The RadioNuclide Metrology Team (RN)

Equipped and organised for supporting and watching over radioactivity measurements in Europe

Mikael Hult, team-leader

Joint Research Centre

RN-team – operating unique infrastructure

Both included in JRC's open access programme since 2014

https://ec.europa.eu/jrc/en/research-facility/open-access

- **RADMET laboratory**

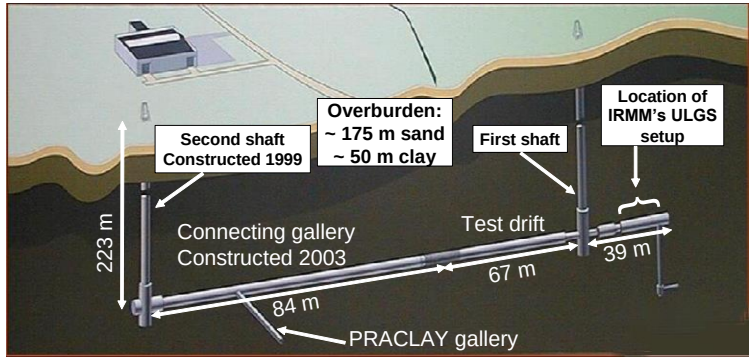
An "armada" of unique instruments.

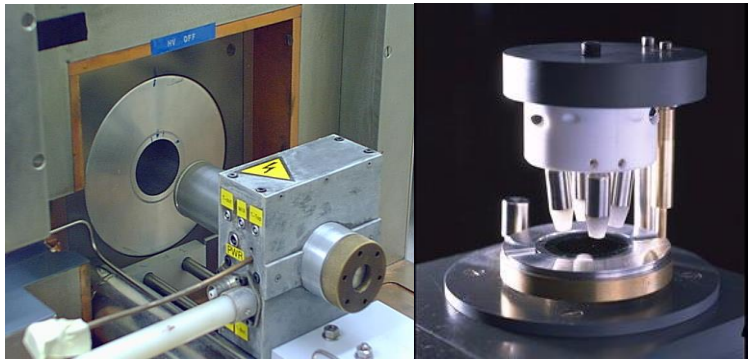
This enables international equivalence for radioactivity measurements

- **HADES underground laboratory (-225 m)** *(see video)*

An "armada" of specially designed gamma-spectrometers

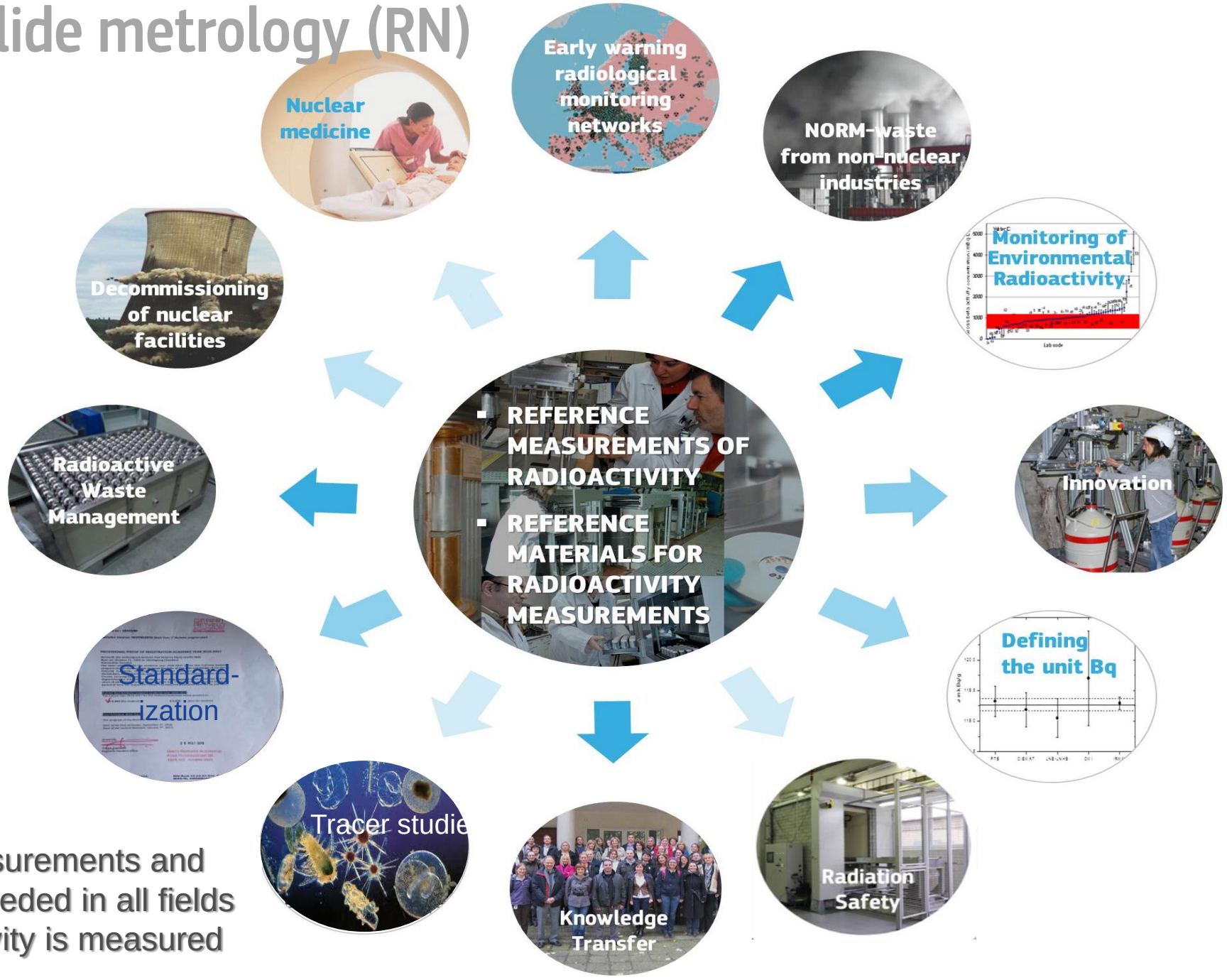
It supports many JRC-projects and interdisciplinary nuclear science applications





European Commission

RadioNuclide metrology (RN)



Reference measurements and materials are needed in all fields where radioactivity is measured

European Commission

RN represented at the highest levels

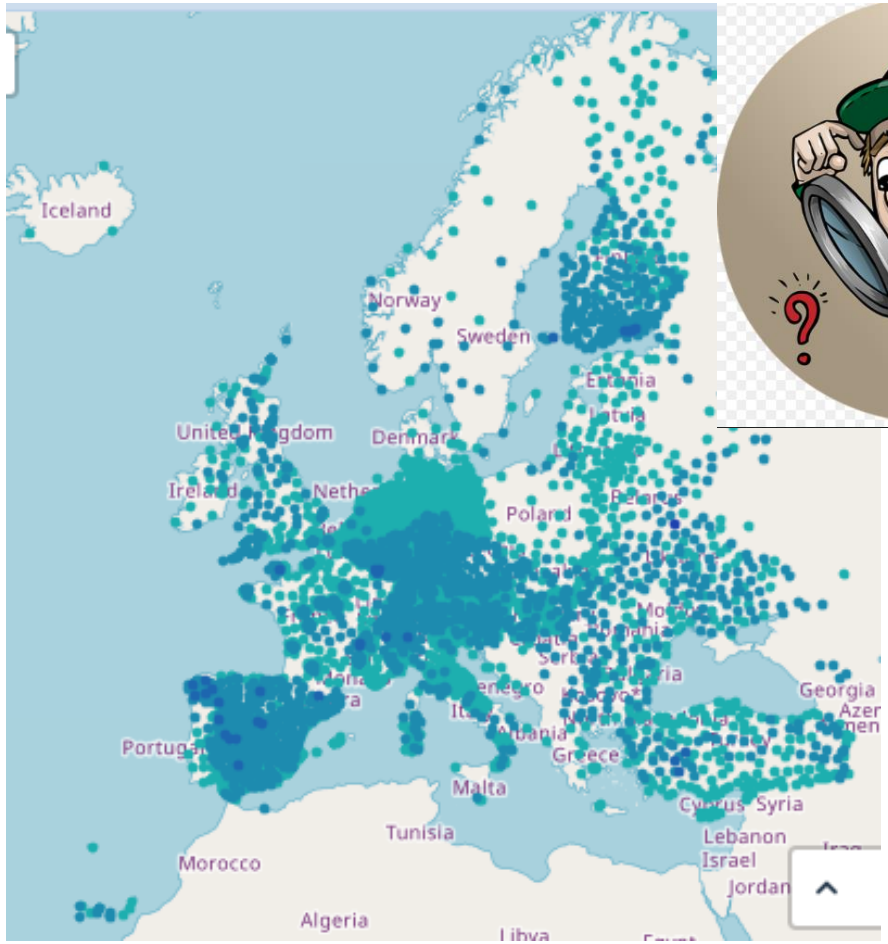
- CCRI – Consultative Committee for Ionising Radioactivity (at BIPM)
- ICRM – International Committee for Radionuclide Metrology
- Euramet Technical Committee (TC) for Ionising Radiation
- EC-Liaison with TCs in IEC and ISO
- Collaboration agreements with IAEA, WHOI, SCK CEN, CEA, CIEMAT, …..

RN Key activity-1

PTs and RMs for ~ 300 labs

It enables:…..

- DG ENER and national authorities to check labs – each year!
- Labs to obtain accreditation
- Labs to discover errors and improve
- Input for European standards
- Realisation of Euratom treaty Art. 35 &39



PT=Proficiency Test, RM=Reference material, CRM = Certified RM, MS=Member States

European Commission

REM 2019 PT

JRC-GAB1 gross alpha

Natural mineral water

https://remon.jrc.ec.europa.eu/About/Environmental-Monitoring/Proficiency-Tests

Proficiency Tests in support of Article 35 (since 2003)

Year	Matrix	Radionuclide(s)
2010	Soil	^{40}K, ^{137}Cs, $^{212/214}$Bi, $^{212/214}$Pb, ^{226}Ra, $^{230/232}$Th, $^{234/235/238}$U, $^{238/239/240}$Pu, ^{90}Sr
2011	Bilberry	^{90}Sr, ^{137}Cs, ^{40}K
2012	Water	Total α / ß activity
2014	Air filter	^{137}Cs
2017	Maize	^{134}Cs, ^{137}Cs, ^{131}I
2018	Water	Radon
2019	Water	Total α / ß activity
2020	Building materials	^{226}Ra, ^{40}K, ^{228}Ra, ^{228}Th
2016	Air filter	^{134,137}Cs, ^{131}I (MetroERM reserach-project)

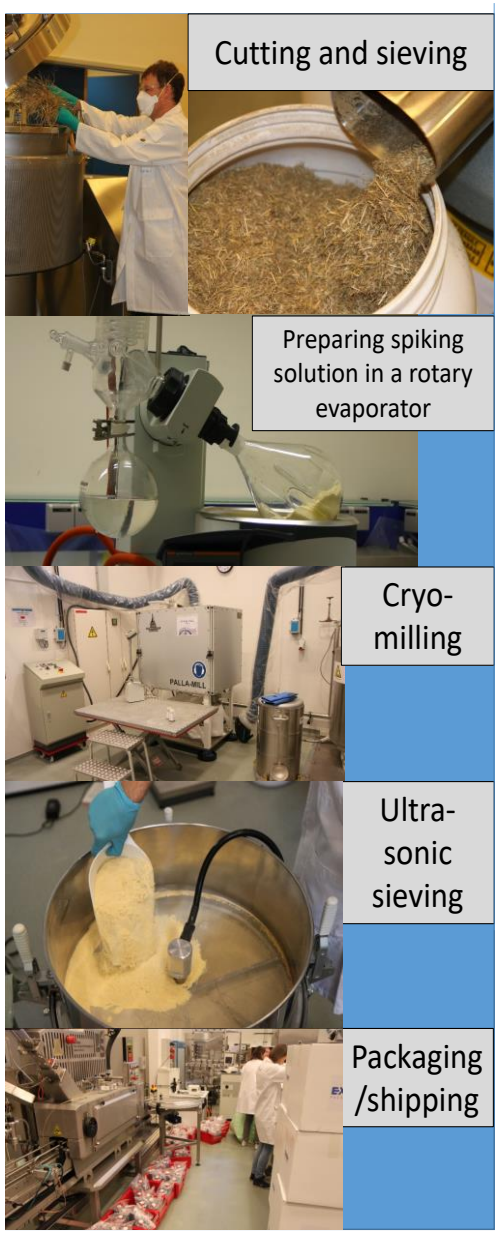
REM Proficiency Tests: ttps://remon.jrc.ec.europa.eu/Services/Proficiency-Tests

European Commission

World-leading lab for reference materials production

2011-2021:

- 30,000 units CRM
- 6,000 units radioactive CRM
  - 30 different matrices



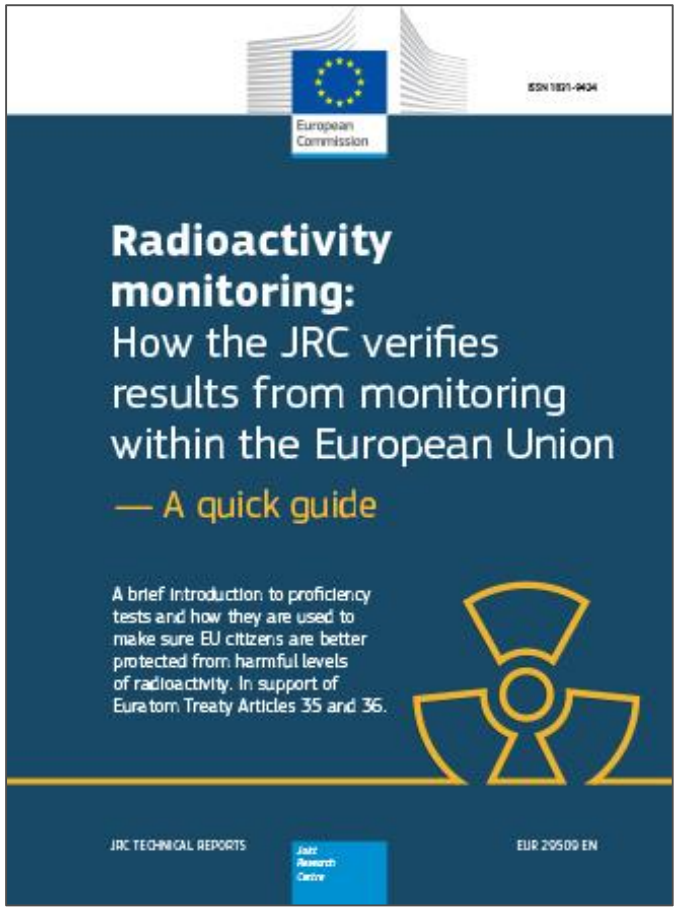
RN Key activity-1

300 labs depending on PTs and RMs from JRC

Big demand for future support from Member States!

- More matrices
- More radionuclides
- More Certified Reference Materials
- PTs for sampling
- More frequent PTs

Requires flexibility, expertise & research



PT=Proficiency Test, RM=Reference material, CRM = Certified RM, MS=Member States

European Commission

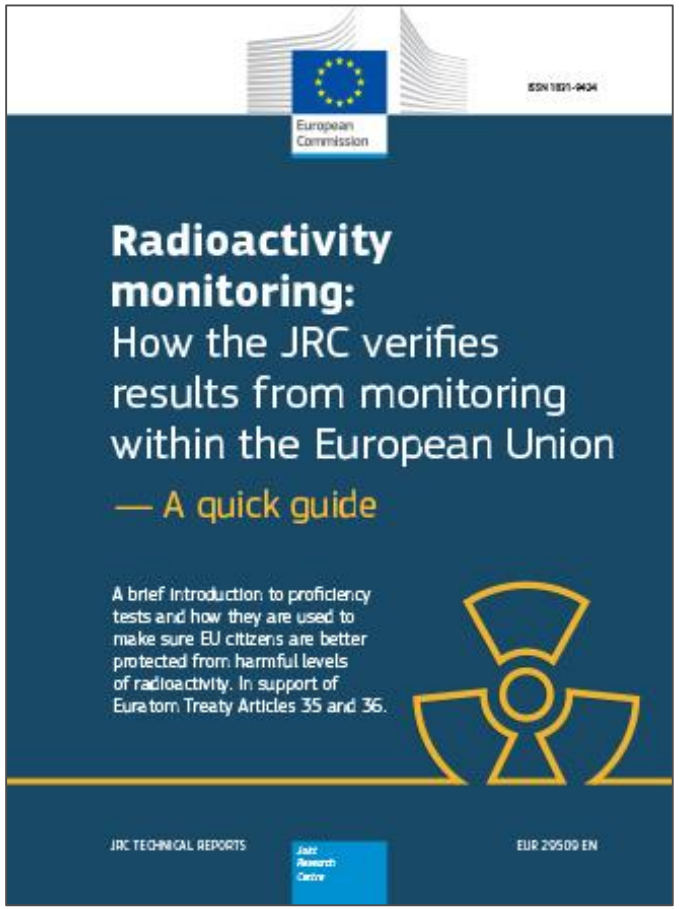
What of Chernobyl happened today?

How is the status of radioactivity monitoring in Europe?

Can we only detect major releases?

Can we use monitoring data for science?

https://publications.jrc.ec.europa.eu/repository/handle/JRC117258?mode=full



European Commission

RN Key activity-2

Foundation for international equivalence – Article 8

Above: The CsI detector at JRC-Geel on which part of the international reference system for radioactivity relies

- International equivalence of radionuclides and traceability to the unit Bq

Can we trust each others measurements? Trade!

Needs implementation for <u>every</u> radionuclide..

- Definition of a Bq: (s^{-1}).. But not so simple in reality

European Commission

RN Key activity-2

Foundation for international equivalence – Article 8

Above: The CsI detector at JRC-Geel on which part of the international reference system for radioactivity relies

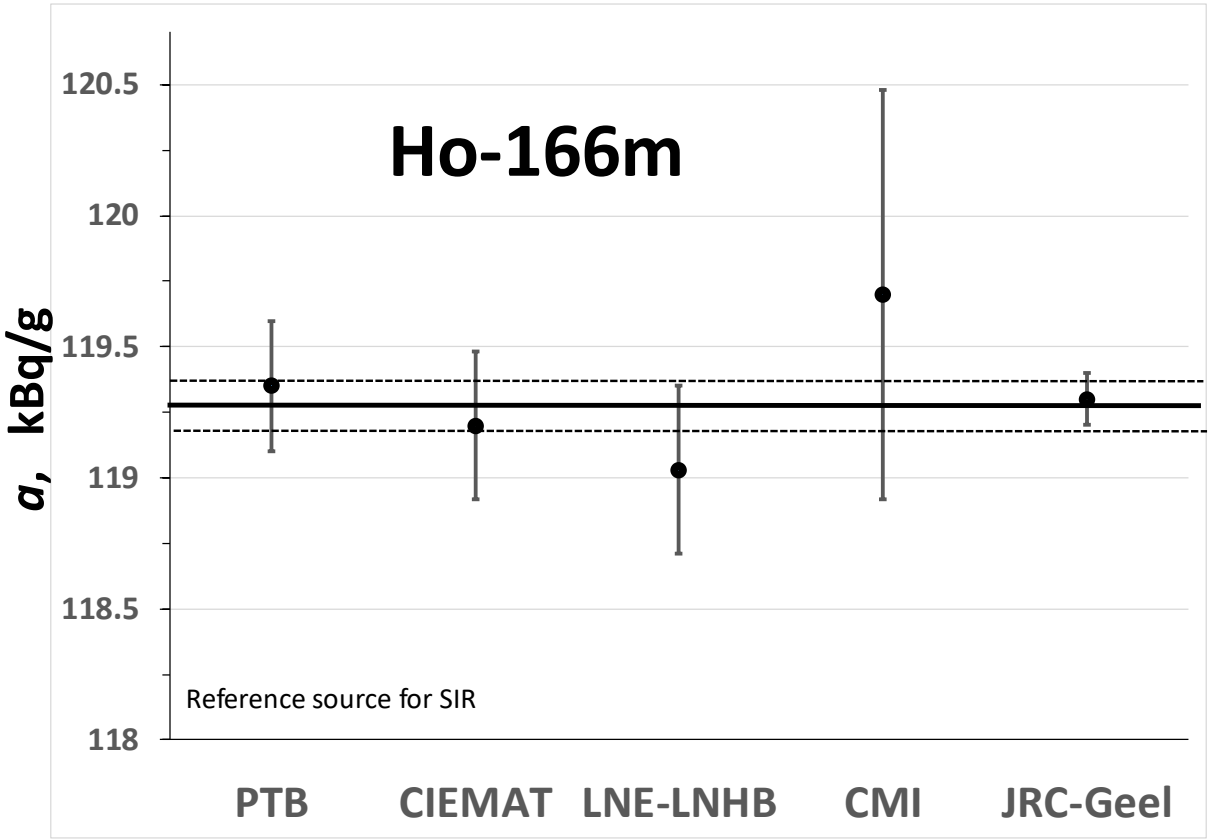
Compare with “the old” realisation of the unit kg

As a figure of speech one could say that each radionuclide is “a kg”

RN Key activity-2

Foundation for international equivalence – Article 8

Above: The CsI detector at JRC-Geel on which part of the international reference system for radioactivity relies



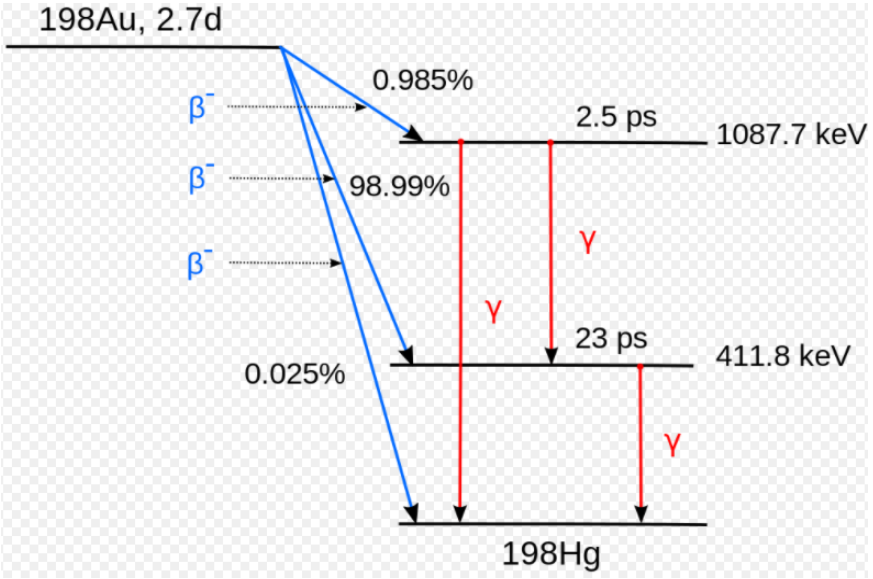
RN Key activity-2

Foundation for international equivalence – Article 8

Using the same instruments

- Provision of **decay data** for the needs of modern society *nuclear medicine (theranostics, alpha-immunotherapy), industry, science, radioprotection,..*

- Lots of parameters to measure in just one decay



European Commission

RN Key activity-3

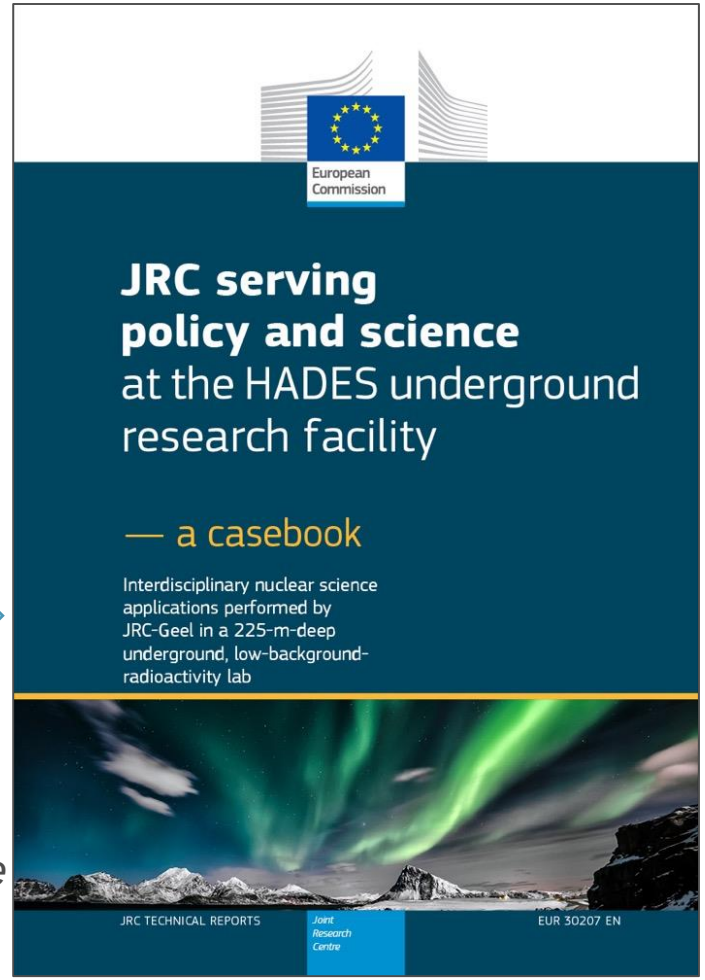
Nuclear Science Applications in HADES (-225 m)

https://publications.jrc.ec.europa.eu/repository/handle/JRC120311

- Support a multitude if JRC-projects
- Gives member state scientists access to novel technology – interdisciplinary!
- Euratom treaty Art. 6 and Art. 4 +Annex I

See selected case-stories from 162 scientific articles

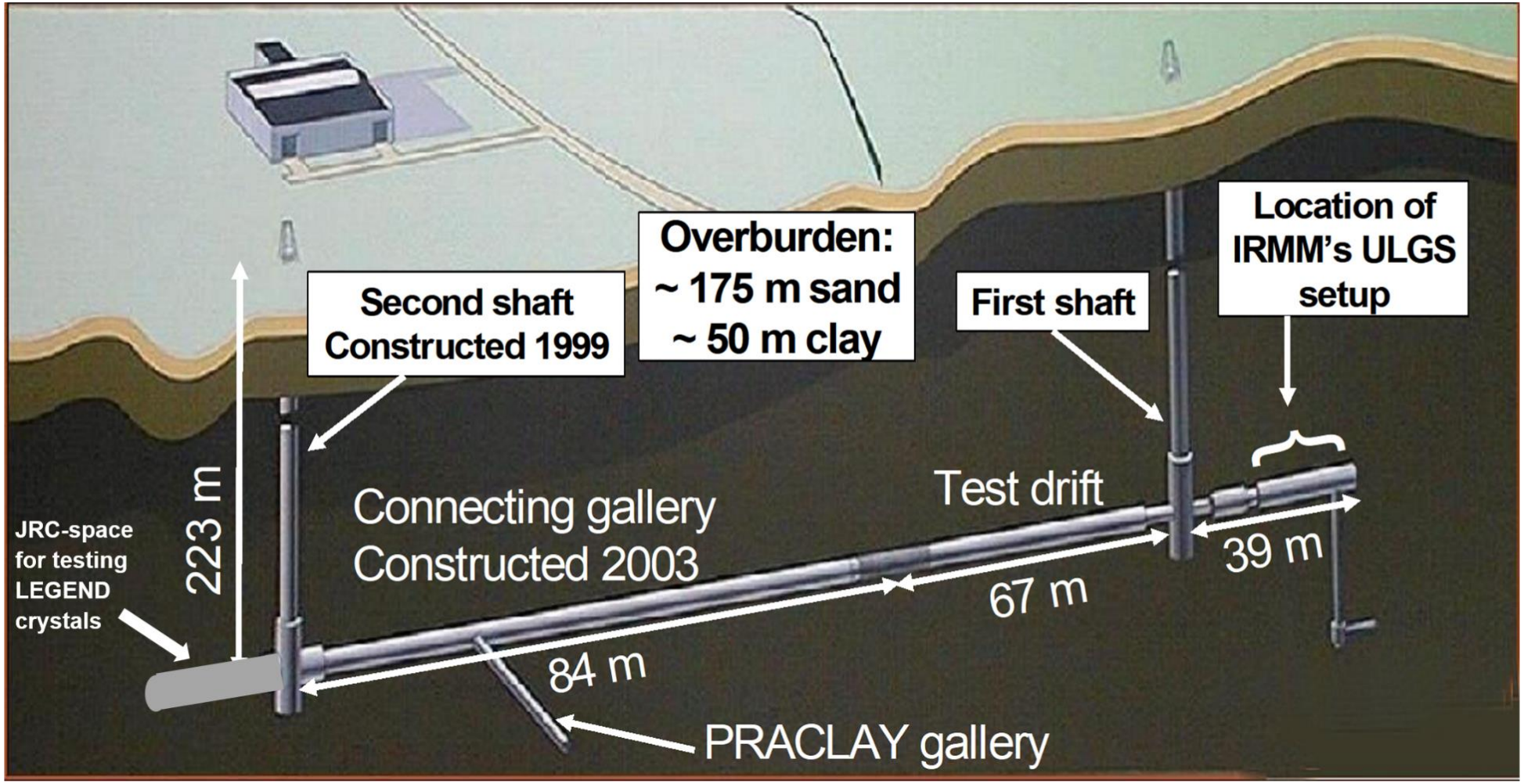
-Mapping ocean currents
-The world's oldest living organism?
-Least radioactive space on Earth
-Most long-lived isomeric state in Universe
-How to cultivate on contaminated soil
-CO_2-free concrete
-Solving the Hiroshima enigma
-……



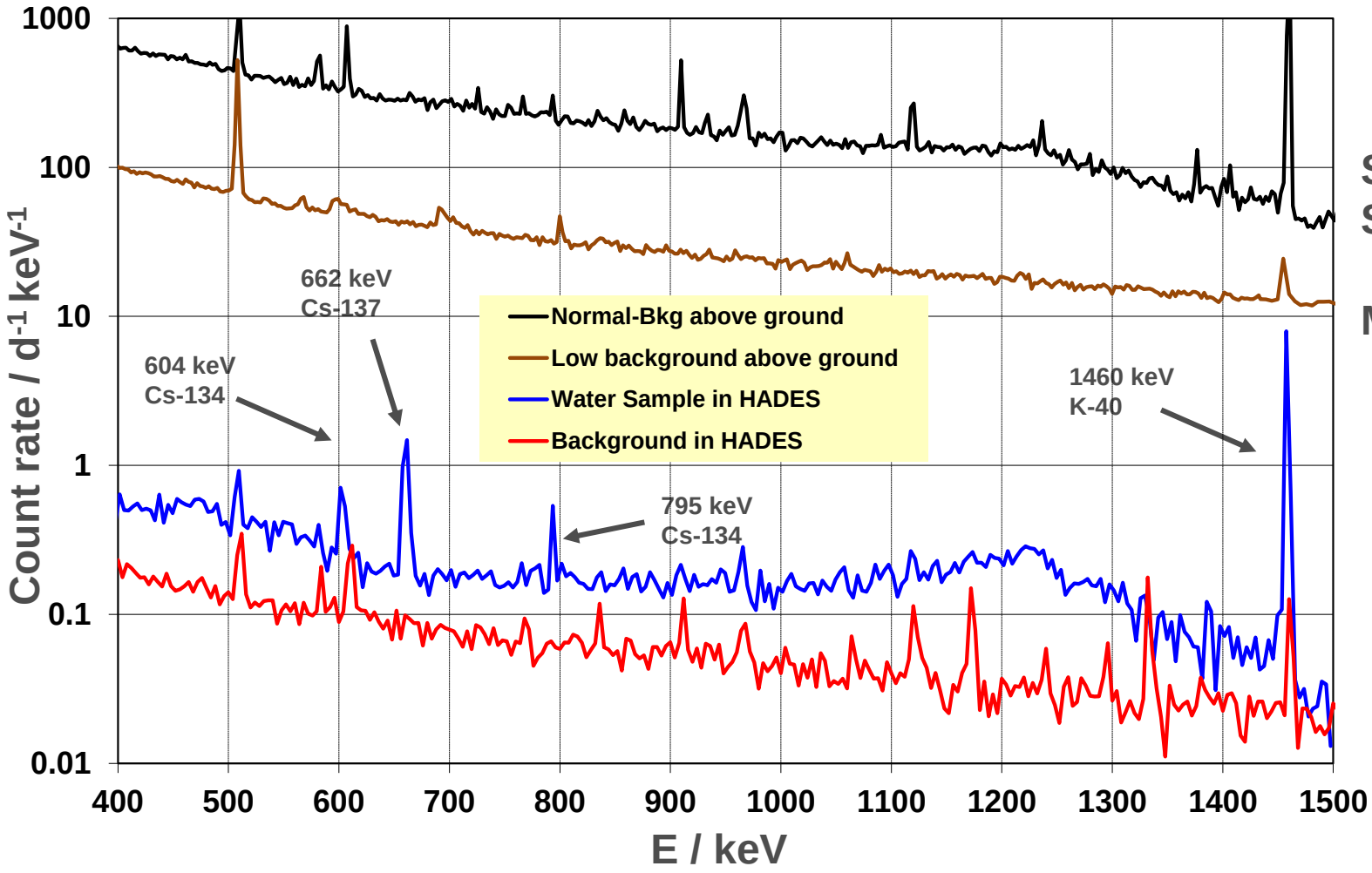
European Commission

HADES

HADES = High Activity Disposal Experimental Site
– Operated by EURIDICE and located at SCK CEN in Mol
https://www.youtube.com/watch?v=CqcT9ny0hZA



Water sample from the Pacific after Fukushima



Spectrum from a 4 g pacific Sea water precipitate

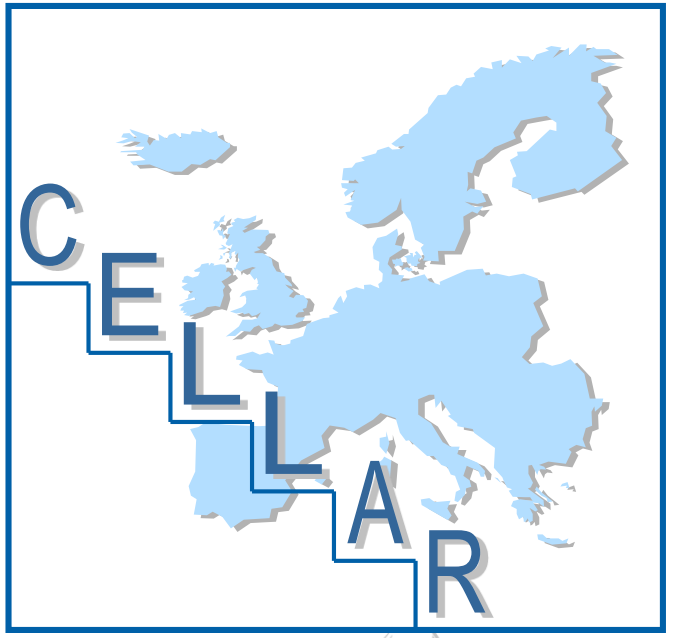
Measured in HADES

European Commission

CELLAR

- Collaboration of European Low-level underground LAboRatories
- Network for underground radioactivity labs since 2000
- 14 meetings, last one December 2018 in Monaco (IAEA)
- 13 partners, 2nd renewal of collaboration agreement ongoing

Mission: **To promote higher quality and sensitivity in ultra low-level radioactivity measurements for the improvement of crisis management, environment, health and consumer protection standards of Europe.**



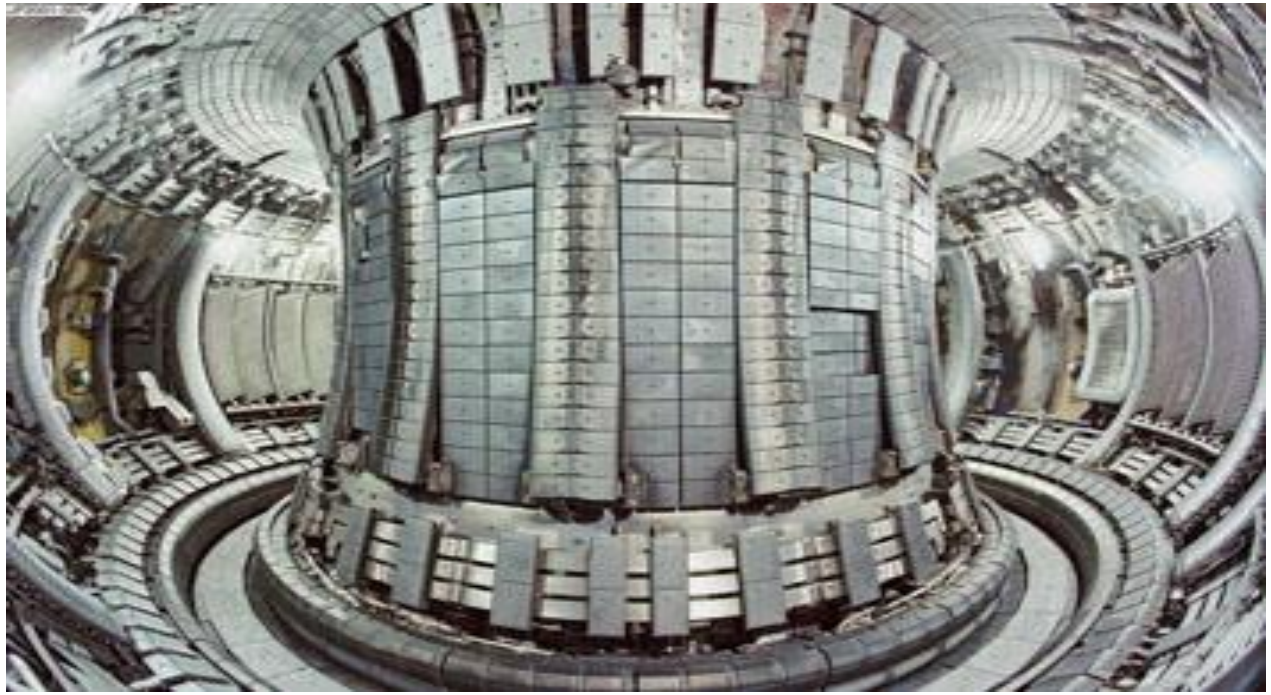
European Commission

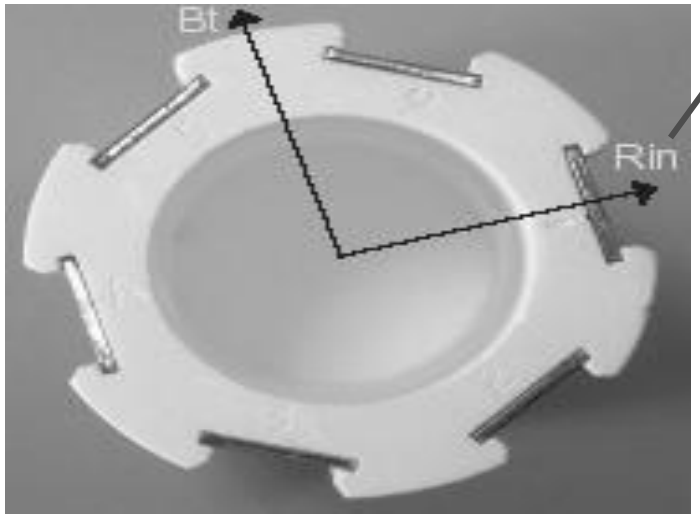
One example of a project CELLAR to which several labs collaborated

Monitoring of leakage of charged particles from fusion plasma

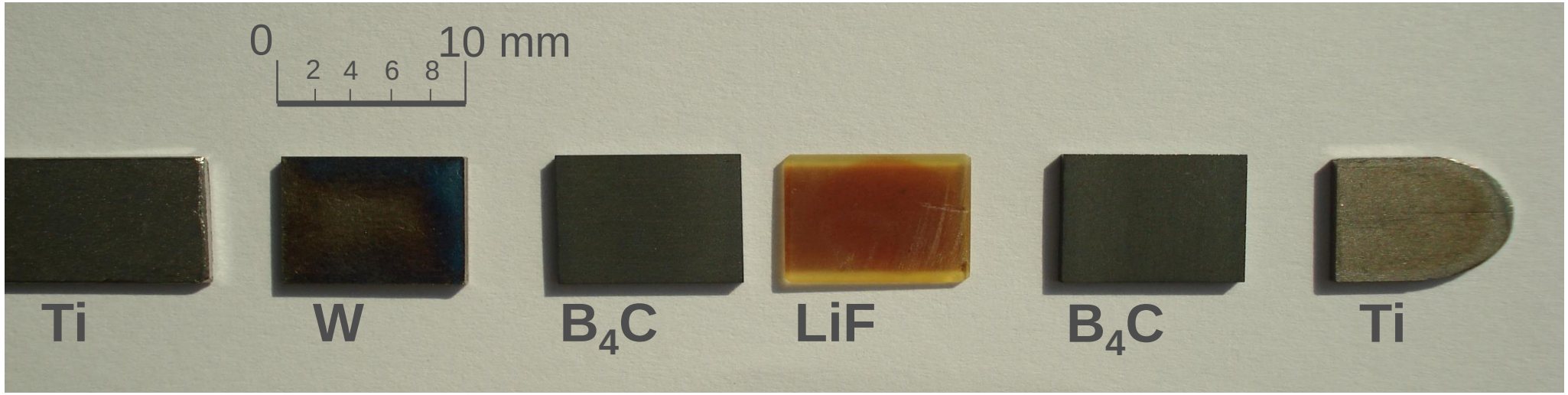
Motivation for CELLAR: Many samples arriving in short period of time (from fusion experiment). Some radionuclides have relatively short half-lives (days/weeks) $\Rightarrow$ Many detectors/labs needed in short period of time (a few weeks)

Experiments in JET 2004-2009 (1st reported at ICRM-conference 2005)



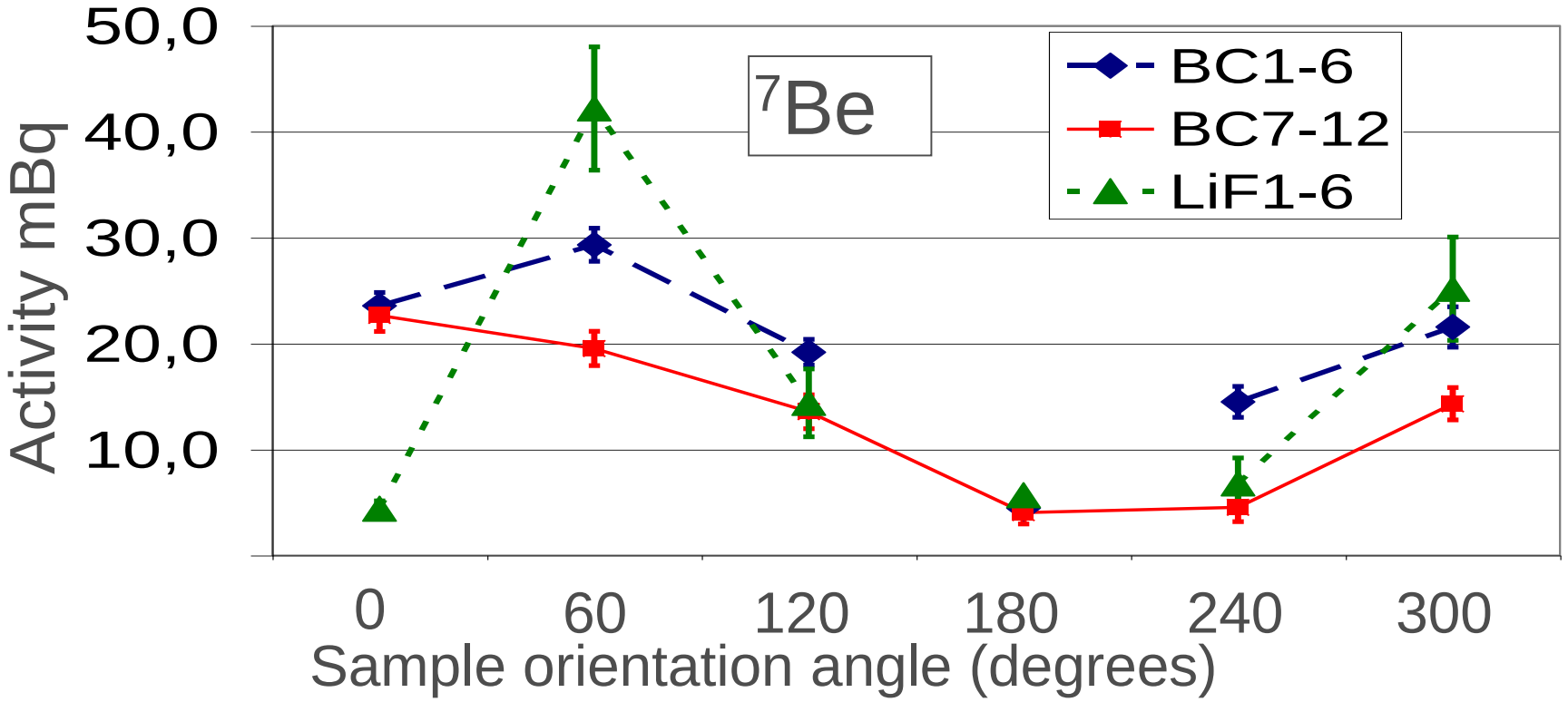


Samples from first experiment at JET



JET - 2005

Irradiation during multiple plasma pulses



Sample	**Reaction**	**Threshold** (MeV)	**σ·θ**
B_4C	$^{10}B(p,\alpha)^{7}Be$	0,5	7,9
LiF	$^{6}Li(d,n)^{7}Be$	0,1	0,4-0,5
LiF	$^{6}Li(p,n)^{7}Be$	1,5	51-55

[σ = cross section]
[θ = isotopic abundance]

European Commission

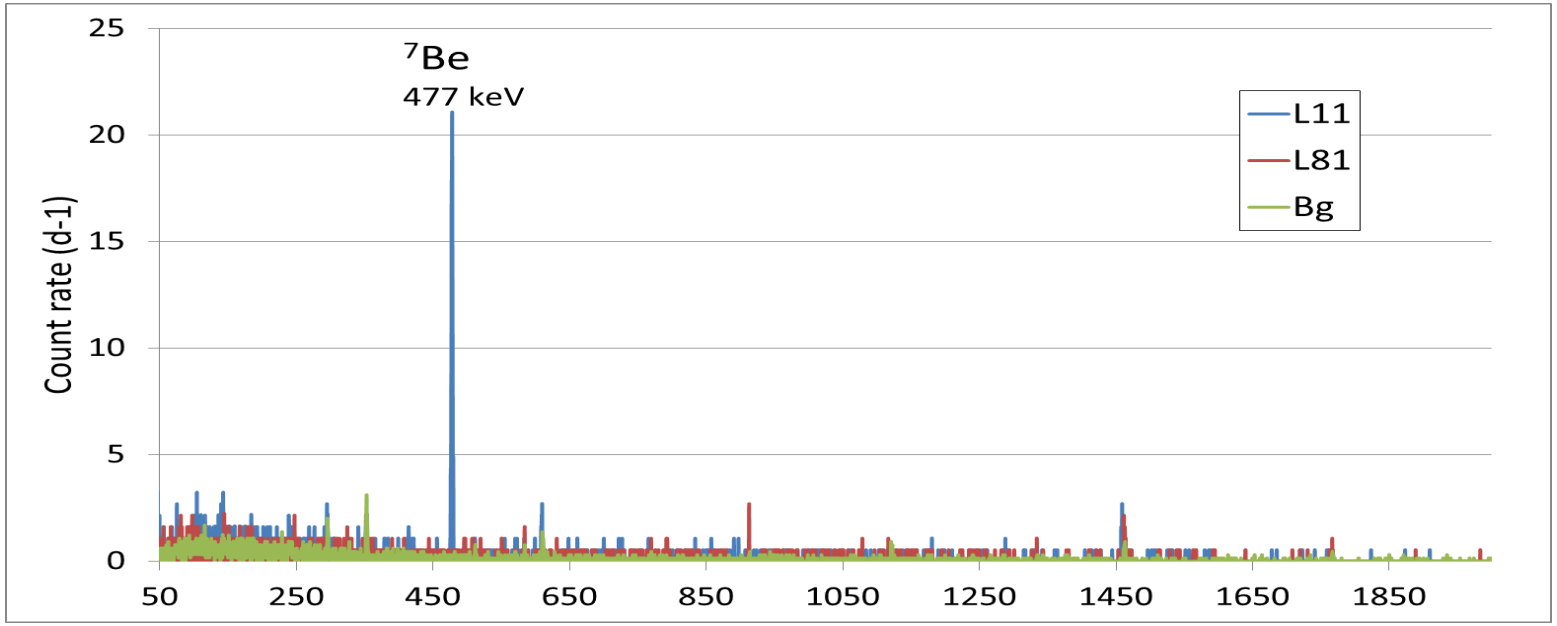
Activation probe at KSTAR 2015

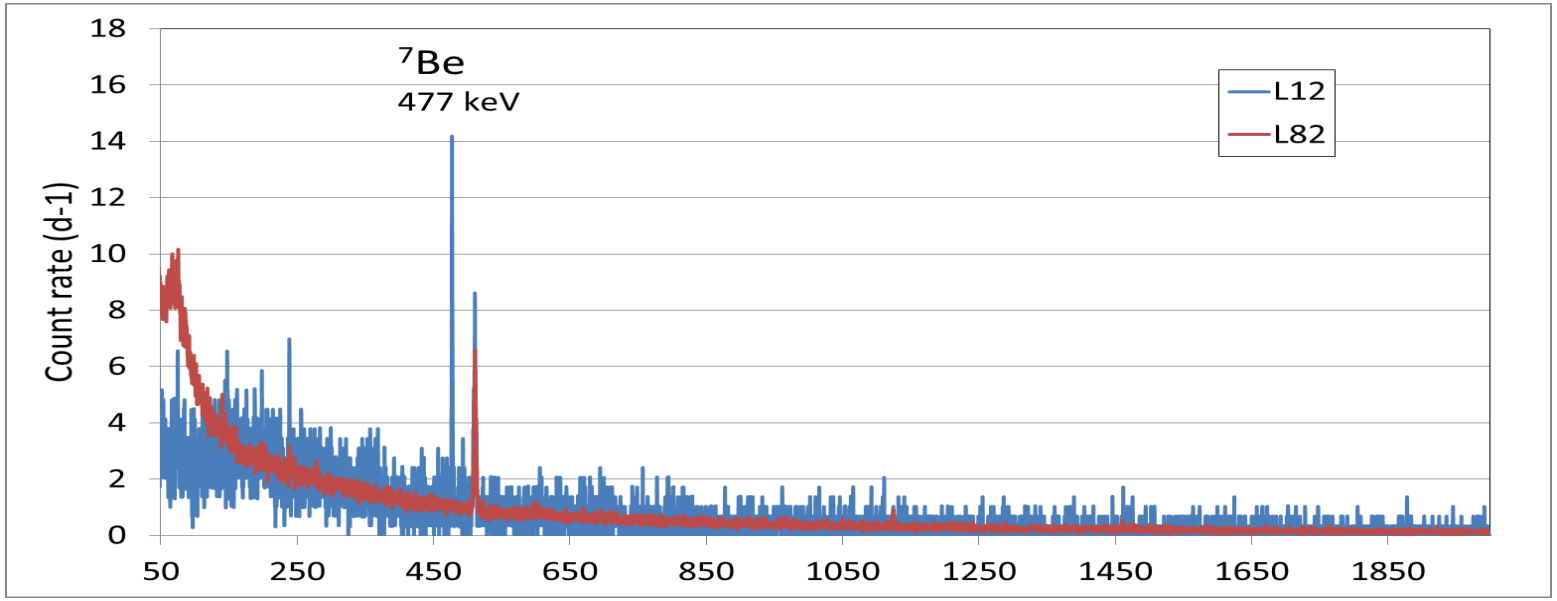
CELLAR (Collaboration of European Low-level underground LAboRatories)

For the detector used

Institute / Laboratory	depth (m) depth (m w.e.)	Location	Number of HPGe-detectors	Muon reduction factor	count rate 100-2000 keV cpd kg^{-1} of Ge
INFN-LNGS/ STELLA	1400 3500	Apennine mountains, Italy	14	1,000,000	458
Canfranc	850 2450	Spanish Pyrenees	8	40,000	142
JRC-Geel / HADES	225 500	Mol, Belgium (SCK CEN)	11	5,000	162 - 512
IRSN / LSM	1700 4800	The Alps, France	3 out of the 20	3,600,000	124
VKTA / Felsenkeller	47 125	Dresden, Germany	7	30	2090

LiF measurements at Modane & Felsenkeller

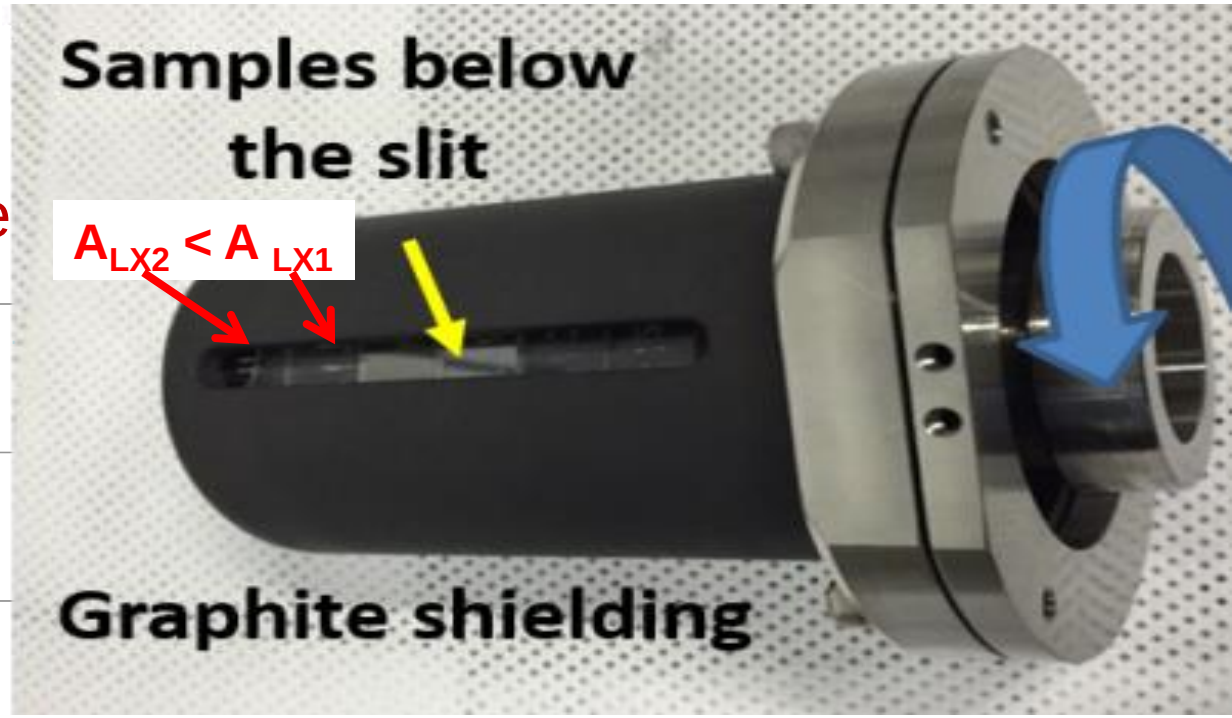


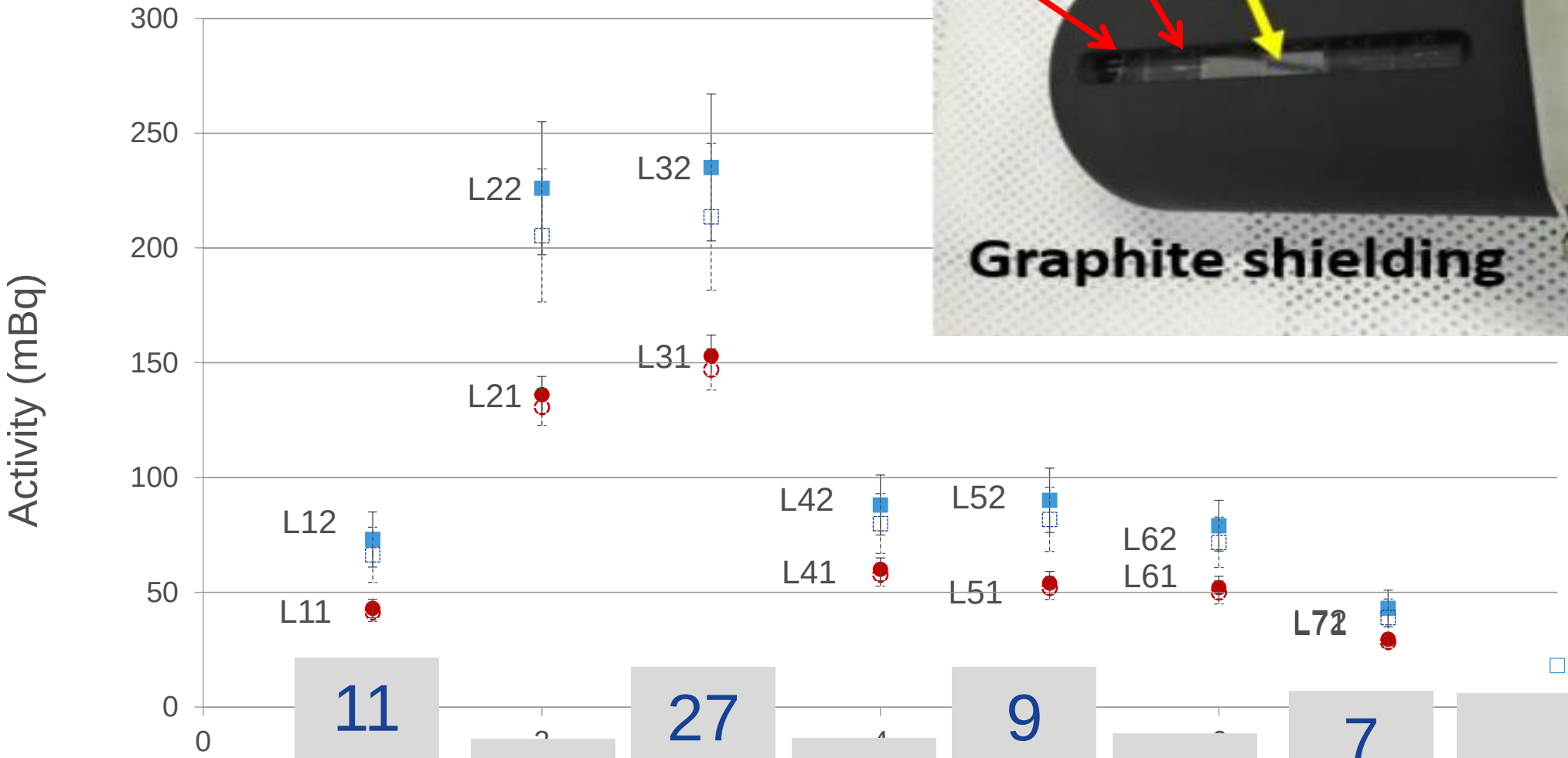


European Commission

LiF results ^{7}Be

Measured at LSM/IRSM and Felsenkelle





11

26

27

9

9

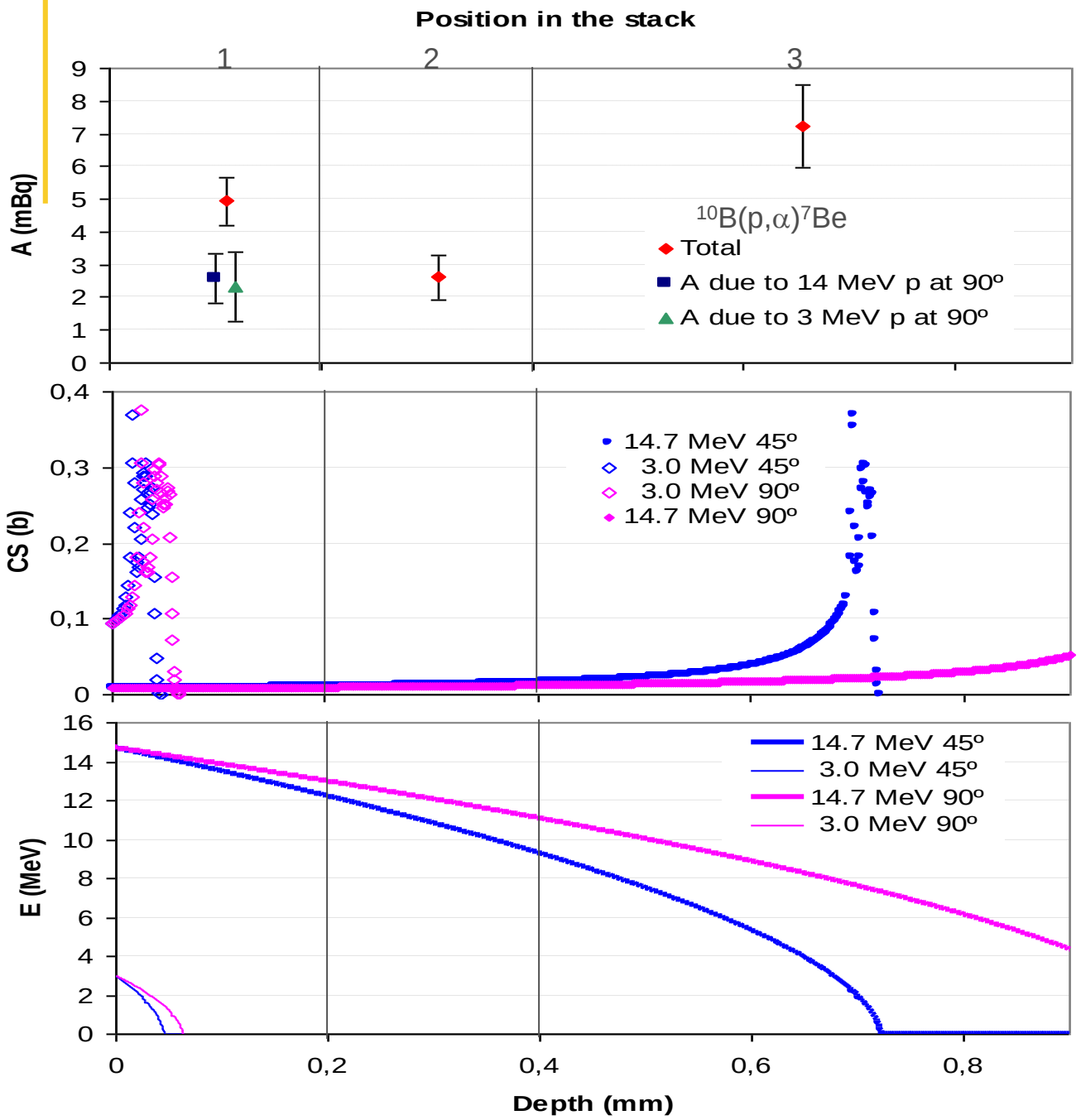
7

7

97 shielded

Plasm e

European Commission



3 MeV vs 14 MeV protons

Training & Education

- Depends on expertise gained from RN key activities
- Courses for/in connection/supporting:
  - European Enlargement & Integration,
  - JCPOA,
  - European monitoring labs,
  - National Metrology Institutes,
  - JRC staff,
  - Commission staff,
  - Universities

Thank you

European Commission