Baryon Instability Workshop

Summary Talk

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Baryon Instability

Motivation –

- Origin of matter-antimatter asymmetry in the Universe
  (Sakharov 1967)
  - baryon nonconserving interaction
  - CP violation
  - thermal non-equilibrium of these interactions

- Grand Unified Theories
  - specific predictions of SU(5) motivated last generation of experiments

Manifestations of Baryon Instability

① Decay of protons (bound neutrons)

$\Delta B = 1$

② neutron - antineutron oscillations

$\Delta B = 2$

Minimal SU(5) $\Rightarrow$ ① eg $p \rightarrow e^+ \pi^0$

② NONE

Table 3

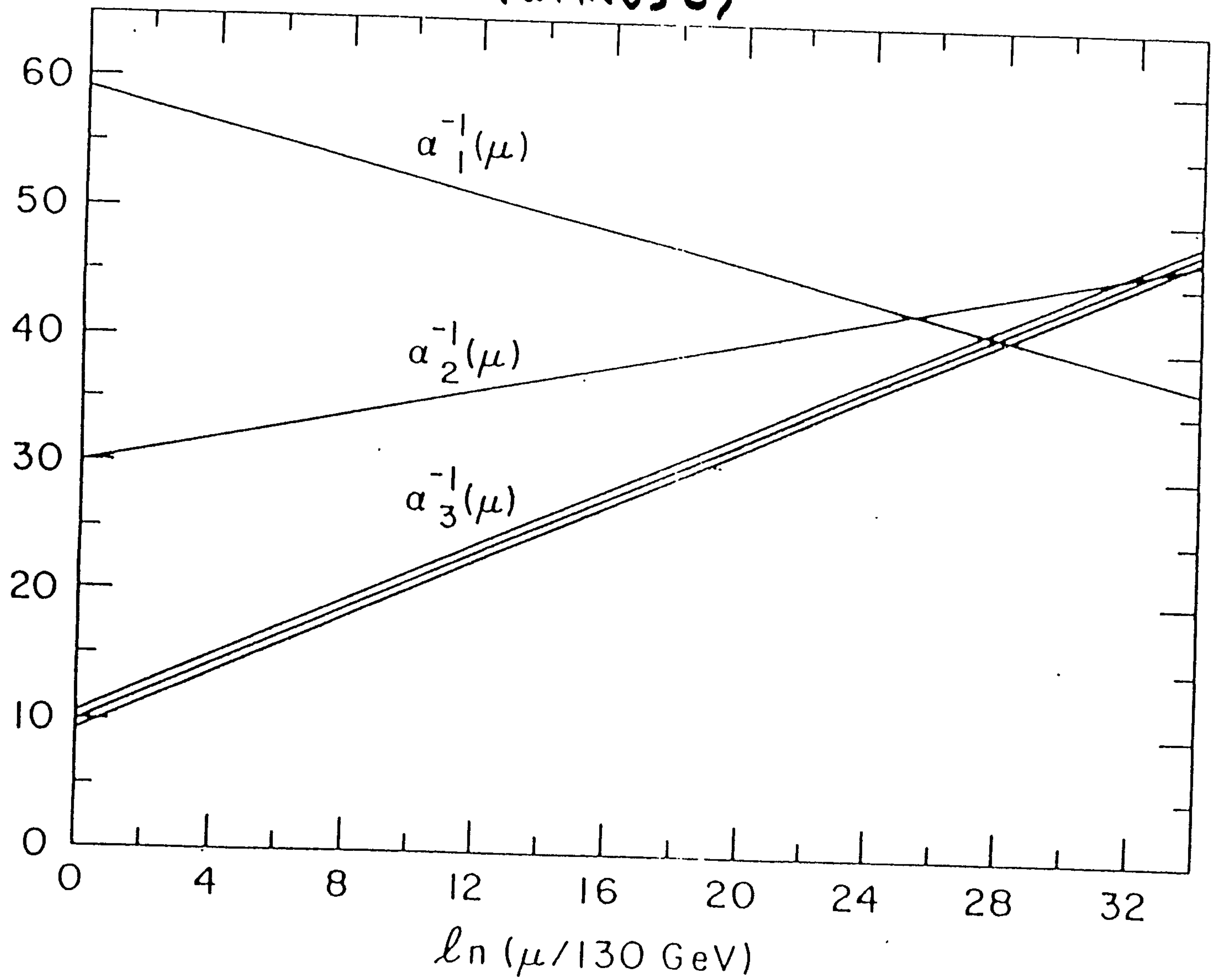
Summary of Predicted Nucleon Decay Modes and Branching Rates for SU(5) Theories (from Refs. 16 and 41).

$p \rightarrow e^+\pi^\circ$	9% - 38%	$n \rightarrow e^+\pi^-$	23% - 73%
$p \rightarrow e^+\rho^\circ$	6% - 21%	$n \rightarrow e^+\rho^-$	12% - 55%
$p \rightarrow e^+\eta$	~ 3%	---	---
$p \rightarrow e^+\omega$	24% - 56%	---	---
$p \rightarrow \bar{\nu}_e\pi^+$	3% - 15%	$n \rightarrow \bar{\nu}_e\pi^\circ$	2% - 7%
$p \rightarrow \bar{\nu}_e\rho^+$	3% - 8%	$n \rightarrow \bar{\nu}_e\rho^\circ$	1% - 5%
---	---	$n \rightarrow \bar{\nu}_e\eta$	~ 1%
---	---	$n \rightarrow \bar{\nu}_e\omega$	5% - 14%
$p \rightarrow \mu^+K^\circ$	0 - 11%	$n \rightarrow \bar{\nu}_\mu K^\circ$	0 - 2%

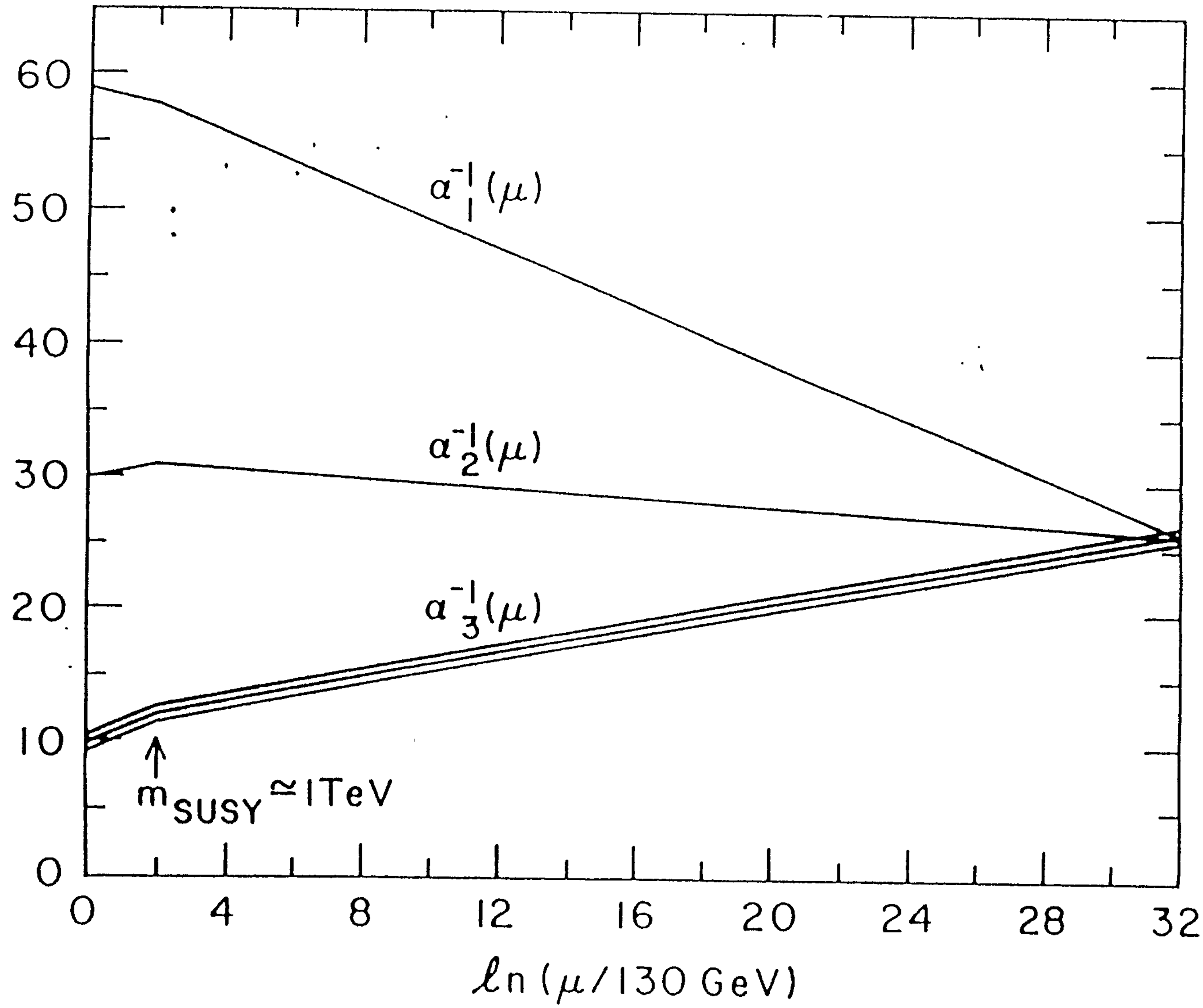
PROTON DECAY CHANNELS [redacted]

SU(5)

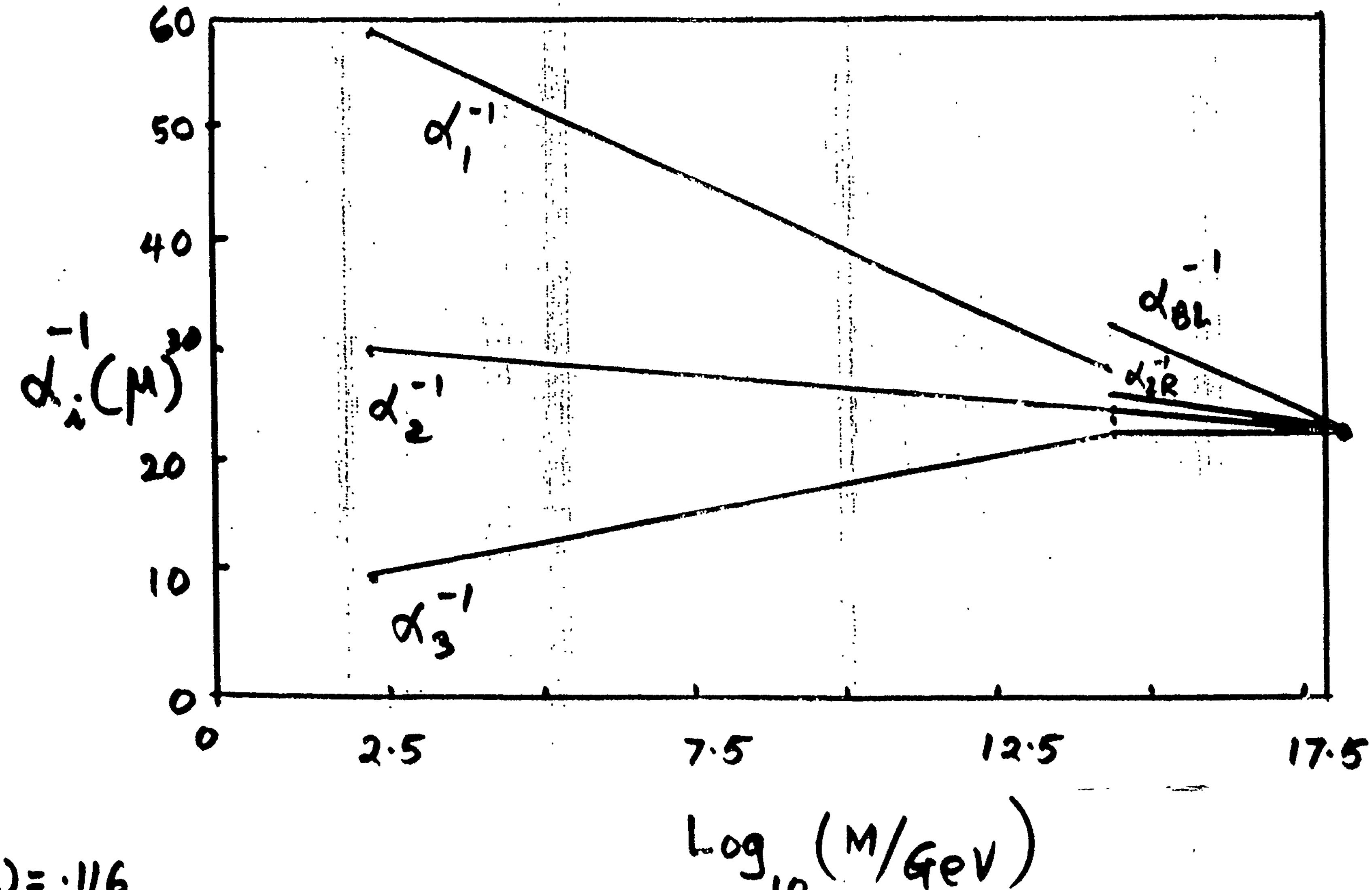
Grand Unification
(almost)



Evidence for SUSY ?



A GAUGE COUPLING UNIF. SCENARIO IN E_6-TYPE SUSYGUT.



$\alpha_s(M_Z) = .116$

$\Rightarrow \frac{V_{BL}}{M_U} \simeq 10^{-4}$

N-N̄ OSC. IN GUT THEORIE

MODEL	$N-\bar{N}$	IMPLICATI
NON-SUSY		
1. SU(5)	X	$\Delta(B-L)=$
2. $SU(2)_L \times SU(2)_R \times SU(4)_c$	✓	$M_c \simeq 10^5$ Ge; $B(K_L^0 \to \mu \bar{e})$
3. SO(10) (MINIMAL)	X	
4. E_6	X	
SUSY (STRING INSPIRED)		
5. E_6	✓	BROKEN R-PARITY
6. SO(10)	X	NO STABLE SUSY PARTICL

Neutron-Antineutron Transitions

Nonconservation

Strangeness	$K^0 \rightarrow \overline{K^0}$
Beauty	$B^0 \rightarrow \overline{B^0}$
Baryon Number	$n \rightarrow \bar{n}$

$n\bar{n}$ oscillations –

- probe mass scale $\sim 10^5 - 10^6$ GeV
- $\Delta B = 2$ transitions
  - reactors : free moving neutrons
  - intranuclear transitions

PROTON DECAY

IMB } Č Detectors
Kamiokande

NUSEX }
Frejus } Fine Grain Sampling
Soudan 2

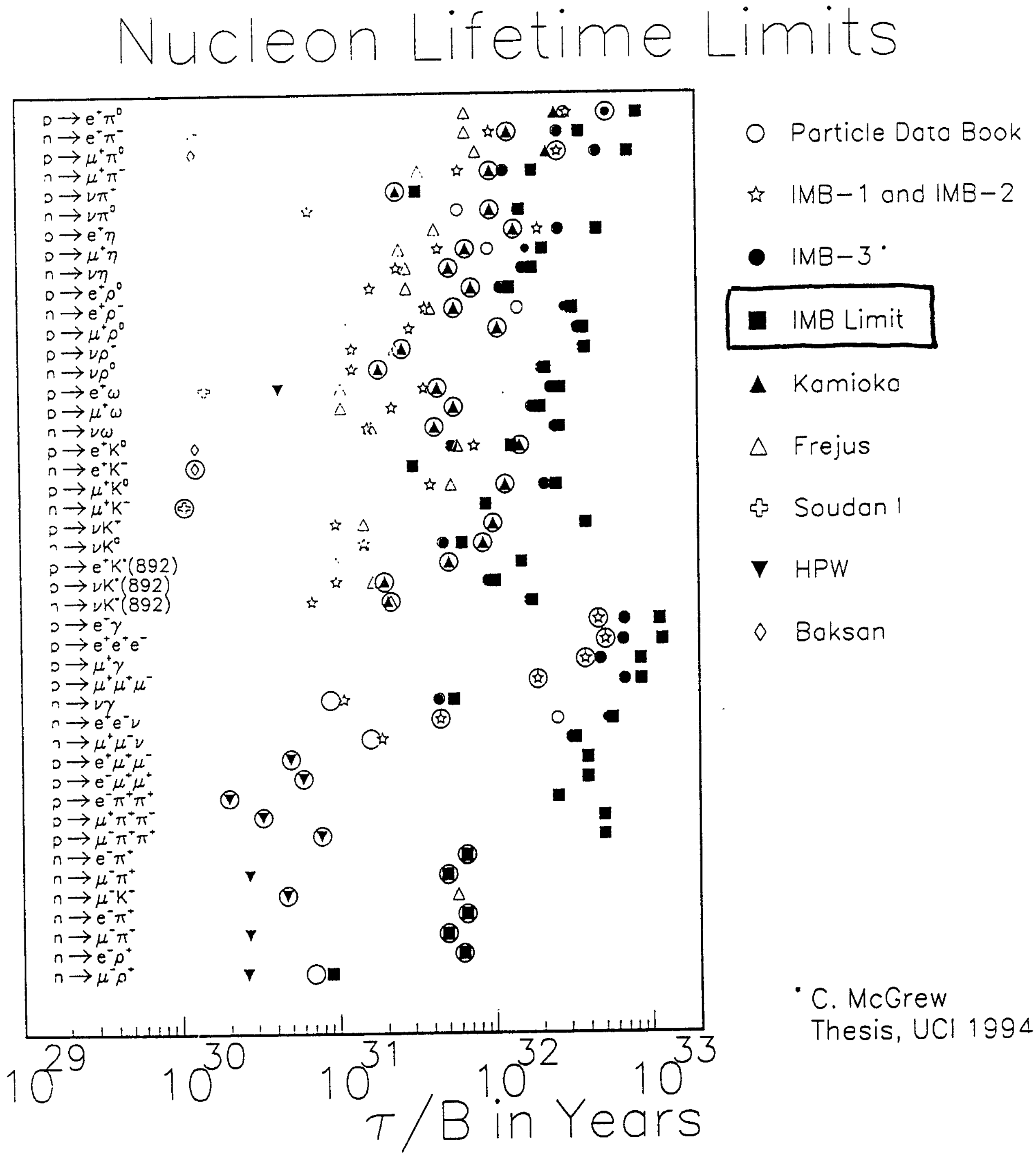
- NO EVIDENCE FOR PROTON DECAY

  - many channels
  - $\tau(e^+\pi^0) \gtrsim 10^{33}$ yrs
    $\tau(\bar{\nu}K^+) \gtrsim 10^{32}$ yrs

EXCEPT ?!

Current Experimental Limits

All Experiments



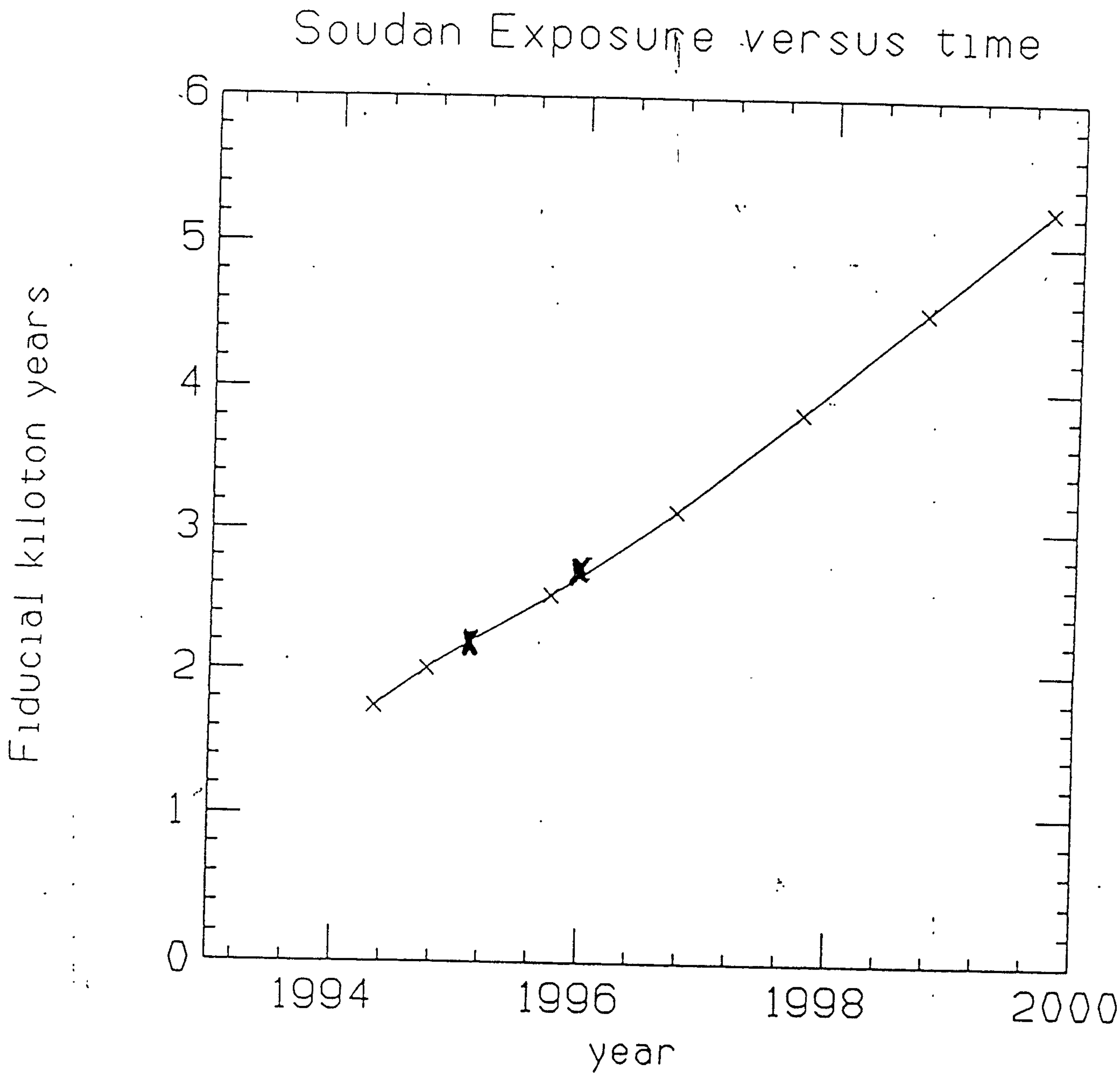
* C. McGrew Thesis, UCI 1994

Soudan 2 Detector
Key Features for Proton Decay

1. Check of Kamiokande limits
2. Lower backgrounds for candidates in some modes
3. Low backgrounds for multi-track events
4. Ionization gives track direction
5. Recoil protons and neutrons from ν interactions, not p decay

Soudan 2 Proton Decay Limits
Exclusive channels

mode	exposure (kt-yr)	$\tau/B@90\%CL$ (yr)
$n \rightarrow e^+ e^- \bar{\nu}$	(1.0)	5.0×10^{31}
$n \rightarrow \eta \bar{\nu}$	(1.0)	1.6×10^{31}
$n \rightarrow \pi^0 \bar{\nu}$	(1.0)	3.2×10^{31}
$p \rightarrow K^+ \bar{\nu}$	(0.5)	4.5×10^{30}
$n \rightarrow e^- K^+$	(0.5)	7.5×10^{30}
$n \rightarrow \mu^- K^+$	(0.5)	6.5×10^{30}



Soudan Exposure versus time
Fiducial kiloton years
year
0
1
2
3
4
5
6
1994
1996
1998
2000

Atmospheric ν Anomaly

$R\left(\frac{\mu}{e}\right) \simeq 0.6$ (prediction)

- μ-deficit $\Rightarrow$ ν-oscillation
- e-excess $\Rightarrow$ proton decay?

(Mann, Kafka & Leeson Phys Lett. B 291 (1992))

Definition? $p \to e^+ \nu \nu$ ([illegible])

rarely considered in GUT models

except (Pati & Salam PRL 31 (1973) p661)

- SU(4) of Color (unify quarks/leptons)
- $\Delta(B-L) = -2$ nucleon decay modes predicted
- $p \to e^+ \nu \nu$ can dominate over
  - $\to \mu \nu \nu$
  - $\to$ others

ATMOSPHERIC NEUTRINOS

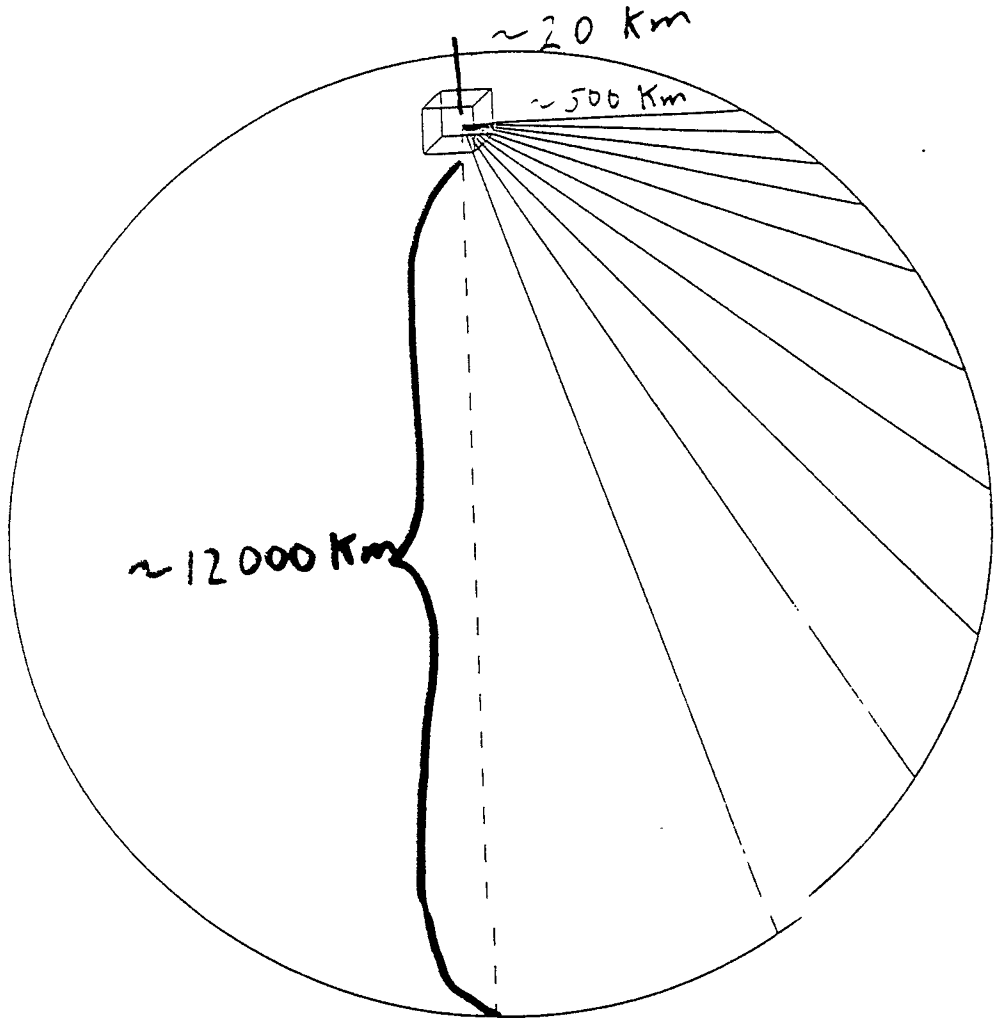
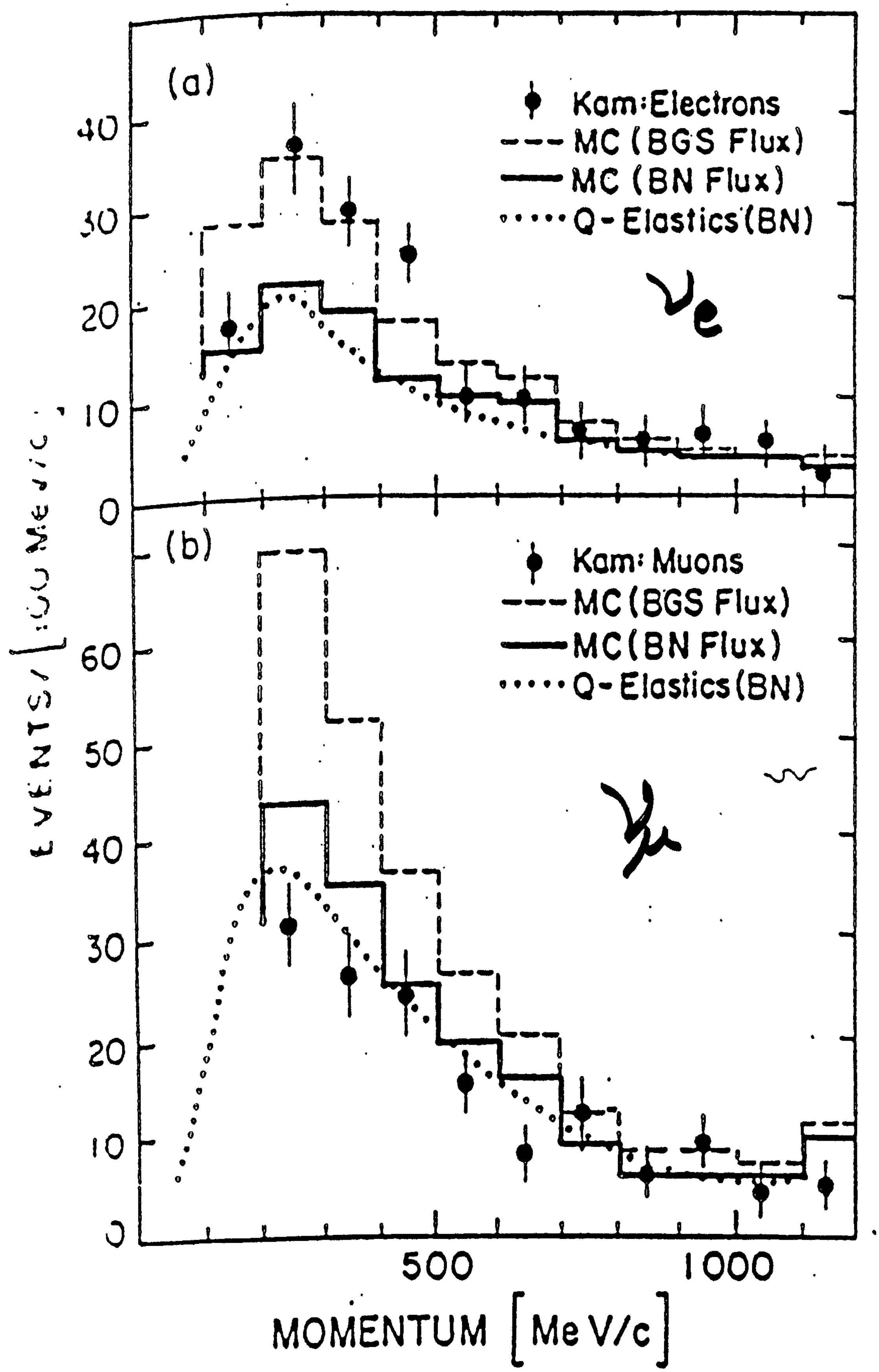


FIGURE 4.9: Zenith angle bins.

Oscillation Probability

$$P_{1\to 2} = \sin^2 2\theta_{12} \sin^2 \frac{1.27 L \Delta m^2_{12}}{E_\nu}$$

$[L] = \text{Km}$, $[E_\nu] = \text{GeV}$, $[\Delta m^2] = \text{eV}^2$

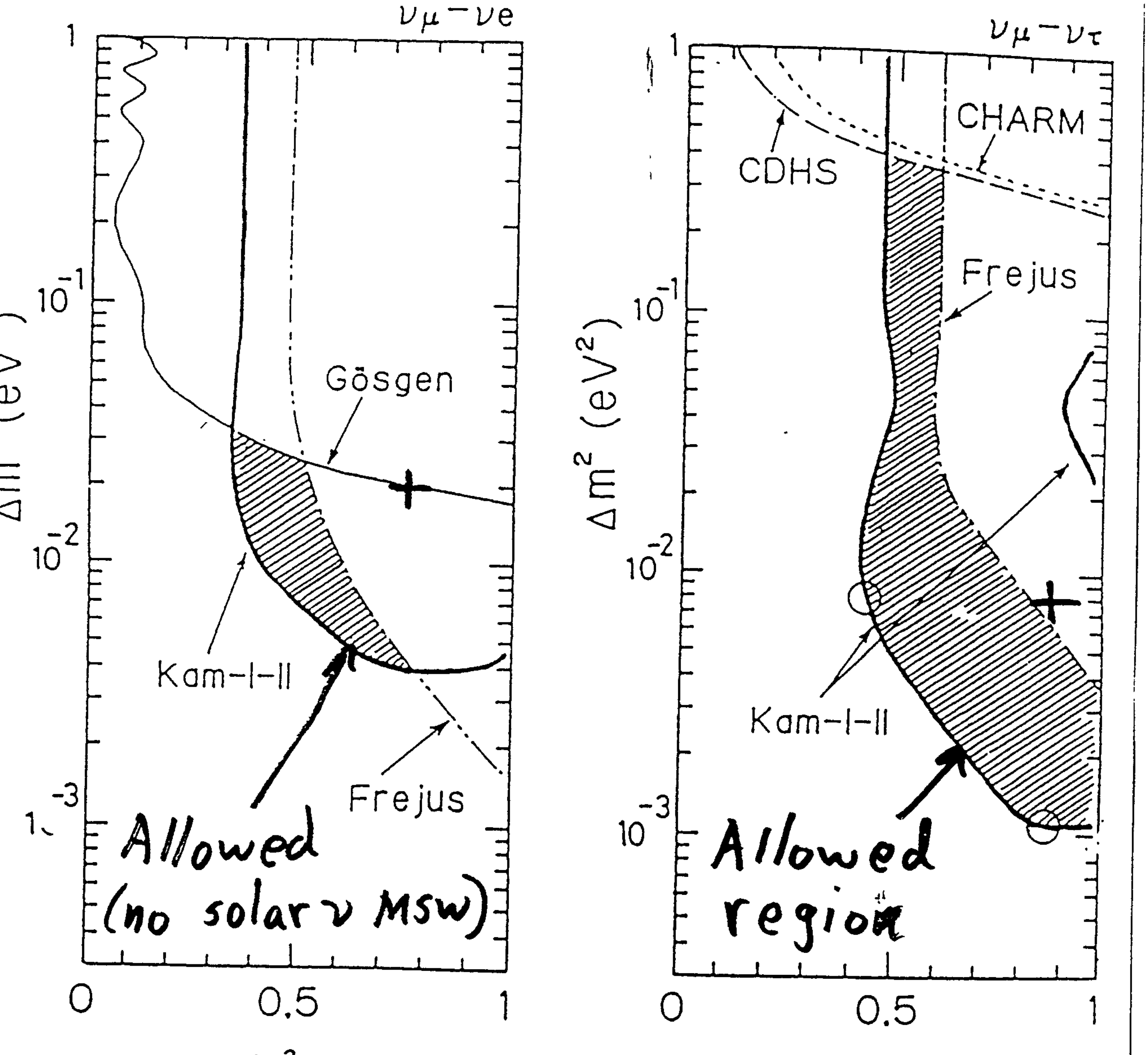

(a)
Kam: Electrons
MC (BGS Flux)
MC (BN Flux)
Q-Elastics (BN)
(b)
Kam: Muons
MC (BGS Flux)
MC (BN Flux)
Q-Elastics (BN)
EVENTS / 100 MeV/c
MOMENTUM [MeV/c]
0
10
20
30
40
50
60
500
1000

Typical Oscillation Distance

Δm^2 (eV^2)	E_ν (GeV)	Distance (Km)
1	1	~1
	10	~10
	100	~100
0.1	1	~10
	10	~100
	100	~1000
0.01	1	~100
	10	~1000
	100	~10^4

$$\left(\sin^2 \frac{1.27\, L\, \Delta m^2}{E} = 1 \right)$$

Kamiokande lower limits and Allowed Oscillation Parameters



90% C.L.

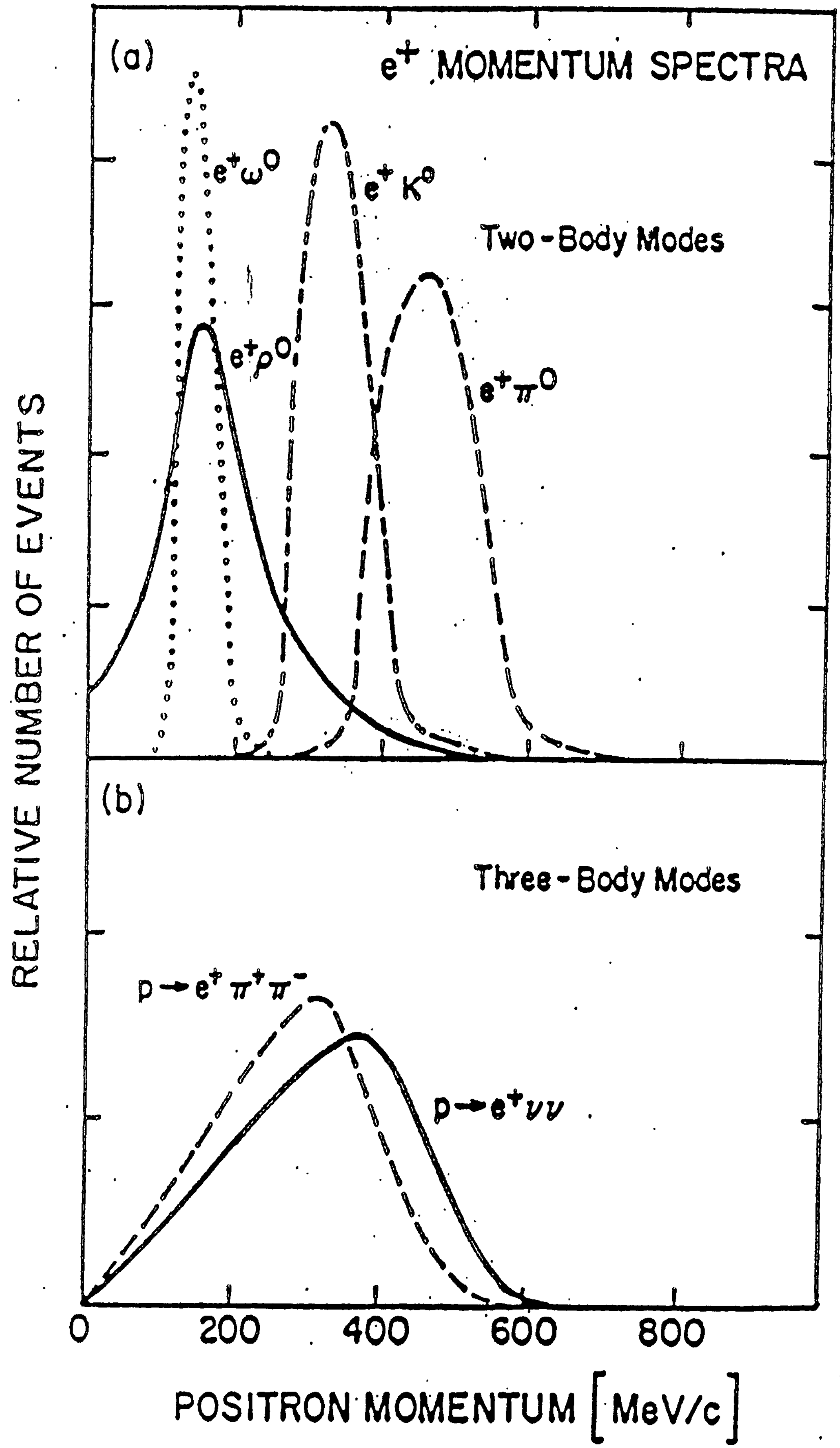
$\nu_\mu \leftrightarrow \nu_e$

$\nu_\mu \leftrightarrow \nu_\tau$

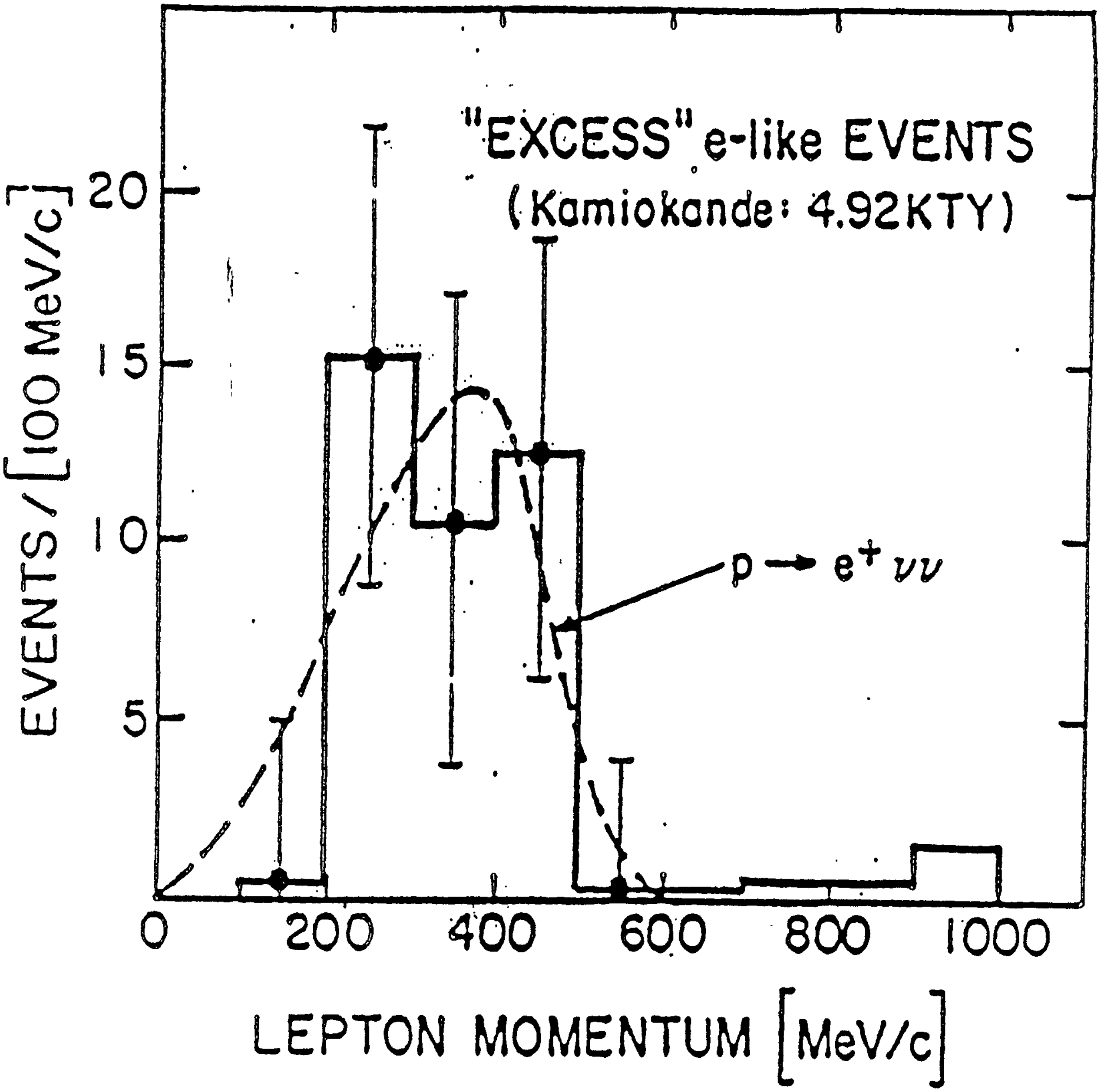
Soudan II consistent with Kamiokande

PH Let B 280; 146

Submitted to Ph. Let., Jan 1992



(a)
e+ MOMENTUM SPECTRA
e+ω0
e+K0
Two - Body Modes
e+ρ0
e+π0
(b)
Three - Body Modes
p → e+π+π-
p → e+νν
RELATIVE NUMBER OF EVENTS
0
200
400
600
800
POSITRON MOMENTUM [MeV/c]



"EXCESS" e-like EVENTS
(Kamiokande: 4.92KTY)
EVENTS / [100 MeV/c]
20
15
10
5
0
200
400
600
800
1000
p → e+ νν
LEPTON MOMENTUM [MeV/c]

Kamiokande —

4.92 kton-yr

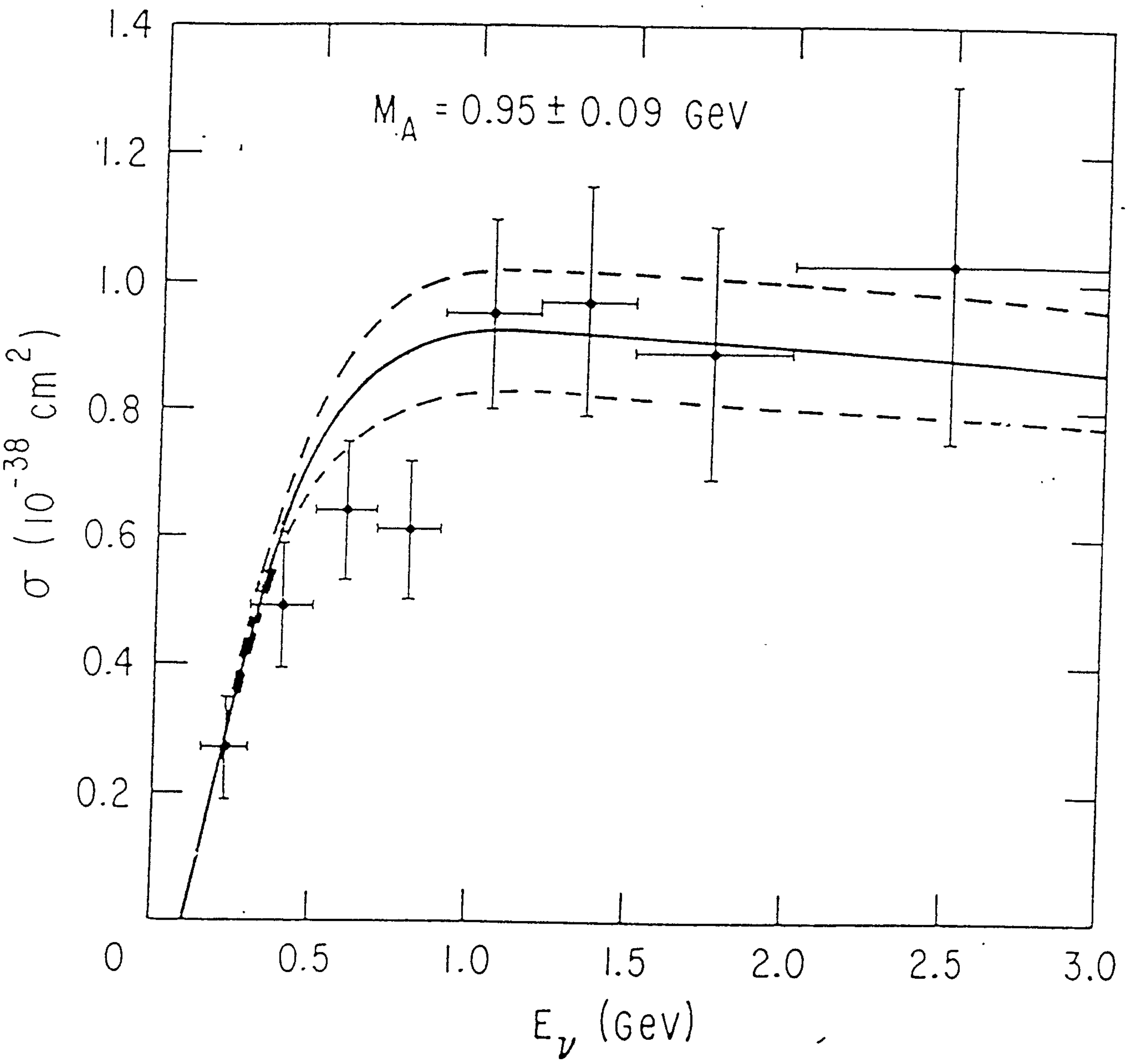
37 ± 12 excess events

$$\tau/B = 4.0^{+1.9}_{-1.0} \; 10^{31} \; yr$$

Frej[illegible] →

2 kton-yr

	observe	Bartol
e	11	6.08
μ	7	11.[illegible]



$M_A = 0.95 \pm 0.09$ GeV
$\sigma\ (10^{-38}\ cm^2)$
E_ν (GeV)
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.5
1.0
1.5
2.0
2.5
3.0

Kamiokande Zenith Distribution of Ratio of Ratios for multi-GeV Events!

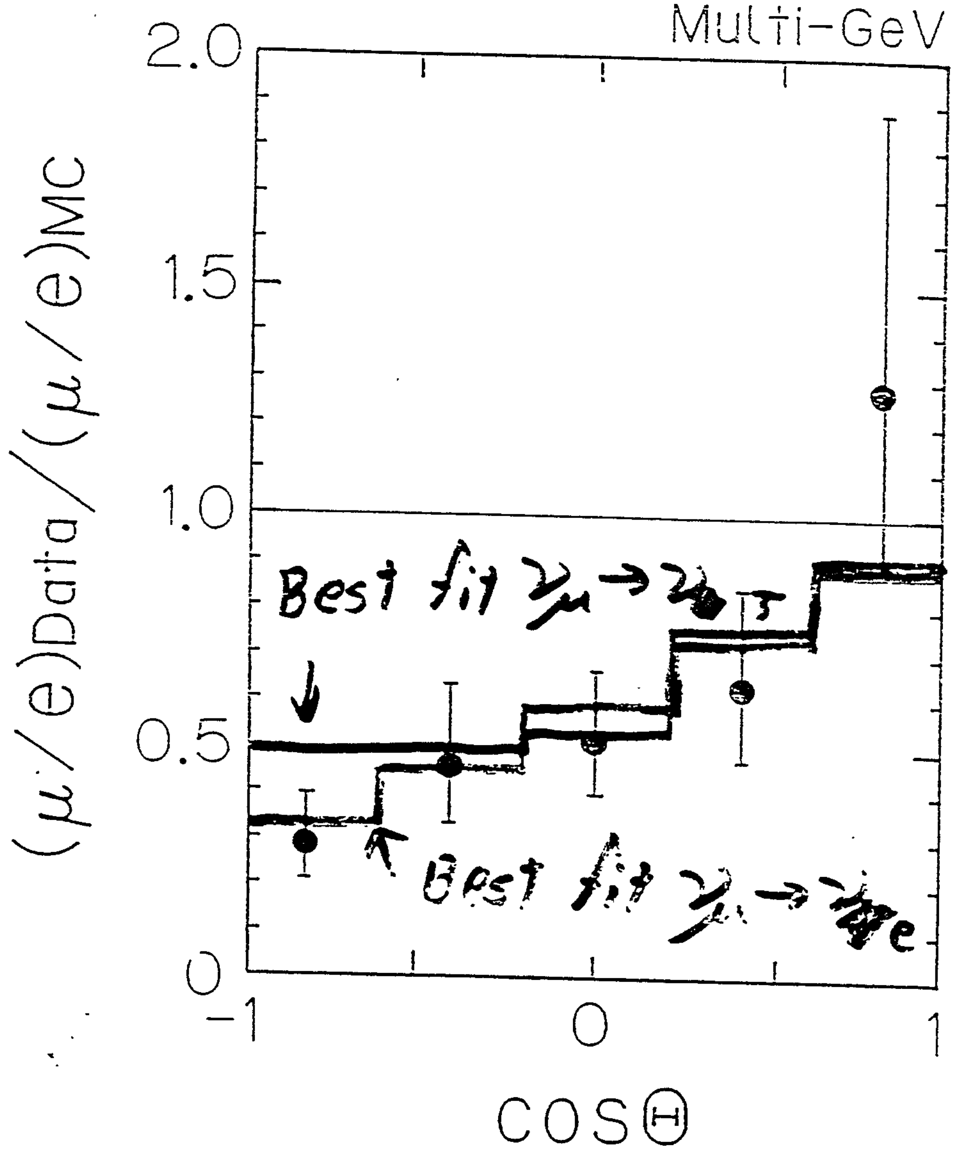


Fig.4

Next Generation Proton Decay

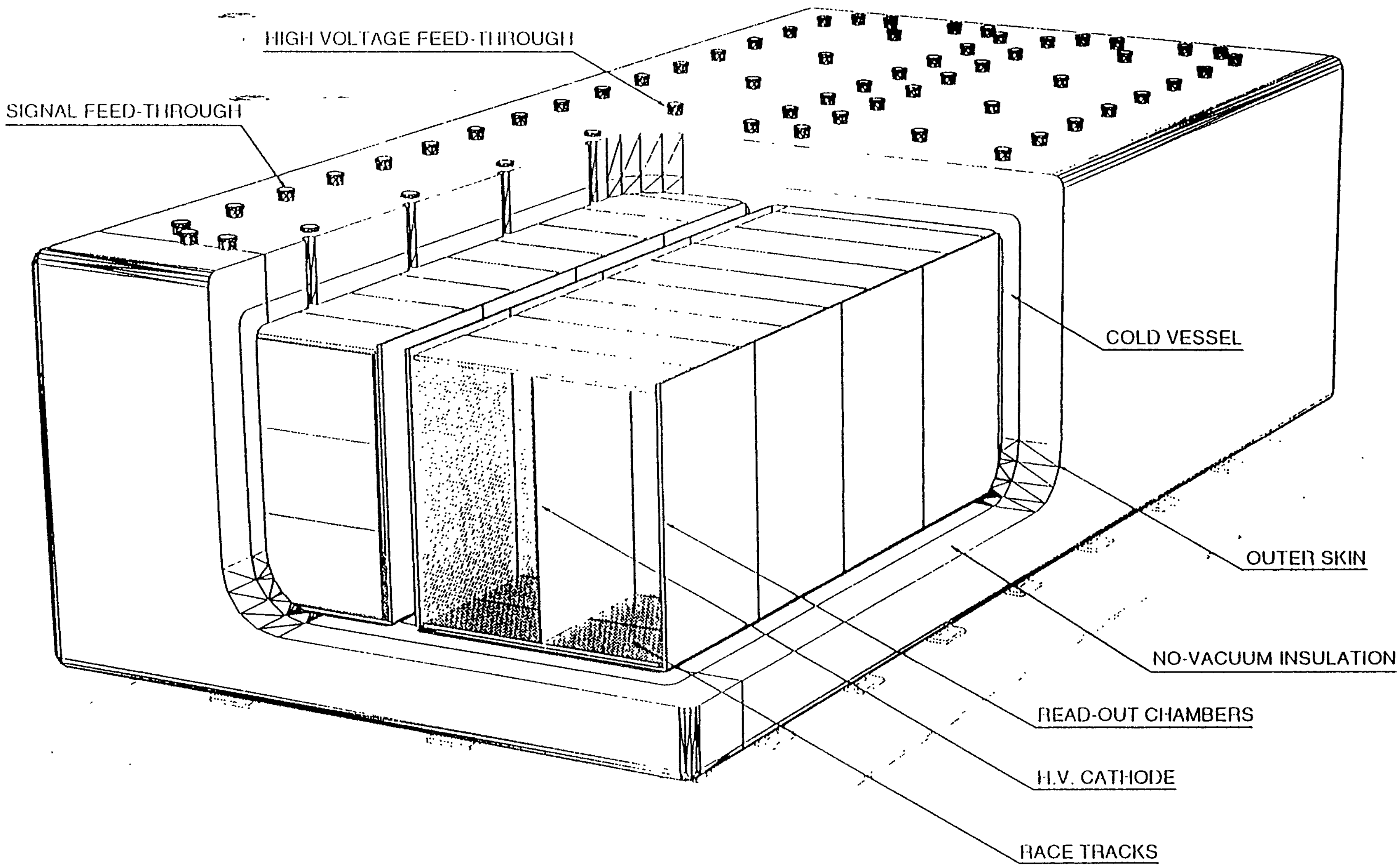
- ICARUS : reconstruction ability
  low background
  ([illegible])

- SUPERK : improved sensitivity
  ([illegible])

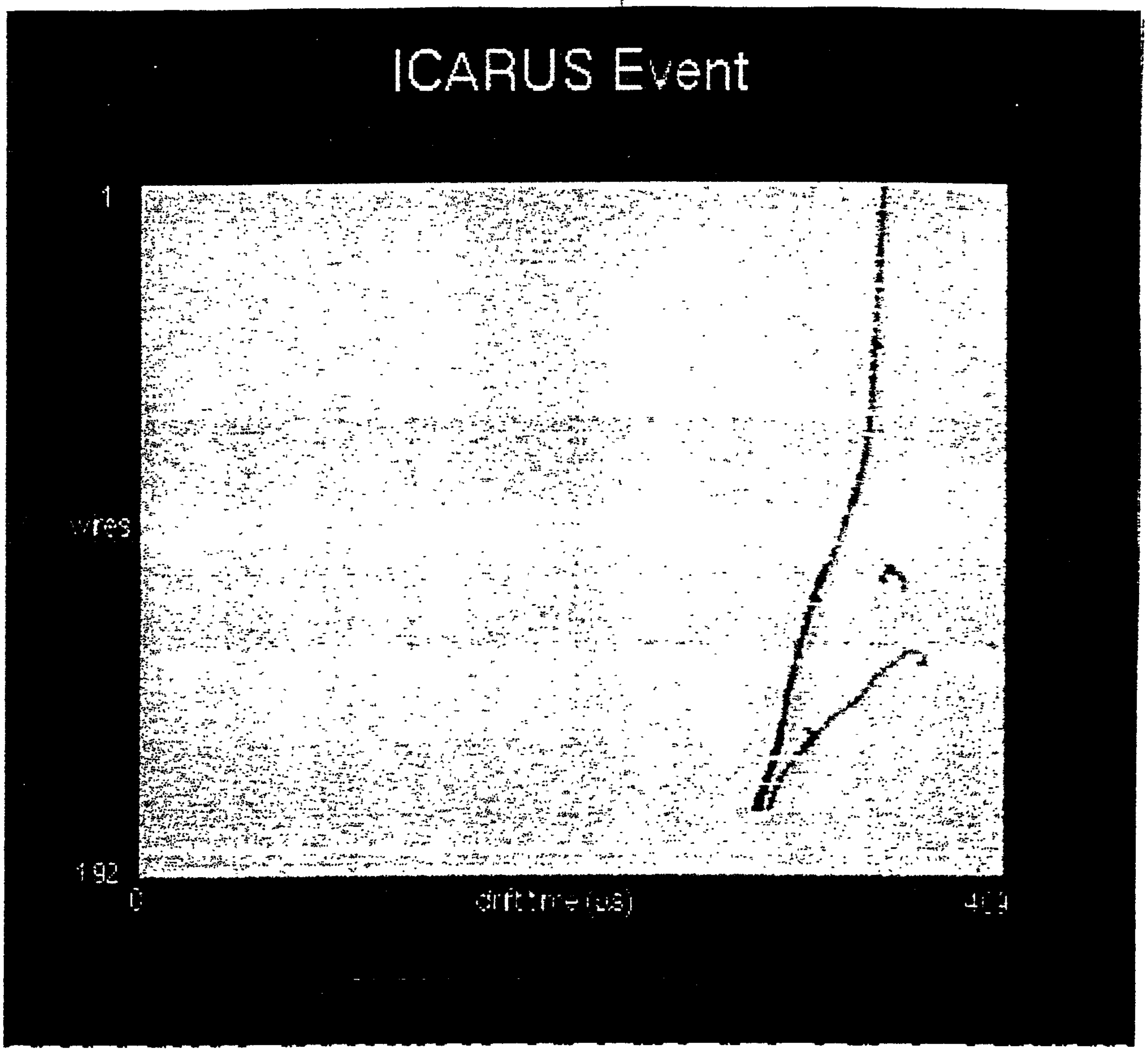
- SOUDAN 2 : fine grain
  ([illegible])

- AMANDA ; KM^3 etc.

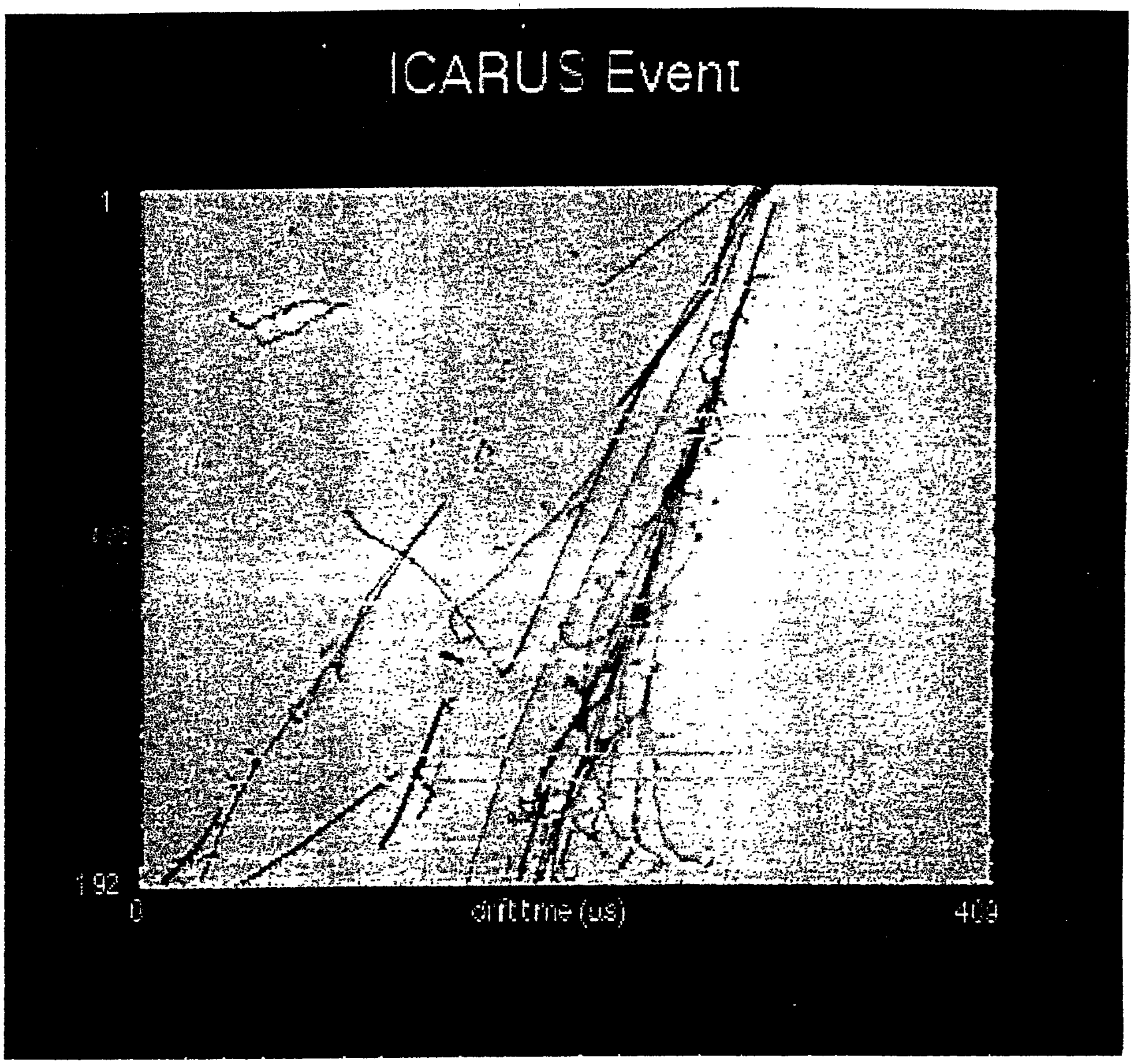
The ICARUS 600 Ton Detector

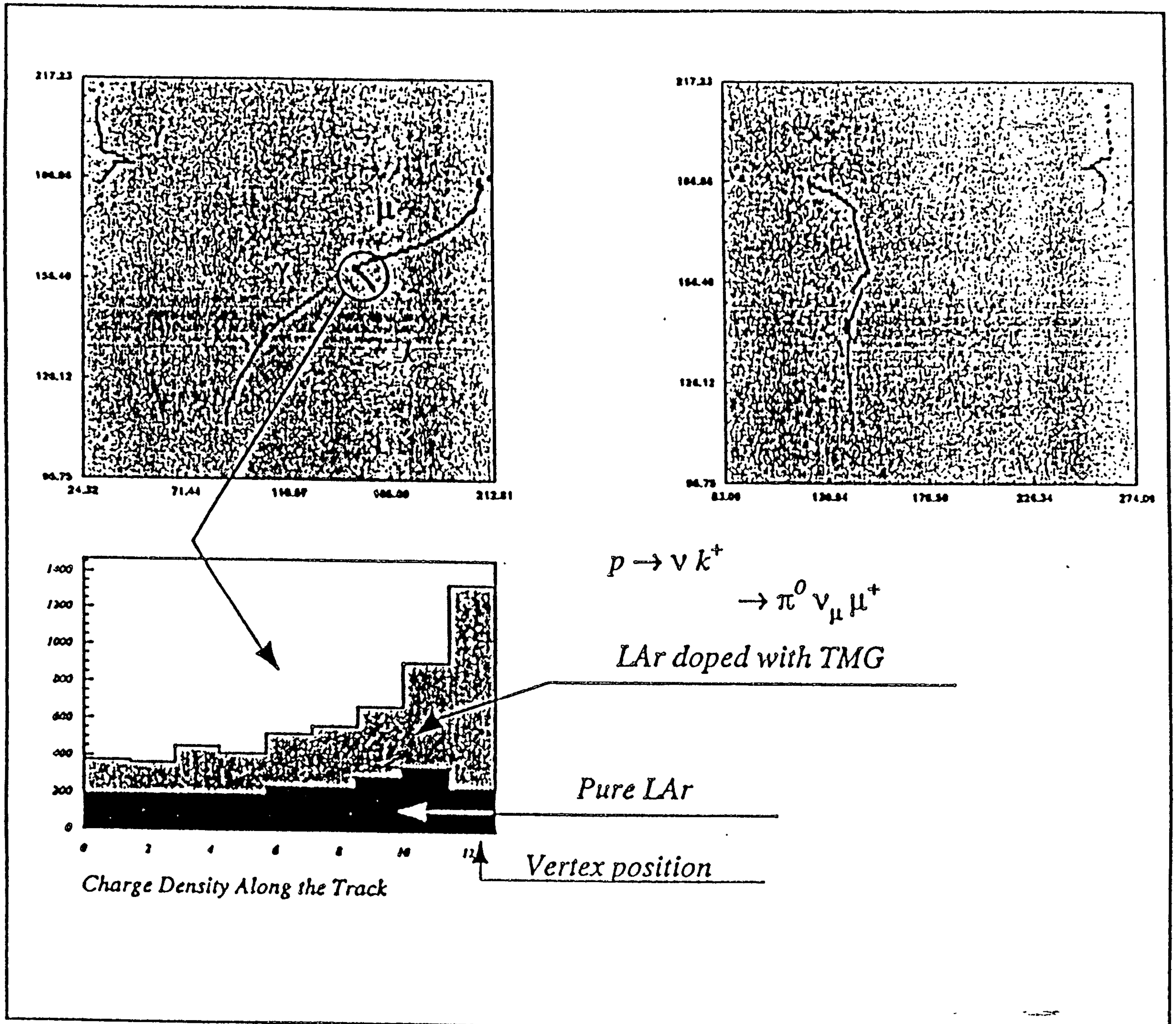


ICARUS
MUON DECAY



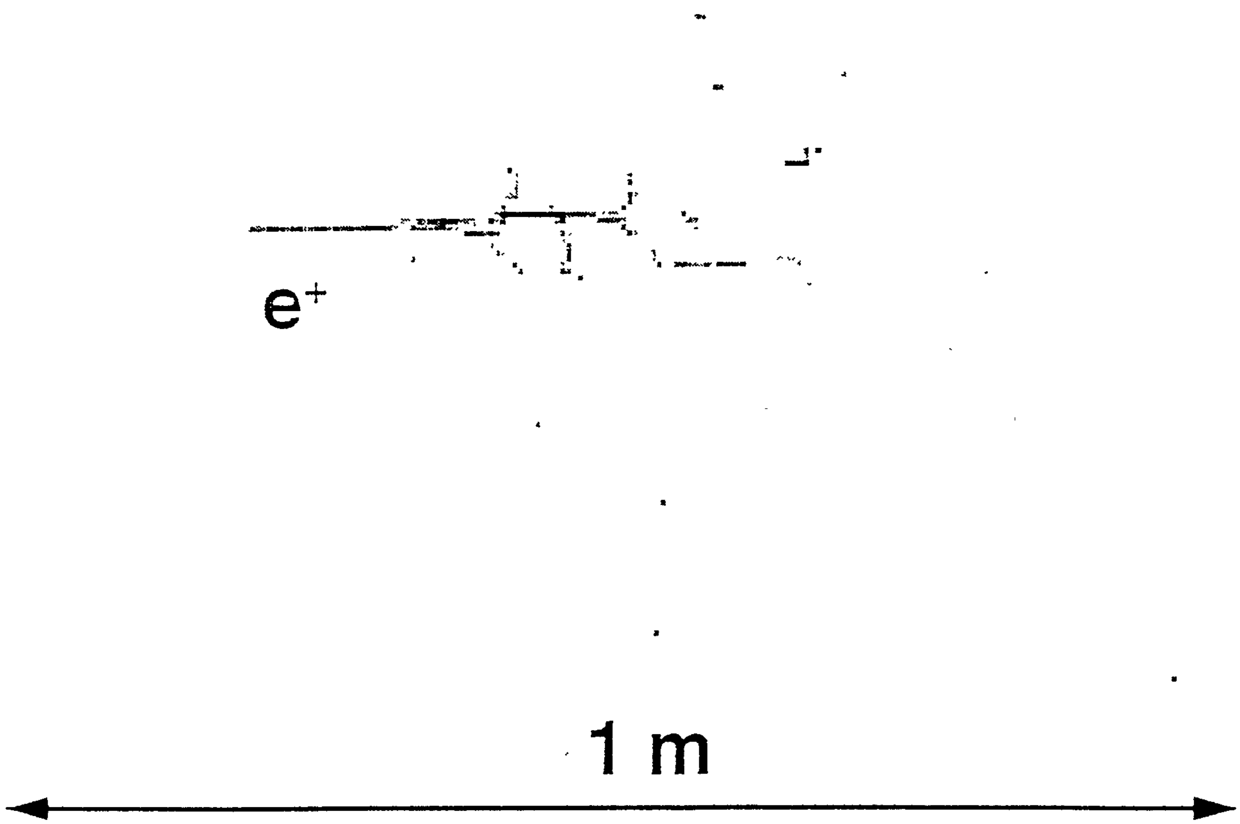
ICARUS
COSMIC RAY SHOWER




μ+
γ
p → ν k+
→ π0 νμ μ+
LAr doped with TMG
Pure LAr
Vertex position
Charge Density Along the Track

$p \rightarrow e^{+} \nu \nu$

ICARUS



Results on $p \to e^+ \nu \nu$

Selection criteria:

1) One isolated electron shower.
2) Reconstructed energy 150MeV < Etot <450MeV

Results:

Generated 2500 events

519 $p \to e^+ \nu \nu$ proton decays
1981 atmospheric ν_e's (CC only)

Selected 444 events

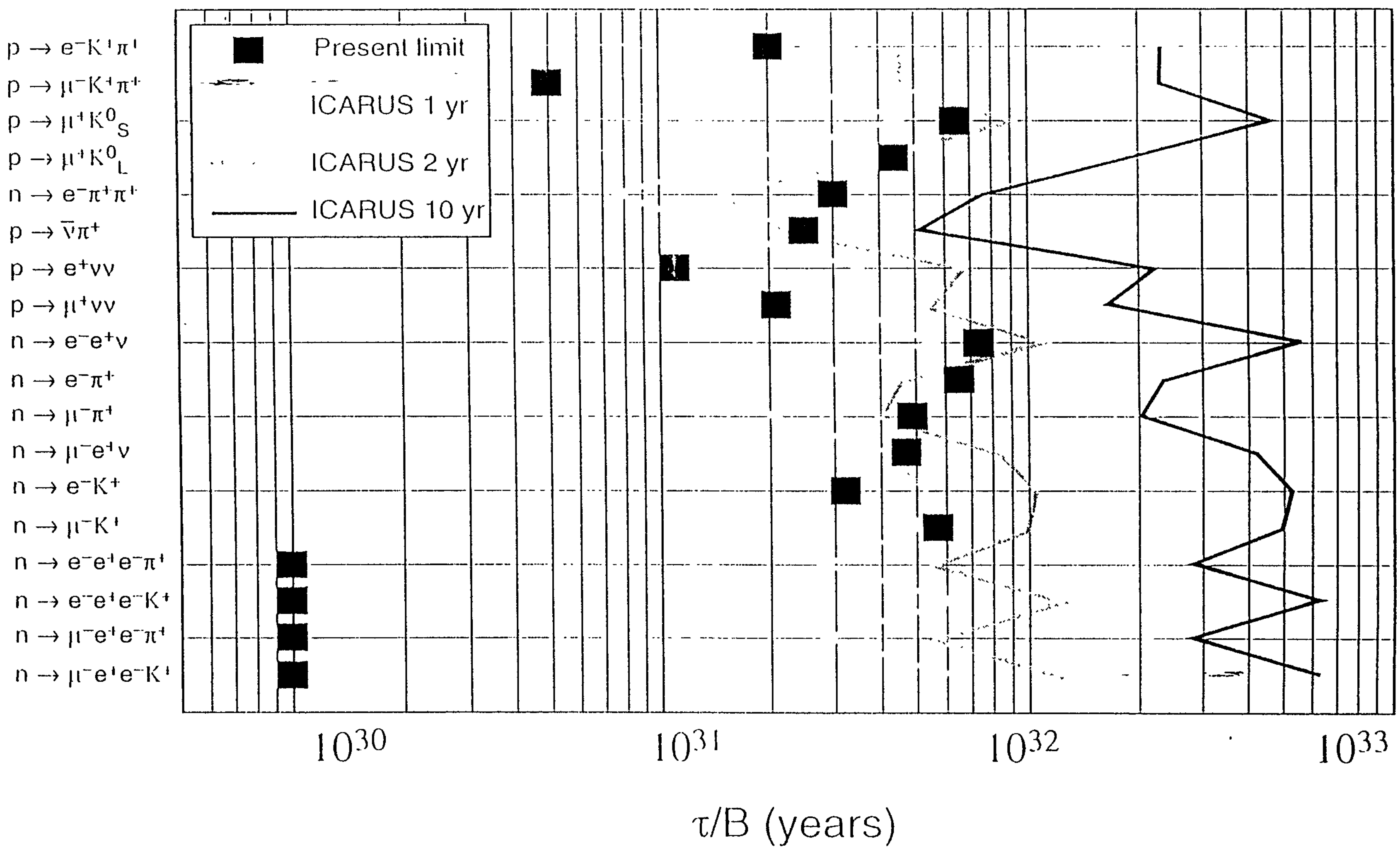
399 proton decays
45 Atmospheric neutrinos

Detection efficiency = 0.769 ± 0.019 on non reinteracting p.d.
Expected background = 5.7 ± 0.02 ± 1.7 ev. / module / year
Expected signal from atmospheric ν data = 25 ev. / module / year

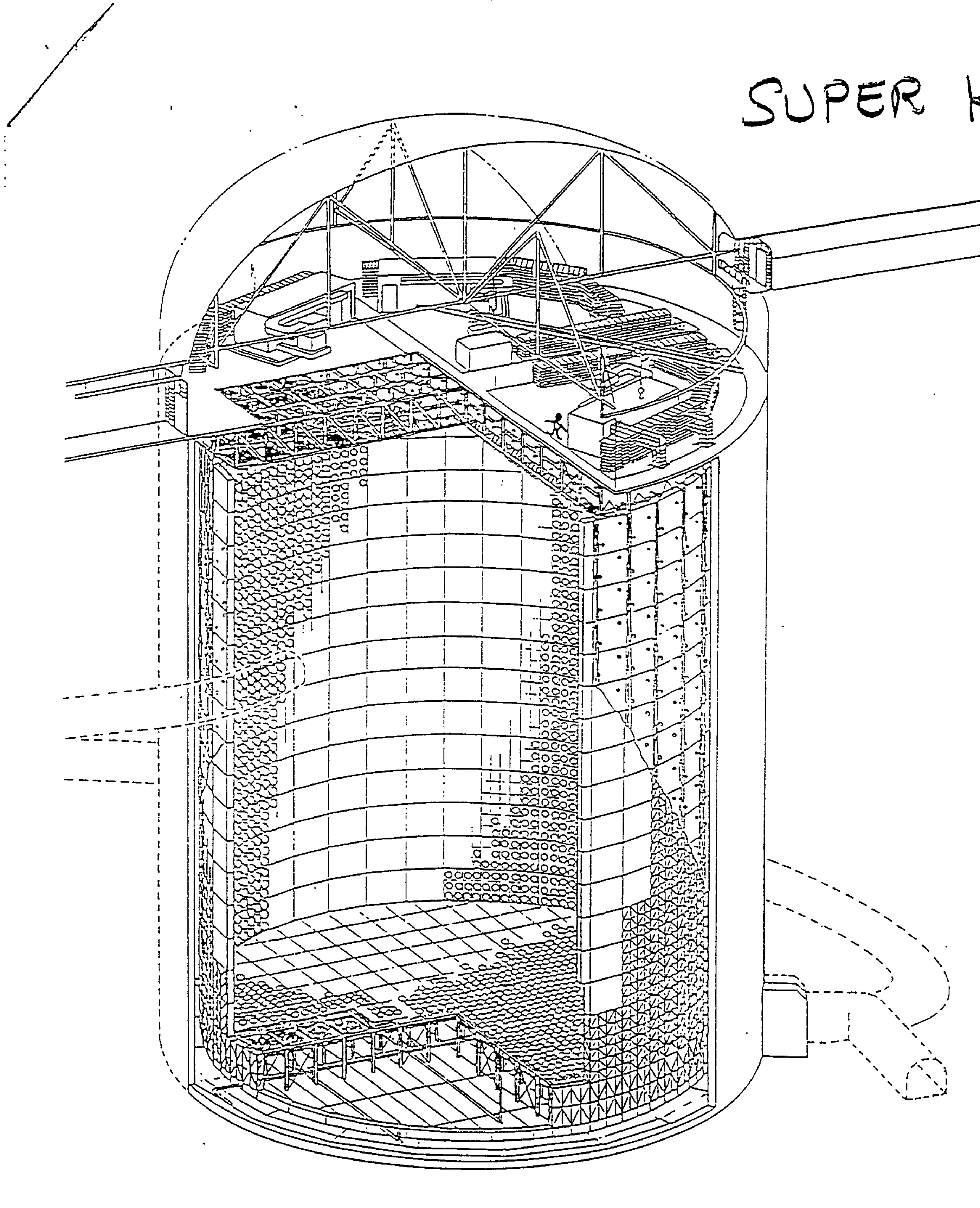
Nuclear efficiency (MC)

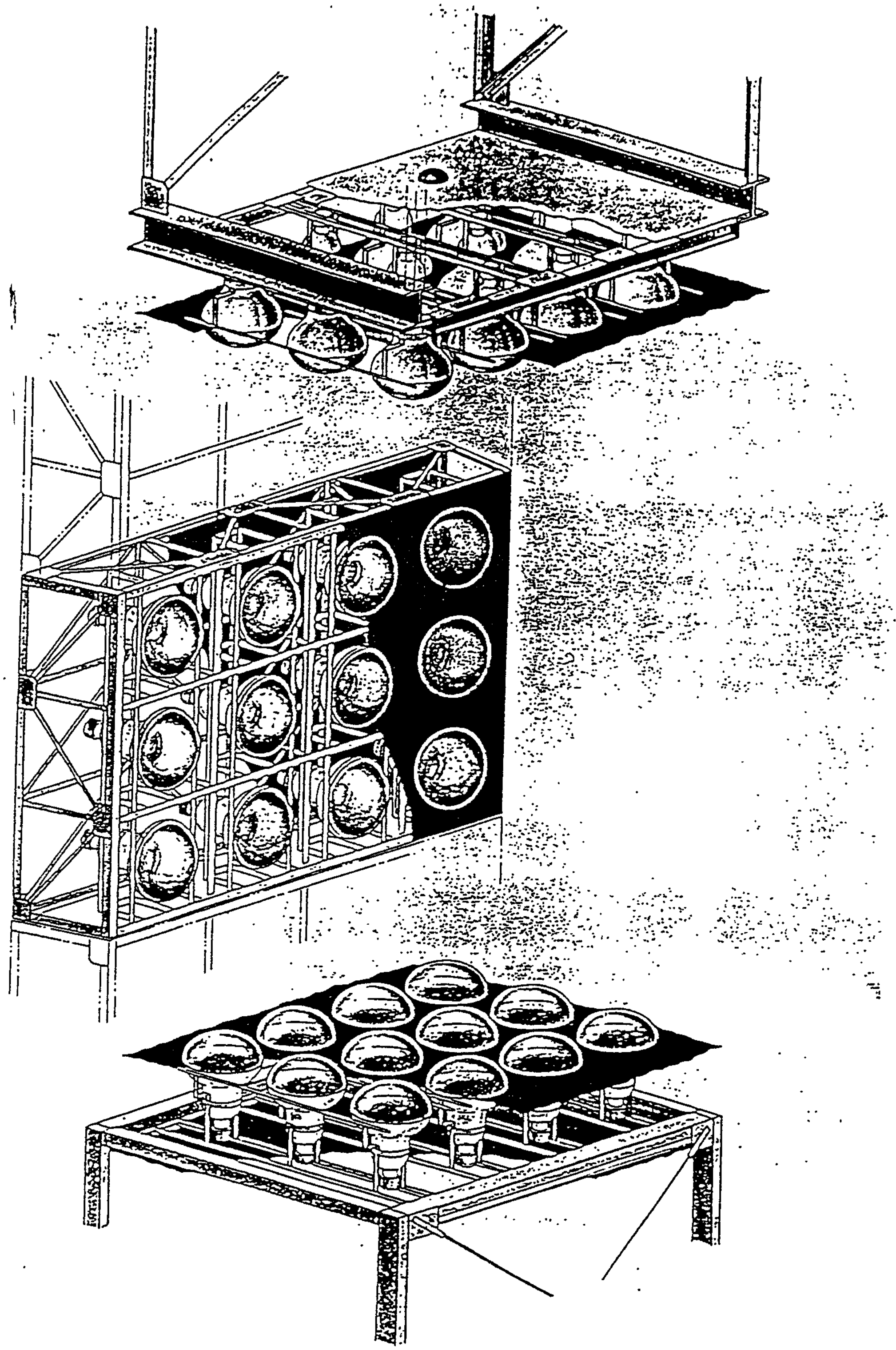
Decay mode	ε_N
$p \rightarrow e^+ \pi^0$	0.42
$p \rightarrow \nu \pi^+$	0.42
$p \rightarrow \mu^+ \pi^0$	0.38
$p \rightarrow \nu k^+$	0.85
$p \rightarrow e^+ \pi^+ \pi^-$	0.13
$p \rightarrow e^+ \rho^0$	0.08
$n \rightarrow e^+ \pi^-$	0.4
$n \rightarrow \mu^+ \pi^-$	0.37
$n \rightarrow \nu \pi^0$	0.42
$n \rightarrow e^- k^+$	0.85
$n \rightarrow e^+ \rho^-$	0.08
$n \rightarrow e^+ \pi^- \pi^0$	0.13
$p \rightarrow e^+ \nu \nu$	1.0

ICARUS 600 ton limits for Exotic Decay Modes



SUPER K





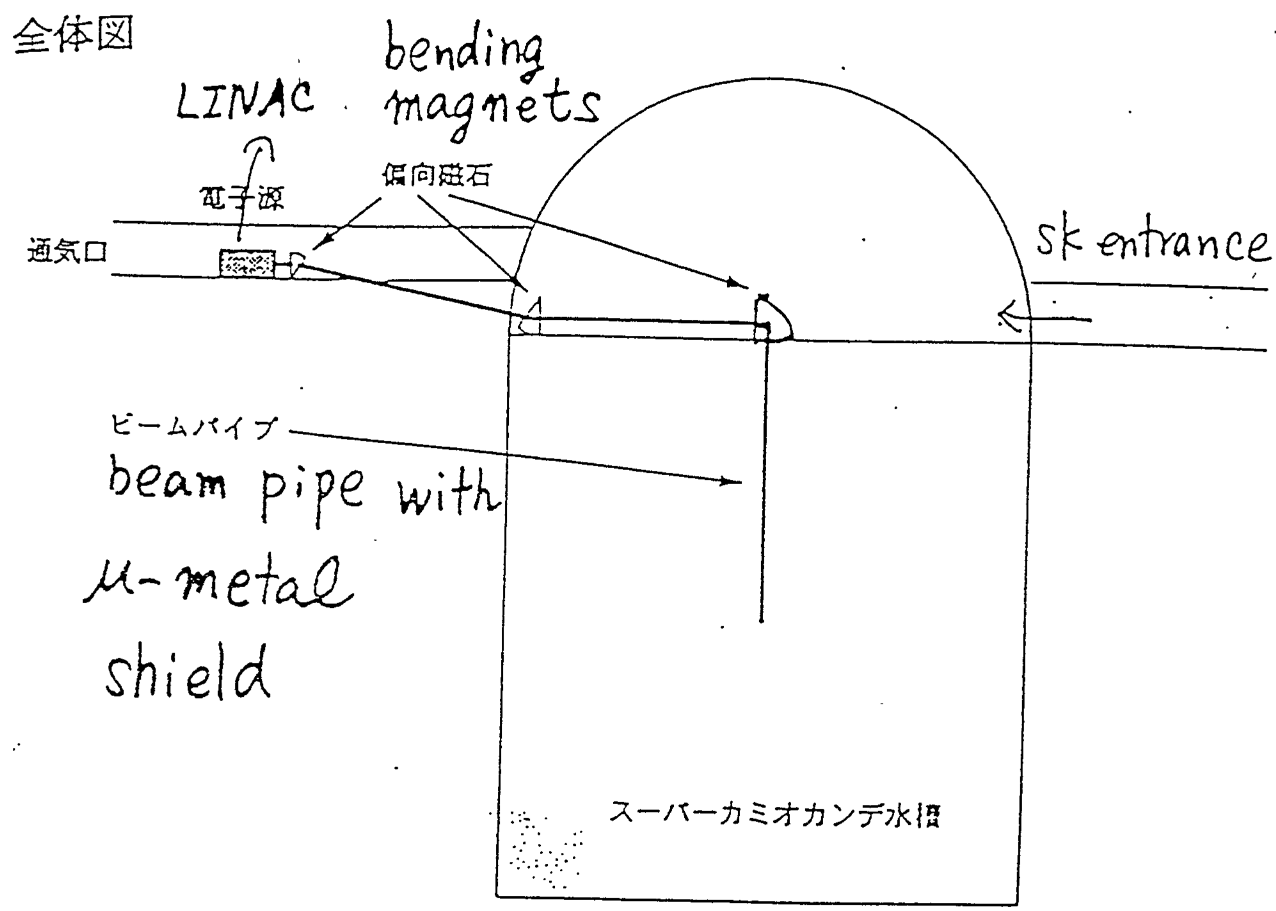
SUPERKAMIOKANDE INSTITUTE FOR COSMIC RAY RESEARCH UNIVERSITY OF TOKYO

NIKKEN SEKKEI

Physical Parameters of Large Water Čerenkov detectors

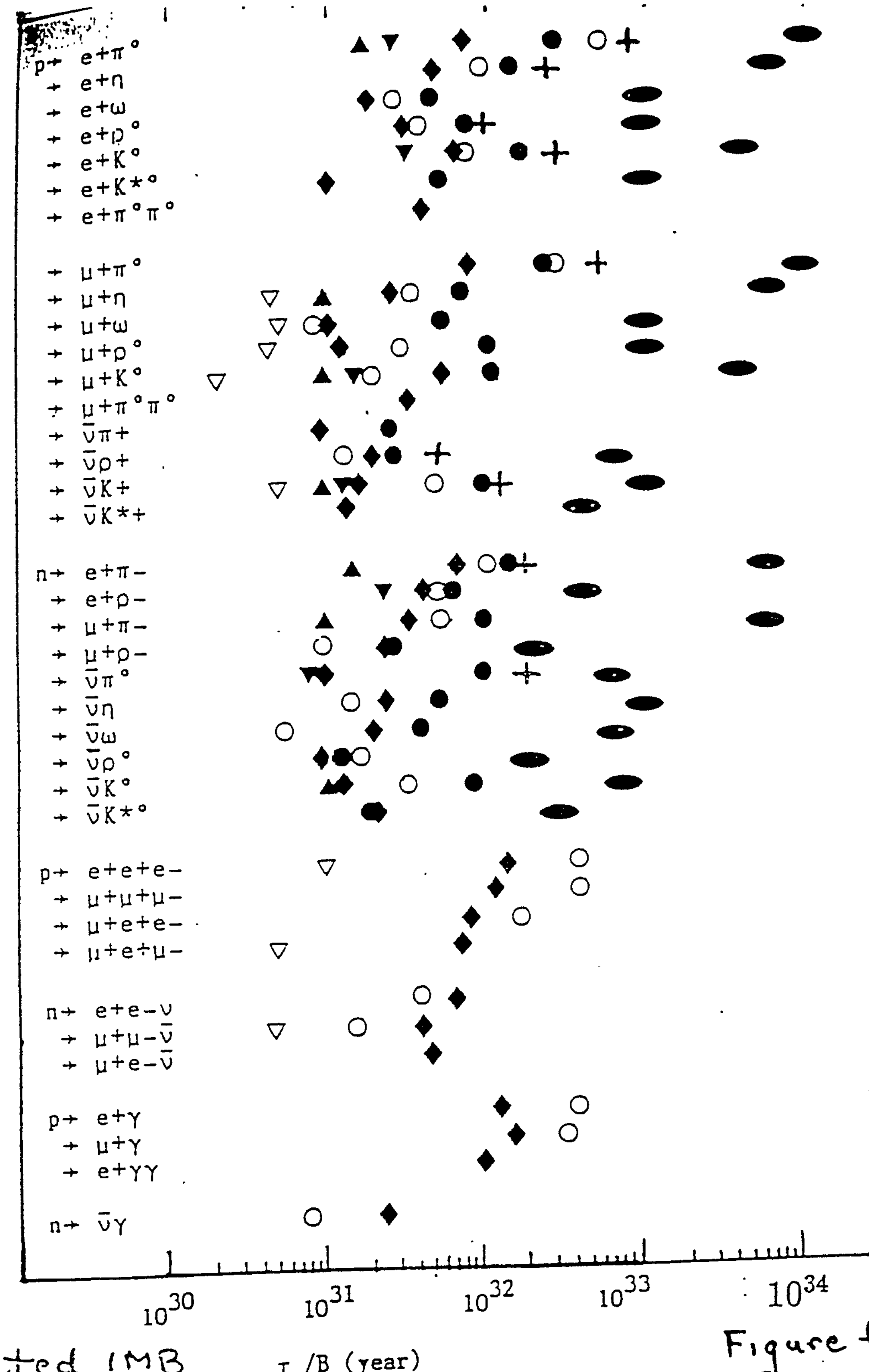
PARAMETERS	KAMIOKANDE III	IMB-3	SUPER KAMIOKANDE
TOTAL MASS	4500 tonnes	8000 tonnes	50,000 tonnes
FIDUCIAL MASS			
p-decay	1040 tonnes	3300 tonnes	22,000 tonnes
Solar ν	680 tonnes	None	22,000 tonnes
Supernova	2140 tonnes	6800 tonnes	32,000 tonnes
DEPTH	2700 mwe	1570 mwe	2700 mwe
TOTAL SIZE	16 mh $\times$ 19 mϕ	22 $\times$ 17 $\times$ 18 m^3	41 mh $\times$ 39 mϕ
# PMTs	948 @ 50 cm	2048 @ 20 cm + WLS	11,200 @ 50 cm + 2,200 @ 20 cm
PHOTO-CATHODE COVERAGE	20% ~5 pe/MeV	4% ~1 pe/MeV	40% ~7 pe/MeV
PMT TIMING RESOLUTION	4ns @ 1 pe	11 ns @ 1 pe	2.5 ns @ 1 pe
ANTI-COUNTER	~1.5 m	None	2.5 m All Sides

Electron Source
5 - 15 MeV



Remaining:

- Development of low intensity (100μA) electron gun
- Beam monitor - anti
- Absolute energy measurement Ge



\+ Projected IMB

⬬ Super-K

Figure from: Barloutaud Nuc. Phys. B, 28A (1992) 437

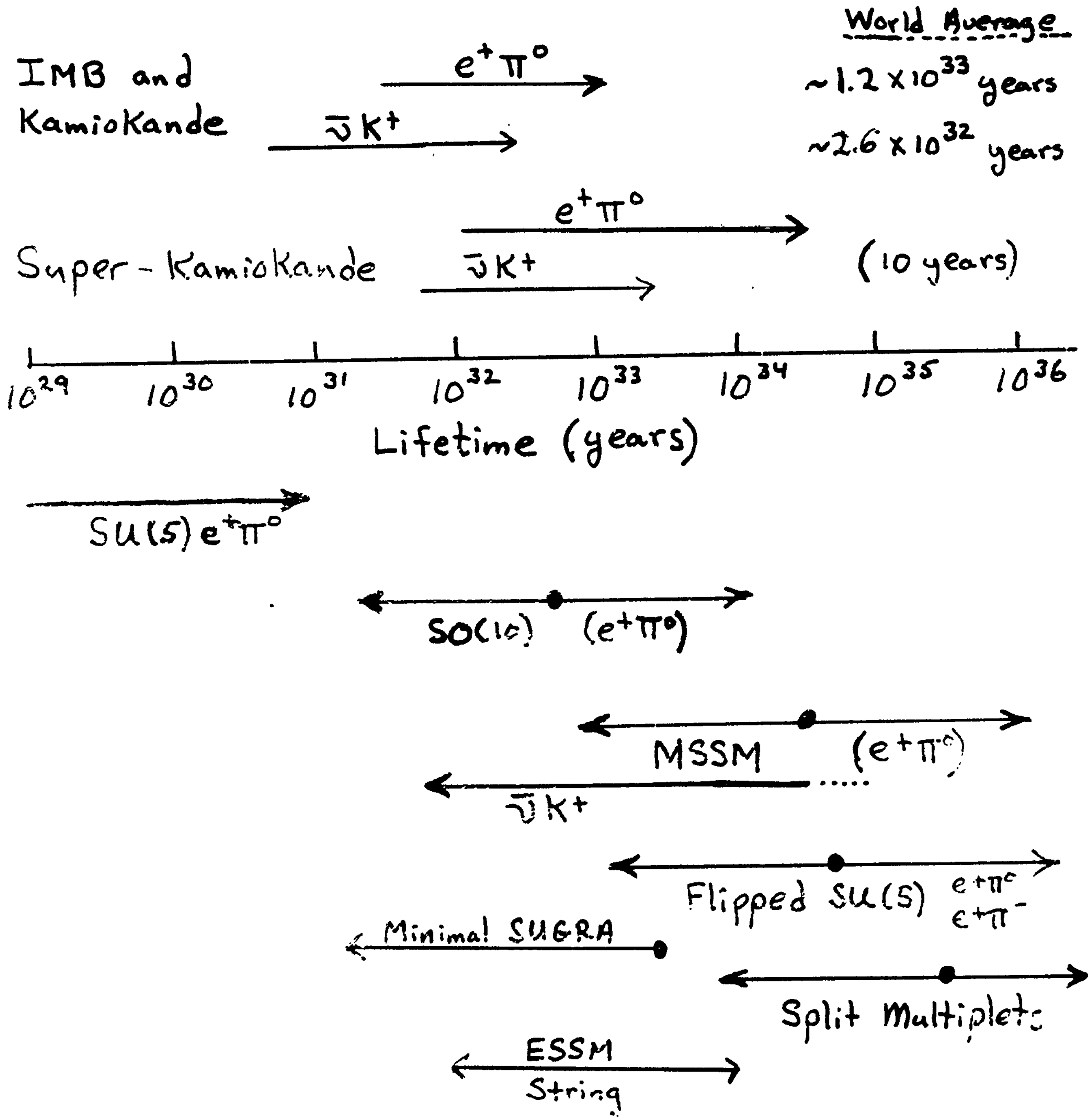
FIGURE 1

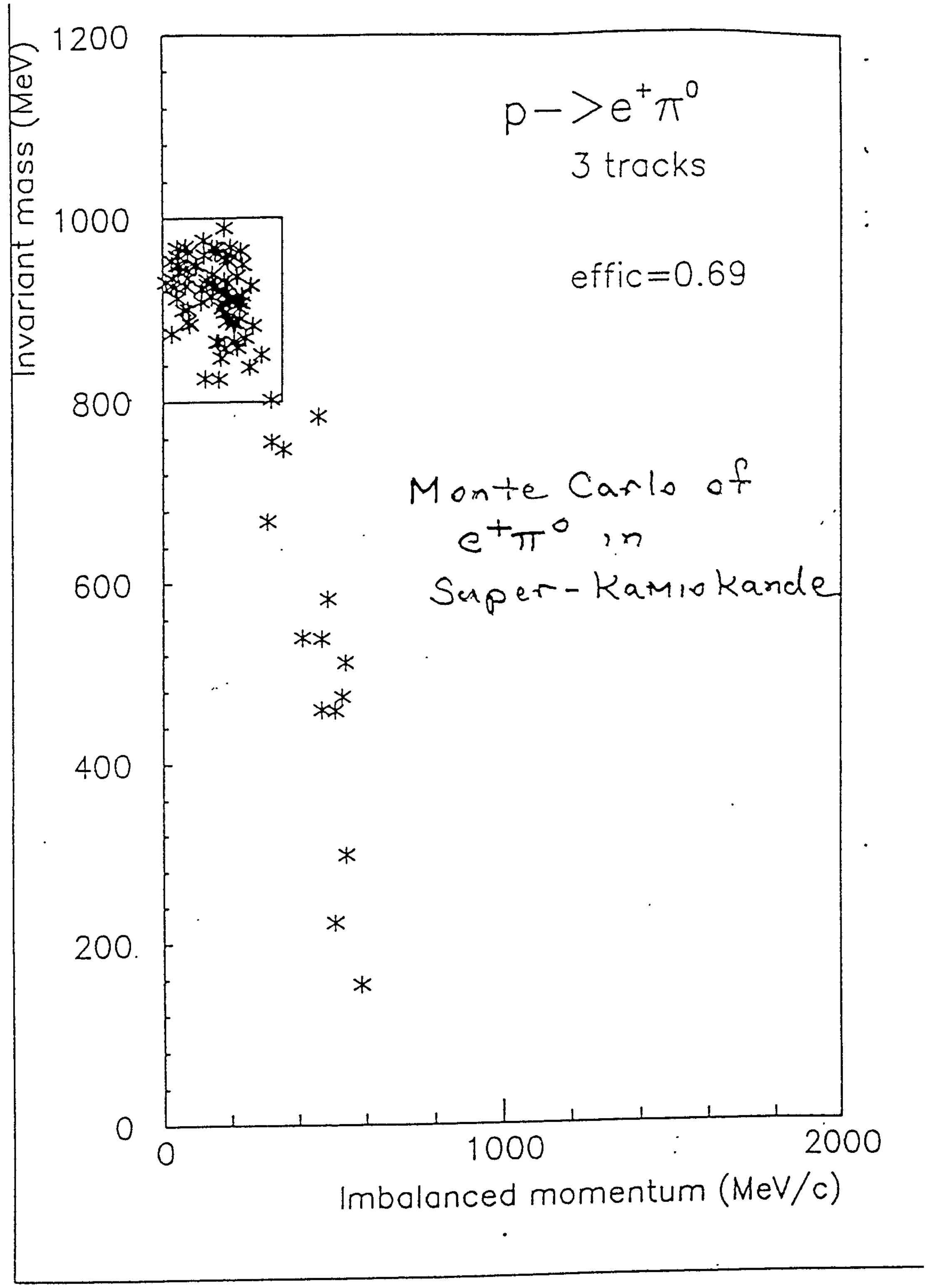
Background subtracted lower limits at 90% C.L. of the partial lifetimes for the processes $\Delta B=1$, $\Delta(B-L)=0$: $N\to \bar{L}$+meson(s), $N\to \bar{L}\bar{L}\bar{L}$ and $N\to \bar{L}\,\gamma$. The symbols correspond to the following experimental results:

▼ KOLAR, ○ IMB, ▲ NUSEX, ▽ HPW
● KAMIOKA, ◆ FREJUS

SUPER K

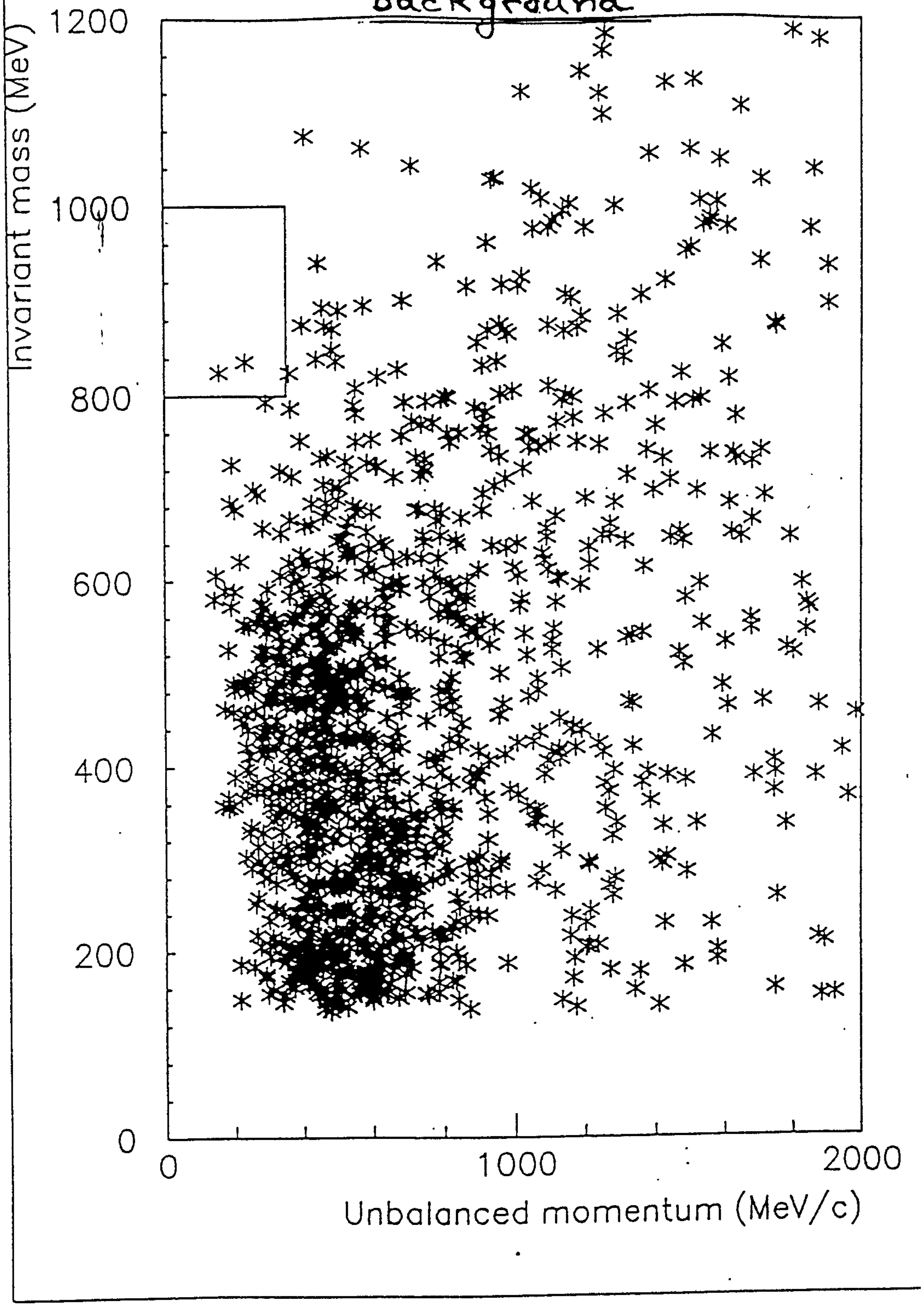
Present Limits and Sensitivty of Super-Kamiokande Compared to Various Grand Unification Schemes





p->e$^+\pi^0$
3 tracks
effic=0.69
Monte Carlo of
e$^+\pi^0$ in
Super-Kamiokande
Invariant mass (MeV)
1200
1000
800
600
400
200
0
0
1000
2000
Imbalanced momentum (MeV/c)

Simulation of atmospheric neutrino background



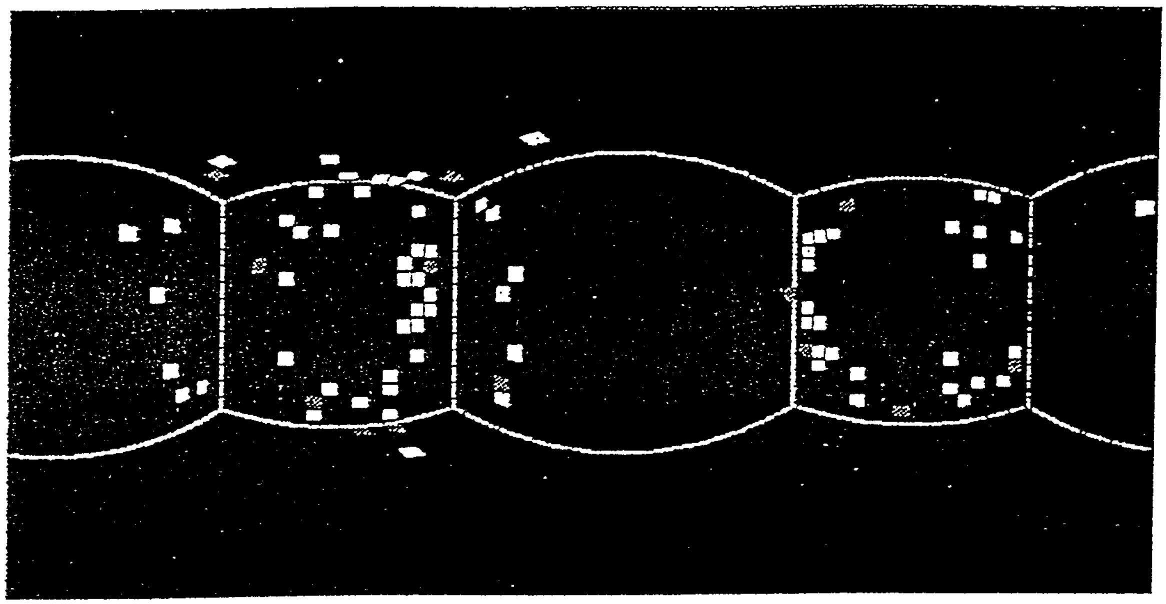
After simulating <u>65 years</u> of background we get

<u>< 1 event in 10 years</u>

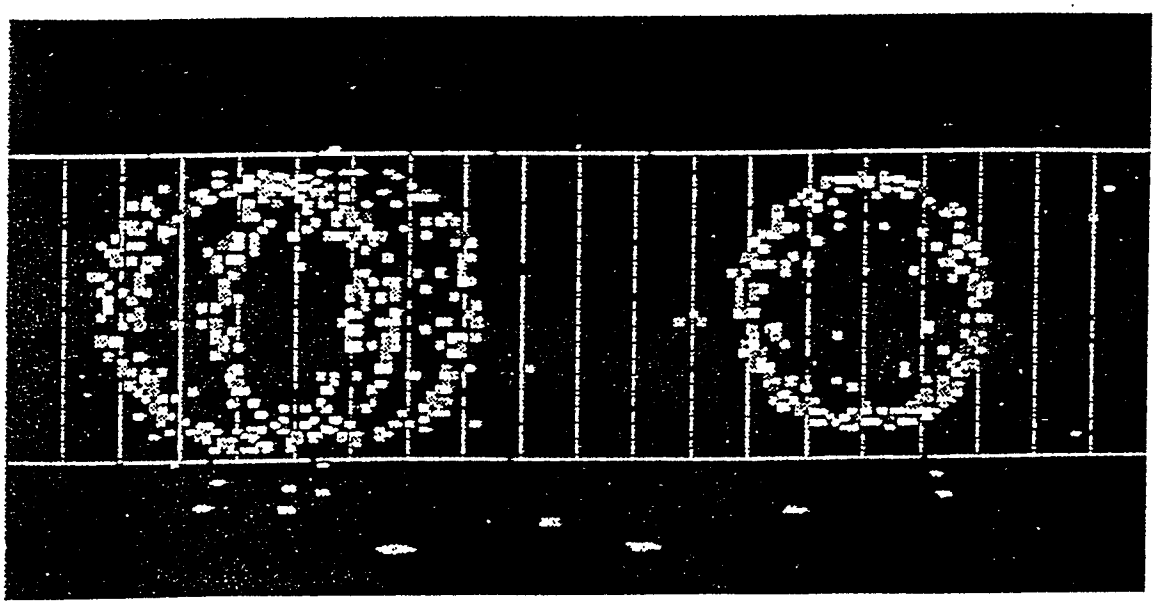
$\Rightarrow$ $\tau/B > 10^{34}$ years (0 in 5 yrs)

Simulated $p \to \mu^+\pi^0$ Candidates

IMB-3



SuperKamiokande



$p \to \bar{\nu}_\mu K^+$

- Even with maximum momentum boost from Fermi motion, K^+ is below Cherenkov threshold.

- K^+ goes short distance, comes to rest and decays ($\tau \approx 12$ ns)

$$K^+ \to \mu^+ \nu \quad 63.5\%$$
$$\to \pi^+ \pi^0 \quad 21.2\%$$

Prob. inflight decay < 10%

- IMB analysis looks only at $\pi^+\pi^0$ branch:

  $\pi^0 \to \gamma\gamma \Rightarrow 207 \pm 49$ PMTs

  π^+ just above threshold, can look for $\pi^+ \to \mu^+ \to e^+$ (delayed).

$\therefore$ IMB Signal =

2 tracks which reconstruct to π^0

\+

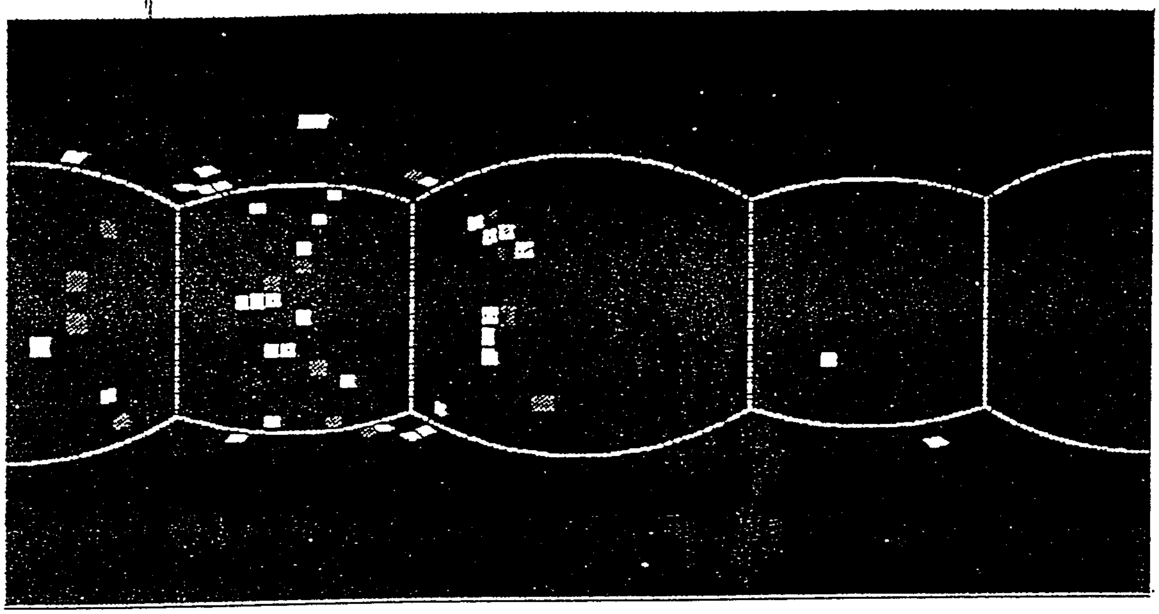
μ decay

Efficiency × Branching Ratio = 0.11

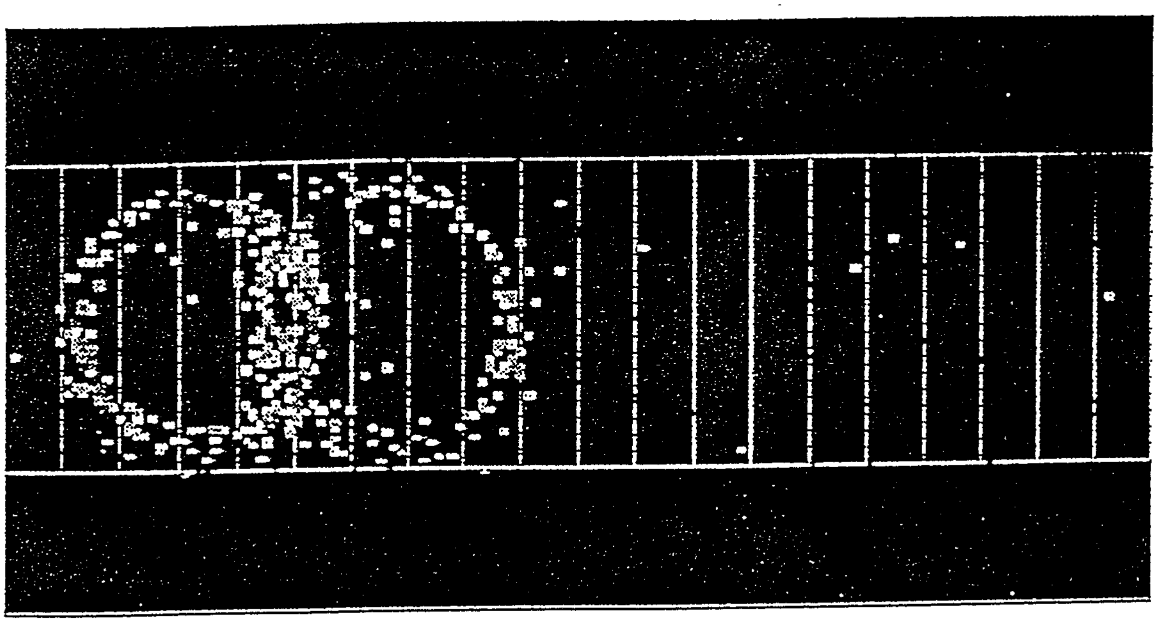
IMB Limit $> 1.2 \times 10^{32}$ years

Simulated $p \to \nu K^+ \to \pi^+ \pi^0$ Candidates

IMB-3



SuperKamiokande



Additional New Analysis For $p \to \nu K^+$ with Super-Kamiokande

- Proton in ^{16}O decays - 50% of ^{15}N (or ^{15}O) go to excited state - rapid decay to 6 MeV in γ ray
- SuperKamiokande can see this 6 MeV! This defines vertex and initial time. K decay occurs 12 ns lat[er]
- Now able to observe $K^+ \to \mu^+ \nu$ as well as $\pi^+ \pi^0$ - since 236 MeV/c μ^+ can now be seen.
- Additional coincidence + increased sensitivity (63.5% + 21.2%)

  $\Rightarrow$ Low background & better limit

Estimate $p \to \nu K^+$ $\tau/B > 10^{33}$ y

May approach $e^+\pi^0$ i.e. $\sim 10^{34}$

Neutron-Antineutron Transitions

- p-decay $\Delta B = 1$, $\Delta B - \Delta L = 0$
- $n\bar{n}$ Oscillation $\Delta B = 2$ $\Delta L = 0$

  Suppressed in SU(5)

Two Approaches -

- $n\bar{n}$ oscillations in a nucleus
- free neutron-antineutron oscillations

Kamiokande

O^{16} — Total Multiplicity ~5.1 (4.1)

Charged Multiplicity ~3.2 (2.6)

$\langle p \rangle$ ~ 350 MeV/c (300 MeV/c)

Nuclear Effects

Data : 474 days

141 fully contained events

97 Single ring

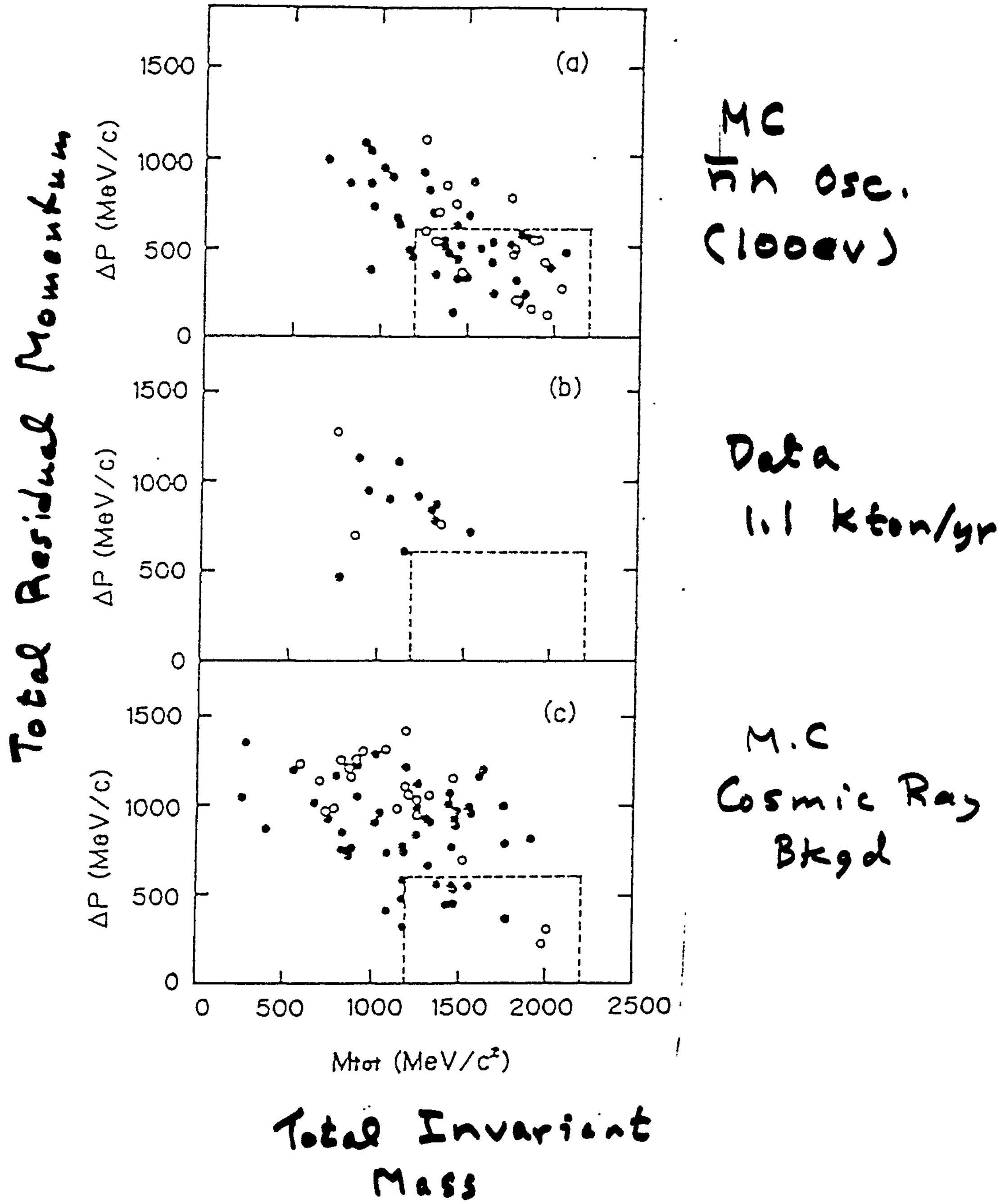
44 multiple ring

- ring multiplicity (mean 3.4) ⟶ Require ≥ 3.
- large energy release
- μ-e decays - observe
- large invariant mass ⟶ $1200 < M_t < 2200$ MeV/c^2

small residual momentum ⟶ $P_t < 600$ MeV/c

Kamiokande

$\bar{n}n$ Oscillation in ^{16}O nuclei



Frejus

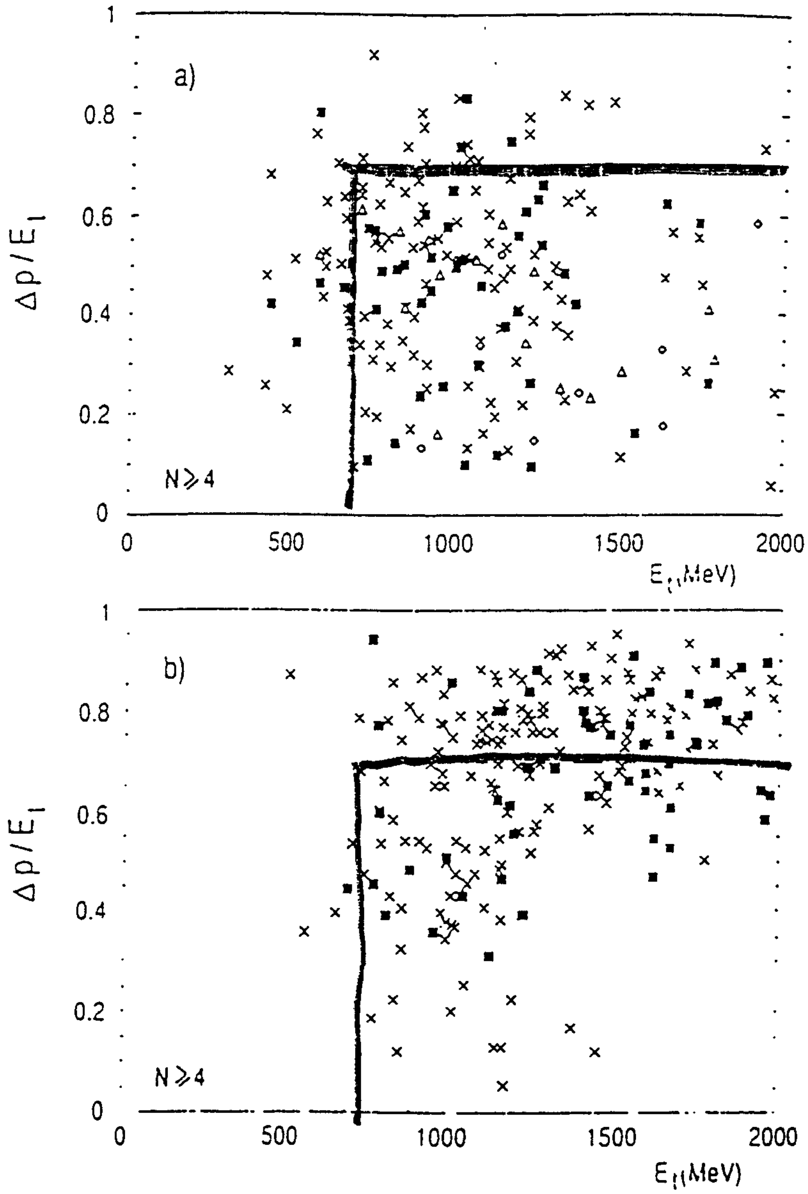
Fe^{56}

- 1600 days
- 192 fully contained
- $N \geq 4$

<u>Similar</u> <u>Analysis</u>

Frejus

$n\bar{n}$ Oscillations in ^{56}Fe nuclei



$\frac{\Delta p}{E_T}$

MC $\bar{n}n$ oscill.

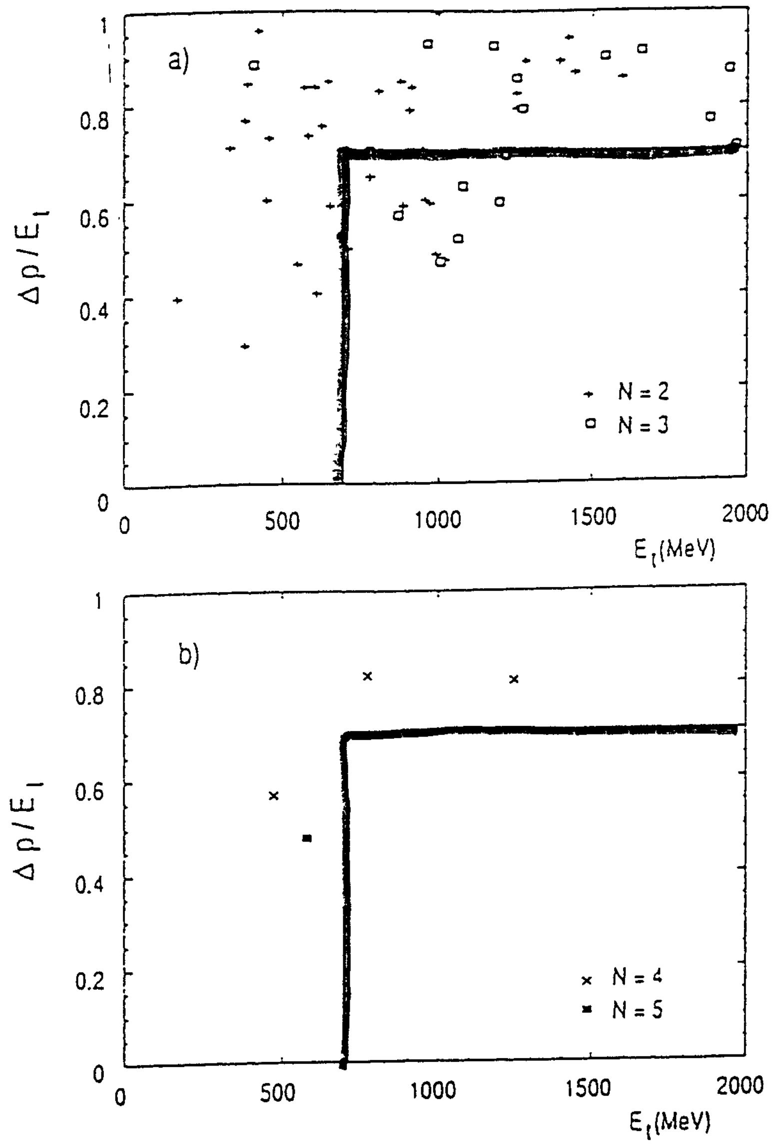
$\bar{\nu}$ Bkgd (Aachen-Pavi

50xStatist

E_t

Frejus DATA

$\frac{\Delta p}{E_t}$ N = 2, 3



$\frac{\Delta p}{E_t}$ N = 4, 5

E_t

$n\bar{n}$ Oscillations in Nucleus

RESULTS

⇒ **Kamiokande - O^{16}**

Cosmic Ray Bkd (predict) = 0.9 ev/yr

Events Observed = 0

$T_{n\bar{n}} > 4.3 \; 10^{31}$ yr

Dover et al ⇒ $\tau_{n\bar{n}} > 1.2 \; 10^{8}$ sec (90% CL)

⇒ **Frejus Fe^{56}**

Events Observed = 0

$T_{n\bar{n}} > 6.5 \; 10^{31}$ yr (90% CL)

Dover et al ⇒ $\tau_{n\bar{n}} > 1.2 \; 10^{8}$ sec (90% CL

ILL - Free Neutron - Antineutron Oscillations

High Flux Reactor (Grenoble) ~ 10^{11} n/sec

T ~ 1 year

---

t > 0.1 sec

v ≃ 600 m/sec

vacuum, reduced B-field

"quasi-free condition"

$\tau_{n\bar{n}} \gtrsim 0.86\ 10^{8}$ sec (90% CL)

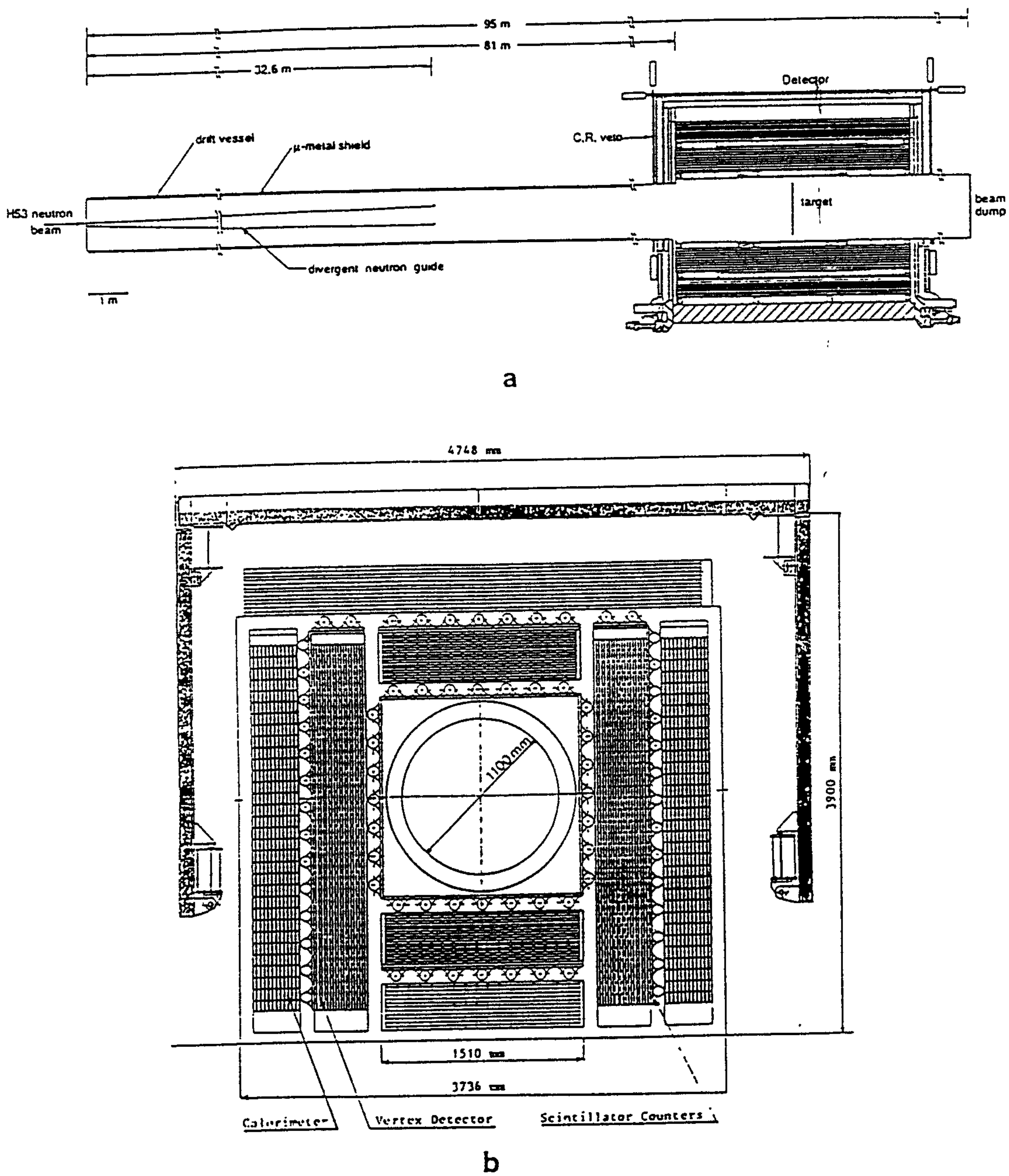


Fig. 1. (a) Experimental apparatus showing the "quasi free" neutron propagation length with the divergent guide, the target and the detection system. (b) Cross sectional view of the detector.

ILL Features

BEAM: cold $\langle E \rangle \sim 2\ 10^{-3}$ eV

$v \sim 600$ m/sec

$\delta_{div} \sim 5.7$ mrad

DRIFT: $L \sim 60$ m (to get 0.1 sec)

'neutron horn' (divergent guide)

33 m, $\delta \sim 3$ mrad

reduce divergence $\Rightarrow \sim 2$ mrad

TARGET 1.1 m Graphite.

MAG FIELD passive + active shield

$B_{init} = 5\ 10^{-5}$ T $\Rightarrow$ 10 nT

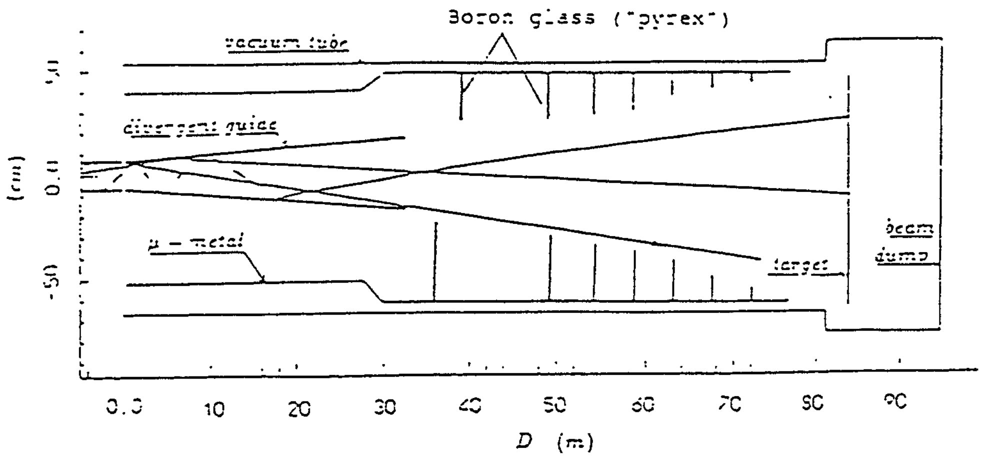


Fig. 8. The $n\bar{n}$-experimental "quasi-free" neutron propagation region with the neutron horn inserted. Note the diff[...] and vertical scales.

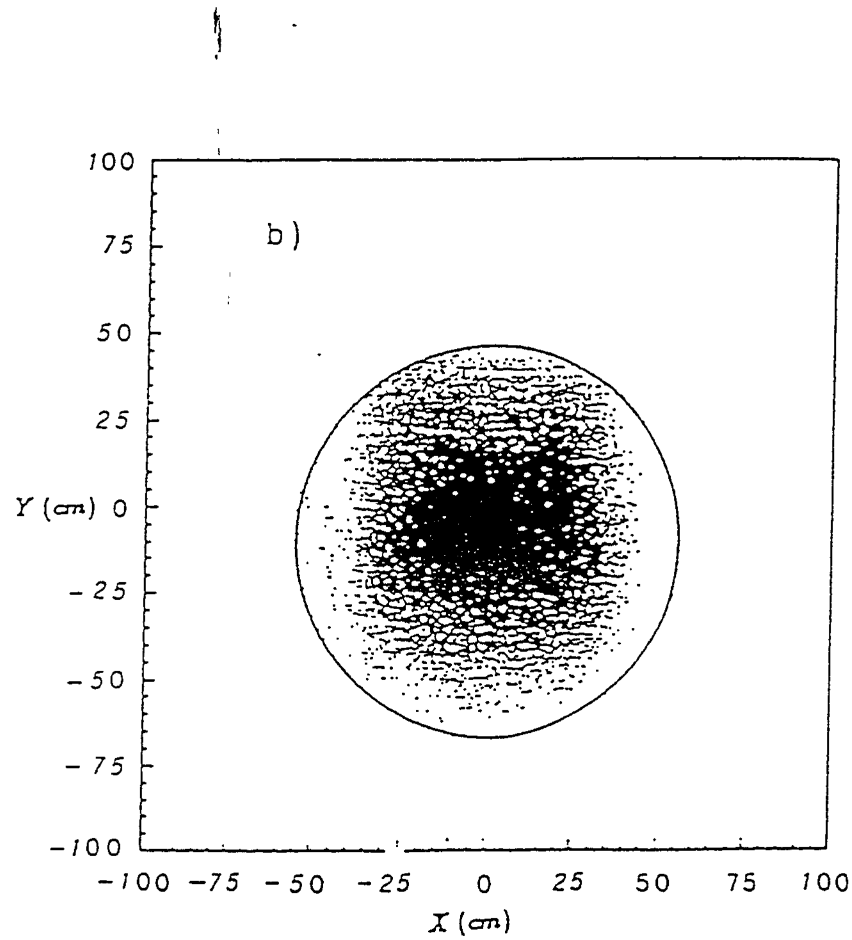


Fig. 10. Simulated intensity distribution of the neutron beam on the antineutron annihilation target of 1.1 m diameter. Only 2×10^{-3} of the neutrons miss the target. The slight asymmetry in the (y-)distribution is due to gravitational effects.

ILL —
DATA / ANALYSIS

DETECTOR: $\Omega = 0.94$
Iarocci Tubes
Scintillator

TRIGGER RATE $\sim 1\,MHz$

⇓

$4\,Hz$ $(\epsilon \approx 77\%)$

$T = 2.4\ 10^7$ sec ⇒ $6.3\ 10^7$ events

require: vertex condition
visible energy
etc

⇒ 12 K events
HAND SCANNED
335 reconstructed

No Candidates ⇒ $\tau_{n\bar{n}} \geq 0.86\ 10^8$ sec

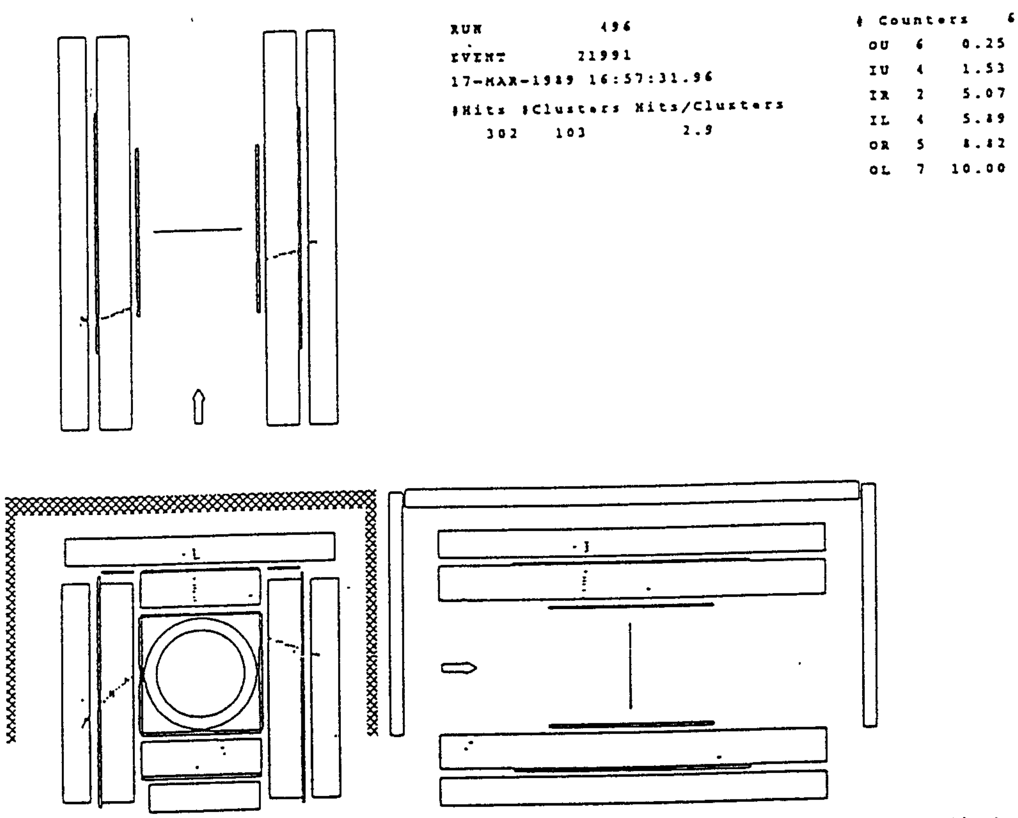


Fig. 3. A typical recorded event. The three orthogonal projections are shown. The black areas on the drawing represent the hitted scintillator counters in the projection orthogonal to the beam axis and the evaluated track crossing point in the scintillators in the other projections. Reported are also the recorded crossing times of the scintillators for the time of flight analysis (I, O for inner, outer sectors; L, R, U, D for left, right, up and down).

Possible
New Experiment
@
ORNL HFIR

Kamyshkov et al

or

future spallation source

Gains –

- x1.75 • Reactor Power - 100MW vs 57MW
- x3.3 • Larger Area Detector
- x50 • Large Acceptance Elliptical Focusing Reflector
- • Cold Neutron Moderators
- x16 • Larger cold source area
- x3 • 3 years running

$\times 10^4$ in 'discovery Potential' $N \cdot \langle t^2 \rangle$ sec

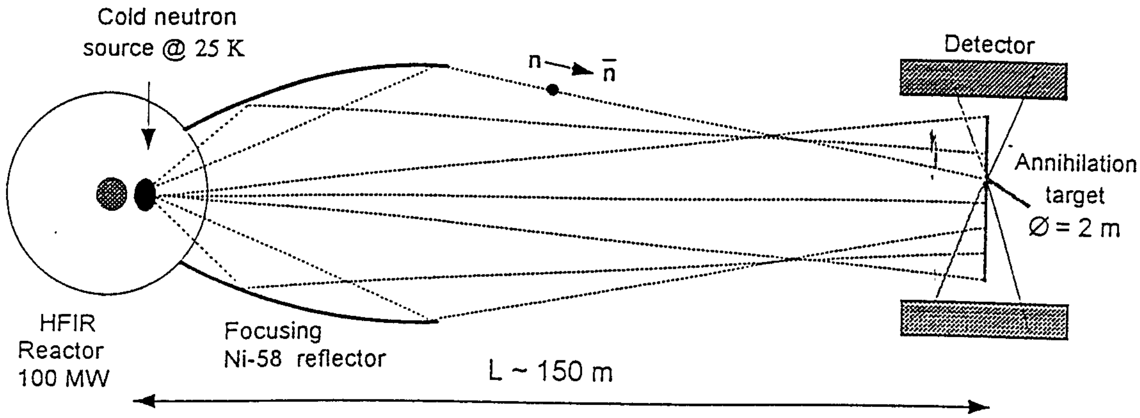


Fig. 1 Conceptual layout of $n\bar{n}$ - search experiment proposed for Oak Ridge HFIR reactor (not to scale)

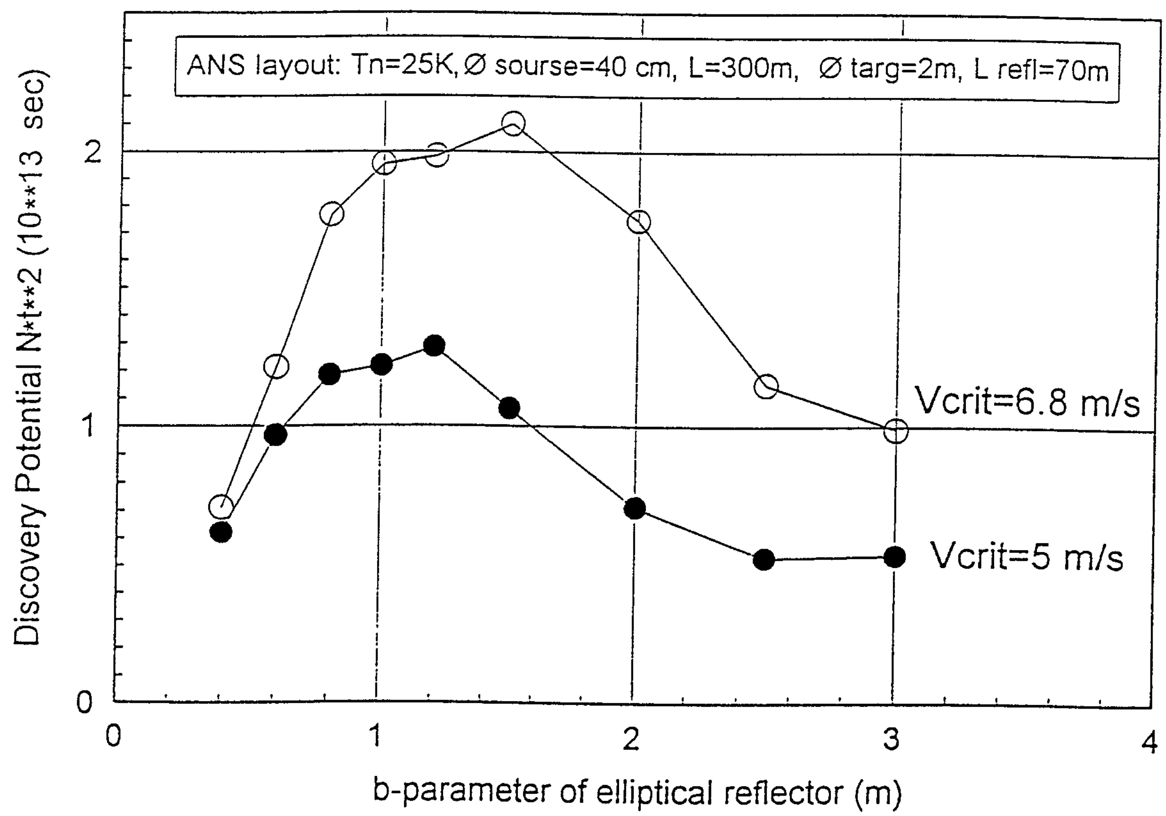


Fig. 2 Monte Carlo optimization of b-parameter of elliptical reflector

Table 2. Comparison of neutron-antineutron search experiments. The upgraded HFIR configuration shown in this table corresponds to the option of row 7 in Table 1.

Neutron source	ILL' 94	ORR' 82	ANS	HFIR (upgraded)
Status	Completed experiment	Rejected proposal	Discontinued project	New proposal
Power (MW)	57	30	330	100
Max. thermal neutron flux ($n/cm^2/s$)	$1.5\cdot10^{15}$	$(7\cdot10^{13})$	$7\cdot10^{15}$	$2\cdot10^{15}$
Moderator	Liq. D_2 @ 25 K	D_2O @ 300 K	Liq. D_2 @ 25 K	Liq. D_2 @ 25 K
Source area	6×12 cm^2	∅ 42 cm	∅ 40 cm	∅ 40 cm
$\varnothing_{det}$ (m)	1.1 m	1.0 m	2.0 m	2.0 m
L_{free} (m)	76	20	~300	~150
n/s @ target	$1.25\cdot10^{11}$	$2\cdot10^{13}$	$4.4\cdot10^{13}$	$5.1\cdot10^{13}$
$\sqrt{<t^2>}$ (s)	0.109	0.01	0.672	0.384
Detector efficiency	0.48	~ 0.5	~ 0.5	~ 0.5
Run time (s)	$2.4\cdot10^{7}$	$3\cdot10^{7}$	$3\cdot10^{7}$	$9\cdot10^{7}$
Discovery potential $N\cdot\langle t^2\rangle$ (s)	$1.5\cdot10^{9}$	$2\cdot10^{9}$	$2\cdot10^{13}$	$0.75\cdot10^{13}$
$\tau_{n\bar{n}}$ limit, s (90% CL)	$8.6\cdot10^{7}$	$1.1\cdot10^{8}$	$1.1\cdot10^{10}$	$1.0\cdot10^{10}$

Range of neutron - antineutron transition search at HFIR

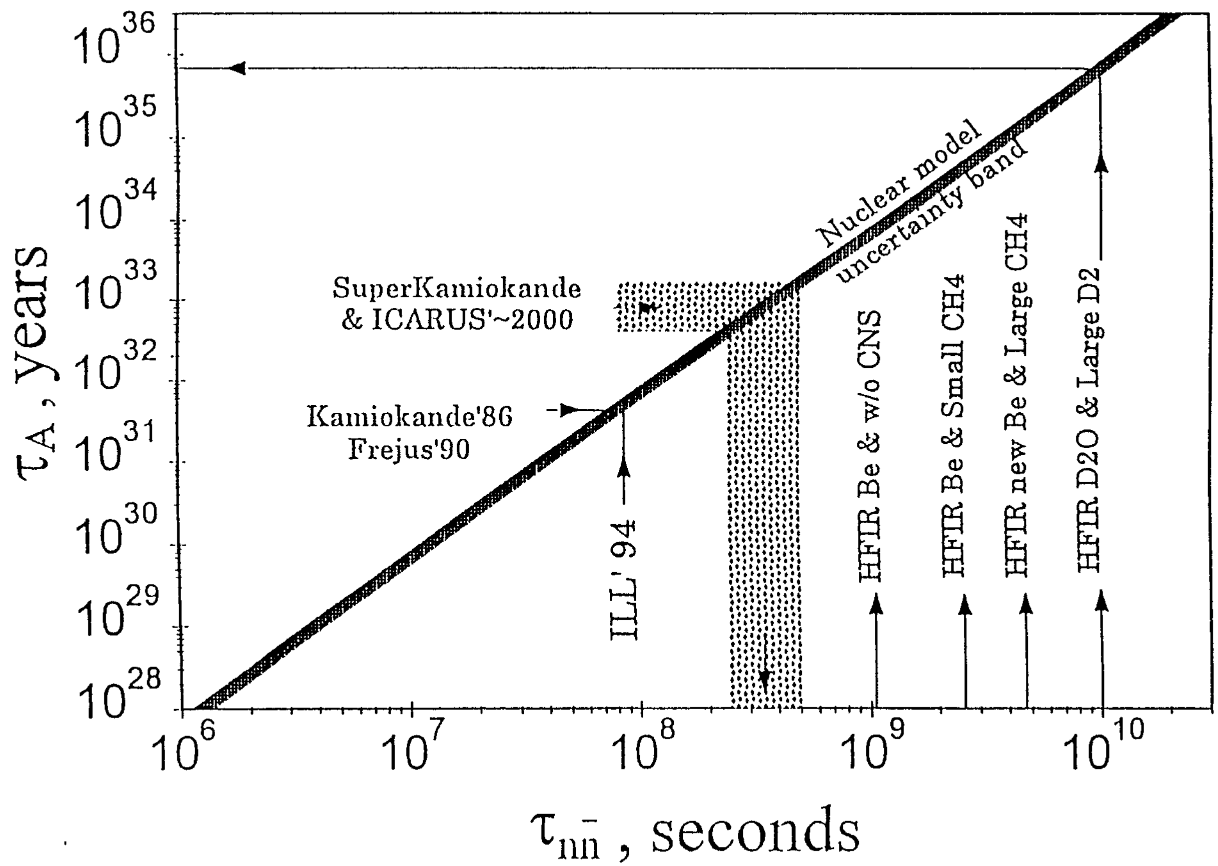
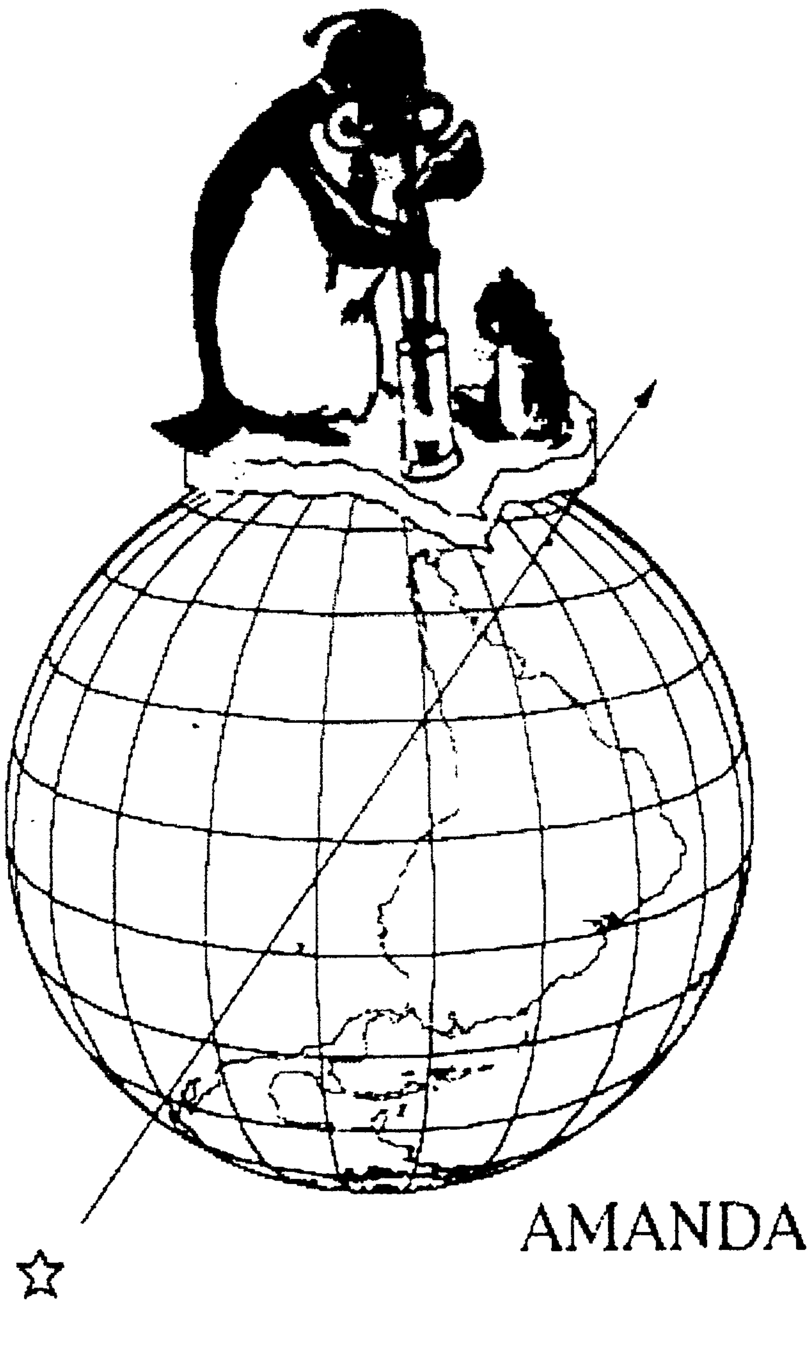


Figure 1

OTHER PROJECTS/IDEAS

- 2β Decay
- Gaseous β-decay detector
- Under ice
- In space

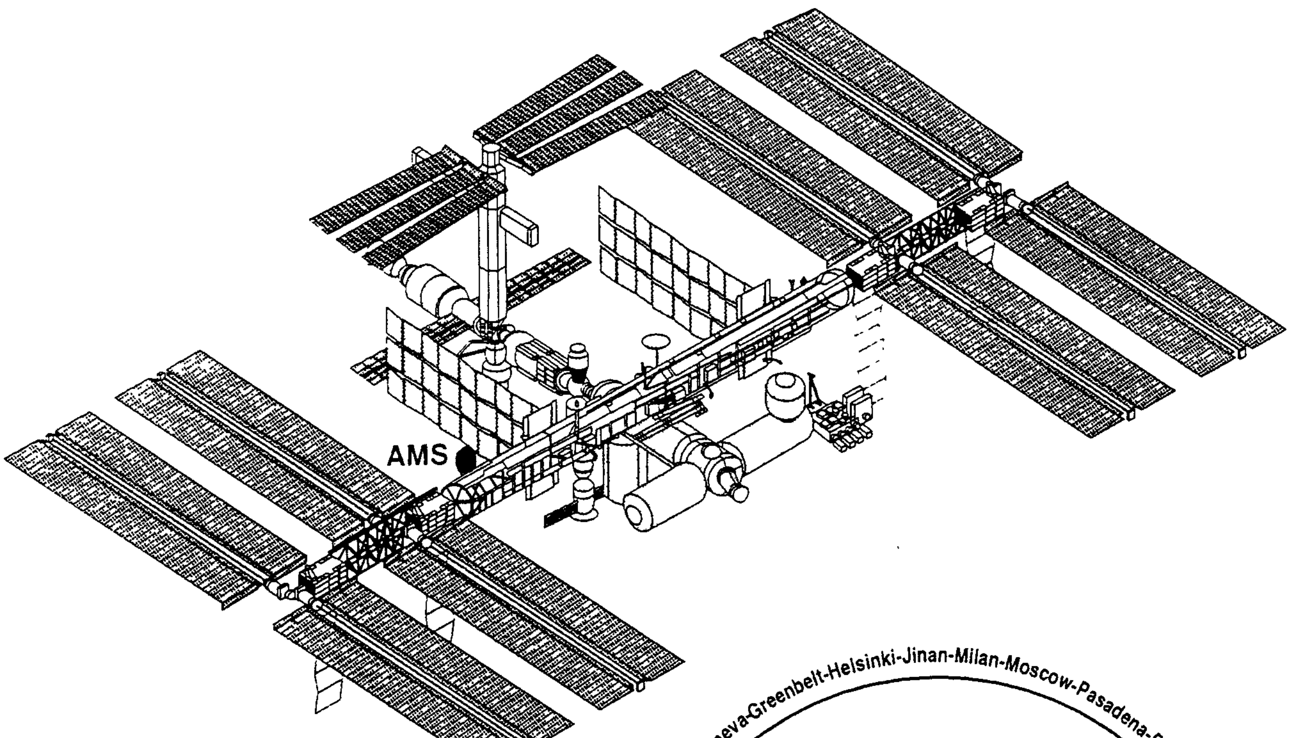
UNDER ICE



Alpha Magnetic Spectrometer (AMS)

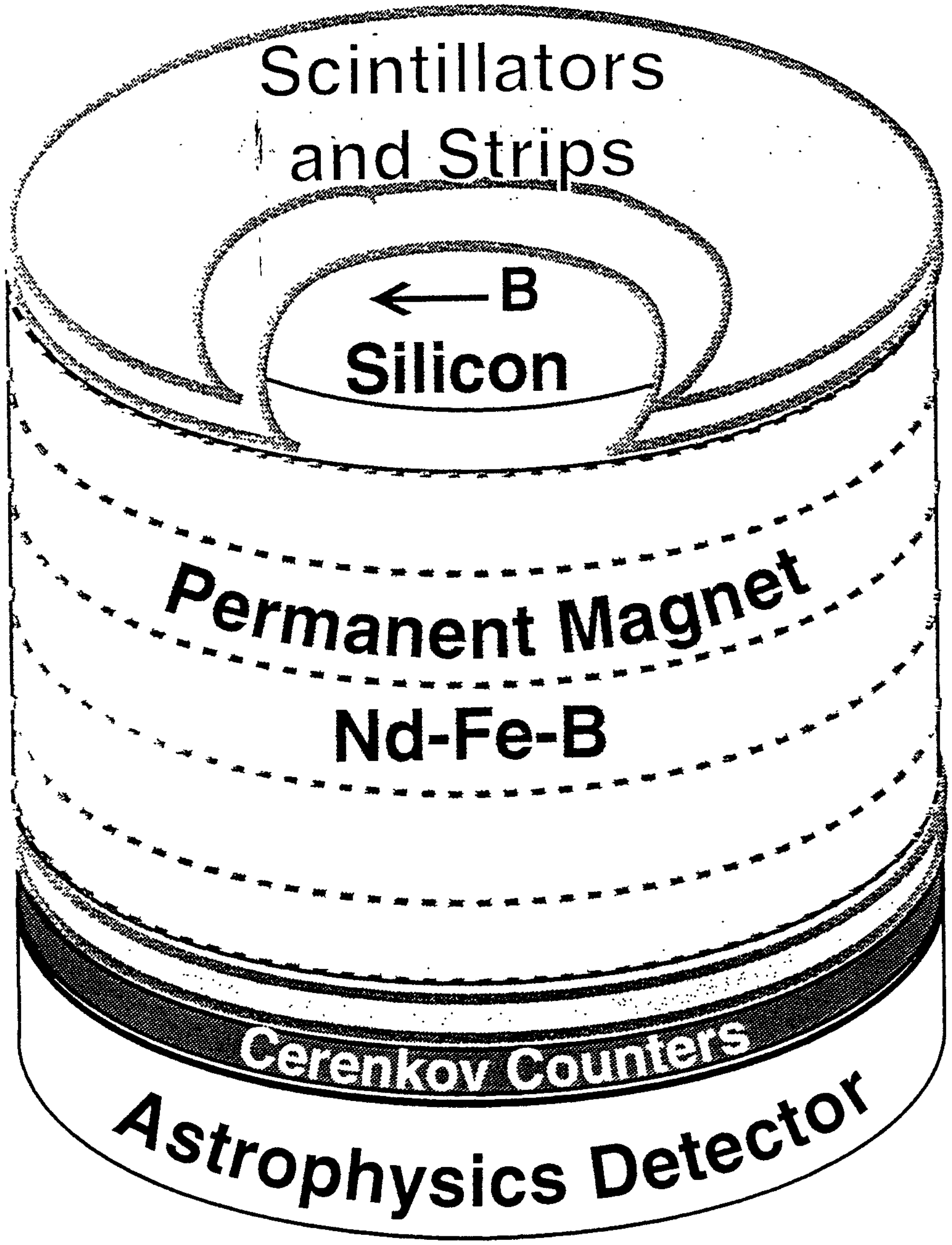
for

Extraterrestrial Study
of
Antimatter, Matter and Missing Matter
on
The International Space Station Alpha



y95354c

AMS: Solid State Tracker



6 (x, y, z) coordinates (10 μ) and
6 dE/dX measurements

Δ P/P = ~ 7% at 10 GeV/N

y95431Ting

AMS Detector

Physics

1• To search for Antimatter ($\overline{He}$, $\overline{C}$) in Space with a sensitivity of 10^4 to 10^5 better than current limits.

2• To search for Dark matter. (90% of the missing matter in the universe)

High statistics precision measurements of e^+, γ, and $\bar{p}$ spectrum.

3• To study Astrophysics.

High statistics precision measurements of D, ^3He, ^4He, B, C, Be^9, Be^{10} spectrum.

B/C: to understand Cosmic Ray propagation in the Galaxy (parameters of galactic wind).

Be^9/Be^{10}: to determine Cosmic Ray confinement time in the Galaxy.

y95165b

AMS: Design principles

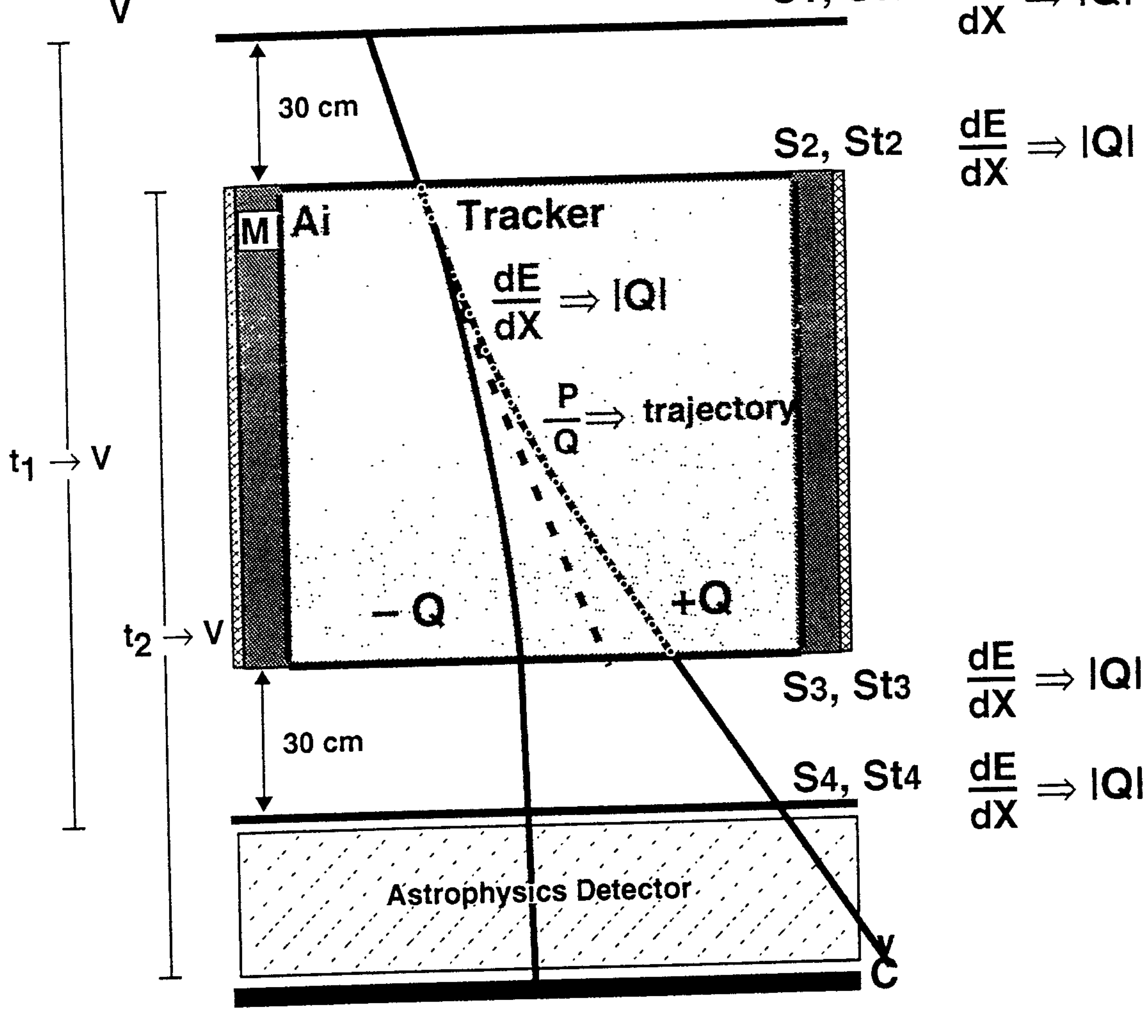
Carbon: mass m , charge +Q

Anti carbon: mass m , charge -Q

Measurements:

1. Charge |Q|: by energy loss dE/dX in tracker and counters
2. Momentum and sign of charge (P/Q): by trajectory in tracker
3. Velocity (V): by Time of Flights t_1 and t_2

$$m = \frac{P}{V}$$

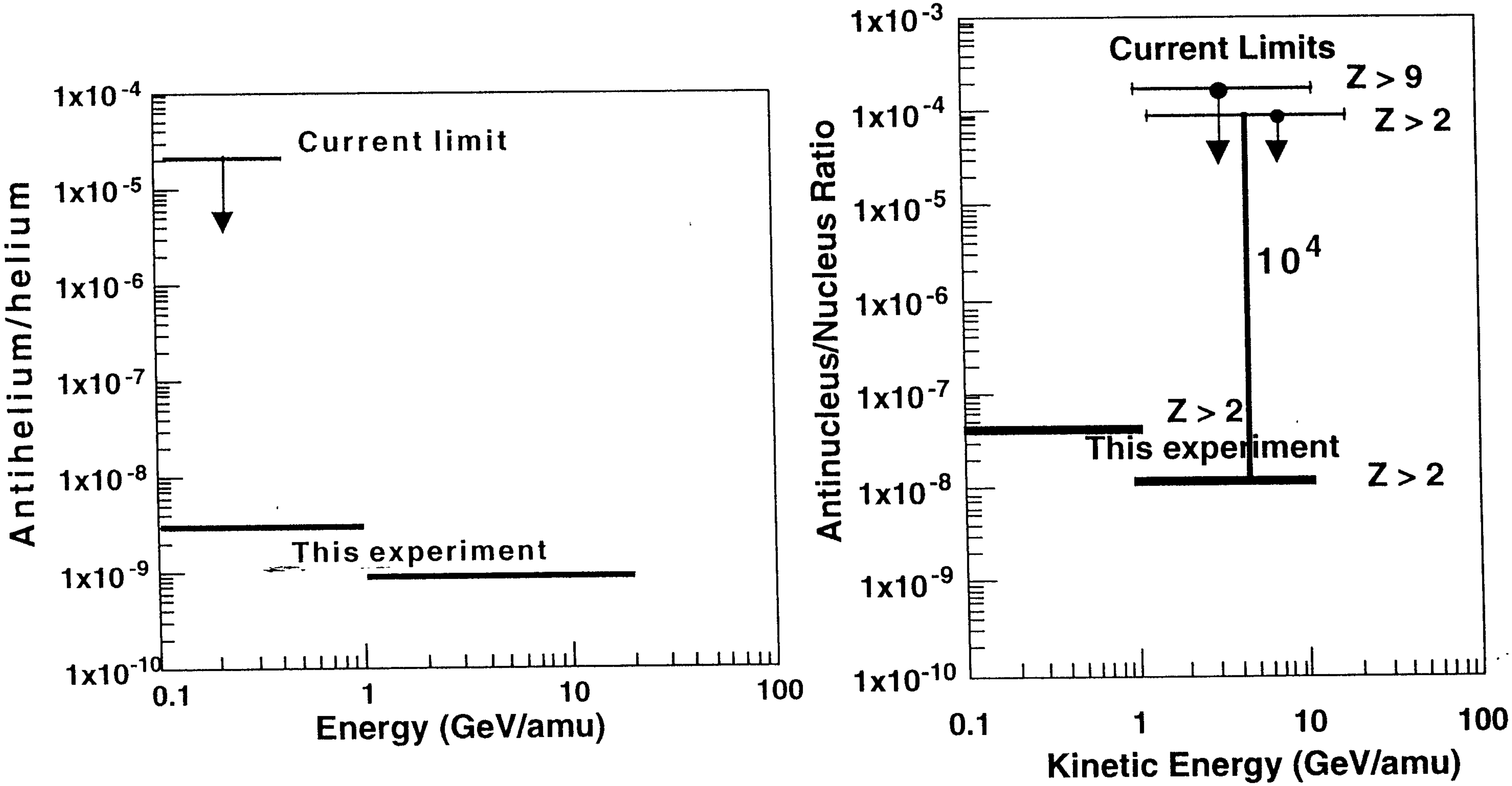


1) Minimum amount of material in the Detector
2) Many repetitive measurements
3) Many redundancy elements

y95334a

AMS Potential

This detector will improve the existing sensitivity by 10^4 to 10^5 in searching for antimatter.



Sensitivity of AMS (3 years on ISSA) in a search for $\overline{He}$ and Z > 2 antinuclei. (95% C.L.)

y95090a(94659d/60a)

Conclusions

- The stability or instability of baryons is fundamental to our understanding of particle physics
- Experimental Probes
  - proton decay : SUPERKAMIOKANDE
  - neutron-antineutron oscillations ORNL PROPOSAL ??
- New Ideas