Underground Multi-Muon Experiment EMMA

P. Kuusiniemi for EMMA collaboration

- **Intro**
- **EMMA**
- **Summary**

EMMA - Experiment with MultiMuon Array

New cosmic-ray experiment under construction
+ at the depth of 75 metres in the Pyhäsalmi mine
+ designed for composition studies at the knee region

First larger-scale experiment at Pyhäsalmi
+ consists of 9 detector stations ($\approx 4 \times 4$ m^2 each)
+ total detector area $\sim$ 300 m^2

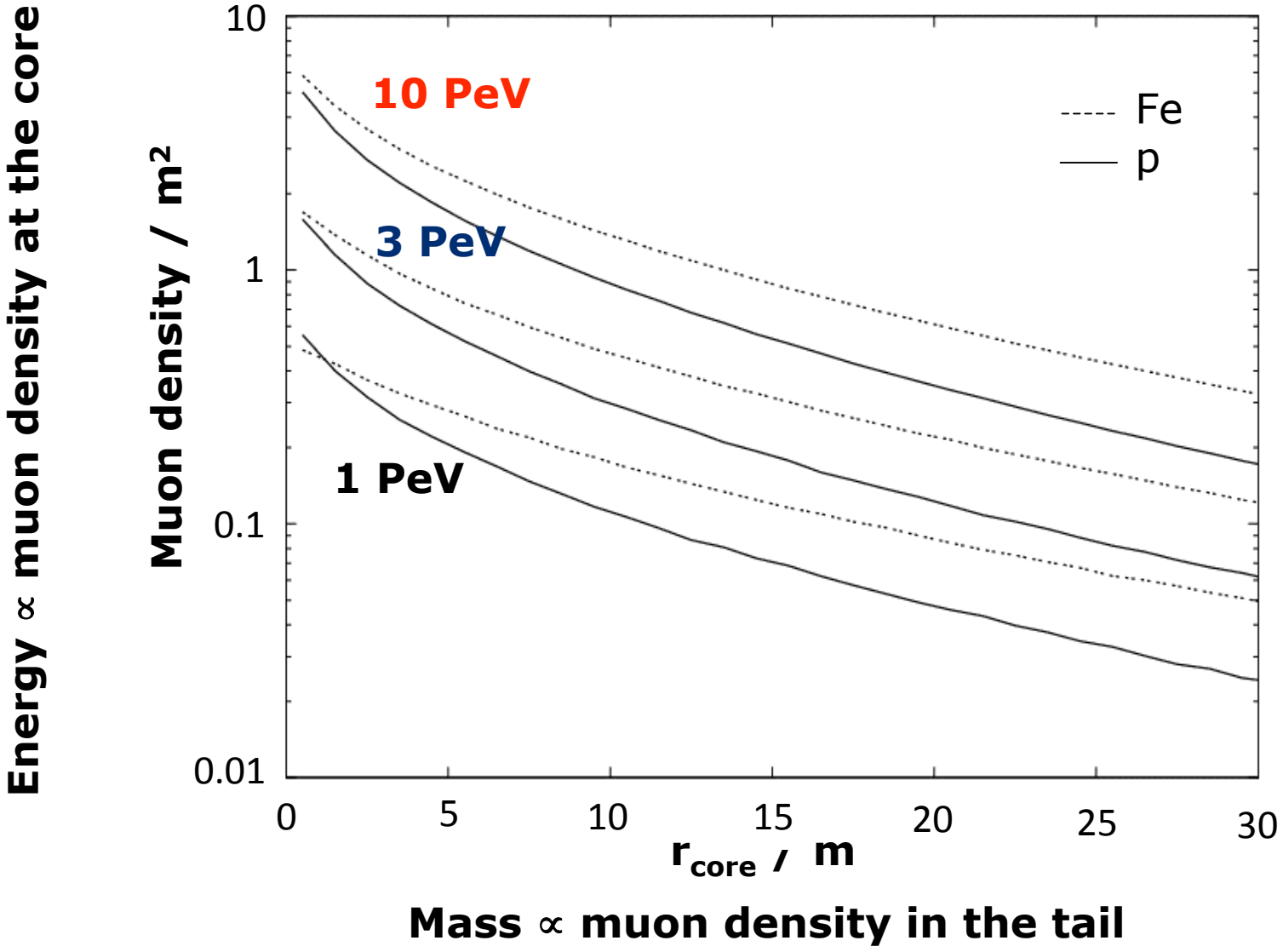
Design started 2005
+ 5 detector stations installed (and 4 have detectors in)
+ first muon tracks in the beginning of 2010

Detectors from
+ CERN (former LEP-DELPHI drift chambers) and
+ Moscow (small-size plastic scintillators)

Idea: EMMA measures muon multiplicities and lateral distributions

Simulated muon distributions

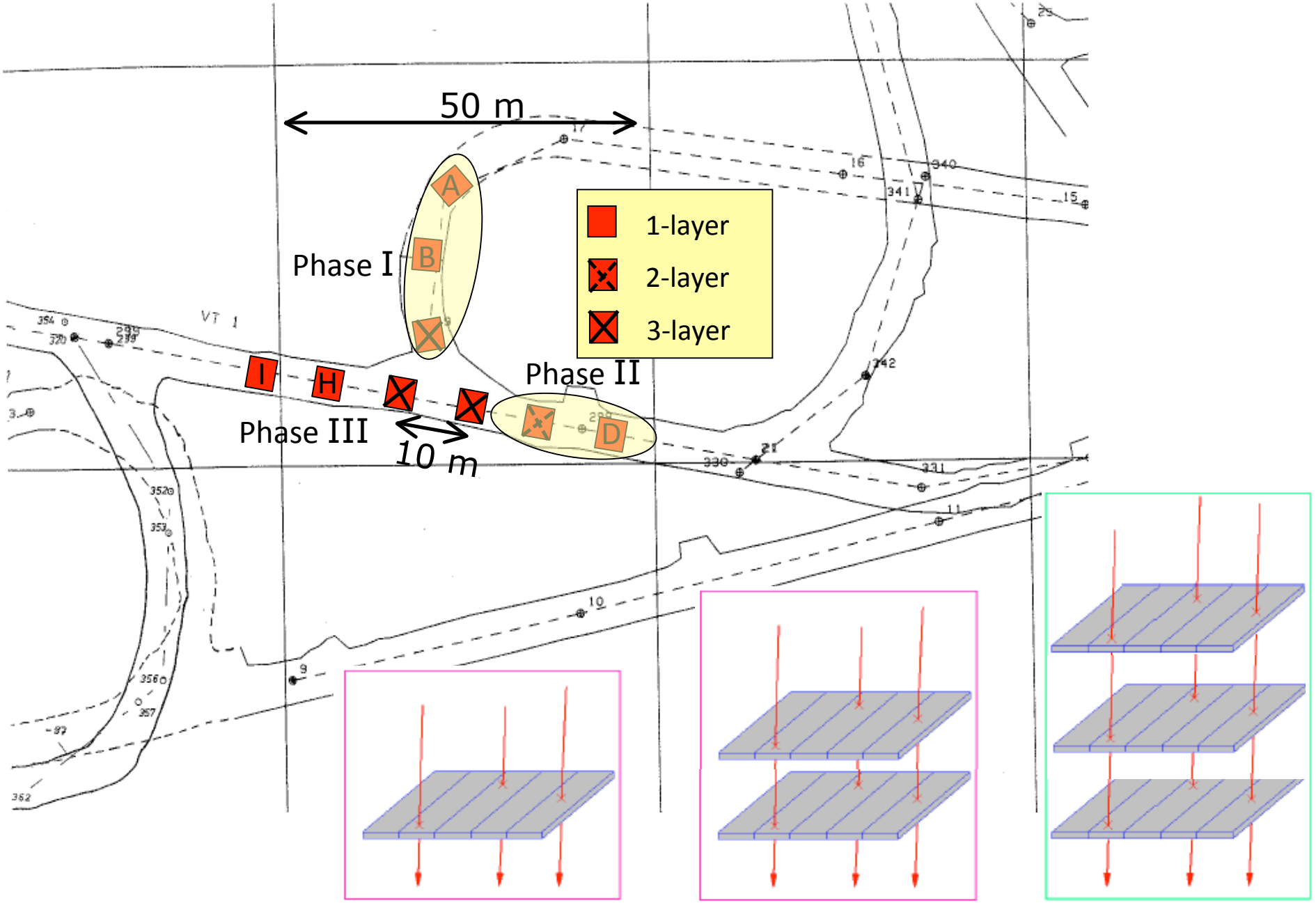
(CORSIKA+QGSJET 01 with **50 GeV cut-off**)



Mass ∝ muon density in the tail


EMMA cavern at 75 m

EMMA - Layout at 75 m



EMMA - Detector stations A, B and C



EMMA - Detector stations D and E



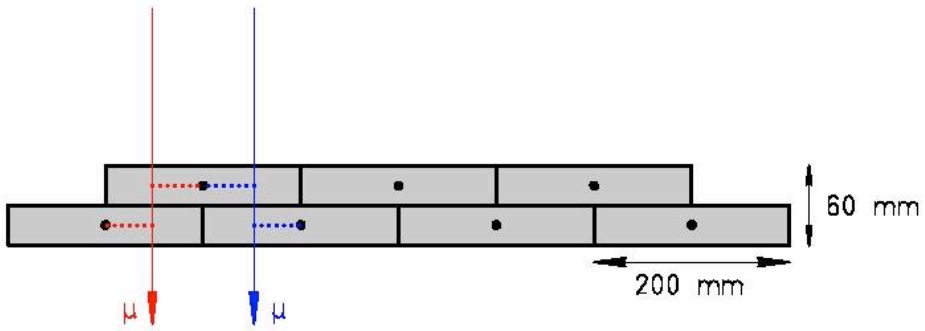
EMMA - Station C

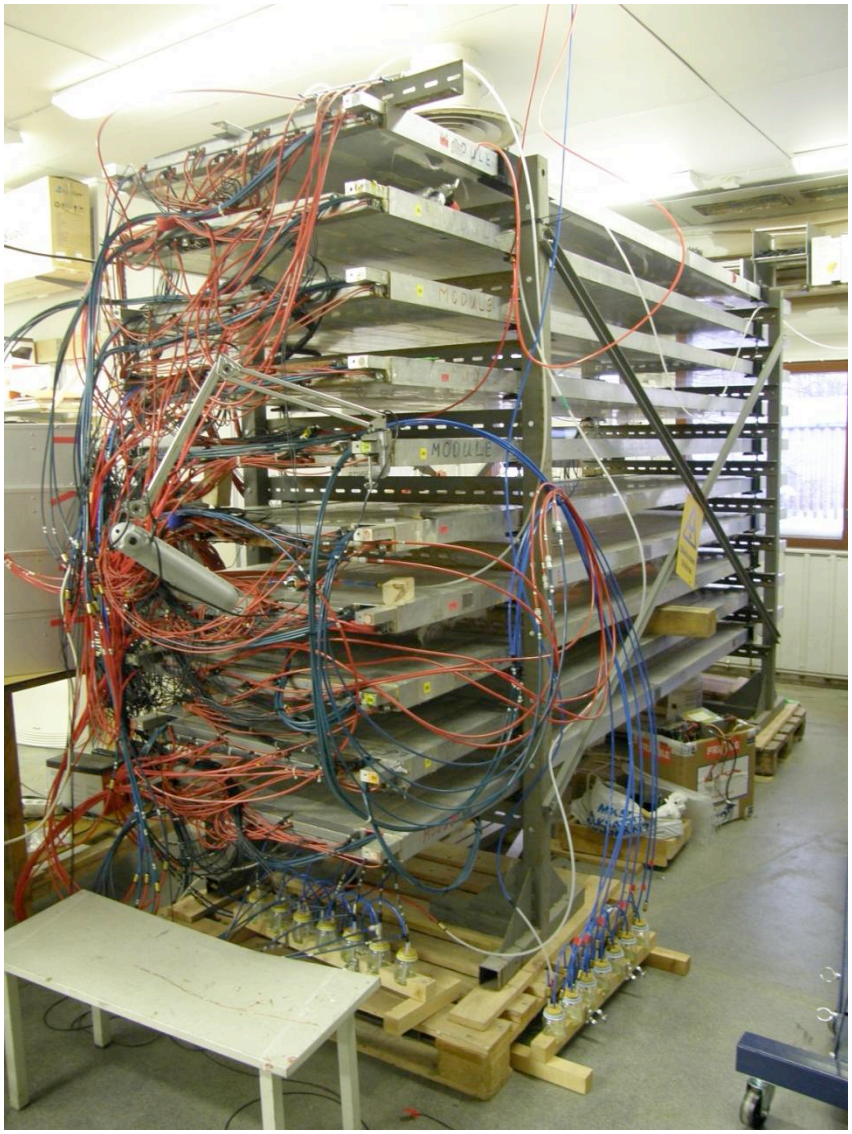


EMMA - Drift Chambers

Former LEP-DELPHI
MUBs (80 planks)

- **7 individual chambers,**
- **365 × 20 cm² each,**
- **m ≈ 120 kg,**
- **position resolution ~ 1 cm²,**
- **Ar(92%):CO_2(8%) at 1 bar,**
- **min 0.25 bar·l/min (/plank),**
- **max 4 consecutive chambers.**

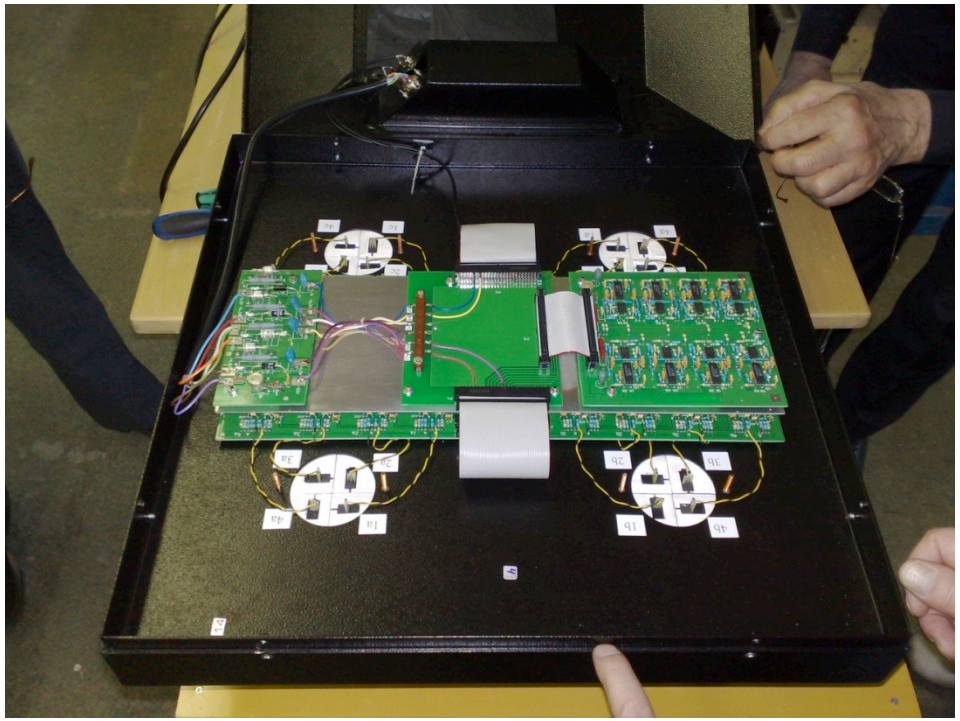




EMMA - Plastic scintillators (≈ 50 m²)

- **50 × 50 cm², height ≈ 13 cm, m ≈ 20 kg,**
- **arranged to 16 individual pixels, 12 × 12 cm², 3 cm thick each,**
- **employ APDs (**avalanche photodiodes**),**
- **time resolution ~ 1 ns.**





EMMA - Gas control

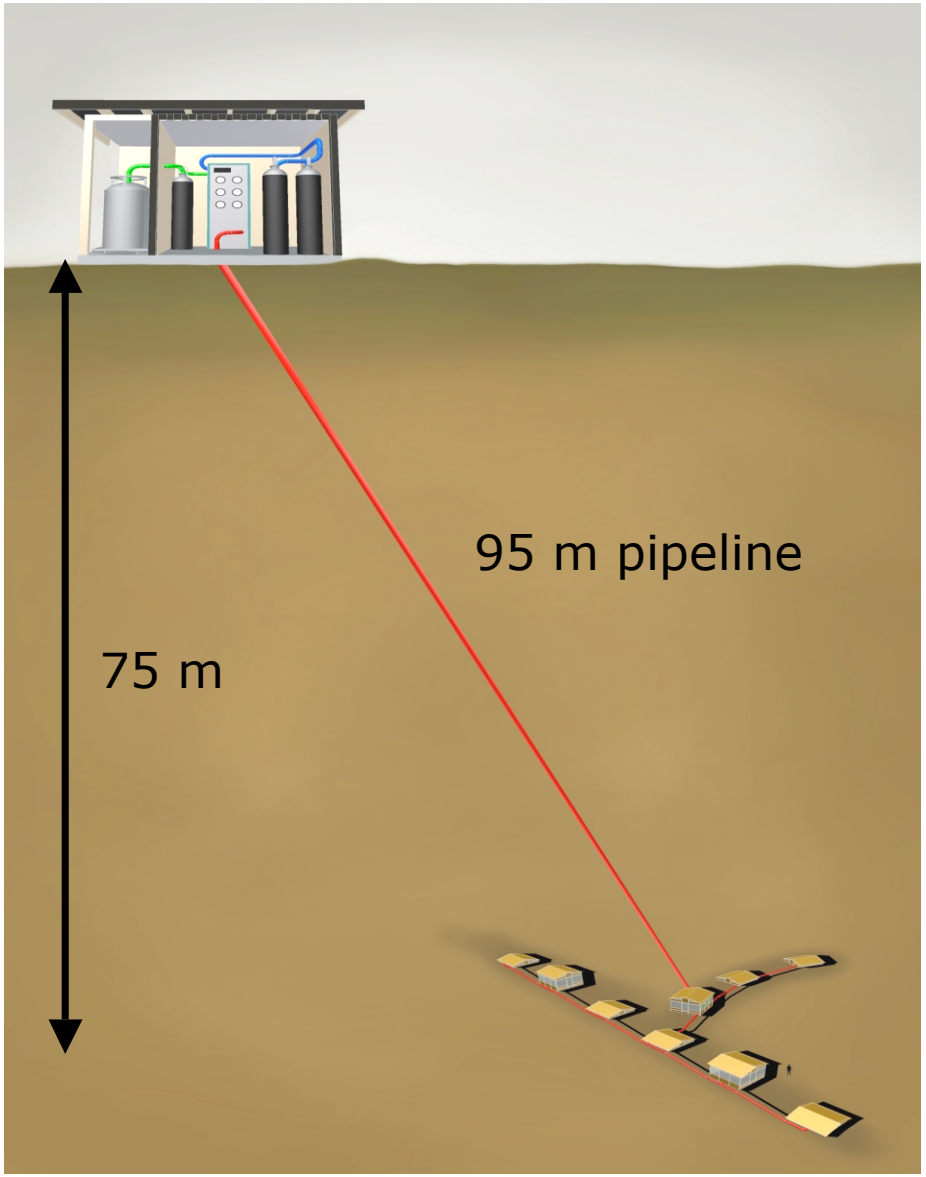


EMMA - Gas control

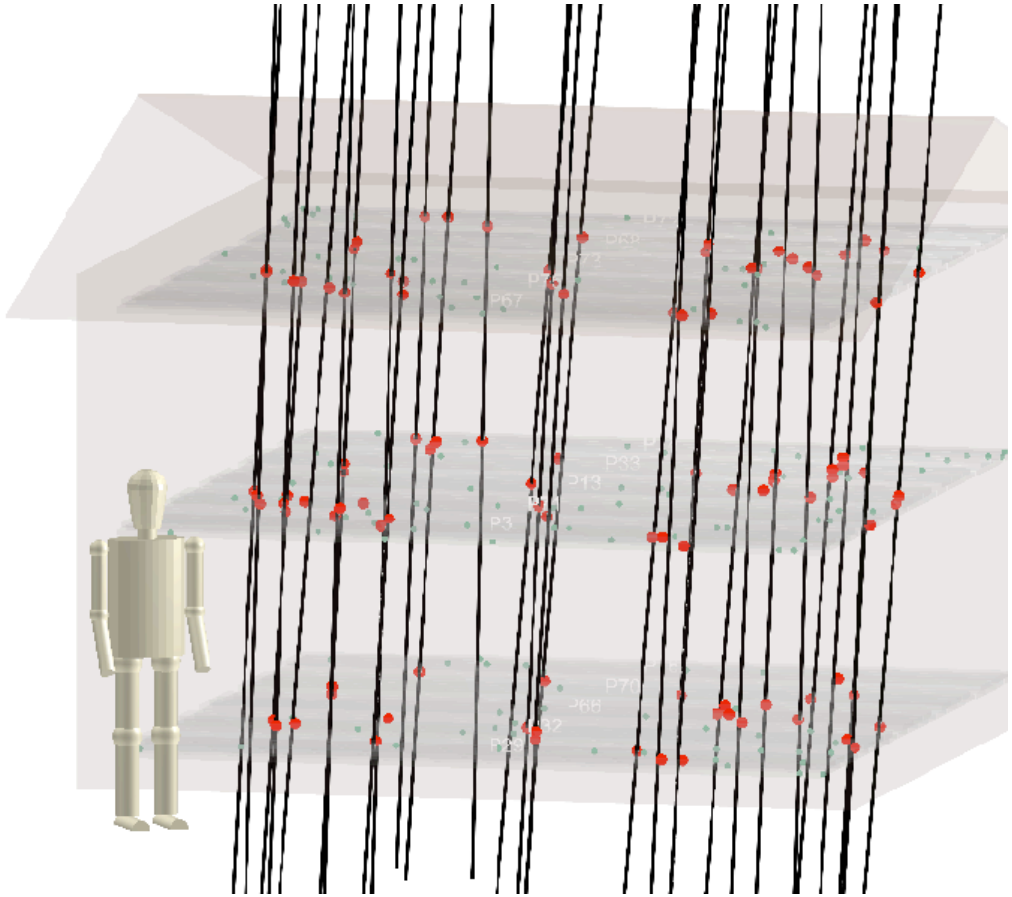
Ar-CO_2 mixture:

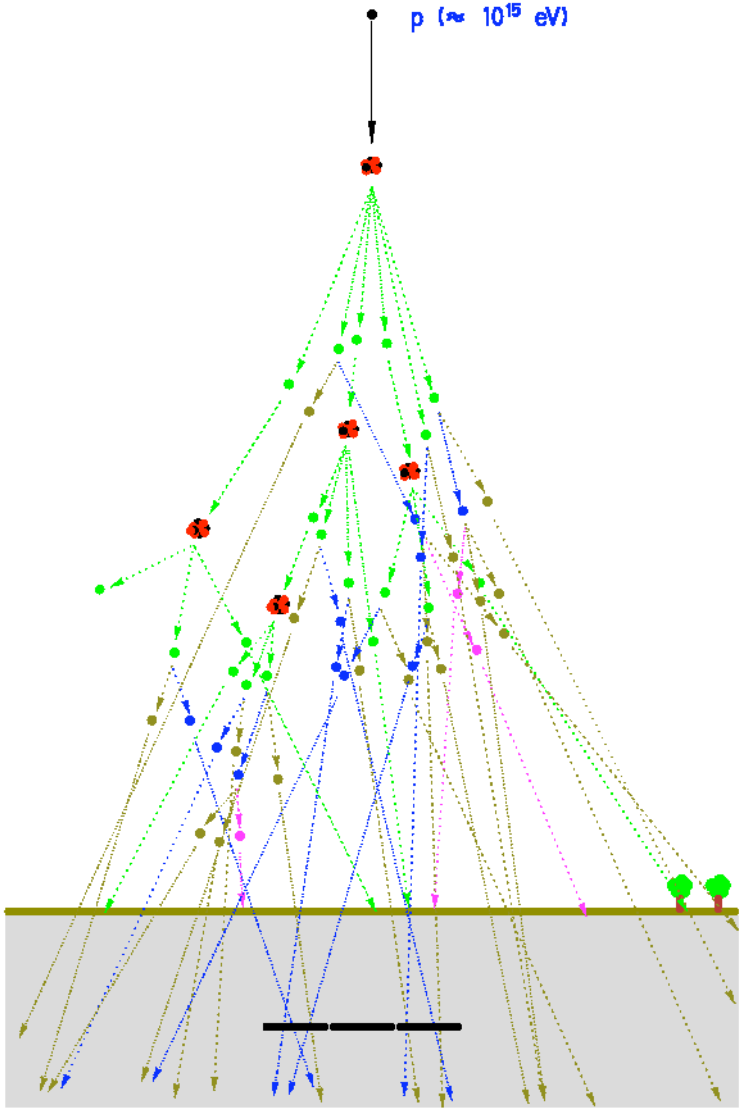
- Ar (92%) from dewar (LAr),
- CO_2 (8%) from 30 kg bottle,
- total 6 bar·litres/min, or
  200 bar × 50 litres/day.





EMMA - 29 tracks in station C





EMMA - Summary

New type of cosmic-ray experiment
+ takes the advantage of 75 m of rock and muon distributions

Studies the composition around the knee region
+ proton/iron –ratio below and above the knee

Is the first larger-scale physics experiment in the Pyhäsalmi mine
+ first test measurements in 2008
+ first tracking tests started in the beginning of 2010
+ construction phase ready within a year
+ records data for 5 – 10 years

EMMA - Collaboration

T. Enqvist, J. Joutsenvaara, P. K., K. Loo, T. Räihä, J. Sarkamo
University of Oulu, Finland

T. Kalliokoski, M. Slupecki, W.H. Trzaska, A. Virkajärvi
University of Jyväskylä, Finland

L. Bezrukov, L. Inzhechik, B. Lubsandorzhiev, V. Petkov, V. Volchenko, A. Yanin
RAS/INR, Moscow, Russia

H. Fynbo
University of Århus, Denmark

See also posters:

T. Räihä: Event reconstruction in EMMA

V. Volchenko: The features of electronics structure of the multichannel scintillation module for the EMMA experiment