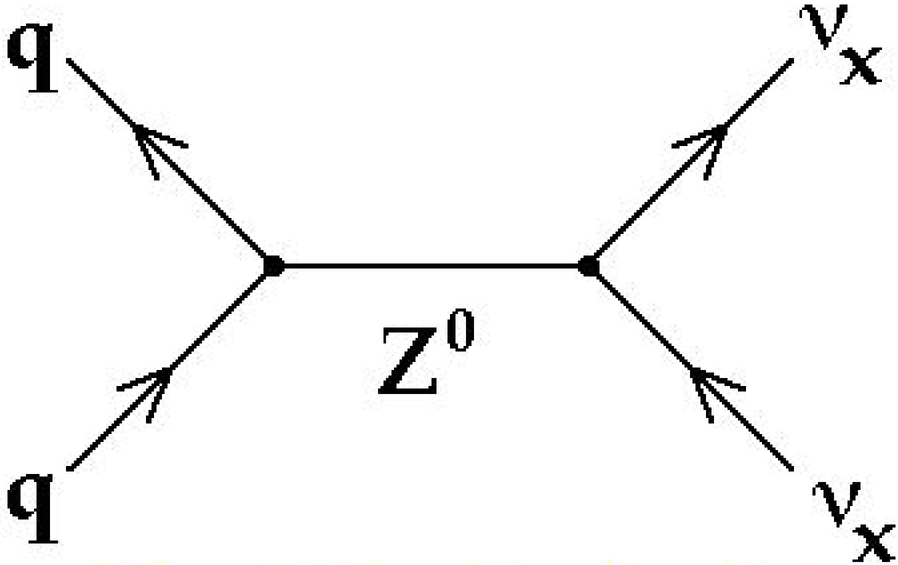
Neutral-Current Detection at SNO



Something New Under the Sun?

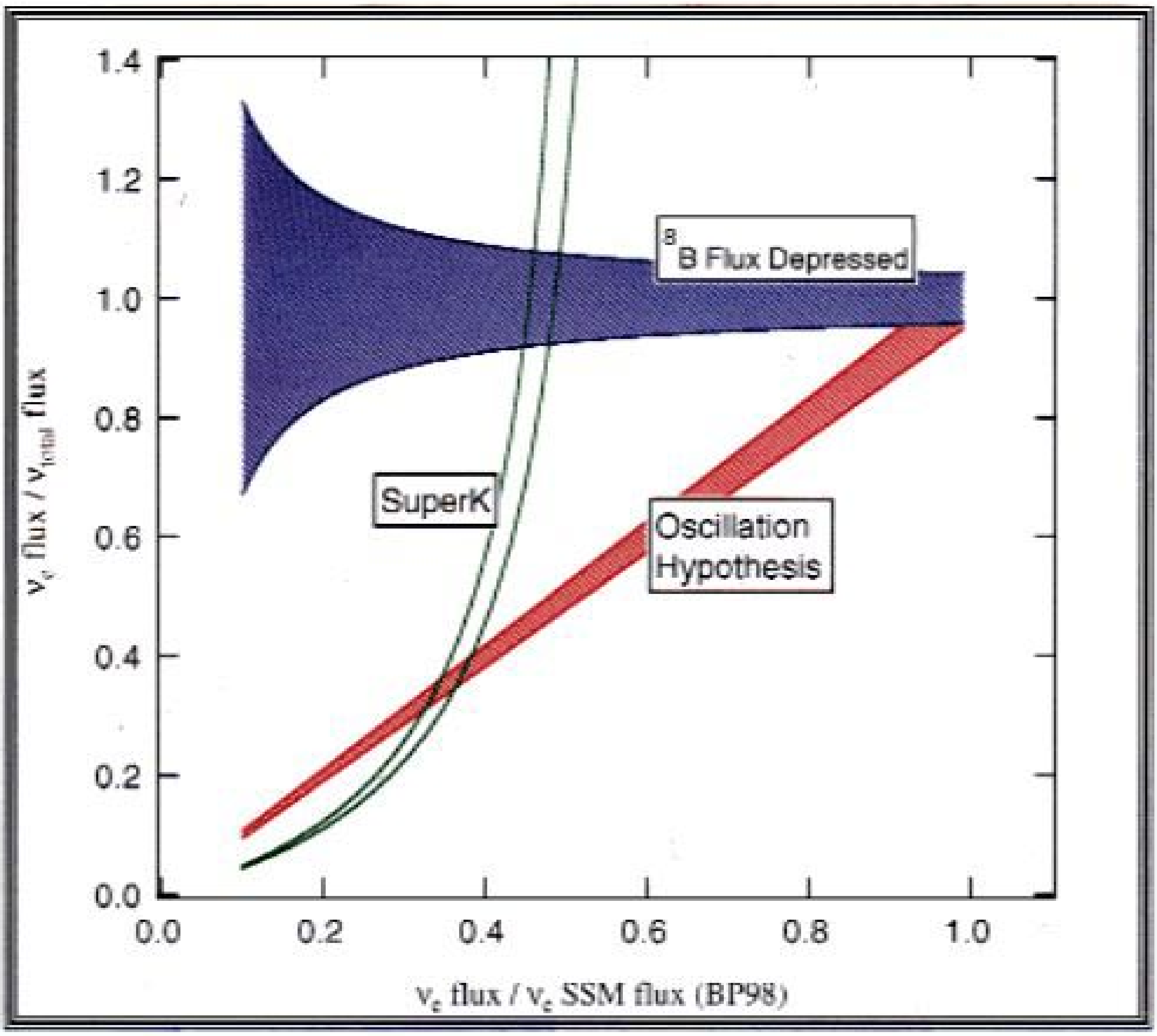
Tom Steiger

(on behalf of the NCD Group and the SNO Collaboration)

INT Workshop on Neutrino Physics
University of Washington

July 27, 1999

CC/NC Ratio
1 Year



photodisintegration neutrons: 900/year
CC efficiency: 0.61, CC run time: 1 years
NC efficiency: 0.45, NC run time: 1 years

STEVE ELLIOTT 99

SuperKamiokande result from WIN99 (708 days)

Outline

- Overview of Neutral-Current Options
  - Pure D_2O
  - Additives
  - The Question
- Neutral Current Detectors (NCDs)
  - Construction, installation, etc.
  - Background measurements
  - Status

Options for NC Detection

Pure D_2O

- **Capture on deuterium** $^{2}H(n,\gamma)^{3}H$
  - ~32 - 37% capture efficiency
  - Use radial dependence to discriminate NC & CC

PROS:

- Technologically simple
- No sources of background added to detector

CONS:

- 6.25 MeV γ near threshold
- No event-by-event discrimination of NC & CC
- Not systematically independent from CC
- Statistics aren't great

- **SNO + Super-K** $R_{SK}(CC_{SNO}, NC_{SK})CC/NC$

PROS:

- As above

CONS:

- Not an independent measurement

Options for NC Detection
Additives

- **MgCl salt** $^{35}Cl(n,\gamma)^{36}Cl$
  - ~84% capture efficiency

PROS:

- Technologically (relatively) simple
- High efficiency
- 8.6 MeV γ well above threshold

CONS:

- Radial dependence lost
- No event-by-event discrimination of NC & CC
- Not systematically independent from CC

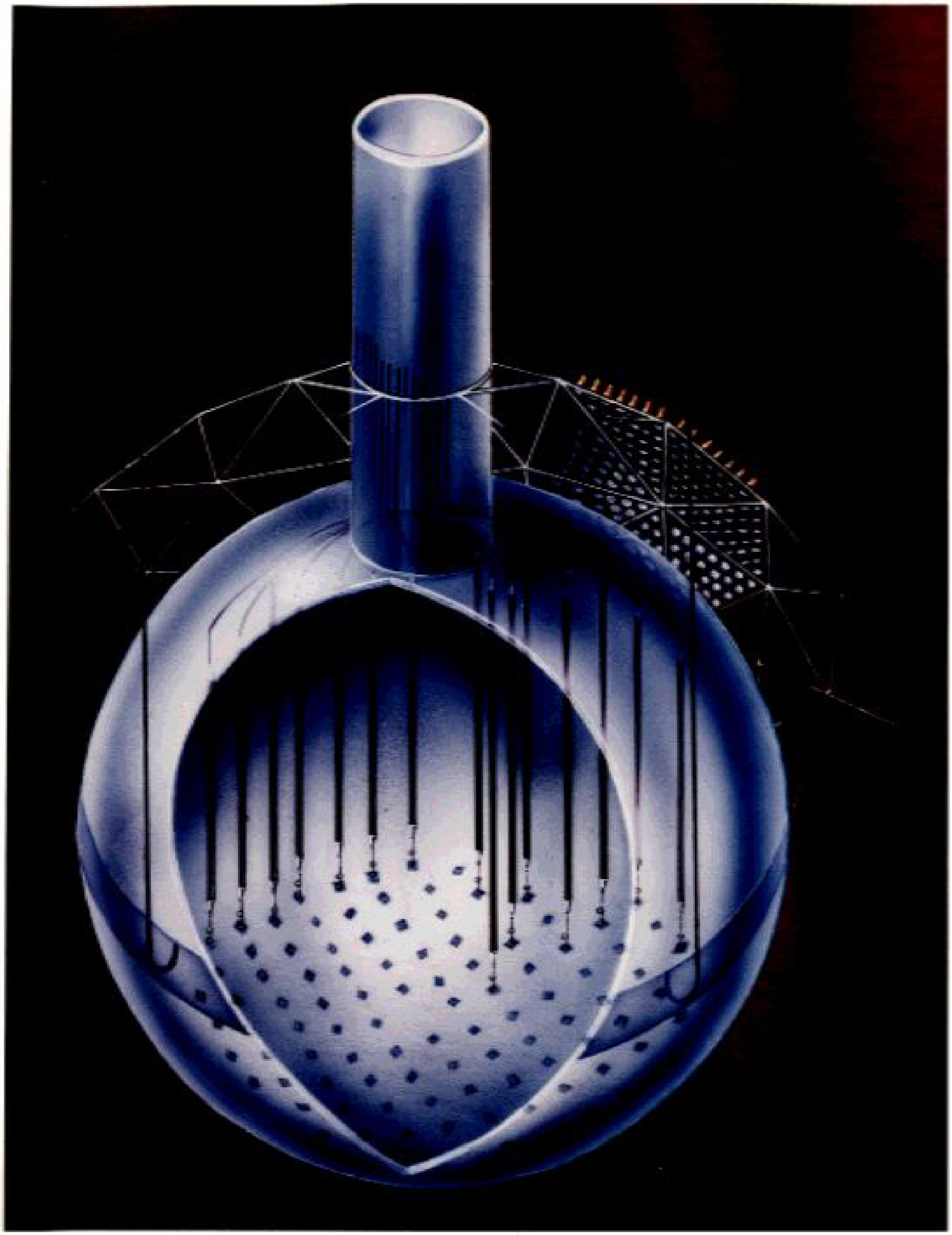
- **NCDs** $^{3}He(n,p)^{3}H$
  - ~45% capture efficiency

PROS:

- Event-by-event discrimination of NC & CC
- Systematically independent from CC

CONS:

- Technologically complicated
- Occlude ~15% CC light
- Must shut detector down for ~1 month to install



Chemical Vapor Deposition (CVD)

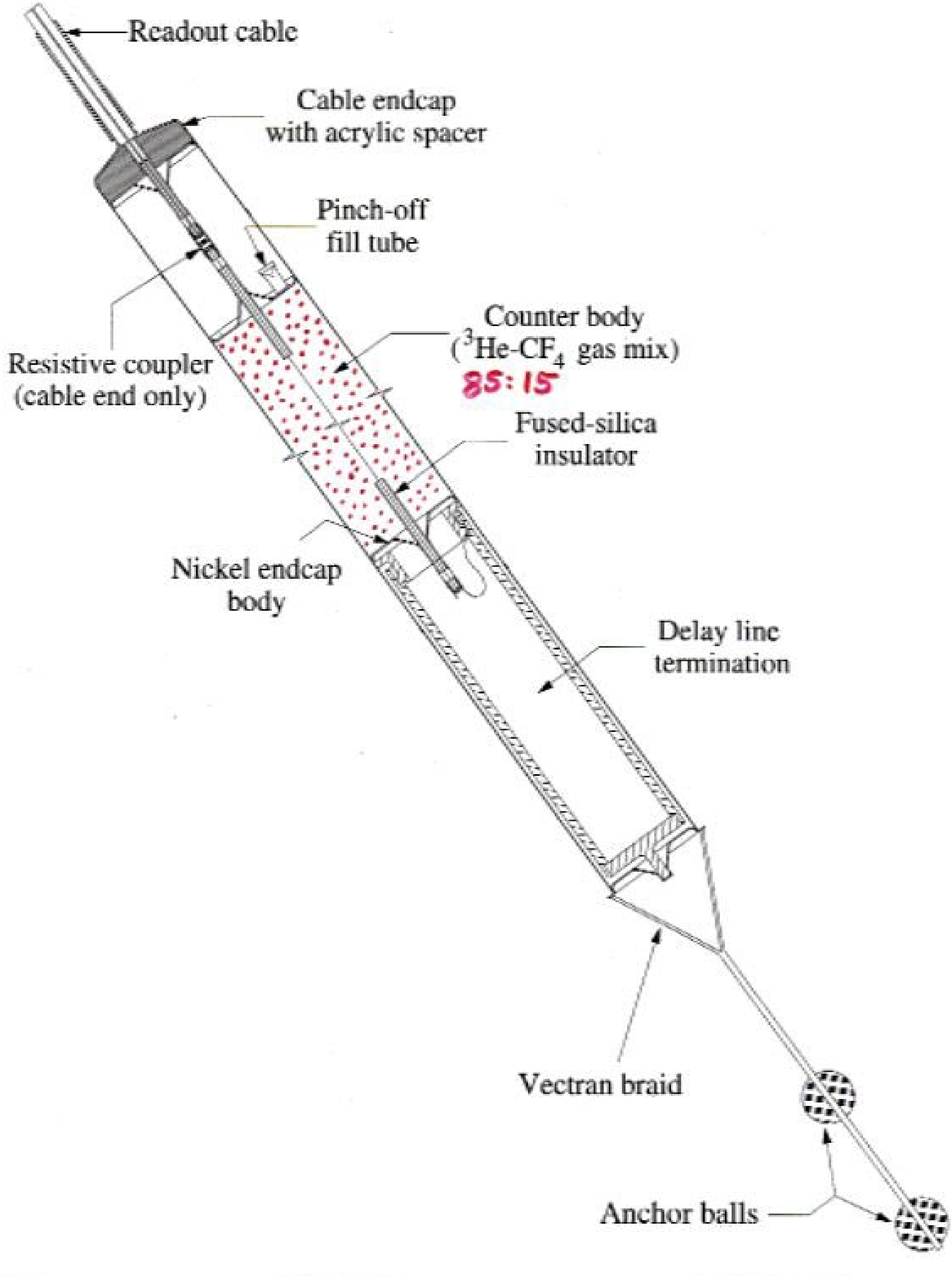
~100° C: $Ni + 4CO \longrightarrow Ni(Co)_4$

~200° C: $Ni(CO)_4 \longrightarrow Ni + 4CO$

Very few elements form carbonyls
U, Th, Ra, and Pb, in particular, do NOT

NO other element has a reversible carbonyl reaction in this temp. range

CVD Ni contains <2 ppt Th !

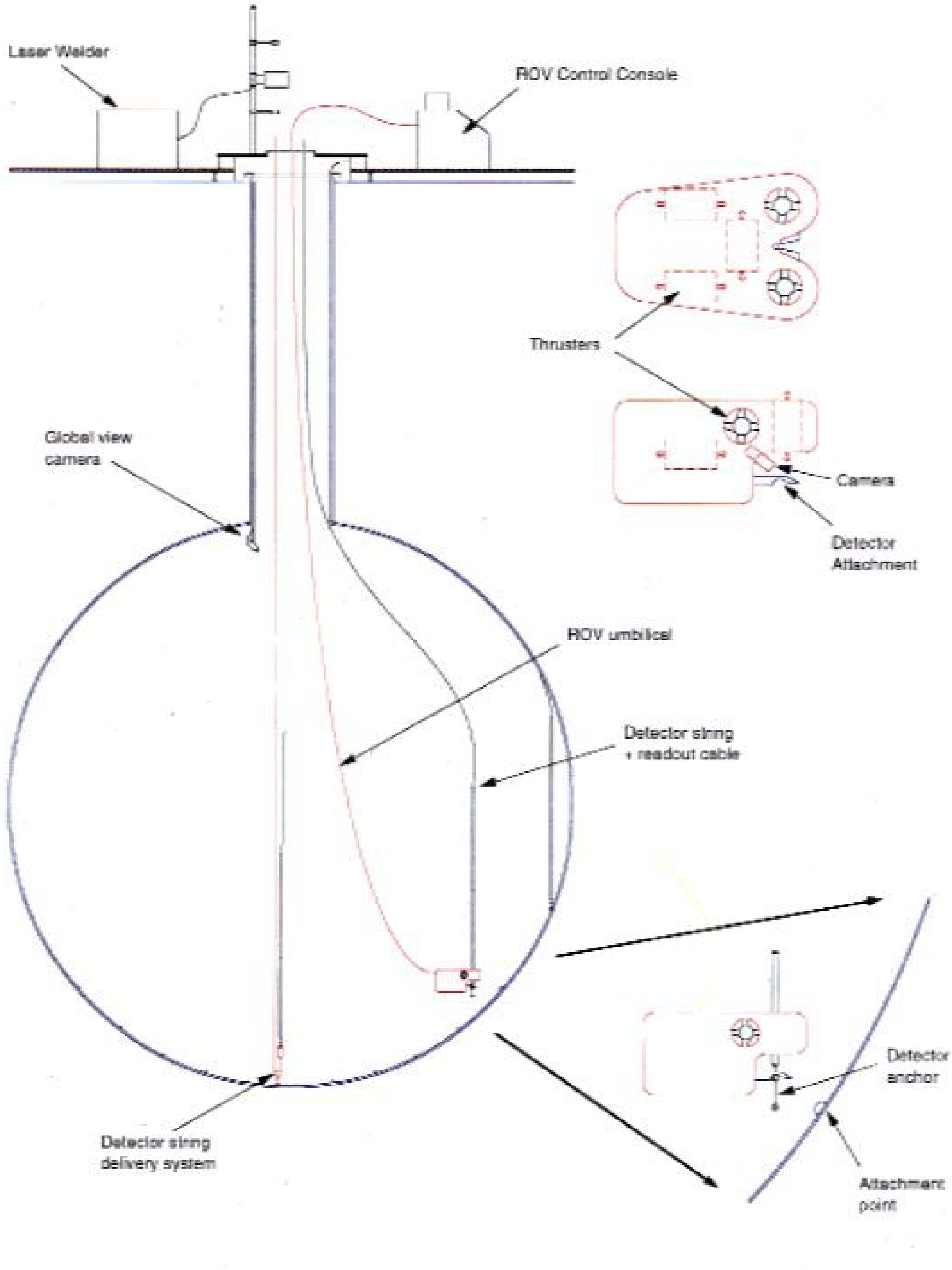


Readout cable
Cable endcap
with acrylic spacer
Pinch-off
fill tube
Counter body
(^{3}He-CF_4 gas mix)
85:15
Resistive coupler
(cable end only)
Fused-silica
insulator
Nickel endcap
body
Delay line
termination
Vectran braid
Anchor balls

NCD Executive Summary

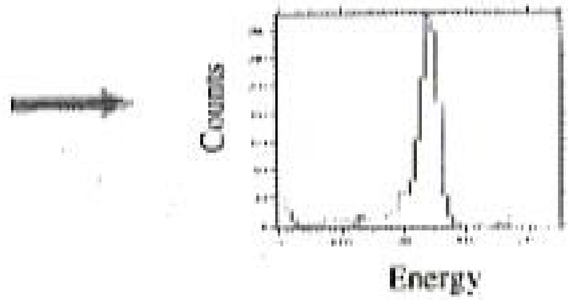
- 300 counters
- 96 strings on a 1-m lattice
- 770 m total active length
- ~2200 neutrons/year (SSM) total
- ~1000 neutrons/year (SSM) in background free region
- ~100 counters underground (7/99)

SCHEMATIC OF ROV DEPLOYMENT HARDWARE

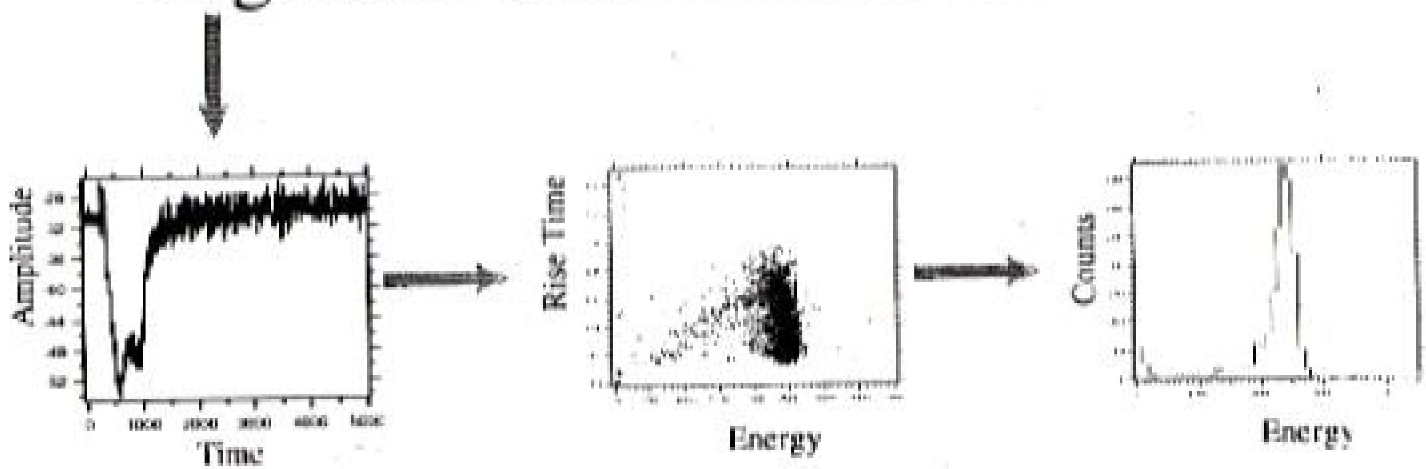


NCD Data Formats

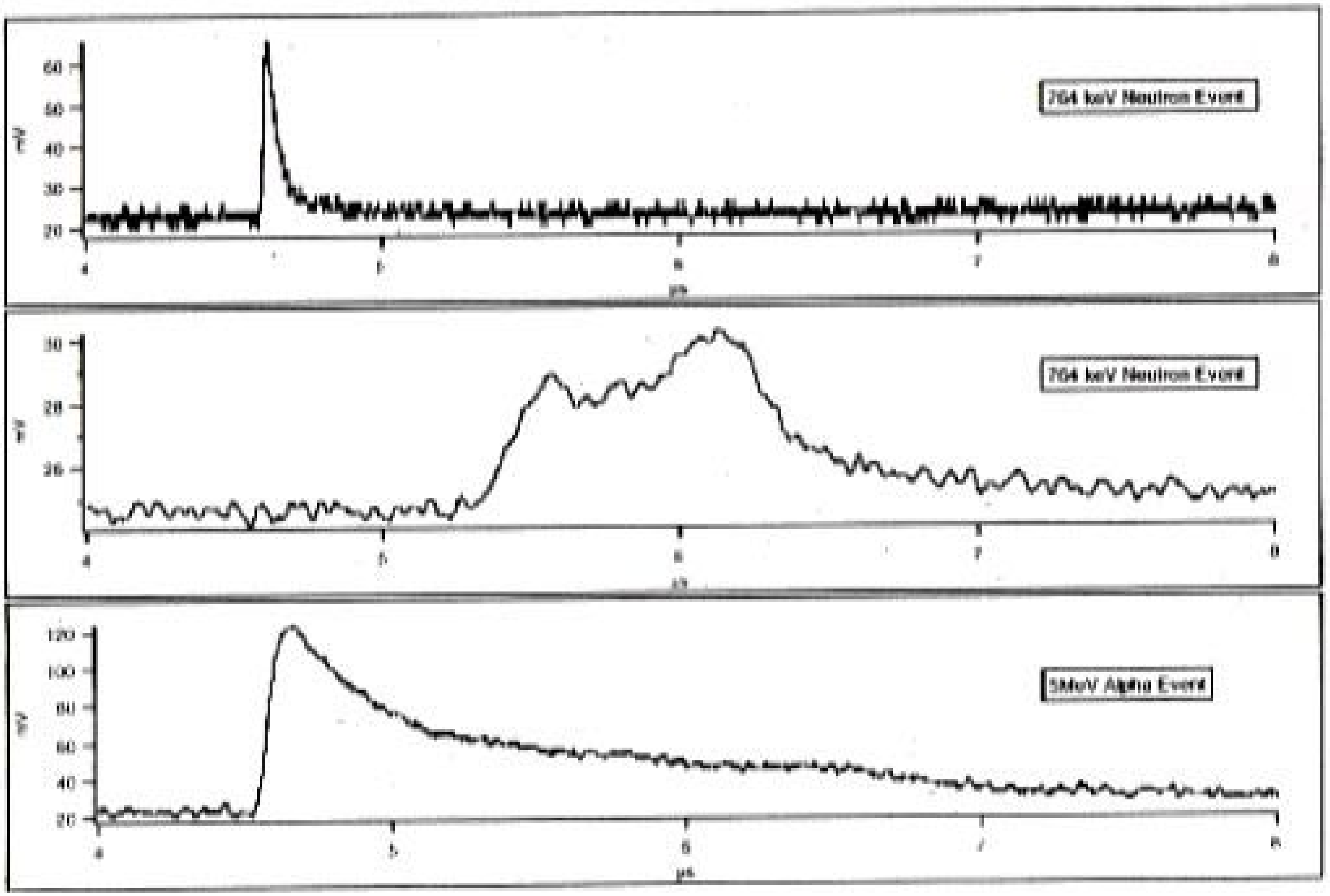
- ADC Data



- Digitized Waveform Data



Cooldown Phase Detector Events

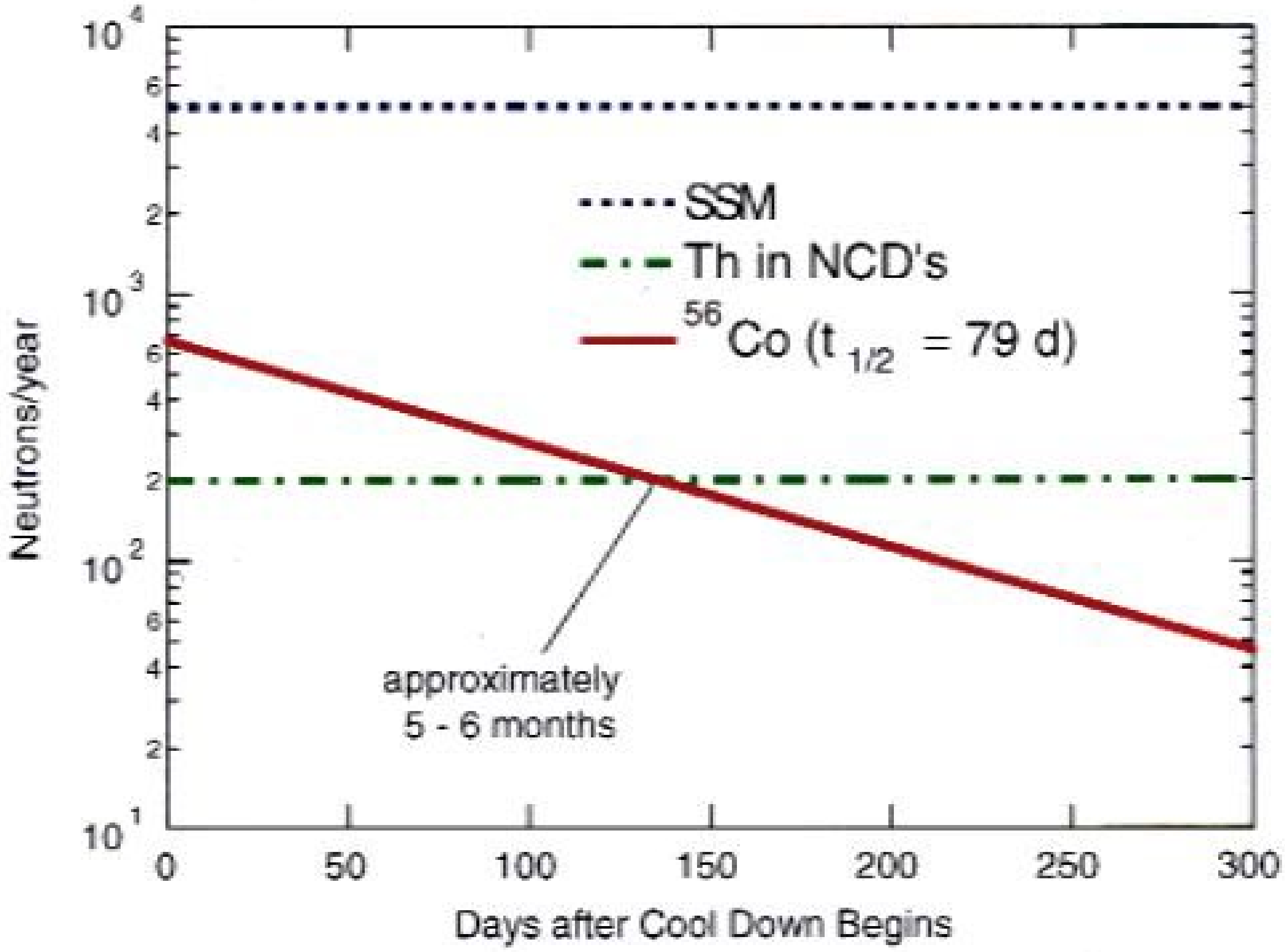


Neutral Current Detector Events

NCD Background Sources

- ^{56}Co
- ^{3}H
- ^{208}Tl (Th) and ^{214}Bi (U)
  - Radio-assay
  - Direct measurement of α particles
  - CHIME
  - Cerenkov light
  - $\beta-\gamma$ or β-n coincidences

Photodisintegration Neutrons from Cosmogenic ^{56}Co

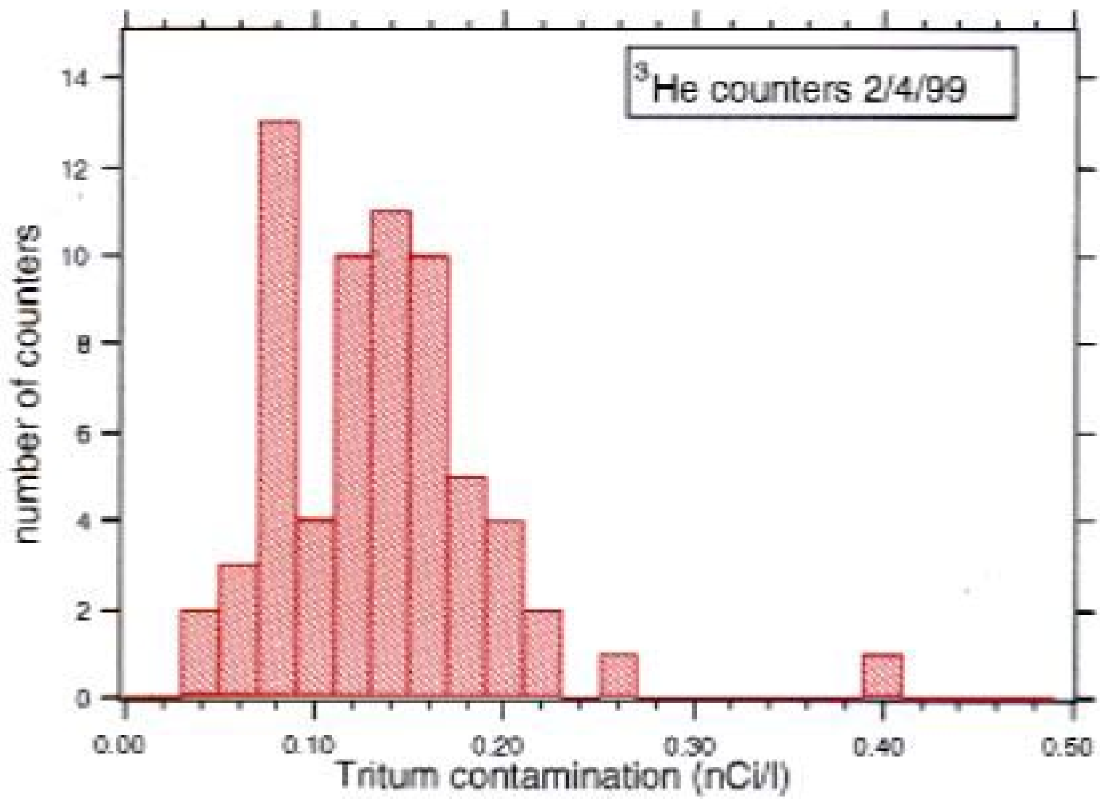


Tritium Contamination

Target activity: 1% probability for an event in 10μs integration window

OR

2.7 nCi/STP-liter



NCD Construction Hardware In-Situ Monitoring Experiment (CHIME)

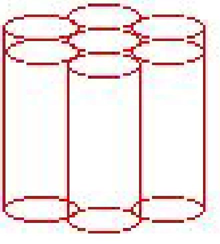
Background Test

- In-situ measurement of the photodisintegration background from the NCD array:

$^{208}Tl \rightarrow {}^{208}Pb$, E= 2.615 MeV
$^{214}Bi \rightarrow {}^{214}Po$, E= 2.445 MeV
$^{56}Co \rightarrow {}^{56}Fe$, E= 2.224 MeV

Design

- 7 close-packed NCDs
- construction materials and procedures identical to NCD array



Source Deployment

- CHIME is negative buoyant and can be deployed using the calibration source manipulator system