



# External and Internal Individual Monitoring of Occupationally Exposed Workers at CNAEA 1 and CNAEA 2 Nuclear Power Plants.

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# External Dosimetry

Individual monitoring  
for photons and neutrons.

# External Individual Monitoring of CNAEA Nuclear Power Plants

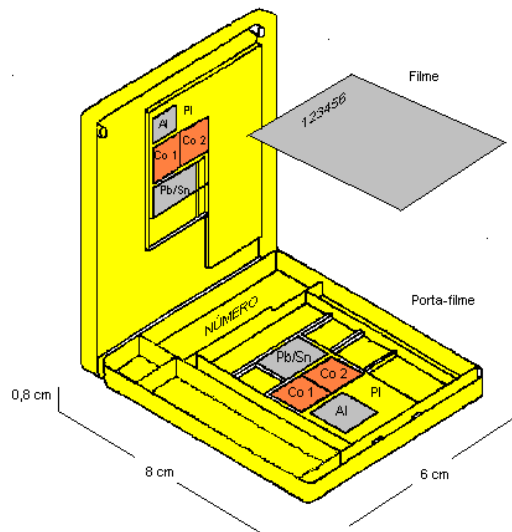
IRD carried out the routine external individual monitoring of all the occupationally exposed workers of the CNAEA NPPs from 1983 to 2008:

- CNAEA 1 started commercial operation in 1985.
- CNAEA 2 started commercial operation in 2000.

IRD external individual monitoring systems:

- whole body photons, with film badge dosimeter;
- extremities photons, with TLD ring and
- whole body neutrons, with TLD albedo dosimeter.

# IRD Monitors



IRD thorax film badge individual monitor

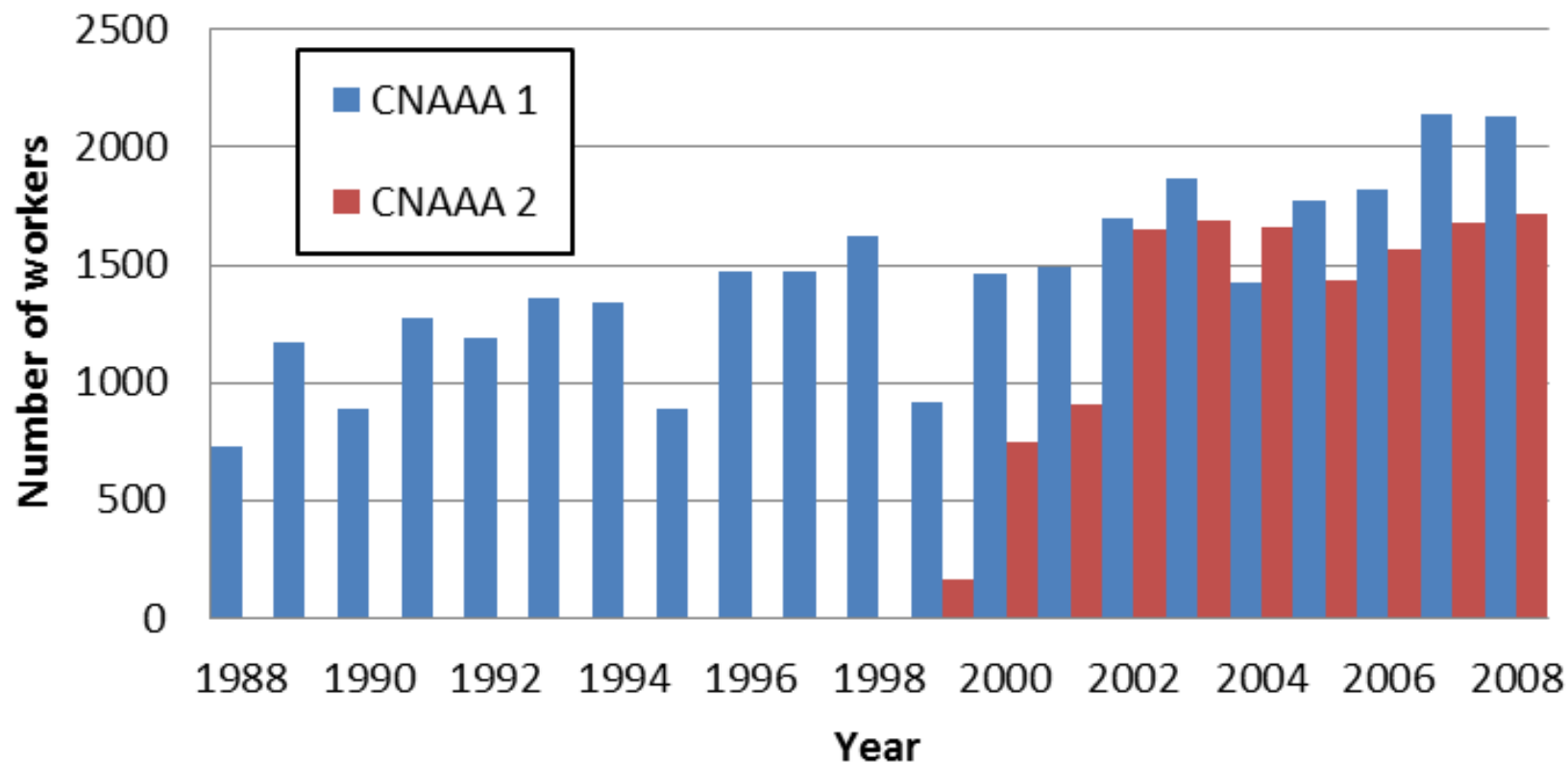


IRD TLD extremity individual monitor (ring)

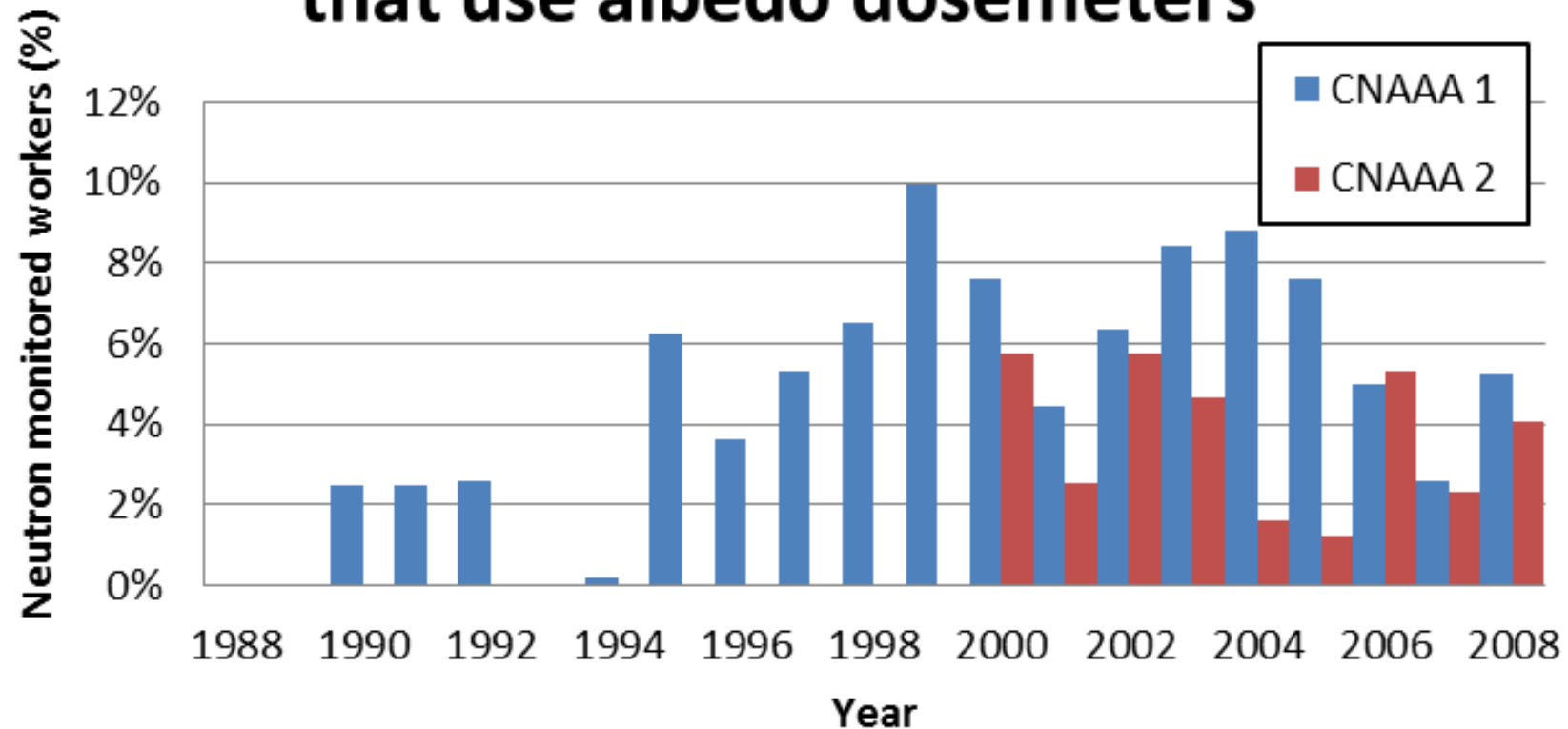


IRD TLD albedo neutron individual monitor

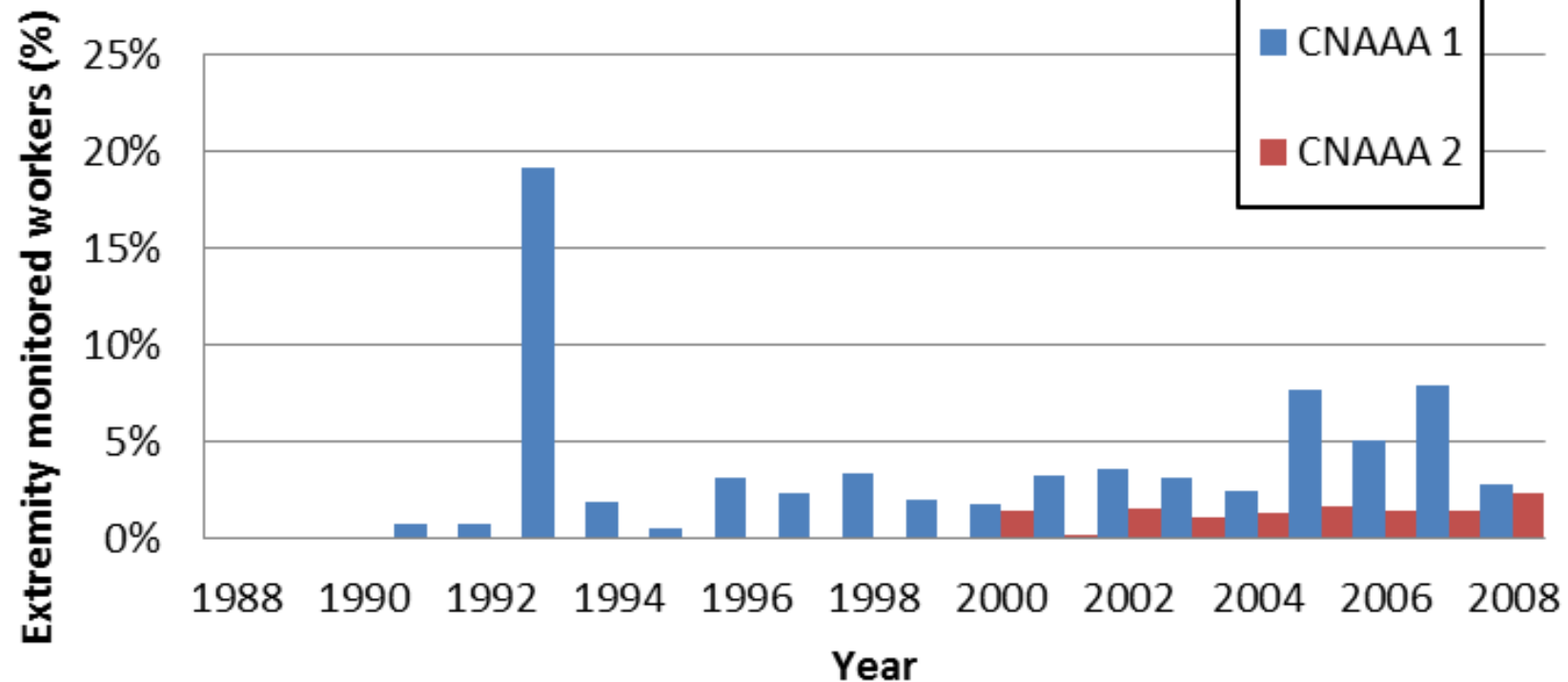
## Number of Monitored Workers



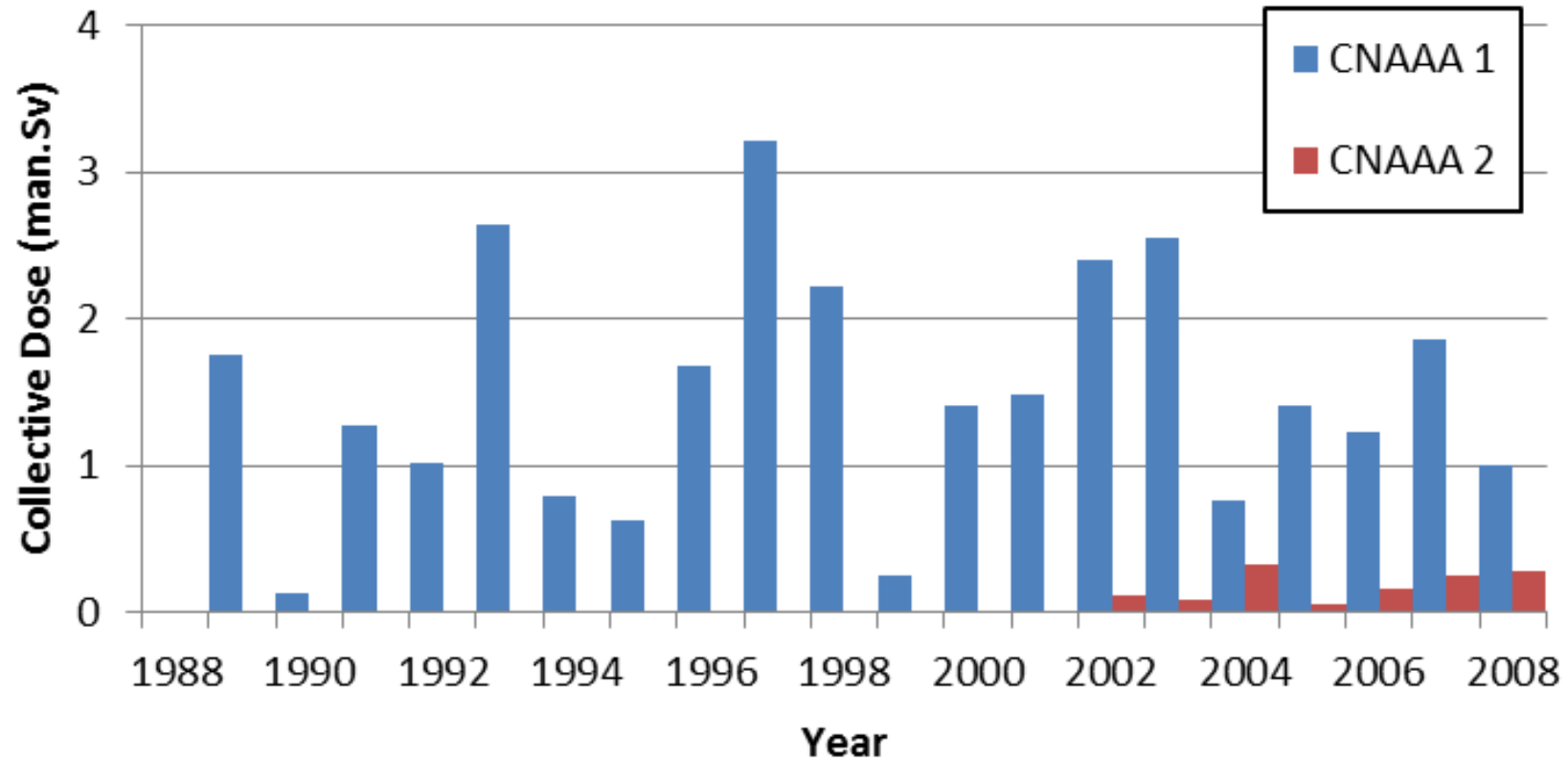
## Percentage of monitored workers that use albedo dosimeters



## Percentage of monitored workers that use ring dosimeters



## Collective Dose





# Effective Dose

All the annual effective doses are lower than the occupational limit of 50 mSv in one year (100 mSv in 5 years) and only one is higher than 20 mSv in one year.

## ➤ CNAAA 1:

- Only 2 doses > 20 mSv:
  - 2003 (27.6 mSv)
  - 1989 (23.5 mSv)
- Most doses  $\leq$  1.0 mSv (75%)

## ➤ CNAAA 2:

- All doses < 20 mSv
  - Highest dose in 2004 (5.3 mSv)
- Most doses  $\leq$  1.0 mSv (97%)

# Neutron Doses

The neutron dose contribution is negligible compared to the photon doses:

➤ CNAAA 1:

- Neutron contribution to annual collective dose  $< 1\%$ , except in:
  - 1995 (1.1%)
  - 1999 (6.5%)
  - 2003 (1.3%)
- Mean annual neutron effective dose  $\leq 0.2$  mSv.

➤ CNAAA 2:

- Only 1 neutron dose  $\neq 0.0$  mSv:
  - 2003 (0.2 mSv)

# Extremity doses

The annual extremity equivalent doses are very low:

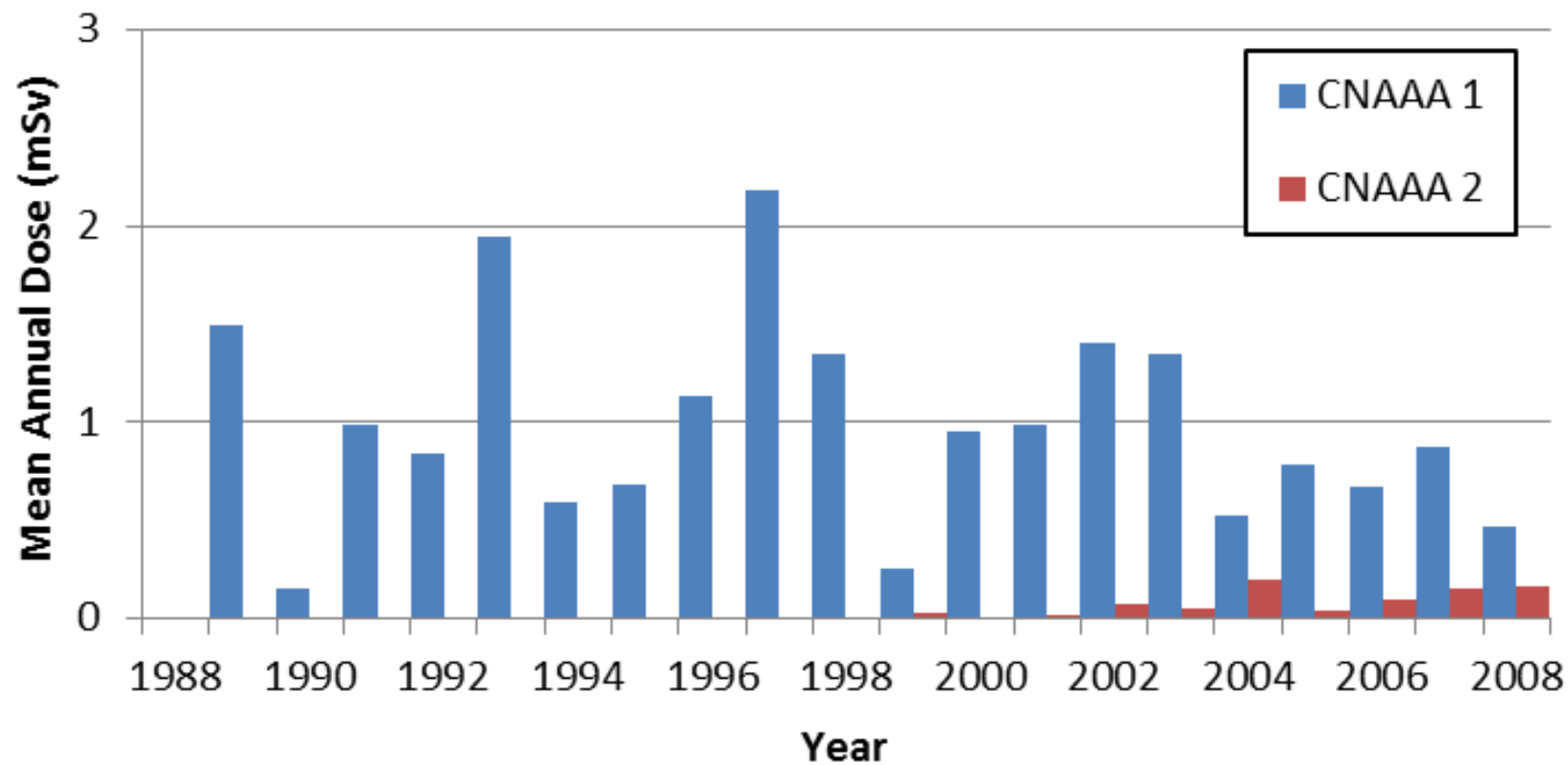
➤ CNAAAA 1:

- Only 1 dose near the occupational limit (500 mSv)
  - 1993 (390.0 mSv)
- All others < 25 mSv

➤ CNAAAA 2:

- All doses < 20 mSv
  - Highest dose in 2003 (17.8 mSv)

## Mean Effective Dose per Year

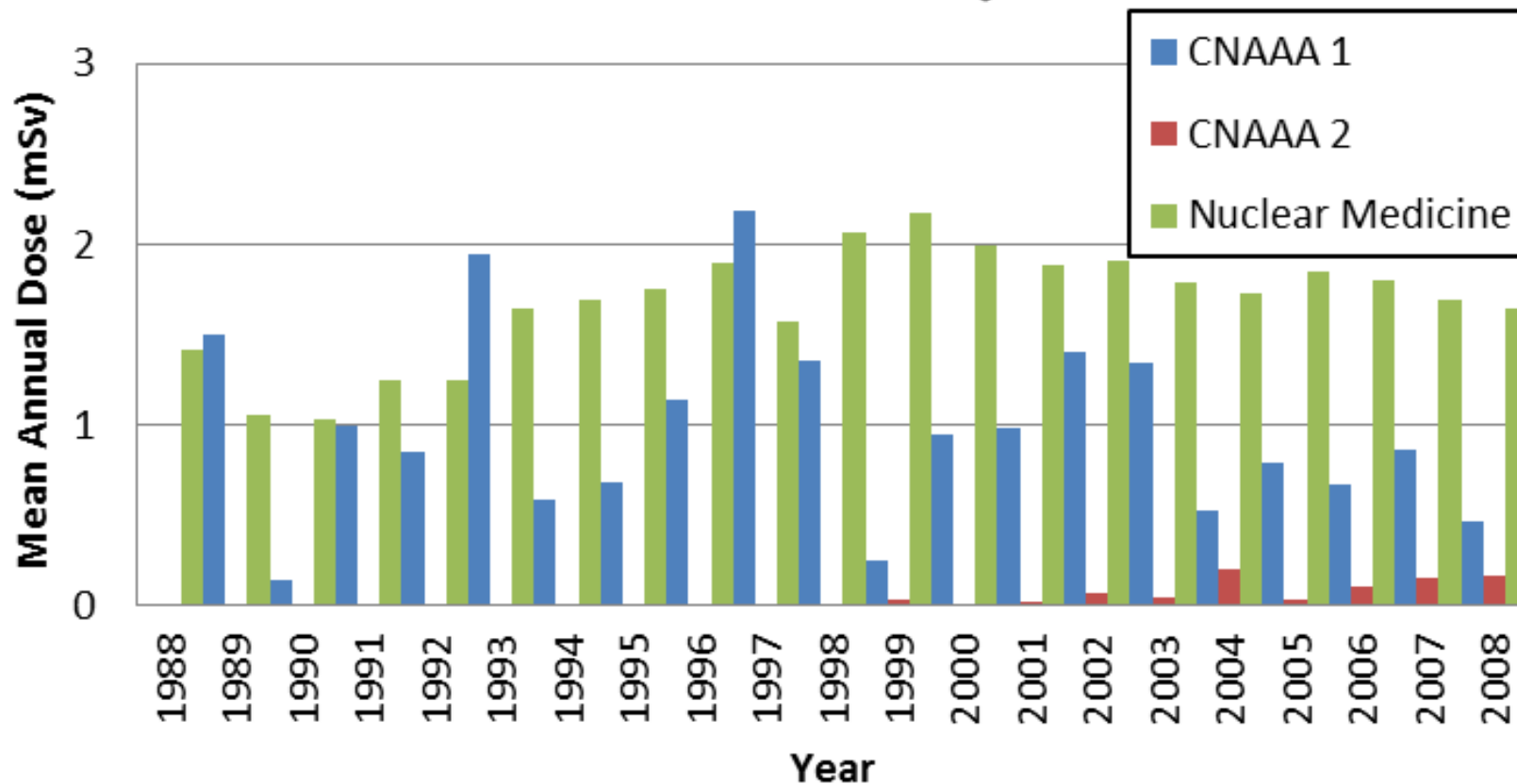


# Annual Effective Doses CNAAA x Nuclear Medicine

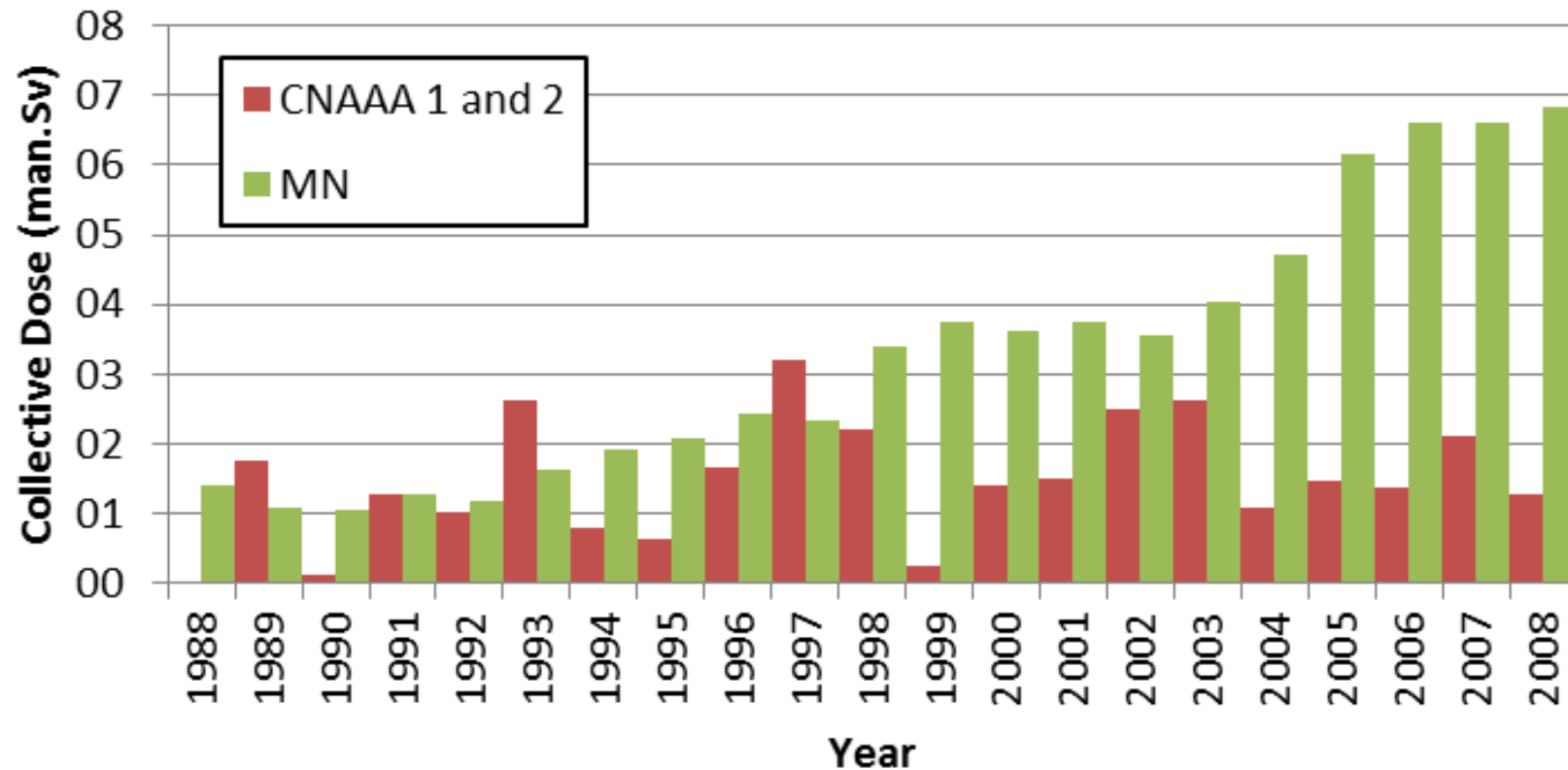
Comparison of occupational doses received at CNAAA 1 and 2 with those received in nuclear medicine services of the state of Rio de Janeiro.

| Year | Maximum and Mean Annual Effective Dose (mSv) |            |            |           |            |            |
|------|--|------------|------------|-----------|------------|------------|
|      | Doctor                                       | Technician | Nurse      | Physicist | CNAAA 1    | CNAAA 2    |
| 2005 | 9.0 (0.8)                                    | 17.8 (2.9) | 21.2 (2.7) | 0.7 (0.1) | 10.2 (0.8) | 3.2 (0.04) |
| 2006 | 7.4 (0.6)                                    | 59.7 (3.3) | 23.9 (2.1) | 1.4 (0.4) | 10.2 (0.7) | 3.3 (0.1)  |
| 2007 | 5.2 (0.5)                                    | 18.1 (2.9) | 10.9 (1.8) | 0.8 (0.1) | 13.6 (0.9) | 5.0 (0.1)  |
| 2008 | 12.9 (0.6)                                   | 17.7 (2.6) | 14.0 (1.8) | 1.8 (0.1) | 7.1 (0.5)  | 4.3 (0.2)  |

## Mean Effective Dose per Year



## Collective Dose - Brazil



# Internal Dosimetry

In vivo and in vitro measurements



## In Vivo and In Vitro Measurements

The in Vivo system is mounted in a van with internal dimensions of 3.30 m x 1.60 m x 1.70 m.



The detection system is able to identify and quantify photon emitters in the energy range of 100 - 3000 keV in the whole body, organs or tissues and urine.

## In Vivo and In Vitro Measurements

The NaI(Tl) 8x4 detector used for whole body measurements is calibrated with a plastic-bottle phantom containing standard solutions uniformly distributed among its various sections representing the members of a human body.



The calibration of the NaI(Tl)3x3 thyroid monitor is performed with a neck and thyroid phantom developed at the IRD.



# Project TC-IAEA BRA9055

## An Internal Dosimetry Network in Brazil

The project IAEA BRA 9055 has resulted in a long term collaboration between the Brazilian internal dosimetry laboratories in Brazil.

The IRD and Eletronuclear internal dosimetry centers have, as a result of the IAEA project, promoted the harmonization of bioassay techniques and dose estimation in case of an emergency response.



# In Vivo and In Vitro Measurements

Up to the present moment, 416 internal monitoring measurements were performed on CNEN and ABACC inspectors. The results are all lower than the minimum detectable activity.

It is possible to conclude that the inspection activities at the CNAEA plants is carried out with a high degree of radiation safety.

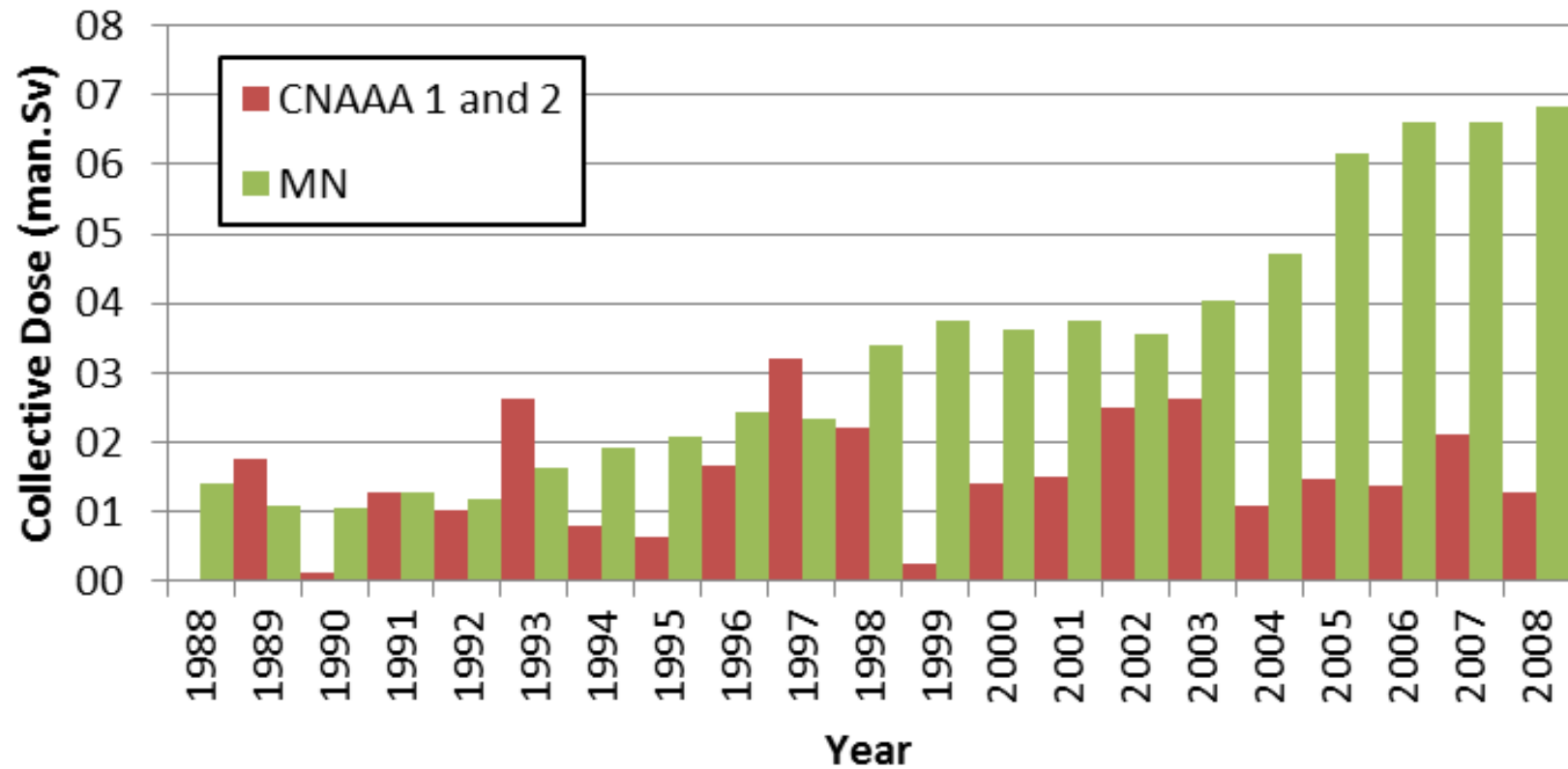
# Conclusions

The individual monitoring results of CNAEA 1 and 2 show good ALARA radiation protection practices. The yearly average and collective doses for CNAEA 2 are considerably lower than those of CNAEA 1.

In terms of occupational radiation protection, it can be seen that the collective annual doses of the nuclear medicine clinics in Brazil are on the whole higher than those of the CNAEA workers.

This trend of higher collective annual doses in nuclear medicine clinics will increase over the next years.

## Collective Dose - Brazil





Thank you for your attention!

