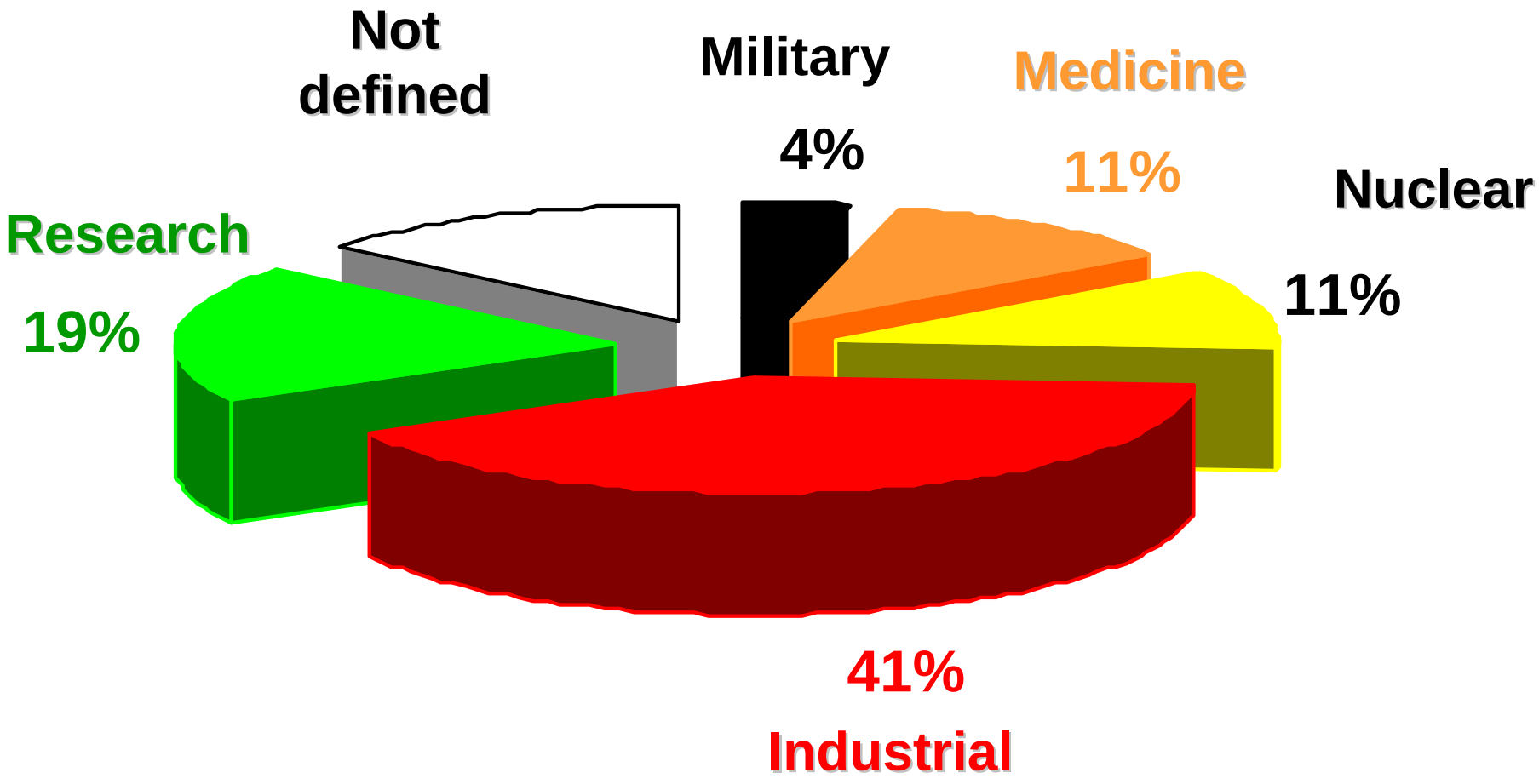
J.F. Bottollier-Depois - M. Benderiter - P. Gourmelon

Contribution of IRSN in the medical management of radiological accidents

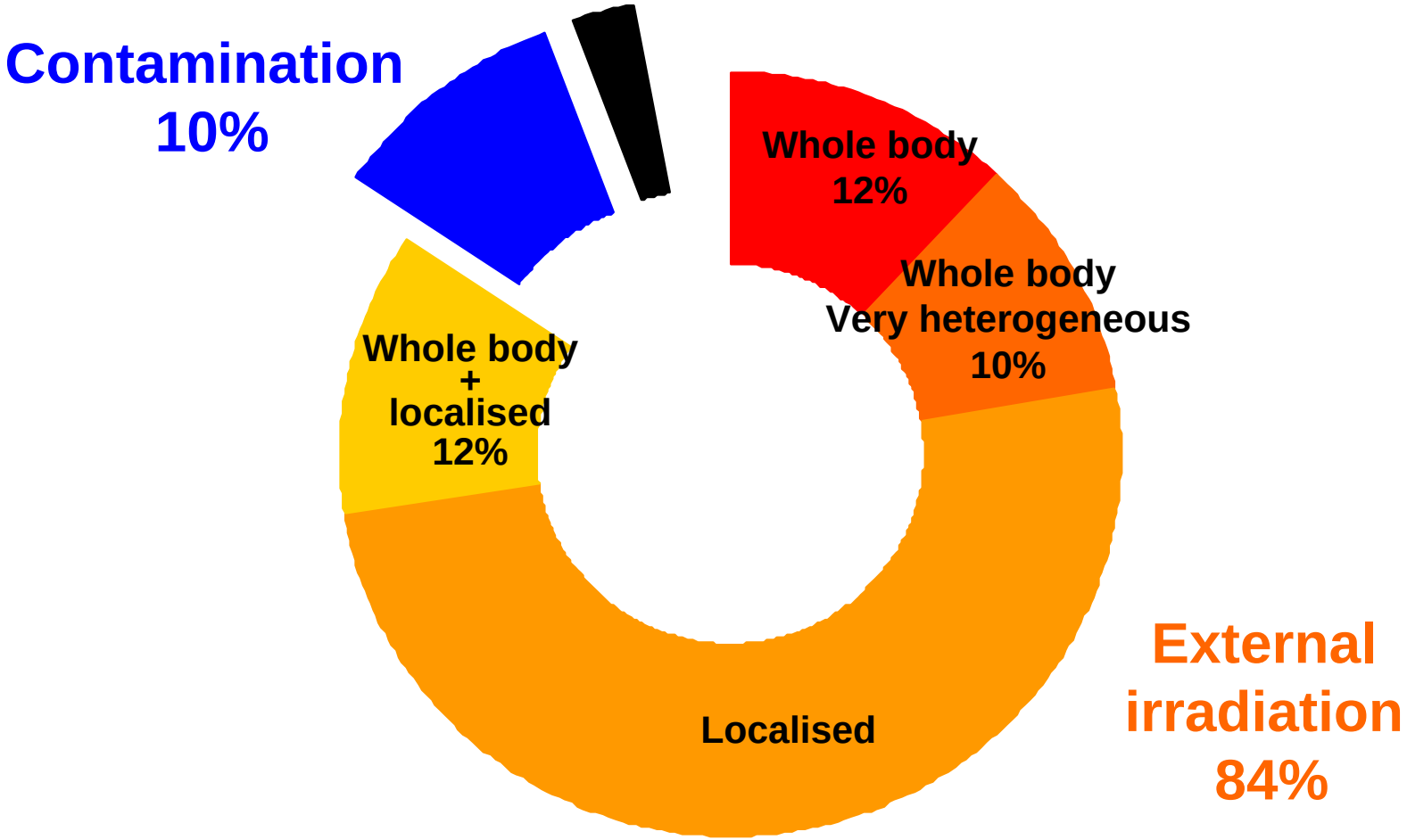
Radiological accidents

More than 600 incidents/accidents are known since 1945 (~200 deaths)



Different types of overexposures

Because of the large variety of accidents, a good medical management requires a multidisciplinary expertise and a dedicated technical plateau



IRSN medical assistance in case of radiological accidents

IRSN provides a multidisciplinary expertise and a technical support to hospitals

IRSN

- Radiopathology
- Dose assessment
- Support to define the therapeutic strategy

Hospitals

Researchers
- Suitable dosimetry techniques
- New therapeutic approaches

Physicians
Victim's management

Experienced and reactive teams

Dose assessment

The dose assessment is the key point to establish the diagnostic and define the therapeutic strategy

- **Clinical observations:** *symptomatology*
- **Biological dosimetry:** *biochemical parameters…*
- **Physical dosimetry:** *dose reconstruction using experimental and numerical-anatomical tools and dose from irradiated materials*

Clinical observations based on deterministic effects

- **Acute irradiation syndrome (global irradiation)**

Mean body dose	1 Gy	5 Gy	10 Gy	20 Gy	50 Gy
Hematological symptoms					
Digestive symptoms					
Neurological symptoms					

- **Localized irradiation syndrome**

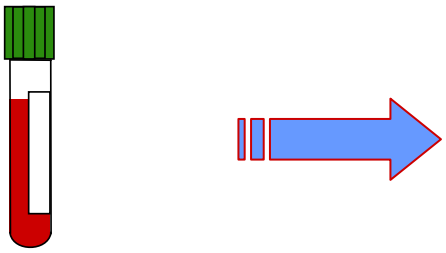
Skin dose	5 Gy	10 Gy	20 Gy	25Gy
	ERYTHEMA	DRY DESQUAMATION	MOIST to WET DESQUAMATION	NECROSIS

➡ **Dosimetry: a key point for therapeutic strategy**

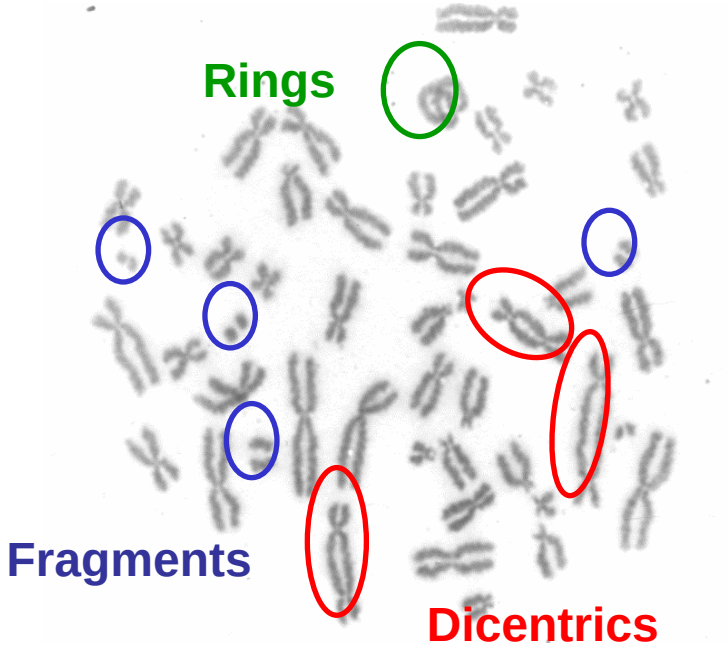
Conventional biological dosimetry

In case of overexposure suspicion, a biological dosimetry could be useful to assess the dose received by victims

- **Numbering of dicentrics and centric rings in the peripheral blood lymphocytes**
- **Assessment of the mean dose in the body**



Blood sample



Physical dosimetry: experimental tools

If possible, reproduce the accident using experimental tools (dummies…) in conditions as close as possible of the actual ones

« Small » dosemeters

Physical dosimetry: numerical-anatomical tools (1)

Usually, a dose reconstruction is made using numerical-anatomical model and Monte Carlo calculations

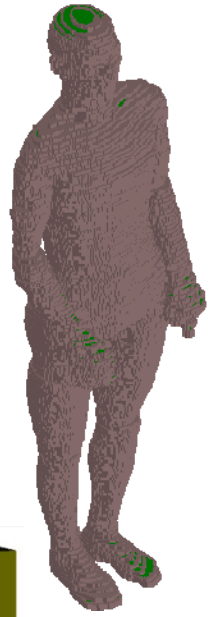
Numerical model

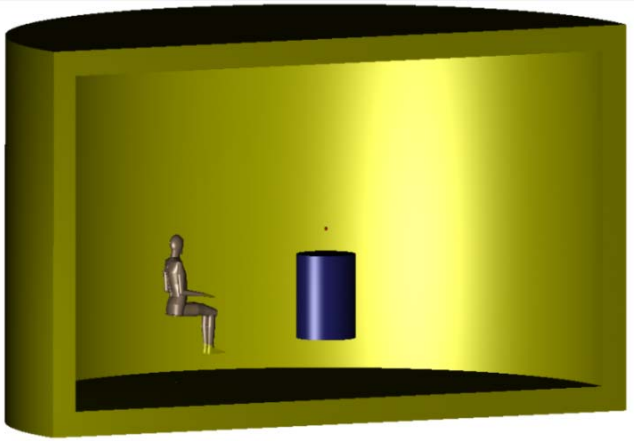
+

Environment

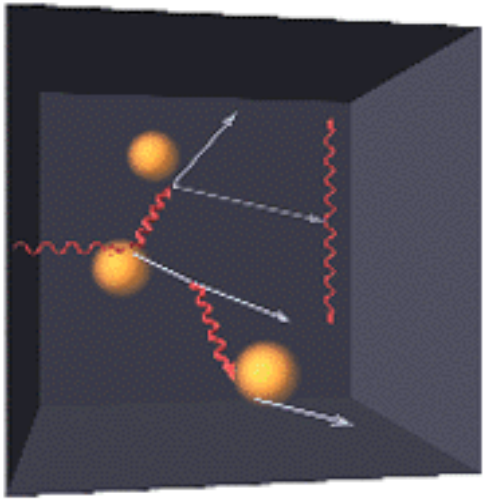
+

source





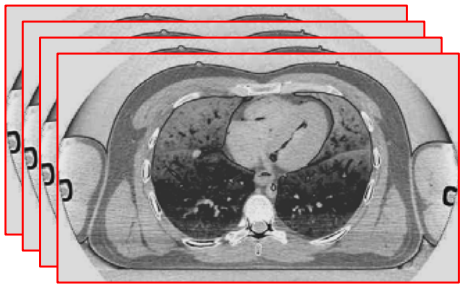
Monte Carlo code



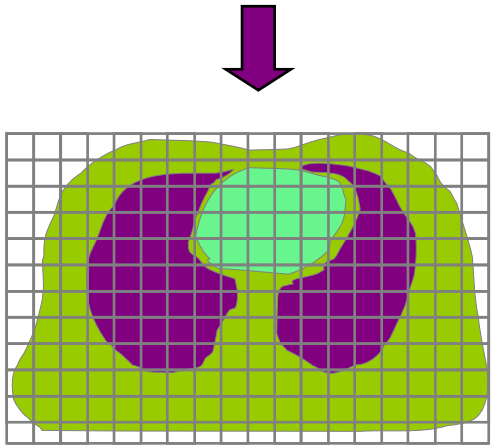
- Simulation of the transport of particles through matter
- Determination of the dose distribution

Physical dosimetry: numerical-anatomical tools (2)

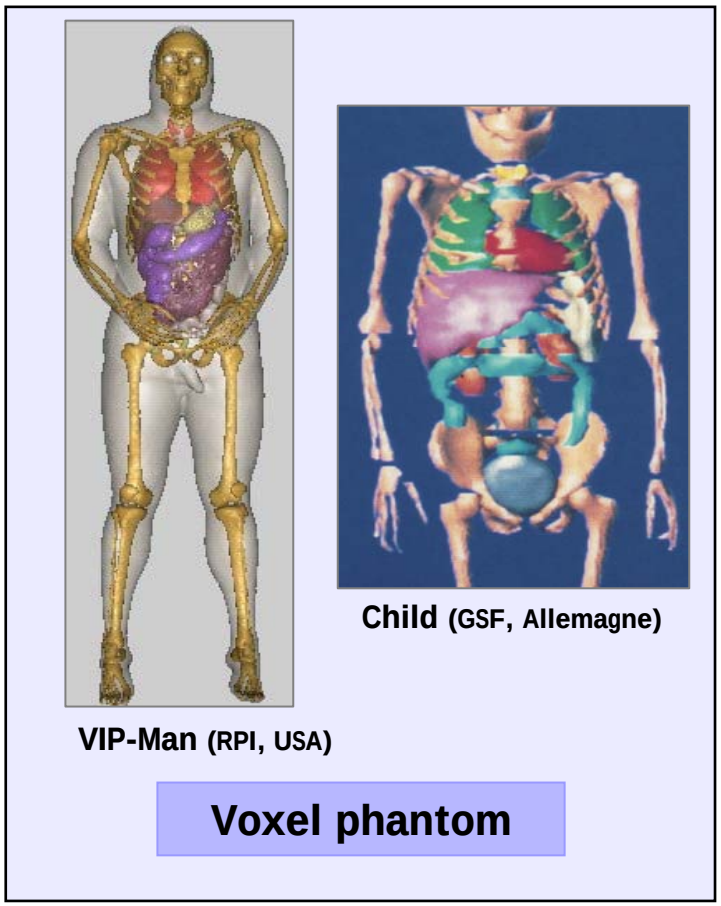
Construction of a "voxel" phantom of the victim as representative as possible



Medical images of the victim (CT, MRI)

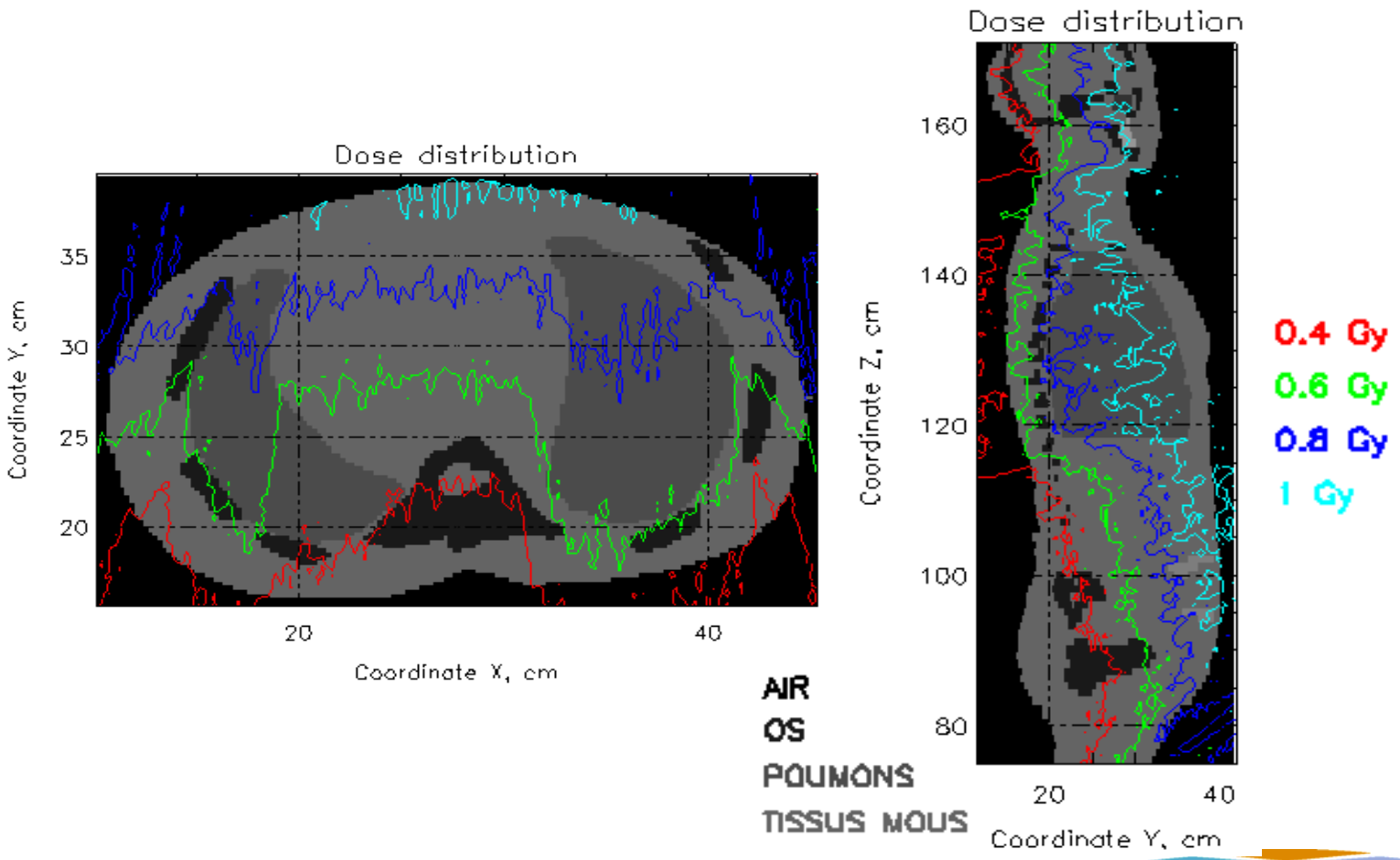


Segmentation step



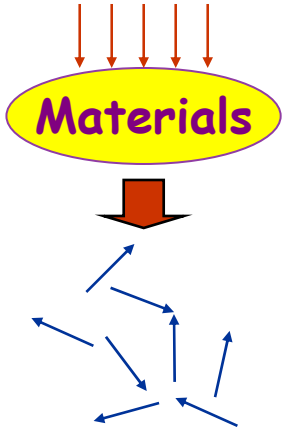
Physical dosimetry: numerical-anatomical tools (3)

Calculation of the dose distribution at the tissue and organ level



Dose measurement on irradiated materials

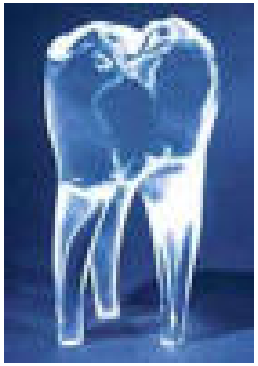
Dosimetry using ESR (electron spin resonance) : measurement of free radicals created in irradiated materials



IONISATION
Free radicals
(unpaired electrons)

Number of unpaired electrons proportional to the dose

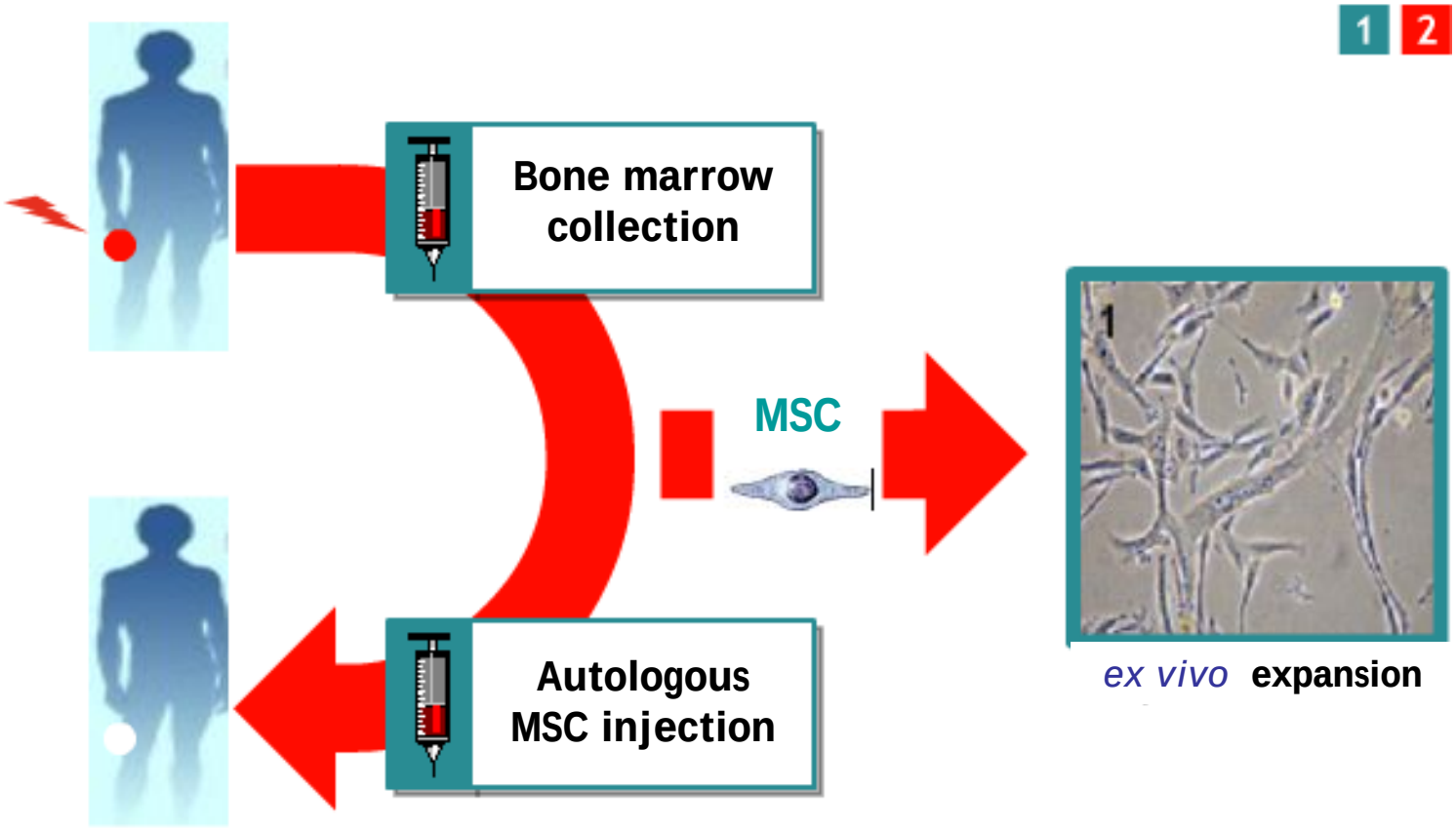
ESR spectrometer



- Operational technique for accidents implying a small number of victims on biopsy of bone & tooth enamel (~1 mg to 100 mg)
Sensitivity: 0,1 – 0,5 Gy for γ and 1 Gy for neutrons
- Can be used on materials from the environment (glass…)

Example of R&D application: mesenchymal stem cell (MSC) therapy

Cell therapy is a new promising therapeutical strategy based on stem cell injection having the capacity to acquire morphology and function of the deficient cells after tissue damage



Case report on a localised irradiation: the accident occured in Chile (2005)

The accident of Chile (2005)

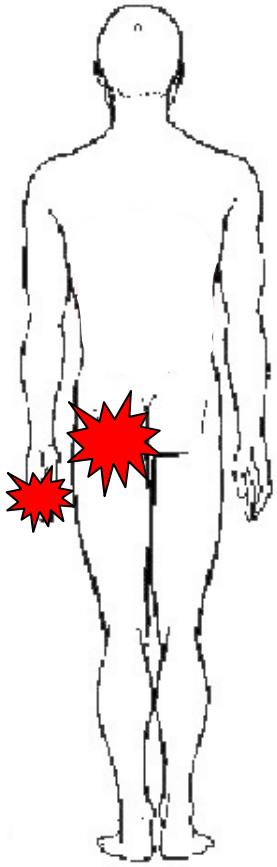
- **Location:** building site for a celluloses manufacture plant, Chile, 15th December, 2005
- **Context:** source used for welding control and found outside its storage container
- **Characteristic of the source:** iridium-192, 3.3 10^{12} Bq (90 Ci)
- **Exposure:** manipulation of the source during 40 mn, including 10 mn in the back pocket

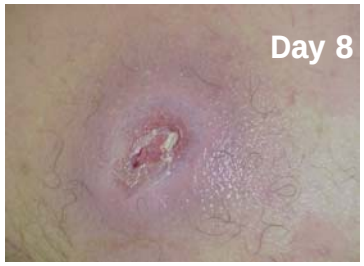
source

Clinical symptoms

Localized irradiation suspected: buttock, hands, head and chest

Cutaneous Radiation Syndrome of the Left Hand





Radiological lesion of the buttock

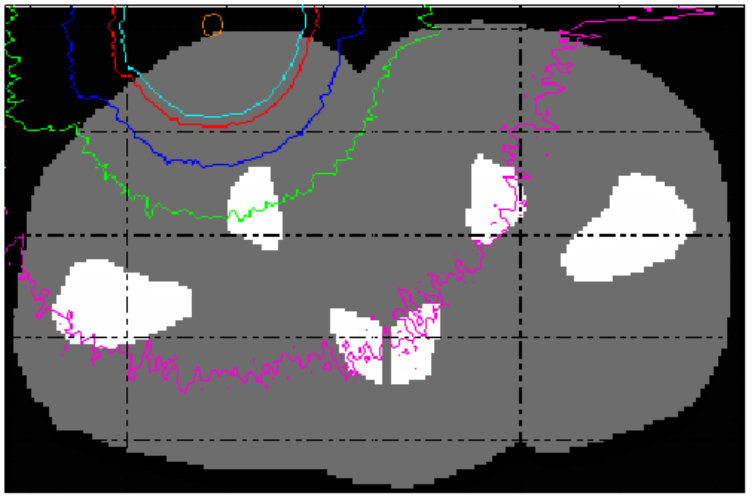
Hospitalized in France on December 26th, 2005, in the burn treatment department of the Percy Hospital, for a cutaneous radiation syndrome

Numerical-anatomical dose reconstruction

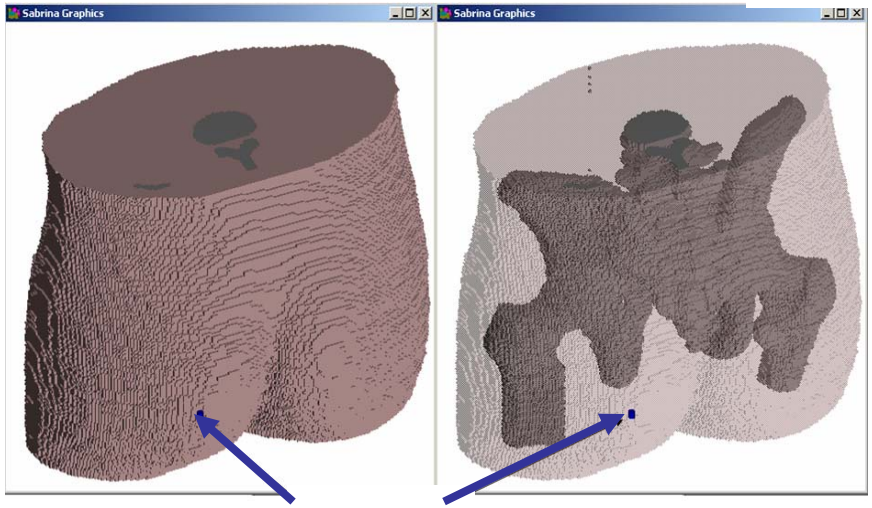
Calculations of the dose distribution at the buttock level

CT images of the patient

1900 Gy
25 Gy
20 Gy
10 Gy
5 Gy
1 Gy



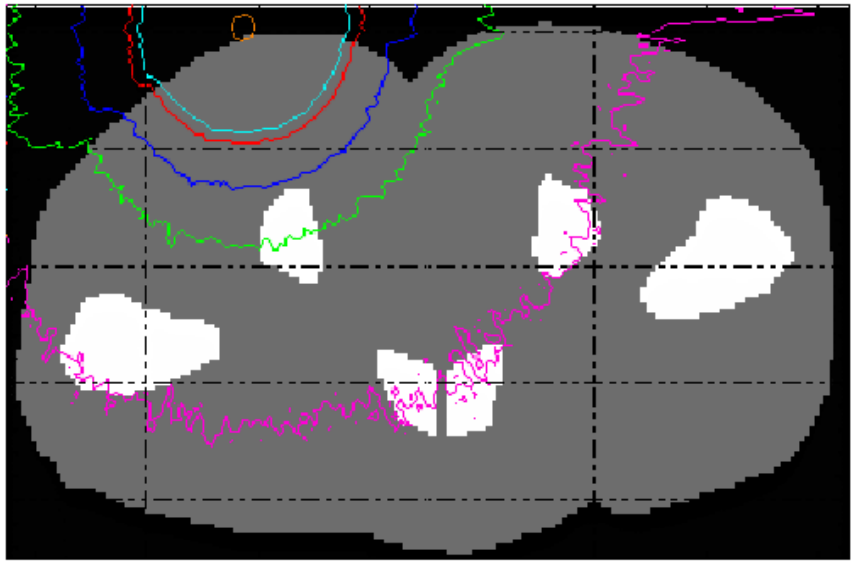
Voxel phantom



Dose distribution

Surgery

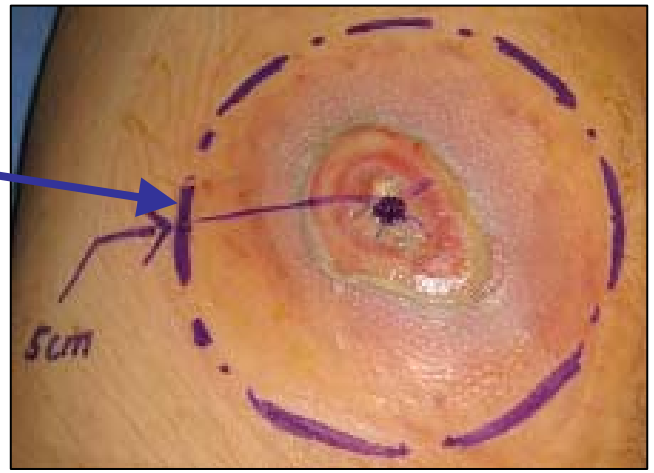
New approach: surgery « guided » by the dosimetry



1900 Gy
25 Gy
20 Gy
10 Gy
5 Gy
1 Gy

Dose distribution

D > 20 Gy
Φ = 10 cm



Surgery

Hand lesion treatment

Skin auto-graft & mesenchymal stem cell (MSC) injection

D+42 PI

Skin graft biopsy
(back thigh)

Skin auto-graft & MSC injection

Hand lesion evolution

1 month

2 months

3 months

Buttock lesion treatment after the surgery

Skin auto-graft

MSC injection

Lessons learned from the Chile accident regarding the medical management

New therapeutical approach in case of severe radiological burn

- Surgical intervention as soon as possible before the occurrence of the radionecrosis
- Excision of tissues with dose > 20 Gy guided by numerical-anatomical dosimetry
- Classical skin auto-graft associated with cellular therapy: local mesenchymal stem cell injection
- Medical breakthrough in the treatment of irradiated tissue!

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French experience in the medical management of radiological accidents during the last decade

- 12 accidents, including 8 via IAEA
- 350 suspected victims, including 47 with deterministic effects
- 23 patients with specific treatments, including 4 using the new therapeutic approach for severe radiological burns (surgery + skin auto-graft + MSC injection)

  - GEORGIA Lilo (1996-97): via IAEA, military sources, Cs-137, 11 pers., localised irr., surgery + skin graft
  - GEORGIA Matcoji (1998): via IAEA, military sources**,** population of a village, 85 suspicions of global irr.
  - PEROU (1999): via IAEA, gammagraphy Ir-192, 1 pers., localised irr., surgery + amputation
  - GEORGIA Lia (2002): via IAEA, former RTG Sr-Y, 3 pers., localised irr., surgery + skin graft
  - POLAND (2002): via IAEA, radiotherapy, 1 pers., localised irr., surgery + skin graft
  - CHILE (2005): via IAEA, gammagraphy Ir-192, 1 pers., localised, surgery + skin graft & MSC injection
  - BELGIUM (2006): Sterilization facility, Co-60, 1 pers., global irr., haematopoietic syndrome, cytokine injection
  - SENEGAL (2006): gammagraphy Ir-192, 60 suspicions, 3 pers., localised irr., surgery + skin graft & MSC injection
  - FRANCE Epinal (2006): radiotherapy, 24 pers., localised irr.
  - TUNISIA (2008): via IAEA, gammagraphy Ir-192, 1 pers., localised irr., skin graft & MSC injection
  - FRANCE Toulouse (2008): radiotherapy, ~150 pers., localised irr.
  - ECUADOR (2009): via IAEA, gammagraphy Ir-192, 1 pers., localised irr., surgery + skin graft & MSC injection