

IRIS INSTRUMENTS

IRIS Instruments, a subsidiary of BRGM and the Japanese group OYO Corporation, has been designing and manufacturing geophysical equipment dedicated to subsurface imaging for the geosciences and civil engineering since 1990. Its main areas of activity include mining exploration, groundwater research and the environment.



With five key technologies - electrical resistivity, induced polarization, electromagnetism, nuclear magnetic resonance and muography - its expertise meets a wide range of needs. Its international customer base includes socio-economic players and academics. Sales are mainly exported (>90%), with Asia the main market, followed by the Americas, Africa and the Middle East.

Its mission: to offer innovative, reliable and durable equipment, through complete control of the value chain, from R&D design to manufacturing, sales and repair. The products, designed with precision electronics, can be used in a wide range of climatic conditions and are repairable for life. The same instrument meets the needs of an academic researcher looking for high measurement accuracy and a field operator looking for productivity. Research and Development dynamic fuels innovation, making its products competitive on world markets.

In addition to the technical quality of its instruments, IRIS Instruments relies on personalized support, efficient logistics and fast delivery times, delivering worldwide in just a few weeks. Finally, IRIS Instruments is committed to responsible business, combining technical performance with respect for environmental and social standards, while promoting reparability and a positive impact at every stage of its activity.



CASSI: FROM RESEARCH DEVICES TO TURNKEY INSTRUMENTS

Started as research projects to better understand the phreatic system of La Soufriere volcano and the Khufu's pyramid. The muon telescope technology is brought to you by Iris Instruments to take advantage of, the unmatched efficiency and on one hand, the collection surface and on the other hand, the unequaled resolution for muon reconstruction. Already deployed in many different environments (archeological sites, tunnel boring machines, mine tunnels, quarries, border control points, nuclear industry,...), they will suit many different applications. They provide a timestamped muon trajectory parameter list to allow for an in-depth analysis either in static imaging or in temporal variations.



STATE OF THE ART PARTICLE DETECTORS IN A FIELD READY INSTRUMENT

The instruments are compact and sturdy : they will handle many deployment environments. From confined places to rough transport winced up into a helicopter, the instruments can be brought to nearly any site. With their modular strut legs, they can be easily aimed at any direction above the horizon. When in place, a simple 12V supply will bring them to life either from grid power or a battery backed solar power array, the instruments will tolerate voltage variations from the battery. They will operate autonomously but they can be monitored remotely using its network port. The gas needed to operate the micromegas one is readily available in premixed compressed gas bottles. This gas is non toxic, non flammable and harmless for the environment. The low gas consumption of the instrument will allow its operation for several months with a single bottle.



FIELD VALIDATED WITH BRGM AND MUODIM

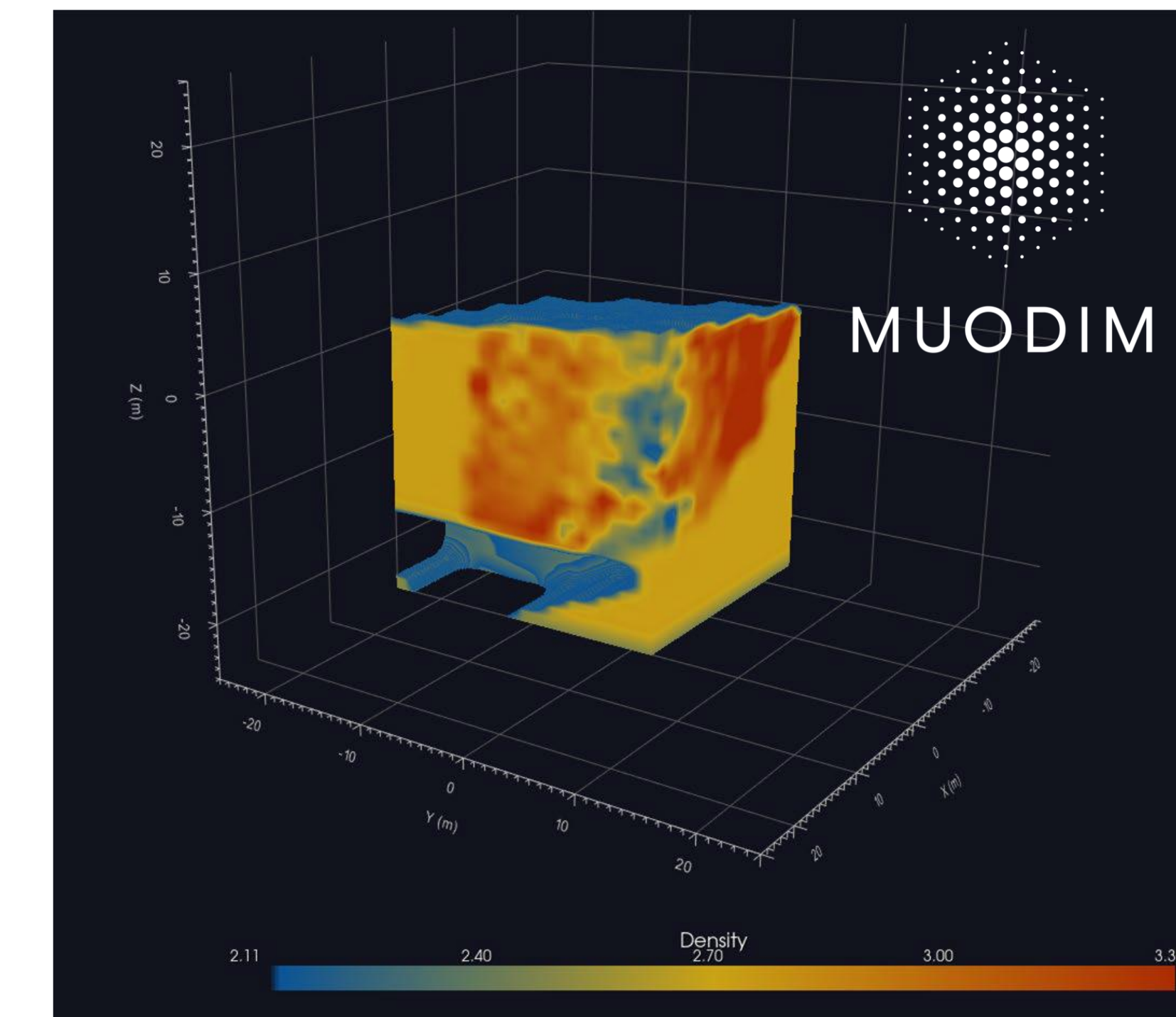
To ensure the performances of our instruments, we deployed them in various environments with the help of our partner the BRGM. This allowed us to test them in real geophysics setups. In particular in decommissioned mines and cliff monitoring. These sites present real challenges in order to ensure the safety of the surface activities: from sinkhole formation to boulder fall. Since IRIS Instruments does not specialize in data analysis. We also partnered with Muodim to interpret it.



MUOGRAPHY: A NEW TOOL TO ENHANCE THE GEOPHYSICIST TOOLBOX

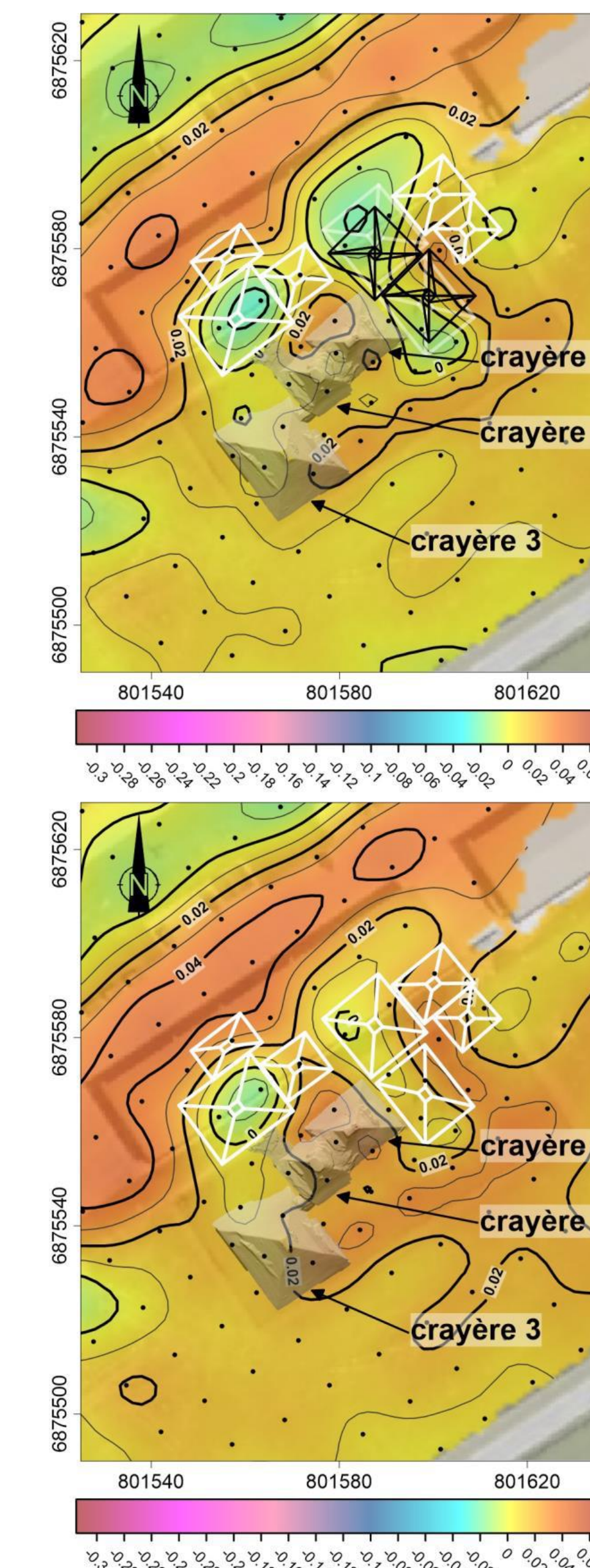
Electromagnetic and seismic methods can unveil a lot of the unknown of the subsurface. However, muography can shed a new light on studied objects, unveiling new features that other methods failed to show or did not characterize with enough precision. Our proof of concepts showed that it can image and monitor a cliff at more than 1km distance, safe from hypothetical boulder falls. It can also image poorly known voids of a decommissioned mine below a suburb.

In decommissioned mines, we can also use multiple instrument to produce a 3D scan of the overburden below the town. The contours of the decompressed volume is clearly identified from the surface to the gallery 30m below. This information was not available to the team in charge of the security of the mine despite multiple surveys

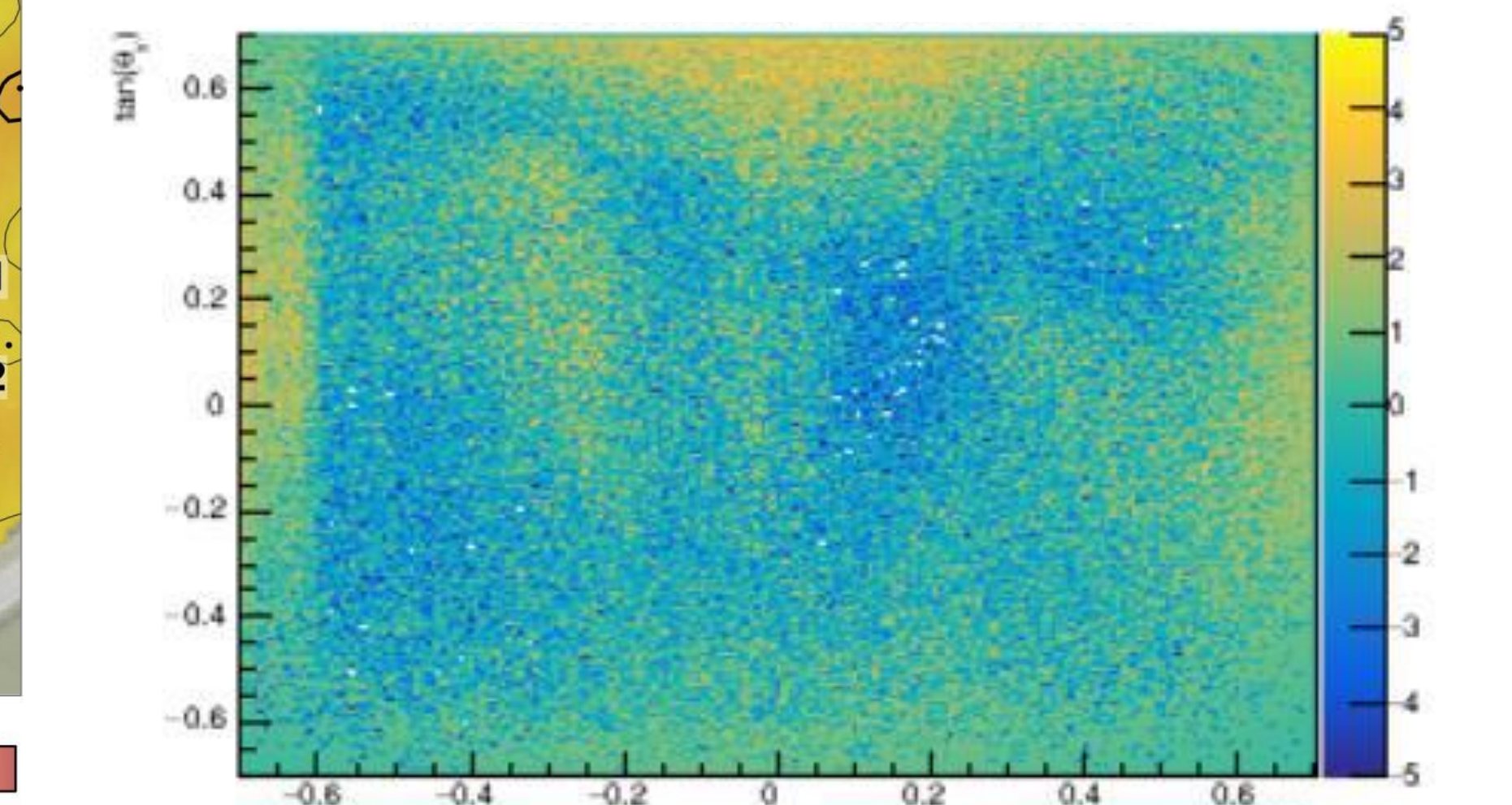


MUOGRAPHY: A TOOL BEST PAIRED WITH GRAVIMETRY

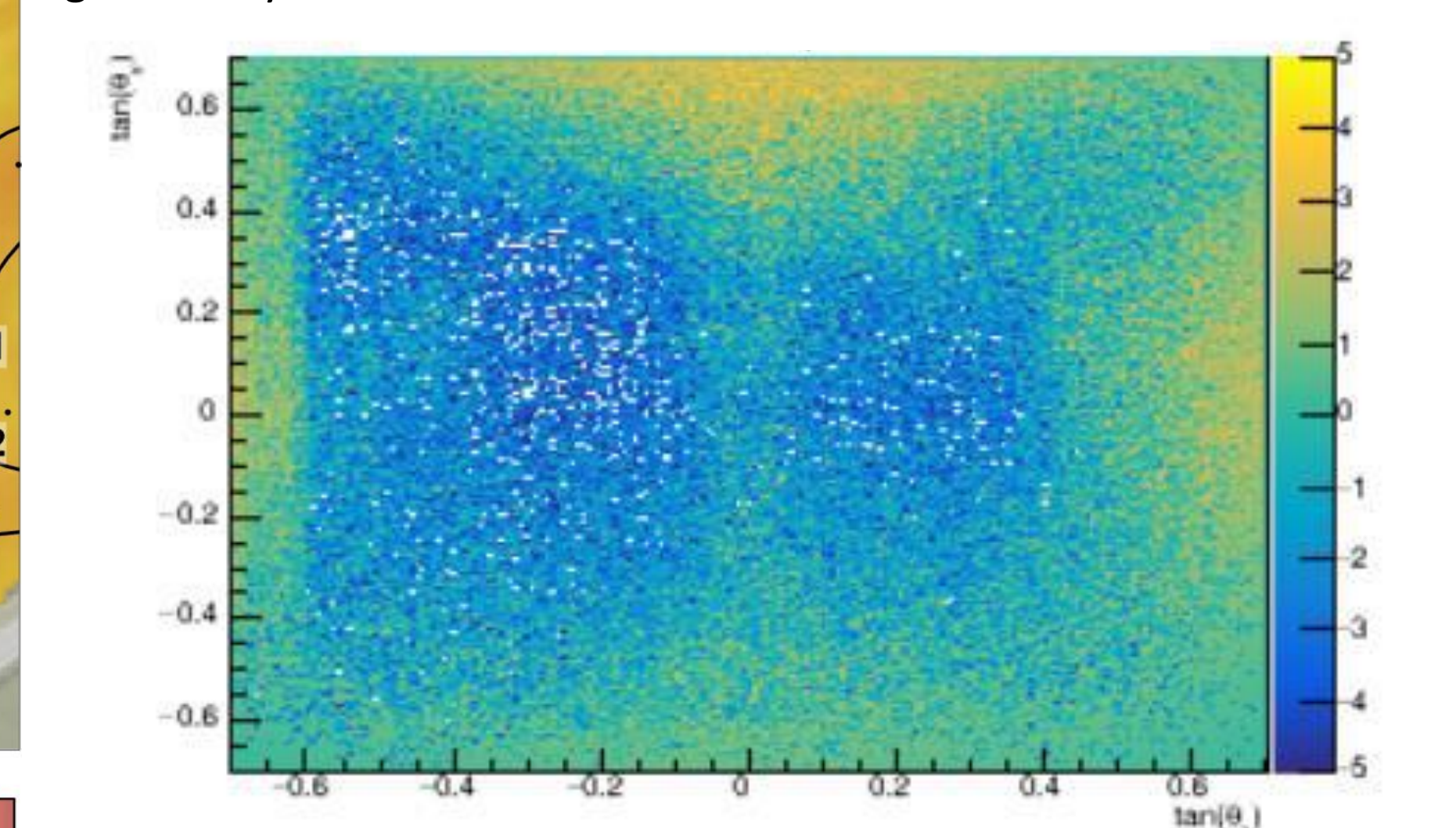
Muography and gravimetry are sensible to the same physical property of matter : its density. This allow to make joint study of the same object and even to have a joint data inversion. In our particular case study, a complex of chalk quarry consisting of merged hollow pyramids of 20m wide base at 30m below the surface. However, these quarry are normally found in larger clusters. This triggered a gravimetric study of the zone. After the suppression of the known voids' contributions, a model was made to explain the remaining anomaly. However, recording muography data from the bottom of the quarry, allowed us to greatly refine the model.



Remaining anomaly after model contribution subtraction, best muon fit



Remaining anomaly after model contribution subtraction, best gravimetry fit



	CASSIs	CASSIm
Technology	Scintillator	Micromegas (MPGD)
Dimensions (mm)	1000x1000x1200	664x664x900
Weight without shielding (kg)	130	90
Possible inclination	Continuous from zenith to horizon	
Low energy shielding	Optional, up to 5cm	
Power supply	9-18V DC (12V nominal) Battery compatible	
Power consumption	<50W	
Spatial resolution	<15mm	<300µm
Active area (mm)	800x800	500x500
Filed of view	72° to 111°	64° to 100°
Angular resolution	Up to 22mrad @ 72°FoV Up to 45mrad @ 111°FoV	Up to 750µrad @ 64°FoV Up to 1.5mrad @ 100°FoV
Communication	Ethernet : Web DAQ, SSH available	
Data output	Timestamped muon position and direction	
Needed supply	None	Ar:CO ₂ :iC ₄ h ₁₀ gas mixture @ <1.5L _n /h
Backed by state-of-the-art technology		