Increased leukemias near nuclear power stations

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Childhood Leukemias near Nuclear Facilities

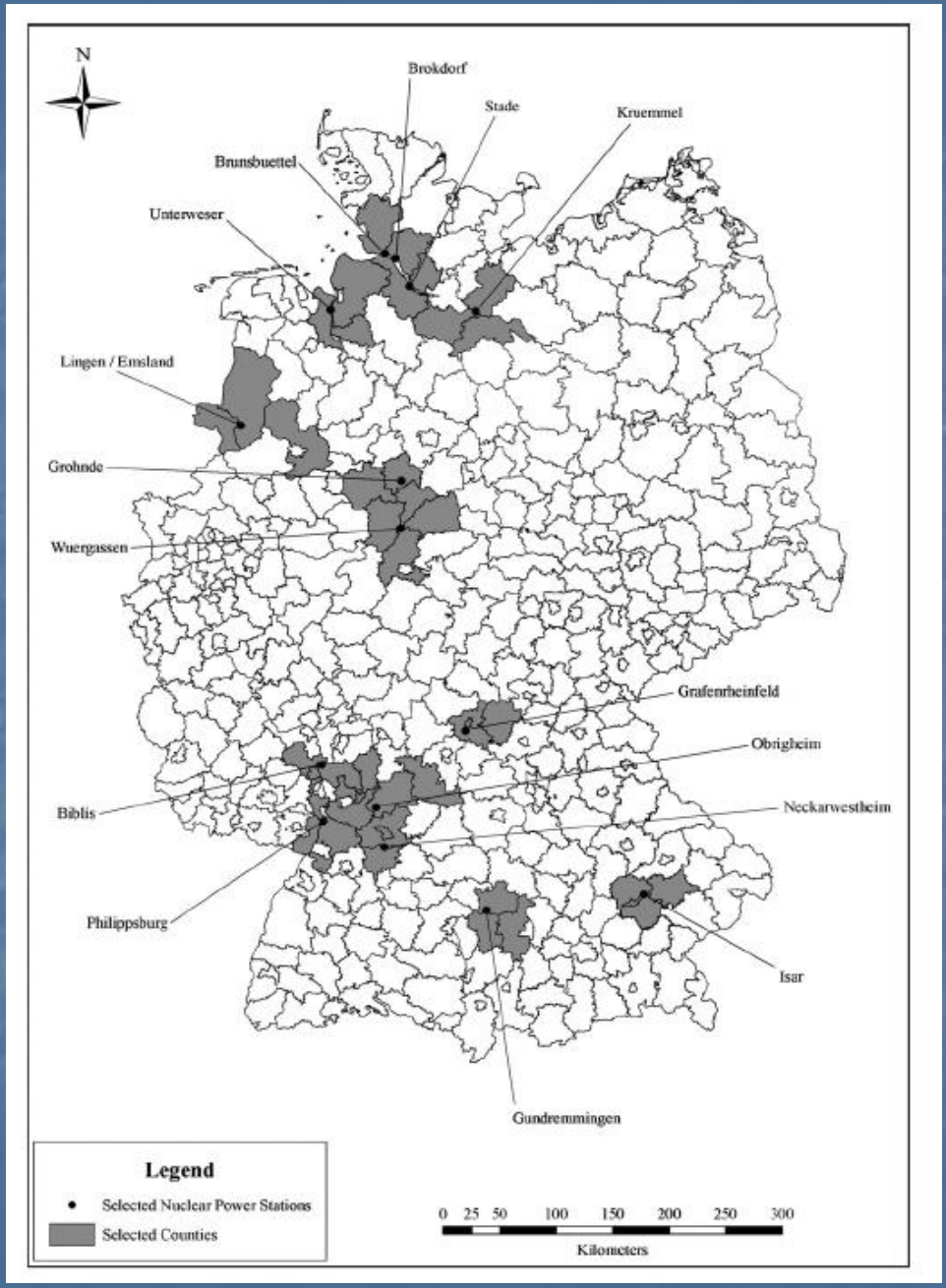
- in 1980s and 1990s, large increases found near in the UK (Dounreay, Windscale, Burghfield)
- UK Government said were not due to radiation as doses were too low x 300
- debate fizzled out
- no-one had the expertise to challenge Govt
- Reay v BNFL – defendants lost a very long case

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?)

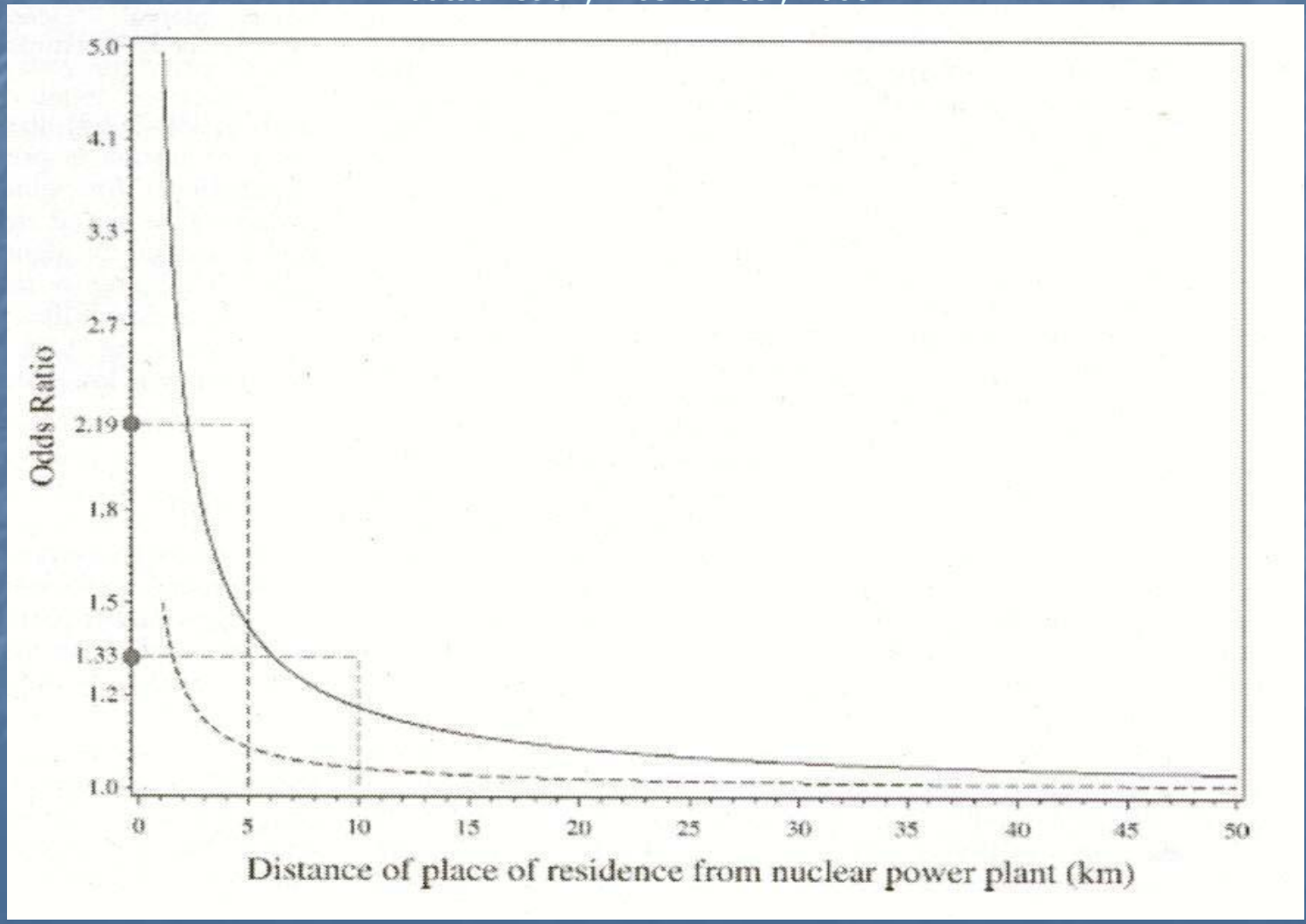

N
Brokdorf
Stade
Kruemmel
Brunsbuettel
Unterweser
Lingen / Emsland
Grohnde
Wuergassen
Grafenrheinfeld
Obrigheim
Neckarwestheim
Philippsburg
Isar
Gundremmingen
Legend
Selected Nuclear Power Stations
Selected Counties
0 25 50 100 150 200 250 300
Kilometers

KiKK Study: 2008

- very large study of cancer incidence near all (16) German nuclear reactors
- commissioned by German Government
- 2.2 x increase in child leukemias
- 1.6 x increase in child solid cancers
- 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 Back up KiKK?

(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 YES, in over 60 STUDIES!

What do 26 latest studies show?

from table 1 of Laurier D et al (2008)

	Number of studies (datasets)	Leuk Increase	No Leuk increase	% observed
Studies	26	19	7	73%
Studies where increases/decreases statistically significant at 95% level	7	6	1	85%

Conclusion: a steady pattern of leukemia increases near NPPs

Possible Causes

- Confounders X
- Coincidence X
- Population mixing X
- Exposure to chemicals X
- Exposure to viruses/fungi X
- Exposure to radiation ?

KiKK study "*said*" radiation doses were too low

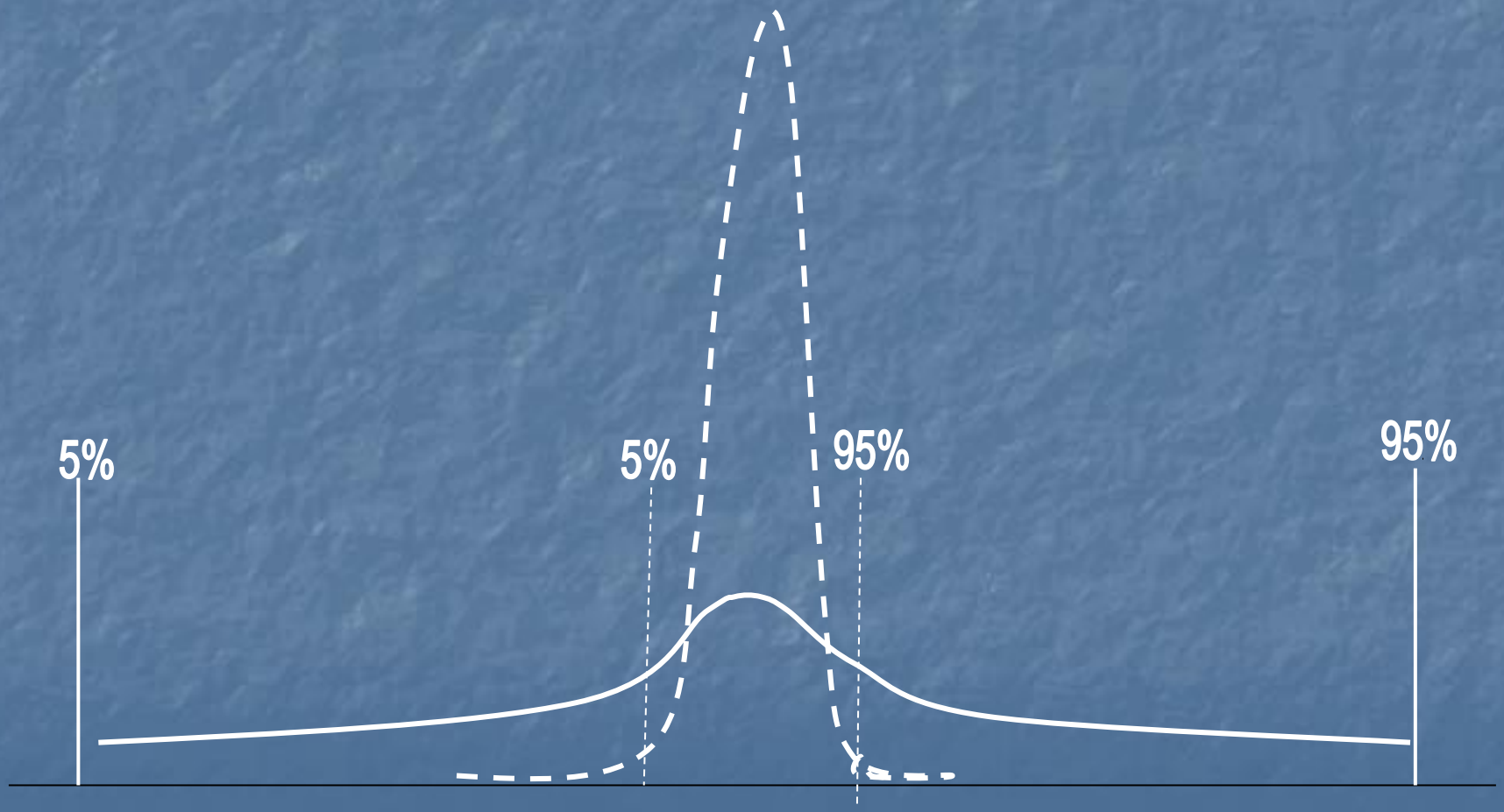
Large uncertainties in estimated doses/risks near reactors

- 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 (ICRP model from Japanese 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



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 to nearby people could be a cause

KiKK: cancer increases strongly associated with nuclear reactors

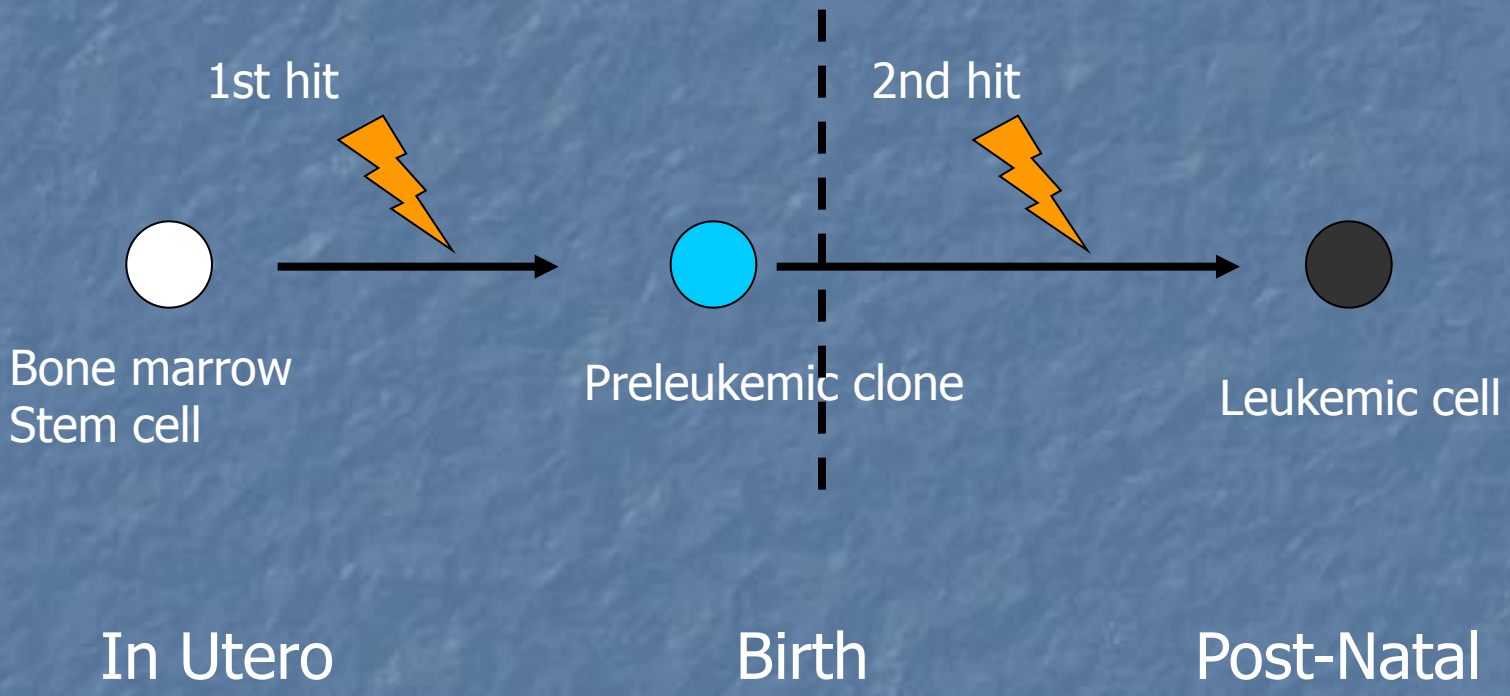
- direct radiation from reactors? X
- EM radiation from power lines? X
- cooling tower emissions? X
- reactor emissions and discharges?

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

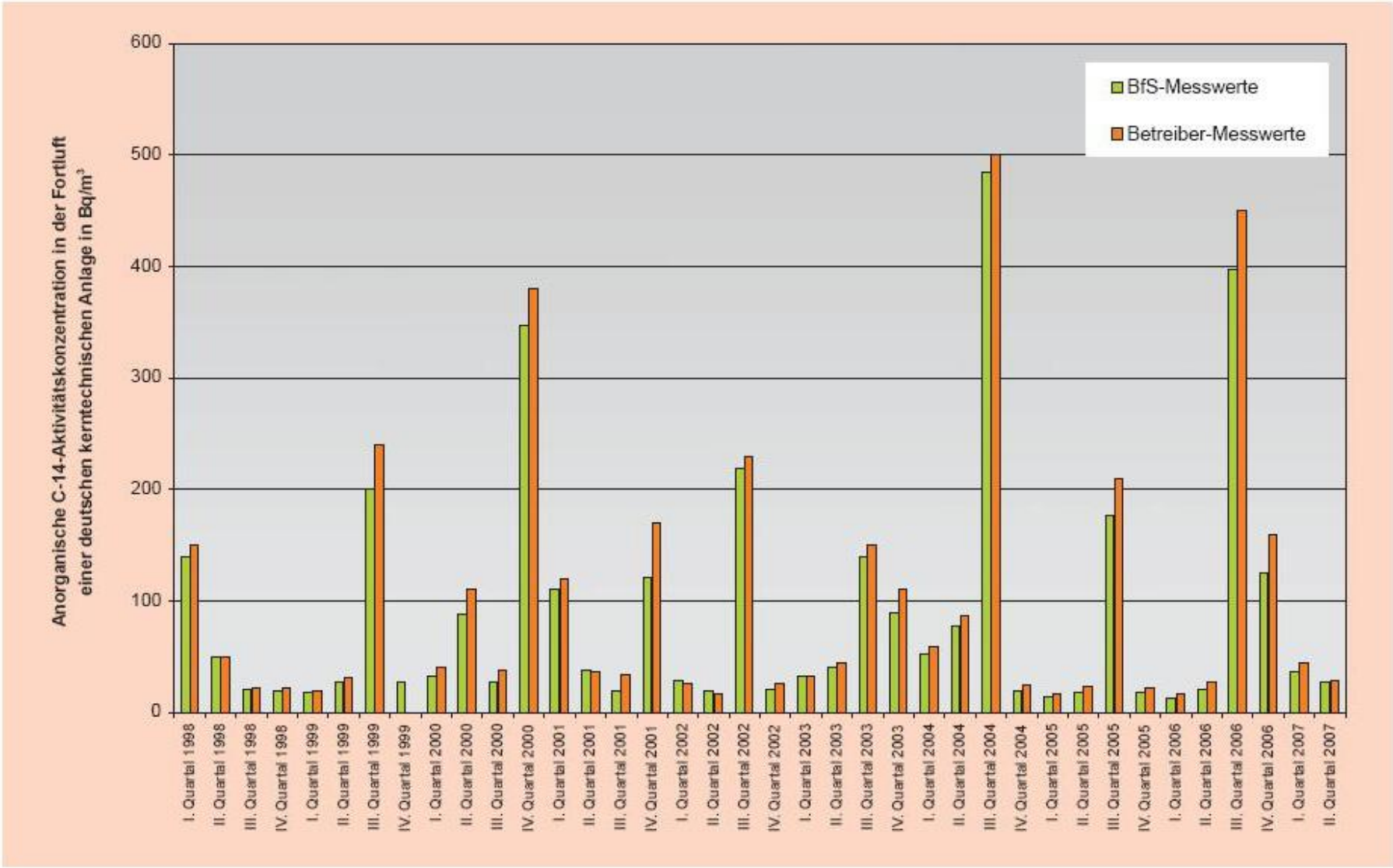
Leukemogenesis in Children

(after Professor Roessig)



1st Stage – Environmental Emissions

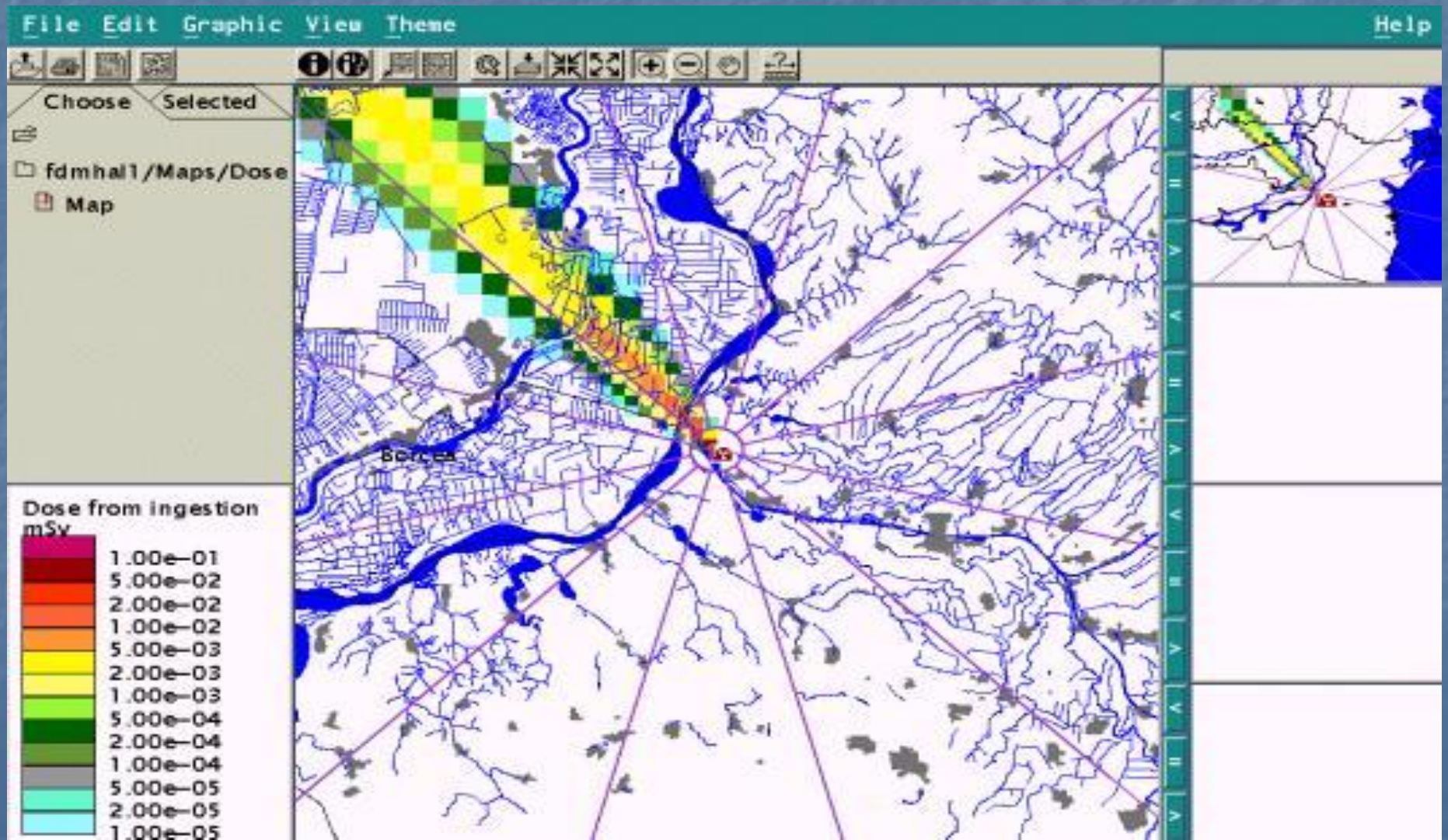
- when reactors opened - large pulse of H-3, C-14, Kr-85



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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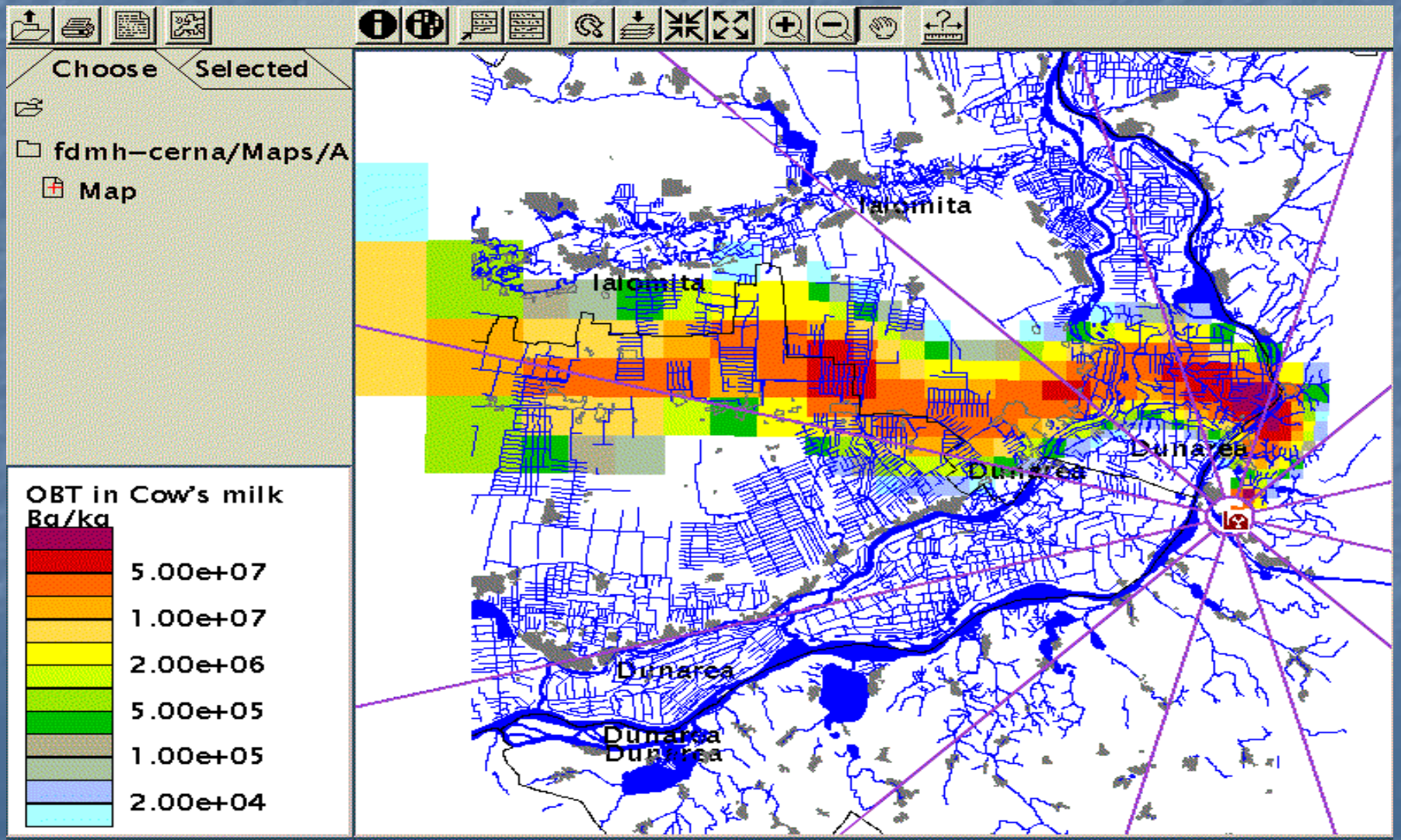


Embryos/fetuses: we don't know

(a) radiation doses?
(b) how radiosensitive, cf adults?
(c) risks from internal nuclides?

Ask UK Government for its estimate of doses/risks to embryos, and the uncertainties involved ?

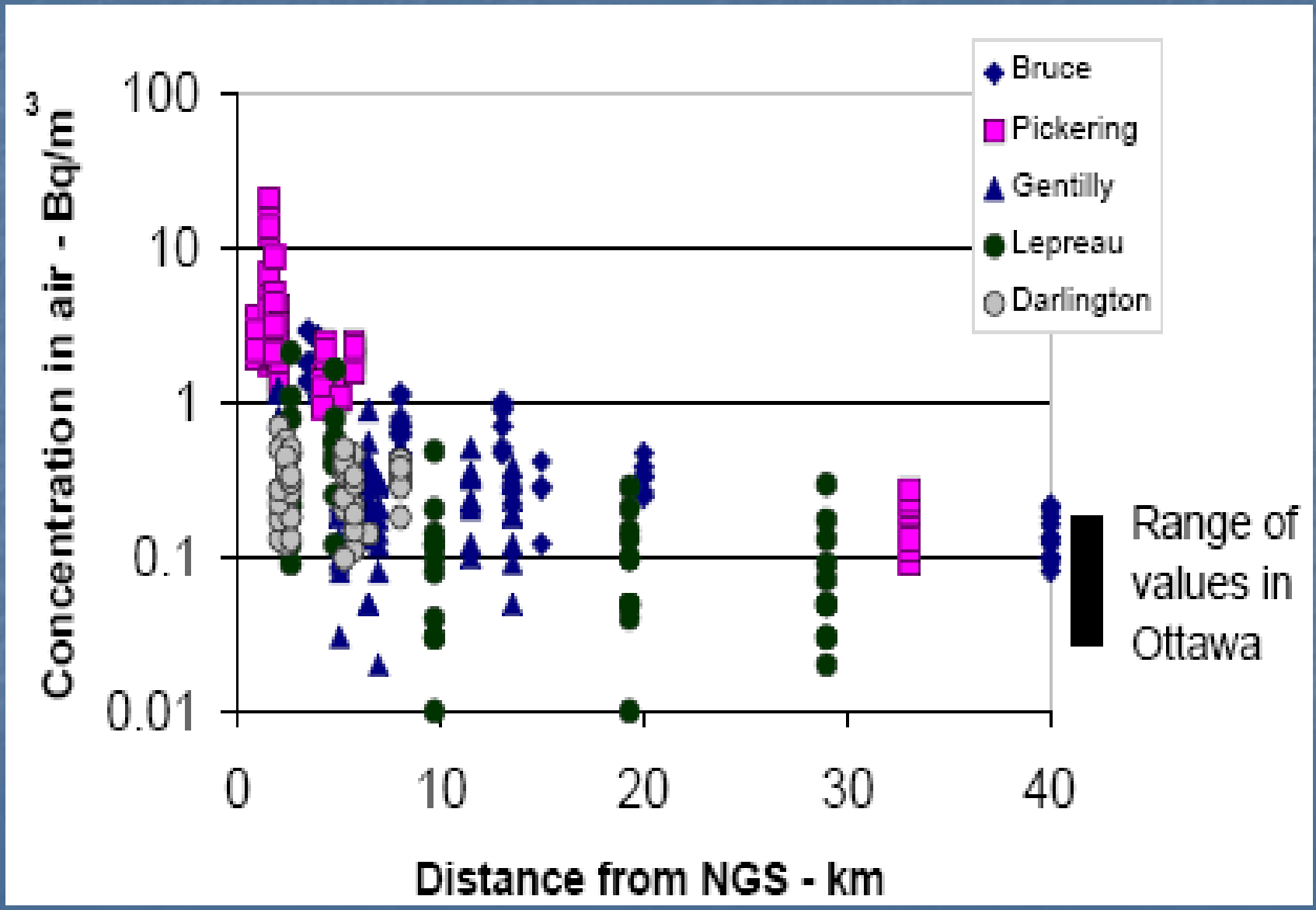
"We conclude that there is strong evidence that low dose irradiation of the fetus *in utero*, particularly in the last trimester, causes an increased risk of cancer in childhood."

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

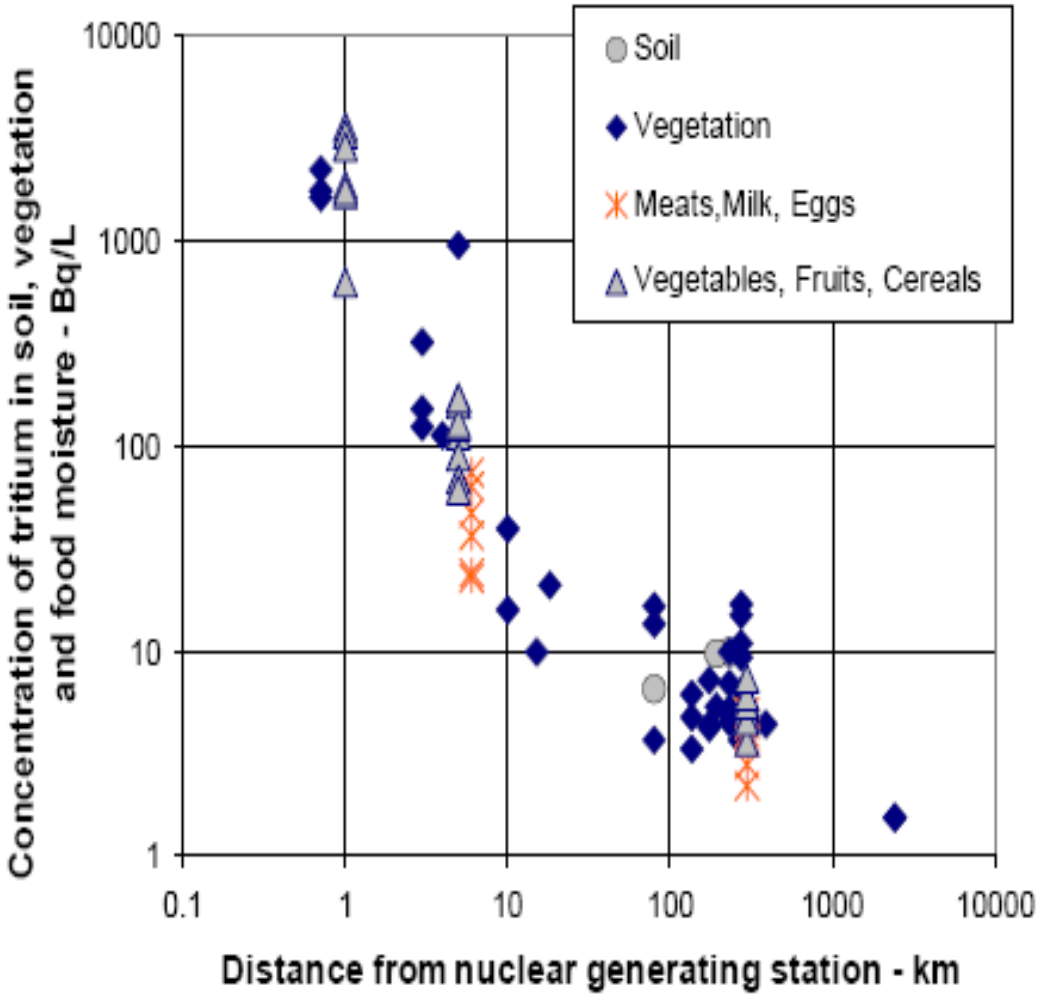
Main Radioactive Releases to Air from all Nuclear Facilities

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

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 its doses and its dangers

Hazardous Properties

(after Dr Gerald Kirchner)

Tritium = √ Carbon-14 = √

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)

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

Thanks to

Dr Alfred Körblein
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Dr Keith Baverstock