The Fluids Integrated Rack and Combustion Integrated Rack Provide Key Research Facilities on the ISS

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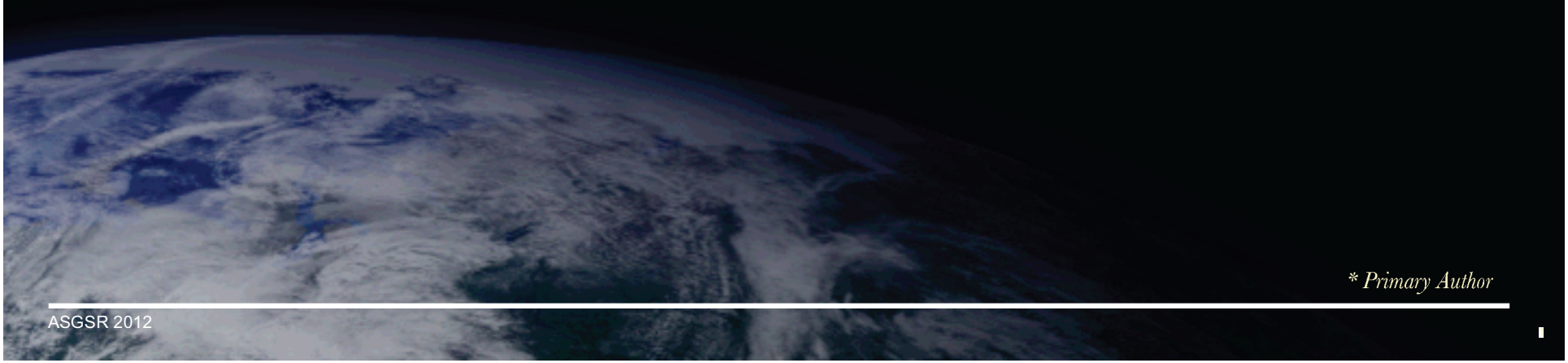
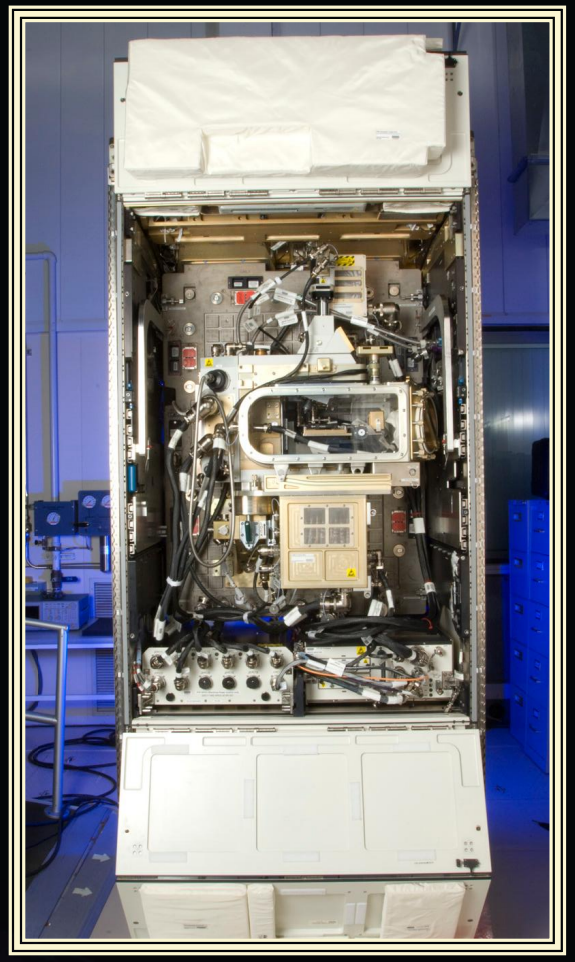
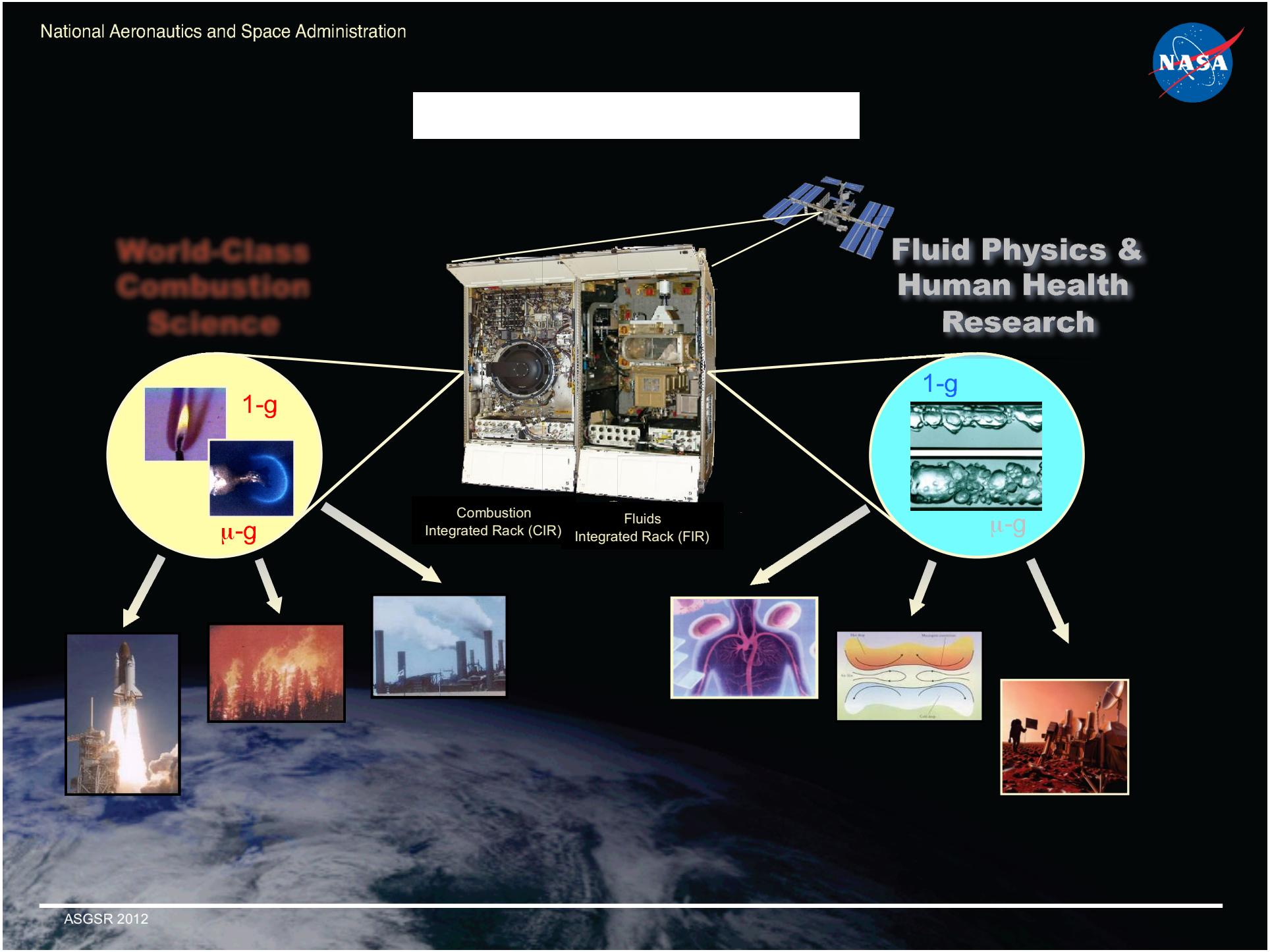


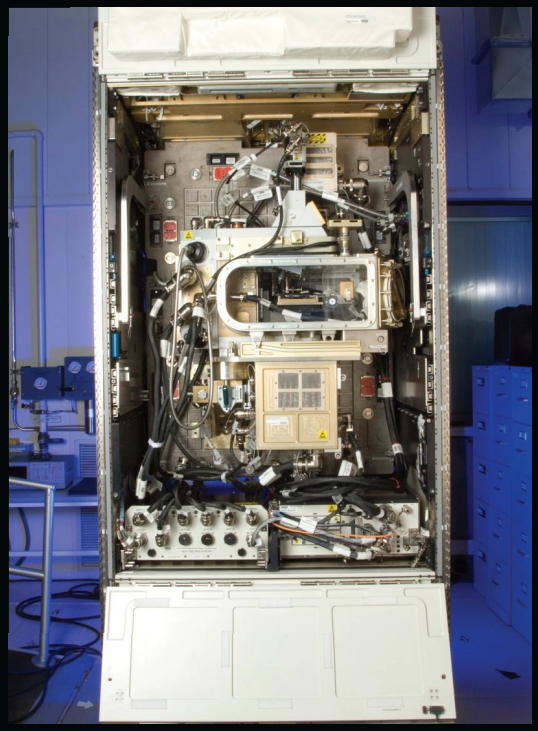
** Primary Author*



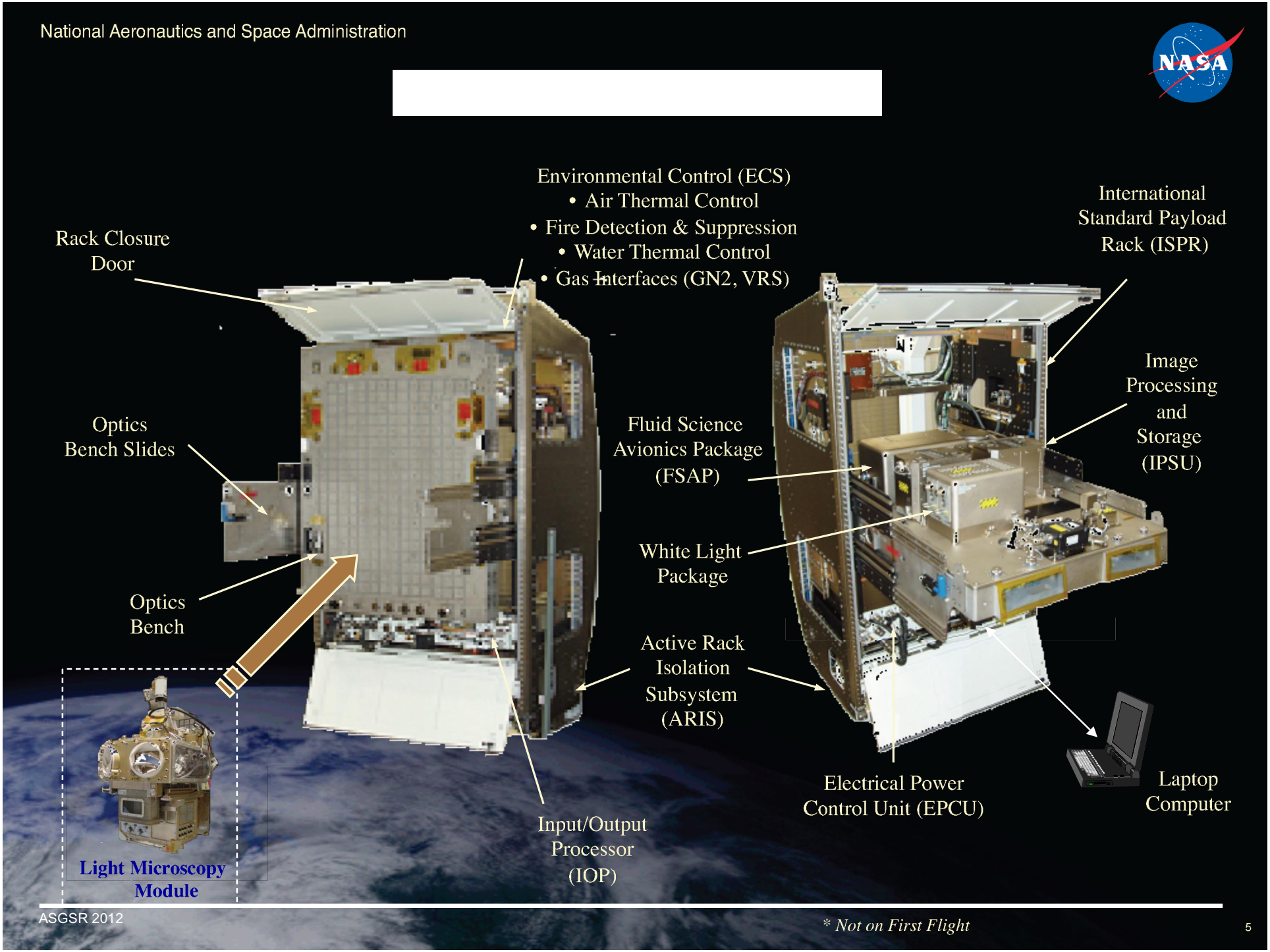

World-Class Combustion Science
1-g
μ-g
Combustion Integrated Rack (CIR)
Fluids Integrated Rack (FIR)
Fluid Physics & Human Health Research
1-g
μ-g

FIR designed to test and understand critical technologies needed for advanced life support and future spacecraft thermal control. Hardware was delivered on STS-128 (August 2009) to ISS and installed in the USLAB.

Astronaut Bob Thirsk completing install of the FIR/ LMM prior to FIR activation in December 2009.

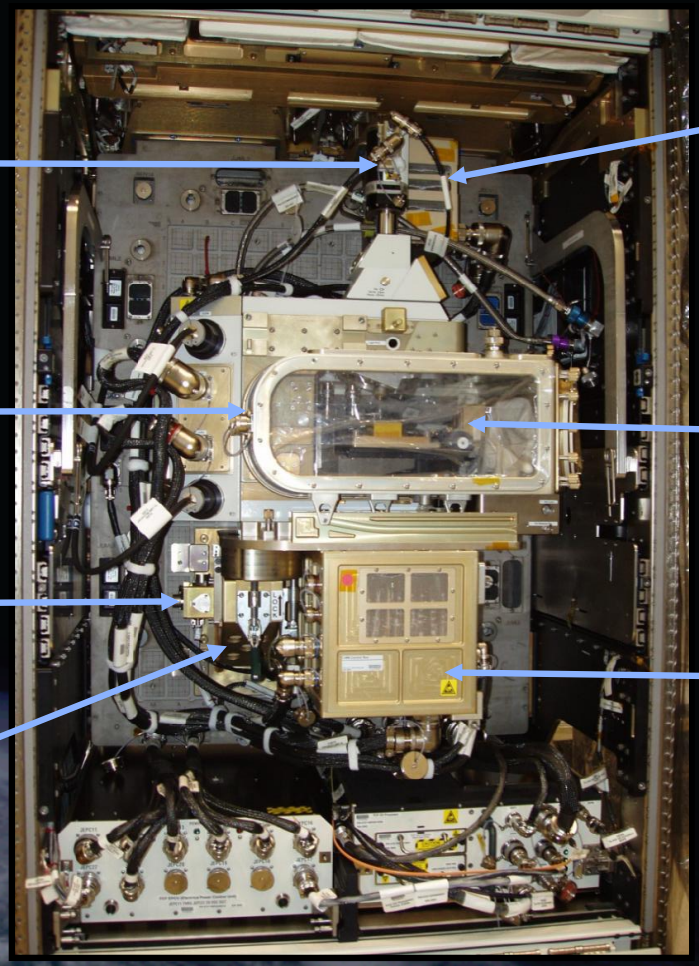


Critical Design Review	Dec 2002
ISS Activation	Jan 2010
ARIS Commissioned	Jul 2011



** Not on First Flight*

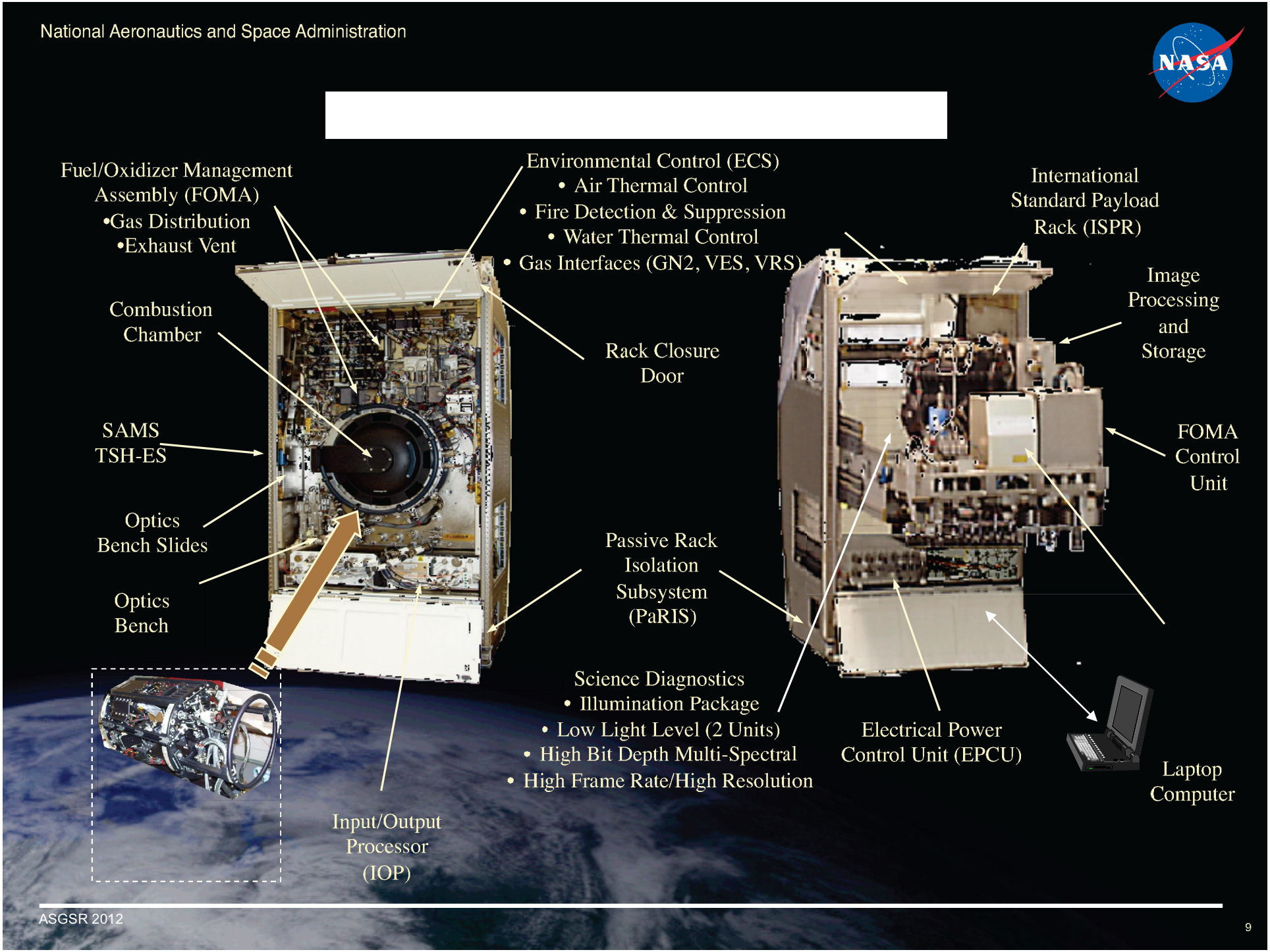
- Subrack payload that provides a remotely controllable, automated on-orbit microscope for physical and biological science experiments
- Designed to be used as a fully functional microscope operated from the ground. The microscope can house many different objectives to perform brightfield and Epi-illumination microscopy.


Camera
CVB Control Box
Microscope
Auxiliary Fluids Container
SAMS TSH
LMM Control Box
Spindle Bracket

CIR designed to test fire prevention, detection and suppression of fires in space. Hardware was delivered on STS-126 (November 2008) to ISS and installed in the USLAB.

Astronaut Mike Fincke completing install of the CIR/ MDCA insert prior to CIR activation in January 2009.

Critical Design Review	May 2002
ISS Activation	Jan 2009
FLEX-2 Reconfiguration	Oct 2011


Fuel/Oxidizer Management Assembly (FOMA)
•Gas Distribution
•Exhaust Vent
Environmental Control (ECS)
• Air Thermal Control
• Fire Detection & Suppression
• Water Thermal Control
• Gas Interfaces (GN2, VES, VRS)
International Standard Payload Rack (ISPR)
Combustion Chamber
Rack Closure Door
Image Processing and Storage
SAMS TSH-ES
FOMA Control Unit
Optics Bench Slides
Passive Rack Isolation Subsystem (PaRIS)
Optics Bench
Science Diagnostics
• Illumination Package
• Low Light Level (2 Units)
• High Bit Depth Multi-Spectral
• High Frame Rate/High Resolution
Electrical Power Control Unit (EPCU)
Laptop Computer
Input/Output Processor (IOP)

High Resolution/High Frame Rate Camera

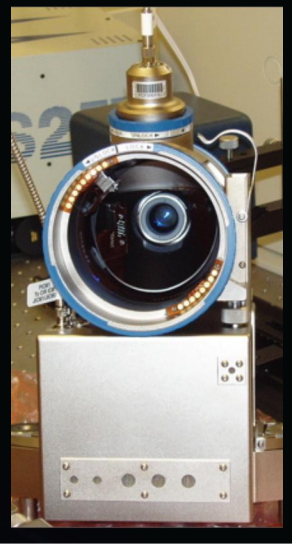
- High Resolution Mode: 1024x1024 pixels at 7.5, 15, or 30 fps
- High Frame Rate Mode: 512x512 pixels at 60 or 110 fps
- Focus over 30 mm object depth; 5mm/s focus speed
- Resolution is 20 lp/mm at 50% contrast in HR mode

High Bit Depth/Multi-Spectral Camera

- 1024x1024 pixels at programmed rates of 7.5, 15, or 30 fps
- 12 bit dynamic range
- Field of View: 50 mm square or 80 mm diameter
- Resolution: 10 lp/mm maximum (0.05 mm)
- Liquid Crystal Tunable Filter: 650-1050 nm spectral range

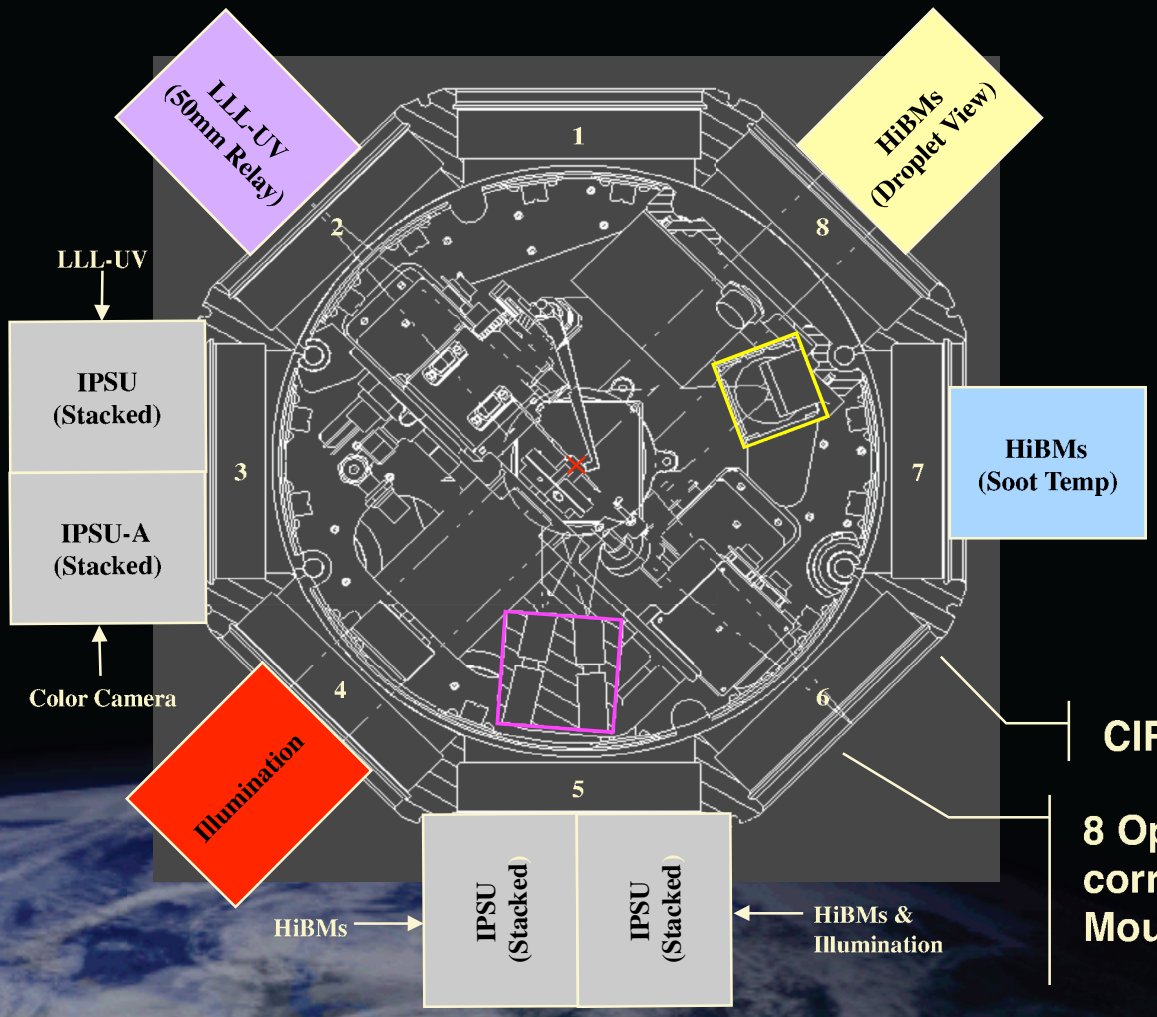
Low Light Level Packages (UV)

- FOV: UV 42 or 100mm
- 54 Frames per second
- UV package uses industry standard Gen II intensifier
- UV Spectral range: 220-850nm



Illumination Package

- 80mm diameter Collimated Beam
- Diffuse Laser Diode source
  - 10 mw coupled power
  - 655 nm peak wavelength



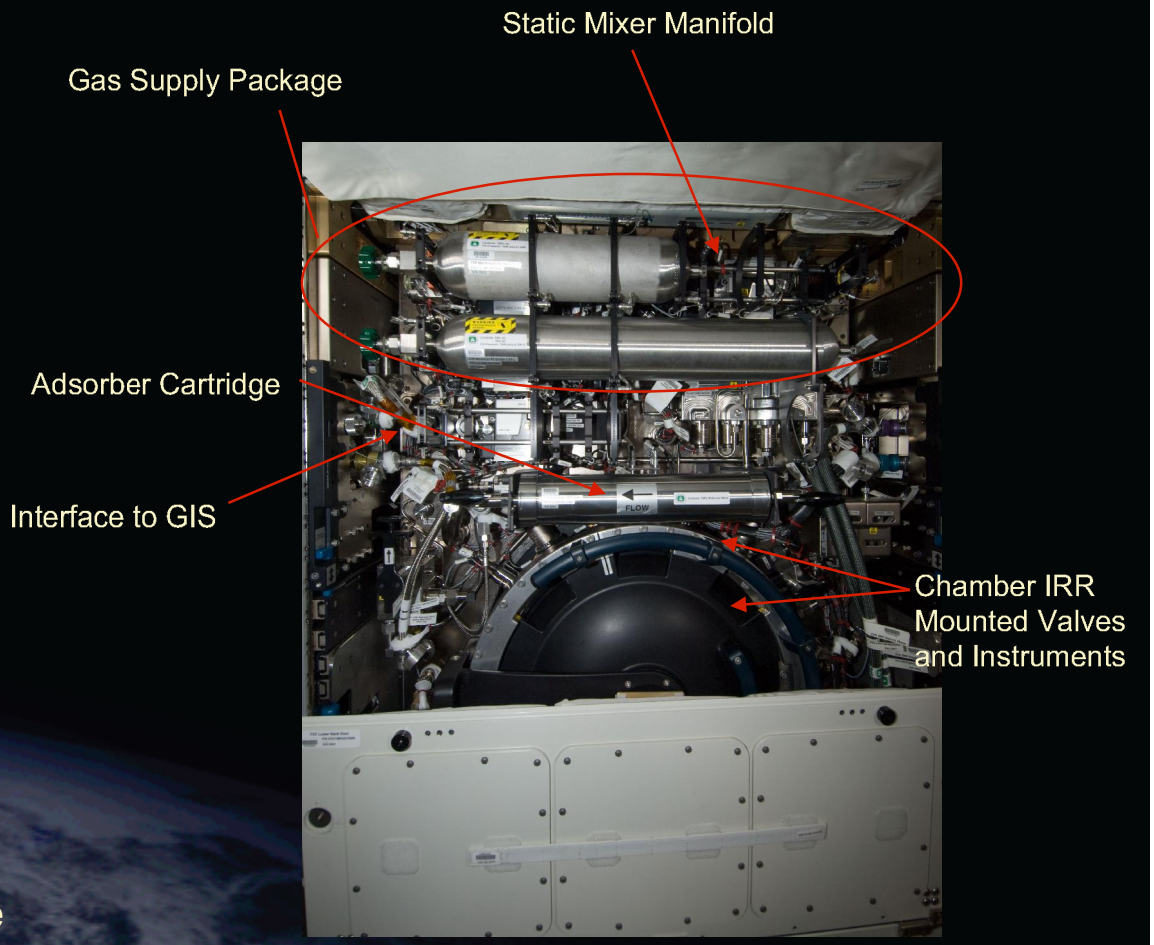
CIR Combustion Chamber

8 Optical windows correspond with Universal Mounting Locations (UML)

CIR Optics Bench – Rear View

Functions

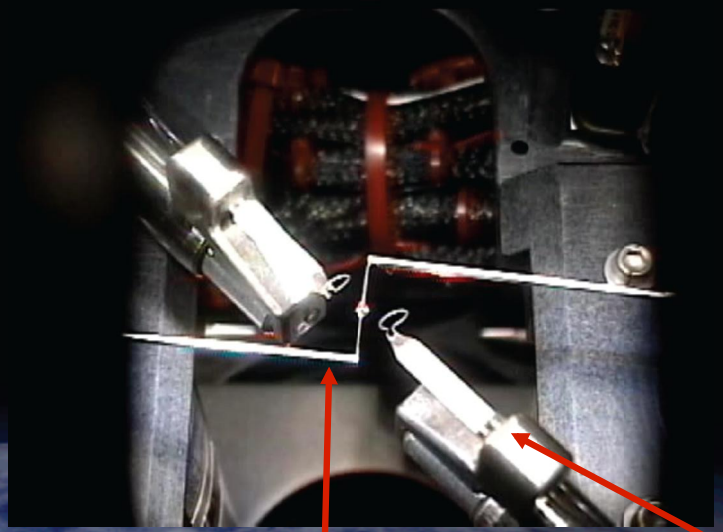
- Supplies gaseous fuel, oxidizers and diluents to the combustion chamber
- Oxidizers:
  - 1.0 liter up to 85% O2
  - 2.25 liter up to 50 % O2
  - 3.8 liter up to 30 % O2
- Quick disconnects used for easy attachment to manifolds
- Maximum oxidizer flow rates
  - 30 slpm per manifold
  - 90 slpm total
- Maximum fuel flow rate 2 slpm
- Removes unacceptable gases including water vapor, and particulates from the combustion event
- Provides the vent path to the ISS VES through an interface with the GIS



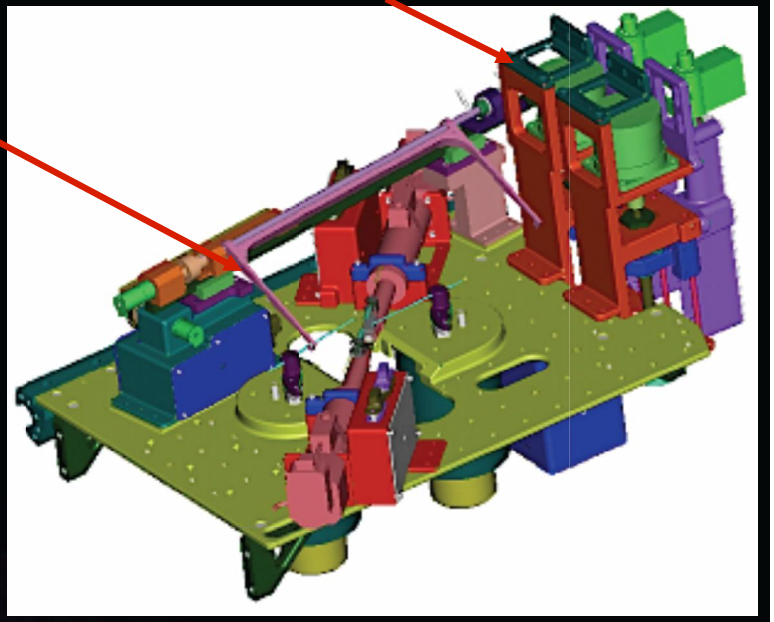
- Subrack payload used for the Flame Extinguishment Experiment (FLEX) investigations and follow-on investigations
- Designed to accommodate multiple droplet combustion experiment investigations for fire suppression/flame extinguishment

Main Features:

- MDCA provides the core capabilities of the Flame Extinguishment investigations:
  - ❖ Droplet Dispensing
  - ❖ Droplet Deployment
  - ❖ Droplet Ignition
  - ❖ Color Imaging System
  - ❖ Radiometric measurement system
  - ❖ Fiber Support System
- Providing these common capabilities on one platform allows many PIs to use MDCA for their own, independent investigations.



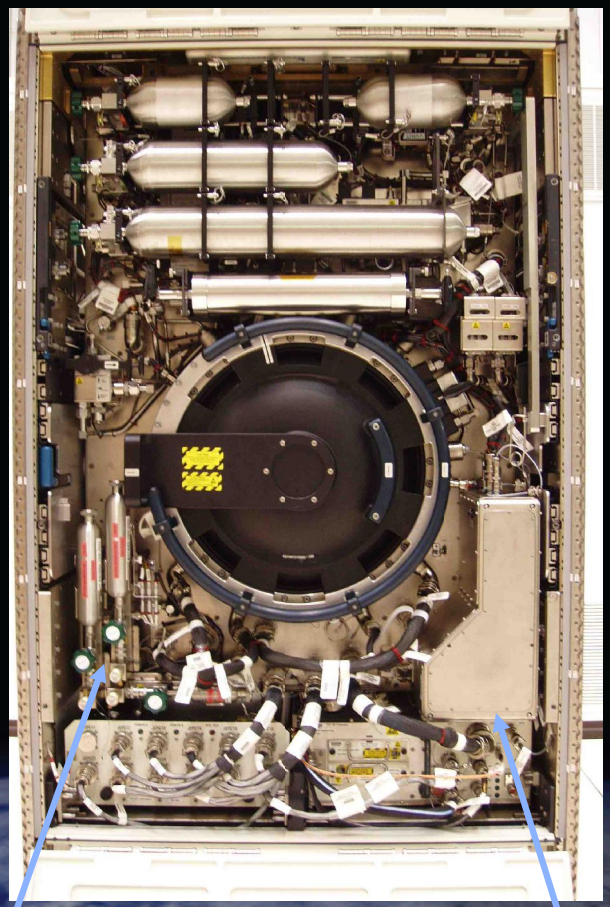
Droplet Deployment
- Precisely aligns two needles during the fuel droplet formation process and deployment sequence



Droplet Ignition
- Consists of two opposing ignition wire mounted and independently controlled linear actuator assemblies.

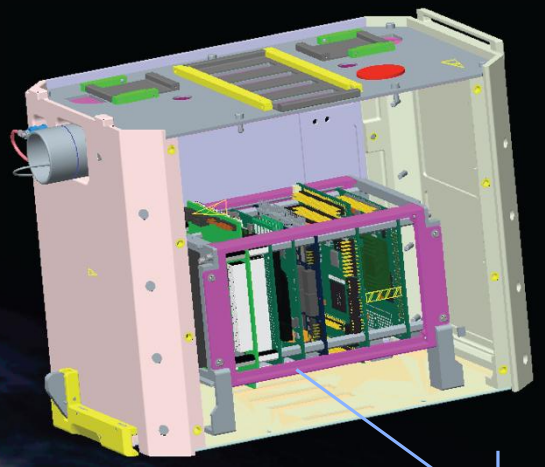
- Crew Time
  - Crew Time is a premium resource on ISS
  - Need crew for change-out of bottles, fuel reservoirs, fibers, igniters, releasing rack for ARIS/PaRIS, LMM Samples, etc
- Data Management
  - Current hard drives (vintage 2001) limit amount of data
  - Currently must move files to IOP then downlink
- Operations Time
  - Lots of variables (power, commanding, HRDL, vehicle traffic, etc) limit the amount of on-time for the racks
- Obsolescence
  - Sparing required to maintain FIR and CIR till 2020 and beyond; parts no longer available (ex. Hard drives)
  - Scientists wanting the latest and best capability

- CIR's Gas Chromatograph Instrument Package (GCIP)
- Image Processing and Storage Package- Gig E (IPSU-G)
- LMM Enhancements: Camera/ Confocal/ NdYAG Laser



- CIR interfaces already exist on optics bench
  - Structural mounting, air-cooling, power and data interfaces through Optics Bench
  - Sample inlet and vent I/F's through FOMA
  - 28VDC, 50 watt power distribution from EPCU
  - RS-232 and software interface with FCU
- Designed as an ORU
- Based on the commercial Agilent 3000A – Micro GC
- Measurement repeatability of ±2% relative standard deviation
- Utilizes a thermal conductivity detector and three separate columns to provide a range of analysis capabilities

- Provide enhanced camera interface, larger storage capability, and direct interface to ISS HRDL
  - IEEE 1394 FireWire → Gig-E Vision Standard
  - Two 36 GB hard drives → Two 512 GB Solid State drives
  - 9 Mbps to IOP → 20 Mbps data throughput direct to ISS



IPSU-G Concept
PC104 Stack

Camera

Low light sensitivity camera

Gig-E Interface

Radiation Tolerant

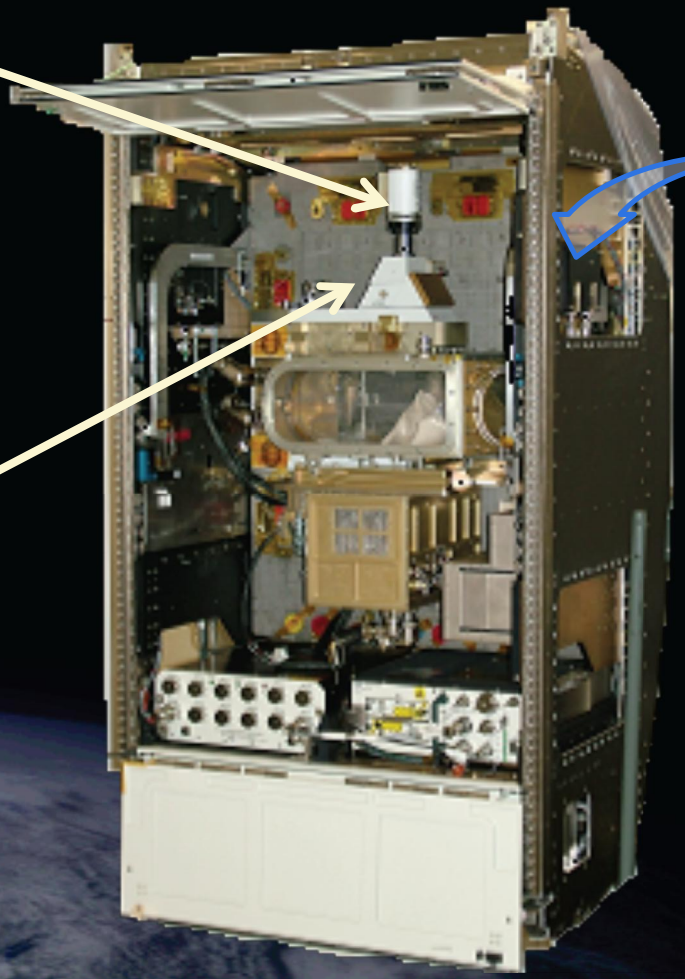
Compact footprint to allow mounting at 45 degree location

Confocal Unit

Optical sectioning (imaging) of samples

Nipkow Disk Design

Fast scanning rate of up to 360 frames per second



Nd:YAG Laser

Provide a laser source for various diagnostic techniques

532 nm, 150mw Output power

Analog control of laser functions

Bench mounted rear, fiber coupled to front

Laser output power monitoring

Previously developed by FIR, but not certified yet for flight

- CIR and FIR performing critical research on ISS
- FCF provides unique capabilities for ISS Users
  - Large chamber (100 liter, vacuum to 3 atm) to support combustion and other discipline research
  - Automated microscope
  - Large open volume in FIR to support many discipline