High-Altitude Long-Duration Ballooning: Auroral Observations in Sunlight

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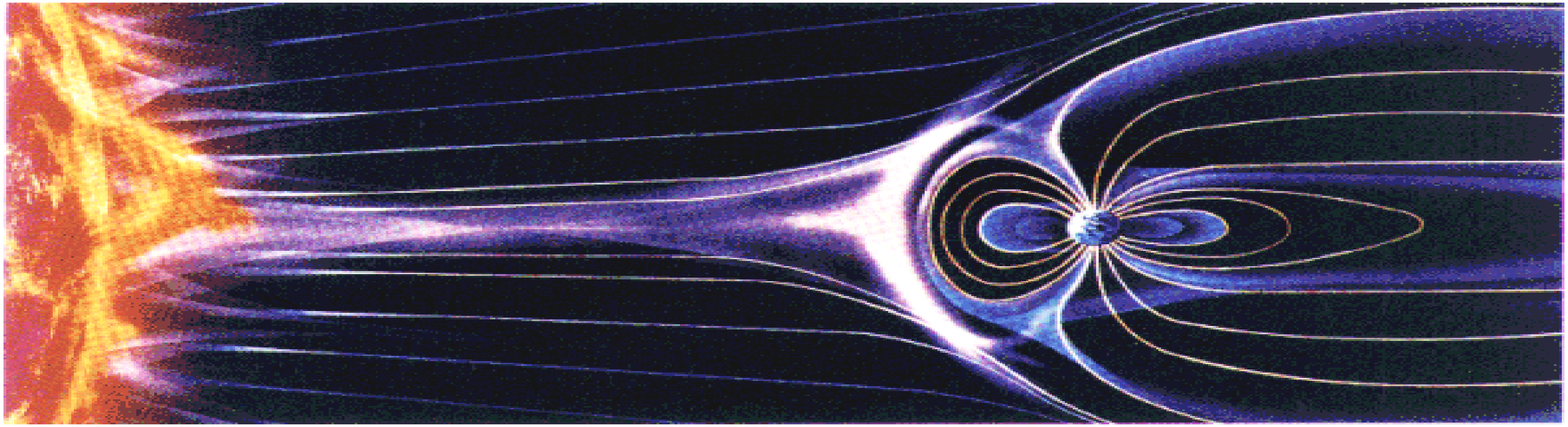
Science Highlights

- Solar wind-magnetosphere-ionosphere coupling is controlled by a wide variety of processes at the dayside magnetopause. This interaction has a direct effect on space weather.

- Based on space UV remote sensing dayside auroras are particularly notable under disturbed solar wind conditions.

- Signatures of auroral small-scale structures can be used to derive the mechanisms of how (and where) the magnetopause processes occurred.



One of NASA’s Strategic Goals and Outcomes is

“Understand the Sun and its effects on Earth and the solar system;”

One of Heliophysics Science Objectives (Recommended Roadmap for Science and Technology 2005-2035)

“Open the Frontier to Space Environment Prediction
Understand the fundamental physical processes of the space environment - from the Sun to Earth, …” (Roadmap page 7)

New Results Since 2004

We are convinced after test observations from the ground that

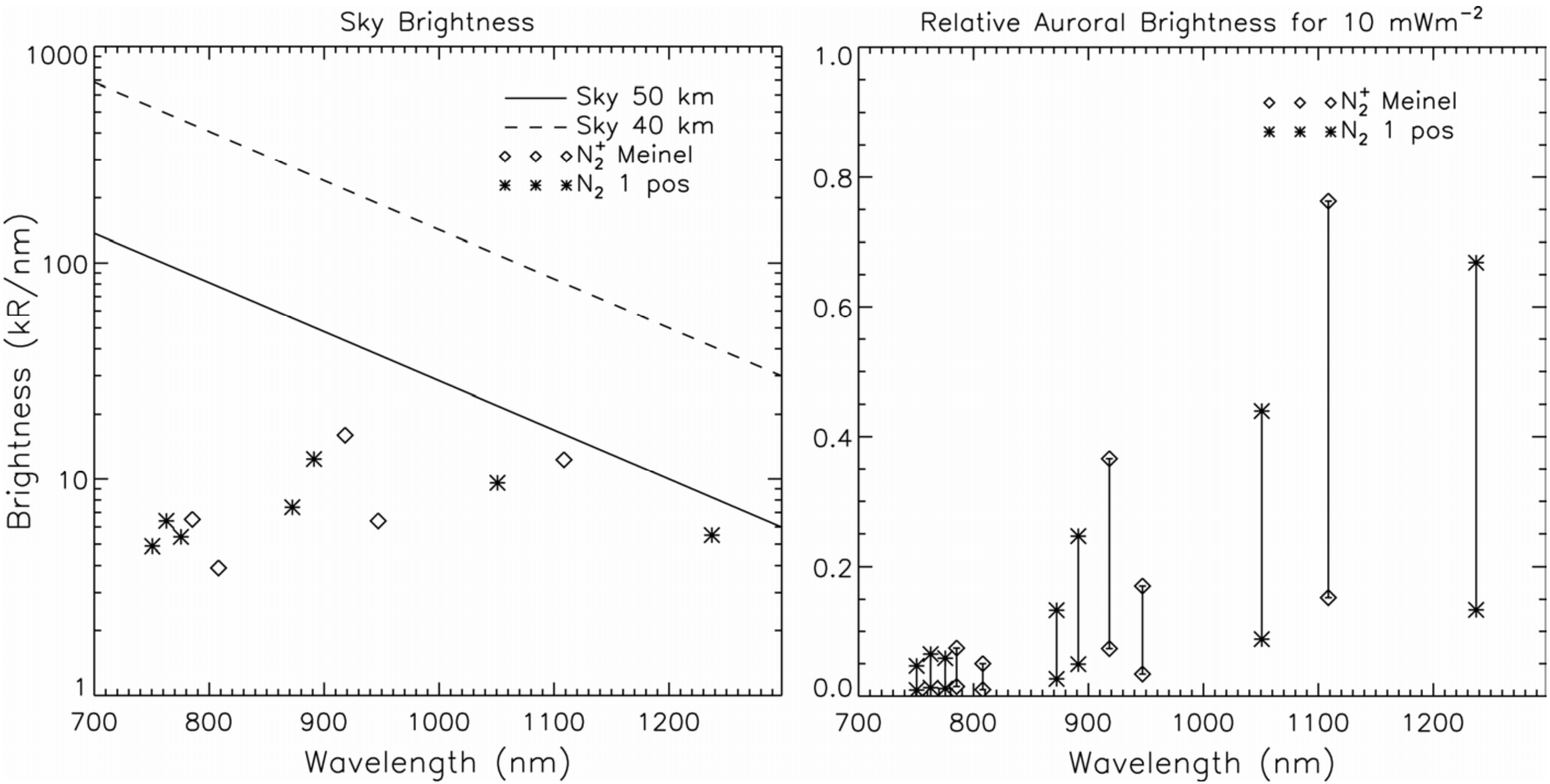
1. It is feasible to observe dayside aurora from balloons using near-infrared cameras that use InGaAs or HgCaTe detectors.

2. Technical concerns exit and will be the focus of current and future efforts.

Why Balloons

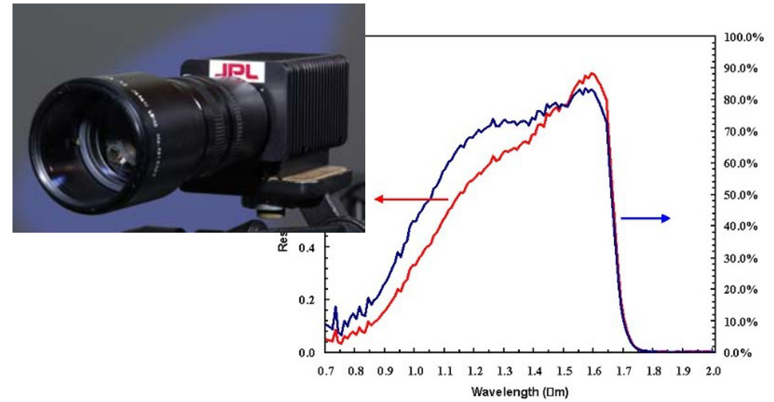
High-altitude long-duration balloons provide an excellent vantage point to observe dayside aurora.

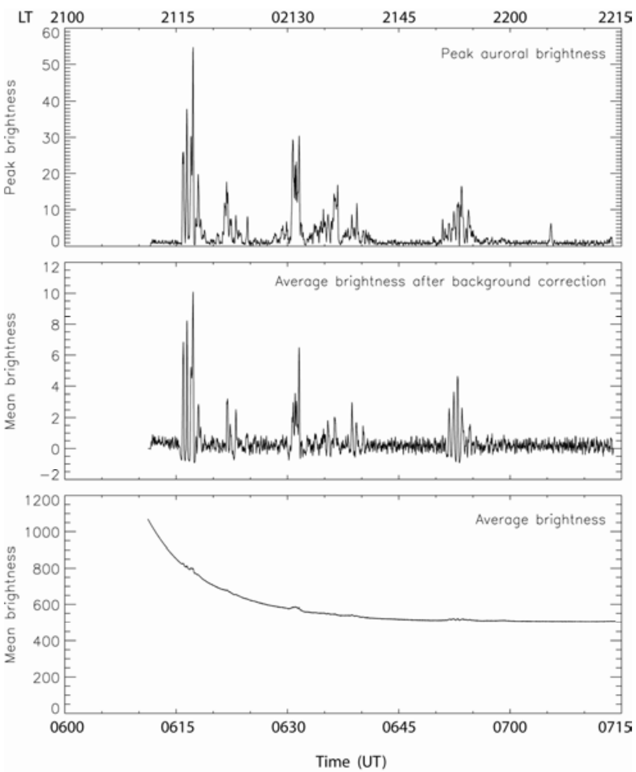
- Dayside auroral observations are very difficult and expensive to do from the ground.
- Conjugate auroras

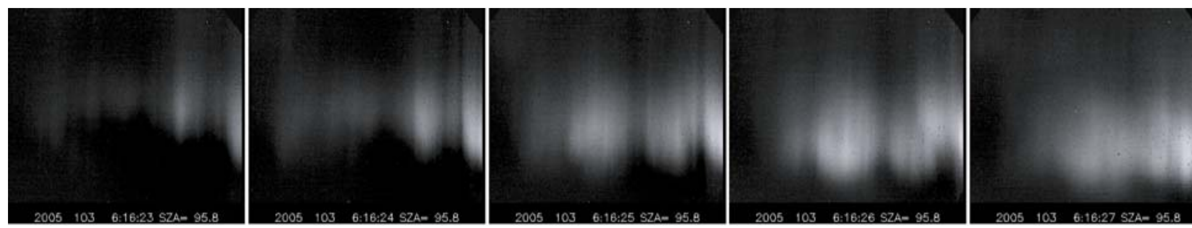


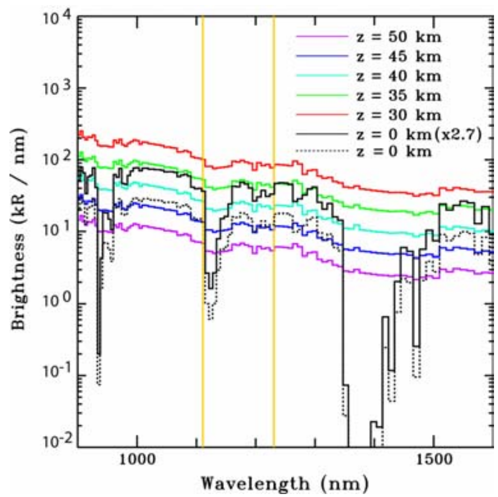
(Zhou et al., GRL, 2007)

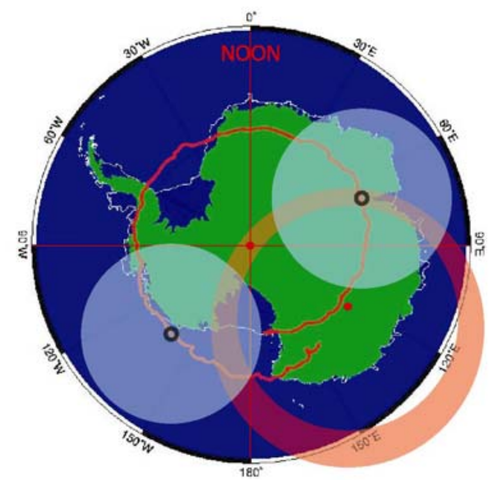
First test observation results from Poker Flat, Alaska in April 2005





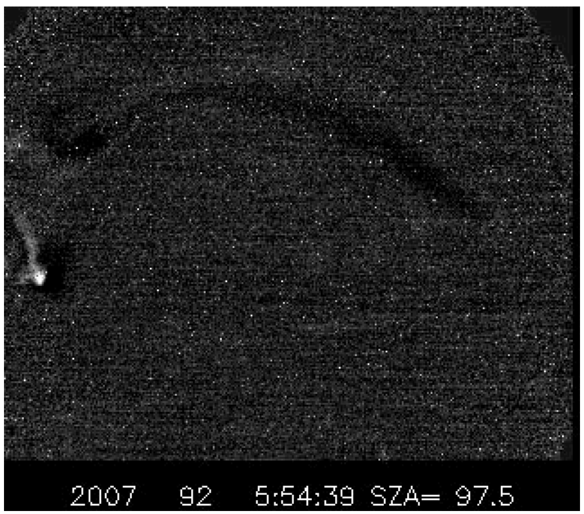


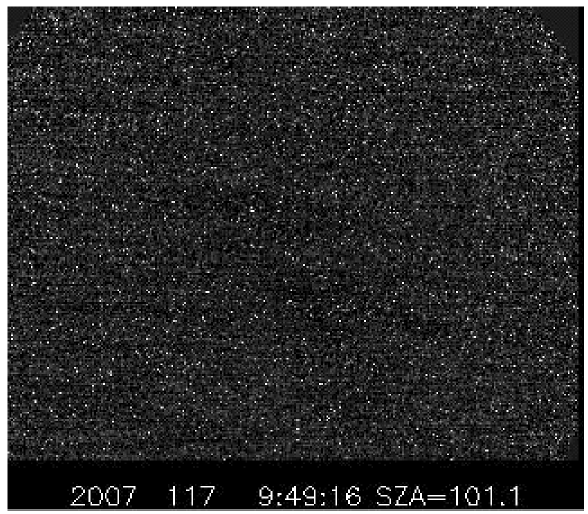


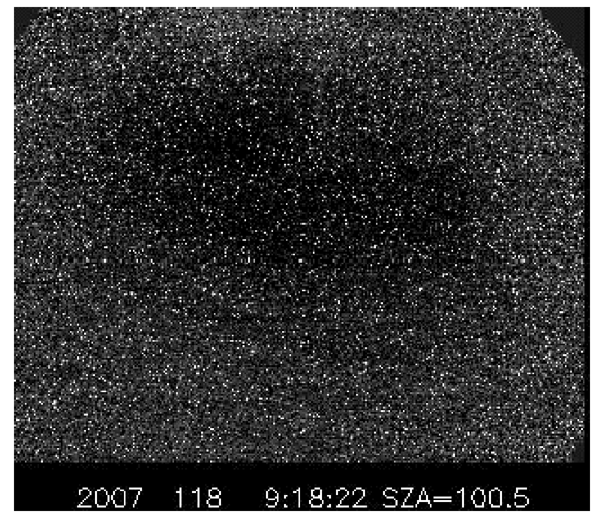


(Zhou et al., GRL, 2007; Zhou et al., ASR, 2007)

Second test observation results from Poker Flat, Alaska in April 2007







Substorm in evening twilight on April 2, 2007. One second exposure without NIR filter.

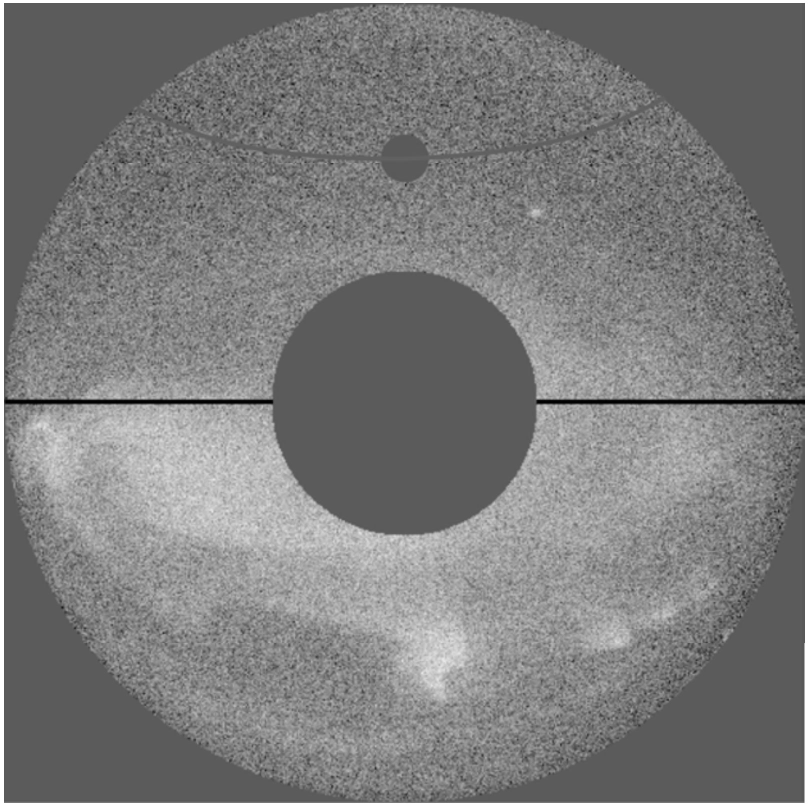
Meinel band auroral arcs on April 27, 2007. Three second exposure with NIR filter.

Meinel band auroral activity on April 28, 2007. Eight second exposure with NIR filter.

Camera parameters and flight requirements

- **Technical parameters**
  1. Mass: < 20 kg (not including the boom)
  2. Power: ~50 W
  3. Data rate: ~45 kbps (for 1 sec temporal resolution)
  4. Dimension: ~15x15x30 cm^{-3} (not including the boom)
  5. Boom length: ~6 m (deployed after launch; guided by a solar sensor installed at the end with an occulter in 10 cm diameter)
  6. Wavelength: 0.9-1.7 μm without filter; ~1.1 and ~1.4 μm with filter
- **Flight requirements**
  1. Altitude: above 40 km (in Antarctica or Arctic)
  2. Duration: longer than 3 weeks (the longer the better)
  3. Pointing: 1° accuracy
  4. No near-infrared contaminations
  5. No direct and scattered sunlight shinning on the camera lens
  6. Three-axis stabilization (no wobbling, no swinging, no rotation and fixed image coordinates)
  7. Direct downlink to the ground once per orbit circle?
  8. Trajectory control?

Camera system design (1) - Optics

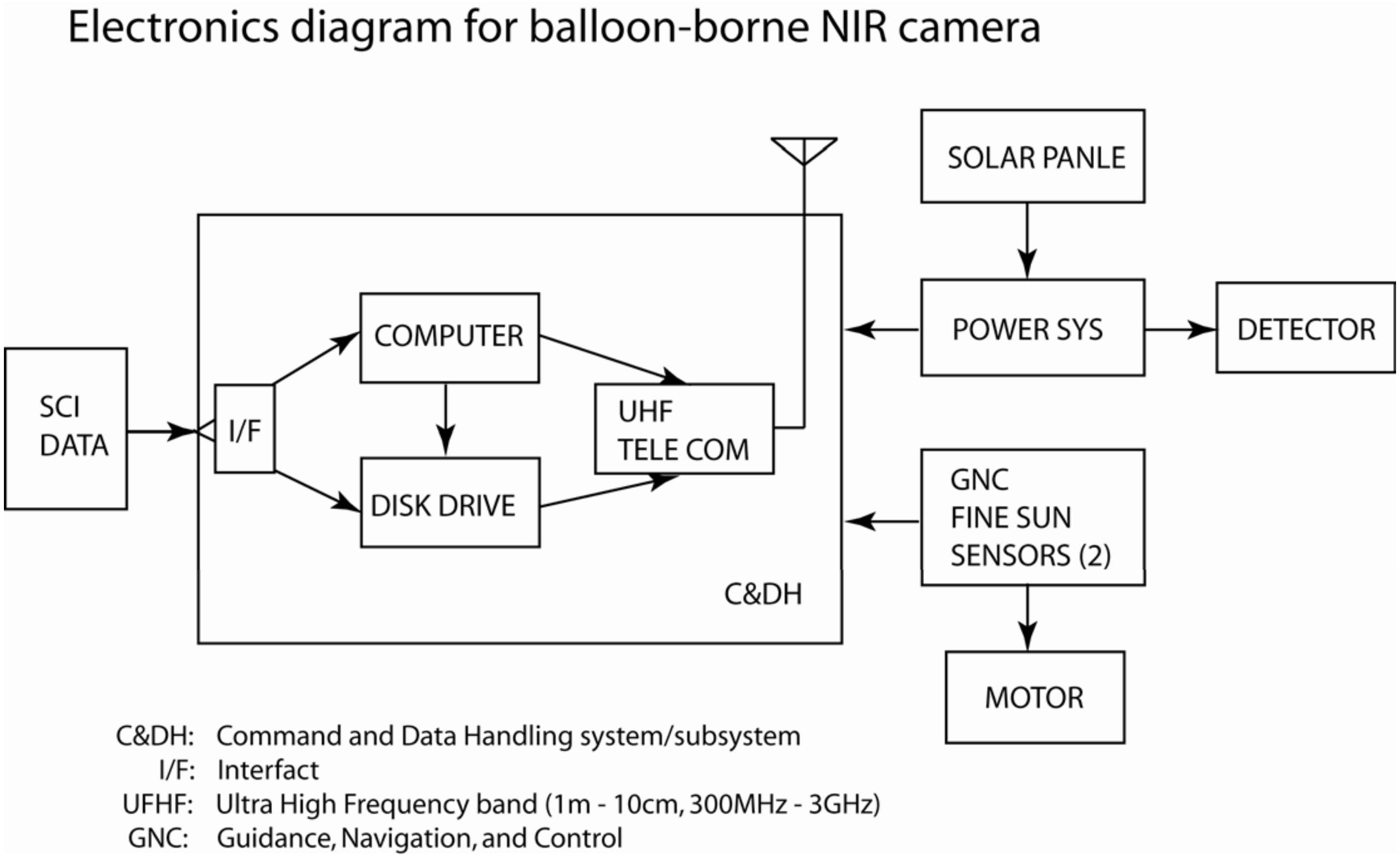


A simulation of relative auroral brightening (at ~1100 nm) in upper atmospheric sky (50 km). The auroral energy flux is assumed to be 10 mV m^{-2}.

The design is driven by science objectives as well as technical and cost concerns.

1. Assuming that balloon diameter is ~71 m and ~60 m away from the camera lens, the balloon creates a 60° solid cone occulting at the center of an all-sky image (see left).
2. Due to the availability of NIR detectors and due to difficulties of occulting the balloon, two detectors will be employed.
3. Each detector has its own optics that has 180°x60° FOV.
4. The two detectors point to opposite directions with 180° apart.
5. The two detectors share one electronics system.
6. To avoid sunlight from directly shines on the lens, we will employ a boom that is ~6 m long and carries a fine solar sensor and an occulter at the end.
7. Solar sensor and boom technologies are available at JPL.
8. InGaAs detector with 1024x256 FPA can be purchased from INTEVAC at ~$50k each.
9. JPL is very experienced with balloon payload design and development.

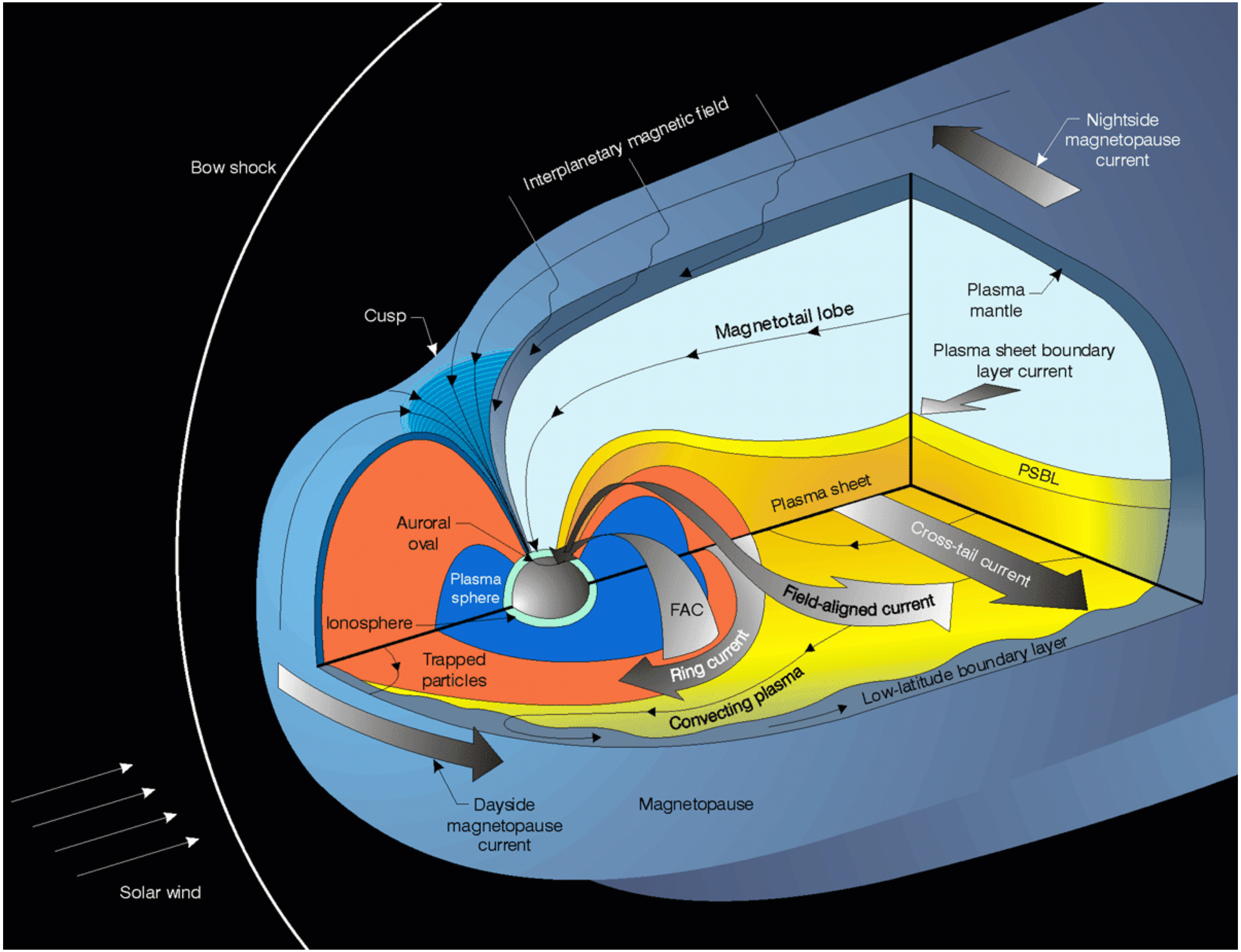
Camera system design (2) - Electronics



Software will be Class D, non-space flight s/w that was developed to perform science data collection, storage, and distribution; or perform engineering and hardware data analysis.

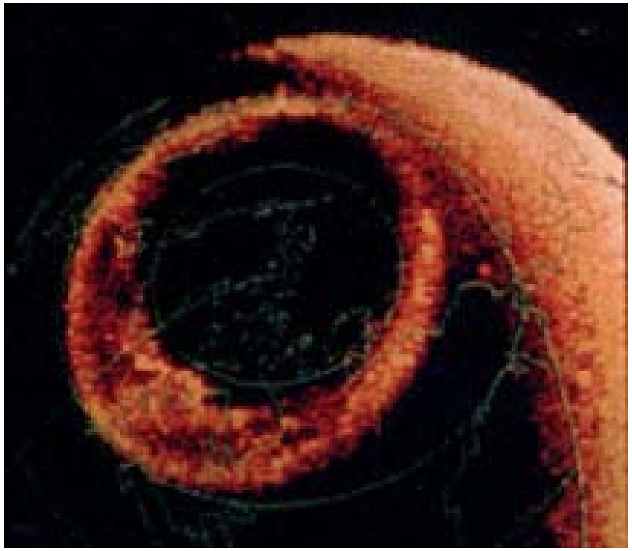
Questions

- Where to submit the proposal?
- What does exactly the balloon facility provide? Power? Telemetry? Launch and Recovery? Funding?
- What interface(s) is(are) needed?
- Can data directly downlink to the ground?

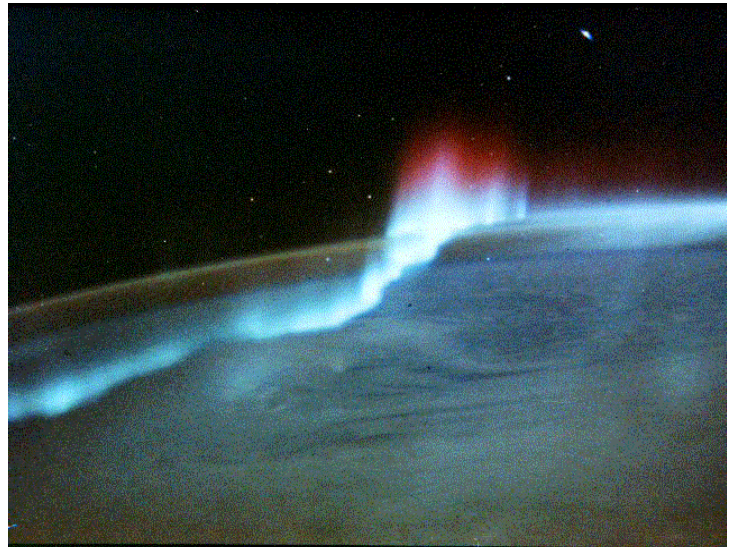


Terrestrial magnetosphere and current system therein.

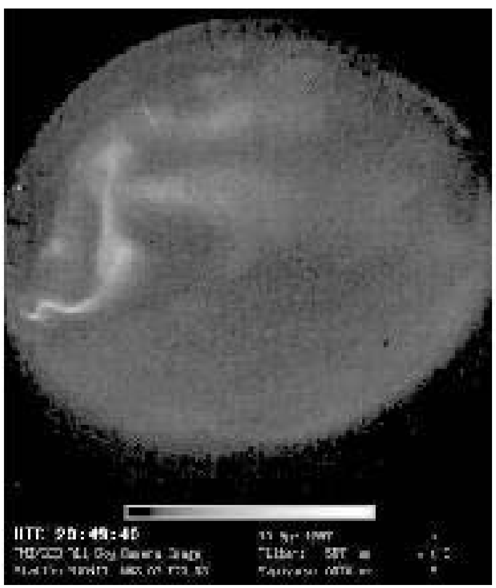
From polar orbit



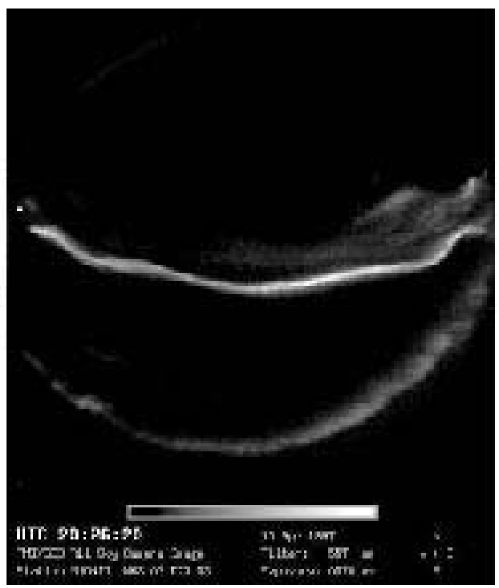
From Space Shuttle



From ground



Diffuse aurora



Discrete aurora

From ground