Real-time β and γ Detection of I-131 Using Nanoscintillator Fiber-Optic Technology

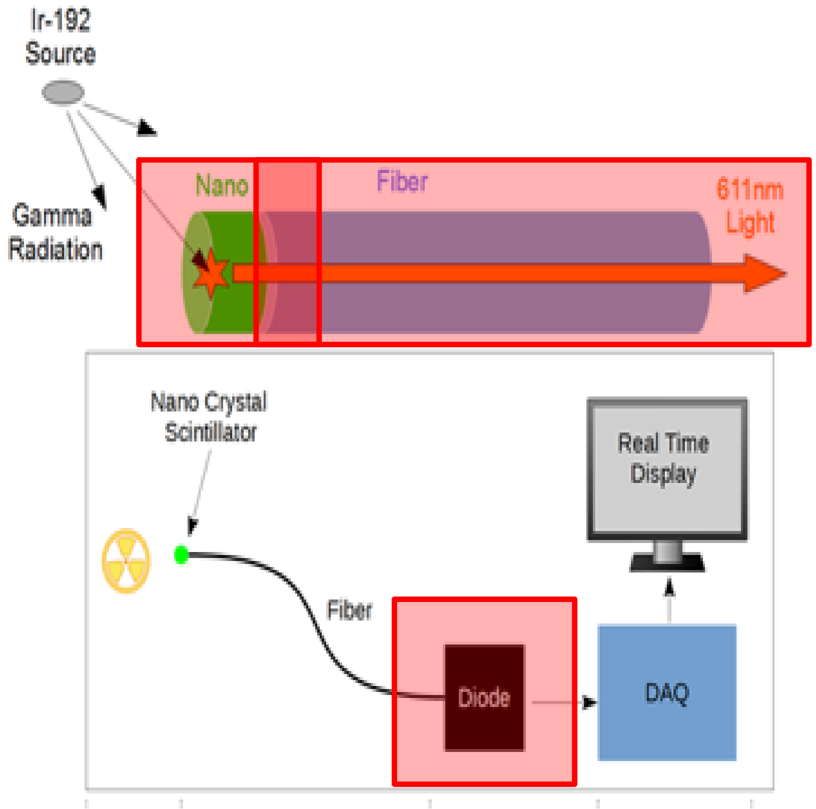
Justin Raudabaugh, Brianna Smiley, Neil A. Petry, Michael Therien, Terry Yoshizumi

Duke University, Durham NC

Background

- Real-time detection of beta particles has often proven a troublesome task due to their relatively short range in tissues and solid materials
- Conventional detectors are typically limited by their ***size*** and the ***thickness*** of their entrance windows
- Other methods, such as liquid scintillation, require later readout

Introduction: Nano-FOD



Nano-FOD has 3 major components

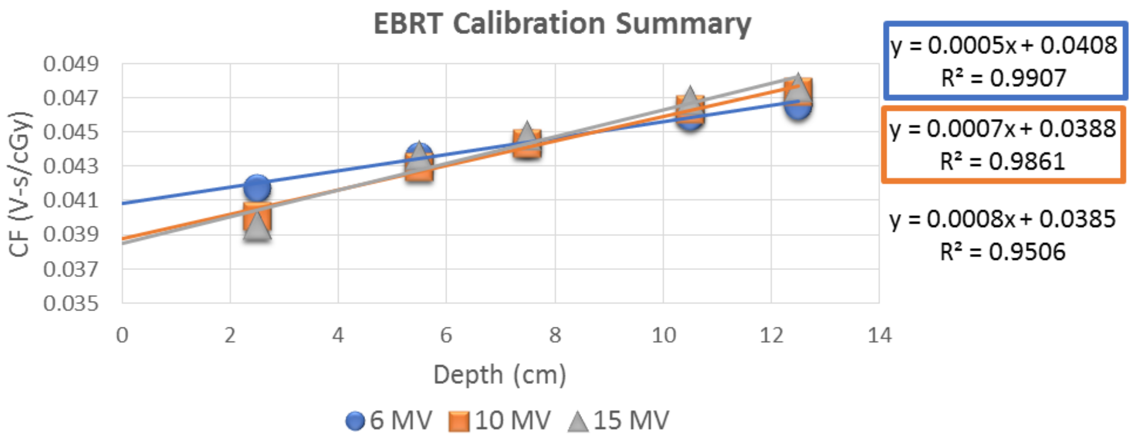
1. **Scintillator** - a pressed pellet of inorganic scintillator material, [Y1.9O3; Eu0.1, Li0.16]; light output is proportional to exposure

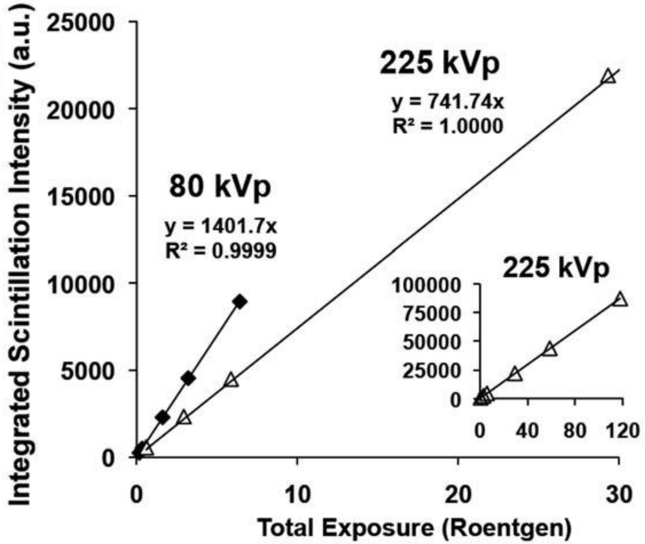
2. **Fiber** – silica core optical fiber capable of transmitting emitted light to diode

3. **Diode** – photo diode that converts light output to voltage values

Introduction: Nano-FOD

- Findings thus far have demonstrated a linear response to x-rays ranging from diagnostic imaging (80 kVp) and radiation therapy (15 MV) energy levels

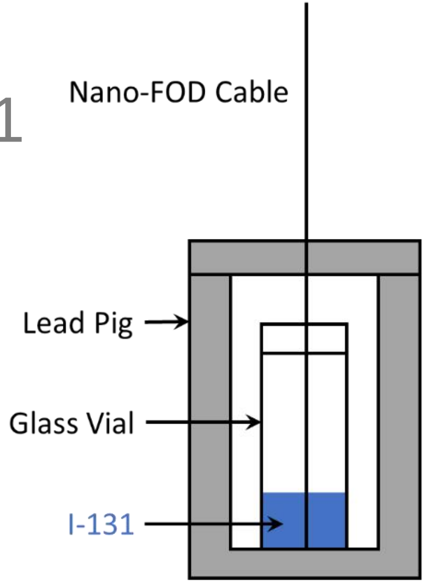


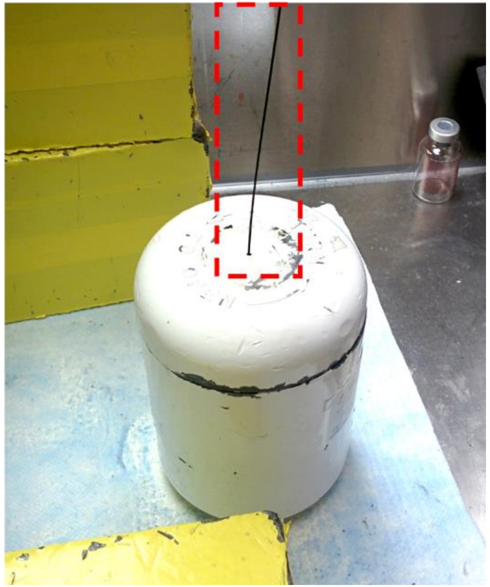


Previous Investigation Method

Vial containing 100 mCi of I-131 in 2cc of stabilizing solution

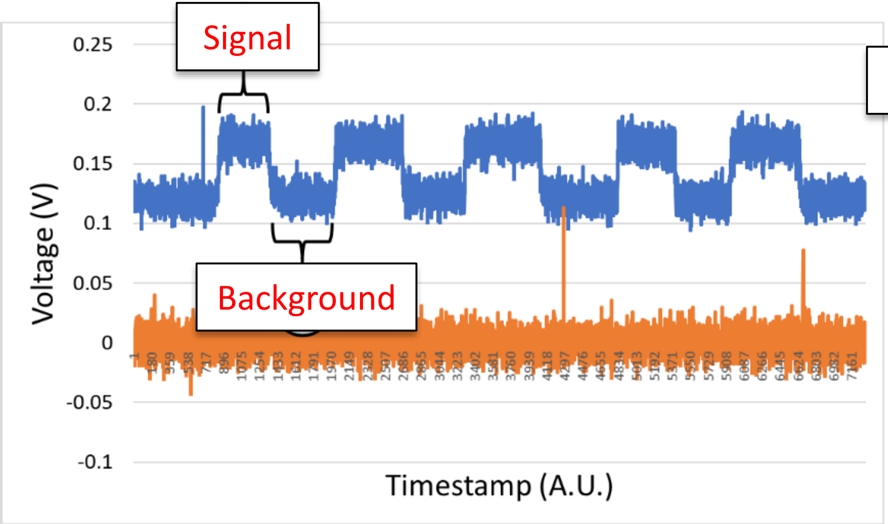
Measurements taken over a 17 day period

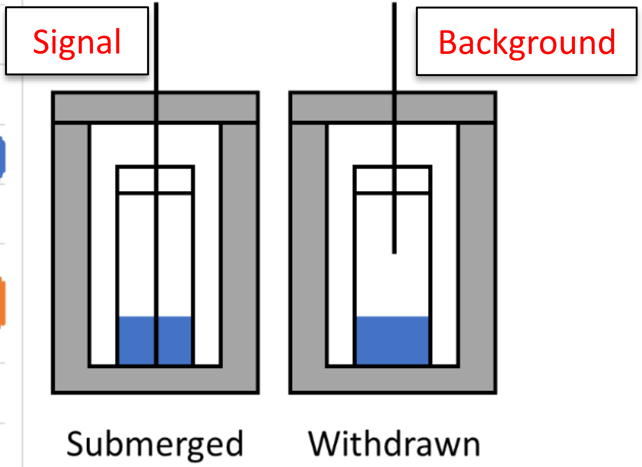




Previous Investigation Method

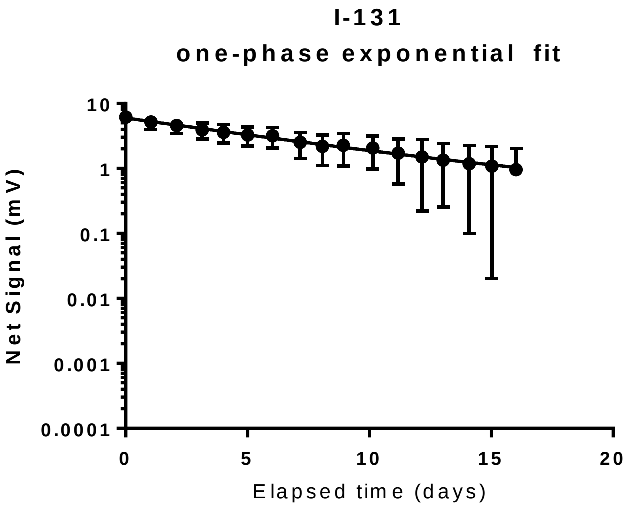
- Each data point was averaged over 5 measurements





$$Net\ Signal = Signal - Background$$

Previous Investigation Results



Non-linear exponential fit	$T_{1/2}$ (day)	Goodness of fit
One-phase model	5.42	0.993

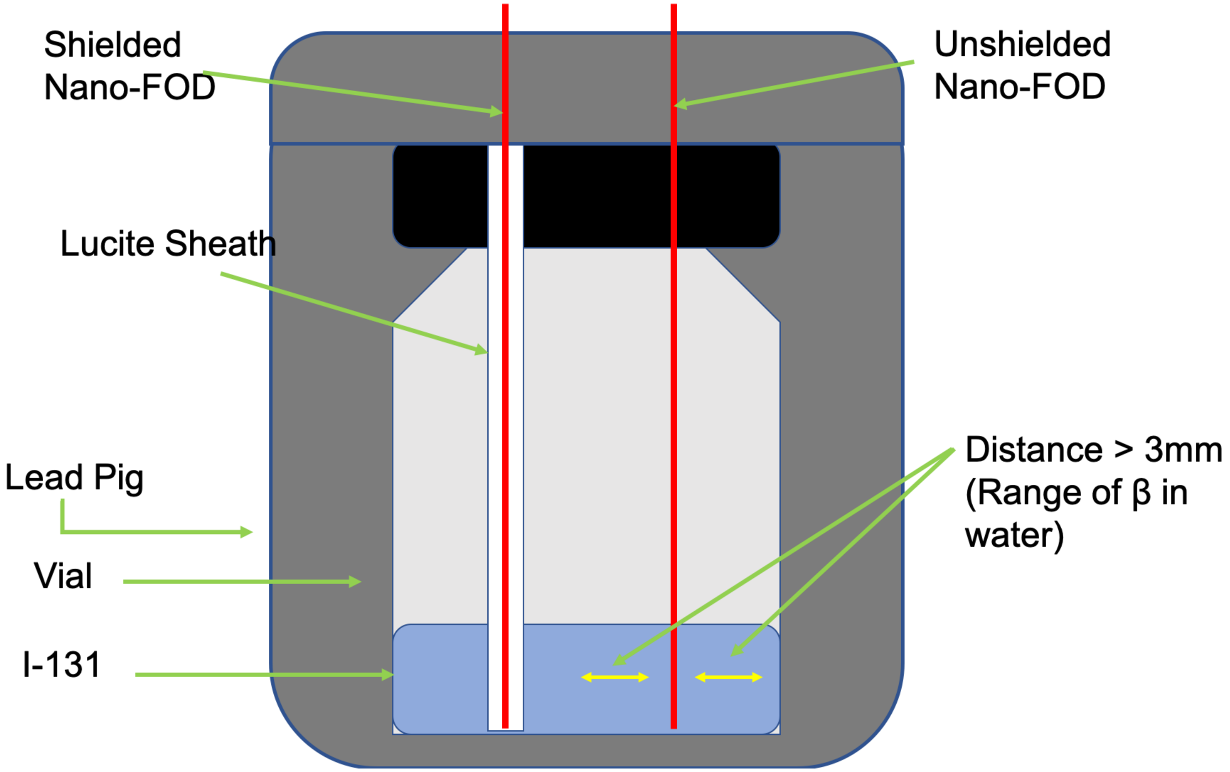
Previous Investigation Results

- The single fiber method works well with pure β emitters such as P-32, but is inadequate for I-131

Goal

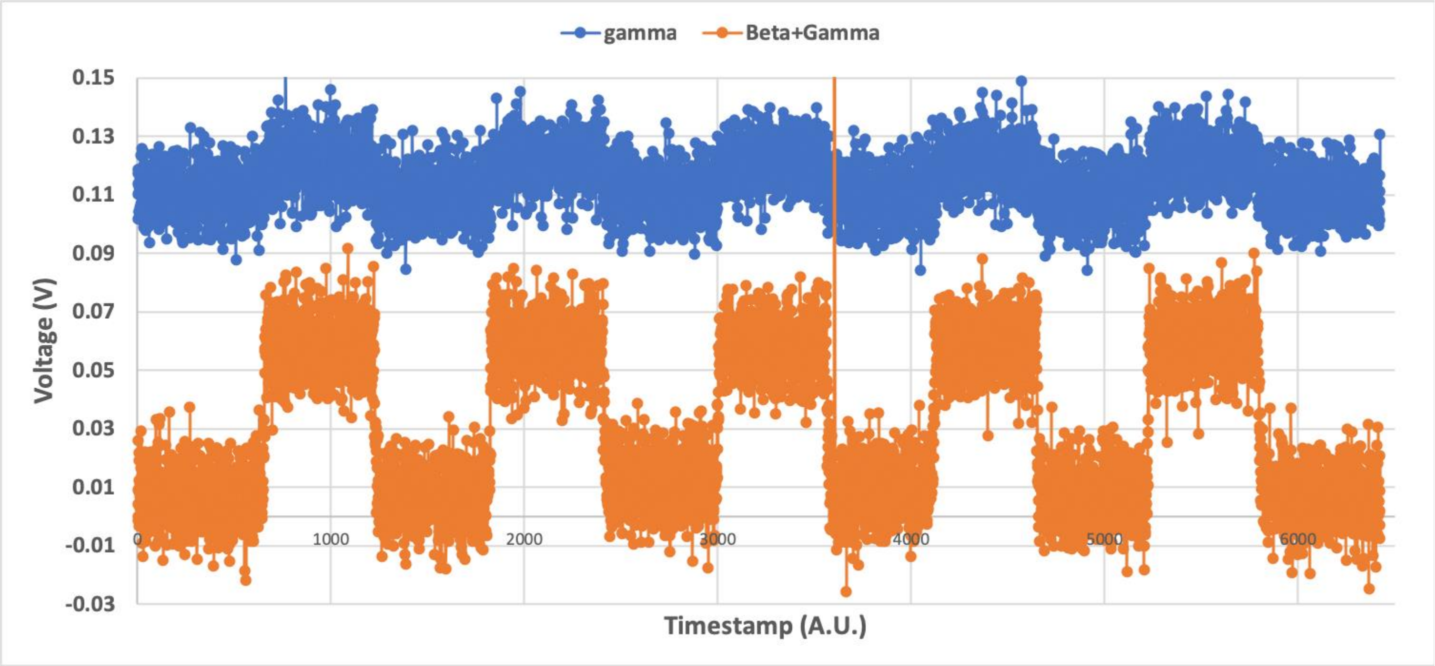
1. Design an experiment to simultaneously measure both
    - Signal from combined B+G emissions
    - Signal solely from G contribution

Materials and Methods

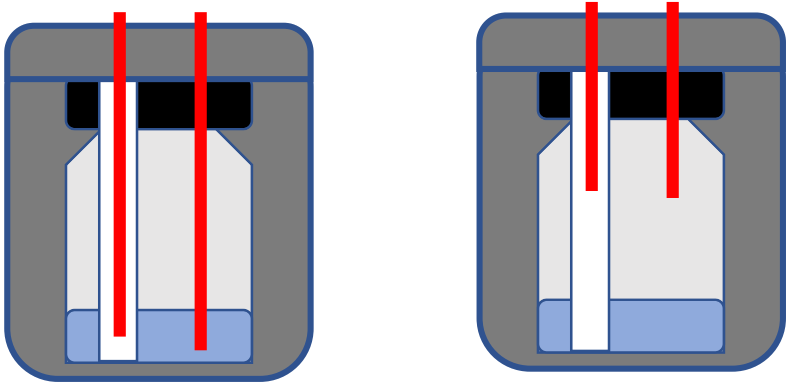


Materials and Methods

Measured signal from 101 mCi of I-131 over the course of 20 days



$$Net\ Signal = Signal - Background$$



- For mixed β and γ emitters:
  - When the fiber is raised out of the solution it is still exposed to the γ component of the decay
  - Therefore it is not representative of true background noise

Goal

1. Design an experiment to simultaneously measure both
   - Signal from combined B+G emissions
   - Signal solely from G contribution

2. Determine a method to characterize the true background signal in the absence of radioactivity

3. Verify the Nano-FOD signals decay with I-131 half-life (8.04 days)

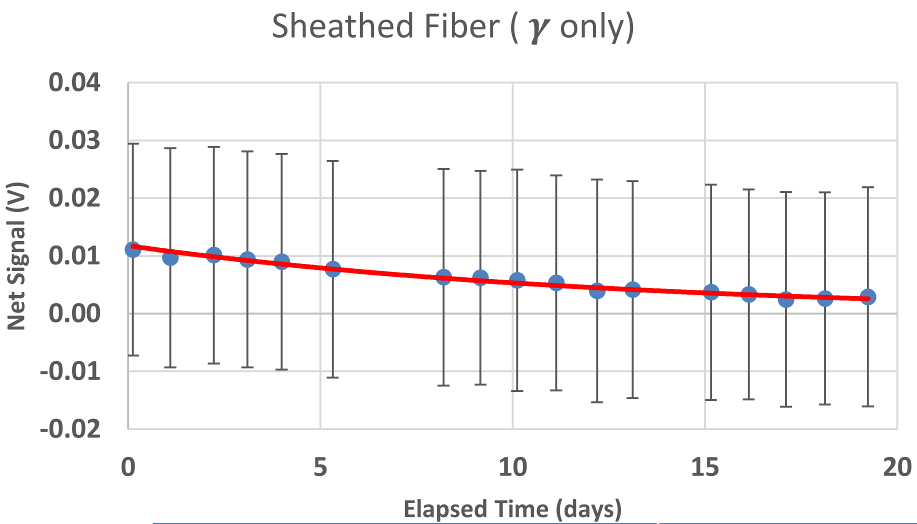
Determining Background Noise

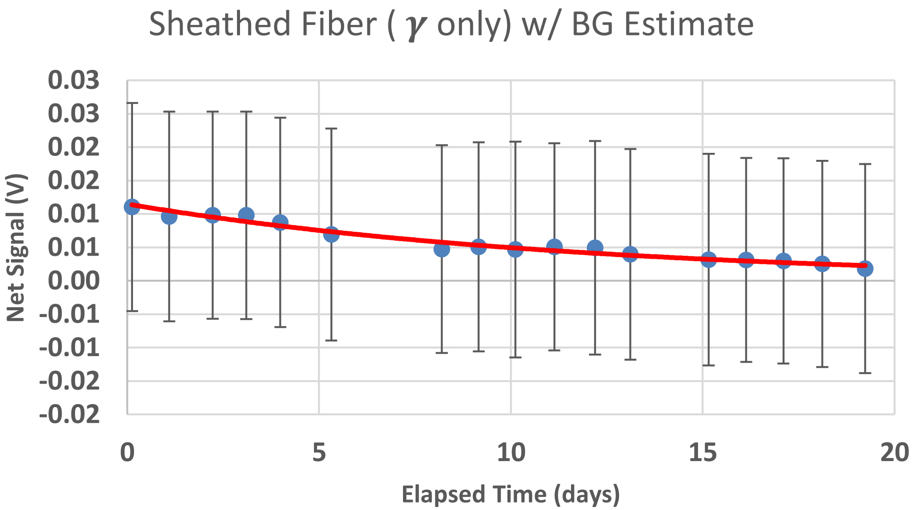
- Electronic background noise is dependent on:
  - The individual fiber-optic detector
  - The photodiode to which it is attached

Determining Background Noise

- Electronic background noise for the sheathed fiber was estimated by measuring signal from an empty vial inside of the modified lead pig.
- We were unable to do this for the unsheathed fiber due to contamination from being submerged in the I-131 solution.

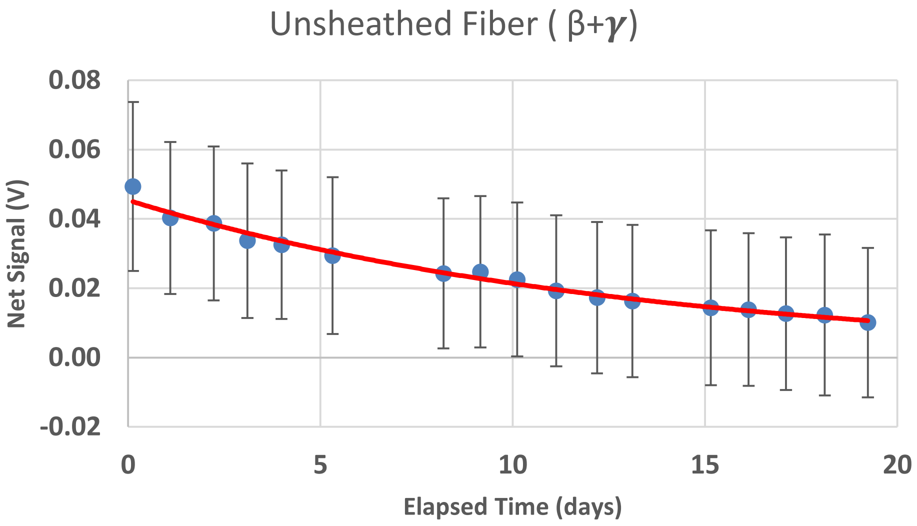
Results: Sheathed (γ only) signal





Non-linear exponential fit	$T_{1/2}$ (day)	Goodness of fit
Without True BG Estimate	8.76 ± 0.46	0.969
With True BG Estimate	8.05 ± 0.47	0.964

Results: Unsheathed (β and γ) Signal



Non-linear exponential fit	$T_{1/2}$ (day)	Goodness of fit
Without True BG Estimate	9.2 ± 0.35	0.989
With True BG Estimate	--	--

Conclusions

- Data demonstrated that Nano-FOD detected signal from both β an γ contributions

- Nano-FOD gamma signal decays with expected 8 day half-life when electronic background noise is appropriately accounted for

Future Work

- Characterize signal conversion factors for each fiber/diode combination
- Repeat experiment measuring electronic BG for unsheathed fiber before submersion into I-131 solution
- Develop a method to correlate signal to dose rate through Monte Carlo simulations