ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 10

EO C440.08 – WATCH *BLAST! (BALLOON-BORNE LARGE APERTURE SUB-MILLIMETRE TELESCOPE)*

Total Time: 90 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Create slides of the figures located at Attachments A and B.

Photocopy Attachment C for each cadet.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for TP 1 to introduce the cadets to cosmology and give an overview of the BLAST mission.

An in-class activity was chosen for TP 2 as it as it is an interactive way to reinforce cosmology, provoke thought and stimulate interest among cadets.

A group discussion was chosen for TP 3 as it allows the cadets to interact with their peers and share their knowledge, experiences, opinions, and feelings about cosmology using a balloon-borne large aperture sub-millimetre telescope.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall be expected to discuss the professional challenges that astrophysicists faced in the BLAST mission.

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IMPORTANCE

It is important for cadets to discuss the professional challenges that astrophysicists face so that they understand how astrophysics is influenced by aerospace technologies.

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Teaching point 1 **Describe the BLAST mission.**

Time: 10 min Method: Interactive Lecture



The word sub-millimetre, as it is used in this lesson, refers to the proximate wavelength of near-infrared electromagnetic energy, which can be thought of as the warmth of the sun. Most animals see the sun at visible wavelengths but they feel the sun in the far-infrared. Sub-millimetre near-infrared energy is blocked by atmospheric water vapour.

OBSERVATION OF STAR FORMATION

Astrophysicists are interested in learning more about how the earliest galaxies and stars were formed. However, these objects are often hidden by gas and dust so they cannot be seen in visible light. Fortunately, star births are fiery events. Heat from the newborn stars warms the surrounding dust, which then emits sub-millimetre radiation —a form of infrared electromagnetic radiation close to visible light. Infrared radiation, having wavelengths that are longer than visible light, can pass through dusty regions of space without being scattered. In order to detect much of this radiation, however, sub-millimetre telescopes must be built.

Water vapour in the Earth's atmosphere absorbs radiation across large parts of the infrared and sub-millimetre wavebands, making ground-based observations at some of these wavelengths impossible. Limited observations can be made from high-altitude balloons, such as BLAST, but space-based observatories such as the European Space Agency's Herschel are the only truly satisfactory solution to this problem.



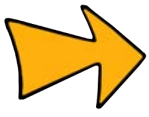
Show the cadets the slide of Figure A-1 located at Attachment A.

OBSERVATION OF GALAXY FORMATION

When astronomers look further out into space, they are actually looking further back in time. Light travels incredibly fast and seems instantaneous at short distances on the Earth, but light from distant galaxies takes millions or even billions of years to reach Earth. The further out one looks into space, the longer that light has travelled. Observers are literally seeing the light of events that happened in the remote past. Looking further and further back, astronomers can develop a timeline for the evolution of the universe.



Show the cadets the slide of Figure A-2 located at Attachment A.



Learn more about infrared astronomy in The Cosmic Classroom: The Infrared Universe at http://coolcosmos.ipac.caltech.edu/

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THE BLAST MISSION DESIGN



Key words:

Bolometers. The sensors that detect sub-millimetre light.

Gondola. The large metal structure that holds the telescope, motors, and computers.

Payload. Anything dangling from the balloon.

Star cameras. Cameras that BLAST uses to orient itself in the sky.

Large unmanned helium balloons have long provided NASA with an inexpensive means to place payloads into a near-space environment. The unique capabilities of this program are crucial for the development of new technologies and payloads for NASA's space flight missions. They also offer essential training for the next generation of scientists, as can be seen in *BLAST!* As well, many important scientific observations are made from long-duration balloon flights.

BLAST used the Sun’s energy to power instruments and took advantage of the Sun’s continuous presence during the summers at the North and South Poles. Flying only in constant daylight, BLAST was ensured a steady source of power and a flight at a stable altitude. If the Sun were to set during the flight, the helium in a balloon would cool and it would drop to a lower altitude. At sunrise, the helium would heat and the balloon would rise.

BLAST needed a way to orient itself and point the telescope in the right direction. Although it had an onboard Global Positioning System (GPS), BLAST relied on the stars for its navigation. On top of the main mirror are two star cameras (long white tubes). These cameras took pictures of stars whose positions in the sky are well known. BLAST’s computers then analyzed these reference points and, through a series of motors and gyroscopes, adjusted its orientation accordingly.

When landing, a remote-controlled system separated BLAST from the balloon and a parachute opened to help slow the telescope’s descent. It took about 45 minutes for BLAST to reach the ground. The parachute was designed to then detach itself from the gondola. The precious hard drive, containing all of the data, had to be physically recovered. Recovery could be very difficult, depending on where BLAST landed.

In 2005, BLAST flew from Sweden to Canada while making moderately successful observations.



Show the cadets the slide of Figure B-1 located at Attachment B.

In 2006, BLAST flew over Antarctica while making very successful observations.



Show the cadets the slide of Figure B-2 located at Attachment B.

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CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. Why are sub-millimetre telescopes, which observe infrared radiation, needed for studying star formation?

Q2. Why must sub-millimetre telescopes operate in or near space?

Q3. How long did it take BLAST to descend to the ground on its parachute?

ANTICIPATED ANSWERS:

A1. Infrared radiation has wavelengths that are much longer than visible light, so it can pass through the dusty regions of space where stars are formed without being scattered.

A2. Water vapour in the Earth's atmosphere absorbs radiation across large parts of the infrared and sub-millimetre wavebands, making ground-based observations at some of these wavelengths impossible.

A3. It took about 45 minutes for BLAST to reach the ground.

Teaching point 2 **Have the cadets watch *BLAST!***

Time: 55 min Method: In-Class Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets watch the 53-minute motion picture *BLAST! (Balloon-Borne Large Aperture Sub-Millimetre Telescope*).

RESOURCES

- *BLAST!* DVD, and
- Handout of Attachment C.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Distribute Attachment C to each cadet.

2. Instruct the cadets to consider the questions posed on the handout while watching *BLAST*!

3. Play the entire 53-minute motion picture *BLAST! (Balloon-Borne Large Aperture Sub-Millimetre Telescope*).

SAFETY

Nil.

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CONFIRMATION OF TEACHING POINT 2

The cadets' participation in the activity will serve as the confirmation of this TP.

Teaching point 3 **Discuss the science and the design of the BLAST mission.**

Time: 15 min Method: Group Discussion

BACKGROUND KNOWLEDGE



The point of the group discussion is to draw the following information from the group using the tips for answering / facilitating discussion and the suggested questions provided.

The background knowledge for this discussion is to be based on TP 1 and the material in the motion picture *BLAST! (Balloon-Borne Large Aperture Sub-Millimetre Telescope)*.

GROUP DISCUSSION



TIPS FOR ANSWERING / FACILITATING DISCUSSION:

- Establish ground rules for discussion, eg, everyone should listen respectfully; don't interrupt; only one person speaks at a time; no one's ideas should be made fun of; you can disagree with ideas but not with the person; try to understand others as much as you hope they understand you; etc.
- Sit the group in a circle, making sure all cadets can be seen by everyone else.
- Ask questions that will provoke thought; in other words avoid questions with yes or no answers.
- Manage time by ensuring the cadets stay on topic.
- Listen and respond in a way that indicates you have heard and understood the cadet. This can be done by paraphrasing their ideas.
- Give the cadets time to respond to your questions.
- Ensure every cadet has an opportunity to participate. One option is to go around the group and have each cadet answer the question with a short answer. Cadets must also have the option to pass if they wish.
- Additional questions should be prepared ahead of time.

SUGGESTED QUESTIONS:

Q1. What are the main features of the professional relationship between the graduate student responsible for the Star Cameras and her two professors?

Q2. Other than geography, what important similarities and links are there between Shackleton's missions and the BLAST mission?

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Q3. Why is it so important for visitors to McMurdo Station to be physically qualified (PQ)?

Q4. How might a better understanding of the early universe affect everyday life?



Other questions and answers will develop throughout the group discussion. The group discussion should not be limited to only those suggested.



Reinforce those answers given and comments made during the group discussion, ensuring the teaching point has been covered.

CONFIRMATION OF TEACHING POINT 3

The cadets' participation in the group discussion will serve as the confirmation of this TP.

END OF LESSON CONFIRMATION

The cadets' participation in watching and discussing *BLAST!* will serve as the confirmation of this lesson.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Astrophysicists face daunting challenges while pushing back the frontiers of science. Fortunately, the tools and the constant development of aerospace technologies allow scientific research to progress.

INSTRUCTOR NOTES / REMARKS

It is recommended that this EO be presented in three consecutive periods.

If EO C440.07 (Operate a Telescope) is selected, it is recommended that it be presented prior to this lesson.

REFERENCES

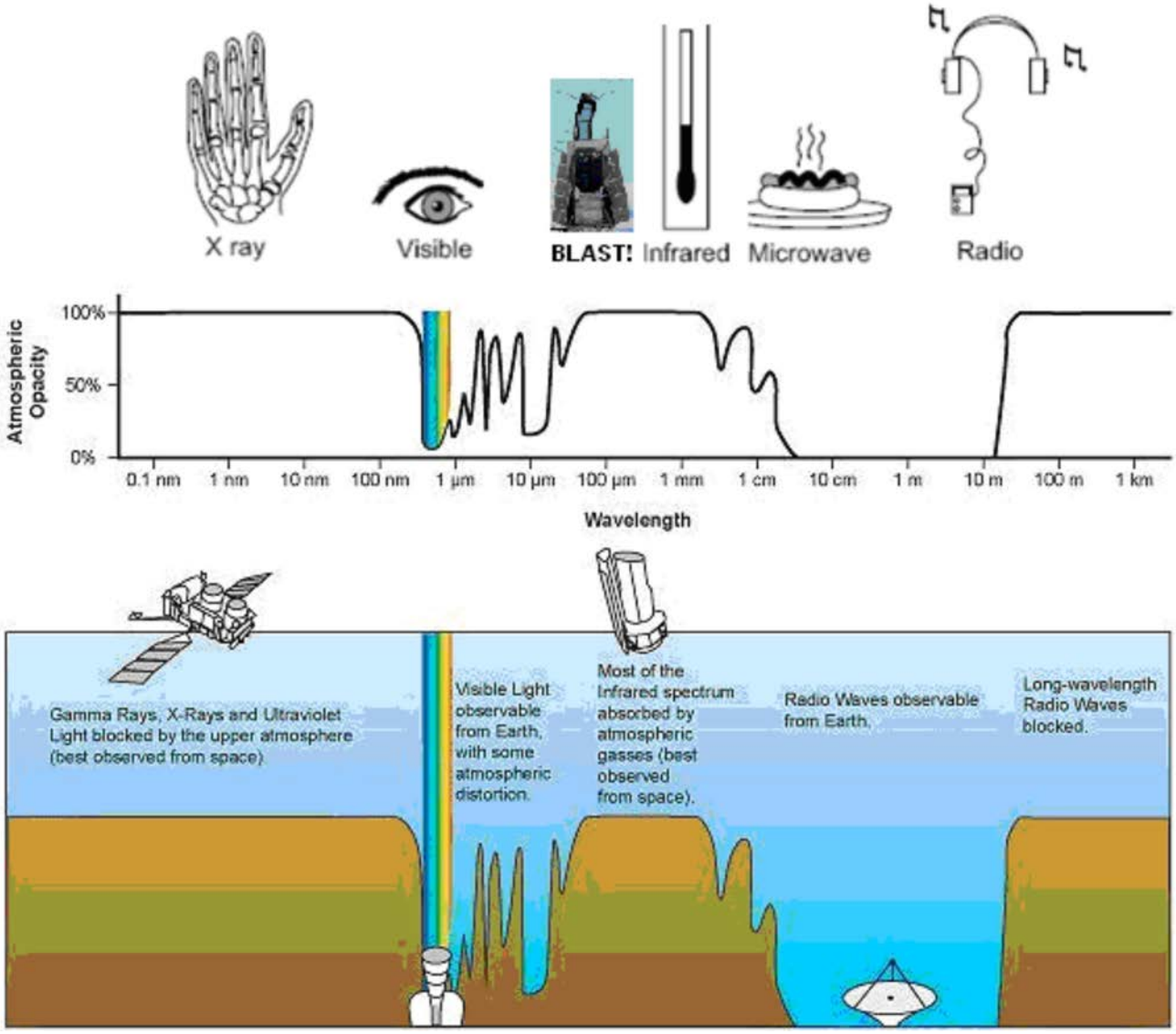
C3-295 Devlin, P. (Producer & Director). (2008). *BLAST!* [Motion picture]. United States: The ArtistShare Project.

C3-298 *BLAST (Balloon-Borne Large Aperture Sub-Millimetre Telescope)*. University of Pennsylvania Department of Physics and Astronomy. Retrieved January 30, 2009, from http://blastexperiment.info/

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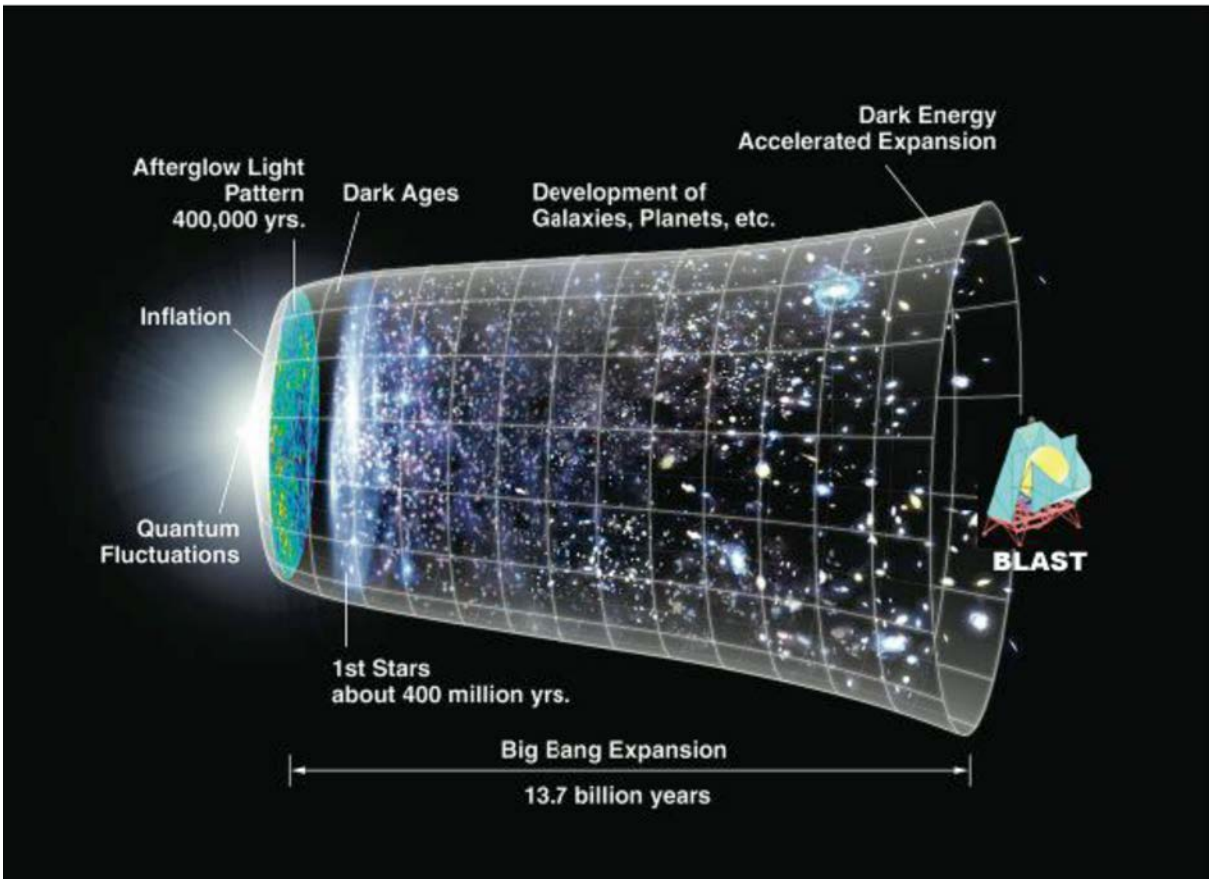
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Note. From "Infrared Windows", The Cosmic Classroom, by California Institute of Technology, 2009. Retrieved March 27, 2009, from http://www.ipac.caltech.edu/Outreach/Edu/Windows/irwindows.html

Figure A-1 The Electromagnetic Spectrum and Atmospheric Opacity

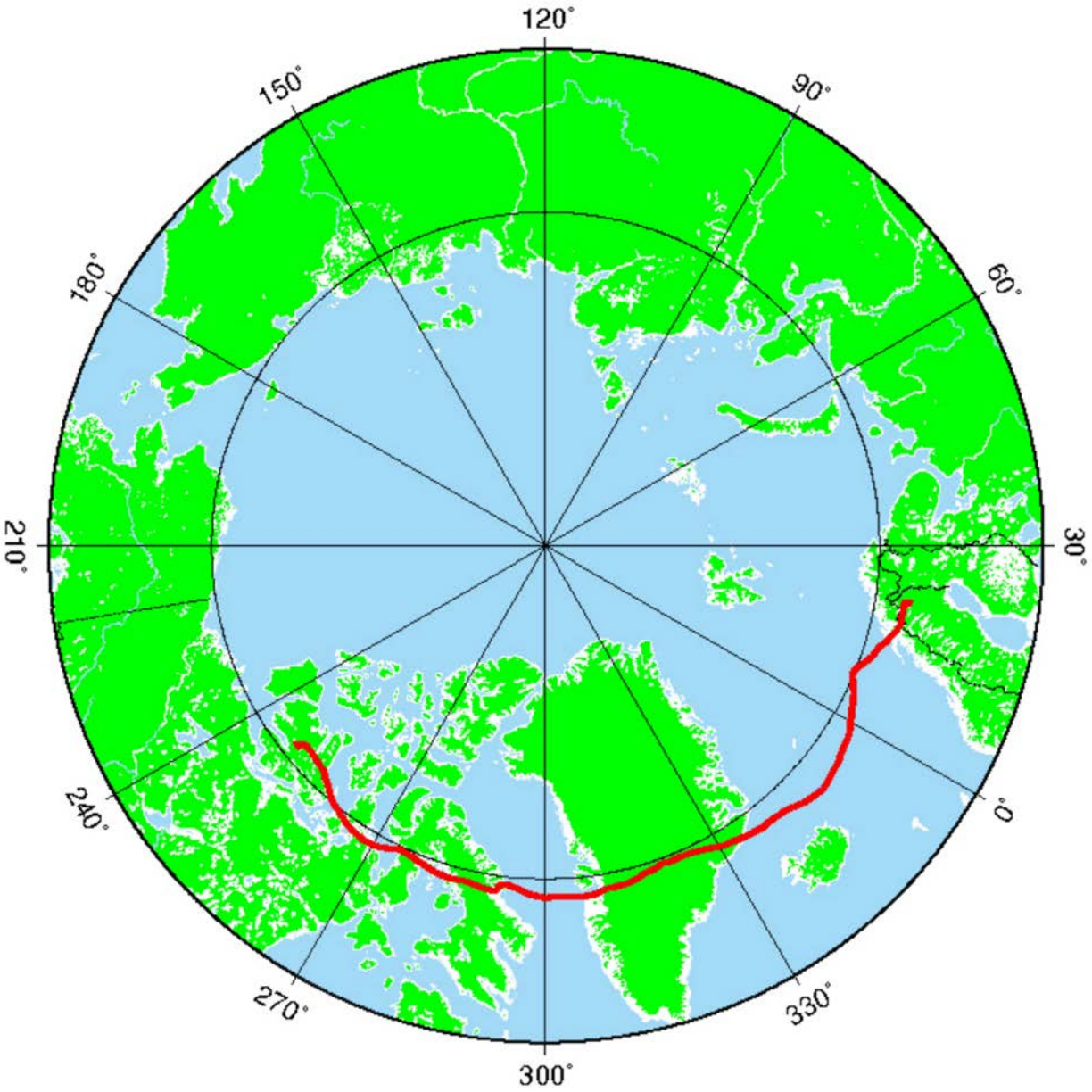
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Note. From "BLAST: How It Works", The Importance of BLAST, by the ArtistShare Project, 2009. Retrieved March 28, 2009, from http://www.blastthemovie.com/press/BLAST_HowItWorks.pdf

Figure A-2 The Big Bang

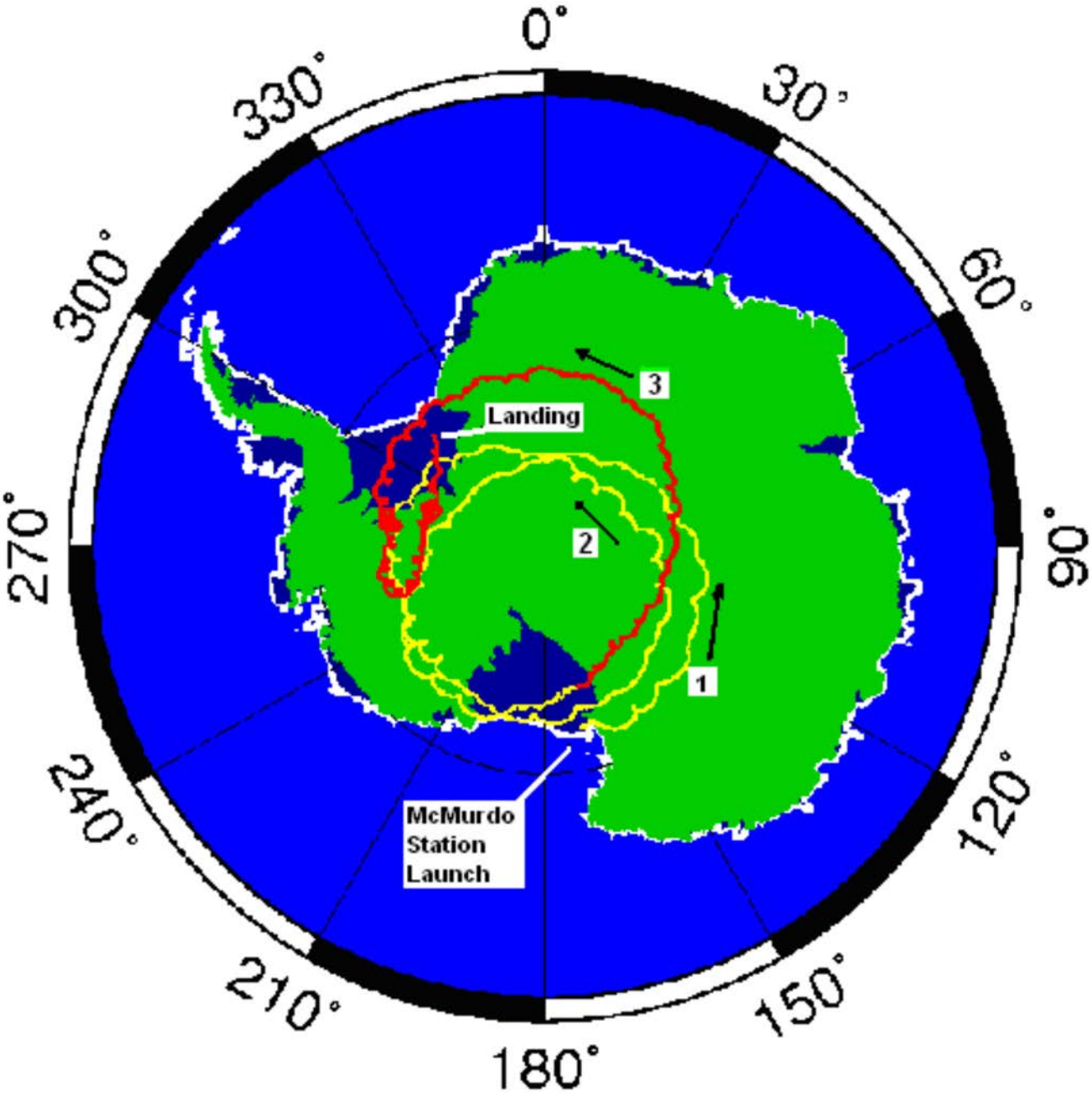
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Note. From "Flight Trajectory", BLAST, by Swedish Space Corporation, 2009. Retrieved March 28, 2009, from http://www.ssc.se/?id=7082

Figure B-1 BLAST Path 2005

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Note. From "Flight Trajectory", BLAST, by Swedish Space Corporation, 2009. Retrieved March 28, 2009, from http://www.nsbf.nasa.gov/map/balloon4/balloon4.png

Figure B-2 BLAST Path 2006

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QUESTIONS TO CONSIDER WHILE WATCHING *BLAST!*

- What advantages are there in doing balloon missions during the Arctic and Antarctic summers?
- What is the nature of the professional relationship between graduate students and professors?
- Why do scientists attach great importance to priority—being the first to publish new knowledge?
- How might the European Space Agency's Herschel space telescope benefit from a balloon-based test of its cutting-edge infrared bolometers?
- Why do countries such as Canada and institutions such as York University see great value in this expensive pure science, which concerns events that happened billions of light-years away and billions of years ago?

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