HYBRID

RADIOCHEMICAL - ELECTRONIC SOLAR ν_e DETECTOR

$$\nu_e + \left\{ \begin{matrix} {}^{37}Cl \\ {}^{127}I \end{matrix} \right\} \rightarrow \left\{ \begin{matrix} {}^{37}Ar \\ {}^{127}Xe \end{matrix} \right\} + e^-$$

GOAL: SEPARATELY & DIRECTLY MEASURE:

FLUX OF ν_e FROM ^8B

&

FLUX OF ν_e FROM ^7Be, PeP & CNO

TECHNIQUE: SINGLE ATOM EXTRACTION & CLASSIFICATION OF ELECTRONICALLY LABELED ν_e INTERACTION PRODUCTS FROM KILOTON SOLAR ν_e DETECTOR

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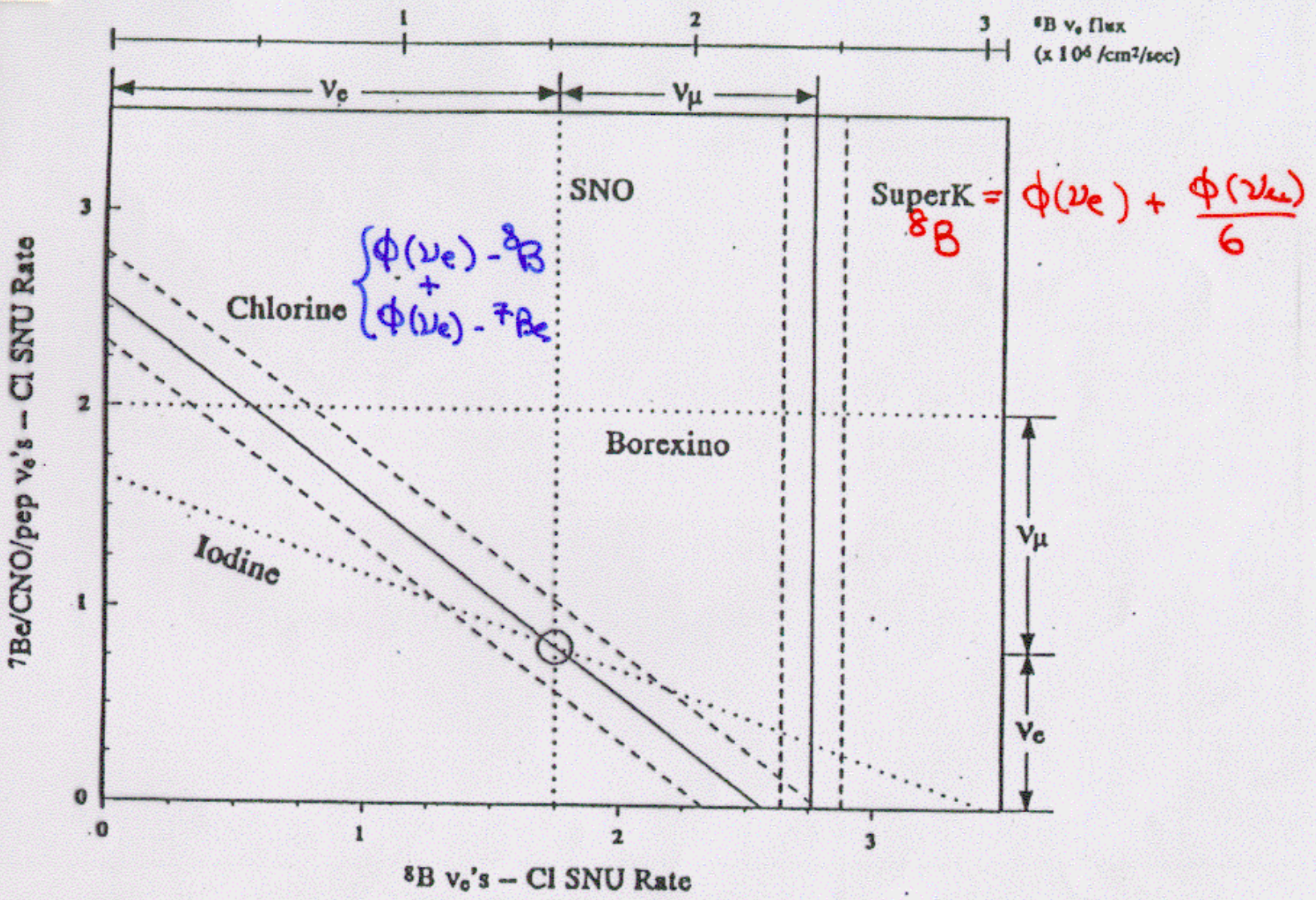
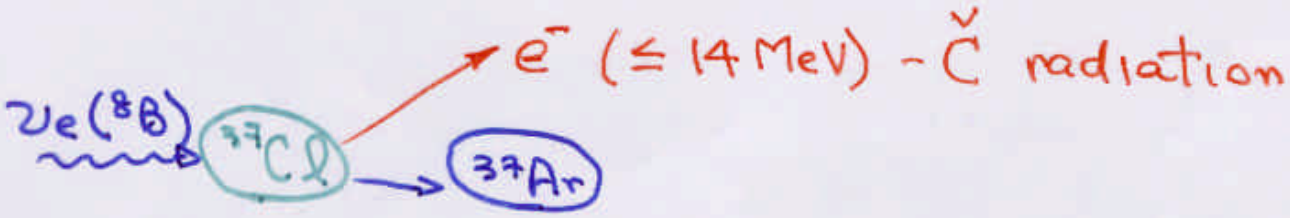
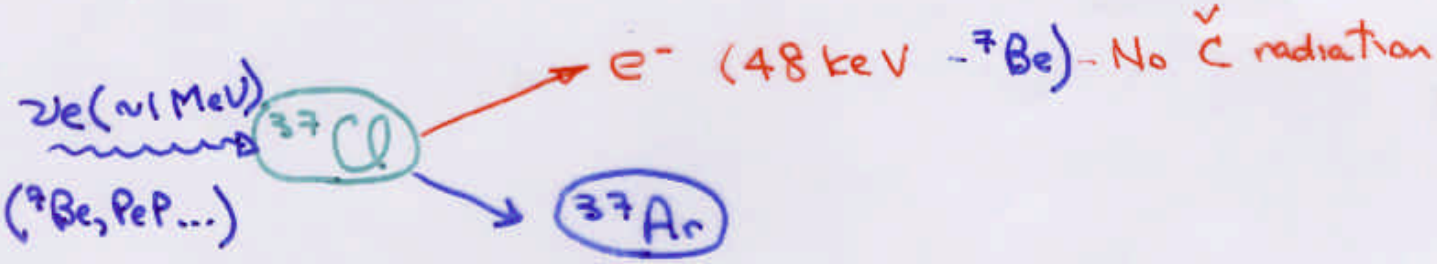
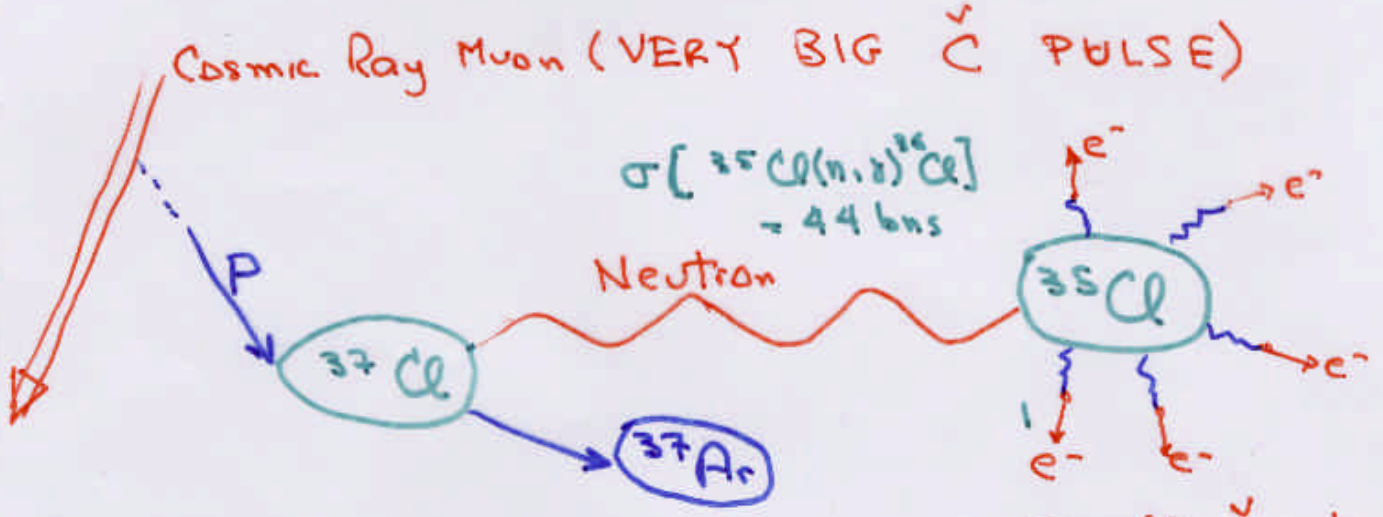

1
2
3
^{8}B ν_e flux
(x 10^6 /cm^2/sec)
ν_e
ν_μ
SNO
SuperK = $\phi(\nu_e) + \frac{\phi(\nu_\mu)}{6}$
^{8}B
Chlorine
$\phi(\nu_e) - {}^8B$
+
$\phi(\nu_e) - {}^7Be$
Borexino
Iodine
ν_μ
ν_e
^{7}Be/CNO/pep ν_e's -- Cl SNU Rate
^{8}B ν_e's -- Cl SNU Rate
0
1
2
3

^{37}Ar Production Processes







Similar Diagrams for $^{127}I \rightarrow ^{127}Xe$

$\sigma[^{127}I(n,\gamma)^{128}I] = 6.2$ bns

① CAN WE REMOVE EACH ^{37}Ar ATOM DUE TO ν_e FROM ^{8}B WHEN IT IS MADE?

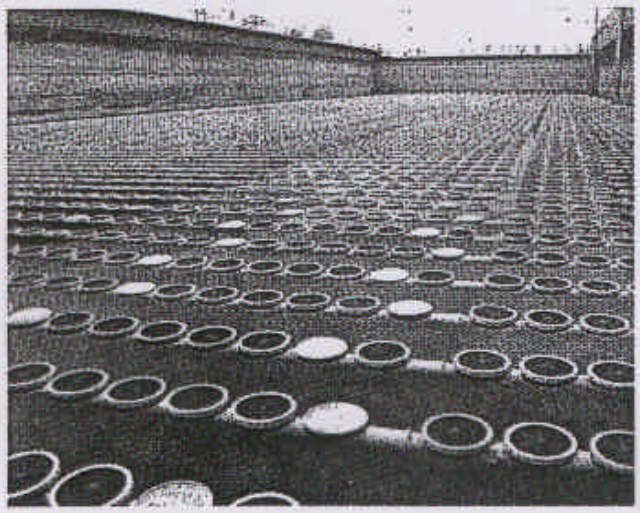
NEED:

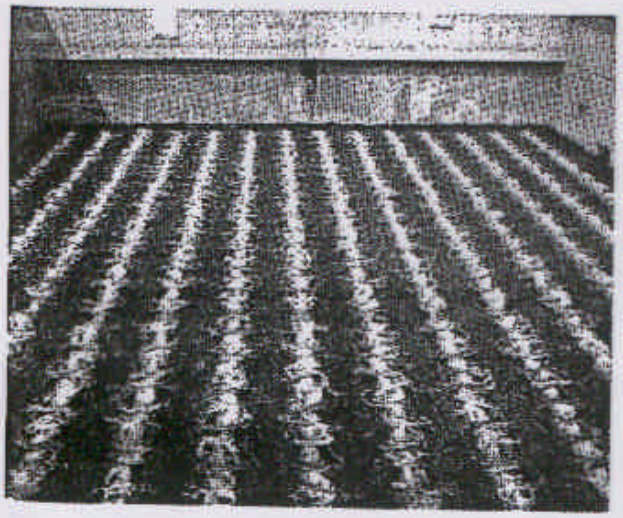
a) FAST EXTRACTION PROCESS

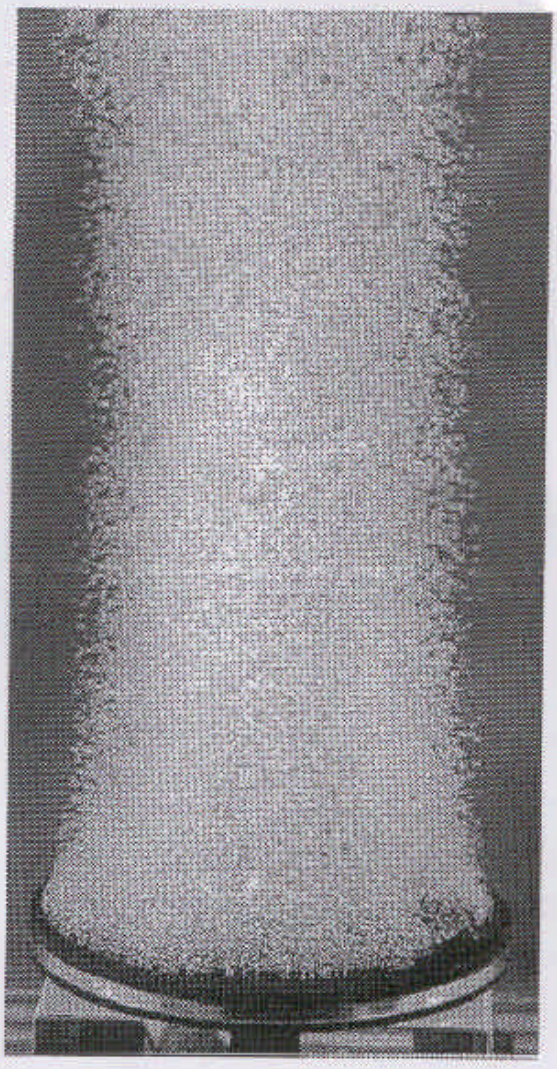
b) MULTIPLE SEGMENT DETECTOR

c) ^{8}B ν_e EXTRACTION TRIGGER

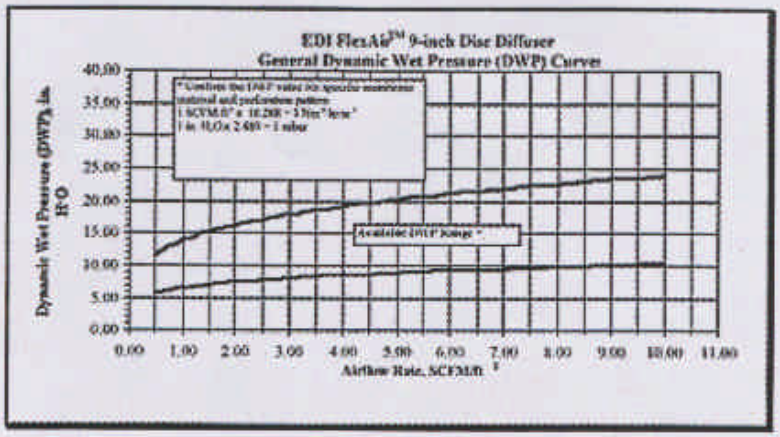
d) COSMIC RAY TRIGGER



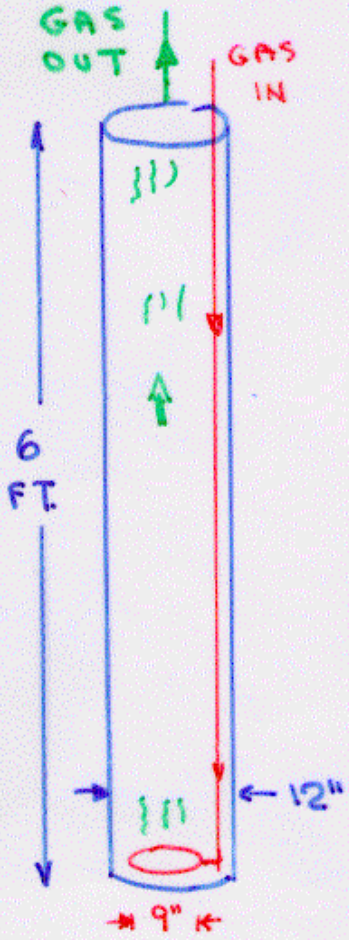




9" Disc Dynamic Wet Pressure (DWP)



GAS DIFFUSER EXTRACTION RATE



MAKE ^{127}Xe WITH Pu-Be SOURCE

1/e EXTRACTION GAS FLOW = 30 LITERS He @ S.T.P.

$$\text{GAS COLUMN HEIGHT} = \frac{30 \text{ LITERS}}{\text{DIFFUSER AREA } (410 \text{ cm}^2)} = 75 \text{ cm.}$$

SINCE DIFFUSER CAN EMIT 3 m HIGH COLUMN / min $\Rightarrow$

$\tau(1/e) \sim 15$ sec

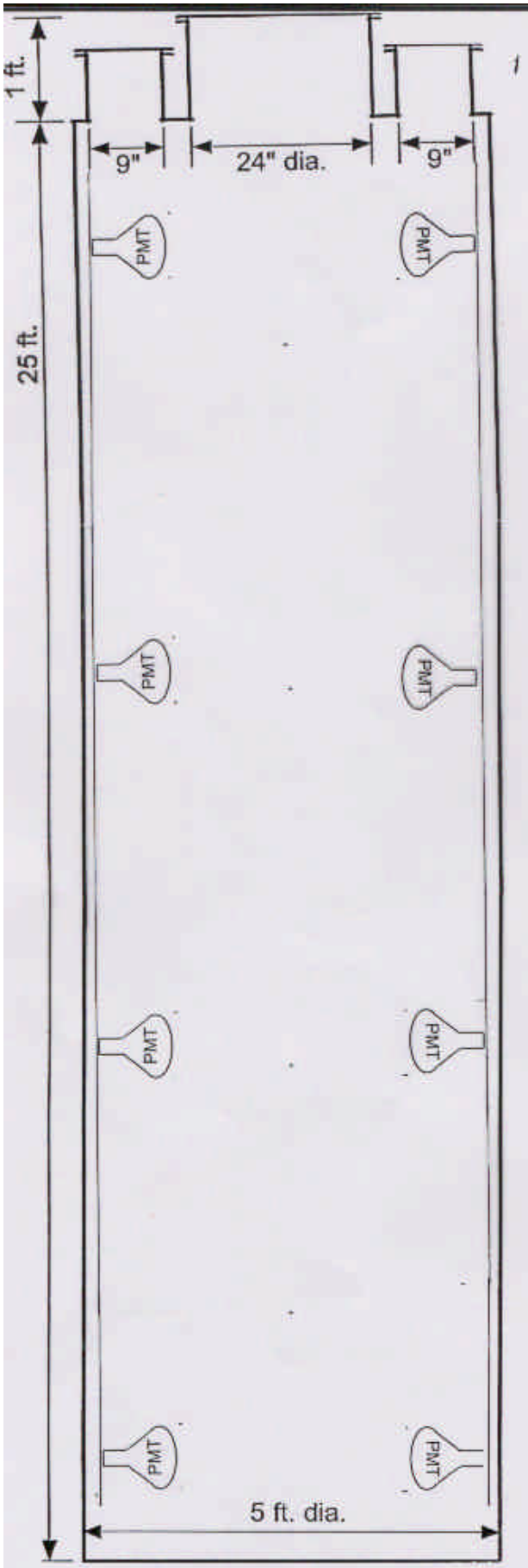
& $1 - e^{-4}$ IN $\sim$ 1 MINUTE

BUBBLE (1mm dia) RISE VELOCITY $\sim$ 20 cm/sec

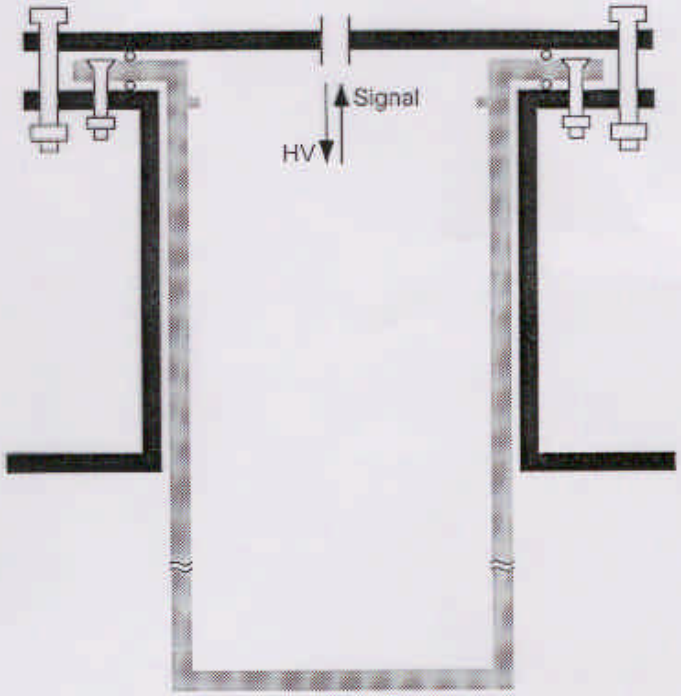
FOR 8.5 m HIGH DETECTOR - T(RISE) : 45 sec

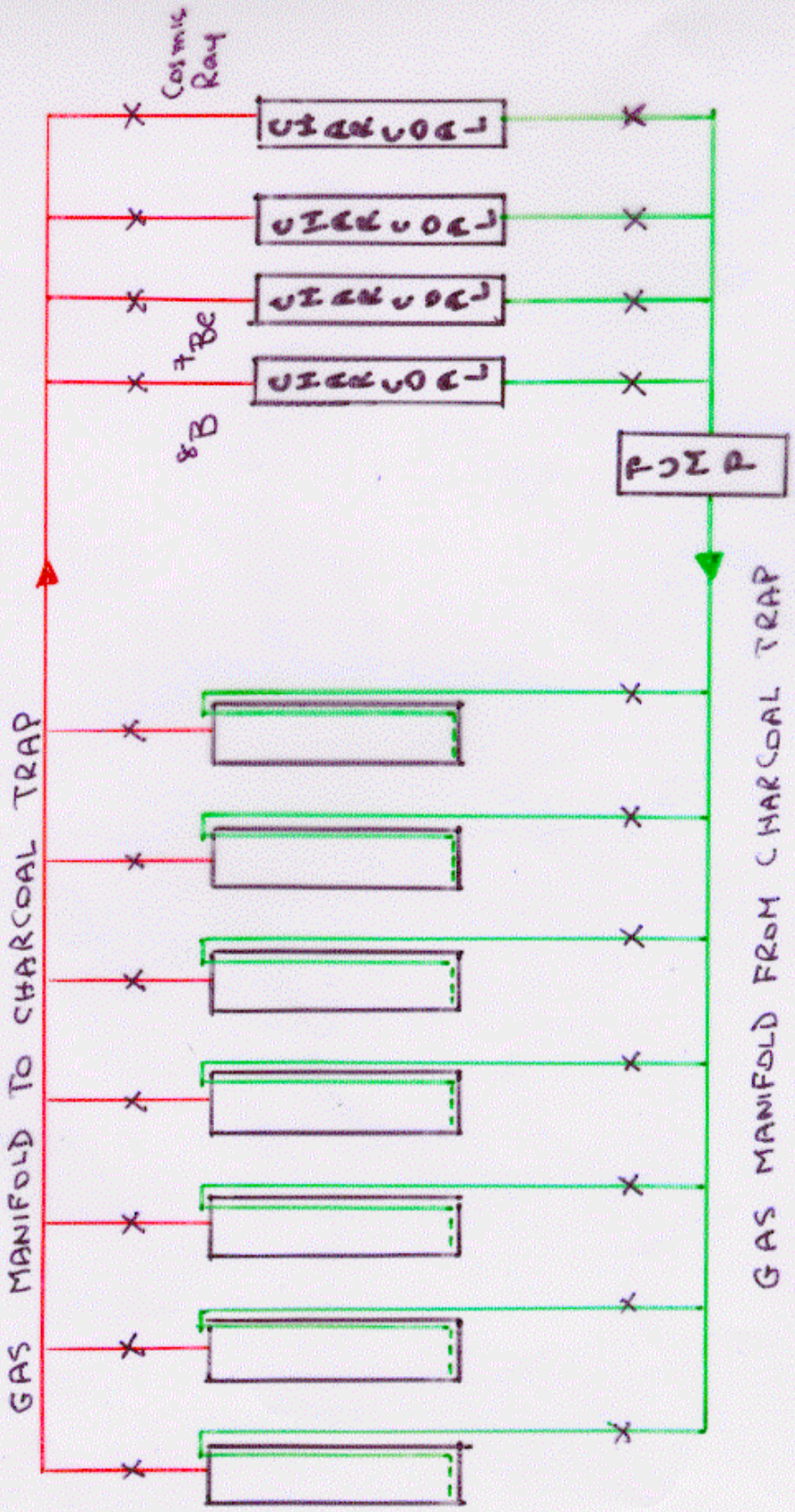
TOTAL EXTRACTION TIME = 1 min + 45 sec

$\lesssim$ 2 min


1 ft.
9"
24" dia.
9"
25 ft.
PMT
PMT
PMT
PMT
PMT
PMT
PMT
PMT
5 ft. dia.

Seal Detail


Signal
HV


Cosmic Ray
7Be
8B
GAS MANIFOLD TO CHARCOAL TRAP
GAS MANIFOLD FROM CHARCOAL TRAP

ANOTHER POSSIBILITY

ASSUME SK SIGNAL CONSISTS OF

$\phi(\nu_e) = 1.90 \times 10^6$

$\phi(\nu_\mu) = 3.25 \times 10^6$

} $\Sigma = \phi(^8B)$ from BP98

SINCE $\sigma(\nu_\mu + e^- \rightarrow\ ) = \frac{1}{6}\sigma(\nu_e + e^- \rightarrow\ )$

THE OBSERVED INTERACTION RATE WILL BE

$(\nu_e) \qquad (\nu_\mu)$

$1.90 + \frac{3.25}{6} = 1.90 + 0.54 = \underline{2.44}$

$\phi(\nu_e) = 1.90 \times 10^6 \Rightarrow 2.17$ SNU (Cl)

DETECTION RATES

CASE (1) $\phi(\nu_e)$ from $^7Be = 0 \Rightarrow$ Cl signal all ^8B

SK- $\phi(\nu_e) = 2.44 \pm 0.09 \times 10^6$ /cm²sec

	C_2Cl_4 ^{37}Cl	NaI + H_2O ^{127}I
1 MODULE	24 TONS 5.3 TONS	24 TONS 9 TONS
# TARGET ATOMS	8.7×10^{28} ^{37}Cl	5×10^{28} ^{127}I
^8B- ν_e int/day-module	.02	.04

TOTAL RATE IN 50 MODULES: 1/DAY; 2/DAY (500 TONS ^{127}I)

CASE (2) SK $\begin{cases} \phi(\nu_e) = 1.9 \times 10^6 \\ \phi(\nu_\mu) = 3.25 \times 10^6 \end{cases}$ $\left(1.9 + \frac{3.25}{6} = 2.44\right)$

Now Cl has 2.16 SNU ^8B + 0.4 SNU ^7Be

^8B RATE	0.94/DAY (300/YR)	1.7/DAY (620/YR)
^7Be RATE	0.15/DAY	0.41/DAY
	55/YR	150/YR

FOR 3 YEARS OF DATA

& ASSUMING THAT 60% OF PRODUCED ATOMS ARE COUNTED

	^{37}Cl	^{127}I
^{8}B - Case (1)	657	1314
^{8}B - case (2)	552	1117
Δ	$= 105 \pm 35$ (3σ)	197 ± 49 (4σ)
^{7}Be	$= 100 \pm 10$ (stat)	270 ± 16 (stat)
Cosmic Ray + Neutron Bkgnd	$\sim 60\text{-}70$	~ 5

$\bar{\nu}_e$ DETECTION IN IODINE DETECTOR

($NaI + H_2O$) DOUBLE PULSE PATTERNS

① $\bar{\nu}_e + {}^{23}Na \rightarrow {}^{23}Ne + e^+$ ($E_{th} = 4.4$ MeV)

followed by ($\tau_{1/2} = 37.6$ sec)

${}^{23}Ne \rightarrow {}^{23}Na + e^- + \bar{\nu}_e$

② $\bar{\nu}_e + p \rightarrow n + e^+$

followed by ($\tau_{mod} \sim 300$ μ sec)

$n + {}^{127}I \rightarrow {}^{128}I + \gamma$ (~ 8 MeV) $\sigma = 6.2$ b

$\gamma + e^- \rightarrow \gamma + e^-$

○ ≡ CERENKOV RADIATORS

HAXTON (1988)

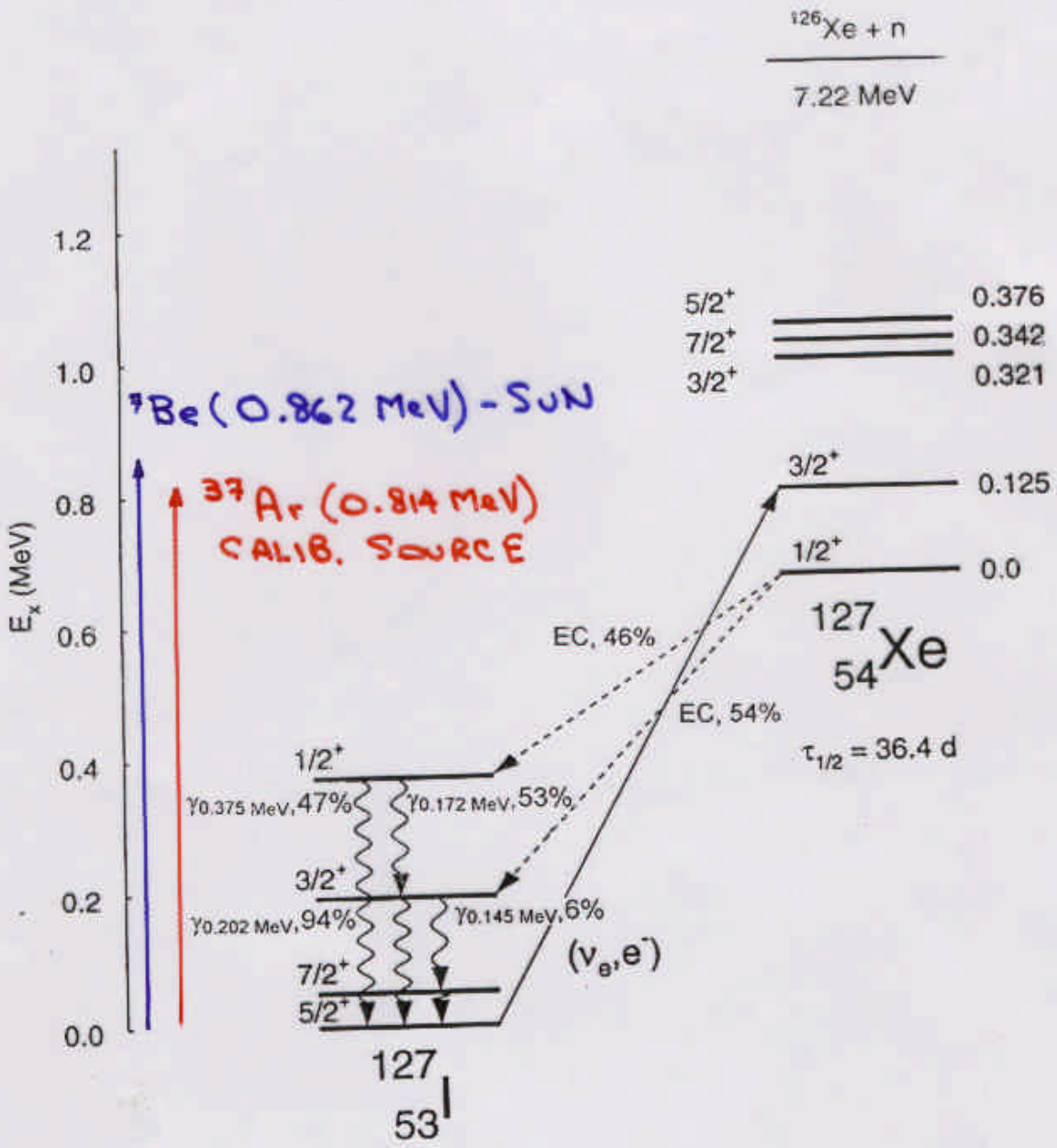
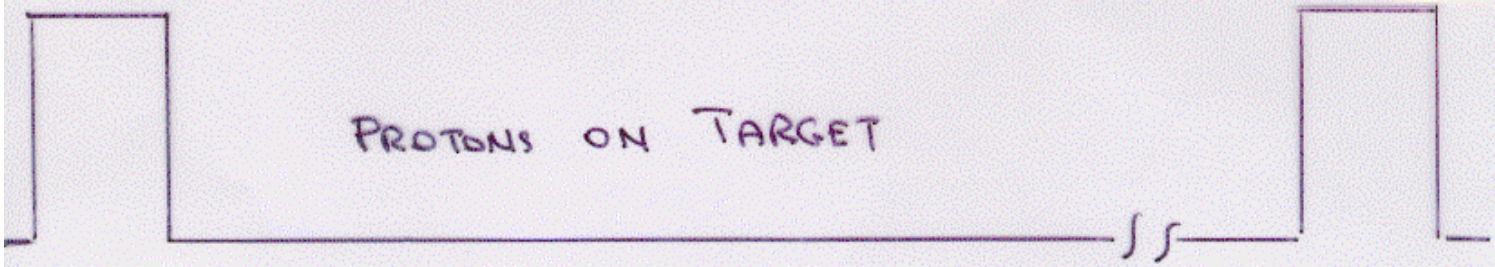
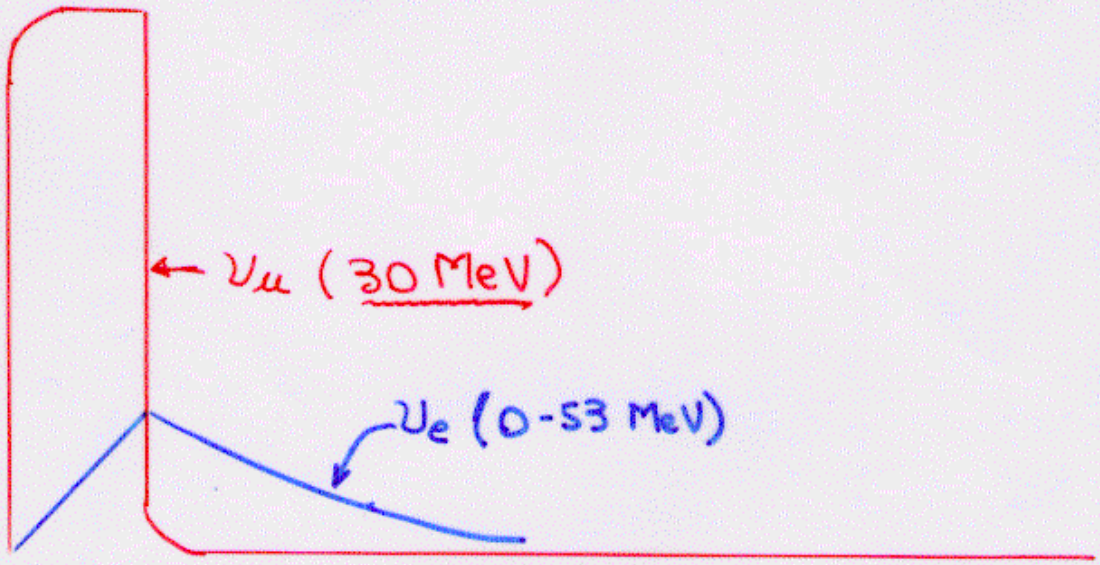


Figure 1.4 Decay scheme for ^{127}Xe $\rightarrow$ ^{127}I. The decay proceeds via electron capture. The absence of a ground state to ground state transition means that ^{127}Xe decays to an excited state of ^{127}I. Deexcitation of the ^{127}I nucleus results in nuclear gamma rays in the proportions and energy shown.

SNS NEUTRINO

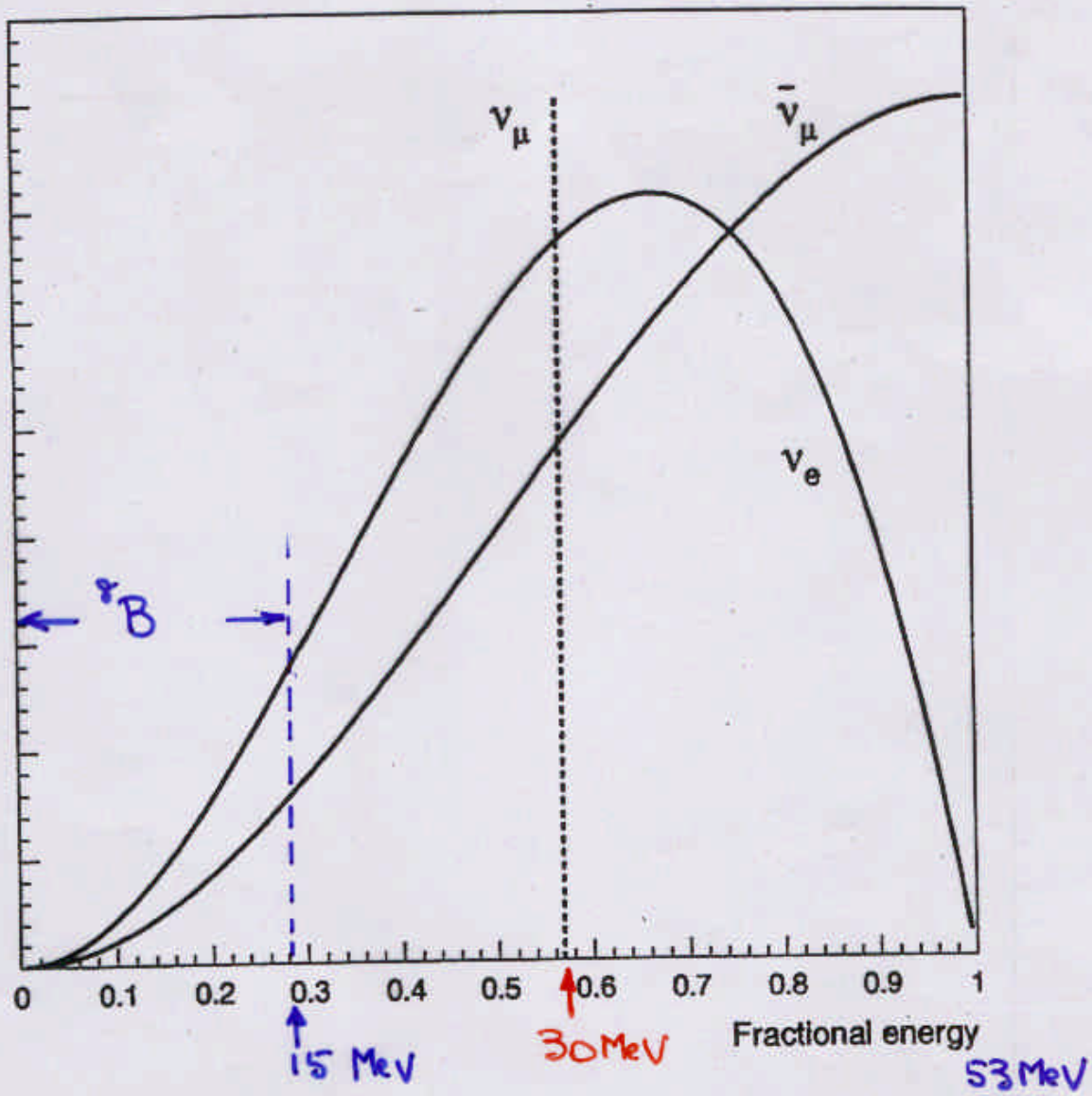




8 CHARCOAL TRAPS

ENERGY	τ_1 (0-650ns)	τ_2 (650ns - 10μs)	τ_3 (10μs - 1ms)	τ_4 (1ms - 16ms)
53 to 15 MeV	$\nu_\mu \to \nu_e$ TEST REGION	σ (ν_e - SUPER-NOVA		
15 to 0 MeV	EARLY ν_e - COMPARE TO TOP	$\sigma[\nu_e + {}^8B]$	N bkgnd	C.R backgnd

ν_μ ν_e NEUTRONS COSMIC RAYS


ν_μ
$\bar{\nu}_\mu$
ν_e
^8B
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Fractional energy
15 MeV
30MeV
53MeV

POSSIBLE LAYOUT OF HYBRID DETECTOR AT SNS