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Staff dosimetry in interventional radiology/cardiology and nuclear medicine

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11 MGP Intruments (MGPi), France
12 RADCARD, Krakow, Poland

13th EAN Workshop – "ALARA and the medical sector" – 7-10 June 2011 – Oscarborg Fortress (Norway)

Objectives

- FP6 CONRAD project:
  - highlighted high extremity doses to the staff in interventional radiology/ cardiology (IR/IC) and in nuclear medicine (NM)
  - lack of systematic data analysis in IR/IC and in NM
  - Unknown response of APDs in pulsed fields of IR/IC

- Improve the knowledge on extremity and eye lens exposure
- Provide recommendations for optimization of working practices
- Provide recommendations for optimization of the use of active personal dosemeters (APDs)
- Develop and edit training materials

General overview

2008 – 2011

12 partners (2 manufacturers); 9 countries

Coordinator: SCK-CEN: Filip Vanhavere

- **WP0: Management**

  Filip Vanhavere, SCK-CEN, Belgium

- **WP1: Extremity (hand, leg) and eye lens dosimetry in IR/IC**

  Eleftheria Carinou, GAEC, Greece

- **WP2: Development of practical eye lens dosimetry in IR/IC**

  Gianfranco Gualdrini, ENEA, Italy

- **WP3: Optimization of the use of active personal dosemeters in IR/IC**

  Isabelle Clairand, IRSN, France

- **WP4: Extremity dosimetry in NM**

  Marta Sans Mercé, CHUV, Switzerland

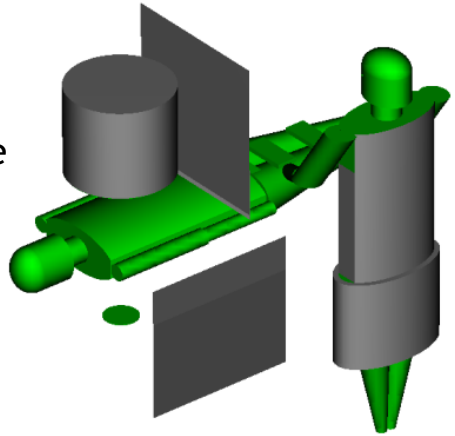
- **WP5: Dissemination and training**

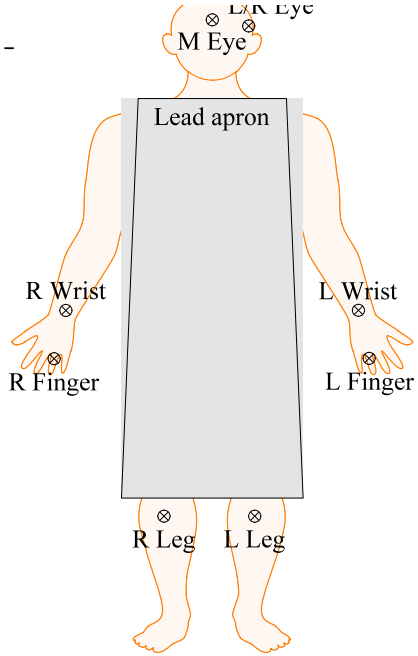
  Mercè Ginjaume, UPC, Spain

Extremity and eye lens dosimetry in IR/IC

- Main achievements

- **1329 measurements** (x 8 dosemeters) in 6 countries, > 40 hospitals/rooms
- Unified protocol
- Types of procedures:
  - **IC: CA/PTCA, RFA, PM/ICD**
  - **IR: DSA/PTA LL, Re, Ca/Ce**
  - **Embolization**
  - **ERCP**
- Analysis of the **parameters influencing the**
  - Room protective equipment – Tube configuration – Catheter access
- Monte Carlo simulations
  - Study of the influence of each parameter separately
- Recommendations
- Training materials





Extremity and eye lens dosimetry in IR/IC

Main results

- **Personal protective equipment** (lead apron, thyroid collar) are widely used (>60%), leaded glasses for ~30%.
- No room protective equipment is used for ~25% of cases.
- **Large spread** of doses are observed.
- For IR and IC, embolization and PM/ICD lead to the highest doses, respectively.
- **Left wrist and finger** are the positions with highest doses (closest to the scattering center). However, when respective annual limits are taken into account, the **left eye** position become more important.
- Effect of the **room protective equipment** on doses is smaller than (theoretically) expected.

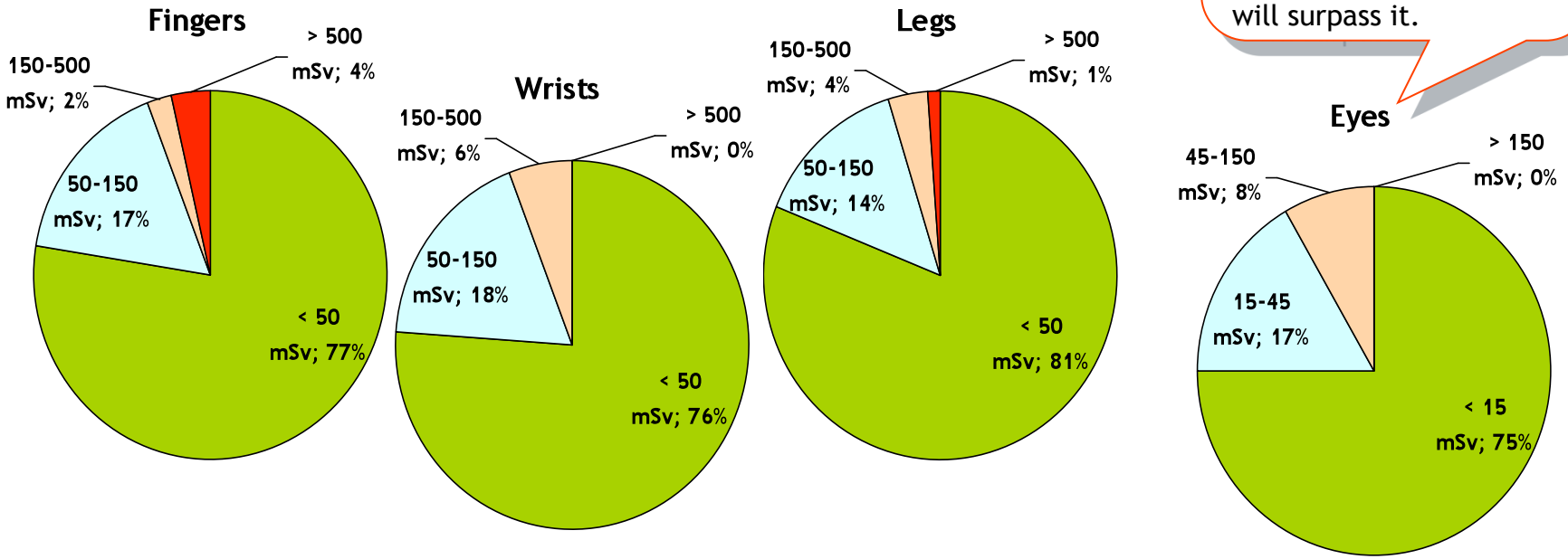
Effect of the room protective equipment	Fingers and Wrists	Legs	Eyes
Without / With	1.3 - 2.3	1.1 - 4.0	1.6 - 7.4

- Well designed and used room protective equipment are essential for a better protection.
- Hand and eye doses are significantly higher for overcouch **tube configurations** (by 2-50 times) than for undercouch.
- Hand and eye doses are higher for radial **catheter access** (by 2-7 times) than for femoral access.
- Use of an **automatic injector** is associated with lower doses, by 4-16 times.

Extremity and eye lens dosimetry in IR/IC

- Main results
  - Annual extrapolations:

Frequency distribution for all procedures
(84 physicians)



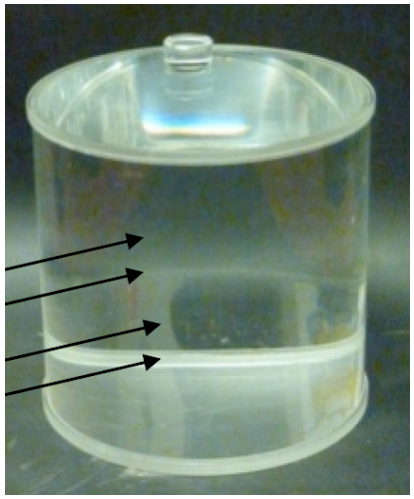
If the new recommended dose limit of 20 mSv (ICRP statement, 2011) is applied, many workers will surpass it.

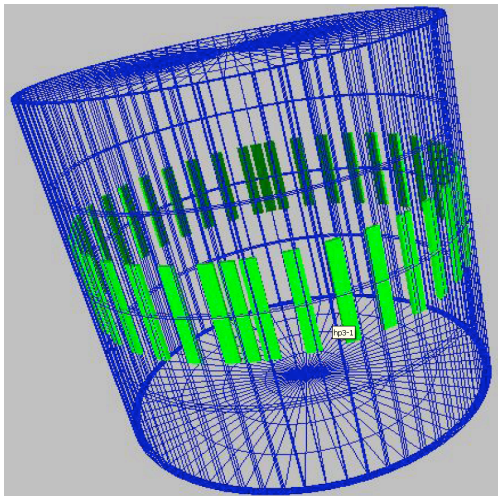
- ➔ Monitoring of the hands is recommended (especially for cardiology)
- ➔ No need for leg monitoring if a table shield is properly used
- ➔ Use of leaded glasses and monitoring of the eyes are recommended (except for ERCP)

Practical eye lens dosimetry in IR/IC

- Main achievements

- Proposal for eye lens dosemeter **calibration and type testing** for Hp(3)
  - **New phantom**



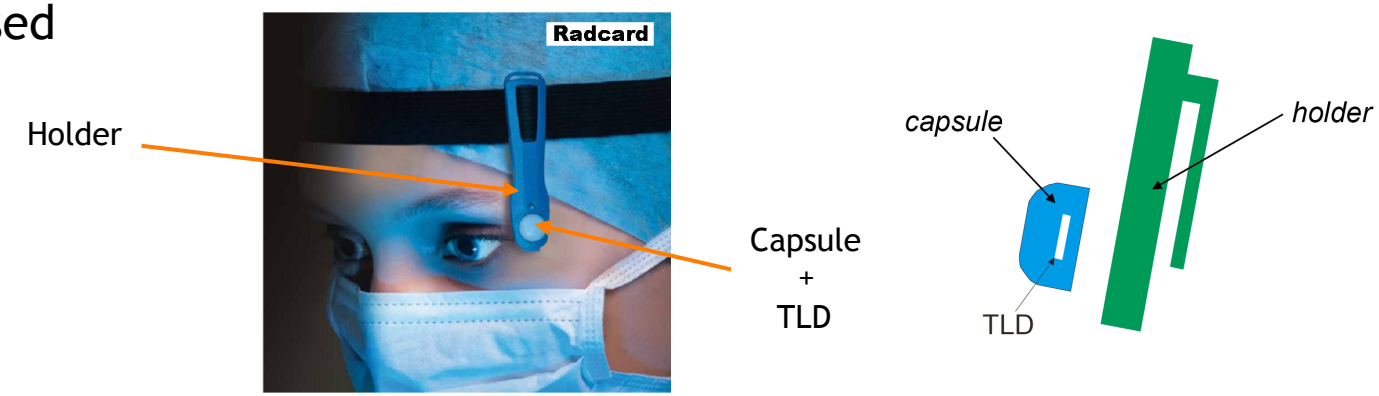


  - Extensive calculations of **conversion coefficients** $H_p(3)/K_a$ for photons

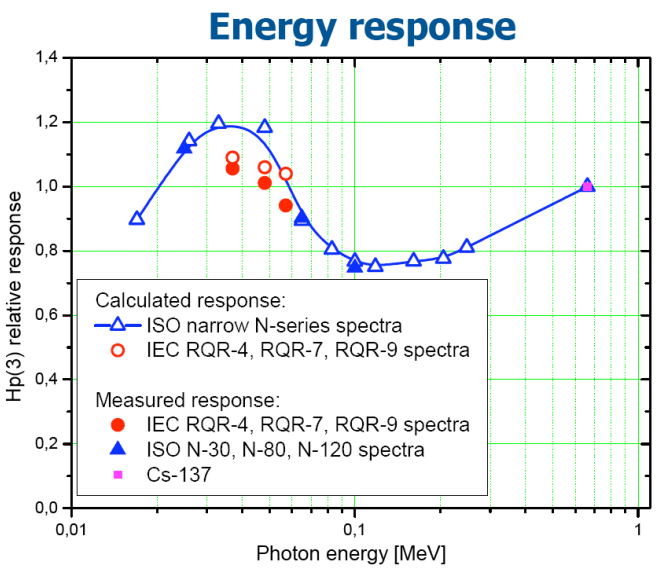
- **Design** and test of a dosemeter to measure Hp(3) (RADCARD)

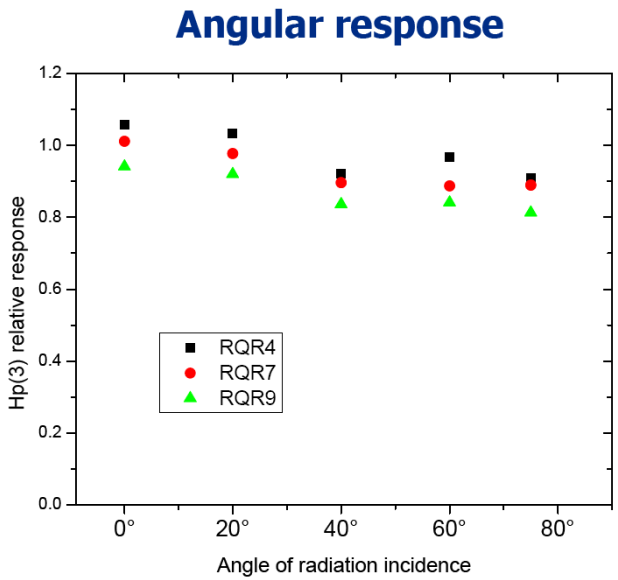
Practical eye lens dosimetry in IR/IC

- Results
- A dosemeter to measure $H_p(3)$
  - TLD-based



  - Satisfactory energy and angular response curves





Use of active personal dosemeters in IR/IC

- Main achievements
  - **8 commercially available APDs** chosen

MGPi
DMC2000XB

Thermo
EPD Mk2.3

Dosilab
EDM III


Polimaster
PM1621A


Rados
DIS-100

Unfors
EDD 30

Atomtex
AT3509C


Philips
DoseAware

  - Tests:
    - in laboratory conditions, in **continuous fields**: dose, dose rate, energy and angular responses
    - in laboratory conditions, in **pulsed fields**: dose rate, pulse frequency, pulse width
    - at a **medical X-ray facility** (on phantom)
    - in **7 European hospitals**, in real conditions (102 measurements on operators, for 5 APD types out of 8)
  - Development of a **prototype** specifically designed for medical pulsed fields (MGPi)
  - **Recommendations** relating choice and use of APDs in IR/IC

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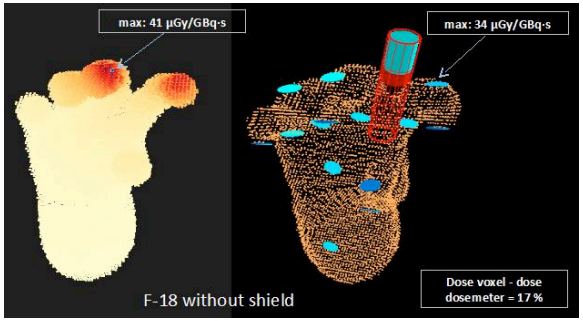
Use of active personal dosemeters in IR/IC

- Main results
  - **In continuous X-ray beams:** most APDs have **correct behavior** up to 10 Sv/h (according to IEC 61526 standard)
  - **In pulsed X-ray beams:** except for PM1621A, all APDs **provide a reading**. Limitations are mostly due to high dose rates rather than pulse frequency.
  - **In hospital conditions:** behavior **even more satisfactory** than in laboratory conditions. Due to low dose rates in the scattered field.
  - **On operators:** slight (by 20-30%) dose underestimation with respect to a passive dosemeter.
  - The **APD prototype** (MGPi) was developed and tested.
  - A standard for the type testing and calibration of APDs in pulsed field is needed.
  - It is not recommended to use APDs as 'legal dosimeters' in IR/IC.

Extremity dosimetry in nuclear medicine

Main achievements

- **735 measurements** (x 22 dosemeters) in 7 countries, 34 NM departments, for 124 worl
- Unified protocol
- **^{99m}Tc, ^{18}F, ^{90}Y-Zevalin®** (+ others)
- Preparation and administration stages
- Classification of workers according to their maximum dose
- Identification of good and bad practices
- Analysis of the parameters influencing the doses
- Monte Carlo simulations (~200) for realistic scenarios (voxel phantoms)



- Recommendations
- Training materials
- Freeware: dose calculation tool

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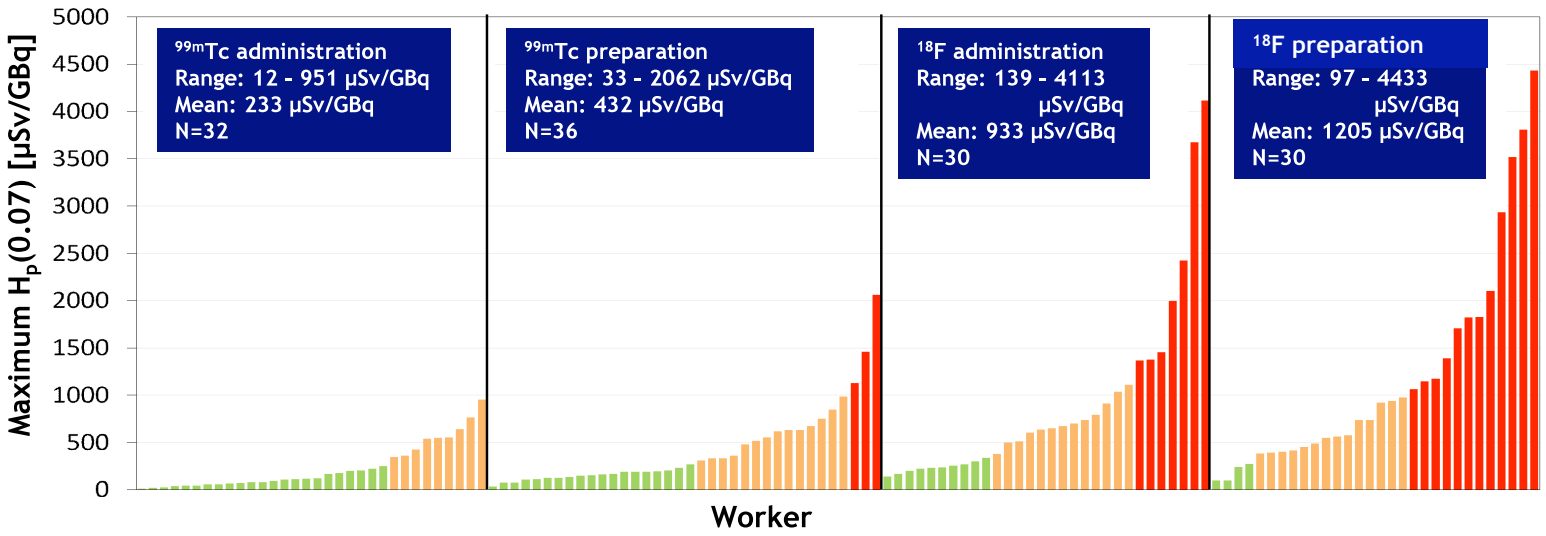
Extremity dosimetry in nuclear medicine

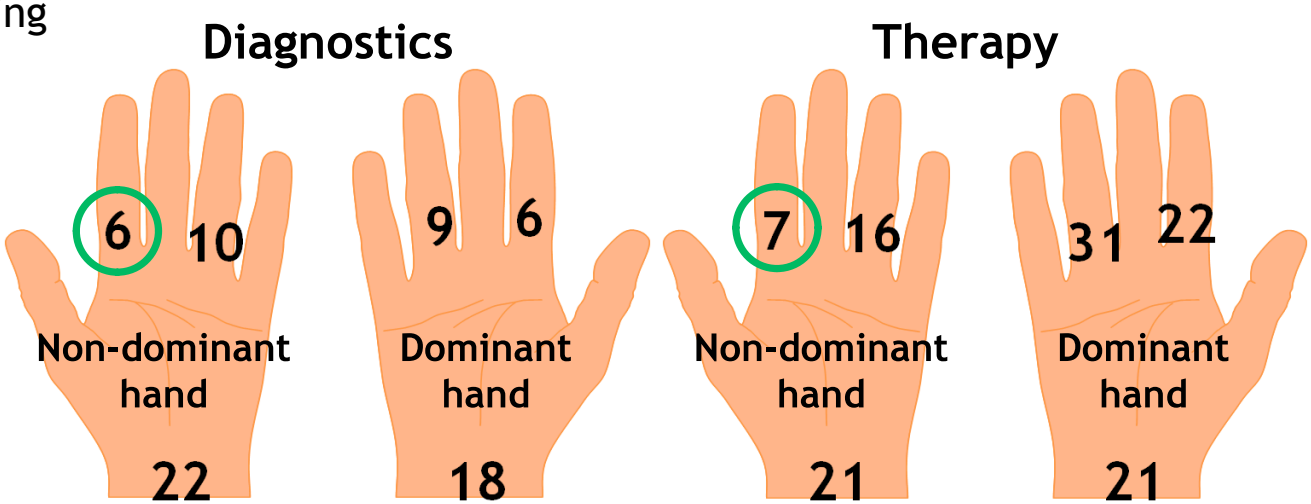
- Main results
  - **Large spread of doses** is observed. Due to: practice, individual habit.



  - **Bad practices** are clearly associated with high doses, so are **good practices** with low doses.
    - Bad practices: no shielding, direct contact with the source container.
    - Good practices: shielding, semi-automatic dispensing tool.
  - **Preparation** leads to higher doses than **administration**.
  - The **non-dominant hand** receives higher doses than the dominant hand.

Extremity dosimetry in nuclear medicine

- Main results
  - Ratios between the maximum dose and dose at possible locations for routine monitoring



  - Good correlation are found between the maximum dose and doses at positions used for routine ring dosemeters

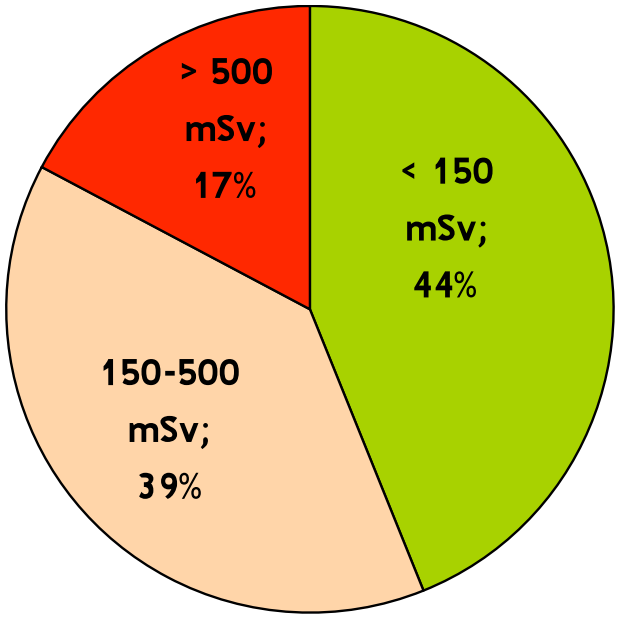
  - ➔ **Hand monitoring**
    - Routine ring dosemeter shall be located at the base of the index finger of the non-dominant hand with the sensitive part of the dosemeter oriented towards the inside of the hand.
    - For estimation of the maximum hand dose: multiply by 6

Extremity dosimetry in nuclear medicine

- Main results
  - Annual extrapolations:

Estimated for each worker from the position receiving the maximum average dose

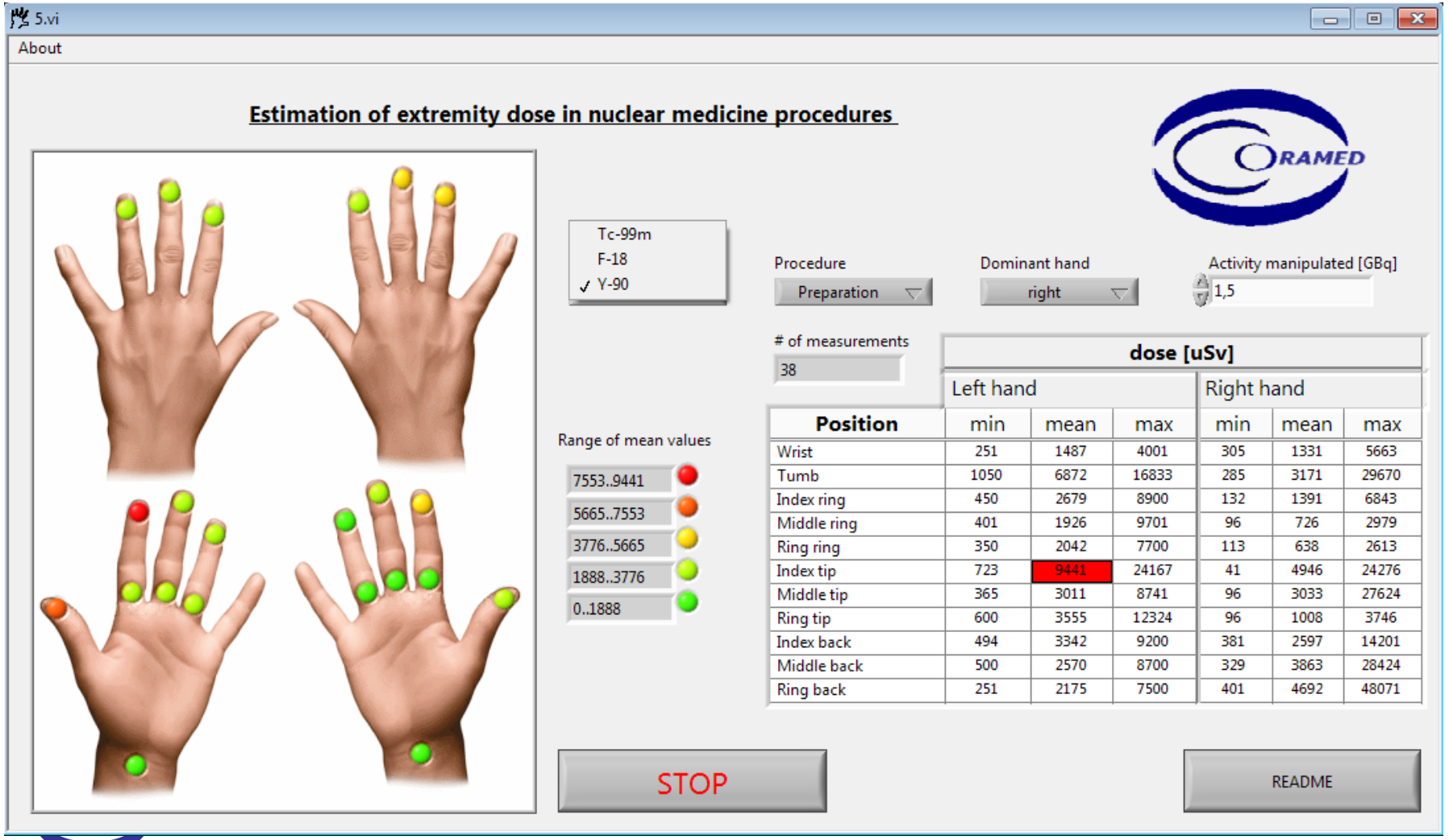
Diagnostics ^{99m}Tc, ^{18}F
1000 patients/year



Depend slightly on the hypotheses made for the estimation

Extremity dosimetry in nuclear medicine

- Main results
  - Freeware (IRA): dose calculation tool available on request.



Position	dose [uSv] Left hand min	Left hand mean	Left hand max	Right hand min	Right hand mean	Right hand max
Wrist	251	1487	4001	305	1331	5663
Tumb	1050	6872	16833	285	3171	29670
Index ring	450	2679	8900	132	1391	6843
Middle ring	401	1926	9701	96	726	2979
Ring ring	350	2042	7700	113	638	2613
Index tip	723	9441	24167	41	4946	24276
Middle tip	365	3011	8741	96	3033	27624
Ring tip	600	3555	12324	96	1008	3746
Index back	494	3342	9200	381	2597	14201
Middle back	500	2570	8700	329	3863	28424
Ring back	251	2175	7500	401	4692	48071

Conclusions

- ORAMED
  - Extensive dosimetric study on RP of medical staff, covering:
    - ✓ IR/IC and NM
    - ✓ Extremities, eye lens, whole-body
    - ✓ Measurements / MC simulations
    - ✓ Developments by manufacturers
  - Dissemination and training
    - ✓ ORAMED workshop, 20-21/01/2011, UPC, Barcelona, Spain
    - ✓ Training materials
    - ✓ Recommendations / guidelines
    - ✓ > 20 publications
    - ✓ Several communications
    - ✓ Contacts with scientific organizations and networks, standard organizations…

Thank you for your attention!

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