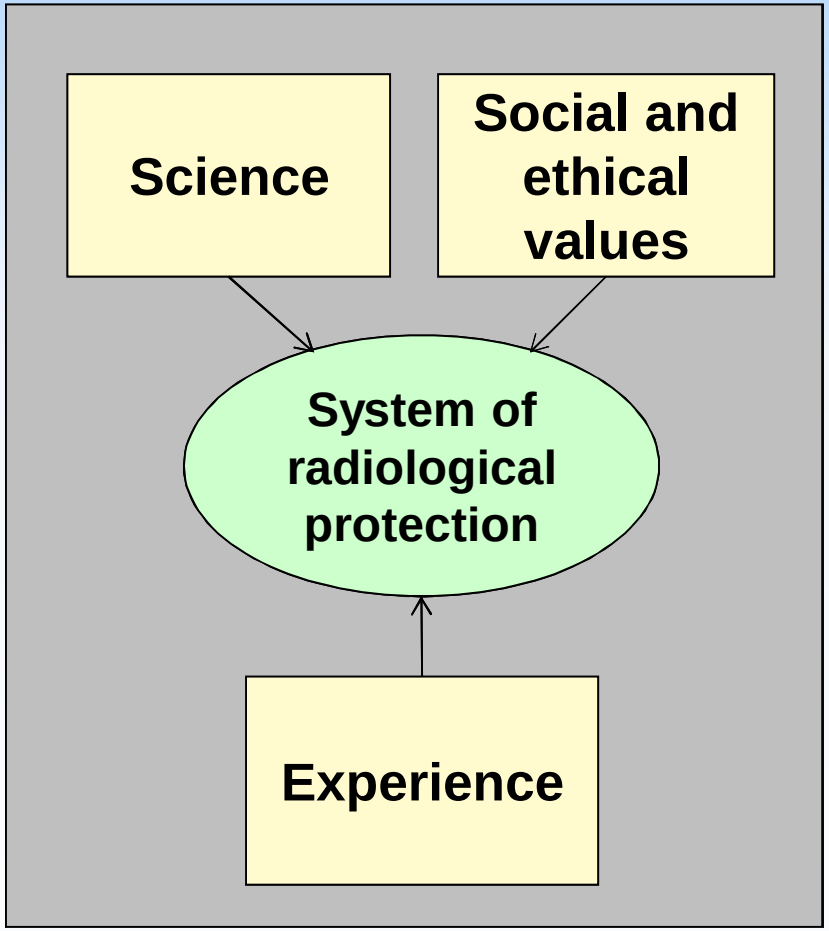
Protection Principles in Ionizing Radiation as in ICRP Publication 103 (2007)

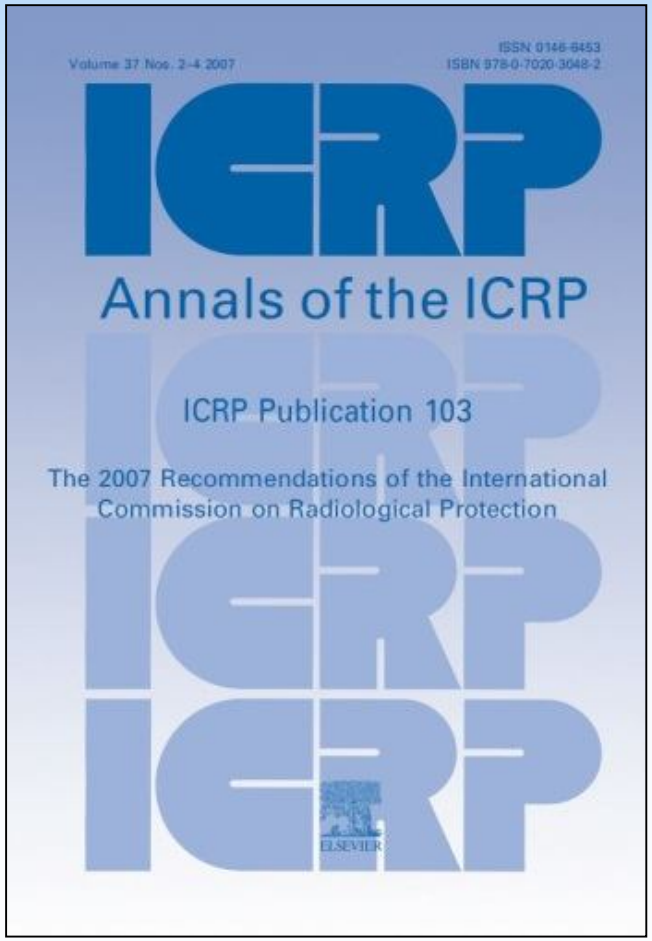
Jacques LOCHARD
Vice-Chair of ICRP

ICNIRP/WHO/ICRP/IRPA/ILO Workshop
"Radiation protection principles: similarities and differences in ionizing and non-ionizing radiation"
Geneva, Switzerland, 27–28 June 2014

This presentation has neither been approved nor endorsed by ICRP

The three pillars of the system of radiological protection





Publication 103

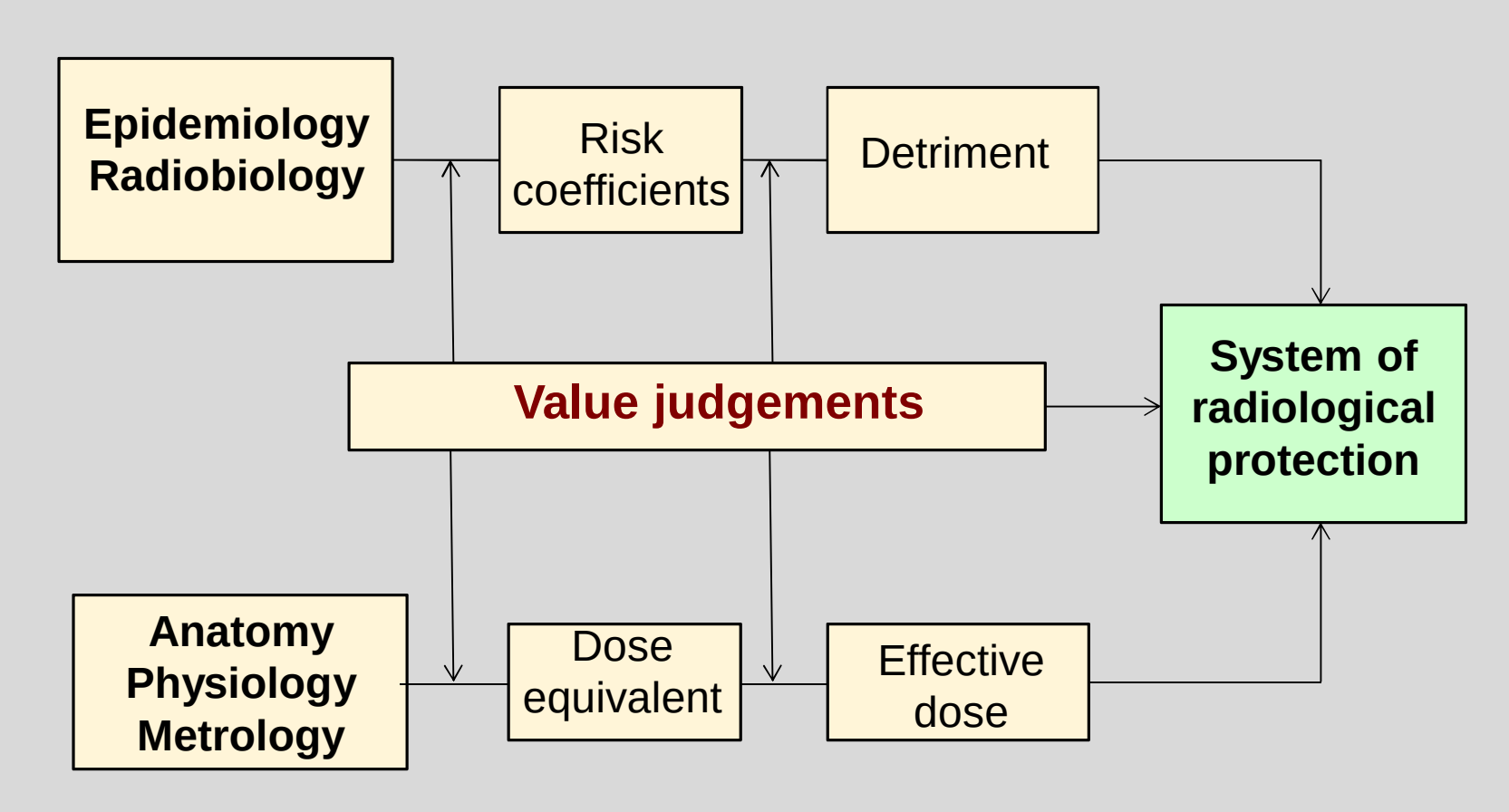
The aims of the system of radiological protection

- "… to contribute to an appropriate level of protection against the **detrimental effects** of ionising radiation exposure without unduly limiting the **benefits** associated with the use of radiation." ICRP 103, § 26

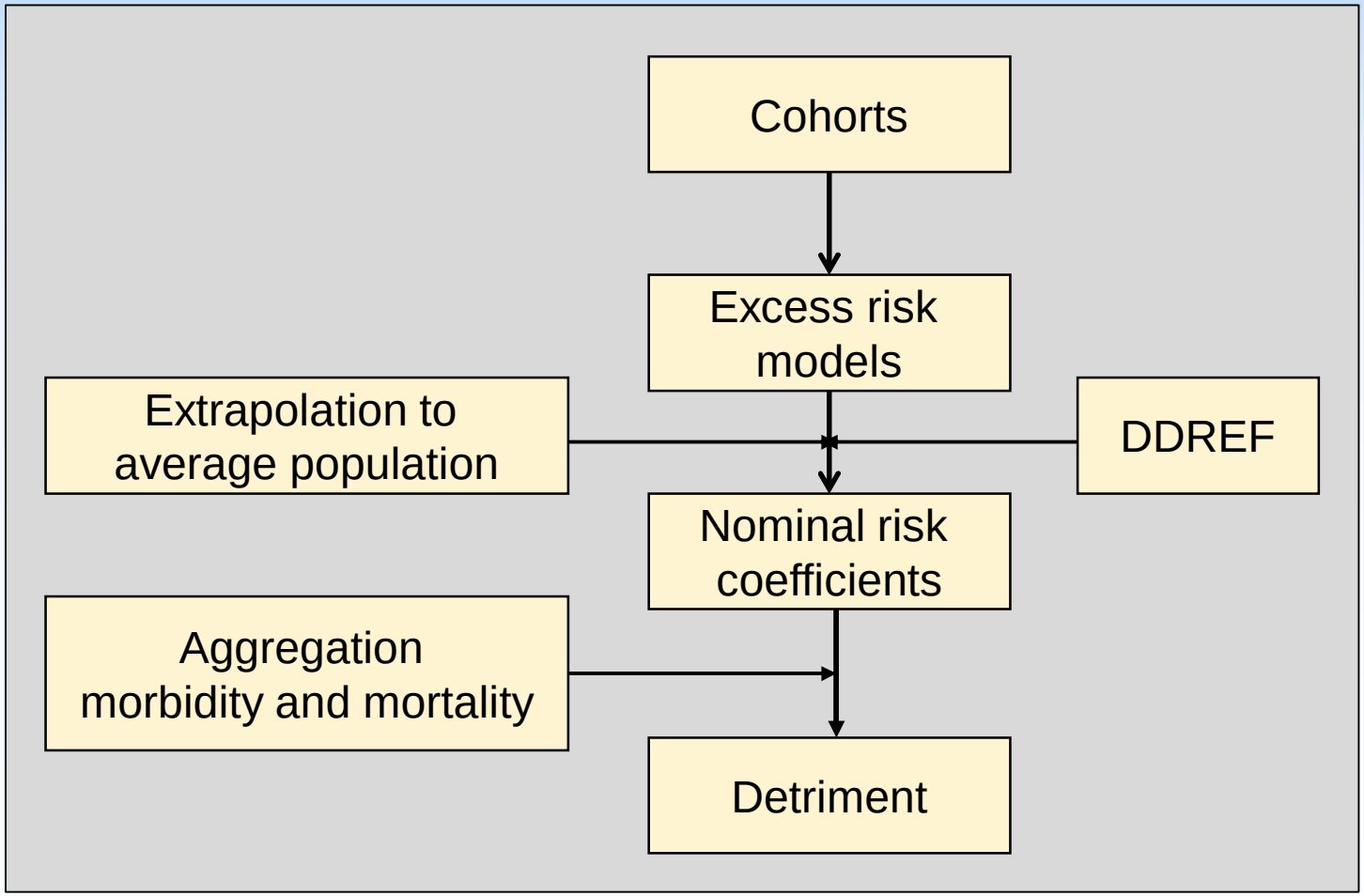
- "… to manage and control exposures to ionizing radiation so that deterministic effects are **prevented**, and the risks of stochastic effects are **reduced to the extent reasonably achievable.**" ICRP 103, § 29

- Balancing benefits and risk is one of the **most common ethical dilemmas.** The potential benefits of any decision must outweigh the risks in order for the associated action to be ethical

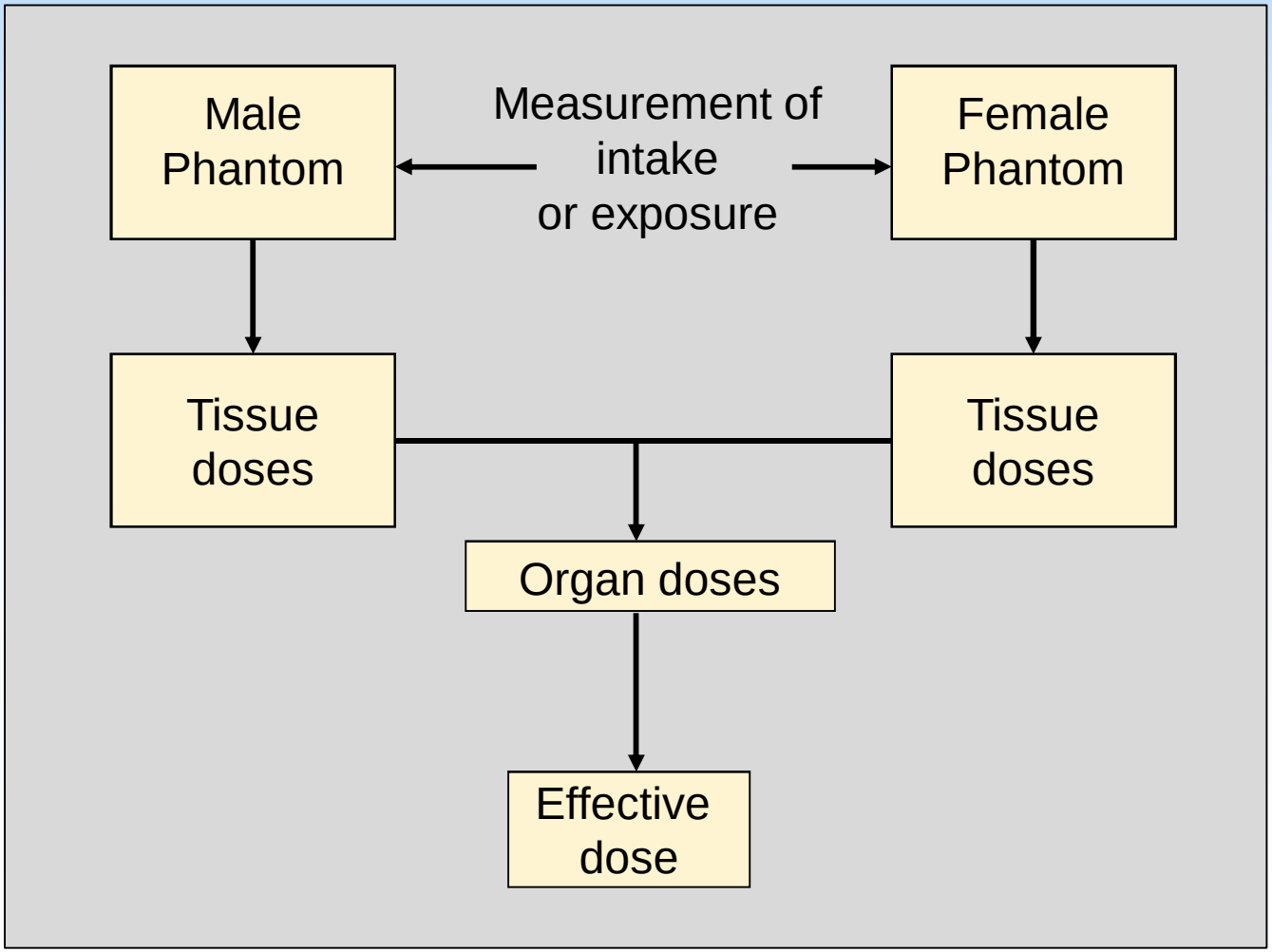
The scientific basis of the system of radiological protection



The construction of the detriment



The construction of the effective dose



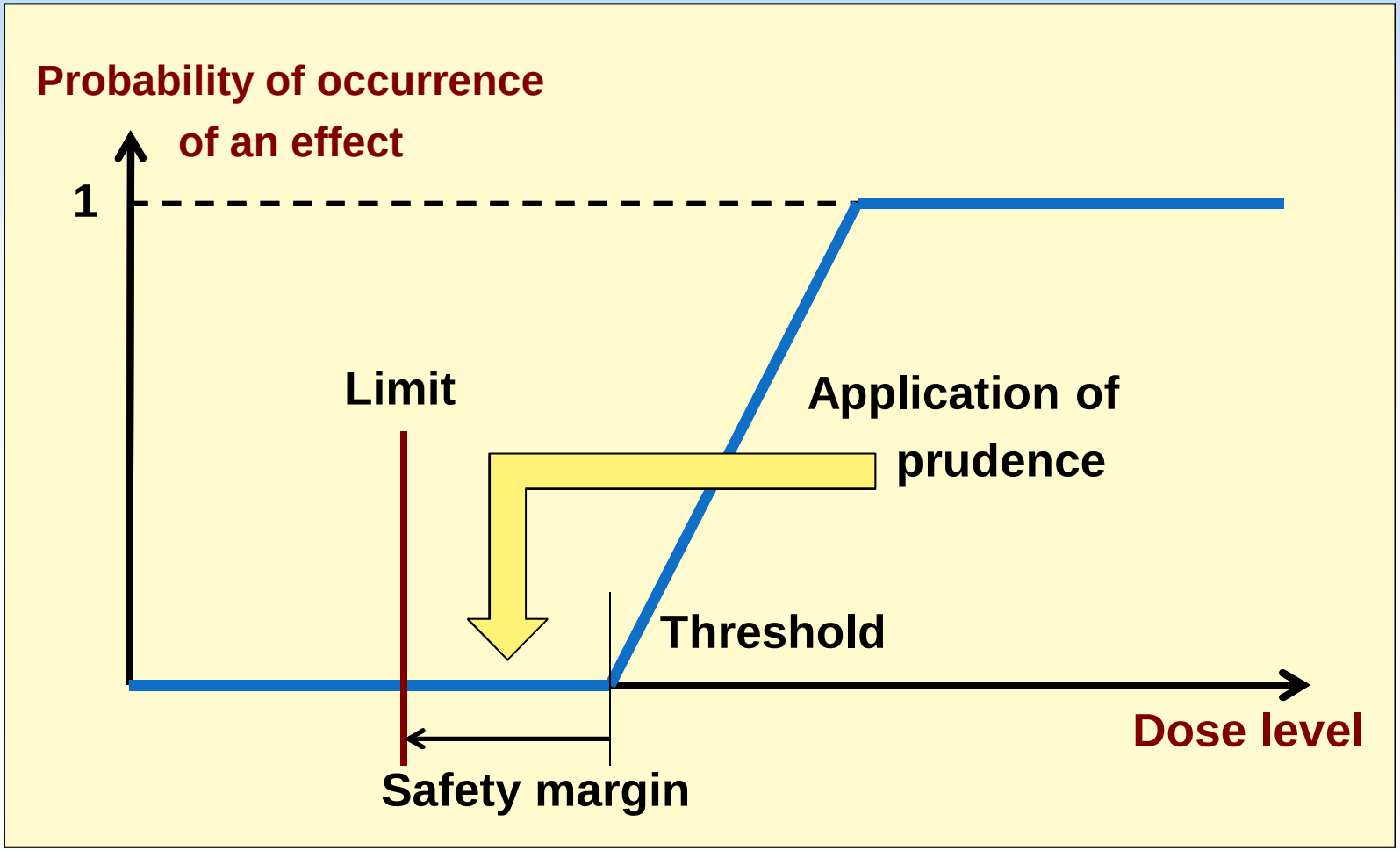
A key value judgement: prudence

- *« It is **prudent** to take uncertainties in the current estimates of thresholds for **deterministic effects** into account… Consequently, annual doses rising towards 100 mSv will almost always justify the introduction of protective actions »*. ICRP 103, § 35

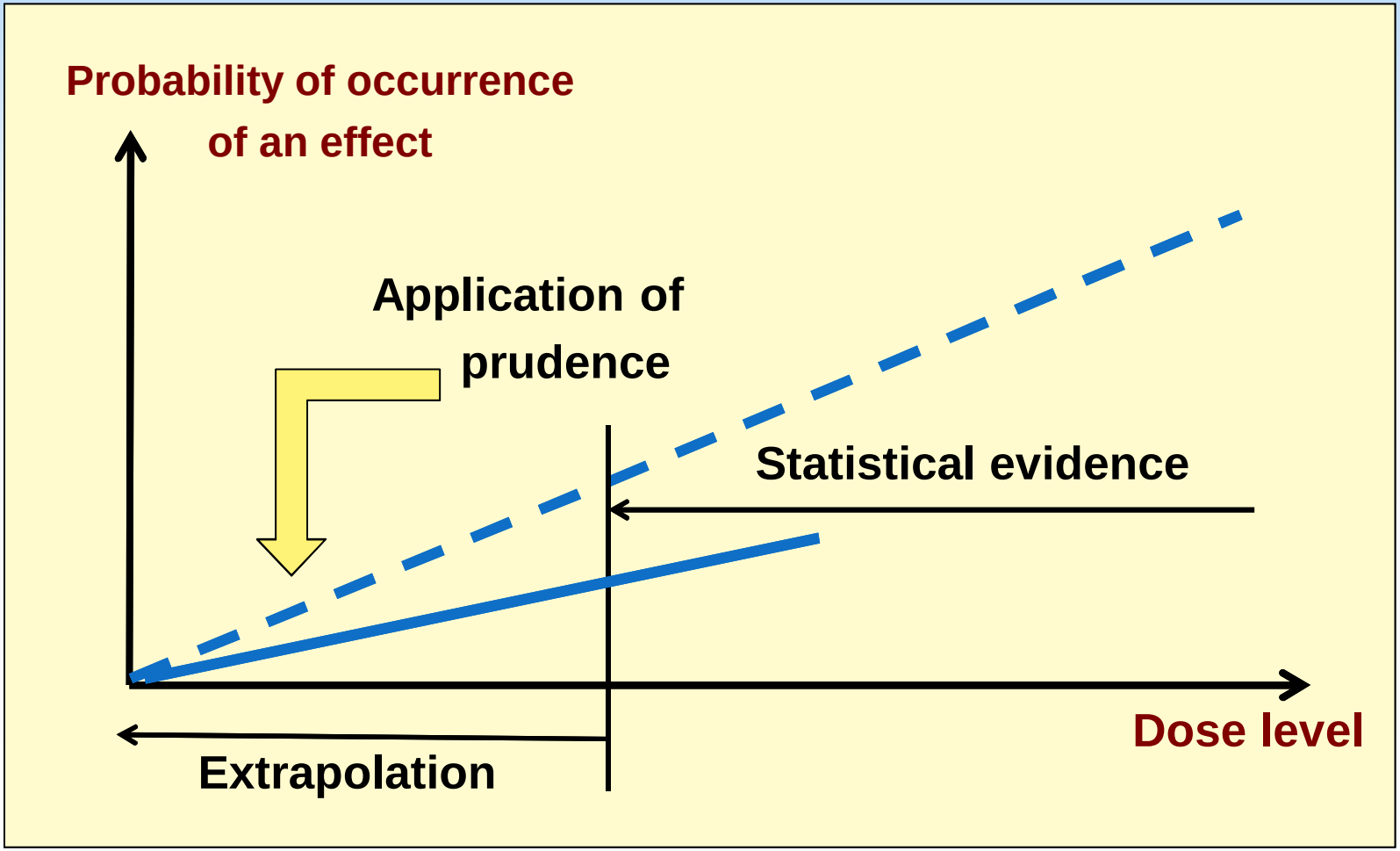
- *« At radiation doses below around 100 mSv in a year, the increase in the incidence of **stochastic effects** is assumed by the Commission to occur with a small probability and in proportion to the increase in radiation dose… The Commission considers that the LNT model remains a **prudent** basis for radiological protection at low doses and low dose rates. »* ICRP 103, § 36

- *«There continues to be no direct evidence that exposure of parents to radiation leads to excess heritable disease in offspring. However, the Commission judges that there is compelling evidence that radiation causes **heritable effects** in experimental animals. Therefore, the Commission **prudently** continues to include the risk of heritable effects in its system of radiological protection.»* ICRP 103, § 74

The prevention of deterministic effects



The management of stochastic effects



The management of stochastic effects

- The main implications of adopting a **prudent attitude** with regard stochastic effects (i.e. the Linear No Threshold model) are that:
  - Exposing individuals is **justified** only if there is a benefit in return
  - Maintaining exposures below a limit is **not a guarantee of absence of risk**
  - Exposures must be kept **as low as reasonably achievable**

The inclusion of hereditary effects

Application of prudence

Exposed population	Cancer	Heritable effects	Total
Whole	5.5	0.2	5.7
Adult	4.1	0.1	4.2

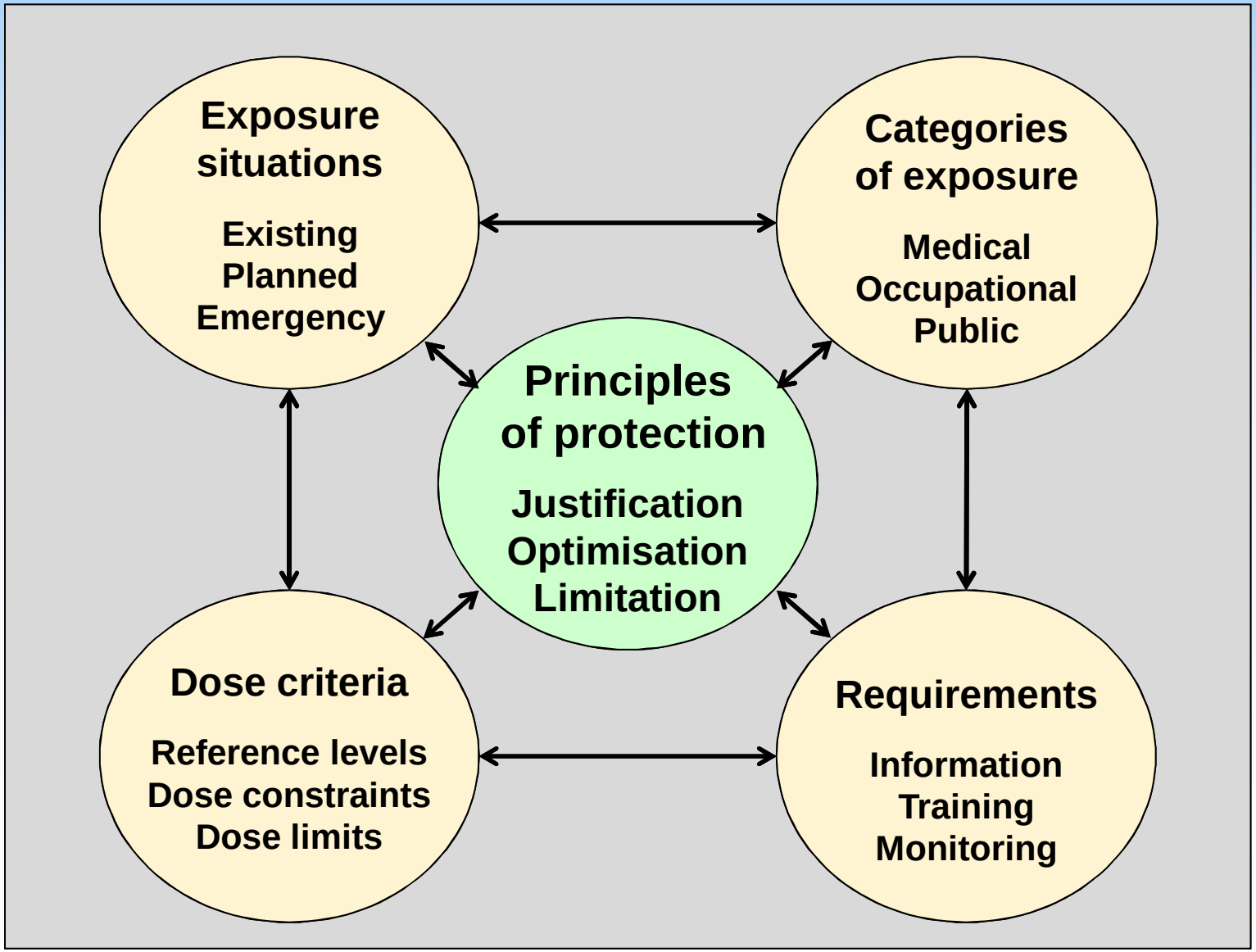
Detriment-adjusted nominal risk coefficients (10^{-2} Sv^{-1}) for stochastic effects after exposure to radiation at low dose rate

Prudence in summary

- The value of prudence is the **cornerstone of the system of protection**: it allows to take into account the inevitable uncertainties of radiation science and to **act judiciously and reasonably**

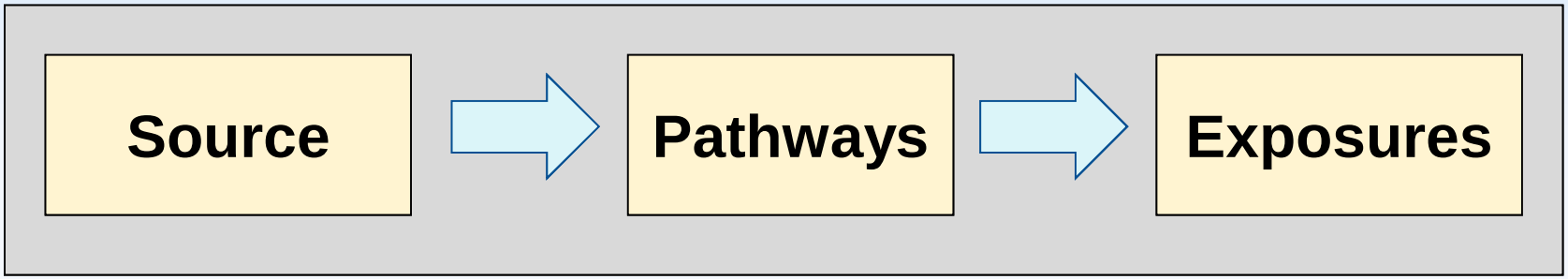
- Prudence implies a duty of vigilance regarding the effects of radiation: the requirement of **radiation and health monitoring** of exposed populations and the duty to relentlessly pursue **research in the fields of epidemiology and radiobiology**

The system of radiological protection



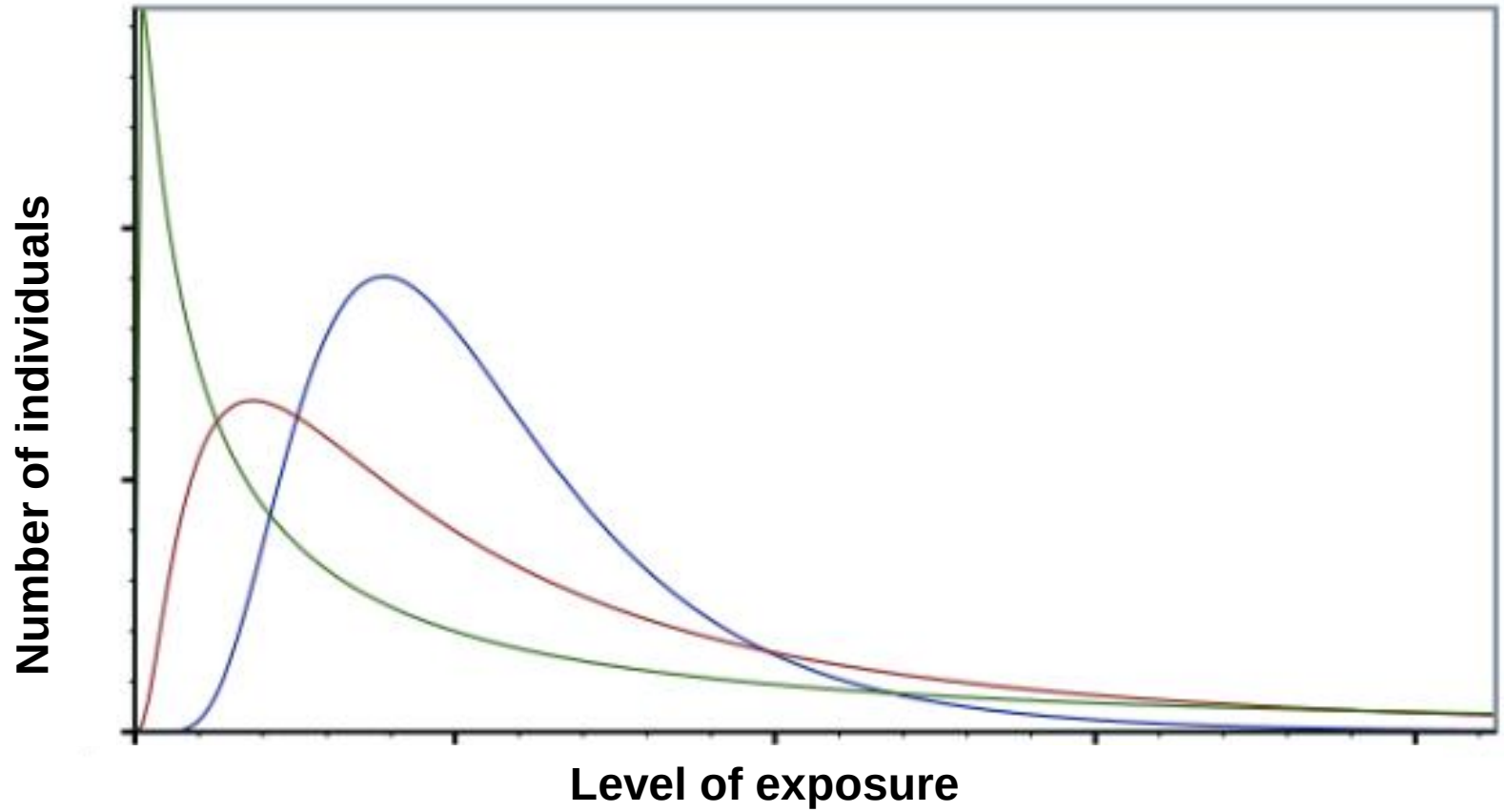
Exposure situations – Definition

- "The process causing human exposures from **natural** and **man-made** sources."



- "Protection can be achieved by taking action at the **source**, or at points in the exposure **pathways**, and occasionally by modifying the location or characteristics of the **exposed individuals**."
  ICRP103, § 169

Individual dose distributions associated with exposure situations



The 3 types of exposure situations

- **Existing exposure situations :** when exposures result from **sources that already exist when decisions to control them are taken**. Characterization of exposures is a prerequisite to their control
- **Planned exposure situations :** when exposures result from the **deliberate introduction and operation of sources.** Exposures can be anticipated and fully controlled
- **Emergency exposure situations :** when exposures result from the **loss of control of a source**. These situations require urgent and timely actions in order to mitigate exposures

Exposure situations

- **Existing**
  - **Natural sources**: cosmic radiation, NORM and radon
  - **Man-made sources**: contaminated sites and areas
- **Planned**
  - Medical facilities
  - Research, industrial and nuclear installations
- **Emergency**
  - Loss of control of planned sources
  - Malicious acts

The categories of exposure

- **Medical exposure:** radiation exposures received by patients in the course of diagnostic, interventional, and therapeutic procedures

- **Occupational exposure:** radiation exposures incurred at work as a result of exposure situations that can **reasonably** be regarded as being the responsibility of the operating management

- **Public exposure:** encompasses all radiation exposures of the public other than occupational and medical exposure

Remark: Although individuals may fall into the 3 categories respectively as workers, patients or members of the public, the management of each category is kept separated

The principles of radiological protection

- **The principle of justification:** Any decision that alters the radiation exposure situation **should do more good than harm**

- **The principle of optimisation of protection:** All exposures should be **kept as low as reasonably achievable**, taking into account economic and societal factors **with restrictions on individual exposure to limit inequities** in the dose distribution

- **The principle of application of dose limits:** The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients **should not exceed** the appropriate limits recommended by the Commission.

Justification: « do more good than harm »

- *« This means that, by introducing a new radiation source (Planned exposure situations), or by reducing existing exposure (Emergency and existing exposure situations)…, one should achieve* ***sufficient individual or societal benefit to offset the detriment*** *it causes. »* ICRP 103, § 203

- Actions taken to help prevent or remove harms are called **beneficent** actions in ethics and those taken to avoid to do harms are called **non-maleficent**

- ***Beneficence*** *and* ***non-maleficence*** *concerns* ***human welfare*** *with the objective to reduce the harms and optimise the benefit of social practices*

Optimisation: « keep exposures as low as reasonably achievable and restrict inequities between individual exposures »

- As already mentioned **reasonableness** is closely related to **prudence**
- *"Optimisation of protection may introduce a substantial **inequity** between one individual and another. This inequity can be limited by incorporating source-related **restrictions on individual dose** into the process of optimization."* ICRP 103, § 232
- **Inequity/equity** refer to **fairness** i.e. how radiation risks are distributed within the exposed individuals

The quest for reasonableness

- Recognition of uncertainties about the effects at low doses, **prudent attitude**, assumption of no-threshold - As Low As Possible - ALAP (1950)

- If an activity is justified, how far to reduce the risk without endanger the activity? - As Low as **Reasonably Achievable** - ALARA (1958)

  "As Low as" is the echo of the no-threshold assumption and "Reasonably Achievable" of the idea of avoiding carelessness and paralysis in front of the risk suspicion

- Attempt to found the reasonableness on the economic science: the **cost-benefit model** (1973)

- Combining **collective and individual** protection : the “beta value” (1988), pragmatism : **the ALARA procedure** (1999) and **democratic rights**: stakeholder involvement (2007)

Dose restrictions for optimisation

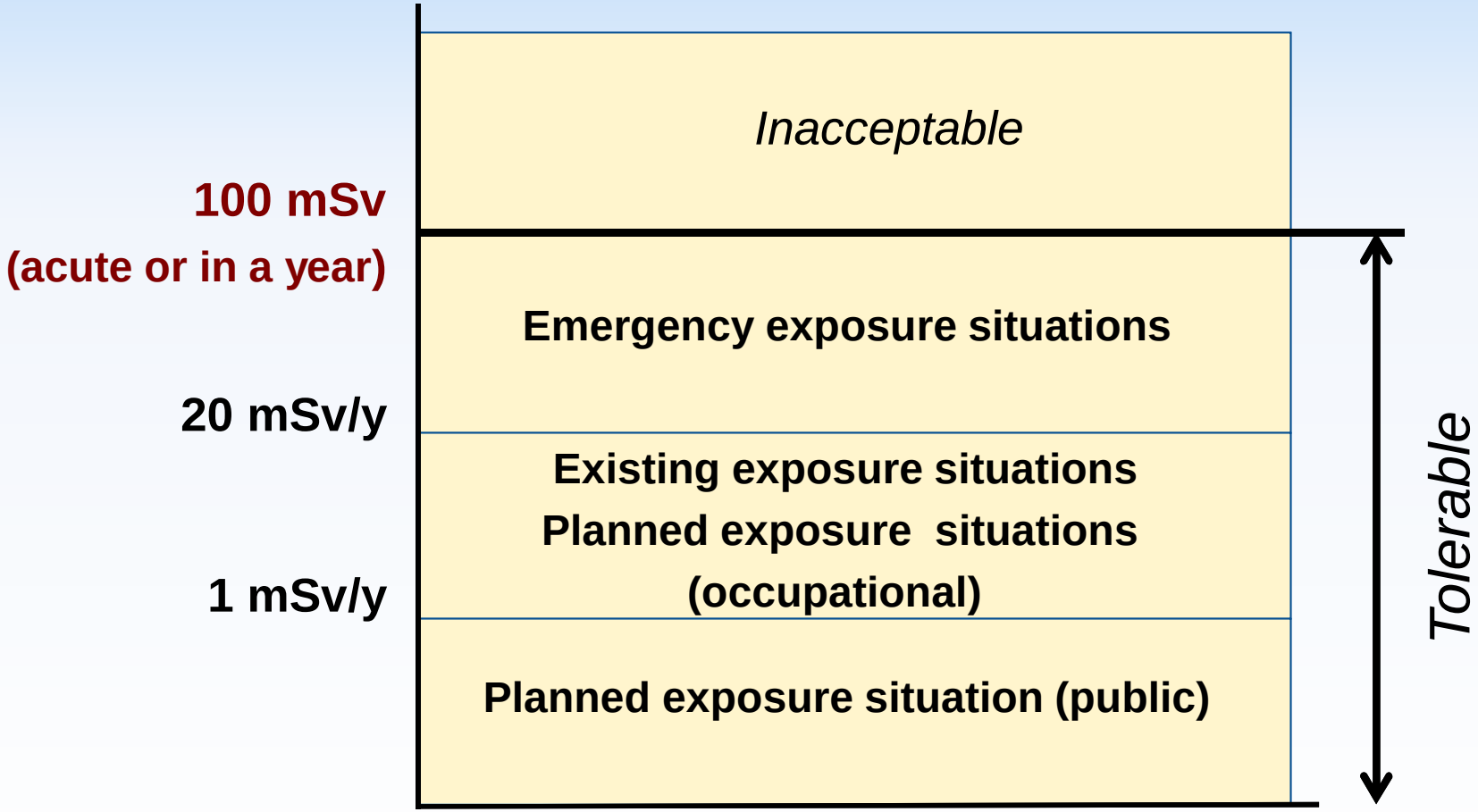
- Levels of individual dose, above which it is judged to be inappropriate to allow exposures to occur and below which the goal is to reduce all doses as low as reasonably achievable

- Dose restrictions for optimizing protection in planned exposure situations are called **dose constraints** and in emergency and existing exposure situations **reference levels**

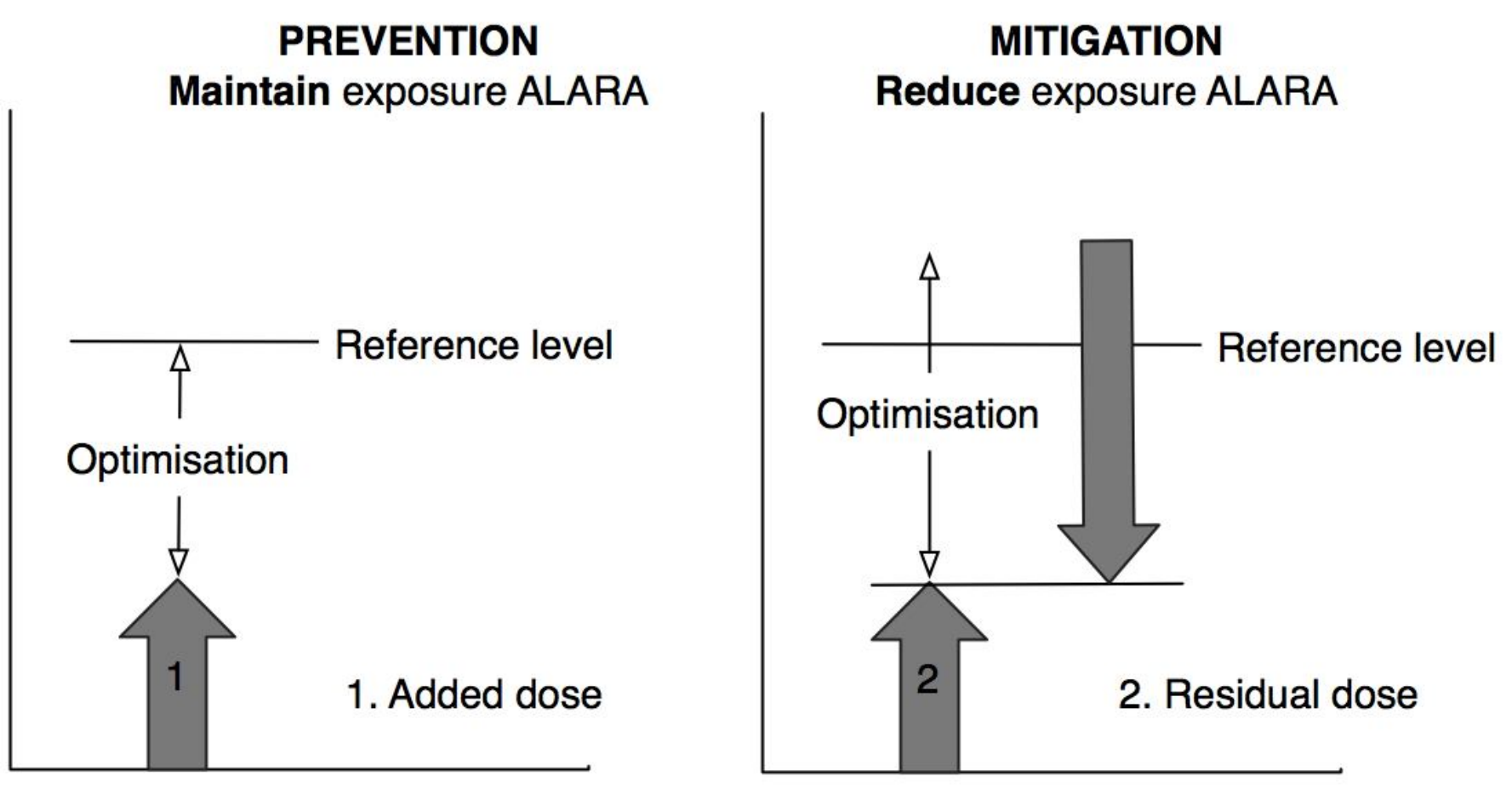
- For the selection of an appropriate value for the dose constraint or the reference level one should consider the relevant **exposure situation** in terms of the nature of the exposure, the **benefits from the exposure situation to individuals and society**,…, and the **practicability** of reducing or preventing the exposures (ICRP 103, § 242)

- *"At doses higher than 100 mSv, there is an increased likelihood of deterministic effects and a significant risk of cancer. For this reason the Commission considers that the **maximum value for a reference value is 100 mSv** incurred either acutely or in a year." (ICRP 103, § 236)*

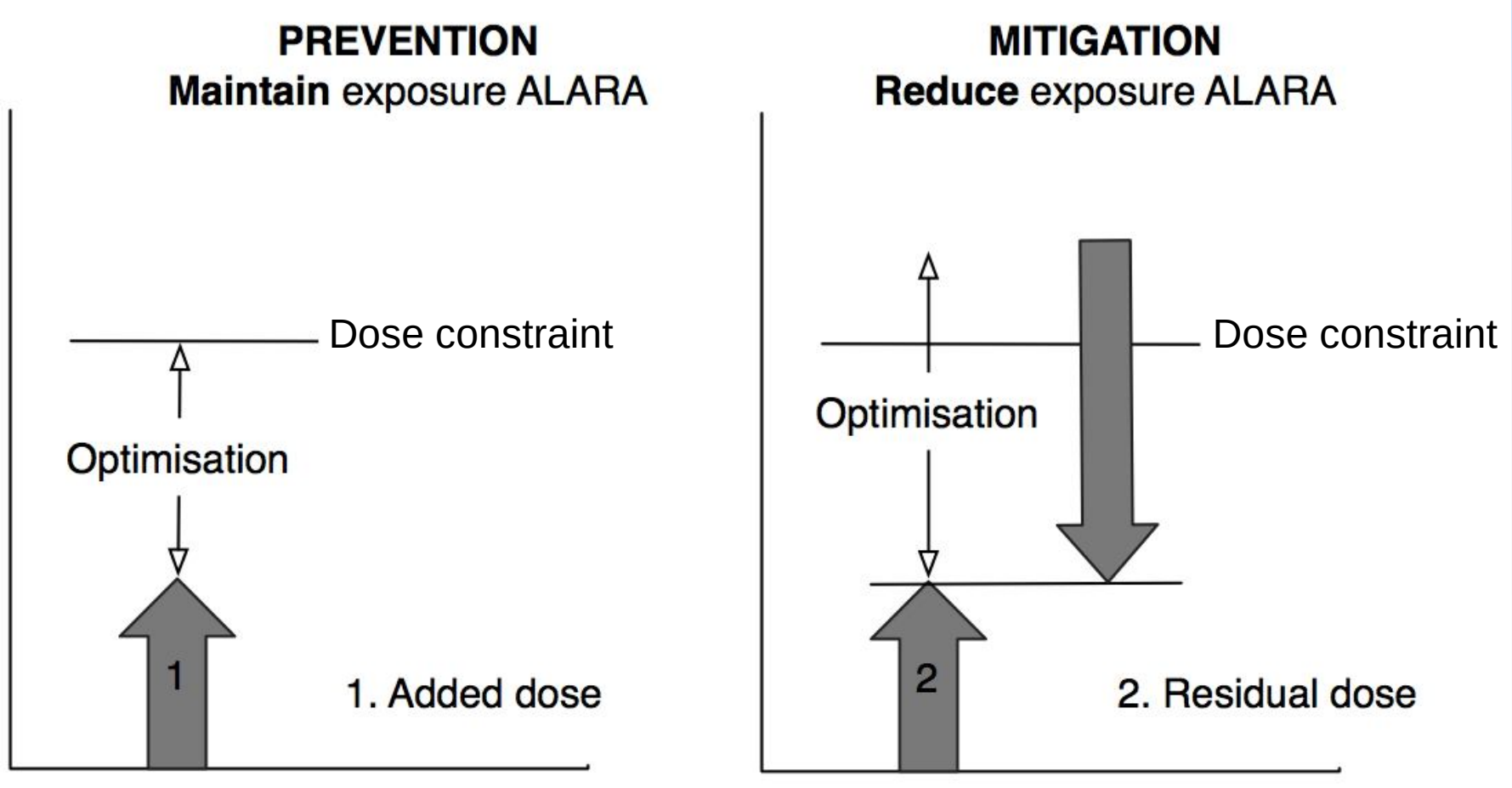
Bands of dose for selecting reference levels and dose constraints



The principles of optimisation for existing and emergency situations



The principles of optimisation for planned exposure situations



Limitation : «ensure that no individual is exposed to unacceptable radiation risks in planned exposure situations»

- In order to prevent excessive individual risk in planned exposure situations the Commission is recommending the use of dose limits

- "***Dose limits*** *are aimed at ensuring that no individual is exposed to radiation risks that are judged to be* ***unacceptable*** *in any normal circumstances.*" ICRP 60, § 112

- The limitation principle recognizes that each exposed individual has the **right** that the risk she /he is subjected do not exceed a level **judged socially unacceptable**

- This position is consistent with the ethical **principle of egalitarian justice** which states that in similar situations individuals should be treated the same

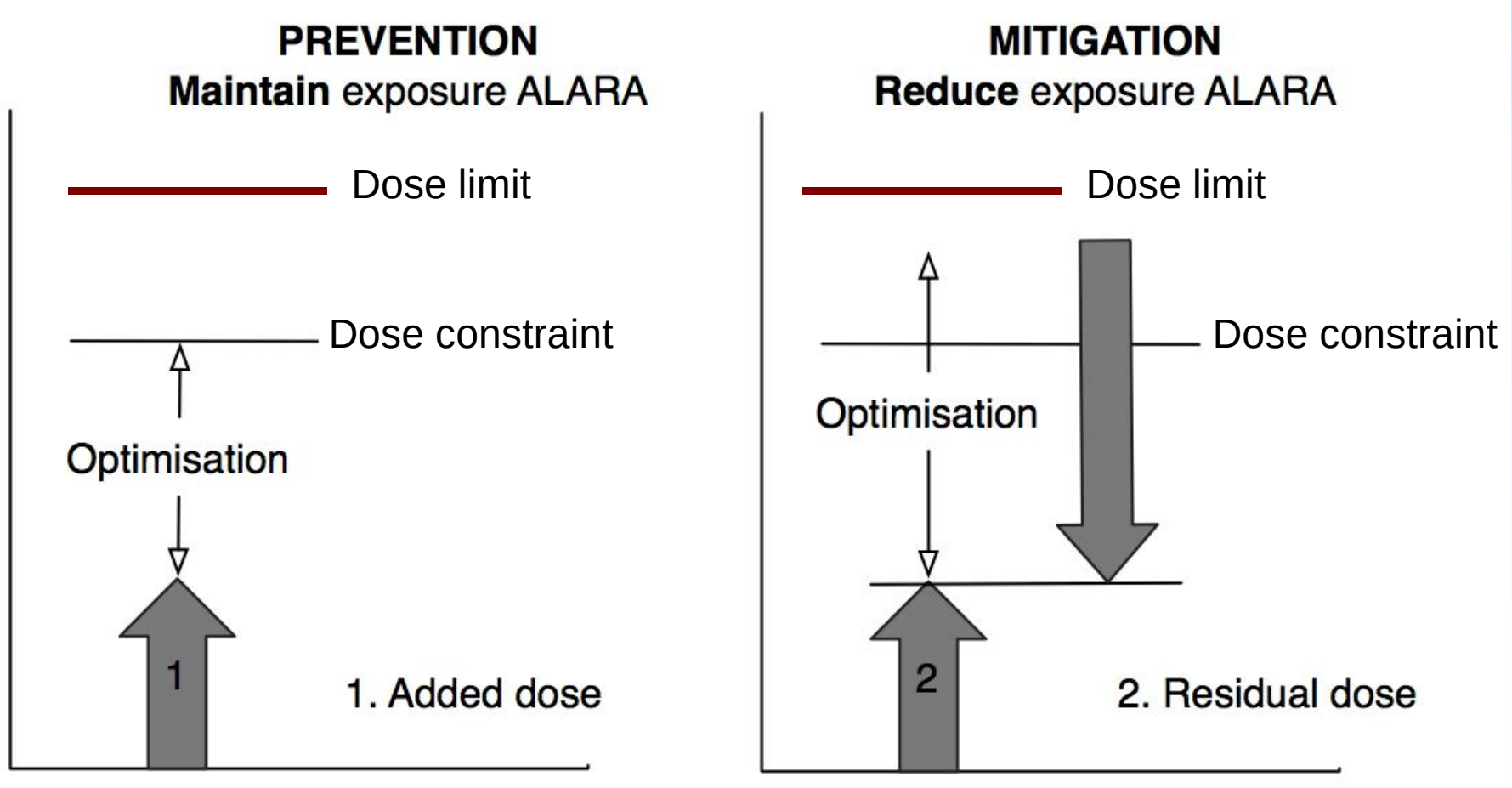
The quest for tolerableness

- **Publication 26 (1977)** : the risk associated with dose limits compared with safe occupation for occupational exposures and risk regularly accepted in everyday life (e.g. public transport) for public exposures

- **Publication 60 (1990)**: introduction of the tolerability of risk model: difference between unacceptable, tolerable and acceptable. Use of a multi-criteria approach for the occupational dose limit and reference to the natural background for the public dose limit

- **ICRP Committee 4** is currently considering the implications of the situation–based approach introduced in **Publication 103** with regard to the tolerability of risk model

The principles of application of dose limits for planned exposure situations



Dose criteria in summary

Exposure situations	Medical exposure	Occupational exposure	Public exposure
Existing	-	RL ≤20 *	RL≤ 20**
Planned	DRLs	DC ≤ 20 L= 20	DC ≤ 1 L= 1
Emergency	-	RL≤100	RL≤ 100

RL = reference level ; DC= dose constraint ; L = dose limit

* RL = 10 mSv/y for radon

** RL = 10 mSv/y for radon, and lower part of the 1-20 mSv/y band with long term objective of 1 mSv/y for long term contaminated territories

Basic requirements

- Information
- Education/training
- Radiation assessment and monitoring
- Medical surveillance

Stakeholder engagement (1)

- ICRP mentions, ***"for the first time, the need to account for the views and concerns of stakeholders when optimising protection"*** in its 2007 recommendation (Pub 103, Editorial; see also § 224 in section 5.8 on optimisation)

- **Why to engage stakeholders?**

  - To take into account their **concerns and expectations** as well as the **prevailing circumstances** of the exposure situations

  - To favour their **empowerment** and **autonomy** i.e to promote their **dignity**

  - To diffuse **radiation protection culture**

  - To adopt more **effective** and **fairer** protection actions

Stakeholder involvement (2)

- Stakeholder engagement in radiation protection emerged in the **late 80s and early 90s** in the context of the management of exposures in contaminated areas by the **Chernobyl accident** and contaminated sites by **past activities**
- **Publication 82** (1999) on the protection of the public in situations of prolonged radiation exposure is the first ICRP Publication mentioning explicitly stakeholder involvement.
- Then **Publications 91** (2003) on the protection of non-human species and **Publication 101** (2006) on the optimisation of protection

Concluding remarks

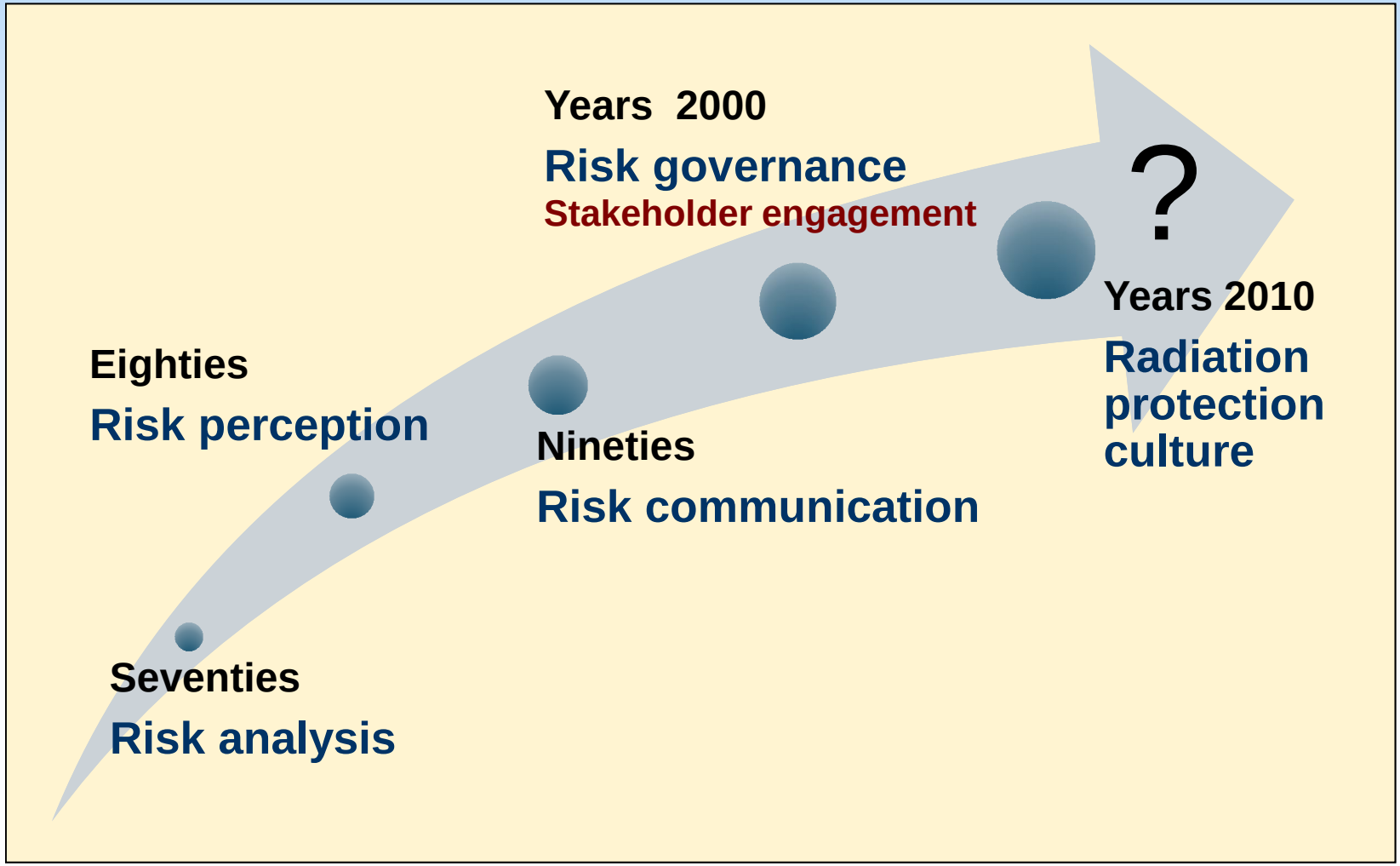
- The system of radiological protection developed gradually during the XXth century integrating advances in knowledge about the effects of radiation, the evolution of the ethical and social values as well as the feedback experience from its practical implementation in all relevant domains
- Until the Second World War the Commission was only dealing with the protection of medical staffs
- After the war the focus was on nuclear energy and radiological protection developed to protect workers inside nuclear installations and the public outside. This resulted in a coherent and effective system based on solid concepts and principles (ICRP 60, 1990)
- The raising concerns on “existing exposure situations” (natural and man-made) in the nineties profoundly challenged the 1990 system and resulted in the principles presented in ICRP Publication 103

Epilogue

- Apart from scientists, experts and professionals, citizens are rarely informed about radiation and radiological protection
- The relationship of our contemporaries to radioactivity remains largely dominated by the spectre of Hiroshima and Nagasaki
- The uncertainty about the effects of low doses feeds for decades an on-going scientific and social controversy on the effects of radiation
- “Risk communication” has globally failed to reduce the gap between experienced professionals and non informed people
- Lessons from engaging stakeholders during the last 2 decades (Chernobyl, Fukushima, contaminated sites from the past,…) tell us that we, as professionals, we must develop a narrative about radiation and radiological protection to reconcile citizens with this reality of daily life

The basic function of language is not to inform but to relate events and to tell stories about individual and social life

From radiation risk to radiation protection culture



www.icrp.org