Longitudinal Migration Tracking of Fluorescent Stem Cells in Vivo in the Mouse Brain

Team Members: Dana Stumpfoll (Co-Team Leader)
Lauren Heller (Co-Team Leader)
Rebekah Makonnen (BSAC)
Tyler Anderson (BPAG)
Alex He (BWIG)
Alexis Block (Communicator)

Client: Dr. Jayshree Samanta
Advisor: Dr. Sarah Gong

BME Design

Overview of Presentation

1. Problem Statement
2. Background
3. Design Alternatives
4. Product Design Specification
5. Design Ideas
6. Design Matrix
7. Future Work
8. References and Acknowledgements

Alexis Block

Problem Statement

- Multiple lenses and field of view
- Endoscopes currently on the market
- In vivo
- Minimally Invasive and sustainable

Alexis Block

Background

Target area:

Lateral Ventricle

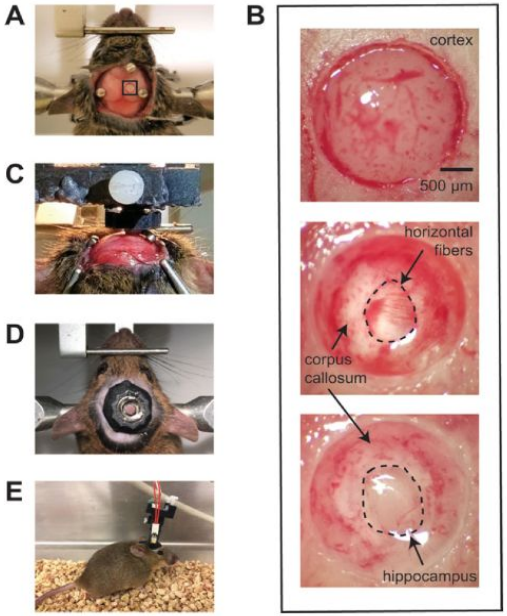


Figure 1: Location of implantation [1]

GRIN relay:

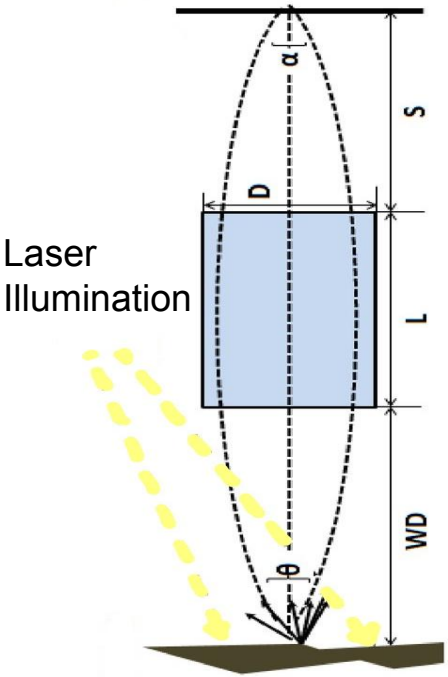


Figure 2: GRIN lens [2]

Stem cell labeling:

Labeled NSC's

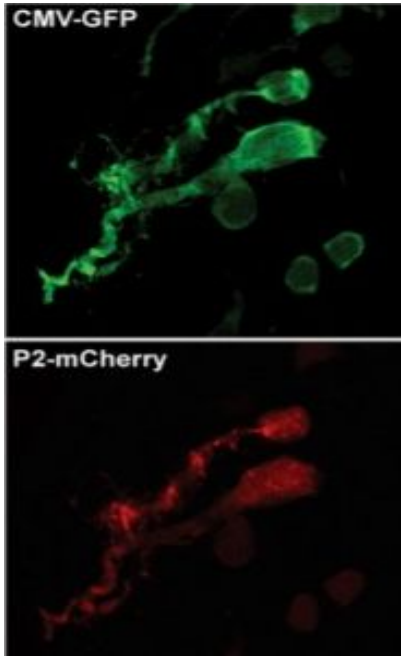


Figure 3: Protein creating fluorescence[1]

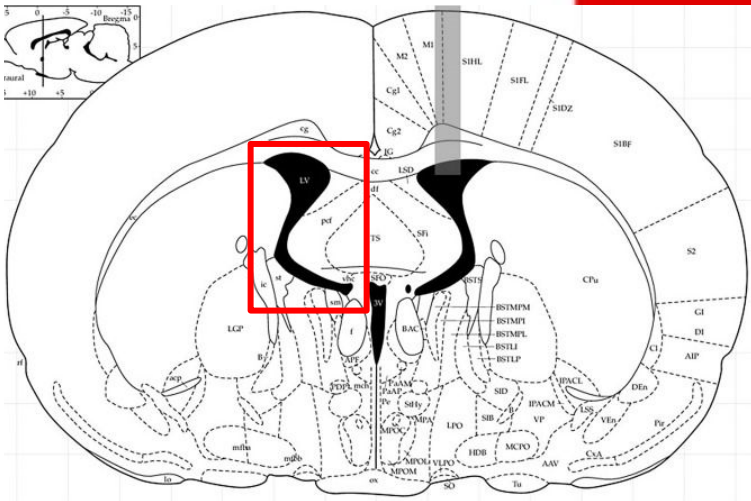
Alexis Block

Summary of Product Design Specifications

The Device Must Be:

- Small in size; Lateral Ventricle Ø 1.19mm [4]
- Lightweight, ideally < 7 grams [5]
- Under $750 total
- No innate immune response
- Submersible
- Up to four weeks of continuous acquisition

Fig. 4: Lateral Ventricle of Mouse Brain [3]



Lauren Heller

Competing Designs

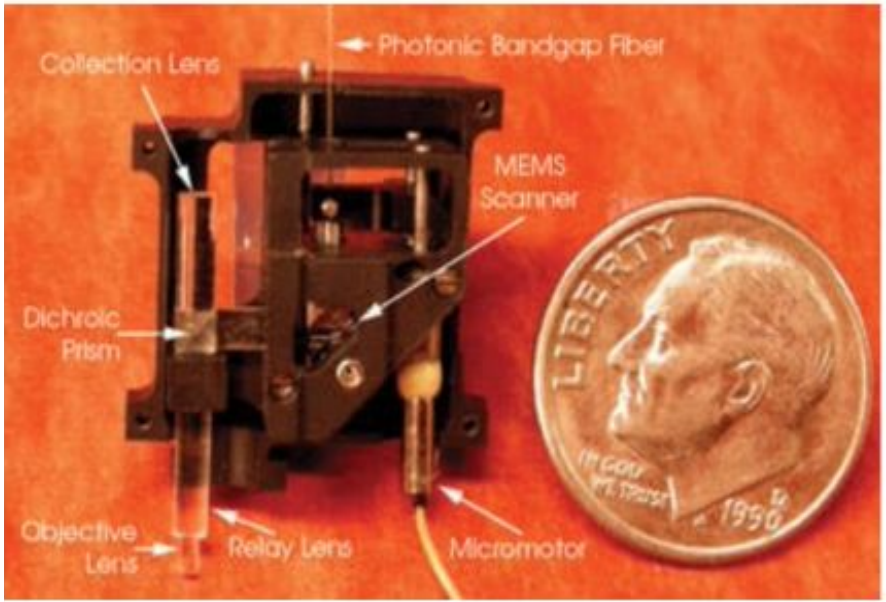


Figure 5: Size reference of endoscope [6]

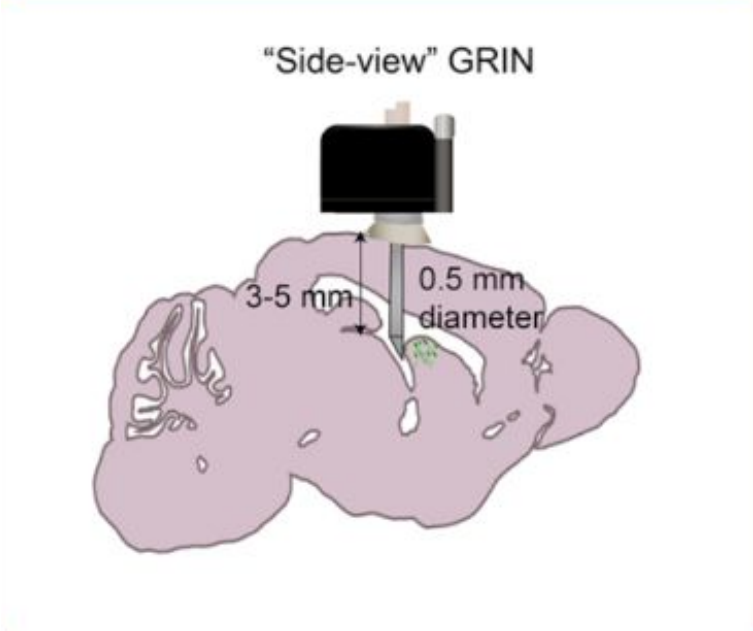


Figure 6: Star protocols side view lens [1]

Dana Stumpfoll

Competing Designs

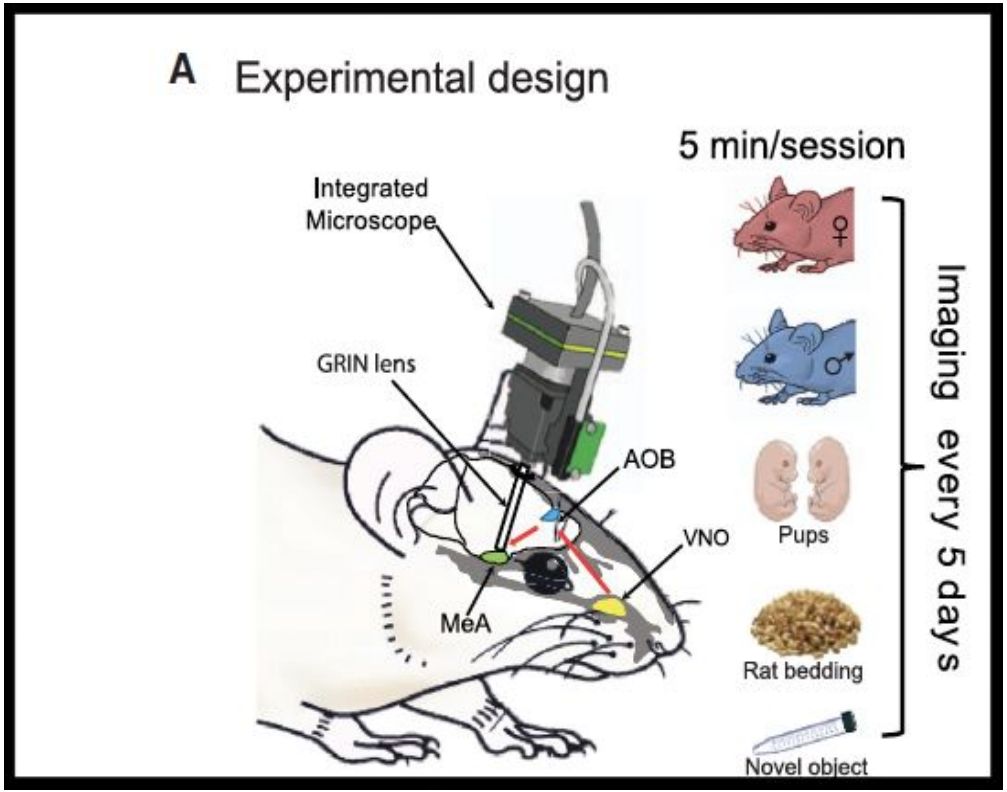


Figure 7: Inscopix nVista implant [7]

Inscopix nVista

- Large-scale brain circuit imaging
- Used in freely behaving animals
- Sex-specific behavioral cues
- Visualize same field of view longitudinally

Competing Designs

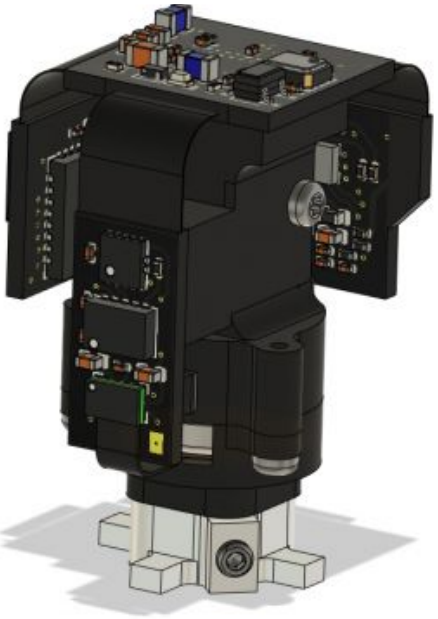


Figure 8: UCLA Miniscope design [8]

Design 1 : Elongated Lens Design

- Elongated Lens increases field of view
- Prism angled at 90° below lens
- Allows for less parts and assembly
- Requires custom manufacturing
- Requires extensive knowledge of optics

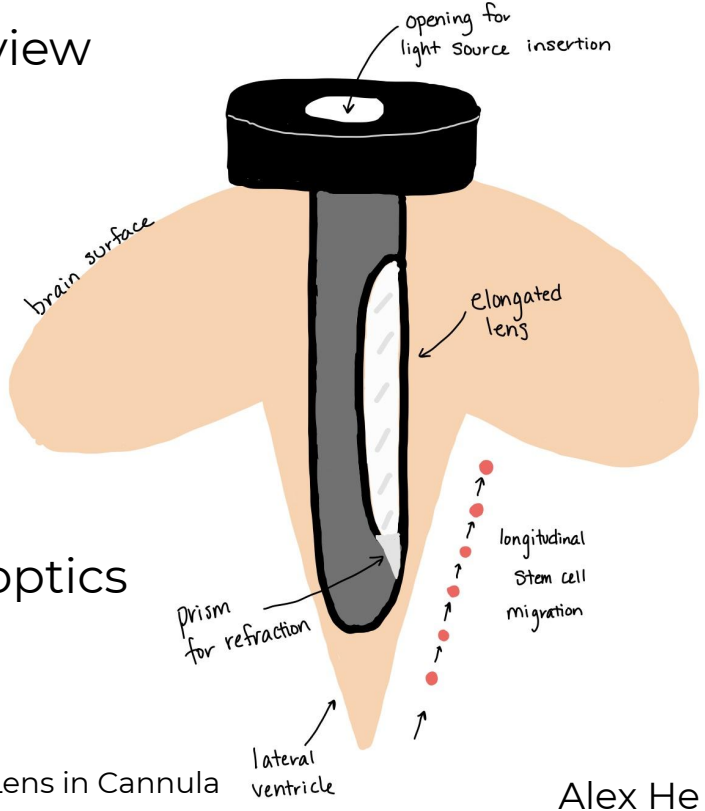


Figure 9: Elongated Lens in Cannula

Alex He

Design 2 : Three GRIN outside brain

- Beveled tip to decrease tissue damage
- Prisms angled at 90° inside cannula
- Separation of light to decrease interference
- Bypasses Size Restrictions
- Likely requires excessive testing (more moving parts)

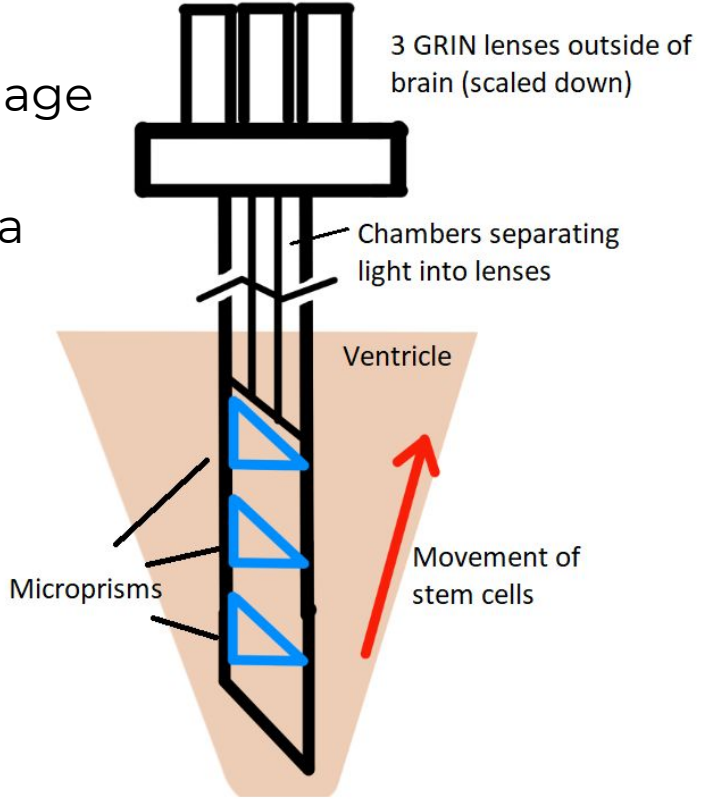


Figure 10: Three GRIN lens with microprisms in cannula

Alex He

Design 3 : Three Lenses Inside Cannula

- Three stacked GRIN lenses inside of the cannula
- Microprisms utilized to obtain a 90 degree angle
- Series of cables and wires to accommodate each GRIN lens

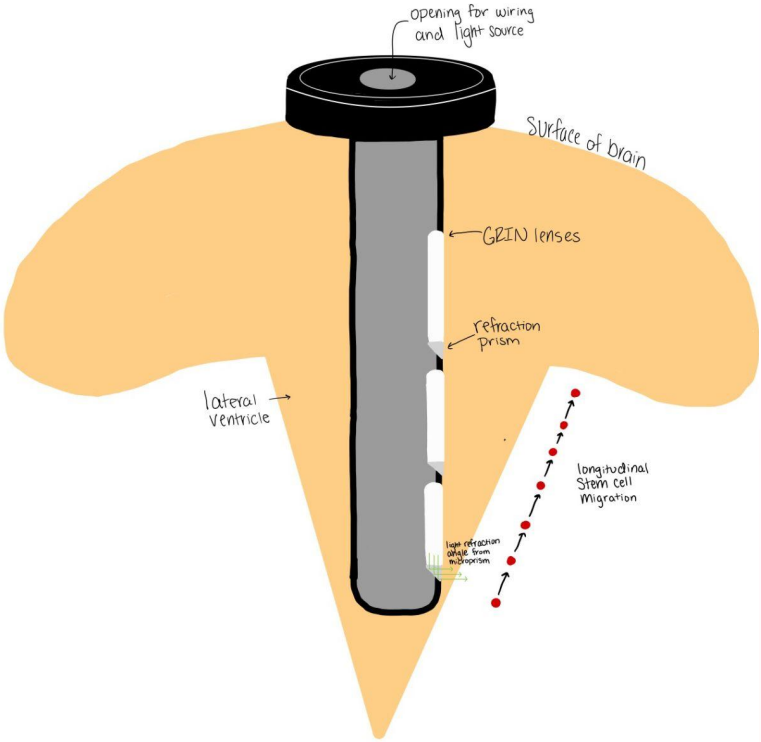


Figure 11: Three GRIN lens staggered within the cannula

Tyler Anderson

Design Matrix

		Outside the Brain Lenses		Elongated Lens		Three Lenses at Different Depths	
Criteria	**Weight**	**Score(10 max)**	**Weighted Score**	**Score (10 max)**	**Weighted Score**	**Score (10 max)**	**Weighted Score**
Feasibility	25	4	10	3	7.5	5	12.5
Reliability	20	7	14	7	14	8	16
Accuracy/Precision	20	5	10	3	6	6	12
Safety	15	8	12	8	12	8	12
Ease of Use	15	5	7.5	8	12	5	7.5
Cost	5	5	2.5	3	1.5	9	4.5
Sum	100	**Sum**	56	**Sum**	53	**Sum**	64.5

Figure 12: Design Matrix

Future Work

- Concerns about current design feasibility
- Alternatives to proposed designs
    - Mechanical design for wider FOV
    - Existing miniscope and GRIN setup

Acknowledgements

Dr. Sarah Gong

Dr. Jayshree Samanta, Dr. Daniel Radecki, Ms. Abigail Johnson

Dr. Kevin Eliceiri

BME Department

References

[1] S. Malvaut, A. Marymonchyk, A. Gengatharan, and A. Saghatelyan, “Live imaging of adult neural stem cells in freely behaving mice using mini-endoscopes,” *STAR Protoc*, vol. 2, no. 2, p. 100596, 2021. Available: https://starprotocols.hivebench.com/protocols/723.

[2] P. Prabhathan, A. S. Guru Prasad, A. Haridas, K. H. K. Chan, and V. M. Murukeshan, “Design and simulation of GRIN objective lenses for an imaging fiber based speckle metrology system,” in *Second International Seminar on Photonics,Optics, and Its Applications (ISPhOA 2016)*, 2016.

[3] B. Seyer, V. Pham, A. L. Albiston, and S. Y. Chai, “Cannula implantation into the lateral ventricle does not adversely affect recognition or spatial working memory,” *Neuroscience Letters*, 21-Jun-2016. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0304394016304438.

[4] “ISH data :: Allen Brain Atlas: Mouse brain,” *ISH Data :: Allen Brain Atlas: Mouse Brain*. [Online]. Available: https://mouse.brain-map.org/.

[5] Barbera, G., Liang, B., Zhang, L., Li, Y., & Lin, D.-T. (2019). A wireless miniScope for deep brain imaging in freely moving mice. *Journal of Neuroscience Methods*, *323*, 56–60.

[6] Bernhard Messerschmidt, Grintech GmbH, “Gradient index optical microsystems visualize living cells in deep tissue,” *Photonics.com*, 01-Sep-2007. [Online]. Available: https://www.photonics.com/Articles/Gradient_Index_Optical_Microsystems_Visualize/a38235.

[7] Inscopix, Inc, “NVista miniature microscope A deep brain calcium imaging dynamics,” *Inscopix.com*. [Online]. Available: https://www.inscopix.com/nvista.

[8] “UCLA Miniscope,” *Miniscope.org*. [Online]. Available: http://miniscope.org/index.php/Main_Page.