

Other Atmospheric Hazards

Richard Hess

Technology Trends

- **Greater Dependence on Digital Technology for Functions Critical to Flight**

Problem

Soft Fault Characteristics of Digital Technology

- **Application of “Commercial Off The Shelf” (COTS) Electronics to Commercial Aviation Products (also, greater application of COTS electronics to space and defense products)**

Problem

COTS Digital Technology not Designed for Operation in “High Energy” Environments in which Aerospace Vehicles must Operate (electromagnetic, radiation)

- **Greater Application of composite material technology in vehicle construction**

Problem

Creates potential for greater EM energy penetration

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Atmospheric (Natural) Threats to Aircraft Electronic Systems

- **Lightning**

- Ideal (for all practical purposes) current source
- Energy deposition in a relatively good conducting structure (one hundredth of an ohm across structure) on the order of ten thousand joules within 0.1 millisecc (one hundred millionths of a second)

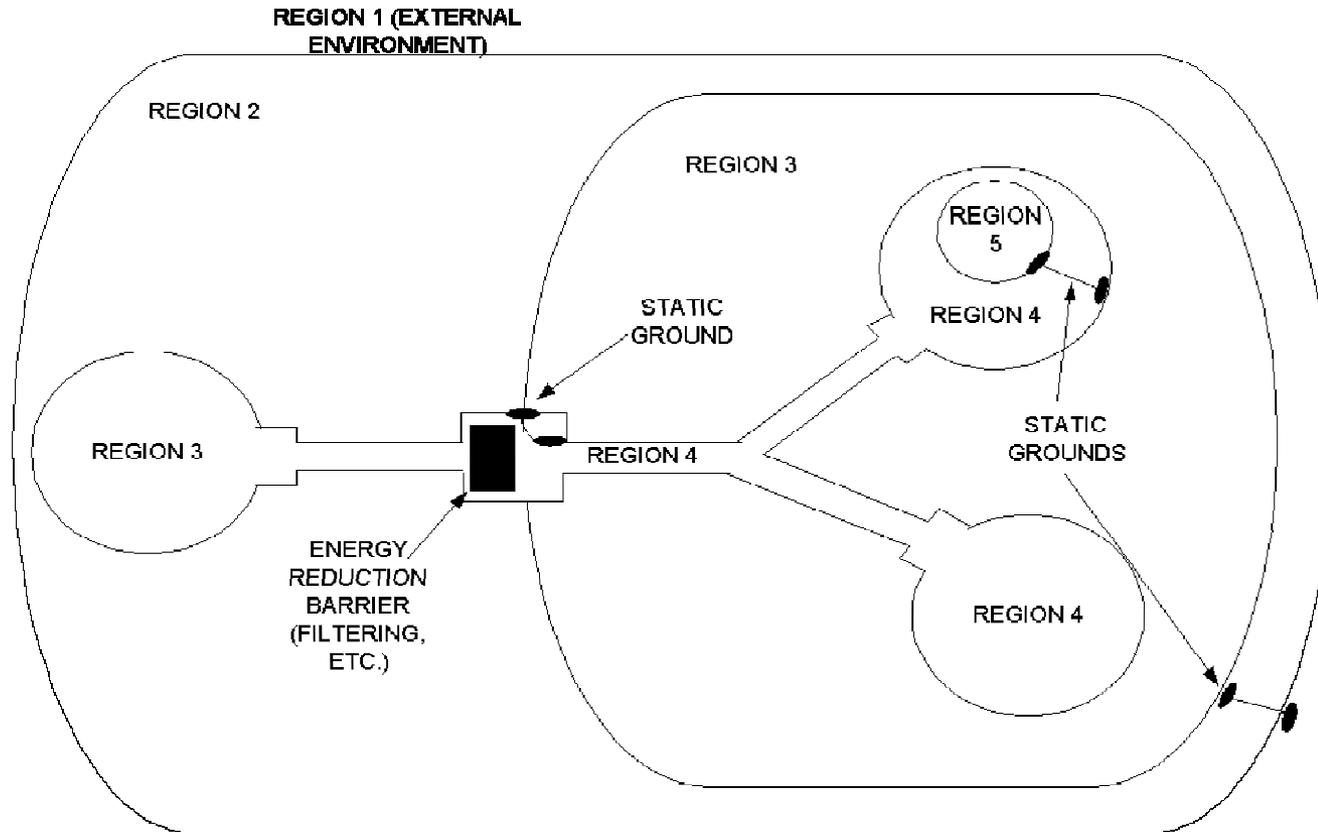
- **Neutrons**

Essentially in a 1 to 100 Mev Spread Energy Spectrum

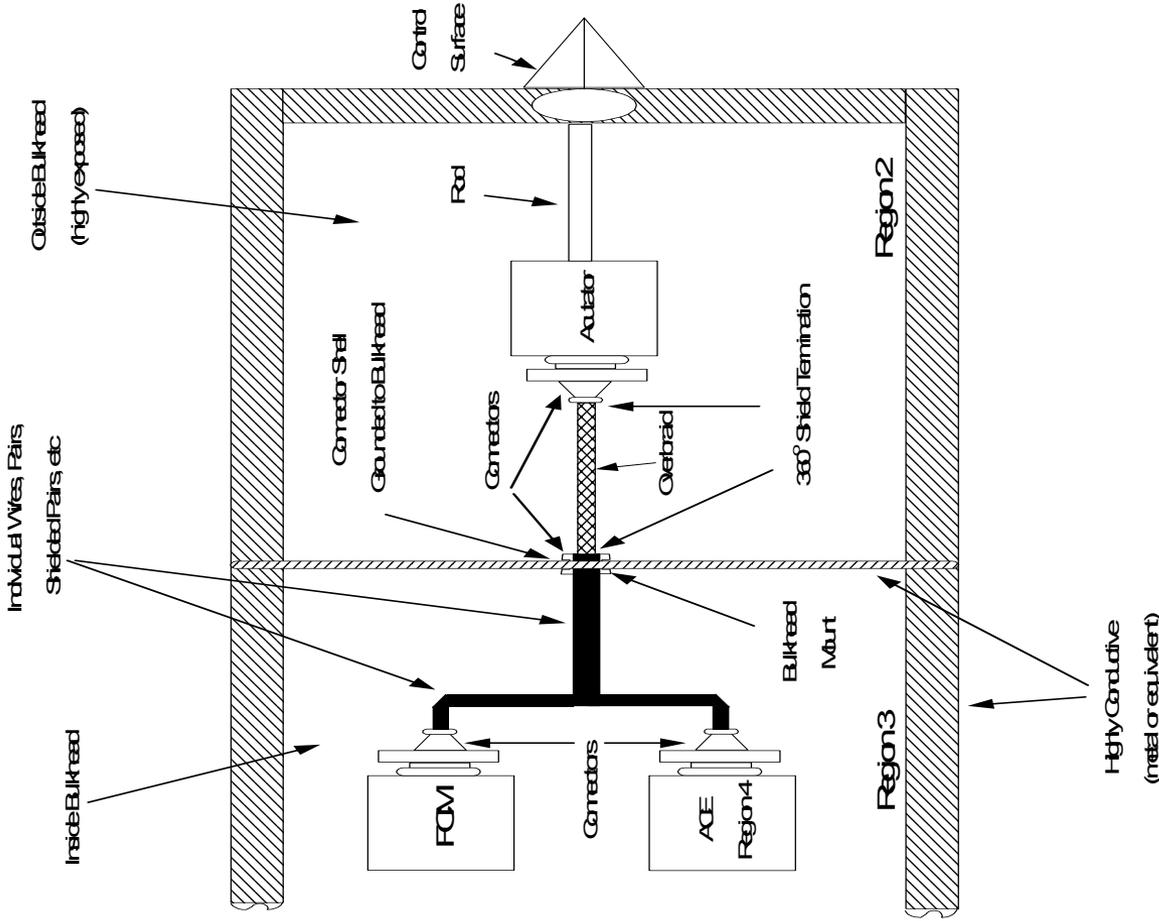
Airplane/Lightning Interaction



Installation Protection – Topology Representation



Interconnected Flight Control System



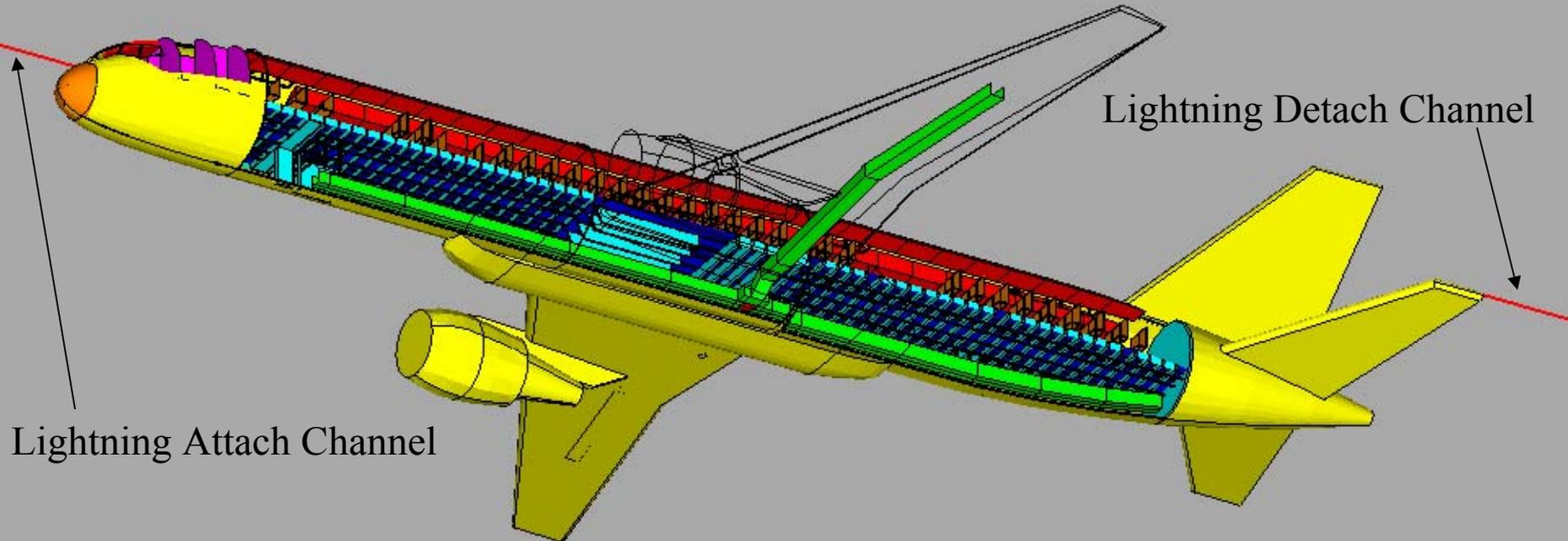
Interconnected Flight Control System

Airplane Model – Composite Fuselage

Fuselage (Composite)

Internal Super Structure (PEC)

Cable Tray (PEC)



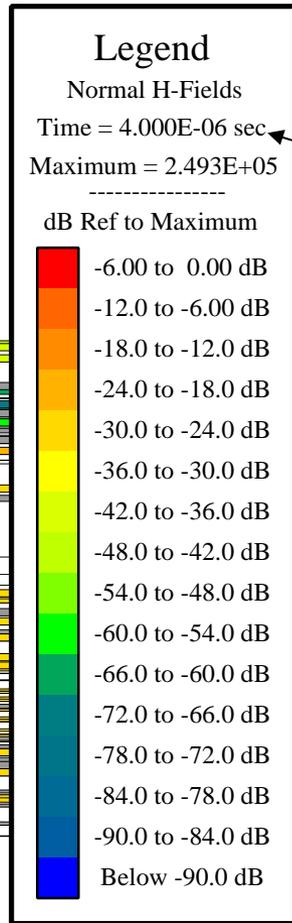
Lightning Attach Channel

Lightning Detach Channel

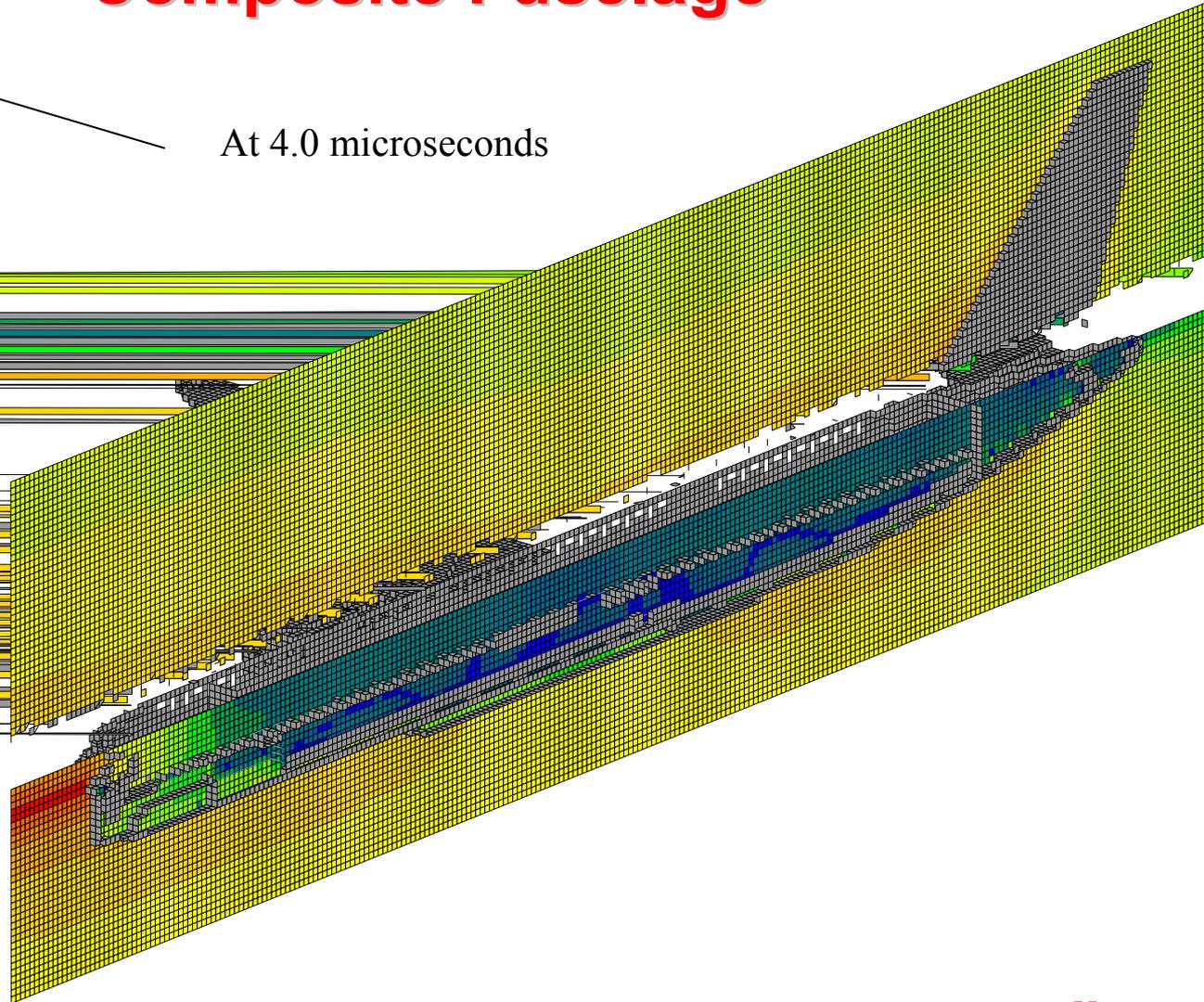
Composite
Conductivity: 10,000 mhos/meter
Thickness: 6 millimeters

Normal Magnetic Fields on Spatial Slices

Composite Fuselage



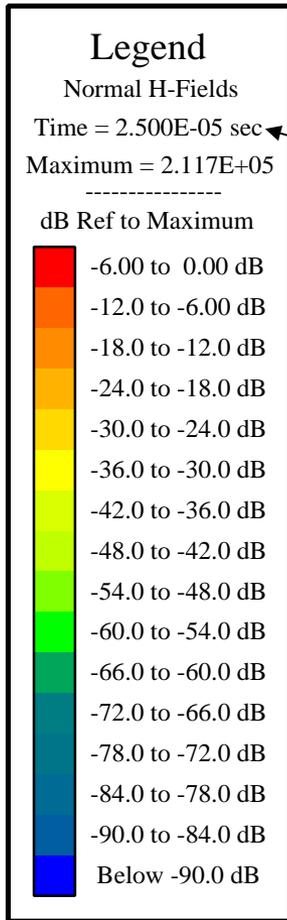
At 4.0 microseconds



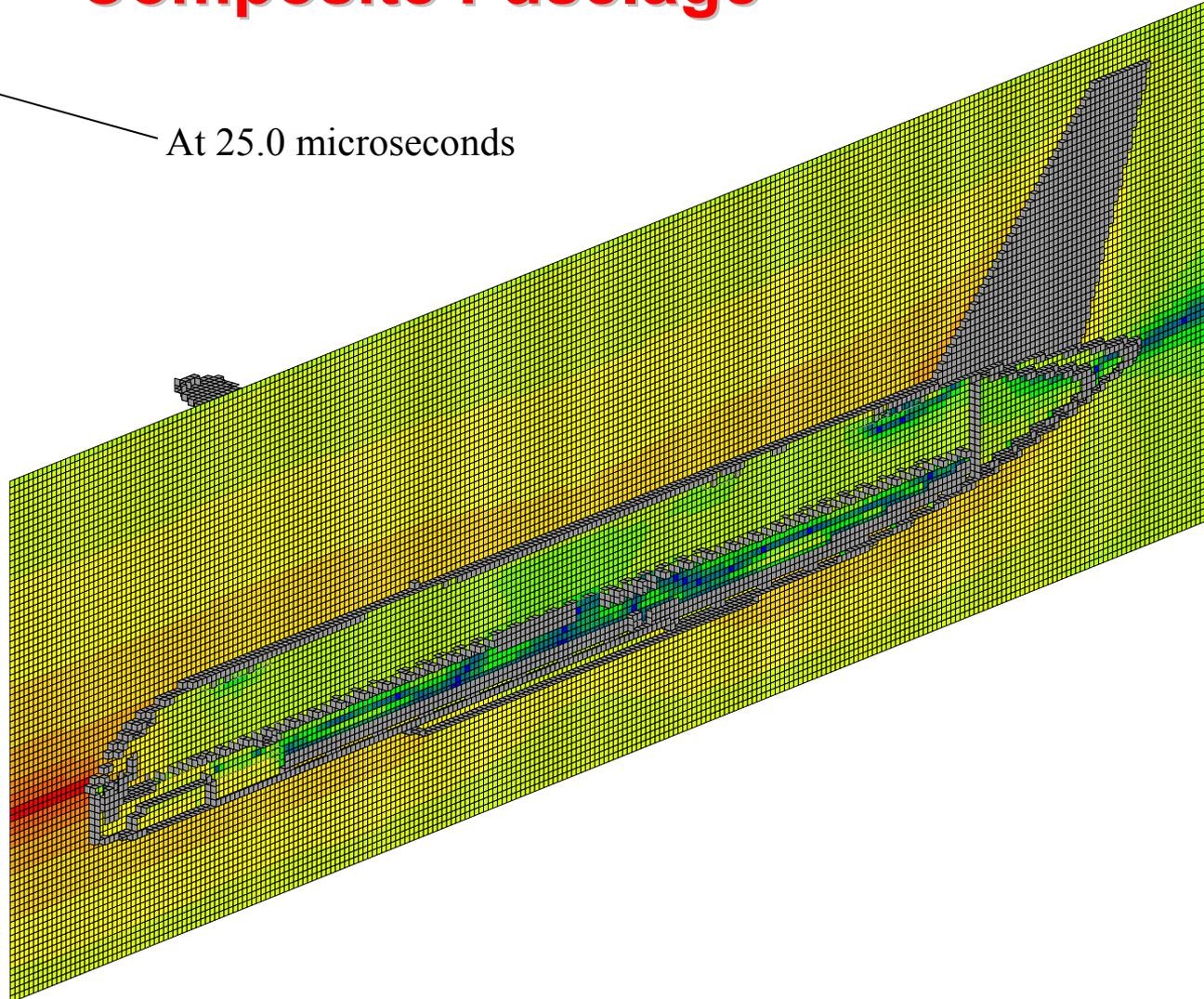
- PEC Materials
- Isotropic Materials
- Composite Materials
- Thin Wires

Normal Magnetic Fields on Spatial Slices

Composite Fuselage



At 25.0 microseconds



- PEC Materials
- Isotropic Materials
- Composite Materials
- Thin Wires

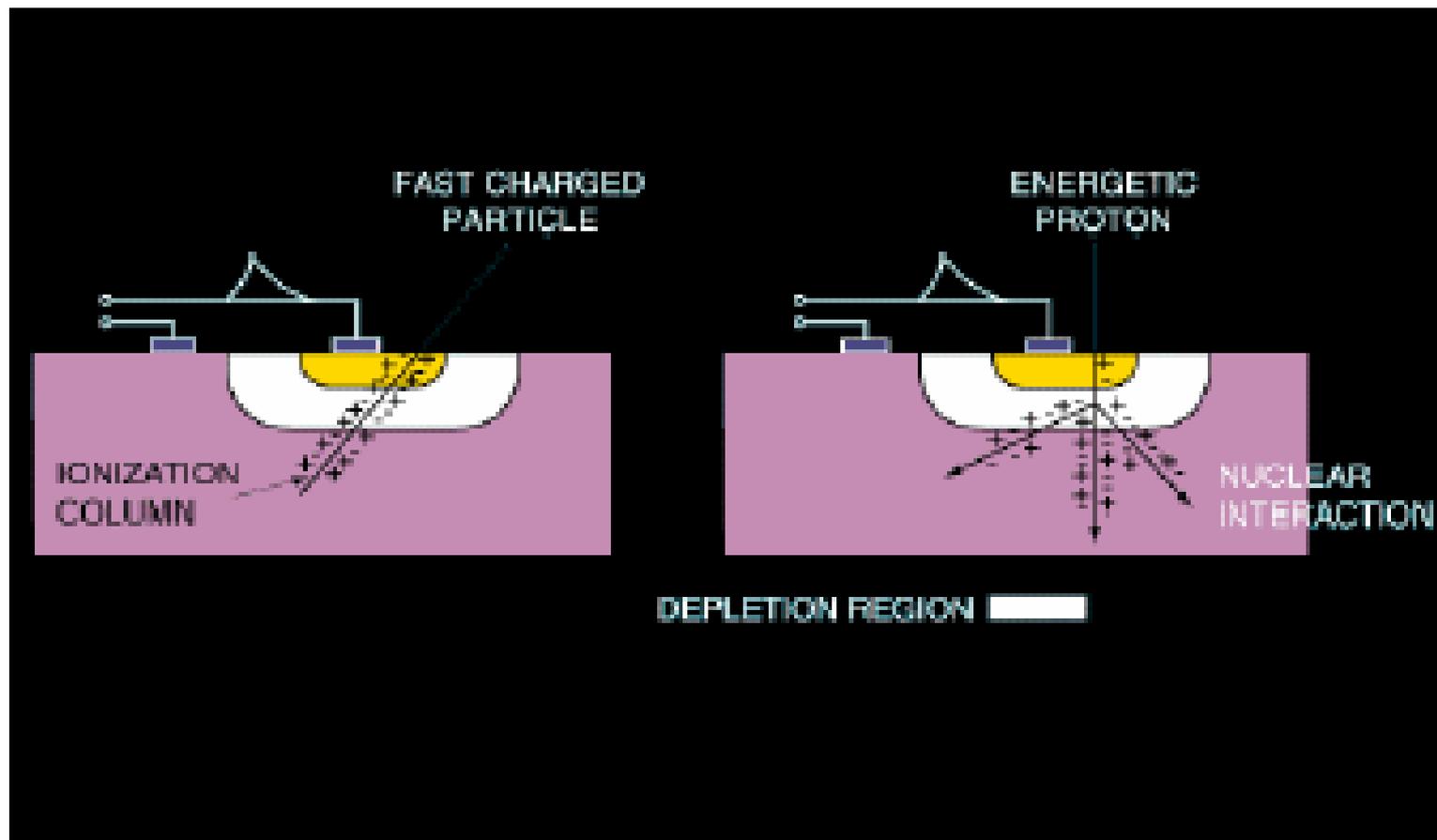
Particle Cascades in Atmosphere

- Galactic cosmic rays and solar rays hit the earth's atmosphere, penetrate and produce particle cascades
- Therefore single event effects occur within Earth Atmosphere
 - ◆ First recognized in 1980s
 - Aircraft
 - Ground based systems
 - ◆ Probability - function of:
 - Device physics
 - Physical Location of the device
 - » Altitude
 - » Latitude and Longitude



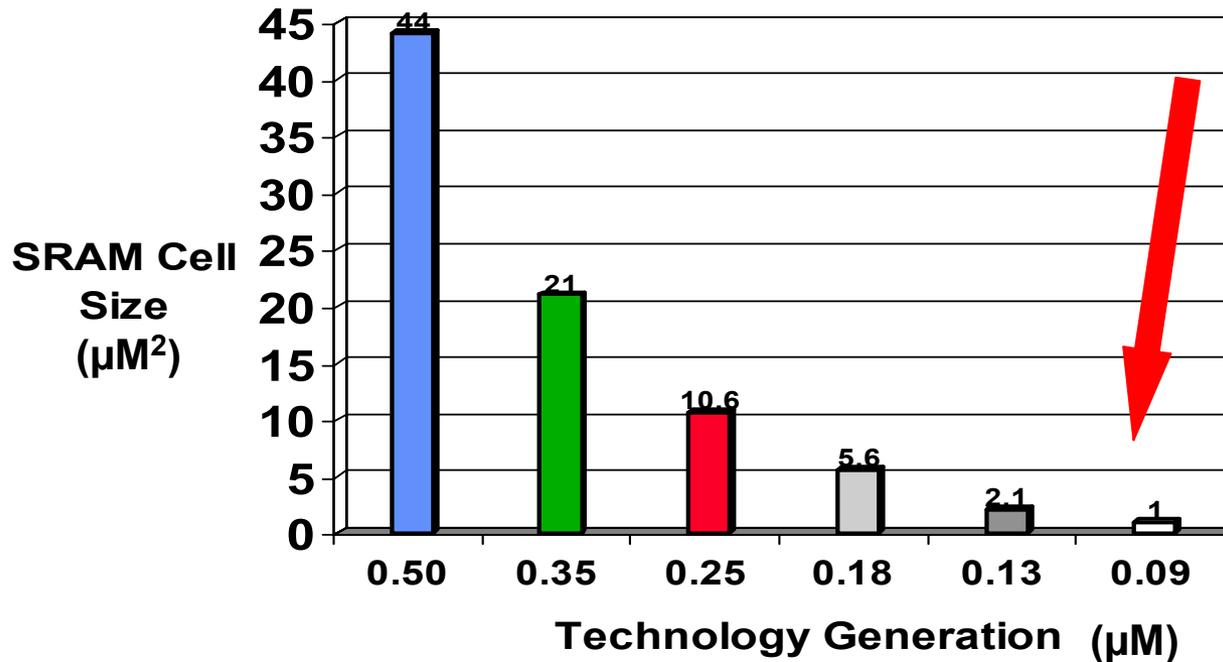
Source: IBM, Journal of
Research & Development
*Terrestrial Cosmic Rays
and Soft Errors*

Interaction of Charged Particle and Silicon



Nanometer Processes Increase Probability of Firm

SRAM Cell Size Continues to Scale ≈ 0.5 x per Generation



Smaller RAM cell with low charge is easily upset by a random low energy particle

Greater percentage of neutrons can now generate sufficient energy to cause a firm error

Smaller SRAM Cell = Increased Susceptibility to Firm Errors
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NASA Involvement in Atmospheric Environment Aircraft Electronic System Threats

- **Lightning Environment**
 - LaRC - J. Beggs Proposed Research
 - LaRC - SAFETI Lab Capability for Conducting Lightning Effects Experiments (closed loop,etc) on Aircraft Performance

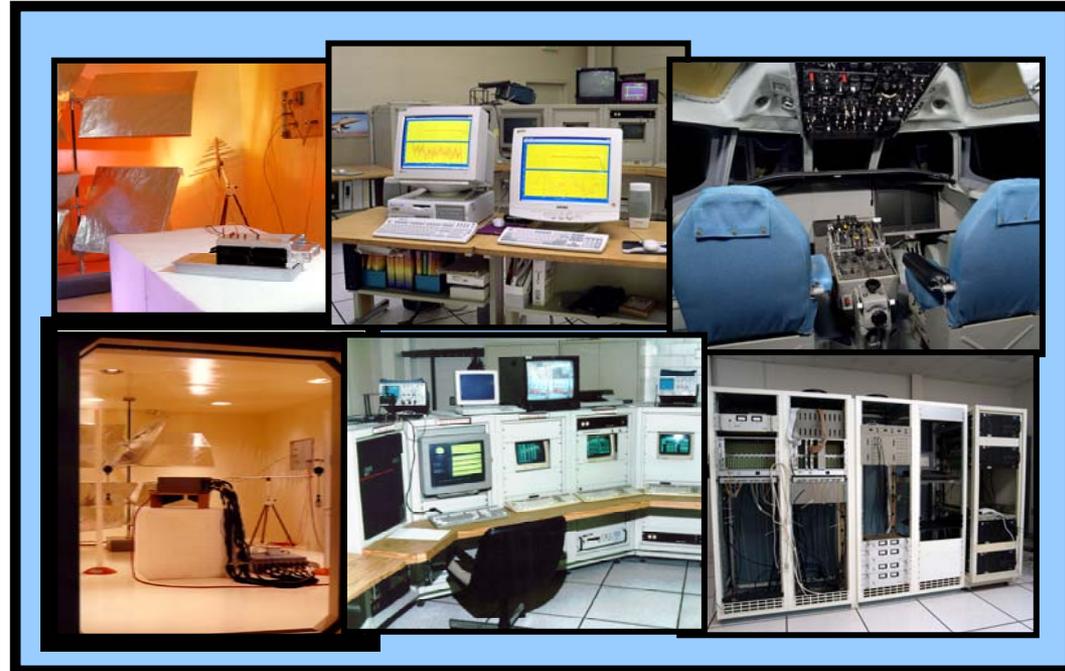
- **Atmospheric Neutron Environment**
 - GSFC - E. Stassinopoulos Characterization Measurement Program to Refine Understanding of the Atmospheric Neutron Environment
 - LaRC - SAFETI Lab/LANSCE Capability for Conducting Neutron Effects Experiments (closed loop,etc) on Aircraft Performance

- **Celeste Belecastro SAFETI Lab Point of Contact**

SAFETI Lab Summary

Capability

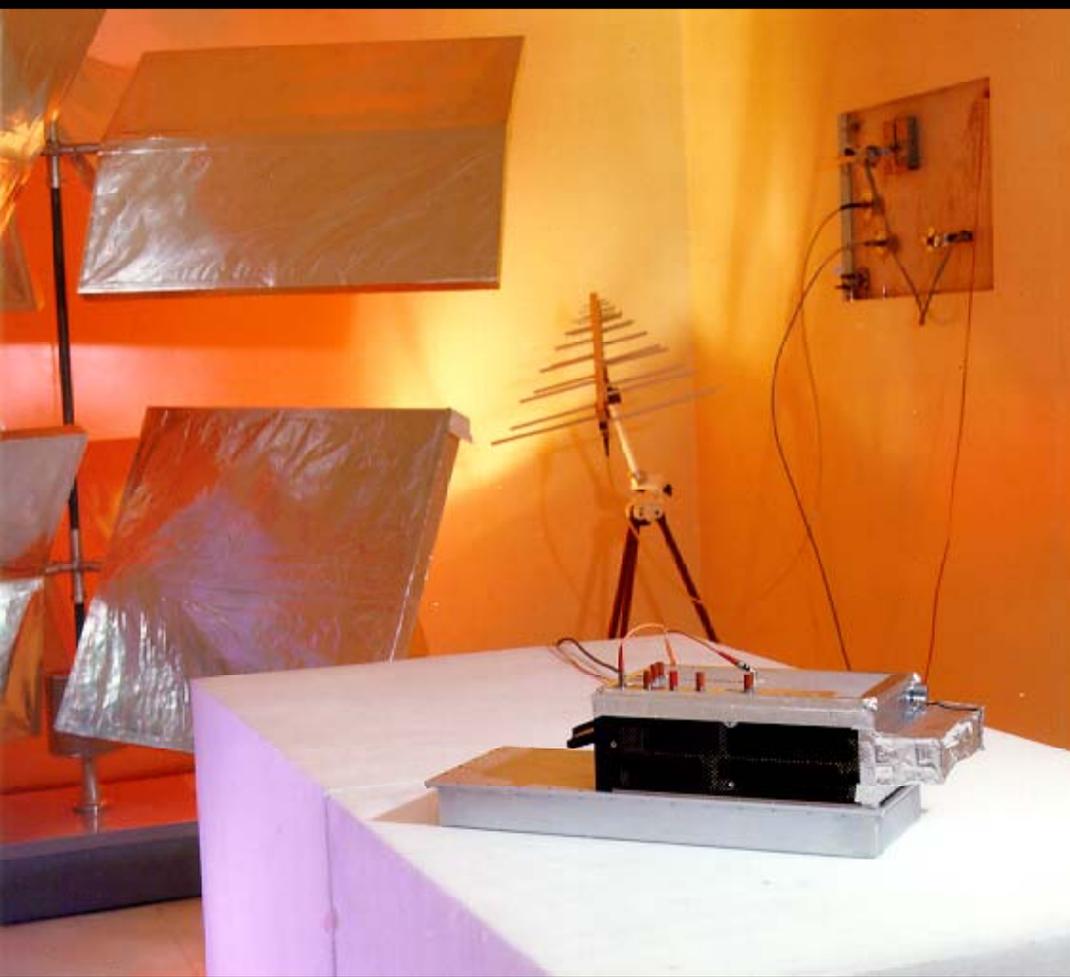
- Ability to Assess Complex and Highly Integrated Airborne Systems Technology
 - Closed-Loop Environment
 - Hardware in the Loop
 - Pilot in the Loop
- Ability to Introduce Faults in Complex and Highly Integrated Systems
 - HIRF (Link to HIRF Lab)
 - Lightning (Bulk Cable Injection)
 - EMI/EMC
 - Faulty or Malfunctioning Components
 - Failed or Damaged Components
- Comprehensive System Assessment
 - Covers Entire Flight Envelope
 - Equipments Mode Switching
 - Operational Envelope of Equipment
 - Atmospheric Disturbances
 - ◆ Winds and Gusts
 - ◆ Turbulence
 - ◆ Wind Shear
 - Flight Beyond Normal Envelope
 - ◆ Unusual Attitudes
 - ◆ Out-of-Control Motion



Features

- Reconfigurable Testbeds
 - Components
 - Data Buses
 - Vehicle Simulations
- Links to NASA Langley and Off-Site Laboratories
 - LaRC HIRF Lab
 - LaRC Cockpit Motion Facility
 - LaRC Structures Lab
 - GRC Engine Lab
 - Los Alamos National Lab

RC HIRF Experiment Arrangement and SAFETI Lab



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Links to Other Labs

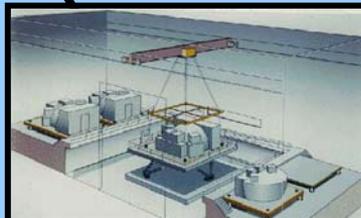
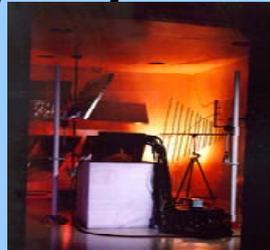
LANL Neutron Particle Lab



GRC Engine Lab



SAFETI Lab Network Hub



LaRC Structures Lab

LaRC HIRF Lab

LaRC Cockpit Motion Facility

• Current Links

- NASA LaRC HIRF Lab
 - ◆ Electromagnetic Environment Effects Testing

• Planned Links

- NASA LaRC Structures Lab
 - ◆ Integrated Aircraft Structure Health Management Technologies Validation
- NASA LaRC Cockpit Motion Facility
 - ◆ Control Upset Prevention & Recovery Technologies Validation
- NASA GRC Engine Lab
 - ◆ Integrated Propulsion System Health Management Technologies Validation
- Los Alamos National Lab Neutron Particle Facility
 - ◆ Single Event Upset System Effects Testing **Honeywell**