Exploiding Muongraphy for Finding the Hidden Room in a Pyramid

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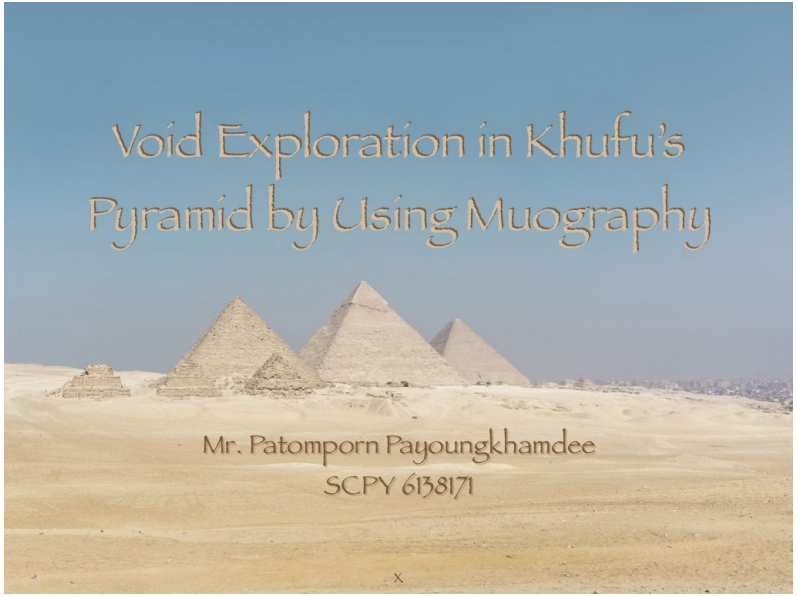
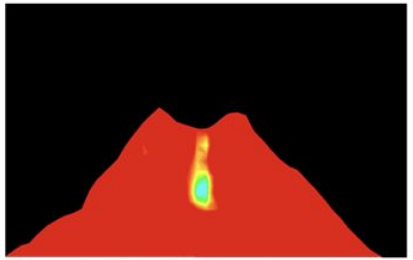
Motivation



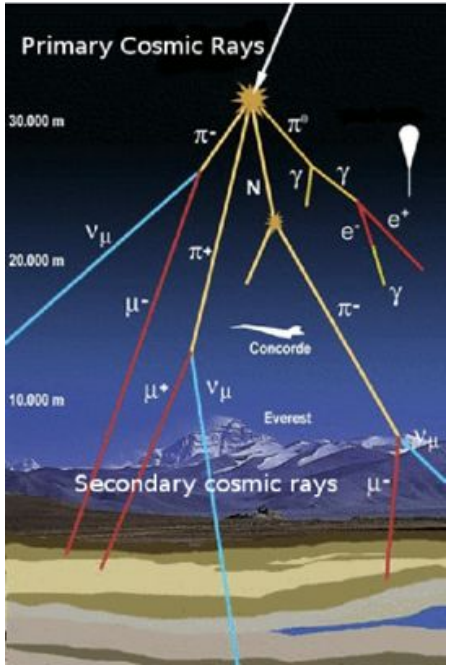
Smoke rising from Mount Iwo-dake on Satsuma-Iwojima Island (© 2014 Hiroyuki Tanaka)



Muograph of Mount Iwo-dake on Satsuma-Iwojima Island. A larger-than-expected mass of low-density magma is seen about 300 meters below the volcano crater. (© 2014 Hiroyuki Tanaka)

Relevant theory/equation

Muography



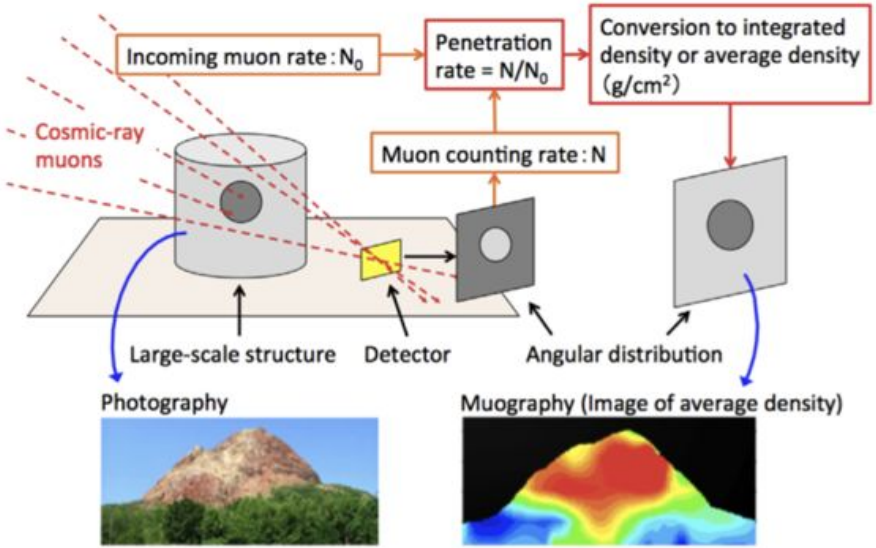
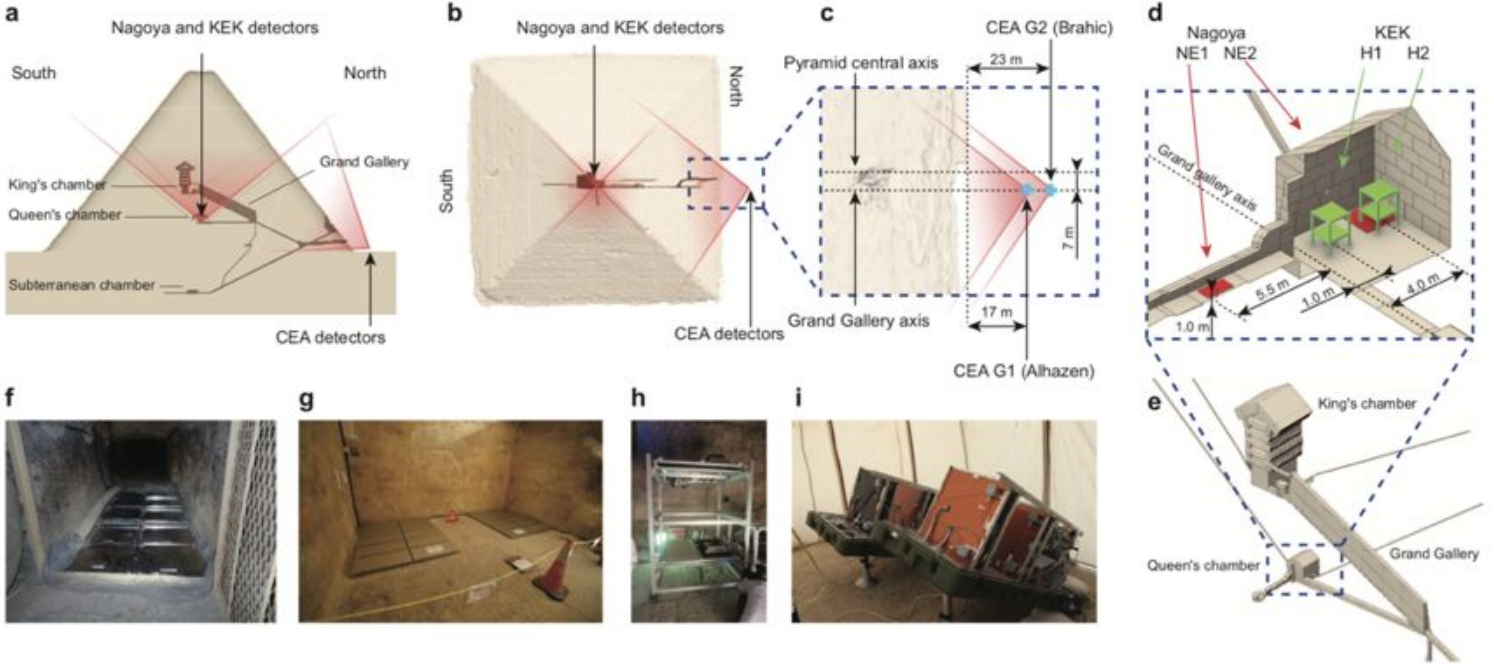


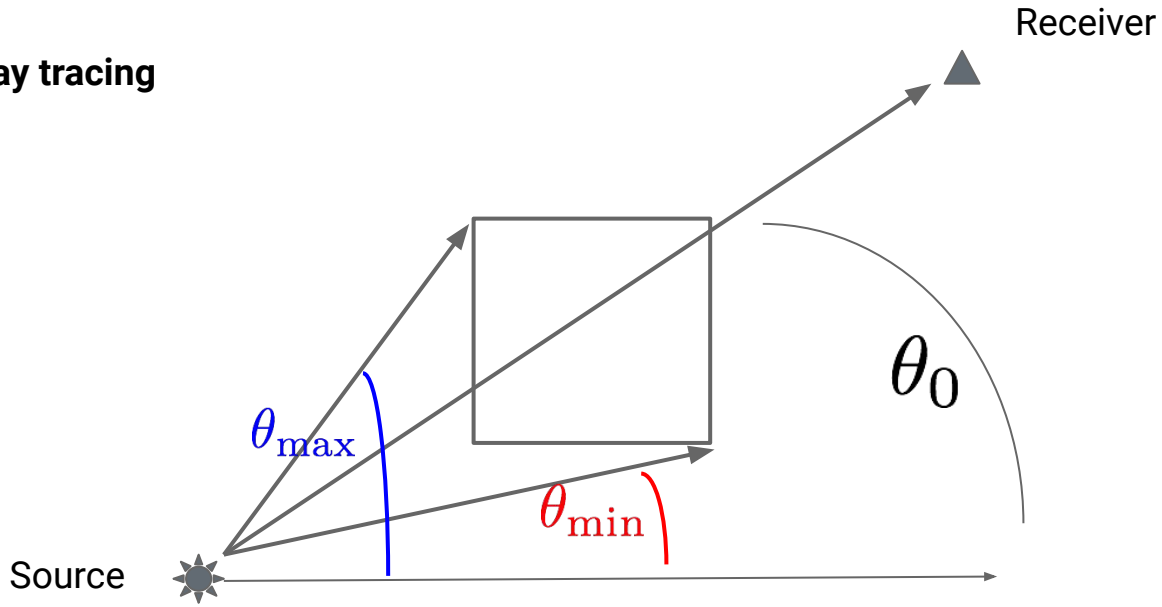
Figure 3. A schematic diagram of muography. A photography and a muography in the lower part of the figure are referenced from Tanaka et al. [2007a].

Muography


a
Nagoya and KEK detectors
South
North
King's chamber
Queen's chamber
Grand Gallery
Subterranean chamber
CEA detectors
b
Nagoya and KEK detectors
South
North
CEA detectors
c
CEA G2 (Brahic)
Pyramid central axis
23 m
7 m
Grand Gallery axis
17 m
CEA G1 (Alhazen)
d
Nagoya
NE1 NE2
KEK
H1 H2
Grand gallery axis
5.5 m
1.0 m
4.0 m
1.0 m
e
King's chamber
Queen's chamber
Grand Gallery
f
g
h
i

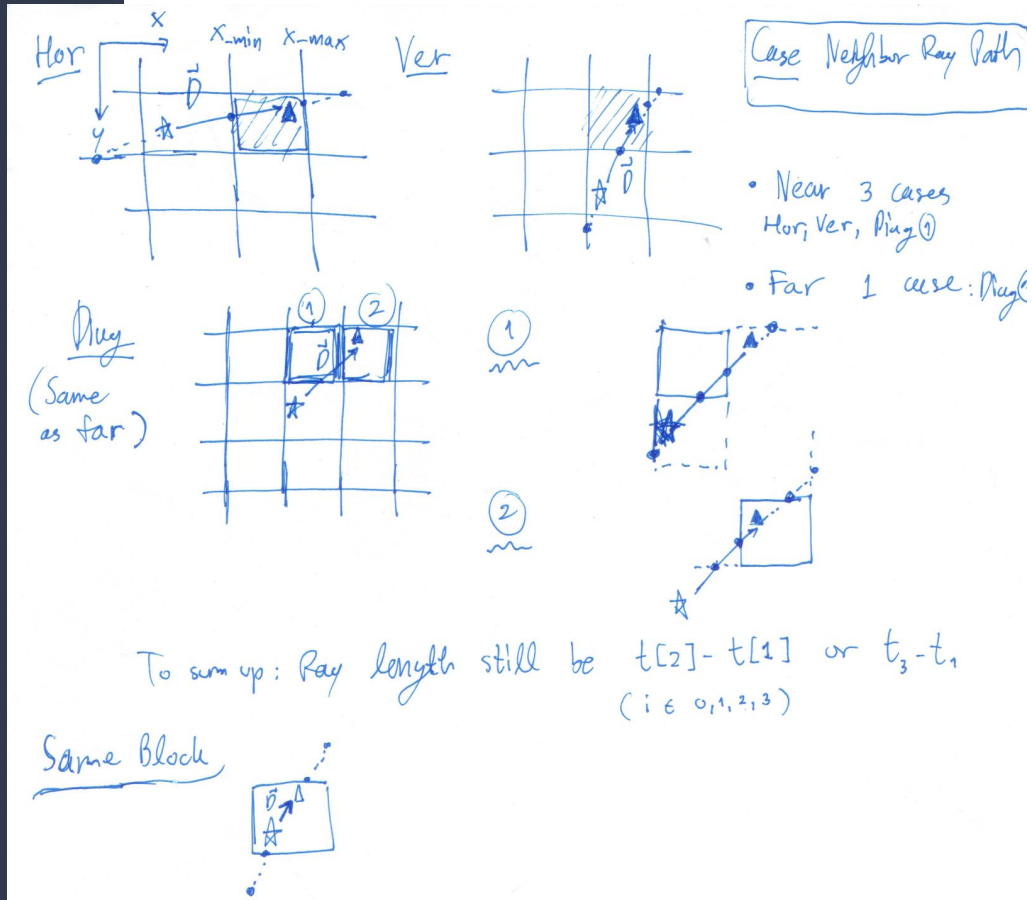
Straight-ray tracing

Far block ray tracing



Straight-ray tracing

Near block ray tracing



Muon path length (Governing Equation)

- Number of remaining muon could approximately be governed by

$$N(r) = N_0 e^{-\lambda(\vec{x})r}$$

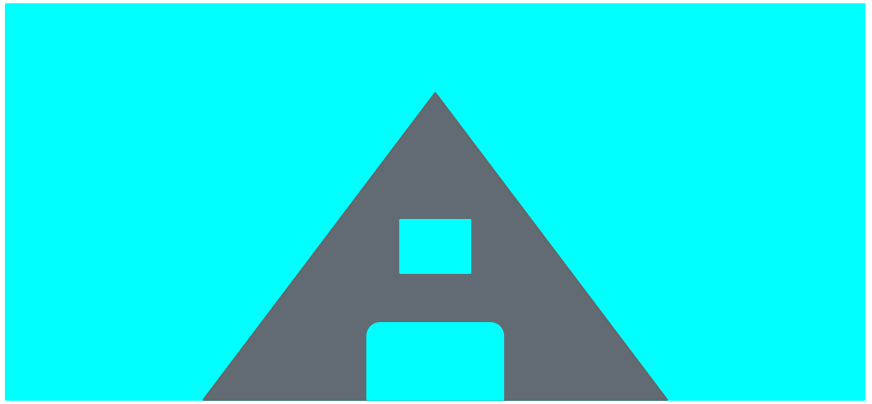
- Obviously, this system is non-linear
- Require the non-linear technique for inverse problem

Methods for solving

Non-linear least square problem

- Defining least square loss function
- Line search
  - Gradient
    - Steepest descent
    - Conjugated gradient
  - Step length
    - Backtracking
    - Quad/Cube interpolations
- This work will be conducting in 2D system

Real model



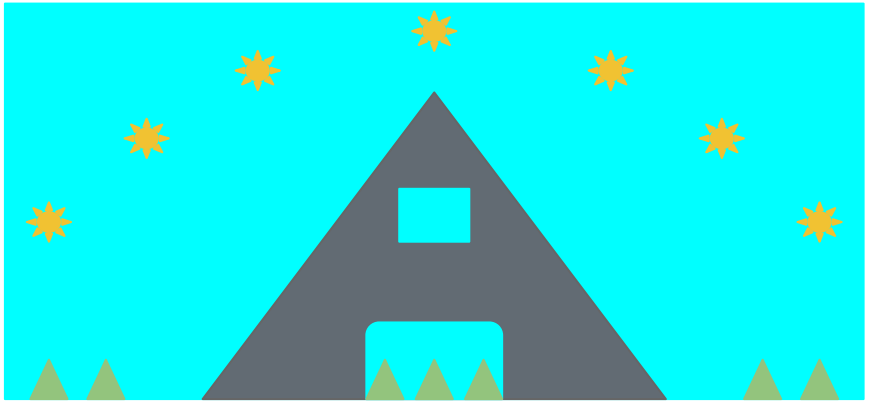
Initial model

Conventions

- Detector would be located in the main chamber and outside of the building
- Assuming that muon source is isotropically distributed over the sky

Receiver

Source



System