The MONOLITH Project

Progress Report:
LNGS-LoI 20/99
CERN/SPSC 99-24

A. Geiser
Hamburg University

for the MONOLITH Collaboration
(~ 80 physicists)

Italy
Bologna, CNR, Frascati, L'Aquila, LNGS, Milano, Napoli, Rome, Torino &INFN

Germany
Bonn, Hamburg, HU Berlin, Münster

USA
Columbia Univ., N.Y.

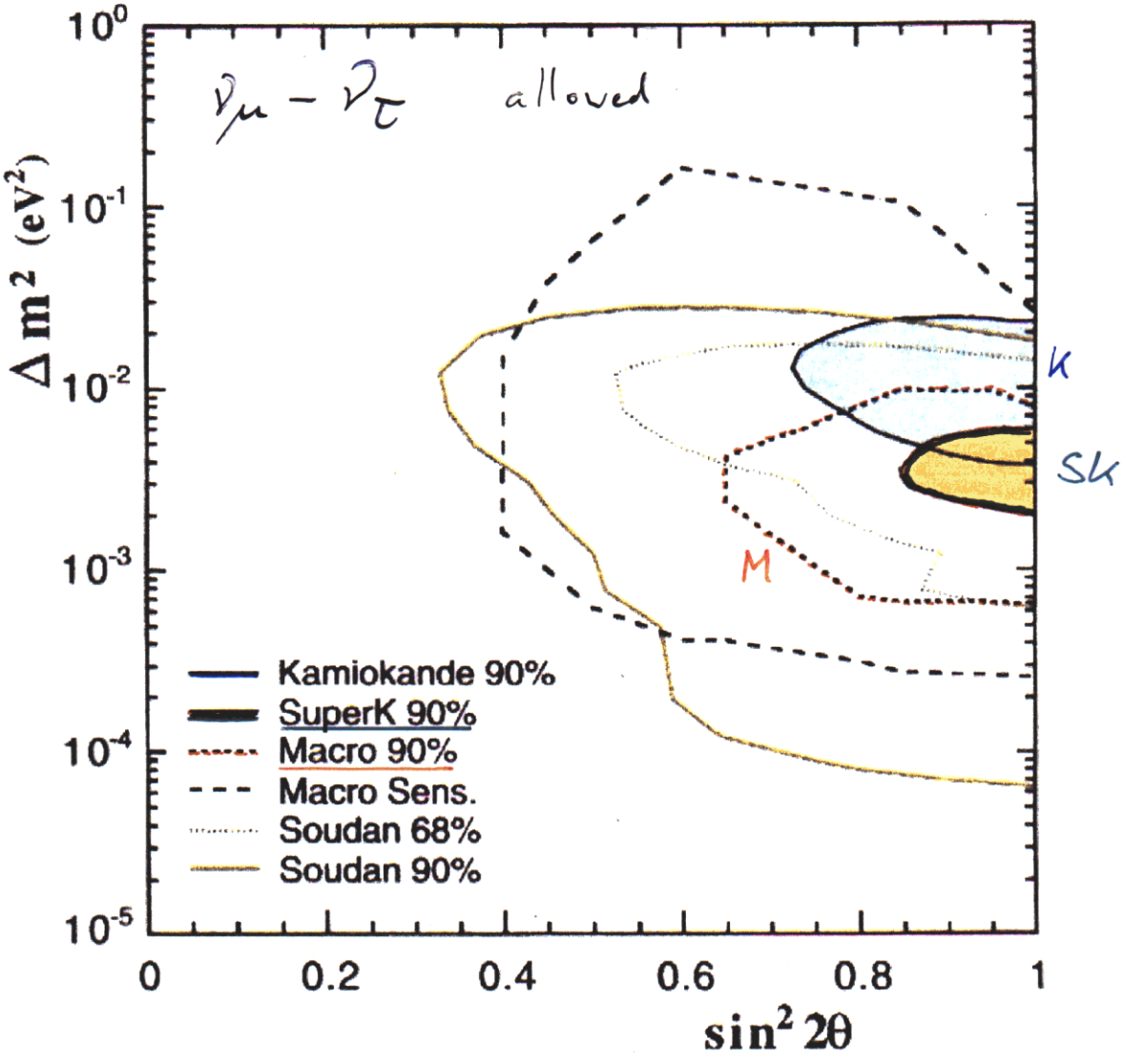
Russia
INR, MEPHI (Moscow)

NUFACT '00, Monterey, CA, USA
23 May 2000

- Physics at Gran Sasso/It. with atmospheric neutrinos $\gtrsim$ 2003/4
- Detector for entry level ν factory?

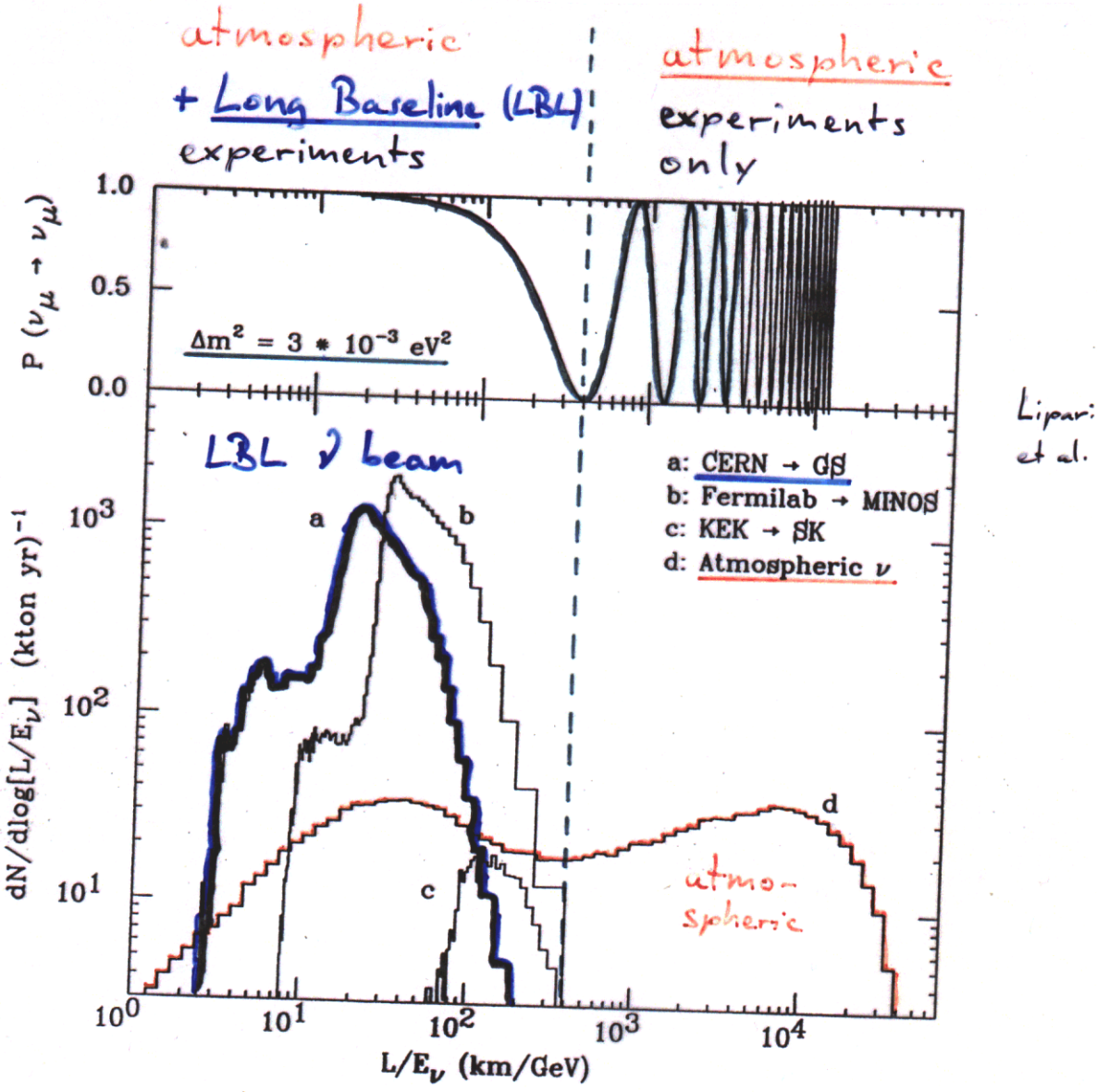
Atmospheric neutrinos,

Oscillation Parameters - Best Fits:



- **atmospheric neutrinos**

confirm Super-K, δm^2? $\nu_\mu - \nu_{\tau(e)}$? $\nu_\mu - \nu_s$? oscillations?



3 complementary strategies:

- ν_μ disappearance: $\frac{\nu_\mu \text{ far}}{\nu_\mu \text{ near}} < 1$
- NC/CC: $\frac{\nu_\mu + \nu_\tau \text{ NC}}{\nu_\mu + \nu_\tau \text{ CC}}$ enhanced
- ν_τ (ν_e) appearance:

$$\nu_{\tau(e)} + X \rightarrow \tau\,(e) + X$$

atmospheric ν anomaly:

ν oscillations or ν decay?

e.g. $\nu_\mu \rightarrow \nu_s$ + majoron

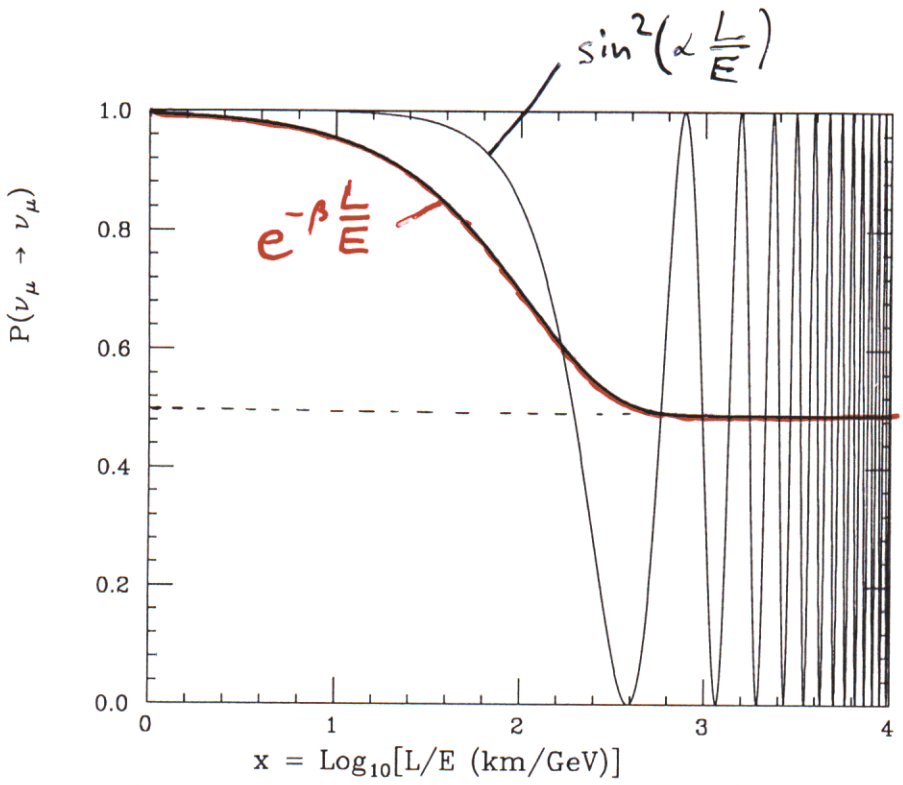


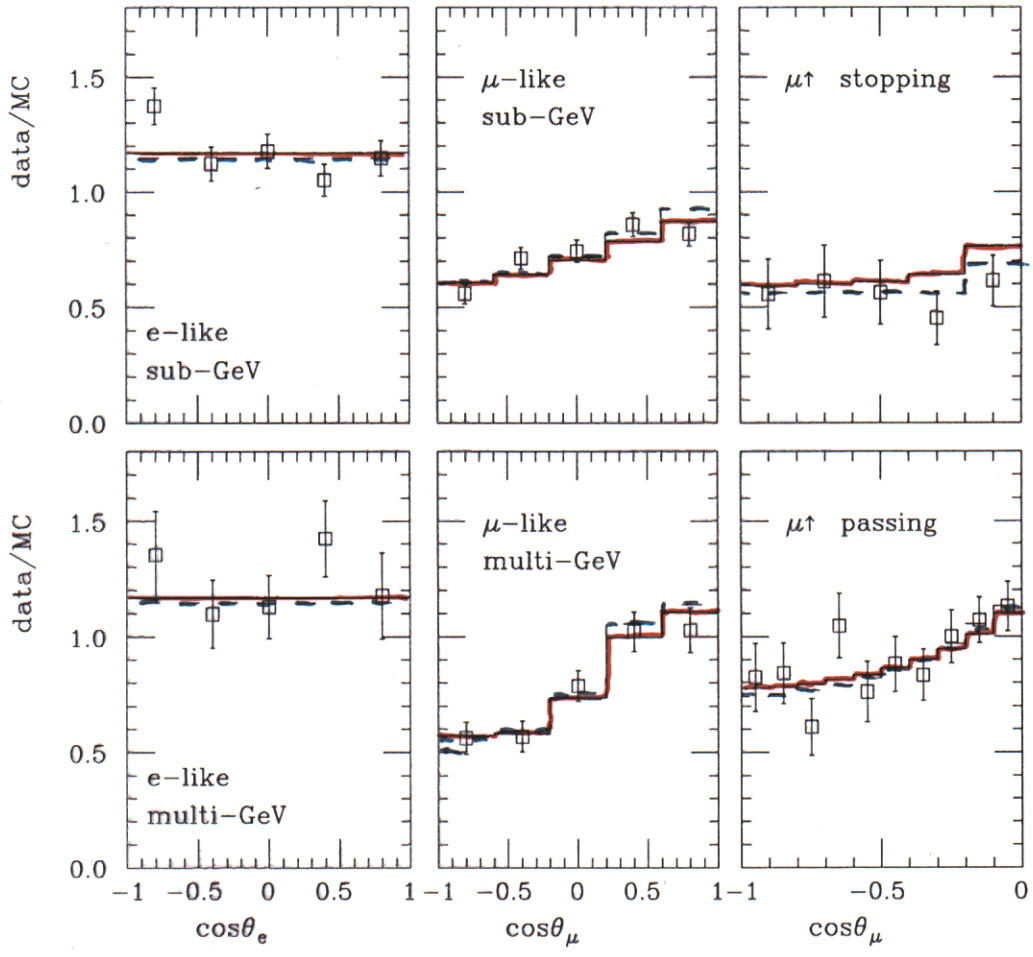
FIG. 2. Survival probabiliity for ν_μ versus $\log_{10}(L/E)$ for the decay model (heavy solid curve) and ν_μ oscillation model (thin curve).

Barger et al.

Super-Kamiokande

—— ν decay

- - - - - ν oscillations



Barger et al.

FIG. 1. Comparison of decay model (solid histograms) and ν_μ–ν_τ oscillation model (dashed histograms) with SuperK data from Ref. [3].

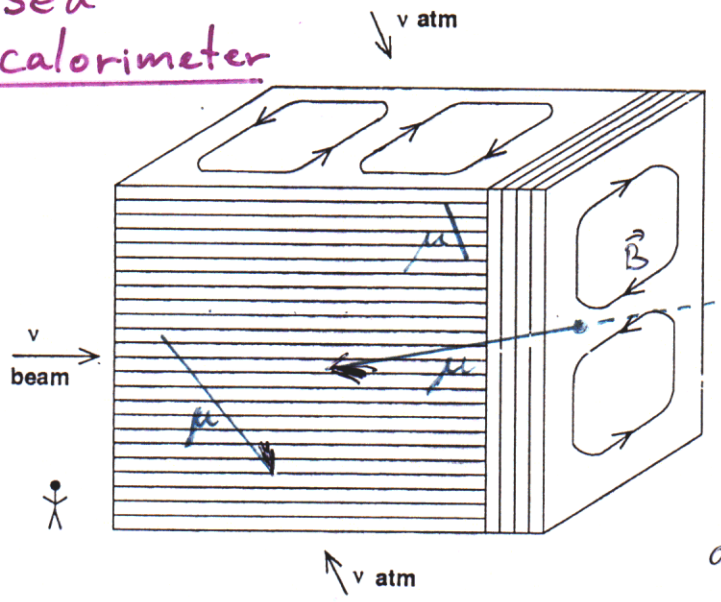
indistinguishable !

MONOLITH

magnetised tracking calorimeter

2 or 3 modules

120 8cm Fe-plates + RPC's



atmospheric neutrinos

34 kt

B = 1.3 T

proposal in preparation

data: ≳ 2003/4

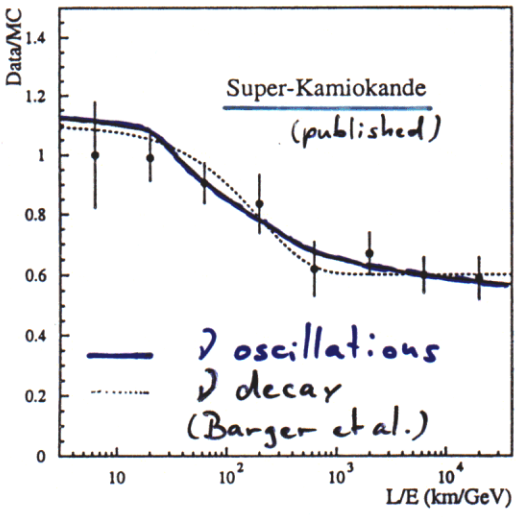
improvements w.r.t. Super-K: (ν_μ - disappearance)

- momentum and charge measurement for all muons ($p_\mu > 1$ GeV)
- measurement of hadronic energy
  ⇒ better resolution in E_ν
- more useful statistics at high E_ν
  ⇒ better ν angular resolution
  ⇒ better resolution in L

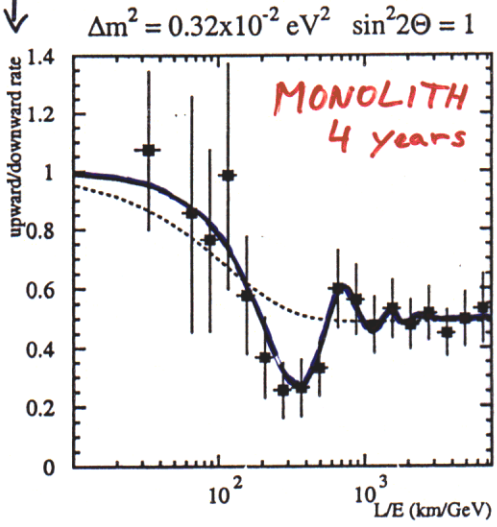
} better L/E resolution

Measurement of the first oscillation minimum

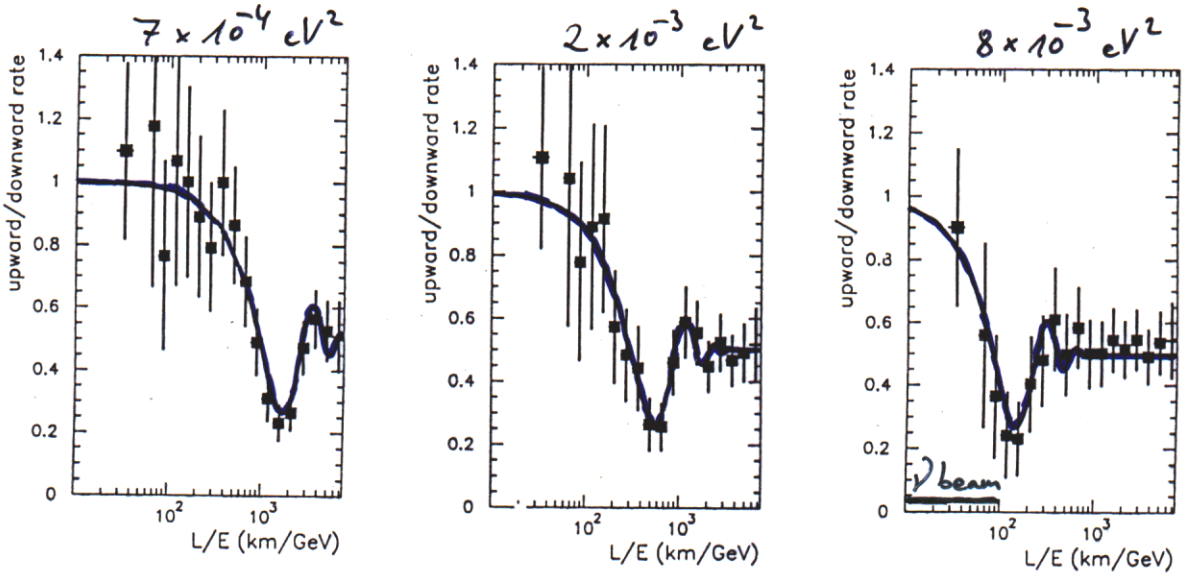
ν_μ - disappearance



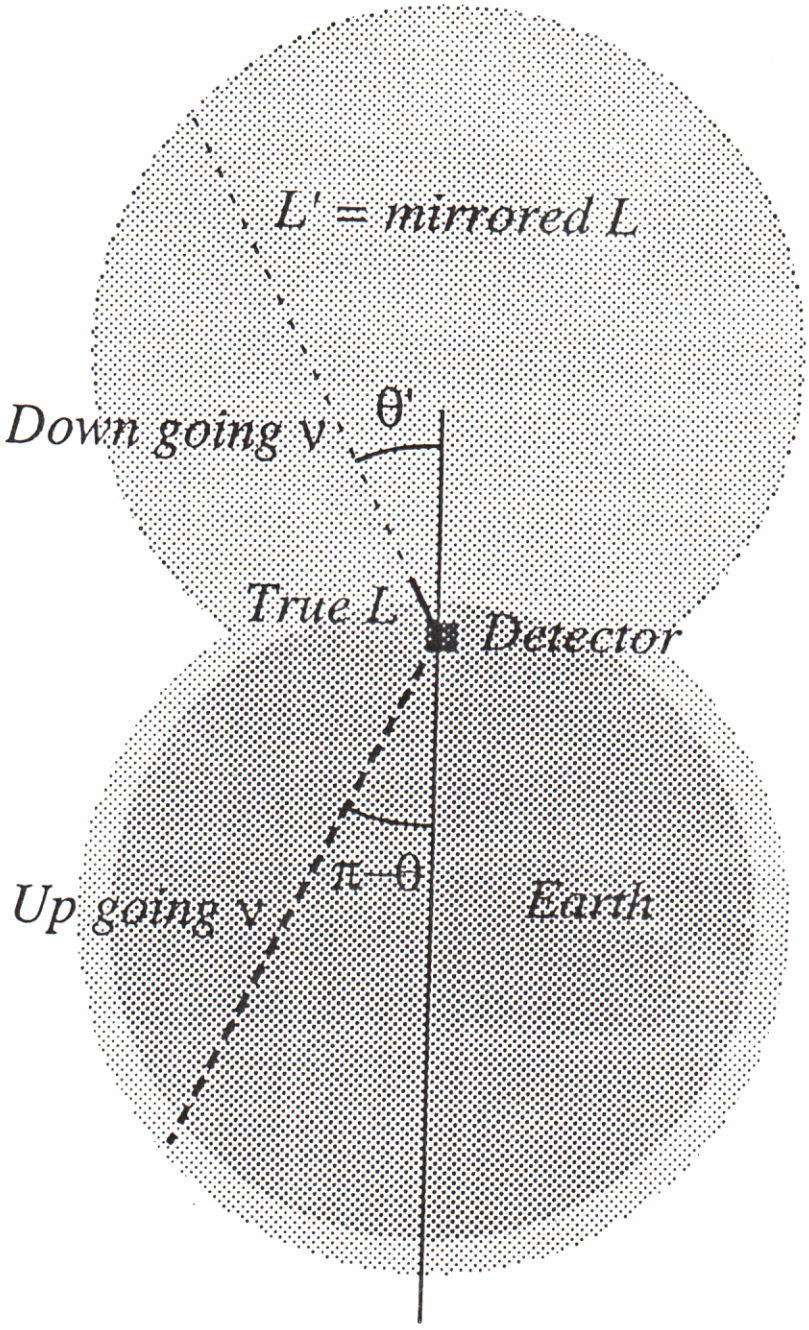
MONOLITH:
Systematics limited by ratio measurement



MONOLITH: $\sin^2 2\Theta = 1$, $\Delta m^2 =$



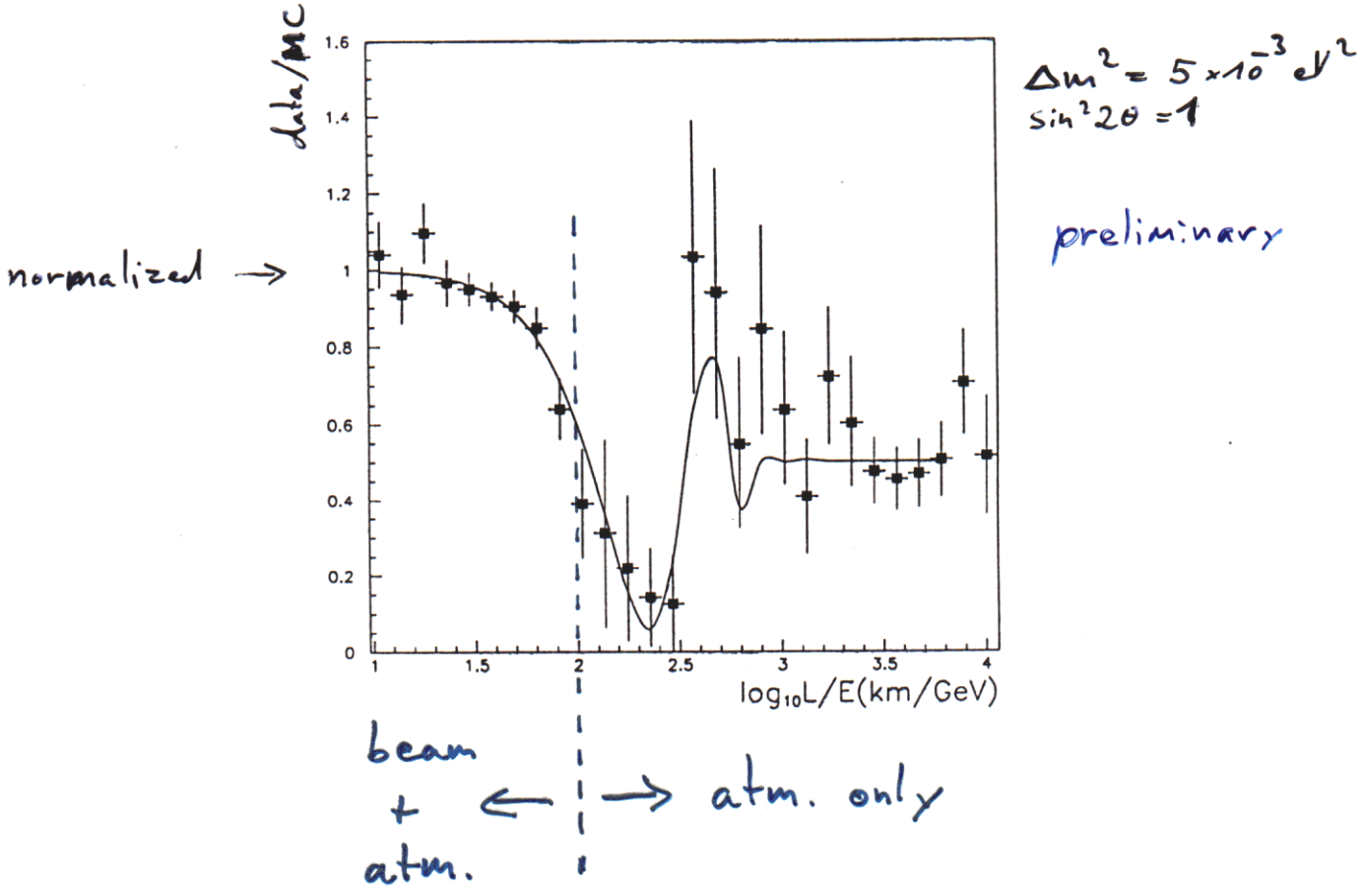
⇒ proof of oscillation hypothesis over full SK allowed range


L' = mirrored L
Down going ν
θ'
True L
Detector
Up going ν
π−θ
Earth

CERN / Gran Sasso beam $\geq$ 2005

example:

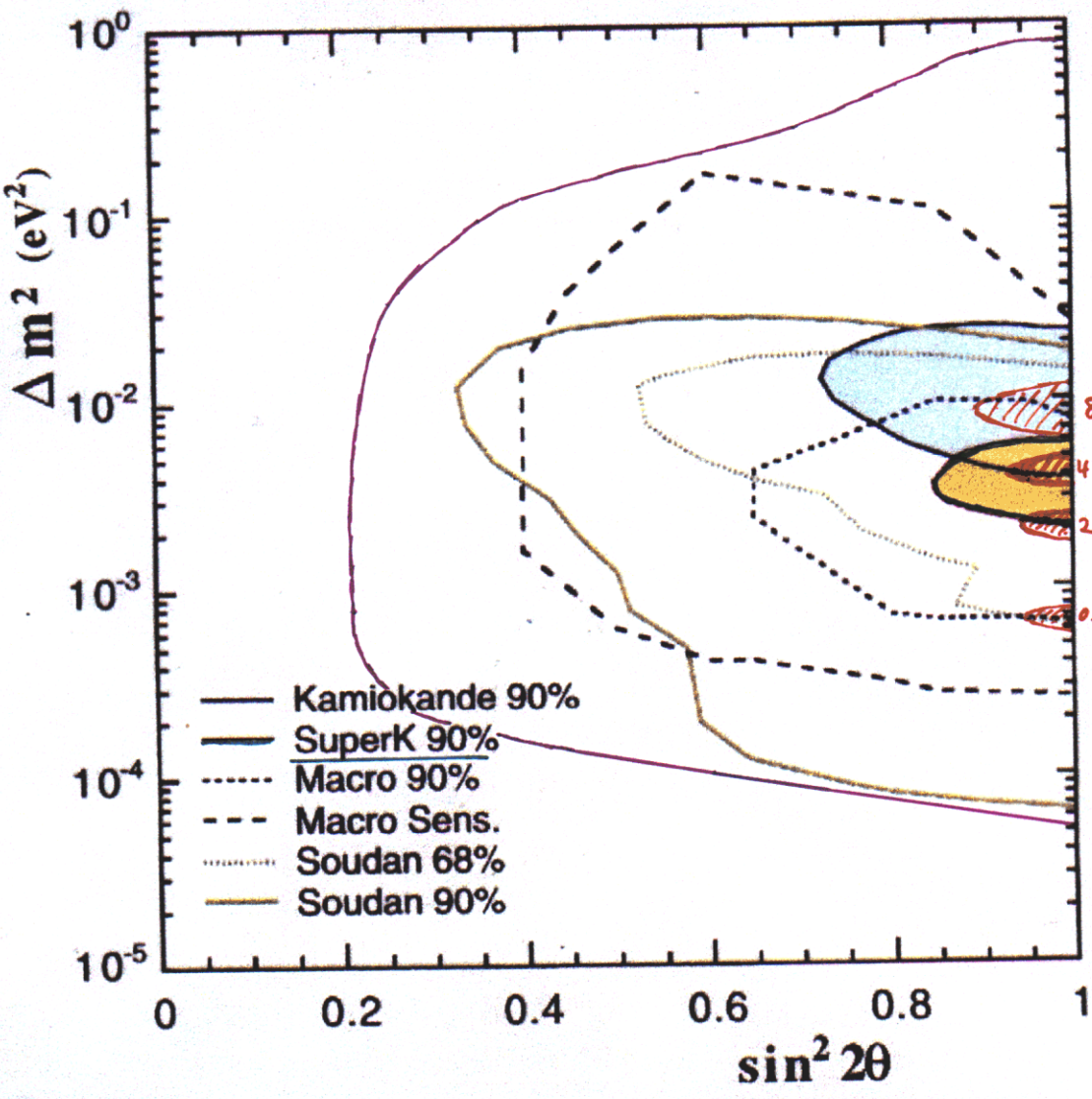
MONOLITH 2 years atm. + 1 year beam



$\Delta m^2 = 5 \times 10^{-3}\ eV^2$
$\sin^2 2\theta = 1$

preliminary

Oscillation Parameters - Best Fits:



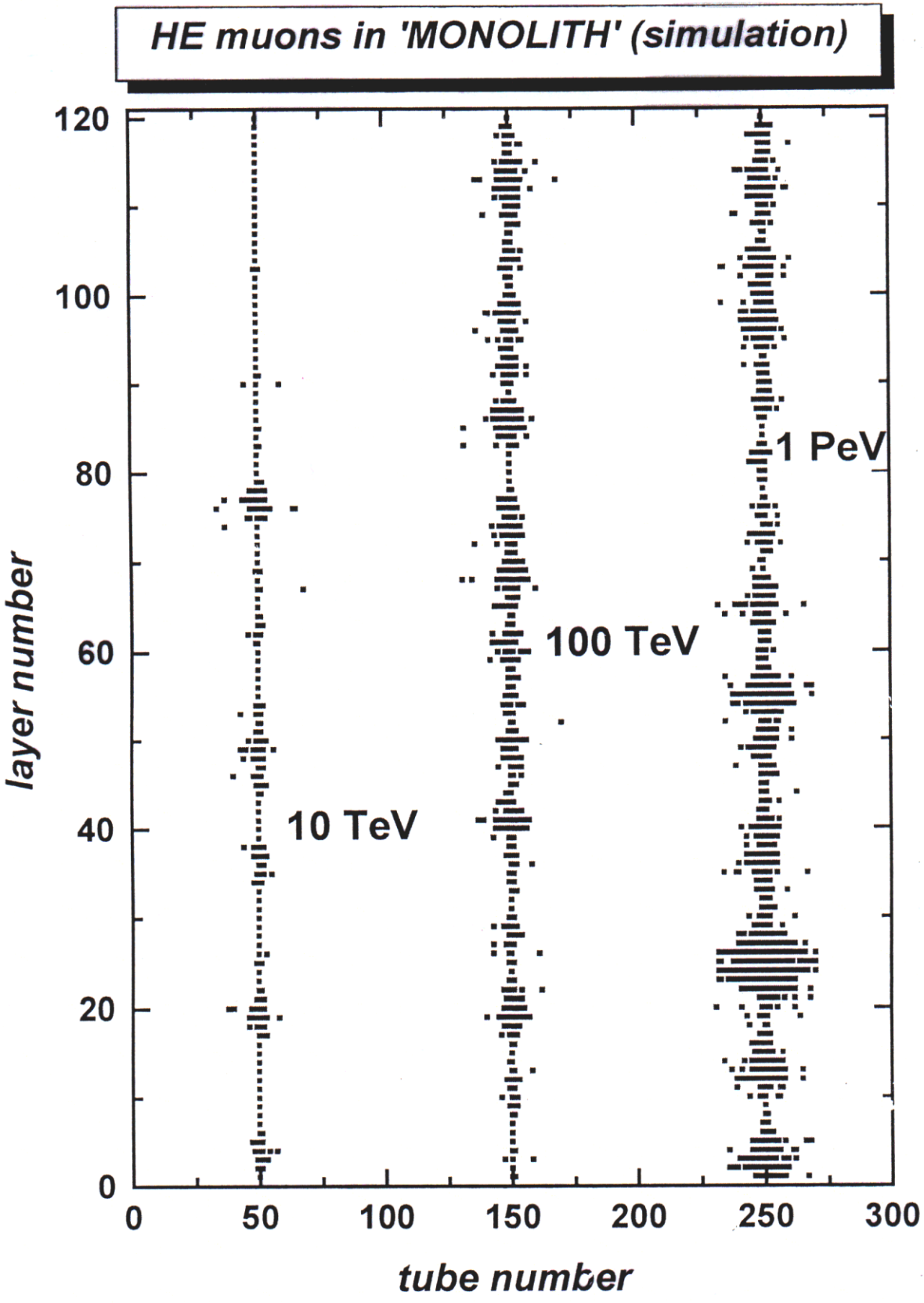
Other MONOLITH physics topics

- **$\nu_\mu - \nu_\tau$ / $\nu_\mu - \nu_s$ separation** ($\nu_\mu - \nu_e$ contribution)
  - matter effects
    - spectral shape
    - ν_μ vs. $\bar{\nu}_\mu$
  - "NC" up/down ratio
    - τ "appearance" at high E_ν ($\delta m^2 \gtrsim 5 \times 10^{-3}\,eV^2$)

- **atm. + CNGS beam monitor**
  - high statistics
  - $\nu_\mu / \bar{\nu}_\mu$ separation
  - check HARP prediction

- **astrophysical observations**
  - cosmic ray muons
    momentum measurement up to PeV energies
    ⇒ check origin of cosmic ray knee
  - MACRO-type physics
    - shadow of sun/moon
    - astrophysical point sources
    - DAMA WIMPs
    - Supernova bursts

- **detector for entry level ν-factory ?**



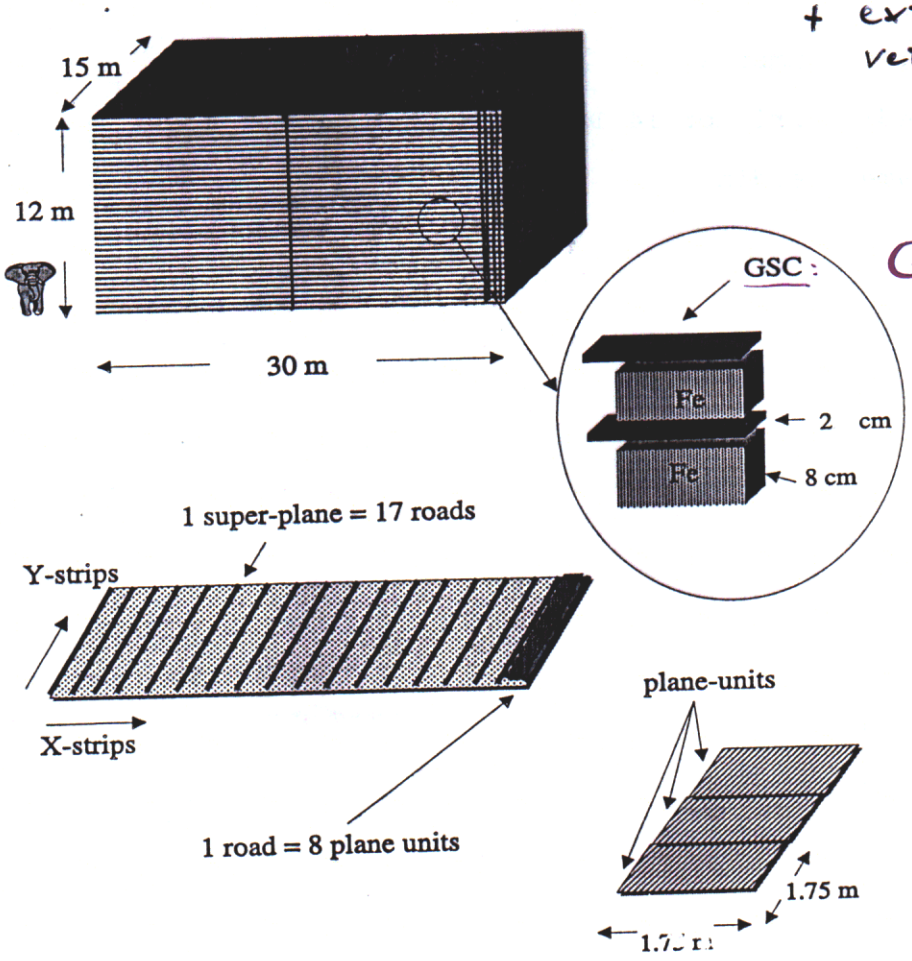
$\sigma_{E/E} \simeq \sqrt{137/d} \simeq \underline{\underline{50\%}}$ für $d \geq 500\,\lambda$ (MONOLITH)

The MONOLITH detector

+ external veto (scintillator)

120 planes

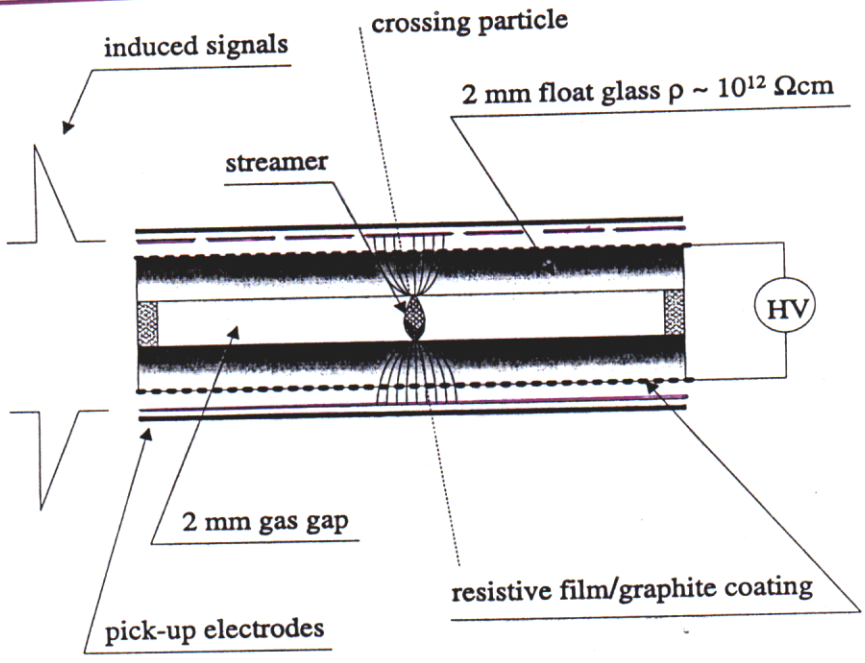
34 kt



Glass Spark Counters (RPC's)

$50.000\ m^2$

principle of Glas Spark Counter:



time resolution:

~ 1 ns

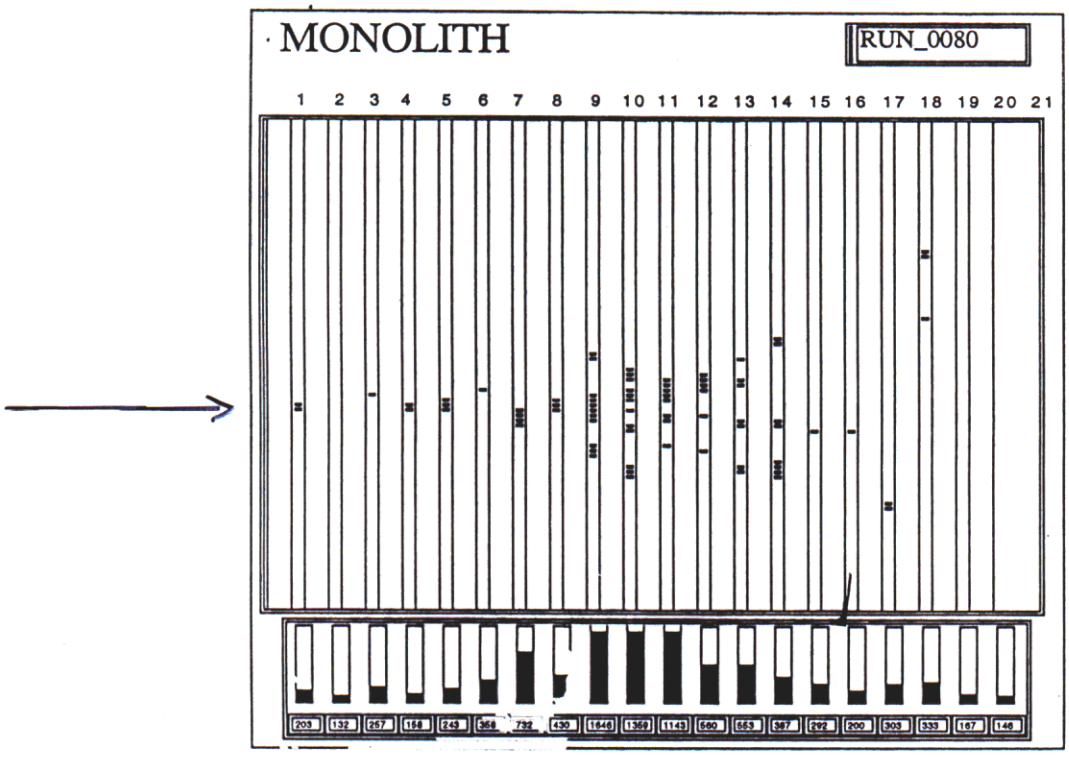
X

Y

3 cm pitch

CERN/PS test beam:

10 GeV π^- in MONOLITH prototype:



5 cm Fe
1 cm pitch

Fig. 5. Typical digital pattern of a 10 GeV pion.

count hits
→ linear response

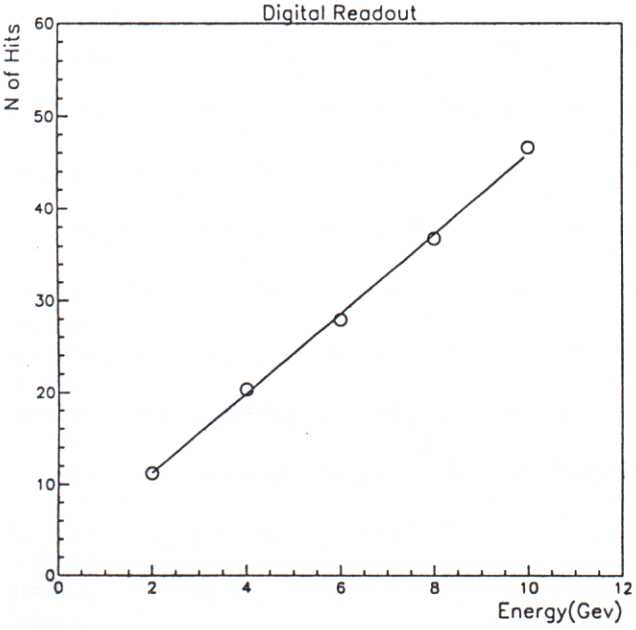


Fig. 7. Digital response for pions.

hadronic
energy resolution:

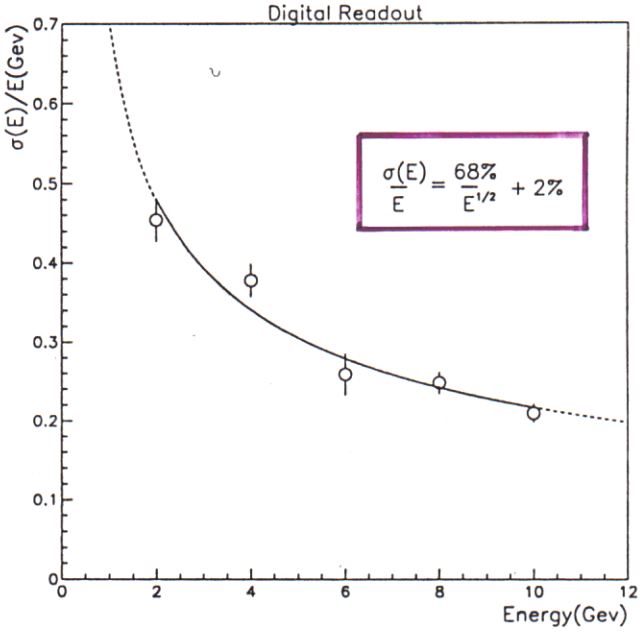
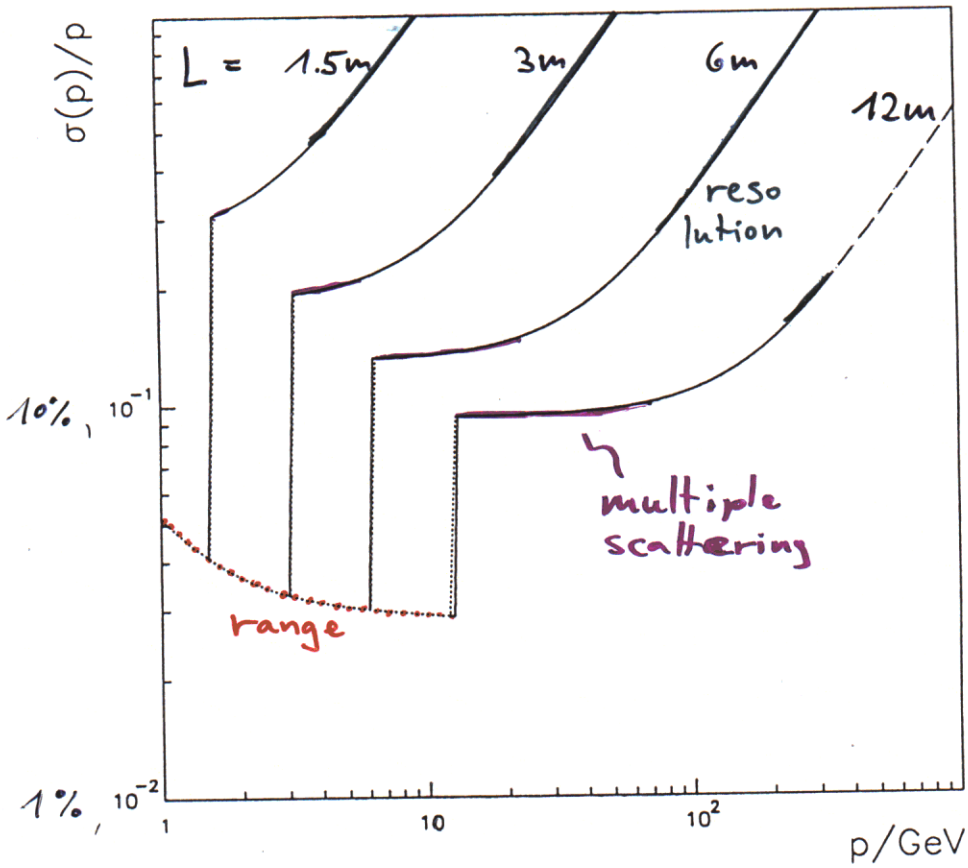


Fig. 8. Digital resolution for pions.

simplified parametrisation of muon momentum resolution

vertical, 8cm Fe, 3 cm pitch, B = 1.3 T



simulation, preliminary

ν factory ?

charge discrimination so far ν dominated by

- pattern recognition
- large angle scattering
- technicalities of momentum fit

} non-Gaussian tails

→ needs more work

Conclusions

- MONOLITH:
  34 kt iron tracking calorimeter
  at Gran Sasso

- main physics goal:
  measurement of oscillation pattern
  in atmospheric neutrinos
  ⇒ proof of oscillations
  (disproof)
  (+ many other physics topics)

- proposal in preparation
  first data: $\gtrsim$ 2003/4 (partial detector)

- suited as
  detector for entry-level ν-factory?

  probably yes
  more study needed