EMERALD

ElectroMagnetic imaging for a novel genERation of medicAL Devices

An Innovative Framework for Advancing Microwave Medical Imaging: the EMERALD European Network

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Origin…

Everything starts from the **COST action MiMed**!

What we are

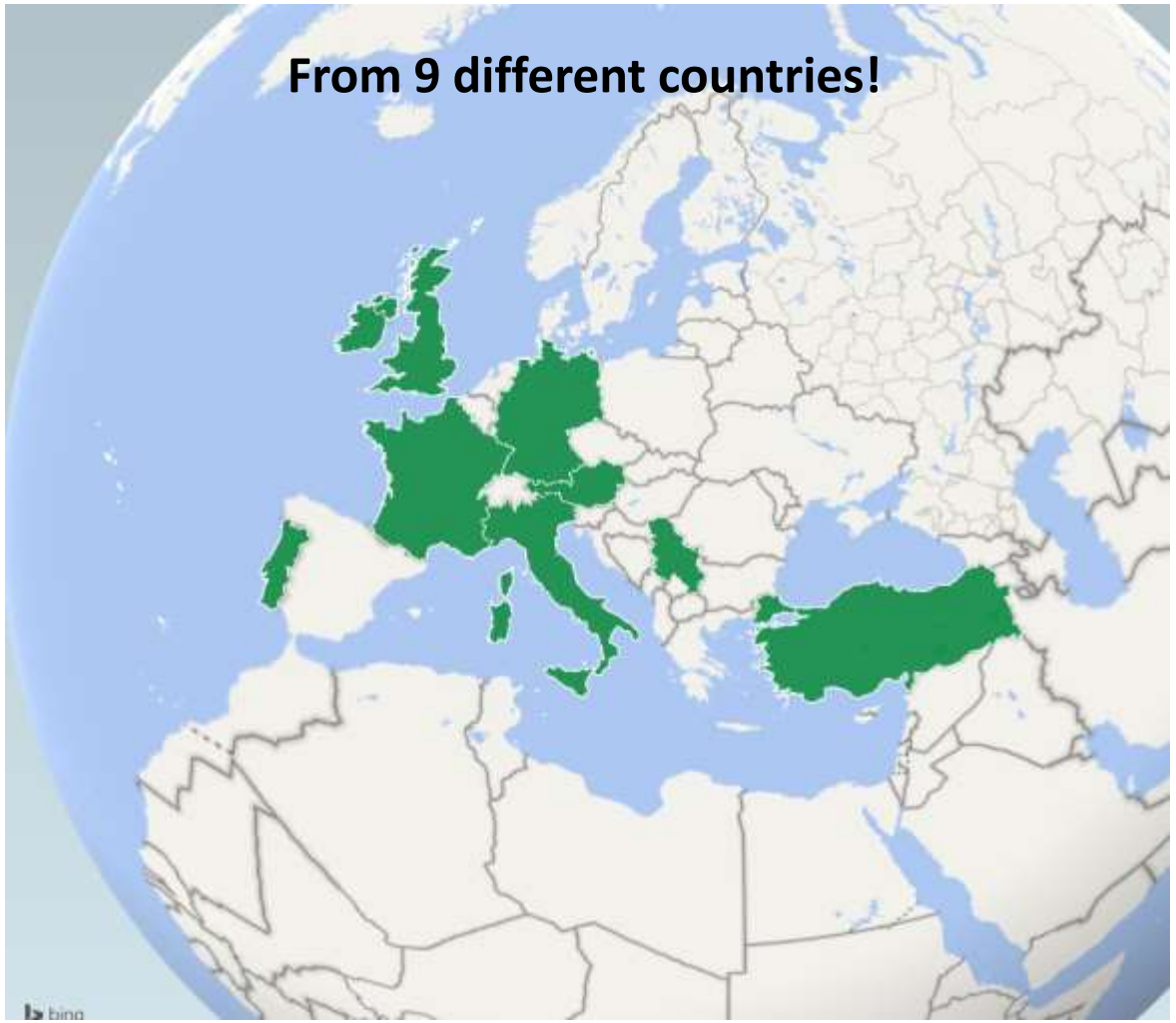
EMERALD

ElectroMagnetic imaging for a novel genERation of medicAL Devices

Coherent action of leading European **engineering** groups involved in **electromagnetic (EM) technology** for medical imaging to form a cohort of highly-skilled **researchers** capable of accelerating the translation of this technology *"from research bench to patient bedside"*

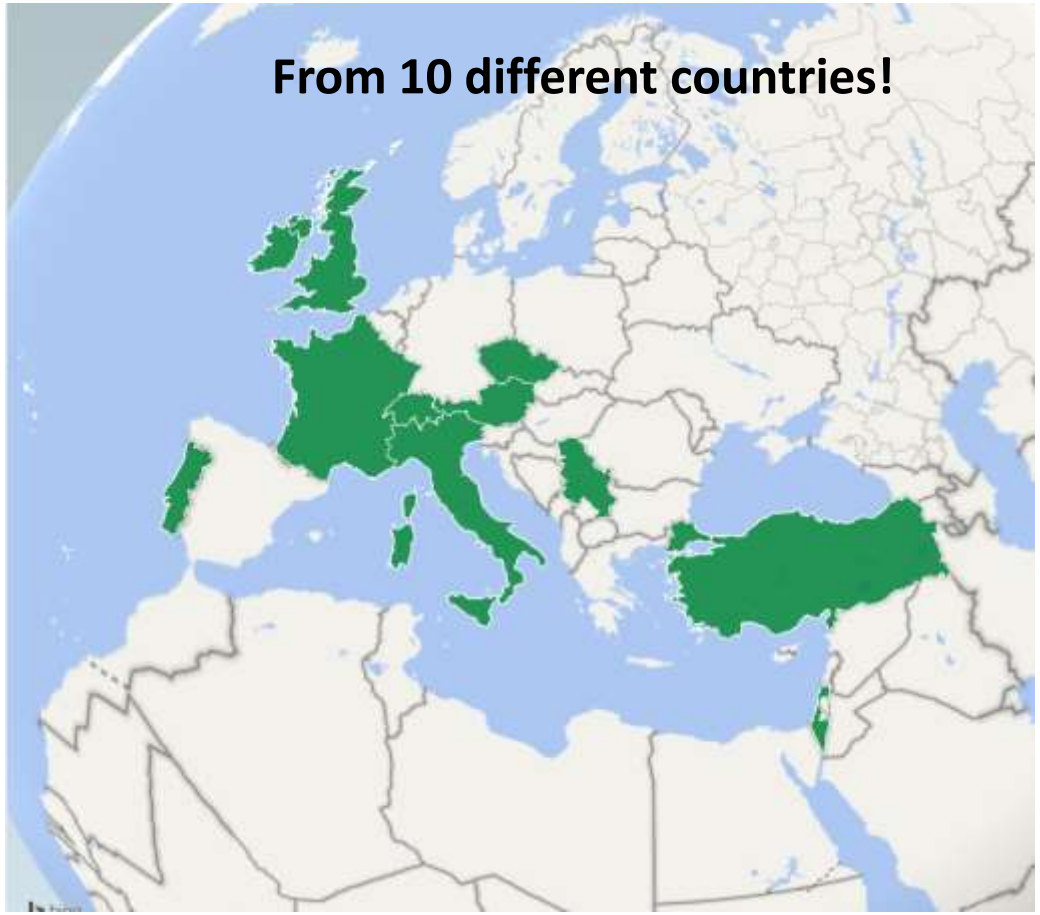
Consortium: beneficiaries

No.	Beneficiary name	Short name
1	**Politecnico di Torino**	**POLITO**
2	National Research Council of Italy	CNR-IREA
3	National University of Ireland, Galway	NUIG
4	FCIENCIAS.ID Associacao para a Investigacao e Desenvolvimento de Ciencias	FC.ID
5	Centre National de la Recherche Scientifique	CNRS-SUPELEC
6	Technische Universität Ilmenau	TUIL
7	Keysight Technologies Austria	KEYSIGHT
8	King's College London	KCL
9	WIPL-D	WIPL-D
10	Mitos Medical Technologies	MITOS



Consortium: partner organizations

No.	Partner organization	Short name
1	Czech Technical University in Prague	CTU
2	University of Belgrade	UB
3	Neurent Medical	NEU
4	Institute of Telecommunications	IT
5	Medical Wireless Sensing	MEDIWISE
6	University of Rome Sapienza	UNIROMA1
7	Italian National Agency for New Technologies, Energies and Sustainable Economic Development	ENEA
8	Istanbul Technical University	ITU
9	Johannes Kepler University Linz	JKU
10	European Association on Antennas and Propagation	EuRAAP-ESoA
11	**University Hospital Bern**	**INSEL**
12	**Hadassah Hebrew University Medical Center**	**HADUMC**
13	University of Trento	UNITN
14	**Lariboisière University Hospital, Paris 7 University**	**UP7**
15	**Luz Saúde, S.A., Sociedade Aberta Hospital da Luz**	**LUZ**
16	Faculdade de Ciencias da Universidade de Lisboa	FCUL
17	Sorbonne Université	SU



+ Czech Republic, Switzerland, Israel

Early Stage Researchers (ESRs)

- **All the 13 ESRs** have been recruited
- Starting contract date:
  September 2018 – February 2019
- **From 10 different countries in 3 continents!**

General Objectives (GO)

GO1. **To accelerate translation of research of EM medical imaging into clinical prototypes** by advancing the technology, standardizing procedures and developing prototypes for novel applications.

GO2. To set-up and support **the first complete scientific and training programme in EM medical imaging** at a European Level (and possibly worldwide).

GO3. To provide the Early Stage Researchers (ESRs) with **excellent, multi-disciplinary scientific training** and a set of competitive, transferable skills.

GO4. To expose the ESRs to **academic and non-academic sectors**, improving their future career perspectives.

Scientific Objectives (SO)

SO1. To develop **standardized phantoms** for laboratory assessment of EM medical imaging devices based on accurate knowledge of **EM properties of human tissues** (WP1).

SO2. To develop **new components and core elements** for enhanced performance EM imaging systems (WP2).

SO3. To develop ad-hoc **full-wave modelling tools** and **image formation hardware accelerated procedures**, tailored for specific applications/devices (WP2 and WP3).

SO4. To develop and assess **prototype devices** for new applications of EM imaging **in medical diagnosis** (WP4).

SO5. To develop and assess **prototype devices** for new applications of EM imaging for **clinical follow-up and image guided treatment** (WP5).

SO1: ESR1 (CNRS-SUPELEC & SU)

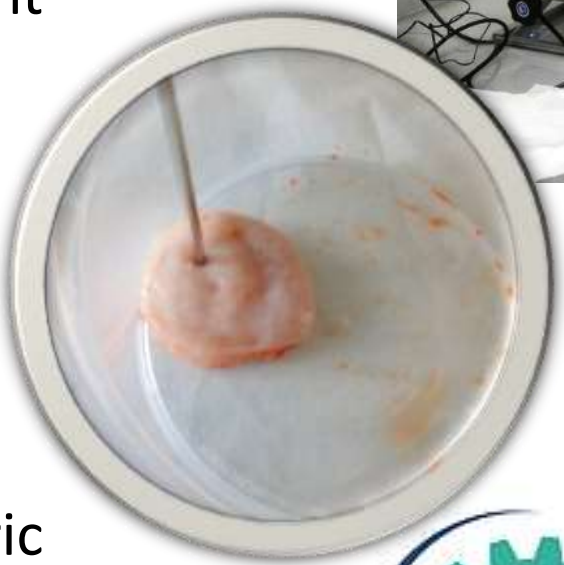
- ✓ Design and production of anthropomorphic standardized phantoms via 3-D printed technology
- ✓ Development, production and dielectric characterization of liquid mixtures that mimic human tissues
- ✓ Using anthropomorphic phantoms STL format files for 3-D EM simulations
- ✓ Using 3-D printed anthropomorphic phantoms to assess the developed EM prototype devices

GeePs-L2S breast phantom

JPS
Jean Paul Sartre head phantom

Thursday, April 4, CS33, h9:00
«*Phantoms for a Novel Generation of Medical Microwave Imaging Devices*»

SO1: ESR2 (NUIG)



- ✓ Accurate knowledge about dielectric properties of tissues and their interactions with EM wave at different volume scales
- ✓ How accurate and adequate are tissue dielectric properties values currently reported in literature
- ✓ Define and optimize the measurement protocol for complex tissues
- ✓ Development of an open-access repository of dielectric properties of human tissue
- ✓ Using this repository as a platform for novel EM-based imaging and therapeutic applications

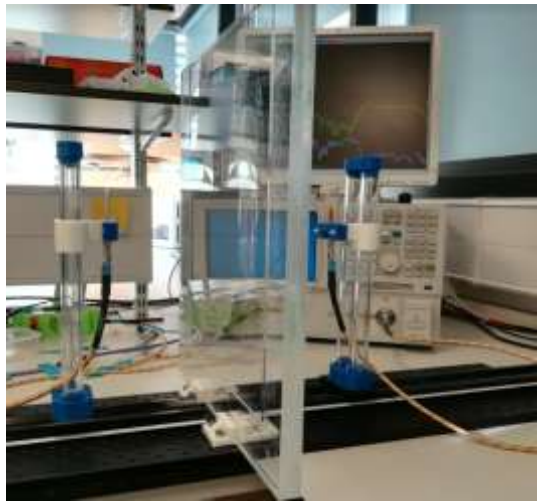
Thursday, April 4, CS33, h9:40
«*Early-stage Dielectric Characterization of Renal Cell Carcinoma for Positive Surgical Margin Detection*»

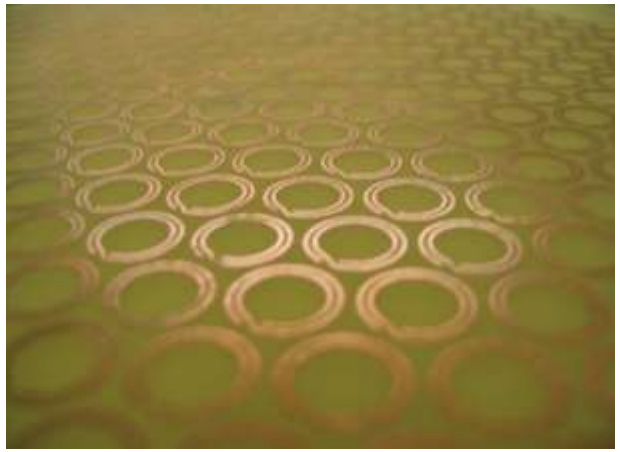
SO2: ESR4 (KEYSIGHT & JKU)

- ✓ Development of a pre-commercial digital network analyzer, including software application specific interfaces and hardware adaptations.
- ✓ The size of the new hardware developed will be very small to facilitate its integration including many antennas and microwave switching matrices.
- ✓ The developed novel measurement platform will be evaluated in terms of speed of measurement, dynamic range, sensitivity and noise level.

Thursday, April 4, CS33, h11:30
«*S-parameter Calibration Procedure for Multiport Microwave Imaging Systems*»

SO2: ESR5 (KCL)



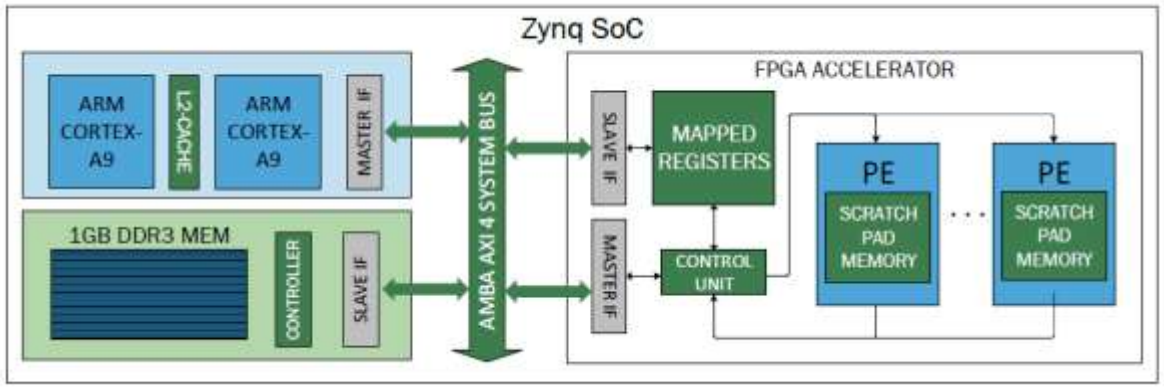


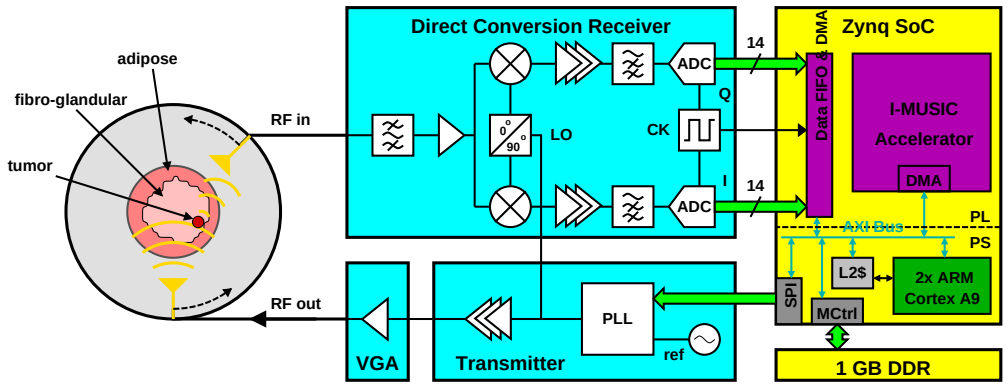
- ✓ Miniaturized EM antennas using smart materials will be studied, designed and realized.
- ✓ The antenna meta-surface will be designed to enhance the EM penetration into the human body.
- ✓ Development of meta-material as “matching medium”

Thursday, April 4, CS33, h10:00
«*Advances Towards the Development of a Brain Microwave Imaging Scanner*»

SO3: ESR3 (POLITO)

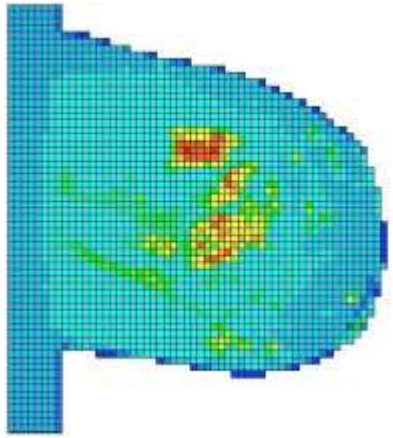
- ✓ Real time performance of the EM imaging algorithms via hardware implementation
- ✓ Identify a comprehensive set of computational kernels in microwave imaging algorithms
- ✓ These kernels will be implemented in a high-level programming language to create a benchmark implementation.
- ✓ The best hardware platforms will be selected to accelerate the execution of these kernels under various constraints.





Thursday, April 4, CS33, h9:20
«*Development of an EM Device for Cerebrovascular Diseases Imaging and Hardware Acceleration for Imaging Algorithms Within the EMERALD Network*»

SO3: ESR6 (WIPL-D & UB)

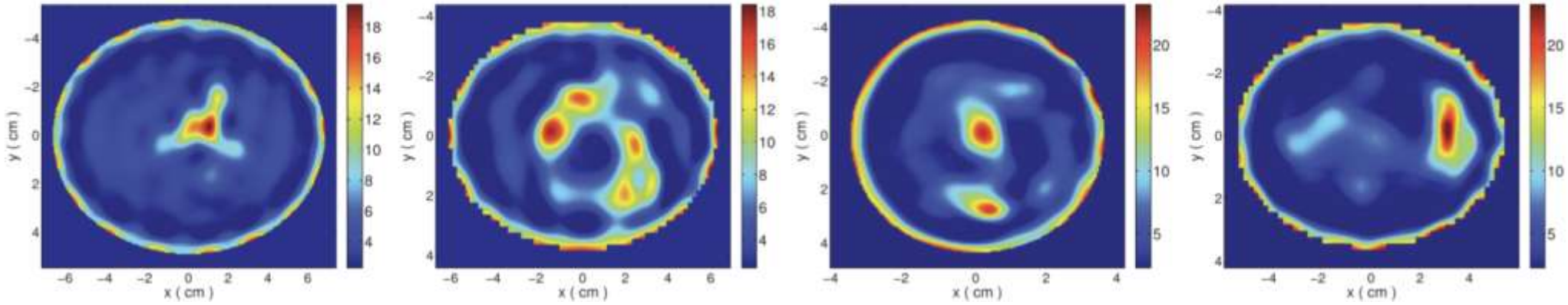


- ✓ Ad-hoc full-wave tools for the numerical modelling of the whole EM device
- ✓ Selection of the best hardware platform to accelerate the execution of these computational kernels
- ✓ Creation of canonical antenna models for 3-D EM simulation of medical imaging scenario
- ✓ Collecting data related to phantoms and creation of canonical phantoms
- ✓ Development of controllable homogenization and re-meshing techniques

Thursday, April 4, CS33, h10:50
«*Survey and Classification of Antennas for Medical Applications*»

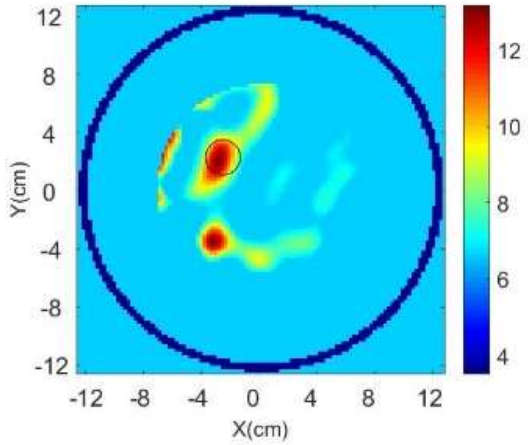
SO3: ESR7 (KCL)

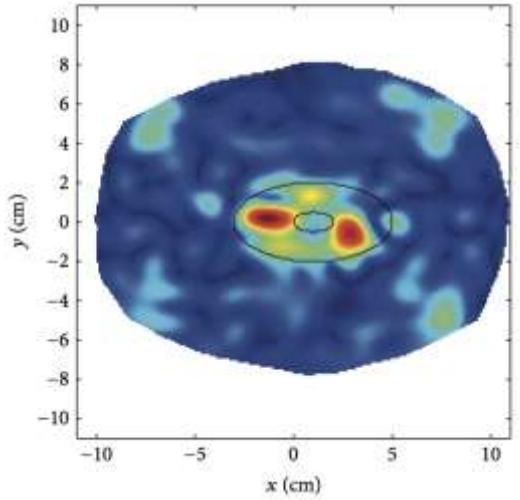
- ✓ Image formation algorithm implementation and testing for medical diagnosis
- ✓ In-house microwave imaging algorithms: distorted Born iterative method (DBIM), two-step iterative shrinkage/thresholding method (TwIST) and radar-based techniques
- ✓ Ad-hoc tailored algorithms
- ✓ To properly support the clinician's decisions



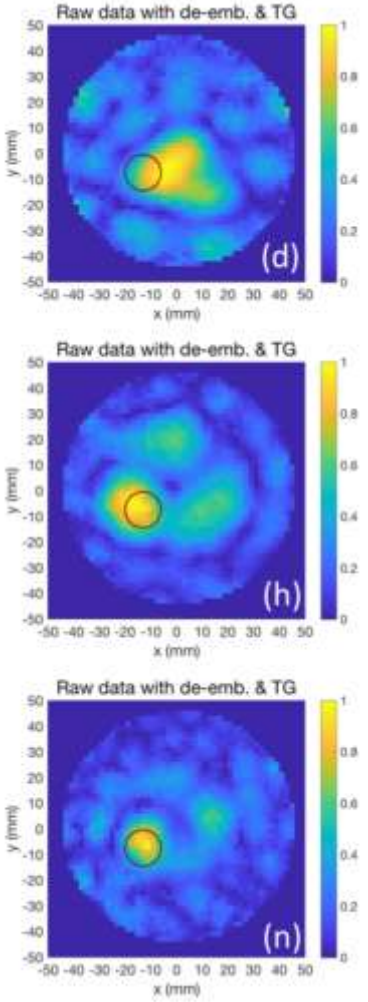
Thursday, April 4, CS33, h10:00
«*Advances Towards the Development of a Brain Microwave Imaging Scanner*»

SO3: ESR8 (CNR-IREA & UNITN)



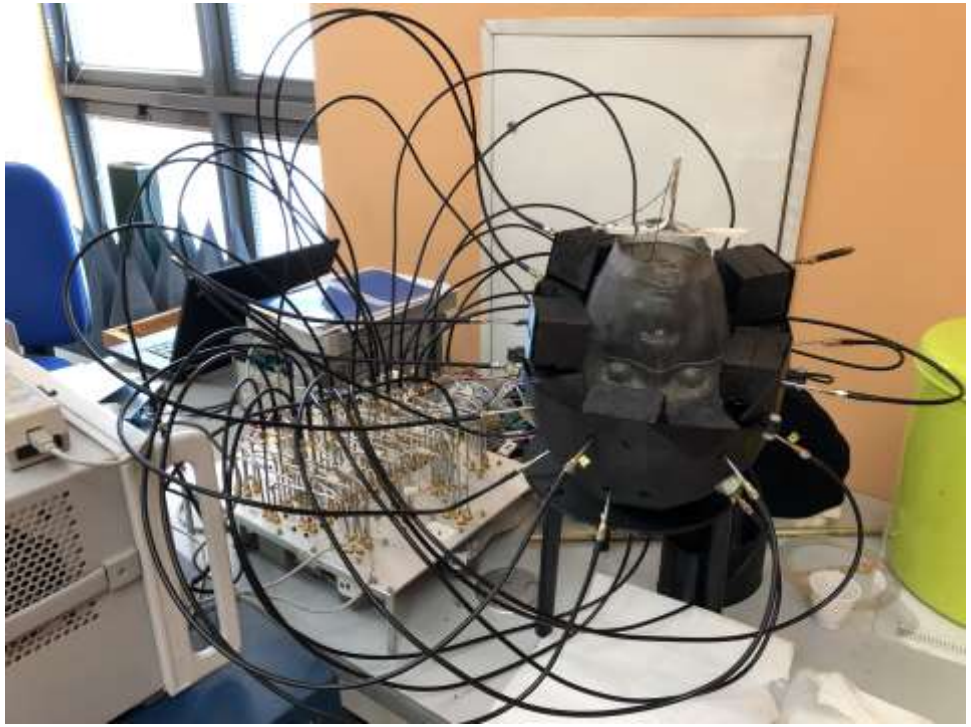


- ✓ Development and testing of ad-hoc microwave imaging tools tailored to the hardware systems for clinical follow-up
- ✓ Cross-validation and fusion frameworks to enable enhanced clinical information
- ✓ Developed imaging algorithms: Truncated Singular Value Decomposition (TSVD), Linear Sampling Method (LSM), …
- ✓ Expertise on Compressive Sensing and Machine Learning



Thursday, April 4, CS33, h11:10
«*Innovative Imaging Tools and Devices for Clinical Monitoring within the EMERALD Network*»

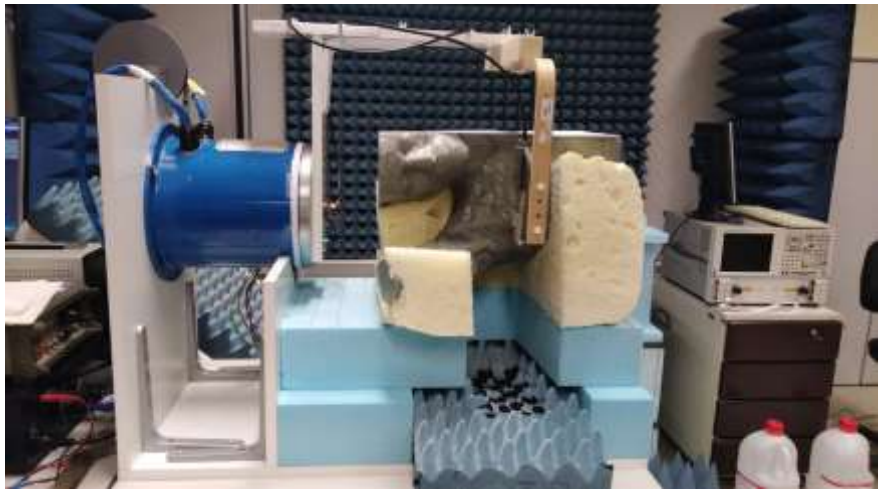
SO4: ESR9 (POLITO)



- ✓ Cerebrovascular diseases represent one of the major clinical challenges nowadays
- ✓ Better management of traumatic events, such as hematoma
- ✓ Realization of a non-invasive, safe, portable and cost-efficient microwave device able to image the features of the affected brain tissues

Thursday, April 4, CS33, h9:20
«*Development of an EM Device for Cerebrovascular Diseases Imaging and Hardware Acceleration for Imaging Algorithms Within the EMERALD Network*»

SO4: ESR10 (FC.ID & FCUL)



Institute of Telecommunications
Hospital da Luz

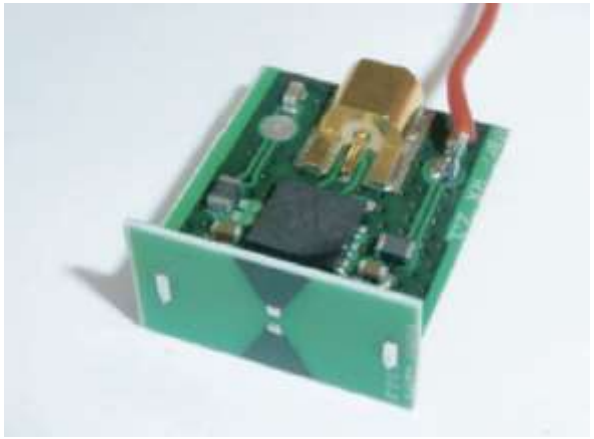
- ✓ To support the early stage diagnosis of breast cancer and limit surgical procedures
- ✓ First EM device for the diagnosis of axillary lymph nodes
- ✓ Development of computational models of axillary lymph nodes
- ✓ Development of physical realistic anthropomorphic phantoms of axillary lymph nodes
- ✓ Review of the dielectric properties of healthy and malignant lymph nodes

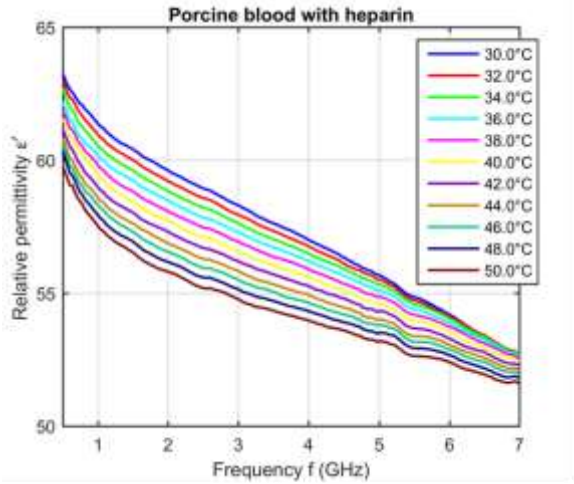
SO5: ESR11 (MITOS & ITU)

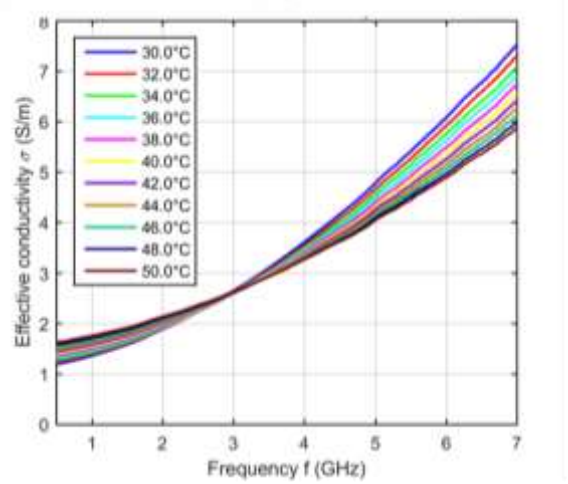
- ✓ Clinical follow-up treatment
- ✓ Information not available with current techniques
- ✓ Monitoring of the regression of the tumor in the clinical follow-up of breast cancer chemotherapy/radiotherapy, without resorting to X-Rays
- ✓ Design and realization of a prototypal device for periodical monitoring of breast cancer patients under chemotherapy treatment
- ✓ The device will rely on novel differential imaging algorithms

SO5: ESR12 (TUIL)

- ✓ Development of a prototype for non-invasive tissue temperature monitoring inside the human body during hyperthermia treatment based on UWB radar
- ✓ Implementation and test of robust and real-time capable algorithms for tissue temperature imaging
- ✓ Design and realization of UWB sensors for co-existence with high power microwave heating applicators

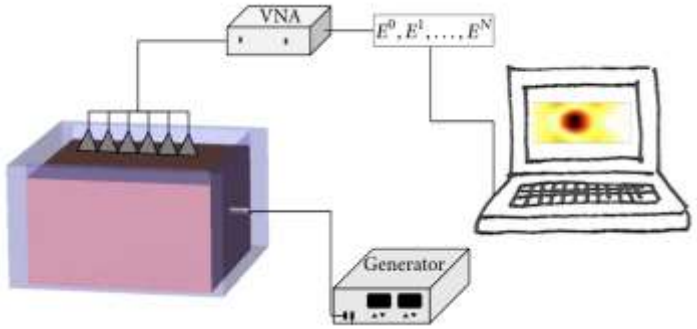


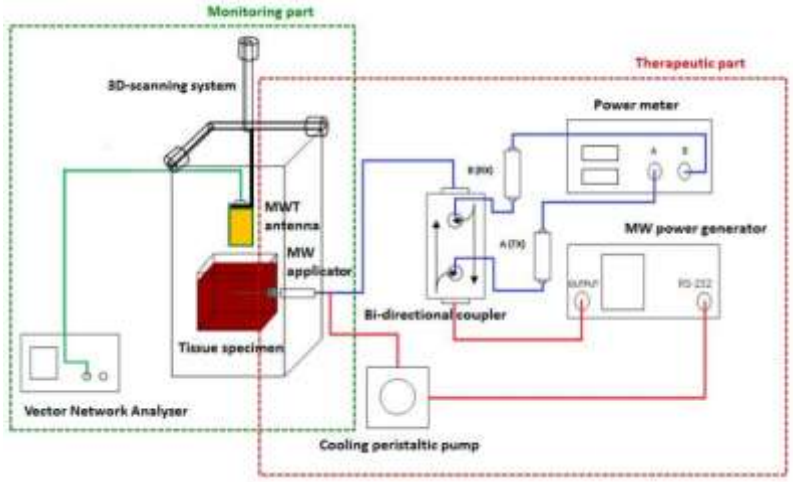




Thursday, April 4, CS33, h11:50
«*Numerical Study of Differential Temperature Measurement in Human Muscle Tissue Using UWB Radar*»

SO5: ESR13 (CNR-IREA & UniRoma1)

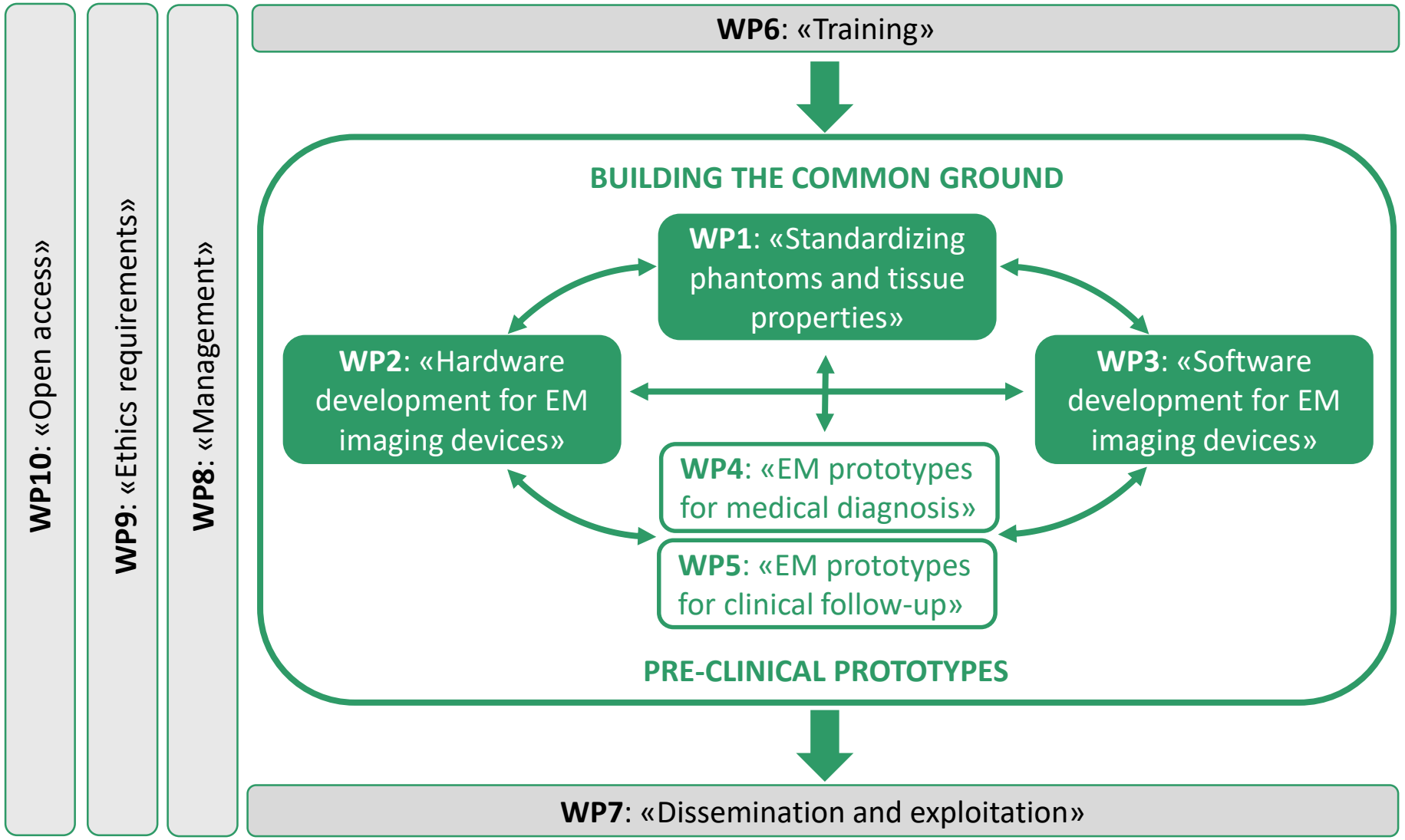




- ✓ Image-guided treatment: monitoring of an invasive tumor ablation process
- ✓ Development of a non-invasive system for the real-time monitoring of the evolving dimension and shape of the thermally ablated area.
- ✓ Advantage from the dependence of the electromagnetic properties of biological tissues from temperature.
- ✓ Development of tailored imaging algorithms

Thursday, April 4, CS33, h11:10
«*Innovative Imaging Tools and Devices for Clinical Monitoring Within the EMERALD Network*»

WP Structure



Task Breakdown

BUILDING THE COMMON GROUND

WP1: **Standardizing phantoms and tissue properties (Leader 3 NUIG)**
Task 1.1: Standard phantoms for EM device testing — **CNRS-SUPELEC** ESR1
Task 1.2: Characterization of the tissue dielectric properties — **NUIG** ESR2

WP2: **Hardware developments for EM medical devices (Leader 7 KEYSIGHT)**
Task 2.1: Hardware acceleration for imaging algorithms — **POLITO** ESR3
Task 2.2: Development of customized radiofrequency front-end systems — **KEYSIGHT** ESR4
Task 2.3 Metamaterial technology for improved EM medical devices — **KCL** ESR5

WP3: **Software developments for EM medical devices (Leader 2 CNR-IREA)**
Task 3.1: Full wave modeling for EM medical devices — **WIPL-D** ESR6
Task 3.2: Imaging algorithms for medical diagnosis devices — **KCL** ESR7
Task 3.3: Imaging algorithms for clinical follow-up devices — **CNR-IREA** ESR8

WP4: **EM prototypes for medical diagnosis (Leader 1 POLITO)**
Task 4.1: EM device for cerebrovascular diseases imaging — **POLITO** ESR9
Task 4.2: EM device for axillary lymph node diagnosis — **FC.ID** ESR10

WP5: **EM prototypes for clinical follow-up (Leader 6 TUIL)**
Task 5.1: EM device for chemotherapy monitoring — **MITOS** ESR11
Task 5.2: EM device for hyperthermia treatment monitoring — **TUIL** ESR12
Task 5.3: EM device for imaged guided microwave ablation — **CNR-IREA** ESR13

PRE-CLINICAL PROTOTYPES

Training

- ✓ Three EMERALD General Objectives (GO2-GO4).
- ✓ Based on the triangle research-education-innovation
- ✓ ESRs co- and cross-supervised by experts in from academia, industry as well as clinicians
- ✓ Significant involvement of clinical partners
- ✓ Several planned network-wide events
- ✓ Involvement of the European School of Antennas (ESoA)
- ✓ Transferrable skills' courses for ESRs
- ✓ All ESRs will be enrolled on local PhD beneficiaries' training program

Dissemination & Exploitation

- To ensure strong dissemination and exploitation activities in order to promote the main outcomes of the EMERALD action;
- To engage relevant institutional, industrial and scientific community in Europe and elsewhere in order to ensure appropriate exposure of the ESRs;
- To promote EMERALD and its results ensuring maximum visibility and highlighting the European dimension of the action;
- To raise public awareness about the action and its potential benefits to the society at large.

Ethics requirements

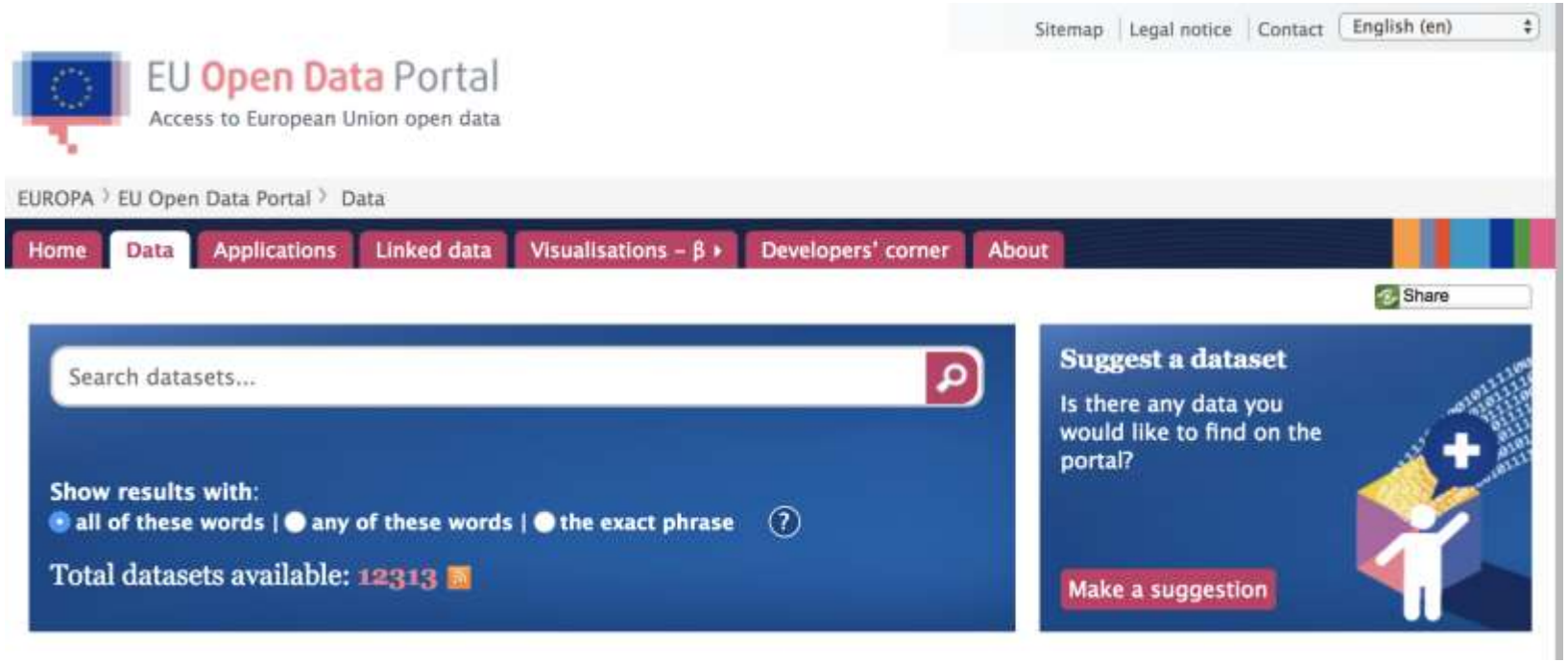
Ethics report now mandatory deliverable for all projects

Main issues:

- Human embryos and foetuses
- Human participants / patients
- Human cells/tissues
- Personal data
- Animals
- Work in non-EU countries
- Environment & Health and Safety
- Dual use
- Misuse
- Other issues (ethics & research integrity)

Open Access

- EMERALD network is engaged in Open Research Data in Horizon 2020
- Making data FAIR: Findable, Accessible, Interoperable and Re-usable



Gender balance

- ✓ An appropriate gender balance should be respected in the governing board's composition.
- ✓ Selection committees should bring together diverse expertise and competences and should have an adequate gender balance
- ✓ In the recruitment all beneficiaries guarantee equal gender opportunities for the provision of the grants

In EMERALD Consortium composition 8 over 27 (30%) Scientists-in-charge and 4 over 13 (30%) ESRs are women

Contacts

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MSCA Emerald

@mscaemerald

Thursday, April 4, 8:40 – 12:30
CS33 “Horizon 2020 research and innovation session (EMERALD): ElectroMagnetic imaging for a novel genERation of medicAL Devices”

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 764479