CHERNOBYL ACCIDENT: 25 YEARS LATER

Leonid Chunikhin,
RC Radiation Medicine, Gomel, Belarus

Using Materials of the WHO Symposium (September 1-3, 2010,Gomel)
&
Research Conference “ CHERNOBYL READINGS” (April 12-15, 2011)

April 26, 1986 01:24 a.m.

Up to 5:00 a.m. (after 3 hours) – the fire was put out

The information did not correspond to the real situation

Среда, 30 апреля 1986 года

От Совета Министров СССР

По предварительным данным, авария произошла в одном из помещений 4-го энергоблока и привела к разрушению части строительных конструкций здания реактора, его повреждению и некоторой утечке радиоактивных веществ.

...авария произошла в одном из помещений 4-го энергоблока и привела к разрушению части строительных конструкций здания реактора, его повреждению и некоторой утечке радиоактивных веществ...

Четверг, 1 мая 1986 года

От Совета Министров СССР

Проводимые измерения свидетельствуют о том, что цепной реакции деления ядерного топлива не происходит, реактор находится в заглушенном состоянии.

...цепной реакции деления ядерного топлива не происходит, реактор находится в заглушенном состоянии...

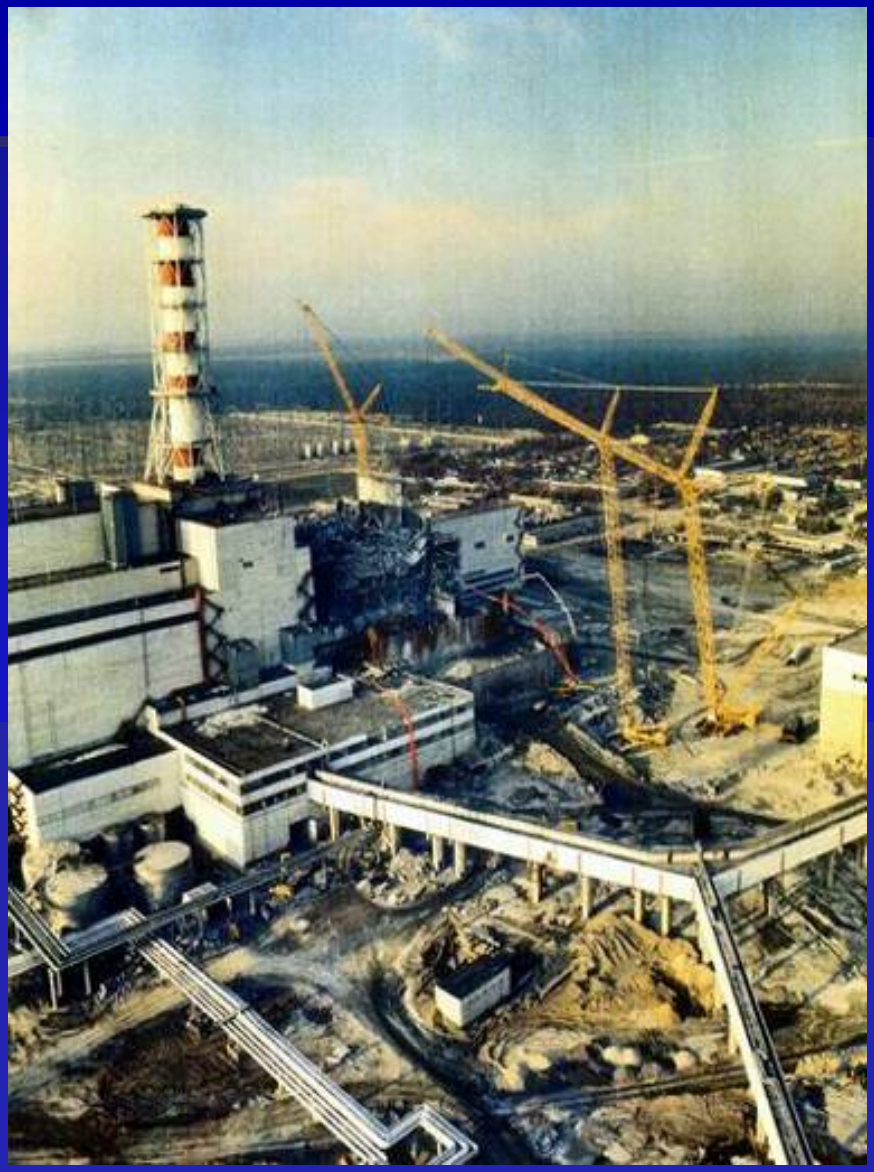
CHERNOBYL ACCIDENT

Causes

- defence system were switched off
- technology procedures were roughly distorted
- reactor construction defects
- “ nobody believed that it was possible”

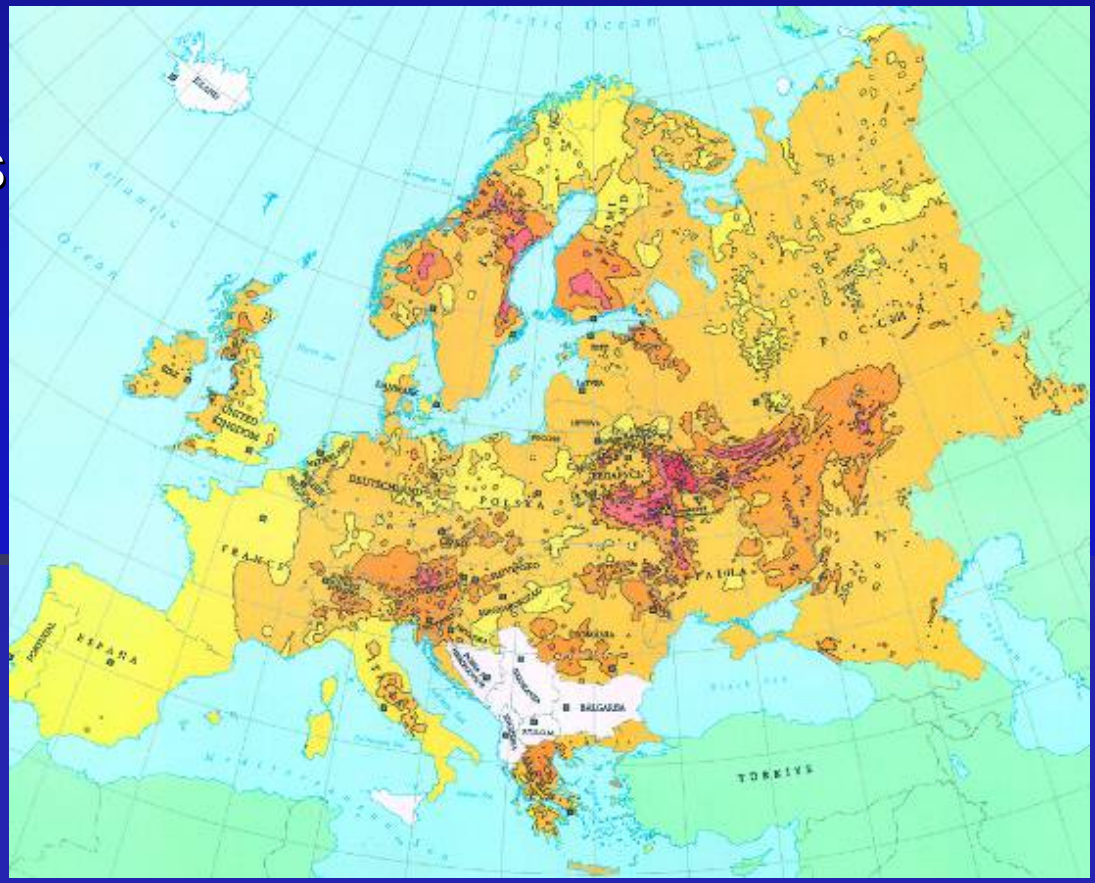
Results

- great increase in power(1000 times)
- reactor active zone & protective covering destruction

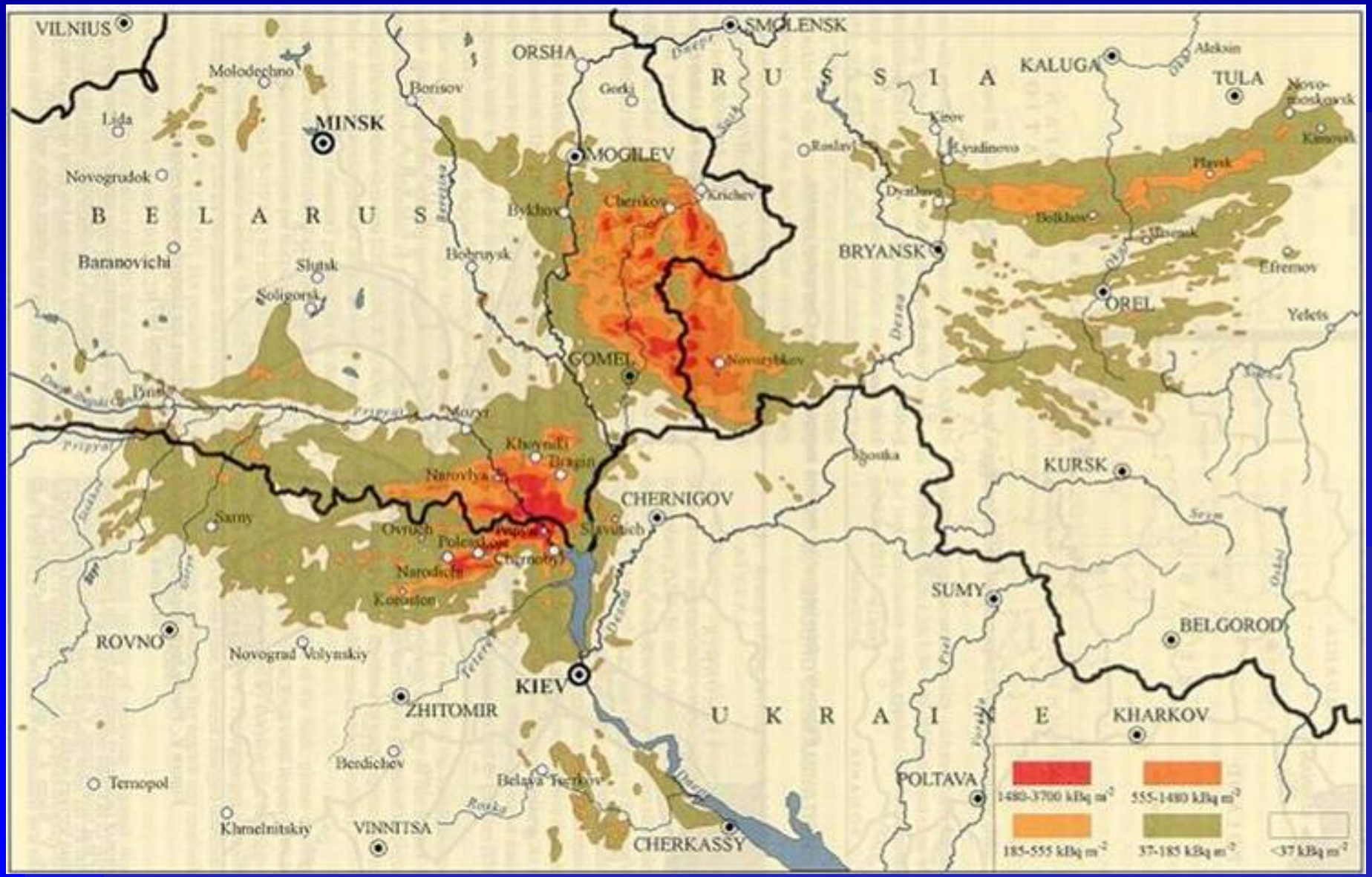


RADIONUCLIDE EMISSION

- Radionuclides were releasing during 10 days
  - Iodine
  - Cesium
  - Other radionuclides
  - Inert noble gases
- Total radionuclides
- released
- on the 6th of May
  (18-35) x 10^{18} Bq



^{137}Cs “ spots” in Belarus, Russia, Ukraine



Cesium - 137 Contamination > 37 kBq/m^2

COUNTRY	Square км
Russian Federation	57,900
Belarus	46,500
Ukraine	41,900
Sweden	12,000
Finland	11,500
Austria	8,600
Norway	5,200
Bulgaria	4,800
Switzerland	1,300
Greece	1,200

RELEASED RADIONUCLIDES MASSES, G

- IODINE -131 – 59
- CESIUM-134 – 412
- CESIUM -137 – 11800
- STRONCIUM-90 – 1496
- PLUTONIUM-238 – 47
- PLUTONIUM -239 – 11410
- PLUTONIUM -240 – 4390
- PLUTONIUM -241 – 2072

These were thrown down the reactor

40 t boron compounds

2400 t lead

1800 t sand&clay

600t lime

- It was inefficient because of the targets being missed.
- There were too many radiation risks for the pilots.

Liquidators

Liquidators
(disaster fighters)
were mainly in
reproductive age

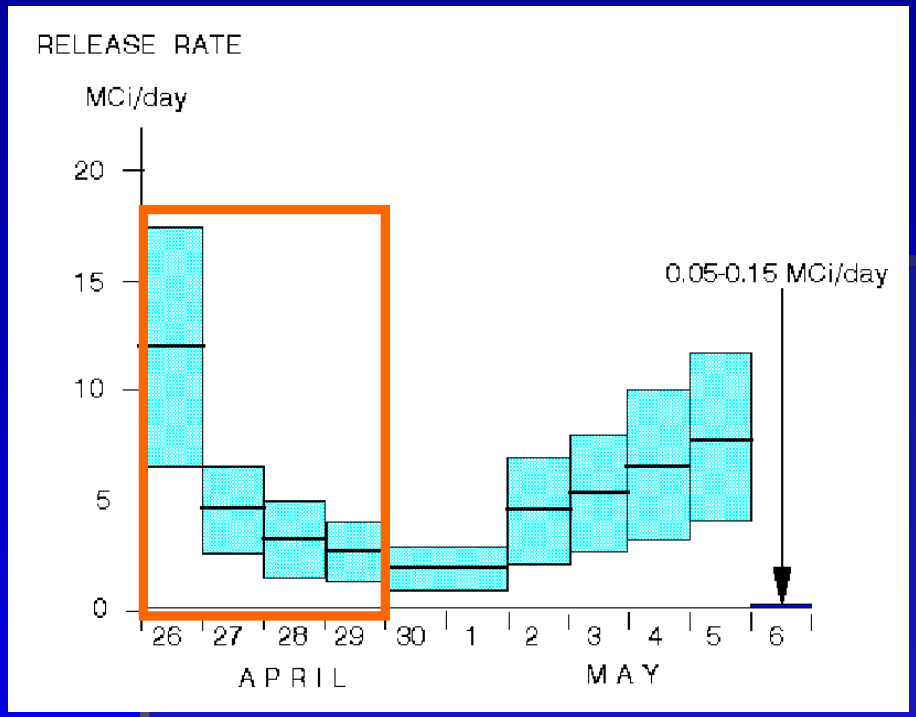
Total 230,000 people, of them
55% military men

16% liquidators were under the individual dosimeter control.

The control wasn't adequate

There was no psychological rehabilitation after the works had been finished

DAY WEEK MONTH YEAR 25



By the end of the day (April 26) 1100 buses & 3 trains were sent to Chernobyl

45,000 people (17,000 children) were evacuated in 3 hours (!)

On 27.04 at 2 p.m.

the evacuation of the Prypyat inhabitants began

The evacuation was an adequate & appropriate countermeasure against radiation but it must have been done much earlier.

By the end of 1986, 116,000 people were taken out from 188 settlements

The evacuation turned into resettling

THE 10,000 Sv·Man LEVEL OF THE COLLECTIVE IRRADIATION DOSE
WAS PREVENTED.
THERE WERE NO DETERMINIST RADIATION EFFECTS

LONG-TIME EFFECTS

- Resettlement: 1989-1993
  - 220,000 people
- VERY CONSERVATIVE CRITERIA WERE USED
- They weren’t based on the International Recommendations
- The superfluous resettlement resulted in great budget losses
- THIS PRACTICE LED TO:
  - Increased risk perception of the people
  - People stopped trusting the authorities because of the untrue information

IRRADIATION DOSES DISTRIBUTION IN TIME AFTER THE ACCIDENT

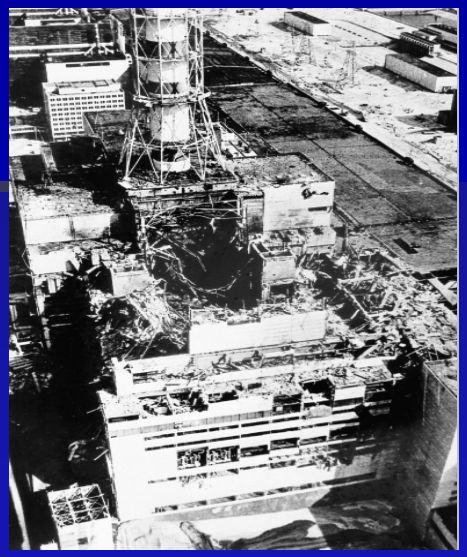
IN BYELORUSSIAN SETTLEMENTS

settl.	Cont. dens. KBq/м^2	Dose, mSv								$\frac{\text{Доза}_{86-92}}{\text{Доза}_{\text{сумм}}}$, %	
		1986		1987-1992		1993-2008		Summary			
		ext	int	ext	int	ext	int	ext	int	ext	int
Savichy	392	20	5.6	8.0	8.4	11	3.0	39	17	72	82
Zabolotge	651	12	9.2	14	14	18	6.0	44	29	60	80
Novilovka	877	16	12	19	19	24	8.0	59	39	60	80
Svetilovichy	847	15	12	19	18	23	7.0	57	37	60	82
Khalgch	503	9.1	7.1	11	11	14	4.0	34	22	60	82
Sherstin	666	12	9.4	14	14	18	6.0	44	29	60	80
Valavsk	400	8.4	5.6	8.6	8.4	11	4.0	28	18	61	78
Hrebeny	255	6.9	3.6	5.1	5.4	8.0	2.0	20	11	60	82
Fizinky	381	8.0	5.4	8.0	7.6	11	4.0	27	17	60	77
Verbovichy	722	15	10	15	15	21	7.0	51	32	59	78
Hrushevka	462	9.8	6.6	10	9.4	13	5.0	33	21	61	77
Gazhin	333	7.0	4.7	7.0	7.3	10	3.0	24	15	58	80
Demidov	433	9.1	6.1	8.9	8.9	12	4.0	30	19	60	79
Zavojtg	507	11	7.2	10	11	15	4.0	36	22	58	82
Kyrov	666	14	9.4	14	14	19	6.0	47	29	60	80
Strelichevoe	477	20	6.3	10	9.7	12	4.0	42	20	72	80
Zalesye	400	7.2	5.7	8.8	8.3	11	4.0	27	18	60	80
Belyaevka	252	4.5	3.5	5.5	5.3	7.0	2.2	17	11	59	80
Bolsuny	352	6.3	5.0	7.7	7.0	10	4.0	24	16	59	75

SOME COUNTERMESURES

MORE HARM THEN BENEFIT

- CAUSES:
  - They weren't based on the radiation protection principles
  - They were based on the criteria devised after the accident
  - The political & society opinion influenced the development of the criteria
  - SOME COUNTERMEASURES WEREN'T ADEQUATE
    - Decontamination of the evacuated territories



ONE OF THE MAIN LESSONS

- Non-radiation (economical, social, psychological & other) effects can bring more negative results then direct radiation exposure;

- Lack of the countermeasure recommendations, which were clear for the people & authorities strongly increased non-radiation effects.

- Almost 1200 people were on the nuclear power plant territory (NPP personnel, firemen, rescuers)
- Irradiation doses in the personnel & firemen were in the interval **2-20 Gy**
- **Early aftermath for health**
  - 2 men died
  - 134 workers developed radiation sickness, 47 people died (28- in 1986 &19 – in the period from 1987 to 2004)

People	Number	Dose average mean, mSv
Liquidators(1986-1989)	**600,000**	**~100**
Evacuated (1986)	**116,000**	**~33**
Population of the highly contaminated territories (1986-2005)	**270,000**	**~70**
Other citizens (1986-2005)	**5,000.000**	**~10-20**

Background irradiation dose for 20 years: ~50mSv (20-200 mSv)

According to Radiation Safety Norms -“ NRB-76”

- Dose limit: personnel – 50 mSv / per year

limited part of population - 5 mSv / per year

Before the Document - “ NRB-69”

- Dose limit : personnel – 50 mSv / per year

population – 1 mSv / per year

According to “SNIIP AES”

- document for “limited propagation”

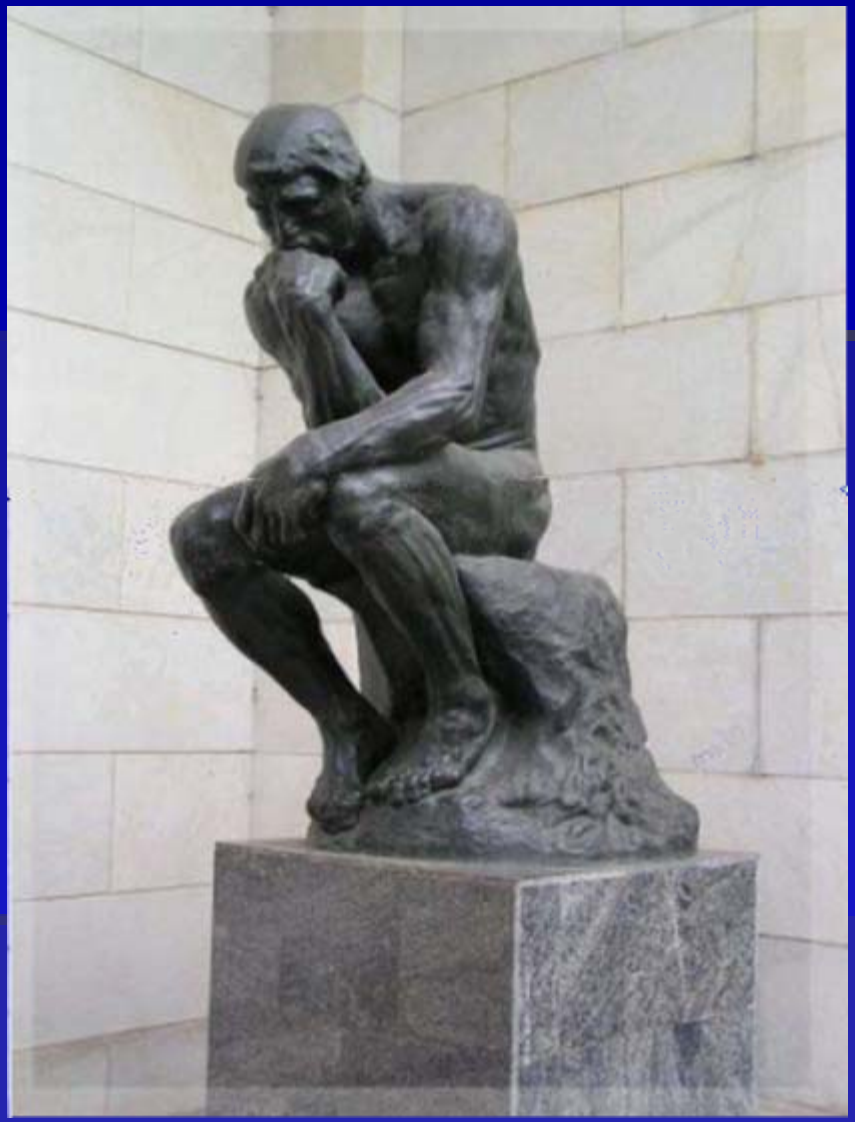
the dose limit for the accident was 500mSv.

Final dose limits

1986	1987	1989	1990
100 mSv	30 mSv	25 mSv	25 mSv

350mSv

70 mSv



Everybody was thinking for a long time…

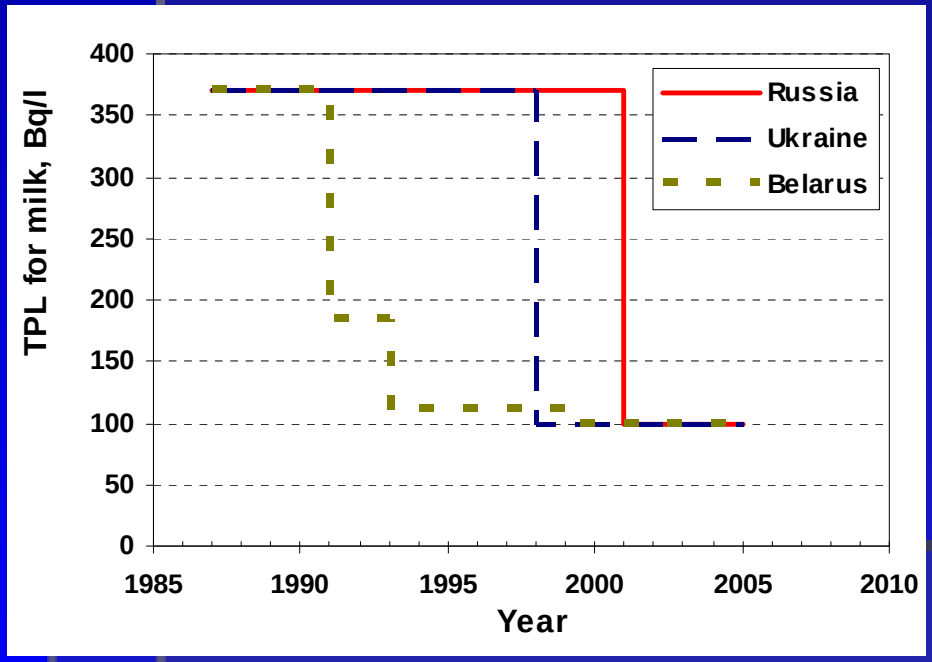
All the people were violently discussing…

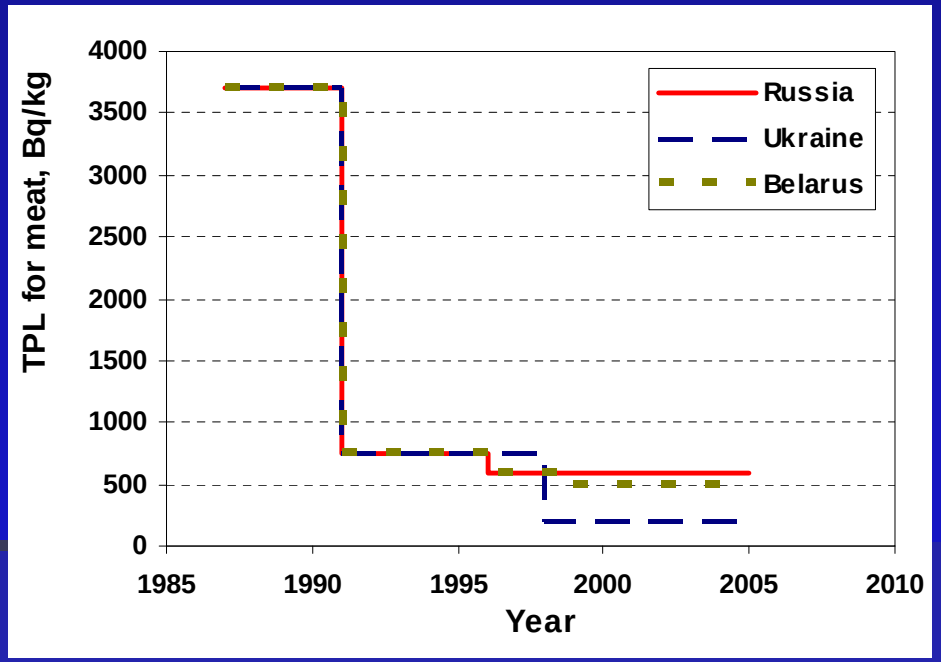
And at last they decided:

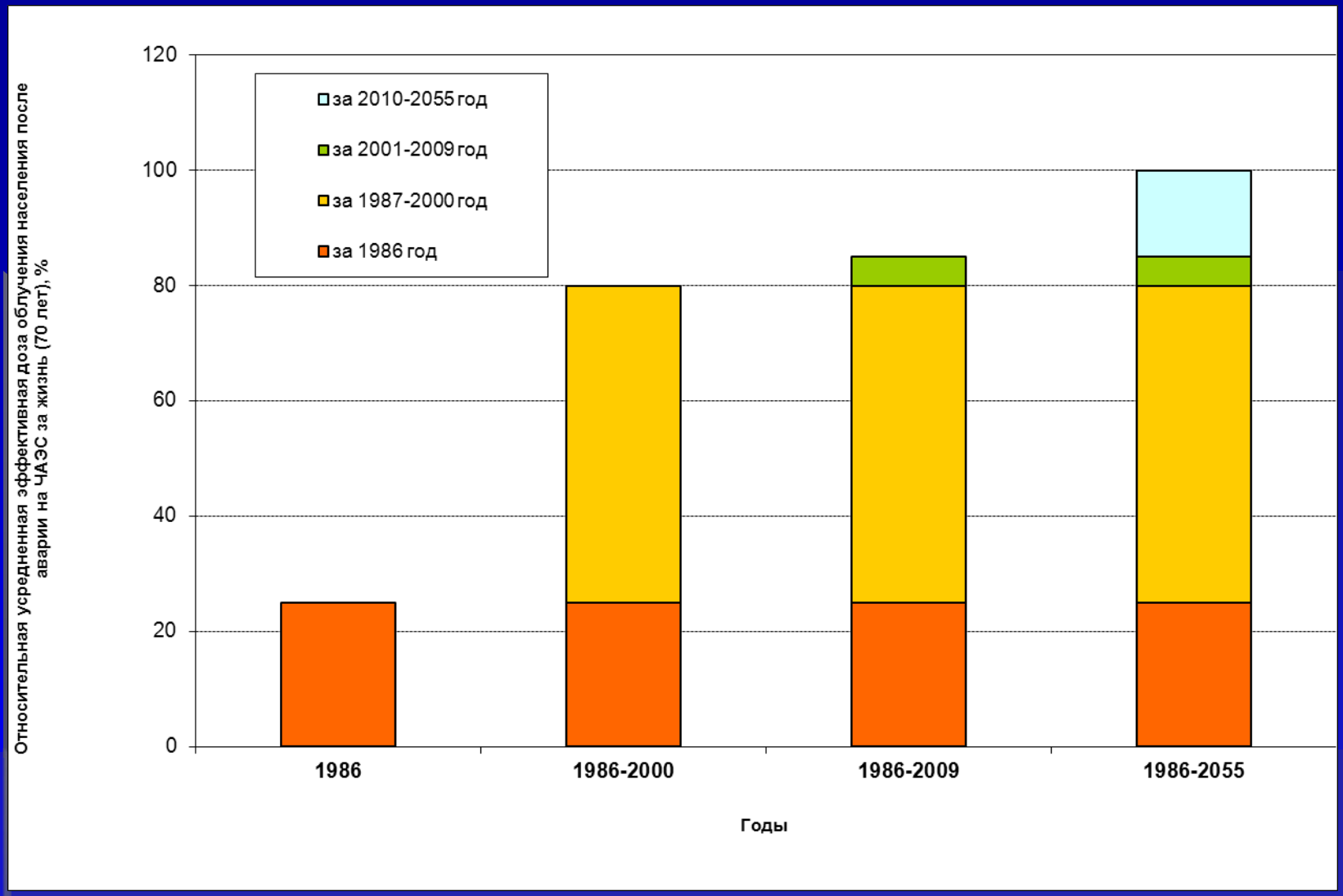
evacuation – 5 mSv

intervention level – 1 mSv

PERMISSIBLE LIMIT LEVELS FOR FOODSTUFFS DYNAMICS

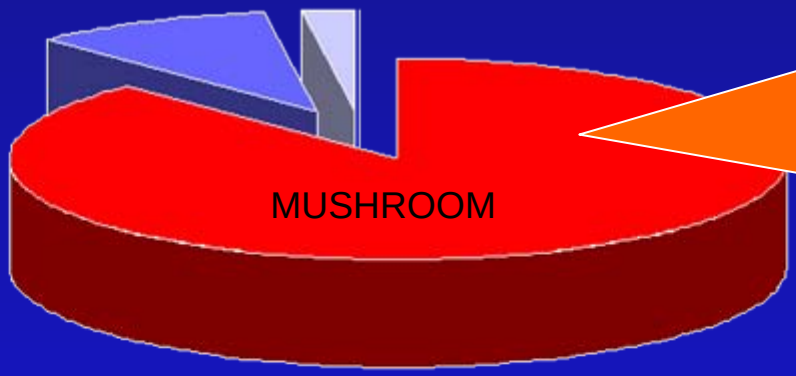






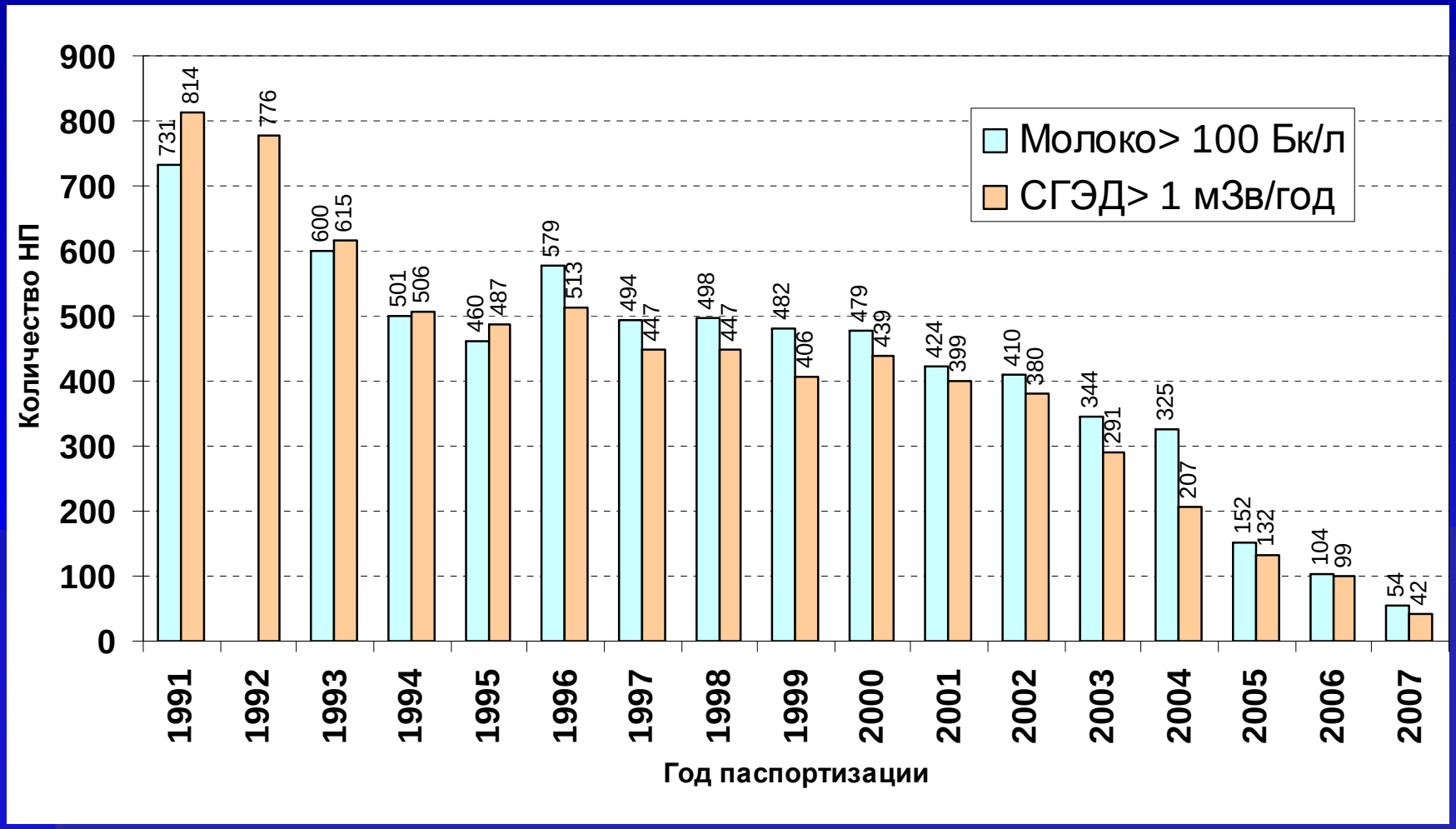
In Ukraine the people got 80-90% of the lifelong irradiation dose

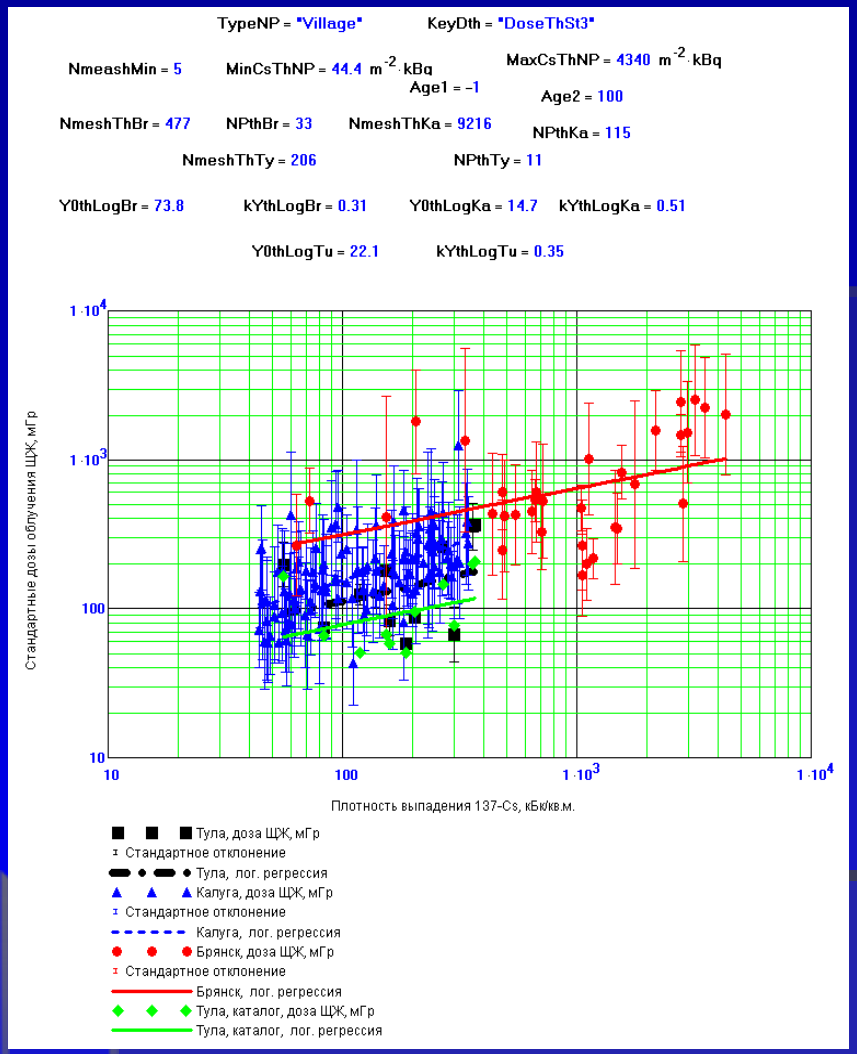
Irradiation Doses Structure for Polesye Inhabitants

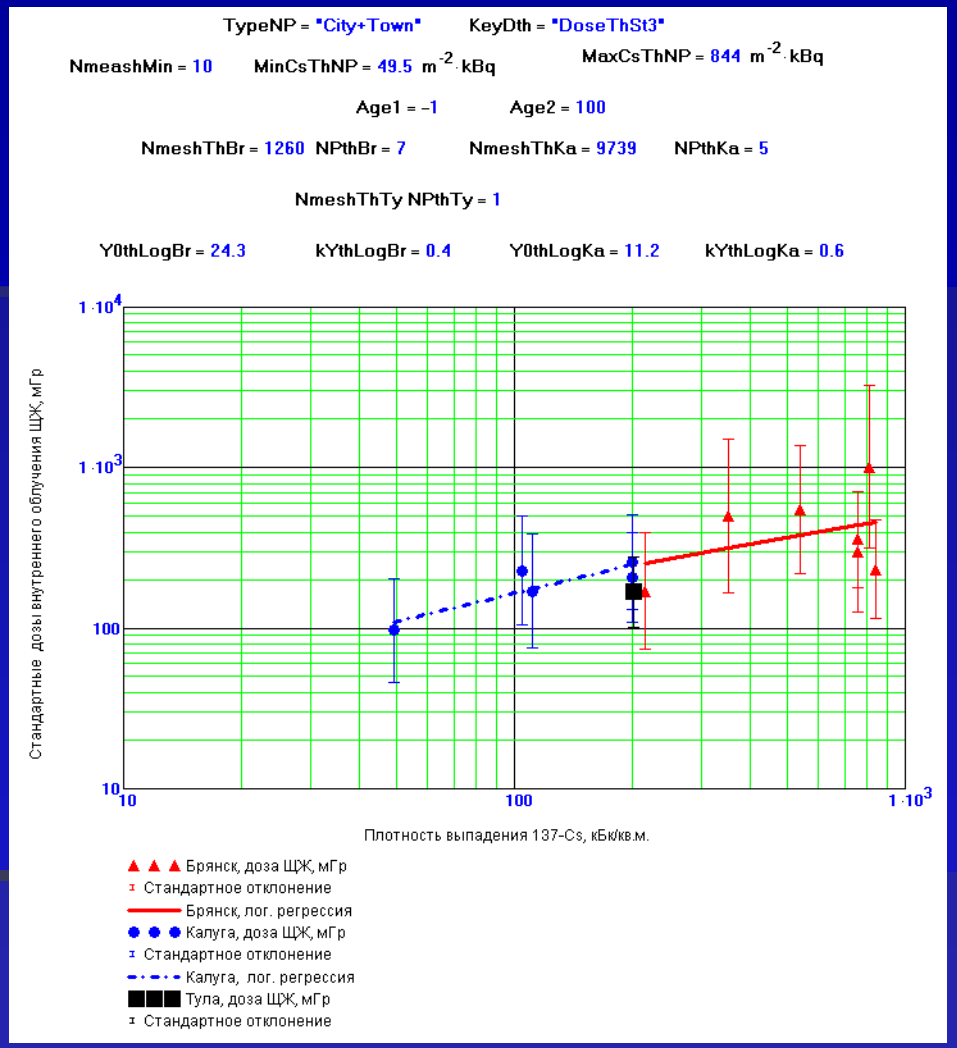


- 70-95% - внутреннее облучение от радионуклидов, поступающих в организм с продуктами питания
- 5-30% - внешнее гамма облучение
- <2% - внутреннее облучение от радионуклидов, поступающих в организм с питьевой водой
- <0,1 - внутреннее облучение от ингаляционногопоступления радионуклидов в организм

Radiology Situation Changing at the Ukraine Rural Settlements

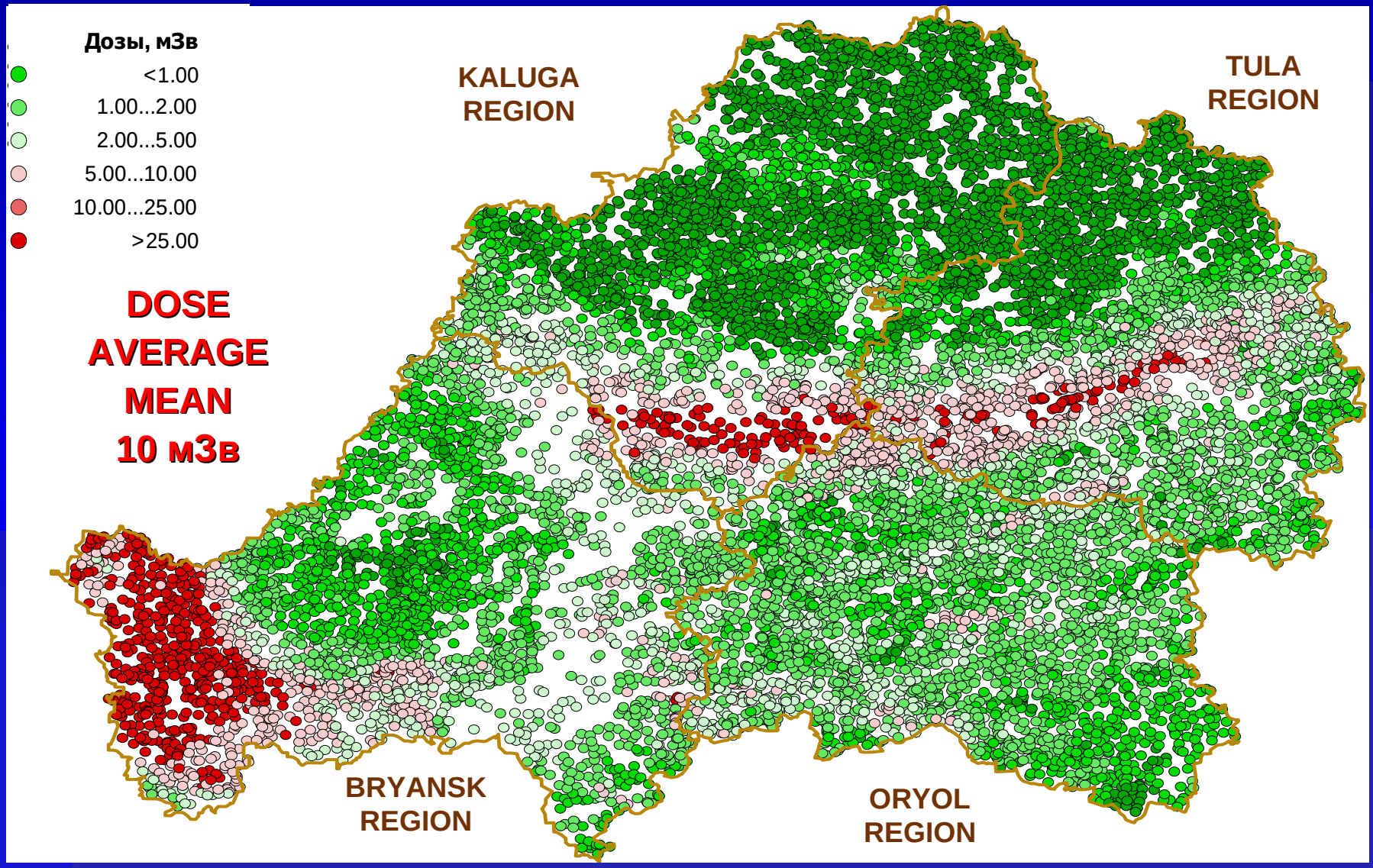




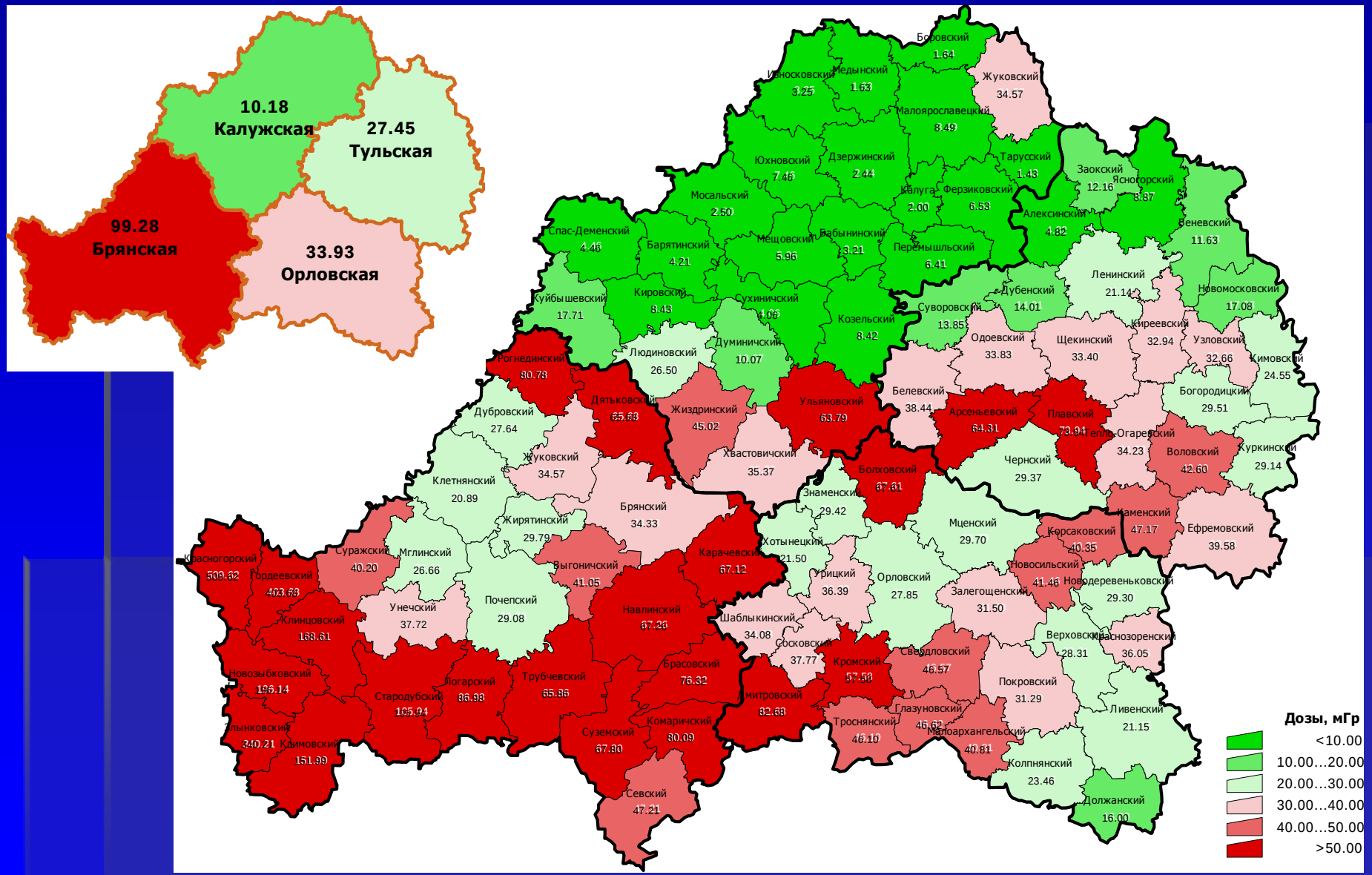


Average irradiation doses in thyroid gland of the inhabitants in Bryansk, Tula, Kaluga regions versus cesium-137 soil density contamination

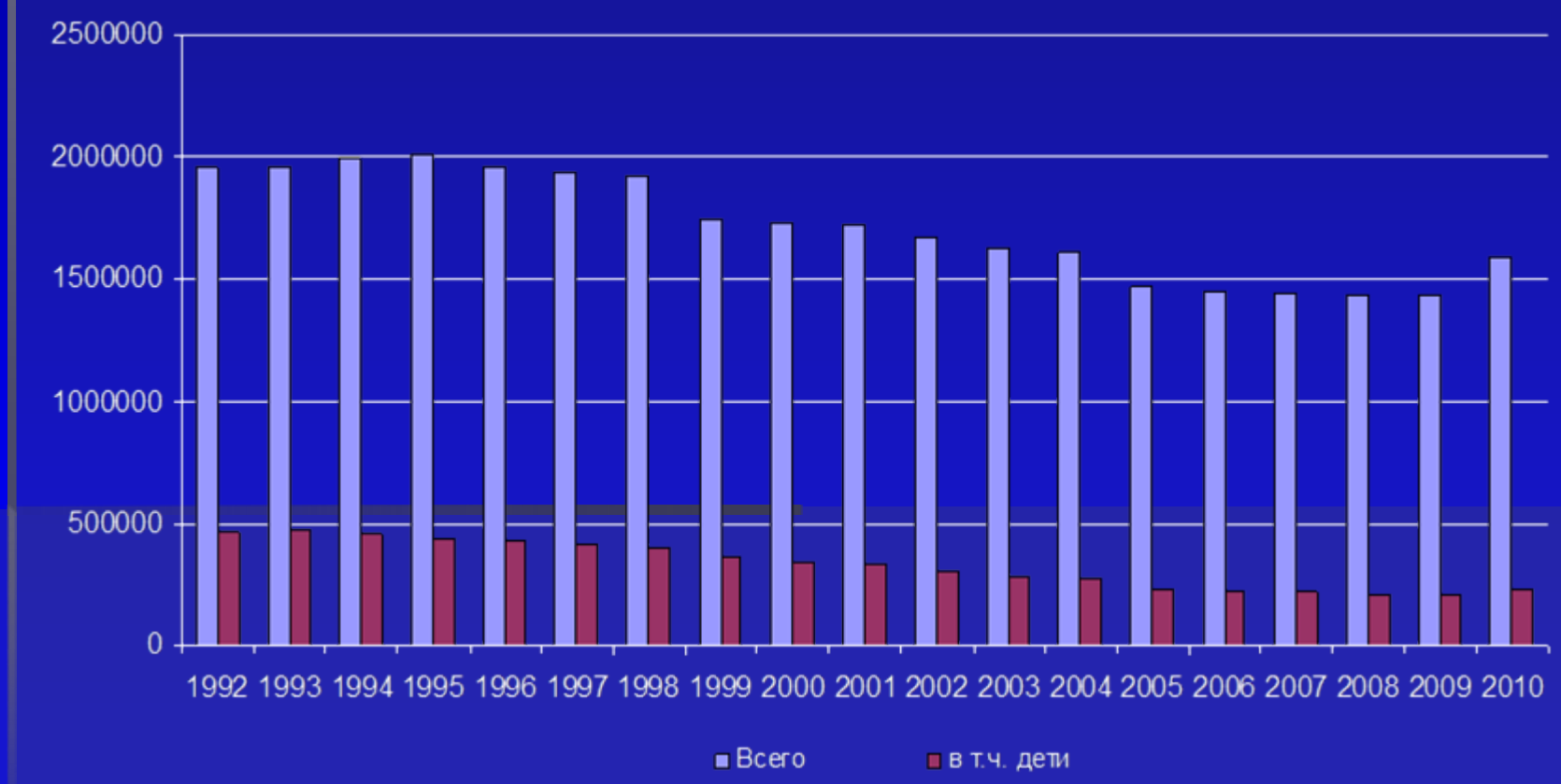
EFFECTIVE ACCUMULATED (1986-2010) IRRADIATION DOSE OF THE RESIDENTS OF BRYANSK, TULA, KALUGA, ORYOL REGIONS



THYROID GLAND IRRADIATION DOSES IN CHILDREN & TEENAGERS (AVERAGE INDICES FOR THE DISTRICTS)



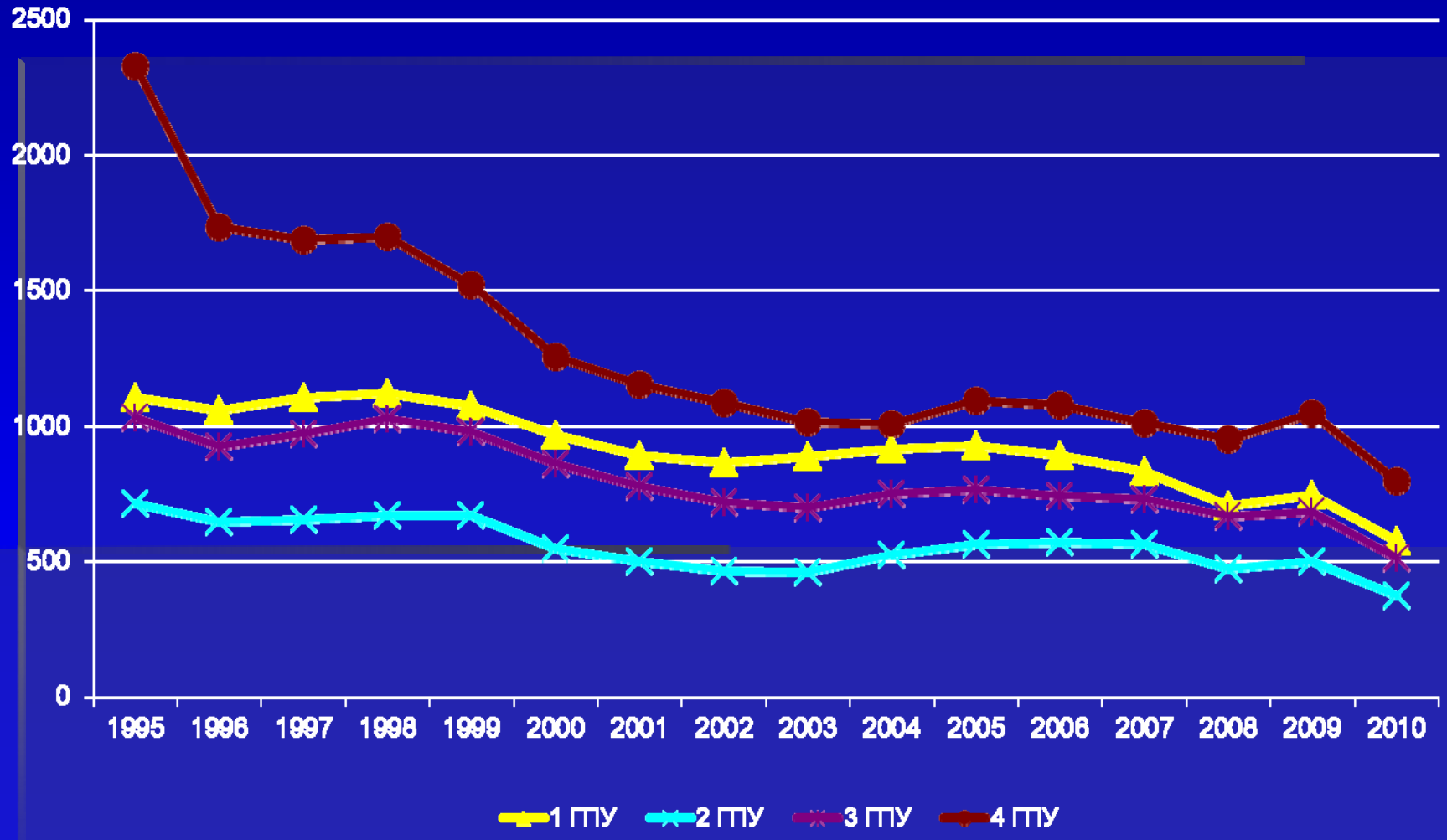
NUMBER OF THE SUFFERED POPULATION



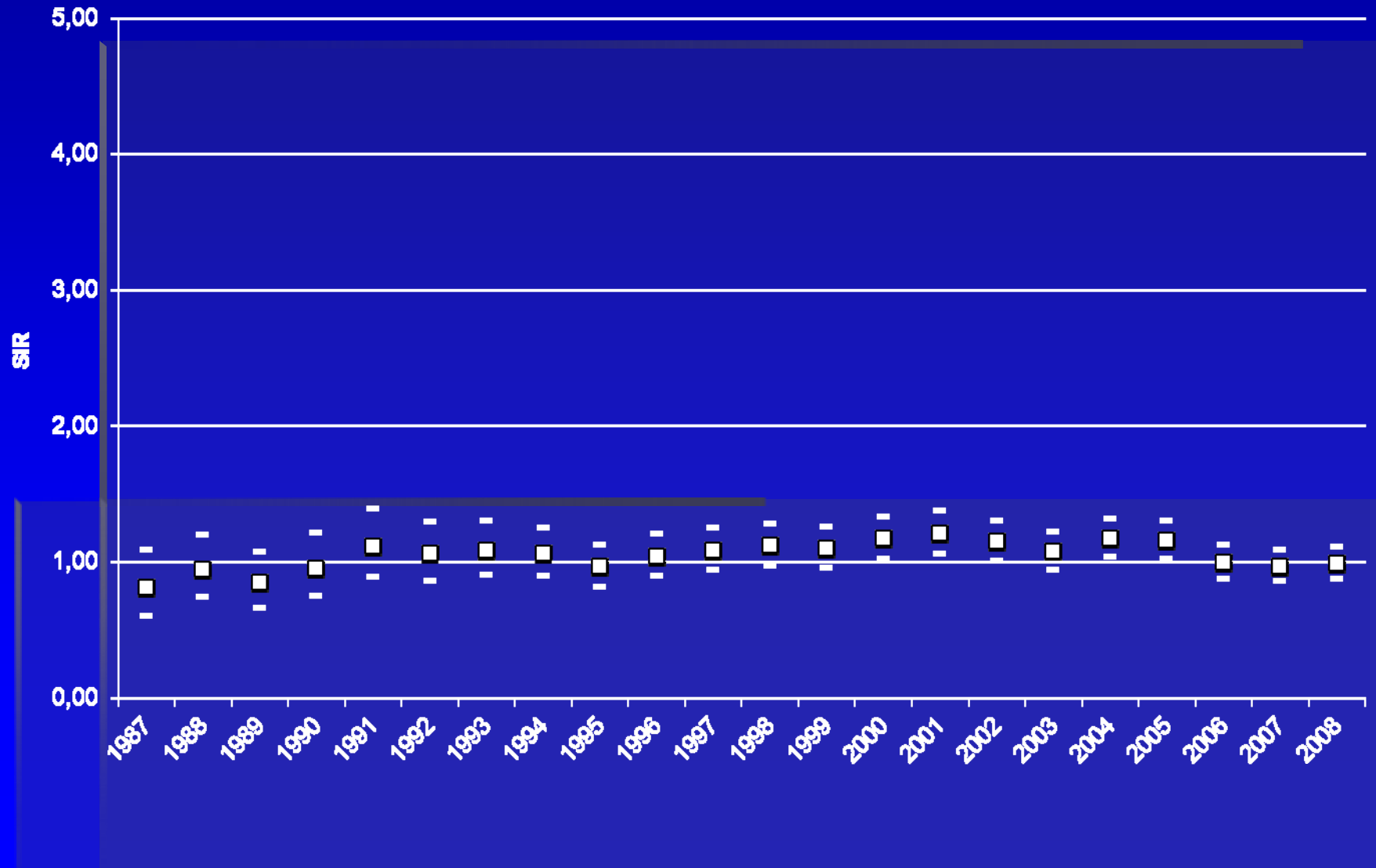
IRRADIATION DOSES IN DIFFERENT CATEGORIES OF THE BELARUS POPULATION

Категория лиц	Численность	Эффективная доза, мЗв
Ликвидаторы 1986 г.	67 000	60
Ликвидаторы (1987-1989)	27 000	23
Эвакуированные	24 700	80
Планово отселенные	135 000	100
Гомельская область в целом	1 500 000	37
Республика в целом	10 000 000	8,5

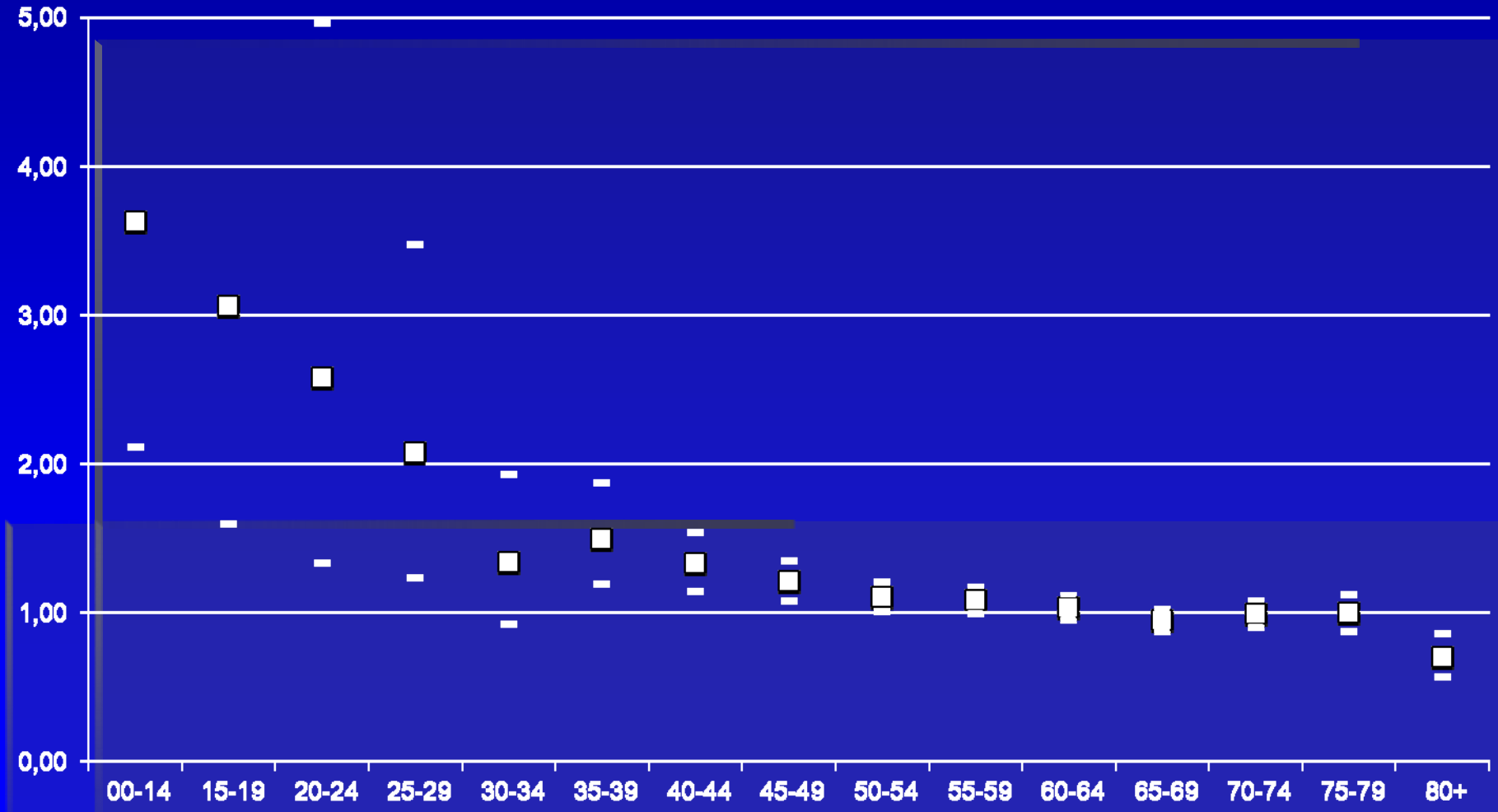
INCIDENCE RATE DYNAMICS IN DIFFERENT CATEGORIES OF THE SUFFERED POPULATION, ($^{1}/_{0000}$)



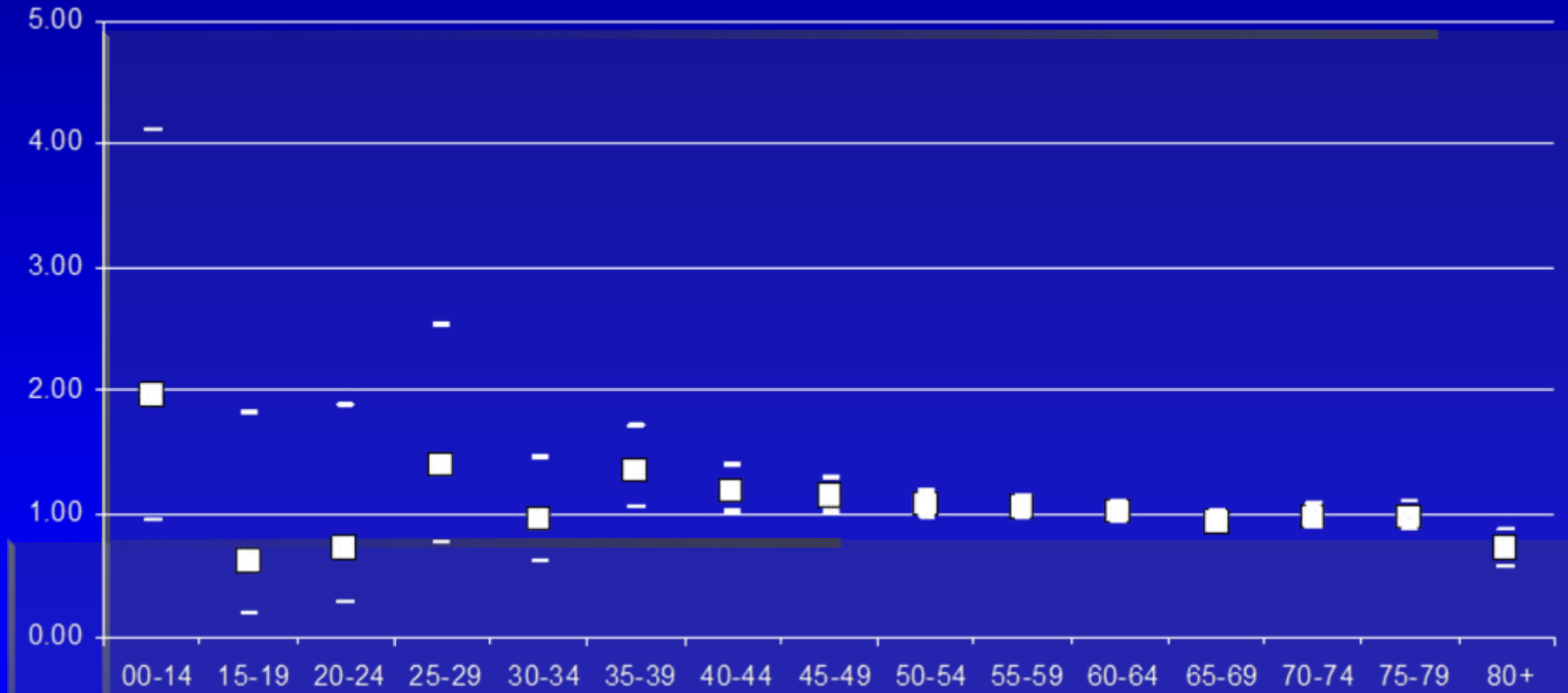
SIR DYNAMICS, MEN, ALL LOCALIZATIONS



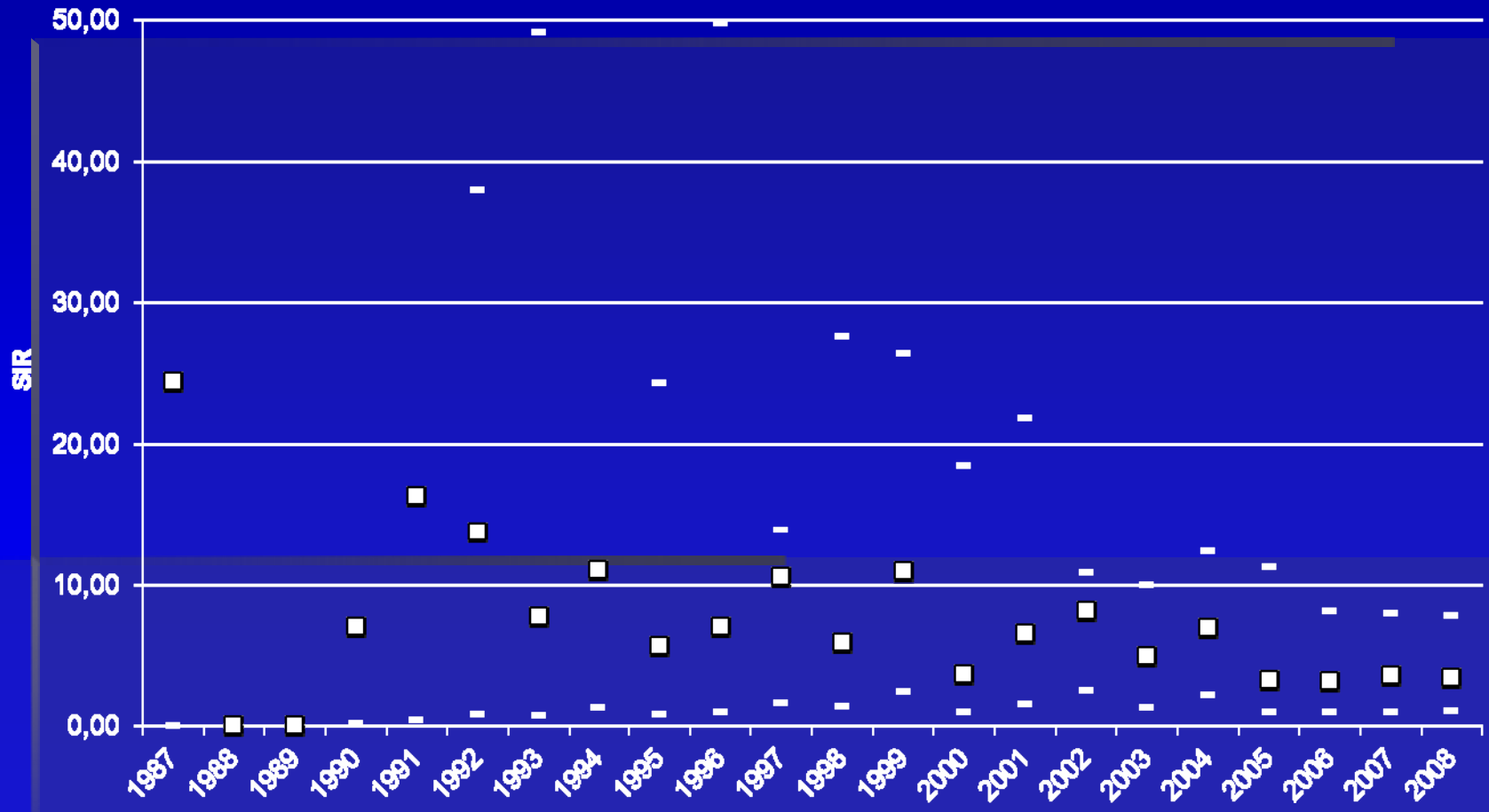
SIR MEANS IN DEPENDENCE ON AGE, MEN, ALL LOCALIZATIONS



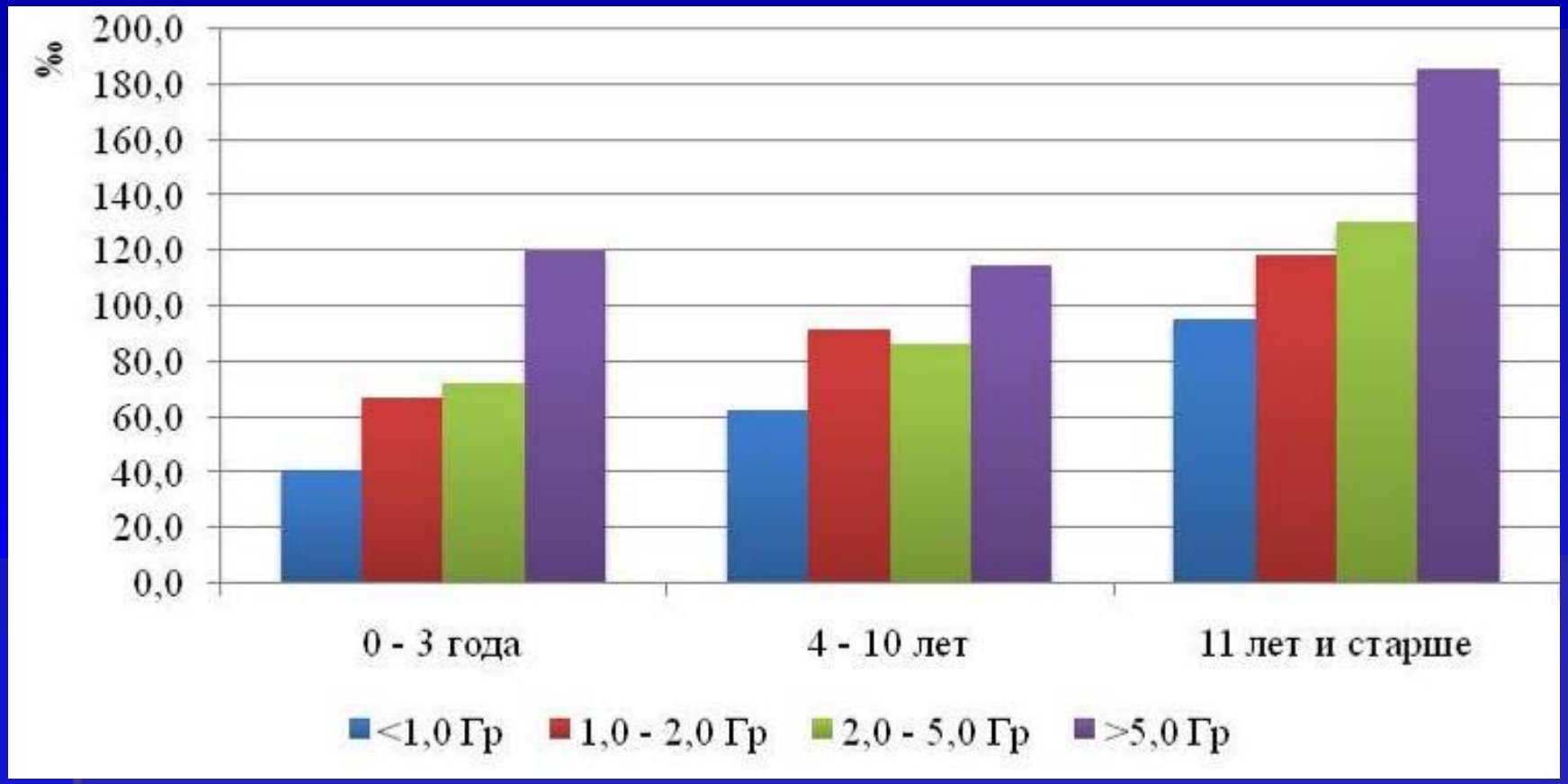
SIR DYNAMICS, MEN, SOLID CANCER (WITHOUT THYROID CANCER)



SIR DYNAMICS IN MALE LIQUIDATORS, THYROID CANCER



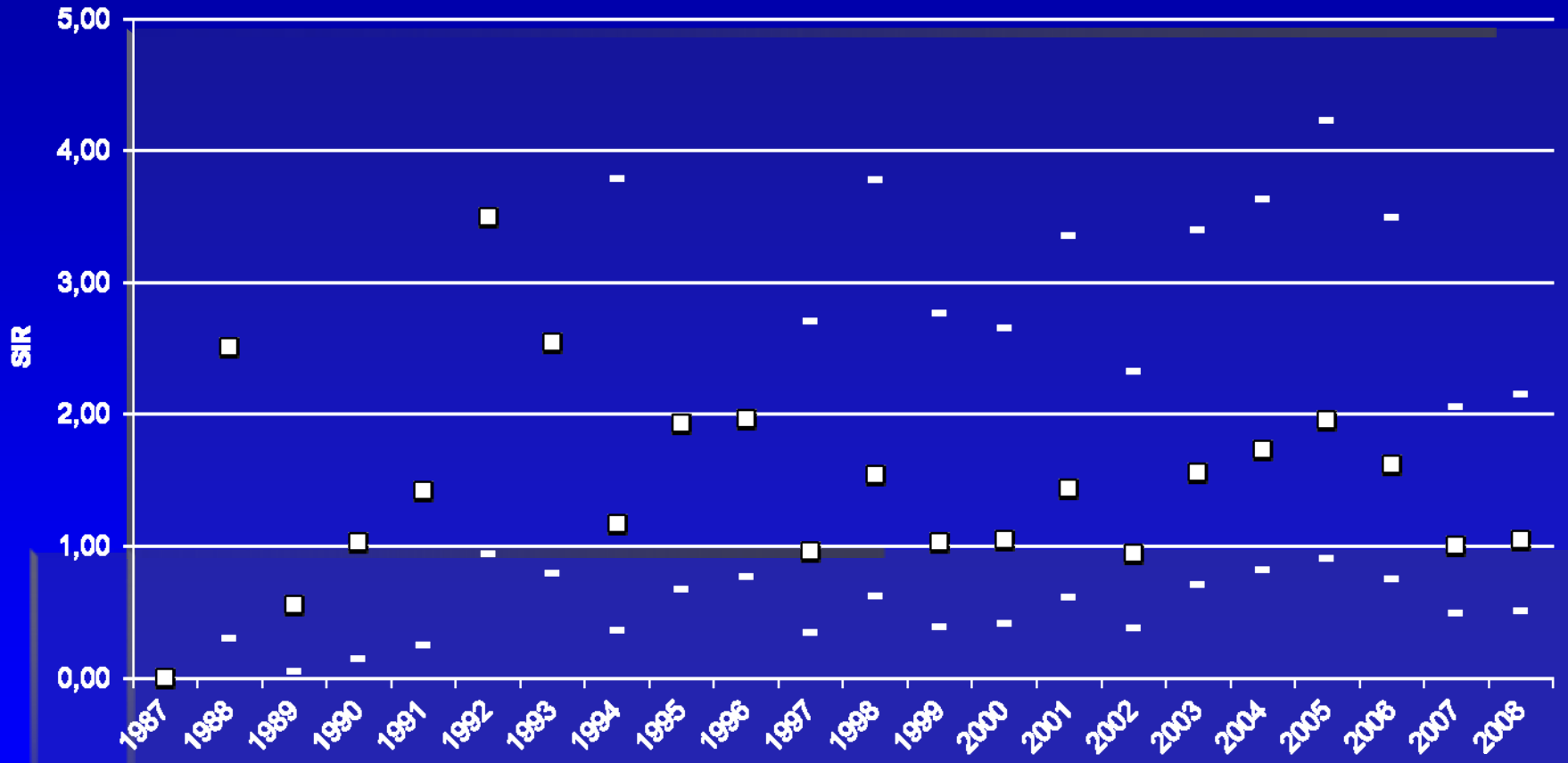
NODULES GOITER INCIDENCE RATE IN POPULATION DEPENDING ON AGE & IRRADIATION DOSES



RELATIVE RISK FOR THYROID PATHOLOGY IN CHILDREN AGED FROM 0 TO 3 IN TIME OF THE ACCIDENT

	MODEL	SEX	RISK EXCESS.	IT (95%, Wald)	P	ATTRIBUTIVE RISK,%
SINGLE NODULES GOITER	ERR	M	0,68	0,37÷0,98	<0,001	40,5
		W	0,19	0,05÷0,33	0,006	16,0
	EAR	M	9,61	5,25÷13,96	<0,001	
		W	5,08	1,43÷8,74	0,006	
MULTIPLE NODULES GOITER	ERR	M	1,28	0,26÷2,30	0,013	56,1
		W	1,07	0,36÷1,77	0,003	51,7
	EAR	M	2,79	0,57÷5,01	0,013	
		W	3,98	1,35÷6,61	0,003	
ADENOMATOZE GOITER	ERR	ALL	2,42	1,11÷3,72	<0,001	70,8
	EAR	ALL	2,80	1,29÷4,32	<0,001	
THYROID CANCER	ERR	M	11,59	6,42÷16,76	<0,001	92,1
		W	7,46	3,56÷11,37	<0,001	88,2
	EAR	M	7,69	4,26÷11,11	<0,001	
		W	5,65	2,70÷8,61	<0,001	
AIT	ERR	M	0,73	0,017÷1,44	0,045	42,2
		W	-0,002	-0,01÷0,06	>0,5	
	EAR	M	3,1	0,25÷5,87	0,045	
		W				

SIR HEMOBLASTOSISES DYNAMICS FOR MALE LIQUIDATORS



Cohort Relative Risk as a peculiarity of Gomel Region

sex	LOCALIZED	RR	SIR
men	ALL CANCER LOCALIZATIONS	1.07	1.09
	COLON CANCER	1.05	1.08
	SKIN CANCER	1.27	1.13
	KIDNEY CANCER	0.93	1.10
	BLADER CANCER	1.06	1.12
	HEMOBLASTOSISES	0.96	1.23
women	ALL CANCER LOCALIZATIONS	1.09	1.10
	SKIN CANCER	1.35	1.30
INDEPENDENCE DISTRIBUTION TEST χ^2(df=7) – 0,143; p =0.999988747			

RESULTS:

- In general, there is no significant increase of cancer cases among the suffered population except thyroid cancer;

- There is a relatively high risk of thyroid cancer not only in children & teenagers but also in adult suffered population.


КПП
ДИТЯТКИ

AUTHORS

Profs. *J. Kenigsberg, V.Kashparov, O.Vlasov,*

Drs. *A.Rozhko, M.Savkin, V. Masyakin*

REFERENCES

1. *International Chernobyl Project. Technical Report.- IAEA, Vienna, 1990*

2. *International Nuclear Safety Advisory Group.- IAEA, 1986*

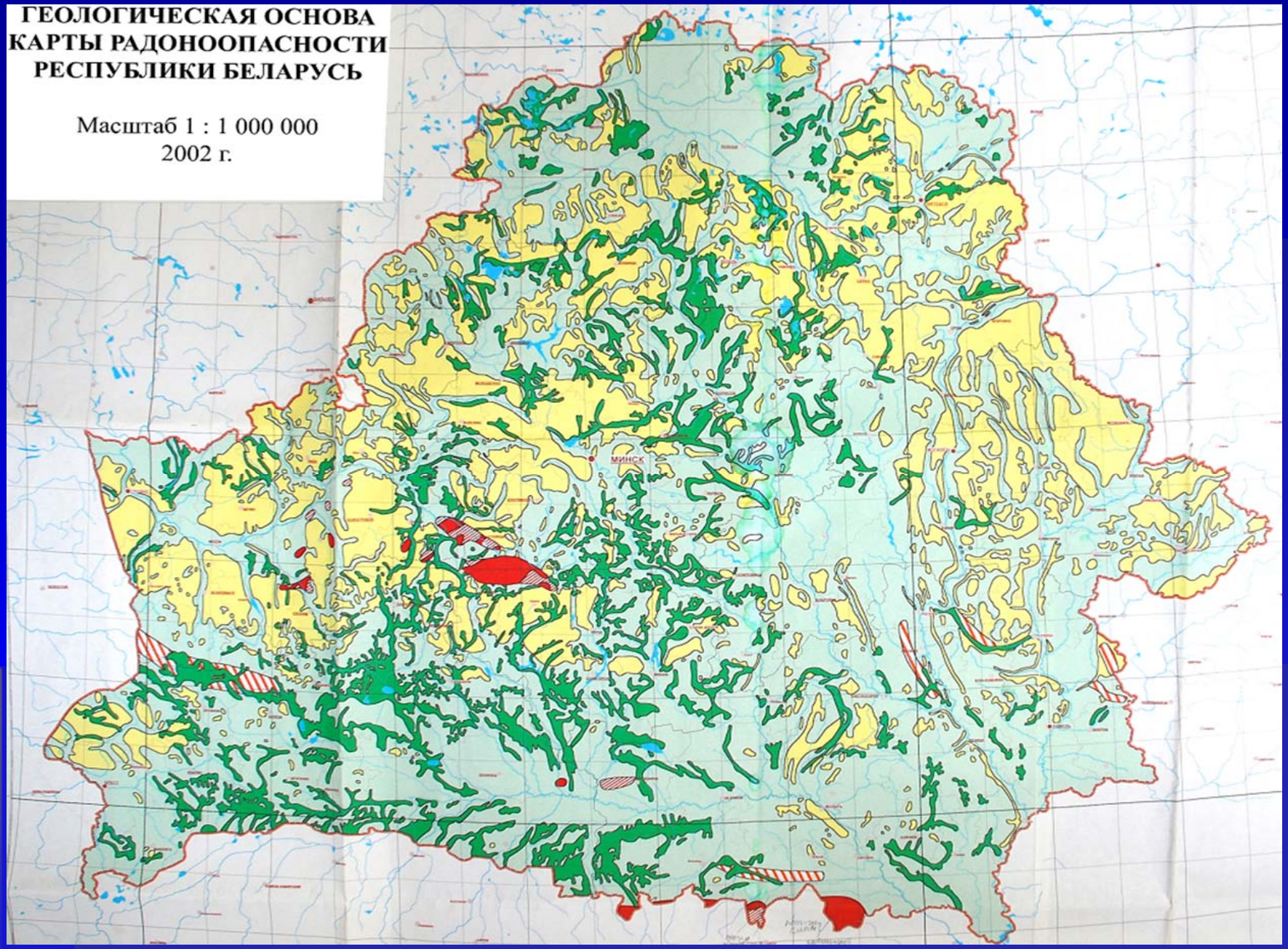
3. *National Report of Republic Belarus.- Minsk, 2011*

SOME ASPECTS OF RADON PROBLEM IN BELARUS

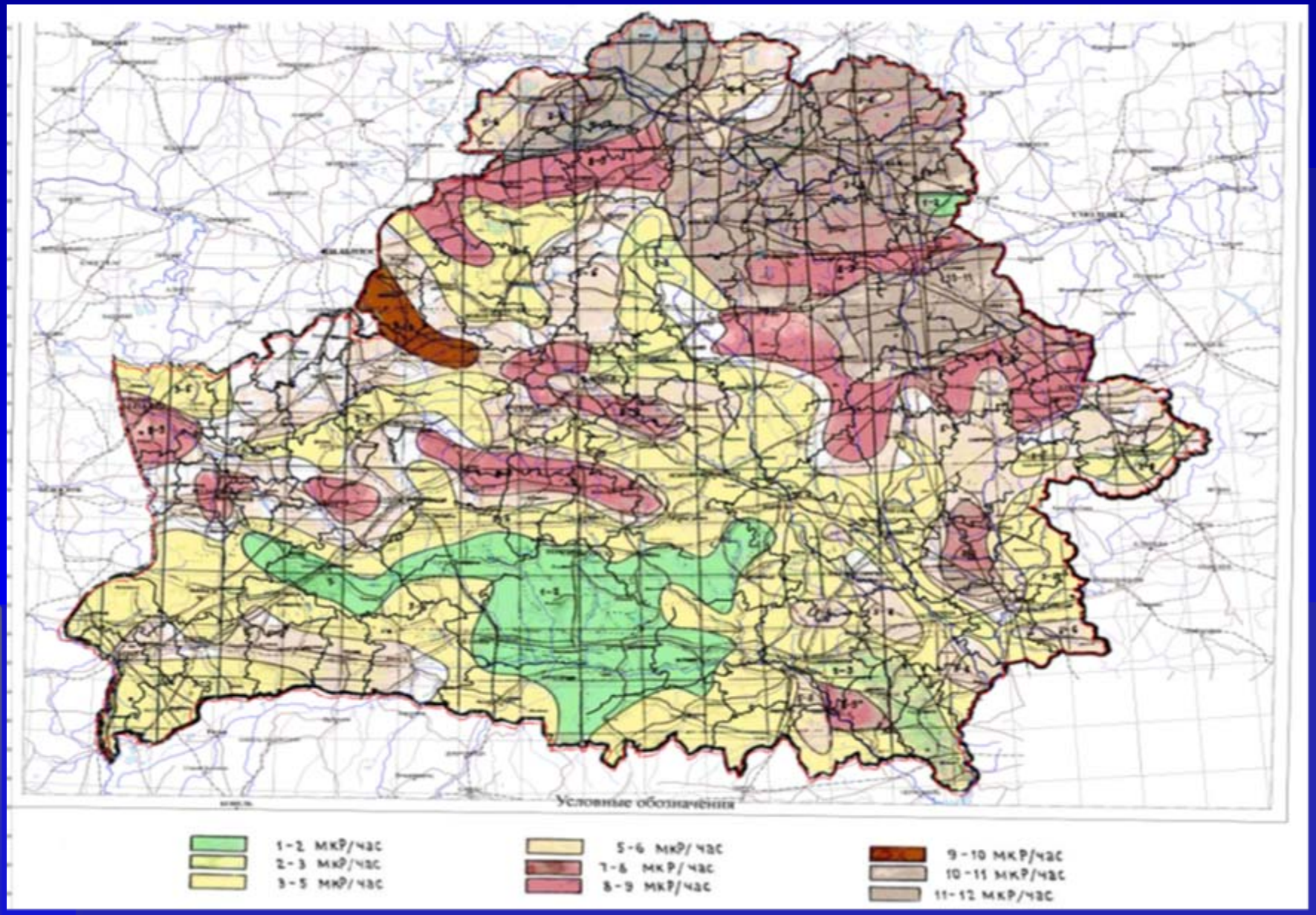
- We consider the radon problem in Belarus in connection with the problem of the contamination of Byelorussian territory after the Chernobyl accident.
- Southern, South-Eastern, South-Western territories of the country are the most contaminated with Chernobyl radionuclides.
- On the other hand, radon concentrations in the dwellings, soil air have the lowest levels in these regions.
- Northern, Western, Eastern Belarus and center of the country are the most radon-hazardous areas
- The soils of these regions have an insignificant Chernobyl radionuclide contamination level

To investigate the radiation exposure, we have to take into account the real radiation situation has been formed in the concrete place

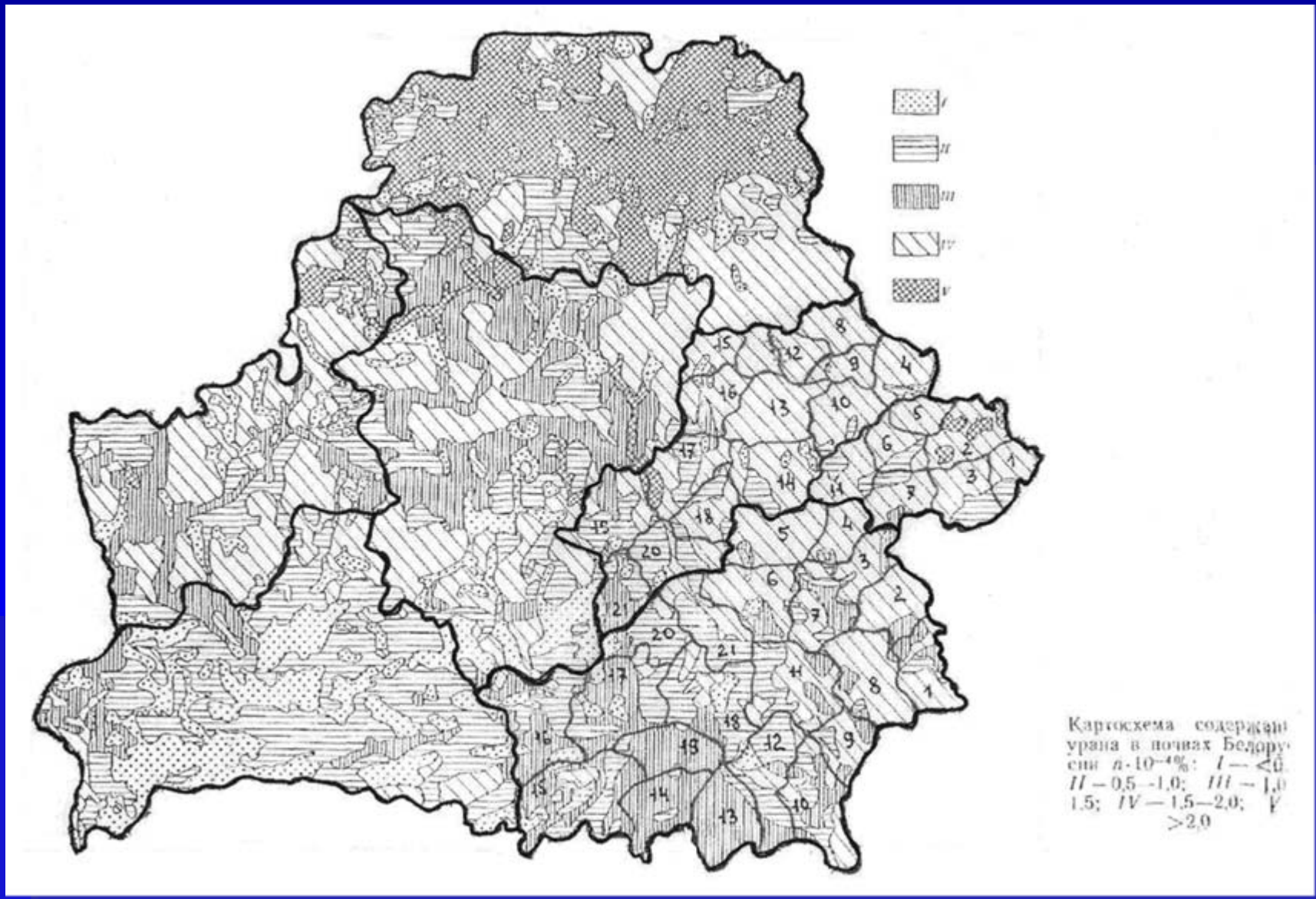
- There are no systematic investigations of the radon hazard problem in Belarus
- There is no radon map of the Byelorussian territory.


ГЕОЛОГИЧЕСКАЯ ОСНОВА
КАРТЫ РАДОНООПАСНОСТИ
РЕСПУБЛИКИ БЕЛАРУСЬ
Масштаб 1 : 1 000 000
2002 г.
МИНСК

BEFORE CHERNOBYL GAMMA-BACKGROUND MAP



MAP OF SOIL URANIUM CONTENTS IN BELARUS



REGRESSION OF LUNG CANCER INDEX ON THE URANIUM CONTENT IN SOIL

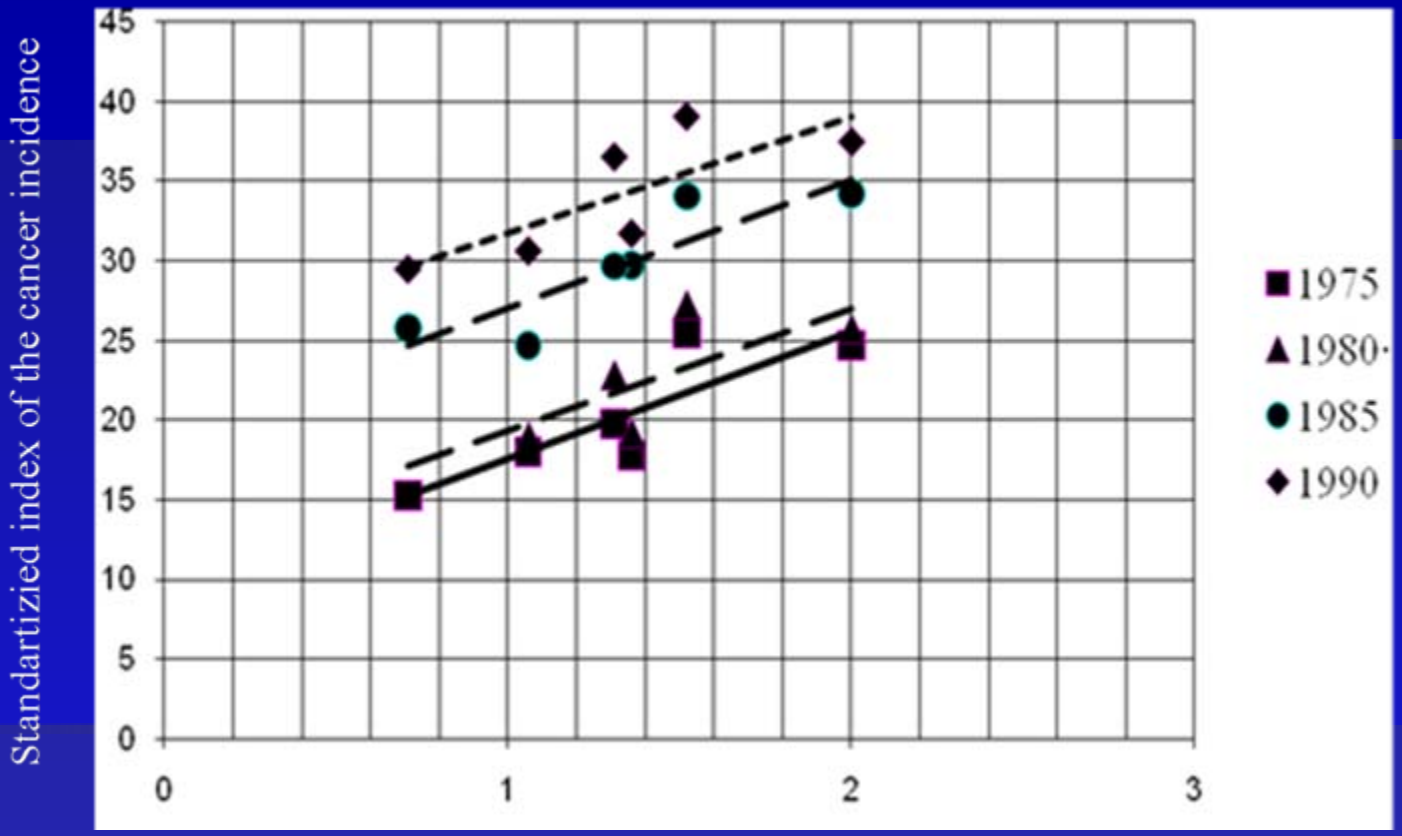


Figure 1 - Dependence of the lung cancer incidence index on the uranium concentration in the soils.

REGRESSION LUNG CANCER INDEX ON THE POWER DOSE

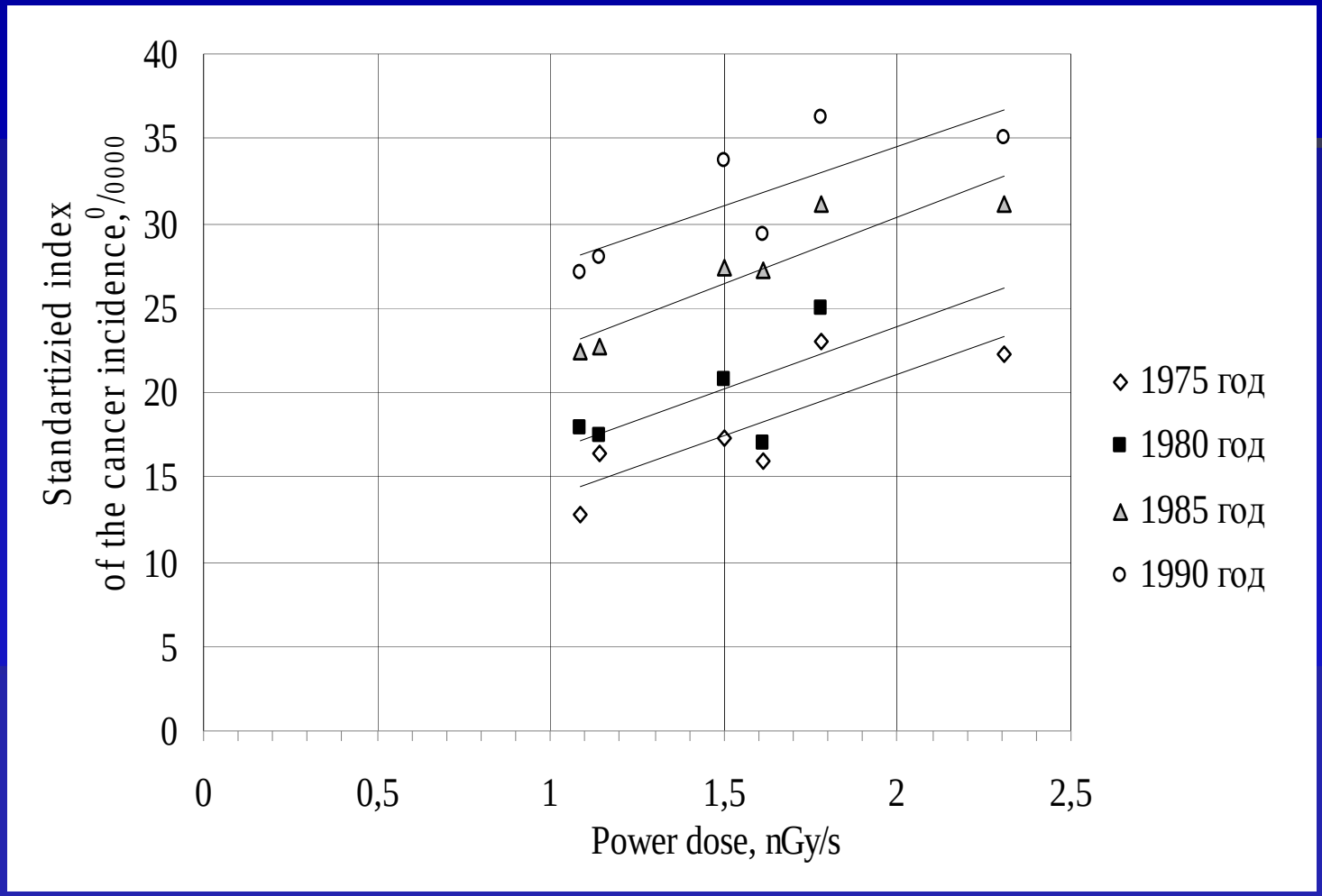


Figure 2- dependence of the lung cancer incidence index on the power dose

URANIUM CONTENTS IN SOIL REGRESSION ON POWER DOSE

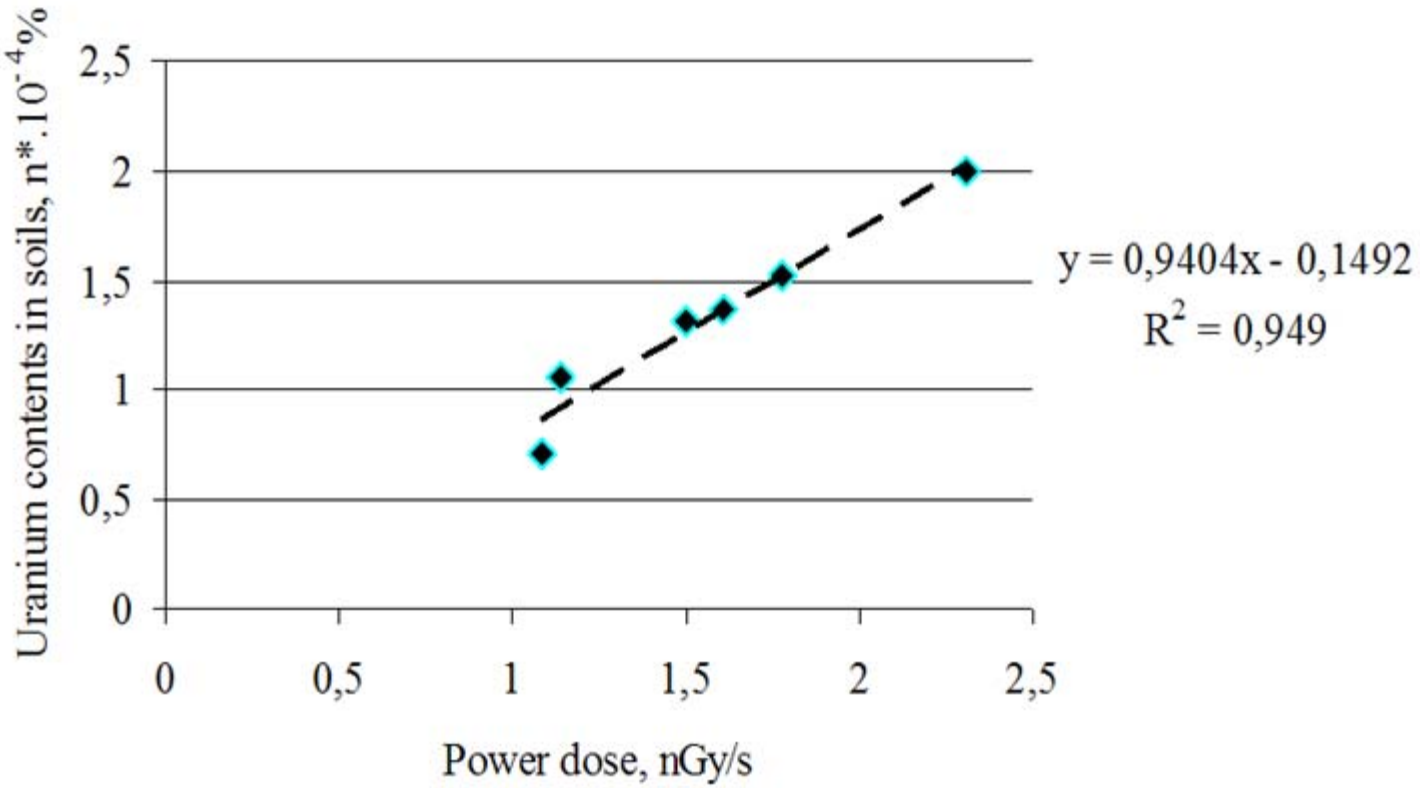
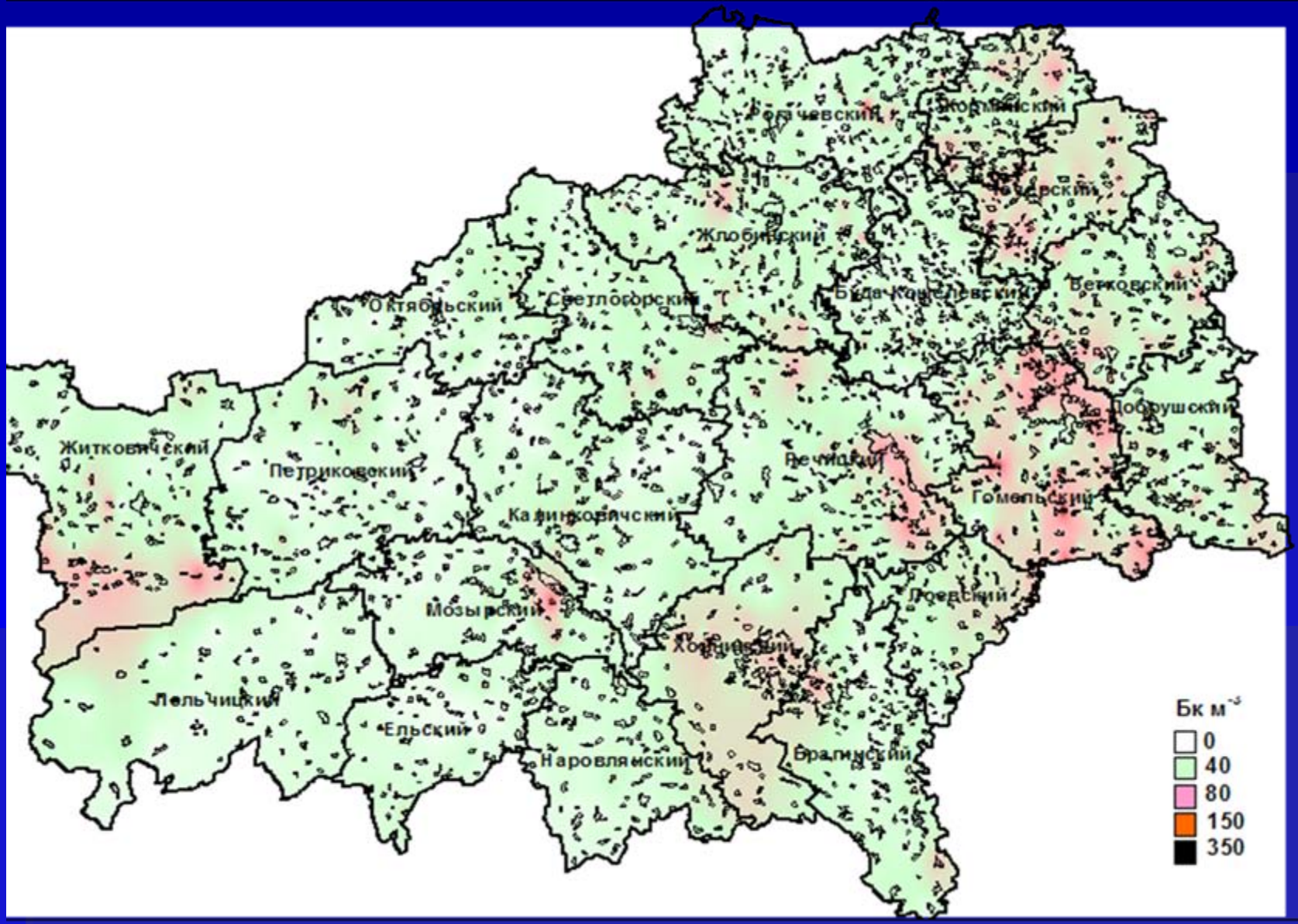
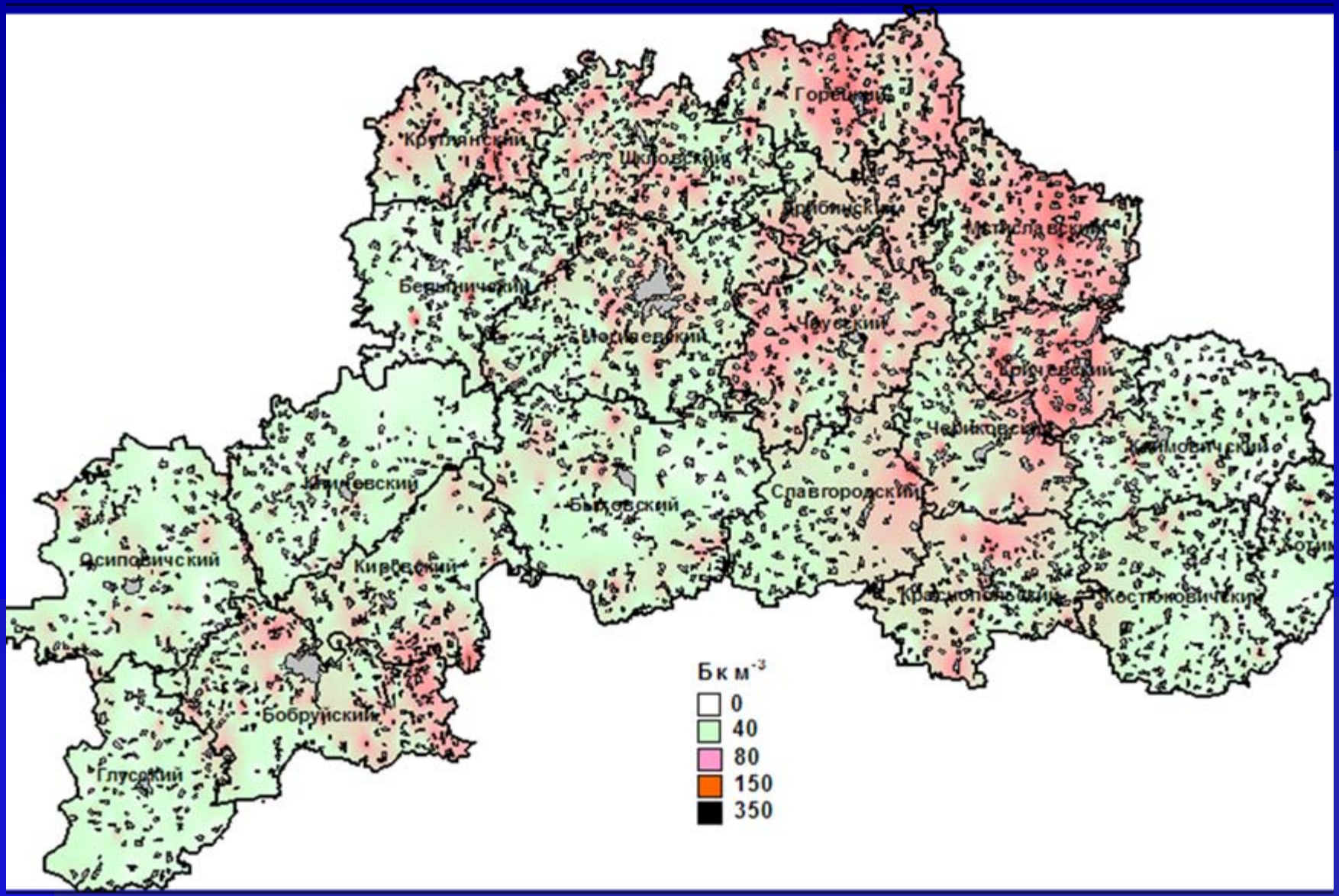


Figure 3 - Dependence of the weight-average uranium contents in the soils

GOMEL REGION RADON MAP



MOGILEV REGION RADON MAP



CONCLUSIONS:

- The lung cancer index regressions on the soil uranium concentration & power dose may be confirmed with the epidemiological investigations
- Such indirect factors as before-Chernobyl power doses & the soil uranium concentration may be used for the determination of critical zones in radon-hazard mapping.

СПАСИБО ЗА ВНИМАНИЕ

ДЗЯКУЮ ЗА УВАГУ

MUCHAS GRACIAS

THANK FOR YOUR ATTENTION