University of New Hampshire
College of Engineering and Physical Sciences

Department of Physics and Astronomy
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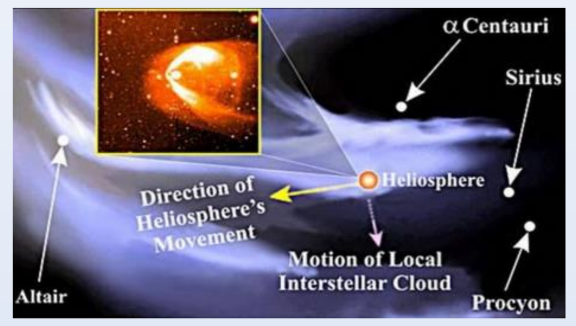
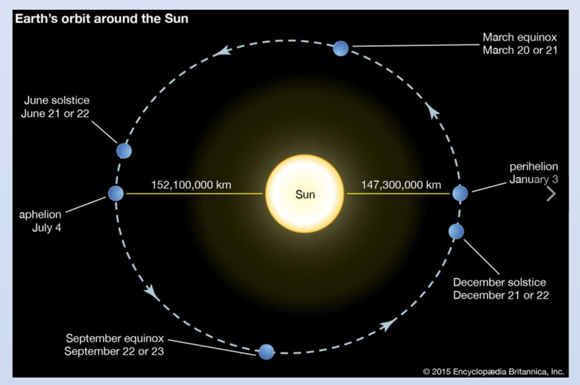
Advisor: Harald Kucharek
Acknowledgements: Colin Frost

Star Sensor for the Interstellar Mapping and Acceleration Probe

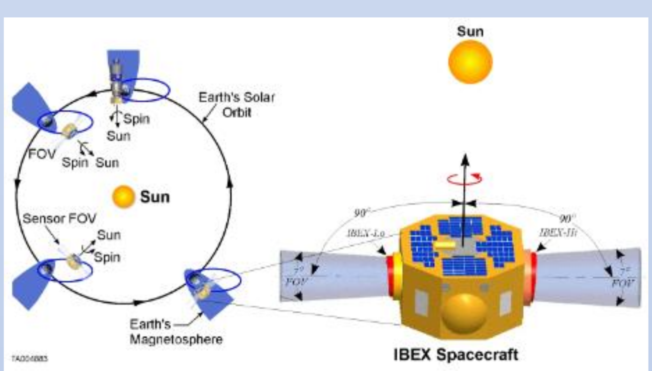
Mission Overview:

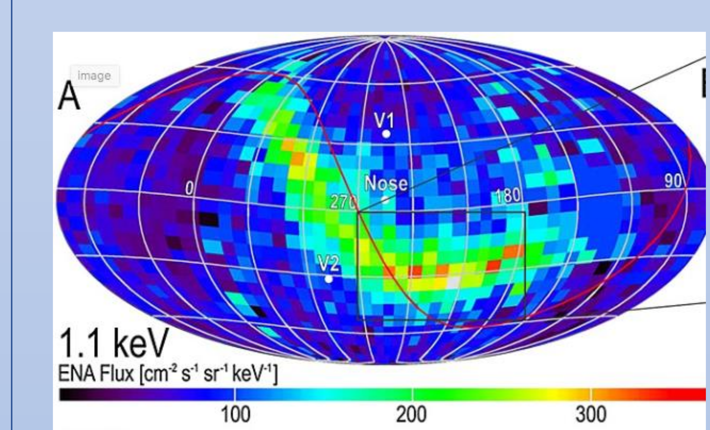
- Mission to understand boundary of Solar System
- Heliosphere – definable and measurable boundary of the Solar System
  - Made from solar winds emitted by the Sun
  - Encapsulates the Solar System
  - Boundary is called the "Termination Shock"
  - Protects Solar System from cosmic rays
- Beneficial to understand how the boundary interacts with the Interstellar Medium
  - Aid in understanding the strength and behavior of the Termination Shock
  - How solar winds behave outside of the Heliosphere
- A satellite to remotely collect particle data from the Heliosphere
  - Look at the particles at and around that boundary





IBEX Overview





- First satellite dedicated to observing the Heliosphere
- Observes neutral atoms at the Termination Shock
  - Those affected by gravitational pull of the sun
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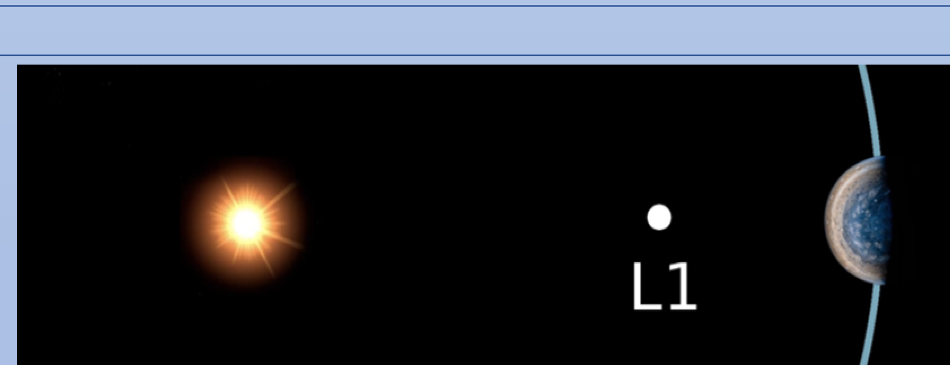
- Determine amount and direction of particles
  - Understanding of the processes occurring at the boundary
- Sun-facing spinning satellite
- Eccentric orbit around Earth
  - Good view of the Sun
  - Avoids Earth's Magnetosphere
    - Interfered with observation of energetic neutral atoms
- Full map of the sky with respect to the energies of neutral atoms

IMAP Overview



- Successor to IBEX
  - More sophisticated instrumentation
  - More detailed measurements of the Heliosphere
- Orbiting the L1 Lagrange point
  - Eliminates interference by the Magnetosphere
  - Earth and Sun gravitation is canceled out
- IMAP-Lo is one of the two instruments
  - Will be on a pivot-platform unlike IBEX
  - One-pixel particle "camera"
  - Creates a "photo" of the Heliosphere using "light" of energetic neutral atoms from the interstellar medium
- "Camera" needs highly precise pointing data for accurate measurements
  - Star Sensor mounted on the instrument
    - Star map to correlate Heliosphere data with location in space

My tasks on this project:

Completed Tasks:

- Mechanically integrating the UV filters in the Star Sensor housing.
- Make the design vacuum safe (No air trapped between the filters)
- Accommodate these filters in the Star Sensor housing

Tasks to be Done

- Operate the light sphere and operate the data acquisition of the Star Sensor in the optical laboratory.
- Calibrate the new and improved Star Sensor.

Basic Star Sensor design:

- Main components:
  - PMT and "V" shaped aperture
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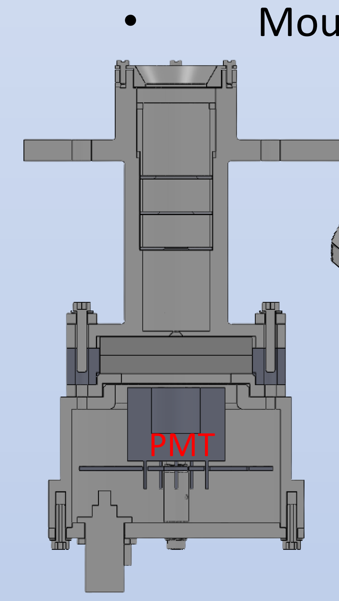
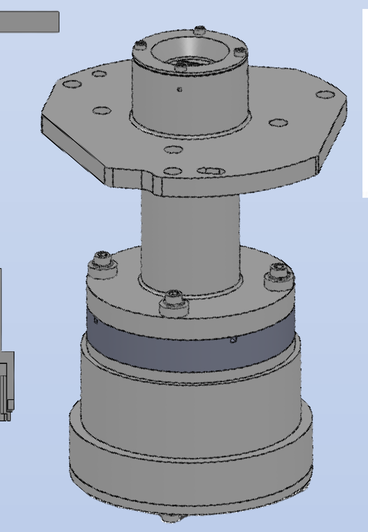
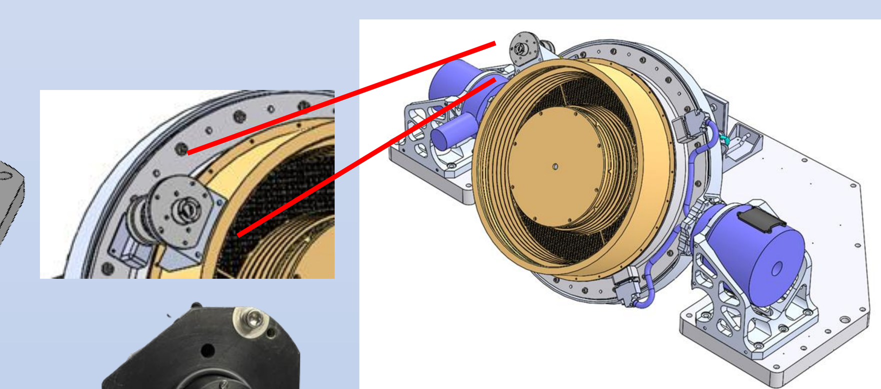
    - "V" shaped aperture gives information on elliptic latitude and elevation
- Star Sensor is mounted perpendicularly to spin direction of spacecraft
  - Mounted in parallel with IMAP-Lo FOV







Improved Star Sensor Design

- Above PMT are two UV filters
  - Previous design neglected UV light and resulted in inaccurate data
  - Spacer ring was designed to accommodate the filters and release trapped are in vacuum of space
- Above filters is 2mm diameter aperture
  - Only direct light from stars directly in line with sensor
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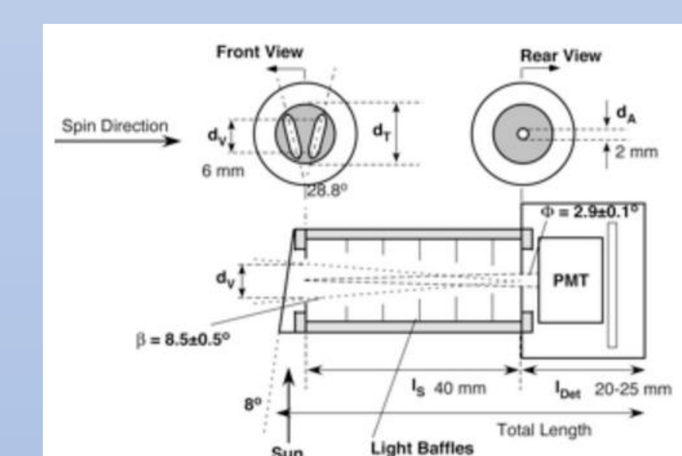
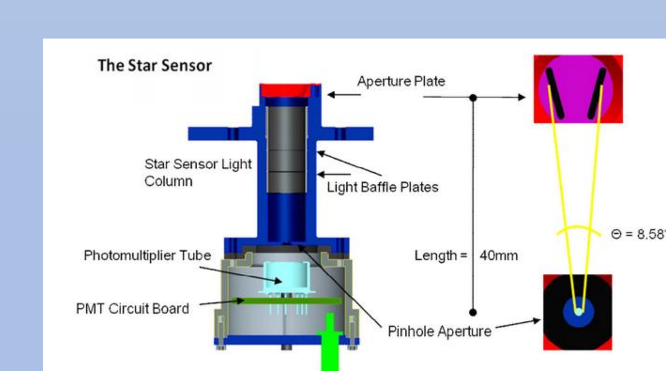
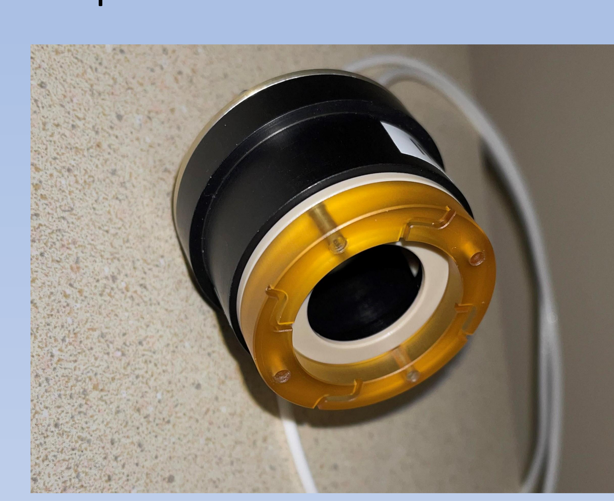
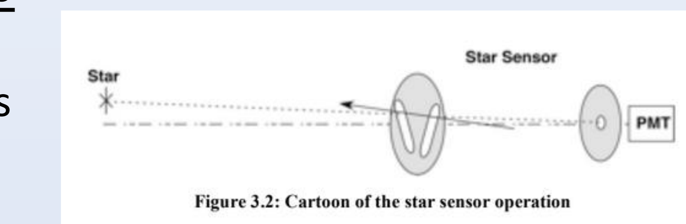


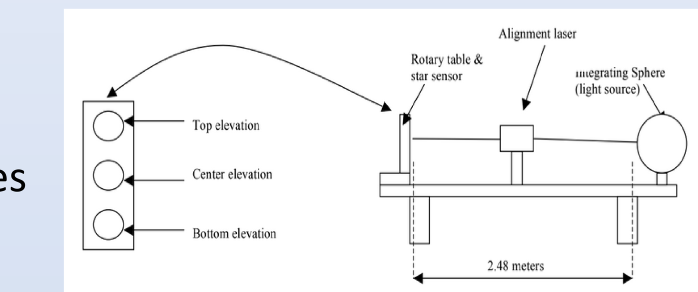


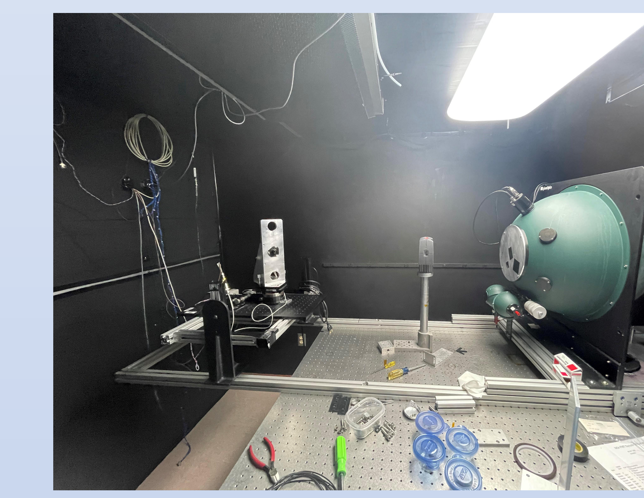


Star Sensor Test and Calibration Setup

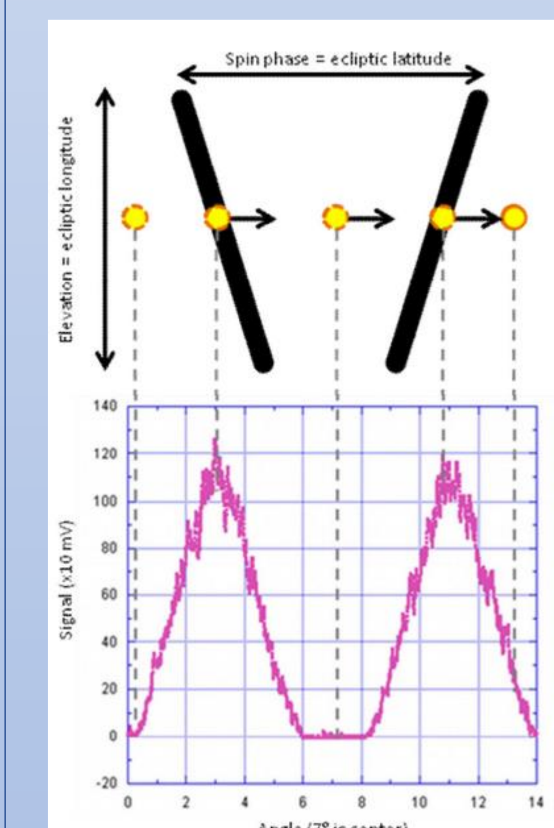
- Star Sensor calibrated to known brightness and locations of stars
- Tests taken in a dark room with an integration sphere
  - Homogonous lighting
  - Highly sensitive
  - Aperture plates for different star sizes
  - Varying brightness for different star brightness magnitudes
- Star Sensor mounted 2.43 meters from integration sphere
- Laser level and mirror used to ensure true boresight alignment of Star Sensor to IS
- Rotary table used to simulate the Star Sensor rotating on IMAP





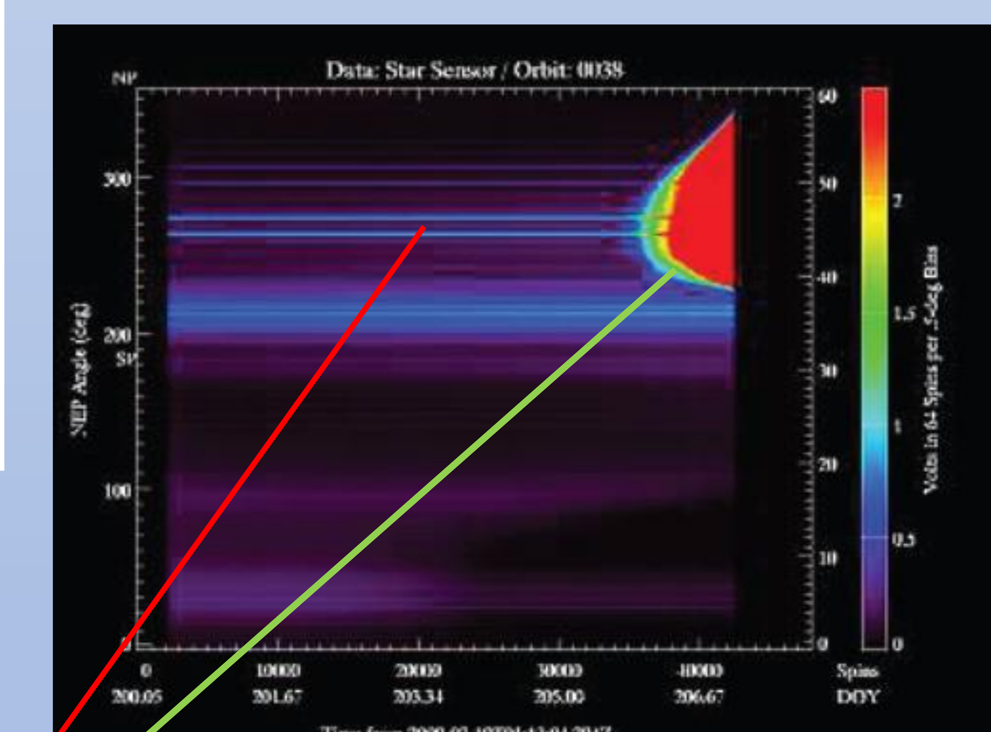


Star Sensor Signal improvements:



Data collected from IBEX

- Field of view of Star Sensor over 7 days (single spacecraft revolution)
- Shows two peaks relating to a star



- Each Star produces two voltage spikes
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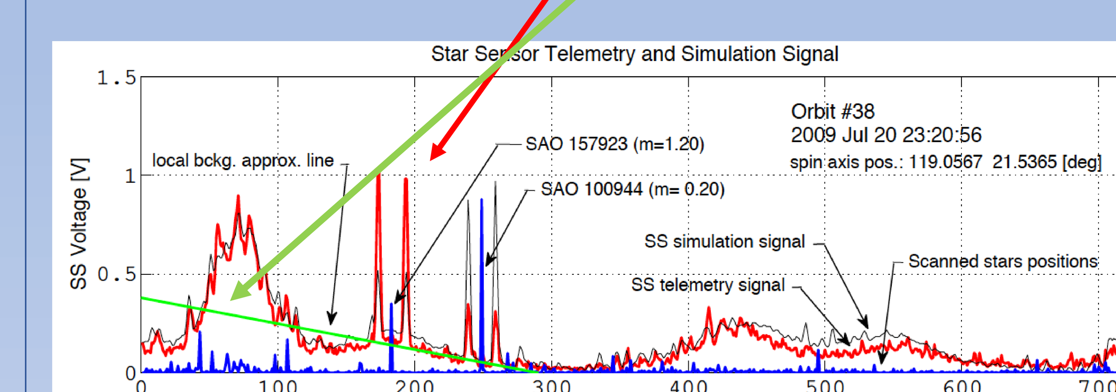

Detailed analysis of the data

- Shows the witnessed stars
- Shows background light
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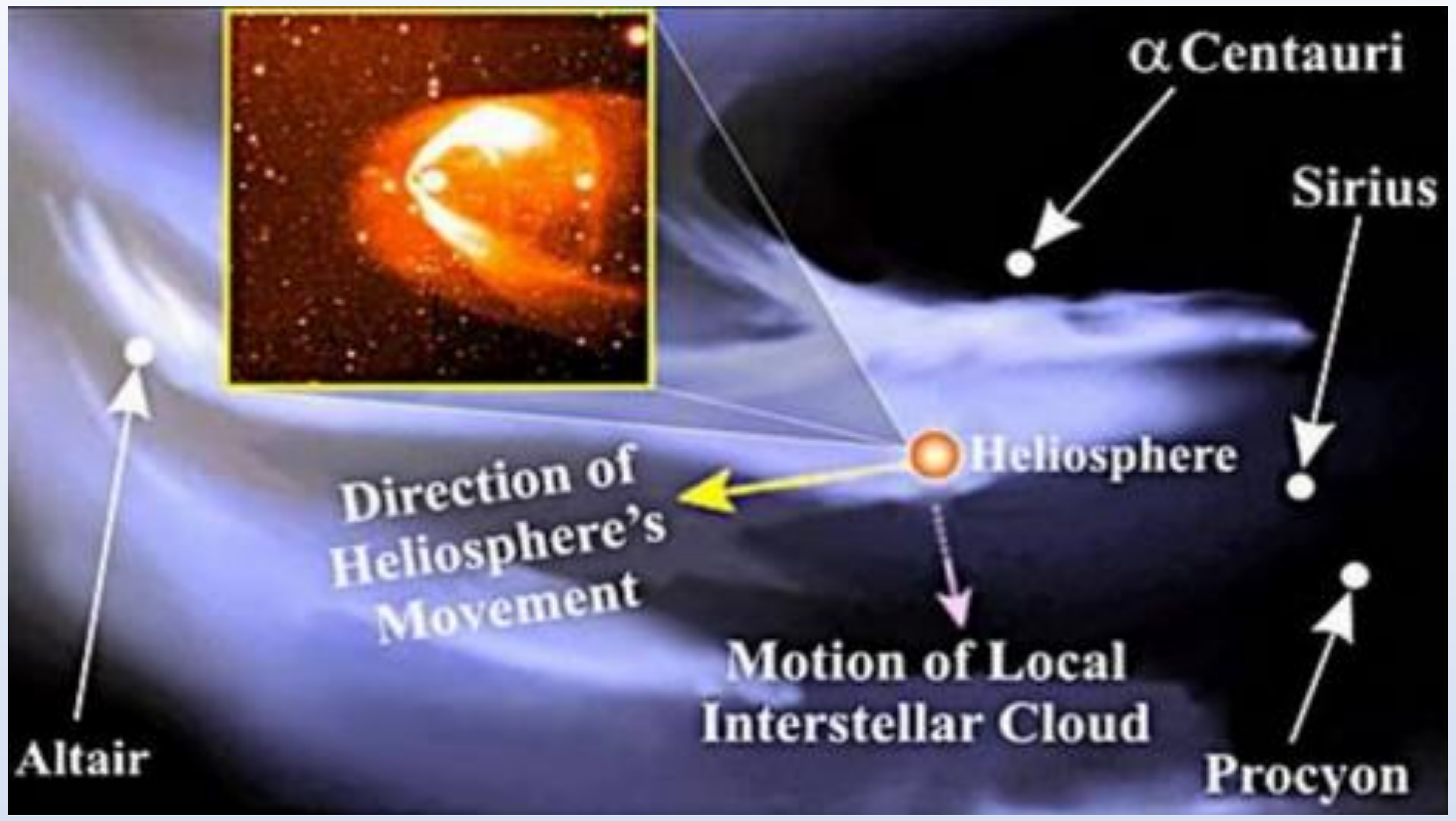

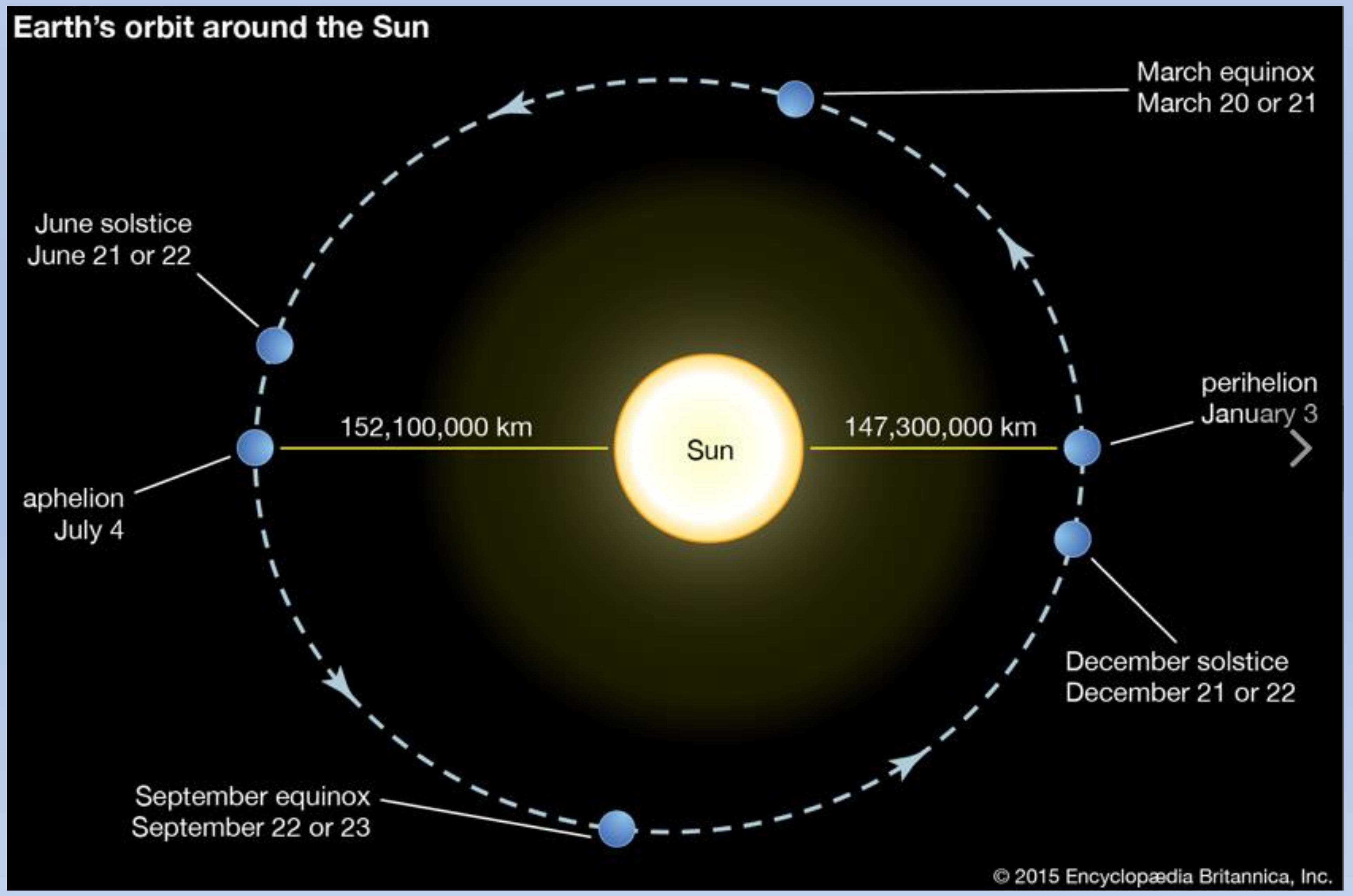

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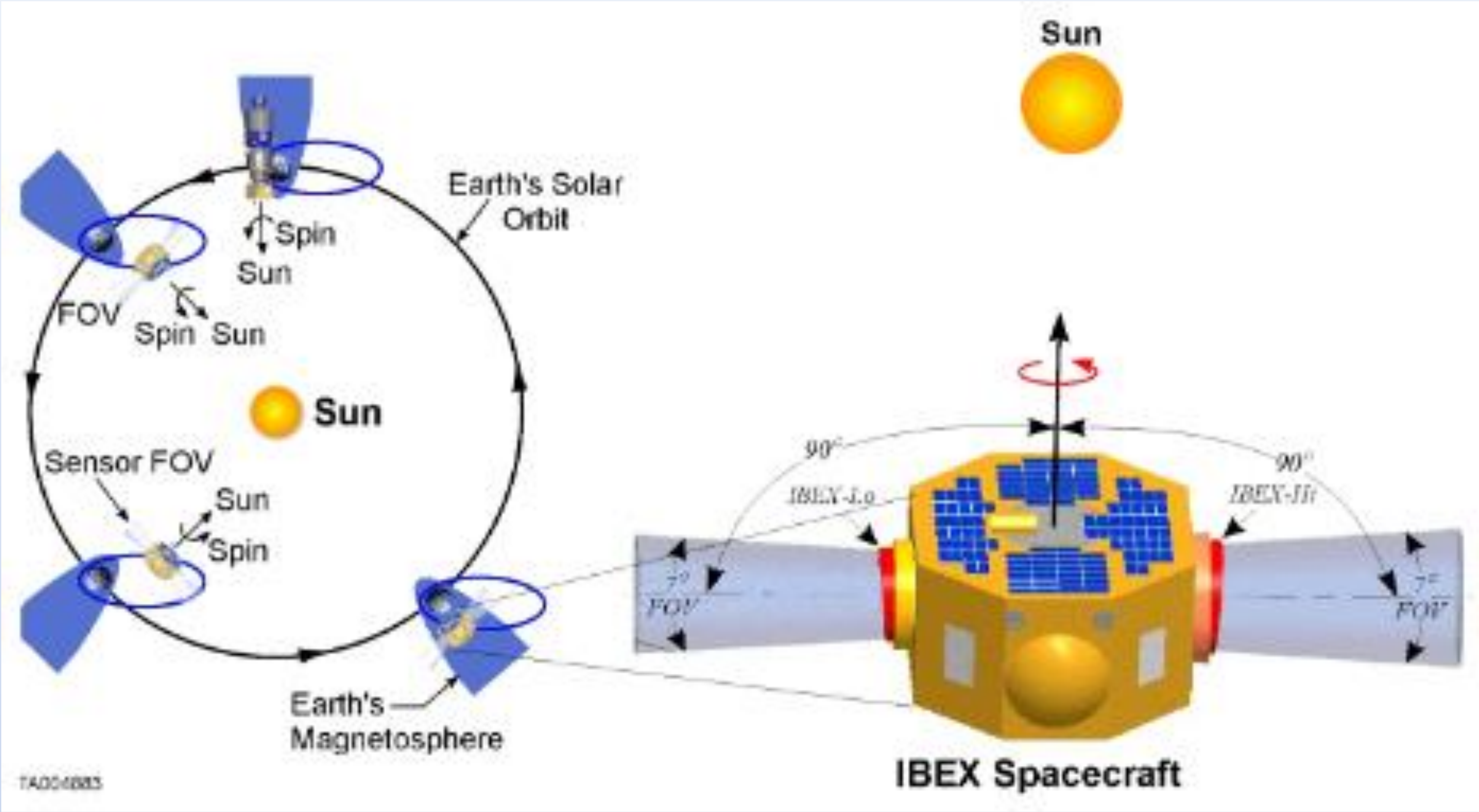

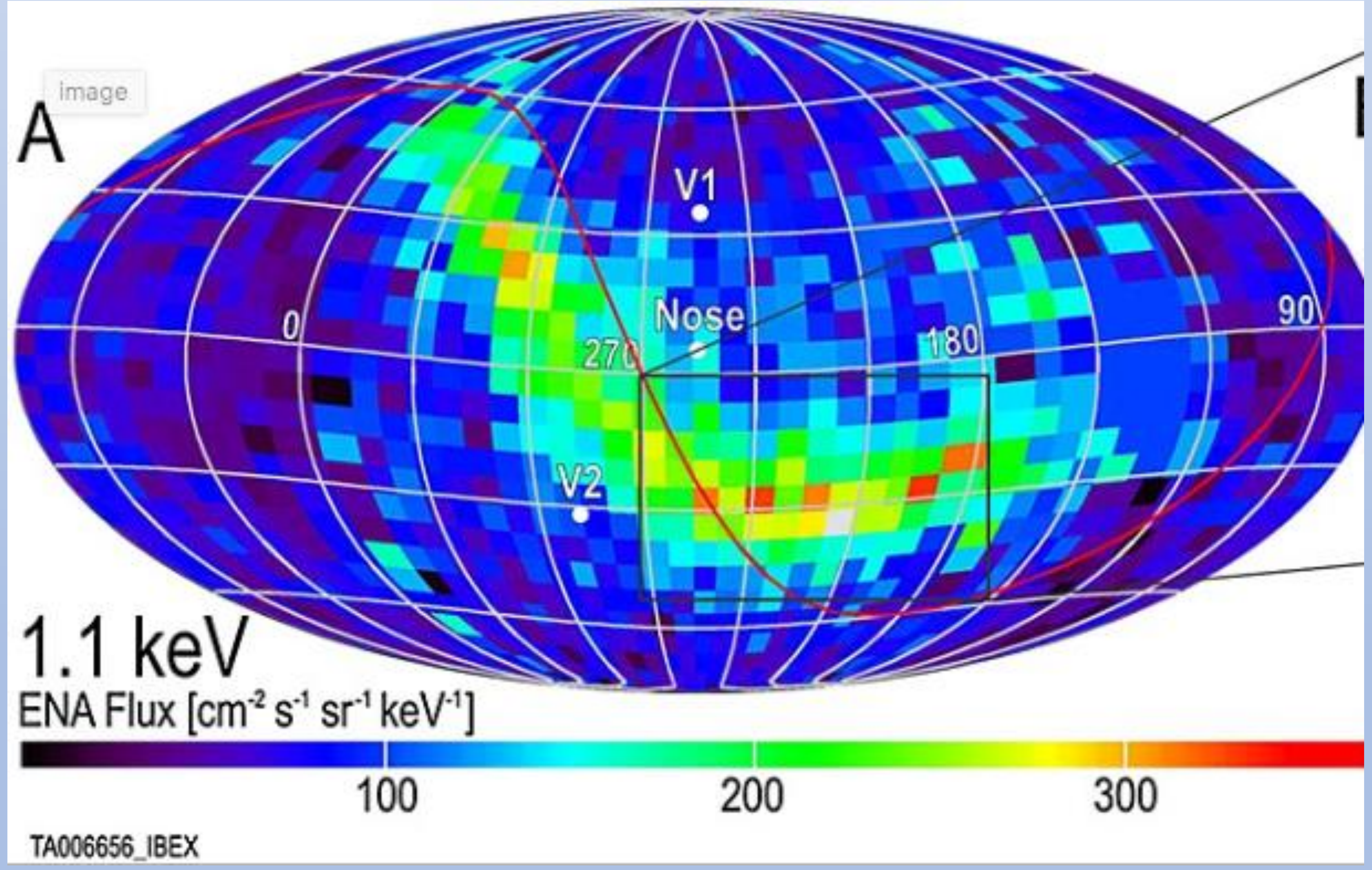

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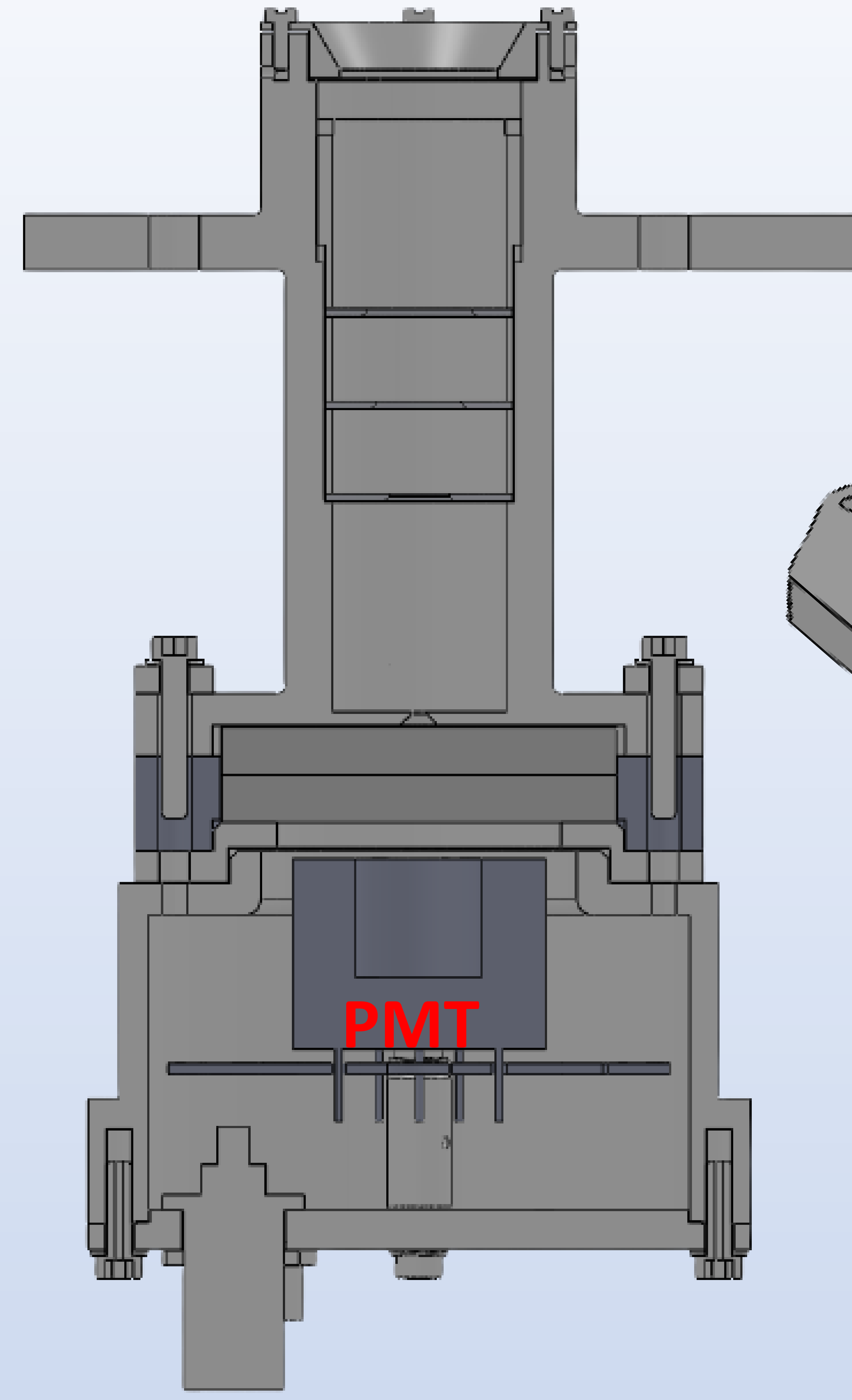

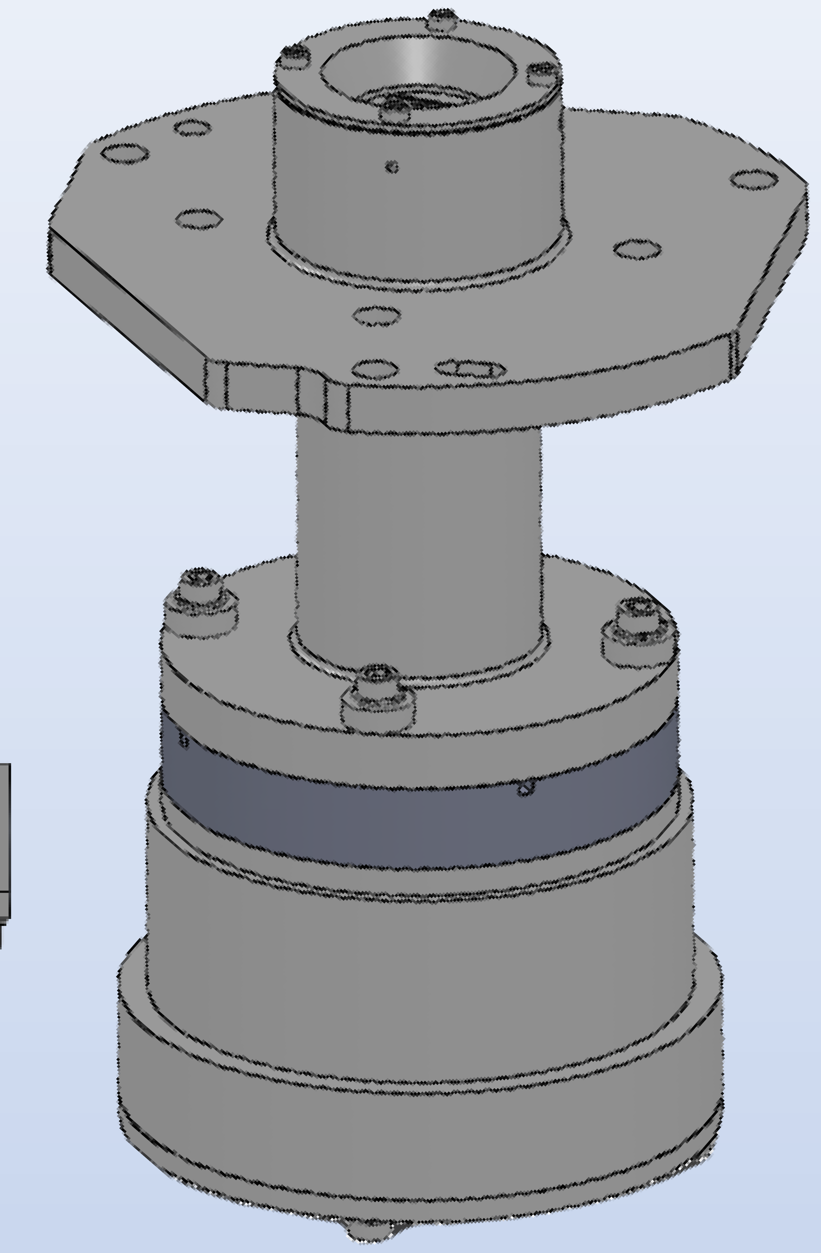

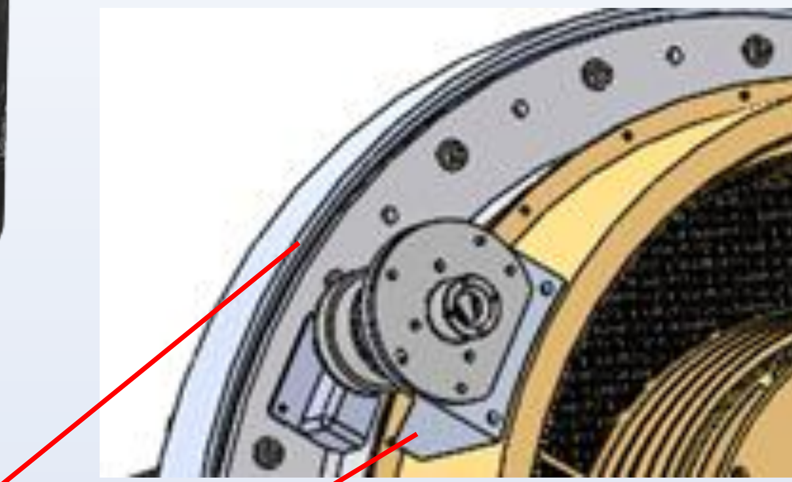

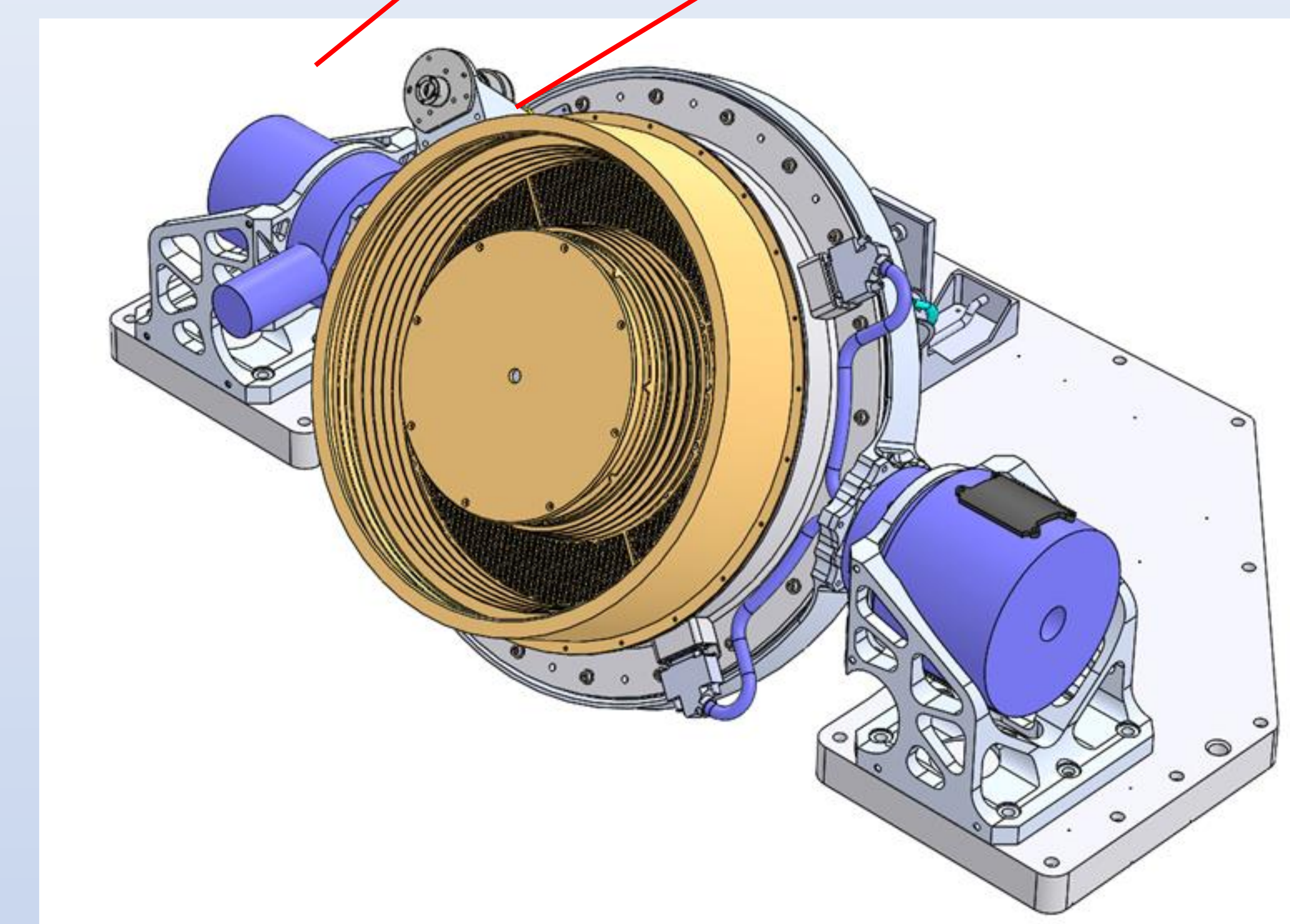

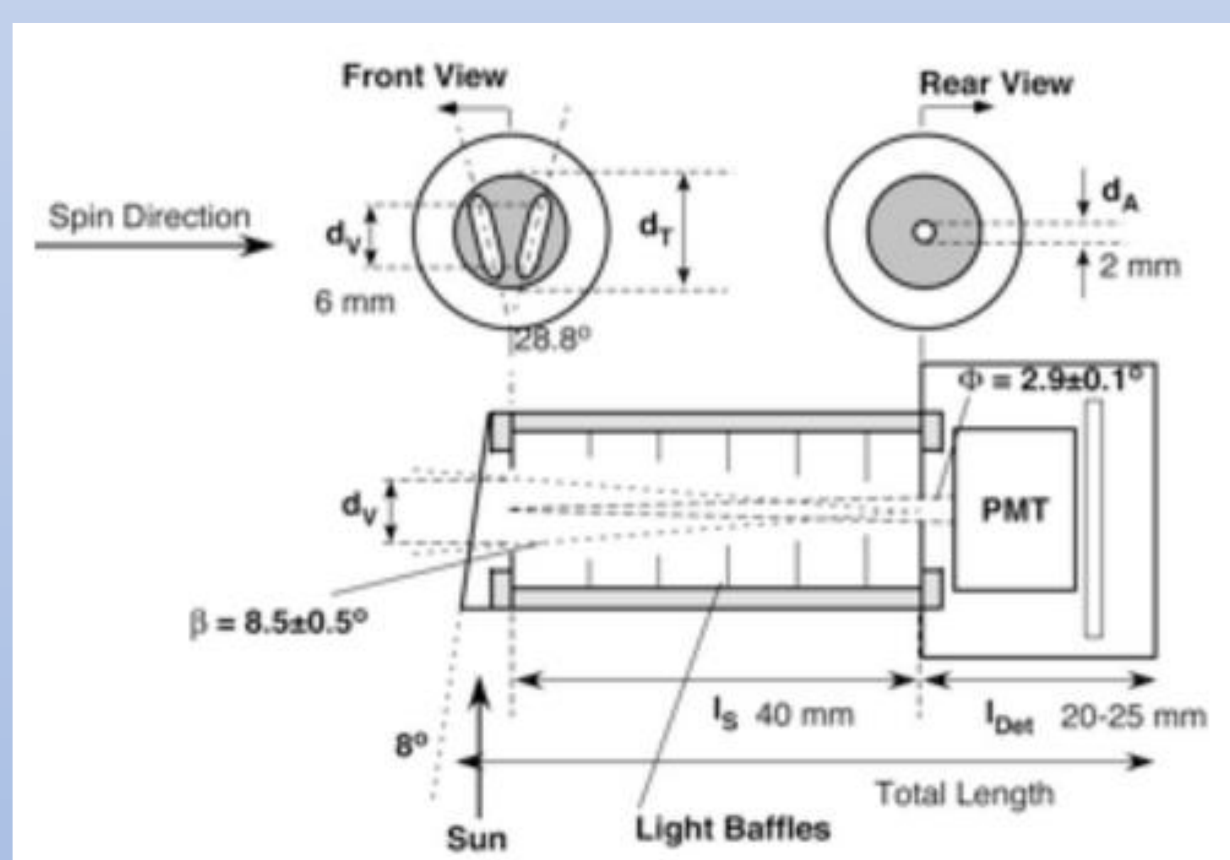

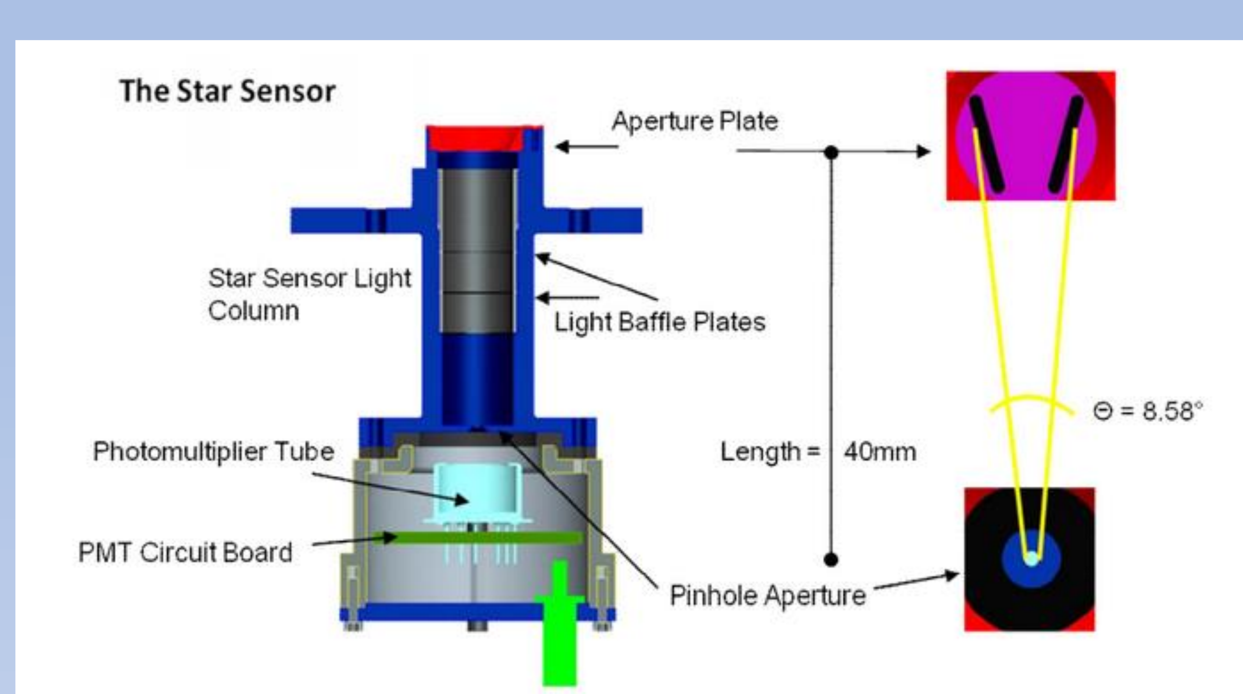

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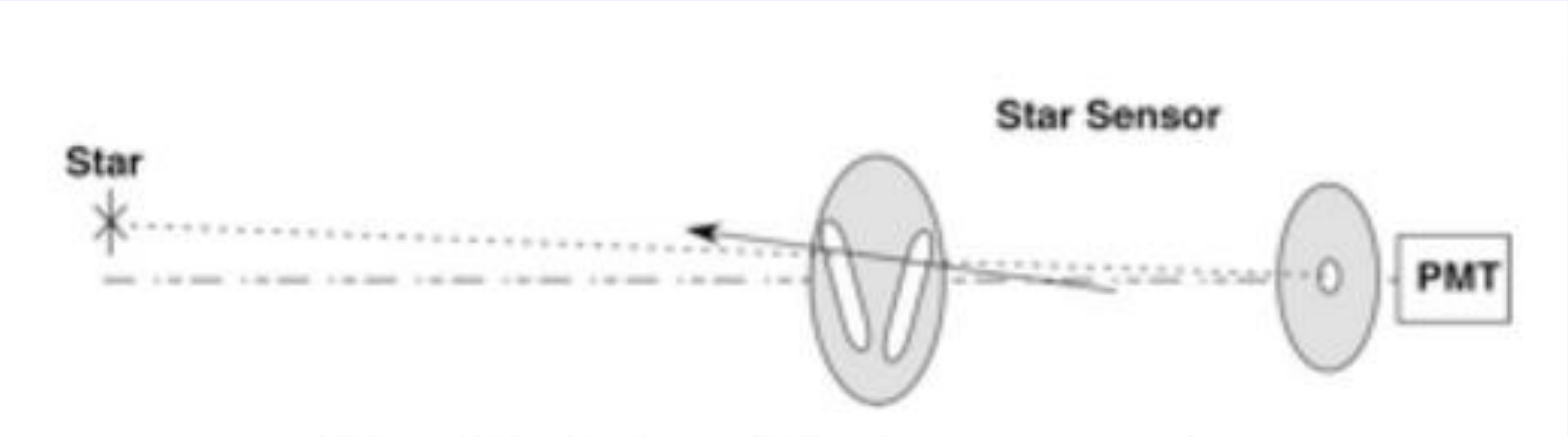
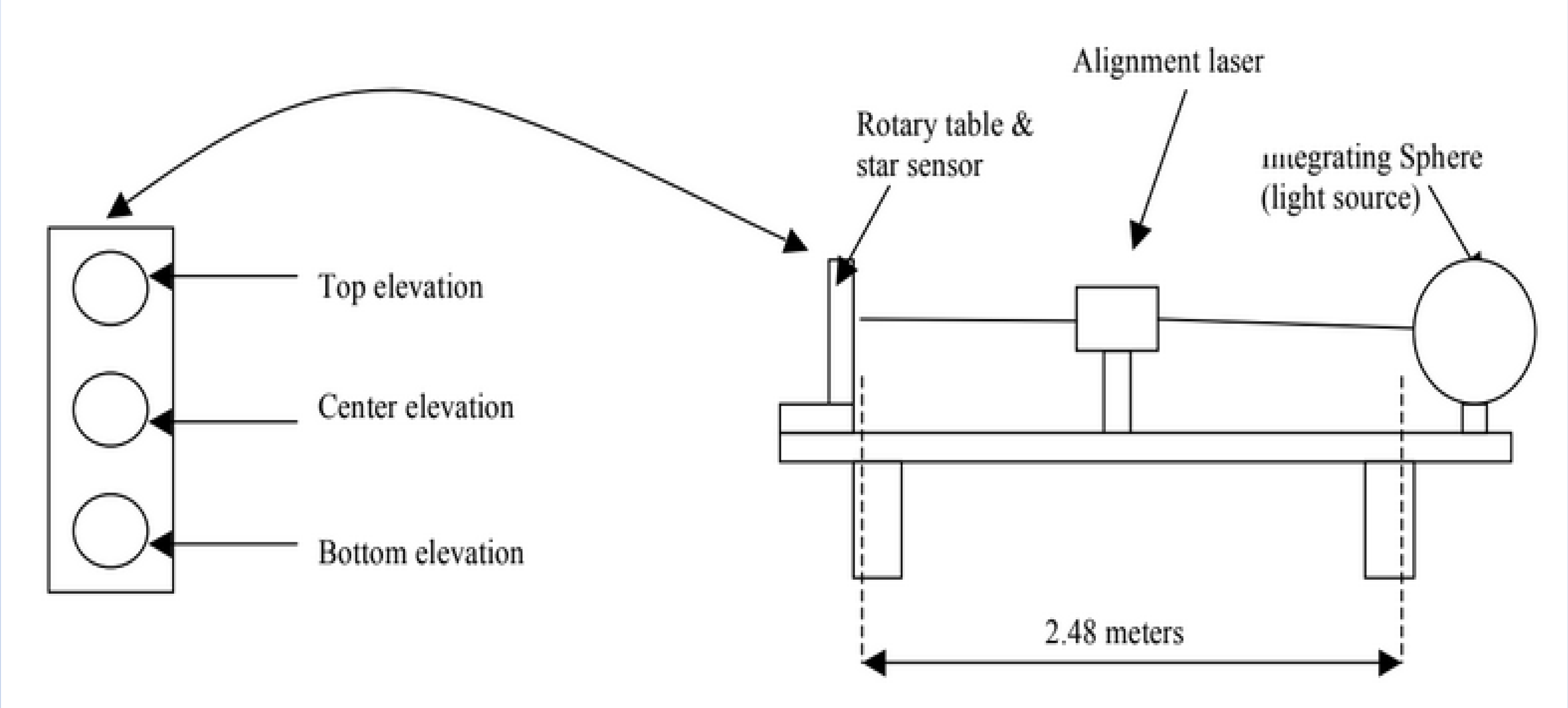
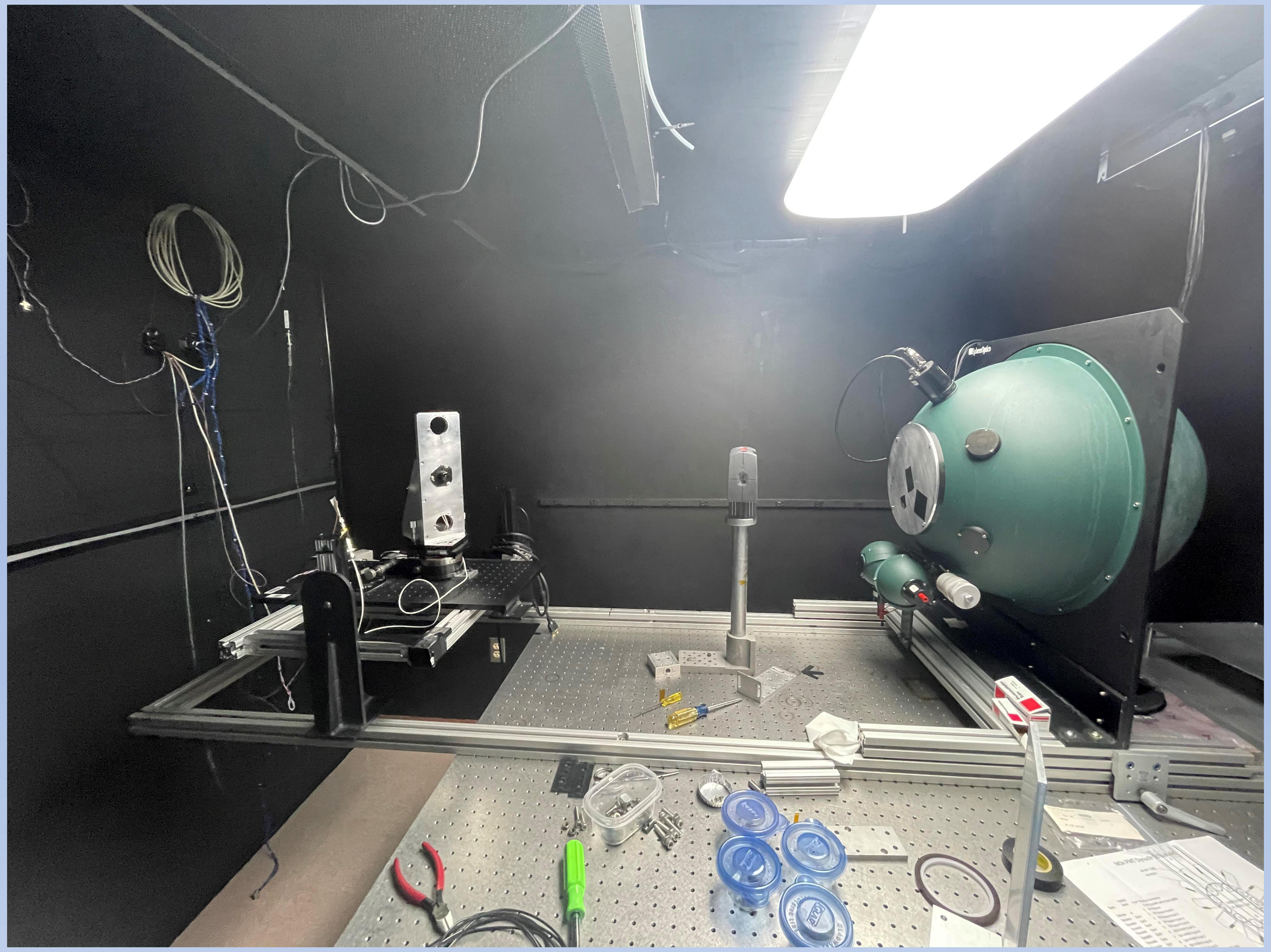
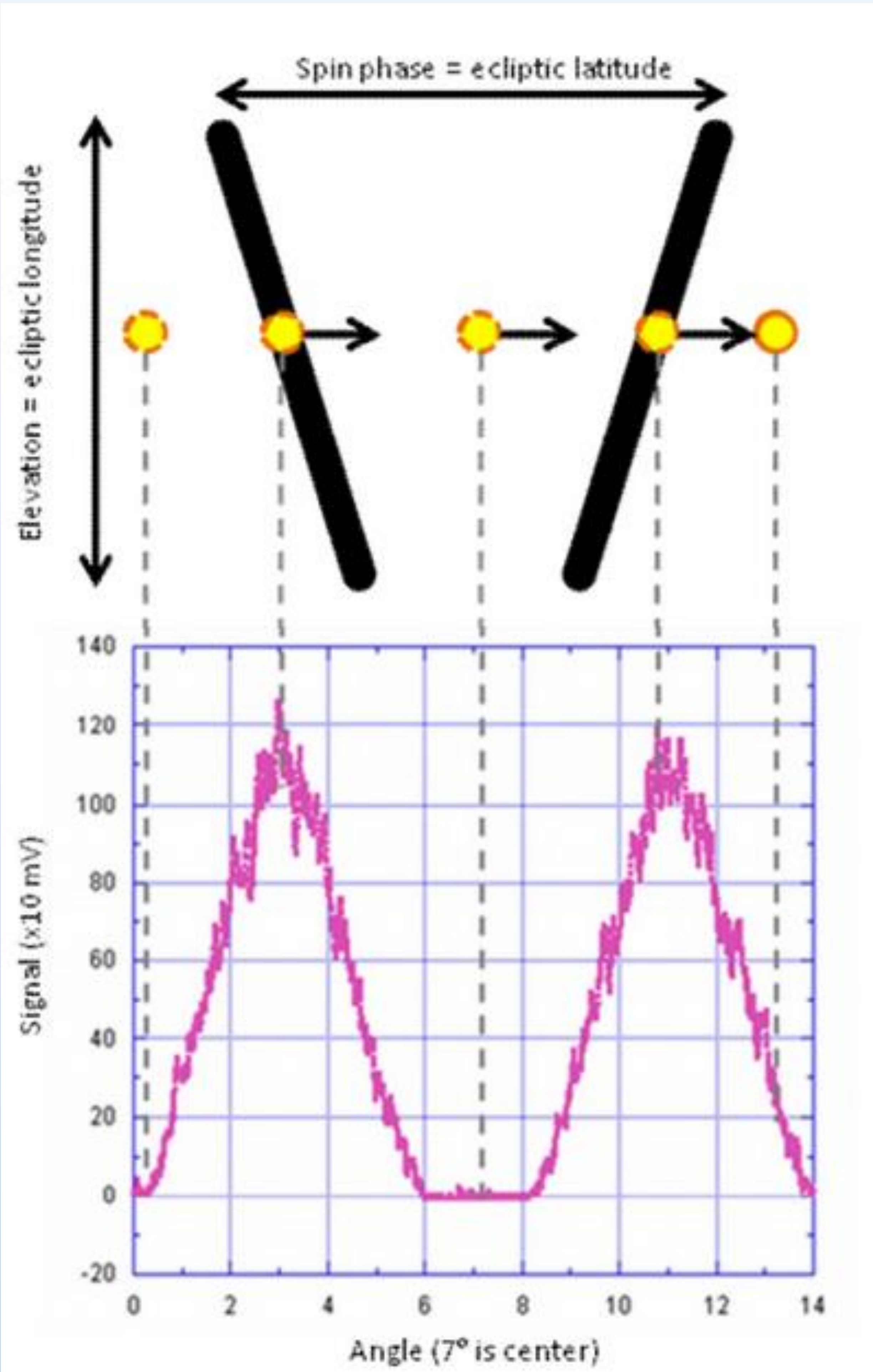


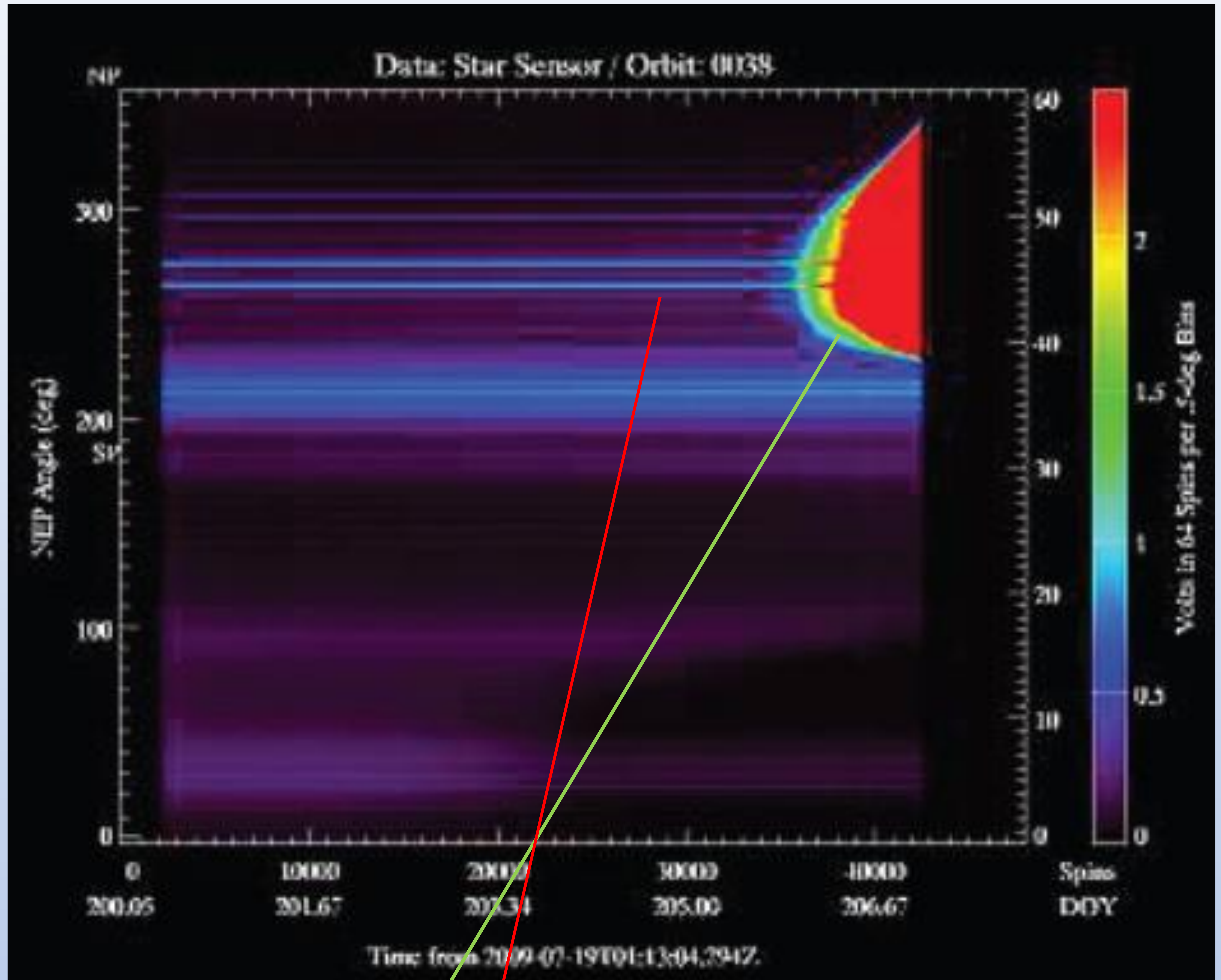
Figure 3.2: Cartoon of the star sensor operation





Star Sensor Signal Improvements





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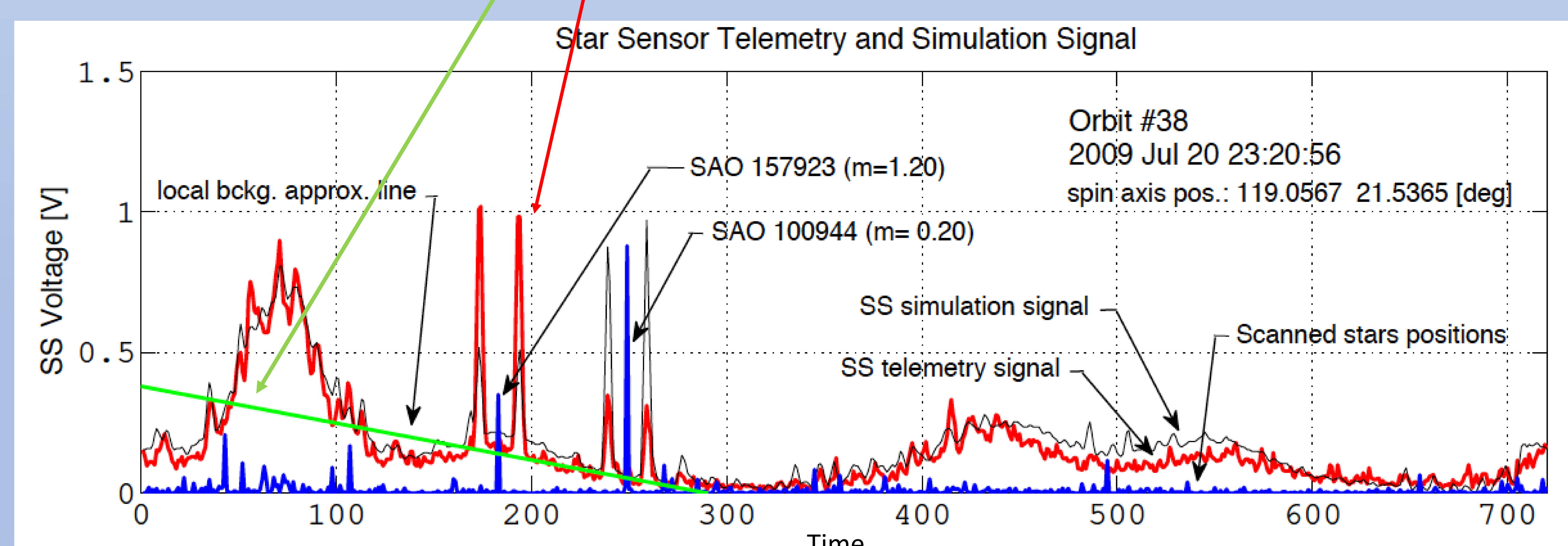

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