Virtual Bio-Instrumentation

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Potential VBI Applications

- Basic Research
  - Medical Schools / Universities
  - Private Research Companies (e.g. Pharmaceuticals)
  - Typically Animal based (Human data available in some cases)
  - Freedom to acquire and analyze data according to individual investigators requirements
- Clinical Research
  - Collect data from existing equipment
  - Often includes statistical analysis based on treatment protocols
  - Typically conducted by MDs who may or may not be computer literate
  - Not many willing to devote time to learn or program in LabVIEW

Potential VBI Applications

- Medical Informatics
  - Hospital/Bed Management
  - ICU Data Monitoring / Display
- Hospital / Clinic Diagnostic Tools
  - Diagnostic Equipment
    - e.g. Plethysmograph, Echocardiograph Machine
  - Treatment Equipment
    - e.g. TEMS Unit, Ventilator

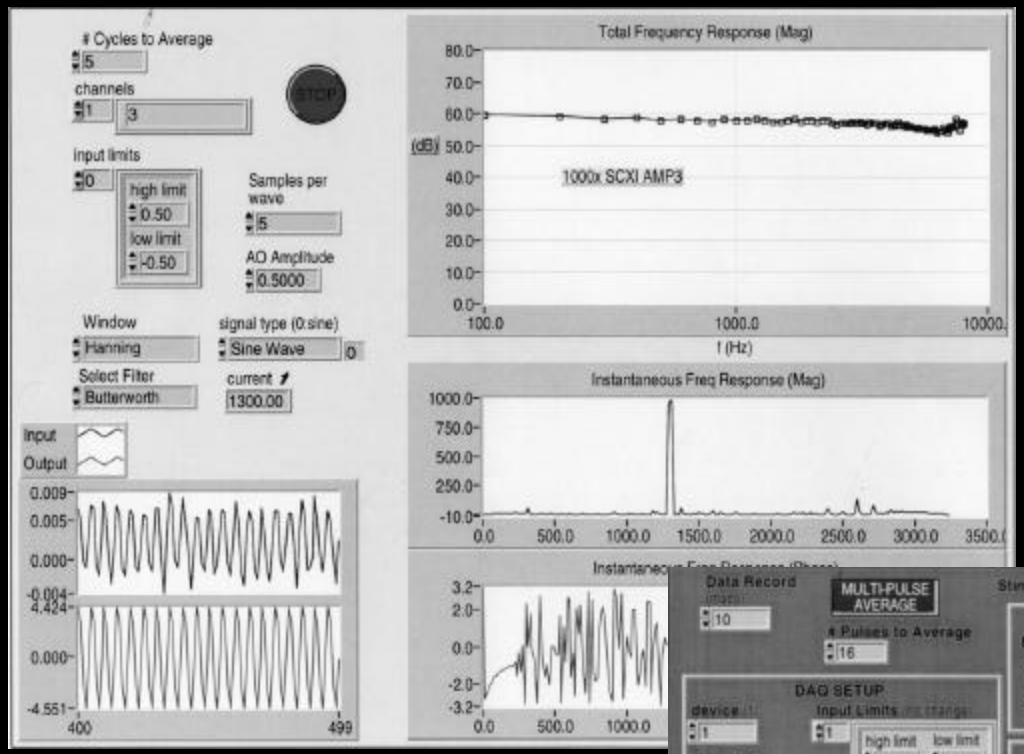
} Governed by FDA

- Extended Applications

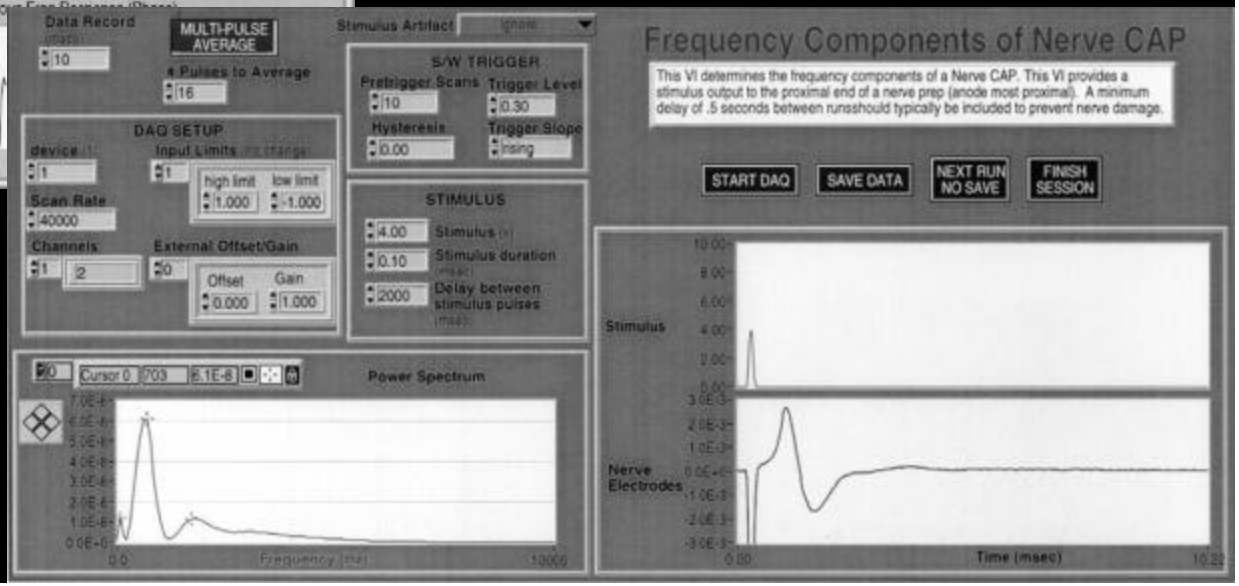
Biomedical Fields for DAQ

- Common Mechanical Stimuli
  - Pressures, Flows, Temperatures
- Biopotentials
  - ECG, EMG, ERG, EEG, ENG, etc
  - μV/mV levels, > 20 kHz Sample Rate
- Imaging Techniques
  - Echocardiogram, blood vessel contraction
  - Edge detection, microscopic imaging
- Clinical Instrumentation
  - Acquisition from existing equipment (mostly serial)

Generic DAQ/Instrumentation Issues

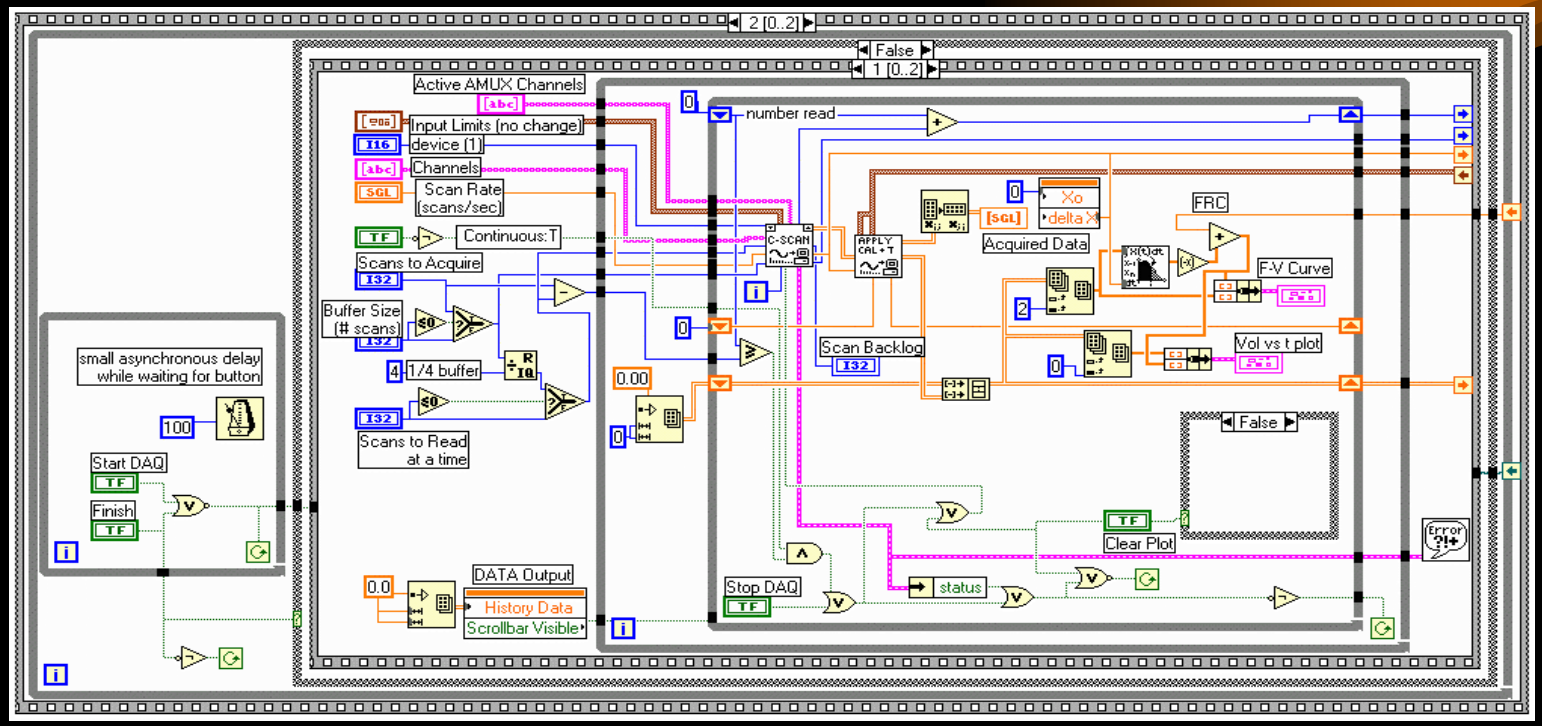


- Amplifier Frequency Response



- FFT of Nerve CAP

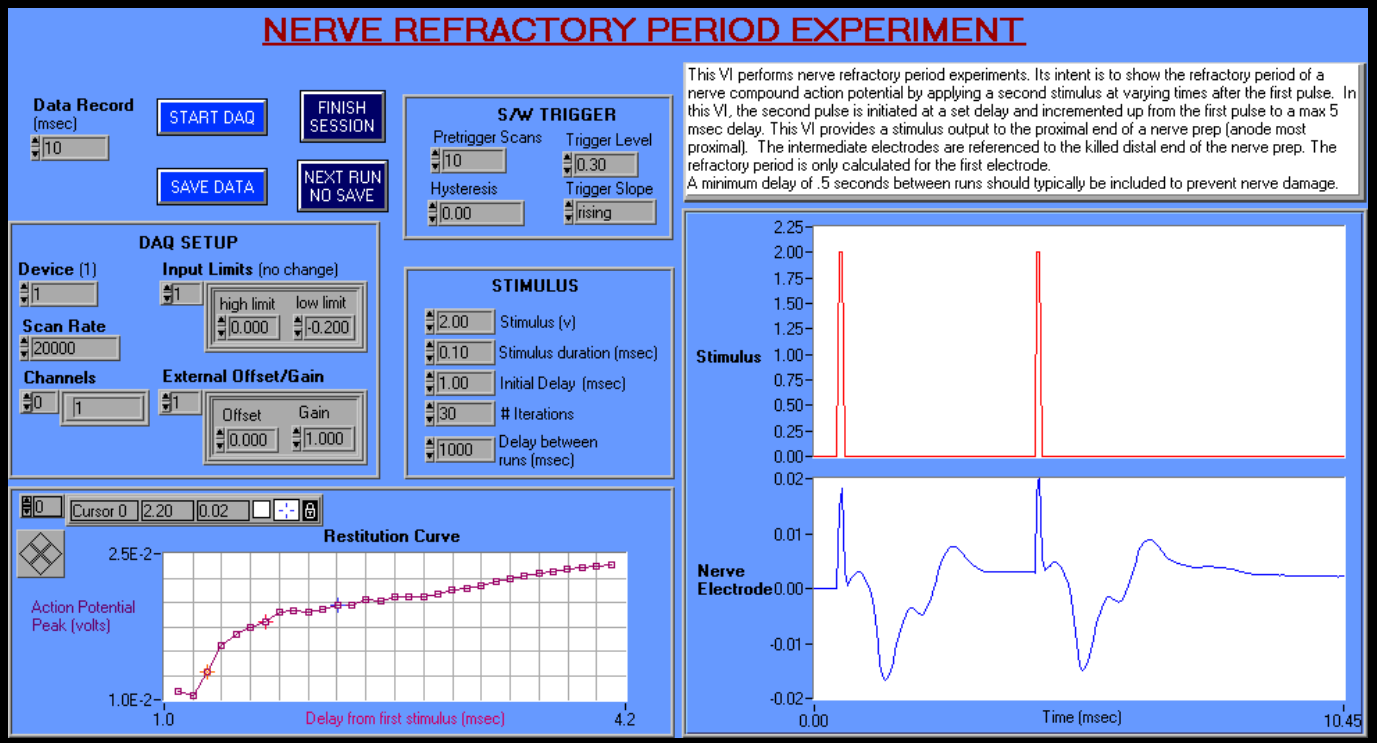
Role of Virtual Instrumentation



- User-Friendly GUI Interface for Experiments and Analysis
- Modular Development Scheme
- Flexibility/Adaptability

Generic VI Development Issues

- Simultaneous I/O
- Data storage for post-processing
- Automation and HMI

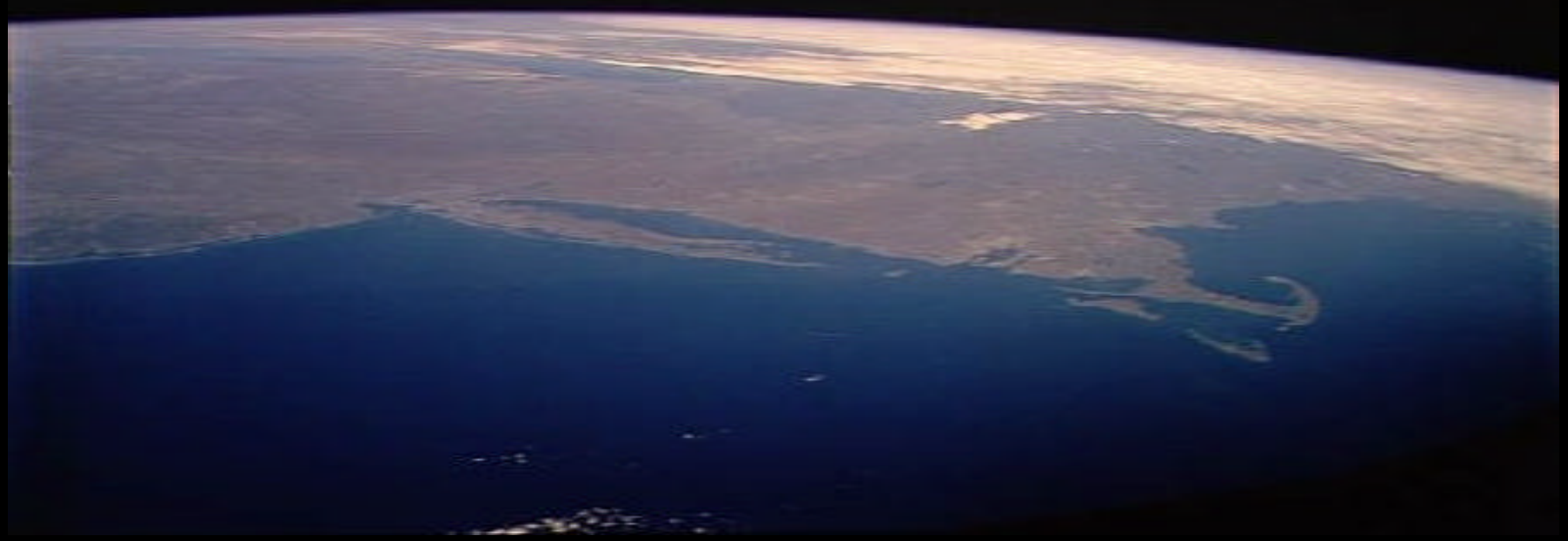


Basic Research

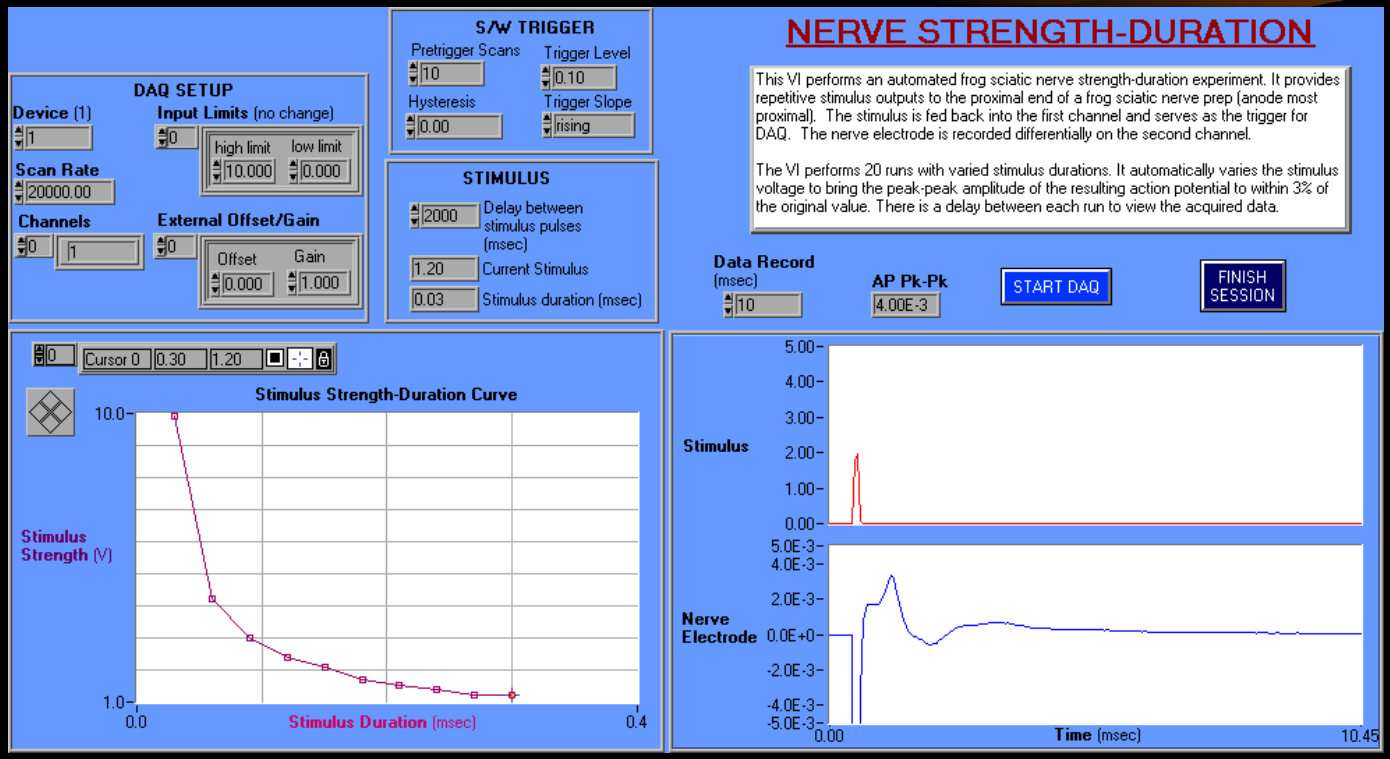
- Basic Research Field ideal for incorporation of existing NI hardware & LabVIEW / LabWindows.
  - Requires NI personnel be familiar with biomedical applications and sufficiently able to converse in medical lingo.
  - Requires stronger ties with research equipment suppliers [e.g. World Precision Instruments (WPI)].
  - BioBench has been retooled to accommodate a wider variety of experiments and analysis.
- NI, suppliers and users should exercise a substantial list of typical biomedical experiments to understand and document issues.
    - e.g. to understand the appropriate equipment required to record ENG data at 10 μV and 50 kHz, while supplying a 10 sec stimulus pulse every 100 msec.

Basic Research Applications

- Vertebrate Systems
- Mammalian Systems
- Cellular Technology
- Electroneurology
- Cardiopulmonary
- Mathematical Modeling

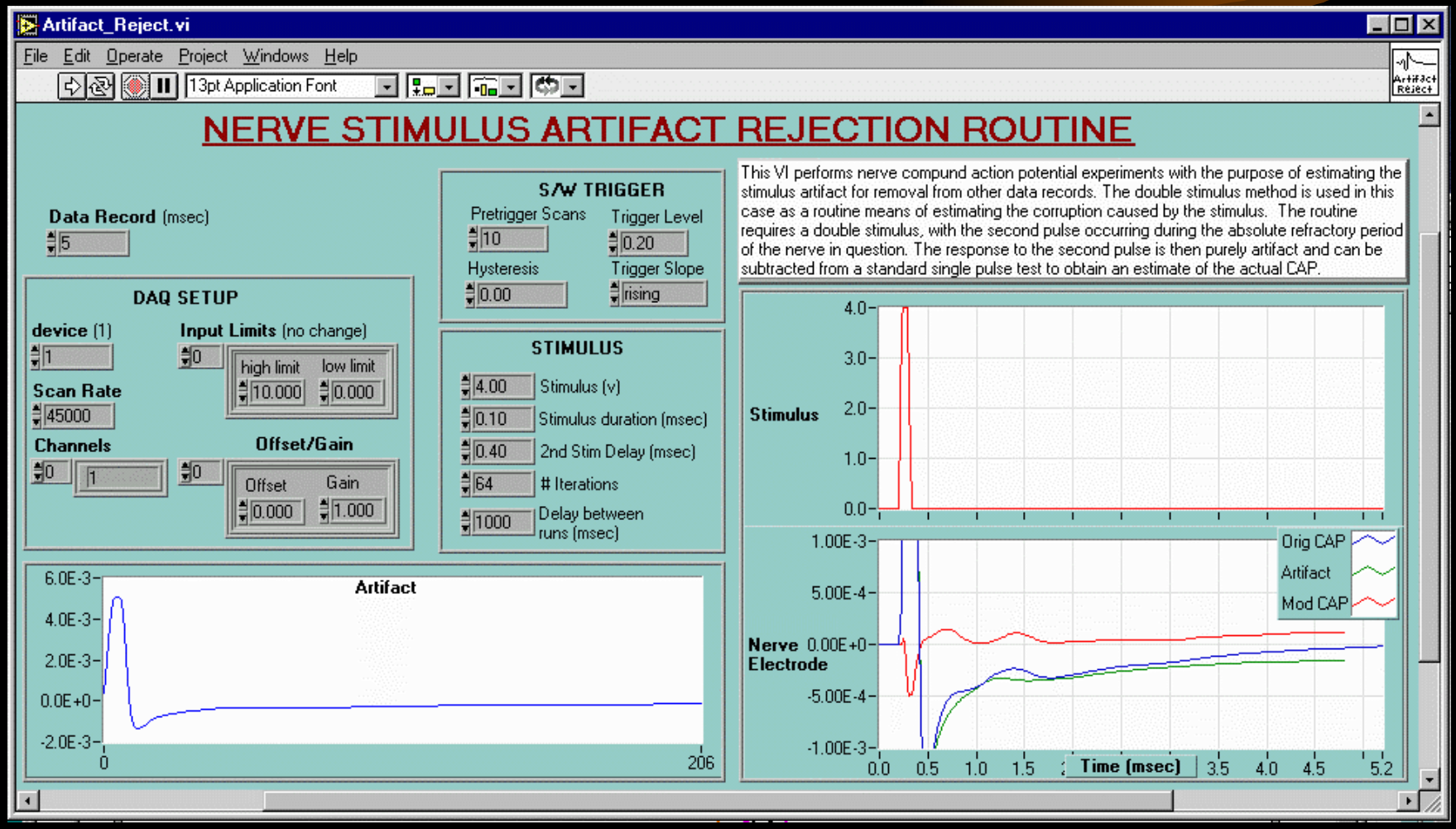


Electrophysiology

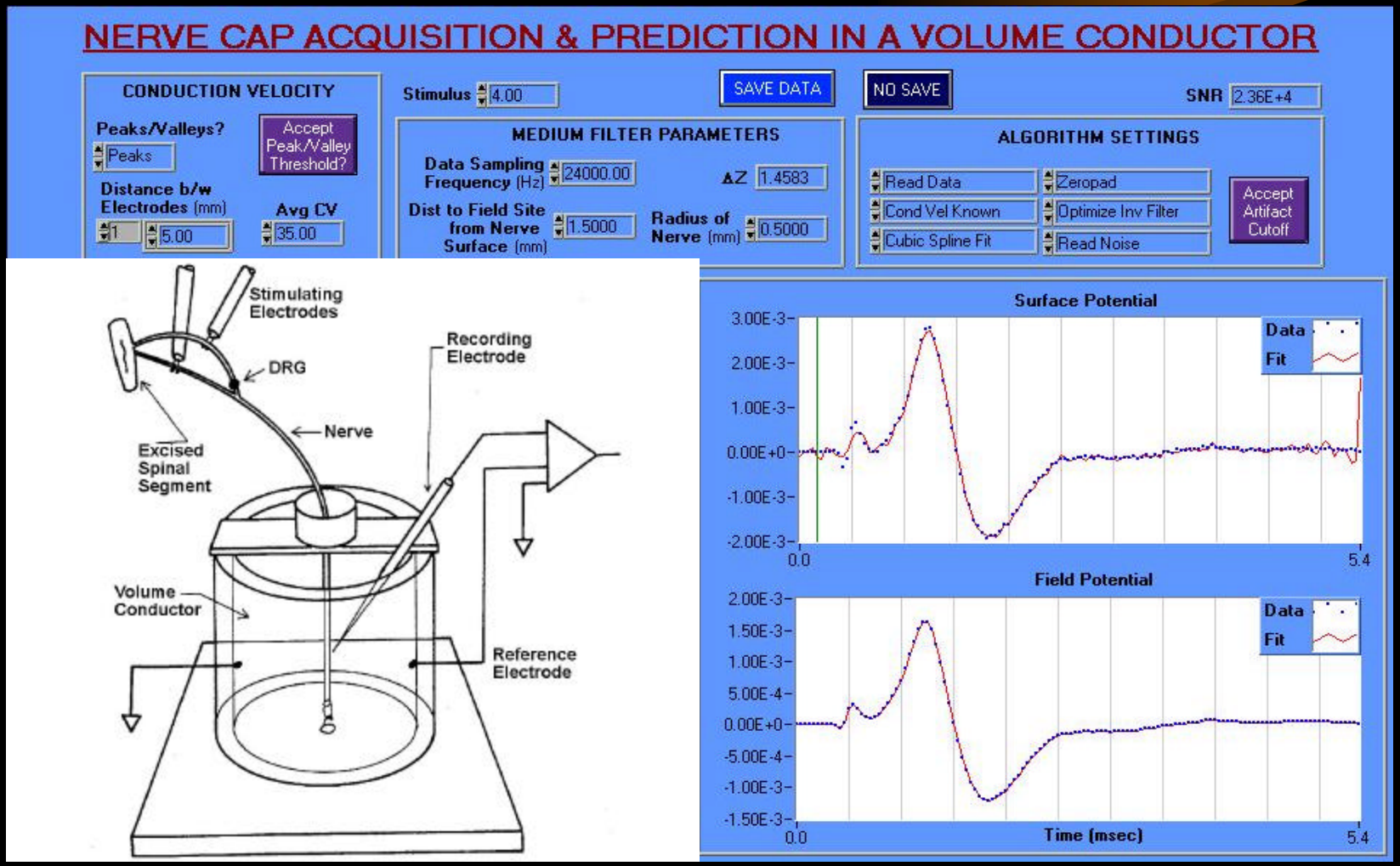


- Recruitment
- Conduction Velocity
- Excitability
- Restitution
- Excitation-Contraction Coupling
- Tetany

Stimulus Artifact Rejection

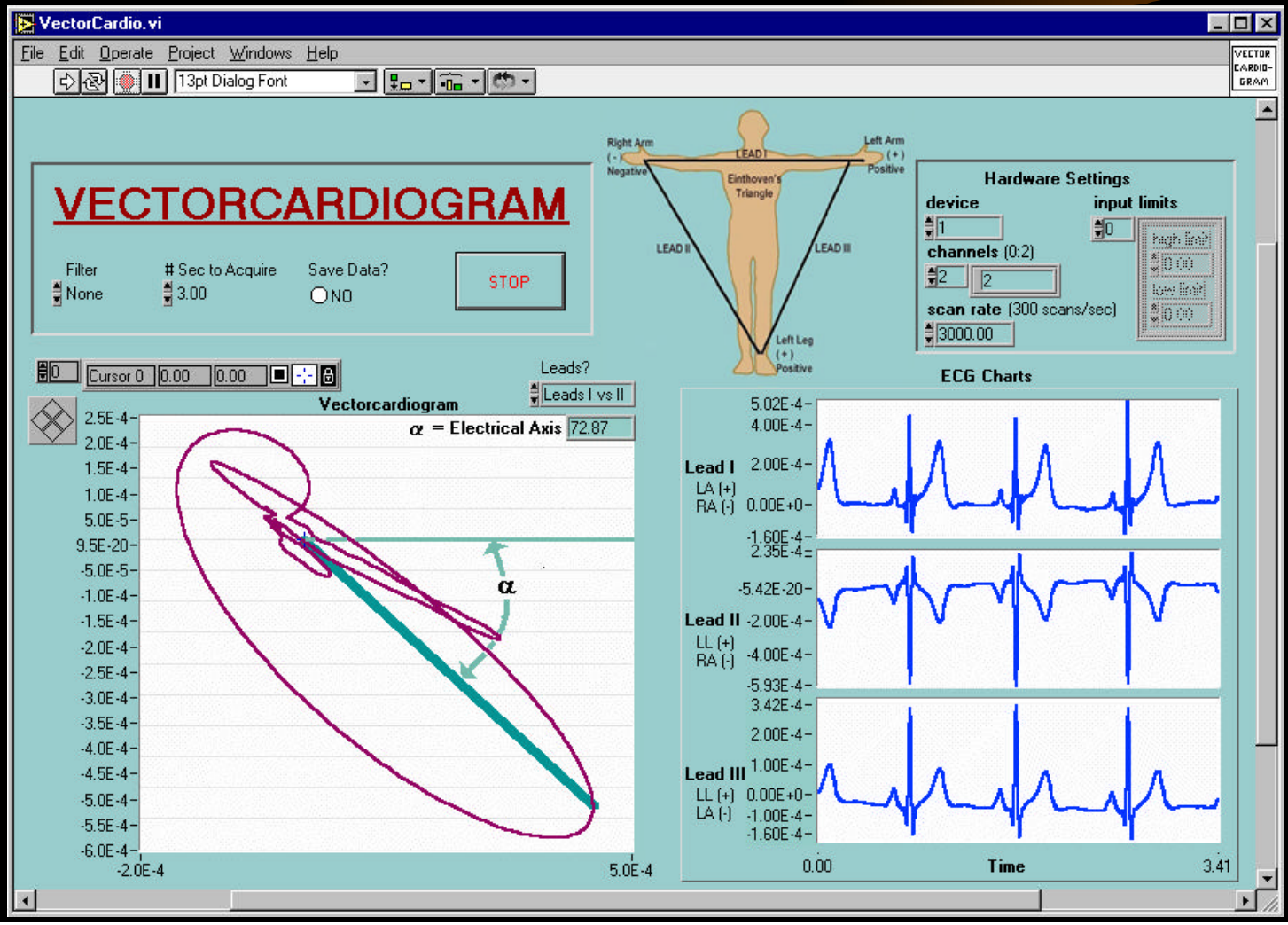


Volume Conductor Problem

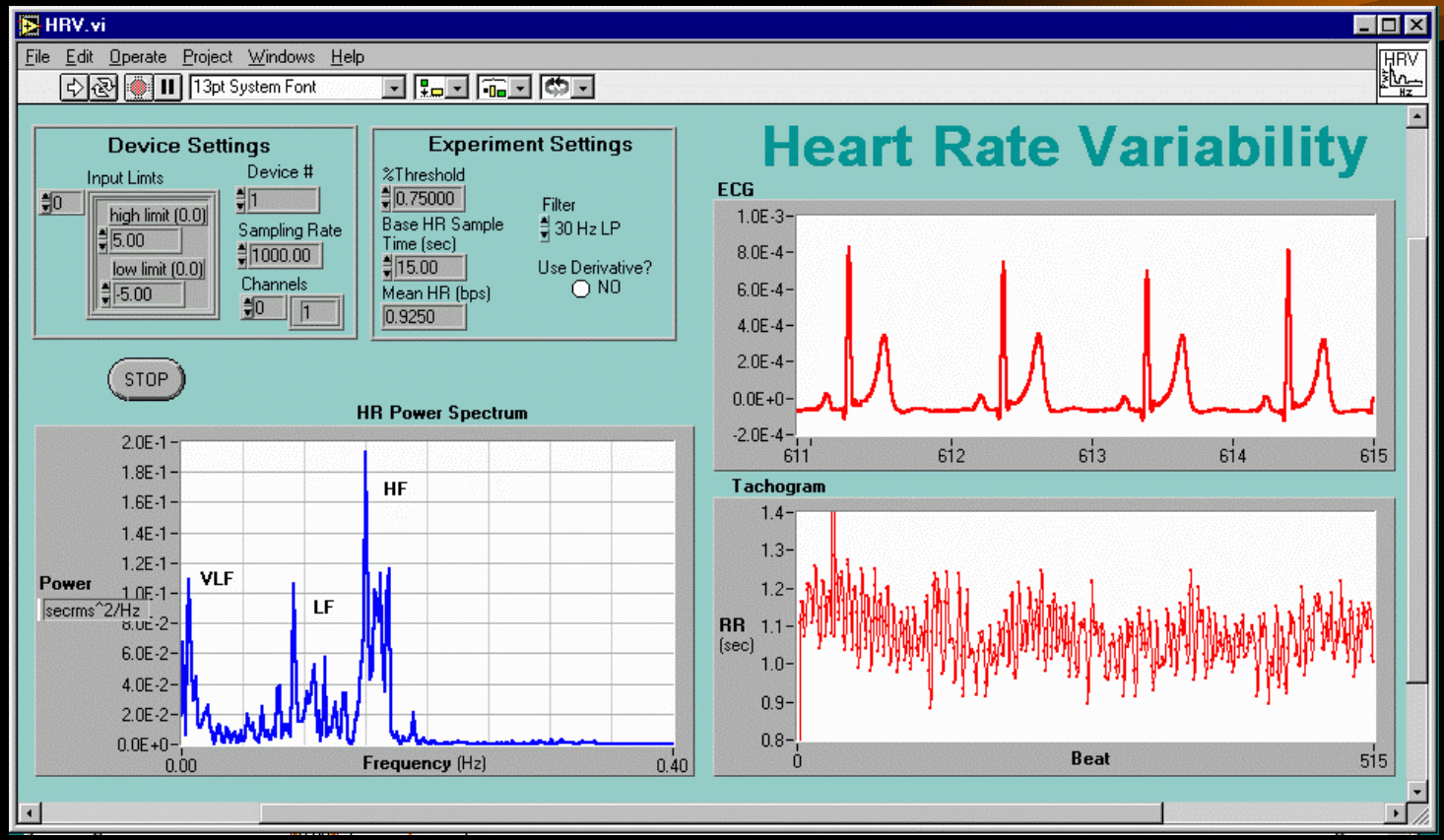


Cardiac Electrophysiology

- Electrocardiography
- Vectorcardiography



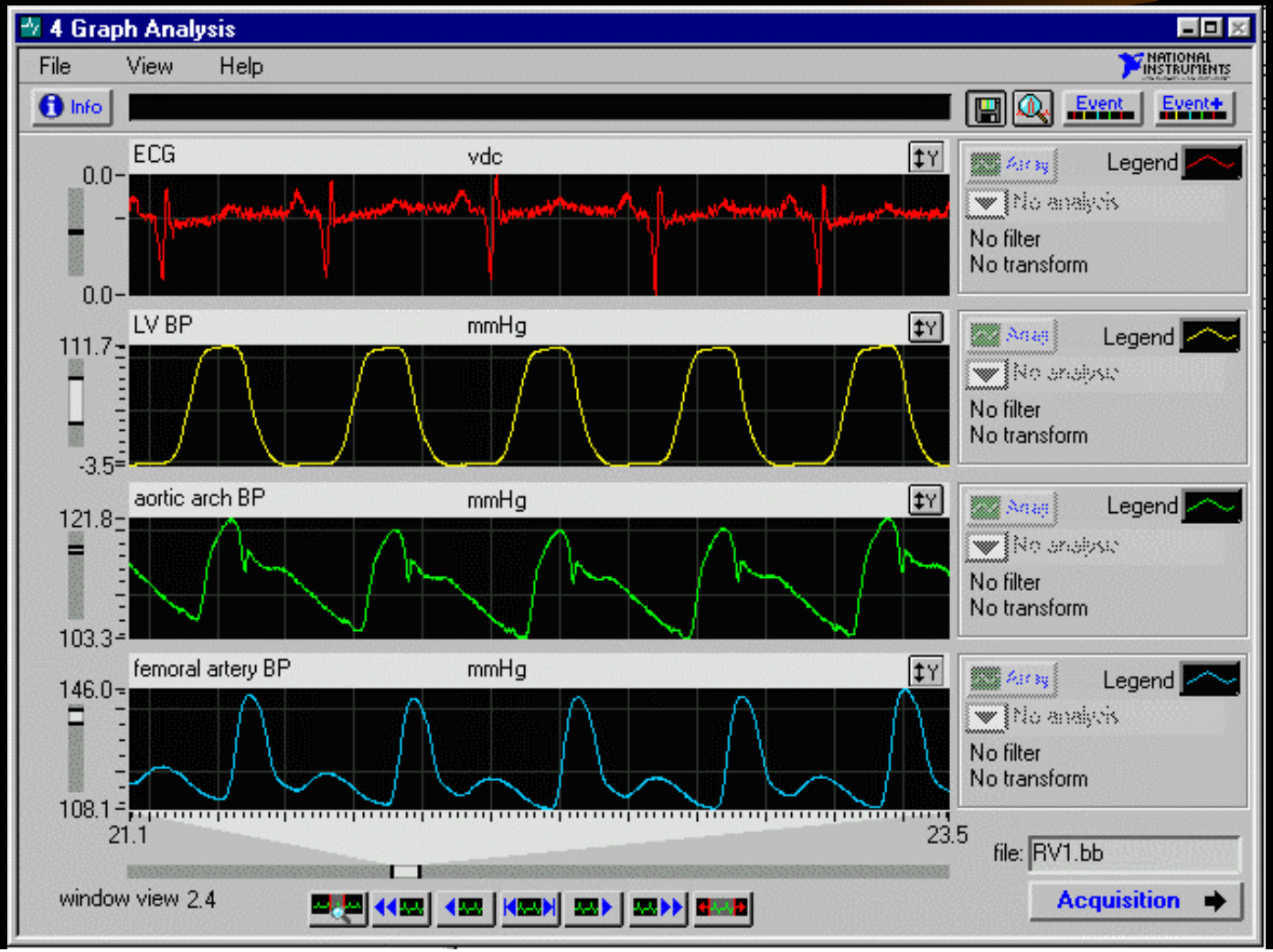
Research Topics



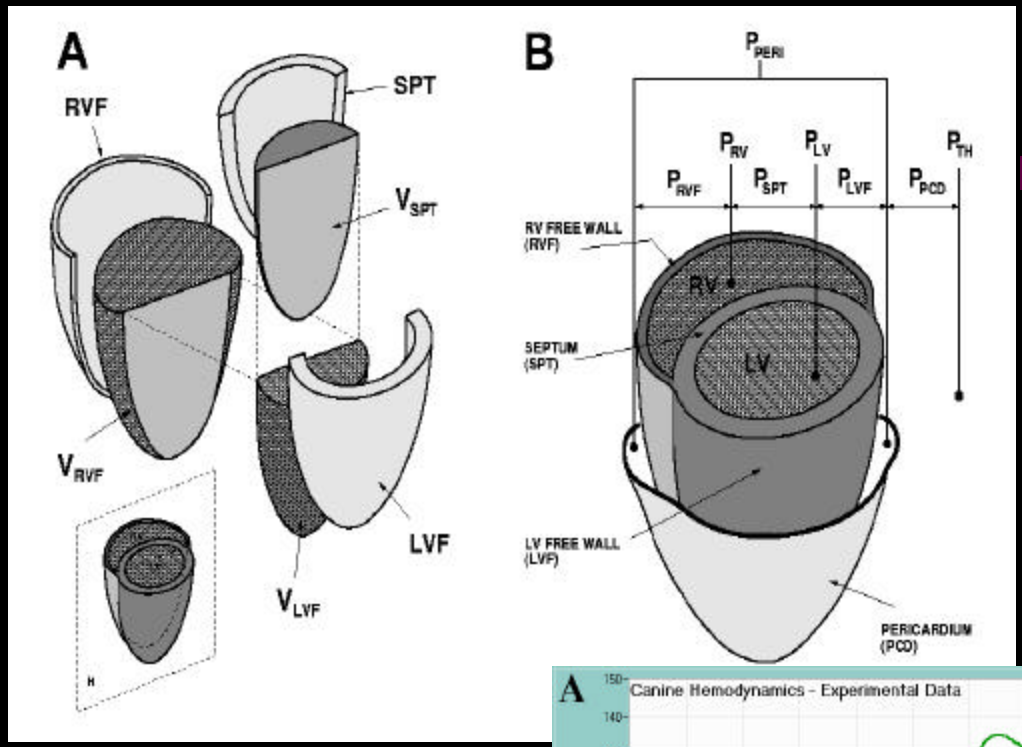
- Heart-Rate Variability
- Parasympathetic Neural Control
- Phase Response
- Entrainment

Cardiovascular Hemodynamics

- Cardiac Function
- P-V Characterization

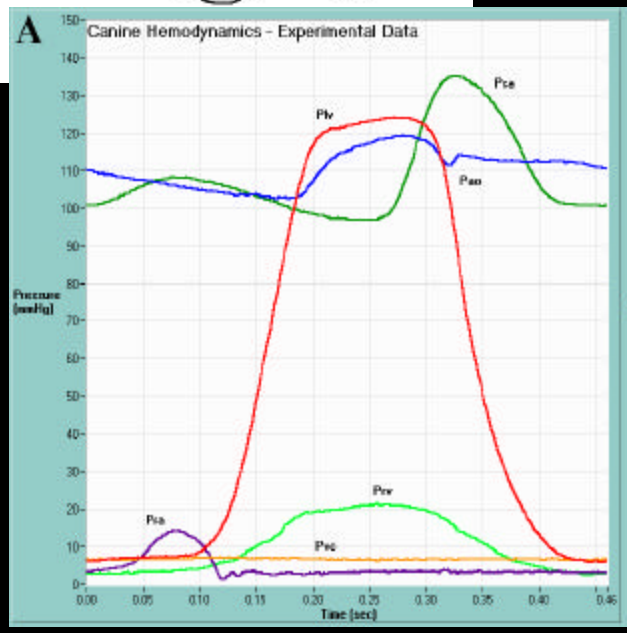


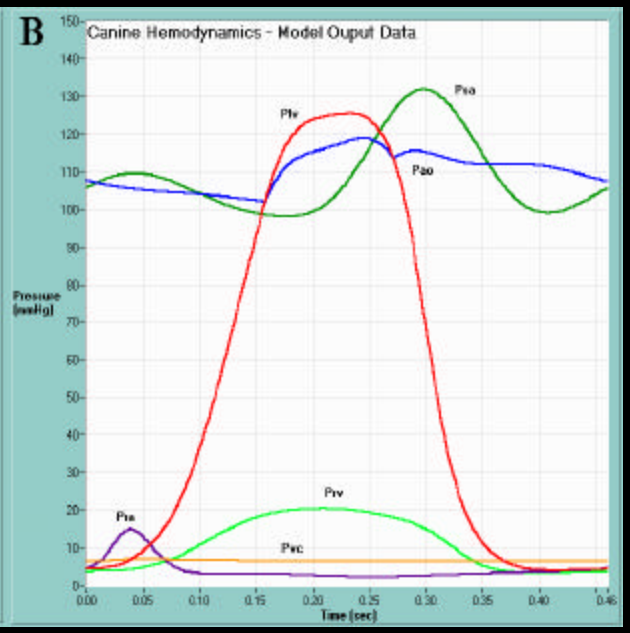
Modeling



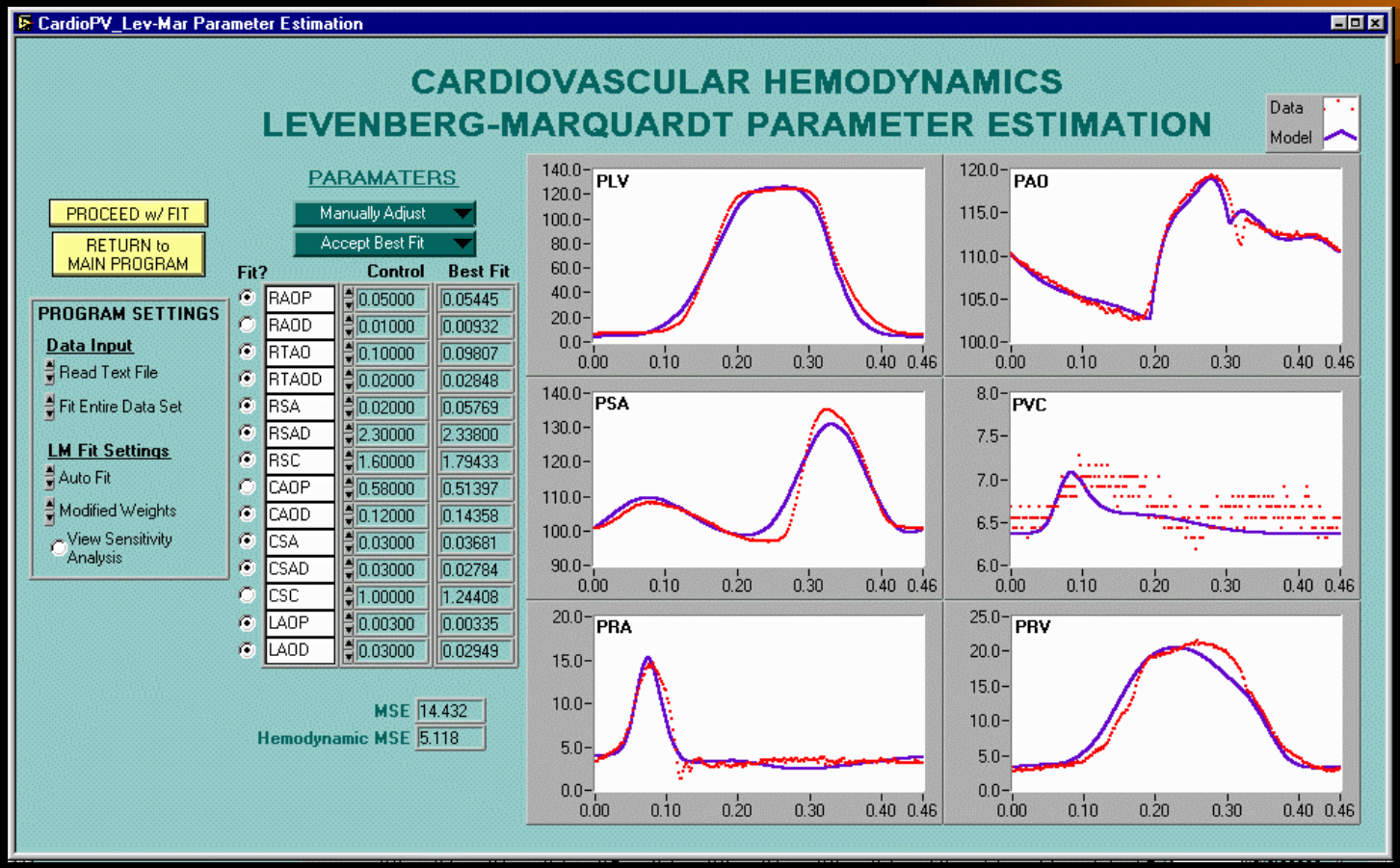
- Right-Left Ventricular Interaction

- Closed-loop Circulatory Modeling



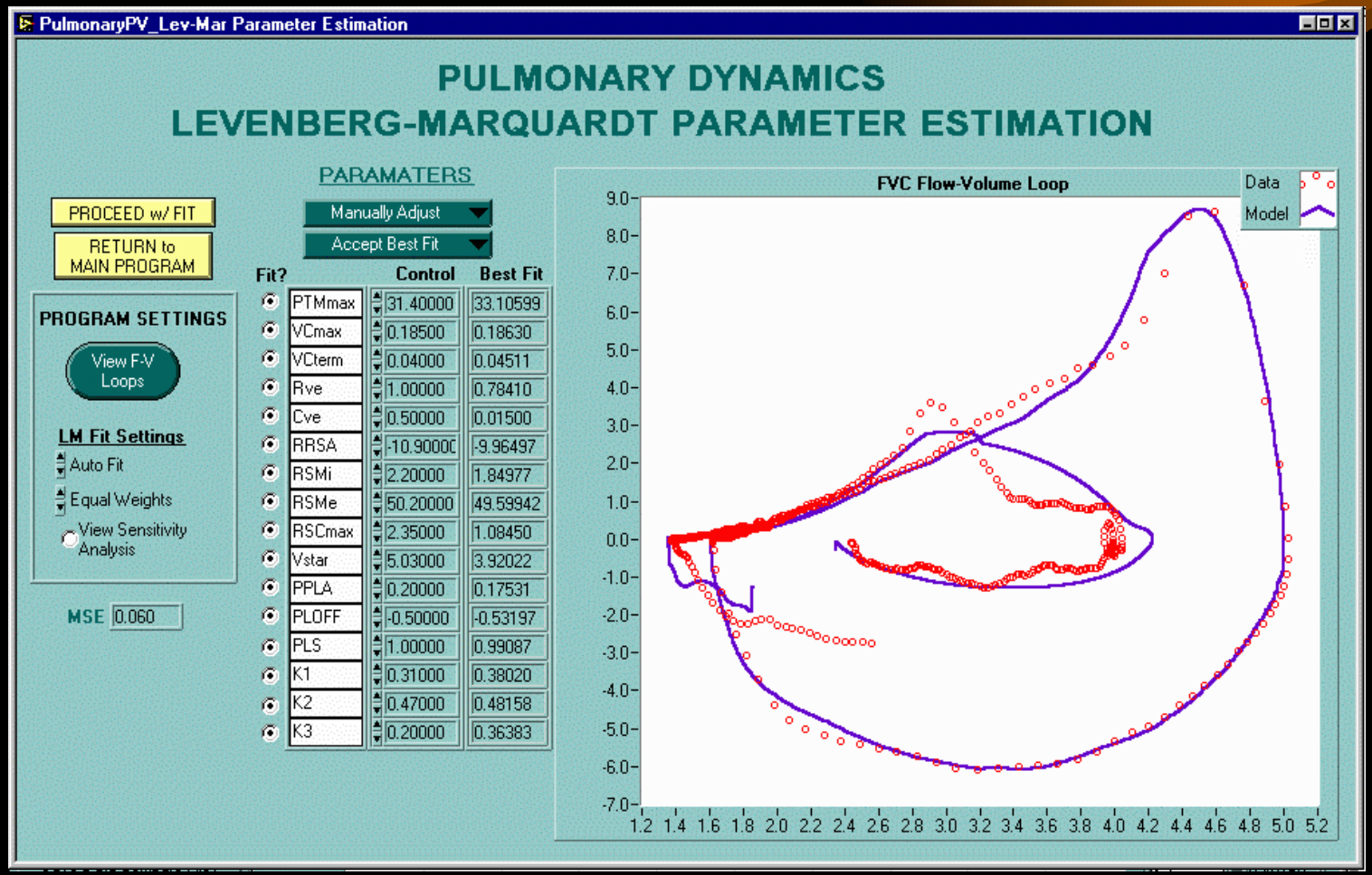


Cardiovascular Modeling

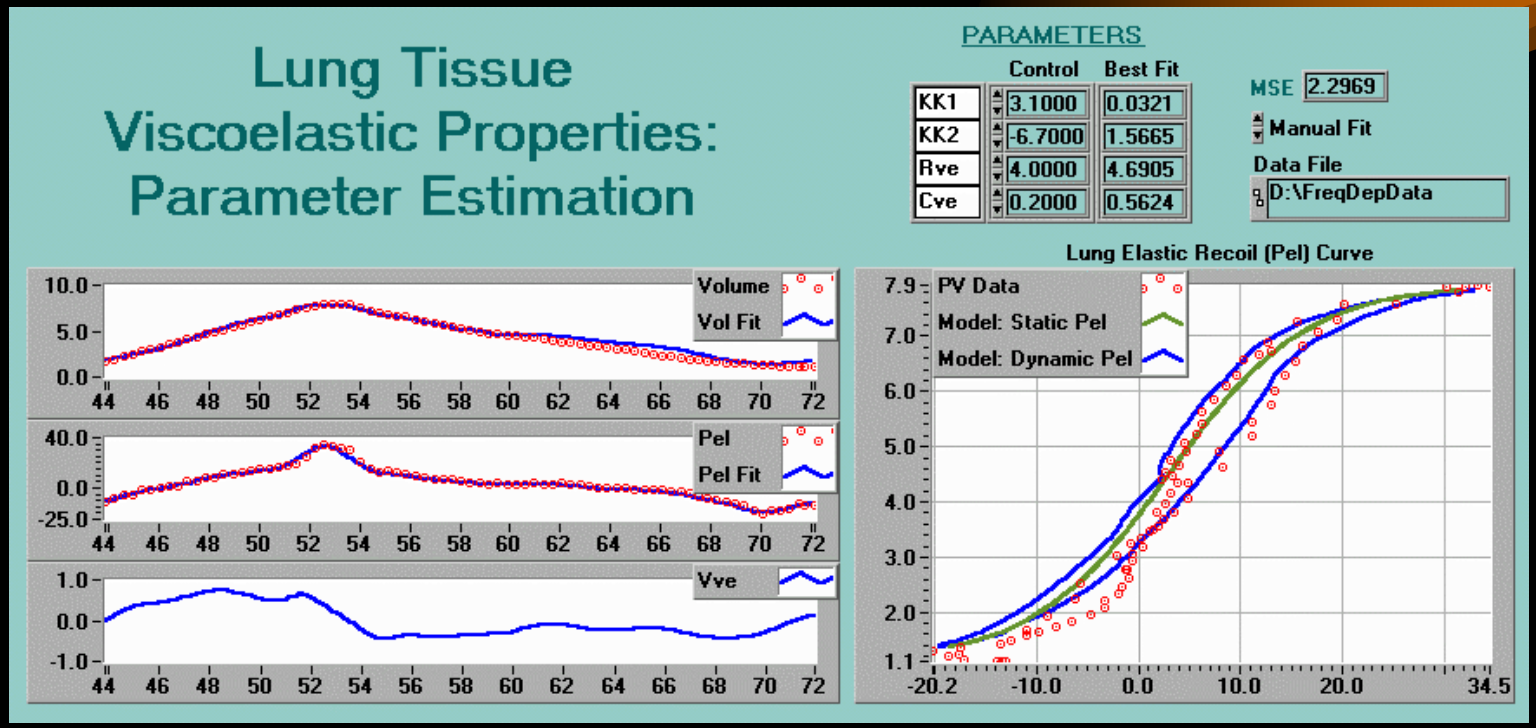


- Nonlinear Parameter Estimation
- Online Parameter Sensitivity Analysis

Lung Model Parameter Estimation



Lung Tissue Parameter Estimation

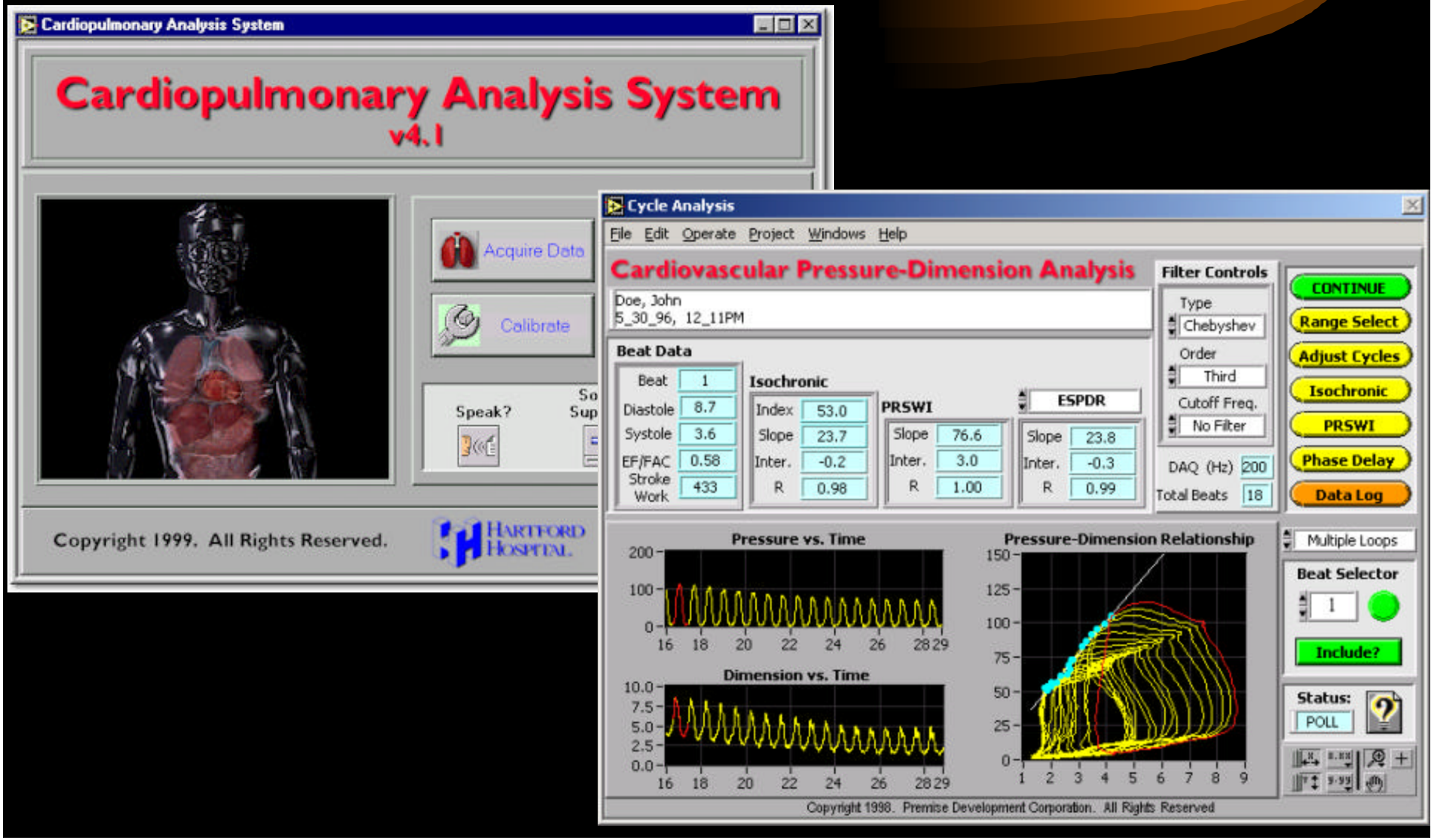


- Pulmonary System Modeling
- Work of Breathing
- Pulmonary Energy Analysis
- Integrated CO_2 / Airway Mechanics Analysis
- Nonlinear Parameter Estimation

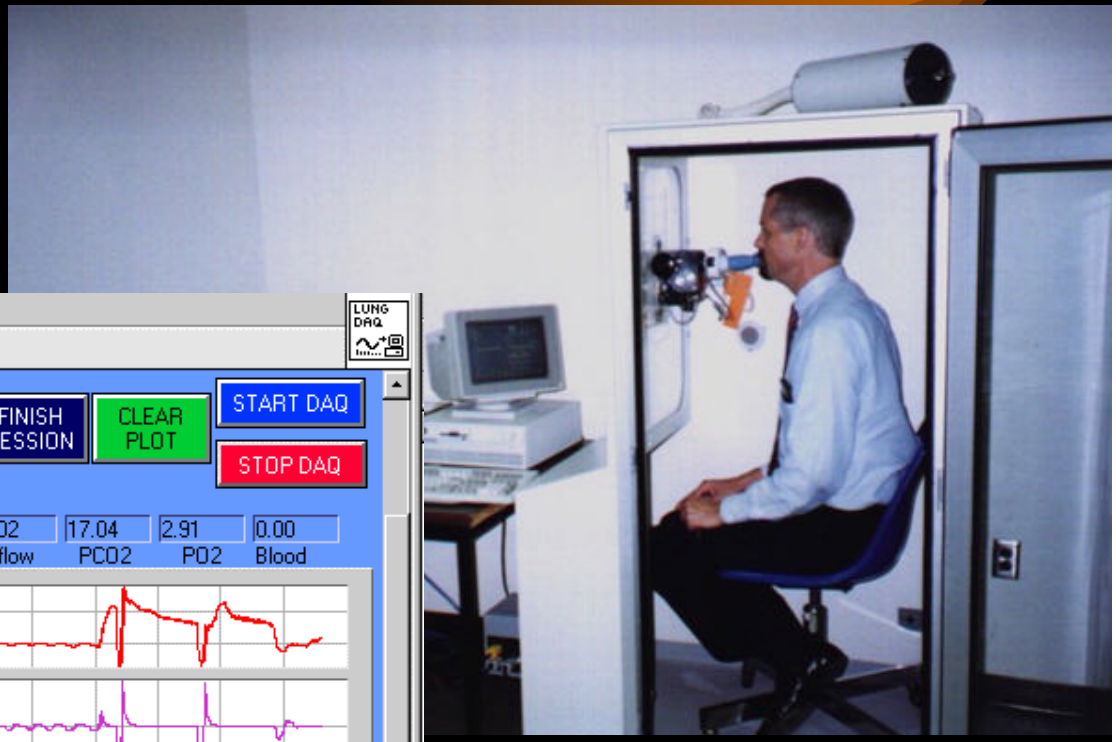
Clinical Research

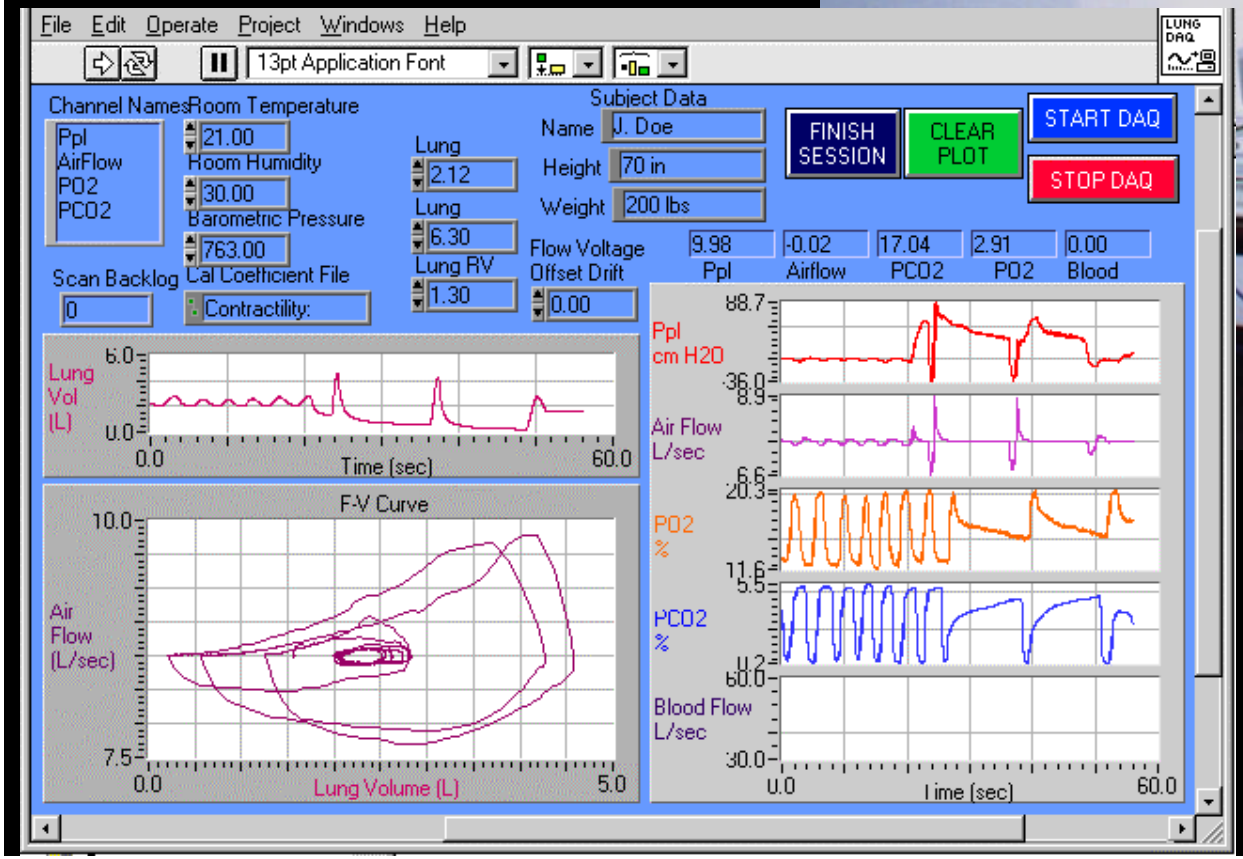
- Clinical Research also has potential for significant infiltration of VBI
  - Requires NI personnel be familiar with biomedical applications and sufficiently able to converse in medical lingo.
  - Requires stronger ties with clinical equipment suppliers.
  - BioBench / LabVIEW incorporate a user-friendly means of collecting and automatically synchronizing data from multiple serial, GPIB, and analog sources.
    - Serial (RS232) output is most common form available from commercial equipment.
  - BioBench now has additional flexibility in allowing data to be analyzed during or after collection

Cardiopulmonary Analysis

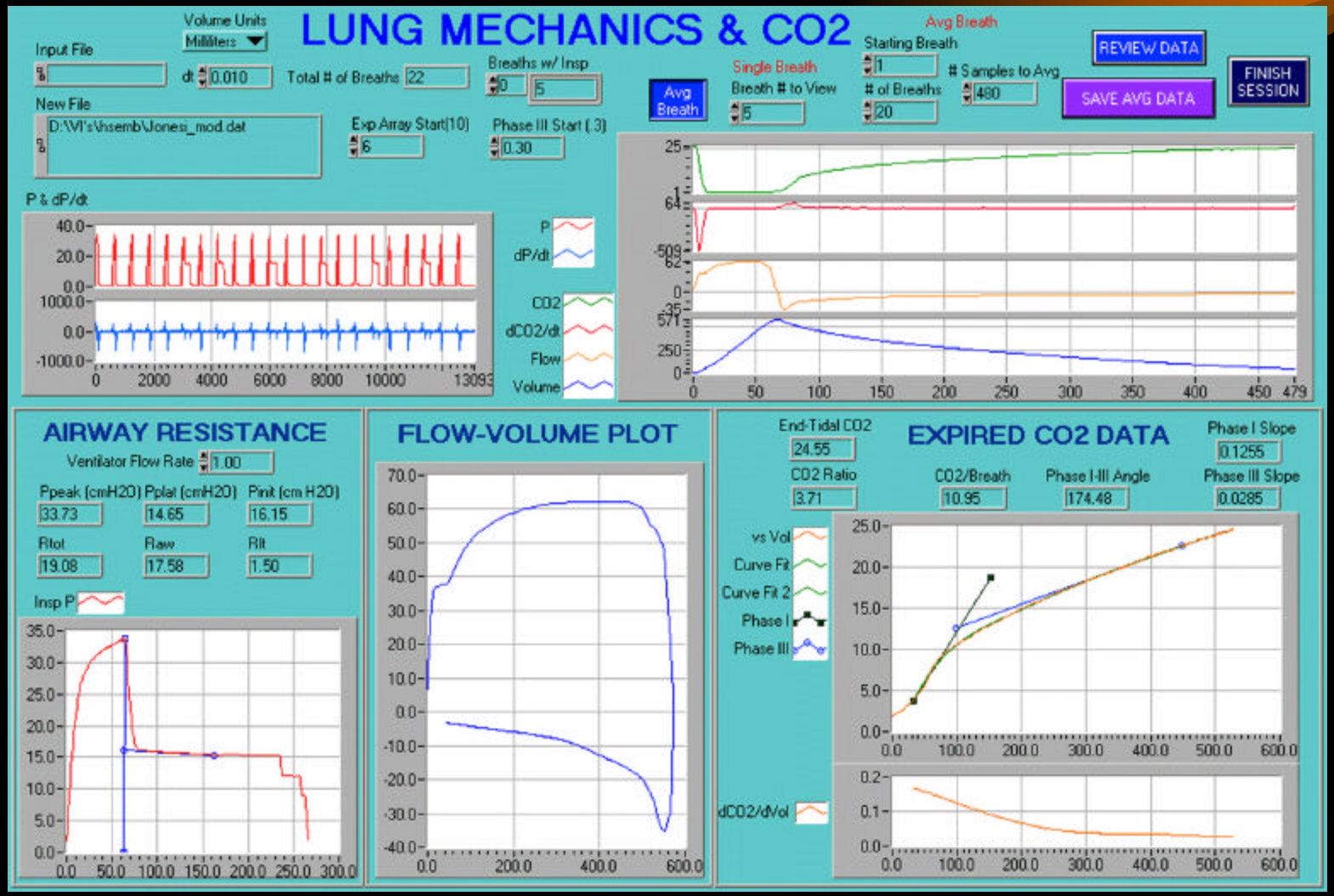


Pulmonary Function Testing

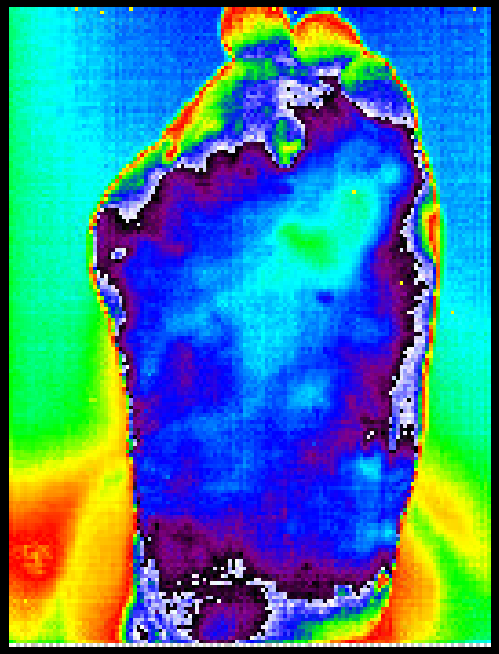


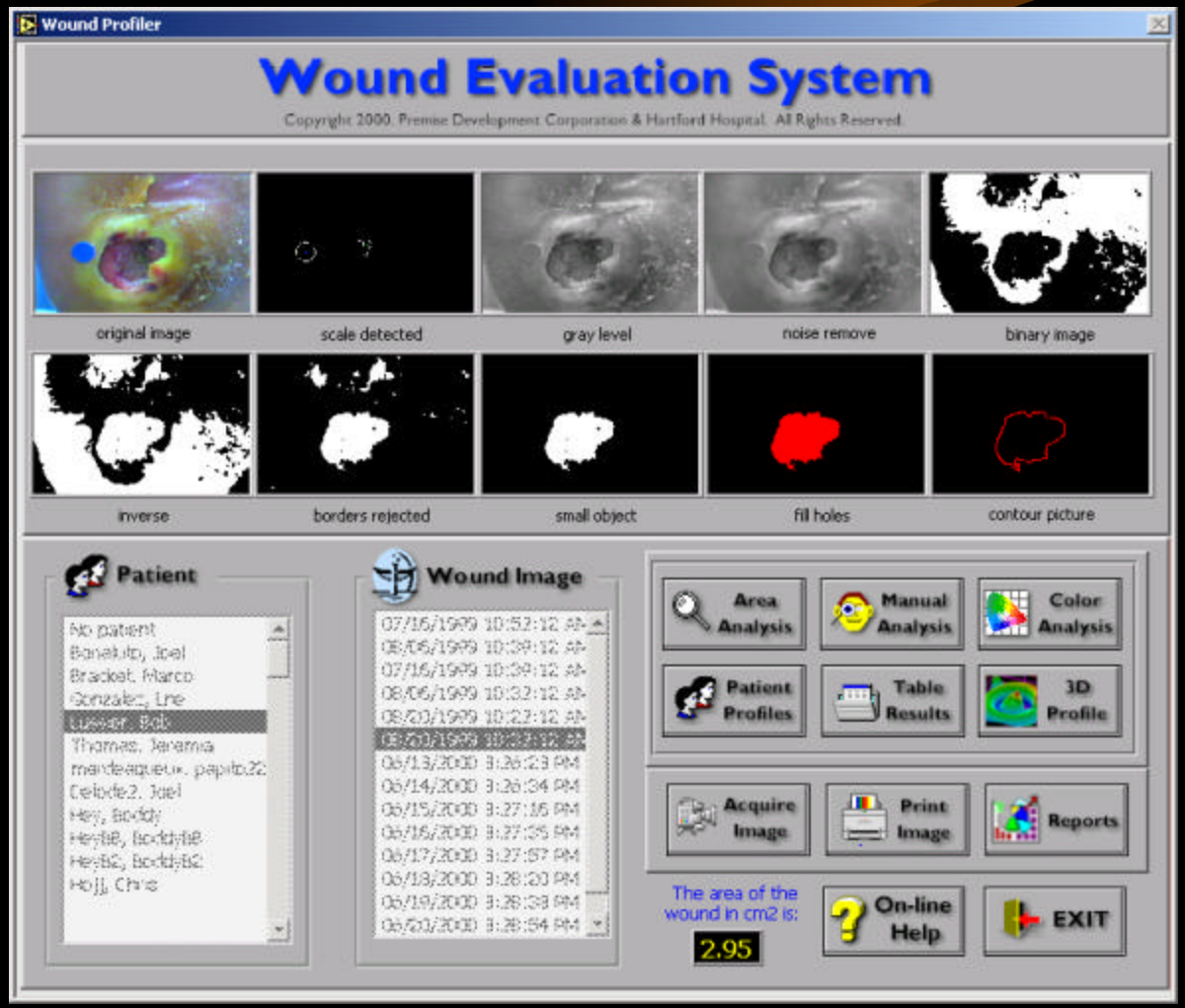


Ventilatory Patient Management



Imaging Techniques

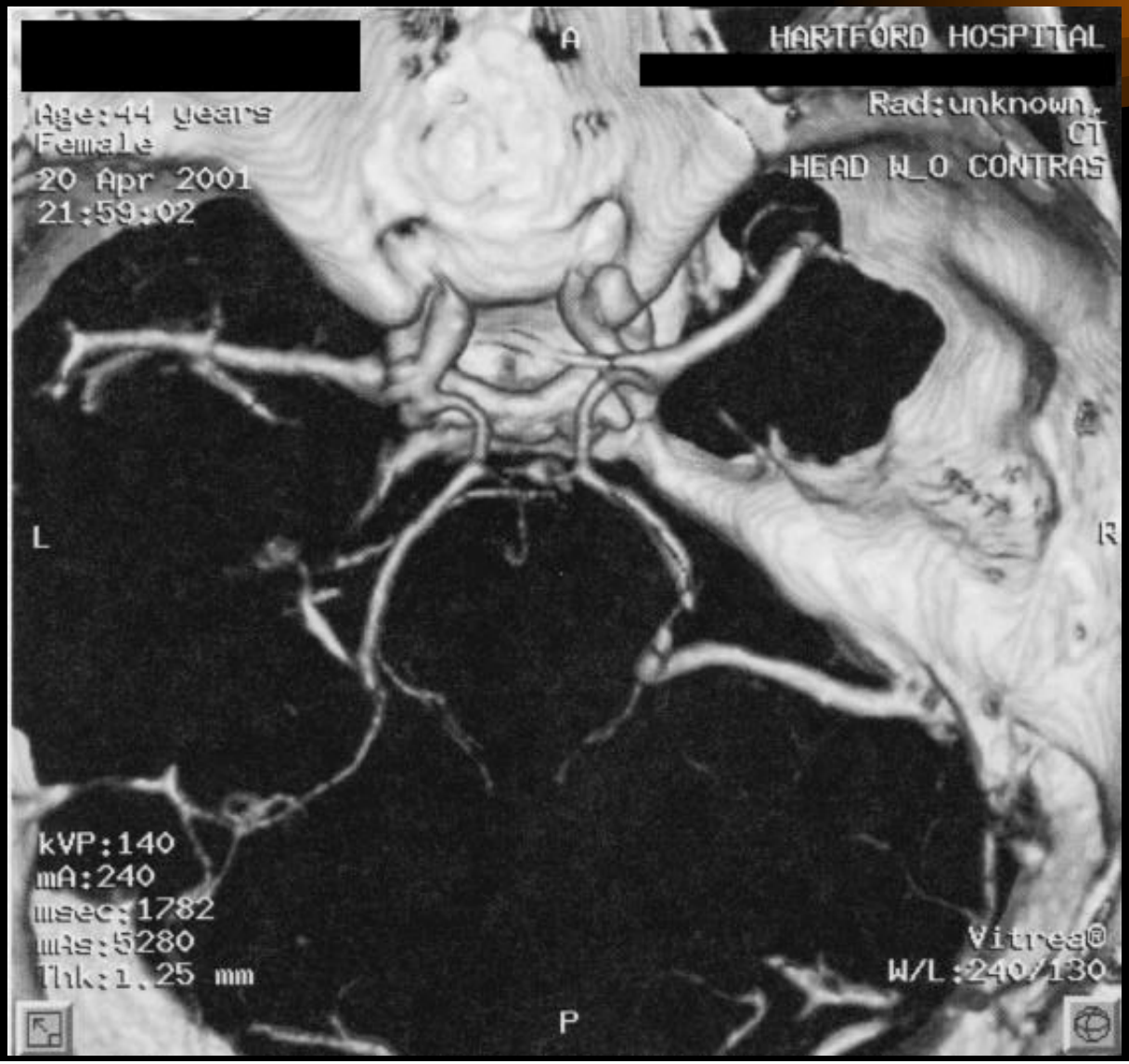




Medical Informatics

- The process of transforming data into information in healthcare
  - Electronic Medical Record (EMR)/Computerized Patient Record (CPR)
  - Decision support
  - Information retrieval
  - Imaging / Telemedicine
  - Medical education
  - Consumer health information systems
  - Public health information systems
  - Bioinformatics
  - Outcome analysis
  - Patient monitoring

Medical Imaging

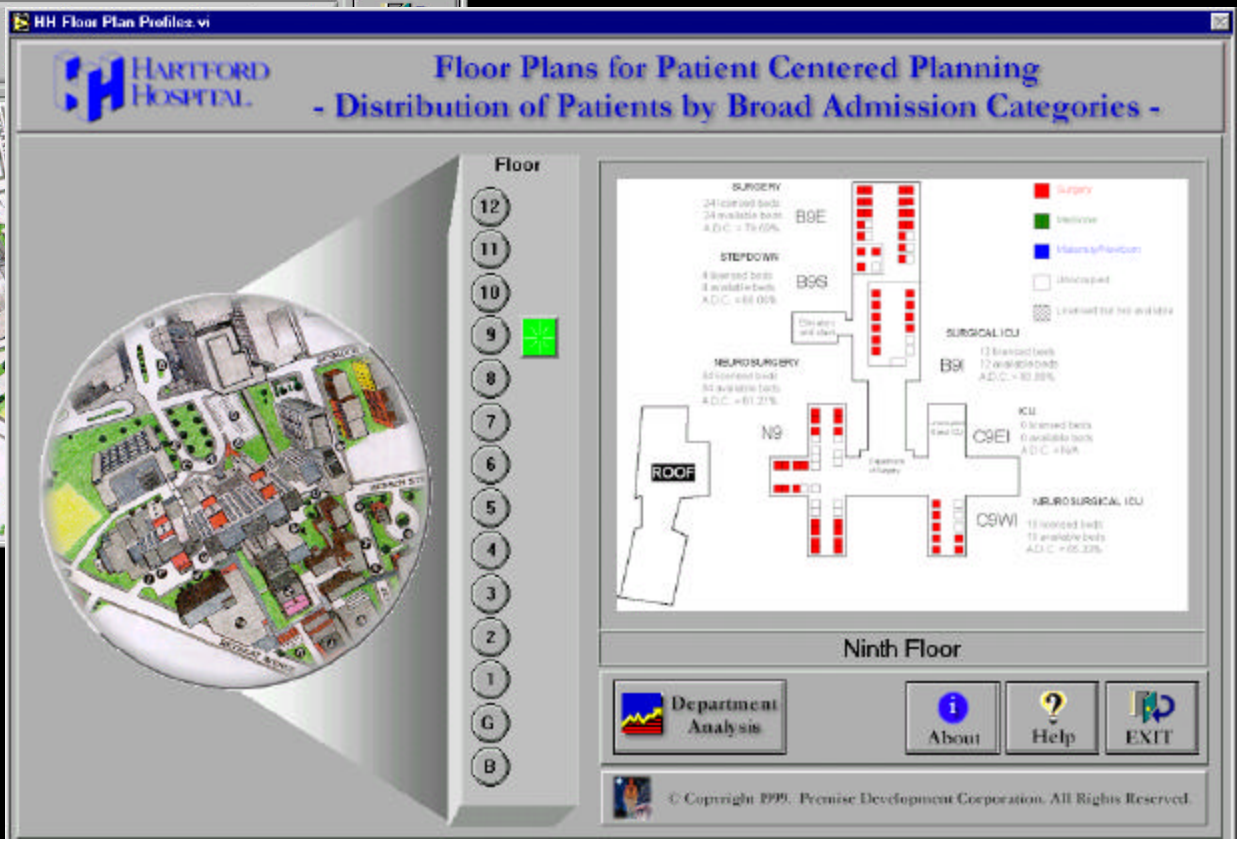


Patient Monitoring

Telemedicine

- Telerobotic control and data feed

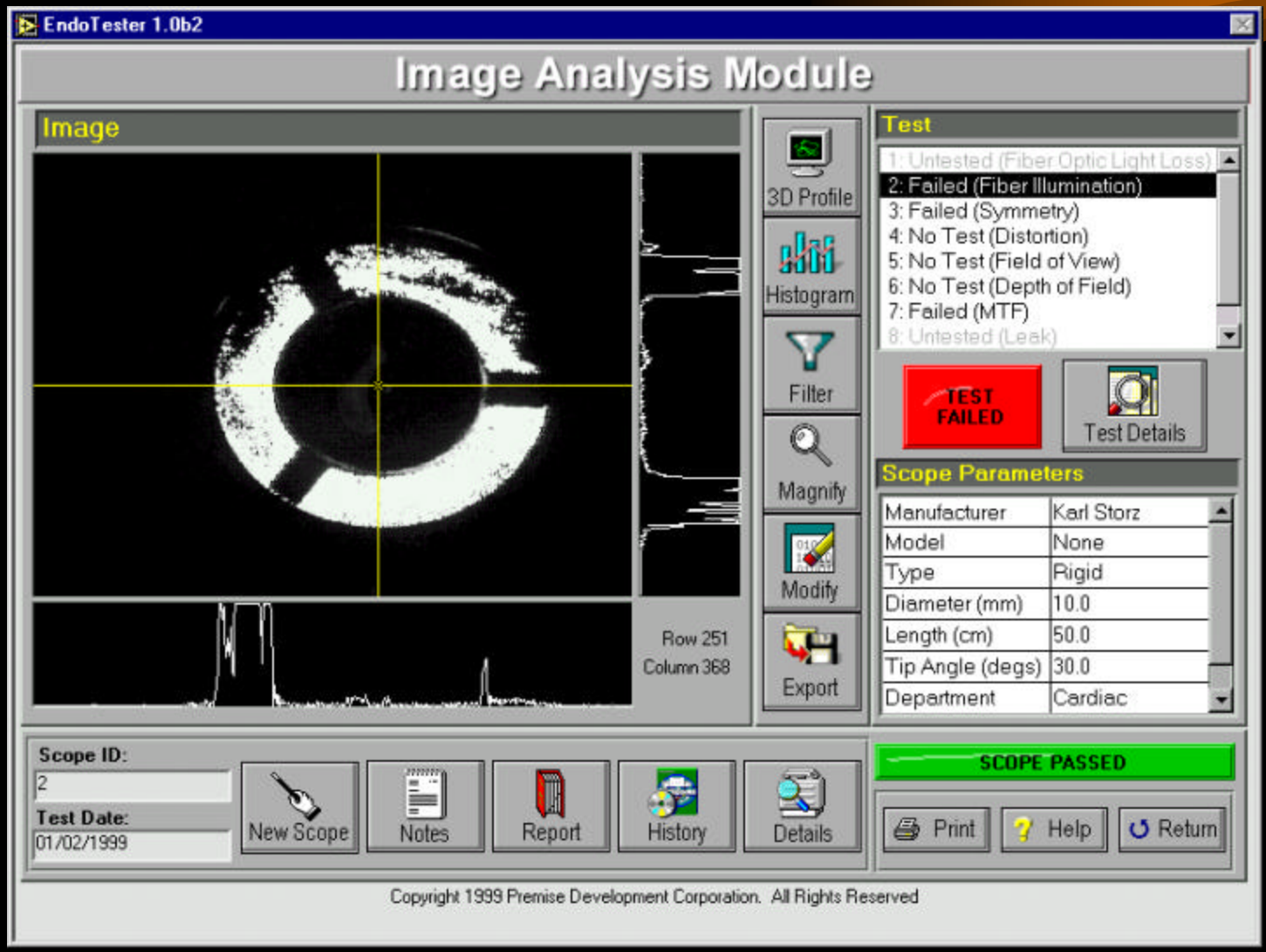
Hospital Information Management



Commercial Medical Devices

- Hospital / Clinical Diagnostic Tools
  - Testing and/or development
  - Requires FDA involvement / approval.
  - Significant time / resource cost for each piece of equipment developed.
  - Recommend this development be left to third party vendors for the near future.

Medical Device Testing



Medical Device Development

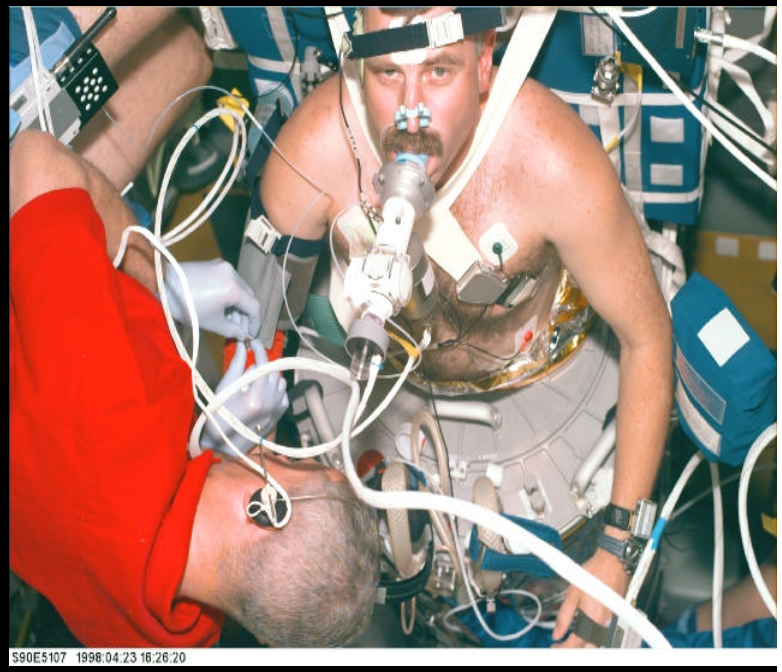
- **Controlled with LabVIEW-based executable**

- RSI Diagnostic Aid
- FDA Approved

Space Environment

Med Ops Hardware & Operations

- Medical Restraint System
  - Integrated with diagnostic/therapeutic equipment
  - Patient transport during return and recovery
- Cardiac Defibrillator/Monitor
  - Adhesive conductive pads
  - Insulation to protect avionics from EMI
- Advanced Life Support Pack
  - Stowage of emergency meds and equipment
  - Human factors strongly influence success
  - Med shelf-life and waste concerns
- Ventilator
  - Self-contained or overboard dump to prevent O_2 buildup in confined volume



Med Ops Hardware & Operations

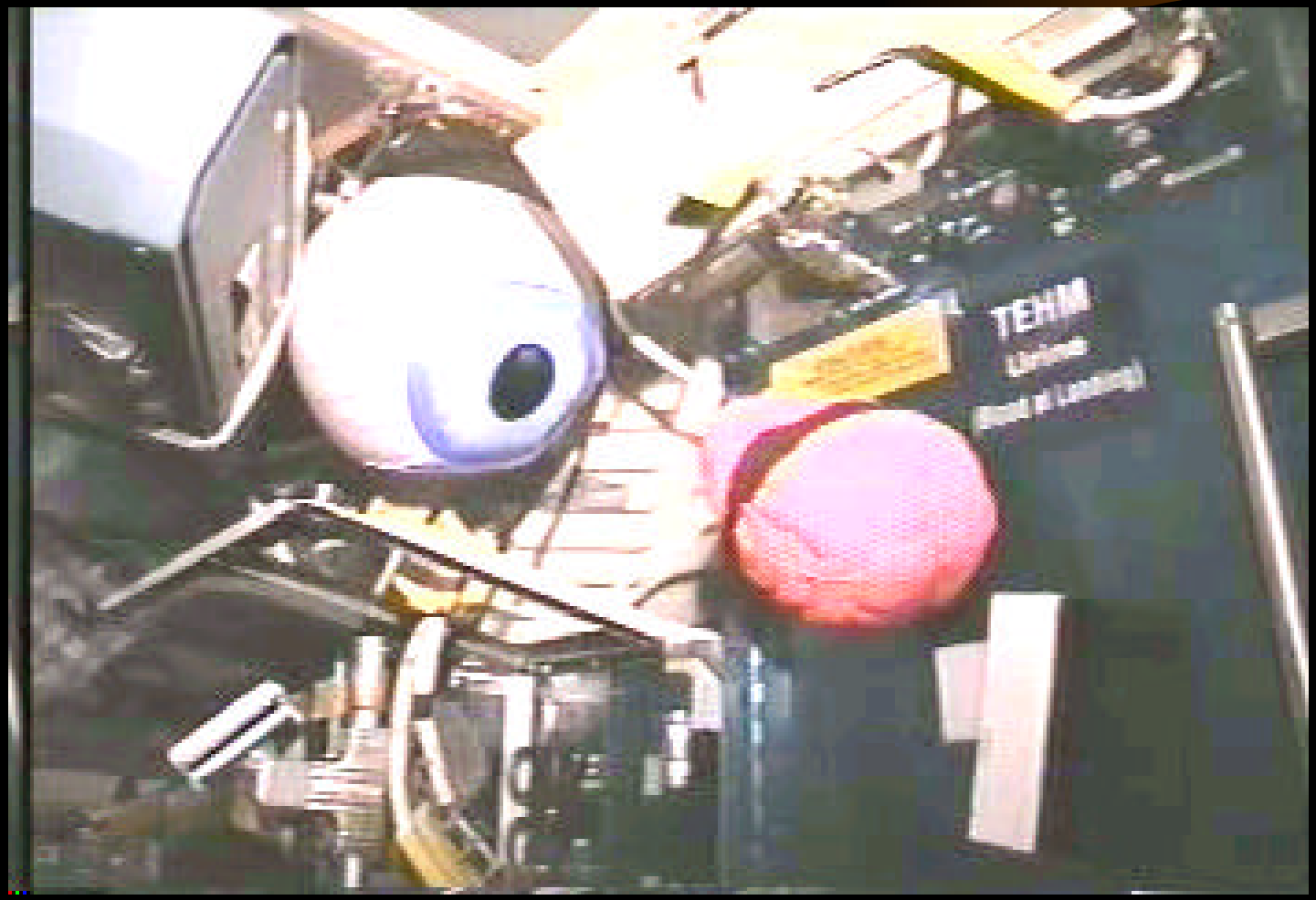
- Stored Intravenous Fluids
  - Must use pressure infusion device
- Medical Computer System
  - Diagnostic Aid
  - Proficiency
  - Medical Records
  - Occupational Exposure Tracking
- Endoscopic Capability
  - Diagnostic/Therapeutic
- Splints and Traction Devices

Cellular Bio-Technology

- *Characterization* of the response of the human body to the space environment
- Primary outlook is *Investigational*
- Results are viewed in terms of *Scientific Return*

Colon Cancer cells cultured in a Bioreactor

Research Hardware & Operations



Research Hardware & Operations

The effects of μG can be difficult to anticipate without operational experience.

Space Medicine

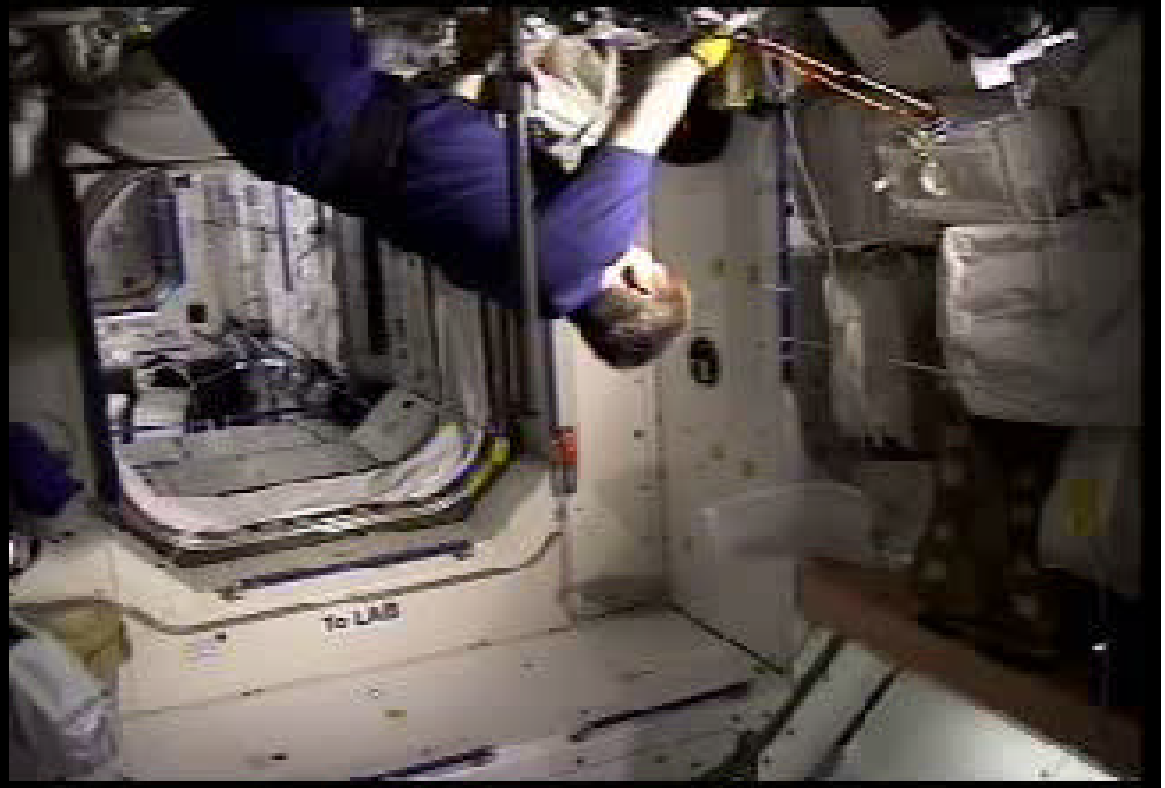
- *Proactive and Reactive Care* of the human organism to optimize physical, physiological and mental well-being
- Primary outlook is *Operational*
- Results are viewed in terms of *Mission Impact*

Cardiovascular Assessment on ISS in Russian Chibis Suit

Space Medicine (Proactive Care)

Exercise is one of the most important proactive medical countermeasures.

- But how do you get good exercise in μG ?



Space Medicine (Reactive Care)

Reactive care also requires special attention to operability in μG.

- e.g. How do you respond to cardiac arrest? CPR?

Conclusions

Virtual Bio-Instrumentation

- Academic Applications
  - Instructional
  - Basic Research
  - Clinical Research
- Commercialization
  - Development
  - Test
- Extraterrestrial