



Developments on the Boston 256-Channel Retinal Implant

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The Boston Retinal Prosthesis

*An electronic implantable device to restore functional vision to patients with **retinitis pigmentosa** and **age-related macular degeneration.***

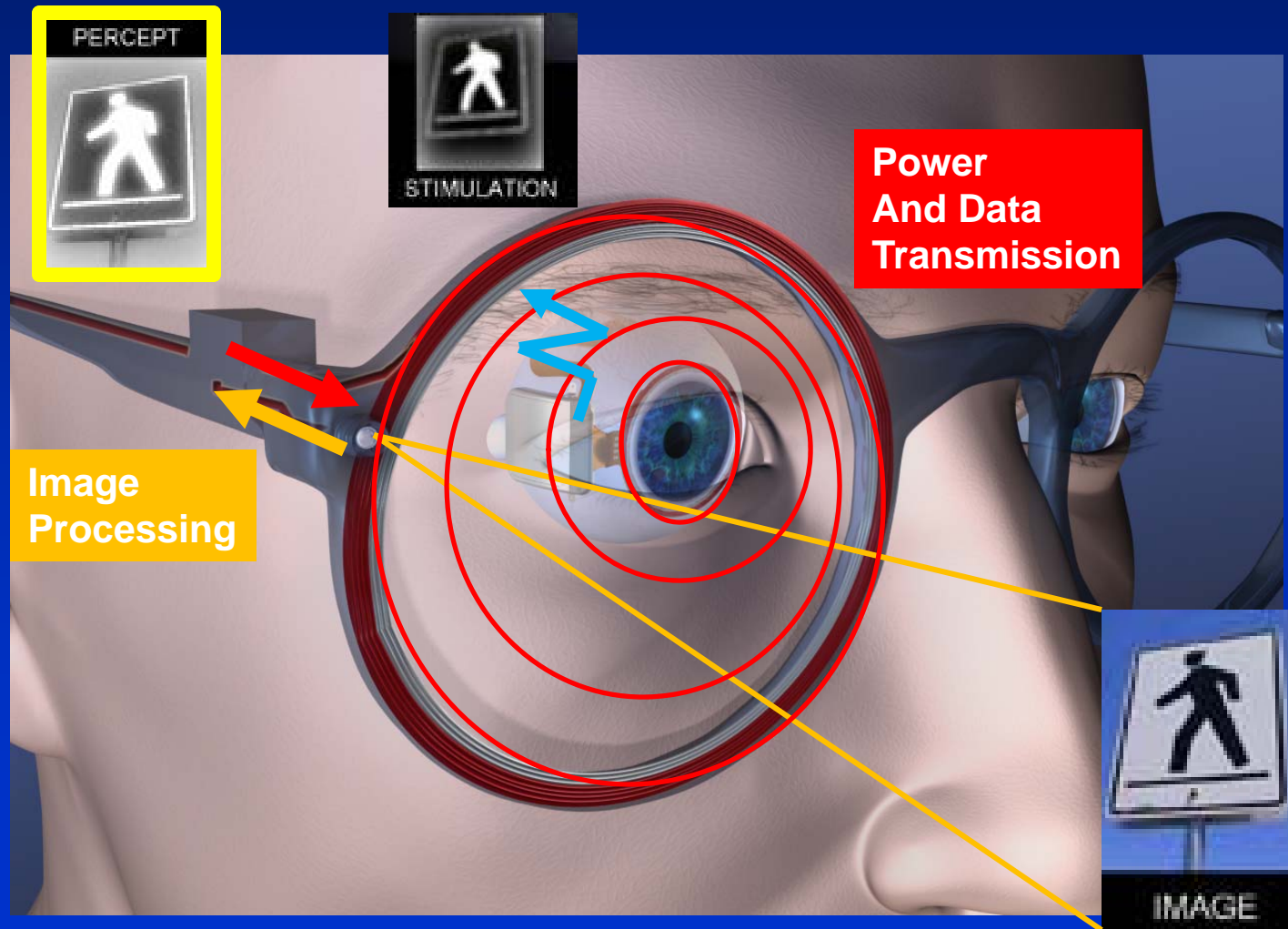
The device stimulates nerves in the visual system based on an image from an external camera.

20+ year collaboration between MIT, Harvard Medical School, Cornell, CMU, and others.



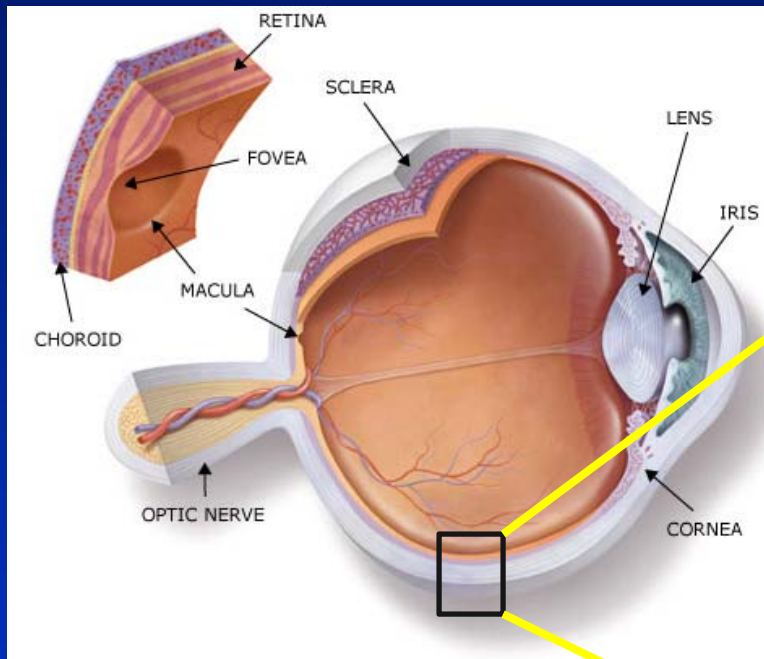
Retinal Prosthesis Function

- Electrically stimulates ganglion nerves based on an external camera image



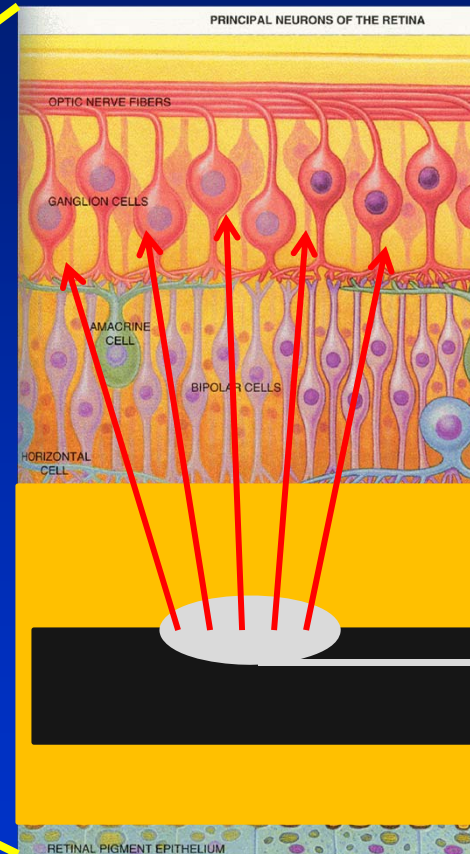


Subretinal Implant Placement



Inside/
Front

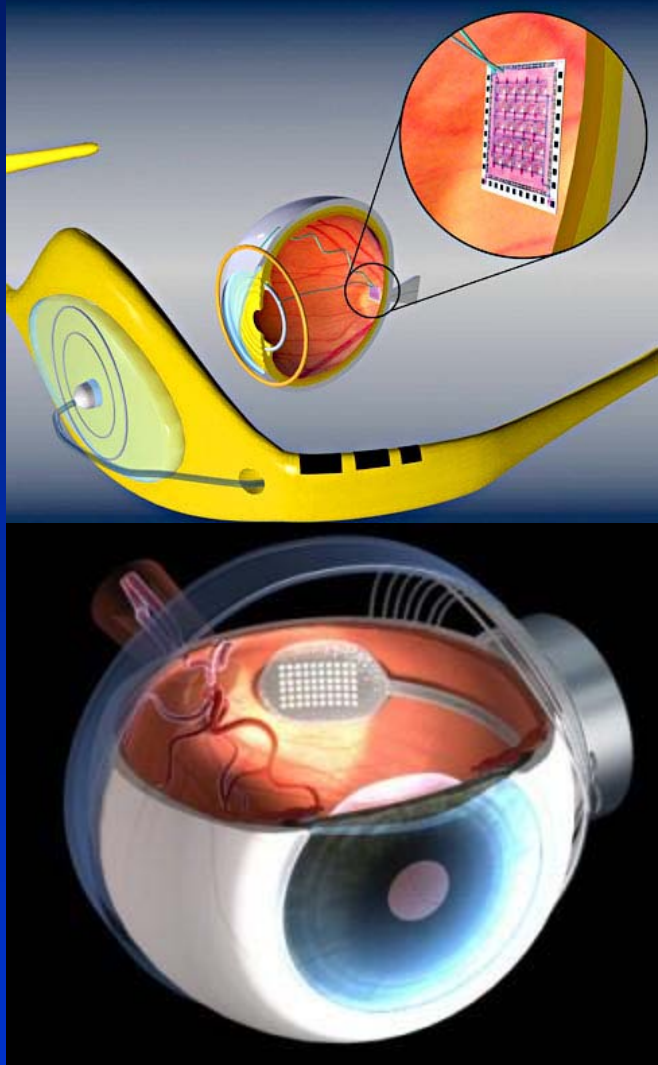
Outside/
Back



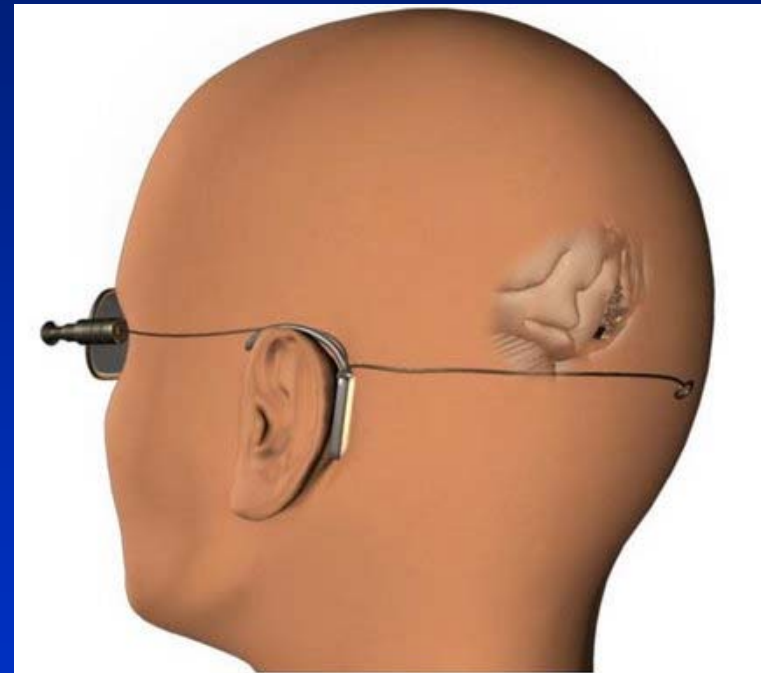
Direction of Light



Other Visual Prostheses



Epiretinal

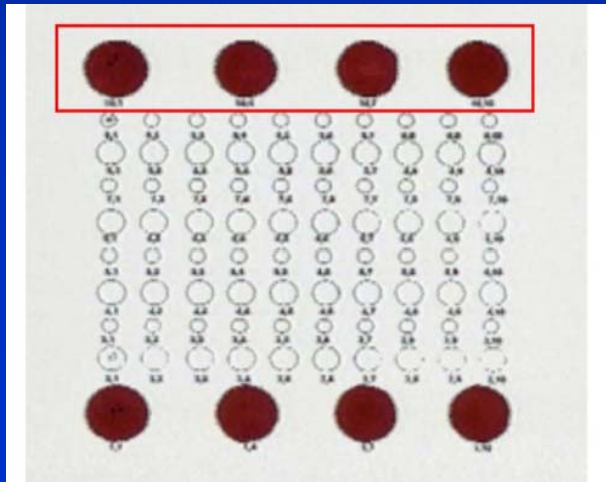


Cortical

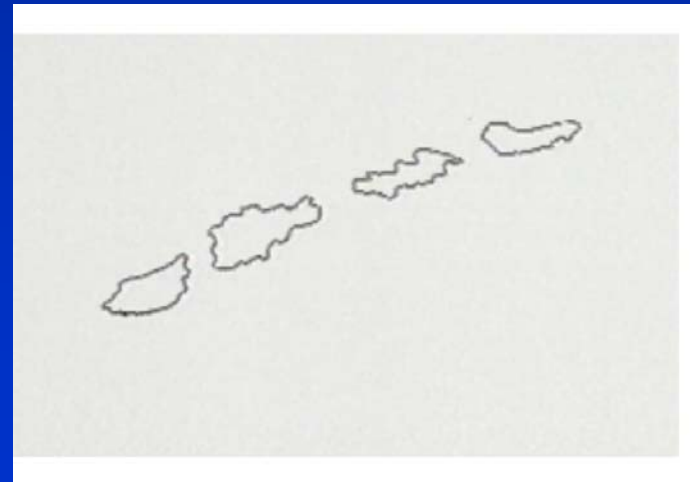


Short-term Human Proof-of-concept Trials

- 1998 – 2000, Surgical trials on six volunteers
- Epiretinal stimulation for a few hours
- Reported spots, lines, not complex shapes



Rizzo, et al. IOVS, 2003

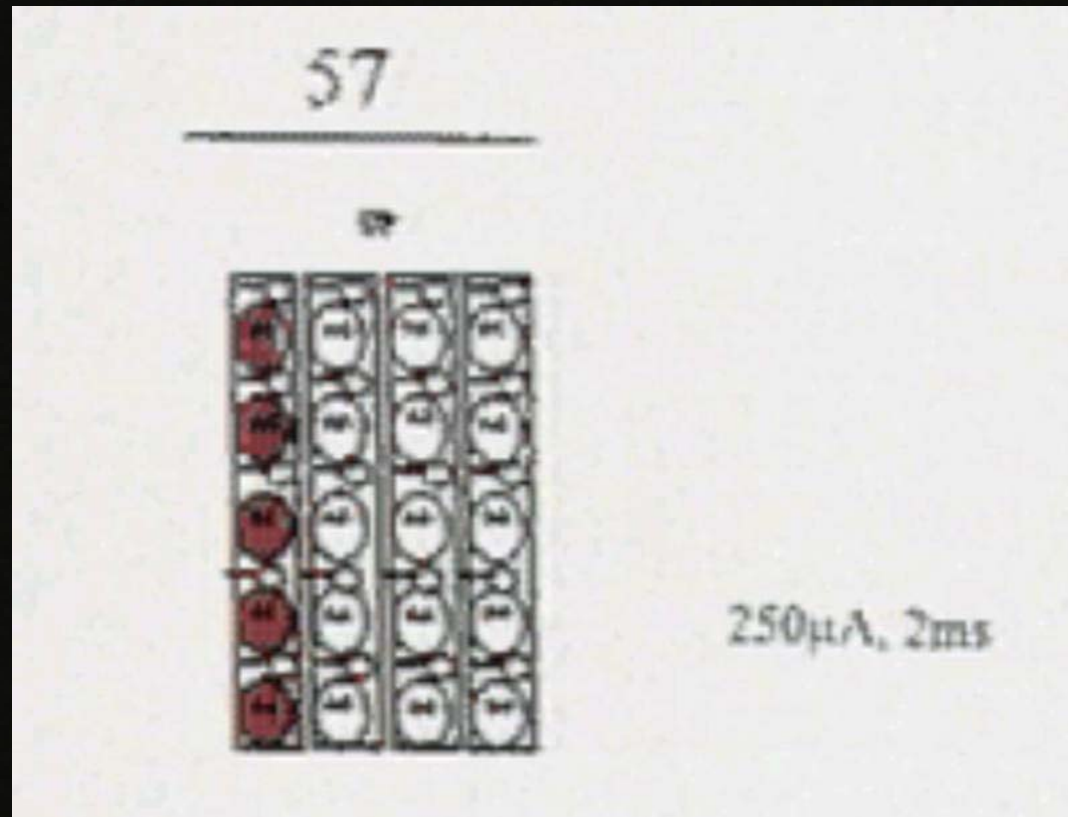


Rizzo et al. IOVS, 2003



Short-term Human Proof-of-concept Trials

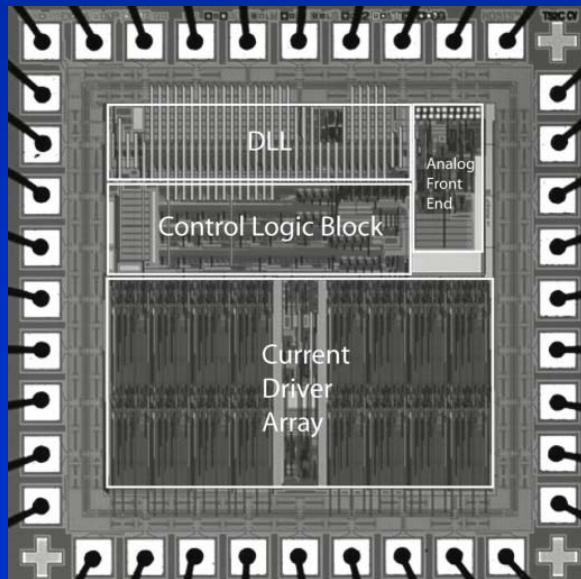
Video - spots





First-Generation Implant

- Implanted in 3 minipigs for up to 10 months in 2008
- Wireless power and data telemetry
- Coated in silicone – viable for many months, not decades



Theogarajan et al. IEEE ISSCC, 2006
Theogarajan IEEE JSSC, 2008

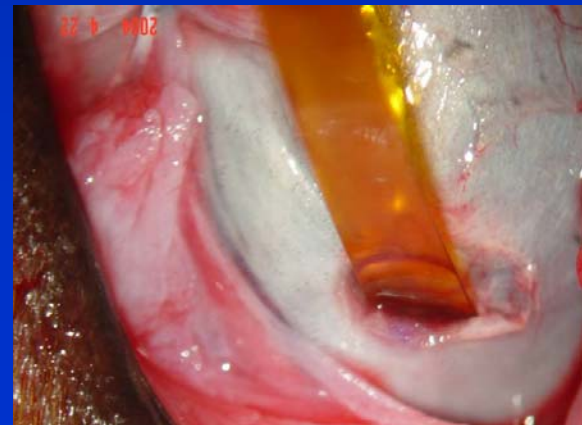
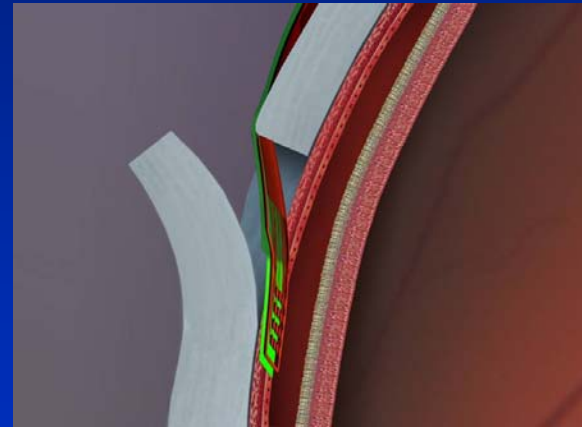
Shire, et al. IEEE TBME, 2009
Kelly, et al. IEEE TBioCAS, 2011



Second Generation Implant

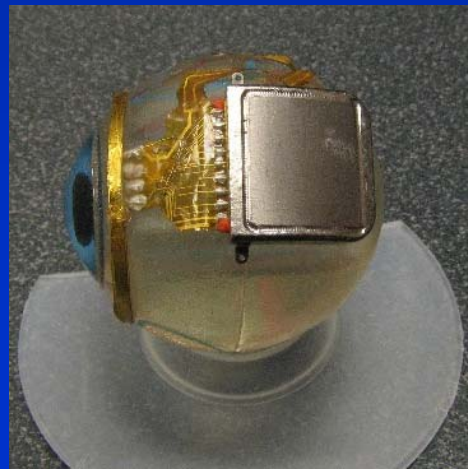
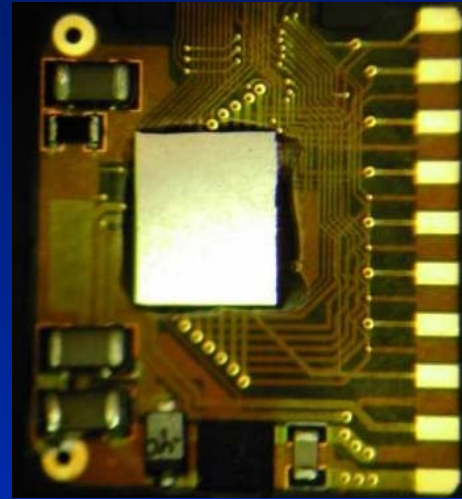
Ab externo approach

- Electrode array enters the space under the retina through the scleral wall of the eye.



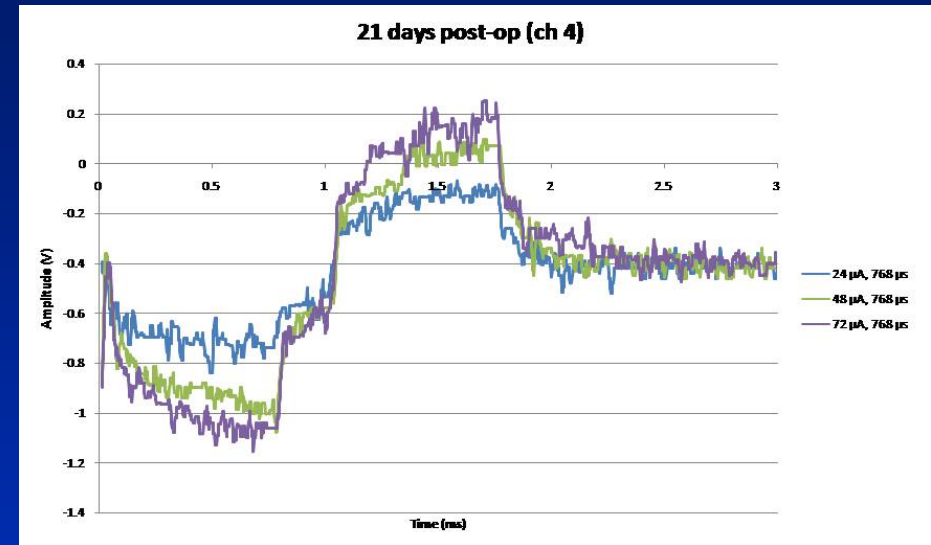
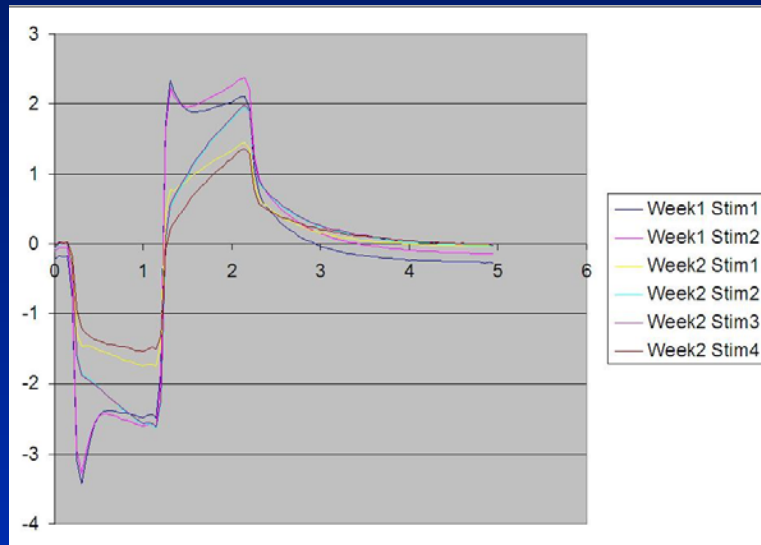


Prototype Implant





In vivo Results



- Recorded artifact of current pulses from cornea – shows implant was working

- Waveform is measured at implant and telemetered out
- Noisy, but you can see the step-ramp components, and variation of voltage with current

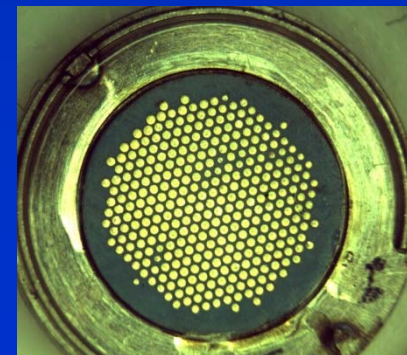
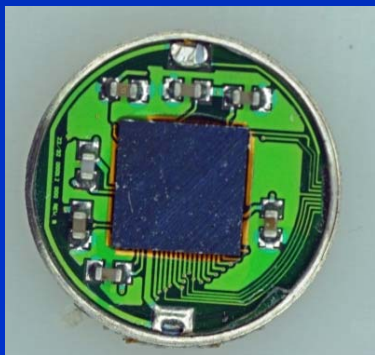
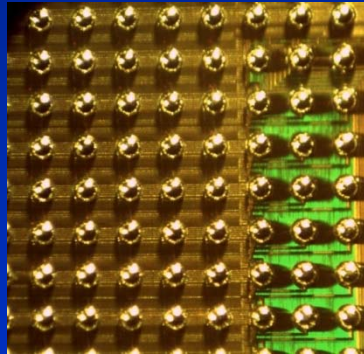
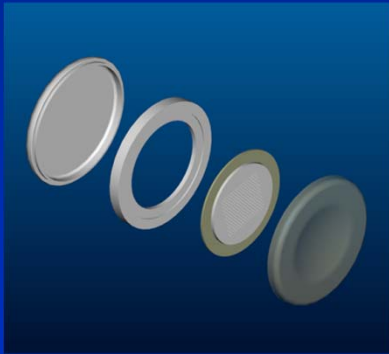
Kelly, et al. IEEE ISABEL, 2009
Kelly, et al. IEEE EMBC, 2009

Kelly, et al. IEEE TBME, 2011
Kelly, et al. BSPC, 2011



Third Generation Prosthesis

- Hundreds of channels (>256)
- Smaller hermetic case
- Devices being assembled and tested in the lab now





Wireless Power and Data for High Channel Count Implant

Power and data are delivered by inductively coupled coils via magnetic fields

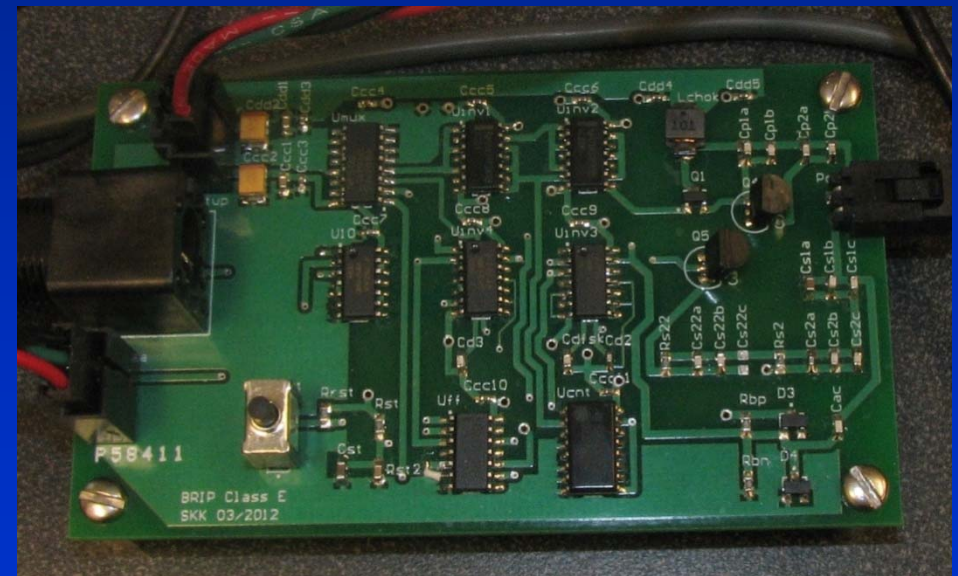
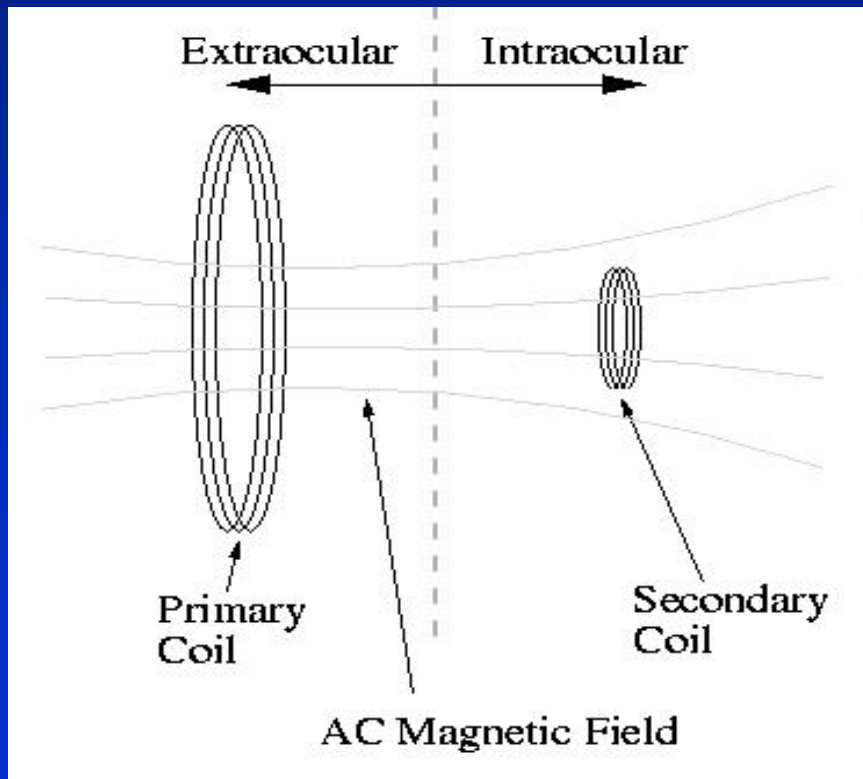




Image Processing

Increasing Resolution



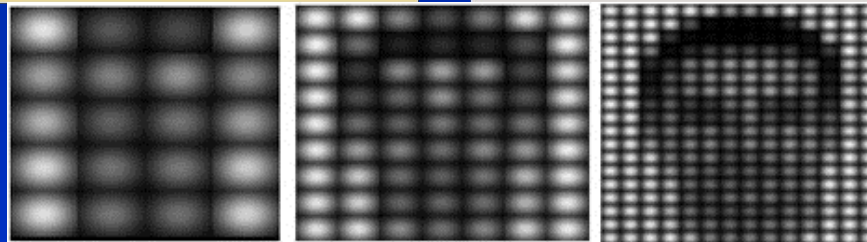
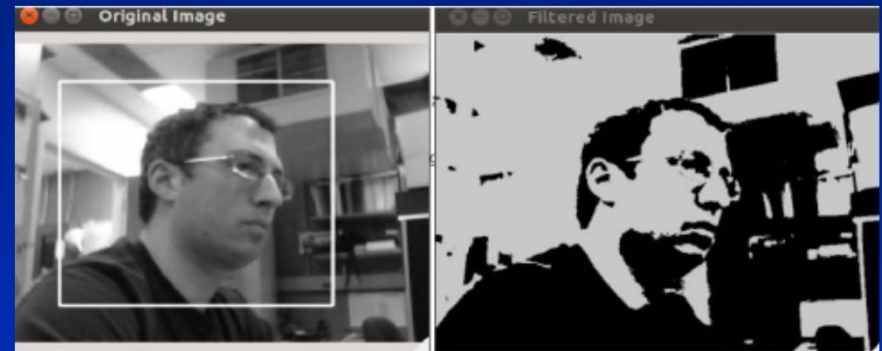
16 electrodes

200+ electrodes

1000+ electrodes

These images approximate what patients with retinal devices ideally could see. It is hoped that increasing the number of electrodes will result in more visual perceptions and higher-resolution vision.

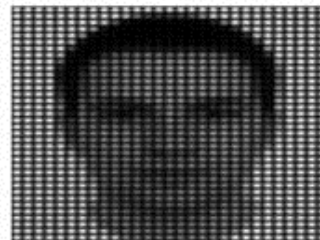
[Credit: California Institute of Technology]



20 Pixels

63 Pixels

252 Pixels



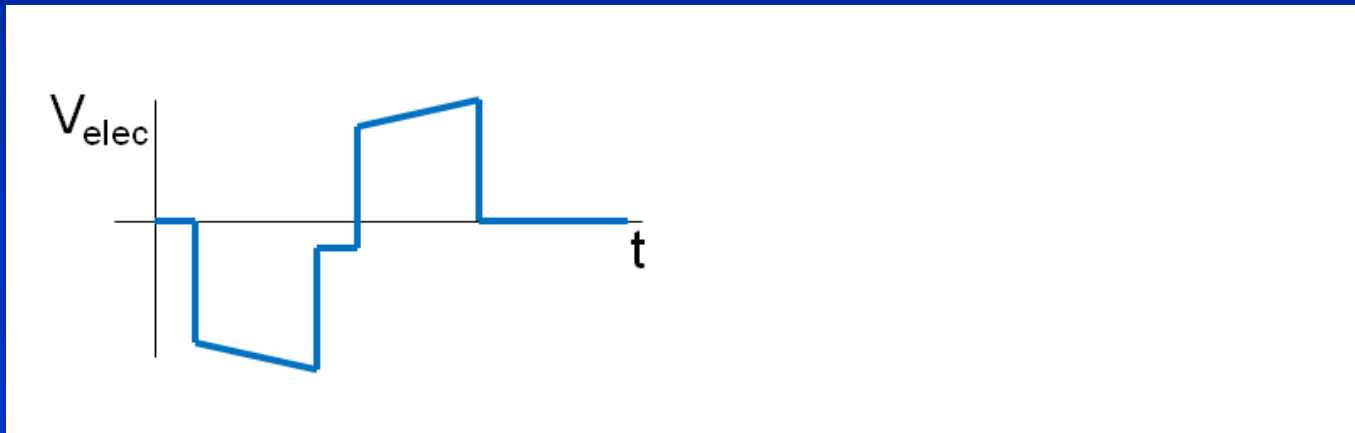
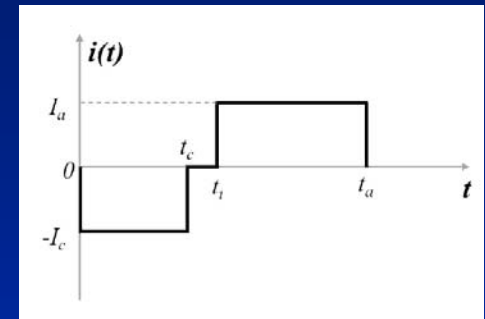
1044 Pixels





Stimulation Safety Circuitry

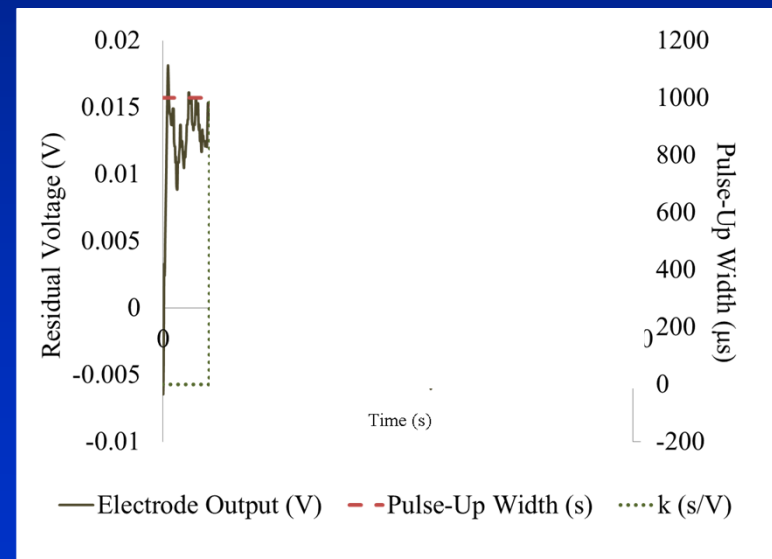
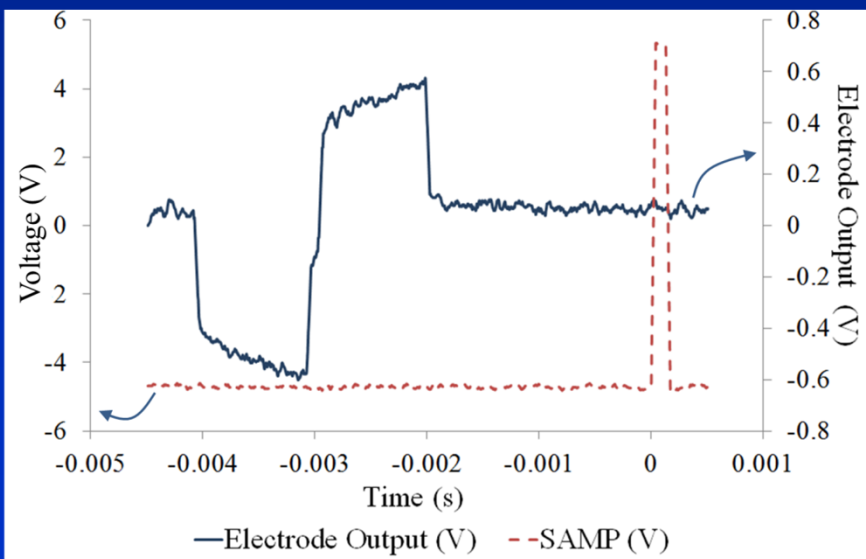
- Biphasic, charge balanced currents are generally used for stimulation
- Because of leakage pathways, these waveforms result in residual charge





Stimulation Safety Circuitry

- We prevent this residual charge from occurring by adjusting the stimulation pulse parameters.





Future Research

- Finish assembly and testing of 256+-channel retinal prosthesis, prepare for FDA clinical trials
- Design external camera system, portable telemetry system, image processing, etc.



The Boston Retinal Implant Project

Engineering

- John L. Wyatt, PhD (MIT)
- Douglas B. Shire, PhD (VA, Cornell)
- Shawn K. Kelly, PhD (VA, CMU)
- Ashwati Krishnan, MS (CMU)
- Marcus Gingerich, PhD (VA, Cornell)
- William Drohan, MS (VA, MIT)
- Oscar Mendoza (MIT)
- Carmen Scholz, PhD (Alabama)

- Stuart Cogan, PhD (EIC Biomedical)
- William Ellersick, PhD (Analog Circuit Works)
- Sonny Behan (Sonny Behan Consulting)

Medicine and Biology

- Joseph F. Rizzo, MD (VA, MEEI)
- Jinghua Chen, MD, PhD (MEEI)
- Hank Kaplan, MD (Louisville)
- Vasiliki Poulaki, MD (MEEI)
- Shelley Fried, PhD (VA, MGH)
- Ralph Jensen, PhD (VA)
- Lotfi Merabet, OD, PhD (VA)

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Discussion

