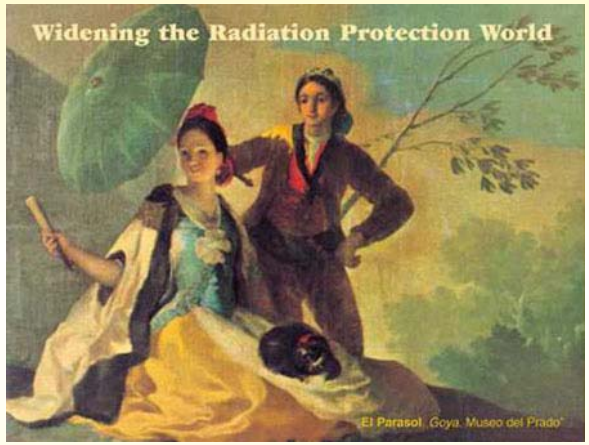
International Radiation Protection Association
11th International Congress
Madrid, Spain - May 23-28, 2004



Refresher Course 2a

Justification, Optimisation and Decision-Aiding in Existing Exposure Situations

Per Hedemann-Jensen - Section of Applied Health Physics
Danish Decommissioning - Risø
DK - 4000 Roskilde, Denmark

Outline of presentation

- system of protection for practices
- system of protection for interventions
- decision-aiding/-making in radiation protection
- societal aspects and radiation protection
- stakeholder involvement in decision-making
- upcoming ICRP recommendations
- summary and conclusions

Characterising practices

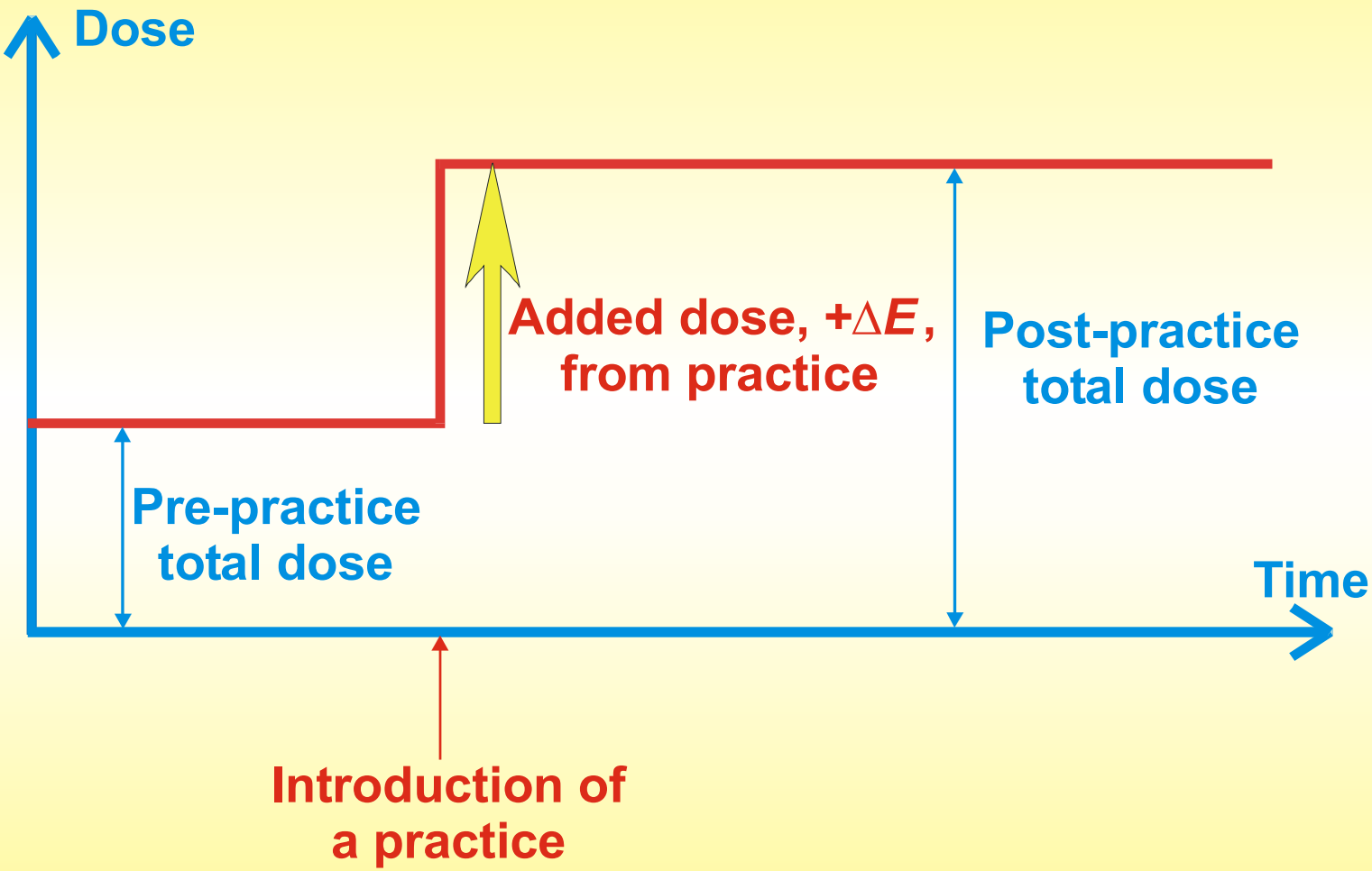
Any human activity that:

- introduces additional sources of exposure or exposure pathways
- extends exposure to additional people
- modifies the network of exposure pathways from existing sources, so as to:
  - increase the exposure of people
  - increase the likelihood of exposure of people
  - increase the number of people exposed

Examples on practices

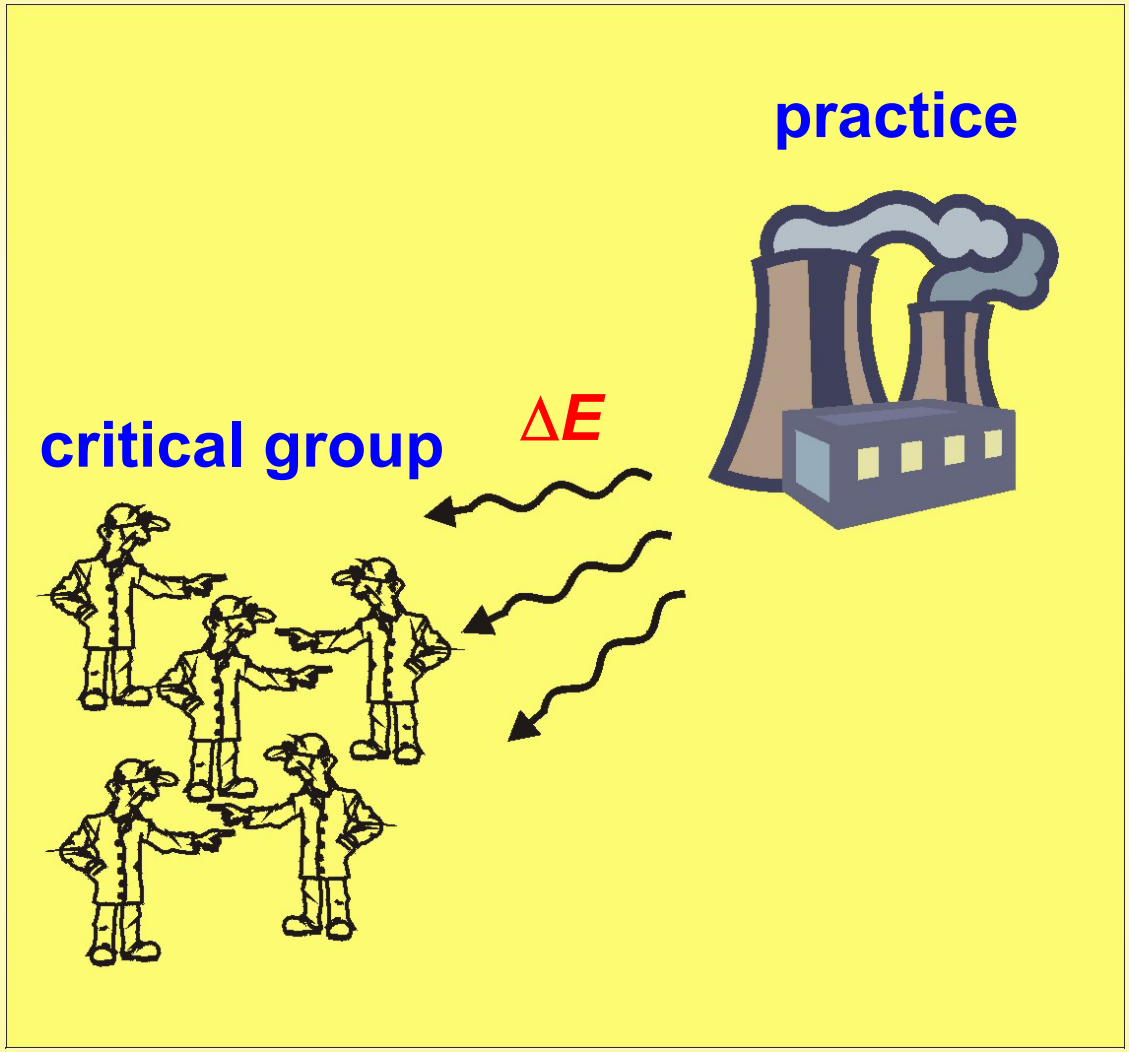
- nuclear power plants
- nuclear research facilities
- nuclear fuel fabrication plants
- radioactive waste treatment facilities
- nuclear fuel reprocessing plants
- departments for radiation diagnostic and therapy
- radioisotope production facilities
- workplaces with elevated natural radiation

System of protection - Practice

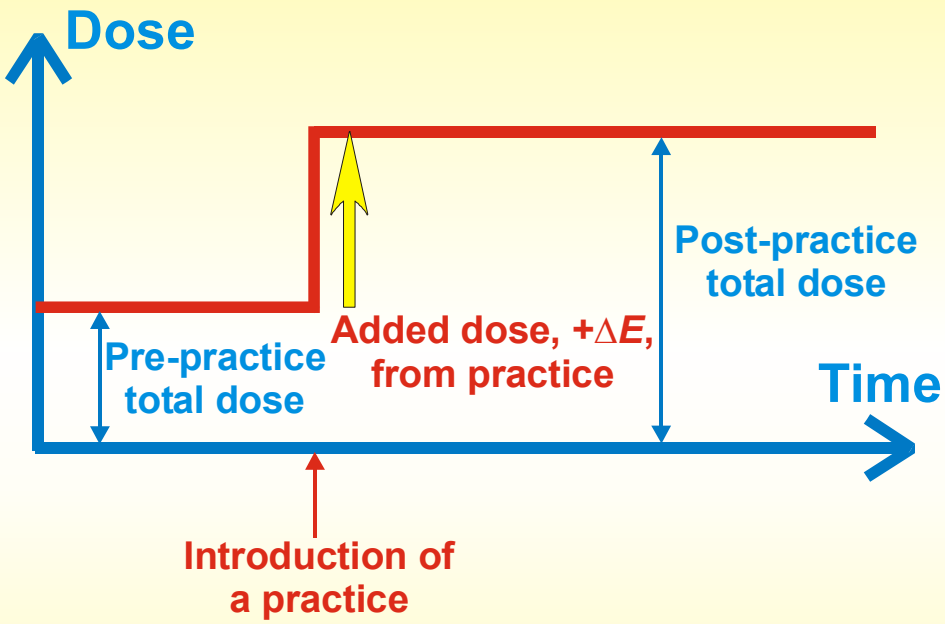


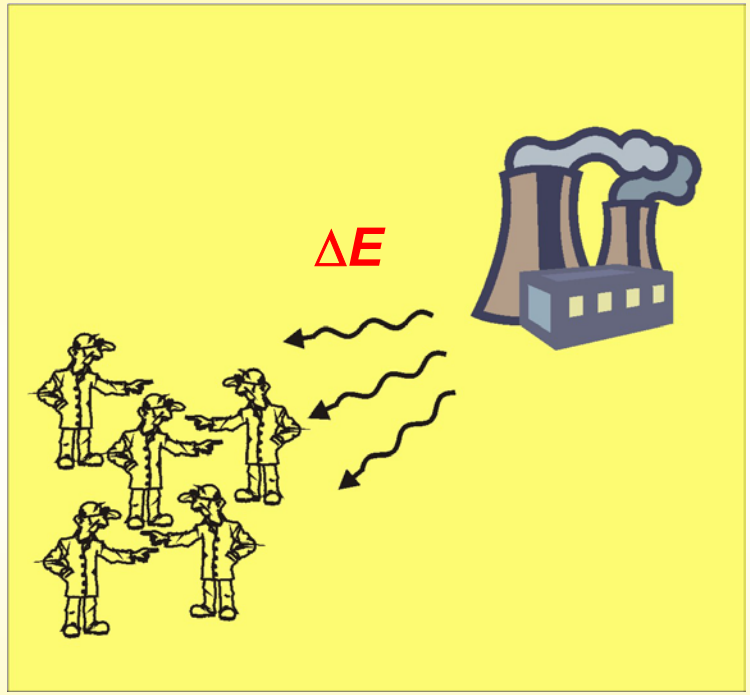
SOURCE- AND INDIVIDUAL-RELATED PROTECTION FOR PRACTICES

Source-related protection - practices



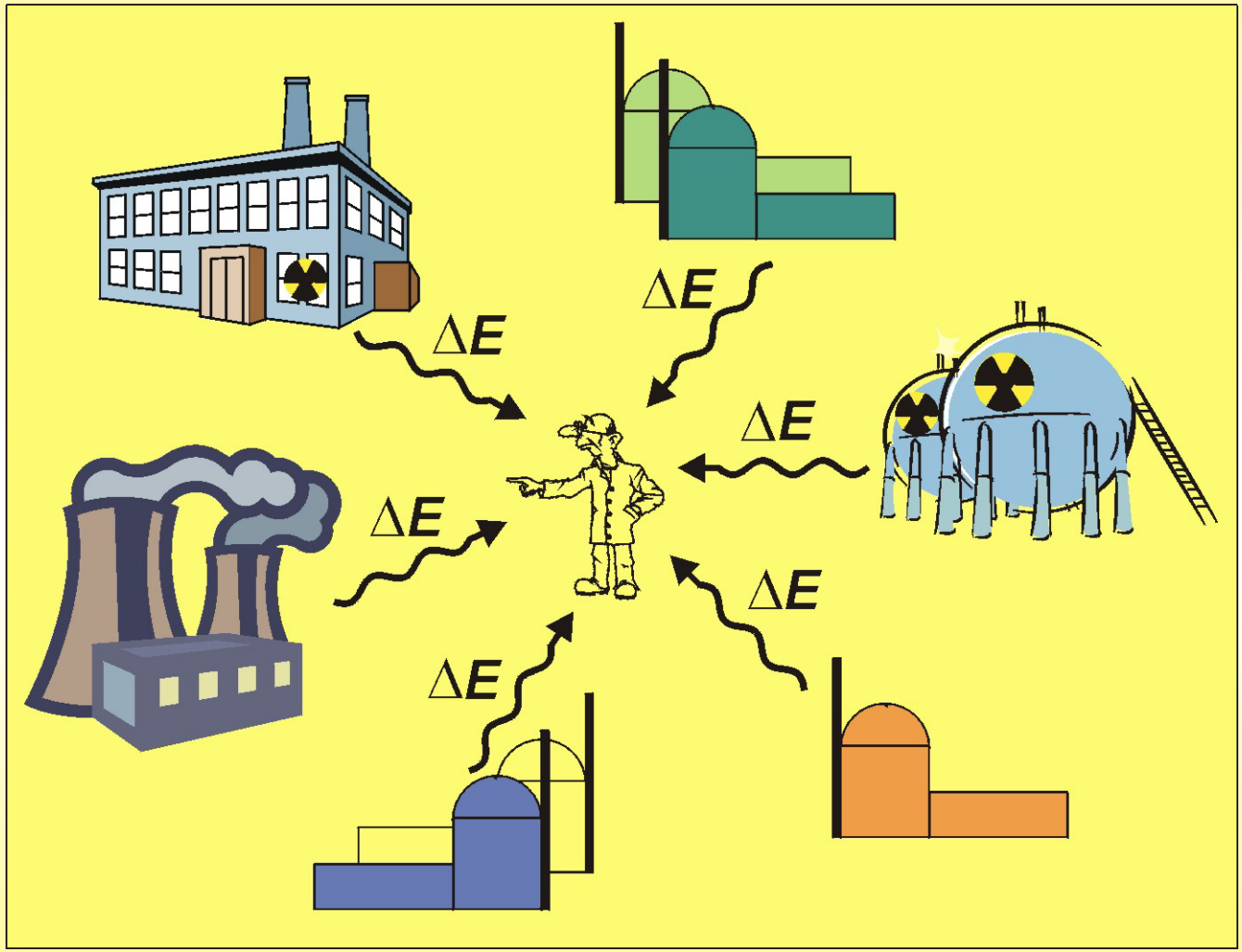
Dose constraints for practices



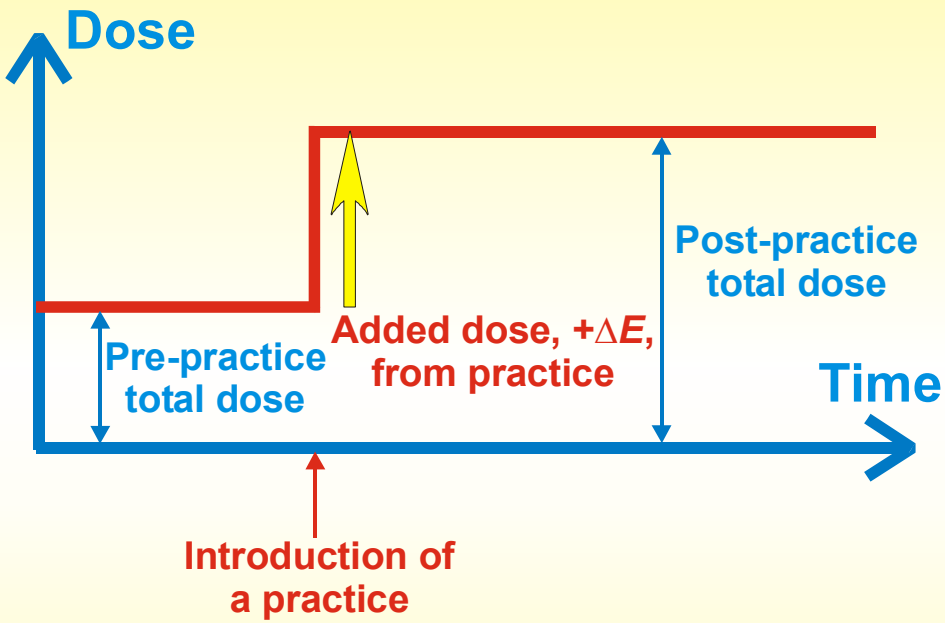


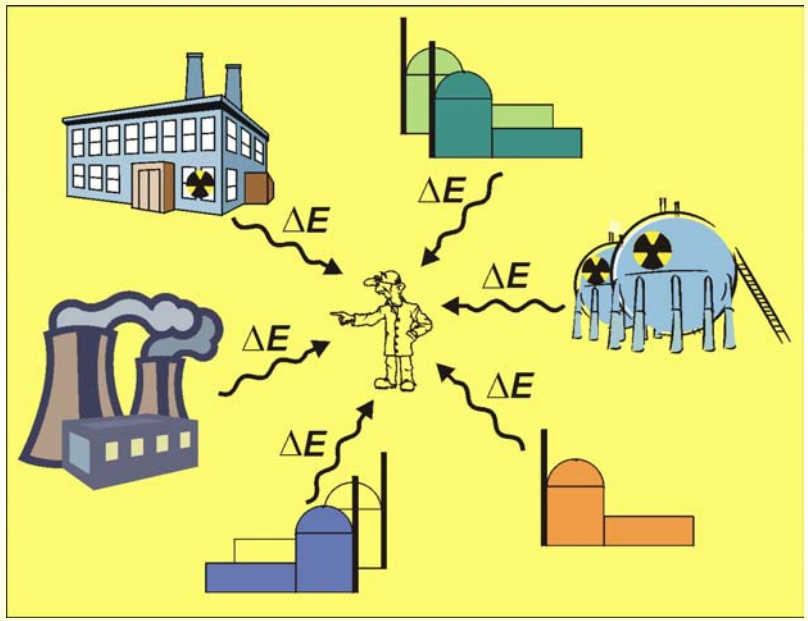
$$\Delta E \leq f \cdot E_{limit}$$

Individual-related protection - practices



Dose limits for practices





$$\Sigma \Delta E \leq E_{limit}$$

Dose constraints and dose limits for public exposure from practices

- **Typical dose constraints:**

  0.1 - 0.3 mSv/a as effective dose

- **Dose limit:**

  1 mSv/a as effective dose

Characterising interventions

Any action intended to:

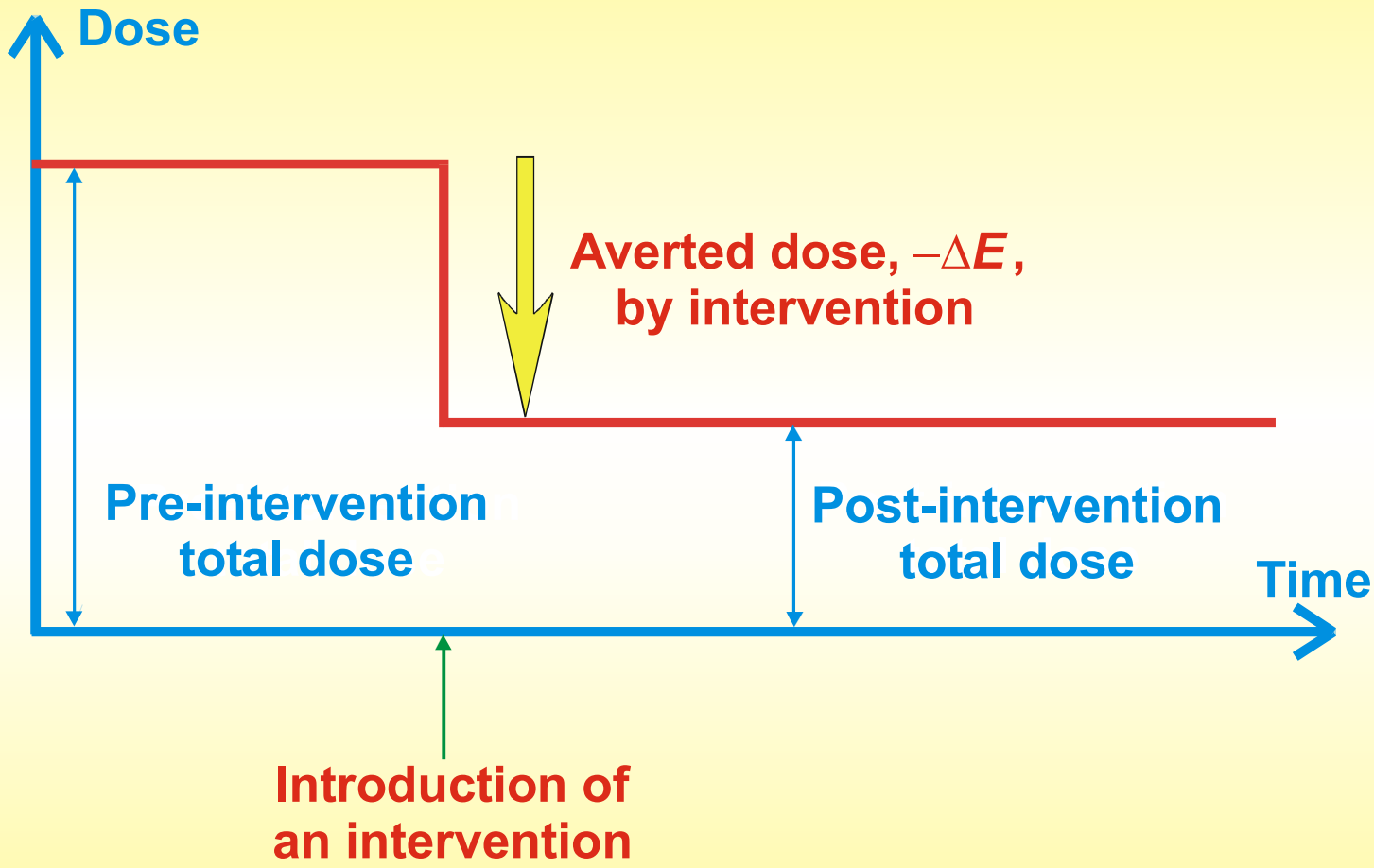
- **reduce or avert exposure to sources, or**
- **reduce or avert the likelihood of exposure to sources,**

which are not part of a controlled practice or which are already existing and out of control, *e.g.* as a consequence of an accident

Existing exposure situations which might require intervention

- natural gamma-emitters in buildings and soil
- radon in dwellings
- past activities and practices
- military operations and nuclear weapons testing
- nuclear or radiological accidents
- waste and by-products from NORM-industries

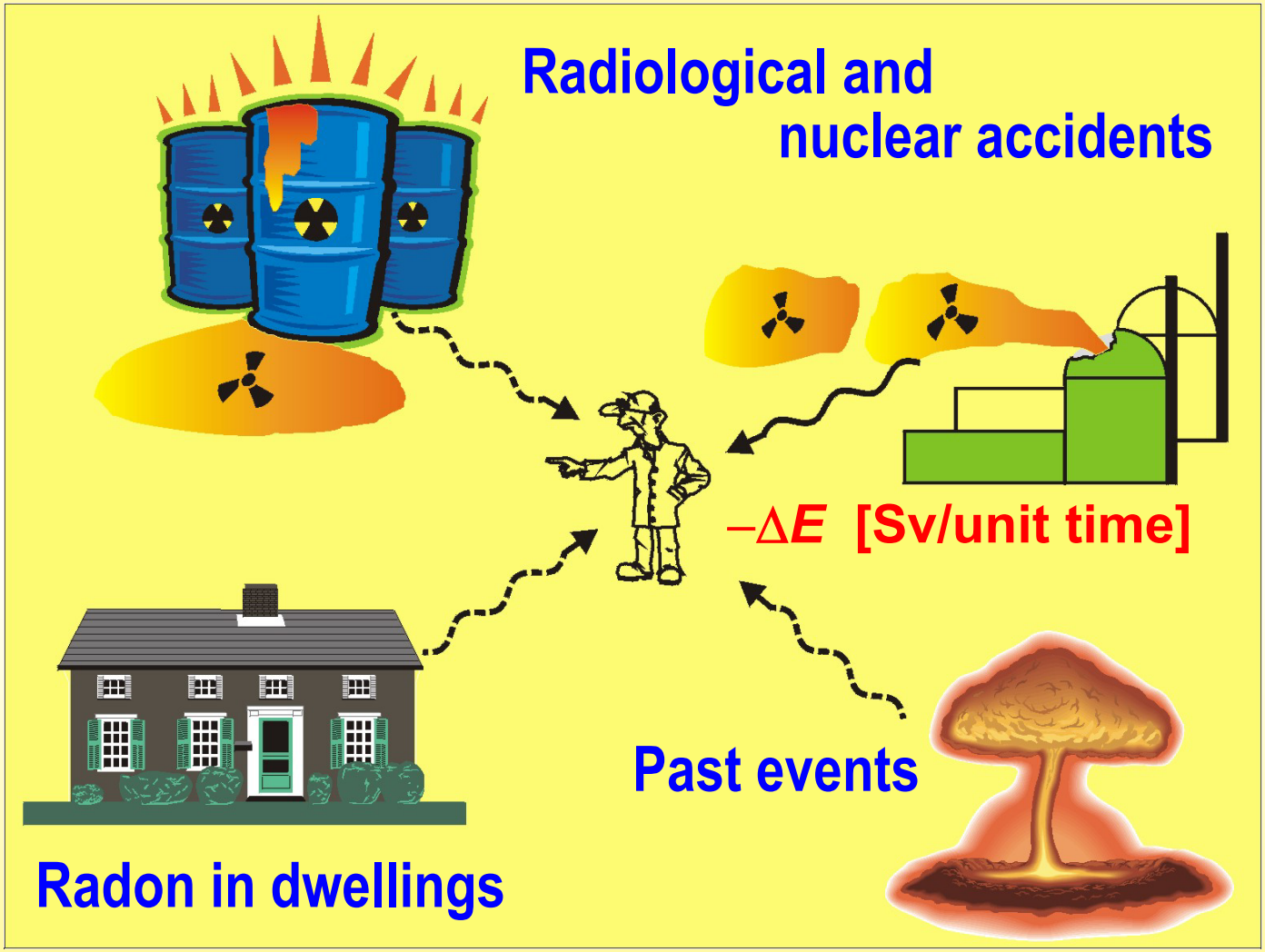
System of protection - Intervention



SOURCE- AND INDIVIDUAL-RELATED PROTECTION FOR INTERVENTIONS

Source-related protection - interventions

Individual-related protection - interventions



Practices versus interventions

- **Practices ADD exposures**
- **Interventions SUBTRACT exposures**

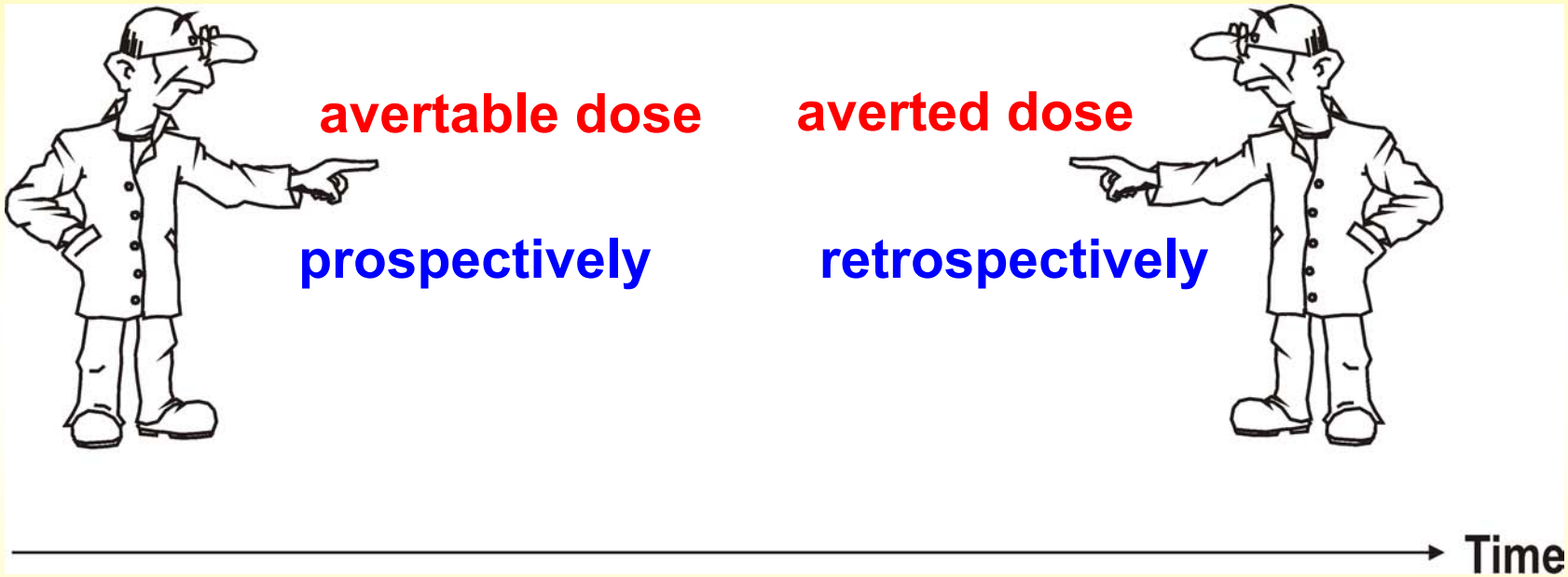
Distinguishing practices from interventions

***The ability to choose a priori whether to accept beneficial sources and the consequent exposures*:**

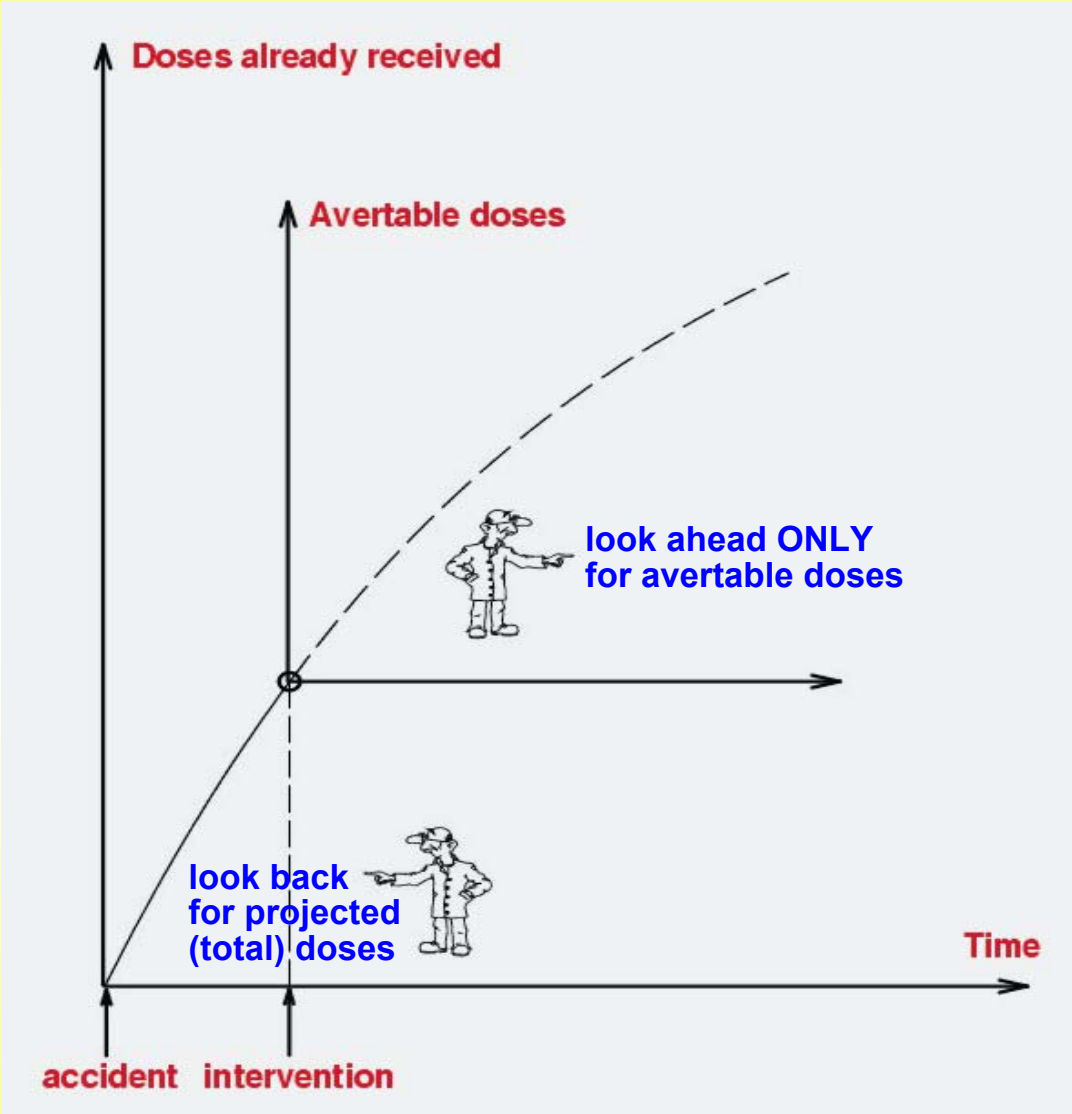
- **If a choice is still available, the exposure can usually be said to be due to a practice**
- **The control of annual doses attributable to the practice can and should be planned in advance**
- **Subsequent steps to reduce the annual doses attributable to the practice are improvements in the practice and not necessarily an intervention**
- **If there is *no choice*, because the sources already exist, any action taken to reduce exposures is an intervention**

DOSE QUANTITIES FOR INTERVENTION

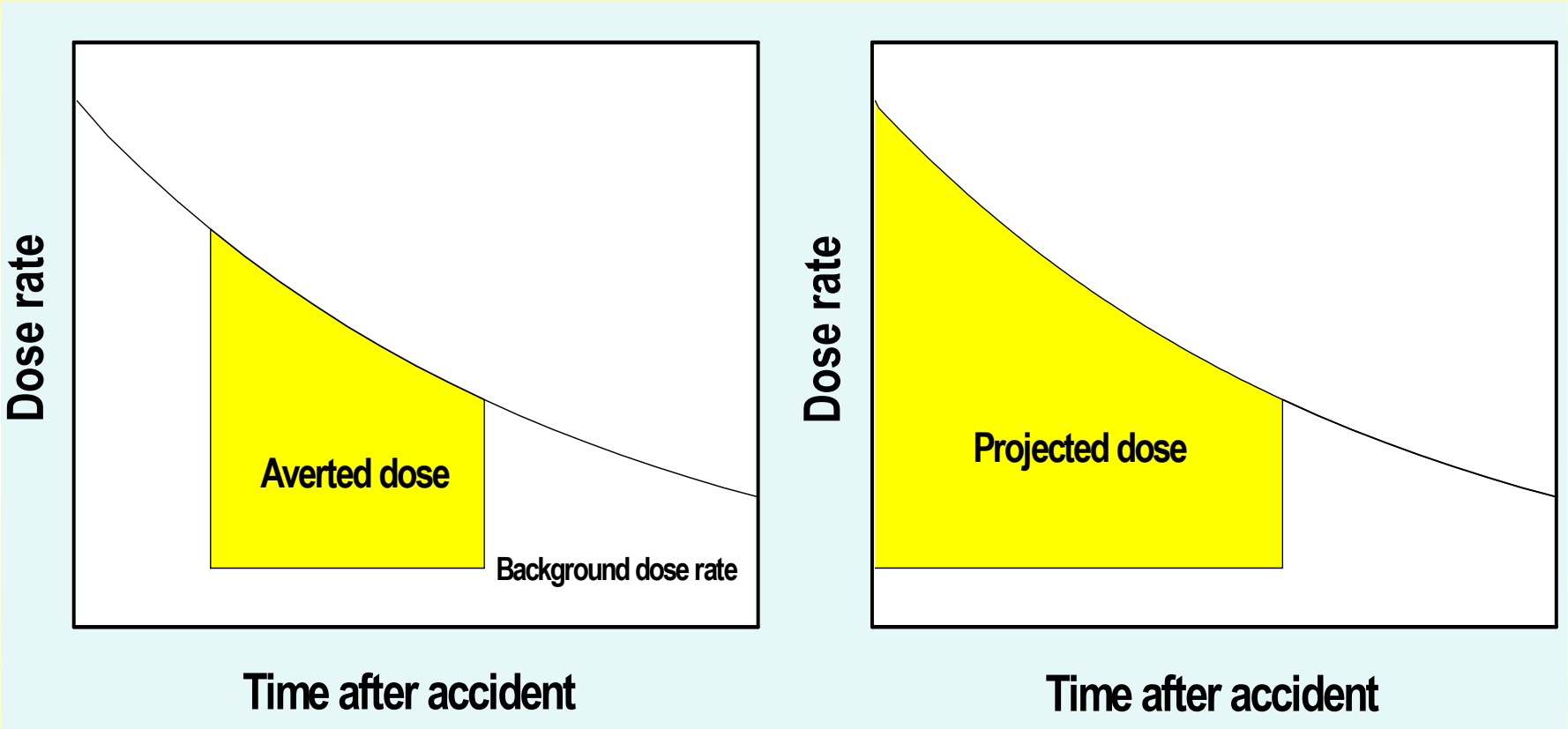
Avertable and averted dose



Avertable and projected dose



Avertable and projected dose over time



Example on avertable dose by relocation

Measured outdoor effective dose rate in an urban area from deposited long-lived activity:

20 μSv/h

Time-averaged location factor accounting for indoor and outdoor occupancy and shielding by buildings:

0.3

Avertable effective dose from relocation in a month:

$E_{avertable} = 0.3 \times 20\ \mu Sv/h \times 720\ h/month = \underline{4\ mSv/month}$

PRINCIPLES FOR INTERVENTION

Justification of intervention

The proposed intervention should do more good than harm, *i.e.* the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs of the intervention

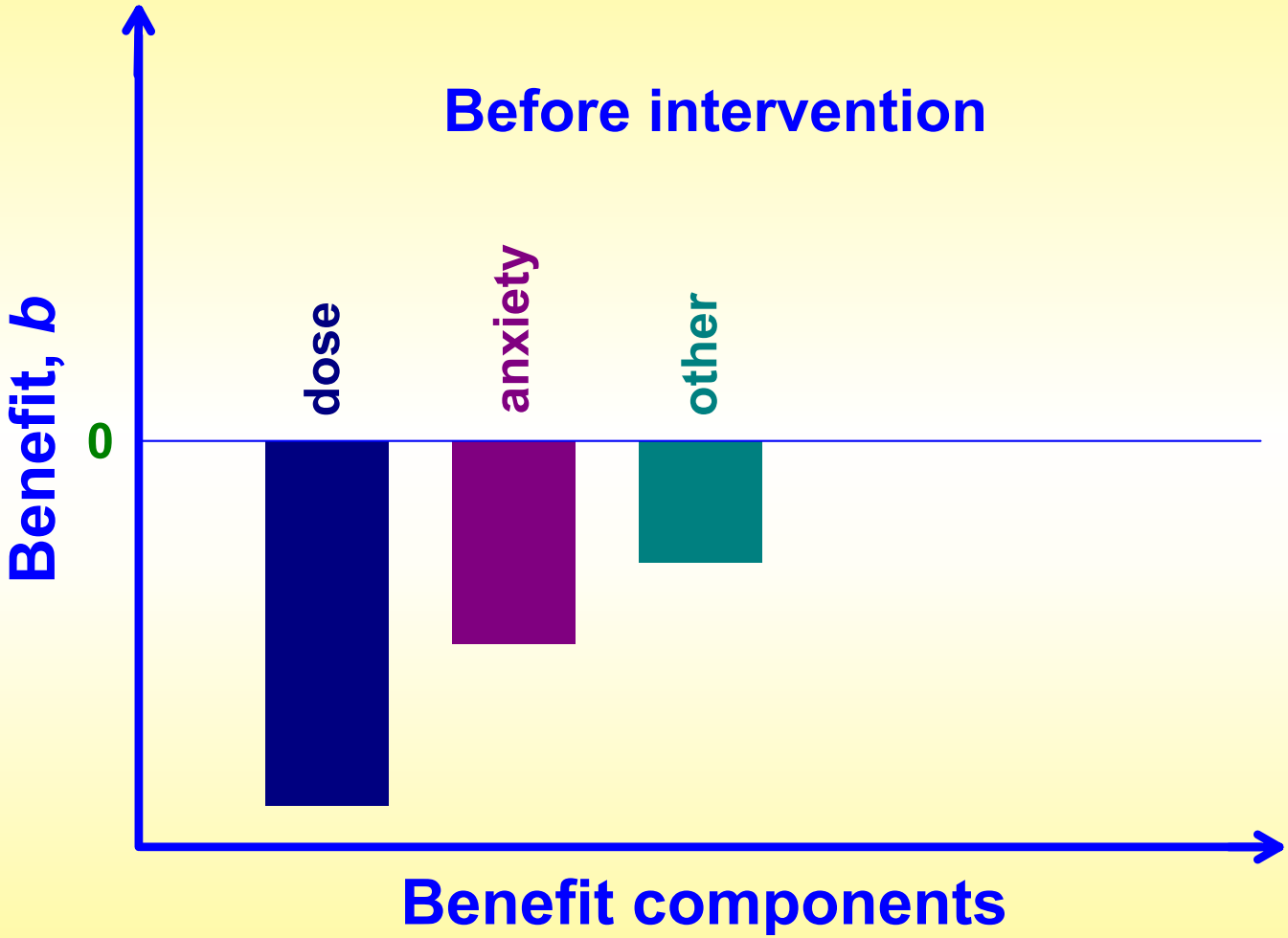
Radiation protection attributes

- individual and collective radiation risks to population
- individual and collective physical risks to population by the protective measures
- individual and collective risks to personnel carrying out the protective measures
- monetary costs of the protective measures

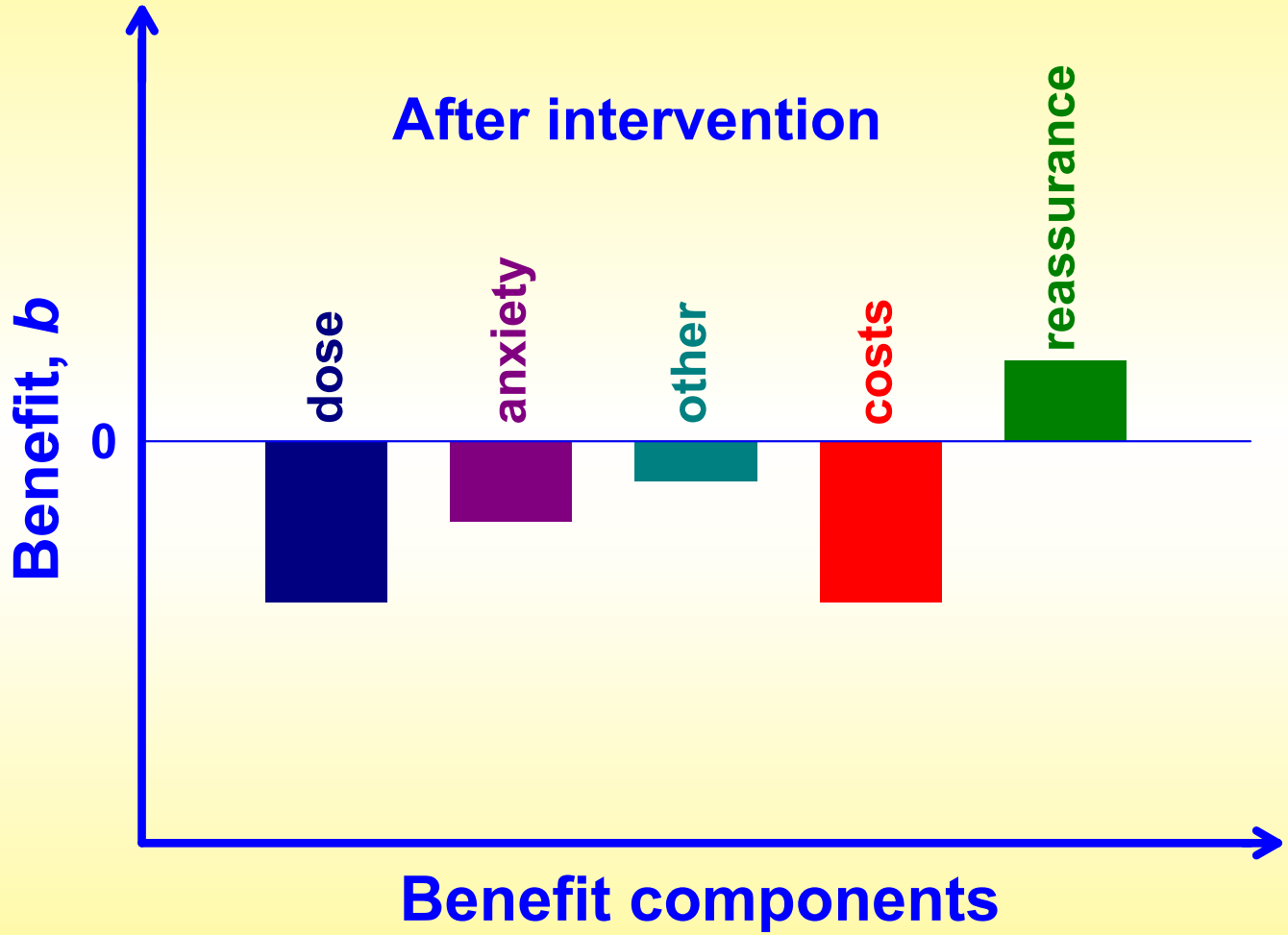
Non-radiation protection attributes

- perception of risk
- anxiety and other psychological impacts
- reassurance by protective measures
- individual and social disruption
- political considerations
- many others

Justification of intervention



Justification of intervention



Net benefit of intervention

$$\Delta B = \sum_i b_i(\text{after}) - \sum_i b_i(\text{before})$$

b_i are the benefit components (positive and negative)

$\Delta B > 0 \Rightarrow$ the intervention option is justified

Optimisation of protection

The form, scale, and duration of the intervention should be optimised so that the net benefit of the reduction of dose, less the detriment associated with the intervention, should be maximised

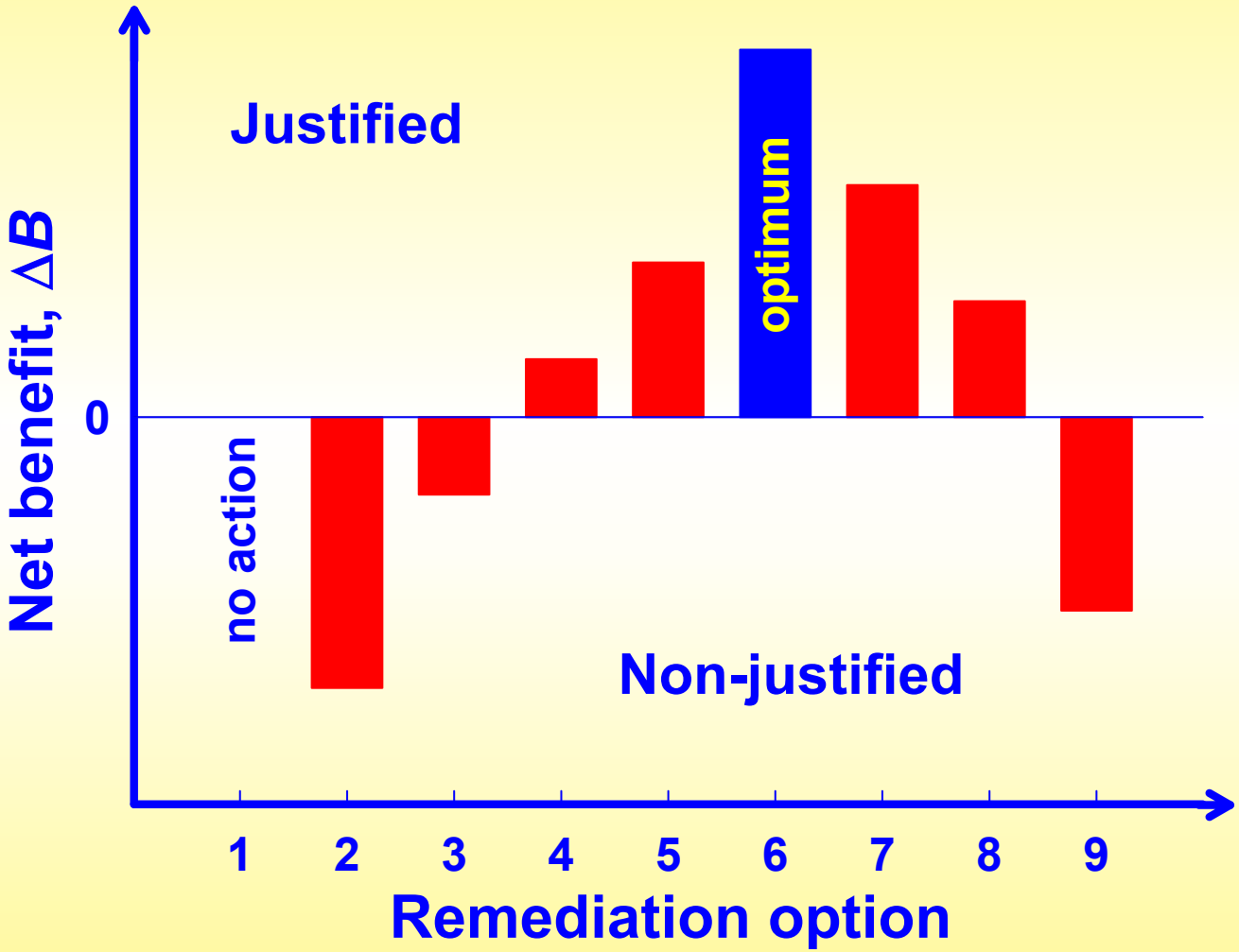
Optimisation of protection

From the justified protection options select that for which:

$$\Delta B = \sum_i b_i(\text{after}) - \sum_i b_i(\text{before})$$

IS MAXIMISED

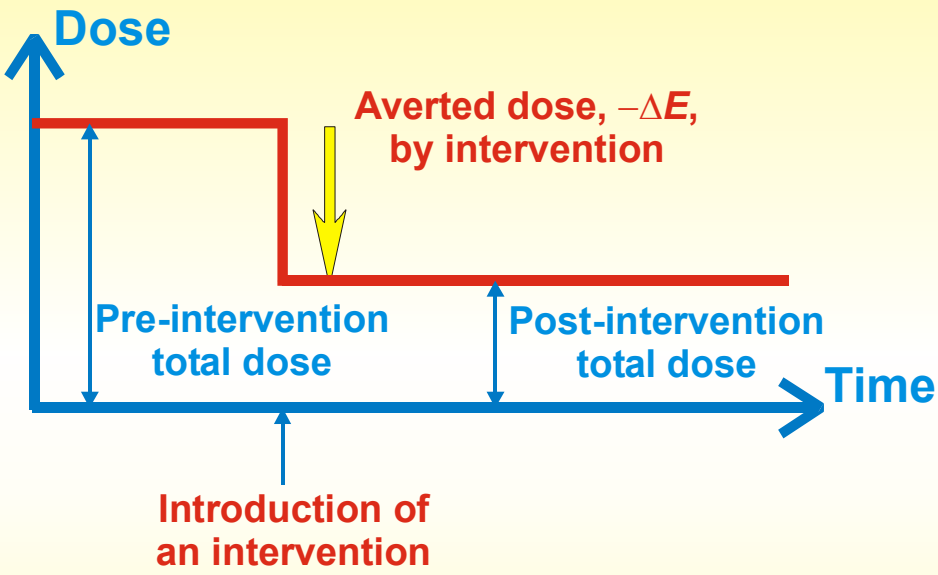
Justified and non-justified options

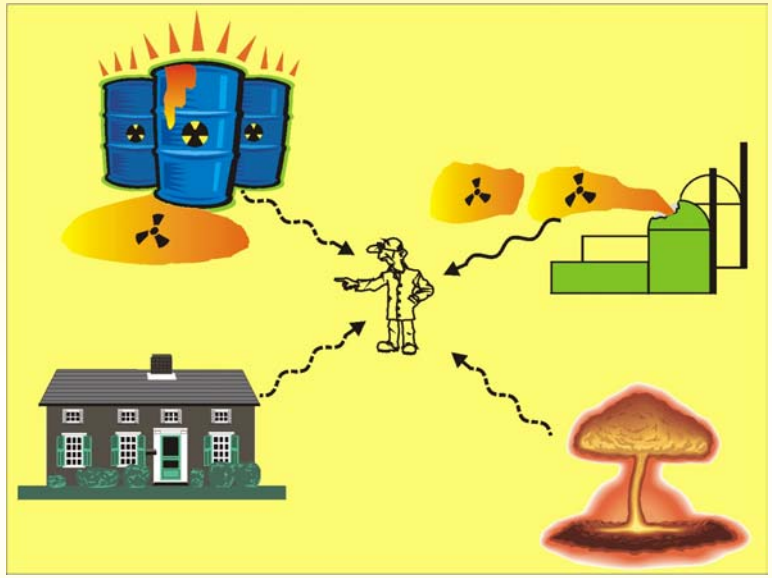


Intervention level, *IL*

An Intervention Level is the level of avertable dose at and above which a specific protective action should be taken in an emergency or a prolonged exposure situation

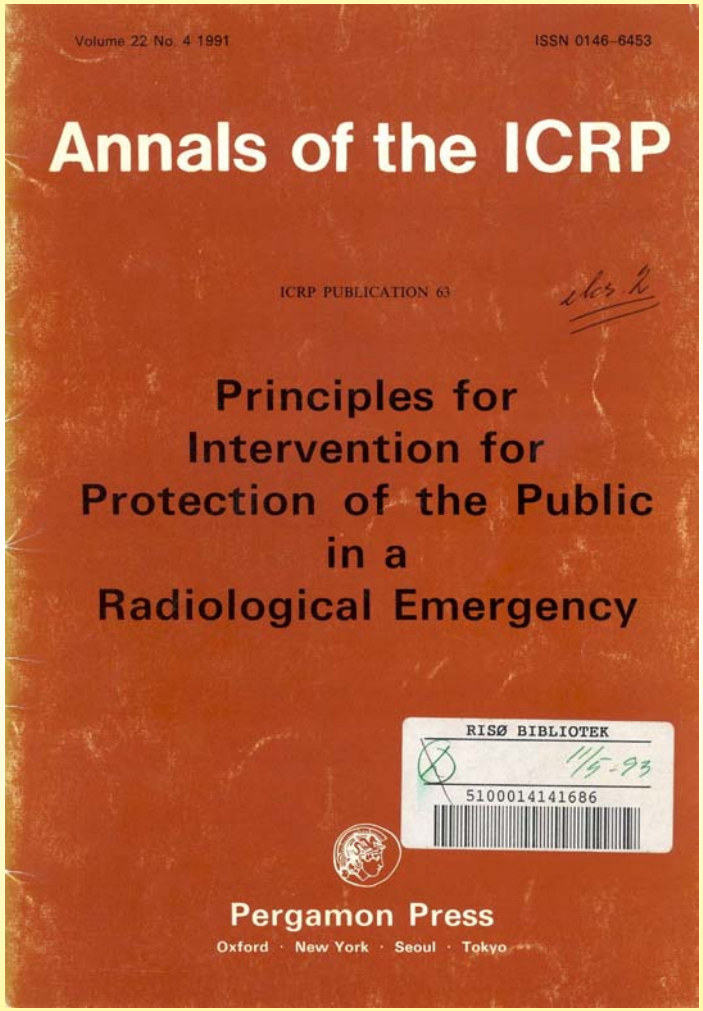
Intervention Level, *IL*

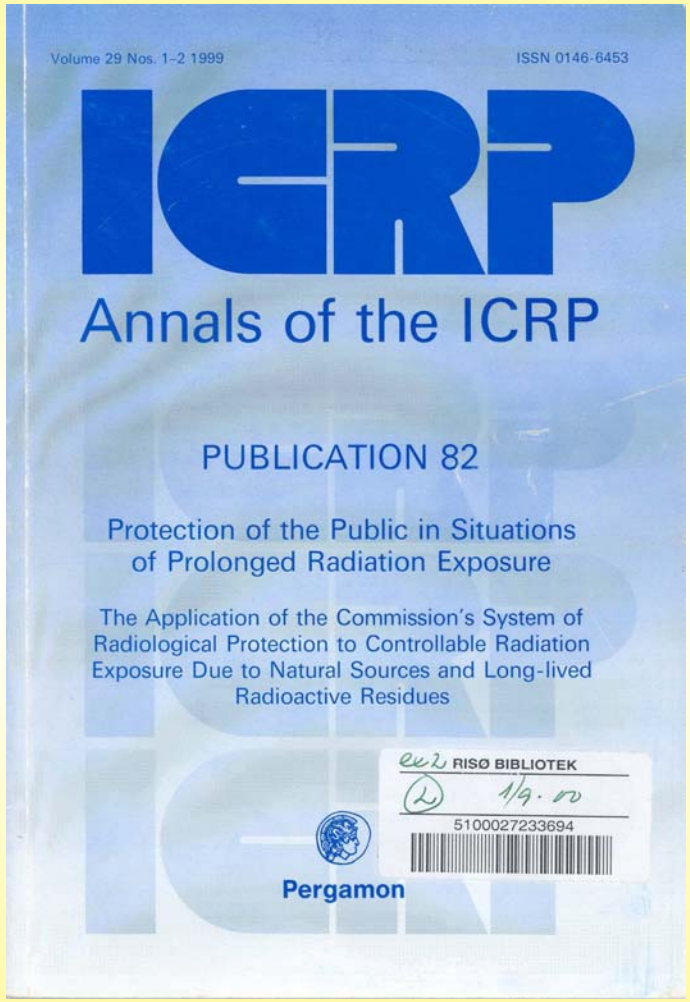




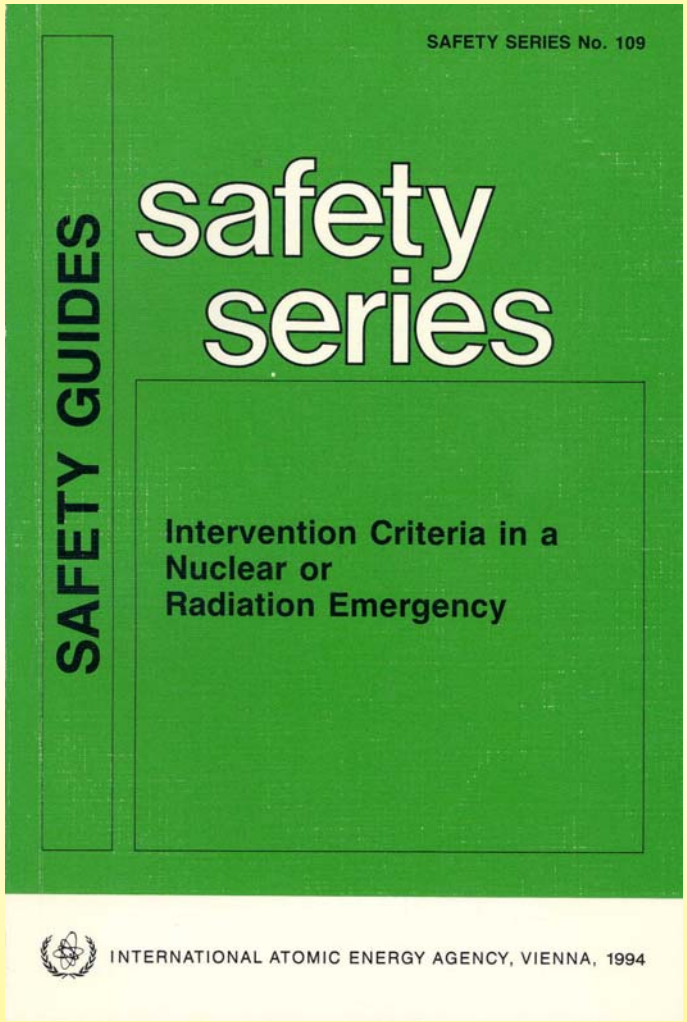
if $\Delta E \geq IL \Rightarrow$ intervention

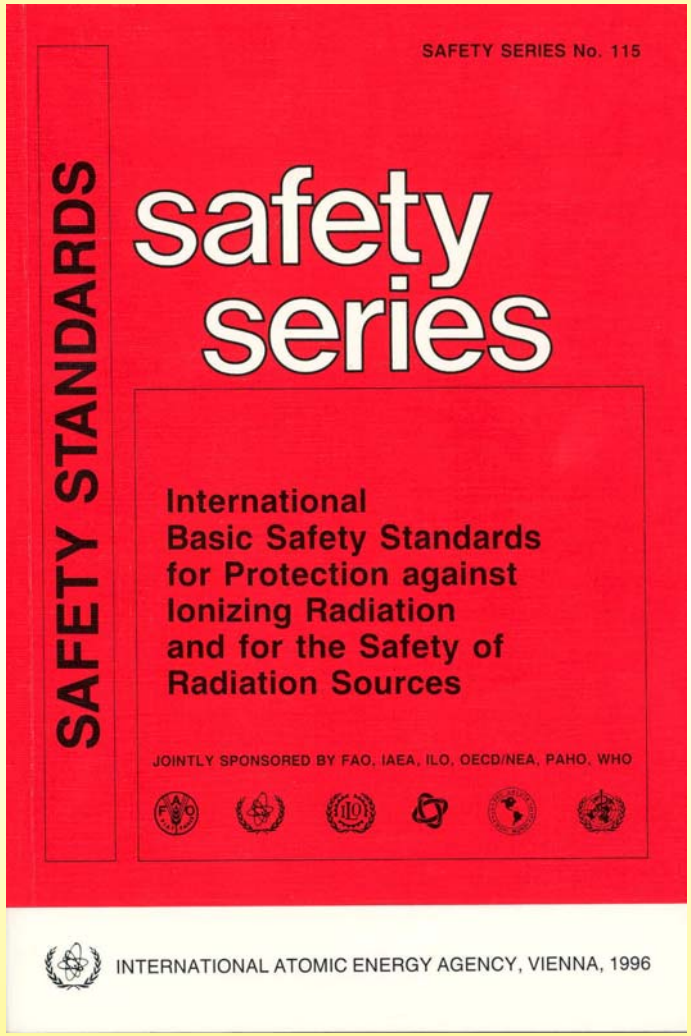
Recommendations from the ICRP





Recommendations from the IAEA





Intervention levels for accidents

Urgent measures (reduce doses > 10 - 100 mSv in days)	
Evacuation	> 50 mSv in 7 days
Sheltering	> 10 mSv in 2 days
Iodine prophylaxis	> 100 mSv to thyroid
Long-term measures (reduce doses > 10 mSv in a year)	
Initiating temporary relocation	> 30 mSv in a month
Terminating temporary relocation	< 10 mSv in a month
Permanent resettlement	> 1 Sv in a lifetime
Initial foodstuff restrictions	> 1,000 - 100,000 Bq/kg (β)
Long-term foodstuff restrictions	> 100 - 1,000 Bq/kg (β)

Intervention levels for relocation

Protective action	Generic intervention levels of avertable dose by relocation		
	ICRP	BSS, IAEA	EU
Temporary relocation	> 5 - 15 mSv/month	initiate at > 30 mSv/month suspend at < 10 mSv/month	> 10 mSv/month
Permanent resettlement	> 1 Sv in a lifetime	> 1 Sv in a lifetime or if temporary relocation time exceeds 1 - 2 years	> 1 Sv in a lifetime

DECISION-AIDING AND DECISION-MAKING IN EXISTING EXPOSURE SITUATIONS

Decision-aiding

Decision-aiding process based on radiological protection considerations:

Input to a wider decision-making process that:

- **involves relevant stakeholders**
- **searches for their informed consent**

Decisions on radiation protection in existing exposure situations

Integrating societal aspects into radiation protection decisions

OR?

Integrating radiation protection into societal decisions

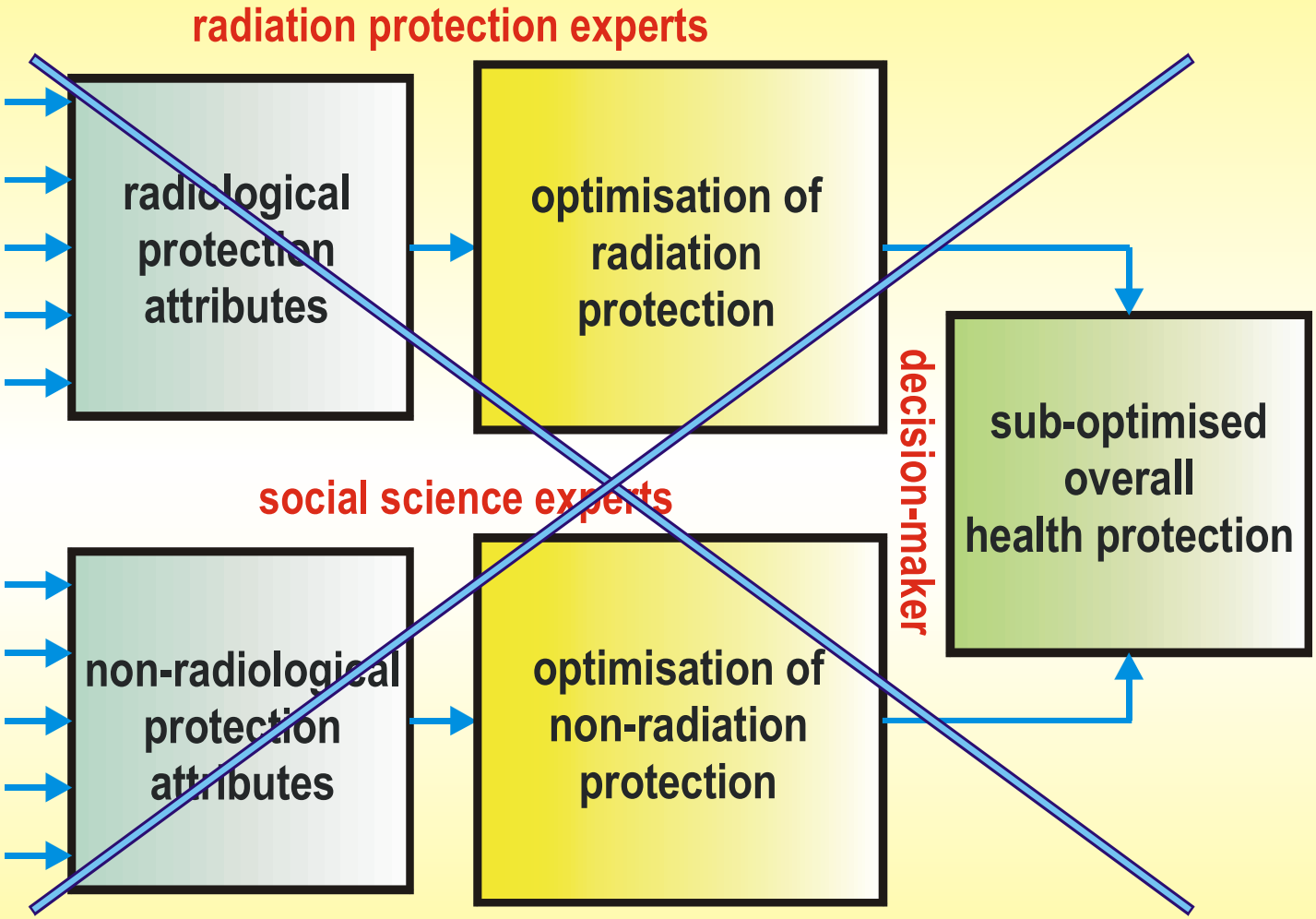
Decision-making versus decision-aiding

- decision-making is out of the scope of the radiation protection community as of any other scientific bodies
- scientific bodies have no mandate to make societal decisions

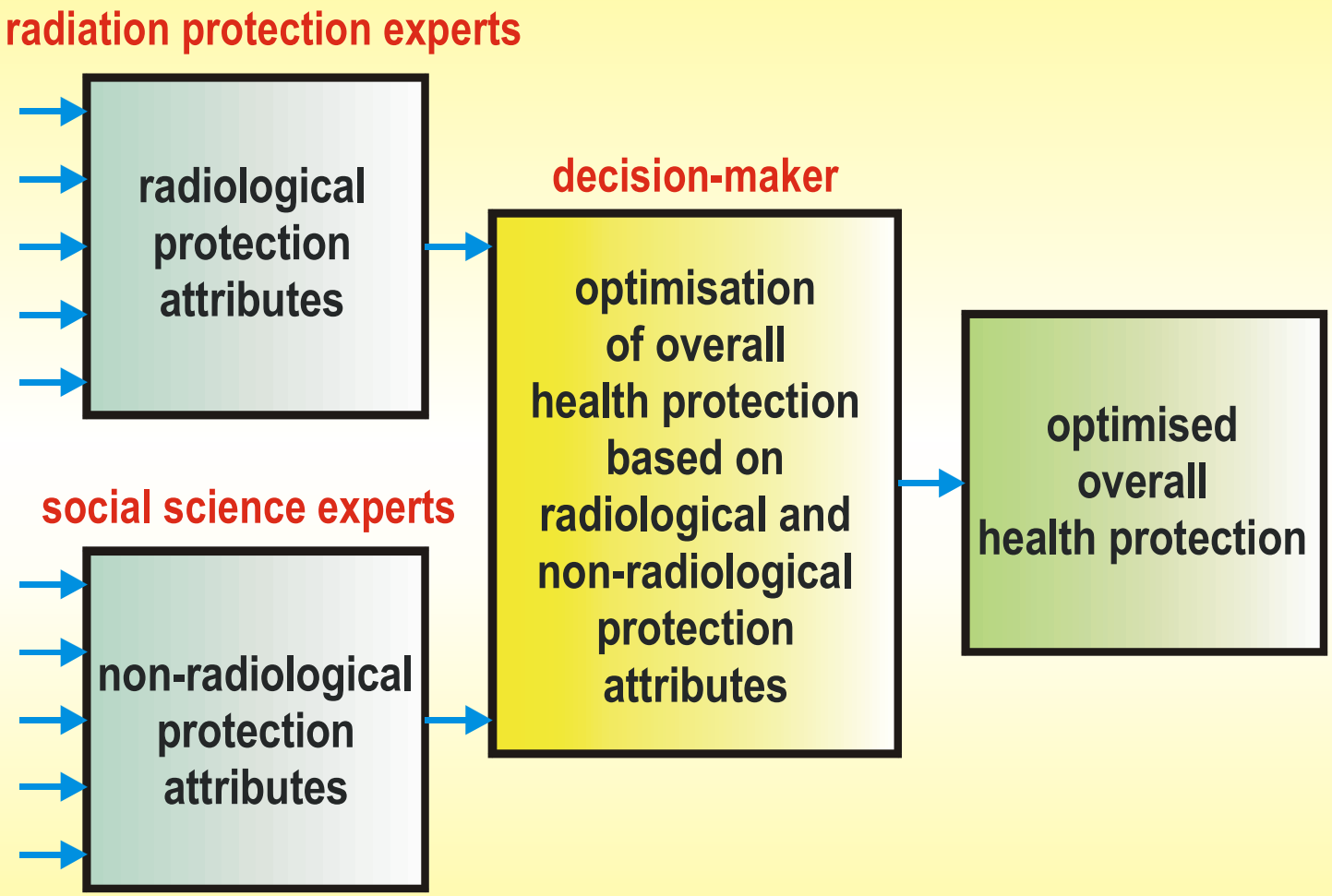
Decision-making versus decision-aiding

- radiation protection professionals should provide clear advice based on science and judgement
- the professional radiation protection advice would form only one of several inputs to decision-making
- other inputs to the decision-making process include psychological, social and political issues

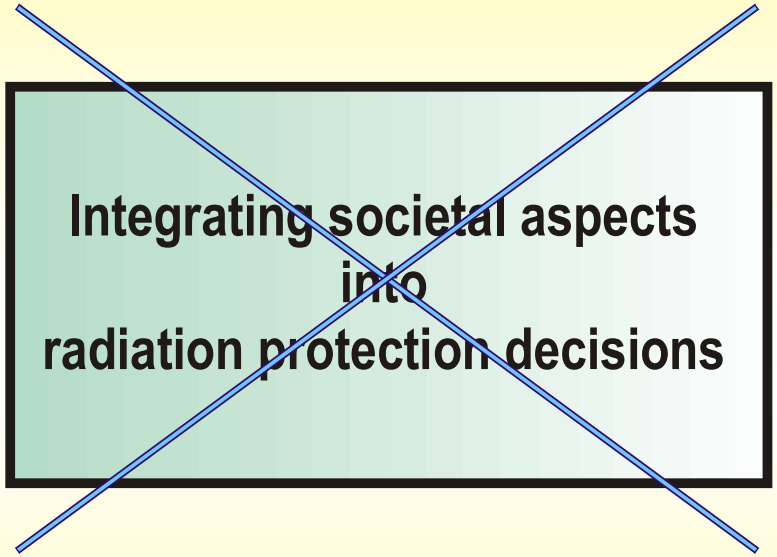
Sub-optimisation of overall health protection



Optimisation of overall health protection



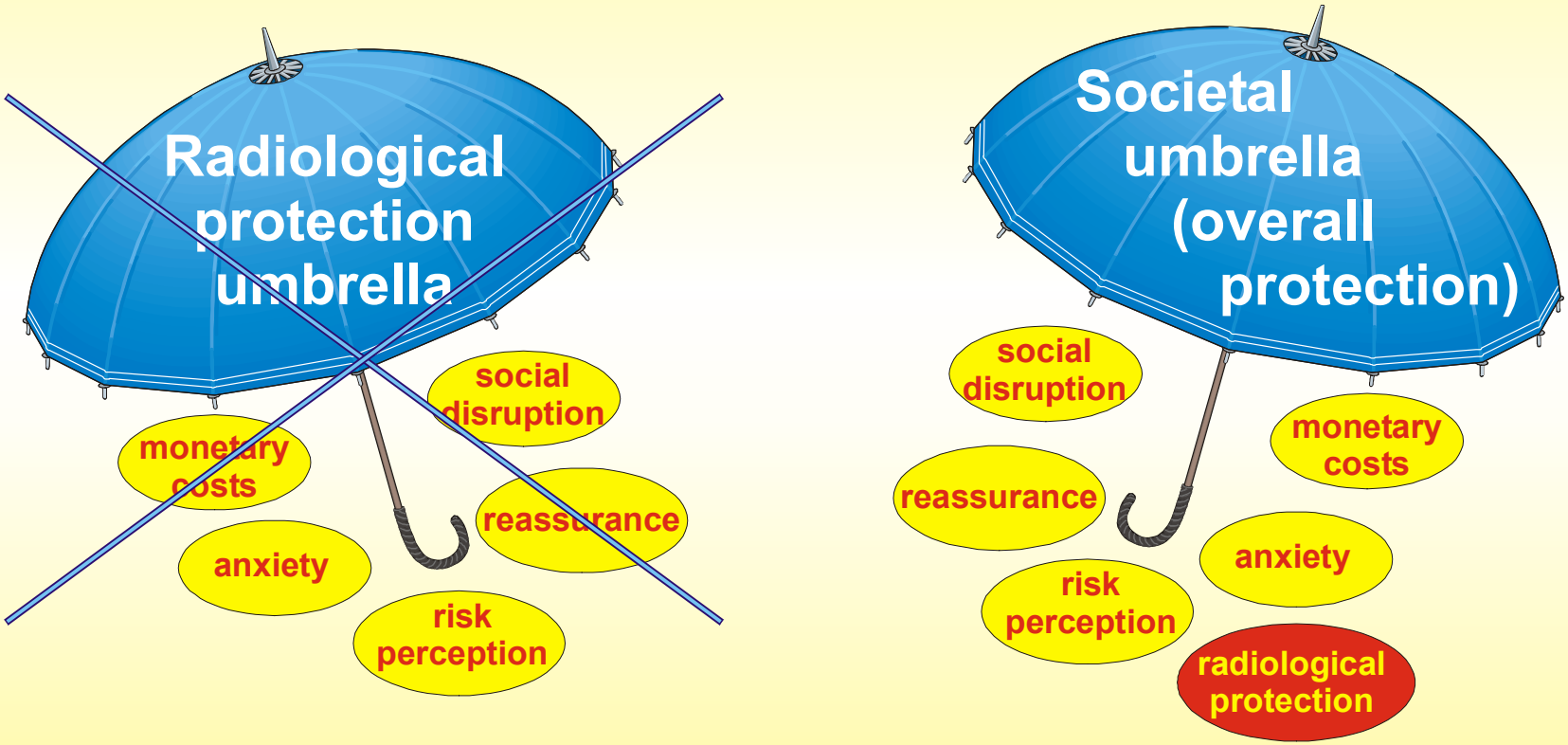
Decisions on radiation protection in existing exposure situations



OR?

Integrating radiation protection
into
societal decisions

Decision-making in radiological protection

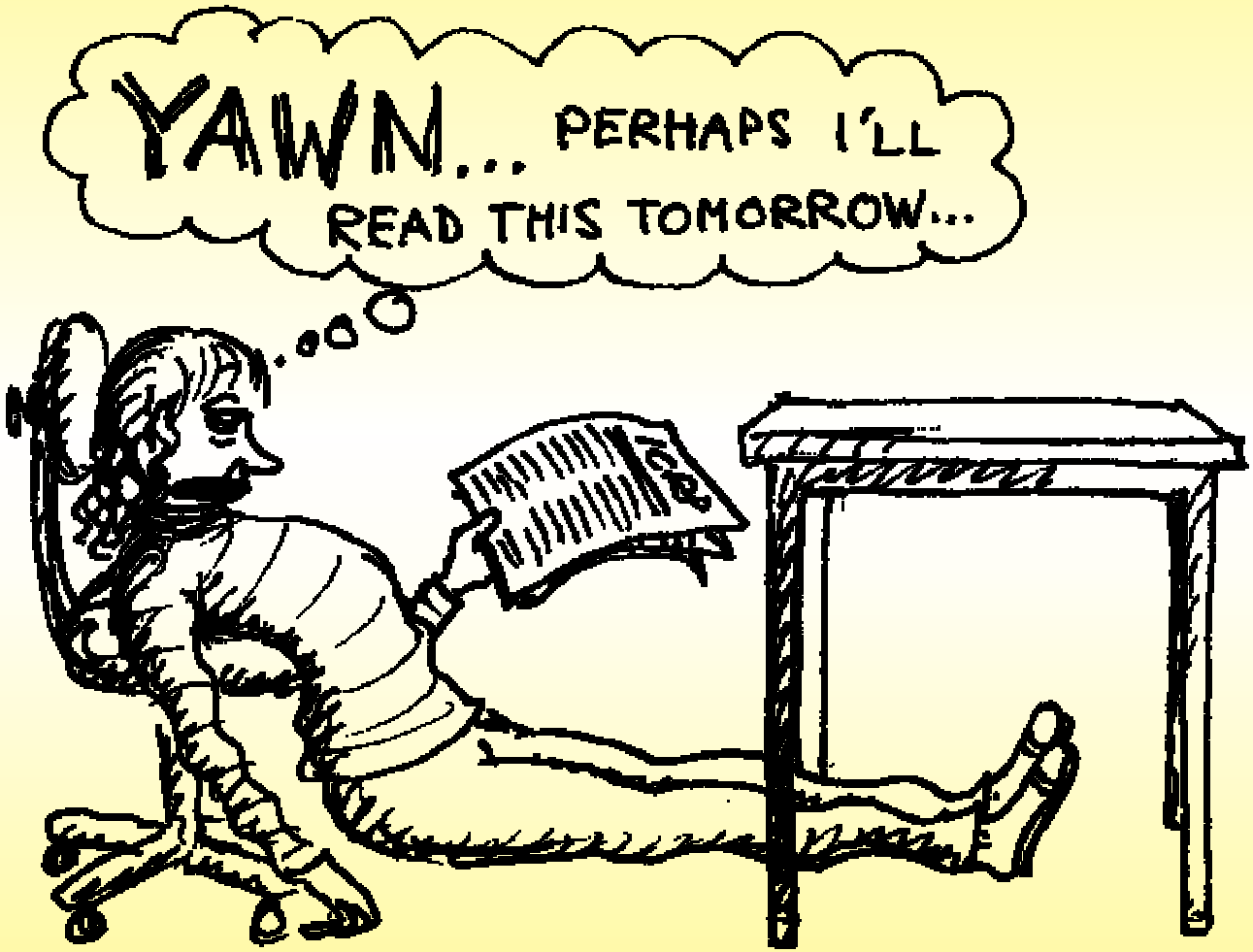


Role of the radiation protection community

- to develop guidance on interventions after a nuclear or radiological accident being based solely on radiation protection considerations
- to develop a common language explanation that clearly state the residual risk of radiation exposure after the implementation of protective measures
- to develop as input to the decision-making process a common language explanation of the concepts of 'safe', 'safe living conditions' and 'return to normality'

NEW ICRP RECOMMENDATIONS

Existing ICRP recommendations



AS SEEN BY THE ICRP !

Arguments for a change

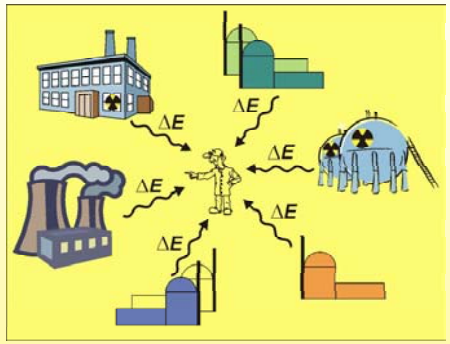
- biological assumptions need updating (minor)
- unnecessarily complicated, confusing terminology
- shifting values: emphasising individual over society
- the dose limits for the public are unhelpful
- focusing on man alone is insufficient
- existing recommendations need to be consolidated
- simplification by reducing the number of numerical figures (approximately 30 values)

Arguments for a change

Dose limits for the population:

- sum of contribution from many sources
- doses can only be regulated at the source
- do not include the dominant natural background
- do not apply to interventions
- do not apply in emergencies

DO NOT APPLY AT ALL !



$\Sigma \Delta E \leq E_{limit}$

Arguments for a change

Practice versus intervention

- some situations can be difficult to characterise as either a practice or an intervention
- the difference between the concepts of dose limits and intervention levels difficult to grasp
- affected populations are demanding the "same standard" of radiation protection as in practices
- dose reduction below constraints in all situations is easier to understand

New ICRP recommendations

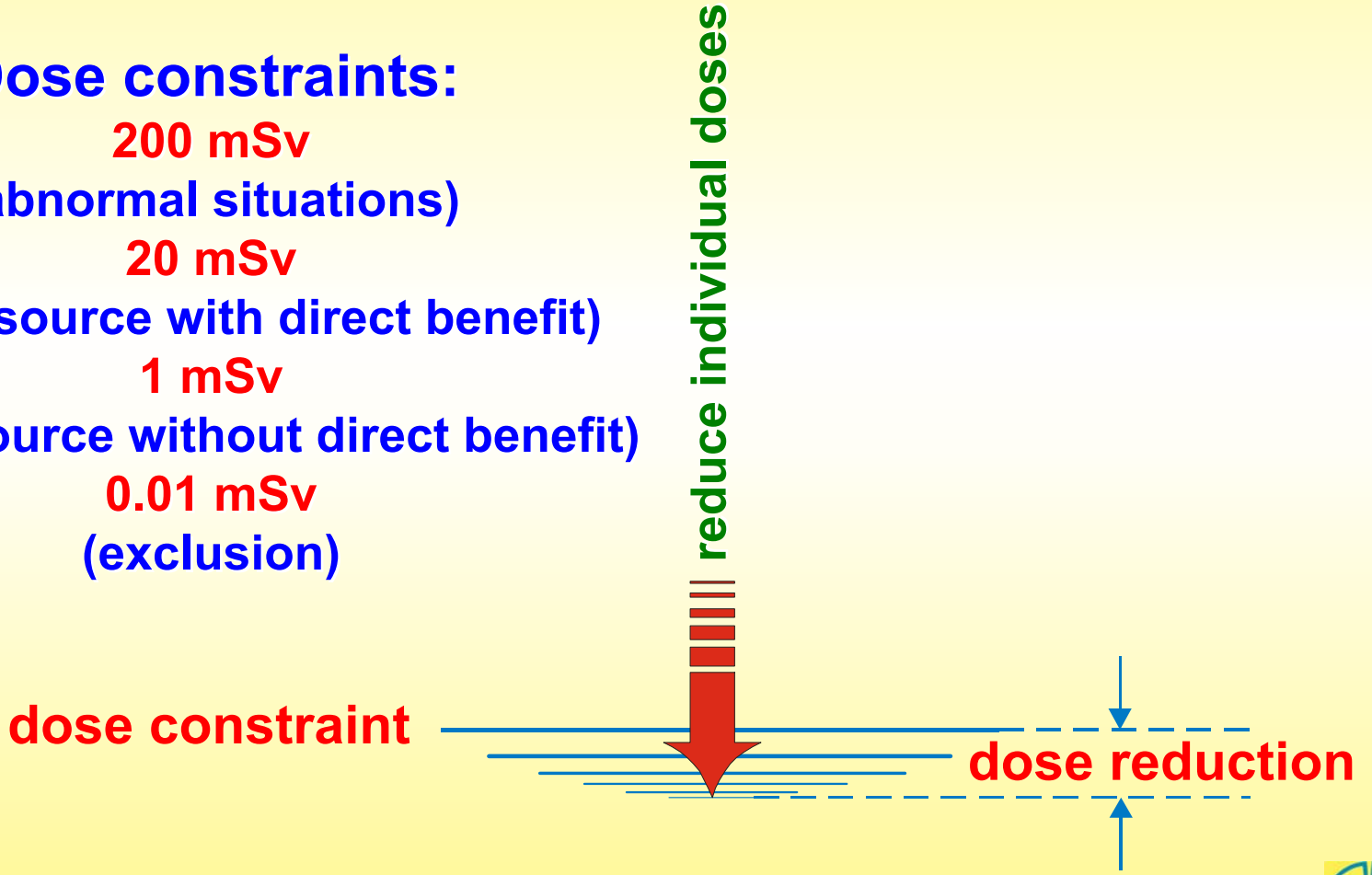
Concern	Proposed constraints	
High	risk not justified	> 100 mSv/a
Raised	concern begin to be raised	> a few tens mSv/a
Low	benchmark for judgement about additional exposures	1 - 10 mSv/a
Very low	not of concern to the individual	< 1 mSv/a
None	risk negligible, protection assumed to be optimised	< 0.01 mSv/a

New ICRP recommendations

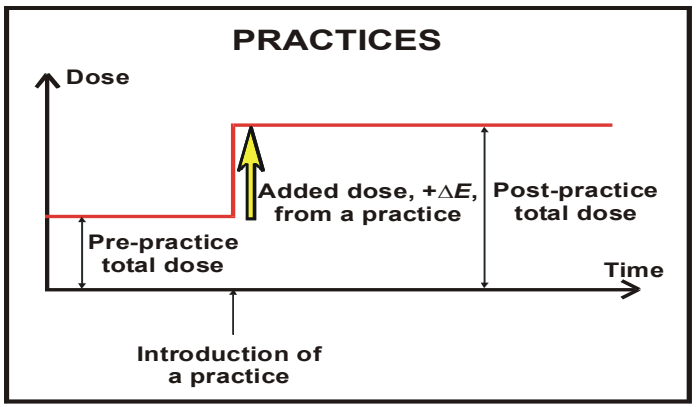
More an "intervention-like" than "practice-like" system

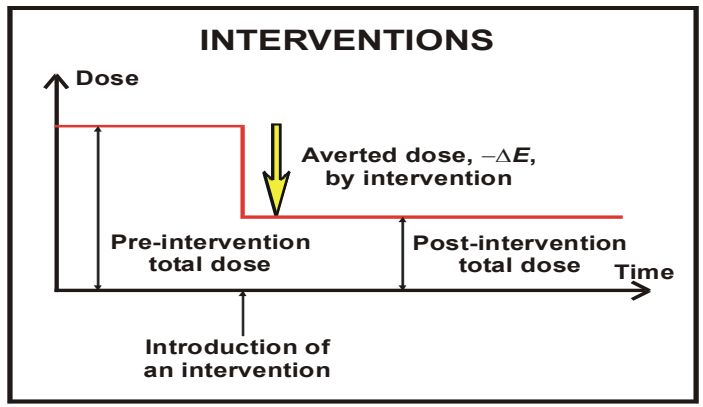
Dose constraints:

200 mSv
(abnormal situations)
20 mSv
(single source with direct benefit)
1 mSv
(single source without direct benefit)
0.01 mSv
(exclusion)



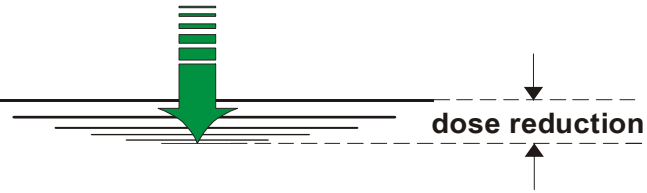
ICRP – from dual to single-line system





New ICRP system in 2005 as a single line system

reduce individual doses in normal and abnormal situations



dose constraints

200 mSv
(abnormal situations)
20 mSv
(single sources with direct benefit)
1 mSv
(single sources without direct benefit)
0.01 mSv
(exclusion)

New ICRP Recommendations

AS SEEN BY THE ICRP !

Summary and conclusions

- Justification of intervention and optimisation of protective actions are applicable to any existing exposure situation of both man-made or natural origin (present system of protection)

- In the new ICRP system of protection, maximum source-related dose constraints are expressed as individual doses at which protective measures to avert (reduce) doses are almost always justified; the actual level of protection should be optimised

Summary and conclusions

- Only minor differences between the present and the new system of radiological protection seem to exist regarding the principles of radiological protection in existing exposure situations

- The dose constraints in the new system could be regarded in the same way as action levels in the present system of radiological protection

Summary and conclusions

- In the present system of radiological protection, justification and optimisation should be assessed by a decision-aiding process
- The result of this process is meant to be used as input to a wider decision-making process (not performed by radiation protection professionals)
- The decision-making process should result in an optimisation of the overall health protection of the affected population

Summary and conclusions

- The fundamental question still stands if societal aspects should be integrated into radiation protection or if radiation protection should be an integral part of societal decisions

- The integration of societal aspects into radiation protection appears to be incorrect as the radiation protection community (or any other scientific community) has no mandate to make societal decisions

Summary and conclusions

- From past experience it is evident that some methodology is needed in which all relevant protection attributes can be included to reach an optimised (final) decision on countermeasures
- The final decision should be taken by a decision-maker not being a radiation protection professional
- The decision-making process and the involvement of relevant stakeholders is being addressed in the new ICRP recommendations but it appears to be somewhat vague