

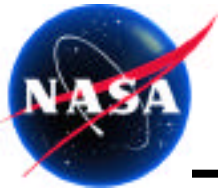
μ Newton thrust-stand for testing drag free control requirements for LISA

Stephen M. Merkowitz
NASA/GSFC

- Drag Free Control
- FEEP Thrusters
- LISA thrust-stand



LISA



LISA Thrust-Stand Team

Space Sciences Directorate

Stephen Merkowitz & Bonnard Teegarden

GN&C Propulsion Branch

Dewey Willis & Chuck Zakrzwski

GN&C Systems Engineering Branch

Jesse Leitner, Landis Markley & Alan Reth

GN&C Flight Dynamics Analysis Branch

Steven Hughes & Chad Mendelsohn

GN&C Component & Hardware Systems Branch

Bernie Edwards

Electromechanical Systems Branch

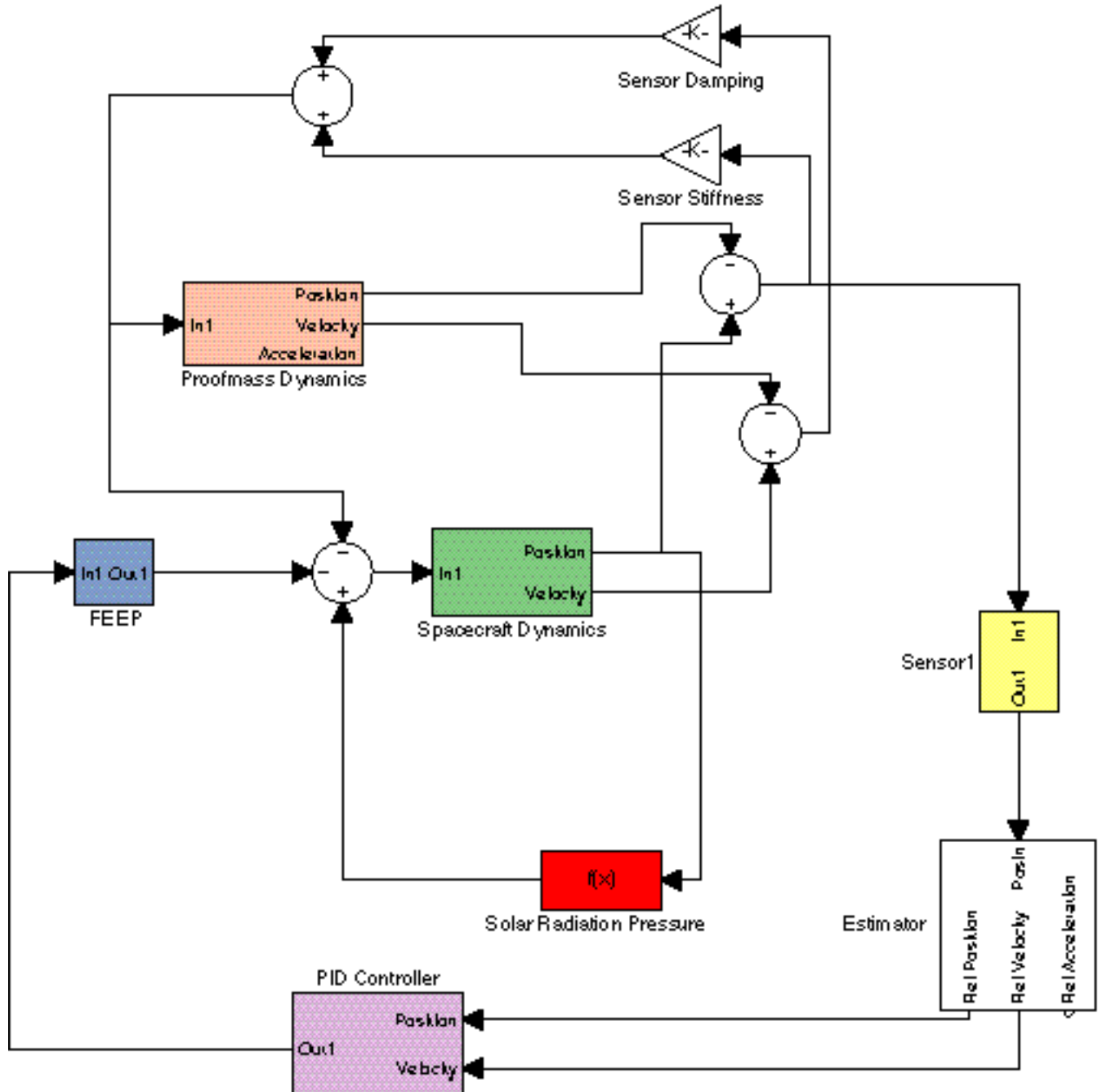
John Vranish

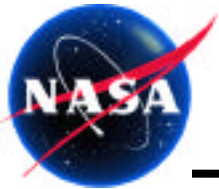
Mechanical Systems Analysis & Simulation Branch

Pete Mulé

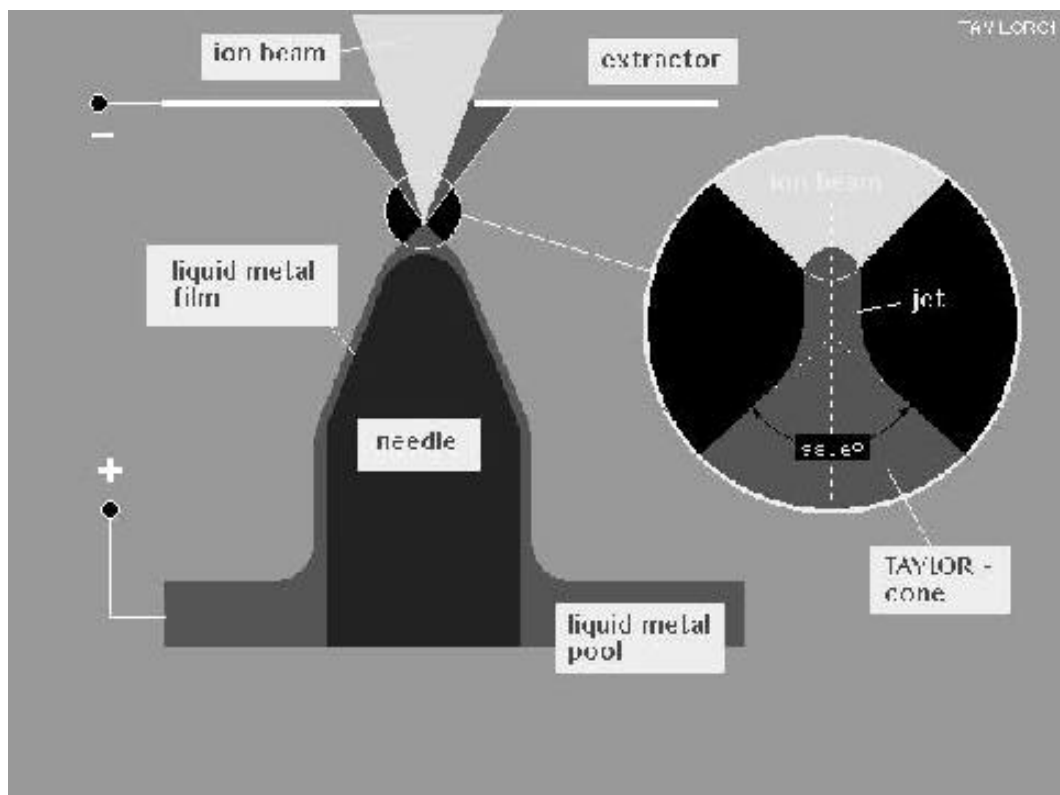
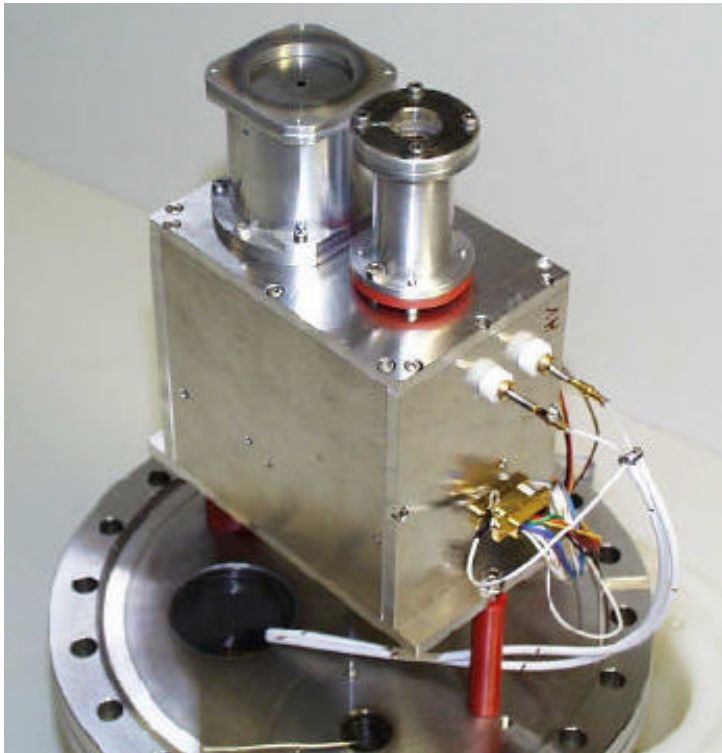


Drag Free Control

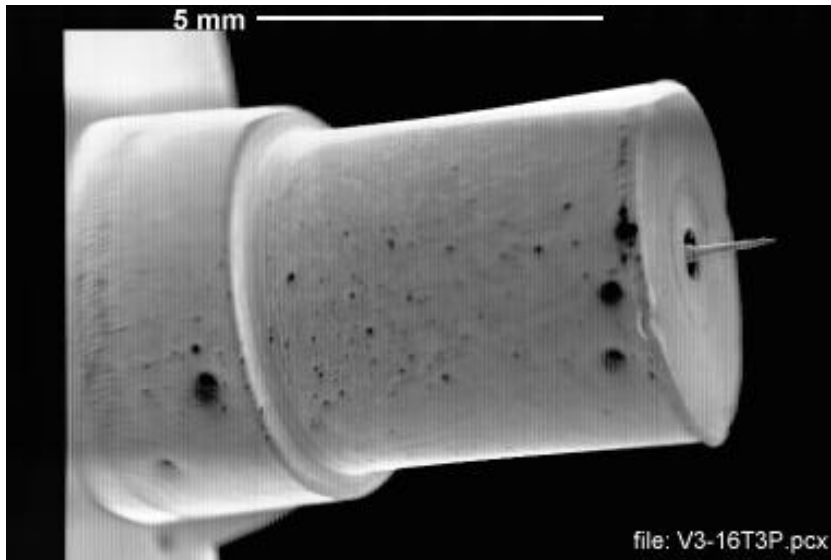




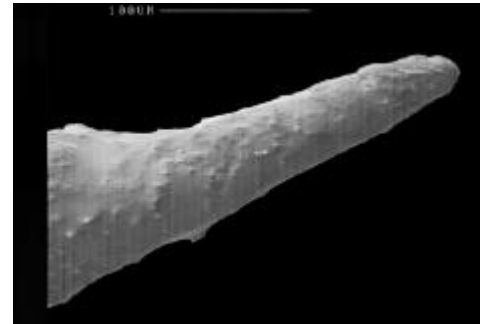
ARCS Indium FEEP



Liquid Metal Ion Source

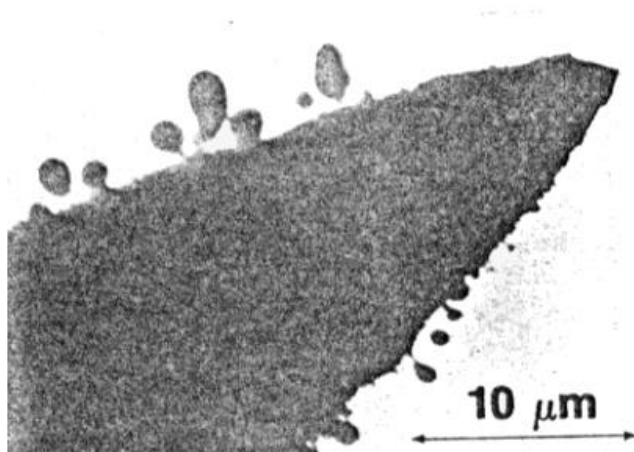


1.2 mg Reservoir Needle Emitter

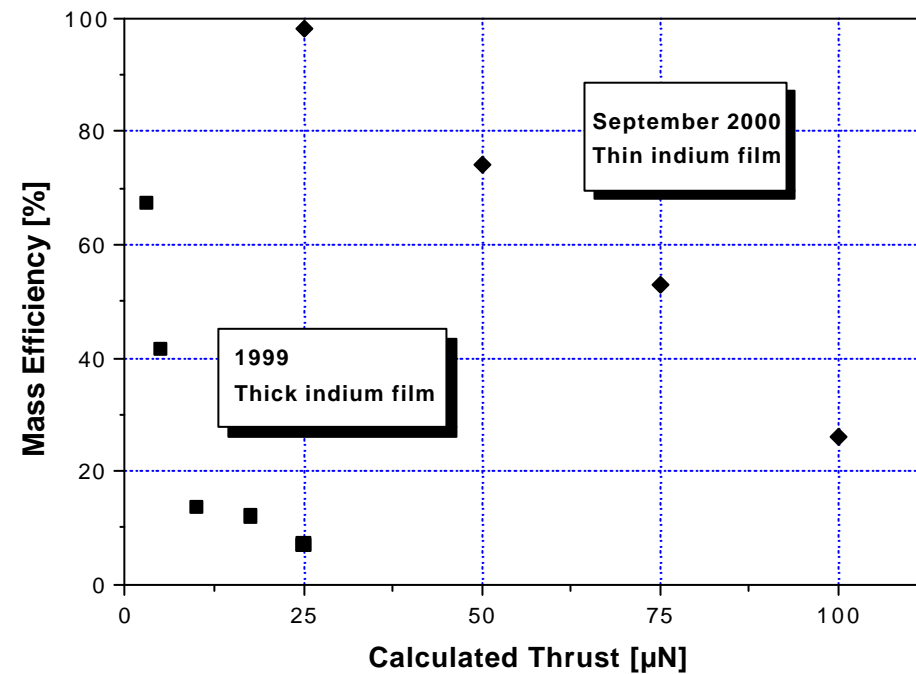


Needle Tip Close Up

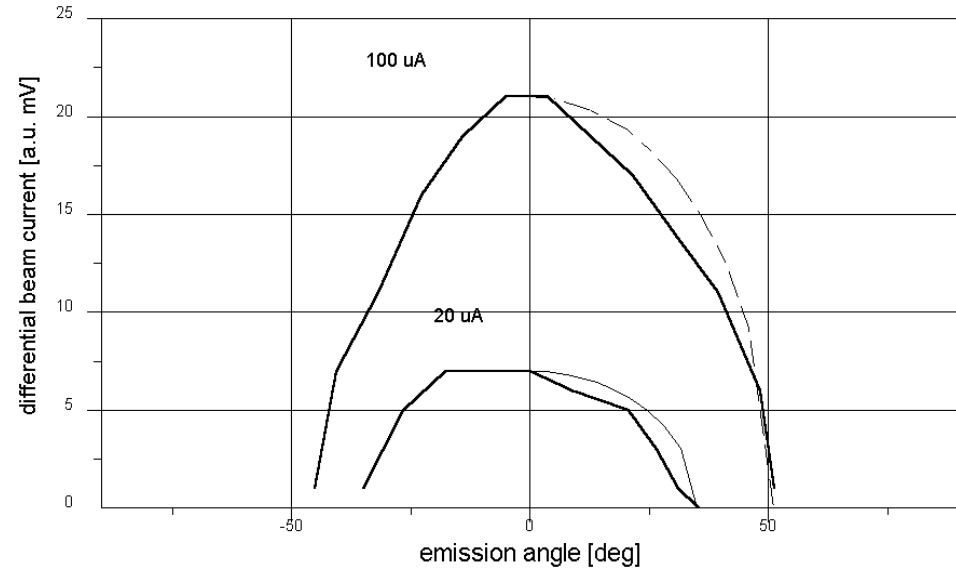
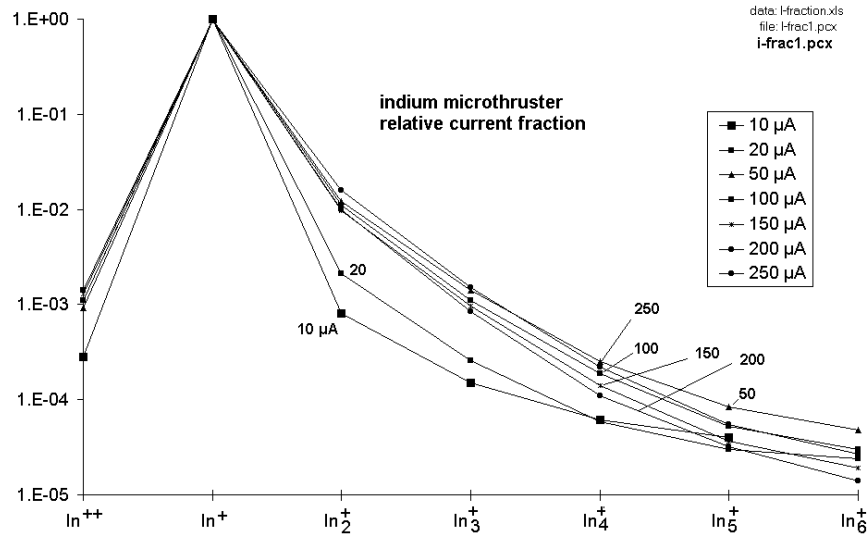
Film Thickness - Droplets: • Instabilities
• Surface Waves



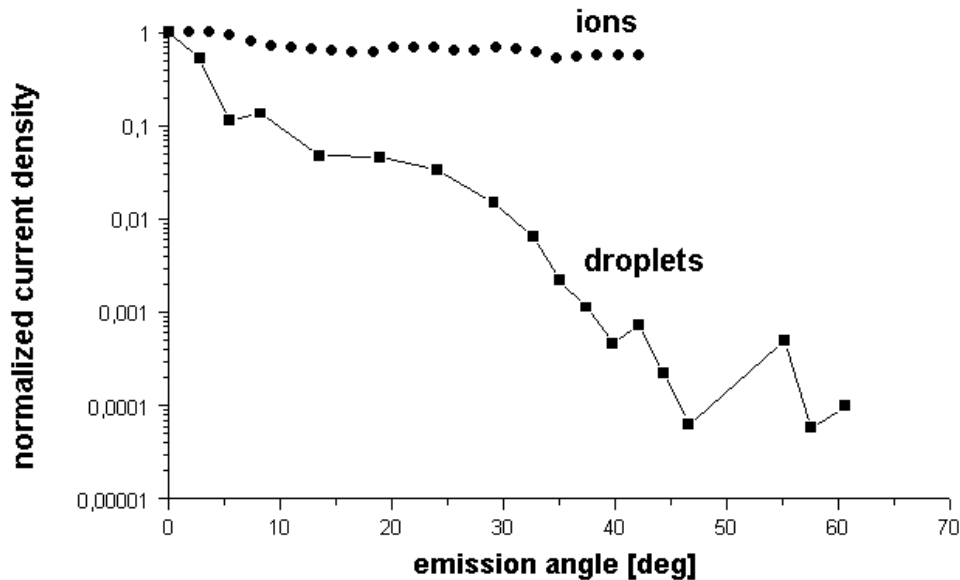
Droplets



Ion Beam Characteristics

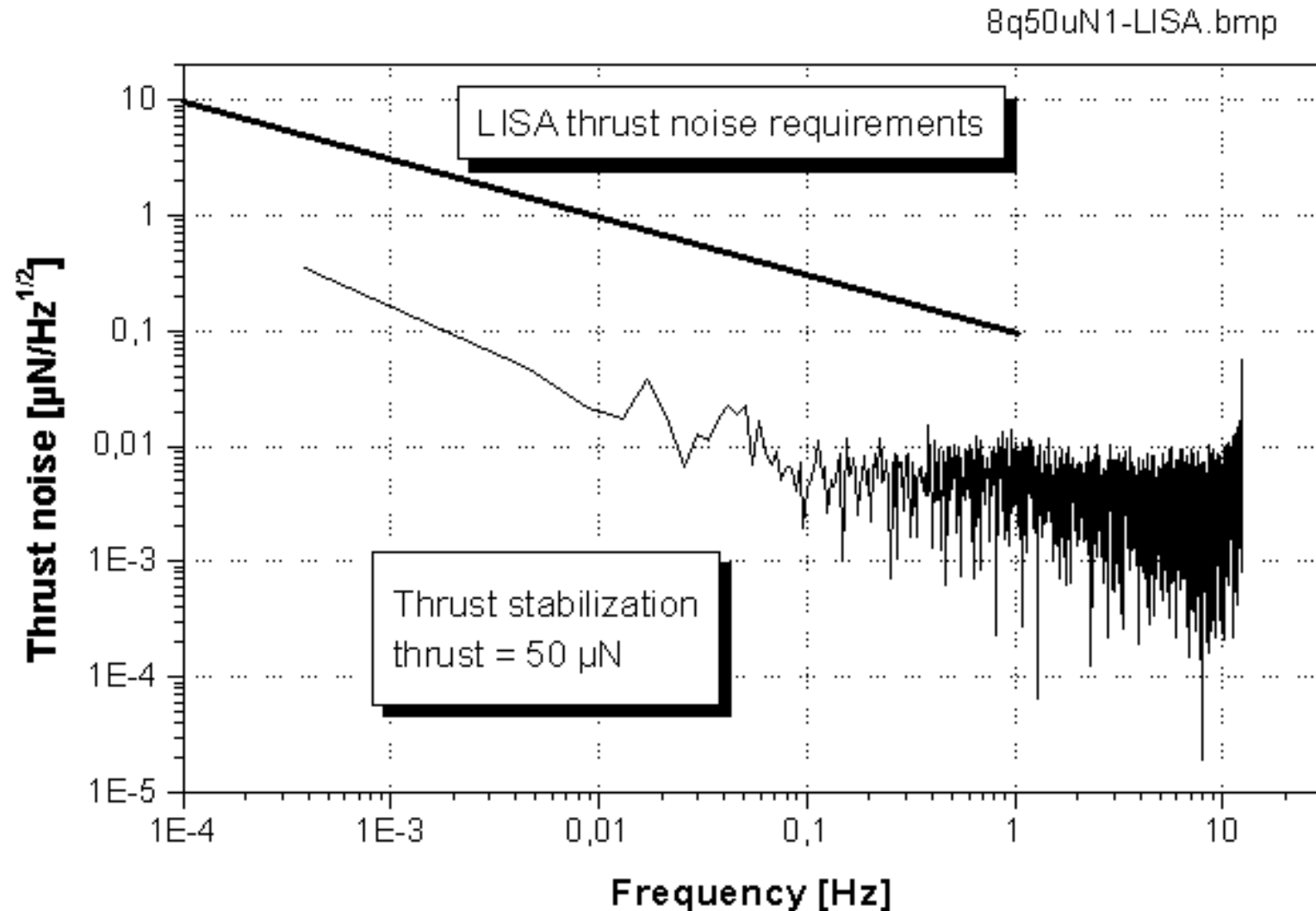


iondr100.pcx



- In^+ Dominant
- Cosine Distribution of Ion Beam
- Droplets more Peaked than Ions

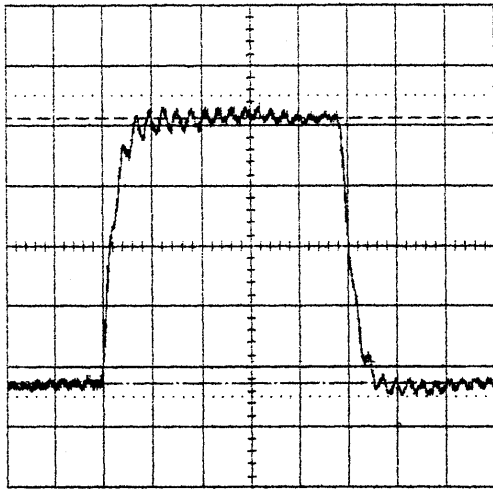
Already One Order of Magnitude below LISA Requirements !



Preliminary Results

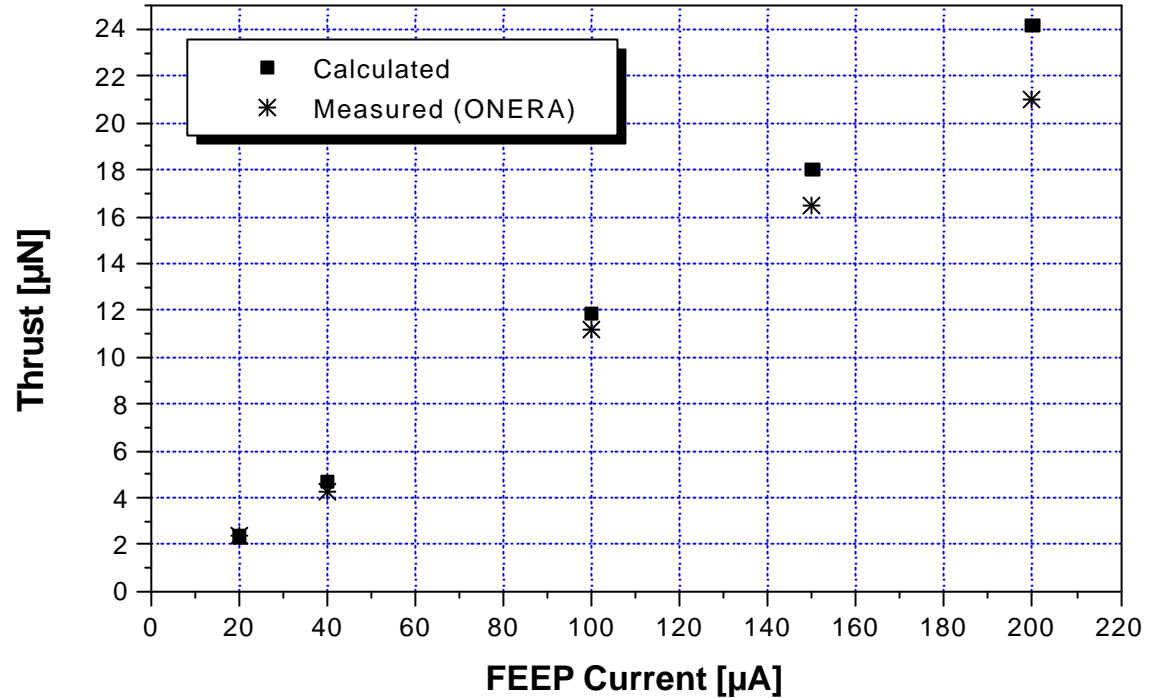
22-sep-00
15:17:43

10 s
20.0 mV
88.1 mV



20 N Impulse

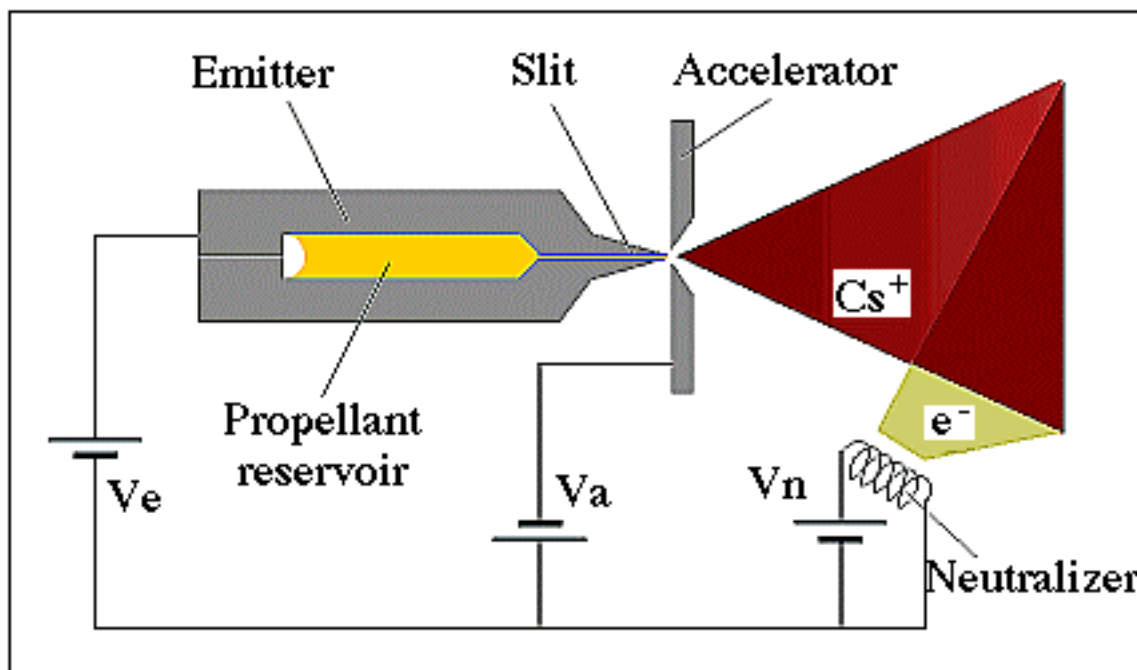
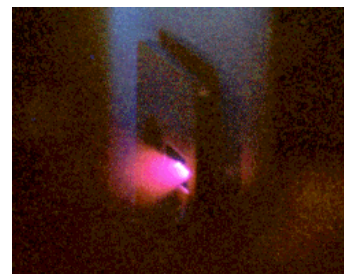
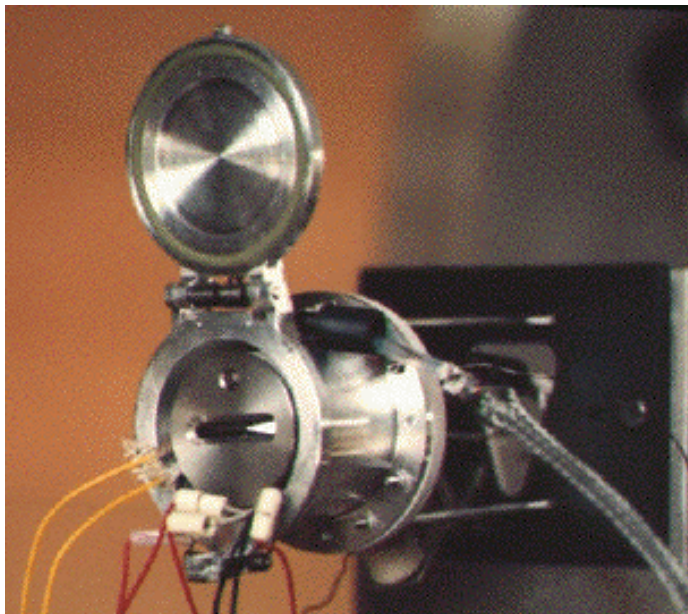
23/10/2000

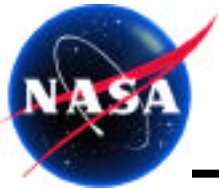


**World First μN Thrust Measurements using
ARCS In-FEEP Thruster !**

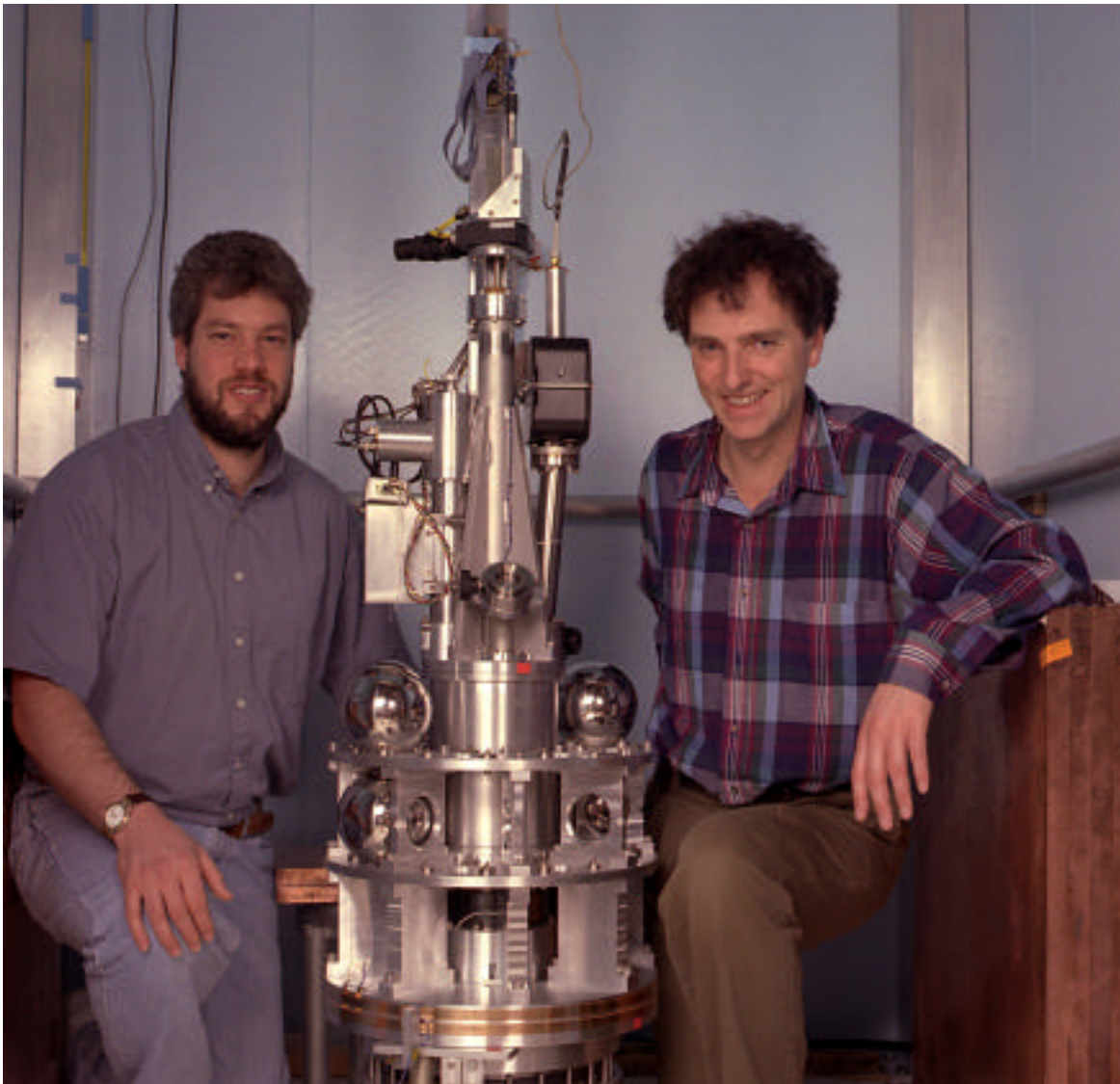


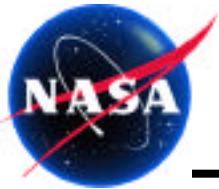
Centrosazio Cesium FEEP



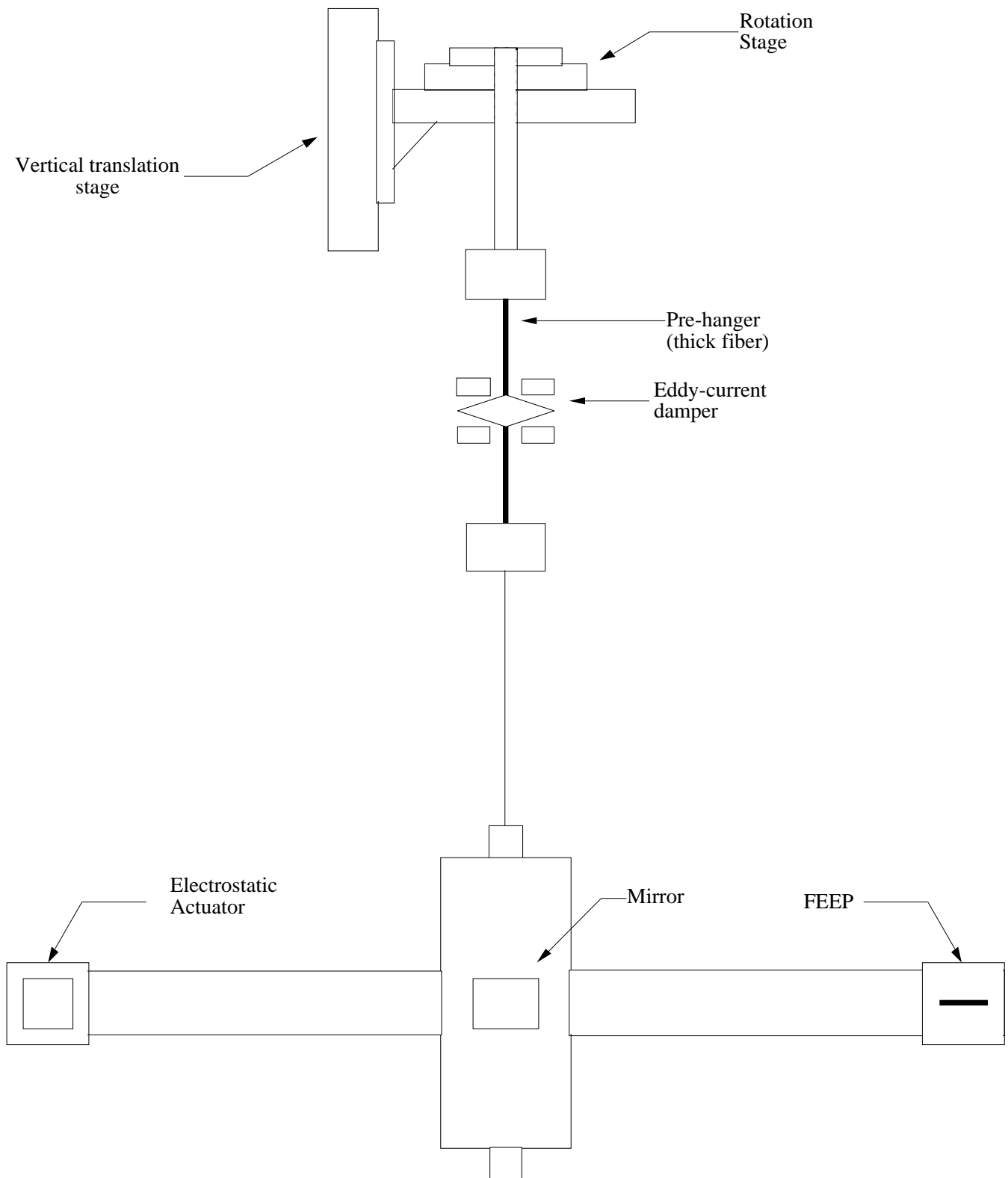


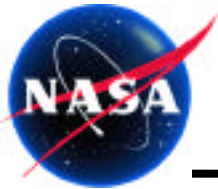
UW Big G Measurement



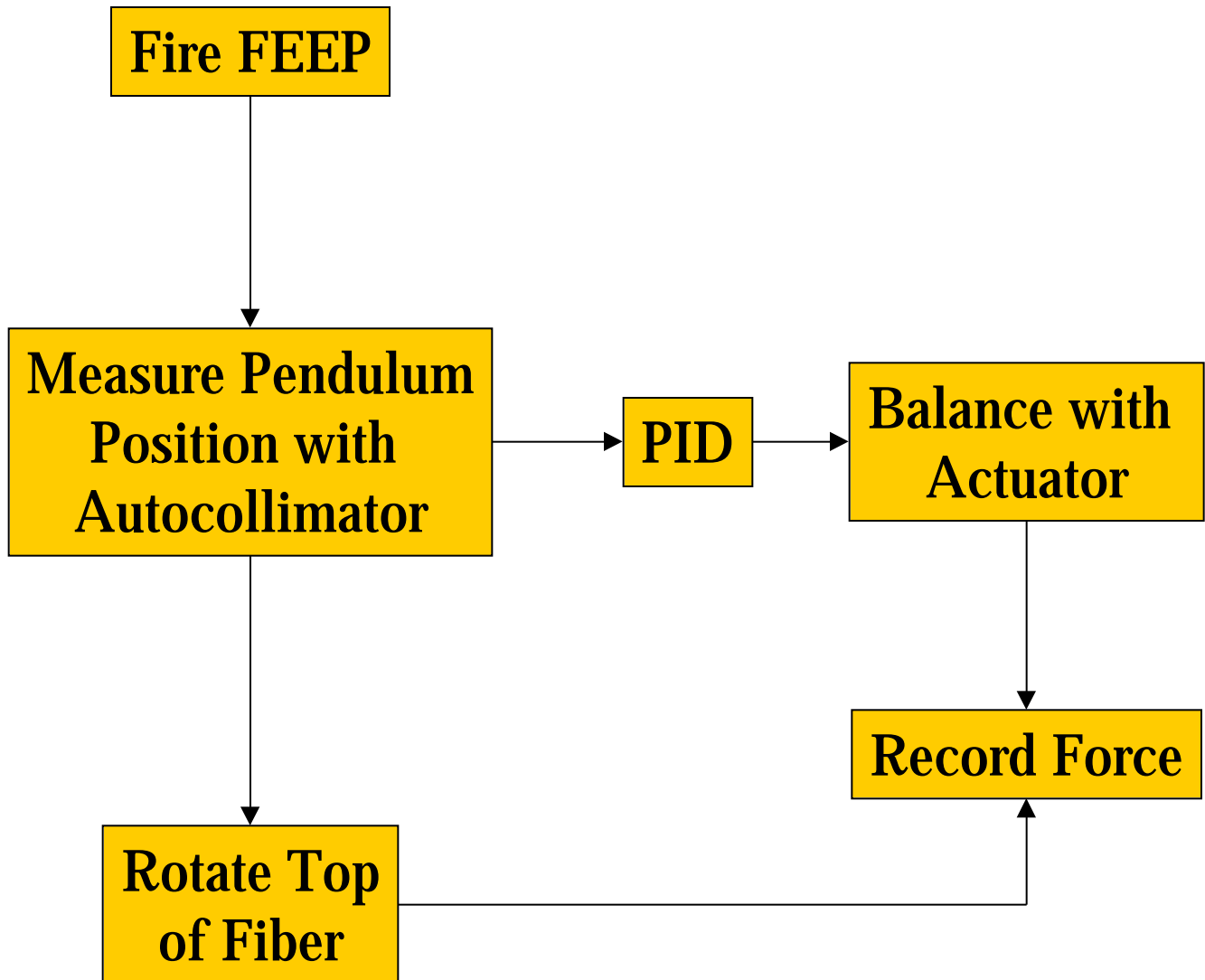


Thrust-Stand





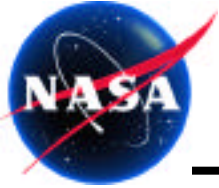
Thrust-Stand Operation





Schedule

| Major Task | Minor Task | J | F | M | A | M | J | J | A | S | O | N | D |
|--------------------|-------------|---|---|---|---|---|---|---|---|---|---|---|---|
| Vacuum Chamber | | █ | | | | | | █ | | | | | |
| Fiber Support | | █ | █ | █ | █ | █ | | | | | | | |
| DAQ/DSP | | █ | █ | | | | | | | | | | |
| Actuator | | | | | | | | | | | | | |
| | Design | █ | █ | █ | | | | | | | | | |
| | Fabrication | | | | █ | █ | █ | | | | | | |
| Control Code | | | | | █ | █ | | | | | | | |
| Thruster Mount | | | █ | █ | | | | | | | | | |
| Wiring | | | █ | █ | | | | | | | | | |
| Pendulum | | | | | | | | | | | | | |
| | Design | █ | █ | █ | | | | | | | | | |
| | Fabrication | | | | █ | █ | █ | | | | | | |
| Fiber Choice | | | █ | █ | | | | | | | | | |
| Autocollimator | | █ | █ | █ | | | | | | | | | |
| Isolation | | | | | | | | | | | | | |
| | Order | █ | | | | | | | | | | | |
| | Assemble | | | | | | | █ | | | | | |
| System Integration | | | | | | | | █ | | | | | |



FEEP Measurements

- Absolute thrust from 1-100 μN with better than 0.1 μN resolution.
- Stationary thruster force noise in the LISA band with an instrument noise floor below 0.1 μN .
- Sinusoidal thruster response in the LISA band.



Control Design

- 2-DOF drag-free simulation
 - Understand FEEP requirements
 - Understand numerical techniques for simulating the LISA dynamics
- 10-DOF drag-free simulation
- Characterizing the LISA orbits with respect to all relevant perturbations.
- Advanced nonlinear control design
 - control law design
 - stability analysis
 - estimation, and implementation in the FFTB
- Integrate the FEEP thrust-stand into the FFTB in conjunction with the LISA models.



Goddard Space Flight Center

GN&C Technology Testbed

