimoto	August 22, 2003	Female	Waseda University Honjo senior High School Super Science Club
Kenshiro Aoki	August 24, 2004	Male	Waseda University Honjo senior High School Super Science Club

Syunki Koizumi	December 27, 2004	Male	Waseda University Honjo senior High School Super Science Club

5. Name of school(s) or organization(s) represented by the team:

1) Huechulafquen Science Club (Club de Ciencias Huechulafquen) - Argentina

2) Waseda University Honjo Senior High School (早稲田大学本庄高等学院) - Japan

6. Proposal:

a. Briefly (around 100 words) why you want to come to DESY

Cancer is the leading cause of death in Japan and the second in Mexico and Argentina (Fig.1). Particle therapy is a form of cancer treatment and performed mainly with protons and heavy particles. There are few cases where electrons are used and none with positrons. We think that it might be possible to apply particle therapy with electron beams and positrons in humans and large animals. Furthermore, DESY can supply high-energy electron/positron beams that would make this experiment possible. We previously prepared ourselves by making gels to measure the dose distribution and carrying out simulations. We are ready!

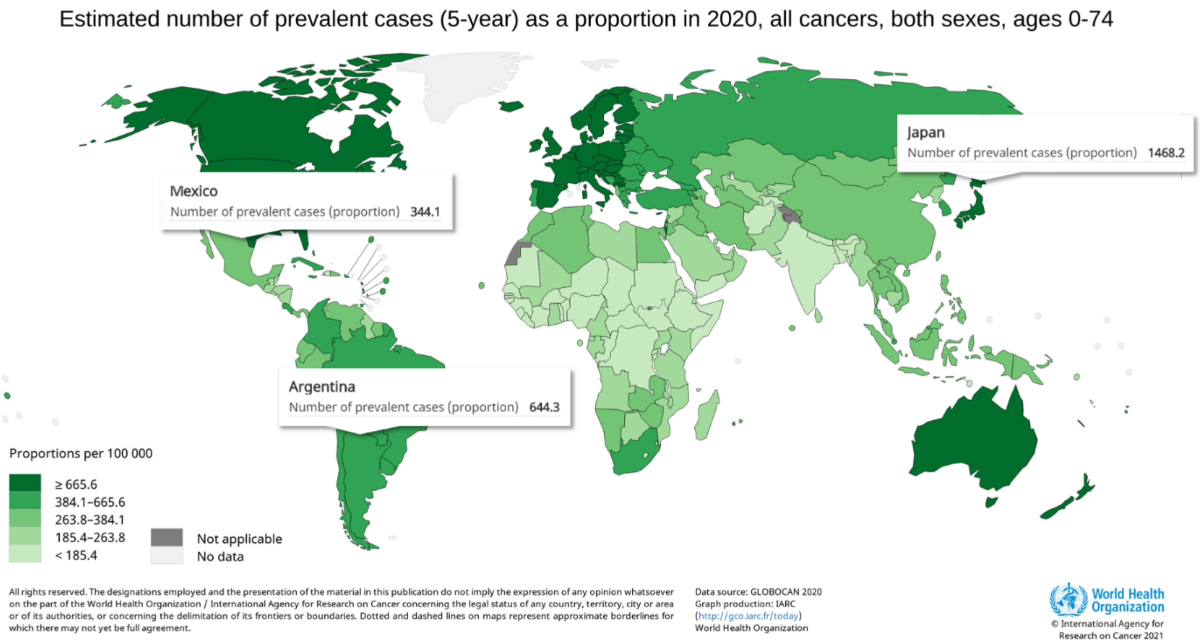

Fig. 1. Comparison of the prevalence of cancer cases in Argentina, Japan and Mexico.

b. In detail (around 800 words) how you would like to use the particle beamline for your experiment.

Purpose

We would like to know what the dose distribution will be like when the rays hit the body. Therefore, we would like to set up a gel dosimeter on the beamline, which is known as a method to obtain the dose distribution in three dimensions at once and measure it with electron beams and positrons from the degree of whiteness.

About MAGAT Gel Dosimeter

The gel we use is called MAGAT gel, which is one of the most easy-to-make, safest, and easy to analyze polymer gel dosimeters. It can be made by mixing water and gelatin etc. [1] Using this recipe, we made several of these at CYRIC at Tohoku University and irradiated them with X-rays (Fig.2, Fig.3). We would like to set up a 1-meter-long MAGAT gel on the beamline and do an experiment with about 100,000 1-GeV / 1.5-GeV / 2-GeV / 2.5-GeV /3-GeV beams.

Fig.2 Making gel.

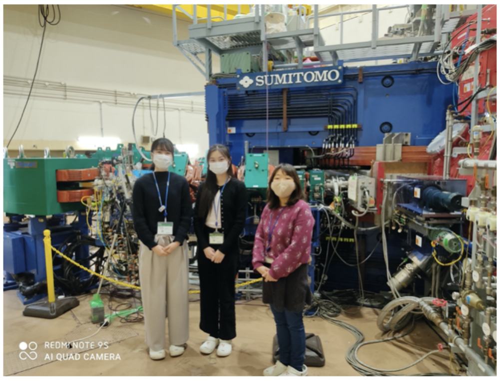

Fig.3 Accelerator in CYRIC (Cyclotron and Radioisotope Center)

Experimental setup (Fig.4)

1. Accelerator: we use electron beams and positron beams.
2. Collimator: use for narrowing down the thickness of the beam. We would like to use a 2mm one if it's possible.
3. Scintillation counter: measure the number of the electron comes from the accelerator per unit time.
4. Gel: put Gel
5. CCD camera: this detector can be worked by observing how gels become clouded objectively.
6. Lead crystal calorimeter: we use it as measuring the amount of the beam energy which passes through the gel.

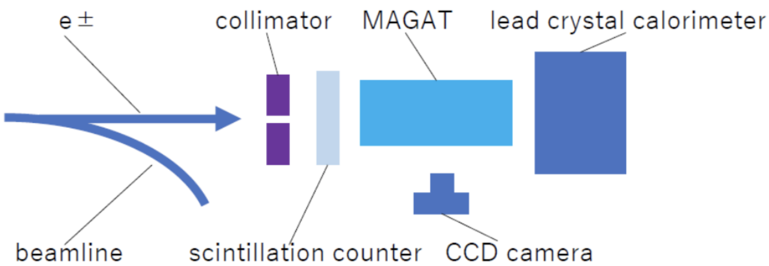

Fig.4 Experimental setup

How to evaluate

1. Take photos of the gel from three directions (x, y, z) before beam irradiation (Fig.5).
2. Irradiate the gel with the electron and positron beams for a predetermined irradiation time. An experiment with electrons and another with positrons
3. Take photos from all three directions again.
4. Analyze the gel focusing on brightness change. *Brightness after irradiation - Brightness before irradiation = Absorbed dose distribution
5. Compare and verify the actual results with simulation results.

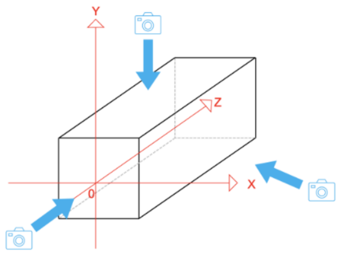

Fig.5 photo taking direction

What We Discover Through Preliminary Research

Before conducting beam performance tests, we had to know two things: first, whether our gels are sufficiently applicable. And second, how much size of the gel we need.

For the first, we made MAGAT gels and conducted X-ray irradiation performance tests, and analyzed. For the second, we conducted simulations using a simulation package called Geant4.

Analysis

・*Analysis-1*

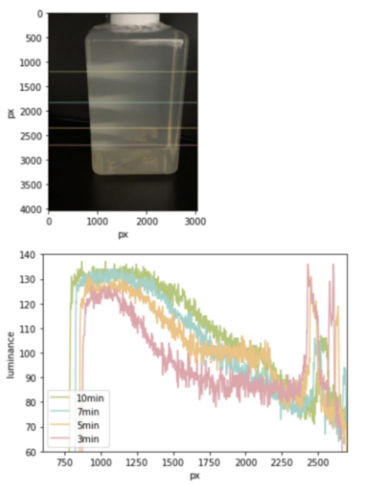

Fig.6 *changed the irradiation time and fixed the number of W*

The X-rays are irradiated from the left side. The beam strength is fixed at 40kV and 100μA (4000mW). The irradiation time is 10minutes, 7minutes, 5mintes, and 3minutes from top to bottom.

The white part of the gel is the part where the gel reacts with chemical reaction and is colored by X-rays. Around 700px to 1250px, since it is closer to the X-ray source and lots of energy is absorbed, the color change appears sufficiently, and we cannot find the luminance change much with different irradiation time. But for the tail area behind, we can see that the degree of luminance changes with time, so that we can properly confirm the performance and accuracy of the MAGAT gel.

・*Analysis 2*

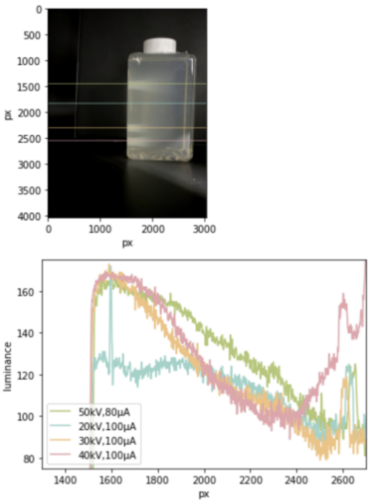

Fig.7 *changed the number of W and fixed the irradiation time.*
The X-rays are irradiated from the left side. The irradiation time is 5mintes. The beam strength is 50kV 80μA (4000mW), 20kV 100μA (2000mA), 30kV 100μA (3000mA) , and 40kV and 100μA (4000mW) from top to bottom.

By varying the number of W, it was confirmed that the appearance of the distribution changed according to the number of V and A.

What we found out through analysis

Although it is common to use MRI for analysis, we were able to confirm changes in the absorbed dose distribution by focusing on changes in luminance. So, we deem that it’s possible to adopt the same method of experimenting and analyzing in DESY.

Simulation

・Purpose

We predicted the distribution from the simulation to experiment safely.

We simulated the absorbed dose distributions for 100,000 electron and positron beams of 1 GeV. Since the beam size is enormous, we predicted the absorbed dose distribution in advance to prepare gels of appropriate size. We simulate with water because it is the main ingredient of the gel.

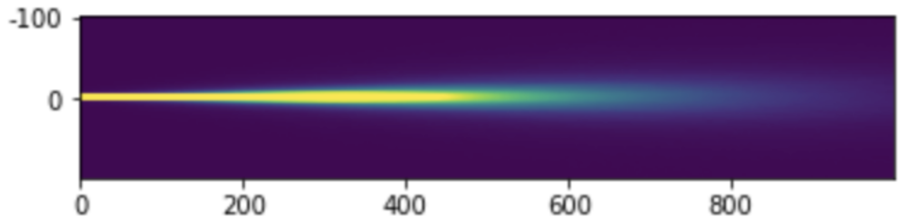

Fig.8 Simulation result of **electron** irradiation field in XZ direction (Fig.10).
100 thousand 1 GeV electron beams are irradiated from the left side. The yellow color means high energy is absorbed, and the blue color means less energy is absorbed. The axes of both X and Y are [mm].

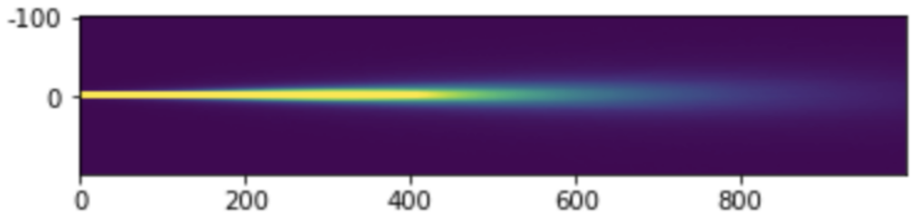

Fig.9 Simulation result of **positron** irradiation field in XZ direction (Fig.10).
100 thousand 1GeV positron beams are irradiated from the left side. The yellow color shows high energy is absorbed, and the blue color shows less energy is absorbed. The axes of both X and Y are [mm].

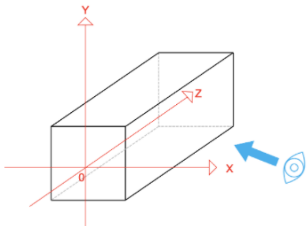

Fig.10 The imaginary view of simulation in xz direction.

From the simulation of the electron and positron beam in XZ direction, it was found that the dose was absorbed linearly, that a large amount of dose was absorbed in a relatively close distance from the irradiation position and it was sufficient to prepare a gel for a length of about 1 m. The difference is, the absorbed dose distribution of electrons tends to converge after around 350 mm, while the absorbed dose distribution of positrons tends to converge after around 300 mm. The positron beam seemed to converge more quickly.

Therefore, we analyzed the results from the XY direction between 300mm-400mm.

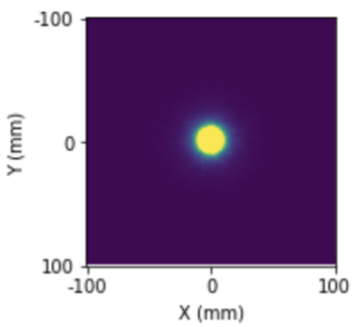

Fig.11 Simulation result of **electron** irradiation field in xy direction (Fig.15).

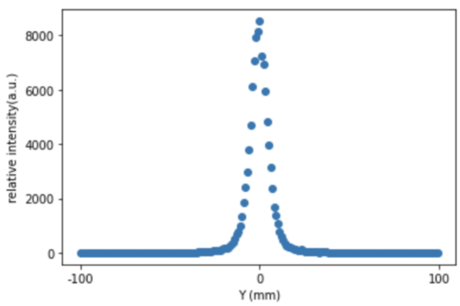

Fig.12 It shows the relative intensity of the electron irradiation field in xy direction. We extract z=300[mm] to z=400[mm] from Fig.8.

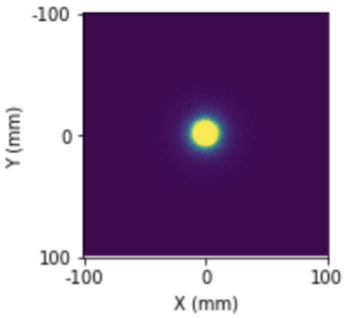

Fig.13 Simulation result of **positron** irradiation field in xy direction (Fig.15).

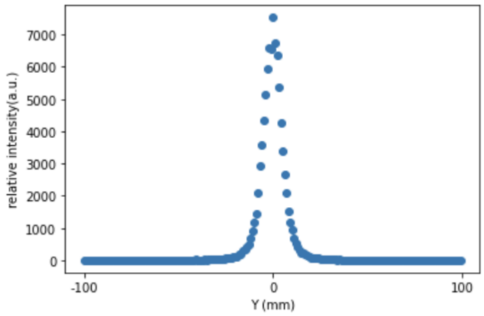

Fig.14 It shows the relative intensity of the positron irradiation field in xy direction. We extract z=300[mm] to z=400[mm] from Fig.9.

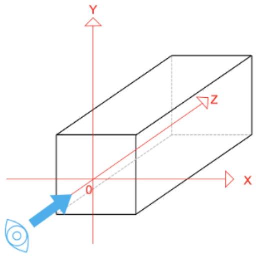

Fig.15 The imaginary view of simulation in xy direction.

From the simulation of the electron and positron beam in the XY direction, it was found that the relative intensity of electrons is much higher than that of a positron. So we confirmed that more energy remains in the electron beam.

c. Briefly (around 100 words) what you hope to take away from the experience.

We are very curious about the results of our experiments and we want to save lives through particle physics as radiation therapy for cancer. Also, we would like to have the opportunity to learn more about science, visit important laboratories, talk with scientists, see the facilities, how they work, meet other students and work together.

We are an international team, and our activity is based on online meetings. We think it's a great opportunity to step out of the computer world and deepen international exchange and communication in DESY.

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Annex 1

Gel preparation and safety

1. Measure the amount of pure water and gelatin, then add them into a beaker.
2. Keep swelling and stirring them for about 30 min.
3. Measure of the methacrylic acid using graduated cylinders. Invest them into the beaker.
4. Take the beaker out from the constant temperature bath and cool them to 37°C.
5. Add THPC with micro pipette and stir again.
6. Pour them into the container. Be careful not to inflow air from gaps between the container and the lid. It is recommended to place plastic wrap over the lid.
7. Wrap around the container with aluminum foils, preserve them with 20 degree Celsius in the constant temperature bath.

Safety

Methacrylic acid and THPC are a bit hazardous but safe enough for students to handle. SDS [1] are attached to the references.