

EXPOSURE TO THE ATMOSPHERIC IONIZING RADIATION ENVIRONMENT: STUDIES ON ITALIAN AIRCREWS

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Study Rationale

- **Developing a new better model for the Atmospheric Ionizing Radiation (AIR) environment to evaluate radiation fluxes at different times, coordinates and altitudes in the Earth atmosphere**
- **Developing a new tool to evaluate radiation fluxes and doses all along aircraft flight paths at different times and coordinates in terms of quantities to be used in biomedical and epidemiological studies targeted to aviation flight personnel crewmembers**

Physics vs. Epidemiology

Work Hypothesis

(De Angelis et al., *Radiat. Res.*, 156, 689-694, 2001)

Low-dose low-dose-rate high-LET chronic radiation doses due to the atmospheric ionizing radiation environment may cause delayed health effects (mostly cancer induction) on airline flight crew member

To be tested again:

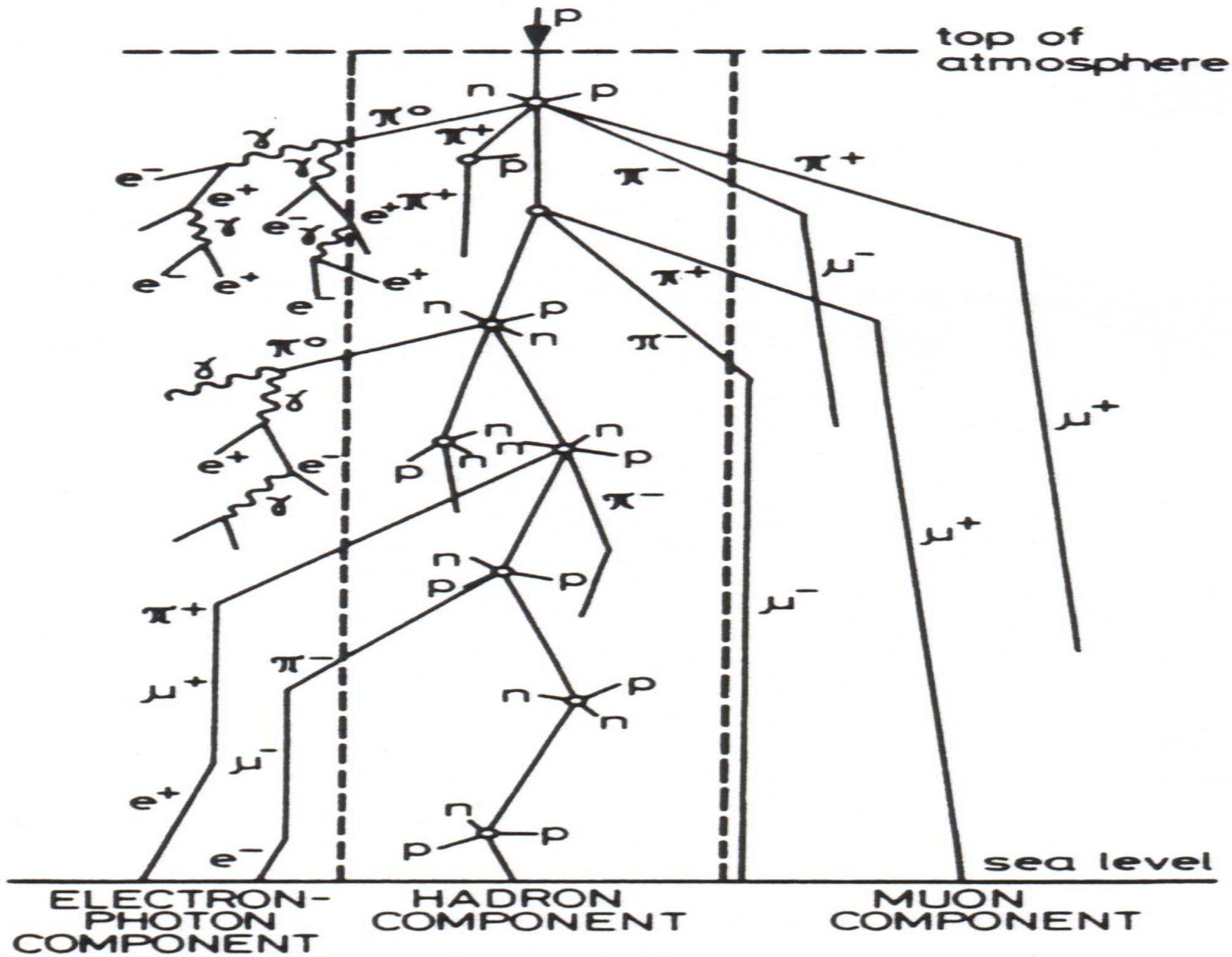
- atmospheric radiation environment**
- flight personnel work history**
- aircraft flight route profiles**

Issues Considered - Physics

- **Primary Particles (GCR)**
- **Solar Modulation on GCR**
- **Geomagnetic Cutoff Properties**
- **Earth Atmosphere Modeling**
- **Transport in the Atmosphere**
- **Aircraft Trajectory Modeling**

Issues Considered - Epidemiology

- **Particles/Human Body Interaction**
 - ➔ **Fluxes/Doses Conversion Tools**
- **Dose Integration along the Trajectory**
- **Presentation of Results**



ATMOSPHERIC RADIATION ENVIRONMENT

Radiation dose due to:

Galactic Cosmic Rays (GCR) Generated Radiation, i.e. Secondary Particles created in the interaction between GCR and the atmospheric nuclei (**neutrons** less than 10% in dose, but **more than 50%** in dose equivalent)

Solar Particle Events (SPE) due to Solar Flares and the relative particle flux (mainly protons)

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Alitalia Cargo

RETE EUROPEA

EUROPEAN NETWORK



Alitalia cargo

RETE INTERCONTINENTALE
INTERCONTINENTAL NETWORK



COHORT DESCRIPTION

eligibility

all civilian airline flight personnel (cockpit crew, i.e. Pilots and Flight Engineers, and cabin crew, i.e. Hostesses, Stewards) employed between January 1, 1965 and December 31, 1996 (follow-up updated till December 2003, collected data until October 2004 but not implemented yet in database)

3,022 male cockpit crewmembers

3,419 male and 3,428 female cabin attendants

data sources

National Pension System - special fund flight personnel
Istituto Superiore di Sanità, Rome
Airline companies - Alitalia and other smaller companies

RADIATION EXPOSURE ASSESSMENT

individual records of flight personnel:

- job title
- haul type (short, middle, long)
- interruptions of service
- date and type of retirement (normal, medical)
- annual block hours and/or individual flights

(source: ALITALIA and other Italian airlines)

RADIATION EXPOSURE ASSESSMENT

Flight and route-related data sources and variables used:

- 1) ALITALIA and other companies:
 - timetables from 1947-2006
 - actual flight routes data (briefing, logbooks, others)

- 2) ANPAC - pilot's union
 - data set on Italian airports

- 3) LANDING data bases
 - data sets on Worldwide airports

RADIATION EXPOSURE ASSESSMENT

- **calculation of flight path radiation doses and**
- **dose equivalents (effective dose) - software:**
 - CARI 6 program, provided by FAA, based on LUIN2000 as the radiation transport code, modified to consider actual 3-D flight profiles (for the European ESCAPE)
 - a new version of the NASA AIR code, currently being developed at NASA Langley Research Center, to take also into account very old flights (before 1958) as well as Solar Particle Events

Some Samples of Exposure Results

- Doses in individual flights and dose rates for aircraft types for the **Italian** flights:
- e.g. for the **winter season** of the year **1977** the average doses for **DC8** and **B727** flights is **2.72** and **3.36 $\mu\text{Sv/hr}$**

STUDY OUTCOMES

Final results obtained for:

- 1- mortality for all causes (first study carried out on cabin crew mortality)**
- 2- crew employment history**
- 3- aircraft routes profiles**
- 4- average doses by year and aircraft**

FUTURE OUTCOMES

Goals of current studies

- 1- atmospheric radiation environment characterization (IN PROGRESS)**
- 2- disease morbidity vs. exposure to cosmic radiation (IN PROGRESS)**
- 3- in-flight measurement campaign (IN PROGRESS)**
- 4- dose vs. response and risk analysis**

Problems envisaged because it is now needed an agreement with the new company CAI (routes, lengthy way, new hubs, maybe they say no...)