3.1 Discovering the ALARA approach through a simple workstation analysis in radiopharmaceutics production

The annual dose distribution in the laboratory: recognition of the problem

Worker	Annual dose (mSv)
Radiochemist 1	1,2
Radiochemist 2	0,9
Radiochemist 3	6
Physicist 4 Physicist 5 All others	0,5 0,4 Under 0,1

- What are the actual stakes?
- What are your questions looking at the situation?
- What are the needed data to « optimise the situation »?

What are the stakes?

Only one radiochemist has more than 5 mSv /year

This is much more than all others

He feels that this is totally inequitable

He is the only one working on the fluorine 18 workstation (one of the several workstations in the lab)

He thinks his dose is mainly coming from that job on that workstation

Is it ALARA to better distribute the doses only? To spread the collective dose more equitably among all the workers ?

Better distributing the collective dose is not optimizing

It can be considered as good radiological protection:

- As the exposure risk relationship is assumed to be linear and without threshold, when an individual has a higher dose he takes higher risk proportionally to his dose (here the risk of the radiochemist is 5 five times or more higher than the one of all the others)
- Modifying the dose distribution through asking more people to work on the fluorine 18 workstation, should be considered as good "risk distribution management", but this should not reduce at all the collective dose, and hence the total detriment
- In many cases (not here) putting more people to do the same job will even increase the collective dose (due to time spent to reach the workstation if in controlled area, due to lack of information transfer on an on going task…)

It is equity but not at all optimisation

An analytical approach has to be performed

The radiochemist ask for the help of the RPO

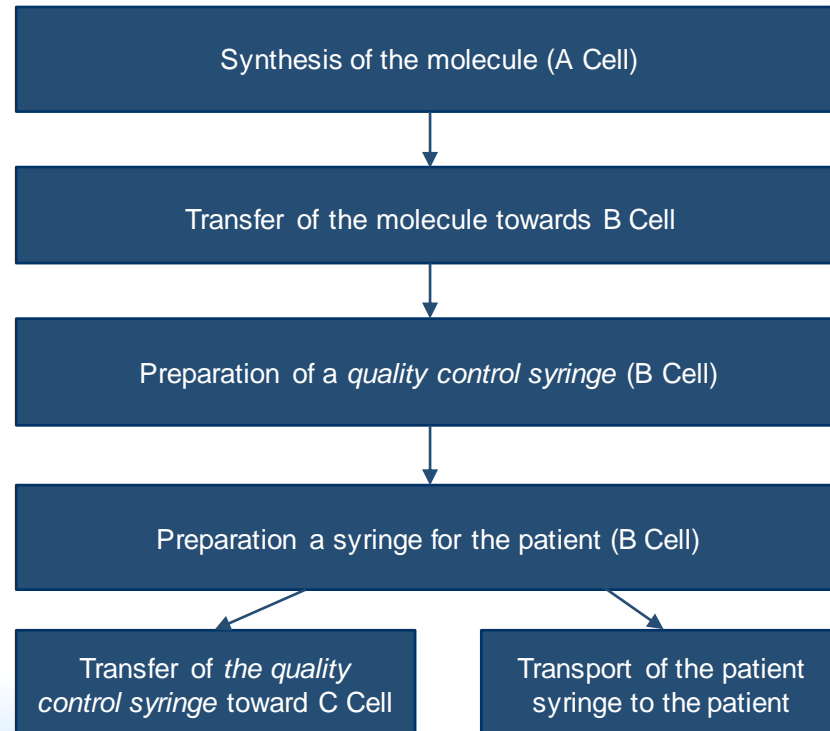They decide together to perform an analysis of the job and doses to better answer to the questions:
- Where are the doses undertaken?
- When? (during what task),

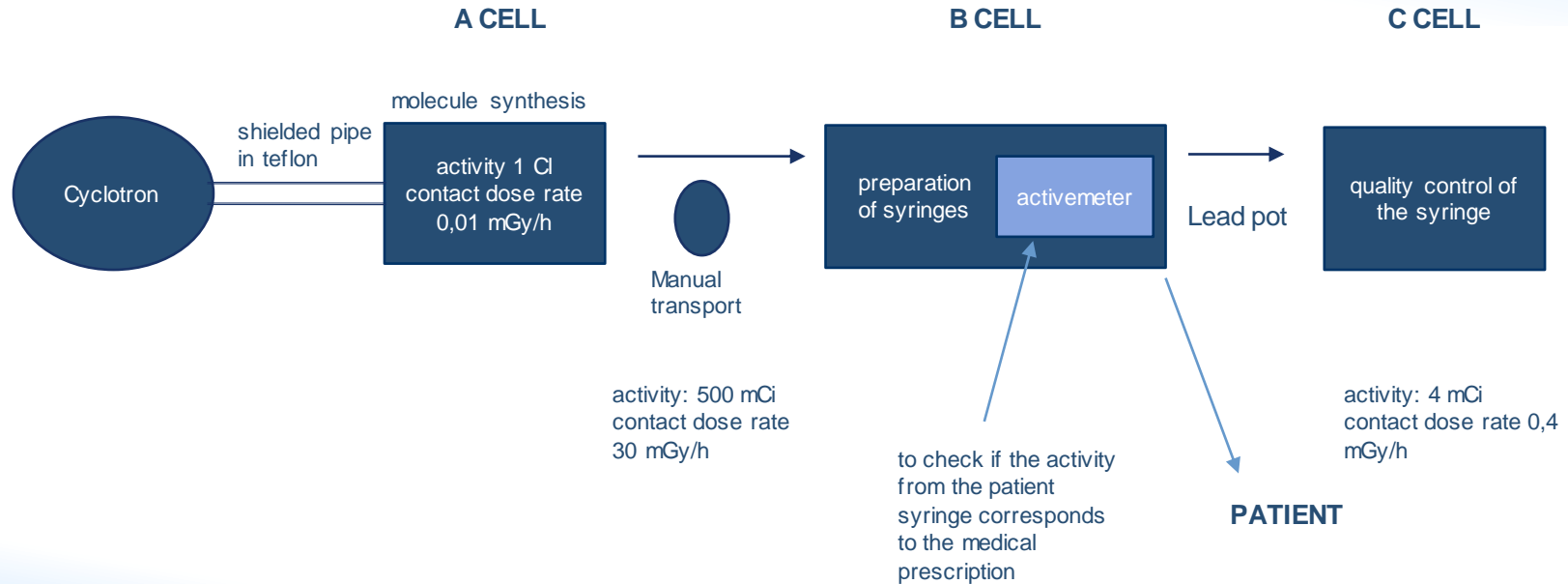To check also what about extremity doses?

Without answers to these questions no further optimisation can be performed

When an operational dosimetry exists it is of help, but often not enough. Why?

Workstation analysis: synthesis of a fluorine 18 molecule and preparation of the injection syringe

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┌─────────────────────────────────────────────┐
│        Synthesis of the molecule (A Cell)     │
└─────────────────────────────────────────────┘
                        │
                        ▼
┌─────────────────────────────────────────────┐
│      Transfer of the molecule towards B Cell  │
└─────────────────────────────────────────────┘
                        │
                        ▼
┌─────────────────────────────────────────────┐
│   Preparation of a *quality control syringe* (B Cell) │
└─────────────────────────────────────────────┘
                        │
                        ▼
┌─────────────────────────────────────────────┐
│   Preparation a syringe for the patient (B Cell) │
└─────────────────────────────────────────────┘
              ↙                    ↘
┌────────────────────────┐  ┌────────────────────────┐
│ Transfer of *the quality│  │ Transport of the patient│
│ control syringe* toward │  │ syringe to the patient  │
│ C Cell                  │  │                         │
└────────────────────────┘  └────────────────────────┘
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6

Workstation analysis: synthesis of a fluorine 18 molecule and preparation of the injection syringe

A CELL

B CELL

C CELL

Cyclotron

shielded pipe in teflon

molecule synthesis

activity 1 Cl
contact dose rate
0,01 mGy/h

Manual transport

activity: 500 mCi
contact dose rate
30 mGy/h

preparation of syringes

activemeter

to check if the activity from the patient syringe corresponds to the medical prescription

Lead pot

PATIENT

quality control of the syringe

activity: 4 mCi
contact dose rate 0,4 mGy/h

Job description: main phases and tasks

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The system will not be analysed up to :

- Transfer of the fluorine Desoxy Glucose up to B Cell
- Preparation of the *quality control* syringe
- Adding physiological solution
- Preparation of the patient syringe
- Re-adjustment of the activity in the syringe
- Transport of the syringe to the patient

The job is then taken by another technician; a specific follow up of the above mentioned tasks is then performed by the RPO several times.

A precise follow up is performed

- To keep track of the dose for each task both at the level of efficient dose and extremity doses, with "ad hoc" dosimeters and follow up of the time spent for each task

- Taking care of the two types of activities encountered during the year

  - ➢ 25 times 28,5 GBq
  - ➢ 50 times 11.1 GBq

Results in terms of effective dose

Main job phases	Effective dose in mSv Manipulated activity 11,1 GBq-300 mCi	Effective dose in mSv Manipulated activity 18,5 GBq-500 mCi
Transfer of the Fluoro Desoxy Glucose up to B Cell	0.022	0.058
Preparation of the *quality control* syringe	0.003	0.022
Adding physiological solution	0.002	0.008
Preparation of the patient syringe	0.009	0.039
Re adjustement of the activity in the syringe	0.009	0.041
Transport of the syringe to the patient	0.003	0.001
Total	**0.049**	**0.170**

What about extremity doses?

More or less between one third and half of the efficient dose came from one task: the manual transfer between Cell A and B

What about extremity doses?

- LiF dosimeters were put on fingers and wrists
- They were not operational (per task), but provided full job dose
- Due to the type of job the break down between tasks should follow the one for efficient dose; therefore when known the global dose to the extremity should be reduced in line with the reduction of the efficient dose

Extremities doses results (1/2)

	Equivalent dose in mSv Manipulated activity 11,1 GBq-300 mCi	Equivalent dose in mSv Manipulated activity 18,5 GBq-500 mCi
Left thumb	0.615	0.650
Right thumb	0.714	0.850
Right wrist	0.210	0.230
Left auricular	0.523	1.2
Right auricular	0.669	1.55
background (reference)	0.006	0.008

Extremities doses results (2/2)

- What is the estimated annual dose to extremities?
- One can assume that the average dose to the hand is
  - 0, 5 and 0,7 mSv respectively for the two types of manipulations (11,1 and 18,5 GBq)
- Therefore the annual dose to the hands should be
  - 0,5* 25= 12,5 mSv

    +

  - 0,7 * 50= 35 mSv
- In total around 50 mSv to the hands (extremities)
- Is it worthwhile to optimise these doses?

Reminders

SOURCE		Absorbed Doses		Equivalent Doses		Effective Doses
Within or outside the body	Emission of radiations →	D_T [Gy] ORGANS	Type of radiations weighting Factors, W_R →	H_T [Sv] ORGANS	Tissues weigthing factors, W_T, And addition →	E [Sv] WHOLE BODY
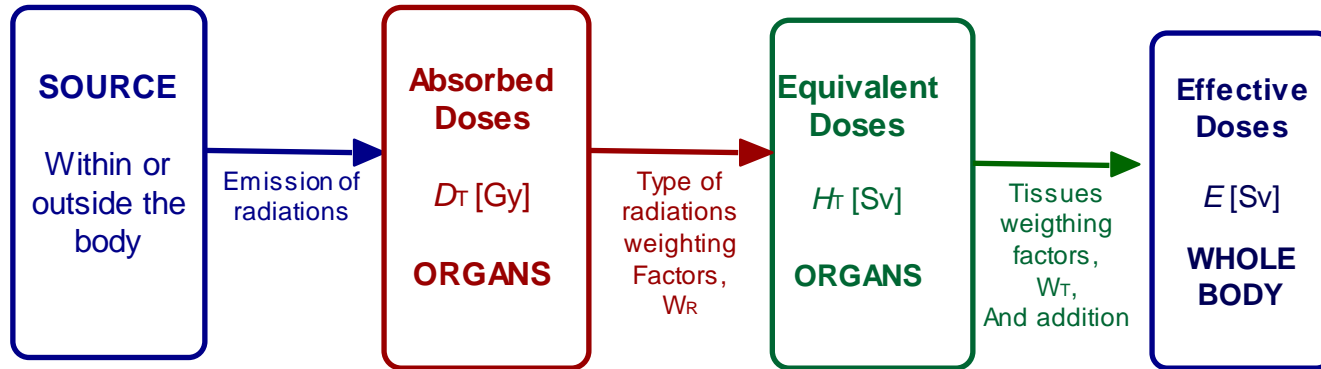
Extremities' doses management with regards to types of effects

Deterministic effects :

- *coping with the specific limits to organs is enough to avoid any deterministic effect, as limits are supposed to be established quite far under the threshold*

Stochastic effects:

- *to check the level of the risk and therefore how to manage it, it is mandatory to make use of the dose risk relationship, i.e. to transform the extremities' equivalent doses into the corresponding efficient doses, making use of the skin W_T as well as of the proportion of the whole body skin surface corresponding to the extremities.*

Extremities doses management with regards to types of effects

- For example :
  - If the limit of dose equivalent 500 mSv is undertaken at the hand level
  - Having in mind that

    The Tissue weighting factor W_T for the skin is 0,01

    And that Extremities represent around 5% of the whole body skin surface
  - We can assume that the efficient dose corresponding to 500 mSv equivalent at the hands is :
  - 500 x 0,01 x 0,05 = 0,25 mSv

To optimize extremities doses?
A first approach

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Of course, as for any dose it has to be put under the dose limit and further reduced, but then taking care of the actual stakes in terms of risks and therefore implementing means adapted and reasonable

Here the equivalent dose is 50 mSv which contribute in terms of efficient dose to 0,025 mSv i.e 25 micro Sievert

Be reasonable means do not focus too much on hand doses

Let envisage an optimization of the efficient dose and expect it will decrease also extremity doses.

Workstation analysis: Identifying options and criteria

As already said the most costly work phase in terms of doses is the manual transfer between cells A and B

Radiation protection options should therefore be envisaged in priority for reducing the dose during that phase

What options?

A single option is envisaged by the RPO and radiochemist to install a shielded pipe in teflon between both cells to avoid any manual transport of the molecule

What criteria?

Only two here: Dose savings and cost of the option

Workstation analysis: Criteria quantification dose savings

- Annual reference dose before option :
  - Only one radiochemist concerned
  - Yearly : 25 casks (containers?) with 28,5 GBq (0,058 mSv/cask)
  - 50 casks with 11.1 GBq (0,0022 mSv/cask)
- **Total : 2,55 mSv/year**

- The option allows to suppressing the exposure
- **i.e 10 years savings: 25,5 mSv**

- To install the pipe will cost 0,16 mSv

- **Net Savings after 10 years: 25,5 - 0,16 = 25,34 Man mSv**

19

Workstation analysis (1):
Criteria quantification Costs

Actual cost of the option : **7290 €**

This includes:

- Purchase cost of the shielded teflon pipe
- Adaptation cost of the pipe to the casks transfers
- Man power for installation

There is no operating cost during the life of the pipe, which should last 10 years.

Is the cost of the option reasonable with regards to the dose savings ?

Workstation analysis (2):
is the option reasonable ?

The cost of the option is considered negligible with regards to the operating budget of the laboratory.

The improvement in terms of equity is considered significant

Implementing the option is considered reasonable

Workstation analysis (3):
The decision making

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Taking into account the technical feasibility and the radiological protection aspects, the decision was to install the shielded pipe in teflon.

Considering the actual stakes, the implementation of that optimization approach and procedure was very simple, pragmatic and not too much formalised.

In most cases the question to be solved is just "to do or not to do" a single action of protection…

… But this is often just a step in the optimization process

Has optimization been truly performed? (1/2)

At the end the radio-chemist remains two times more exposed than the others

Why not to have looked for more options ? And why not to take into account all the other tasks of the radiochemist, even on other workshops?

A question there is the definition/scope of the "system" to be optimized

Another question is that we are not sure that there is no risk of exceeding the extremity dose limit when taking into account the other tasks of the radiochemist as there is no data on these exposures.

So may be also the approach was too restricted for the extremities.

Has optimization been truly performed? (2/2)

➢ So an optimization approach has been actually implemented ; however it was incomplete with regards to what is called the

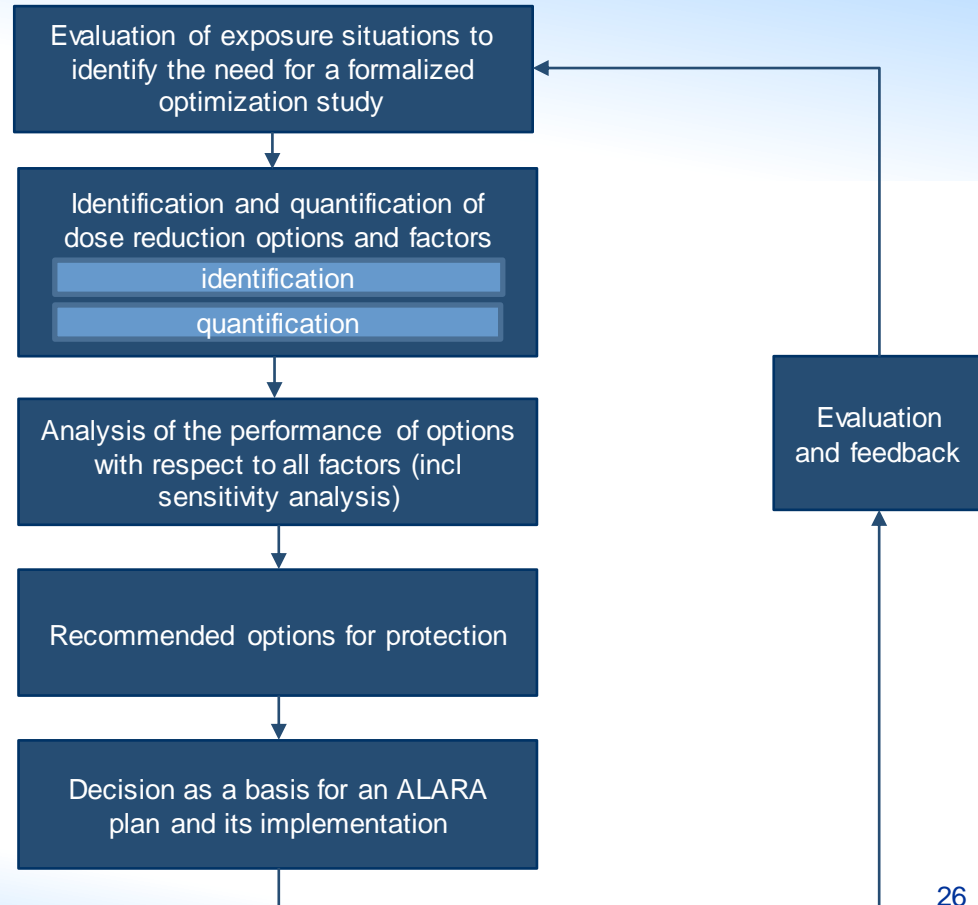*"ALARA or Optimization of protection and safety procedure".*

The radiation protection optimization procedure

Recognition of the problem

ALARA Procedure

Radiation protection factors

other factors

Final decision
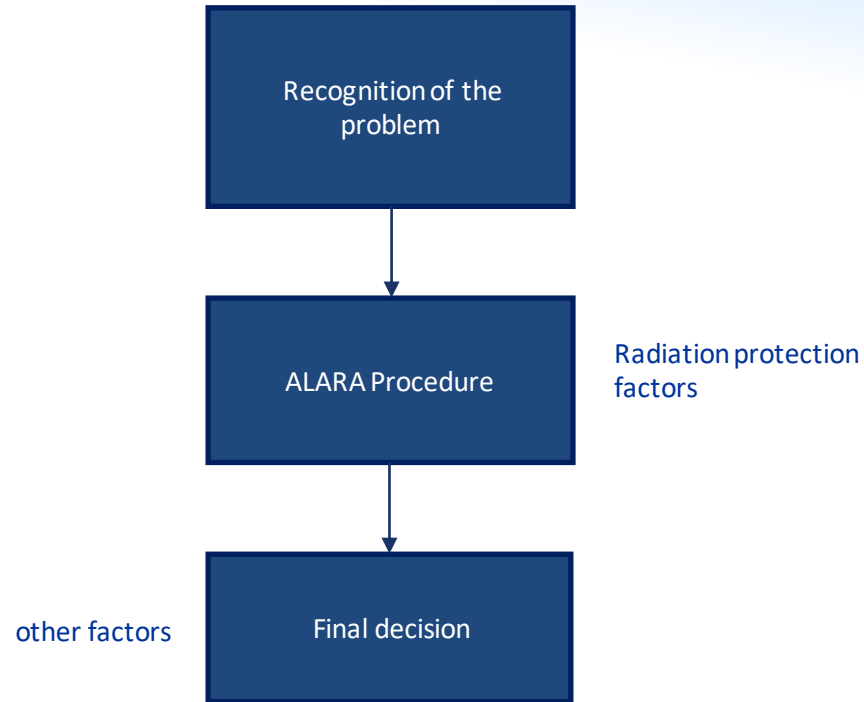
The radiation protection optimization Procedure

The procedure is a simple checklist of steps that structure the approach to any problem or decision in radiation protection.

One can find a lot of information on the optimisation process and procedure in the IAEA Safety report no. 21, 2002 (under revision)

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Evaluation of exposure situations to
identify the need for a formalized
optimization study
        ↓
Identification and quantification of
dose reduction options and factors
    [ identification ]
    [ quantification ]
        ↓
Analysis of the performance of options
with respect to all factors (incl
sensitivity analysis)
        ↓
Recommended options for protection
        ↓
Decision as a basis for an ALARA
plan and its implementation
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Evaluation and feedback

Conclusions

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The Optimization procedure helps towards standardizing the process of decision making.

The level of the decision usually dictates the amount of effort and detail that should be devoted to the study and the presentation of the results.

Here the stakes were not so important: therefore it took a few hours for the RPO and the radiochemist to perform that analysis and to provide the decision maker with enough elements.

Other studies can be much more time consuming and need the involvement of the hierarchy, even some times top managers.