GP-B Lessons for LISA and STEP

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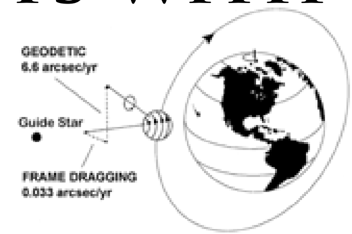
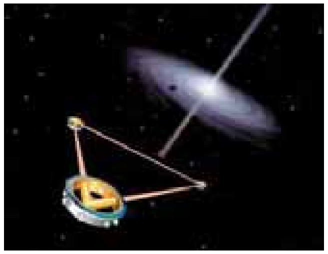
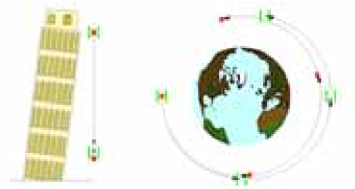
Three unique experiments with common interests



- Gravitational Experiments
- Satellite Technology
- Low disturbance environment
- Precision control
- Highly demanding





GP-B Experience is invaluable to STEP, LISA and physics in space generally

GP-B shows feasibility of complex experiments in space

GP-B Lessons for Lisa and STEP

Particularly valuable GPB Experience

- –Demonstration of Technologies
  - Cryogenic
  - Drag-free
- –Operations with spacecraft
  - Day-to-day
  - Anomaly recovery
- –Data Analysis Techniques
- –The data itself

GP-B Lessons for LISA and STEP

Generic lessons for space missions

Only one chance

- –Test it like you fly it
- –Test and inspect at all levels
- –Have the right people and experience
- –Maintain program continuity (keep a core team)
- –Need independent assessment
- –Adequate funding profile is critical
- –Satellite must be designed as a single integrated system

These are Exemplified in GP-B's Lessons

Specific Lessons From GP-B

- Verify drag-free and attitude control systems prior to launch with a <u>high fidelity</u> fixed-base payload/spacecraft simulator. Include flight hardware as much as possible.
- Experimentally verify assumptions about the instrument to the extent possible on the ground. Test as much like the flight instrument as possible.
- Perform end-to-end and environmental testing on the integrated payload/spacecraft as early as possible and *fully* analyze the data. *Pay attention to detail.*
- Allow sufficient time for spacecraft initialization, experiment setup, and unanticipated problems.
- Have the ability to measure everything on the spacecraft, including power supply voltages, to high precision. This requires a very flexible telemetry system.

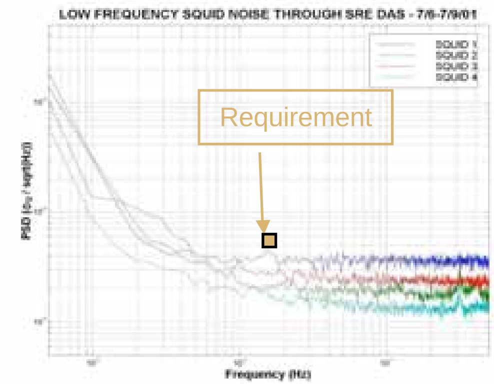
GP-B Lessons for LISA and STEP

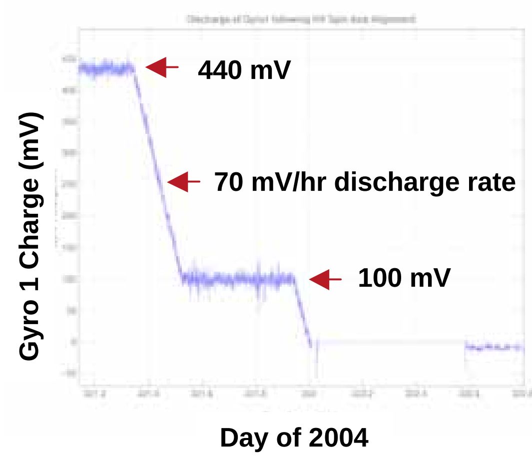
More Specific Lessons

- The SQUIDs met requirements with margin during ground testing and perform even better in space.

- Test mass charging is less important than expected before launch

- Surface-related and patch effect forces are more important than expected before launch





GP-B Lessons for LISA and STEP

GP-B Attitude and Control

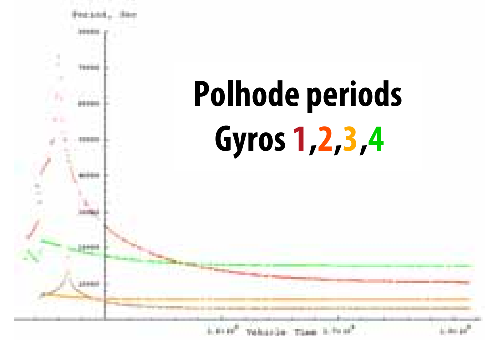
- –Unexpected thruster failures
  - •Longer than expected recovery
  - •Extra 20 days

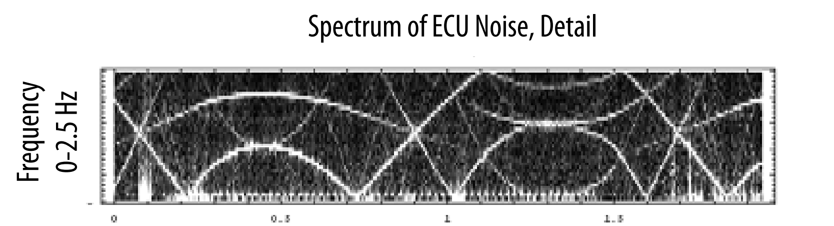
- –Much longer than expected initialization period
  - •120 rather than 60 days
  - •Risk to mission, science

Allow extra schedule

GP-B Instrument

- Changing polhode period
  - Complex data analysis
  - Varying scale factors
- Classical torques present
  - Disturbance from patch effect?
- Electronic noise
  - ECU noise
  - Conversion errors





Verify assumptions
Early end-to-end Test
Pay attention to detail
Expect the Unexpected

Conclusions

- GP-B experience is invaluable to LISA and STEP
- Experience gained = Lessons learned
- Verification of technologies

It is possible to take advantage of the unique space environment to do physics experiments