The Center for Comparative Neuroimaging

A collaborative research center between WPI and UMASS focused on the use of high field magnetic resonance imaging

John Sullivan and Reinhold Ludwig

Board of Trustee Meeting

May 17, 2002
Background

- In May of 1999 Craig Ferris and Jean King of the department of Psychiatry, UMASS Medical School, requested help to design specialized coils for functional MRI of fully conscious animals.

- In May of 2001, CCNI was formally proposed by Craig Ferris to UMASS and WPI:
  - Construction of a separate building
  - Renovation of lab facilities in AK

- In November of 2001 a 4.7T, 30 cm, MR system from Bruker Medical Systems became fully operational.

- In March of 2002 a 9.4T, 9cm MR system from Varian Inc. became fully operational.
CENTER MISSION
To conduct high-resolution anatomical and functional imaging of brain activities in wide-awake animals
Research Activities

- **Biomedical focus** (CF and JK)
  - Imaging functional brain activities
  - Quantitative neuroanatomy
  - Imaging of brain metabolism
  - Imaging brain receptors with ligand specific contrast agents

- **Engineering focus** (JS and RL)
  - RF electronics and coil technology
  - Data processing and visualization
Staffing and funding

- CCNI – MR Facility (3,000 sqft) is jointly financed by WPI/UMASS (Craig Ferris and Jean King)
  - Two magnets (4.7 T and 9.4T)
  - Animal care facilities, graduate student offices, electronic shop, conference rooms,
  - One nuclear physicist and secretary

- CCNI - RF Electronics and Visualization Lab in AK (2100 sqft) (John Sullivan and Reinhold Ludwig)
  - 2 research assistant professors, 1 technician
  - 5 PhD students
  - 4 MS students
  - 3 MQP students

- External funding (9/1/00 – 3/1/02): $972K received
The TEM-resonator consists of volume and surface coils that can be adjusted over the region of interest. The fully conscious animal resides in a mechanical restrainer in the center of the main magnet.
This MR scanner features an 89mm inner diameter bore and a 9.4 T actively shielded superconducting main magnet.

The 9.4T system has 4 times better SNR compared to the 4.7T system and allows the study of synaptic brain activities.
RF- Coil Technology

Key idea: multi transmission line system that forms a microwave resonator structure

Inspired by: EE 3113 Introduction to RF Circuit Design
A range of volume and surface coils are under development

Systems have been tested at: Yale, U of Minnesota, Emory, Dartmouth, MGH.
Performance of coil technology

Rhesus TEM Coil
Axial (left)
Coronal (right)
Different phantoms
SNR = 298 (coronal)

Large Bruker
volume coil
SNR = 109 (coronal)
Superior image quality and resolution of actively tuned/detuned dual coil system

Adapted from Hagino et al., Brain Res ……

Adapted from Ogawa et al., PNAS
The Future?

11.7T system at NIH, Bethesda, MD

Tim Fisher '02
Making measurements at NIH

Coil performance with a phantom

11.7T magnet = 19 tons, shielding = 65 tons
Research challenges – Gradient Coils

Conventional gradient coil set

New surface gradient

- designed and built by F. Shi/ R. Ludwig

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L_s = 0.274 \text{ mH} \\
R_s = 0.918 \Omega
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Research challenges – Standing Wave effect

Unloaded coil, f = 200 MHz

Loaded coil, f = 400 MHz
CCNI is a team effort
Special thanks

- Jack Carney and Bill Durgin for having providing institutional support
- John Orr for lab renovation
- Alex Emanuel for lab space