

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

- $\mu\text{V}/\text{mV}$ levels, > 20 kHz Sample Rate

➤ Imaging Techniques

- Echocardiogram, blood vessel contraction

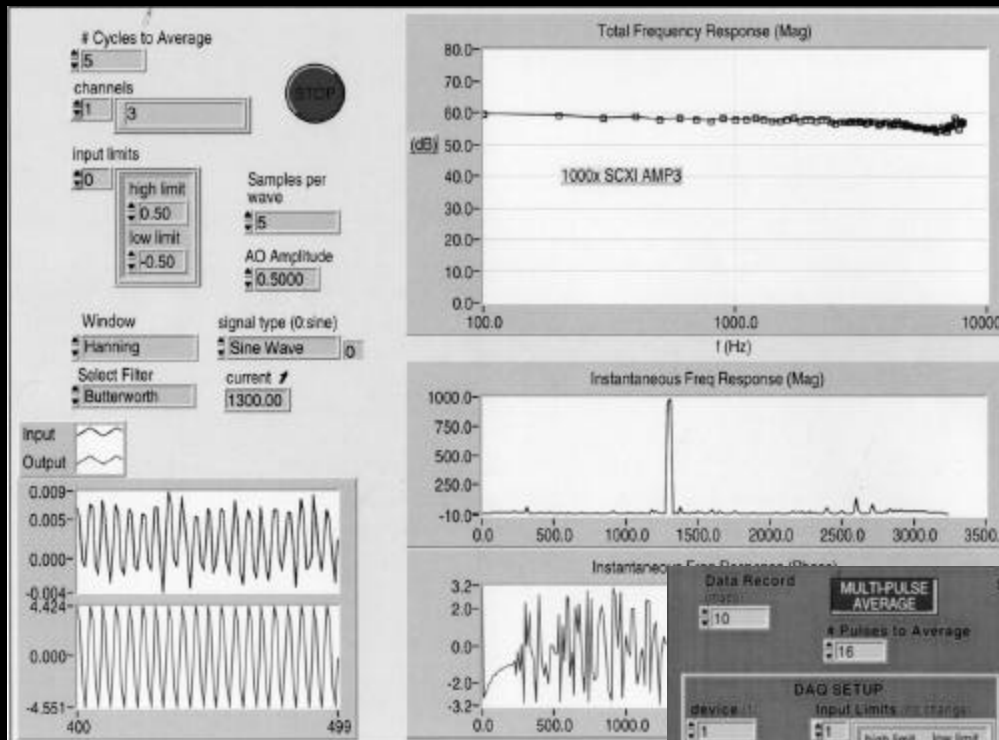
- Edge detection, microscopic imaging

➤ Clinical Instrumentation

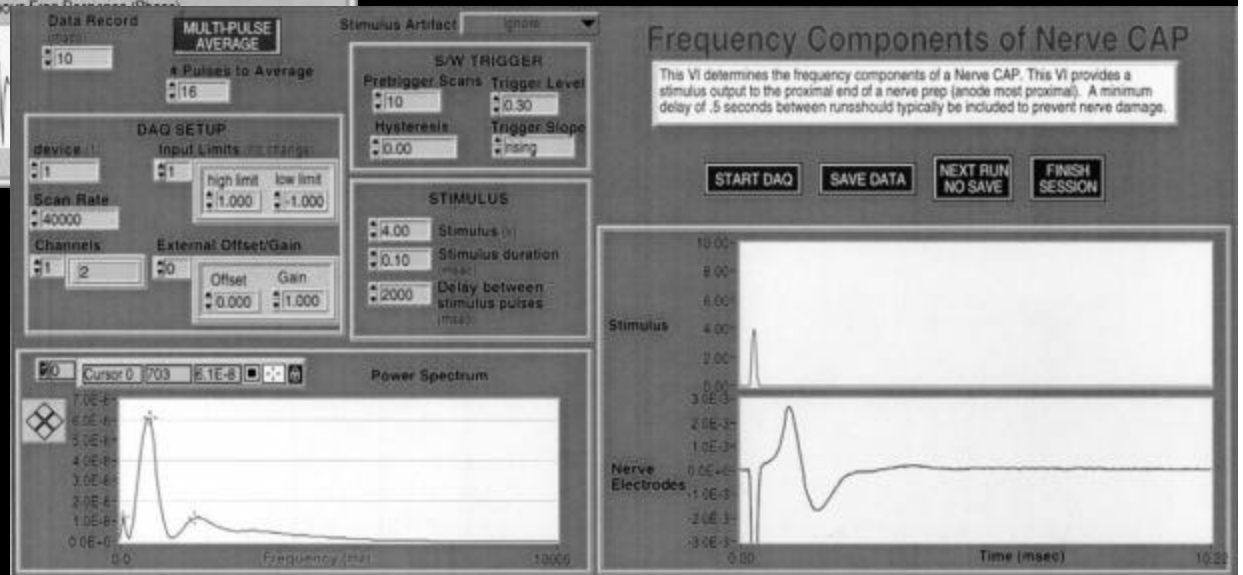
- Acquisition from existing equipment (mostly serial)

Generic DAQ/Instrumentation Issues

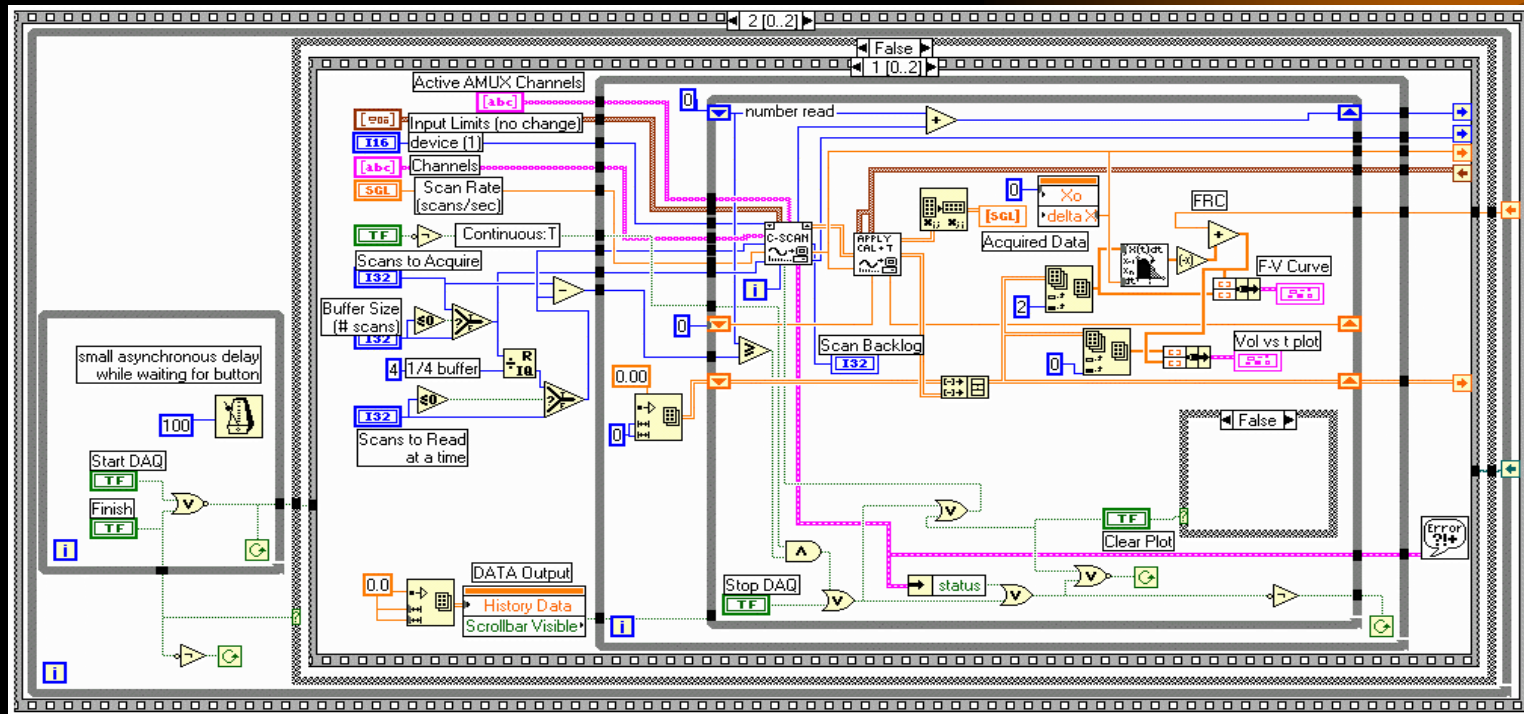
➤ Amplifier Frequency Response



➤ FFT of Nerve CAP



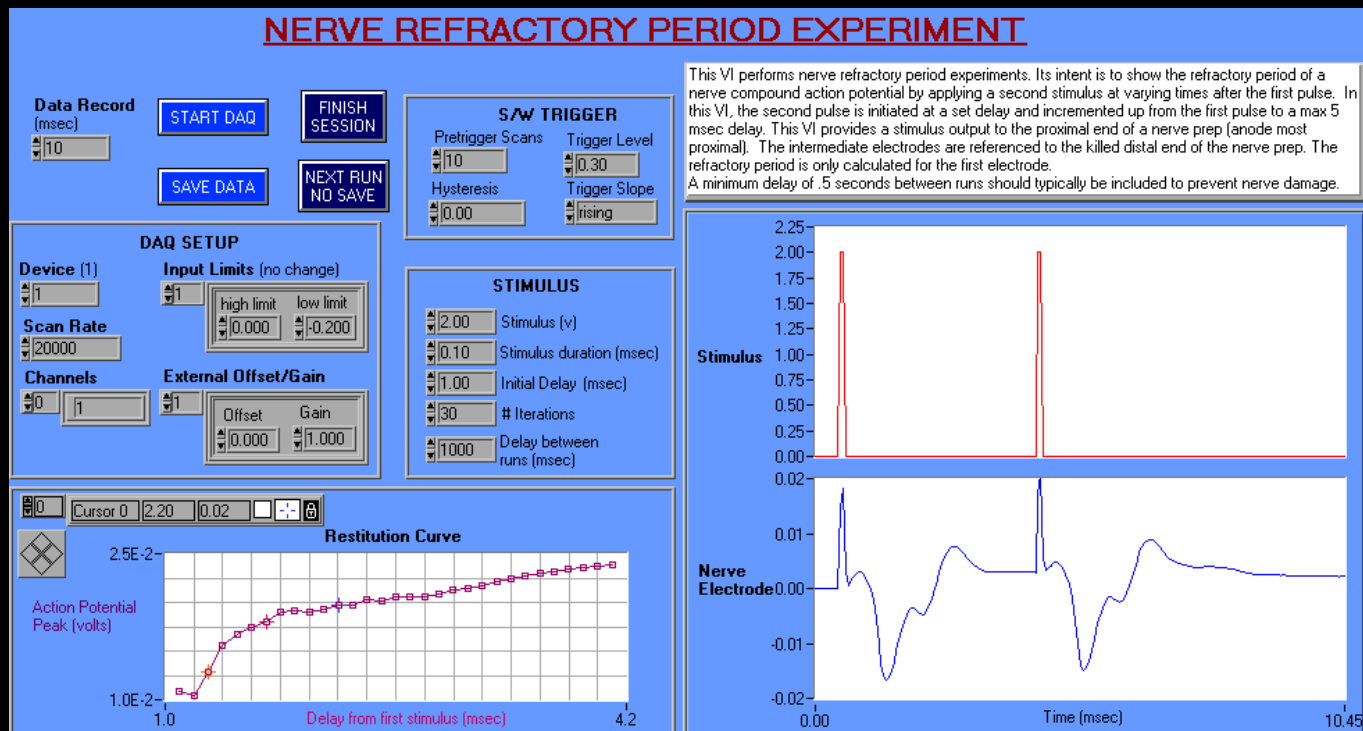
Role of Virtual Instrumentation



- 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

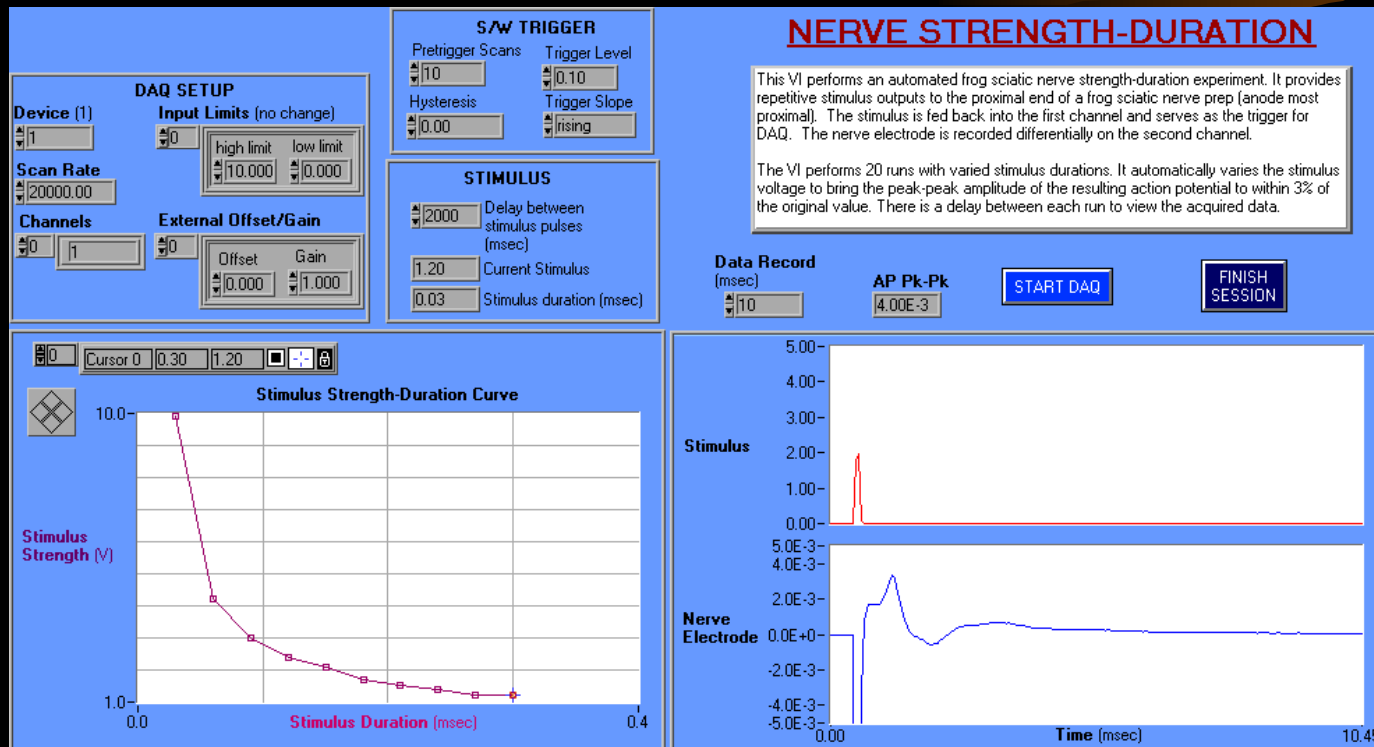
- Basic Research Field ideal for incorporation of existing NI hardware & LabVIEW / LabWindows.
 - ‡ Requires NI personnel be familiar with biomedical applications and sufficiently able to converse in medical lingo.
 - ‡ Requires stronger ties with research equipment suppliers [e.g. World Precision Instruments (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 μ V 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

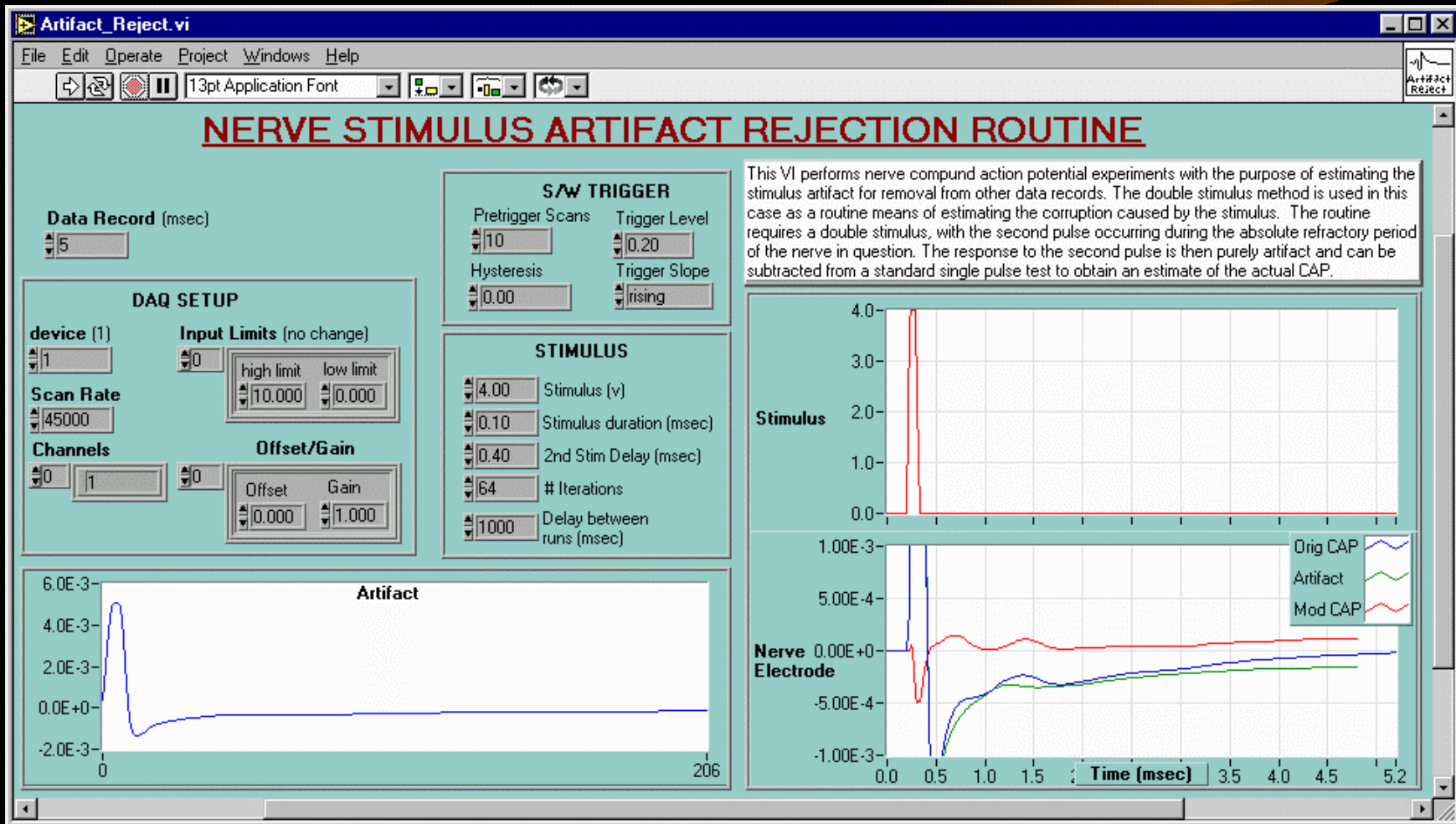


Electrophysiology



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

Stimulus Artifact Rejection



Volume Conductor Problem

NERVE CAP ACQUISITION & PREDICTION IN A VOLUME CONDUCTOR

CONDUCTION VELOCITY

Peaks/Valleys?

Distance b/w Electrodes (mm) Avg CV

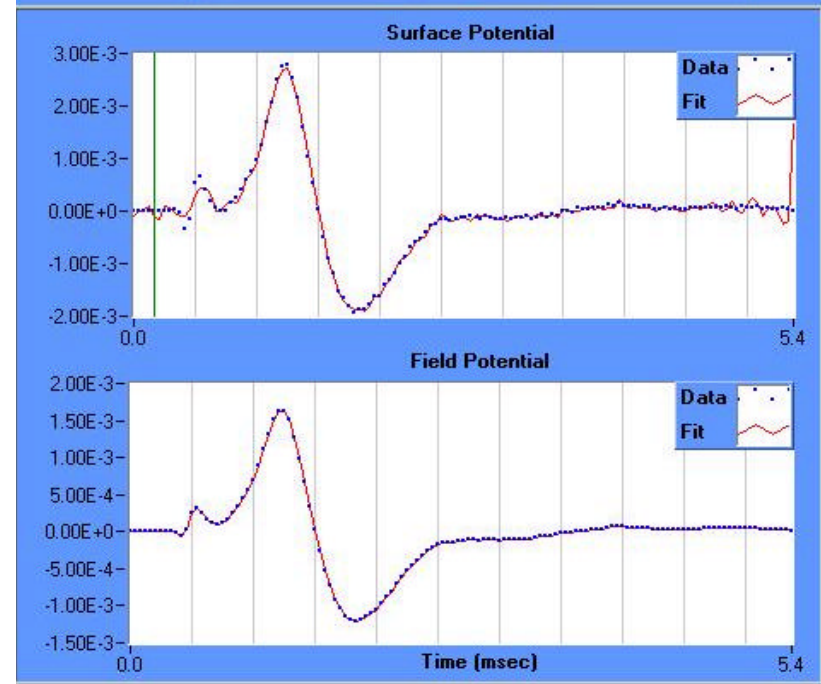
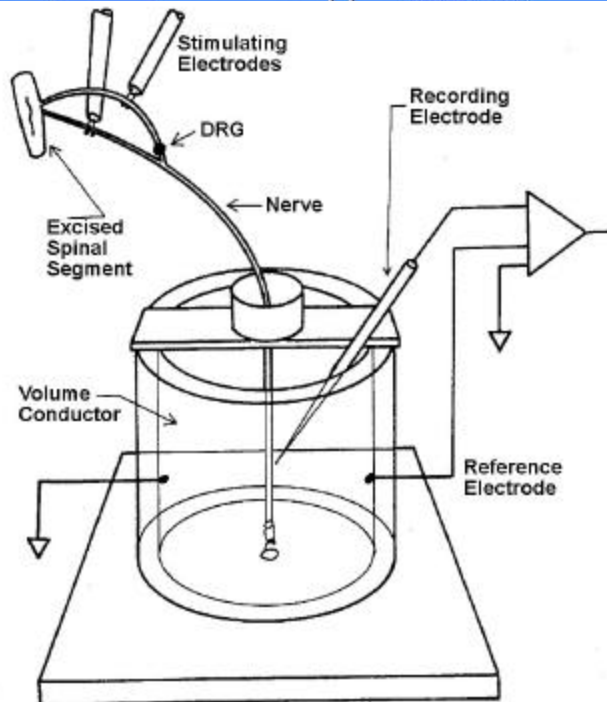
Stimulus SNR

MEDIUM FILTER PARAMETERS

Data Sampling Frequency (Hz) ΔZ

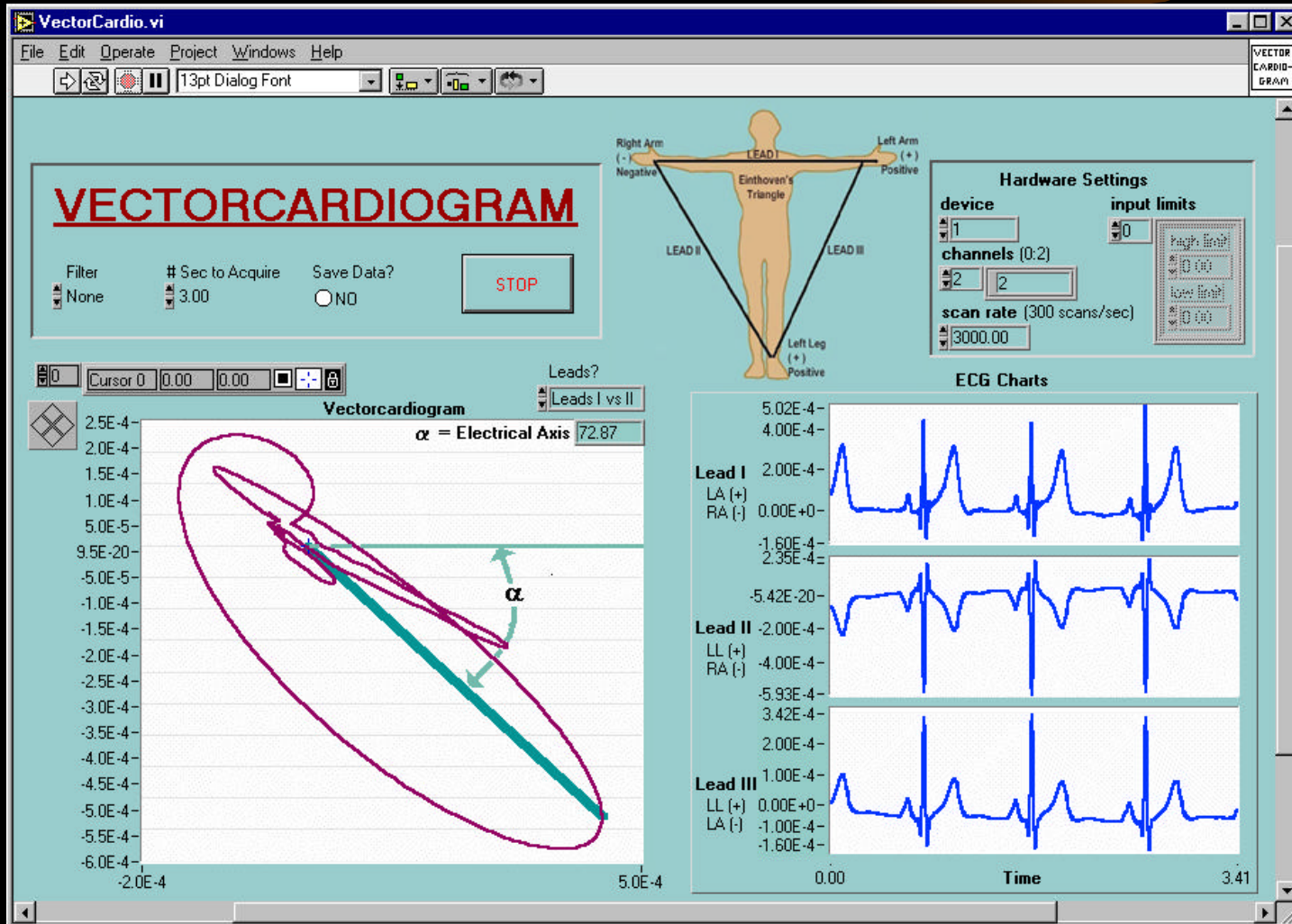
Dist to Field Site from Nerve Surface (mm) Radius of Nerve (mm)

ALGORITHM SETTINGS

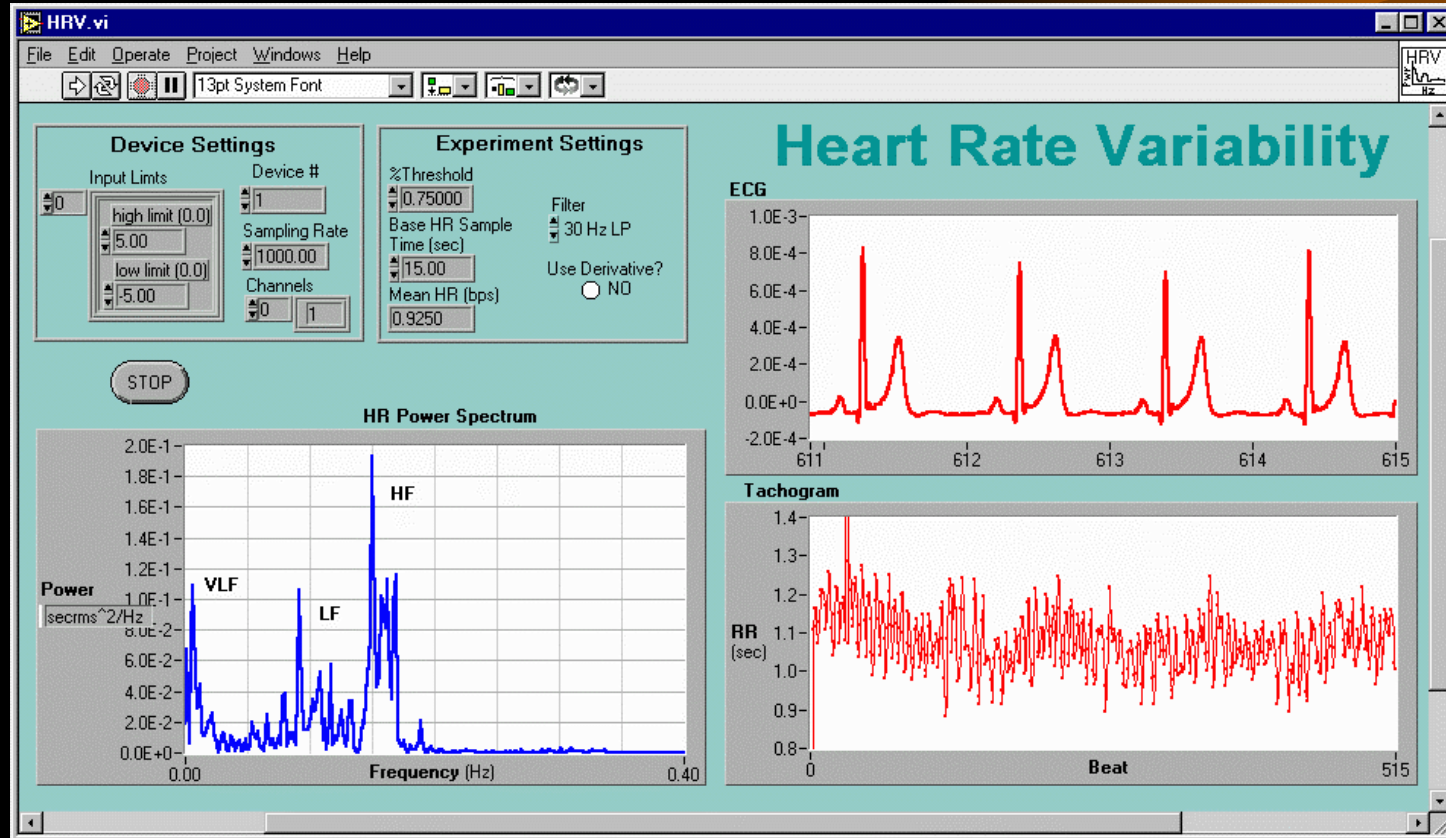


Cardiac Electrophysiology

- Electrocardiography
- Vectorcardiography



Research Topics



‣ Heart-Rate Variability

‣ Parasympathetic Neural Control

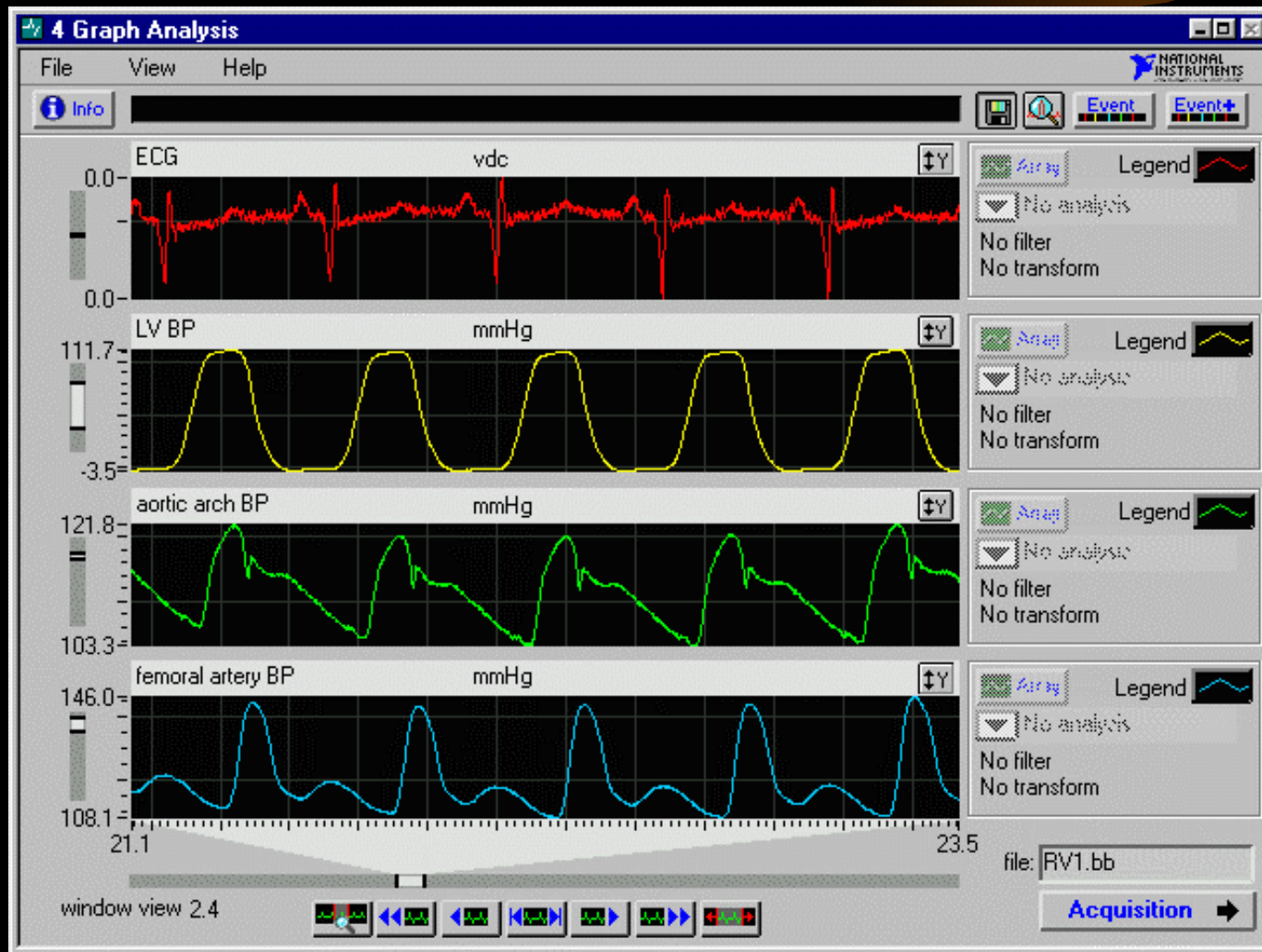
‣ Phase Response

‣ Entrainment

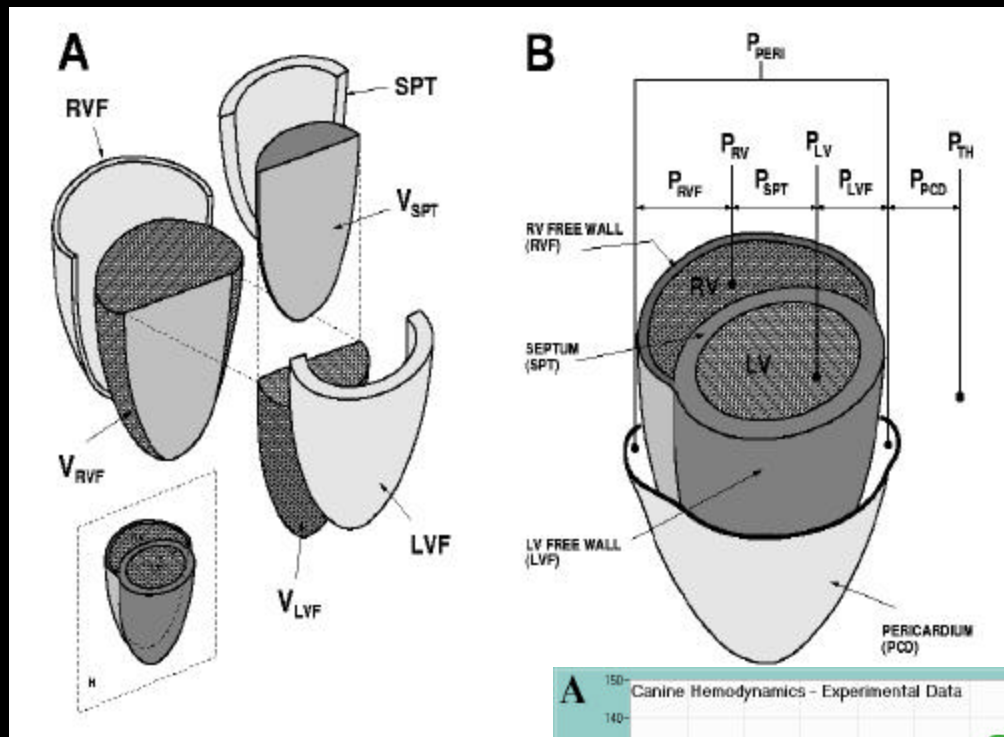
Cardiovascular Hemodynamics

➤ Cardiac Function

➤ P-V Characterization

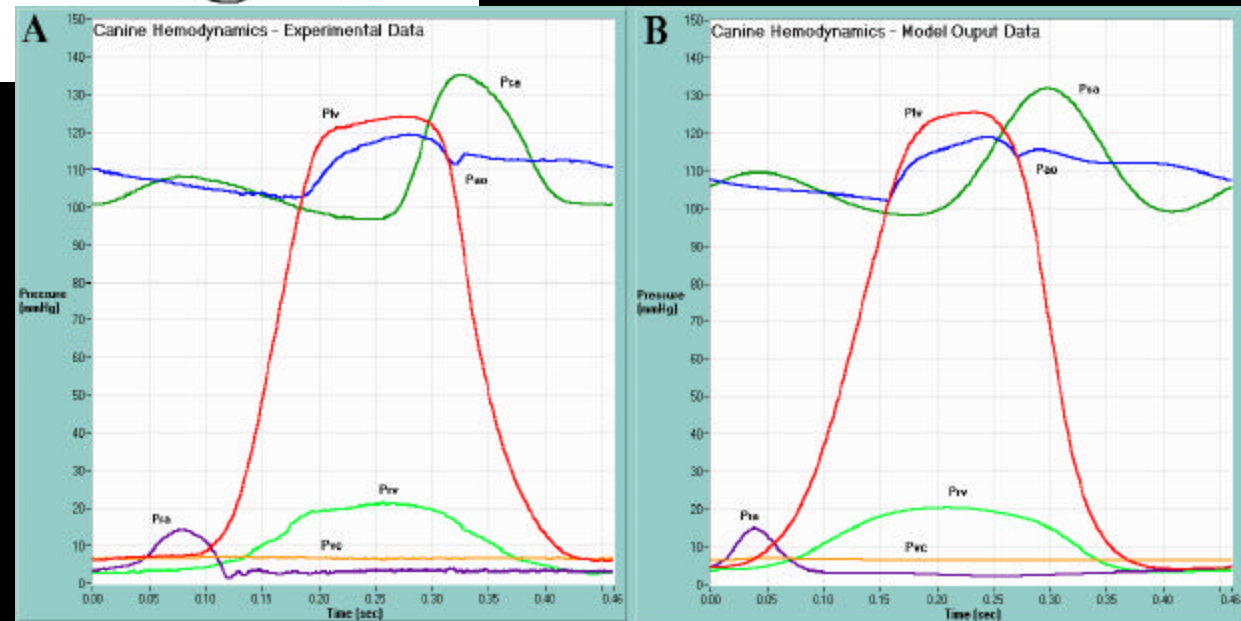


Modeling

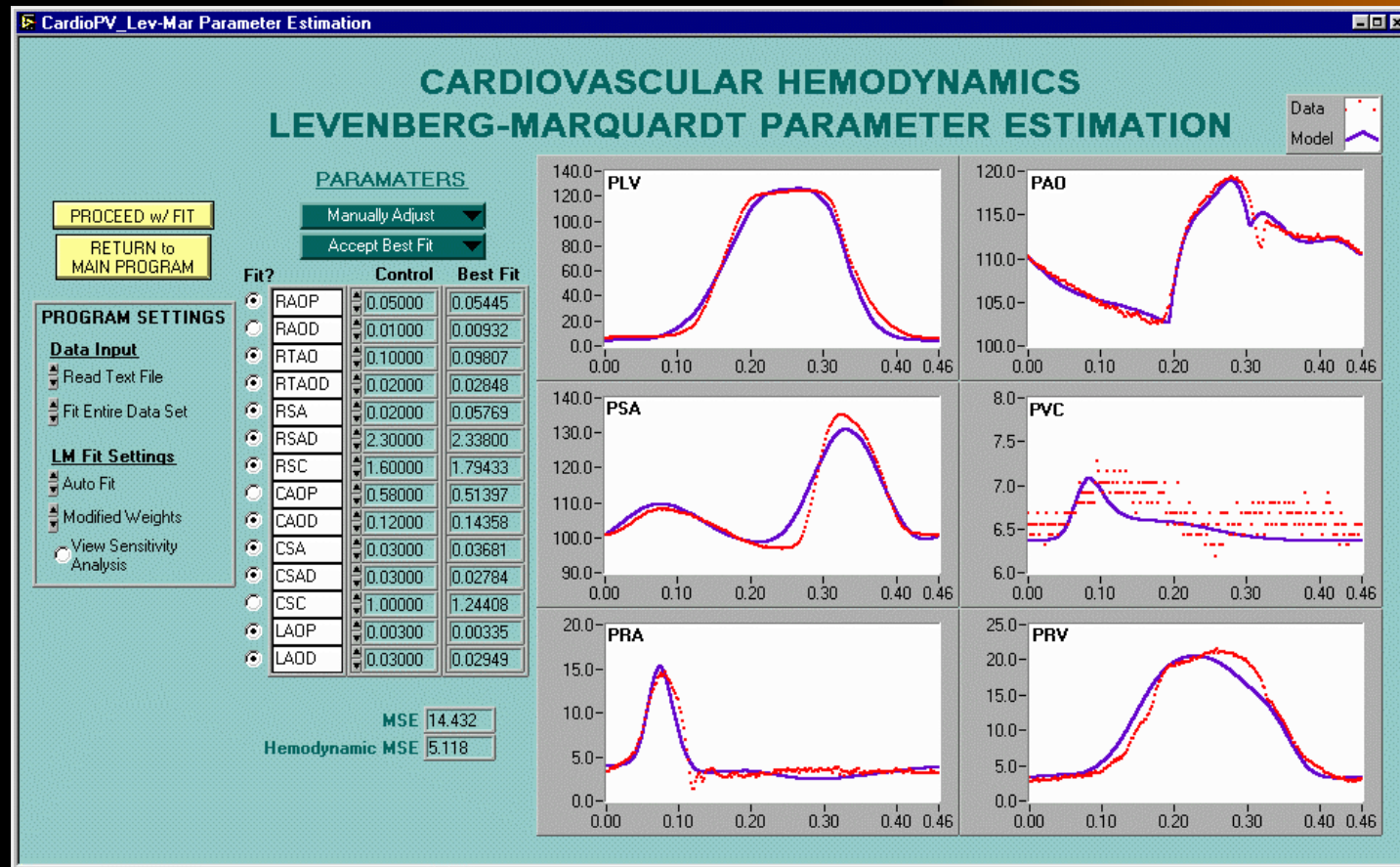


➤ Right-Left Ventricular Interaction

➤ Closed-loop Circulatory Modeling



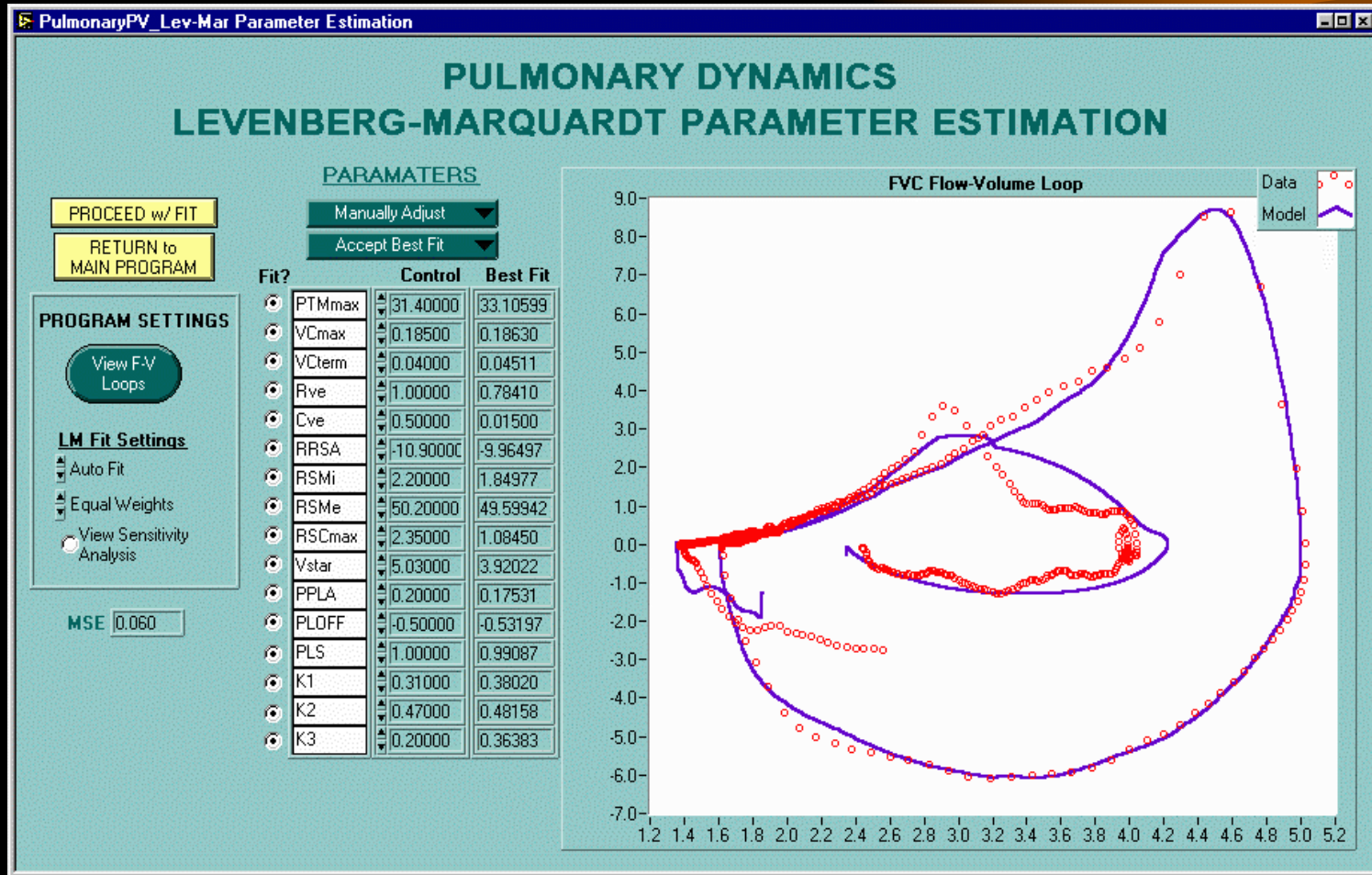
Cardiovascular Modeling



‡ Nonlinear Parameter Estimation

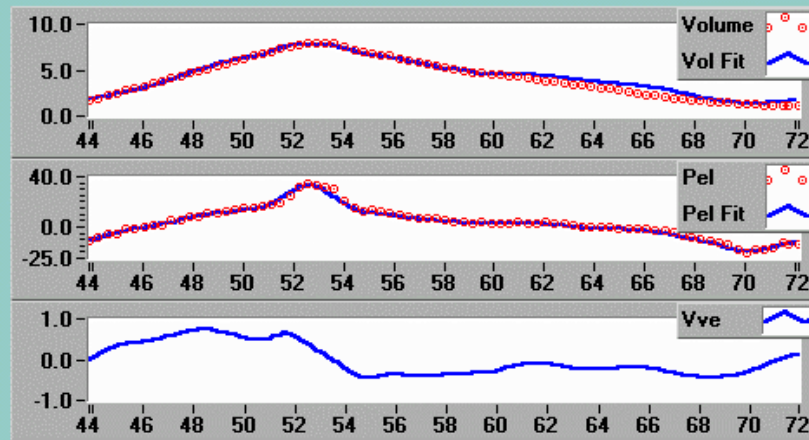
‡ Online Parameter Sensitivity Analysis

Lung Model Parameter Estimation



Lung Tissue Parameter Estimation

Lung Tissue Viscoelastic Properties: Parameter Estimation



PARAMETERS

	Control	Best Fit
KK1	3.1000	0.0321
KK2	-6.7000	1.5665
Rve	4.0000	4.6905
Cve	0.2000	0.5624

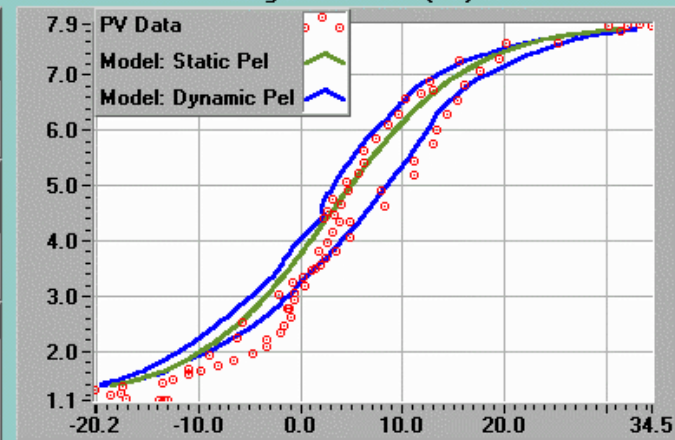
MSE 2.2969

Manual Fit

Data File

D:\FreqDepData

Lung Elastic Recoil (Pel) Curve



- ‡ Pulmonary System Modeling
- ‡ Work of Breathing
- ‡ Pulmonary Energy Analysis

- ‡ Integrated CO₂ / Airway Mechanics Analysis
- ‡ Nonlinear Parameter Estimation

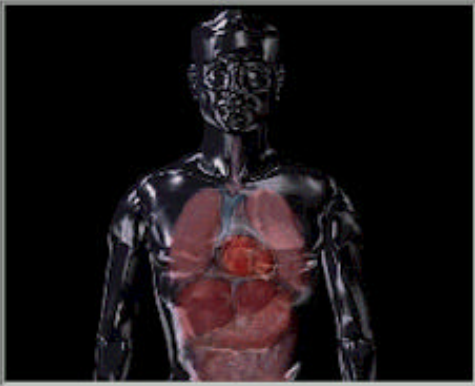
Clinical Research

- 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

Cardiopulmonary Analysis System

Cardiopulmonary Analysis System v4.1




Acquire Data

Calibrate

Speak?

So Sup

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Cycle Analysis

File Edit Operate Project Windows Help

Cardiovascular Pressure-Dimension Analysis

Doe, John
5_30_96, 12_11PM

Filter Controls

Type: Chebyshev
Order: Third
Cutoff Freq.: No Filter
DAQ (Hz): 200
Total Beats: 18

CONTINUE

Range Select

Adjust Cycles

Isochronic

PRSWI

Phase Delay

Data Log

Multiple Loops

Beat Selector: 1

Include?

Status: POLL

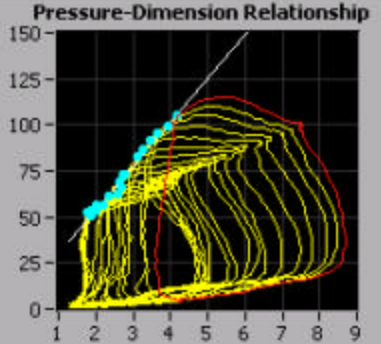
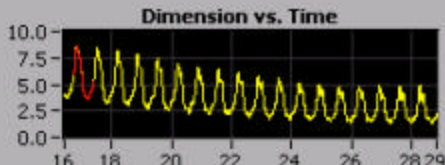
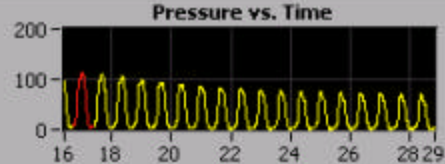
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Beat	1
Diastole	8.7
Systole	3.6
EF/FAC	0.58
Stroke Work	433

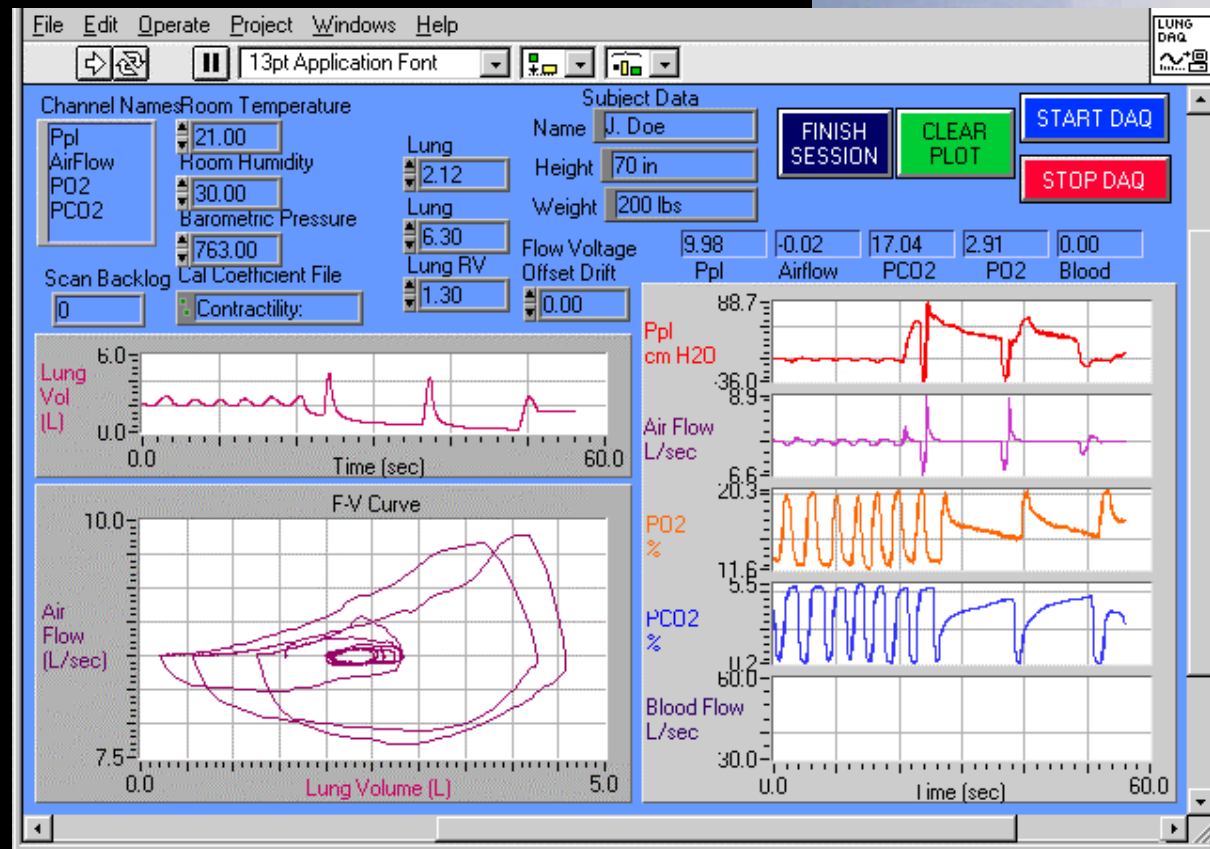
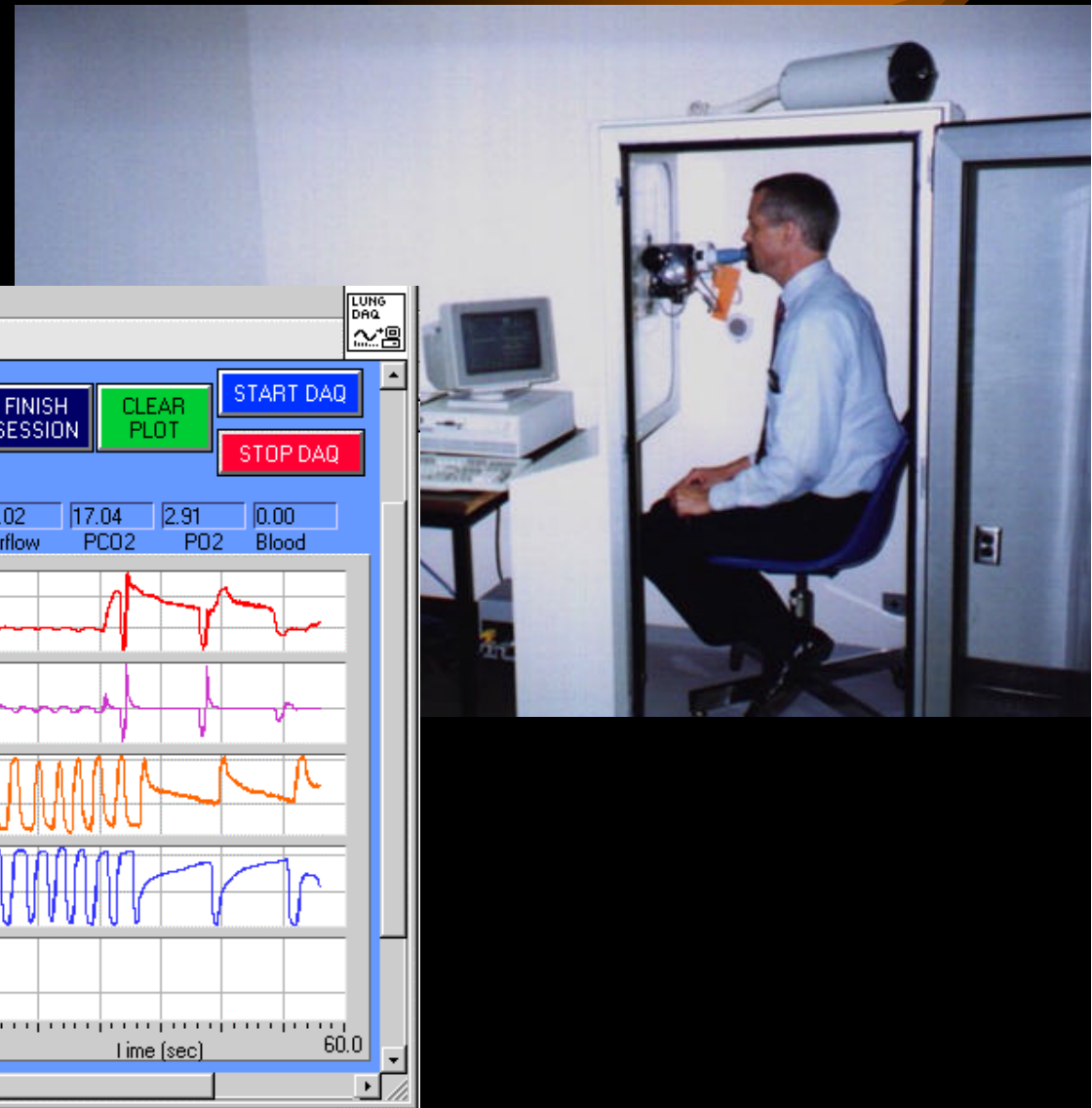
Index	53.0
Slope	23.7
Inter.	-0.2
R	0.98

Slope	76.6
Inter.	3.0
R	1.00

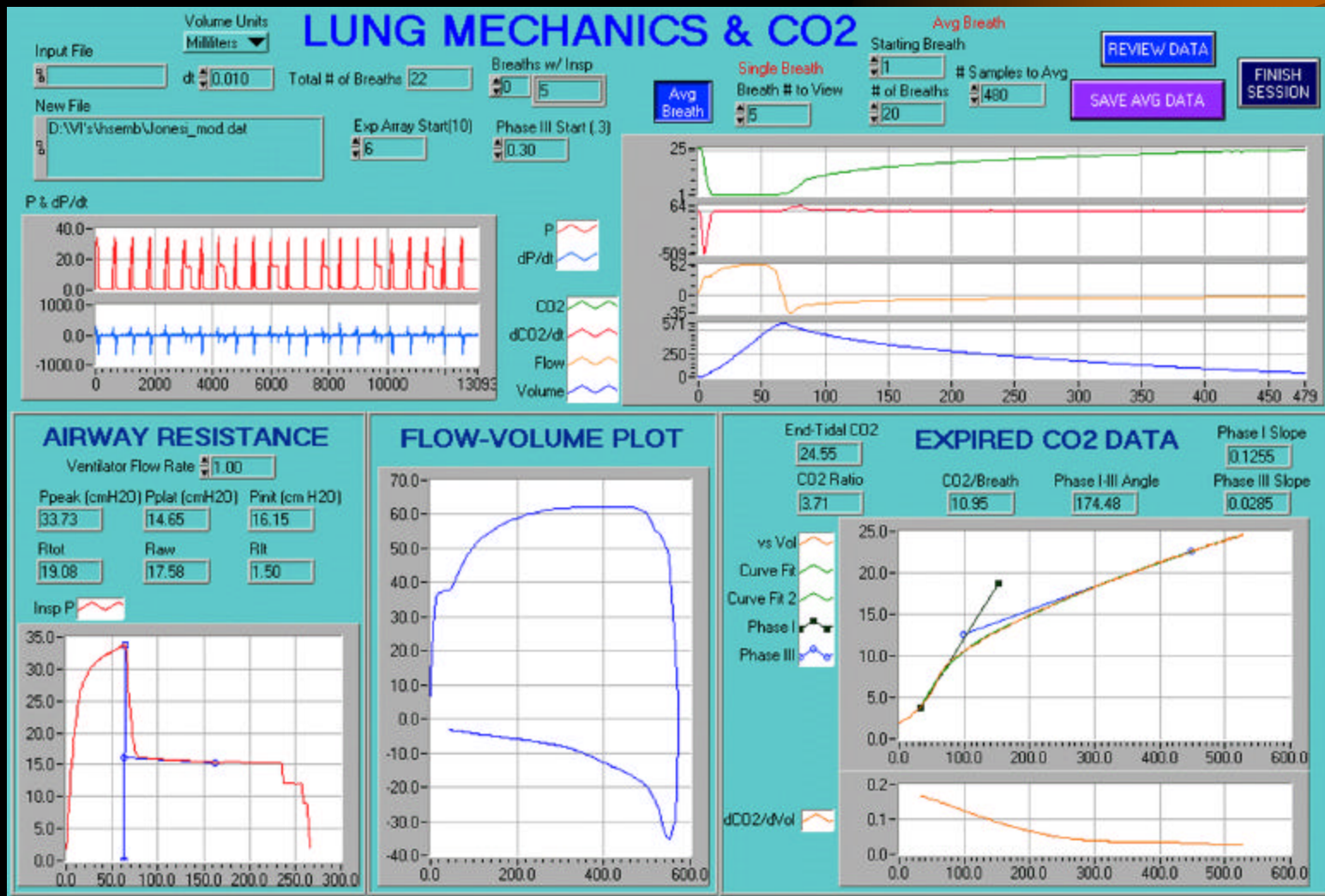
Slope	23.8
Inter.	-0.3
R	0.99



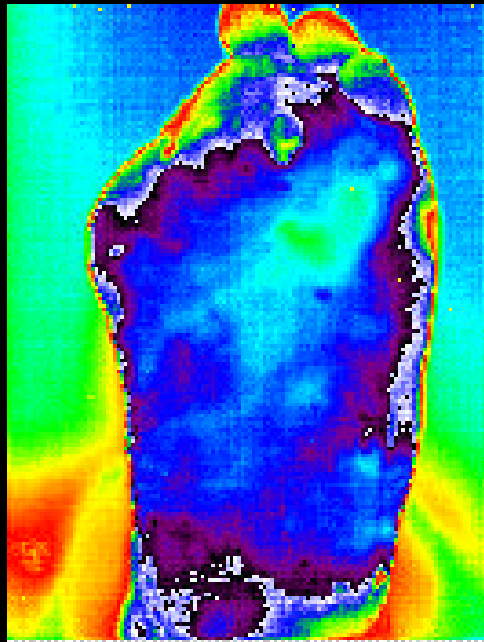
Pulmonary Function Testing



Ventilatory Patient Management



Imaging Techniques



Wound Profiler

Wound Evaluation System

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original image scale detected gray level noise remove binary image

inverse borders rejected small object fill holes contour picture

Patient

- No patient
- Bonakub, Abel
- Bracket, Marco
- Gonzalez, Lne
- Lusser, Bob**
- Thomas, Jernia
- mandeaqueux, papib22
- Celode?, Joel
- Hey, Boddy
- HeyB0, BoddyB0
- HeyB2, BoddyB2
- Hojj, Chris

Wound Image

- 07/16/1999 10:52:12 AM
- 08/06/1999 10:09:12 AM
- 07/16/1999 10:09:12 AM
- 08/06/1999 10:02:12 AM
- 08/20/1999 10:27:12 AM
- 08/20/1999 10:27:12 AM**
- 08/13/2000 3:26:23 PM
- 08/14/2000 3:26:34 PM
- 08/15/2000 3:27:15 PM
- 08/16/2000 3:27:55 PM
- 08/17/2000 3:27:57 PM
- 08/18/2000 3:28:20 PM
- 08/19/2000 3:28:28 PM
- 08/20/2000 3:28:54 PM

Area Analysis **Manual Analysis** **Color Analysis**

Patient Profiles **Table Results** **3D Profile**

Acquire Image **Print Image** **Reports**

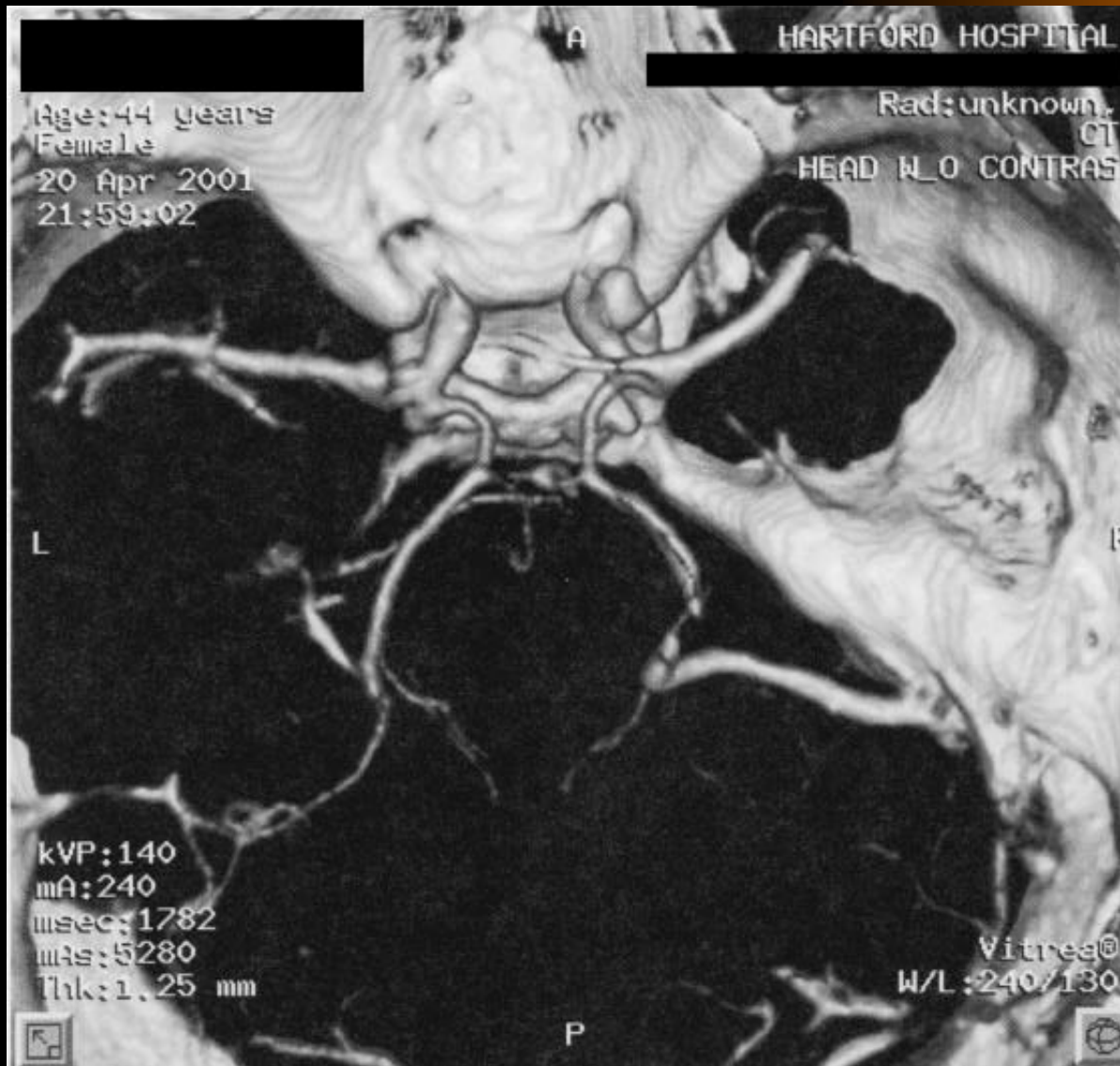
The area of the wound in cm2 is: **2.95**

On-line Help **EXIT**

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

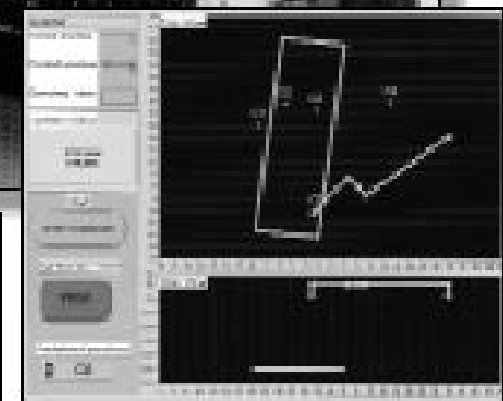
Medical Imaging



Patient Monitoring

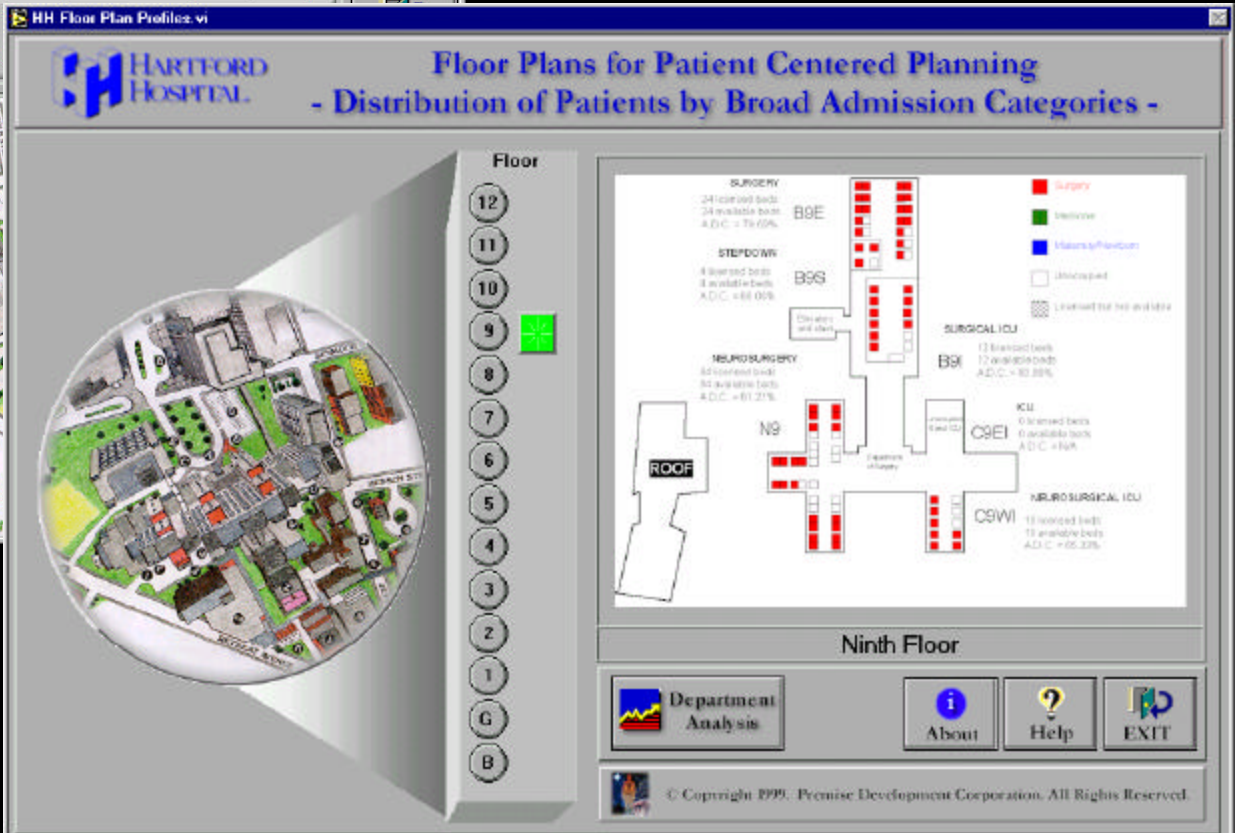


Telemedicine



➤ Telerobotic control and data feed

Hospital Information Management



Commercial Medical Devices

➤ Hospital / Clinical Diagnostic Tools

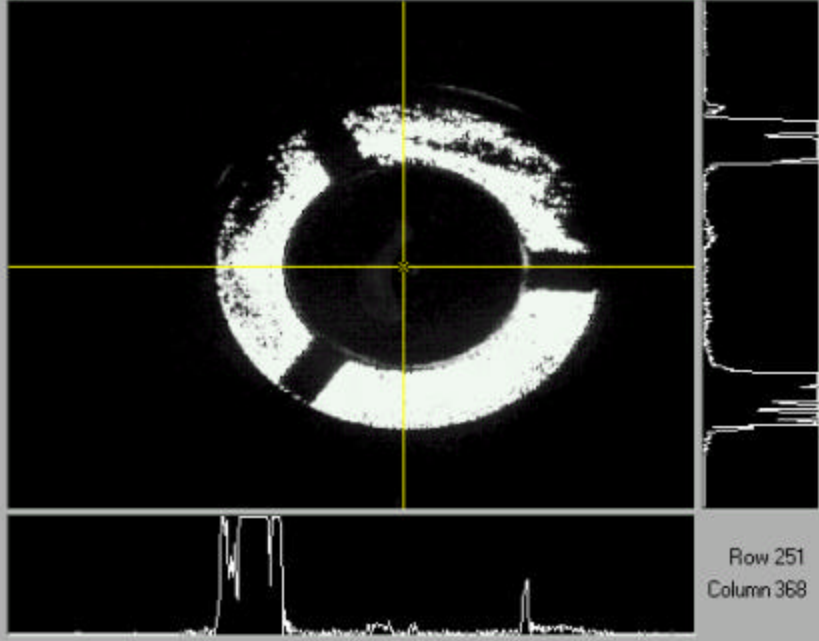
- ‡ Testing and/or development
- ‡ Requires FDA involvement / approval.
- ‡ Significant time / resource cost for each piece of equipment developed.
- ‡ Recommend this development be left to third party vendors for the near future.

Medical Device Testing

EndoTester 1.0b2

Image Analysis Module

Image



Row 251
Column 368

Test

- 1: Untested (Fiber Optic Light Loss)
- 2: Failed (Fiber Illumination)
- 3: Failed (Symmetry)
- 4: No Test (Distortion)
- 5: No Test (Field of View)
- 6: No Test (Depth of Field)
- 7: Failed (MTF)
- 8: Untested (Leak)

TEST FAILED Test Details

Scope Parameters

Manufacturer	Karl Storz
Model	None
Type	Rigid
Diameter (mm)	10.0
Length (cm)	50.0
Tip Angle (degs)	30.0
Department	Cardiac

Scope ID: 2
Test Date: 01/02/1999

New Scope Notes Report History Details

SCOPE PASSED

Print Help Return

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Medical Device Development

KaDance 2000™
Motor Performance Screening Tool
Version 1.0
KaDa Research, Inc.
Instrumentation & Analysis

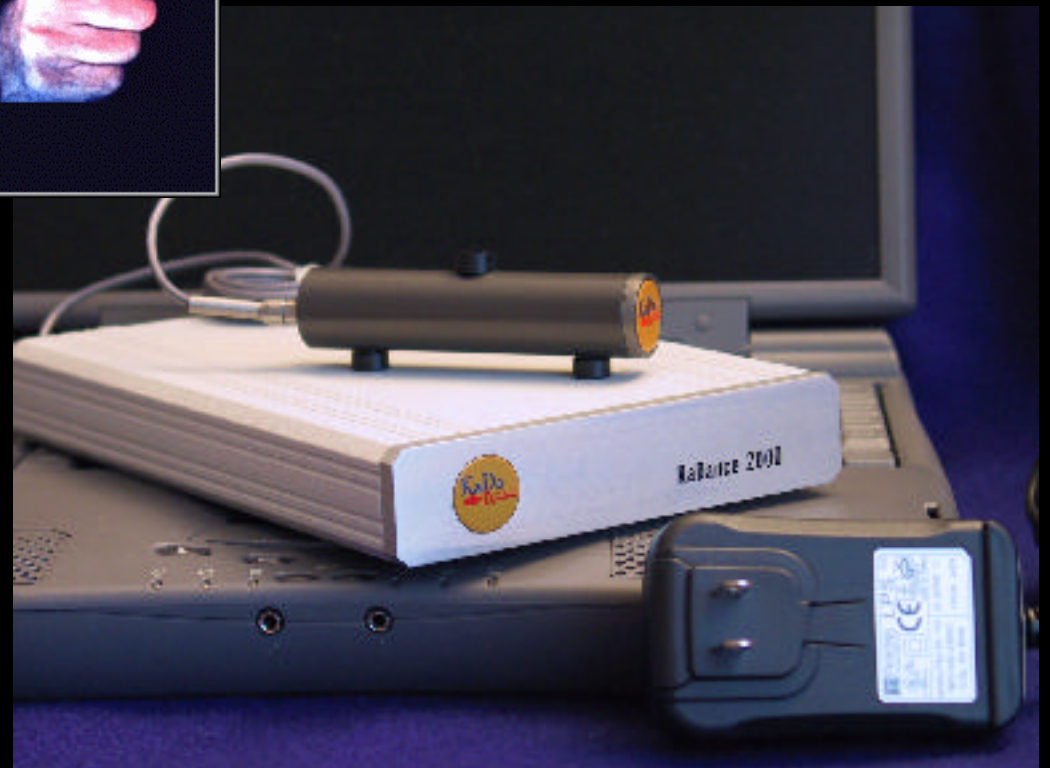
Initializing.....

KaDance Copyright 2000 VBI Development Company
LabVIEW Copyright 2000 National Instruments
This software is licensed for use on only one computer at a time.



- **Controlled with LabVIEW-based executable**

- **RSI Diagnostic Aid**
- **FDA Approved**

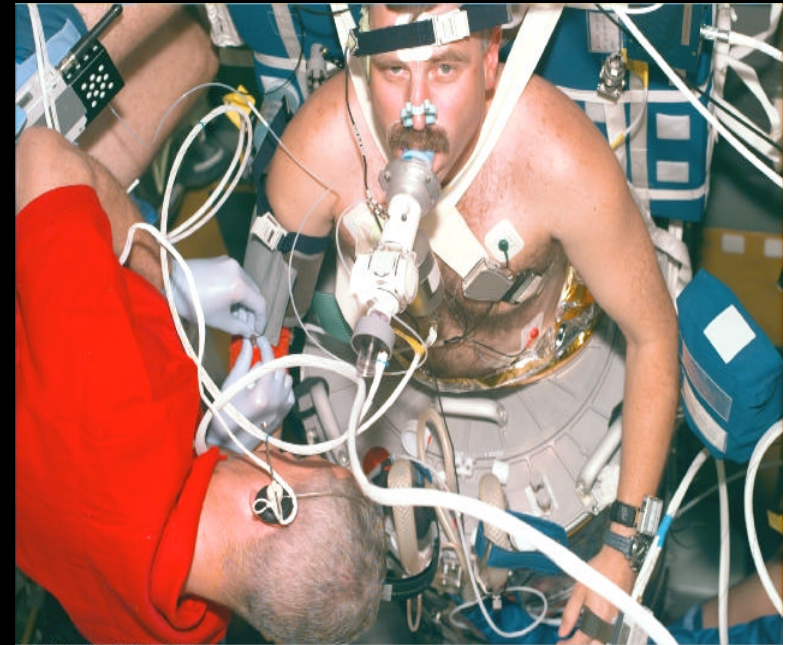


Space Environment



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 O₂ buildup in confined volume



S90E5107 1998:04:23 16:26:20

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



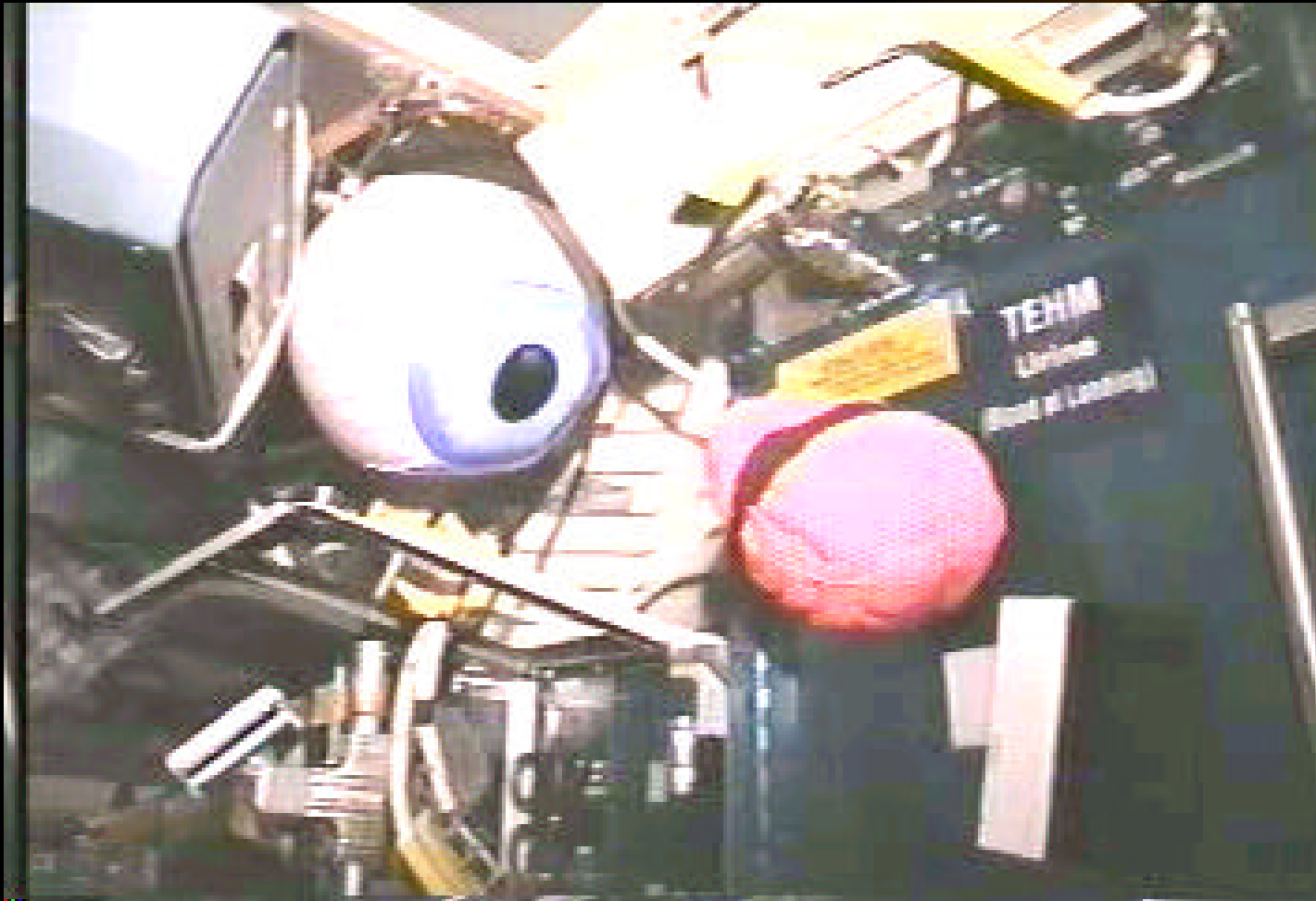
Cellular Bio-Technology

- *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

