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# Design and construction of a straw chamber telescope for muography of the steppe kurgans

Abstract:
High energy cosmic ray muons have highly penetration capability which allows them to cross kilometers of rocks. Due to the reasonable rate of cosmic muons at the Earth's surface and their high penetration capability they are of great use in fields beyond the particle physics, such as geology, archaeology, speleology and industrial construction.
The above mentioned features of cosmic muons have founded the development of such applied technique as muonography, which can be used for non-invasive inspection of large inaccessible volumes to determine their density distribution, as well as for reconstruction a three-dimensional image of the examined volume. The novel technique of muography has motivated to build a muon telescope based on straw drift tubes to monitor and explore steppe kurgans in Kazakhstan.

# Introduction

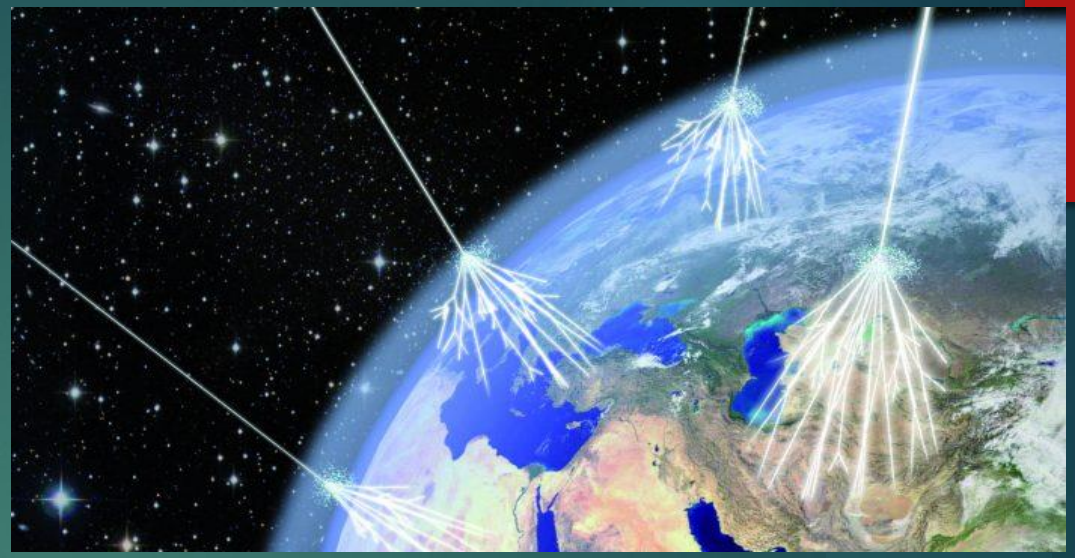
WHY MUONS SO IMPORTANT ?

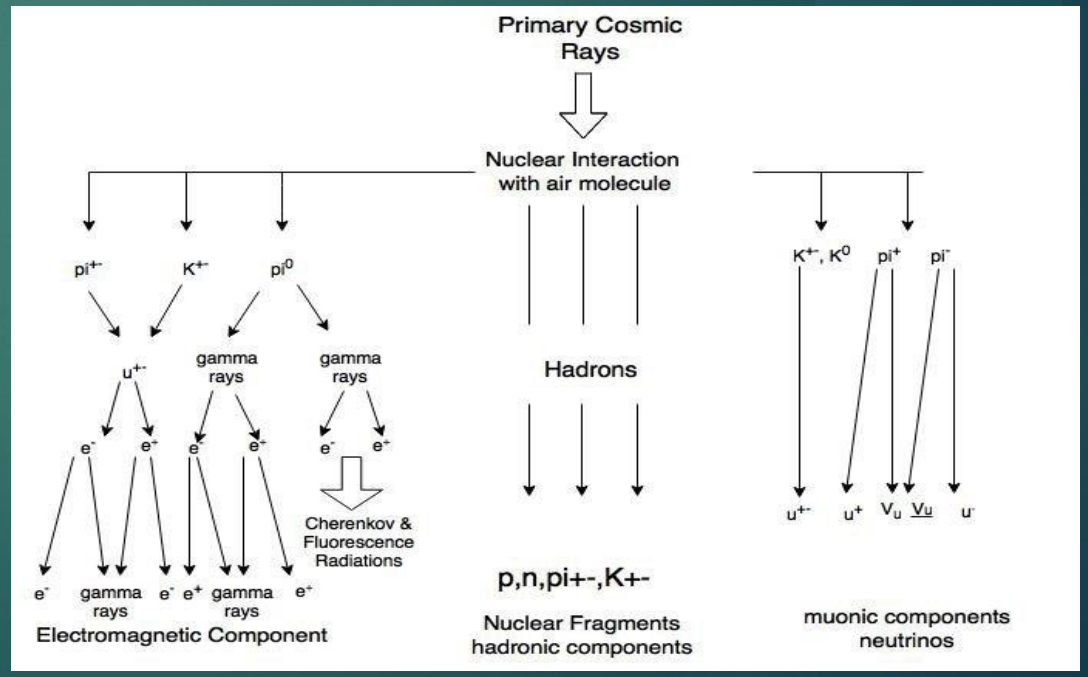
FREE

HIGH RANGE OF PENETRATION

ALMOST EVERYWHERE

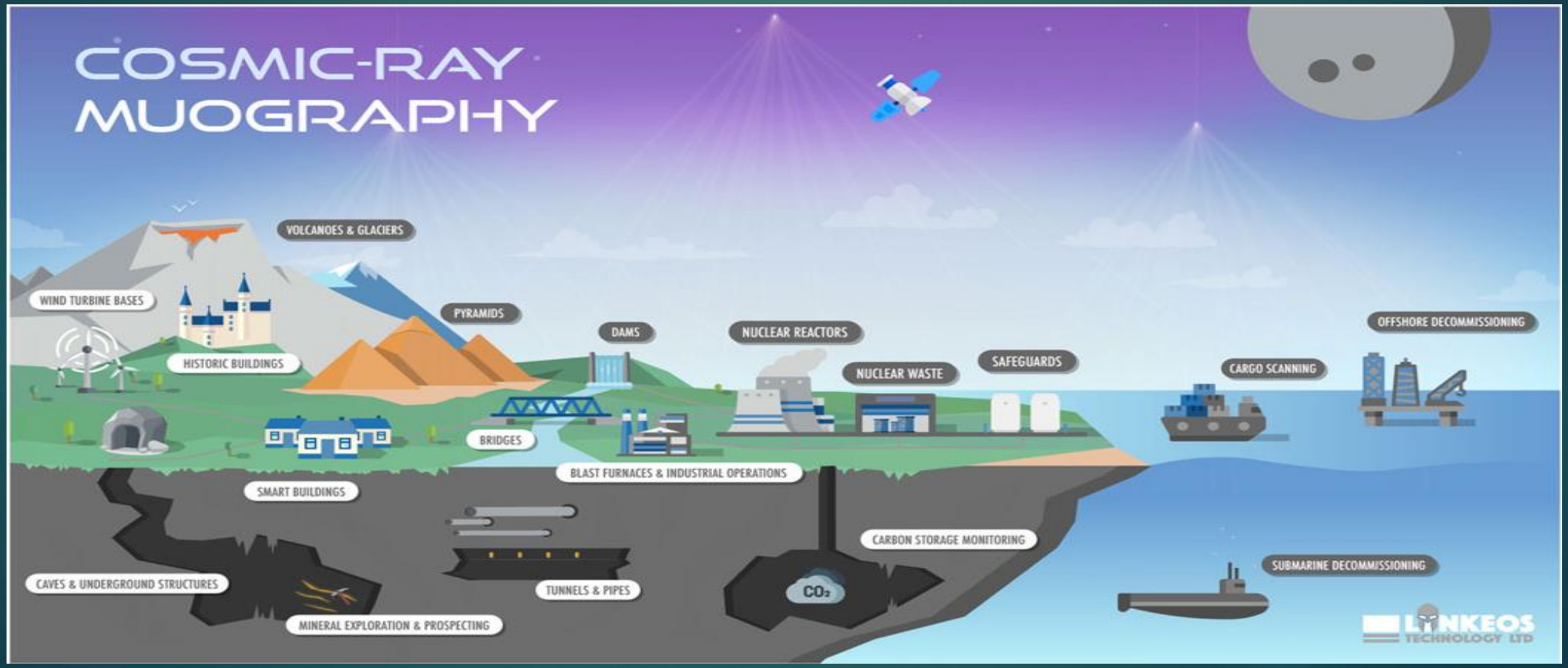
LOW INTENSITY





# What is  Muography ?

- Muography is a technique that uses high-energy muons as a radiographic probe to image the internal structure of gigantic objects. Since high-energy muons have a stronger penetration power than X-rays, this technique can create projection images of hectometric to kilometric sized objects.



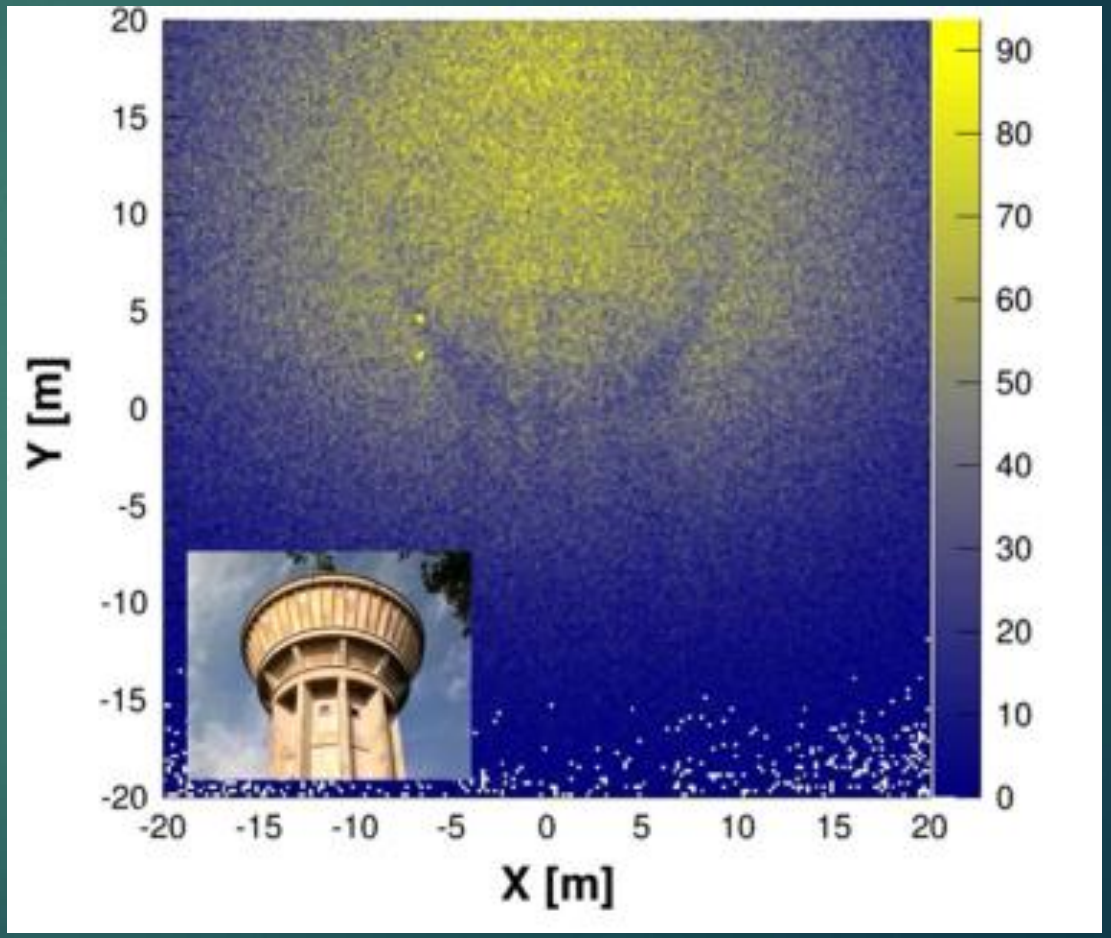
# Examples of muography

Telescope installed outside of Giza pyramids

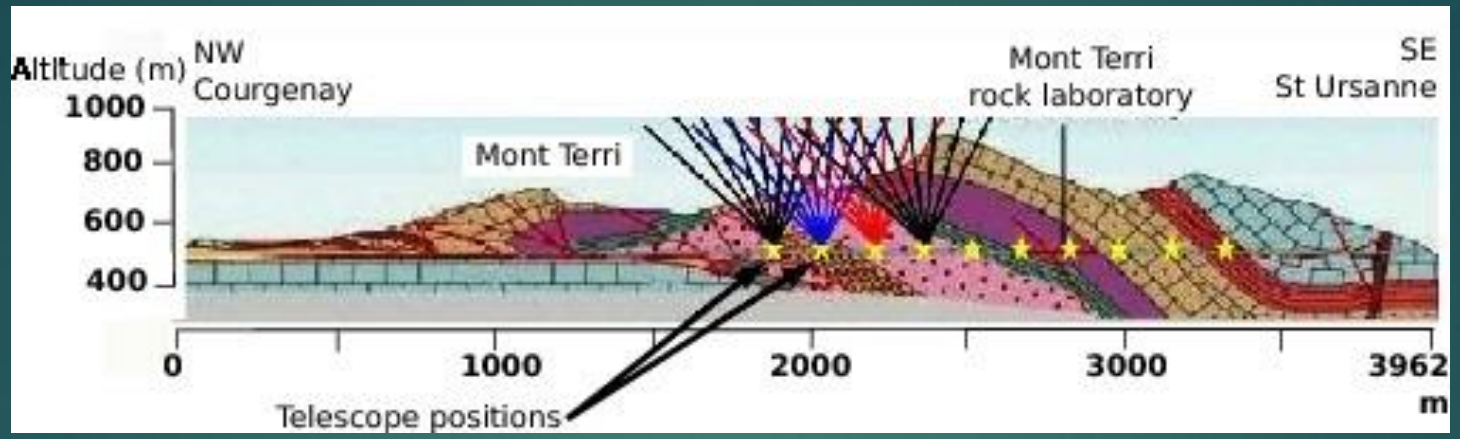
# Examples of muography

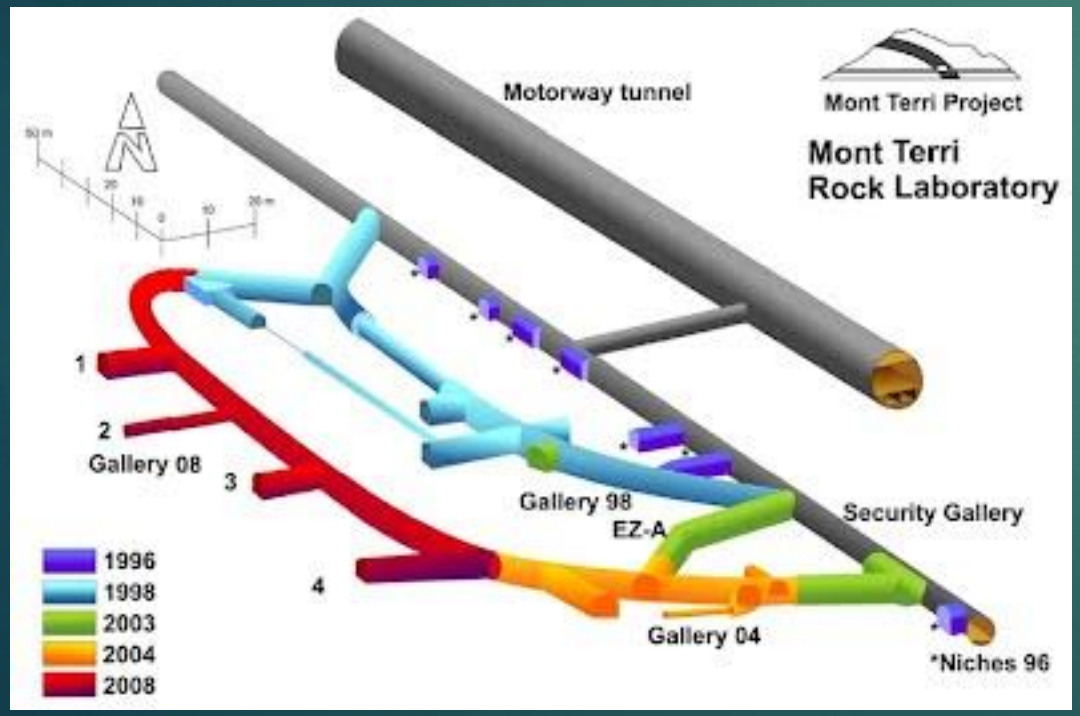
## A Micromegas-based telescope for muon tomography: The WatTo experiment

**Fig. 2.** Design of the WatTo telescope, represented here with only three detectors.



# Examples of muography




# Examples of muography

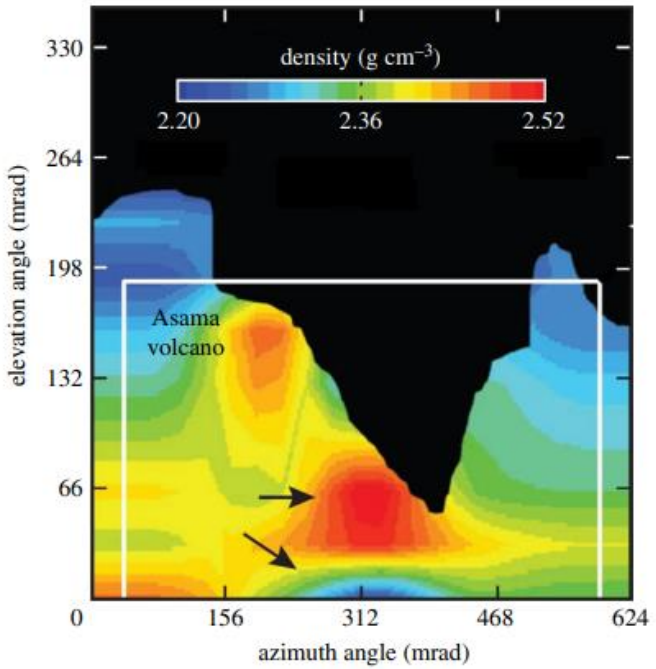
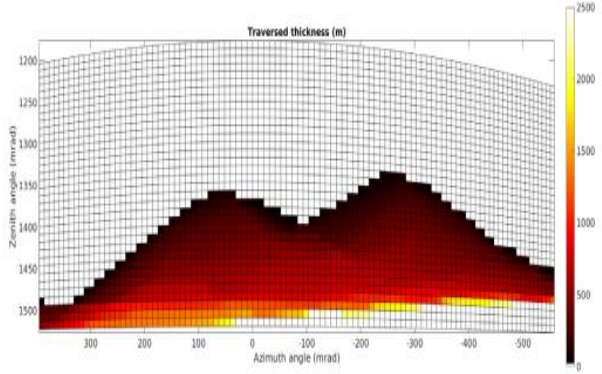



**Figure 1.** Muographic image of the top part of Asama volcano. The white lines indicate the region shown in the time sequential muographic images in figure 2. The upper arrow indicates the high-density solidified magma deposited on the crater floor, and the lower arrow indicates the low-density magma pathway.




(b)

(c)

**Fig. 10.** Comparison between measured muon transmission for each trajectory given by zenith and azimuth angles (a), traversed thickness calculated from DEM (b) and a picture of Monti Rossi from a point close to the installation site of the telescope (c). The trajectory with zenith angle = $\pi/2$ rad and azimuth angle = 0 corresponds to the telescope axis.

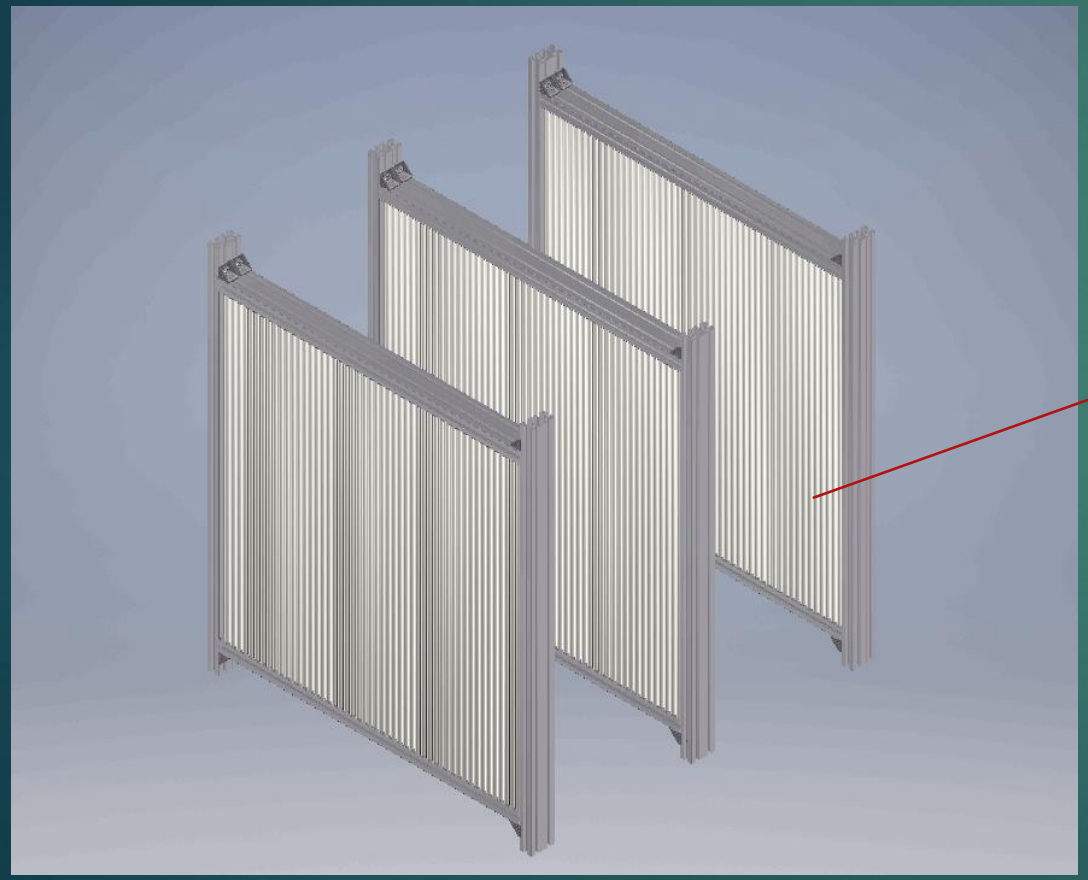
# What's all this STRAW DETECTOR stuff, anyhow?

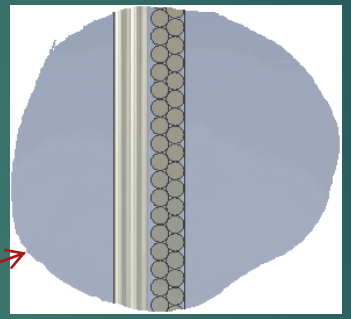
- Sort of proportional drift tube
  - Tracking detector
- Difference
  - Low material budget
  - Smaller in diameter (2-10 mm)
  - Large number of detector elements crossed by particle
  - Can be used also for particle identification (TRT)
  - (tuned to sustain high particle rate)
- How to recognize
  - Fancy detector which looks like a stock of hay
  - Distributor of straws for drinking your favorite potion

# Where are straws used?

- Many experiments
  - DELPHI, HERA-B, FINUDA, COMPASS, LHCB, **ATLAS, NA62**,**NA64**
- Different environments
  - High radiation > 10 MRad (TRT)
  - High rate > 20MHz/straw (TRT)
  - Low material budget < 0.5% rad length (NA62)
  - Resolution of single straw < 50um (FINUDA)

# Design of muon telescope



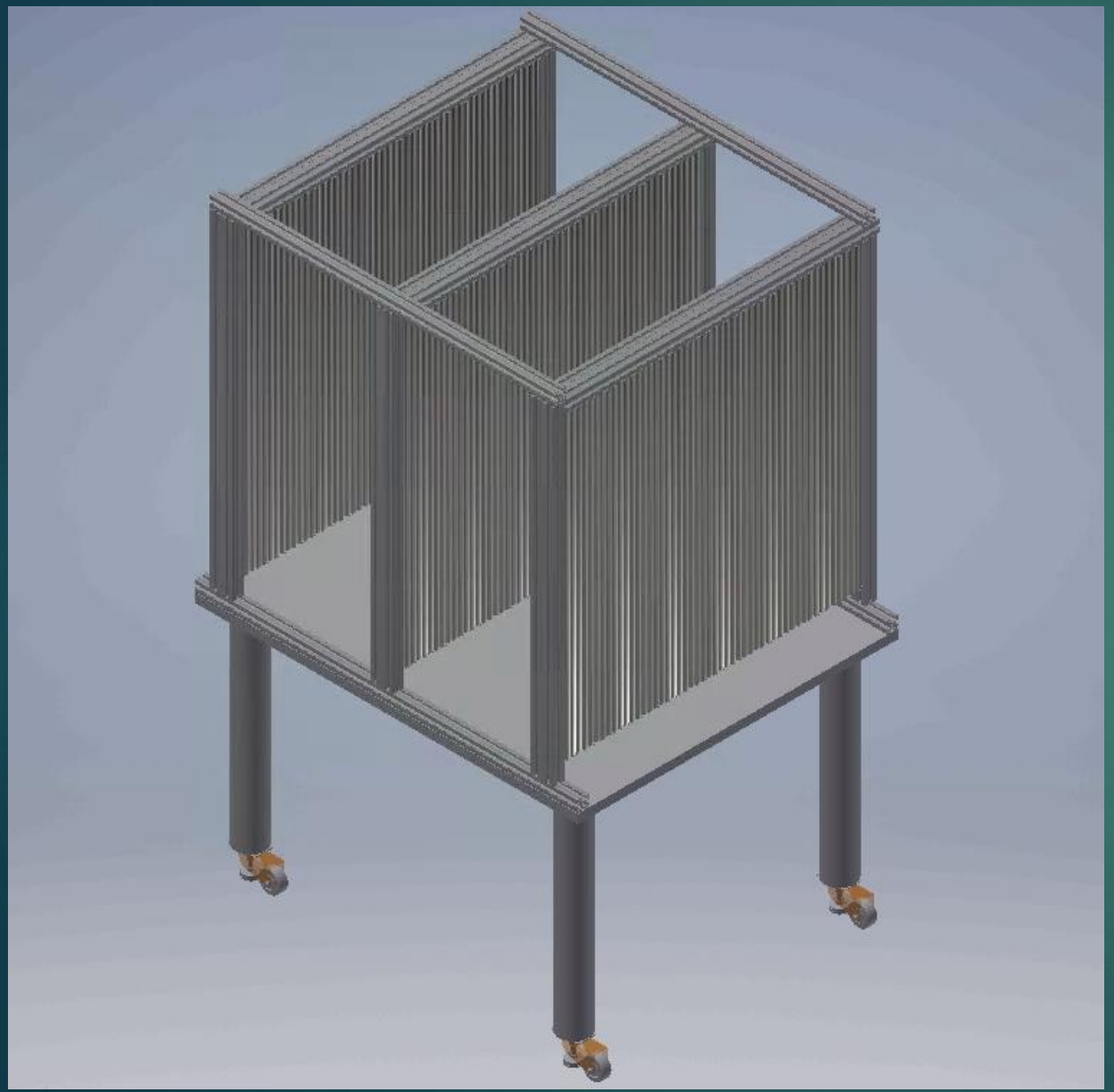


1 m x 1 m x 1 m “straw box”
d – 10 mm

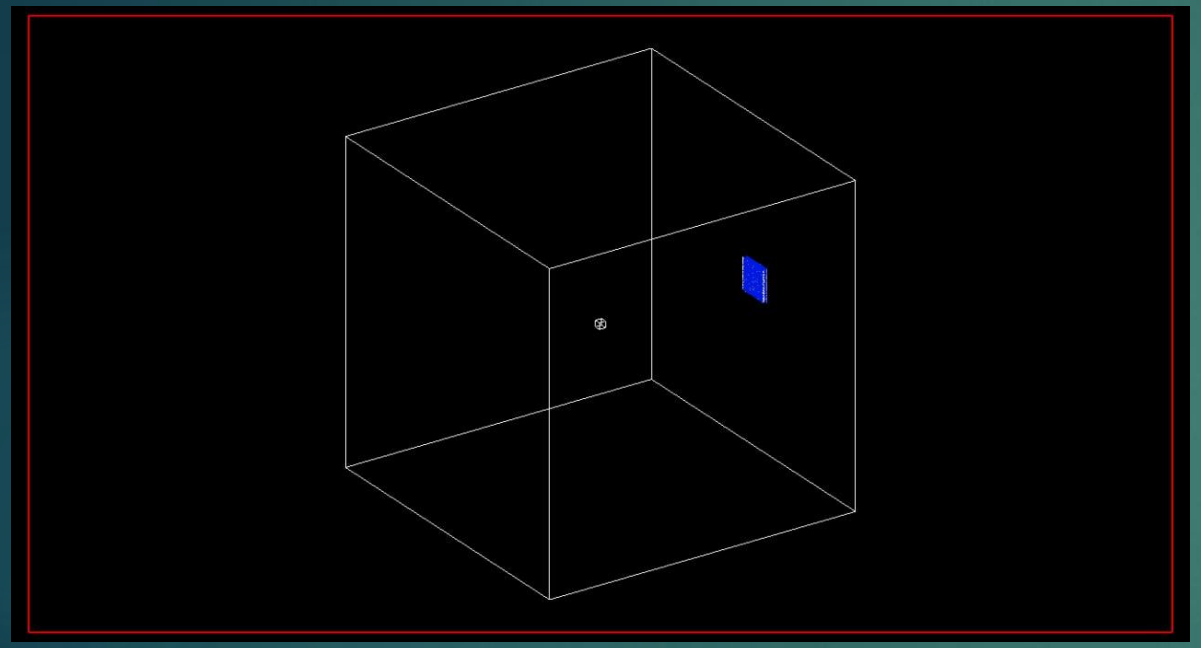
length – 1 m

Each straw detector contains
4 layers of straw tubes

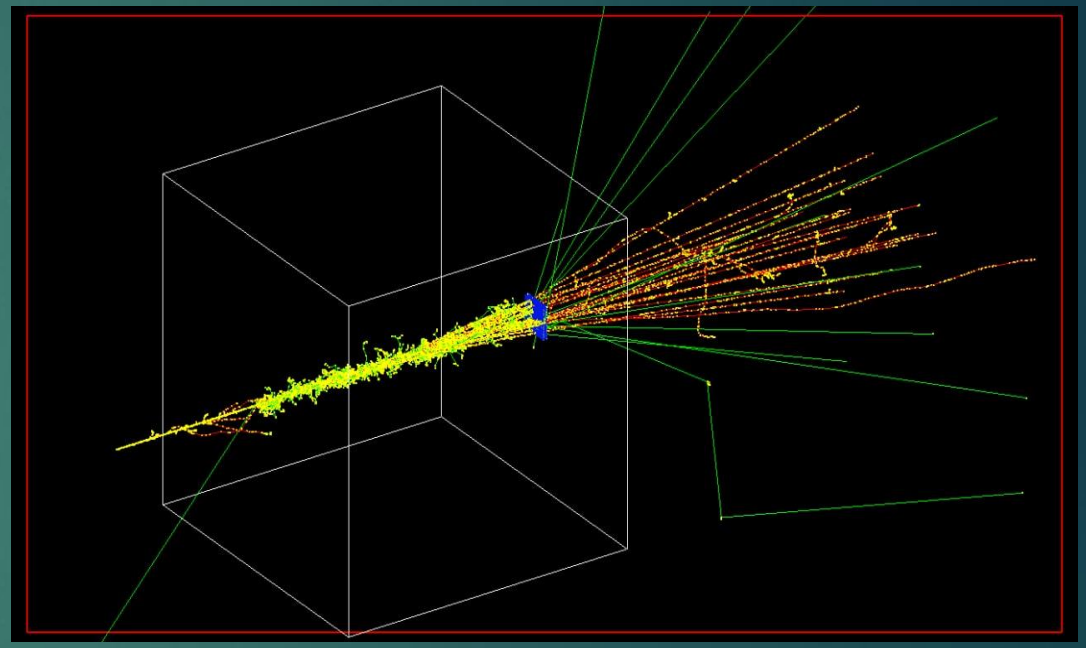
# Early conception of muon telescope



# GEANT4 Simulations

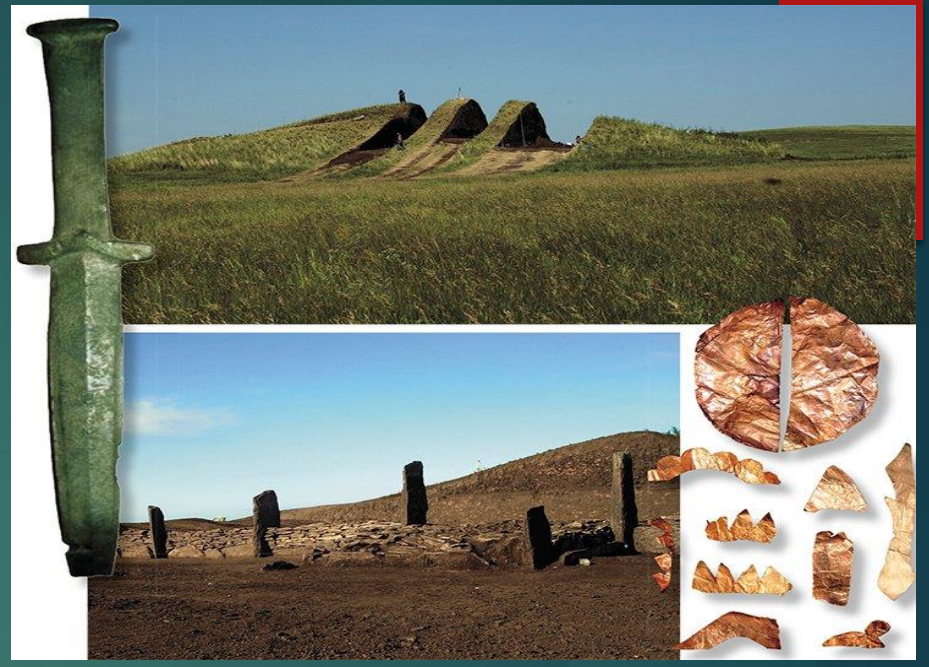


Gold target inside of the box filled with rocks

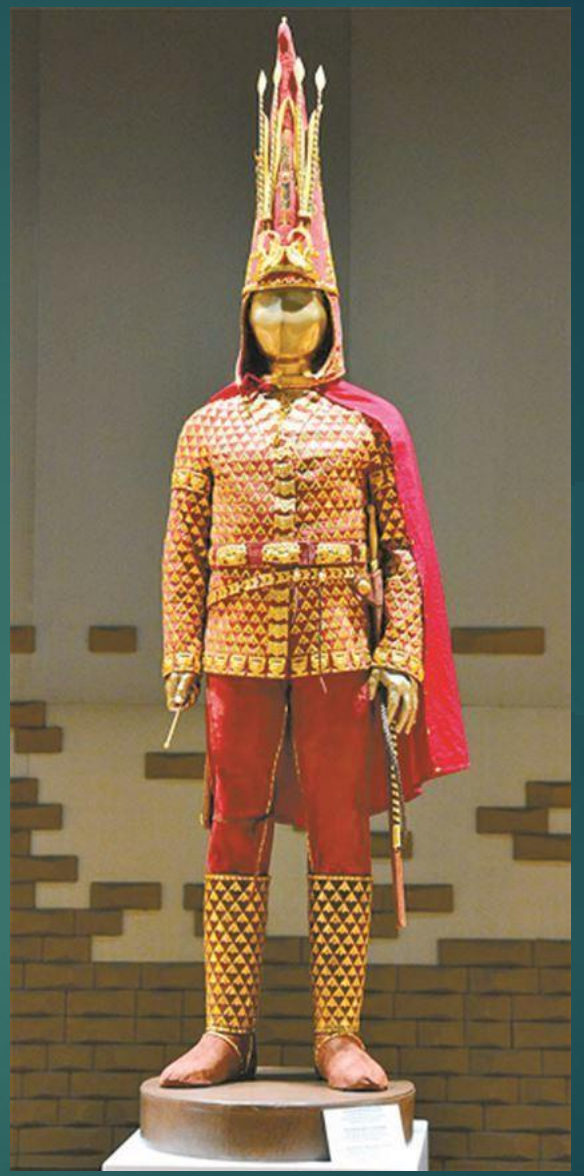


104 GeV muons are hitting gold target

# Kurgans of Kazakhstan



Kurgan “YSSYK”



“Golden human”

# Conclusions