IC/76/78
INTERNAL REPORT
(Limited distribution)

International Atomic Energy Agency

and

United Nations Educational Scientific and Cultural Organization

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

T O P I C A L M E E T I N G

ON LEPTON INTERACTIONS AND NEW PARTICLES

6 - 9 July 1976

P A R T I

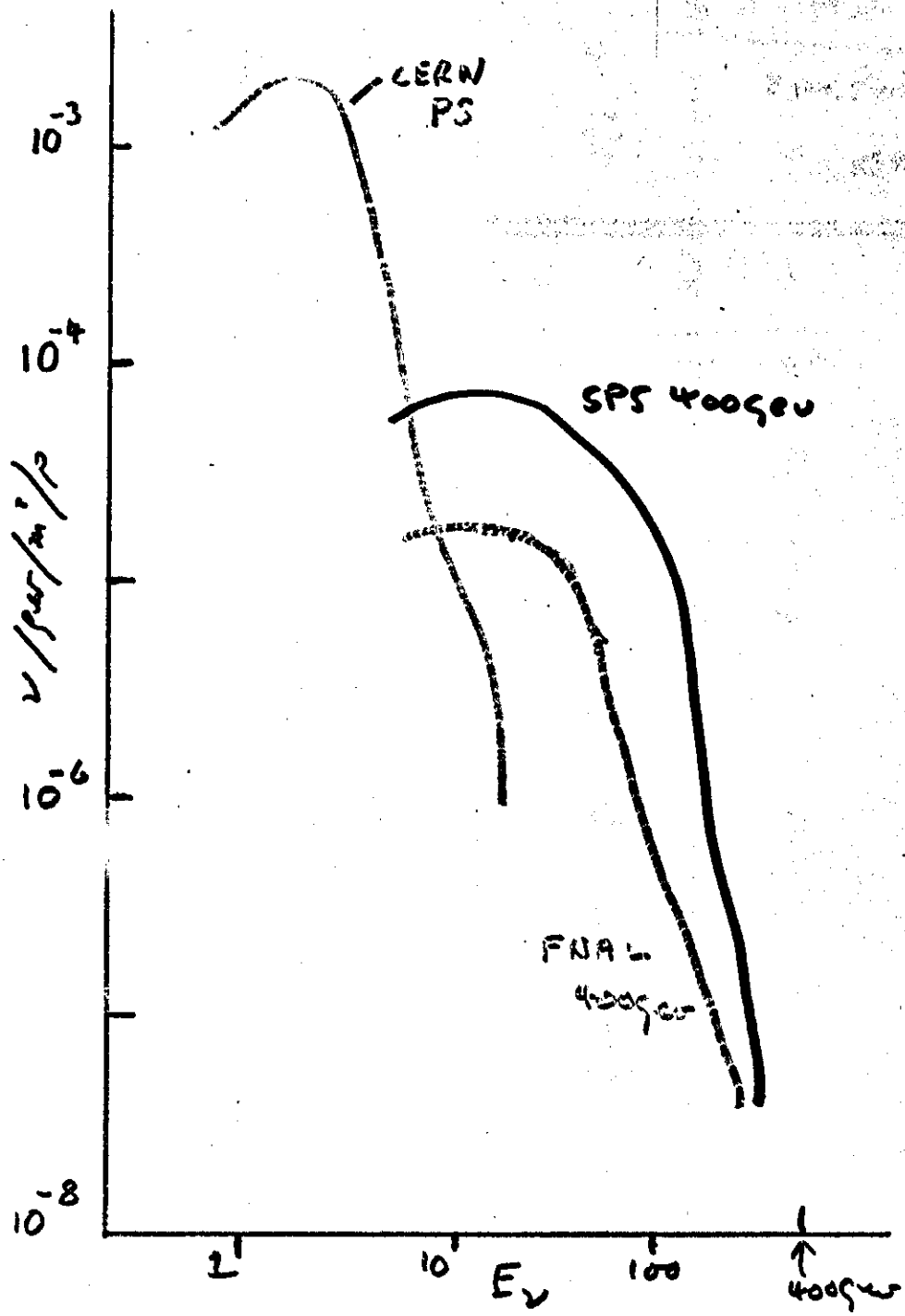
(Contributions)

MIRAMARE - TRIESTE
July 1976

PREPARATIONS FOR NEUTRINO PHYSICS AT CERN SPS ACCELERATOR

D.C. Cundy

CERN, 1211 Genève 23, Switzerland.



$\pi \to \mu + \nu$ } $\frac{1}{2}$ ν's in angle $\frac{1}{\gamma}$
$K \to \mu + \nu$ }

Flux $\sim \frac{1}{L^2}$ if beam larger than detector

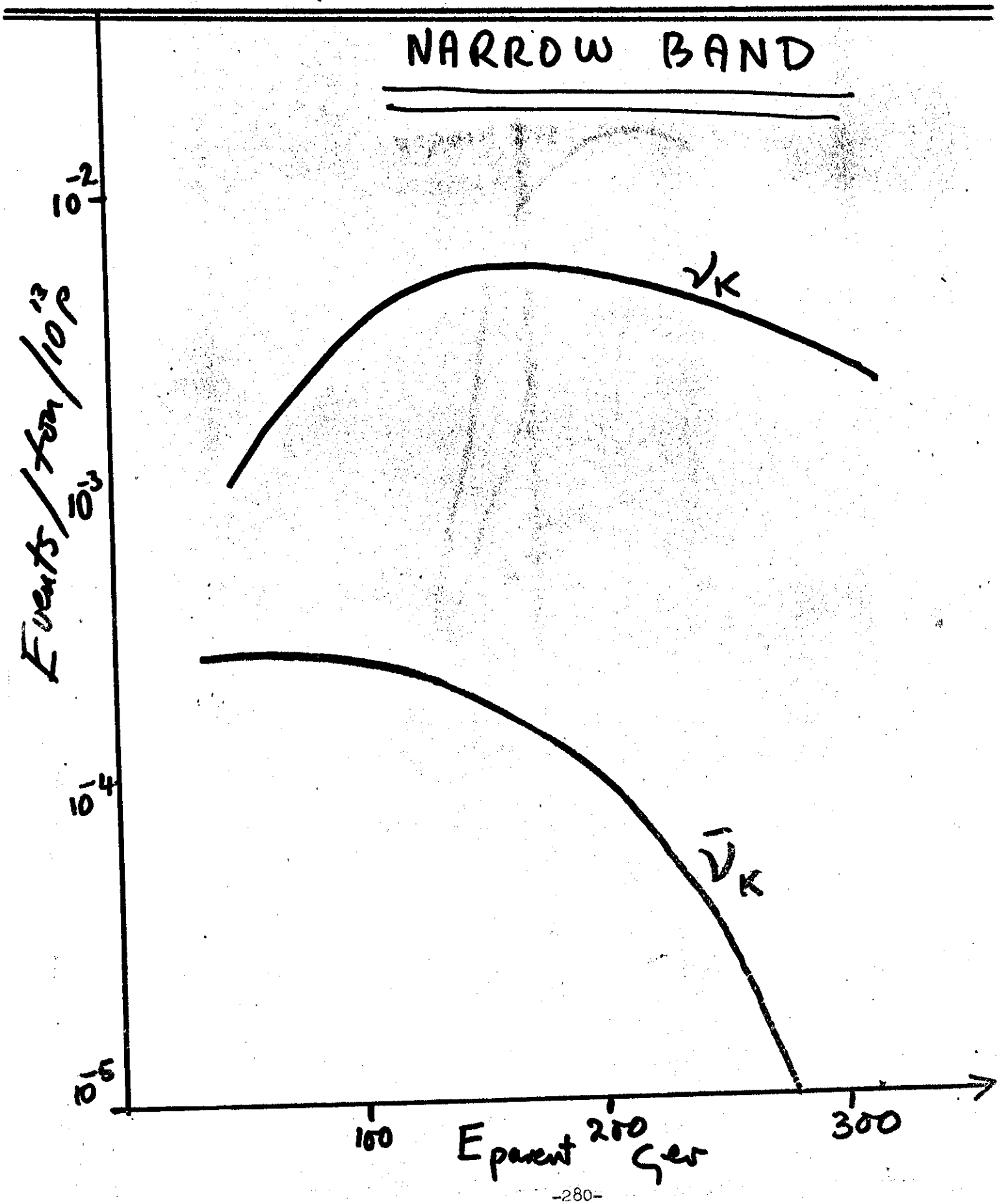
NE if FNAL use iron can go to 1 Te

WIDE BAND RATES

400 Gev protons
10^{13} PPP

ν 0.28 ev/ton

$\bar{\nu}$ 0.06 ev/ton



EXPERIMENTS

P1

CERN - DORTMUND - HEIDELBERG - SACLAY

1200 ton iron - scintillator calorimeter - muon spectrometer

Stage 1 Using dichromatic beam

Study of

a) Inclusive charged-current reactions in Fe.

Total Cross-sections, $\frac{d\sigma}{dy}$, $\frac{d\sigma}{dx}$

b) Inclusive neutral-current reactions

Total Cross-sections, $\frac{d\sigma}{dy}$

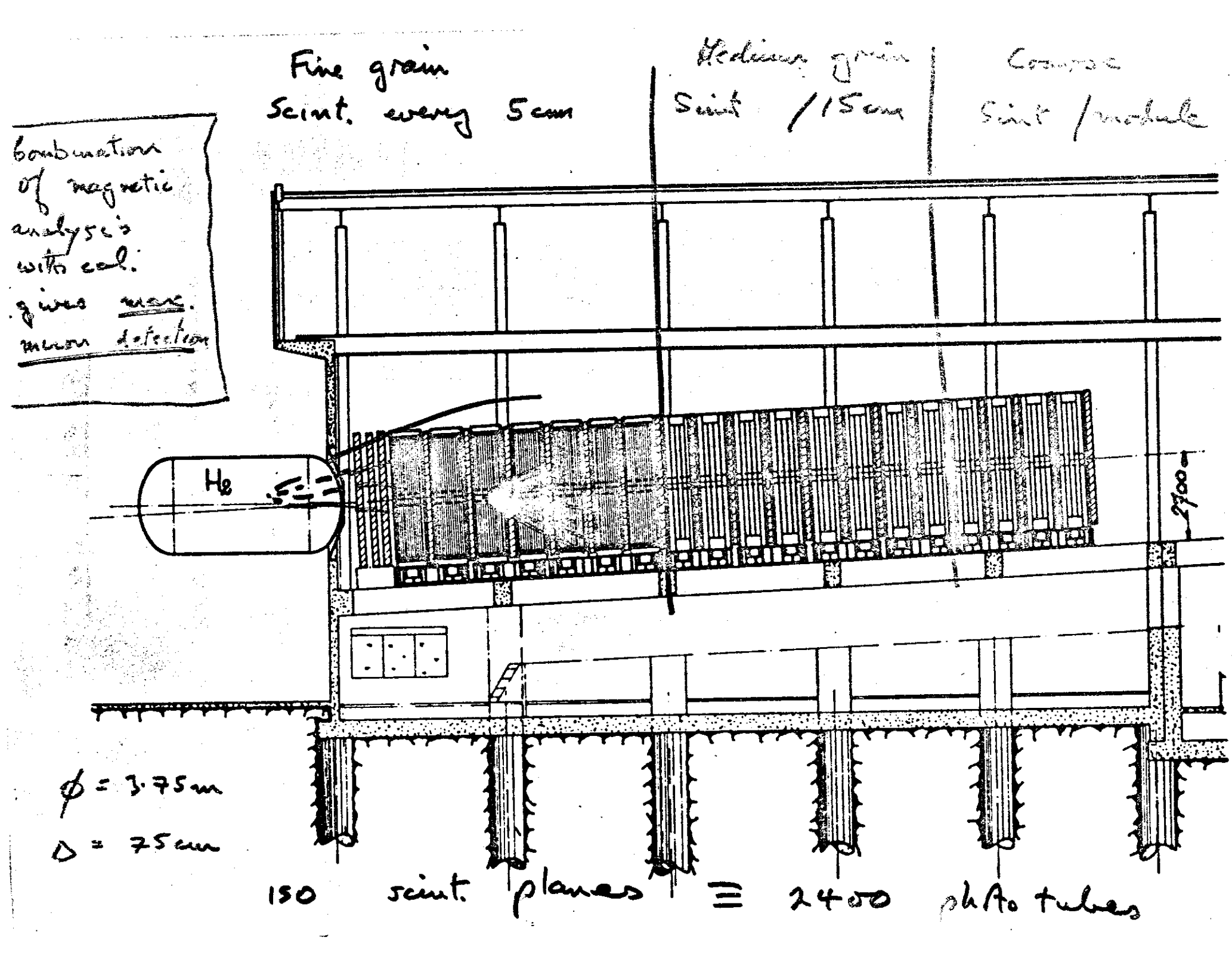
c) Di-muon production - inclusive distributions as E_ν is known

d) Inverse muon decay

$\nu_\mu + e^- \rightarrow \mu^- + \nu_e$

e) Heavy lepton production

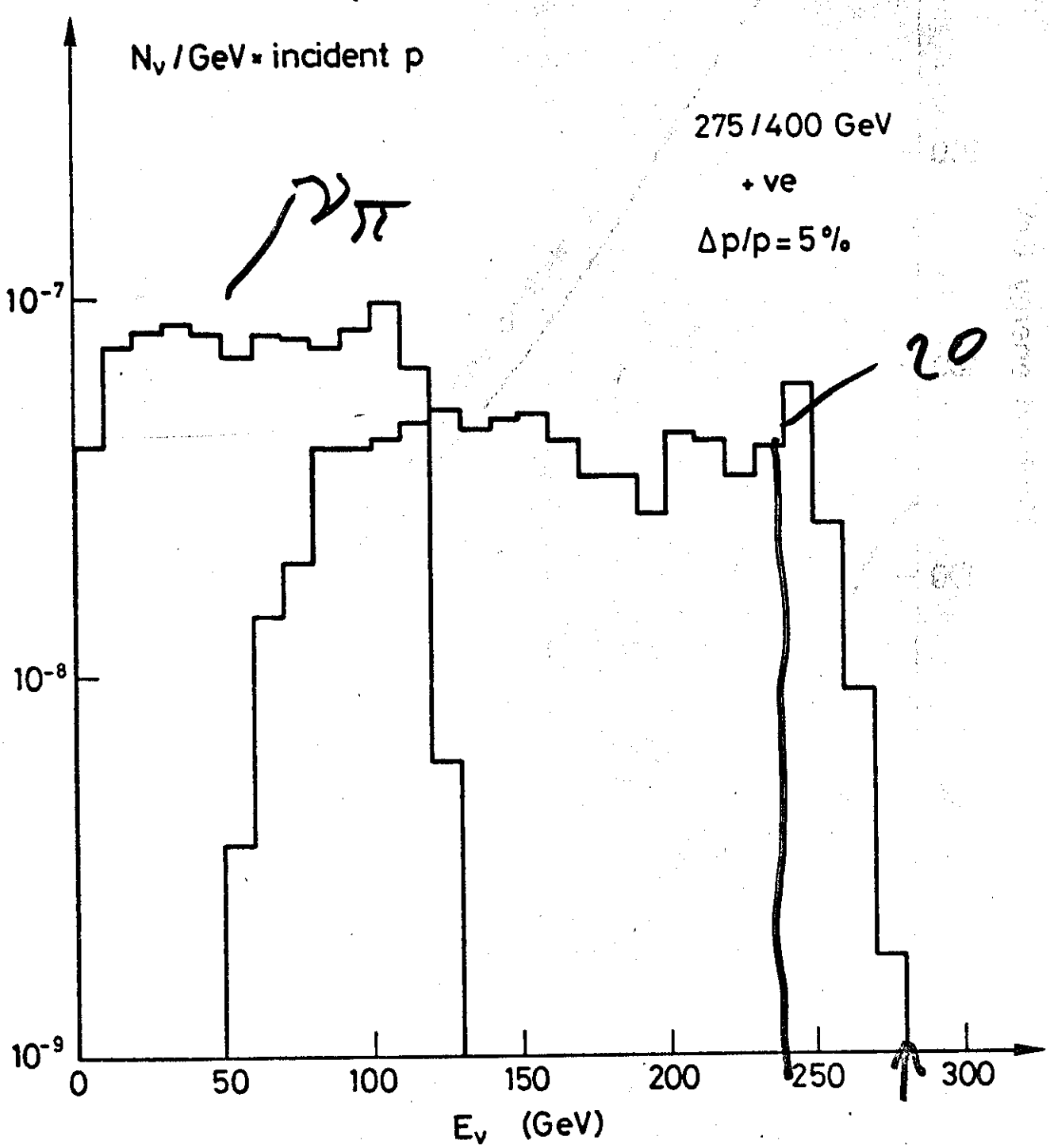
Type $L^+ \rightarrow \mu^+ + \nu_\mu + \nu_\mu$


Fine grain
Scint. every 5cm
Medium grain
Scint / 15cm
Coarse
Scint / module
combination of magnetic analyses with cal. gives max. muon deflection
He
2700
ϕ = 3.75m
Δ = 75cm
150 scint. planes ≡ 2400 phA.o tubes

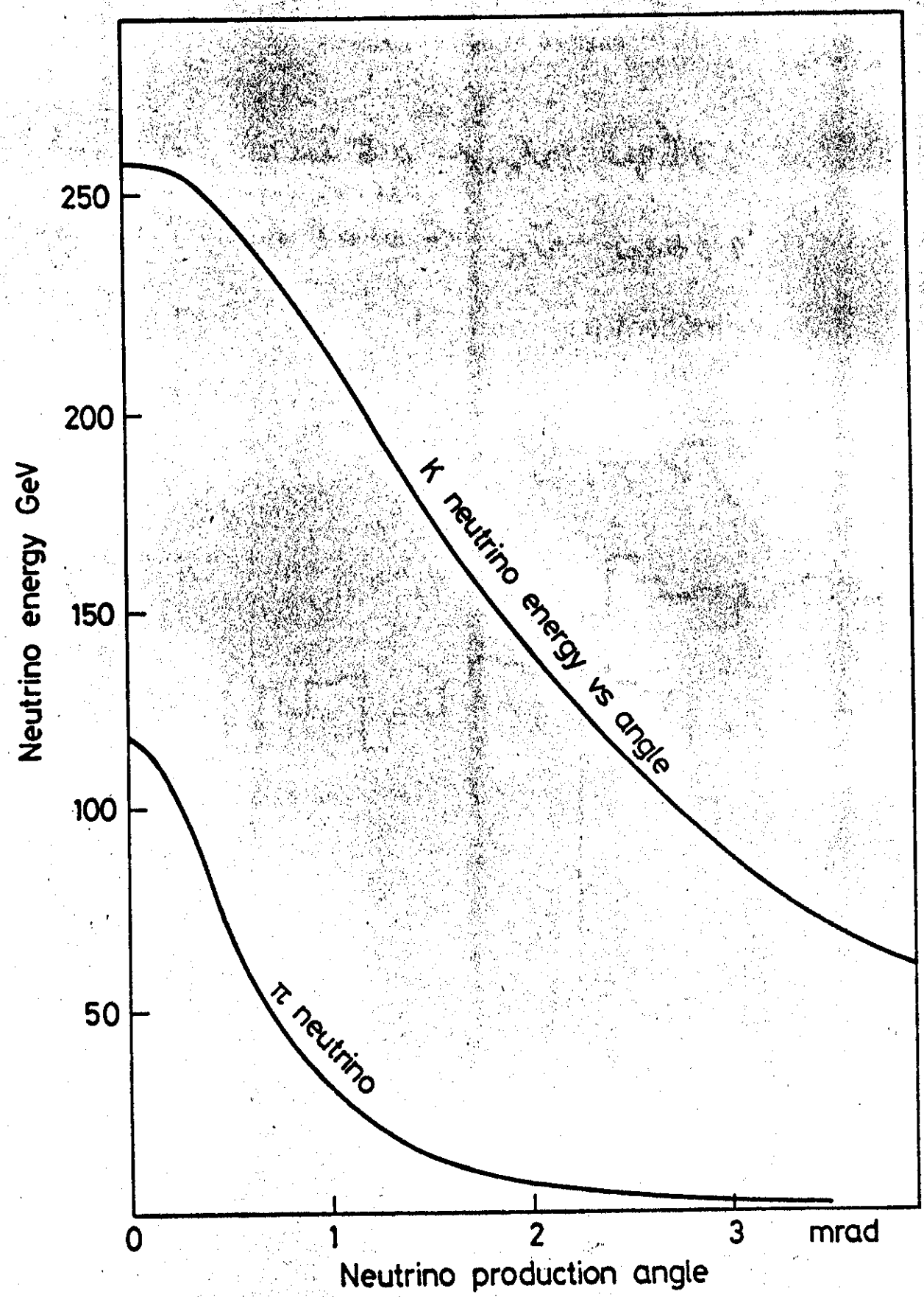
$\frac{\Delta p}{p}_{muon} \propto \frac{\cdot 2}{\sqrt{\ell}}$ metres in iron

Rate at 275gev $\nu_K \sim 0.5$ event / 10^{13} ppp
100 di-muons / day

200gev $\bar{\nu}_K \sim 0.01$ event / 10^{13} ppp



favours all energy regions in same


Charged particle energy 275 GeV
Neutrino energy GeV
250
200
150
100
50
K neutrino energy vs angle
π neutrino
0
1
2
3
mrad
Neutrino production angle

Stage 2 In W.B. beam

Use 35 m^3 (F.V. 20 m^3) H_2, D_2 target

Try to measure CC and NC inclusive distributions for N and P targets by subtraction.

9 planes of 3mm spacing MWPC to reconstruct tracks and hence vertex in the target (wall ~ 13 mm steel)

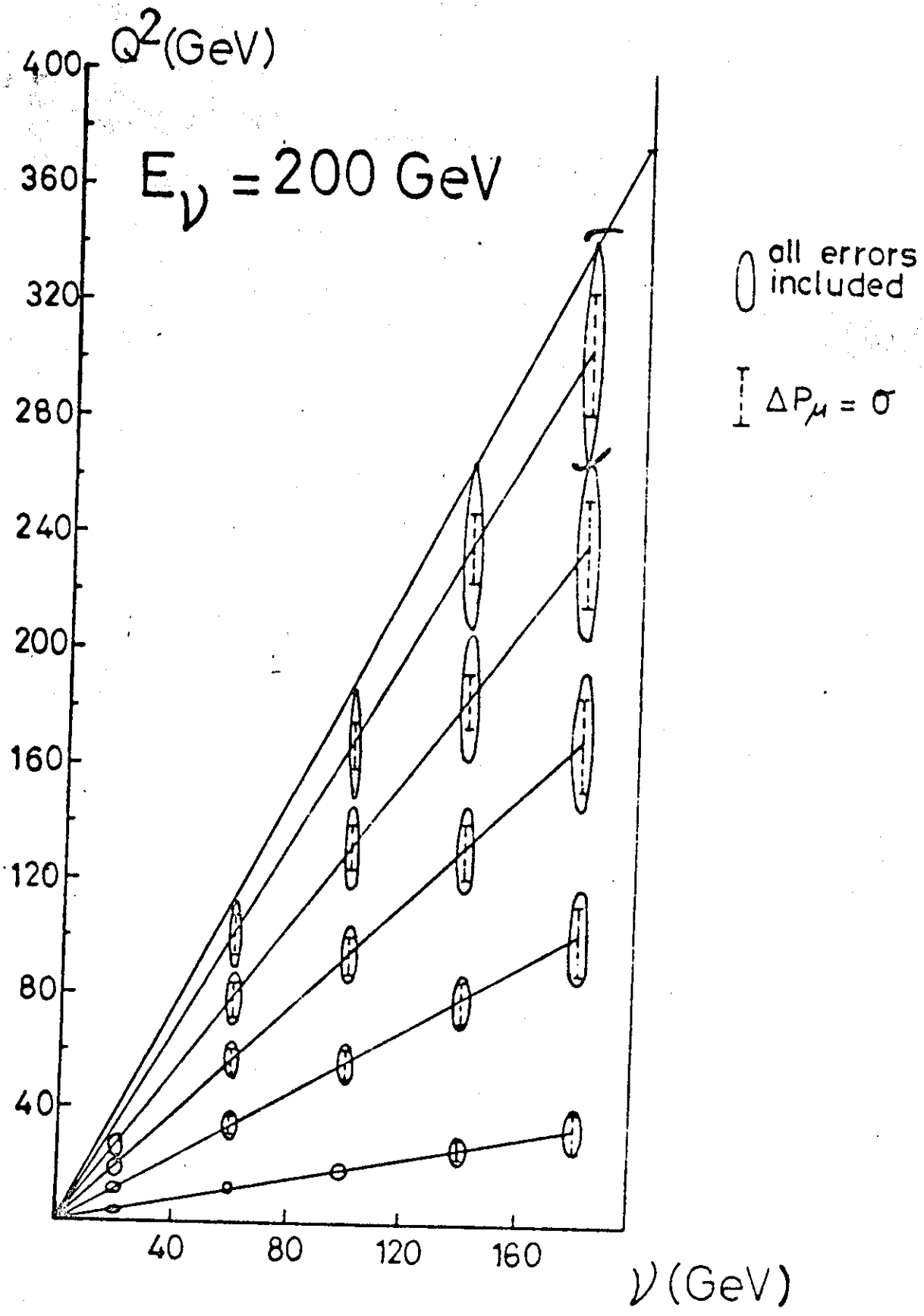


Fig. 14 Measurement errors in the Q^2-ν plot

EXPERIMENT P49

CERN - HAMBURG - MOSCOW (ITEP) - ROME

COLLABORATION

AIMS:

(1) SEMILEPTONIC NEUTRAL CURRENTS IN NARROW BAND BEAM

a) SPACE-TIME STRUCTURE OF NC

b) RATIO OF $\sigma(\bar{\nu})$ TO $\sigma(\nu)$ FOR NC

c) DETERMINATION OF STRUCTURE FUNCTIONS

d) PRODUCTION OF NEW PARTICLES

(2) MEASUREMENT OF μ^+ POLARIZATION IN BROAD BAND BEAM

a) "SINGLE" MUONS: $\bar{\nu} N \to \mu^+ X$

(V-A) CHECKS

LOW x LARGE y ANOMALY

b) "DI MUON" EVENTS: $\nu N \to \mu^- \mu^+ X$

c) PRODUCTION OF NEW PARTICLES IN WA1

(HEAVY LEPTONS, MANY MUONS ...)

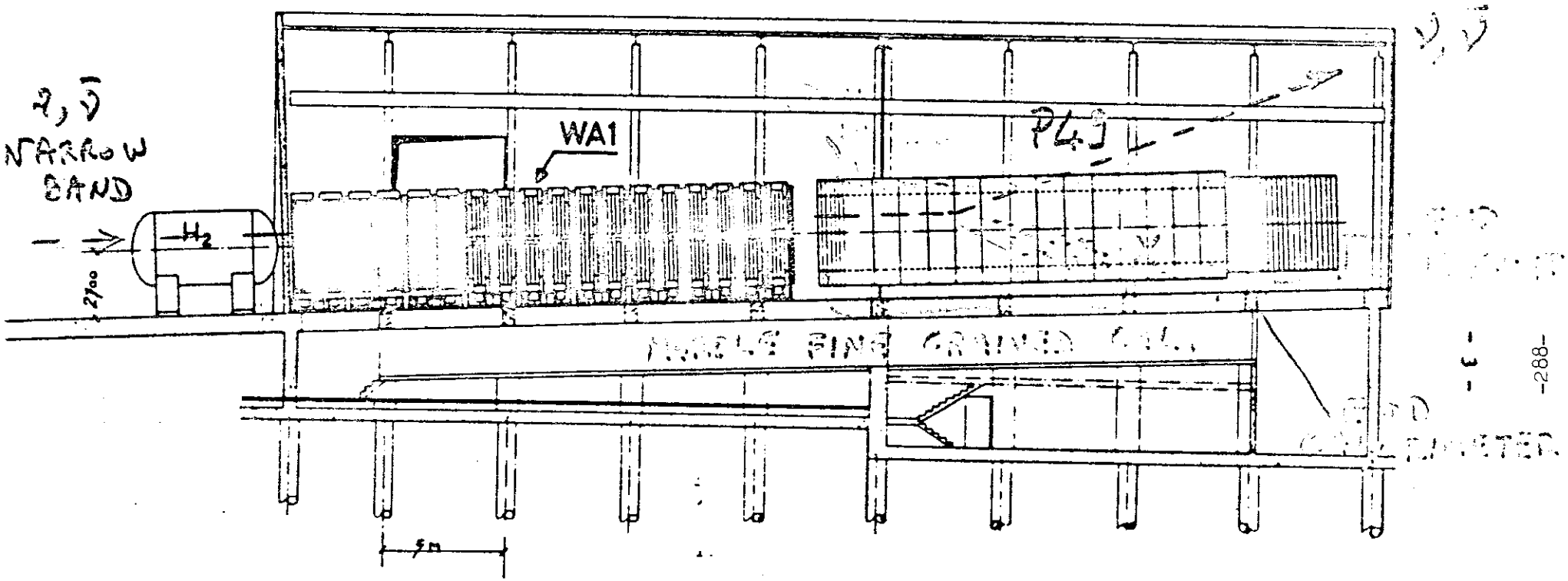
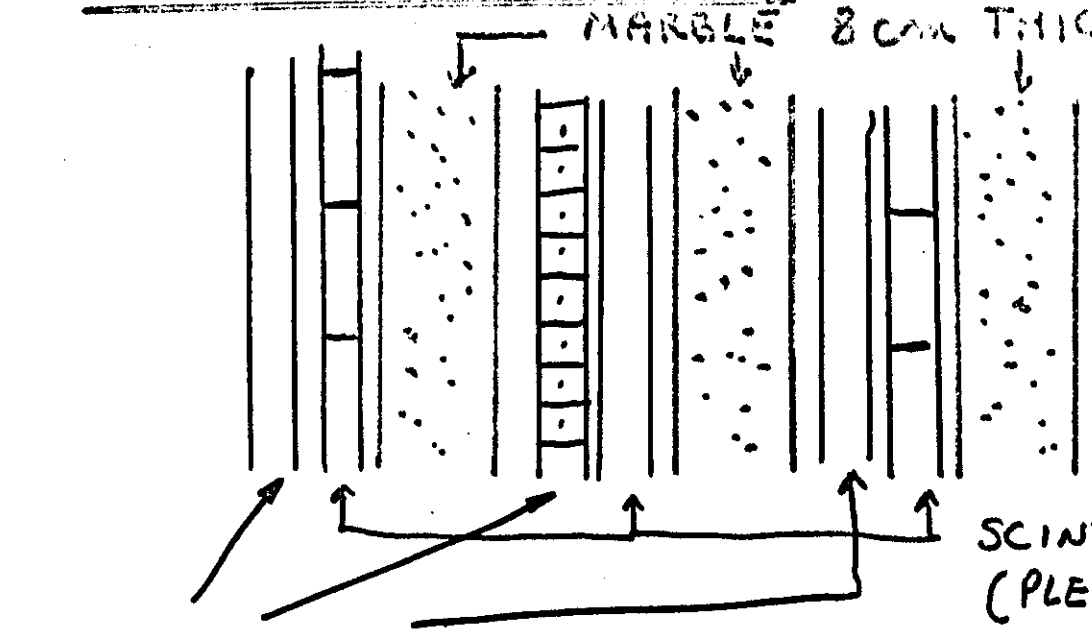


Figure 1.1

The lay-out of experiment WA1 and the proposed experiment in Hall 182.

FUNCTIONS OF VARIOUS PARTS

1. MARBLE CALORIMETER (84 PLATES) (3X3 ...)



SCINTILLATORS: (a) ENERGY MEASUREMENT

(b) DETERMINATION OF BARICENTER OF SHOWER

PROPORTIONAL TUBES WITH DRIFT MEASUREMENT:

(a) DETERMINATION OF VERTEX OF SHOWER

(b) μ TRAJECTORY TO $\pm$ 1 mm

MARBLE (AS Al BUT LESS EXPENSIVE)

"LIGHT" MATERIAL : HADRONIC AND E.M. SHOWERS HAVE SIMILAR DEVELOPMENTS

ERROR ON ANGLE OF SHOWER

$$\Delta\theta_H \approx 0.004 + \frac{0.6}{(E_H)_{GeV}}$$

(10 mrad at 100 GeV)

RATES EXPECTED FOR $5 \cdot 10^{18}$ PROTONS

(100 DAYS)

	NC	CC	K ENERGY (GeV)
ν	16,000	126,500	240
$\bar{\nu}$	2,400	13,500	100

↑

THESE EVENTS WOULD GIVE

$$\int F_3(x)\,dx \simeq 3.28 \pm 0.45$$

(GROSS-LLEWELLYN SMITH)

ERRORS COME FROM $\times \leq .2$

2. μ^+ POLARIZATION

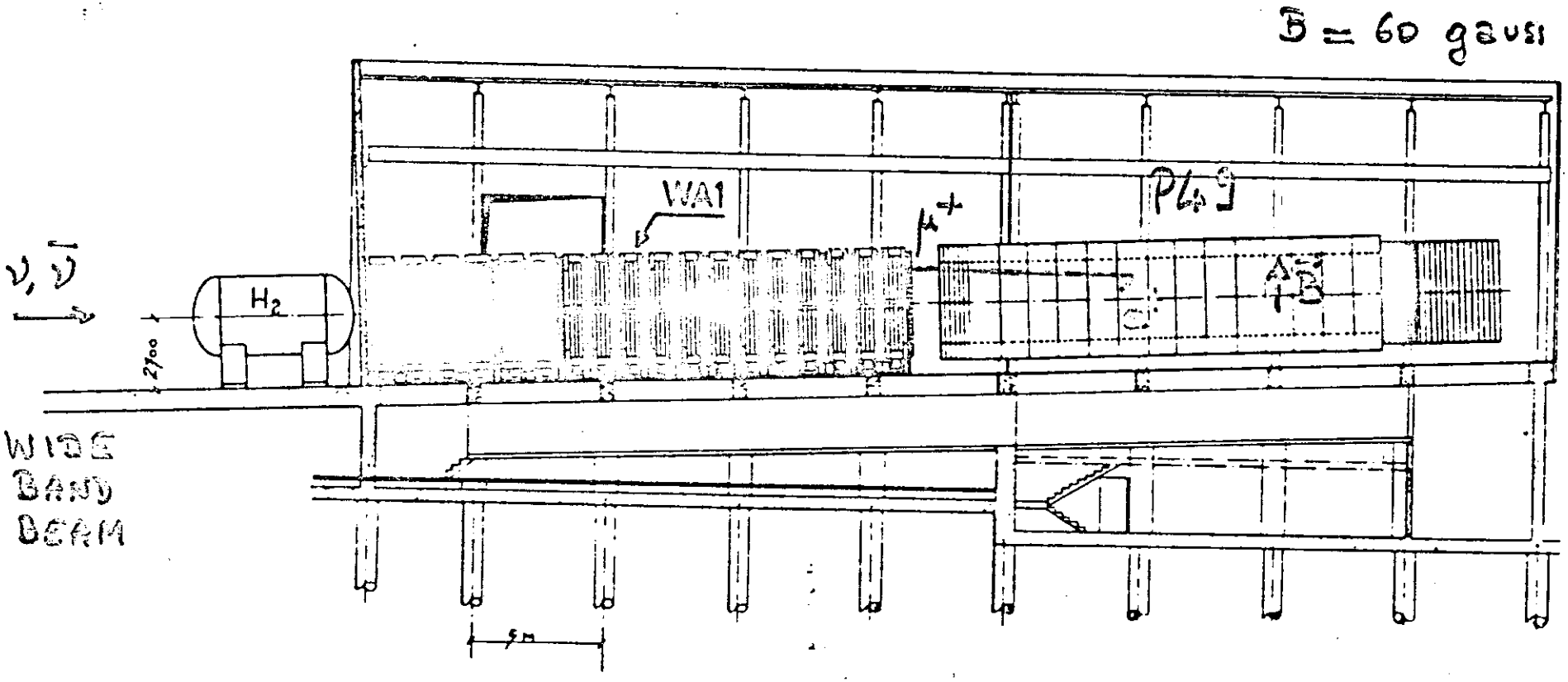


Figure 1.1

The lay-out of experiment WA1 and the proposed experiment in Hall 182.

BUBBLE CHAMBERS

BEBC $18\ m^3$ visible volume

$H_2 \sim 1$ ton

$D_2 \sim 2$ tons

$Ne, H_2 \sim 20$ tons

TRACK SENSITIVE TARGET TST $\sim 3\ m^3$

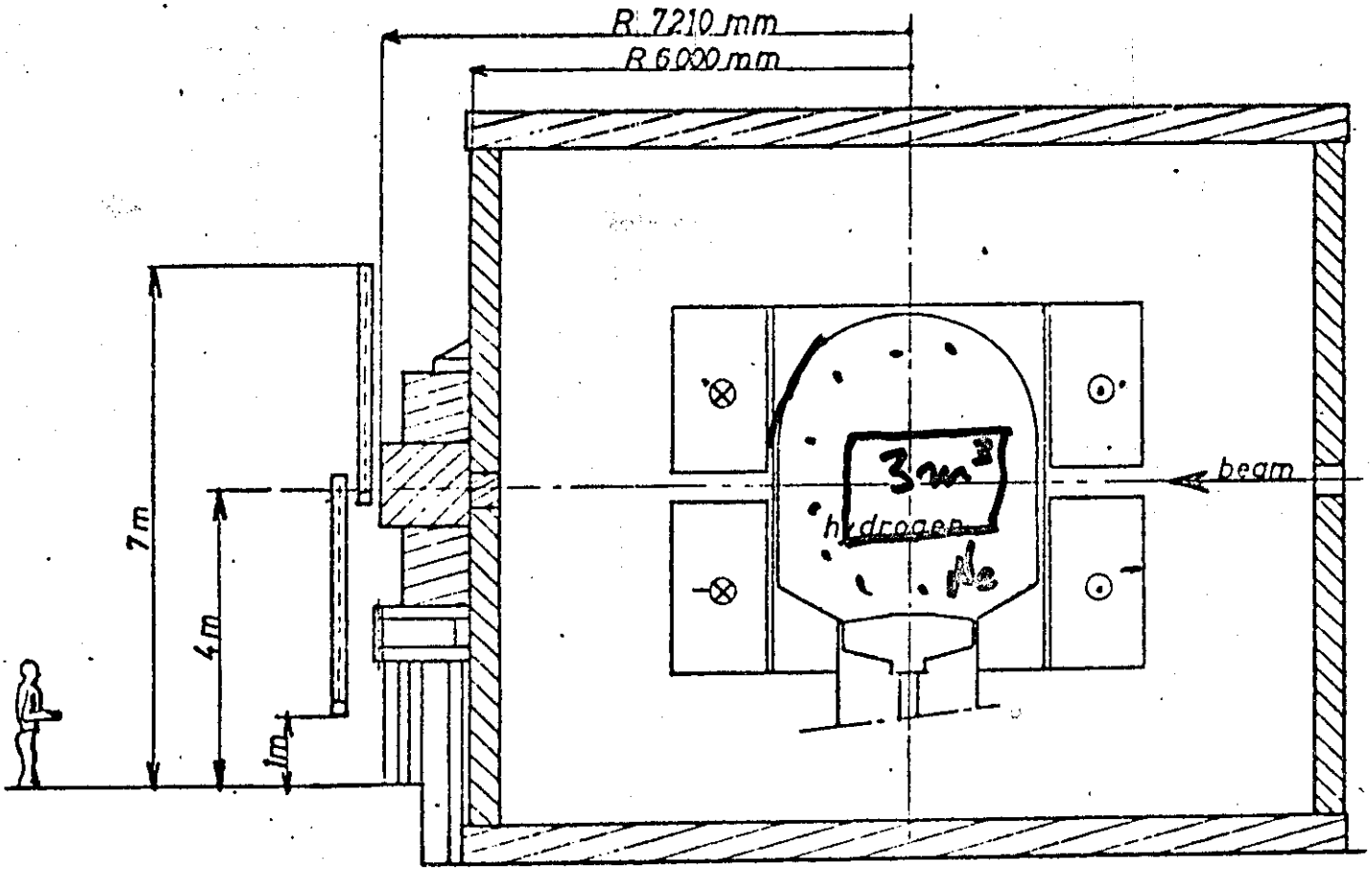
H_2, D_2 in Ne

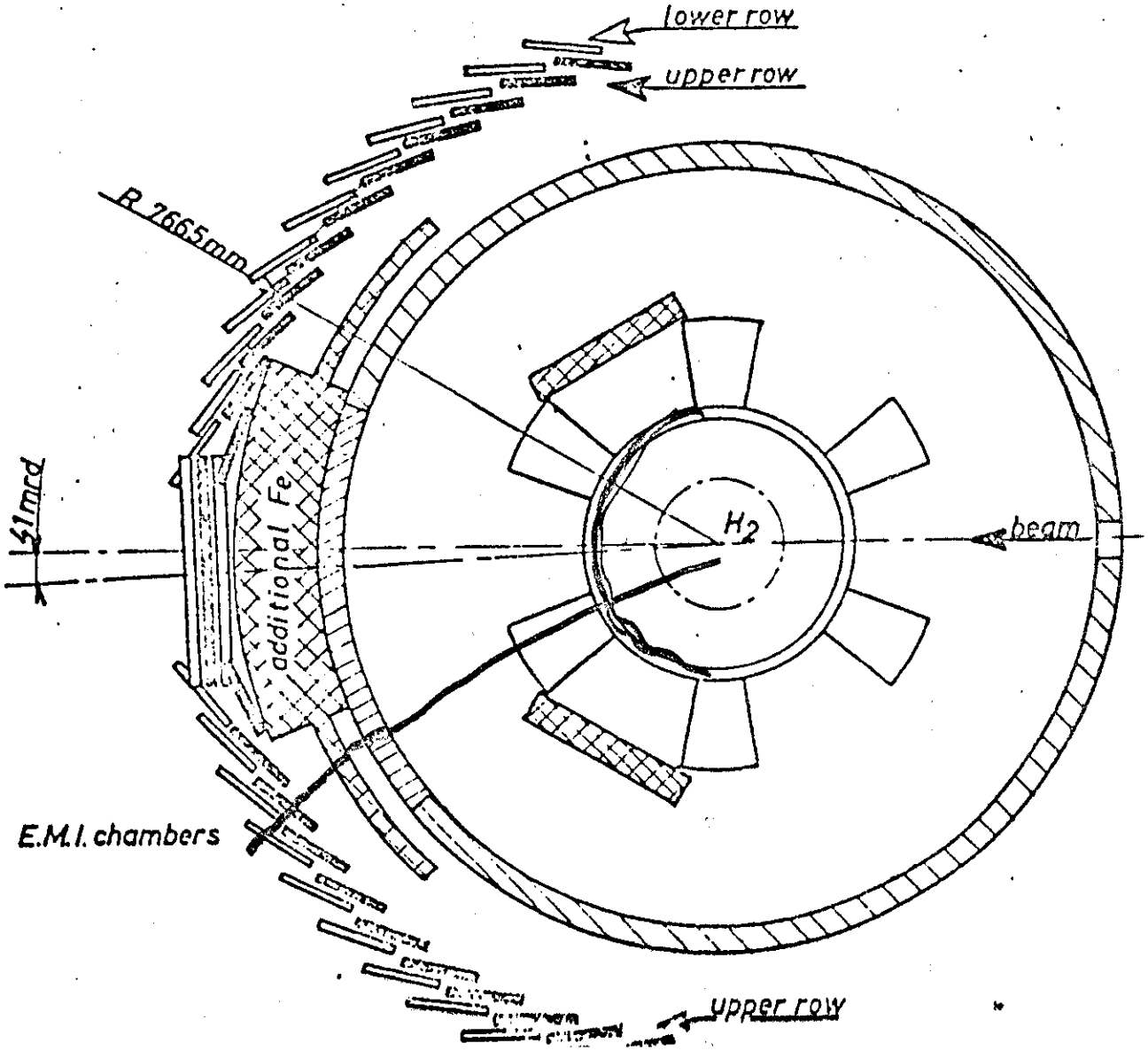
SARSAMELLE $6\ m^3$ visible volume

CF_3Br → 10 tons → $X_0 = 11$ cms

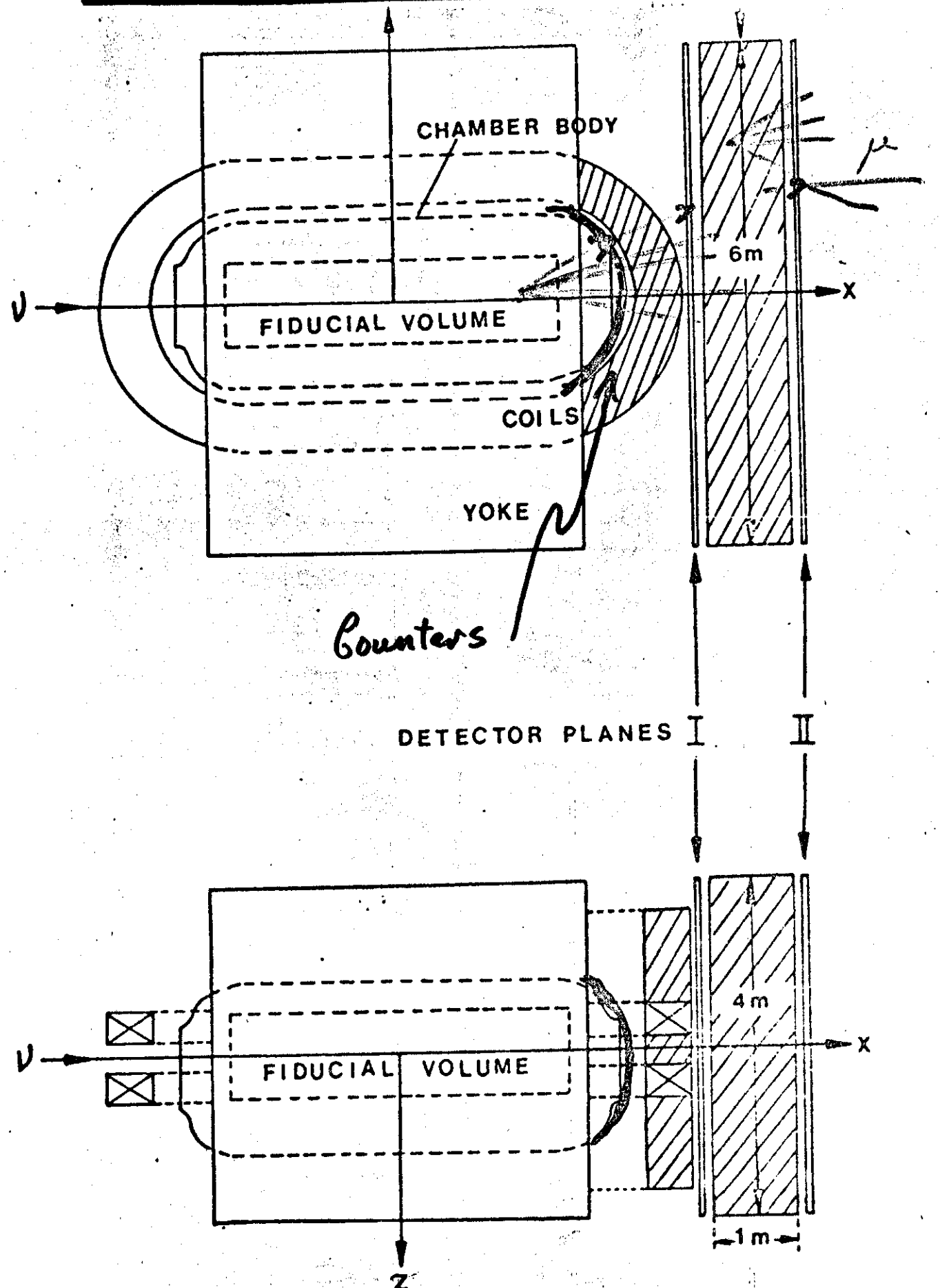
C_3H_8 → 3 tons → 0.6 tons H_2 → $X_0 = 100$ cms

Low mass of B.C. is off-set by fact that can study and identify the particles produced (esp. strange partic) - can measure exclusive channels.


R 7210 mm
R 6000 mm
7m
4m
1m
3m³
hydrogen
beam


lower row
upper row
R 2665 mm
51 mrd
additional Fe
H2
beam
E.M.I. chambers
upper row

GARGAMELLE EMI



Program

BEBC H_2, D_2, Ne, TST (H_2, D_2)

GGM CF_3Br, C_3H_8

Wide-Band beam, Dichromatic

up to date exists proposals for all combinations — except

N.B. H_2 TST
W.B. Ne ?

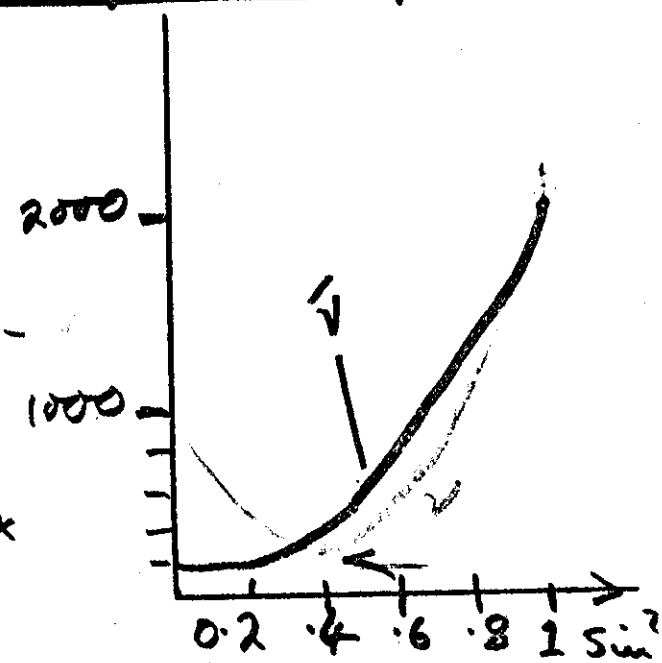
Bubble Chamber Unique Experiments

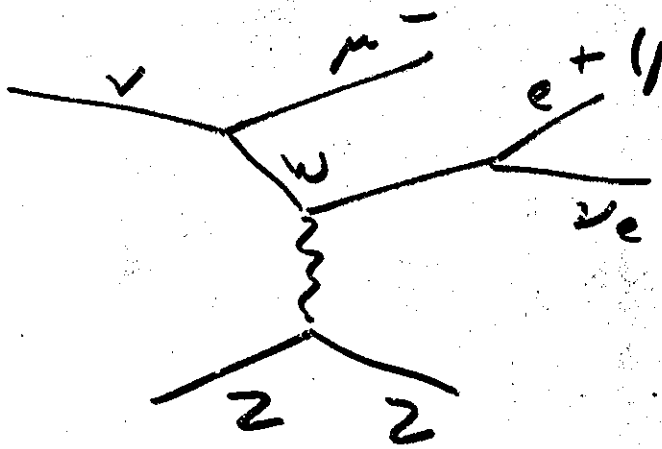
Purely leptonic

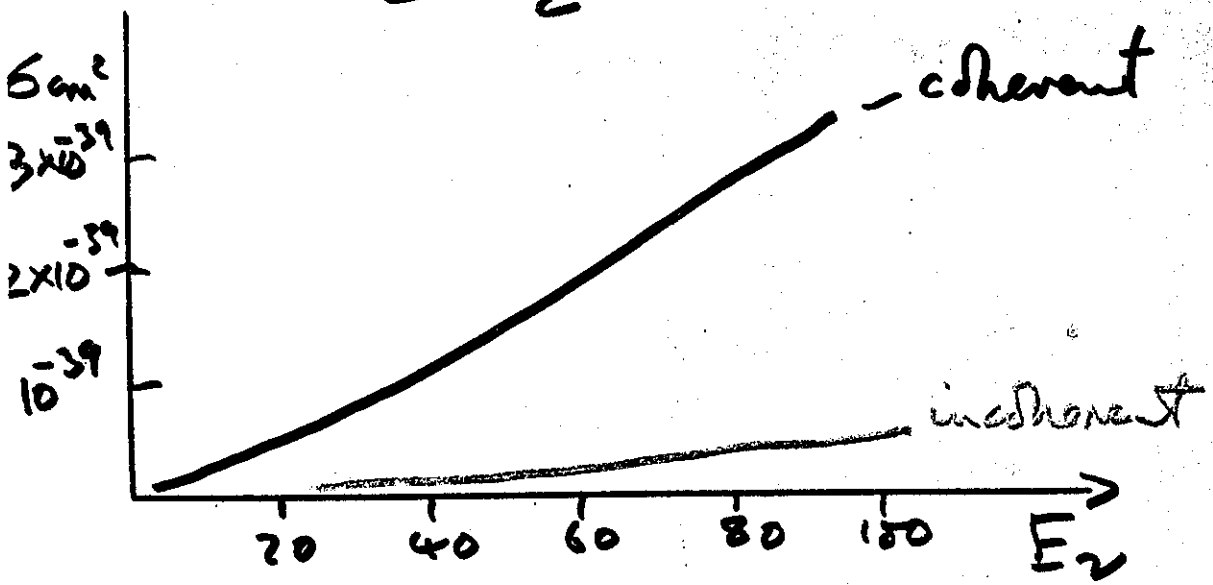
a) $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$
$\sim 10^{-41}$ Ev cm^2

$\sim$ 100 events / 10^6 px

(exist 3 $\bar{\nu}$, 1 ν)







~ 50 events / 10^6 CCM.

NARROW BAND Ne - BEBC

100,000 px , 10^{13} → 5000 ν_K events CC

3500 ν_π " "

cross-check on σ_{Total}, $\frac{d\sigma}{dy}$, $\frac{d\sigma}{dx}$ $x \to 0$

N.B. Flux error ~ 5% (limited by systematics

~ 100 $\mu^-\mu^+$ as 1% rate ⟷ see if they are the same

100 $\mu^- e^+$ process

Estimated event rates H_2

400 Gev protons 10^{13} pp.

500 K ν, 500 K $\bar{\nu}$

$\nu_\mu + p \to \mu^- + X^{++}$	240,000
$\bar{\nu}_\mu + p \to \mu^+ + X^0$	80,000
$\nu_\mu + n \to \mu^- + X^+$ } ~ "	
$\bar{\nu}_\mu + n \to \mu^+ + X^0$	
$\bar{\nu}_\mu + p \to \mu^+ + n$	6,800
$\nu_\mu + n \to \mu^- + p$	14,000
$\nu_\mu + p \to \mu^- + \Delta^{++}$	25,000
$\bar{\nu}_\mu + n \to \mu^+ + \Delta^-$	2,400
$\bar{\nu}_\mu + p \to \mu^+ + \Lambda^0$	500
$\nu_\mu + e^- \to \mu^- + \nu_\mu$	250

TST experiments

TST ~ $3\,m^3$ (H_2 ~ 0.2 tons)

100,000 px at 10^{13} p/p

~5000 ν ~2000 $\bar{\nu}$

If ~5% charm production

$\frac{1}{2}$ → $\Delta S = -\Delta Q$

↓

$\frac{1}{2}$ give 3C fits

should detect ~50 $\Delta S = -\Delta Q$ states

Look for narrow

COMBINE TST WITH D_2

- measure $\nu, \bar{\nu}$ $\frac{\sigma(n)}{\sigma(p)}$, $\frac{d\sigma(n)}{dx}$, $\frac{d\sigma(p)}{dx}$

Test charge-symetry — sum rules etc.

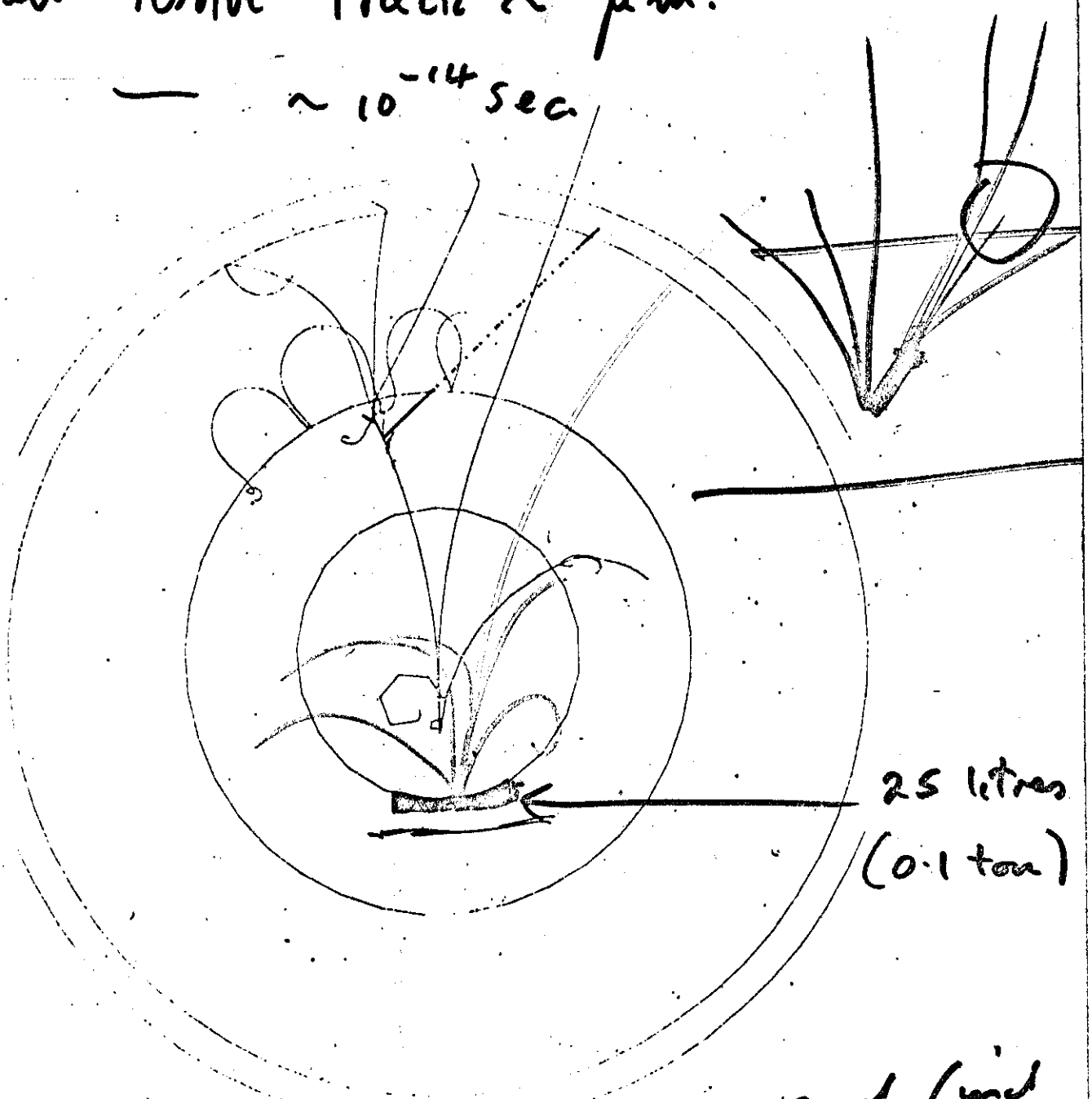
Emulsion Experiment

200 events (CC)/day (400 GeV
5×10^{12}
10^4 pulse/day)

CHARM

can resolve track ~ μm.

— ~ 10^{-14} sec



Measure tracks in B.C. and find origin in emulsion.