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Equipping the Workforce with Space Weather Measurement and Interpretation Skills: THE INCOHERENT SCATTER RADAR SUMMER SCHOOL

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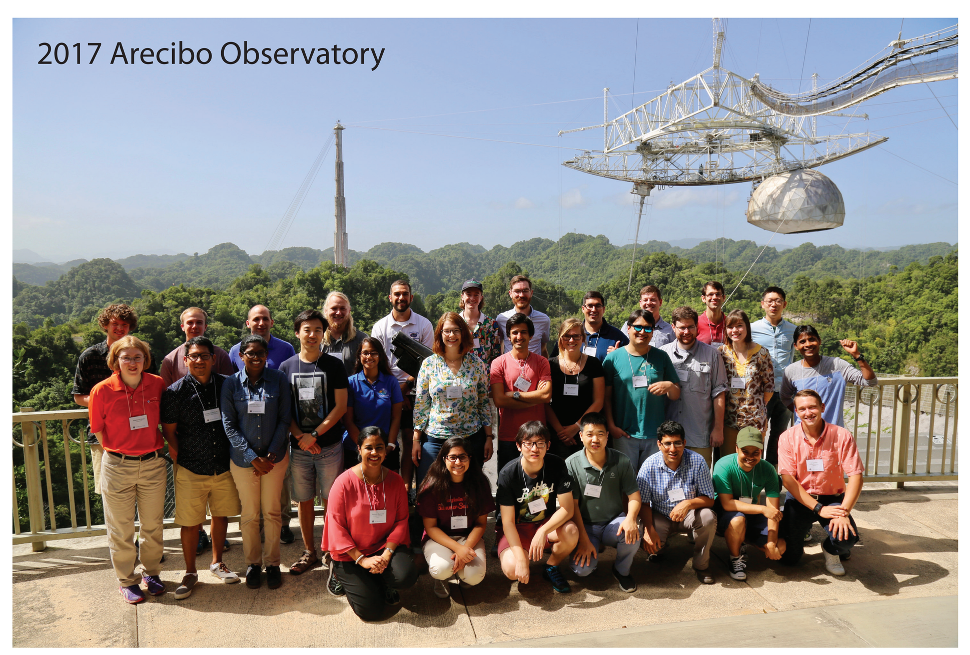
THE INCOHERENT SCATTER RADAR SUMMER SCHOOL

Starting in 2008, MIT and SRI International collaboratively organized a summer school to educate undergraduate and graduate students about ISR theory and techniques, through an intense hands-on program involving a radar experiment and lectures from experts in the field. Over the past eleven years, the program has proven highly successful and is always fully subscribed with both US and international students. Some schools have been held outside the country, and international collaborations on lectures and experiments have been developed. Many students trained in these schools have continued in the field and become a part of the ISR community. The ISR Summer School is a week-long course for undergraduate and graduate students. The students spend the mornings in lectures with experts from the field. In the afternoon, they participate in a hands-on experiment involving data from ISRs around the world.

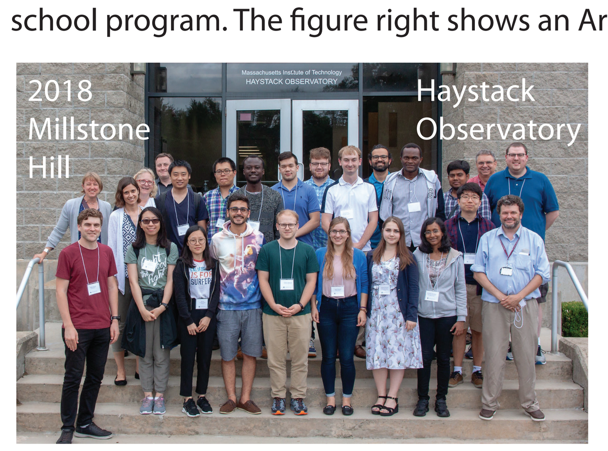
The core goal of the ISR summer school is to develop a new user base for the facility data and to encourage new participants to enter the field of Incoherent Scatter Radar.

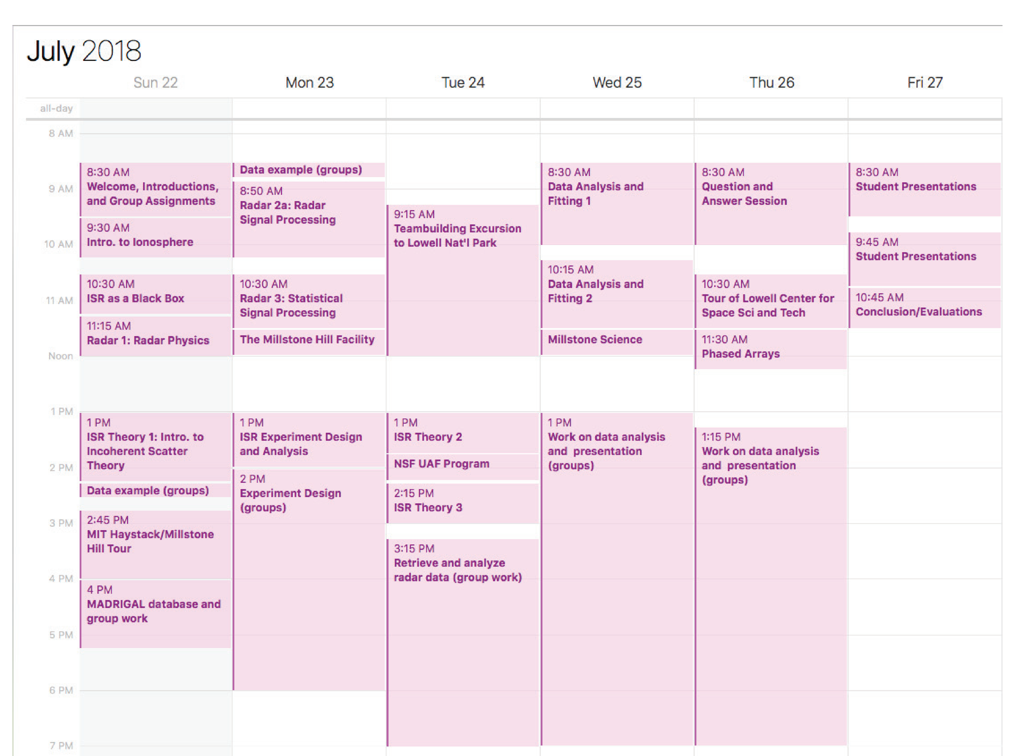
The incoherent scatter radar (ISR) technique provides many significant space weather state variables – e.g. electron and ion density, temperature, and velocity - with unparalleled accuracy and precision. ISR research ranges from space weather forecasting, satellite drag, atmospheric loss, plasma physics, atmospheric turbulence, and communications disruption. The Geospace Facilities (GEO/AGS/GF) program at the National Science Foundation supports several incoherent scatter radar (ISR) facilities worldwide. A community of highly trained scientists operates and uses the data from these radars; however, there is no clear path for graduate students to become a part of this community. While a handful of schools do provide training in ISR theory and techniques, most interested students need to cobble together an educational path for themselves or pursue the program through a postdoctoral position.



Month	Tasking
September	After consultation with lecturers, confirm location and date of next school with venue and place reservations
December	Meet with lecturers at AGU meeting Discuss school updates, personnel availability, unique needs of next site, and lecturing assignments
January	Create announcement and update application web site
February	Distribute announcement to community newsletters and targeted email list
March	Application deadline
April	Review applications with lecturers, rank students and begin accepting/declining/waitlisting. Continue working with venue on preparations.
May	Purchase plane tickets and make needed travel arrangements. Advise lecturer travel plans. Set up purchase orders with vendors or make other payment arrangements. Set up meeting with lecturers to discuss agenda and make assignments.
June	Meet with lecturers at CEDAR meeting to discuss agenda and updates to school. Ensure lecturers have coordinated and material is covered as needed.
July	Continue final logistics preparations. School will occur at end of the month. Lecturers travel to site with PI and assistant arriving one day in advance to make sure site is prepared and hosting institution has support needed.
August	Complete school. Hold discussions with lecturers while at school. Decide next school dates and discuss next venue. Debrief on school's success and improvement needs.

The figure above left shows a typical annual planning cycle for the summer school program. The figure right shows an Arecibo Observatory tour.





The figure above shows the daily schedule for the 2018 summer school held in Lowell Massachusetts. Half a day (Wednesday morning) is reserved for a teambuilding excursion to allow students to network.

STUDENT-LED INCOHERENT SCATTER RADAR EXPERIMENTS

Experiment

On the second day of the school, student groups learn about the radar parameter space and create proposals to answer a relevant science question. That night the experiments are run on the participating radar or radars. A sample proposal is shown below and a group remotely operating the PFISR radar is shown above.

Experiment Proposal – Group 5

Time: 18-20 or 20-22 UT / 2100-2300 or 2300-0100 EEST
Location: PFISR

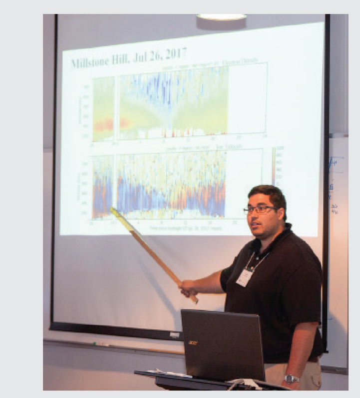
Polar mesospheric summer echoes (PMSE) occurrence is most probable in the period between May and early August in the region between 80 km to 100 km of altitude. The most probable frequency range for PMSE detection is between 50 MHz to 250 MHz. The proposed objective is to characterize PMSE observation at higher frequency using PFISR, as explained below. If we do not detect PMSE, we will concentrate on what we observe which may include sporadic E and particle precipitation
.
Experimental Design:We want to use PFISR and are basing our experiment off of a previously run experiment ThemisD1 that can be found here https://amisr.com/database/61/experiment/20180715.001/ because of its already proven effectiveness at detecting PMSEs.We plan to use 22 beams in barker mode to increase the chance of PMSE detection, and examine spatial extent of PMSEs, and would like to adjust from long pulse to alternating code to get more ionospheric context.We request the 2nd or 3rd time slot to maximize the probability of detecting PMSEs, which occur most often between 10:00-12:00 AKST according to https://www.sciencedirect.com/science/article/pii/S1364682610001598

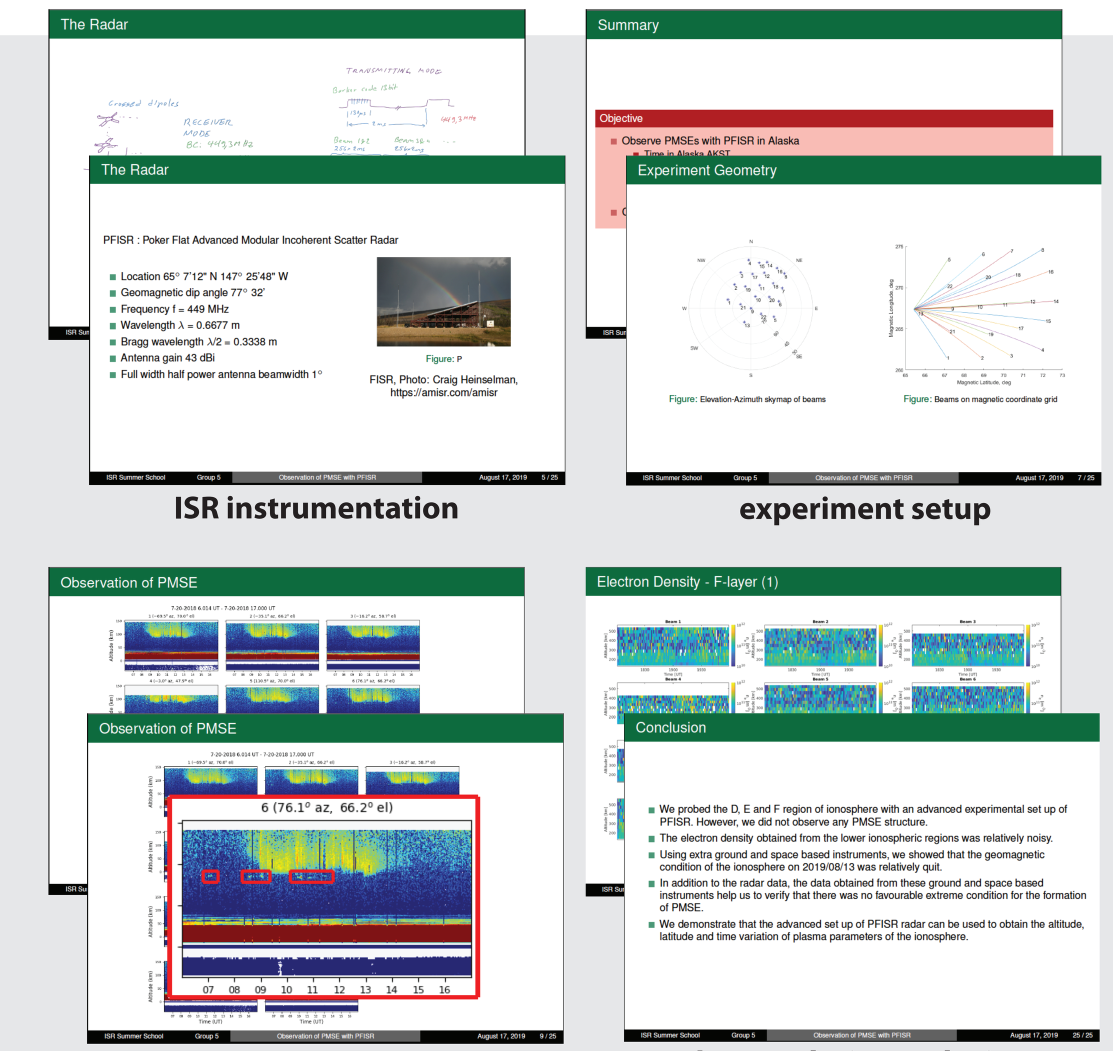
Data Analysis

Radar site staff process data from the student experiments and submit the data to the Madrigal database by the following afternoon (Day 3). Student download the data using techniques taught during the Madrigal group exercise on Day 1. They then begin to plot data and look for results consistent with their overarching science question. When results are not evident, the students are encouraged to look at similar datasets from past experiments. The lecturers are available thoughout the group work time to answer questions and provide mentorship.

Presentation

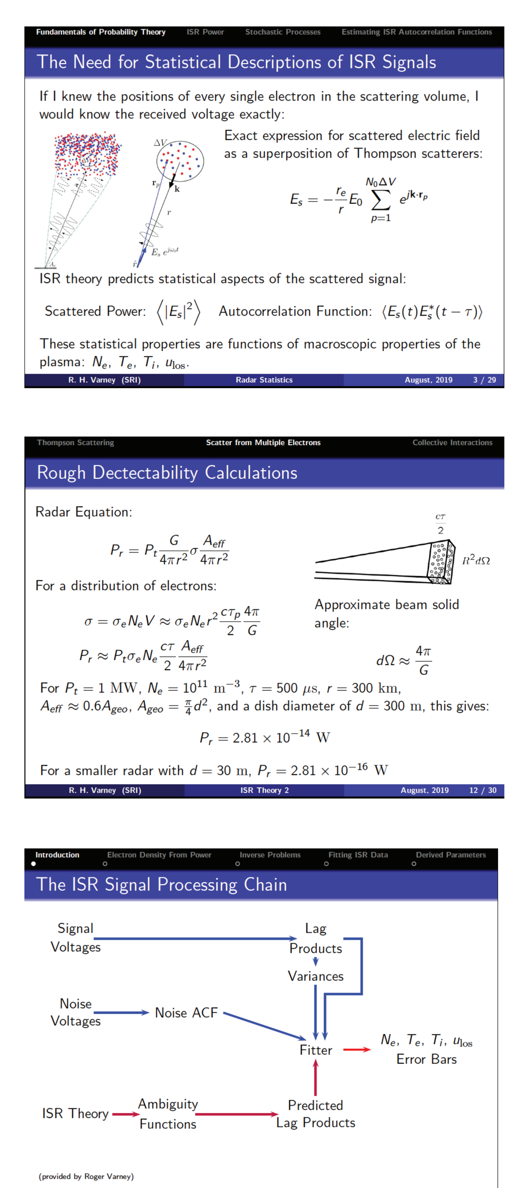
The students give presentations on their results on the final day of the school. Every student is required to participate in the presentation. A good example of a group presentation is shown on the right. This presentation shows understanding of the ISR technique, their experiment setup and data analysis in context of historic datasets.





ISR instrumentation | experiment setup | historical context | data analysis conclusions

LECTURES BY FACILITY PRINCIPAL INVESTIGATORS AND FIELD EXPERTS

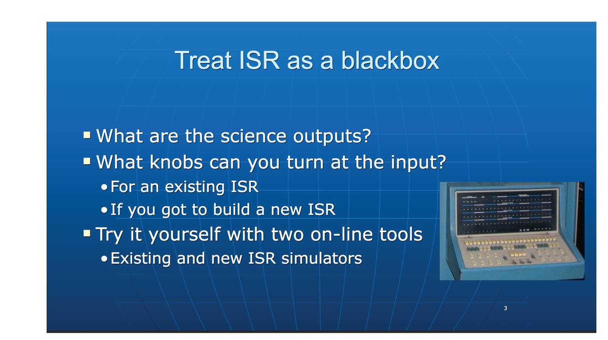


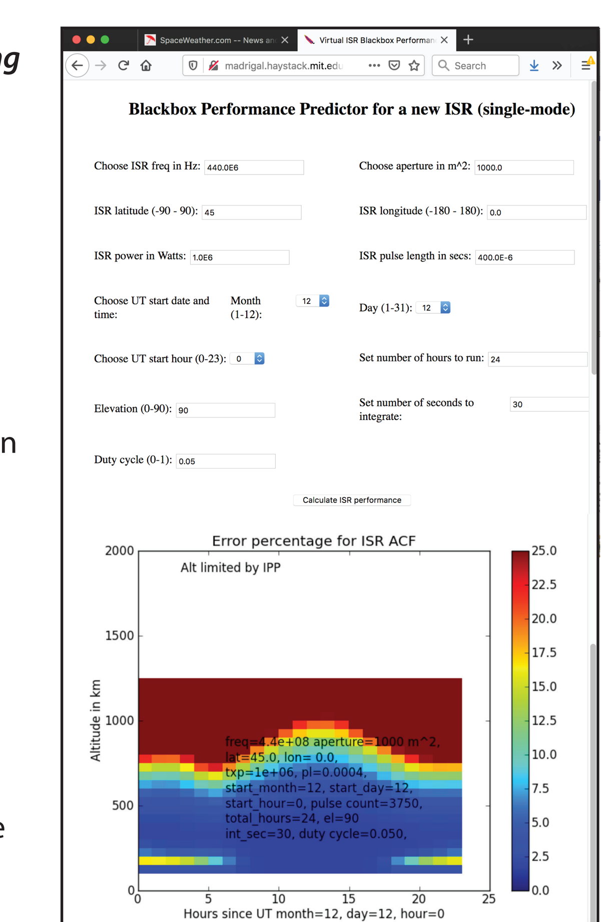
The school is structured with lectures in the mornings and experiment group work in the afternoons. Lectures begin with introductory material about the ionosphere and radars. Then incoherent scatter theory is introduced and supporting topics are explored in more detail. Each school also has lectures on science relevant to the hosting radar facility. The final day includes an extended question and answer session where students are able to ask the lecturers about any topic previously discussed in the school.

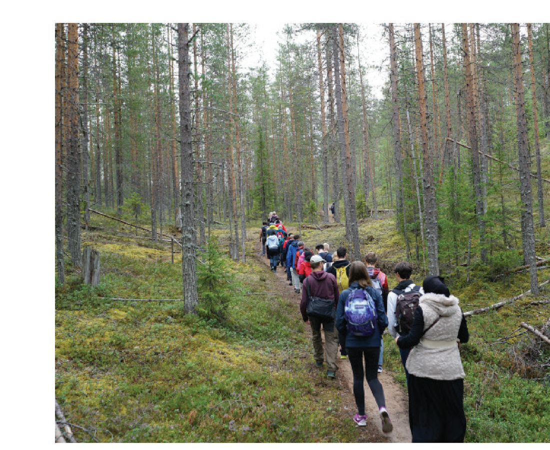
Lecture topics include:

Intro to the Ionosphere
Radar Physics
ISR Theory
Statistical Signal Processing
Data Analysis and Fitting
Phased Arrays

Evaluations are collected and analyzed each year. The program is updated accordingly. One such addition to the school is shown in the two panels on the right. MIT Haystack developed a "black box" ISR where students are able to input ISR variables and see how the system would respond. This gives students a chance to learn how the ISR specifications determine the types of measurements that can be made.







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SRI International | NSF | MIT Haystack Observatory | Boston University