JEM-EF's Accommodation of the Low Temperature Microgravity Physics Facility

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JOHN PENSINGER, DONALD LANGFORD, ARVID CROONQUIST, FENG-CHUAN LIU

Jet Propulsion Laboratory, California Institute of Technology
Pasadena, CA 91109, USA

The Japanese Experiment Module's Exposed Facility (JEM-EF) provides the Low Temperature Microgravity Physics Facility (LTMPF) with the power, command, and telemetry resources to meet its scientific objectives. The International Space Station (ISS) provides microgravity and communication infrastructure. The LTMPF is a Fundamental Physics research facility for long-duration science investigations whose objectives can only be achieved in microgravity and at low temperature. This talk will present some of the issues associated with doing high-resolution measurements in the unique ISS environment. LTMPF is a pathfinder for the processes and documentation required for a NASA payload that is attached to and operated at the JEM-EF.

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John Pensinger, Donald Langford, Arvid Croonquist, Feng-Chuan Liu
Jet Propulsion Laboratory, California Institute of Technology

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john.pensinger@jpl.nasa.gov

LTMPE* Background

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History:

- Shuttle experiments in the Fundamental Physics program have achieved benchmark science results in Microgravity (μg).
- End of regularly scheduled Shuttle flights for science payloads; start of ISS era.
- Scientists need longer time in μg.
- NRC Space Studies Board & Science Discipline Working Group recommended a cryogenic facility on ISS in 1995.
- JPL with strong support from the Low-Temperature research community began developing a Facility concept.
- Industrial partners: Ball Aerospace, Design_Net Engineering.
- NRC Board on Physics and Astronomy voiced strong support (Oct. 1999).

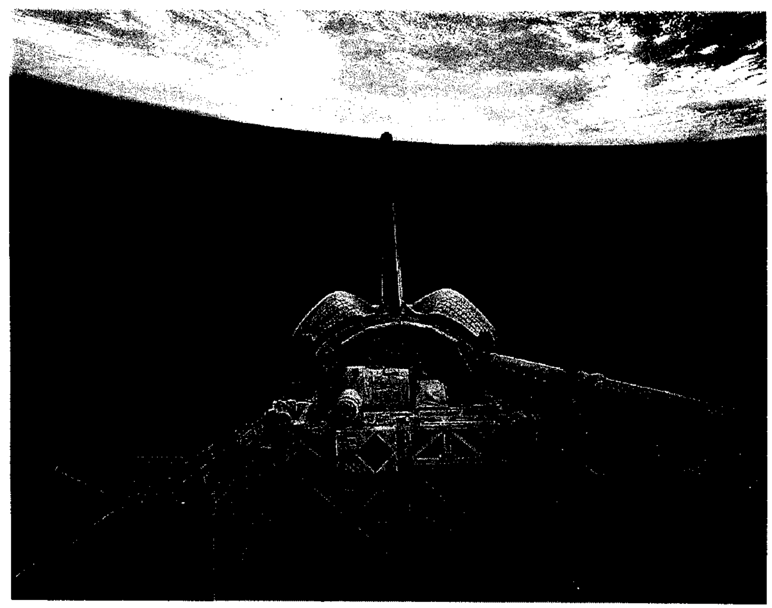
Recent JPL Cryogenic Experiments on Shuttle

Superfluid Helium Experiment (SfHe, 1985)
Lambda Point Experiment (LPE): 1992
Confined Helium Experiment (CHeX) : 1997

- benchmark science results
- 10^{-10} Kelvin thermometry in space
- trailblazing technology demonstration

5 experiments in flight-definition/development

UNM, JPL, Stanford, UCSB, Caltech.



Lambda-Point Experiment in STS Cargo Bay

* Low Temperature Microgravity Physics Experiments (LTMPE) Project

Objectives

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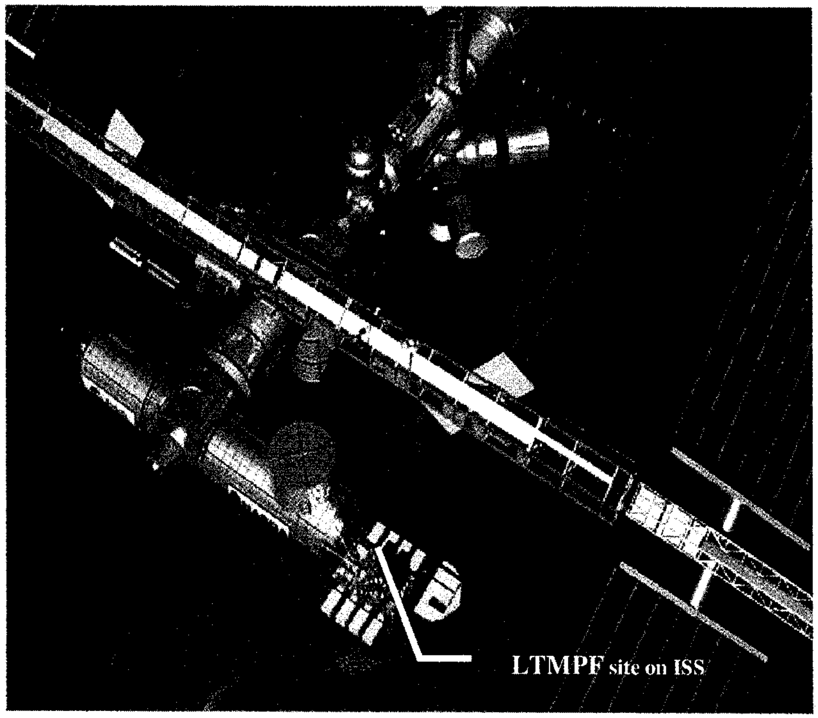

- To provide a major low-temperature research laboratory for Fundamental Physics experiments on the International Space Station over the next ten-plus years.
- To take advantage of low temperature and microgravity in order to study matter under unique conditions to uncover underlying organizing principles.
- To develop more capable sensors and to produce order-of-magnitude improvements in scientific observations.
- To carry at least two new investigation into orbit every two years.
- To build on benchmark Shuttle flights - LPE and CHeX - and advances in sensor technology.

Facility Design Features

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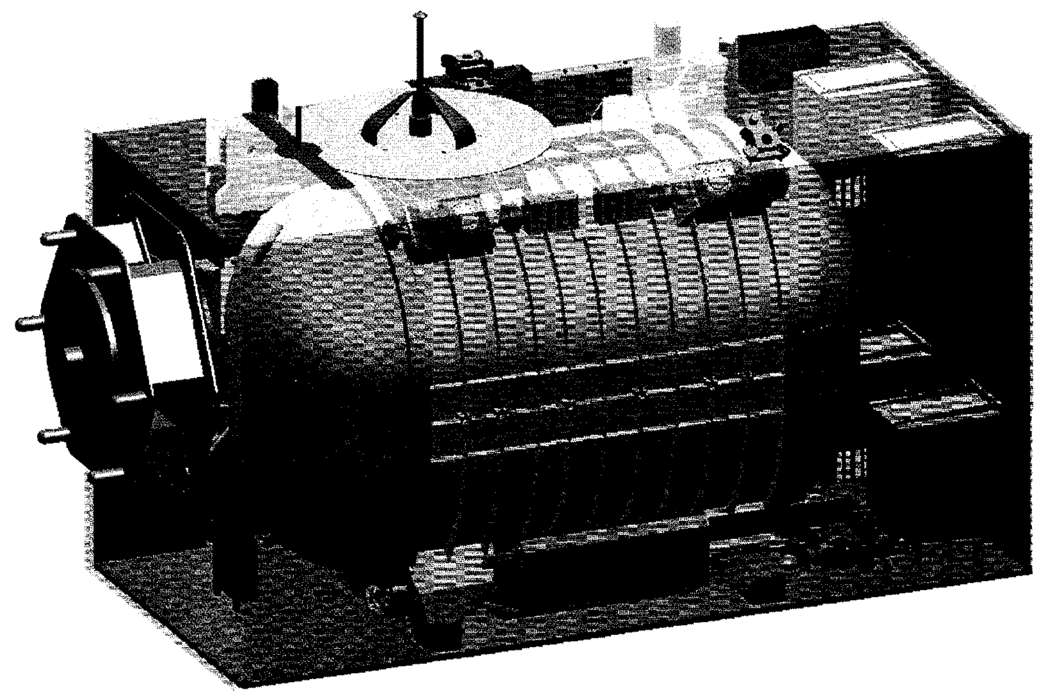
- A 182-liter superfluid-helium dewar provides experiments at least four and a half months of science operations in microgravity.
- The helium tank has space, wiring, and plumbing for an Insert at each end of the dewar.
- External honey-comb panels support interface hardware, electronics, and radiate heat.
- Superconducting Quantum Interference Device (SQUID) preamps and controllers enable measurements with a part-per-billion resolution.
- A truss structure with Germanium Resistance Thermometers and heaters isolates the science cell from external thermal fluctuations.
- VMEbus Electronic Assemblies provide internal & external communications, instrument control, and data handling.
- 1.0 x 0.8 x 1.8 m^3; 560 - 600 Kg.
- Ball Aerospace develops the Dewar and Enclosure. Design_Net provides the Electronics and Software.



LTMPF =
Facility + Instrument

Instrument Design Features

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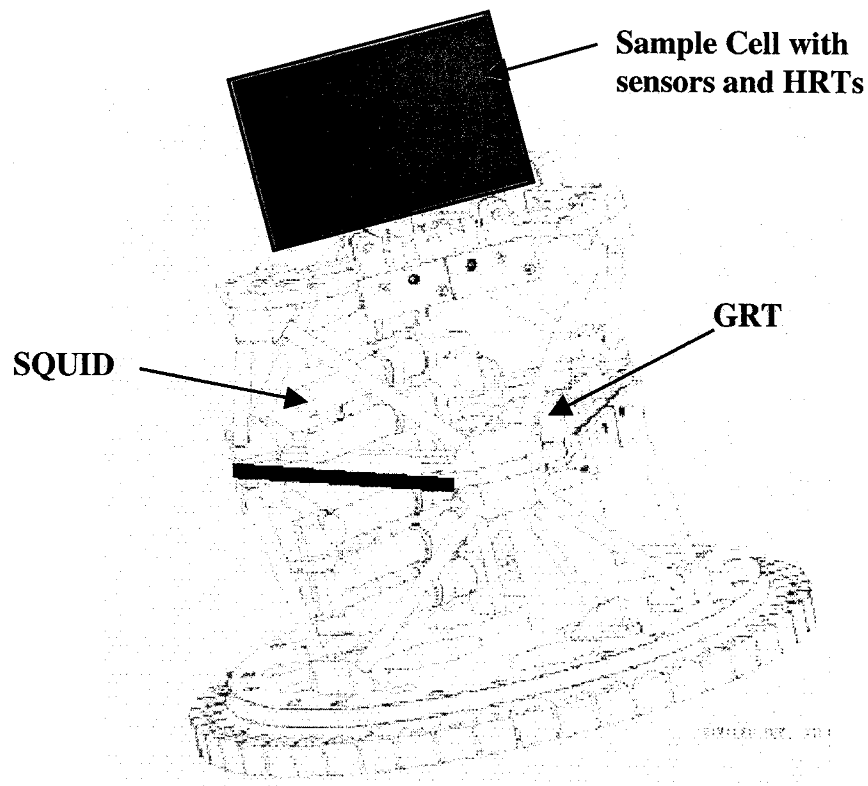
- **Principal Investigator (PI) team develops, assembles, and tests their Instrument:**
  - **Cryo Insert, custom electronics, experiment software.**
- **PI team develops and qualifies sample cells and actuators.**
- **JPL provides standard components:**
  - **Thermo-mechanical truss with Cold Plate**
  - **Magnetic shield/Vacuum Can**
  - **Charcoal Sorption Pump**
  - **GRTs, SQUIDs**
  - **Wires, capillaries, & fasteners**
- **Instrument is integrated into the Facility and tested at JPL with participation of PI team.**



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Operational Features

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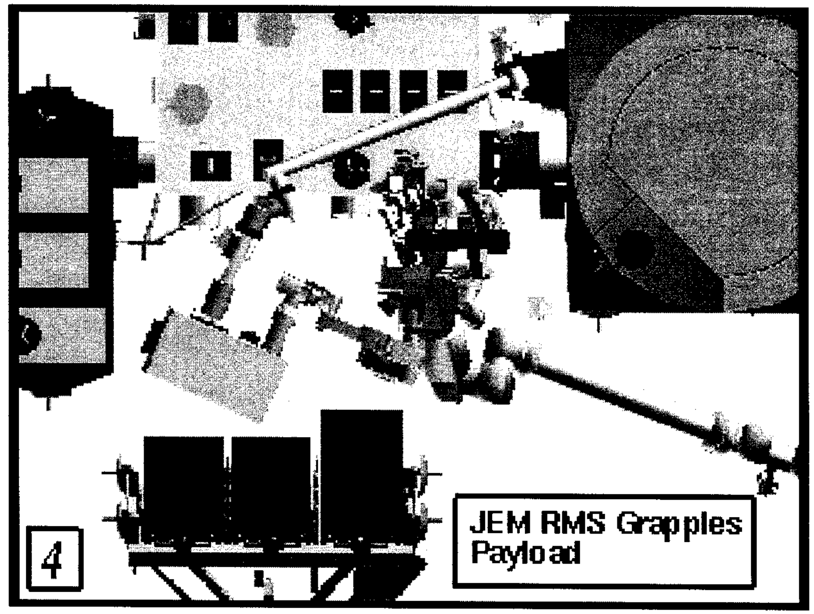
- Use of FRAM will provide flexible manifesting: it is used by the ExPRESS Pallet/ULC, ICC, LMC, & HTV-EP.
- STS is the baseline launch vehicle; ExP/ULC is the baseline carrier.
- The two experiments and the Facility are operated independently via ground command.
- LTMPF scientists conduct their experiments from their home institutions (slow telescience and autonomous sequences).
- JPL provides infrastructure to support science investigations: planning, integration, test, verification, & operations.
- Instruments from the University of New Mexico/Caltech (DYNAMX/CQ) and JPL (MISTE/COEX) are being developed for the first mission in 2005.
- Investigations from UCSB (BEST) and Stanford University (SUMO) have been chosen for the second mission.
- Future investigations will be selected from AOs & NRAs.

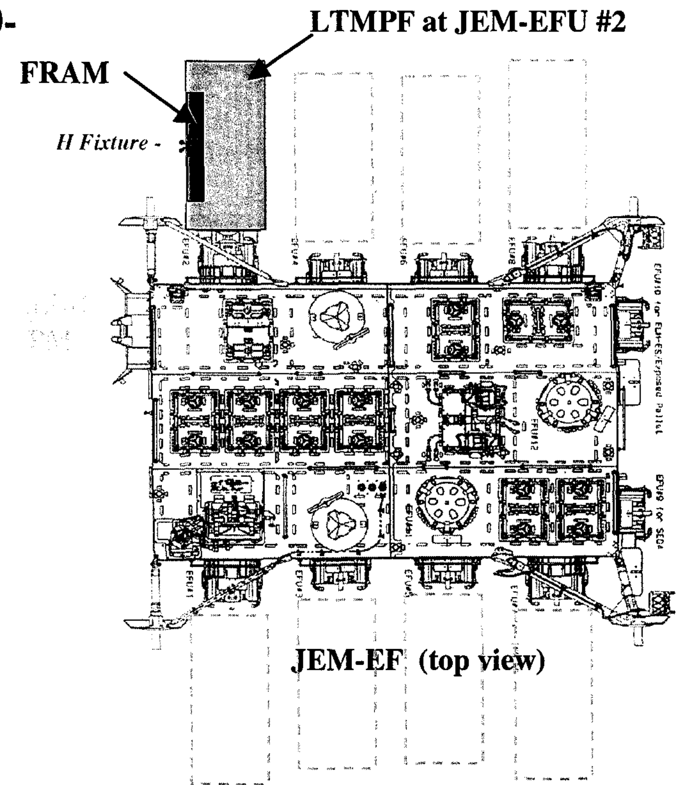


John Bussell, MAGIK Analysis, JSC (11/00)

AO - NASA's Announcement of Opportunity
FRAM - Flight Releasable Attachment Mechanism
ICC - Spacehab's Integrated Cargo Carrier
LMC - Lightweight MPESS Carrier
NRA - NASA Research Announcement
ULC - Unpressurized Logistics Carrier

JEM-EF Utilization

- JEM-EF provides a good accommodation for LTMPF.
  - Mass and Envelope capabilities are compatible with 200-liter Dewar.
    - LTMPF has increased its mass to roughly 560 kg.
    - It is now a Large EF Payload.
    - EFU#2 accommodates large-mass payloads.
  - JEM/Payload Local Bus provides MIL-STD-1553B connection with Payload Multiplexer/Demultiplexer for commands, ISS time , and Health & Safety data.
  - JEM-EF provides Experiment Power and Keep-Alive Power.
  - Data will be sent to ground via Ethernet (~0.1 Mbps, average) and KuBand.
  - Fluid Loop offers a back-up design option.



- LTMPF does require some exceptions
  - Accommodation of envelope exceedances due to the FRAM and H Fixture
  - Waiver for violation of FRGF Keep-Out Space by FRAM hardware
  - LTMPF software interface is directly with ISS

Design Challenges

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- Provide maximum Science Data Acquisition Time
- Build largest Dewar compatible with JEM-EF Standard Payload envelope
- Develop robust and flexible system that can be reused for five missions
- Make precision measurements in the varying microgravity, electromagnetic, and thermal environments
- As much as possible accommodate a "Standard" Flight Releasable Attachment Mechanism (FRAM)
- Radiate heat generated from electronics

Operations Challenges

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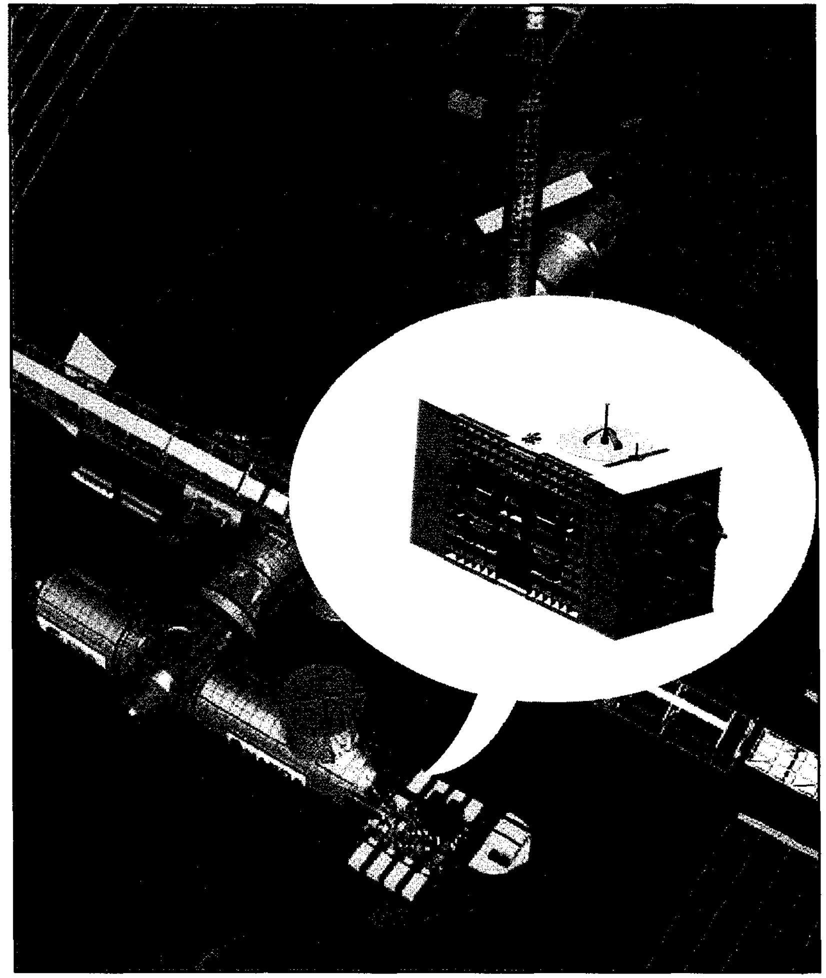
- Operate experiments from PI Institutions
- Operate science experiments using autonomously operated scripts instead of telescience; develop the proper mix to achieve 24x7 operations
- Insure that data is received on the ground
- Attribute spurious heating to ISS events such as microgravity, radiation, and/or EMI
- Anticipate the future ISS environment so we can schedule the higher-sensitivity science measurements when conditions will be best.

Interface Concerns

- JEM-EF
  - LTMPF is a pathfinder for documentation and integration of a NASA payload on the JEM-EF.
  - LTMPF (and/or NASA) needs to obtain waivers from NASDA for interface exceptions.
- Carrier
  - The development of Flight Releasable Attachment Mechanism (FRAM) suitable for use with the JEM-EF and HTV-EP has been a slow and difficult process.
  - NASA is developing several carrier options in parallel; at present none completely address a JEM-EF payload.



Interface Concerns (cont.)

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- ISS Environment
  - Microgravity is critical to producing quality science.
    - Experiment designers are building hardware to residual dc orientation.
    - LTMPF will have to operate during non-Microgravity Mode periods.
  - Precision measurements require minimizing thermal variations in electronics as the external thermal environment changes.
  - Charged particle strikes and ISS vibration cause heating in the science sensors which result in spurious signals or increased noise levels.
  - EM fields produced by ICS antenna and ISS collision-avoidance radars will produce non-calibratable noise in our low-signal instrumentation.
- ISS Communications
  - The low uplink command rate of just a few commands per day will drive the design of experiment-control software.
  - Interruptions in data downlinking due to Loss of Signal with TDRSS are expected; the sharing of the access port to the High Rate Framer by the two on-Station LANs causes longer delays in obtaining feedback on the ground.