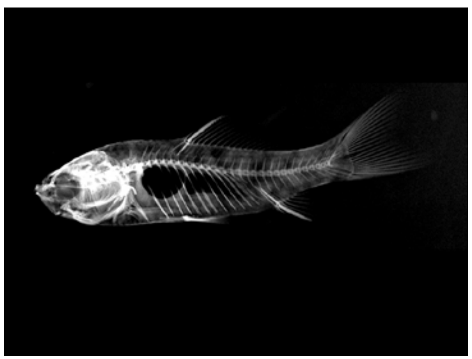
General introduction to physics case for the detectros in volcanology, seismic fault, industries, and extraterrestrial planetary explorations

Hiroyuki Tanaka

Particle radiography

photography



muogrphay

neutrinography

m

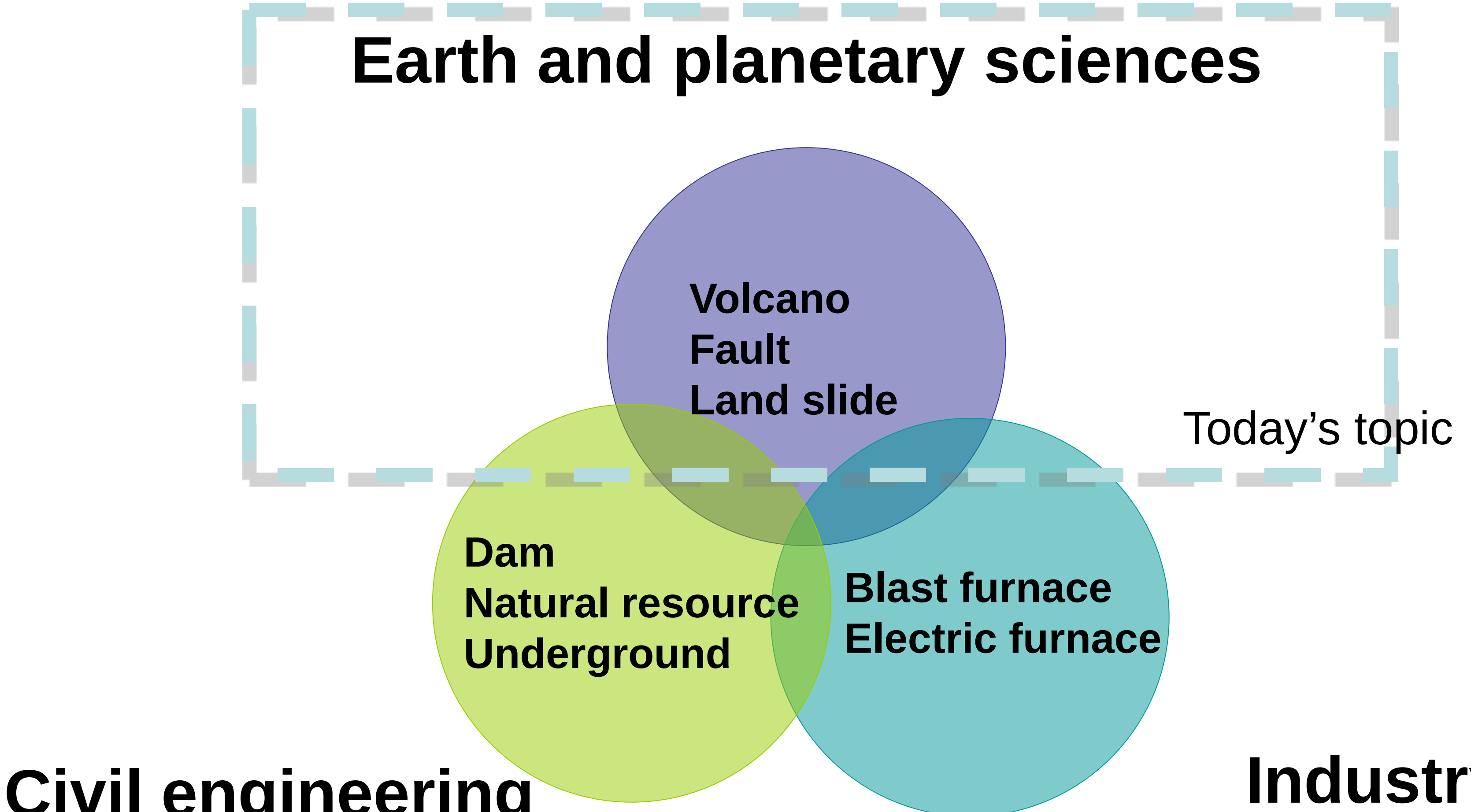
km

Mm

scale

Today's topic

Target of muon radiography



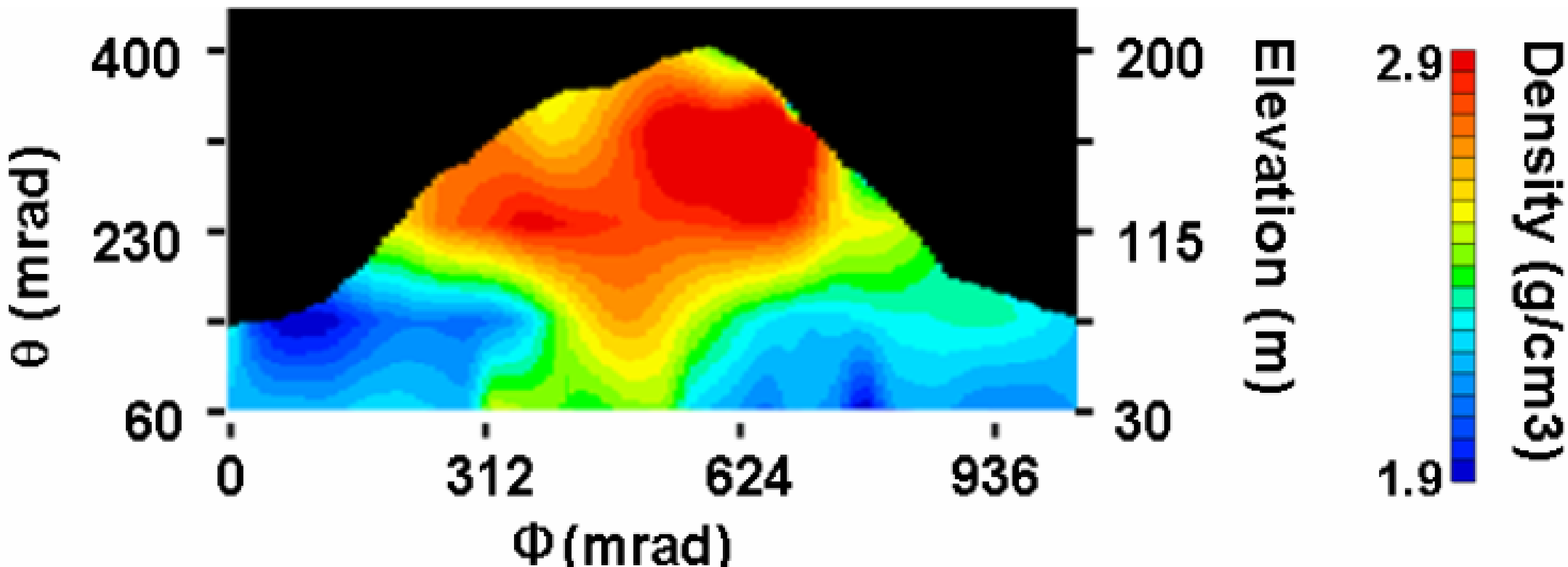
Emulsion chambers

Pros:
- Light
- Portable
- Electric power is not necessary

Cons:
- Long duration for analysis
- Noise reduction problems
- Temperature
- Non real time

Good for small target without necessity of an electric infrastructure

Showa-shinzan lava dome



4-month result

The simplest electronic detector

Pros

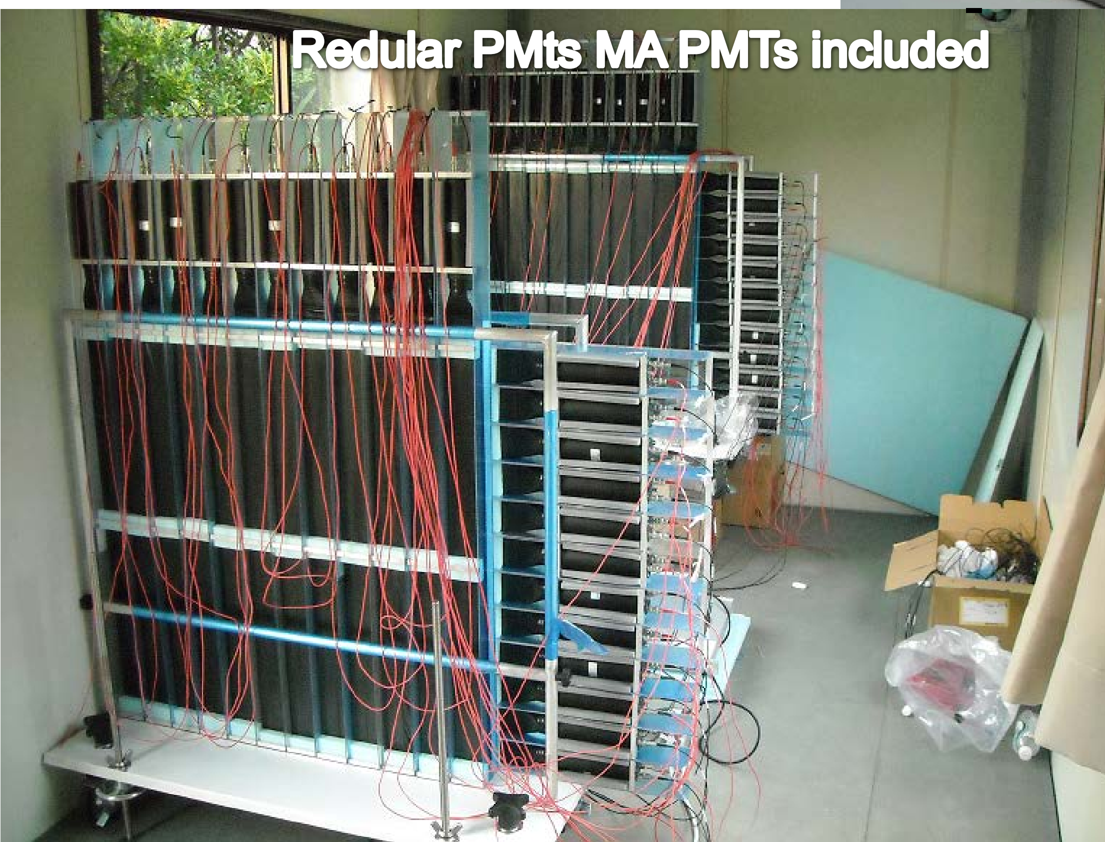
- Real time readings
- Transportable
- Low power consumption

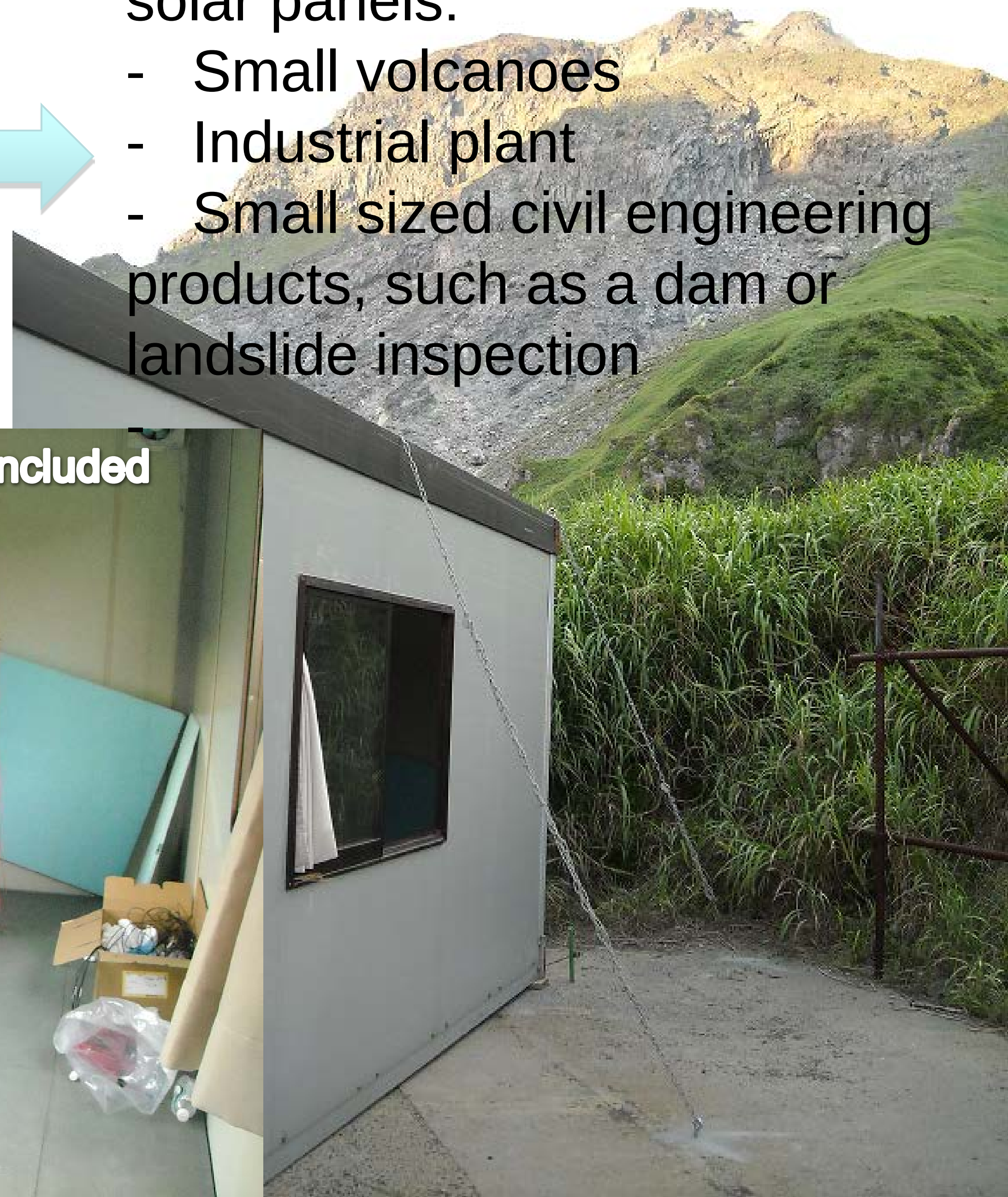
Cons

- Noise reduction problems
-

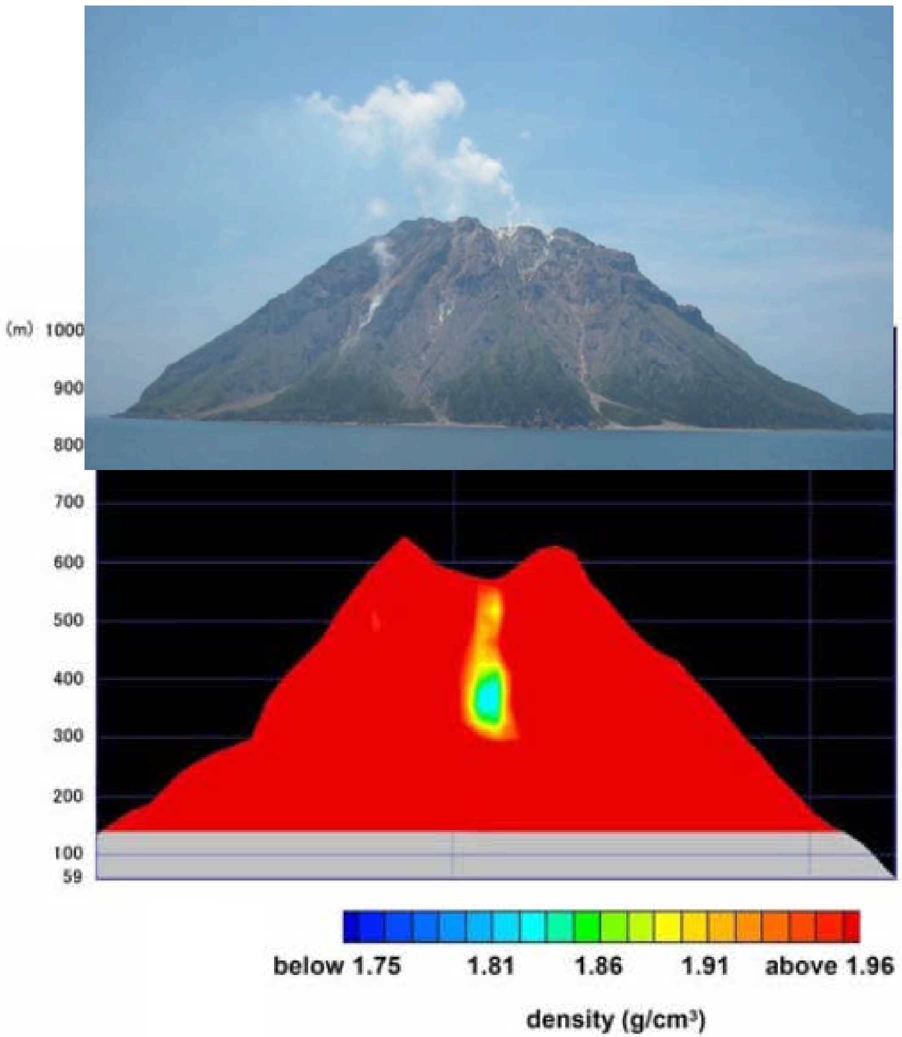
Good for a small size target with solar panels:

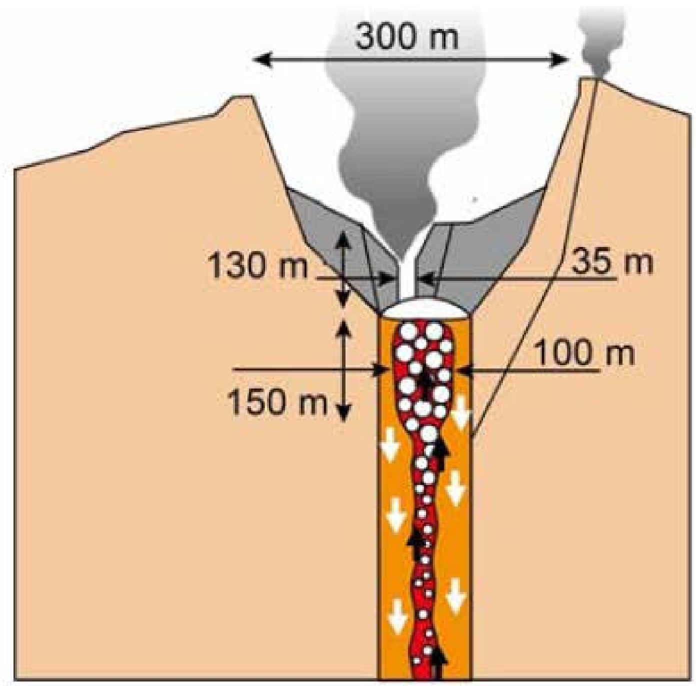
- Small volcanoes
- Industrial plant
- Small sized civil engineering products, such as a dam or landslide inspection
-





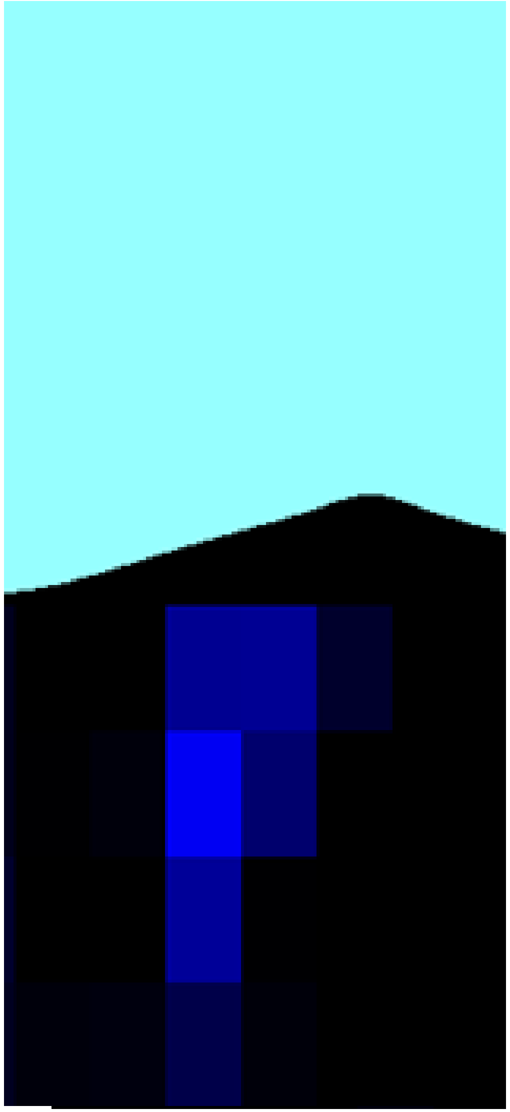
Radiograph in Iwojima



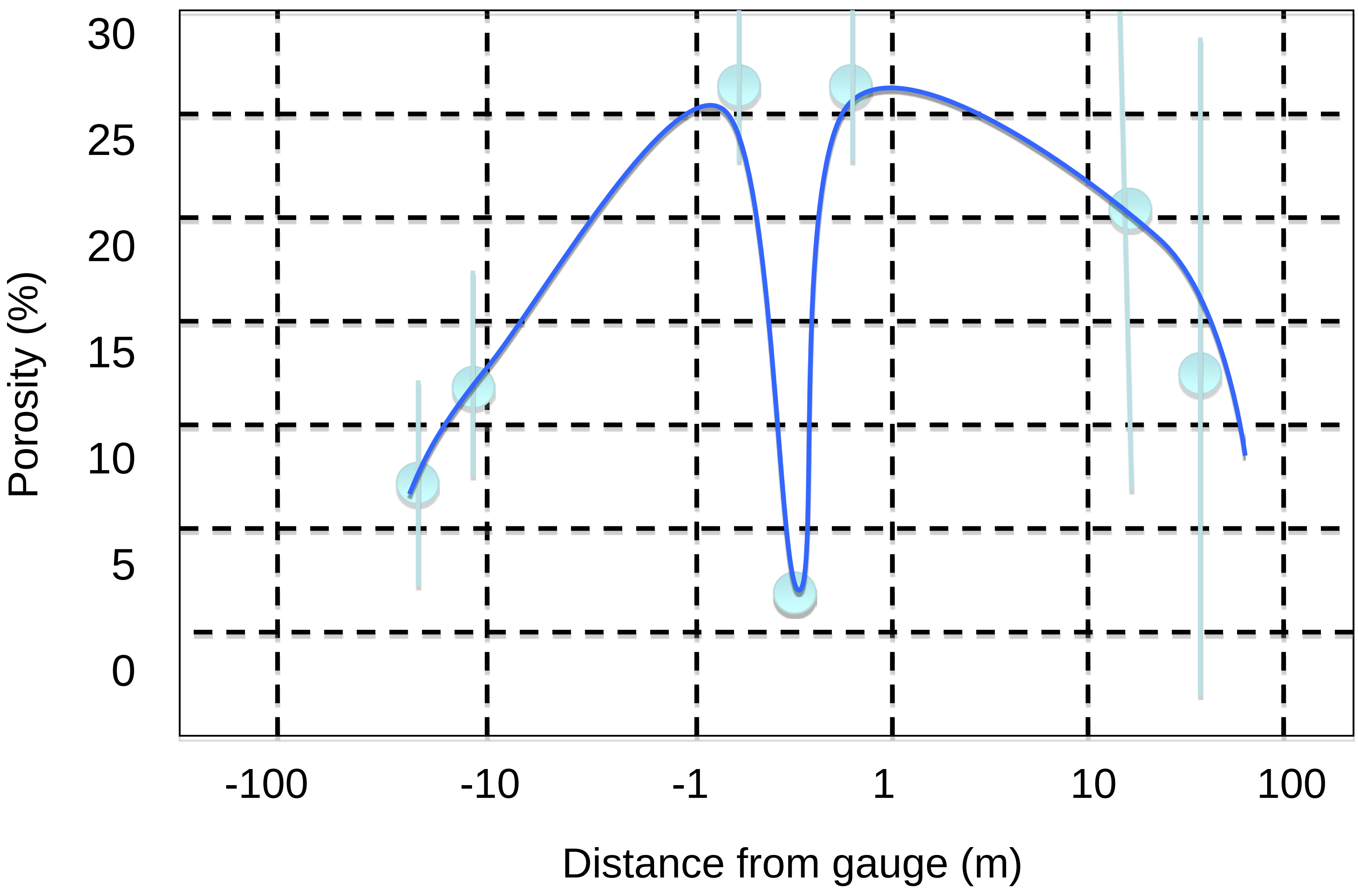


<u>40 days result</u>

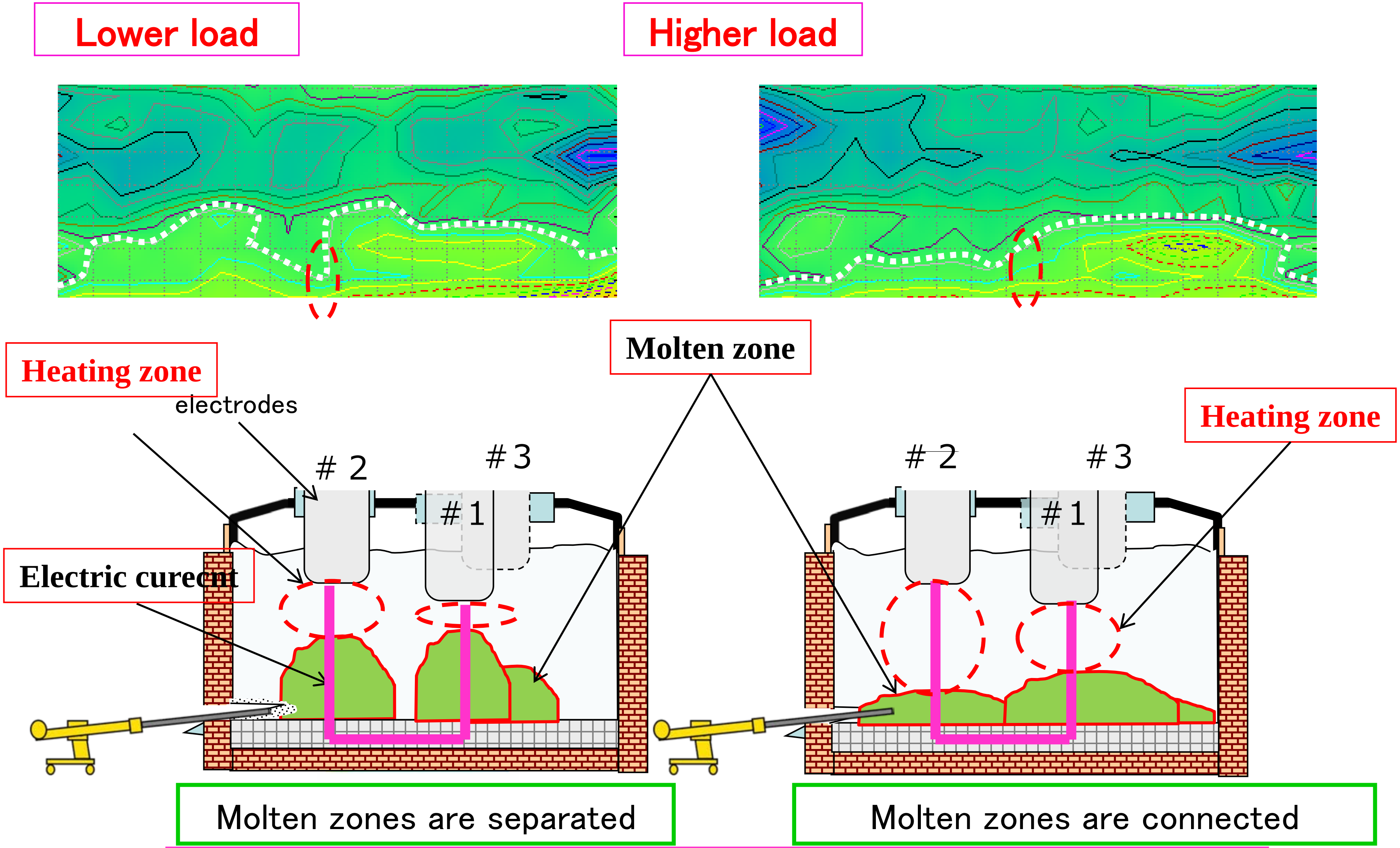
Seismic fault



Porosity distribution from gauge



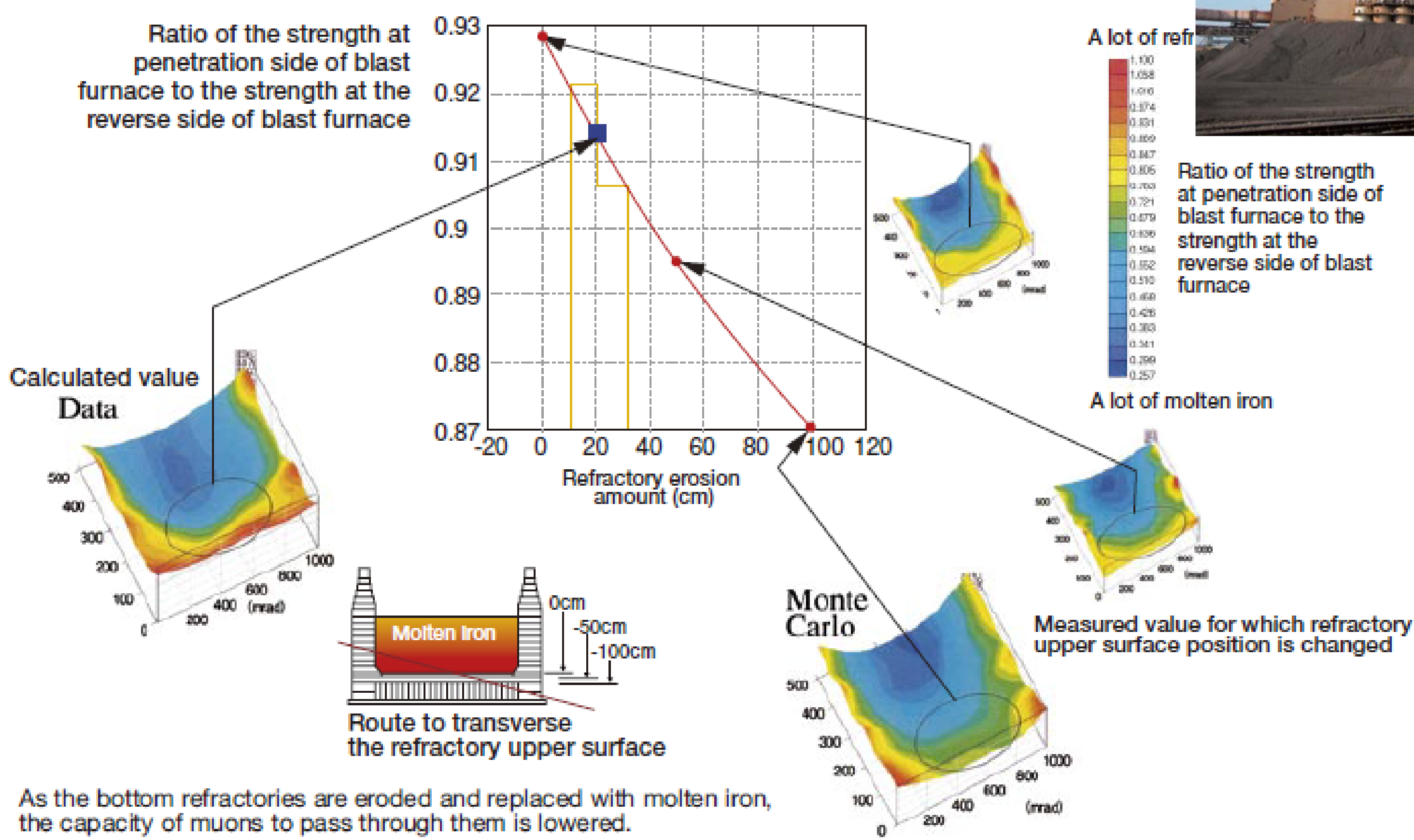
Electric furnace

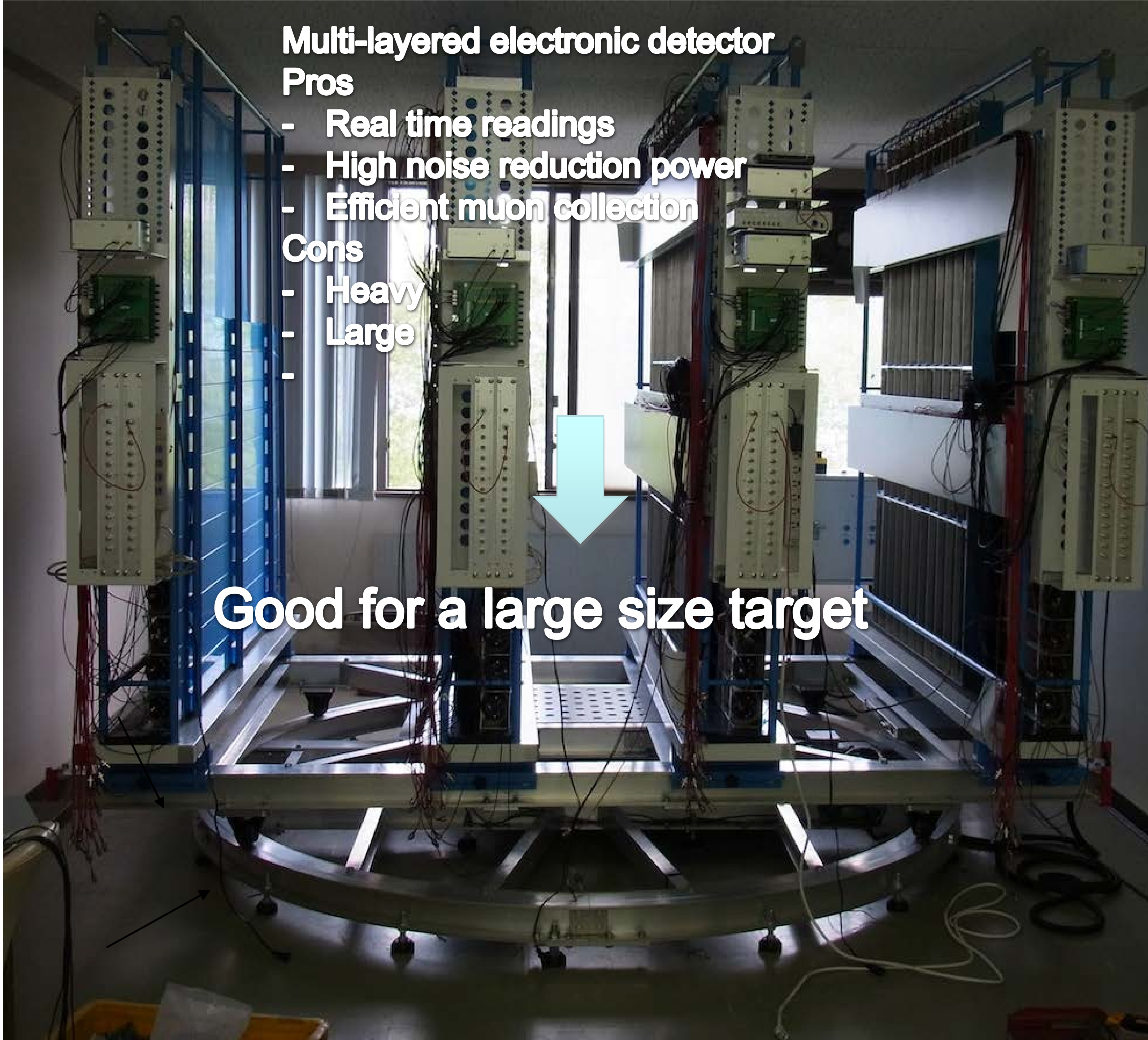


Higher productivity with higher load

Blast furnace

Estimated amount of erosion



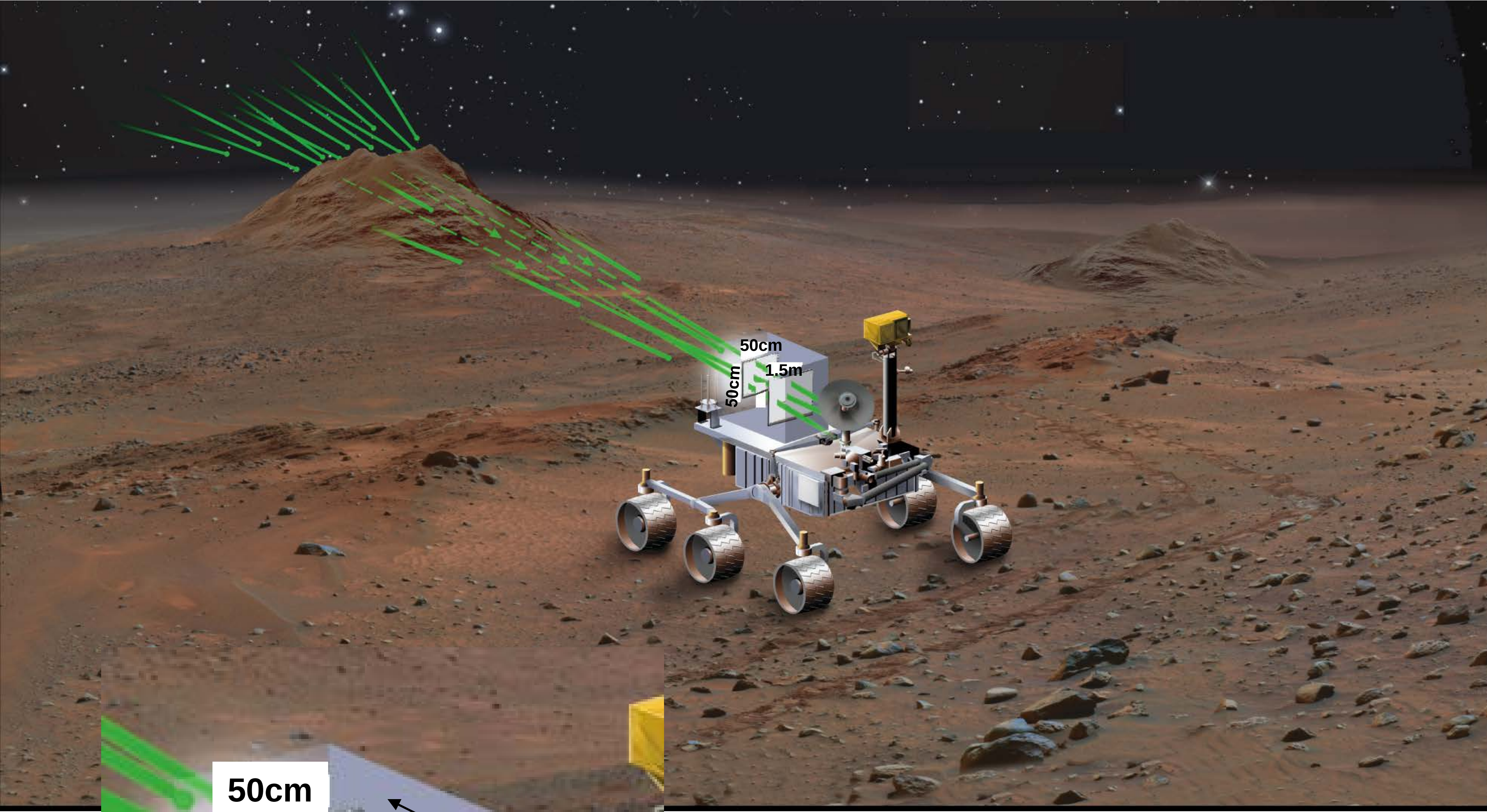

Multi-layered electronic detector
Pros
- Real time readings
- High noise reduction power
- Efficient muon collection
Cons
- Heavy
- Large
-
Good for a large size target

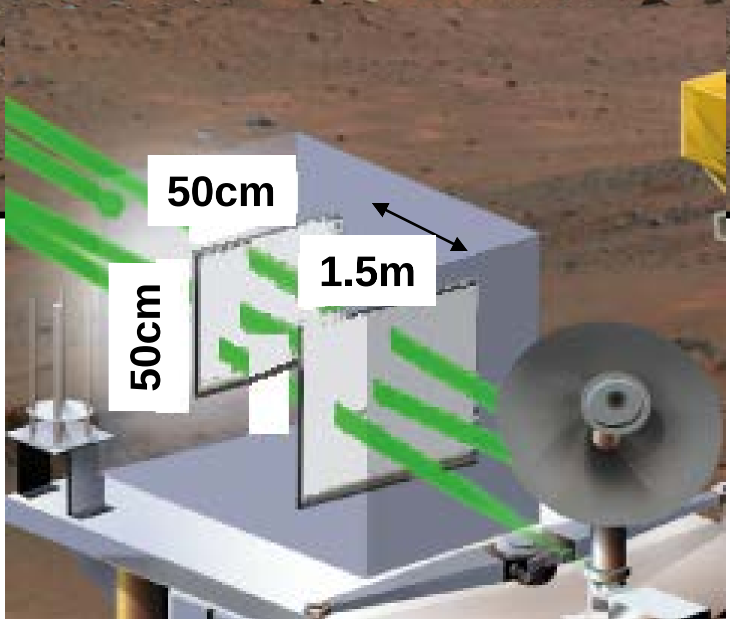
Very simple battery operated mobile detectors

Mobile observation

Lithium Batteries

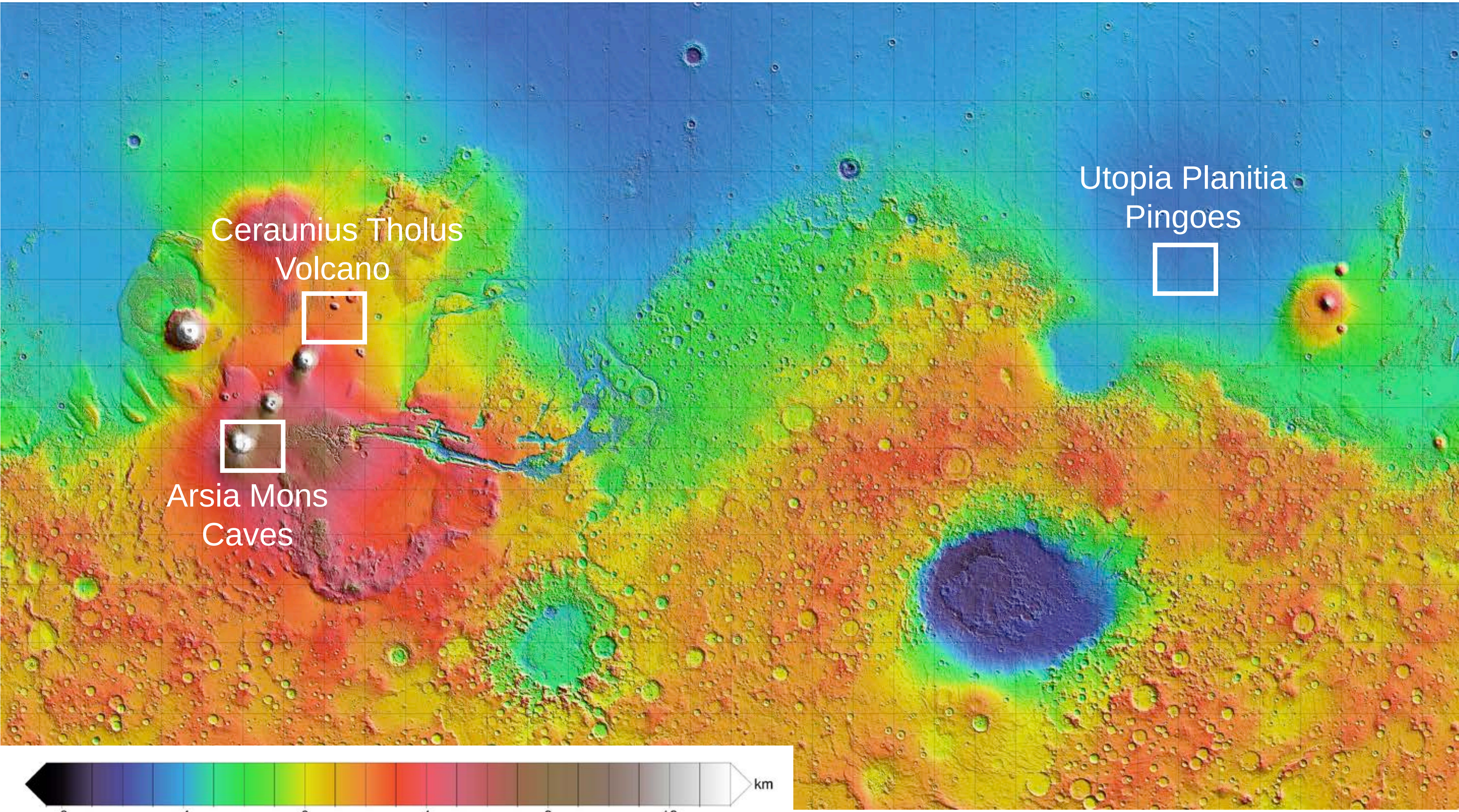
Can be applied to the muon measurement in more harsh environment.





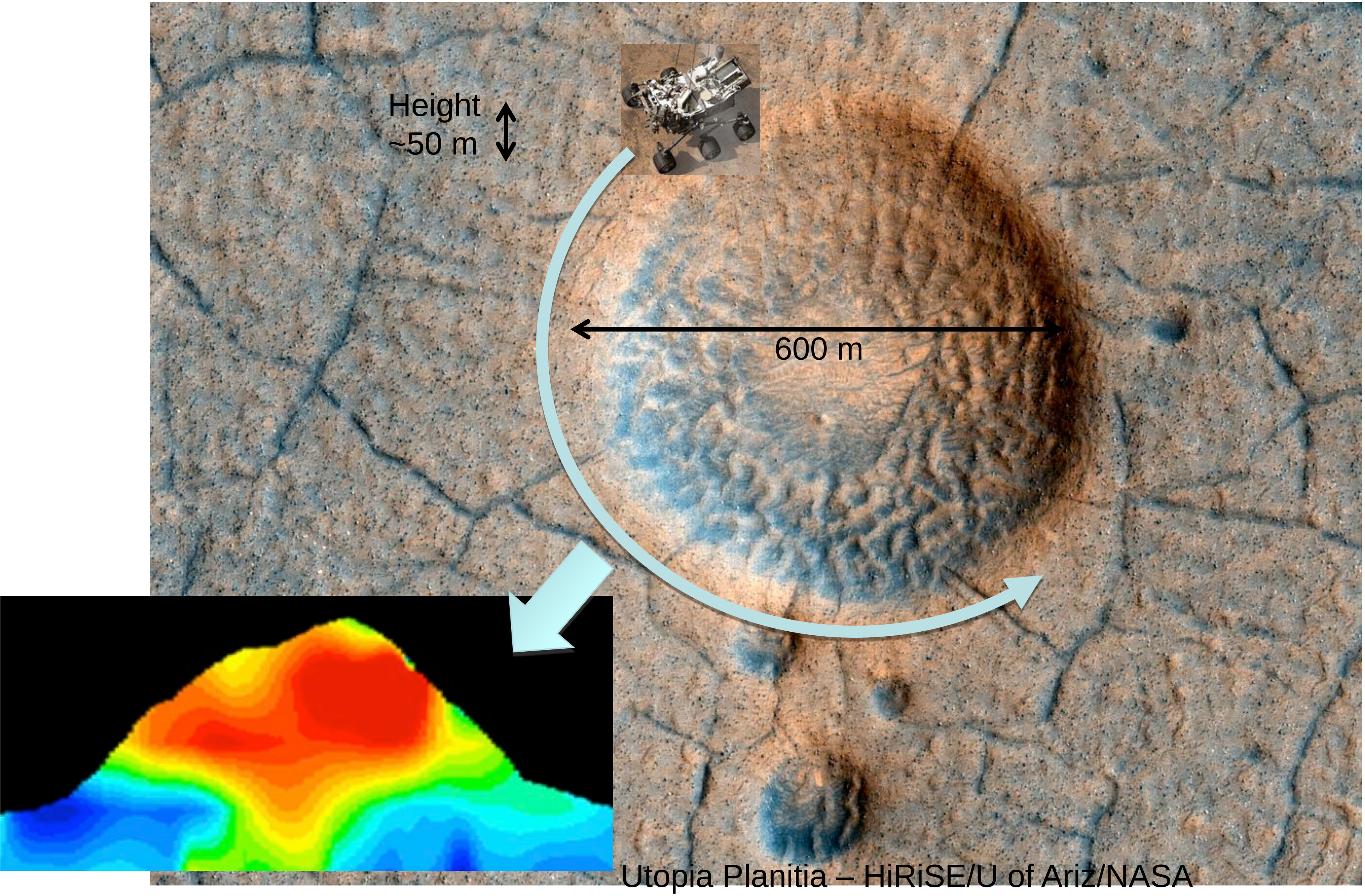
Mars exploration

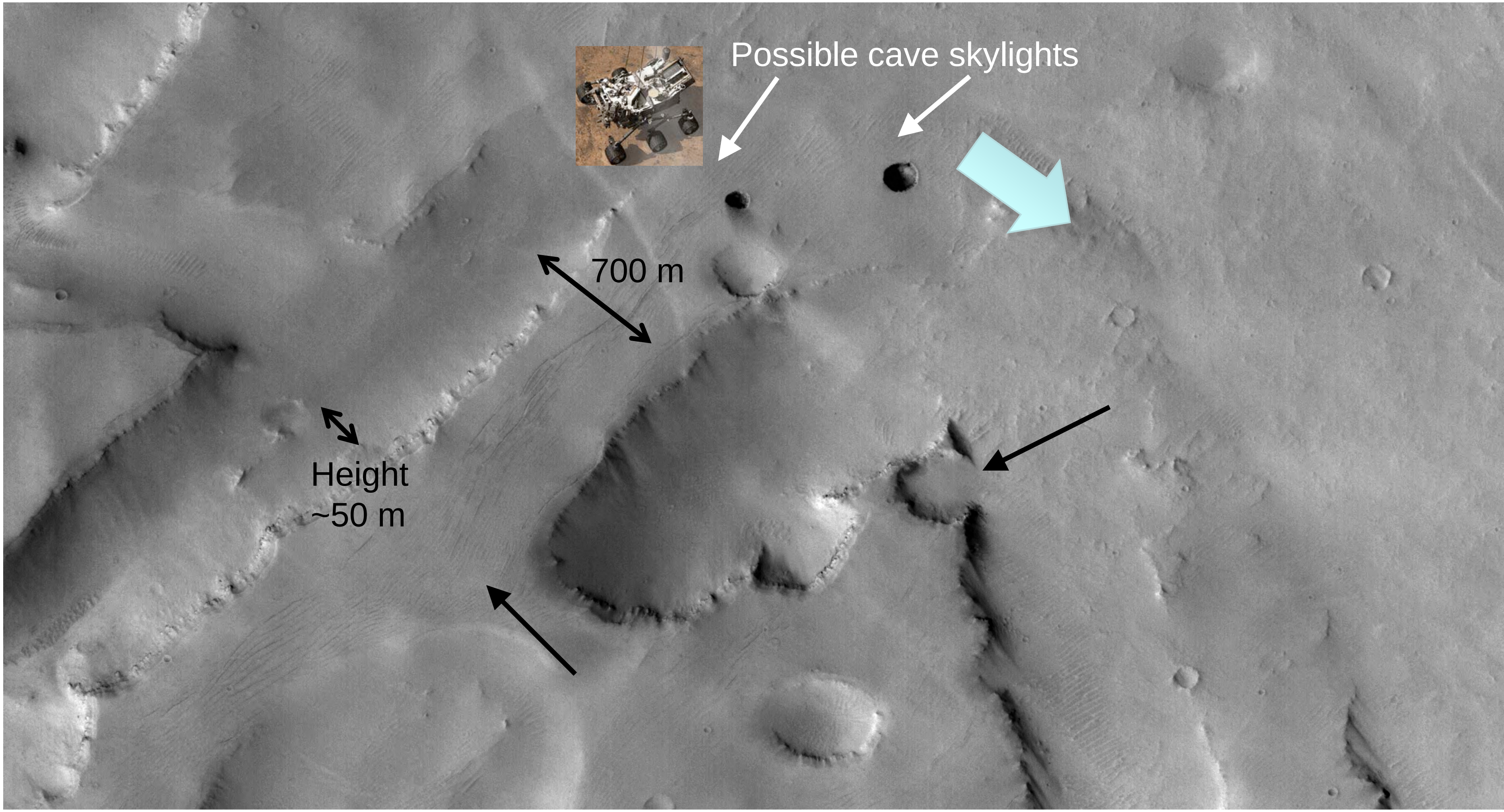
Possible target



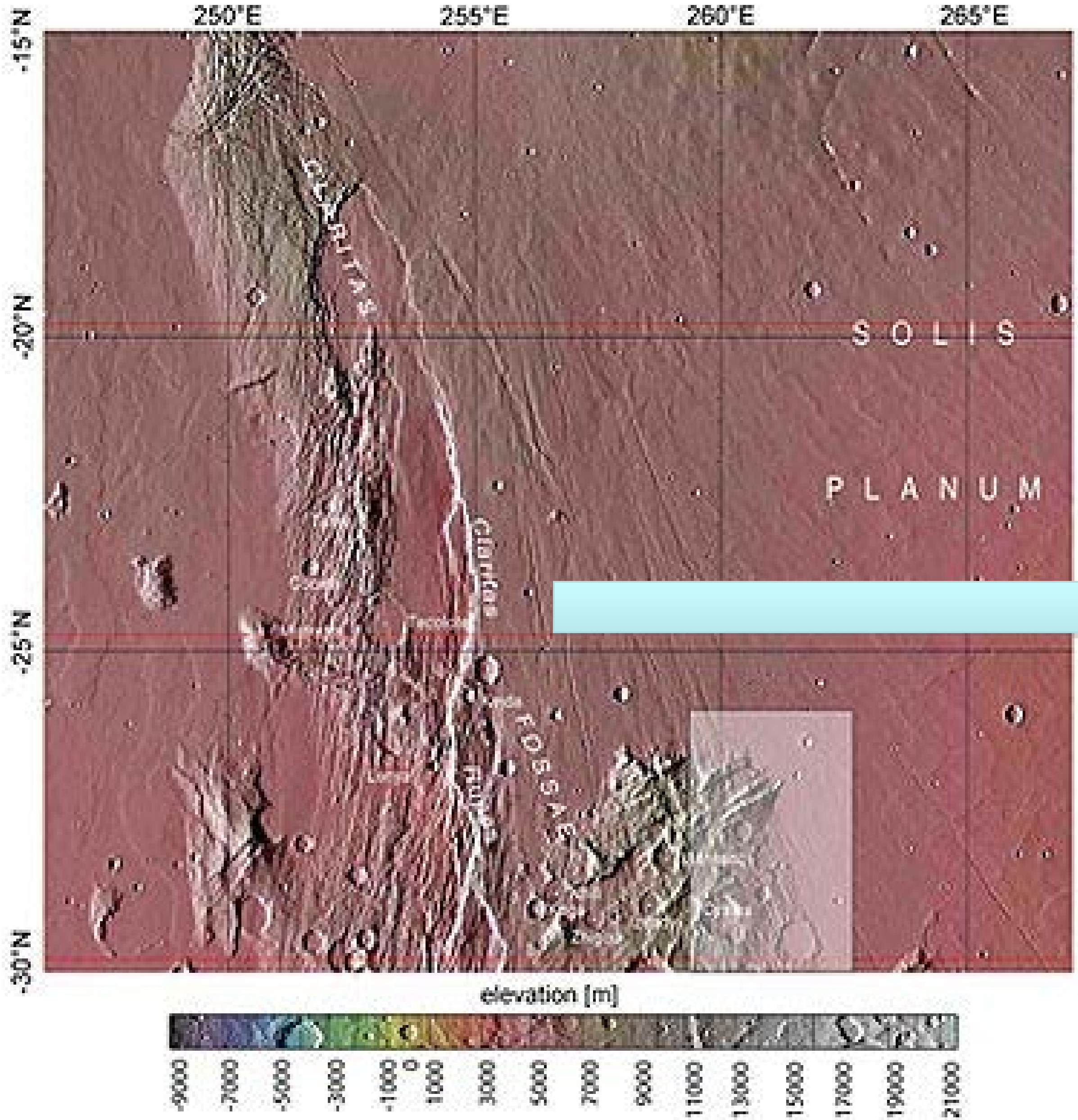
MOLA Elevation – NASA/GSFC

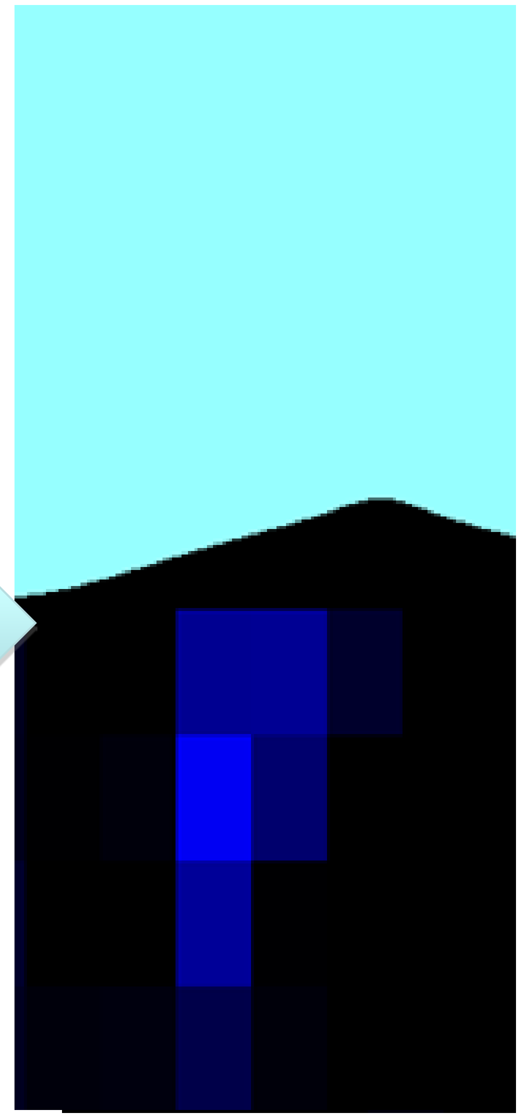
Thermal water products





Arsia Mons - HiRiSE/U of Ariz/NASA


250°E
255°E
260°E
265°E
-15°N
-20°N
-25°N
-30°N
SOLIS
PLANUM
Claritas
elevation [m]
-9000
-7000
-5000
-3000
-1000
0
1000
3000
5000
7000
9000
11000
13000
15000
17000
19000
21000



First muon radiography

Commonwealth Engineer, July 1, 1955

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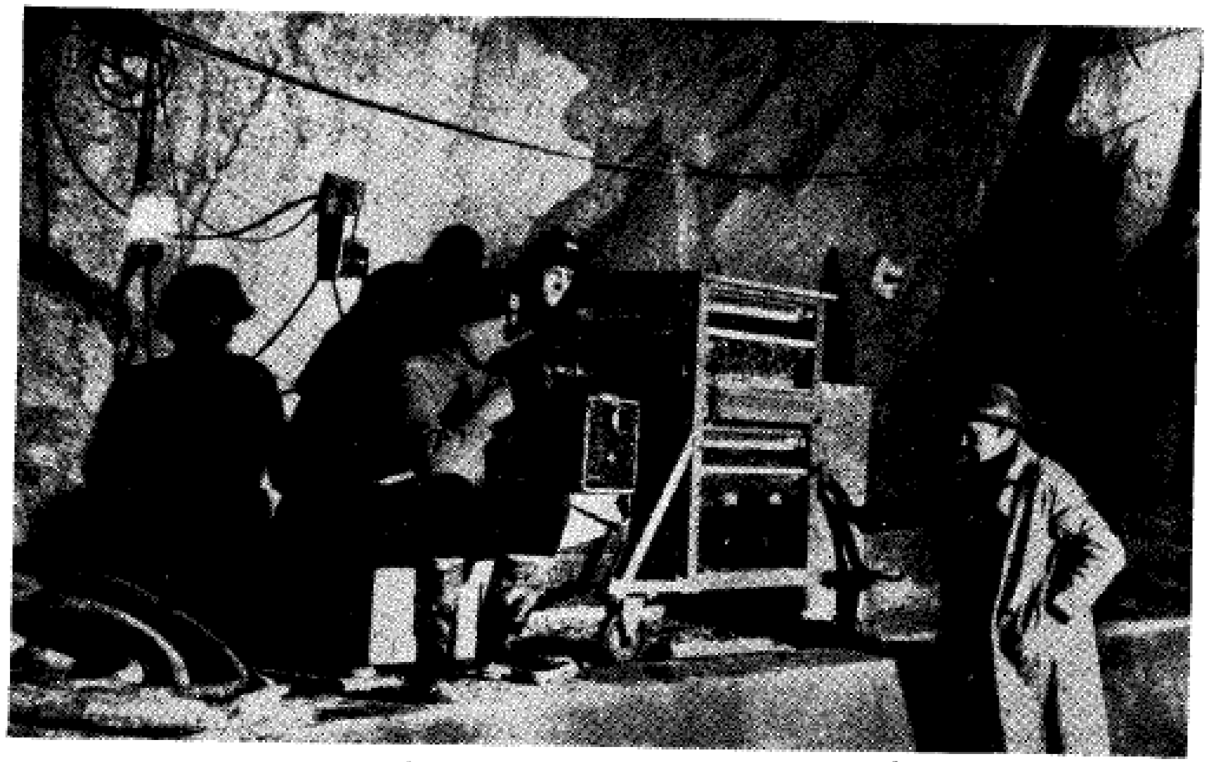
Cosmic Rays Measure Overburden of Tunnel

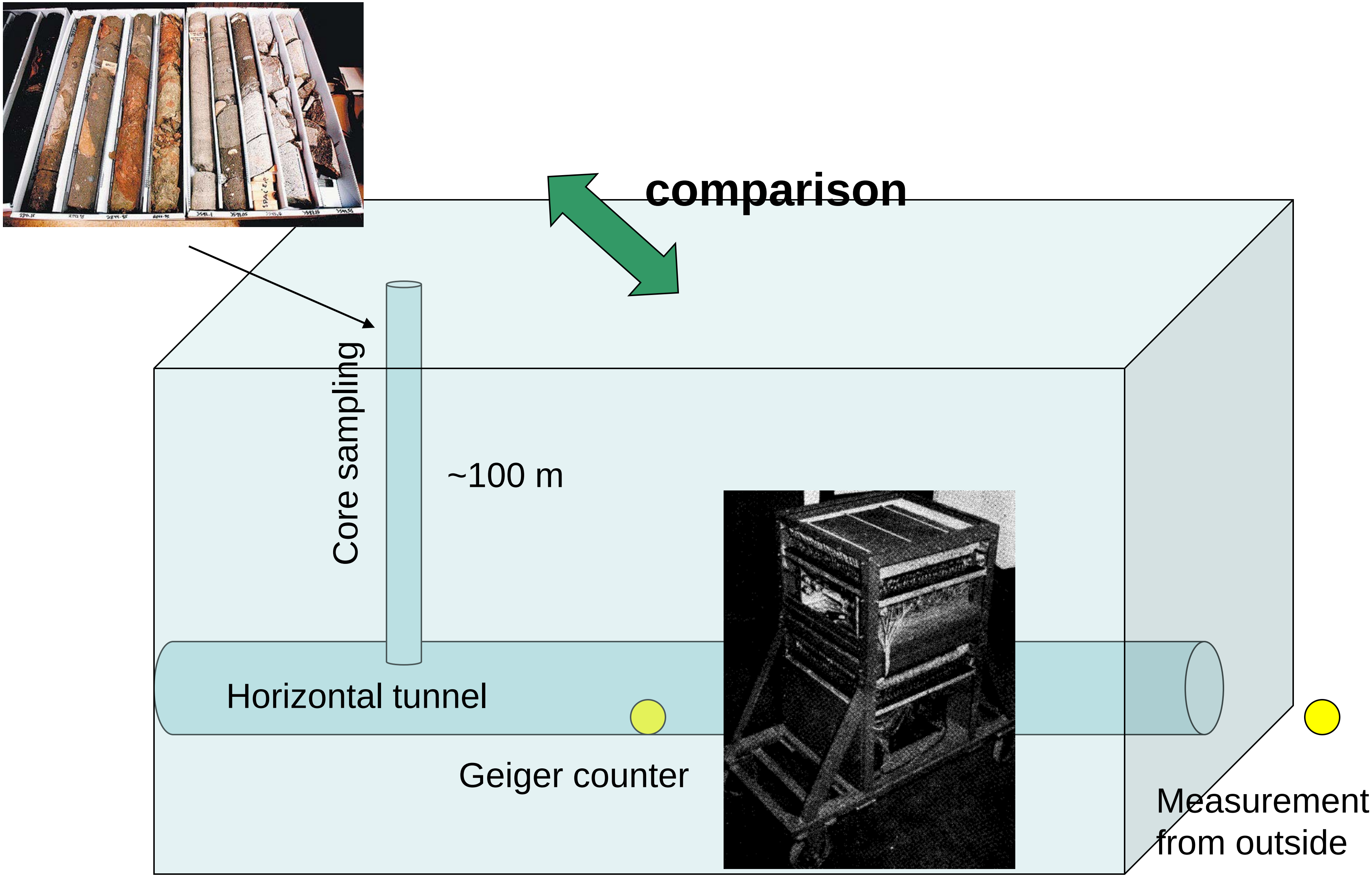


● Fig. 1—Geiger counter "telescope" in operation in the Guthega-Munyang tunnel. From left are Dr. George and his assistants, Mr. Lehane and Mr. O'Neill.

Geiger counter telescope used for mass determination at Guthega project of Snowy Scheme . . . Equipment described

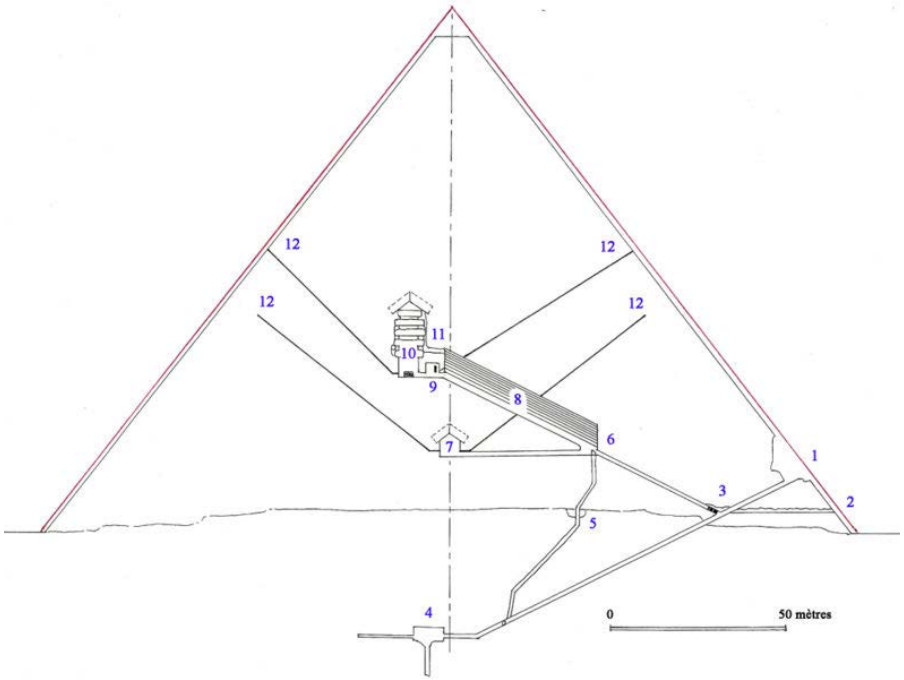
By Dr. E. P. George*
University of Sydney, N.S.W.

1955

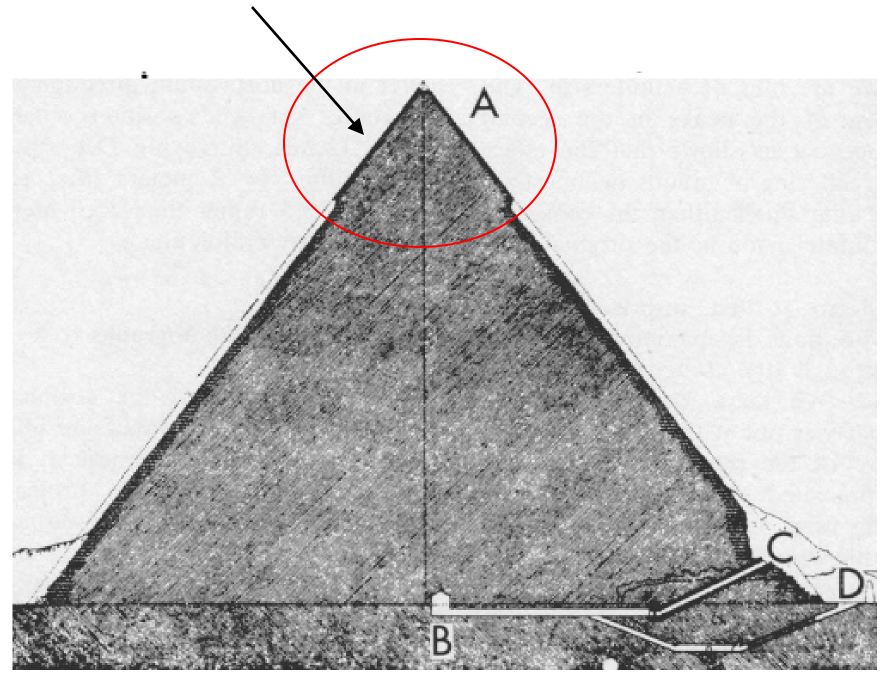

comparison
Core sampling
~100 m
Horizontal tunnel
Geiger counter
Measurement
from outside

Muon radiography by Alvarez

1968

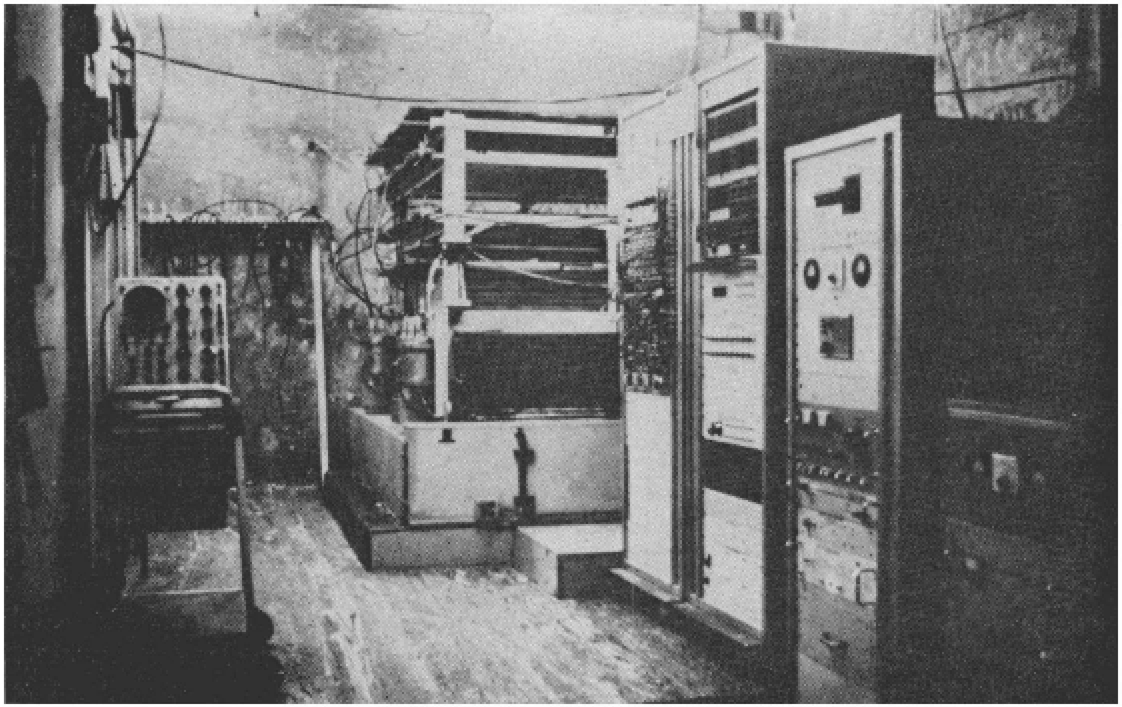


limestone cap with a thickness of 2 m



He wondered why Chephron’s pyramid only has a small room although Khufu’s pyramid has many spaces such as “King’s chamber”, ”Queen’s chamber”, ”Grand gallery”.

Alvarez’s apparatus



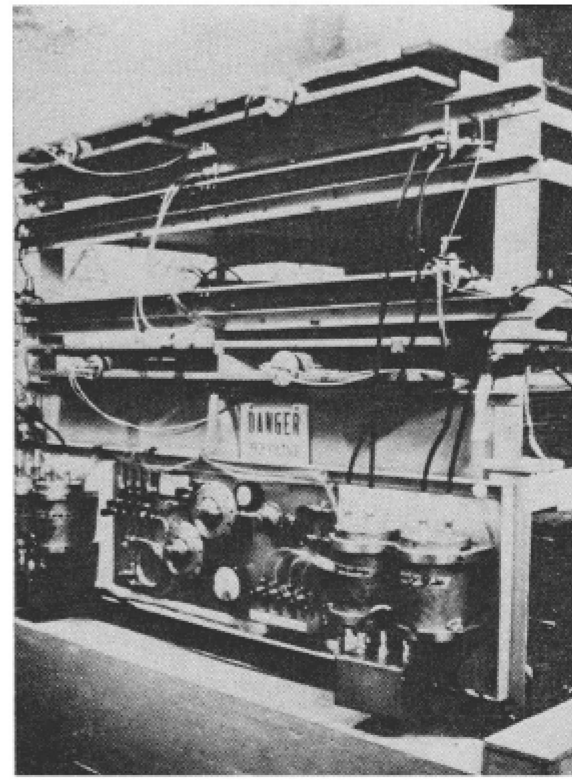


Fig. 6 (left). The equipment in place in the Belzoni Chamber under the pyramid.
Fig. 7 (right). The detection apparatus containing the spark chambers.

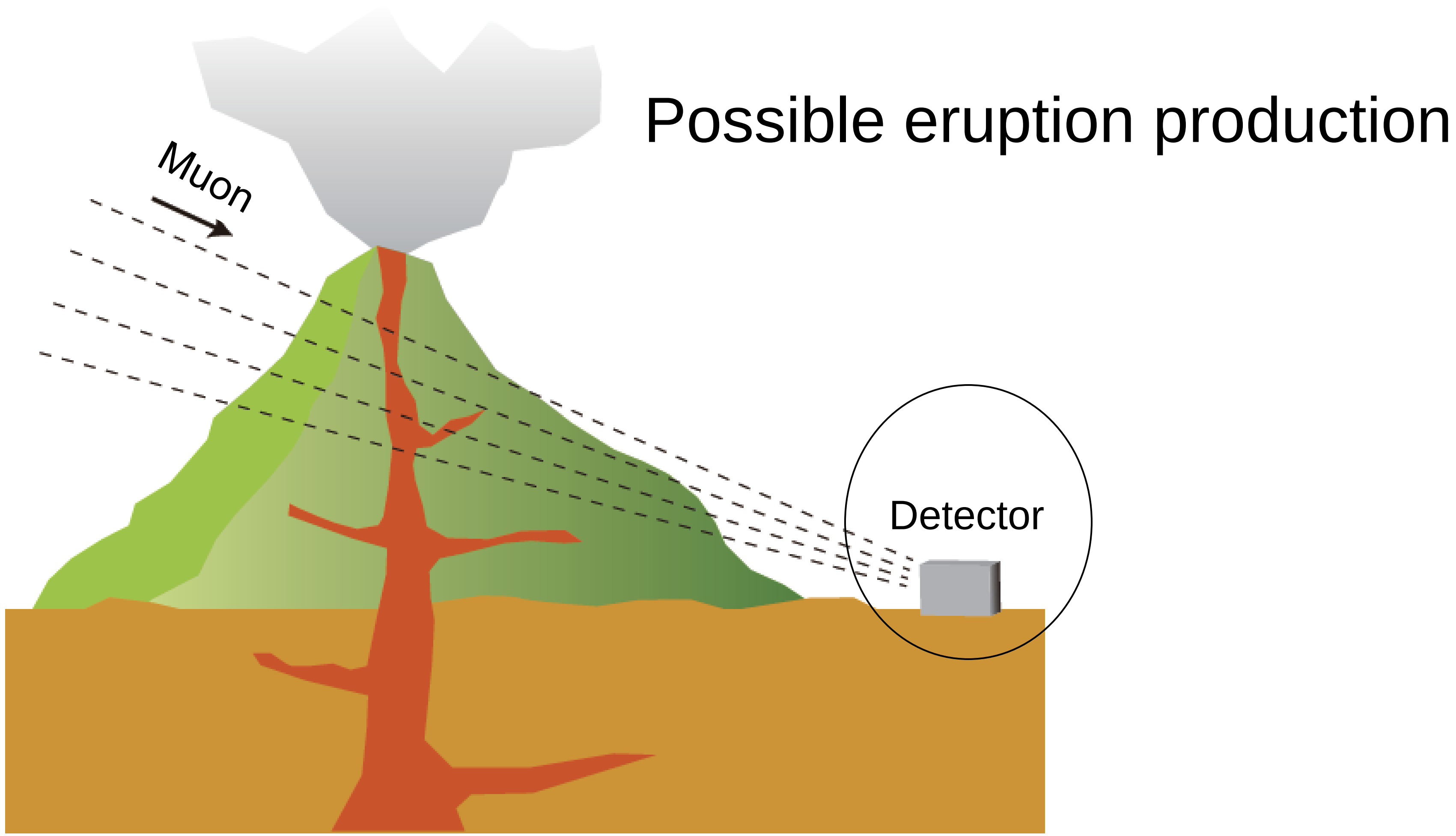
6 FEBRUARY 1970 835

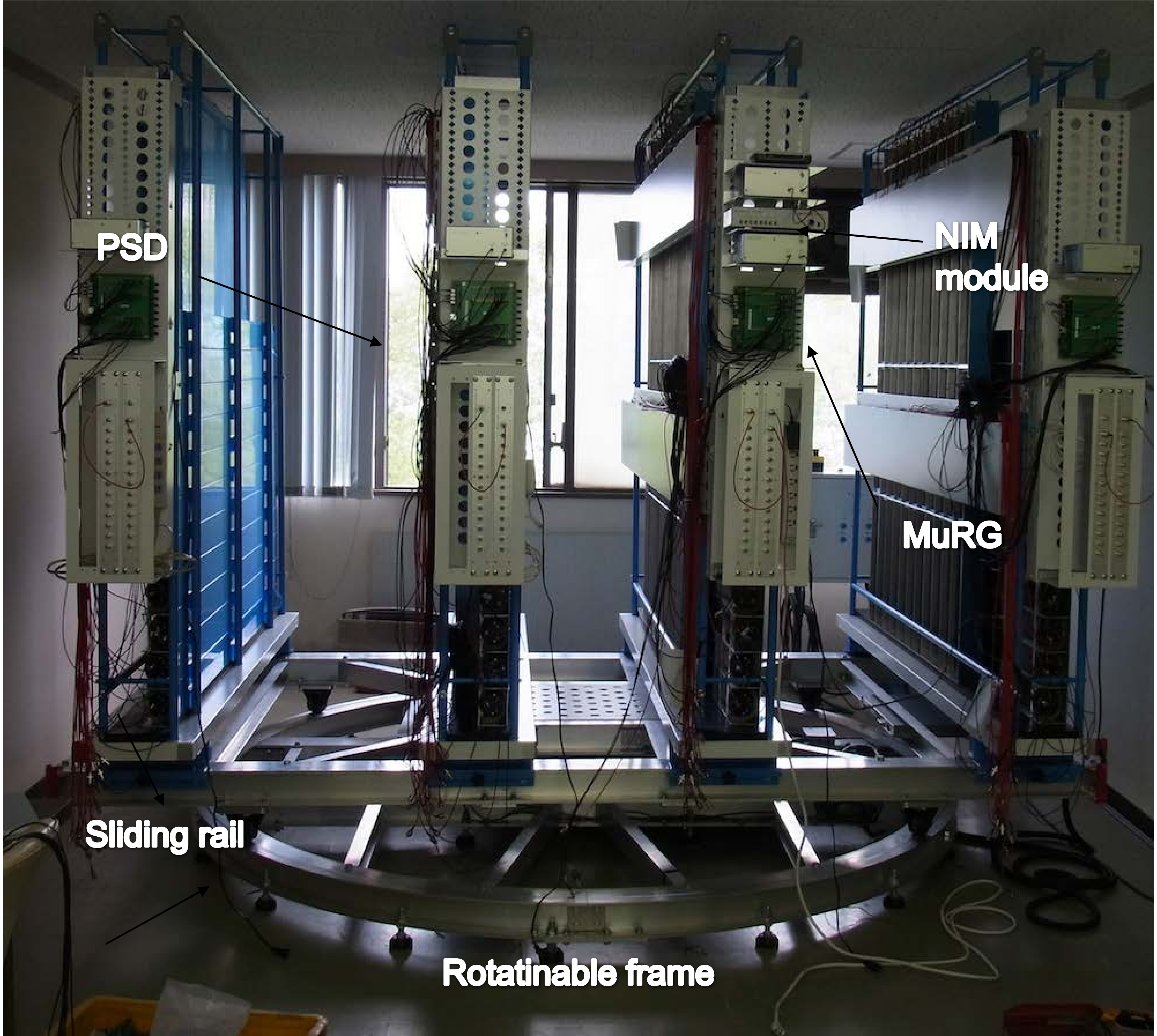
2 spark chambers + 1 plastic scintillater above + 2 plastic scintillaters below

Can we apply muon radiography for other targets?

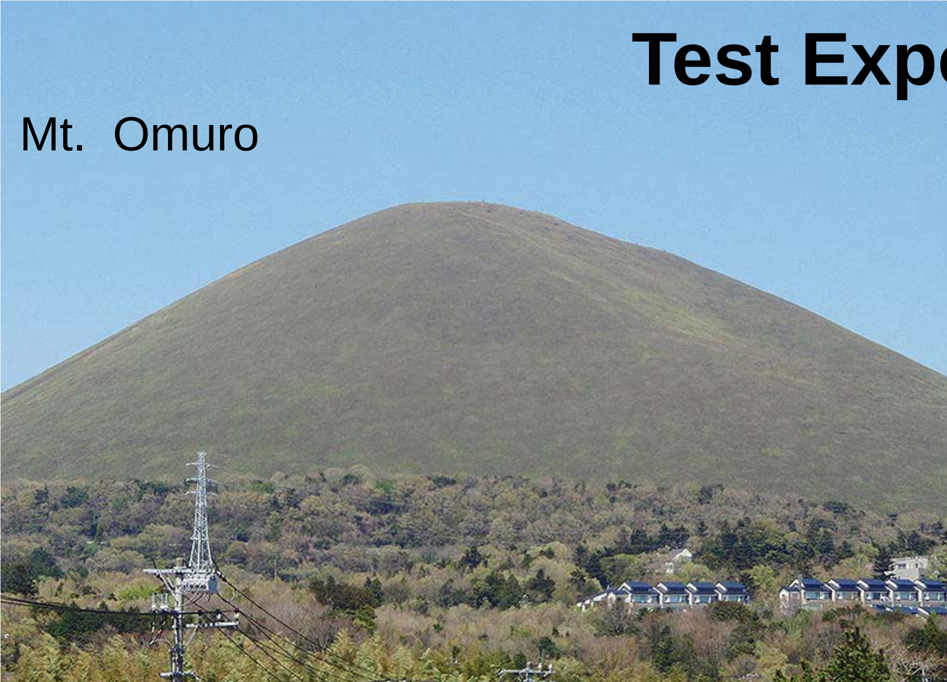
- Volcanoes
- Geologic faults (seismic/landslide)
- Industrial plants
- Extraterrestrial geological objects

There are density anomalies in a volcano





PSD
NIM
module
MuRG
Sliding rail
Rotatinable frame

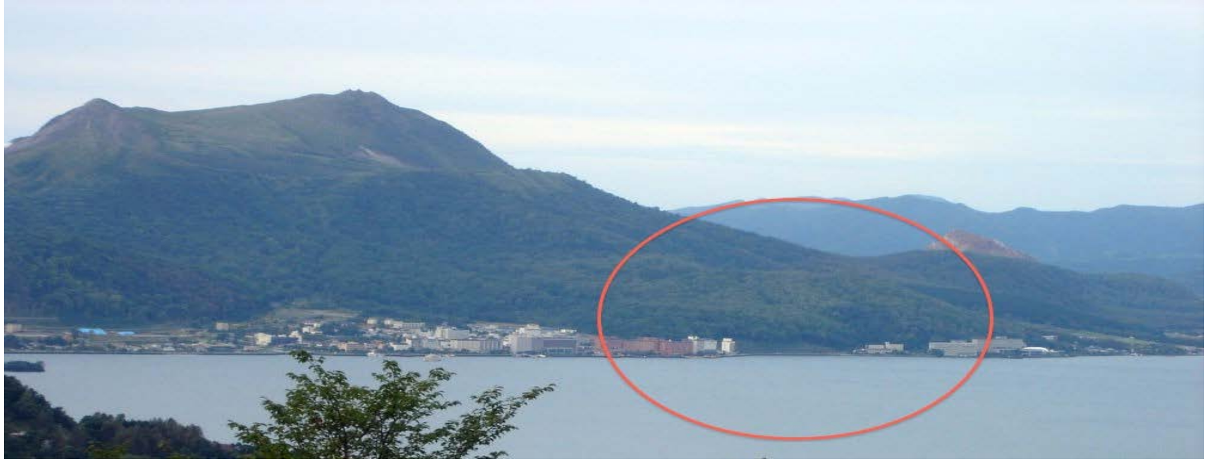
Test Experiment

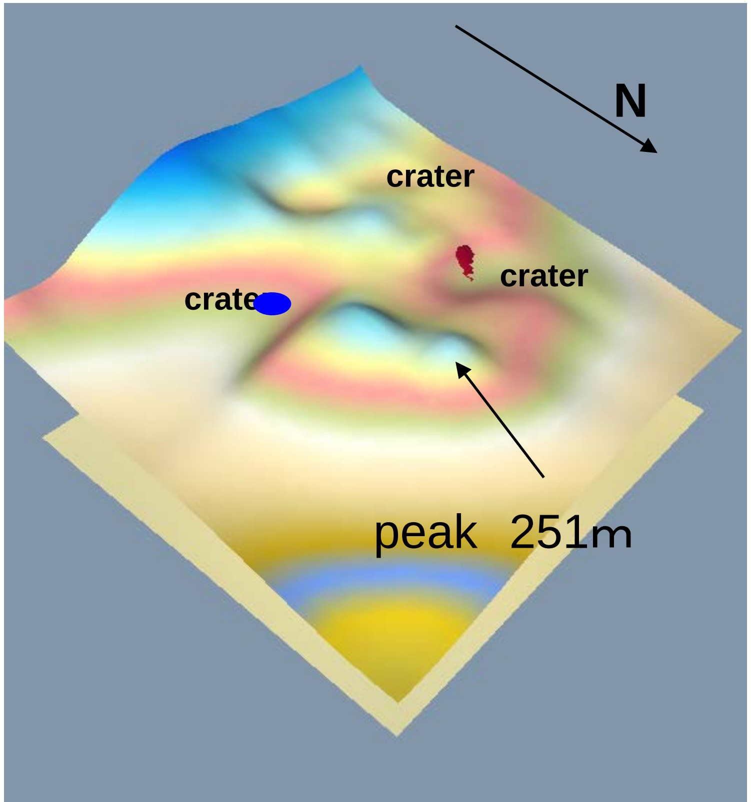


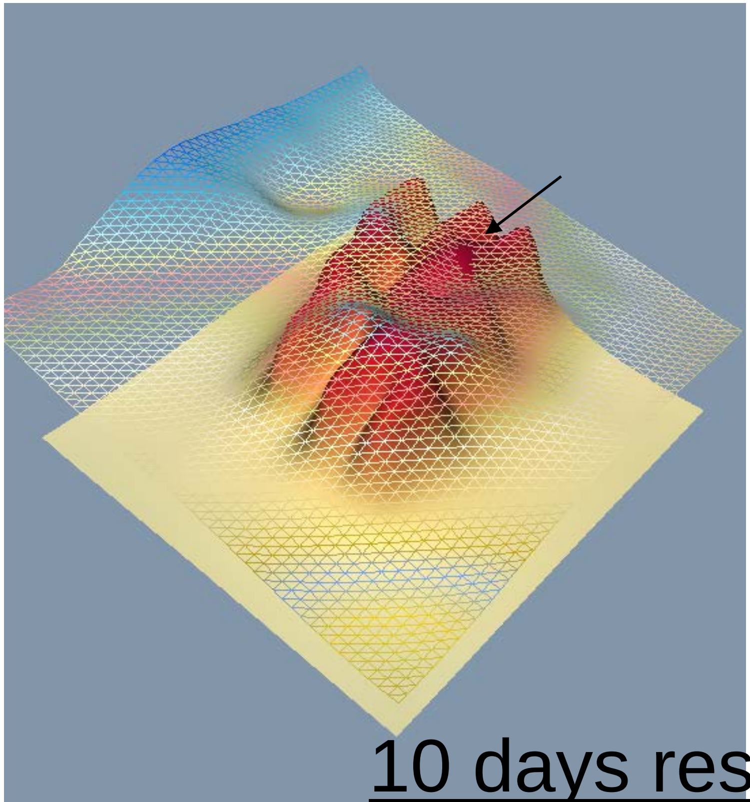
Crater on the top

Mobile
observation

Meiji-shinzan lava dome

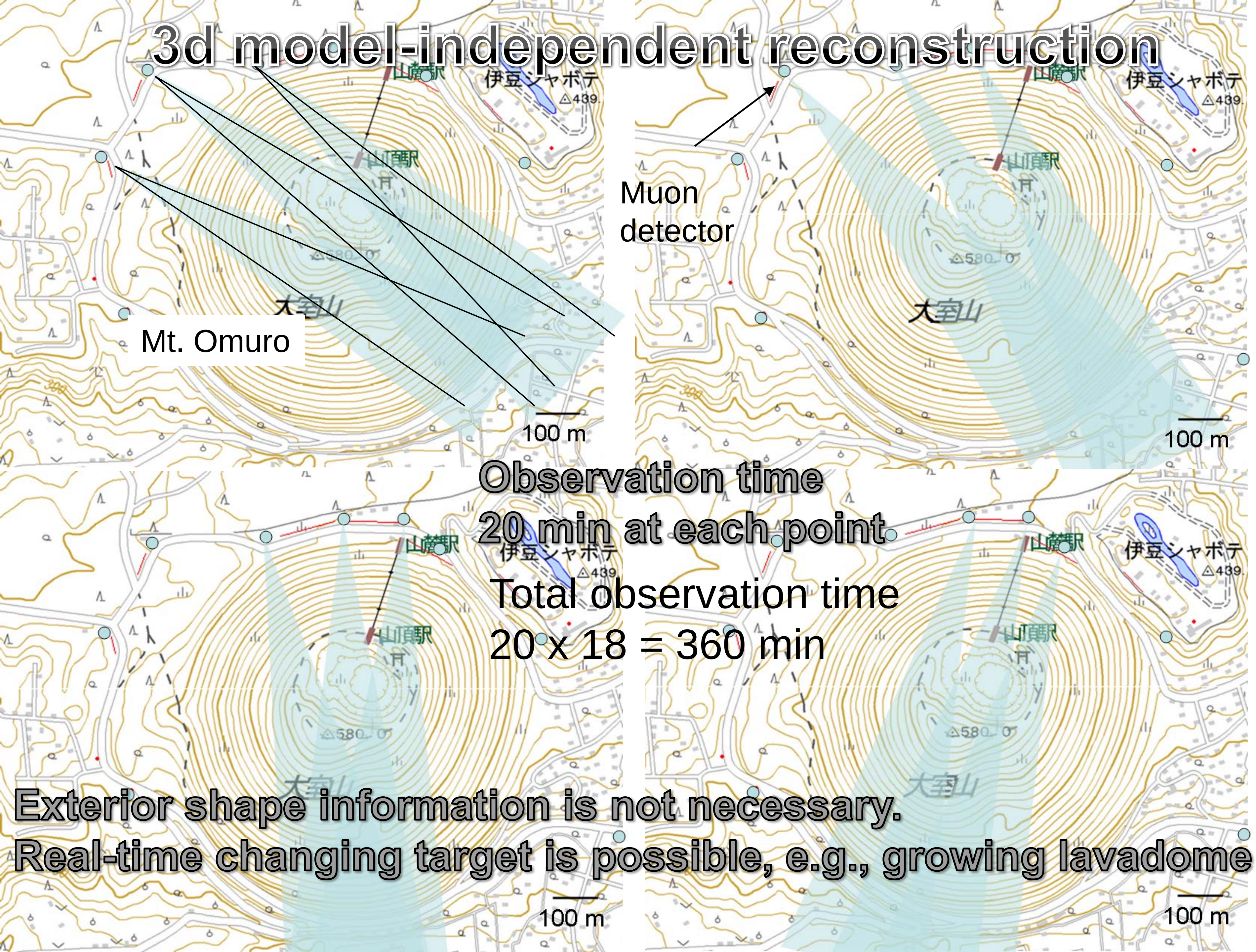






10 days result

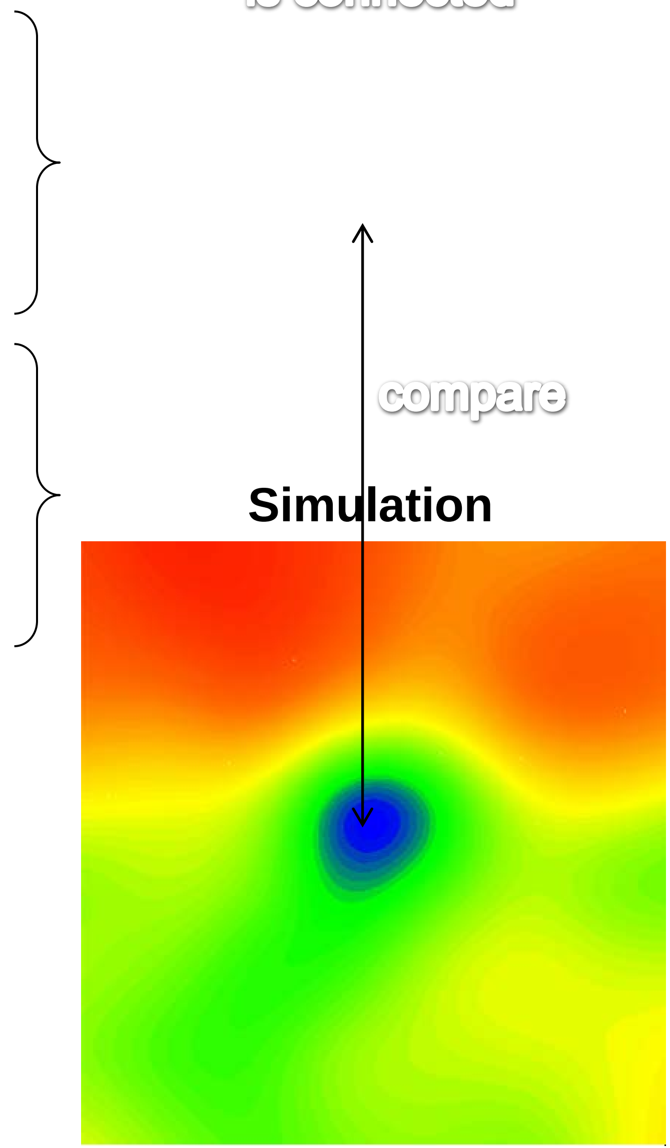
3d model-independent reconstruction



Observation time
20 min at each point

Total observation time
20 x 18 = 360 min

Exterior shape information is not necessary.
Real-time changing target is possible, e.g., growing lavadome



20 min x 12 = 6 hrs!!!

Making two slices and compare