

Epidemiological investigations of aircrew – an occupational group with low-level cosmic radiation exposure

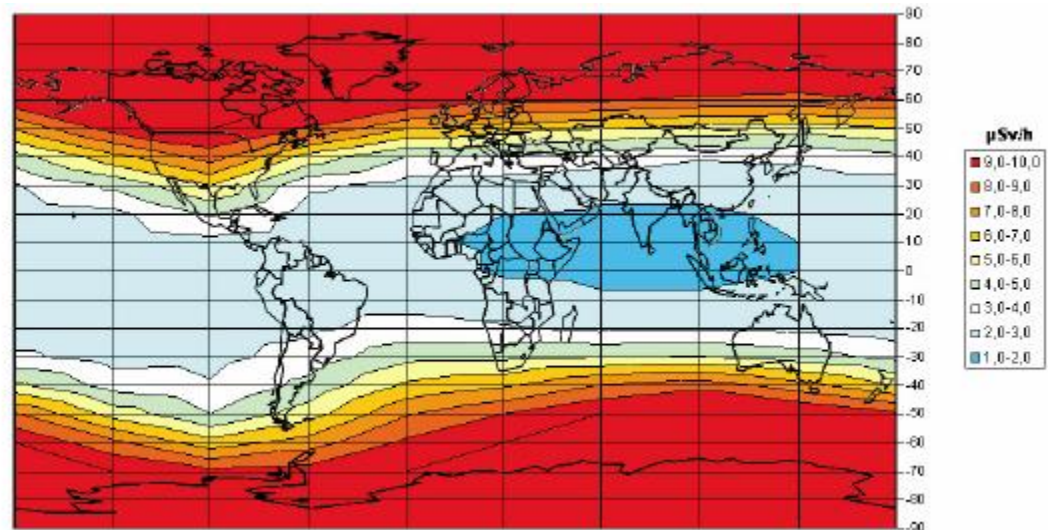
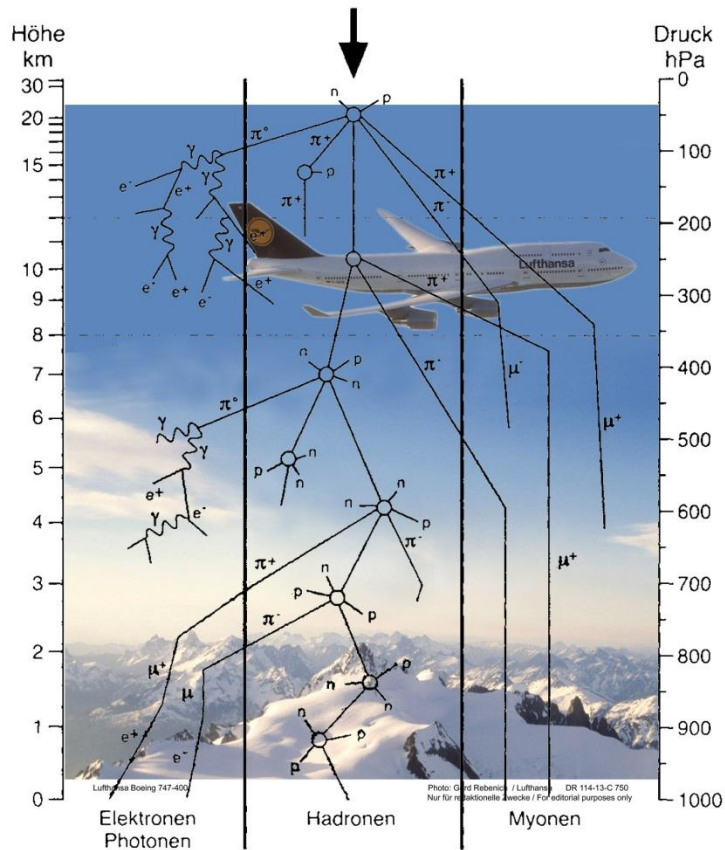
Hajo Zeeb

Bremen, Germany

Structure

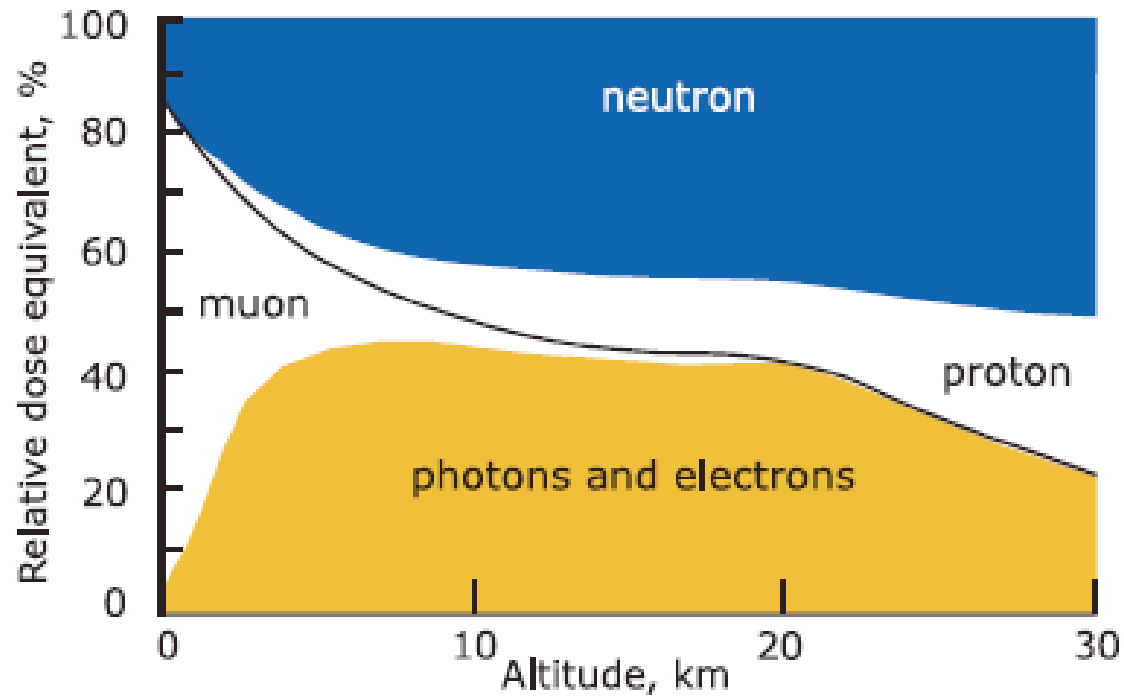
- Cosmic radiation
- Exposure assessment for aircrew
- Results of epidemiological studies
 - 'dose' - response
- Conclusion

Cosmic radiation



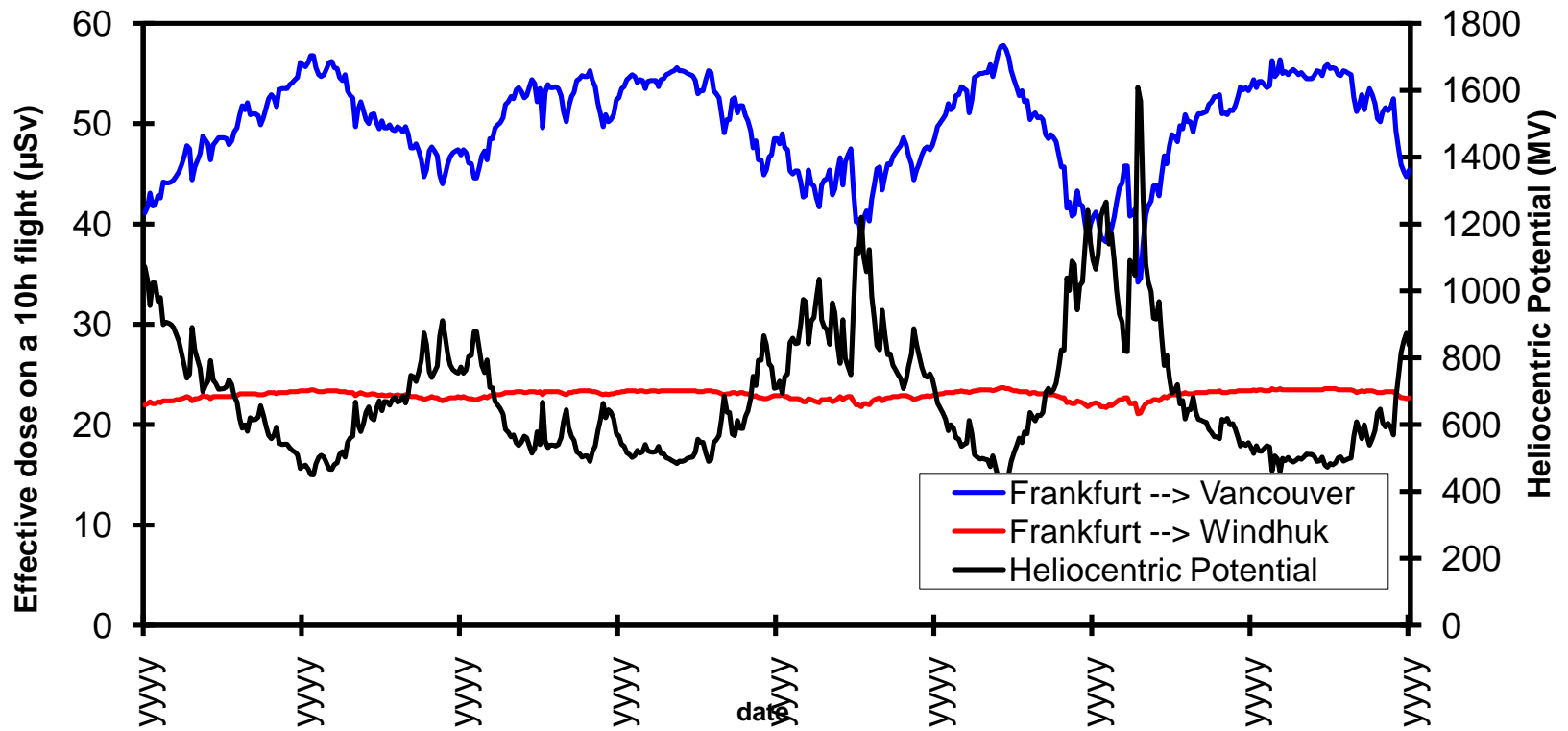
Images from PTB, Braunschweig, and BfS, Salzgitter

Cosmic radiation, contributions to total dose



Bartlett, 2004

11-year solar cycle



Exposure assessment for aircrew

- No personal measurements
- Based on:
 - Individual licences, types of aircraft used
 - Flight details (times, altitudes, direction)
 - Frequency of different flights per time period
 - Information on radiation levels, implemented in specific software programmes, e.g.
 - CARI (US)
 - EPCARD (Europe)

Firefox | EPCARD-Portal: Dosisberechnung auf... | European Program Package for the C... | http://www.helmholtz-muenchen.de/epcard/eng_fluginput.php | EPCARD



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EPCARD

Please enter the date, the flight data, and the airports of origin and destination. You may choose a flight profile with up to 12 different flight altitudes.

Date:	<input type="text" value="25"/> <input type="text" value="8"/> 2011	Flight number:	<input type="text" value="XX001"/>
Departure airport:	<input type="text" value="FRANKFURT, GERMANY --EDDF--FRA"/>		<input type="text" value="FRA"/>
Duration of ascent:	<input type="text" value="00:30"/> <input type="text" value="hh:mm"/>		
To first flight altitude	<input type="text" value="10000"/> <input type="text" value="meter"/>		
Duration of descent :	<input type="text" value="00:30"/> <input type="text" value="hh:mm"/>		
Destination airport:	<input type="text" value="TOKYO, JAPAN --NRT --RJAA"/>		<input type="text" value="RJAA"/>
Definition of flight profile:	Number of flight levels: <input type="text" value="1"/>		
E-mail	<input type="text"/>		
<input type="button" value="Forward"/>		<input type="button" value="Default values"/>	



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Windows taskbar: Internet Explorer, File Explorer, Windows Media Center, Calculator, PowerPoint, Word, Firefox, System tray: DE, 77% battery, 13:18, 25.08.2011

Early Studies – Standardized Mortality Ratio SMR for pilots

Tumor	Band et al., 1990	Kaji et al., 1993	Band et al., 1996	Irvine et al., 1999
All	0.80*	0.87	0.63*	0.61*
Rectum	4.35*	-	-	0.66*
Brain	4.17*	-	1.42	1.28
Lung	0.52	-	0.25*	0.42*
Leukaemia	-	-	0.86	-
Prostate	-	-	1.52	1.11
Melanoma	-	-	1.49	3.33*

* Statistically significant

ESCAPE

European Studies of Cancer Among flying PErsonnel

- Low doses: small potential increases in risk
- Increase power by large study size
- European cooperation, 9 countries
 - (Denmark, Finland, Germany, Greece, Iceland, Italy, Norway, Sweden, United Kingdom)
 - ~28,000 pilots, 44,000 cabin crew
- Cohort mortality studies
- Follow-up 1960 – 1997 (some variations)

Exposure assessment: Job-Exposure-Matrix

Job history x Job-Exposure-Matrix = estimated radiation dose

PK 50319F Name [REDACTED] Flugstunden

Muster	F/; LOCKHEED 1049/1049	F/; B707	F/; DC10	FE B747	
Vorjahre	910	3.647	2.004		
1978			290		
1979			377		
1980			446		× r μSv/h = Dose
1981			510		
1982			445		
1983			440		
1984			456		
1985			319		
1986			212		
1987			377		
1988				354	
1989				312	
1990				269	
1991				333	
Total	910	3647	5876	1268	

Cumulative doses:

retired pilots:
42 mSv

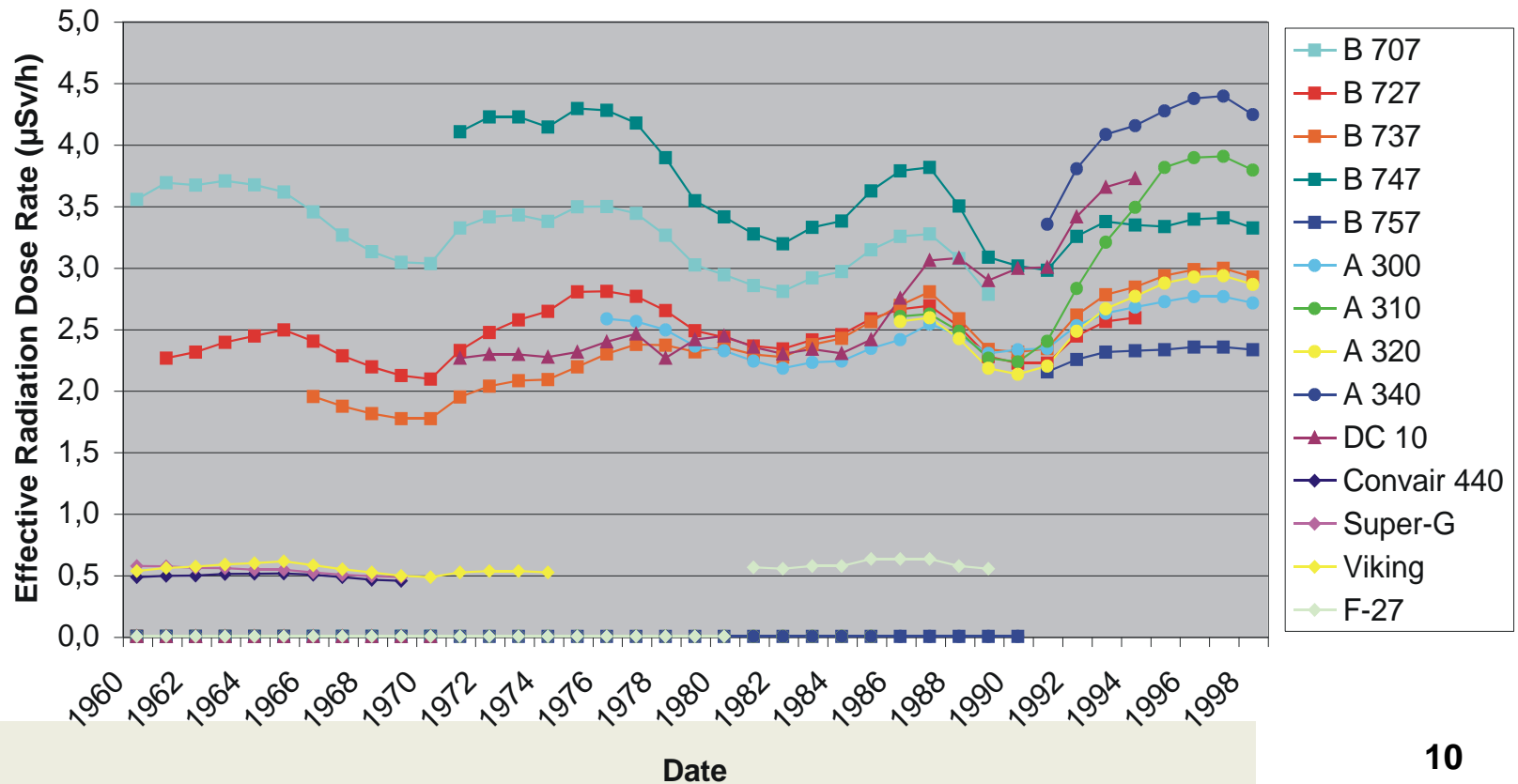
active pilots:
20 mSv

Max. lifetime:
~ 80 mSv

Form 4458 B-78 (FRA NV 1) Printed in Germany

Job Exposure Matrix (JEM) – “dose rate” per aircraft type

Job Exposure Matrix for Lufthansa cohort
computed from flight schedules with CARI-5E



ESCAPE study: mortality [SMR]

Cause of death	Cockpit, Men			Cabin, Men			Cabin, Women		
	O	SMR	95% CI	O	SMR	95% CI	O	SMR	95% CI
All causes	2244	0.64	0.61 - 0.67	571	1.09	1.00 - 1.18	441	0.80	0.73 - 0.88
All cancer	677	0.68	0.63 - 0.74	119	0.90	0.74 - 1.12			
All cardiovascular disease	534	0.51	0.46 - 0.56	66	0.62	0.48 - 0.83	13	0.27	0.14 - 0.49
Liver cirrhosis	45	0.56	0.40 - 0.75	18	0.78	0.46 - 1.29	11	0.63	0.31 - 1.21
Motor vehicle accidents	62	0.70	0.53 - 0.90	26	0.76	0.48 - 1.15	24	1.05	0.63 - 1.58
Aircraft accidents	244	87.73	76.5 - 100.8	17	24.70	13.8 - 41.0	31	59.00	38.5 - 86.9
All other external causes	236	0.68	0.59 - 0.78	86	0.80	0.63 - 1.02	106	1.14	0.90 - 1.42
Suicide	73	0.63	0.48 - 0.79	39	1.09	0.76 - 1.54	49	1.19	0.85 - 1.63
HIV/AIDS				118	19.6	15.2 - 23.3			

ESCAPE study: cancer mortality

Cause of death	Cockpit, Men			Cabin, Men			Cabin, Women		
	O	SMR	95% CI	O	SMR	95% CI	O	SMR	95% CI
All cancer	677	0.68	0.63 - 0.74	119	0.90	0.74 - 1.12			
Buccal cavity/pharynx	13	0.54	0.29 - 0.95	9	1.70	0.77 - 3.43			
Large intestine	64	1.07	0.81 - 1.38	5	0.71	0.23 - 1.75	7	0.65	0.26 - 1.42
Rectum	30	0.80	0.54 - 1.16	3	0.72	0.15 - 2.24	3	0.58	0.12 - 1.88
Lung	153	0.53	0.44 - 0.62	24	0.75	0.47 - 1.17	17	0.82	0.48 - 1.41
Malignant melanoma	25	1.78	1.15 - 2.67	6	1.93	0.70 - 4.44	2	0.36	0.04 - 1.37
Breast							59	1.11	0.82 - 1.48
Prostate	54	0.94	0.71 - 1.26	5	1.09	0.35 - 2.68			
CNS	41	1.20	0.87 - 1.67	6	0.94	0.33 - 2.11	7	0.67	0.27 - 1.49
All lymphoma	25	0.75	0.48 - 1.13	11	1.86	0.92 - 3.50	8	1.06	0.44 - 2.18
Non-CLL leukemia	21	1.12	0.67 - 1.70	5	1.57	0.50 - 3.81	7	1.20	0.49 - 2.73

Incidence Studies

- Cabin attendants
 - Pukkala et al, 1995 (Finland)
 - Reports increased breast cancer incidence (SIR = 1.87)
 - Reynolds et al, 2002 (California, USA)
 - Breast cancer SIR ~ 1.3

Pooled Nordic studies: Incidence (SIR)

	Cockpit		Cabin			
			Men		Women	
All Cancer	1.0	(0.9-1.1)	1.5	(1.2-1.8)	1.1	(1.0-1.2)
Melanoma	2.3	(1.7-3.0)	3.3	(1.8-5.8)	2.0	(1.5-2.8)
Leukaemia	1.2	(0.7-2.0)	1.2	(0.2-8.7)	2.0	(1.1-3.4)
Colon	0.9	(0.6-1.3)	0.8	(0.1-0.3)	1.0	(0.3-3.5)
Breast					1.4	(1.1-1.6)

Simple meta analysis

ESCAPE study: risk trends with dose

		Cumulative Dose (mSv)				P (Trend)
		0-4.9	5.0-14.9	15.0-24.9	25.0+	
All causes	Cases	493	298	287	156	
	RR	1	0.68 (0.58-0.78)	0.71 (0.61-0.83)	0.54 (0.45-0.66)	<0.0001
All cancers	Cases	105	74	93	66	
	RR	1	0.75 (0.53-1.05)	0.79 (0.58-1.09)	0.74 (0.51-1.06)	0.101
Radiogenic cancer	Cases	27	21	28	18	
	RR	1	0.81 (0.44-1.47)	0.95 (0.54-1.65)	0.82 (0.43-1.55)	0.645
Leukaemia excl. CLL	Cases	4	5	2	3	
	RR	1	1.56 (0.48-5.04)	0.75 (0.16-3.51)	2.00 (0.49-8.08)	0.567
Malignant melanoma	Cases	5	3	5	1	
	RR	1	0.71 (0.23-2.18)	1.26 (0.45-3.50)	0.33 (0.06-1.85)	0.481

Conclusion

- Aircrew cosmic radiation exposures roughly comparable to nuclear industry
 - Only small risk increases to be expected a priori
 - Factors influencing risk are difficult to disentangle, e.g. circadian rhythm changes
- Current evaluation: no clear health risks associated with exposure to cosmic radiation
 - New results coming up soon



Thank you !

Collaborators

Germany:

G Hammer, S Bennack, I Langner, T Schafft, M Blettner

ESCAPE partners from 8 countries