International Conference on Radiation Safety: Improving Radiation Protection in Practice
IAEA Headquarters Vienna, Austria; 9–13 November 2020
Organized by the International Atomic Energy Agency (IAEA); in cooperation with: the European Commission (EC); the Food and Agriculture Organization of the United Nations (FAO); the International Labour Organization (ILO); the OECD Nuclear Energy Agency (OECD-NEA); the Pan American Health Organization (PAHO); the United Nations Environment Programme (UNEP); and, the World Health Organization (WHO)

Emerging Challenges in Radiation Protection

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Member of the Commission of Safety Standards of the IAEA
Member of the Committee of Radiation Protection and Public Health of NEA (OECD)

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The international radiation safety system is one of the more significant international and intergovernmental successes!

The international radiation safety system

- Universal and consensual
- Founded on internationally accepted science
- Based on an universal paradigm recommended by a non-governmental charity.
- Resulted in an intergovernmental regime of standards and norms co-sponsored by all relevant international agencies.
- Includes provisions for practical applications from international professional societies.

CONSENSUAL SCIENCE

↓

UNIVERSAL PARADIGM

↓

INTERGOVERNMENTAL STANDARDS & NORMS

↓

PRROVISIONS FOR APPLICATION

UNSCEAR

ICRP

Euratom FAO IAEA ILO IMO OECD/NEA PAHO UNEP WHO

IAEA WHO

IRPA

Notwithstanding this success

….after nearly a century on the run,……

……the system may need some review…

…and… eventually…..

revision and fixing!…

Purposes of this presentation

1. Submitting a personal diagnosis of problems, and
2. Describing challenges for fixing them….but…

…in order to prevent misunderstanding, I will present it as a

..because, I was involved in developing the system!

Sorry. Sorry. Sorry. Sorry. Sorry.
Sorry. Sorry. Sorry. Sorry. Sorry.
Sorry. Sorry. Sorry. Sorry. Sorry.
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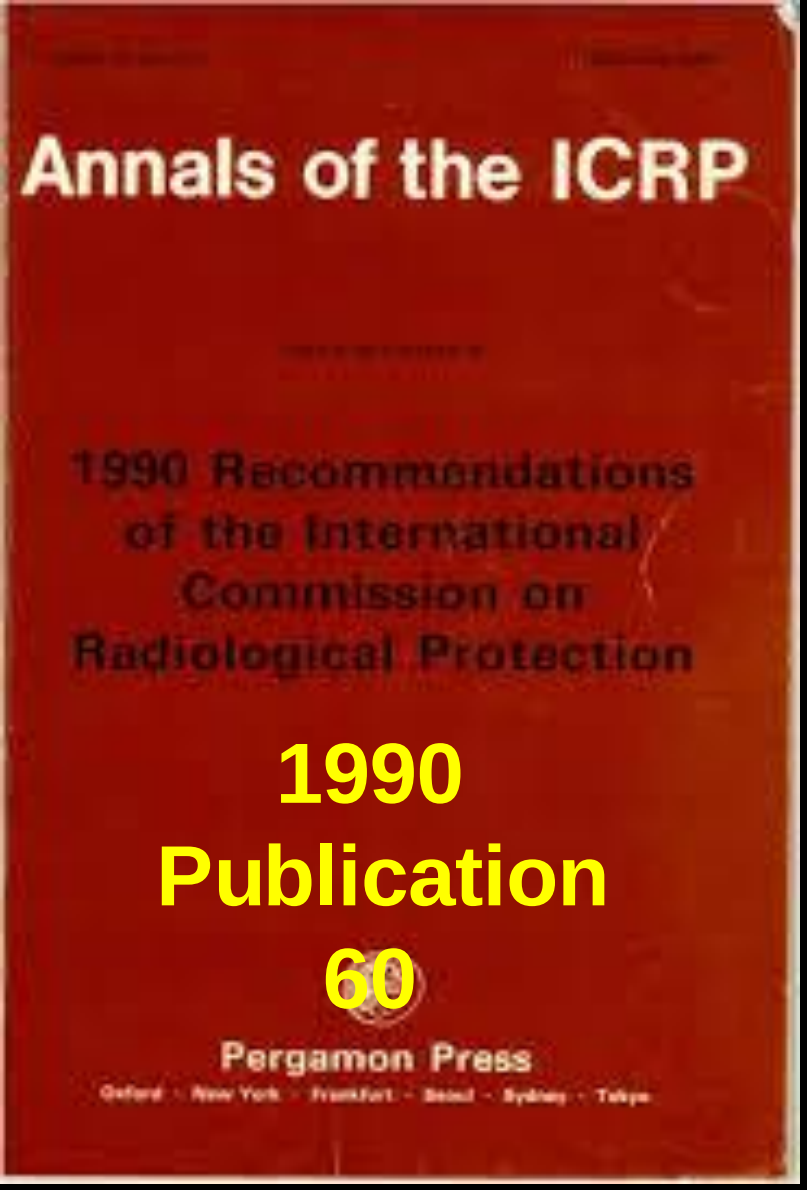
Annals of the ICRP
1990 Recommendations of the International Commission on Radiological Protection
1990
Publication
60
Pergamon Press

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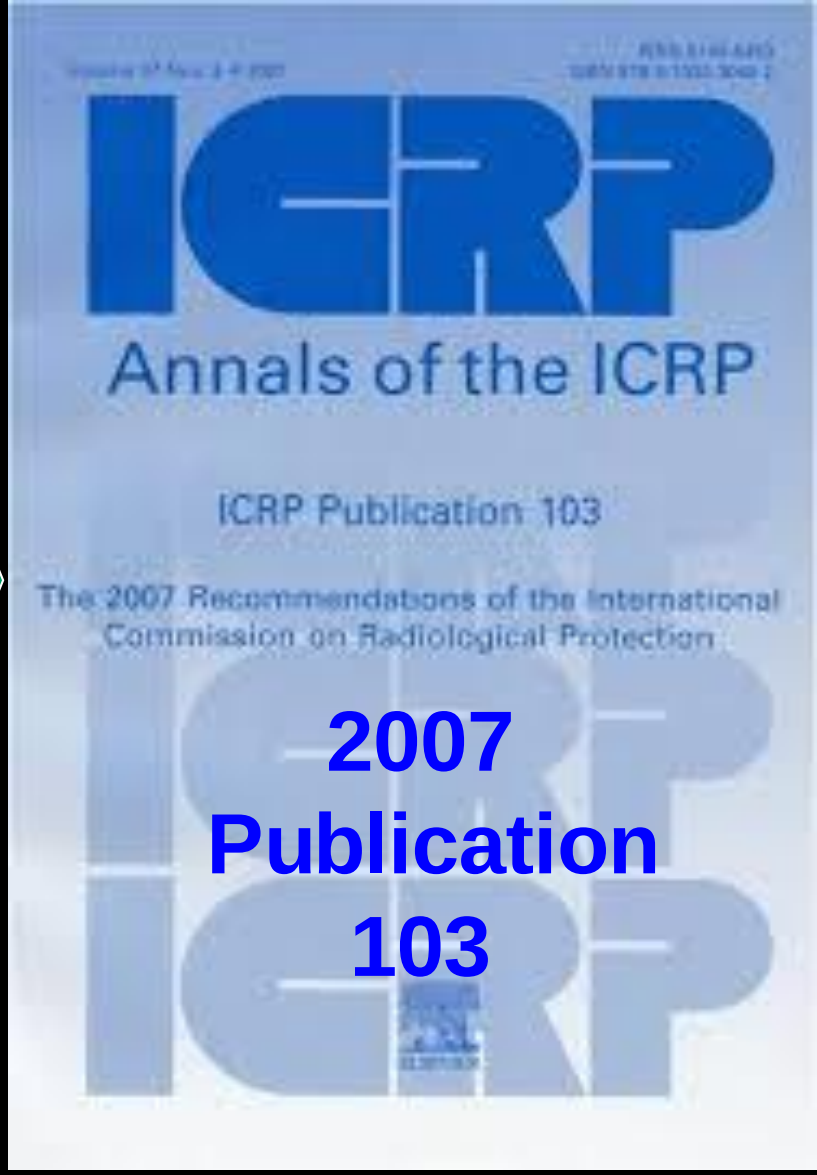
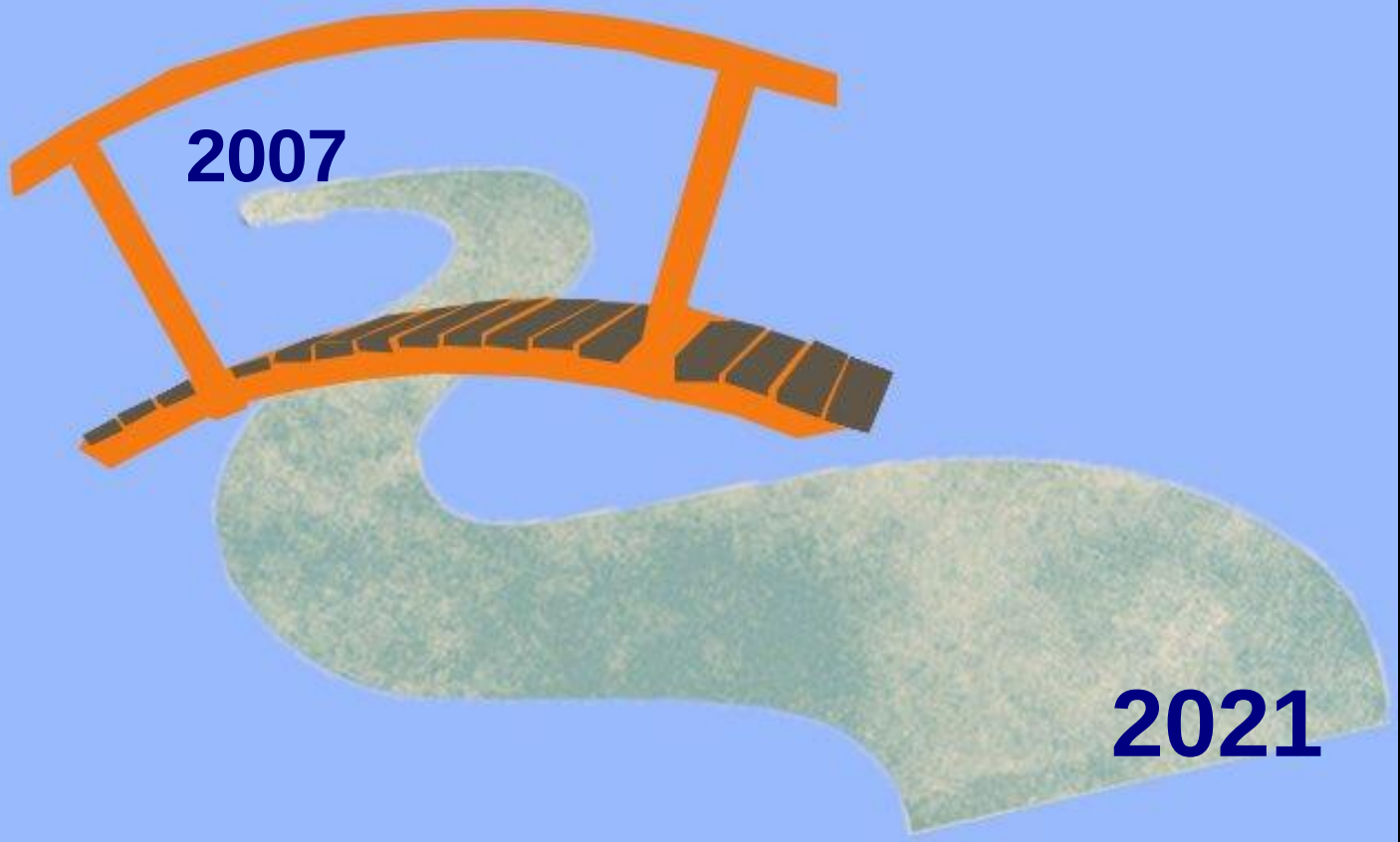

ICRP
Annals of the ICRP
ICRP Publication 103
The 2007 Recommendations of the International Commission on Radiological Protection
2007
Publication
103



Water under the bridge

Lessons learned?

Content
(Emerging Challenges)

1. Scientific basis
2. Ethics & Principles
3. Situations & Categorization
4. Standards & Applications
5. Epilogue

1.
Scientific basis
(The LNT conundrum)

Mea culpa

We did not clearly differentiate between:

- **Proved THESIS on radiation EFFECTS**

(and their retrospective attribution)

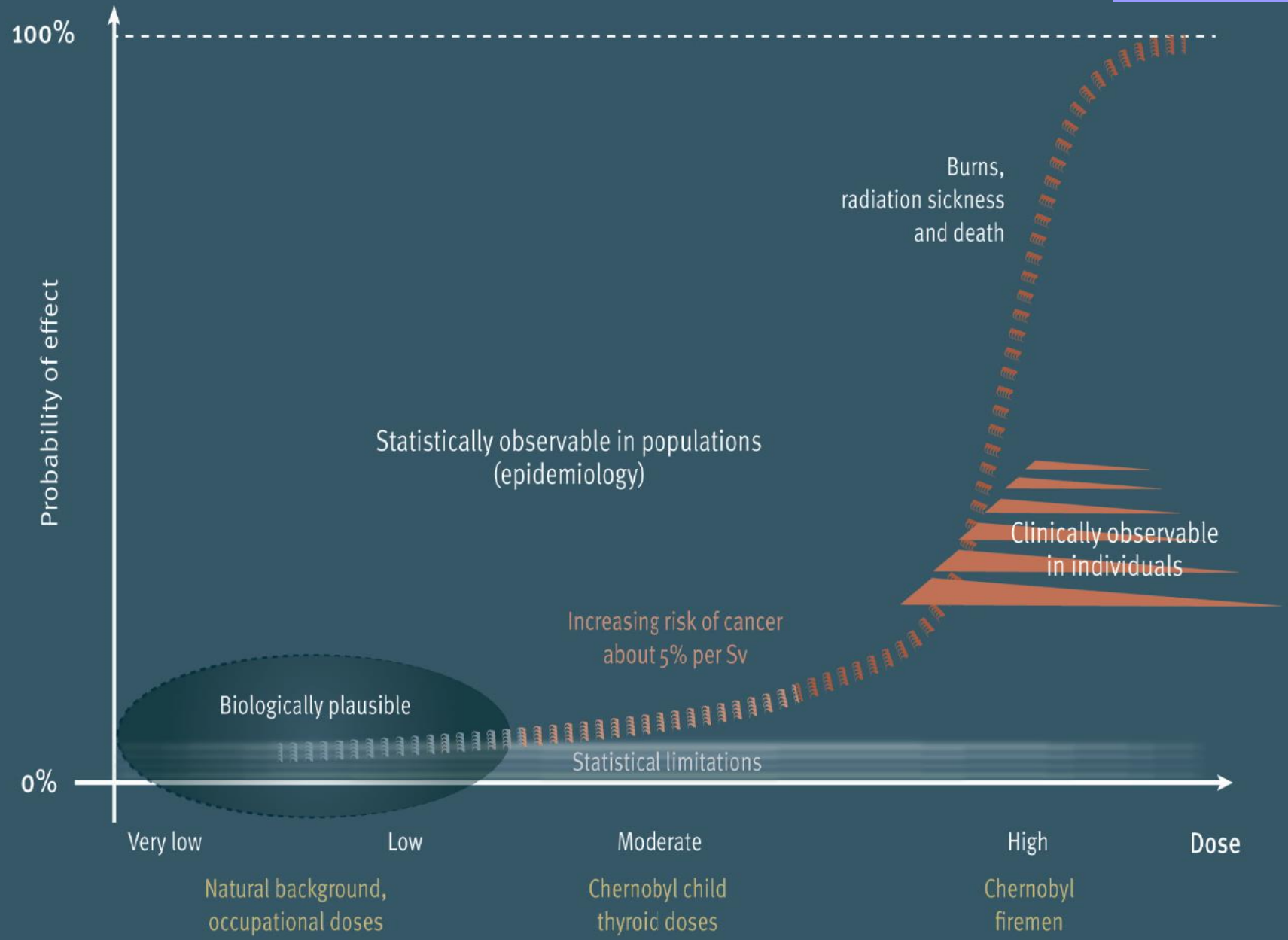
and

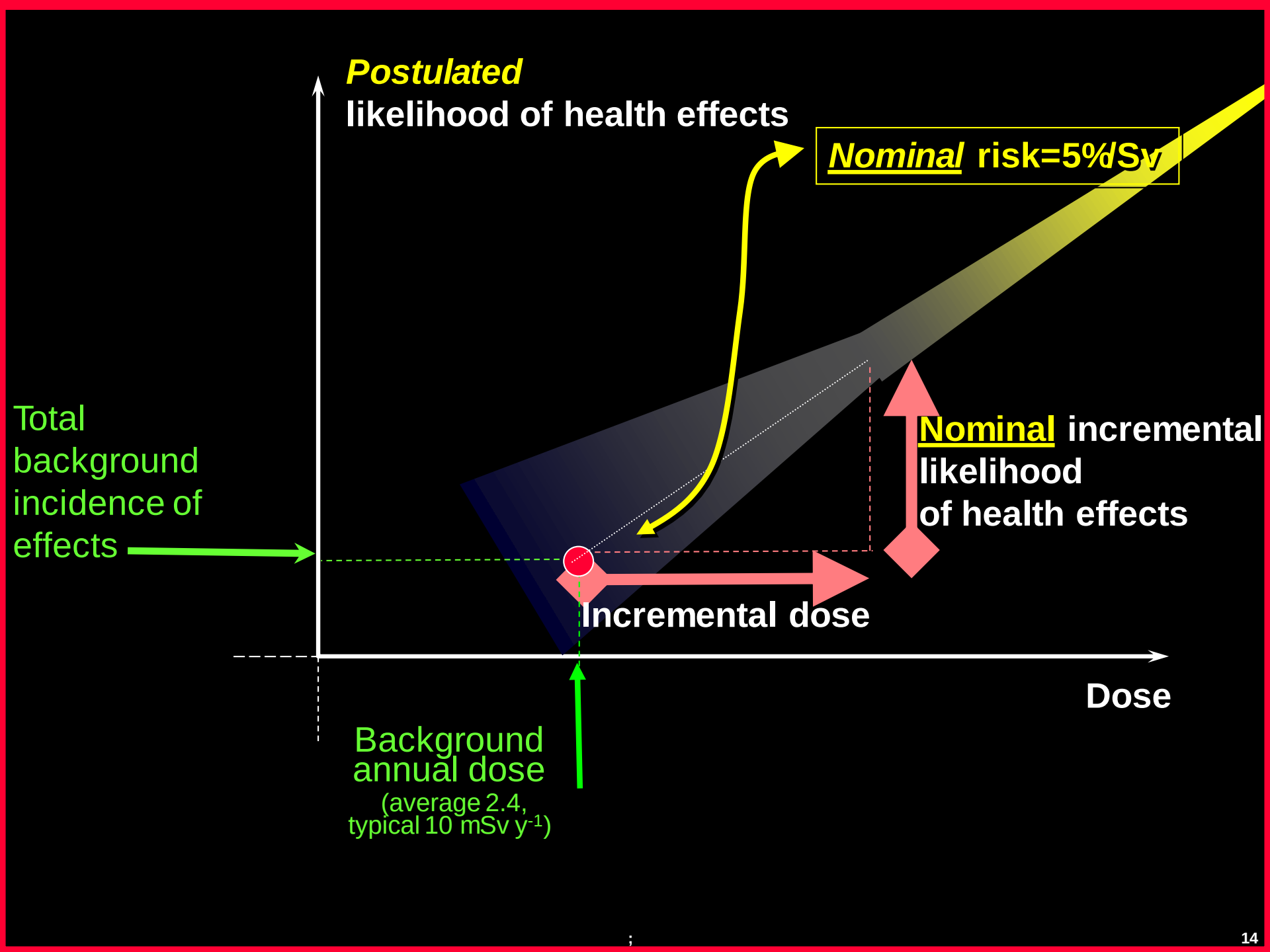
- **Conjectural HIPOTHESIS on radiation RISKS**

(and their prospective inference)

Thus, A LNT protection model was confusedly explained and contradictorily presented as a LNT scientific fact!

Relationship of radiation doses and health effects




Postulated
likelihood of health effects
Nominal risk=5%/Sv
Total background incidence of effects
Nominal incremental likelihood of health effects
Incremental dose
Dose
Background annual dose
(average 2.4, typical 10 mSv y-1)

LNT
The critical question

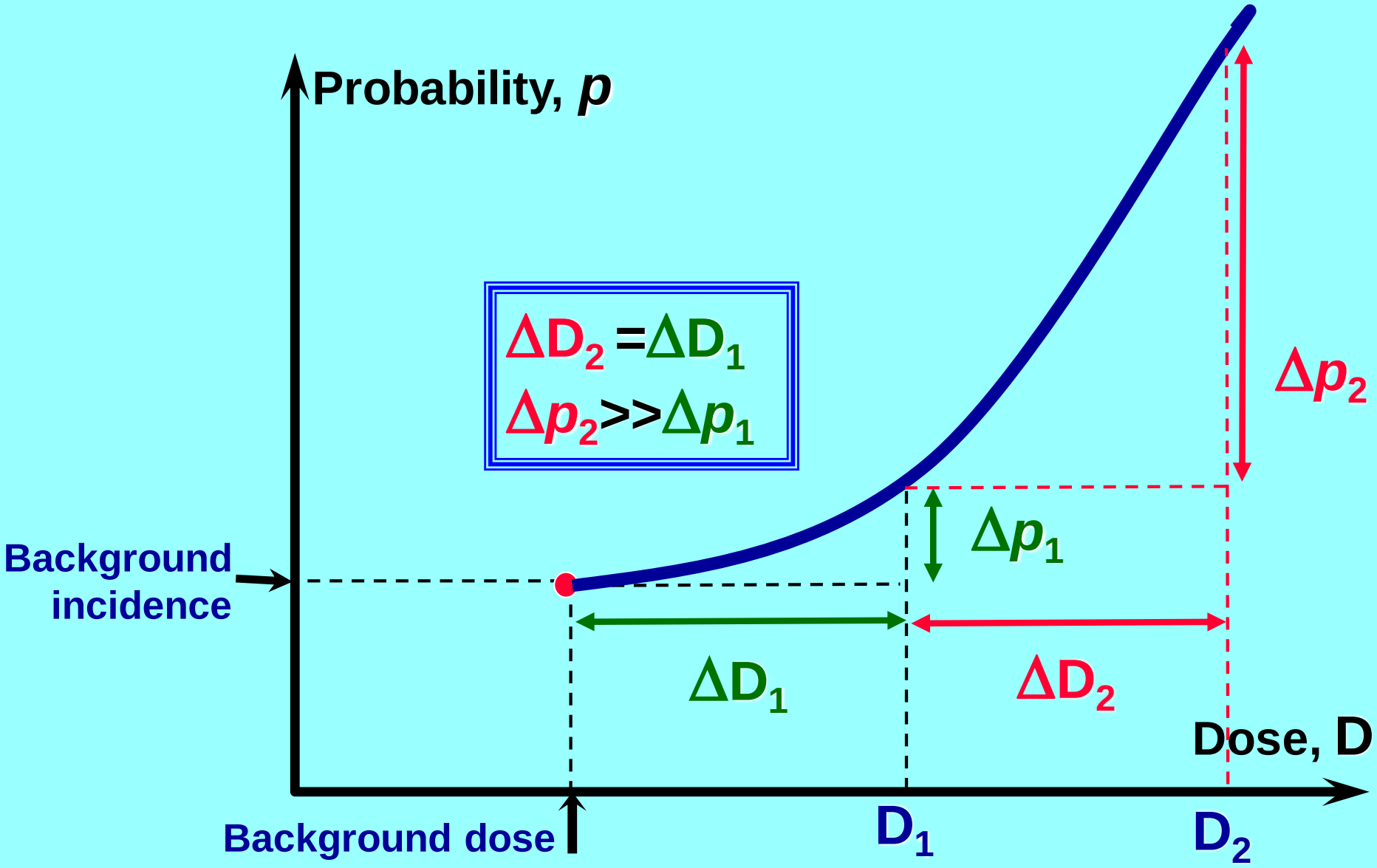
Is the recommended LNT :

- a proved **thesis**?

or

- an operational practical **model**?

- The intention was to recommend LNT as a **model** used for radiation protection purposes
- For ICRP, LNT '**provides the basis for the summation of doses from external sources of radiation and from intakes of radionuclides**'


Probability, p
ΔD2 =ΔD1
Δp2>>Δp1
Δp2
Δp1
Background incidence
ΔD1
ΔD2
Dose, D
Background dose
D1
D2

Challenge

If the LNT conundrum

is not clarified,

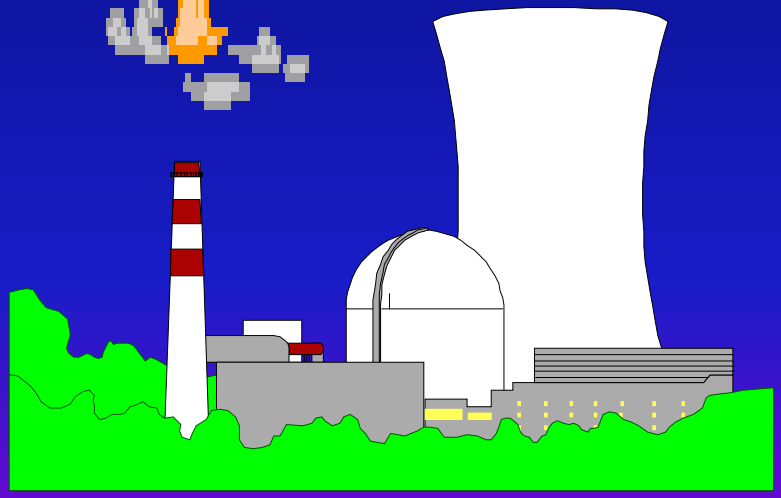
another more difficult conundrum will

continue to emerge:

counting corpses following low-dose radiation exposure situations

,

Modeling

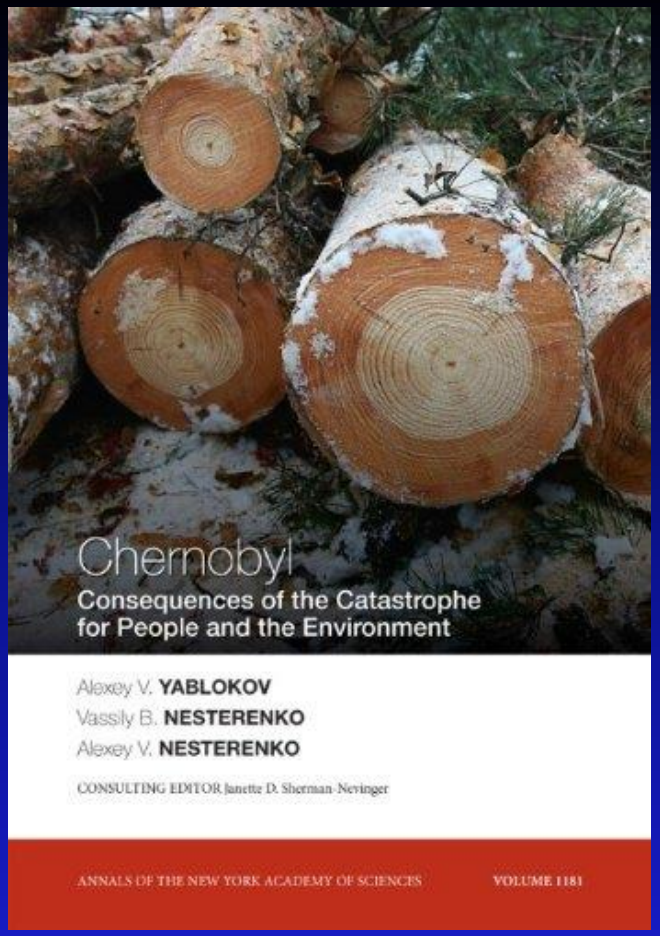


Discharges

Collective doses

X 5%/Sv =

Collective Dose x Nominal Risk Coefficient = Nominal Deaths



Chernobyl

Consequences of the Catastrophe for People and the Environment

Annals

of the

New York Academy of Sciences

It concludes that,

some 985,000 people died due to the Chernobyl accident!

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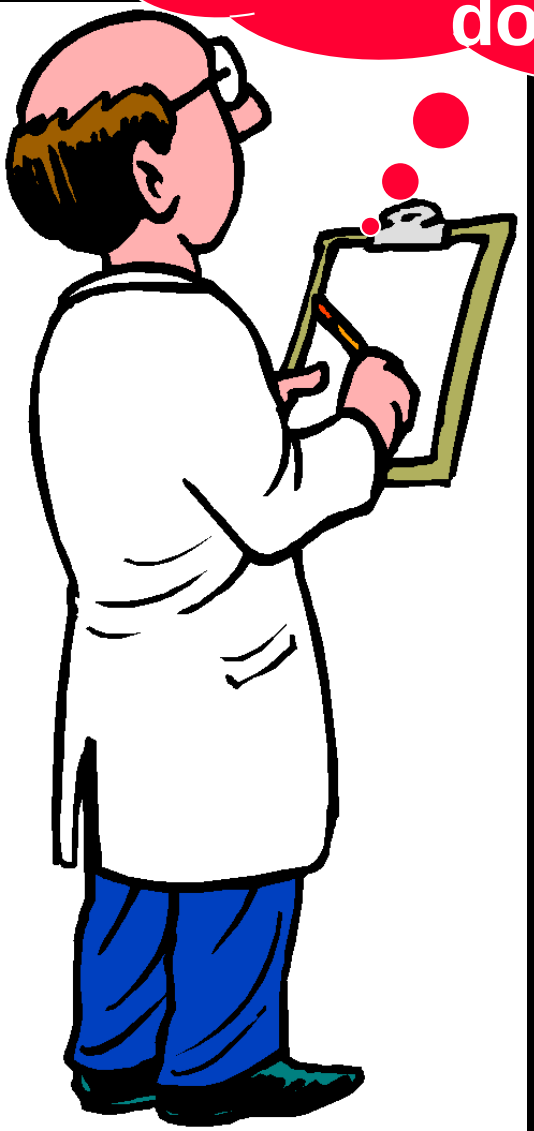
s

This calculation should not be done!



Why not?

s

UNSCEAR

Clarified the issue in 2012!

SOURCES, EFFECTS AND RISKS OF IONIZING RADIATION

UNSCEAR 2012 Report

Report to the General Assembly

SCIENTIFIC ANNEXES A AND B

ANNEX A

ATTRIBUTING HEALTH EFFECTS TO IONIZING RADIATION EXPOSURE AND INFERRING RISKS

UNITED NATIONS

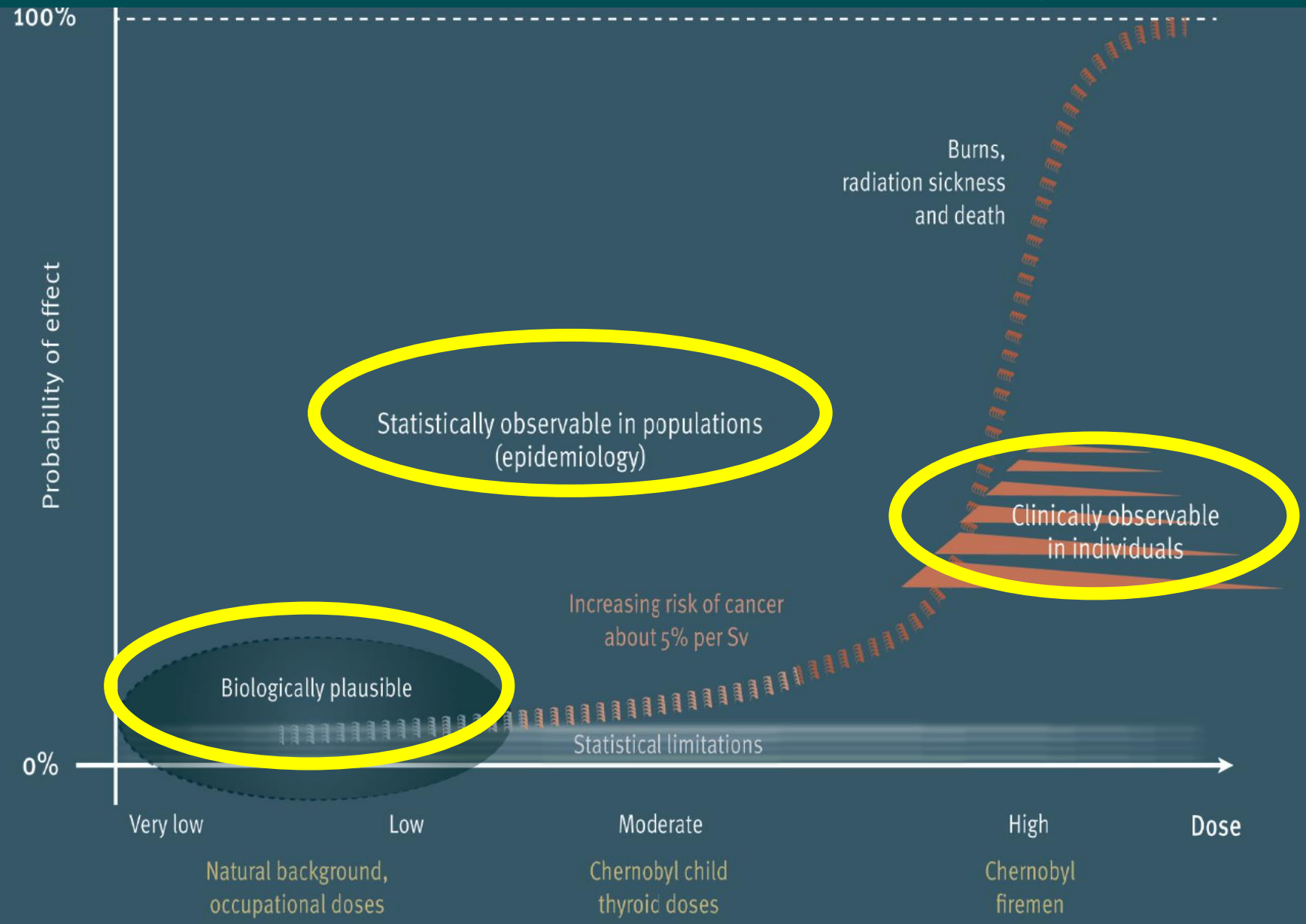
Identifying factual thesis

vs.

Conjectural hipothesis

A clear distinction between effects:

clinically observable, statistically observable and biologically plausible

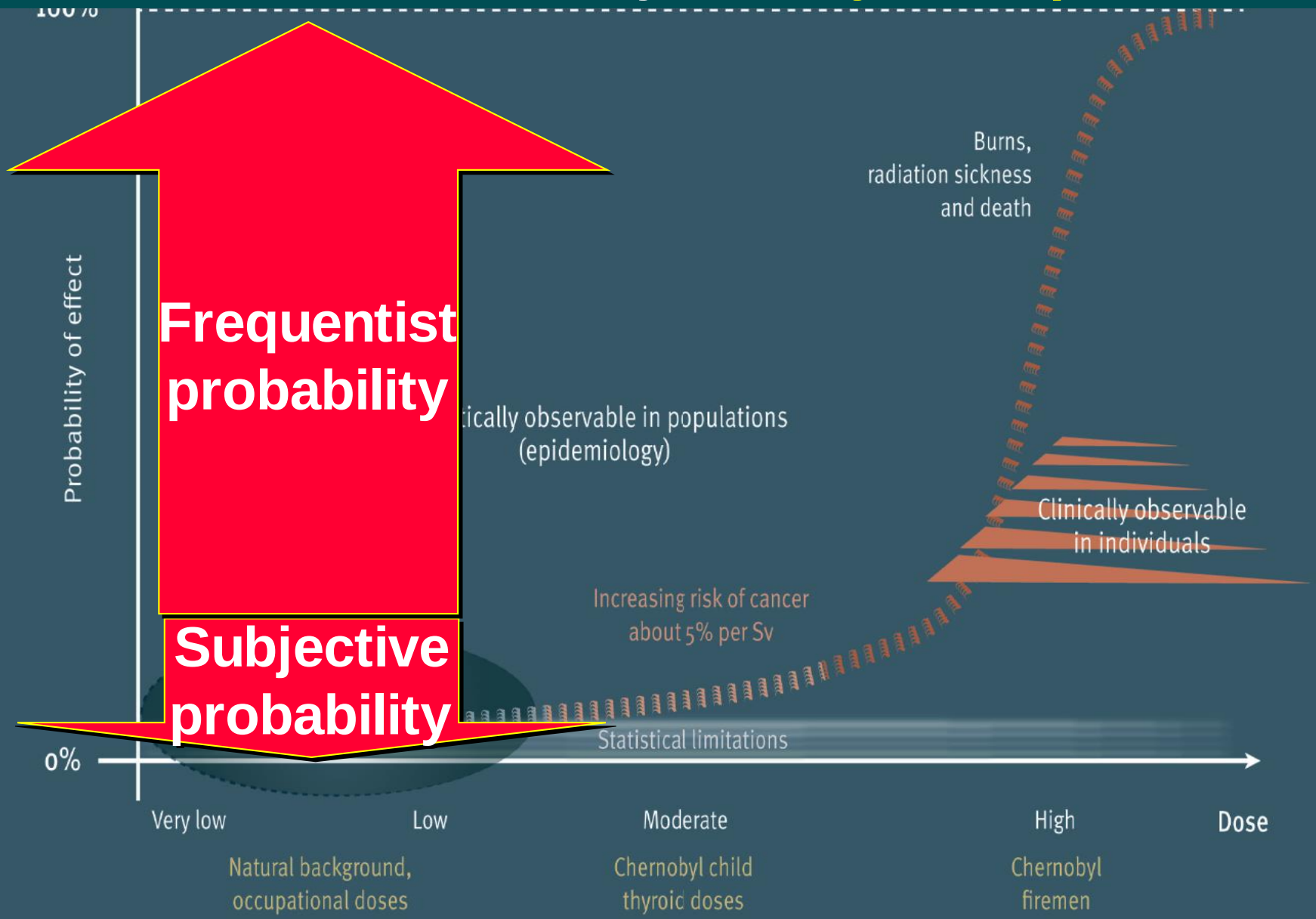


How the effects are quantified:

frequentist vs. subjective probabilities

;

At high doses there are measurable frequencies of effects but at low doses just subjective probabilities

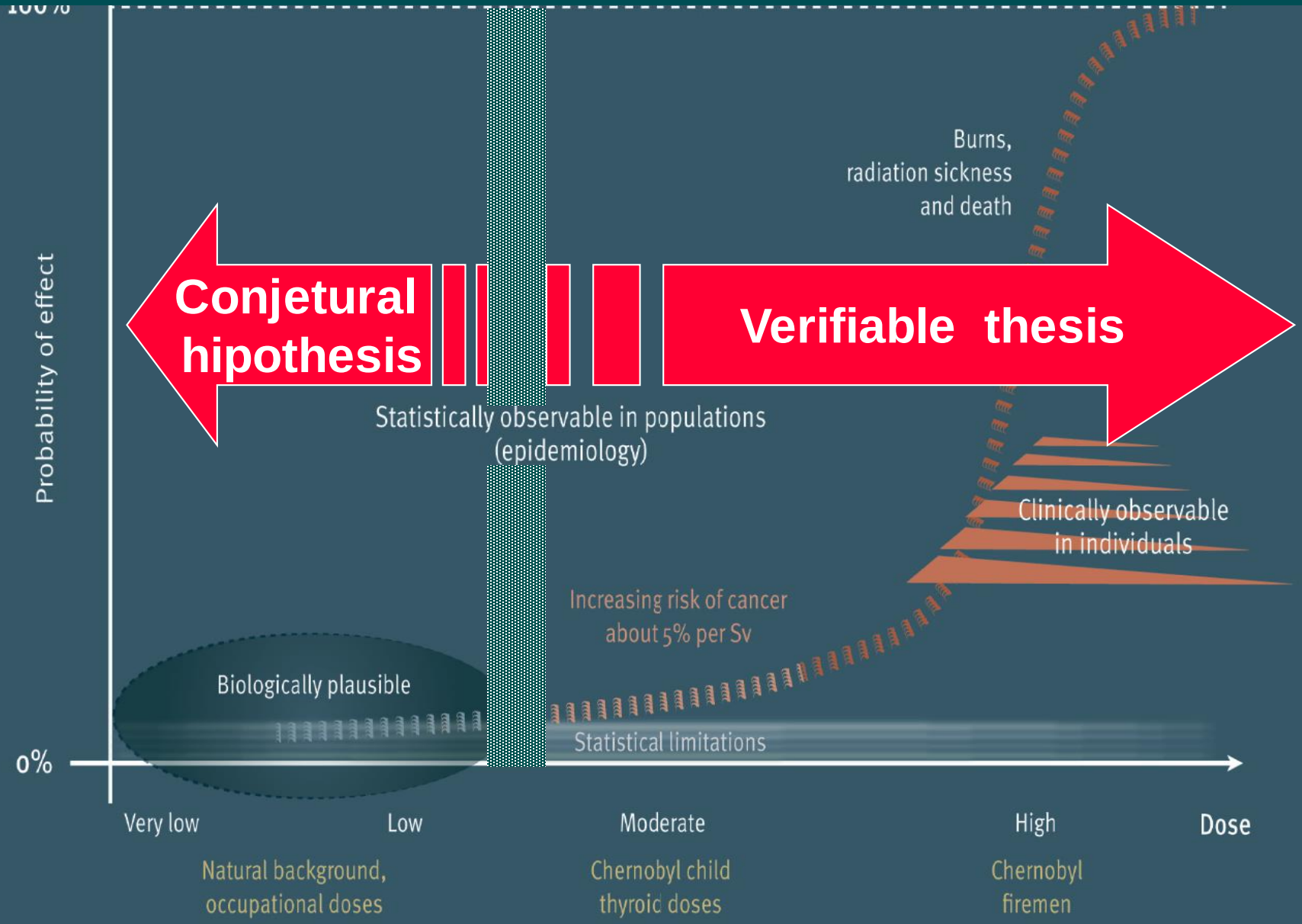


Verifiable thesis

vis-à-vis

Conjectural hipothesis

At high doses the effects are verifiable facts, but at low doses they are subjective conjectures

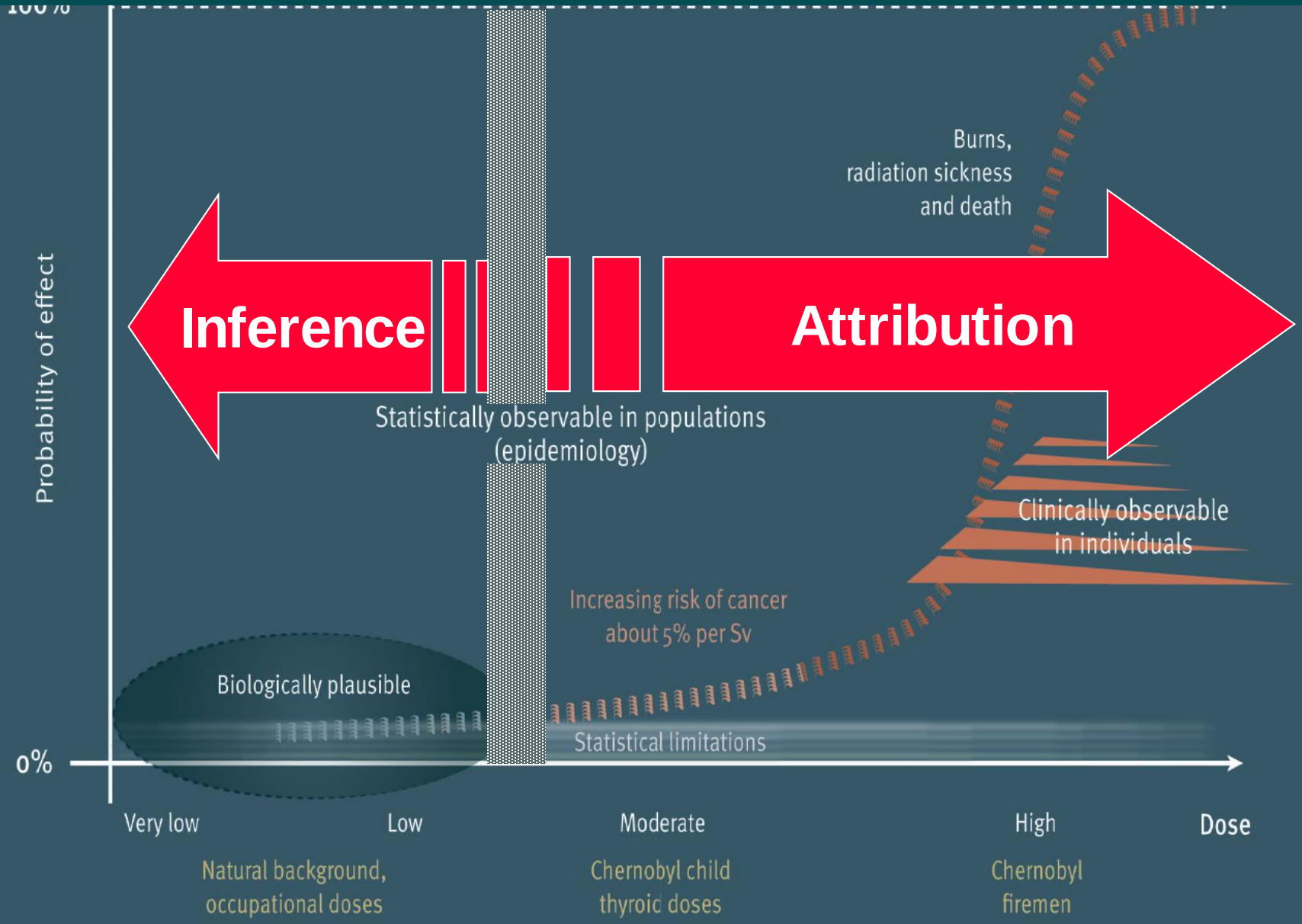


Attribution

vis-à-vis

inference

At high doses, *effects* are *attributable*; at low doses there might just be a *inference* of radiation *risk*



Thesis **of deterministic effects**

↓

Individual radio-pathological diagnosis

Thesis **of stochastic effects**

↓

Collective radio-epidemiological estimates

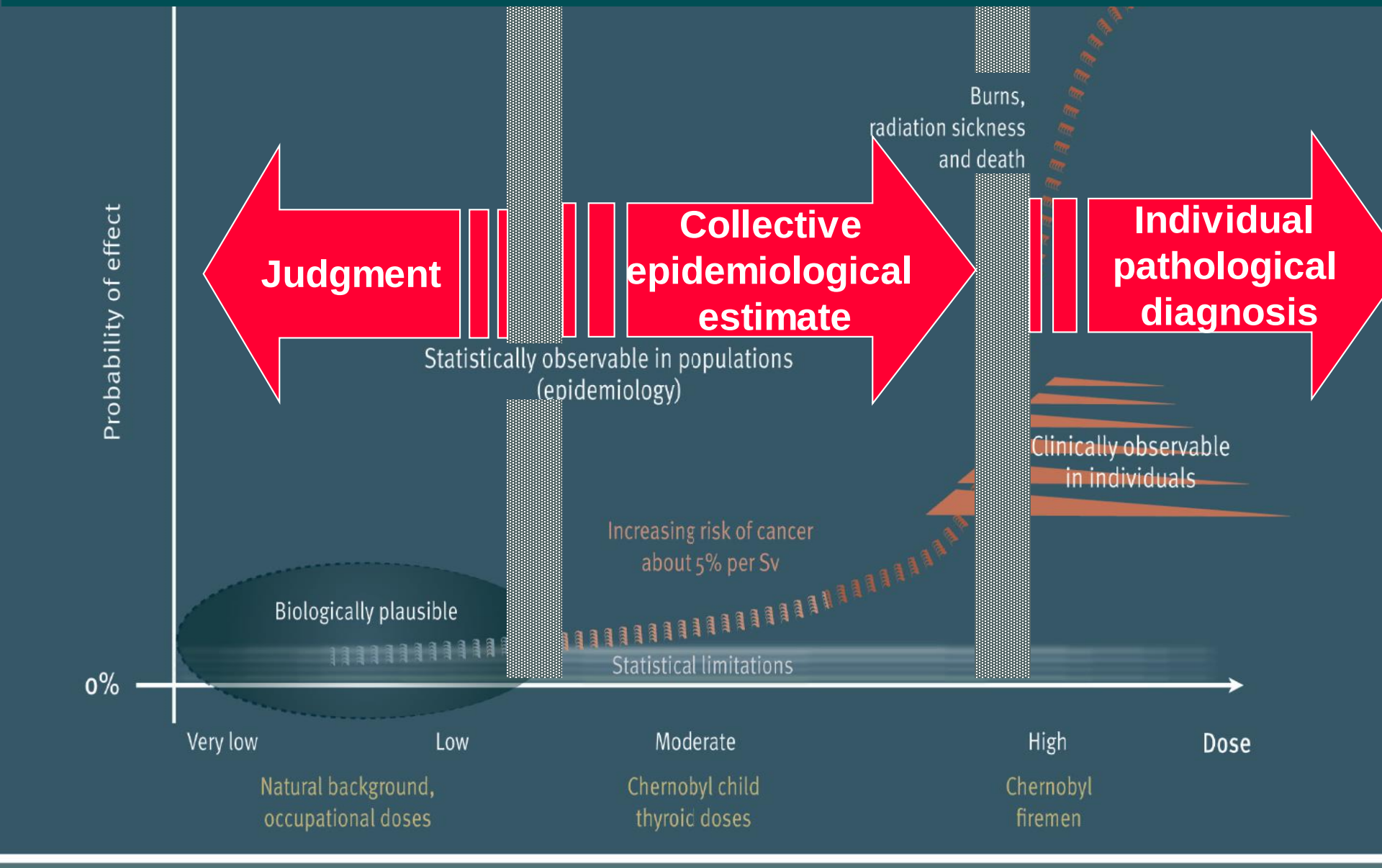
Hypothesis **of risk**

↓

Radio-protection scientific judgment

;

At very high doses the effects are diagnosable in the exposed individual, at moderate doses they can be collectible estimated, at low doses they are just extrapolable



Individual attribution

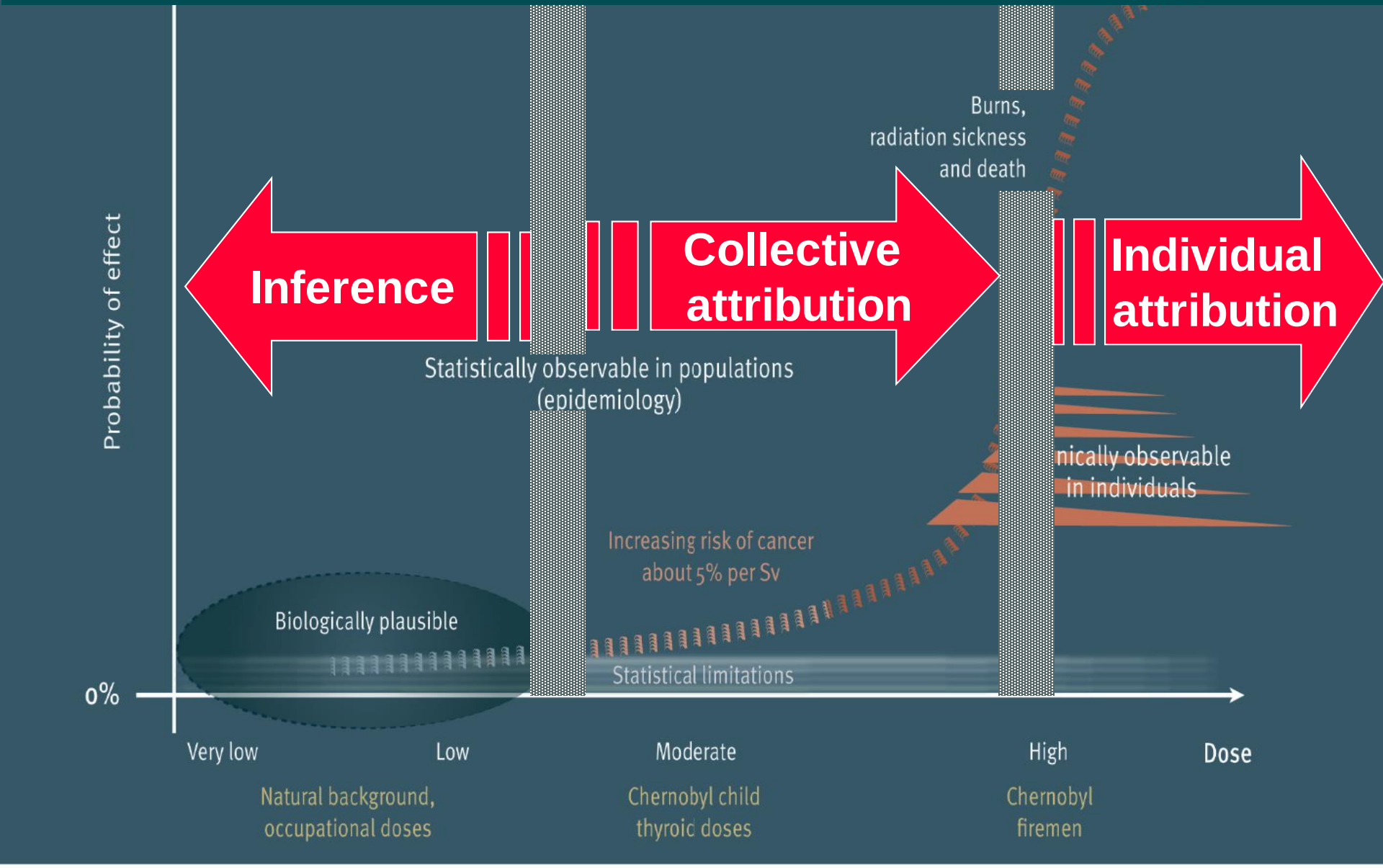
vis-à-vis

collective attribution

vis-à-vis

conjectural inference

High doses → Individual attribution
Moderate doses → collectible attribution
Low doses → just inference



Attesting

(providing formal evidence of)

- **Radio-Pathologists**

(Individual diagnosis of deterministic effect)

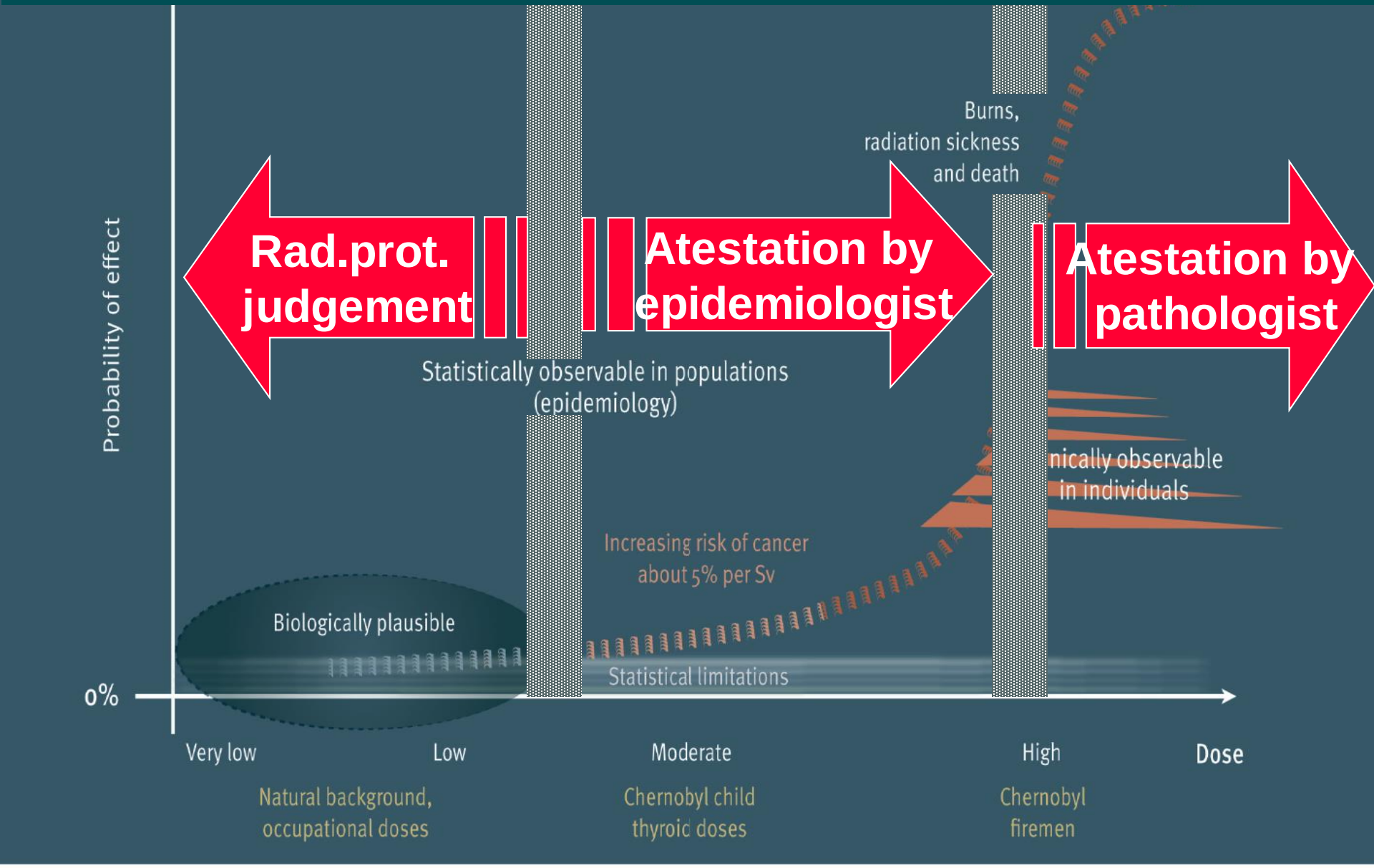
- **Radio-Epidemiologists**

(Collective estimate of stochastic effects)

- **Radio-protectionists**

(Judgement of hypothetical risk)

Individual effects → high doses → radio-pathologists
Collective effects→ Moderate doses → radio-epidemiologists
Risks → low doses → radio-protect. judgment



Emerging challenges for the future

Distinguishing

probabilities based on frequencies of factual occurrences

from

probabilities based on subjective judgments about potential occurrences.

Distinguishing

the attribution of provable radiation effect

from

***the inference of probable radiation risks*.**

Distinguishing

attribution of radiation effects incurred by

individuals

from

attribution of changes in the incidence of radiation effects on large

populations

Clarifying

attestation of individual effects by

radio-pathologists

from

attestation of collective changes in the

incidence of effects by

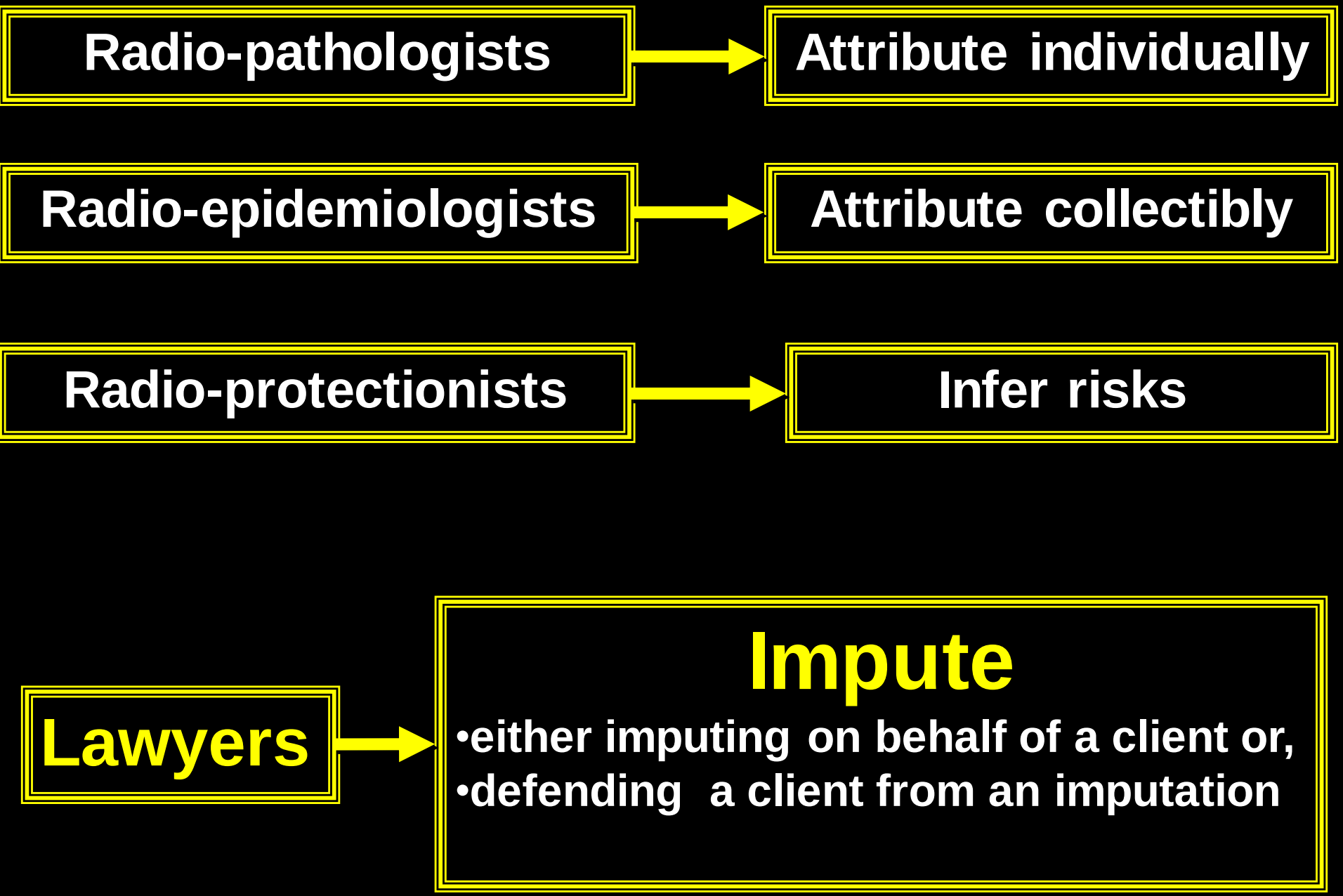
***radio-epidemiologists*.**

Distinguishing

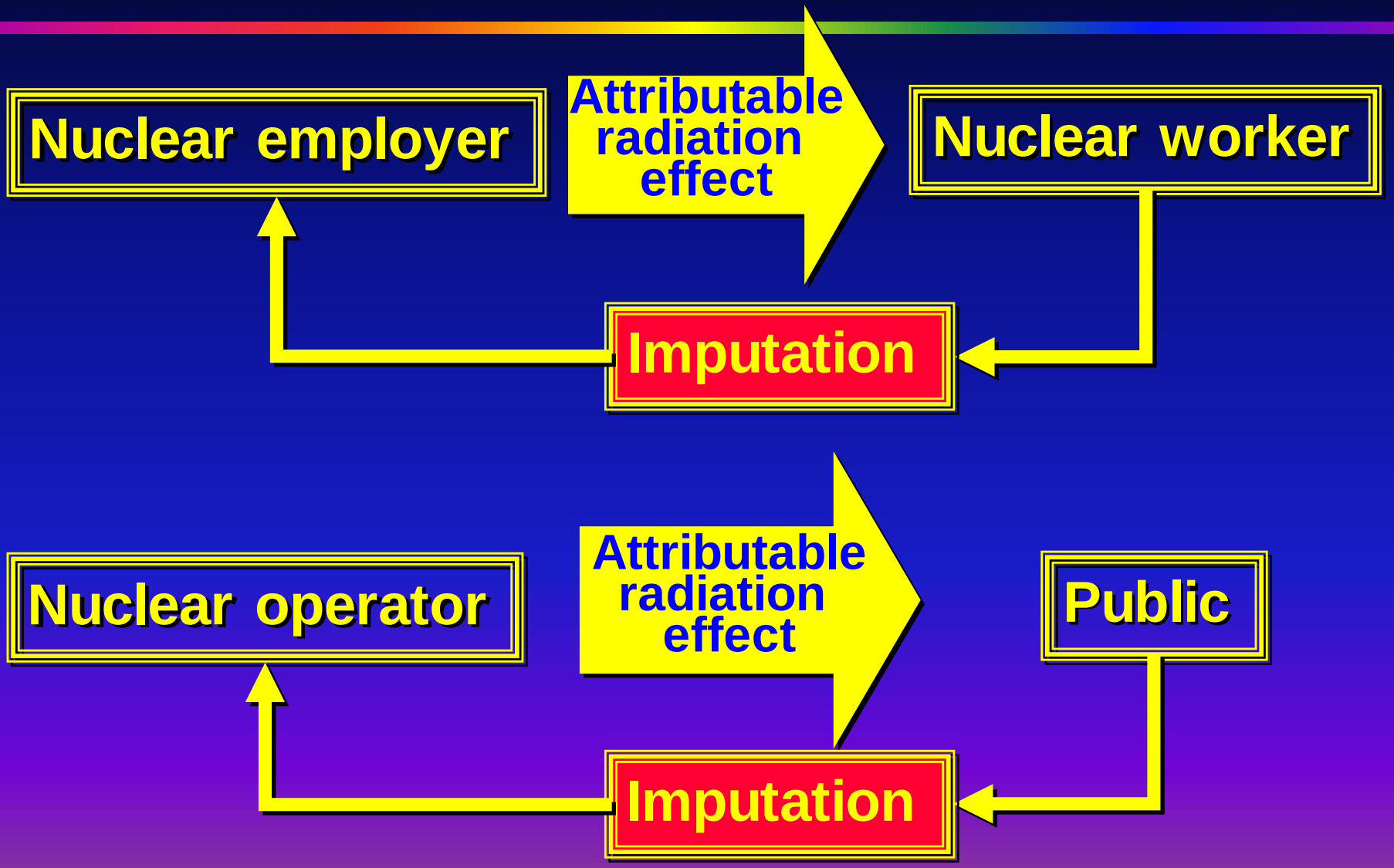
scientific attribution

from

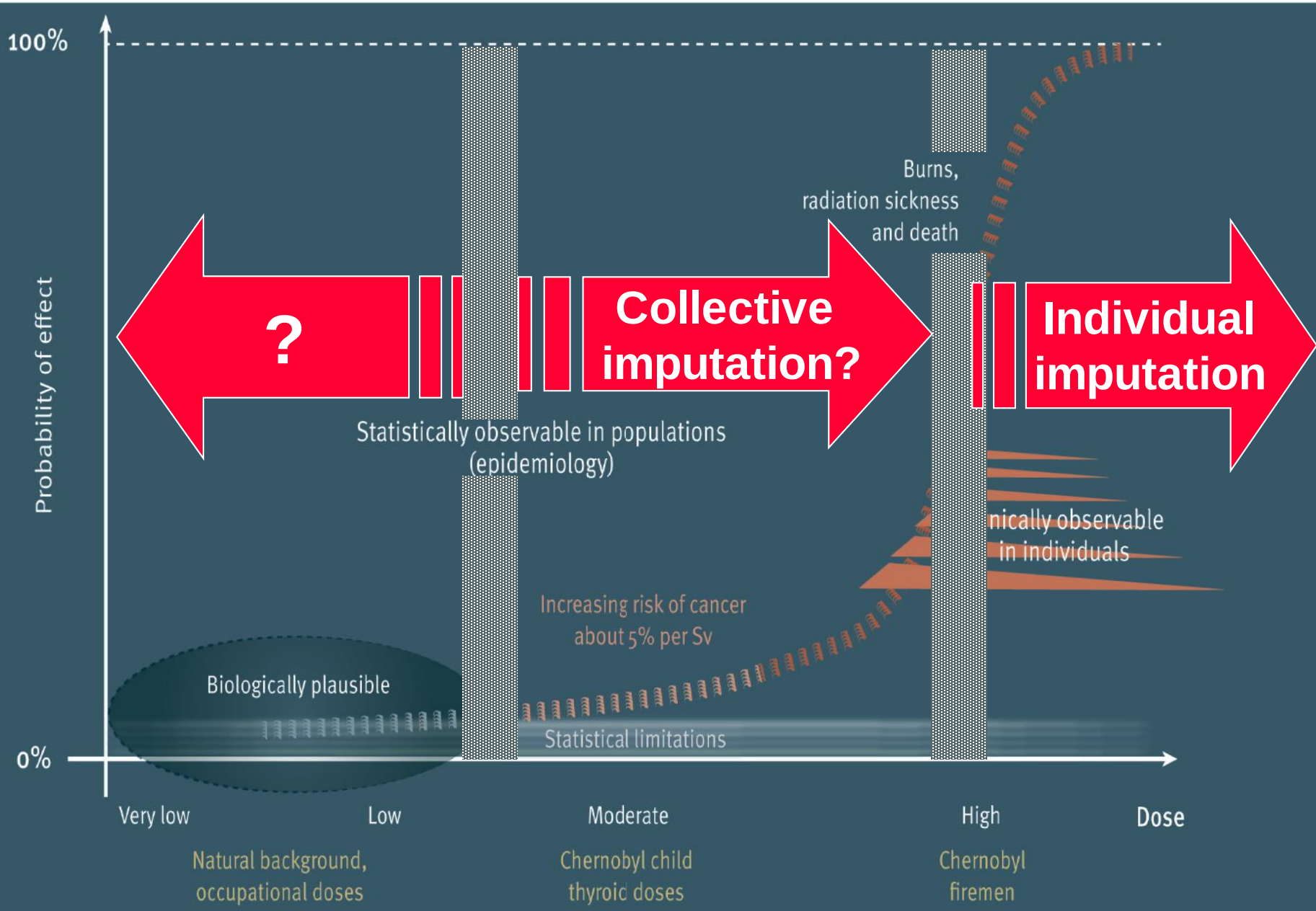
legal imputation


Radio-pathologists
Attribute individually
Radio-epidemiologists
Attribute collectibly
Radio-protectionists
Infer risks
Lawyers
Impute
•either imputing on behalf of a client or,
•defending a client from an imputation

Imputation


Nuclear employer
Attributable radiation effect
Nuclear worker
Imputation
Nuclear operator
Attributable radiation effect
Public
Imputation

Relationship of radiation doses and health effects



2.
Ethical foundations and fundamental principles

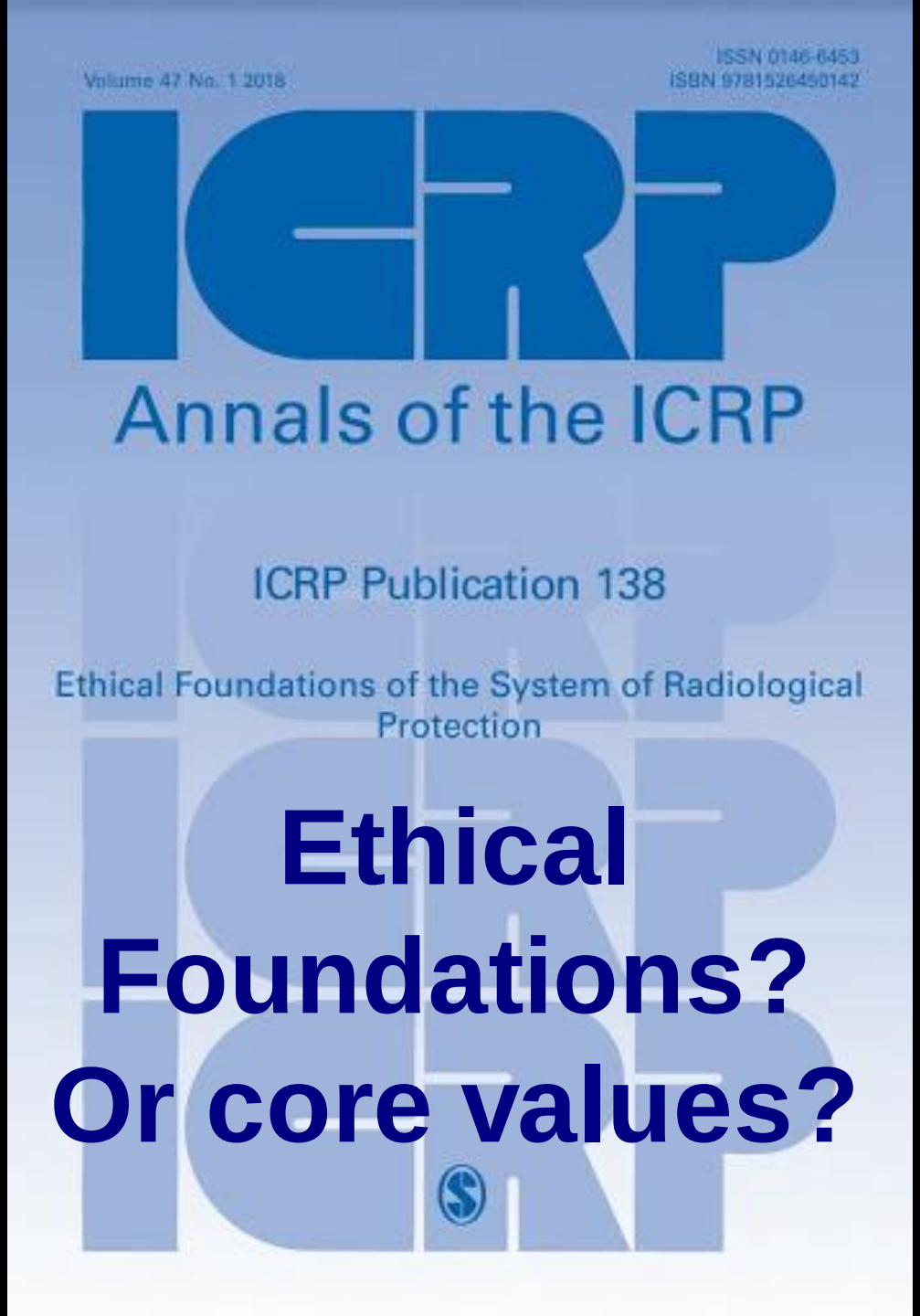
Mea Culpa

- Any system affecting human life shall be based on solid ethical foundations, and the RP system complies with this rule

…but….

- Our explanation has not been clear enough

We have to improve it in view of UNSCEAR's output



Ethical Foundations? Or core values?

Values ≠ Ethics

Values

- basic beliefs that motivate attitudes and motives behind purposeful action

Ethics

- philosophy defining good and evil, right and wrong, virtue and vice, justice and crime, by systematization and logic.

Core values in ICRP 138

- **Beneficence and non-maleficence**

prevents harmful effects for humans and the environment

- **Prudence**

allows uncertainties to be taken into account

- **Justice**

ensure social equity and fairness in decisions

- **Dignity**

consider the respect that one must have for people

ANNEX A. ETHICAL THEORIES

- **Virtue ethics**
- **Consequentialist ethics**
- **Deontological ethics**

Basic ethics doctrines (in ICRP tradition)

- **Individual** oriented ethics
- **Societal** oriented ethics

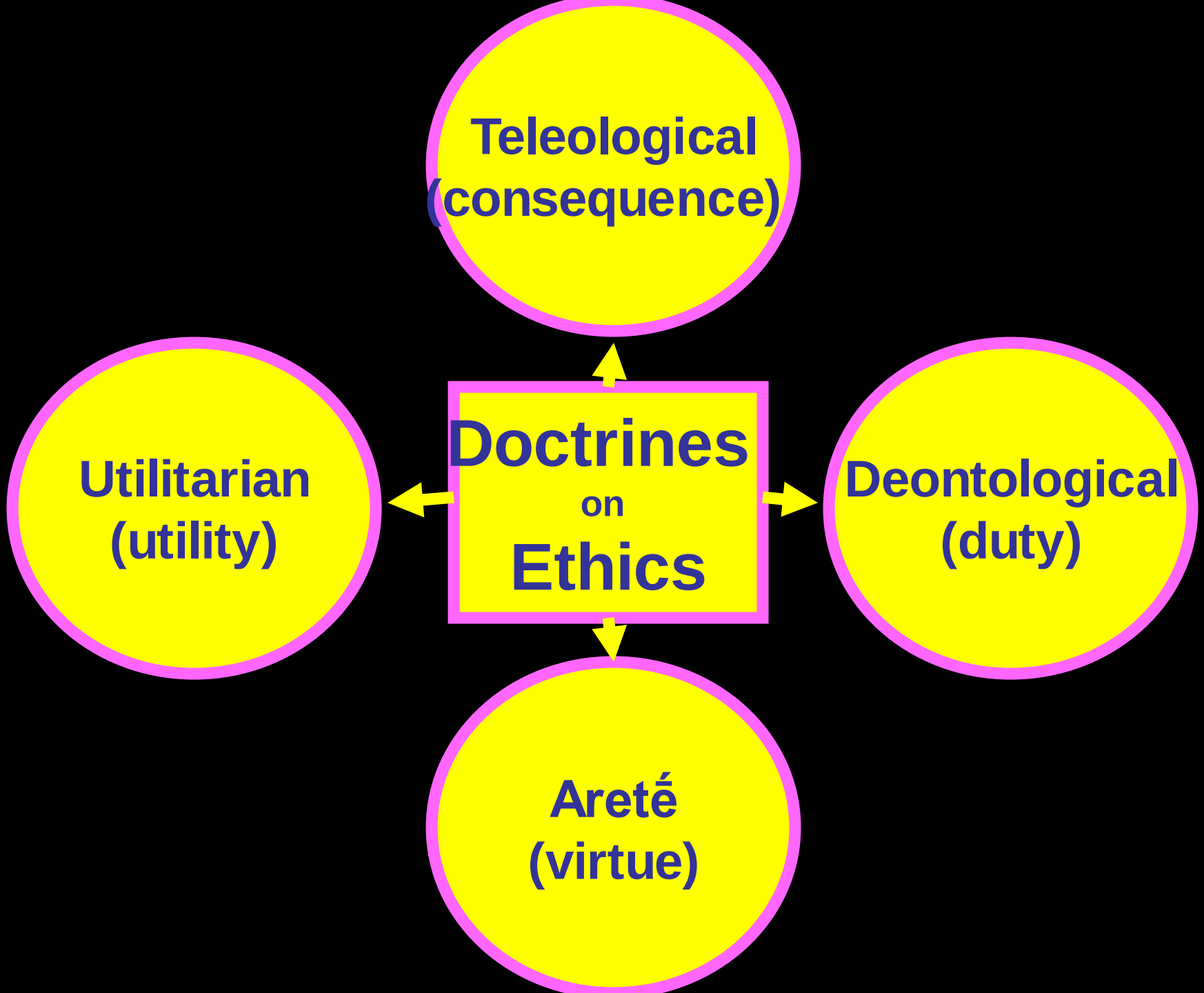
Fundamental Ethical Doctrines in ICRP

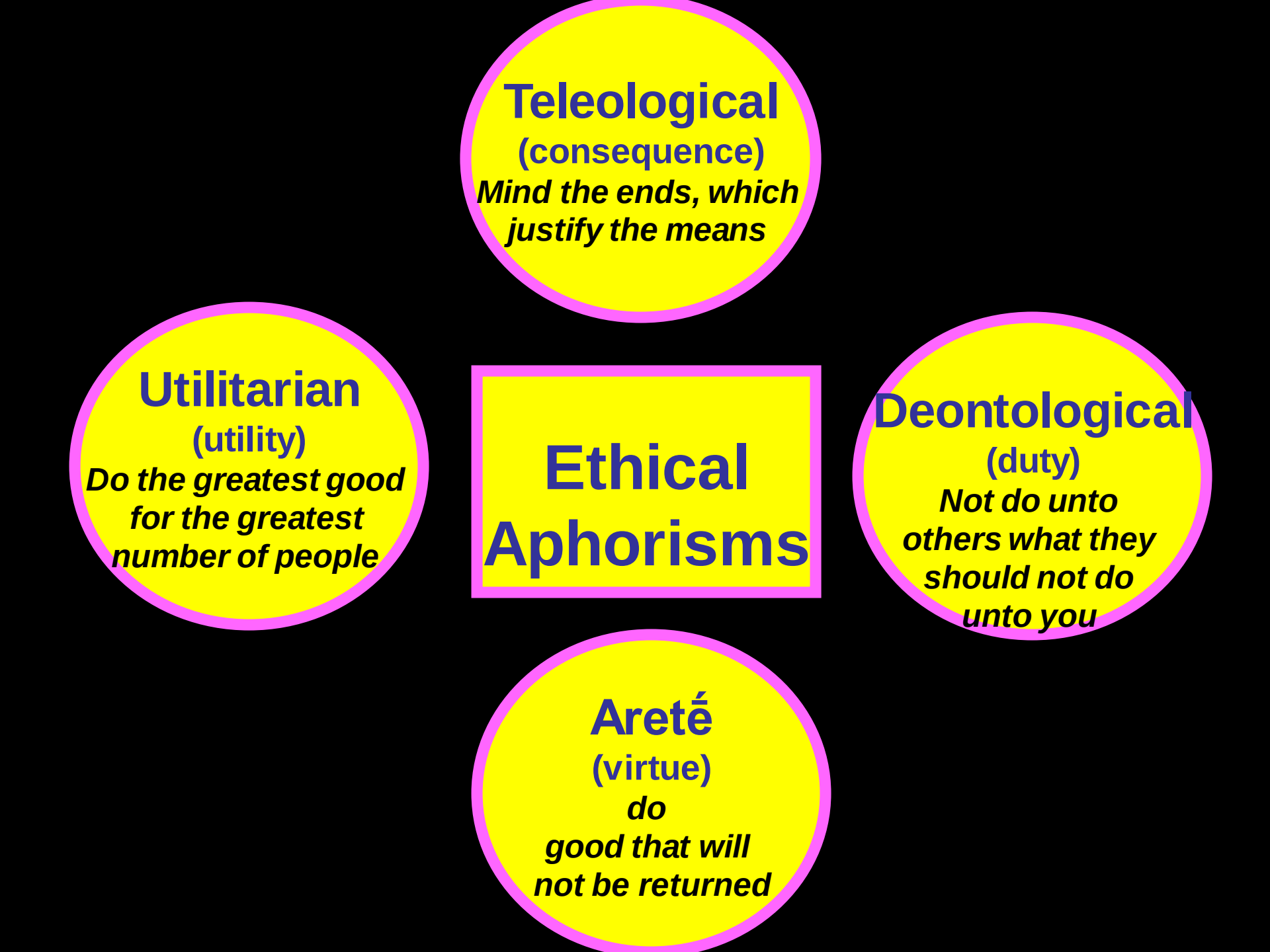
- Deontological Ethics (based on *duty*)
- (ἀρετή) Aretḗ Ethics (based on *virtue*)

INDIVIDUAL

- Teleological Ethics (*consequence*)
- Utilitarian Ethics (*utility*)

SOCIETAL


Teleological
(consequence)
Utilitarian
(utility)
Doctrines
on
Ethics
Deontological
(duty)
Areté
(virtue)


Teleological
(consequence)
Mind the ends, which justify the means
Utilitarian
(utility)
Do the greatest good for the greatest number of people
Ethical Aphorisms
Deontological
(duty)
Not do unto others what they should not do unto you
Areté
(virtue)
do good that will not be returned

Intergovernmental Fundamental Safety Principles

Jointly sponsored by

Euratom FAO IAEA ILO IMO OECD/NEA PAHO UNEP WHO

IAEA

WHO

IAEA
International Atomic Energy Agency

Intergovernmental Fundamental Safety Principles

- 1: Responsibility for safety
- 2: Role of government
- 3: Leadership and management for safety
- **4: Justification of actions**
- **5: Optimization of protection**
- **6: Limitation of risks to individuals**
- **7: Protection of present and future generations**
- **8:** Prevention of accidents
- 9: Emergency preparedness and response
- 10: Protective actions to reduce existing or unregulated radiation risks

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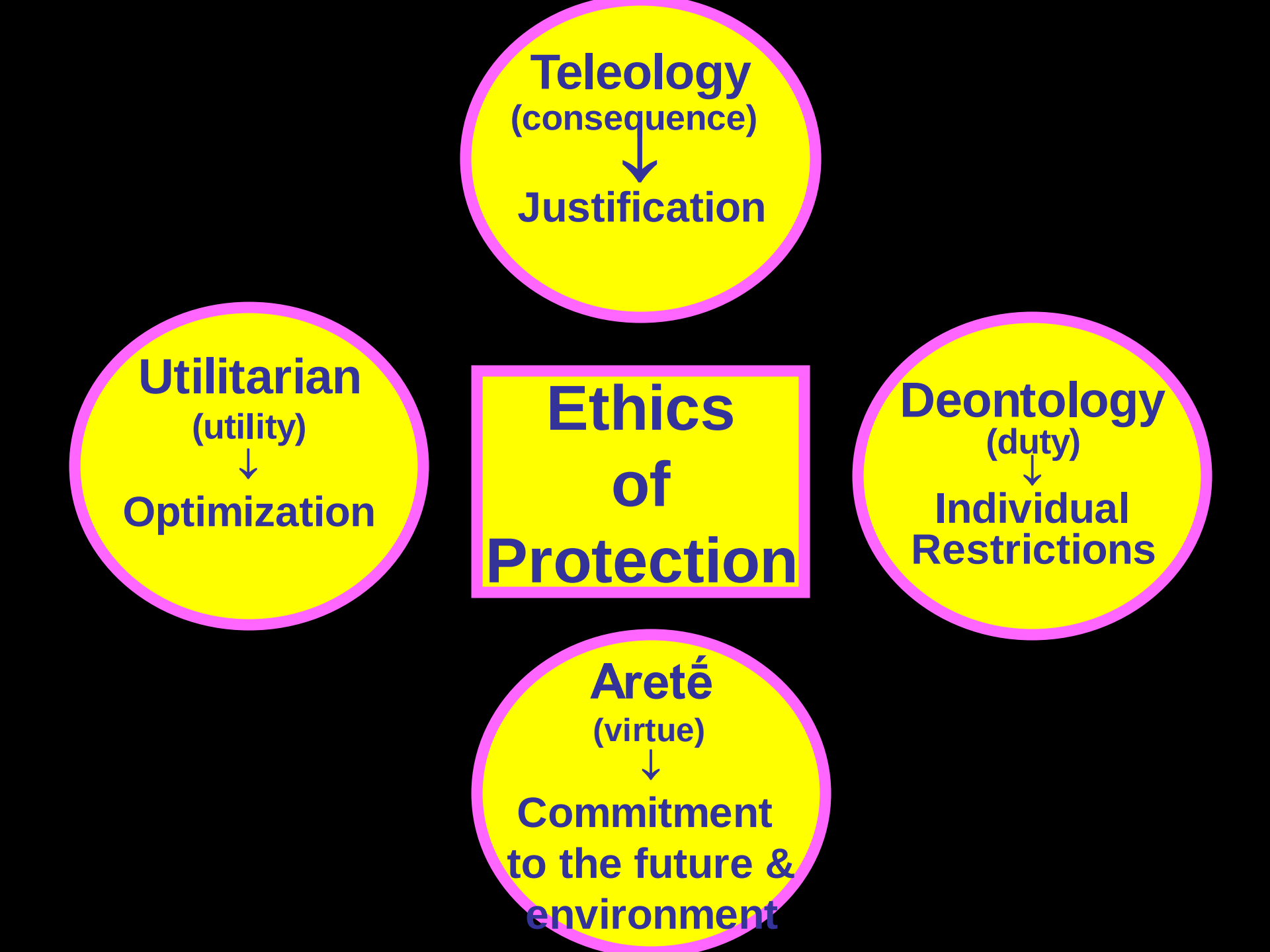

Teleology
(consequence)
↓
Justification
Utilitarian
(utility)
↓
Optimization
Ethics
of
Protection
Deontology
(duty)
↓
Individual
Restrictions
Areté
(virtue)
↓
Commitment
to the future &
environment

Teleologism (consequences)

- The morality of protective actions should be judged against its overall consequences.

Justification

- Any decision that alters the radiation exposure situation should do more good than harm

Utilitarianism (utility)

- The morality of protective actions should be judged against its contribution to the overall utility, namely to the best welfare among all people.

Optimization

- The selected radiation protection option should be the best under the prevailing circumstances, maximizing the margin of benefit over harm.

Deontologism (duty)

- The morality of protective actions should be judged by the duty to protect individual human beings, rather than by their overall consequences or utility.

Individual Protection

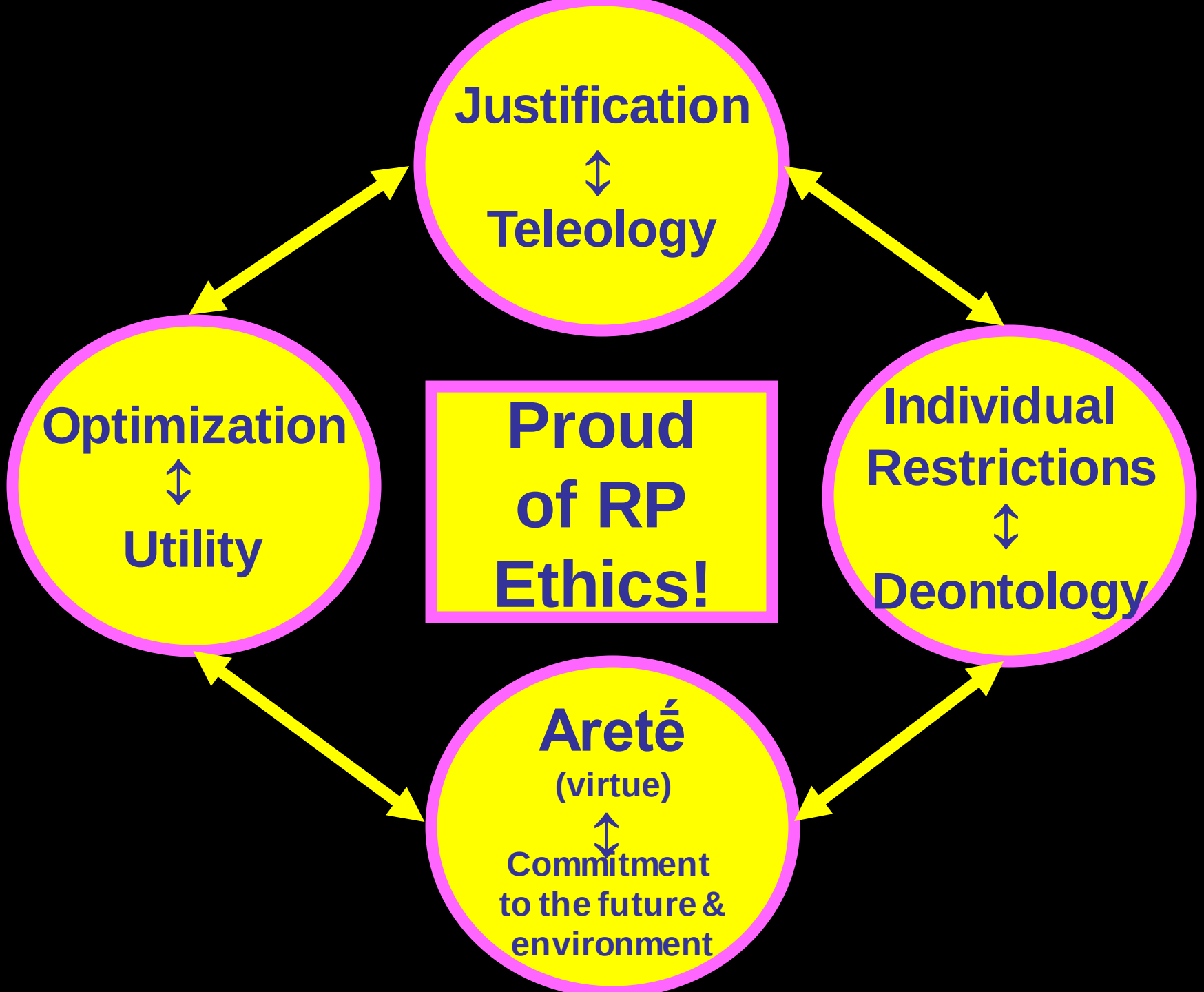
- Inequitable protection options should be prevented by restricting individual risks.

Areté (virtue)

- The morality of protective actions should be judged by their virtuosity rather than their consequences, utility or duty.

Future

- Protection should be provided to both, present and future generations and their environment, against scientifically plausible radiation harm even if it is uncertain.


Justification
↕
Teleology
Optimization
↕
Utility
Proud of RP Ethics!
Individual Restrictions
↕
Deontology
Areté
(virtue)
↕
Commitment to the future & environment

Challenge

- Reformulate the fundamental principles
- Associate them to the ethical basis

The fundamental principles

- Principle of Justification of changes in exposure
- Principle of Optimization of protection options
- Principle of individual risk restrictions
- Principle for the future and the environment

‘Limits’ that are not limits

The ‘Dose Limits’ are not:

- a point beyond which doses may not pass,
- or a terminal point or boundary for doses
- or the furthest extent of dose endurance.
- or a restriction on the size or amount of the radiation dose people were permitted.

Namely, THEY ARE NOT LIMITS!

3.
Exposure situations
&
Categorization of exposures

Mea culpa

1. The description of "**radiation exposure situations**" were probably informative but perhaps confusing and thus unhelpful in practice
2. In addition three "**categories of exposure**" were identified, but they are unclear and incomplete.

,

Exposure situations

- Existing (or extant?)
- Planned
- Emergencies

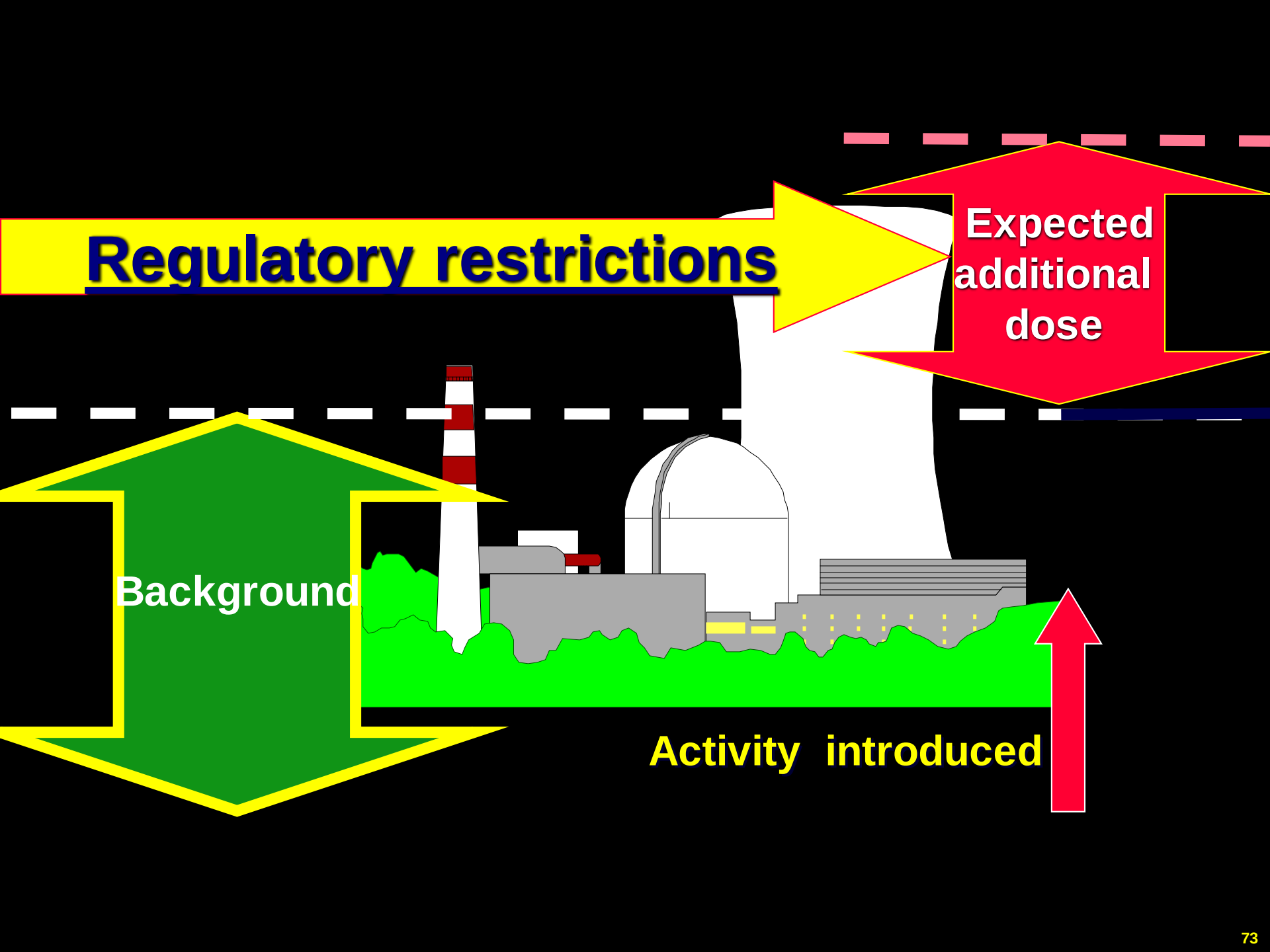
,

Challenge

- Was categorization in exposure situations helpful?
- For people expecting to be protected….

….Will they be interested on where the radiation dose they are incurred is arising from an planned, emergency or existing situation?

- Perhaps it was more logical and understandable the old approach of simply:
  - Restricting increases of doses
  - Requiring decreases of doses


Regulatory restrictions
Expected additional dose
Background
Activity introduced

DANGER

CONTAMINATED AREA

Extant dose

Doses that can be averted

Regulatory ambition

Current categories of exposure

Precisely defined:

- Occupational
- Public

Less precisely defined:

- Medical

In semi-limbo:

- Rescuers
- Volunteers
- Comforters

Medical exposure

Exposure incurred by:

- **patients** undergoing:
  - **diagnosis** (medical or dental)
  - **treatment**;
- **comforters**

  (persons voluntarily helping in the support of patients)
- **volunteers**

  (in a programme of biomedical research involving their exposure)

,

Challenge

Revising the categorization of exposures

Possible re-categorization

- Patients undergoing radio-diagnosis
- Patients undergoing radiotheraphy
- Comforters
- Volunteers in medical research
- Workers under ILO 105
- Rescuers workers
- Volunteered workers
- Members of the public

4.
Establishing standards and setting up norms

Mea Culpa

We have consolidated a confusing mix of:

- **Conventions**
- **Declarations**
- **Standards**
- **Norms**

Conventions≠Declarations≠Standards≠Norms

- Conventions describe binding commitments
- Declarations express non-binding policies
- Standards establish level of attainment.
- Norms detail binding requirements.

Standard

(from Latin *estendre* ‘extend’, influenced by stand)

An agreed level of attainment or achievement

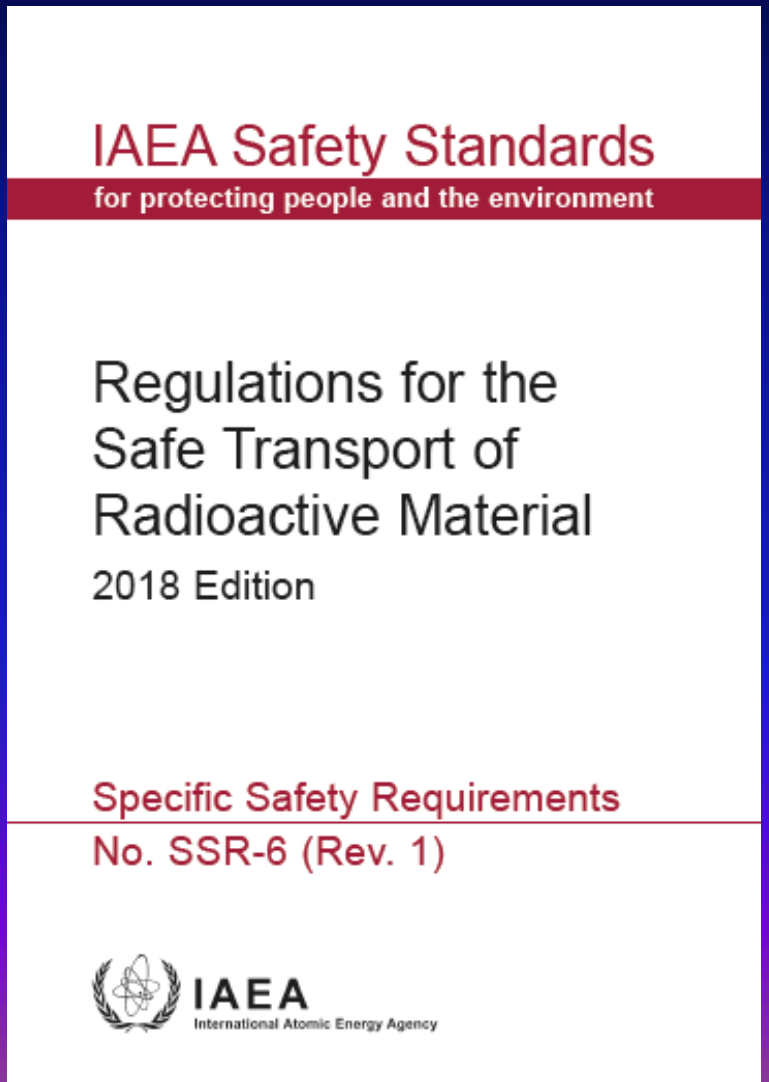
Norm

(from Latin *norma,* precept, rule)

A prescription that is required or ruled

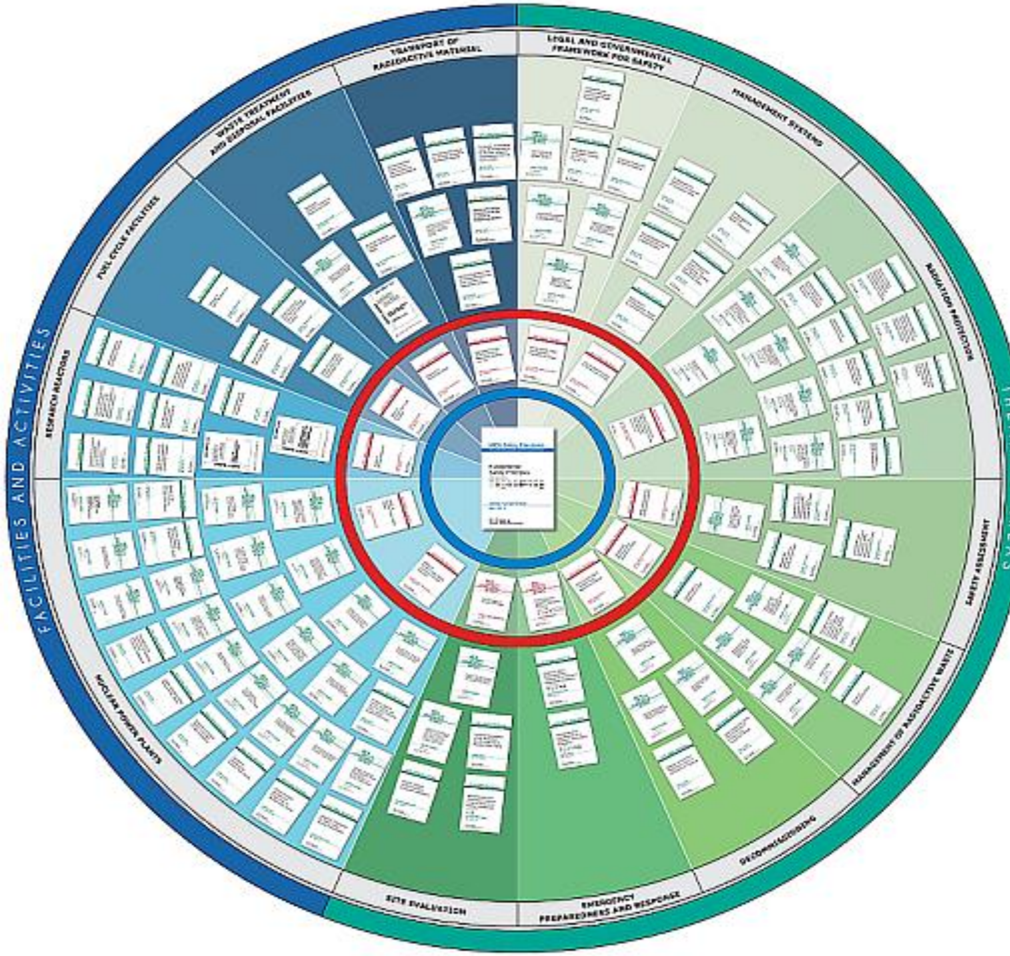
Example of standard

Quasi example of Norm



IAEA Safety Standards

protecting people and the environment



Status as of June 2012

IAEA
International Atomic Energy Agency
Atoms for Peace

Challenge

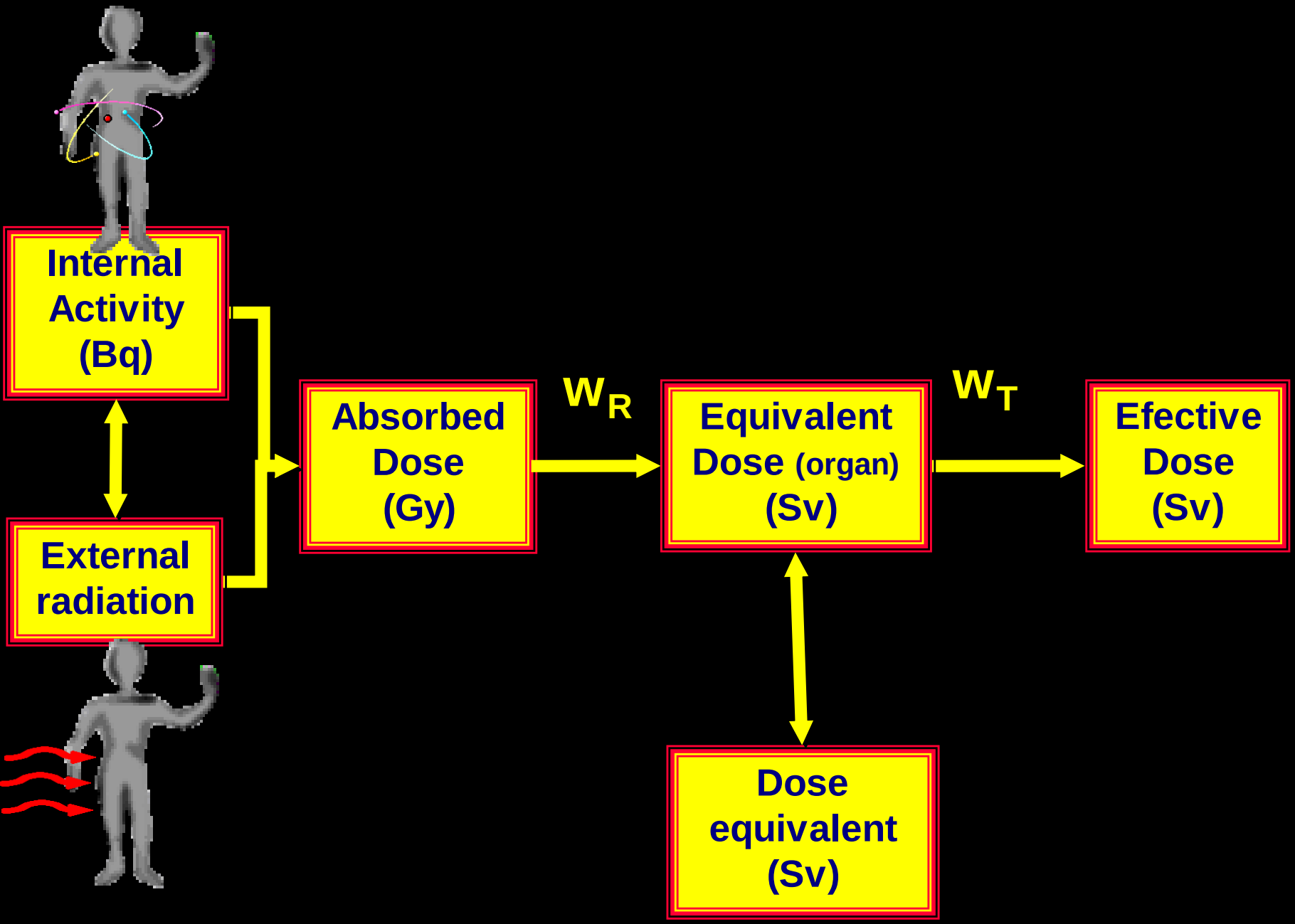
- Promote quantitative (↓ 'incentive') conventions.
- Convert 'declarations' into standards.
- Depurate norms from standards
- Establish few fundamental basic standards
- Expand and specify the corpus of internationally accepted intergovernmental norms

Operational quantities & units

(it cannot be norms without quantities and units)

Mea Culpa

- We have created a sophisticated system of quantities and units that do not respect the basic rules for quantities and units.
- *Interalia*:
  - Many are not directly measurable
  - They are not traceable


Internal Activity (Bq)
External radiation
Absorbed Dose (Gy)
W_R
Equivalent Dose (organ) (Sv)
W_T
Efective Dose (Sv)
Dose equivalent (Sv)

Challenge

- The international system of quantities and units need a full review and eventual revision.
- The objective should be measurability, traceability and simplification

Providing for the applications of standards & norms

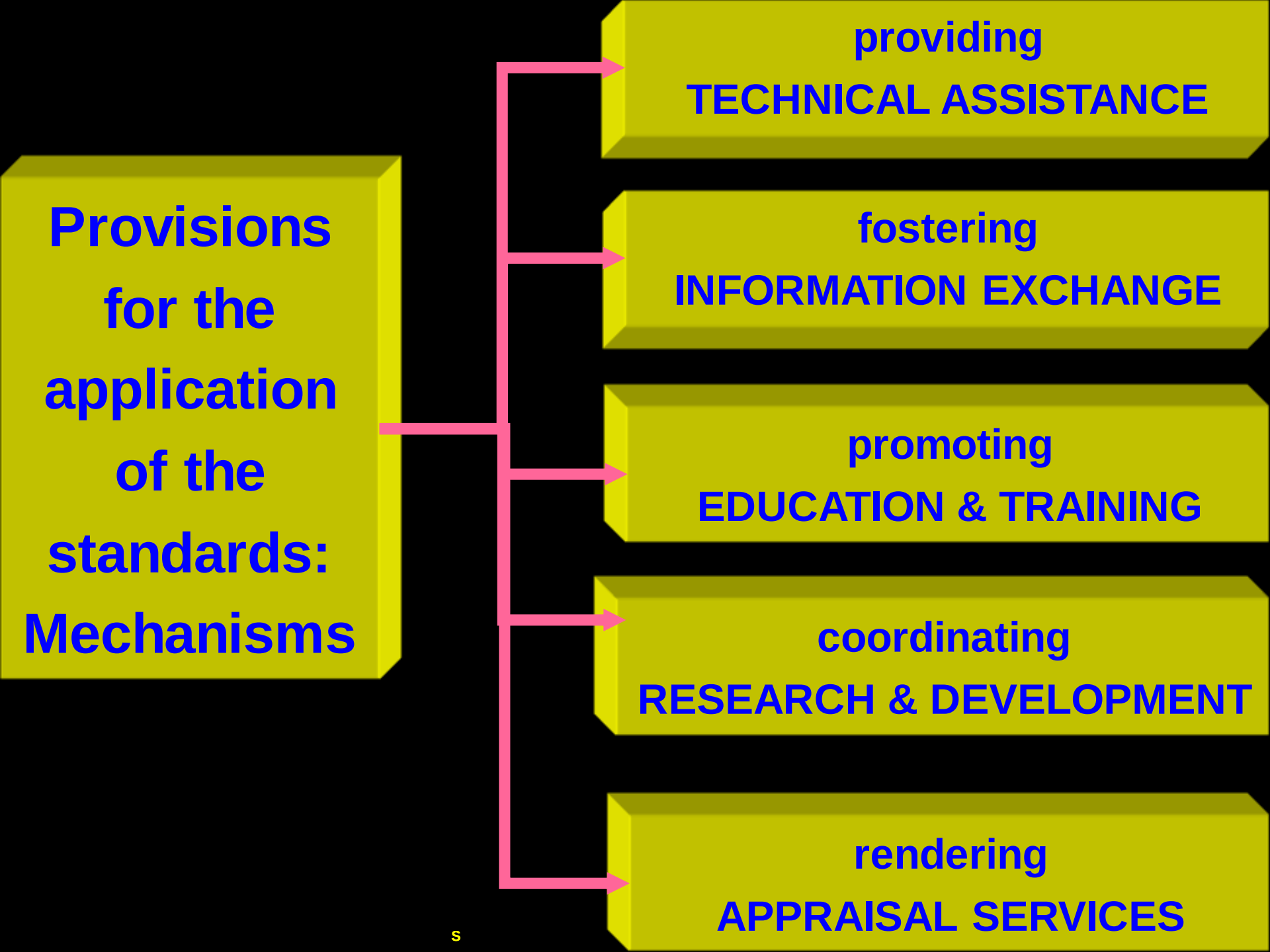
Mea Culpa

The balance between:

- **Establishing international standards, and**
- **Providing for their application**

…has been far from perfect!

More reliance on IRPA


Provisions for the application of the standards: Mechanisms
providing TECHNICAL ASSISTANCE
fostering INFORMATION EXCHANGE
promoting EDUCATION & TRAINING
coordinating RESEARCH & DEVELOPMENT
rendering APPRAISAL SERVICES

Challenge

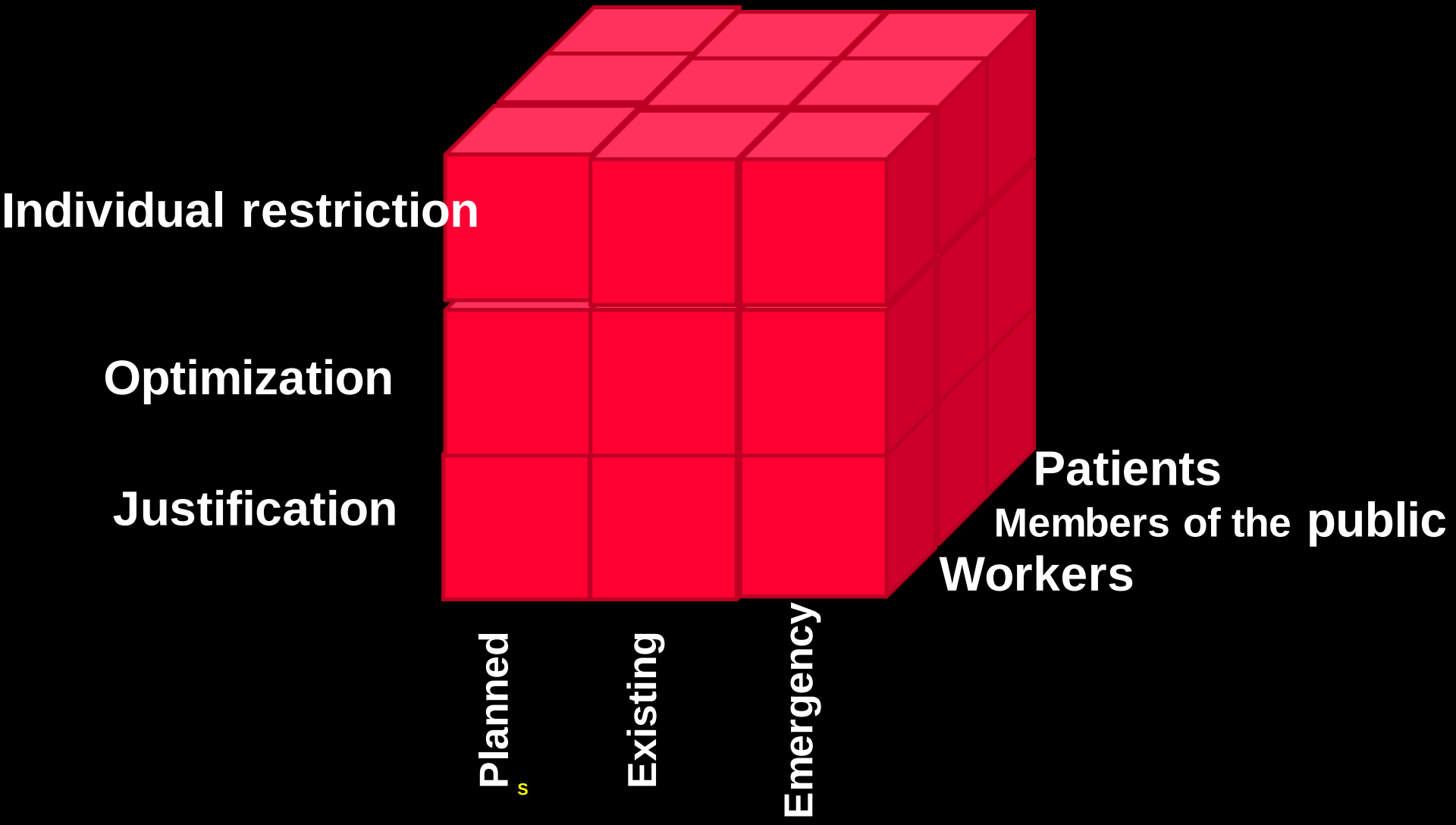
- Generalization of technical assistance
- Increase in information exchange
- Specific courses for specific standards
- R & D projects for open issues
- Appraisals ≠ “peer reviews”

5.
Epilogue

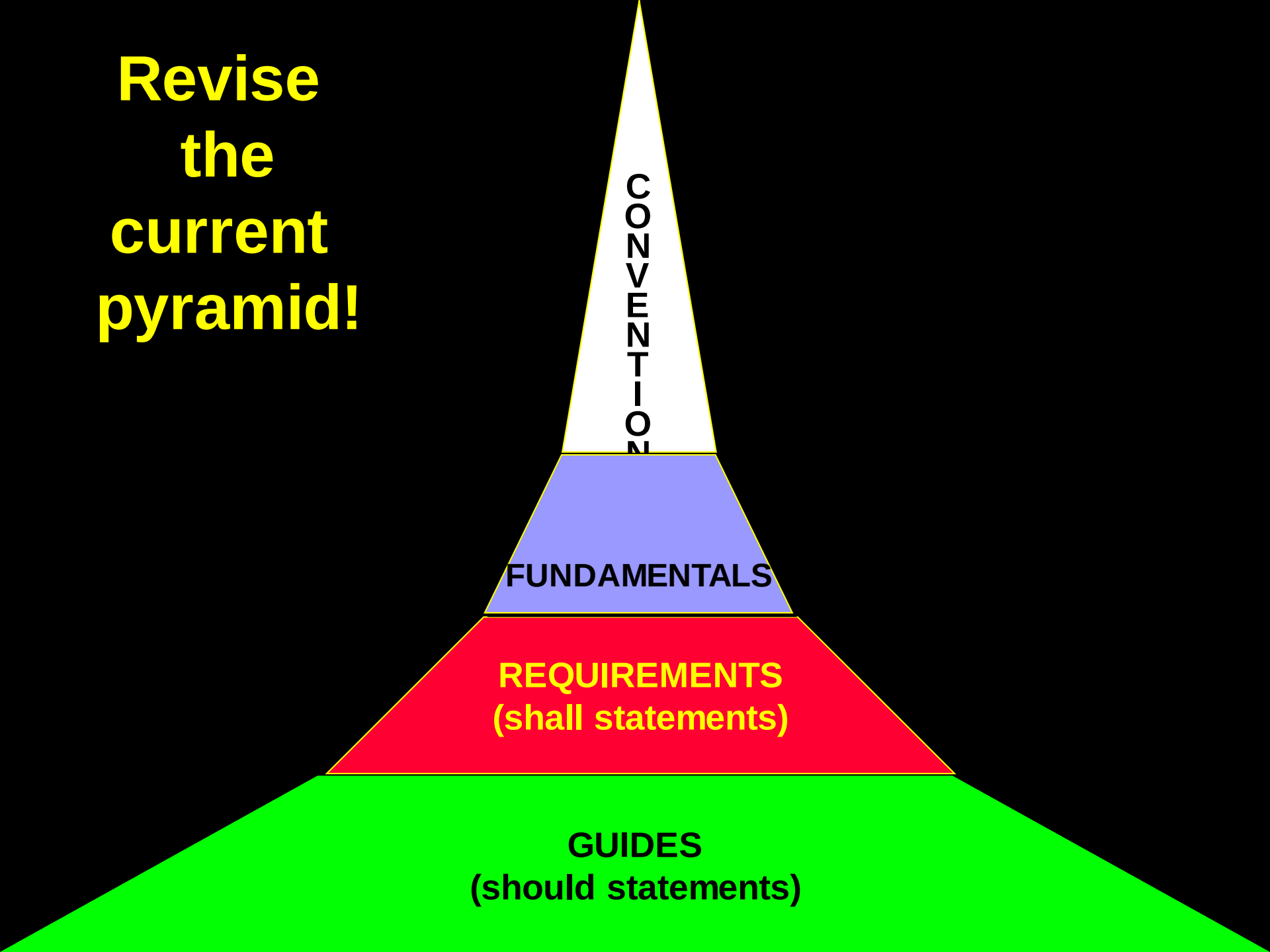

PRESENT
PAST
FUTURE

Key elements to be reviewed and eventually revised

A Perfect Rubik's cube?



Revise the current pyramid!



Let’s improve understanding!

Confusing Words

,

Radiation *effects*

vis-à-vis

Radiation *risk*

,

The risk communication problem

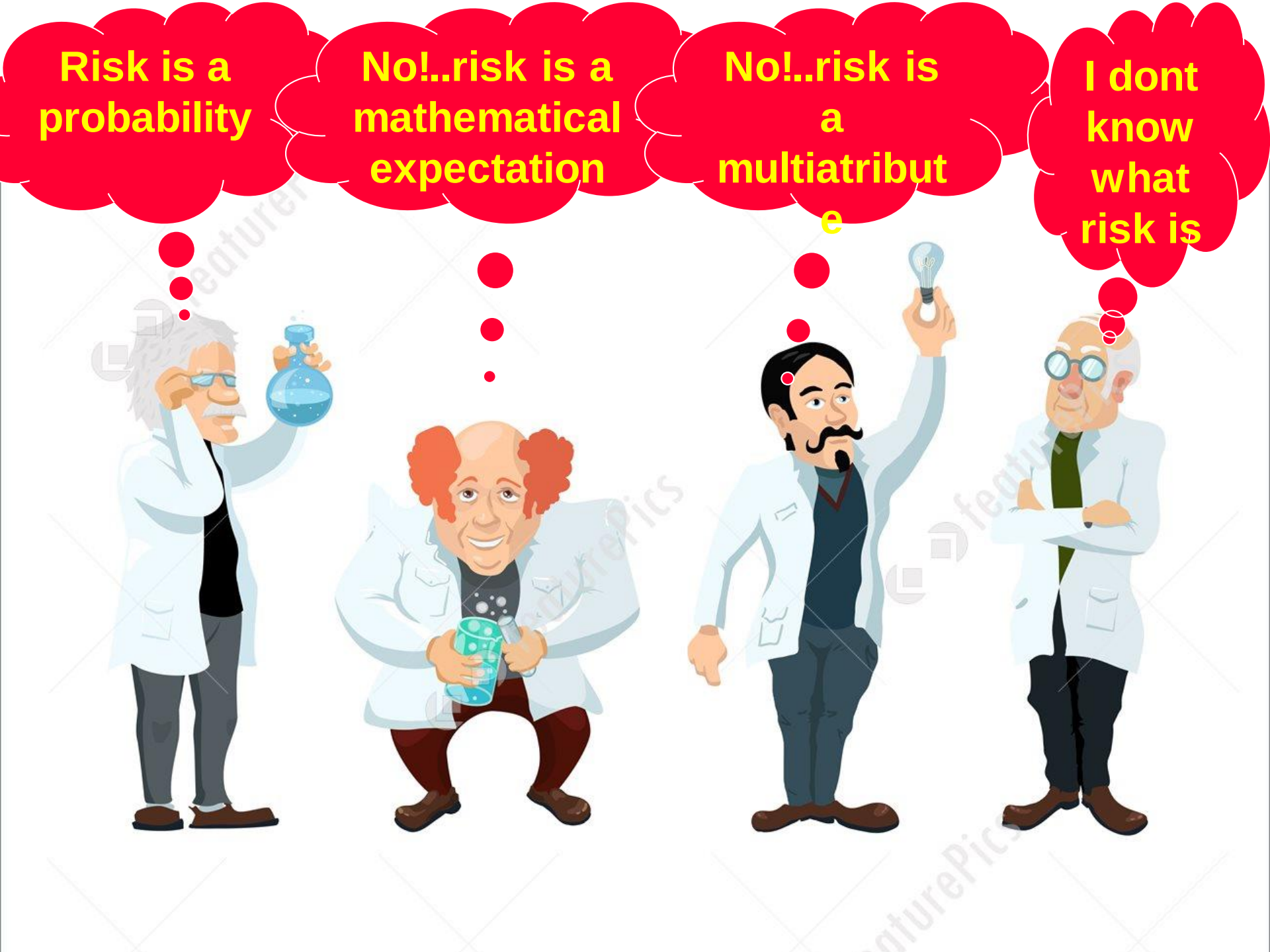
But this is the real problem!

Communication

Among experts

This is difficult

Between experts and the public

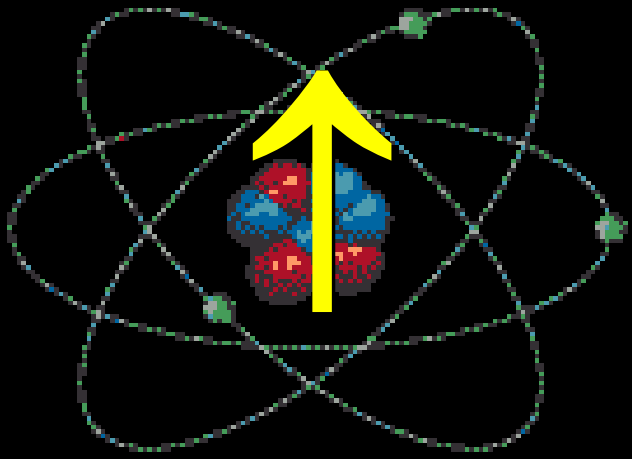

Risk is a probability
No!..risk is a mathematical expectation
No!..risk is a multiatribute
I dont know what risk is

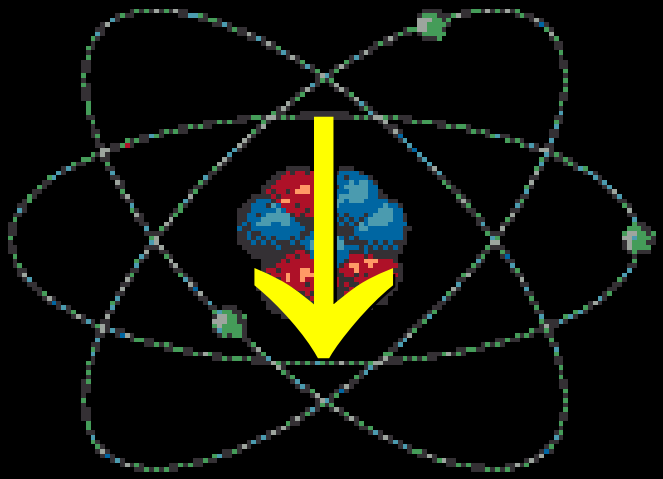

Risk?


Risk!

Exposure to ‘natural’ radiation

,





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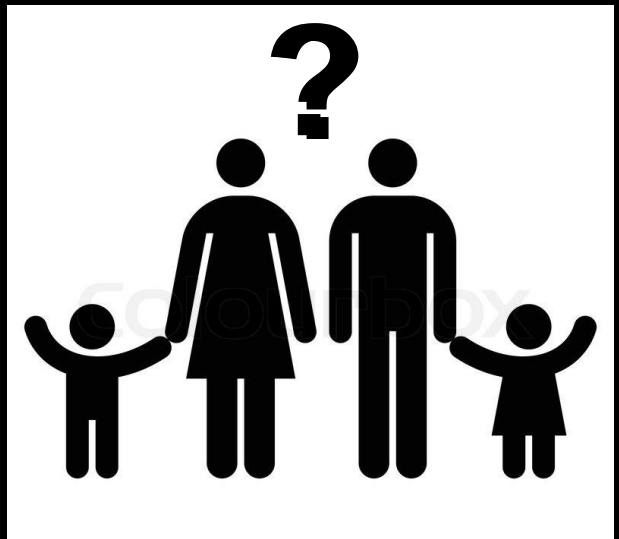
Sophisticated system for controlling low radiation

Limbo for controlling high radiation



The coconut tree is solid!

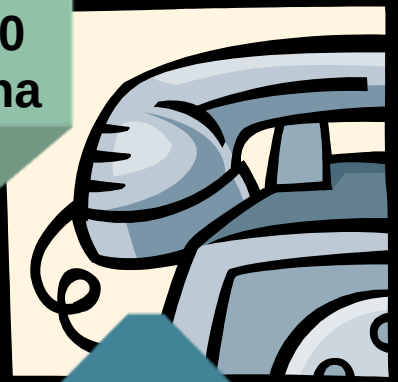
- But it seems that….

..shacking of the coconut tree could be beneficial!!!

I have no doubt that…
….this is necessary…. and…

…will be done!

Av. del Libertador 8250
Buenos Aires, Argentina



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Than you for your tolerance!

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