New mapping tools for VT ablation

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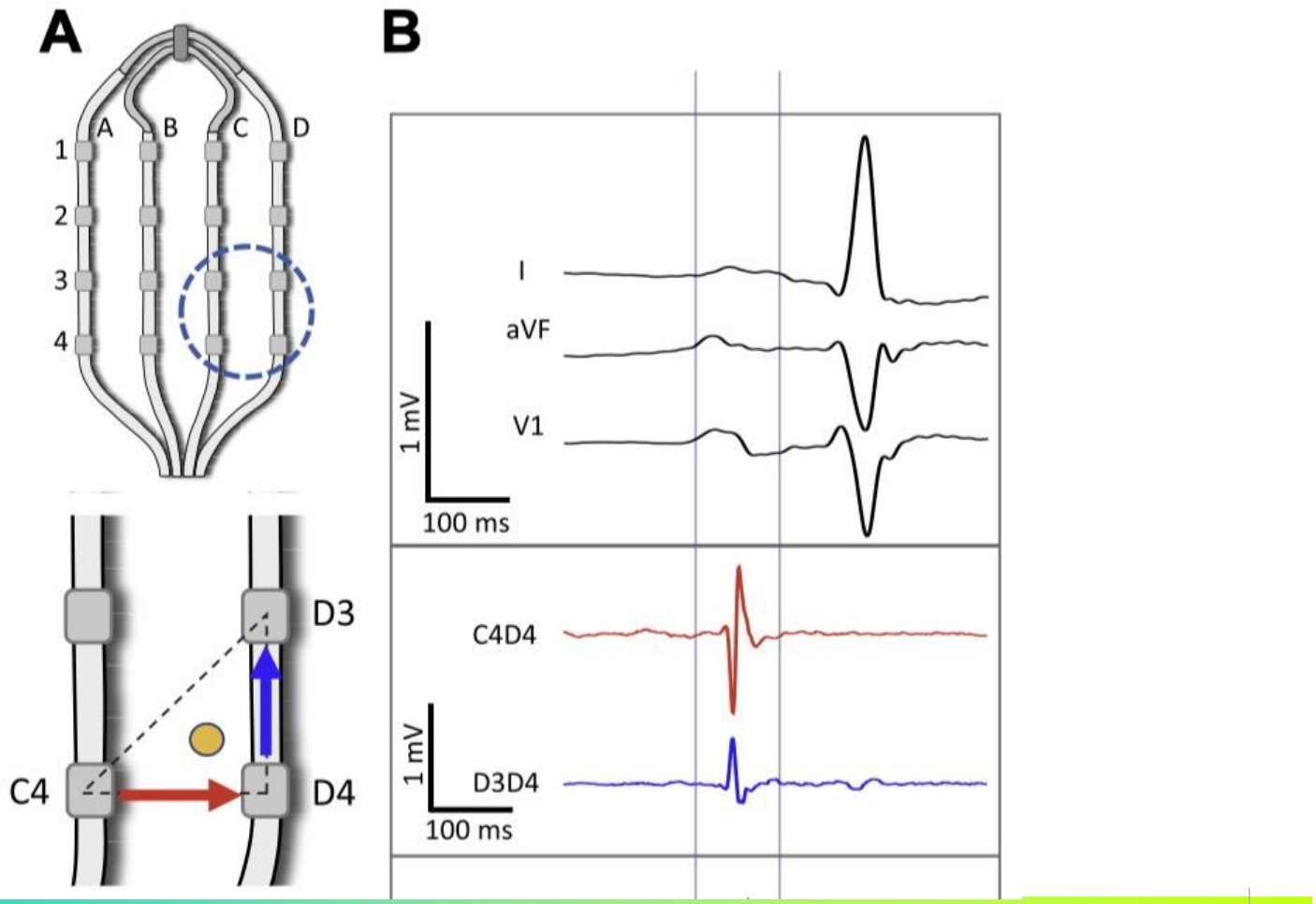
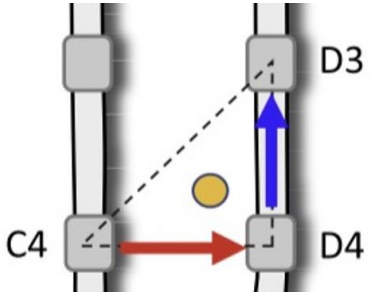
Disclosure of Conflict of Interest

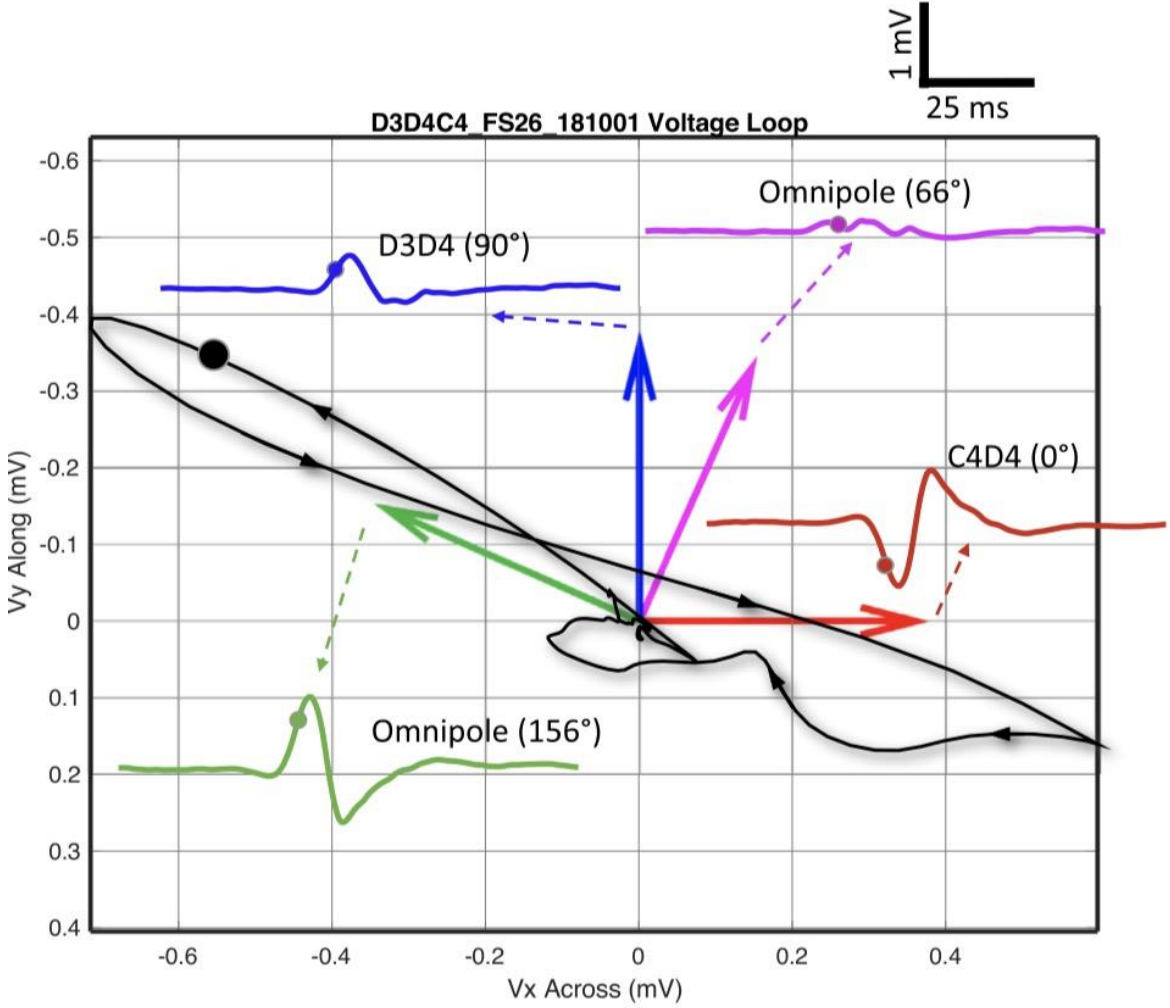
- *Fees and honoraria for lectures, education and scientific advice from Abbott, Biosense-Webster, Biotronik, iRhythm Technologies, Microport & Zoll*

Limitations of conventional mapping

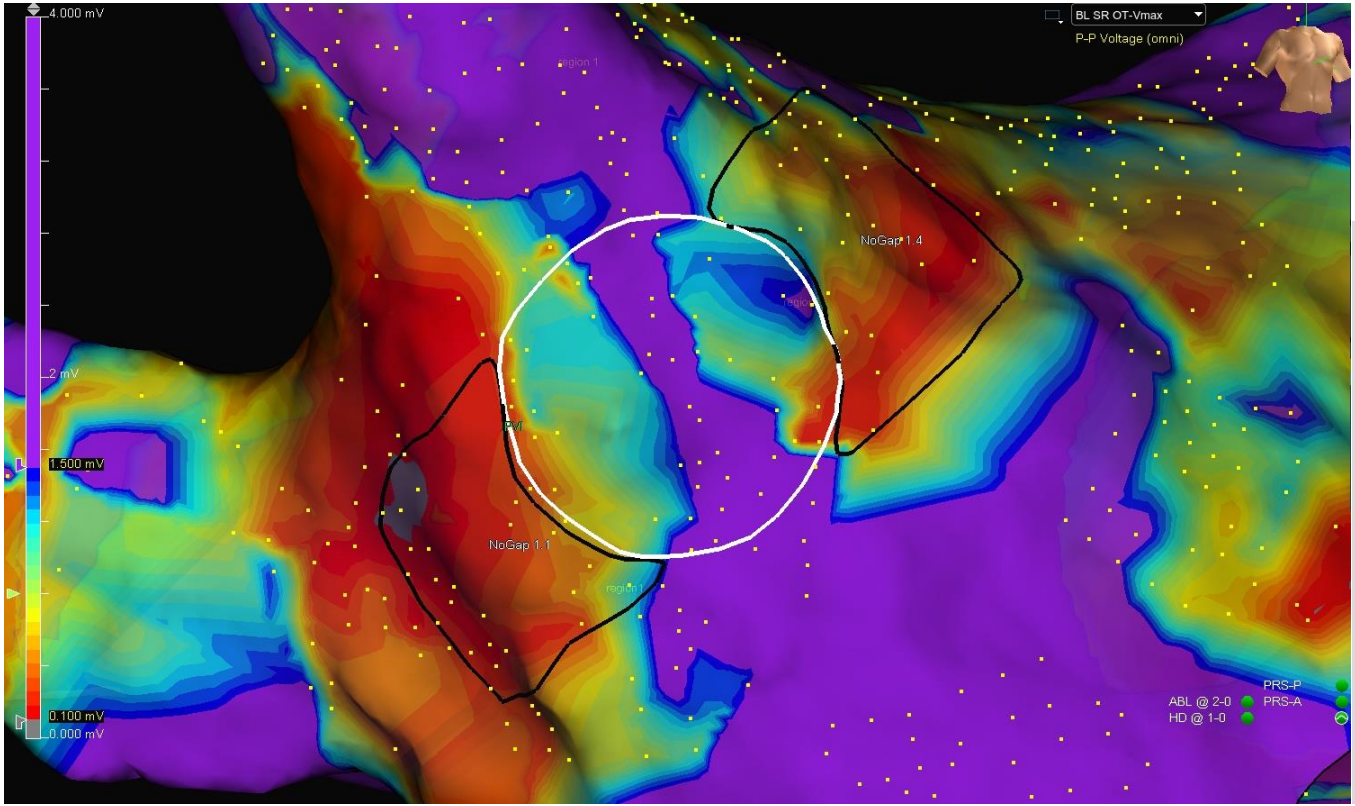
1. Direction of activation front & fusion of components
2. Noise and artefacts
3. Near field vs far field

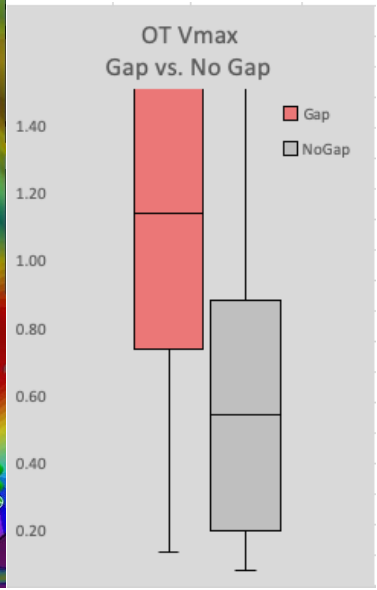

A
B
A
B
C
D
1
2
3
4
D3
C4
D4
I
aVF
V1
1 mV
100 ms
C4D4
D3D4
1 mV
100 ms


D3
C4
D4

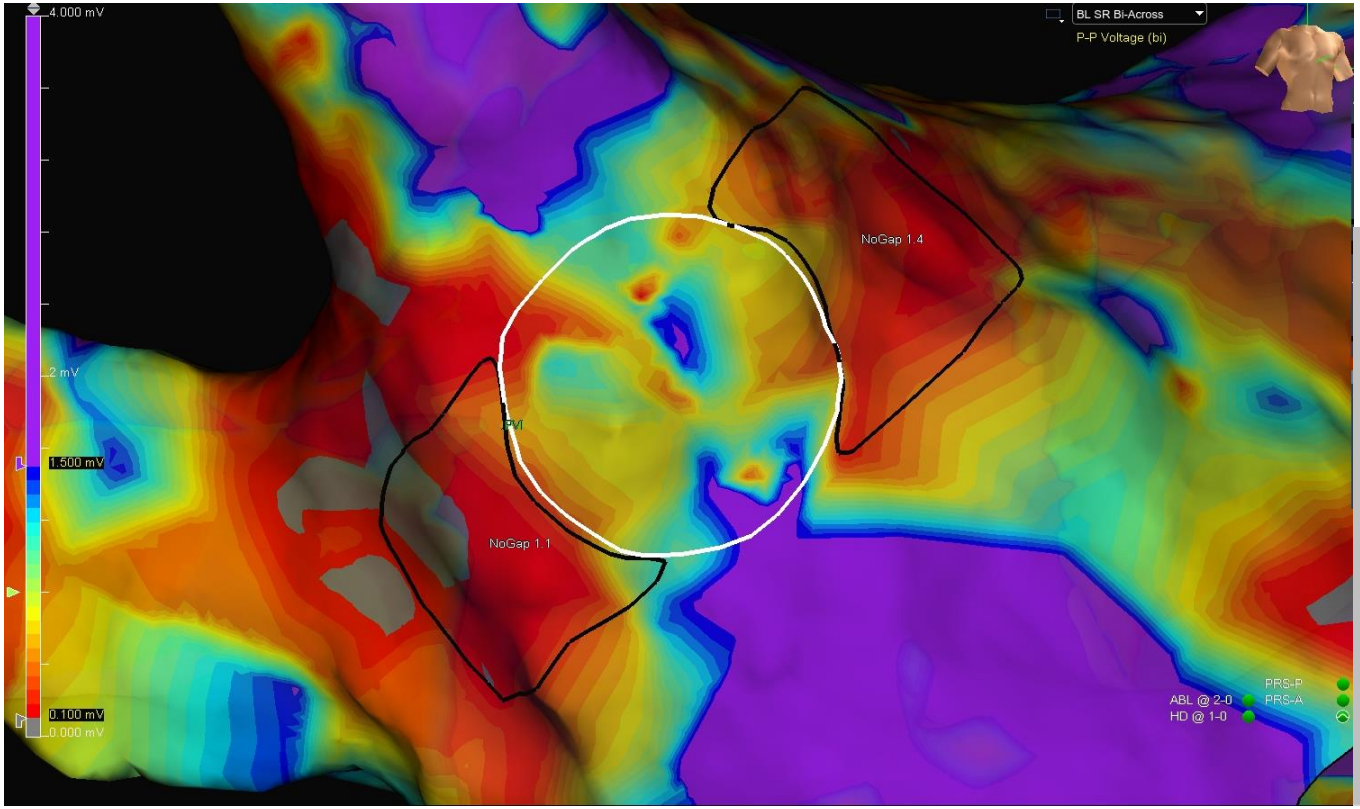

1 mV
25 ms
D3D4C4_FS26_181001 Voltage Loop
Omnipole (66°)
D3D4 (90°)
C4D4 (0°)
Omnipole (156°)
Vy Along (mV)
Vx Across (mV)
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4

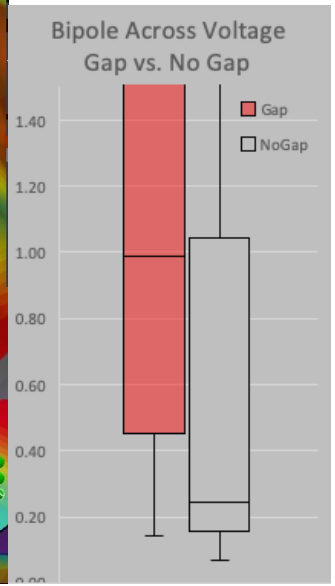
OT Vmax


4.000 mV
2 mV
1.500 mV
0.100 mV
0.000 mV
BL SR OT-Vmax
P-P Voltage (omni)
NoGap 1.4
NoGap 1.1
PVI
PRS-P
PRS-A
ABL @ 2-0
HD @ 1-0


OT Vmax
Gap vs. No Gap
Gap
NoGap
1.40
1.20
1.00
0.80
0.60
0.40
0.20

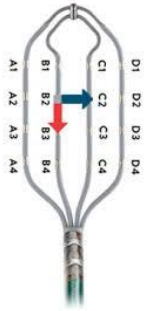
Bipolar Across voltage



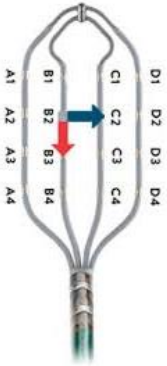


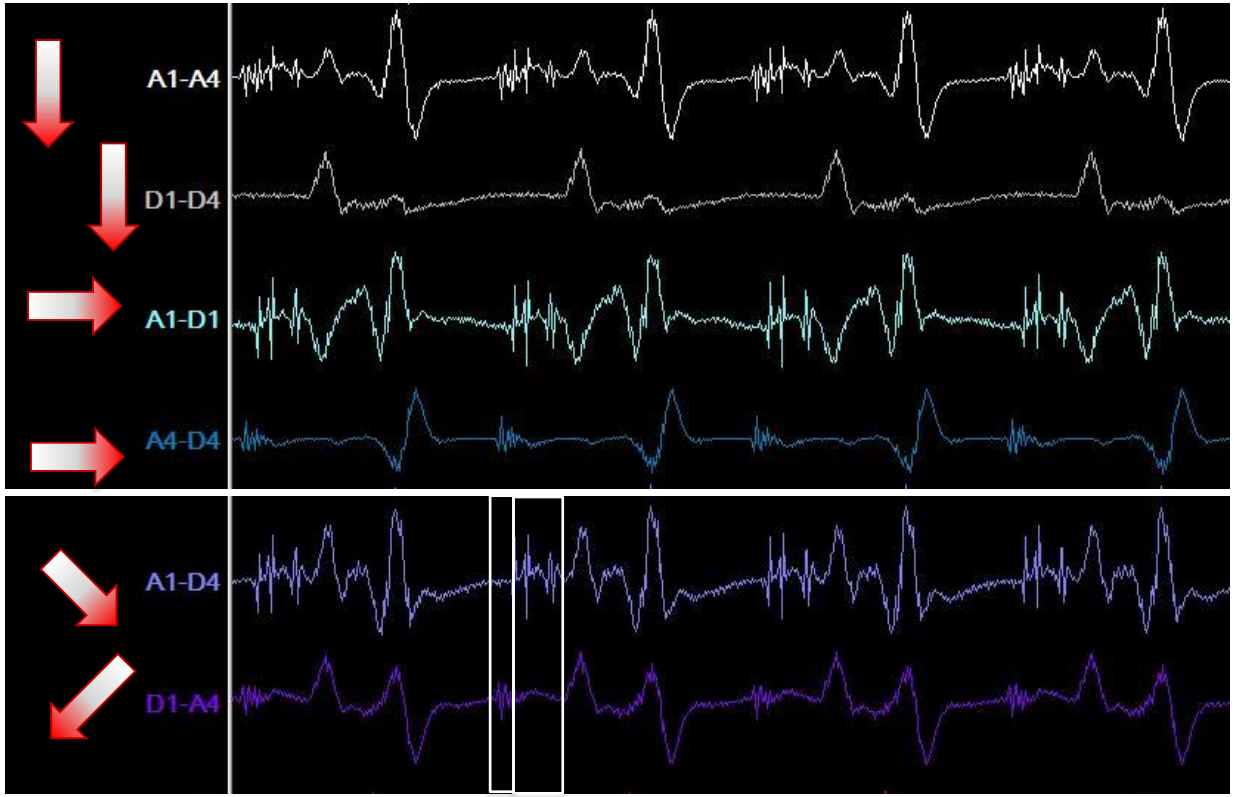
VT channel


V1
A1-A2
A2-A3
A3-A4
B1-B2
B2-B3
B3-B4
C1-C2
C2-C3
C3-C4
D1-D2
D2-D3
D3-D4
A1-B1
B1-C1
C1-D1
A2-B2
B2-C2
C2-D2
A3-B3
B3-C3
C3-D3
A4-B4
B4-C4
C4-D4
A1-A4
D1-D4
A1-D1
A4-D4
A1-D4
D1-A4
REF 1-2


A1
A2
A3
A4
B1
B2
B3
B4
C1
C2
C3
C4
D1
D2
D3
D4

Bipole orientation

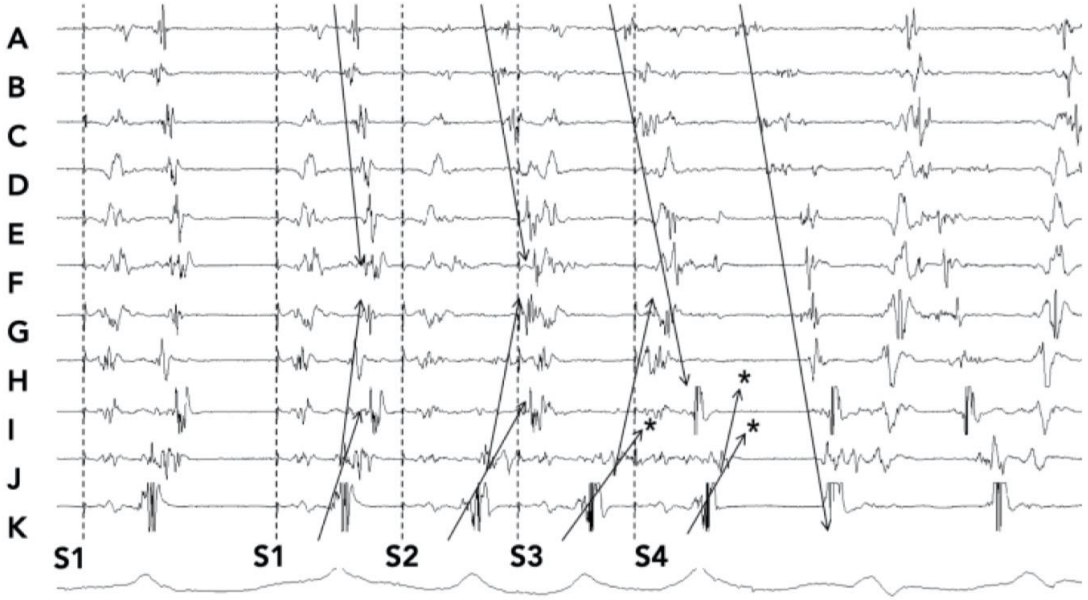


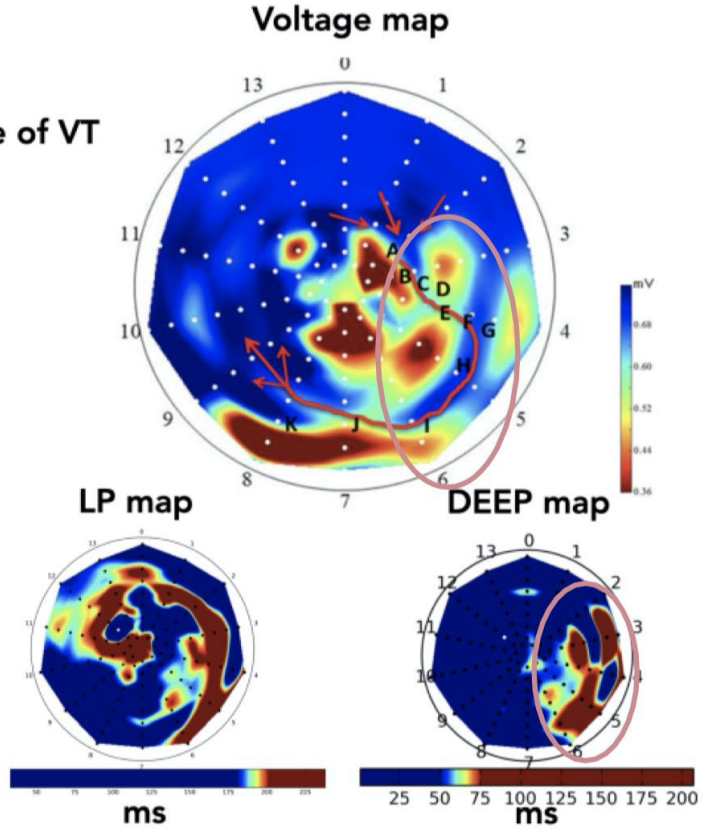


What is DeEP?

Decrement - > Unidirectional block -> VT

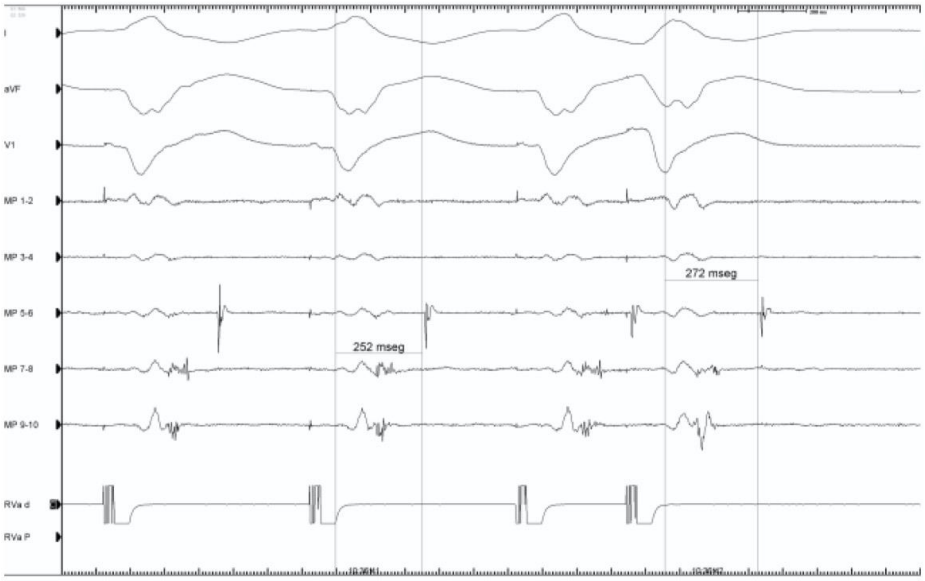
Decrement Initiation of VT Maintenance of VT





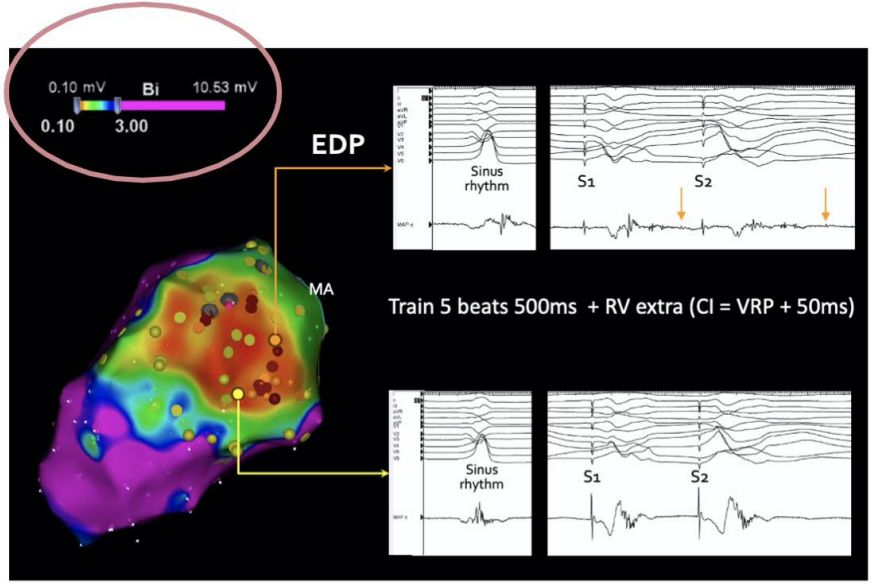
Focused DeEP outcomes:

Based on preexisting LPs



Nanthakumar K, Porta-Sanchez A, et al. approach

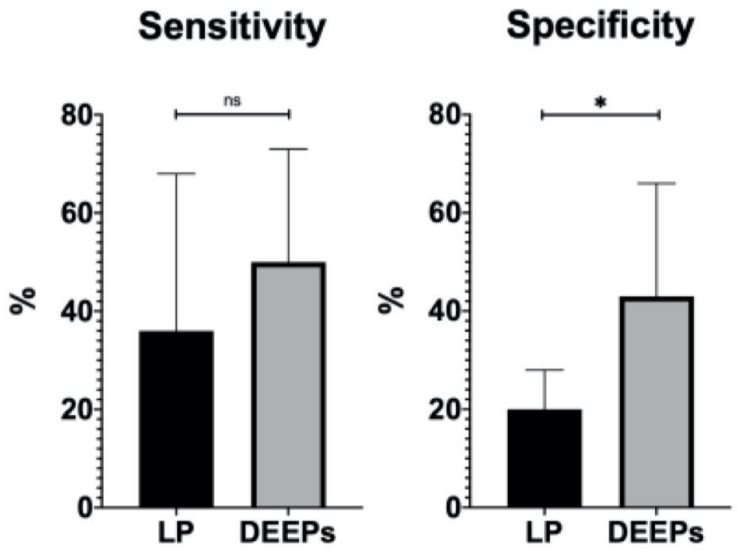
Based on low voltage areas



Zeppenfeld K, de Riva M et al. approach

Focused DeEP detection and ablation outcomes:

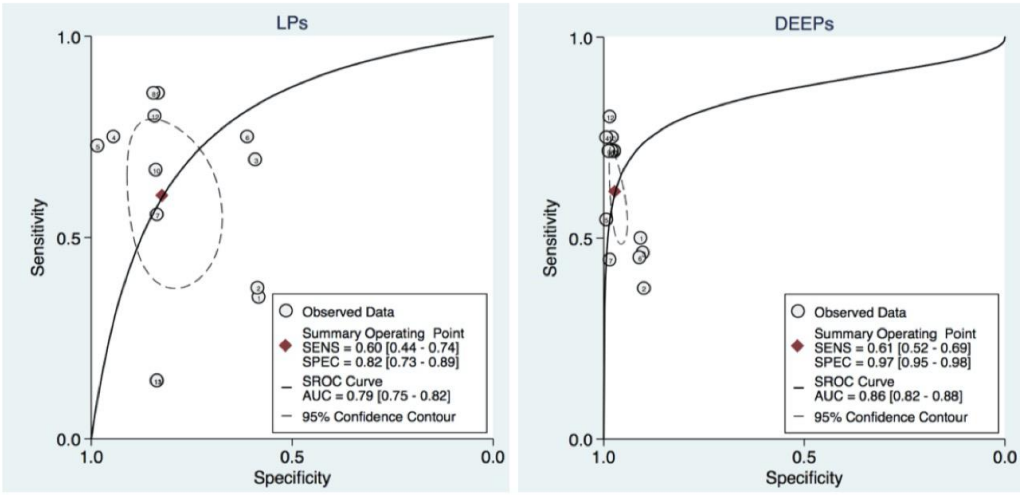
n=6, 9 VTs, intraop, fully-mapped isthmus



Jackson N et al, Circ AE 2015

Diastolic EGM detection, 13 VTs of 9 patients
Act Map 485 points

n=20



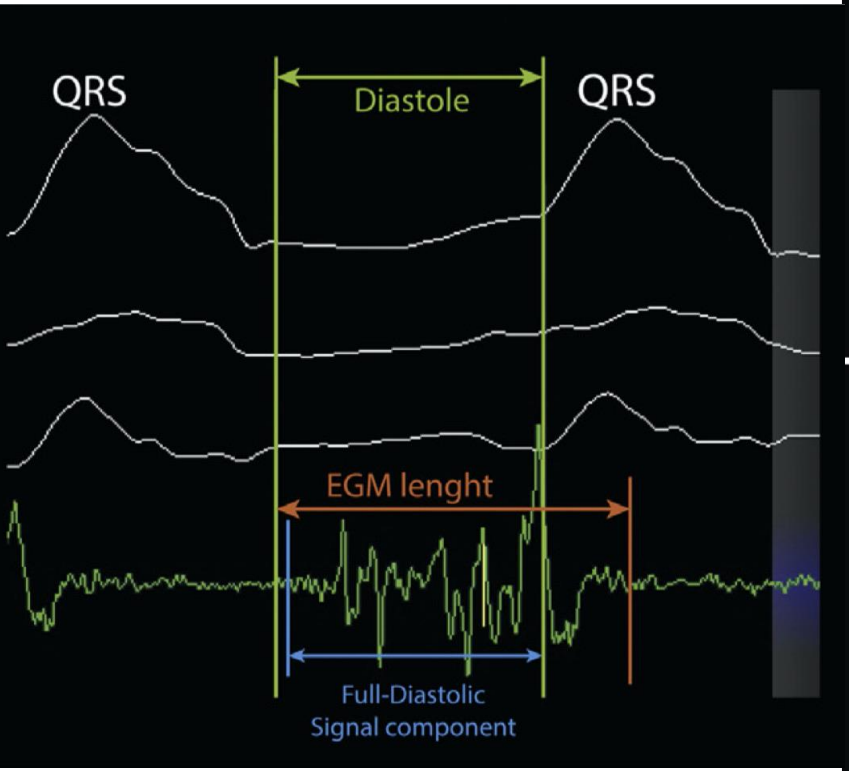
Porta-Sanchez A, et al. JACC EP 2018

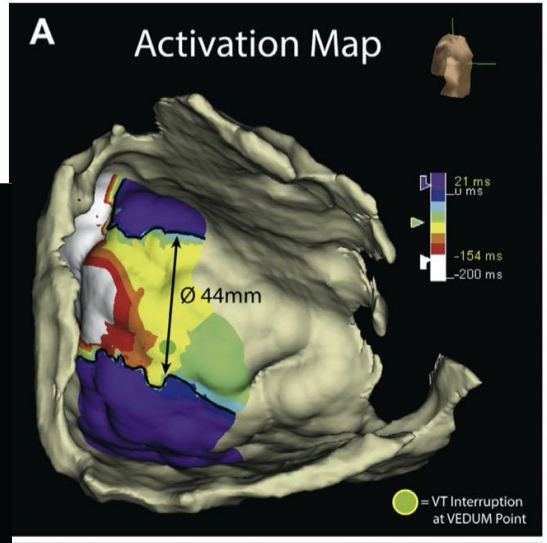
2021

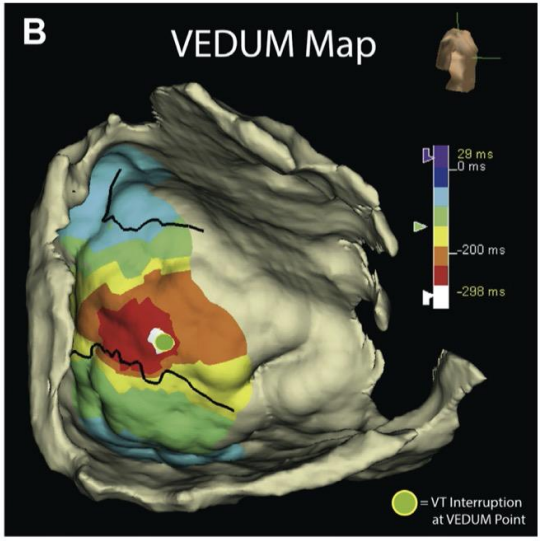
A novel Ventricular map of Electrograms DUration as a Method to identify areas of slow conduction for ventricular tachycardia ablation: The VEDUM pilot study

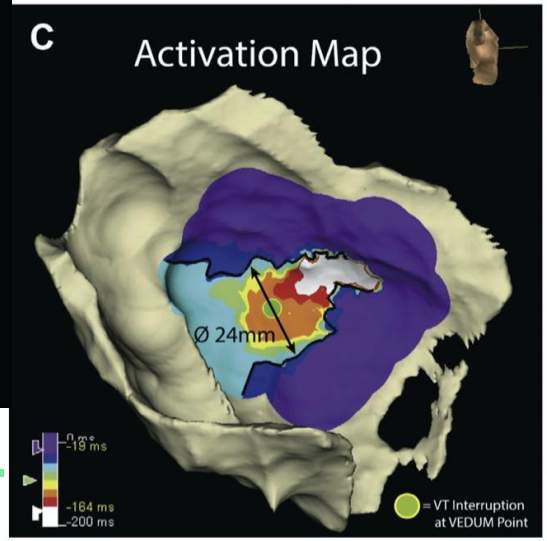
Pietro Rossi, MD, PhD,*[1] Filippo M. Cauti, MD,*[1] Marta Niscola, MSc,[†]
Federico Calore, MSc,[†] Veronica Fanti, MSc,[†] Marco Polselli, MD,*
Antonio Di Pastena, MD,* Luigi Iaia, MD,* Stefano Bianchi, MD*

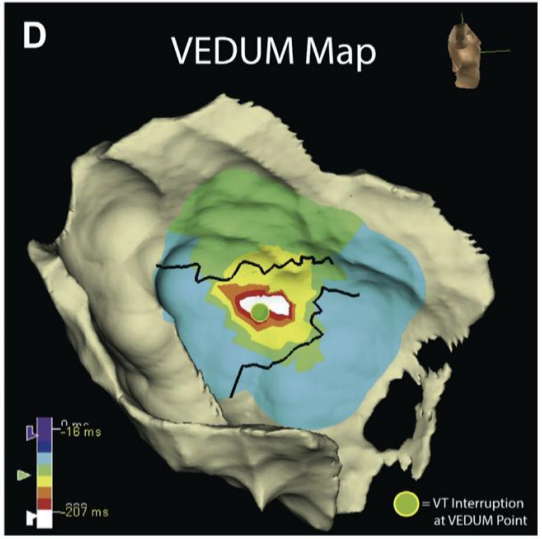
*From the *Arrhythmology Unit, Ospedale San Giovanni Calibita, Fatebenefratelli Isola Tiberina, Rome, Italy, and [†]Abbott Medical Italy, Sesto San Giovanni, Milan, Italy.*

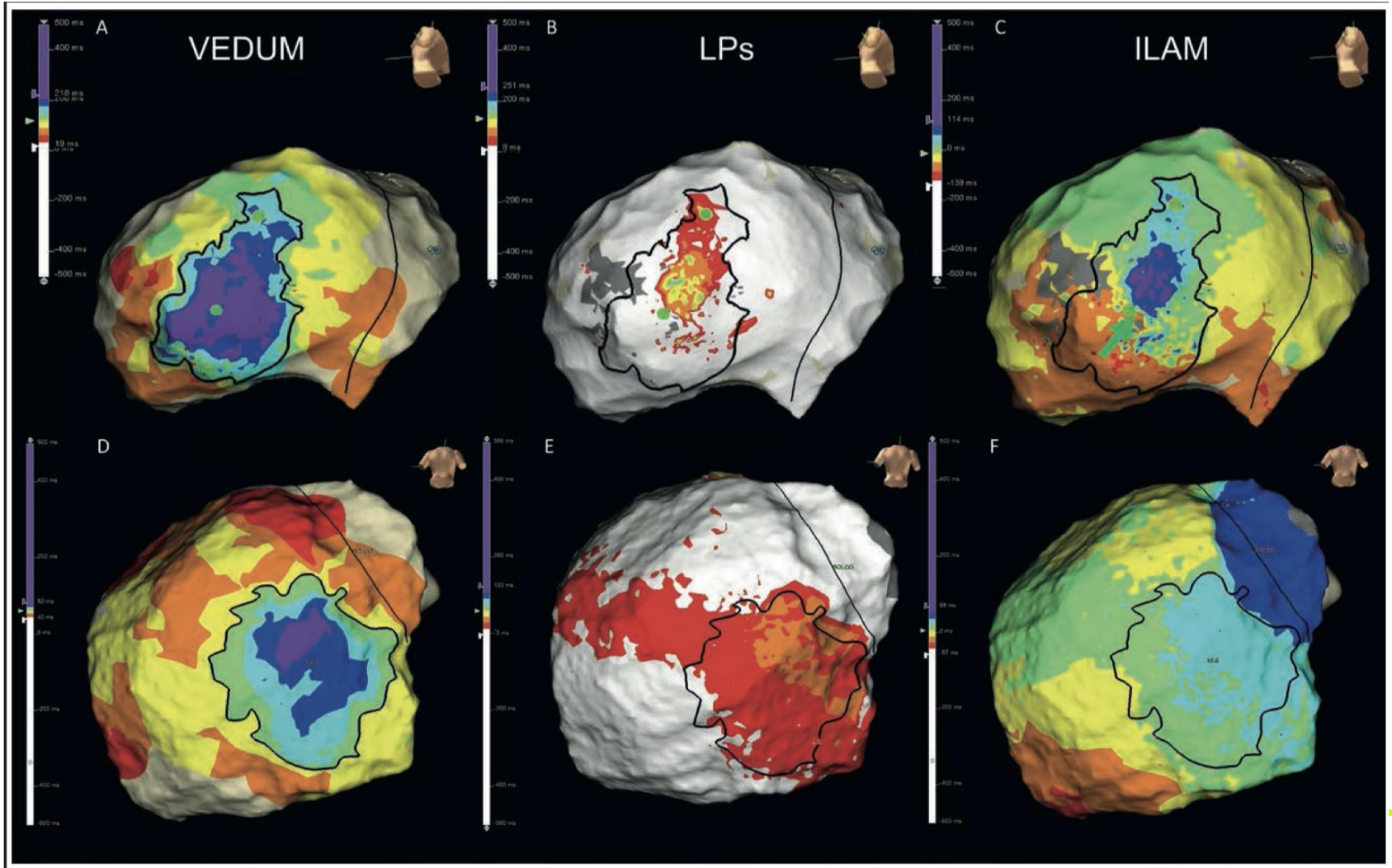

QRS
Diastole
QRS
EGM lenght
Full-Diastolic
Signal component

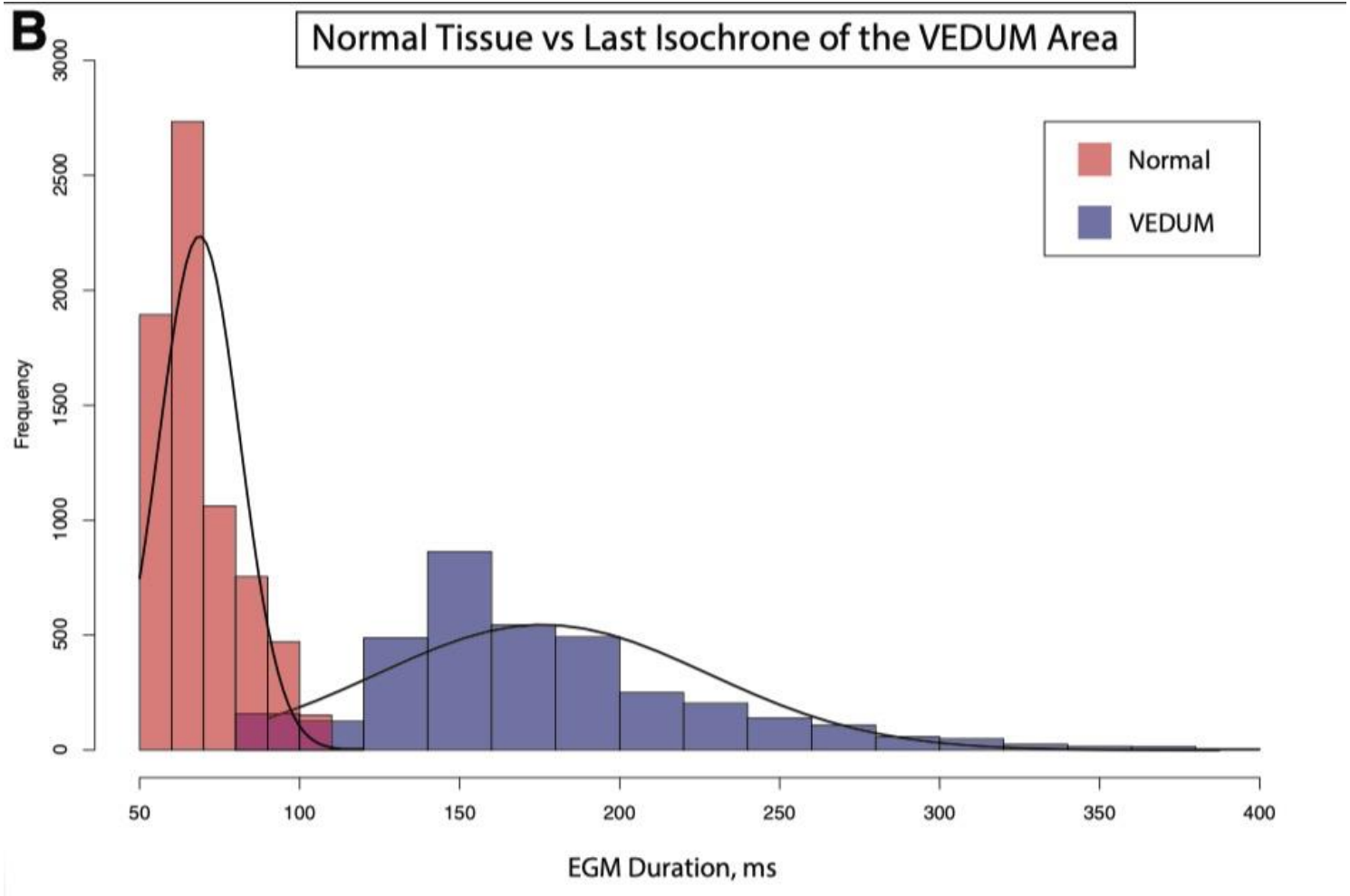

A
Activation Map
21 ms
0 ms
-154 ms
-200 ms
Ø 44mm
= VT Interruption
at VEDUM Point


B
VEDUM Map
29 ms
0 ms
-200 ms
-298 ms
= VT Interruption
at VEDUM Point


C
Activation Map
-19 ms
-164 ms
-200 ms
Ø 24mm
= VT Interruption
at VEDUM Point


D
VEDUM Map
-18 ms
-207 ms
= VT Interruption
at VEDUM Point

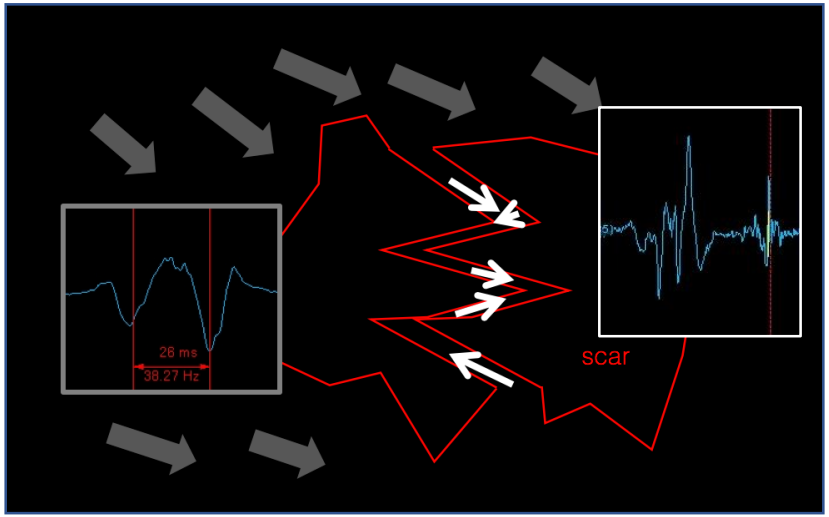

A
VEDUM
B
LPs
C
ILAM
D
E
F



Rossi et al. Circ AE 2023

How can we further improve?

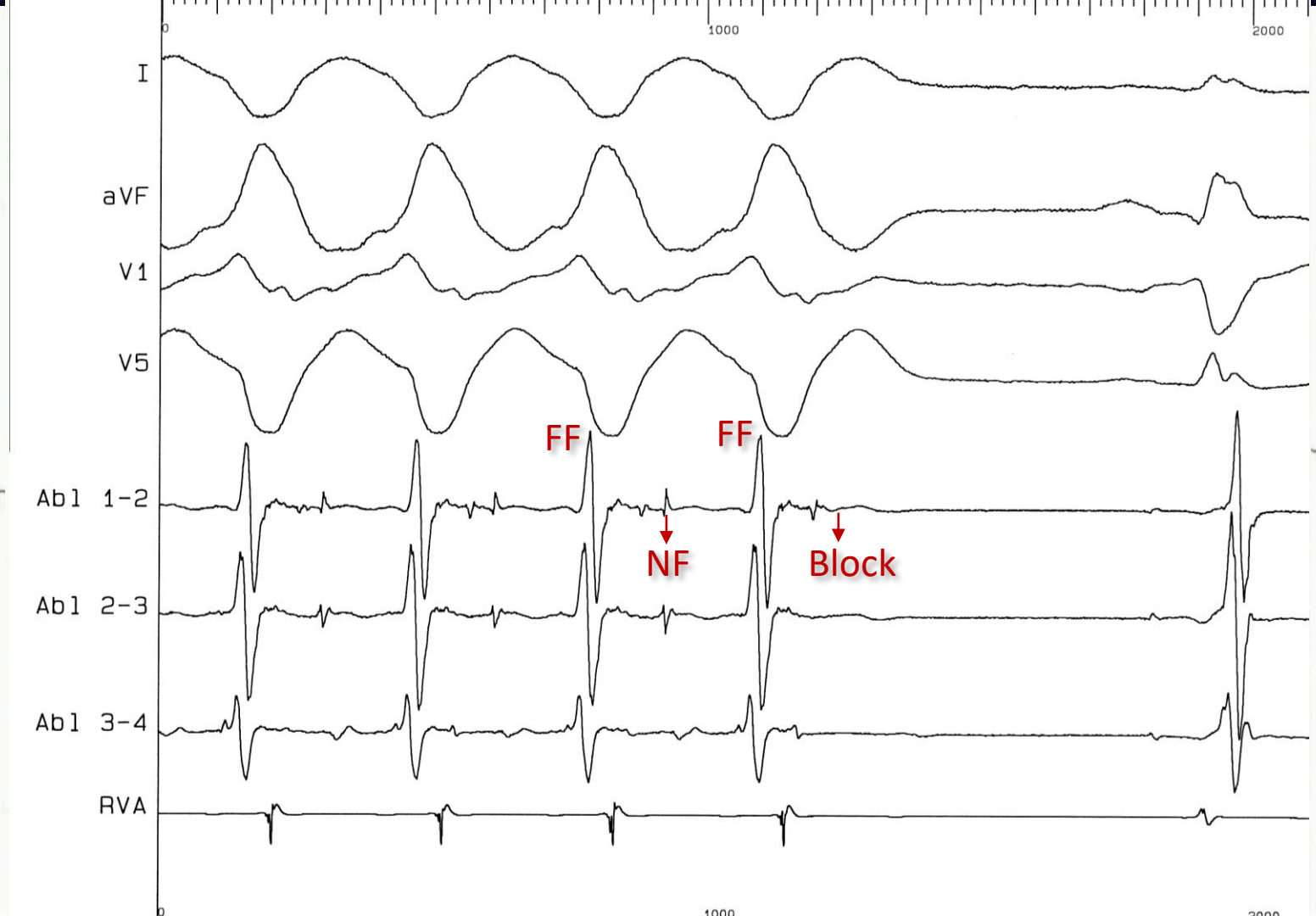
Clinical problem statement

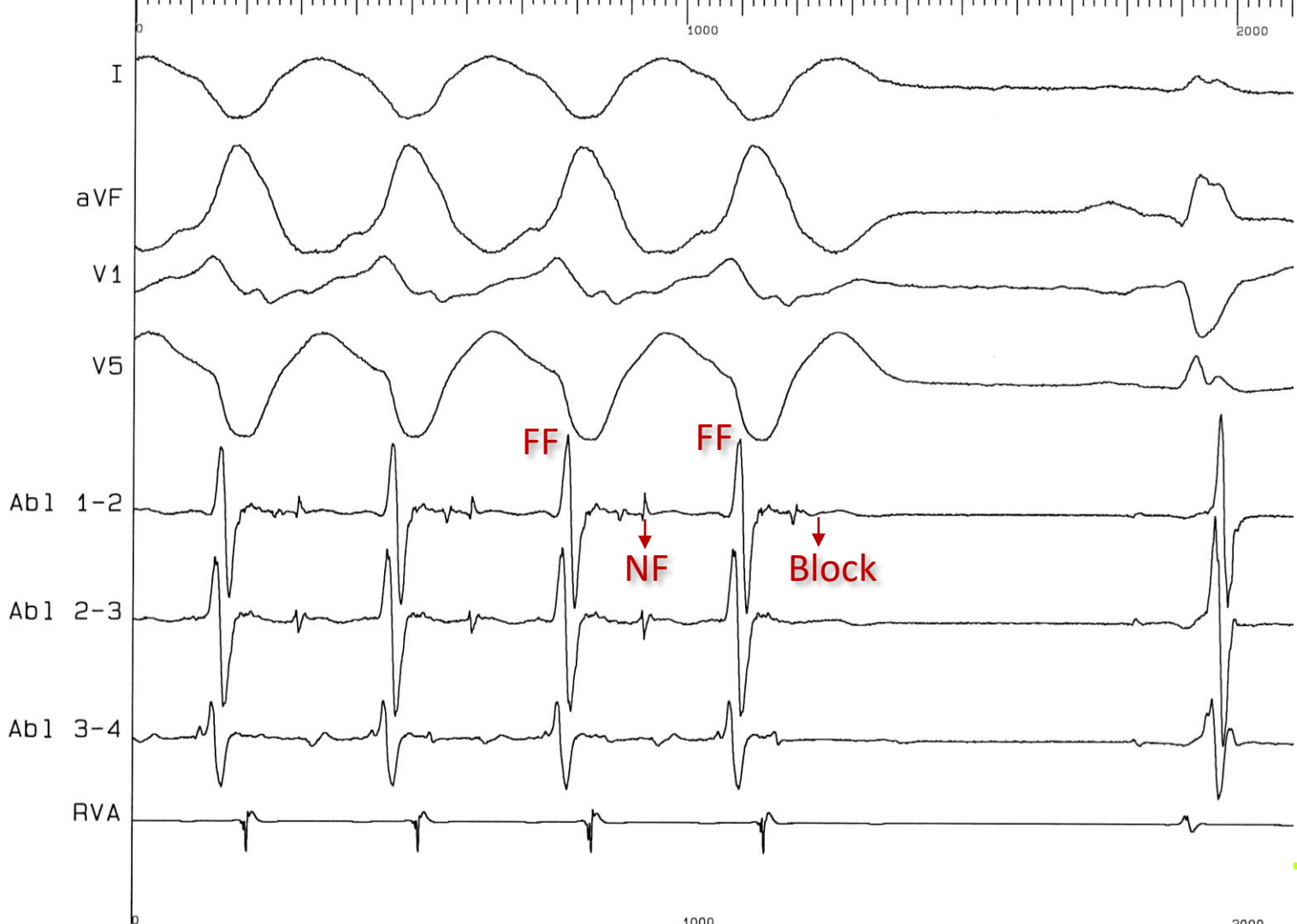


EGMs = summation of both near field and far-field sources

Jais et al., Circulation 2012

How to detect true local activation signals & time?

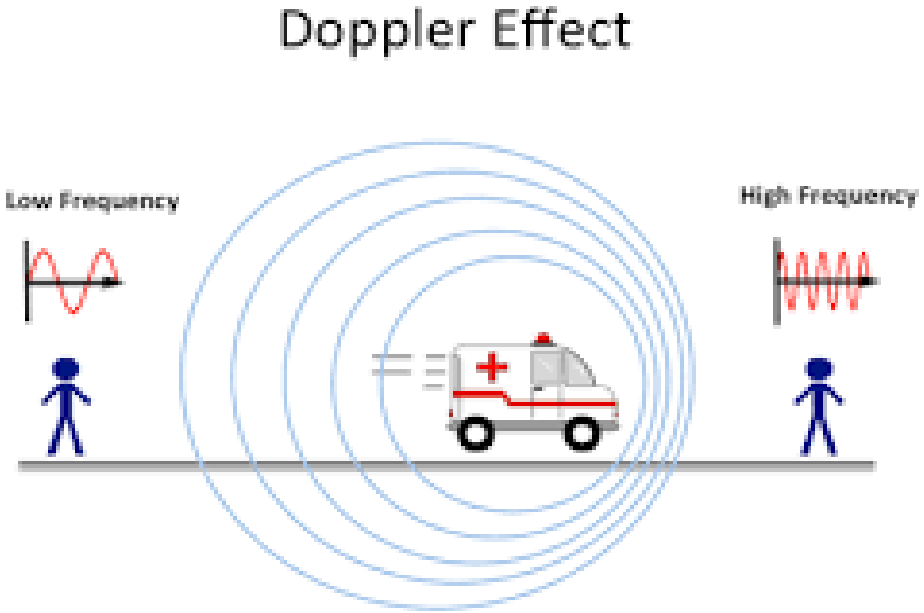

0
1000
2000
I
aVF
V1
V5
FF
FF
Abl 1-2
NF
Block
Abl 2-3
Abl 3-4
RVA
0
1000
2000


0
1000
2000
I
aVF
V1
V5
FF
FF
Abl 1-2
NF
Block
Abl 2-3
Abl 3-4
RVA
0
1000
2000

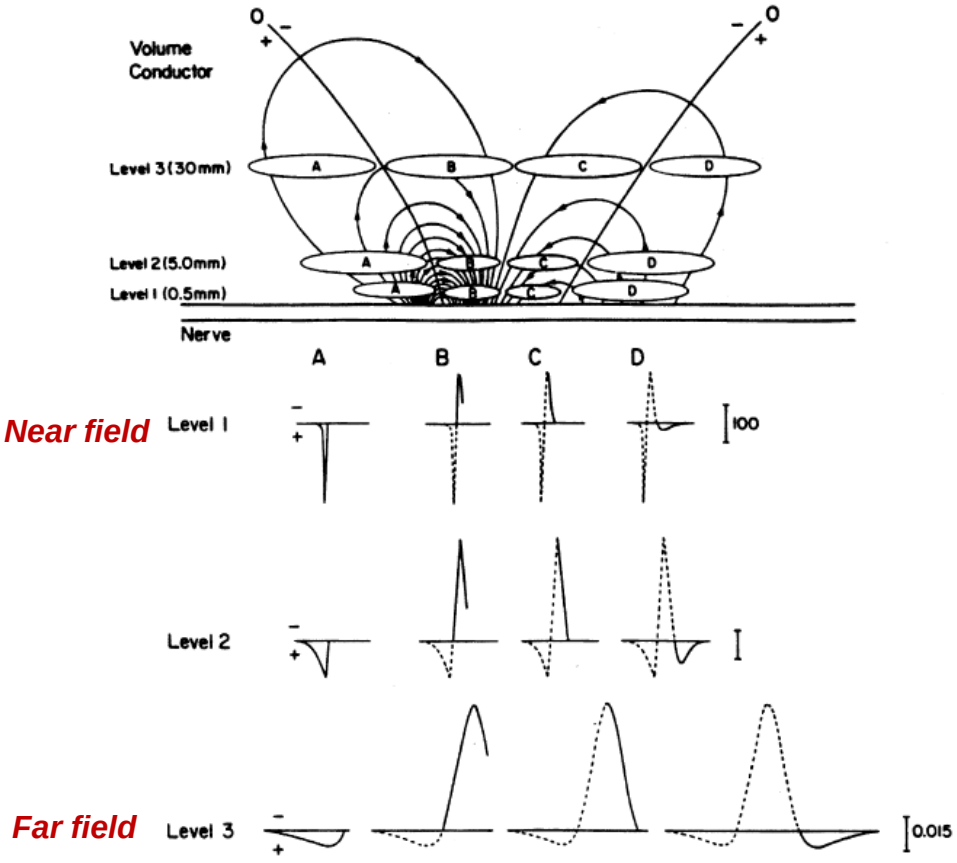
Back to the Present!

Frequency as a surrogate for near field activity

- EGM frequency is impacted by proximity of sensing electrodes to the signal source



Rutkove, *Introduction to volume conduction; The Clinical Neurophysiology Primer, 2007*



Model of the effects of volume conduction on a recorded neuron or muscle potential

Upper row: recordings made from nearby the nerve fiber source appear as very sharp or high frequency

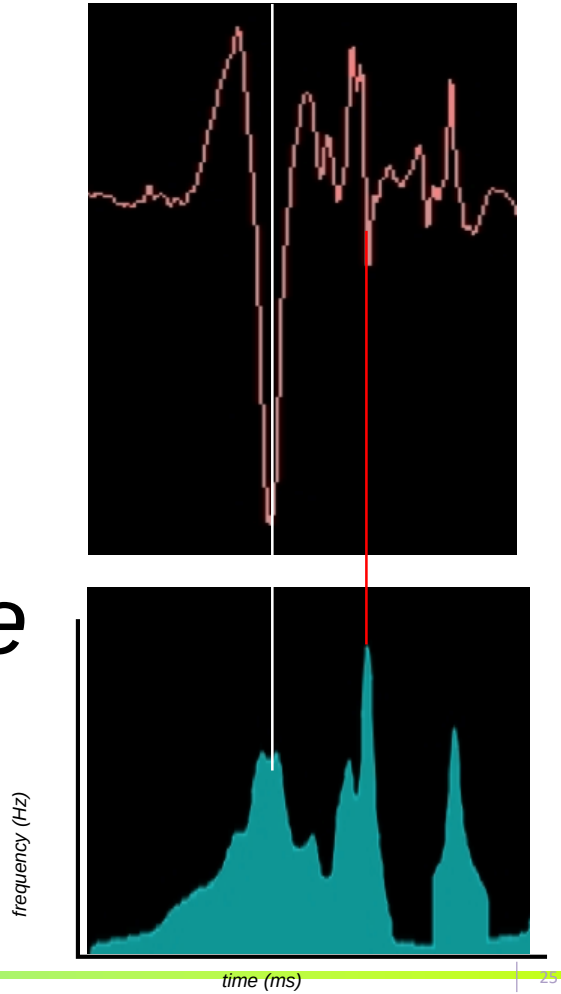
Lower row: recordings taken distal to the source appear unsharp or low frequency (like ECG)

Rutkove, *Introduction to volume conduction; The Clinical Neurophysiology Primer, 2007*

Near Field (NF) detection

Energy of the highest frequency components in the signal as a function of time

Peak Frequency (PF) trace

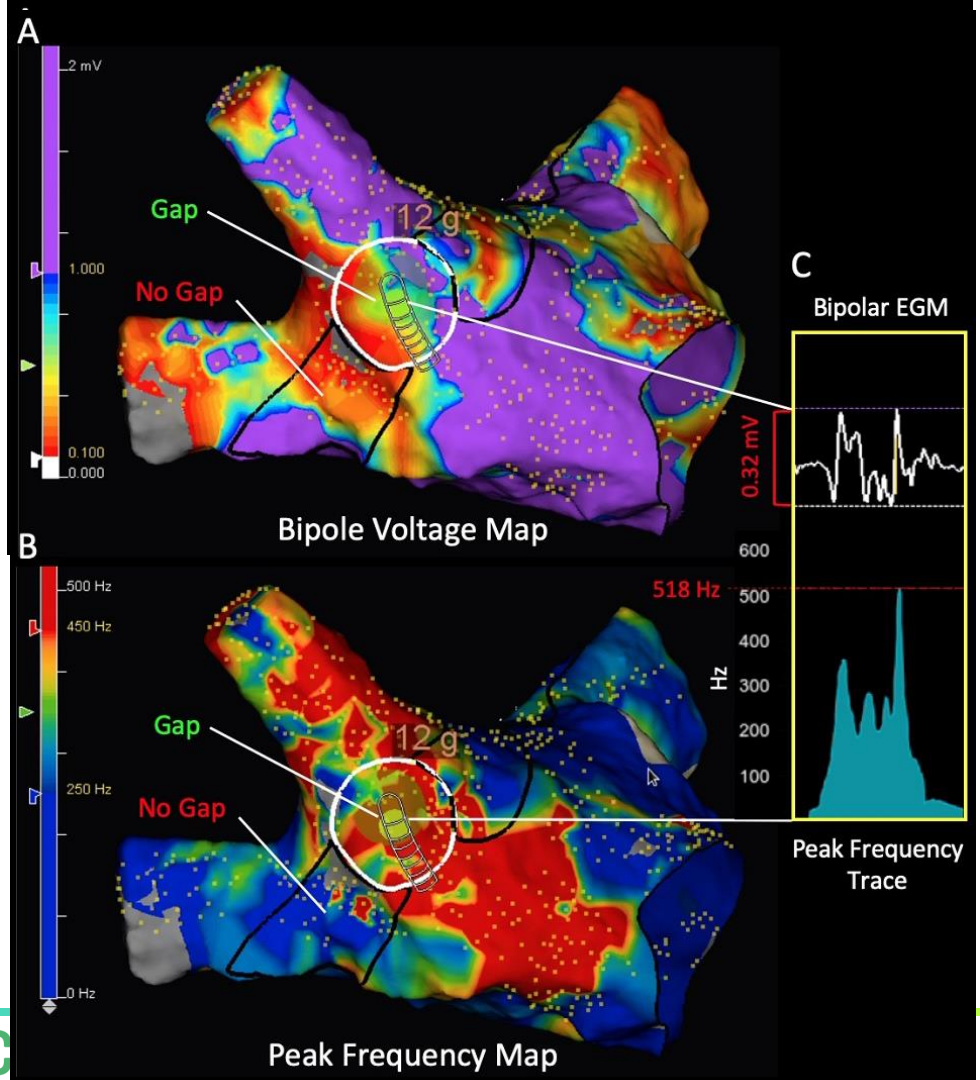


Peak Frequency trace

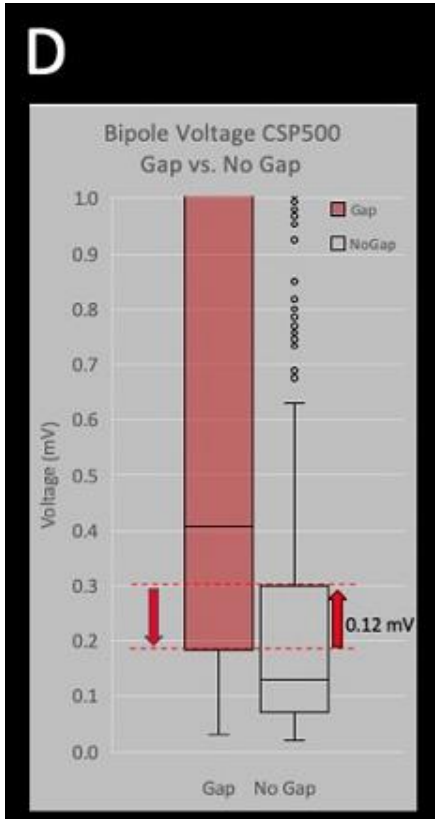
Validation of the peak frequency of bipolar electrograms for detection of residual conduction in atrial scar tissue

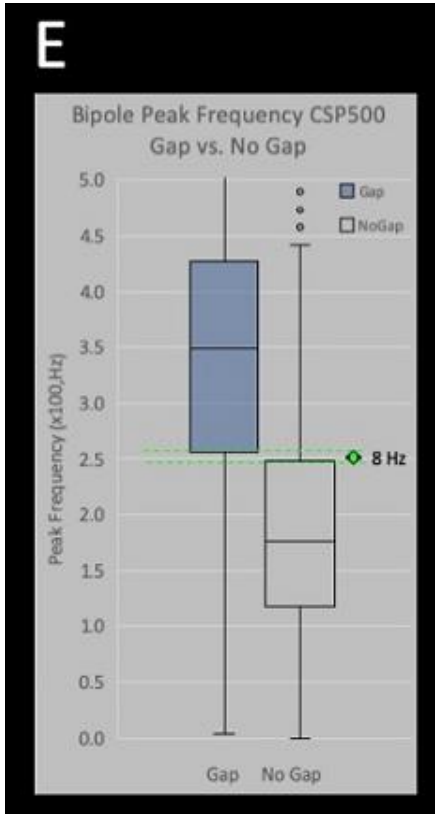
JL. Merino[1], S. Kim[2], M. Sanroman[3], S. Castrejon[1], J. Relan[4], JJ. De La Vieja Alarcon[3], M. Martinez Cossiani[1], C. Cervantes[1], A. Carton[1], B. Rivero Santana[1], P. Tauber Molina[1]

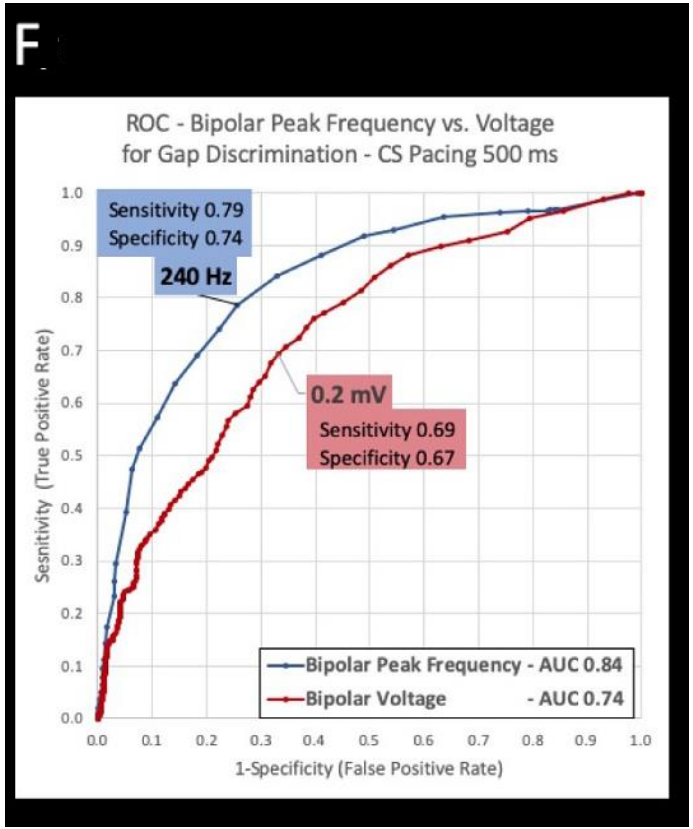
(1) **La Paz University Hospital, Madrid, Spain** (2) **Abbott**, New York City, United States of America (3) Abbott, Madrid, Spain (4) Abbott, Minneapolis, United States of America


A
2 mV
1.000
0.100
0.000
Gap
No Gap
12 g
Bipole Voltage Map
C
Bipolar EGM
0.32 mV
B
500 Hz
450 Hz
250 Hz
0 Hz
518 Hz
600
500
400
300
200
100
Hz
Gap
No Gap
12 g
Peak Frequency Map
Peak Frequency Trace

Results

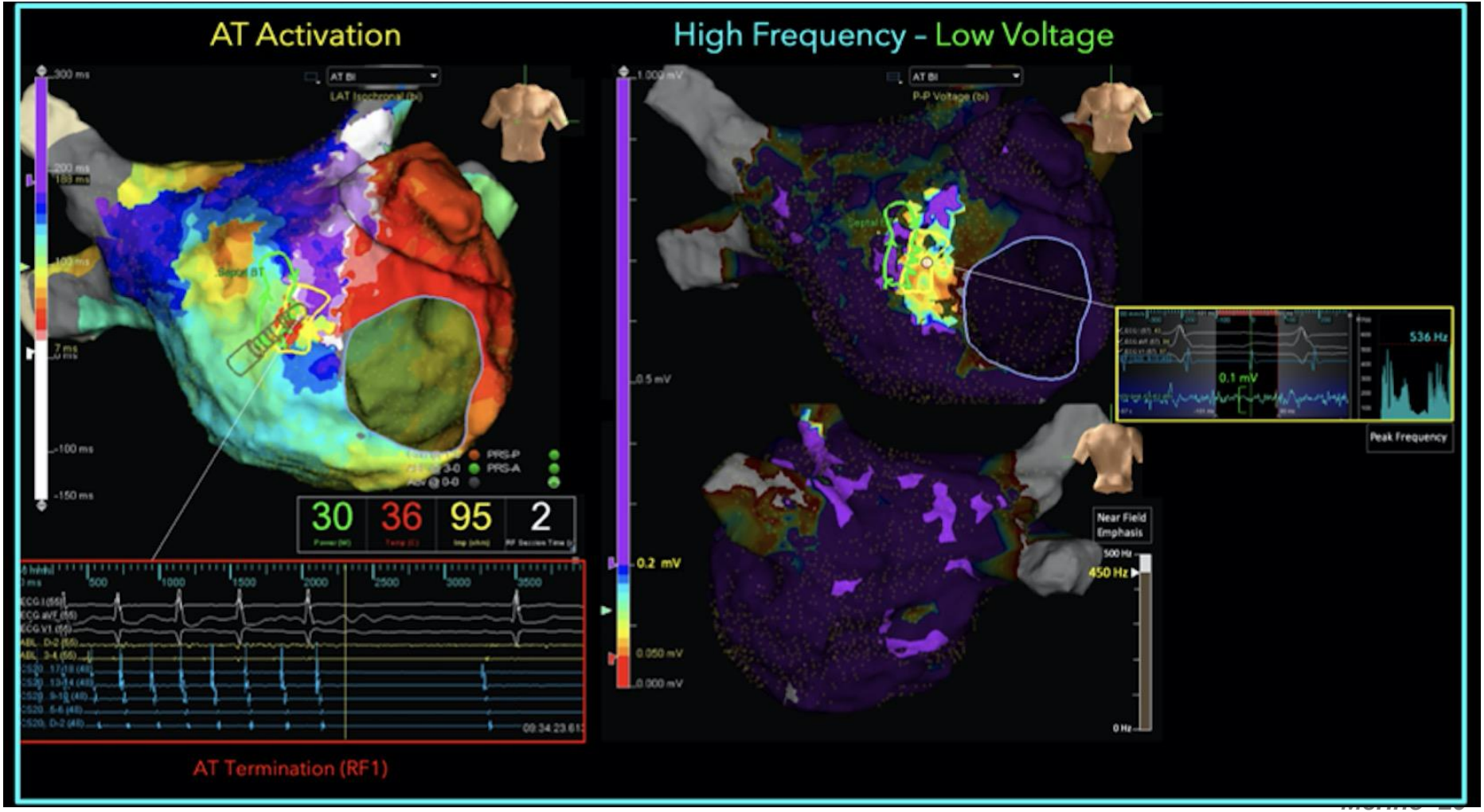


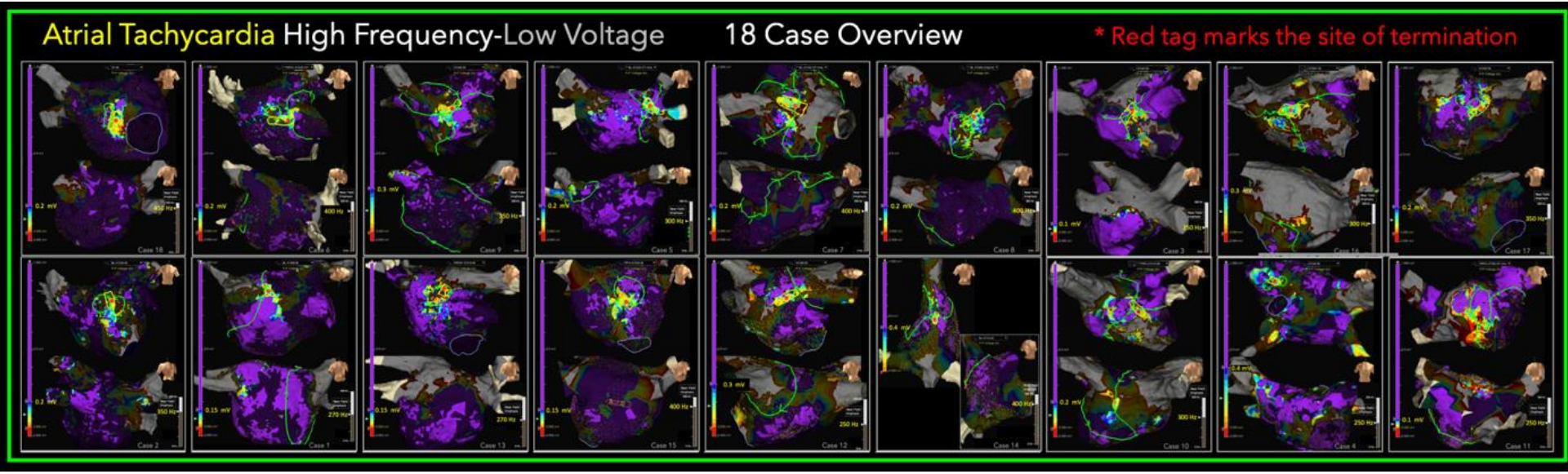




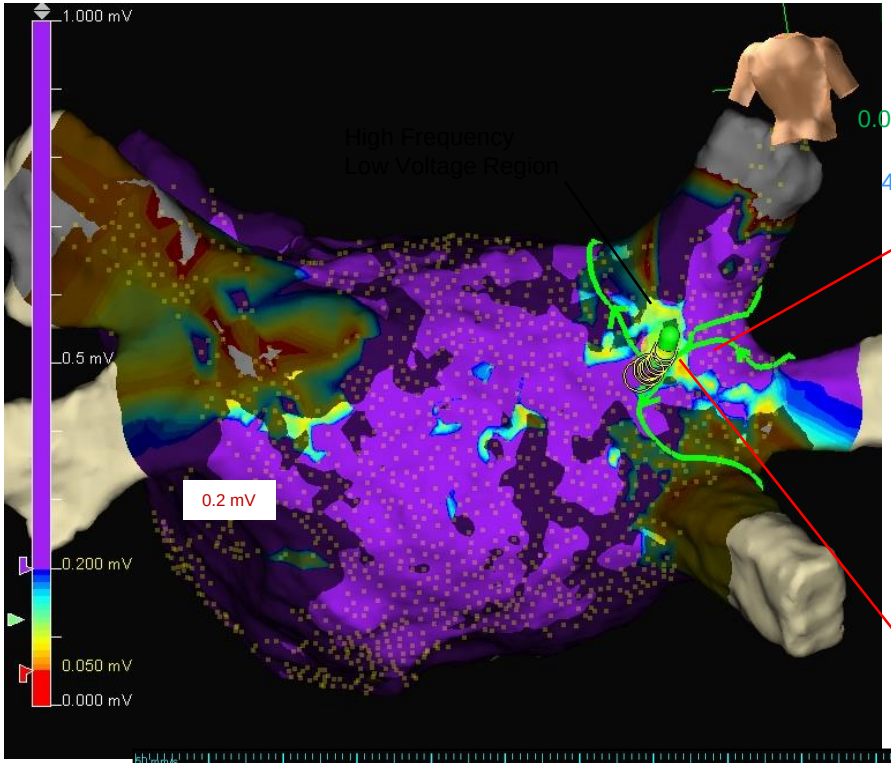
1.9±2.1 mV vs 0.6±1.2 mV
P<0.0001

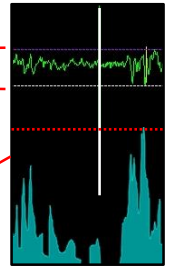
345 ±135 vs 181±116 Hz
P<0.0001


AT Activation
High Frequency – Low Voltage
AT Termination (RF1)
536 Hz
0.1 mV
Peak Frequency
Near Field Emphasis
500 Hz
450 Hz
0 Hz
0.2 mV
30
36
95
2


Atrial Tachycardia High Frequency-Low Voltage
18 Case Overview
* Red tag marks the site of termination

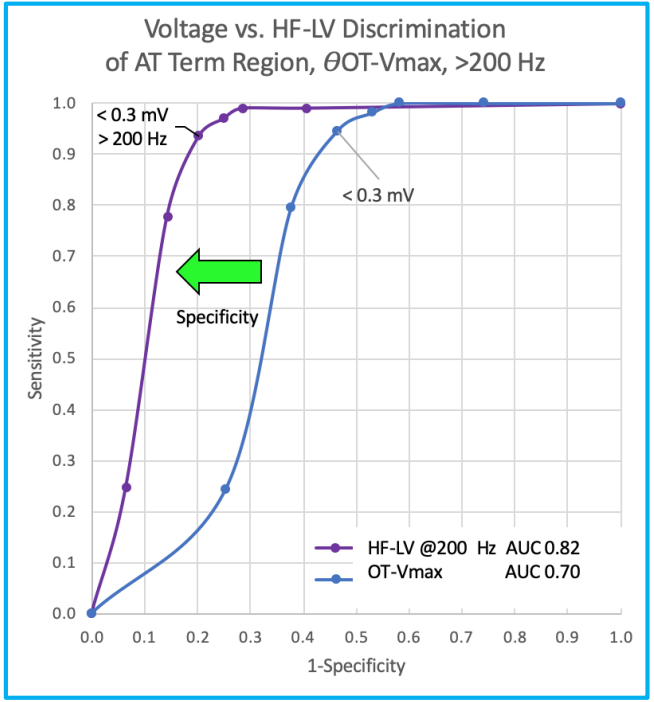
Low voltage with peak frequency emphasis improves specificity to detect the region of AT termination

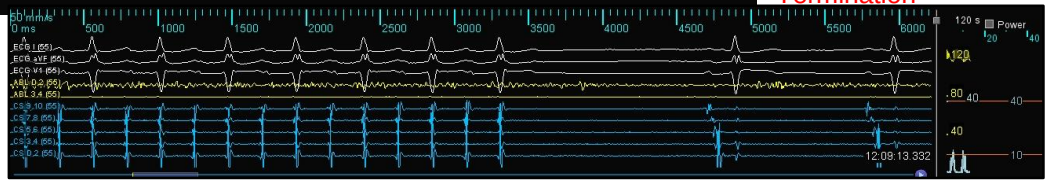




High frequency
Low voltage

Single RF lesion
Termination

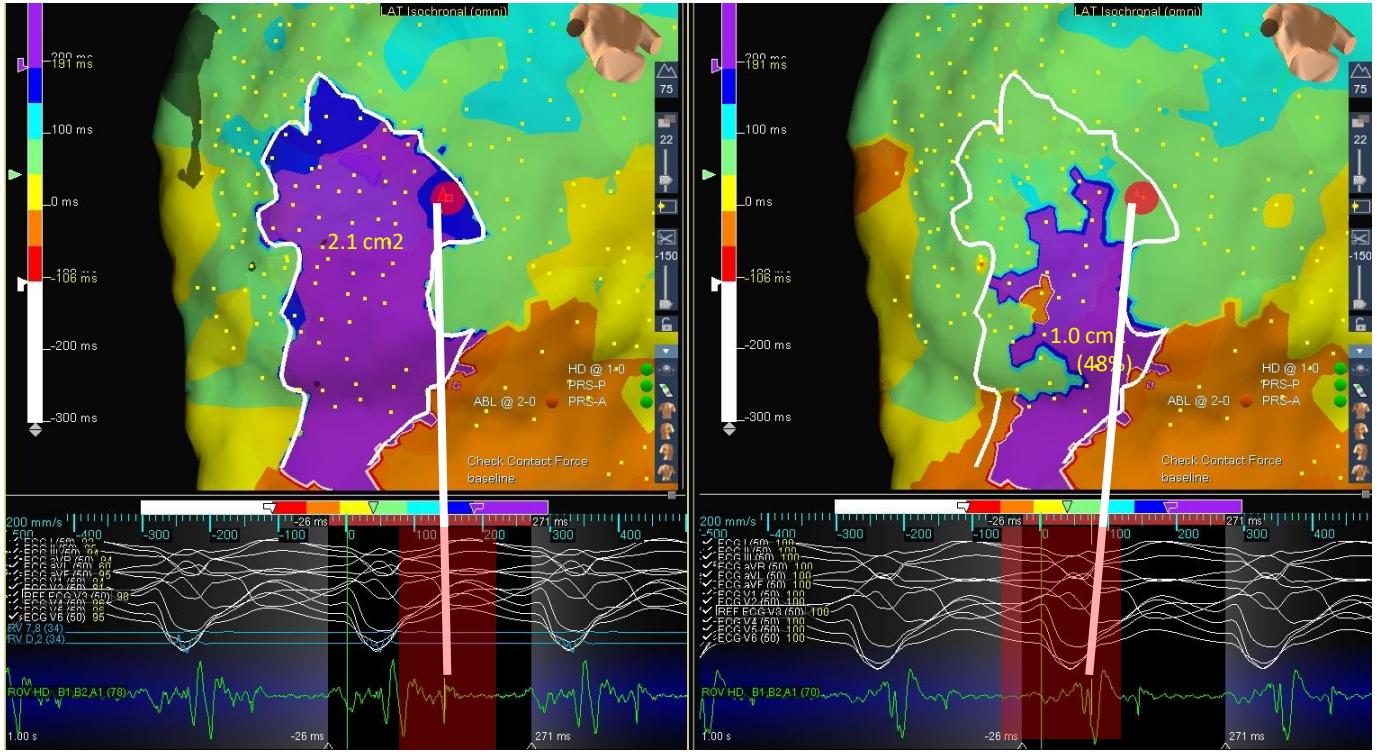




High frequency-low voltage
Discrimination of AT termination region
AUC 0.82
Optimal cutoff <0.3 mV, > 250 Hz
Sensitivity 0.87
Specificity 0.85

Resolving the Diastolic Potential Timing During VT

NF vs. Abs dV/dt detection



Near Field Detection **abs dV/dt detection**

Peak Frequency Mapping to Differentiate Near-Field from Far-Field EGMs for VT ablation: *Initial results*

Jose L. Merino[1], Takanori Yamaguchi[2], Steven Kim[3], Jatin Relan[3], Sergio Castrejón[1], Toyokazu Otsubo[2], Marcel M. Cossiani[1], Kana Nakashima[2], Margarita Sanroman[3], Juan J. De la Vieja[3]

[1.] La Paz University Hospital, Madrid, Spain [2.]Saga University, Saga, Japan [3.]Abbott, New York, NY, US

Background

- Localization of the diastolic conduction isthmus of VT in patients with structural heart disease (SHD) is challenging because it is usually located in low-voltage (LV) areas where near-field (NF) and far-field (FF) electrograms (EGMs) are merged.
- The peak frequency (PF) associated with bipolar electrograms (EGMs) may distinguish NF from FF EGM components (Panel A).

Objective

To evaluate if VT PF mapping adds specificity to voltage mapping to better discriminate the critical VT conduction isthmus.

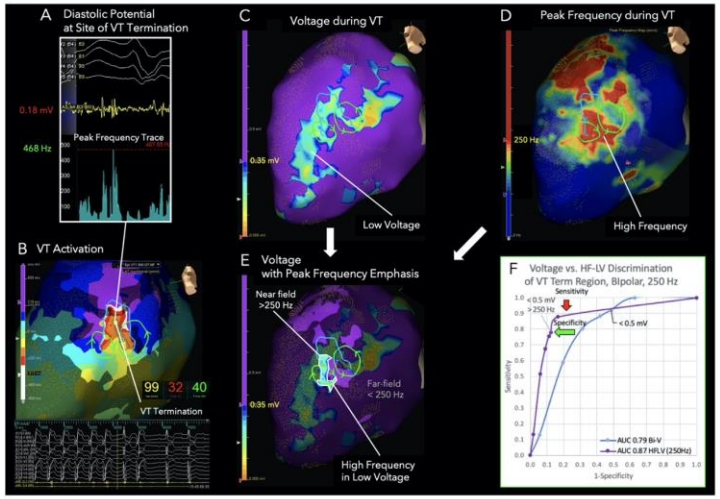
Methods

- Bipolar voltage and activation maps were generated with a 16-pole grid catheter (HD Grid) during VT (Panels B,C). PF maps were retrospectively computed (Panel D).
- VTs were only included if acute termination was achieved by focal RF application (RFa) within a boundary diameter <1.5cm.
- The mapped surface area (SA) was sub-regioned into the termination (T-ZONE) and non-termination (NT-ZONE) zones. The T-ZONE surface was centered about the termination site and was allowed to extend to a rectangular kernel >0.5cm and <1.5cm across perpendicular axes, with the NT-ZONE encompassing the remainder of the mapped SA.
- Sensitivity (SE) and specificity (SP) of discrimination of the T-ZONE vs NT-ZONE were measured according to the %SA covered at LV thresholds ranging from 0.1-1.0mV in increments of 0.1mV (Panel F). In addition to LV, LVHF at different PF cutoffs from 150Hz (LVHF150) to 300Hz (LVHF300) were also assessed.

Results (1)

- 15 patients with SHD and sustained monomorphic VT. 6 patients (60-74 years, 6 male, 3 ischemic) had 7 VT's terminated by 1.43±79 focal RFa.
- The T-ZONE occupied 0.52±0.34cm2 (84.54±44.63 cm2 global SA) and consisted of 28±20 EGM points (1766±1009 global points).
- T-ZONE voltage during VT (0.25±0.20mV) was significantly lower vs. global voltage (1.56±0.74mV, P<0.001), while T-ZONE PF was higher (335±82Hz) vs. global (263±57Hz , P<0.001). All areas of VT termination were located in an LVHF region (Panel E).
- ROC discrimination of the T-ZONE yielded AUC's of 0.79 -LV alone, 0.84 -LVHF150, 0.85 -LVHF200, 0.87 -LVHF250 (delta +8.2% compared with LV alone) and 0.79 -LVHF300. At a 0.5mV cutoff, LVHF250 yielded a SE/SP of 0.78/0.87 vs. LV alone (0.92/0.52)(Panel F).

Results (2)



Activation map of VT guides focal RF termination at the critical diastolic isthmus (Panels A,B). LV during VT is sensitive but not specific to the site of VT termination (Panel C). PF is tracked as a function of time for each EGM (Panel A), resulting in a spatial distribution of high vs. low-PF regions (Panel D). The voltage map with PF emphasis serves to highlight regions of LV overlapped with high frequency, thus improving specificity to detect the site of termination (vs. low voltage alone) (Panel E). Global ROC curves demonstrate the improved specificity of LV-HF during VT (AUC 0.87) vs. LV alone (AUC 0.79) to discriminate the VT site of termination (Panel F)

Conclusion

Detection of high-frequency EGM regions during VT provides complementary information to bipolar voltage mapping to discriminate the diastolic conduction isthmus associated with the site of VT termination by RFa.

Disclosures

Jose L. Merino, MD, PhD: Organization: Abbott, Relationship: Honoraria/Speaking/Consulting Fee, Role: Speaking and Teaching; Organization: MicroPort Scientific Corporation, Relationship: Honoraria/Speaking/Consulting Fee, Role: Speaking and Teaching; Organization: Sanofi, Relationship: Honoraria/Speaking/Consulting Fee, Role: Consulting, Comments: Atrial fibrillation advice; Organization: Boston Scientific, Relationship: Honoraria/Speaking/Consulting Fee, Role: Consulting

NF mapping in VT

- **15 pts with SHD and SM VT ➔ 6 patients had 7 VT's terminated by 1.43±79 focal RFa.**
- **T-ZONE:**
  - **Voltage 0.25±0.20mV vs. global voltage 1.56±0.74mV, P<0.001**
  - **PF 335±82Hz vs. global 263±57Hz , P<0.001.**
  - **All areas of VT termination were located in an LVHF region.**

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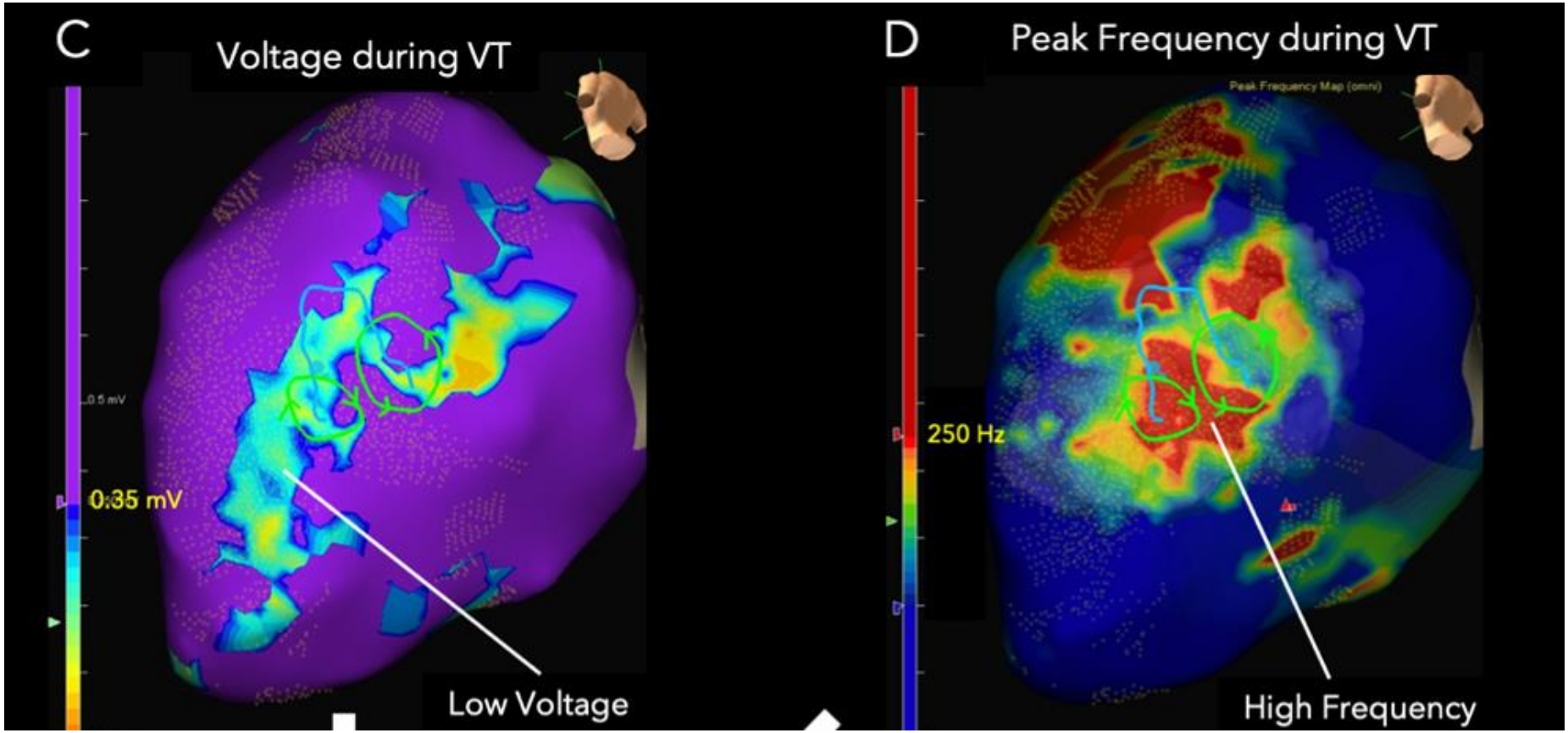
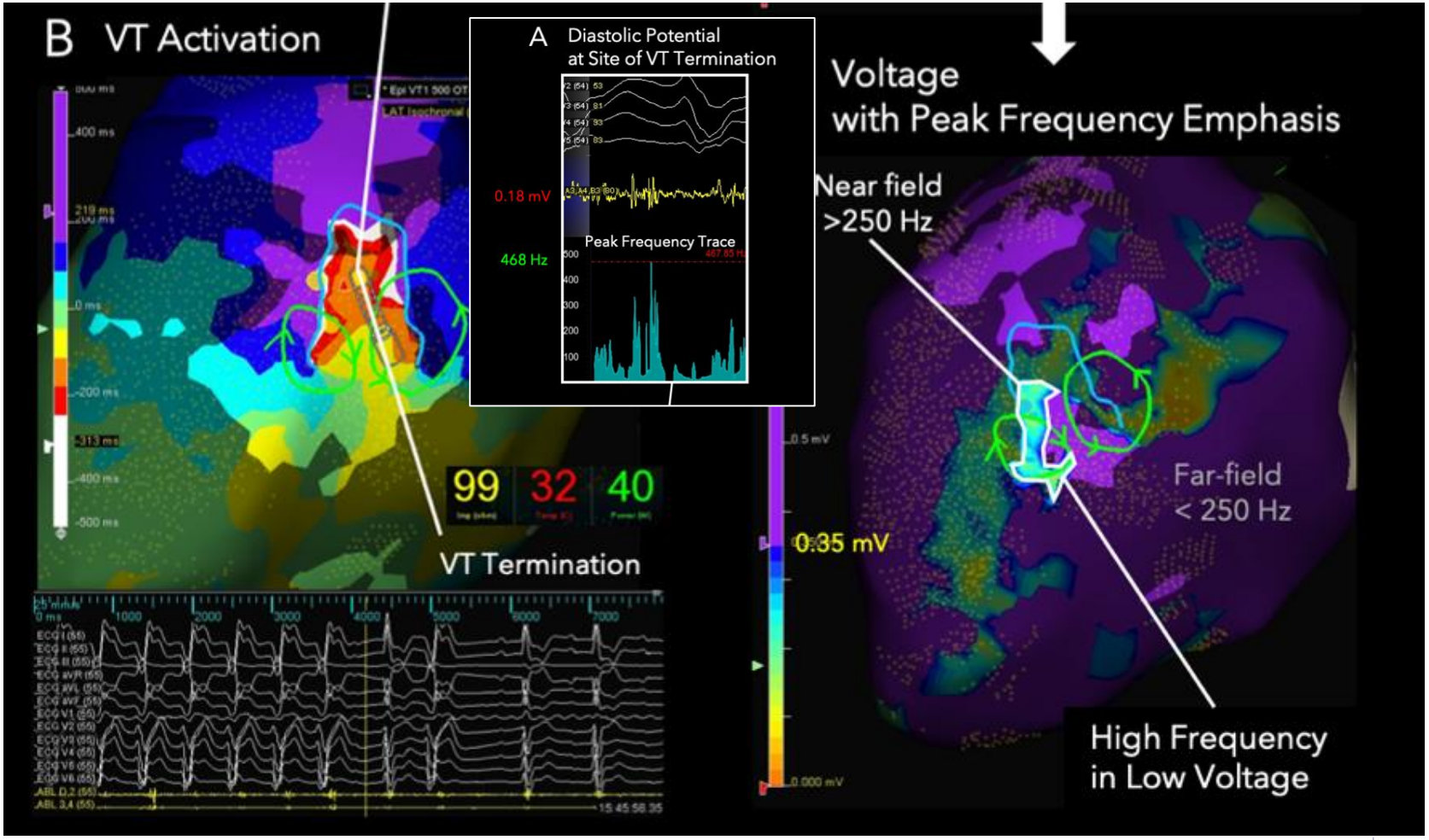
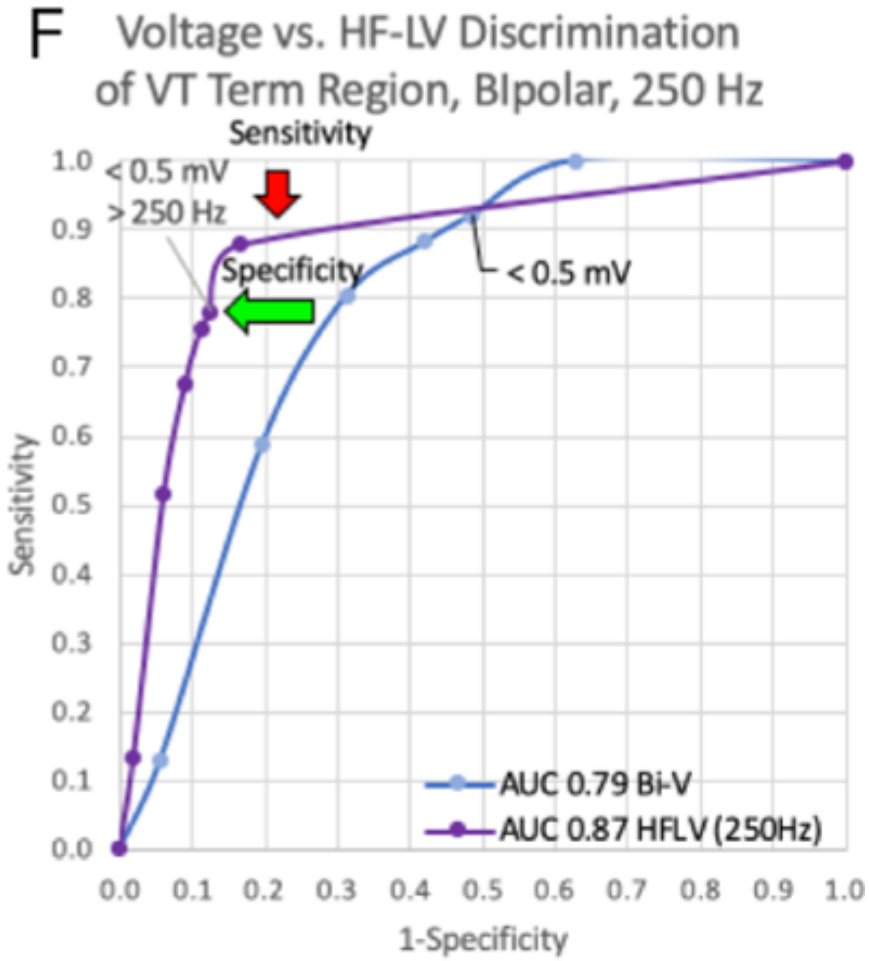
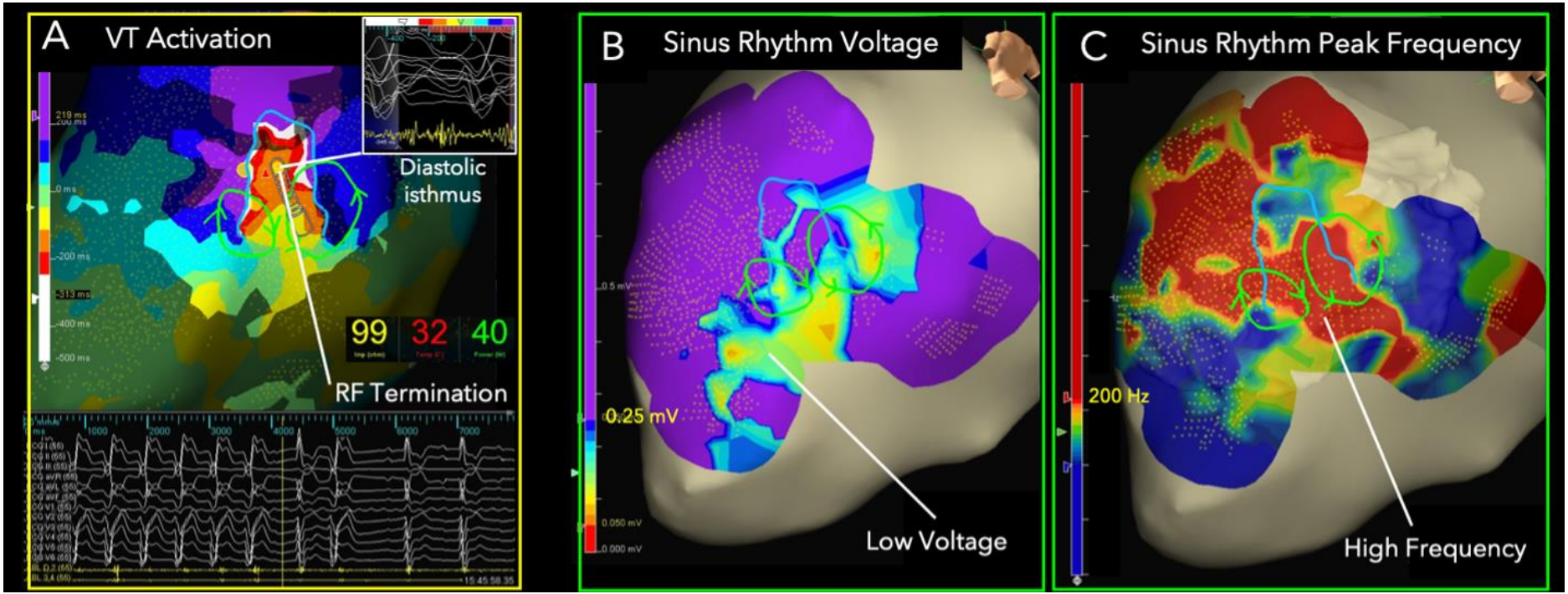
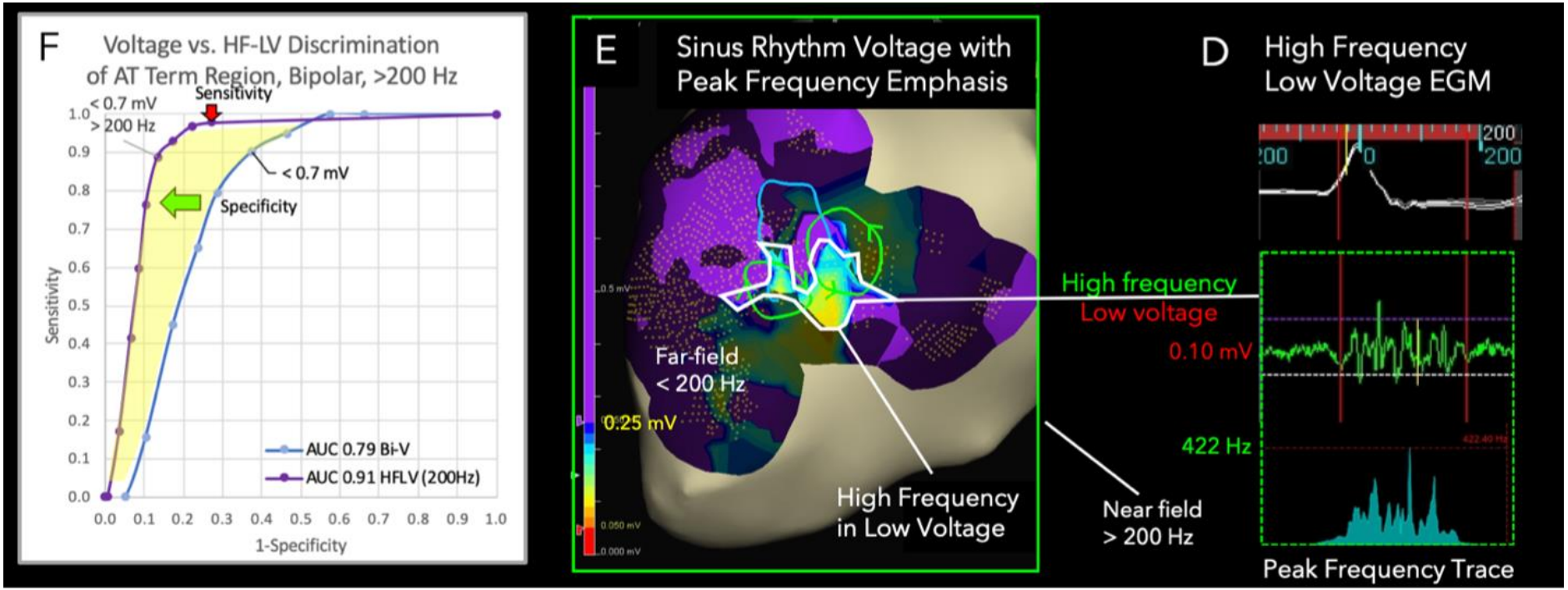

C
Voltage during VT
0.35 mV
Low Voltage
D
Peak Frequency during VT
Peak Frequency Map (omni)
250 Hz
High Frequency


B VT Activation
A Diastolic Potential at Site of VT Termination
0.18 mV
468 Hz
Peak Frequency Trace
Voltage with Peak Frequency Emphasis
Near field >250 Hz
Far-field < 250 Hz
0.35 mV
VT Termination
High Frequency in Low Voltage
99
32
40

F

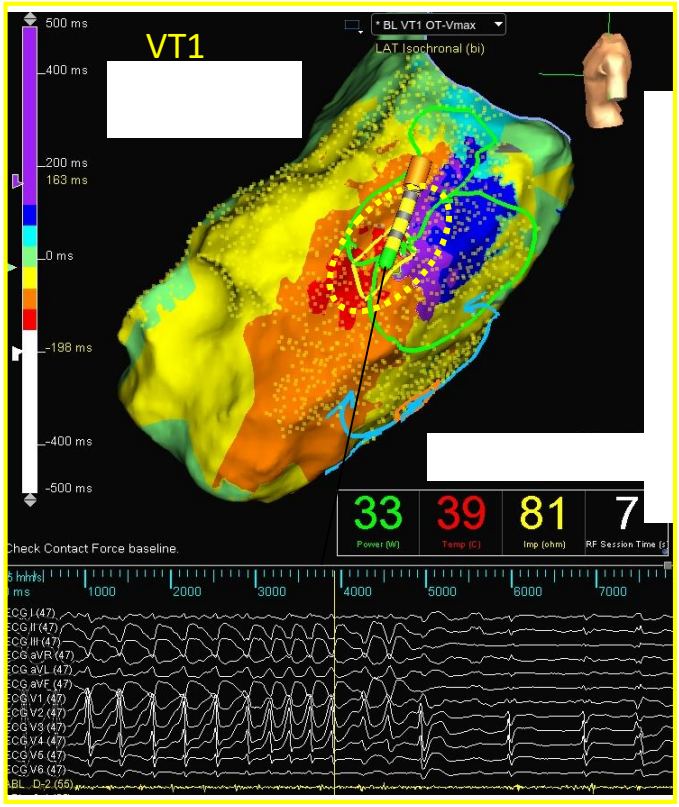

Voltage vs. HF-LV Discrimination of VT Term Region, BIpolar, 250 Hz
Sensitivity
< 0.5 mV
> 250 Hz
Specificity
< 0.5 mV
Sensitivity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
1-Specificity
AUC 0.79 Bi-V
AUC 0.87 HFLV (250Hz)

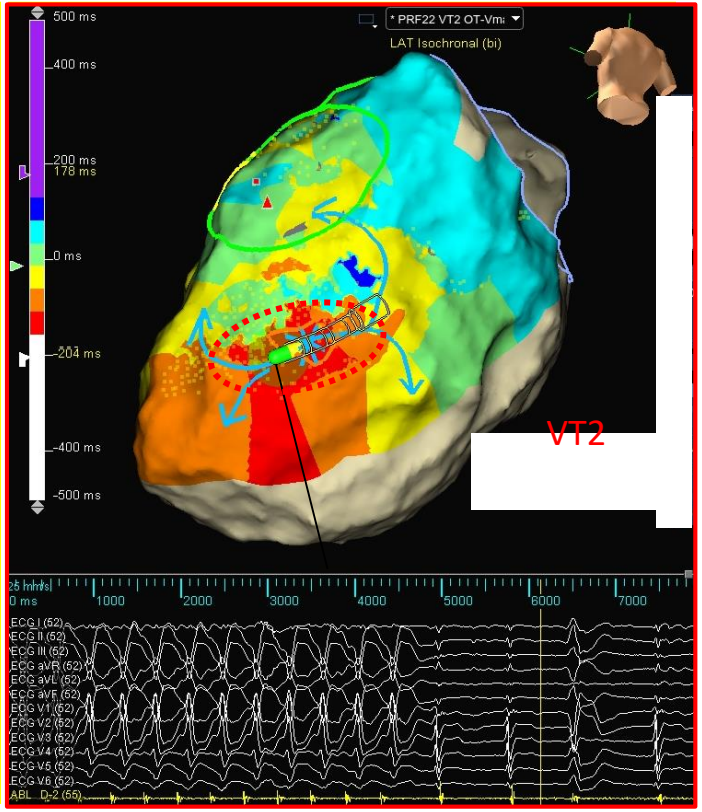

A
VT Activation
Diastolic isthmus
RF Termination
99
32
40
B
Sinus Rhythm Voltage
0.25 mV
Low Voltage
C
Sinus Rhythm Peak Frequency
200 Hz
High Frequency


F
Voltage vs. HF-LV Discrimination of AT Term Region, Bipolar, >200 Hz
Sensitivity
< 0.7 mV
> 200 Hz
< 0.7 mV
Specificity
Sensitivity
1-Specificity
AUC 0.79 Bi-V
AUC 0.91 HFLV (200Hz)
E
Sinus Rhythm Voltage with Peak Frequency Emphasis
Far-field
< 200 Hz
0.25 mV
High Frequency in Low Voltage
D
High Frequency Low Voltage EGM
High frequency
Low voltage
0.10 mV
422 Hz
Near field
> 200 Hz
Peak Frequency Trace

VT CASE 2

High frequency–low voltage substrate specifies the diastolic conduction zones for 2 VT's



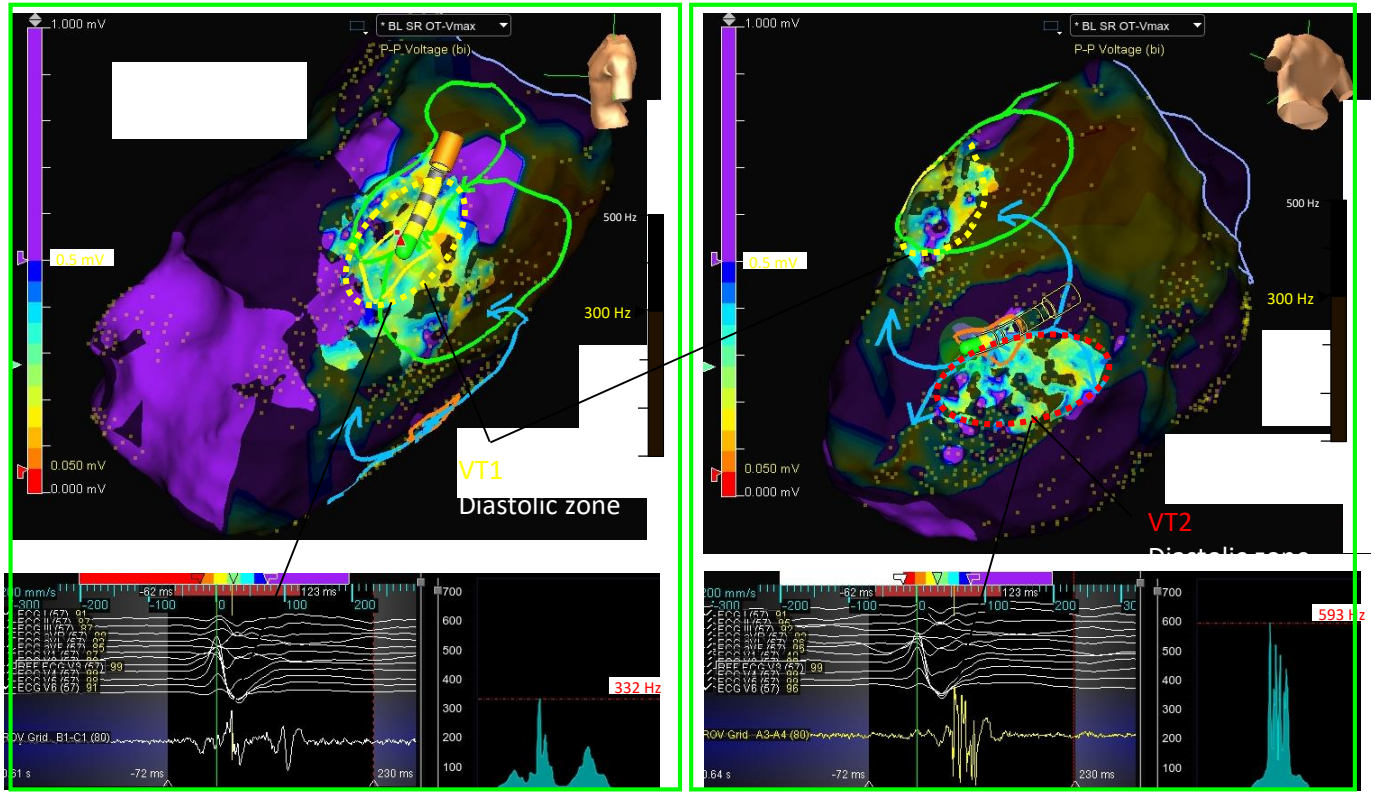


VT1 Termination

VT2 Termination

VT CASE 2

High frequency–low voltage substrate in sinus rhythm specifies the diastolic conduction zones for VT1 and VT2



Sinus rhythm

Beyond Voltage:
Applying NF Emphasis to improve specificity of substrate mapping

- The voltage map serves as a conventional marker for the abnormal substrate

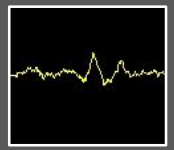
Voltage

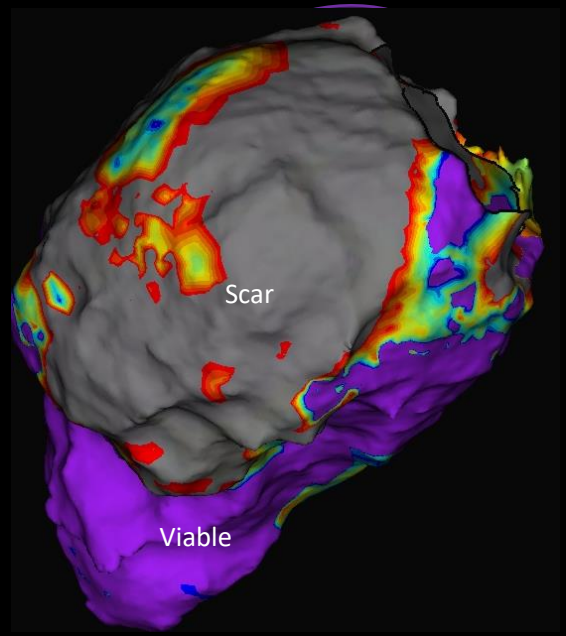
High Voltage

- "Normal" tissue

Low Voltage

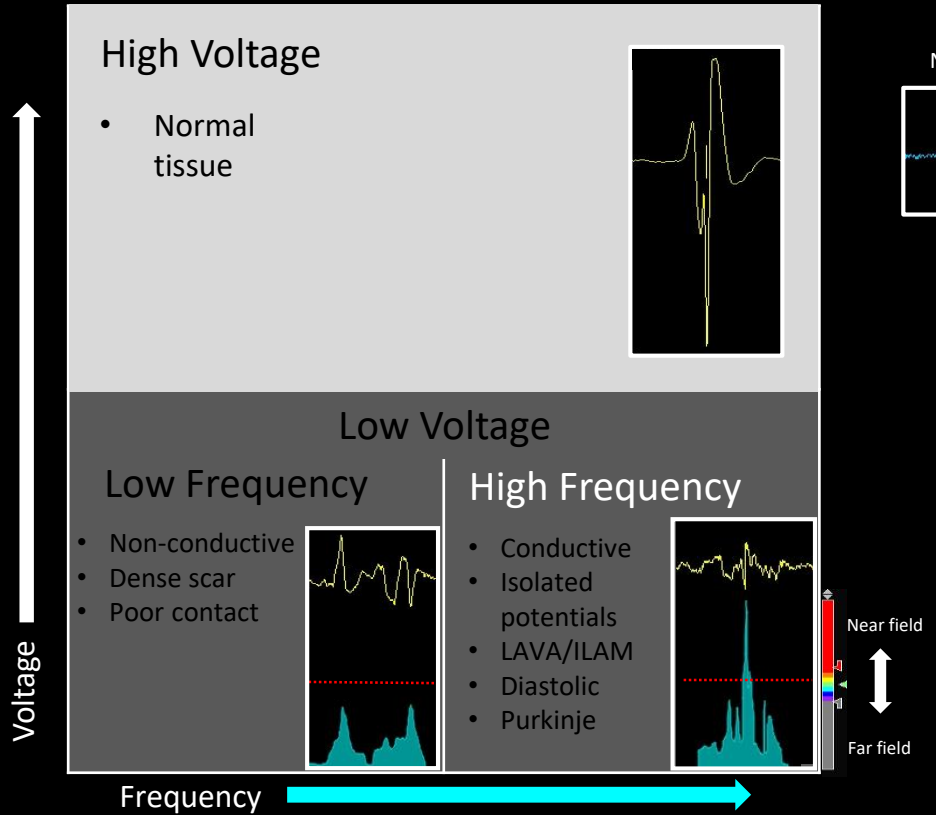
- "Scar" tissue
- Voltage thresholds non-specific

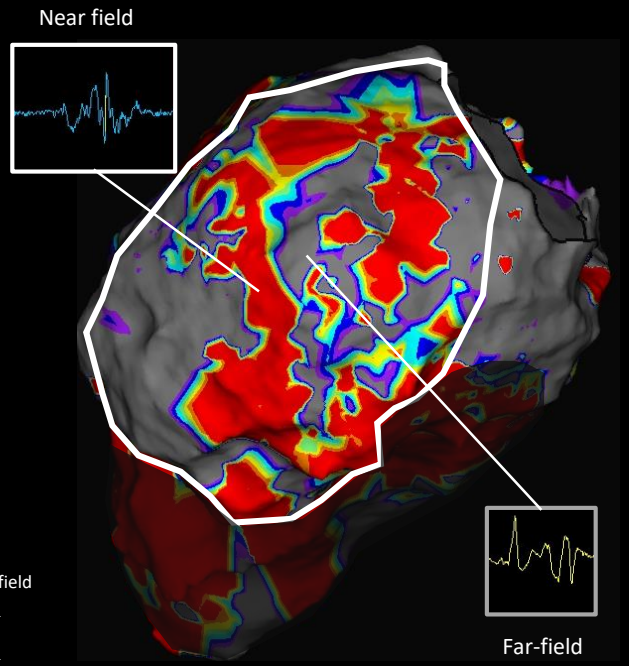




Beyond Voltage: NF Emphasis improves the specificity of substrate mapping

- Near Field Emphasis enhances specificity of the voltage map by discriminating subregions of high frequency within the low voltage zone



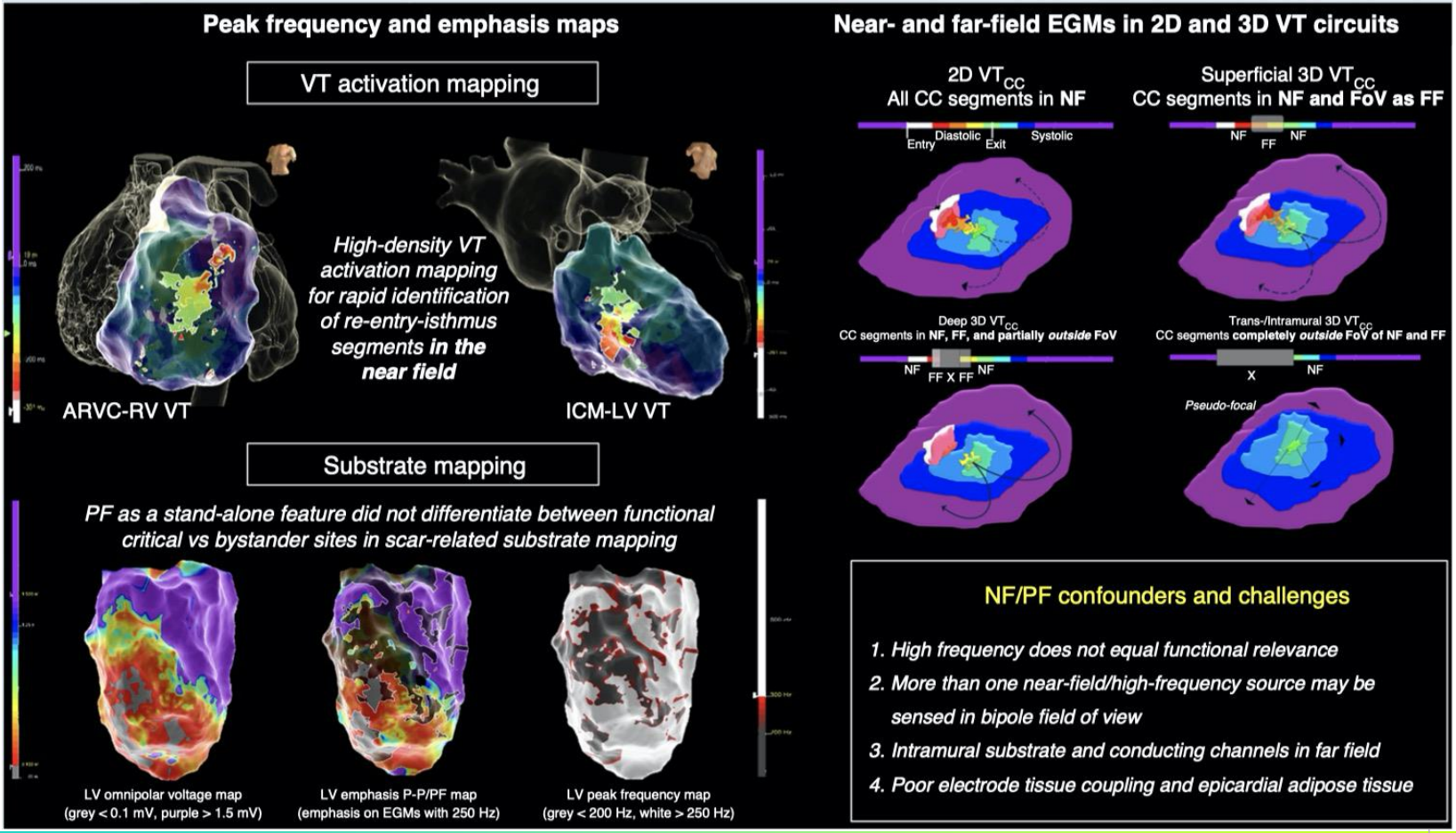


Peak frequency map

Combining Peak Frequency & Voltage Maps

	High Voltage Eg (HiVE)	Low Voltage Eg (LoVE)
High Frequency (HF)	Normal	Protected channel
Low Frequency (LF)	Far Field *(low contact)*	Scar *(far field from healthy)*

LoVE HF



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Take Home Messages

1. Addtional mapping tools (DEEP, VEDUM, etc)
2. PF better detects residual conduction within an scar region than conventional Bi-V and it is independent from it.
3. Peak Frequency magnitude:
    1. Correlates with electrogram sharpness.
    2. Is useful to enhance specificity of the low voltage substrate

Thank you!

EHRA 2026

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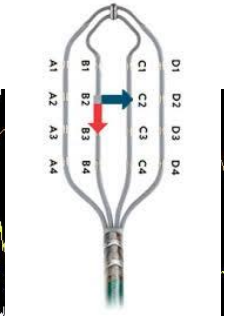
Bipole size



4 mm

12 mm

17 mm

V1

A1-A2

A1-A4

D1-D4

A1-D1

A4-D4

A1-D4

D1-A4

REF 1-2

0.396 mV
A1-A2

0.503 mV
A1-A2

0.4 / 0.5 ➔ 0.8

0.518 mV
A1-A4

1.16 mV
A1-A4

0.371 mV
A1-D1

0.498 mV
A1-D1

0.37 / 0.5 ➔ 0.74

0.371 mV
A1-D4

0.562 mV
A1-D4

0.37 / 0.56 ➔ 0.66