Calculation of Cosmic Radiation Exposure of Aircrew: PCAIRE Code

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Outline

- Cosmic Radiation Considerations
- Cosmic Radiation Study
- PCAIRE Model & Code
  - Demonstration
- PCAIREsys Development
  - Demonstration
Cosmic Radiation Considerations

- Relatively constant radiation field:
  1. Solar Activity
  2. Latitude
  3. Altitude

- Complicated
  - Many particle types, large energy range
  - High quality factor & biological risk

- Other
  - Radiation measurements +/- 20%
  - Canadian & EU regulations similar
1. Solar Activity

Radiation intensity anticoincident with 11-year solar cycle

Difficult to model due to non-uniformity
2. Latitude

- Earth’s magnetic field
- Greater shielding at equator than geomagnetic poles (factor of 2-3)
- Levels off at Geomagnetic Knee, ~50°
3. Altitude

Radiation field is higher at jet altitudes (factor of 100)
Cosmic Radiation Study (1991-2002)

- **Surveys**
  - Air Force, 6 Canadian Airlines
    - Neutron Bubble Detector

- **Experimentation**
  - 62 Flights (Portable Instruments)
    - Tissue Equivalent Proportional Counter (TEPC)
    - Ionization Counter (low-LET)/TLDs + Remmeter/Bubble Detector (high-LET)

- **Code Development**
  - Predictive Code - Aircrew Radiation Exposure (PC-AIRE)
Equipment Suite Development

- MNS
- LET Chamber
- NE213 Scintillator
- LLRM
- Detector NIMs, Computers, UPS
- BGO Scintillators
- Anthropomorphic Phantom with TLDs and BDs
Equipment Suite Development
Equipment Suite Development

- Tissue Equivalent Proportional Counter
- Bubble Detectors and TLD's under Foam
Dose Equivalent Distribution ($\mu$Sv)

TOTAL DE = IONIZING + NEUTRON
Data Coverage
TEPC Data Analysis (36 Flights)

Geomagnetic latitude calculated from geographic latitude & longitude

Data plotted digitally from equator to poles

Affected by difference in geographical & geomagnetic poles
Dose Rate Vs Cutoff Rigidity

Dose equivalent rate (35000 ft, 650 MV)

- Better way of digitally plotting data & thus providing a function

GCR ability to penetrate magnetic field
Solar Cycle Effects

TEPC data for 2 sets of measurements near max & min of solar cycle

2 corresponding functions, $f_1$ & $f_2$ adjust for solar cycle

Ongoing measurements
Altitude Effects

Atmospheric Depth (g cm$^{-2}$)

Balloon Data (July 14, 2001)
Balloon Data (July 23, 2001)
Model

$(\xi_s)_{GCR} = 0.0068$ cm$^2$ g$^{-1}$

Function adjusted for altitude
PCAIRE Code Demonstration
(Single Entry)
Model and Code Validation

PTB Data and LUIN Code

26 Independent TEPC Route Dose Data
Code Development: PCAIRESys

- Operational environment:
  - Management system for large number of personnel and flights
PCAIRESys Features

- **Platforms:**
  - Standalone application (personal PC/Web access)
  - Kernel incorporated into airline personnel database
  - Data treatment centre
    - Web/LAN batch processing/Airline database interface

- **Functionality:**
  - Single flight entry or batch file processing
    - Query by flight, crew, occupation or date
  - Great circle route or way points
  - Secure access
PCAIRESys Demonstration
(Multiple entry)

- Create an organization
- Create an administrator for the organization
- Enter users
- Enter one flight by city pair
- Enter batch flights (show one file that works and modify slightly)
- Enter batch flight by way point (take a small file)
- Query
  - By admin for one year
  - By admin for one crew
- Log out and log on as user, and query by quarter, then year, then flight
Summary

- Research over a decade
  - Surveys, Experimentation, Modelling
    - Measurements continuing
  - PCAIRE Code development
    - Experimentally-based (TEPC data) PCAIRE Code
    - PCAIREsys Code for batch aircrew exposure calculation
      - Canadian air force, Canadian-based airlines
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