# Environmental aspects of nuclear energy

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Environmental aspects of energy

# Environmental aspects assesment

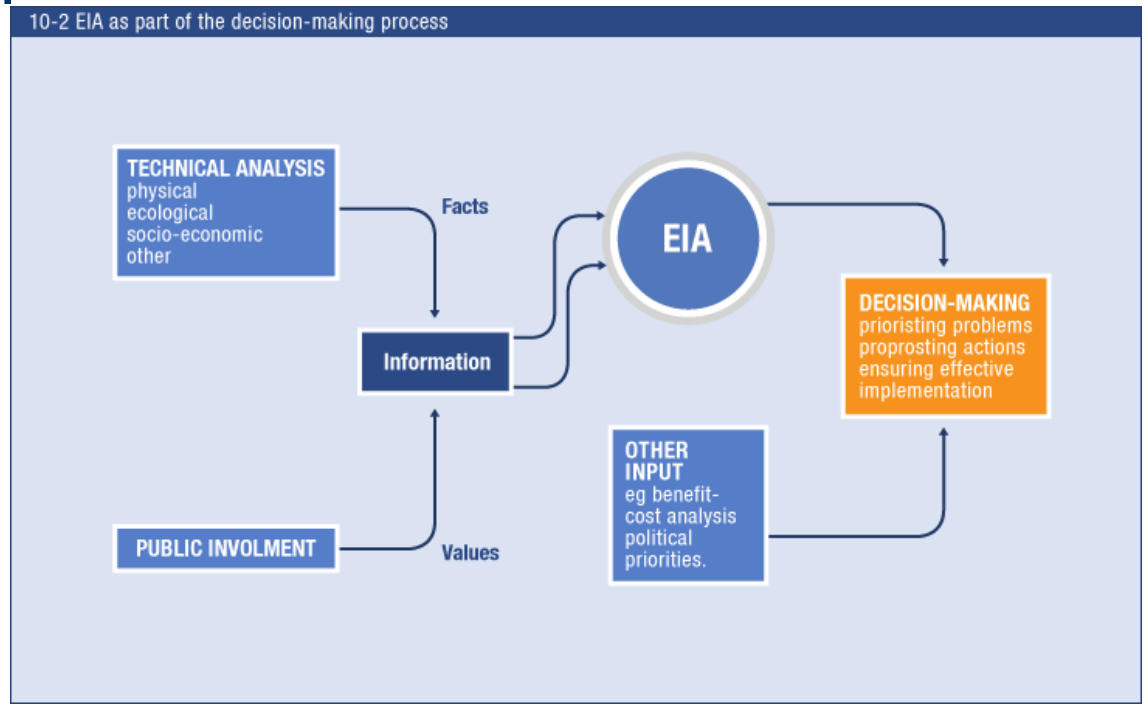
Over the next five minutes each of you write pros and cons of nuclear energy in terms of national energy security.

# Environmental aspects assesment

Over the next five minutes each of you write pros and cons of nuclear energy in terms of purely subjective, personnal point of view.

# Environmental aspects assesment

To bridge the conflict between state and industry interests and personal subjective perception of the problem serves the EIA.



# Environmental aspects assesment

What is an *environmental aspect* ?

According to ČSN EN ISO 14001 definition:

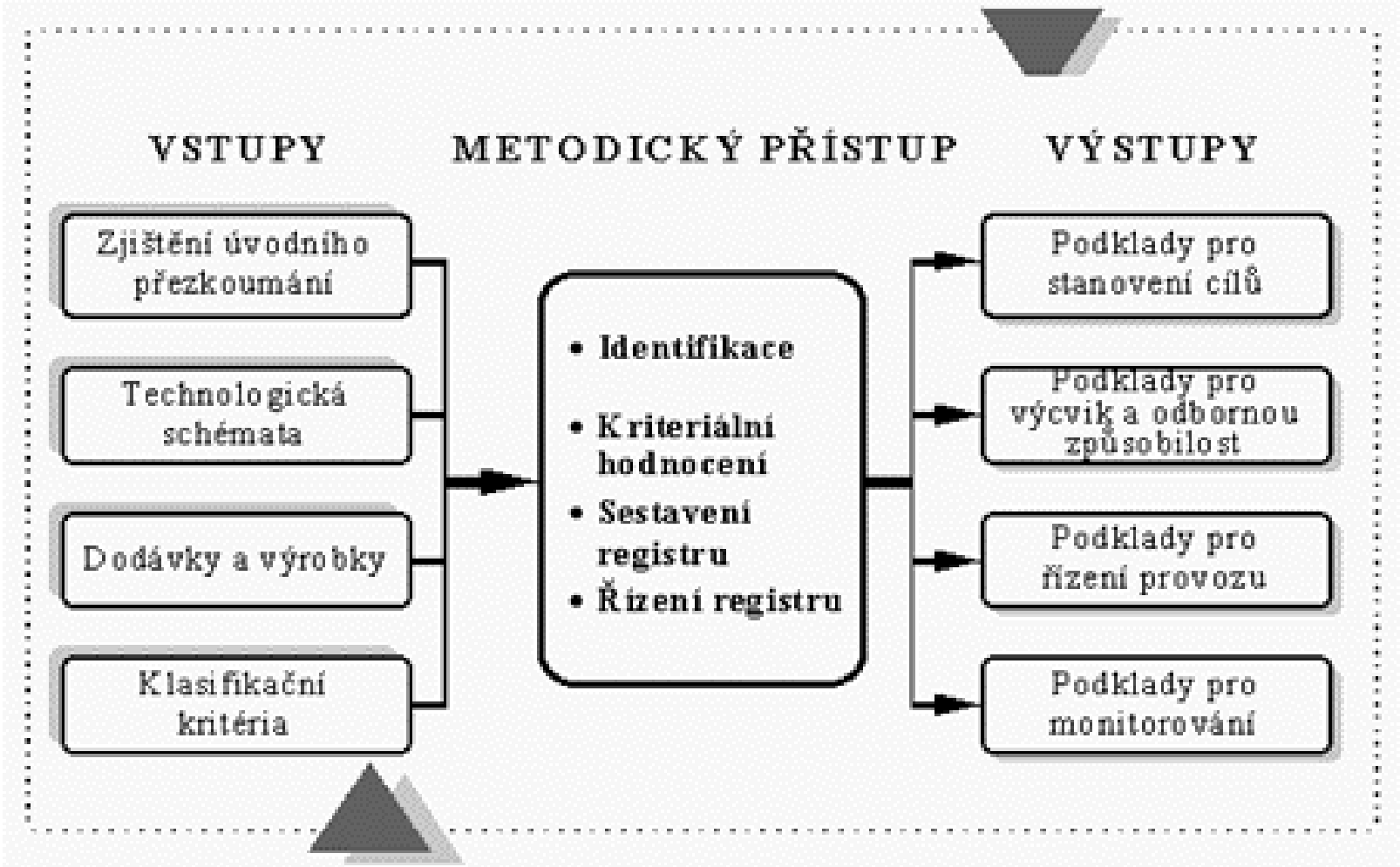
„The environmental aspect is an element of the activities, products or services that can interact with the environment.“

# Environmental aspects assesment

**ISO 14001** (voluntary norm of the International Organization for Standardization on environmental management, prestige of the company, the norm requires to have an **environmental policy and environmental risk assessment**)

**EMAS** (Environmental management and audit system developed by EC in 1993, it requires ISO 14001 and other requirements such as the involvement of employees, etc., EMAS is thus perceived as a **premium tool** for environmental management. As part of this process so called **Environmental review** takes place - own risk identification, preparation of environmental policy, determining environmental aspects, objectives, programs)

# Environmental aspects assesment



# Environmental aspects assesment

**Tabulka registru aspektů a dopadů – část A – přímé**

VEA – významný environmentální aspekt,NEA – nevýznamný environmentální aspekt, H- stav havarijní , B –běžný provoz, M – mimořádný stav S - součet

| Poř. Číslo | Místo vzniku (pracoviště, proces) | Činnost | Aspekt | Dopad | Provoz B/M/H | Významnost | L | D | P | S | Opatření,odpovědnost (měření, cíl atd.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ředitelství ZZS OK | administrativa | vznik sběrového papíru | čerpání přírodních zdrojů | B | NEA | 1 | 1 | 1 | 3 | optimalizace spotřeby papíru v administrativě |
| | | | spotřeba el. energie | čerpání přírodních zdrojů | B | NEA | 1 | 1 | 1 | 3 | nesvítit zbytečně, el. energii odebírat co nejrovnoměrněji |
| | | | spotřeba pitné vody | čerpání přírodních zdrojů | B | NEA | 1 | 1 | 1 | 3 | kontrolovat vypnutí kohoutků, neplýtvat pitnou vodou |
| | | | vznik odpadních splaškových vod | zátěž přírody v podobě odpadních vod | B | NEA | 1 | 2 | 1 | 4 | neznečišťovat splaškové vody závadnými látkami |
| | | | spotřeba zářivek | vznik nebezpečného odpadu | B | VEA | 1 | 2 | 2 | **5** | nesvítit zbytečně, zářivky opakovaně nezapínat a nevypínat ***EMS 1/2013*** |
| | | | spotřeba tonerů | vznik nebezpečného odpadu | B | VEA | 1 | 2 | 2 | **5** | maximální šetření při tisku dokumentů, zpětný odběr zajištěn smluvně |
| | | | vznik komunálního i ostatního odpadu | zátěž přírody v podobě ukládání odpadů | B | NEA | 1 | 1 | 1 | 3 | maximální množství obalů vracet k recyklaci, třídit odpady |

# Environmental aspects assesment

**Methodology for assessing the environmental aspects**

Assessment of the EA is performed using following 4 criteria.

Criteria:

-compliance with the limits and mandatory requirements

-frequency impact

-impact associated with the effects on the environment (size, persistence, scale)

-impact on society (its economy and image)

# Environmental aspects assesment

| klasifikace (K) | | 1 bod | 2 body | 3 body |
|---|---|---|---|---|
| kritérium č. | váha kritéria (V) | problém není nebo je malý | existuje problém | existuje zásadní problém |
| **1.** | 3 | limity a zákony jsou plněny nebo limity a zákony nejsou stanoveny | limity a zákony nejsou občas plněny nebo jejich plnění je na hranici limitu | limity a zákony nejsou plněny nebo jsou často překračovány |
| **2.** | 2 | výskyt dopadu je minimální a/nebo dopadu lze zabránit | výskyt dopadu je častý a/nebo dopadu lze částečně zabránit | výskyt dopadu je vysoký a/nebo dopadu nelze zabránit |
| **3.** | 2 | dopad se dá odstranit a/nebo ovlivnění ŽP je minimální a není trvalé a/nebo ovlivnění ŽP je v lokálním měřítku | dopad se dá částečně odstranit a/nebo ovlivnění ŽP je velké ale není trvalé a/nebo ovlivnění ŽP je v regionálním měřítku | dopad se nedá odstranit a/nebo ovlivnění ŽP je trvalé a/nebo ovlivnění ŽP je v globálním měřítku |
| **4.** | 1 | EA nemá vliv na společnost (neohrožuje ani nezatěžuje její ekonomiku) a/nebo není příčinou stížností a/nebo dopad EA není viditelný | EA má vliv na společnost (zatěžuje její ekonomiku) a/nebo ojediněle je příčinou stížností a/nebo dopad je viditelný | EA má významný vliv na společnost (významně zatěžuje její ekonomiku) a/nebo v minulosti byly stížnosti a/nebo v lokalitě má společnost špatné jméno |

# Environmental aspects assesment

| | |
|---|---|
| **Important EA** | Over value less equals or higher then 15<br>(and all rated 3 in criterium 1) |
| **Not important EA** | Over value less than 15 |

**EIA** (Environmetal Impact Assessment, all projects that could have a negative impact on public health, flora, fauna, ecosystems, soil, air, but also on cultural heritage, natural resources or assets, are within the scope of the assessment according to the law - a list of projects is given in Annex Law)

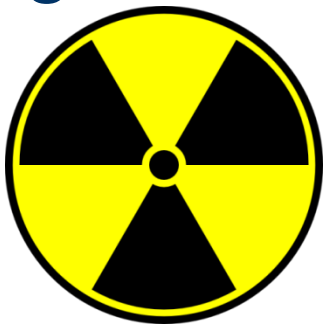
# Environmental aspects assesment

The process is:

- announcement to the authorities (Region, ME)
- official publication/announcement by the competent authorities
- 20-day deadline for comments
- screening procedure
- documentation
- preparing the report (90 days)
- Comments (30 days)
- the final opinion as a professional basis for related procedures (eg. land, construction) valid for 5 years and with the possibility of extension

# Nuclear energy in general

- **production of fissile materials**
- production of electricity in nuclear power plants
- release of nuclear energy from the atomic nucleus
- chain fission in nuclear fuel
- accompanying phenomenon - **ionizing radiation**



# Production of fissile materials

Mining in the open pit mines:

- extraction in open pit mines very similar to coal production
- generally the least impact on the environment with respect to other methods of mining
- extraction of nuclear fuel is just as harmful as other methods of mining
- intervention in the landscape depends on the amount of ore and yield (percentage of) nuclear fuel

# Rössing, Namibia

# Brown coal production – chateau Jezeří

# Uranium production – Rožná

# Production of fissile materials

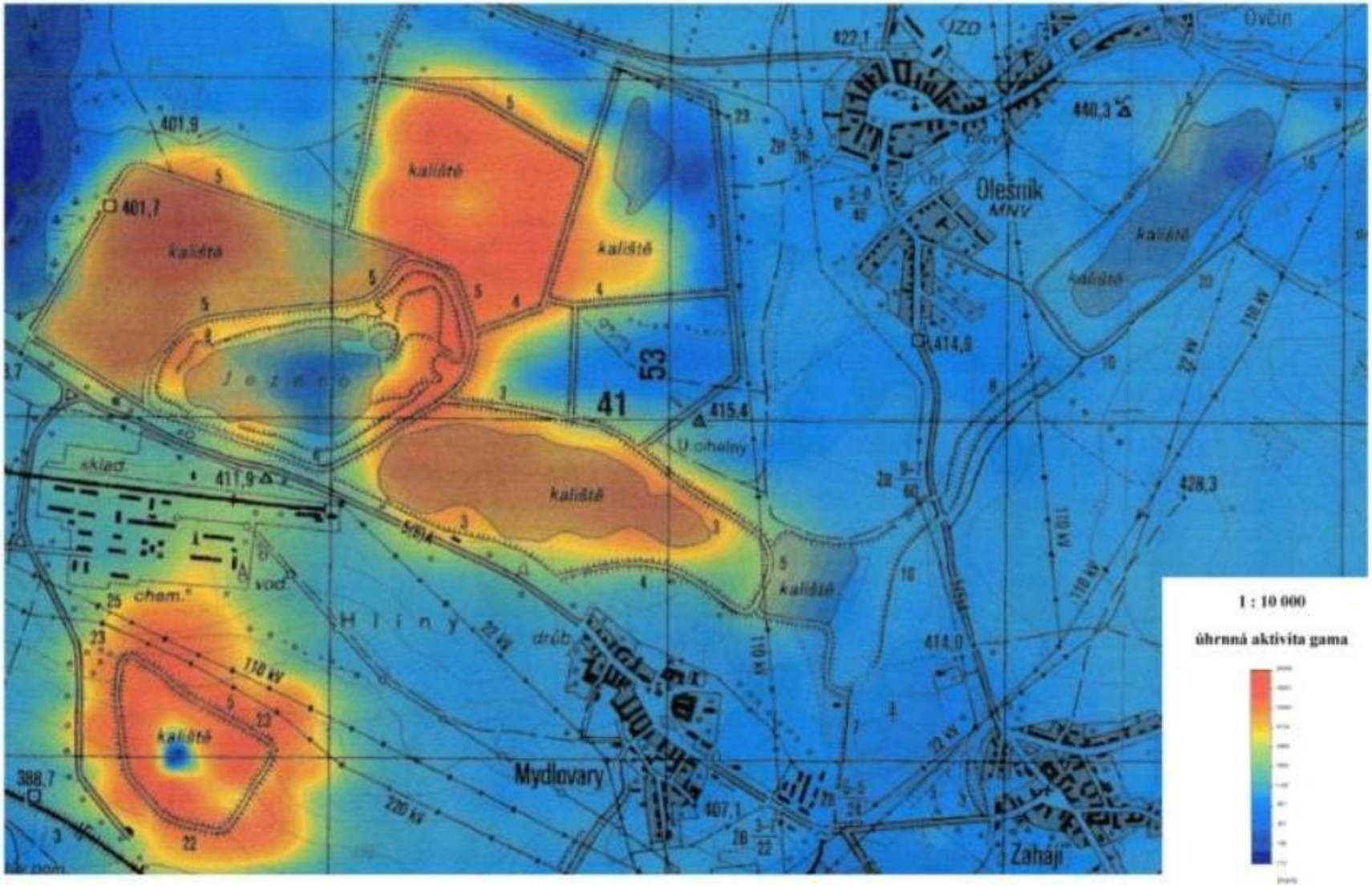
Chemical processing of mined ore (Mydlovary MAPE, 20 km from ETE):

- leaching with sodium bicarbonate (higher content of carbonates) or sulfuric acid (reduced content of carbonates)
- ratio of sulfuric acid up to 560 g of 94% acid per one liter of the leached material
- processed 16.7 mil. tonnes of ore, formation of tailing ponds with a total area of 300 ha - 36 mil. tonnes of sludge
- heavy metals and radioactive substances

# Production of fissile materials

# Radiokontaminace půd a sedimentů:

Uran, alfa zářiče, radon apod.



# Production of fissile materials

# Production of fissile materials

Underground mine in Straz pod Ralskem

- 1966-1970 first attempts introducing methods of chemical leaching
- until the early 90s leaching fields with a total area of 7 km2
- during the entire period of the chemical extraction of underground injected more than 4 mil. tons of sulfuric acid

# Production of fissile materials

Underground mine in Straz pod Ralskem

- contamination has spread to an area covering about 27 km2
- affected 370 mil. m3 of groundwater
- currently the contamination in an amount of 4.9 mil. t of solutes
- beginning of restoration

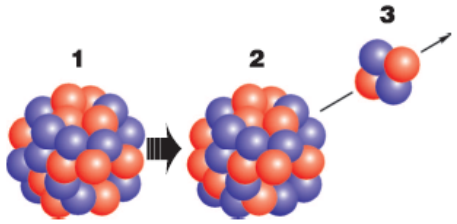
# Restoration – Stráž pod Ralskem (DIAMO)

- restate geological environment to the state that will ensure exploitation of drinking water in the region
- dispose of wells and surface facilities
- incorporate the surface of extracted fields in ecosystems with regard to regional systems of ecological stability
- several stages of redevelopment, estimated cost of 40 billion CZK

# Radioactivity

- radioactivity (or radioactive decay) is the spontaneous transformation of nuclei unstable nuclides other cores
- at the same time it generates ionizing radiation
- natural or artificial radioactivity
- transmutation
- decay of nuclei by decay series and the established principles

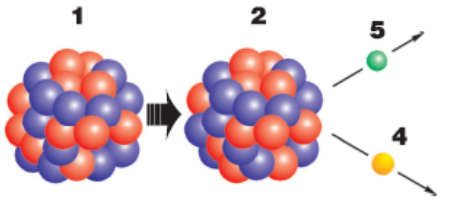
# Radioactivity




**PŘEMĚNA ALFA**

$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$

$^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{4}_{2}He$

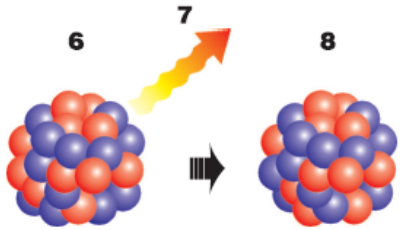



**PŘEMĚNA BETA**

$^{137}_{55}Cs \rightarrow {}^{137}_{56}Ba + e^{-} + \tilde{\nu}$

$n \rightarrow p^{+} + e^{-} + \tilde{\nu}$

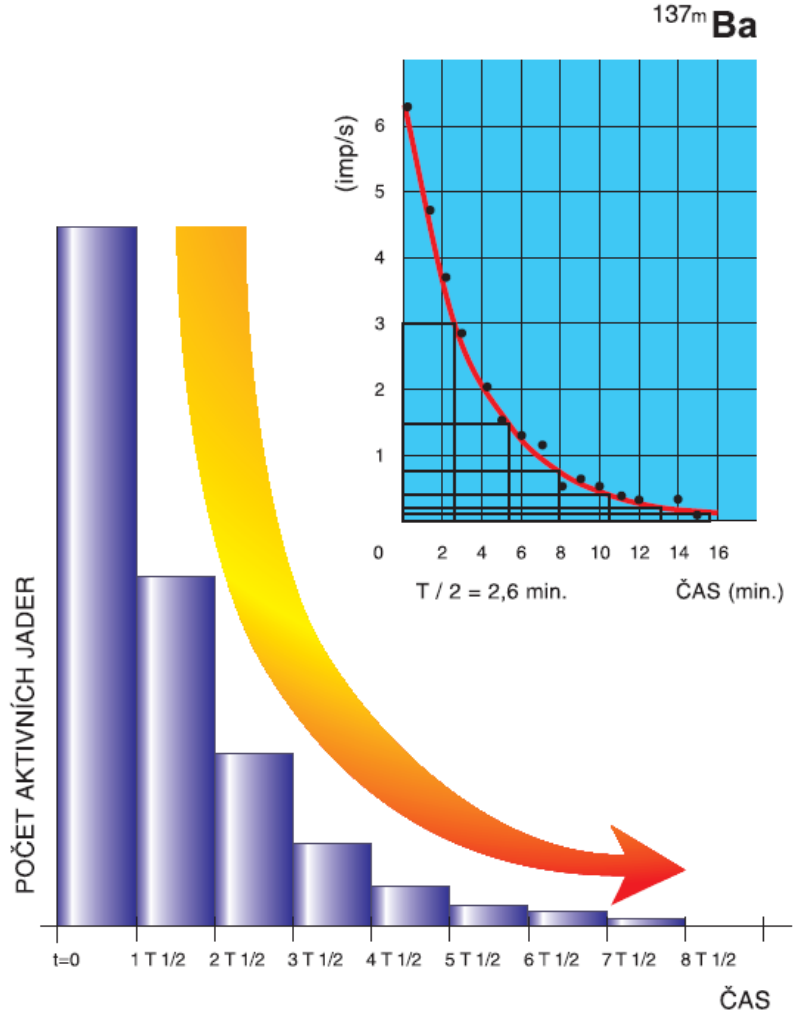
$p^{+} \rightarrow n + e^{+} + \tilde{\nu}$




**PŘEMĚNA GAMA**

$^{222}_{86}Rn^{excit.} \rightarrow {}^{222}_{86}Rn^{stabil.} + \gamma$

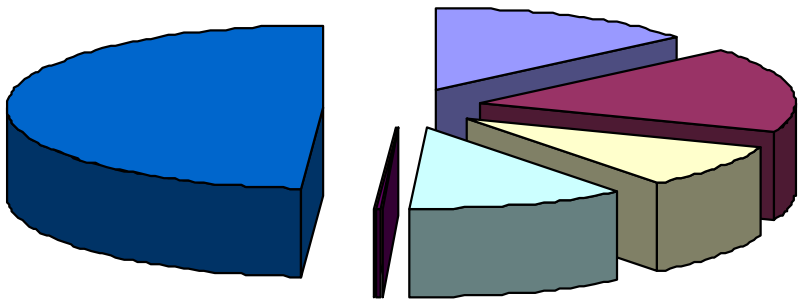
1. MATEŘSKÉ JÁDRO
2. DCEŘINÉ JÁDRO
3. $\alpha$ ČÁSTICE
4. ELEKTRON ($\beta^{-}$)
5. ANTINEUTRINO ($\tilde{\nu}$)
6. EXCITOVANÉ JÁDRO
7. $\gamma$ ZÁŘENÍ (fotony)
8. STABILIZOVANÉ JÁDRO



# Radioactivity

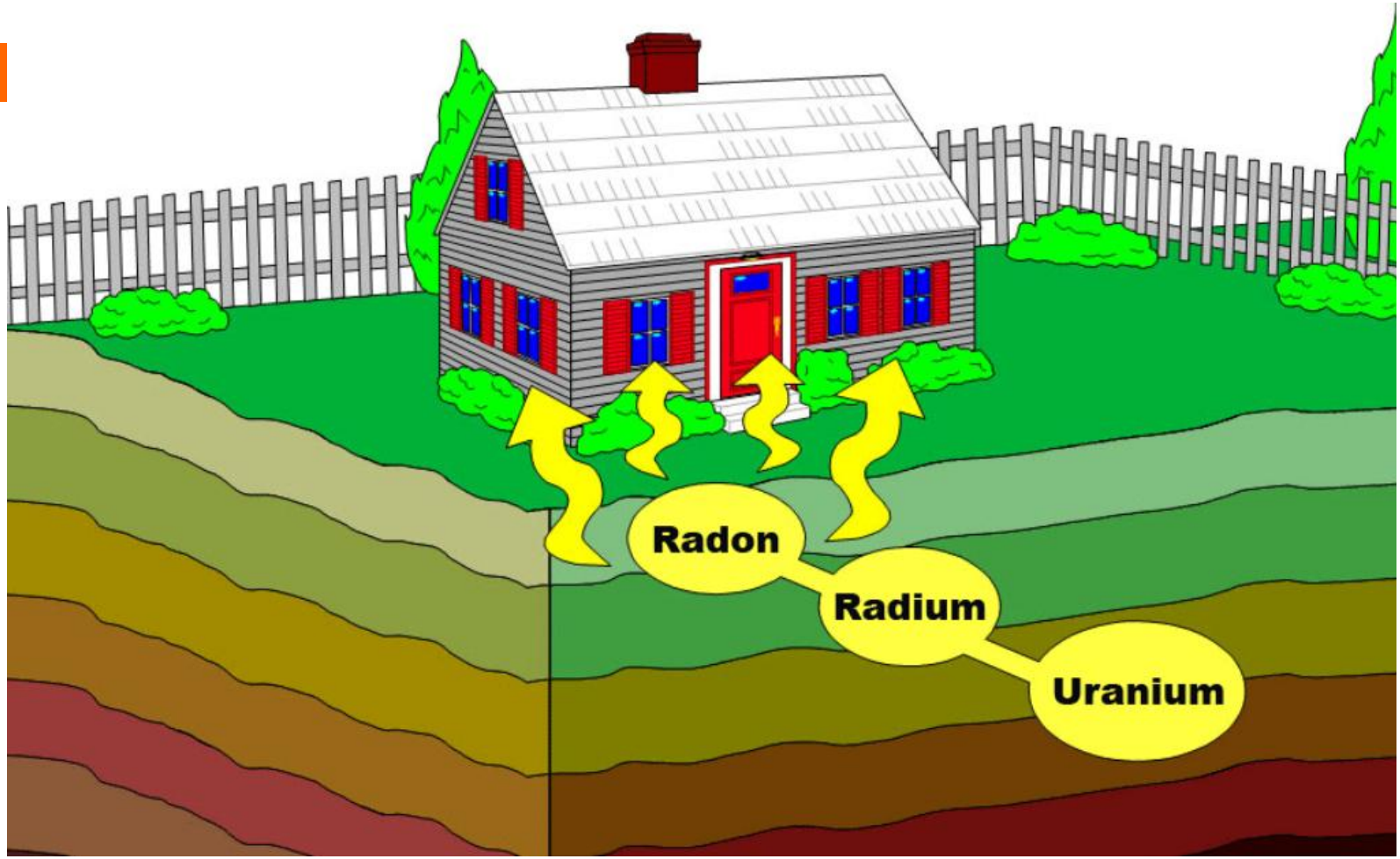
- **cosmogenic radionuclides**: tritium $^{3}H$ (half-life 12,5 years), carbon $^{14}C$ (half-life 5730 years)
- **Primary radionuclides** : potassium $^{40}K$ (half-life $1{,}26 \times 10^{9}$ years), thorium $^{232}Th$ (half-life $1{,}4 \times 10^{10}$ years), uranium $^{238}U$ (half-life $4{,}5 \times 10^{9}$ years), $^{235}U$ ($7 \times 10^{8}$ years)
- **Secondary radionuclides**: radionuclides of decay series – thorium, uranium, aktinouranium, neptunim

# Sources of radiation



- Kosmické zářežní - 14 %
- Záření z půdy a hornin - 17 %
- Přírodní radionuklidy v lidském těle - 9 %
- Lékařství - 11 %
- Spad z testů jad. zbraní - 0,3 %
- Jiné - 0,13 %
- Radon v domech - 49 %

# Radon



# Nuclear energy safety and environmental aspects

- the use of nuclear energy is regulated by law
- Nuclear safety is not a mere formality, it is an enforceable requirement
- All effects are monitored and evaluated
- responsibility is transferred to the operator's license holder

# Nuclear safety – deep protection

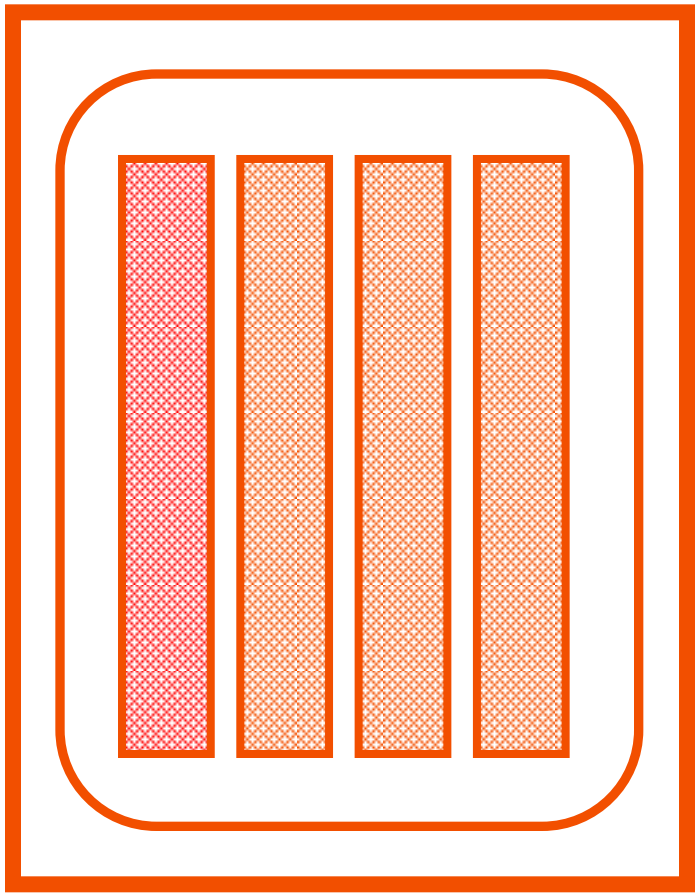
**Deep protection = means to achieve the basic objective of safety**

First barrier: **molecular matrix fuel** (almost all the fission products resulting from fission are captured in the matrix of the uranium tablets)

Second barrier: **hermetic fuel cladding** (an alloy of zirconium-niobium)

Third barrier: **the primary circuit pressure limit** (resistant to high pressure, temperature, radiation and radiation dynamic conditions of operation)

Fourth barrier: **hermetic borders of rooms - containment** (building design protection, resists airplane crash, blast wave, explosion, storm, extreme temperatures, extreme precipitation, etc.)



# Operation of nuclear power plant

- nuclear fission
- necessary operating conditions
- waste production
- disposal of spent nuclear fuel

All the above can be part of the process or source of ionizing radiation.

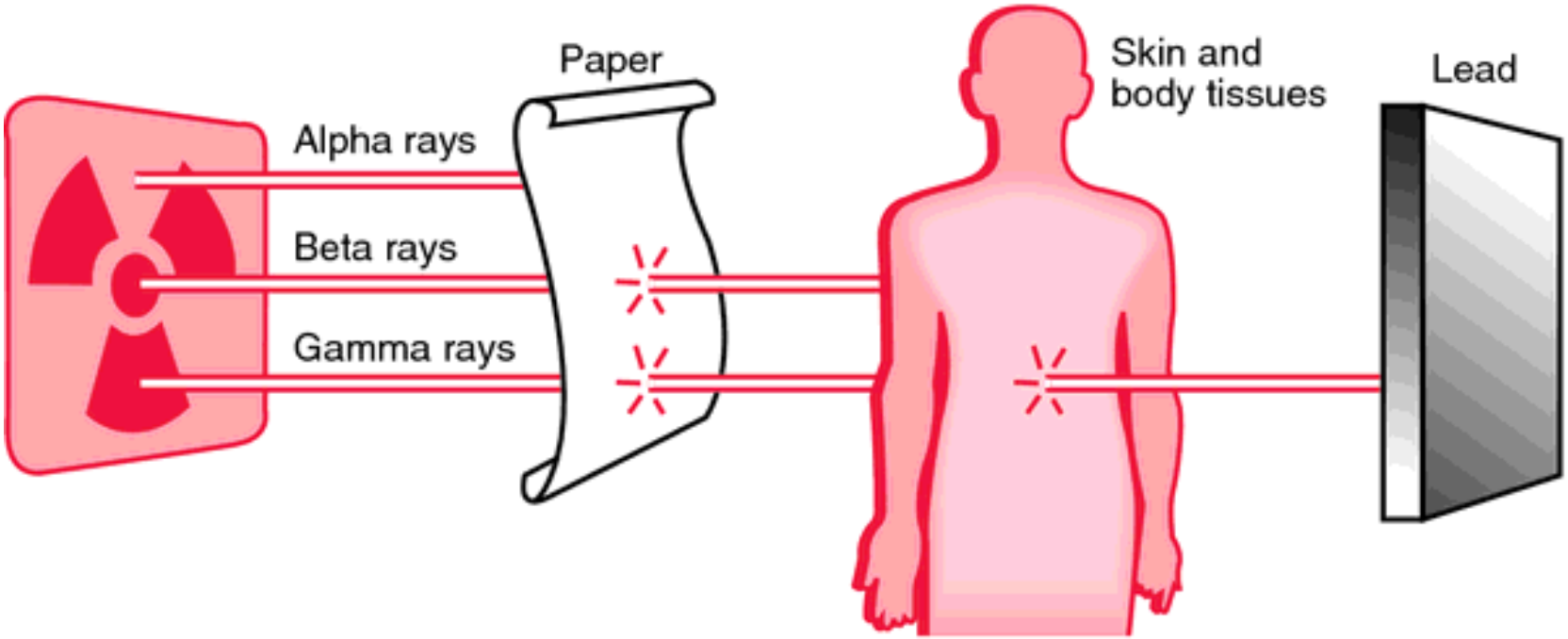
# Protection against radiation

**Distance -** ionizing radiation intensity decreases with the square of the distance, ie. after 10 m it is 100 times lower, after 100 m it is 10000 times lower, after 1 km it is a million times lower.

**Time -** the shorter the exposure, the smaller the cumulative dose

**Shielding** - depending on the type of radiation: alpha radiation skin tones, clothing, paper; beta radiation, aluminum sheet; gamma rays concrete, a layer of water, soil; neutron radiation, water, polystyrene, paraffin.

# Protection against radiation



# Protection against radiation

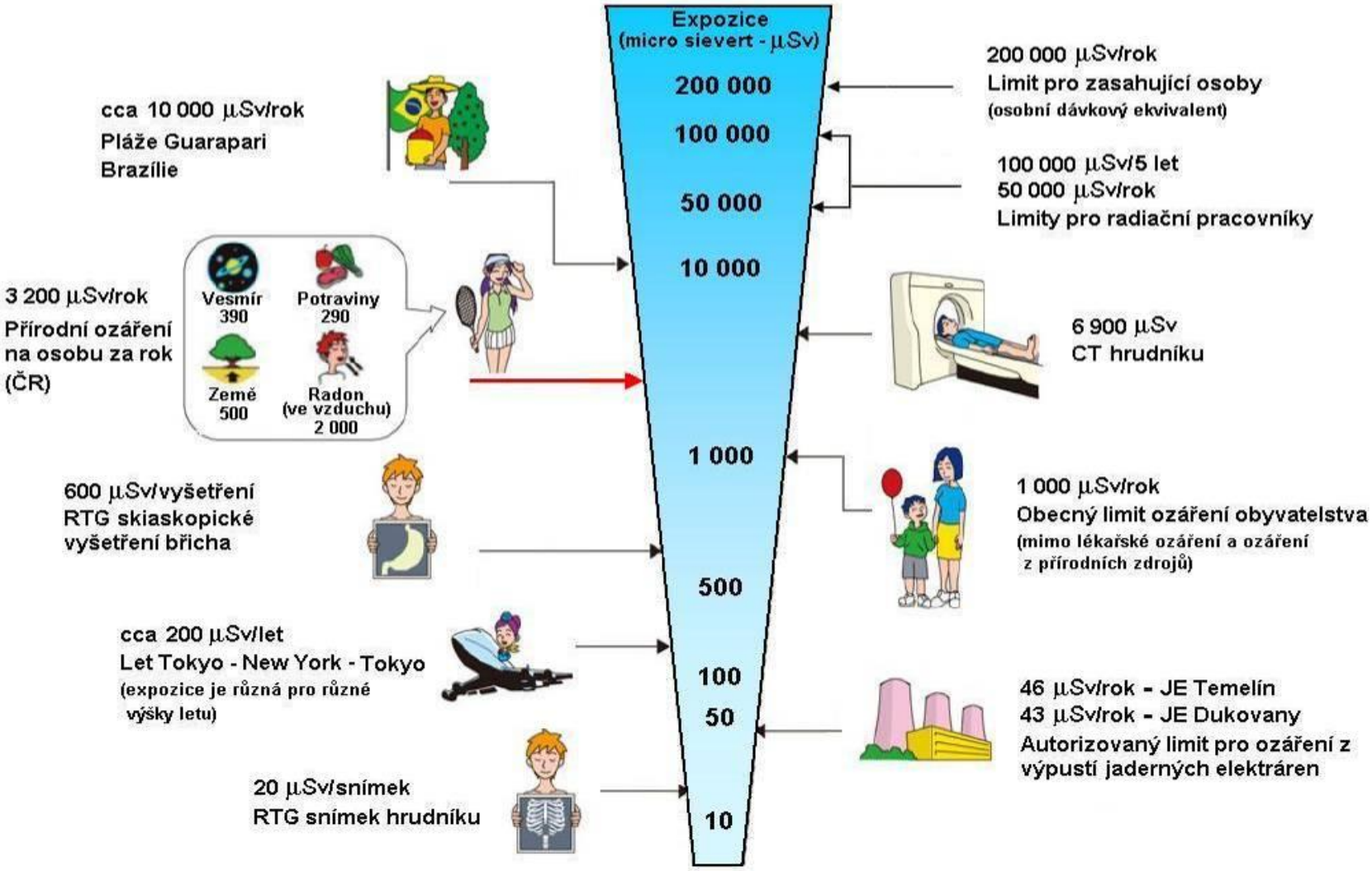
**Objective of the radiation protection**

**To ensure that during normal operation the radiation exposure inside the device and/or the release of radioactive materials into the environment is as low as reasonably achievable, taking into consideration economic and social factors and prescribed limits and ensure mitigate the extent of exposure to radiation accidents.**

**The principle of ALARA**

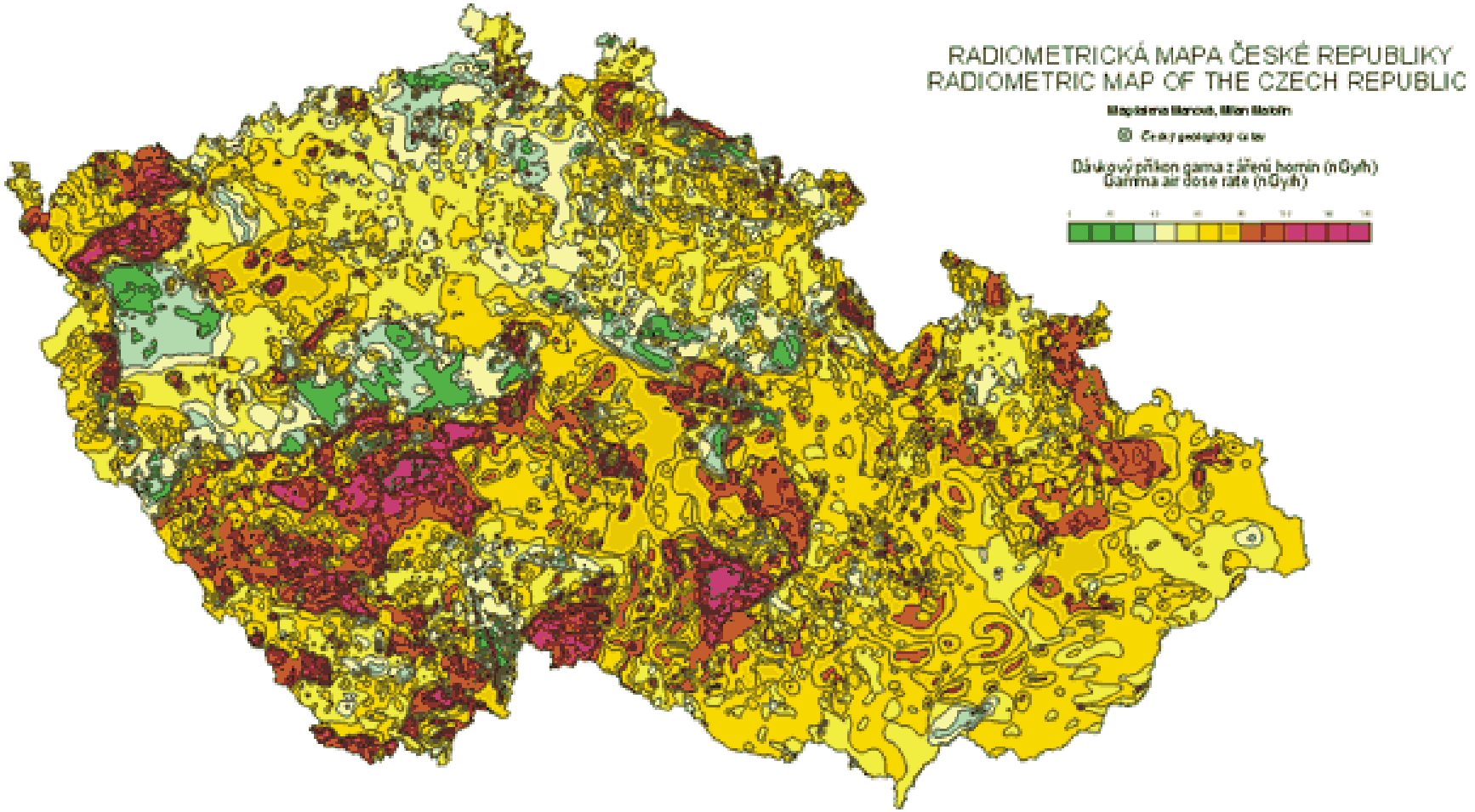
- **Observe the rules and seek new and better ways of performing work**
- **Already applied in the design**

# Příklady expozic ionizujícímu záření včetně limitů platných v ČR

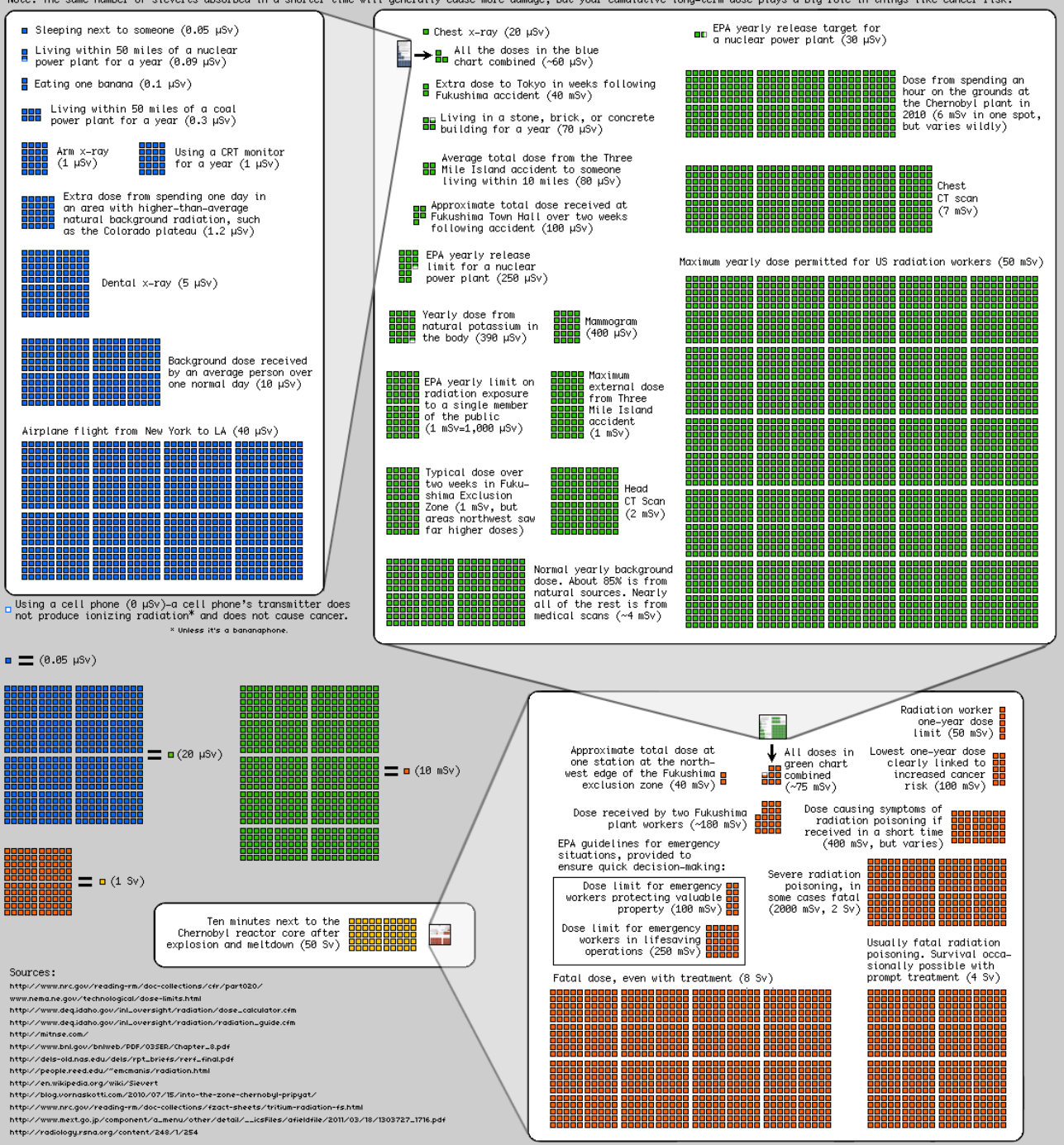



**Průměrný dávkový příkon z přírodního pozadí v ČR: 0,14 µSv/h = 1226,4 µSv/rok**

| | |
|---|---|
| Czech Republic | - cca 3 mSv/year |
| Iran (Ramsar) | - up to 400 mSv/year |
| India (Kerala) | - up to 17 mSv/year |
| Brazil (Guarapari) | - up to 175 mSv/year |



# Protection




Sources:

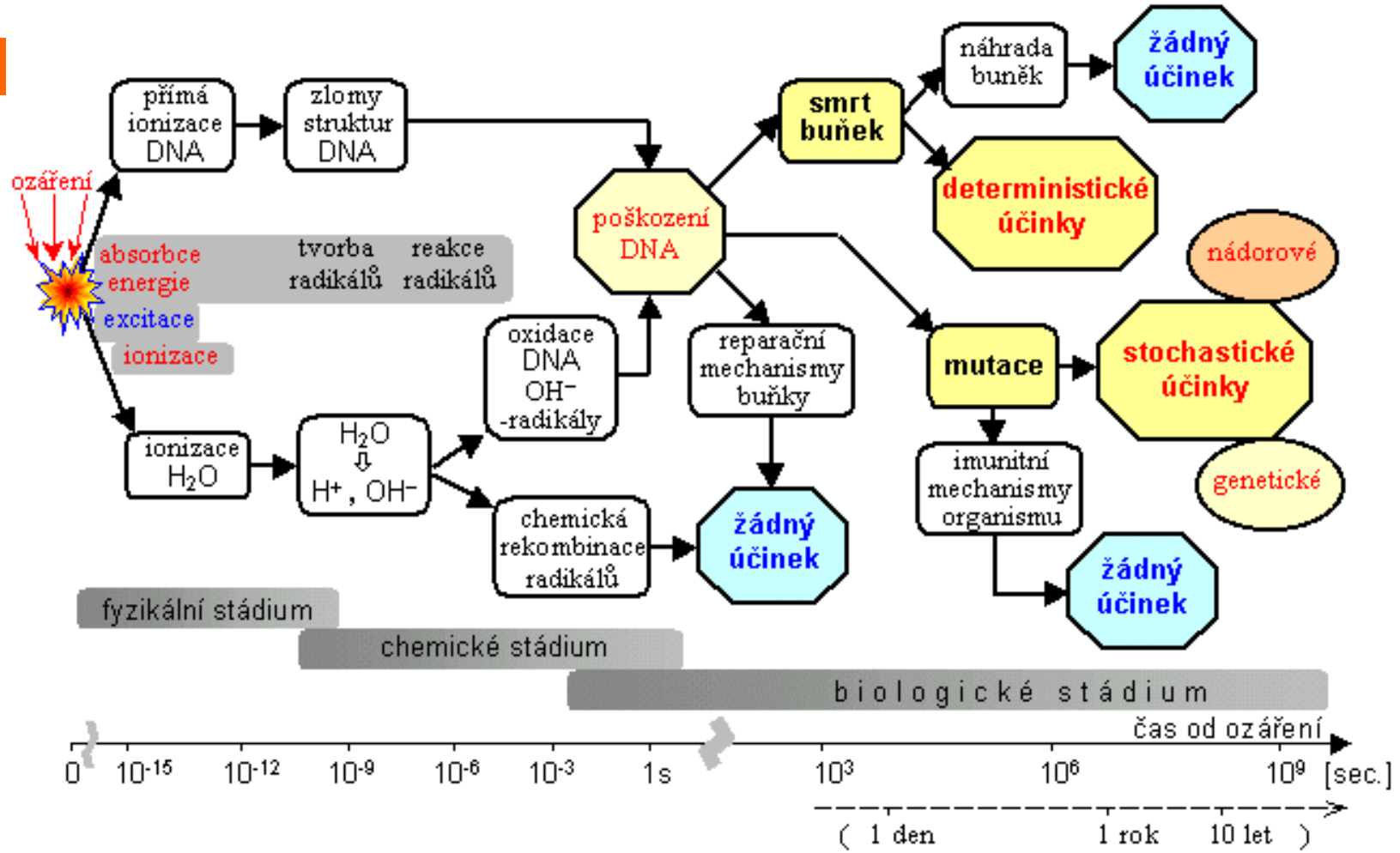
http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/
www.nema.ne.gov/technological/dose-limits.html
http://www.deq.idaho.gov/inl_oversight/radiation/dose_calculator.cfm
http://www.deq.idaho.gov/inl_oversight/radiation/radiation_guide.cfm
http://mitnse.com/
http://www.bnl.gov/bnlweb/PDF/03SER/Chapter_8.pdf
http://dels-old.nas.edu/dels/rpt_briefs/rerf_final.pdf
http://people.reed.edu/~emcmanis/radiation.html
http://en.wikipedia.org/wiki/Sievert
http://blog.vornaskotti.com/2010/07/15/into-the-zone-chernobyl-pripyat/
http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/tritium-radiation-fs.html
http://www.mext.go.jp/component/a_menu/other/detail/__icsFiles/afieldfile/2011/03/18/1303727_1716.pdf
http://radiology.rsna.org/content/248/1/254

Chart by Randall Munroe, with help from Ellen, Senior Reactor Operator at the Reed Research Reactor, who suggested the idea and provided a lot of the sources. I'm sure I've added in lots of mistakes; it's for general education only. If you're basing radiation safety procedures on an internet PNG image and things go wrong, you have no one to blame but yourself.

# Porovnání ra

| Type of Radiation (dose in mSv)† | Equivalent Period of Natural Background Radiation‡ | Estimated Lifetime Risk of dying from cancer that results from a single exposure§ |
|---|---|---|
| Airport Security x-ray scanner [23] (~0.0001mSv) | less than one hour | Almost 0 (less than 1 in 100,000,000) |
| 7 hour airplane flight [9] (~0.03 mSv) | a few days | Almost 0 (1 in 1,000,000 – 100,000) |
| Chest x-ray [5] (~0.1 mSv) | ~ one week | Almost 0 (1 in 1,000,000 – 100,000) |
| Mammogram [27] (~0.4 mSv) | a few months (~2 months) | 1 in 100,000 to 10,000 |
| CT of chest [27] (~7 mSv) | a few years (~2.3 years) | 1 in 10,000 to 1,000 |
| Fluoroscopy: colon (barium enema) [27] (~8 mSv) | a few years (~2.7 years) | 1 in 10,000 to 1,000 |
| CT of heart (angiography) [27] (~16 mSv) | a few years (~5.3 years) | 1 in 10,000 to 1,000 |
| PET scan, whole body [5] (~14 mSv) | a few years (~4.6 years) | 1 in 10,000 to 1,000 |
| Fluoroscopy: kidneys, ureters and bladder [5] (~15mSv) | a few years (~5 years) | 1 in 10,000 to 1,000 |
| Whole-body CT scan [5] (~22.5 mSv) | several years (~7.5 years) | 1 in 1,000 |
| Nuclear Medicine: Cardiac stress-rest test (thallium) [27] (~40.7mSv) | many years (~13.6 years) | ~2 in 1,000 |
| Transjugular intrahepatic portosystemic shunt placement [27] (~70mSv) | many years (~23.3 years) | 1 in 100 – 1,000 |
| Lifetime risk of cancer death NOT caused by radiation§§ | | 1 in 5 |

# Chemical effects of radiation



# Effects on human organism

**Stochastic (random) - few cells damaged, subliminal dose or repeated small doses.**

- we can only calculate the probability of injury, no injury may in fact occur.
- can be detected only by observing a large number of people. Risk of small doses? Scientists still do not match, they can not confirm nor deny it for there is not a sample of people who are not exposed to any radiation at all. No control sample.
- It is known that there is a "protective effect" radiation (hormesis) - in places with higher radioactivity there is less incidence of cancer (cells repair any damage).

# Effects on human organism

**Non-stochastic effects (deterministic) - after a large dose of radiation, many cells, appear in a short time.**

Examples:

local dermatitis
Lenticular opacities
birth defects
fertility
Acute radiation sickness

# Protection against outer sources

**Protection against earthquake**

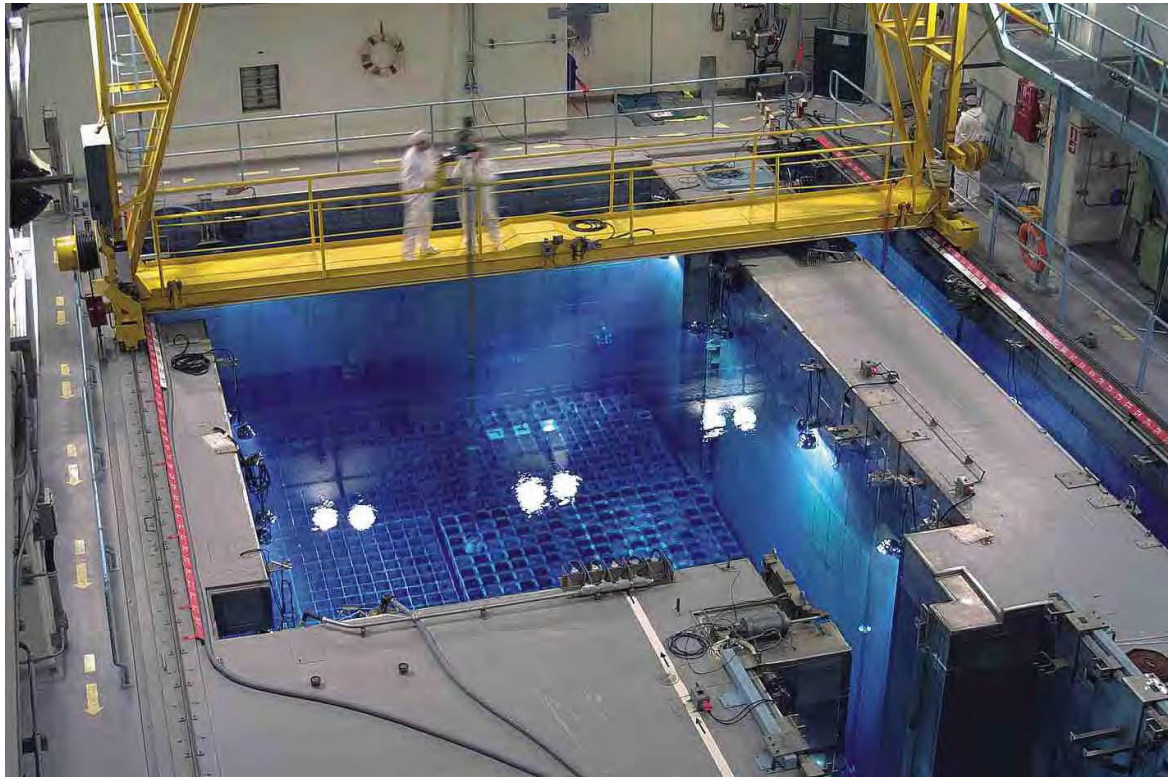
**Protection from flood and adverse meteorological phenomena**

**Protection against pressure waves from explosions**

**Protection against the effects caused by the fall of the aircraft**

**Protection against the influence of third parties**

# Storage



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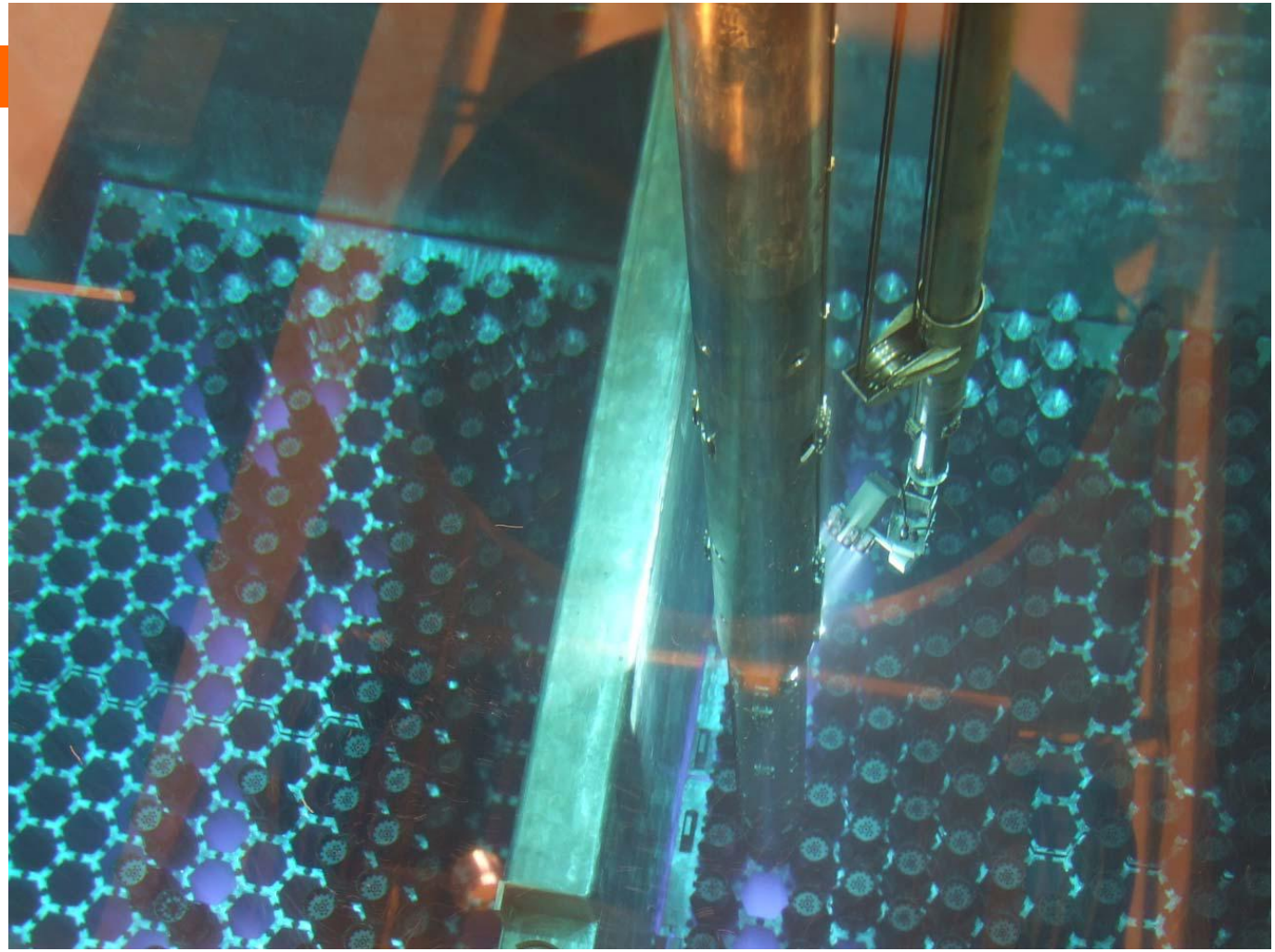


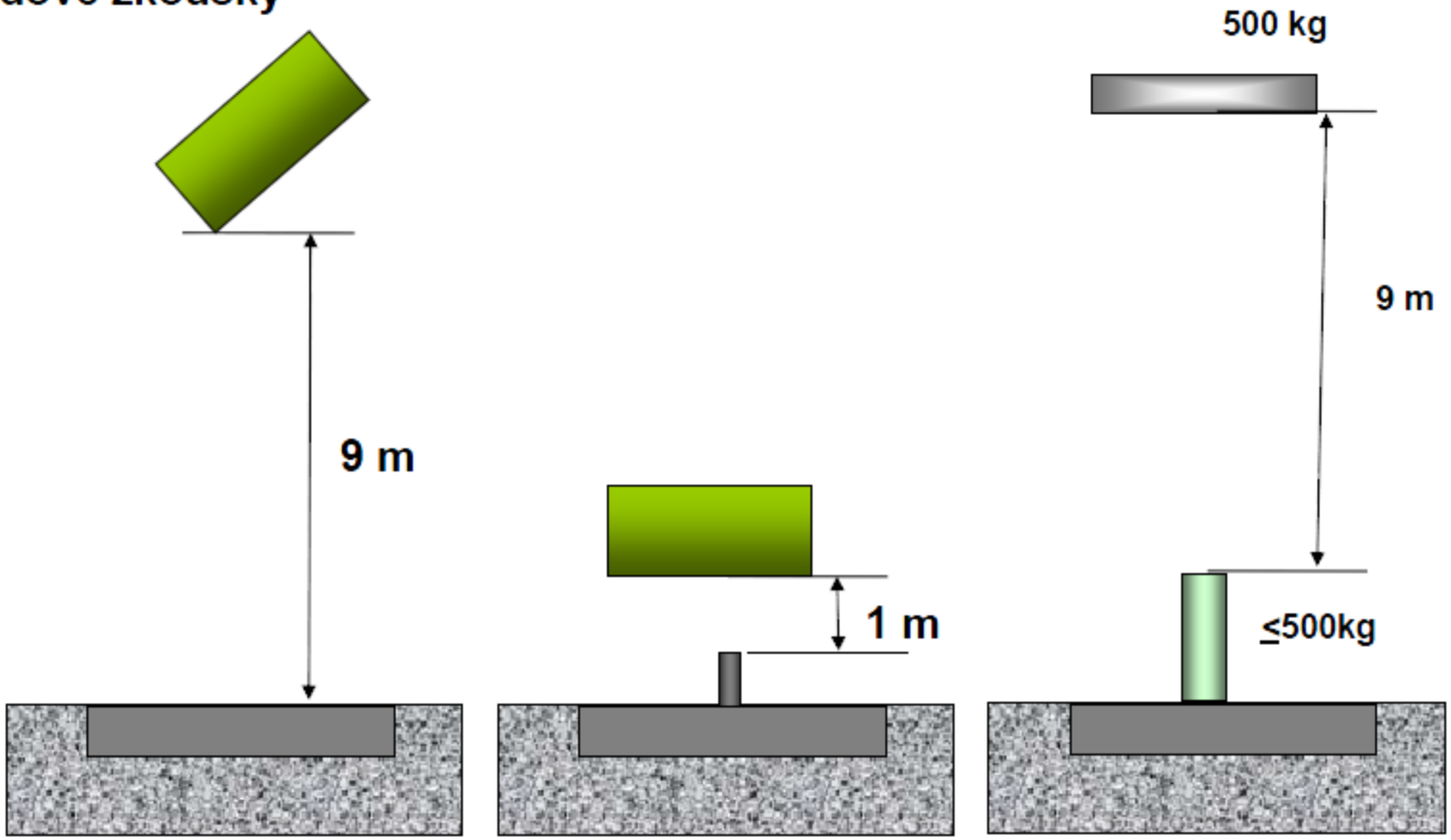
# Storage

# Storage

# Storage

Zkoušky prokazující schopnost přestát podmínky nehody při přepravě

- **Pádové zkoušky**



# Storage

Zkoušky prokazující schopnost přestát podmínky nehody při přepravě

- **Požár**
- **Ponoření**