

The Particle Tracking Silicon Microscope PTSM

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Particle Tracking Silicon Microscope (PTSM)

Goal: Develop a versatile and inexpensive particle tracking system for

- broad-beam and micro-beam irradiations
- Protons, alpha particles and heavy ions
- wide range of energies (1 MeV - 70 MeV protons)
- *in vitro* and *in vivo* radiobiological studies
- research studies for radiation therapy and protection
- support of DOE and NASA low-dose research programs

Implementation is based on Silicon Microstrip Detectors SSD

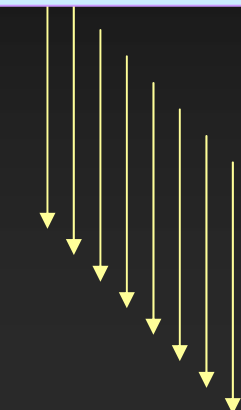
- Combined measurement of position, angle and energy / LET of single particles
- High spatial resolution (10's of microns)
- Fast response, high particle rate, self-triggering, time-resolved measurements
- Radiation hardness
- Simple operation (e.g. low voltages), no consumables, compact

Particle Tracking Silicon Microscope (PTSM)

Protons produce damage AND identify damaged cell

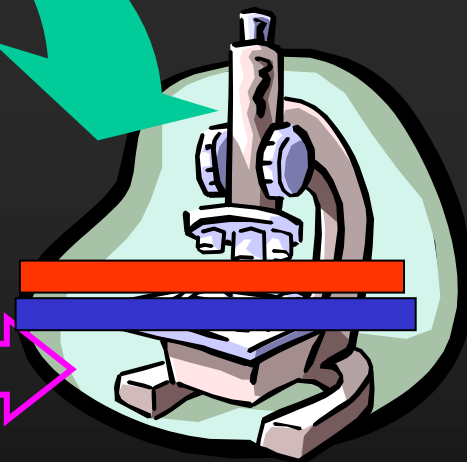
Organism in liquid or dry phase
(directly on SSD)

Double-sided SSD:
x-y coordinate, Energy,
“Cluster characteristics”.



Transfer to Automated
Microscope when
Occupancy ~ 10%

Assay with
Automated
Microscope using
stored x-y coordinates

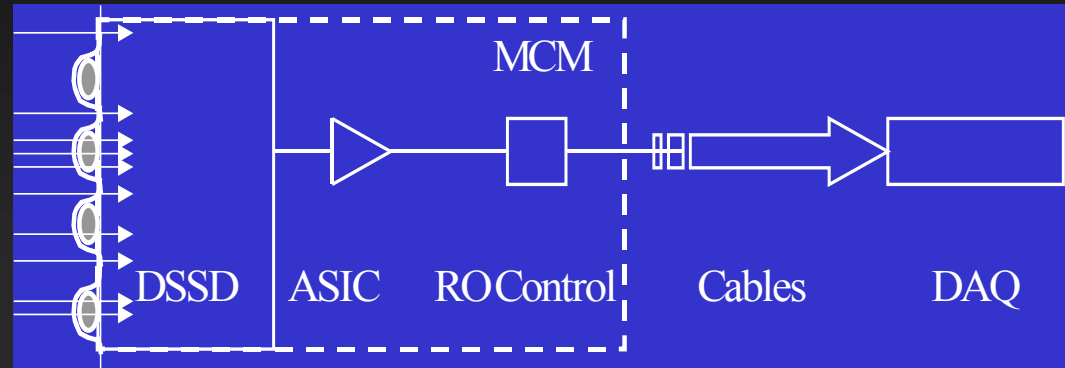


Allows delivery of radiation, with planned location and intensity

Particle Tracking Silicon Microscope

Conceptual design of readout

Critical Issue: speed



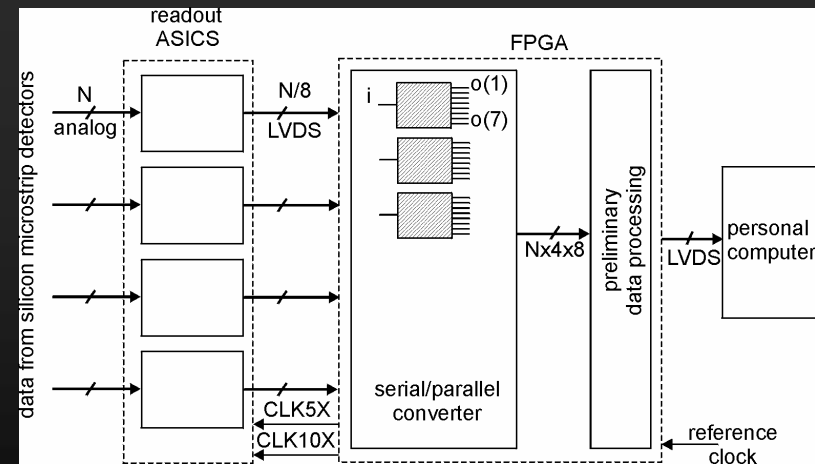
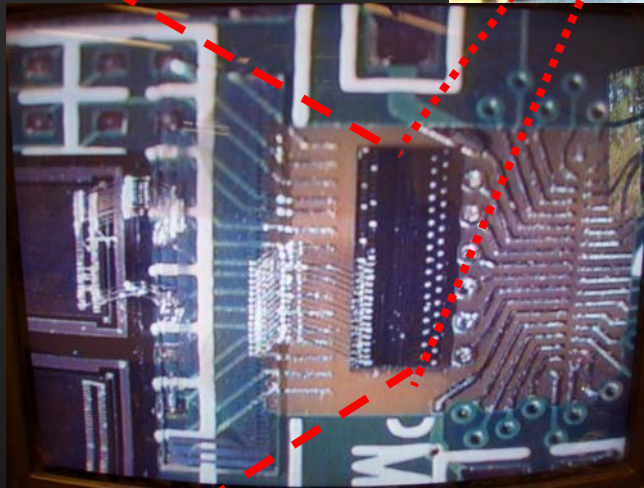
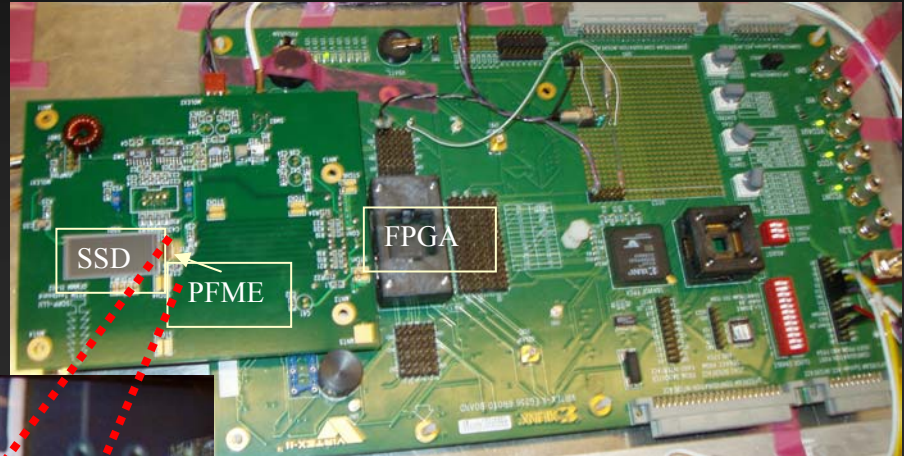
	Detector	ASIC	FPGA	Transm.	I/O
BW [MHz]	100	30	800	100	20
Apply Parallel Processing Techniques in ASIC/FPGA					
Low Noise/Low Power ASICs, LVDS drivers					

PTSM Electronics System

Hardware:

Modular

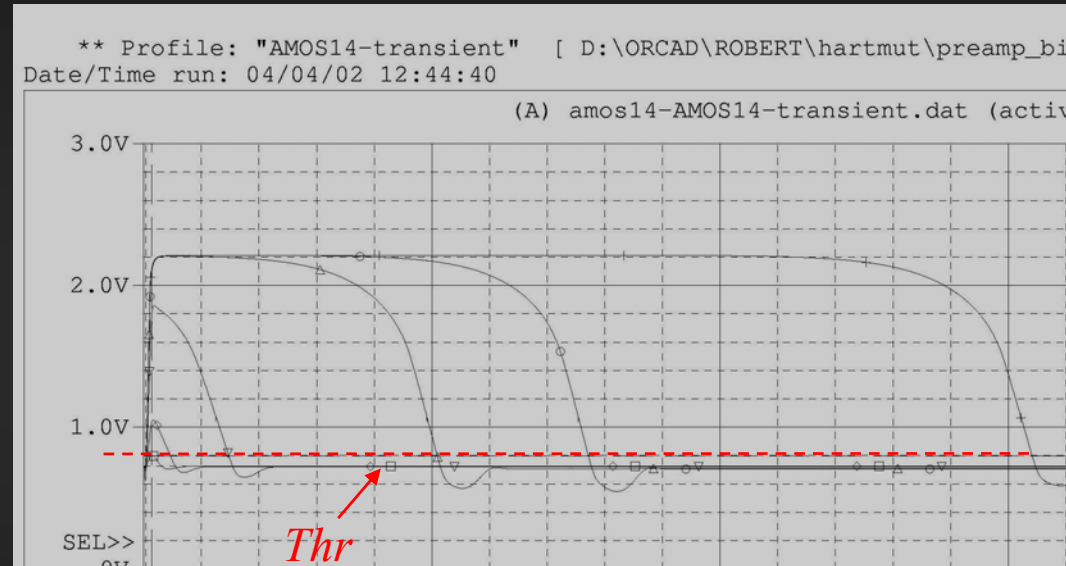
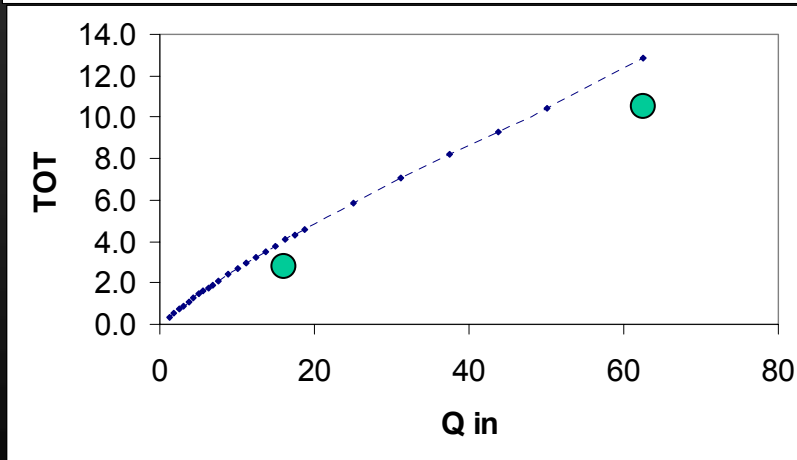
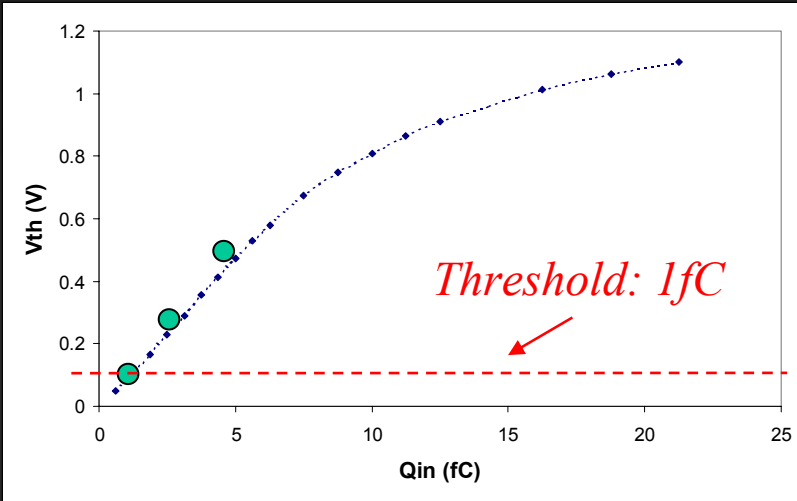
Commercial (amap)



New ASIC PMFE

Binary readout (one threshold),
Selectable Negative and Positive Signal polarity.

Gain: Threshold vs. Charge



Time-over-Threshold TOT
measures charge.

Linear Relationship
TOT Saturation at 300 fC

Important Practical Questions

Can we separate SSD / Frontend from local readout?

SSD carries biological samples directly.

Can a connector be made between the (expendable?) SSD and the more expensive readout controller, which has to be provided only once to the lab.

YES!

(use LVDS drivers)

Can *C. elegans* and Silicon Co:exist?

Place directly on the silicon detector:

worms

gel

saline solution

Measure

leakage current (long-term)

noise (very sensitive)

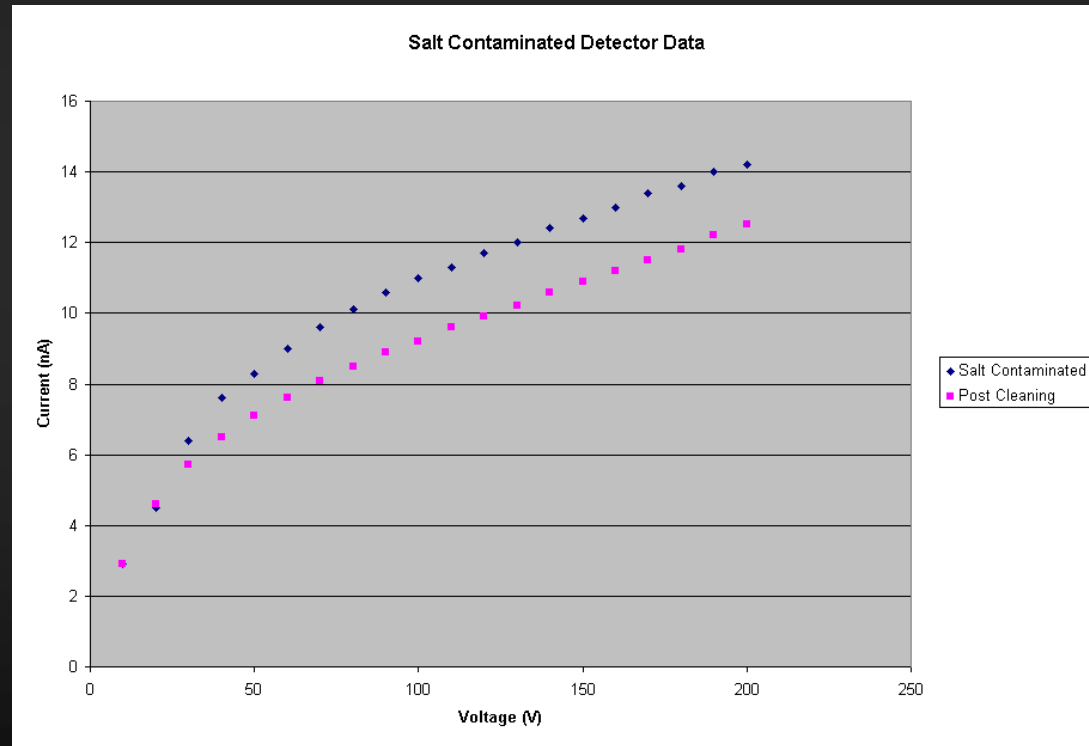
Sodium and SSD

Kamal Prasad UC Santa Cruz Senior Thesis 2001:

“Detector 5 was sprayed with a salt solution made of 5g of NaCl and 500ml of de-ionized water.

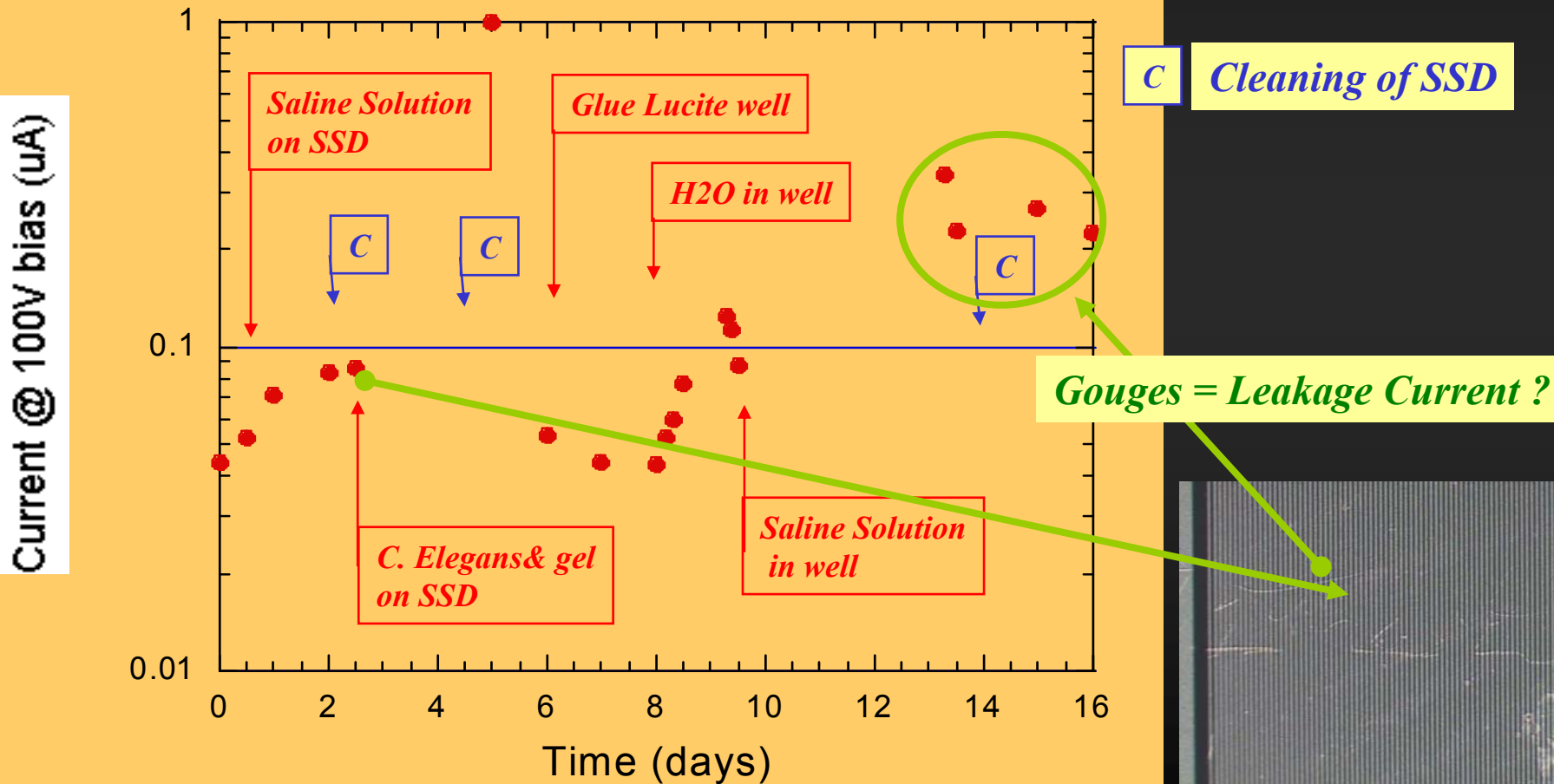
After seven days, the detector was cleansed using ultra-sonic cleaner and de-ionized water. While we expected the salt contaminated detector to break down [7], an I-V curve for the detector showed it to be functioning normally.

This was quite a surprise. “



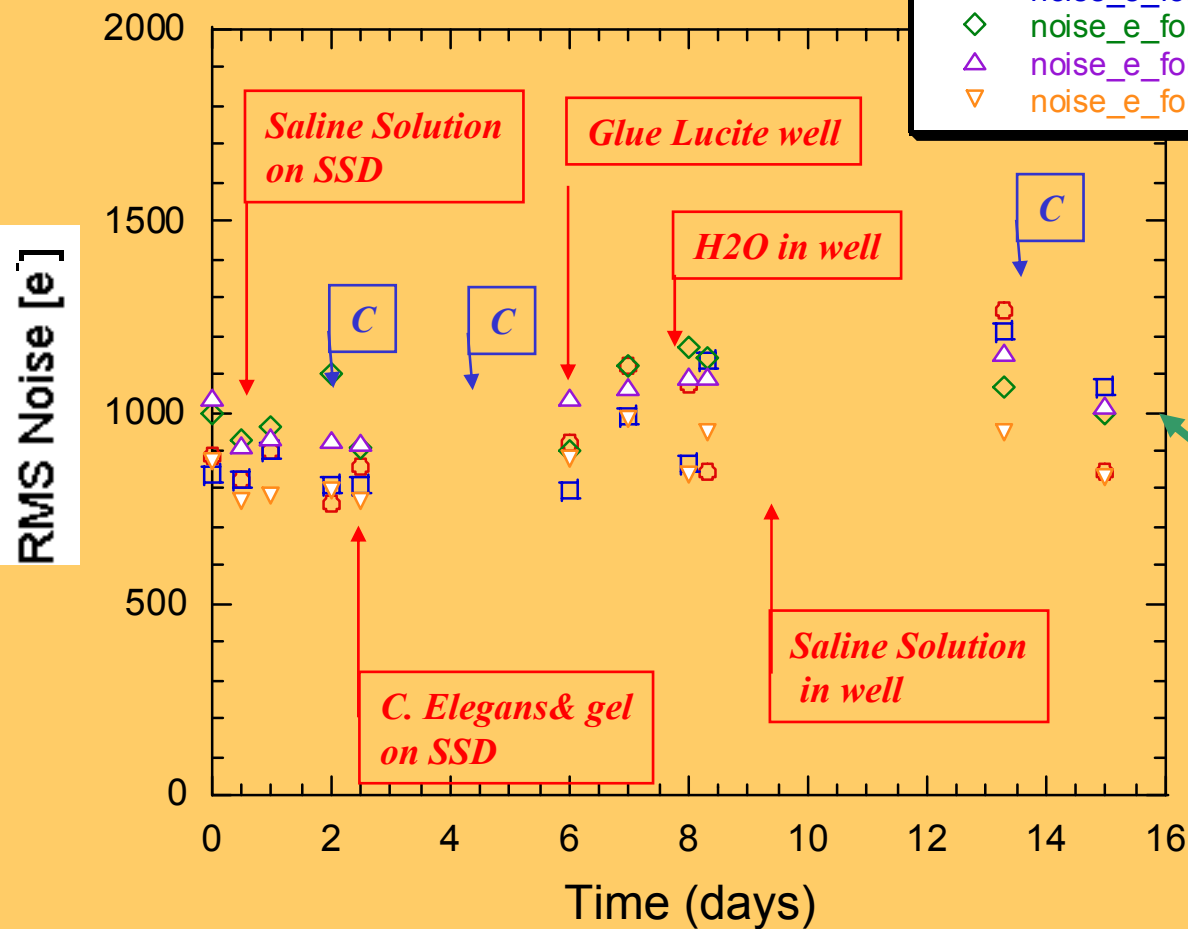
Can *C. elegans* and Silicon Co:exist?

Detector Leakage Current

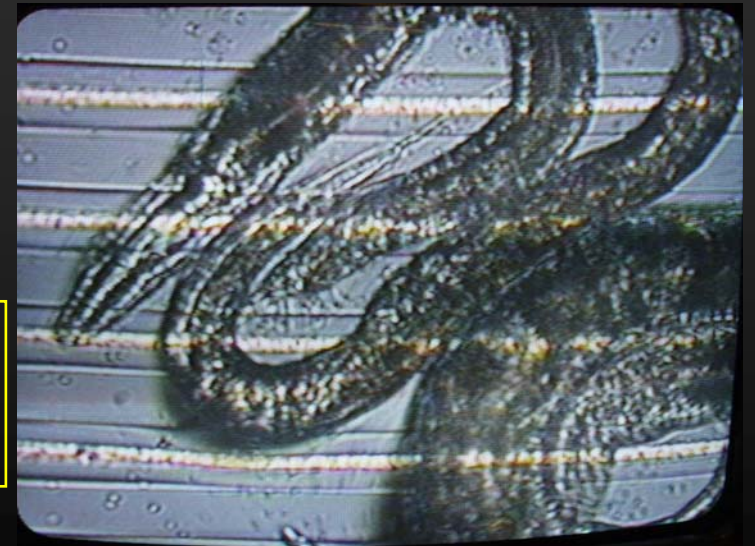
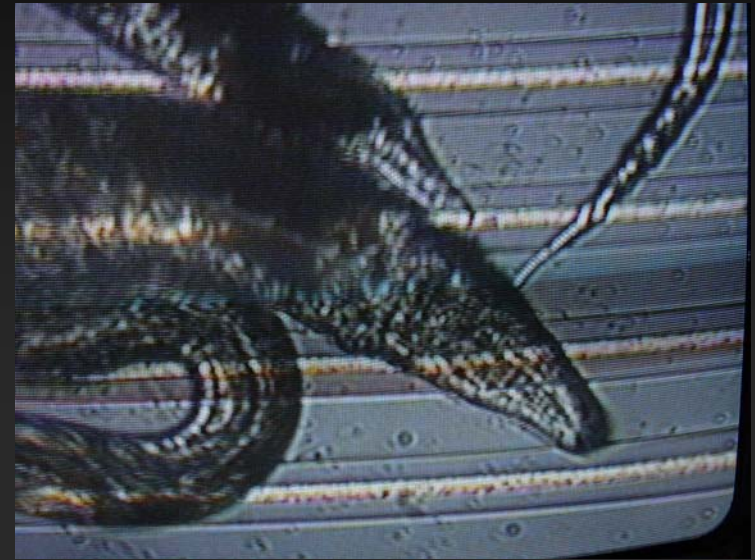
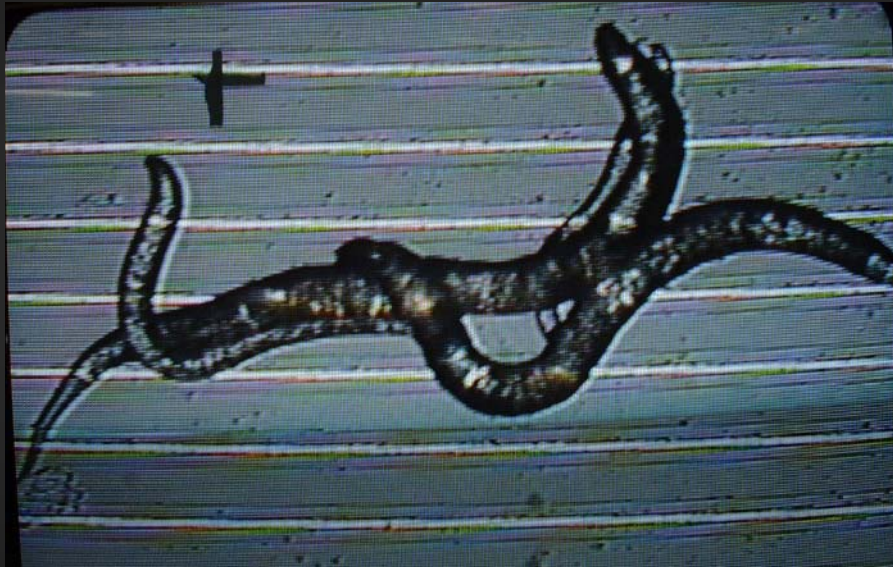


Can *C. elegans* and Silicon Co:exist?

Detector Noise



Caenorhabditis “C.” elegans live!



SSD with 50 μm strips good match

We have just started:

Developed a readout system for Silicon Strip Detectors with good S/N

Next step: Double-sided silicon sensors

We are encouraged to continue to test for long-term stability of SSD in direct contact with biological sample (just keep the biologists out!)

**Studies to prevent *C. elegans* from what they do best:
wriggling about.**

Immobilization strategies:

- **Anesthetize the worms with sodium azide
(at low concentration < 10 mM).**

It is important to find the best concentration because the window between toxic effects and sufficient immobilization is narrow.

- **Drug with levamisole**
- **Put to sleep in CO₂ atmosphere**