Laser Cooled Atomic Clocks in Space

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PARCS

Clock Operation: Example

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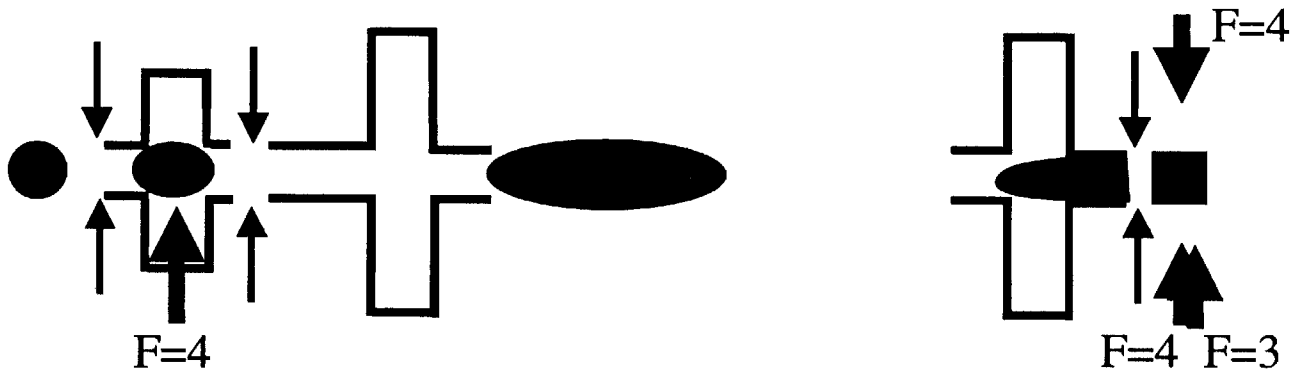

Collect: $N_0 = 8 \times 10^7$ cold atoms/ball
Launch: $N_{m=0} = 9 \times 10^6$ in m=0 with 2 balls/s
Detect: $N_D = 1.5 \times 10^4$
Ramsey Time: $T_R = 5$ s
Cycle Time: $T_c = 15$ s

» $\sigma_y(\tau) = 1.6 \times 10^{-14} \tau^{-1/2}$

Source "brightness" achieved so far:

1) $N_0 \sim 2 \times 10^8$ (in 1 sec.) in vapor cell molasses (Ch. Salomon, Paris)
2) $N_0 \sim 5 \times 10^7$ (in 1 sec.) in small beam filled molasses (NIST Fountain)

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Basic Clock Layout

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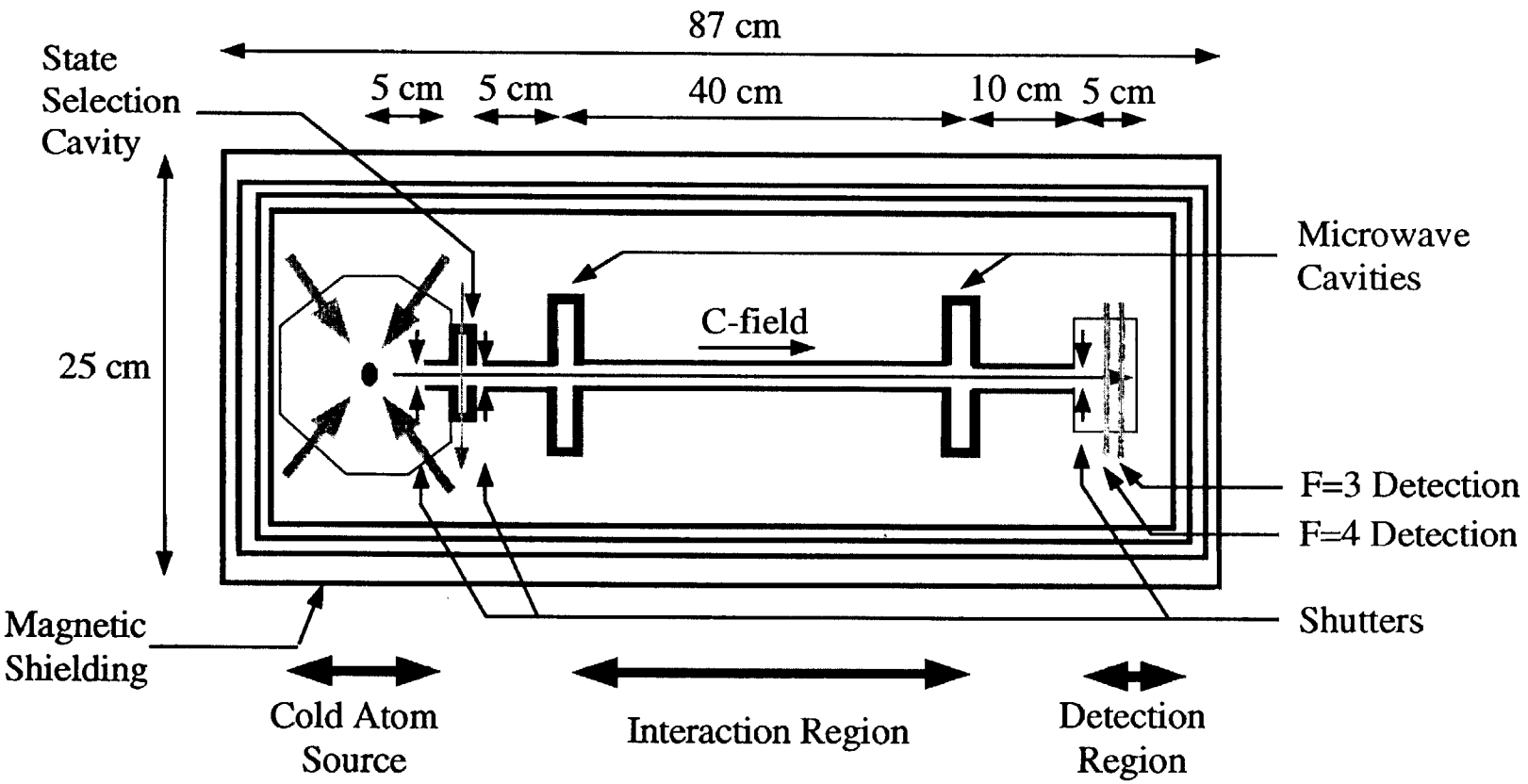


GLACE: Glovebox Laser-cooled Atomic Clock Experiment

Principle Investigator: K. Gibble (Yale)

Goals:

- First utilization of tunable, frequency-stabilized lasers (300 kHz @ 852 nm) in space.
- Demonstrate laser cooling and trapping in microgravity.
- Demonstrate longest 'perturbation-free' interaction time for a precision measurement on neutral atoms.
- Resolve Ramsey fringes 2–10 times narrower than achievable on Earth.

Approach:

- COTS components (HP 5071 cavity, commercial lasers and vacuum components).
- Utilize prototype hardware from LCAP flight definition experiments.

Launch date: Oct. 2002 (UF-3)

Space Qualification of Components

Shuttle requirements:

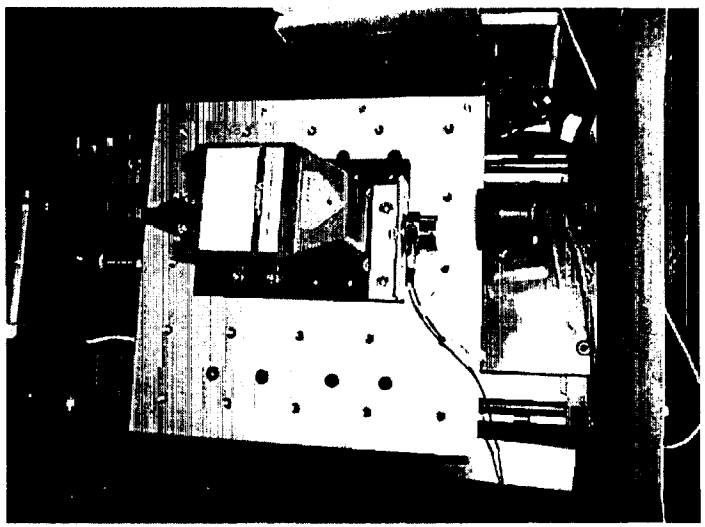
•Vibration Testing:

Freq. Range	Design/Protoflight (PF)	Flight Acceptance (FA)
20 to 150 Hz	+6dB/Octave	+6dB/Octave
150 to 1000 Hz	0.06 g2/Hz	0.03 g2/Hz
1000 to 2000 Hz	-6dB/Octave	-6dB/Octave

Duration: Design: 2 minutes; PF or FA test: 1 minute

•Temperature:

Must survive over a -5 to 50 C range



New Focus Vortex laser on vibration test bed at JPL

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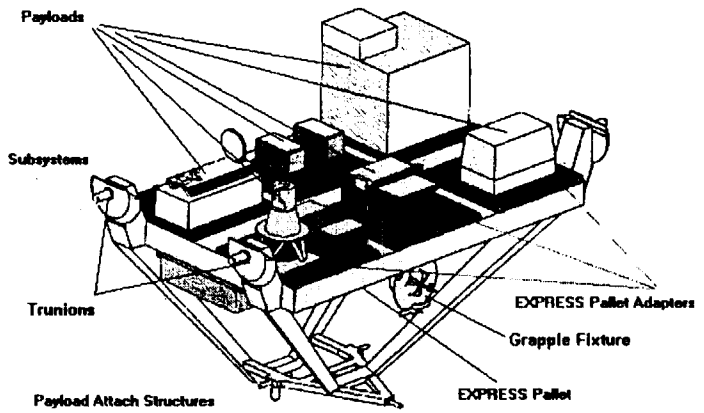
ISS Science Platforms:

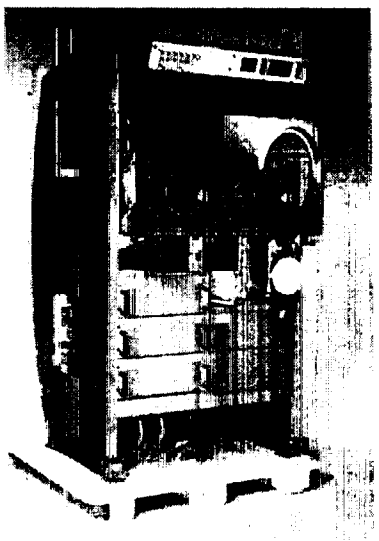
Express Pallet

- For External Payloads



Microgravity Science Glovebox(MSG)

- 260 liter working volume



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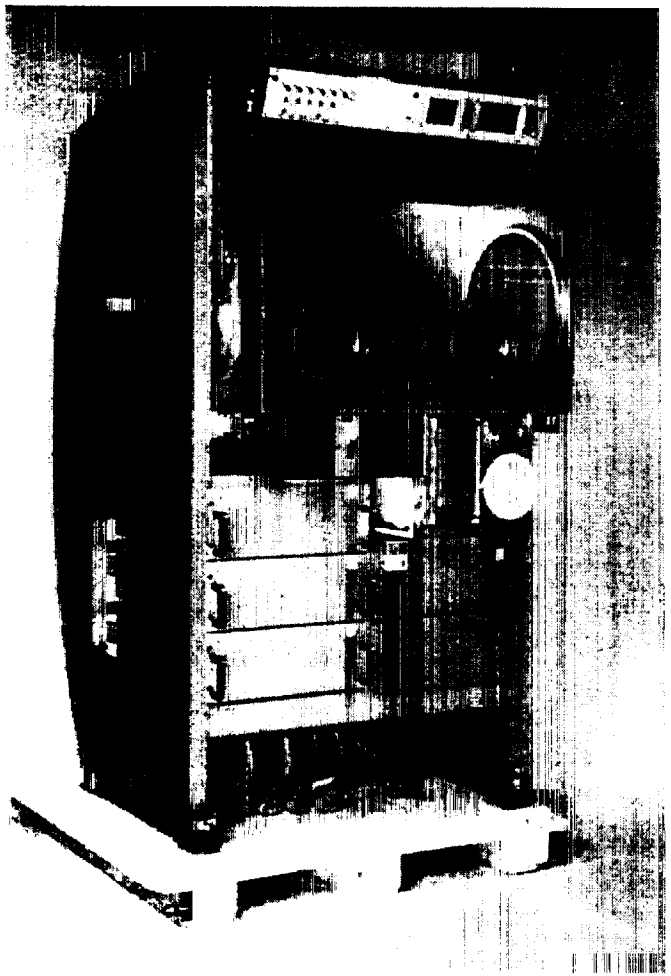
Microgravity Science Glovebox



MSG specifications

- **Working volume**:
  260 liters (92 cm×65 cm×50 cm)
- **Vibrational isolation**:

Frequency Range	RMS Acceleration
0.01–0.1 Hz	< 0.21920 μg
0.1–100 Hz	< f×0.21920 μg/Hz
100–300 Hz	< 219.20 μg

- **Electrical power**
  1000 W (8.3 A @ 120 V, 7 A @ 28 V, 2 A @ ±12 V, 4 A @ 5 V)
- **Heat dissipation**
  1000 W (800 W via coldplate, 200 W via air flow)
- **Data I/O**
  RS-422, MIL STD 1553B, digital I/Os, analog outputs, ethernet.

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