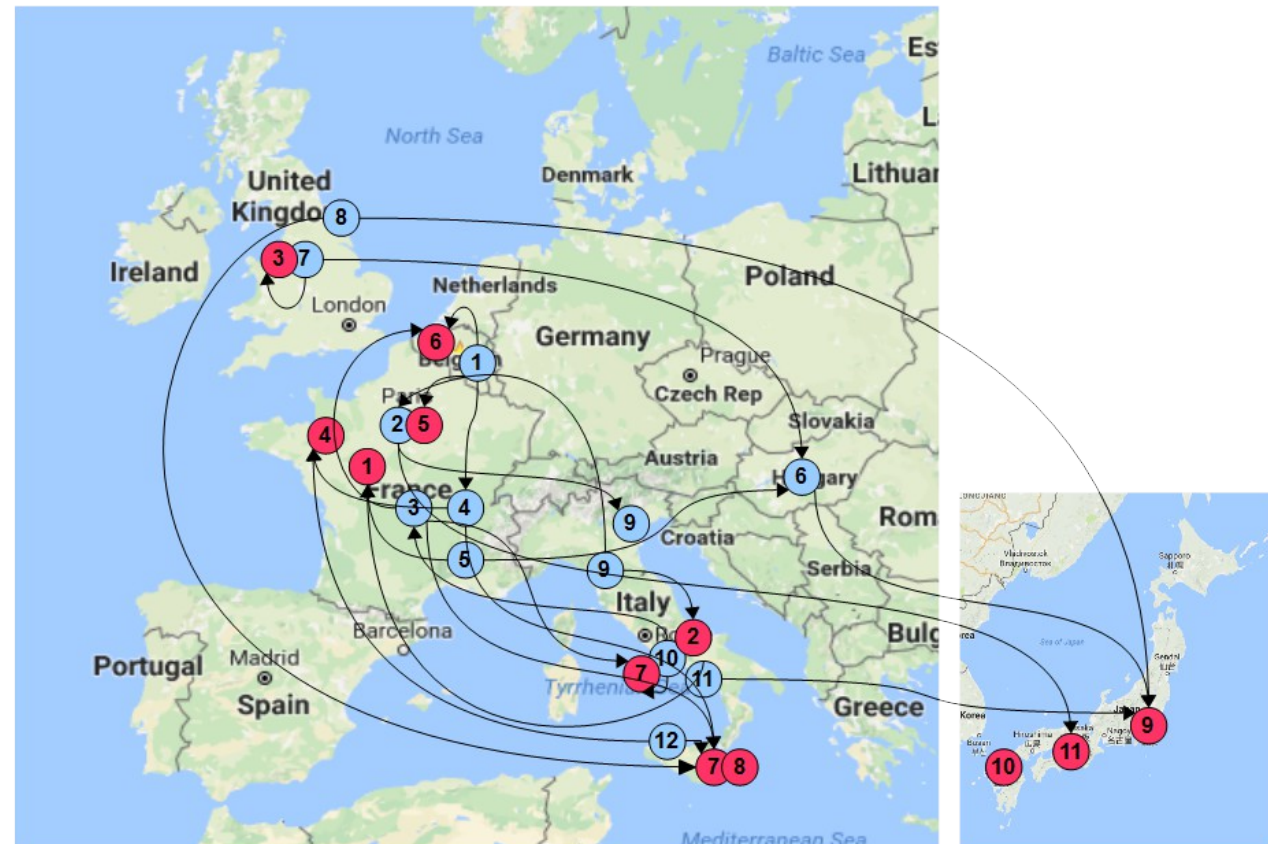# The European Muography Network
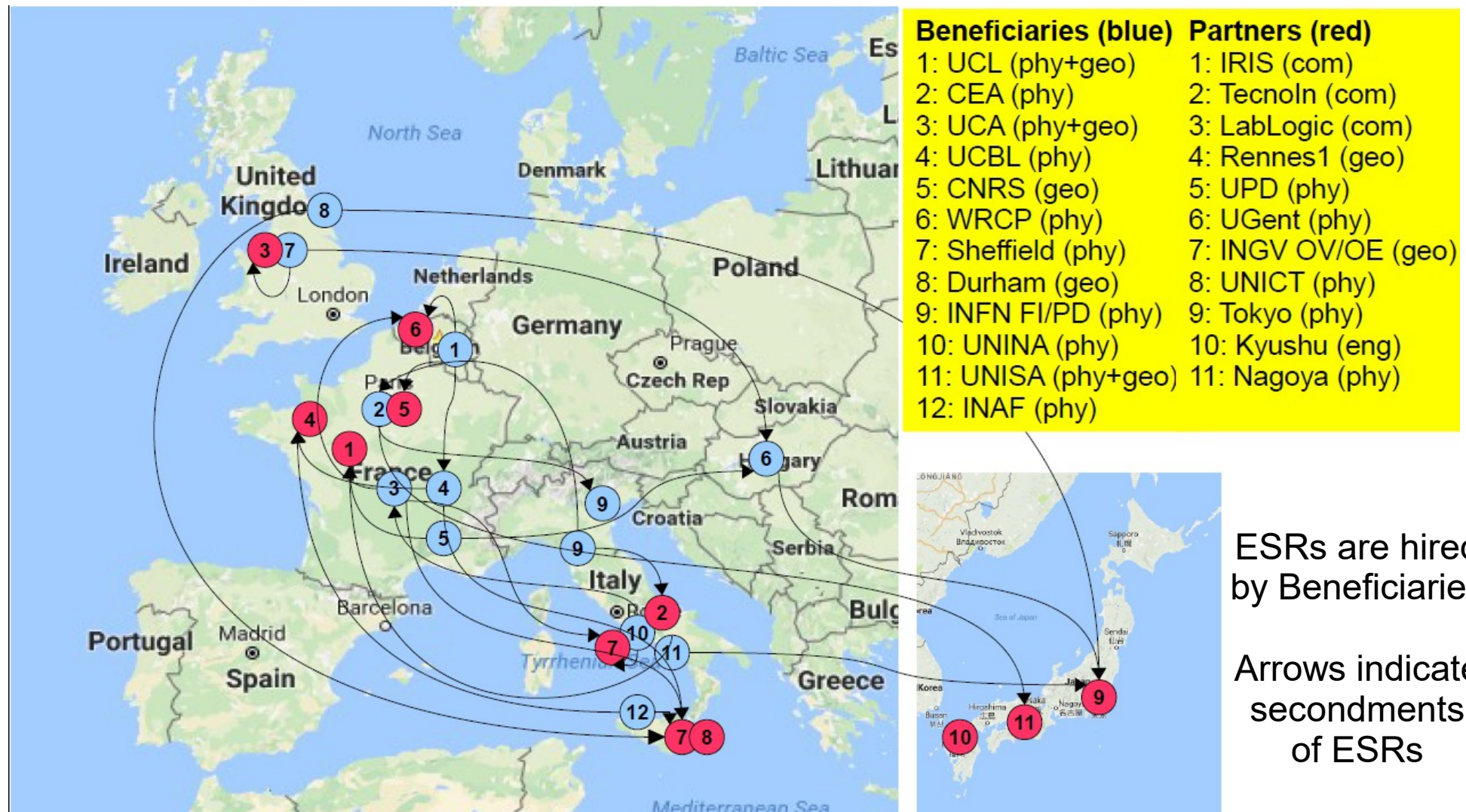

Andrea Giammanco
(UCLouvain)

Antecedents and context

- First large-scale EU-funding bid for a muography consortium in EU + Japan: G-ENDEAVOR, coordinated by Cristiano Bozza

  - INFRAIA call in 2016, meant for funding of research infrastructures, including budget for personnel (post-docs)

  - Very good score, just below the threshold for "step 2"

  - Alas, no new INFRAIA call since then

- Muographers 2016: discussion on EU funding opportunities

- I suggested that muography is intrinsically fit for a MSCA-ITN, and we could build upon the G-ENDEAVOR experience

  - General rule: if you propose extra work, you do it – so that's why consensus was that I would have led this adventure :)

  - Some familiarity with ITNs as member of AMVA4NewPhysics (became its deputy coordinator few months ago)

The spirit of an Innovative Training Network (ITN)

- Training (in a broad sense) is the key

  - Emphasis on *training through research*

    - Typical use for most of the budget is funding PhD scholarships (max 3 years)
    - Early Stage Researchers (ESRs) may not be PhD students, but must be within 4y of their diploma
    - ESRs should receive excellent training opportunities through the network

  - Emphasis on *dissemination*

    - Scholarly papers and talks, outreach to society, open data, etc...

- "Making bridges" is valued, e.g.:

  - Multidisciplinarity

  - Connection between academia and private sector

  - Creation of new shared tools

Our network

Beneficiaries (blue)   Partners (red)
1: UCL (phy+geo)   1: IRIS (com)
2: CEA (phy)   2: TecnoIn (com)
3: UCA (phy+geo)   3: LabLogic (com)
4: UCBL (phy)   4: Rennes1 (geo)
5: CNRS (geo)   5: UPD (phy)
6: WRCP (phy)   6: UGent (phy)
7: Sheffield (phy)   7: INGV OV/OE (geo)
8: Durham (geo)   8: UNICT (phy)
9: INFN FI/PD (phy)   9: Tokyo (phy)
10: UNINA (phy)   10: Kyushu (eng)
11: UNISA (phy+geo)   11: Nagoya (phy)
12: INAF (phy)

ESRs are hired
by Beneficiaries

Arrows indicate
secondments
of ESRs

4

Secondments

From the FAQs:

Q45: (ETN) - Are secondments important in ETN mode?

A: Yes. Secondments are strongly encouraged and expected. Secondments can contribute to the inter-sector experience and may also contribute to the multi/inter-disciplinary experience of the researchers. They will be assessed by the expert evaluators under the criterion "excellence". Secondments may not, however, exceed 30% of a fellow's recruitment period.

- 30% of a 3-year ESR contract means up to 10 months
  - Not necessarily consecutive, not necessarily with the same partner
  - Typically, private-sector partners prefer long secondments, to maximize the ratio between return and training investment

Work Packages

WP No.	WP Title	Lead Beneficiary No.	Start Month	End month	Activity Type	Lead Beneficiary Short Name	ESR involvement
1	Management	1	1	48	Management	UCL	Two ESRs in the Supervisory Board
2	Training	7	4	40	Education	Sheffield	All
3	Events	1	4	48	Education	UCL	All
4	Outreach	12	2	48	Education	INAF	All
5	Simulations	11	4	40	Tools&Standards	UNISA	All
6	Analysis Tools	9 & 3	4	40	Tools&Standards	INFN & UCA	All
7	Combination with Standard Methods	4 & 8	4	40	Tools&Standards	UCBL & Durham	All
8	Open Data	6	2	48	Tools&Standards	WRCP	All
9	Volcano Studies	10	4	40	Applications	UNINA	1,3,4,8,10,11,12
10	New Applications[28]	5	4	40	Applications	CNRS	2,5,6,7,9

Education, Training, Outreach

	Main Training Events & Conferences	Days	ECTS[37]	Lead Institution	Action Month (*estimated*)
1	*EMN workshop*, Brussels (Belgium)	3	2	UCL	6
2	Workshop on Physical Volcanology, Durham (UK)	3	2	Durham	10
3	*EuroMuographers 2018*, Catania (Italy), with field training on Mt.Etna	3+2	3	UNICT / INGV-OE	12
4	*EMN workshop*, Ghent (Belgium)	3	2	UGent	18
5	*EuroMuographers 2019*, Salerno (Italy), with field training on Mt.Vesuvius	3+2	3	Salerno / UNINA / INGV-OV	24
6	*EMN workshop*, Orléans La Source (France)	3	2	IRIS / CNRS-LSBB	30
7	*EuroMuographers 2020*, Palermo (Italy), with field training on Mt.Etna	3+2	3	INAF / INGV-OE	36
8	Training Course in Science Communication, Serra La Nave (Italy)	5	2	INAF, in collaboration with SISSA	15
9,10,11	"Think Ahead" workshops	3*2	3*1	Sheffield	10, 22, 34

We also foresee cycles of lectures and seminars by several members of the network, and six prominent non-members accepted to be listed as visiting lecturers

Volcano studies

- More than half of the institutes involved are interested in volcano studies, so it came natural to have a Work Package (WP9) entirely for that
- Our network is meant to create new links: this WP foresees joint data-taking campaigns at Stromboli, Etna, La Soufriere
- Data sharing would be an essential feature of this WP, in collaboration with WP8
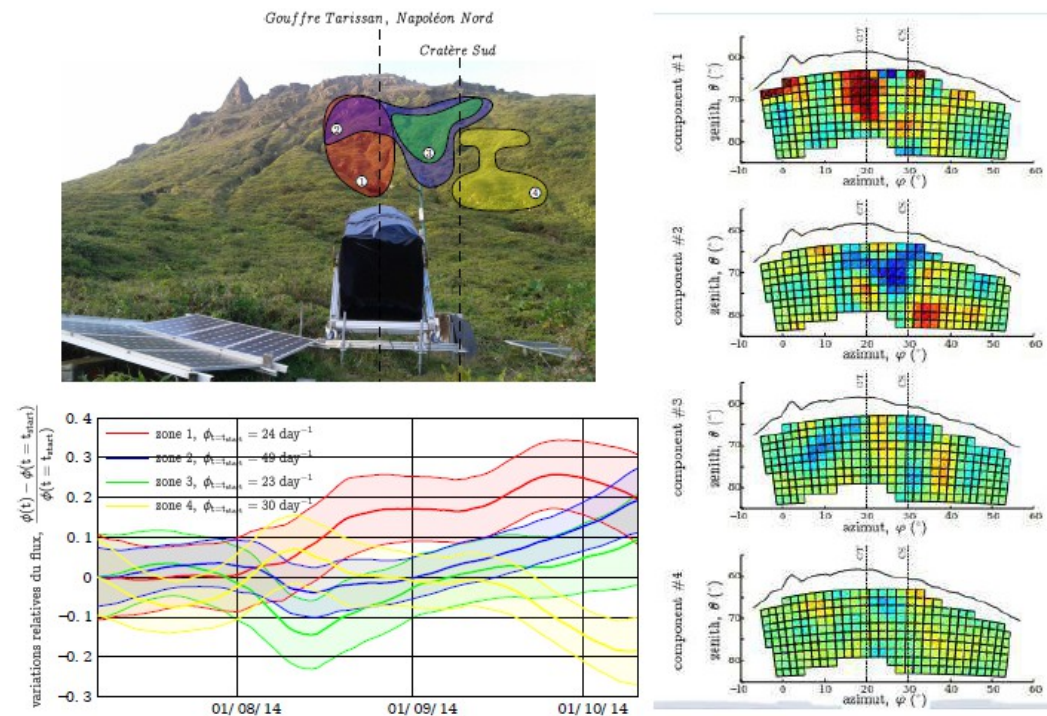
Representative example from a study of La Soufrière de Guadeloupe coauthored by members of the EMN based in Lyon and Rennes

New applications

- WP 10 is the umbrella for all other muography applications: archaeology, civil engineering, geophysics (outside of volcanology), industrial applications...

- None of them, alone, would make a large WP, and there is no point in creating a WP if it does not create links between institutes that would not collaborate otherwise

- It can be argued that they are not all *new*, in strict sense: after all, Alvarez used muography in a pyramid in the 60s... but what is new, we argue, is making muography a game-changer for the field
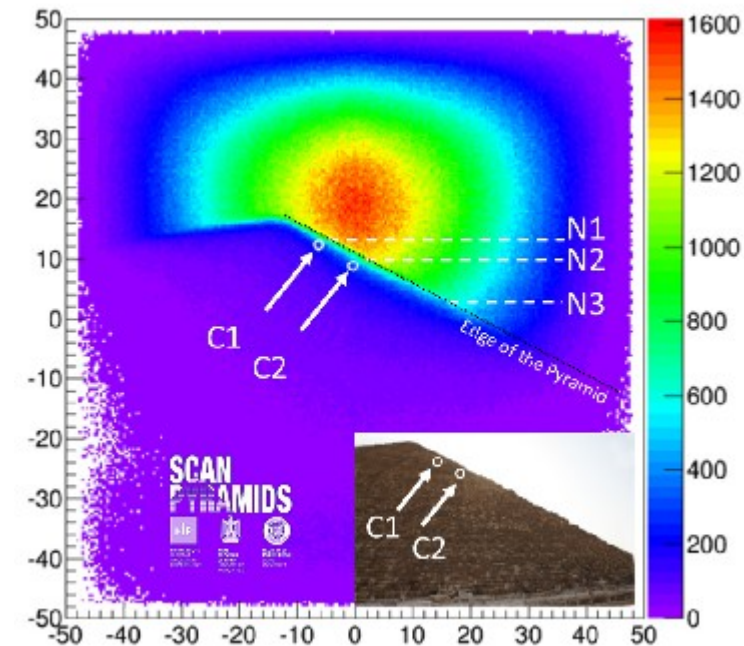

Representative example from a study of Khufu's pyramid coauthored by members of the EMN based in Paris (CEA) and Nagoya

Common tools

- WP 5: Simulations

  - Common open-software tools to simulate cosmic showers, particle transport, detector response

- WP 6: Analysis Tools

  - Common open-software tools for 2D and 3D imaging

- WP 7: Combination with Standard Methods

  - Here "Standard Method" refers to non-muographic methods from geophysics (e.g., gravimetry)
  - Several ongoing disconnected efforts, to be merged

- WP 8: Open Data

  - Open to other scientists, "citizen scientists", outreach, ...

Governance
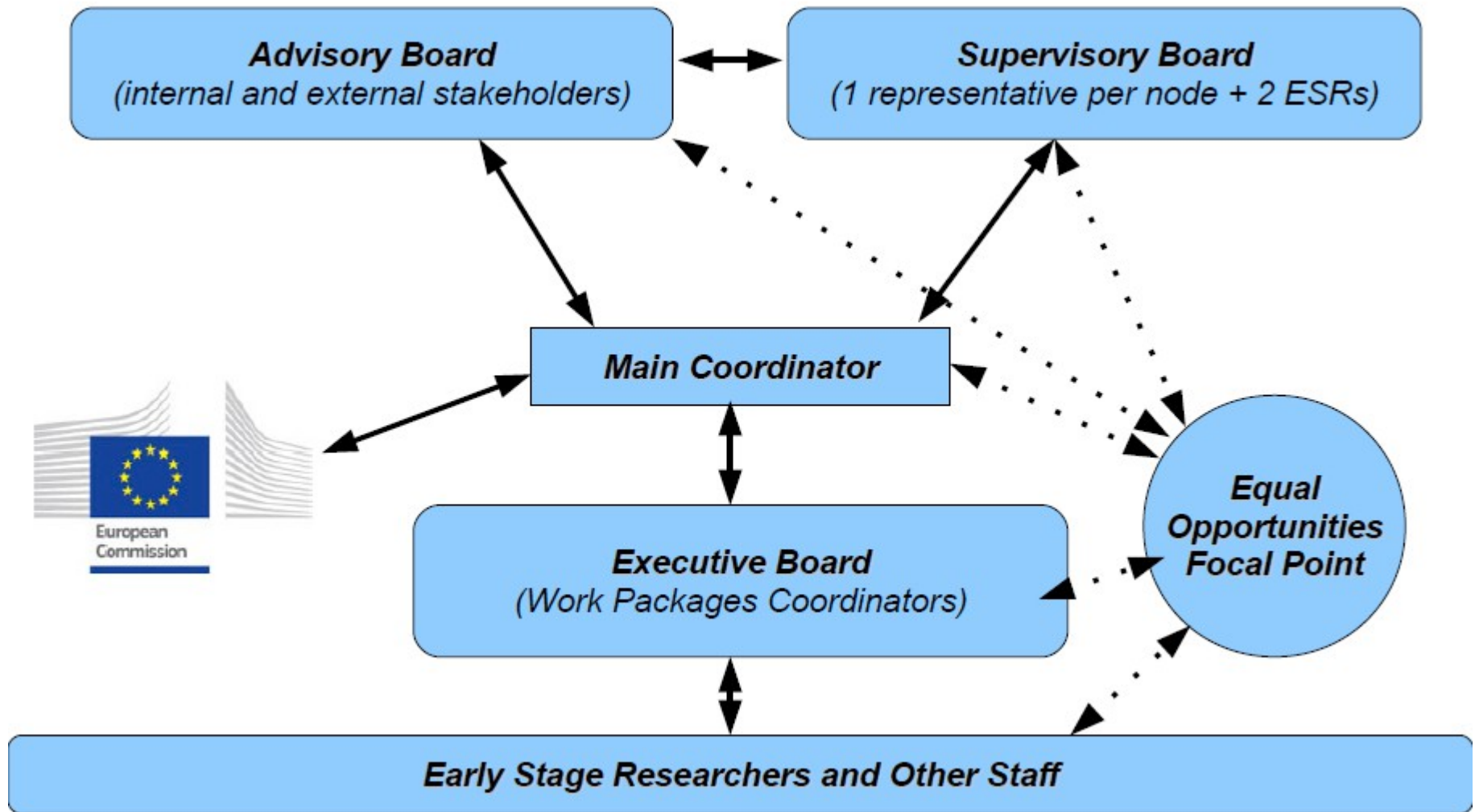
Referee report

Evaluation Result

Total score: 94.60% (Threshold: 70/100.00)

Criterion 1 - Excellence

Score: **4.80** (Threshold: 0/5.00 , Weight: 50.00%)

Criterion 2 - Impact

Score: **4.70** (Threshold: 0/5.00 , Weight: 30.00%)

Criterion 3 - Quality and Efficiency of the Implementation

Score: **4.60** (Threshold: 0/5.00 , Weight: 20.00%)

Interpretation of the score:

*0– The **proposal fails to address the criterion** or cannot be assessed due to missing or incomplete information.*

*1– **Poor.** The criterion is inadequately addressed, or there are serious inherent weaknesses.*

*2– **Fair.** The proposal broadly addresses the criterion, but there are significant weaknesses.*

*3– **Good.** The proposal addresses the criterion well, but a number of shortcomings are present.*

*4– **Very good.** The proposal addresses the criterion very well, but a small number of shortcomings are present.*

*5– **Excellent.** The proposal successfully addresses all relevant aspects of the criterion. Any shortcomings are minor.*

Not bad for a first attempt!

In the past, some ITNs were funded with lower scores; but now the bar is higher: more applicants, and many previous applicants have learnt by trial and error

We probably got close: one ITN has been funded in 2017 with 96%

In the next slides you will learn where we lost that ~1% that could have made the difference; the positive points are in backup

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Referee report

Criterion 1 - Excellence

Score: **4.80** (Threshold: 0/5.00 , Weight: 50.00%)

Quality, innovative aspects and credibility of the research programme (including inter/multidisciplinary, intersectoral and, where appropriate, gender aspects)
Quality and innovative aspects of the training programme (including transferable skills, inter/multidisciplinary, intersectoral and, where appropriate, gender aspects)
Quality of the supervision (including mandatory joint supervision for EID and EJD projects)
Quality of the proposed interaction between the participating organisations

Weakness:

- The simultaneous occurrence of the first joint academic training and the ESRs recruitment (M4) may reduce the effectiveness of both events.

The referees mis-read it (M4 is when the joint academic agenda is agreed upon; the first event was foreseen on M6); but anyway, that would be too early, indeed, as there are large uncertainties in the starting dates of the ESRs

If that error alone costed 0.2/5.0 (i.e. 2% overall), it was a dear price to pay!

Note that all those dates were guessworks anyway (as we clearly indicated, we are fully flexible on all of them); it should be easy to fix

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Referee report

Criterion 2 - Impact

Score: **4.70** (Threshold: 0/5.00 , Weight: 30.00%)

Enhancing the career perspectives and employability of researchers and contribution to their skills development
Contribution to structuring doctoral / early-stage research training at the European level and to strengthening European innovation capacity, including the potential for:
a) meaningful contribution of the non-academic sector to the doctoral/research training, as appropriate to the implementation mode and research field
b) developing sustainable joint doctoral degree structures (for EJD projects only)
Quality of the proposed measures to exploit and disseminate the project results
Quality of the proposed measures to communicate the project activities to different target audiences

Weaknesses:

- The plurality of skills gained is an obvious benefit for some disciplines, but depth of knowledge required in others is greatly reduced: this aspect has not been addressed in detail in the proposal.
- Only 5 out of the 12 ESRs will have secondments at non-academic partners, which limits the industrial exposure for the ESRs.
- The details of the outreach events and the specific commitments of the ESRs to communicate results to different target audiences are not clearly described.
- The potential of non-academic partners to further contribute to training and dissemination is not clearly explained.

The second and the last points demand:
- A greater commitments by our non-academic partners
- The cooptation of new non-academic partners to strengthen this particular aspect of training by our network

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Referee report

Criterion 3 - Quality and Efficiency of the Implementation

Score: **4.60** (Threshold: 0/5.00 , Weight: 20.00%)

Coherence and effectiveness of the work plan, including appropriateness of the allocation of tasks and resources (including awarding of the doctoral degrees for EID and EJD projects)

Appropriateness of the management structures and procedures, including quality management and risk management (with a mandatory joint governing structure for EID and EJD projects)

Appropriateness of the infrastructure of the participating organisations

Competences, experience and complementarity of the participating organisations and their commitment to the programme

Weaknesses:

- The function provided by a separate Executive Board is unclear.
- No technical risks to the work have been identified.

I feel quite bad for having wasted 0.4 points over 5 (although weighted by 0.2) on something that could have been easily written better...

We need:
- More discussion among us about what role we wish the EB to have
- A better description of the EB and a longer list of risks (and how we would deal with them)

Conclusions

- This bid for an Innovative Training Network has demonstrated that muography is recognized as an ideal field for training-through-research

- The work spent on that was not wasted: on the path initiated by G-ENDEAVOR, we tightened the existing links and created new ones

- We will try again this year, learning from our mistakes, taking into account the constructive criticism received

- The **European Muography Network** can provide a boost to the trend towards integration of muography developments in Europe and Japan

Thanks for your attention!

And thanks to the main contributors of the first EMN proposal, in particular the prospective node coordinators (in random order of appearance in the EMN tables):

Sébastien Procureur (CEA-IRFU), Cristina Carloganu (UCA-LPC), Jacques Marteau (UCBL),
Stéphane Gaffet (CNRS-LSBB), Dezso Varga (Wigner RCP), Lee Thompson (Sheffield),
Edward Llewellin & Jon Gluyas (Durham), Lorenzo Bonechi & Raffaello D'Alessandro (INFN-Firenze), Giulio Saracino (Napoli), Cristiano Bozza (Salerno), Melania Del Santo (INAF);
Catherine Truffert (IRIS Instruments), Lucio Amato (TECNO IN), Tom Deakin (LabLogic);
Dominique Gilbert (Rennes1-OSU), Alessandra Tonazzo (UPD-APC), Michael Tytgat (UGent),
Giovanni Macedonio & Daniele Carbone (INGV), Domenico Lo Presti (Catania);
Hiroyuki Tanaka (Tokyo-ERI), Tadahiro Kin (Kyushu), Kunihiro Morishima (Nagoya)

Part II:
Role of Early Stage Researchers in the European Muography Network
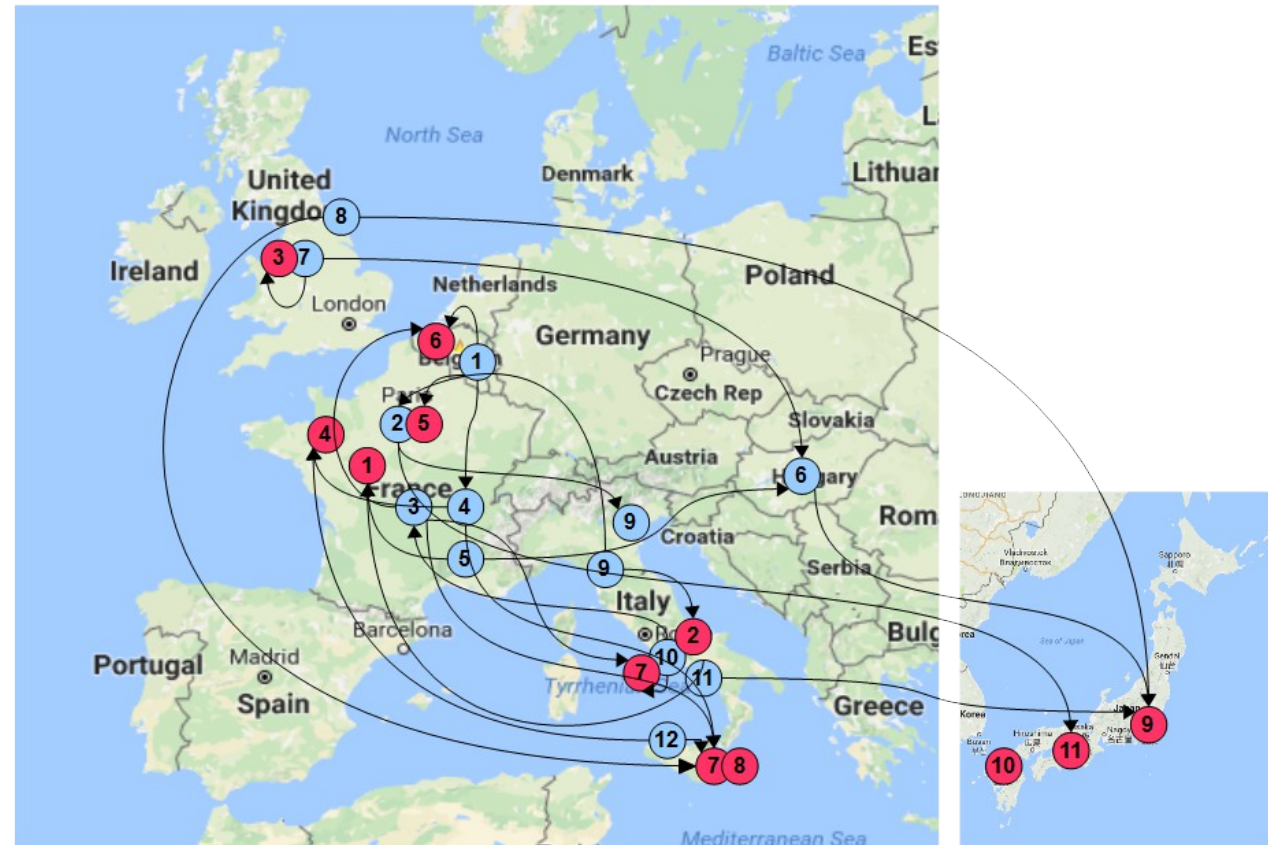
Early Stage Researchers

- ESRs are the main focus of ITNs

- Can apply to ESR positions people with ≤4 years of research after obtaining a degree giving access to a doctoral program, but not having a PhD yet

- Typically ESRs are enrolled as PhD students

  - (That's the case we foresee in the EMN)

- ESRs are expected to be mobile within the network: up to 30% of their time can (should) be spent in secondments to partner nodes

  - Secondments to non-academic partners: encouraged

Example #1: with IRIS Instruments

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables
ESR5	CNRS	Y[56]	4	36	D5.4, D6.2, D7.3, D10.3

Project Title and Work Package(s) to which it is related: "Design, construction and in situ testing of a muon camera for Earth science and civil engineering applications", WP 10, 5, 6, 7

Supervisors: S.Gaffet (main), geologist @ CNRS; C.Truffert, geologist @ IRIS company; D.Varga, particle physicist @ WRCP

Objectives: Fine characterization of the current detector setup in order to start the industrialization process of a new tool in geophysics, designed to fill the gap between the existing technologies in terms of autonomy, ease of deployment, speed of acquisition. The studentship will focus both on the development of muon flux simulations and on development of algorithms for 3D inversion (tomography). The student will further work on joint inversion with standard methods.

Expected Results: Optimization of detector setup for specific application, patent, oral presentation in relevant international conferences and at least one peer-reviewed publication.

Planned secondment(s): S1: WRCP, under co-supervision of D. Varga, 2 months during the 1st year and 2 months during the 3rd year, to work on cavity detection using muography. S2: IRIS, under co-supervision of C. Truffert, total time of 6 months, interaction with the industrial environment taking advantage of IRIS' expertise in electronics and international market trends in Geosciences. IRIS will lead the industrialization process of the detector. Benchmarking survey with WRCP (D. Varga) and UCBL (J. Marteau)

56 Through third party agreement with Université Côte d'Azur.

Example #2: with LabLogic

Fellow	Host institution	PhD enrolment	Start date	Duration	Deliverables
ESR7	Sheffield	Y	4	36	D5.4, D6.2, D10.3

Project Title and Work Package(s) to which it is related: "Muon transport simulation and low-cost detector optimisation", WP 5, 6, 10
Supervisors: L.Thompson (main) and V. Kudryavtsev, particle physicists @ Sheffield; T.Deakin, R&D manager @ LabLogic company; J.Gluyas geo-energy scientist @ Durham; D.Varga, particle physicist @ WRCP.

Objectives: This studentship will focus on 2 key areas to the success of muography, namely the improvement of the simulation of the passage of muons through material and the development of low-cost detectors for the implementation of large area muographic instrumentation systems. V.Kudryavtsev is one of the principal authors of the MUSIC and MUSUN codes[58] which are used heavily by this community in the simulation of muon transport through matter. It is particularly applicable to the work described in this proposal. The student will work to further develop and refine this code and will incorporate recent empirical data into the software. The second part of the work programme will focus on the development of low-cost detectors based on plastic scintillators and/or gaseous detectors to drive down overall costs per unit area whilst maintaining high levels of muon efficiency, reliability and longevity. Here the combined expertise of U. Sheffield, WRCP and LabLogic will provide a powerful collaboration.

Expected Results: Improved muon transport simulations via updates to the MUSIC simulation code. Optimised detector system. Oral presentations at relevant conferences (e.g. IEEE NSS), at least one peer-reviewed paper.

Planned secondment(s): S1: WRCP; D.Varga, 4 months during 1st and 2nd year, knowledge exchange between gaseous and scintillator-based detectors, general solutions for DAQ. S2: LabLogic, T. Deakin, 6 months interspersed, for industrialisation and commercialisation.

Secondments as bridges between two worlds

- ESR's interest (the main consideration in an ITN) is to gain experience in a variety of work environments

  - ✔ Non-academic partners provide complementary skills

  - ✗ Possible risk: incoherence in supervision

- Non-academic partner's point of view:

  - ✗ Burden of supervision (but it pays off if secondment is long)

  - ✔ If ESRs arrive after significant training at the academic beneficiary, they transfer knowledge from there

  - ✔ Access to some of the most brilliant young graduates on the academic job market

- Academic beneficiary's point of view:

  - ✗ Loss of precious months of personpower

  - ✔ ESRs bring to the main supervisor know-how from the partner

Thanks for your attention!

Extra slides

The strong points

Score: **4.80** (Threshold: 0/5.00 , Weight: 50.00%)

Quality, innovative aspects and credibility of the research programme (including inter/multidisciplinary, intersectoral and, where appropriate, gender aspects)
Quality and innovative aspects of the training programme (including transferable skills, inter/multidisciplinary, intersectoral and, where appropriate, gender aspects)
Quality of the supervision (including mandatory joint supervision for EID and EJD projects)
Quality of the proposed interaction between the participating organisations

+The scientific case is of very high quality, building on a series of successful achievements in the field and a growing worldwide activity in muography. It takes advantage of recent progress made in other areas such as particle physics.
+The research and training programs display true multidisciplinarity and strong intersectoral components (with participation of many scientific fields - particle physicists, geologists, archaeologists and civil engineers).
+ Strong established interactions between the participating organisations, on muography and also in particle physics experiments, make the well-integrated work and training plan highly credible.
+ Critical connections with non-academic companies carrying out R&D for muography (IRIS Instruments, TECNO IN and LabLogic Systems) and the well-established effort in Japan add high-quality complementary resources and training on technical and transferable skills.
+ Development of better (frontier) tools for muography and of new international standards for monitoring volcanoes are to be expected.
+ The universities and the scientists leading this network have an excellent record of research training, including outstanding supervisors and interdisciplinary co-supervisors.
+ The project has a highly innovative training and research potential for Europe in that it would consolidate, connect and improve its muography effort, which is needed to monitor volcanoes and other structures.
+ Synergy is fostered through the extended participation in the recently launched European efforts "Virtual Muography Institute" and "Global Muography Network".
+ The non-academic sector is well integrated; non-academic partners will directly supervise some of the ESRs which is likely to lead to stronger connections than presently.

The strong points

Score: **4.70** (Threshold: 0/5.00 , Weight: 30.00%)

Enhancing the career perspectives and employability of researchers and contribution to their skills development
Contribution to structuring doctoral / early-stage research training at the European level and to strengthening European innovation capacity, including the potential for:
a) meaningful contribution of the non-academic sector to the doctoral/research training, as appropriate to the implementation mode and research field
b) developing sustainable joint doctoral degree structures (for EJD projects only)
Quality of the proposed measures to exploit and disseminate the project results
Quality of the proposed measures to communicate the project activities to different target audiences

+ *Career perspectives and employability will be strongly enhanced via the multidisciplinarity and intersectorial aspects of the project.*
+ *The training in detector technology and analysis using advanced computing developed for the LHC experiments, together with the practical aspects of taking imaging data, will lead to a very rounded skill set that is very attractive for a very broad range of career choices, both in academia and industry.*
+ *The results will impact on a rich list of recipients and extend muography to new areas of application thereby strengthening EU innovation capacity.*
+ *To make open access the software tools developed and the data gathered is a positive initiative which will reinforce the potential for EU innovation.*
+ *The formulation and publication of new standards for analysis and data processing in this area of study will have a extended and large impact in EU and world-wide practises.*
+ *An impressive and complete plan of dissemination and communication with many different audiences has been proposed. It includes standard academic practices and direct interaction with civil-society stakeholders.*
+ *The proposal of additional publications, targeting audiences with specialized knowledge, is a good initiative.*
+ *The dedicated website for outreach foreseen is a good way to promote the project.*
+ *The planned public exhibition on cosmic rays and their use for understanding volcanoes at the theme-park Vulcania near Clermont-Ferrand is an innovative idea, well suited to reach the wider public.*

The strong points

Criterion 3 - Quality and Efficiency of the Implementation

Score: **4.60** (Threshold: 0/5.00 , Weight: 20.00%)

Coherence and effectiveness of the work plan, including appropriateness of the allocation of tasks and resources (including awarding of the doctoral degrees for EID and EJD projects)
Appropriateness of the management structures and procedures, including quality management and risk management (with a mandatory joint governing structure for EID and EJD projects)
Appropriateness of the infrastructure of the participating organisations
Competences, experience and complementarity of the participating organisations and their commitment to the programme

+ The work and the individual ERS projects are very well developed and detailed.
+ The network will try to accommodate issues arising from child care and work-family balance, which is critical to guarantee the equal participation of women.
+ The WP structure is very complete, with appropriate deliverables and addressing the scientific program but also specifically addressing outreach and training.
+ The network will benefit from outstanding infrastructure which provides access to precious volcano-monitoring data in many locations through partnership with INGV, UCA-LMV, UCA and the collaboration with Tokyo.
+ A strong equal opportunity statement is put forward, wherein gender aspects are well dealt with with measures to promote gender balance in research driving roles and positions of responsibility.
+ The secondments organised in non-academic partners are well integrated with the research goals.
+ The management structure is well detailed and planned, including quality control. Tasks and accountability in the execution plan are clearly developed.
+ The Advisory Board incorporates appropriate external members and matches the interdisciplinary aims of the network.
+ The foreseen Equal Opportunities Focal point can address effectively the issue of equal opportunities for all under-represented minorities.
+ All participating organizations bring important and different (complementary and balanced) expertise and have been active in the field for a very long time (sometimes with outstanding pioneering contributions).

4. Gantt Chart

(Month 0 is set at September 2017. Years: yellow = 2018, blue = 2019, magenta = 2020.)

ESR hirings (Months 1–3, light grey) — **ESR calendar (indicative)** (Months 4–39)
S: secondments (S1, S2, …: at co-supervising nodes 1, 2, … , see Table 3.1d)

Buffer for recruitment delay; more ESR time if extra funding (Months 40–48)

ESR	Secondments (month: code)
1	9: S1; 11: S2; 17: S2; 33: S3; 34: S3; 35: S3
2	12: S1; 13: S1; 19: S2; 20: S2; 21: S2; 23: S2; 25: S2; 26: S2
3	7: S; 8: S; 19: S; 20: S; 21: S; 22: S; 23: S; 24: S
4	9: S1; 11: S1; 13: S1; 19: S2; 21: S1; 23: S1; 25: S1; 33: S1; 34: S1; 35: S1
5	6: S1; 7: S1; 10: S2; 13: S2; 15: S2; 19: S2; 23: S2; 27: S2; 34: S1; 35: S1
6	7: S; 8: S; 18: S; 19: S; 34: S; 35: S
7	7: S1; 8: S1; 10: S2; 12: S2; 16: S1; 18: S1; 20: S2; 22: S2; 33: S2; 34: S2
8	9: S1; 19: S2; 20: S2; 21: S2
9	7: S1; 8: S1; 11: S1; 16: S2; 18: S2; 19: S2; 20: S2; 22: S2; 24: S2
10	8: S1; 11: S1; 14: S1; 16: S1; 20: S2; 21: S1; 25: S1; 28: S1; 31: S1; 36: S1
11	12: S1; 13: S1; 20: S2
12	6: S1; 9: S1; 16: S1; 18: S2; 19: S2; 20: S2; 25: S1; 29: S1

Work Packages timeline (main deliverables, milestones, and events)

WP	Entries (month: code)
1	1: K
2	4: A; 6: L; 9: C; 11: L/S; 16: A; 18: L; 22: C; 24: L/S; 28: A; 30: L; 34: C; 36: L/S
3	6: E; 11: E; 18: E; 24: E; 30: E; 36: E
4	3: V; 6: O; 7: V; 10: V; 11: O; 14: V; 16: O; 17: V; (red exhibit from ~19 to 48) V … O … V across the period
5	24: (orange); 36: W; 39: P
6	24: W; 39: R
7	36: R
8	6: W; 24: T; 36: T
9	8–12: (orange); 24: W; 39: P
10	16: (orange); 24: (orange); 39: P

A: definition of joint academic training programmes for the rest of the year; C: complementary skills workshops; E: network-wide event (workshop or conference); K: kick-off SB meeting; L: lectures; O: outreach event; P: scientific paper for peer-review; R: public recommendation; S: school; T: software tool developed; V: outreach videos; W: public data or software tools released on the web; **light grey**: recruitment; **dark grey**: training-through-research; **green**: training events; **orange**: data-taking campaigns; **red**: exhibit.

Three kinds of ITN

- European Training Network (ETN)

  - It is our case

  - Between 3 and 15 beneficiaries; suggested ≥6 and ≤10

  - No limit on number of partners; but each partner has to be carefully justified, and play a role

  - We are a large network, with 12 beneficiaries!

- European Industrial Doctorate (EID)

  - At least two beneficiaries, mix academic / non-academic

  - Must get a PhD; at least 50% of time in non-academic sector

- European Joint Doctorate (EJD)

  - Joint PhD degrees awarded in different countries

External lecturers

- the geophysicist Claude Jaupart (Professor at Université Paris Diderot), former Director of the *Institute de Physique du Globe de Paris*, member of the French Academy of Sciences[30] and holder of several other distinctions in France and abroad, author of several popular books on volcanology;

- the physical volcanologist Bruce Houghton (MacDonald Professor in Volcanology at University of Hawaii), currently the Hawaiian State Volcanologist and Science Director at the National Disaster Preparedness Training Center, USA;

- the archaeologist Anna Chiara Fariselli (Professor at *Università di Bologna*), expert of Middle Eastern and Mediterranean heritages;

- the physicist Vladimir Ivantchenko (CERN & Geant4 Associate International Ltd) will lecture on particle transport simulations and will provide hands-on training on the Geant4[31] usage; he is a member of the Geant4 Steering Board, coordinator of the Electromagnetic physics group of the Geant4 collaboration, coordinator of the Simulations group of the CMS experiment at the LHC;

- the geologists Antonio Ricciardi e Domenico Mangione (Italian Department of Civil Protection) will lecture on volcanic hazards, eruption forecasts and volcano surveillance;

- the physicist Tommaso Dorigo (INFN), former Chair of the Statistics Committee of the CMS collaboration, main coordinator of the ITN AMVA4NewPhysics (related to statistics and particle physics), author of one of the most popular blogs related to particle physics[32] and of a recent science popularization book[33], will lecture on data reduction and practical statistics and will give seminars and tutoring on web- and stage-based scientific outreach.

Pre-existing links (one year ago)

EMN nodes concerned	Collaboration and target
UCA, UCBL	TOMUVOL Project[42] (Puy de Dôme), also including CNRS, ISTerre Grenoble.
UCBL, Rennes 1	DIAPHANE Project[43] (volcanoes of the Lesser Antilles), also including IPGP.
INFN, INGV, UNINA, (UCL)[44]	MURAVES Project (Mt.Vesuvius), also including UNIFI.
UCA, UCBL, INFN, INGV, UNINA	Joint data taking campaigns at Puy de Dôme between the TOMUVOL and MURAVES collaborations that led to peer-reviewed publications.
Durham, Sheffield	Project Deep Carbon[45] (monitoring in carbon capture and storage), also including STFC
CEA, Nagoya	ScanPyramids Project[46] (Egyptian pyramids).
CNRS, IRIS	TM2DM2 Project, also including GEOAZUR and BRGM and in partnership with the RD51 collaboration[47] at CERN, for the development of a new "muon camera" and development of the associated data processing tools, open to any kind of application.
Tokyo, INFN, INGV	Academic agreement signed at the Embassy of Italy in Tokyo, 2014; Researchers exchange based on the Executive Programme of Cooperation in Science and Technology between the governments of Italy and Japan, 2014.
Tokyo, WRCP	Academic agreement signed at the Embassy of Hungary in Tokyo, 2015; Intellectual Property Cooperation Agreement, 2016.
Tokyo, INAF	Academic agreement signed at the Embassy of Italy in Tokyo, 2016.
UCA, UNINA	Researchers exchange, 2013 and 2015.
Tokyo, INFN, INGV, WRCP	Joint exhibition "Muography: Perspective Drawing in the 21st Century", event of the 150th anniversary of Italy-Japan diplomatic relationship in 2015, supported by the Embassies of Italy and Hungary in Tokyo.
UNISA, INFN, Tokyo	International graduate student professional development supported through Winter internship from November to December 2013.

42 http://ppse.in2p3.fr/Tomography%20of%20volcanoes
43 http://www.agence-nationale-recherche.fr/?Project=ANR-14-CE04-0001
44 UCL recently joined as external partner, contributing to time-of-flight studies and offline calibration.
45 https://www.dur.ac.uk/dei/news/?itemno=16051
46 http://www.scanpyramids.org/
47 http://rd51-public.web.cern.ch/RD51-Public/
48 Including EMN participants at UCA, but not the CNRS-LSBB laboratory.
49 Including EMN participants at UNINA and at the INFN-Firenze section, but not the INFN-Padova section.

And we remarked that most members also belong to the VMI

Scientific deliverables

Scientific Deliverables						
Deliverable Number	**Deliverable Title**	**WP No.**	**Lead Beneficiary Short Name**	**Type**	**Dissemination Level**	**Due Date**
D5.4	Article on simulations for muography	5	UNISA	Tools & Standards	Open	39
D5.5	Sharing of simulation software and results	5	UNISA	Tools & Standards	Open	36
D6.1	Repository for analysis tools and documentation	6	INFN/UCA	Tools & Standards	Open	24
D6.2	Public recommendations for muographic inversions	6	INFN/UCA	Tools & Standards	Open	39
D7.3	Public recommendations for joint inversions	7	UCBL/Durham	Tools & Standards	Open	24
D8.1	Repository for data and publications	8	WRCP	Tools & Standards	Open	6
D8.2	Event display online	8	WRCP	Tools & Standards	Open	24
D8.3	Intuitive software for open-data analysis	8	WRCP	Tools & Standards	Open	36
D9.4,D9.5,D9.6	Release of data from joint volcano campaigns	9	UNINA	Applications	Open	24
D9.7,D9.8,D9.9	Articles on volcano campaigns	9	UNINA	Applications	Open	39
D10.3	Article on benchmarks	10	CNRS	Applications	Open	24

Other deliverables

Management, Training, Recruitment and Dissemination Deliverables						
Deliverable Number	Deliverable Title	WP No.	Lead Beneficiary Short Name	Type	Dissemination Level	Due Date
D1.1	Recruitment Project Manager	1	UCL	Management	Open	1
D1.3	Advertisement ESR positions	1	UCL	Management	Open	1 to 4
D1.4	ESR recruitments	1	UCL	Management	Open	4
D2.2	European Muography Schools	2	Sheffield	Education	Open	12,24,36
D2.3	Joint academic training	2	Sheffield	Education	EMN	4,16,28
D2.4	Complementary skills workshops	2	Sheffield	Education	EMN	10,22,34
D3.1,D3.2,D3.3	EMN workshops	3	UCL	Education	EMN	6,18,30
D3.4,D3.5,D3.6	EuroMuographers conferences	3	UCL	Education	Open	12,24,36
D4.2	Training in Science Communication	4	INAF	Education	EMN	38
D4.3	Website	4	INAF	Education	Open	3
D4.4, D4.5	Blog and videos	4	INAF	Education	Open	3 to 48
D4.6	Comics	4	INAF	Education	Open	6
D4.7	Vulcania exhibit	4	INAF / UCA	Education	Open	20