Overview of dose reconstruction after Chernobyl

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Why dose reconstruction?

Chernobyl - the typical example of a large scale ('communal') accident

- Release of radioactive materials outside the perimeter of a nuclear facility
- Engagement of the personnel, emergency workers and members of public
- Transport of radionuclides by air, aquatic systems, mechanically by men and vehicles
- On-site irradiation of personnel and emergency workers

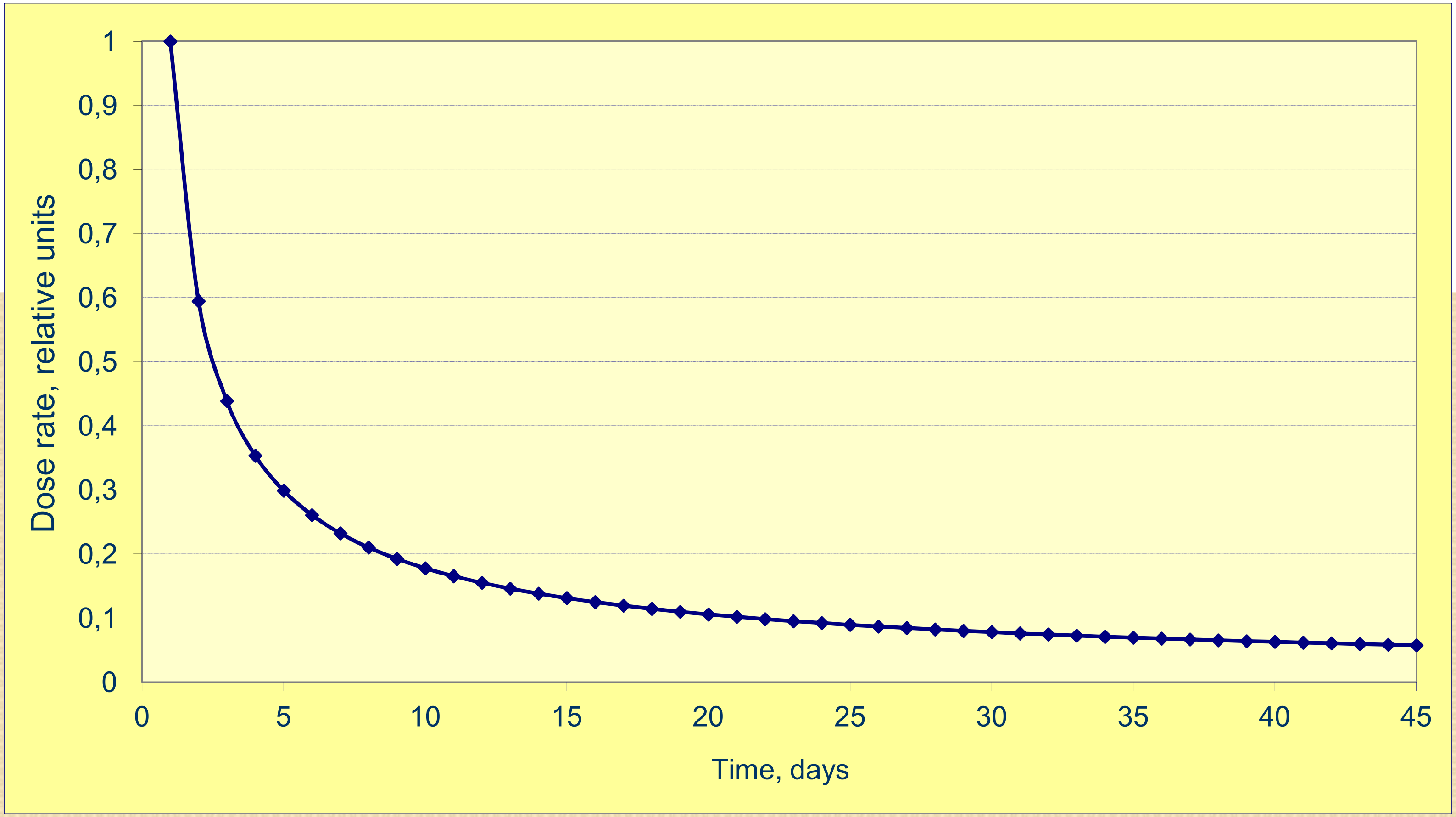
Radioactive mix in the release

- Noble (inert) gases – ^{85}Kr, ^{133}Xe
- Volatile elements – ^{129m}Te, ^{132}Te, ^{131}I, ^{133}I, ^{134}Cs, ^{136}Cs, ^{137}Cs
- Elements with intermediate volatility - ^{89}Sr, ^{90}Sr, ^{103}Ru, ^{106}Ru, ^{140}Ba
- Refractory elements (including fuel particles) - ^{95}Zr, ^{99}Mo, ^{141}Ce, ^{144}Ce, ^{239}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{242}Cm

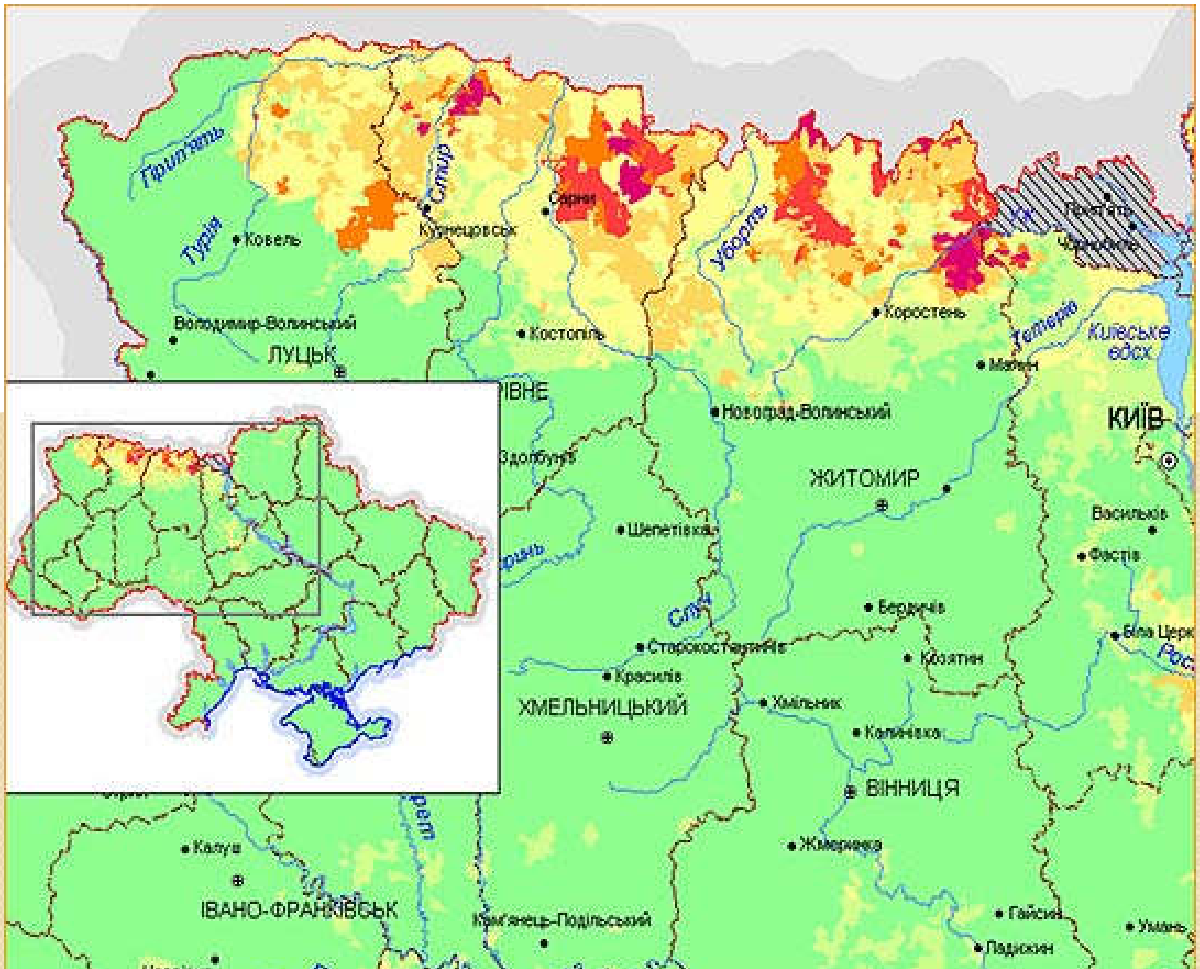
Dosimetric features of different phases of a reactor accident

- Initial phase – continuing release and rapidly changing radiation conditions, great uncertainty about dose rate and concentration levels, lack of measurements => lack of information about individual and collective doses
- Early (acute) phase – most significant pathways are external exposure and intake of radioactive iodine by ingestion and inhalation, thyroid doses depend on time course of intake and stable iodine administration
- Intermediate (stabilization) phase – external exposure by short-lived radionuclides, ingestion via root intake
- Late (recovery) phase – chronic internal and external exposure due to long-lived radionuclides (^{137}Cs, ^{90}Sr, ^{241}Am)

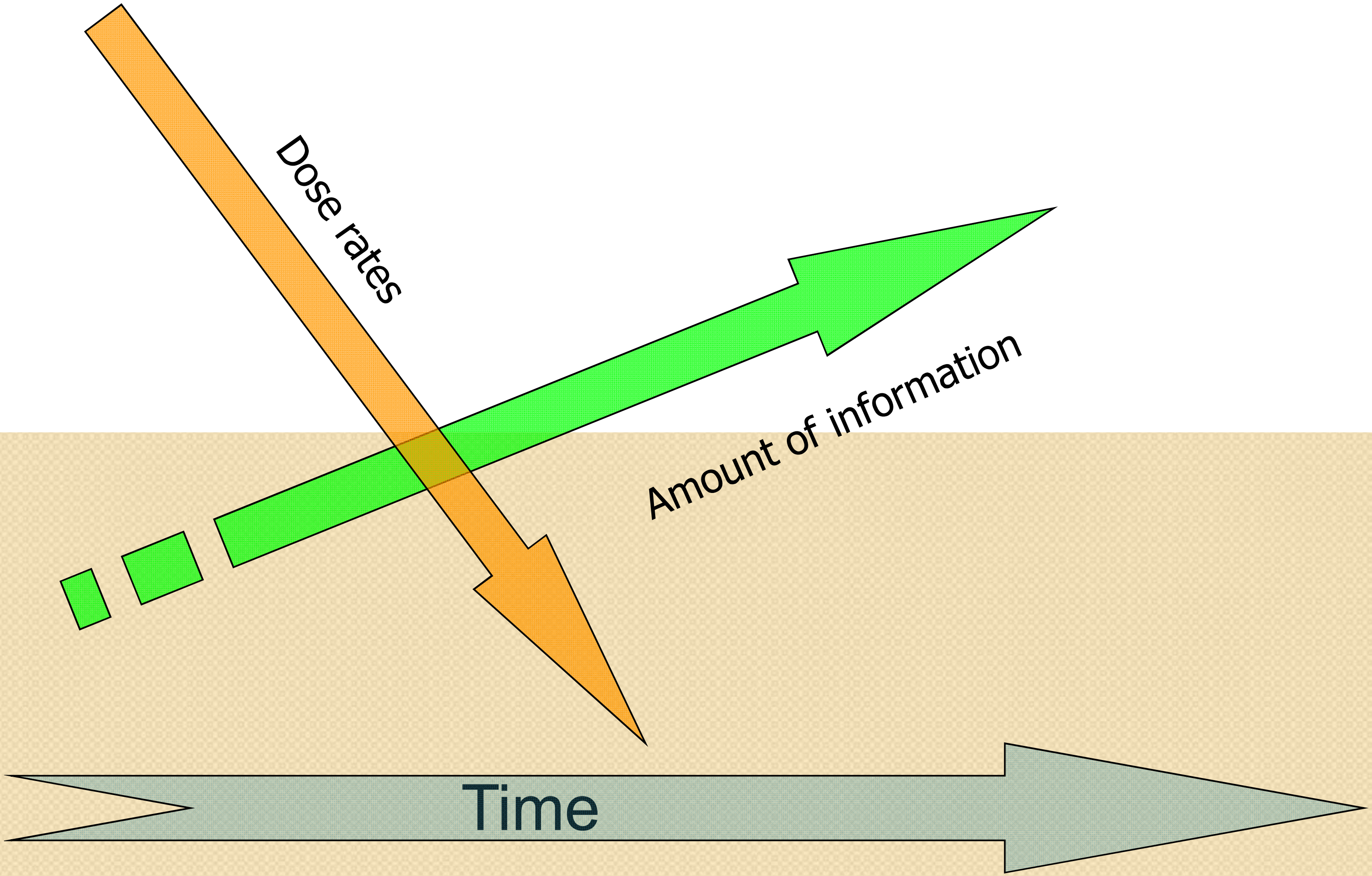
Decline of dose rate after reactor mix release



Spatial variation of doses



General rule



The case: Chernobyl accident

Accident at Chernobyl NPP

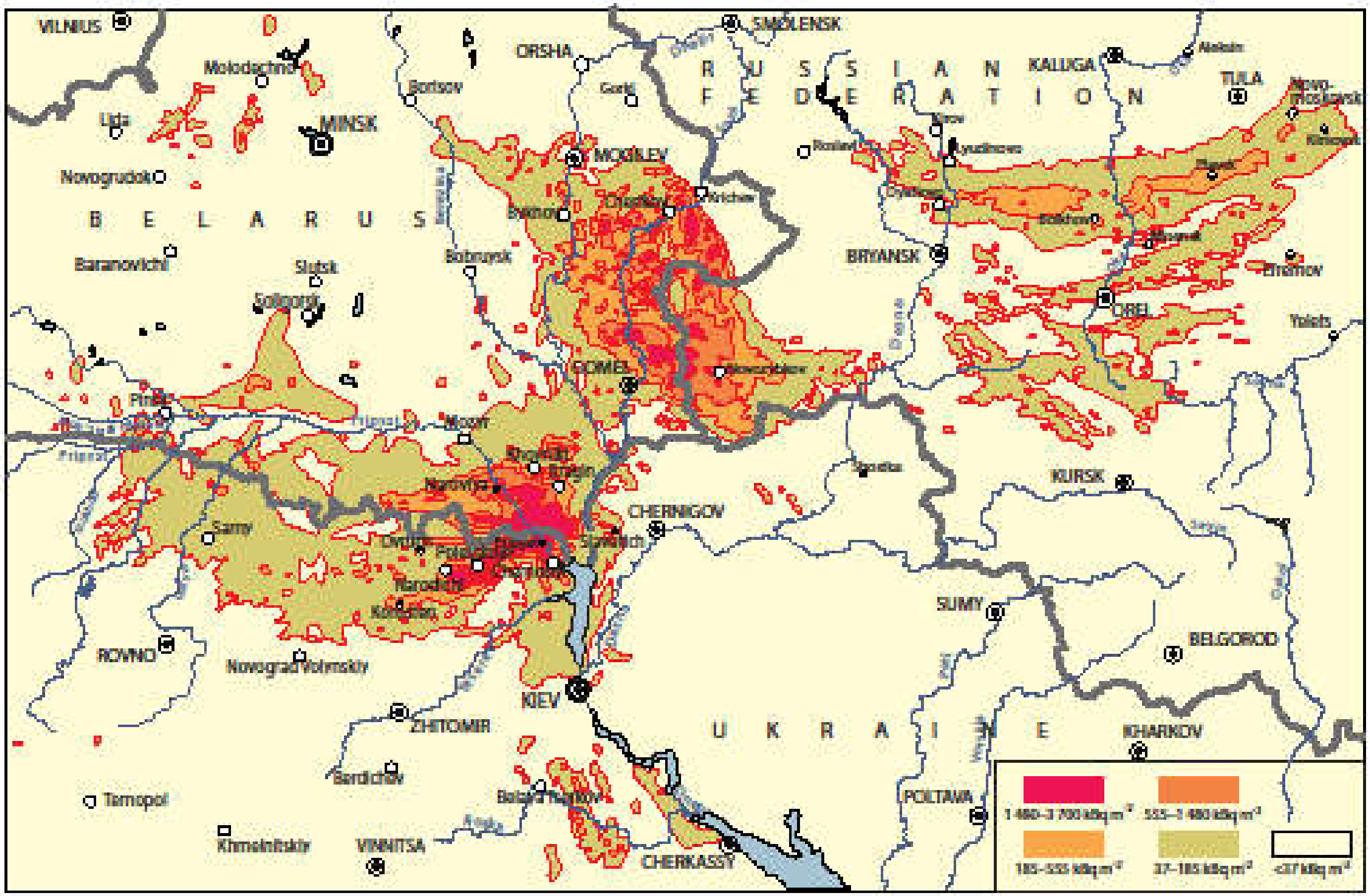
- April 26, 1986 reactor No.4 of the Soviet Union's Chernobyl NPP had exploded and destroyed both reactor itself and reactor building
- Fires were extinguished soon after explosion
- Radiation release lasted for about 10 days
- Total release amounted in more than 12,000 PBq and contained several dozens of radionuclides
- Hundreds of thousands of individual were exposed as residents of contaminated areas and emergency workers

Affected populations: some numbers

- 2 persons died in course of the accident
- 28 died within four months after the accident due to radiation injures (doses up to 16 Gy)
- 134 had Acute Radiation Syndrome (dose >0.8 Gy)
- 600 workers exposed within the first day
- 115,000 evacuated in 1986
- Some 440,000 worked in 1986-1987
- 600,000 official liquidators in 1986-1990 (about 300,000 – Ukrainians)
- 6,400,000 residents of contaminated (above 37kBq m^{-2} by ^{137}Cs) areas in Ukraine, Belarus and Russia

^{137}Cs contamination

Figure II. Map of ^{137}Cs deposition levels in Belarus, the Russian Federation and Ukraine as of December 1989 [I28]



UNSCEAR, 2011

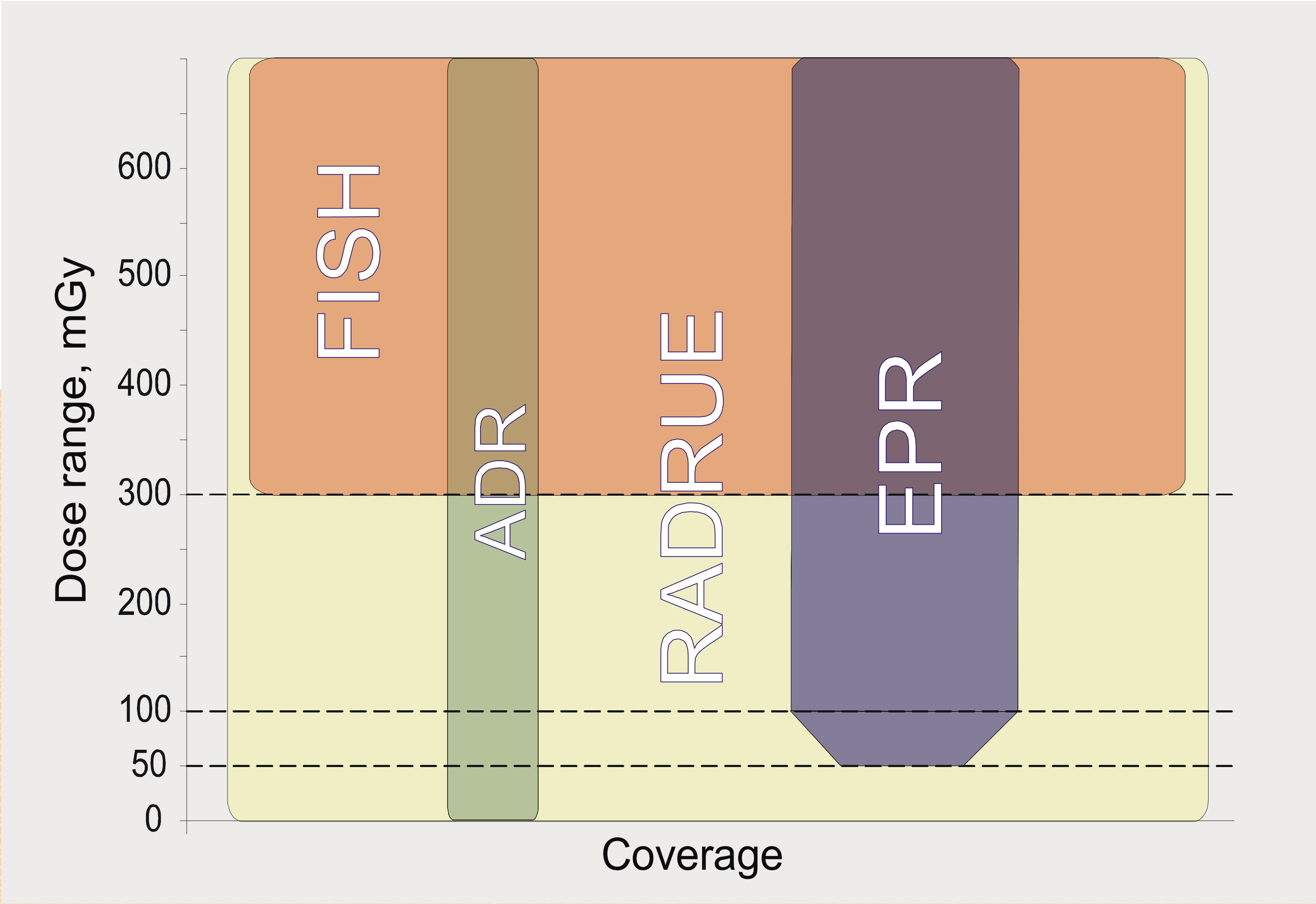
Retrospective dosimetry in Chernobyl

- For evaluation of acute exposure (not the topic of this talk)
- For assessment of possible health detriment
- For validation of models
- For epidemiological health effects studies
- For reassuring public in reliability of existing estimates

Plausible methodologies

- Biodosimetry (unstable chromosome aberrations, FISH)
- Instrumental dosimetry (EPR with tooth enamel)
- Analytical (time-and-motion) dosimetry
- Ecological models
- Retrospective validation of historical dose records

Application areas of plausible methods of individual dose assessment



Chumak, Radiat Meas, 2013

Specific requirements to dose assessment in Epidemiological studies:

- coverage of all subjects;
- need to evaluate doses long time after exposure and also to the subjects *post mortem;*
- provide dose estimates of comparable quality to all subjects (traceability and cross-calibration).

Practical examples of post-Chernobyl retrospective dosimetry

- Dose reconstruction to evacuated population of the 30-km zone and Pripjat town
- TL dosimetry with quartz in fired ceramics in the areas downwind from Chernobyl
- EPR dosimetry with teeth
- Dose reconstruction to Chernobyl clean-up workers (liquidators)
- Assessment of beta doses to lens – study of cataracts among liquidators
- Estimation of thyroid doses due to intakes
- . . .

Not possible to present in detail all Chernobyl dose reconstruction accomplished to date in a short talk …

… just several examples

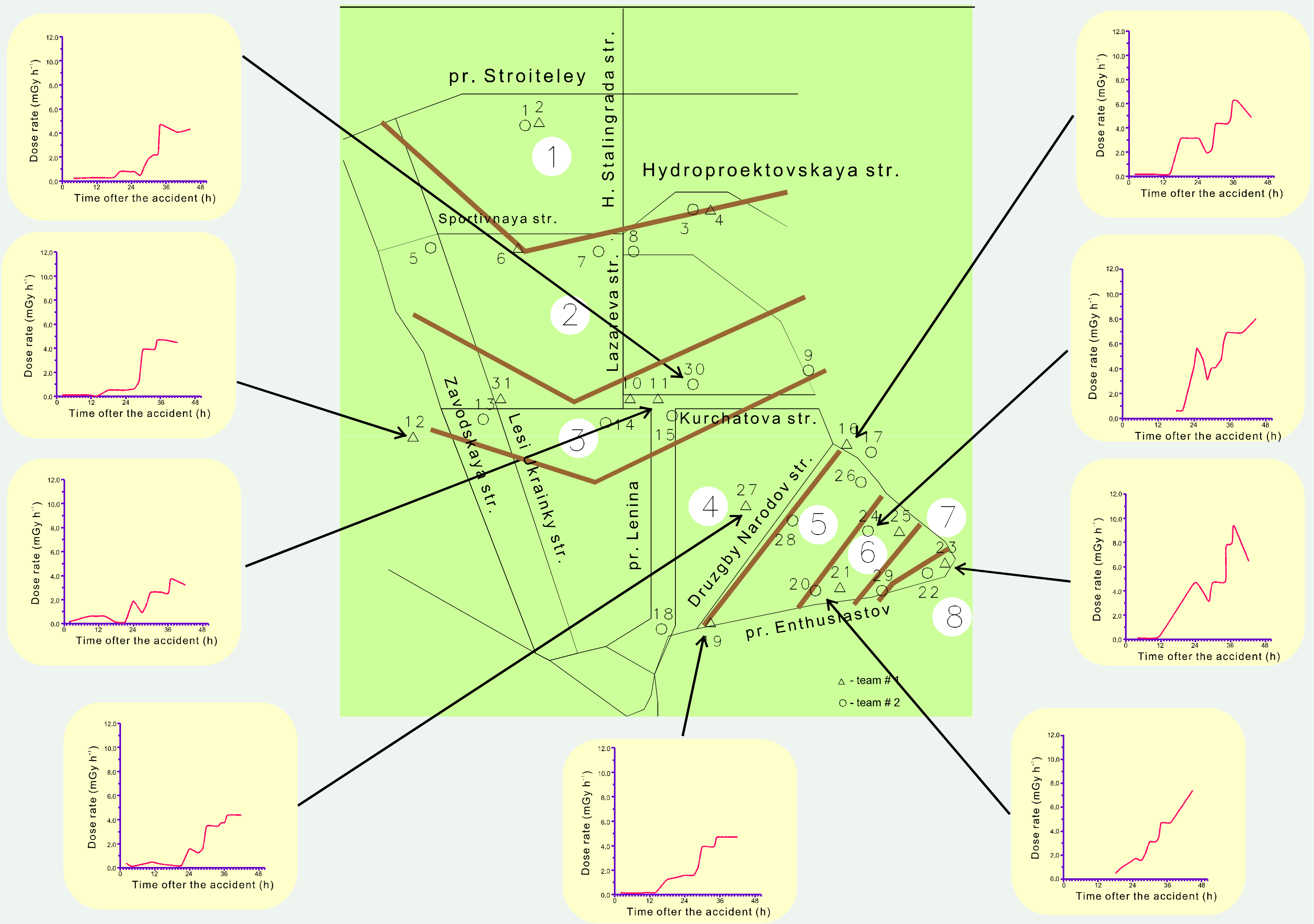
Application example 1: Reconstruction of individual doses to evacuees

Doses to evacuees

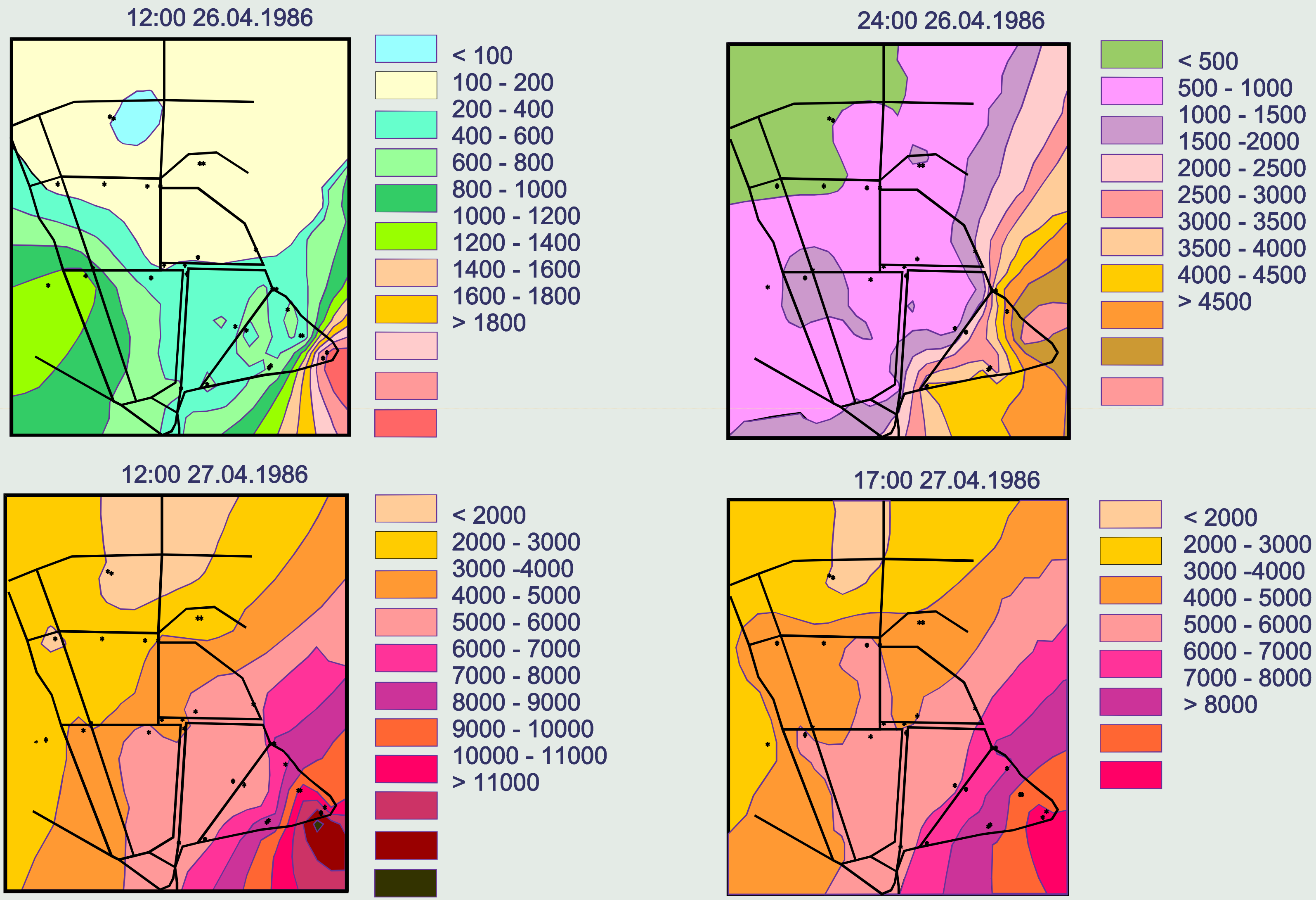
- Evacuated population:
  - Very variable;
  - Not measured at time of exposure;
  - => need to be estimated individually to rule out overexposure and, possibly, use in health studies

Likhtarev et al, Health Phys, 1994, Meckbach and Chumak, EU Chernobyl conference, Minsk, 1996

DOSE RATE MEASUREMENTS IN PRIPJAT



DOSE RATE PATTERN IN PRIPJAT AREA



WIDE SCALE PUBLIC SURVEY OF EVACUATED POPULATION

DESIGN OF THE SURVEY:

- public survey of evacuees who were included into the National Registry
  - contact people at their new locations 2-3 years after the accident
  - acquire individual behavior and migration information using formalized questionnaires

FQ FOR PRIPJAT CASE

Resolution:
- one hour in time
  - sector (1 of 8) in space

Dwelling data:
- type of the building
- floor
- address in Pripjat

Additional information:
- personal data (age, gender, profession)
- stable iodine intake (with day discretion)
- emergency countermeasure practice
- route of evacuation

Covered period:

FQ FOR THE 30-KM ZONE CASE

Resolution:
- one day in time
  - settlement in space

Dwelling data:
- type of the house

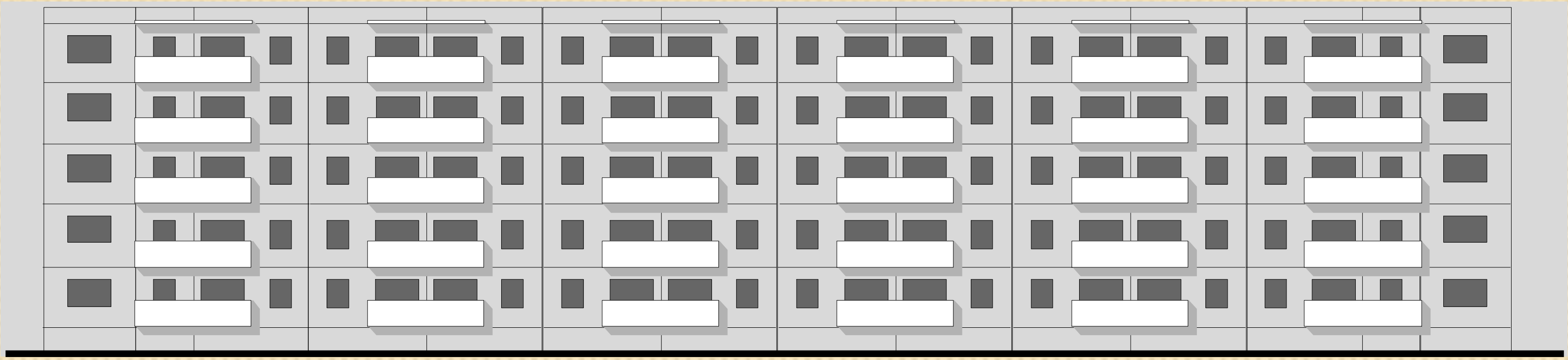
Additional information:
- personal data (age, gender, profession)
- source of water supply
- stable iodine intake
- consumption of local foodstuffs
- route of evacuation

Covered period:
20 days

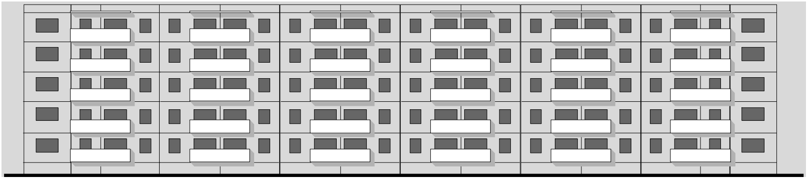
Monte Carlo simulation of photon transport in a house block

Monte Carlo simulation of photon transport in a house block

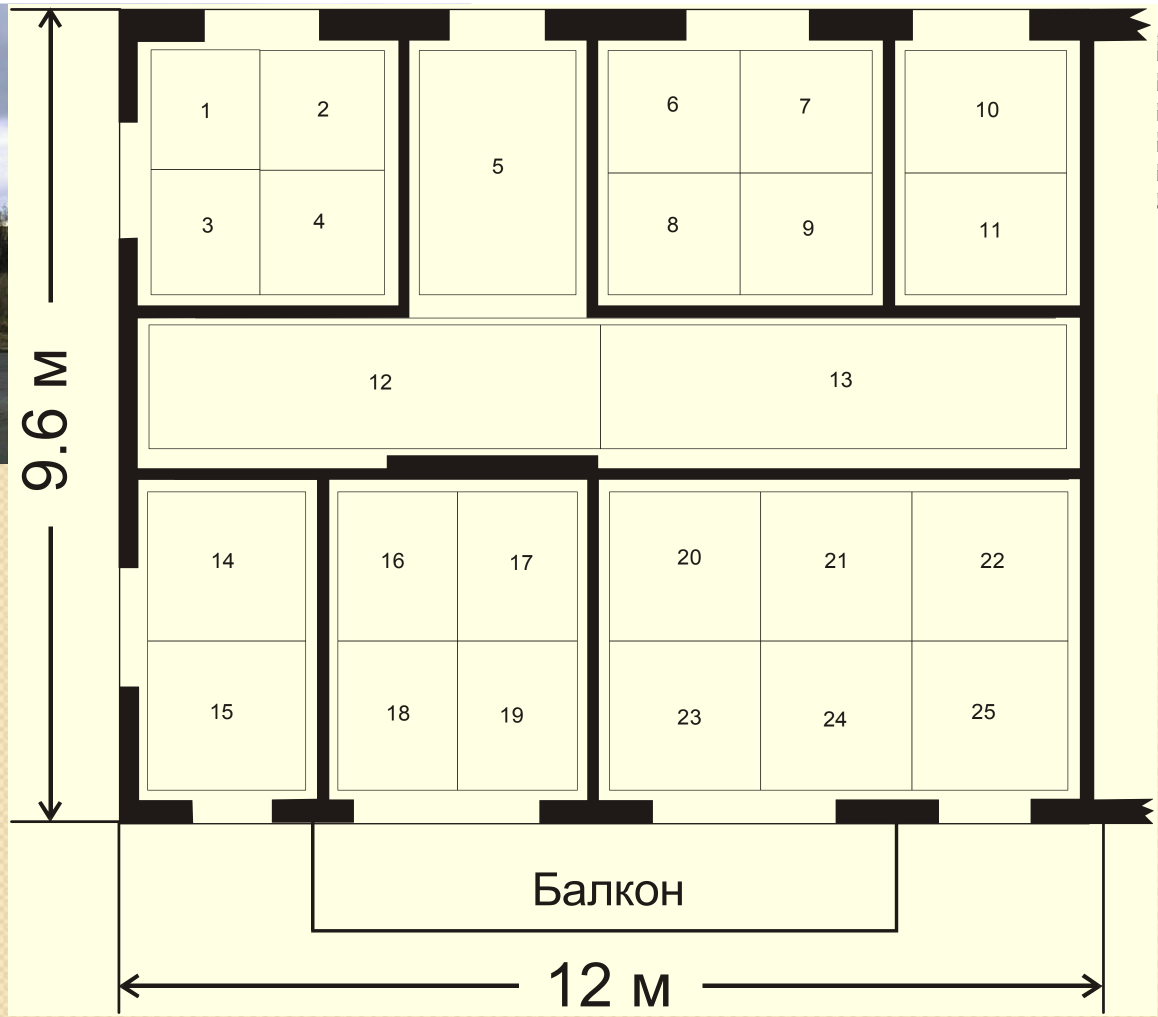
Monte Carlo simulation of photon transport in a house block

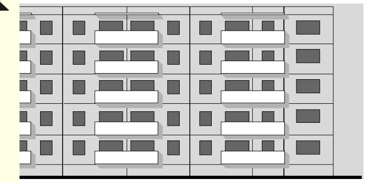


Monte Carlo simulation of photon transport in a house block

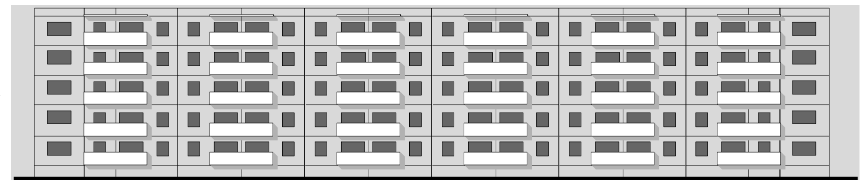


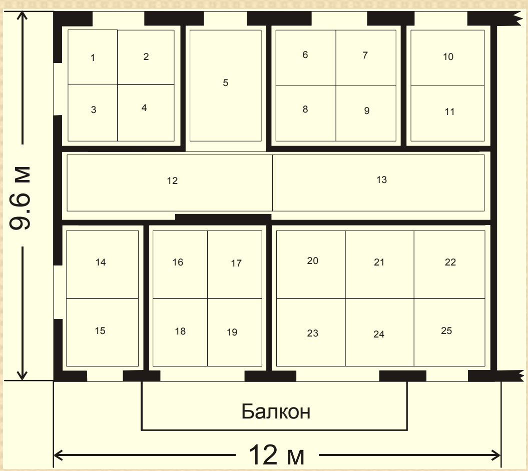
Monte Carlo simulation of photon transport in a house block



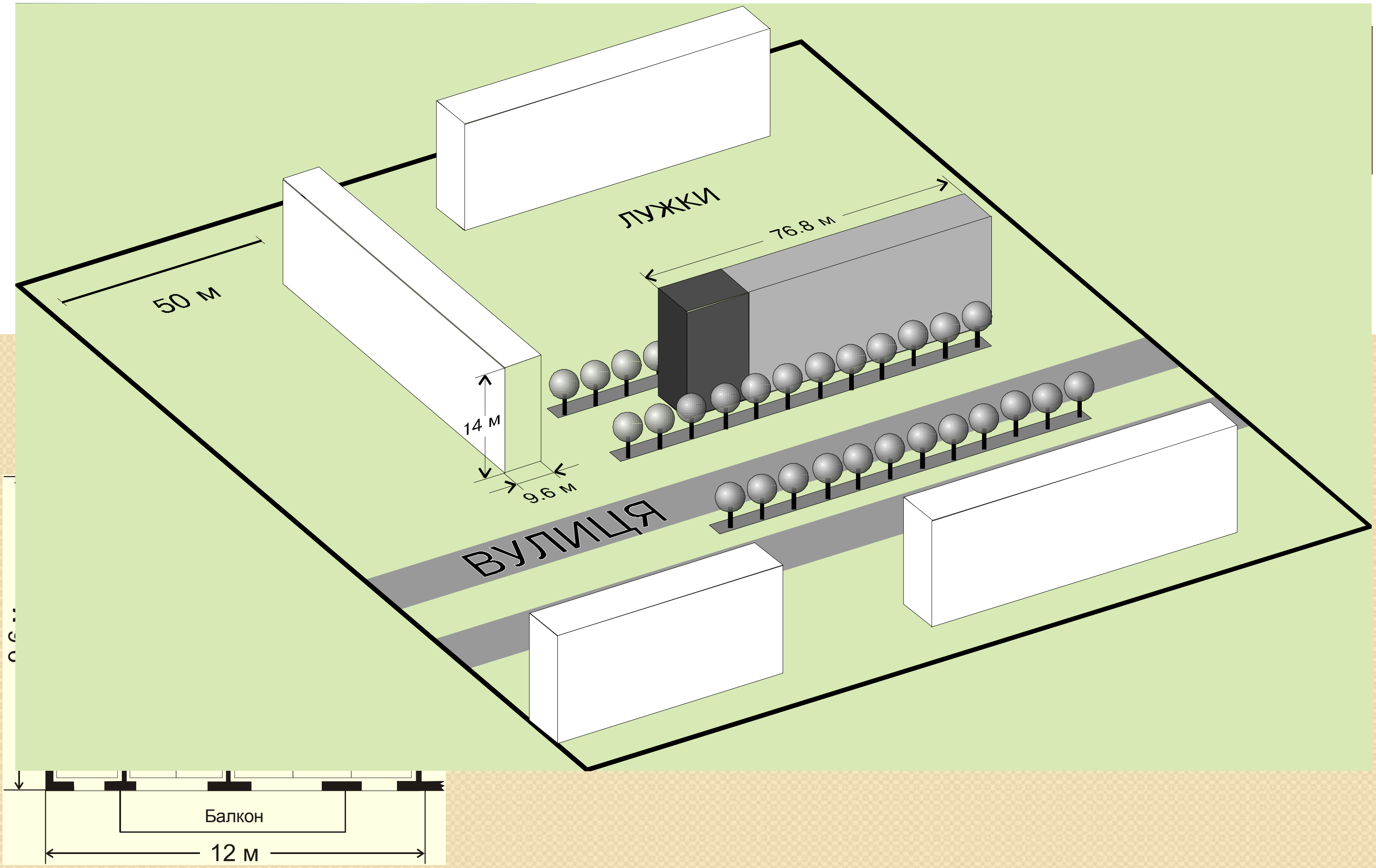


Monte Carlo simulation of photon transport in a house block

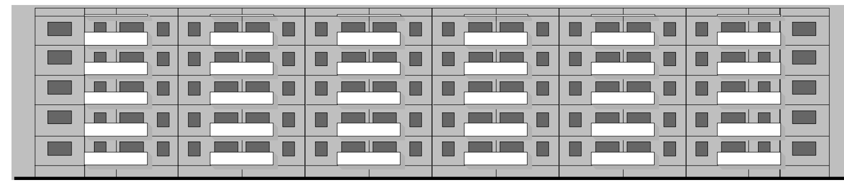


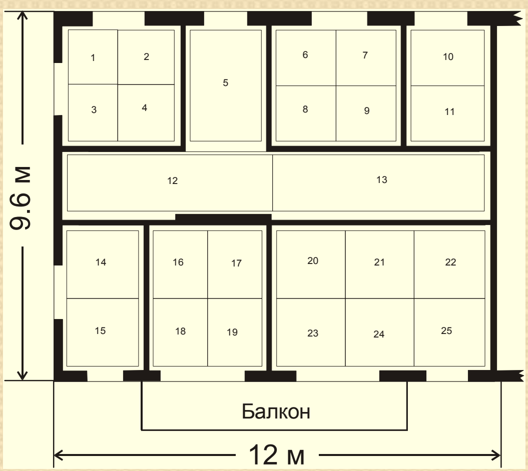


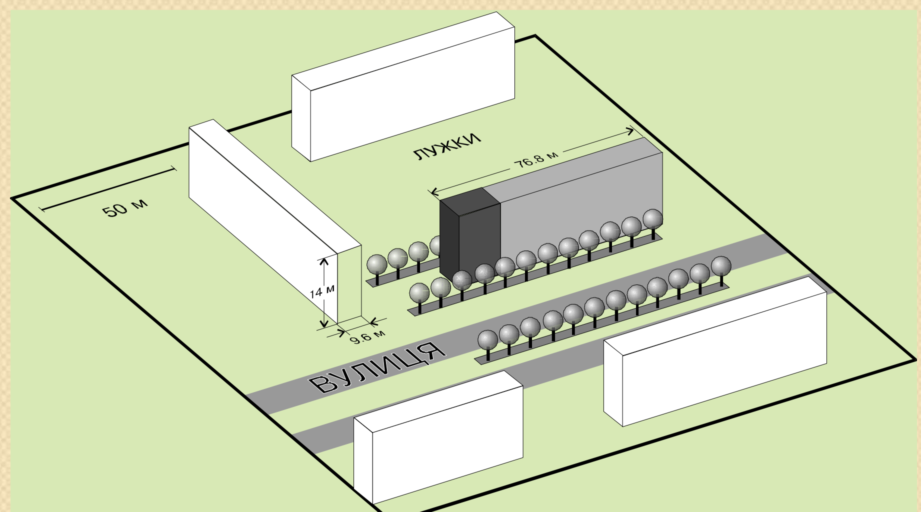
Monte Carlo simulation of photon transport in a house block



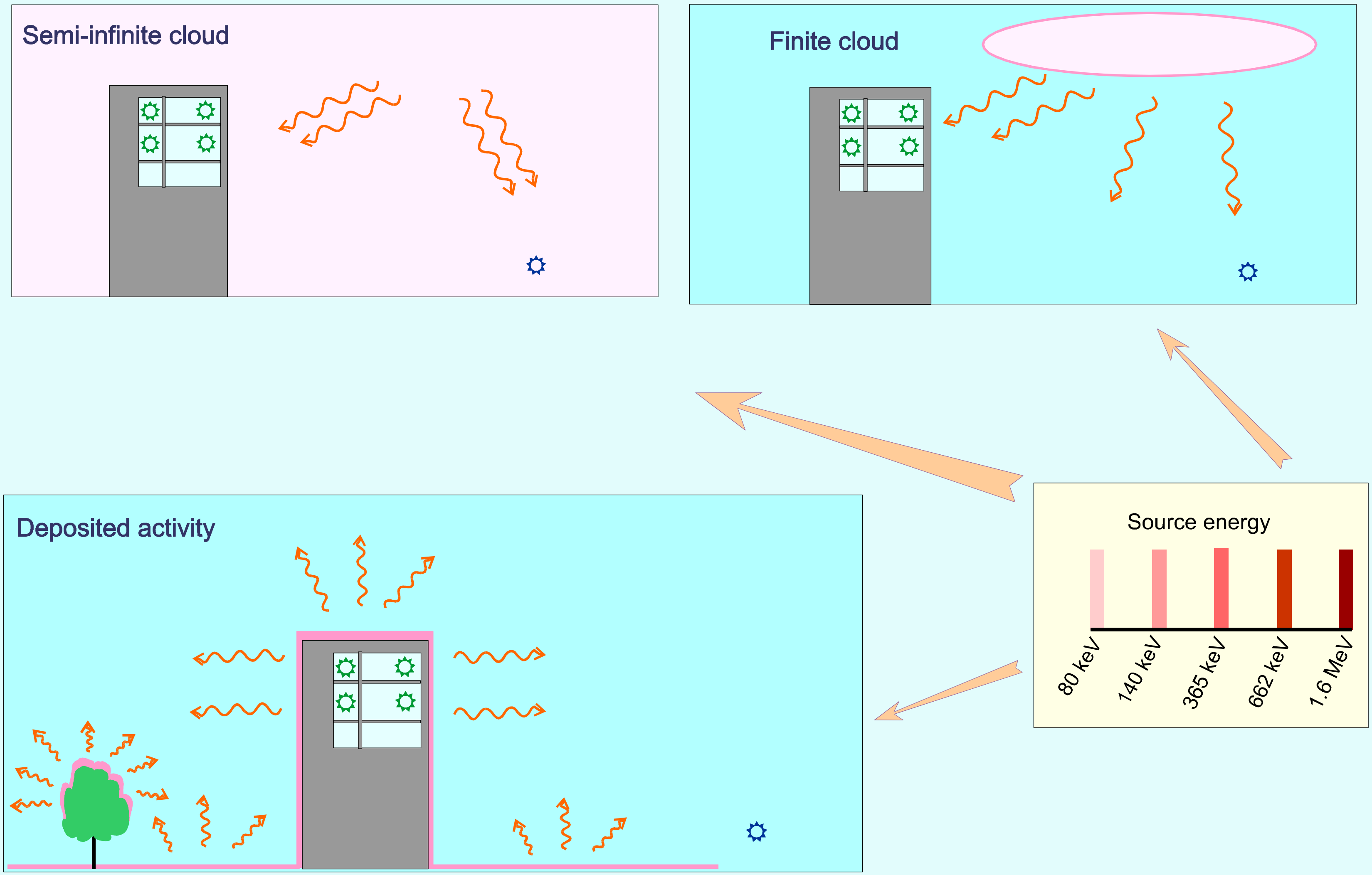
Monte Carlo simulation of photon transport in a house block



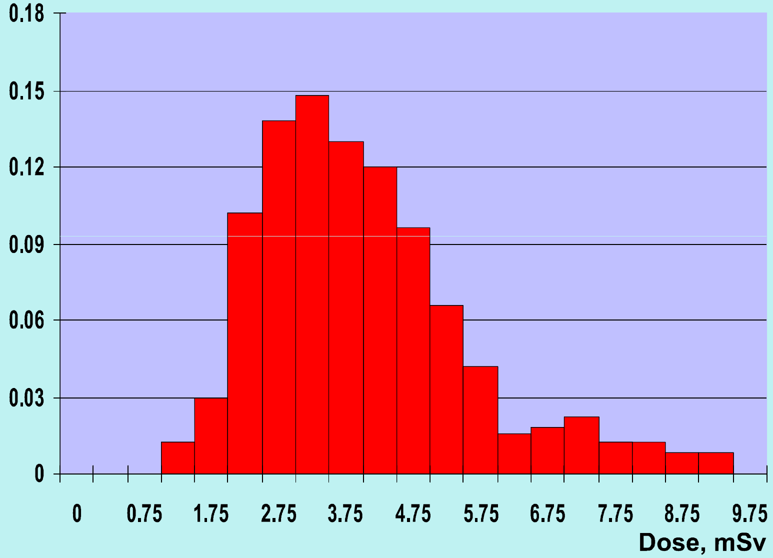




CONFIGURATIONS SIMULATED IN MONTE CARLO PHOTON TRANSPORT CALCULATIONS



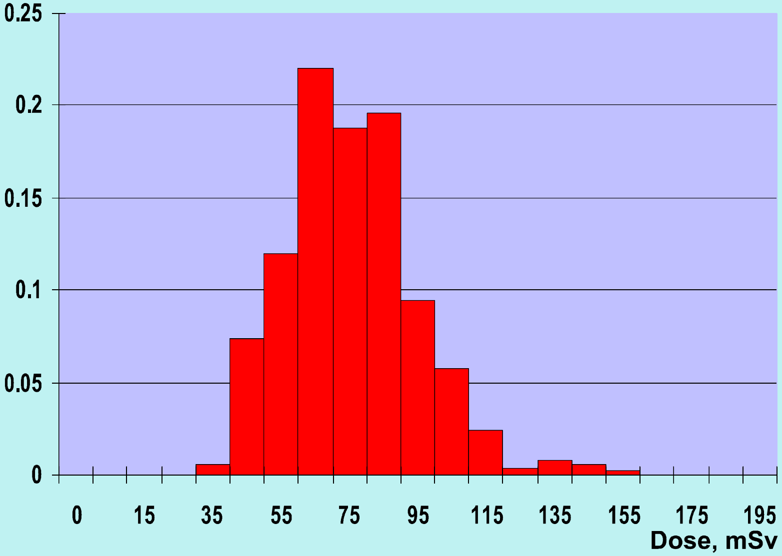
DOSE DISTRIBUTIONS FOR TWO INDIVIDUALS FROM PRIPJAT
(horisontal scale is different)



Iindividual N 555

A child was born 1980, lived in sector 1, evacuated after 36 hours, was only for one hour outdoors

Median: 3.8 mSv, 95 percenticle: 7.9 mSv



Individual N 15219

A male worker, born 1955, lived in sector 4, evacuated after 44 hours, worked outdoors in sector 7.

Median: 75 mSv, 95 percentile: 107 mSv.

Dosimetry of evacuees: summary

Individual doses were estimated to:

- 16,193 residents of Pripjat (33% of pre-accidental population)
  - Mean dose – 10 mSv
  - 95-percentile – 24 mSv
- 19,605 residents of other settlements of the 30-km zone (49% of pre-accidental population)
  - Mean dose – 16 mSv
  - 95-percentile – 68 mSv

Meckbach and Chumak, EU Chernobyl conference, Minsk, 1996, unpublished data

Methodological inlay 1:

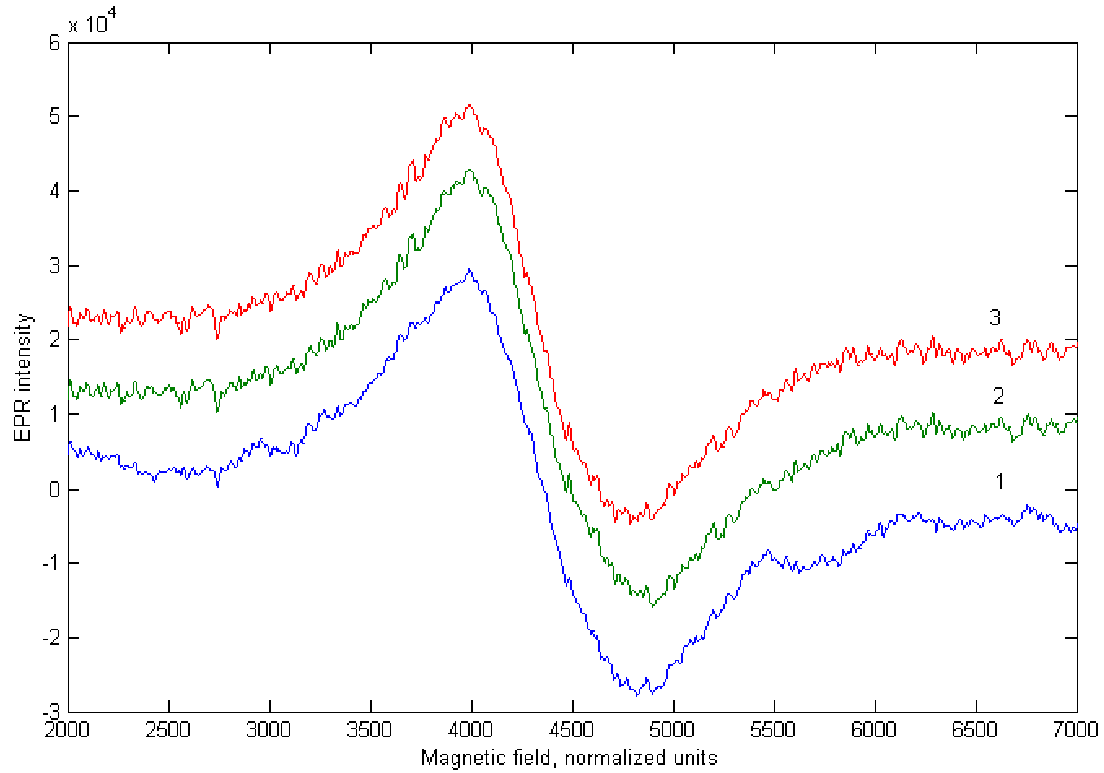
EPR dosimetry with tooth enamel

Application of EPR dosimetry with teeth as a “gold standard”

- Validation of other dose assessment methods
- Verification of existing dose estimates
- Routine individual dose reconstruction

Typical useful dose range: < 300 mGy

Example of decomposition of the spectrum of non-irradiated sample

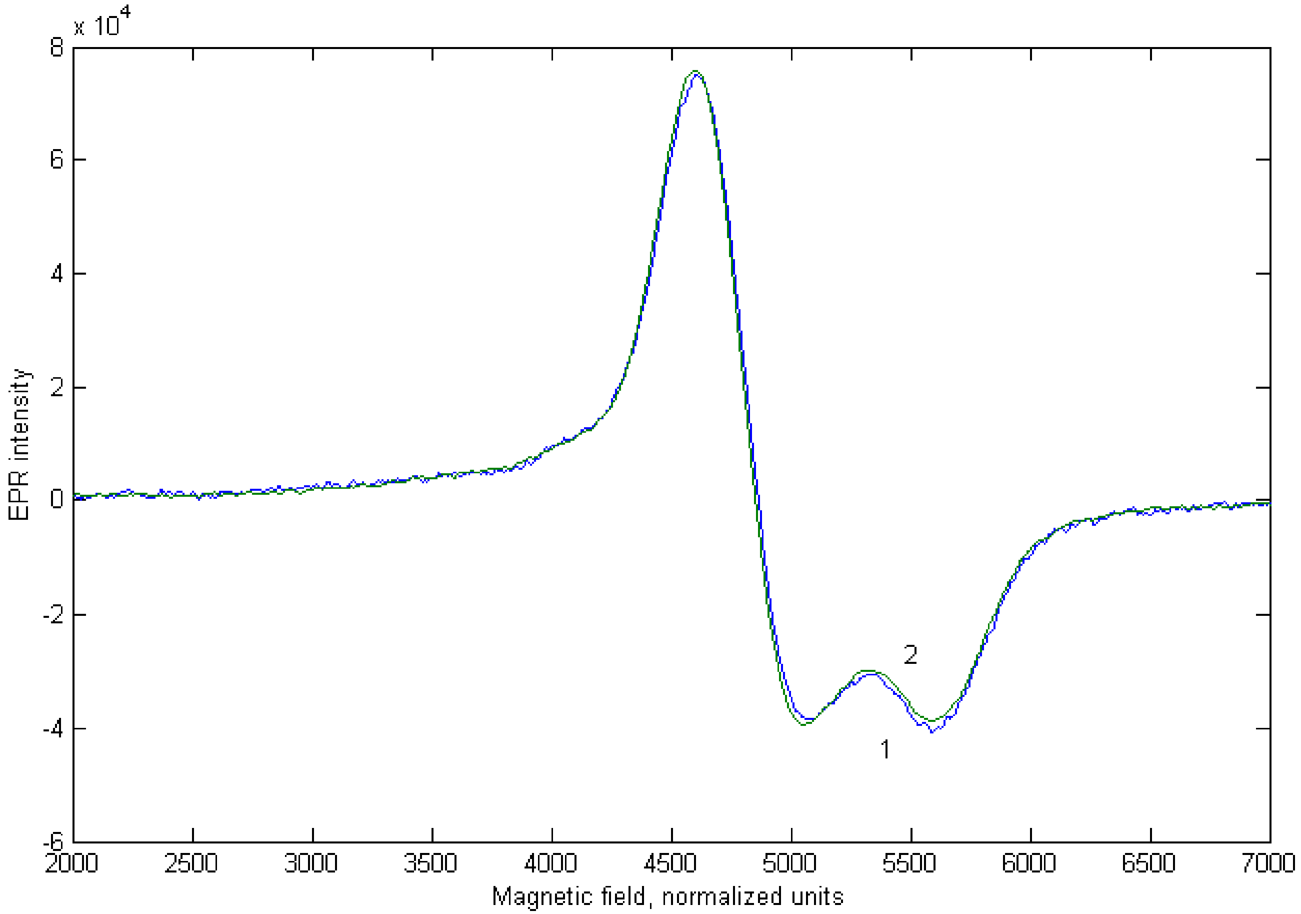


1 - original spectrum

2 - spectrum 1 minus empty tube spectrum

3 - spectrum 1 minus empty tube spectrum minus dosimetric signal

The shape of dosimetric signal



1 – high dose spectrum after subtraction of native signal and empty tube spectrum

2 – standard of dosimetric signal

Metrological parameters of SCRM High Precision Technique

Sensitivity threshold – 50 mGy

Simplified error propagation model:

- ± 25 mGy for dose ≤250 mGy
- ± 10% for dose >250 mGy

Chumak et al, Radiat Meas, 2005

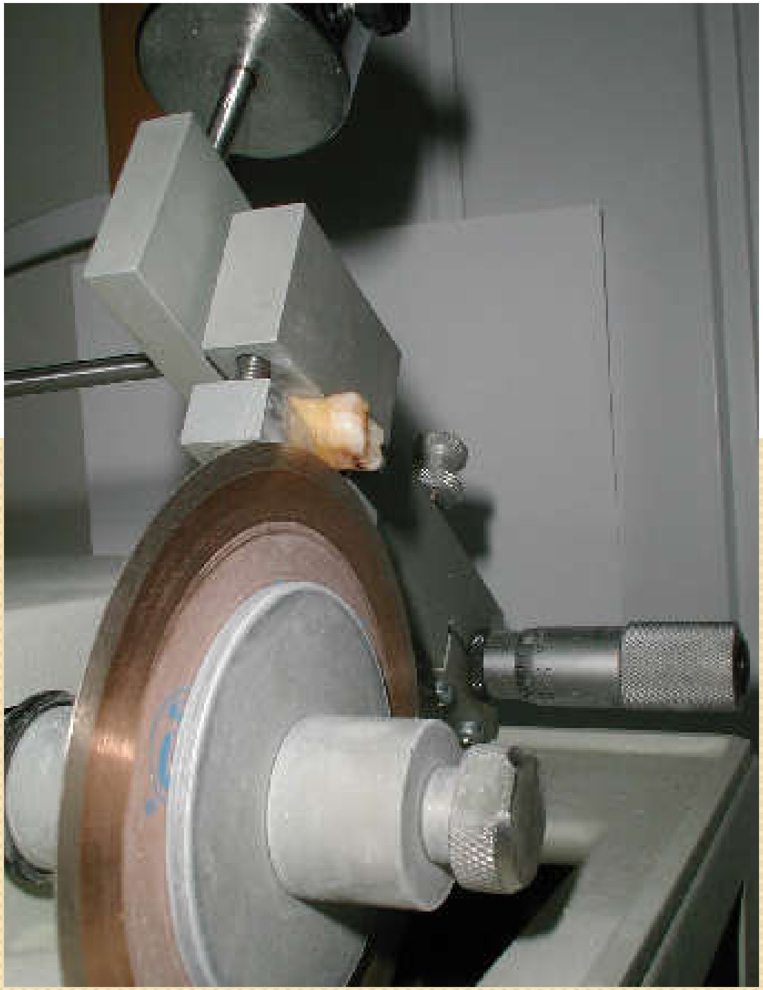
Main contributors into the cumulative dose

Cumulative dose, measured by EPR includes several components:

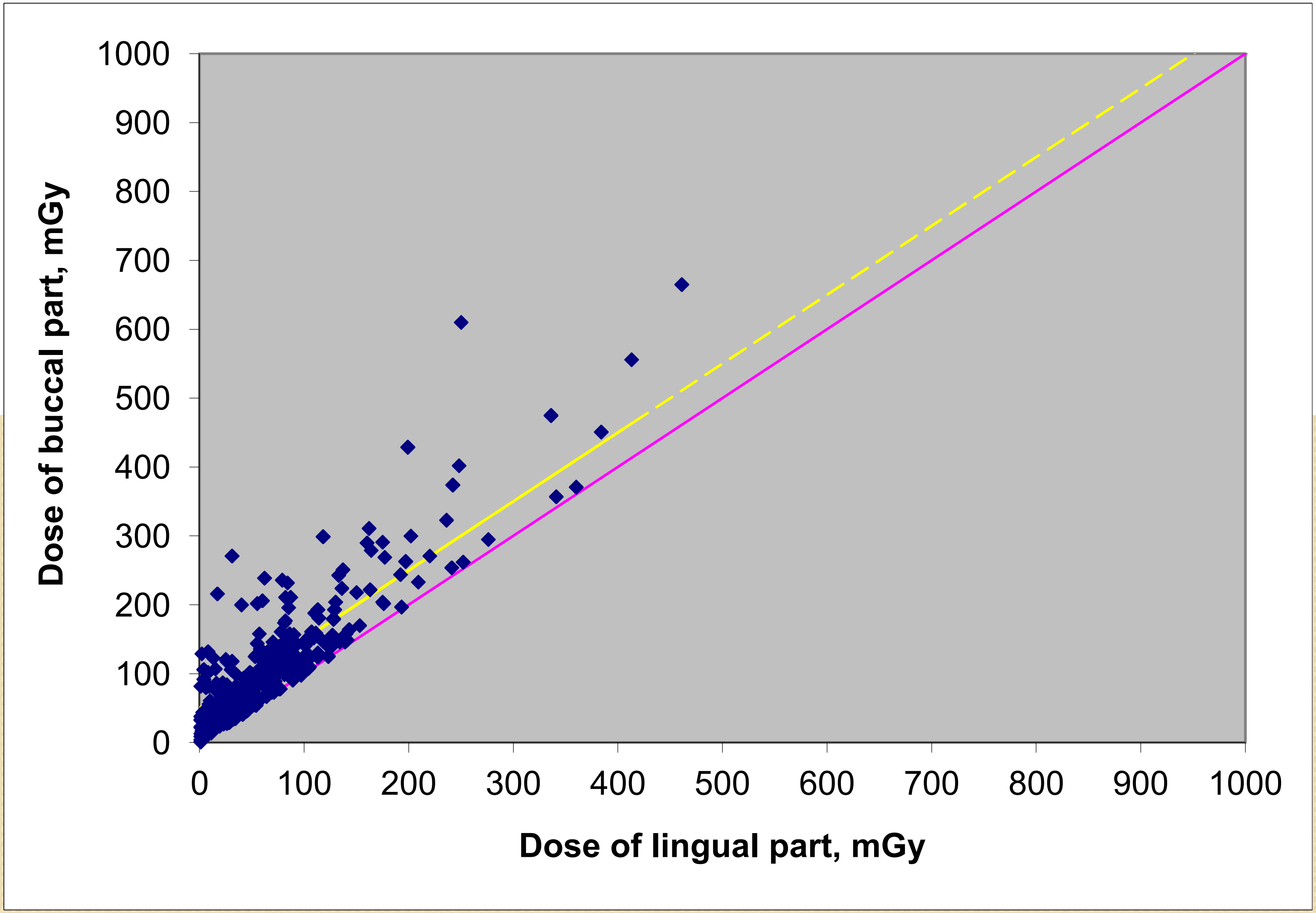
$$D_{EPR} = D_{acc} + D_{BG} + D_{UV} + D_{dent} + D_{med} + D_{occup}$$

each component can act as confounding factor!

Cutting tooth into lingual and buccal parts



Buccal vs. lingual doses



Samples for analysis: results of tooth collection effort

- Teeth are being collected in 167 hospitals by 314 dentists
- 10,521 teeth were collected over the period of operation (as per August 1, 2011)
- 5,875 liquidators had donated teeth
- 5,511 teeth are appropriate for high precision EPR dosimetry
- 805 doses were reconstructed including 638 with HPT

Reference inlay 1:
Cohort of Chernobyl clean-up workers

Chernobyl clean-up workers (liquidators):

- Total number (Ukraine):
  - > 300,000
  - ca. 200,000 included into the State Registry of Ukraine (SRU)
- Demographical structure:
  - Age at time of clean-up – 20-40 years
  - Healthy at time of exposure
  - Predominantly (95%) - male
- Dose level – moderate
- Mode of exposure – protracted (several hours to several years)
- Epidemiological relevance - high

Total number of liquidators
(UNSCEAR, 2000)

Country and period	Number of clean-up workers	Percentage for whom dose is known
Belarus		
1986-1987	31 000	28
1986-1989	63 000	14
Russian Federation		
1986	69 000	51
1987	53 000	71
1988	20 500	83
1989	6 000	73
1986-1989	148 000	63
Ukraine		
1986	98 000	41
1987	43 000	72
1988	18 000	79
1989	11 000	86
1986-1989	170 000	56

Liquidators are extremely heterogeneous cohort:

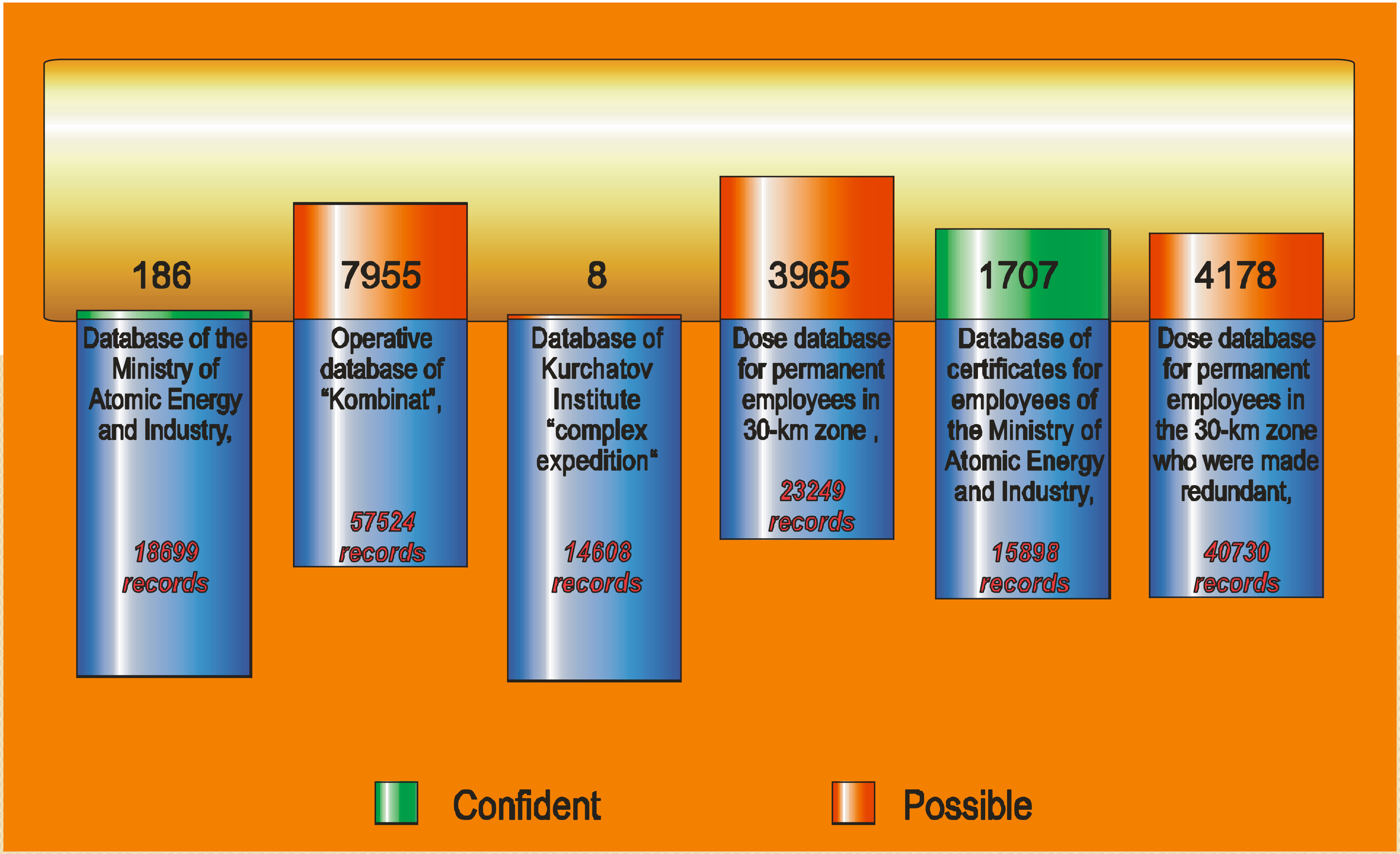
- Duration of work – from hours to years.
- Locations of work – ruins of the reactor 4 to remote places at the border of the 30-km zone
- Tasks – from manual removal of reactor debris to support activities (cooks, secretaries etc).
- Doses – from a fraction of mSv to lethal.
- Radiation safety and dosimetric monitoring – from perfect organization to complete absence

Status of dosimetry for liquidators:

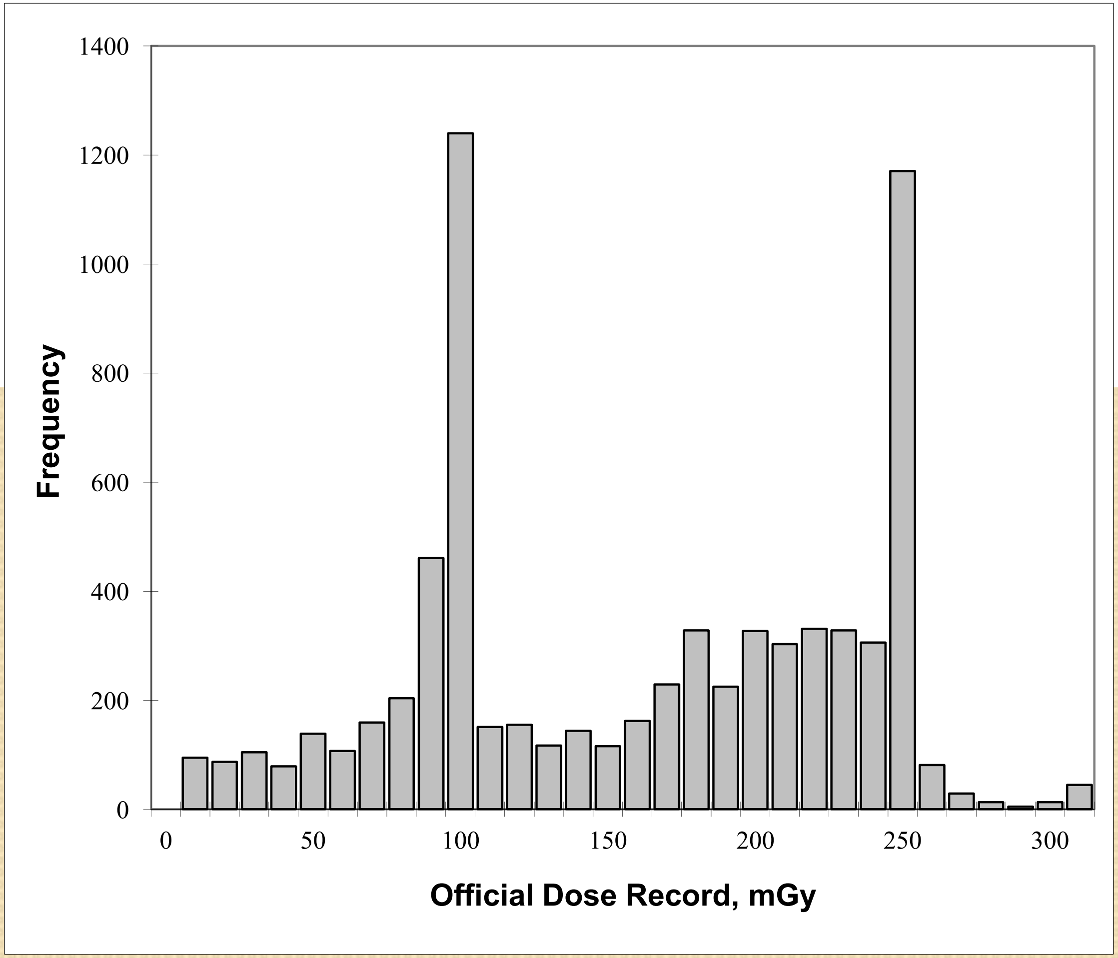
- Doses were determined and recorded only to a fraction of liquidators
- Doses to majority of liquidators were determined by inaccurate methods
- No beta doses measured
- There are concerns regarding possible falsification of dosimetric data

Conclusion: There is a need for retrospective dose reconstruction and verification of existing dose records

Results of IDM linkage with SRU

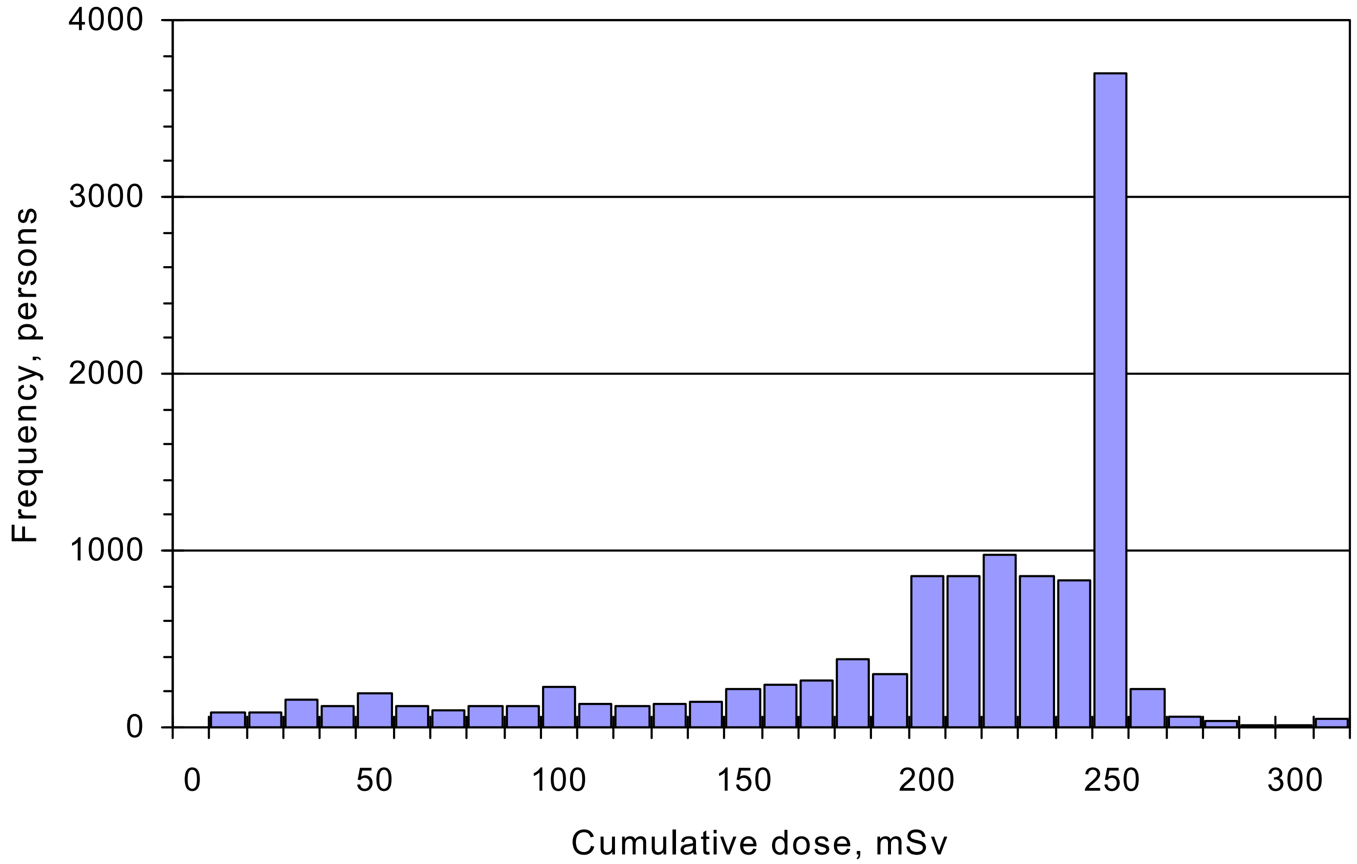


Distribution of Official Dose Records



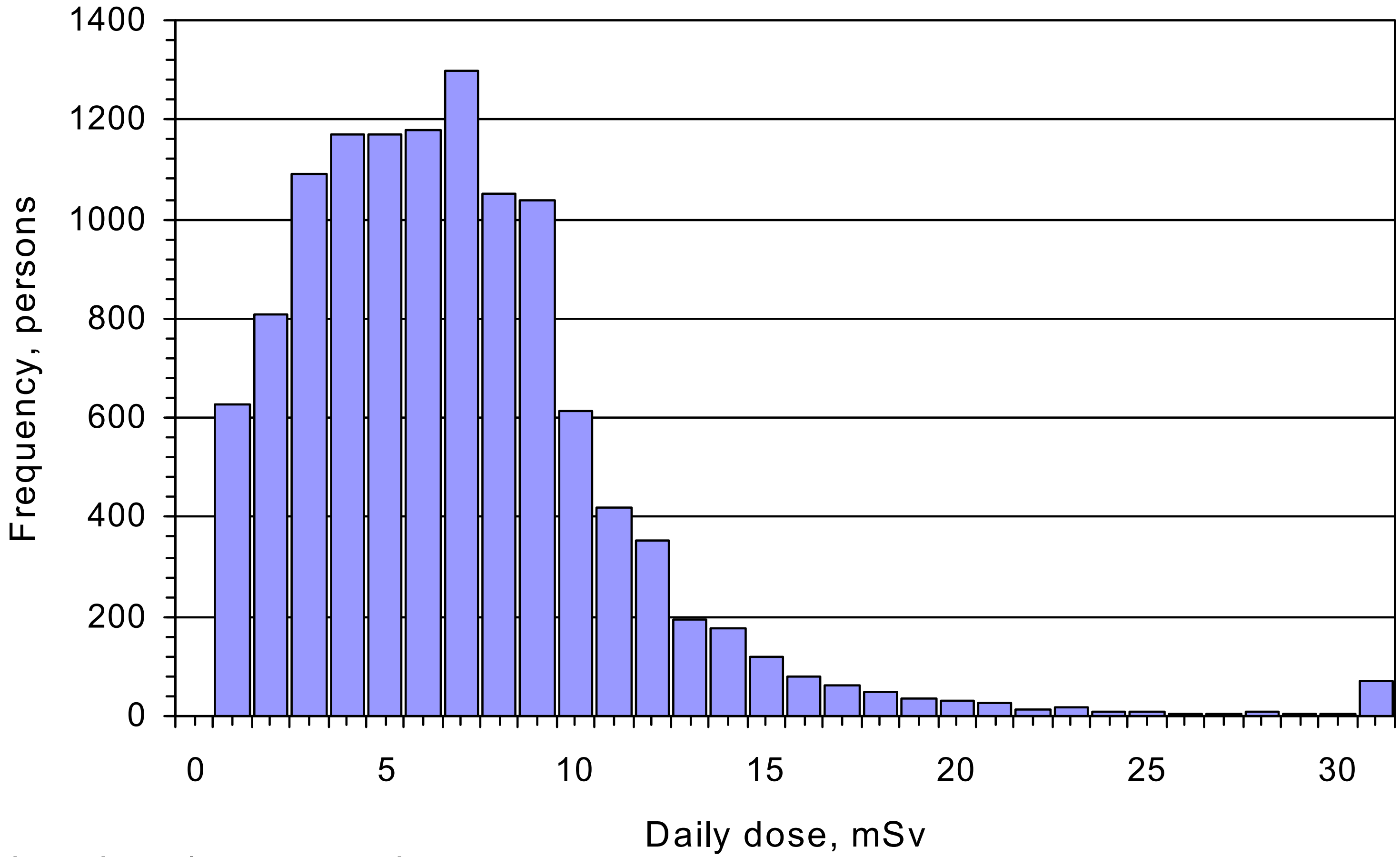
Chumak et al, IRPA, Hiroshima, 2000

Frequency histogram of doses of military liquidators (“partisans”) of 1986



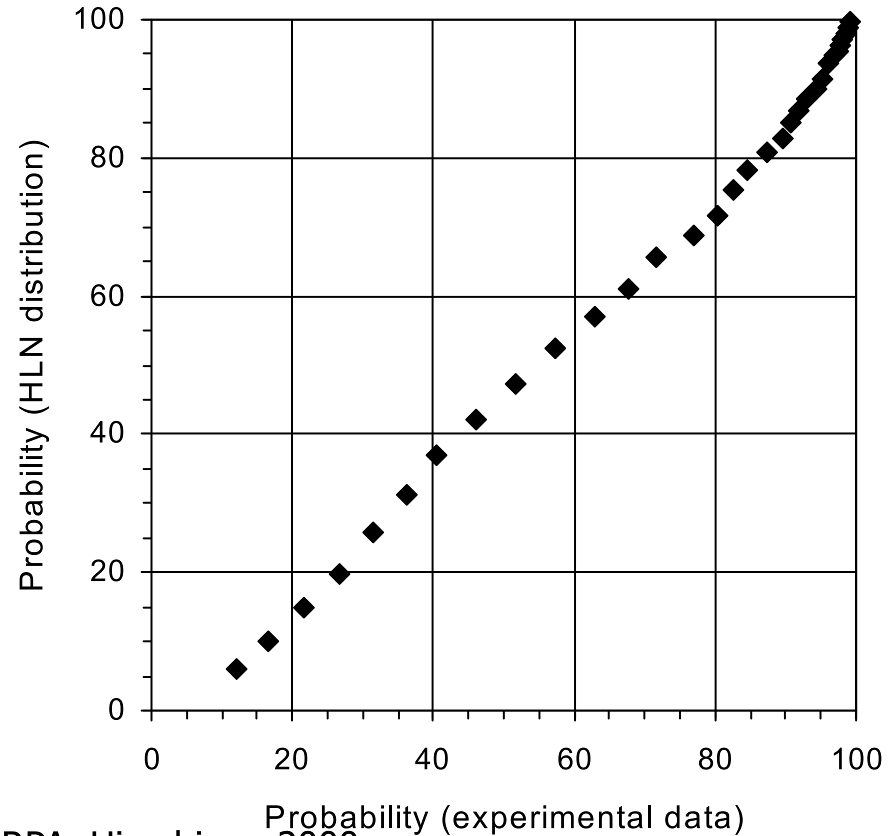
Chumak et al, IRPA, Hiroshima, 2000

Frequency histogram of individual daily doses of military liquidators of 1986



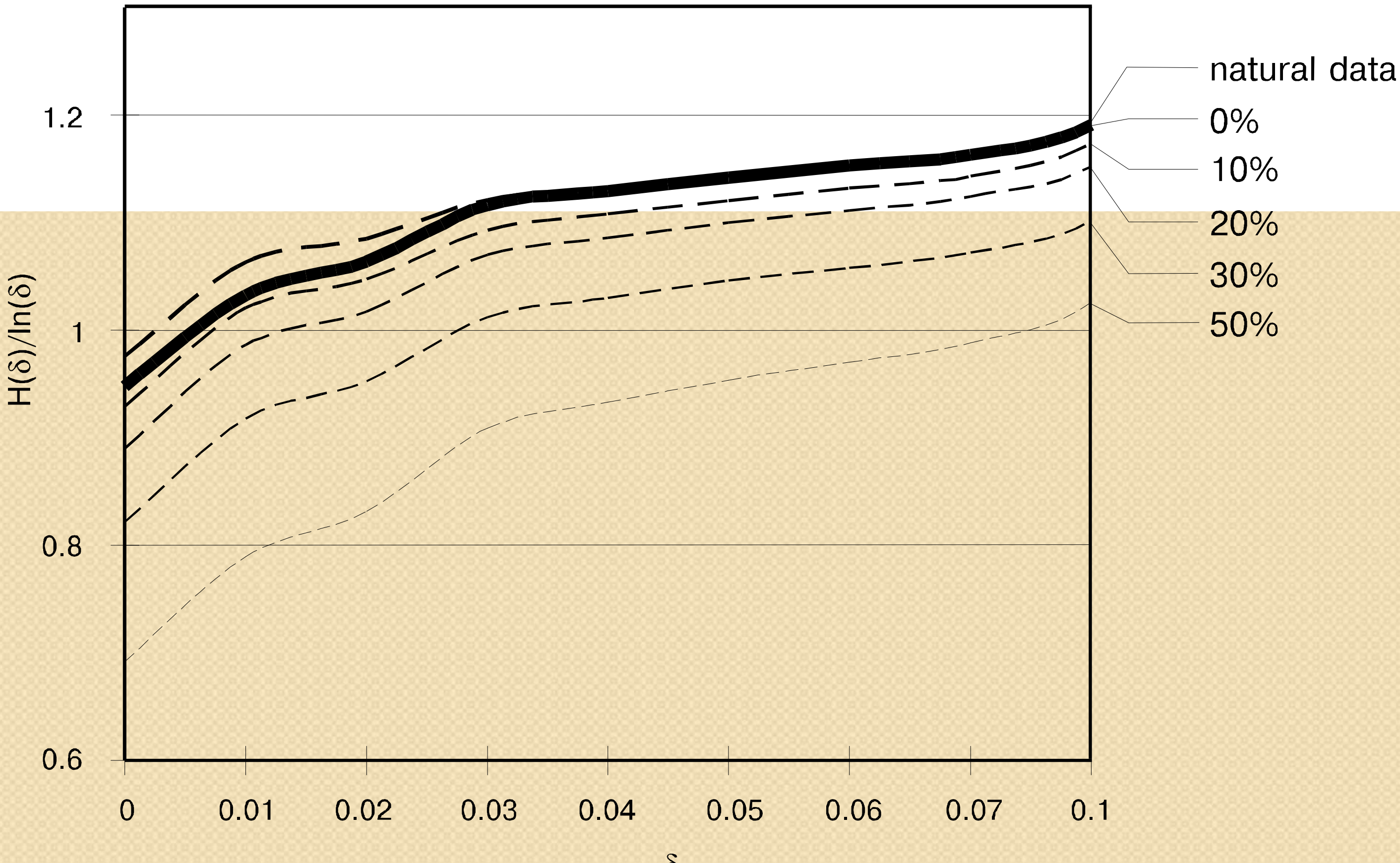
Chumak et al, IRPA, Hiroshima, 2000

Normalized probability plot for distribution of daily doses of military liquidators ("partisans") of 1986 (HLN hypothesis)



Chumak et al, IRPA, Hiroshima, 2000

Experimental dependence of entropy coefficient on increment of histogram δ (solid line) and modeled calibration dependencies



Chumak et al, IRPA, Hiroshima, 2000

Workhorse methods of retrospective dosimetry of liquidators

- EPR dosimetry with tooth enamel
- RADRUE/Rockville
- Validation and correction of Official Dose Records
- Modeling of beta doses to lens

Application example 2:
Cohort study of cataract among Chernobyl liquidators - Ukrainian-American Chernobyl Ocular Study (UACOS)

UACOS

Study design:

- A cohort of 8,607 Ukrainian Chernobyl clean-up workers during 1986-87 was formed to study cataract formation following ionizing radiation exposure.
- Two rounds of standardized ophthalmic examination
- Study eligibility required the availability of sufficient exposure information to permit the reconstruction of doses to the lens of the eye.
- Eligible groups included:
  - civilian workers, such as those who built the "sarcophagus" over the reactor,
  - Chernobyl Nuclear Power Plant Workers
  - military reservists who were conscripted for clean-up work.

Worgul et al, Radiat Res, 2007

Estimation of eye lens doses

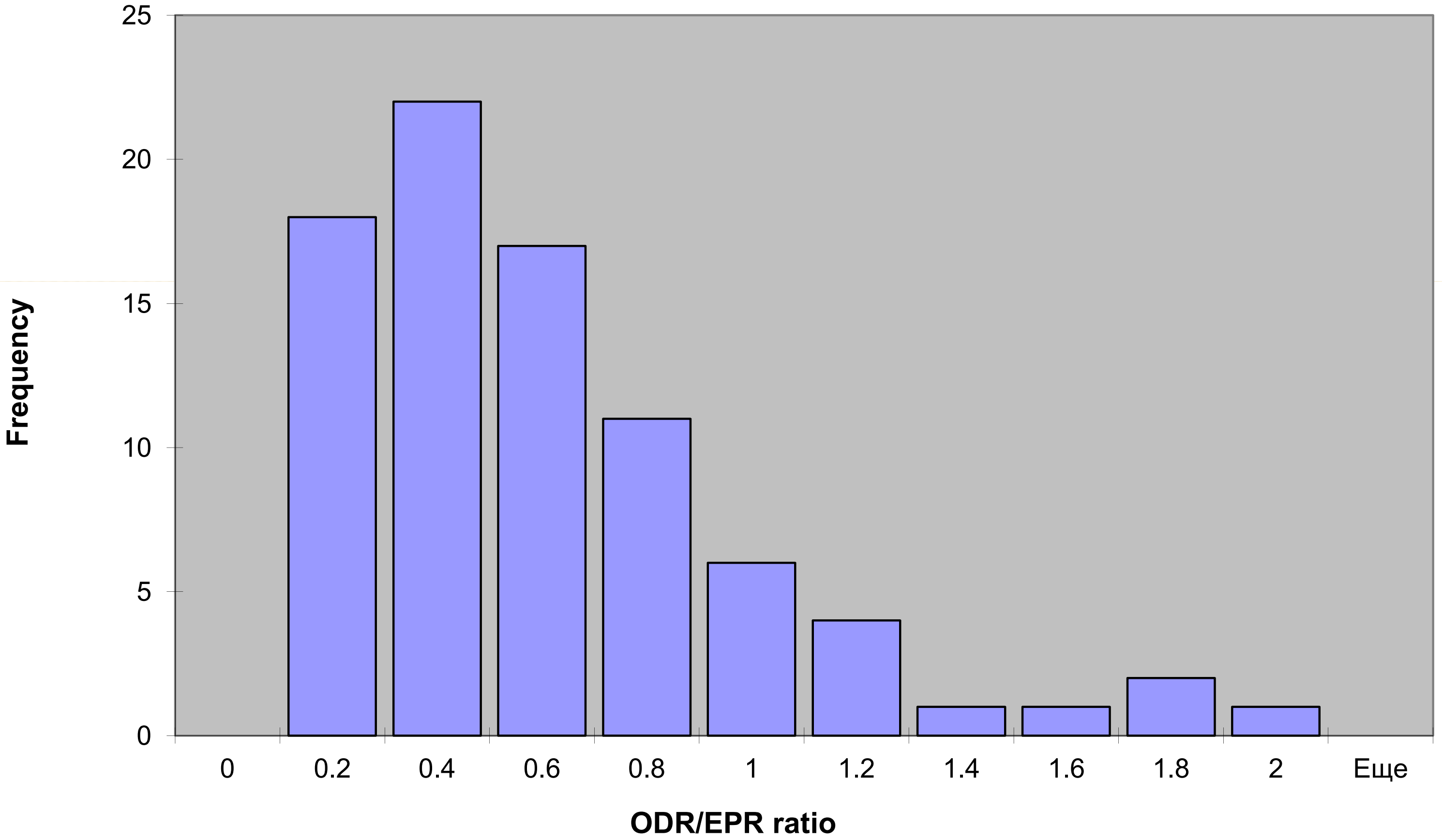
Starting point

- No direct lens measurements at time of clean-up
- External gamma doses from a number of sources, some are biased

Approach:

- Retrospective validation of historical gamma dose records
- Recalibration against single ‘gold standard’ - EPR
- Relation of eye lens beta dose to whole body gamma exposure
- Stochastic modeling

Calibration against EPR dosimetry: Distribution of ODR/EPR ratio



Retrospective assessment of bias and uncertainty of ODR (2002)

- 92 subjects with group assessment ODR (military liquidators of 1986-1987)
- EPR used as a reference (point dose estimate)
- Ratio ODR/EPR is considered as model uncertainty distribution
- Parameters of distribution
  (2003 data for 119 subjects):

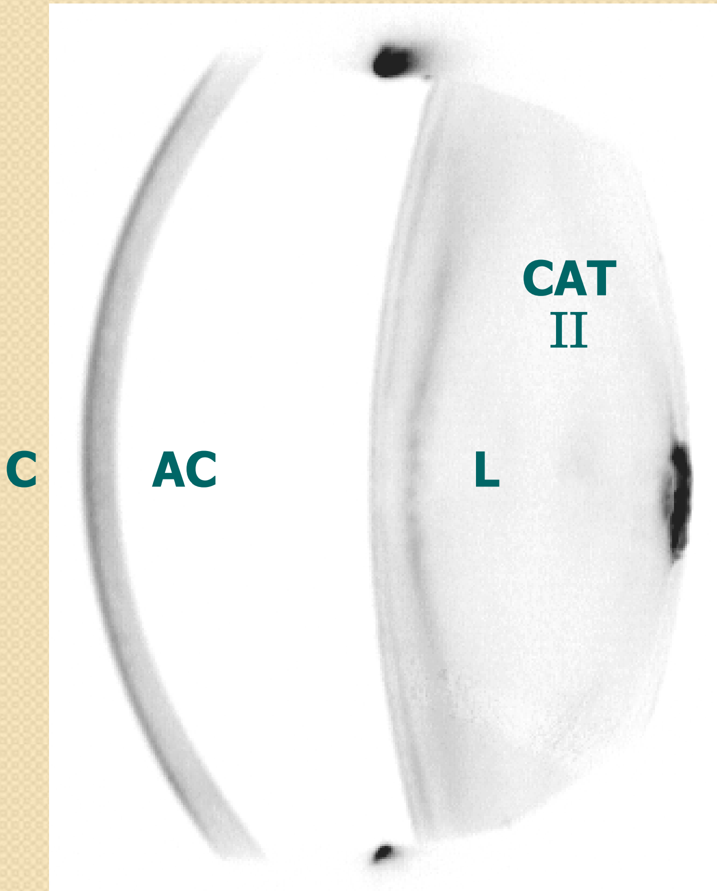
GM	–	0.39	(0.43)
GSD	–	2.14	(2.05)

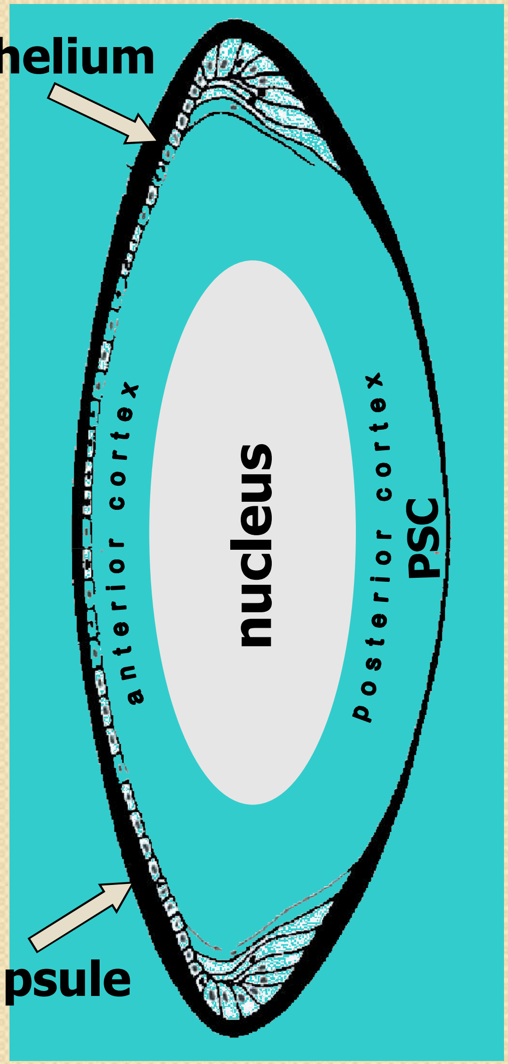
Assessment of beta doses

- Relation of lens beta dose to gamma dose
- Monte Carlo estimation of partial per unit source beta doses for various elementary sources of different roughness and with different energies of emitted electrons
- Individualization of beta doses through composing individual beta exposure profiles for the subjects of the study, which were acquired in course of survey.
- Individual account of modifying factors (protective gear, effect of windows, work environment)

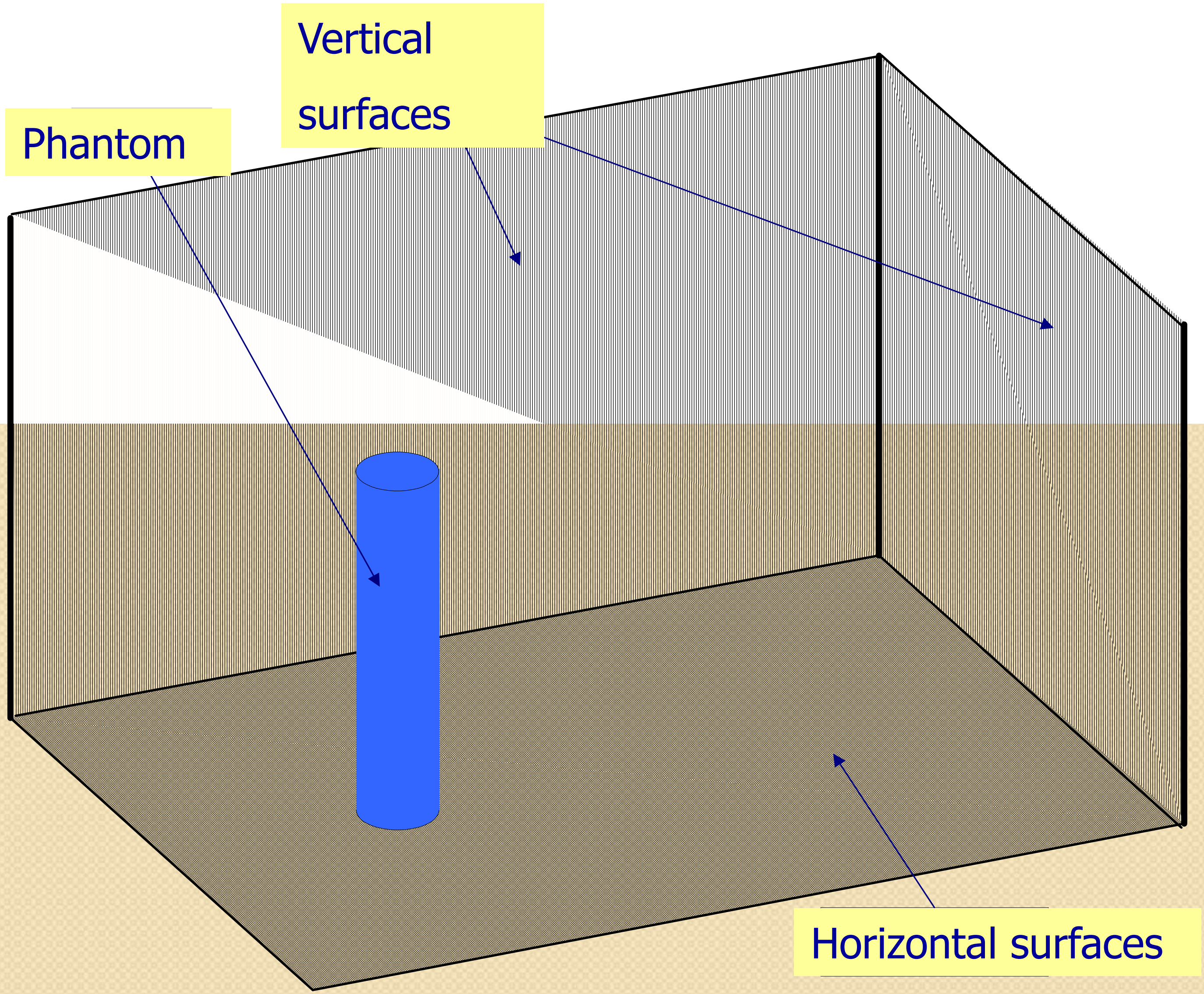
Chumak et al, Radiat Res, 2007

Eye anatomy and cataract

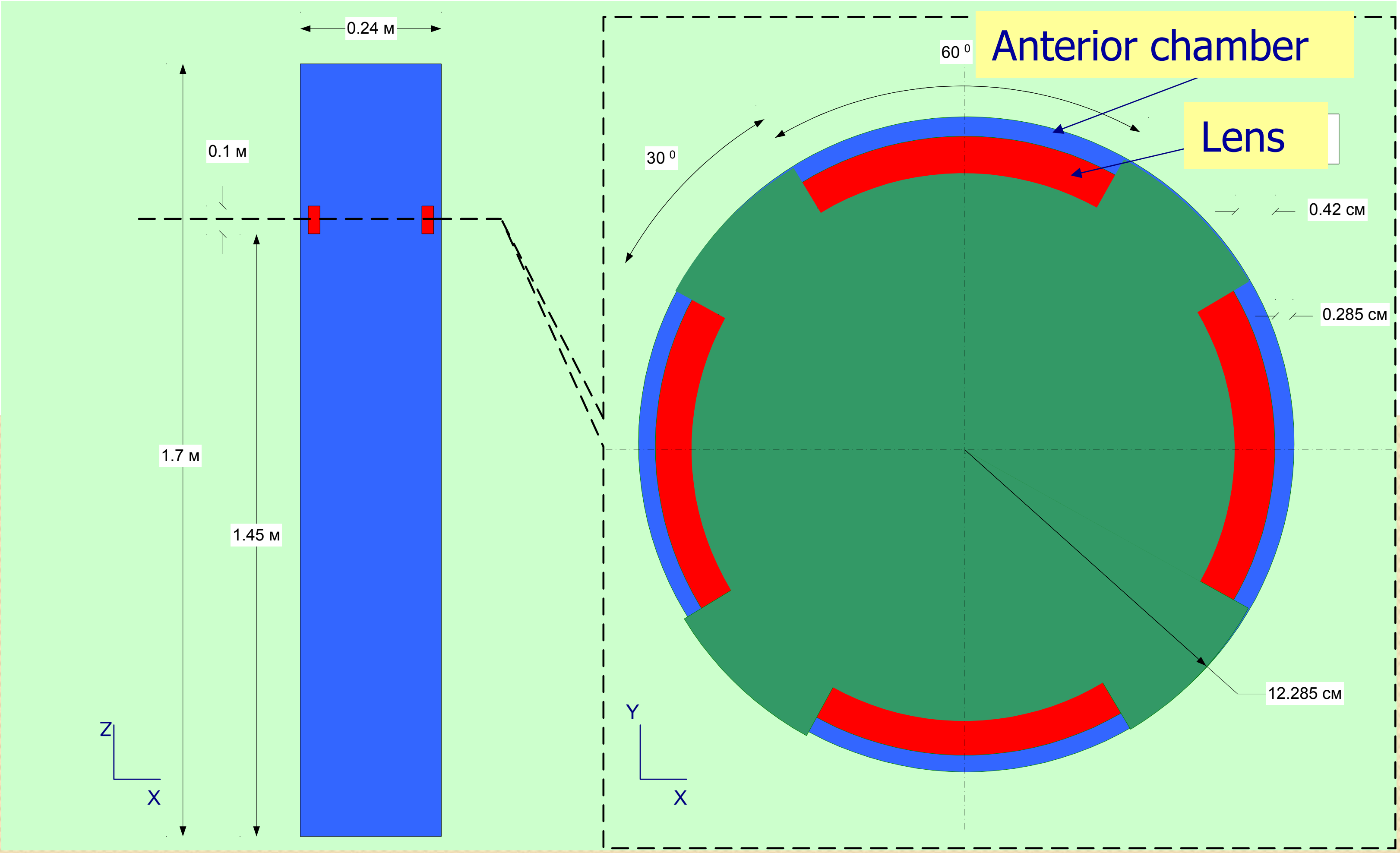




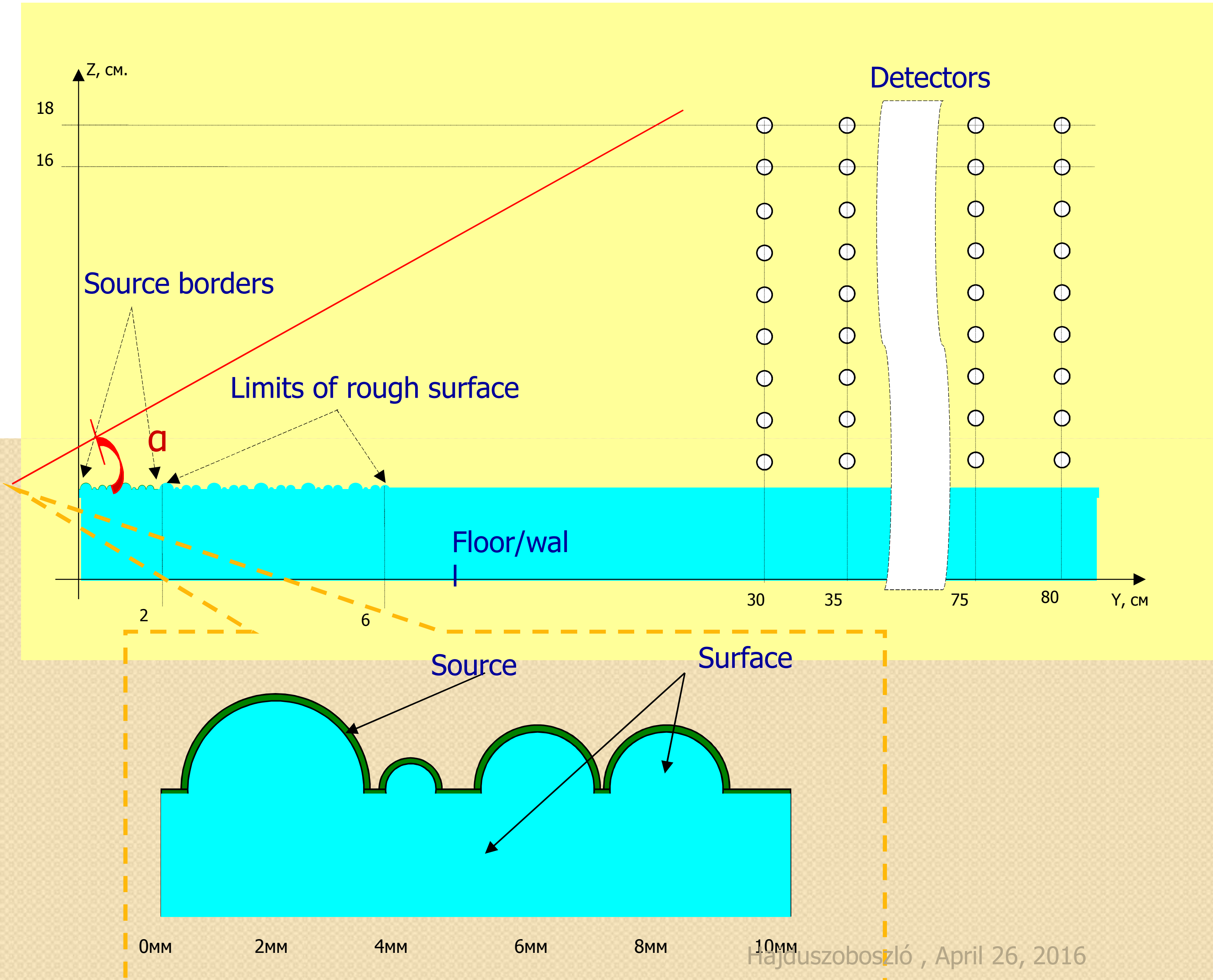
Beta doses: geometry



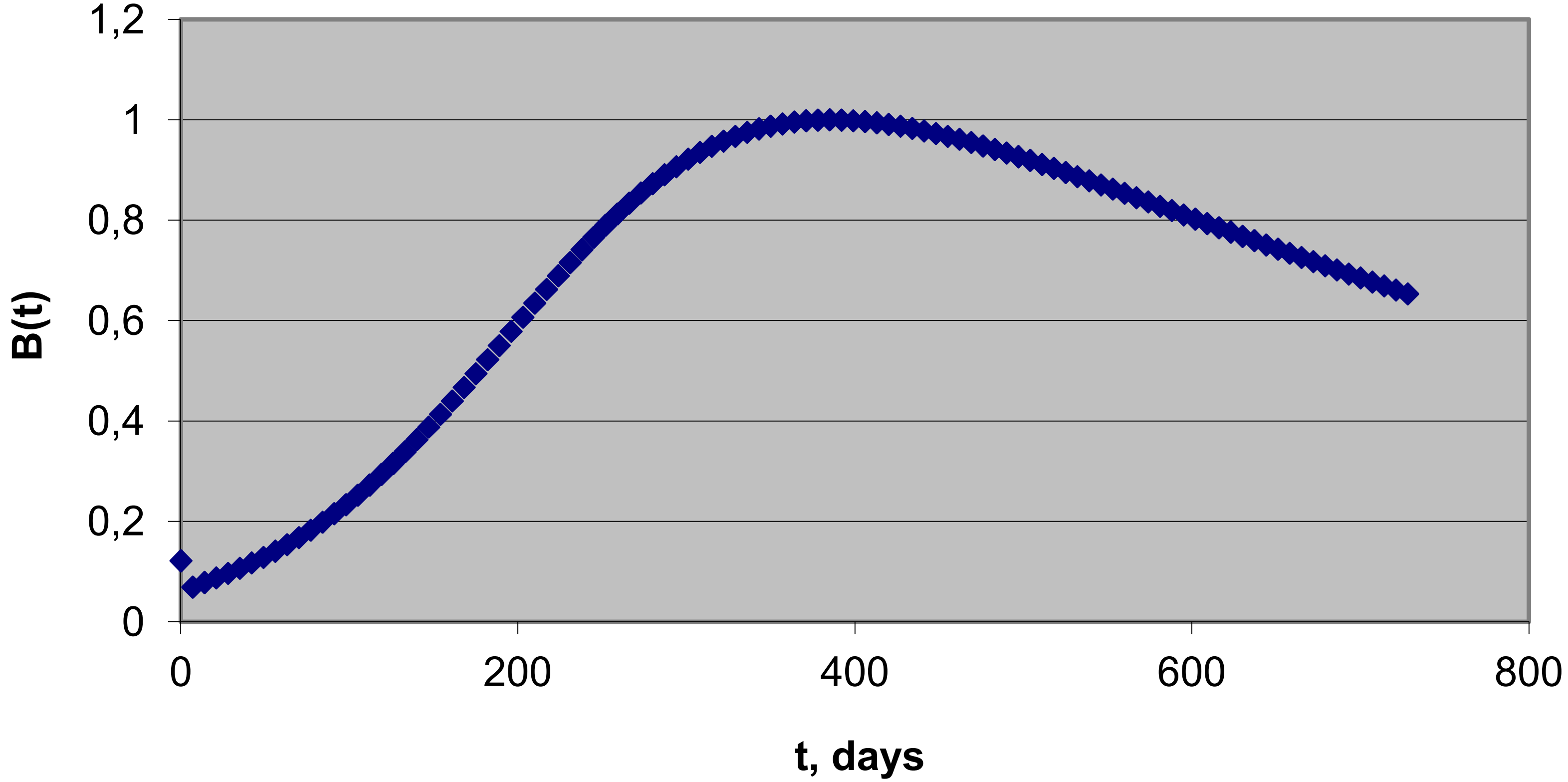
Beta doses: phantom



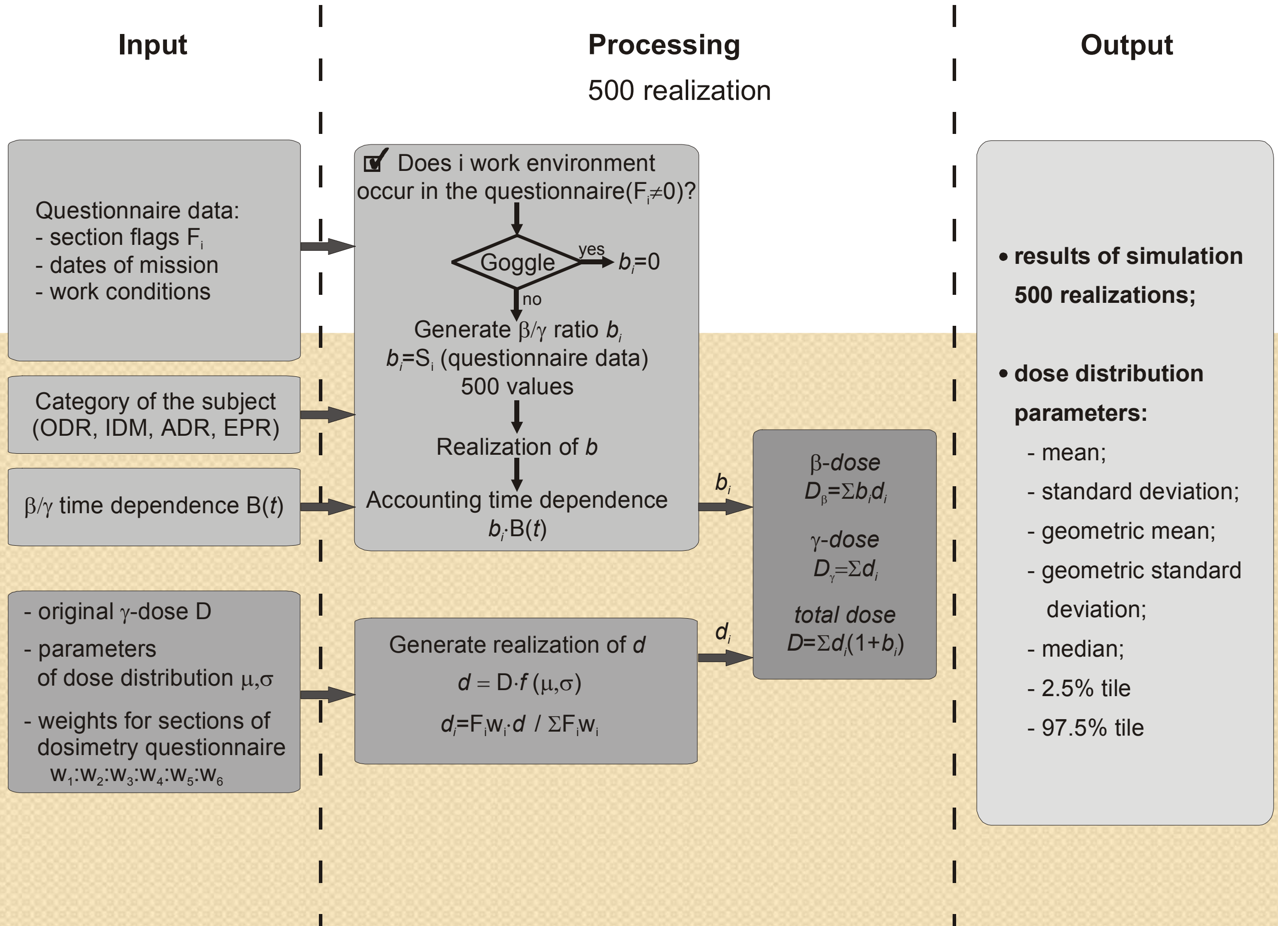
Effect of surface roughness at beta doses



Time dependence of beta/gamma ratio



Stochastic model for estimation of individual lens doses



Chumak et al, Radiat Res, 2007

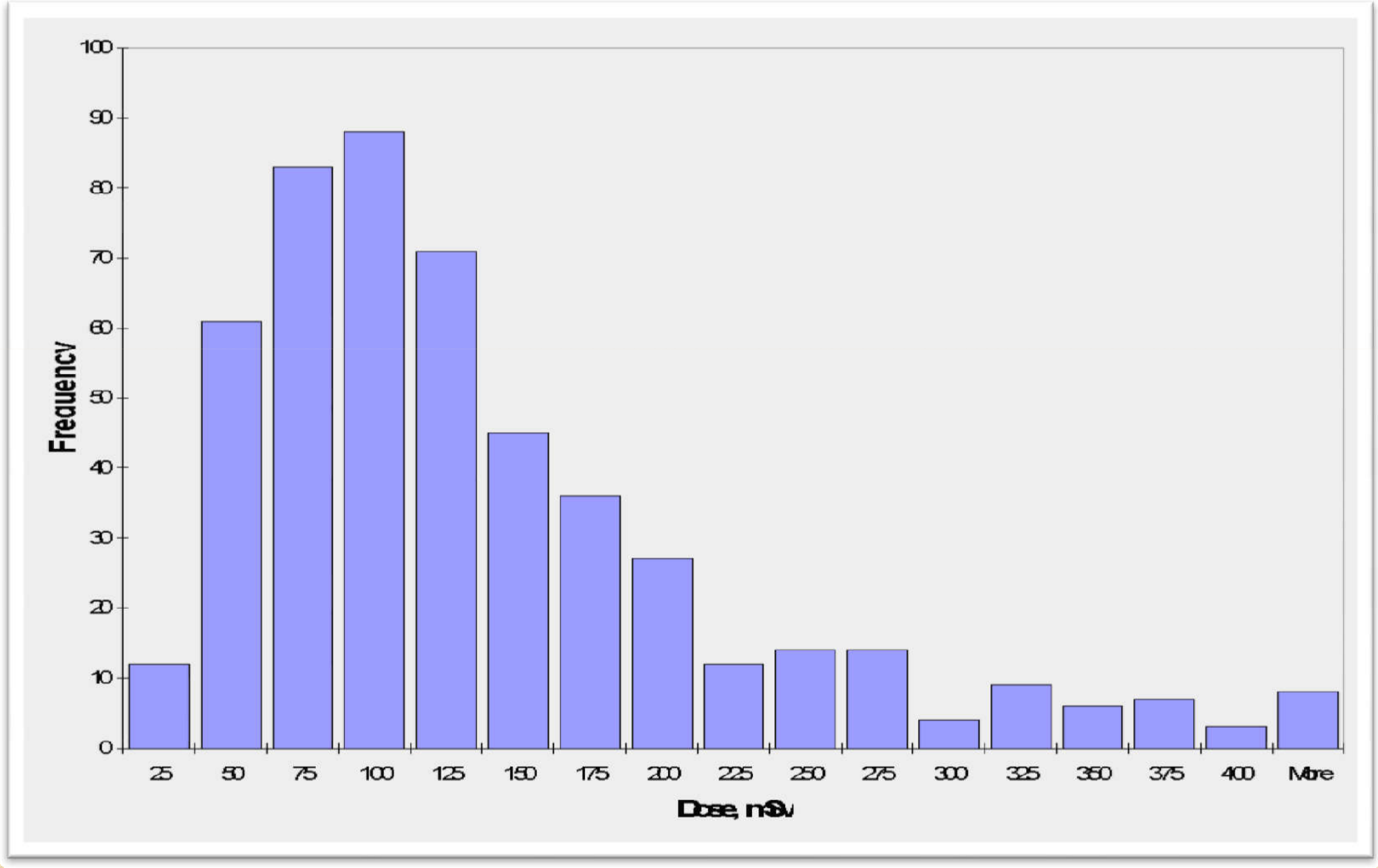
Parameters of uncertainty model

Data Source	Uncertainty Distribution	
	Type [a]	Parameters
Comprehensive dose monitoring	Lognormal	GM_C=1.0; GSD_C=1.4
ADR (ChNPP)	Combination of two lognormal distributions	(GM_C=1.0, GSD_C=2.0) x (GM_C= 0.71 $D^{-0.17}$, GSD_C=1.4)
ADR (SE "Radec")	Lognormal	GM_C=1.0; GSD_C=2.0
Military	Lognormal	GM_C=0.5, GSD_C=2.2
EPR (two halves of tooth – no dose from dental x-rays)	Normal	M=0; SD=25 mGyB
EPR (whole tooth – unknown x-ray dose)	Combination of normal and lognormal [b]	M=0; SD=25 mGy GM_C=34 mGy; GSD_C=3.2

Chumak et al, Radiat Res, 2007

Individual uncertainty distribution

Subject P01279. Male, 1955 year of birth, worked in Chernobyl from 1 June to 3 September 1986. Locations of work – variable but not including roof decontamination.
Distribution Parameters: mean – 128 mSv, SD – 96 mSv, GM – 101 mSv, GSD – 2.01, Median – 103 mSv, 2.5% percentile – 25 mSv, 97.5% percentile – 370 mSv

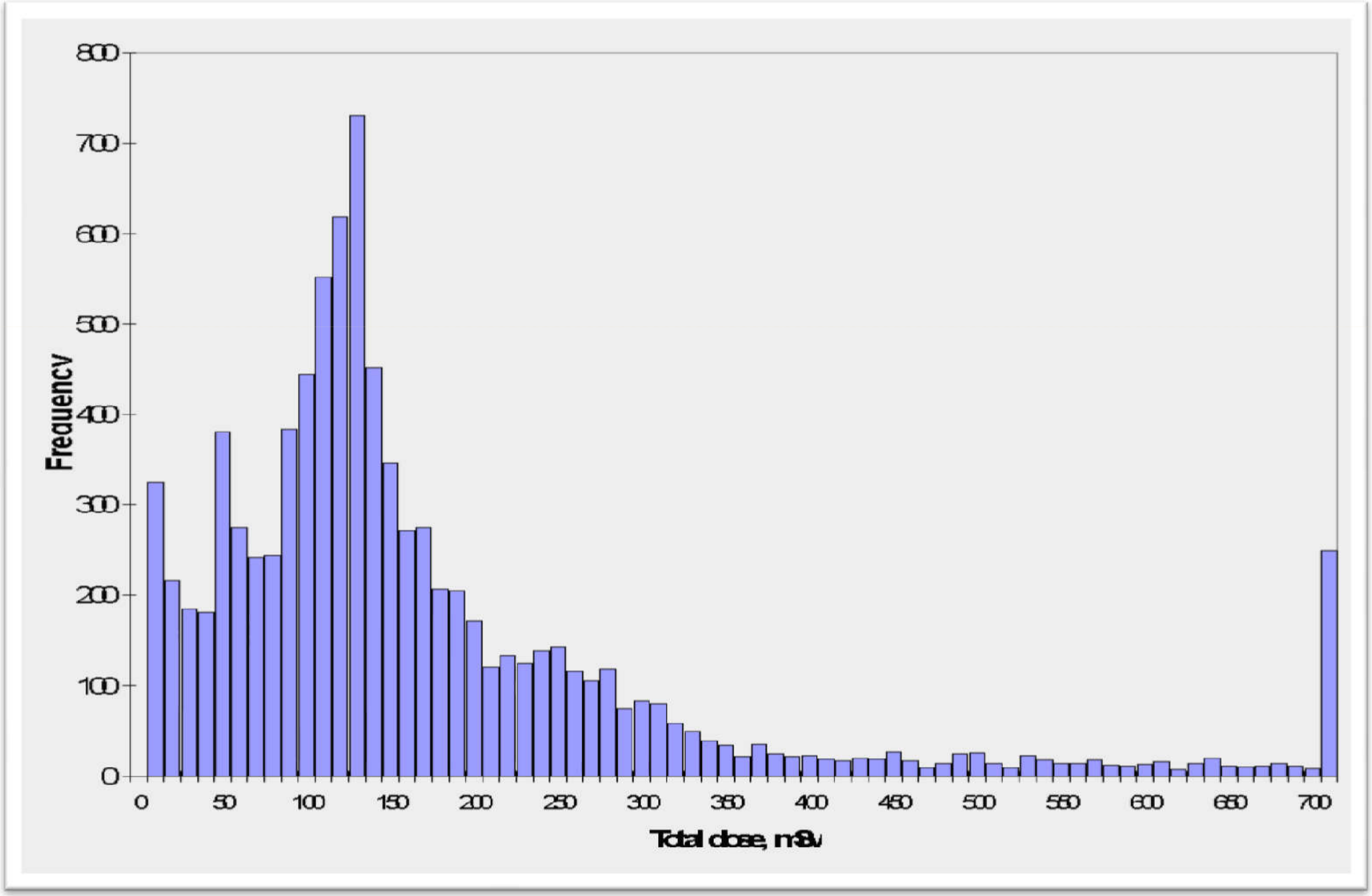


Results of dose estimation

Liquidator Group	Number in the Study	Imputed Dose (Gamma + Beta) Distribution (mGy) Median (5th, 95th Percentiles)
Measured dosy group (personal dosimeters)	410	16 (2, 235)
EPR measurements	104	94 (19, 426)
Analytical Dose Reconstruction (ADR) - ChNPP	712	502 (142, 1143)
ADR - RADEC	126	16 (1, 242)
Military	7,255	121 (30, 287)
Total	8,607	123 (15, 480)

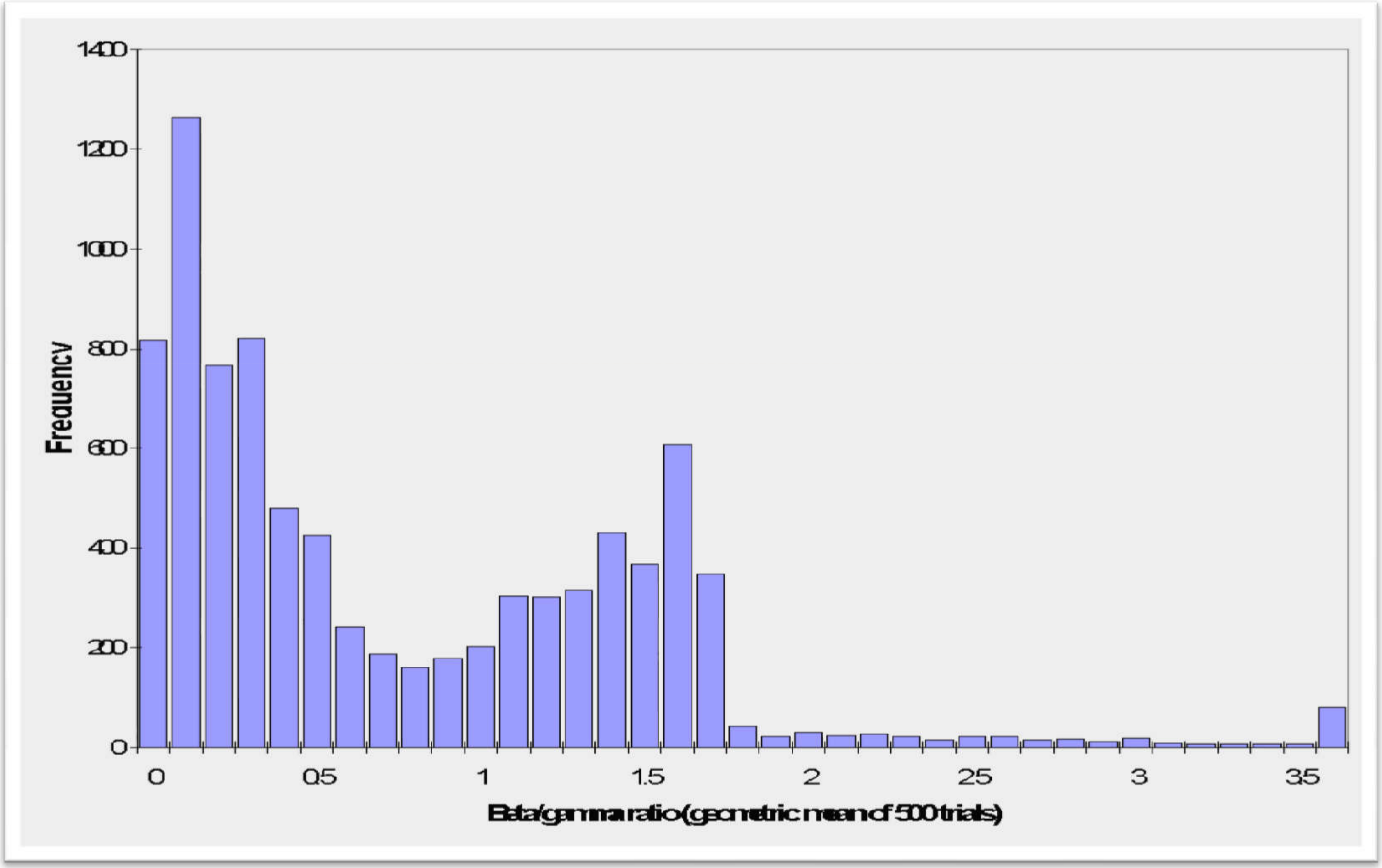
Chumak et al, Radiat Res, 2007

Distribution of individual doses
(GMs of individual uncertainty distributions) for 8,607 study subjects



Worgul et al, Radiat Res, 2007

Distribution of beta/gamma dose ratios for 8,607 study subjects



Application example 3: Case-control study of leukemia among Chernobyl liquidators

Ukrainian-American study of leukemia and related disorders among liquidators

- Performed in 1996-2011
- Participants:
  - Research Center for Radiation Medicine AMS Ukraine
  - National cancer registry of Ukraine
  - National Cancer Institute
  - Columbia University

Romanenko et al, Radiat Res, 2008

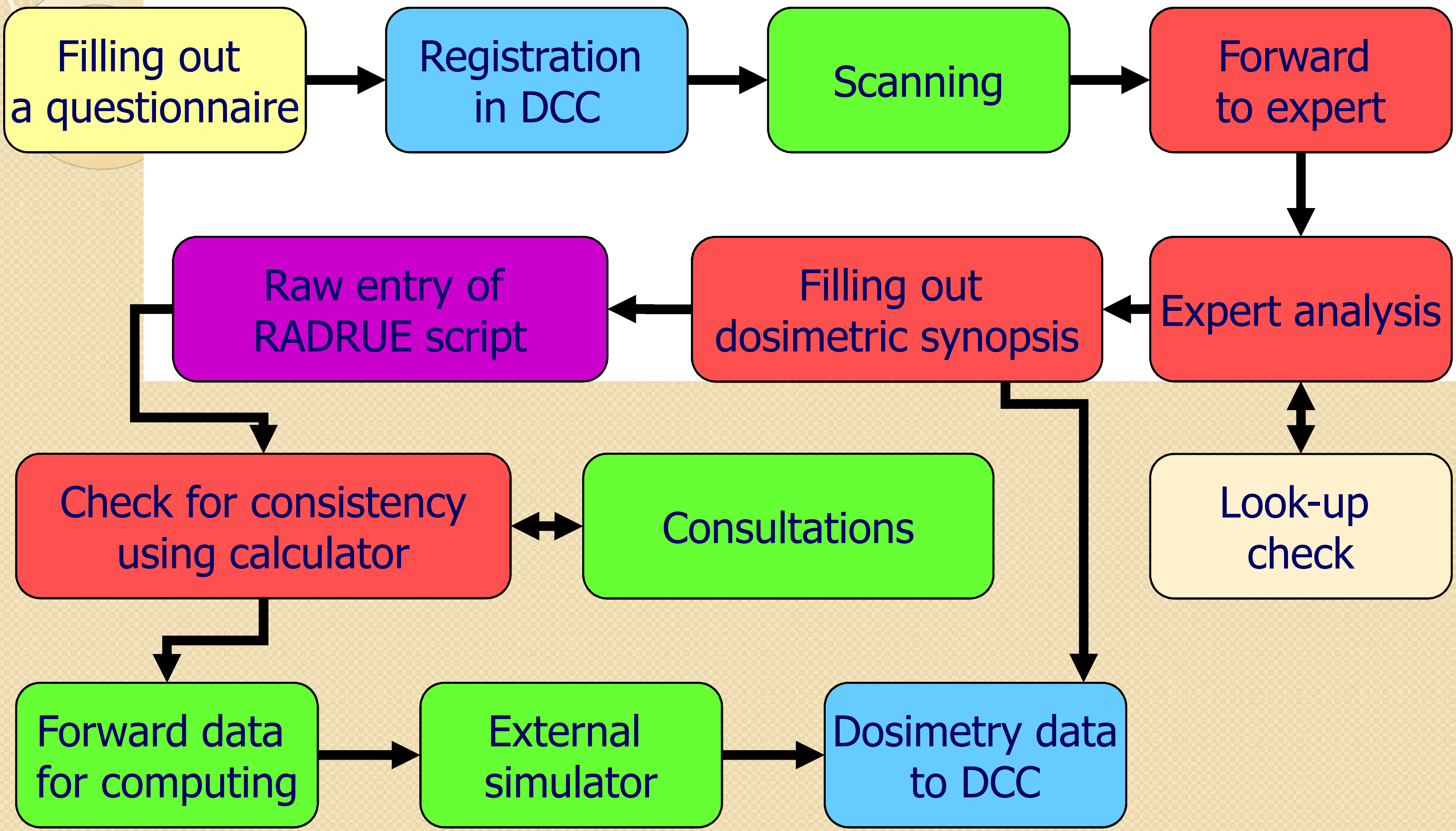
Specific requirements to dosimetric support of Leukemia study

- Doses need to be evaluated by a single method
- Doses need to be estimated to all study subjects
- Need for dose reconstruction even for diseased cases

Plan of dosimetric support of the study

- Dose assessment by RADRUE
  - Interview of alive subjects
  - Interview of proxy relatives and colleagues for diseased subjects
- Selective verification of doses by EPR
- Verification of high doses by FISH
- Quality assurance at all levels

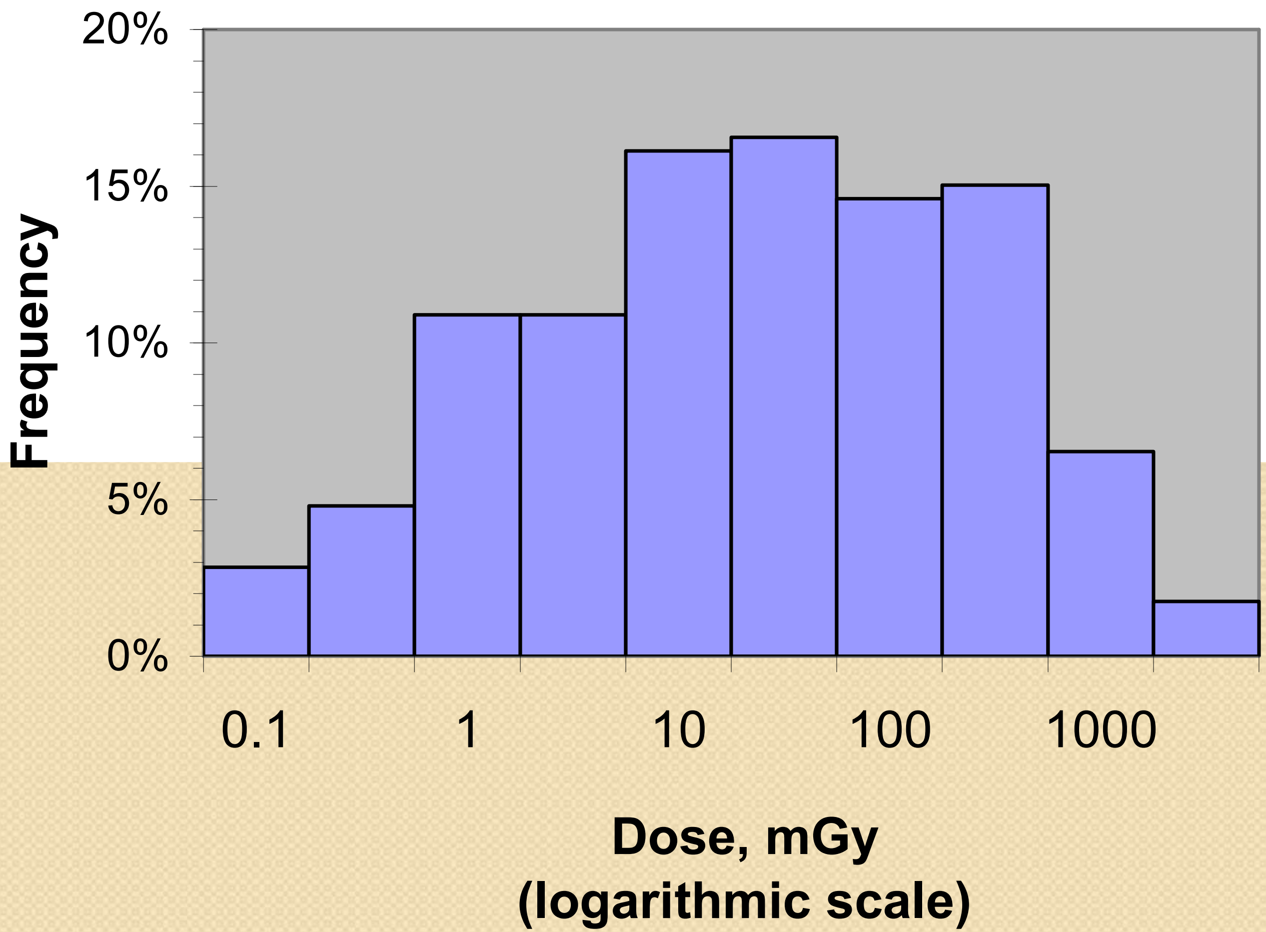
RADRUE processing sequence



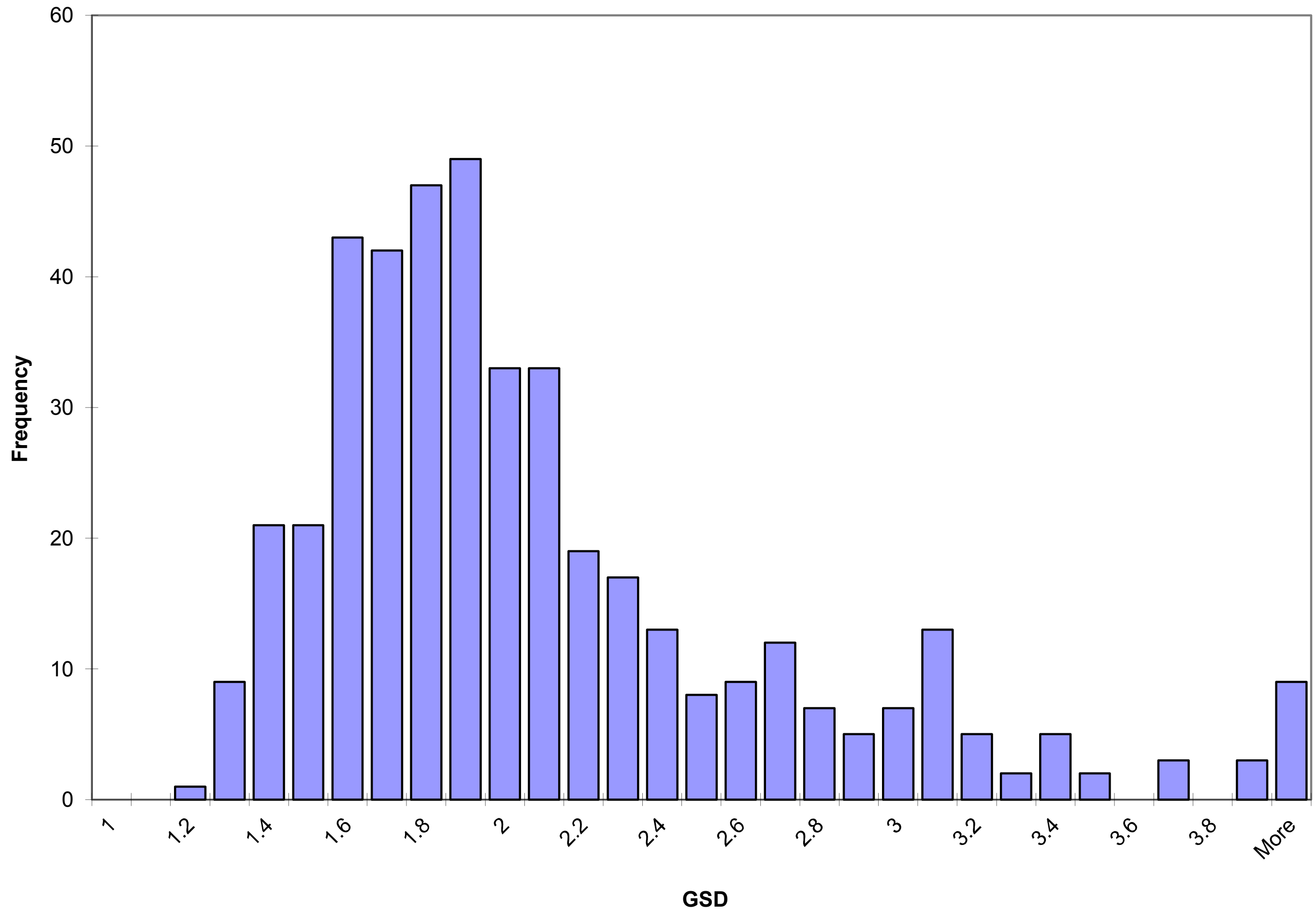
Chumak et al, Radiat Res, 2008, Krjuchkov et al, Health Phys, 2009

RADRUE dose estimates (Phase 1)

Mean: 109 mGy, SD: 299 mGy, GM: 12 mGy, GSD: 12.2, min: 0, max: 3.1 Gy



Routine RADRUE application:
Distribution of GSDs



Doses of different categories of liquidators (phases 1&2)

Category	Number	RBM dose, mGy			Mean GSD
		Mean	Min	Max	
Witnesses of the accident	8	190	4.7	840	2.3
Victims of the accident	2	2880	2580	3170	3.4
Military liquidators	377	79	0.008	831	2.1
Early liquidators	113	92	0.15	1010	2.1
ChNPP personnel	10	222	23	966	1.8
Assigned to ChNPP	4	88	1.9	205	1.7
Sent on Mission to the 30-km zone	318	39	0.000037	1444	2.0
AC-605 personnel	9	182	0.9	483	2.1
PA “Combinat” personnel	7	63	2.9	240	1.8
IAE personel	4	186	15	338	2.6
Mixed	148	185	0.4	3260	1.7
All	1000	91	0.000037	3260	2.0

Chumak et al, Health Phys, 2015

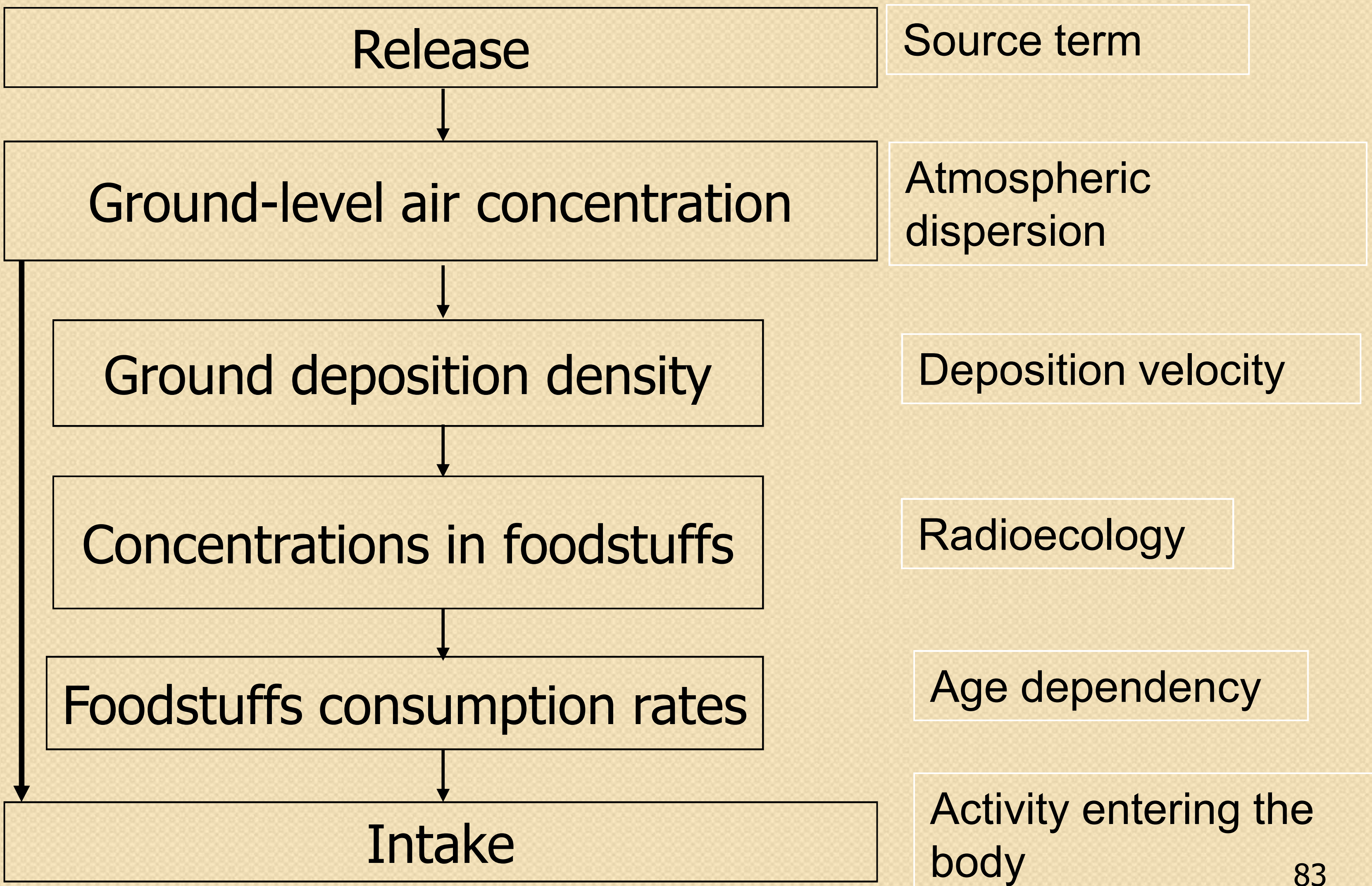
Studies among Chernobyl Liquidators: Mean Individual Stochastic Doses (RADRUE/Rockville)

Study	N	Mean of individual stochastic doses to bone marrow / thyroid (mGy)		
		External	Internal	Total
Leukemia among Ukrainian liquidators	1,000	91	-	91
Hematological malignancies among liquidators from Belarus, Russia and Baltic states (1986-1987)	357	45	-	45
Thyroid cancer among liquidators from Belarus, Russia and Baltic states	530	33	182	171

Bouville and Kryuchkov, Health Phys, 2014; Chumak et al, Health Phys, 2015; Kryuchkov et al, Health Phys, 2009

Methodological inlay 2: **Estimation of internal doses**

General Scheme of Internal Dose Calculation



General Scheme of Internal Dose Calculation (2)

↓

Intake

↓

Activities in blood and in organs — Radionuclide dependent biokinetic models

↓

Monte Carlo simulation of radiation transport — Use of phantoms

↓

Dose estimate — W/ or w/o uncertainty

Important Radionuclides

Radionuclide	Half-time	External irradiation	Internal irradiation
Short-term exposure			
^{131}I	8.04 d	+	+++
$^{132}Te + ^{132}I$	3.26 d	+++	+
^{133}I	20.8 h	+	+
$^{140}Ba + ^{140}La$	12.74 d	+++	
$^{95}Zr + ^{95}Nb$	63.98 d	++	
Other γ-emitters	-	+	
Long-term exposure			
^{134}Cs	2.06 y	++	+
^{137}Cs	30.0 y	+	+++
^{90}Sr	29.12 y		+

Databases of Measurements in Environmental Samples and Humans

- Deposition density of radionuclides:
  - ^{137}Cs
  - ^{131}I (+ calculations where measurements are not available)
  - Other γ-emitting radionuclides (e.g., ^{95}Zr, ^{103}Ru, ^{106}Ru, ^{134}Cs, ^{140}Ba, ^{141}Ce, ^{144}Ce) (measurements)
  - ^{132}Te and ^{133}I (calculations, measurements are not available)
  - ^{90}Sr (measurements)
- Exposure rates
- Radioactivity concentration in grass and cow milk (total β-activity, ^{131}I and Cs isotopes)
- ^{131}I activity in the thyroid (measurements)
- ^{137}Cs body burdens (WBC measurements)
- TLD measurements

Application example 4: Estimation of thyroid doses due to intakes

Measurements of ^{131}I Activity in the Thyroid in April-June 1986

Country	N	Method of measurement	Detector type
Belarus	130,000	Exposure rate	GM, NaI(Tl)
Ukraine	150,000	Exposure rate Spectrometry	NaI(Tl)
Russian Federation	46,000	Exposure rate Spectrometry	NaI(Tl)

Gavrilin et al Health Phys 1999; Likhtarev et al Health Phys 1995; Zvonova et al Radiat Prot Dosim 1998

Verification / Intercomparison of Model Calculations

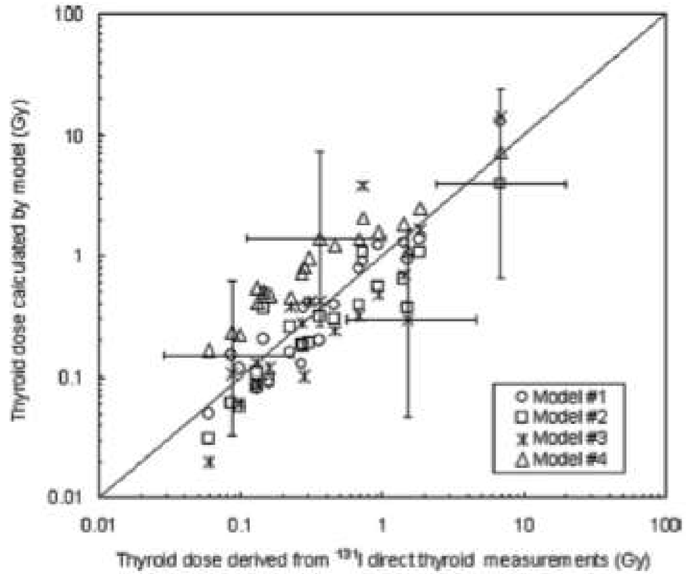
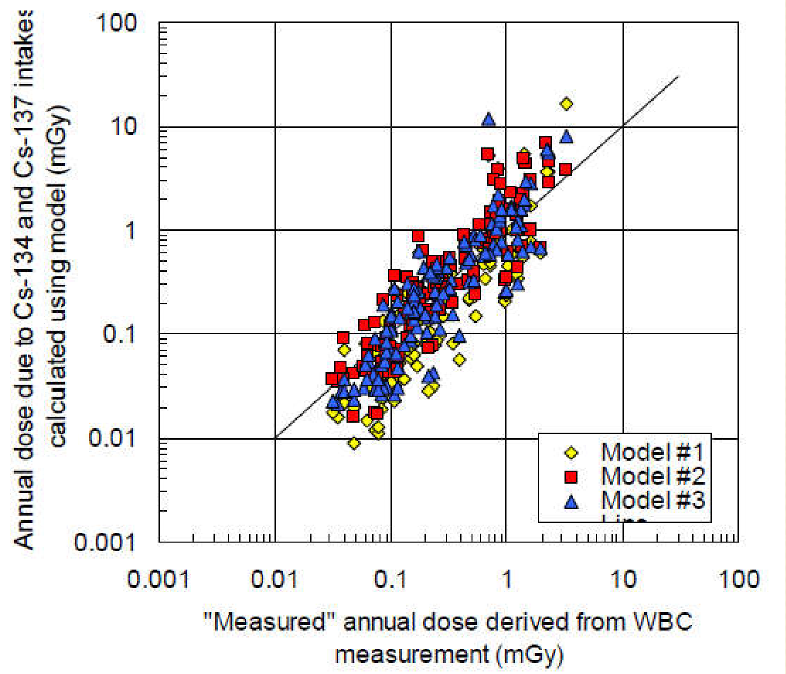


Fig. 2. Comparison of the average thyroid dose estimates from ^{131}I that were calculated by four models for 1-y-old children in 20 settlements with the doses derived from direct measurements. The error bars represent 95% confidence intervals.



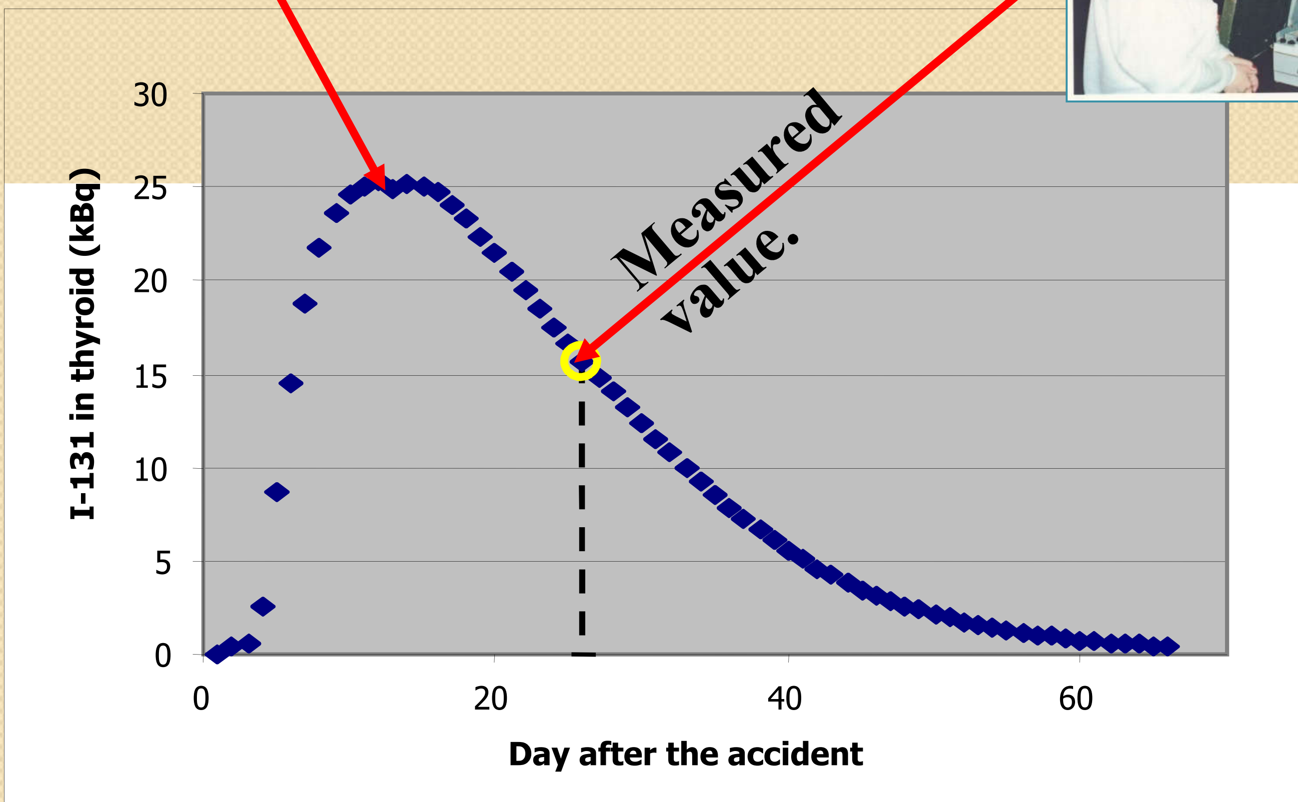
Drozdovitch et al Health Phys 2010; IARC, unpublished material – courtesy of V. Drozdovitch

Thyroid Cohort Studies

- About 25,000 individuals exposed as children and adolescents (aged 0-18 y): ~12,000 in Belarus, and ~13,000 in Ukraine
- Lived in contaminated areas
- Subjected to direct measurements of exposure rate against the thyroid which have been used to estimate ^{131}I activity in thyroid gland
- Detailed behavior and diet information was collected by means of personal interviews

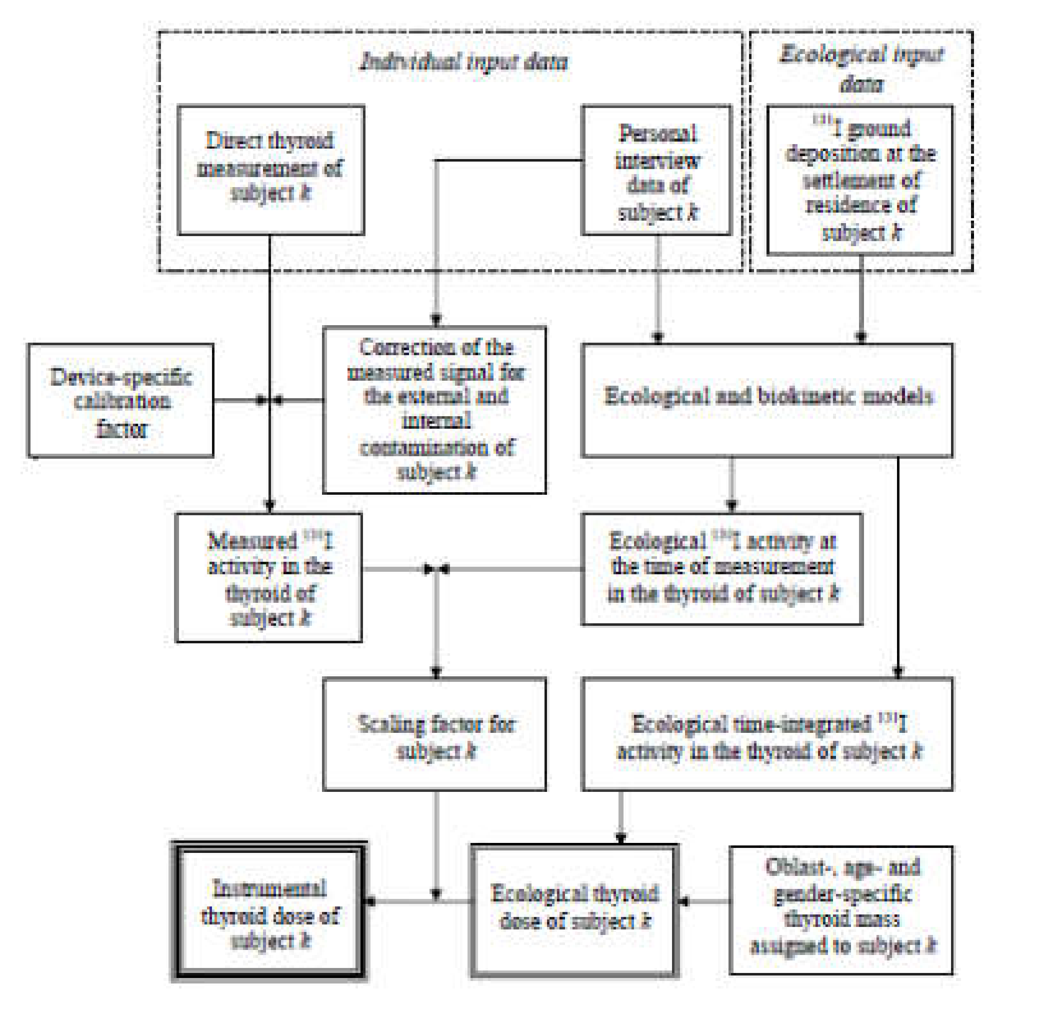
Direct thyroid measurement

Curve derived from ^{131}I models plus data from questionnaire



Thyroid dose is proportio-nal to area under the curve

Cohort study: Scheme of Dose Calculation



Drozdovitch et al. Radiat Res 2013

Individual Stochastic Thyroid Doses from ^{131}I Intakes

Mean stochastic thyroid dose (Gy)	Belarus		Ukraine	
	N	%	N	%
< 0.2	4,987	42.5	6729	51.0
0.2 – 0.49	2,819	24.0	2829	21.4
0.5 – 1.99	3,083	26.3	2735	20.7
2.0 – 9.99	792	6.8	838	6.3
> 10.0	51	0.4	73	0.6
Total	11,732	100.0	13,204	100
Mean	0.68		0.65	
Median	0.27		0.19	

Drozdovitch et al. Radiat Res, 2015; Likhtarev et al. Health Phys 2014

Summary

Reconstructed doses used:

- Evaluation of doses to evacuees
- For ruling out unconfirmed dose rate measurements
- For risk assessment of leukemia among liquidators
- For study of cataracts among liquidators
- For risk assessment of thyroid cancer among exposed in childhood

Conclusions - general

Retrospective dosimetry in Chernobyl is unique and challenging experience in many respects.

- For assessment of doses to evacuated population:
  - Analysis and interpolation of dose rate data
  - Large scale interviewing of evacuees
  - Reassessment of shielding factors of buildings
  - Application of detailed time-and-motion procedures
- For instrumental verification of cumulative doses:
  - Development of new TL protocols
  - Monte Carlo calculations and conversion between contamination density and dose in bricks
- In course of dosimetric support of Chernobyl follow-up studies:
  - Individual dose reconstruction
  - Retrospective re-evaluation and verification of existing dose records
  - Development of new techniques to fit the demands of epidemiological studies
  - EPR dosimetry with teeth as ‘gold standard’; collection of teeth from exposed persons
  - Use of combination of different methods to address practical needs

Conclusions - epidemiology

- A consistent dosimetry system, based on combination of historical dose records and retrospective dosimetry techniques allowed to assess individual lens doses from both gamma and beta radiation for 8,607 subjects of the cohort ocular study (UACOS).
- Individual doses were estimated by universal RADRUE method for 1,000 subjects (cases and controls, alive and diseased) of the Ukrainian-American leukemia study
- Dosimetric support of large scale post-Chernobyl epidemiological studies is doable is sufficient resources (human, financial, time) are allocated

Outlook

CO-CHER – attempt to systematize plausible approaches, data arrays and cohorts

European Commission 7th Framework Program project “CO-CHER – Cooperation on Chernobyl Health Research”

Coordinated by IARC

Years of implementation: 2014-2016

Attempt of classification of studies from the dosimetric standpoint

Environmental studies:

Category 1 studies – individual-based measurements are available, doses and uncertainties are rigorously estimated for ALL study subjects

Category 2 studies – individual-based measurements are available for SOME study subjects, doses and uncertainties are quantified

Category 3 – no individual-based measurements are available

Attempt of classification of studies from the dosimetric standpoint

Studies on clean-up workers:

Case-control studies – individual doses and uncertainties are rigorously estimated for ALL study subjects using single (unbiased) method

Cohort studies – individual doses are evaluated by review and (where needed) recalibration of existent dose arrays with selective validation against ‘gold standard’

Expected outcome

- Catalogue of plausible Chernobyl cohorts
- Report describing dose assessment done to date and considering promising methodologies for the future *(paper in press)*
- Inventory (catalogue) of the available dosimetric databases

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Köszönöm!