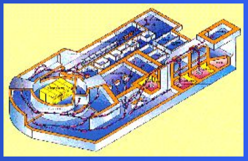
10th Workshop on Radiation Monitoring for the International Space Station
Sep. 7-9th, 2005 Chiba Japan

Neutron Spectrometer Onboard Aircraft and Spacecraft

T. Nakamura, M. Takada and K. Fujitaka

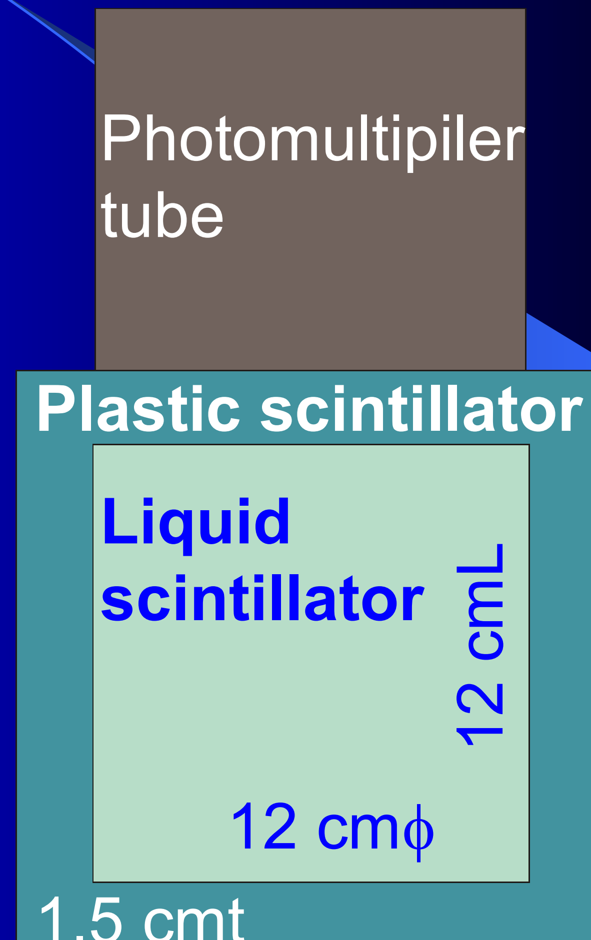


JSPS 日本学術振興会

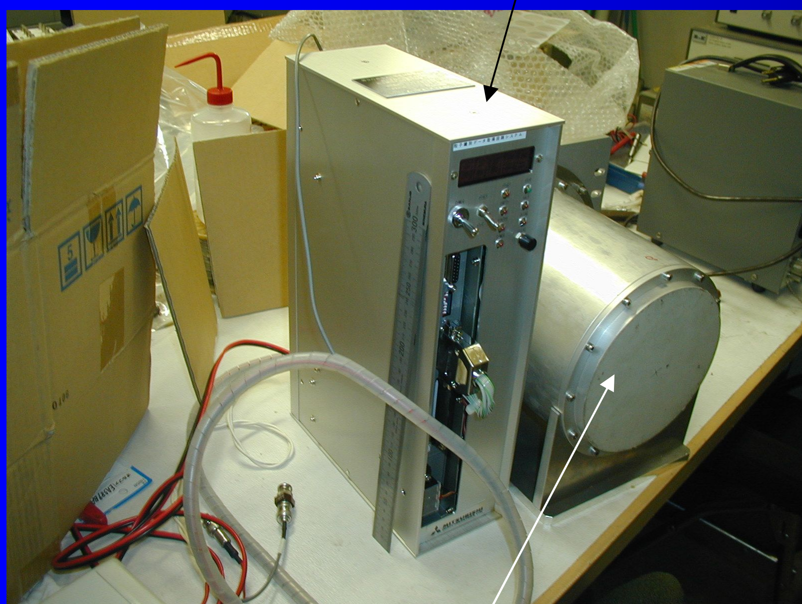
Motivation

- Neutron energy spectrum over 10 MeV is necessary for radiation protection for aircrew and astronauts.
- Using the Bonner ball detector, neutron spectra were measured.
- Problem; Particle discrimination of neutrons from charged particles.
- To measure neutron spectrum over 10 MeV, we studied the phoswich typed neutron detector.

High Energy Neutron Detector



Data Acquisition Unit

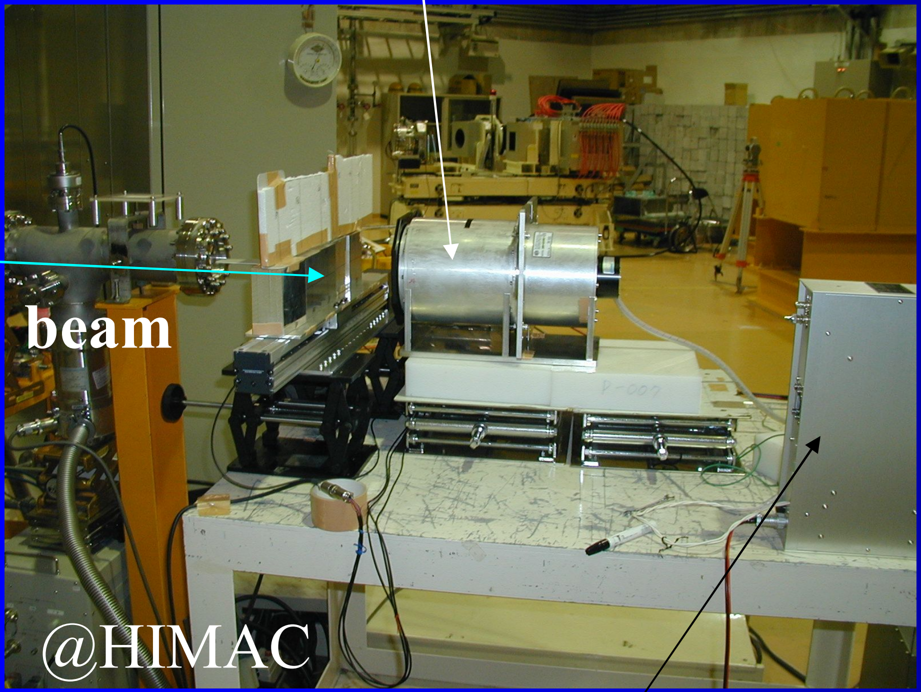


Neutron detector

- Measure signal pulse shapes
  - 20 ns/pt and 20 points
- And pulse heights
- Small data loss
  - Counting rate > 1,000 cps
- Simple operation
  - Push the start/stop switch
- Possible battery operation
  - + 24 V and 35 W

Proton and Neutron Measurement

Neutron detector

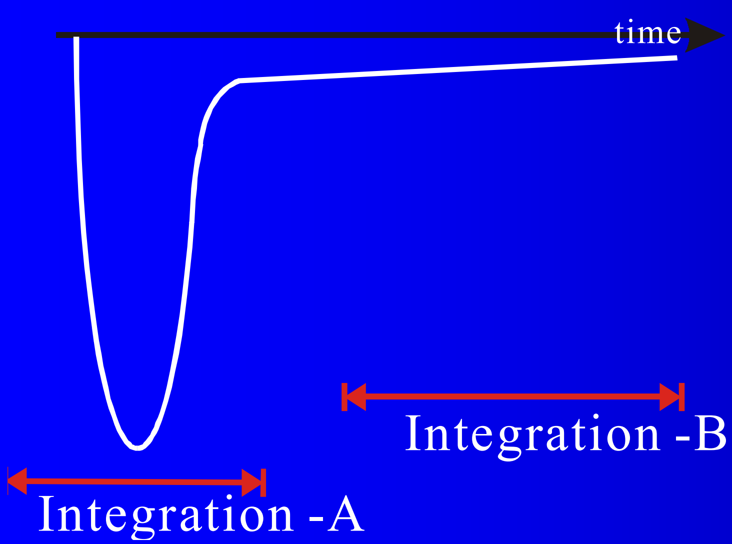


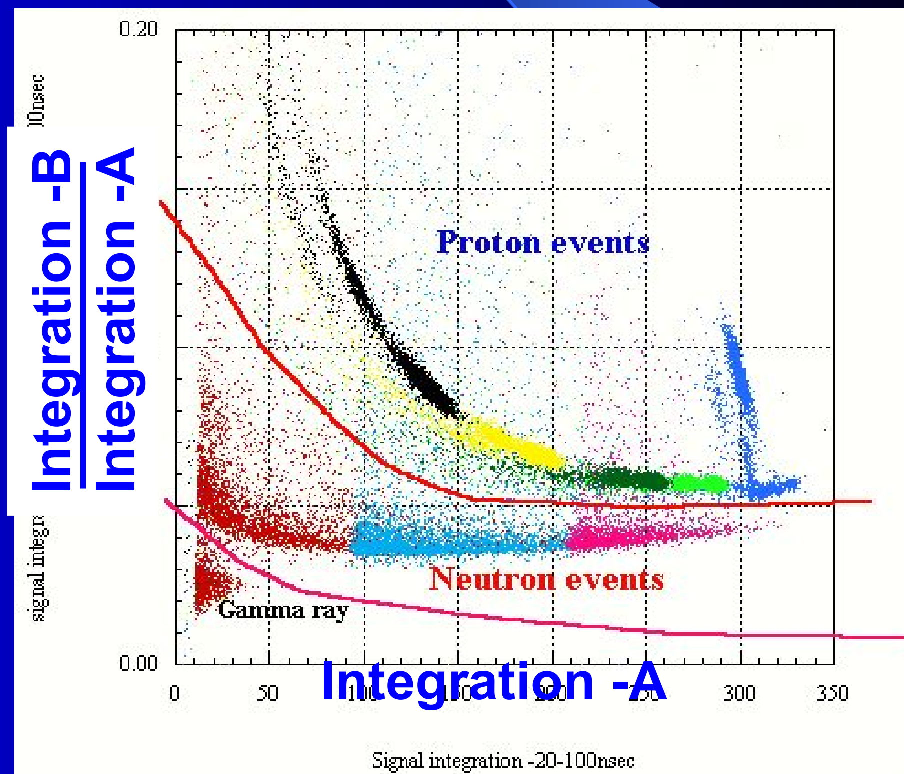
Data acquisition unit

- Proton signals;
  - 160 MeV protons
  - Change energy using Al absorbers
- Neutron signals;
  - Produced by the p(160 MeV)–C reaction
- Signals were acquired by using:
  - The digital storage oscilloscope
  - The onboard data acquisition unit

Particle Discrimination

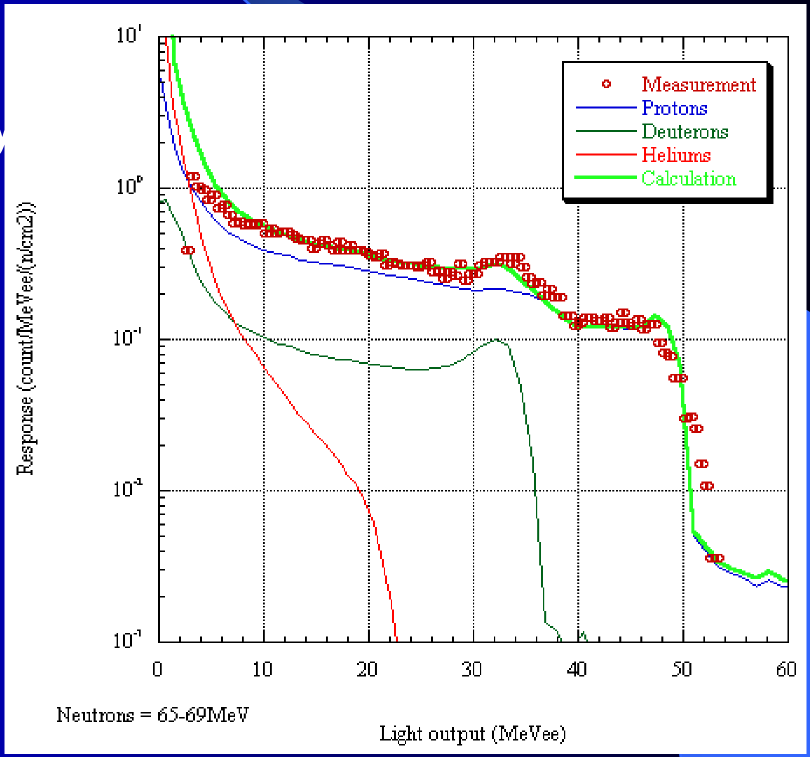
- Signals acquired by using the digital oscilloscope
- Integrate signals with two gates;
  A. At the signal peak
  B. At the signal tail



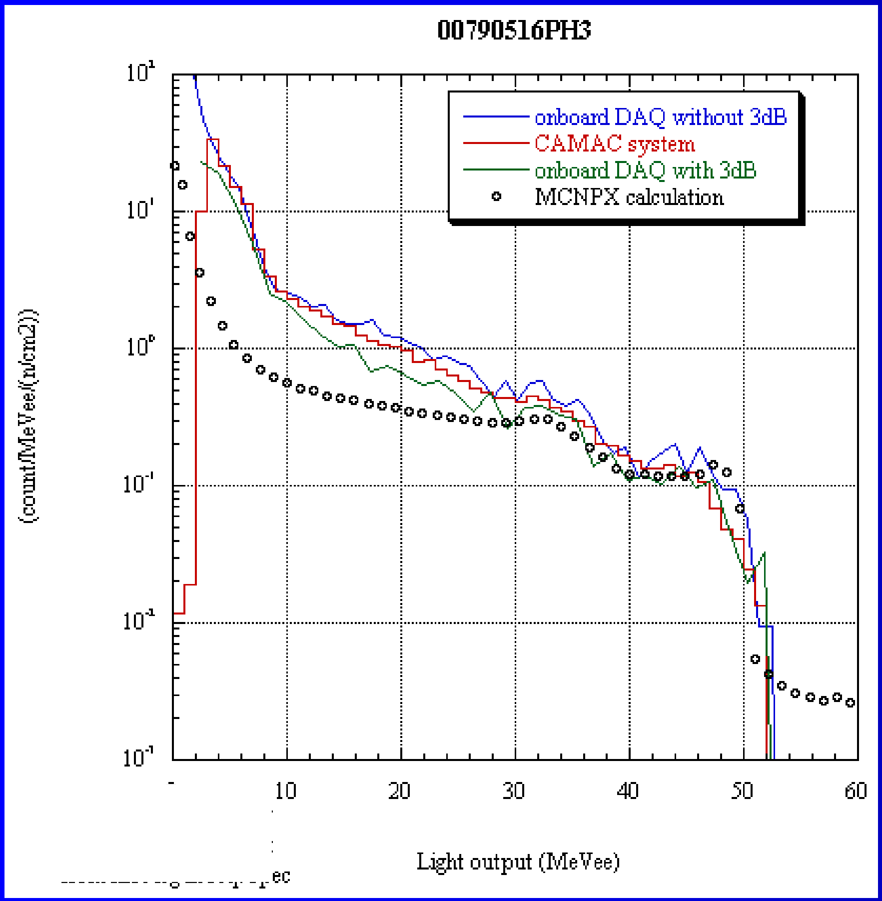


Response to Neutrons

1. Calculate energy deposition spectrum using MCNPX
2. Measure particle light output by directing beams into the detector
3. Convert deposited energy to light output
4. Measure neutron response at NIRS cyclotron (p-Li) and HIMAC (p-C)
5. Meas. and cal. agree each other, except low light output



Using Onboard DAQ Unit



- At high light output, pulse heights agreed;
  - Onboard DAQ unit
  - CAMAC system
  - MCNPX Calculation
- Below 30 MeVee, calculation is small
  - No tail component of p-Li neutron source is included in the calculation

Results

- The detector has the possibility to discriminate neutrons from gamma rays and protons; However, using the onboard DAQ unit, lost the possibility to discriminate neutrons from gamma rays.
- We should solve this problem.
- The measured and calculated neutron responses agreed each other. The DAQ measured the absolute pulse heights.
- Up to 160 MeV and more, we will make the response function.
- We hope to measure neutrons onboard aircraft and spacecrafts.

Small Commercial Dosimeters for Cosmic Ray Measurements Onboard Aircraft

T. Nakamura, M. Takada, T. Nunomiya, Y.Uchihori, L.G.I. Bennett, A.R. Green and B.J. Lewis,

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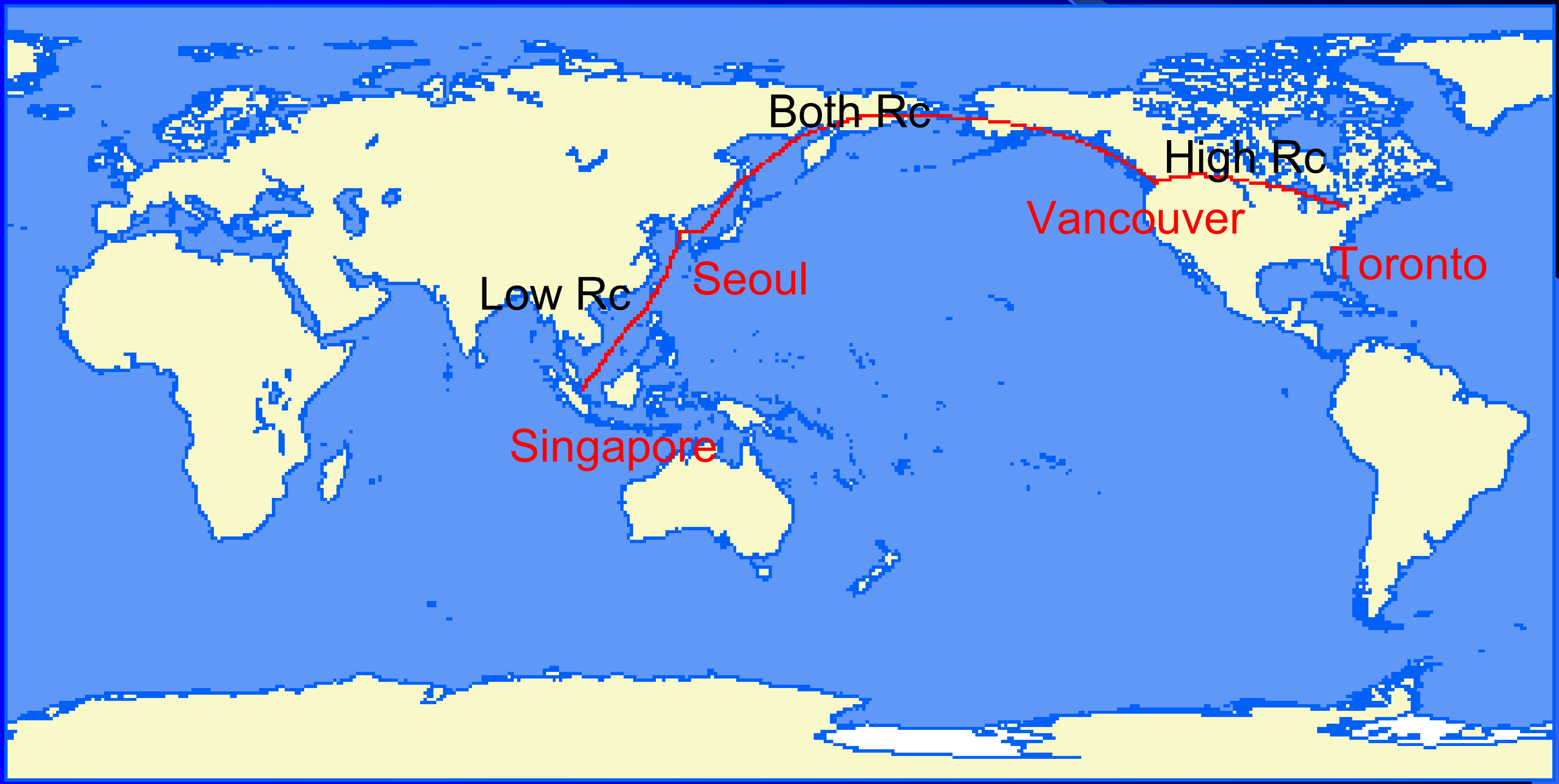
Small Commercial Dosimeters

NRF-20, Fuji Elect. Sys. Co. Ltd.
Si detector
Calibrated with Cs gamma ray
Can work for 2 months with a battery

DIS-100
Direct Ion Storage Technology (DIS)
Calibrated with Cs gamma ray
Can work for 2 weeks with a battery

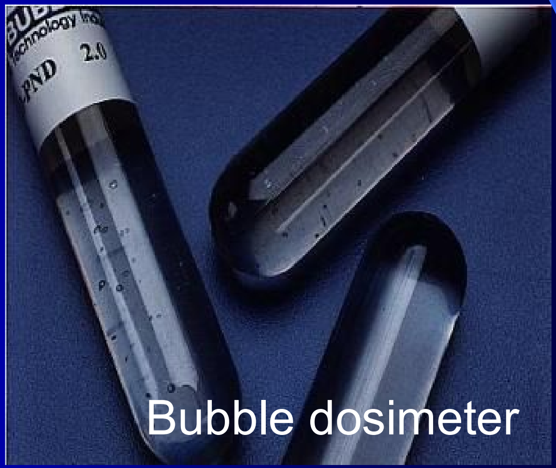
Flight From Toronto to Singapore



RMC Detectors

FH41B-10

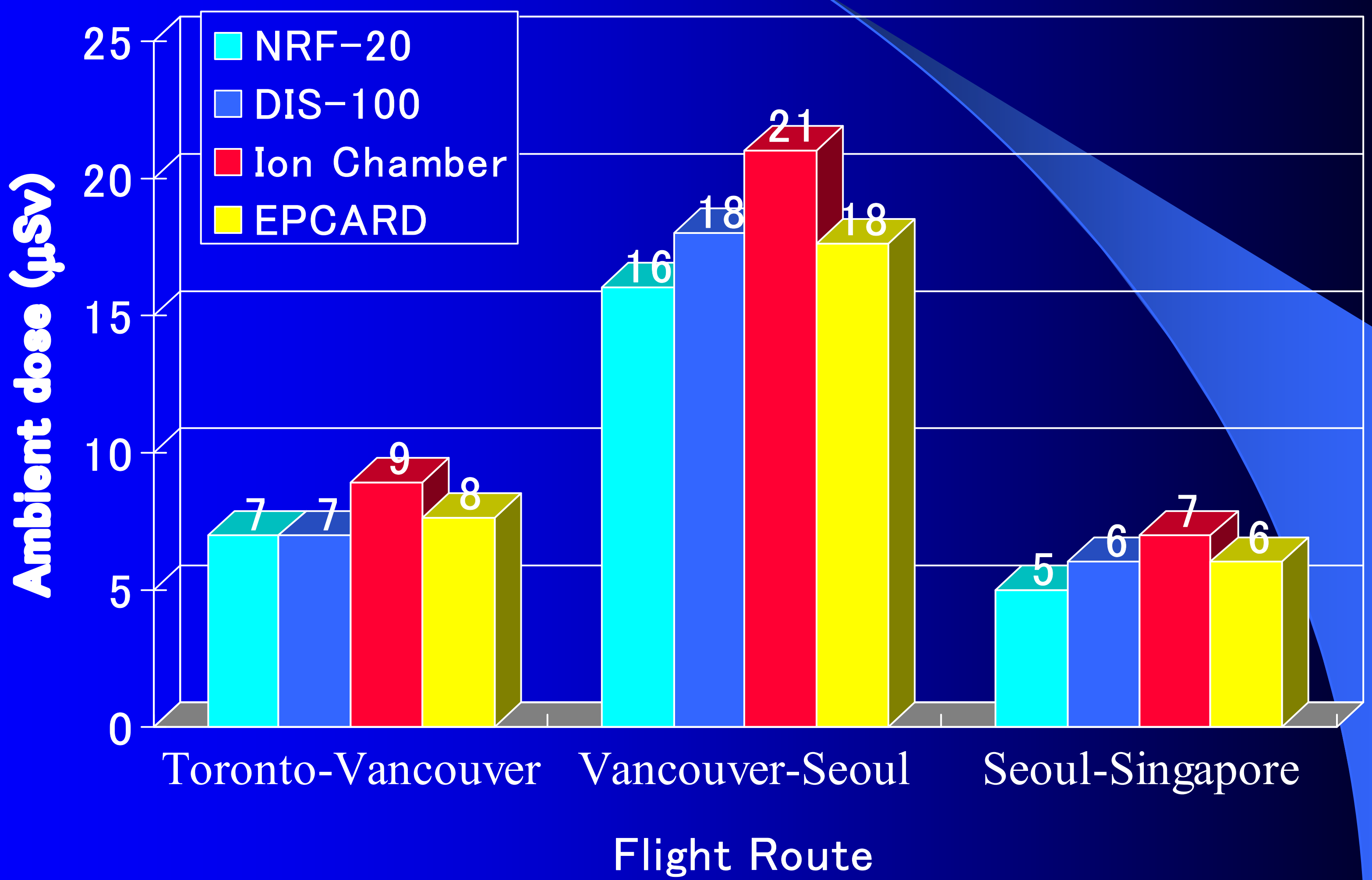
Ion Chamber



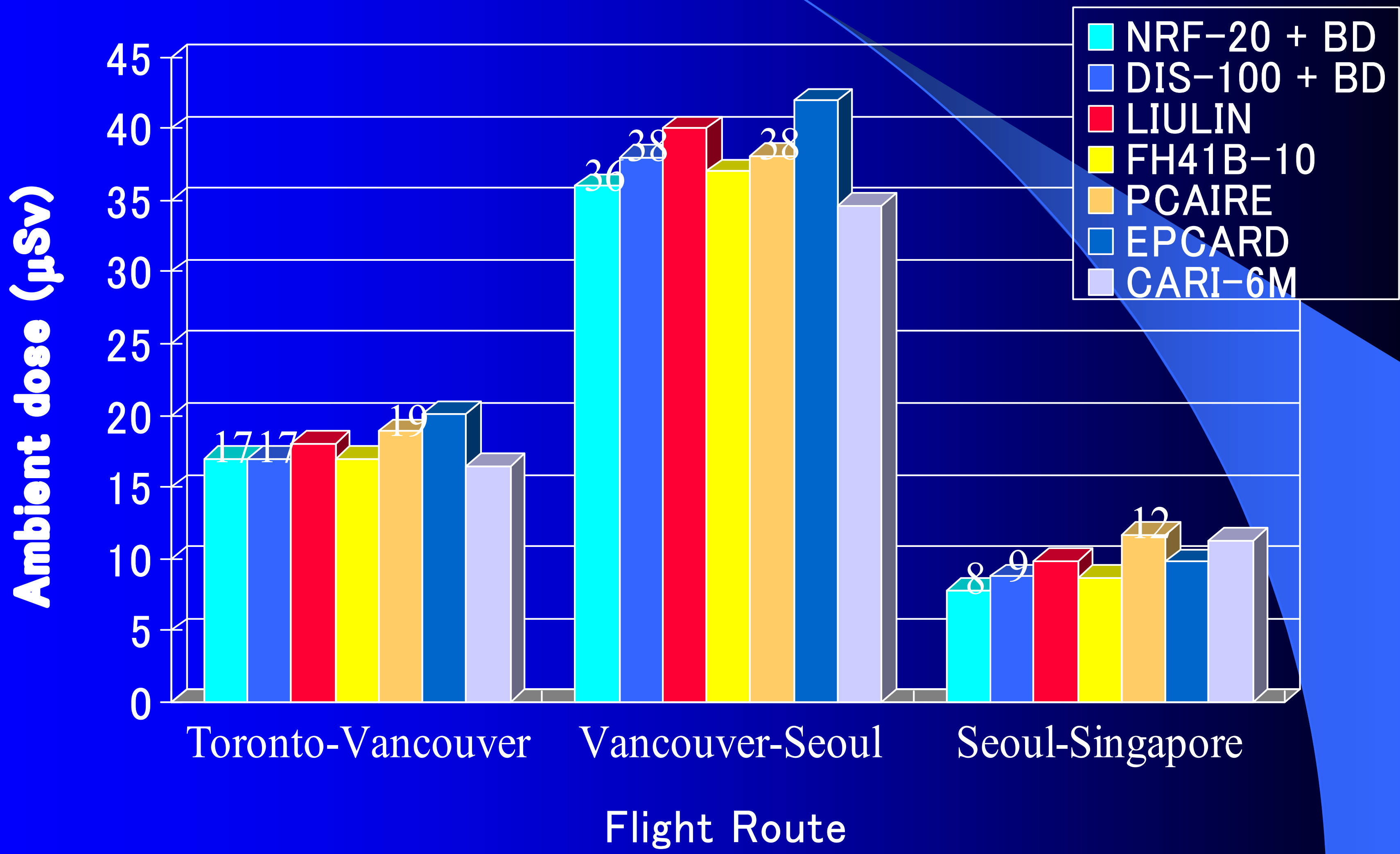
Calculation Code

- PCAIRE 7.2
  – Semi-empirical model
- EPCARD 3.2
  – Based on the FLUKA calculation
- CARI-6M
  – Theoretical model, LUIN

Non-neutron Radiation

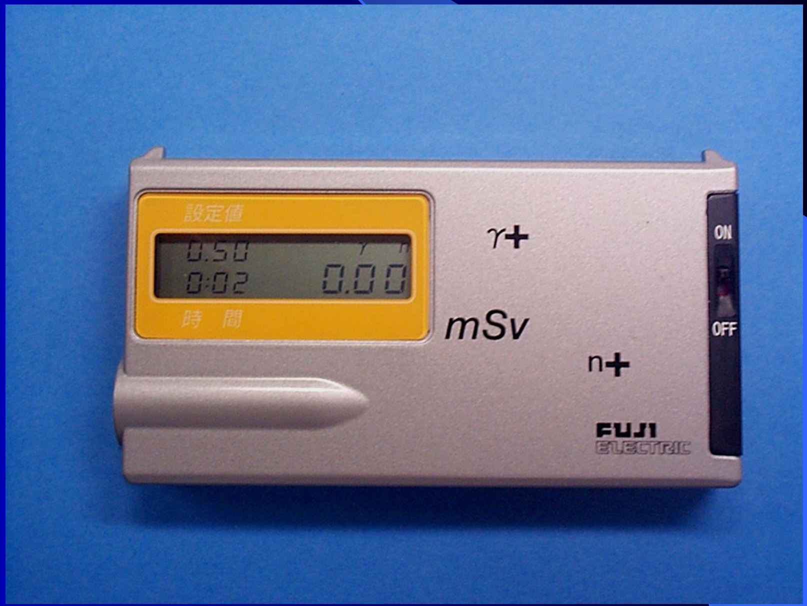


Total Radiation

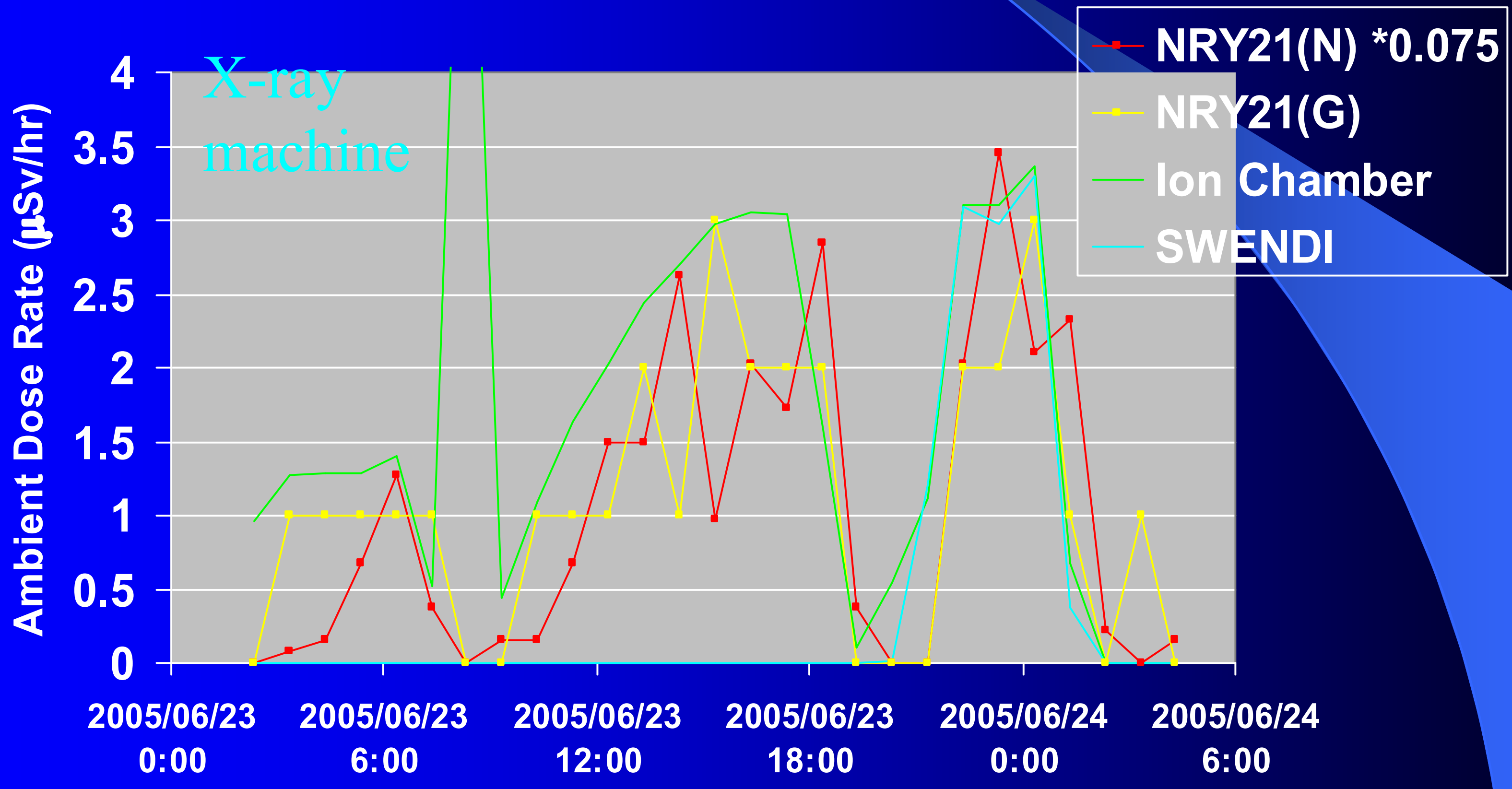


Another Small Dosimeter

- NRY-21
- Two Si detectors, gamma and neutron
- Tokyo-Paris return flight
  - 20 μSv_{ave}
- Cal. Non-neutrons
  - 18-25 μSv, 33-35,000 ft



NRY21, Flight Dose Rate



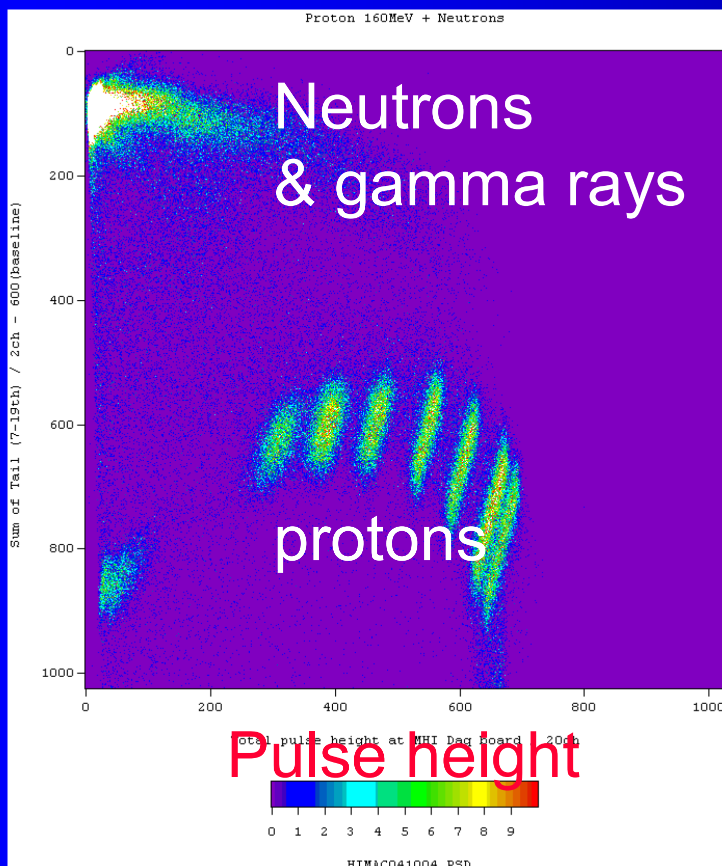
Return flight, Singapore to Toronto

Conclusion

- The small detectors gave comparable LET results for the flights flown. They are useful due to their long battery life and compact.
- Potentially, they will give correct results for often routes, but further measurement is required. Now much more data are being measured.
- It is possible that they then could measure low LET radiation in spacecraft.
- To measure total dose equivalent, a neutron dosimeter is necessary. It has been developed.

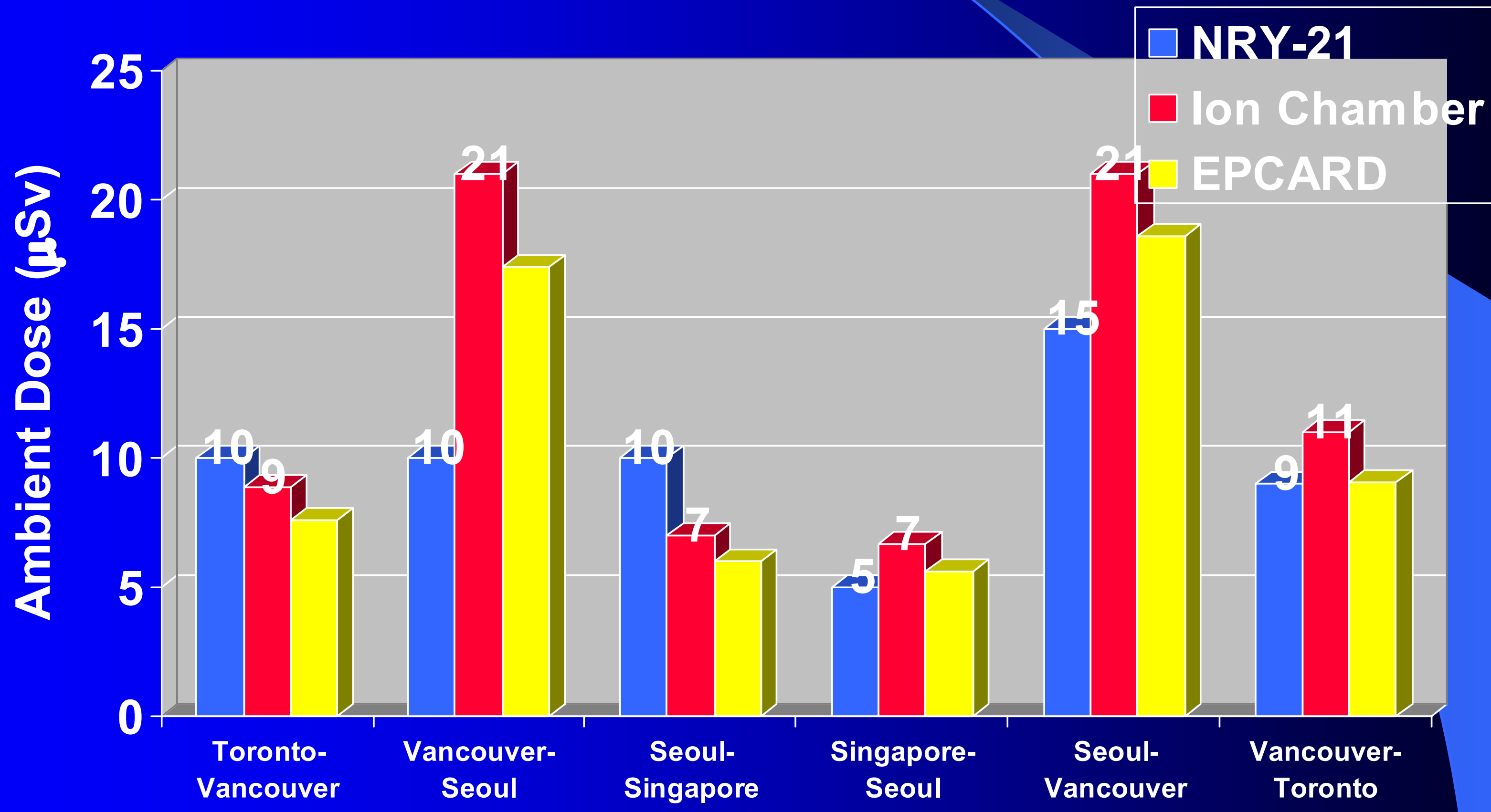
Using Onboard DAQ Unit

Ratio of signal tail to pulse height

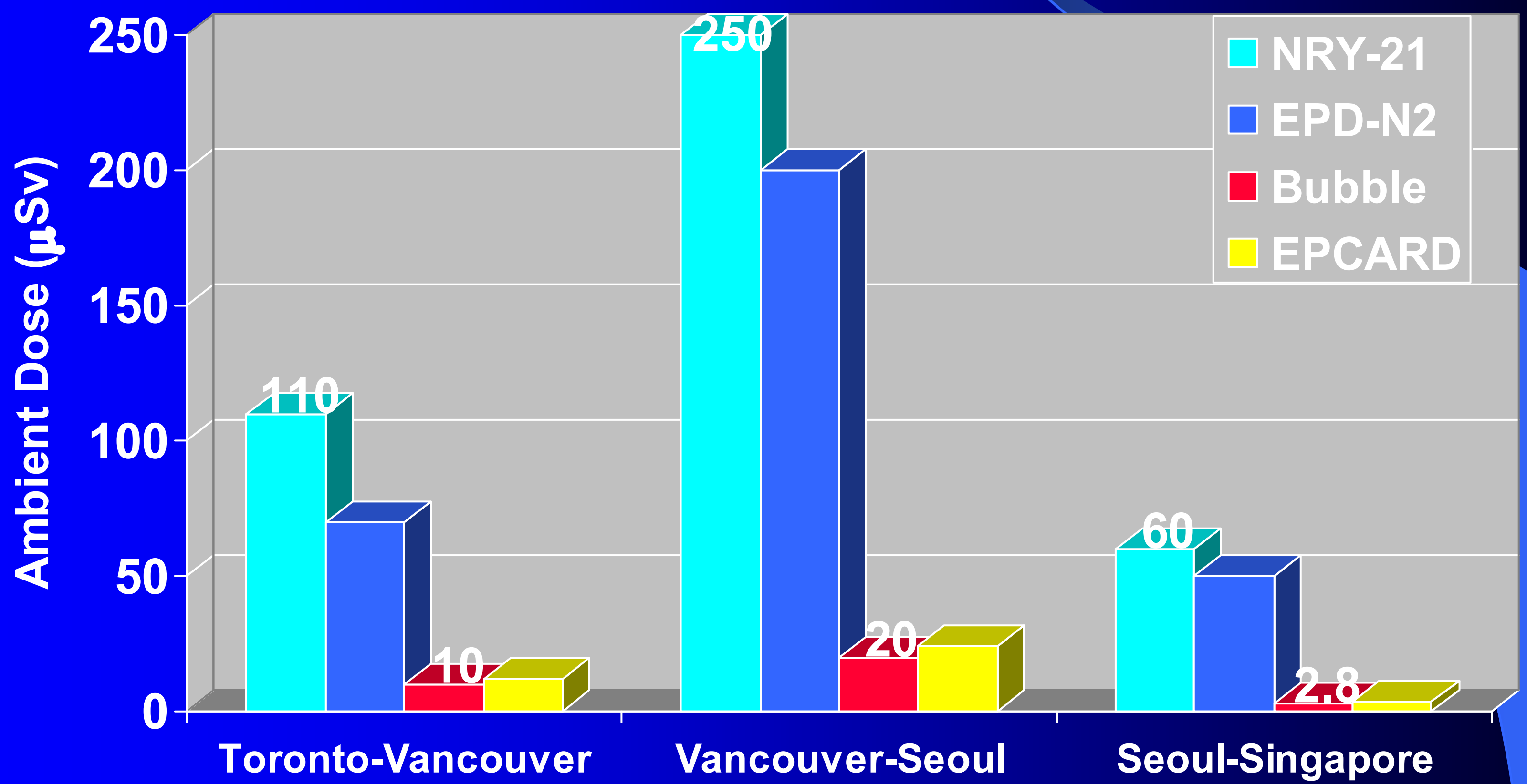


- Discriminate neutrons from protons
  - At high channel of pulse height, difficult to decide PSD because of small neutron event
- Gamma rays are not discriminated from neutrons

NRY20, Non Neutrons



Neutrons



Ambient Dose (µSv)
250
200
150
100
50
0
110
10
250
20
60
2.8
Toronto-Vancouver
Vancouver-Seoul
Seoul-Singapore
NRY-21
EPD-N2
Bubble
EPCARD

Acknowledgement

- We want to thank Air Canada and Singapore Airlines staff for their help and flight data.
- We also thank for Nagase Landauer, Ltd who loaned us the DIS dosimeter.