Science Team Semester Review
Spring 1998

Jim Collins, Science Team Leader

SCIENCE OBJECTIVES

Lightning Experiment

- Primary Mission: Improve Understanding of:
  - Thunderstorm Distributions
  - Cloud Processes
  - Storm Variability
- To Achieve Mission: Detect and Locate Lightning Activity Over Large Areas of the Earth's Surface.
  - Cloud to Ground
  - Cloud to Cloud
  - Intra-Cloud
- Ground-based Techniques Detect Only Cloud-to-Ground

- Obtain Data to Constrain Theoretical Models
  - Global Climate Models
  - Global Warming Models
  - Theoretical Algorithms Which Describe the Electrical, Microphysical, and Kinematic Properties of Tropical Thunderstorms.
- Locate Areas of Atmospheric Deep Convection

SCIENCE OBJECTIVES

Sprite Experiment

- Good Public Relations (Pretty Pictures)

- Constrain Atmospheric Chemistry and Space Physics Models

- Investigate Correlations Between:
  Sprite Production Over Land vs. Ocean
  Frequency of Sprites (Relative to Cloud Flashes) vs. Latitude, Season, Storm Intensity
  Frequency of Sprites vs. Cloud-to-Ground Strikes

- Determine If Sprites Can Occur Over Single Thunderstorm Cells As Opposed to Mesoscale Convective Systems.

SCIENCE OBJECTIVES

Photometry Experiment

- Improve Accuracy of Ground-Based Measurements of UBVRI Colors for a Selected Set of Standard Stars

- Obtain and Publish an Internally Consistent Data Set Spanning a Range of Magnitudes and Spanning the Northern and Southern Hemisphere

- Possible Search for Extra-Solar Planets through Investigation of Micro-Magnitude variability.

PROGRESS - CLARIFICATION OF SCIENCE OBJECTIVES
Lightning Experiment

Supplement LIS, OTD Data Set -- Test Hypotheses For:

- Extreme Ratio of In-Cloud Lightning to Ground Strokes in Severe Storms Including Tornadic Storm
- Relationship Between Lightning and Graupel/Hail Production
- Non-linear Relation Between Cloud Height and Lightning Rates
- Coordinate with Gamma Ray Observatory Observations of Unexplained Terrestrial Gamma Ray Bursts (Sprite Detection May Correlate)

PROGRESS - CLARIFICATION OF SCIENCE OBJECTIVES

Sprite Experiment

- Investigate Temporal Characteristics of Sprites

- Supplement Data from Midcourse Space Experiment (MSX) Mission (Dr. David Pollock at University of Alabama in Huntsville): UV and IR Sensors May Provide Information On:
  - -- Various Chemical Species in the Atmosphere
  - -- Temporal Characteristics of Sprites
  - -- Spectral Characteristics of Sprites

PROGRESS - CLARIFICATION OF SCIENCE OBJECTIVES

Photometry Experiment

- Preliminary Observing Strategy Defined
  Multiple Observations of Calibration Target
  Multiple Excursions with Heavy to Complete Overlap

- Preliminary Target Identification (David Sing)

- Prototype Operational Algorithm (David Sing)

PROGRESS - LIGHTNING EXPERIMENT

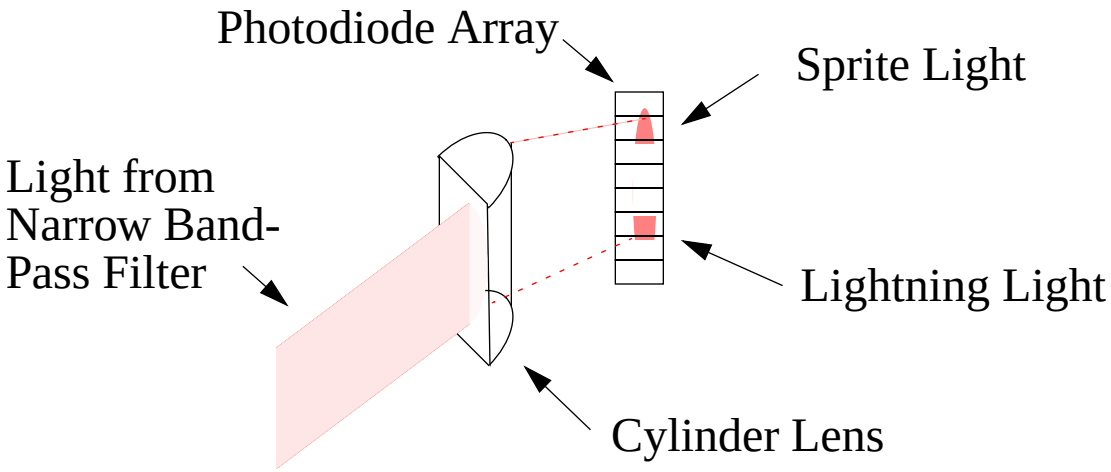
- Approximate Flux Values Determined:
  Lightning flux $10^{-6}/m^2/srad$ at All Wavelengths

- Lightning Detection Algorithm Under Development

PROGRESS - SPRITE EXPERIMENT

- Approximate Flux Values Determined
  - $10\text{-}100 \times 10^{-6} W/m^2/srad$ for sprite light between 660-700nm
  - Lightning is about the same order of magnitude between 660-700nm

- Sprite Detection Method Modified
  - Lightning and Sprite Fluxes Comparable at 660-700nm
  - Use of Photodiode Array Introduces Geometric Dependence on Detectability



- New Alternate/Additional Dual CCD Algorithm
  - Possibly Use Active Pixel Sensors

PROGRESS - INSTRUMENT DESIGN

- Chose reflector not refractor
  - 5 degree by 5 degree FOV possible
  - Observations at Edge of FOV Still Allow 5km Resolution

- Preliminary Ray Diagram Generated
- Preliminary Spot Diagram Generated
- Preliminary Radiometry Calculations Completed
  - Combined Lightning and Sprite Power at CCD (for 20 μm pixels) approx. 2×10^{-14} W
  - D* ("Detectability") for CCD with SNR approximately equal to 100 is 10^{13}
  - (compared with typical 10^{11} to 10^{14})

- Flip Mirror Replaced by (Flip) 50/50 Beam Splitter
- Determined Band Pass for Narrow Band Filter for Sprite Detection
- Cylindrical Lens Introduced for New Sprite Detection Algorithm
- Selected 512 x 1024 CCD Array with Virtual Shuttering
- Two Binning Modes -- High and Low Resolution
- Added Aperture Wheel for Photometry Experiment
- Instrument Prototype Radiometry Program (Mike Hay)|

INSTRUMENT PROTOTYPE RADIOMETRY PROGRAM

An Input File Contains Optical Transmission Values for Vaious Components:

```
-------------------------------------------------------------------
|   Optical Transmission Variables for the Student Satellite Project   |
-------------------------------------------------------------------
0.95              *  primary mirror
0.95              *  secondary mirror
0.95              *  fold mirror
0.91              *  photometry lens
0.90              *  photometry filter wheel
0.88              *  sprite array lens
0.87              *  sprite filter wheel
20/80             *  flip beam splitter (reflection/transmission)
20/80             *  sprite beam splitter
50/50             *  communications beam splitter
-------------------------------------------------------------------
```

PROGRESS - ALL EXPERIMENTS

- Lab Space at Remote Sensing Labs
- Optical Table at Remote Sensing Labs (Dr. Bill Wing, STI Team)
- Prototype Under Construction
  8-inch F10 Schmidt Cassegrain with 0.5 degree FOV
- Data and Command Handling Protocols Under Development
  -- Details Of Electronics Still in Flux
  -- **We will have our own CPU** (At least one probably several)
  -- Data Rate
  -- Science Instrument Command Format
  -- Science Status Information (Housekeeping) Format
  -- Science Data Command Format
  -- Typical Format
    Sync Byte
    Byte Count
    Command/Status/Data ID Byte
    CommandStatus/Data Bytes
    Check Byte
    Byte Count

PROGRESS - ALL EXPERIMENTS (CONT')

- Electrical Characteristic Definitions Under Development
  - -- Max Power Ripple and Transient Requirements
  - -- Max/Min Voltages and Tolerances
  - -- Probably 2 to 3 buses : +/- 5, 12, 28 volts)
  - -- Max Energy Usage
  - -- Max Current Requirements (approx 10 Amps)
  - -- Rise/Fall Times
  - -- Max/Min Impedance
  - -- Max Capacitance

PROGRESS - FUNDING & SUPPORT FOR PROTOTYPE

- Evergreen Airfield
  - -- Raw Materials
  - -- Machining
  - -- Expertise
  - -- Flight Testing
- Burr-Brown
  - -- Electronic Components
  - -- Operational Amplifiers
  - -- A-to-D, D-to-A Converters
  - -- CCD Signal Processor
  - -- Photodiodes
  - -- Voltage and Current Regulators
- Research Corporation (Photometry Sub-Team)
  - -- $5000
- UA Remote Sensing Laboratory (Kurt Thome)
  - -- ~$2000
  - -- Laboratory Space
  - -- Equipment

PLANNED FIELD TESTING

- Lab Test - Phase 1
- Lab Test - Phase 2
- Kitt Peak/Mount Bigelow Observations of Thunderstorms
- Yucca Ridge Colorado - Sprite Observation/Verification
- Flight Test

ISSUES TO RESOLVE - INSTRUMENT DESIGN

- Reflector Design vs. Optical Speed to Maintain 5 Degree By 5 Degree FOV

- Fold Mirror (Would Require Dedicated Processor and Increased Electro-Mechanical Complexity)

ISSUES TO RESOLVE - LIGHTNING EXPERIMENT

- Refine Lightning Detailed Detection Algorithm
  Perform Daytime Detection?

ISSUES TO RESOLVE - SPRITE EXPERIMENT

- Refine Sprite Detailed Detection Algorithm
  Daytime Detection?
  Detection in Moonlight?
- Will Dayglow, Nightglow, Auroras Cause False Sprite Detections?
- Maybe Replace Cylinder Lens with Semi-Spherical Lens?

ISSUES TO RESOLVE - PHOTOMETRY EXPERIMENT

- Optimize Target list
- Quantify Accuracy and Calibration
- Verify Scientific Merit
- Can the CCD be Used for Tracking & Pointing Correction?
  - -- Slewing Accuracy & Stability of Satellite
  - -- Common Data/Command Area Needed with Both TTC and Science Having Input Access
- Overfill or Underfill Photodiode?

ADMINISTRATIVE ISSUES

- Opinion: Team Leader Meetings Should be Used for Technical Exchanges
  - -- Many Administrative Matters Can Be Done By E-Mail
  - -- Most Technical Matters Should Be Addressed By Group Interaction at this stage

- Semester Reviews At Beginning of Semester Rather Than End

- Tech Notes - Will Complete over Summer as Information Becomes Available

- Meteorology Short Courses May Be Offer In June

- Machine Shop Training Needed