EDF Radiation Protection Fleet Program
Successes & Challenges

Alara in EDF's Nuclear Production Division between 2003 and 2011

G. Abéla, Radiation Protection Officer, Nuclear Engineering Division

Some key actions

- Multi-year Project "Source Term Control"

-Clean-up engineering

- "Optimisation of radiation protection" reference system made applicable to all sites

-Information system redesigned, with the creation of PREVAIR and CARTORAD

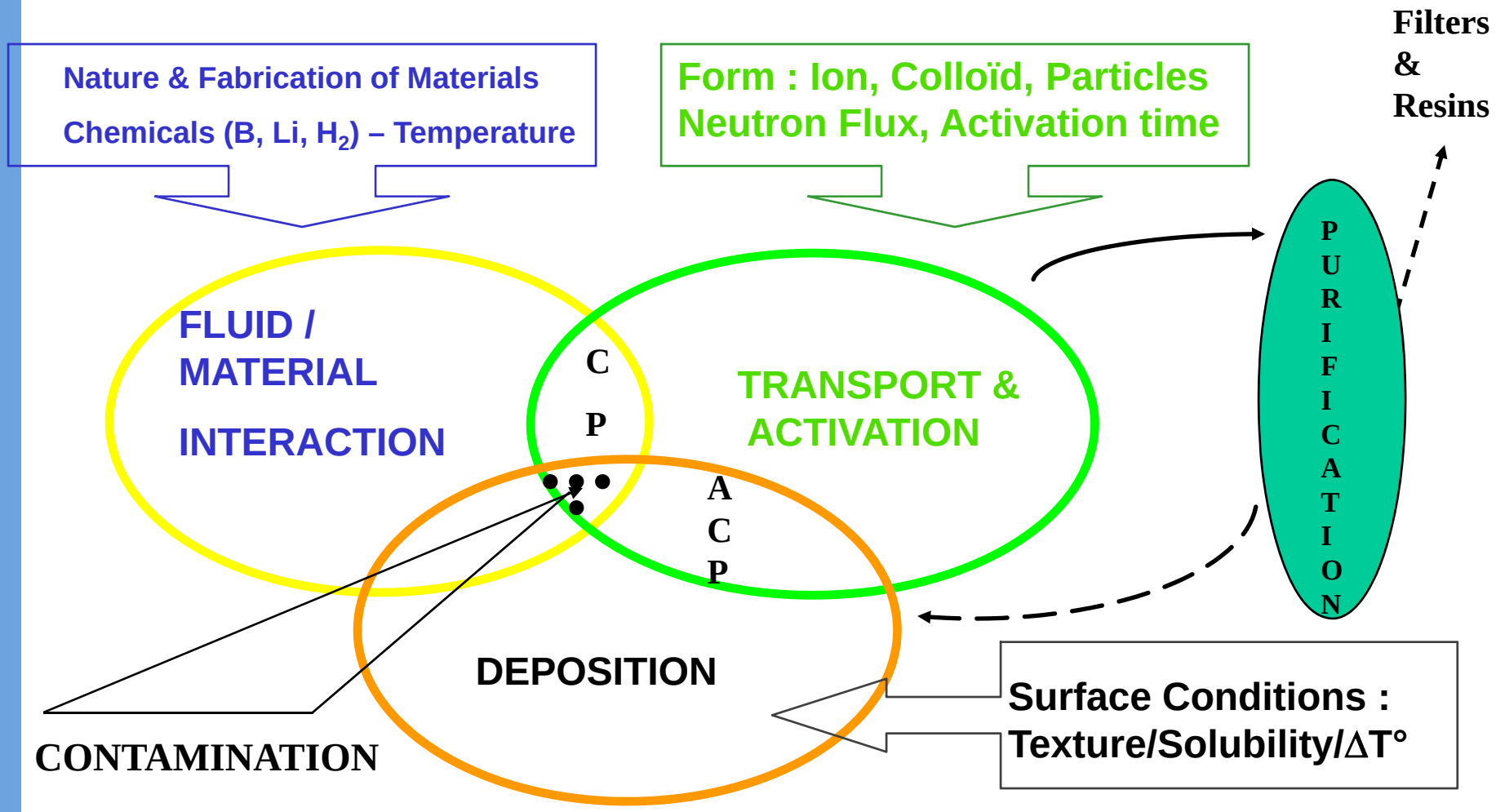
- Workstation studies using Panthère software

- "Insulation" case

- "Biological Protection" case

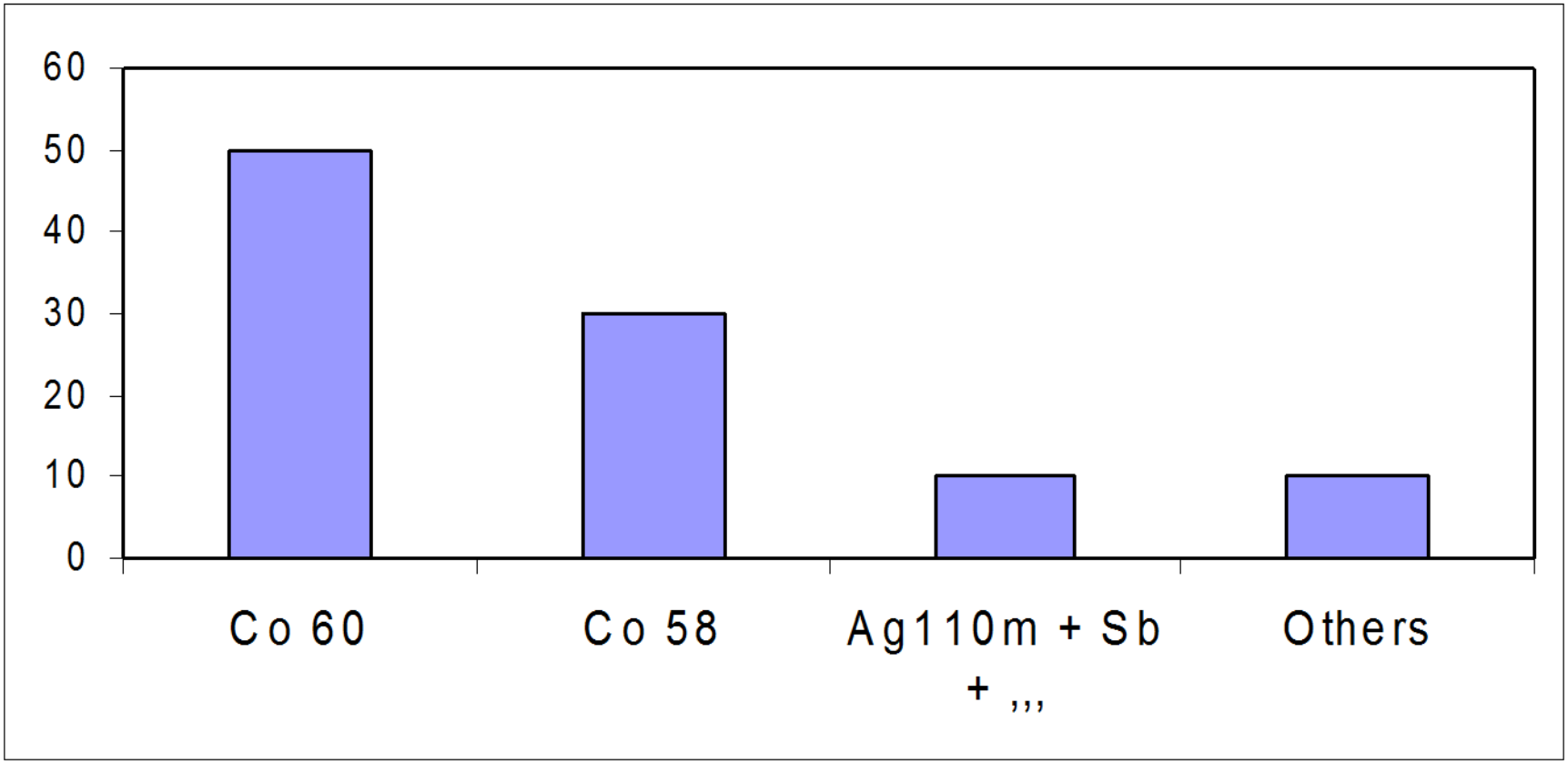
Multi-year Project "Source Term Control"

CONTAMINATION MECHANISMS (REMINDER)

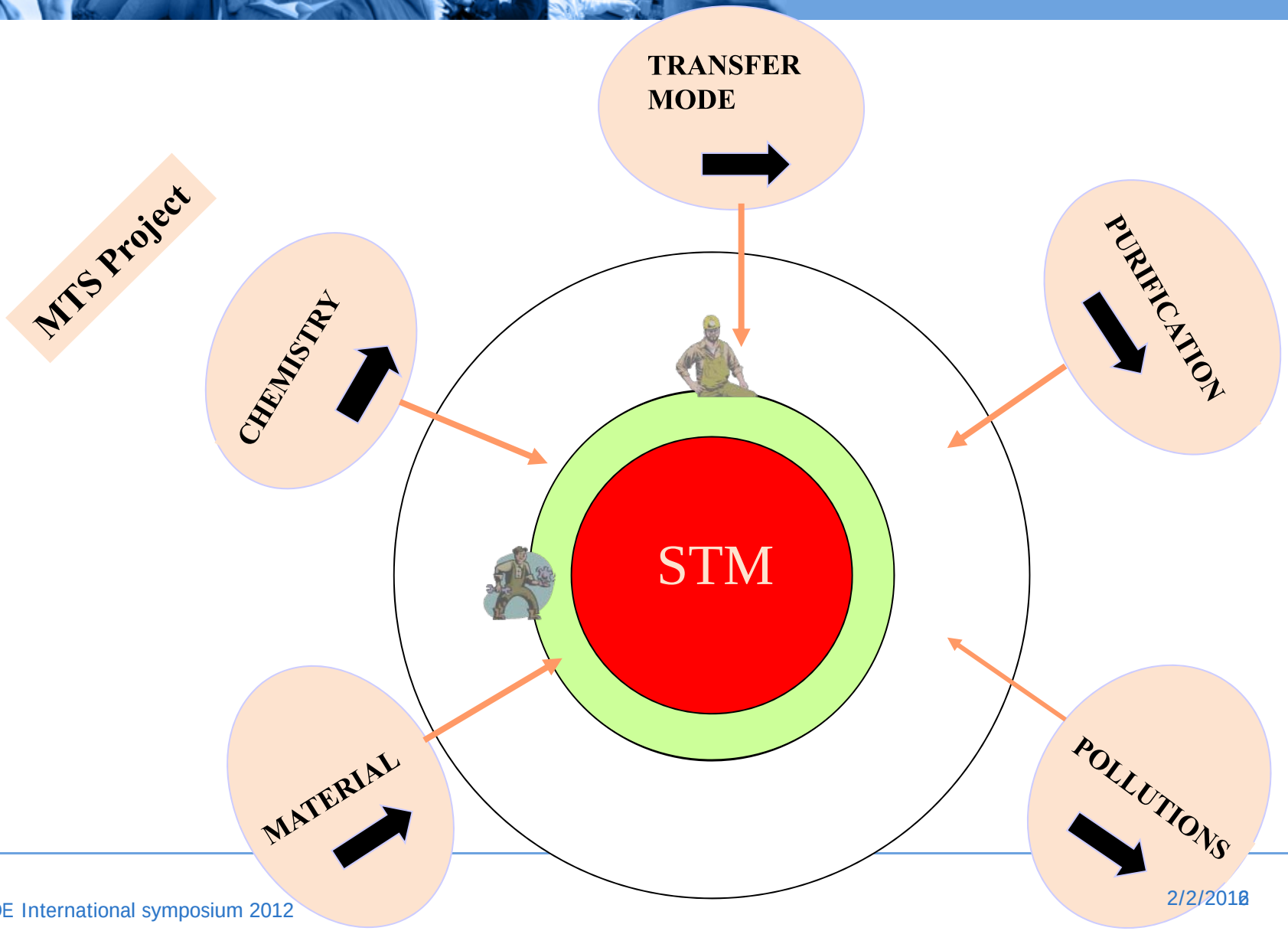


NORMAL CONTAMINATION (REMINDER)

90% of DOSES are due to CORROSION PRODUCTS



TO ACT ON SOURCE TERM



MATERIAL

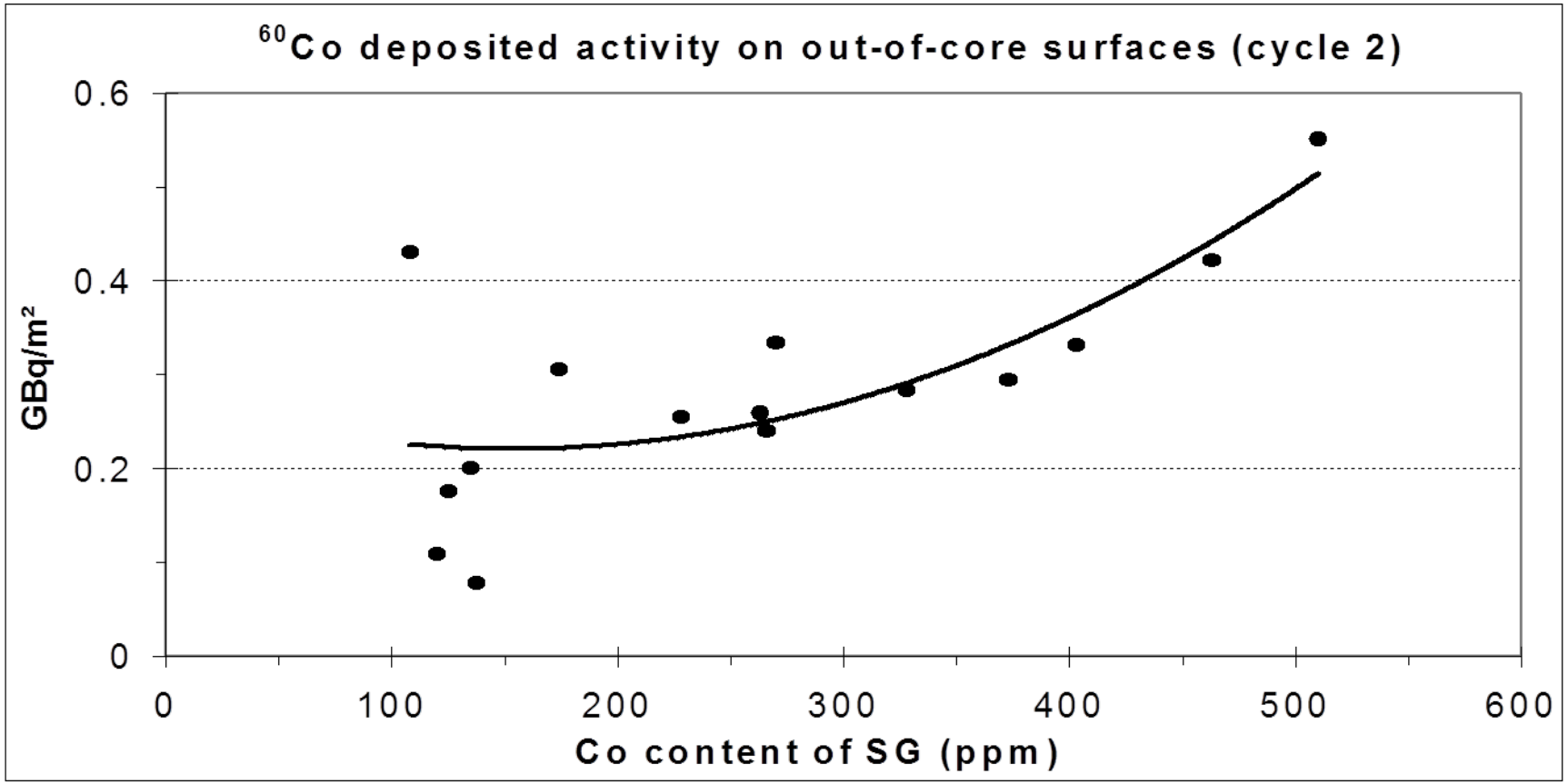
Objectives : Optimise the design to reduce doses & increase plant avaibility

SG manufacturing Advice for manufacturing : less particles release by tubes

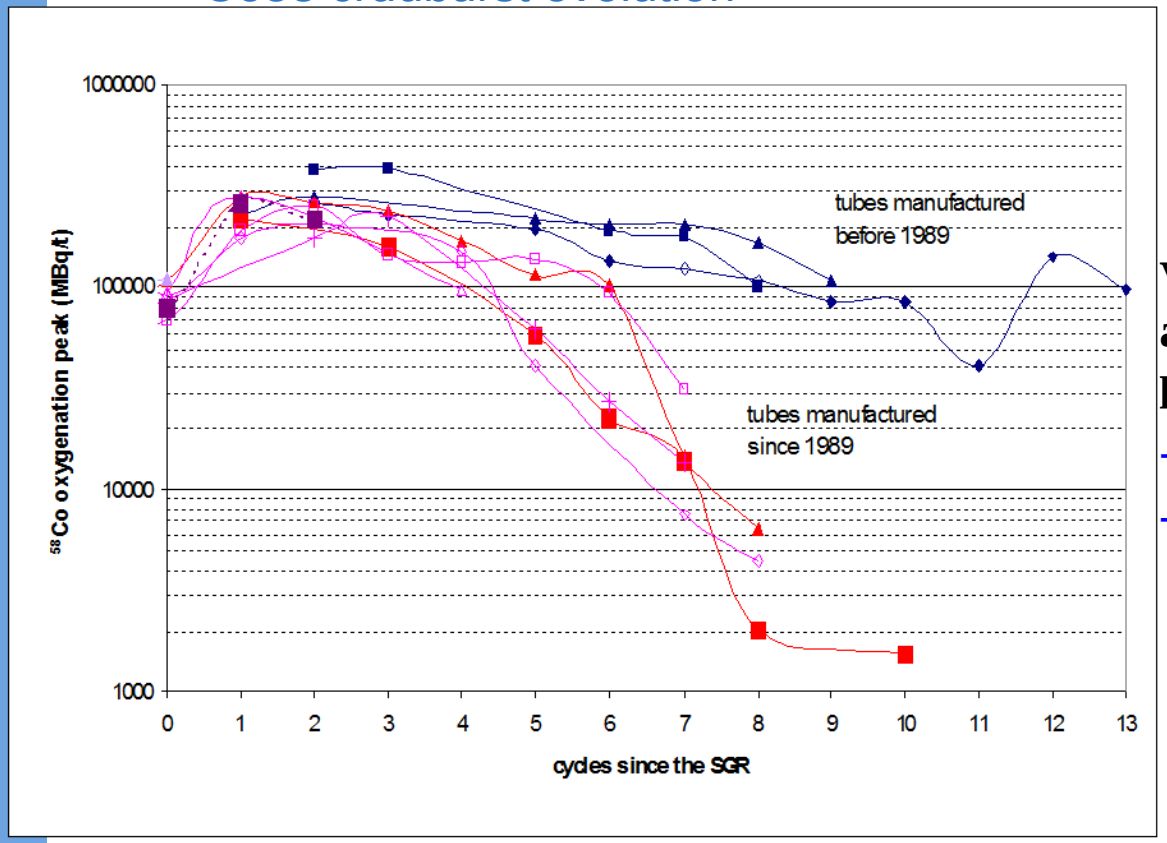
Electropolissage of SG channel head : Now electropolissage will be done systematically during manufacturing.

SG tubes Treatment before first start in operation : Passivation

Material : Impact of reduction of Co content in SG tubing alloy



Material : Impact of manufacturing process improvement for 690 SG tubing – Co58 crudburst evolution



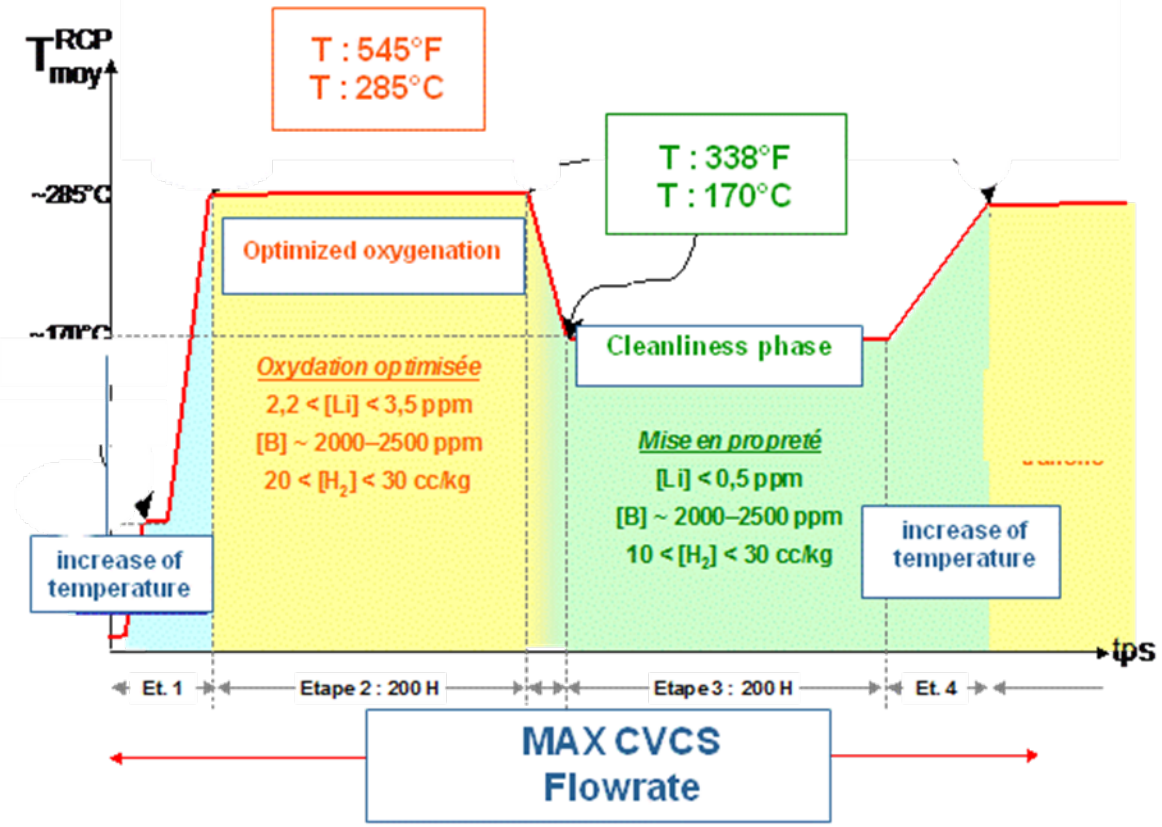
Very low level of Co58 crudburst after more than7 cycles for all tubes processed since 1989

- best availibilty

- minimization of Co58 source term

Material : 690 SG tubing pseudo-passivation – after SGR

Optimized oxygenation

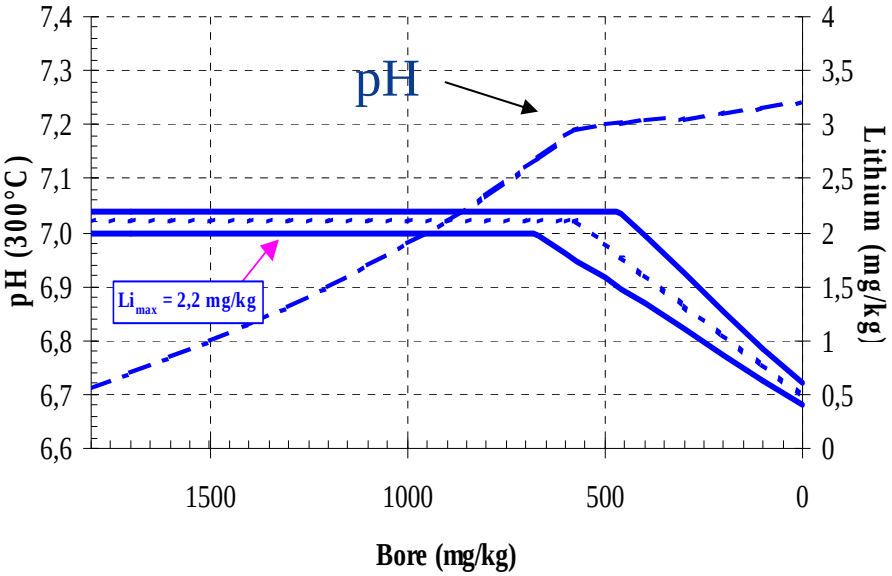


Cleanliness phase

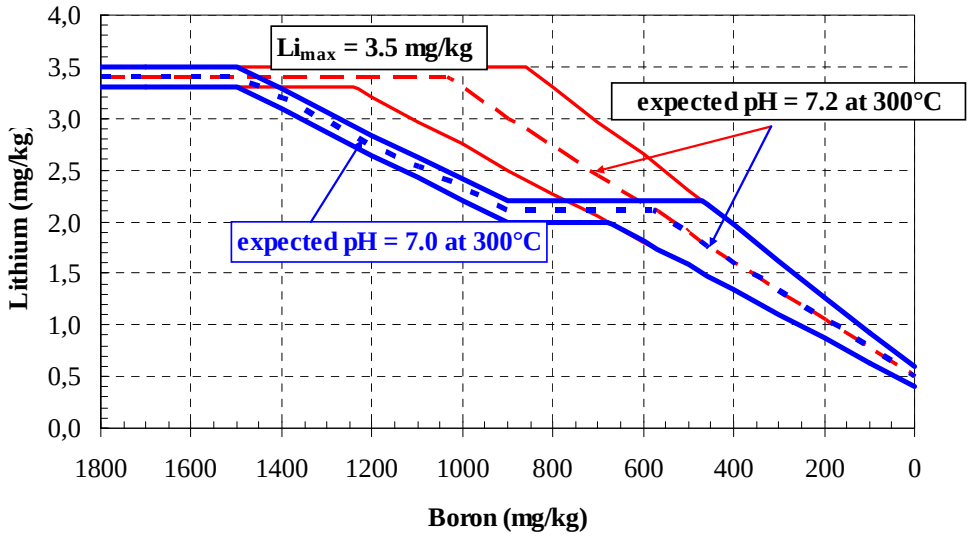
First experiment at Bugey 3 NPP, just after SGR (2011)

CHEMISTRY : pH

Current Chemistry



New Chemistry (DUO)
Chemistry with high Lithium



CHEMISTRY : ZINC INJECTION Experimentation (5 – 10 ppb)

Objective :

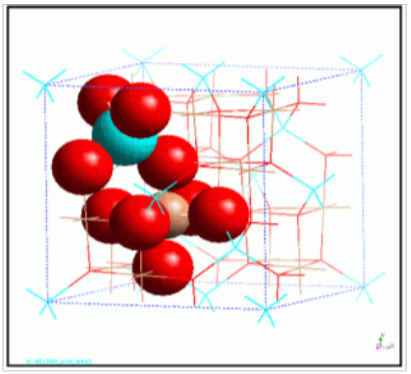
- To reduce the surface contamination by preventing the Cobalt incorporation in the primary materials by its substitution with an element without dose impact (Zinc)

Realized injections on :

- 5 fuel cycles (4 complete cycles) on BUGEY 2,
- 1 complete fuel cycle before a SGR + 2 complete cycles after SGR on BUGEY 4.

Realized measures :

- Characterization of deposit out of neutron flux by CEA
- Dose rate induced,
- Oxides build up on the fuel claddings by scraping



CHEMISTRY : ZINC INJECTION Experimentation (5 – 10 ppb)

Analysed impacts:

- Nature and amounts of effluents (no impact) ;
- Nature and spectra of filters and resins CVCS (no impact) ;
- Measures of metals and long life isotopes (no impact).

Results :

- After 2 complete cycles with zinc injection on BUGEY 2 : a 12 to 14% reduction of Cobalt 60 has been observed.

Prospects :

- Technical review in April, 2008 : decision was made to inject 5 more Units :

Paluel 1, Flamanville 1, Bugey 3, Blayais 4, Gravelines 3.

PURIFICATION : Filters & Resins

New contracts for Filters & Resins

- Homogeneous filters installed on the fleet
- Decreasing the cost

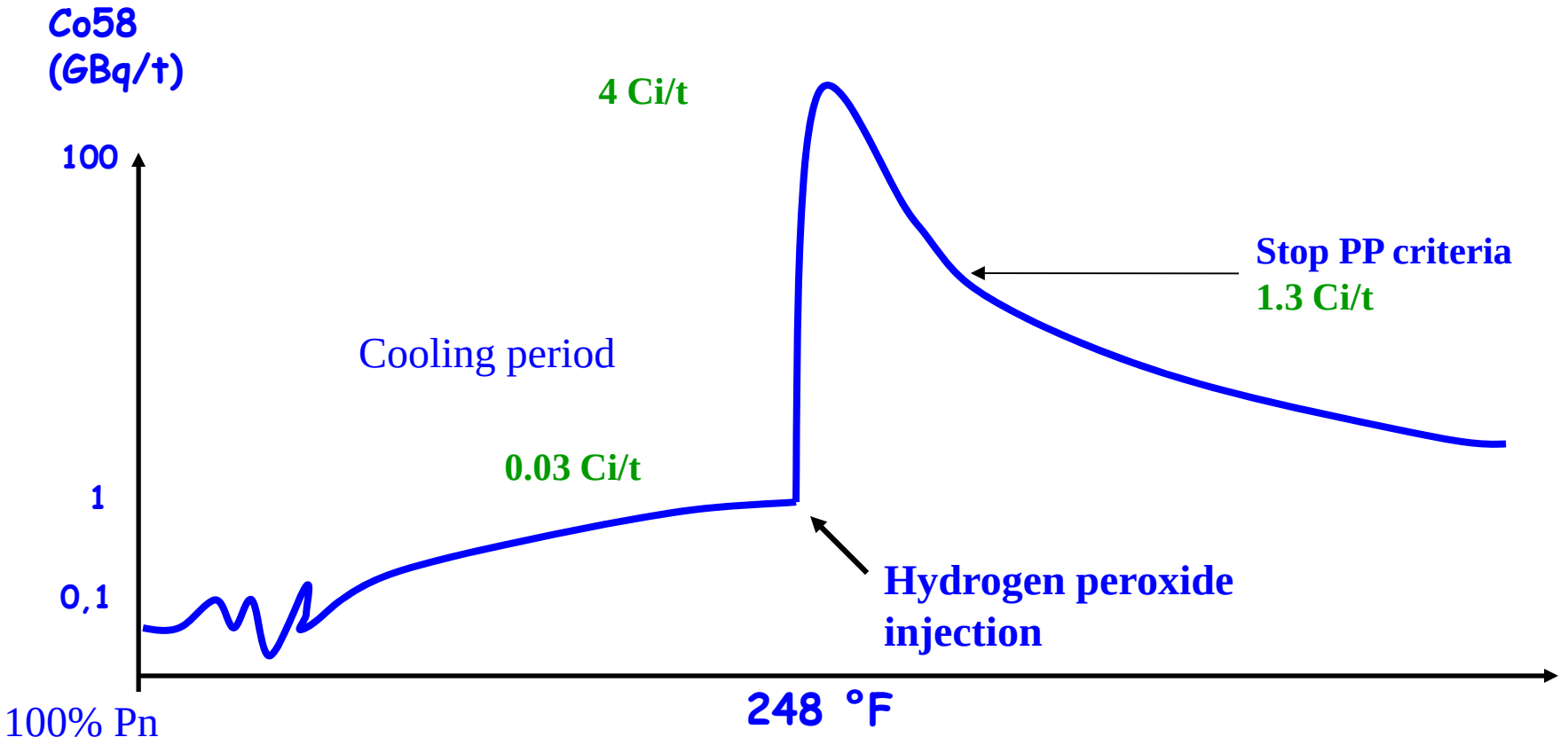
Filters Qualification under AFNOR standards

Recommandation for filters:

- Characterization of the filters : filtration threshold, capacity of retention, …)
- Identification of the filters circuit by circuit
- Replacement criteria : Delta P, dose rate, in service duration

Recommandations for resins still in progress

TRANSFER MODE : Shutdown transient



EXTRA POLLUTIONS : Origin, Dosimetry penalty, Indicators, Strategy

	Co60 (hot spots)	Ag110m	Sb124
Origins	Stellites : valves, pumps, internal, … **INSOLUBLE PARTICLES**	- Control road leaks in AIC areas -Helicoflex silver coated sealants wear **VERY SLIGHTLY SOLUBLE**	- Pump bearing made of antimony and carbon -Secondary neutron cluster source **SLIGHTLY SOLUBLE**
Dosimetry penalty (% of collective shutdown dose)	**15 – 25 %** (VDS circuits)	5 – 15 % (Cold part of auxiliaries : CVCS, …)	5 % (RCS homogeously
Indicators	Cartographies : valves, pumps, socket welding, …	Primary Water Activity : - In operation (> 2 Mq/t) - Oxyg. peak (> 3 GBq/t)	Primary Water Activity : - Oxyg. peak (> 60GBq/t)
Strategy	- Stelittes replacement if possible - Specific filtration with specific devices	- Standard Control Road replacement by « Coating » Control Road - Acidic shutdown purification	- Pumps replacement - Acidic (to improve Sb + Co removal)

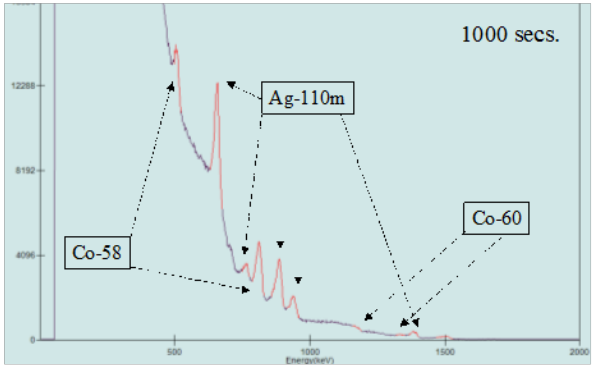
Characteristics of the Gamma CZT spectrometer

Used by NPP's since 2006

- Sensor : Cd-Zn-Te (semi conductor)
- Energy range: 300 keV to 1.8 MeV
- Sensitivity : 0.1 to 10 mSv/h
  60 or 500 mm^3 sensor
- Acquisition time : 1000 s

Compact probe &
w/o cooling

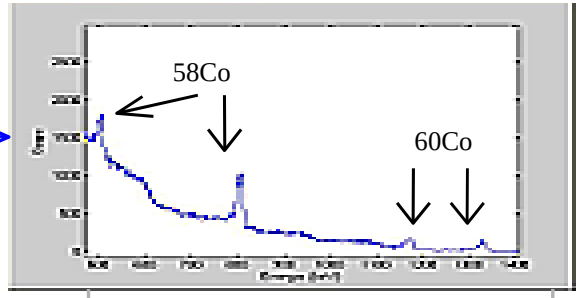
Connecting cable: 20m



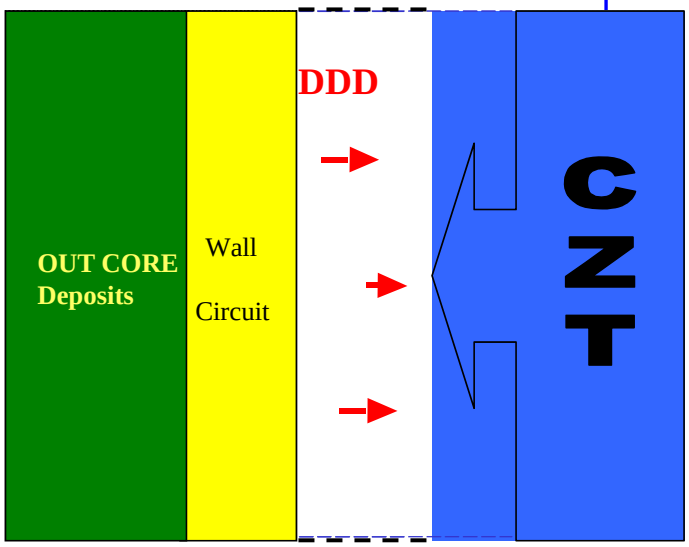
Operation principle of the CZT in NPP

ANALYSIS

100 keV - 1800 keV



MEASURE



Sensor collimator

Acquisition time # 1000 s

Contribution
% DDD
Sv /h

% Co58
% Co60
% …

RADIOPROTECTION

Wall attenuation

Contribution
% DEPOSIT
Bq

% Co58
% Co60
% …

SOURCE TERM

8 points Before and After Oxygenation

Outage Systematic Schedule

CHEMICAL and VOLUME CONTROL SYSTEM

P1 : RCV - Amont purification

P1 : CVCS – Upline purification

P2 : CVCS – Outline purification

P3 : CVCS – Non regenerative heat exchanger

REACTOR CAVITY DRAINING

P4 : Spent Fuel Pit Cavity

PRIMARY AND AUXILIARY SYSTEMS

P5 : RCS – Hot leg

P6 : RCS – Cold leg

P7 : SIS – Outline RCS valve

P8 : RHRS – Heat exchanger

P7 : 1300 MW

RCS-172VP / RC702

Harmonization : comparative examination - assessment

Average values expected: Co60, Co58, Ag110m

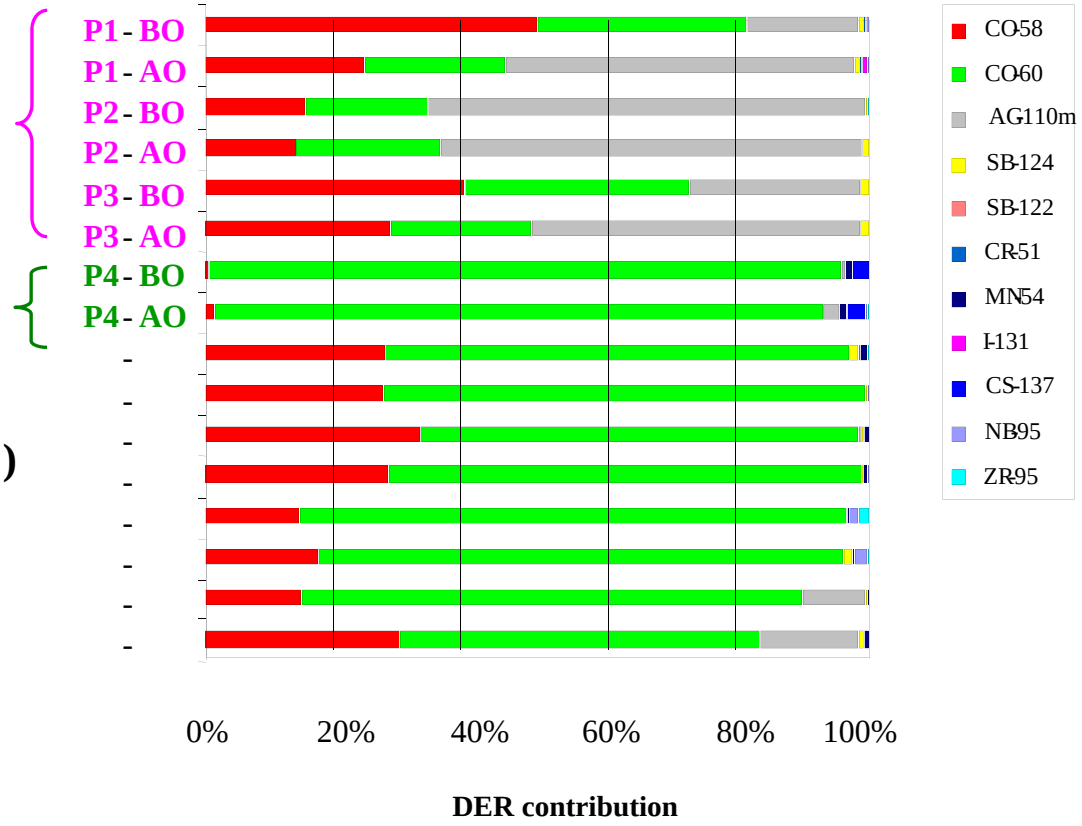
CVCS: large differences between the units Co58-60 and Ag110m

Reactor cavity: 100 % Co60

RCS: Co58 (15-45%) - Ag110m (# 0%)

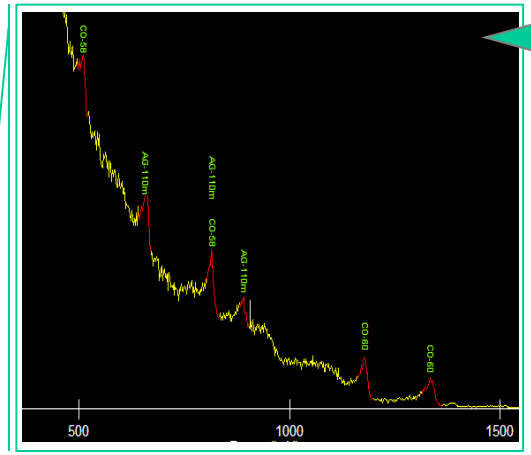
SIS: similar to loops but Co60 higher

RHRS: between RCS and CVCS

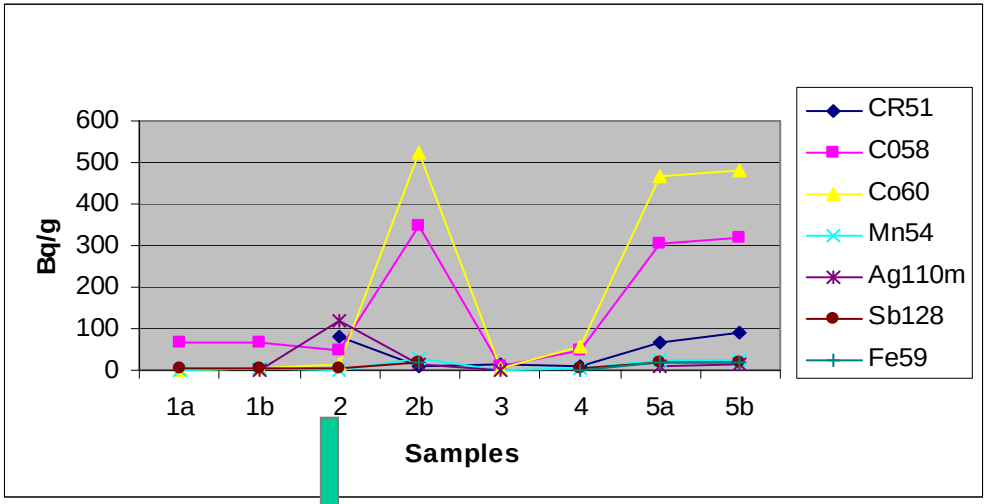


CZT IMPLEMENTATION: CVCS and RHRS decontamination

Decontamination process : depends on the radio isotope to removed



DR : 70% Ag110m + 20 %Co60 + 10% Co58



Emmag process

Emmag qualified process :
Ag removal

Dissolution Ag110m

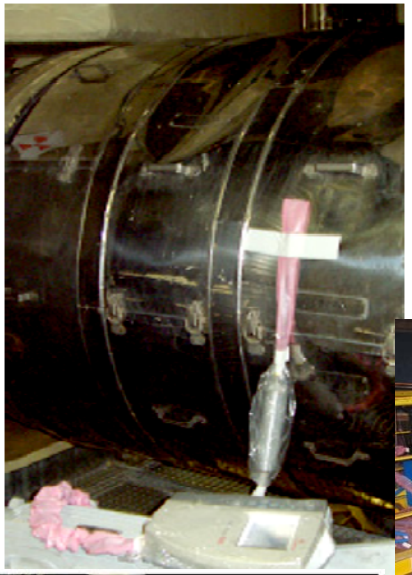
RESULT
Decontamination Factor > **3**

CZT Prospect : wall contamination measurements : GBq/m^2

Integration of software to calculate the deposited activity of selected geometry.

→Assessment of local decontamination efficiency (before and after cartography).

Heat exchanger

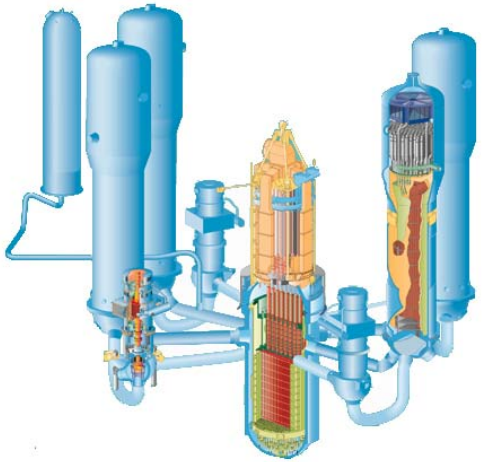


tanks

Decontamination

Fuel pit storage

Outage Systematic Schedule



Loops, …

Outage Systematic Schedule - CONCLUSIONS

Since 2006, the RP services have been equipped with a portable CZT gamma spectrometer. We consider it to be an indispensable tool for contamination diagnosis and for the prevention of over-contamination.
The CZT measurements are complementary to the water analyses carried out by chemists.

After three years of experience, CZT-Users confirmed the need of the spectrometer to understand contamination phenomena.

The spectrometer is easy to use. It is very important for the NPPs operators to implement a specific schedule of measurements during each outage.

Curative plans to decrease the high dose rate units

GOAL : **Estimated dose gain**
for the last six years of operation

CHINON 2	2004	- 0.7 H.Sv
FLAMANVILLE 1	2006	- 1 H.Sv
GRAVELINES 3	2007	- 2 H.Sv
BUGEY 2	2008	- 0.4 H.Sv
BLAYAIS 4	2009	- 0.6 H.Sv
TOTAL		**- 4.7 H.Sv**

A specific plan of actions

Preventive actions

- ✓ Master source term
- ✓ Avoid re-pollution

  - modification of installation
  - specific detection and measurement of pollution

Curative actions

- ✓ Eradicate hot spots and fixed contamination
- ✓ Protect from residual and recurring zones of pollution

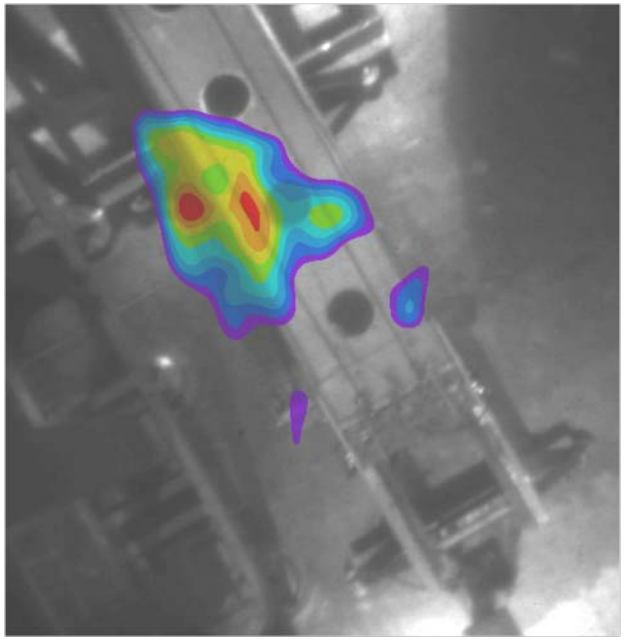
  - equipment decontamination
  - optimised biological protection

Detection and measurement tools

→ diagnostic of the location and origins of the contamination, the type of pollution, its form (mobile hot spots, oxide layers) and its localisation.

Gamma photography

Precise location of hot spot / contamination



Spectro gamma CZT

Analysing composition of radioactive deposit before and after each decontamination

Chemical decontamination EMMAC

Innovation in decontamination

- Target : RHRS an CVCS heat exchangers and circuits
- Objective : remove a large amount of fixed activity
- One loop of decontamination : circulation of an oxydo-reduction solution

Pools decontamination

Under water aspiration system

Complete decontamination of pools' walls

Results : ≈1 Man.Sv / reactor

A decreasing dose :

- Reduction of the general dosimetry and removal of hot spots (DRRF of 3 to 10)
- **NO** high dose rate areas
- Important “know how” and development of skills in decontamination for EDF and its partners
- Increase of RP culture and important exchange between concerned NPP

NEW REACTOR BUILDING INDICATOR

Report : No inter-comparable mappings of the radiological Reactor building state

Indicator : Mean of 50 dose rate measurements located on 6 levels of the RB

Goal : To create a global RB cartography in order to analyse :

- the state of the pollution level

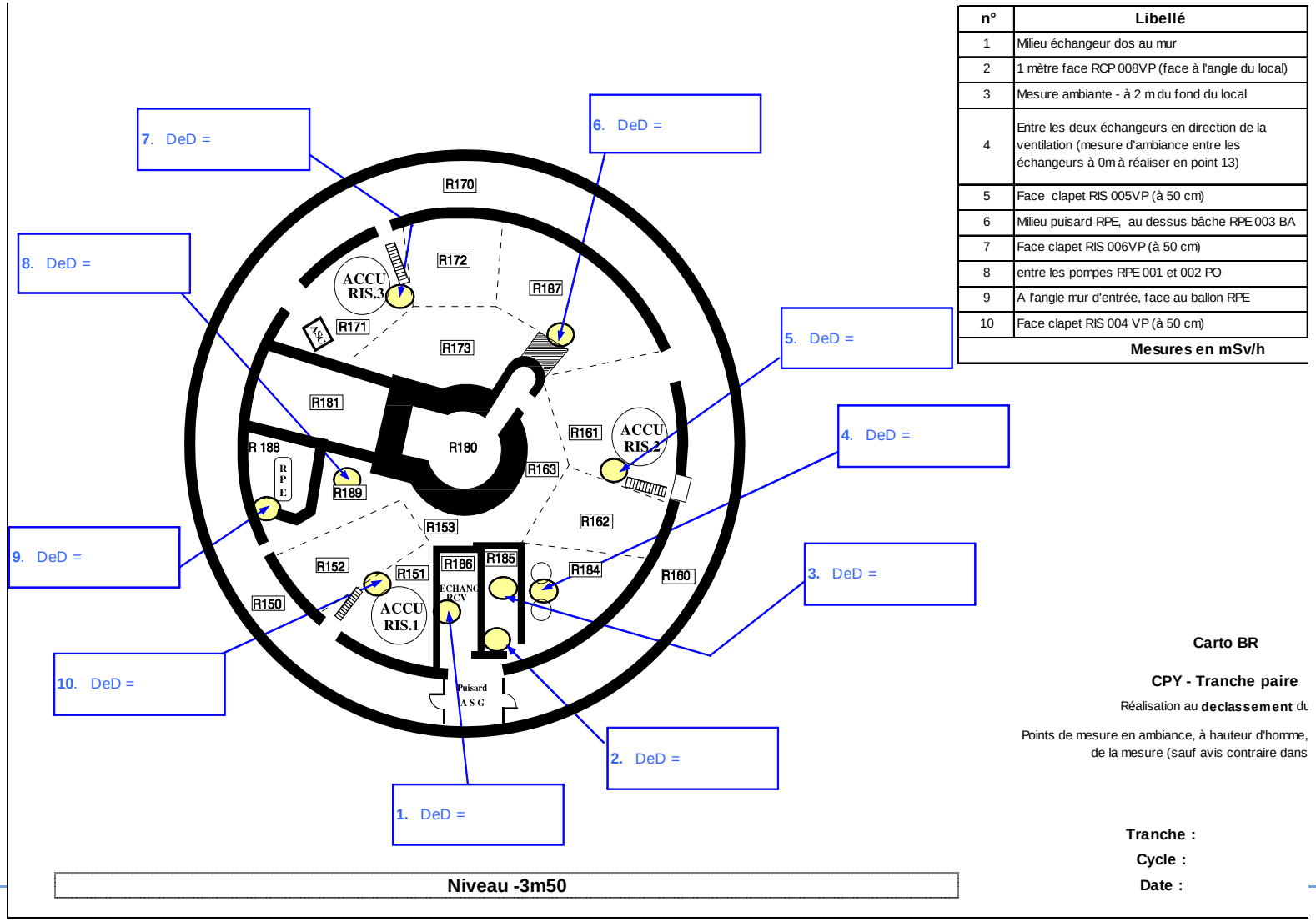
- **the plant evolution**
- **the intercomparison between the different plants**
- **to identify quickly the pollutions.**

Every point is representative of the radiological state of a circuit in particular

- Sub-indications: I^{RCS}, I^{CVCS}, I^{SIS}, I^{SG}, …

Implementation : November, 2009

NEW REACTOR BUILDING INDICATOR



n°	Libellé
1	Milieu échangeur dos au mur
2	1 mètre face RCP 008VP (face à l'angle du local)
3	Mesure ambiante - à 2 m du fond du local
4	Entre les deux échangeurs en direction de la ventilation (mesure d'ambiance entre les échangeurs à 0m à réaliser en point 13)
5	Face clapet RIS 005VP (à 50 cm)
6	Milieu puisard RPE, au dessus bâche RPE 003 BA
7	Face clapet RIS 006VP (à 50 cm)
8	entre les pompes RPE 001 et 002 PO
9	A l'angle mur d'entrée, face au ballon RPE
10	Face clapet RIS 004 VP (à 50 cm)

Mesures en mSv/h

Carto BR

CPY - Tranche paire

Réalisation au **declassement** du

Points de mesure en ambiance, à hauteur d'homme, de la mesure (sauf avis contraire dans

Tranche :

Cycle :

Date :

FLUSHING ACTIONS : Operational document

This document specifies the principle of these flushing actions, the necessary equipment, the planning in workshift change

17 flushing actions are detailed for RCS/SIS, RHRS, CVCS and fuel pit drainlines .

Each operational document mentions:

- Description and objectives
- Requirements
- Teams and their roles in intervention
- Expected results
- Link with the action and its impact on the RB indicator

FLUSHING ACTIONS : Operational document

Example: Flushing on SIS drain line through a pre-confined filter

Objective : get DR decrease

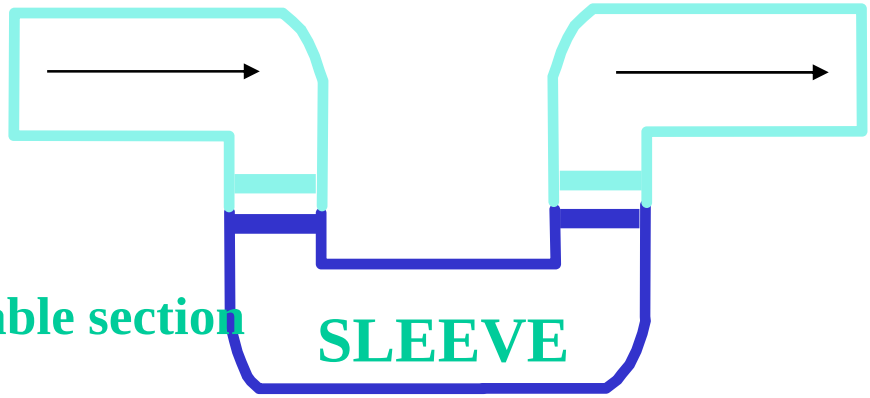
- on the drain line
- in the adjacent zones (-3,50 m).

RB indicator decrease due to the impact of the points 5, 7 and 10

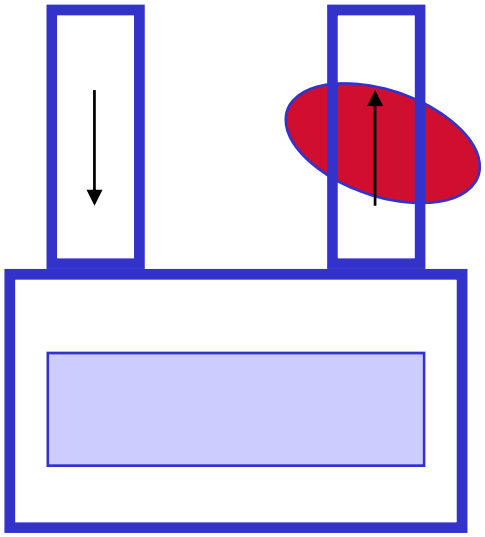
Requirement : the realization of this flushing is recommended for an ambient DR higher than 0.1 mSv/h.

Filtration sleeve (design)

Migration of hots spots



Fixed section

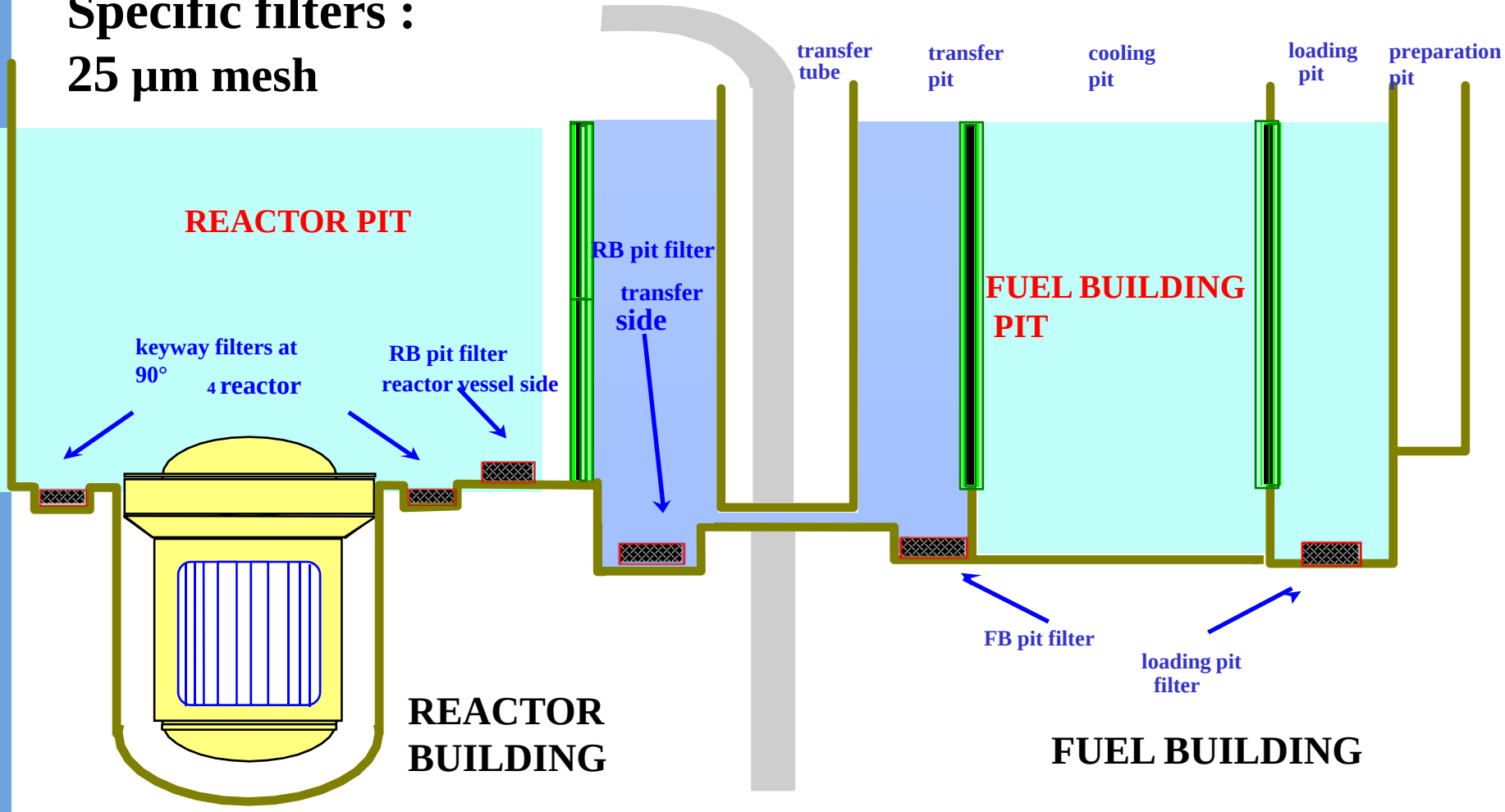


Pump

Pre-confined filters

HOT SPOTS – PREVENTIVE STRATEGY

Specific filters :
25 µm mesh

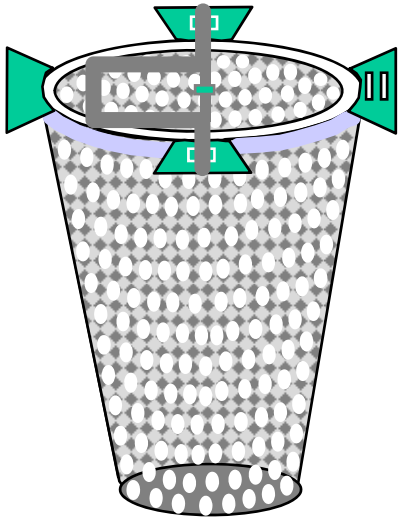


Pit bottom filters (design)

- Retention threshold 25 µm

- Sealed by means of ‘O’ rings

- Removal is quick and possible under water and simple to install



PREVENTION IS ESSENTIAL AGAINST HOT SPOTS

"Optimisation of radiation protection" reference system made applicable to all sites

"Optimisation of radiation protection" reference system made applicable to all sites

NIVEAU D'ENJEU RADIOLOGIQUE DE L'ACTIVITE	0 ou très faible	1 ou faible	2 ou significatif	3 ou fort
Dose collective (homme.mSv)	1	10	20	
Débit d'équivalent de dose (mSv/h)	0,1	2	40	
Propreté radiologique	NC0	NC1	NC2	NC3

N.B. : l'enjeu retenu pour l'activité est le plus élevé obtenu après l'application des 3 critères.

Professional sector

RP (power operation)

Alara Committee

Workstation studies using Panthère software

Workstation studies using Panthère software (radiation protection calculation code)

- A digital simulation tool: PANTHERE

  * Forecasting and Theoretical Analyses of Exposure Inside the Reactor Building

- Geometric modelling of the site

- A description of the contamination spectrums

- Workspace exposed

The reality

Workstation studies using Panthère software (radiation protection calculation code)

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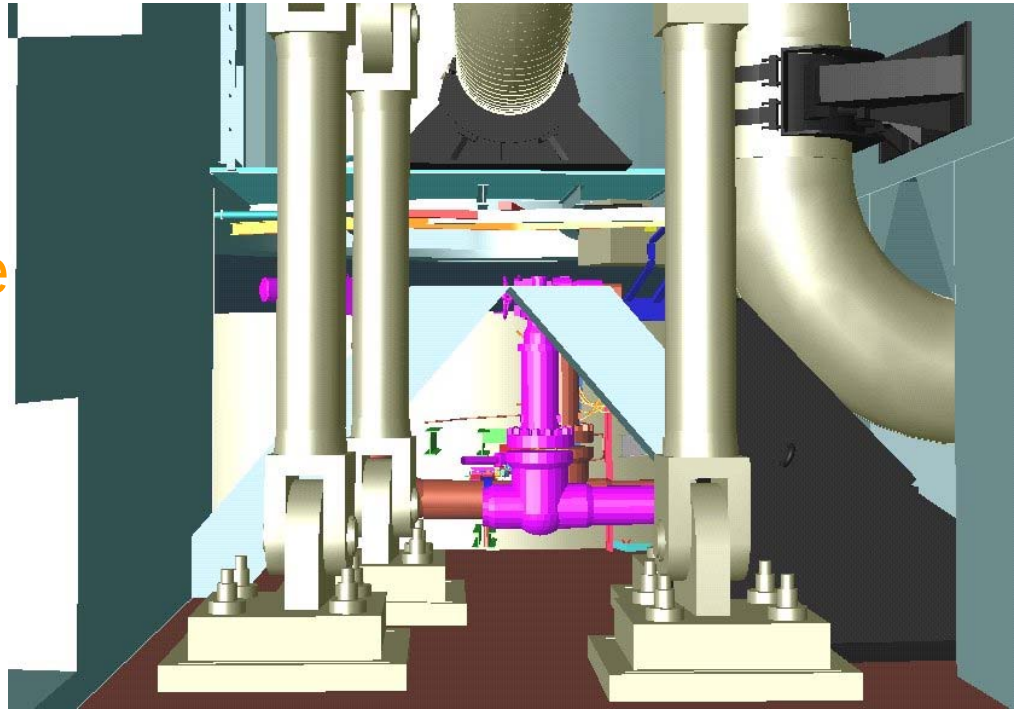

Modelling in a 3D environment

Workstation studies using Panthère software (radiation protection calculation code)

- A digital simulation tool: PANTHERE

  * Forecasting and Theoretical Analyses of Exposure Inside the Reactor

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- A description of the contamination spectrums

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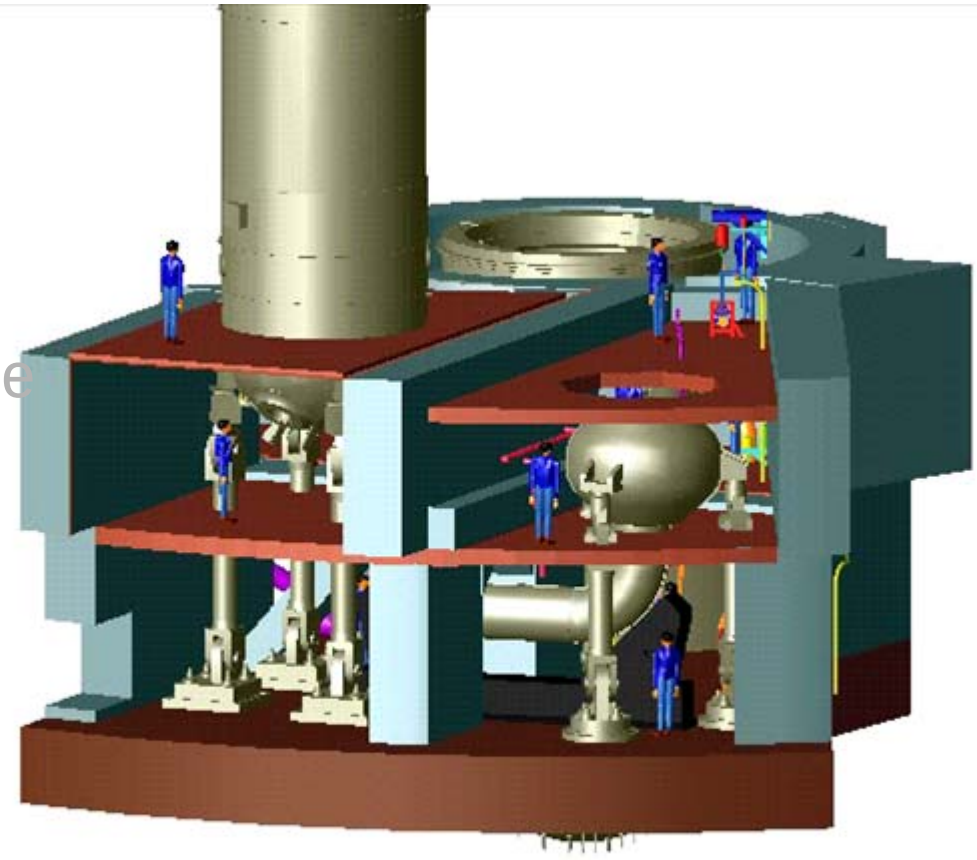
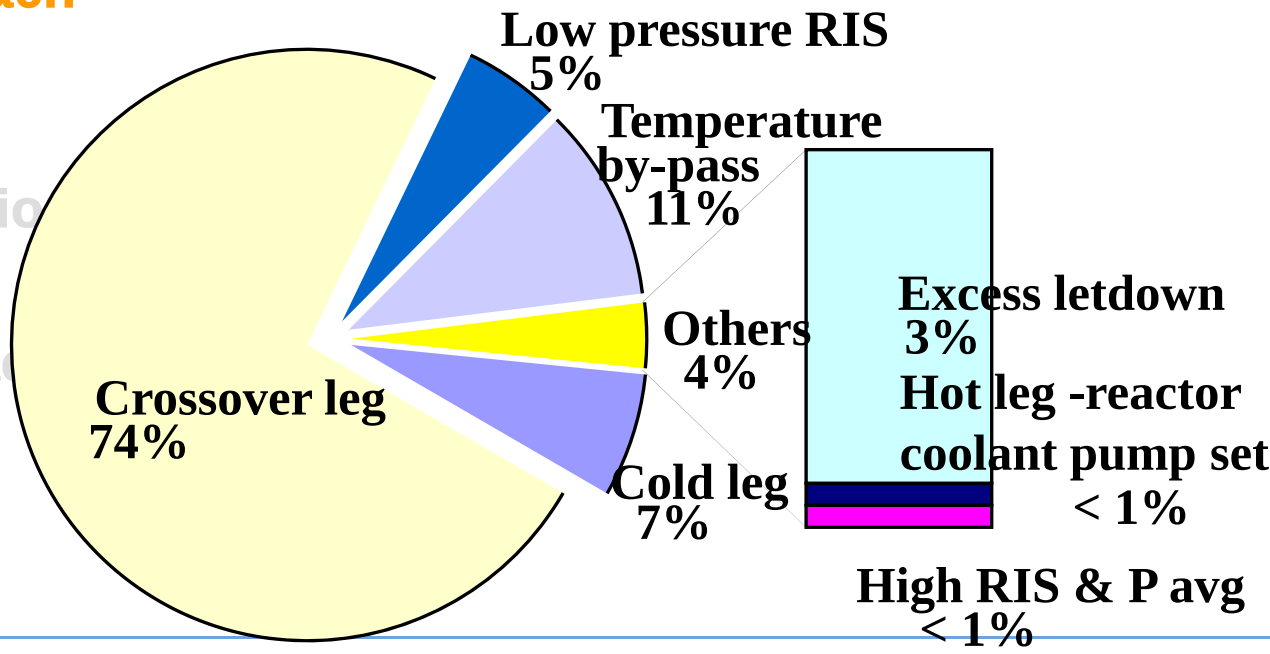


Workstation studies using Panthère software (radiation protection calculation code)

- the radiological context of the sites:
  - **contribution of each source**
  - dose
  - action quantificatio optimisation
  - contribution of ea radionuclide

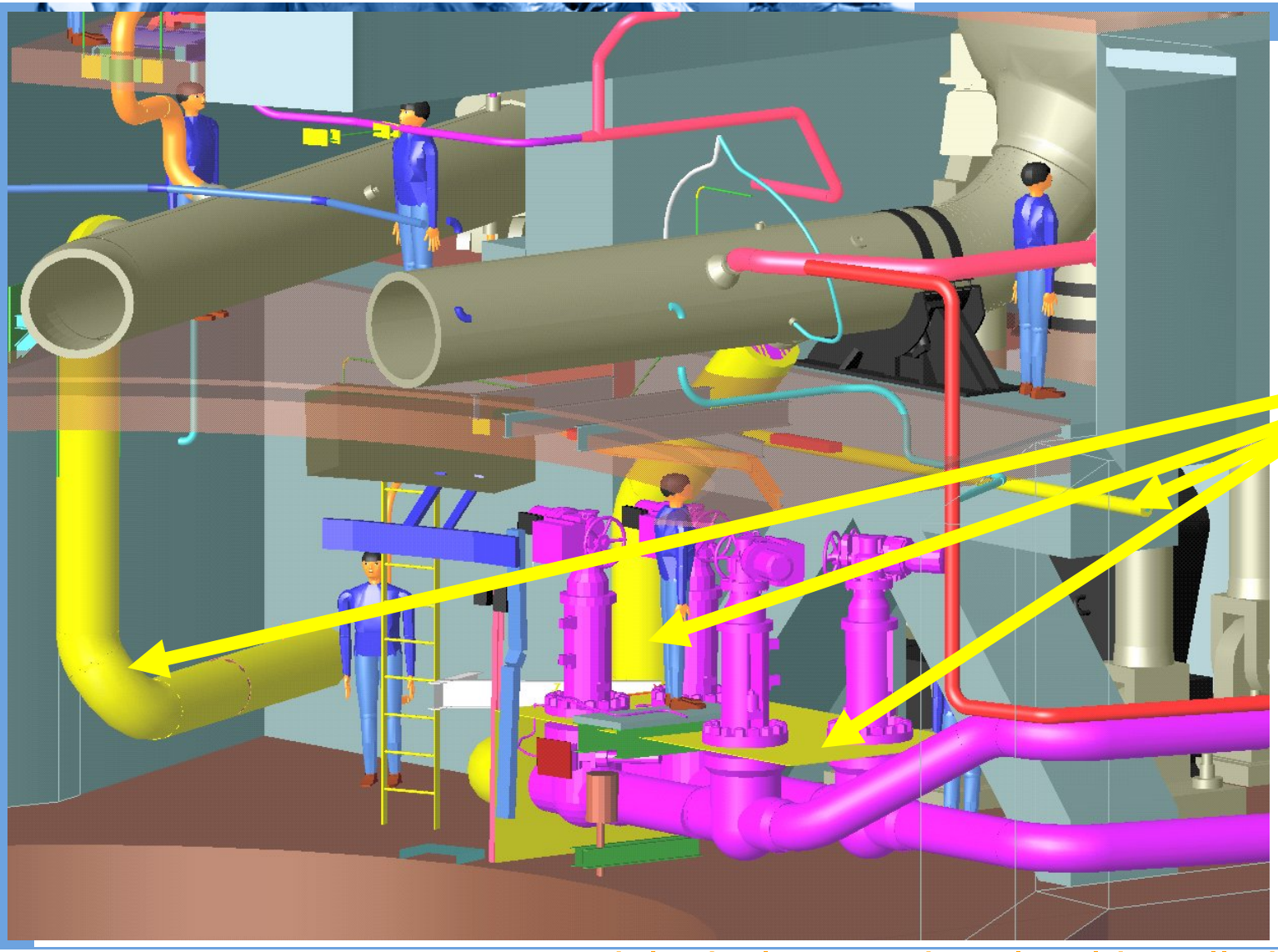
Equivalent dose rate at the workstation



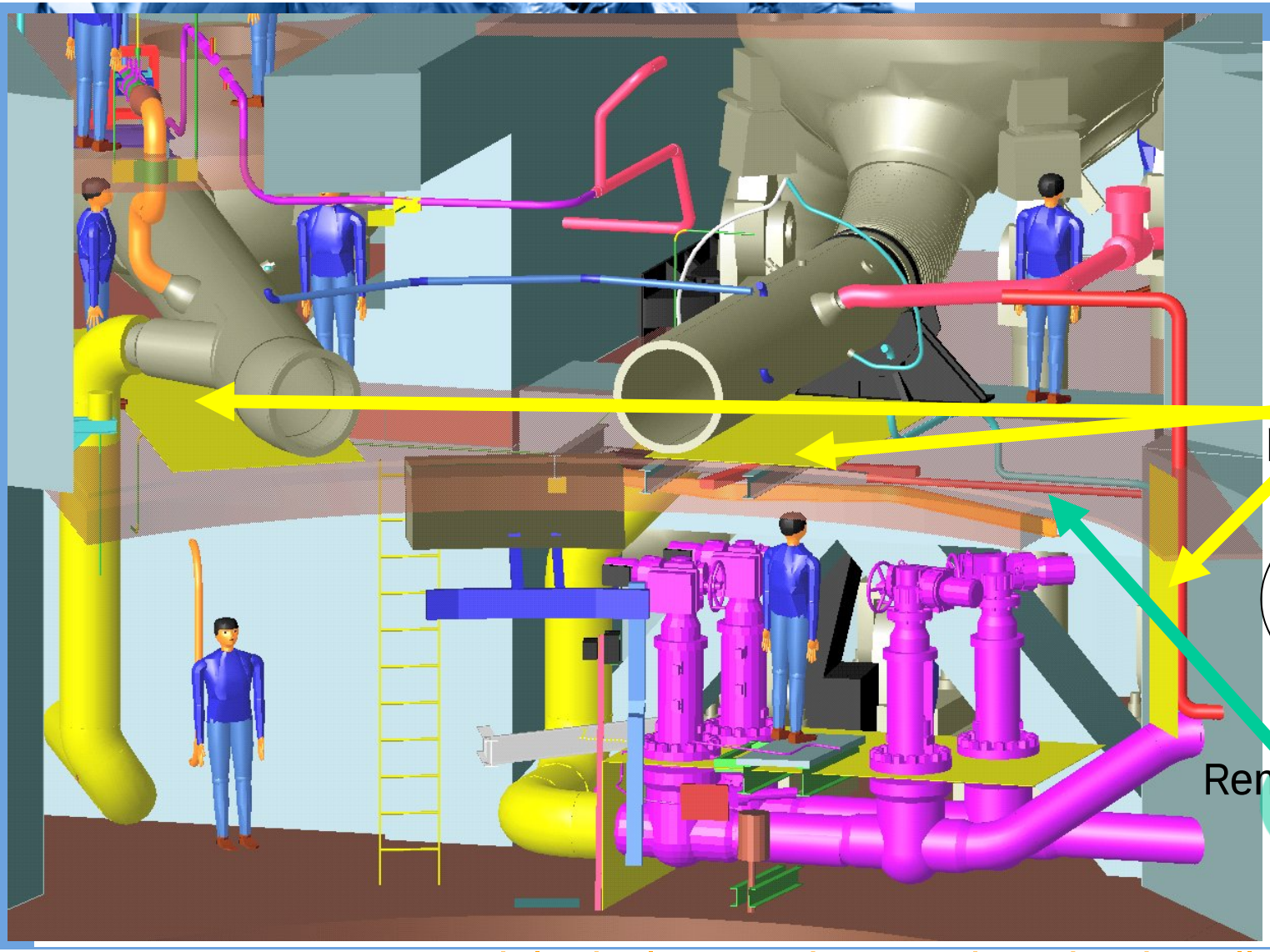
Workstation studies using Panthère software (radiation protection calculation code)

- the radiological context of the sites:
  - contribution of each source
  - **dose**
  - **quantification of optimising actions**
  - **contribution of each radionuclide**

equivalent thickness of lead	empty system	water system
	mm	mm
steam generator source	12	6
temperature by-pass source	12	12
steam generator and hot leg w ater box	6	6

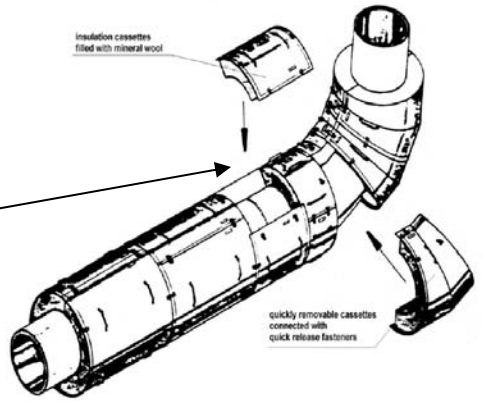


Biological protection: local installation programme



Biological protection: engineering installation programme

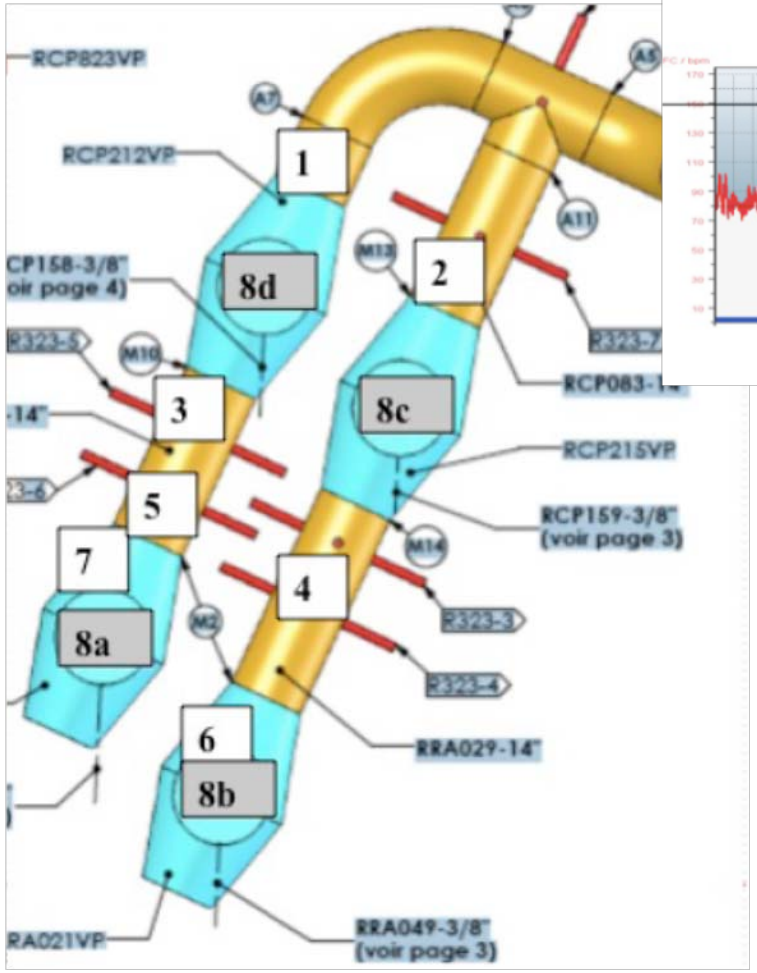
"Insulation" cases

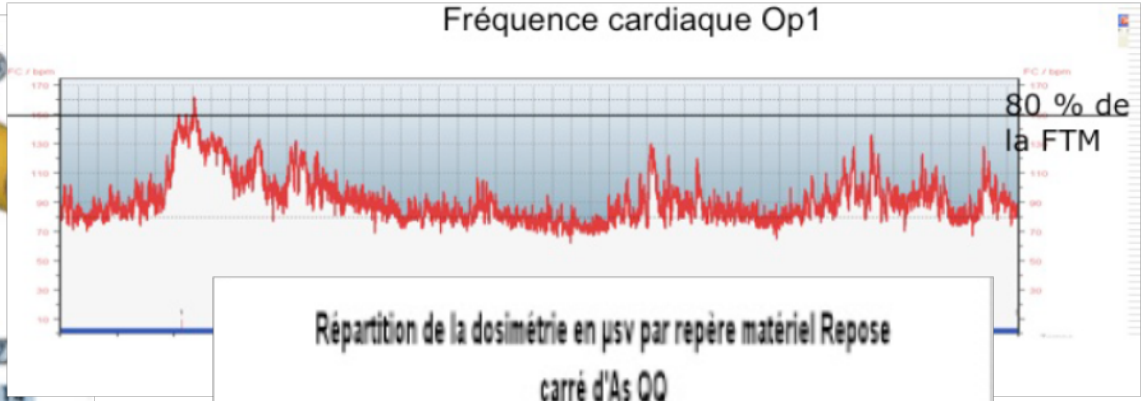


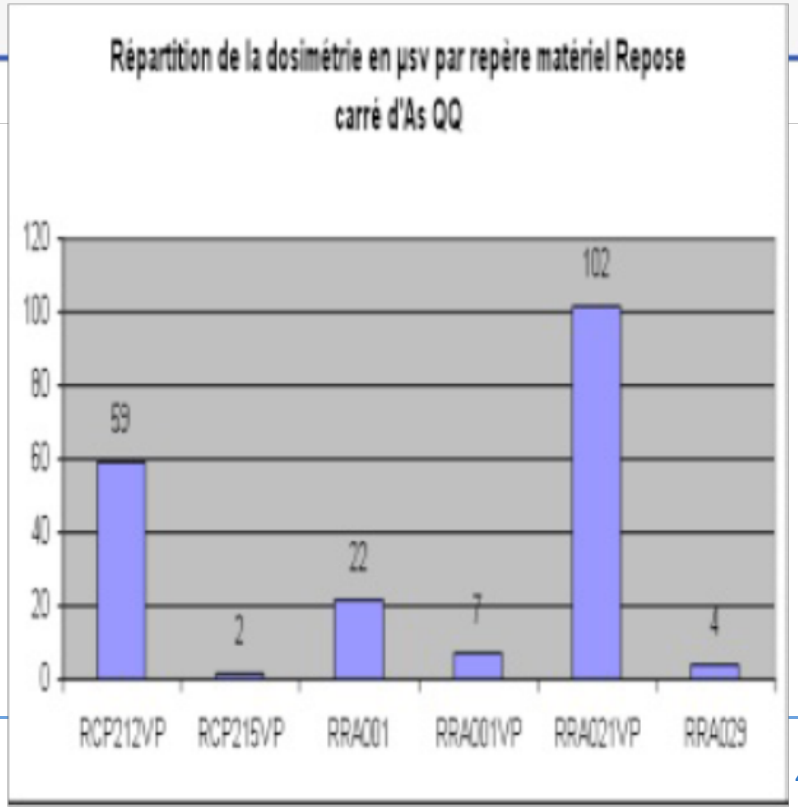
4 batches:

1. Replacement and development of insulation design
2. Workstation analysis (ergonomics)
3. Organisation of implementation and technical coordination
4. Training

"Insulation" cases: 4) Workstation analysis







"Biological Protection" case

3 batches:

1. Publication of biological protection catalogues per series.

   Definition of a biological protection installation reference system.

   Line calculation with "direct installation".

   Development of a prototype decision-making tool to for the selection of shielding options. (CADOR tool)

2. Review of the inclusion of the "shielding" activity in standard logistics contracts.

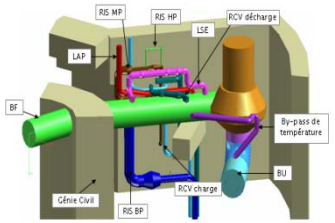
3. Installation of fixed supports or permanent shields.

"Biological Protection" Cases:

Batch 1) Cador Tool

CADOR

- 3D Diagrams
- List of sources



UTO (National level) **Sites**

WSE - shielding options
- maintenance operations
- master equipment isolatio

RP (power operation) Carto

Panthère

Matrix
Mitigation
Dose rate

- Where
- When
- How

Validation of variants

Updates

Dose

Dosimetry results

THINKING in the early 90s

In 1990, the Directorate of EDF decided to develop an information system to track, manage and control the dosimetry of ALL workers exposed to IR, whether EDF employees or contractors (subcontractors).

DOSINAT was born. This application consolidates, at a national level, all of the asymmetric data used in local applications (A22).

In 1992, when this tool was first set up, the following observations were made: 1,200 workers were higher than 20 mSv.

Objectives:

- 1.6 HSv/plant in 1995
- 1.2 HSv/plant in 2000
- Nobody > 20 mSv/12 consecutive months in 2000

Priority actions:

- Optimisation of sites
- Implementation and operation of operational feedback
- Source term control
- Shutdown control committee

Operation:

- Project mode
- Variation from national to local

Some of the priority actions:

- **Identification of the most heavily dosed businesses and specialities**
  - ✓ 80% of people > 20 mSv/12 months are employed by 24 companies.
  - ✓ Meeting with the companies
  - ✓ Identification of weaknesses and strengths
  - ✓ Development of shared action plans

- **Monitoring of these companies by Industrial Policy Managers on site and nationally**
  - ✓ Distribution for "human scale" monitoring

- **Implementation of improvement initiatives**
  - ✓ Cefri qualification
  - ✓ Triannual contractualisation
  - ✓ Contract awards based on results

PROJECT ALARA "2" - Since 1998

The project ALARA "2" focuses on radiological cleanliness and the industrialisation of Forecast Dosimetry Assessments (FDA).

It also includes measuring equipment issues (changing dosimeters, setting out monitoring areas,…) and an IS component (communication between preparation and dosimetry).

PROJECT ALARA "2" - Since 1998

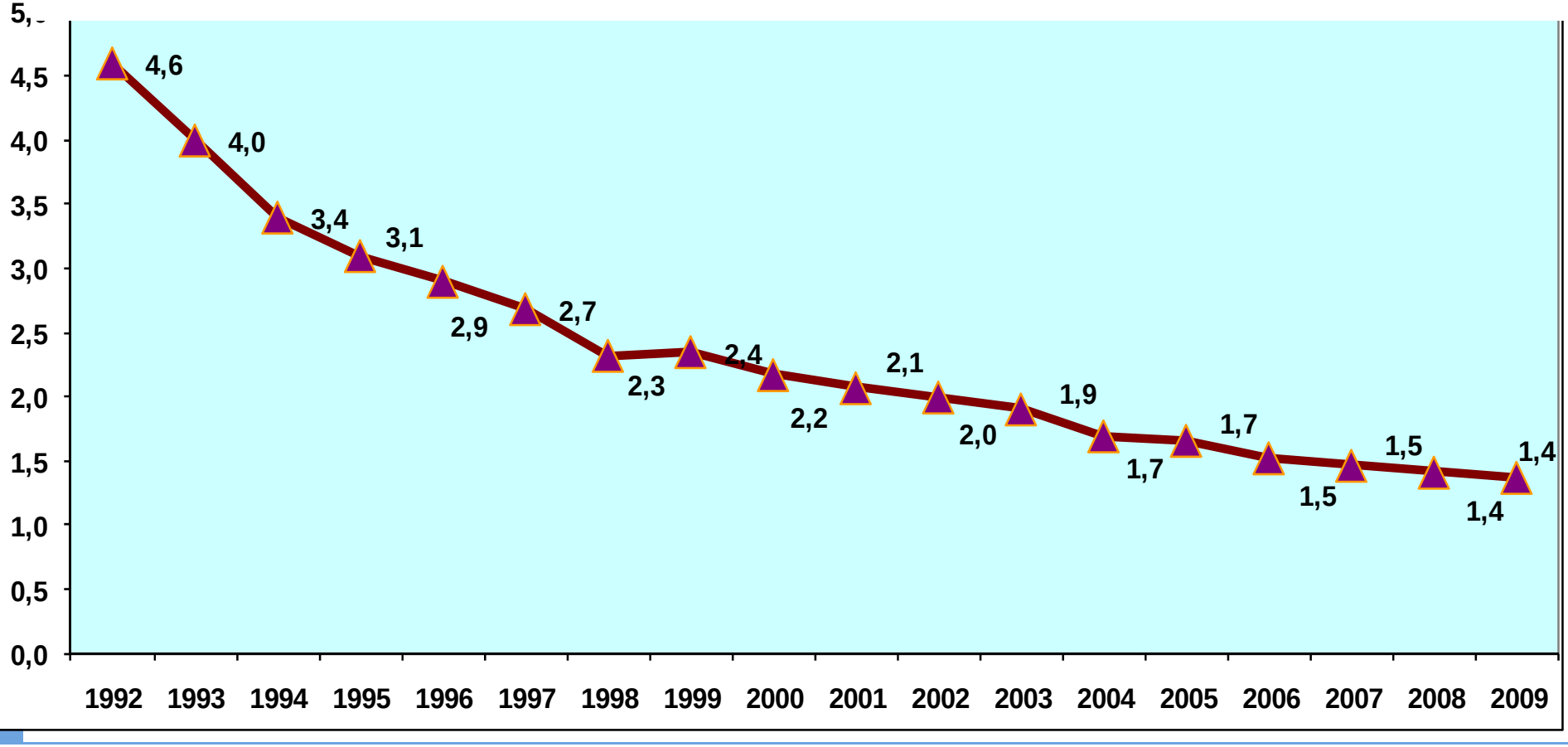
Some of the priority actions:

- **Action on "Insulators" specialties**
  - ✓ Workstation analysis
  - ✓ Establishment of a GOA devoted to optimisation;
  - ✓ Training / site support…
  - ✓ Planning (re)insulation activities as well as other AT activities
  - ✓ Installation of "encapsulated" heat insulation whenever possible during 10 Years Outages

- **Term source control**
  - ✓ Zinc injection file. action carried out in 2004.

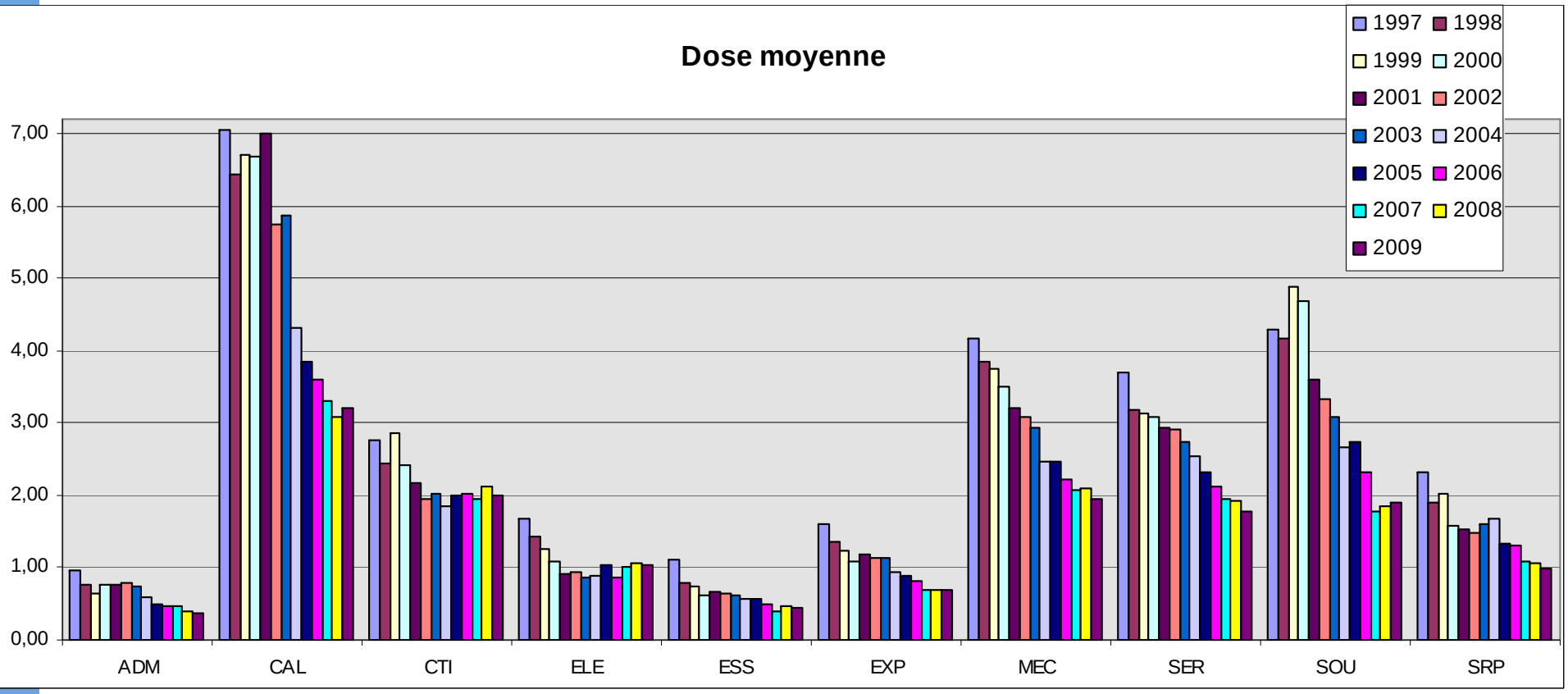
- **Continued implementation of appropriate biological protection.**

Wokers average dose (workers with dose > 0, in mSv)

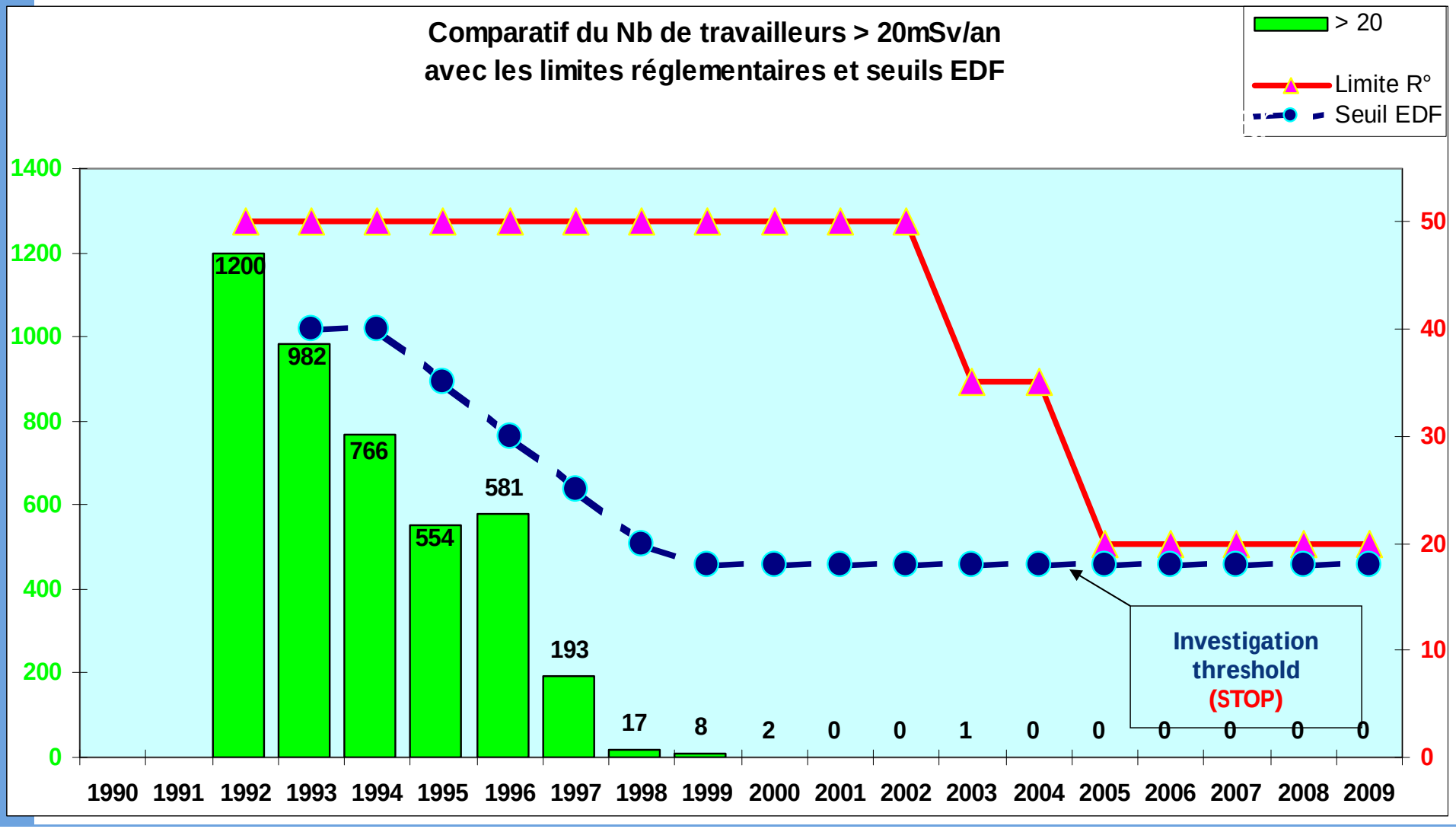


RESULTS – Changes in dosimetry by specialty

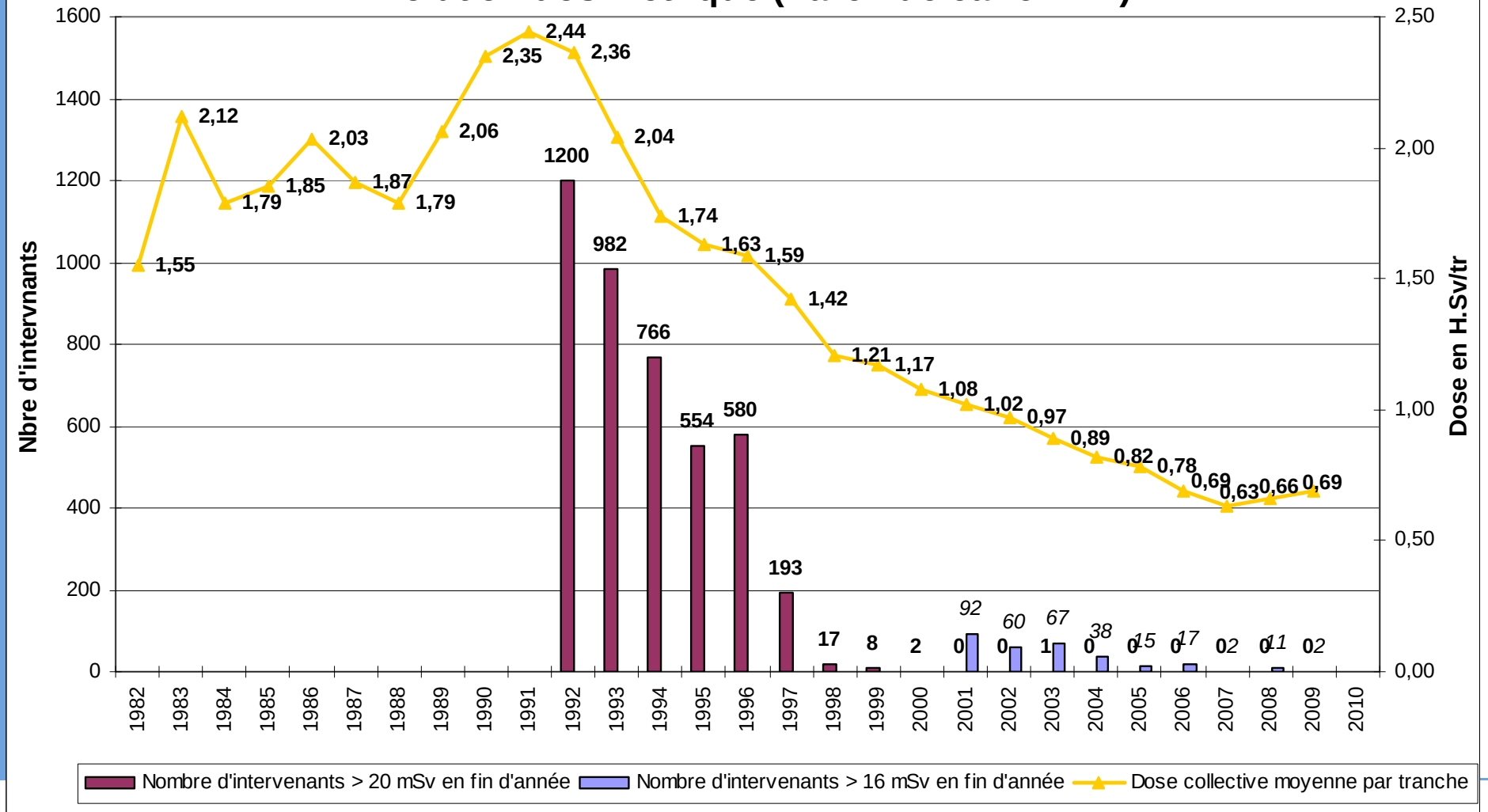
Workers are classified by type of main activity in order to better target the PR actions to be undertaken



Comparatif du Nb de travailleurs > 20mSv/an avec les limites réglementaires et seuils EDF

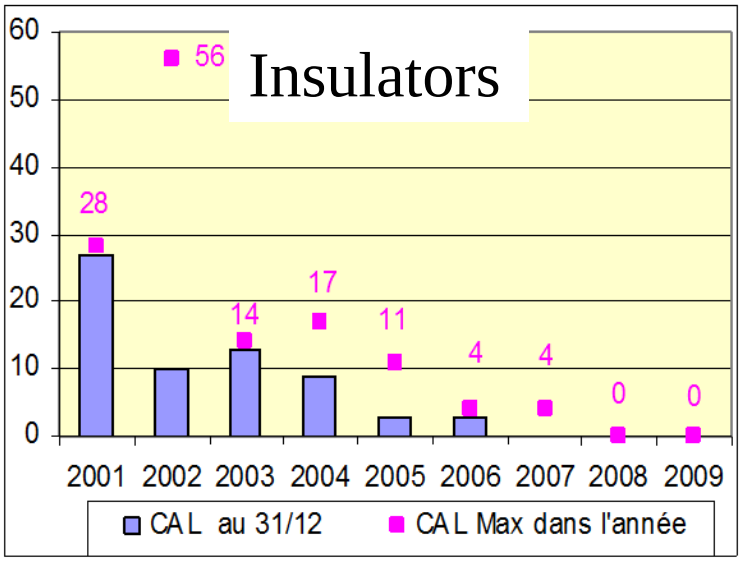


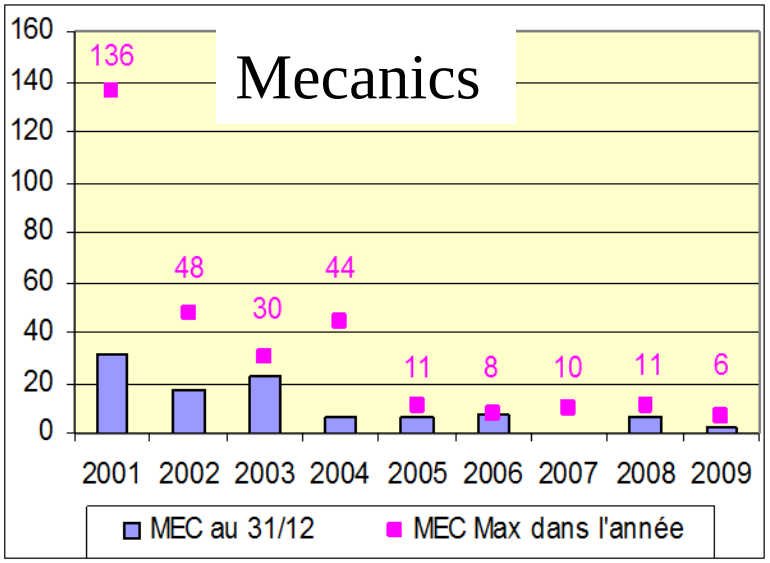
Evolution dosimétrique (Parc nucléaire EDF)

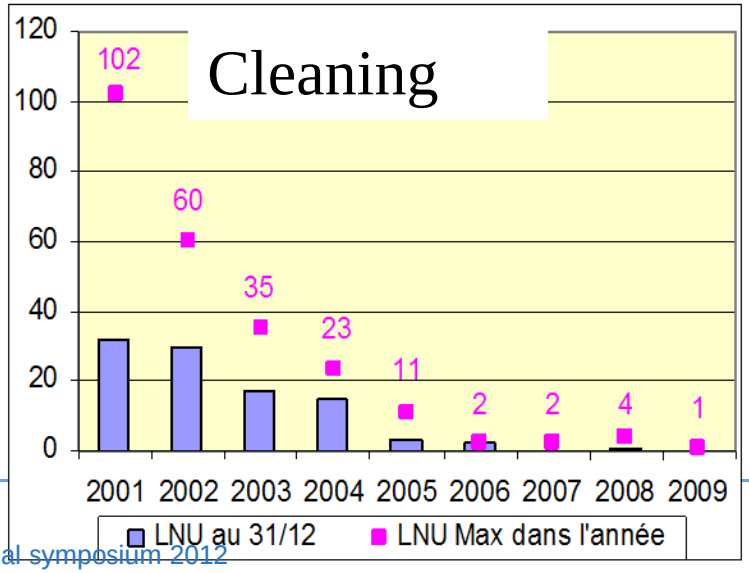


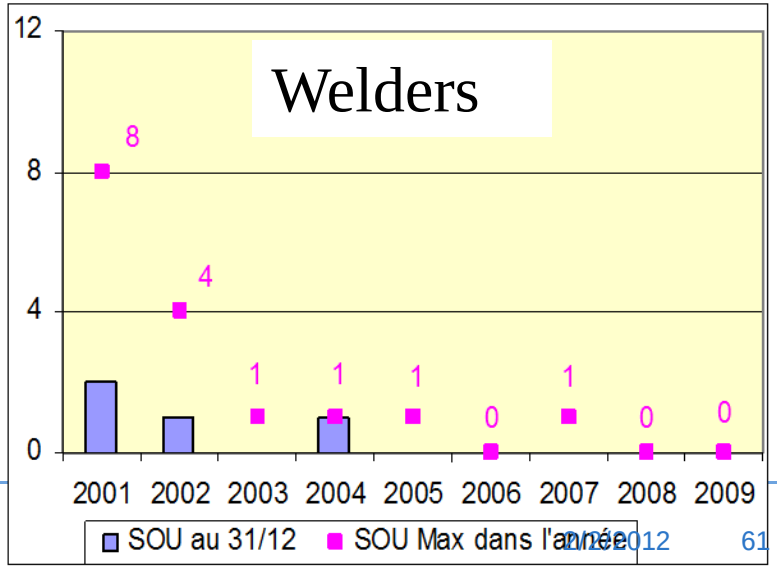
RESULTS – Changes in dosimetry by specialty

Focus on the most highly exposed specialties (> 16 mSv)

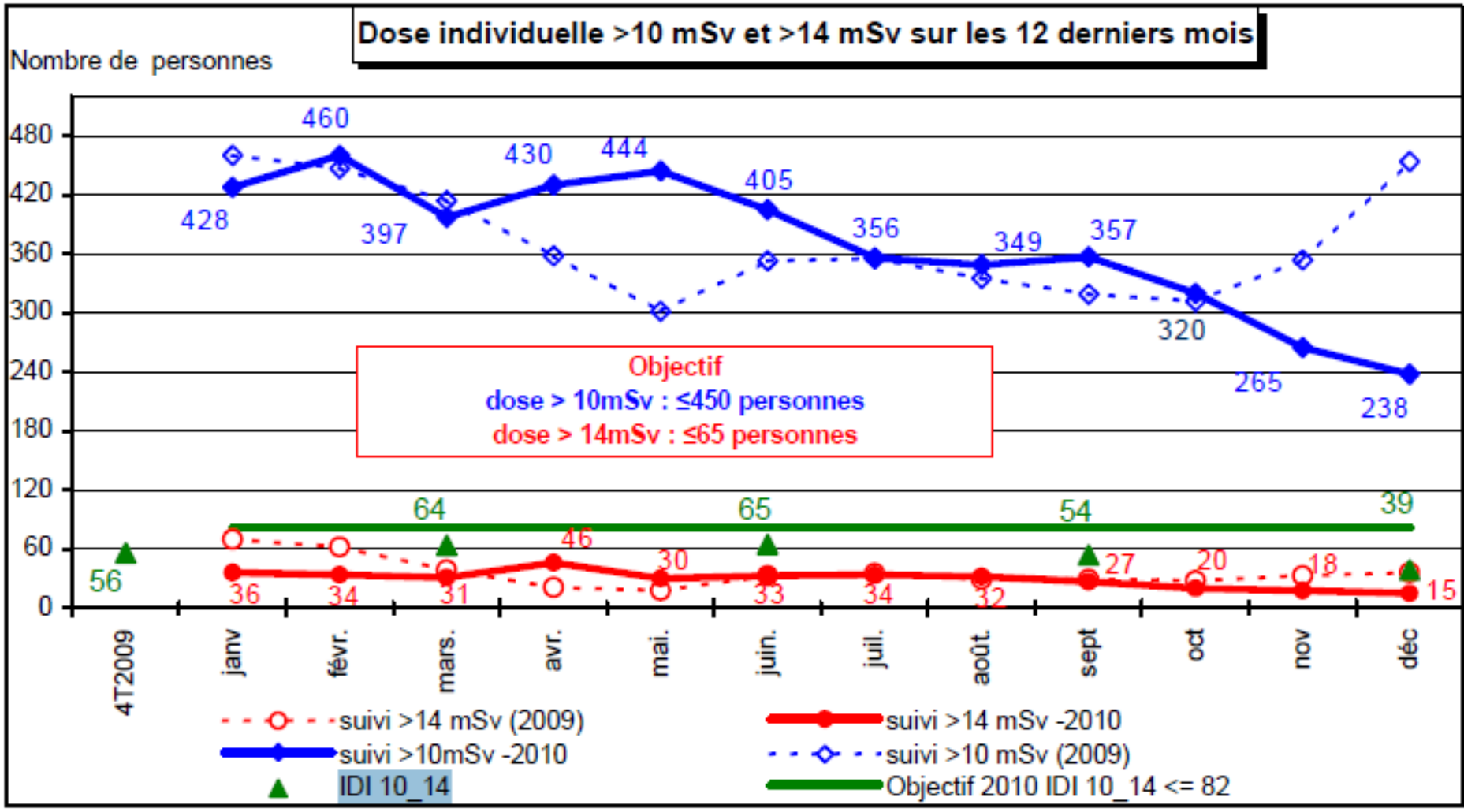








Dose individuelle >10 mSv et >14 mSv sur les 12 derniers mois




Thank you