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Nuclear and non-nuclear safety aspects

Philippe ANTOINE

SCK•CEN

Nuclear and non-nuclear safety aspects

- Nuclear safety
- Nuclear Radioprotection
- Non-nuclear safety aspects

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Nuclear safety

- General nuclear safety aspects
  - Protect individuals, society and environment
- Radiation Protection Objective
  - ALARA
- Technical Safety Objective
  - Practical measures to prevent accidents

➢ Execution of safety analysis

Concept of defence in depth

- Level One
  - To prevent deviation and system failures
- Level Two
  - To detect and intercept deviations
- Level Three
  - Inherent safety features, fail safe design, additional equipment to control consequences
- Level Four
  - To address severe accidents
- Level Five
  - To mitigate the radiological consequences of potential release

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Safety Assessment

- Different methods exist
  - Hazard and operability Study (Hazop)
  - Failure Modes and Effects Analysis (fmea)
- Evaluation of risk
  - Risk = Probability occurrence x Gravity effects
  - P : given by manufacturers of assumptions
  - Safety assessment = unceasing process

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Nuclear safety and Decommissioning

- Knowledge of the installation
- Nature of the operations
- Nature of the tools
- Behaviour of the manpower
- State of regulation
  - Management nuclear wastes
  - Free-release of wastes

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Main safety problems during decommissioning

- Areas with high radiation fields
- Opening loops and piping with internal contamination
- Continually changing environment
- Potential unforeseen situations
- « One-shot » operations

➢ Situations encountered during the dismantling of reactor BR3

Decommissioning BR3

- To avoid transferring radiological risks from one operation to the next one
  - Decontamination primary loop: cost 160 man.mSv
  - 4 to 7 man-Sv avoided afterwards
- Optimisation of dismantling operations
  - 3D-modelling – VISIPLAN tool

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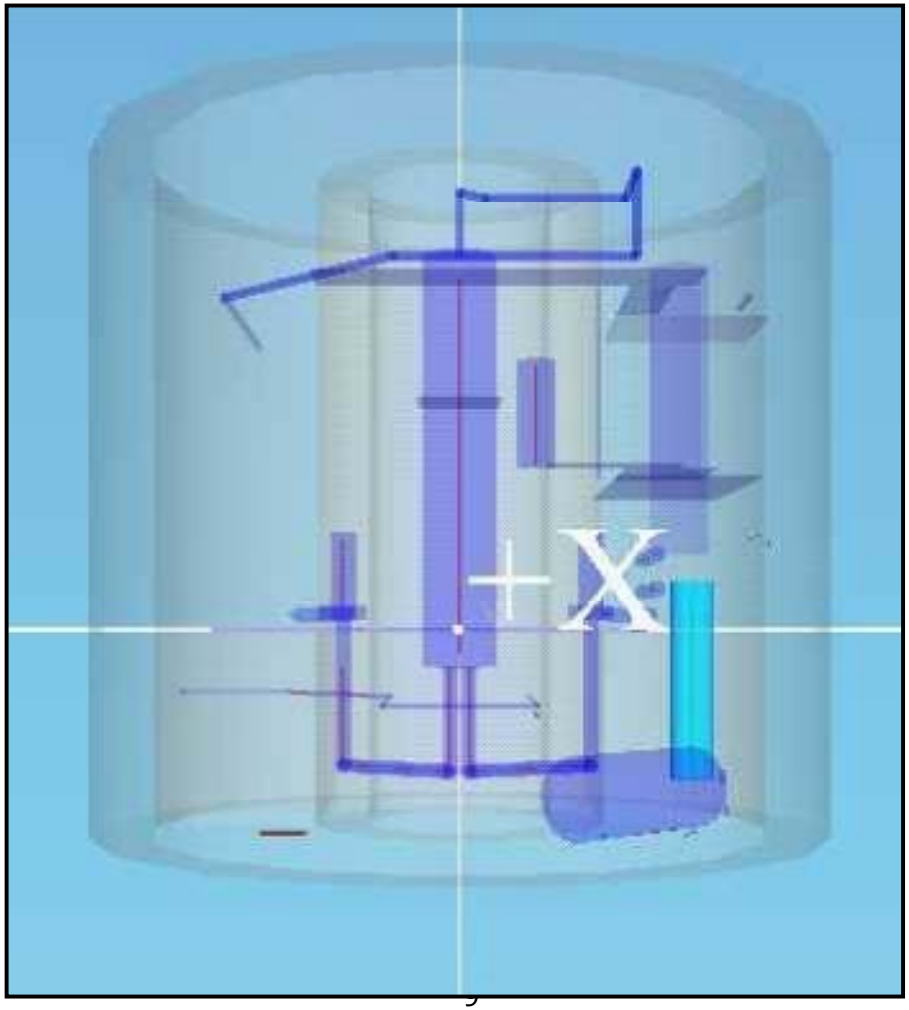
VISIPLAN ALARA planning tool



Driving forces safety during decommissioning

- Open and frequent communication
- Support from the Health Physic and Safety Department of the site
- Development of adapted tools
- Management of the yard with more flexibility and open-mindedness

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Characteristics of radiations

	Type	Charge	Mass
α	Particle $_2^4He$	+ 2	+ 4
β	Particle e^- of e^+	- 1 of +1	1/2000
γ	Wave	0	0
neutron	Particle	0	1

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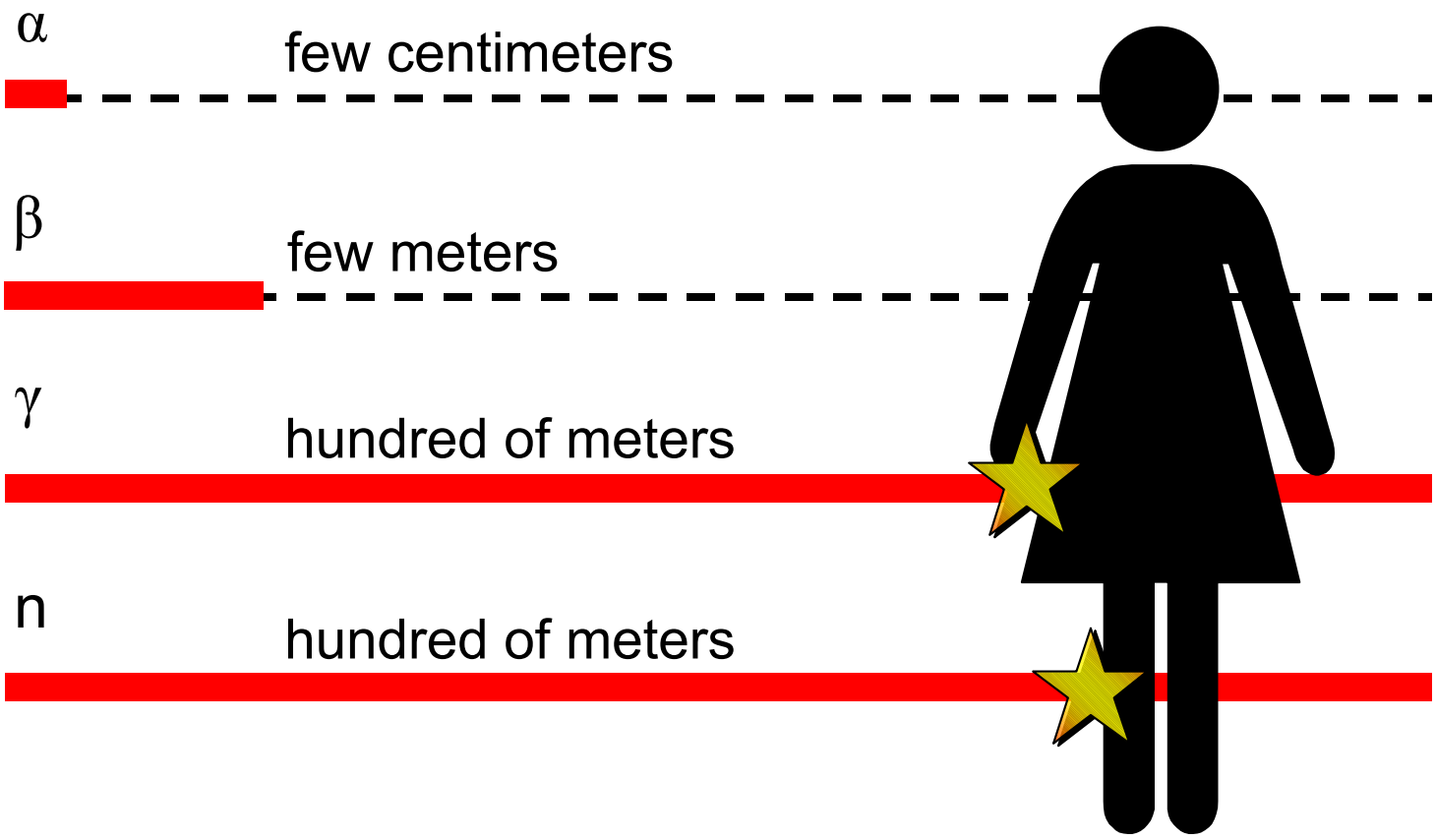
Radiations



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Some definitions

- Irradiation – Contamination
- Absorbed dose D
  - energy absorbed per unit mass
  - Unit : Gray = 1 Joule/kg = 100 rad
- Equivalent dose H_T
  - $H_{T,R}=w_R\ D_{T,R}$
  - w_R= weighting factor for radiations

Weighting factor W_R

Type and energy range	Radiation weighting factor, W_R
Photons, all energies	1
Electrons and muons, all energies	1
Neutrons, energy < 10 keV	5
10 keV to 100 keV	10
> 100 keV to 2 MeV	20
> 2 MeV to 20 MeV	10
> 20 MeV	5
Protons, other than recoil protons, energy > 2 MeV	5
Alpha particles, fission fragments, heavy nuclei	20

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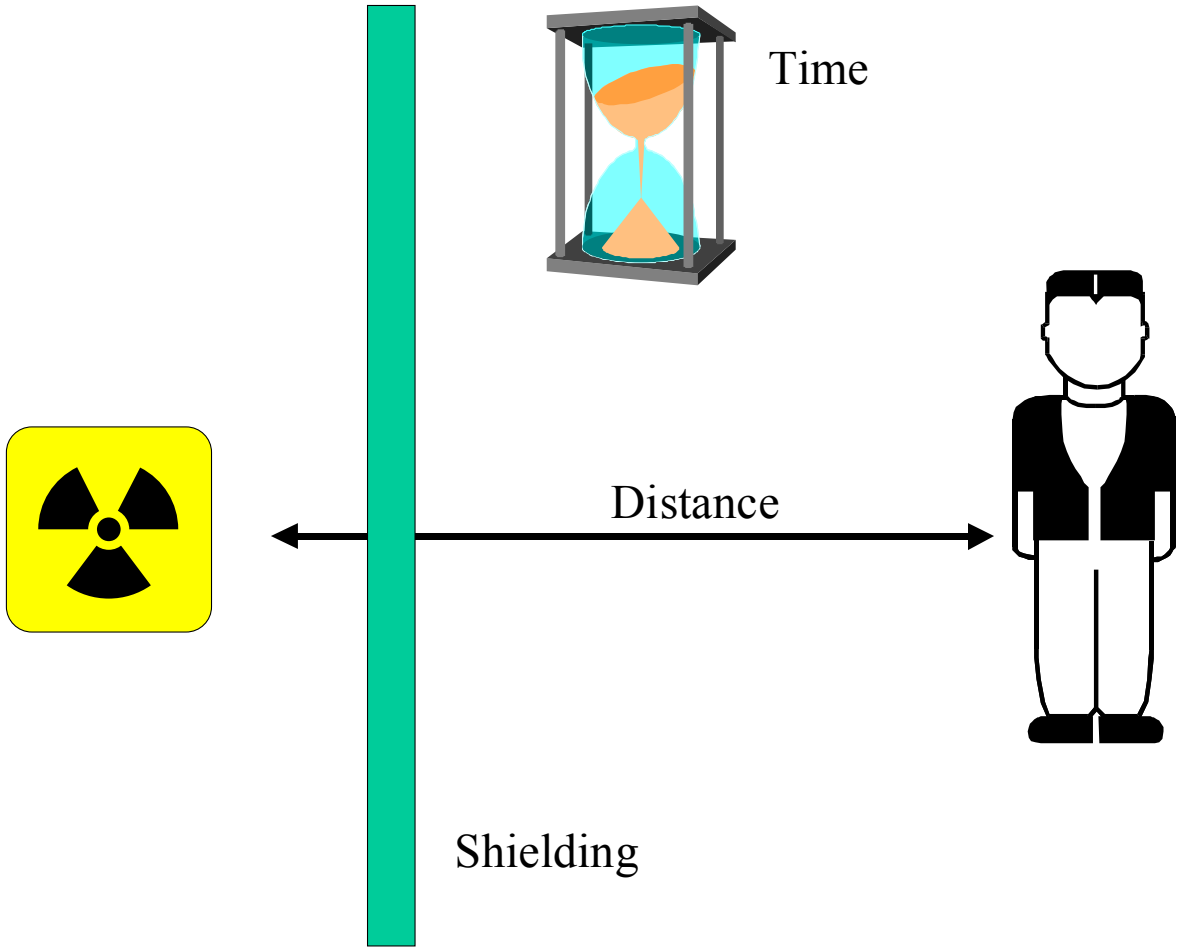
Some definitions

- Effective Dose
  - E = Equivalent dose H_T . W_T
  - Unit : Sv
- Collective dose of a group
  - S = Effective dose . Population
  - Unit : man.Sv
- Dose limitation
  - 100 mSv in five years : 20 mSv/year
  - 500 mSv/year for the skin

Weighting factor Tissues W_T

Tissue or organ	Tissue weighting factors, W_T
Gonads	0,20
Bone marrow (red)	0,12
Colon	0,12
Lung	0,12
Stomach	0,12
Bladder	0,05
Breast	0,05
Liver	0,05
Oesophagus	0,05
Thyroid	0,05
Skin	0,01
Bone surface	0,01
Remainder	0,05

Protection against irradiation



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Protection against intake in the body

- Avoiding contaminations of workplaces
- Indicating contaminated areas
- Protective clothing
- Refraining from eating, smoking, drinking in controlled aeras
- Good ventilation – Gas masks,…
- Gloves – glove box

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ALARA-analysis of a work

- Collective dose
  - S=d.t.N
  - d = average dose rate
  - t = time of exposure
  - N = number of people exposed
- Complex geometry
  - e.g. : VISIPLAN
  - Information gathering and model building
  - General analysis stage
  - Detailed analysis stage – work planning
  - Follow-up stage

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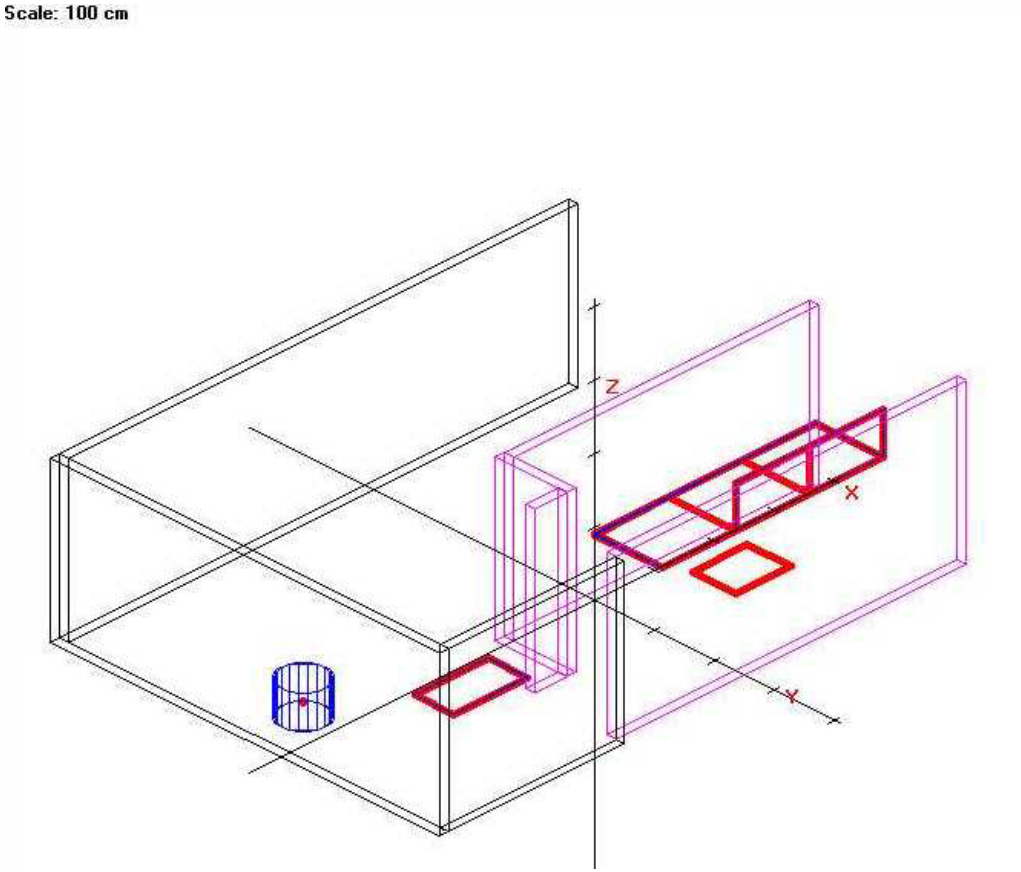
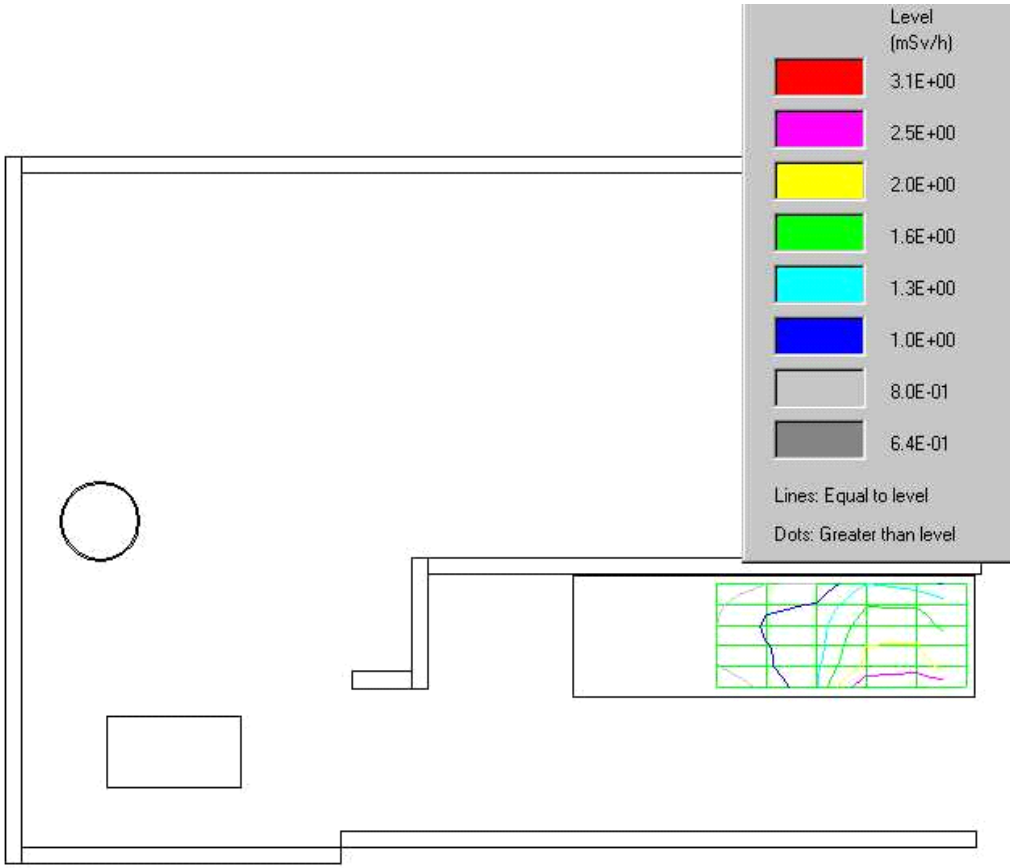
Example : Dismantling Hot Cell



Example : Dismantling Hot Cell



Controls dismantling operations

- Work environment
  - Ventilation : Depression – Global - partial
- Worker
  - Air contamination : mask – overpressure pack
- Surface contamination
  - Specific clothes – Controls
- Internal Contamination
  - Whole Body Counter – nose-blow
- Registration of doses
  - Film-, TLD-dosimeter, Electronic dosimeter

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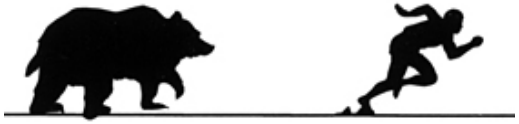
Protection materials

Electronic Dosimeter

General safety aspects

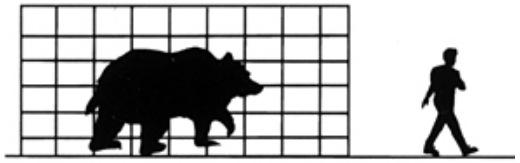
risk



2. to reduce risk

4. individual protection

1. to eliminate risk



3. collective protection

5. to inform

Non radiological hazards

- Safety assessment
  - Indentification of risks
  - To eliminate or to reduce the hazards
  - Study of risks
  - Evaluation of risk
  - Def. of potential countermeasures
  - Selection of actions
  - Enforcement of actions
  - Follow-up of the actions
  - Analysis of the results
- Potential interactions between different types of risks

Non Radiological risks and decommissioning

- Decommissioning : several aspects of classic and industrial safety
  - Risks of falling, load handling, cutting tools wound,…
  - Importance of changing environment
  - Potential presence of toxic or dangerous materials : e.g. asbestos in thermal insulation, acids or chemical in tanks
  - e.g. : « Ladder syndrome »