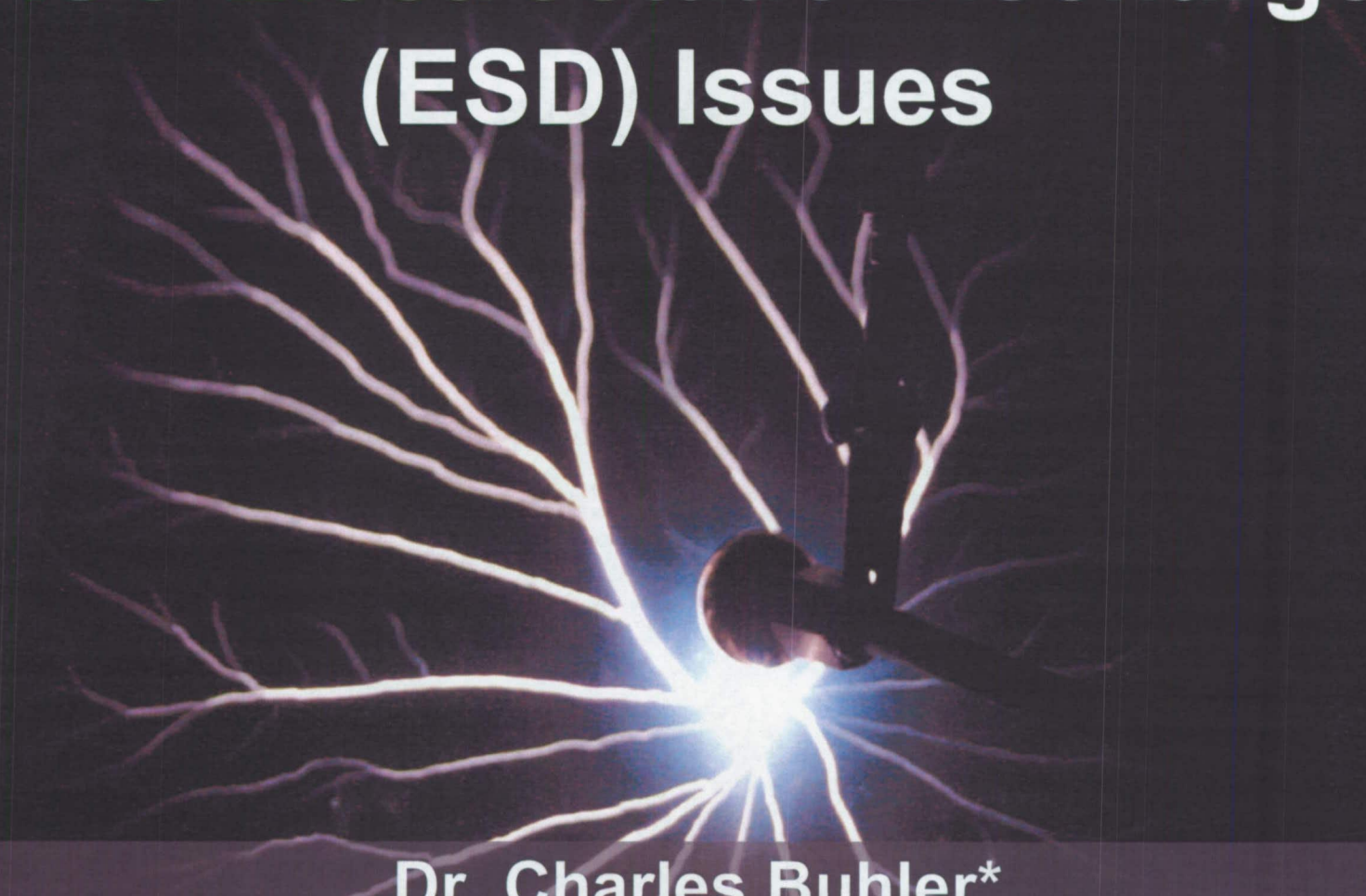


KSC Electrostatic Discharge (ESD) Issues

A photograph of a Van de Graaff generator with a large, branching electrostatic discharge (ESD) visible against a dark background. The discharge consists of many bright, white, branching lines radiating from a central point, resembling a starburst or a tree. The background is dark, making the bright discharge stand out.

Dr. Charles Buhler*

Electrostatics and Surface Physics Laboratory

ASRC Aerospace

NASA Kennedy Space Center, FL

9:30 A.M., the giant Thor-Delta's third-stage motor was ready for final checkout. Suddenly, Spin Test Lab technicians heard a loud crack. As they stared in horror, the five-foot package of hell sizzled into premature life, kicked out with a 3000-pound thrust and tore loose—turning the sealed room into a missileman's nightmare.

11 MEN BURNING ALIVE"

WORLD'S WORST SPACE AGE DISASTER

STORY STARTS ON NEXT PAGE ►

Spectacular as on-pad misfires have been, none compare with holocaust that exploded inside the Cape's Spin Facility Building.

Background of the ESPL

- As a result of the disaster, NASA KSC developed a test method to evaluate the ESD properties of materials and has continued testing >40 years.
- The ESPL broke away from the Material Science Laboratory at KSC to form an Electrostatics research laboratory in 1998.

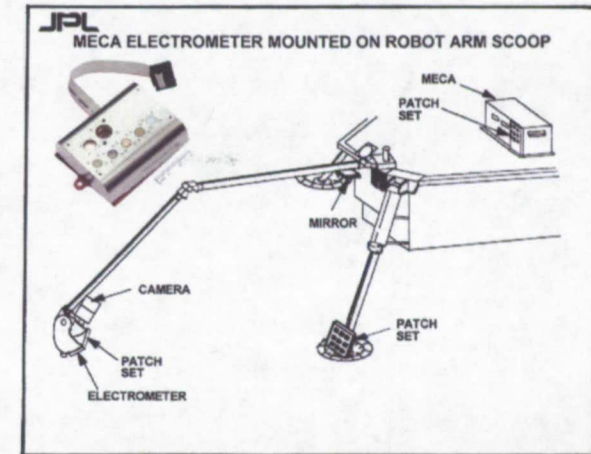


- Dr. Carlos Calle, Lead Scientist
- Dr. Sid Clements
- Dr. Albert Chen
- Dr. Michael Hogue
- Ellen Arens
- Mindy Ritz
- Judith McFall
- Sarah Snyder

Electrostatics = Dust Studies + ESD

Recent Dust Studies

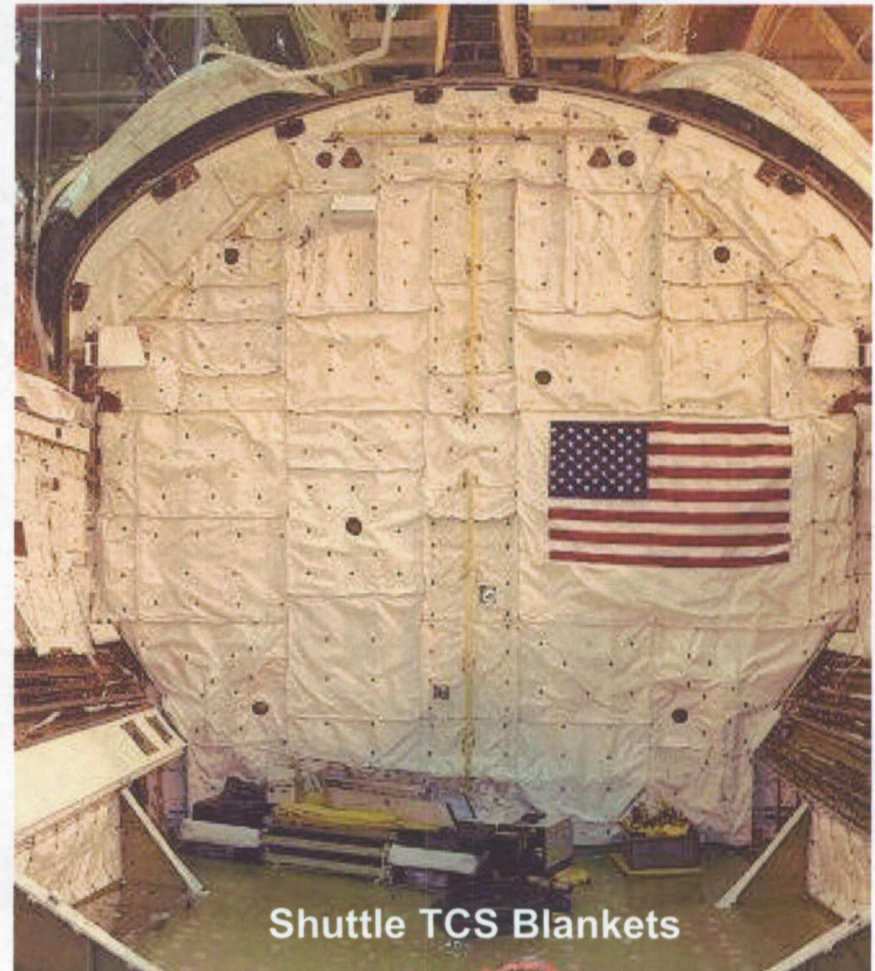
- Science Team Member for the Mars 2001 Lander mission – Co-developed MECA Electrometer with JPL
- Initial Team Members for Phoenix
- Science Team Member for the 2003 Mars Lander.
- Consulted with Mars Exploration Rovers
- NRA - Develop devices to measure the size and charge of dust particles in the Martian atmosphere.
- NRA - Study of triboelectric glow discharges as a cause for degradation of organics on Mars.
- NRA – Dust removal from solar panels on Mars.
- GSE - Electrostatic Precipitation of GN₂ lines at KSC.
- Constellation
 - ISRU - Use of tribocharging in electrostatic beneficiation of lunar simulant.
 - Project Dust Team Members - Develop dust mitigation technology for Mars and the Moon (solar panels, thermal radiators, optical windows, space suits, etc.) that actively removes and repels dust from surfaces with no moving parts.
 - Cryogenic Storage and Transfer Lines – Develop dust mitigation technology to keep quick disconnects dust free with no moving parts.



Shuttle/ISS Support



- Electrostatic characterization of:
 - Thermal Control System blankets
 - Orbiter (STS-114 RTF)
 - ISS payloads
 - Pan Tilt Cameras
 - Shuttle Crew Escape Equipment Life Preserver and Life Raft Inflator
 - GSE – Aclar purge curtain
 - Orbiter - Kapton Purge Barrier Curtain
 - Orbiter - TVC Actuator Blankets
- 2008 Hubble Space Telescope repair mission
 - Characterization of materials
 - Advise on design of tool extraction unit for replacing the Space Telescope Infrared Spectrometer power board
 - Advise on design of Card Transport Enclosure



Shuttle TCS Blankets

ESD Safety

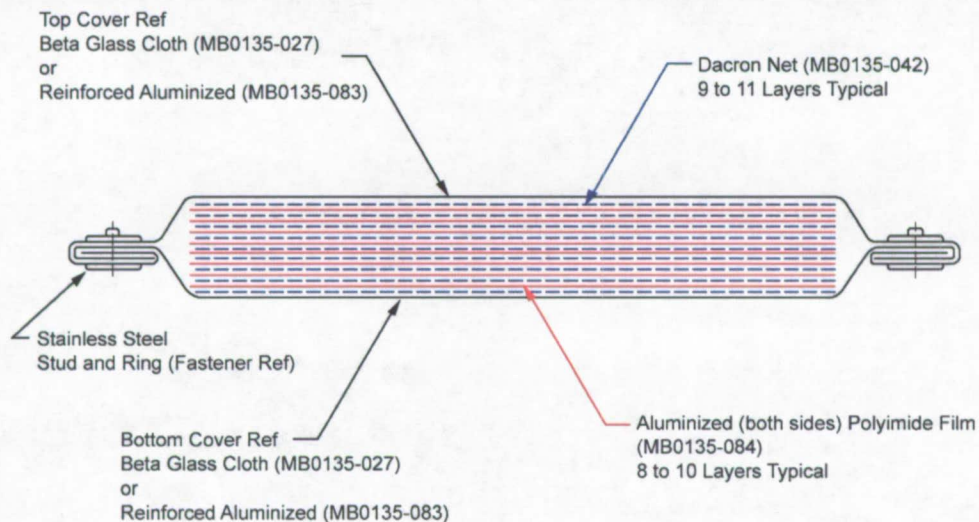
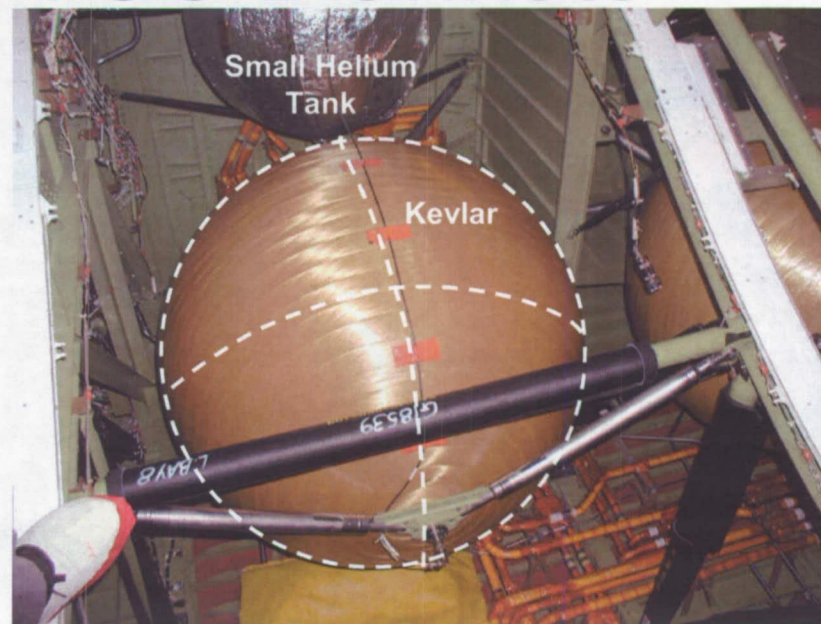
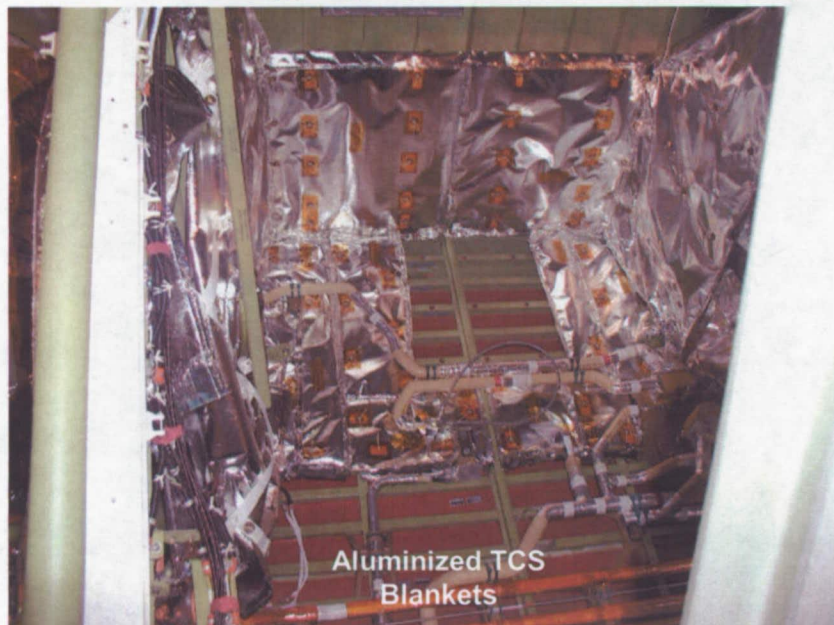
- NASA document 21492 titled “Space Shuttle Program Payload Bay Payload Users Guide” specifies:

“The major ESD concern for the orbiter is triggering an explosion of hydrogen gas that might inadvertently leak into the payload bay during launch, Return to Launch Site, Abort Once Around, or normal landing from residuals in the aft equipment bay plumbing”

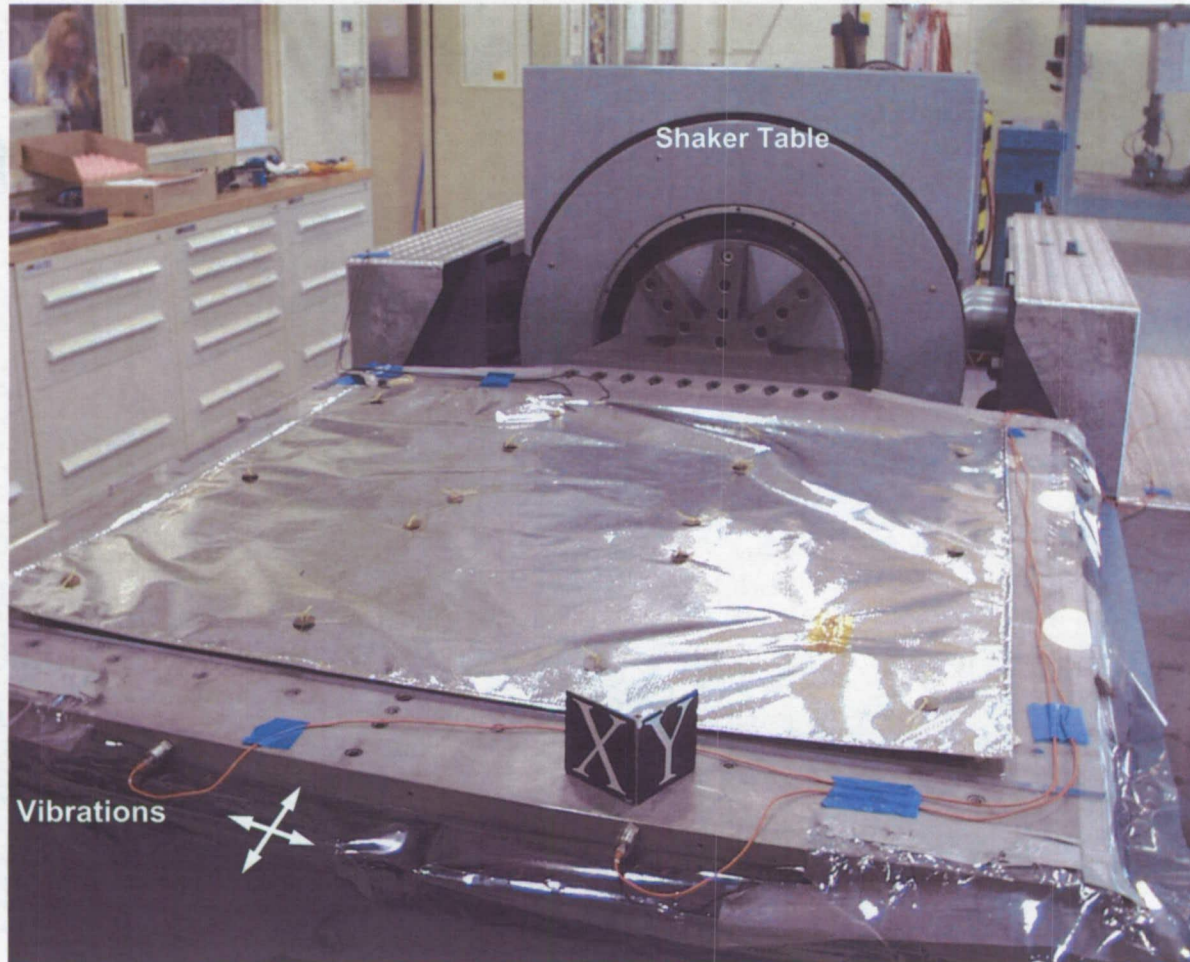
- Although measurements of hydrogen concentrations have never exceeded its lower flammability limit* for any missions, increased hydrogen levels above ambient have been measured in nearly every catch bottle for every launch up to STS-113

* MIE (H₂): 20 μ J (30% H₂ in air)

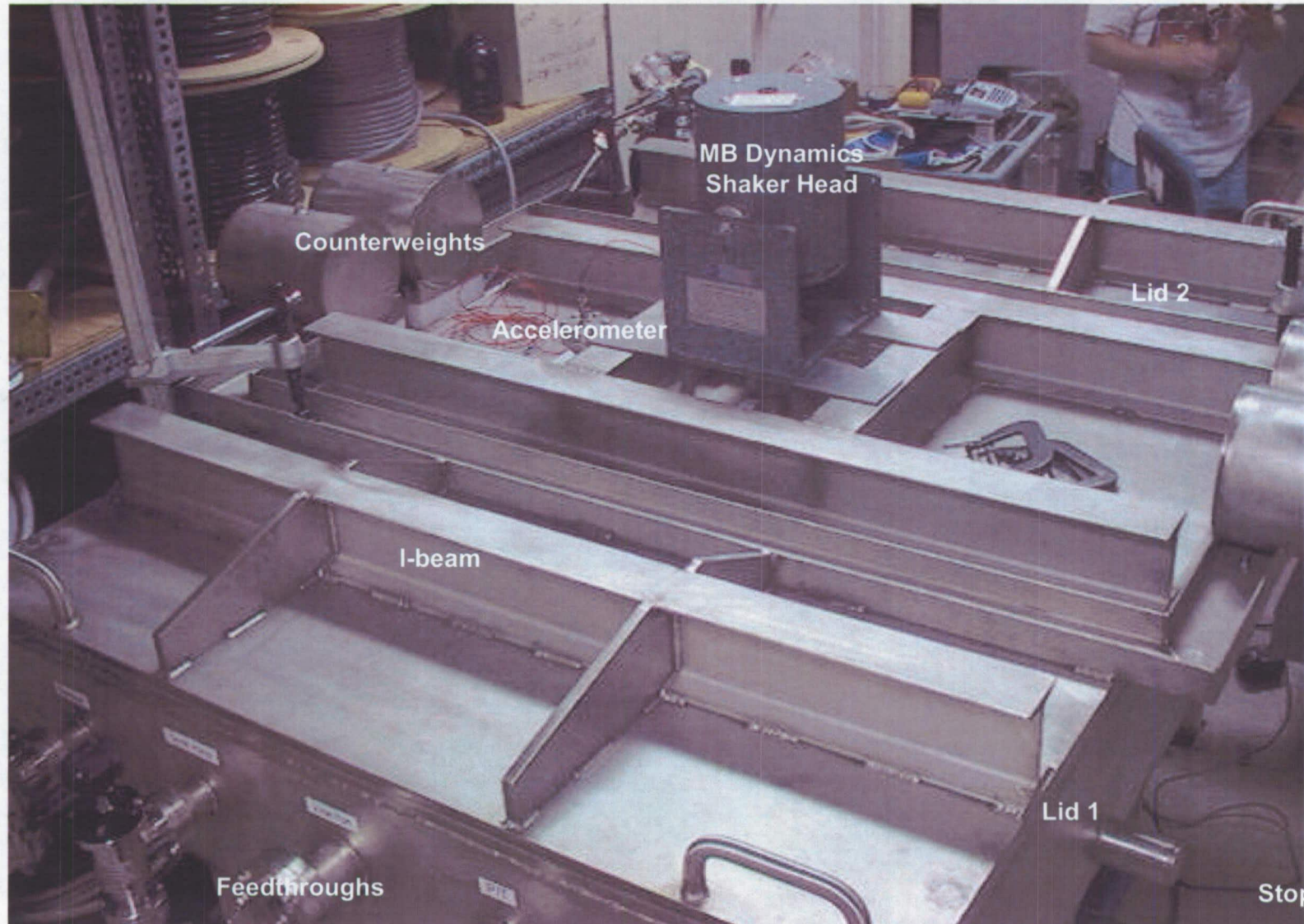
STS-114 RTF TCS Blankets



STS-114 RTF TCS Blankets



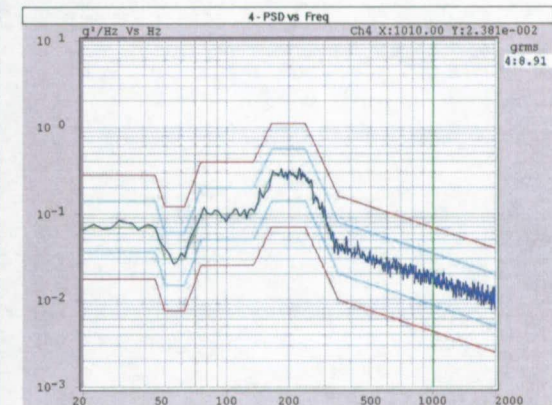
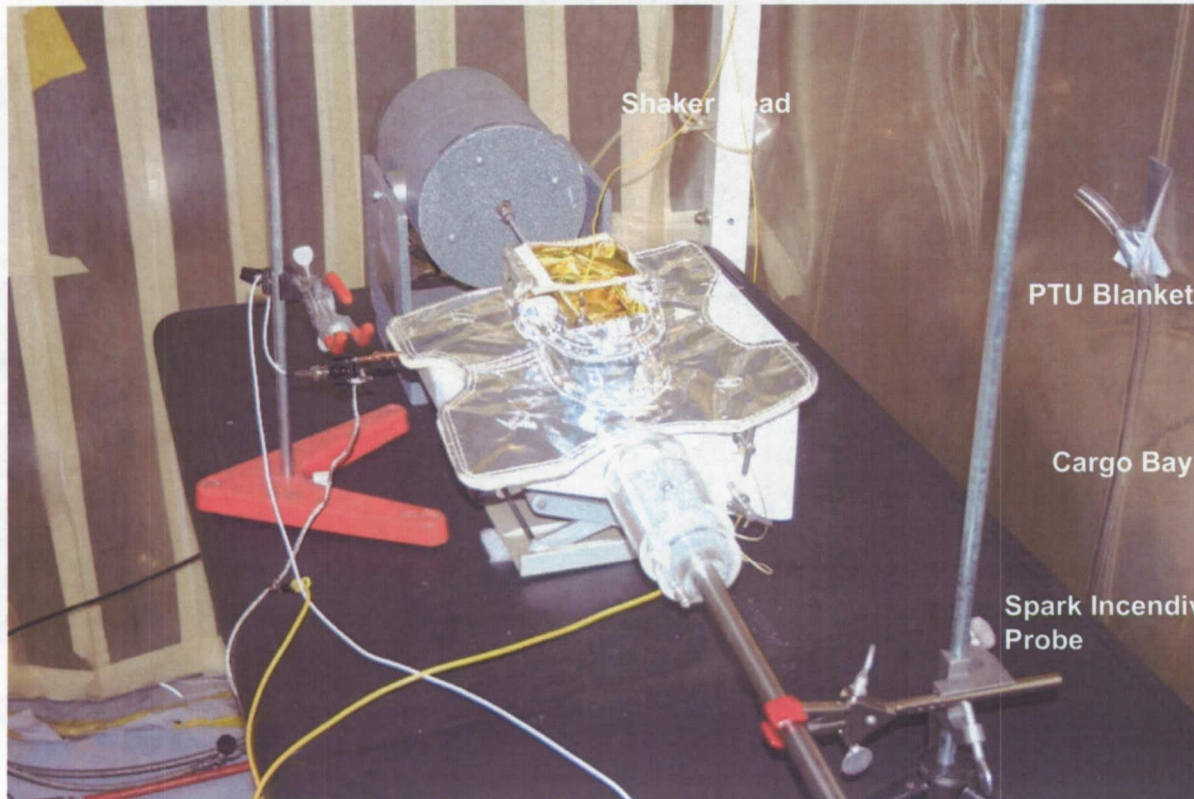
STS-114 RTF TCS Blankets



Spark Incendivity Test

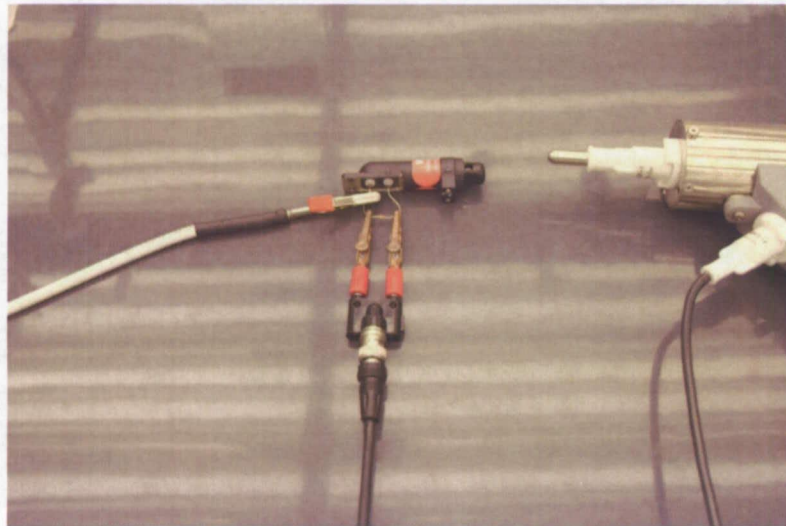


Shuttle Pan/Tilt and CCTV Camera Thermal Blankets



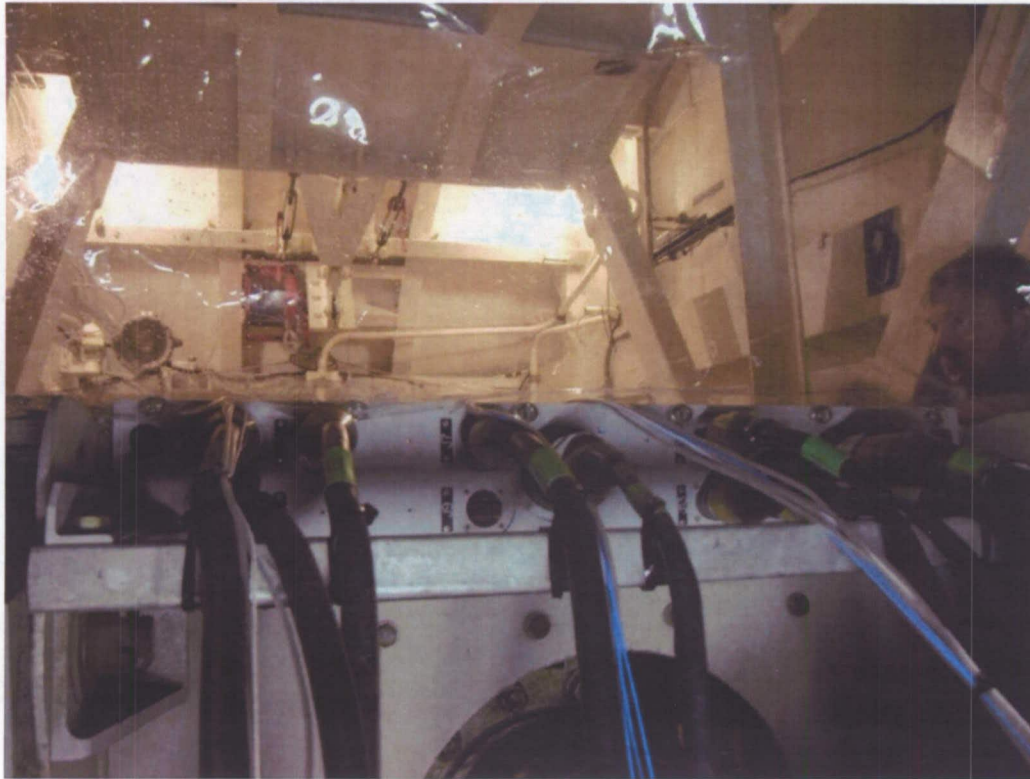
Spark Incendivity testing cleared both the *camera blankets* and the *PTU yoke blankets* to use as is. Representative Testing of the *Pan/Tilt Unit blankets*, has shown that these blankets are also cleared to use as is and do not require to be bonded to ground

Shuttle Crew Escape Equipment Life Preserver and Life Raft Inflator



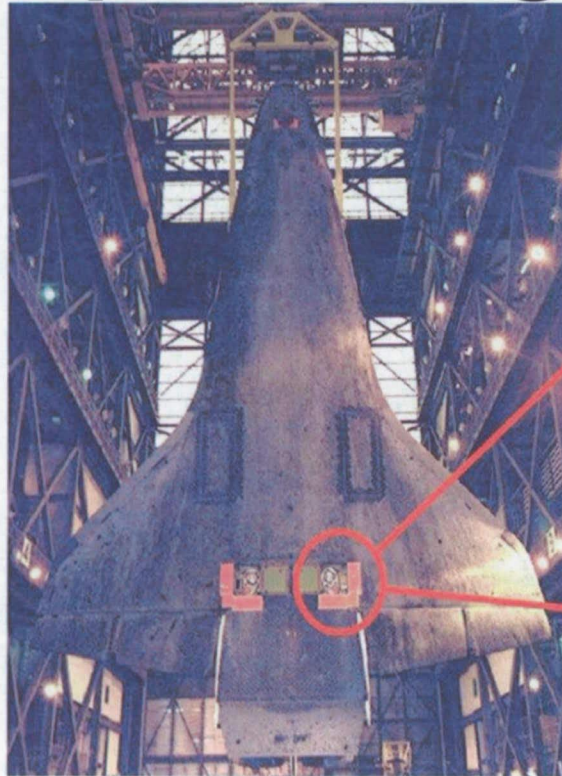
- Concern: Human body discharge could set off explosive and inadvertently deploy units
- Tests performed using IEC 61000-4-2 test standard using 25,000 volts to simulate human generated spark.

Tail Service Mast Aclar Purge Barrier Curtain



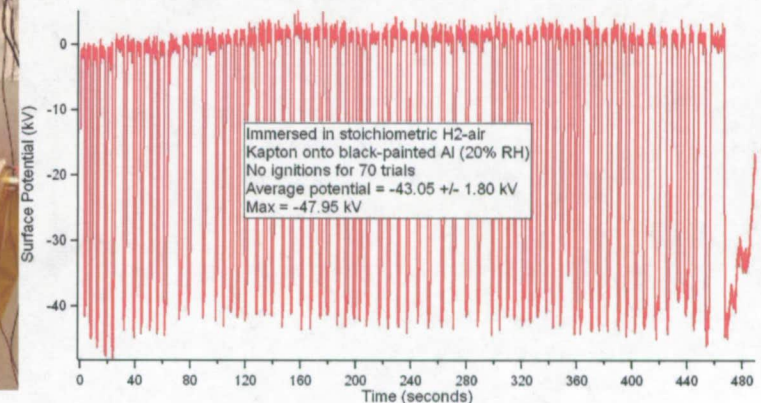
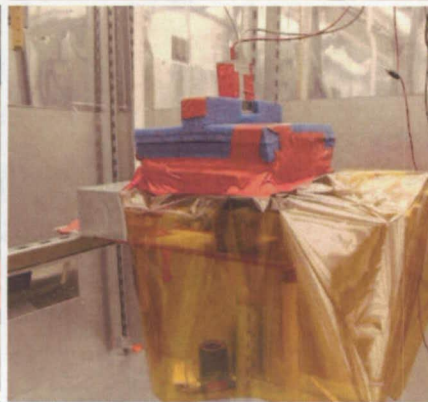
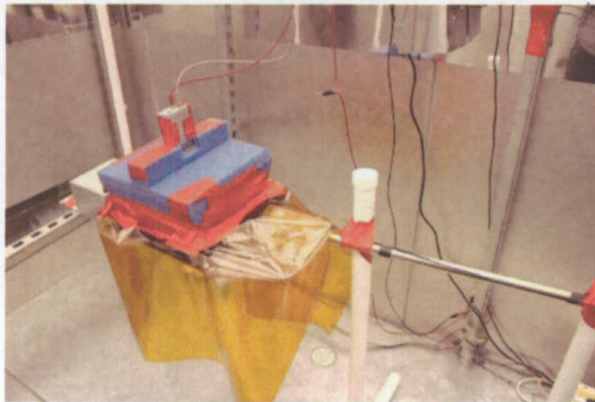
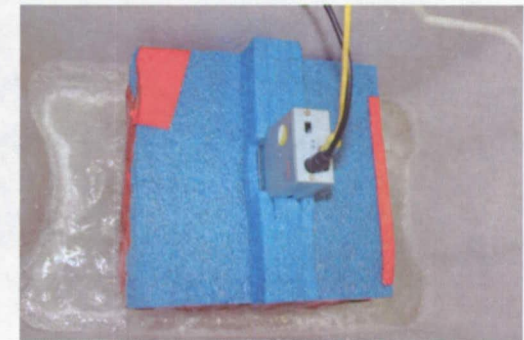
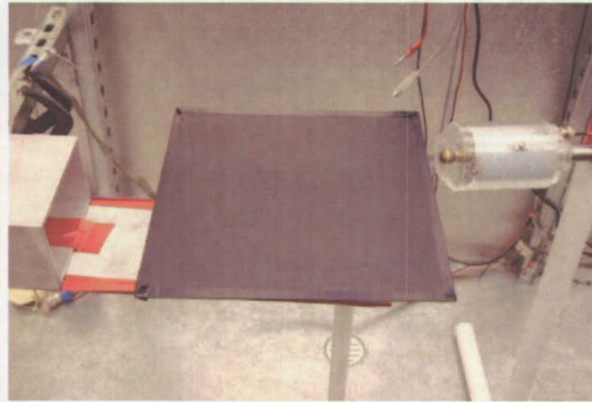
- Concern: Triboelectric charging of curtain during operations
- Measurements showed large potentials reached when deploying
- Aclar failed Spant Incendivity Testing
- Solution: Simple wet wipe to dissipate charge

Kapton Purge Barrier Baggie



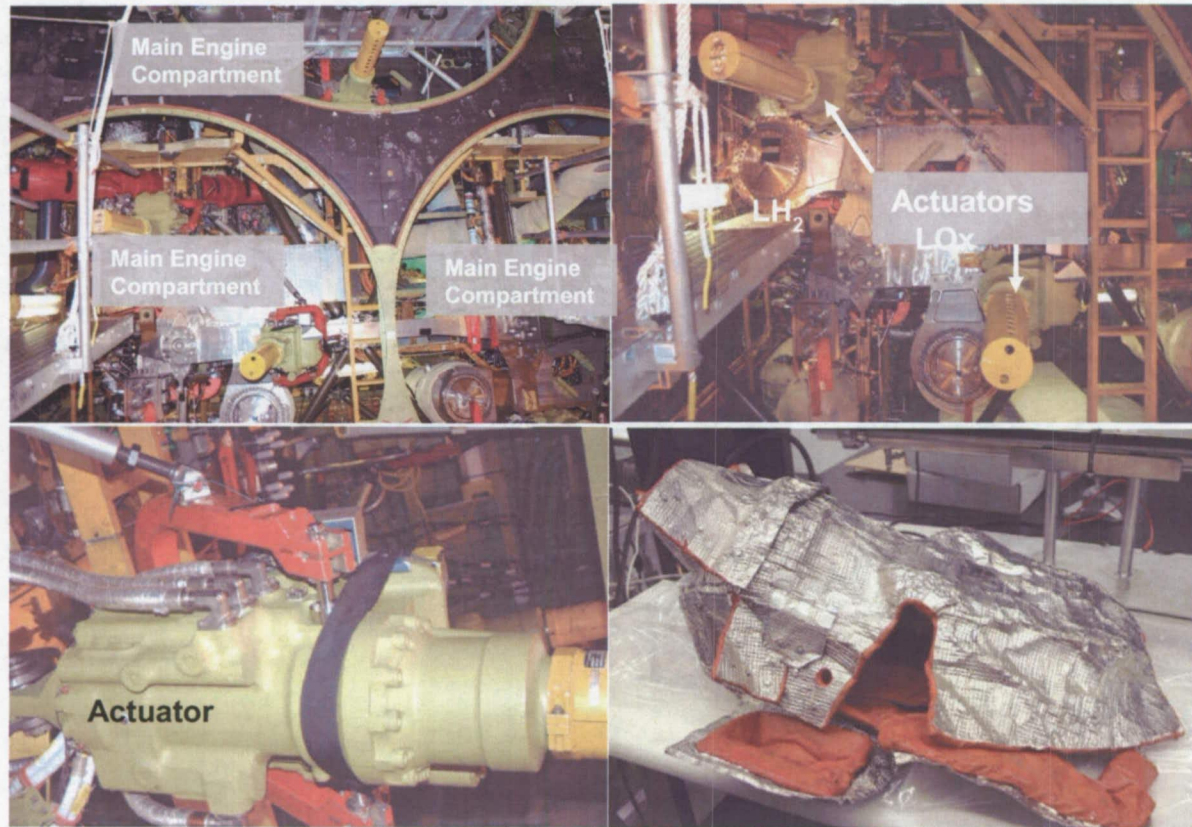
- Concern with triboelectric charging of baggie during installation and during launch
- Kapton fails standard Spark Incendivity Test

Kapton Purge Barrier Baggie



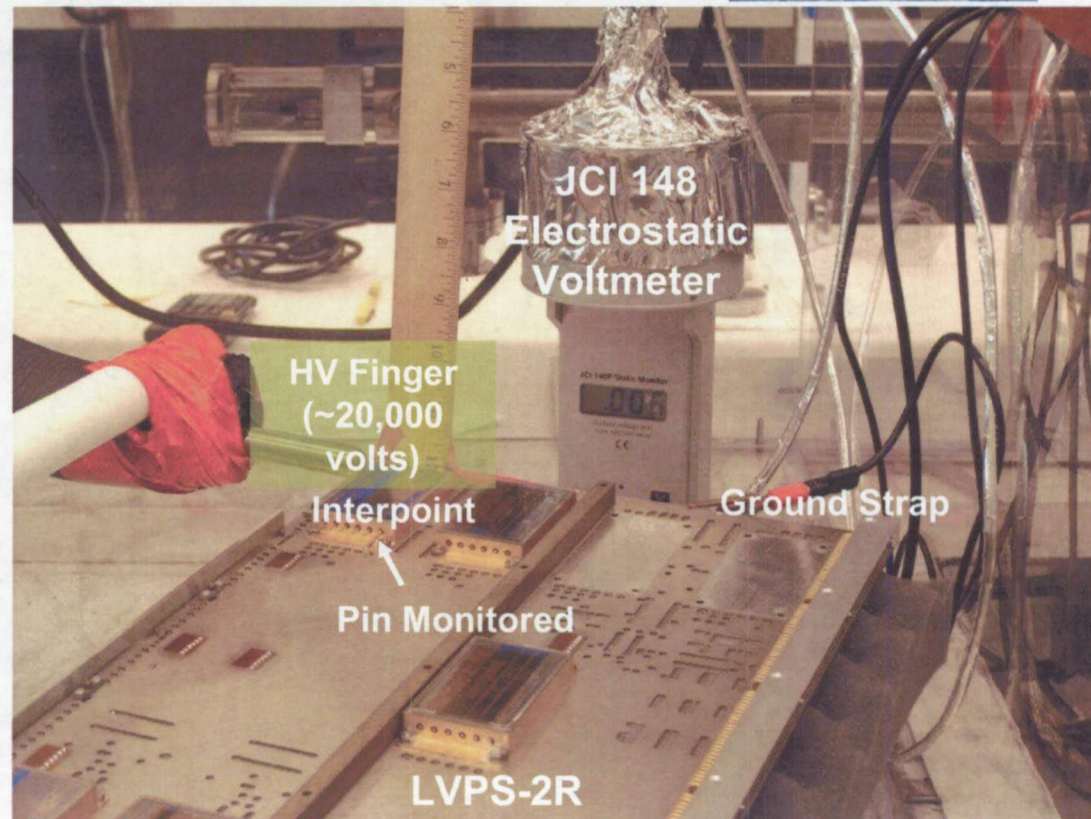
Hundreds of realistic Spark Incendivity Tests showed that charge levels obtained with internal components reached -55 kV but were not capable creating ignitions (67 KV needed for ignition)
Charge induced during installation dissipates at 70% RH (Kapton is hydrophilic)
Future launches: Lowest recorded RH: 7% - Tests are ongoing

TVC Actuator Blankets



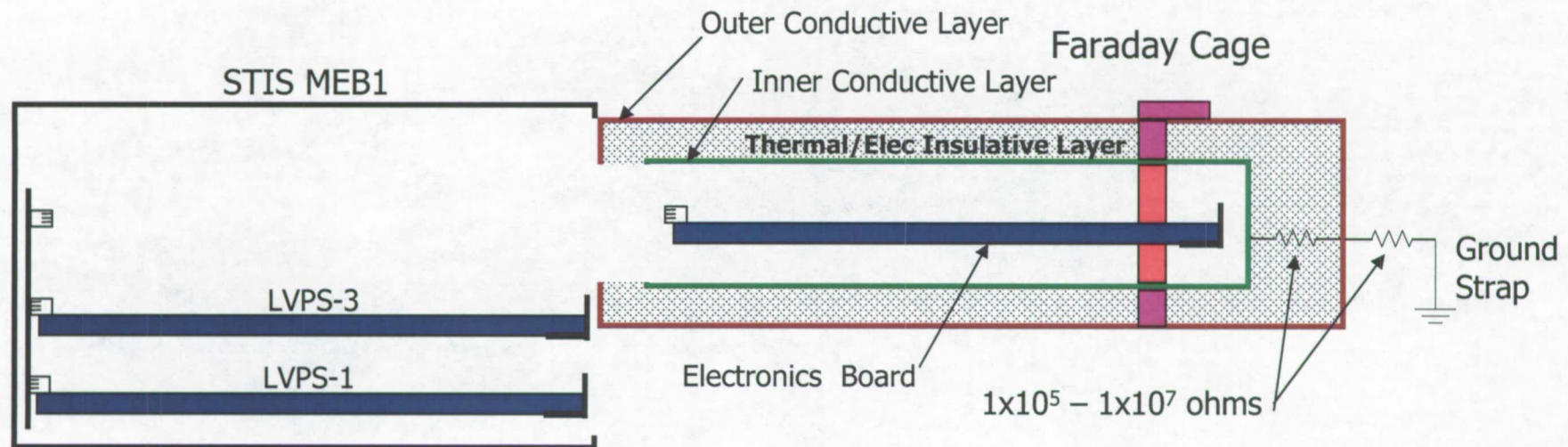
- Thrust Vector Control Actuator Blankets were not electrically grounded by design (based on faulty analysis)
- Measurements of capacitance led to determination of minimum potentials required to reach the MIE of a stoichiometric mixture of hydrogen and air
- Measurements of electrostatic potentials obtained by contact and separation of the blanket material and the actuator showed that these potentials could easily be exceeded
- Our lab recommended strongly the implementation of electrical grounding to the metal surface of the blankets. This recommendation was accepted and has been implemented for STS-117

HST STIS Repair



- Testing and evaluation of the ESD threat due to triboelectric charging of ST Infrared Spectrometer electronic boards to be replaced

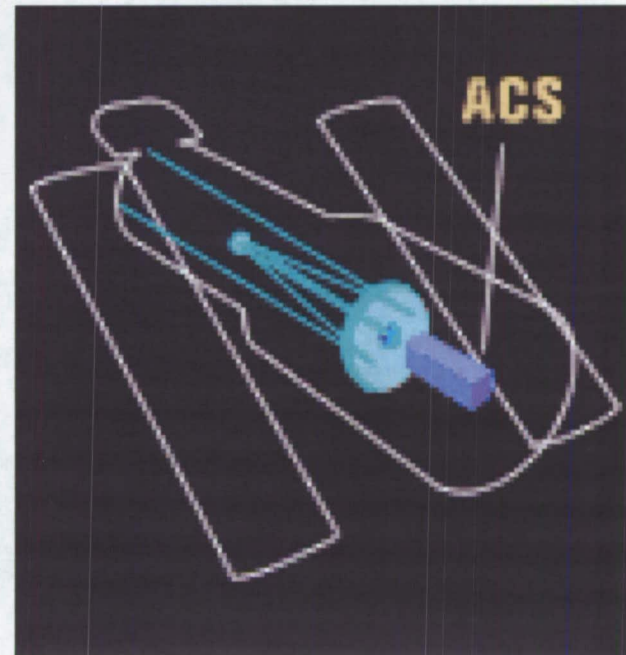
HST Repair Mission: STIS



Proposed Faraday Cage Design

This design will save 15 min of EVA time at
\$1 million/EVA

HST Repair Mission: ACS



- Electrostatic evaluation of Advanced Camera for Surveys electronic card replacement unit

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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14. ABSTRACT Discussion of key electrostatic issues that have arisen during the past few years at KSC that the Electrostatics Laboratory has studied. The lab has studied in depth the Space Shuttle's Thermal Control System Blankets, the International Space Station Thermal Blanket, the Pan/Tilt Camera Blankets, the Kapton Purge Barrier Curtain, the Aclar Purge Barrier Curtain, the Thrust Vector Controller Blankets, the Tyvek Reaction Control System covers, the AID-PAK and FLU-9 pyro inflatable devices, the Velostat Solid Rocket Booster mats, and the SCAPE suits. In many cases these materials are insulating meaning that they might be a source of unsafe levels of electrostatic discharge (ESD). For each, the lab provided in-depth testing of each material within its current configuration to ensure that it does not cause an ESD concern that may violate the safety of the astronauts, the workers and equipment for NASA. For example the lab provides unique solutions and testing such as Spark Incendivity Testing that checks whether a material is capable of generating a spark strong enough to ignite a flammable gas. The lab makes recommendations to changes in specifications, procedures, and material if necessary. The lab also consults with a variety of non-safety related ESD issues for the agency. One example is the					
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16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 19	19a. NAME OF RESPONSIBLE PERSON Charles Buhler
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code) (321) 867-7965