

Radiation Risks at Low Doses

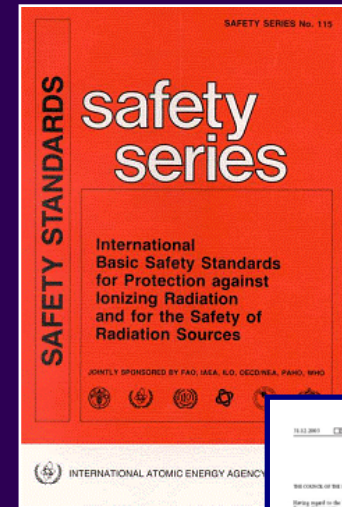
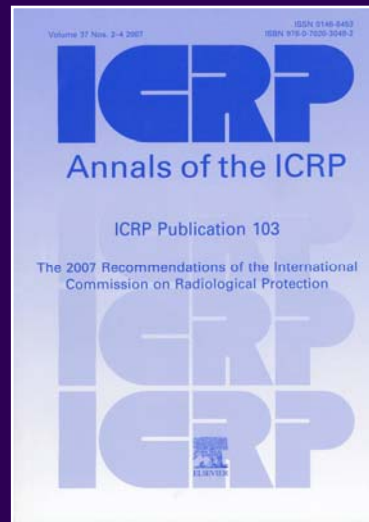
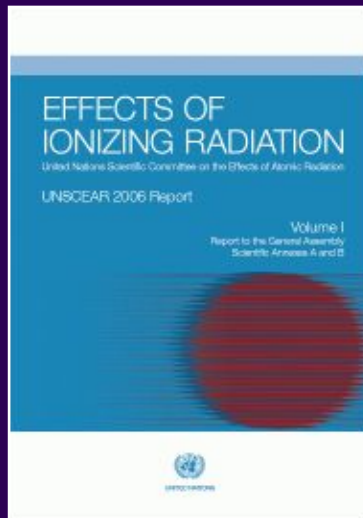


NGO Seminar, June 2009

John Harrison

- Sources of information
- Cancer risks
- Internal cf. external
- Protection system
- Concerns / research

Sources of information



**UNSCEAR Reports
on doses and effects
*Science***

**ICRP
Recommendations
*Policy***

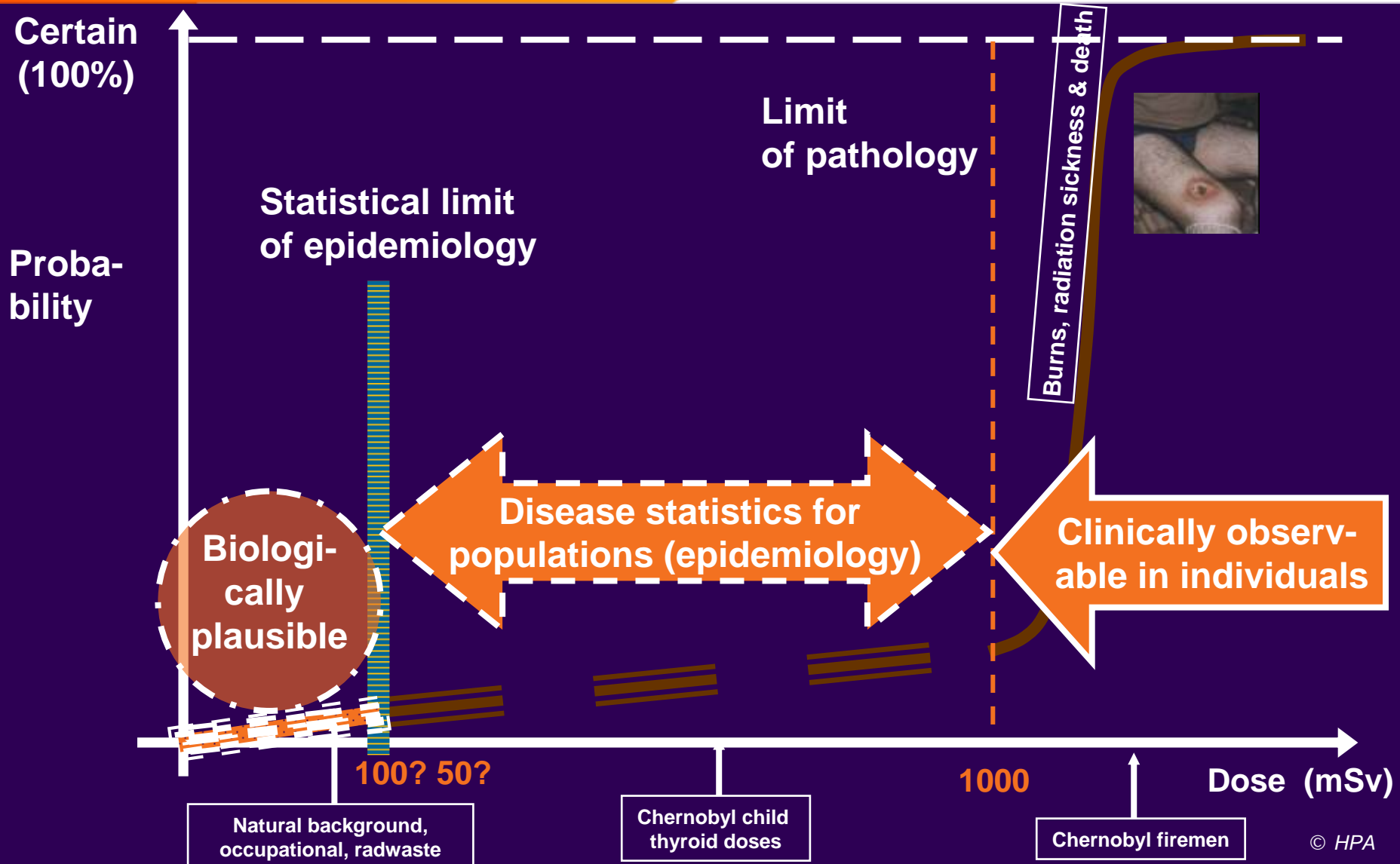
**UN, EU Basic
Safety Standards
*Regulations***

- Epidemiological studies
- Experimental studies
- Modelling

- 'A' bomb survivors
- Nuclear workers
- Patients
- Chernobyl
- Radon – mines/houses
- Radium exposures
- Plutonium workers

- Dose-response
- Radiation type: α , β , γ
- Acute/chronic
- Radionuclides in the body
- Mechanisms

Radiation Health Effects



Cancer risks from external radiation



- Hiroshima and Nagasaki 'A' bomb survivors
- UK National Registry of Radiation Workers (NRRW)

Cancer risks from external radiation



'A' bomb survivors

- 44,635 with > 5 mGy, 7851 solid cancers 1958-98, 11% attributable

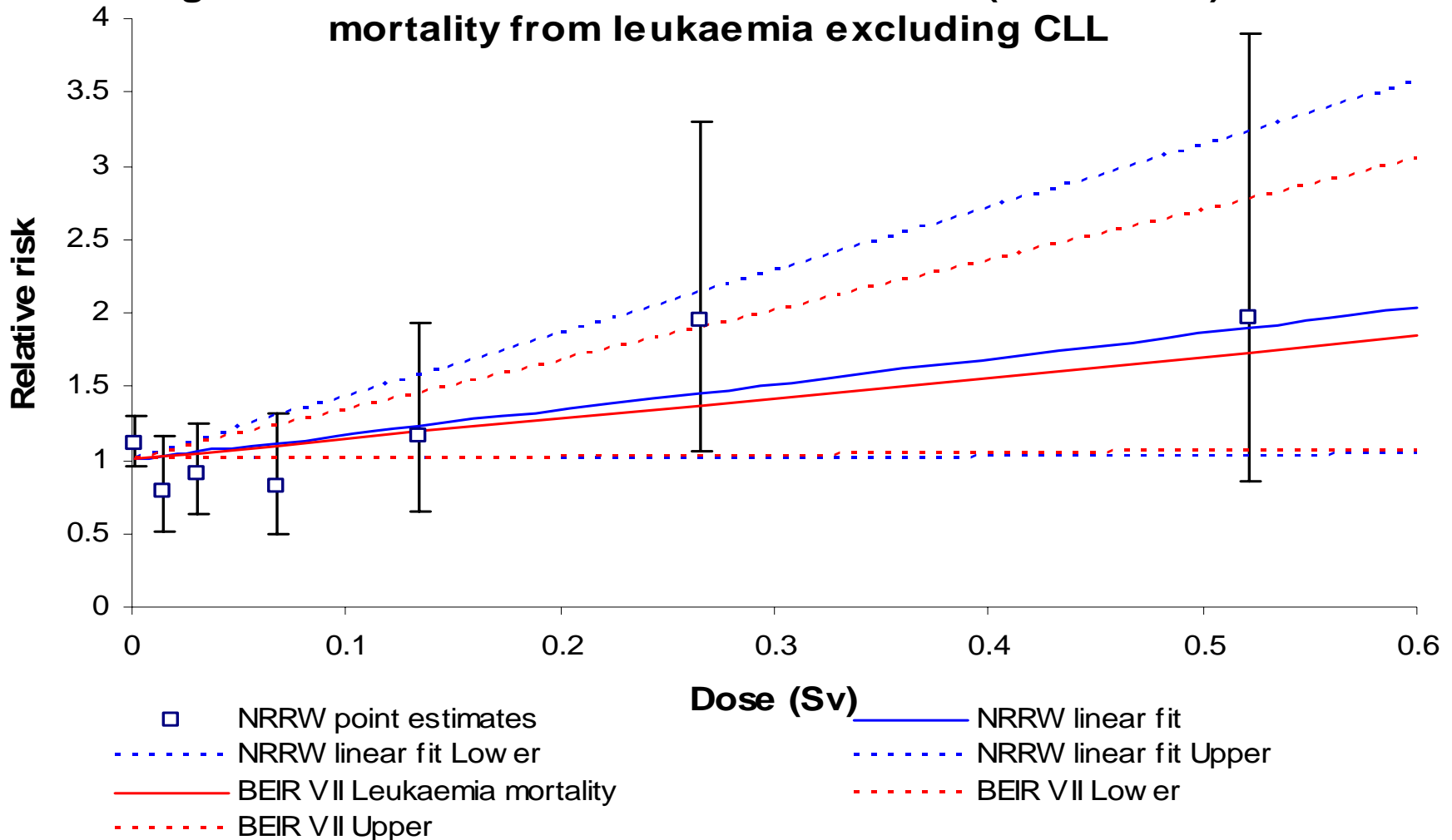
NRRW

- 174,541 with average dose 25 mSv

Leukaemia in the NRRW & 'A' bomb survivors



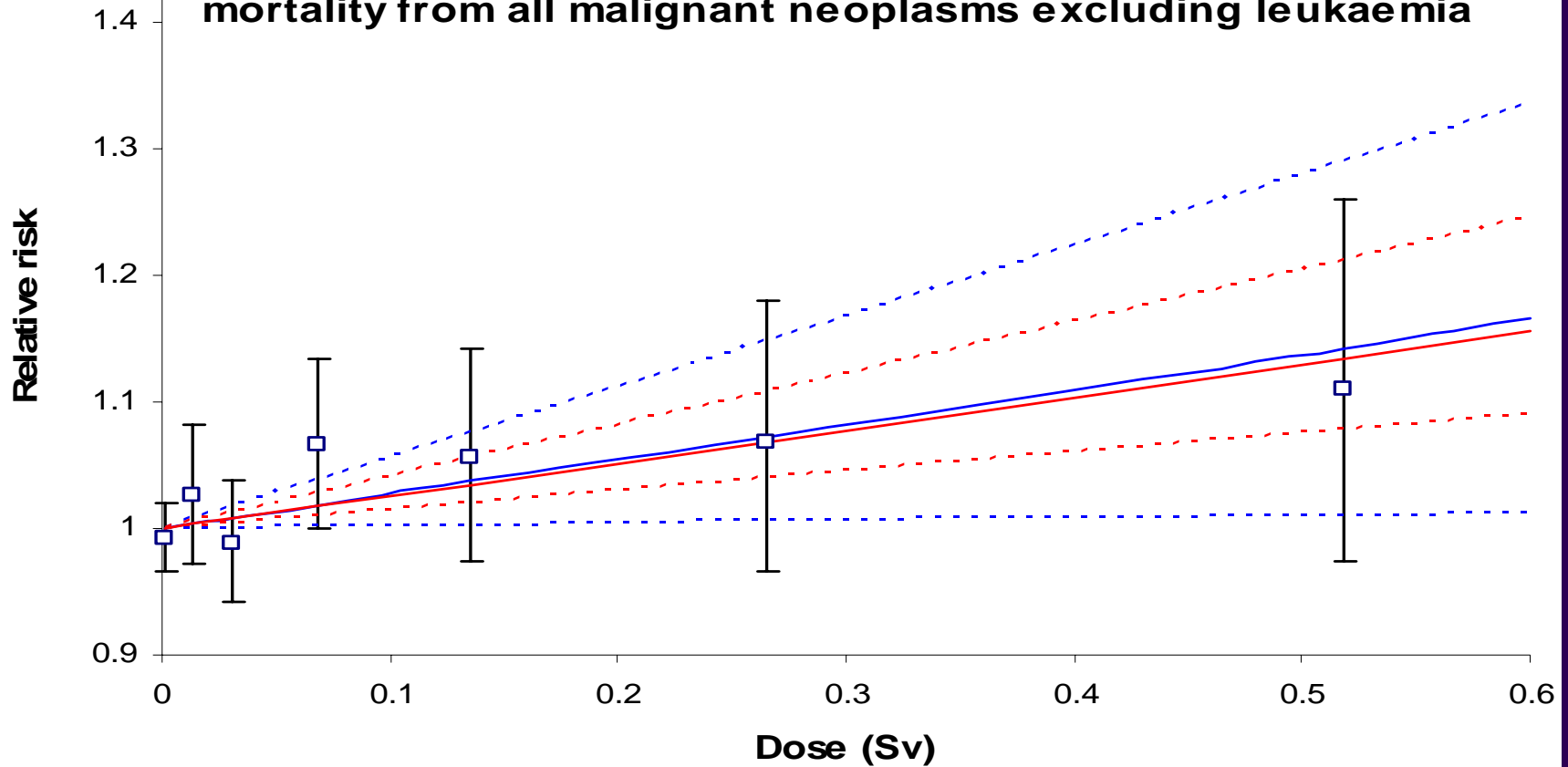
Figure 1 Trends with dose in relative risk (and 90%CI) for mortality from leukaemia excluding CLL



Solid cancers in the NRRW & 'A' bomb survivors



Figure 2 Trends with dose in relative risk (and 90% CI) for mortality from all malignant neoplasms excluding leukaemia



- NRRW point estimates
- NRRW linear fit
- - - NRRW linear fit Low er
- BEIR VII All Solid
- - - NRRW linear fit Upper
- - - BEIR VII All Solid Upper
- - - BEIR VII All Solid Low er

Age-specific cancer risks

- life-time attributable risk for U.S. population



Cases per 10^6 exposed to a single dose of 10 mGy (BEIR VII)

Cancer site	Age at exposure, years					
	Males			Females		
	0	20	60	0	20	60
Breast	-	-	-	1171	429	31
Colon	336	173	94	220	114	62
Liver	61	30	14	28	14	7
Lung	314	149	89	733	346	201
Thyroid	115	21	0.3	634	113	1
Leukaemia	237	96	82	185	71	57
All cancers	2563	977	489	4777	1646	586

Cancer risk estimates for alpha emitters

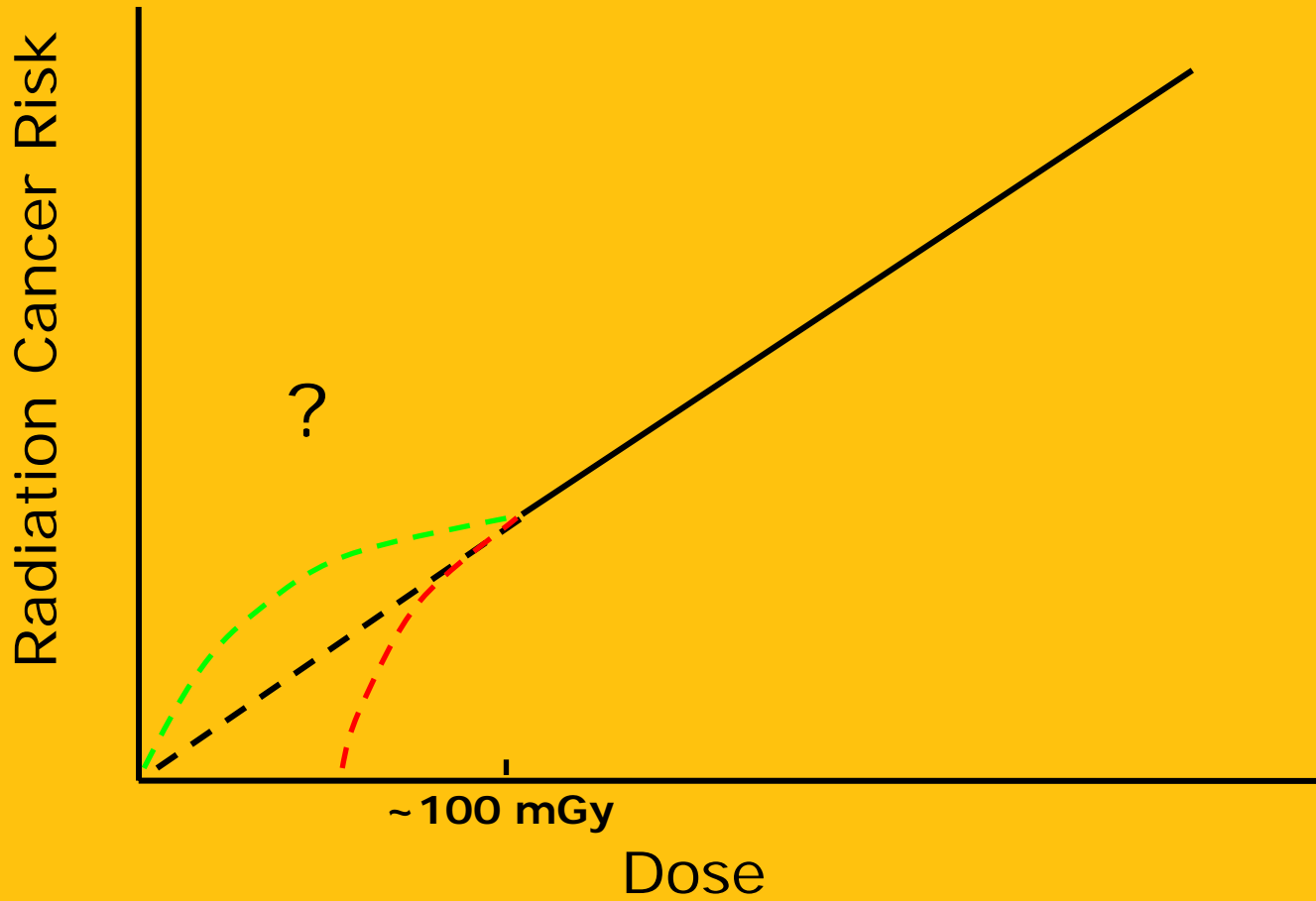


- Radon Lung cancer
- Thorotrast Liver cancer & Leukaemia
- Radium isotopes Bone cancer
- Plutonium-239 Lung (liver & bone cancer)

Harrison and Muirhead *J. Radiat. Biol.* **79**, 1-13 (2003)

- Kinderkrebs der Umgebung von Kernkraftwerken (KIKK) study showed excess in < 5 y with 5 km of German reactors
- Similar studies in UK and France do not show excess
- Excesses near Sellafield and Dounreay cannot be explained by radiation
- Childhood leukaemias do cluster – largest in USA near Fallon Naval Air Station
- Population mixing and infections – Kinlen hypothesis

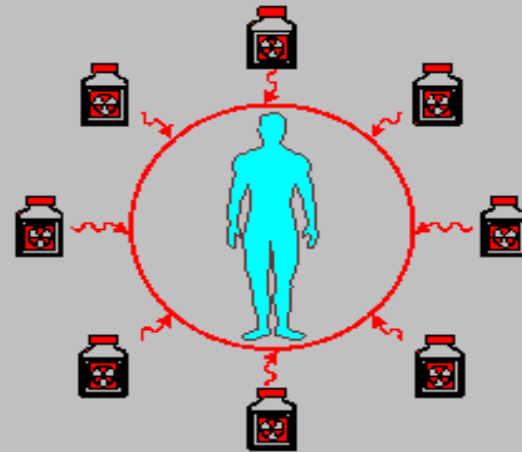
Linear non-threshold (LNT) dose response



Constraints, reference levels, limits



Protection of workers and public primarily using constraints and reference levels applying to doses from a single source



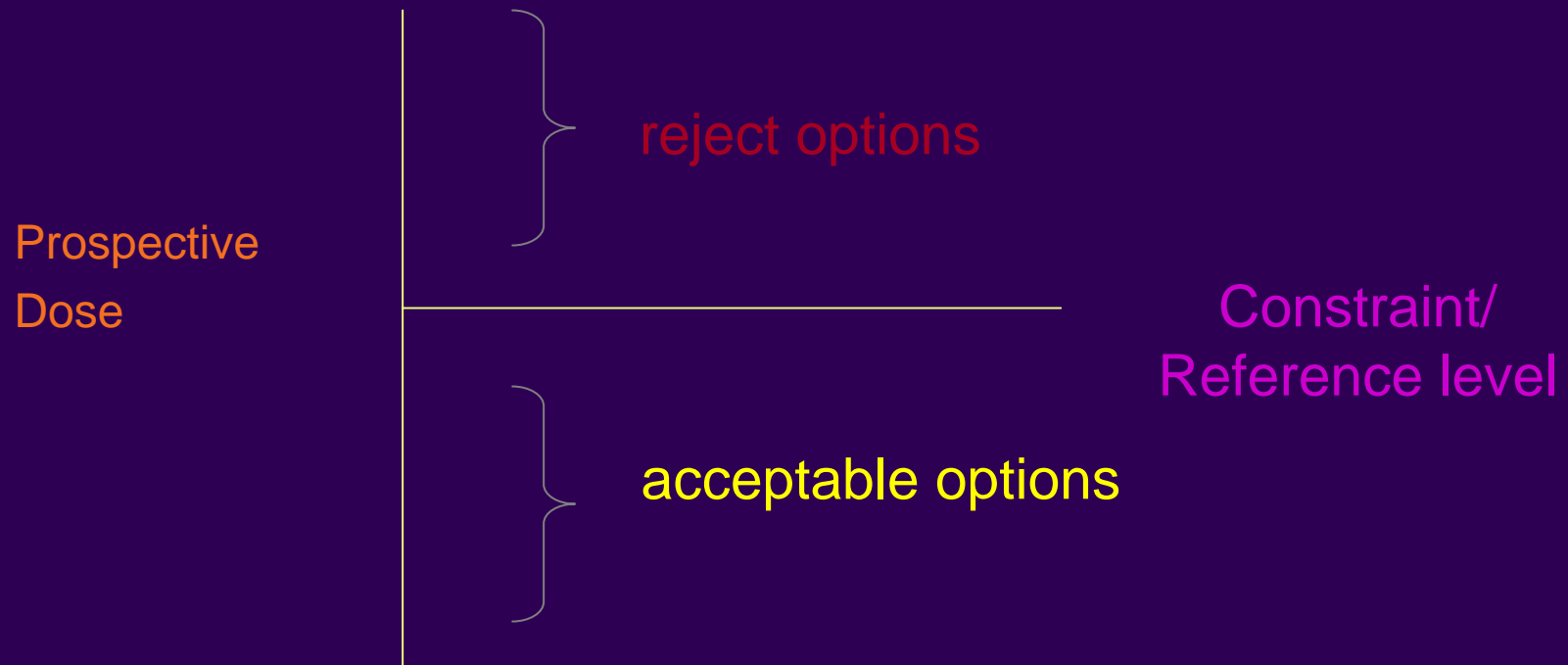
From a single source in normal, emergency, or existing controllable situations by

From **all** regulated sources in normal situations by

Constraints / reference levels

Limits

Optimisation



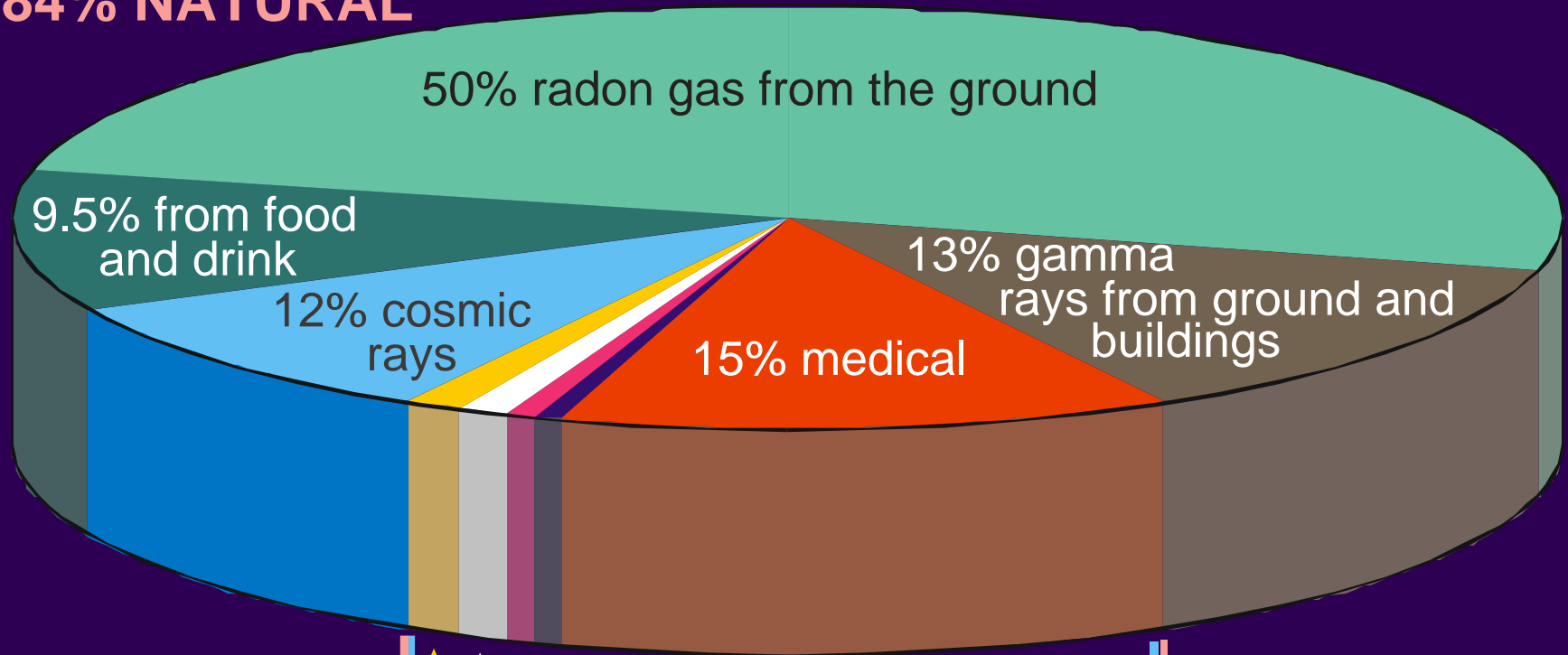
Constraints and reference levels are an integral part of optimisation

BANDS OF PROJECTED DOSE	CHARACTERISTICS AND REQUIREMENTS
Greater than 20 - 100 mSv	Exceptional situations. Benefit on a case-by-case basis. Information, training and individual monitoring of workers, assessment of public doses.
Greater than 1 - 20 mSv	Individual direct or indirect benefit. Information, training and either individual monitoring or assessment.
1 mSv or less	Societal benefit (not individual). No information, training or individual monitoring. Assessment of doses for compliance.

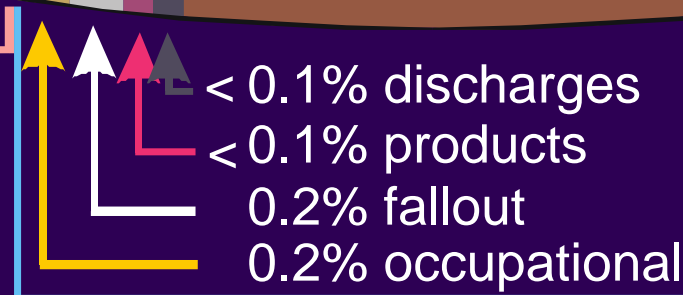
Average Annual Dose to UK population - 2.7 mSv



84% NATURAL



16% ARTIFICIAL



Critical group doses	mSv
Sizewell	< 0.01
Sellafield	0.5 (0.2)
Cardiff	0.01

HPA advice:

0.15 for new nuclear build

- Epidemiology, including internal emitters, cardiovascular disease
- Mechanisms at low doses
- Uncertainties

- Easy to measure
- All exposed
- Cancer risks quantified
- Sophisticated system of control