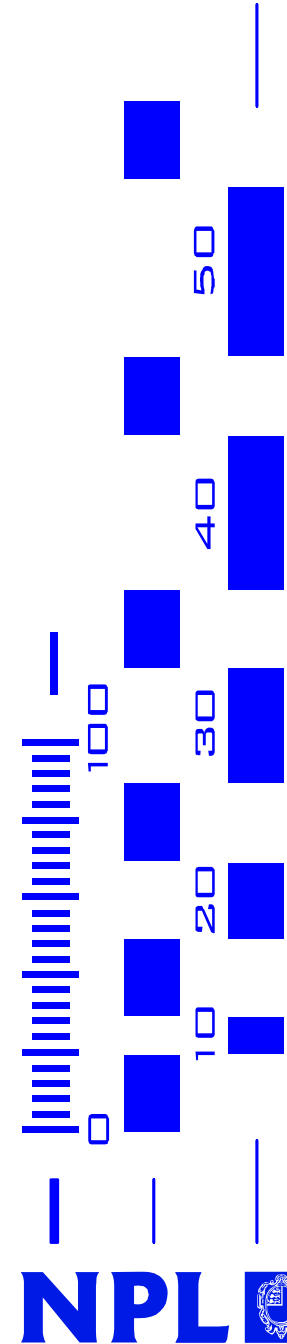


10<sup>th</sup> Neutron Users' Club

# Aircrew Dosimetry using TEPCs

Graeme Taylor



# Scope of Talk

- Introduction
- Cosmic Radiation
- TEPCs
- The Portable TEPC
- Measurements
- Summary / Conclusions

# Introduction (1)

- Air crew average doses per year:
  - \* Short haul: 2 mSv
  - \* Long haul: 4 mSv
- Industrial workers average doses per year:
  - \* Fuel fabrication: 1.5 mSv
  - \* Nuclear power: 1.4 mSv
  - \* General industry: 0.7 mSv
  - \* (All classified workers: 1.3 mSv)

# Introduction (2)

- Additional factors in air crew exposure
  - \* Unable to shield!
  - \* Many different radiation types.
  - \* Very high energy particles.
- Dose limitation options:
  - \* Limiting crew air time.
  - \* Flying at lower altitudes (and latitudes?).

# Cosmic Radiation (1)

- Origins:
  - \* Galactic CR: stellar flares, stellar coronal mass ejection, supernovae, pulsar acceleration and galactic nuclei explosions.
  - \* Solar CR: solar flares, CMEs, solar wind.
- Typical composition:
  - \* Protons (85%), alphas (12%), heavier ions (1%), electrons (2%).

# Cosmic Radiation (2)

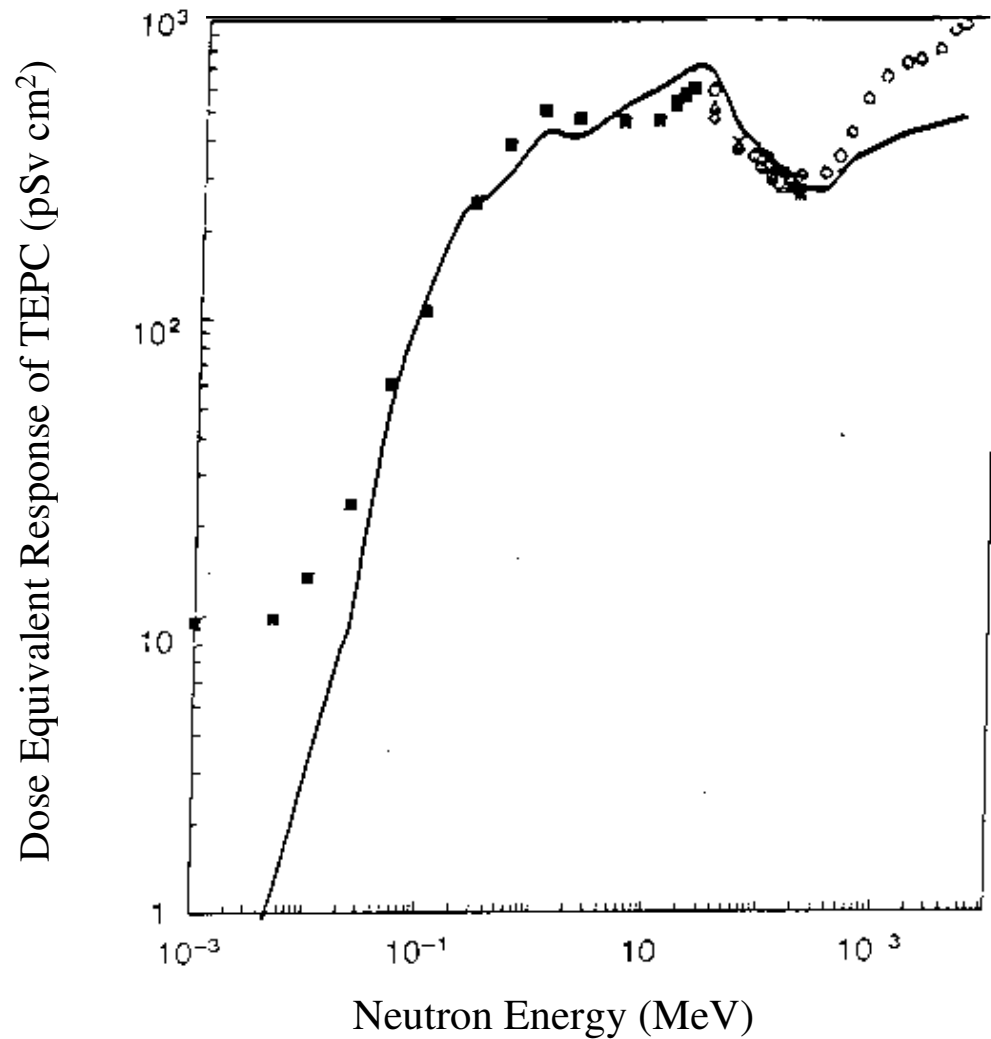
- Energy spectrum:
  - \* Varies roughly as  $N(E) \sim E^{-2.5}$  (ish!)  
(lower energy intensities lower, due to deflection by solar wind).
  - \* Particles with energies  $> 10^{20}$  eV detected.
- Composition influenced by:
  - \* 11 year solar cycle (currently solar maximum).
  - \* Altitude.
  - \* Magnetic Latitude.

# Cosmic Radiation (3)

- Radiation environment at aircraft altitudes:
  - \* Nearly always Galactic in origin.
  - \* Interaction of Primary radiation with atmosphere creates secondary protons, neutrons, gammas, muons, electrons, etc.
  - \* Very rare solar events may increase doses dramatically. Feb 1956:  $\sim 50 \text{ mSv h}^{-1}$  at 20 km,  $\sim 10 \text{ mSv h}^{-1}$  at 10 km. Aug 72 and Aug 89:  $\sim 1 \text{ mSv h}^{-1}$  at 20 km.

# TEPCs

- Basic principles:
  - \* Tissue Equivalent Proportional Counter.
  - \* Similar composition to human tissue.
  - \* Responds like a microscopic volume of tissue.
  - \* Sensitive to all types of ionising radiation.
  - \* Capable of determining Radiation Quality.
- NPL system:
  - \* TEPC, preamp, amps x3, HT supply, MCA cards x3 (in Desktop PC).



Variation with neutron energy of the dose equivalent response of a TEPC compared to evaluations of ambient dose equivalent ( $H^*(10)$ )

Line: TEPC response (Alexeev et al. 1998)

Points: various  $H^*(10)$  evaluations

# The Portable TEPCs

- Details of portable TEPCs
  - \* Prototype on loan from Far West Technology,  
2 Commercial instruments owned by group.
  - \* Entire system miniaturised to fit in a small case.
  - \* Battery operated. Prototype can run for 4 - 6 days,  
commercial instruments for 11 – 12 days.
  - \* Stores data every minute on memory card.

# Measurements (1)

- NPL involvement:
  - \* Characterisation of instruments with neutrons from monoenergetic and radionuclide sources and photon sources.
  - \* Calibration of instruments at the CERN cosmic ray field simulator by NPL.
  - \* Some analysis and interpretation of in-flight data.

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<b>RADIATION FIELD</b>	<b>H*(10) Response R<sub>H</sub></b>
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**X-Ray**

40 KV quality	0.05
150 KV quality	0.84
250 KV quality	1.03

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**Neutron**

Thermal	0.28
144 keV	0.74
565 keV	1.34
1.2 MeV	1.50
2.5 MeV	1.62
5.0 MeV	1.40
14.8 MeV	1.16
<sup>252</sup> Cf	1.46
<sup>241</sup> Am-Be	1.57

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**CERF (CERN)**

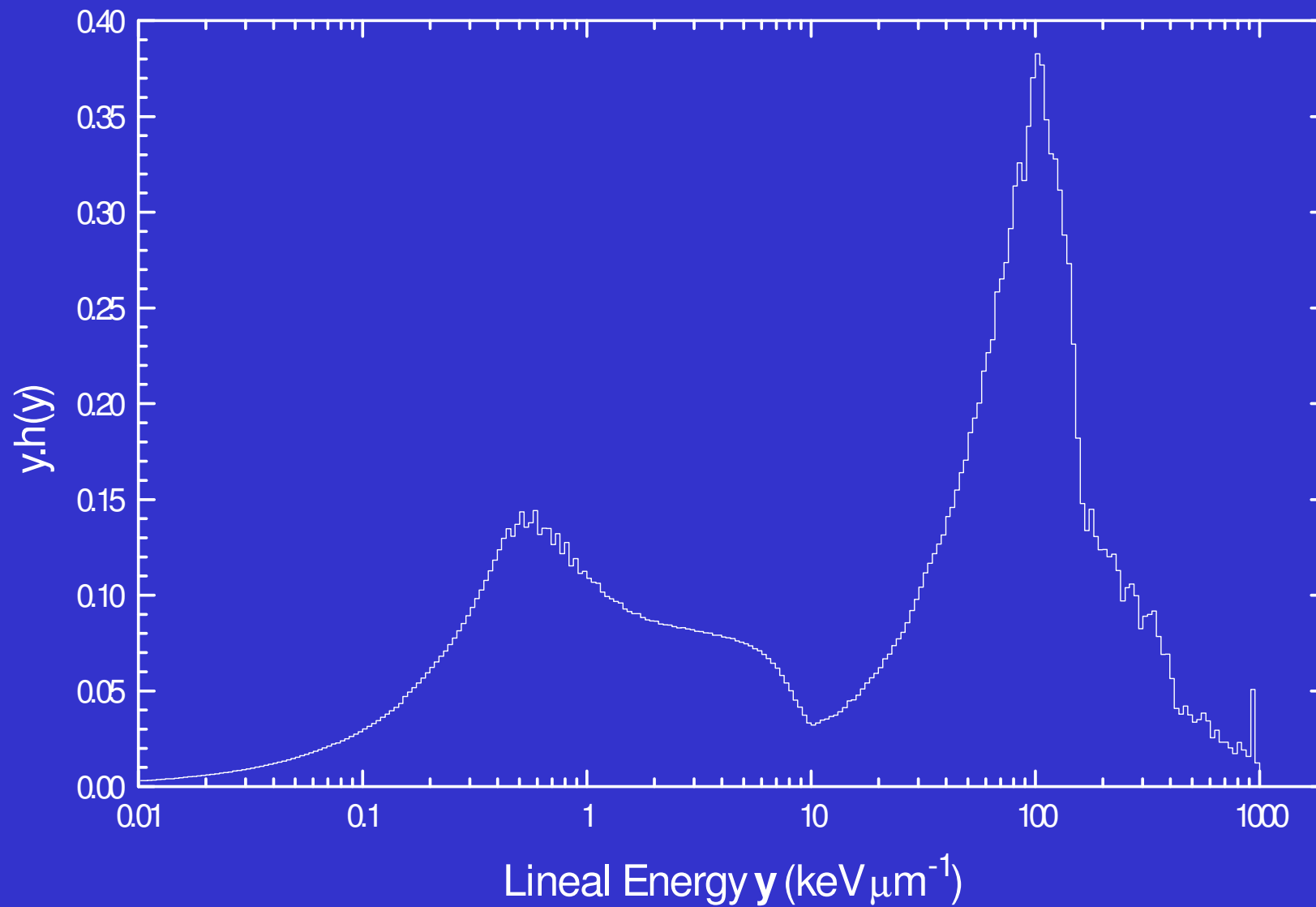
Low LET	1.41
High LET	1.28
Combined	1.30

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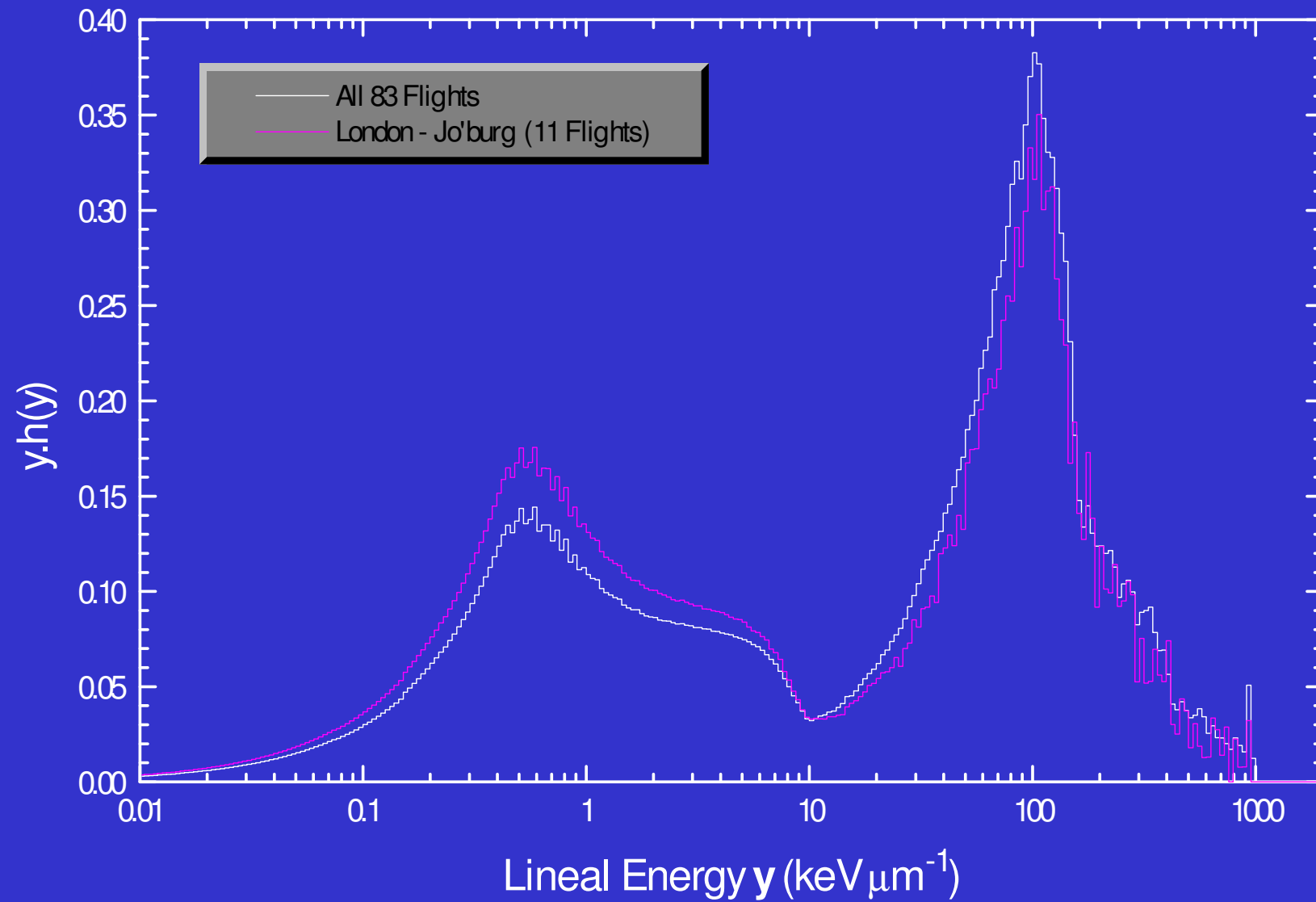
# Measurements (2)

- Flight information:
  - \* TEPCs flying with Virgin Atlantic Airways organised by the CAA and VAA, together with some CAA flights.
  - \* ! Flight numbers now into triple figures !
  - \* Aim to keep instruments flying as much as possible over next 2 years, during the solar maximum period, where it may catch a solar flare.
  - \* Result: massive database of TEPC CR mmts.

# $y \cdot h(y)$ Spectrum for the Sum of 83 Flights Jan 00 - Jun 01 (Prototype)



## Comparison of $y \cdot h(y)$ Spectra



# Summary / Conclusions

- Air crew typically receive higher annual dose than workers in the nuclear industry.
- They are exposed to radiation fields very different from most other radiation workers.
- TEPCs mimic radiation interaction in human tissue: good devices for measuring CR doses.
- New suitcase sized TEPC system can be left unattended for many days at a time - may catch solar flare in next 2 - 3 years ?