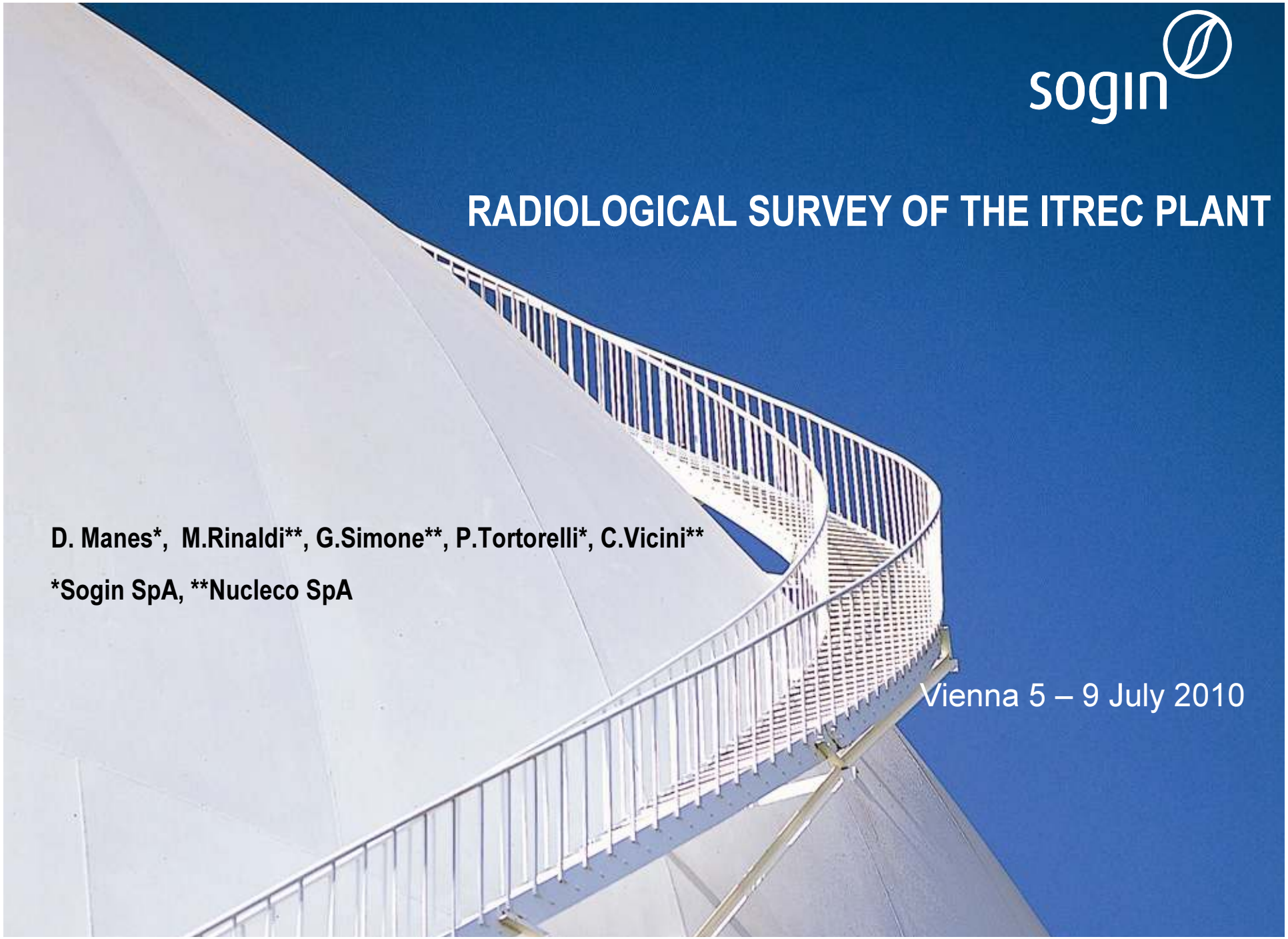

RADIOLOGICAL SURVEY OF THE ITREC PLANT

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***Sogin SpA, **Nucleco SpA**

Vienna 5 – 9 July 2010

DECOMMISSIONING IN ITALY

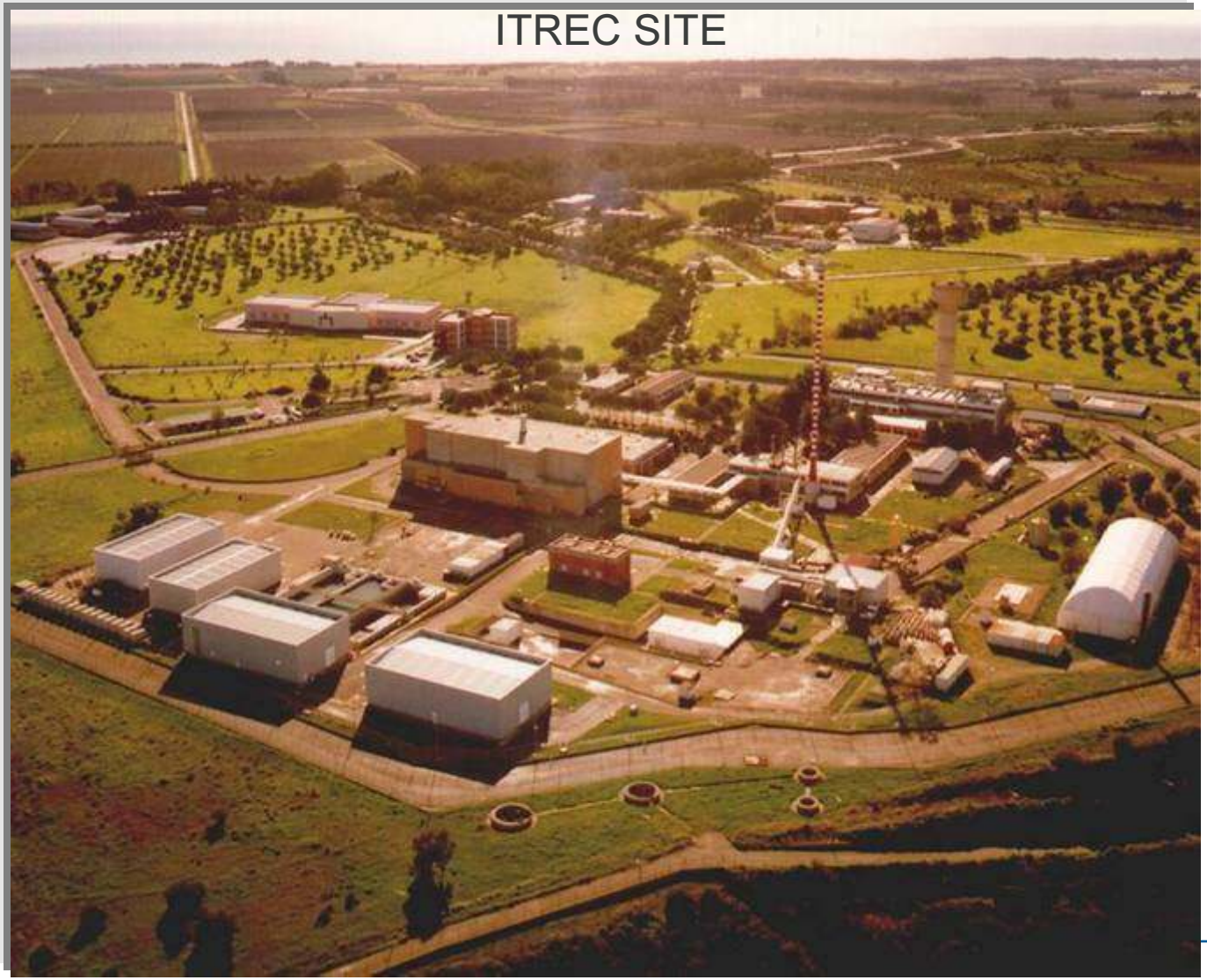
- **Italy stopped all its nuclear plants and installations in 1987 following a referendum.**
- **In 1999 Sogin was created with the duty to decommission Italian nuclear facilities and to manage the radwastes resulting from the past operation and from dismantling activities.**
- **One of those nuclear facilities is the Itrec Plant, whose radiological characterization is part of the Overall Decommissioning Plan**

Radiological Survey Of The Itrec Plant

SITES TO BE DECOMMISSIONED

Radiological Survey Of The Itrec Plant

ITREC SITE



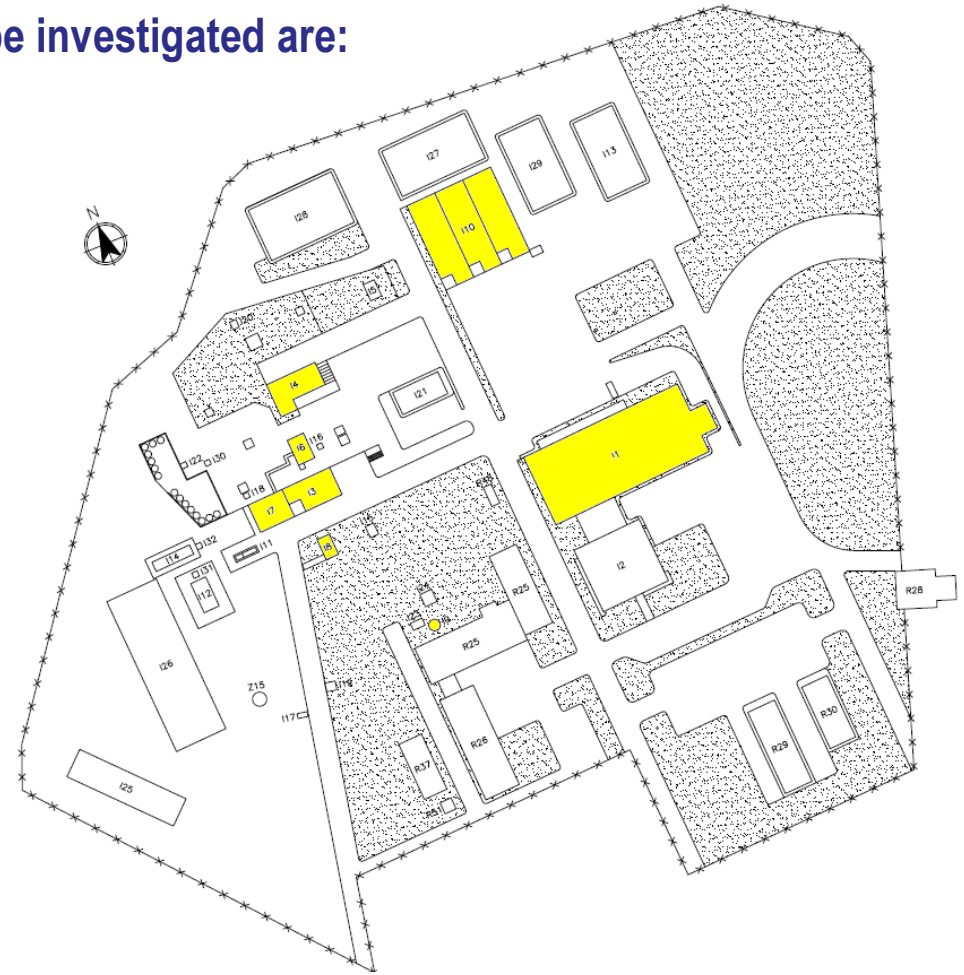
Radiological Survey Of The Itrec Plant

- The characterization program has been implemented as an initial step of the Overall Decommissioning Plan (ODP)
- The objective of radiological characterization is to collect sufficient information in order to assess the radiological status of the facility (quantity, type and distribution of radionuclides)
- Data collected are used in planning the ODP as well as sequencing decommissioning activities:
  - ✓ operating techniques: decontamination processes, dismantling procedures (hands on, semi-remote or fully remote working) and tools required;
  - ✓ radiological protection of workers, general public and environment;
  - ✓ waste classification;
  - ✓ resulting costs.

Radiological Survey Of The Itrec Plant

Radiological impacted buildings to be investigated are:

- **Main building (process building);**
- **OFF-GAS building;**
- **SIRTE-MOWA Unit.**



Radiological Survey Of The Itrec Plant

- ITREC facility was built for re-processing and re-assembly of Uranium and Thorium mixed oxide fuel elements from Elk-River Reactor (USA) spent fuel, in operation during '70s.
- Eighty-four assemblies were sent to Trisaia (1968-1970): 20 fuel elements were processed, , while 64 fuel assemblies are today stored in the ITREC Plant pool in stainless steel capsules.
- In 1990 the experimental program terminated.
- The SIRTE-MOWA facility was erected for liquid radwaste processing:
  - 80 m^3 low level liquid waste were processed,
  - later, after SIRTE-MOWA optimization 3 m^3 higher level liquid waste mixed with contaminated cleaning solution were processed

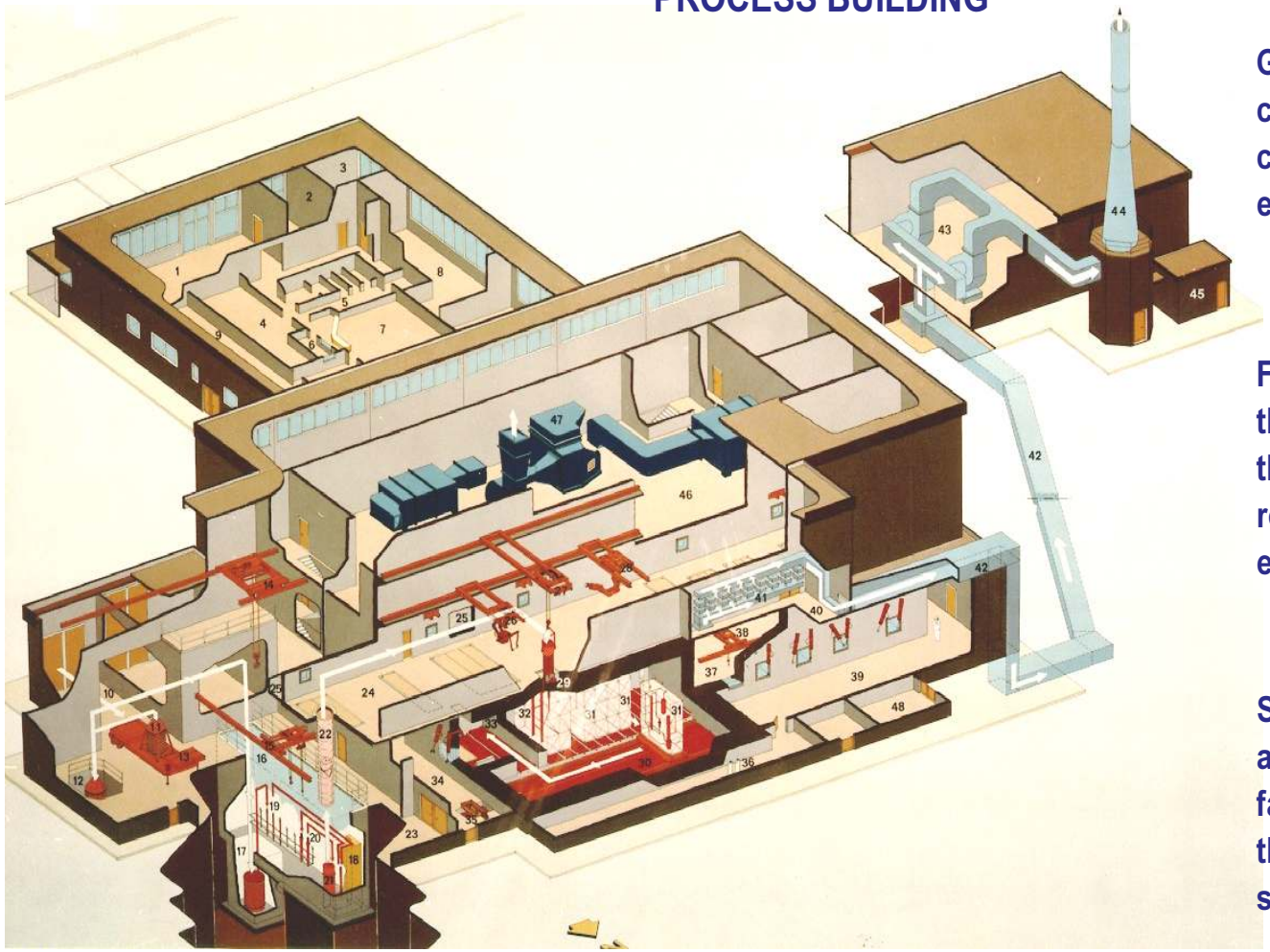
Radiological Survey Of The Itrec Plant

RADIONUCLIDE INVENTORY

- Radionuclides to be investigated depend on the operational history of the facility.
- The main ones are:
  - ✓ Actinides: ^{233}U, ^{234}U, ^{235}U, ^{238}U, ^{232}Th;
  - ✓ Fission products: ^{137}Cs, ^{90}Sr;
  - ✓ Major activation products: ^{60}Co, ^{59}Ni e ^{63}Ni in particular plant section;
  - ✓ ^{152}Eu, ^{154}Eu (fission and/or activation product)

- ETM Radionuclides
- HTM Radionuclides

PROCESS BUILDING



GROUND FLOOR: hot cell, "warm" cell, decontamination cell, fuel pool, control room, the labs, the offices, etc.

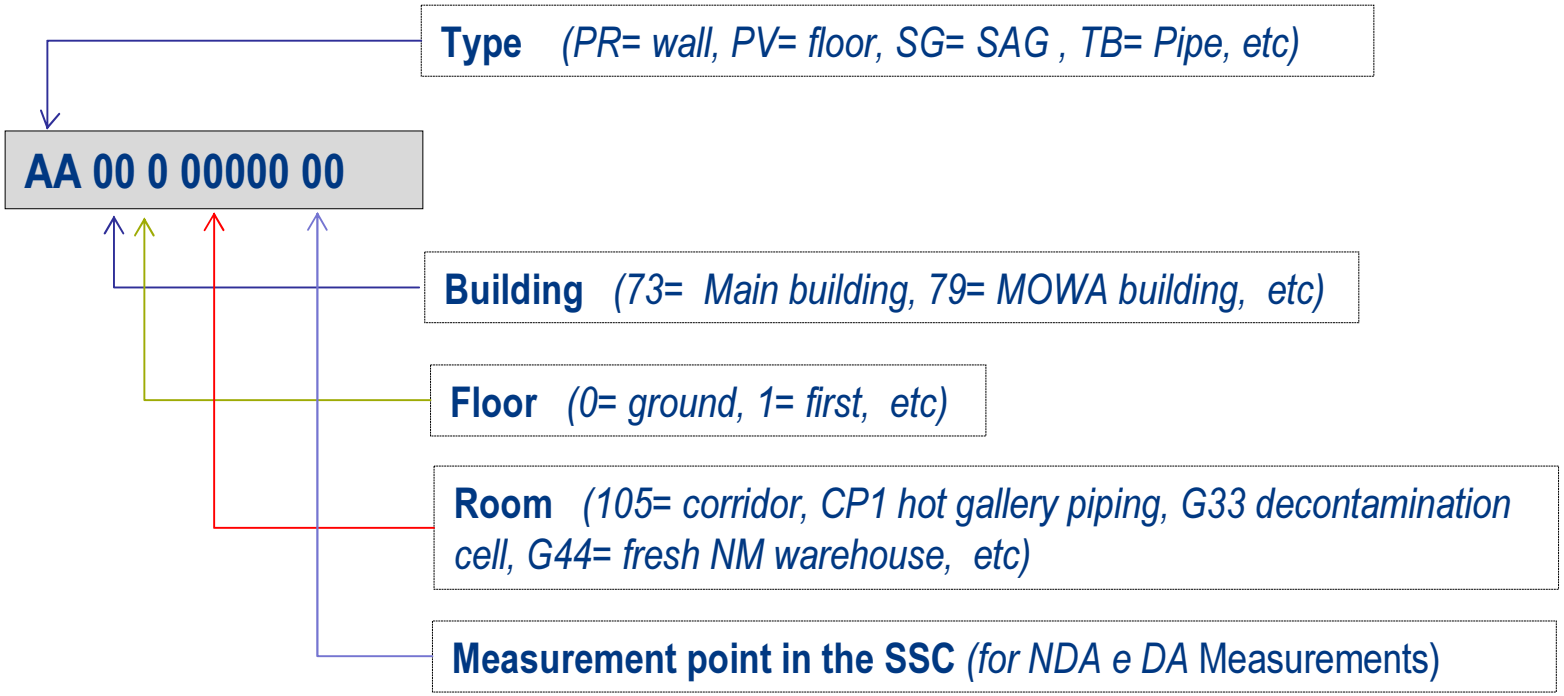
FIRST FLOOR cold reactants room, the nuclear warehouse, analysis cell, the sampling hall, the transmitter room, the processing cell hallway, etc.

SECOND FLOOR : venting ducts area, the plenum, the inwards fans of the warm and hot systems, the exausting fans of the warm system, etc.

Radiological Survey Of The Itrec Plant

PHYSICAL INVENTORY

- **A physical inventory of the facilities was carried out based on the review of existing documentation and on site inspection**
- **Systems, Components and Structures to be surveyed have been identified with a code:**



Radiological Survey Of The Itrec Plant

- **The Itrec plant characterization program includes 3 main tasks:**
  1. **Scanning measurements: dose rate, surface contamination and qualitative gamma isotope mix analysis by means of Hand Held Spectrometric Systems (HHSS).**
  2. **Management of Non-Destructive radiological Anlysis (NDA) for determination of ETM (Easy to Measure) radionuclides:**
     - **2.1. Planning**
     - **2.2. In-situ Gamma Spectrometry measurements**
     - **2.3. Data process and evaluation of results**
  3. **Performance of Destructive radiological Analyses (DA) for determination of HTM (Hard to Measure) radionuclides and related Scaling Factor**

Radiological Survey Of The Itrec Plant

- A radiometric survey (scanning measurements) of all Systems, Components and Structures (SSCs) inventoried is the first step of the characterization program.
- The measurements employing Hand Held Systems are:
  - ✓ Dose rate measurements
  - ✓ Surface contamination measurements (performed into contact)
  - ✓ Qualitative spectrometry measurement (Inspector 1000) to verify the presence and the ratio of most important gamma emitting radionuclides
- Scanning measurements have been performed to map the surface contamination and radiation dose and to locate radiation anomalies (hot spots) inputs for the NDA and for the DA tasks
  - Background measurement were performed for every SSC in areas were dose rates and/or contamination values were lower

HAND-HELD INSTRUMENTS

DOSE RATE METERS	SZINTOMAT	TELETECTOR	CONTAMINA METERS	BERTHOLD LB124 SCINT
Detector	Scintillator ZnS	Geiger Müller	Detector	Scintillator ZnS
energy range	30keV – 3MeV	40keV – 1.3MeV	Beta efficiency	50 %
Dose rate range	0.02 μSv/h	0.10 μSv/h	Alpha efficiency	22,5 %

LRGS	INSPECTOR 1000
Detector	NaI
Energy range	50 – 3000 KeV
Efficiency calculation	ISOCS Canberra
Software gamma spectrometry	Genie 2000 Canberra

Radiological Survey Of The Itrec Plant

- Gamma-Ray Imaging System was also performed to detect the position of the activity and the relative dose rates of selected hot spots.
- The main advantage of the GRIS system compared to others is that it superimposes visible and gamma images using the same optics

GAMMA-RAY IMAGING INSTRUMENTS

GRIS	CARTOGAM
Detector	CsI(tl)
Energy range	50 – 1500 KeV
Spatial Resolution	Collimator 662 keV 1332 keV 50° (standard) 2.5° 4.5° 30° (optional) 1° 2°
Software gamma spectrometry	Gamma view (Canberra

Radiological Survey Of The Itrec Plant

Scanning measurements

Radiological Survey Of The Itrec Plant

- **The second task of the plant characterization program is the management of the Non Destructive Analysis.**
- **The main goals of the NDA are:**

1. ***Identify the complete set of the ETM radionuclides*** **(gamma emitters) using "In Situ" Spectrometric Gamma Measurements.**
2. ***Determine the surface activity or activity concentration*** **of ETM radionuclides for single components and structures.**
3. **Update the subdivision of the facility components and structures in *Homogenous Groups***

Radiological Survey Of The Itrec Plant

- **Statistical Planning:**
  - **The sampling design for the NDA is based on the interpretation and analysis of the radiometric survey results and historical data that show evidence of an homogeneus contamination distribution,**
  - **Then an unbiased survey was used, and the minimum data number to characterize a SSC were decided to be 5.**
- **Three kinds of NDA were performed:**
  - **“In Situ” Spectrometric Gamma Measurements, using High Resolution Gamma Spectrometry (HRGS) and Low Resolution Gamma Spectrometry (LRGS)**
  - **Dose rate Measurements**
  - **Surface contamination (total and smear tests) measurements**

A total of 5000 LRGS and 1000 HRGS were made

"IN SITU" SPECTROMETRIC GAMMA INSTRUMENTS

HRGS		FALCON 5000
Detector	HPGe Canberra Extended Range	HPGe
Energy range	50 – 3000 KeV	20 – 3000 KeV
Relative efficiency	30%	20%
Cooling system	Liquid nitrogen	electric
Software efficiency calculation	ISOCS Canberra	ISOCS Canberra
Software gamma spectrometry	Genie 2000 Canberra	Genie 2k Canberra

- ✓ HRGS LRGS measurements were collimated measurements (30°)
- ✓ Measurements time was 1200 s for HRGS and 300 s for LRGS
- ✓ The Detector to object distance was different depending on dose rate, dead time, SSC conformation, interfering object into the field view.
- ✓ The object measured is assumed to have a geometry that can be reduced to a standard geometry (e.g cube, cylinder, sphere, surface).

Radiological Survey Of The Itrec Plant

Radiological Survey Of The Itrec Plant

- **Data processing. Calculations make the following assumptions:**

  - ✓ ***Floor/walls***

    the activity is uniformly distributed over the whole surface

  - ✓ ***Instruments, panels etc, etc,***

    100% of the activity is on 1 mm cm of dust on the surface

  - ✓ ***Ventilation ducts***

    The activity is uniformly distributed over the surface (actual lateral surface and thickness used for calculation)

  - ✓ ***Pipes and tanks***

    The activity is uniformly distributed over the inner surface

  - ✓ ***Etc.***

Radiological Survey Of The Itrec Plant

Having at least five values of isotopic activity for each SSC, a representative value of isotopic activity is obtained calculating the weighted average:

$$\overline{x} = \frac{\sum_{i=1}^{n} \left(x_i / \sigma_i^2 \right)}{\sum_{i=1}^{n} \left(1 / \sigma_i^2 \right)}$$

- x_i = activity concentration (Bq/cm^2 or Bq/cm^3)
- σ_i = standard deviation (Bq/cm^2 or Bq/cm^3)

- **Hot spots value do not contribute to the average (added to the average)**
- **For small components Bq/cm^3 is than converted in Bq/g dividing for the density (standard value):**
  - **Concrete = 2,35 g/cm^3**
  - **Metal = 7,86 g/cm^3**
  - **Technological = 1,8 g/cm^3**
  - **Dust = 1,25 g/cm^3**

Radiological Survey Of The Itrec Plant

A Non Destructive Radiological Analysis report has been created for each SSC.

The report presents:

- **Information related to the SSC**
  - **Physical characteristics (dimensions, type, matrix) and picture of the SSC,**
  - **Results of the scanning measurements: (link to the Inspector 1000 file report),**
  - **Isotopic activity (Bq/cm^2 or Bq/g) for the SSC**
  - **Spatial distribution of isotopic activity (Cs-137) in the SSC (if assessable)**

- **Information related to the measurement points for the SSC**
  - **ID, coordinates, dose rate, links to the HRGS and LRGS file reports**

Radiological Survey Of The Itrec Plant

RESULTS

IDSSC PV1730G44NN

DESCRIZIONE

Tipologia	PV1	Pavimento
Materiale	CM	Cemento
Quantità	1	

UBICAZIONE

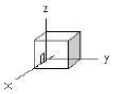
Edificio	73
Piano	0
Locale	G44

Coordinate

X	369
Y	554
Z	0

DIMENSIONI

Altezza [cm]	581
Larghezza [cm]	737
Lunghezza [cm]	1108



File Foto: PV1730G44NN.gif

INSPECTOR 1000

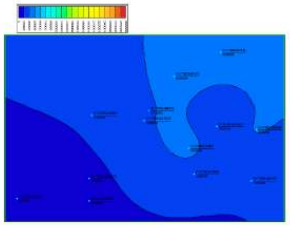
Spettrometro da campo portatile con rivelatore di tipo NaI
misura integrata su SSC e misura su Area

File Report	PV1730G44NN.RPT
LiveTime [sec]	300
Data	30/06/2009

FALCON 5000

Spettrometro da campo portatile costituito da un rivelatore BeGe - HPGe
misura integrata su SSC e misura su Area

File Report	
Live Time [sec]	
Data	



NGVIEW

- CARTOGAM: Sistema di misura per determinazione della distribuzione di dose - misura su SSC
- Software di visualizzazione della distribuzione di attività gamma - analisi su SSC

File NGView: PV1730G44NN.gif

MGAS (Mobile Gamma Assay System)

Sistema di misura da campo portatile del tipo "Open geometry" - misura su Area

RISULTATI

Intensità di dose [µSv/h]	0,2	(MDA = 0.10 [µSv/h])
Contaminazione Sup. tot. β/γ [Bq/cm2]	<MDA	(MDA = 0.005 [Bq/cm2]
Contaminazione Sup. tot. α [Bq/cm2]	<MDA	(MDA = 0.01 [Bq/cm2])

Radionuclide	Attività [Bq/cm2]	Incertezza [Bq/cm2]	MDA [Bq/cm2]
Cs-137	1,50E+01	1,18E+01	9,12E+00
Co-60	< 7,75E+00		
Th-232	< 2,03E+01		
U-235	< 1,31E+01		
U-238	< 1,18E+03		

IDSSC PV1730G44NN

MISURE NDA

"Radiological survey"

ID Area	X	Y	Z	Dose [µSv/h]	MGAS File	Falcon File	Inspector1000 File
PV1730G44NN01	153	64	0	1,2	PV1730G44NN01.rpt		PV1730G44NN01.rpt
PV1730G44NN01T	237	323	0	1,5			
PV1730G44NN02	77	333	0	0,2	PV1730G44NN02.rpt		PV1730G44NN02.rpt
PV1730G44NN02T	459	554	0	1,5			
PV1730G44NN03	489	333	0	0,2	PV1730G44NN03.rpt		PV1730G44NN03.rpt
PV1730G44NN03T	445	863	0	1,5			
PV1730G44NN04	495	570	0	0,2	PV1730G44NN04.rpt		PV1730G44NN04.rpt
PV1730G44NN05	181	980	0	0,2	PV1730G44NN05.rpt		PV1730G44NN05.rpt
PV1730G44NN06	216	761	0	0,2	PV1730G44NN06.rpt		PV1730G44NN06.rpt
PV1730G44NN07	432	740	0	0,2	PV1730G44NN07.rpt		PV1730G44NN07.rpt
PV1730G44NN08	427	1000	0	0,2	PV1730G44NN08.rpt		PV1730G44NN08.rpt
PV1730G44NN09	689	685	0	0,2	PV1730G44NN09.rpt		PV1730G44NN09.rpt
PV1730G44NN10	698	842	0	0,2	PV1730G44NN10.rpt		PV1730G44NN10.rpt

NDA Data sheet

				COORDINATE			Tabella dati Caratterizzazione NDA											
Codice Locale	Tipologia	Area	ID	X	Y	Z	GO	Foto	Intensità di dose [µSv/h]	Contaminazione superficiale trasferibile [Bq/cm2]		Contaminazione superficiale totale [Bq/cm2]		Report MGAS	Report FALCON	Report CARTOGAM	Report INSPECTOR	Area [cm2]
								x		α	β/γ	α	β/γ	1	1	1	1	
G23	PR1	01	PR1730G23NN01	0	1270	179	CM	1	0.1			<MDA	<MDA	1			1	1265.81
G23	PR1	02	PR1730G23NN02	0	735	64	CM	1	0.1			<MDA	<MDA	1			1	706.5
G23	PR2	01	PR2730G23NN01	95	1550	86	CM	1	0.2			<MDA	<MDA	1			1	706.5
G23	QE1	01	QE1730G23NN01	75	1550	71	TL	1	0.2			<MDA	<MDA	1			1	5805.9
G23	QE1	02	QE1730G23NN02	75	1550	36	TL	1	0.2			<MDA	<MDA	1			1	1808.64
G23	PR2	02	PR2730G23NN02	95	1550	33	CM	1	0.2			<MDA	<MDA	1			1	706.5
G23	PR3	01	PR3730G23NN01	142	1341	74	CM	1	0.2			<MDA	<MDA	1			1	1384.7
G23	PR3	02	PR3730G23NN02	142	1057	80	CM	1	0.1			<MDA	<MDA	1			1	1384.7
G23	PR3	03	PR3730G23NN03	142	732	60	CM	1	0.1			<MDA	<MDA	1			1	1133.54
G23	PR3	04	PR3730G23NN04	142	406	36	CM	1	0.1			<MDA	<MDA	1			1	1384.7

Radiological Survey Of The Itrec Plant

- **The main conclusion o the Radiological Survey is the preliminary classification of the SSCs in HGs.**
- **A HG is a collection SSC having the following common characteristics:**
  1) ***The same kind (e.g. metal, concrete, etc.) of materials.***
  2) ***Concentration of total (α+β) activity (expressed in Bq/g or Bq/cm^2) within the same order of magnitude.***
  3) ***Similar isotopic composition (in terms of radionuclide activity concentration).***
- **The advantages of this approach are:**
  - ***Assessment of the plant materials inventory (materials classification and treatment may be effectively performed and planned and materials for clearance can be effectively identified and quantified);***
  - ***Optimization of the DA sampling design and implementation of the use of scaling factors.***

Radiological Survey Of The Itrec Plant

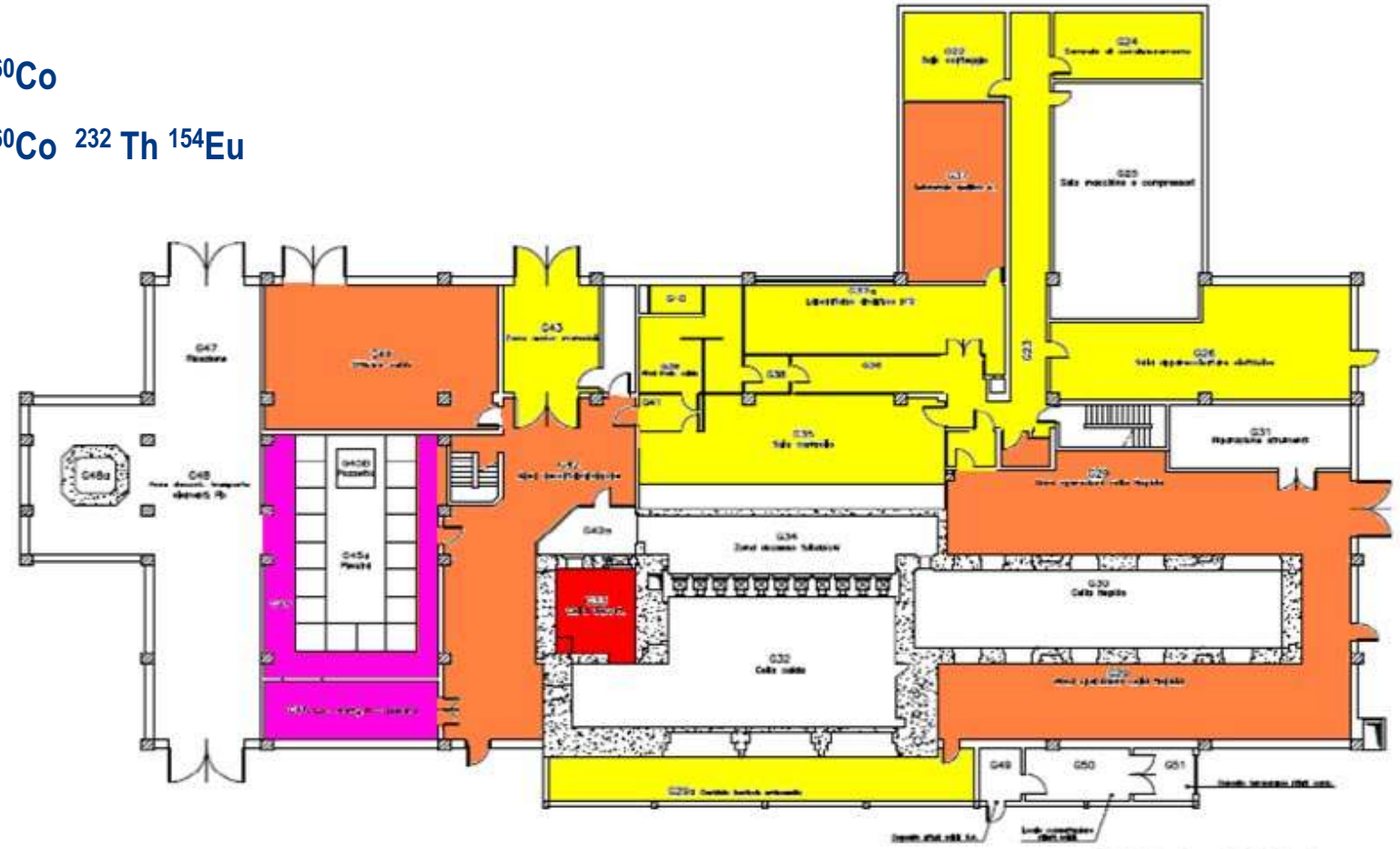
- **7 HGs have been identified:**

I. All isotopes below MDA
II. ^{137}Cs above MDA with values lower than10^3 Bq/g or 10 Bq/cm^2
III. ^{137}Cs and ^{60}Co above MDA
IV. ^{232}Th and ^{137}Cs above MDA
V. ^{232}Th, ^{137}Cs and ^{60}Co above MDA
VI. ^{232}Th, ^{137}Cs, ^{60}Co and ^{154}Eu
VII. ^{137}Cs above MDA with values higher than10^3 Bq/g or 10 Bq/cm^2

Radiological Survey Of The Itrec Plant

RESULTS

- < MDA
- ^{137}Cs
- ^{137}Cs ^{60}Co
- ^{137}Cs ^{60}Co ^{232}Th ^{154}Eu



Radiological Survey Of The Itrec Plant

- ✓ ^{137}Cs

As it was expected ^{137}Cs is the isotope most widely detected above MDA. It's a fission product and is probably present jointly with ^{90}Sr (SF estimated during the DA characterization step)

- ✓ ^{60}Co

Activation product is present in components and areas involved in the first step of fuel reprocessing : fuel pool area (G45, G46), dissolution cell (G33), hot cell/chemical process (G32)

- ✓ ^{232}Th

Present above MDA only in components and areas directly involved in the dissolution process: dissolution cell (G33), sampling hall (110), off gas (110)

- ✓ ^{154}Eu

Above MDA only in components and areas highly contaminated

A1

Slide 28

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Radiological Survey Of The Itrec Plant

- The third task of the plant characterization program is the performance of DA for quantitative determination of HTM radionuclides and related Scaling Factor (ratios of radioactive concentrations between DTM nuclides and key nuclides)
- In the SF method, the concentrations of DTM nuclides are evaluated by multiplying the concentrations of the key nuclide by the SFs calculated based upon radionuclide data obtained by DA analysis
- This method significantly reduces the number of samples that would otherwise have to be taken and analysed, reducing cost of the characterization.

Radiological Survey Of The Itrec Plant

- For a statistically significant correlation, initially 10 samples for each HG are taken:
  - ✓ γ-emitter and ^{90}Sr by LS are analyzed in every sample ,
  - ✓ ^{235}U and ^{238}U by ICP-MS are analayzed in 30 samples from IV, V and VI HGs.

- SFs for every DTM for every HG is calculated according to the Epri criteria:
  - ✓ SFs are determined from the log-mean average of the ratio of the DTM to the key nuclide

$$A_{FC} = e^{\frac{1}{N}\sum_{i=1}^{N}\ln(FC)_i}$$

  - ✓ the dispersion should be less than 10.

$$D_{FC} = e^{\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}[\ln(FC)_i - \ln(A_{FC})]^2}}$$

Radiological Survey Of The Itrec Plant