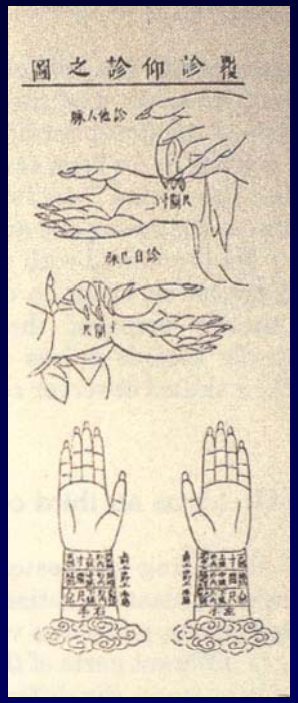
New Mapping Technologies of Arrhythmia

아주의대

황 교 승

Historical Development of Rhythmology

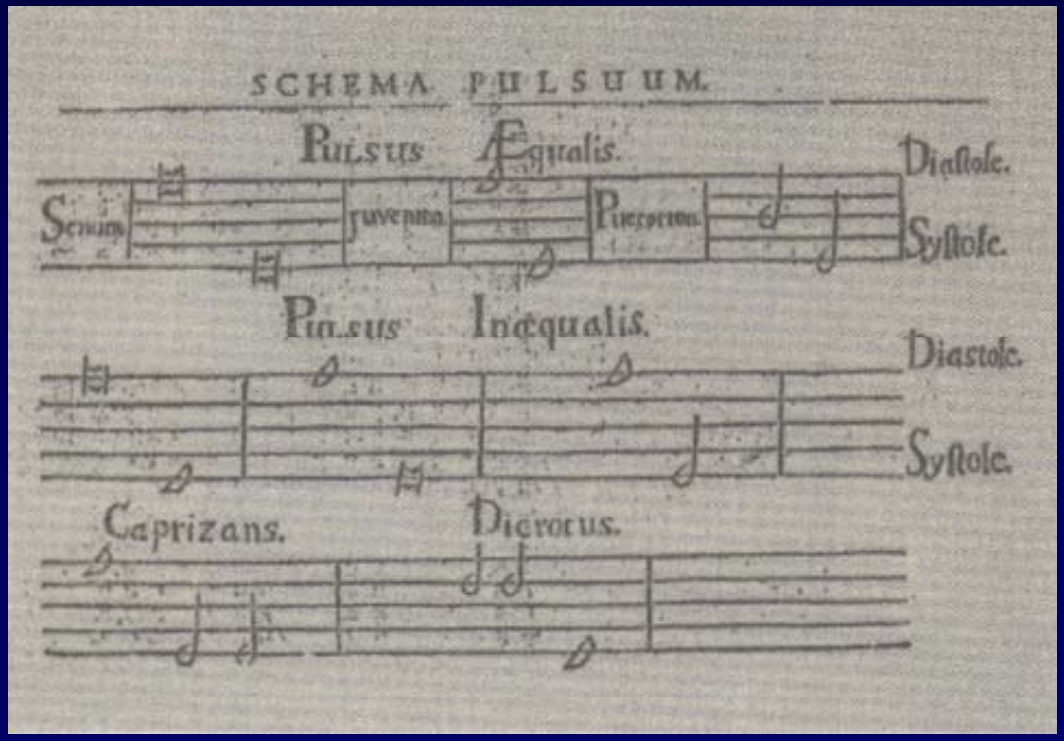
- Pien Ts'lo (the 5th century BC)

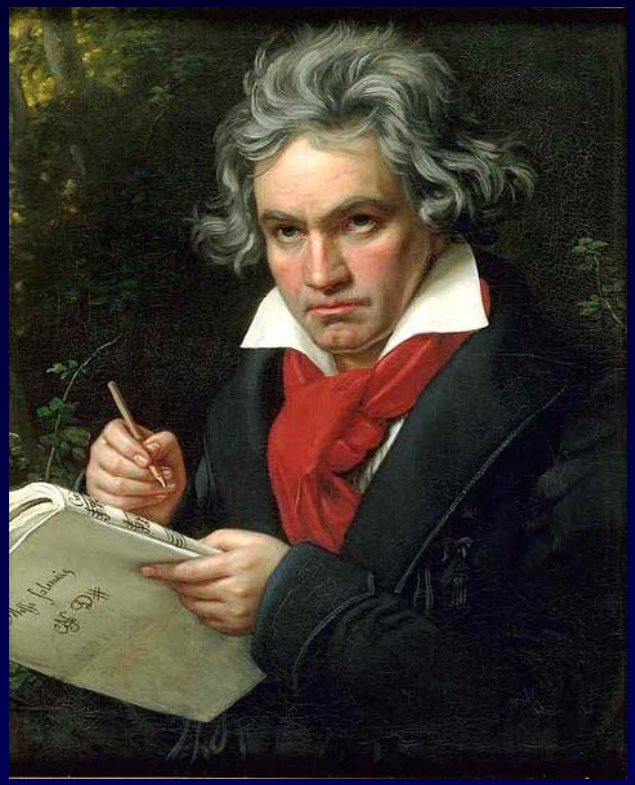


- Claudius Galen (circa AD 129-199)

Historical Development of Rhythmology

- Michael Bernhard Valentini's pulse diagram



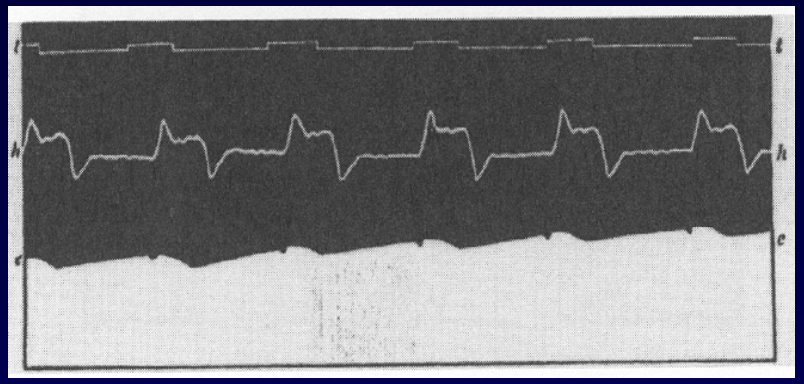


Ludwig van Beethovan (1770-1827)

Piano Sonata No. 26 in E flat major ("Les Adieux"), Op. 81a

Historical Development of Rhythmology

- The 1st human ECG, recorded by D. Waller in 1887



- Willem Einthoven (1860-1927)

Historical Development of Rhythmology

- Werner Forssmann in 1929 (1904-1979)
  Right catheterization
- Puech in 1957
  His bundle electrogram
- Durrer et al in 1967
  Programmed stimulation

Three Dimensional Mapping

- Carto XP System
- ESI Noncontact Mapping
- NavX Mapping System
- Real-time Position Management (RPM) Mapping System

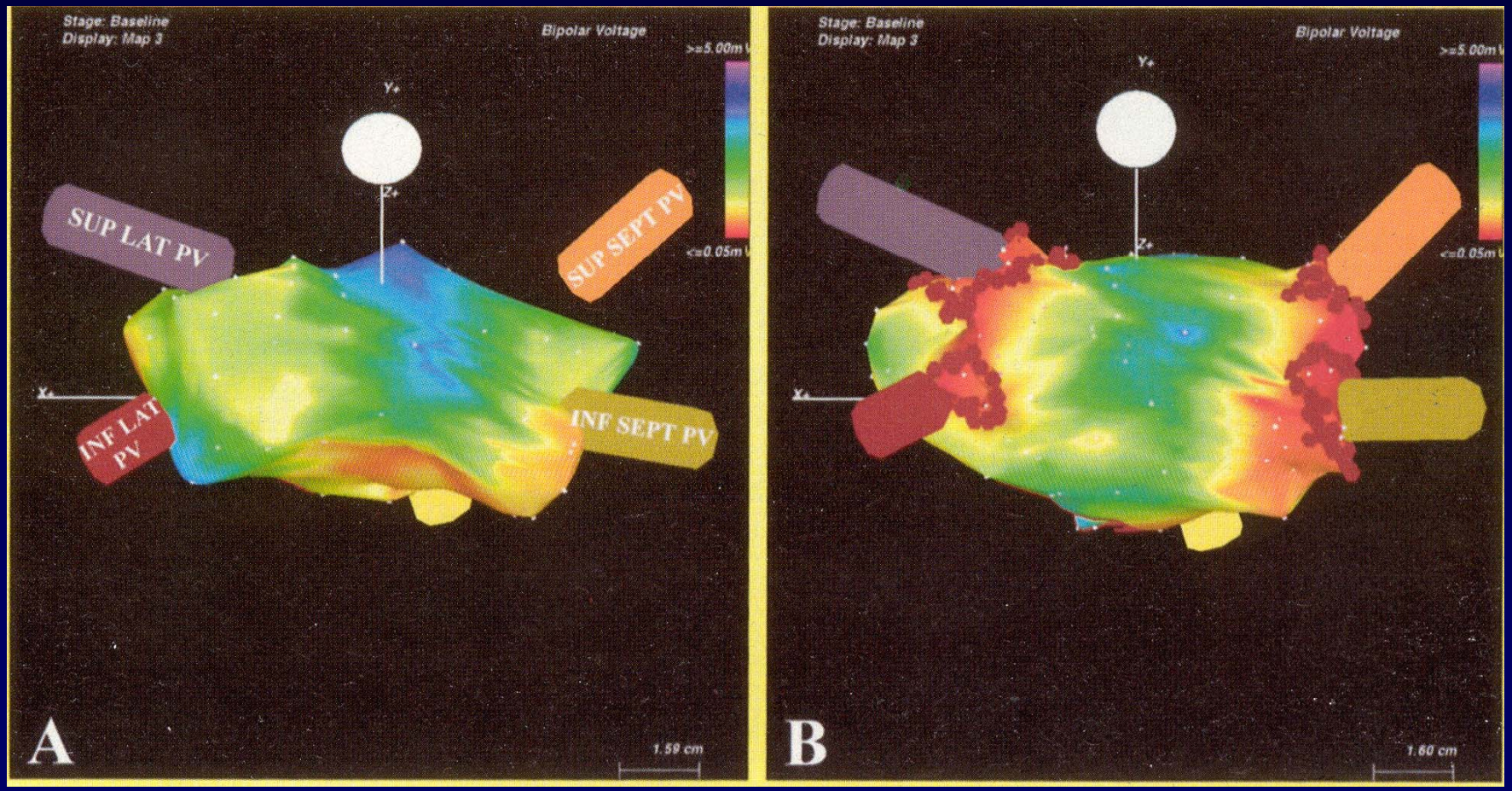
Carto XP System

- The patient is positioned over a tripod emitting 3 electromagnetic waves
- Each beam is registered by one of 3 turned coils embedded in the mapping catheter tip to specify location 3D space.

Carto XP System

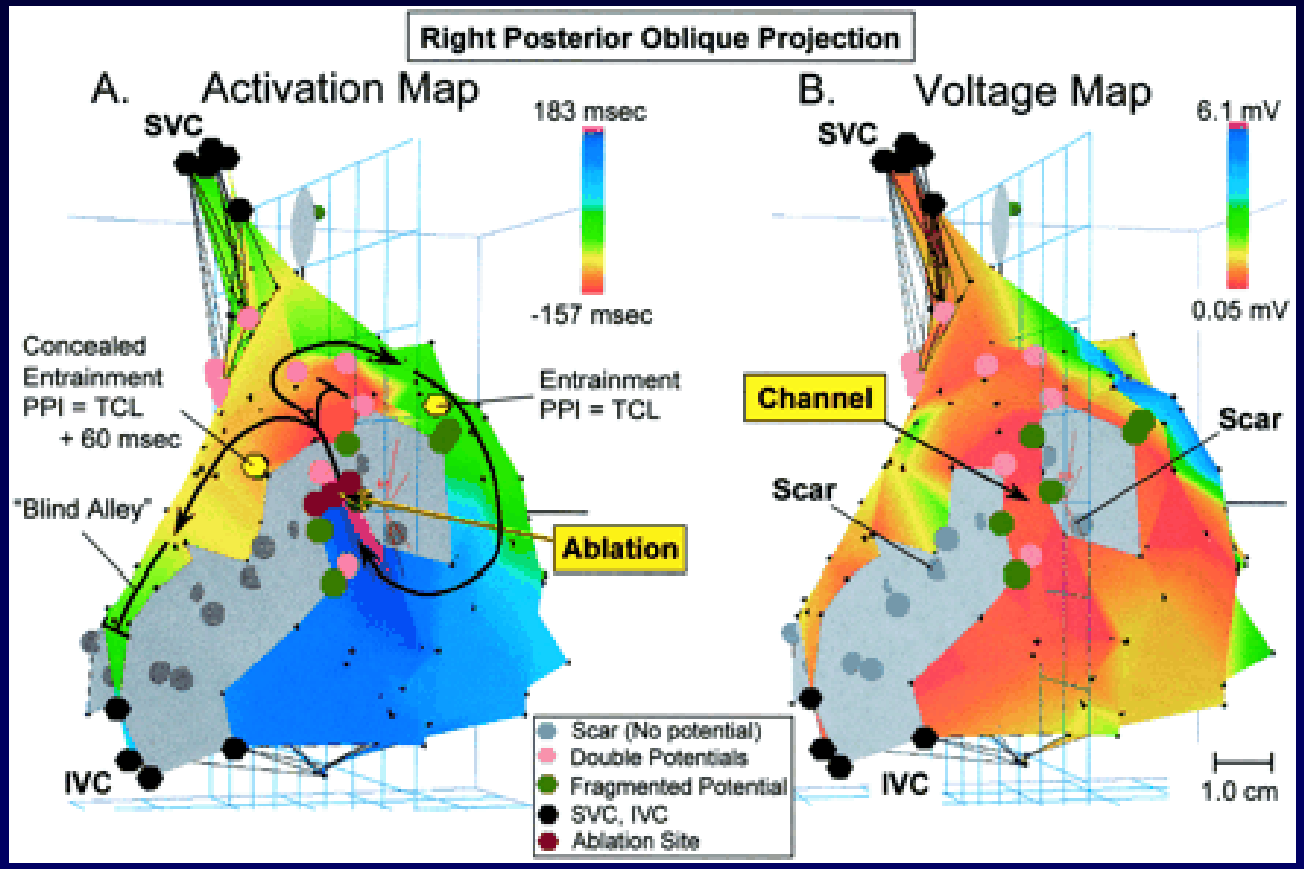
Pulmonary vein Isolation

Circulation. 2000;102:2619-28



Carto XP System

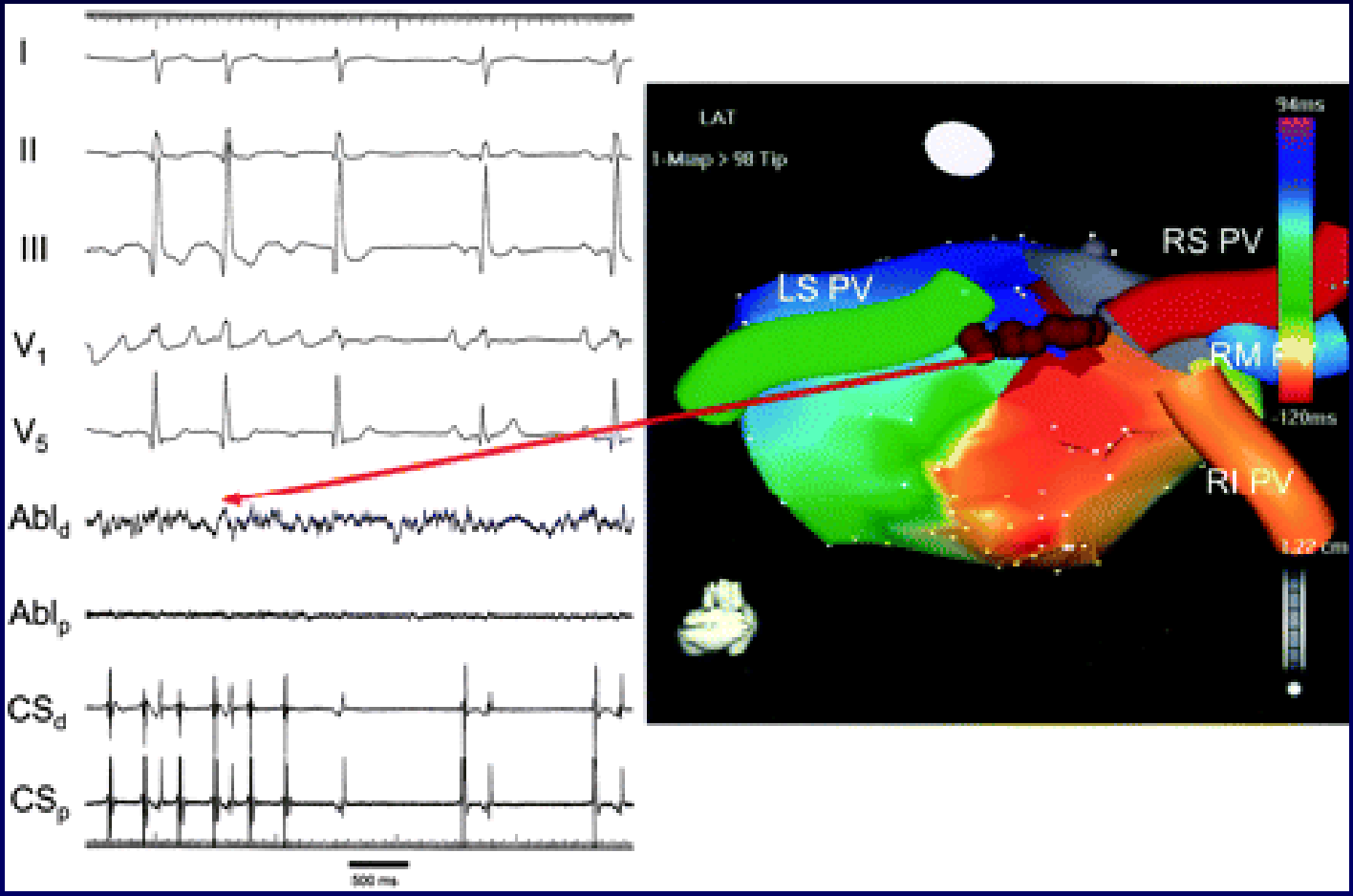
Mapping Scar Borders



Circulation. 2001 Feb 6;103(5):699-709

Carto XP System

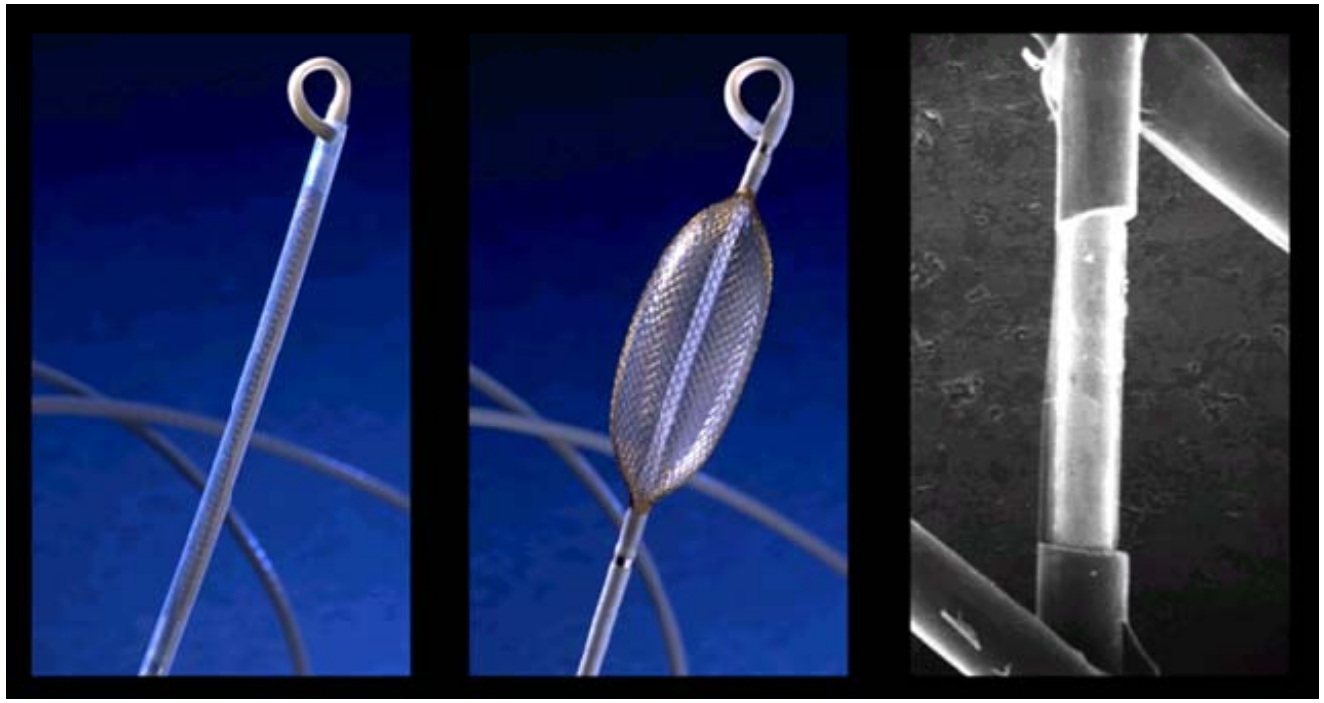
RF Ablation of Complex Fractionated Atrial Electrogram (CFAE)



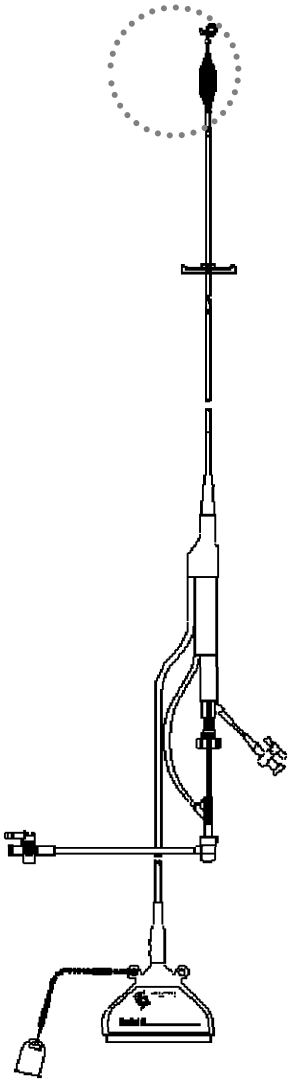
Circulation. 2007;115:2606-2612

ESI Noncontact Mapping

Multi-electrode Array

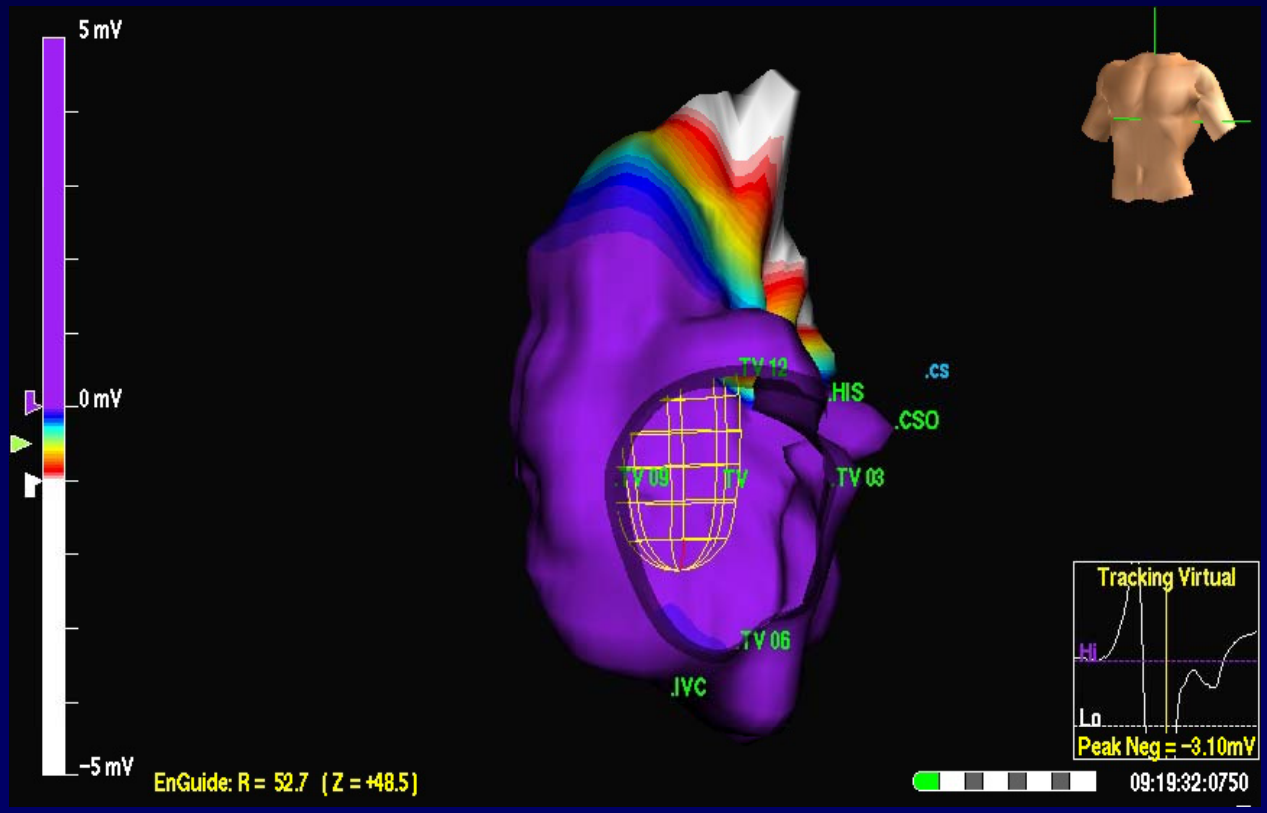


Array of 64 braided electrodes deployed around a 7.5ml balloon



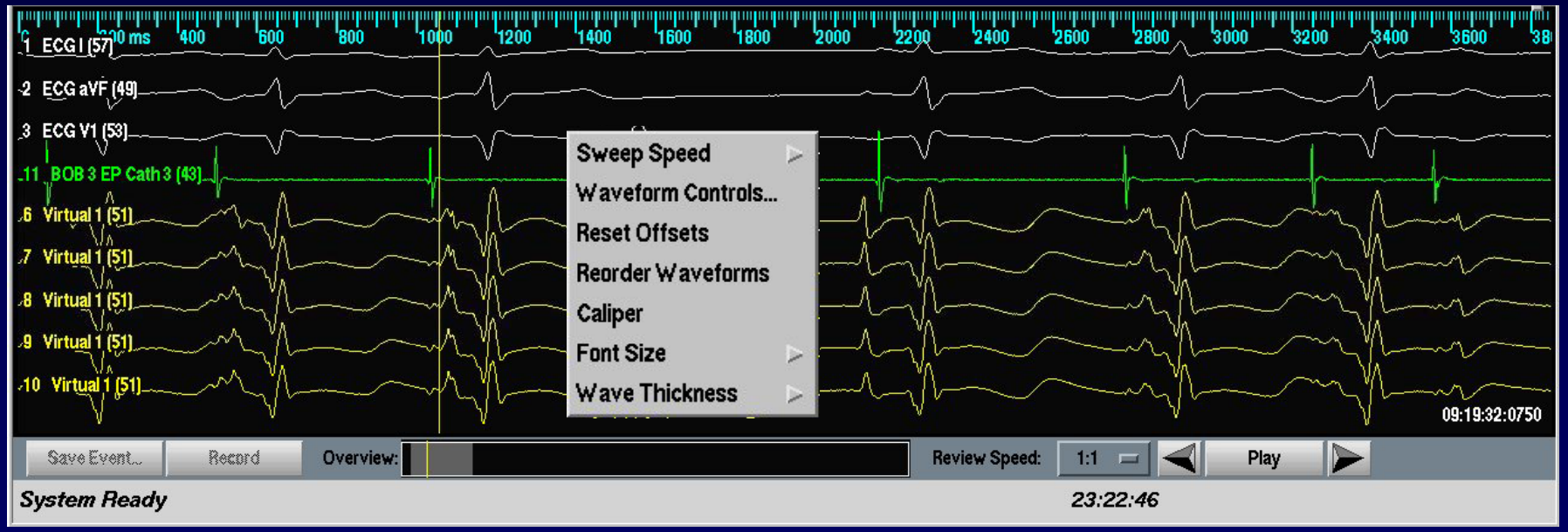
ESI Noncontact Mapping

System Interface: Map Display



Waveform Display

The waveform display provides the presentation of up to 32 waveforms



ESI Noncontact Mapping

Ischemic VT

- Place EnSite catheter in the LV using either a retrograde trans aortic or transseptal approach

- Create geometry of the LV, marking the apex, aorta and mitral valve

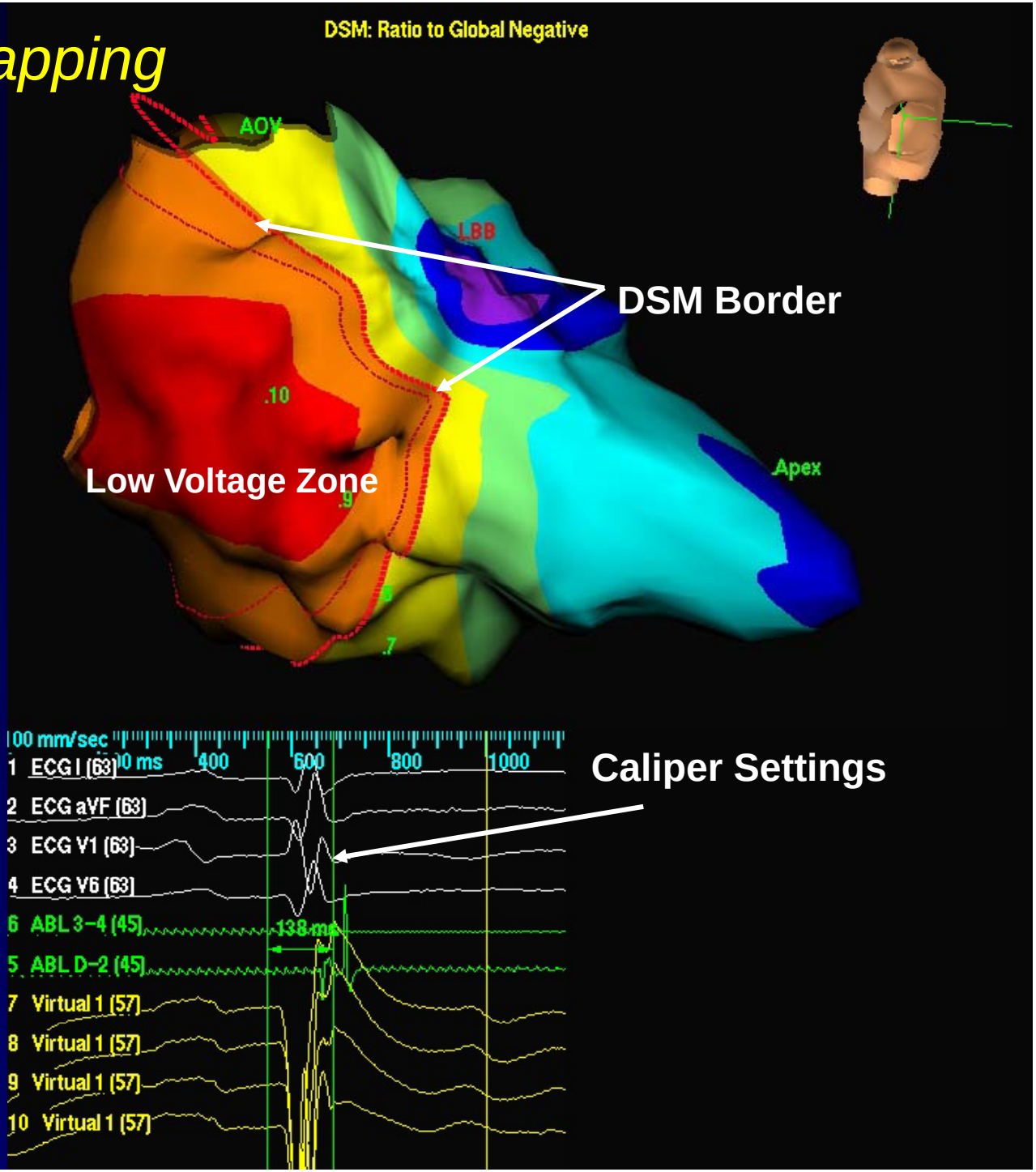
- Observe isopotential map and identify any low-voltage substrate

In the US, the EnSite Array is cleared for use in the right atrium only.
In Europe, the EnSite Array has received CE mark for use in either the right atrium or left ventricle.

ESI Noncontact Mapping

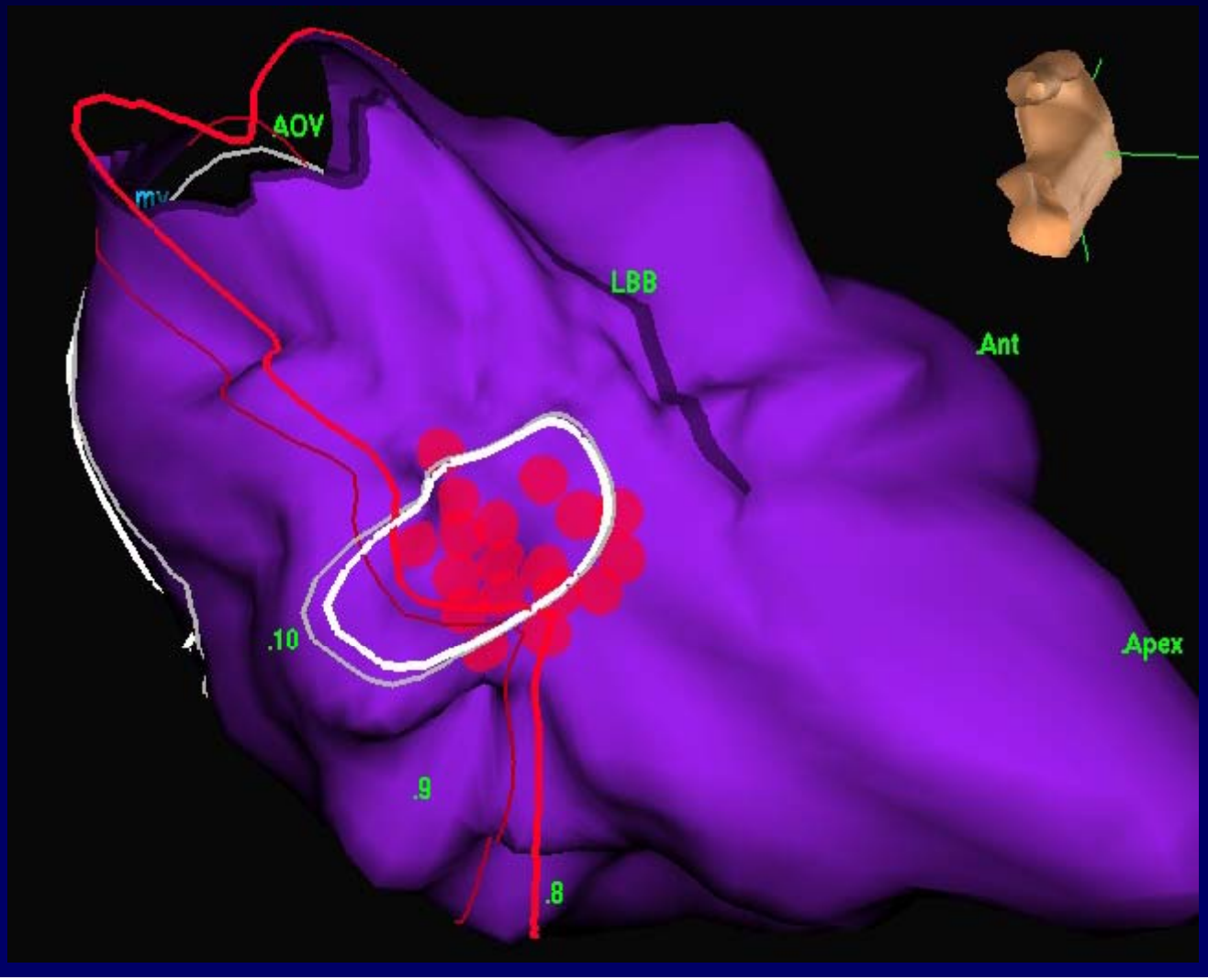
Sinus Rhythm

- Dynamic substrate mapping (DSM) tool was used in SR to identify a low voltage area and the red line was placed at 45% of the chambers peak neg. voltage
- Inf. Basal area is the lowest voltage substrate



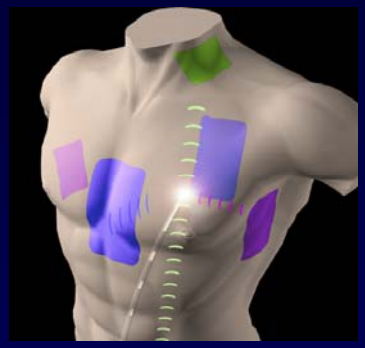
ESI Noncontact Mapping

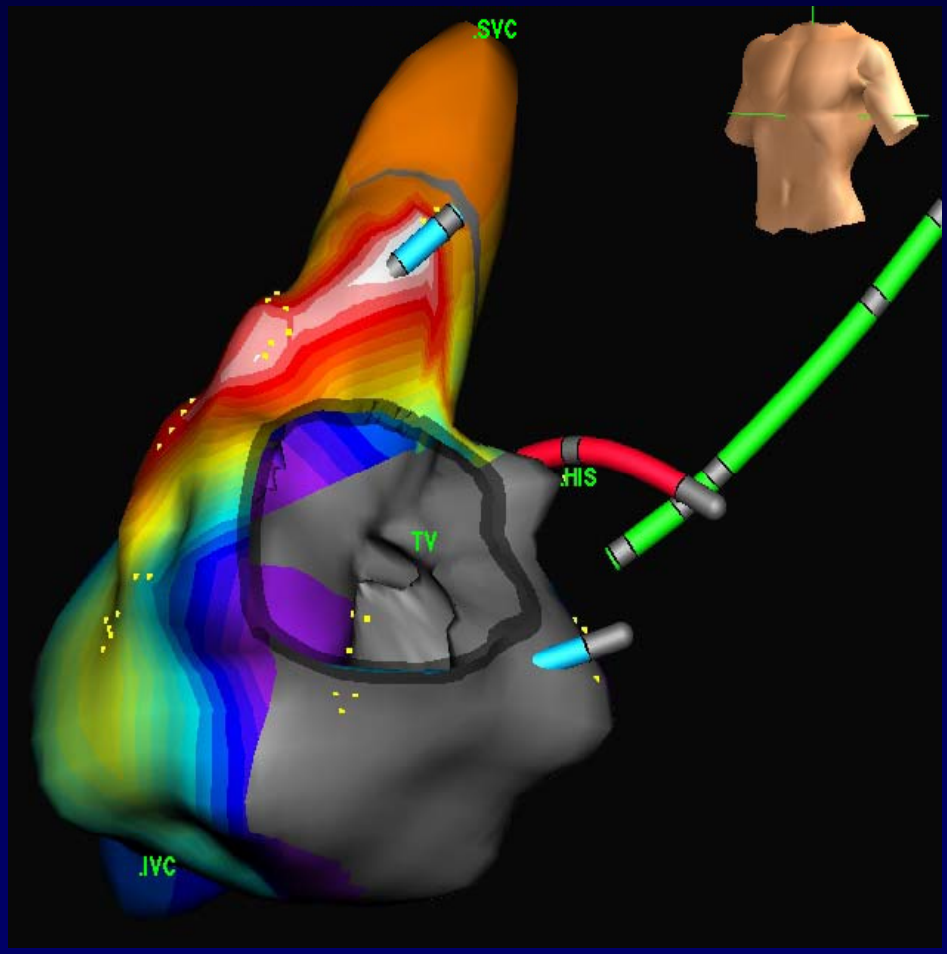
Lesions are placed within and along side the DSM border to eliminate the VT



NavX Mapping System

Low level separable currents from 3 orthogonal electrode pairs

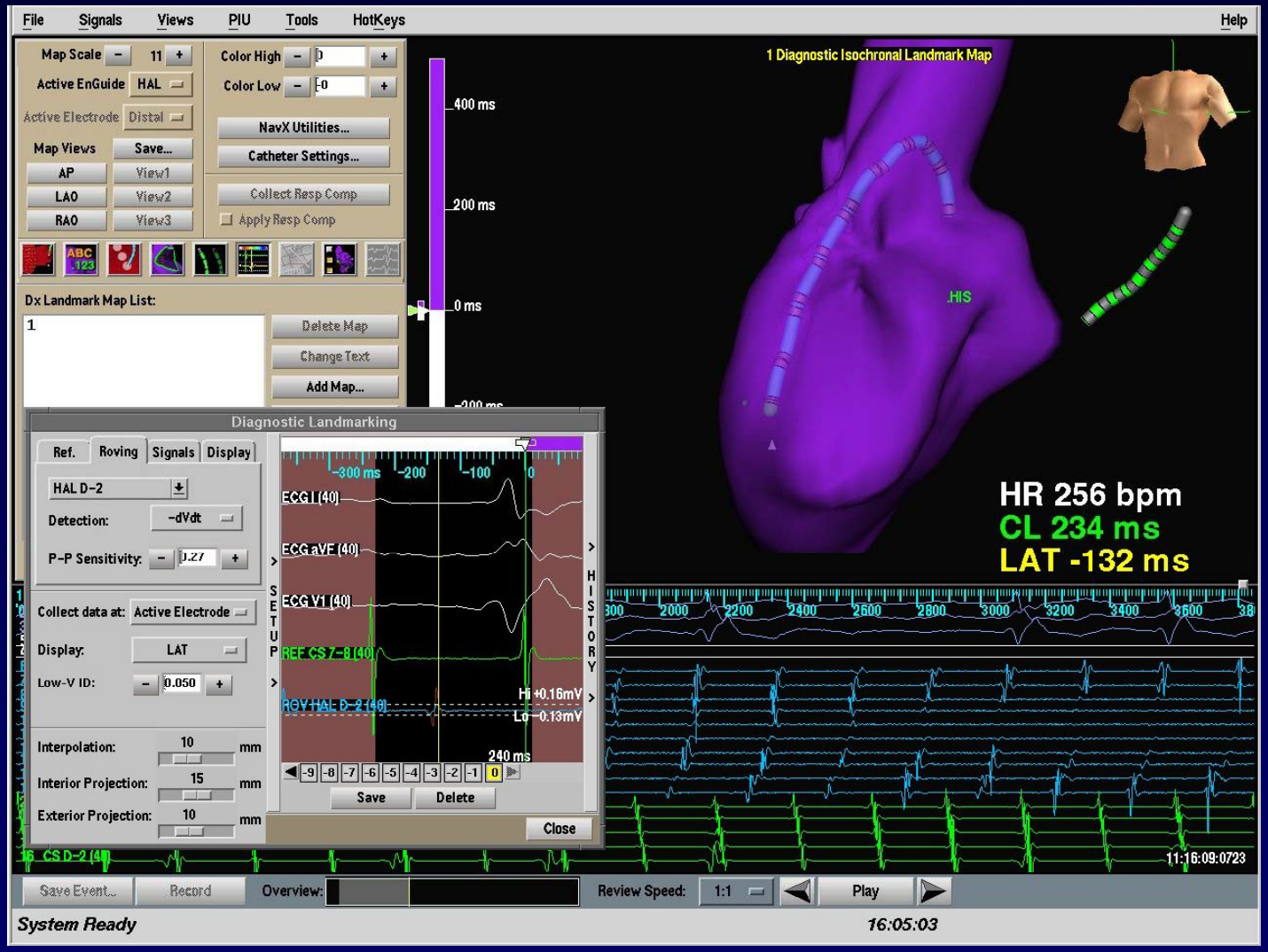




Features:

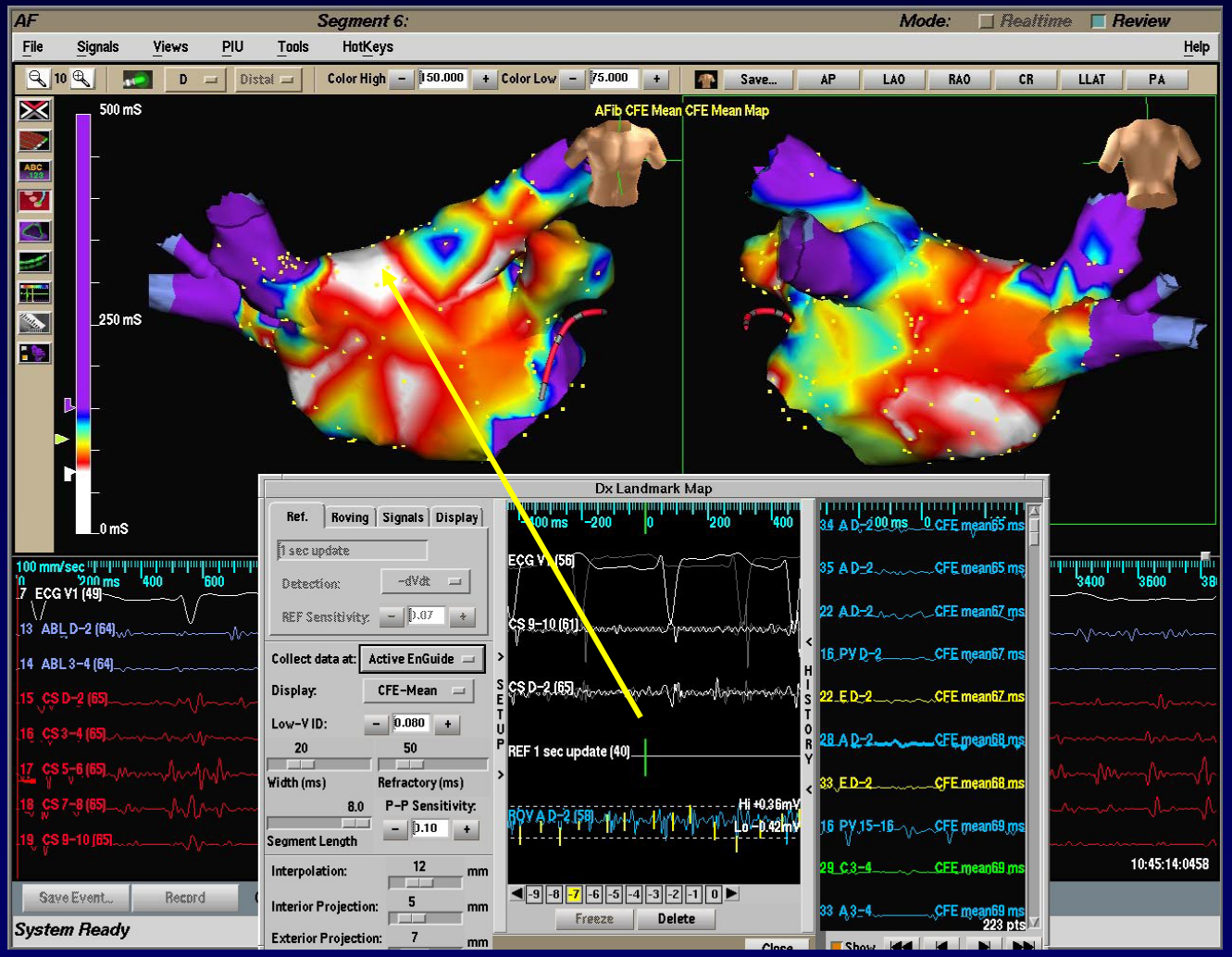
- Uses Conventional catheters of any electrode
- Displays Measured timing or voltages
- Creates 3D color display on geometry surface

NavX Mapping System

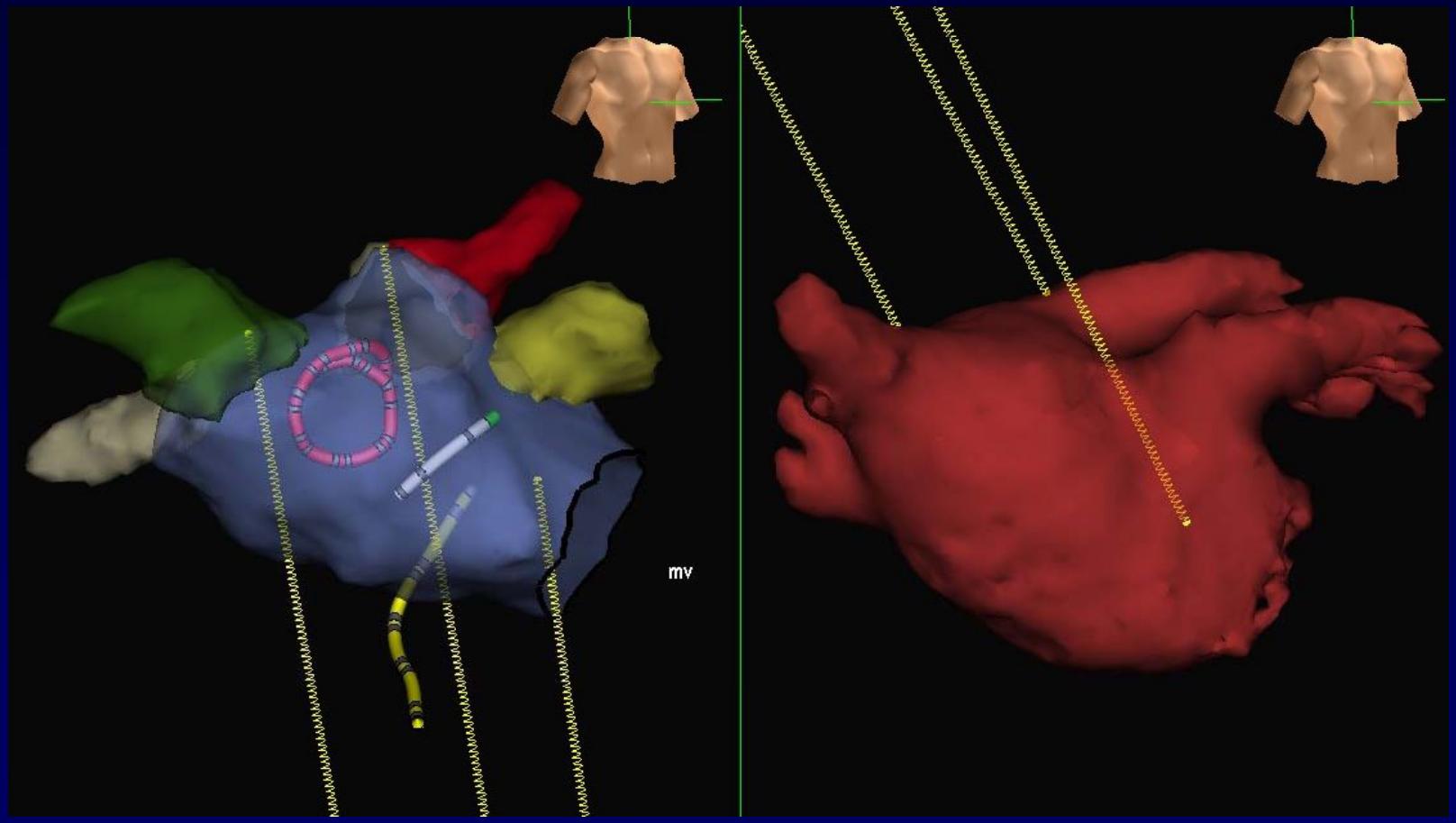


Diagnostic Landmarking

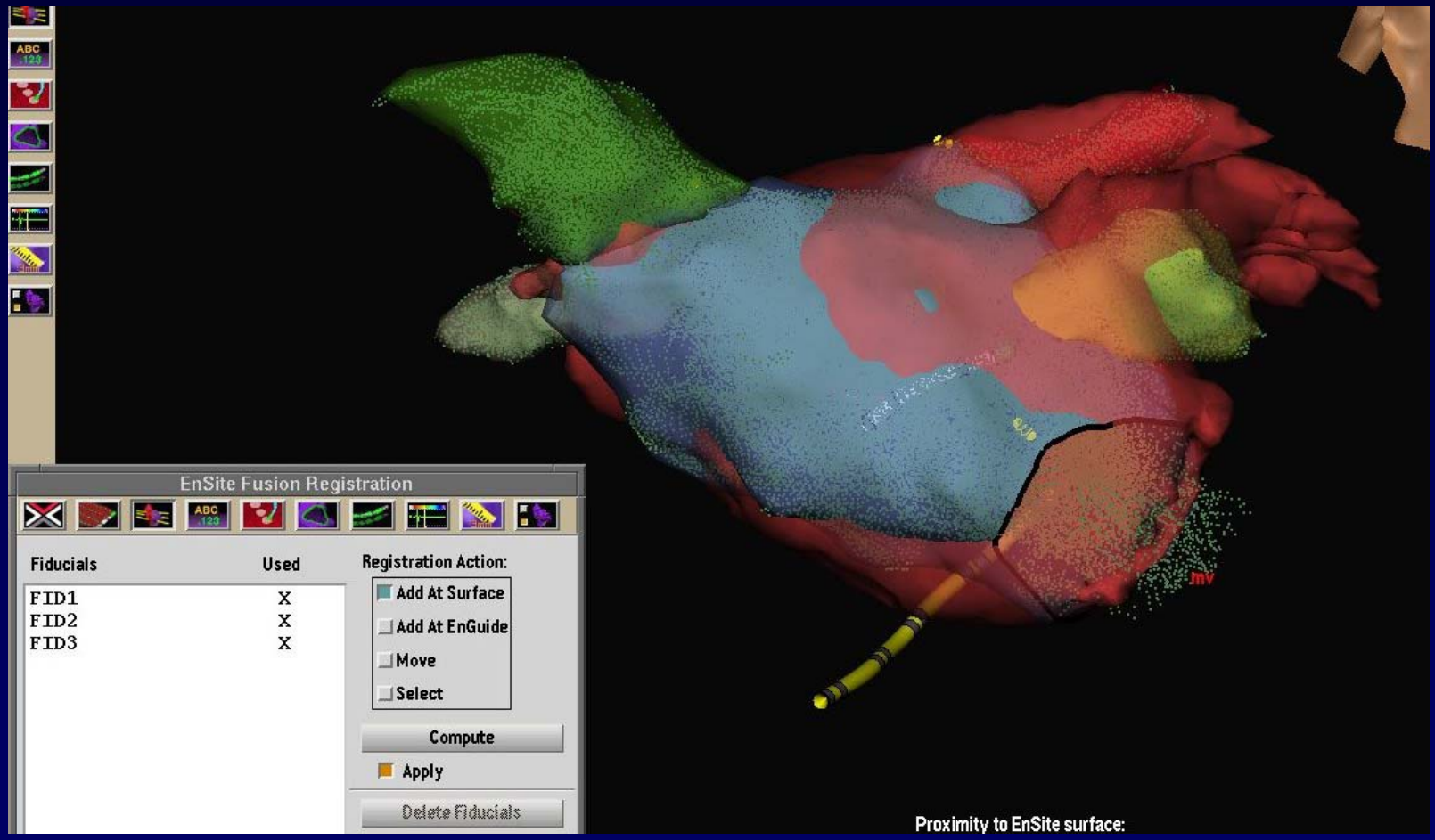
CFE Mean Map: A fractionated signal



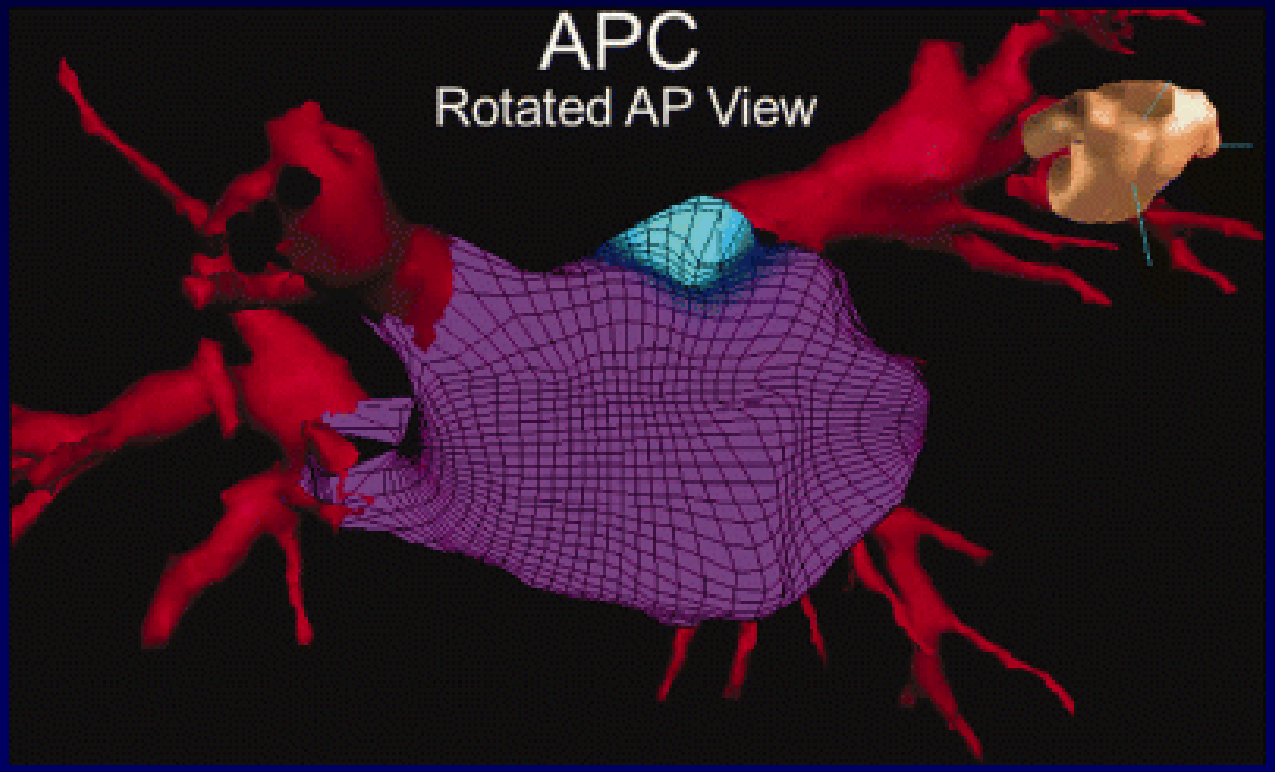
3D Anatomy–Based Mapping



Compute and Refine



3D Anatomy-Based Mapping

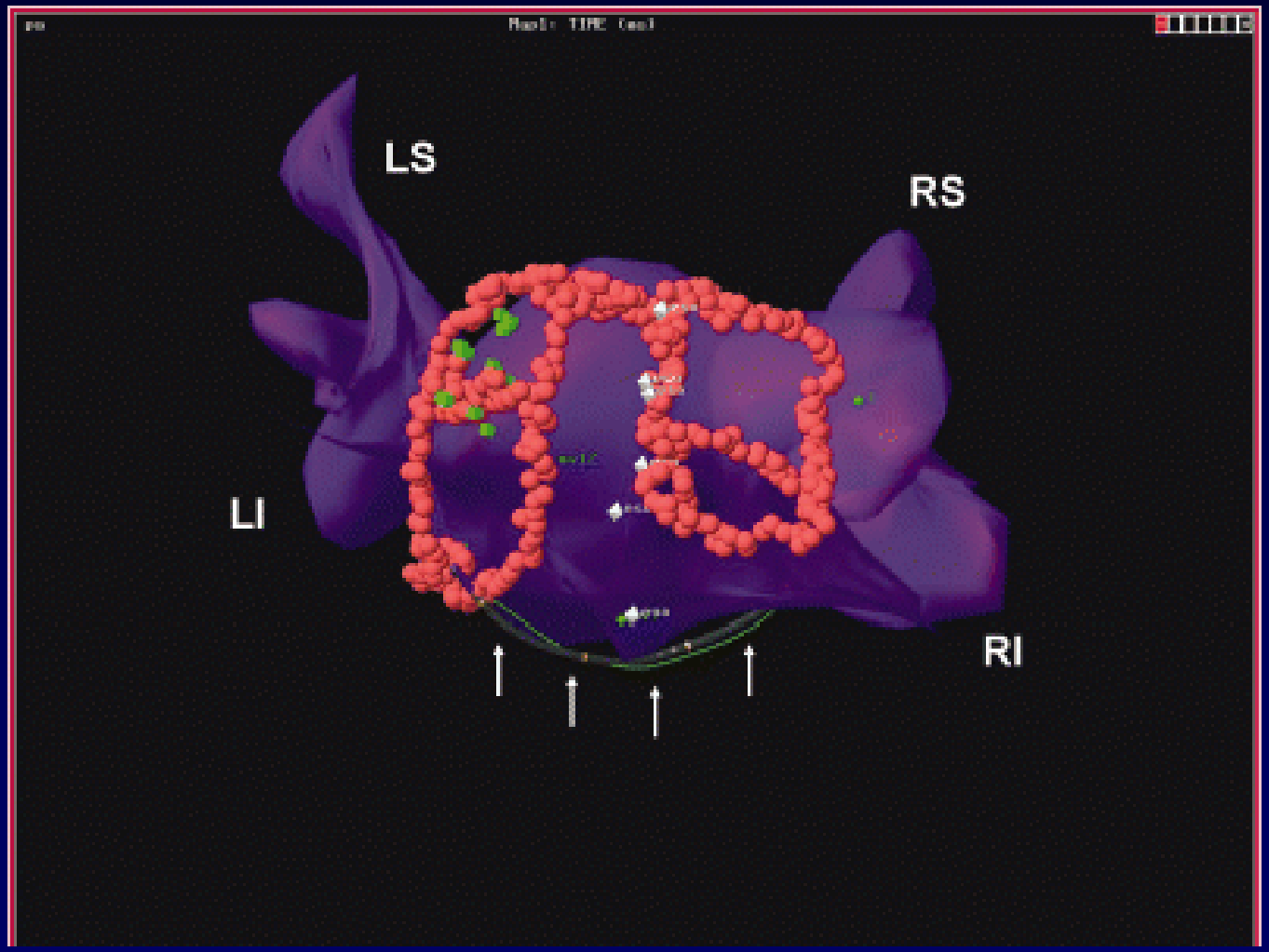


PACE 2004;27:1026-1049

Real-time Position Management (RMP) System

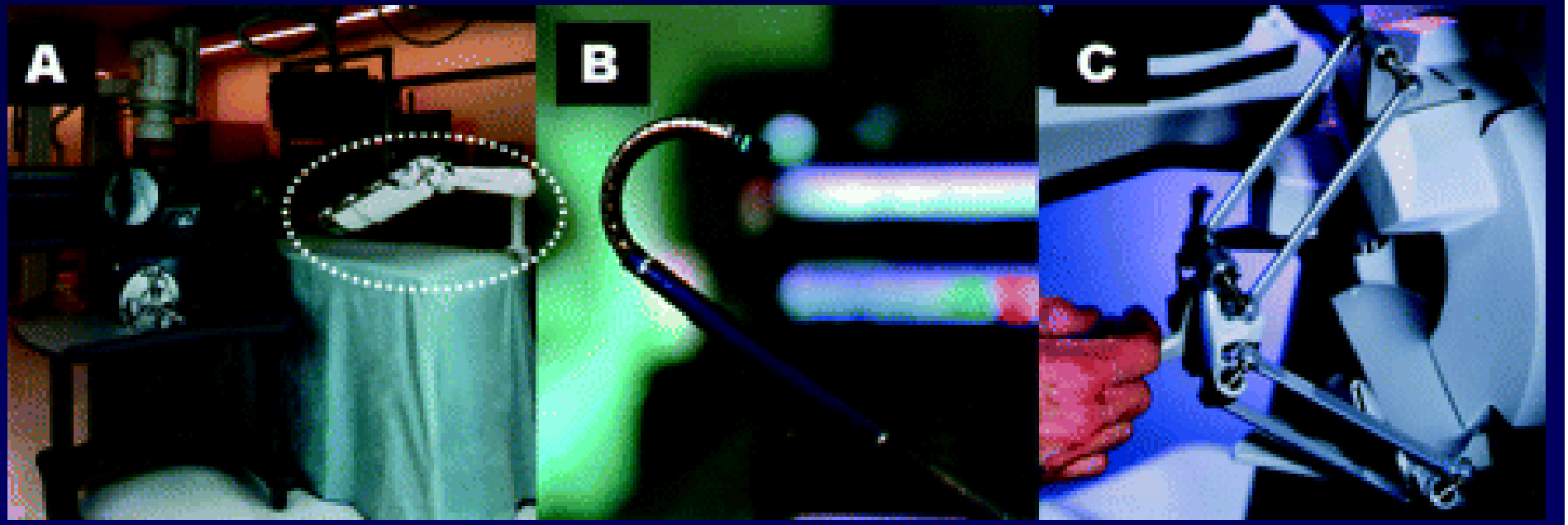
- Ultrasound-distance ranging
- Three catheters (right ventricle, coronary sinus, mapping catheter) fitted with microtransducers
- Point-to-point mapping

RPM Mapping System



J Cardiovasc Electrophysiol 2005;16:1110-1116

Remote Robotic Navigation System (RNS)



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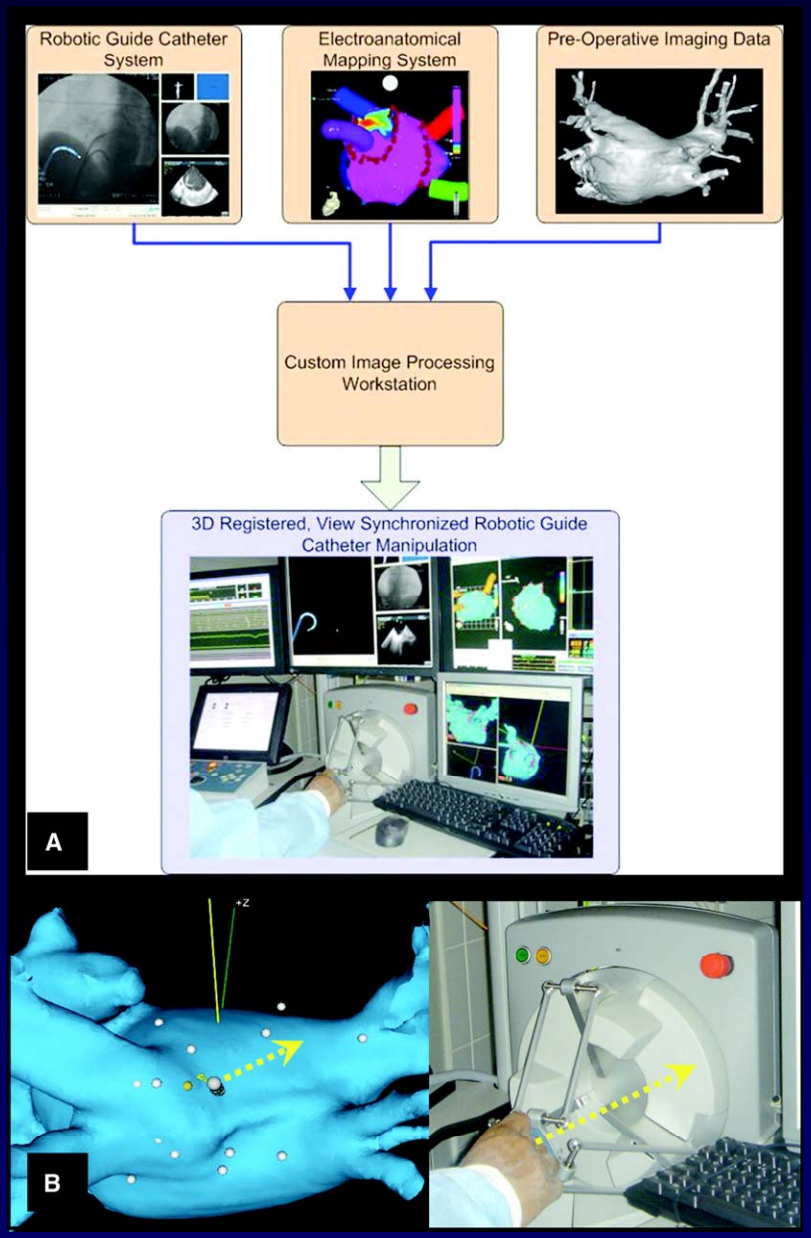
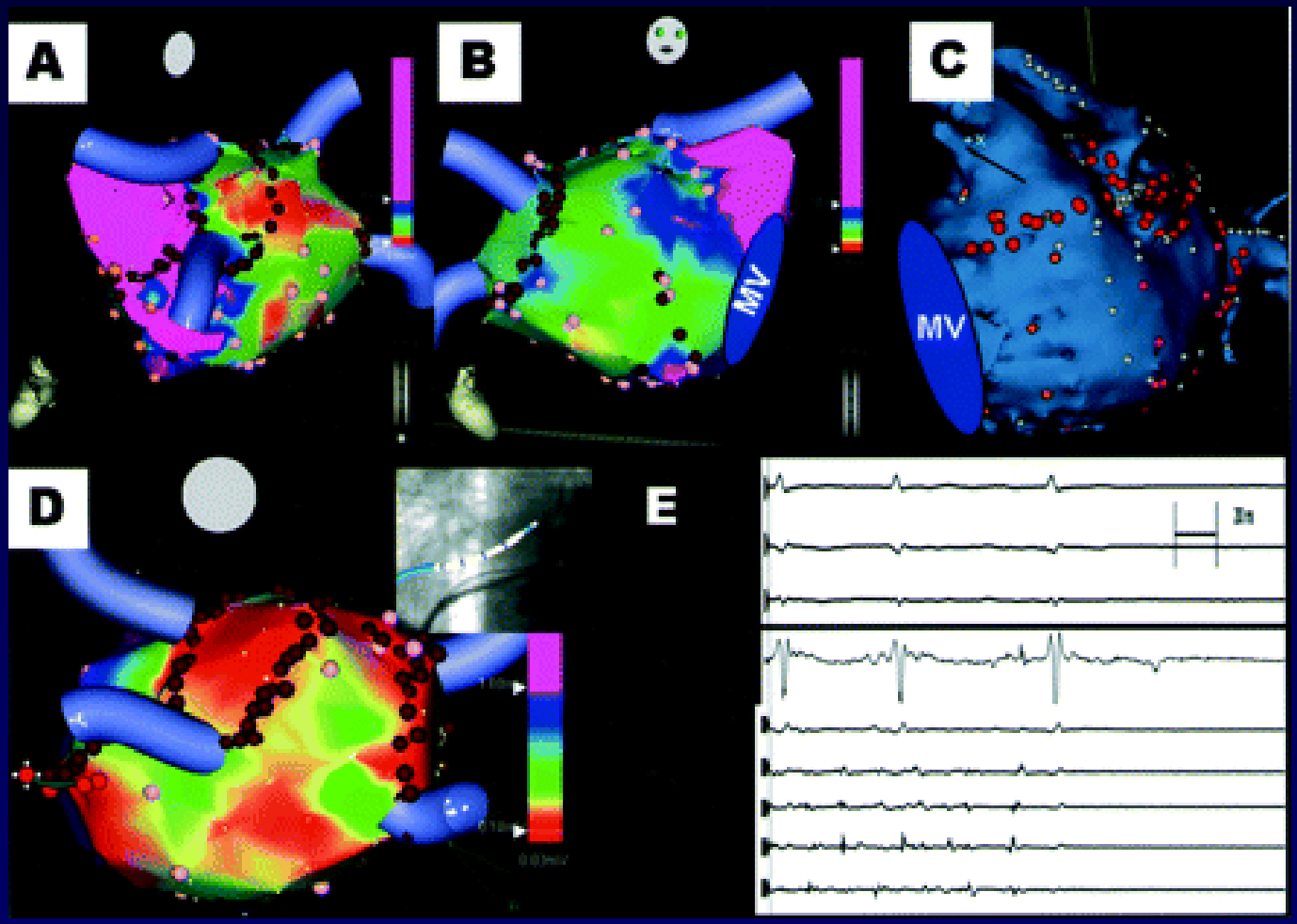


J Cardiovasc Electrophysiol 2005;16:1110–1116

Remote Robotic Navigation System (RNS)



J Cardiovasc Electrophysiol 2005;16:1110-1116

The Future of Cardiac Mapping

- A single coherent display: Automatic segmentation, registration and the capability of fusing multimodality imaging technologies
- Wide variety of physiologic parameters beyond activation times and voltage: vectors, strains, contraction patterns

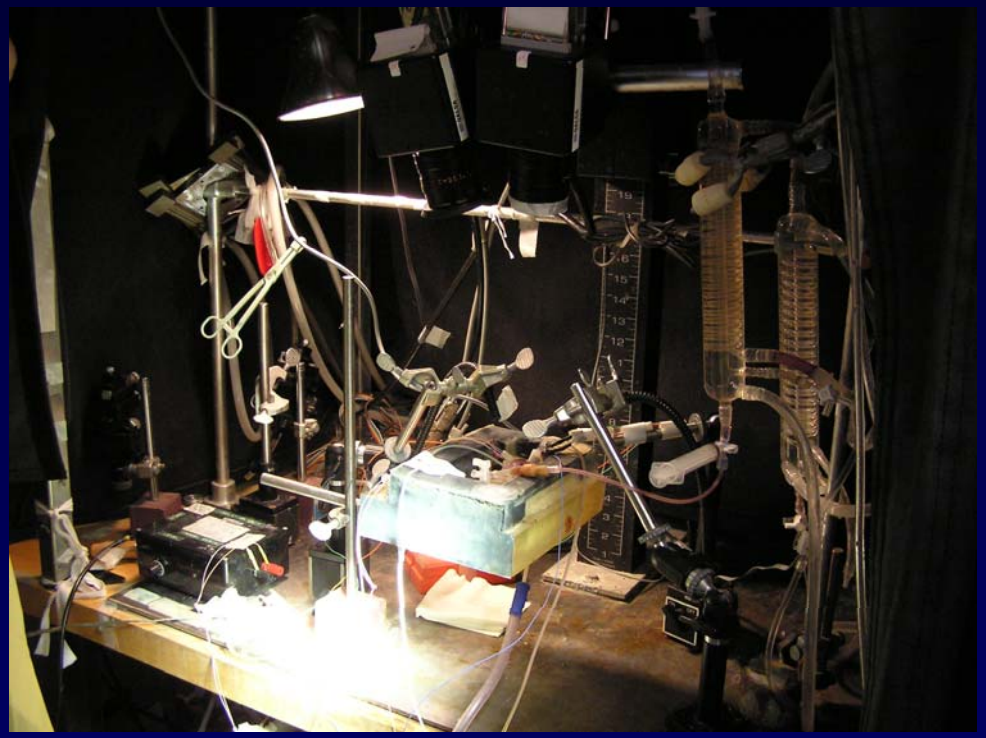
Optical Mapping Study of the Heart

Optical Imaging

- Cardiac cellular physiology
- Basic mechanisms of electrical activity, calcium homeostasis, and metabolism
- Wavelength dependent light-tissue interaction
  : photon scattering, total internal reflection, absorption, reflectance, and fluorescence
- "Fluorescence"

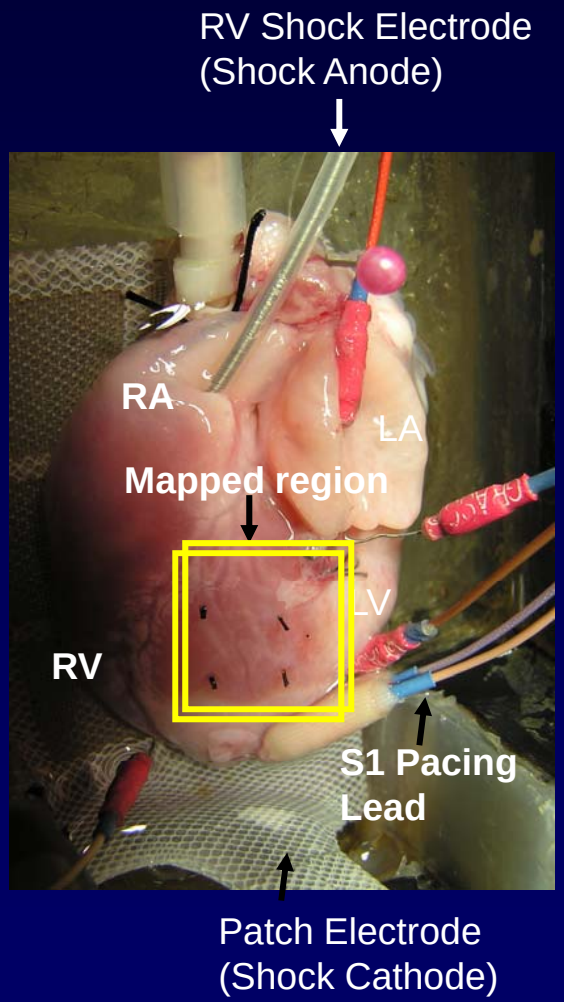
  Optical probes: membrane potential, intracellular free calcium, magnesium, sodium, potassium, PH, nitric oxide, oxygen tension, and sulfhydryl redox state.

Optical Imaging



- Langendorff-perfused heart
- Perfused with oxygenated Tyrode’s solution
- Two charge-coupled device (CCD) cameras

Optical Imaging



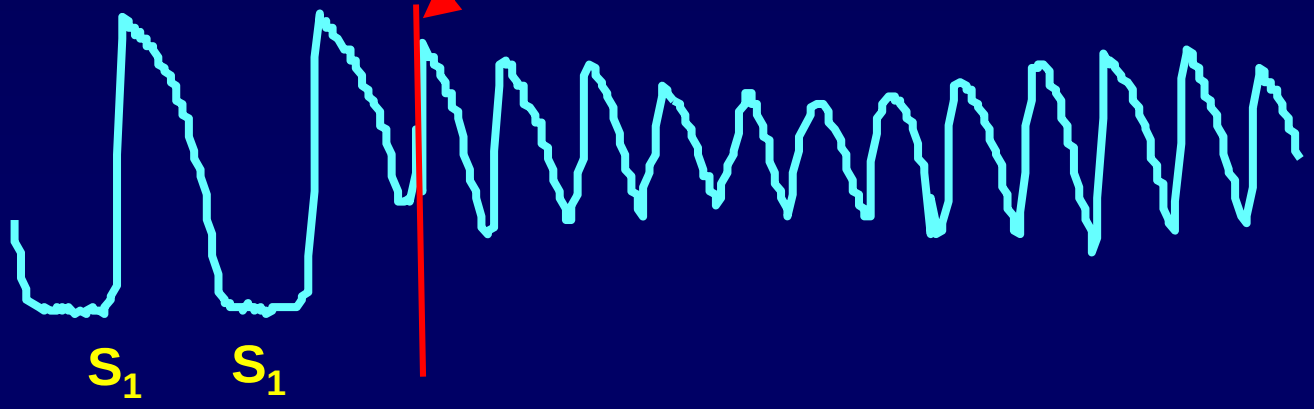
- Calcium sensitive dye (Rhod-2):
  585 nm bandpass filter
- Voltage sensitive dye (RH 237):
  710 nm long-pass filter
- 128x128 pixel (25x25 mm^2)
- Electromechanical decoupler:
  cytochalasin D, 2,3-butanedione

Transmembrane potential (TMP) and Optical Tracing

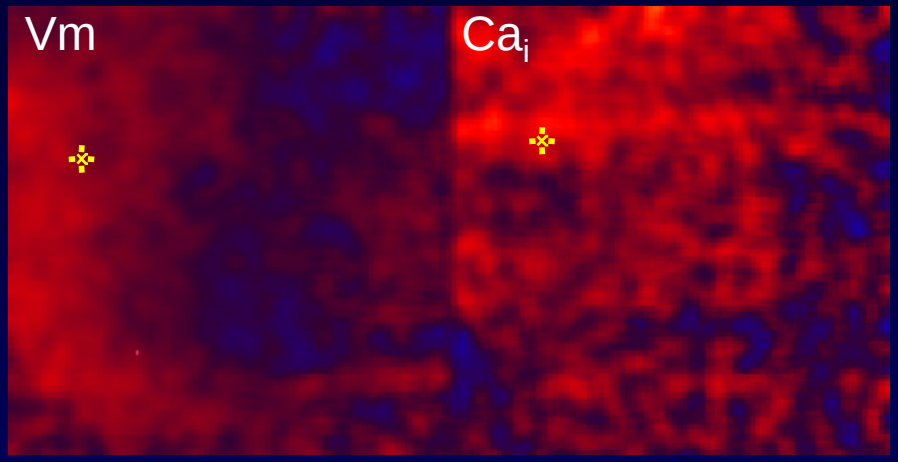
TMP

Shock

Optical tracing

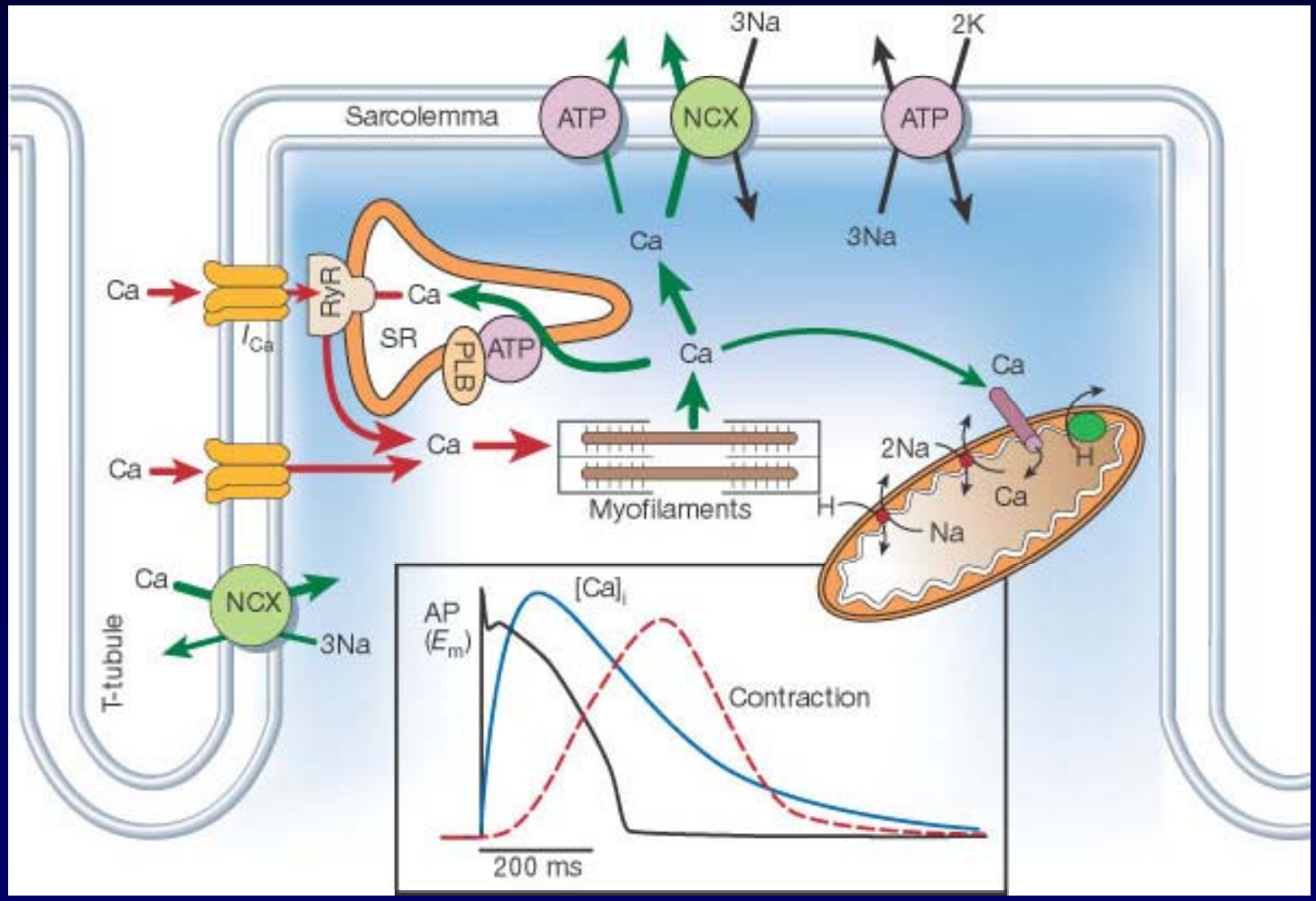


Definition: Percent Depolarized Area



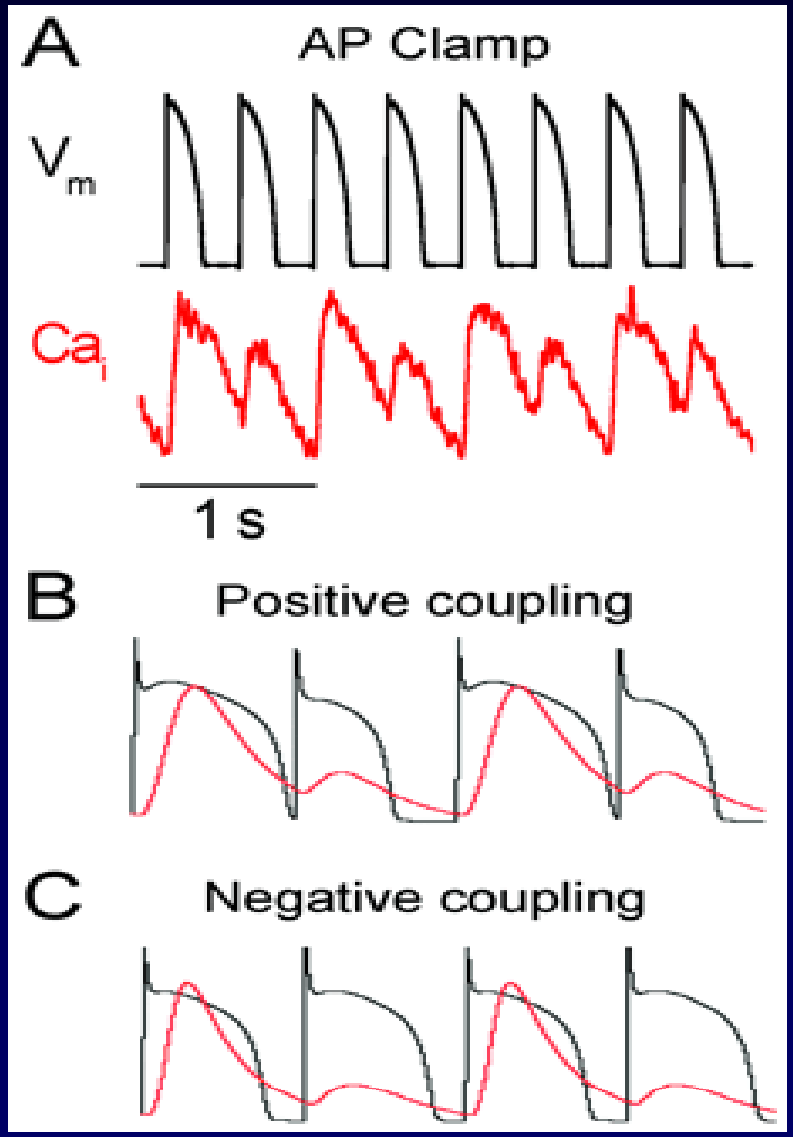
- The mapped area is coded red (depolarized) if the fluorescent level is > 50% of the average fluorescence.
- The % red (depolarized) area is used as a quantitative measure of the shock effects

Calcium Cycling



Bers DM Nature. 2002 Jan 10;415(6868):198-205

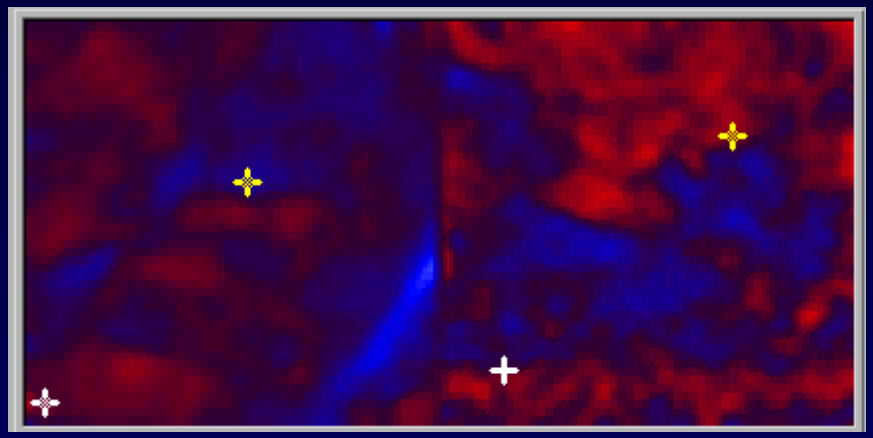
Ca cycling and Wavelength

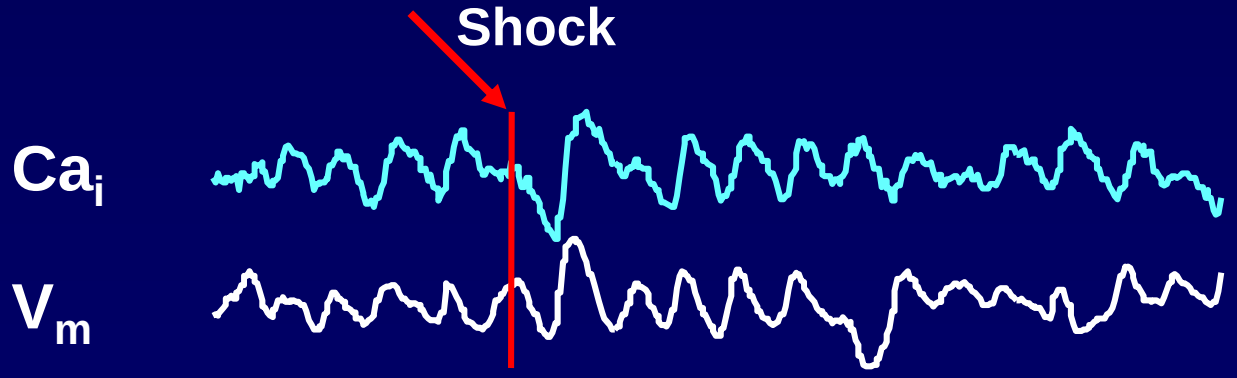


Circulation. 2005;112:1232-1240

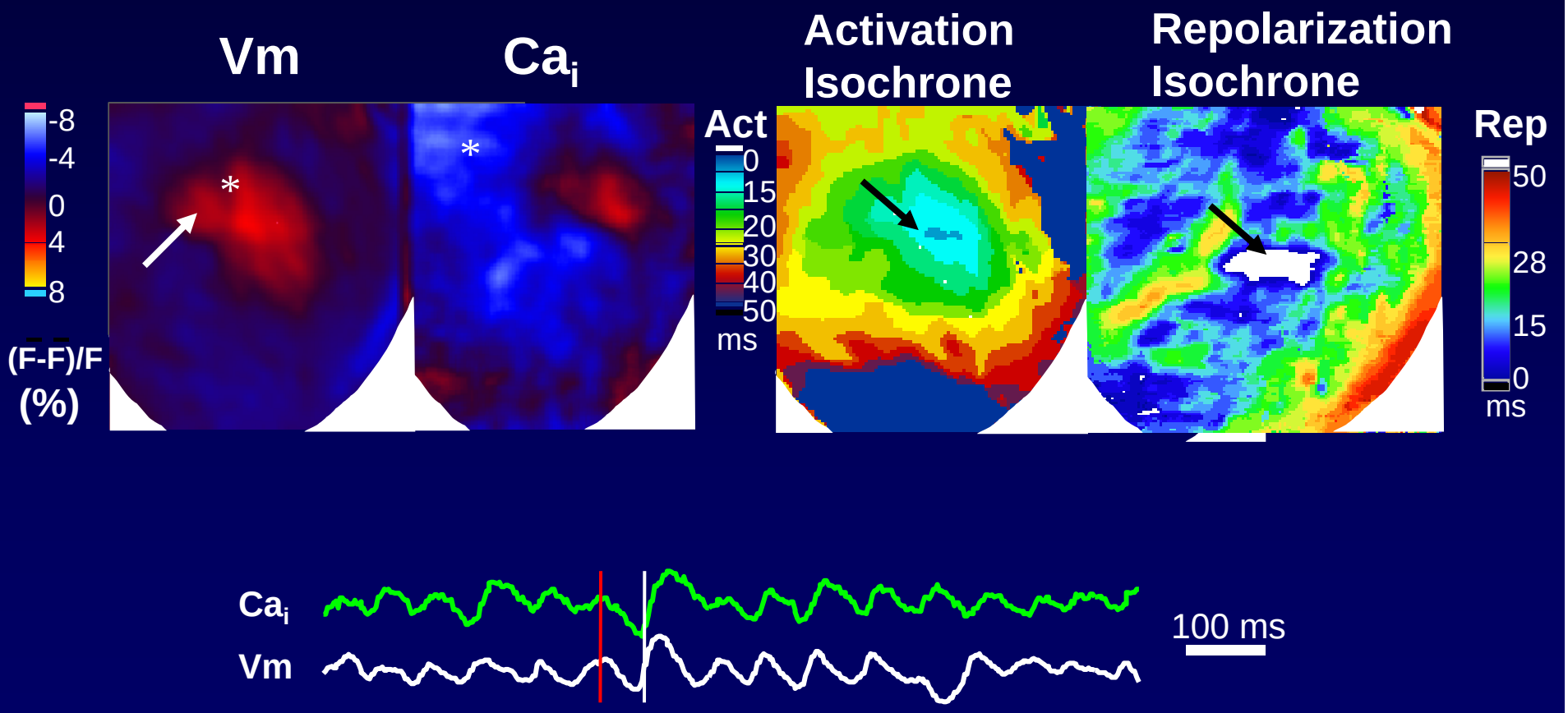
Dual Optical Mapping Study During VF Ongoing

Vm **Ca_i**

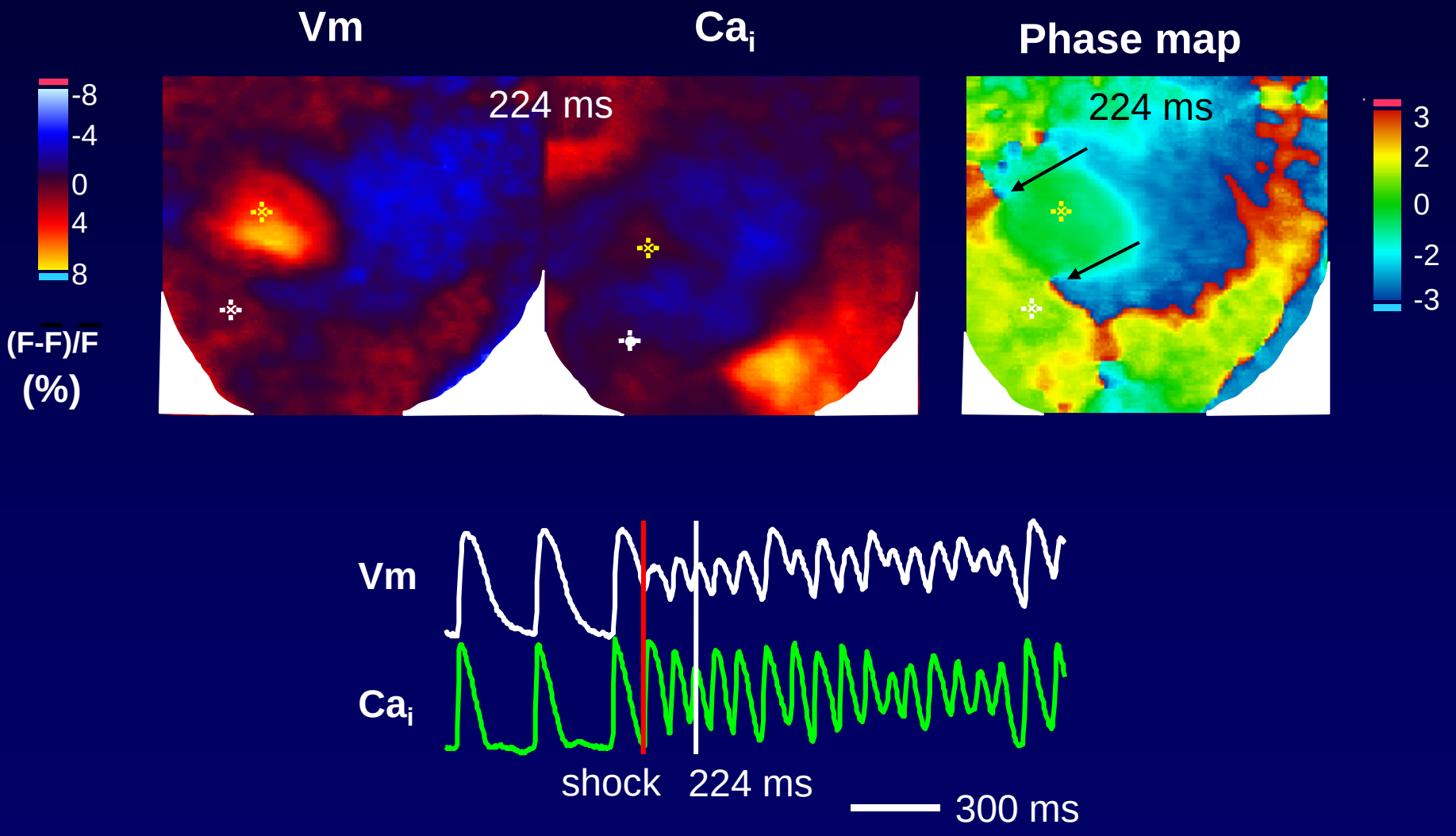




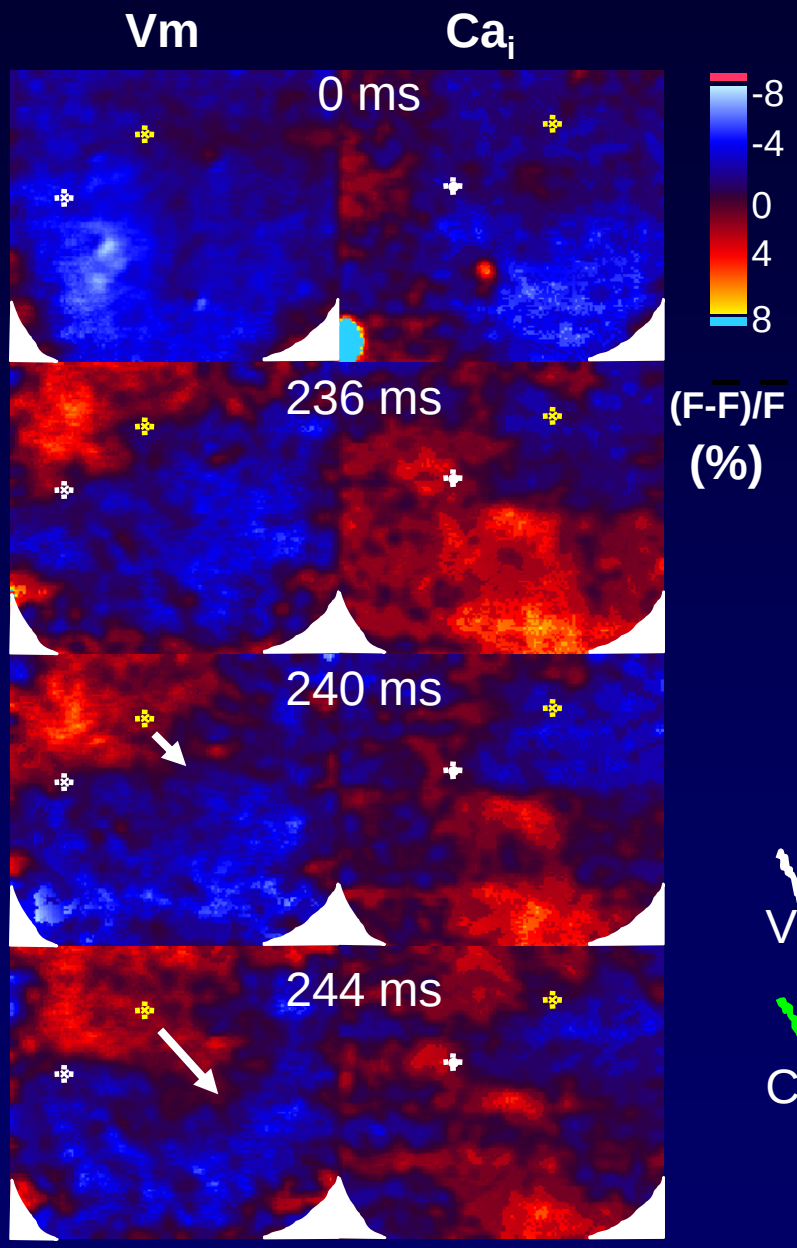
Dual Optical Imaging

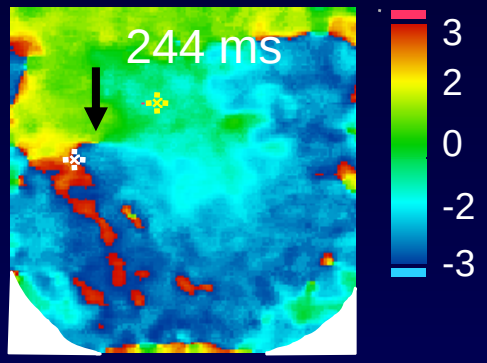


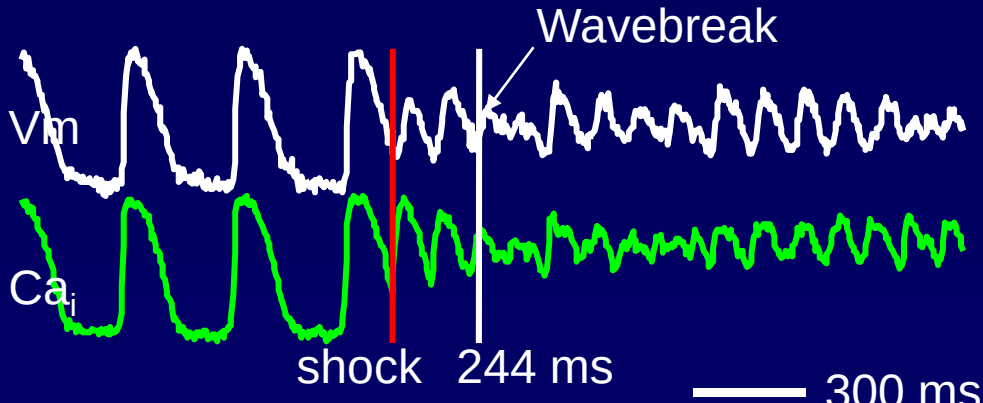
Dual Optical Imaging



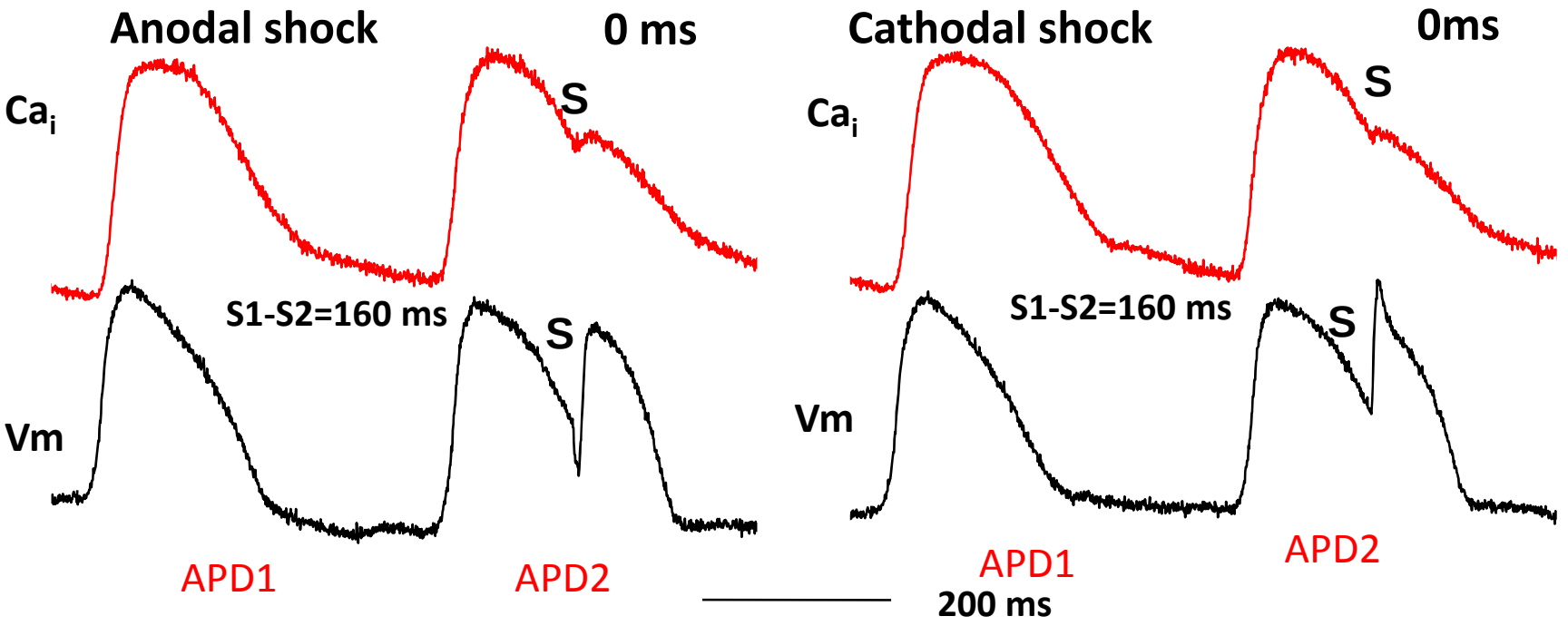
Dual Optical Imaging

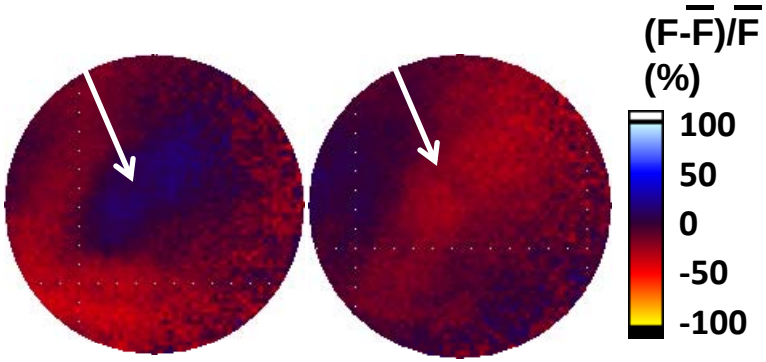






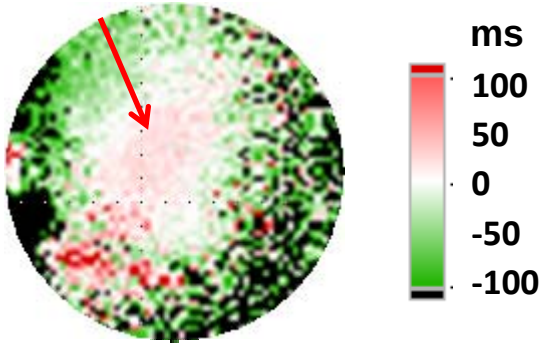
Shock Effects on Virtual Electrodes





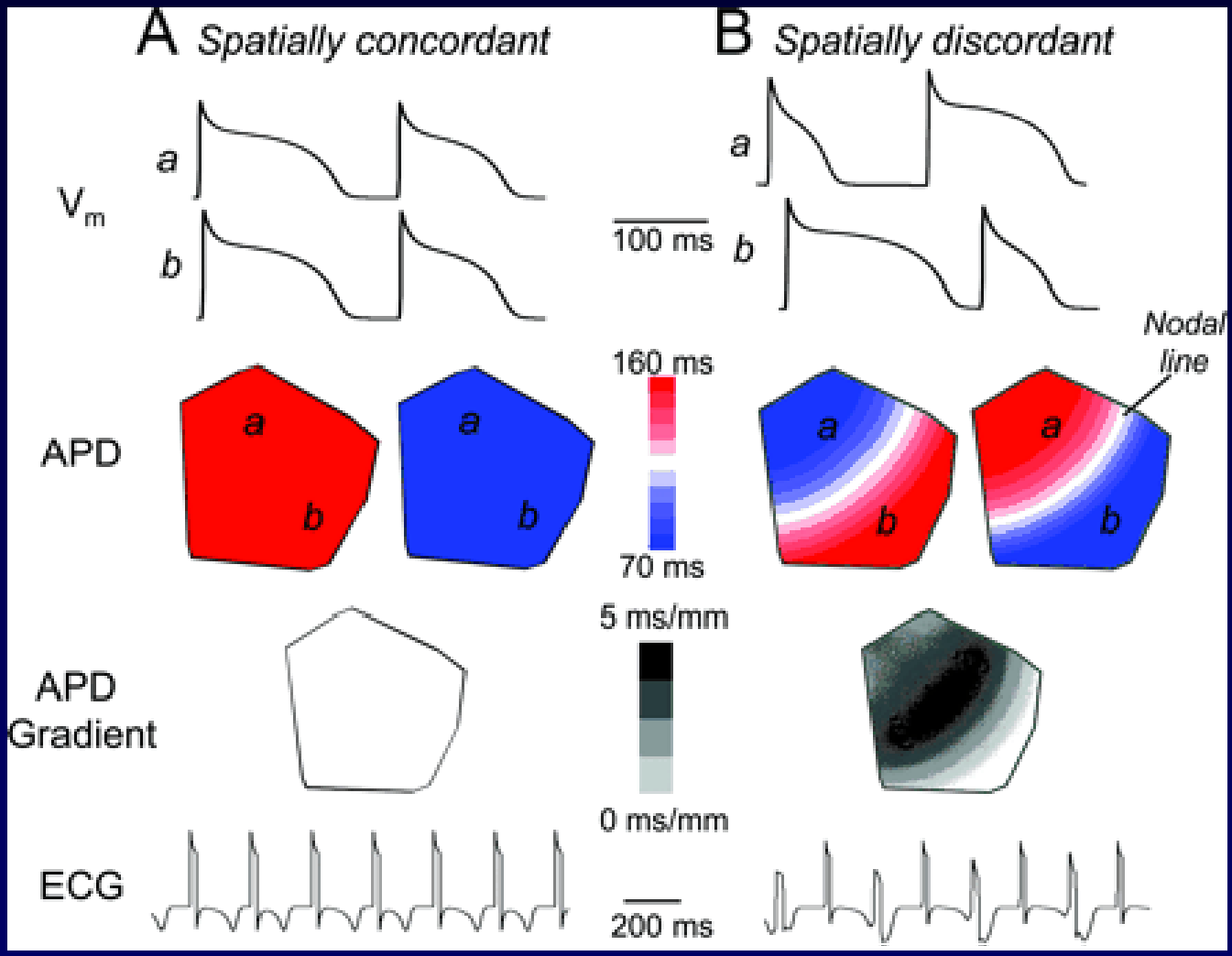
Virtual anode

Virtual cathode



Anodal – Cathodal
Delta APD2

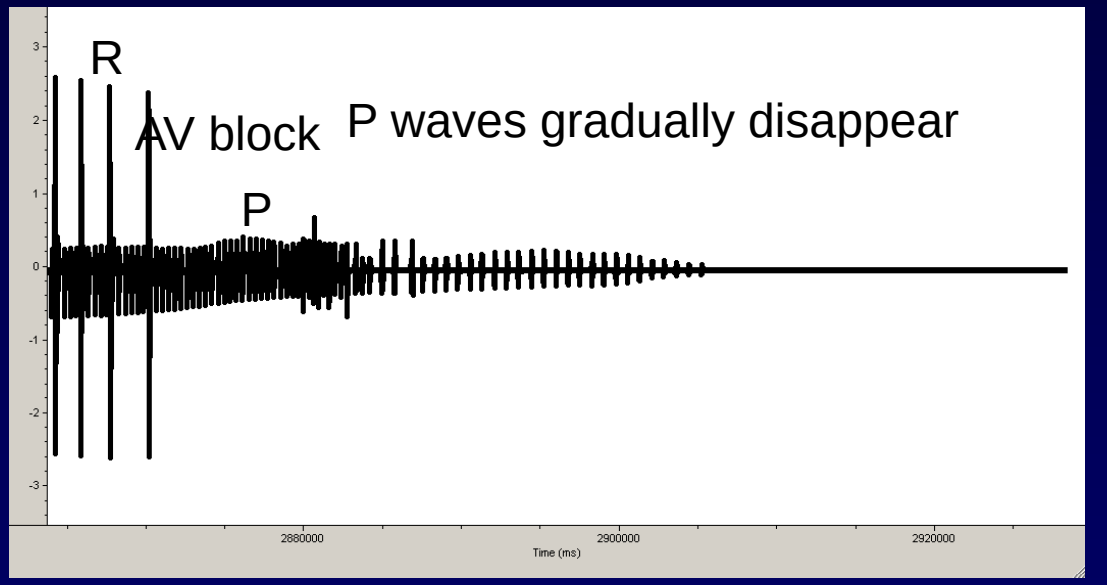
Spatially Concordant and Discordant



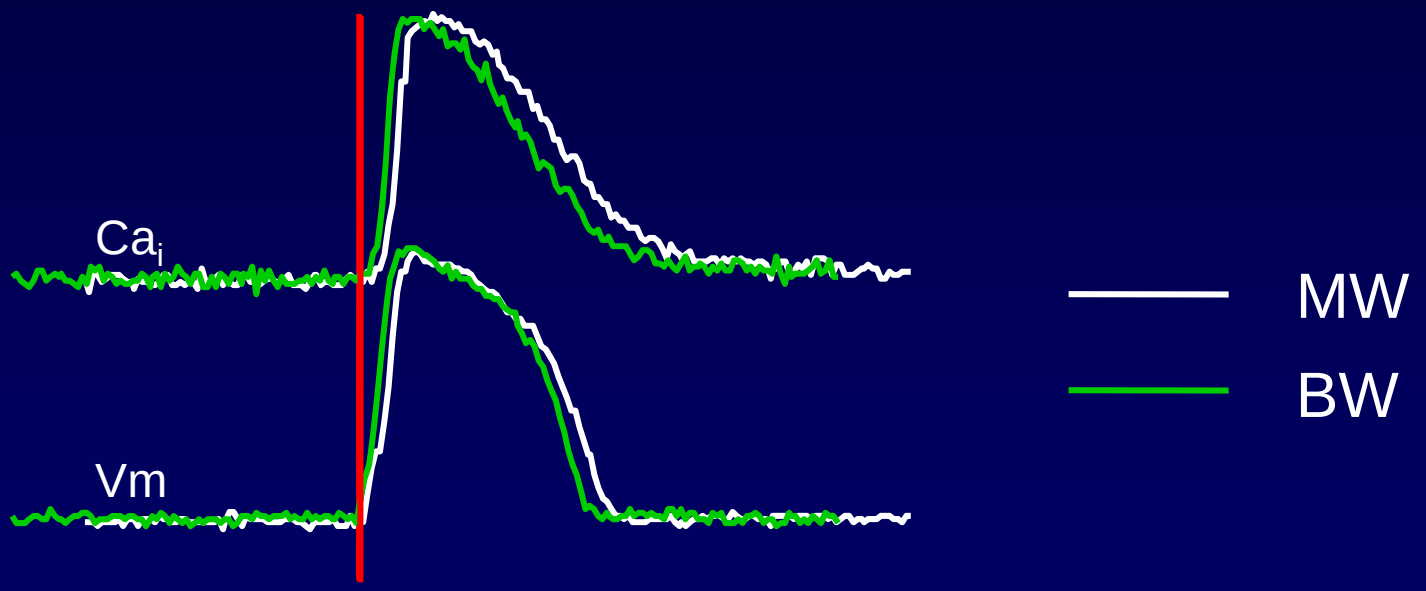
Circ Res. 2006;98:1244-1253

Drugs Effect on Ventricular Vulnerability

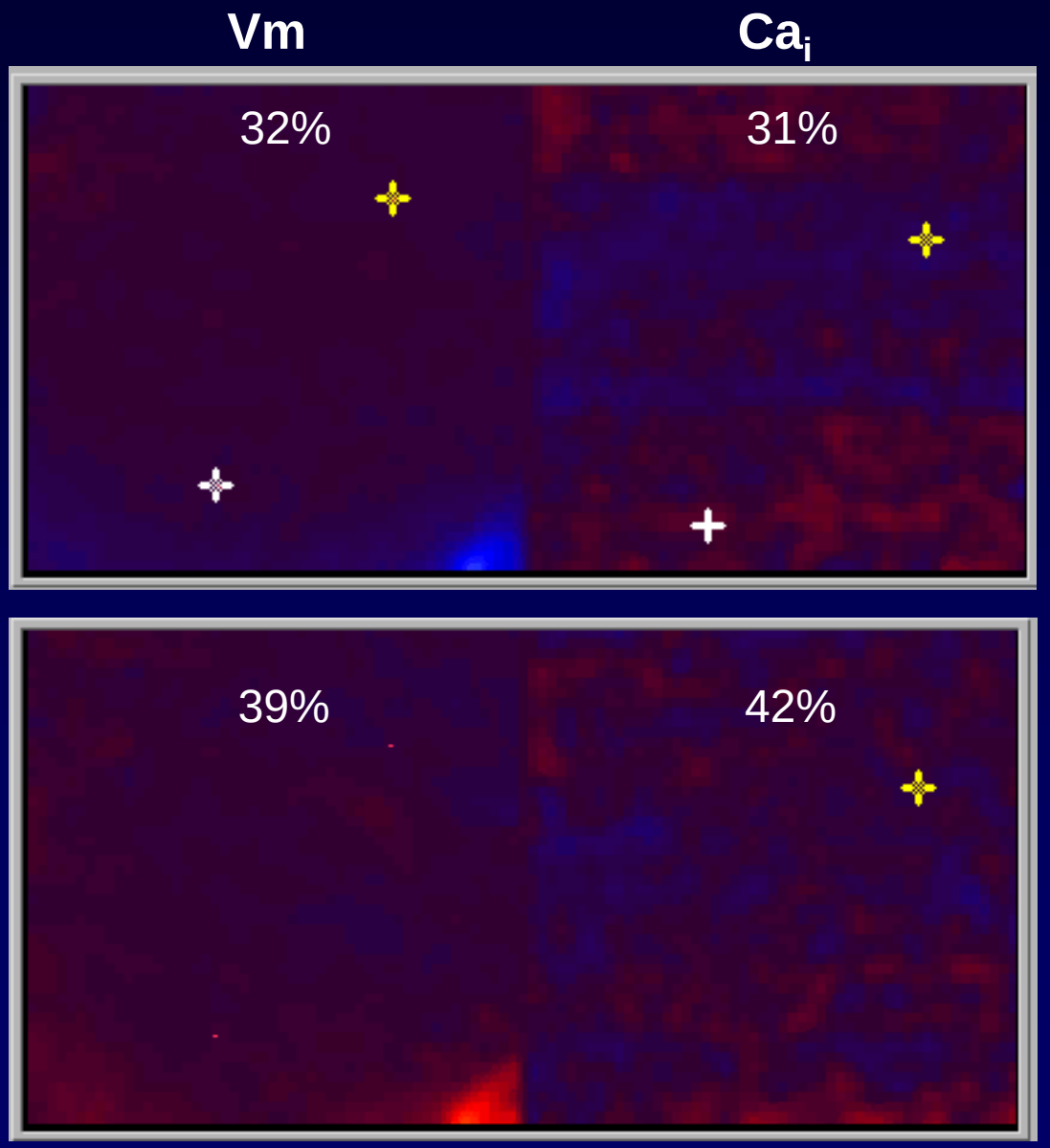
Tetrodotoxin (TTX) 18 μM + verapamil 20 μg/ml



Effects Shock Waveform on Ca Transients with Tetrodotoxin and Verapamil

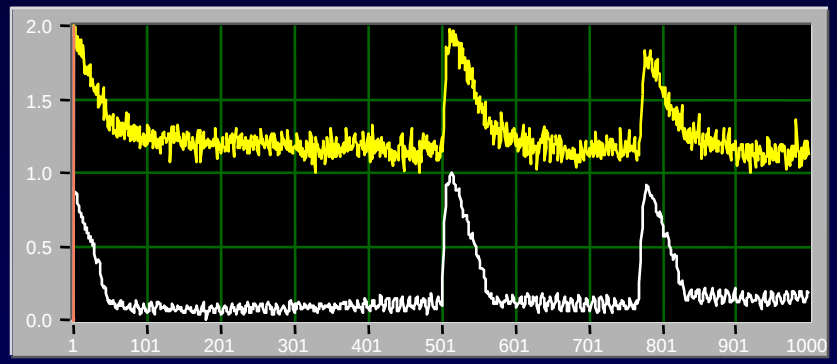


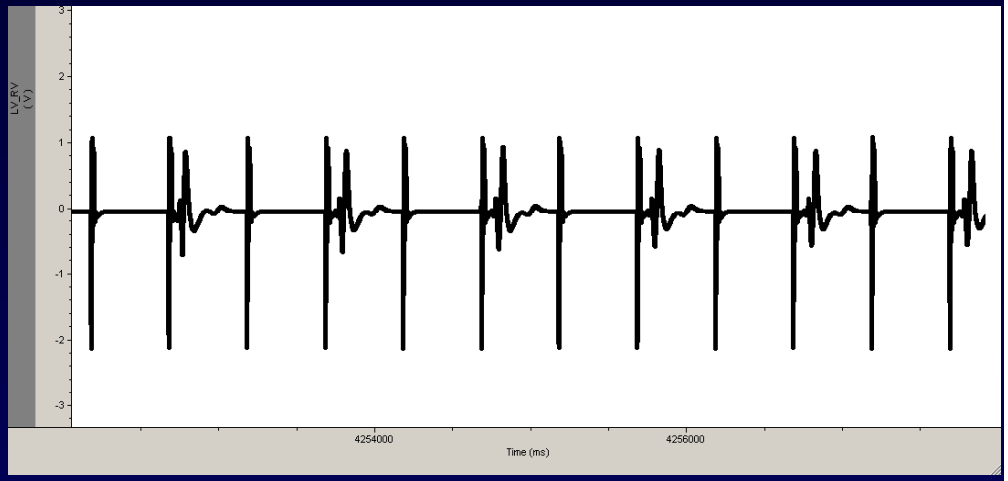
Propagation of Membrane Potential and Ca_i With Tetrodotoxin and Verapamil After MW and BW Shock

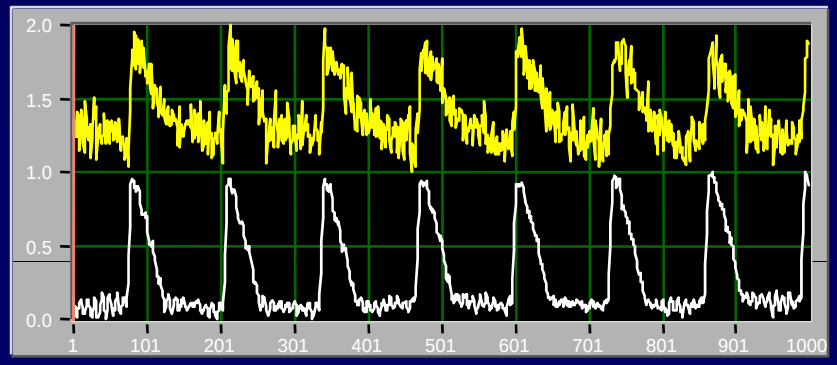


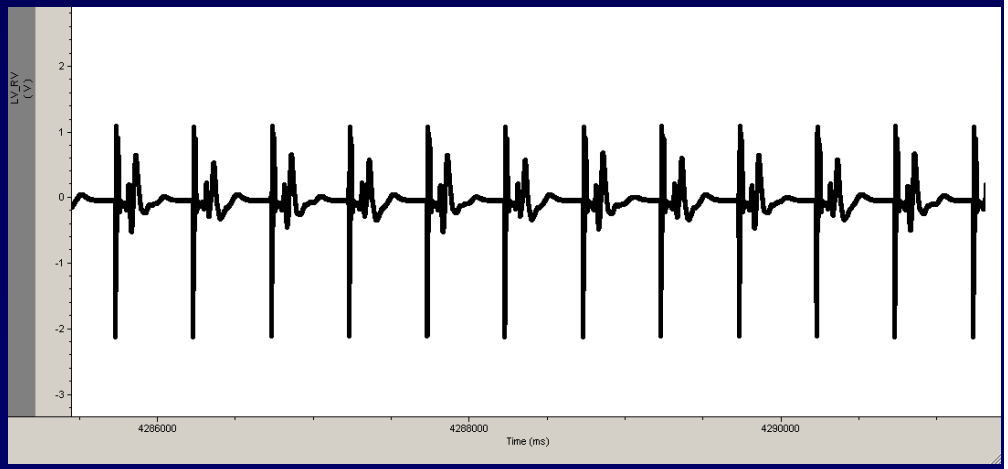
Pacing (3 mA) During Washout

Heart is still excitable









The Future of Optical Mapping

- Novel optical molecular probes for multiparametric optical sensing of varius biological parameters, processes, molecules, proteins, and their functional states in real time with submillisecond resolution

- Novel optical modalities for 3D optical interrogation of molecular probes with precise anatomical localization of the single origin with subcellular spatial resolution

감사합니다

Carto XP System

Advantage

- Highly accurate geometric rendering of a cardiac chamber
- Useful for mapping scar borders

Disadvantage

- Biosense Webster cather is only used
- The magnetic signal creates interference with other EP lab recording system
- Can be distorted surface geometry by catheter movement
- Arrhythmia must be inducible and hemodynamically stable; “QWIKMAP” mapping approach