

**Part C Project Details****C.1. Goals and Objectives****(i) Long-Term Goals**

- Develop model experiments on radiation and radioactivity with documents to supplement the teaching of the Radiation and Radioactivity unit in the Physics subject under the New Secondary School Curriculum.
- Allow teachers to have the necessary safety knowledge to handle radiation sources in experiments on radiation and radioactivity for secondary school students.
- Set up a facility within the university to allow secondary school students to conduct and/or observe demonstration of experiments on radiation and radioactivity that are difficult or infeasible to conduct in secondary schools.
- Promote the use of a Wiki-style e-platform to share electronic education materials.

**(ii) Short-Term Goals and related objectives**

- Collaborate with teachers to design and run a series of model experiments on radiation and radioactivity with supporting documents, lab packages, and online lab demo videos for use by secondary school students. The contents will be arranged to cover the following aspects:
  - A comprehensive document describing the basic units of radioactivity and the concept of radiation dosage.
  - An experimental study for measuring the background radiation and assessing the safety level for handling a radioactive source using a GM counter.
  - An experimental study for assessing the safety level for handling a radioactive source. It is performed to observe the drop of radiation intensity of a radioisotope with increasing distance from source.  $\alpha$ -,  $\beta$ - and  $\gamma$ -radioisotopes (i.e. Am-241, Ra-226, Sr-90 and Co-60) will be used for measurements. Students will then be instructed to compare the results with safety standards to judge how the source can be handled safely.
  - An experimental study for assessing the safety level of storing a radioactive source. It is performed to observe the attenuation of radiation intensity of a radioisotope with increasing thickness of various absorbing shield (paper, aluminum, steel and lead).  $\alpha$ -,  $\beta$ - and  $\gamma$ -radioisotopes (i.e. Am-241, Ra-226, Sr-90 and Co-60) will be used for measurements. Students will then be instructed to judge how a radioactive source can be stored safely.
  - Fabrication of a home-made dry ice-free diffusion cloud chamber and observation of ionization tracks by using the device.
- Application of an existing Wiki-style e-platform to deliver the above education packages. Creative Common (CC) registration will be implemented to preserve the authors' information and facilitate sharing of the materials.
- Organize training courses for teachers to enhance their knowledge of handling radiation sources safely and the knowledge related to the radioactivity teaching materials generated in this project.
- Conduct a trial run of student experimentation lab within the university to conduct experiments on radiation and radioactivity by using the lab packages created in this project.
- Organize a visit to the radiation monitoring station of the Hong Kong Observatory, training courses for teachers and experimental classes to students, and a seminar for students to report results of their studies.

**(iii) Objectives:**

- Objective 1 is to demonstrate to all the participating teachers and students how to assess the safety for handling radioactive substances. They will be inspired to solve problems which are usually encountered when preparing experimental classes in radioactivity. They may refer to the examples generated in the project to gain ideas and techniques for devising new radioactivity experiments performable in schools.
- Objective 2 is to guide students to make simple do-it-yourself radioactivity detectors and perform observations on fundamental radioactivity phenomena. In the long run, the project helps them to gain basic knowledge to comprehend reports on general affairs about nuclear radiation and diminish unnecessary panics possibly caused by related events.
- Objective 3 is to promote the use of a Wiki-style e-platform to motivate more people to participate in enriching the e-library by contributing their own creations. This approach helps to

reduce paper usage from textbooks and reduce schoolbag burden of students.

## C.2 Needs Assessment

This project is proposed based on three main reasons.

### (i) *Promote public general science education in Radiation and Radioactivity*

The Fukushima nuclear accident in March 2011 caused tremendous impacts to the society. The previous illusion about the almost-absolute safety of nuclear energy woven by the nuclear renaissance movement has been shattered. The disaster wakes up the hard fact that despite the many safety mechanisms in place, all facilities are prone to human errors and so nuclear accidents do and will occur, with potentially far-reaching consequences that many in the general public will not tolerate. This sudden wakeup call, coupled with the relative ignorance of the knowledge of radioactivity prevalent among the general public, resulted in irrational sensation and even total panic in the public, as demonstrated by the sudden rush of purchase for iodine tablets and sub-standard Geiger counters of questionable usability. Although the Fukushima disaster has prompted active debates, it is unfortunate that many in the general public, and even the media, lack the necessary general science knowledge to distinguish facts from fiction and thus some of the reports are flawed. For instance, the contents of the reports covered by Apple Daily on 13/11/2011 and Oriental Daily News 16/11/2011 were found to be entirely contradictory from each other. The situation is worsened by parties interested in their own side of the arguments often distorting facts to their own advantage, leaving the general public confused. As a result, many people might not have enough common sense on how to react and what precautions to take should a major nuclear leakage occur. On the other hand, information on radioactivity available from the internet is mostly too lengthy or difficult for the general public. The overall scenario strongly suggests that public science education in this aspect should be strengthened, and motivates us to propose this project.

### (ii) *Support teaching of radioactivity in schools*

The NSSC includes a new compulsory unit called “Radioactivity and nuclear energy” in the Physics syllabus. As a component contributing to 1/6 of the whole subject, substantial experimental training should be incorporated into teaching, but the establishment of the labs is in general obstructed by fear of the potential danger in handling radioactive sources. We are therefore motivated to alleviate the difficulty by guiding teachers through a set of carefully designed experiments to gain hands-on experience in handling radioactive sources, and the concept for assessing the safety level of an experiment in radiation and radioactivity based on experimental data (see the part of “Deliverables” for details). Finally, they should be able to design new experiments by applying the knowledge and their own creativity. In addition, for helping some schools which are building their own radioactivity labs, we will go through the application process for getting exemption of storage and allowance of using radioactive sources for teaching in a school, and pass the experiences to teachers and lab technicians.

We also notice that diffusion cloud chamber is an effective device for students to observe radiation-induced ionization tracks, but its use in teaching is rare due to the inconvenience of buying dry ice (an essential component in the operation of a cloud chamber) in Hong Kong. AP staff members has recently developed a dry ice-free diffusion cloud chamber based on a Peltier cooler, which is purely electrically powered and is hence suitable for classroom teaching. We hope to introduce the related principle to teachers and secondary school students so as to allow them to build their own do-it-yourself cloud chamber for their own teaching and learning purposes.

### (iii) *Use of e-platform in delivering education materials*

Hong Kong, similar to the rest of the developed countries, is facing a trend of rapidly increasing school textbook price at all levels of education, where parents are increasingly vexed by the ever-increasing textbook price and the all-too-frequent update of textbook editions from publishers. As highlighted in the report “Turn the Page: Making College Textbooks More Affordable” (<http://www.ed.gov/about/bdscomm/list/acsf/turnthepage.pdf>) from the American Congress Advisory Committee on Student Financial Assistance in May 2007, the average full-time American undergraduates spent between \$700 and \$1,000 USD on textbooks in 2003–2004, with a price rise of 109% between the year 1987 and 2004. Similar price increase trend is observed in Hong Kong also. Therefore, it is the worldwide trend to begin looking into the feasibility of gradually replacing paper textbooks with electronic ones. Electronic text has the advantage of more environmentally friendly (less paper), much lighter to carry around (improving the back posture of

school children who need to carry their absurdly heavy schoolbags everyday), and more user friendly (easier to share education resources online and to search for certain words in an electronic textbook). Therefore, we believe that it is now the time to begin investing in electronic educational resource for a better future in terms of environment and health of school children. One of the main ideas of this proposed project is to use an existing Wiki style e-platform, namely “Education Resources” of the Co-WIN website, to carry out a piloting practice for educators, students, and the general public alike to find and share teaching materials. The platform primarily centers on meteorology-related topics, but is found to be extendable to cover more subjects. Promoting education on Radiation and Radioactivity is selected to be the focus of this round of development.

### C.3 Applicant's Capability

#### (i) Related educational experiences and facilities of AP

- AP has been offering a general education subject entitled “Climate and Our Environment” for four years. The subject covers a broad spectrum of topics involving meteorology, environmental science and renewable energy. Radioactivity is one of the core topics. In addition, students are required to use the e-platform, “Education Resources” of Co-WIN, to do homework; the same e-platform to be used in this proposed project.
- AP is offering a subject in radiation science to serve another department. The department has a stock of various radioisotopes, including  $\alpha$ -,  $\beta$ - and  $\gamma$ -sources, which are also required in the proposed project. In addition, AP owns a variety of radiation detectors, e.g. G-M counters and survey meters.
- The technical team in AP has the knowledge of fabricating a dry ice-free diffusion cloud chamber. Pilot experiments were done to illustrate how the safety level of an experiment on radiation and radioactivity is assessed based on experiment results.
- Most staff members in the department are degree or higher degree holders in physics. They have the ability to solve the technical problems possibly encountered in the proposed project.

#### (ii) AP's track record in promoting public education in radioactivity

- AP received a fund of \$200K from Love Ideas ♥ HK program to conduct a project entitled “Radiation and You” (1/8/2011 – 31/7/2011) to promote general radiation and radioactivity education to the public.
- Associated with this project, a luncheon for educators from schools was held in November, 2011 to exchange ideas. Meanwhile, AP students gave a series of presentations with topics like common nuclear radiation units, modeling of nuclear decay chain, working principle of G-M counter and diffusion cloud chamber, and Daya Bay contingency plan. They are considered to be part of the preparatory studies for the proposed project.
- A visit to the HKO radiation monitoring station (King's Park) was organized in February 2012.

#### (iii) AP contributes to the establishment of Co-WIN and “Education Resources” platform

- Co-Win is a joint project of AP, HKO and many educational and public institutions. The members span a broad range covering kindergartens, primary and secondary schools, tertiary institutions, and community organizations such as the Hong Kong Scout Association, Elderly Service and World Wide Fund for Nature-Hong Kong. A full member list is shown in the link <http://weather.ap.polyu.edu.hk/memberlist.php>. The locations of some of them are shown in Fig. 1. The main purpose of Co-WIN is to promote meteorological education to the education sector and the public. AP has been helping member institutions to set up automatic weather stations (AWSs) for collecting meteorological information at various places in Hong Kong and advise teachers on how to make use of the collected data for educational purpose.
- Associated with the Co-WIN project, AP team members have over four years of collaboration with member schools to organize student outdoor surveying activities on various topics like urban heat island effect, CO<sub>2</sub> concentration, ultraviolet index, negative ion concentration and heat stress index. Training courses, workshops, seminars and presentations on specific meteorology topics have been arranged with member schools several times a year for the past four years (Fig. 2). The AP department has also worked with teachers to generate lab sheets and education materials. To date, more than 2700 man-times have participated in the activities organized under the project. The social communication network forms a sound foundation to support the presently proposed project.



- A Wiki-style e-platform, called Co-WIN Education Resource, has been established in 2011 as an extension of the Co-WIN web interface for supporting teaching and learning activities ([http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/Main\\_Page](http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/Main_Page)). It is a Wiki-style electronic library to archive lab sheets, templates and instructions of outdoor survey activities generated by our Co-WIN teachers and members in areas related to meteorology and the environment such as urban heat island, radiation, acid rain, carbon dioxide, UV, and relationship between surface and air temperature. Most of the archived lab sheets have been put into actual education use and can be readily downloaded by anyone interested. This is the same e-platform that will be used for sharing educational material in the presently proposed project.

(iv) Selected awards for Co-WIN

- The Co-WIN received the prestigious Vaisala Award for Weather Observing and Instrumentation by the Royal Meteorological Society (RMetS) in 2010. The assessment committee of RMetS commented that the award went to HKO and AP in recognition of their joint effort in raising community awareness toward weather and climate through the establishment of Co-WIN in Hong Kong. **The RMetS highlighted Co-WIN's success in enabling people of all ages, in particular schoolchildren, to appreciate the elements through hands-on activities in running weather stations. Apart from weather-data sharing, Co-WIN also provides a platform for the exchange of observational experiences and for the organization of related educational activities. The RMetS also recognised Co-WIN's achievement in demonstrating how groups can work together to deliver high-quality community education on weather and climate for the benefit of all.**
- The President's Awards for Excellent Performance/Achievement --- Services (Team) of the Hong Kong Polytechnic University, 2010/2011.
- The Faculty/School Awards for Outstanding Performance/Achievement --- Services (Team) of the Hong Kong Polytechnic University, 2010/2011.
- Hong Kong ITC Awards 2011: Best Collaboration (Service) Certificate of Merit Collaboration Partner, presented to AP of PolyU, as collaborator Partner of HKO, from Hong Kong Industrial Association, 15 April, 2011.
- Community Service Learning Awards, presented by PolyU in three consecutive years from 2007/08 to 2010/11.
- "Most Popular Award" (Open Stream) in **"The Best Practice Award on e-Education 2011"** by **e-Education Alliance**.

(v) Capability of collaborators and consultant (HKO)

- \_\_\_\_\_ the ex-Vice Principal and consultant of Lingnan Hang Yee Memorial Secondary School, has dedicated to teaching and school management for more than 30 years. He is now serving as the Chairman of the Executive Committee of Co-WIN, steering the direction of the development of the project. He is enthusiastic in supervising student projects in urban heat island and determination of air temperature based on measured surface temperature. Reports and model investigation template were generated and uploaded to the Co-WIN e-platform for public use.
- \_\_\_\_\_ physics teacher from Po Leung Kuk Wu Chung College, is one of the most active members of the Co-WIN Executive Committee. He supervised his students to perform investigative studies on "Acid Rain Measurement Guide" and "Effect of Weather on Suspended Particulates". Their findings were presented in an open seminar in November, 2011. Reports and model investigation template were generated and uploaded to the Co-WIN Wiki platform. \_\_\_\_\_ was invited to present their projects on the HKO YouTube channel.
- The HKO team has 4+ year history of very close collaboration with Co-WIN members in providing them professional support. The team members include experts in radiation monitoring and IT technology. Their experiences in this aspect might be difficult to seek elsewhere. The past history of partnership and their technical background will be valuable and necessary to ensure the success of the proposed project.

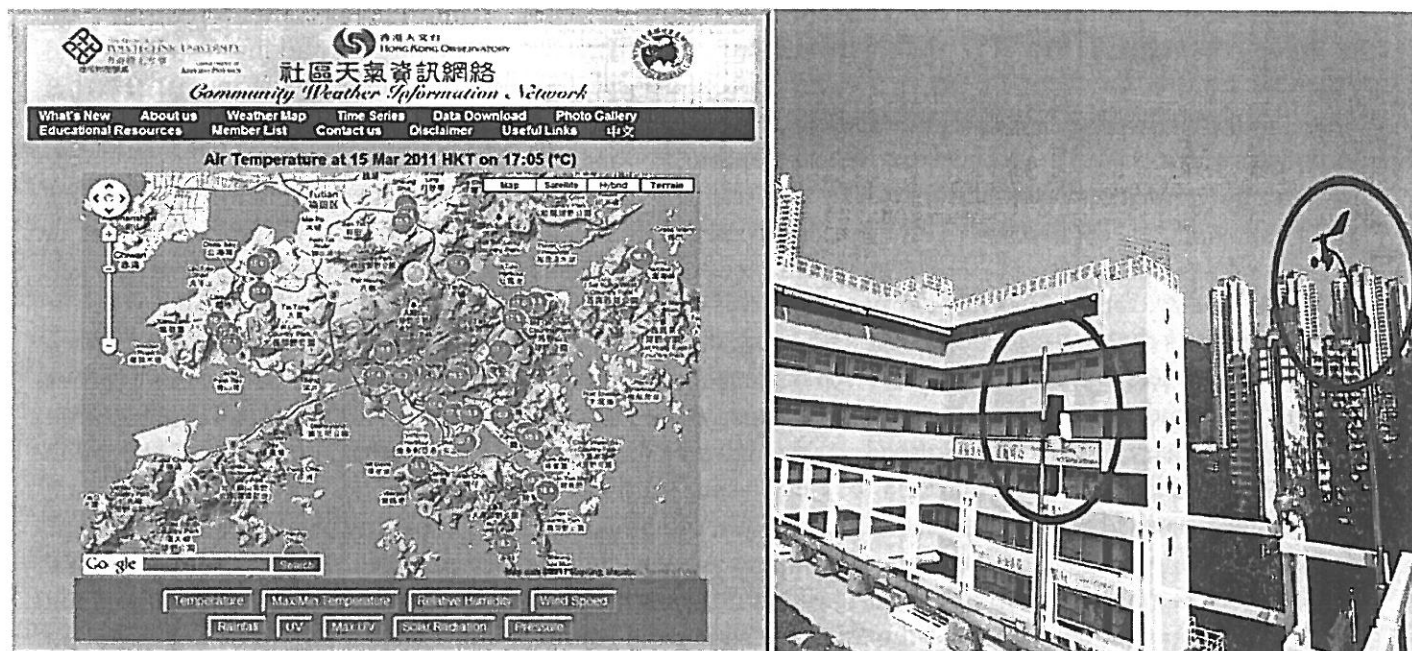


Fig. 1 Co-WIN front page showing the locations of some member institutions (left). AWS on the campus of The Hong Kong Taoist Association Ching Chung Secondary School (right).

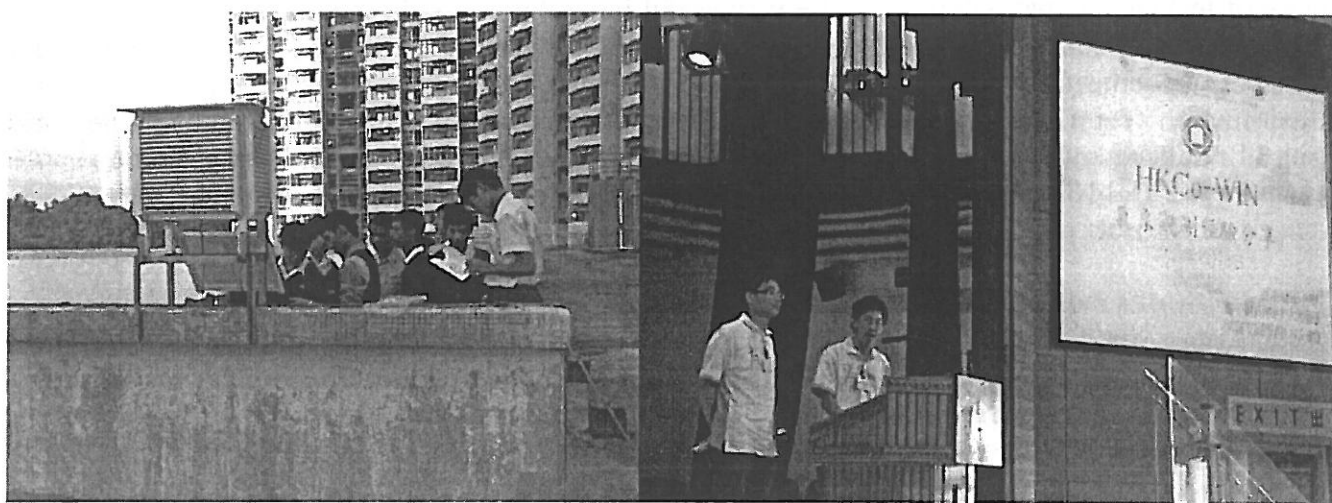


Figure 2 Students of San Wui Commercial Society Secondary School performing outdoor survey (left). Students of Pui Ching Middle Schools giving presentation in a seminar (right).

#### C.4 Targets and Expected Number of Beneficiaries

- (i) Teachers and students of the collaborating schools will have the first priority to join the activities to be organized in this project. The total number of beneficiaries of this group of beneficiaries is around 800.
- (ii) All secondary school students taking the unit “Radioactivity and Nuclear Energy” of physics can use the e-platform to download the education materials to assist teaching and learning activities. The number is estimated to be around 70000 per academic year.
- (iii) Around 30000 non-physics students per academic year, and local and overseas public members may also benefit by viewing and downloading education materials stored in the e-platform.
- (iv) In the long run, students will benefit by reducing expenses on buying textbooks and reducing schoolbag burden with the use of electronic platform.

#### C.5. Conceptual Framework

It is now common knowledge that students learn more effectively with hands-on activities to supplement textbook learning. Therefore, teaching the radioactivity unit in the Physics subject should be more effective if students are able to conduct or at least see demonstrations of some of the important

experiments that can help illustrate concepts covered in textbook. Unfortunately, due to reasons such as safety concern of handling radiation sources and difficulty of obtaining radiation sources and materials needed for some of the experiments (e.g. dry ice for cloud chamber experiment), teachers often do not bother to incorporate experiments in radiation and radioactivity in their teaching. The proposed project aims to alleviate the fear of teachers in handling radiation sources by providing safety assessment guidelines of radiation sources and training courses for teachers for conducting experiments with such sources. Furthermore, the dry ice-free cloud chamber proposed in this project will solve the problem of the difficulty in obtaining dry ice for schools to perform cloud chamber experiments with students. Lastly, for schools that do not wish to invest so much time and resource in running some of the experiments that are more difficult to organize, our proposed project plans to provide a lab facility within the university for the students of such schools. Schools can arrange to have their physics students to spend several hours in our on-campus lab to run experiments in radiation and radioactivity that help to illustrate concepts covered in their physics curriculum. For experiments where allowing the students to handle radiation source is a safety issue, staff in the on-campus lab can demonstrate such experiments instead and allow the students to observe and analyze the observations of the experiments. This model of offering lab service is similar to a very successful example of one of our Co-WIN members Ho Koon Education Centre. Ho Koon Education Centre provides facility for schools in Hong Kong to arrange student visits to their facility, where the students can spend a day to be immersed in various activities related to meteorology and astronomy.

### **C.6 Innovation**

The dry ice-free cloud chamber to be developed in the proposed project is certainly a very innovative piece of technology that will prove to be very useful in teaching in radioactivity. In the past, physics teachers from some of the Co-WIN member schools have mentioned that it is difficult to conduct cloud chamber experiment at school due to the difficulty of obtaining dry ice, an essential ingredient of the experiment. Yet it is a very useful experiment for teaching because it allows students to see the actual path of radioactivity and thus illustrates the concept of the difference in alpha, beta, gamma radiation much more clearly than mere words and still photos in textbooks. Hence, the development of a dry ice-free cloud chamber is definitely very innovative and useful for teaching.

The running of a radioactivity lab on university campus for secondary school students is also a new and useful idea, since it allows schools without adequate resource for conducting experiments in radiation and radioactivity to have their students to experience such experiments themselves on university campus. To our knowledge, this will be the first radioactivity lab service on university campus provided to secondary schools in Hong Kong.

### **C.7 Extent of Teachers' and Principals' Involvement in the Project**

The partners from the collaborating schools will participate and monitor the project from different perspectives. \_\_\_\_\_, ex-Vice Principal of Lingnan Hang Yee Memorial Secondary School and presently a teacher of science subjects, represents the view of a senior management member of a school and a frontier educator as well. He is also the Chairman of the Executive Committee of Co-WIN and is familiar with its operations and facilities. He will organize his colleagues and students to help generate the deliverables and join the activities of the proposed project. Teachers from other collaborating schools, like \_\_\_\_\_ of Po Leung Kuk Wu Chung College, will join the project from the viewpoint of a frontier educator. They will give advice based mostly on the learning/teaching outcomes assigned to the curriculum beforehand. They will participate in the activities and may help produce the online education packages.

### **C.8 Implementation Plan and Time-line**

The proposed project is expected to be conducted from 1 September, 2012 to 31 August, 2013 for a total period of 12 months.



<i>Milestone</i>	<i>Content of work (more details are given in the Deliverable part)</i>
Purchase, set up experiments, prepare documents 8 months (1/9/2012 – 30/4/2013)	(i) Buy parts for the fabrication of diffusion cloud chambers. (ii) Buy radioactivity survey meters. (iii) Set up a series of education packages and instructions, with model radioactivity experiments, to cover the studies in the following aspects: <ul style="list-style-type: none"> <li>• An introduction to units on radioactivity and radiation dose.</li> <li>• An experimental study for measuring the background radiation and assessing the safety level for handling a radioactive source using a GM counter. This will be accomplished by performing an experiment to find out how the radiation intensity from a radioactive source drops with increasing distance and finally becomes lower than the maximum tolerable standard.</li> <li>• Assess the safety level for storing a radioactive source. This will be done by observing the attenuation of radiation intensity, from a radioactive source, with increasing thickness of a shielding material placed in between. This determines the minimum thickness of the shield to be used for making a container for storing the radioisotopes to ensure safety.</li> <li>• Fabrication of dry ice-free diffusion cloud chamber and observation of ionization tracks.</li> </ul> (iv) Upload the above materials to the Co-WIN e-platform. Meanwhile, CC license will be applied.
Promotion activities 4 months (1/5/2013 – 31/8/2013)	(i) Visit to HKO radiation monitoring station. (ii) 2 radiation source safety training courses for teachers. (iii) 1 trial run of experiments in the university's laboratory for each collaborating school. Note that students will not be allowed to use radioactive sources for experiments. (iv) 1 student seminar on radioactivity (or other relevant topics).

### C.9 Collaboration plan

- (i) AP team and the collaborators will work together to design the experiments and the associated lab packages. AP team members will be in charge of buying parts and equipment for installing diffusion cloud chamber and carry out the model experiments at PolyU. After obtaining the data, AP team will discuss with the collaborators on how to further improve on the design of the experiment designs, and the writing of lab packages. The collaborators will also be in charge of arranging their teacher colleagues and students to join the activities, including teacher training courses and student demonstrative experimentation labs and seminars.
- (ii) HKO experts will provide professional advice to the project. They will provide opportunity for teachers and students to visit their radiation monitoring station(s).

### C.10 Expected Deliverables

The deliverables include (i) a series of five education packages and (ii) activities including visit, teacher training courses, student demonstrative experimentation labs, and seminar. The education units involve model experiments and supporting documents compiled in a logical and comprehensive way to support education in radioactivity. Relevant video clips on the experiments (demonstrations) will be uploaded to the wiki-style e-platform for dissemination. Their contents are outlines in the following. The major results have been achieved in pilot studies, confirming that they can be produced satisfactorily and ready for use by the education sector upon completion of the project.

#### *Unit 1 Radiation units*

Objectives: Some units of radioactivity and related terminology are often used in news reports, but their definitions and meanings are not widely understood by the public. As a consequence, most people have difficulty in comprehending the messages. Even worse, some of them may respond irrationally with excessive panic. On the other hand, textbooks at secondary level do not cover the knowledge in detail,

and related online materials are often too copious. We propose to generate this document to introduce the definitions of many commonly used radioactivity units with some useful conversion relationships, which are considered to be fundamental and necessary for assessing the safety level when handling a radioactive substance.

A. Table of commonly used units (To be enriched by adding explanations of the concepts involved and terms generally used.)

Definition	cgs unit	SI unit
<i>Activity, A</i> Number of disintegrations / second	1 curie (Ci) $\equiv 37 \times 10^9$ disintegrations /second Conversion : 1 Ci = $37 \times 10^9$ Bq	1 becquerel (Bq) $\equiv 1$ disintegrations / second
<i>Radiation dose, D</i> Radiation energy absorbed / unit mass	1 rad (rad) $\equiv 100$ ergs g <sup>-1</sup> Conversion : 1 rad = 0.01 Gy	1 gray (Gy) $\equiv 1$ J kg <sup>-1</sup>
<i>Exposure</i> Radiation that liberates unit charge in unit volume (for cgs unit) or in unit mass (for SI unit) of dry air at STP	1 roentgen (R) $\equiv 1$ esu/cm <sup>3</sup> in dry air at STP Conversion: 1 R = 258 $\mu$ C/kg	1 coulomb / kg of air (C kg <sup>-1</sup> )
<i>Equivalent dose</i> D <sub>x</sub> W <sub>R</sub> , where W <sub>R</sub> is 1 for $\beta$ - or $\gamma$ -ray, and is 20 for $\alpha$ -ray	1 rem (rem) $\equiv 100$ ergs/g Conversion: for $\beta$ - or $\gamma$ -radiation: 1 rem = 0.01 Sv	1 sievert (Sv) $\equiv 1$ J/kg
<i>Effective dose</i> weighted average of equivalent dose, $\sum_i D_i \times W_{Ri} \times W_{Ti}$ , where W <sub>Ti</sub> is the weighting factor of a tissue or organs (to be detailed).	in rem	in Sv

#### B. Useful conversion relationships

Nuclear radiation detection including survey meters available in physics lab are mostly configured to show data in the unit R, not in rem or Sv for showing the effective dose which is more relevant to assessment of safety for handling a radioactive substance. This part of the document shows how the effective dose can be estimated from measured data in terms of counts and exposure.

For example, we will show how the relationship: 1 R  $\approx$  0.01 Sv, is derived according to the information on ionization energy of an air molecule. Physical consideration leading to this result will be elucidated in a comprehensive way. More conversion relationships and formula serving the same purpose will be derived and explained. The results facilitate one to perform safety assessment when handling a radioactive source according to the outputs of different types of radiation detectors configured in various scales and units.

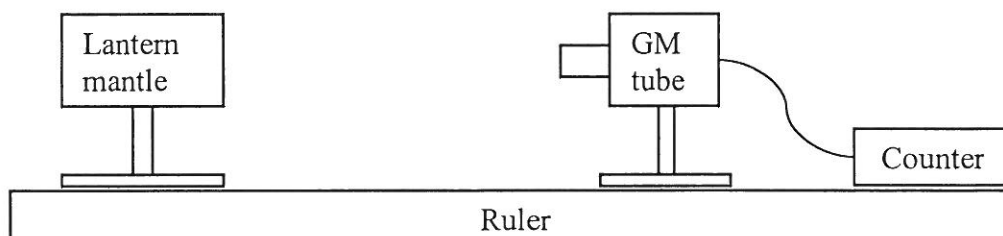


## Unit 2 Safety assessment based on measured radiation intensity~distance dependence

Objective: Use a detector configured in exposure (R) and/or counts to measure the drop of radiation intensity with increasing distance from a radioactive source. One can study the mechanisms causing the drop of intensity and find out the conditions for operating a radioactive source safely.

A. Experiment (applicable to different types of radiations, e.g.  $\alpha$ -,  $\beta$ - or  $\gamma$ -ray)

The setup is shown in the figure. A pilot study using thorium-containing lantern mantle as the source, which gave  $\alpha$ - and  $\beta$ -ray, was carried out. Radiation intensity was measured against distance between the source and detector.



Design of radiation intensity-distance experiment.

B. Results and analysis

Distance (cm)	20	18	16	14	12	10	8	6	4
Count rate (/min)									
Background count rate (/min)									
Net count rate (/min) = Count rate – Background count rate									
Exposure rate (mR/hr)									
Background exposure rate (mR/hr)									
Net exposure rate (mR/hr) = Exposure rate – Background exposure rate									

### Analysis

- Plot net count rate versus distance.
- Plot net exposure rate versus distance.
- Investigate the trend of the curves.
- Fit the data to inverse square law.
- A substantial drop of radiation intensity should be observed. It is a joint effect of inverse square law and absorption by air. The relative contributions from the two factors depend on the type of radiation. This point will be discussed in detail in the final version of this unit.
- The radiation intensity would drop to a safe level (annual effective dose < 1 mSv per year) beyond a certain distance. The data help to set up operation guideline for handling a radioactive source.  
Note: Results of our pilot study using lantern mantle as the source show that an operator who contacts directly with the source for 40 hrs would receive effective dose close to the threshold, but this would not occur in reality. Further, an operator keeping a distance larger than 20 cm from the source would not be affected, as the intensity due to the source drops to reach the background level. More similar investigations will be performed in the project.
- Precautions: (i) handle the sample with long forceps; (ii) avoid any fragment to be detached from a radioactive source; and (iii) always wash hands after the experiment.

### Unit 3 Safety assessment based on the measurement of the attenuation of radiation intensity with increasing thickness of various absorbing materials

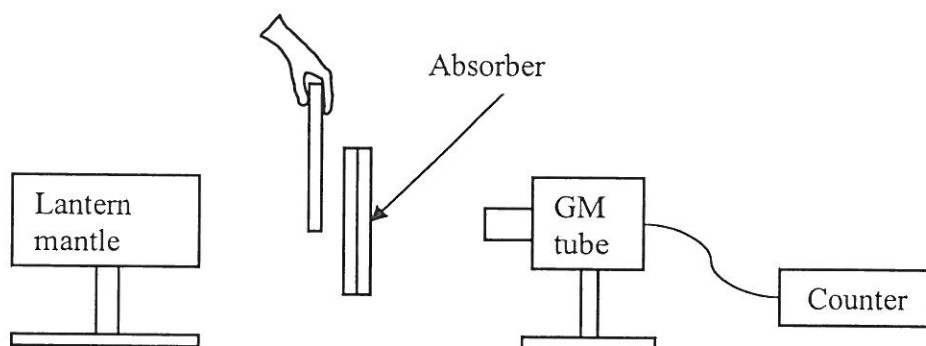
**Objective:** By giving a nuclear radiation detector, an experiment will be performed to measure the attenuation of radiation intensity with increasing thickness of absorbing materials for a specific type of radiation. One can gain information on the design of a container for storing a radioactive source safely.

#### A. Experiment

Sources: Radioisotopes, i.e. Am-241 (592 Bq), Ra-226 (38 Bq), Sr-90 (740 Bq) and Co-60 (1480 Bq).

Radiation types:  $\alpha$ -,  $\beta$ - or  $\gamma$ -ray

Absorber materials: paper, aluminum, steel and lead.



Design of the experiment to show absorption of radiation

#### B. Results and analysis (repeat for $\alpha$ -, $\beta$ - or $\gamma$ -ray; and absorbers made of paper, aluminium, steel and lead)

Distance between the source and detector	10 cm								
Thickness of absorber (mm)	0.5	1	1.5	2	2.5	3	3.5	4	4.5
Count rate (/min)									
Background count rate (/min)									
Net count rate = Count rate – Background count rate (/min)									
Exposure rate (mR/hr)									
Background exposure rate (mR/hr)									
Net exposure rate = Exposure rate – Background exposure rate (mR/hr)									

#### Analysis

- Plot net count rate versus absorber thickness for a certain type of radiation.
- Plot net exposure rate versus absorber thickness for a certain type of radiation.
- Repeat the steps for other sources and absorber materials (expect to see that  $\alpha$ -ray is most readily blocked. Lead is most efficient in shielding nuclear radiation).
- According to the measured data and maximum annual effective exposure, design a container for storing a radioactive source safely.
- Discuss the design of a cabinet for housing the sources.

## Unit 4 Construction of a diffusion cloud chamber and observation of ionization tracks

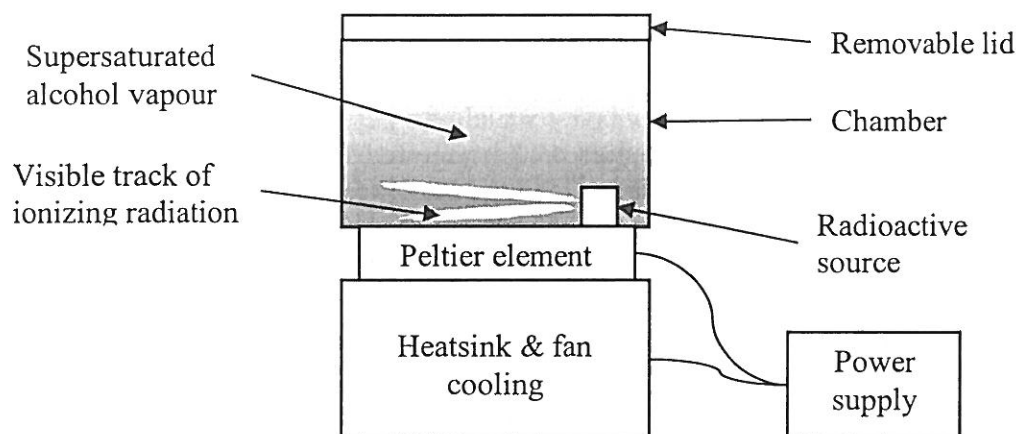
Objectives: The unit of study helps students to fabricate do-it-yourself diffusion cloud chamber and use it to observe ionization tracks.

## A. Fabrication of diffusion cloud chamber

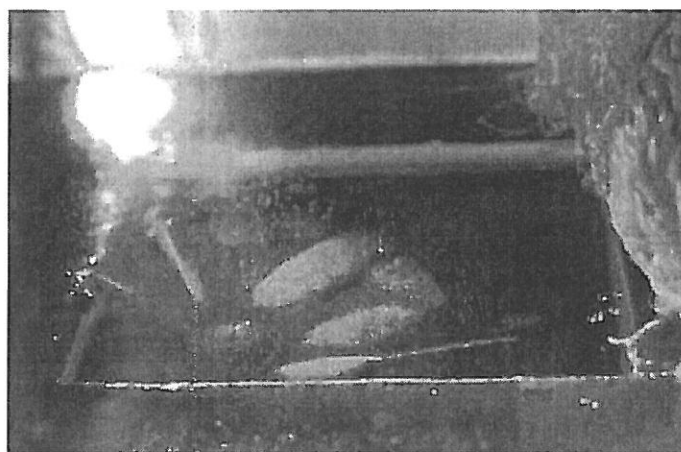
A diffusion cloud chamber is a good setup to illustrate ionization tracks due to energetic particles. However, the conventional design needs dry ice to operate and is inconvenient for classroom teaching. AP staff members have fabricated a dry ice-free diffusion cloud chamber, which relies on a Peltier cooler to generate a temperature reaching  $-40^{\circ}\text{C}$  (see the diagram below). This temperature is low enough to cause downward diffusion of alcohol vapour to be supersaturated, such that radiation tracks can be generated and observed. Importantly, this design allows the device to be electrically powered without the need of dry ice, and hence is convenient to be used in classroom. We will disclose the know-how of the fabrication of the device in this project and guide teachers and students in replicating it. Teachers and students can also modify the design of the cloud chamber for further customization.

## B. Observation and recording of ionization tracks

In our pilot study, video record was produced to show the success of the design. Meanwhile, a very weak radiation source is placed inside the container. The attached snapshot shows the formation of tracks observed from a glancing angle. A student can make a video clip to record the phenomenon, and investigate the difference of the shape of the tracks generated by different types of radiations. Video clips demonstrating the operation of the cloud chamber and generation of tracks by radiation will be produced and uploaded to the Wiki-style e-platform for dissemination.



Schematic diagram showing the design of a diffusion cloud chamber.



Snapshot from a video clip of ionization tracks.



## Unit 5 Usage of Wiki-style e-platform for education and CC registration

The Co-WIN Education Resource, a Wiki-style e-platform, allows users to easily view and upload education resources to facilitate sharing. The platform is located at [http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/Main\\_Page](http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/Main_Page) with step-by-step guide to instruct users to upload content onto the wiki platform ([http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/How\\_to\\_upload\\_a\\_file\\_and\\_create\\_a\\_link%3F](http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/How_to_upload_a_file_and_create_a_link%3F)).

In addition, there is an easy-to-follow guide on how to allow user to obtain Creative Common license for the work they upload ([http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/Guideline\\_of\\_using\\_Creative\\_Common](http://weather2.ap.polyu.edu.hk/cowinwiki/index.php/Guideline_of_using_Creative_Common)).

Other than the above education packages, we will organize

- (i) A visit to a radiation monitoring station of HKO for teachers and students;
- (ii) Not less than two pilot experimental training (for teachers) and demonstrative (for students) courses; and
- (iii) A student seminar for students to present their studies and results.

### C.11 Outcomes of the project

- (i) Teachers and students can assess the safety level of an experiment in radiation and radioactivity; handle radioactive sources safely, fabricate cloud chamber, gain hands-on experience in observing radioactivity phenomena, and design school experiments in radiation and radioactivity.
- (ii) More people use an e-platform and Creative Common (CC) system to share education materials.

### C.12 Budget and Justifications

- Total budget: \$198,700
- Staff Cost: A Project Coordinator in university scale for a period of 12 months will be employed. A high-caliber full-time personnel is required to be recruited to ensure the proposed targets to be reached ideally within the project period of one year. In particular, the candidate will assist in purchasing, designing and performing experiments, preparing e-education materials and organizing activities etc. He/she must have sound background of instrumentation and mature communication skills to manage a broad spectrum of duties. Therefore, an applicant of a good academic background and qualification above a degree level is preferred. A higher salary level is needed to attract a person of this standard.
- Parts and equipment: An amount of \$14420 for buying parts for installing ten sets of dry-ice free cloud chambers and standard nuclear radiation detector for the use in setting up the proposed model experiments.
- General expenses of \$356 for transportation fee for visiting schools, buying stationeries, organizing training courses for teachers and demonstrative classes for students.
- Audit fee of \$5000 is included for audit at the end of the project as required.

**Table 3 Proposed budget**

Table 3 Proposed Budget

Staff cost			
	qty.	Salary (including MPF)	
Project Coordinator	1	\$14,200 × 12 × 1.05 = \$178,920	
		Subtotal = \$178,920	
Parts and equipment			
	qty.	unit price	total
Ten cloud chambers			
• container	12	\$50	\$600
• Peltier elements	24	\$100	\$2400
• thermal paste	10 mL	\$10	\$100
• silicone	1 tube	\$100	\$100
• heat sink	12	\$125	\$1500

• cooling fan	12	\$100	\$1200
• screws & nuts	60	\$2	\$120
• ethanol	1L	\$300	\$300
• transformer	12	\$175	\$2100
Survey meter or nuclear radiation detector	1	\$6000	\$6000
Subtotal = \$14,420			
<b>General Expenses</b>			
Transportation and stationery		\$356	
Audit fee		\$5000	
Subtotal = \$5,356			
<b>Total = \$198,696 → \$198,700</b>			

### C.13 Asset usage plan

Category (in alphabetical order)	Item / Description	No. of Units	Total Cost	Proposed Plan for Deployment (Note)
Others	Cloud chamber	5 to 10	\$14420	They will be deployed at the Dept. of Applied Physics of PolyU. They can be (i) lent by any educational institutions /community organizations; and (ii) used for teaching in PolyU for promoting radioactivity education.

*Note: for use by school / organization / in other projects (please provide details of the department / centre to which the asset will be deployed and the planned usage of the asset in activities upon project completion).*

### C.14 Report Submission Schedule

I / ~~My school~~ / ~~My organization~~ commit(s) to submit proper reports in strict accordance with the following schedule:

Project Management		Financial Management	
Type of Report and covering period	Report due day	Type of Report and covering period	Report due day
Final Report 1/9/2012 - 31/8/2013	30/11/2013	Final Financial Report 1/9/2012 - 31/8/2013	30/11/2013

### C.15 Evaluation parameters and Method

- Feedback from teachers and students on the quality of the education materials, lab packages, guidelines of investigative study projects, safety guides for handling radioactive sources for experiments, workshops, seminars and visits.
- Hit rate and usage rate of the e-platform and materials.
- Comments and responses from public media.

**C.16 How would the project benefit the education sector as a whole**

- (i) Lessen the burden of teachers in finding experiment materials for teaching radioactivity under the New Secondary School Curriculum.
- (ii) Further enhance students' understanding of some of the topics in radioactivity that are covered in their textbooks but need further exploration.
- (iii) All schools in both Hong Kong and oversea will benefit from the project, as their students and teachers can use the materials produced and participate in the activities organized in the project.
- (iv) More students will benefit with the new approach of using e-platform to share and deliver education materials. The success will provide a quick, effective and economical way to distribute high-quality education materials or even e-textbooks in the future.

**C.17 Sustainability of the Outcomes of the Project**

One of the project goals is to develop training courses of radioactivity safety to teachers and student experimentation labs within PolyU. The student experimentation labs will be used for servicing secondary schools that would like to have their students partake in the demonstration or the actual conduction of experiments in radiation and radioactivity in a safe environment that is either difficult or infeasible to be conducted at their own secondary schools. Although these training courses and student demonstrative labs will be provided for free for the duration of the QEF funding, it is planned that these services will be provided for a fee after the course content has matured.

Another major goal of the project is to produce a dry-ice-free cloud chamber so as to eliminate the need of using dry ice (often difficult or expensive to obtain for secondary schools) when conducting cloud chamber experiments. Although this project is planning to produce documentation on how to construct a do-it-yourself version of such a cloud chamber, the design can be further improved and has potential commercial value for sale to schools in order to sustain the project in the long run.

**C.18 Dissemination / Promotion**

The education materials will be distributed by uploading to the Co-WIN wiki-style e-platform, and the platform itself will be publicly accessible. Once the education packages become available on the e-platform, announcement to member schools and the public will be made on the Co-WIN website and electronic newsletters to Co-WIN member schools. Availability of training courses, student experimentation labs, workshops, seminars, and visits to radiation monitoring stations of HKO will be announced by similar means. Related information will be sent to public media.