Interstitial Optical Probe

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Client Background

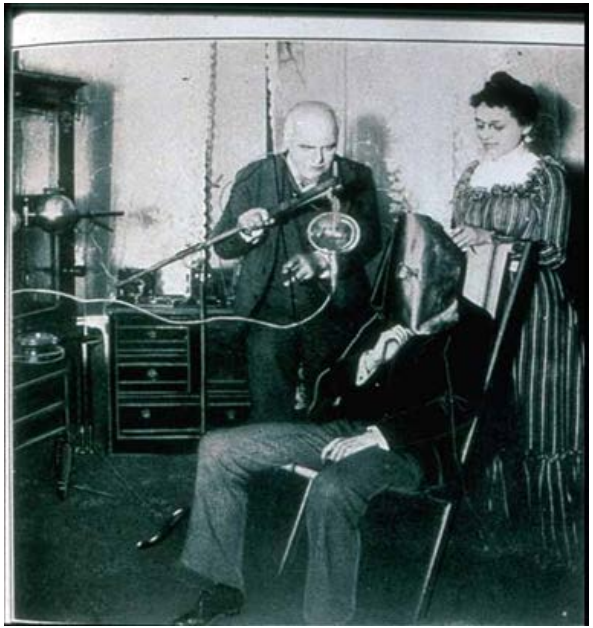
- Client: Dr. Michael Kissick
  - Ph. D. - UW Madison - Theoretical Plasma Physics
  - MS - UW Madison - Medical Physics and Theoretical Plasma Physics
  - BS - Penn State - Plasma/Fusion Nuclear Engineering

- Currently pursuing non-uniform radiation dose prescriptions towards more biologically meaningful patterns

Motivation

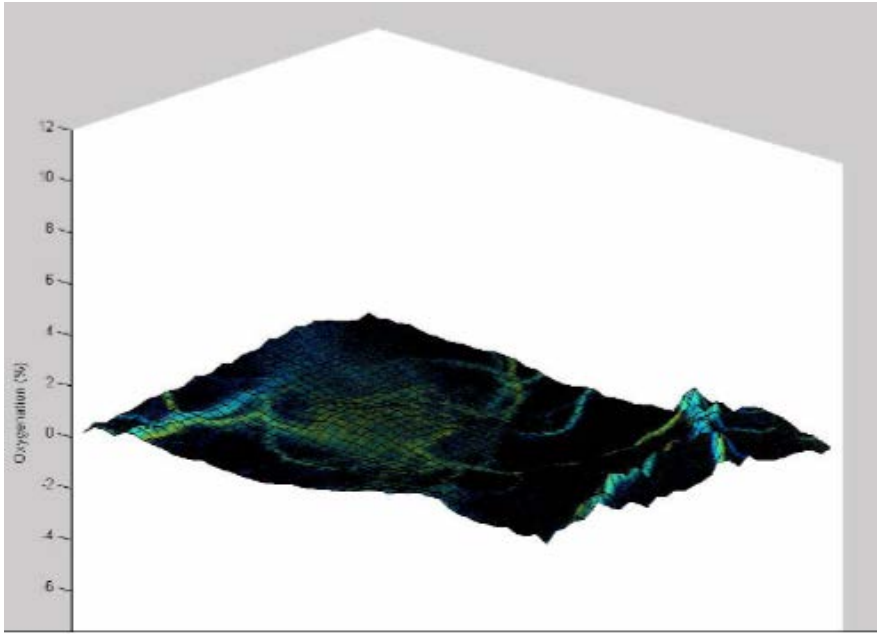
- Radiation treatments can be $1,700 to $4,000 per session (can be 1-50 sessions per treatment plan) [1]
- About 3 out of 5 people with cancer get radiation therapy [2]
- Half of all men and one-third of all women in US will develop cancer during their lifetimes [3]

- Uniform vs. Nonuniform Doses



Early depiction of radiation therapy using external beam. From xray.hmu.psu.edu

Problem Background



- Measuring oxygen distribution within tumors is dominant factor for tracking tumor growth [4]
- Tumors are not uniform, therefore dose application shouldn't be! [5]
- Current methods assume spherical tumor reoxygenation after therapy - too idealized

Oxygen M.W. Dewhirst et al, *Nature Reviews* (2008)

Problem Statement

- Analysis of oxygen saturation in cancerous tissue allows for tracking of development patterns
- Observation of optical diffusion inside tumor is accomplished by using interstitial probes
- There is a need for a device to hold two probes at a set distance for use in mouse xenograft
- Long term goal is to design an optimal probe holder for human use.

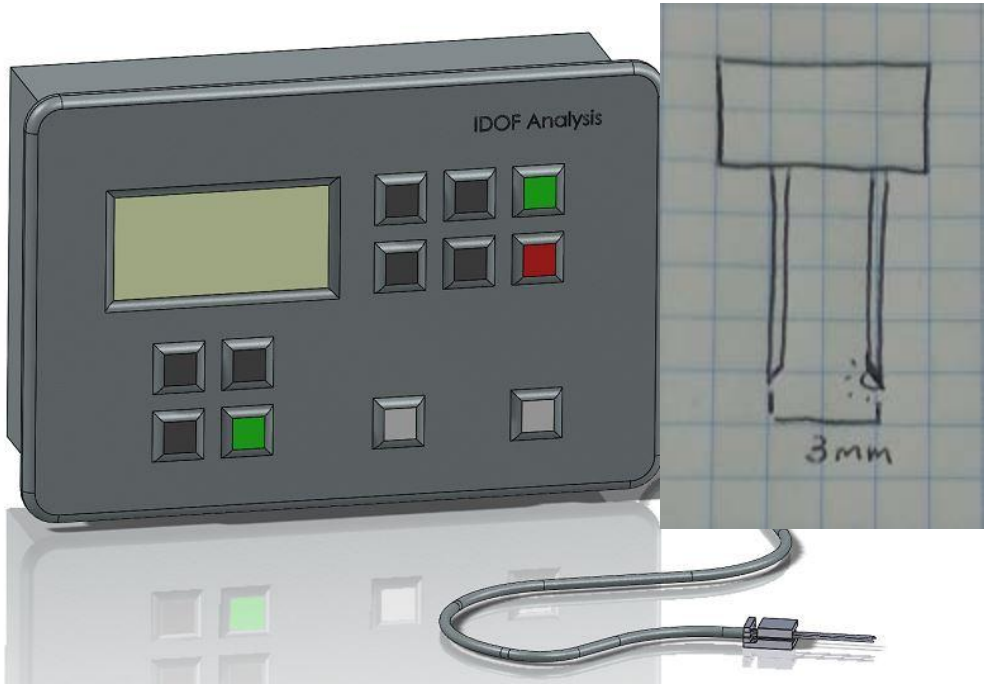
Client Requirements/Design Specifications

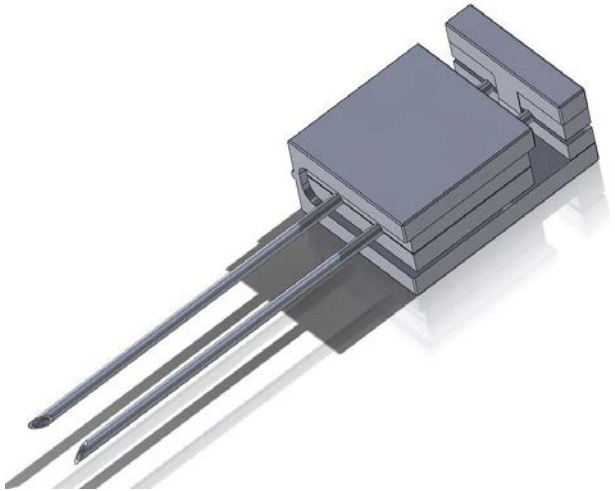
- **Physical/Operational Characteristics**
  - Two optical probe needles fixed 3mm apart tip-to-tip
  - Able to penetrate epidermis of skin at least 2mm with ease
  - Rotationally rigid with bevels of needles facing each other
  - Minimally invasive
  - Reusable
- **Production Characteristics**
  - Easily manufactured - 3D printed
  - Low cost - design budget ~$100
- **Competition**
  - Eppendorf probe
  - OxyLite

Eppendorf probe [6]

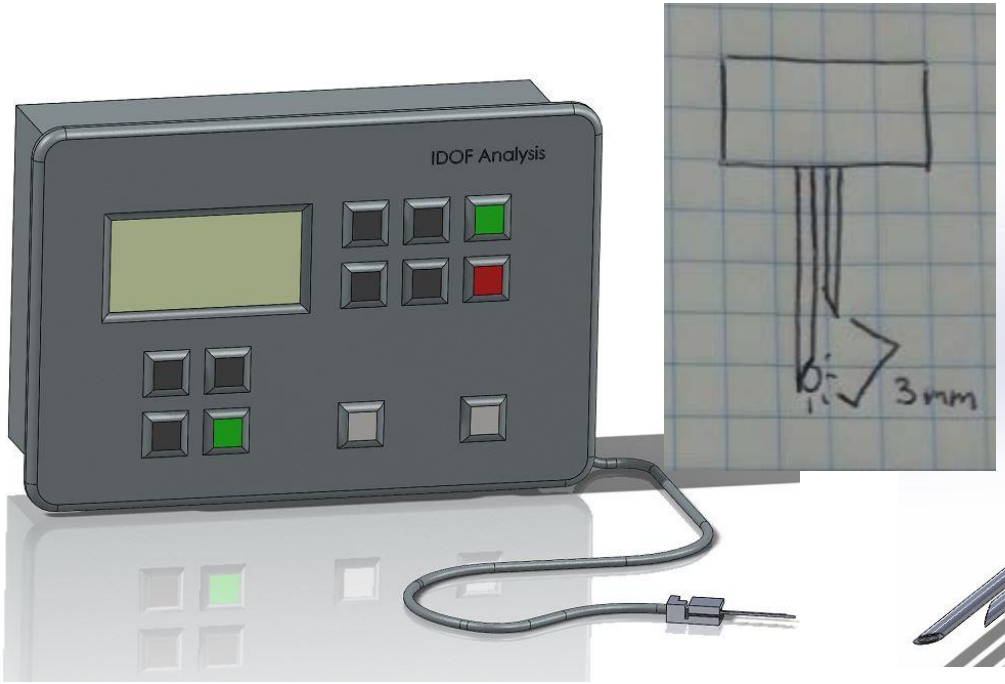
OxyLite probe [7]

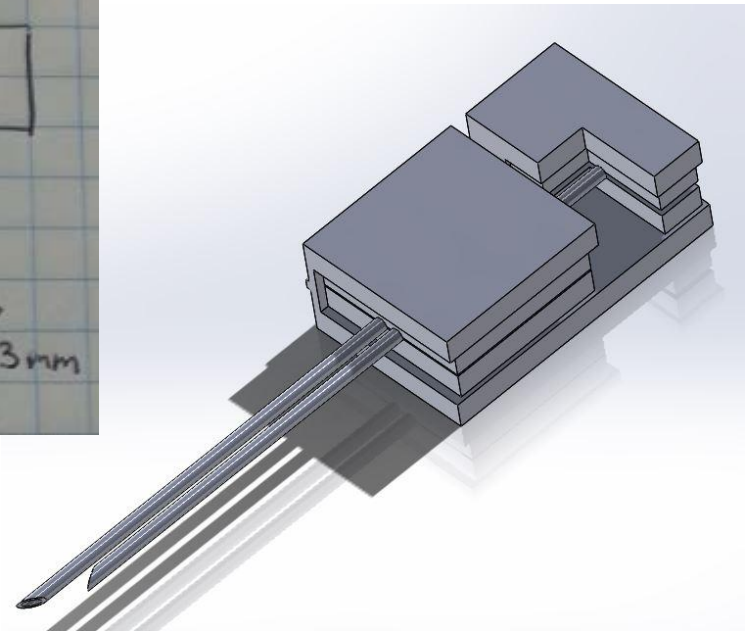
Design One: Modified Clip



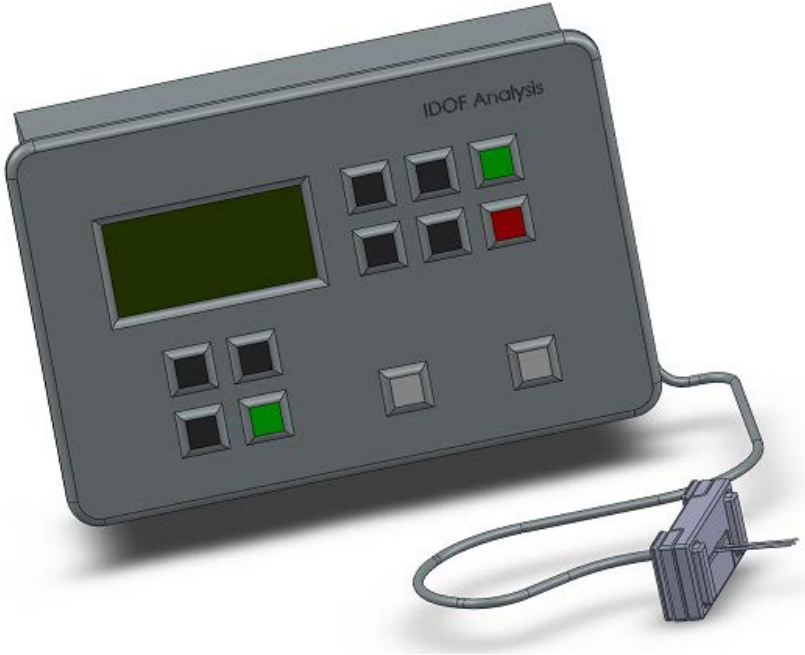


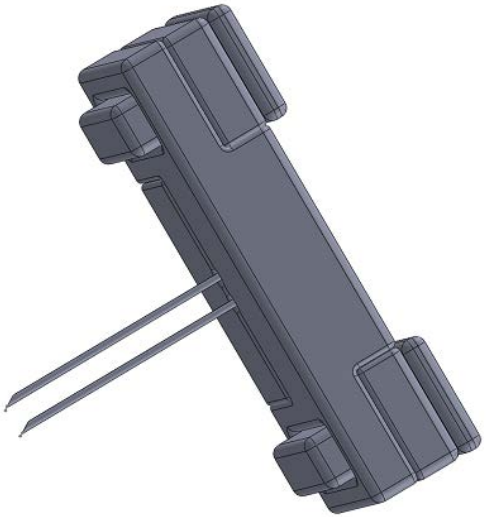
Design Two: Staggered Needles



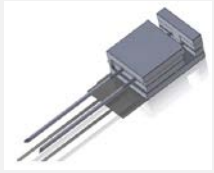
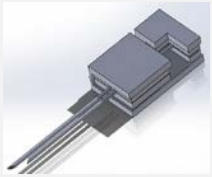


Design Three: Two Unit Clasp





Design Matrix

Interstitial Optical Probe Design Matrix Criteria (weight)	 Design 1 Modified Clip		 Design 2 Staggered		 Design 3 Two Unit Clasp	
Ease of use (30)	4	24	5	30	3	18
Precision (25)	5	25	4	20	3	15
Longevity (25)	4	20	3	15	5	25
Size (10)	5	10	4	8	2	4
Safety (5)	4	4	5	5	4	4
Cost (5)	5	5	4	4	3	3
Total (100)	88		82		69	

Future Work

- Maintain Contact with client and update design
- Device for long term use
  - Needles that can be removed allowing optical fibers to remain in patient
- Device that can be easily used on humans with varying tumor size & location
  - Have several different needle positions
- Easy-To-Use Bedside Convenience

References and Acknowledgements

[1] Comprehensive Cancer Center - University of Michigan. Dr. David D. Howell. (2009, October)

[2] http://www.cancer.gov/cancertopics/coping/radiation-therapy-and-you/page2. National Cancer Institute. (Posted 4/20/2007)

[3] http://www.cancer.org/cancer/cancerbasics/what-is-cancer. American Cancer Society. (Updated 3/21/12)

[4] “The concentration of oxygen… as a factor in Radiotherapy”. L.H. Gray, et al. Journal of Radiology. (1953)

[5] M.W. Dewhirst et al. Nature Reviews, Cancer. (2008)

[6] Kissick, M. (2014, February). On Radiotherapy & Oxygen Dynamics. Lecture conducted from University of Wisconsin-Madison, Madison, WI.

[7] Sensors for Oxygen Monitors. *Oxford Optronix*. February 2014. <http://www.oxford-optronix.com/sensor12/sensor-for-Oxygen-Monitors.html>

We would like to thank our advisor Dr. Paul Thompson and our client Dr. Michael Kissick for their support of this project