Increased leukemias near nuclear facilities

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Childhood Leukemias near UK nuclear facilities

- in 1980s and 1990s, large increases found near Dounreay, Windscale, Burghfield
- COMARE said were not due to radiation as doses were too low x 300
- debate fizzled out
- no-one had the expertise to challenge COMARE
- Reay v BNFL – plaintiffs lost

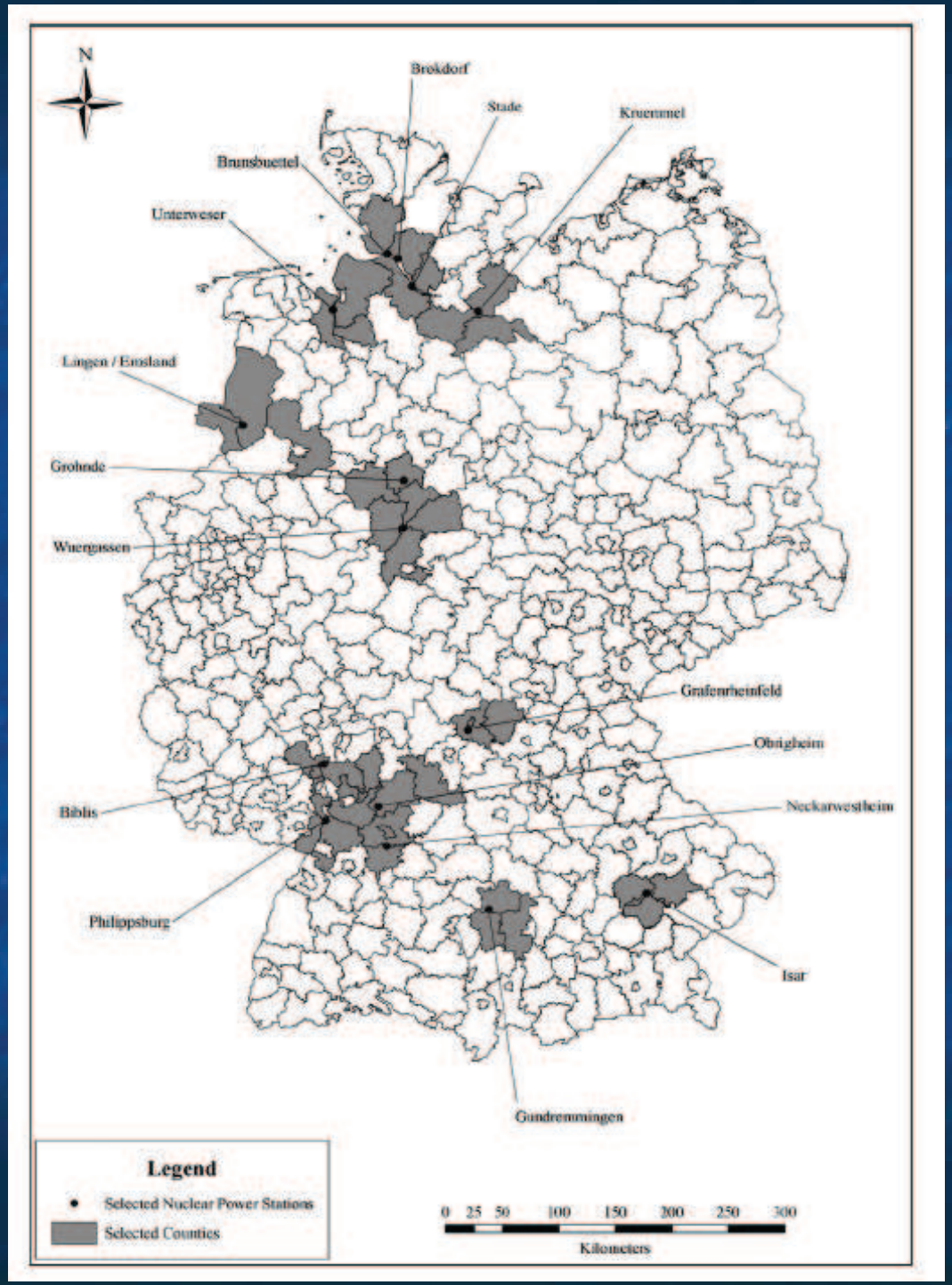
KiKK Report in Germany in 2008

Kinderkrebs in der Umgebung von KernKraftwerken

Kaatsch P, Spix C, Schulze-Rath R, Schmiedel S, Blettner M. 2008. Leukaemias in young children living in the vicinity of German nuclear power plants. Int J Cancer 122:721–726.

Spix C, Schmiedel S, Kaatsch P, Schulze-Rath R, Blettner M. 2008. Case–control study on childhood cancer in the vicinity of nuclear power plants in Germany 1980–2003. Eur J Cancer 44:275–284.

- has reignited the debate
- huge controversy in Germany
- almost unknown in UK
- Comare sub-committee studying KiKK (major Justification issue?)

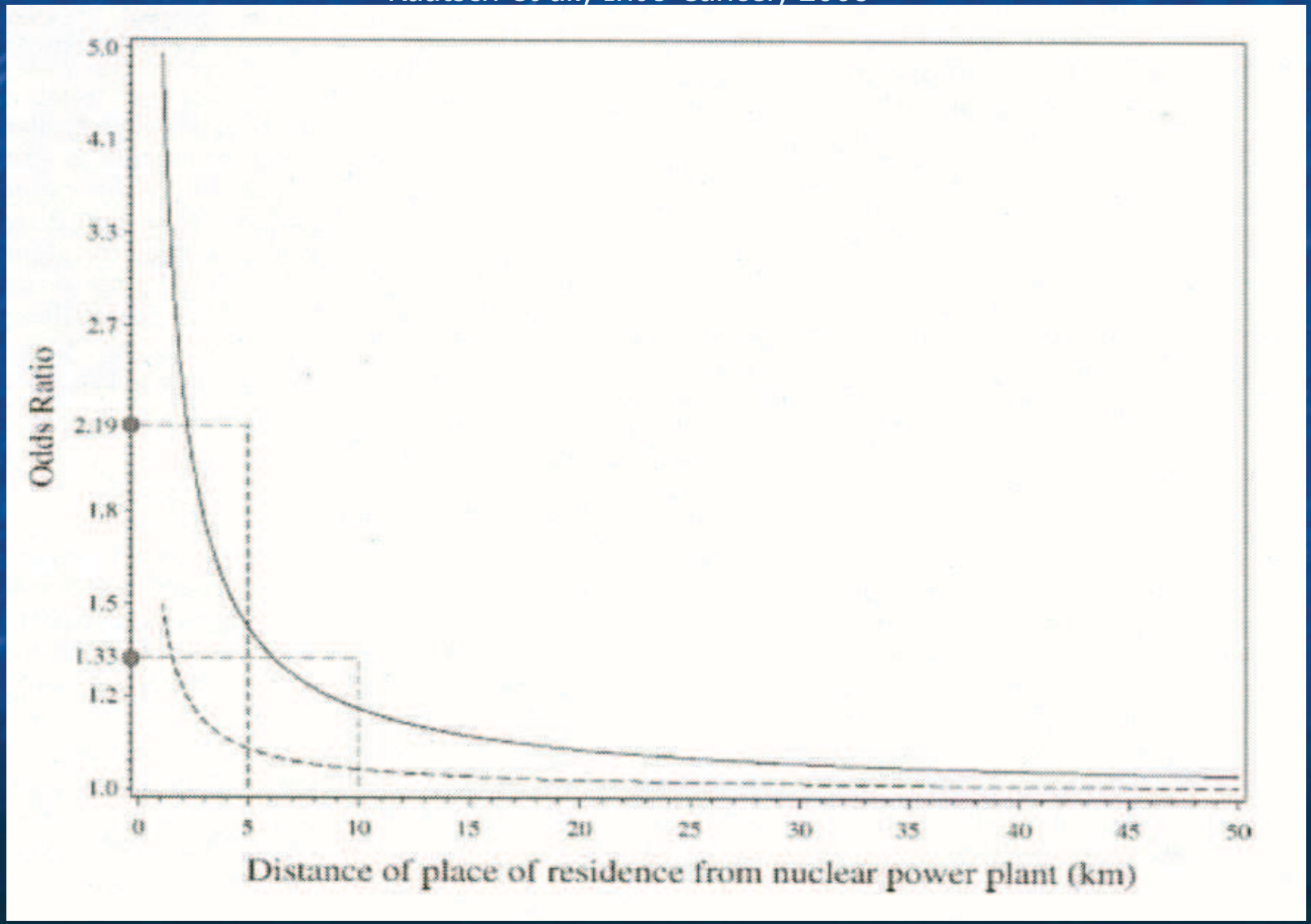

N
Brokdorf
Stade
Kruemmel
Brunsbuettel
Unterweser
Lingen / Emsland
Grohnde
Wuergassen
Grafenrheinfeld
Obrigheim
Biblis
Neckarwestheim
Philippsburg
Isar
Gundremmingen
Legend
Selected Nuclear Power Stations
Selected Counties
0 25 50 100 150 200 250 300
Kilometers

KiKK Study: 2008

- very large study of cancer incidence near all (16) German nuclear reactors
- commissioned by German Government
- 2.2 risk of infant leukemias
- 1.6 risk of solid cancers in babies
- strongly linked to living near reactors
- validity accepted by German Government

the closer to reactor – the greater the risk of child leukemia

Kaatsch et al., Int J Cancer, 2008



Do Other Studies Show this? Yes

(1) Laurier D et al (2008) Epidemiological studies of leukaemia in children and young adults around nuclear facilities: a critical review. Radiat Prot Dosimetry 132(2):182-90. REVIEWED 26 MULTI-SITE STUDIES

(2) Laurier D, Bard D (1999) Epidemiologic studies of leukemia among persons under 25 years of age living near nuclear sites. Epidemiol Rev 21(2):188-206. LISTED 50 STUDIES (36 SINGLE AND 14 MULTI-SITE)

IE, OVER 60 STUDIES!

What do the 26 latest studies show re child leukemias?

from table 1 of Laurier D et al (2008)

Leukemias	Increase observed	No increase observed	%
Number of datasets	19	7	73%
Datasets with statistically significant increases (p=0.05)	6	1	85%

Conclusion: a steady pattern of leukemia increases near NPPs
NB many technical reasons for not observing an increase

Possible Causes

Confounders	No
Coincidence	No
Population mixing	No
Chemicals	No
Viruses	No
Exposure to radiation	?

KiKK study said radiation doses were too low, but made no estimates itself

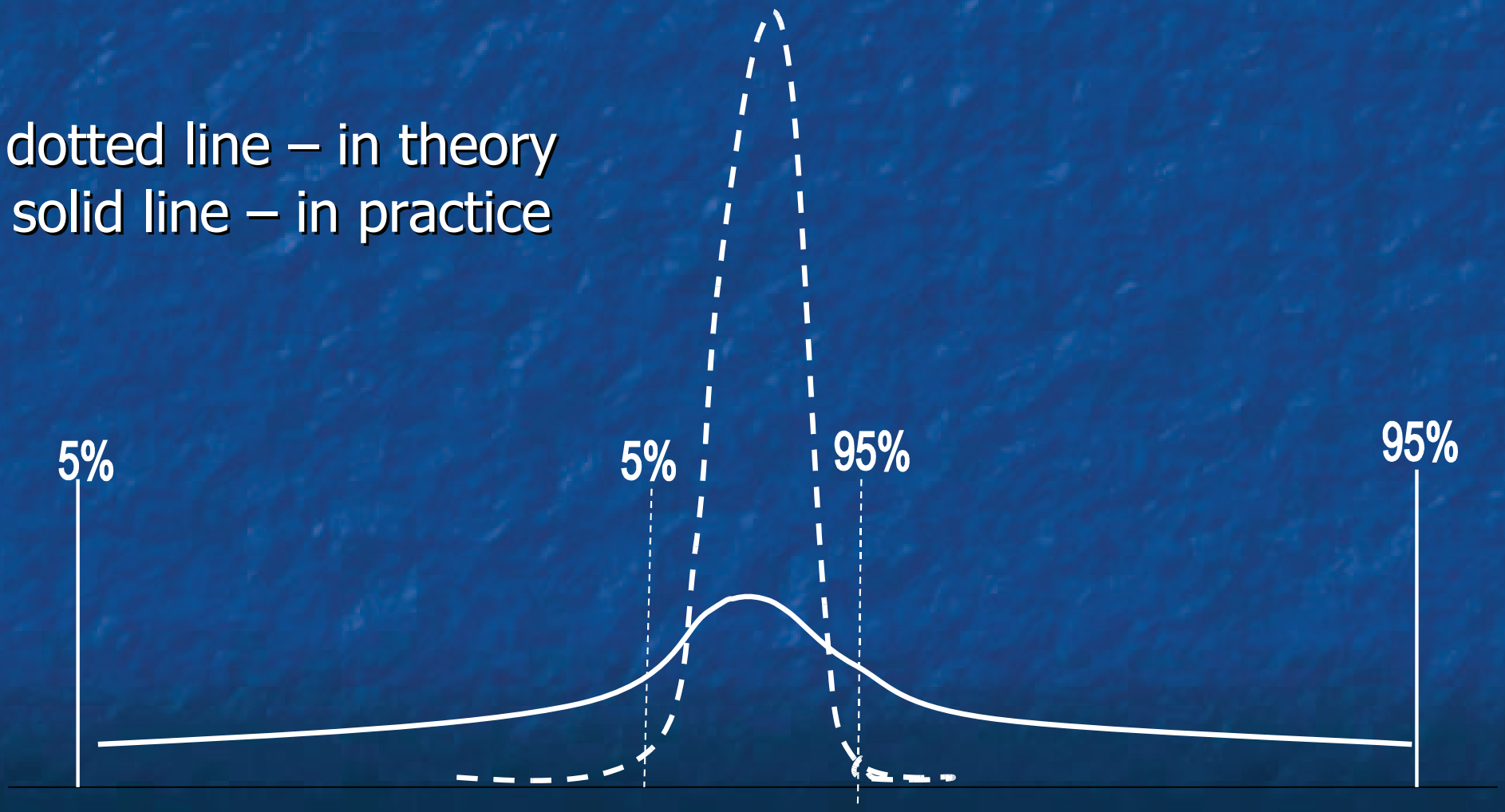
Large uncertainties in estimated doses/risks near reactors: why? need to use many models

- Environmental models (behaviour of nuclides in environment)
- Biokinetic models (uptake and retention of nuclides in humans)
- Dosimetric models (convert Bq to mGy: mSv)
- Weighting factors (tissue W_T and radiation W_R)
- Apply a risk model (from Japanese bomb data)
- Higher risks in infants?
- Higher risks from *in utero* exposures?

= OFFICIAL DOSES/RISKS HAVE MANY UNCERTAINTIES see CERRIE Report www.cerrie.org

Uncertainty distributions in dose estimates

dotted line – in theory
solid line – in practice



Uncertainties in Dose Coefficients

Goossens LHJ, Harper FT, Harrison JD, Hora SC, Kraan BCP, Cooke RM (1998) Probabilistic Accident Consequence Uncertainty Analysis: Uncertainty Assessment for Internal Dosimetry: Main Report. Prepared for U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, USA. And for Commission of the European Communities, DG XII and XI, B-I049 Brussels Belgium. NUREG/CR-6571 EUR 16773.

Nuclide	**Intake**	**Organ**	**U Range = (ratio of $95^{th}/5^{th}$ percentiles)**
Cs-137	ingestion	red bone marrow	4
I-131	inhalation	thyroid	9
Sr-90	ingestion	red bone marrow	240
Pu-239	ingestion	red bone marrow	1,300
Sr-90	inhalation	lungs	5,300
Ce-144	inhalation	red bone marrow	8,500
Pu-239	ingestion	bone surface	20,000

So, radiation exposures could be a cause

KiKK: cancer increases strongly associated with proximity to nuclear reactors

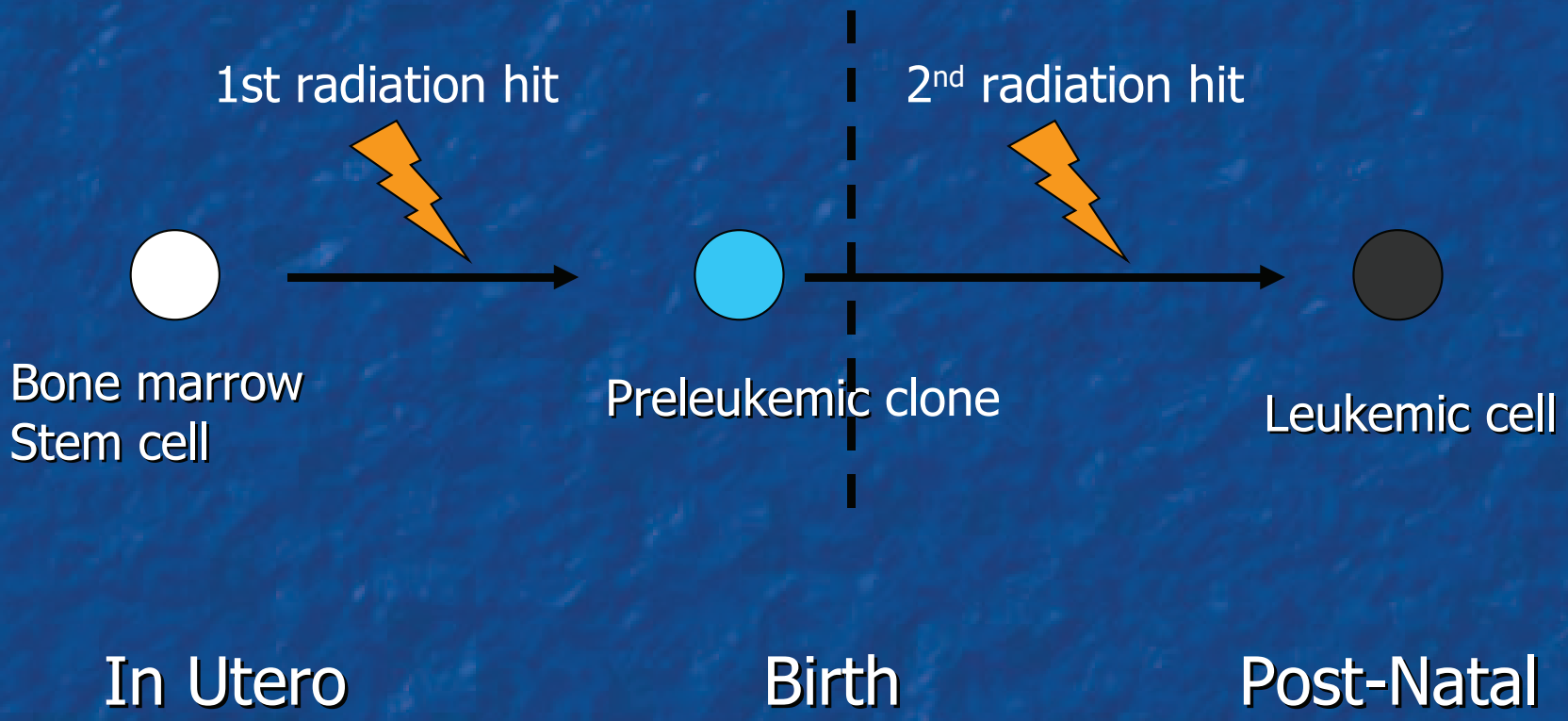
- direct radiation from reactors? No
- EM radiation from power lines? No
- cooling tower emissions? No
- reactor emissions and discharges

A possible biological mechanism to explain KiKK findings

- episodic spikes in reactor releases
- high concentrations in pregnant women
- large doses to embryos/fetuses
- resulting babies are born pre-leukemic
- after 1-2 years, develop full leukemia

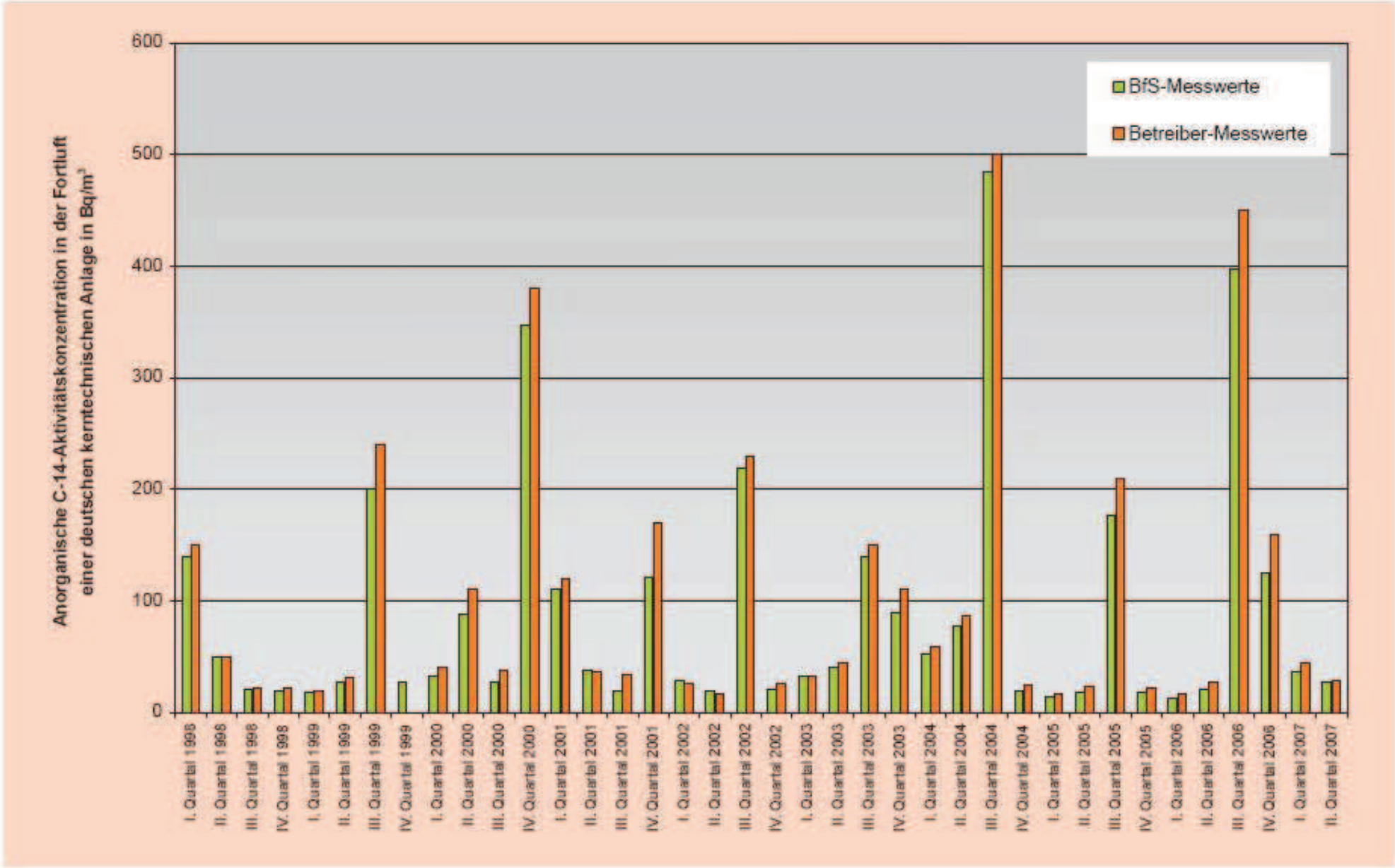
Leukemogenesis in Children

(after Professor Roessig)



1st Stage – Environmental Emissions

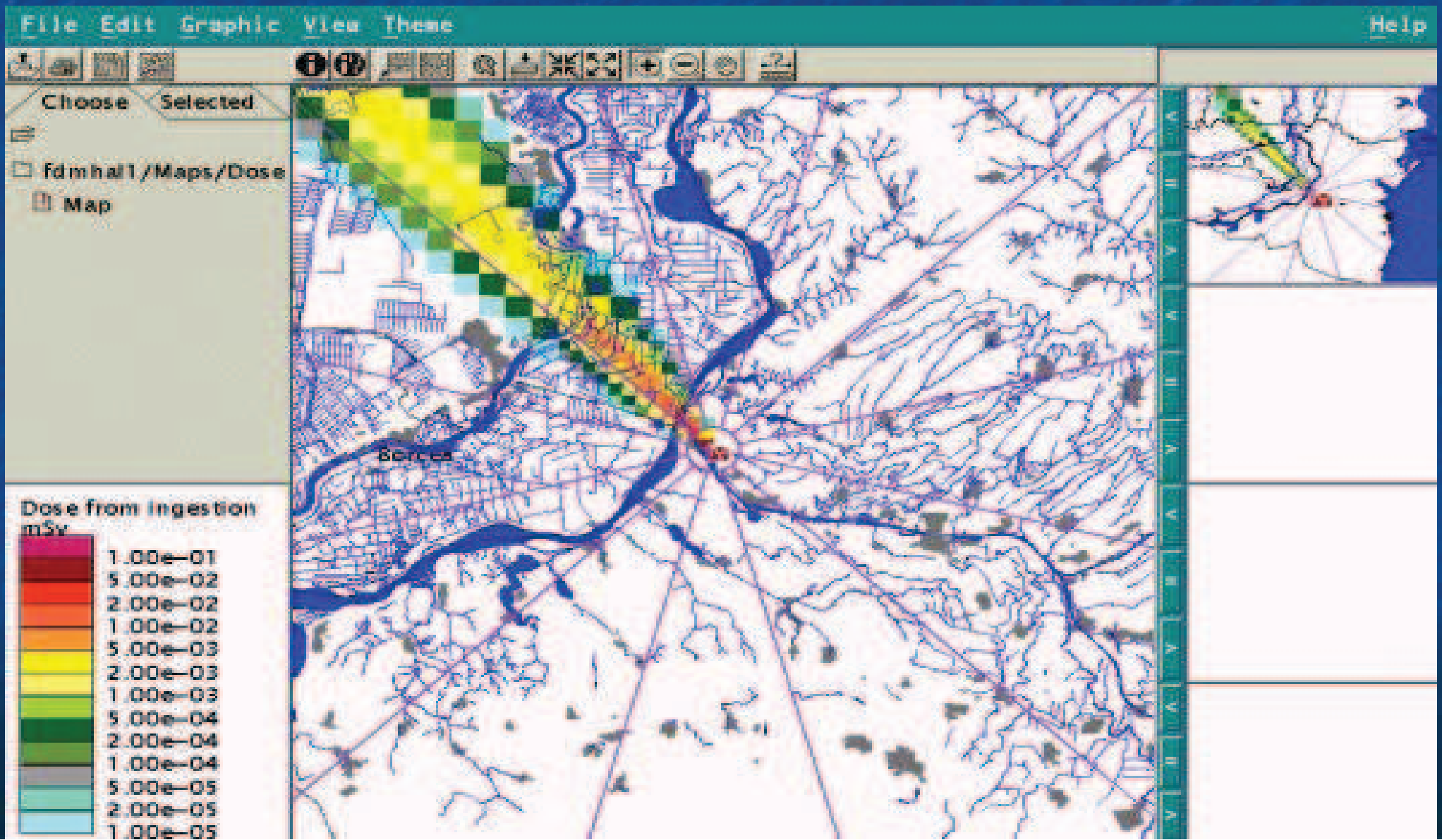
- when reactor is opened - large pulse of reactor gases is emitted
- incl H-3, C-14, Kr-85



Vergleich der vom Betreiber und dem BfS ermittelten Kohlenstoff-14-Aktivitätskonzentrationen in der Fortluft am Beispiel eines süddeutschen Druckwasserreaktors (KKW Neckarwestheim 2)

Tritium doses from ingestion (EU RODOS Model) in mSv

8th Meeting of the IAEA (EMRAS) Tritium & C-14 Working Group
May 30 - June 1, 2007 - Bucharest, Romania (http://www.nipne.ro/emras/)



Estimated tritium levels in cow's milk (EU RODOS Model) OBT Bq/kg

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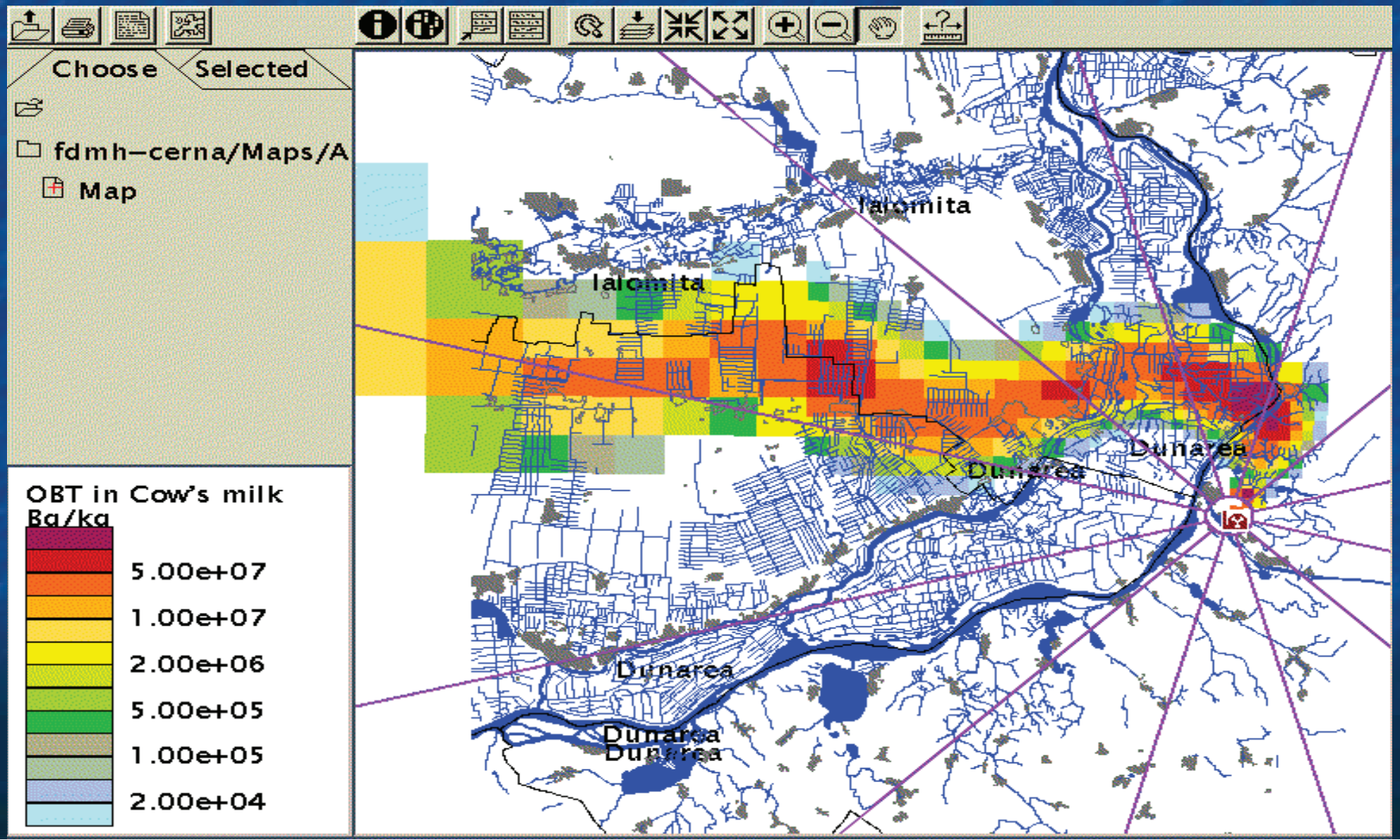
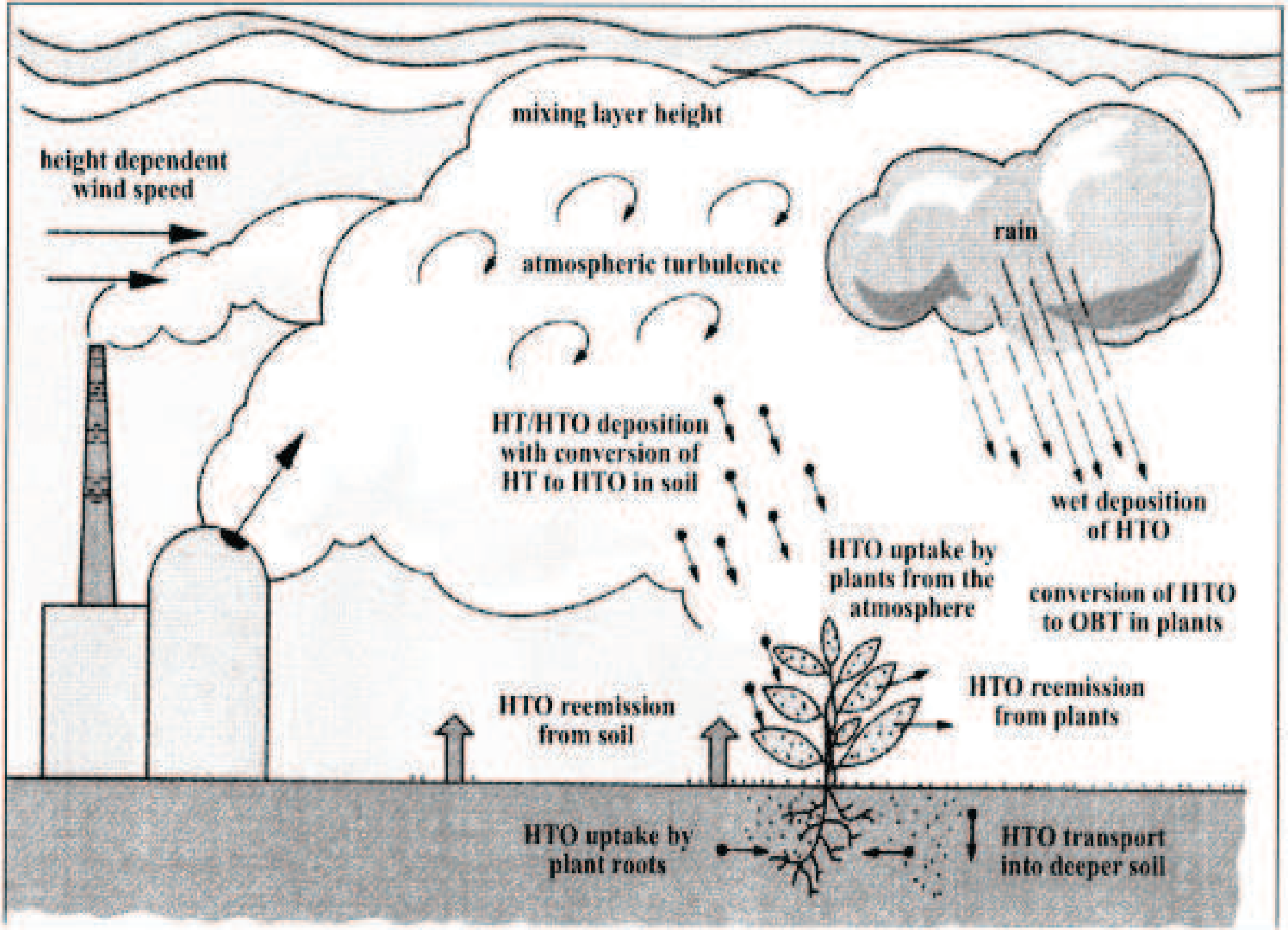
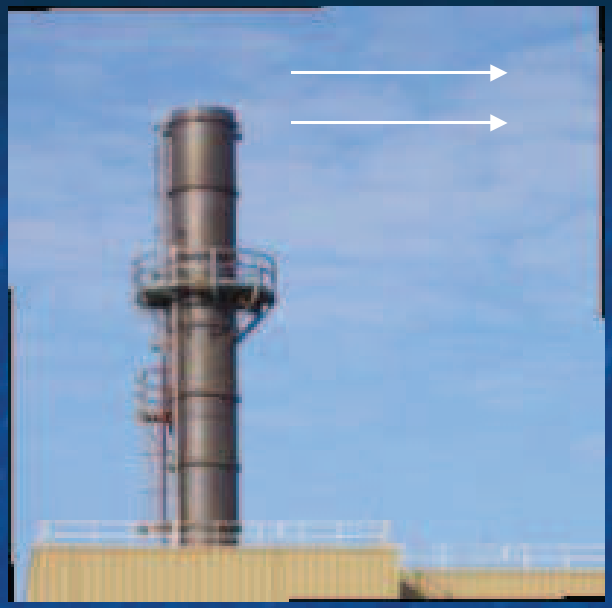
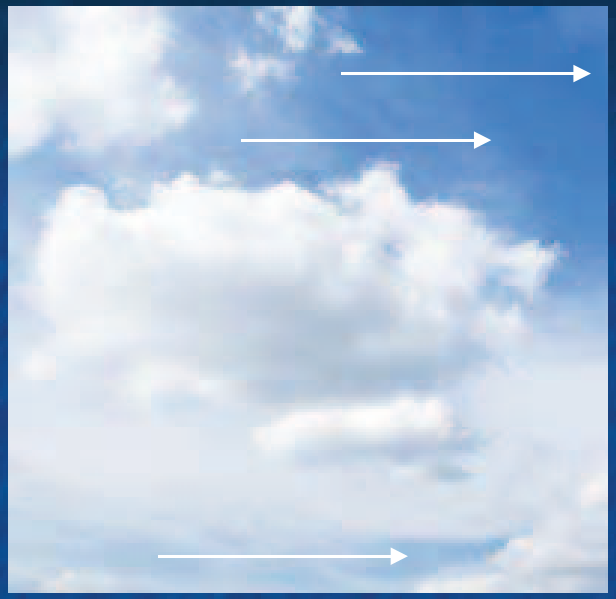
May 30 - June 1, 2007 - Bucharest, Romania (http://www.nipne.ro/emras/)




mixing layer height
height dependent
wind speed
atmospheric turbulence
rain
HT/HTO deposition
with conversion of
HT to HTO in soil
wet deposition
of HTO
HTO uptake by
plants from the
atmosphere
conversion of HTO
to OBT in plants
HTO reemission
from plants
HTO reemission
from soil
HTO uptake by
plant roots
HTO transport
into deeper soil





Embryos/fetuses: we don't know

(a) what are their radiation doses?
(b) how radiosensitive they are?
(c) what risks from internal nuclides?

Should ask Government for its estimate of doses/risks to embryos, and the uncertainties involved

"We conclude that there is strong evidence that low dose irradiation of the fetus *in utero*, particularly in the last trimester, causes an increased risk of cancer in childhood."

Doll R and Wakeford R (1997) Risk of childhood cancer from fetal irradiation. Br J Radiol; 70: 130-9

Increased child leukemias near UK nuclear power stations?

Bithell JF, Keegan TJ, Kroll ME, Murphy MF, Vincent TJ (2008) Childhood leukaemia near British nuclear installations: methodological issues and recent results. Radiat Prot Dosimetry. 132(2): 191-7.

- 24% increase (O= 18; E =14.58)
- NB - omitted Sellafield leukemias!
- Statistically significant? 95% - No; 85% - Yes
- Bithell et al stated "no evidence" of UK increase
- Fairlie and Körblein complained
- Radiat Prot Dosimetry 2009 published 7 October 2009, 10.1093/rpd/ncp207

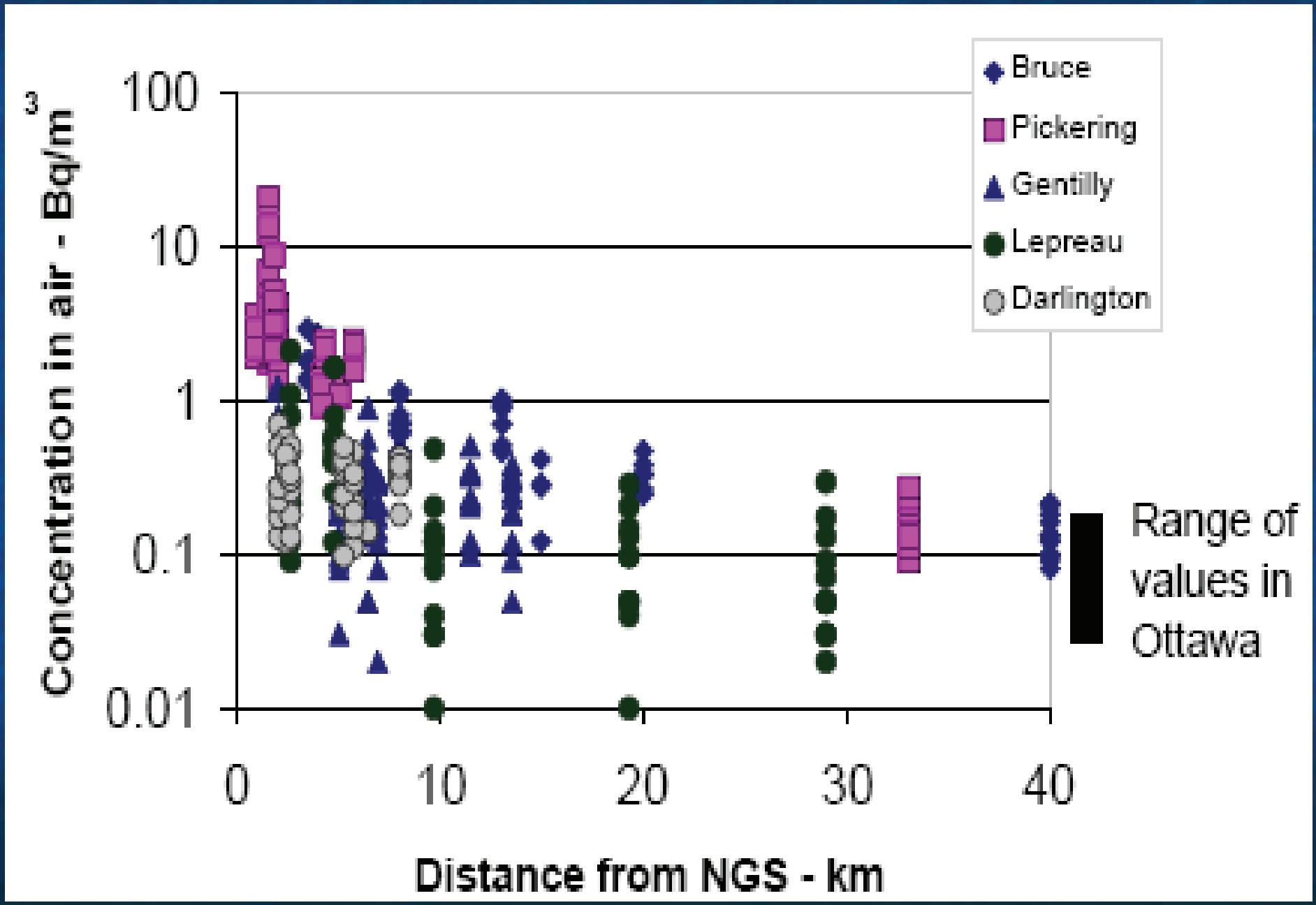
- Conclusion: Need to be guided by the better German KiKK study: not weak, biased UK study

Figure 1.1 Principal sources of radioactive waste disposal in the UK

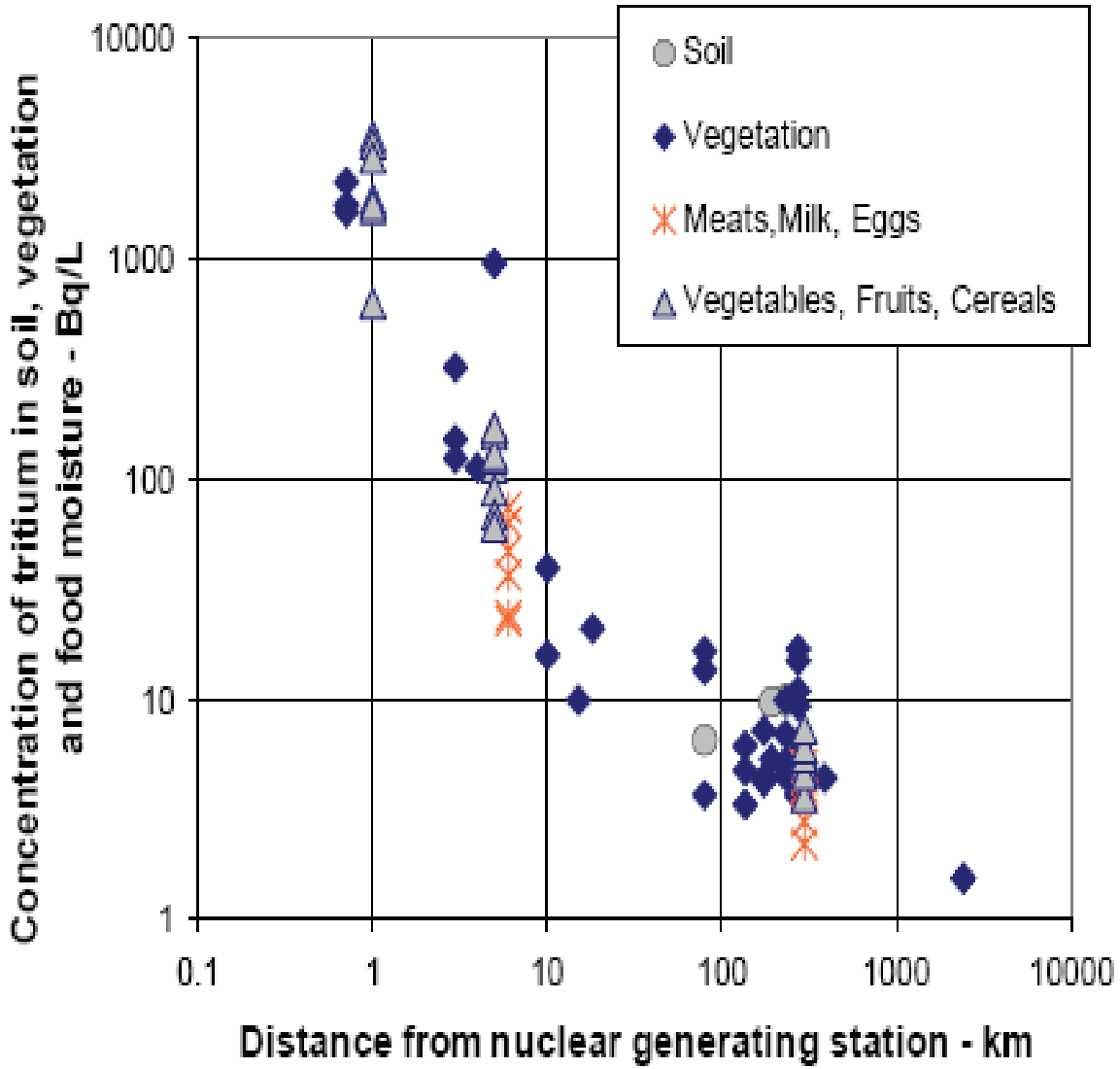
Main Radioactive Releases to Air from UK Nuclear Facilities

- tritium (radioactive water vapour)
- noble gases (mainly Kr, Ar, Xe)
- carbon-14
- iodine-131, iodine-129 …
- some particulates

Tritium in air



Tritium in Food Moisture



What is tritium?

- the radioactive isotope of hydrogen
- mainly in the form ^{3}H-O-H
- tritium = radioactive water
- undetected by all our senses

Unusual Tritium Properties

- Extreme mobility + exchangeability
- Sticks inside us, and builds up
- Very short range, so damage depends on where in cell, eg close to DNA
- Tritium described as "weak", but more dangerous than "strong" emitters

RESULT: Official models significantly underestimate tritium's dangers

Hazardous Properties Tritium = √

(after Dr Gerald Kirchner)

1. large releases to environment √
2. rapid nuclide transport and cycling in biosphere √
3. high solubility √
4. many environmental pathways to humans √
5. rapid molecular exchange rates (ie very fast intakes) √
6. high uptake to blood after intake √
7. organic binding in biota √
8. long biological half-life in humans √
9. long radiological half-life √
10. global distribution √
11. long nuclide decay chains with radiotoxic daughters
12. high radiotoxicity (ie large dose coefficient) (√)

Apply Precautionary Principle

- uncertainty no excuse for inaction
- if reasonable evidence, should take precautionary steps
- eg health warnings near reactors?
- whatever the explanation for KiKK, leukemia risk is still there

Recommendations

- Further studies (EU wide)
- Advise local people of risks
- Health warnings near reactors
- Rethink plans to build more reactors

Main Points

- Large leukemia increases near all NPPs
- Embryonal cancers near NPPs: ie babies born with solid cancers
- Official dose estimates likely wrong
- Main releases are H-3, C-14, inert gases
- Air emissions more important than sea discharges
- Embryos and fetuses very radiosensitive
- Bone marrow very radiosensitive

Thanks to

Dr Alfred Körblein
Dr Philip Day+
Dr Keith Baverstock