The most remarkable aspect of astronomy is not in the sky, but on the Earth, where a species has developed curiosity to look into the sky and wonder.

R. Kolb, Blind Watchers of the Sky

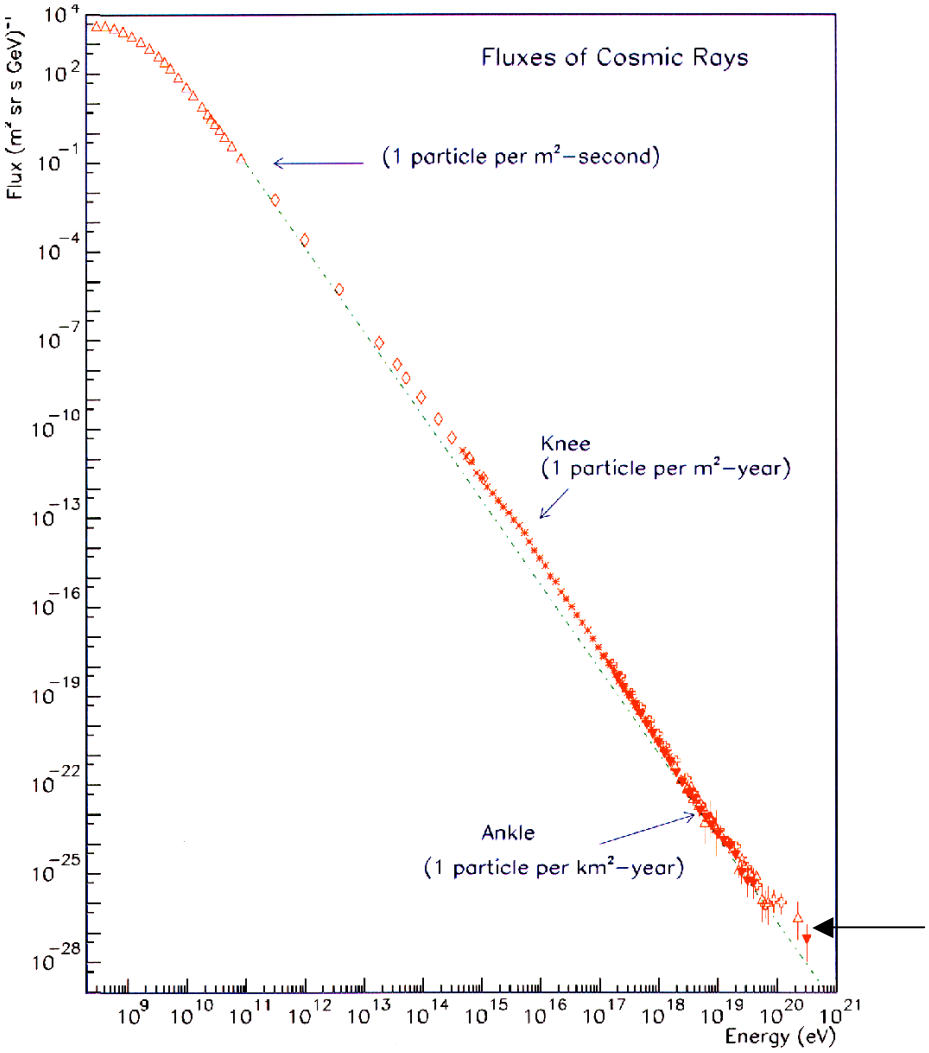
A Personal Retrospective and Prospective on High-Energy Astrophysics: Ruminations and Reflections on Life in Building 2

Jonathan F. Ormes

Space Sciences Director and LHEA Emeritus

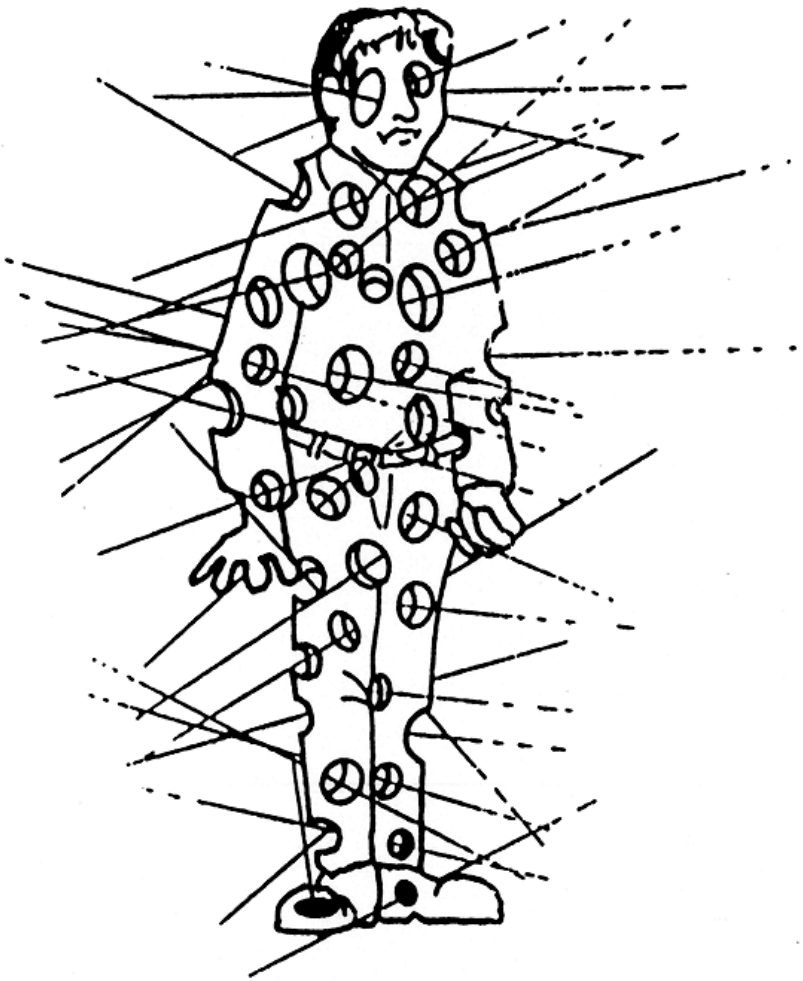
University of Denver

All particle spectrum



1 particle per km^2-millennium

Minnesota *Technolog* circa 1966

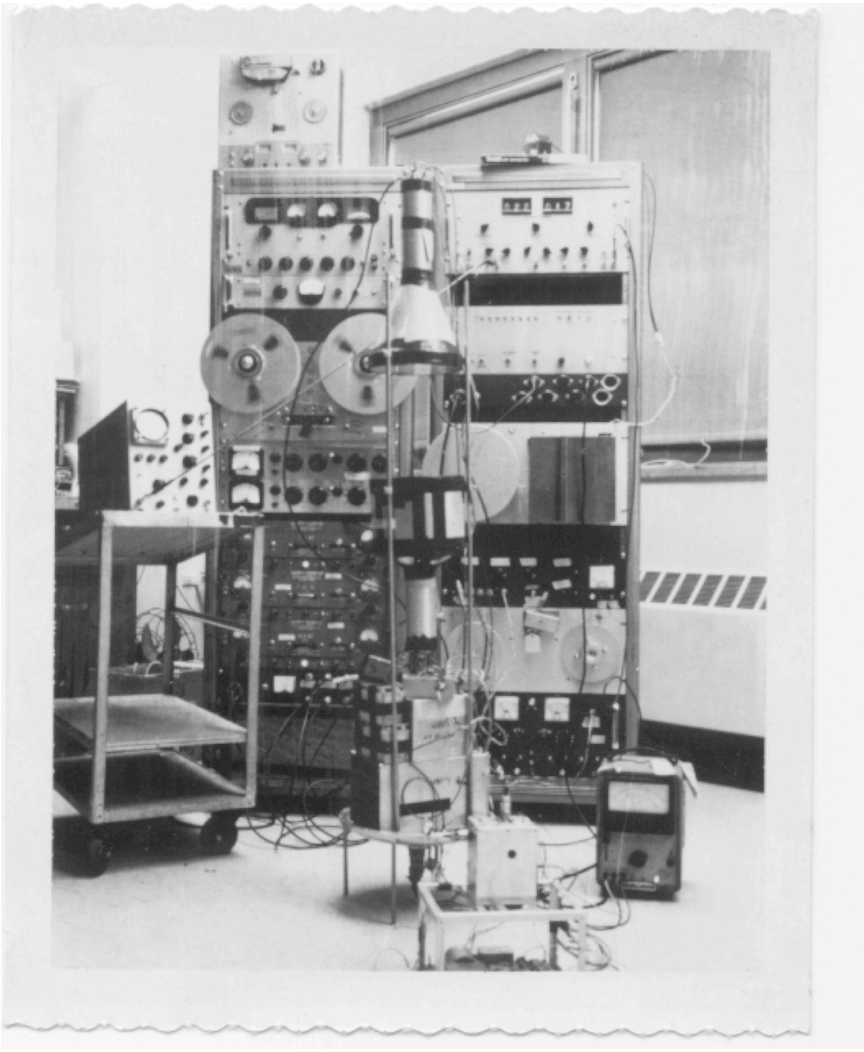


- **Assuming you present about 1/4 of a m^2 sr exposure standing up, about 100,000 cosmic ray muons will pass through you in the course of this talk.**
  - **Fortunately, muons are weakly interacting particles**
  - **They do cause an ionizing background in CCD camera arrays!**

The Retro part

Stanford University

- U of Minnesota
  - Bill Webber
- NRC GSFC
  - Frank McDonald
  - VKB



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LHEA

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Cosmic Rays at NASA/ GSFC

A Tale of Many BALLOON Experiments

Cosmic-Ray Experiments

HECR I-II

HECRe

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GLAST

PAMELA

ACCESS

OWL

At GSFC we were a lot more ambitious

Big News Story Goes Up, Up, Up And Away

It squirreled down from the heavens about 3 a.m. Friday over Highway 70, 13 miles southwest of Orangeburg as three T&D staffers watched in amazement and disbelief. It was odd-shaped and in trouble.

THE CRAFT appeared to be without a pilot as it headed for earth at a modest but determined pace in the pre-dawn sky. Not a sound was heard until the plastic-like tail began ripping the tree tops.

The woods and nearby fields came alive with mild explosions resembling a fusillade of pistol shots. Nobody moved until the shooting was over.

It was an eerie spectacle. A weird phenomenon — and it was about to land.

A STORY was in the making. People from outer space were invading Orangeburg County!

As two of the staffers rushed to a corner of the field to witness the landing, disappointment replaced the expectancy in the air. The flight wasn't over.

Almost as if it had been a planned hedge-hopping, but with a bit of embarrassment, the giant weather balloon regained its composure, pulled in its dangling cords and swiftly climbed back into the moonlit sky.

THREE STUNNED earth men watched the big data bag disappear over a sleeping Orangeburg and drove back to the T&D office without the story that might have been.

Nov. 14, 1970

Big News Didn't Get Away Entirely, Yet

The "weather balloon" spotted Friday morning by three Times and Democrat staffers has turned out to be much more than expected.

According to an Air Force spokesman, the balloon was carrying over 5,000 pounds of intricate equipment to collect data on cosmic radiation. Most of the instruments were found Saturday near Norway and the Air Force plans to recover them Sunday.

It was launched at Holloman AFB, N.M., at 8:30 EST p.m. Wednesday. The balloon, which continued on its merry way after dumping its gondola of equipment, was last reported about 700 miles from Bermuda.

The Times and Democrat hopes to carry pictures and a complete story of today's recovery in Monday's edition.

Nov 15, 1970

Nov. 16

emocrat

sperity

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South Carolina: Fair and continued cold Monday and Monday night. High Monday in the 50s, low Monday night around 30.

NOW LET'S SEE! — Airmen and members of the Orangeburg National Guard decide on the best way to remove a 5,000-pound gondola from a wooded area near Norway. A heavy-duty wrecker from the local Guard unit was employed to pull the huge instrument package onto the roadside about 100 feet away.

Giant Balloon's Scientific Data Safe Again Now

By RICHARD DeWITT
Of The Times and Demcorat

NORWAY, S. C. — An Air Force crew, with the help of several members of the Orangeburg National Guard and four or five Norway residents, Sunday reclaimed the payload of a giant balloon near here.

The gondola, weighing about 5,000 pounds and carrying intricate equipment to measure, record and transmit data on cosmic radioactivity at extremely high altitutes, crashed into a wooded are about 13 miles southwest of Orangeburg approximately 100 feet off Highway 70 about 3 a.m. Friday.

SEVERAL SMALLER instrument boxes

NOW LET'S SEE! — Airmen and members of the Orangeburg National Guard decide on the best way to remove a 5,000-pound gondola from a wooded area near Norway. A heavy-duty wrecker from the local Guard unit was employed to pull the huge instrument package onto the roadside about 100 feet away.

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SEVERAL SMALLER instrument boxes were recovered in the swamps of the South Edisto River several miles away.

A heavy-duty wrecker from the National Guard was used to pull the gondola onto the roadway and load it into an Air Force truck.

According to Maj. Joe Koehy, who headed the six-man Air Force team in Orangeburg, the flight began at 3:30 p.m. EST at Holloman AFB, N.M., near the famed White Plains Testing Range.

Its trajectory was to take it up to 108,000 feet, terminating east of Texarkana, Ark. Due to a malfunction in the insturmentation package, Major Koehly said, the balloon floated eastward over Memphis, Tenn. Birmingham, Atlanta, and Augusta, setting off a series of unidentified flying objects reports.

HE SAID THE helium in the dirigible contracted in the cold air early Friday morning and it crashed. The gondola cleared a six-foot path for almost a quarter of a mile, knocking over at least one big pine tree, before coming to a rest. The balloon then broke away and continued on its merry way, being last reported about 700 miles from Bermuda.

Major Koehly and his crew have been following the object since Thursday and light aircraft were used extensively over this area Friday and Saturday.

Three Times and Democrats staffers heard the crash, saw the airbag regain altitute, but assumed it was only a weather balloon.

G. L. Williams of Norway notified the Air Force Saturday morning that he had found one of the packages in a swampy area. The major then went to the Orangeburg Fire Department to borrow hip boots for his crew to use in the recovery.

Firemen informed him of a story about the incident in Saturday's edition of the T&D. A staff reporter accompanied Major Koehly and SSgt. Robert Glover to the site of the crash, but several deer hunters, including Thomas Godowns Jr. and Chuck Baldwin, were waiting for them near the gondola.

TOTAL HEIGHT of the balloon, parachutes and instruments at the time of launch was about 610 feet, the major said, with the largest part of the airbag measuring 420 feet in diameter. His crew, Detachment 1, Air Force Cambridge Research Laboratory, launches about 80 balloons a year. "We have never lost one," Major Koehly said, "We stay until we find them."

Only visible damage to the gondola was a few scratches and dents. It is now at the Orangeburg National Guard Armory, awaiting a decision whether to ship it back to New Mexico or to its manufacturer in Maryland.

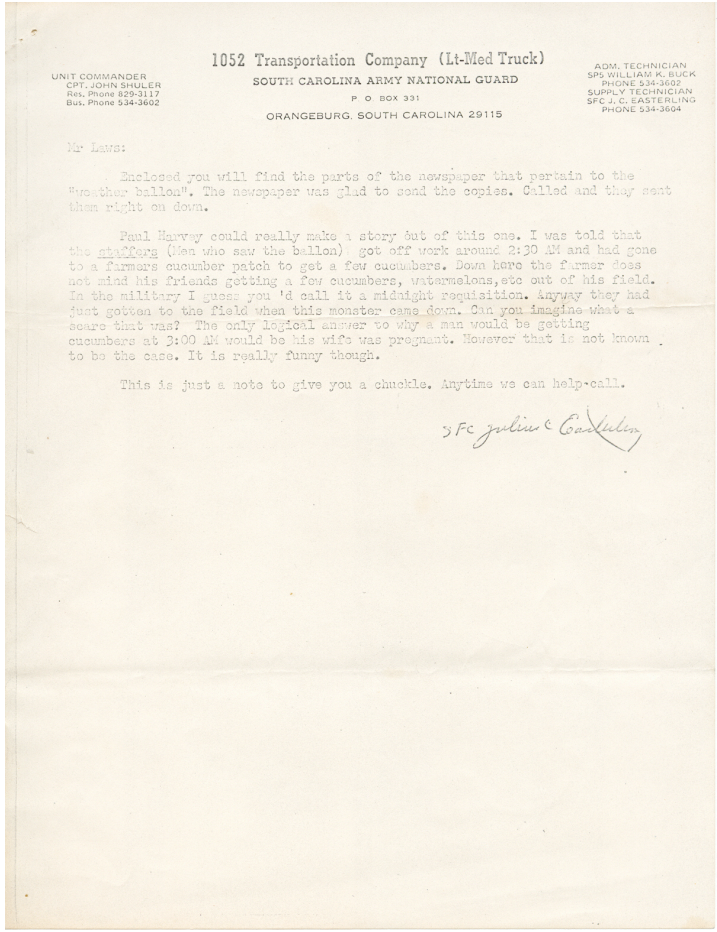
PATH OF DESTRUCTION — This downed pine tree shows the force with which a gondola from an high-altitute Air Force research balloon hit near Norway early Friday morning. It cleared a six-foot path through a quarter mile of woods before coming to a stop.

Dear Mr. Laws:

Enclosed …

Paul Harvey could really make a story of this one. I was told that the staffers (Men who saw the balloon) got off work around 2:30 AM and had gone to a farmers cucumber patch to get a few cucumbers, watermeloons (sic), etc out of his field. In the military I guess you'd call it a midnight requisition. Anyway they had just gotten to the field when this monster came down. Can you imagine what a scare that was? The only logical answer to why a man would be getting cucumbers at 3:00 AM would be his wife was pregnant. However that is not known to be the case. It is really funny though.

SFC Julius Easterling
South Carolina National Guard



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SFC J. C. EASTERLING
PHONE 534-3604

Mr Laws:

Enclosed you will find the parts of the newspaper that pertain to the "weather ballon". The newspaper was glad to send the copies. Called and they sent them right on down.

Paul Harvey could really make a story out of this one. I was told that the staffers (Men who saw the ballon) got off work around 2:30 AM and had gone to a farmers cucumber patch to get a few cucumbers. Down here the farmer does not mind his friends getting a few cucumbers, watermelons, etc out of his field. In the military I guess you 'd call it a midnight requisition. Anyway they had just gotten to the field when this monster came down. Can you imagine what a scare that was? The only logical answer to why a man would be getting cucumbers at 3:00 AM would be his wife was pregnant. However that is not known to be the case. It is really funny though.

This is just a note to give you a chuckle. Anytime we can help-call.

SFC Julius C. Easterling

The "staffers" said nothing to anyone until the payload was found a day or two later. Then this story came out but not in the newspaper!

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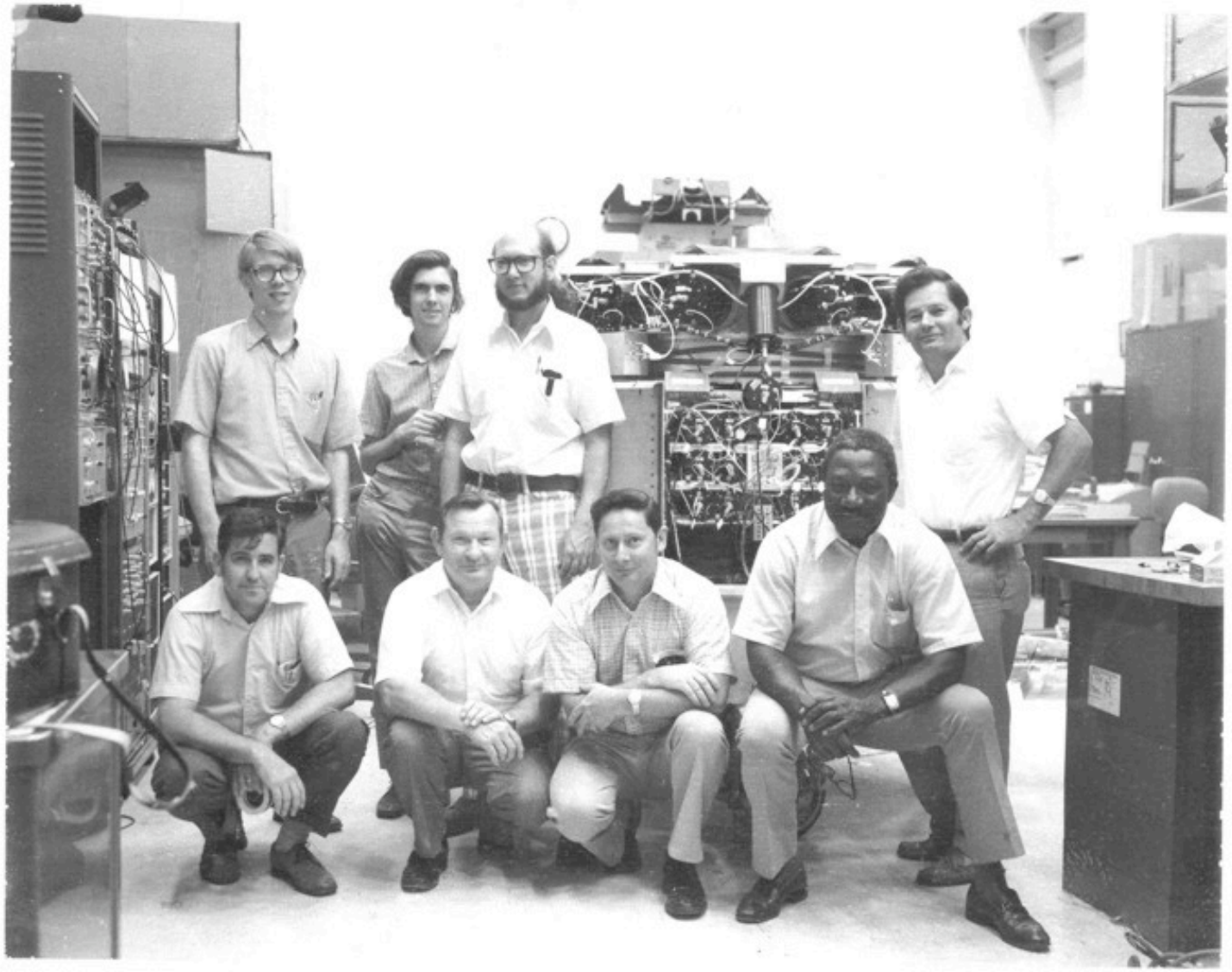
Isotope Experiment



Publications

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P.G. Student Wins Science Prize

By Robert Meyers
Washington Post Staff Writer

A 17-year-old Prince George's county youth was awarded the top prize of a $10,000 scholarship last night in a nationwide science competition for his complex design of a game theory concept, dealing with the ways in which the maximum number of mathematical opportunities are achieved.

The youth, Michael Stephen Briggs of 8504 Laverne Dr., Adelphi, a senior at High Point High School, was selected over 40 other finalists in the 37th annual Westinghouse Science Talent Search Competition. More than 13,000 students from around the country entered the contest this year, according to contest officials.

Briggs told officials he intends to use his $10,000 scholarship award to study next year at Princeton University, aiming toward a career in physics, or astronomy, as well as teaching.

He said he became interested in the concept of game theory after reading an article on computer chess.

According to Briggs, a slender youth who was shaking and almost speechless after the announcement, mathematicians view events in the world as "games" of either finite possibilities, such as chess, or infinite possibilities, such as aerial warfare.

"Mathemetians didn't know how to estimate the number of potential situations in infinite games," he said. "I developed a method whereby one can construct" those estimates.

Briggs said he did this between last August and December by finding two finite games within any infinite situation, this making results far more predictable than before.

See BRIGGS, B5, Col. 4

Michael Briggs gets top national prize.

P.G. Student Wins Prize for Game Theory

BRIGGS, From B1

His theory could be applied to chess or commercial marketing situations in which predictions based on a wide number of variables are desired, he said.

"We were impressed by his potential and general knowledge, as well as by his actual design," said Nobel Prize winner Glenn T. Seaborg, who was one of the judges.

Briggs credited three teachers at High Point School—Linda Kingsley, Sally Buckler and Lena Struglia — with assisting him with the development of the concepts.

Two other local high school students also were finalists in the competition Briggs won. David Theodore Vader, 18, of 19732 Meredith Dr., Derwood, Md., a student at Col. Zadok Magruder High School, Rockville, and Joseph Paul Dougherty, 17, of 1637 Morrill Ct., McLean, Va., a student at McLean High School, each will receive a $250 scholarship.

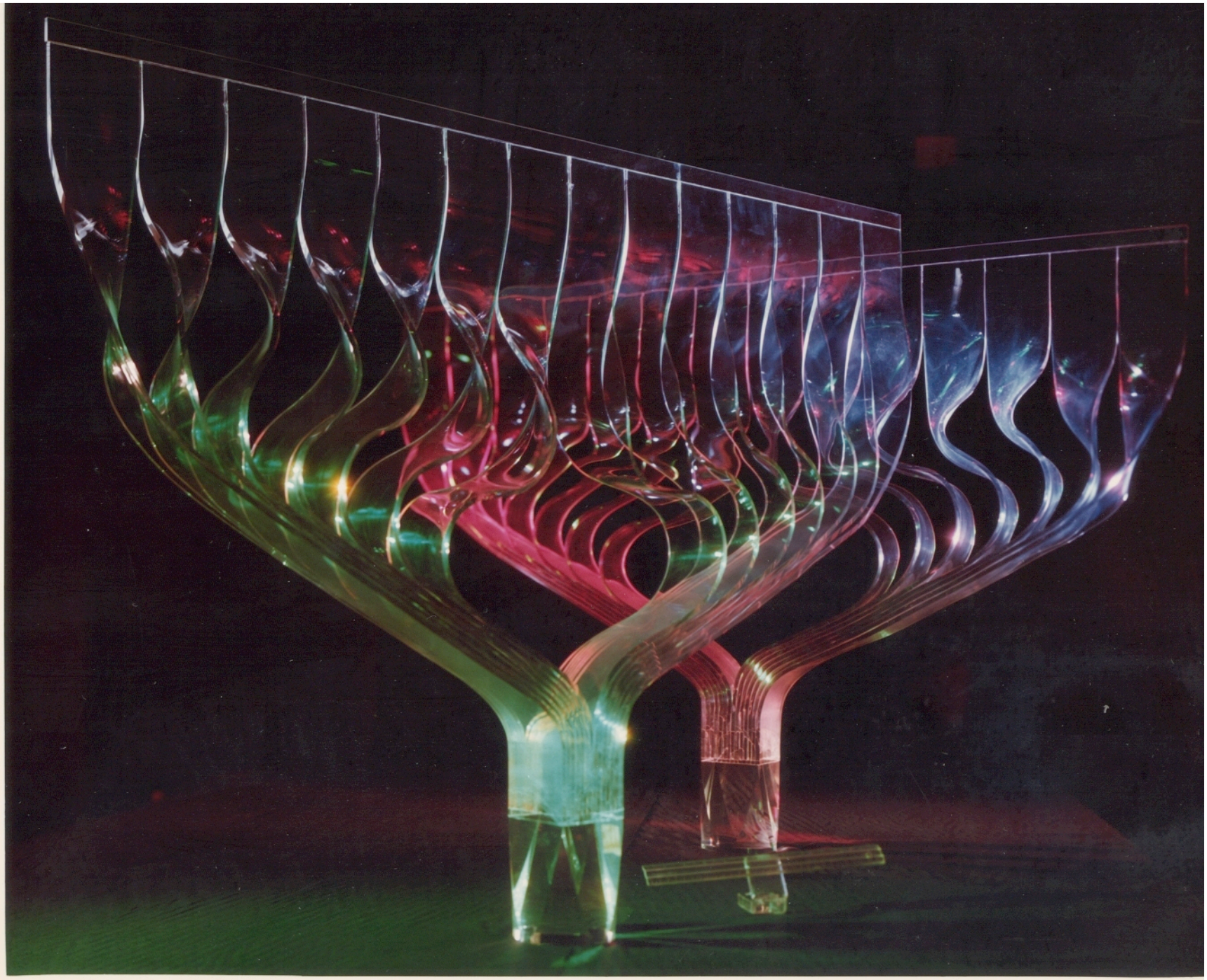
The ten finalists were announced at a banquet attended by 500 persons at the Mayflower Hotel that was addressed by Frank Press, President Carter's science adviser.

In addition to Briggs' $10,000 award, the top nine other winners will share $18,000. The remaining 30 contest winners will each receive $250.

According to officials of the Westinghouse Electric Corp. which sponsors the awards, mathematical concepts such as Briggs' are never patented.

Two of the previous 1,440 national Westinghouse winners later won Nobel prizes. Leon Cooper, who won his scholarship in 1947, was awarded the Nobel prize in physics in 1972, and Ben R. Mottelson, who won in 1944, was awarded the Nobel prize in 1975.

10 NASA G-77-06023 18



NASA G-76-02501

PREPARATION FOR THE SPACELAB SHUTTLE ERA
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HIGH ENERGY
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Mirror
Coincidence Scintillator
Spark Track
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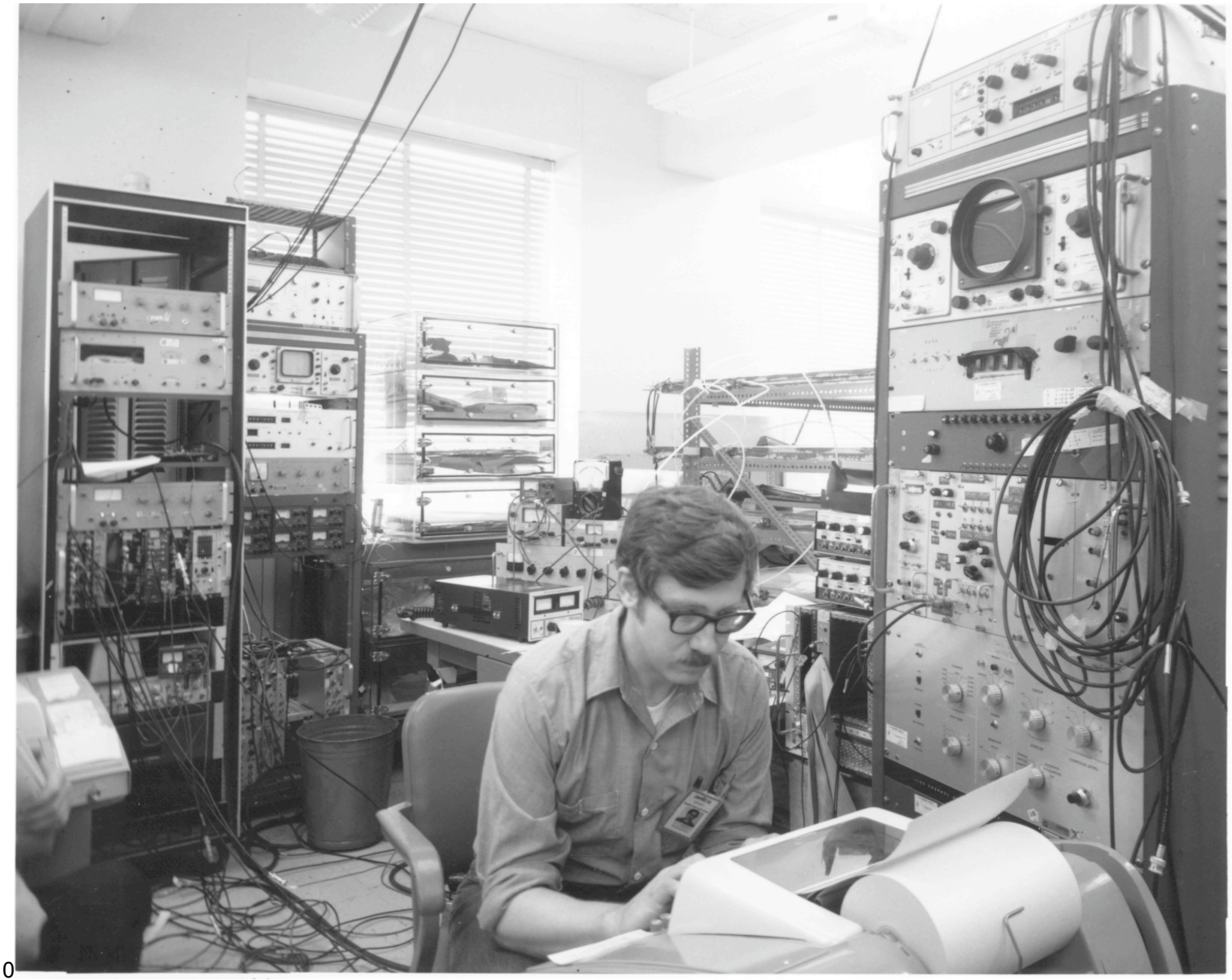
Anti-Coincidence
Scintillators
Coincidence Scintillator
Calorimeter Scintillators
Photomultipliers
ELECTRONICS



10

SECTION 1

TECHNICAL PLAN

ENERGY SPECTRA OF COSMIC RAY ELECTRONS,
PROTONS, AND HEAVIER NUCLEI AT HIGH ENERGIES:

A TRANSITION RADIATION AND IONIZATION CALORIMETER
TELESCOPE FOR SPACELAB (TRIC)

AN INVESTIGATION IN HIGH ENERGY ASTROPHYSICS
SUBMITTED IN RESPONSE TO AO-OSS-2-78

BY

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P. MEYER
T. PRINCE
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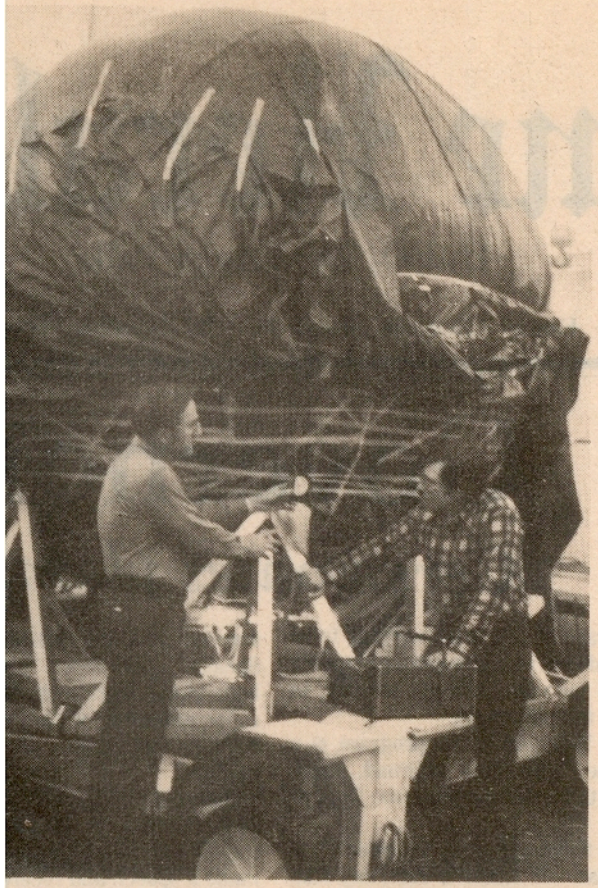

Staff Photo by Robert White

GODDARD-MARYLAND U. CALORIMETER
Righter, Streitmatter with 8,500-pound payload.

A huge aluminum ball covered with insulating material has arrived at the National Scientific Balloon Facility to be groomed for its first flight.

The spherical pressure dome, an energy-measuring device, is called a Calorimeter. It is the joint product of scientists at Goddard Space Flight Center, Greenbelt, Maryland, and the University of Maryland, College Park, Md.

Dr. Robert Streitmatter from the University of Maryland and Don Righter from Goddard SFC, are the scientists here to test the nine and one-half foot diameter instrument.

Other scientists involved in the project include Dr. John Ormes and Dr. V.K. Balasubrahmanyan of Goddard, and Dr. G.B. Yodh, Dr. Robert Ellsworth, Dr. Jordan Goodman and Dr. Palihalli Vishwanath of the University of Maryland.

Their payload will weigh 4¼ tons.

The Calorimeter is designed to measure cosmic ray energy within the high-energy band range of Tev, which is equivalent to a million million electron volts.

Dr. Streitmatter said 13 electron volts are required to pull a hydrogen atom apart.

The spherical pressure dome, to be flown under normal air pressure, is battery-powered. It is designed to measure the energy spectrum of cosmic ray protons and helium.

"If successful, it will measure at approximately to energies 10 times higher than has been done before by direct measurement," Streitmatter explained. He described that hoped-for attainment as evolutionary rather than revolutionary, another step up the ladder in that research field.

Tandem balloons—one above the other—will be used to lift the heavy payload.

The bottom balloon will have 6.7 million cubic feet capacity; the top balloon .47 of a million cubic feet capacity.

"We're here for tests and calibration of the instrument," Dr. Streitmatter said.

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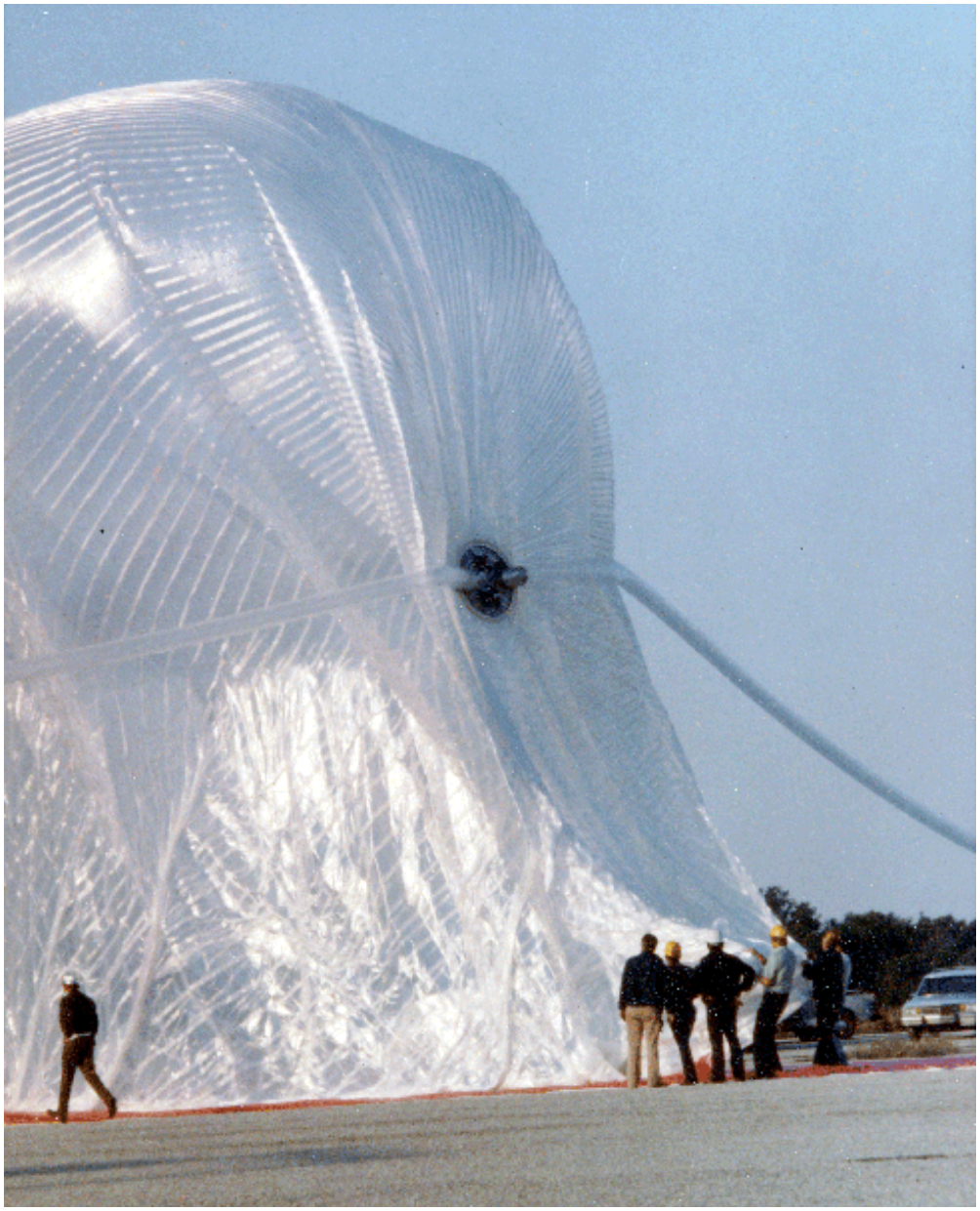
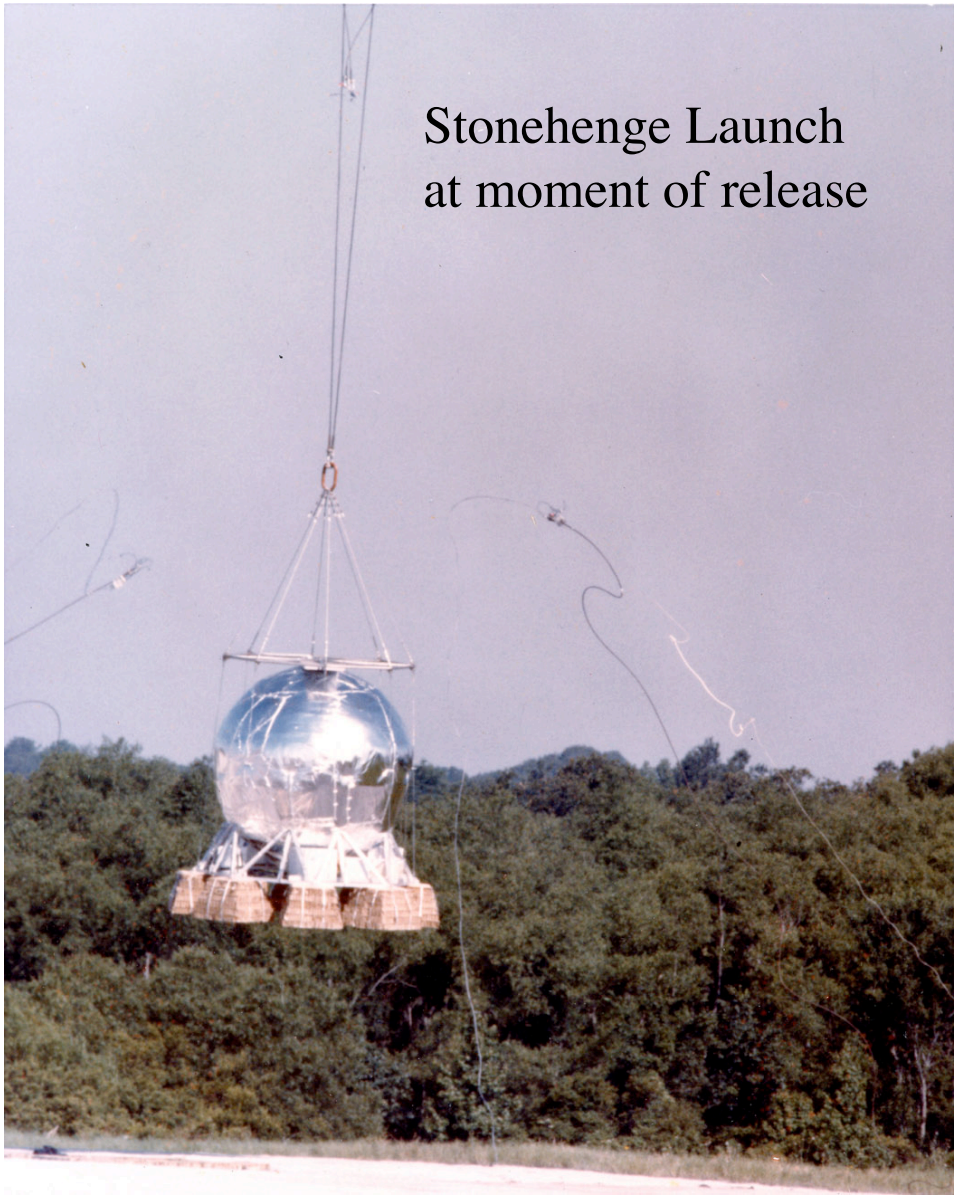
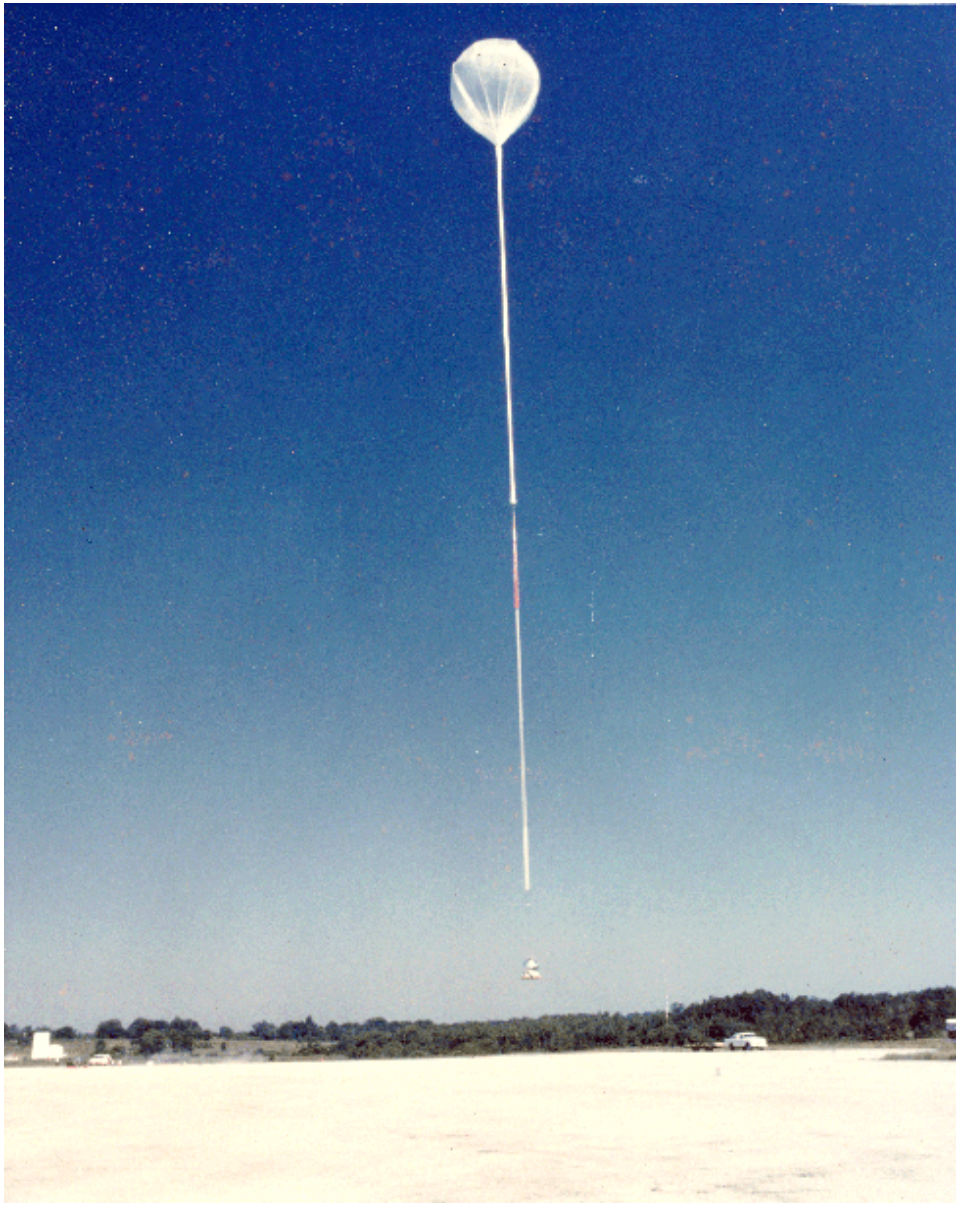
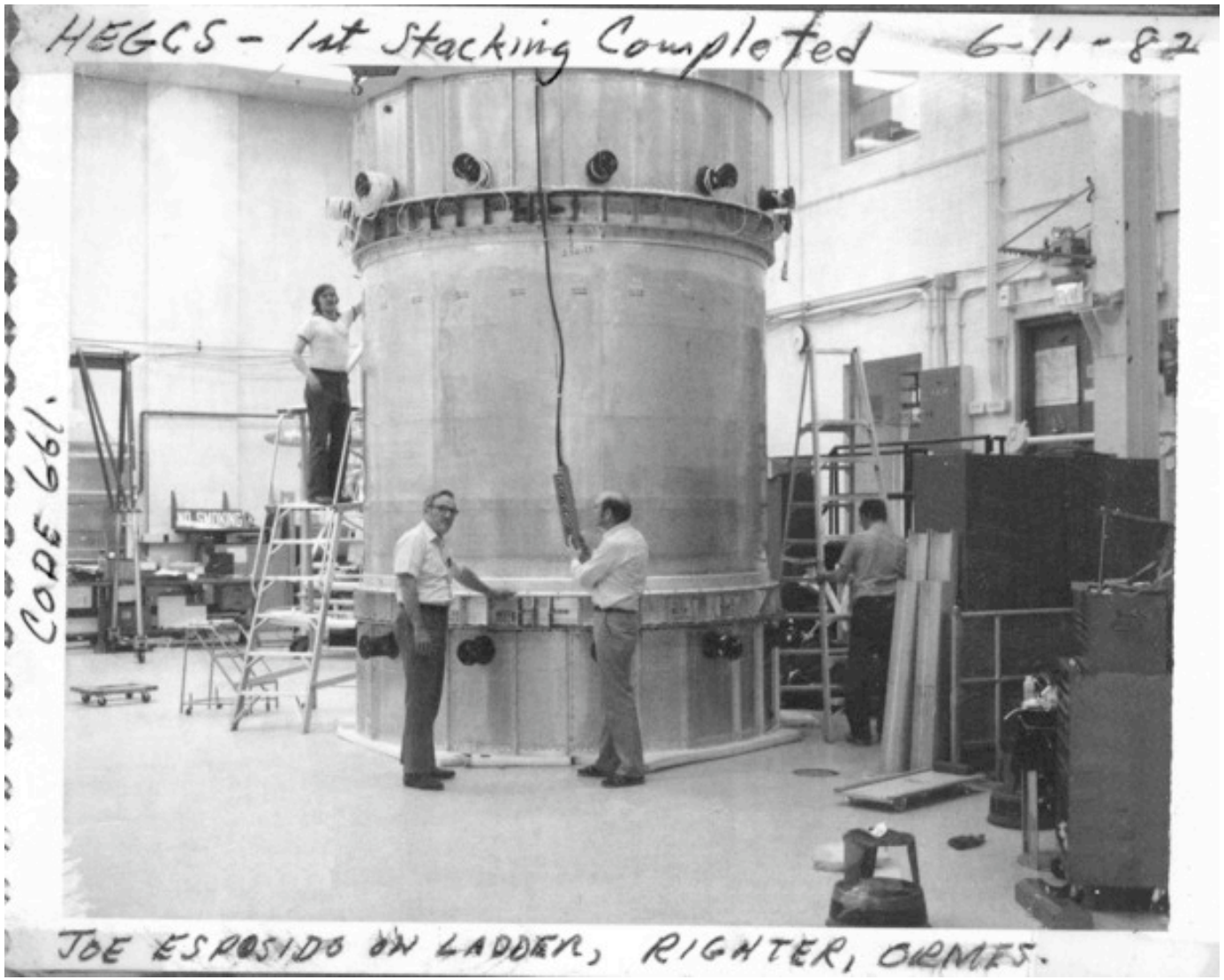
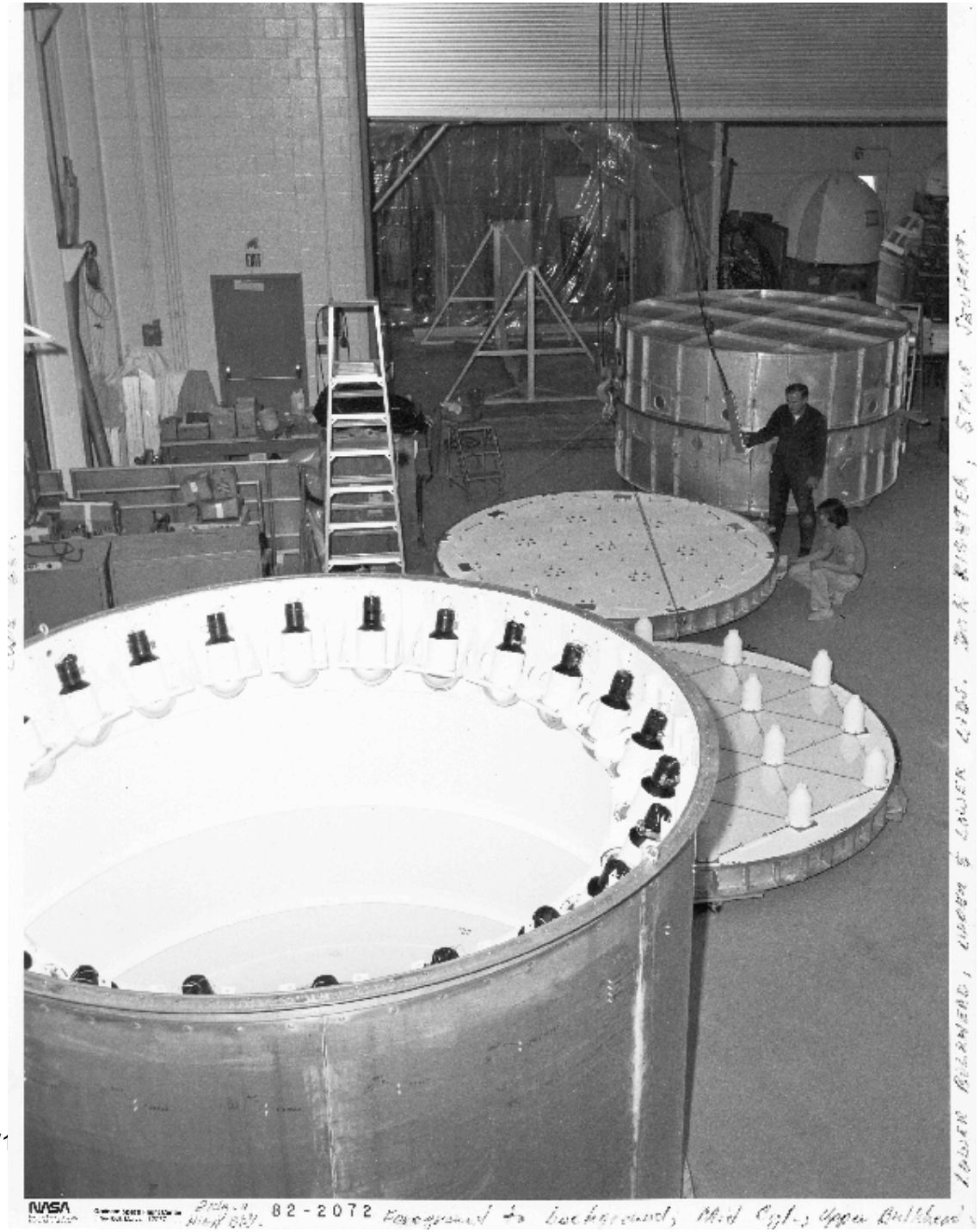



Stonehenge Launch
at moment of release



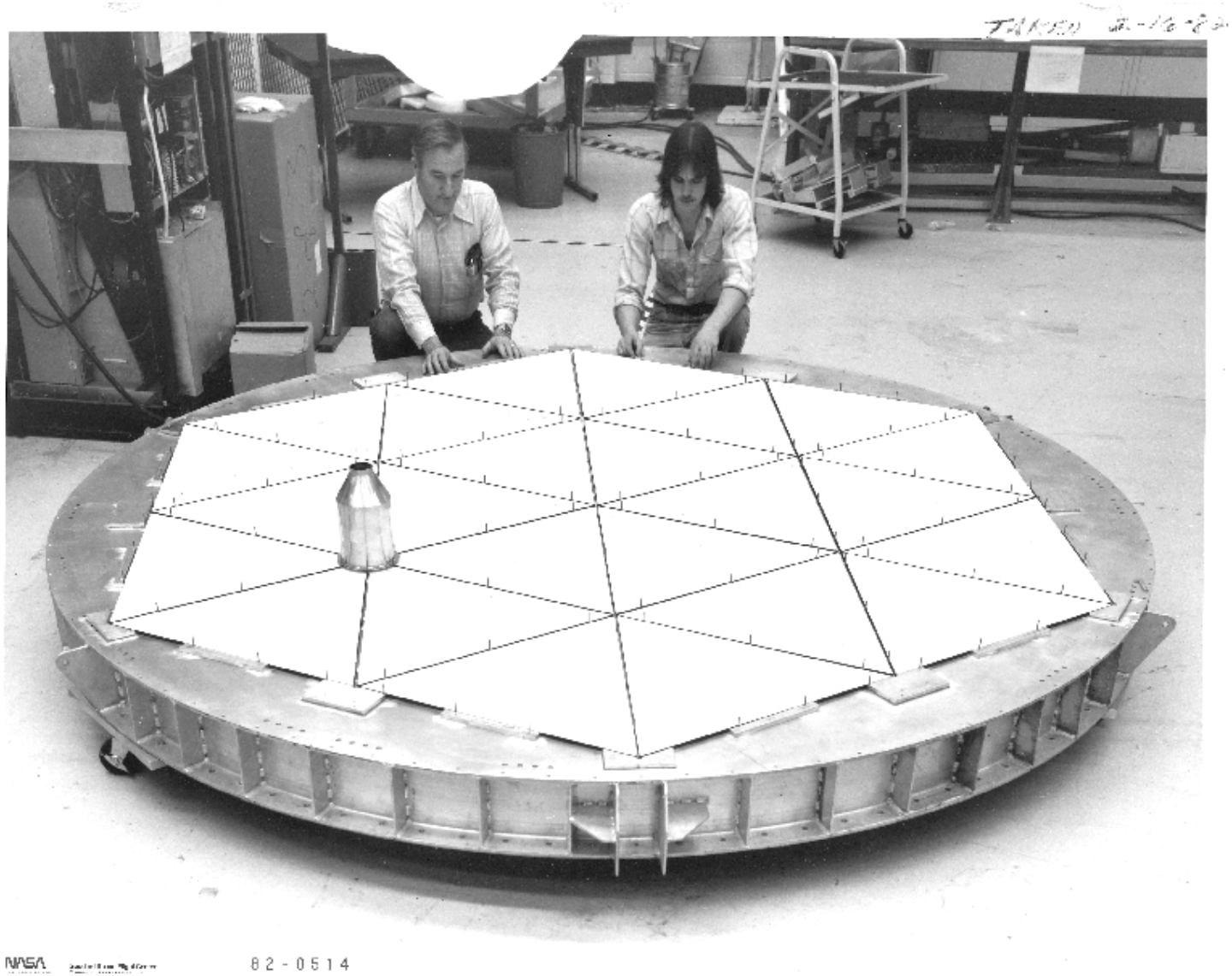


High Energy Gas Cherenkov Spectrometer (HEGCS)



HEGCS

Interior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82-0514

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  EVENT #     61583: NT. NB =   5    24: COSINE =   0.925: LCERT =    1
H( 1)= 115   H( 2)= 115   H( 3)= 107   H( 4)= 122   H( 5)= 105   H( 6)= 120
H( 7)= 100   H( 8)= 118   H( 9)= 100   H(10)= 121   H(11)= 130   H(12)= 133
 TOP HAT AVE =   116  ZTOP =  14.6  TWASC ARRAY :  1 1 1 1 1 1 1 1 1 1 1 1

C( 1)=  47   C( 2)= 251   C( 3)= 307   C( 4)=  55   C( 5)=  -1   C( 6)=  87
C( 7)= 165   C( 8)=  52   C( 9)=   0   C(10)= 155   C(11)=  37   C(12)=  55
C(13)=   7   C(14)=  25   C(15)=  74   C(16)=  33   C(17)=  41   C(18)=  -1
C(19)= 101   C(20)=  -2   C(21)= 235   C(22)=   0   C(23)=   0   C(24)=  -2

 CSUM(1)=   746  CSUM(2)=   464  CSUM(3)=   179  CSUM(4)=   332   GAS C TOTAL=  1721   AVERAGE=   72.04

H( 1)= 134   H( 2)= 100   H( 3)=  93   H( 4)=  93   H( 5)=  89   H( 6)=  96
H( 7)= 100   H( 8)= 108   H( 9)= 114   H(10)= 115   H(11)= 127   H(12)=  77
 BOT HAT AVE=   106  ZBOT =  14.0  TWASC ARRAY:  1 1 1 1 1 1 1 1 1 1 1 0

TOP TRIANGLE ARRAY: GAIN=1.0            BOTTOM TRIANGLE ARRAY: GAIN=1.0

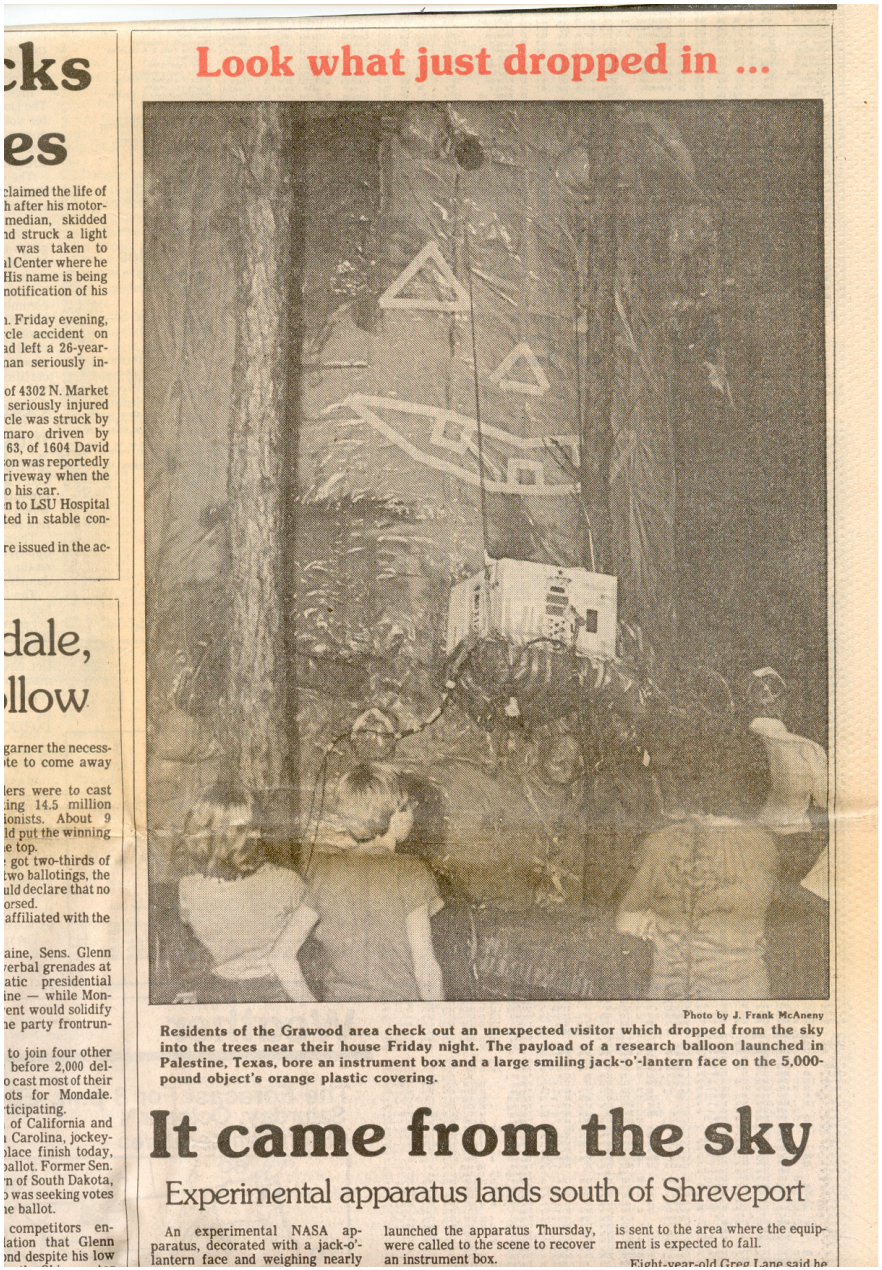
          4      -1       3                          0       0       0

       3     978       4       0                  0       0       0       0

    1      30      49       1       1          4       6       2       0       2

       1       1       3       1                 45     972       1       0

          1       1       0                         51       0       2
```



Look what just dropped in ...

Photo by J. Frank McAneny

Residents of the Grawood area check out an unexpected visitor which dropped from the sky into the trees near their house Friday night. The payload of a research balloon launched in Palestine, Texas, bore an instrument box and a large smiling jack-o'-lantern face on the 5,000-pound object's orange plastic covering.

It came from the sky

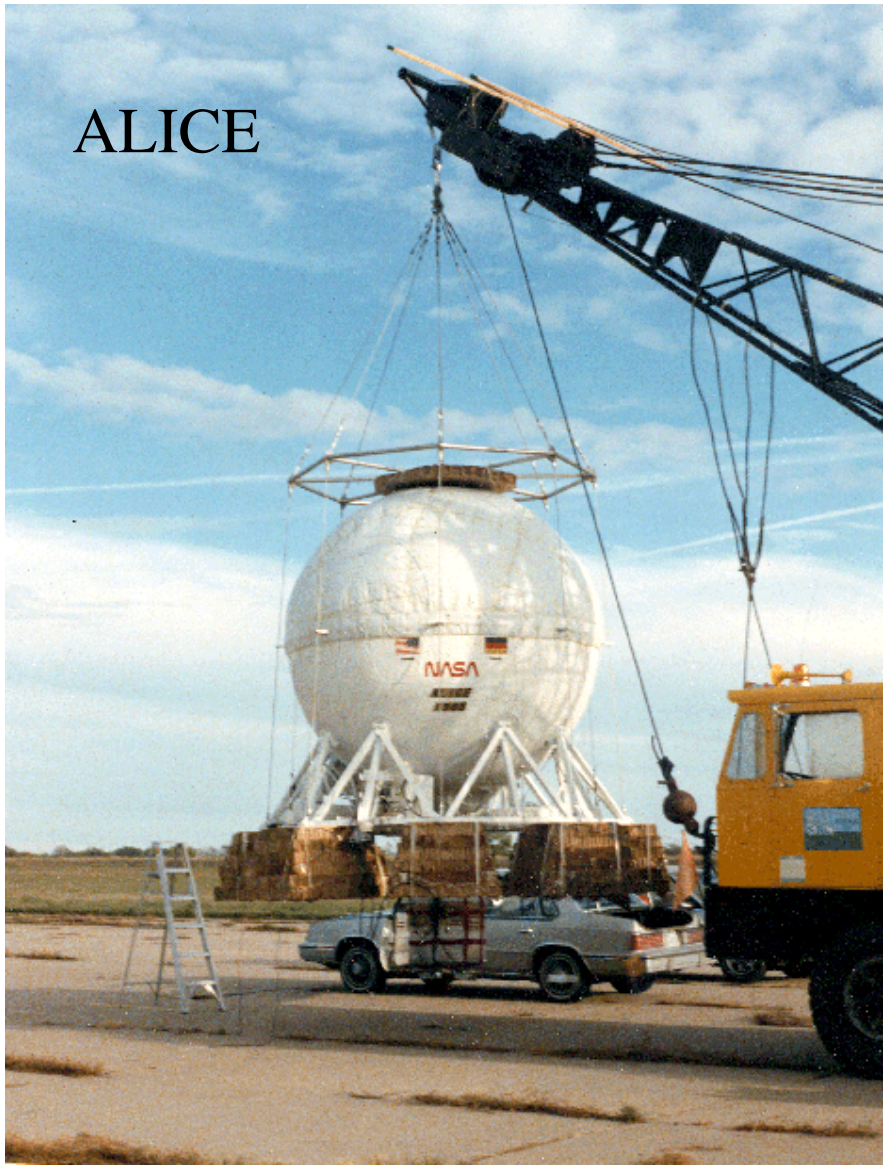
Experimental apparatus lands south of Shreveport

An experimental NASA apparatus, decorated with a jack-o'-lantern face and weighing nearly

launched the apparatus Thursday, were called to the scene to recover an instrument box.

is sent to the area where the equipment is expected to fall.

Eight-year-old Greg Lane said he



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"Measurement of the Cosmic Ray Iron Spectrum Between 60 and 200 GeV/nucleon", **J.A. Esposito**, R.E. Streitmatter, V.K. Balasubrahmanyan, and J.F. Ormes, 1990, Astrophysical Journal, **351**, 459.

"Experimental Limit on Low Energy Antiprotons in the Cosmic Radiation", R.E. Streitmatter, S.J. Stochaj, J.F. Ormes, R.L. Golden, S.A. Stephens, T. Bowen, A. Moats, and J. Lloyd-Evans, 1989, Advances in Space Science, **9**, (12) 65.

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"**A Local Superbubble Model of Cosmic Ray Origin**", R.E. Streitmatter, V.K. Balasubrahmanyan, R.J. Protheroe, and J.F. Ormes, 1985, Astronomy and Astrophysics, **143**, 249.

"Implications of HEAO-3 Data for the Acceleration and Propagation of Galactic Cosmic Rays", **J.F. Ormes and R.J. Protheroe**, 1983, Astrophysical Journal, **272**, 756.

High Energy Cosmic Ray Group Scientists

V. K. Balasubrahmanyan	**Bob Streitmatter**
John (Eric) Arens	Louis Barbier
Eric Christian	John Mitchell
Alex Moiseev	John Krizmanic
Frank Jones	

The Postdocs, Visiting Scientists

Michael Ryan	Ron Maehl
Andrew Fisher	Vernon Jones
Francois Siohan	Jeremy Lloyd-Evans
Ray Protheroe	B. Acharya
Ted Bowen	Alfred Stephens
Eugene Loh	Pierre Sokolsky

The Students

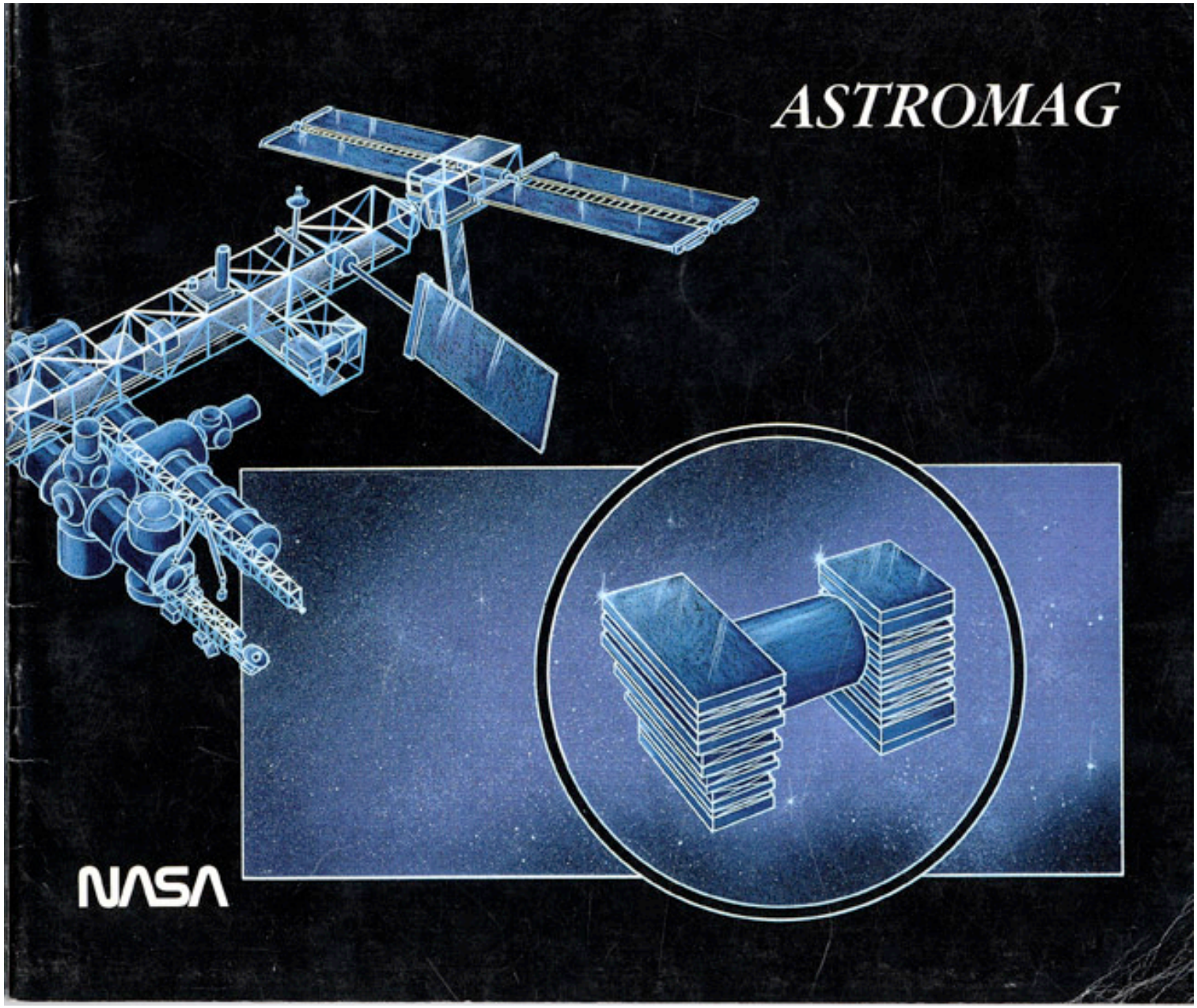
Bob Price (CU)	Bob Silverberg (UMD)
Manfred Simon (MPE)	Frank Hagen (UMD)
Steve Stochaj (UMD)	Eun-suk Seo (LSU)
Thomas Hams (Siegen)	Joe Esposito (UMD)
Alan Labrador (CIT)	Olaf Reimer (Siegen)

Andreas Hess, Wolfgang Menn, Michael Hof, Jens Kremer. Mathias Bremerich (Siegen), several Italians (Bob Golden and Steve Stochaj's programs) and many Japanese on BESS.

The Muscle

Russ Greer	Tony Puig
John Laws	Jessie Purvis
Lee Stonebraker	Jerry Cooper
Don Righter	Frank San Sebastian
Steve Holder	

Special thanks to many others like Charlie Ehrmann, Don Stilwell, Chuck Glasser, Beth Jacob, Pat Tyler and David Friedlander who helped along the way.



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LEAP

IMAX

Astromag spawned

- Renewed support for Bob Golden's balloon program (taken over by Steve Stochaj)
- The HEAT line of balloons. Some of these folks got Ting interested in antimatter which led to AMS.
- Italian balloon program collaborating with Golden. Many of these people are working on GLAST today.
- Japanese balloon program collaborating with GSFC and UMD (BESS).

Astromag went poof…

- Only choice is to be serious about management

Albert Einstein was once quoted as saying something like “To punish me for my contempt for experts, God has seen fit to make me one.” I have paraphrased this as follows: “To punish me for my contempt for management, Frank McDonald saw fit to make me one.”

- And get onto the next generation gamma-ray astronomy
- Best hope for solving the origin of cosmic rays

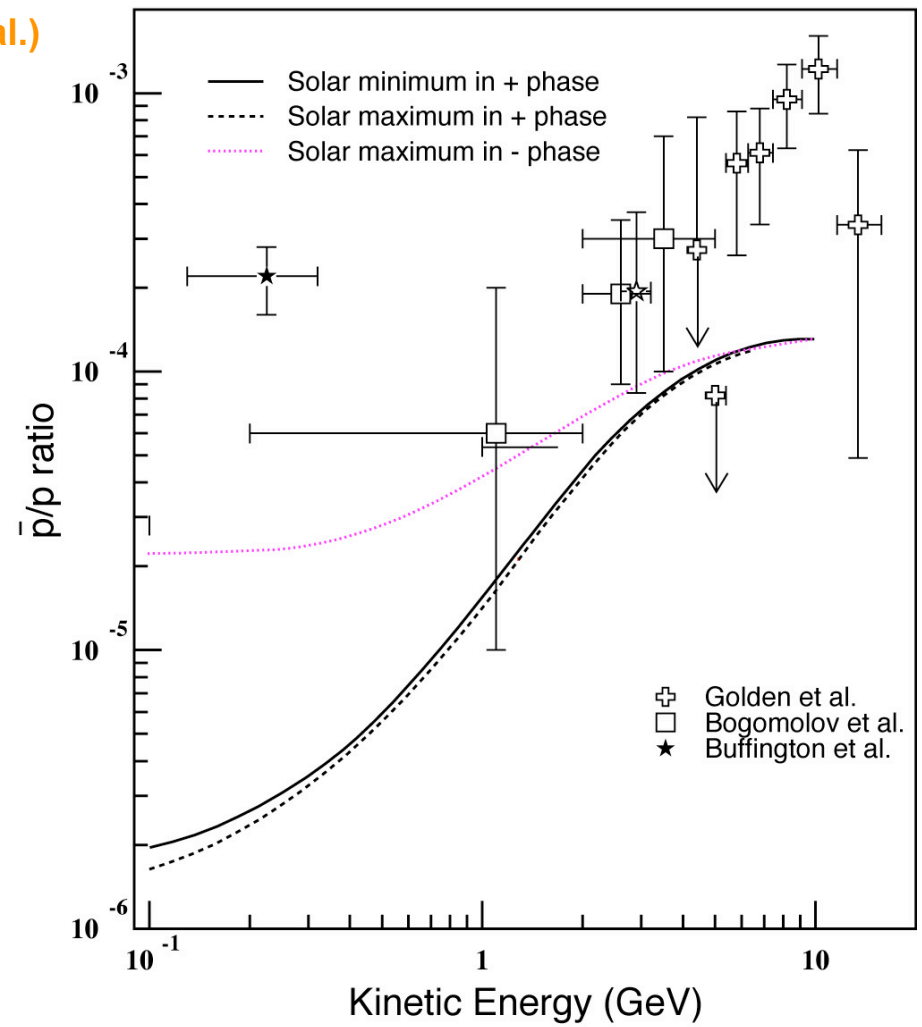
Searching for Antimatter II - - BESS

Japan-U.S. Astromag was the beginning !

History of the Search for Cosmic-ray Antiprotons

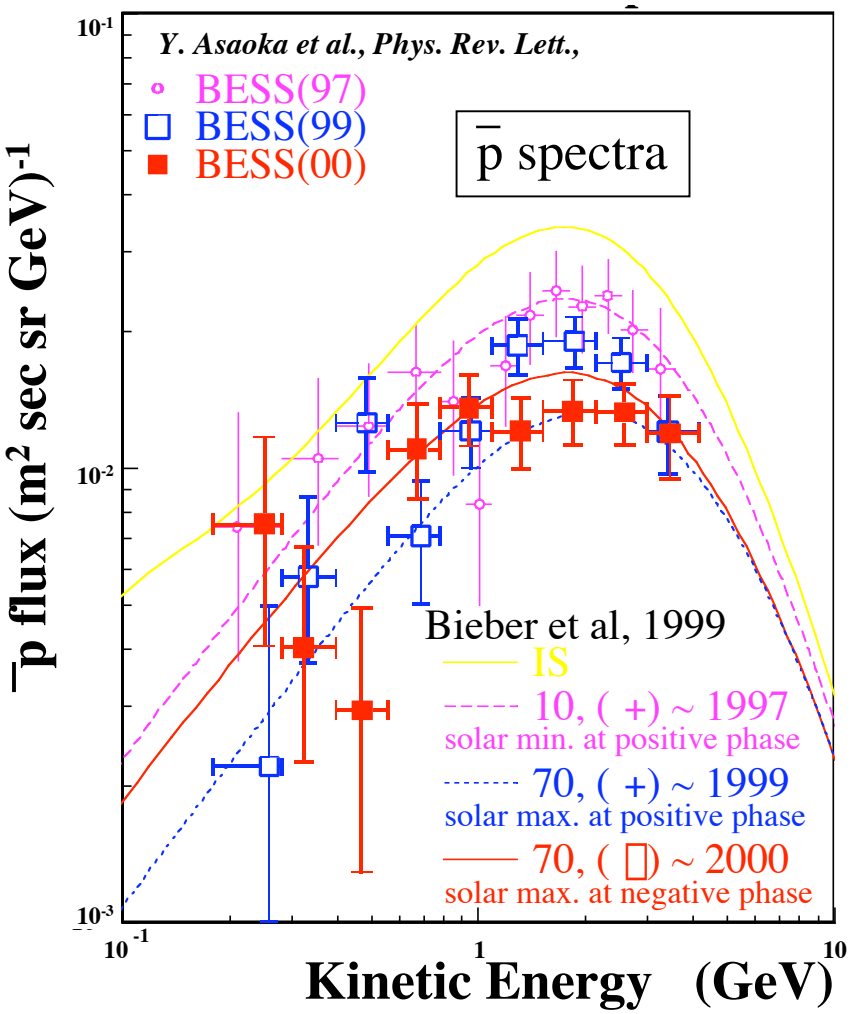
1960s: L. Alvarez et al. Balloons & HEAO
1979: First claimed observations (Bogomolov et al. and Golden et al.)
1981: Low-energy excess (Buffington et al.)
1985: ASTROMAG Study Started
1987: LEAP, PBAR (upper limits)
1991: MASS
1992: IMAX (16 mass-resolved antiprotons)
1993: BESS (6 antiprotons), TS93
1994: CAPRICE94, HEAT-$e^{\pm}$
1996-7: BESS series to Solar minimum
1998: CAPRICE98, AMS-01
2000: BESS 99-00, HEAT-pbar
2004-5: BESS-Polar, PAMELA
2006: BESS-Polar
2007: Solar minimum
2007-8: AMS-02

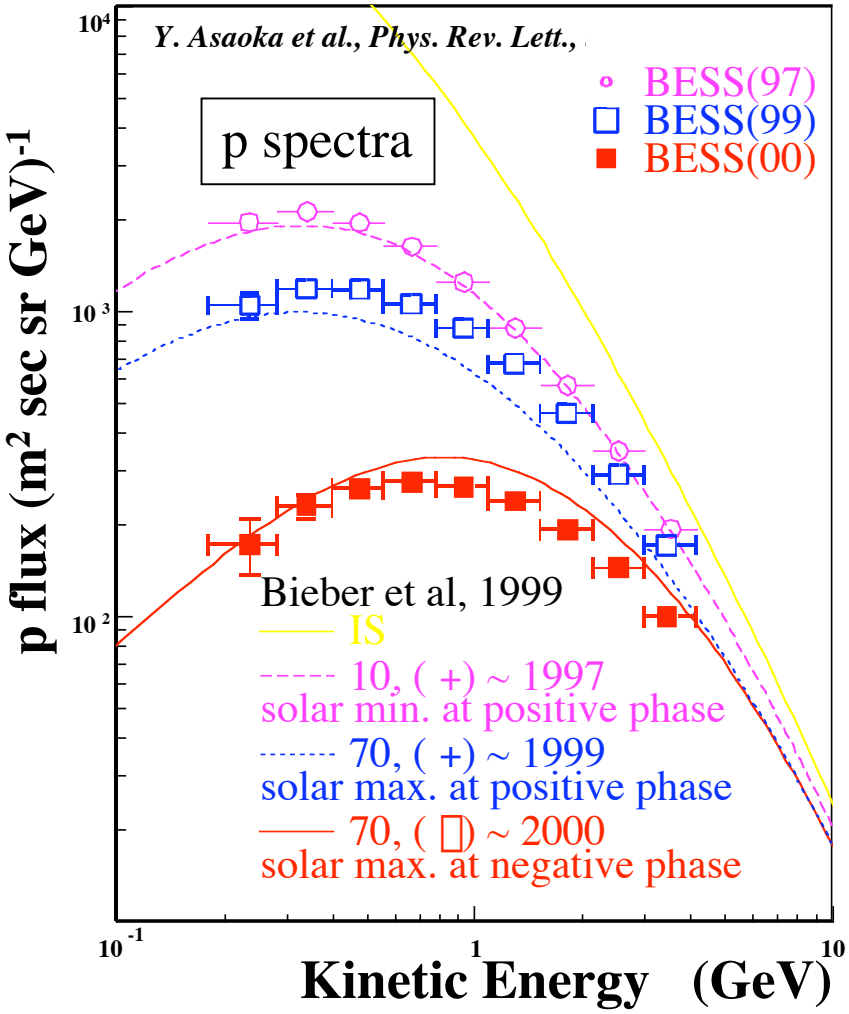
Antiproton measurements, ca 1980
Disagreement with "theory"



Prepared with R. E. Streitmatter

Effect of Solar Modulation on $\bar{p}$ and p Spectra



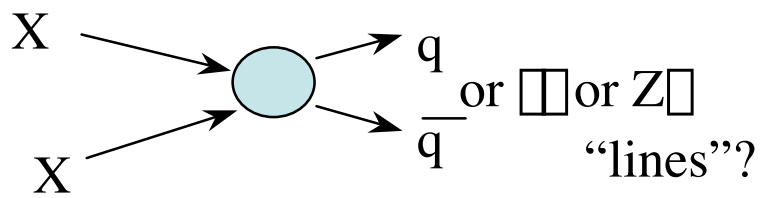


Y. Asaoka et al., PRL, Vol. 88, No. 5, 2002

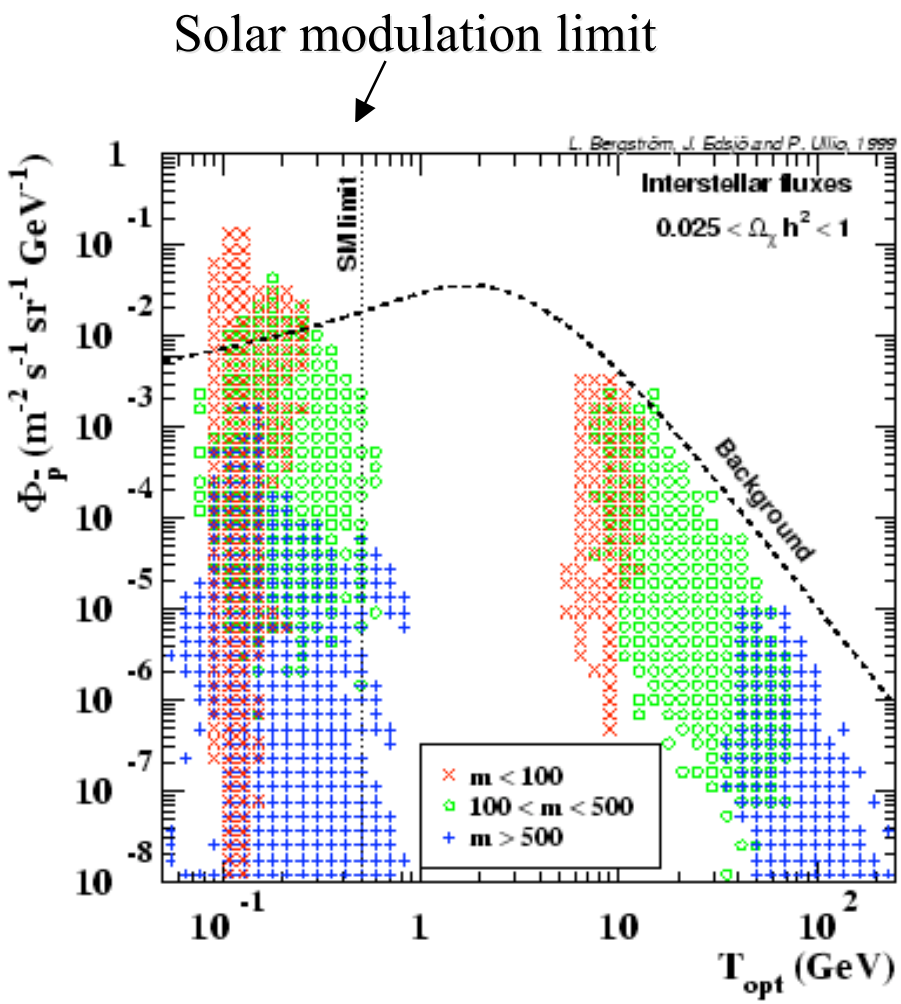
WIMP Dark Matter Annihilations?

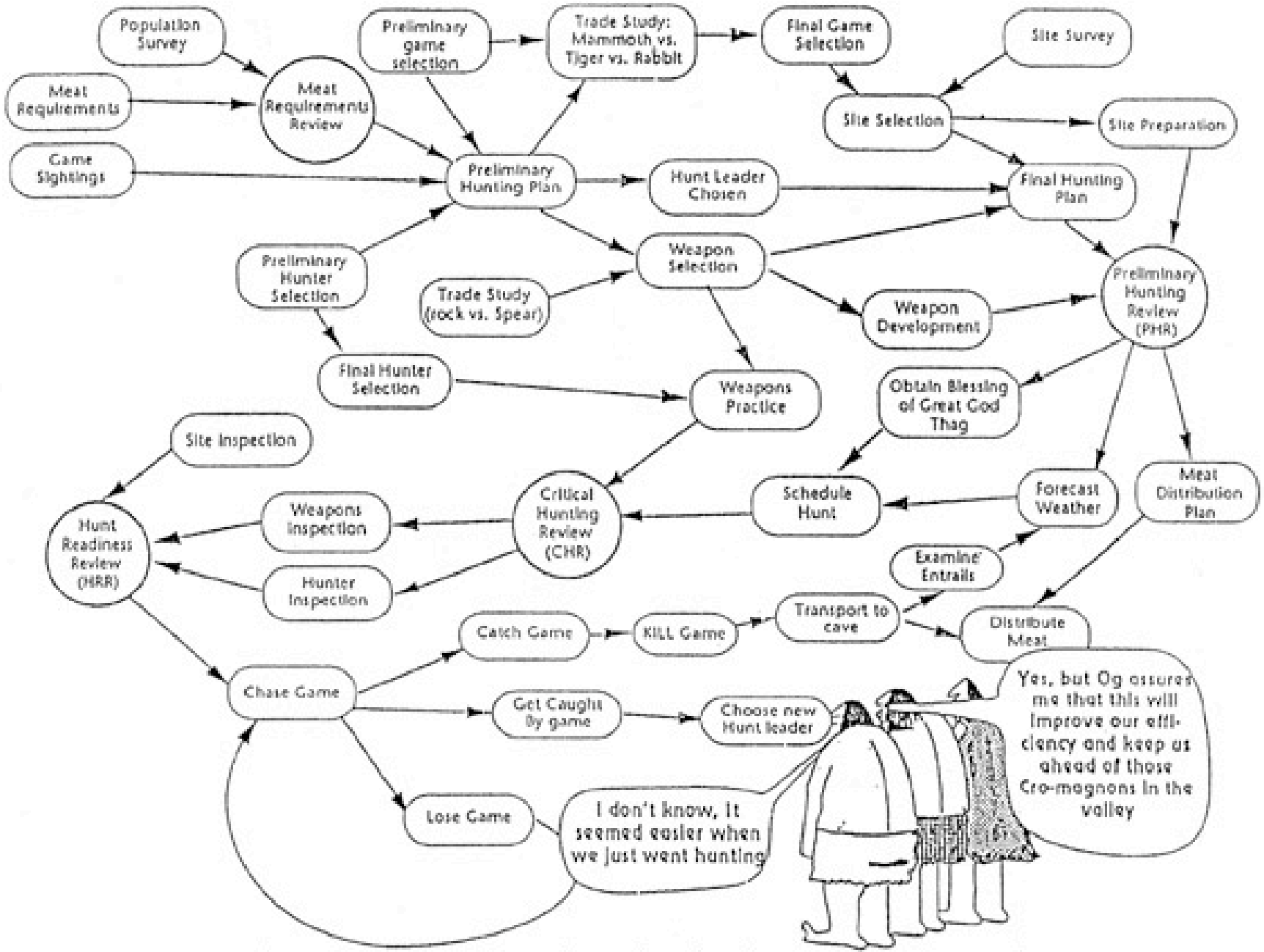
Extensions to the Standard Model of Particle Physics provide candidates for galactic halo dark matter. This would be a totally new form of matter.

If true, there may well be observable halo annihilations into continuum and mono-energetic gamma rays,



cosmic-ray antiprotons and positrons.

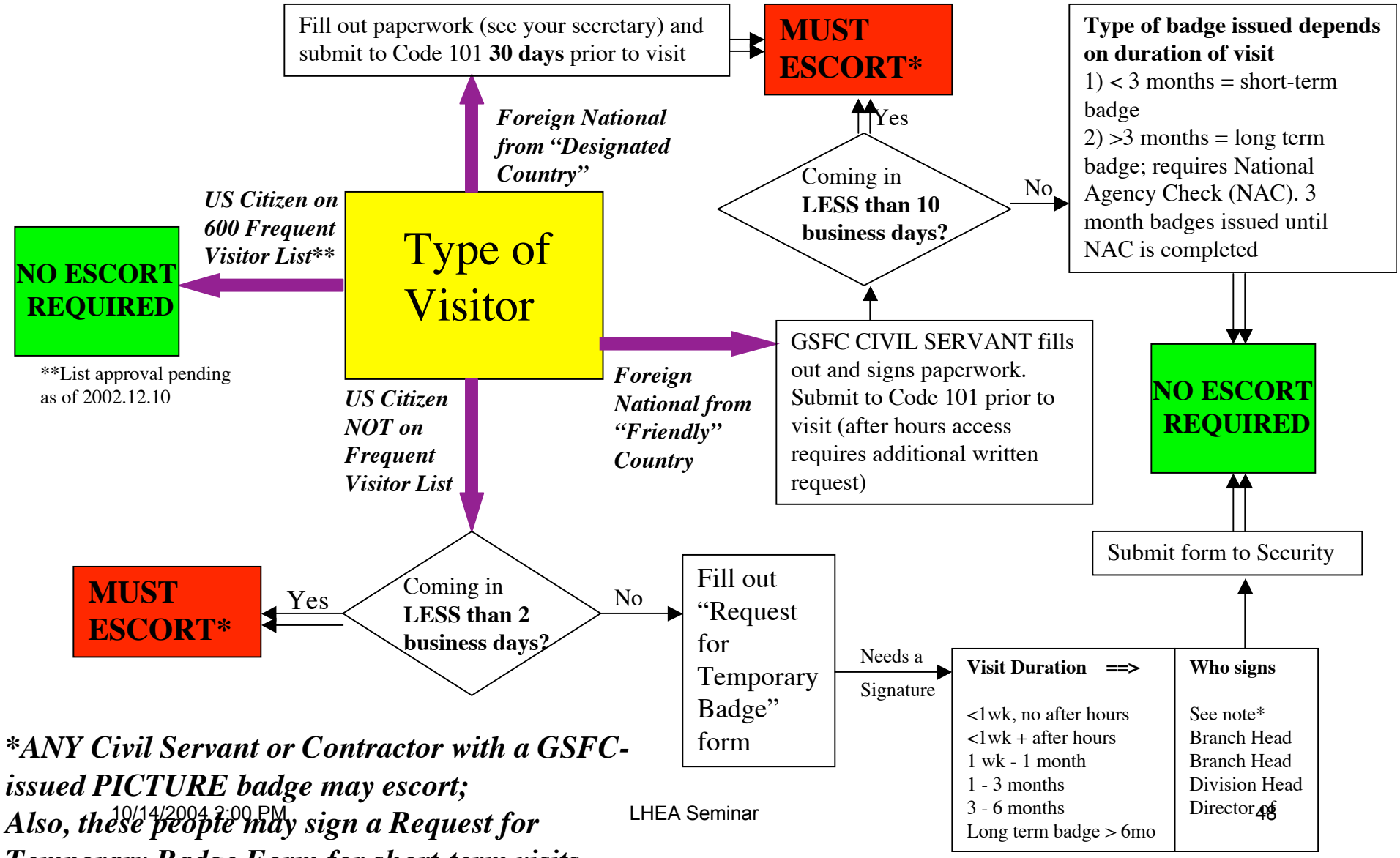




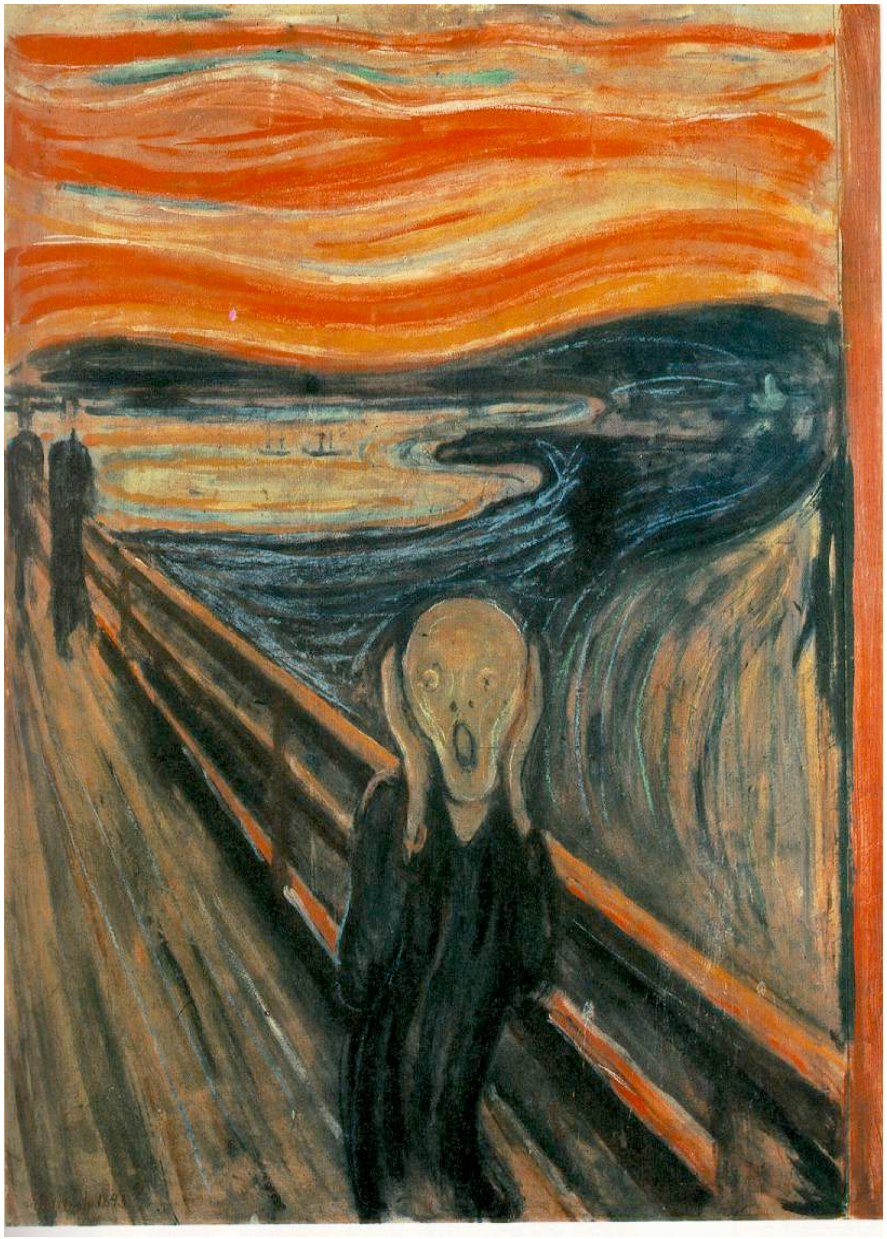
Why the Neanderthals became extinct

Summary of GSFC Visitor Access Rules/Processes

(as of 12/03/2002)



ANY Civil Servant or Contractor with a GSFC-issued PICTURE badge may escort;
Also, these people may sign a Request for Temporary Badge Form for short-term visits



The Scream

ISO9001

ITAR

Full Cost Accounting

Travel Manager

Integrated Financial Management

Security Training

WebTADS

OneNASA

Dun & Bradstreet Number

Strategic Plans

Why I retired - professional

"If the horse dies, dismount."

- Always wanted to be an academic
- Had gotten away from doing research
- Was getting disconnected from GLAST
- Had spent the past year dealing with change (especially full cost) and more was on the horizon (little did I know)
- If I don't do it now, I won't ever be able to do it - I'm 65, maybe it's already too late

On management

- For the most part I enjoyed it
  - Broader perspective on the science
  - Meeting some very impressive people
- It's not as arbitrary and capricious as it seems from below, the goals are just different
- When things were out of my control, I didn't like it
  - Working other peoples agendas
  - Inefficiency - time is a precious commodity
  - Lack of interest in and understanding of the science by upper management

Why I retired - personal

- Grew up in Colorado
- We came here for 2 years -
  - one day I was a civil servant
- Thirty five years went by
- Jan began complaining about the humidity
- Always wanted view of mountains and sunset
- Had decided several times to look for property in CO
- Son got a job in Colorado, granddaughter is already 4!
- Found a house that we could afford that has the view, the space and the state

"Sometimes I wonder if there's more to life than unlocking the mysteries of the universe."

The looking ahead part

The Space Science Enterprise

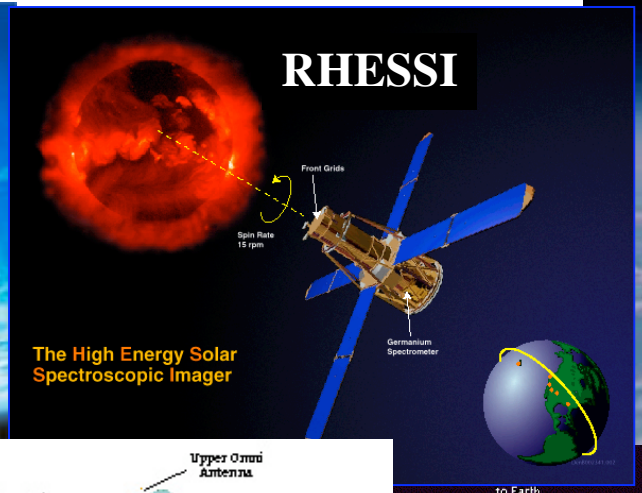
Seeks to discover

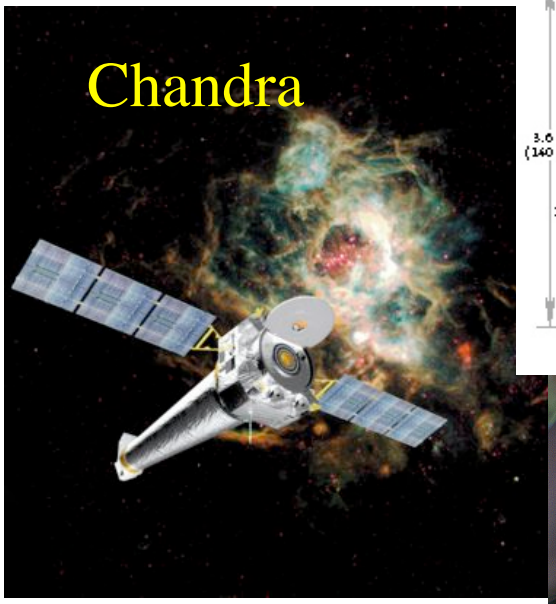
- How the universe began and evolved,
- How we got here,
- Where we are going and
- Whether we are alone.

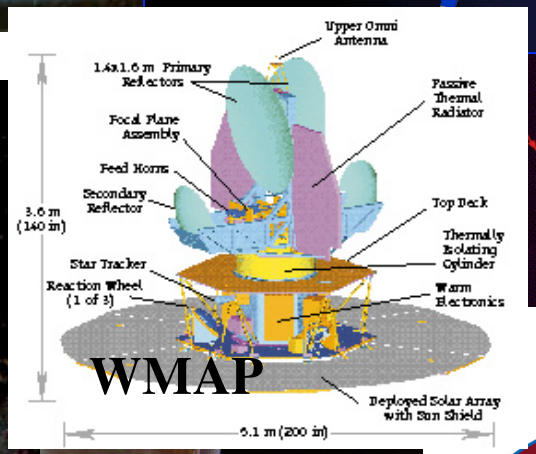
By these efforts we hope to inspire the next generation

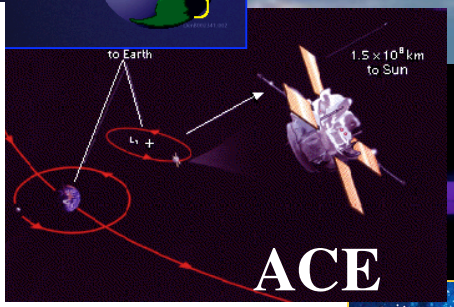
This is great stuff!!

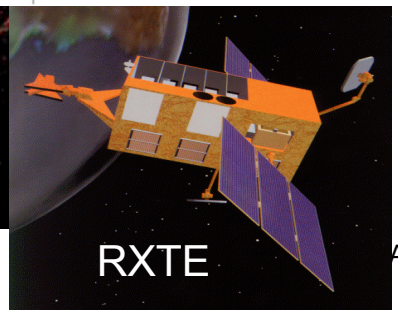
Currently Operating Flight Projects

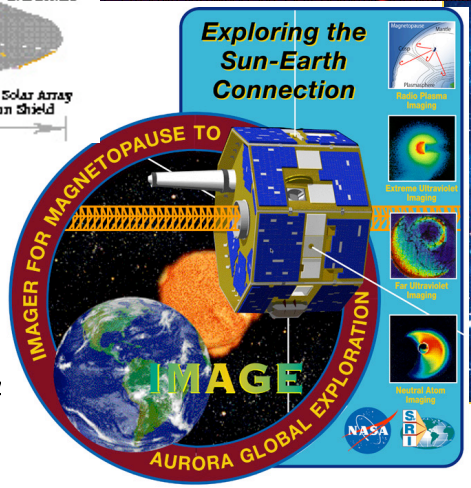


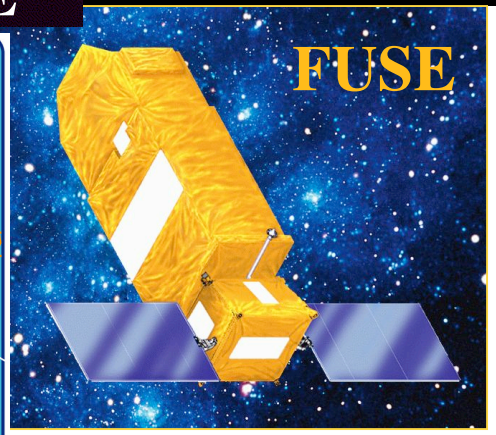




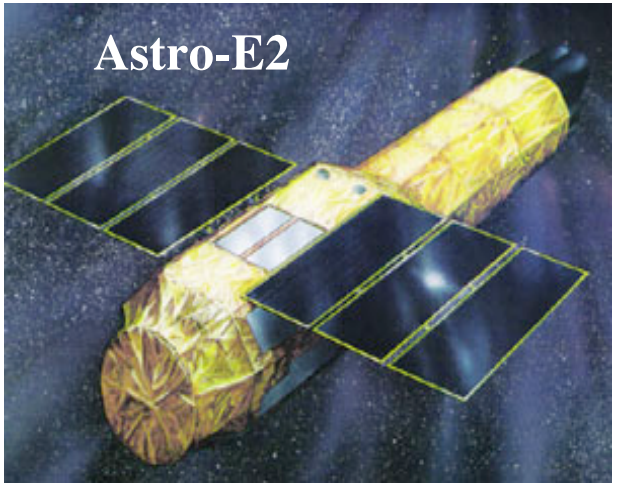


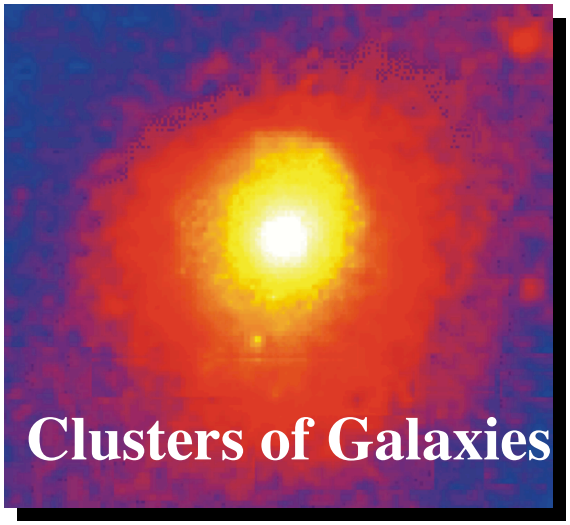


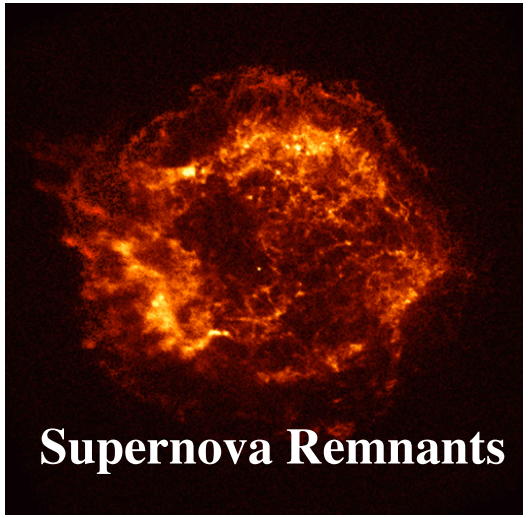


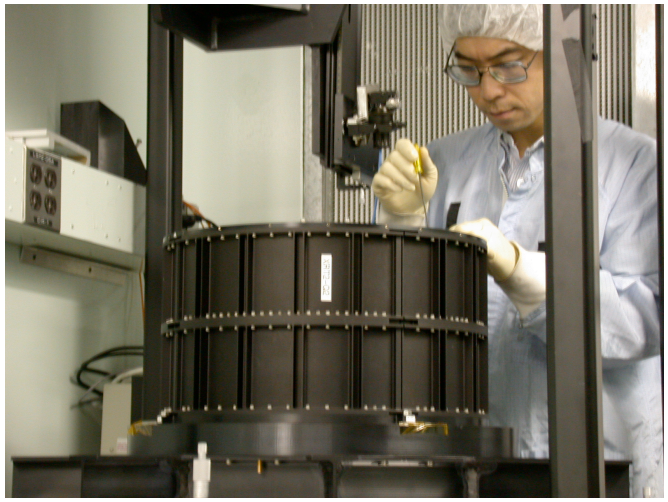


Astro-E2

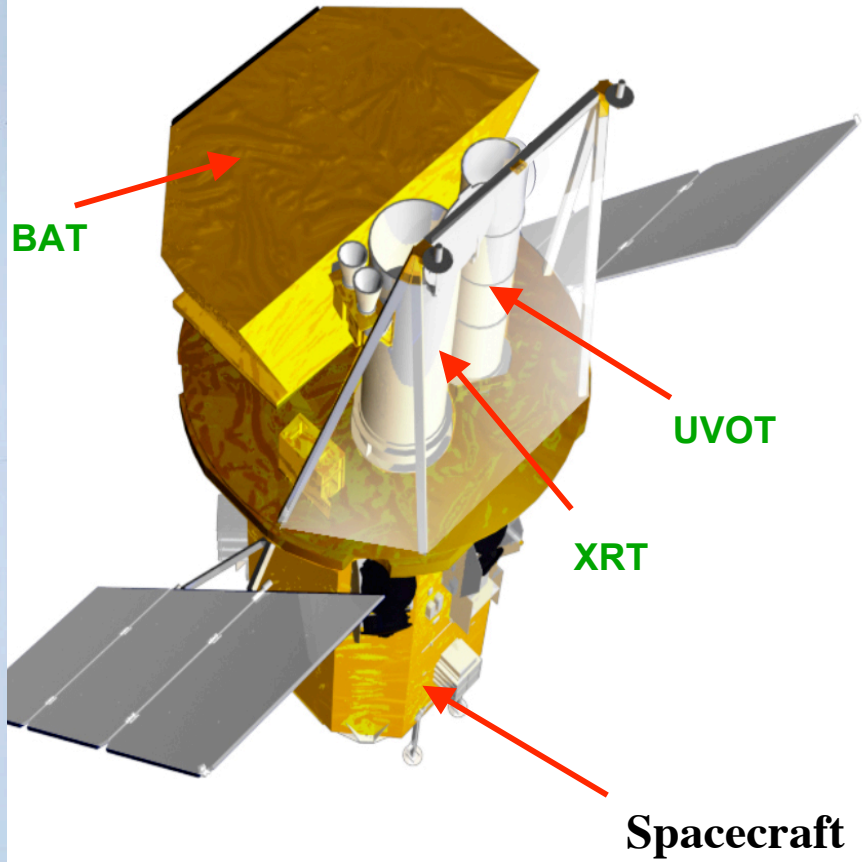




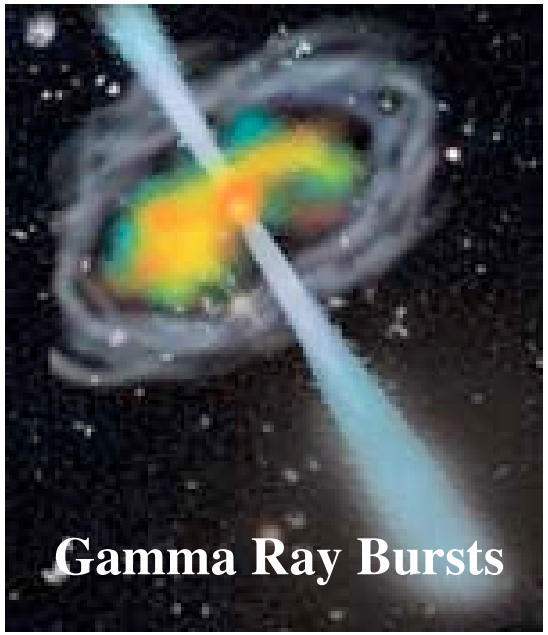


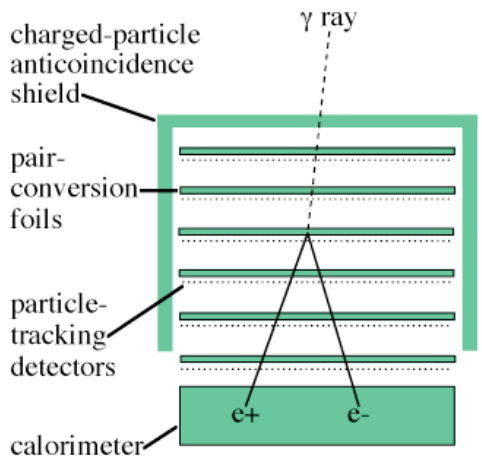


Swift Instruments



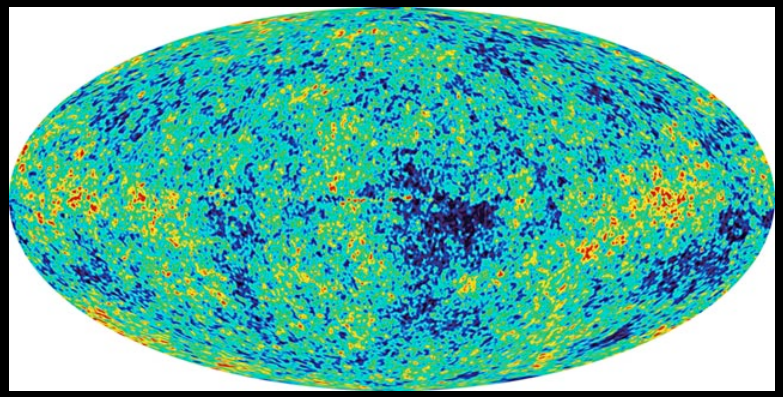
Gamma-ray Large Area Space Telescope (GLAST)

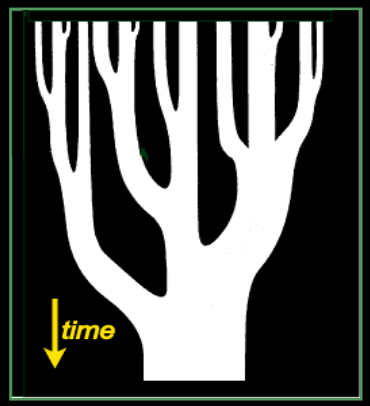




- **Understand the mechanisms of particle acceleration in astrophysical environments such as active galactic nuclei, pulsars and supernova remnants**
- **Determine the high energy behavior of gamma-ray bursts and other transients**
- **Resolve and identify point sources with known objects**
- **Probe dark matter and the extra-galactic background light in the early universe**

Top JWST Goal - Find the First Light after the Big Bang

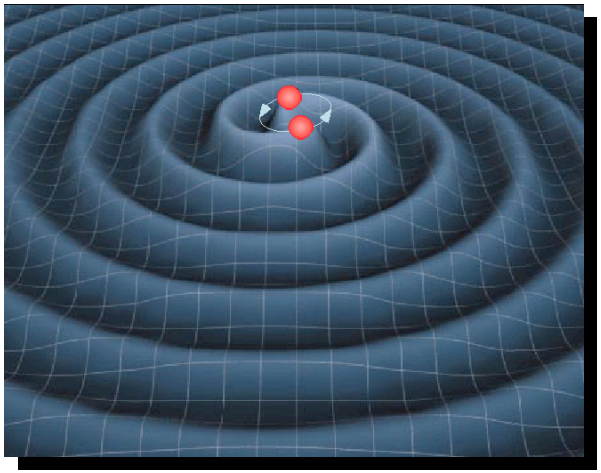




- How and from what were galaxies assembled?
- What is the history of star birth, heavy element production, and the enrichment of the intergalactic material?
- How were giant black holes created and what is their role in the universe?
- Three instruments to do this: NIRCam (NASA/CSA), NIRSpec (ESA), MIRI (ESA/consortium/NASA)

Gravitational Radiation

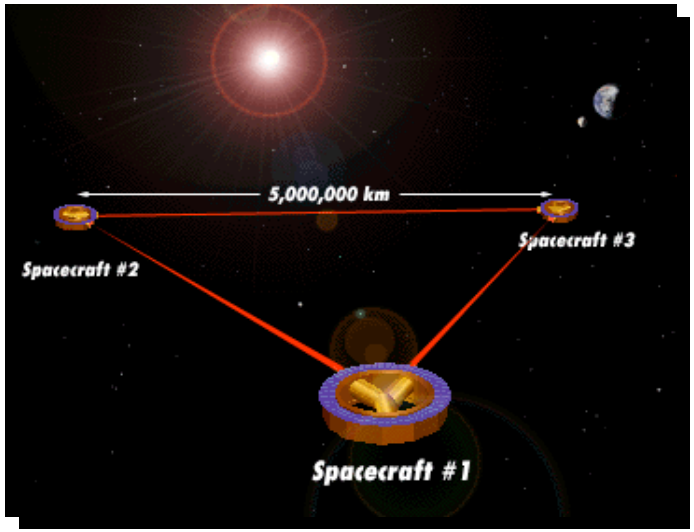
A new window on the universe….



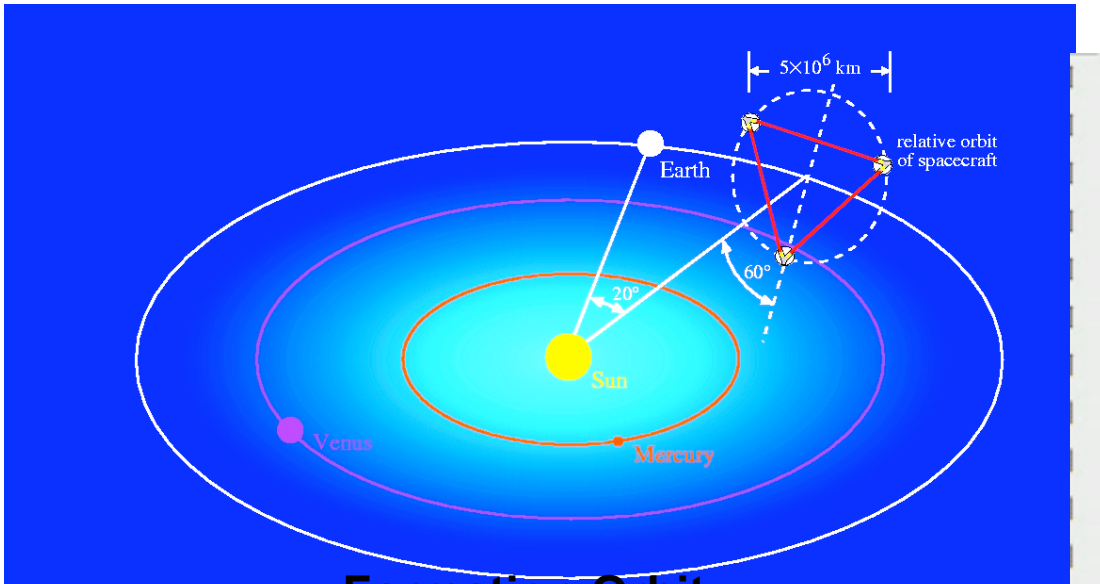
Orbiting objects will emit gravitational radiation

The strongest signal comes from two black holes

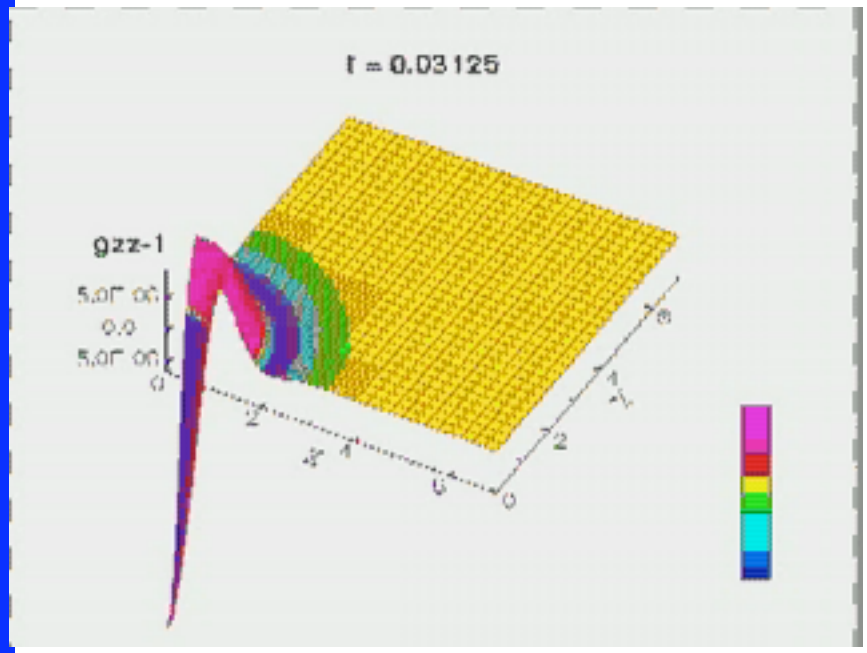
Black hole mergers in distant galaxies will test General Relativity in the extreme

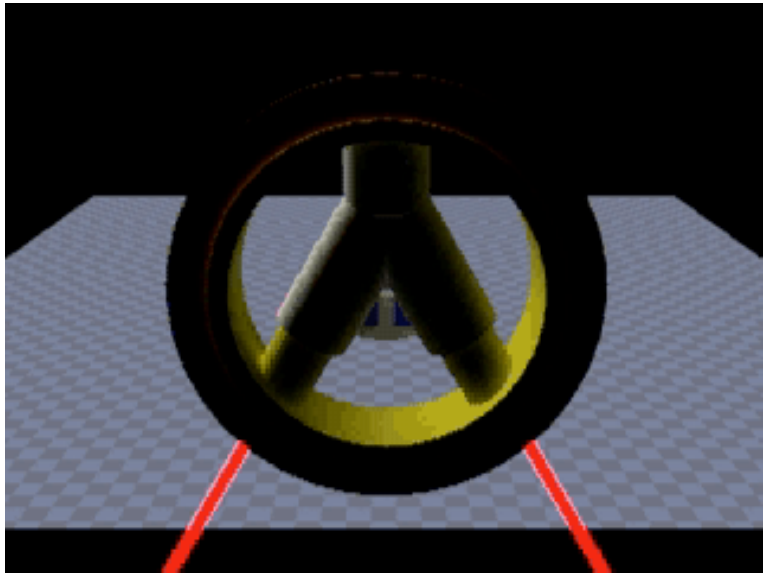


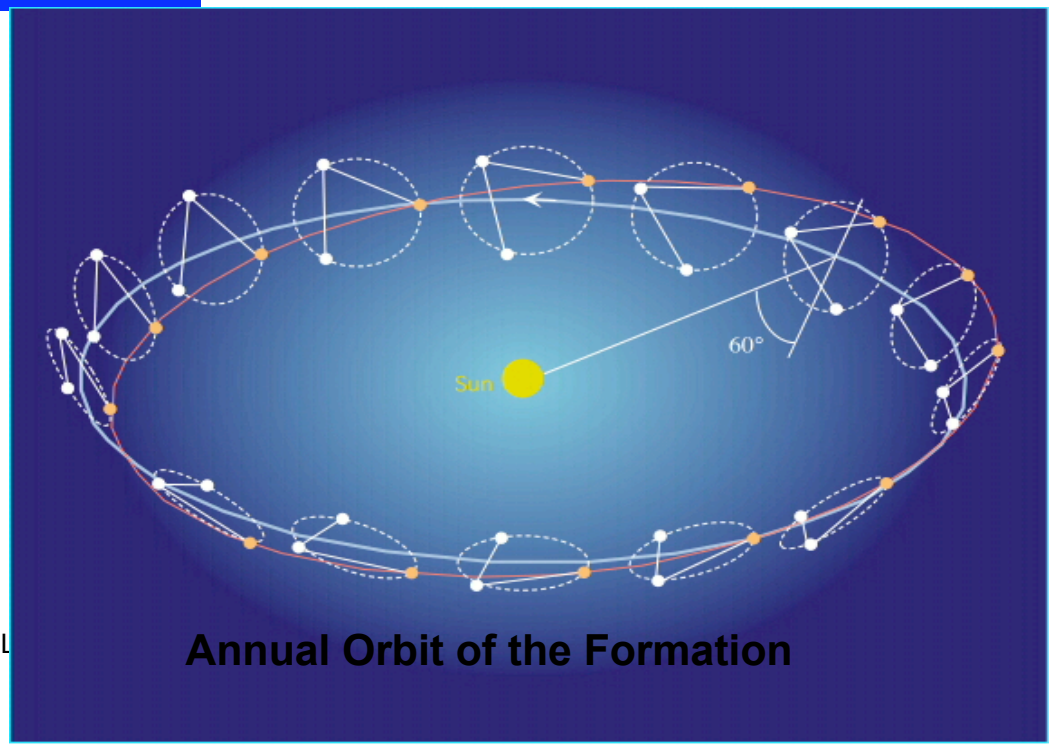
LISA - First space based Gravitational Wave Telescope



Formation Orbit Relative to the Earth

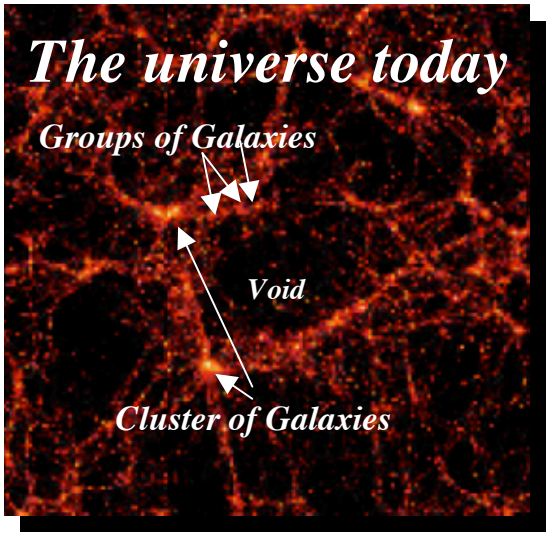






Annual Orbit of the Formation

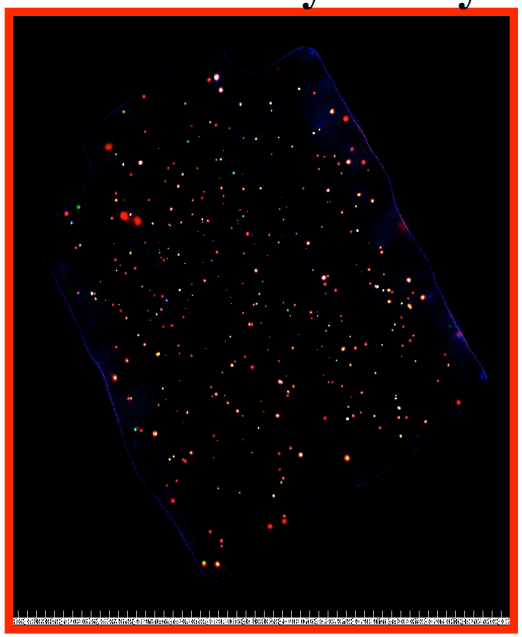
Constellation X-ray Mission

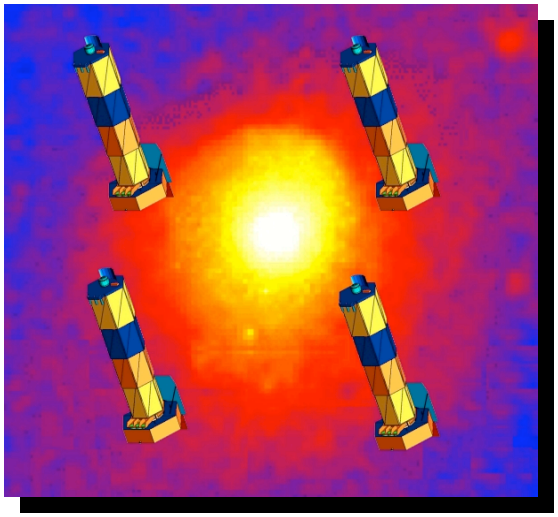


Map dark matter & study black holes

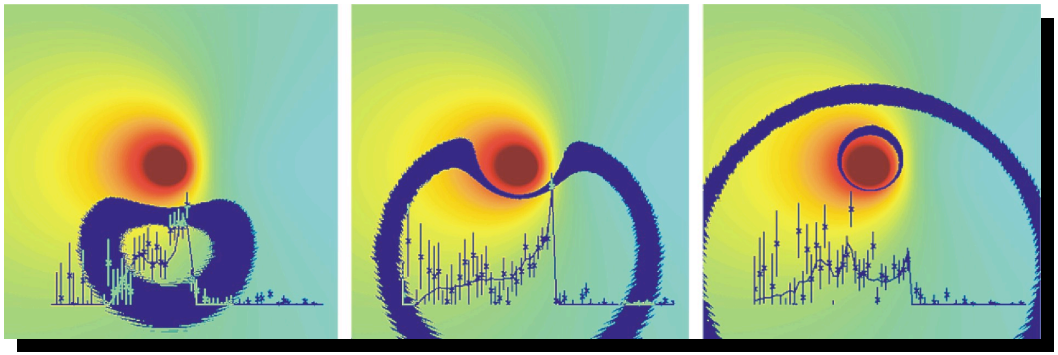
100 times Chandra for high fidelity spectroscopy

Chandra Large Area Sky Survey

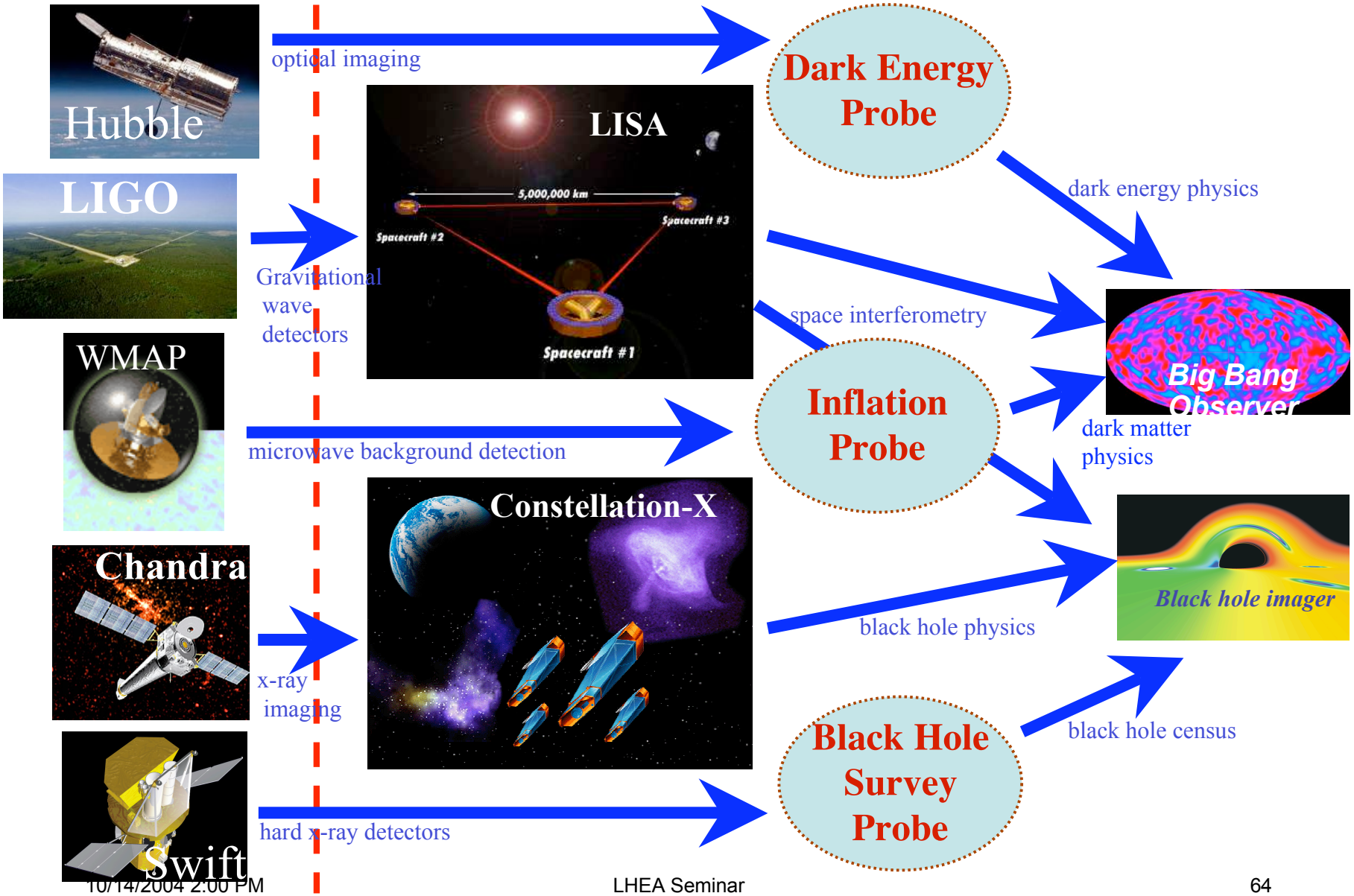




Constellation-X simulated black hole observation



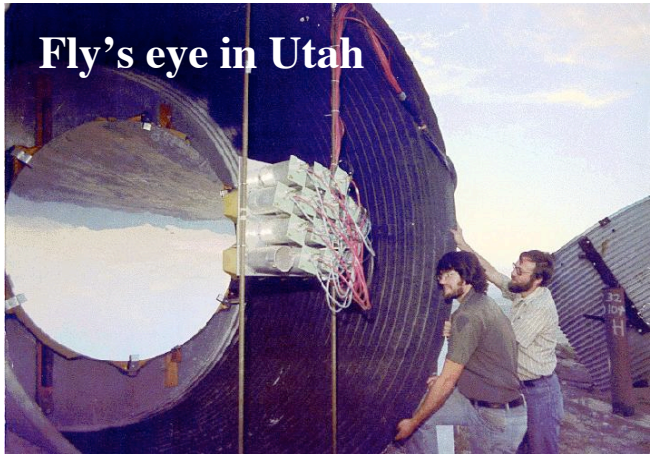
The Beyond Einstein Program



The Most Energetic Particles Known!

The highest energy cosmic rays have an energy of over 10^{20} eV, equivalent to that of universe ~10^{-27} s after the big bang!

These are very rare events with only 1 particle per sq kilometer per century, detected as air showers by ground based *fly's eye* telescopes

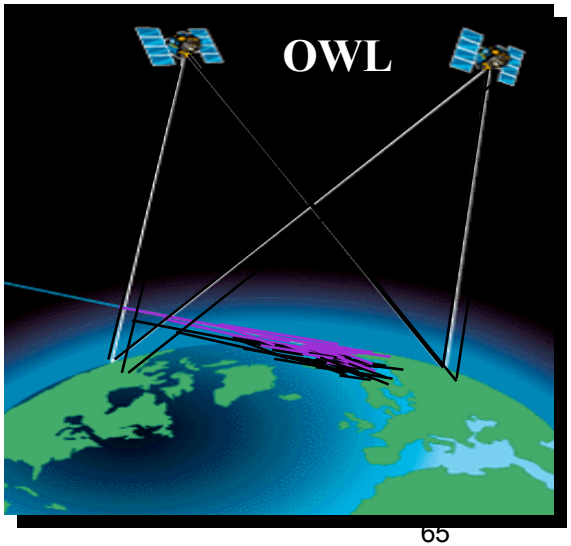


Their origin is a mystery, models include:

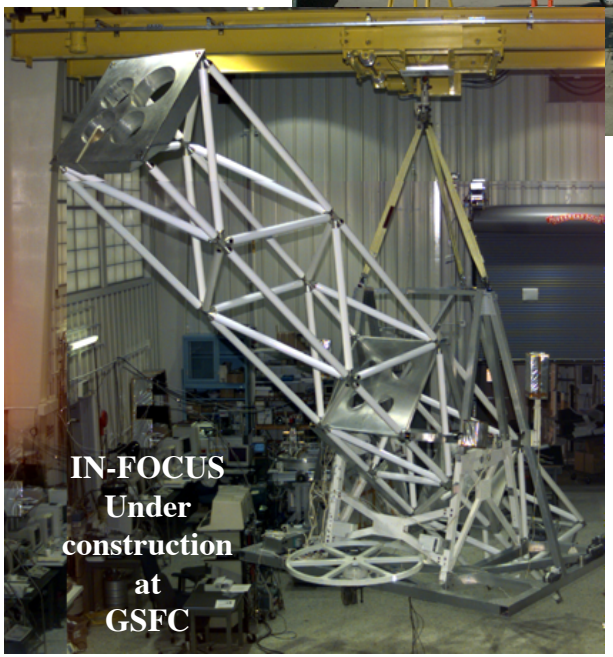
- Acceleration by spinning super-massive black holes in nearby galaxies?
- Decay products from the early universe?

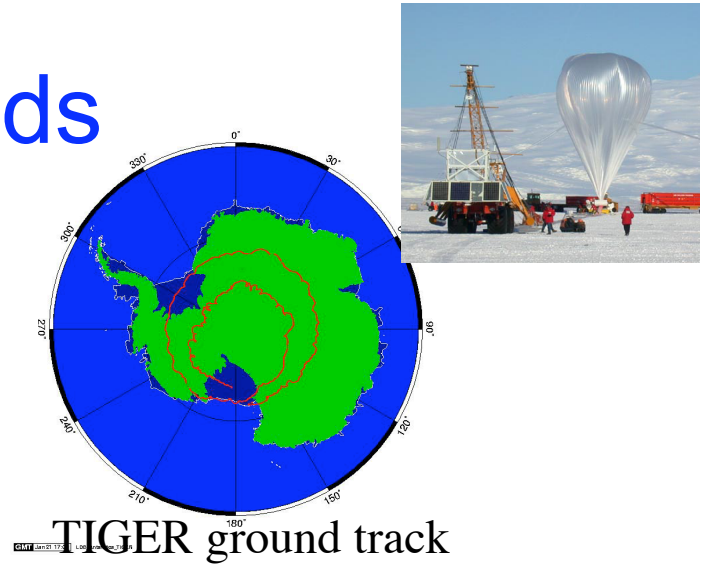
OWL will use the Earth as a gigantic detector to detect cosmic rays by observing thousands of events to determine direction and spectrum

OWL will also be able to detect neutrinos

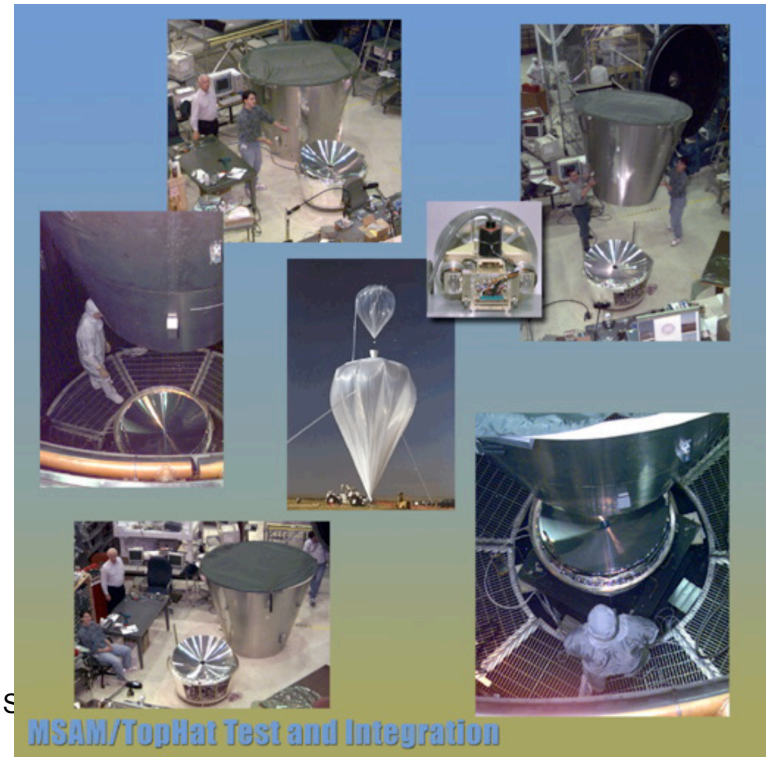


Balloon borne payloads

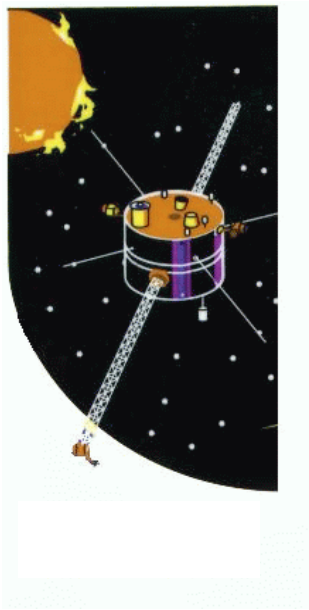


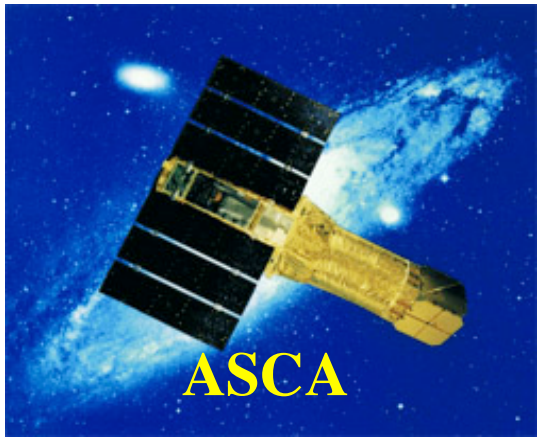


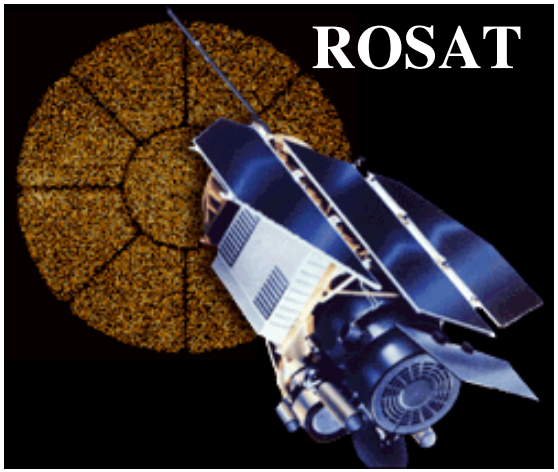
TIGER ground track

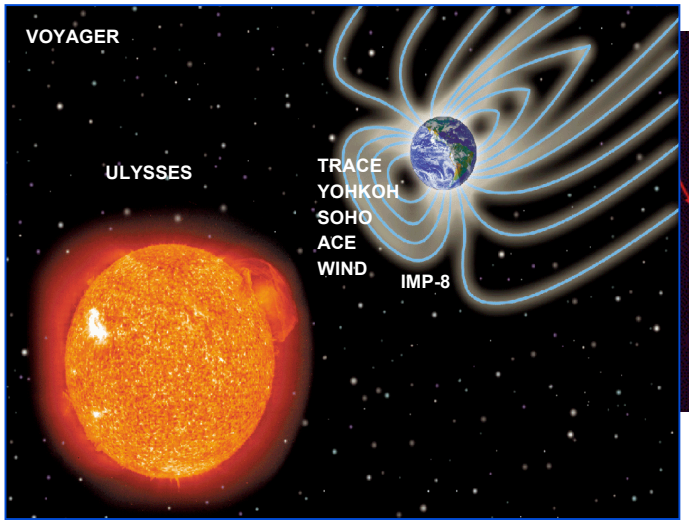


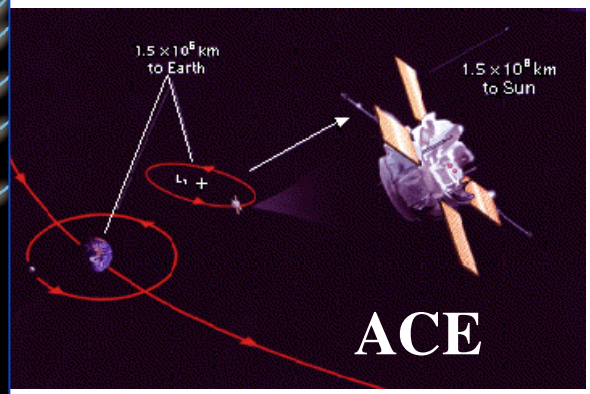
Archival and On-going Data Analysis





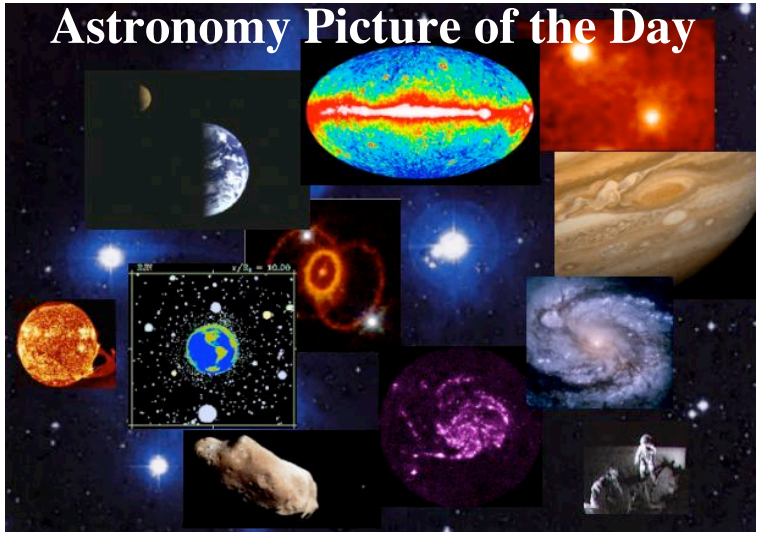


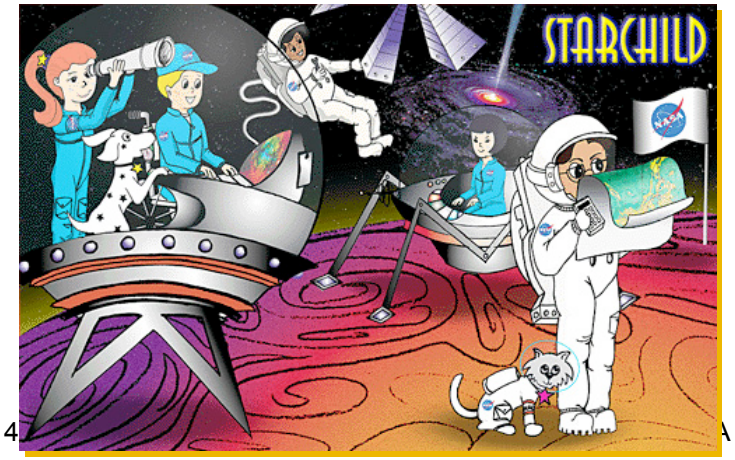




Education & Public Outreach

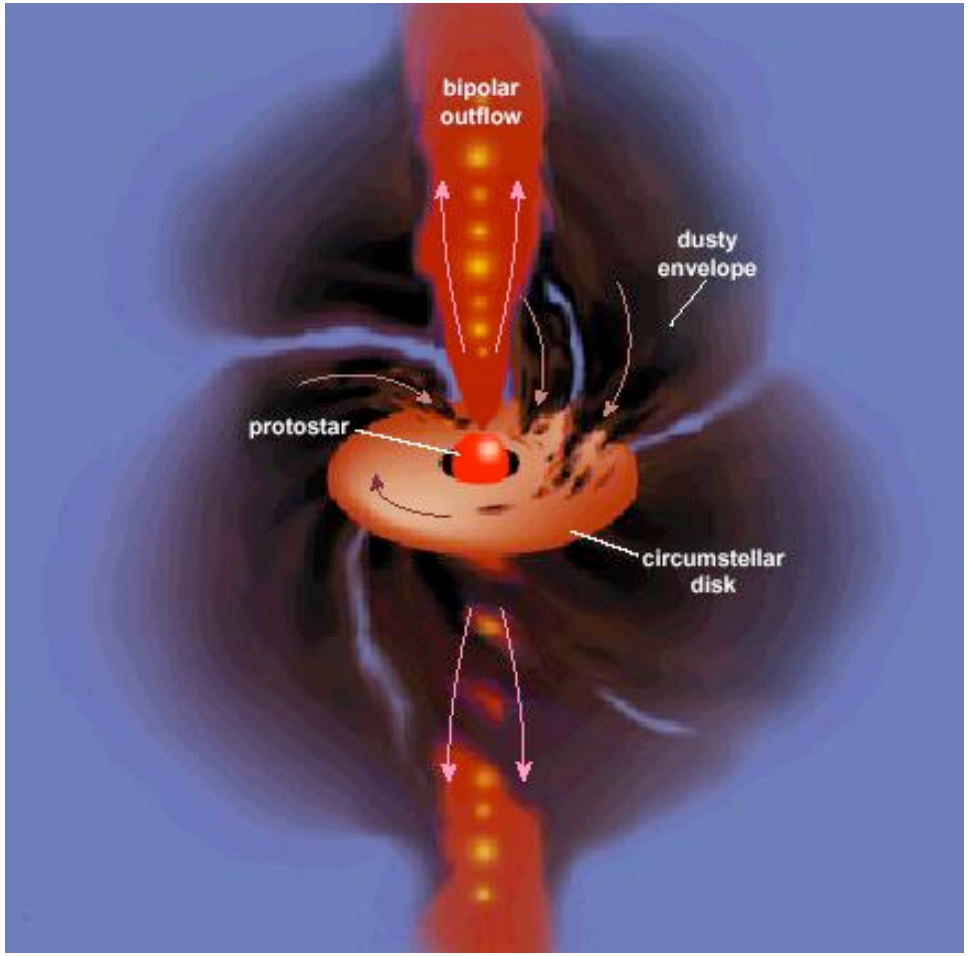
- Astronomy Picture of the Day Web site
- Imagine the Universe! Web site
  - Multi-level discussion of astronomy
  - Created by LHEA scientists & programmers collaborating with teachers
  - Lesson plans using actual satellite data
- Starchild Web site for K thru 14
- CD-ROM's, posters, lesson plans
- Teacher conference support and workshops
- Ask A High Energy Astronomer service



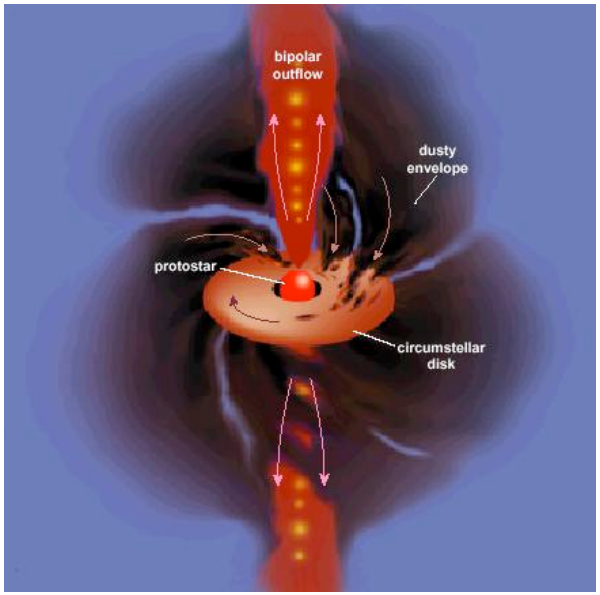


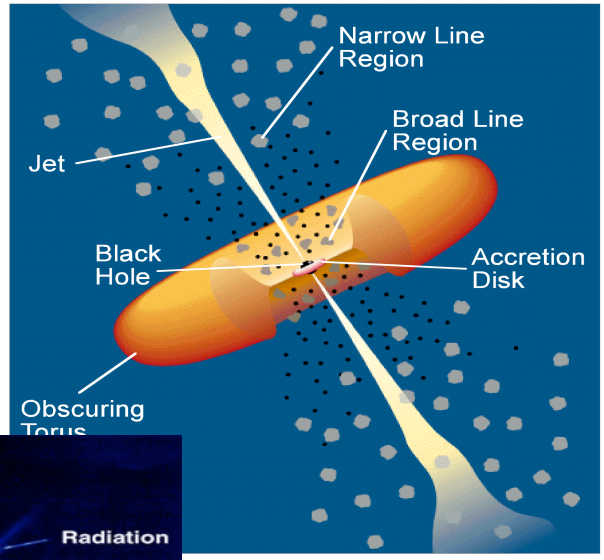
Outstanding Questions in Star Formation

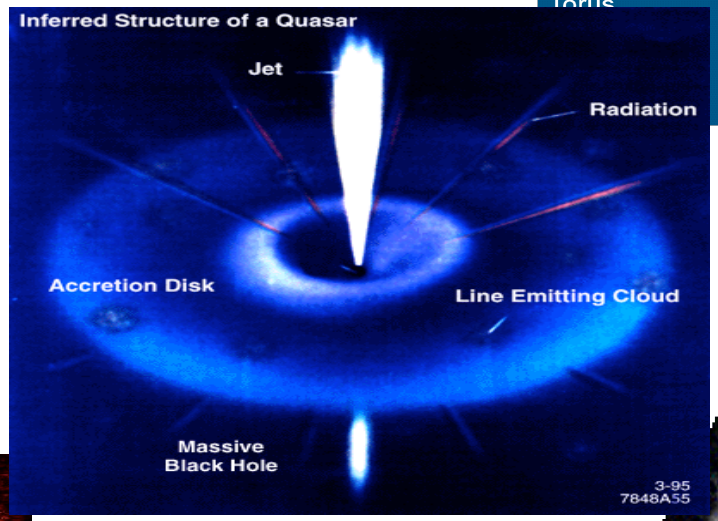
- ***By what process do pre-stellar cores collapse to form stars?*** Are their density distributions consistent with the "standard model" of star formation, Bonner-Ebert? spheres, or ambipolar diffusion support?
- ***What are the physical natures*** (effective temperatures, radii, etc.) ***of the nascent stellar cores of the youngest protostars?*** How does matter accrete onto them?
- ***What organic matter is present in the circumstellar environments of protostars?*** Is this matter more processed (more complex) than in the ISM, and is it located in planet-forming regions of disks? Similarly, ***is there water, and where is it located?***

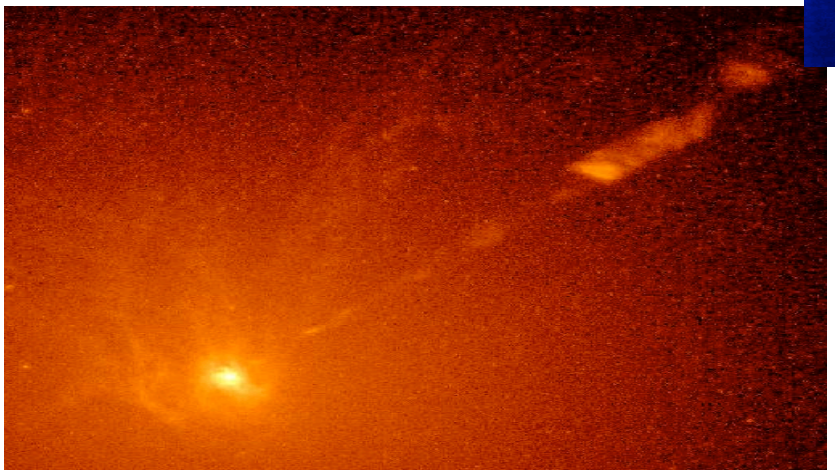


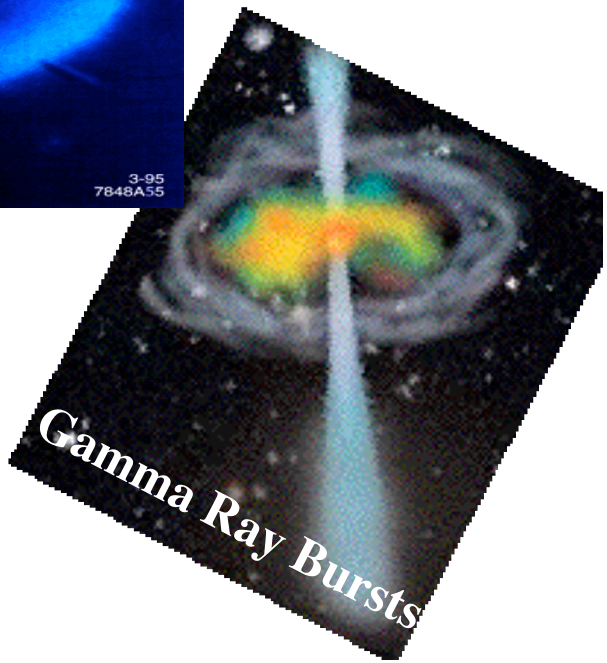
Jets on all scales





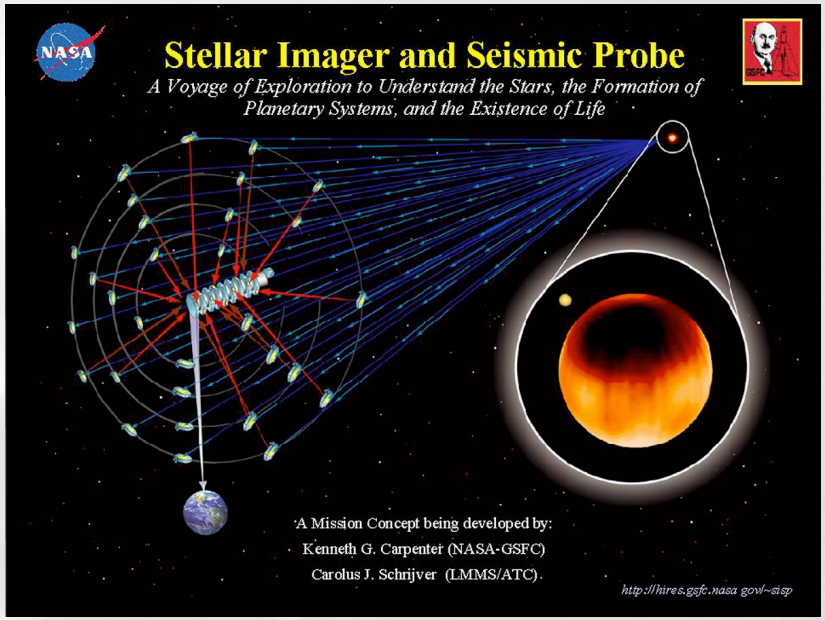






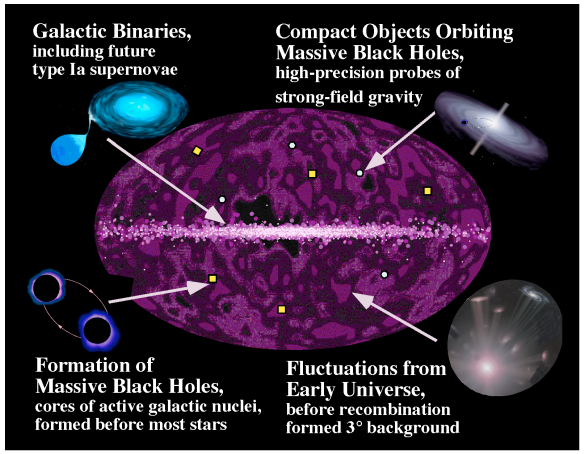
Interferometry Missions

- Space interferometry missions feature prominently in the future of astrophysics
- GSFC is working on interferometers that will operate at sub-mm, IR, UV, and x-ray wavelengths
  - Visible-UV Stellar Imager
  - SPIRIT and SPECS for far IR/sub-mm
  - MAXIM to image a Black Hole in X-rays



Areas of Growth

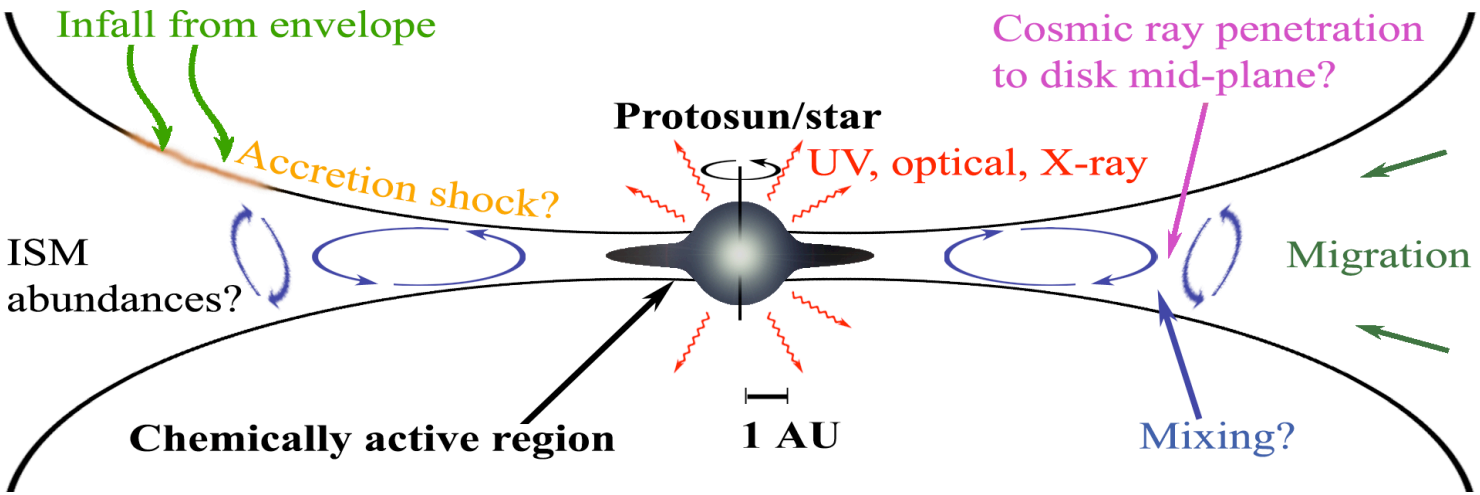
- Planet finding, studies of their origin and evolution
  - TPF pathfinder, Origins Probes, Life Finder
- Solar system planets, comets and prebiotic molecules and astrobiology
  - Comet Surface Sample Return (CSSR)
- Computational astrophysics and space physics
  - Gravitational waves from colliding objects, Space Weather, interpretation of cosmology and what to measure next, NVO
- Gravitational Wave missions
  - LISA, Big Bang Observer
- Cosmology
  - Dark energy: JDEM/SNAP, DUO, CMBPOL
  - Dark matter: GLAST, DUO
  - Galaxy formation and evolution: Con-X, NHST
- Galaxy evolution
  - SAFIR, SIRCE, SPECS, JWST, Con-X, VLST



Strategic thrust areas

- Astrobiology
- Pre-biotic molecules
- Comets

Organics Observatory



Way beyond!

- The space science program is a bold attack on the most basic and challenging of today's science issues. It will study the underlying laws of nature that govern the assemblage of the building blocks of life. It will investigate the laws of physics in unEarthly conditions such as those near black holes, in proto-planetary nebulae, and on the sun. And it will uncover important relics of the birth of the universe. Together, these studies will help us to understand why the nature of the universe permits the existence of life, the likely future of the universe, and even the apparently complicated nature of the vacuum that remains when matter is removed.

- The missions involved will enable human beings to explore environments completely different from those they experience on Earth and even in our solar system. They will extend our senses to the edges of black holes, explore the birthplace of pre-biotic molecules and discover the very beginnings of the universe. This quest will inspire future generations with images and knowledge gained from this cosmic journey.

Dreams and challenges

- Every person should have access to a “virtual observatory” that can take them on multiwavelength journeys to the edges of space and time
- That the balloon, aircraft and sounding rocket programs remain alive and viable, justified in their own
- To find evidence for dark matter with BESS or GLAST
- To find the “smoking gun” for the origin of cosmic-ray nuclei
- To see the gravitational waves with LISA
- To find out how common are Earthlike planets in long-term stable orbits and where life came from

Commentary

- There is just one thing I can promise you about the outer-space program: your tax dollar will go farther.

- Wernher von Braun

Search for life

- Scientists Decode the First Message From an Alien Civilization...

  Send 6 x 10^{50} atoms of hydrogen to the star system at the top of the list, cross off that star system, then put your star system at the bottom of the list and send it to 100 other star systems. Within one-tenth of a galactic rotation you will receive enough hydrogen to power your civilization until entropy reaches its maximum!

Thanks

One of the biggest pleasures of working at GSFC has been the quality of the people. You are intelligent and interesting people with high integrity. You are all highly motivated (so I never had to attend training on how to motivate people). When I went from building 2 over to 26, I left without having an opportunity to say goodbye properly. I hope it isn't too late. I thank lots of folks for their support and guidance throughout my career, especially my colleagues Tom Cline, Reuven Ramaty, Carl Fichtel and Elihu Boldt. Don Stilwell, Chuck Glasser and Andy Dantzler were Godsends who took most of the bureaucratic heat for me. I always had great clerical and administrative help. The biggest support of all was the quality work you did, designing and building sophisticated one-of-a-kind instruments, working uncountable hours, discovering interesting new phenomena and explaining them (sometimes), and doing everything else the institution demanded. I am extremely proud to have been associated with the science and proposals that came out of this laboratory during my tenure. I didn't have much to do with most of this work personally, but I hope I had some small part in creating the environment in which it could flourish. I am also very proud of the staff, including the recent new hires, to carry forth the tradition of excellence. Looking ahead, I know there will be an outstanding future for not only high energy astrophysics, but also the astronomy and astrophysics of gravitational waves. If NASA's interests are directed elsewhere, the DoE and NSF will be interested because the science is compelling. Someday I hope this lab will be involved exotic particles such as neutrino and ultra-high energy cosmic ray astronomy. May you all continue to have fun studying the entrails of radiations from the cosmos.

Thanks

- I want to also thank Steve Holt for seeing in me abilities I didn't always know I had and for his constant encouragement. I am always amazed by Steve's ability to see and know the talents and character of his fellow human beings. His caricatures aren't bad either!

- And, of course, the mentor of many of us, Frank McDonald, who assembled this highly talented team in the first place, made sure we all grew to our fullest potential and taught us how to develop the talents of others.

The end

- The most remarkable aspect of high energy astrophysics is not in the sky, but in building 2, where a species has developed the ability to send new “eyes” above the sky and see.

J.F. Ormes, from my book “Not Quite So Blind Watchers of the Sky”