

# Integrating muography research infrastructures in Europe

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# Volcanoes and Europe

## Eyjafjallajökull (Iceland)

Disruption of air traffic – happened in 2010



## Cumbre Vieja (Canary Islands)

West flank collapse and landslide tsunami – might happen



## Mt. Vesuvius (Italy)

What if...? > 1,000,000 persons living close-by

# Muography in Europe

An incomplete list of muography know-how and research centres in Europe:

INFN Italy  
INGV Italy  
INAF Italy  
Wigner Institute Hungary  
STFC UK  
ITER Spain  
UC-Louvain Belgium  
U-Salerno Italy  
U-Napoli «Federico II» Italy  
CEA France  
CNRS France  
U-Sheffield UK  
U-Durham UK  
U-Rennes France  
UBP-Clermont-Ferrand France  
UCB-Lyon1 France  
U-Nice France

Recently, interest in muon radiography or combined studies also by

KM3NeT EU ESFRI  
EMSO EU ERIC

It is impossible to list all projects in just one slide!

Most centres have links or partnerships with Tokyo ERI



# Muography in Europe

## Strong links between Europe and Japan in muography!

- ERI-INFN agreement of the academic exchange in muography Nov 2014
- ERI-INGV agreement of the academic exchange in muography Nov 2014
- ERI-Wigner RCP agreement of the academic exchange in muography June 2015
- ERI-Wigner RCP intellectual property agreement in muography May 2016
- ERI-INAF agreement of the academic exchange in muography (to be signed on Nov 8 2016)
- ERI-USalerno collaboration agreement for the VMI (to be signed)

+

Many other occasions of meetings, workshops, internships, collaborative experiments, equipment exchange, etc.



Academic agreement between INFN, INGV and The University of Tokyo (2014)



Opening ceremony of the INFN-INGV-WRCP-UTMT-ERI joint exhibition entitled "Muography: Perspective Drawing in the 21<sup>st</sup> Century" (2015)

12<sup>th</sup> Intergovernmental Consultation on Cooperation in the field of Science and Technology between Japan and Hungary (2015)



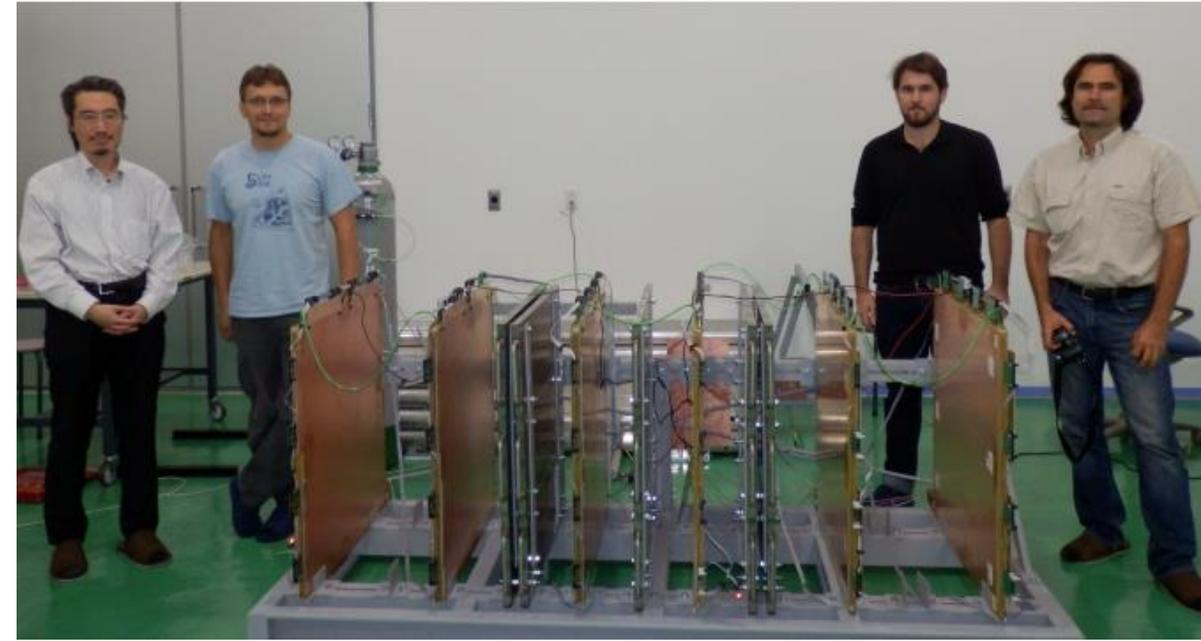
Academic agreement between Wigner Research Centre for Physics of the Hungarian Academy of Science and The University of Tokyo (2015)



# Muography in Europe

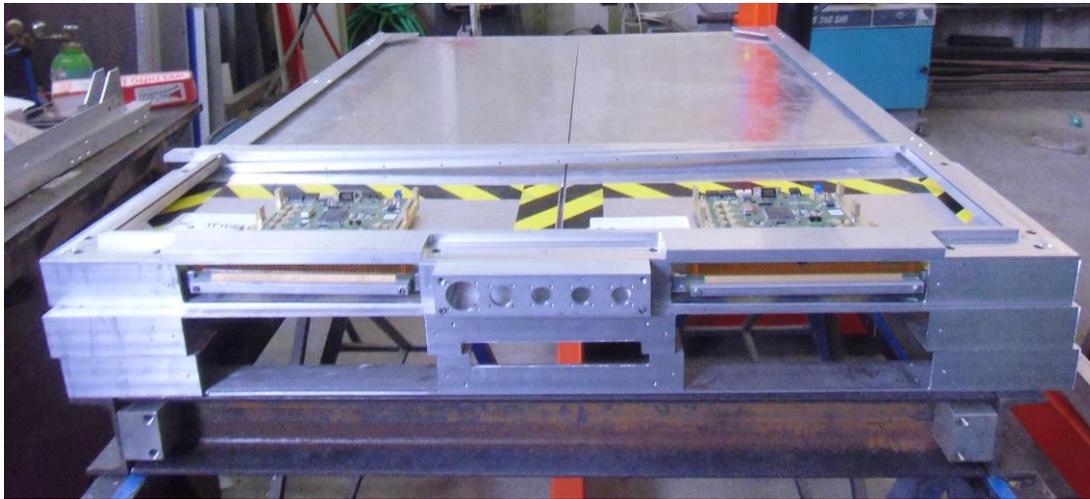
Detectors

Muographic Observation  
Instrument D. Varga - Wigner



MURAVES detector

G. Saracino – INFN, G. Macedonio - INGV



Nuclear emulsion  
muon detector  
V. Tioukov – INFN



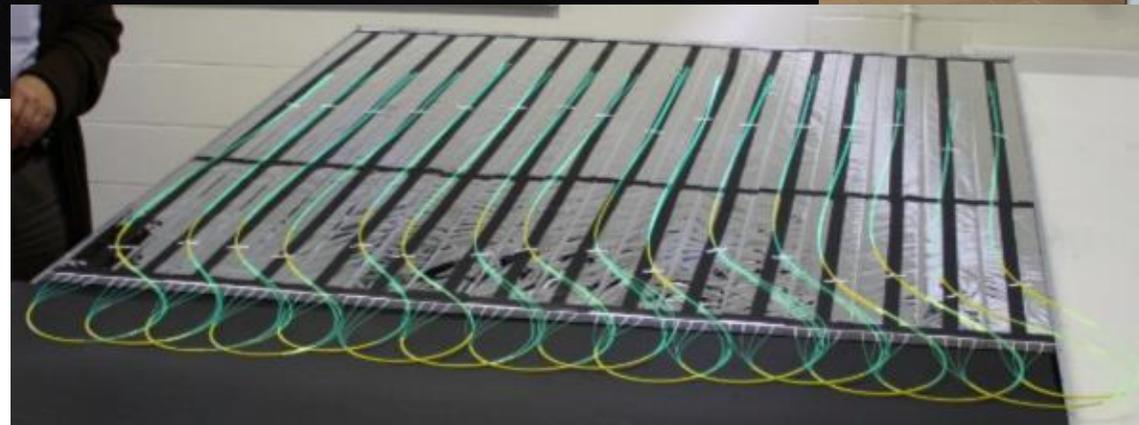
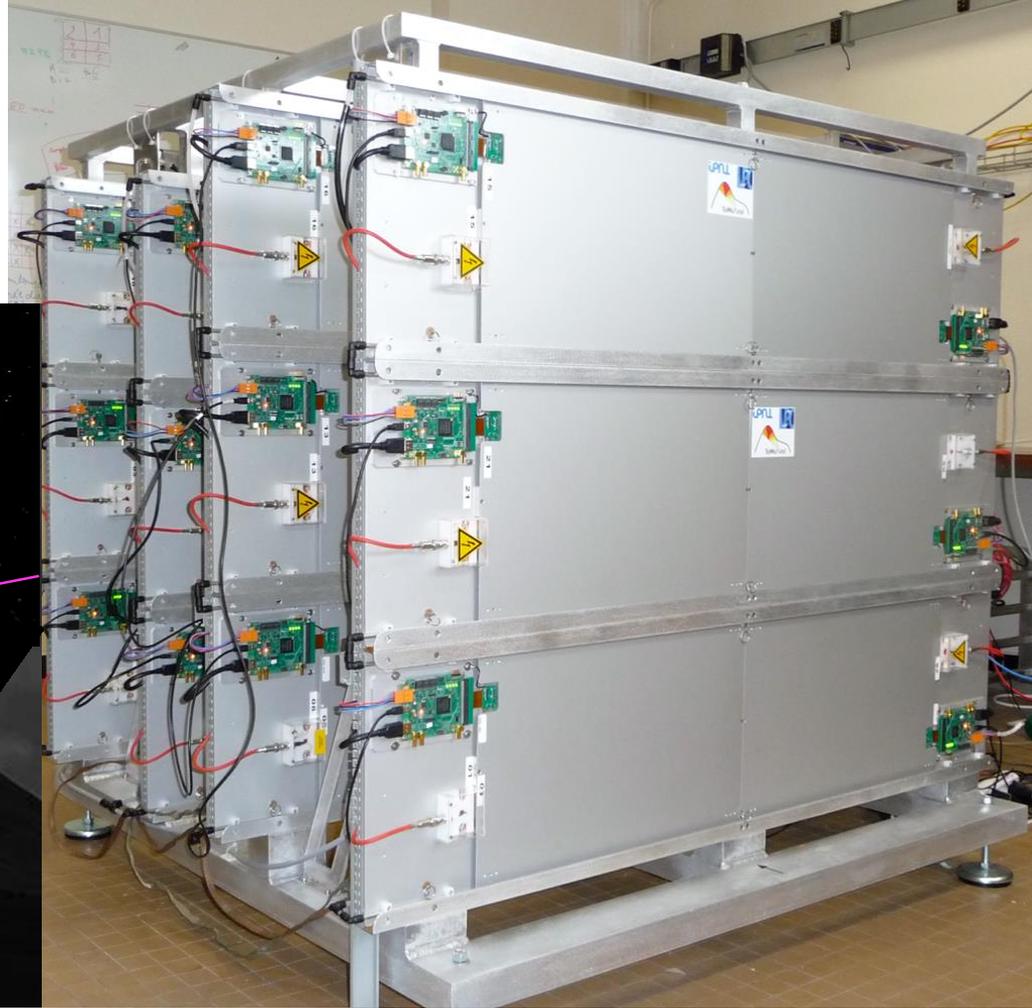
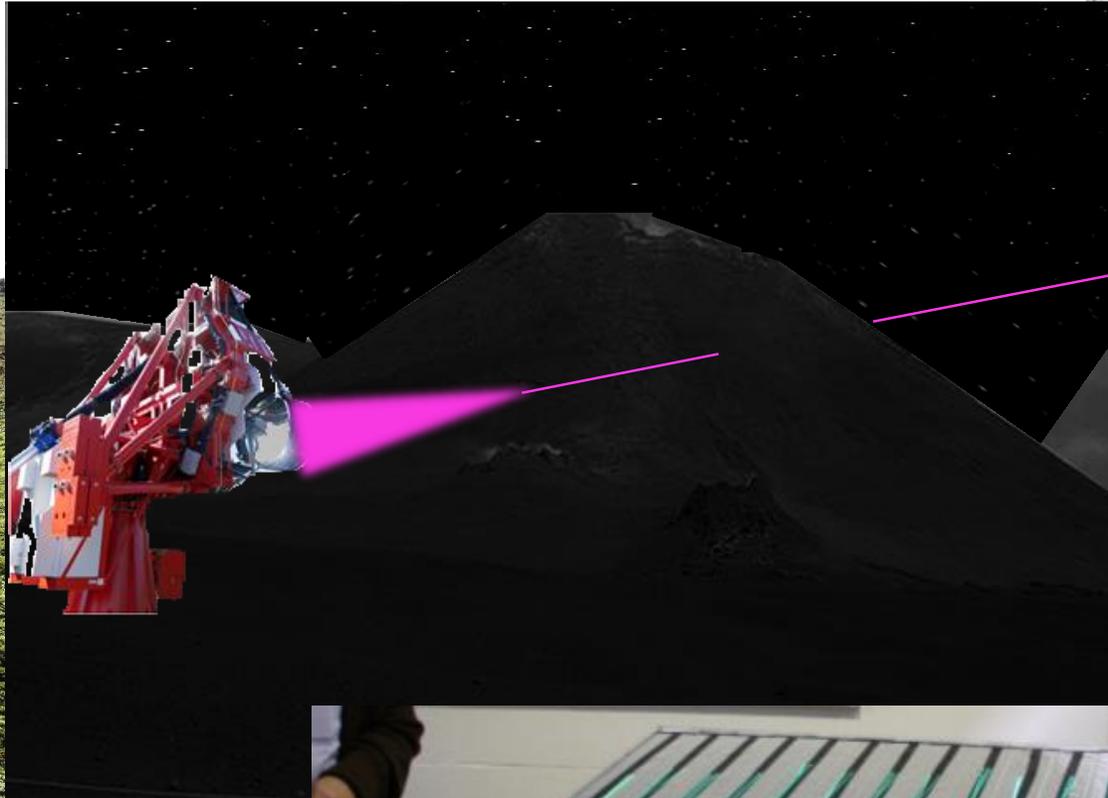
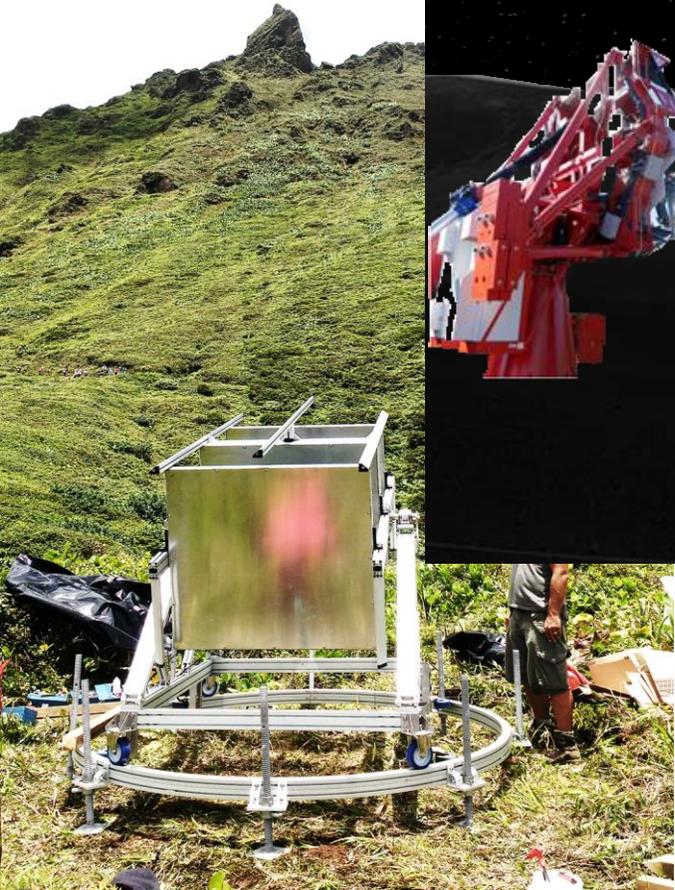
# Muography in Europe

Detectors

ASTRI telescope  
O. Catalano – INAF

TOMUVOL detector  
C. Carloganu – LPC

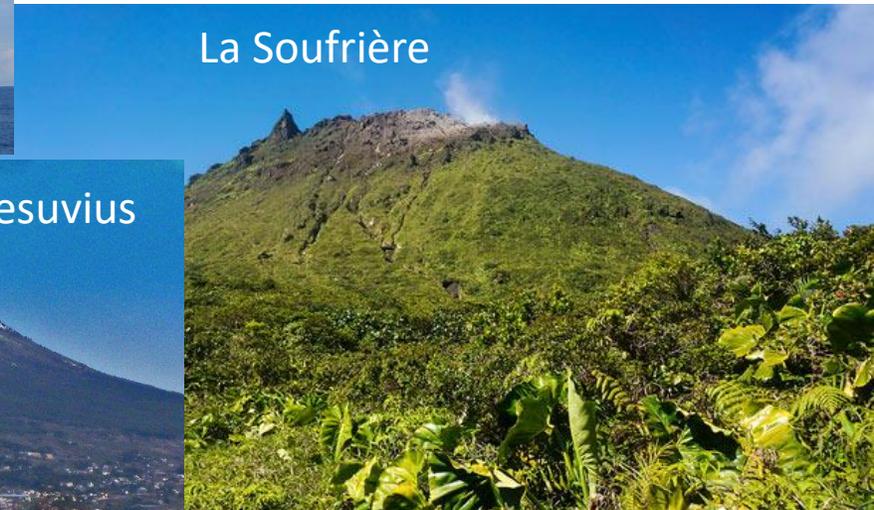
Muon detector  
J. Marteau – IPNL Lyon



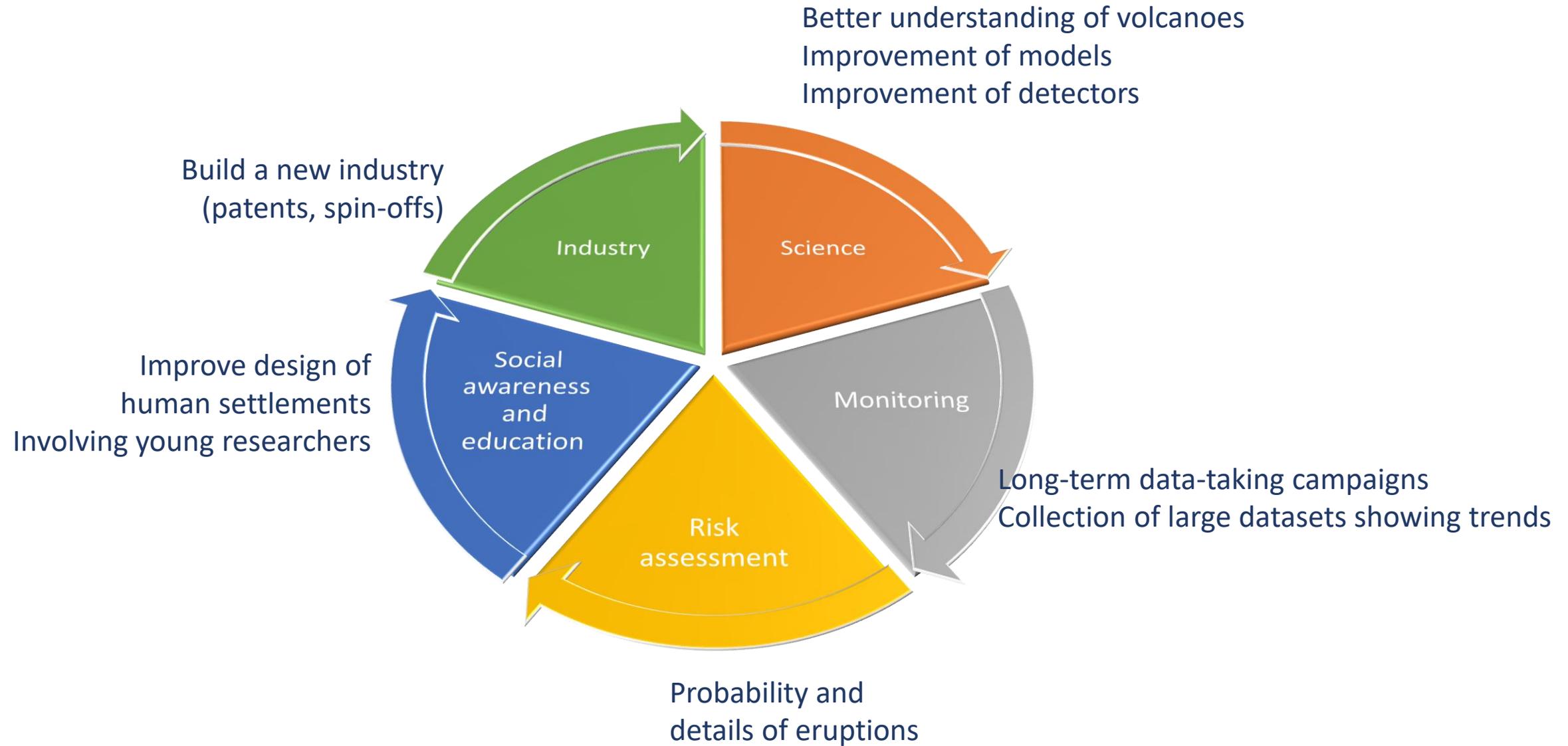
Scintillating Fibre Tracker  
A. Giammanco, E. Cortina - UCLouvain

# Muography in Europe

Some targets – not all in Europe



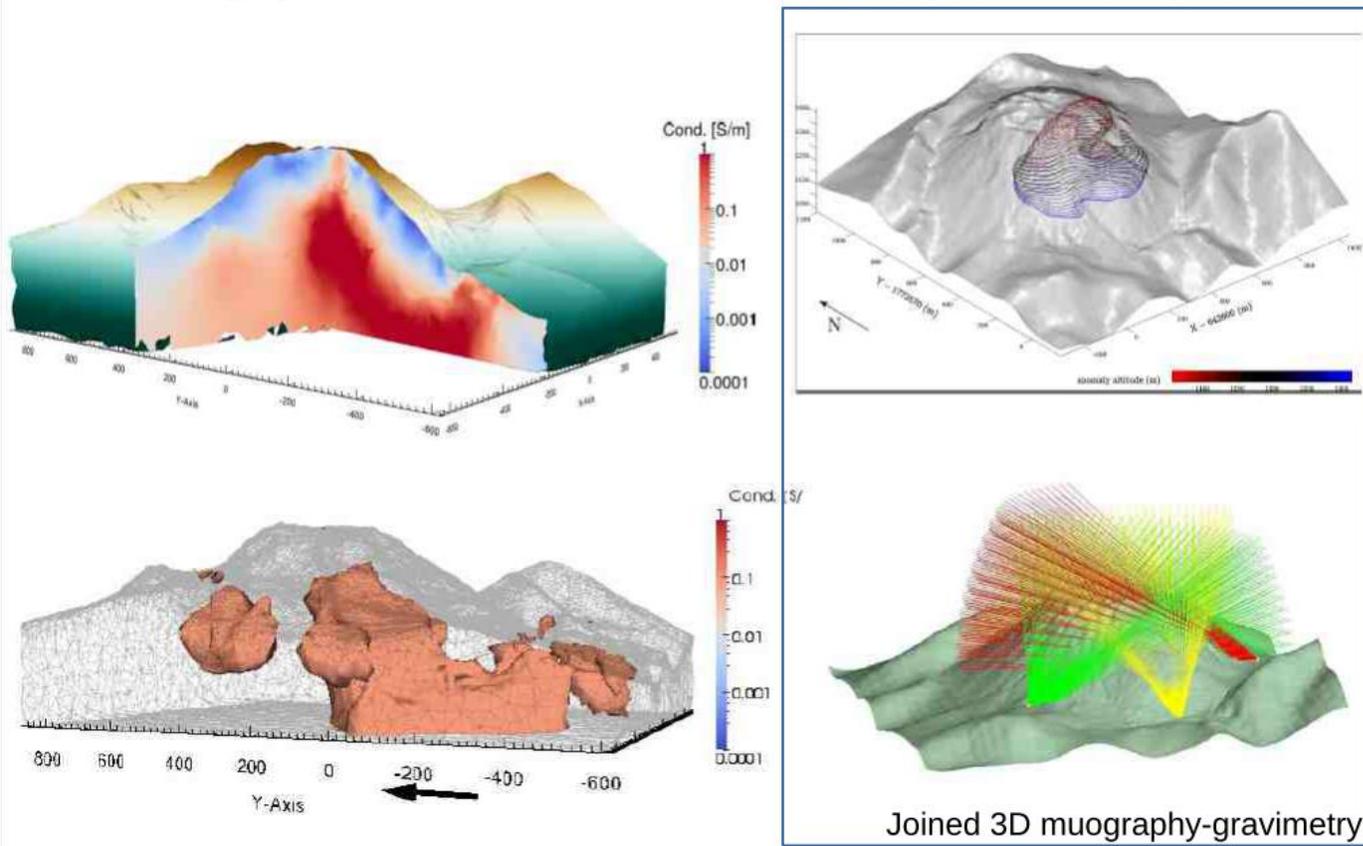
# Goals for muography



# Integration: merging Geophysics and Particle Physics

From the DIAPHANE project – courtesy of J. Marteau

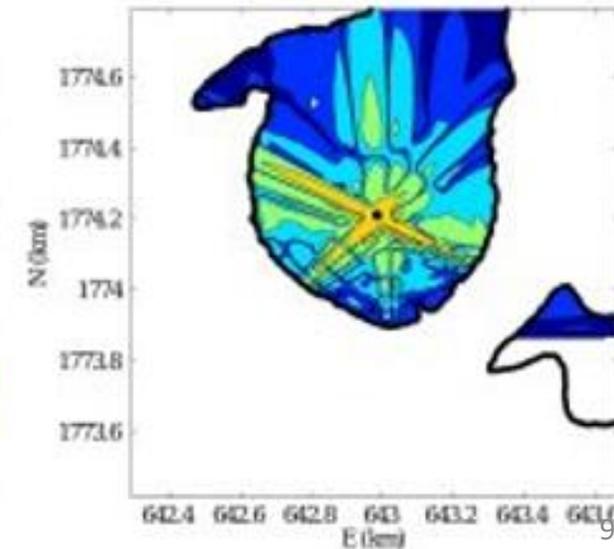
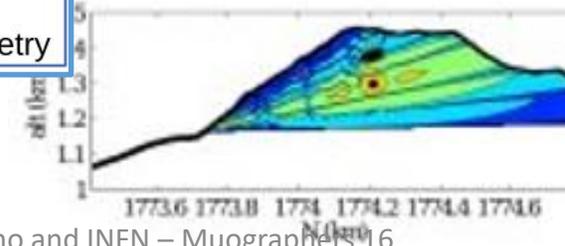
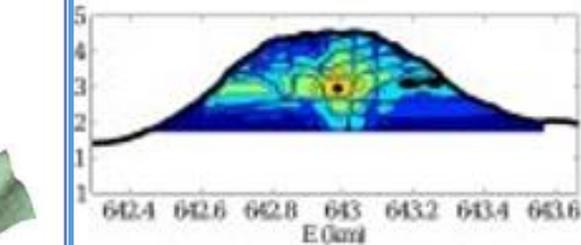
Electrical tomography – Gravimetry – Cosmic muons tomography



Observation campaign at La Soufrière de la Guadeloupe

Data taken with different techniques

Combination allows cross-correlation and disambiguation of physics phenomena



# Integration: a Great ENDEAVOR

Geophysicists-Elementary particle physicists Network DEvelopment Alliance for new style of VOlcano Research

Most knowledge is already available or at quick reach

Duplication of efforts and techniques is frequently found

## Internal dissemination and cultural exchange:

- Don't reinvent the wheel!
- Foster common design
- Promote reuse and adaptation of existing equipments
- Enable module sharing
- Learn how to combine knowledge and techniques from geophysics and particle physics to get complete pictures

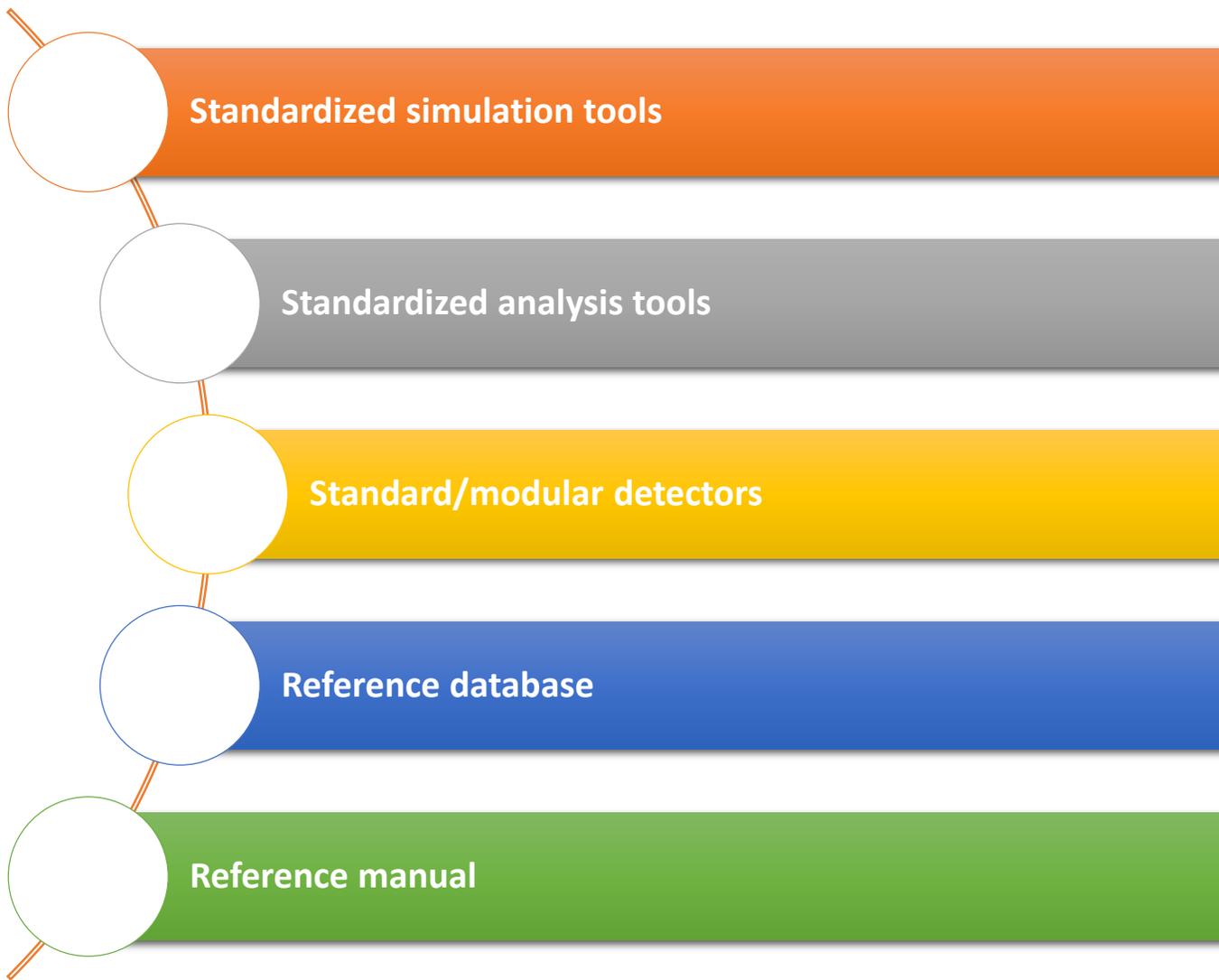
## Outbound dissemination:

- Support disaster prevention and mitigation agencies
- Educate people
- Improve awareness of volcano dynamics and risks



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**Standardized simulation tools**

**Standardized analysis tools**

**Standard/modular detectors**

**Reference database**

**Reference manual**

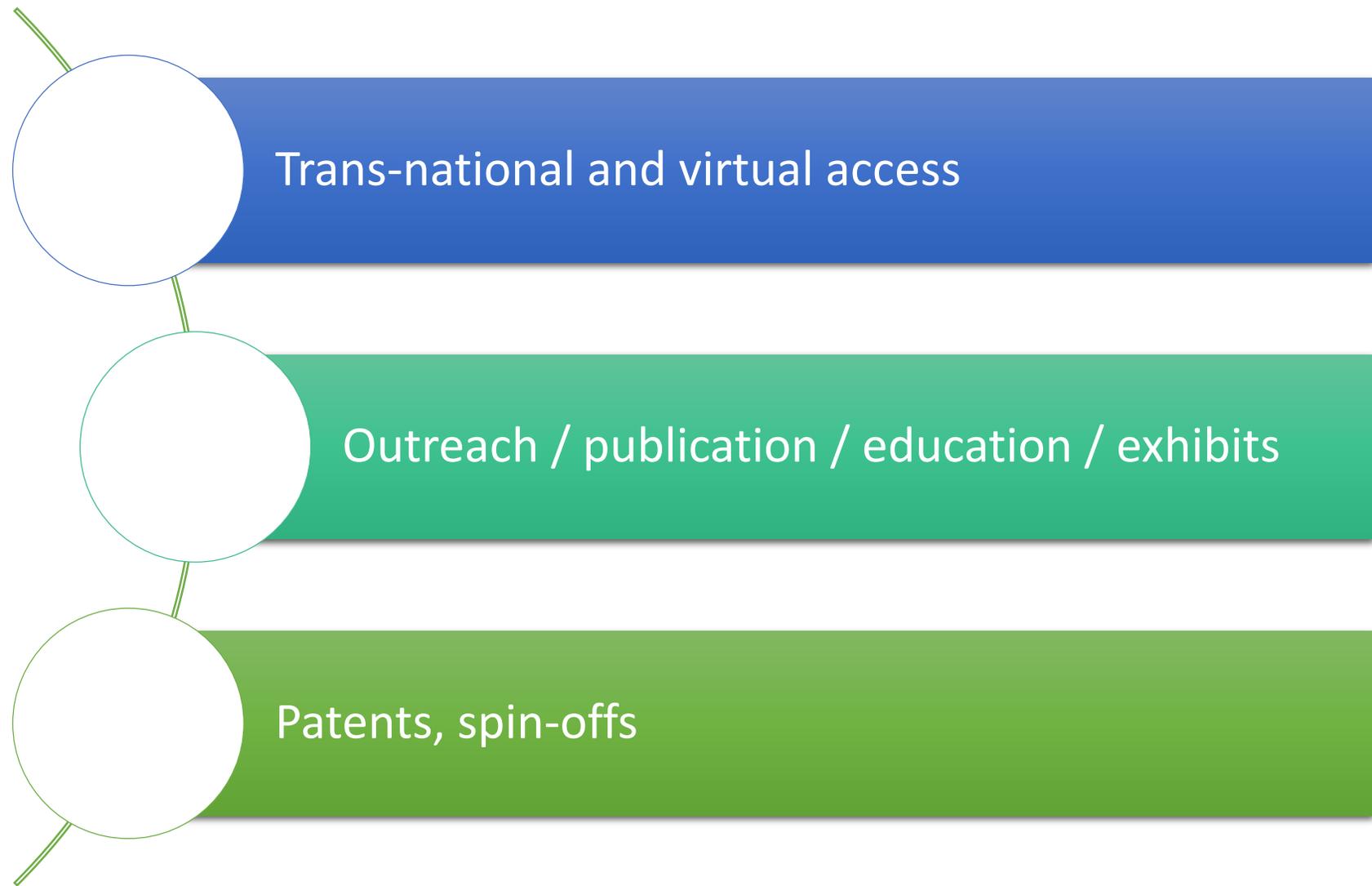
Integration is all about standardization

Joint efforts easier/only possible by means of common references and conventions

Large-scale (industrial) exploitation of techniques requires standardization

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Trans-national and virtual access

Once a network of research facilities using standardized tools and procedures exists, researchers can use it to promote and speed up science achievements

Outreach / publication / education / exhibits

For higher societal impact, the usual scientific communication is not enough and needs to be complemented with stable links both to disaster prevention and mitigation agencies and to general public education programmes

Patents, spin-offs

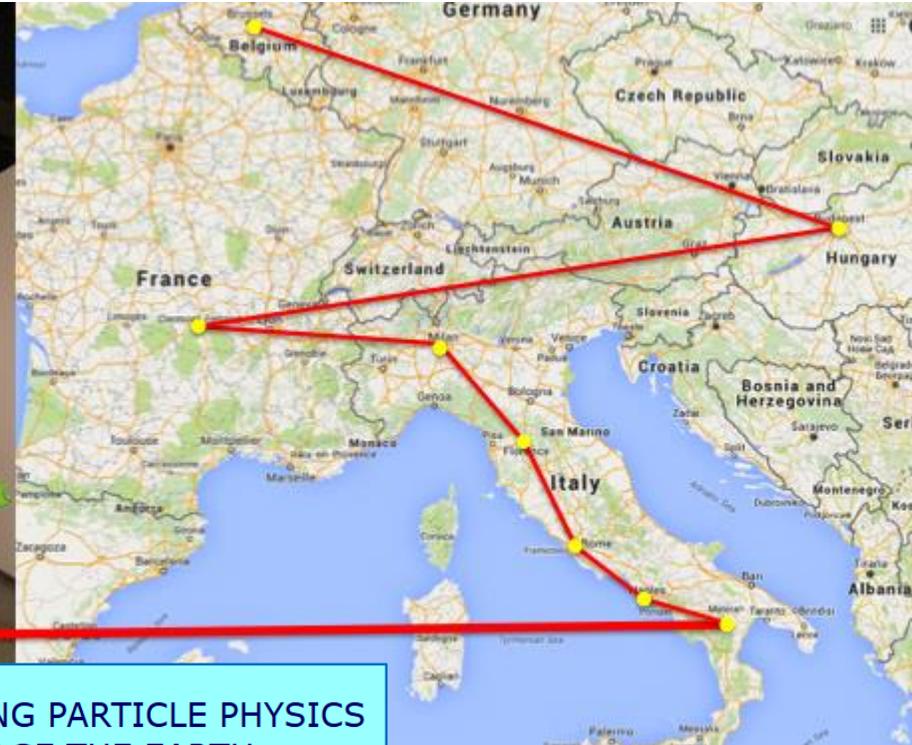
Patents can be generated from detector and analysis/simulation code development and standardization, ready for exploitation in geophysics as well other fields

# Muography dissemination

G. Ferrari – INGV – Travelling exhibit on muography



D. Varga – Wigner & Prof. H. Tanaka – Tokyo ERI  
Working sample detector



## SUMMER INSTITUTE: USING PARTICLE PHYSICS TO UNDERSTAND AND IMAGE THE EARTH

11-21 July 2016 Gran Sasso Science Institute  
Europe/Rome timezone

- Home
- Timetable
- Scientific program
- Contribution List
- Informations on GSSI
- Poster
- How to reach L'Aquila

✉ Contacts



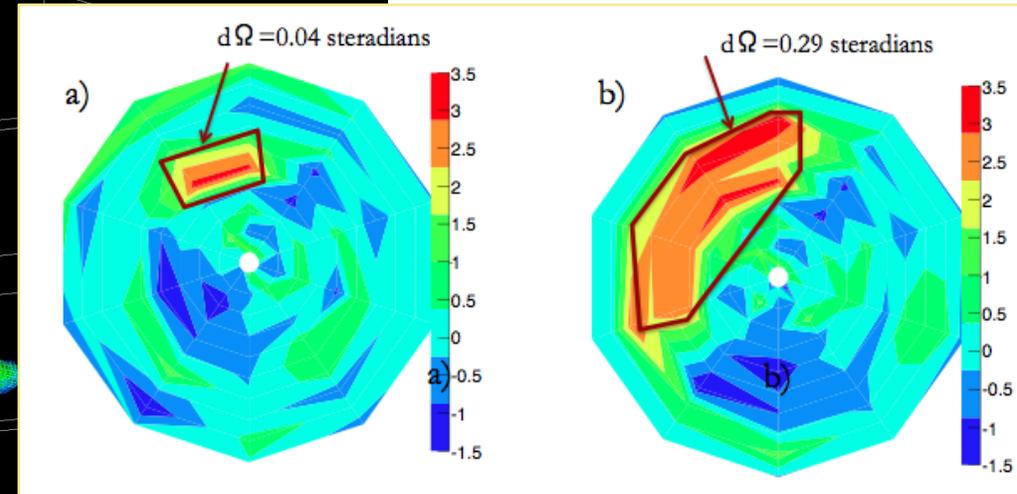
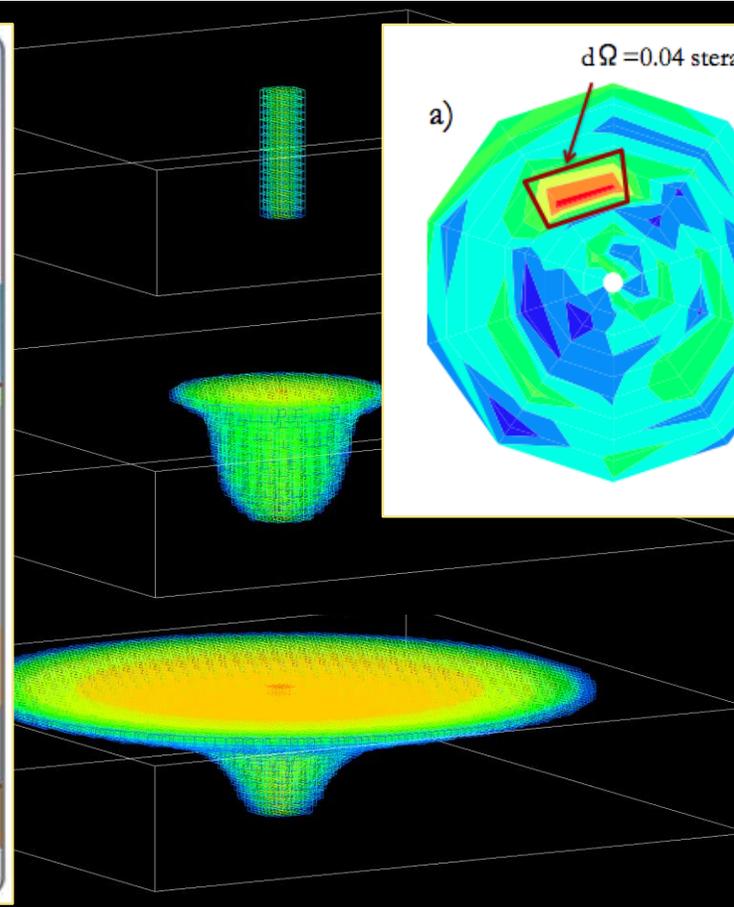
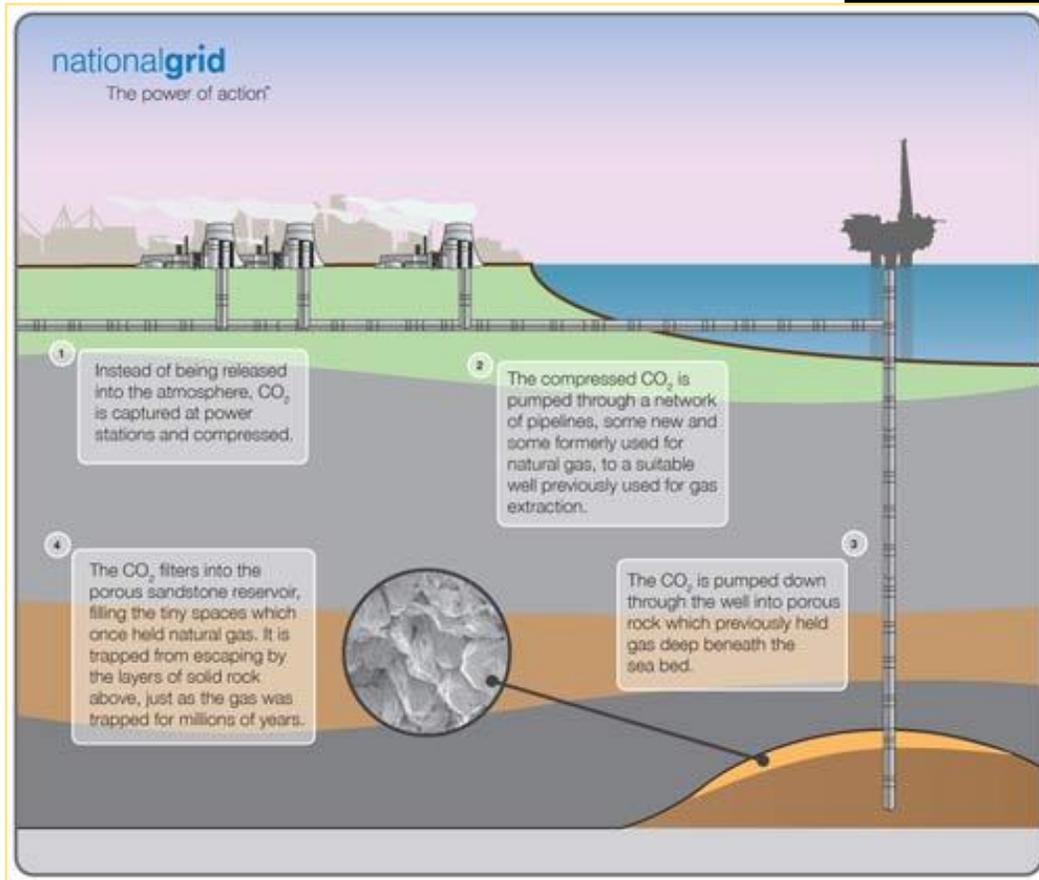
### Presentation

The techniques and methods developed originally in particle physics are finding their applications in a wide variety of fields. Also in geosciences, a new era in the study of the Earth interior came with a possibility to detect neutrinos, messengers from the radioactive decays inside the Earth, and to use cosmic ray products for a sort of radiography of the volcanic edifices, and, in perspective, of the Earth itself. The study of cosmogenic nuclides, which can give information about several aspects of the Earth's life and

Muography – related school  
at GSSI (2016)

# Muography applications

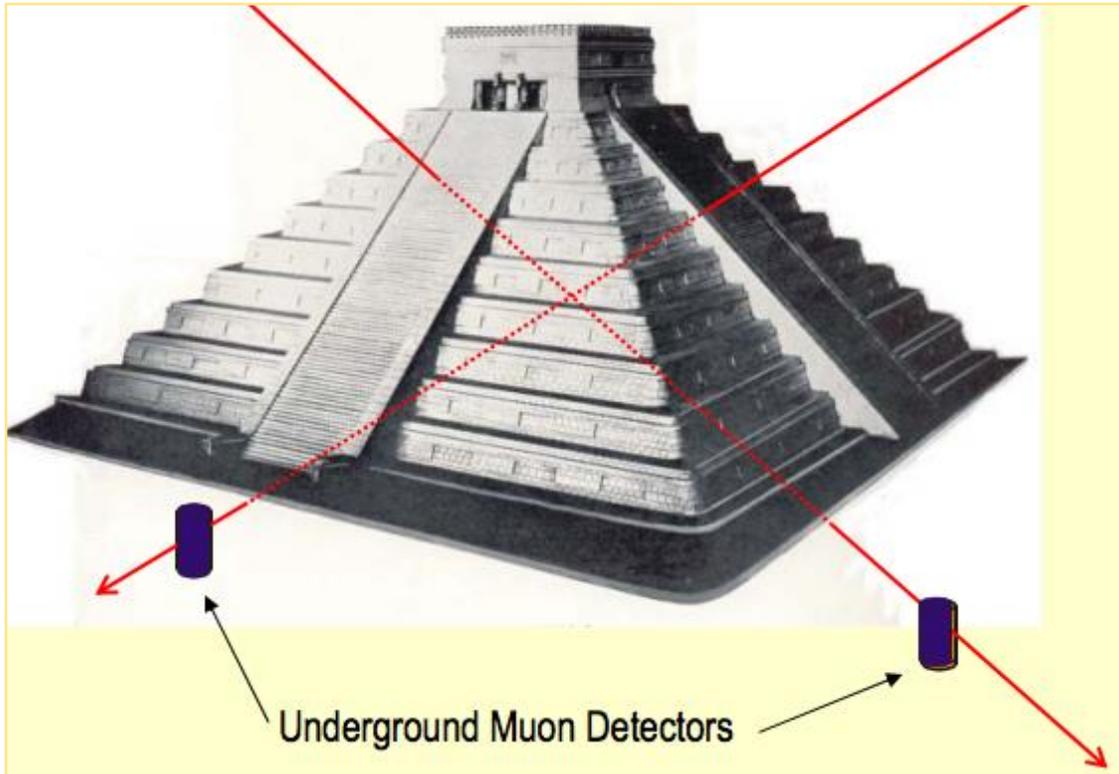
Cheap monitoring of injection and leakage of CO<sub>2</sub> storage



L. Thompson – U-Sheffield, J. Gluyas – U-Durham

# Muography applications

Investigation on historical/cultural inheritance



Detection of contraband high-Z (nuclear) material



L. Thompson – U-Sheffield, J. Gluyas – U-Durham

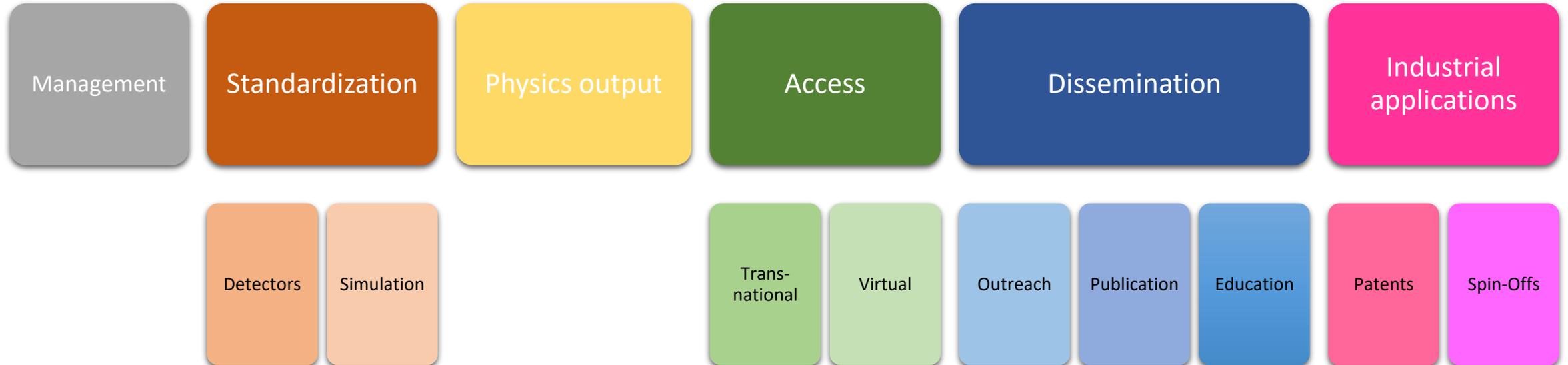
# Integration: a Great ENDEAVOR

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Preparing for  
a near future call

Work packages: a tentative division



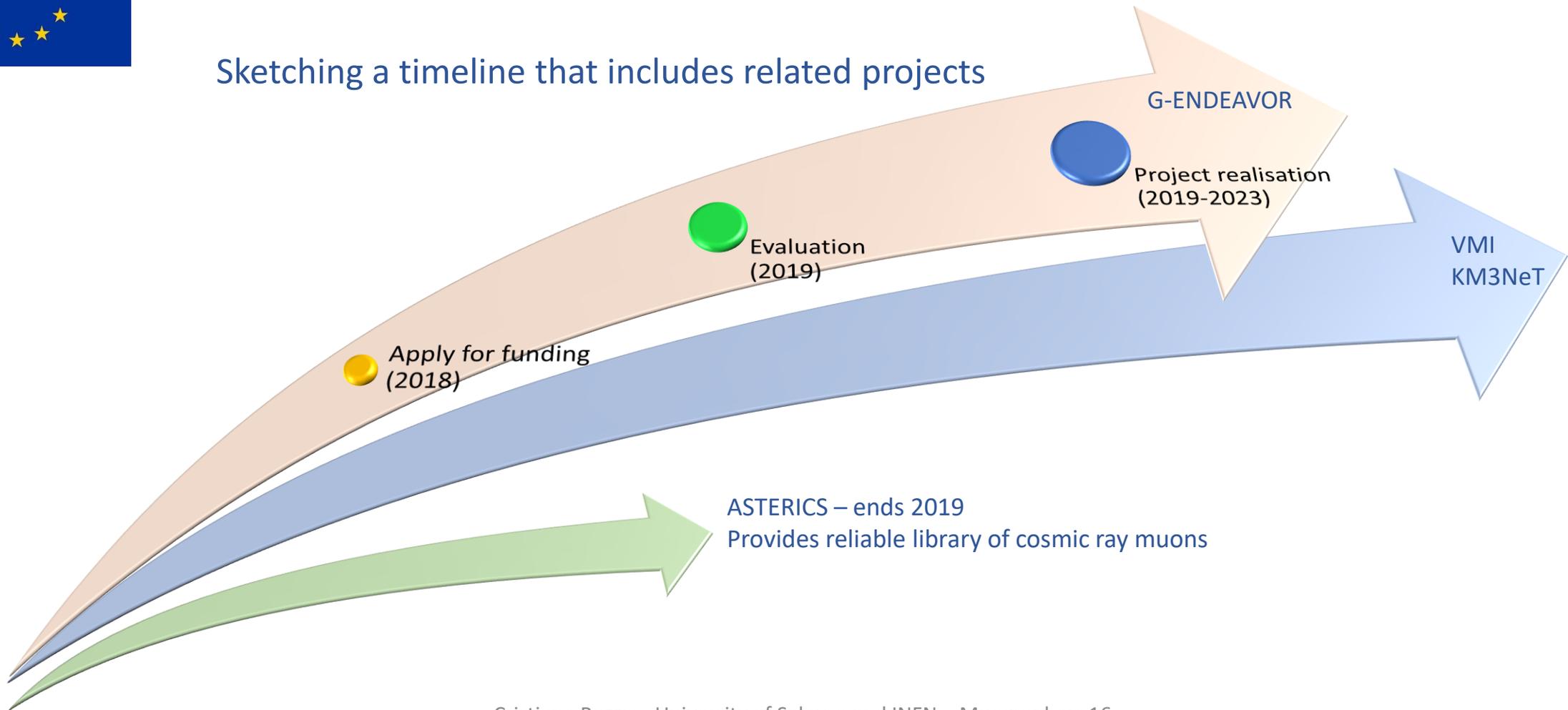
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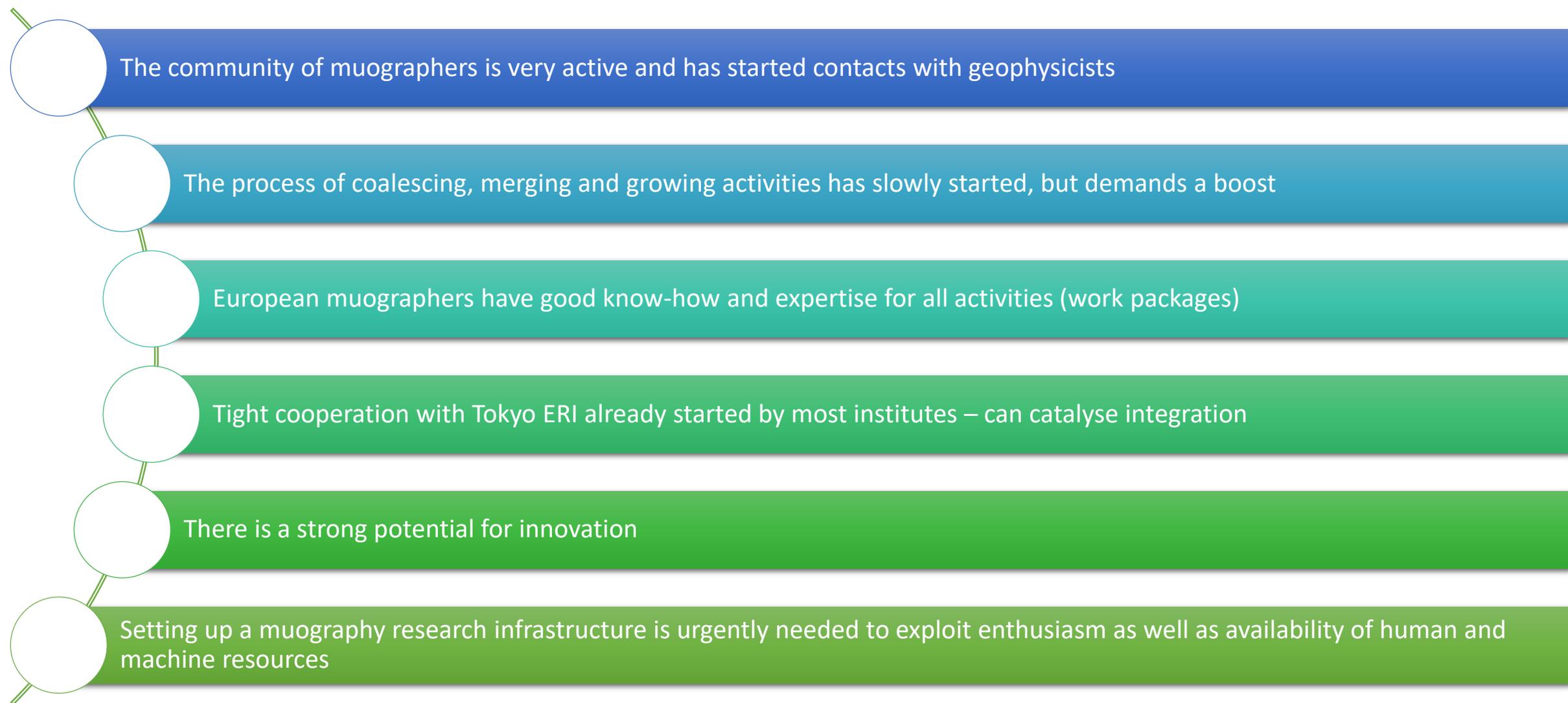


Preparing for  
a near future call

Sketching a timeline that includes related projects



# Conclusions



The community of muographers is very active and has started contacts with geophysicists

The process of coalescing, merging and growing activities has slowly started, but demands a boost

European muographers have good know-how and expertise for all activities (work packages)

Tight cooperation with Tokyo ERI already started by most institutes – can catalyse integration

There is a strong potential for innovation

Setting up a muography research infrastructure is urgently needed to exploit enthusiasm as well as availability of human and machine resources