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Technology Group
Time and Frequency Sciences and

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Laser Cooling and Atomic Physics (LCAP) Program
Clock Technology Development in the
With some science return.

- capability for relativity experiments, less of spatial isotropy. Test time transfer and clock technology.
- Flight of laser-cooled microgravity atomic clock along with high stability ion clock/ master and GPS.
- Space Shuttle

- For at least 30 days. Use of clock for relativity experiments and cold collision studies.
- Laser-cooled Rubidium clock for ultra-high accuracy (exceeding a part in 10^16), to operate continuously.
- RACE (Rubidium Atomic Clock Experiment): Yale.
- PARCS (Primary Atomic Reference Clock in Space): NIST/CU.

International Space Station

Overview of LCAP Flight Projects
SUMO
(requires cavity oscillator such as
Kennedy-Thormidike Experiment
•
(oscillator
requires comparison to another
Local Position Invariance
•
(ground
requires stable frequency transmitter to
Gravitational Frequency Shift
•

Physics with Clocks in microgravity
ISS Science Platforms
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Constraint</th>
<th>Reserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>45cm</td>
<td></td>
</tr>
<tr>
<td>Depth</td>
<td>90cm</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>162 inches</td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td>&gt;500 L</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>&gt;2KW</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>&gt;130kg</td>
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</table>

**Cesium Clock Package**

NOTE: All dimensions are approximate and subject to change.

ISS EXPRESS RACK

PARCS
Vibration Test bed at JPL

New Focus Vortex Laser on

100x Earth dose

Radiation:

Humidity: 20 to 70%
Pressure: 76 torr to 204 torr (1240 Torr/min Max Depressurization Rate)
Temperature: -5 to 50 C
Instrument should operate after exposure to:

Environment:

Duration: Design: 2 minutes; FF or PA test: 1 minute

-6dB/pt case
-6dB/pt case
-6dB/pt case
-6dB/pt case
-6dB/pt case

0.03 Hz to 2000 Hz
0.06 Hz to 150 Hz
20 Hz to 150 Hz

Freq. Range Design/Projection (PA) Flight Acceptance (PA)
Instrument should operate after exposure to:

Vibration Testing:

Shuttle Requirements:

Space Qualification of Components
Laser Configuration
Frequency Transmitter
Clock Rate Comparison: GPS Carrier Phase
Give Position Information to 100 m
Existing GPS antenna will see between 3-6 satellites

Visibility of satellites (desire ~ 12 in view)
Multipath Worse SOME (need ~70 dBm)
No High Quality R/Optical Link between Interior/Exterior
Need external antenna

Issues:

> 1 mm/s velocity information
> > 10 cm position information
> 100 ps resolution

Gps Carrier Phase Technique expected to give:

Gps Carrier Phase Frequency Transfer
ISS Model Views

Another "Normal" View

"Normal" View