Clearance of nuclear biomedical waste:

General concept and potential problems/solutions

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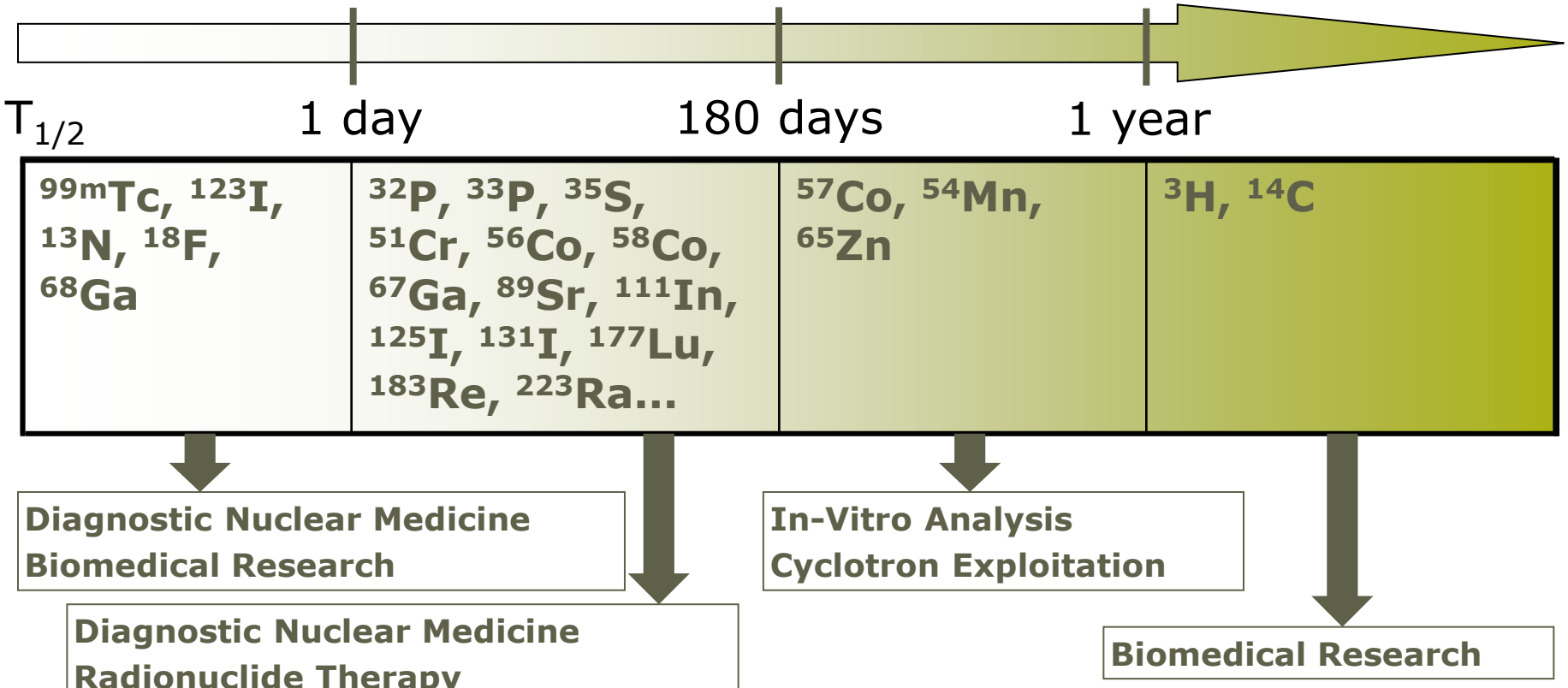
Origin of nuclear waste in a research and medical facility?

Applications

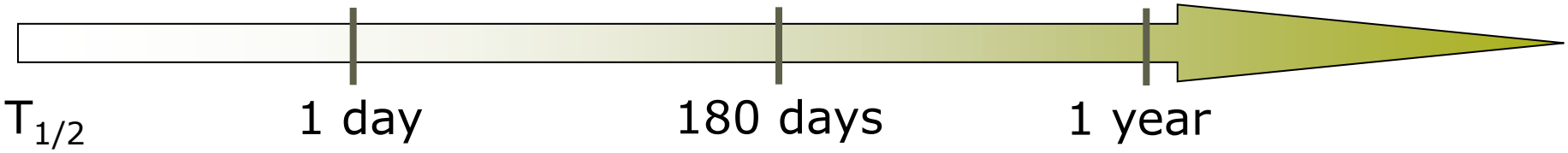
- **Diagnostic Nuclear Medicine**
- **Radionuclide Therapy**
- **In-Vitro Analysis (medical purpose)**
- **Biomedical Research**
- **Cyclotron Exploitation**
- **Brachytherapy**
- **Decommissioning of Cyclotron and LINAC(s)**
- **Used Calibration Sources**

Daily Waste Streams

Radionuclides in nuclear biomedical waste

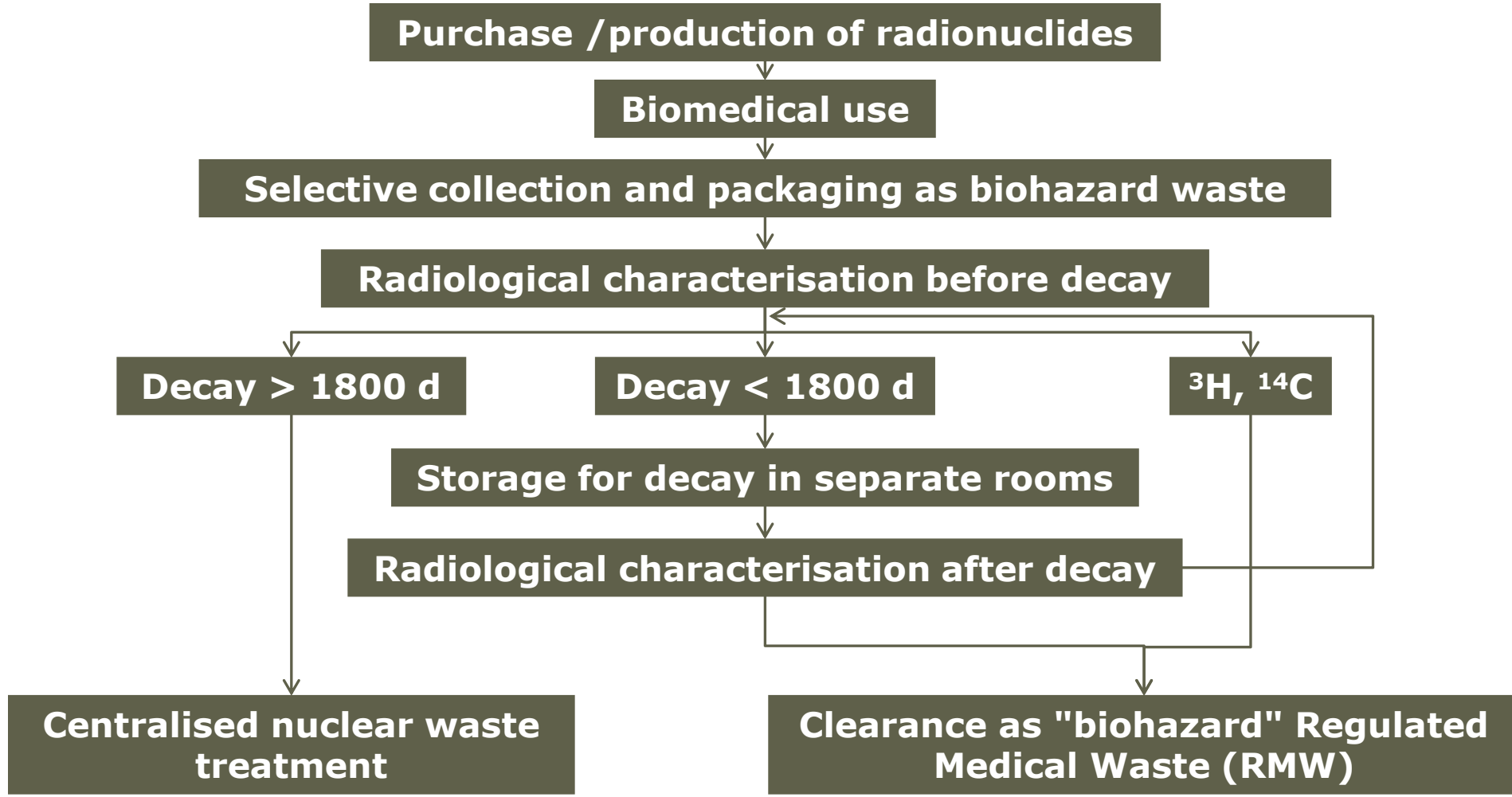


Radionuclides in nuclear biomedical waste



^{99m}Tc, ^{123}I, ^{13}N, ^{18}F, ^{68}Ga	^{32}P, ^{33}P, ^{35}S, ^{51}Cr, ^{56}Co, ^{58}Co, ^{67}Ga, ^{89}Sr, ^{111}In, ^{125}I, ^{131}I, ^{177}Lu, ^{183}Re, ^{223}Ra...	^{57}Co, ^{54}Mn, ^{65}Zn	^{3}H, ^{14}C
Produced activities			
~90%	~8%	~1%	~1%
Produced Volumes			
~20%	~70%	~5%	~5%
Typical activity concentrations at time of waste production (kBq/kg)			
1000-10000	1-100	1-10	1-100

General concept storage for decay nuclear biomedical waste



Physical/Chemical Characteristics

Liquid (~ 10% total volume)

- **Organic solvents**
- **Various aqueous solutions**
- **Patient excreta**

Solid (~ 90% total volume)

- **Used protective clothing, shoes, gloves, benchcoat,…**
- **Lab consumables (plastic, glass)**
- **Small metal parts (scalpels, needles,…)**
- **Syringes, vials with residual small volumes of liquids**
- **Not all waste actually contaminated but potentially contaminated**

No deliberate dilution

Selective collection at radionuclide level

Indispensable for the concept of storage for decay of short lived waste

Automatically at certain level

- **Typical department related radionuclides**
- **Recordkeeping incoming radionuclides /activities**

Advanced selective collection

- **Based on half-lives → single radionuclides (or –groups)**
- **Based on emission characteristics → avoids interference**
- **Department specific exceptions → optimise RP during collection**

The designation "biohazard" – regulated medical waste

Both solid and liquid in many (but not all) cases "biohazard"

Both solid and liquid prepared, packaged and treated as "biohazard" in all cases!

- **Mixed combustible and non-combustible**
- **Hermetically closed!**
- **Physically protected by sharp objects!**
- **Fixed geometry during characterisation**
- **Stackable during storage for decay**
- **Incineration guaranteed after clearance (also for liquid waste)**

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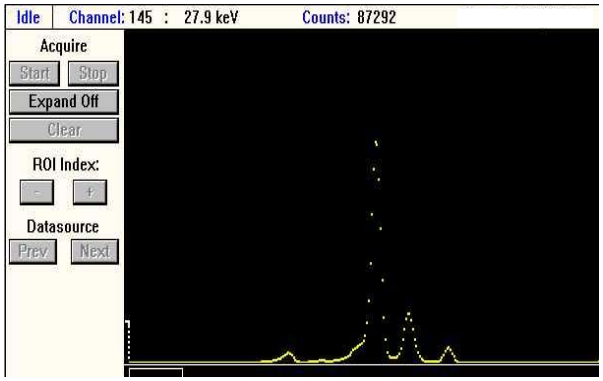
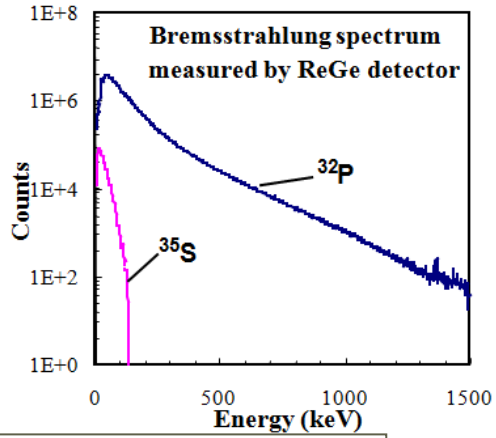
Radiological characterisation The cornerstone!

γ-spectrometry, integral bremsstrahlung spectrometry





Integral quantitative measurements of waste packages solid waste

20 ml samples liquid waste β/γ-emitters, pure β-emitters

Liquid Scintillation Counting

20 ml samples liquid waste pure β-emitters

Radiological characterisation before decay / after decay

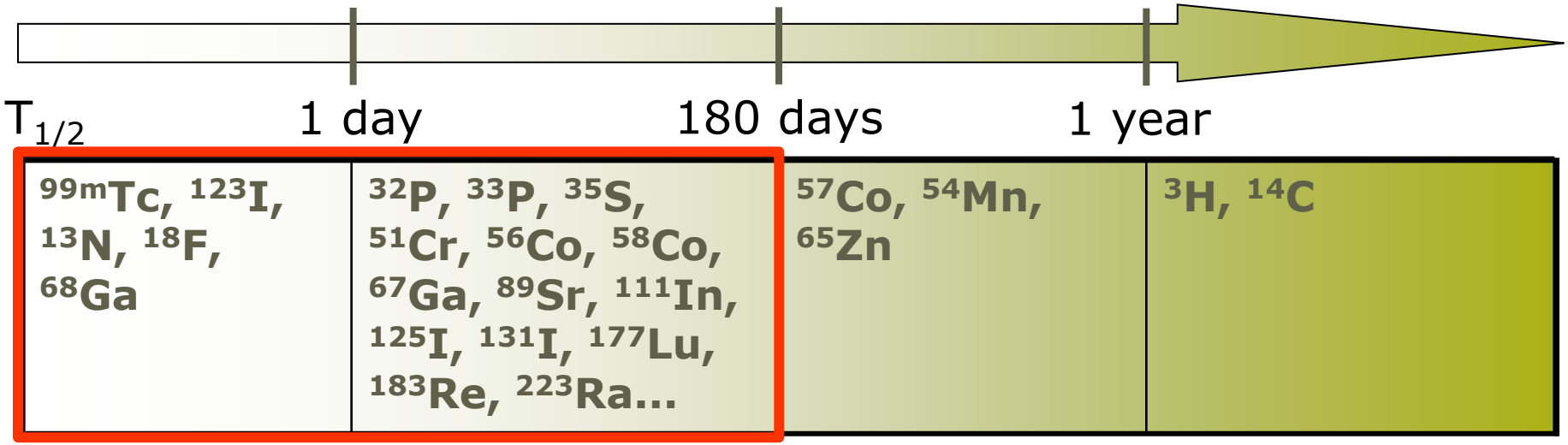
Before

- **Better statistics**
- **Optimisation of decay period**
- **Possibility of clearance far below MDA**

After

- **Final clearance measurement**
- **Second characterisation to correct incorrect or incomplete results**
- **Always redirection of waste possible**

Theoretical decay periods → practical clearance levels



Regulatory minimum

Start act. conc. after 10x$T_{1/2}$

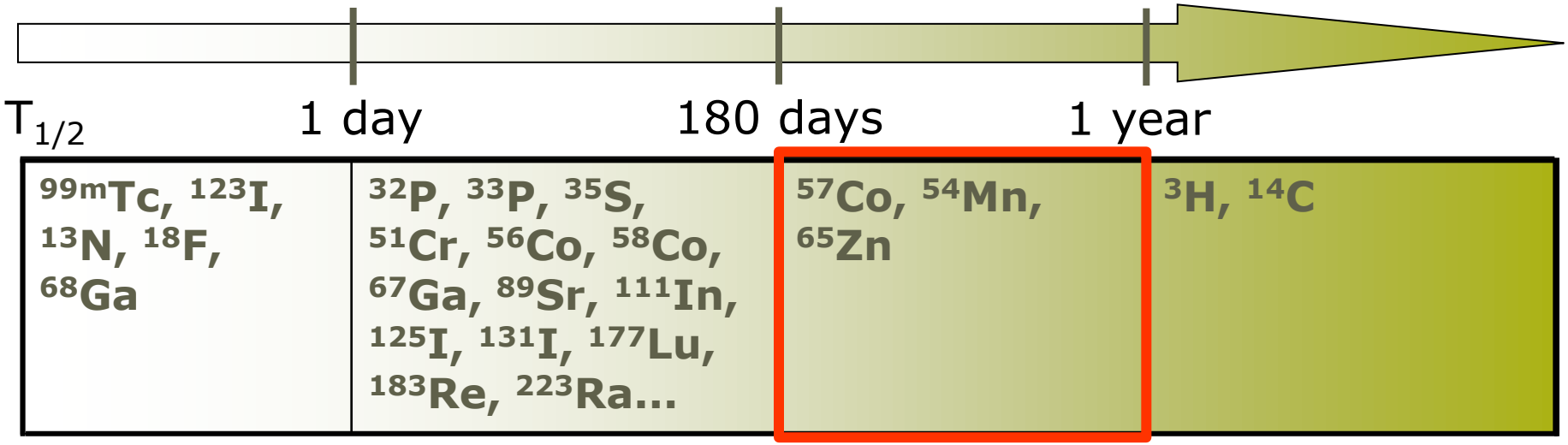
$$\Delta T_i = 10 \times T_{1/2,i} + \left[\ln\left(\frac{A_{C,i}}{1024 \times C_{R,i,1\%}} \right) \right] / \lambda_i$$

1%="almost complete decay"

$A_{c,i}$: Corrected activity conc. (measured+uncertainties) of radionuclide i before decay (Bq/kg)

$C_{R,i,1\%}$: 1% of the Regulatory clearance level for radionuclide i, Annex 1B RD (Bq/kg)

Theoretical decay periods → practical clearance levels



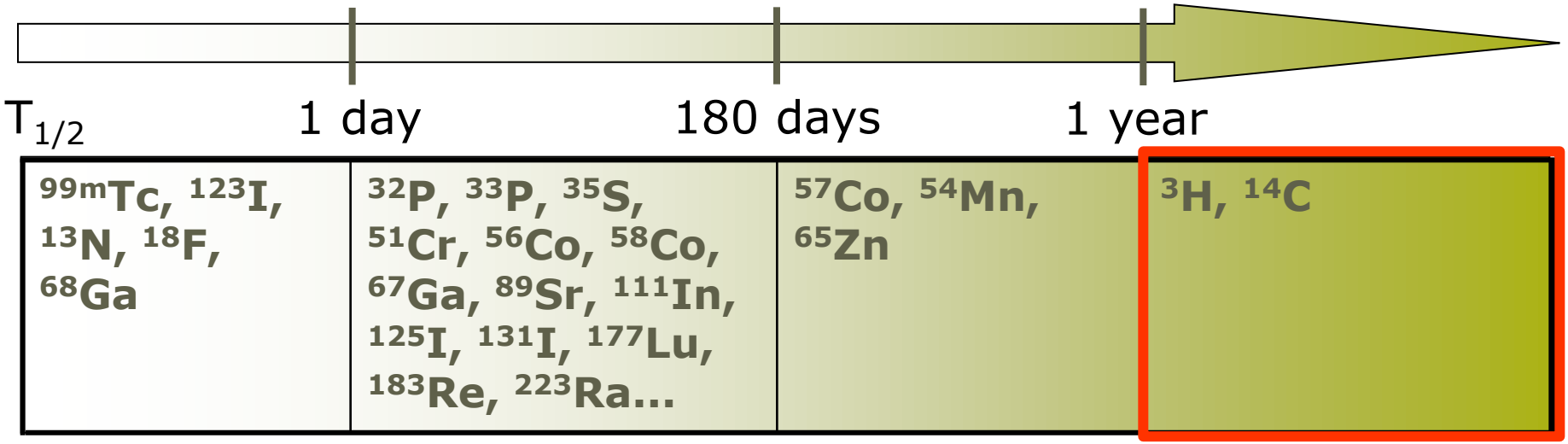
$$\Delta T_i = \left[\ln\left(\frac{A_{C,i}}{C_{R,i,50\%}} \right) \right] / \lambda_i$$

50%= ALARA approach

$A_{c,i}$: Corrected activity conc. (measured+uncertainties) of radionuclide i before decay (Bq/kg)

$C_{R,i,50\%}$: 50% of the Regulatory clearance level for radionuclide i, Annex 1B RD (Bq/kg)

Theoretical decay periods → practical clearance levels



Characterisation difficulties, relatively high costs centralised treatment

Limited quantities, limited concentrations

Clearance (incineration) through license (art 18 RD) for both liquid and solid waste

- First decay of other radionuclides where appropriate
- Limit on yearly cleared activity: 500 MBq, 5 MBq
- Limit on activity concentration: 10^9 Bq/kg, 10^7 Bq/kg

To clear, or not to clear?

To be clear, or not to be clear?

Clearance of liquid waste? Use the letter or the spirit?

Article 34

Release of liquid waste in surface water of sewer systems

→ **Difficult to adopt for biomedical waste**

Recent extension Article 18

License needed for clearance of liquid waste

License needed if liquid waste = solid waste?

Clearance levels in Annex 1B for liquid waste?

Article 35.2 RD 20/01/2001: Use the letter or the spirit?

Article 35.2 §1 very clear

Clearance according levels in annex 1B + ALARA

→ **cfr FANC directive clearance 30/04/2010**

Article 35.2 §2 not so clear

Institutions where radionuclides $T_{1/2}$ < 6 months are used

- **Levels in annex 1B not valid**
- **Storage for decay for at least 10x$T_{1/2}$**
- **Storage for decay until almost complete decay**

Article 35.2 RD 20/01/2001: Use the letter or the spirit?

Can we apply organised storage for decay for waste containing radionuclides with $T_{1/2}$ > 6 months?

Spirit: limit on the storage for decay period, avoiding arising nuclear passive

Why not specify limit on the storage for decay period in the license?

Do we need to apply storage for decay for at least 10x$T_{1/2}$?

Spirit: Solution when one is unable to define accurately the activity concentration in waste (e.g. hospitals without dedicated measuring systems)

What if one is able to specify the activity concentration before decay?

$$\Delta T_i = \cancel{10 \times T_{1/2,i}} + \left[\ln\left(\frac{A_{C,i}}{\cancel{1024} \times C_{R,i,1\%}} \right) \right] / \lambda_i$$

In case $A_{c,i}$ < $MDA_{c,i}$:

$$\Delta T_i = \left[\ln\left(\frac{MDA_{C,i}}{C_{R,i,1\%}} \right) \right] / \lambda_i$$

Article 35.2 RD 20/01/2001: Use the letter or the spirit?

"Almost complete decay" in an exponentially decreasing function?

Spirit: implement ALARA for short-lived waste using relatively limited additional decay

"almost complete decay" translated in a fraction of the clearance level of annex 1B?

Fixed fraction (10%, 1%, 0.1%)?

Weighted fraction?

Numerical value enables an optimisation of the decay period after accurate measurement

To conclude…

Management of nuclear biomedical waste

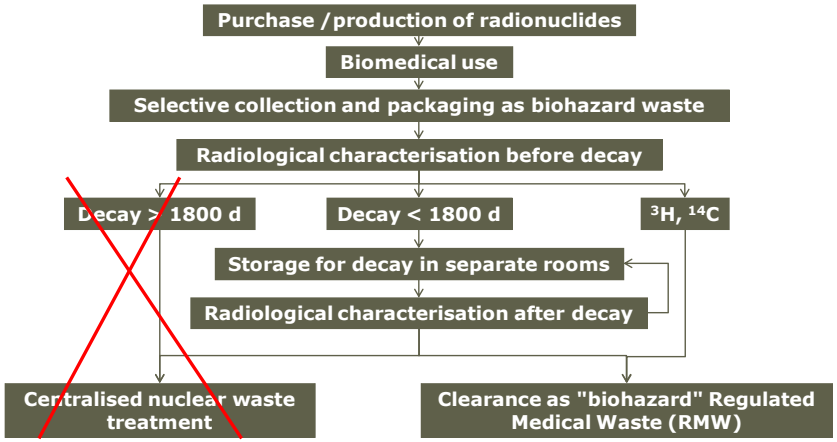
Focused on short- and "medium-" lived waste

Decay storage program at VUB-UZ in operation for 20 years

Based on 2 characterisations

Clearance at ALARA activities

Today: all waste streams cleared within ~1200 days
(Yearly ~ 20 000 m^3, ~ 4 000 kg)



Clear some RD articles?

Thanks for the attention!