July 4

STUDY OF SUPERNOVA II NEUTRINOS Seattle
WITH A COMBINATION OF
POWERFULL DETECTORS

DAVID B. CLINE
UCLA

1) Real Time SN ν Detection Requirements

2) Extracting Neutrino Mass & Mixing
from the SN II Detection

3) Powerful Charged Current Detectors
   - a) Super K $\bar{\nu}_e$
   - b) ICARUS/NOE ν_e at G.S.
   - c) Detection of $\bar{\nu}_e$, ν_e from PAST Supernovas!

4) The OMNIS NEUTRAL CURRENT ν_x DETECTOR
Concept – Status of the Proposed Location

5) Information on $\nu_x \rightarrow \nu_e$ from 2ν detection
– Comparison with a Neutrino Factory
Possibility

– Summary –

Detection of ν_μ and ν_τ From SuperNova Neutrinos In REAL TIME

D Cline
νCLK

Two Possibilities:

a) $\nu_x + e^- \rightarrow \nu_x + e^-$

- Rate Low because $\sigma_{\nu_x e}$ Small
- Background from $\nu_e e \rightarrow \nu_e e$

b) $\nu_x + N \rightarrow \nu_x + N'$

$N = D, C, O, NaCl, Pb, Fe\ldots$

$N' \rightarrow n + X$ ⟨ SNO / SNBO/OMNIS

$N' \rightarrow \gamma + X$ ⟨ Super K / LVD

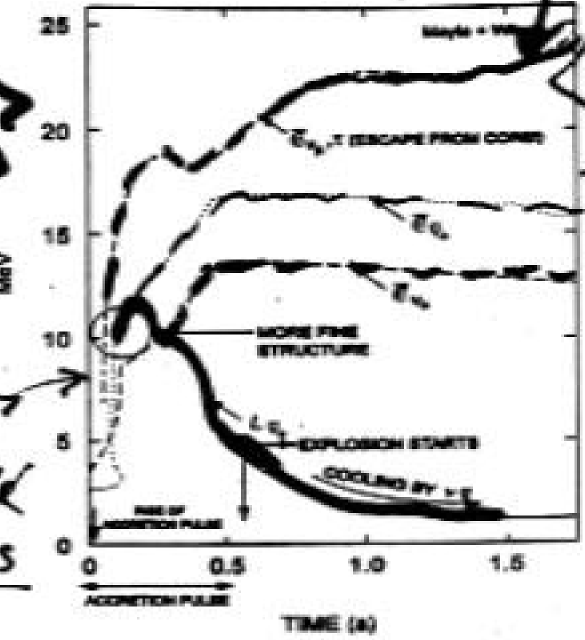
☐ SIGNAL DEPENDS ON ν_μ, ν_τ ENERGY SPECTRUM

USE Jim Wilson Models of SN II

$\langle E_{\nu_x} \rangle > \langle E_{\nu_e} \rangle$

ν_x

$\langle E \rangle_{\nu_{\mu,\tau}} > \langle E \rangle_{\nu_e, \bar{\nu}_e}$



$\bar{\nu}_e$

ν_e

Rise time < 50 ms

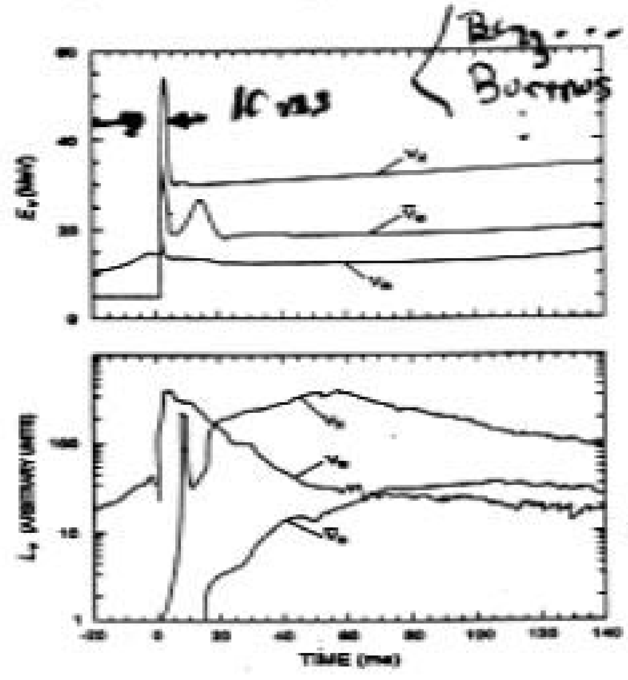
$\langle \tau \rangle \sim 500$ ms SN

→ Real Time Detection

Fig. 2. Schematic of the Supernova ν Burst Properties.

{Bg... et al} Burrows

'Sharp' structure for Timing



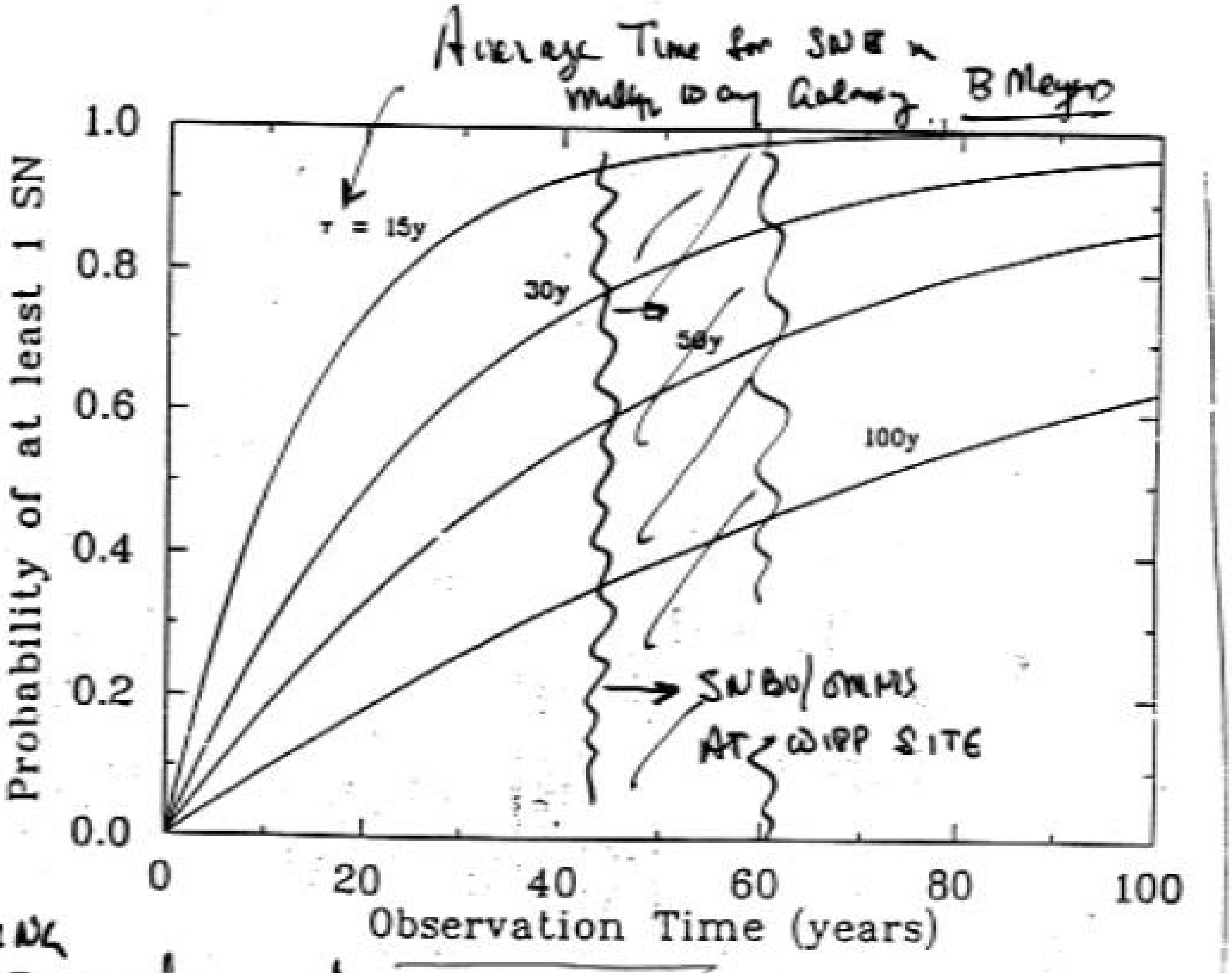
There could be sharp time structures

⇒ For Time of Flight

⇒ δm^2

Fig. 3. Possible Fine Structure in the Supernova ν Burst from Recent Calculations.[7]

— Any sharp time structures (Rise time, structure) provide a better signature for ToF mass measurement —



KEEPING AN OBSERVATORY GOING 50 years is NONTRIVIAL

LENGTH of TIME DCE HAS EXISTED

AT LEAST ONE DETECTOR MUST OPERATE CONTINUOUSLY FOR ≥ 40 YEARS FOR A

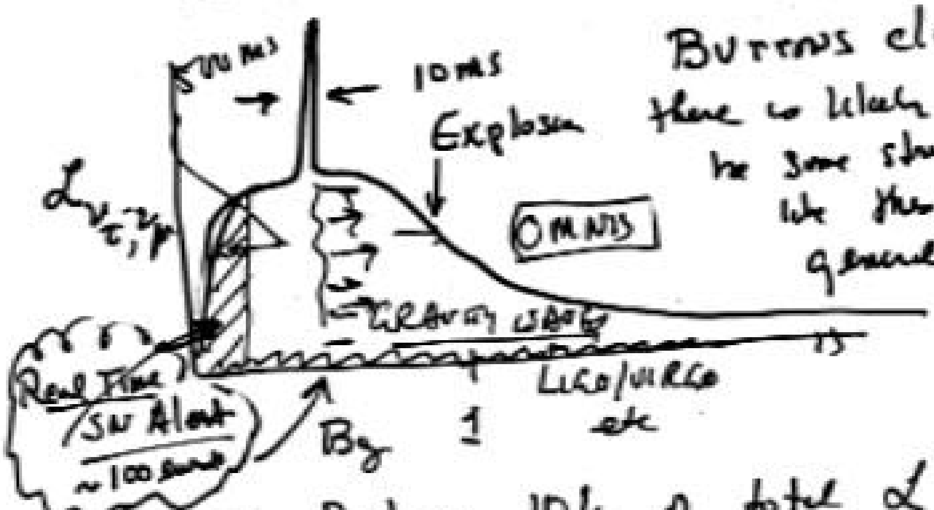
Detector Study Effort

SUPERNOVA OBSERVATORY!

⇒ **SN80**

How well could $m(\nu_\tau)$ be measured in

an IDEAL situation



BURROWS claims there is likely to be some structure like this in any general model

Suppose Spike is 10% of total $\mathcal{L}$ and has normal ν_x energy

FOR 2000 Events in a NC Detector (10 kpc)

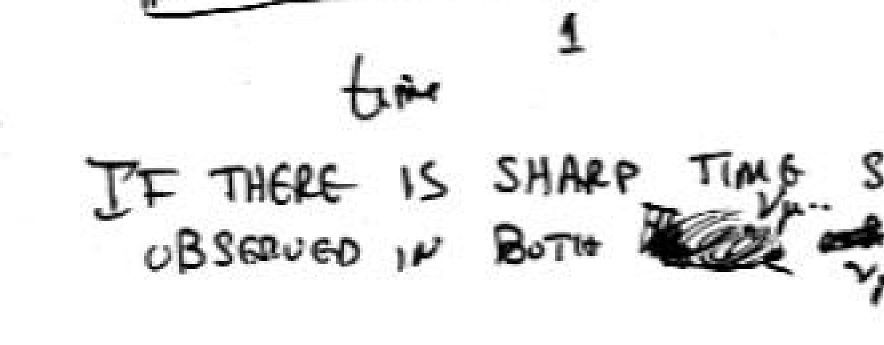
$\Rightarrow$ 100 events from $\nu_\tau + \bar{\nu}_\tau$

$$\Delta t\,(\text{sec}) = 0.5 \left(\frac{m(\nu_\tau)}{80}\right)^2 \left(\frac{20\text{ MeV}}{E(\nu)}\right)^2$$

assume $\langle E(\nu_\tau)\rangle = 30$ MeV

then $\Delta t = 250 \left(\frac{m_{\nu_\tau}}{20}\right)^2$ millisec (Depends on $\langle E_\nu\rangle$ and could be enhanced by the 3 Target OMNIS method)

Suppose we observe



$\Rightarrow$ $m_{\nu_\tau} = 10$ eV

Requires ~1000's of ν_x events !!

IF THERE IS SHARP TIME STRUCTURE OBSERVED IN BOTH [illegible] ν_μ.. ν_τ.. ~~and~~ – possible !

③) REAL TIME SN II DETECTION

REQUIREMENTS OF A SUPERNOVA OBSERVATORY

1. **Life of Observatory ≥ Rate (yr) for SNII on Milky Way Galaxy**

   ≥ 20 - 40 years

   ● ‹KEY›

   (Detectors will have other physics — Not in this talk)

2. **EVENT RATE:**

   ~ 5 - 10 K $\bar{\nu}_e + P \rightarrow e^+ + n$

   ~ Few K $\nu_x + N \rightarrow \nu_x + N^*$

   ↳ 2n ...

   $\nu_x = \nu_\mu + \nu_\tau$

TO:

A) **FIT MODEL OF SNII PROCESS**

B) **EXTRACT A NEUTRINO MASS OR NEUTRINO OSCILLATION** ****

C) **LEARN ABOUT SNII EXPLOSION PROCESS** AND R PROCESS SITE ??? *

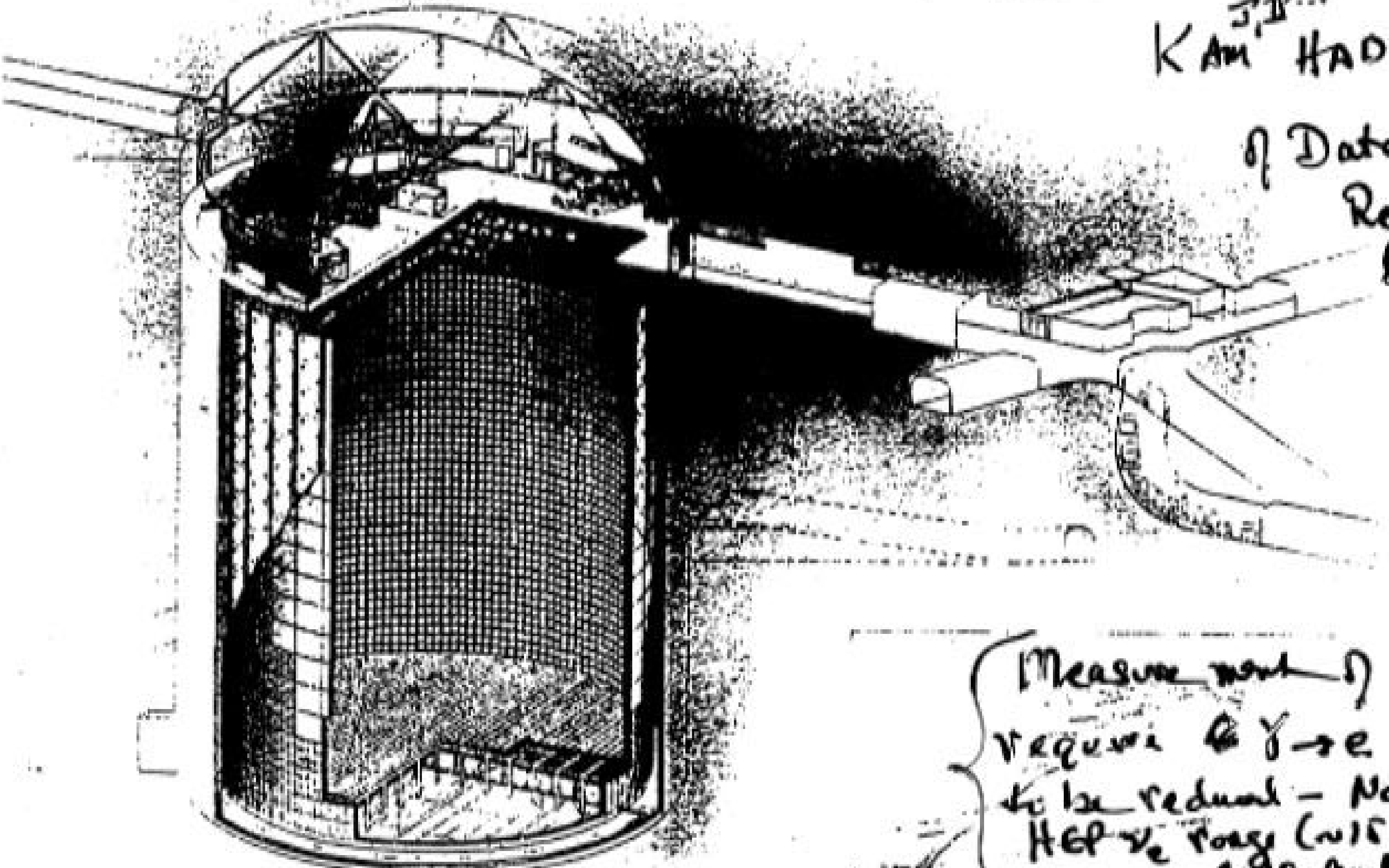
Super K

Kam$^{I, II \ldots}$ HAD ~<u>10 KT years</u>

of Data

Reached a limit of

$\Phi_{\bar{\nu}_e} \lesssim 5500 \ \mathrm{cm}^{-2}\,\mathrm{sec}^{-1}$



SUPERKAMIOKANDE INSTITUTE FOR COSMIC RAY RESEARCH UNIVERSITY OF TOKYO

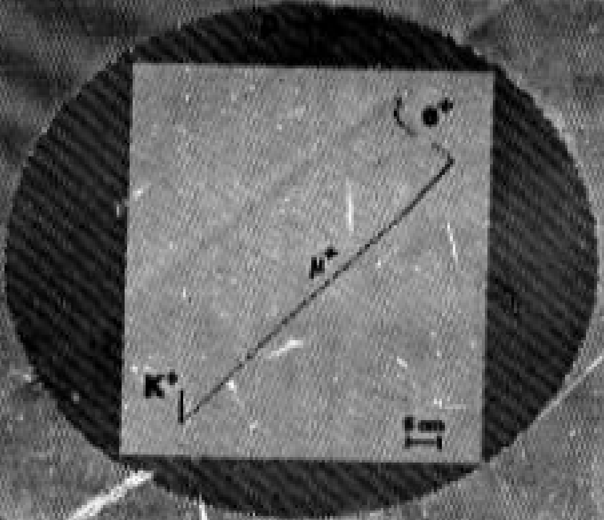
Measurement of $\bar{\nu}_e + p \to e^+ n$
requires a $\gamma \to e$ background
to be reduced – Note even in the
HEP ν_e range (~15 MeV) still
considerable background

Real Time Statement a Change w/ Totsuka

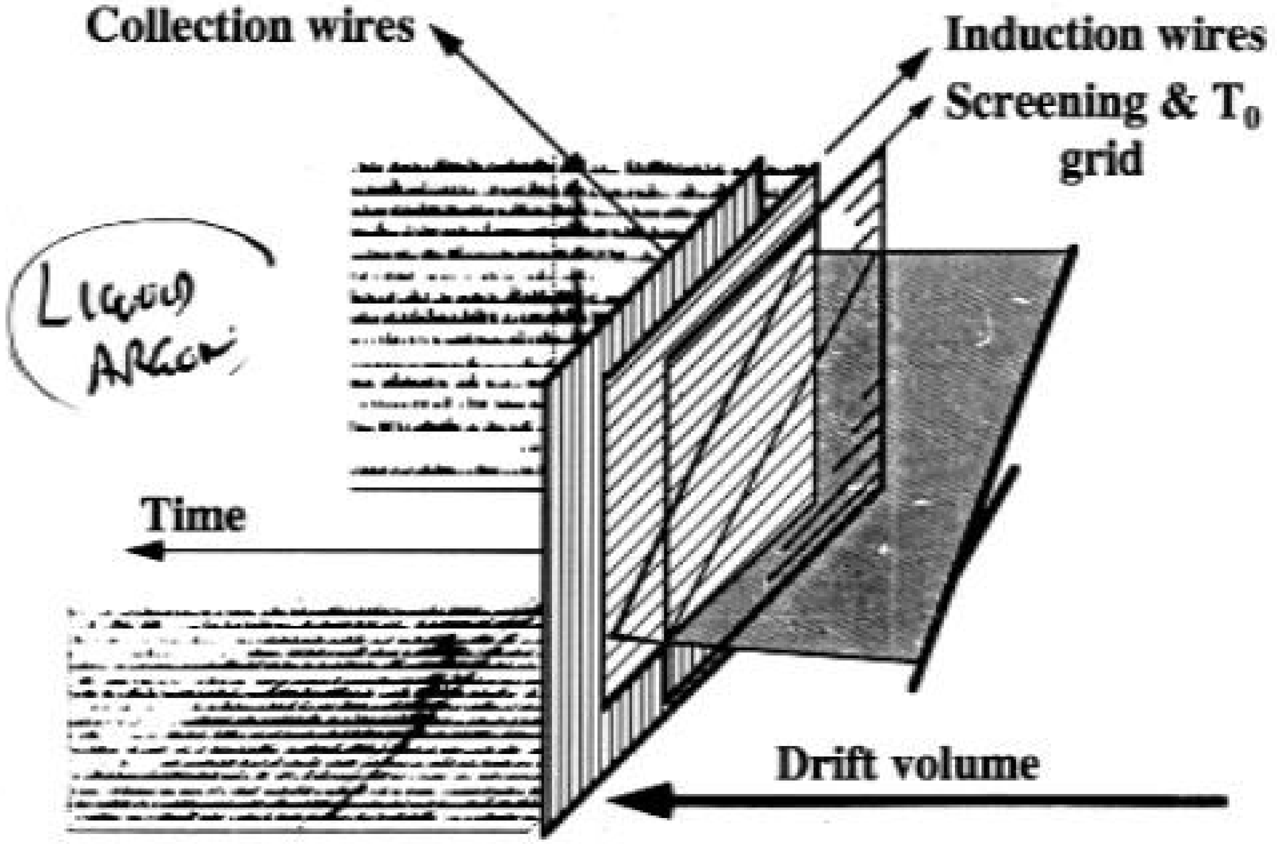
Sci in
SuperK? "will run <u>100</u> years of
[illegible]"

ICARUS

A multipurpose detector for the years 2000

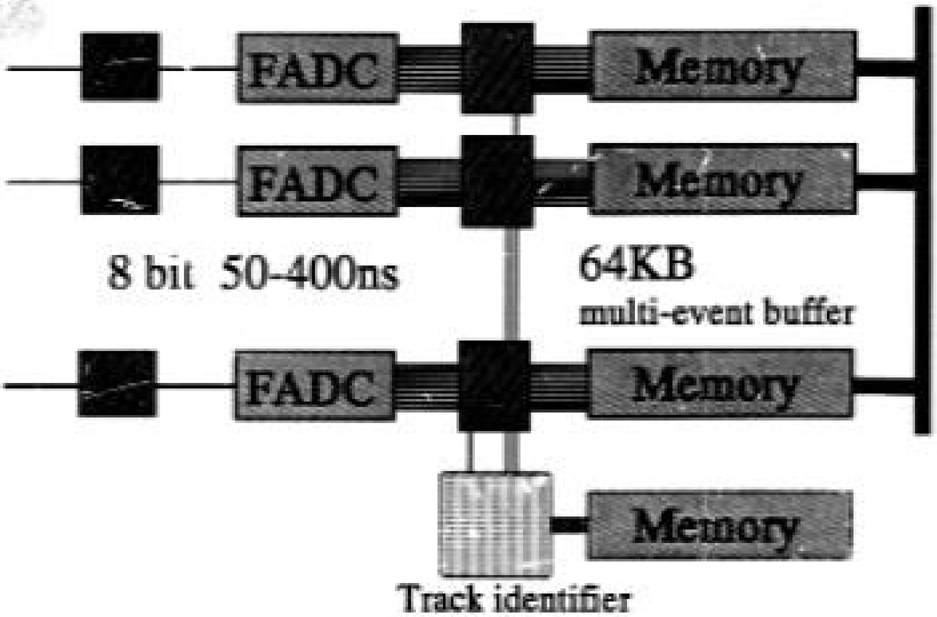


ICARUS Imaging R/O

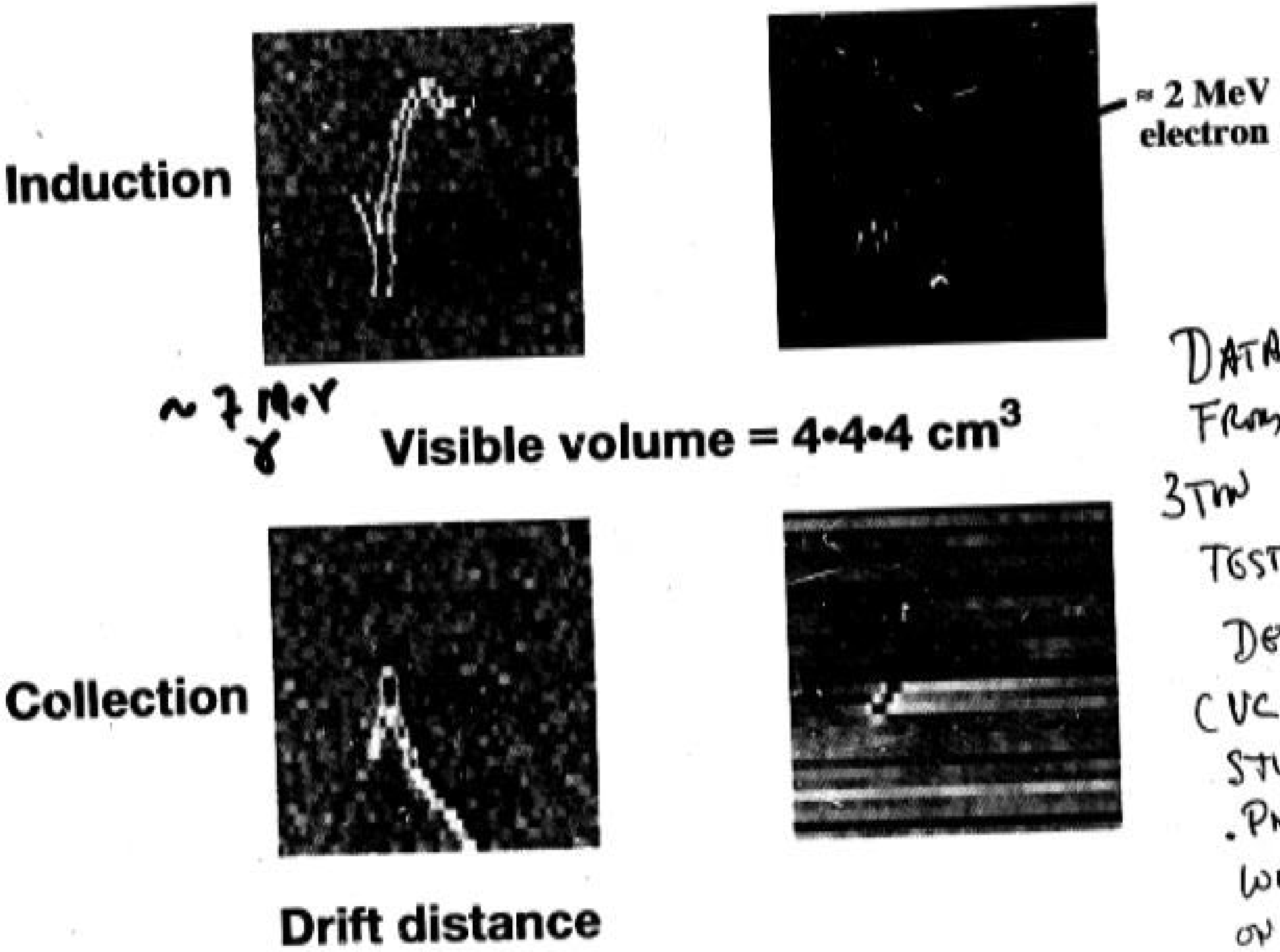


Pixel size limited by diffusion at (1 mm $)^3$

Wires read-out block diagram



Low energy events 3Tøn Detector

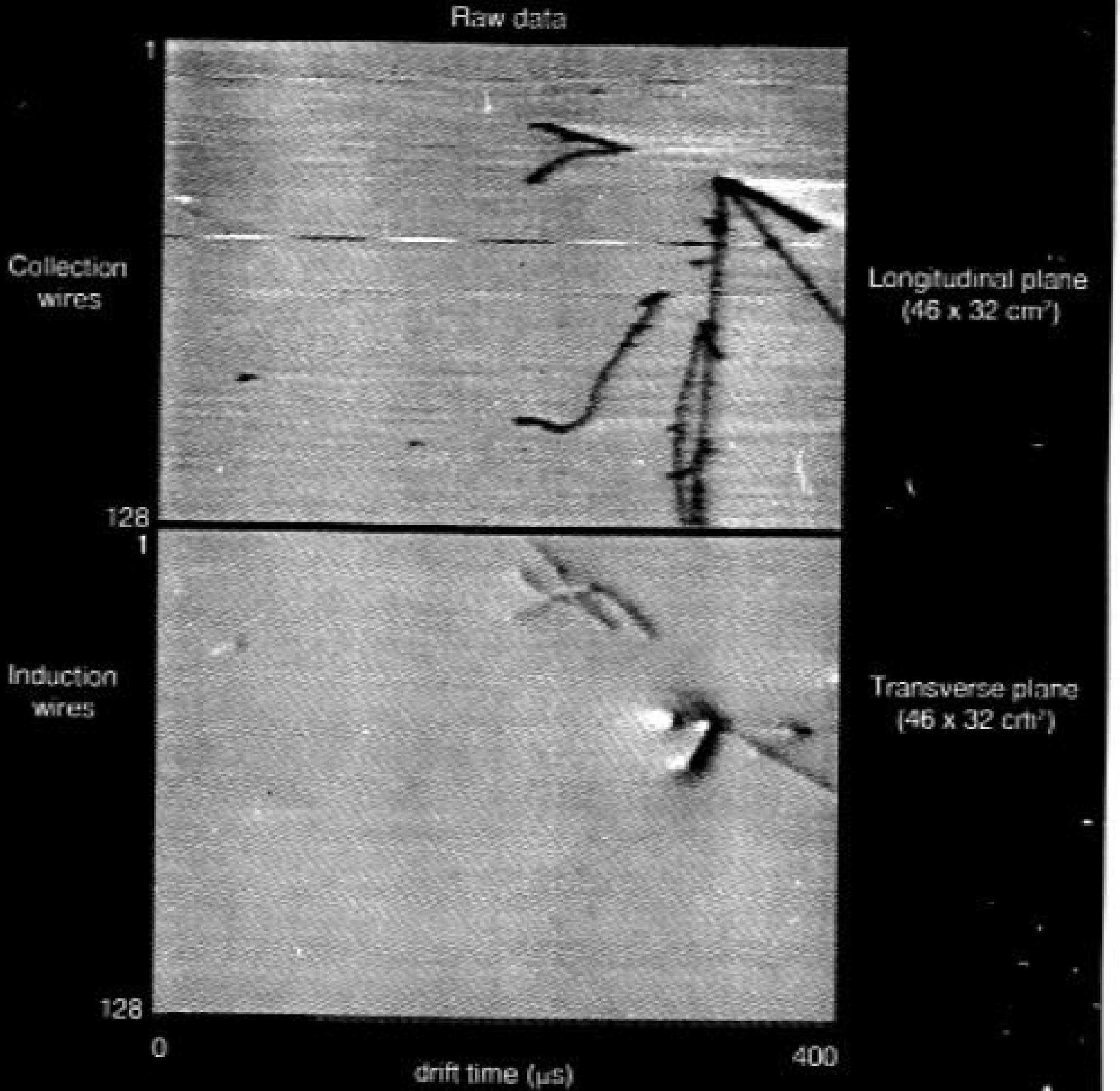


Visible volume = 4•4•4 cm^3

DATA
FROM
3TØN
TEST
DETECTOR
(UCLA
STUDENTS
. PHD's
WORK
ON THIS

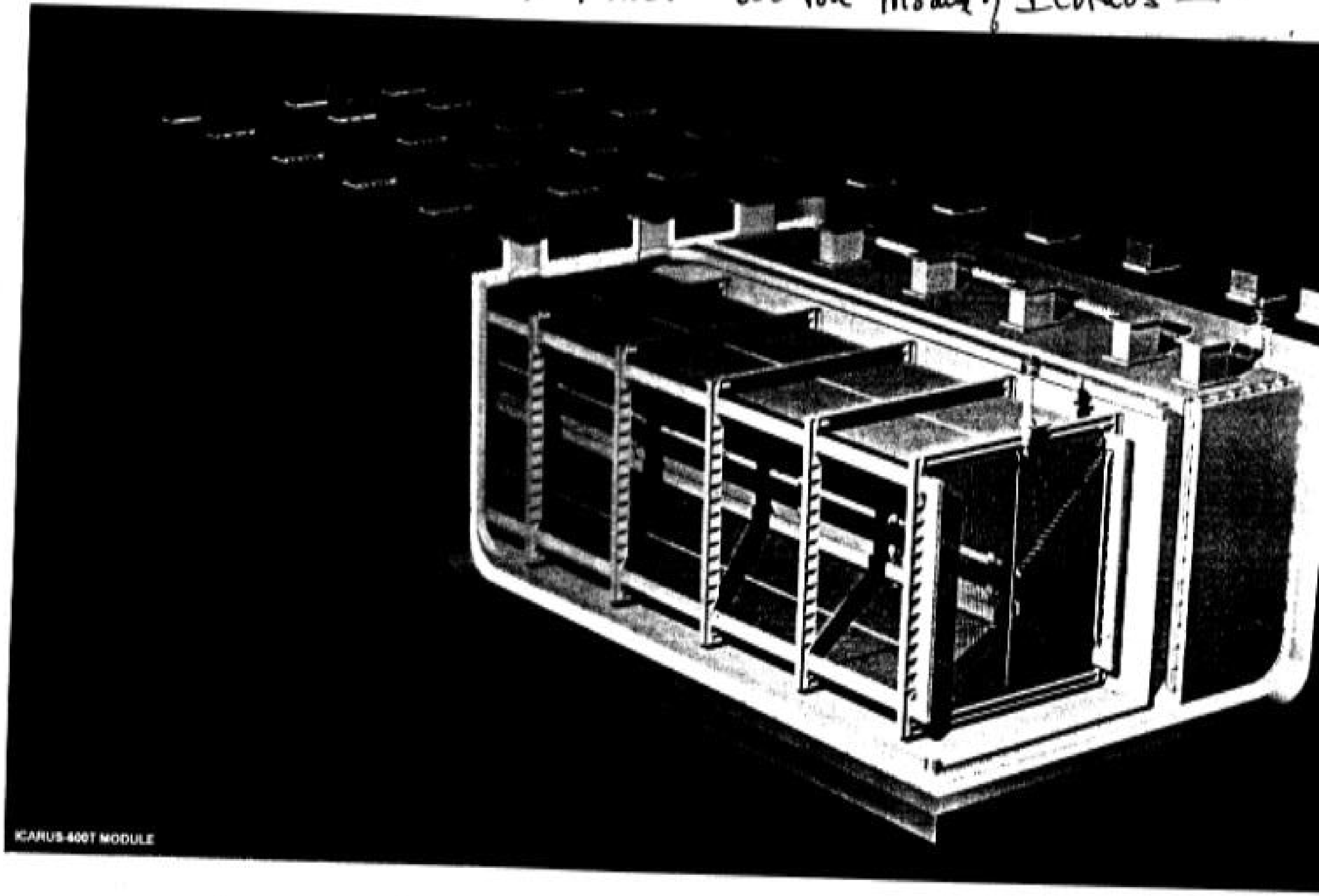
50

CERN



ν BEAM AT CERN → ICARUS 50 lit.
~ 50K events / 1K Quasi Elastic DETECTOR

- FIRST 600 Ton Module of ICARUS -



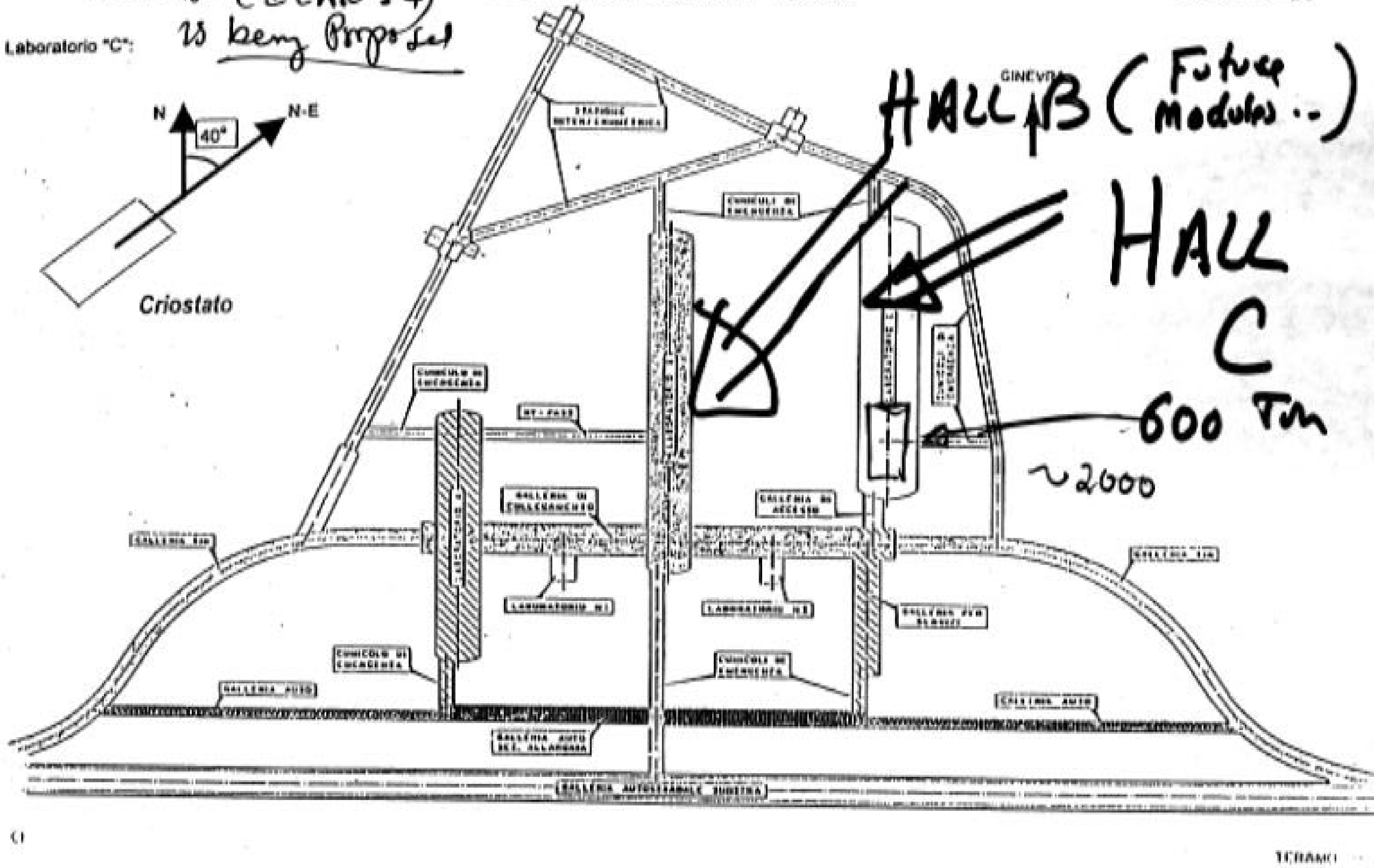
ICARUS-600T MODULE

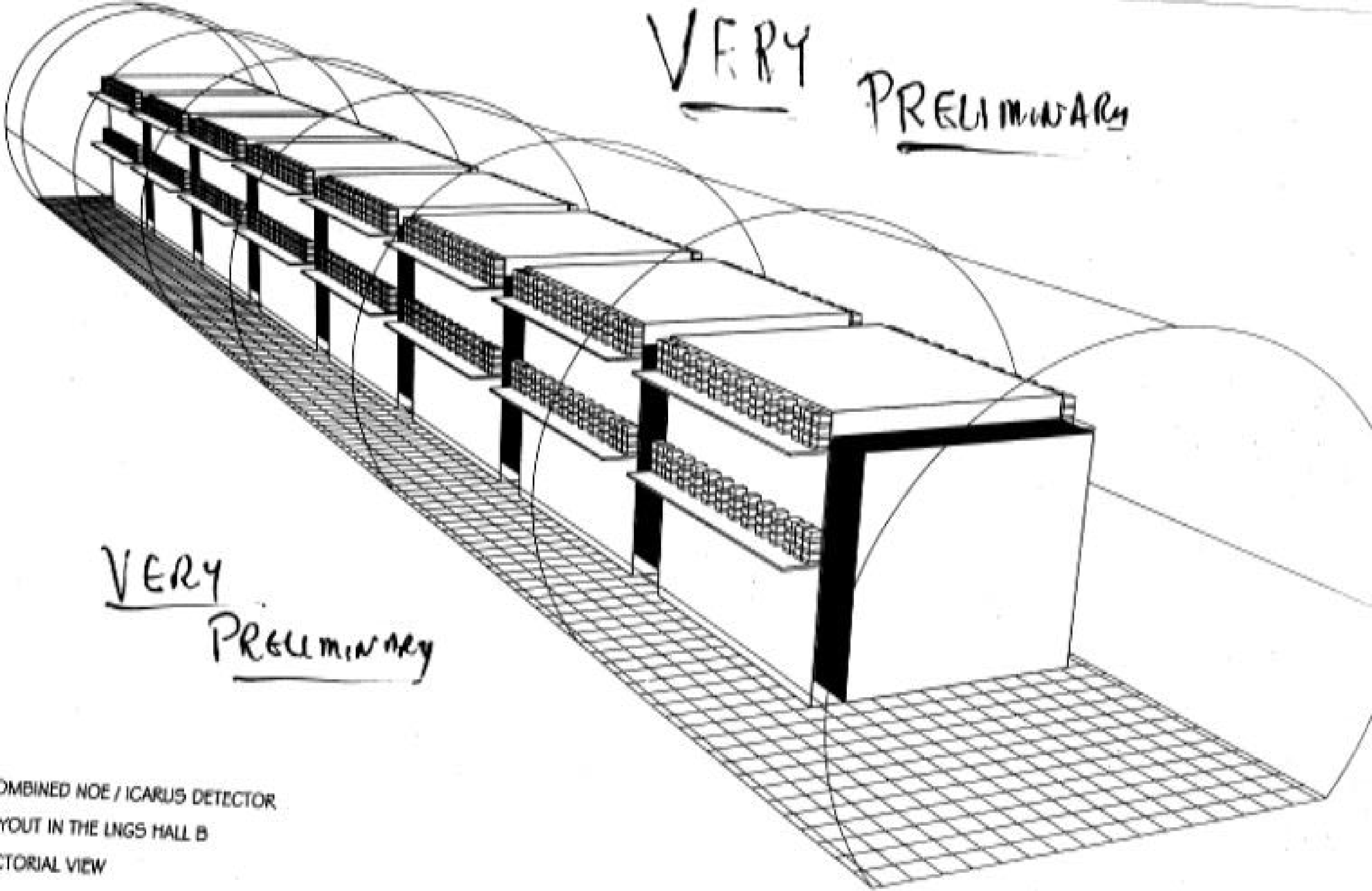
A ~ 10 KT Magnetized Detector (ICARUS +) is being Proposed

LABORATORI INFN DEL GRAN SASSO

PLANIMETRIA GENERALE 1:2000

APRILE 1994
500.3-R-20





VERY PRELIMINARY

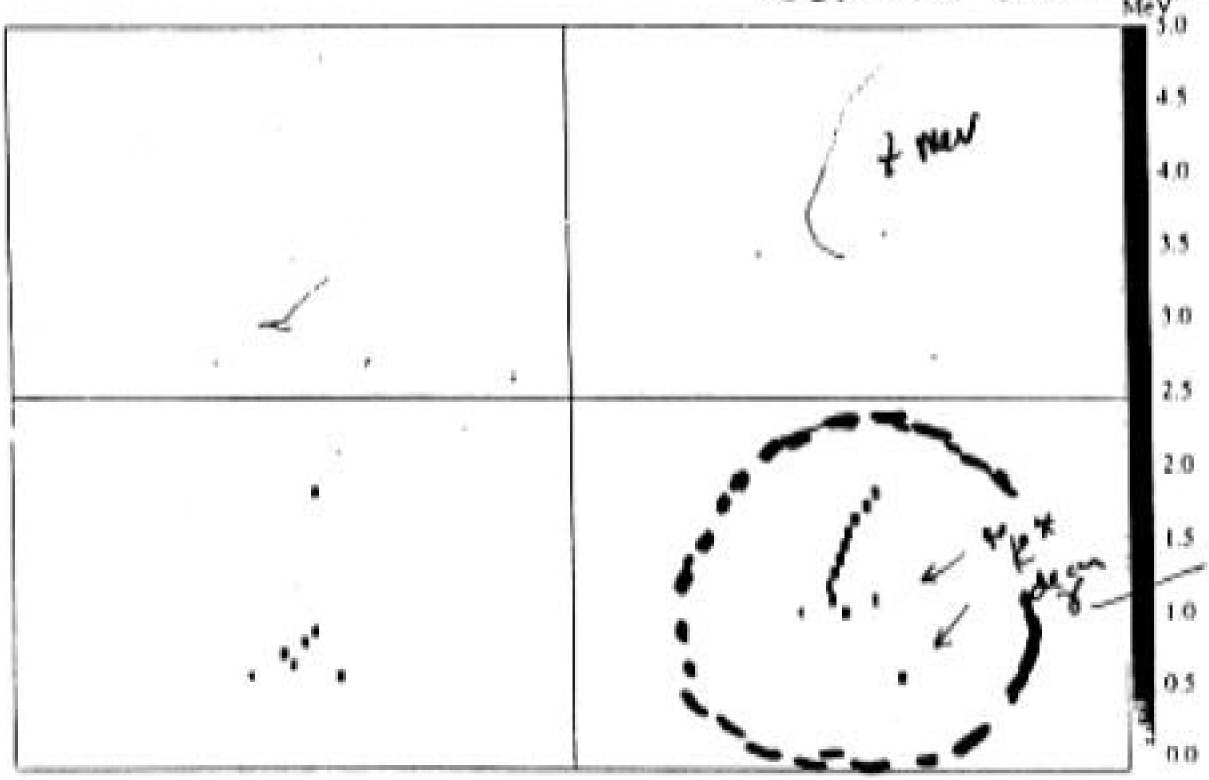
VERY PRELIMINARY

COMBINED NOE / ICARUS DETECTOR
LAYOUT IN THE LNGS HALL B
PICTORIAL VIEW

Absorption Event Simulation

Relic ν_e Detection with ICARUS

Run # 4 12-Oct-1994 Gamow-Teller Event # 39



$\gamma + e \to \gamma + e$ — Could also detect

Fig. 2 Absorption event as generated by the GEANT Montecarlo program in two wire planes put at an angle of 60°. In the bottom it is shown the same event after digitisation. The grey scale of each pixel is proportional to the deposited charge. The resolution in the horizontal axis (drift direction) is 0.1 mm, and in the vertical axis is 3 mm (wire pitch). The projected track length is about 3 cm, the main electron energy is 7 MeV, the associated energy is 2 MeV and the associated multiplicity is 3.

ICARUS Detection of $\nu_e + {}^{40}Ar \to {}^{40}K^* + e$

$\hookrightarrow \gamma$

$\sum E_e + E_\gamma > 15$ M

$\nu_x + {}^{40}Ar \to {}^{40}Ar^* + \nu_x$

$\hookrightarrow \gamma$

? $\hookrightarrow \gamma$

? multi γs

$\sum E_\gamma > 10$ MeV

Relic ν_e ~ few events/year $\hookrightarrow$ ≳20

Real Time SN Detection ≳ 800 events $\nu_e + Ar \to e + K^*$

2400 Ton ICARUS

(2)

II

DETECTION OF ν / $\bar{\nu}$ RELIC NEUTRINO FLUX FROM TIME INTEGRATED SNII

1) **Relic ν / $\bar{\nu}$ From all SNII back to Z ~ 5**

$$< E_\nu > \sim \frac{1}{1+Z} < E_\nu >$$

2) **Detection would give integrated SNII Rate From Universe**
   - Window of Detection ⟨ DBC 1984 / ICARUS Proposal

3) **Neutrino Oscillations in SNII could give $\nu_x \rightarrow \nu_e$ With higher energy than $\bar{\nu}_e$**

4) **Super K - Detect $\bar{\nu}_e$ ICARUS. Attempt to detect $\begin{Bmatrix}\nu_x \\ \nu_e\end{Bmatrix}$ Detection**

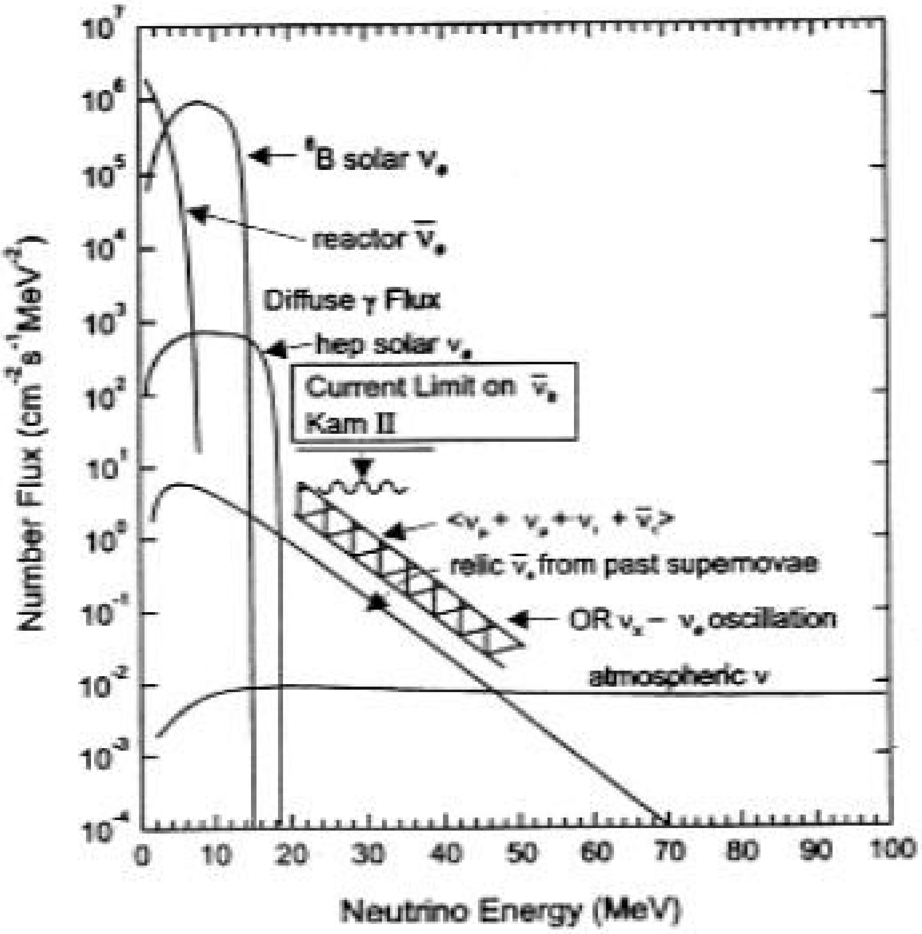


Fig. 2. Relic neutrinos from past supernova. Note: $\nu_x - \nu_e$ in the supernova can boost the energy of the ν_e if we find $<E\nu_e> > <E\bar{\nu}_e>$. This will be a signal for neutrino oscillation in supernovae! and measure $\sin^2 \theta x_e$.

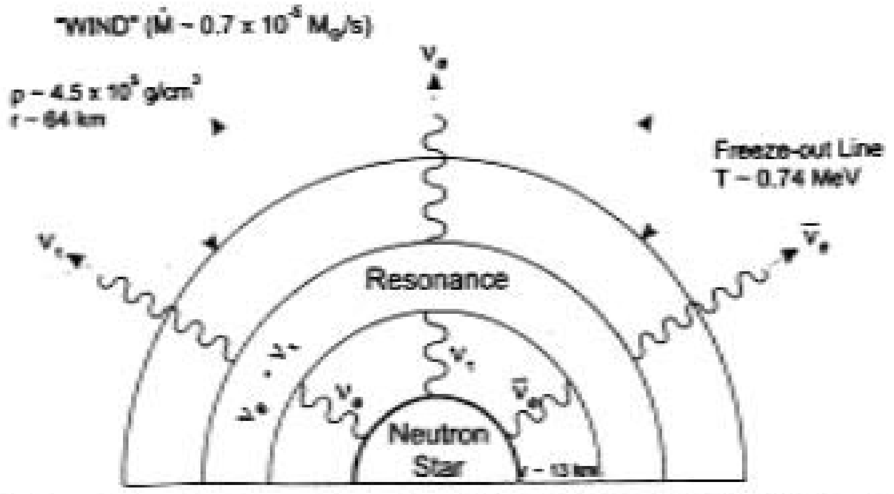
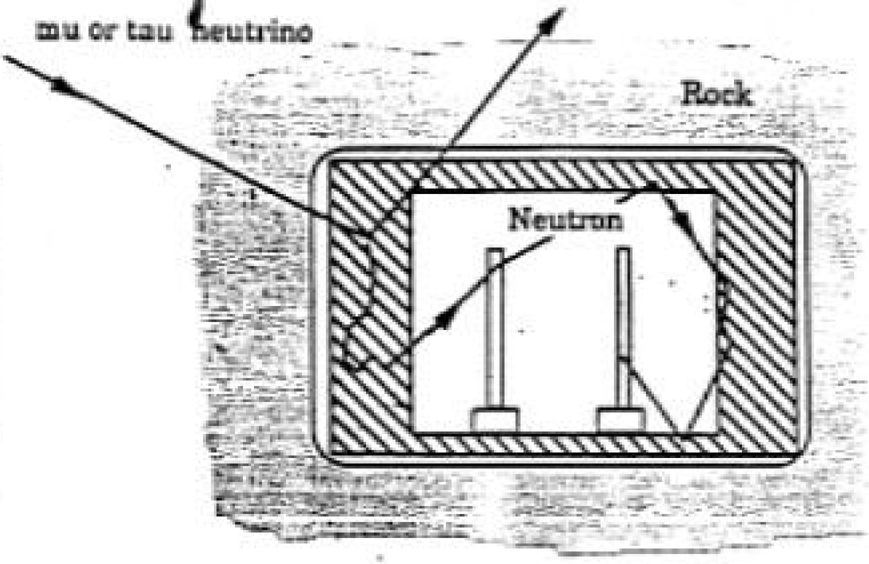
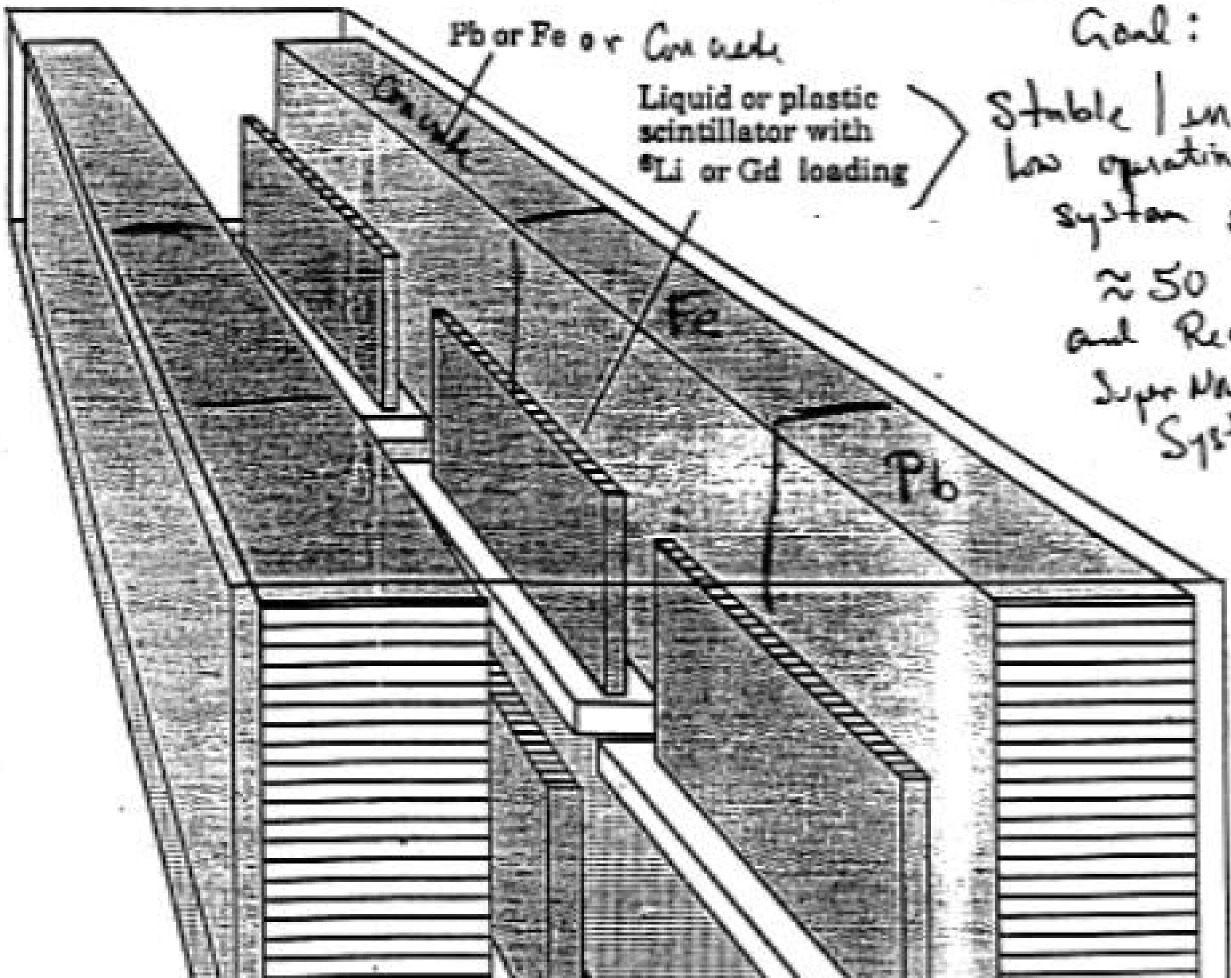


Fig. 3. Transmission of various neutrinos through the outer part of the SNII. It is possible that $\nu_\tau - \nu_e$ conversion can occur in this environment. [G. Fuller, private communication (1999)]

-OMNIS / SNBO-



Observatory for
Multiflavour
Neutrino
Interactions from
Supernovae



Goal:
Stable / inexpensive
low operating cost
system to last
≈ 50 years
and Real Time
SuperNova Alert
System

WHY MULTI TARGETS ?

FOR OMNIS

(Concrete/NaCl), (Fe) (Pb)
<(1) (2) (3)>

PURPOSE:

1) TO REDUCE THE NUCLEAR PHYSICS UNCERTAINTY FOR
$\nu_x + X \rightarrow \nu_x + X' \hookrightarrow n \ldots$

2) TO MAKE AN ENGRY "FILTER" SYSTEM: (i.e DIFFERENT THRESHOLDS FOR (1), (2) (3) FOR N.C. REACTIONS)

3) TO STUDY $\nu_x \rightarrow \nu_e$ IN THE Super Nova Via 2n process (Fuller etal)

4) TO REDUCE THE COST OF THE DETECTOR!

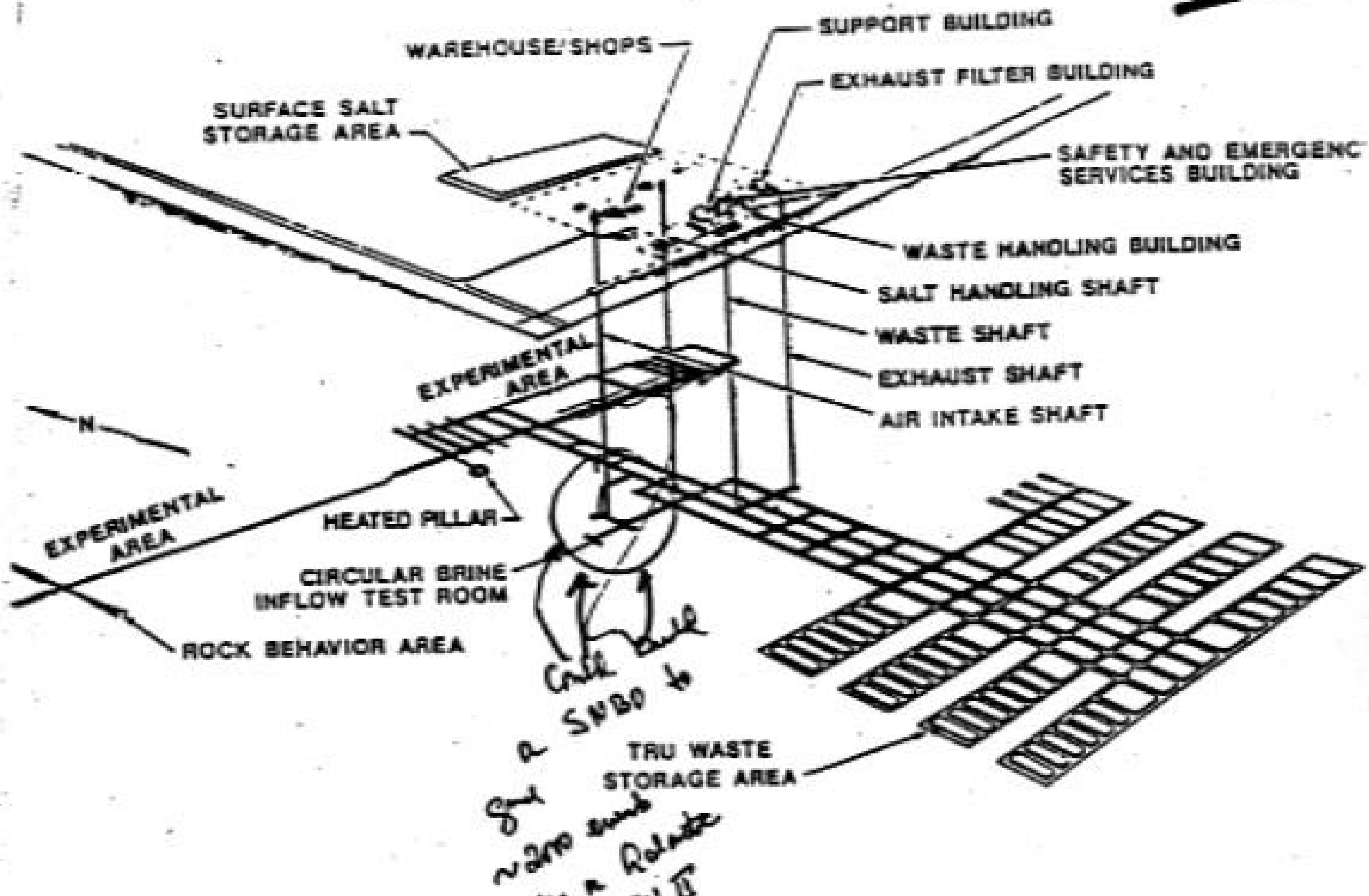
(LANL) → (INPAC) PROPOSAL TO KECK FOR UNDERGR OBSERVATOR

SITE A

CARLSBAD, NEW MEXICO WIPP

WIPP LAYOUT

OMNI



Could build SNBO to a good ~2000 events for a Rotate SN II

This illustration presents an isometric view of the surface and underground, looking toward the northeast.

EXPECT TO OPEN End 98 – Operate At least until 2039 and Possibly much longer – > 40 years

SITE ~~[illegible]~~ OPEN END 98! ~~[illegible]~~ (98) ⇒ UNTIL AT LEAST 2039

WIPP SITE

"HALLS"

(POSSIBLY > 2050!

Extremely Safe – Fully Roof Bolted etc etc

– Impressive underground chambers –

Bin tests will be conducted in Room 1 of Panel 1 in the WIPP underground Ground control in this room has been enhanced to ensure stability throughout the Test Phase

SITE [illegible] OPEN END 98 / [illegible] (9X) ⇒ UNTIL AT LEAST 2039

WIPP SITE "HALLS"

(POSSIBLY > 2050!

Extremely Safe – Fully Rock Bolted [illegible] [illegible]

— Impressive underground chambers —

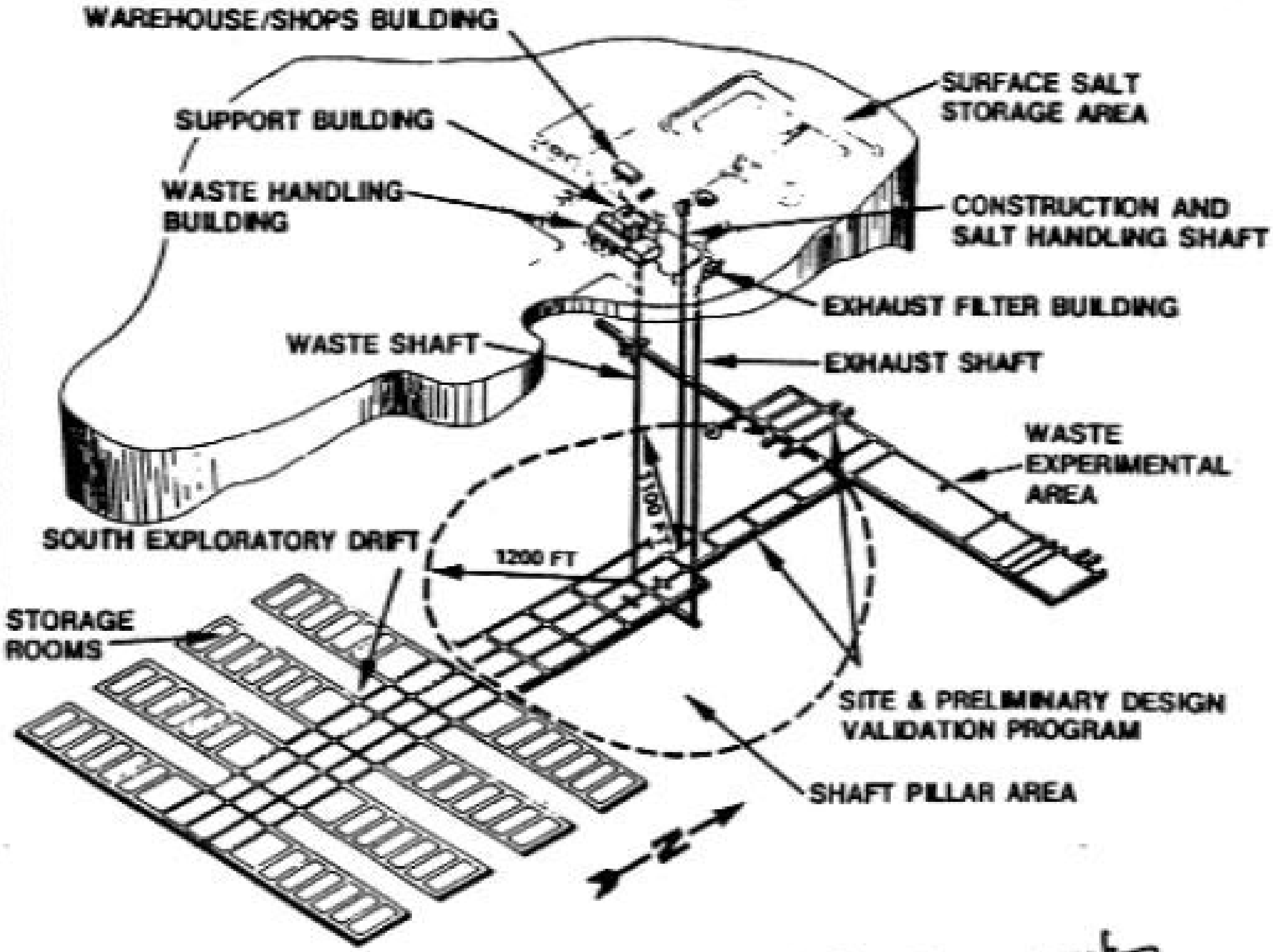
Bin tests will be conducted in Room 1 of Panel 1 in the WIPP underground. Ground control in this room has been enhanced to ensure stability throughout the Test Phase

Five Areas of Focus for "ICRUS"

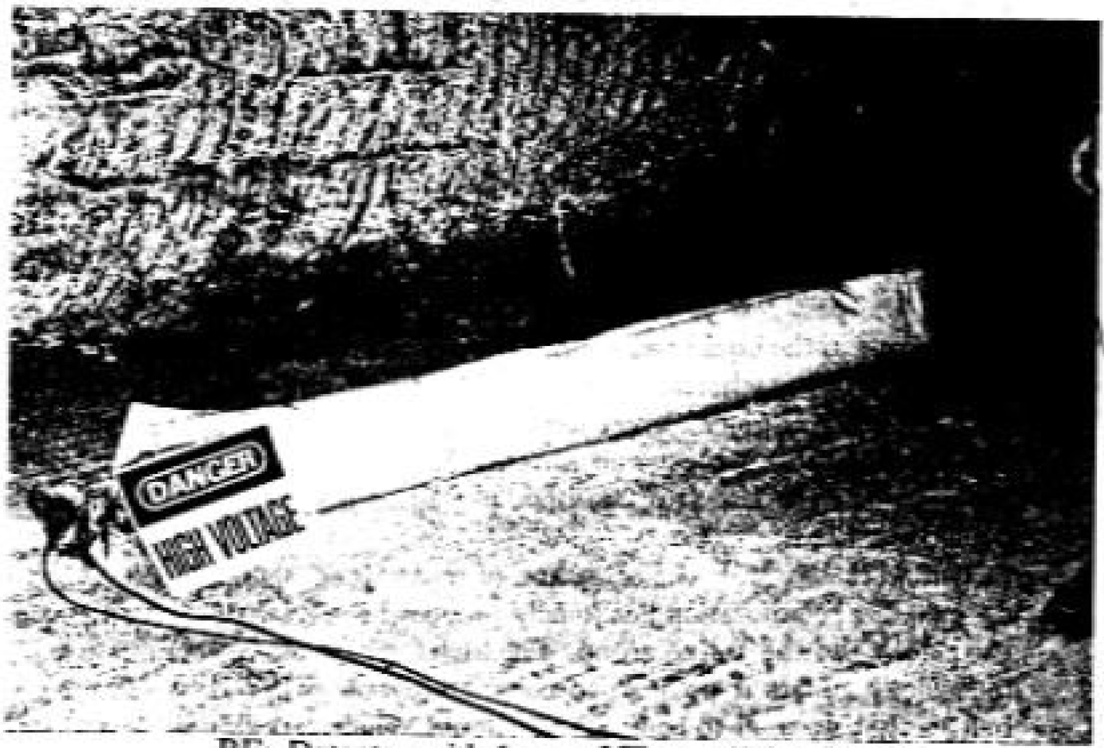
Input to Proposal to Keck Foundation

- Underground Science (dark matter, HEP, gravity, etc.)
- Low Background Radiobiology (LNT, molecular and cellular studies now - animal capability to follow)
- Transparency Technology Demonstration (non-proliferation demonstrations using actual nuclear materials)
- Deep-Geologic Repository for Nuclear Waste Research (primarily in association with international users)
- Natural Resource Extraction Research (potash and oil & gas industries)

— Richardson →
Said he backed
this idea for DOE



UCLA working
there for 7
years like
they want to
make it an
underground lab



BF$_3$ Detector with 1 cm of Thermalizing Plastic

CSU
UCLA
GRNP

Bare BF$_3$ Detector

Wax Neutron Shield

n Flux measured at [illegible] site!

ELSEVIER

Nuclear Instruments and Methods in Physics Research A 399 (1997) 269–274

NUCLEAR
INSTRUMENTS
& METHODS
IN PHYSICS
RESEARCH
Section A

Evaluation of the WIPP site for the supernova neutrino burst observatory

M.J. Balbes[a], R.N. Boyd[a,*,1], J.D. Kalen[a], C.A. Mitchell[a], M. Hencheck[a], E.R. Sugarbaker[a], J.D. Vandegriff[a], D.A. Sanders[a], S.D. Lieberwirth[c]

[a] *Department of Physics, The Ohio State University, Columbus, OH 43210, USA*
[b] *Department of Physics and Astronomy, University of California at Los Angeles, Los Angeles, CA 90095-1547, USA*
[c] *WIPP, 30 miles SE of Carlsbad, Carlsbad, NM 88220, USA*

Received 21 June 1996; received in revised form 17 June 1997

Abstract

Measurements of the neutron background in a potential underground site for the Supernova Neutrino Burst Observatory (SNBO) have been made. The SNBO will ultimately be capable of detecting μ and τ neutrinos from a supernova. Furthermore masses of the μ and τ neutrinos might be measurable in the range of 10–50 eV. SNBO operates by detecting the neutron caused by interaction of the supernova neutrinos with rock. It will consist of order ten thousand neutron detectors locate in an underground environment having a very low intrinsic radiation level. The limit to the size, hence sensitivity, o SNBO is thus the neutron signal-to-noise ratio, which depends on the neutron background in the environment of SNBO. Thus we have made neutron background measurements at the Department of Energy Waste Isolation Pilot Plant (WIPP located near Carlsbad, NM. The value of the ambient neutron flux we determined, 332 ± 148 neutrons m^{-2} d^{-1}, shows that the background levels in this facility are sufficiently low to warrant construction of a galactic supernova neutrino detector.

OSU/UCLA MEASUREMENTS
AT THE WIPP SITE

YIELDS OF SUPERNOVA NEUTRINO DETECTORS

Detector	Target Material	Fiducial Mass (Ton)	Target Element	Yield(ν_e)	Yield($\bar{\nu}_e$)	Yield($\nu_\mu + \nu_\tau + \bar{\nu}_\mu + \bar{\nu}_\tau$)
SuperK	H_2O	32000	p, e, O	180	8300	50
LVD	CH_2	1200	p, e, C	14	540	30
MACRO	CH_2	1000	p, e, C	8	350	25
SNO	H_2O	1600	p, e, O	16	520	6
SNO	D_2O	1000	d, e, O	190	180	300
ICARUS	Argon	4000	Ar	~1000		
OMNIS	Fe *	8000 ?	Fe	20*	20*	1200*
OMNIS	Pb	2000	Pb			
no osc.				110**	40**	860**
$\nu_{\mu,\tau} \rightarrow \nu_e$ osc.				≤ 4420** → 2 × [illegible]	40**	≤ 640**

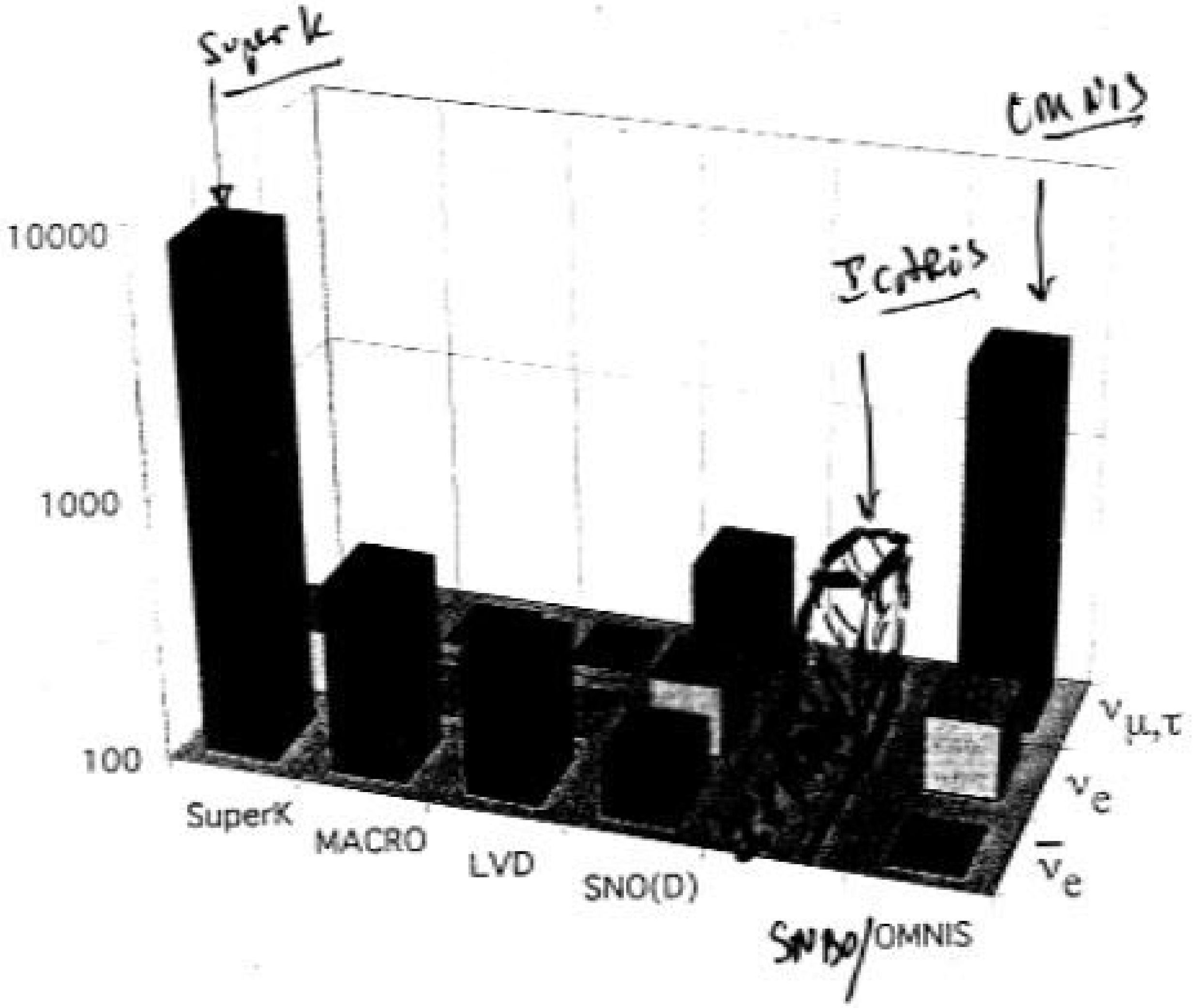
*Assumes same efficiency as in Smith 1997.

**Assumes a single neutron detection efficiency of 0.6.

* May use the SRT Muon Detector
[illegible]

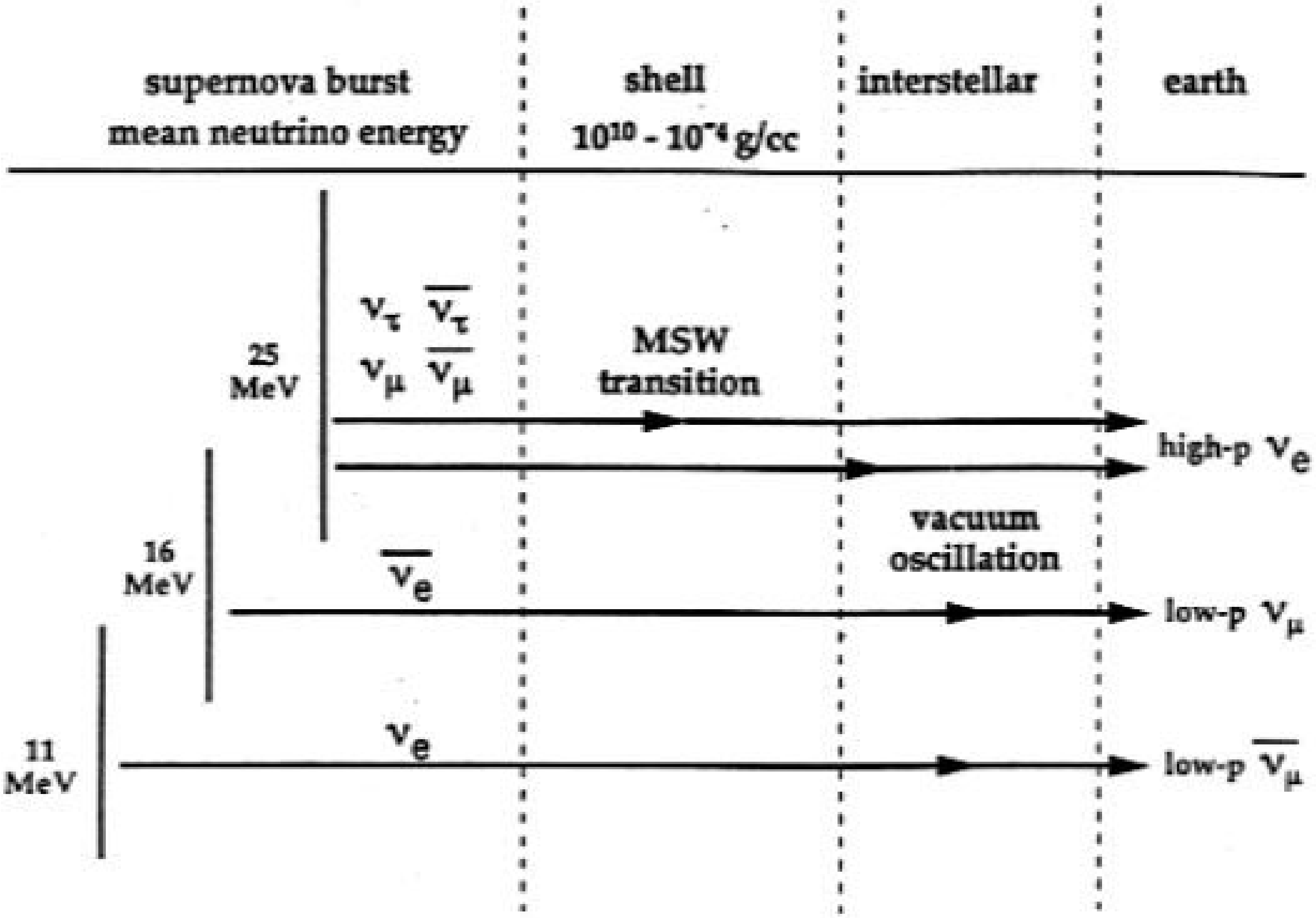
Comparison of world detectors

Event numbers for supernova at 8 kpc



[redacted]

Mixing possibilities from supernova



"CKM" Matrix for
ν Osc.

1) $\nu_\mu \to \nu_\tau$ Presumably a large amplitude

$$\underset{\mu\tau}{P}(\nu_\mu \to \nu_\tau) = \underline{\cos^4\theta_{13}}\,\sin^2 2\theta_{23}\,\underbrace{\sin^2(\text{[illegible]})}_{\nu_\tau\ \text{Term}}$$

$\Rightarrow \theta_{23} \sim 45°$

$\theta_{13} \sim ??$ $(< 20° ?)$

$\sim 8° ???$ – <u>could be zero</u>?

2) To measure θ_{13} need a term with a $\sin\theta_{13}$

$$\underset{e\mu}{P}\overset{\nu_\mu \to \nu_e}{(\nu_e \to \nu_\mu)} = \sin^2\theta_{23}\ \sin^2 2\theta_{13} \cdots$$

$$P_{e\tau}(\nu_e \to \nu_\tau) = \cos^2\theta_{3}\ \sin^2 2\theta_{13} \cdots$$

<u>If θ_{13} is very small</u> } the size of θ_{13} will determine whether ν factories or beta ν beams are the most useful.

$$P_{e\mu} \sim 4\theta_{13}^2 \cdots$$

$$P_{e\tau} \sim 4\theta_{13}^2 \cdots$$

$\nu_e \to \nu_\mu$ does not require high energy ν's

$\nu_e \to \nu_\tau$ requires higher energy ν for τ threshold

GOALS OF NEUTRINO FACTORIES
$\mu^{\pm}$ STORAGE RINGS

1) **To observe neutrino osciallation reactions that are difficult to observe by Normal LBL**

   i.e. $\nu_e \to \nu_\mu$ or $\nu_e \to \nu_\tau$

2) **To reach larger $\langle L/E \rangle$ than Normal LBL**

   (1) **i.e.** FNAL / **BNL → GRAN SASSO** / or SLAC!!

   CERN → SOUDAN or ? SuperK ?

   $\langle L \rangle = 7000$ km $\langle E \rangle \sim 20$ GeV

   $\left\{ \left\langle \frac{L}{E} \right\rangle \sim 350 \right\}$

   $\nu_\mu \leftrightarrows \nu_e$ easy to detect at N.F.

   $\nu_e \to \nu_\tau$ very difficult!

   (2) **CERN → GRAN SASSO**

   FNAL ~~CERN~~ **→ SOUDAN**

   $\langle L \rangle = 700$ km $\langle E \rangle \sim 2$ GeV (ν_e beam)

   $\left\langle \frac{L}{E} \right\rangle \sim 350$

3) **To help unravel a complex neutrino spectrum**
   - **Sterile neutrino and normal neutrino oscillations**

4) **CP Violation Search using ν and $\bar{\nu}$ multi flavor Beams of controlled intensity**

USA $\mu\mu$ Collider Consortium ⟹ $\mu\mu$ Collider and Neutrino Factory Consortium !!

astro-ph/9809164 13 Sep 1998

Prospects for Detecting Supernova Neutrino Flavor Oscillations

George M. Fuller,[1] and Wick C. Haxton,[2] and Gail C. McLaughlin[2,*]
[1] *Department of Physics, University of California, San Diego, La Jolla, CA, 92093-0319*
[2] *Institute for Nuclear Theory, Box 351550, and Department of Physics, Box 351560, University of Washington, Seattle, WA 98195, USA*

(September 13, 1998)

Abstract

The neutrinos from a Type II supernova provide perhaps our best opportunity to probe cosmologically interesting muon and/or tauon neutrino masses. This is because matter enhanced neutrino oscillations can lead to an anomalously hot ν_e spectrum, and thus to enhanced charged current cross sections in terrestrial detectors. Two recently proposed supernova neutrino observatories, OMNIS and LAND, will detect neutrons spalled from target nuclei by neutral and charged current neutrino interactions. As this signal is not flavor specific, it is not immediately clear whether a convincing neutrino oscillation signal can be extracted from such experiments. To address this issue we examine the responses of a series of possible light and heavy mass targets, ^{9}Be, ^{23}Na, ^{35}Cl, and ^{208}Pb. We find that strategies for detecting oscillations which use only neutron count rates are problematic at best, even if cross sections are determined by ancillary experiments. Plausible uncertainties in supernova neutrino spectra tend to obscure rate enhancements due to oscillations. However, in the case of ^{208}Pb, a signal emerges that is largely flavor specific and extraordinarily sensitive to the ν_e temperature, the emission of two neutrons. This signal and its flavor specificity are associated with the strength and location of the first-forbidden responses for neutral and charge current reactions, aspects of the ^{208}Pb neutrino cross section that have not been discussed previously. Hadronic spin transfer experiments might be helpful in confirming some of the nuclear structure physics underlying our conclusions.

14.60.Pq, 26.50.+x, 25.30.Pt

2 n Signal from $\nu_x \to \nu_e$

Real time detection of $\nu_x \to \nu_e$ in SN II

Typeset using REVTEX

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[*] Current Address: TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C. Canada V6T2A3. Electronic address: `gail@alph01.triumf.ca`

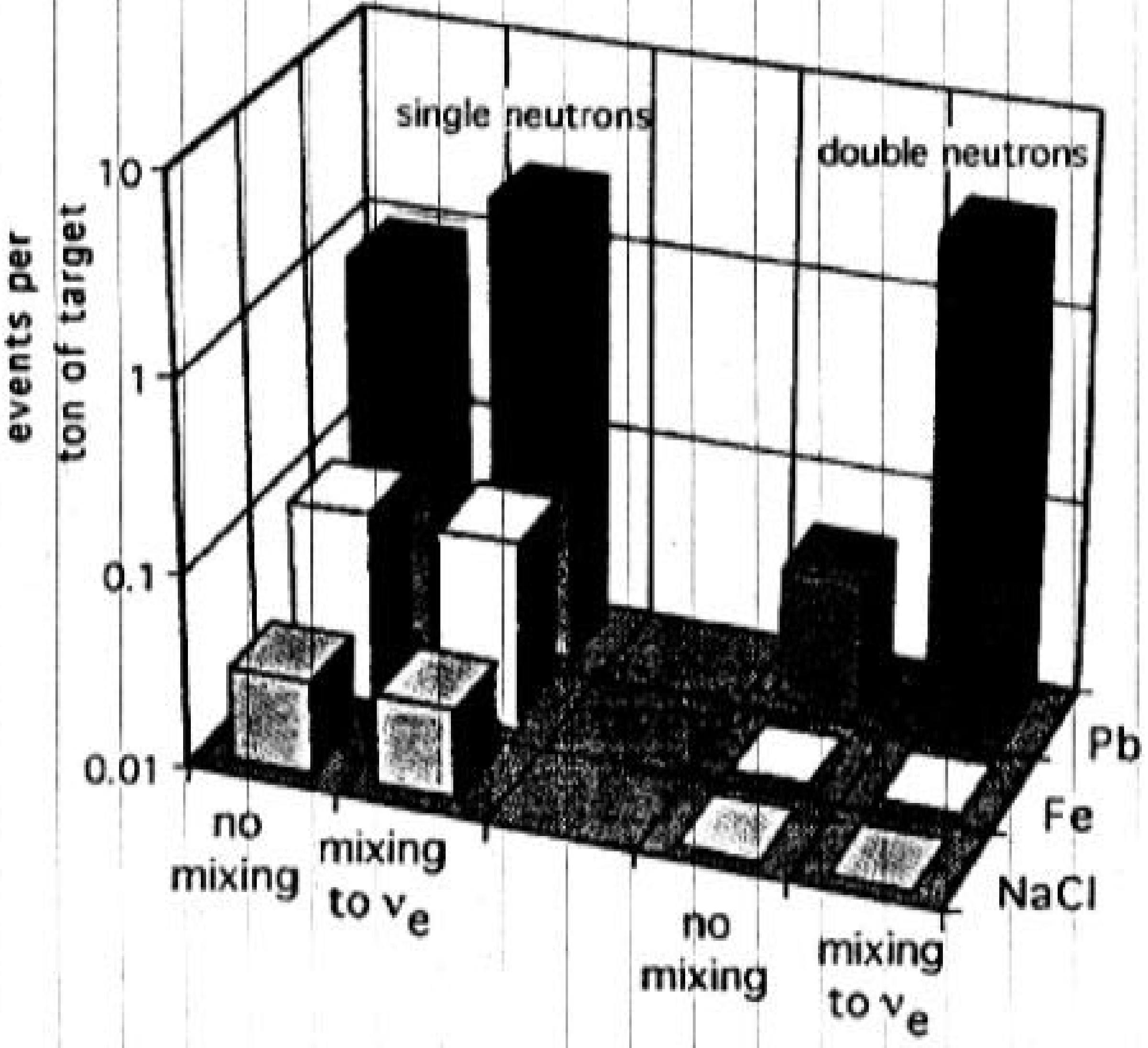


Figure 9. *The estimated number of events per tonne of target material, for each neutrino flavour, with and without full mixing (e.g. MSW) between ν_τ, or ν_μ and ν_e (from numerical data in* ref[13] *for* Pb *and* NaCl, *and* ref[14] *for* Fe.

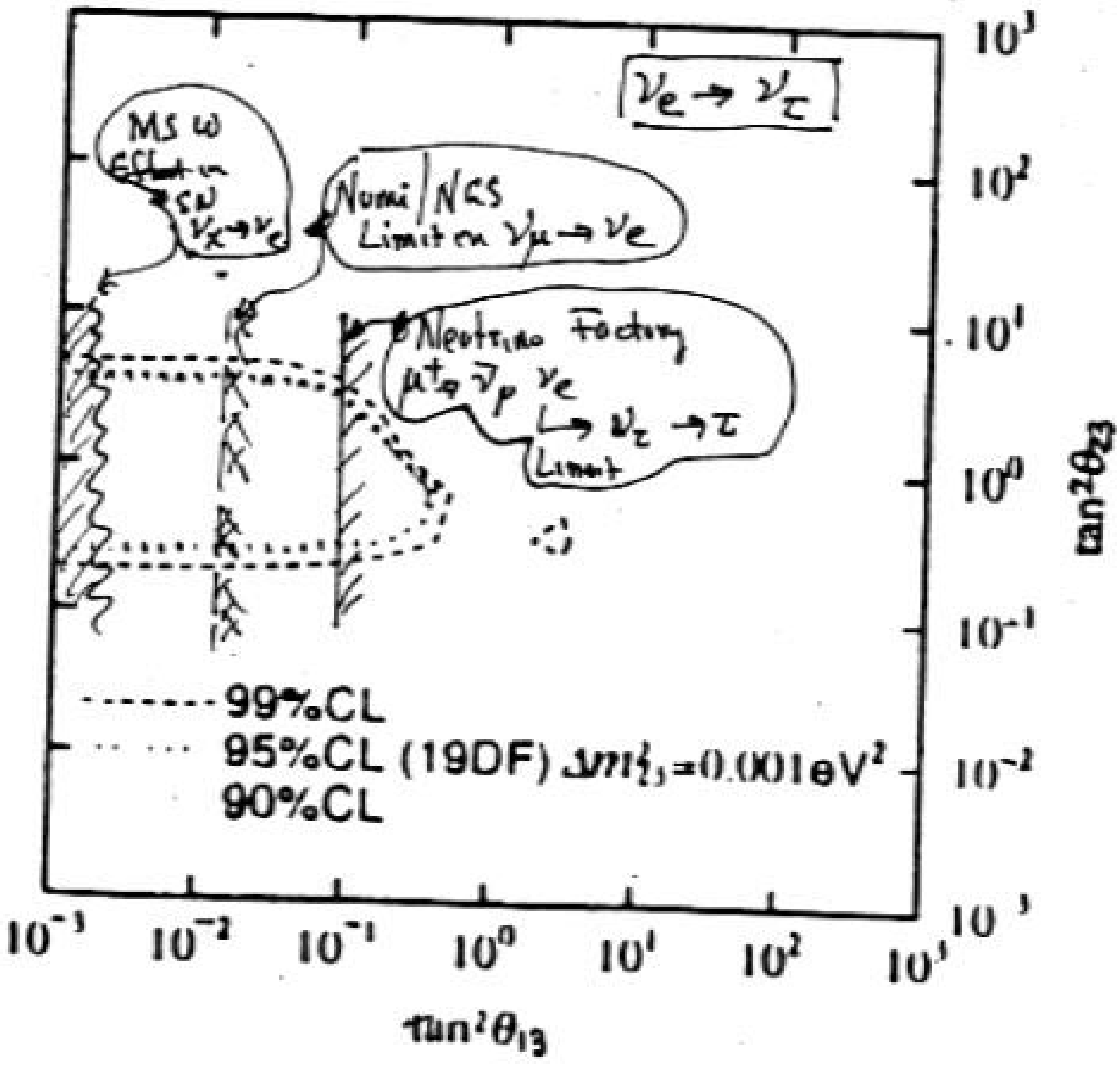
UK:

Proposed

3 Neutrino Mixing

Future Search for
$\nu_x \to \nu_e$

T. Sakai et al
IJMP A 12, 1953 (99)



ASPEN
9E

EXTRACTION OF ν MASS OR OSCILLATION SIGNAL

1. **ASSUME ALL DETECTORS GIVE:**

   ~ 8000 $\bar{\nu}_e$ (E_e+)
   ~ 6000 ~~[illegible]~~ ν_e (E_e-) > Super K / ICARUS SNO ....
   ~ 2000 $\nu_x \equiv (\nu_\mu + \bar{\nu}_\mu + \nu_\tau + \bar{\nu}_\tau)$ SNO + SNBO ...

2. **FIT $\begin{pmatrix}\nu_e \\ \bar{\nu}_e\end{pmatrix}$ TIME AND ENERGY SPECTRUM TO EXTRACT SN MODEL** — Extract $\langle \bar{\nu}_e, \nu_e \rangle$ mass limit

3. **FIT TIME SPECTRUM OF $\begin{pmatrix}\nu_e \\ \bar{\nu}_e\end{pmatrix}$ TO GIVE** [illegible] t_e

4. **USE ν_x DATA TO SEARCH FOR A ν_τ, ν_μ NEUTRINO MASS BY TOF** (SHARP TIME STRUCTURE ??)

5. **SEARCH FOR MSW OSCILLATION $\nu_x \rightarrow \nu_e$**

   a) 2 Neutron Signal in SNBO/OMNIS
   b) ν_e Spectrum in SNO / ICARUS

Expect to measure m_{ν_x} to ~ 15 eV
↓
5 eV
if sharp time structures in ν_x spectrum

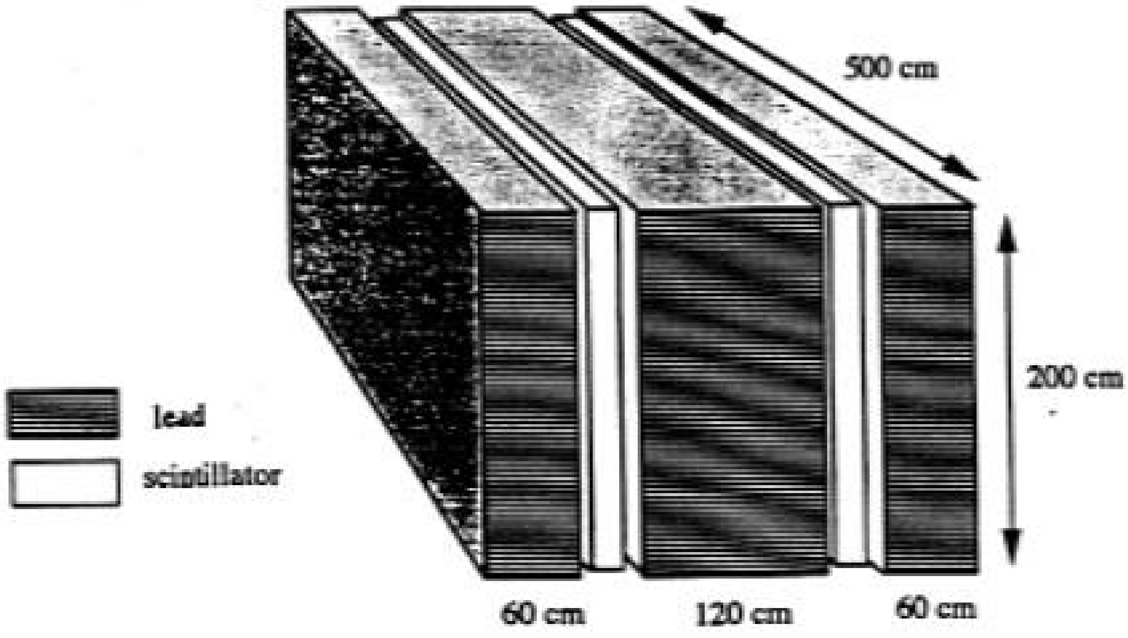
UK
Propose

Proposed OMNIS/SIREN prototype

(Manchester, RAL, Sheffield, Imperial College, QMW)

Boulby.
mine

- Optimised geometry for lead+scintillator module — to detect 100 events from 8 kpc supernova.
- Contains 250 tons lead, 3 tons scintillator
- Mixing from mu/tau to e neutrinos produces additional 140 two-neutron events
- Plastic/Gd layers provide 5% Gd for SIREN target and study of backgrounds



event numbers for supernova at 8 kpc

lead mass	scintillator area	no mixing		full mixing	
		1n	2n	1n	2n
250 t	16 m^2	100	2	600	140

§6 Detector engineering

First realistic designs have been made as shown in Figure 15. The dimensions differ slightly from the outline design above in order to have eight rather than seven channels per module.

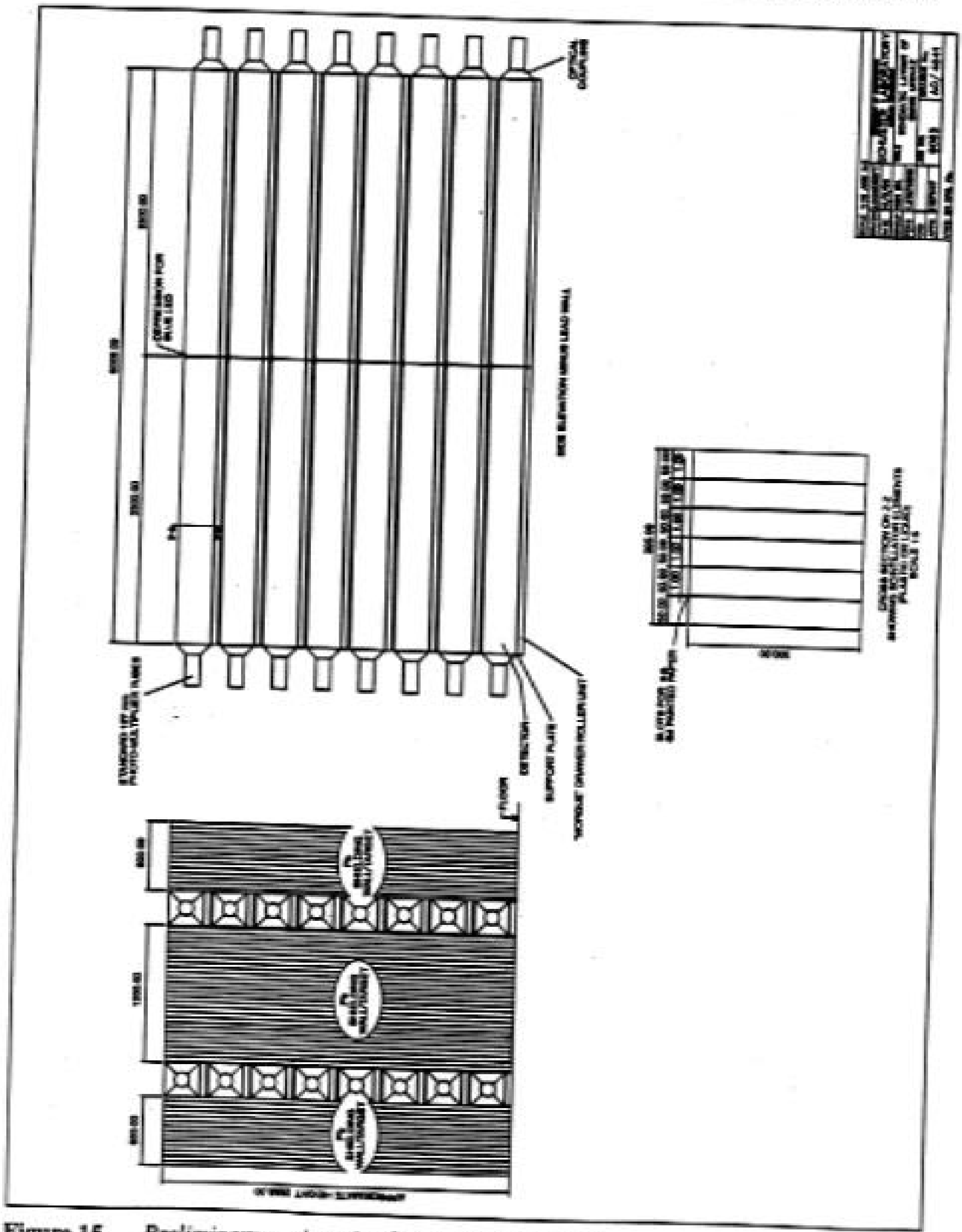


Figure 15. *Preliminary engineering layout of the detector.*

§7 Electronics and data acquisition

In the proposed configuration, the scintillator light would be channelled along the sheets by total reflection, reaching funnel light guides and photomultipliers coupled to the ends of the multilayer assembly. Photomultipliers may be placed at both ends for greater sensitivity and uniformity of response. Calibration is achieved with an LED or laser diode pulser system. The data acquisition system would be required to operate simultaneously in a high resolution and low resolution mode to record simultaneously both the sub 100 keV energy region to explore the solar signal backgrounds and the 1-4 MeV region for the neutron signals. The data acquisition is based on a first stage 32 tube detector, upgradable as further modules are added.

The overall design philosophy of the Data Acquisition System

A block diagram of the proposed data acquistion system is shown in Figure 16 and the actual layout design is presented in Figure 17.

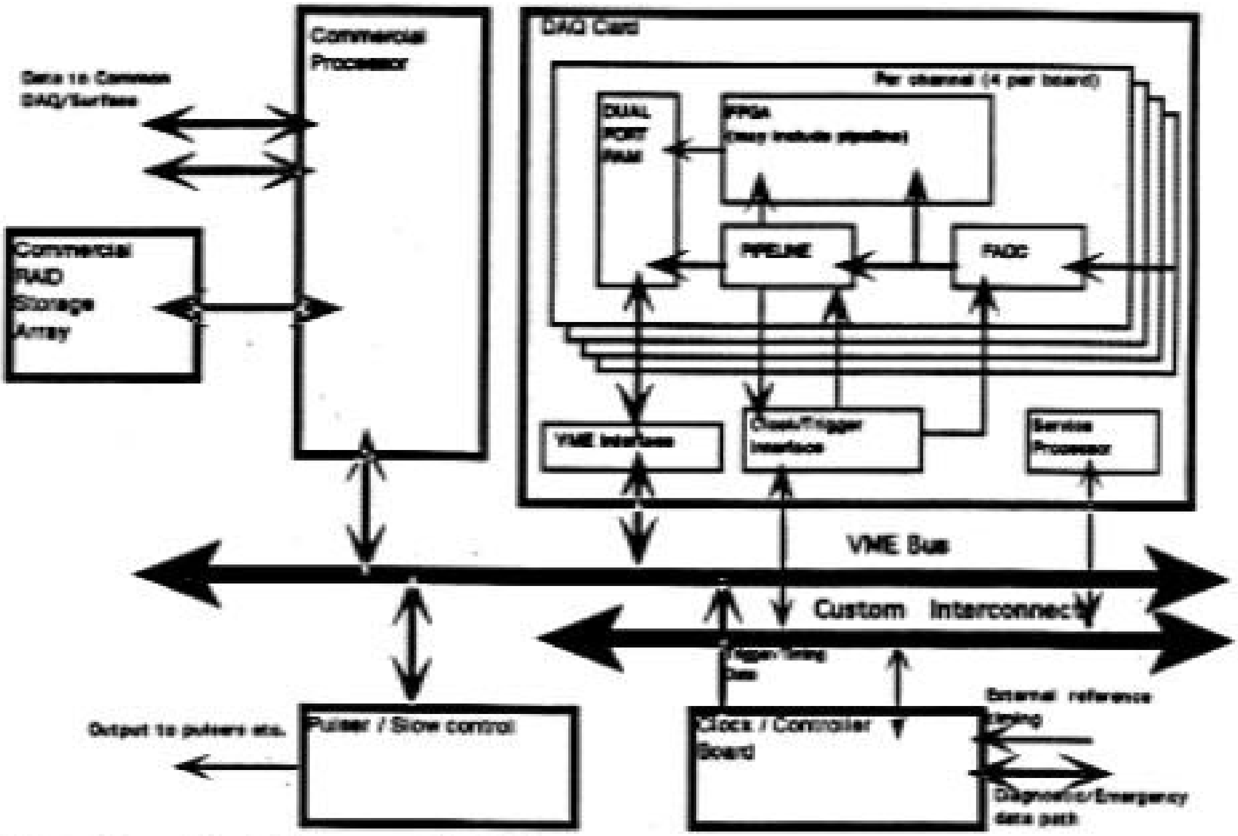


Figure 16. *Block diagram of the DAQ system.*

Signals from photo-multiplier tubes (PMTs) are transferred to the readout crate via drivers built into the bases. Four PMTs are serviced by a single width VME module, so that 8 modules are required in total. Data are digitised using FADCs for which 100 MHz should certainly be enough. The data are stored in a simple pipeline buffer while trigger logic inspects the data independently on a channel by channel basis.

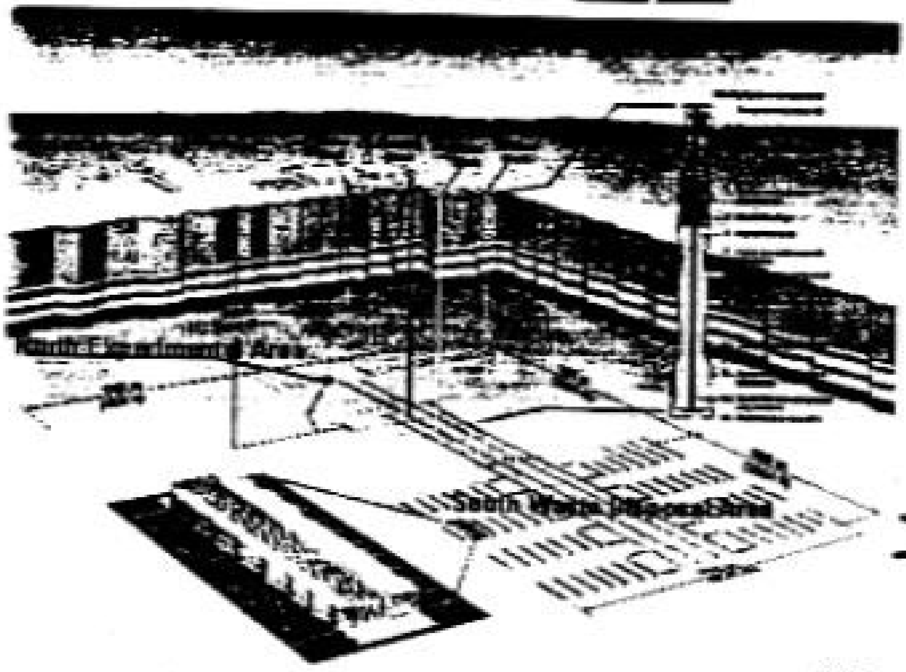
Triggered pulses and associated data are stored in buffers on each DAQ card. These buffers are deep enough to ensure data will not be lost provided the average event rate does not exceed 100 Hz for a period of more than 100 seconds, which should be enough to cope with the nearest possible supernova.

LANL MEETING FEB 99

UC-INPAC
PROPOSAL
TO
KECK
FOUNDATION
MAY 99

WIPP may be an Ideal Setting for Neutrino Observation Experiments

- Federal Facility operated by the Department of Energy
- 650 m below surface
- About 250 m of essentially pure NaCl both above and below facility horizon - surrounded by >10 km of NaCl on all sides
- Extremely low (and soft) gamma background radiation spectrum (0.3 - 0.6 micro R/hr primarily from K-40)
- Waste Disposal and Experimental Areas separated by over 900 m
- Extensive facility infrastructure already in-place:
    - material transport and personnel/equipment access
    - ventilation systems
    - power and high speed data communications
    - surface support and highway access



FOR UNDERGROUND
LAB

⇒ SNBO/OMNIS
WOULD BE
A KEY
PROJECT

PRC

PROPOSAL SENT TO

MINOS Plastic Technology for WIPP Site?

2nd approach load plastic with Gd

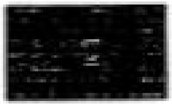
2 Detector Schemes
(1) Gd + Liquid Scint. - OSU [illegible] ([illegible] Tank)
(2) ^{6}Li + Plastic - MINOS Tech - UCLA +

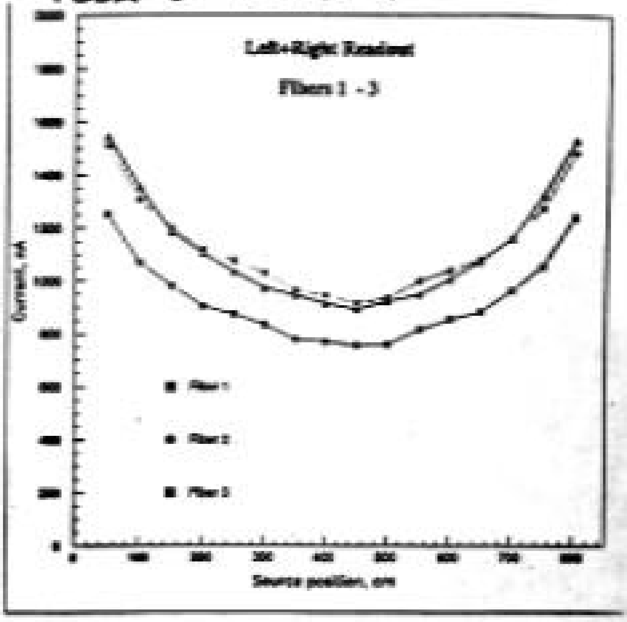
UCLA
Kevin Lee

Load with ^{6}Li

Readout Scin fiber

⇒ A Para [illegible] / FNAL

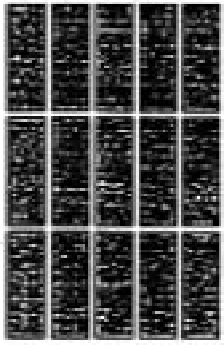




NaI Study

^{6}Li Loaded Detector

OMNIS Solid Detector
- Load Gd, Li6, or B
- Multi-channel PMT (or multiplexing) not necessary
- Dimensions depend on type of neutron absorber (each plane can be 15 cm thick)



Safety: !! Key for WIPP Site
Plastic scintillator is NOT a fire hazzard and has passed safety review for MINOS (M. Goodman and A. Para)
NO PVC and abestos allowed by the Mine Safety and Health Administration but will review materials for safety (W. Walker)
Acrylic plastics are fire hazzardous (deform at 160 deg. F and working point at 320 deg F, Custom Extrusion)

WANT A DETECTOR TO OPERATE ~50 YEARS!

11/8/97

Summary

1) A Super Nova observatory Requires

A) Inexpensive – Long Lived Massive Detector ⇒ OMNIS

B) Neutrino Physics Requires 3 Types of Detector

a) $\bar{\nu}_e + p \to e^+ + n$ Super K

b) $\nu_e + {}^{40}Ar \to {}^{40}K^* + e$ ICARUS
$\quad\hookrightarrow \gamma$

c) $\nu_x + N \to \nu_x + N'$ OMNIS
$\quad\hookrightarrow n$

2) We believe $\nu_x \to \nu_e$ can be detected if $\nu_\mu \to \nu_e$ has been detected on earth ⇒ $\nu_\tau \to \nu_e$ by 2n signal

3) We do not know what ν mass limits can be reached UNTIL we know more about SN Dynamics – if there are very sharp spikes – the ν_x then $m_\nu \lesssim$ keV may still be possible