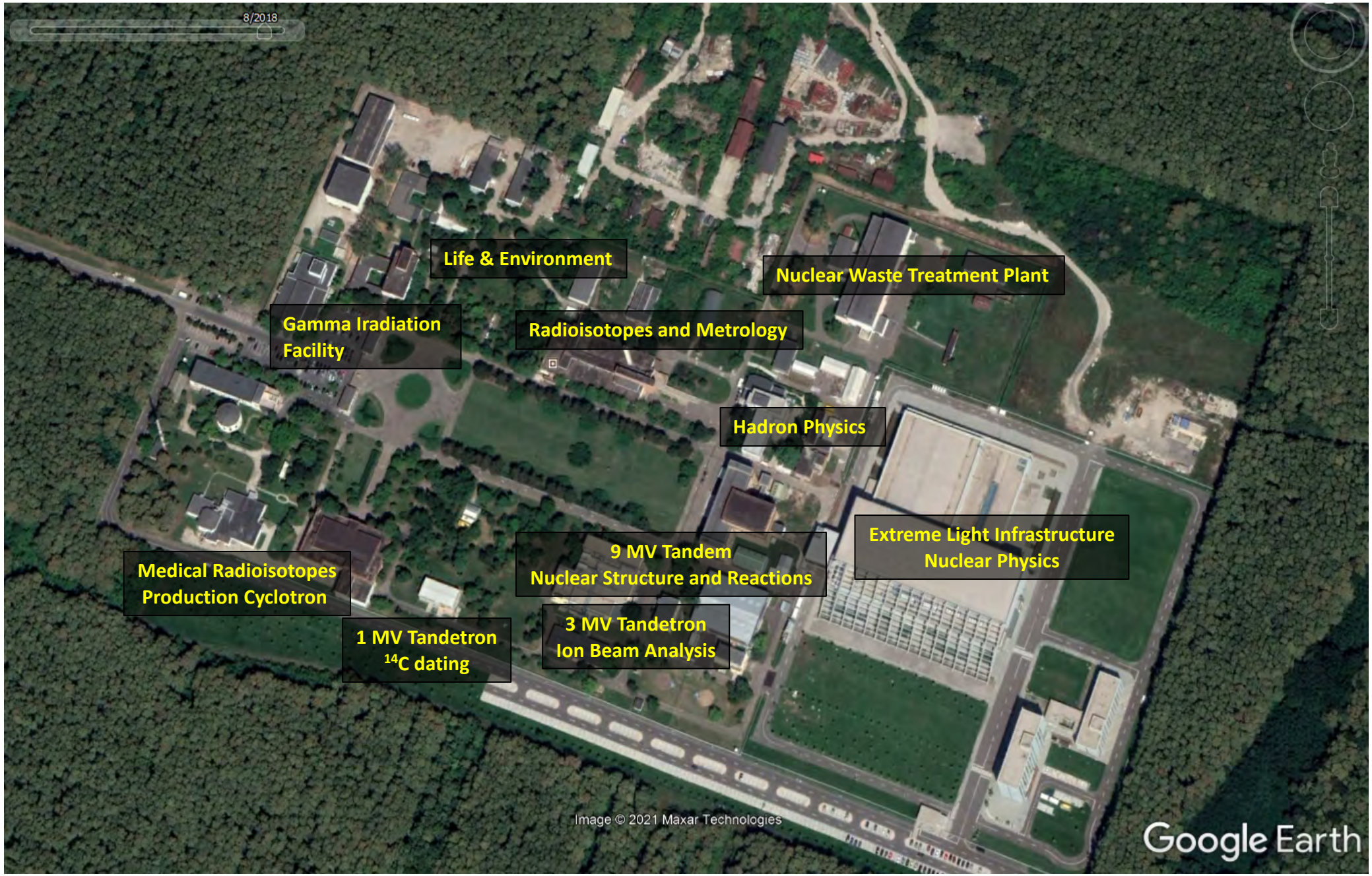
“Horia Hulubei” National Institute for Physics and Nuclear Engineering

Scientific Connections with Canada

Nicolae Marius Marginean


8/2018
Life & Environment
Nuclear Waste Treatment Plant
Gamma Iradiation Facility
Radioisotopes and Metrology
Hadron Physics
Extreme Light Infrastructure Nuclear Physics
9 MV Tandem Nuclear Structure and Reactions
Medical Radioisotopes Production Cyclotron
3 MV Tandetron Ion Beam Analysis
1 MV Tandetron ^{14}C dating
Image © 2021 Maxar Technologies
Google Earth

Project co-financed by the European Regional Development Fund through the Competitiveness Operational Programme "Investing in Sustainable Development"

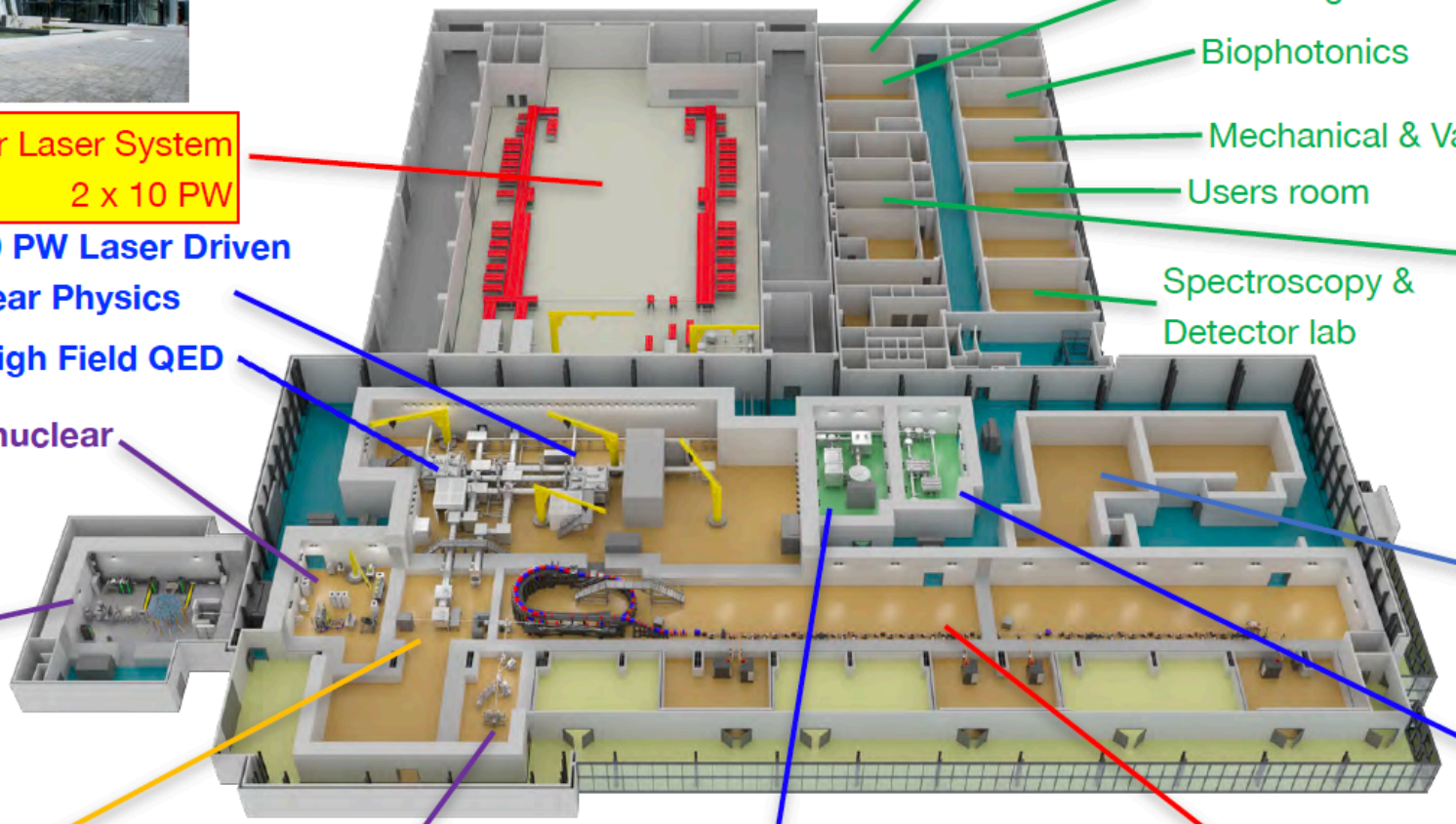
EUROPEAN UNION

GOVERNMENT OF ROMANIA

Structural Instruments 2014-2020

Extreme Light Infrastructure-Nuclear Physics (ELI-NP) - Phase II

Experimental Area Building – about 15000 m²



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For detailed information regarding the other programmes co-financed by the European Union, please visit *www.fonduri-ue.ro, www.ancs.ro*

Project co-financed by the European Regional Development Fund through the Competitiveness Operational Programme "Investing in Sustainable Development"

EUROPEAN UNION

Extreme Light Infrastructure-Nuclear Physics (ELI-NP) - Phase II

GOVERNMENT OF ROMANIA

Structural Instruments 2014-2020

Experiments with extreme light beams

Laser Driven Experiments

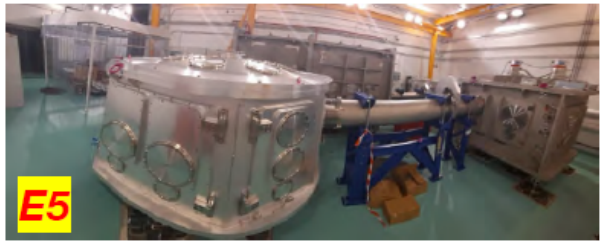
- *Characterization of laser-matter interactions with nuclear methods*
- *Particle acceleration with high power lasers*
- *Nuclear reactions in laser plasma*
- *Medical applications (X-ray imaging, radioisotopes)*

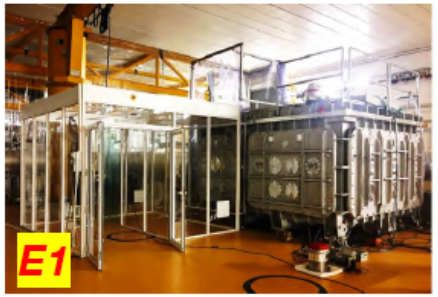
Gamma Driven Experiments

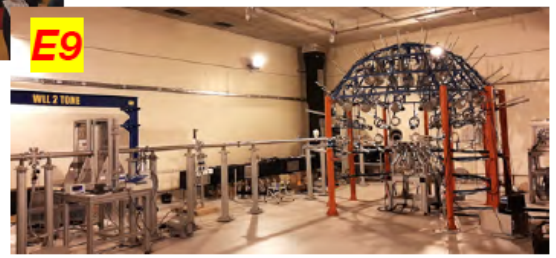
- *Photonuclear reactions, Nuclear structure, Exotic nuclei*
- *Nuclear astrophysics and nucleosynthesis*
- *Medical and industrial applications (non-destructive analysis, active interrogation, radioisotopes)*
- *Material studies with positrons*

Laser Gamma Experiments

- *Nuclear isomers*
- *QED and fundamental physics*







Technical Design Reports

Romanian Reports in Physics

Vol. 62 (2016)

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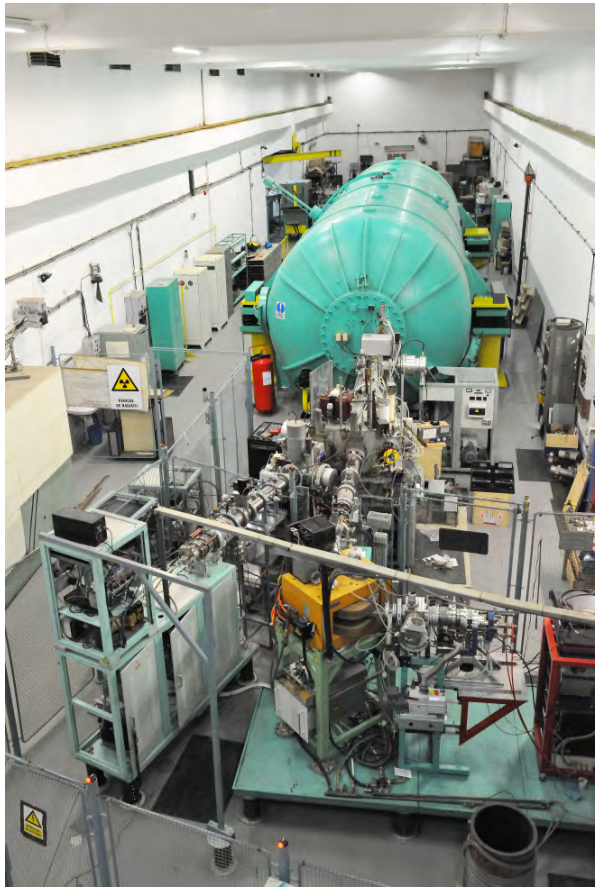
For detailed information regarding the other programmes co-financed by the European Union, please visit *www.fonduri-ue.ro, www.ancs.ro*

Major Research Infrastructures

TANDEM Accelerators

9MV for Basic Research

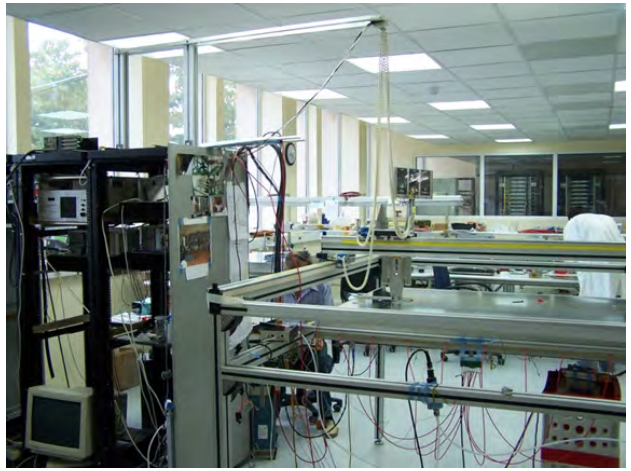


3MV for Ion Beam Analysis

1MV for Mass Spectroscopy

Major Research Infrastructures

Detector Laboratory for CERN and FAIR



Cyclotron for radiopharmaceutical studies

GRID Computing (CERN)

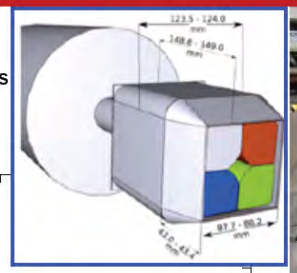
TRIUMF

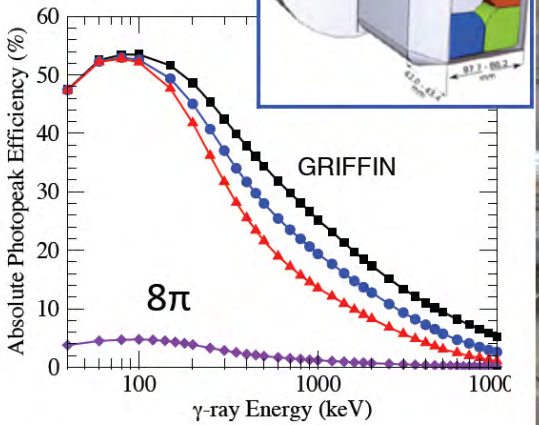
- Tri-University Meson Facility (TRIUMF)
- 1968 Simon Fraser University, University of British Columbia and University of Victoria
- TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics
- Own and operated by a consortium of Canadian Universities

SFU
- 1965
- 30,000 students
- 6,500 faculty and staff
- 130,000 alumni
- TISOL facility

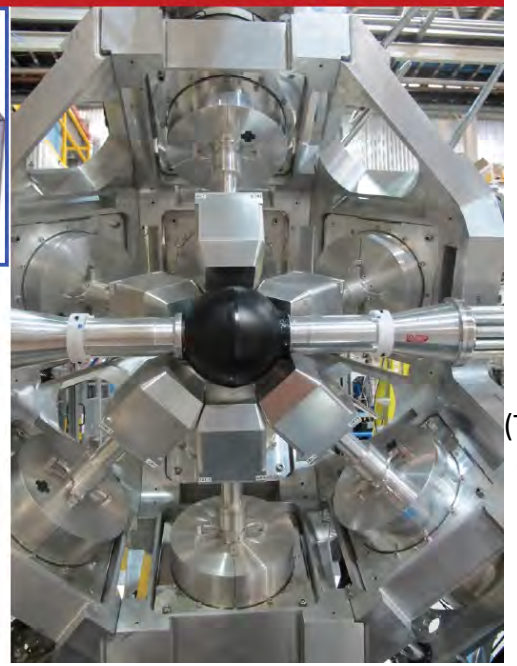
GRIFFIN - The Gamma-Ray Infrastructure For Fundamental Investigations of Nuclei

A close-packed array of 16 large-volume HPGe Clover detectors, 64 crystals





4096 crystal pairs at 52 unique angles for γ-γ angular correlations



Knowledge exchange
A. Garnsworthy (TRIUMF) - R. Lica (CERN, IFIN-HH)

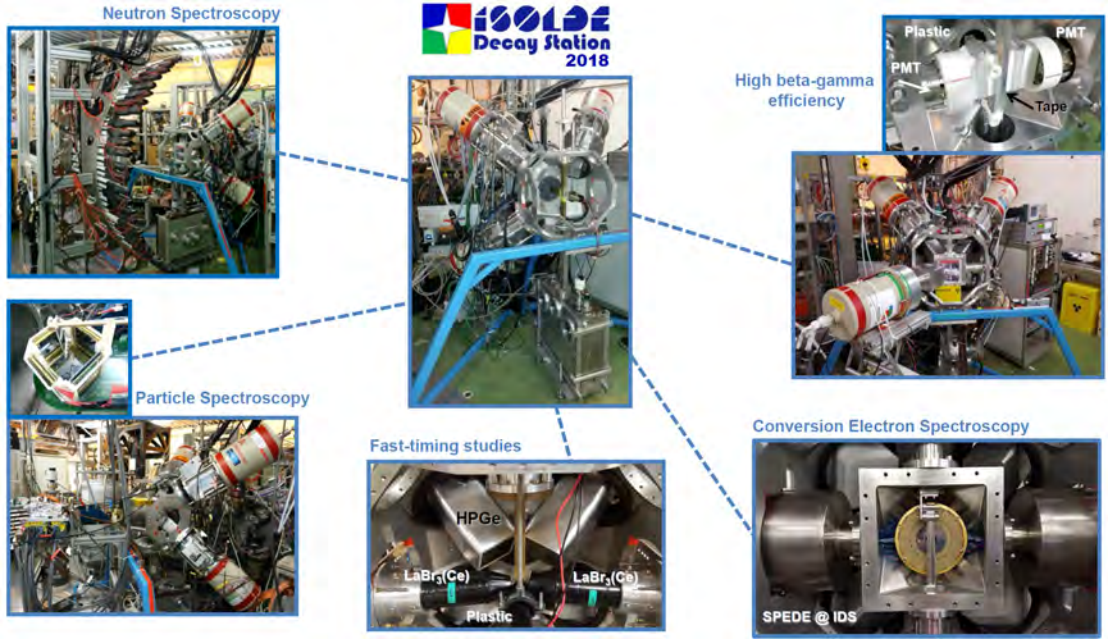
ISOLDE at CERN

Operates
~8 months/year, 24/7

ISOLDE takes ~50% of CERN protons

- 1967 – coupled at the 600 MeV Proton Synchro-Cyclotron
- 1980 – first post-accelerated RIB
- 1992 – moved at the 1.4 GeV Proton Synctrotron Booster

ISOLDE Decay Station 2018



IDS is a permanent detector set-up at the ISOLDE facility at CERN, dedicated to decay spectroscopy for research into nuclear structure, nuclear engineering and astrophysics.

- Belgium (KU Leuven)
- Denmark (Aarhus University, Department of Physics and Astronomy)
- Finland (University of Jyväskylä)
- Germany (Institut für Kernphysik - Universität zu Köln)
- Italy (Università degli Studi e INFN Milano)
- Poland (Faculty of Physics, University of Warsaw)
- Romania (IFIN-HH Bucharest)
- South Africa (iThemba LABS)
- Spain (IEM-CSIC Madrid; IFIC-CSIC Valencia; UCM Madrid)
- Sweden (Lund University)
- Switzerland (CERN - ISOLDE)
- UK (STFC Daresbury Laboratory; University of Liverpool; University of York; University of Surrey)
- USA (University of Tennessee)

IDS is supported by 18 institutes across the world, and used by many more globally.

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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Letter of Intent to the ISOLDE and Neutron Time-of-Flight Committee

Development of neutron-rich Tb beams for a systematic study approaching the doubly mid-shell in Rare-Earth nuclei

May 13, 2020

B. Olaizola[1], A. Illana[2,3], B. Andel[4], A.N. Andreyev[5], R. Bark[6], J. Benito[7], N. Bernier[6], M.J.G. Borge[8], J.A. Briz[8], T.D. Bucher[6], T.E. Cocolios[4], H. De Witte[4], J. Díaz Ovejas[8], L.M. Fraile[7], H.O.U. Fynbo[9], T. Grahn[2,3], P.T. Greenlees[2,3], L.J. Harkness-Brennan[10], M. Huyse[4], S. Ilieva [11], J. Jolie[12], P. Jones[6], D.S. Judson[10], R. Kern[11], U. Koester[13], A. Korgul[14], T. Kröll[11], J. Kurcewicz[12] I. Lazarus[16], R. Lică[17], M. Madurga[18], N. Marginean[17], R. Marginean[17], K. Miernik[14], C. Mihai[17], M. Mougeot[12], J.R. Murias[7], E. Nácher[19], A. Negret[17], C.R. Nita[17], J. Ojala[2,3], N. Orce[6],R.D. Page[10], J. Pakarinen[2,3], T. Parry[20],S. Pascu[17], A. Perea[8], N. Pietralla[11], Zs. Podolyák[20], M. Piersa[14], V. Pucknell[16], P. Rahkila[2], P.H. Regan[20], J. de la Riva[7], F. Rotaru[17], S. Rothe[12], B. Rubio[19], C. Sotty[17], M. Stryjczyk[4], O. Tengblad[8], V. Vedia[1], S. Viñals[8], R. Wadsworth[5], V. Werner[11], P. Van Duppen[4], N. Warr[12], S. Wilkins[15] and
(IDS + ISOLTRAP Collaboration)

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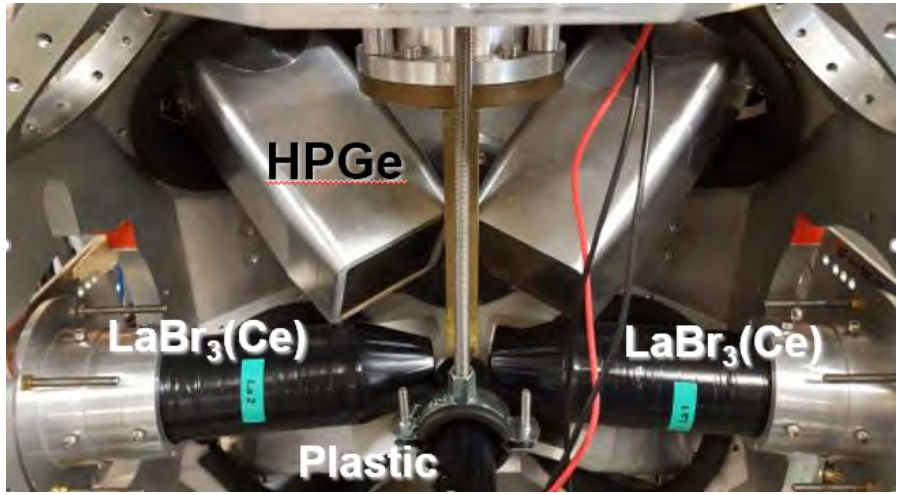
[2] *University of Jyvaskyla, Department of Physics, University of Jyväskylä, Jyväskylä, Finland.*
[3] *Helsinki Institute of Physics, Helsinki, Finland.*
[4] *KU Leuven, Instituut voor Kern- en Stralingsfysica, Leuven, Belgium*
[5] *University of York, Dept Phys, York, UK.*
[6] *iThemba LABS, Cape Town, South Africa.*
[7] *Universidad Complutense, Grupo de Física Nuclear and IPARCOS, CEI Moncloa, Madrid, Spain.*
[8] *Instituto de Estructura de la Materia, CSIC, Madrid, Spain.*
[9] *Department of Physics and Astronomy, Aarhus University, Aarhus C, Denmark.*
[10] *Department of Physics, Oliver Lodge Laboratory, University of Liverpool, Liverpool, UK.*
[11] *Technische Universität Darmstadt, Darmstadt, Germany.*
[12] *Institut für Kernphysik, Universität zu Köln, Köln, Germany.*
[13] *Laboratoire de Physique Subatomique et de Cosmologie Grenoble, Grenoble Cedex, France.*
[14] *Faculty of Physics, University of Warsaw, Warszawa, Poland.*
[15] *ISOLDE, CERN, Switzerland.*
[16] *STFC Daresbury, Daresbury, United Kingdom.*
[17] *"Horia Hulubei" National Institute of Physics and Nuclear Engineering, Bucharest, Romania.*
[18] *University of Tennessee, Knoxville, Tennessee, USA.*
[19] *Instituto de Física Corpuscular, CSIC and Universidad de Valencia, Paterna, Spain.*
[20] *University of Surrey, Surrey, UK.*

CERN-INTC-2020-038 / INTC-I-217
13/05/2020

Development of neutron-rich Tb beams for a systematic study approaching the doubly mid-shell in rare-earth nuclei.

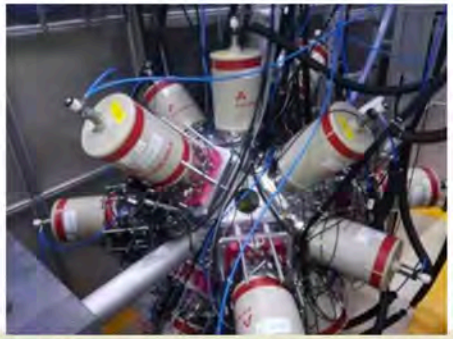
- The goal of the proposal is to study the lifetimes of the first 2+ states in even-A Dy isotopes and particularly in ^{170}Dy (Z=66, N=104) using the beta-decay fast timing method.
- The experiment will use, for yield measurements, the **ISOLDE Decay Station** and a setup including the tape station, plastic scintillator, 4 clovers and 2 LaBr3(Ce) detectors
- An additional 3 shifts were approved in order to determine the yields of the most neutron-rich Tb nuclei using the ISOLDE MR-TOF MS.



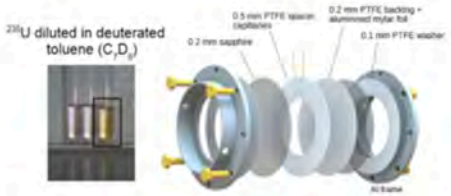
Common experiments at the ILL Reactor in Grenoble

FIPPS + IFIN-HH campaign at ILL

Pencil-like intense thermal neutron beam



16 HPGe clovers high resolution and efficiency γ detector array



- spectroscopy of n-rich nuclei after fission of ^{235}U and ^{233}U diluted in an active target
- Thermal neutron capture on ^{146}Nd
- Thermal neutron capture on ^{61}Ni
- Thermal neutron capture on radioactive ^{63}Ni target

ILL RESEARCH PROPOSAL Printed: 27/02/2020

Title: **High-precision multipole mixing ratios in 60Ni by thermal neutron capture** **3-17-53**

Proposer (to whom correspondence will be addressed)

Name and first name	Address	Phone	Email
Adam GARNSWORTHY	**TRIUMF, VANCOUVER** 4004 Wesbrook Mall V6T 2A3 VANCOUVER CANADA	+16042227450 New neutron user: **Yes** New ILL user: **Yes** Local contact contacted: **Yes**	garns@triumf.ca

Co-proposers

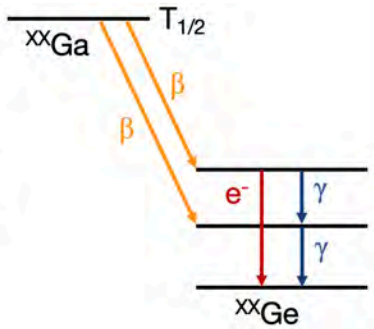
Name and first name	Laboratory	Country
MARGINEAN Nicolae	**IFIN-HH, BUCHAREST**	ROMANIA
MIHAI Constantin	**IFIN-HH, BUCHAREST**	ROMANIA
TURTURICA Andrei	**IFIN-HH, BUCHAREST**	ROMANIA
STAN Lucian	**IFIN-HH, BUCHAREST**	ROMANIA
COSTACHE Cristian	**IFIN-HH, BUCHAREST**	ROMANIA
YATES Steven	**UNIVERSITY OF KENTUCKY**	UNITED STATES
KIBEDI Tibor	**AUSTRALIAN NATIONAL UNIVERSITY ,**	AUSTRALIA
STUCHBERY Andrew	**DEPT NUCLEAR PHYSICS, ANU, CANBERRA**	AUSTRALIA
OLAIZOLA Bruno	**TRIUMF, VANCOUVER**	CANADA
VEDIA Victoria	**TRIUMF, VANCOUVER**	CANADA
UMASHANKAR Rashmi	**TRIUMF, VANCOUVER**	CANADA
LUBNA Rebeka Sultana	**TRIUMF, VANCOUVER**	CANADA
MOUKADDAM Mohamad	**UNIVERSITE DE STRASBOURG**	FRANCE

Local contact(s): **MICHELAGNOLI Caterina**

Common experiments in Canada and Romania

β-decay experiments @ TRIUMF

Radioactive ^{XX}Ga beams (10^5-10^7 pps) are delivered from ISAC facility @ TRIUMF.



GRIFFIN
(15 HPGe clovers) → γ

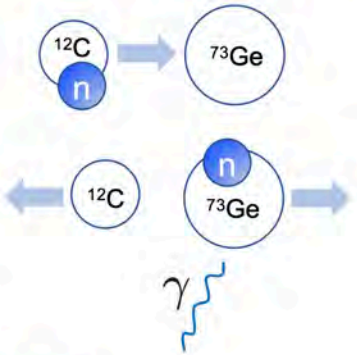
PACES
(5 cooled Si(Li)s) → e^-

Zero Degree
Scintillator → β

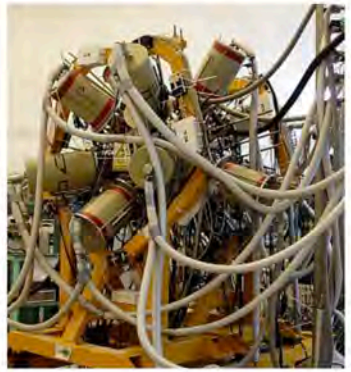
Nucleon-transfer experiments @ IFIN-HH (Romania)

- ^{72}Ge(^{18}O,^{16}O)^{74}Ge *2 neutrons transfer*
- ^{73}Ge(^{13}C,^{12}C)^{74}Ge *1 neutron transfer*
- ^{75}As(^{11}B,^{12}C)^{74}Ge *1 proton pickup*

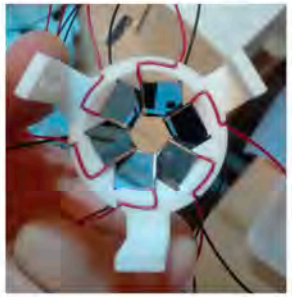
(beam intensity 10^{11} pps)



ROSPHERE
(25 HPGe crystals) → γ

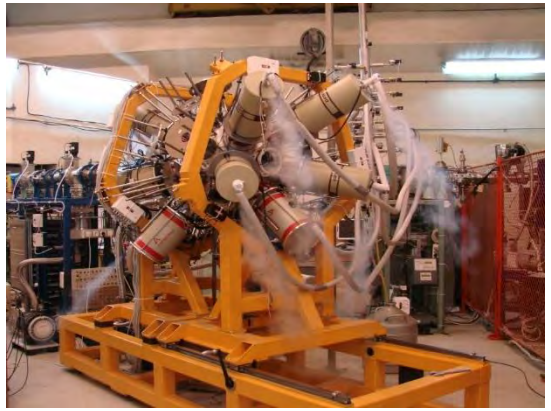


6 Si cells → charged particles



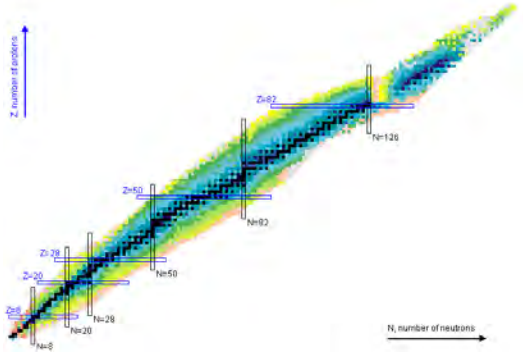
Nuclear Structure evaluation in collaboration with McMaster University

How do we get from **experiments**…



EVALUATION

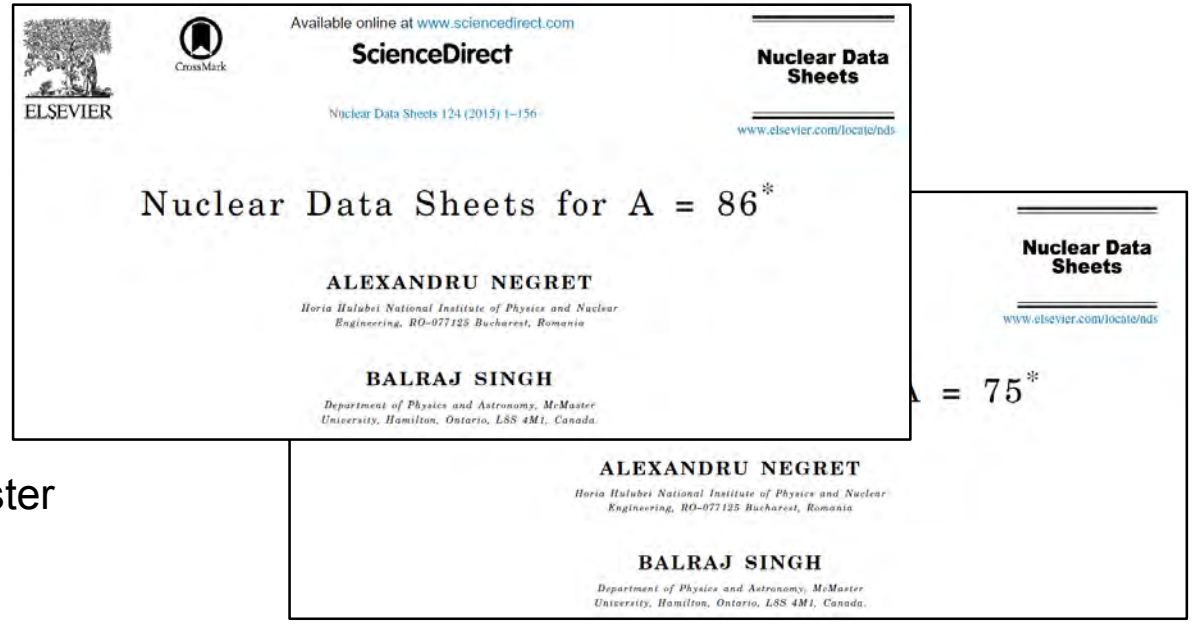
… to nuclear **databases**…



… that are used in **applications**?

Collaboration IFIN-HH - McMaster University:

- ENSDF evaluations: A=57, 75, 86, 130, etc.
- Common articles
- Participation to common IAEA projects
- Scientific visits of A. Negret and S. Pascu (IFIN-HH) to McMaster
- Scientific visit of B. Singh (McMaster) to Magurele



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Nuclear Data Sheets 124 (2015) 1–156

Nuclear Data Sheets

www.elsevier.com/locate/nds

Nuclear Data Sheets for A = 86*

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Department of Physics and Astronomy, McMaster University, Hamilton, Ontario, L8S 4M1, Canada

Nuclear Data Sheets

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A = 75*

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Horia Hulubei National Institute of Physics and Nuclear Engineering, RO-077125 Bucharest, Romania

BALRAJ SINGH

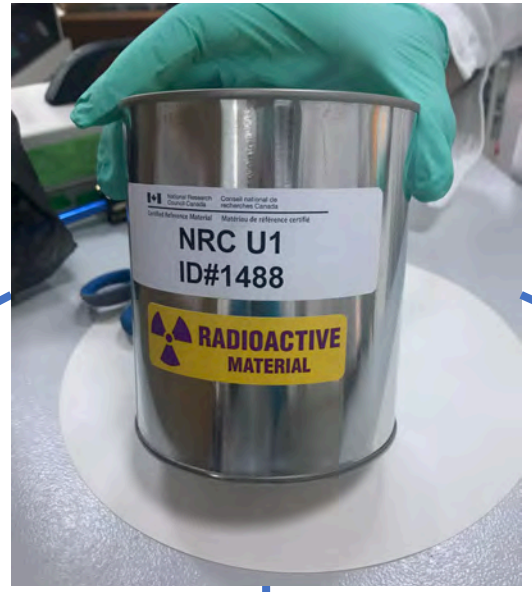
Department of Physics and Astronomy, McMaster University, Hamilton, Ontario, L8S 4M1, Canada

Collaborative Study for Certification of Trace Elements in Uranium Ore Concentrate CRMs

National Research Council
Canada

Horia Hulubei
National Institute of Physics and
Nuclear Engineering

Collaborative Study for Certification of Trace Elements in Uranium Ore Concentrate CRMs



WHAT?

Certification campaign for **3 New Uranium Ore Concentrate (UOC) Certified Reference Materials (CRMs)** from the NRC-MSS
National Research Council Canada, Measurement Science and Standards Research Centre

HOW?

3 materials of different geological origin were sent to **15 participating laboratories** from **10 countries** to analyze fingerprints such as

- **trace element impurities** (64 elements) and
- **isotope ratios** for U, Sr, Pb and Nd.

WHY?

The CRMs will be available for the specialized Laboratories performing analysis on Uranium Ore Concentrates, applicable in:

- Material Characterization for Safeguards

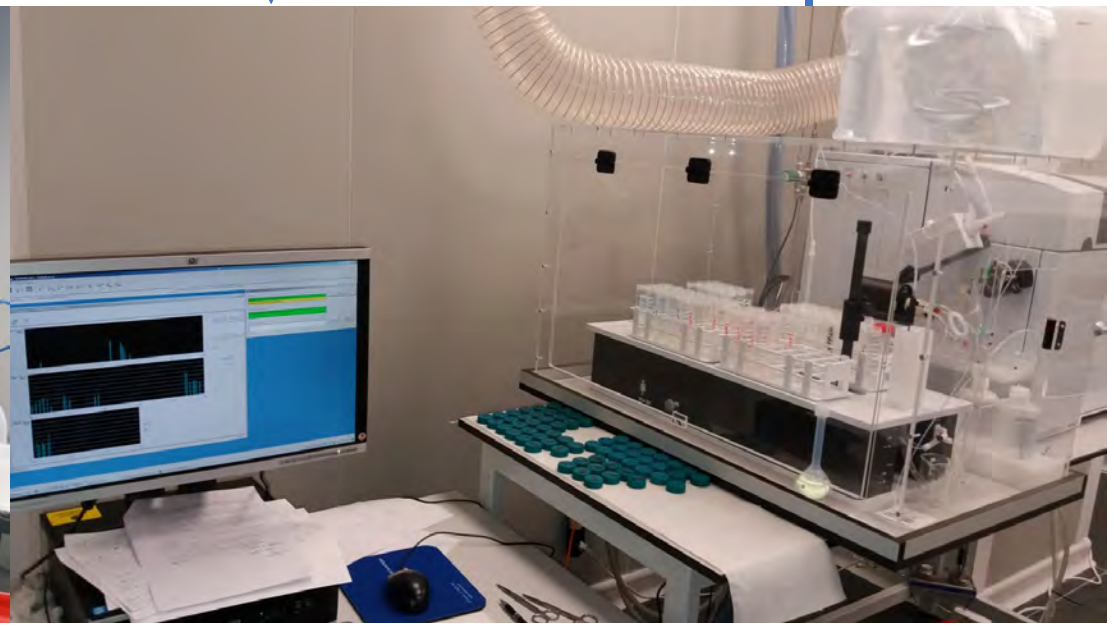
- Nuclear Forensic investigations

- Laboratory intercomparison

Collaborative Study for Certification of Trace Elements in Uranium Ore Concentrate CRMs

1. Collect the material

2. Apply a dedicated chemical protocol



3. Analyze through **ICP-MS**
Inductively Coupled Plasma Mass Spectrometry

4. Data analysis

Olympus Reloaded

Regional Exercise on Nuclear Forensics Support to Investigations
Bucharest, Romania| 7-9 November, 2017

GICNT | GLOBAL INITIATIVE TO COMBAT NUCLEAR TERRORISM

GUVERNUL ROMÂNIEI

Event Objectives

Coordination & Collaboration: Examine common challenges and best practices for national level coordination and mechanisms for international information exchange of nuclear forensic information in support of law enforcement investigations into criminal and terrorist acts involving RN material.

Technical Reachback: Examine common challenges to technical reachback support for an investigation and best practices for interagency coordination of reachback capabilities.

Chain of Custody: Examine best practices for chain of custody procedures in support of a law enforcement investigation into a nuclear security incident.

Legal Frameworks: Promote an understanding of participating nation's legal frameworks for supporting the investigation and prosecution of illicit acts involving RN material.

Contact Information

- Dr. Ali El-Jaby, Canadian Nuclear Safety Commission, ali.el-jaby@canada.ca
- Dr. Andrei I. Apostol, IFIN-HH, andrei.apostol@nipne.ro
- Mrs. Mihaela Stefanescu, Ministry of Foreign Affairs, mihaela.stefanescu@mae.ro

The Government of Romania (**MFA and IFIN-HH**), in cooperation with the Global Initiative to Combat Nuclear Terrorism (**Nuclear Forensics Working group chaired by Canada**), developed the "Olympus Reloaded" Regional Exercise on Nuclear Forensics Support to Investigations for law enforcement officials, legal experts, prosecutors, foreign affairs and liaison officers, technical experts in the field of nuclear forensics throughout the Black Sea region. Participants examined and discussed challenges in building a case to prosecute criminal and terrorist acts involving RN material out of regulatory control.

Participating Countries and Organizations

Albania, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Georgia, Greece, Hungary, Republic of Macedonia, Mexico, Montenegro, Republic of Moldova, Romania, Russian Federation, Serbia, Spain, United States, Ukraine, European Commission, INTERPOL, International Atomic Energy Agency, UN Office on Drugs and Crime, South East European Law Enforcement Center

Key Recommendations

1. National plans should clearly define roles and responsibilities (including the lead agency) for all involved in an investigation of a security event involving RN material.
2. Law enforcement, prosecutors, and technical experts should work together in formulating and prioritizing the right questions to advance the investigation.
3. Identifying in advance national organizations and experts that have relevant technical reachback capabilities.
4. Implement all international treaty provisions through national legislation. Implement strong legal criminalization provisions to deter and successfully prosecute illicit acts. Additional supporting legislation may also be required to set up necessary structures, define roles and responsibilities, and implement national policies and procedures.
5. Protocols, agreements, and legal frameworks should be established in advance of an RN incident to ensure timely exchange of information.
6. Communicate with foreign governments through a central authority to promote unified national/regional action.

…