ALARA in Handling of Beta-Emitters - Measurement Techniques and Optimisation

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Introduction

- Increasing use of beta emitters in nuclear medicine diagnostic and therapy
- Necessity to handle high activities at small distances to the skin
  → increased probability of high skin exposure (>500 mSv/a)!
- Lacking individual awareness of high skin doses to the staff resulting from absent, inadequate or inaccurately placed extremity dosemeters in routine monitoring
  → low radiation protection standard

Introduction

Therapies under review:

- Radiosynoviorthesis (RSO) using Er-169, Re-186, Y-90
- Radioimmunotherapy (RIT) using Y-90-Zevalin®
- Radiopeptidtherapy (PRRT) using Y-90-DOTATOC
- Intravascular Brachytherapy (IVB) using Re-188
- Palliative Therapy using Sm-153

Methods and Materials

Thin-layer thermoluminescence detectors (TLD)

Material:
LiF:Mg,Cu,P type: MCP-Ns™
Area mass of the sensitive layer
<10 mg/cm²

Calibration:
Beta-Secondary Standard facility
BSS 2 with a Sr-90/Y-90-source

Evaluation:
Harshaw 3500 type reader

Results / Radiosynoviorthesis with Y-90

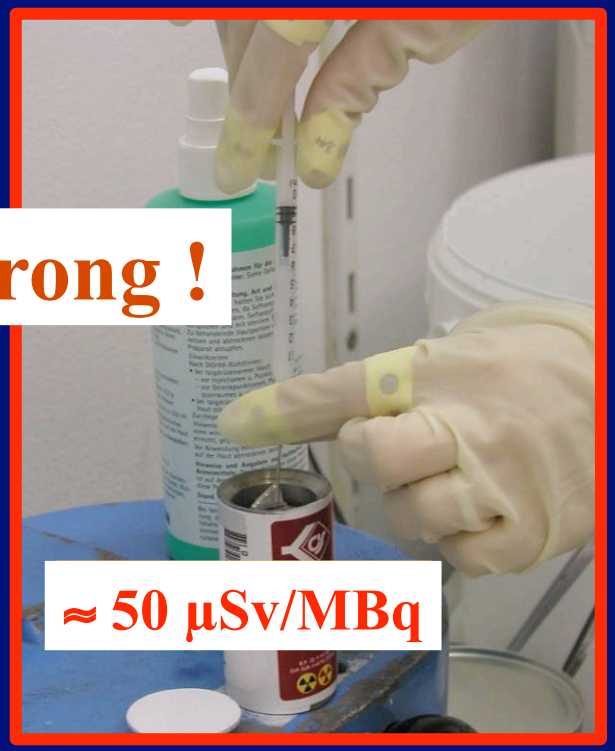
Measurements performed in:

11 Doctor's surgeries
13 Radiologists / technicians
18 Doctors
210 Patients
45 GBq Y-90 administered

Results / Radiosynoviorthesis with Y-90

Influence of the shielding on skin exposure during syringe dispensing

without shielding



wrong !

≈ 50 µSv/MBq

with shielding for vial, syringe and upper needle

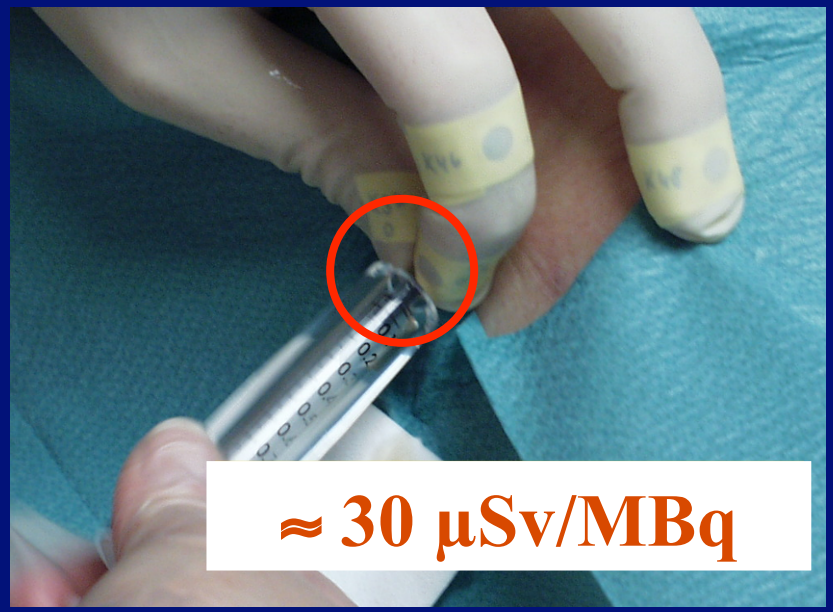
≈ 2 µSv/MBq

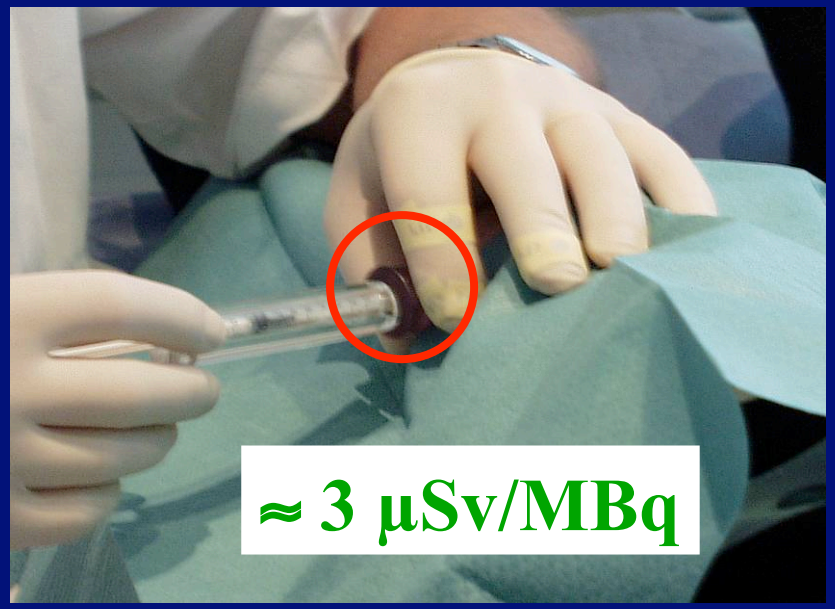
Results / Radiosynoviorthesis with Y-90

Influence of the Makrolonring on the skin exposure

without Makrolonring

with Makrolonring

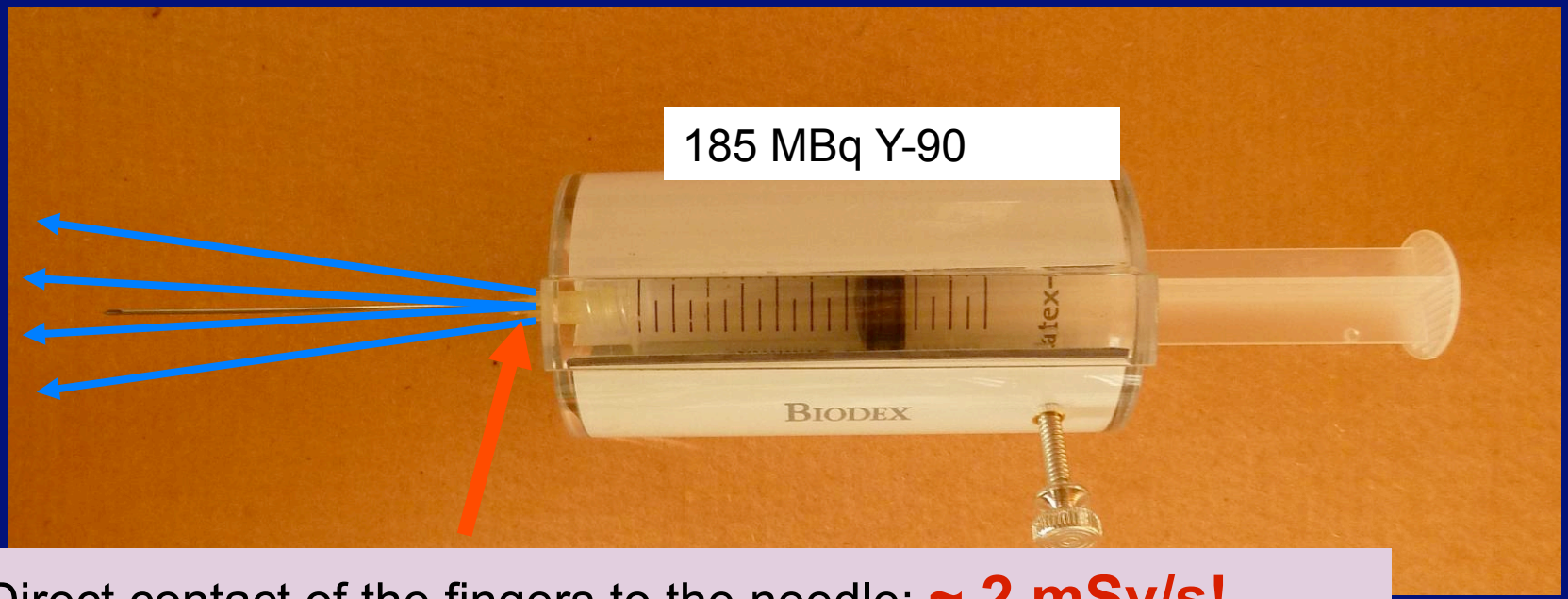




RSO with Y-90: local normalized skin dose

Results / RSO, Administration

Causing very high exposure



Direct contact of the fingers to the needle: **~ 2 mSv/s!**

Results / European ORAMED-Project

Radiotherapies with Y-90

Scope of measurements in preparation (P) and administration (A) of Y-90 in NM therapies

Therapy	Procedures	Number of Countries (B,Ch,D,E, F,,I)	Hospitals	Workers	Data sets
PRRT *Dotatoc*	P A	3 3	3 3	5 7	**16** **17**
RIT *Zevalin*®	P A	6 6	1 6 1 5	20 22	**49** **45**

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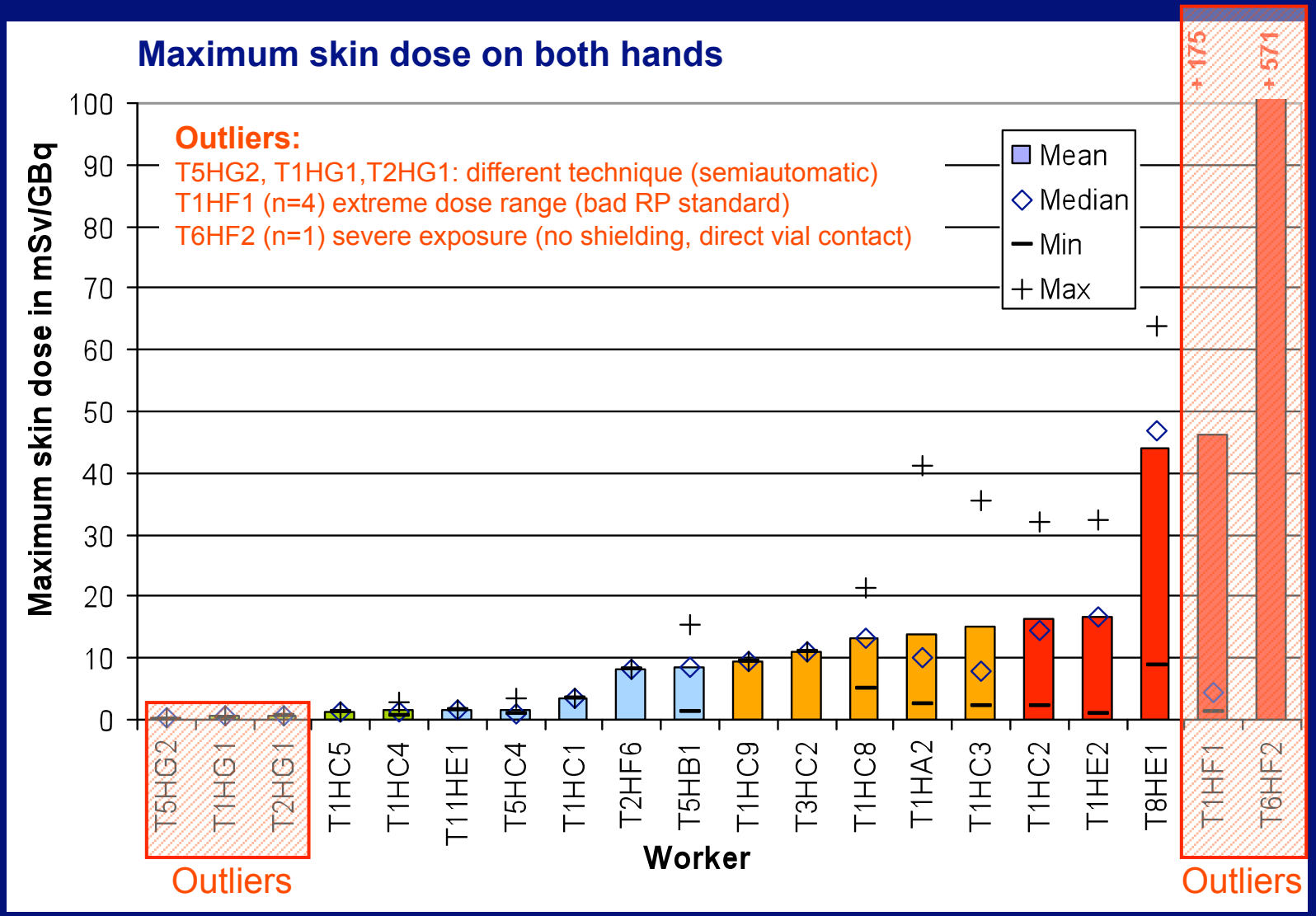
RESULTS / Classification of workers for RIT with Y-90/Zevalin®, Preparation



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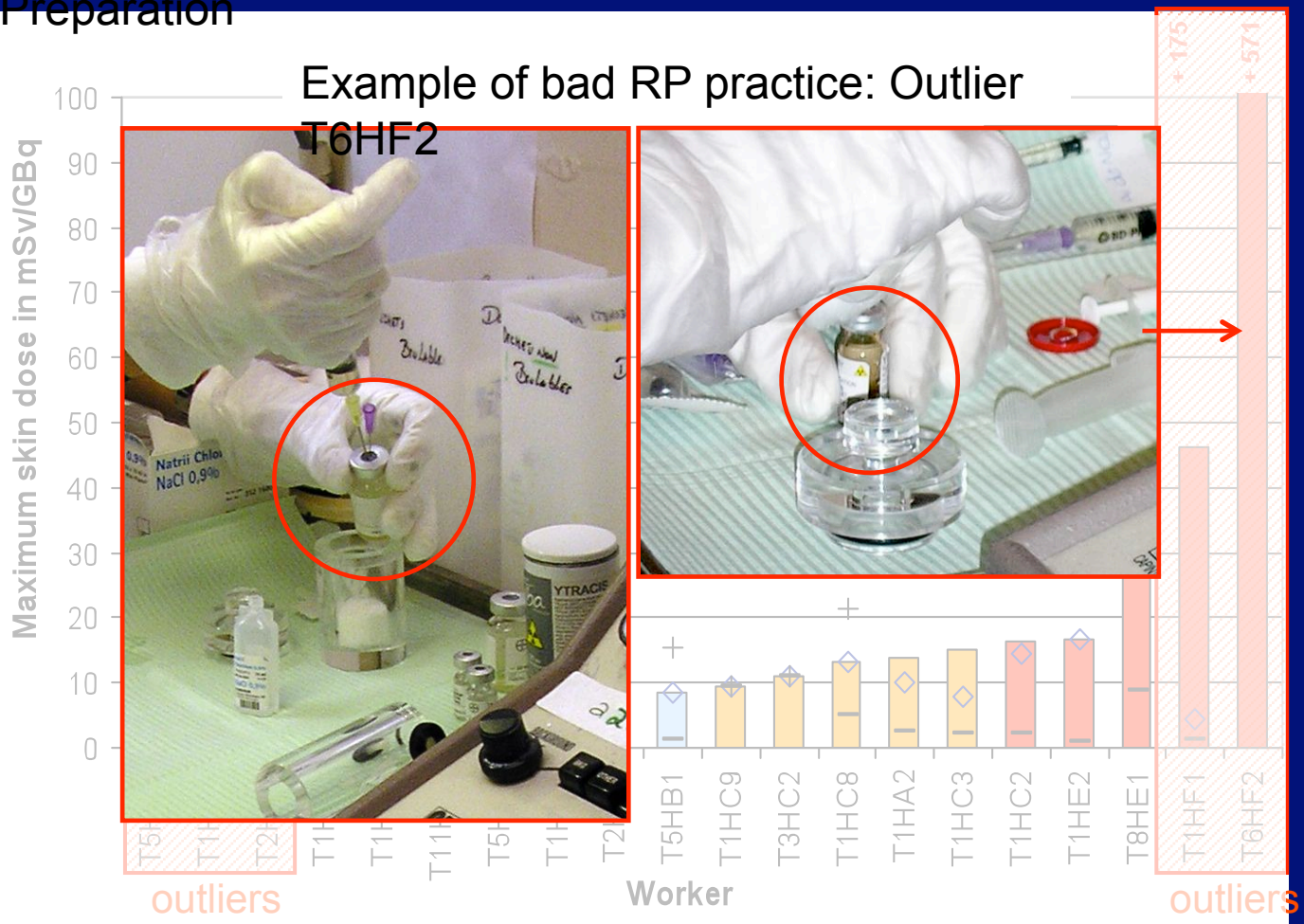
Results / Zevalin® Preparation

RESULTS

Causing very high exposure during Y-90/Zevalin® Preparation

Example of bad RP practice: Outlier T6HF2



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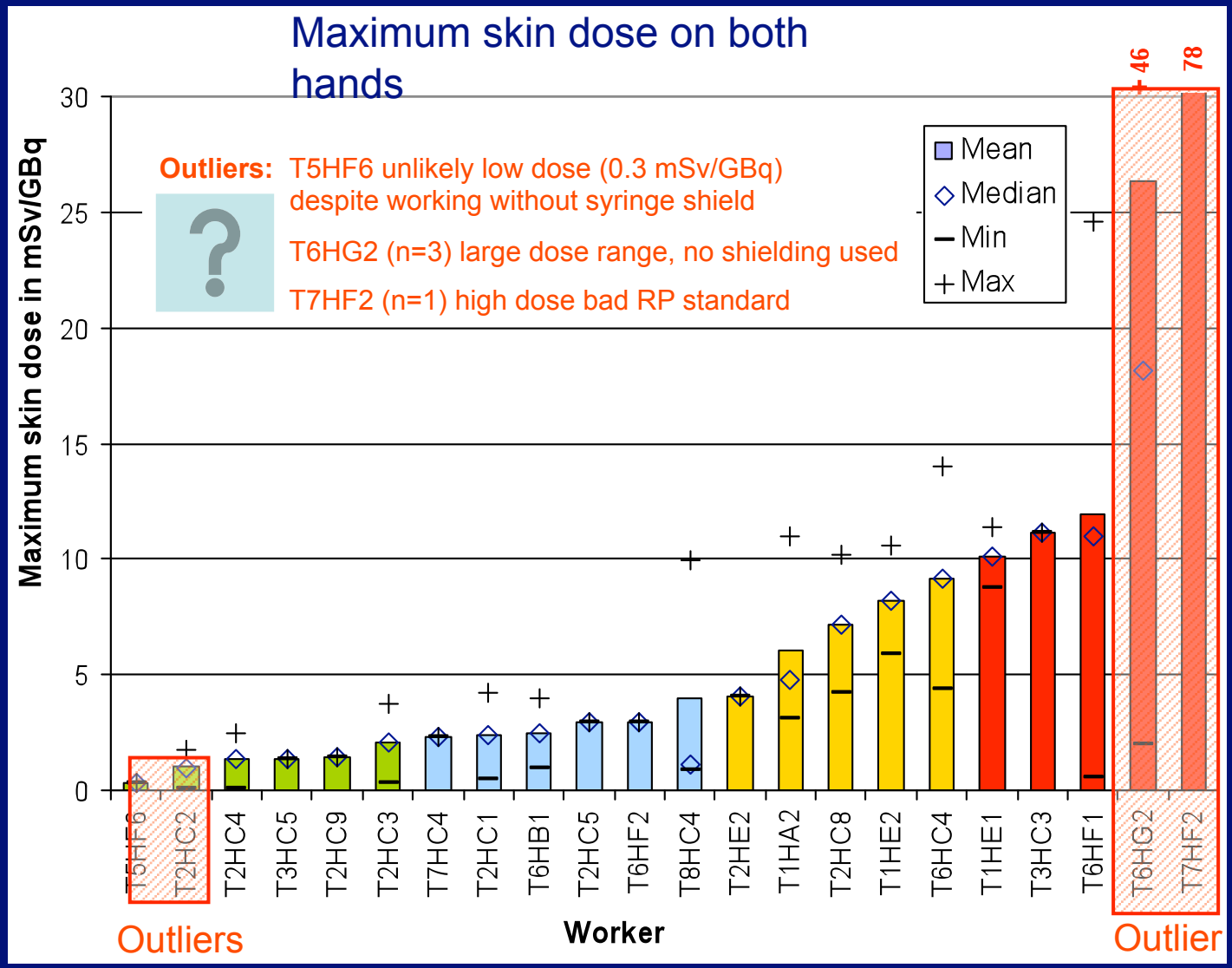
RESULTS/ Classification of workers for RIT, Administration



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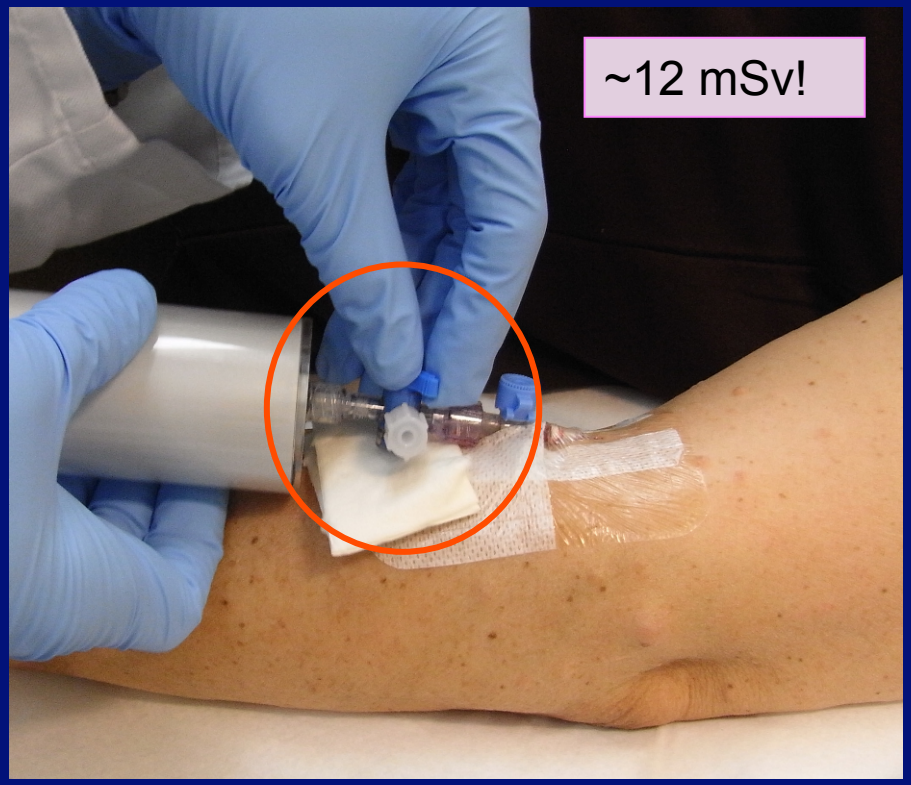
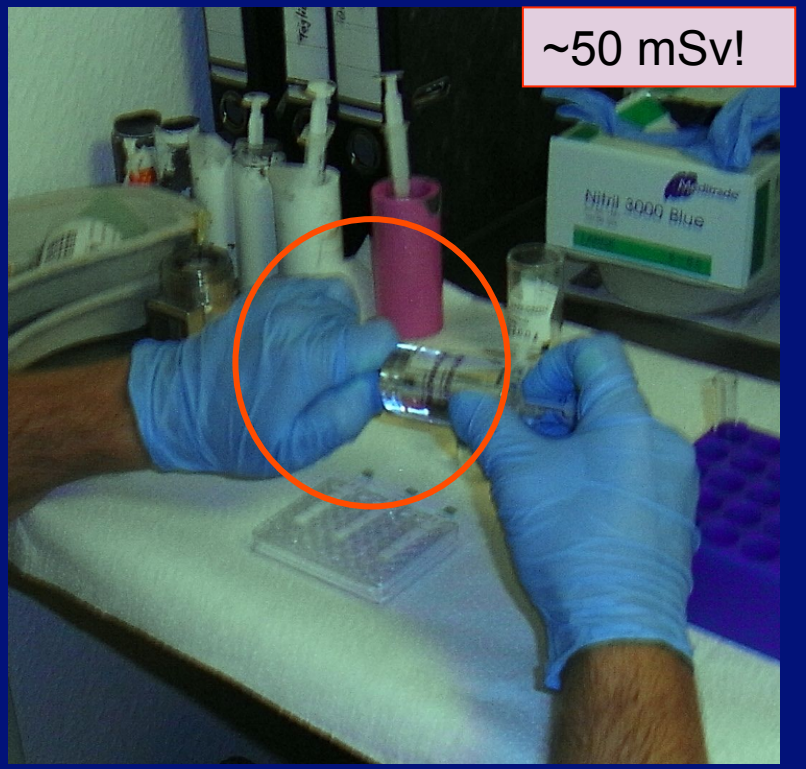
Results / Zevalin®

Causation of very high exposure

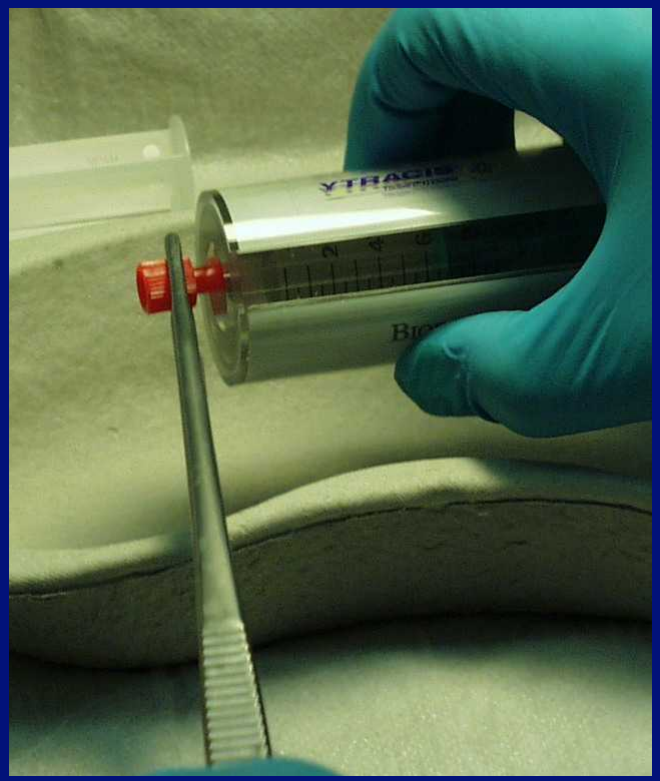




Results / Zevalin®, Administration

Any direct contact to vessels with activity must and can be avoided!!!

Reduction of exposure more than one order of magnitude:



Results / ORAMED

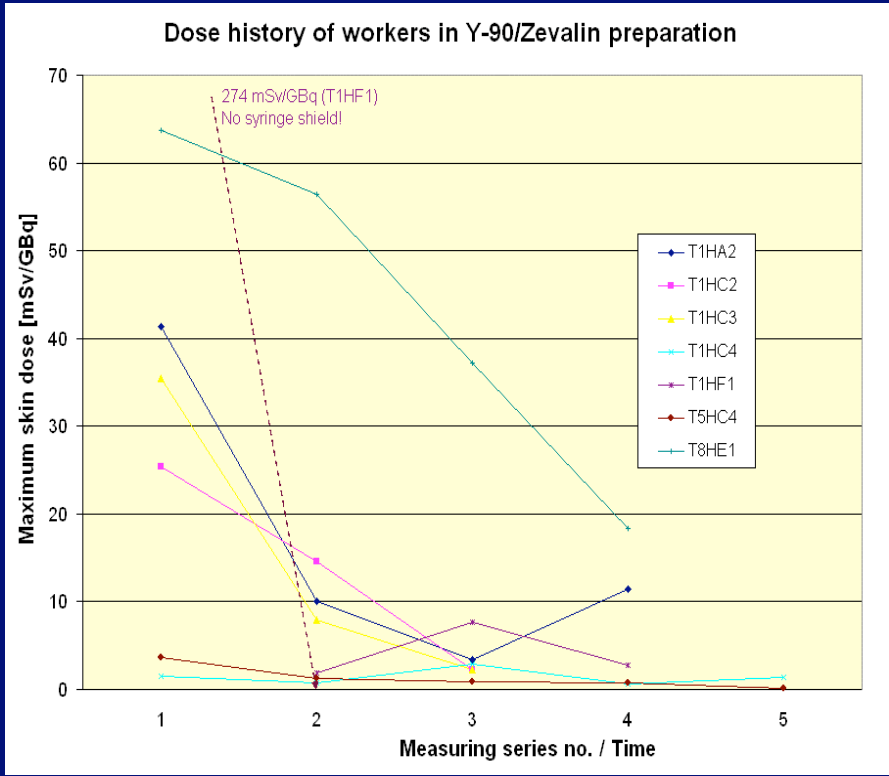
Averaged maximum skin dose per preparation or administration in nuclear medicine therapies

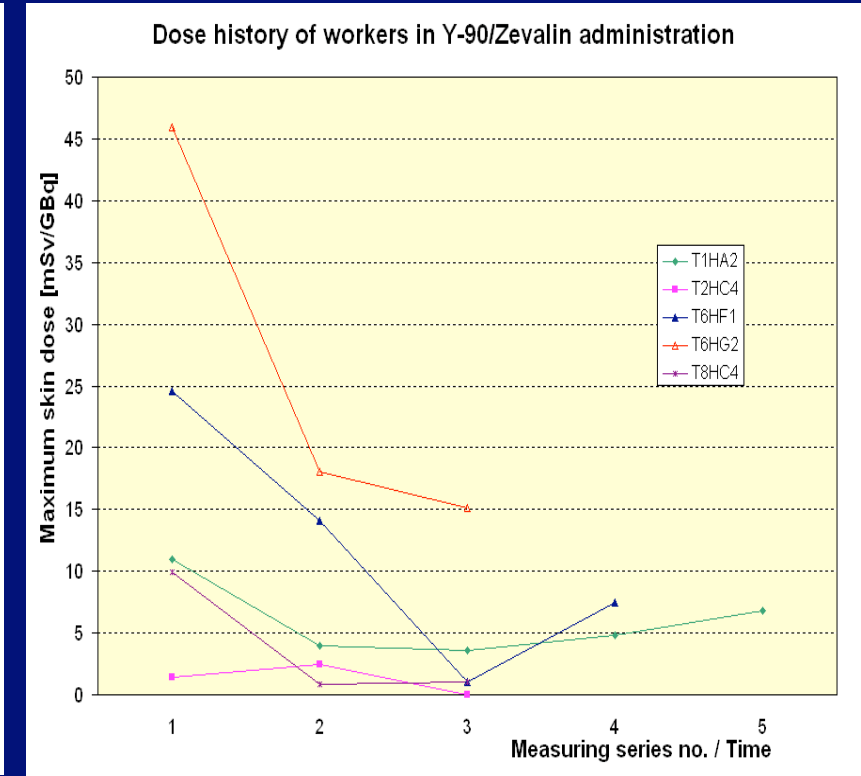
Therapy	Procedure **P** Preparation **A** Administration	Worker	Max. Skin dose [mSv]			
			Mean	Median	Min	Max
^{90}Y - RIT	**P**	15	**16.5**	14.2	1.8	65.9
	A	19	**4.8**	2.9	1.0	11.9
^{90}Y-PRRT	**P**	5	**21.6**	11.3	1.0	76.2
	A	7	**10.4**	8.2	2.2	26.9

Mean activity per procedure: RIT-P: 1.5 GBq RIT-A: 1 .0 GBq

PRRT-P: 10.3 GBq PRRT-A: 5.5 GBq

Results / RIT


Dose history of workers in Y-90/Zevalin preparation
274 mSv/GBq (T1HF1)
No syringe shield!
Maximum skin dose [mSv/GBq]
Measuring series no. / Time
T1HA2
T1HC2
T1HC3
T1HC4
T1HF1
T5HC4
T8HE1


Dose history of workers in Y-90/Zevalin administration
Maximum skin dose [mSv/GBq]
Measuring series no. / Time
T1HA2
T2HC4
T6HF1
T6HG2
T8HC4

Results / ORAMED

RESULTS

Why are/were the high skin doses at the fingers not detected in routine monitoring???

Possible reasons:

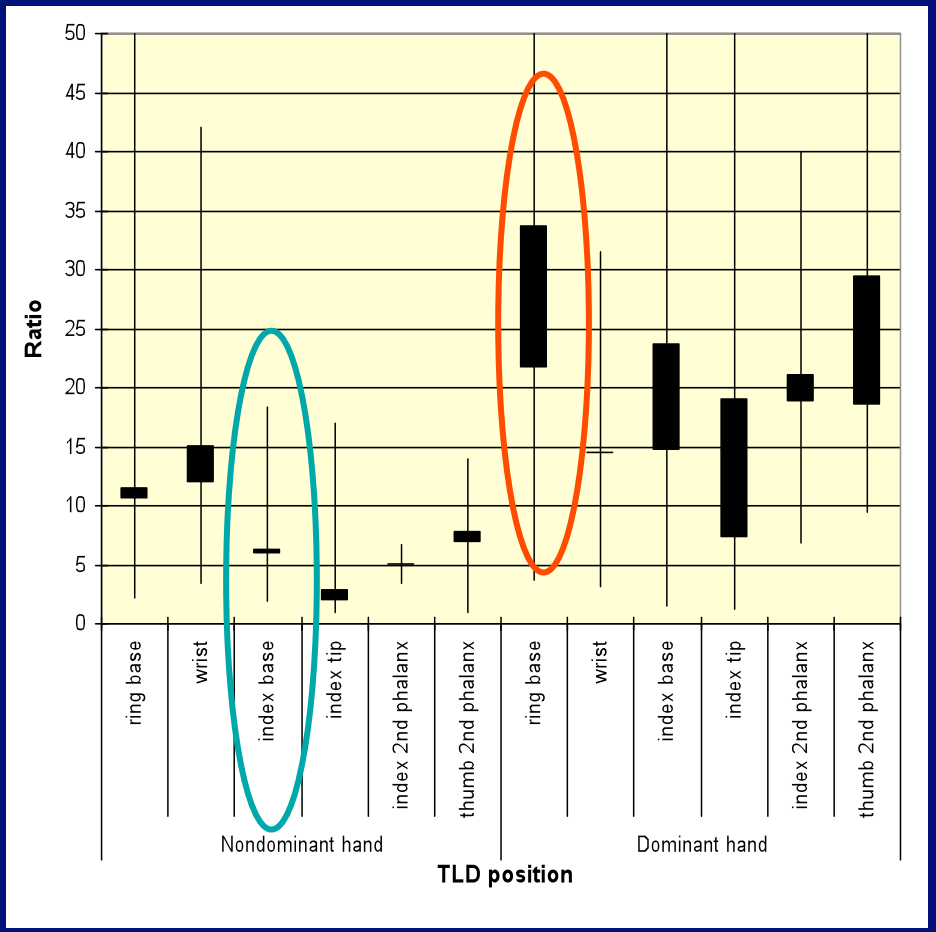
- Inadequate dosemeter?
- Inadequate position where the dosemeters are worn?

Answer:

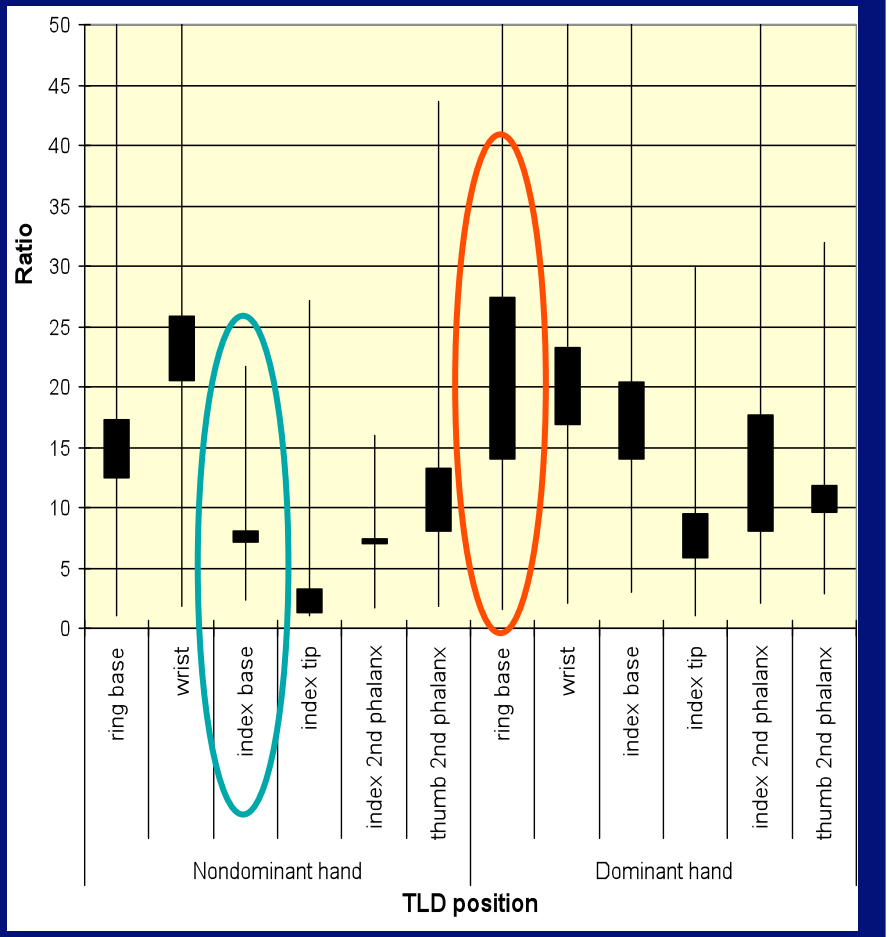
- Ringdosemeter with thin layer TLD of [LiF: Mg,Cu.P] are appropriate to measure correct beta and photon radiation dose
- The best position of routine ringdosemeter should be established in ORAMED studies.

Results / ORAMED

Ratio of maximum dose on both hands to dose on dosemeter position



Y-90/Zevalin® preparation



Y-90/Zevalin® administration

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Results / ORAMED

- The best position for the routine ringdosemeter:

  the base of the index finger of the **non-dominant** hand!

- The ratio of the maximum dose of both hands to the dose of the dosemeter on the base of the index finger of the non-dominant hand is about **6 for all procedures in nuclear medicine** (therapies using Y-90 and diagnostics using Tc-99^{m} and F-18). Generally, a worker performs more than one procedure!

Conclusions

- Local skin dose can exceed the limit (500 mSv/a) by numerous workers in hospitals where radiation protection standard is low
- There is a high potential to decrease exposures by simple means ► **shielding and tools**
- The **awareness** of the necessity to improve the radiation protection standard must be increased
- Adequate skin dose monitoring is urgently needed in nuclear medicine
- Ring dosemeters should be worn **on the base of the index finger of the non-dominant hand**
- Even if the dosemeter is worn on the base of the index finger, the skin dose maximum is considerably **underestimated by a factor of about 6**
- The ringfinger base of the dominant hand, where ring dosemeters are often worn, is not a proper position in routine monitoring and wrist dosemeters are not appropriate for monitoring nuclear medicine staff

Acknowledgement

Parts of the research leading to these results has received funding from the European Atomic Energy Community's Seventh Framework Programme (FP7/2007-2011) under grant agreement n° 211361.

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Thank you for your attention!