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1. GOAL AND OBJECTIVES

After the **Royal Decree 533/1996** (B.O.E. no. 77, 29 March 1996), the Laboratorio de Metrología de Radiaciones Ionizantes (LMRI) of CIEMAT is the **National Standards Laboratory for ionizing radiations** in Spain, and Associated Laboratory to the Centro Español de Metrología (CEM), the Spanish National Metrology Institute (NMI).

Accordingly, as its **main goal**, the LMRI holds the responsibility, on behalf of the State, for the establishment, maintenance and dissemination of the National Standards of the SI units of the quantities :

- Activity (Bq)
- Exposure ($C.kg^{-1}$)
- Kerma (Gy)
- Absorbed Dose (Gy)

Specific objectives by which the main goal is accomplished are:

- to develop new standards and measurement techniques for ionizing radiation
- to maintain the National Standards for radioactivity and dosimetry and its international traceability
- to distribute certified radioactive sources/materials, calibrations of equipment, reference data.

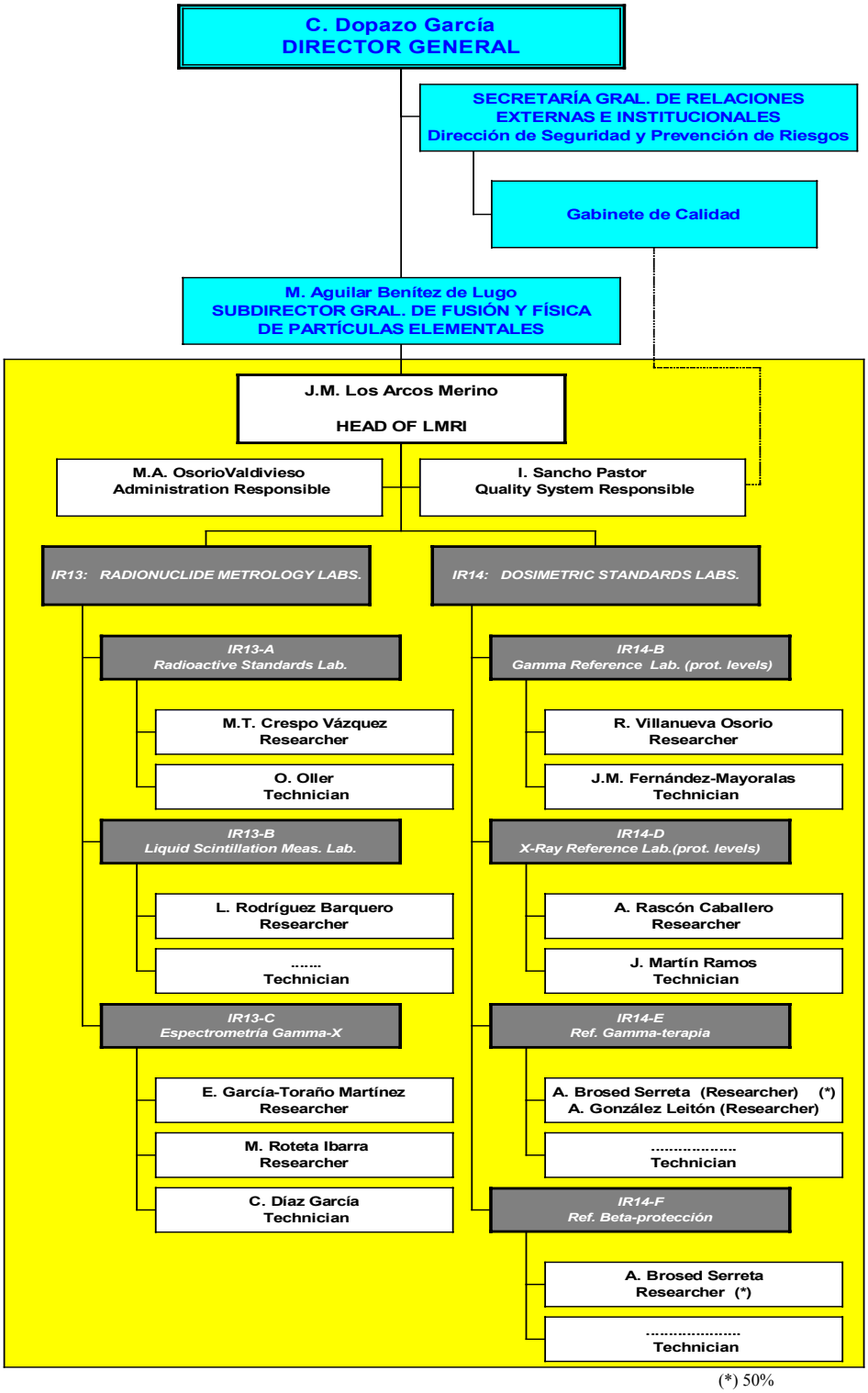
2. ORGANIZATION

2.1 Structure and Staff

As usual in other NMIs, in order to cover both radionuclide and dosimetry standards, the LMRI tasks and staff are **distributed around** two different radioactive facilities, as shown in Figure 1:

- IR13: Radionuclide Metrology Laboratories (3 laboratories: A, B, C)
- IR14: Dosimetric Standards Laboratories (4 laboratories (B, D, E, F)

Figure 1. Organigram of LMRI



(*) 50%

Total staff of LMRI: 14 people from which 9 researchers (5 Ph.D-2 chemists + 3 physicists; 4 Ms Sc.-4 physicists), 4 technicians, 1 administration assistant. Additionally, since July 2002, a **Quality Responsible** has been appointed by the Quality Office of CIEMAT to help establish and maintain the Quality System of LMRI.

2.2 Facilities and equipment

Two radioactive facilities, IR13 and IR14 , officially declared and subjet to control by the Consejo de Seguridad Nuclear (CSN, Spanish Nuclear Safety Council), are used to develop the tasks of LMRI, as described next.

2.2.1 IR13: Radionuclide Metrology Laboratories

These laboratories are scattered in two different (and distant) buildings, nos. 3 (basement and 2nd level) and 12 (basement), each with its own source preparation rooms. Measurements are often disturbed by the need to transport sources among such locations.

- *IR13-A: Alpha-particle Radioactive Standards (E03.S1):*
  - standards (primary): 2 ionization chambers + 1 low-geometry proportional counter
  - subject to PIMIC (Integral Plan for Modification of CIEMAT Facilities)

  Due to obsolescence, this laboratory is being **dismantled** to carry out complete refurbishing. Equipment has been moved to IR13-C and to a conventional laboratory where only exempted amounts of radionuclides will be handled. Optimal uncertainties around 1% (k=2) can be reached, depending on the nuclide.

  A project has been poposed to re-build this laboratory but adding surrounding unused space to move and concentrate there the three current laboratories, thus avoiding duplicate rooms for source preparation and the need for moving sources. This would allow to define and operatethe **future new IR13 facility** in a compact and efficient way.

- *IR13-B: Liquid Scintillation Measurements (E03.P2):*
  - standards (secondary): 2 liquid scintillation spectrometers (CIEMAT-NIST method, using ^{3}H as tracer). This laboratory performs the standardization of beta emitters. Optimal uncertainties around 0.7% (k=2) canbe reached for beta emitters whereas, for electron capture emitters, typical uncertainties are about 3% (k=2) due to the uncertainty of nuclear parameters needed.

- *IR13-C: Gamma and X-ray Spectrometry:*
  - standards (primary) : 2 4π-β(PC,PPC)-γ(NaI) for β-γ emitters
  - standards (secondary): 2 well-type IG11 ionization chambers, for γ emitters.

    1 transfer activimeter for gamma-beta emitters

    2 semiconductor + 2 NaI spectrometers for γ emitters.

  Optimal uncertainties about 0.6% (k=2) can be reached for selected nuclides by using the primary standard. Typical uncertainties obtained by secondary standards are about 2% (k=2).

2.2.2 IR14: Dosimetric Standards Laboratories

All the operating laboratories are located in building no. 2 (basement and level 1),as follows (an obsolete X-ray laboratory exists in building no. 12):

- *IR14-B: Gamma Reference Laboratory at protection levels (E02.P0):*
  - Standards (secondary):

    NE 2551 chamber (NPL traceable) for free-air Kerma at ^{137}Cs energy

    Shonka-type chambers (BIPM traceable) for free-air Kerma at ^{60}Co energy
  - Reference beams: ^{137}Cs and ^{60}Co from sources contained in two automated irradiators with pneumatic shutters; single shielded source.
  - Transfer standards : Shonka and NE2561 chambers for ^{137}Cs

    NE2551 chamber for ^{60}Co
  - Useful ranges:
    - for ^{137}Cs calibrations: tertiary standards, kerma rates 25-100 mGy.h^{-1} (±1.2%, k=2)

      personal dosimeters,$H_p(10)$ rates 8-240 mSv.h^{-1}(±5.4%, k=2)

      area and portable monitors, $H^*(10)$ rates 10 µSv.h^{-1} - 4Sv.h^{-1} (±4.6%, k=2)
    - for ^{60}Co calibrations of tertiary standards, kerma rate 5-20 mGy.h^{-1} (±1.1%, k=2)

- *IR14-D: X-ray Reference Laboratory at protection levels (E02.P0):*
  - Standard (secondary): NE 2575C nº 506 chamber (PTB traceable), for air kerma.
  - Radiation Qualities: In progress: ISO 4037 broad specrum series, 60-300 kV
    ISO 4037 narrow spectrum series, 10-15 kV
    Currently available: ISO 4037 narrow spectrum series, 20-300 kV
  - Reference beams: System MG 103, X ray unit MCN 165 5-100 kV
    System MG 325, X ray unit MCN 321 10-320 kV
  - Useful range: Maximum output of X ray tubes (nominal, without filtration):
    MG 103 at 100 kV,30 mA: 619 Gy h^{-1}
    MG 325 at 320 kV, 10 mA: 168 Gy h^{-1}
    Kerma rate at 1 m FCD, 10mA current tube (preliminary measurements):

NE 10:	63mGy h^{-1}
NE 15:	124mGy h^{-1}
NE 20:	172mGy h^{-1}
NE 25:	148mGy h^{-1}
NE 30:	83mGy h^{-1}
NE 40:	38mGy h^{-1}
NE 60:	57mGy h^{-1}
NE 80:	27mGy h^{-1}
NE 100:	13mGy h^{-1}
NE 120:	15mGy h^{-1}
NE 150:	70mGy h^{-1}
NE 200:	42mGy h^{-1}
NE 250:	48mGy h^{-1}
NE 300:	51mGy h^{-1}

  - Future developements: Installation of a parallel plates, free air ionization chamber for energies up to 50 kV
    Extension to the ISO 4037 low and high air kerna series.

- *IR14-E: Gamma (^{60}Co) Reference Laboratory at therapy levels (E02.S1):*
  - Standard (secondary): 3 Shonka-type chambers (BIPM traceable) for free air kerma at ^{60}Co energy.
  - Reference beam: Theratron 780 cobaltotherapy unit (adapted for metrological use)
  - Useful range: Kerma rate for ^{60}Co energy calibrations: 7.3 mGy.s^{-1} (±0.9%, k=2)

  A new standard of absorbed dose to water (3 Shonka chambers with PMMA envelopes and a PE sheath) has been re-installed at LMRI-CIEMAT and will be under operation in 2003. Dose rate for ^{60}Co energy calibrations: 7.3 mGy.s^{-1} (±1.2%, k=2)

- *IR14-F: Beta Reference Laboratory at protection levels (E02.S1):*
  - Standard (secondary): reference sources of ^{147}Pm, ^{204}Tl (NIST traceable) and ^{90}Sr/^{90}Y (PTB traceable)
  - Irradiation beam: projector and homogeneity filters
  - Useful range for personal dosimeters and portable monitors:

	$D_T(0.07)$ (=$H_p(0.07)$ for electrons)	Uncertainty (k=2)
• ^{147}Pm :	0.03 mGy.h^{-1}	(± 11.1%)
• ^{204}Tl:	0.20 mGy.h^{-1}	(± 5.6%)
• ^{90}Sr/^{90}Y:	0.20 Gy.h^{-1} (without filtering)	(± 2.6%)
	4.0 mGy.h^{-1} (with filtering)	(± 2.6%)

A pictorial overview of some LMRI facilities above described is shown in Figure 2.

Figure 2. Overview of LMRI facilities

3 INTERNATIONAL AND SPANISH FRAMEWORK

The role of the LMRI is strongly influenced by its character (and responsibility) of National Standards Laboratory and, therefore, **its performance**:

- Is done in coordination with the Centro Español de Metrología (CEM), through the technical meetings of the "Spanish National Standards Laboratories" Working Group,

- Follows guidelines similar to those of other more advanced NMIs in Europe, by extending the number, metrological level or mesurement range (calibration capacities) of National Standards according to users' demand of traceability in ionizing radiations applications and to budgetary availability.

  This applies to the new "X-Ray Reference Laboratory at protection levels" (IR14D), "Gamma (^{60}Co) Reference Laboratory at therapy levels" (IR14E) and "Beta Reference Laboratory at protection levels" (IR14F) put into operation very recently. It also concerns very critically to the current refurbishment works of the obsolete IR13A laboratory in order to build the new compact IR13 facility, as mentioned in section 2.2.1.

- Must accomplish with the *"Mutual Recognition Agreement (MRA) of National Measurements Standards and of Calibration and Measurement Certificates issued by National Metrology Institutes"* fostered by the Intenational Committee for Weights and Measurements and signed in 1999 by the NMIs (Spain among them): accordingly, a Quality System compliant with ISO17025(1999) standard must be implemented and participation in the Key Comparisons (organised by the BIPM, EUROMET, …) will be necessary to establish the equivalence among the different NMIs.

  To this regard, the LMRI has participated in almost all the radionuclide intercomparisons organised by the BIPM in 2000-2002, has contibuted to the Système International de Référence(SIR) and, after having put into operation the new IR14 laboratories, is now ready for participation in the dosimetric standards intercomparisons too.

  Besides, a very important effort has been done in 2001-2002 to define and set up the LMRI Quality System in compliance with the ISO17025 standard. Eventually, with the help of personnel from the Quality Office of CIEMAT, the new Quality Manual has been approved in December 2002 and the effective implementation is now progressing very quickly. The definition of the LMRI CMCs (Calibration and Measurement Capacities)is now under preparation, taking into account the new operating laboratories in IR14.

- Includes the participation in Working Groups, Committees, Experts' Meetings and Panels defined at the international level (BIPM, ICRM, EUROMET, IAEA …) in order to permanently contrast the quality, strategy and relationship between LMRI's activities and the international trends.

  To this regard, a significant participation in several international bodies must be mentioned: the LMRI is a permanent member of the Comité Consultatif pour les Rayonnements Ionisants (CCRI), section II (radionuclides), and LMRI staff serve at different international committees: a personal permanent membership (A. Brosed) in the CCRI section I (X-rays, gamma and electrons), Coordinator of the

BIPM "SIR extension Working Group" (J.M. los Arcos), Coordinator of the "Alpha-particle spectrometry" (E. García-Toraño) and of the "Gamma- and Beta-ray spectrometry" (J.M. Los Arcos) Working Groups of the International Committee for Radionuclide Metrology (ICRM), as well as membership in the Scientific Committees of ICRM International Conferences since 1991 and particularly at the ICRM'2001 (PTB, Braunschweig) and ICRM'2003 (UC, Dublin).

Besides, LMRI staff members act as IAEA consultants on definition of Coordinated Research Programs on "Alpha-particle spectrometry" (E. García-Toraño", 2000), "File formats and data file structures for nuclear spectroscopy software" (E. García-Toraño, 2001), and "Intercomparison of Gamma-Ray analysis programs for low level activity measurements and environmental applications" (J.M. Los Arcos, 2001).

Additionally, LMRI staff participate in the effective IAEA CRPs "Alpha-particle spectrometry" (E. García-Toraño", 2001->), "Update of X-ray and Gamma standards for detector calibration" (J.M. Los Arcos, 2000->) and the Workshop on the "Intercomparison of Gamma-Ray analysis programs for low level activity measurements and environmental applications" (J.M. Los Arcos, 2002).

- Includes its participation in Spanish Committees and Meetings organised by national societies and bodies (Nuclear Safety Council, ENAC (National Accreditation Body), Sociedad Española de Protección Radiológica, Sociedad Española de Física Médica, Sociedad Nuclear Española, Sociedad Española de Medicina Nuclear, Sociedad Española de Radiofarmacia, ...) in order to disseminate the metrological capacities already available and to detect new users' needs in different applications.

  Specific mentions to participation in national working groups and committees can be found under section 4.

4 RESULTS AND INDICATORS (2000-2002)

Due to the seasonal character of intrument calibrations, with typical recommended periods of 1-4 years, depending on the class and use of the instrument, the performance of the LMRI is better understood when its activities are reviewed over a 3-year term.

Therefore, the main results reached in the period 2000-2002 are summarised next, with regard to the three specific objectives described in Section 1 namely: development of new standards and measurement techniques, maintenance and traceability of National Standards and dissemination of units.

Besides, a series of indicators such as publications, congresses, technical committees, national/international cooperation, technical services and external incomes are also presented which help quantify the performance of the LMRI for that period in an objective way.

4.1 Main Results

4.1.1 Standards, measurement techniques and reference data:

- Setup and put into operation of IR14D (January 2003), after long delays due to administrative/regulatory reasons, vacancy of researcher in 2000 not replaced until September 2001.
- Setup and put into operation of IR14E (2001) in CIEMAT premises, after two decades of calibration campaigns carried out using a hospital facility. The first calibration campaign in LMRI IR14E facility was held in 2001 in terms of kerma in air, for about 80 Spanish hospitals and 130 reference instruments.
- IR14F was moved into new premises and put into operation (2001).
- Two new secondary standards for gamma emitters, IG11-type ionization chambers were bought and put into operation (2000 and 2001).
- New primary standard for beta-gamma emitters, a 4πβ(PPC)-γ(NaI) counter, built at NIST was received and put into operation (2001).
- Approval and development of EUROMET Project no. 591, for measuring the α-emission probabilities of ^{235}U. Participants: LNHB(France), IRMM(Geel), NPL(UK), University of Extremadura, under coordinated by LMRI (E. García-Toraño).
- Assembly and testing of new triple-to-double coincidence ratio (TDCR) based counter for liquid scintillation measurements (2001). New design needed after breakdown of ^{3}H vial and contamination inside. Currently under construction.
- γ-γ angular correlation measurements in ^{152}Sm and ^{152}Gd (2000).
- Definition and calibration of a certified gamma cocktail, CG1, for detector calibration, containing ^{241}Am, ^{109}Cd, ^{57}Co, ^{60}Co, ^{137}Cs, ^{113}Sn and ^{85}Sr (2000)
- Procedure for the preparation of surface gamma emitters reference sources, on cellulose thermally sealed with polyethylene films (2000).
- Procedure for the preparation of solid reference sources of ^{90}Sr/^{90}Y deposited on 2”-diameter steel planchets(2000).
- Procedure for the preparation of solid reference sources of ^{63}Ni and ^{36}Cl deposited on 2”-diameter steel planchets(2001).
- Design and construction of the ISO phantom for personal dosimetry measurementsin IR14B (2000).
- Design and construction of the annular ISO phantom for beta dosimetry measurements in IR14F (2000).
- Standardization of ^{134}Cs by three methods (2000), ^{152}Eu by coincidence counting and gamma spectrometry (2000),
- Participation in the IAEA CRP on “Update of X- and Gamma ray standards for detector calibration” (2000-2003): evaluation of ^{125}Sb, ^{243}Am and ^{66}Ga.
- Liquid scintillation measurements of ^{3}H, ^{55}Fe, ^{49}V, ^{63}Ni, ^{14}C y ^{147}Pm, for the determination of the kB parameter in ultima Gold. (2001->).
- Coordination of ICRM Action GBS-A01 on the “Intercomparison of performance of coincidence-summing correction procedures”, with 29 laboratories from 22 countries (2001->).
- Procedures P-LMRI-C-01 and P-LMRI-T-01 to –07 (2001) (see publications).
- Design for fabrication and acquisition of PMMA envelopes of 12 types of reference chambers to be calibrated in terms of absorbed dose to water (2002).
- Draft of procedure for calibration of reference chambers in terms of dose absorbed to water (2002).
- Study of U-series disequilibria applied to rock-water interaction processes (2002).
- U/Th dating of geological materials: Inorganic calcium carbonate deposits (2002)
- Standardization of ^{99m}Tc, ^{67}Ga and ^{131}I by 4πβ-γ coincidence counting and gamma spectrometry (2002).
- Standardization of ^{60}co, ^{32}P/^{33}P and ^{204}Tl by liquid scintillation counting (2002).

4.2.2 Maintenance and Traceability:

- Participation in BIPM Key Comparisons of ^{152}Eu (2000), ^{89}Sr (2000), ^{238}Pu (2001, 2 absolute techniques), ^{32}P (2002), ^{204}Tl (2002).
- Contributions to SIR: ^{134}Cs (2001), ^{131}I (2002)
- Re-calibration of the secondary standard, extended-range Ge detector (2000), and efficiency transfer calculations for Marinelli geometries in the extended range Ge detector (2001).
- Calibration of standard solutions of : ^{226}Ra, ^{236}U, ^{229}Th, ^{239}Pu, ^{238}Pu, ^{241}Am, ^{60}Co, ^{131}I, ^{99m}Tc, ^{22}Na, ^{90}Sr, ^{85}Sr, ^{134}Cs, ^{137}Cs, ^{210}Pb, ^{133}Ba, ^{63}Ni, ^{36}Cl, ^{14}C, ^{55}Fe, ^{3}H (2000-2002).
- Calibration of ORTEC 442 time base (secondary standard) at the Real Observatorio de la Armada (National Time Standard Laboratory) (2001).
- Re-calibration of electrical measurements equipment in IR14E (2000).
- Verification of stability of standards in IR14B (2000-2002).
- Quality Manual: first draft (2001), revisions and final document (2002).
- Quality System Procedures P-LMRI-Q-01, -02, -03, -04, and –05 (2002).
- Quality System Procedure P-LMRI-C-01 (2002).
- Quality System Procedures P-LMRI-T-01, -02, -03, -04, -05, -06 and –07 (2002).

4.2.3 Dissemination of units:

a) Calibration and testing services:

Concept	**2000**	**2001**	**2002**
radioprotection monitors	92	142	193
reference chambers(prot./environm.)	11	17	9
surface contamination monitors	59	78	91
dose assignments to TLD dosimeters (batches)	37	157	111
radioassays for type-approval (ionizing radiation equipment)	7	11	23

- Solid and liquid certified sources:

2000: ^{230}Th, ^{238}Pu, ^{239}Pu, ^{232}U, ^{233}U, ^{241}Am, ^{3}H, ^{90}Sr+^{90}Y, ^{137}Cs, ^{60}Co, ^{233}U+^{239}Pu+^{241}Am (17)
^{241}Am,+^{57}Co+^{60}Co+^{137}Cs+^{3}H+ ^{89}Sr+ ^{90}Sr/^{90}Y (XI Interlab. Exerc.Nucl.Power Plants,18)
^{241}Am+^{109}Cd+^{57}Co+^{60}Co+^{137}Cs+^{113}Sn+^{85}Sr+^{123m}Te+^{88}Y(CG1 γ-cocktail for env. labs.,10)
^{154}Eu+^{155}Eu+^{125}Sb cocktail in Marinelli geometries (11)

2001: ^{241}Am,+^{57}Co+^{60}Co+^{137}Cs+^{3}H+ ^{89}Sr+ ^{90}Sr/^{90}Y (XII Interlab. Exerc.Nucl.Power Plants,18)
^{230}Th , ^{238}Pu, ^{239}Pu, ^{232}U, ^{233}U, ^{241}Am, ^{3}H, ^{14}C, ^{63}Ni, ^{36}Cl, ^{57}Co, ^{85}Sr, ^{89}Sr, ^{90}Sr+^{90}Y, ^{137}Cs, ^{60}Co and ^{233}U+^{239}Pu+^{241}Am (37).

2002: ^{241}Am,+^{57}Co+^{60}Co+^{137}Cs+^{3}H+ ^{89}Sr+ ^{90}Sr/^{90}Y (XIII Interlab. Exerc.Nucl.Power Plants,18)
^{3}H, ^{63}Ni, ^{55}Fe, ^{35}S, ^{129}I, ^{210}Pb+^{210}Bi,+^{210}Po, ^{36}Cl and ^{207}Bi. (20)
^{241}Am, ^{233}U+^{239}Pu+^{241}Am (9).

- Special campaigns:

- Calibration campaign for reference ionization chambers in free-air kerma at ^{60}Co energy (therapy level): 75 hospitals with 125 chambers, and 8 CIEMAT chambers (2001).
- "Evaluation of the metrological traceability of Nuclear Medicine Services in the Madrid", with 24 centers and 26 instruments (2001).
- "Traceability verification of ersonal dosimetry services in Spain" (for CSN): 24 centers(2001).
- "Traceability verification of environmental dosimetry services in Spain" (for CSN): 10 centers (one from Cuba) (2001).
- Determination of ^{14}C content of Spanish wine alcohols in 1999 and 2000 crops: Reference values for the Ministry of Agriculture (2001).

b) Internal collaborations with other CIEMAT Projects namely with :

- "Scientific Computing", for developing and updating the National Reference Database for Ionizing Radiations (BANDRRI), accessible through Internet (2000->).
- "Reprocessing of irradiated nuclear fuel", in the DACAPO Project for the EU V Framework Program (2000-2001).
- "Waste management", for determining the activity concentration of U, Pu, Am y Cm in waste samples from nuclear power stations (2000-2001).
- "Dosimetry of Ionizing Radiations", by supplying reference dose values to TLD dosimeters (2000-2003),
- "Radiological Impact on the Environment", by preparing certified reference sources for the XI, XII and XIII Interlaboratory Exercise of Nuclear Power Stations (2000-2002).
- "Hydrogeochemichal Site characterization", by developing a procedure for the sequential lixiviation and isotopic disequilibria analysis of U-series in Mina Fe (2001).
- "Fusion by Magnetic confinment", by preparing thin-layer phosphors deposits (2001->).

c) Courses and Seminars:

- Lectures on "Magnitudes y Unidades Radiológicas", "Estadística de Recuento", "Detección y Medida de la Radiación" in the CIEMAT post-graduate Courses "Protección Radiológica en Instalaciones Nucleares", "Curso de Supervisores de Instalaciones Radiactivas". CIEMAT (2000-2002).
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4.2 Indicators

4.2.1 Publications

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- García G. and Blanco F., "Energy Dependence of the Total Cross Section for Electron Scattering by N_2 and CO". Phys. Lett. A 276(2000)73.
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- Los Arcos J.M., "Procedimiento para Elaboración de Documentos Internos en Metrología de Radiaciones Ionizantes". Procedimiento Específico PE-FP-MR-04 (2000).
- González A., "Procedimiento para Establecer las Condiciones Geométricas de Referencia en un Haz Horizontal de Fotones Emitidos por una Fuente de ^{60}Co y Albergada en una Unidad Theratron 780". Procedimiento Específico PE-FP-MR-05 (2000).
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- García-Toraño E., "Trazabilidad en Medicina Nuclear: El Punto Vista del Laboratorio Nacional". II Congreso Español de Metrología, Sevilla 24-26 May (2000).
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- García G., "Electron Scattering by O_2 at Intermediate and High Energies". IV Iberian Joint Meeting on Atomic and Molecular Physics, El Escorial 30 May-2 June (2000).
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- García-Toraño E., Conferencia Invitada "Analysis of Alpha-Particle Spectra", Seminar on detectors and radionuclide measurement techniques, Nordic Nuclear Safety Research Programme NKS, Lund, 4-5 May (2001).
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4.2.3 Technical Committees

- CEM, CEM-CIEMAT. Steering Committee CIEMAT, 10 February (2000).
- CSN, Reunión de Laboratorios de Radiactividad Ambiental. CSN, Madrid, 29 de February (2000).
- ENAC, Subcomité nº 9 de Calibración. Madrid, 11 April (2000).
- IAEA, Coordination Meeting of the "Update of X- and γ-Ray Data for Detectors Calibration" Coordinated Research Program. PTB, Braunschweig, 10-12 May (2000).
- "International Decay Data Evaluation Project" Meeting. PTB, Braunschweig, 8-9 May (2000).
- Grupo de Trabajo "Normas para medición de Radiactividad Ambiental", Universidad de Valencia, 18 January (2000).
- Grupo de Trabajo "Normas para medición de Radiactividad Ambiental", CIEMAT, 21 September (2000).
- Grupo de Trabajo "Evaluación de Incertidumbres en radiactividad ambiental", CEDEX, Madrid, 20 September (2000).
- European Acreditation Organization Experts Meeting. Bratislava, 19-20 October (2000).
- ICRM "Liquid Scintillation Counting" Working Group Meeting, Laboratoire National Henri Becquerel, Saclay (Francia), 20-21 November (2000).

- "Extended SIR-Beta" Working Group Meeting of the Comité Consultatif pour les Rayonnements Ionisants (II), BIPM, Sèvres, December (2000).
- IAEA, Reunión Constitutiva del Coordinated Research Program "Alpha-particle Spectrometry" . Vienna, December (2000).
- Comité Científico ICRM'2001, PTB, Braunschweig, December (2000).
- EUROMET Ionizing Radiations Delegates Meeting, Bratislava, 26-28 February (2001).
- "Gamma- and Beta-Ray Spectrometry" ICRM Working Group Business Meeting, Braunschweig, 14 May (2001) (Coordinador internacional).
- International Decay Data Evaluation Project, Progress Meeting., Braunschweig, 16 May (2001).
- International Committe for Radionuclide Metrology, General Meeting, Braunschweig, 18 May (2001).
- Comité Consultatif pour les Rayonnements Ionisants (II), BIPM, Sèvres, 21-23 May (2001).
- Grupo de Trabajo "Normas para medición de Radiactividad Ambiental", CEDEX, Madrid, May (2001).
- Grupo de Trabajo " Incertidumbres en Vigilancia Radiológica Ambiental", CIEMAT, May (2001).
- Grupo de Trabajo " Incertidumbres en Vigilancia Radiológica Ambiental", Universidad de Zaragoza, July (2001).
- Grupo de Trabajo "Normas para medición de Radiactividad Ambiental", Universidad de Valencia, August (2001).
- Grupo de Trabajo "Normas para medición de Radiactividad Ambiental", CIEMAT, September (2001).
- Grupo de Trabajo "Patrones Radiactivos", CIEMAT, 16 de November (2001).
- ENAC technical auditor for the Instituto de Técnicas Energéticas, Univ. Politécnica de Catalunya. Barcelona, 8-10 April (2002).

4.2.4 National/International Cooperation

Collaboration with other institutions:

Spanish:

- CEM, for coordination of National Standards Laboratories (2000-2003).
- ENAC (Spanish Accreditation Body), Chairmanship of Ionizing Radiations Subcommittee (A. Bosed) and two more members (E. García-toraño and J.M. Los Arcos) (2000->)
- CSN (Nuclear Safety Council), Campaign for the verification of traceability of Personal Dosimetry Services in Spain (2000-2001).
- UNED (National University for Distance Education), Collaboration Agreement for joint evaluation and diffusion of nuclear data : BANDRRI and IAEA CRP (2000->).
- CAM (Madrid Regional Government), Contract for joining the Technological Infrastructures Network (2000-2003).
- SEFM (Spanish Society of Medical Physics), Survey Report on the "Metrological Needs in Braquitherapy" (A. Brosed) (2000).

International:

- ICRM (International Committee for Radionuclide Metrology), International Coordination of the "Alpha-particle Spectrometry" Working Group (E. García-Toraño) (1992->).
- ICRM (International Committee for Radionuclide Metrology), International Coordination of the "Gamma- and Beta-ray Spectrometry" Working Group (J.M. Los Arcos) (1991->).
- BIPM, Comité Consultatif pour les Rayonnements Ionisants (II), International Coordination of the "Extended SIR Beta" Working Group (J.M. Los Arcos) (2000->).
- Scientific Committee of the Intl. Conferences on Radionuclide Metrology and its Applications, ICRM'2001(PTB, Germany), ICRM'2003(University College, Ireland): two members (E. García-toraño and J.M. Los Arcos.
- IAEA Coordinated Research Program "Update of X- and γ-Ray Data for Detectors Calibration" (J.M. Los Arcos) (2000-2003).
- IAEA Coordinated Research Program "Alpha-particle Spectrometry" (E. García-Toraño) (2000->)
- Laboratoire National Henri Becquerel (CEA, Francia), invited expert for alpha-particle spectrometry advising (E.García-Toraño) (2000).
- IAEA Expert mission in Centro de Isotopos (La Habana, Cuba) for radionuclide metrology advising (J.M. Los Arcos) (2000).
- IAEA training fellowship to a researcher from the Laboratorio de Metrologia de Radiaciones Ionizantes, Comisión de Energía Atómica of Argentina (2000).

- IAEA training fellowship to a researcher from the Departamento de Metrologia de Radionúclidos, Centro de Isótopos (Cuba) (2000).
- IAEA sponsored scientific visit of the Head of the Departamento de Metrología de Radionucleidos, Centro de Isótopos (Cuba) (2000).
- IAEA sponsored scientific visit of the Head of the Departamento de Metrología, Instituto Nacional de Investigaciones Nucleares(México) (2000).
- IAEA Expert mission in Centro de Isotopos (La Habana, Cuba) for radionuclide metrology advising (J.M. Los Arcos) (2001).
- IAEA Expert mission in LNMRI-IRD (Río de Janeiro, Brazil) for liquid scintillation metrology advising (L. Rodríguez Barquero) (2002).
- IAEA Expert mission in the Laboratorio de Metrologia de Radiaciones Ionizantes, Comisión de Energía Atómica of Argentina (2002) liquid scintillation metrology advising (E. García-Toraño) (2002).
- IAEA training fellowship to a researcher from the IPEN (Sao Paulo, Brazil), for nuclear medicine radionuclide standardization (2002).

4.2.5 Certificates issued

Concept	2000	2001	2002
Radioprotection monitors	112	142	193
Reference chambers (prot./environm.)	10	17	12
Radiotherapy reference chambers	0	133	0
Surface contamination monitors	59	78	91
Radioassay of equipment	7	11	23
Dose assignments	7	14	43
Reference sources	54	53	47
TOTAL	**249**	**448**	**409**

4.2.6 External Income (€)

Concept	2000	2001	2002
Technical Services	57600	135800	69300
CAM infrastructure program	81100	52300	82900
CSN contracts	13200	16800	-
CIEMAT in-house services (equivalent)	31250	32400	28500
TOTAL	**183150**	**237300**	**180700**

4.2.7 Expenses (€)

Concept	2000	2001	2002
Project	146600	100100	116100
IR13	4200	10700	9200
IR14	7900	14200	21600
TOTAL	**158700**	**125000**	**146900**

5 CURRENT DEVELOPMENTS

The tasks of the LMRI in the immediate future derive directly from the MRA international requirements (ISO17025 Quality System and SIR/Key comparisons participation to support the equivalence of standards and certificates) to National Standards Laboratories and from the requirements from the users' community in Spain, always being in compromise with the task force and budget available from CIEMAT.

Therefore, in addition to the usual (already mentioned in section 4) calibration services of equipment and reference materials, wich will continue being performed upon demand from users, a series of specific activities of technical/scientific character will be carried out in order to improve the capabilities of LMRI.

5.1 Scientific/Technical tasks

tasks beginning (or ongoing) in 2003 can be summarised as follows:

- Further development of LMRI Quality System, and definition and submission of CMCs tables to EUROMET for inclusion in Appendix B of MRA.
- Systematic contribution to SIR and participation in Key Comparisons, specifically for the dosimetric standards laboratories of IR14.
- Participation in the following international committees, actions or projects:
  - CCRI(I) and CCRI(II) meetings at BIPM, in May 2003.
  - Coordination of CCRI(II) "SIR Extension by LSC" Working Group,with a progress report to be presented at the CCRI(II) meeting (ongoing).
  - Coordination of ICRM Working Groups on "Alpha-particle Spectrometry" and "Gamma- and beta-ray spectrometry" and the GBS-A01 action for the intercomparison of methods to evaluate coincidence-summing corrections" (ongoing).
  - Coordination of the EUROMET-591 Project on the "Measurement of nuclear data of 235U" (alpha emission probabilities) (ongoing; next coordination meeting : March 2003 at CIEMAT).
  - Participation in the IAEA CRP on "Development and application of alpha-particle spectrometry" (ongoing).
  - Participation in the ICRM'2003 Conference (Dublin).
- Further developments concerning IR14 (Dosimetric standards labs.):
  - Experimental setup and Procedure for the determination of absorbed dose to water for ^{60}Co energy (2003)
  - National calibration campaign for electrometer-chamber sets in the energy of ^{60}Co, for Spanish hospitals (2003).
  - Study to determine the correction factor for the radial inhomogeneity of the ^{60}Co beam for any fluence distribution, axis or ionization chamber (2003->)
  - Experimental determination of an analytical function that fits the saturation factor of the 6 most frequent types of chambers in Spain (2003->).
  - Feasibility study for parallel-plate chambers at ^{60}Co energies (2003->).
  - Characterization of the X-ray qualities:ISO 4037 broad spectrum series, 60-300 kV(2003).
  - Characterization of the X-ray qualities : ISO 4037 narrow spectrum series, 10-15 kV(2003).

- Re-installation of the primary standard , free air ionization chamber for energies up to 50 kV(2003->).

❖ Further developments concerning IR13 (Radionuclide metrology labs.):

- Development of a national Protocol for the calibration of activimeters, in cooperation with the Spanish societies of Medical Physics (SEFM), Radiation protection (SEPR), Radiopharmaceuticals (SERF) and Nuclear Medicine (SEMN), under coordination of LMRI (2003).
- Calibration campaign of activimeters from nuclear medicine services and radiopharmacy dealers (2003).
- Participation in the "Radioactive standards", "Uncertainty evaluation" and "Equipment" working groups of the CSN network of environmental radioactivity laboratories (ongoing).
- Experimental testing of the TDCR liquid scintillation counter, after design modifications (2003).
- Definition of reference cocktails for LSC measurements, with accurately known composition (2003->).
- Characterization of ionization quench response of LSC reference cocktails (2003->).
- Development and patent claim for the Absolute Liquid Scintillation Spectral Efficiency method (ongoing).
- In cooperation with the CIEMAT Department of Environmental impact of the Energy:
  - Characterization of radionuclide migration processes-MATRIX II (ENRESA) (ongoing, ->2003).
  - High resolution paleoclimatic analysis by karstic speleothems (CICYT) (ongoing; ->2004).

In the hearth of all sciences is the need
for measuring what is measurable
and for making measurable
what has not yet been measured.
(Galileo)