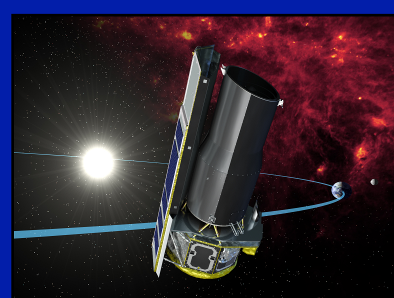
Spitzer and NITARP Programs for Teachers and Students

The story of one teacher's journey.

Tim Spuck - Oil City High School

tspuck@hotmail.com



What am I doing at NSF with my Einstein Fellowship?

NSF Graduate STEM Fellows in K-12 Education (GK-12) Program

Graduate students receive a $30,000/yr Fellowship, and in return the graduate student receives additional training, and takes their research into the K-12 classroom, working with teachers and students for 10-15 hours a week.

Apply for the Einstein Fellowship! Deadline Early January

What are the Expected Outcomes/Goals of the GK-12 Program?

1. For Graduate Fellows: Enhanced understanding of their own research subject area, and its societal and global contexts; improved communication skills of STEM subjects with technical and non-technical audiences, leadership, team building, and teaching capabilities.

2. For K-12 Education: Professional development opportunities for teachers in both STEM content and pedagogy; and enhanced learning and STEM career interest for students.

3. For Institutions of Higher Education: Transformation of graduate programs; strengthened and sustained partnerships with local school districts, industry, non-profit sector, etc.; and enhanced institutional impact of graduate education to society.

What does the research say about the GK-12 Model?

Graduate students reported that the experience

- **improved their time management skills**
- motivated them to complete their graduate degree. In fact, GK–12 fellows spent, on average, the same number of weekly hours on their doctoral research projects and ultimately completed their doctoral degree in the same amount of time as their non-GK–12 peers
- **improved their communication skills**
- 82% of GK-12 Fellows secured employment within 6 months of graduation
- **98% of past GK-12 Fellows replied yes when asked if their participation in GK-12 was worth the time investment.**
- K-12 educators improved their inquiry based teaching skills
- **K-12 student interest in STEM content and careers increased**

Gamse B, Rhodes H, Carney J (2010). Evaluation of the National Science Foundation's GK-12 Program, Summary Report. http://www.gk12.org

Who is Neil deGrasse Tyson?

The Oil City – Pennsylvania STORY

Population: 10,000 and one of the 10 poorest schools in PA

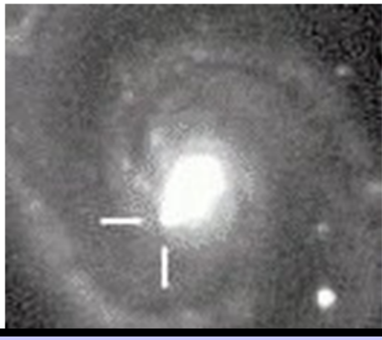
What's the link between Tyson and Oil City, PA?

What did it take to make this story reality?

In the summer of 1992 I attended a 2-week institute at the National Radio Astronomy Observatory in Green Bank, WV.

The program was funded by the National Science Foundation.

Supernova: SN1994I



March 1994 - Oil City Students Heather Tartara and Melody Spence take first light image of SN 1994I providing professional astronomers with some of the earliest supernovae light curve data on record.

The Smithsonian/NASA Astrophysics Data System

Home | Help | Sitemap | images SN1994I | Search

Successful Operation of Remote Telescopes for Education and Research

- Fulltext Article not available
- Find Similar Articles
- Full record info

Pennypacker, C.; Deustua, S.; Perlmutter, S.; Goldhaber, G.; Arsem, E.

American Astronomical Society, 185th AAS Meeting, #69.05; Bulletin of the American Astronomical Society, Vol. 26, p.1423

Since 1986, we have found over 20 nearby supernovae with the U.C. Leuschner Observatory's 30" automated telescope. This pilot search demonstrated that supernovae can be found reliably using automated search techniques, and we discovered a high rate of Type Ibc supernovae. In addition, we have successfully piloted a high school education project - "The Hands-On Universe Project." In this program high school students become proficient with modern CCD-based astronomical imaging, even undertaking real research. An example of the latter was the acquisition of the earliest images of SN1994I by two students from Oil City Pennsylvania. We have had remarkable success in changing students' attitudes about science, scientists, and education. We are in the final stages of completing the automation of a new 30" telescope to be operated robotically in a good, remote site. This telescope will be functioning by spring of 1995. It will serve the Supernova Search and the Hands-On Universe programs.

National Science Foundation

WHERE DISCOVERIES BEGIN

SEARCH

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News

News

News From the Field

Email Print Share

Press Release 98-079

High School Students Discover Distant Asteroid Using NSF Telescope and Education Program

November 20, 1998

Astronomy teacher Hughes Pack directed the students' search of computer images provided by the Berkeley National Lab's Supernova Cosmology Program. A collaborating team, Stacey Hinds and Angel Birchard, students from Pennsylvania's Oil City Area High School, confirmed the location of 1998 FS144 for their peers at Northfield Mount Hermon. The Oil City students were led by teacher Tim Spuck, a 1998 Pennsylvania Christa McAuliffe Fellow.

"This is a fantastic piece of science, of education, of discovery," said Hands-On Universe founder and astrophysicist Carl Pennypacker of Lawrence Berkeley National Lab and The Lawrence Hall of Science. He added, "The Northfield students' discovery has shown that all students from a broad range of backgrounds can make solid, exciting and inspiring scientific contributions."

SCIENCE | TECHNOLOGY | NEWSROOM | EDUCATION | GALLERY | LINKS

National Science Foundation

Media contact: Lee Herring, (703) 306-1070, kherring@nsf.gov
Program contact: Joe Stewart, (703) 306-1613, jstewart@nsf.gov

NSF PR 98-79 November 20, 1998

High School Students Discover Distant Asteroid Using NSF Telescope and Education Program

High school students have discovered a previously unidentified celestial object in the Kuiper Belt using i

Discovered at Berkeley

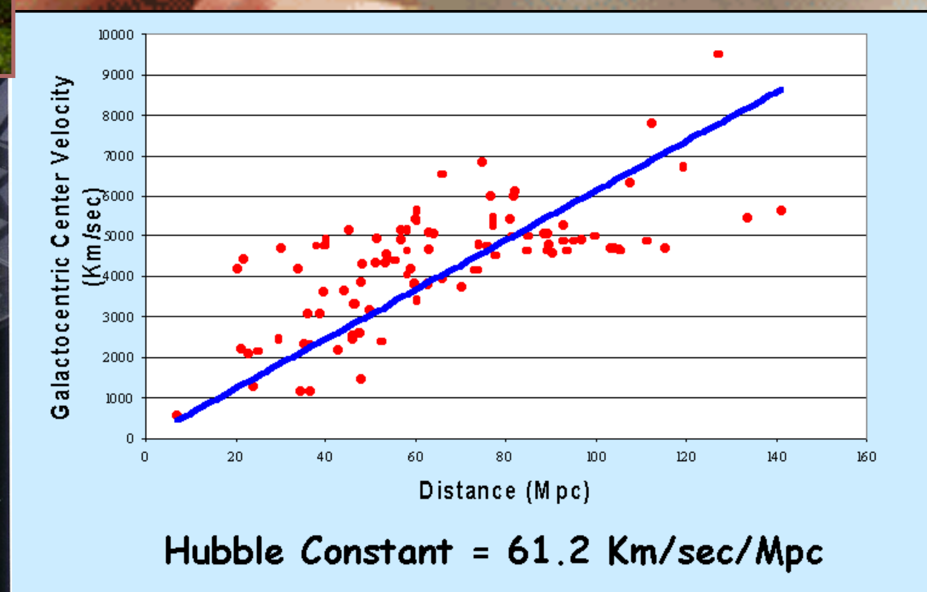
Perlmutter in his Berkeley Hills home; Laura Nelson reacts to a question about her husband's $750,000 prize money; the winner shares a moment with his daughter, Noa. *(Cathy Cockrell/NewsCenter photos)*

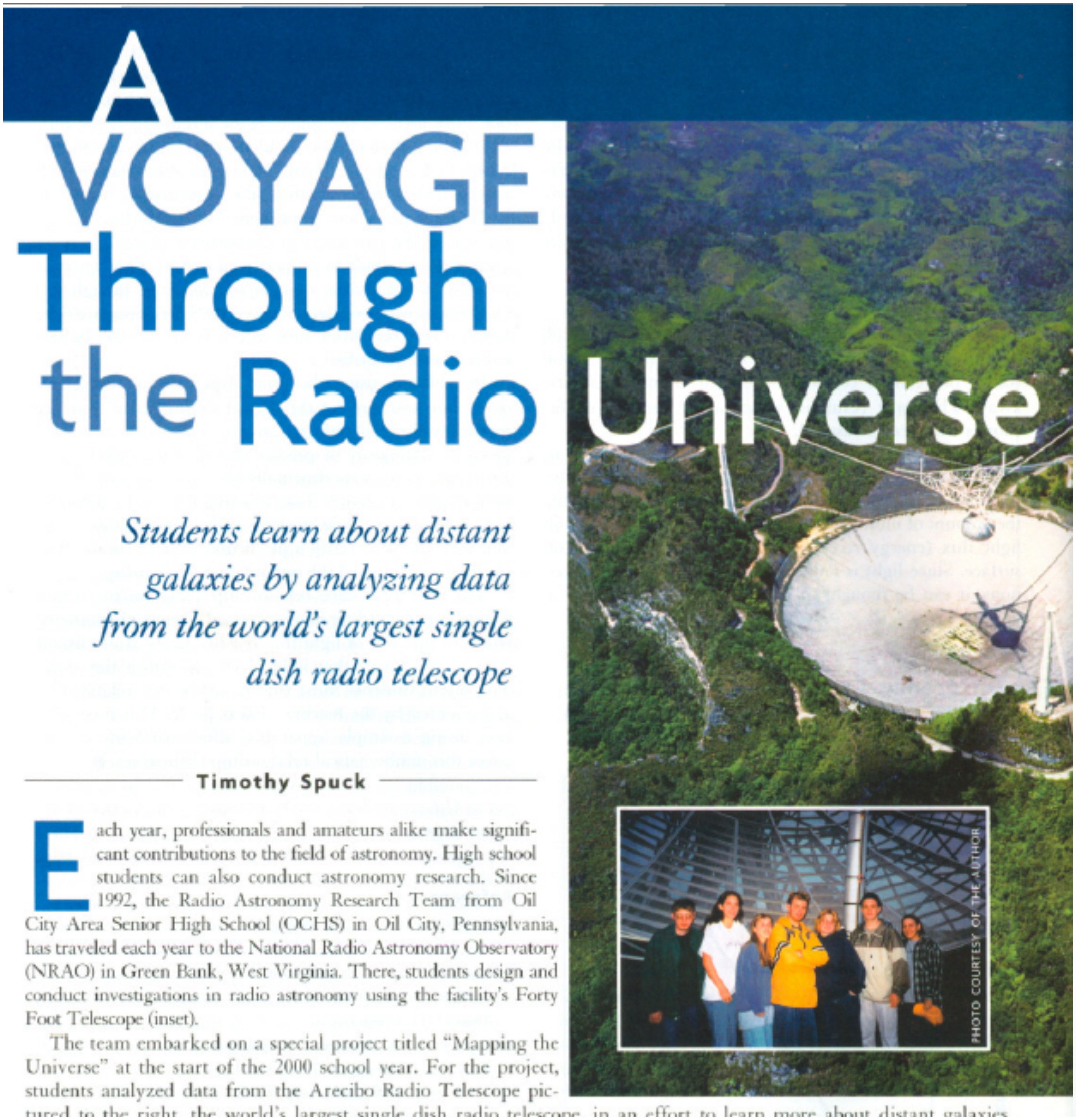
Saul Perlmutter awarded 2011 Nobel Prize in Physics

Unintended Consequences

What's the relationship between the 2011 Nobel Prize in Physics, the Supernova Cosmology Project, the Hands-On Universe Asteroid Search, and the discovery of 1998 FS144 by high school students?

2002 - Thanks to an NSF funded RET experience my students and I designed a project to measure the expansion rate of the universe.





A VOYAGE Through the Radio Universe

Students learn about distant galaxies by analyzing data from the world's largest single dish radio telescope

Timothy Spuck

Each year, professionals and amateurs alike make significant contributions to the field of astronomy. High school students can also conduct astronomy research. Since 1992, the Radio Astronomy Research Team from Oil City Area Senior High School (OCHS) in Oil City, Pennsylvania, has traveled each year to the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia. There, students design and conduct investigations in radio astronomy using the facility's Forty Foot Telescope (inset).

The team embarked on a special project titled "Mapping the Universe" at the start of the 2000 school year. For the project, students analyzed data from the Arecibo Radio Telescope pictured to the right, the world's largest single dish radio telescope, in an effort to learn more about distant galaxies

PHOTO COURTESY OF THE AUTHOR

October 2004

The Science Teacher

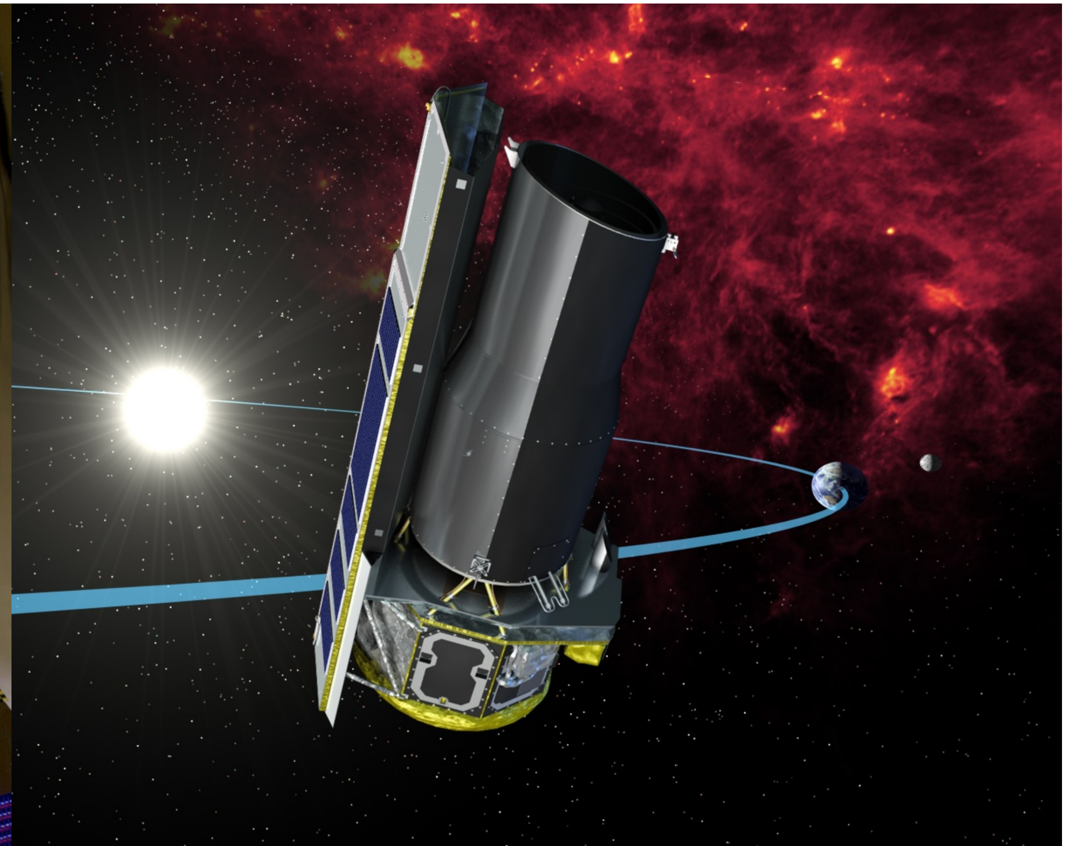
Communicating the research to a broader audience.

What does the research say?

Students who participated in original scientific research while in high school are significantly more likely to both enter and maintain a career in science compared to students whose first experience didn't occur until university. *(2009) Lesley F. Roberts and Richard J. Wassersug Does Doing Scientific Research in High School Correlate with Students Staying in Science? A Half-Century Retrospective Study.*

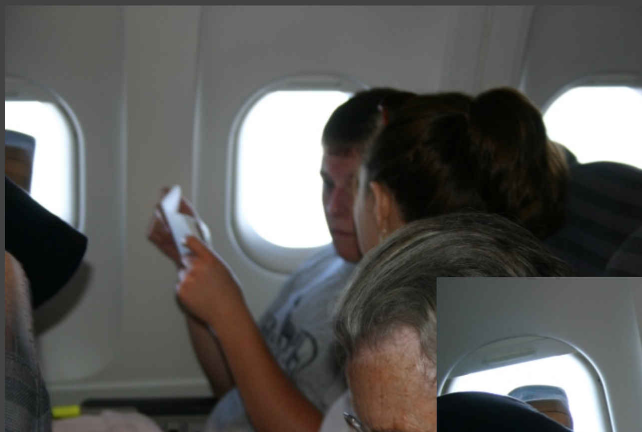
In years three and four after program entry participating in Columbia University's Summer Research Program, teachers' students passed Regents science exams at a rate that was 10.1% higher than that of nonparticipating teachers' students. Other program benefits include decreased teacher attrition from classroom teaching and school cost savings of U.S. $1.14 per $1 invested in the program. *(2009) Samuel C. Silverstein et al - Teachers' Participation in Research Programs Improves Their Students' Achievement in Science*

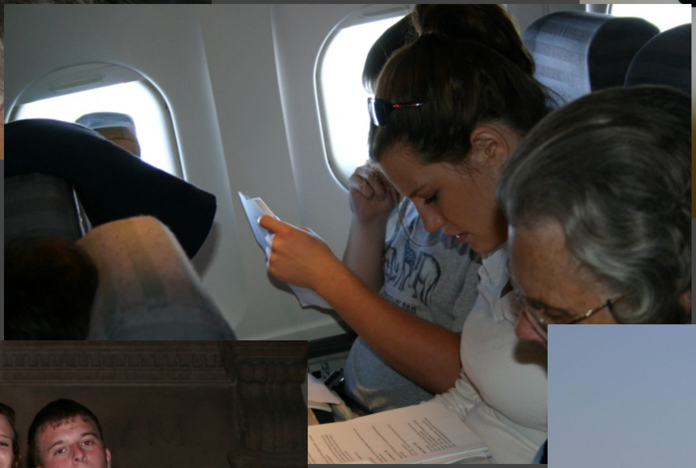
A dynamic learning community, authentic inquiry, a deeper understanding of the nature of science, and learning about scientific careers are all benefits of scientist- teacher partnerships. (2005) Marcelle A. Siegel, Susanna Mlynarczyk-Evans, Tamara J. Brenner, and Katherine M. Nielsen - A Natural Selection – Partnering teachers and scientists in the classroom laboratory creates a dynamic learning community



Spitzer Space Telescope Research Program for Teachers and Students

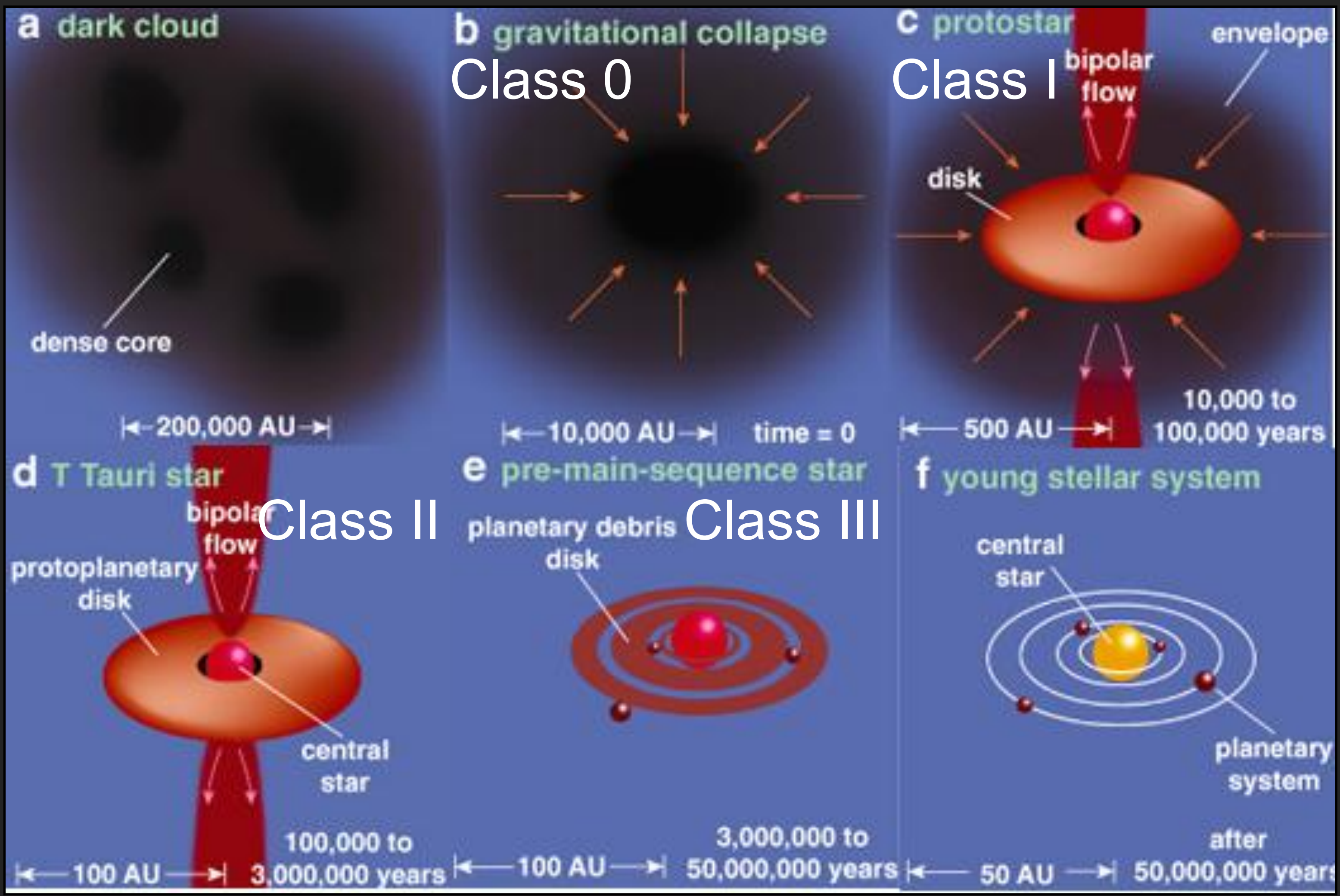
2005 - The Spitzer Space Telescope Research Program for Students and Teachers





A CRASH COURSE . . .

The Science of Low Mass Stars



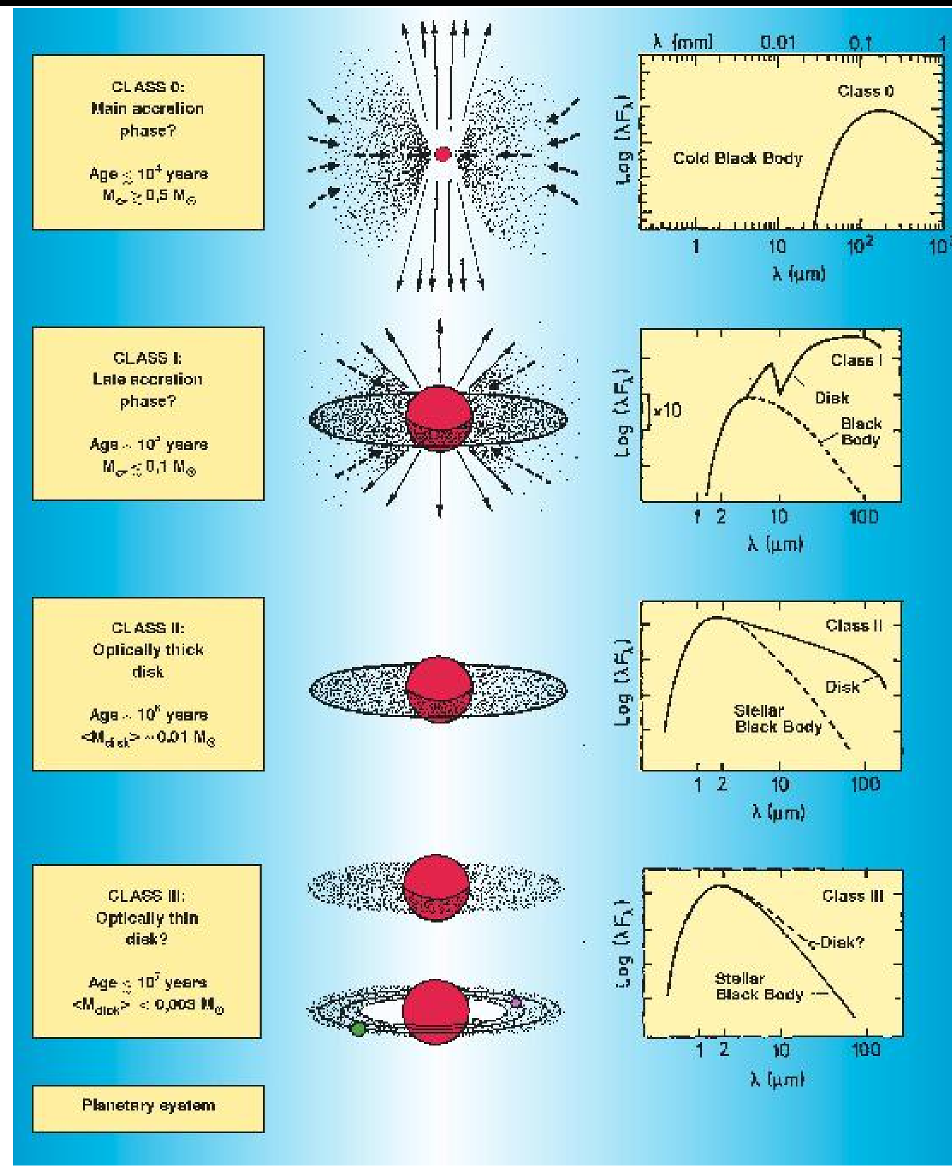
Class and Spectral Energy Distribution (SED)

Class 0
Main accretion phase?
M_{env}>~0.5 Msun
<~10^4 years

Class I
Late accretion phase?
M_{env}<~0.1 Msun
~10^5 years

Class II
Optically thick disk
Avg M_{disk}~0.01 Msun
~10^6 years

Class III
Optically thin disk
Avg M_{disk}<~0.003 Msun
~10^7 years



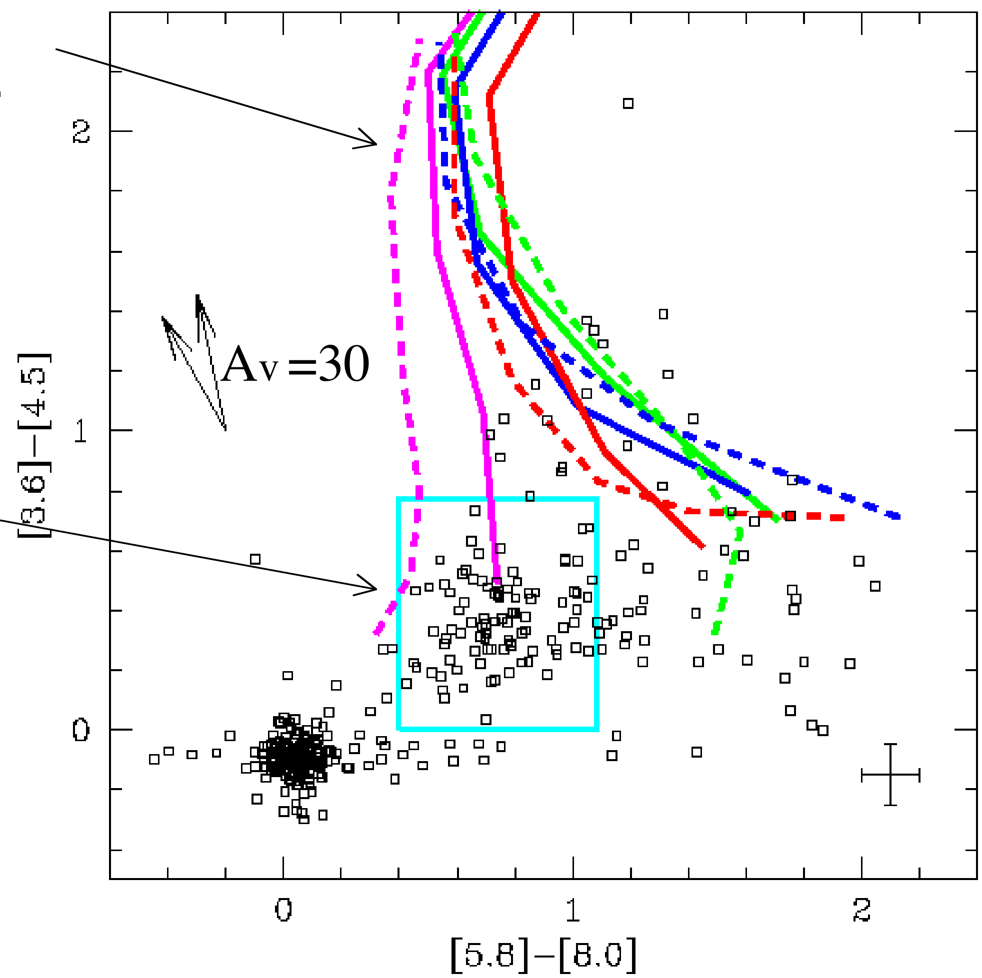
IRAC Color-Color Diagrams

<u>Class I (envelope) models</u>

log ρ = -14 to -12.5 g/cm^3
L = 0.1, 1, 10, 100 Lsun
inclination = 60 deg

<u>Class II (disk) models</u>

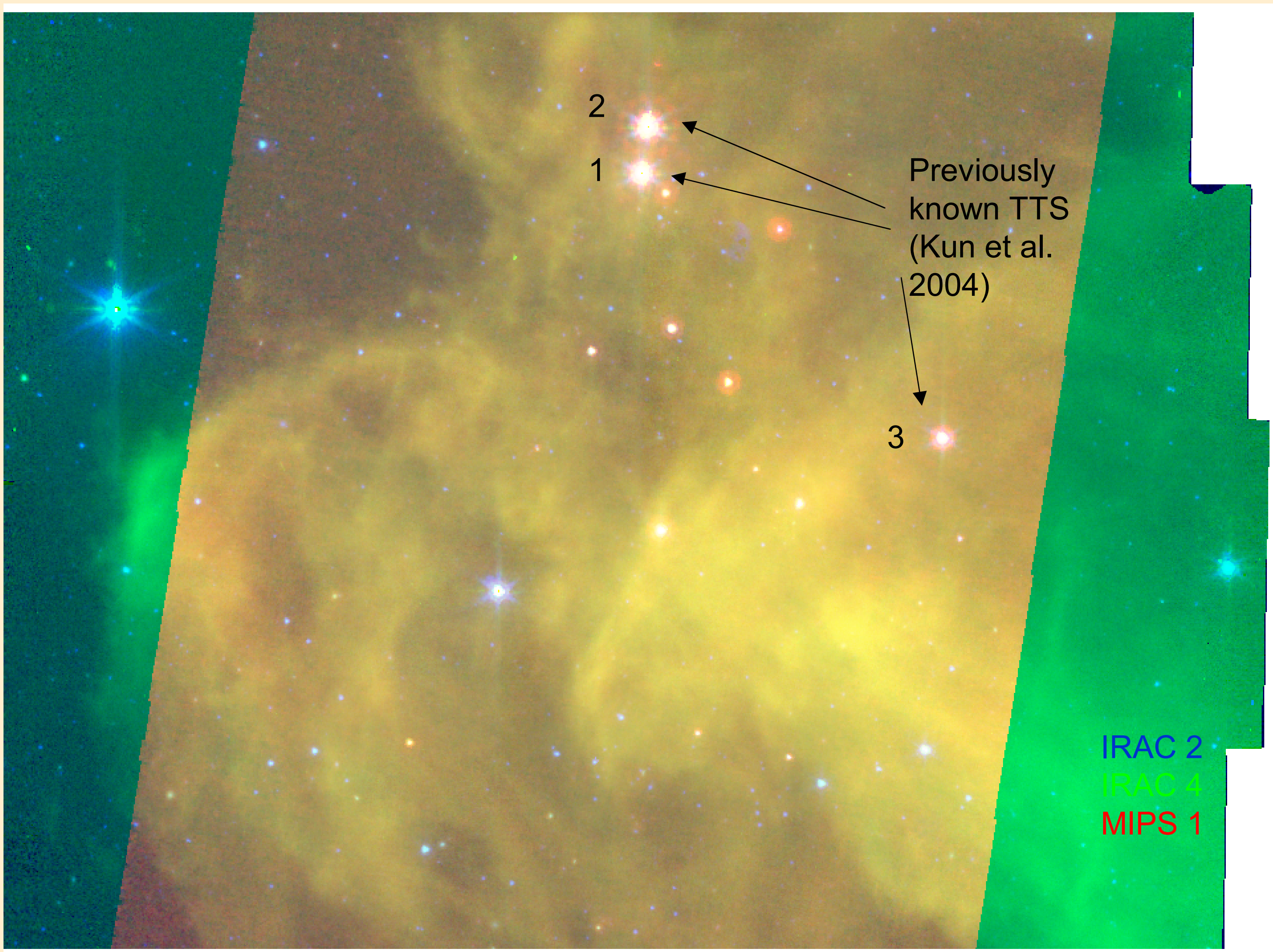
stellar T_{eff} = 4000 K
Mdot = -9 to -6 Msun/yr
inclination = 30, 60 deg

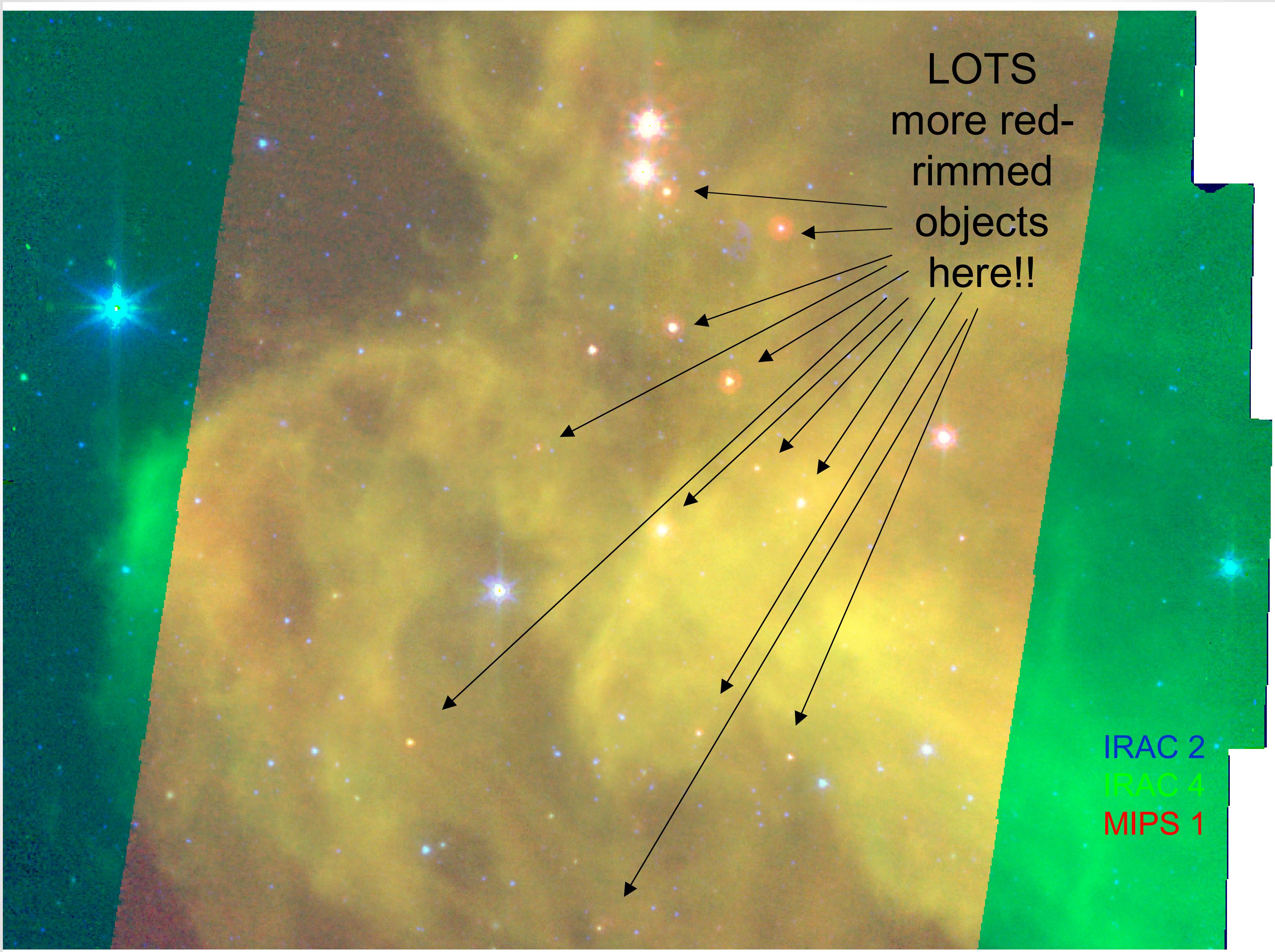


Allen et al. 2004

Literature Search

What do we currently know about IC2118?



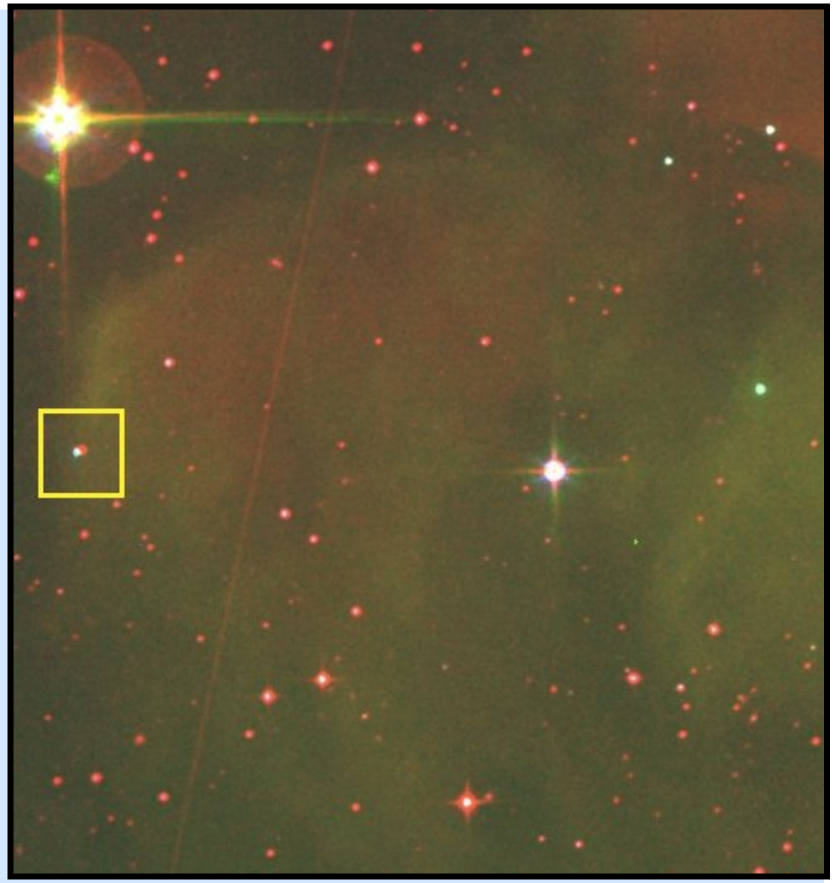

LOTS
more red-
rimmed
objects
here!!
IRAC 2
IRAC 4
MIPS 1

Using Adobe Photoshop and FITS Liberator

ABOVE: A four-color composite image of the region observed by Spitzer. Adobe PhotoShop and FITS Liberator were used to generate the composite image using IRAC 3.6 (blue), 4.5 (green), 5.8 (yellow), and 8 (red) micron data.

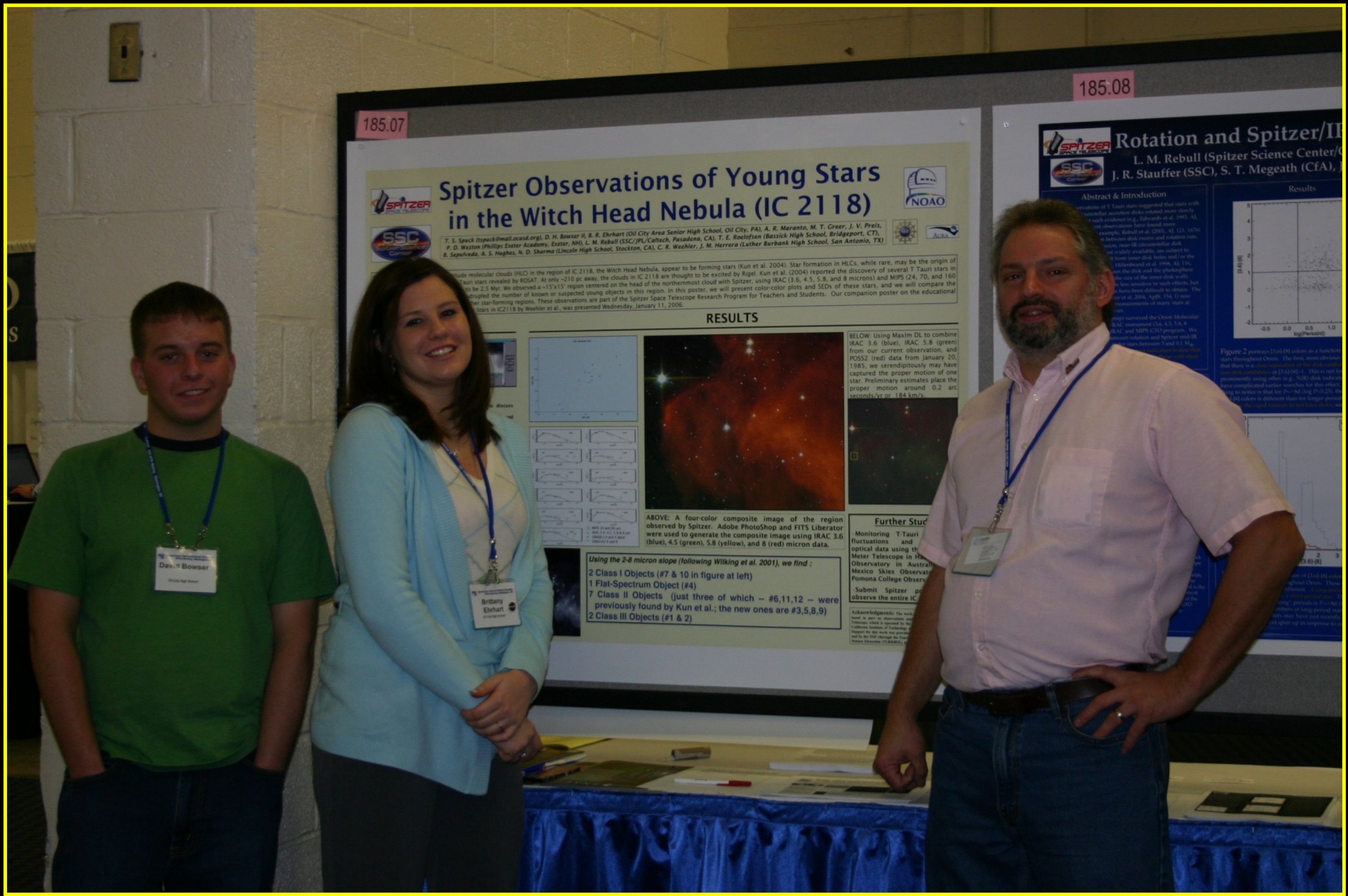
Brittany Ehrhart produced the image to the left. In the photo above she gets some pointers at the 2006 AAS meeting from one of the best astronomy image producers, Astronomer Travis Rector.

Sometimes you find things you never expected … those serendipitous discoveries!

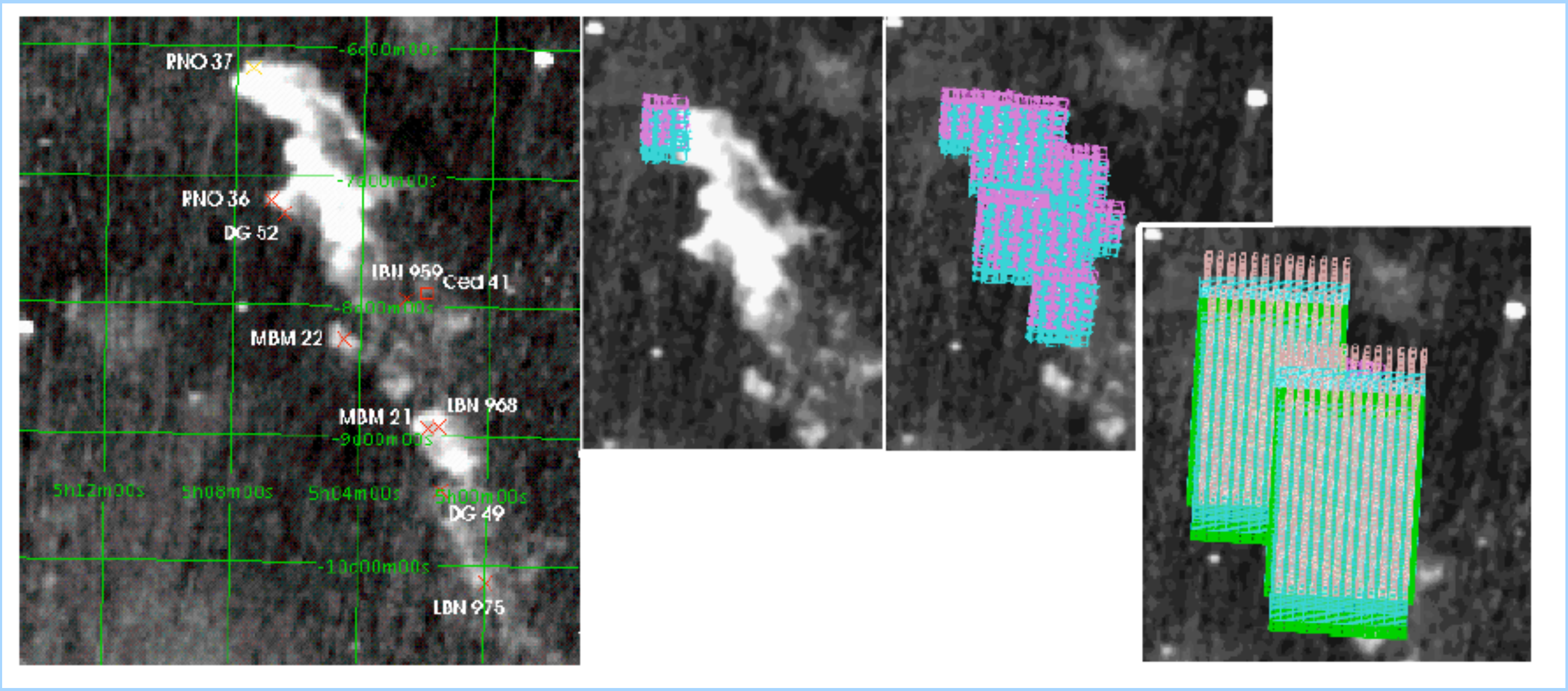


ABOVE: Using MaxIm DL to combine IRAC 3.6 (blue), IRAC 5.8 (green) from our current observation, and POSS2 (red) data from January 20, 1985, we serendipitously may have captured the proper motion of one star. Preliminary estimates place the proper motion around 0.2 arc seconds/ yr or 184 km/s if we assume a distance of 210 pc … the distance to IC 2118. **(Follow-up findings 20 - 70 pc)**

Presentation of findings at the American Astronomical Society Meeting January 12, 2006.



Follow up proposal submitted in February was awarded an additional 12 hours to complete the survey of the cloud.

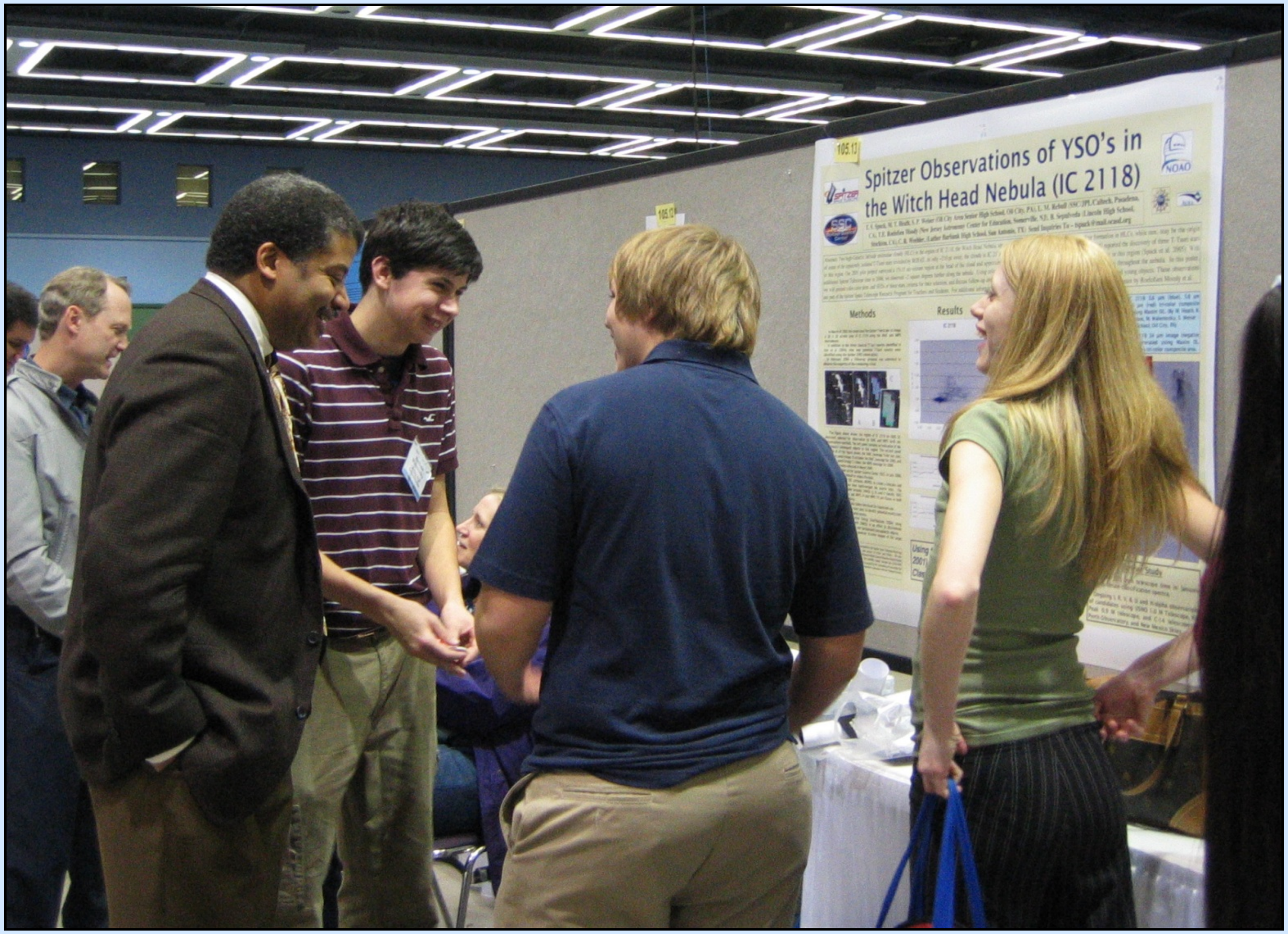


Observations were completed at the end of March 2006!

Again in the

Summer of 2006

January 2007 AAS Conference – Poster Presentation



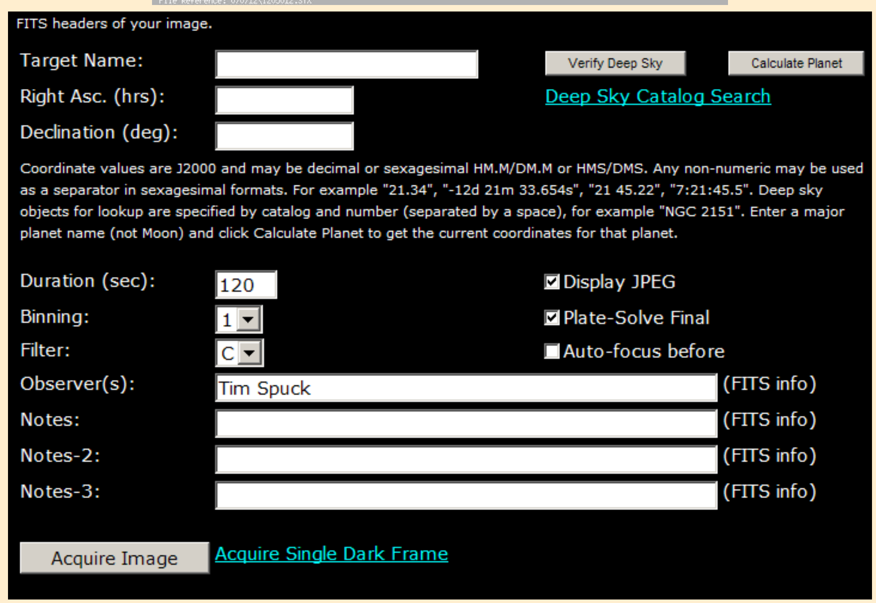
Oil City students Matt Walentosky, Nick Kelley, Paige Morton discuss their research with renowned astrophysicist Neil deGrasse Tyson.

Expanding the Project!

Getting H-alpha Data
Kitt Peak Observatory
January 2007

Perth Observatory – C14 Robotic Telescope . . .

Oil City Students used a remote telescope at Perth Observatory to monitor several of the T-Tauri candidates in IC 2118 for variability.



•The IC2118 Team was awarded time on the Palomar 200-inch telescope to obtain follow-up spectroscopy of our YSO candidates in January 2007. **(Strong winds … poor weather)**

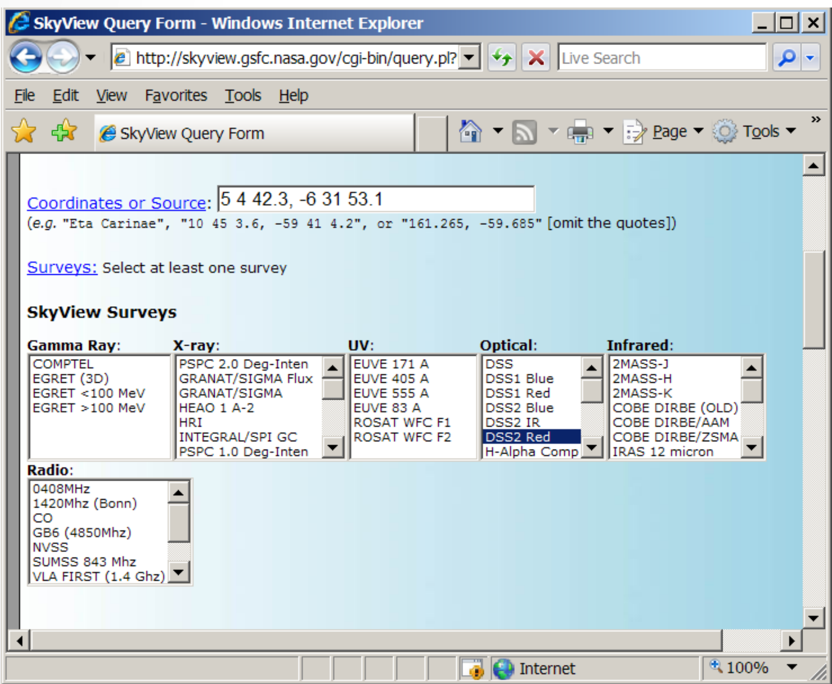
•UVRI images were also obtained using the USNO 40-inch telescope from Nov 2006 – Jan 2007.

Students worked to Eliminate Obvious Galaxies . . .

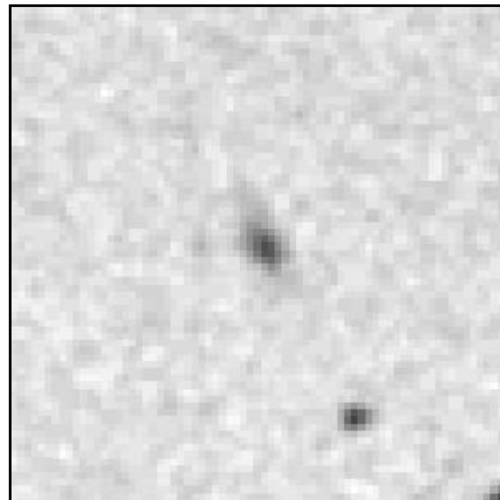
Over 400 targets were analyzed using POSS images.

SkyView

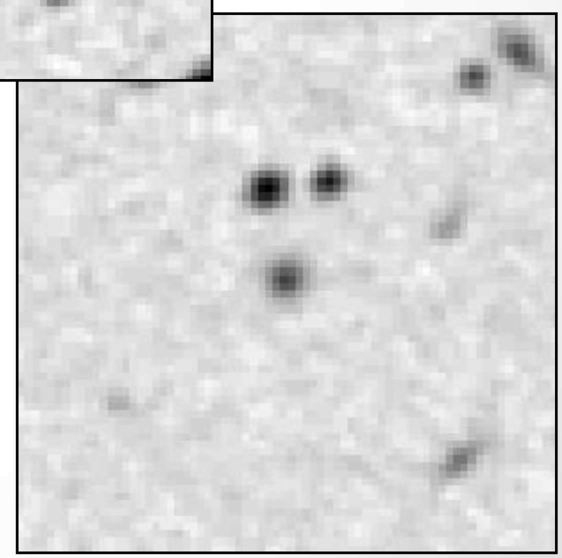
The Internet's Virtual Telescope



F	G	H	I	J	K	L
5	41.9	-6	28	15.8	17.8	S
4	42.3	-6	31	53.1	17.8	G



Galaxy



Star

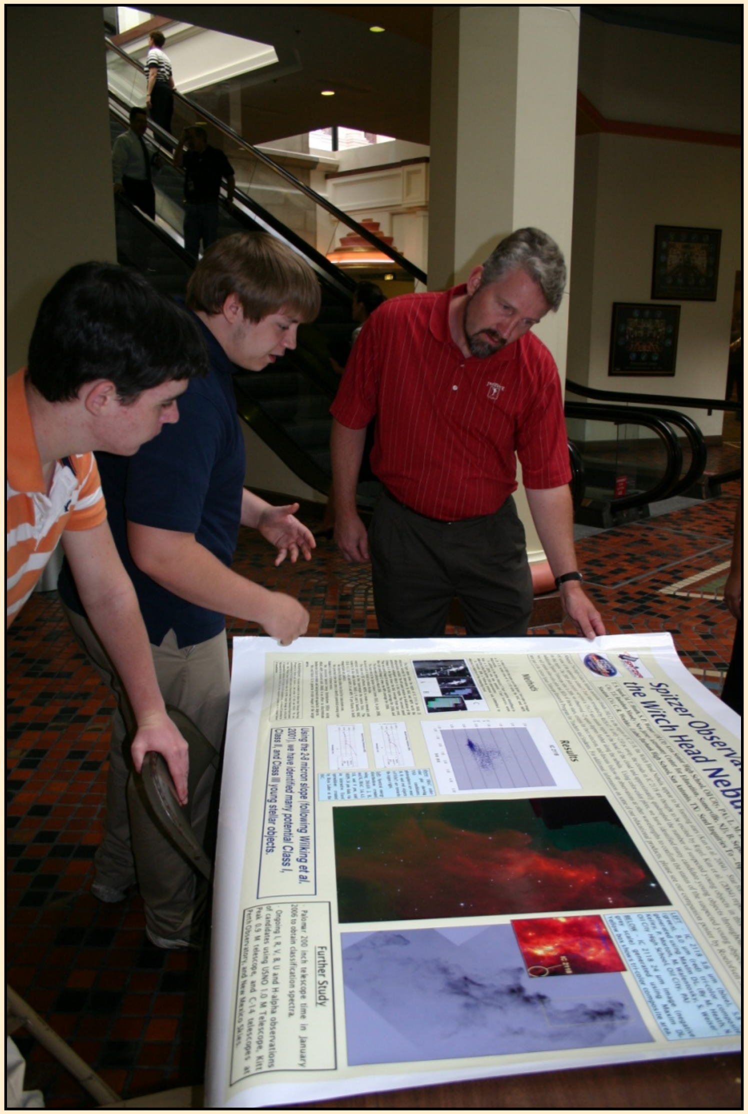
•

Students also looked for evidence of outflows.

- *only present for the very youngest objects, Class Os and Is*

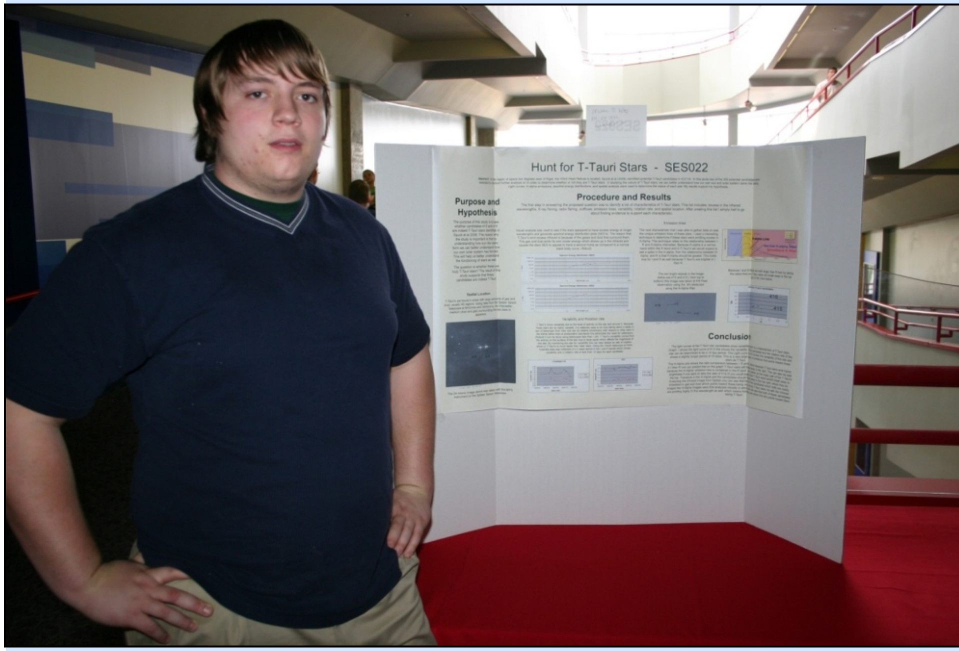
None found in IC2118.

Science In Motion Capital Day – Harrisburg PA



May 2007 - Oil City students present their Spitzer Research to State Officials at the State Capital.

Oil City junior Nick Kelley takes **1st Place Senior Division Earth/ Space/Environment and Best of Science Fair Award** at the 2008 Pittsburgh Regional Science & Engineering Fair for his in-depth analysis of two YSO candidates in IC2118. (April 2008)



And Matt Walentosky goes on to International Science Fair and wins a 2nd Place for his research on the cataclysmic variable star WzSge!

- Rachel and Jennifer awarded time on the Kitt Peak 0.9 M telescope for research testing new method of identifying T-Tauri stars. (November 2008)
- Jennifer wins **1st place at Pittsburgh Regional Science & Engineering Fair and a 4th Place at the International Science & Engineering Fair** in Reno, NV. (May 2009)

All bringing us to the January 2009 AAS Meeting in Long Beach and an interview with Dr. Neil deGrasse Tyson.

Spitzer Space Telescope Research Program for Teachers and Students

Impact Summary

- 32 high/middle school teachers involved with 11 major research projects
- **News audience nearly 6 million people**
- Teachers deliver 200 presentations - reach over 14,000
- **Over 1200 students using Spitzer data**
- 105 students feel the experience has influenced them to pursue careers in science
- **42 students entered science fairs with Spitzer based research and they took many of the top prizes**
- 33 Poster Presentations made at professional conferences
- **As of 2010 there were 5 professional publications and 7 student research publications**

NOTE: These values are likely conservative since the data were collected through analysis of historical records. Only 24 of the 32 teachers completed the requested follow-up survey.

Identifying T Tauri Stars using Small Scale Optical Telescopes

Inga Saathoff – Oil City High School, **Timothy Spuck** – Oil City High School, **Dr. Luisa Rebull** – Spitzer Science Center (Contact Tim Spuck at tspuck@hotmail.com for more information.)

Abstract

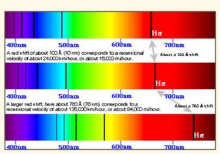
Understanding T Tauri stars is essential if we are to more fully understand our own Solar System. Because T Tauri stars are young versions of our Sun, we can better understand our own history by studying these young stellar objects (YSOs). Hα Survey Method to Recognize T Tauri Stars (HαSMRTS), previously known as the Spuck-Butchart-Optical Survey Method, is a simplified method of identifying T Tauri stars using small-scale optical telescopes. However, to date the method has only been used in an attempt to distinguish T Tauri stars from standard stars. Active Galactic Nuclei (AGN) and active M dwarf (dMe) stars emit excess in both infrared and Hα, similar to T Tauri stars, making it likely that objects such as these may contaminate any T Tauri selection method based on infrared and Hα. This study uses observations from the Kitt Peak National Observatory 0.9 meter telescope to further investigate HαSMRTS and its true ability to accurately distinguish T Tauri stars from other objects in space. Contamination by dMe stars is significant; however, a statistical analysis using Precision and Recall indicates a peak accuracy of 90.8% with a Matthews correlation coefficient of +0.74. These results indicate HαSMRTS shows great promise for both professional and amateur astronomers in identifying YSOs, and perhaps could one day lead to a fast and inexpensive all-sky survey and T Tauri star monitoring program.

Introduction

HαSMRTS– (*Butchart 2009*)

- Successful in distinguishing T Tauri stars from standard stars using simple ratios of Hα, R and I intensity counts
- Based on information that T Tauri stars have significant H-alpha emission
- Target selection could have been improved
- Neither dMe stars nor AGN were included in the study

Both dMe's and AGN have characteristics similar to those of the T Tarui stars which makes significant contamination probable.



Top Figure: This graphic demonstrates how the Hα line will shift as the recessional velocity of the object increases. (image from Red Orbit, 2002)

T Tauri stars – Characteristics

- Young sun like star in the early stages of development
- Large accretion disks
- Bipolar outflow caused by material falling onto the star from the disk
- → Strong Hα emission line
- G, K, or M class star
- → Greater emission at longer λ

Hypothesis

★ Even though dMe stars display a Hα line, these emissions should be significantly stronger in the T Tauri stars as compared to dMe stars.

★ Further, AGN should be distinguishable from T Tauri stars based on their significant cosmological redshift. The Hα line in AGN should be shifted out of the range of the narrowband Hα filter used on the 0.9 meter telescope.

Procedures

- ★ Targets including AGN, dMe stars, T Tauri stars and standard stars were selected from various publications
- ★ R exposure time was based on published R or V magnitudes
- ★ I exposure time was 2 x $R_{exp\ time}$, H-alpha exposure was 10 x $R_{exp\ time}$
- ★ January 30 through February 2, 2010 observing run
- ★ Equipment used: WIYN 0.9 M Telescope at KPNO in Tucson, Arizona
- ★ Used the I-Harris, R-Harris and H-alpha filters
- ★ Data reduction was completed with MaxIm DL and Pinpoint Astrometry
- ★ Used the aperture tool in MaxIm DL to measure R, I, and Hα Intensity values
- ★ Scatter plots were generated in MS Excel
- ★ Statistical analysis was conducted using Precision and Recall methodology
- ★ Test image sets were selected and analyzed using the HαSMRTS

Above: View from KPNO 0.9 M Telescope where data was collected for this study.

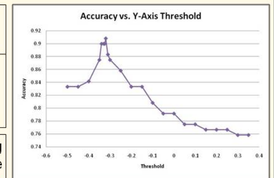
Above: The image displays the aperture tool in MaxIm DL, and the photometry measurements for dMe star *HIP 61413* in the R, I and Hα filters.

$$MCC = \frac{TP \times TN - FP \times FN}{\sqrt{((TP+FP)(TP+FN)(TN+FP)(TN+FN))}}$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

TP – true positive
TN – true negative
FP – false positive
FN – false negative

Above: A statistical analysis was conducted using Precision and Recall methodology to determine Accuracy. Targets are classified as a **true positive (TP) - a confirmed T Tauri star that falls within a set of parameters**, a true negative (TN) - a confirmed non-T Tauri object (e.g. AGN, standard star, dMe star) that falls outside the set of parameters, a false negative (FN) - a confirmed T Tauri star that falls outside the set of parameters, or a false positive (FP) - a confirmed non-T Tauri object (e.g. AGN, standard star, dMe star) that falls inside the set of parameters. The Matthews-correlation coefficient (MCC) is an indicator of prediction capability.

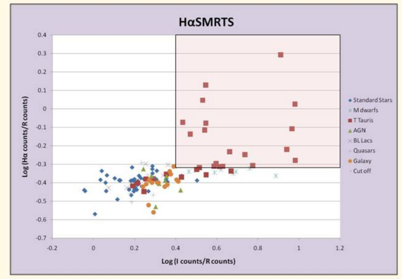


Above: Calculating the accuracy for different threshold values determined the thresholds. An Accuracy vs. X-Axis plot was the basis for holding the x-axis (Log (I counts/R counts)) threshold at 0.4. The accuracy vs. Y-axis Threshold plot above displays a maximum accuracy of 90.8% at a the Y-axis threshold (Log (H counts/ R counts) of -0.32. For this threshold the MCC is 0.74, which emphasizes that the HαSMRTS can be used as a relatively accurate predictor in identifying T Tauri stars.

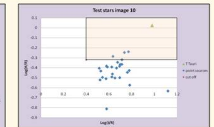
Results

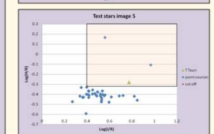
ID	Type	R Intensity counts	I Intensity counts	Hα Intensity counts	Log (I/R)	(Log H/R)
3C 120	AGN	7503	14342	3246	0.281	-0.364
IRAS 04210+0400	AGN	1922	3364	908	0.243	-0.325
MCG +08.15.009	AGN	2223	4961	909	0.349	-0.388

Above: The table was generated in Microsoft Excel and displays a small sample of objects observed in this study and their corresponding intensities in R, I and Hα and the calculated Log ratio values.



Above: The X-Y scatter plot of Log(I-intensity/R-intensity) vs. Log(H-alpha-intensity/R-intensity) displays all targets in the current study including dMe stars, AGN, BL Lacs, Quasars, Galaxies, standard stars and T Tauri stars from the Butchart study (2009). There is significant contamination from dMe stars, however, at a cut-off of Log(H/R) > -0.32 and Log(I/R) > 0.4, 65.5% of previously known T Tauri stars would have been correctly identified using this method.

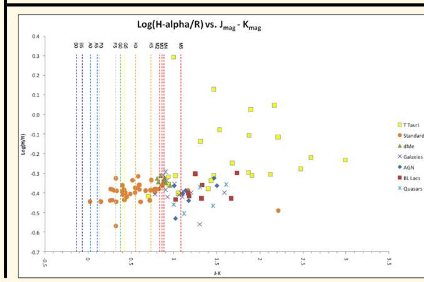




Above: Testing HαSMRTS - Four random test image sets with known T Tauri stars were selected. Point sources were identified by visual inspection of the Hα image. Corresponding targets in the I and R images were measured and data plotted. 93% of known YSO's in the test images were correctly identified.

Conclusions

Based on the evidence in this study, 65.5% of T Tauri stars can be identified using the HαSMRTS with an Accuracy of 90.8%. The Matthews-correlation coefficient of 0.74 indicates a strong correlation between this method and its ability to correctly identify T Tauri candidates. Although there is no single method that can conclusively identify all T Tauri stars, there is strong evidence that supports using the HαSMRTS as a cost-effective tool to initially identify T Tauri star candidates. Observations using additional instrumentation and long-term monitoring programs by the professional and amateur communities could follow to confirm/refute the YSO status of objects discovered using this method.

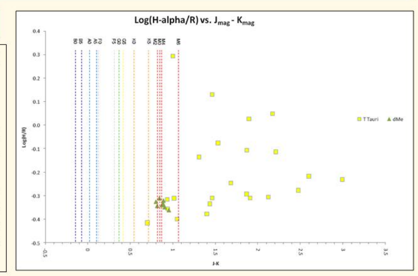


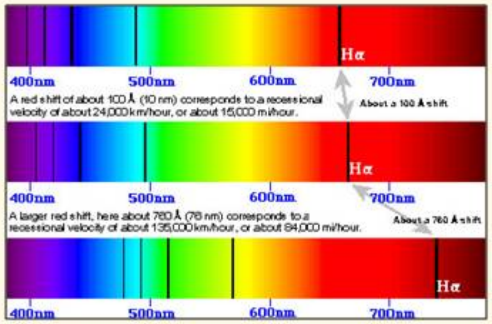
Future Studies

★ **Left and Right:** Even without the 2MASS data the method works. However J,H,and K data may help to distinguish T Tauri stars from dMe stars, as will the WISE catalogue when available.

★ The INT/WFC Photometric Hα Survey (IPHAS) of the northern Galactic plane has identified 4853 point sources that exhibit strong photometric evidence for Hα emission. This may be a source of data to compare our results to. (Witham et al – 2008)

★ Considering the fact that T Tauri stars have a significantly stronger Ca II line in emission, the contamination of dMe stars may be able to be mitigated by taking a simple ratio of intensities using Ca II and U band filters. Additional observational evidence in Ca II and U is required.





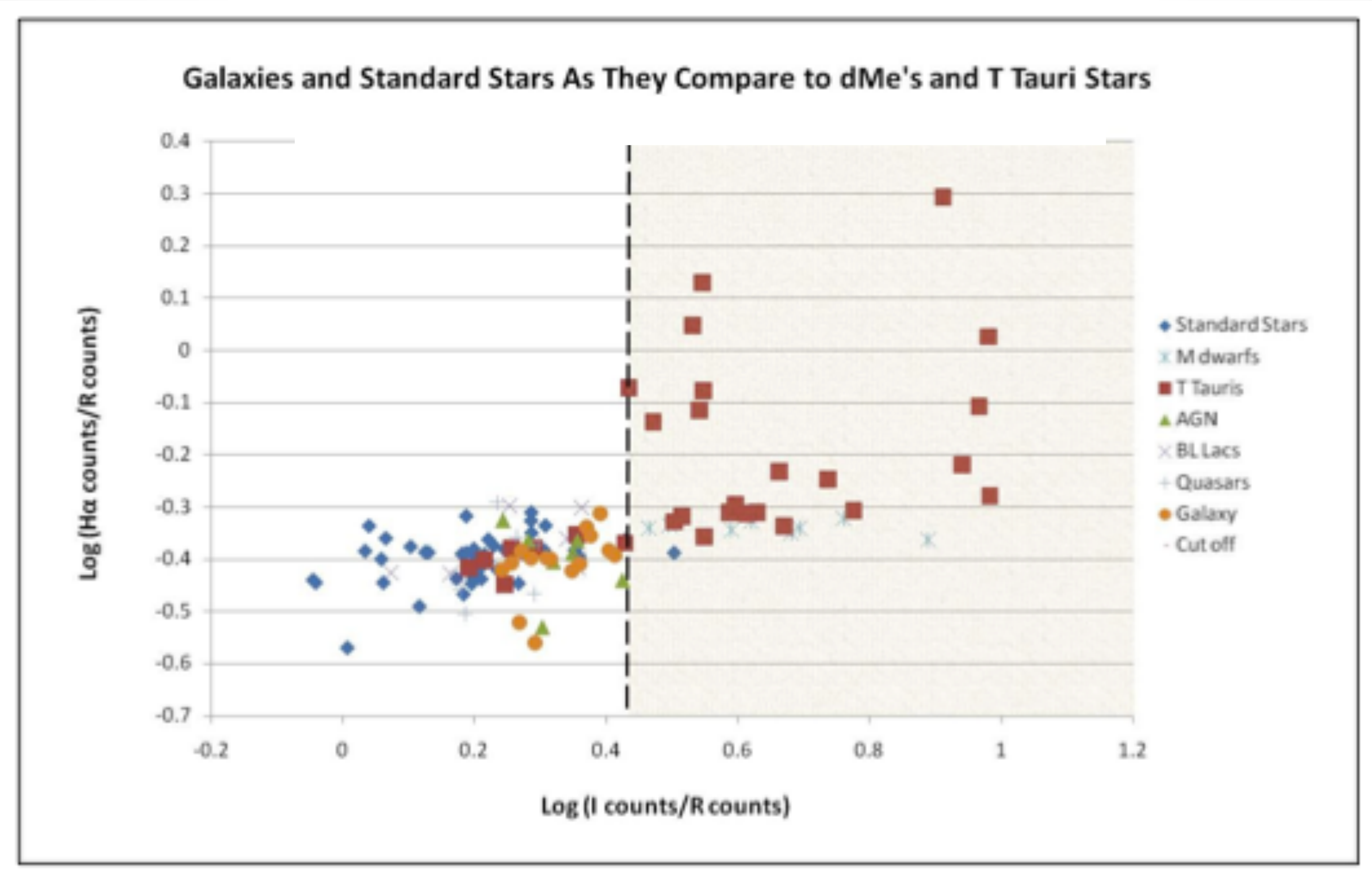
Top Figure: This graphic demonstrates how the Hα line will shift as the recessional velocity of the object increases. (image from Red Orbit, 2002)

Above: View from KPNO 0.9 M Telescope where data was collected for this study.

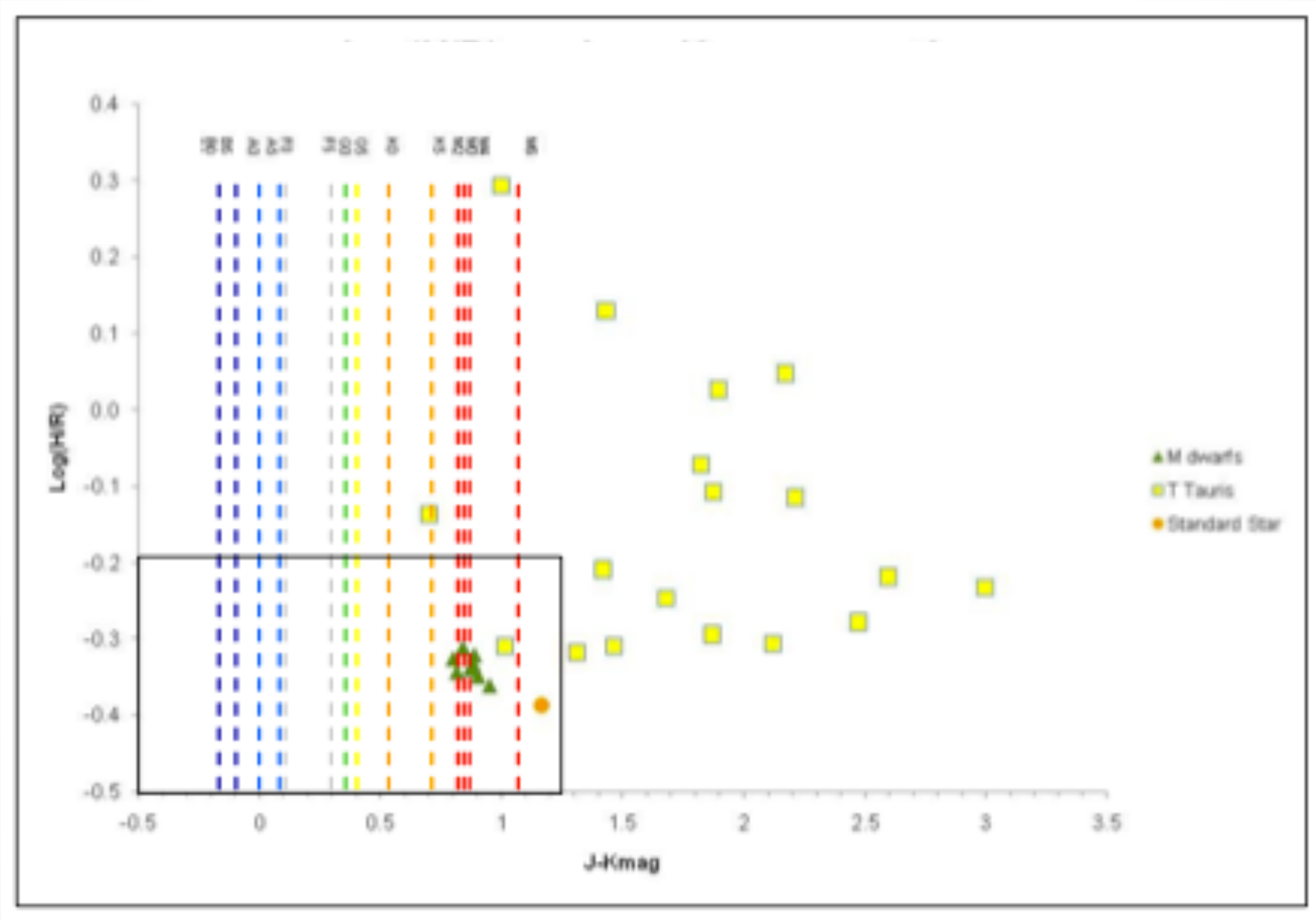
R filter | **I filter** | **Hα filter**

Above: The image displays the aperture tool in MaxIm DL, and the photometry measurements for dMe star *HIP 61413* in the R, I and Hα filters.

Galaxies and Standard Stars as they Compare to dMe’s and T Tauri Stars



Log (Hα/R) vs. J_{mag} - K_{mag} Separation



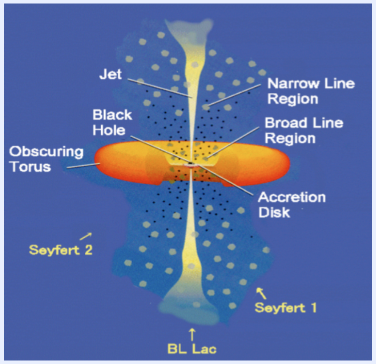
Oil City Students Compete at the 2010 Pittsburgh Regional Science & Engineering Fair – Inga Saathoff wins 1st Place and moves on to the International Science Fair where she was awarded a $50,000 scholarship to Florida Institute of Technology.

NASA IPAC Teacher Archival Research Program

- Astronomy data sets are becoming richer and more accessible
- More and more research conducted by scientists uses data archives as their primary data source
- The Future …. The Large Synoptic Survey Telescope (LSST)

What if we trained teachers and students to access the astronomy data archives to do real research? Can we change the future of STEM Education?

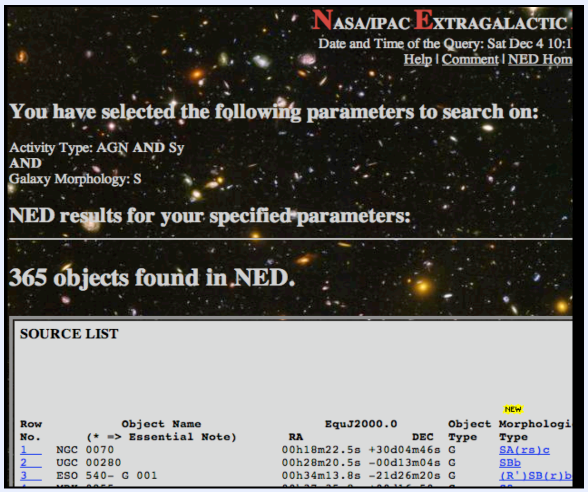
AND … then there was NITARP!

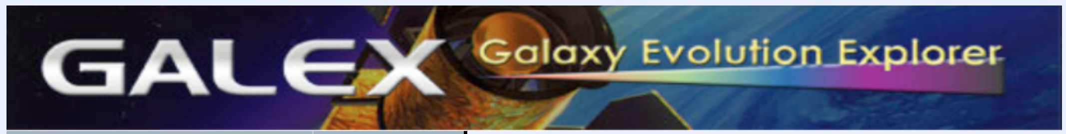


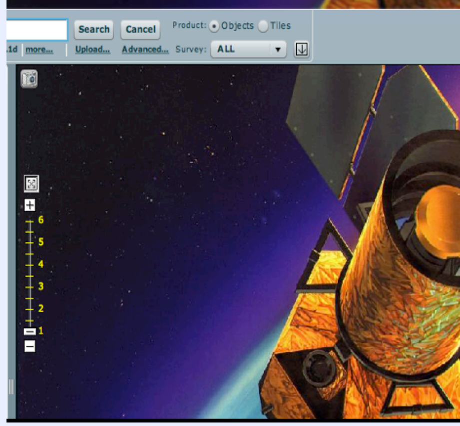
Determination of the Infrared Luminosity of Active Galactic Nuclei (AGN)

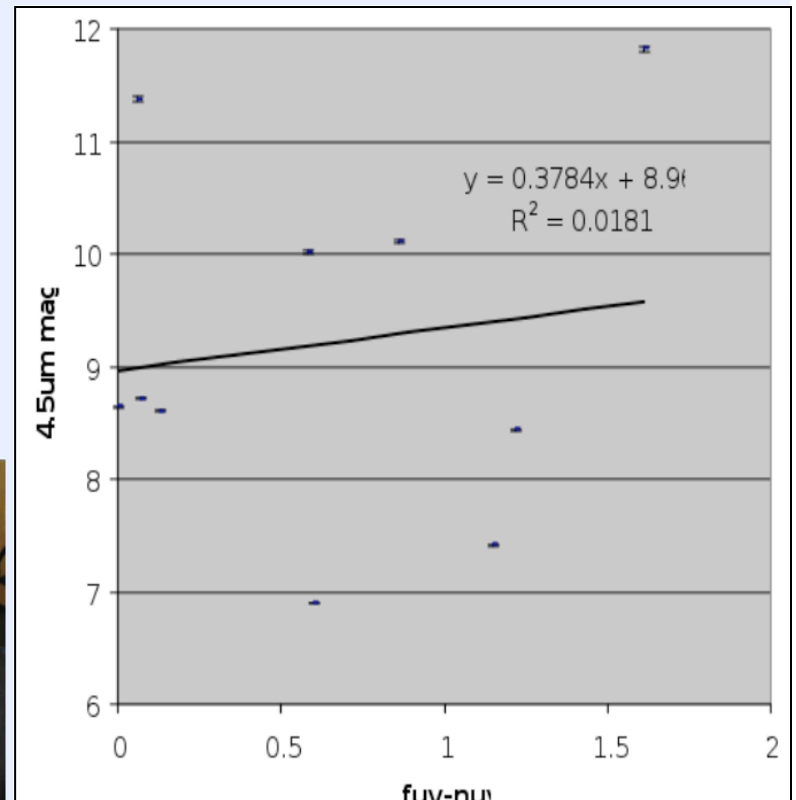
Using archival data from Spitzer and GALEX Space Telescopes to look for a potential correlation between emissions in the UV and infrared.

N.E.D.



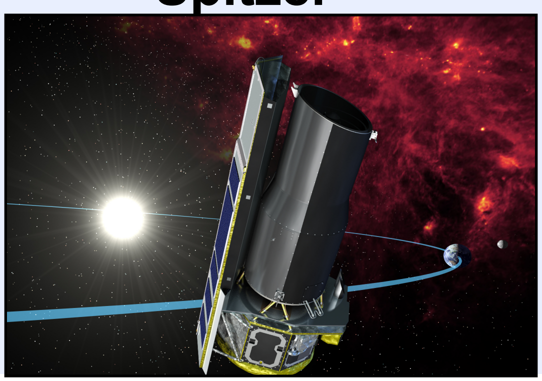






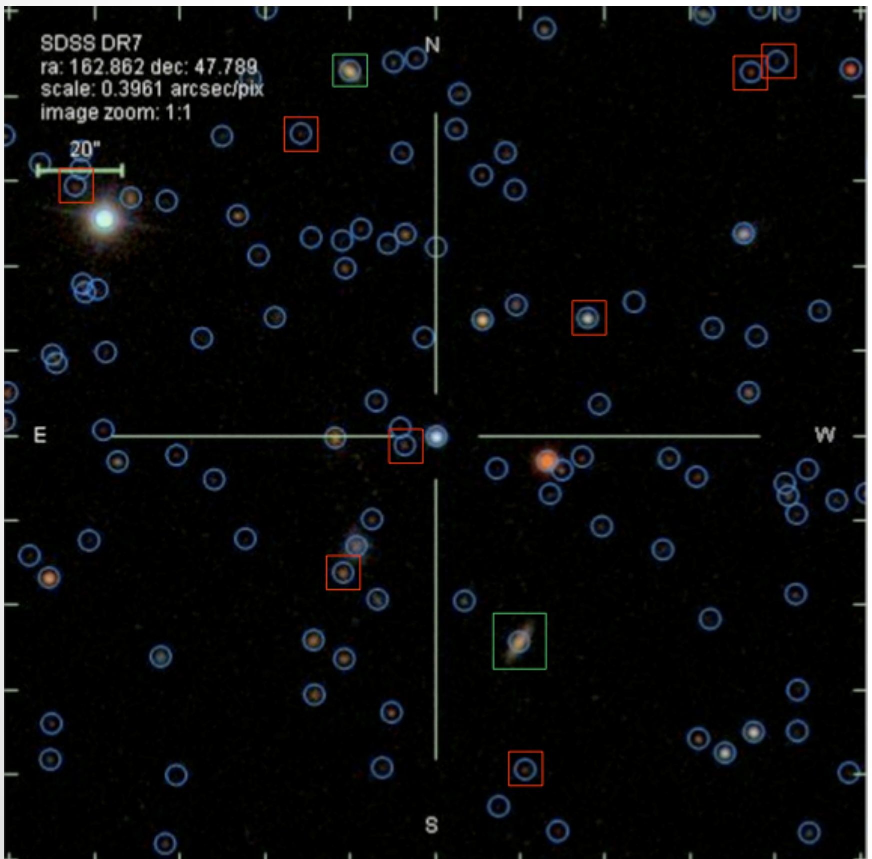
Teachers/Students

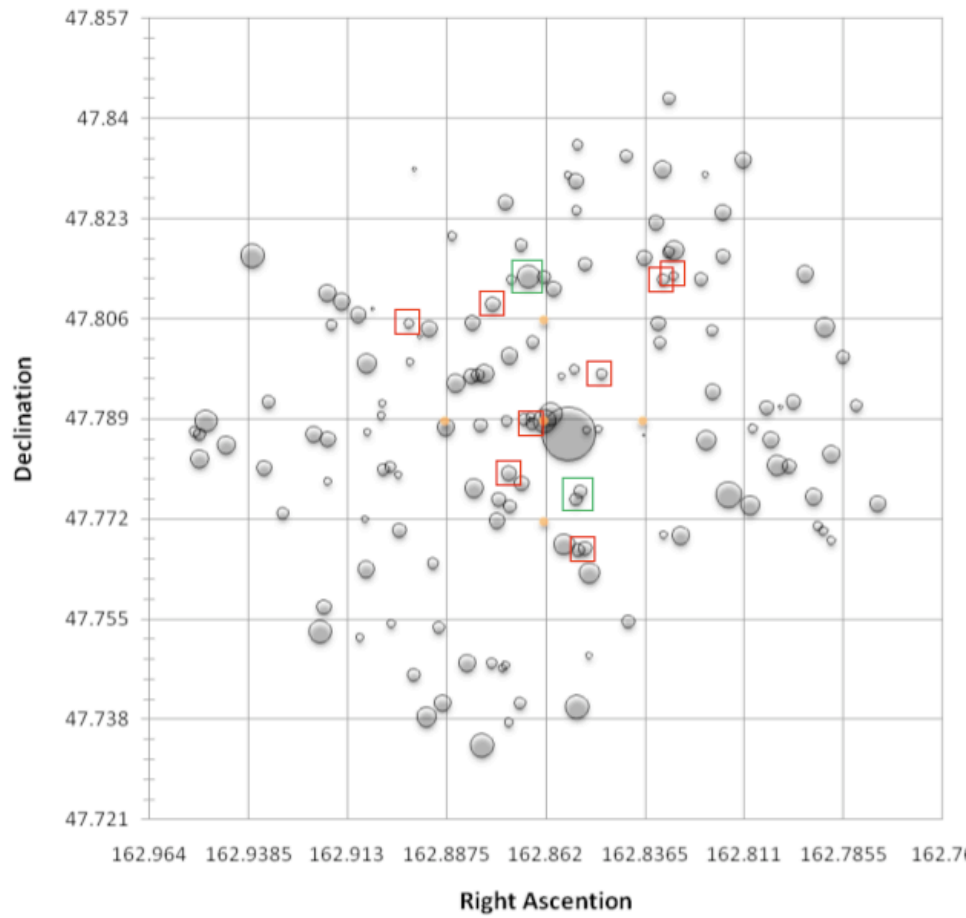
Spitzer



Searching for Galaxy Clusters Around AGN at z~1 Using Spitzer Archival Data

Spitzer Space Telescope archival data from the Infrared Array Camera (IRAC) at 3.6 and 4.5 microns was used to locate galaxy clusters at z~1. 168 fields around Active Galactic Nuclei (AGN) at z~1 were identified from the archive and magnitudes at 3.6 and 4.5 microns were measured for all objects in the field, and a [3.6] - [4.5] color selection was applied.





More Research . . .

Partnerships across the divide between K-12 schools and institutions of higher education are essential in increasing the coherency of science education in the American educational system from the first days of kindergarten through the undergraduate years. - *(2003) Kimberly D. Tanner, Liesl Chatman, and Deborah Allen - Approaches to Biology Teaching and Learning: Science Teaching and Learning Across the School University Divide Cultivating Conversations through Scientist Teacher Partnerships*

A collaborating scientist - a rewarding addition to any high school program - can help students collect and analyze data that either replicates or parallels the work of the partnering scientist. This type of partnership is beneficial for both the students and scientists. *(2006) Cheryl Abbott and Marc Swanson - A Rewarding Partnership - Critical components of a successful collaborative scientist-student project*

All students need to be offered experiences of this nature [real/authentic science] - *(2003) Jrene Rahm, Heather C. Miller, Laurel Hartley, John C. Moore - The Value of an Emergent Notion of Authenticity: Examples from Two Student / Teacher – Scientist Partnership Programs*

Summary of the Benefits . . .

- Improving the STEM Pipeline (We can no longer depend on foreign talent to fill the STEM needs of the Nation)
- Improves STEM professional's communication skills and understanding of current STEM education issues.
- Improves student standardized test scores.
- Students can make discoveries and contributions to science.
- Improve educator science inquiry teaching skills
- Authentic science experiences help develop critical thinking skills.
- Authentic science experiences can help eliminate misperceptions about science and the scientist for both teachers and students.
- As we consider the terabytes of scientific data available now and in the future, students and teachers can play a significant role in the data analysis process.
- The experience can be mutually beneficial "a win-win" for everyone involved!
- Our children are some of our best science ambassadors to the general public
- These types of experiences can significantly impact the future of scientific endeavors, both nationally and internationally.

What did it take to make this story reality?

1. **Funding agencies with the forward vision to see merit**
2. **Scientists that were willing to step outside the box and truly value education, educators, and students**
3. **Sustained teacher development and support**
4. **A teacher with a desire and motivation to learn, and a "*learned*" level of confidence**
5. **Students with interest and motivation**
6. **Time … lots of it!**
7. **And Pizza … lots of it too!**