Zimányi Winter School 2010

Muon tomography experiments in the Jánossy pit

László Oláh

G. G. Barnaföldi, G. Hamar, D. Varga

REGARD

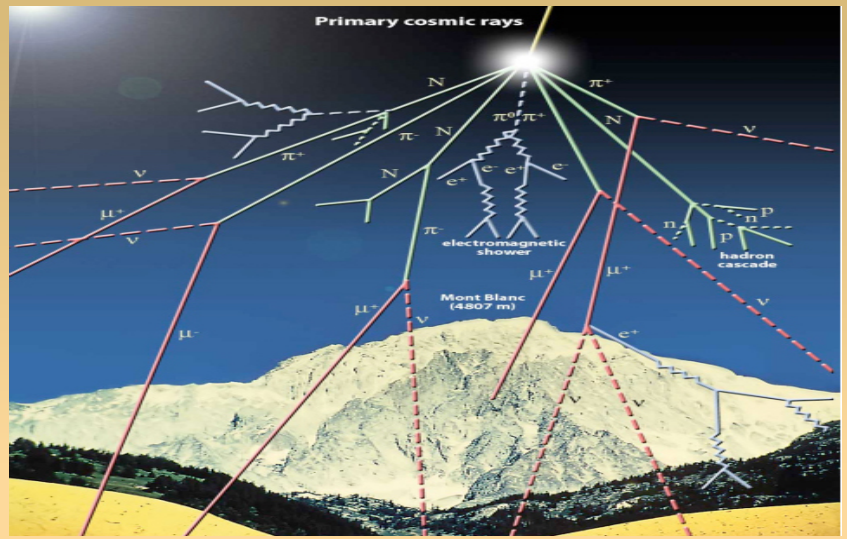
Our research is supported by OTKA NKTH CK 77719, OTKA NKTH CK 77815

and the OTKA NK-77816, OTKA PD-73596 grants.

Outline

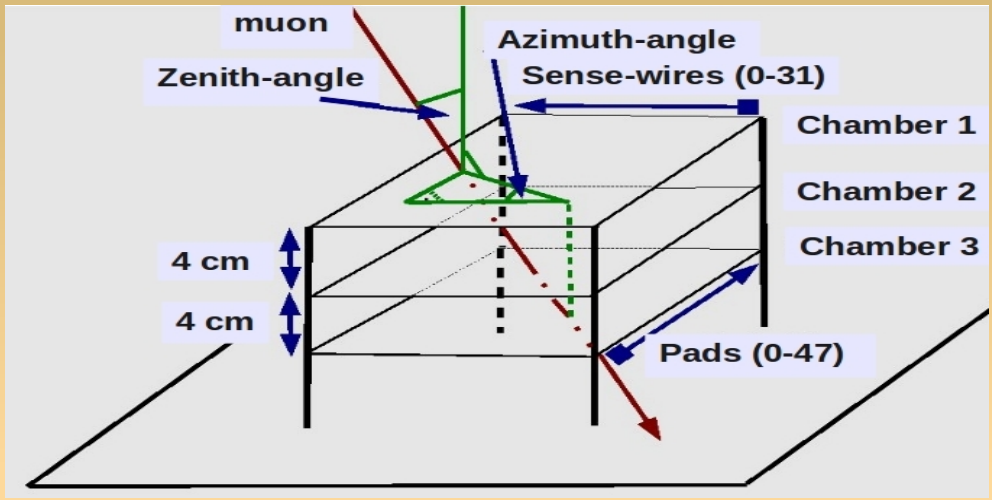
I. Motivation
II. Structure of the detector
III. Beam test at CERN PS
IV. Cosmic muon measurments in the lab
V. First steps to tomography
VI. Summary and outlook

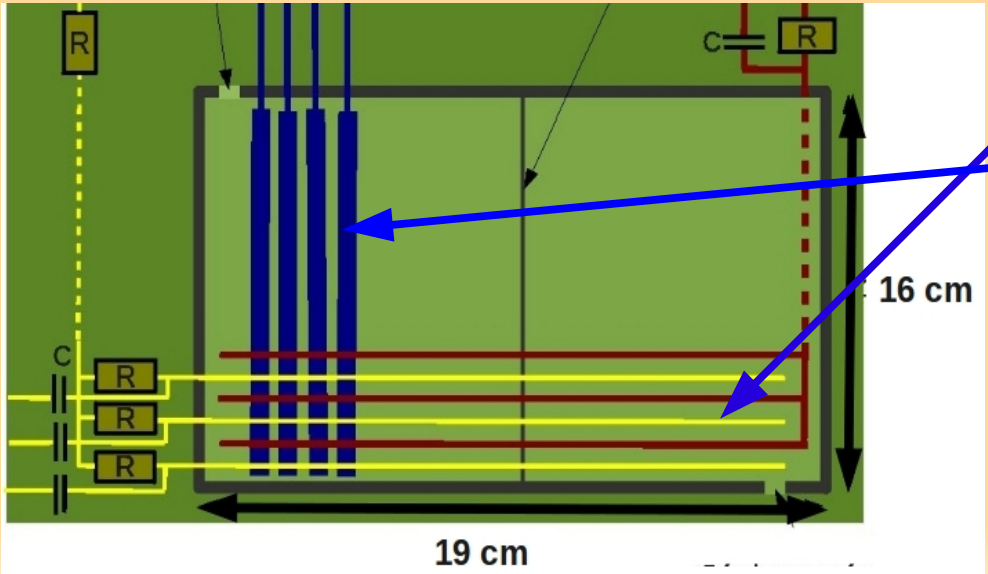
I. Motivation



- Our Earth is continually bombarded by high energy particles (p, ...).
- They interact with the atmosphere: producing pions, muons, etc.
- Cosmic muons reach the surface of the Earth.
- Applications in the XXI. century: archeology, geology, and homeland security, etc.
- Our aim:
  - much cheaper
  - more mobile
  - more energy saving
  - more precise

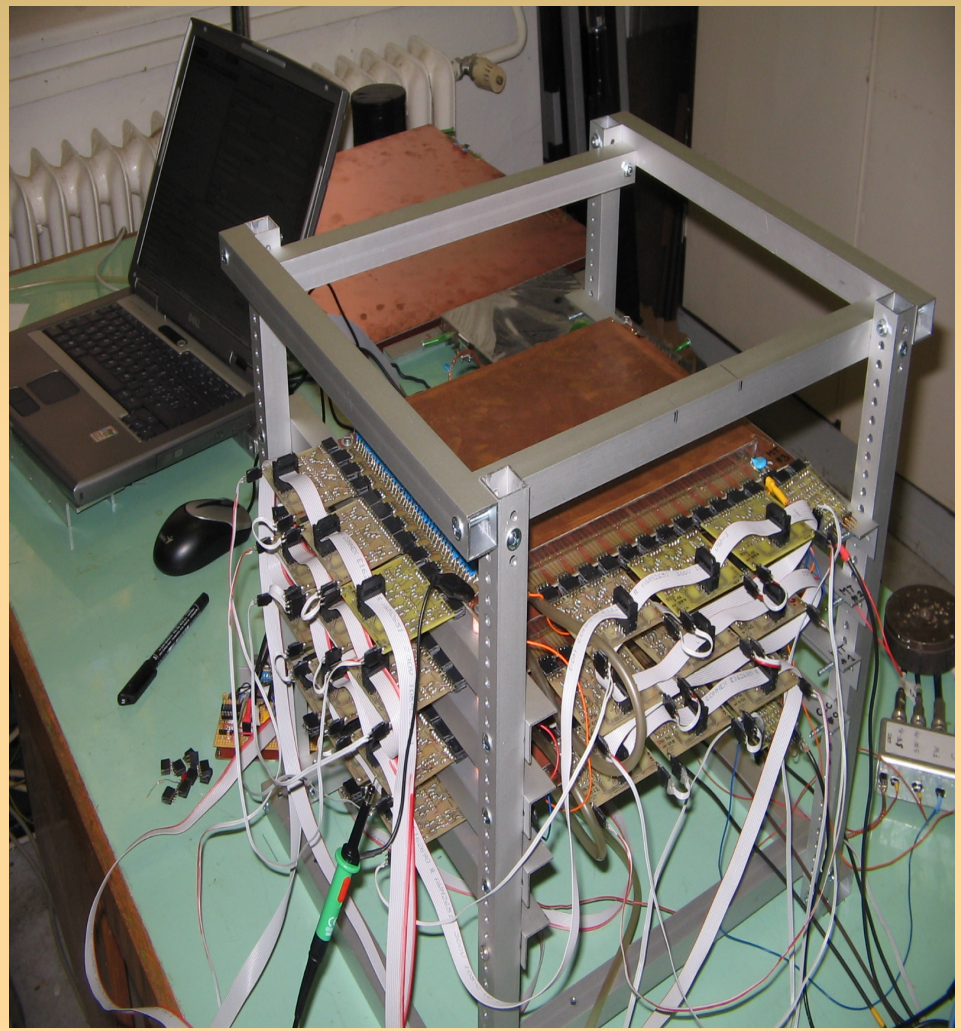
II. Structure of our muon tomograph

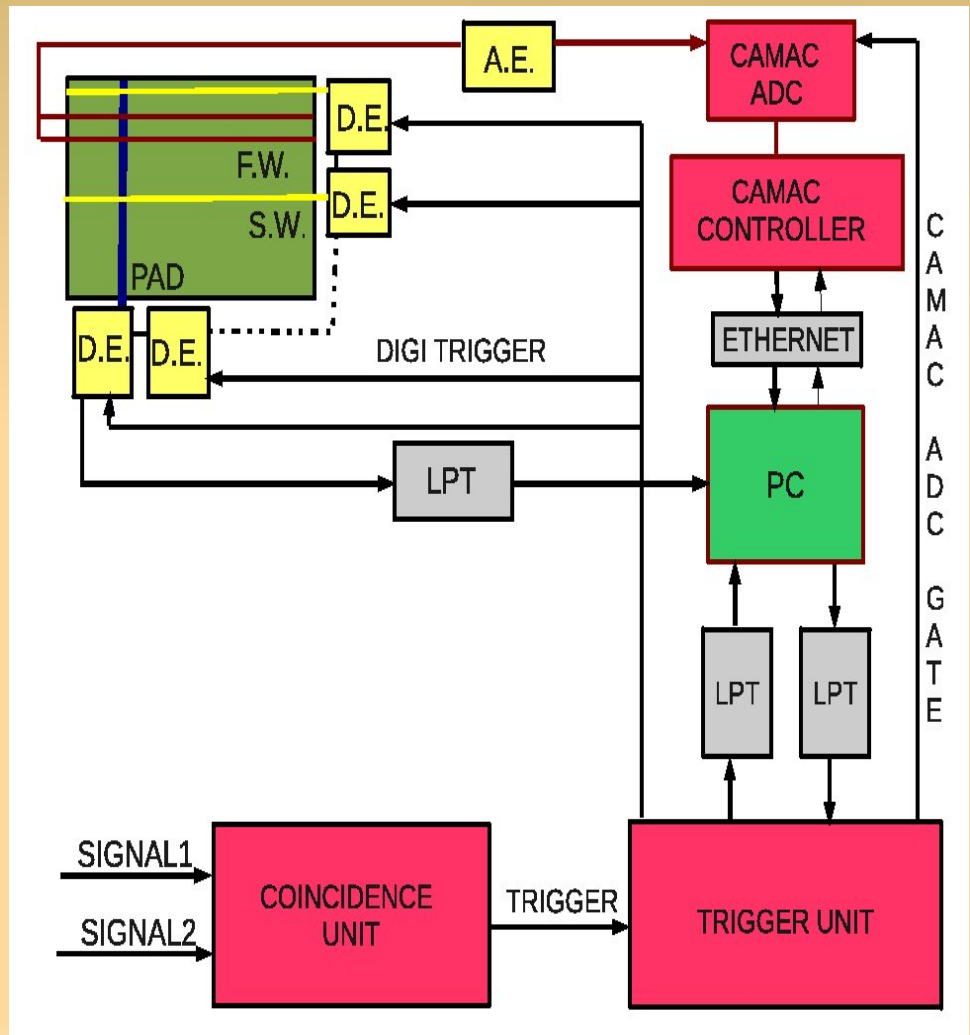




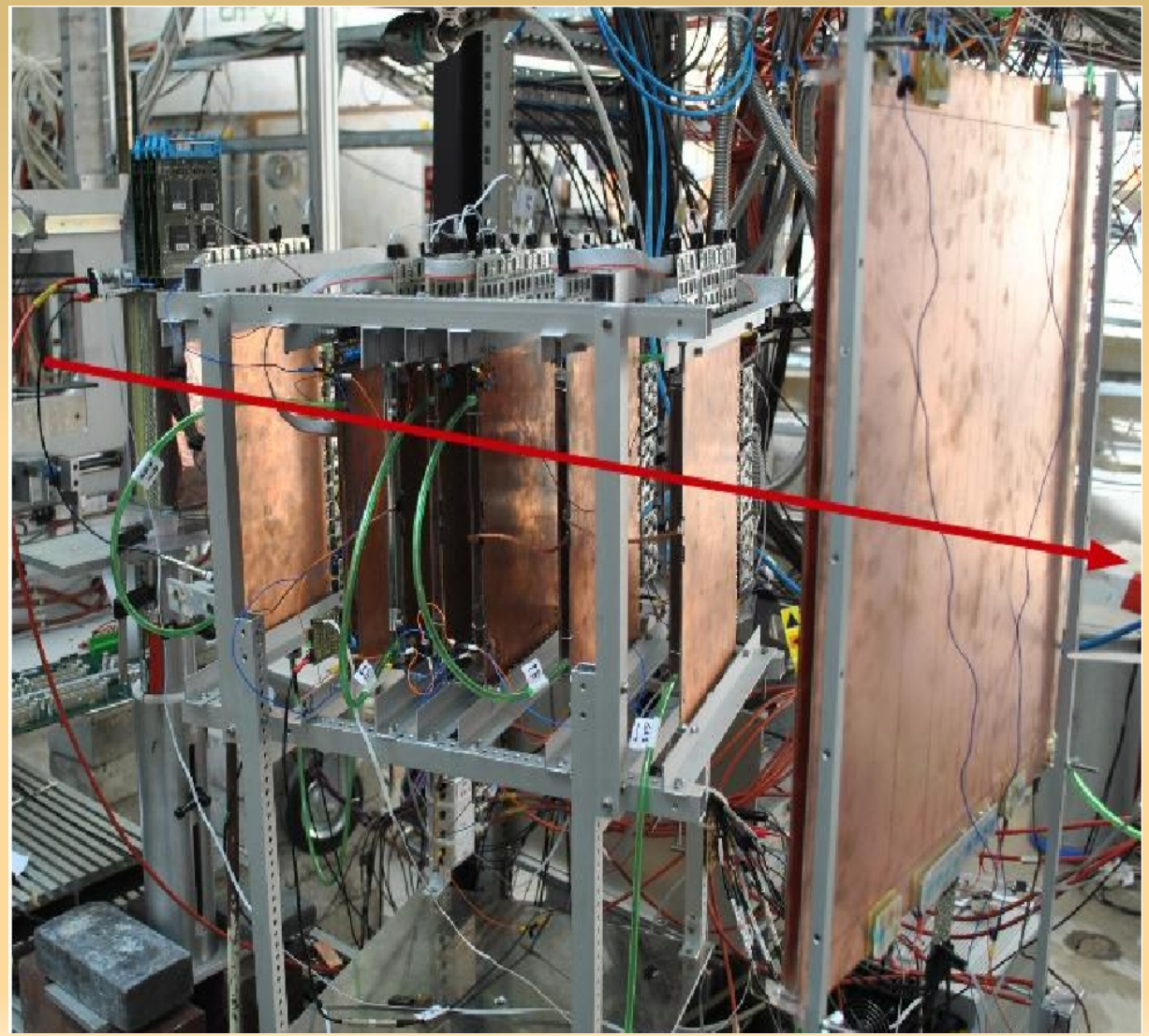
- There are 3 parallel Close Cathode Chambers (CCC) under each other.
- Particle path with 2 coordinates: zenit-angle , azimuthal-angle.
- 2 dimensional location in each of the 3 layers.
  - Sense wire distance 4mm (yellow lines)
  - Cathode is segmented into 4 mm wide pads (blue rectangulars).
- Chamber volume : 1 cm x 19 cm x 16 cm
- Ar - CO_2 gasmixture (90% -10 %)

Signal readout





III. Detector tests at CERN PS



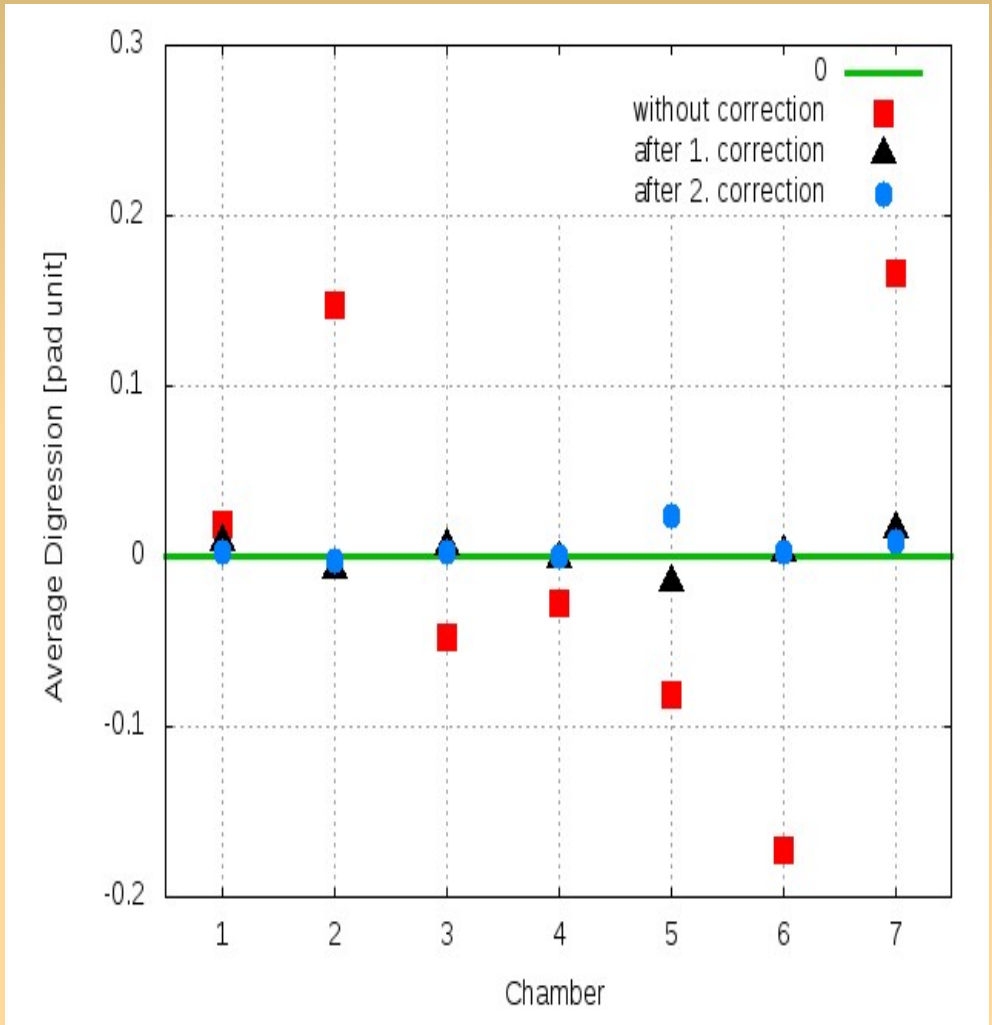
Beam test advances:

- Monoenergetic pion
- High flux
- Well collimated

Beam test setup:

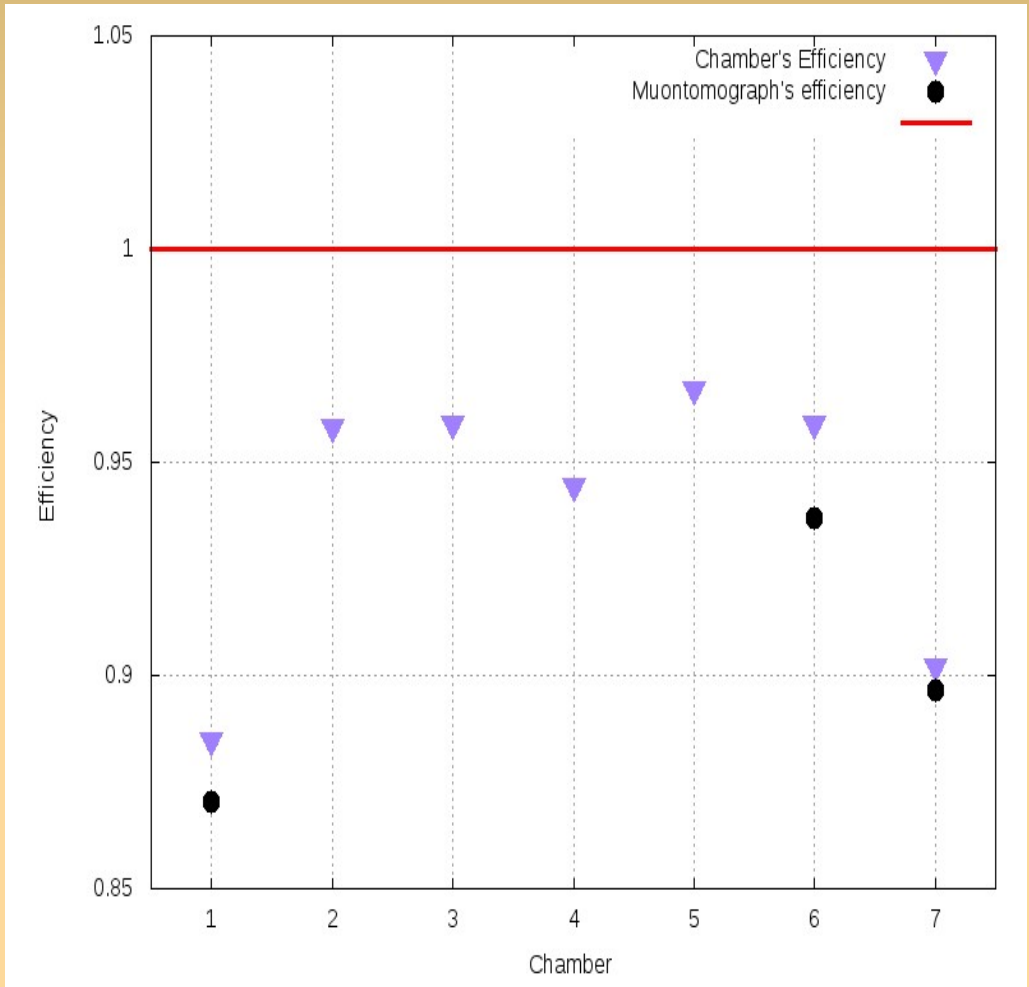
- 7 layers of CCCs: 1th, 6th and 7th chambers are the muon tomographs.

Offline Alignment



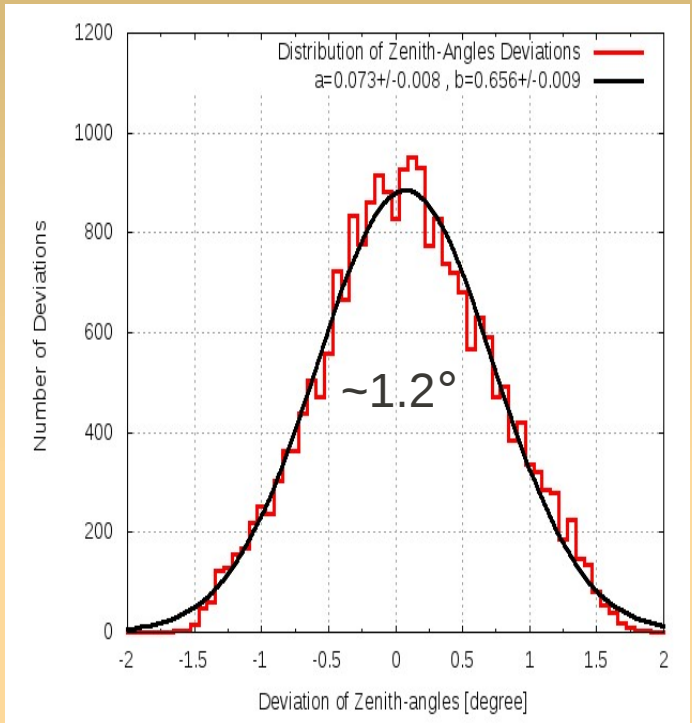
- After finding the clusters in the chambers, a line can be fitted on them.
- Deviations between points and the line can give the difference distribution.
- The average of the distribution gives the average digression and the error of the distribution gives the distance resolution.
- Further correction doesn't take further substantial improvement.

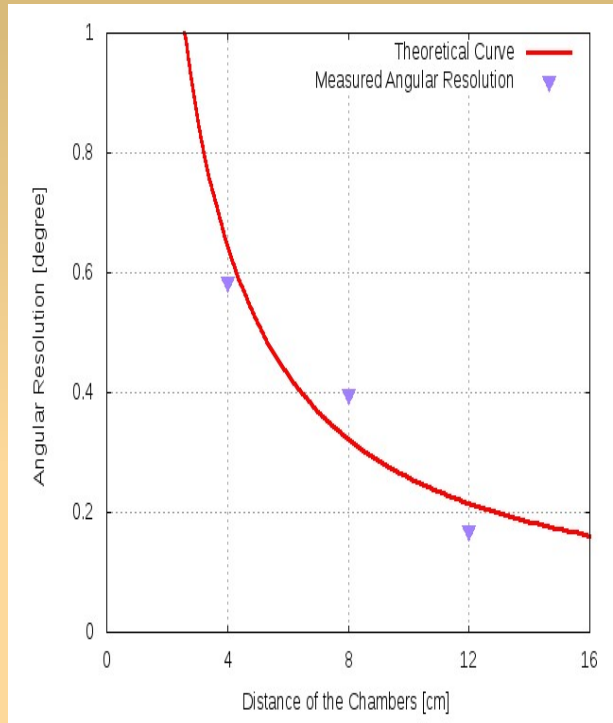
Efficiency

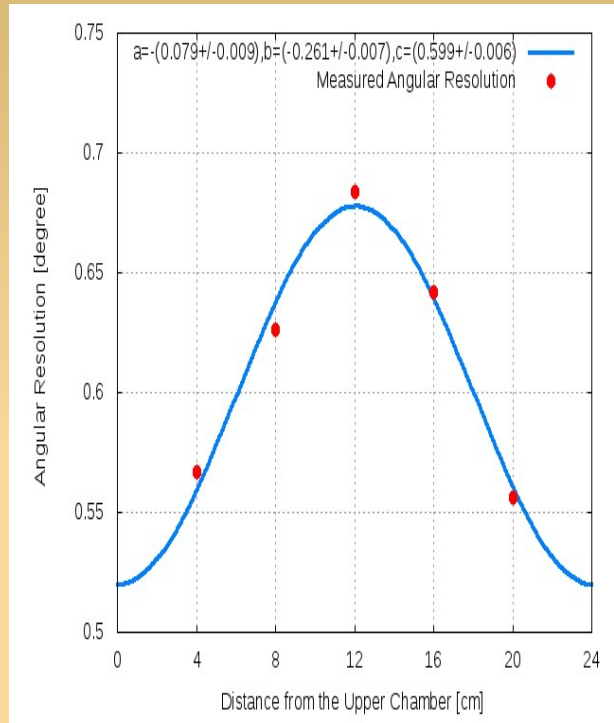


- The efficiency is specified by the ratio of the detected and total number of paticles .
- One can fit a line on 6 chambers (skipping actually tested chamber), if the distance of the extrapolated points and the measured points less than 2 pad unit (8 mm), then it's a ,,good'' count.
- Chambers have 90-95 % efficiency, which is adequate for our needs.

Angular Resolution

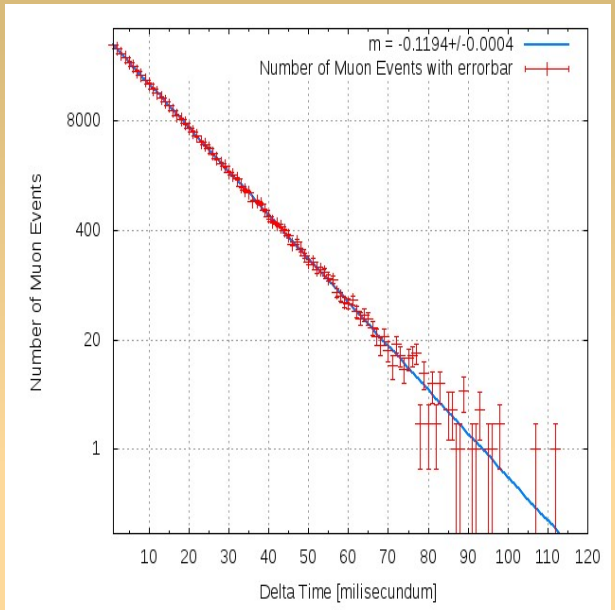


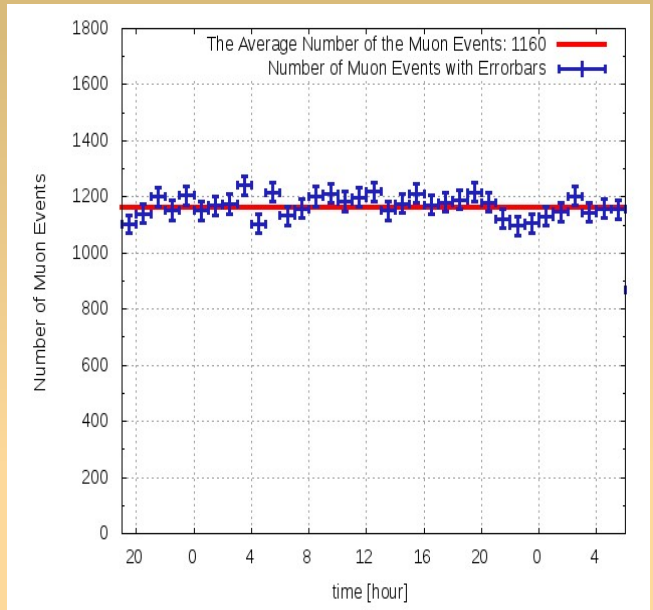


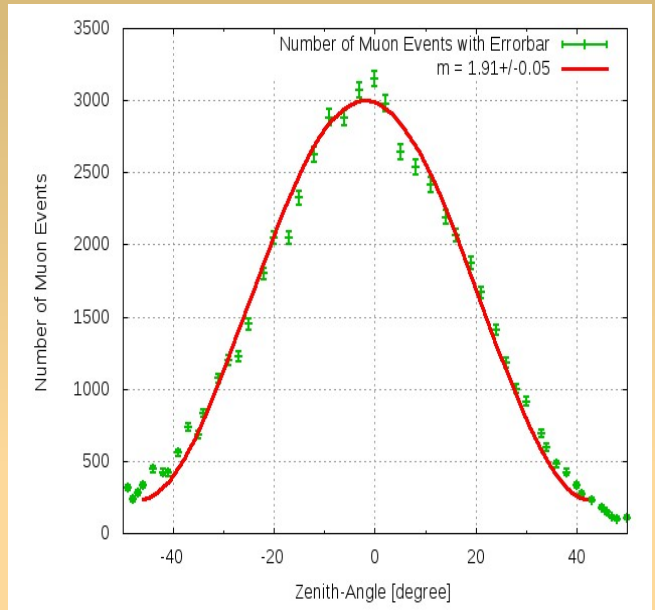


- Angular resolution specify the zenit angle between two points, which are distinct of each other.
- Angular resolution is inversely proportional of the distance of chambers.
- Angular resolution is slightly better (20%) if the middle chamber is placed closer to one of the outer chambers.

IV. Cosmic muon experiments in the lab





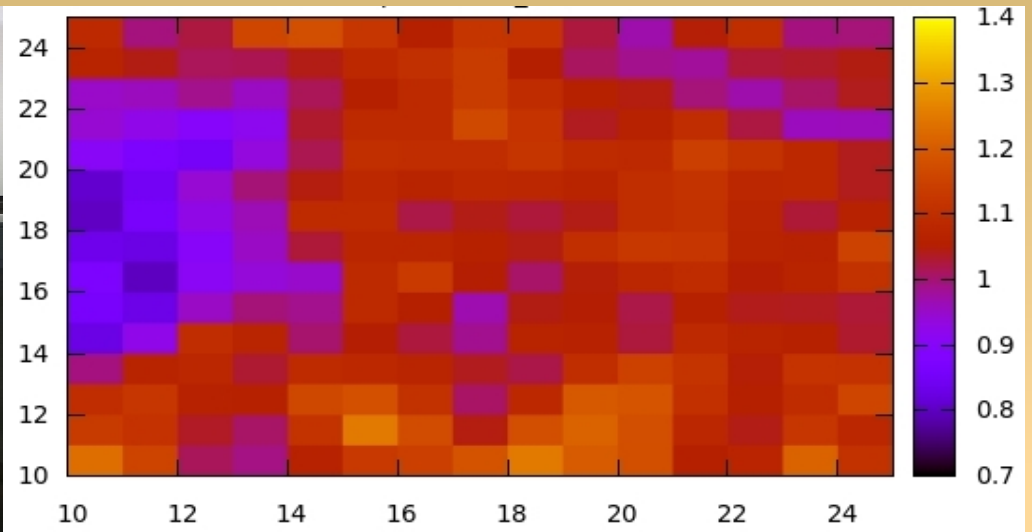


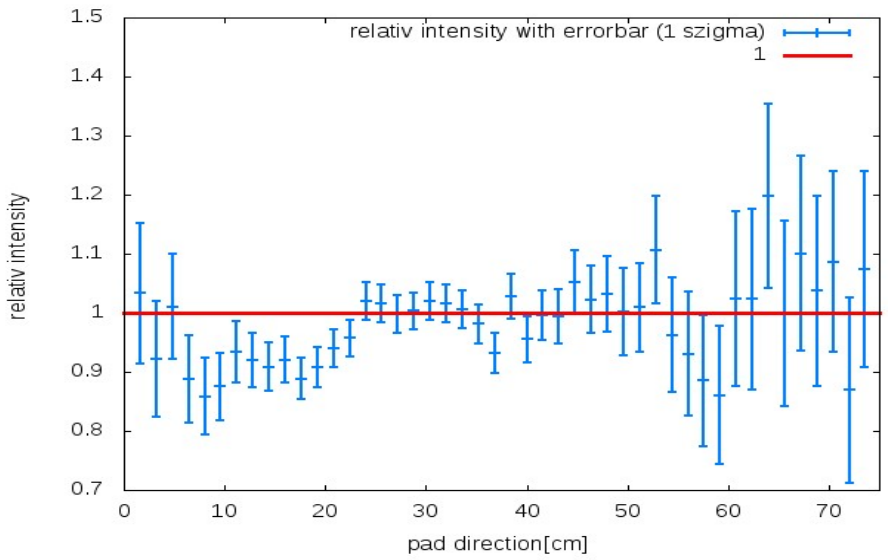
(1) **Distributon of the muon-events's timing :** The muon-events are independent and they reach the surface of the earth in equal chance, so muon event leads to exponential distribution.

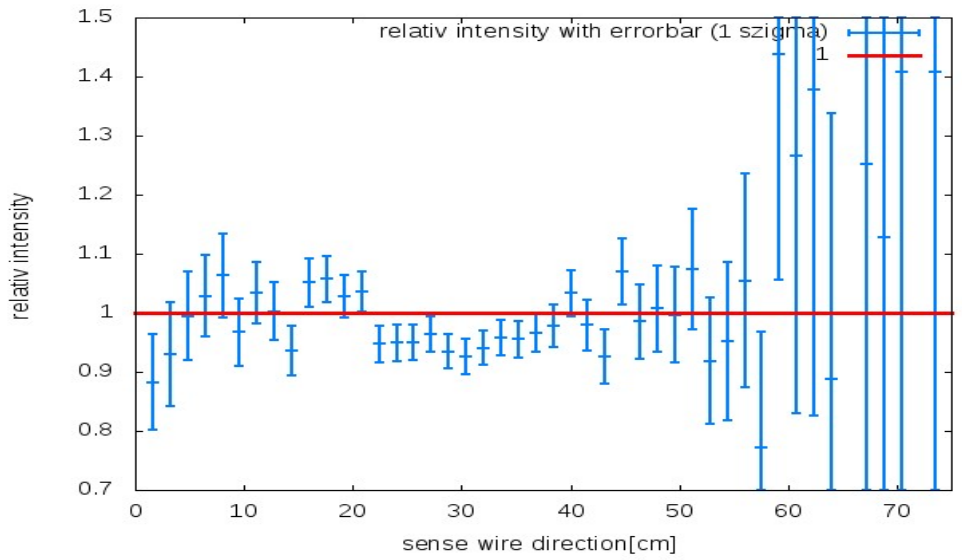
(2) **Solar modulation:** 1 - 2 % different to the average number of muon-events, therefore no relevant solar modulation were found.

(3) **Zenit-angle distribution:** The distribution ~ $\cos^m(\theta)$, where m found to be 1.91± 0.05 (similar in ref. P.K.F.Grieder, Cosmic Rays at Earth,Elsevier, 2001.).

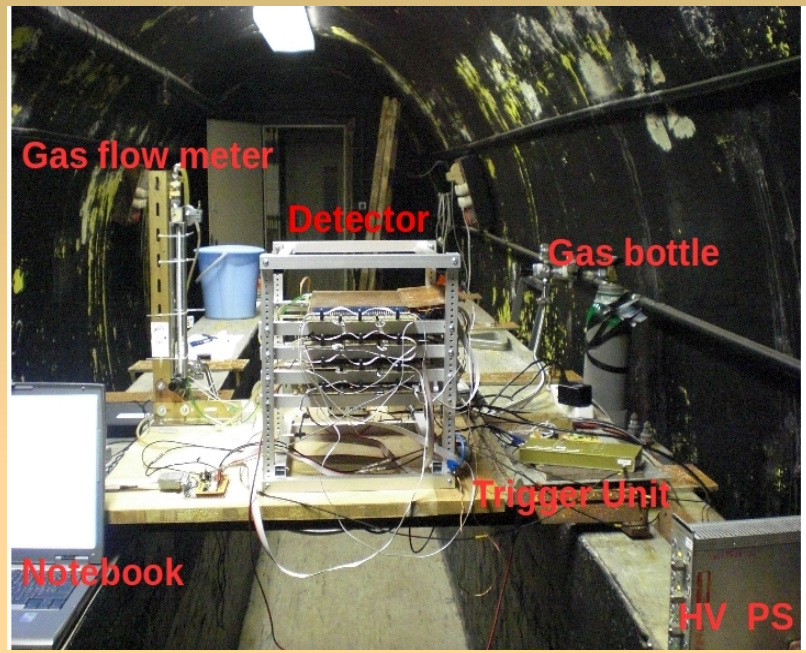
Muon tomography in the lab

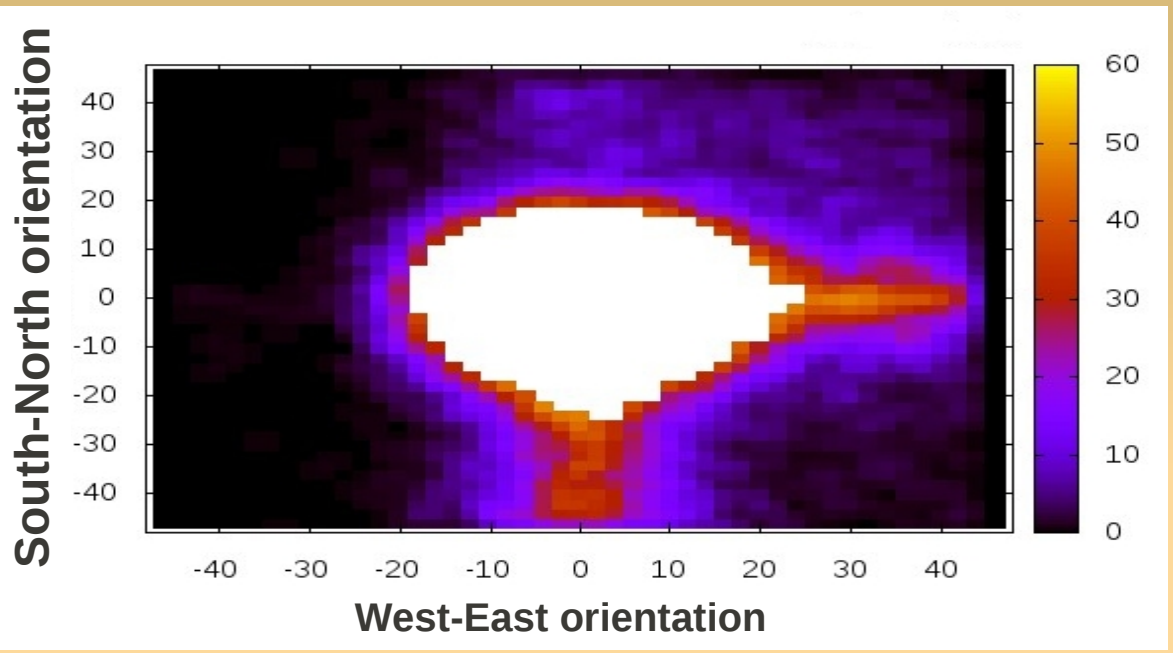






V. Detector tests in the Jánossy pit





- The Jánossy pit is a 30 meters deep underground construction, which is a great place for the tomography experiments.
- We started the measurments at the first level (- 10 m) below the ground.
- The right figure shows the tomography of the staircases of the pit!

Summary & Outlook

- New developed CCC were built in beginning of 2010.
- I wrote a C++ code to analize the collected data.
- Beam tests were done at CERN PS on 2010 August.
- The detector is suitable to cosmic muon tomography.
  - 4 mm spatial resolution
  - Mobile (< 10kg, + 20 kg gas for 2 months)
  - Cheap CCC technology
- Future plans: search for cave cavities, applied in archaeological excavations, in constructions and use for geological research.