IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety

Key scientific elements about radiation protection after a nuclear accident

NTW
Working Group on nuclear Emergency Preparedness & Response (WG EP&R)

Inception Seminar
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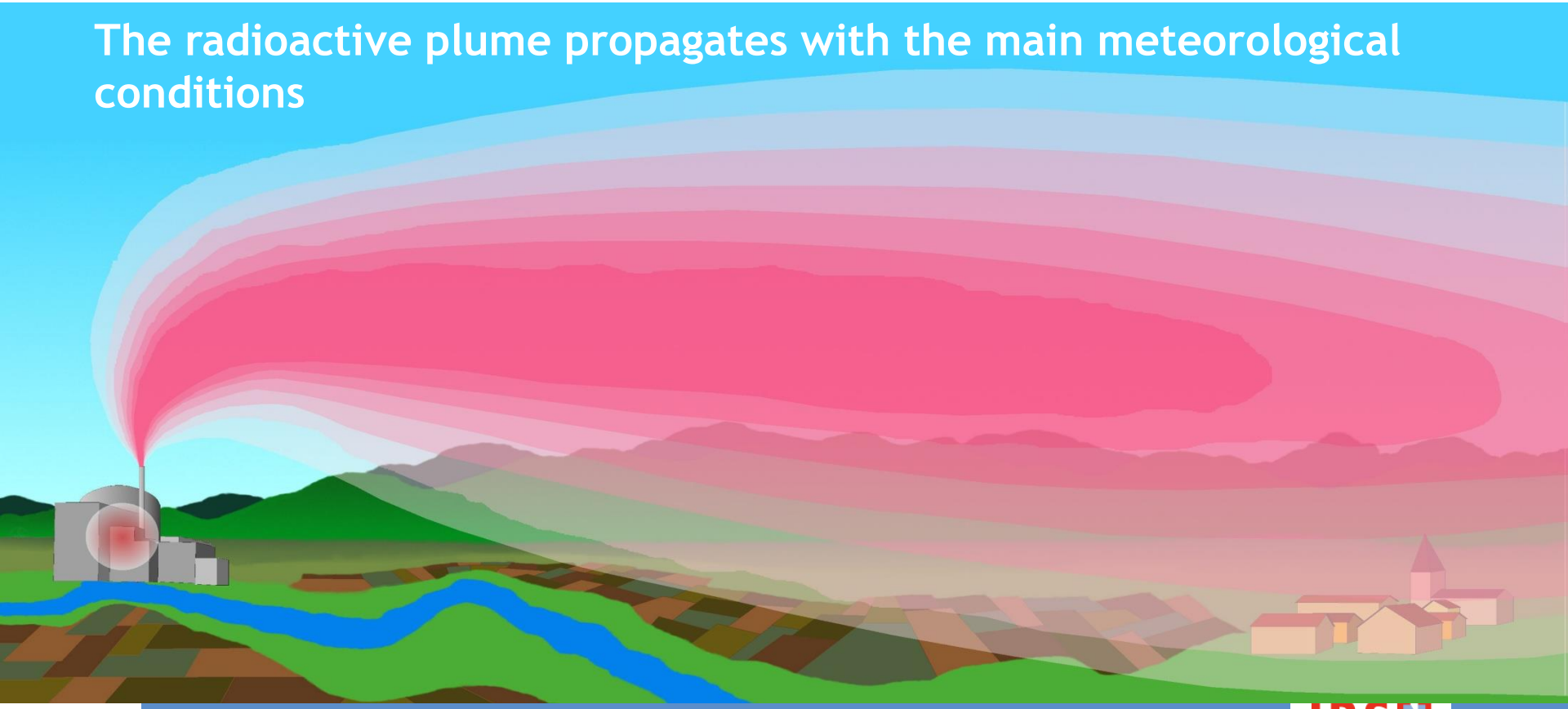
The main hypothesis is that there are numerous failure on the nuclear installation which lead to radioactive atmospheric releases



Transfer pathways in case of a release from a nuclear installation

The atmospheric transfer is the fastest mechanism which transport radioactivity from the installation to man.

The liquid transfer exists but is much more slower.

Atmospheric dispersion if the mechanism which transport the radioactivity from the accidented installation to the environment and man the most rapidly.

Atmospheric dispersion is a physical mechanism which is, by nature, multi-scales

Local scale

The atmospheric dispersion is mainly influenced by the meteorological conditions (wind, stability, rain…)

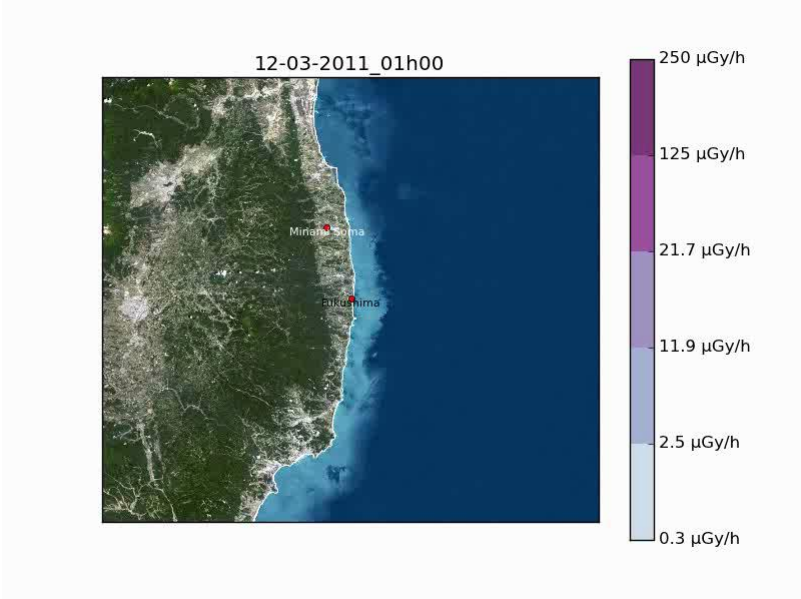
Buildings influence directly the dispersion: propagation direction, turbulence…

Site scale

The atmospheric boundary layer contains the pollution. This layer has a specific behavior over 24h. Turbulence and stability play a major role in this layer.

The pollutant is dispersed by to complementary phenomenon: advection and diffusion (turbulence).

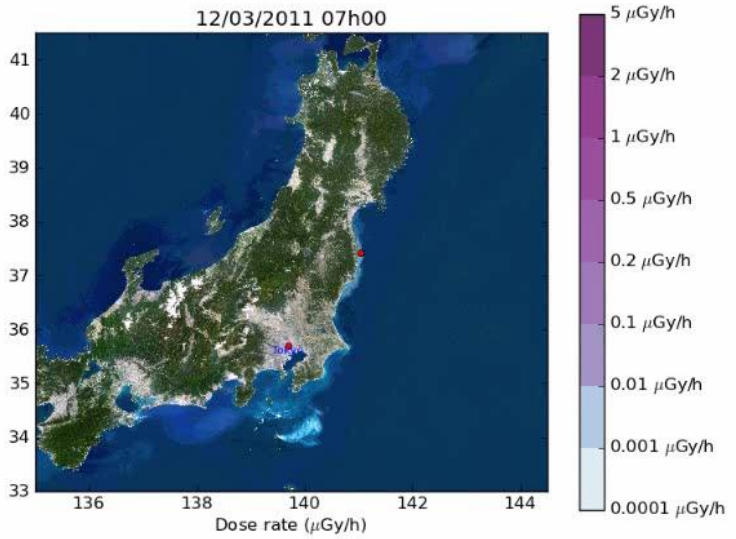
Regional scale



Rain influence directly the radioactive deposition on the ground. Without rain, there is almost no deposition then also smaller consequences for the environment.

Relief between the regional and the national scale influences the atmospheric circulation then the impacted zones.

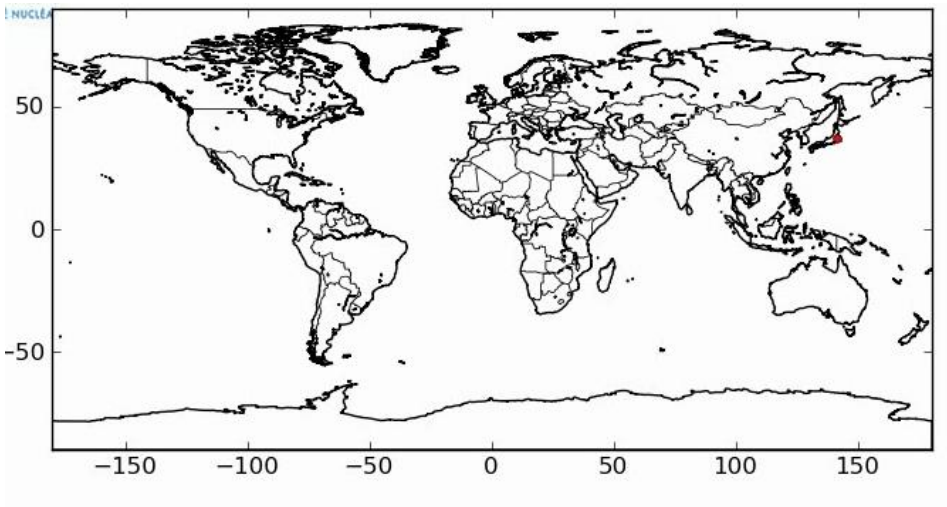
National scale

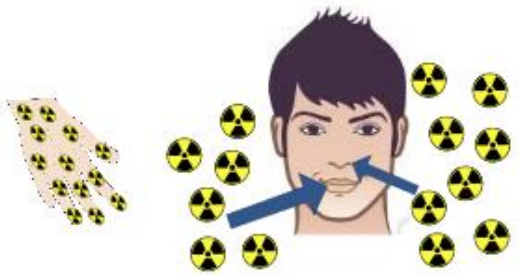


The global atmospheric circulation transport from West to East in the Northern Hemisphere. Except during the Chernobyl accident.

When the pollution raise in the upper part of the atmosphere, it circulate very rapidly. An hemisphere is contaminated in few days.

Global scale



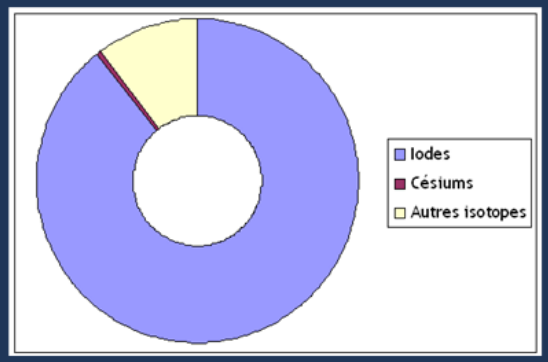


Internal Contamination:

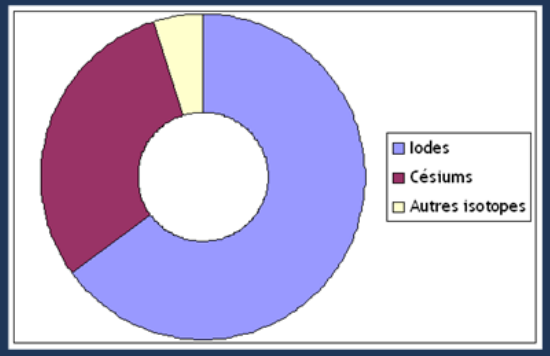
- Inhalation
- Ingestion of contaminated food
- Involuntary ingestion

External Irradiation: particles & gas
In the atmosphere and on the ground

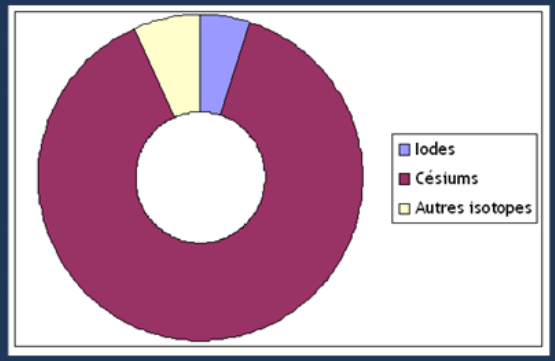
Emergency Phase Inhalation



Exit from the Emergency Phase & Transition Ingestion



One year after External Irradiation



Major Radionuclides related to health

Iodines ^{131}I (8 days)

Caesiums ^{137}Cs (30 years)

Inhalation from the plume

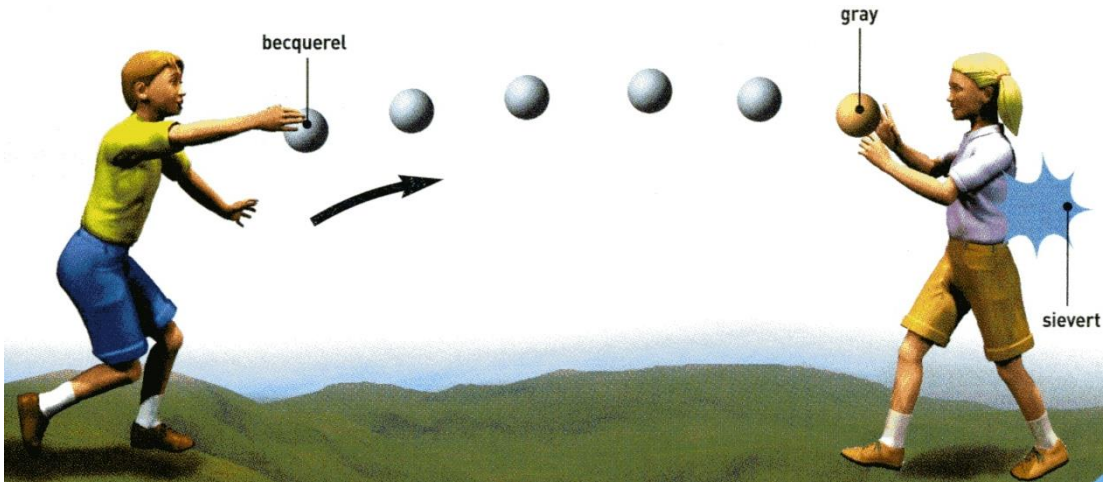
Ingestion of food

Ingestion of food

External Irradiation by the deposition

Concentration in the thyroid

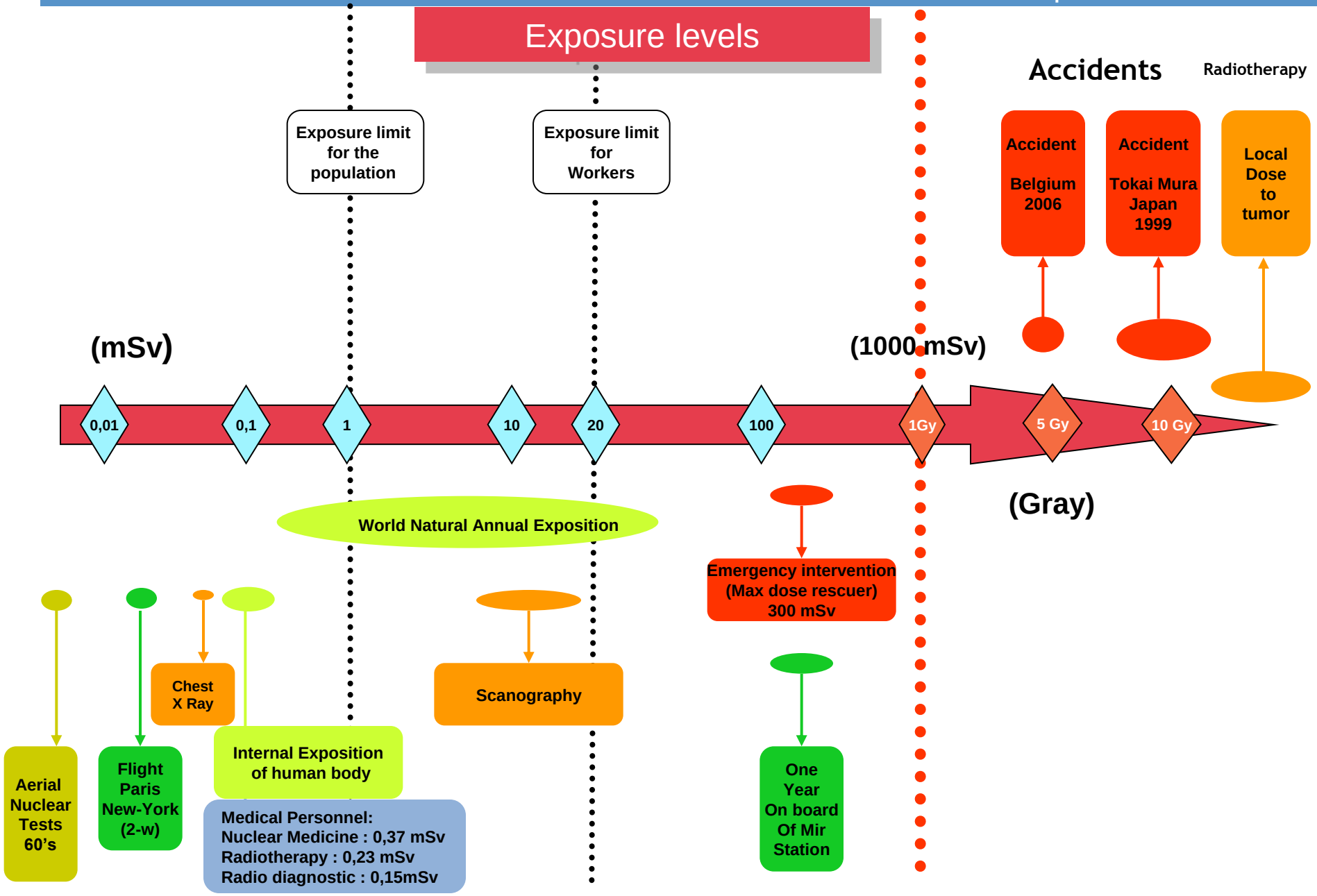
Concentration in muscles



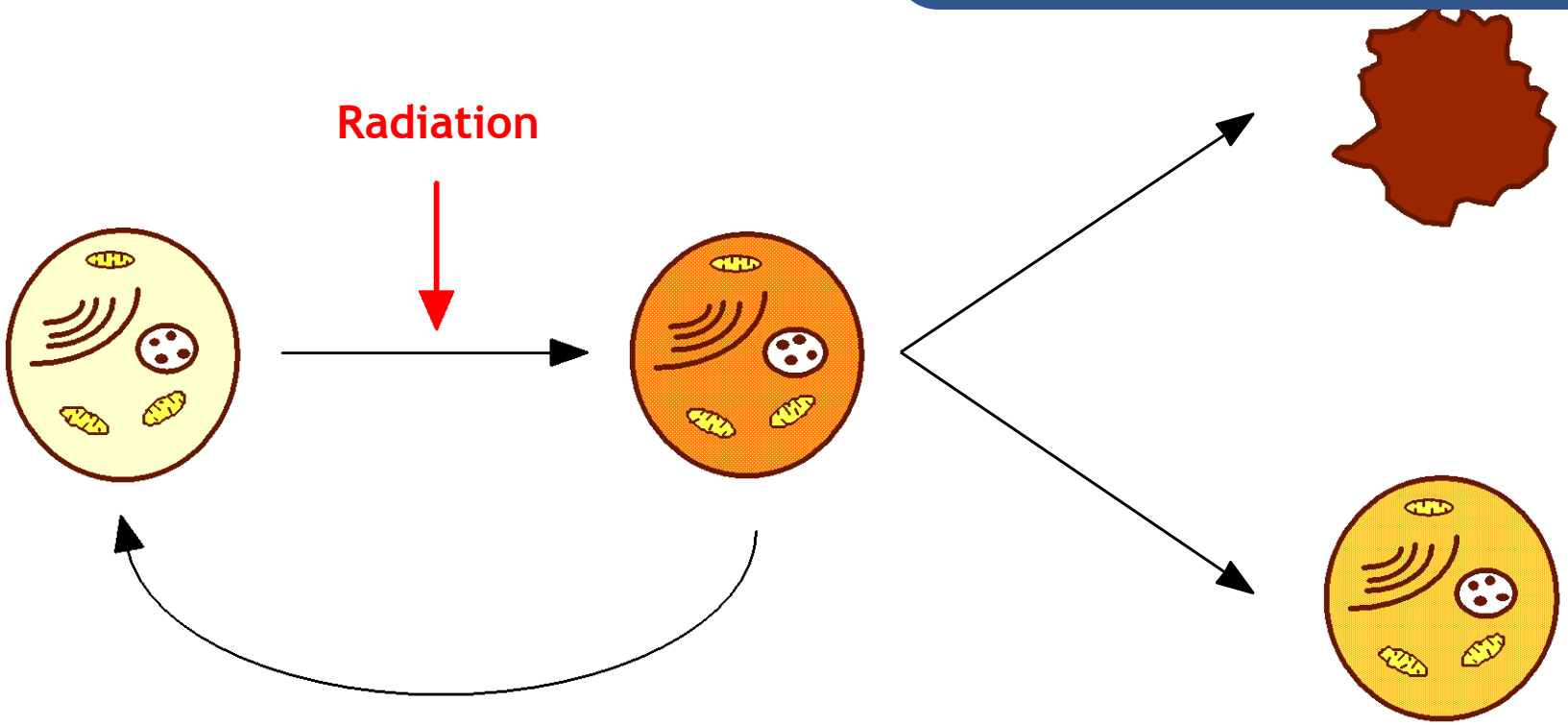
Becquerel (Bq): radioactivity activity
Represents the number of radioactive disintegration per second

Gray (Gy): absorbed dose
Represents deposited energy: expressed in Joule per kilo of irradiated material

Sievert (Sv): effective dose
Take into account the effectiveness of the radiation
Take into account the sensitivity of the tissue
Represents the effects on human


Exposure levels
Exposure limit for the population
Exposure limit for Workers
Accidents
Radiotherapy
Accident Belgium 2006
Accident Tokai Mura Japan 1999
Local Dose to tumor
(mSv)
(1000 mSv)
0,01
0,1
1
10
20
100
1Gy
5 Gy
10 Gy
(Gray)
World Natural Annual Exposition
Emergency intervention (Max dose rescuer) 300 mSv
Aerial Nuclear Tests 60's
Flight Paris New-York (2-w)
Chest X Ray
Internal Exposition of human body
Scanography
One Year On board Of Mir Station
Medical Personnel:
Nuclear Medicine : 0,37 mSv
Radiotherapy : 0,23 mSv
Radio diagnostic : 0,15mSv

High doses: determinist effects
Threshold exists
Severity increases with dose



Lower doses: Stochastic effects
Threshold?
Frequency increases with dose

Evacuation

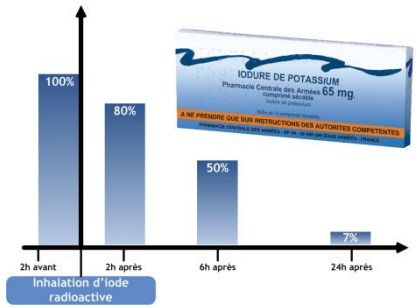
Reference level: 50 mSv (effective dose)

Remove the population from the effects of radioactivity
When sheltering is insufficient
Need to be anticipated (realization time, avoid bigger releases…)
Should be used compared to sheltering if there is small population

Stable Iodine Ingestion

Reference level: 50 mSv (thyroid dose)

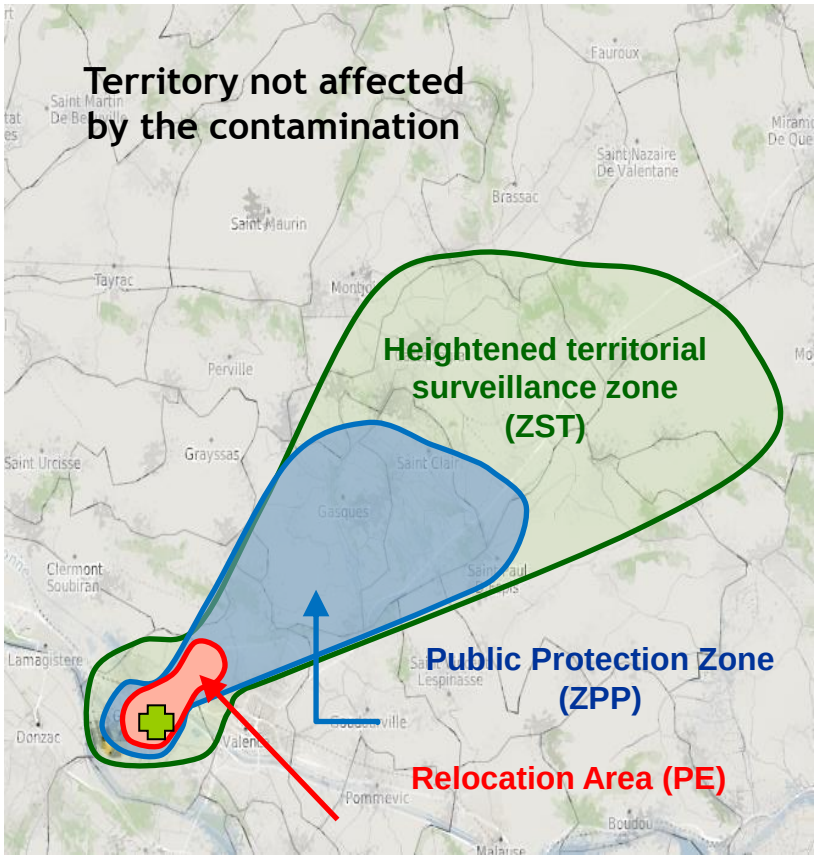
To be implemented only if the releases contain iodine!
To be ingested just before the major releases
Effectiveness decreases with time (exposure)
Most concerned population: kids
Second effects negligeable



Sheltering

Reference level: 10 mSv (effective dose)

Reflex protection mode or concerted
Decided in order to protect (release short in time or imminent)
Allow to listen to instructions (TV, radio, phone)
Must be implemented in a solid shelter (building…)
Effectiveness decreases with time



Public Protection Zone (ZPP)

Reference level 1st month:

10 mSv (effective dose all pathways) or
50 mSv (thyroid dose all pathways)

Systematic prohibition of the consumption and ban of marketing of local products
Sequestration of local farms
Keep the population in place with some recommandation for certain activities

Relocation if the reference level 1st month:

10 mSv (effective dose without ingestion)

Heightened Territorial Surveillance Zone (ZST)

Defined by the greatest distance over which the Maximum Permissible Level (MPL – NMA) is exceeded for the most sensitive product

The population can live in the area without restriction

The marketing of local foodstuff is tamporarily ban until controls are in place.