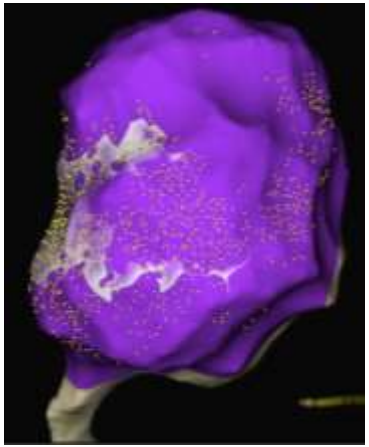
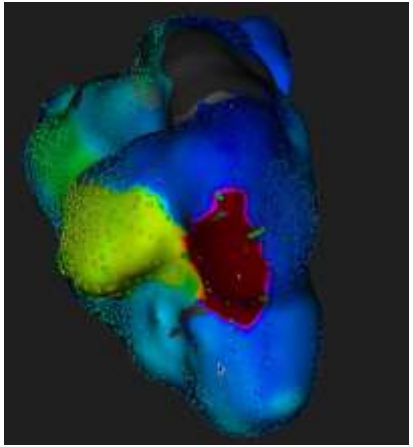
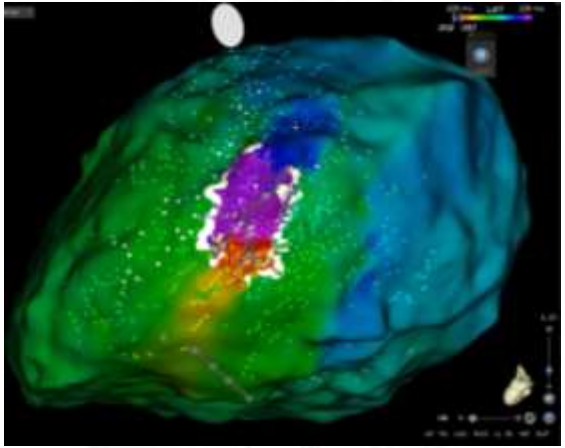
High resolution automated substrate mapping

The more the better or old-fashioned VT mapping?







Antonio Frontera, MD
San Raffaele Hospital, Milan, Italy

OSPEDALE
SAN RAFFAELE

Disclosures

Consultant for Boston Scientific, Abbott

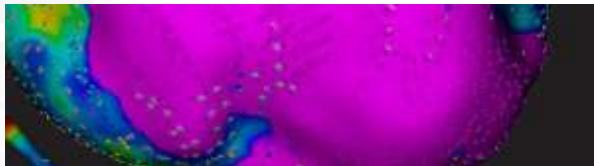
Importance of substrate mapping

1 To distinguish **scar** from **healthy** tissue
Not an easy task.

2 To define ***LPs*** / ***LAVA***
Are always related to the VT circuit?

3 To orientate your self
In presence of multiple VTs and/or arrhythmic storm

4 Improve ***long-term*** VT ablation *outcomes*
As literature demonstrates



Long Term VT ablation outcomes

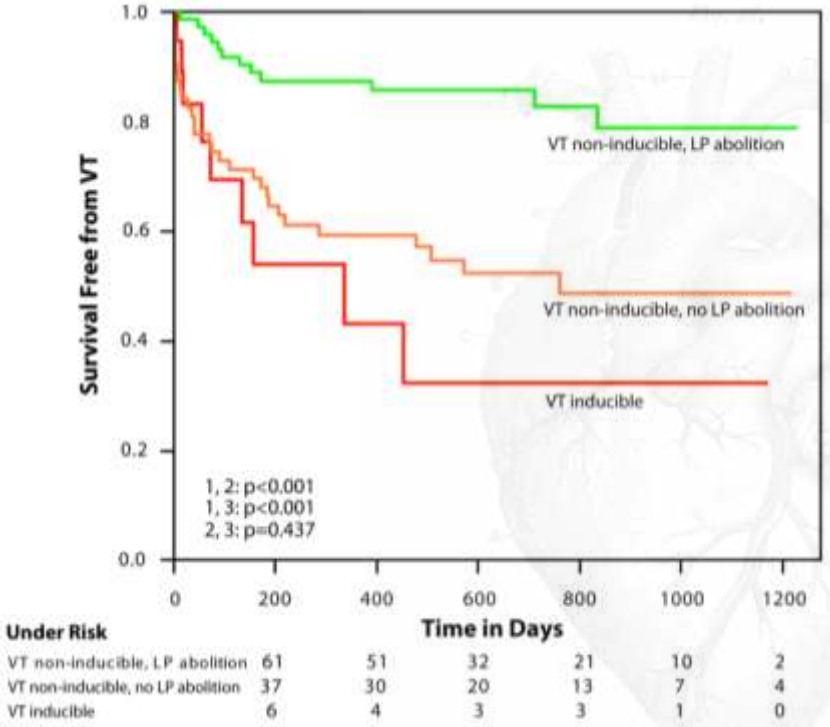
Study population

155 patients (post-MI VT)

Mean EF: 31±3,3%

LPs in 103 pts (65%)

LPs successful ablation: 79/103 (76%)



VT recurrence rate in the overall population

Silbebauer et al.

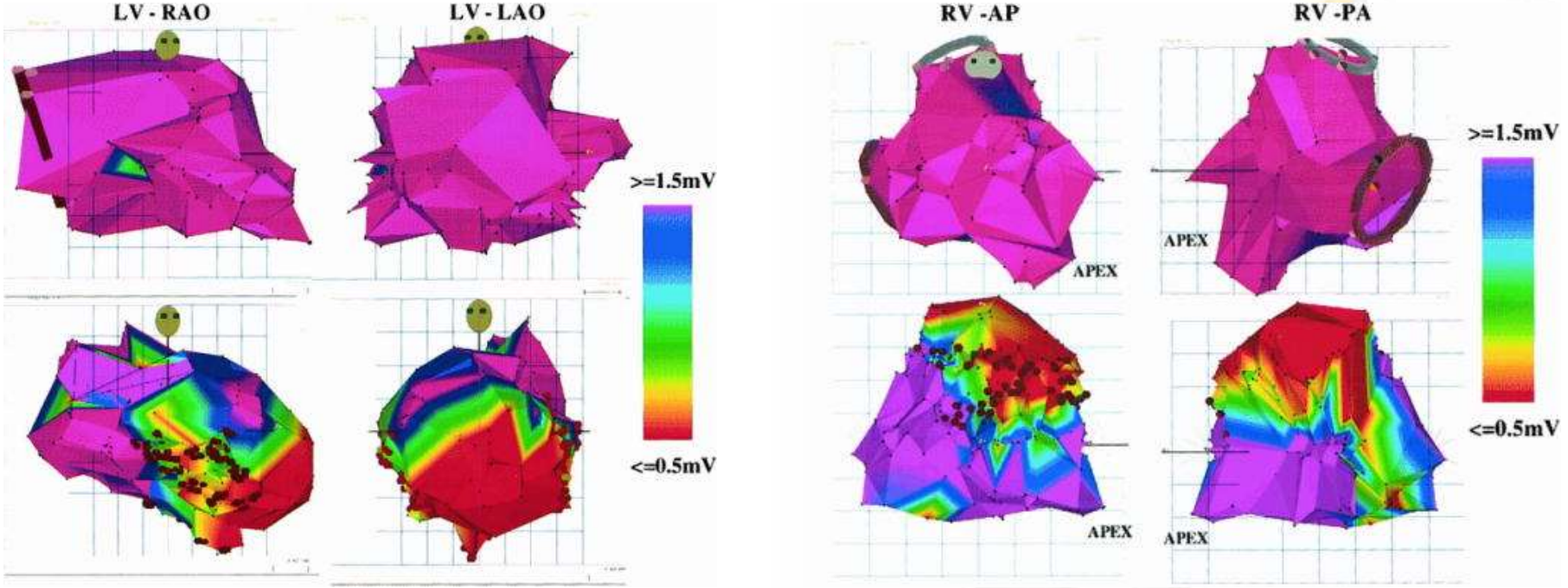
Circulation EP 2014 Jun;7(3):424-35.

Importance of Substrate Mapping

1 To distinguish **scar** from **healthy** tissue

Not an easy task.

Old Fashioned Substrate Mapping



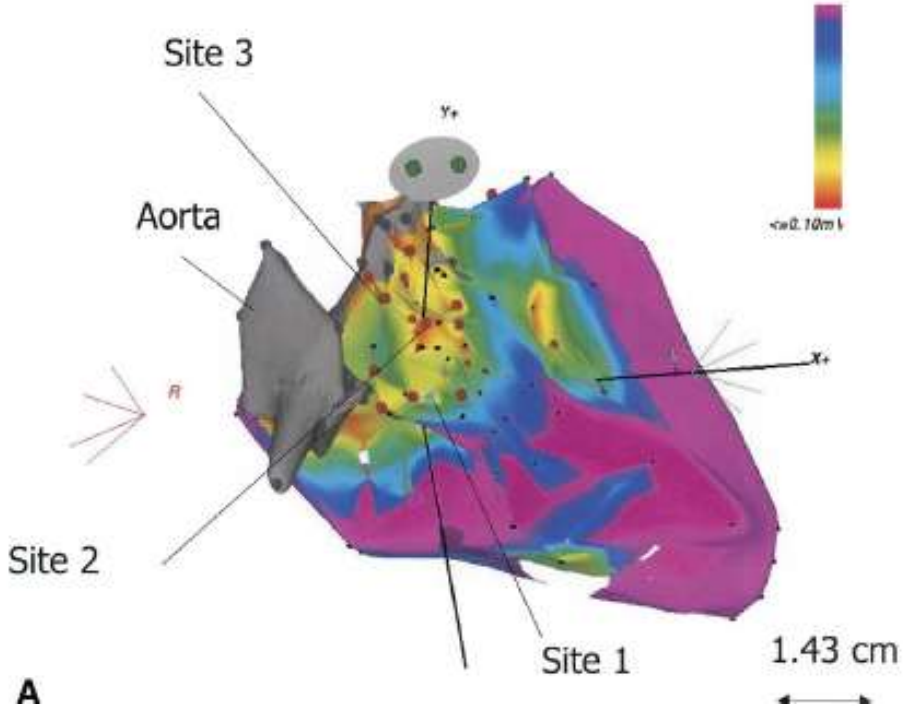
SR mapping in **6** healthy controls:

- Normal endocardium was defined by a bipolar voltage amplitude **>1.5 mV**
- Dense scar was defined by **<0.5 mV**

Marchlinski FE, Circulation 200

Endocardial and Epicardial Radiofrequency Ablation of Ventricular Tachycardia Associated With Dilated Cardiomyopathy

The Importance of Low-Voltage Scars



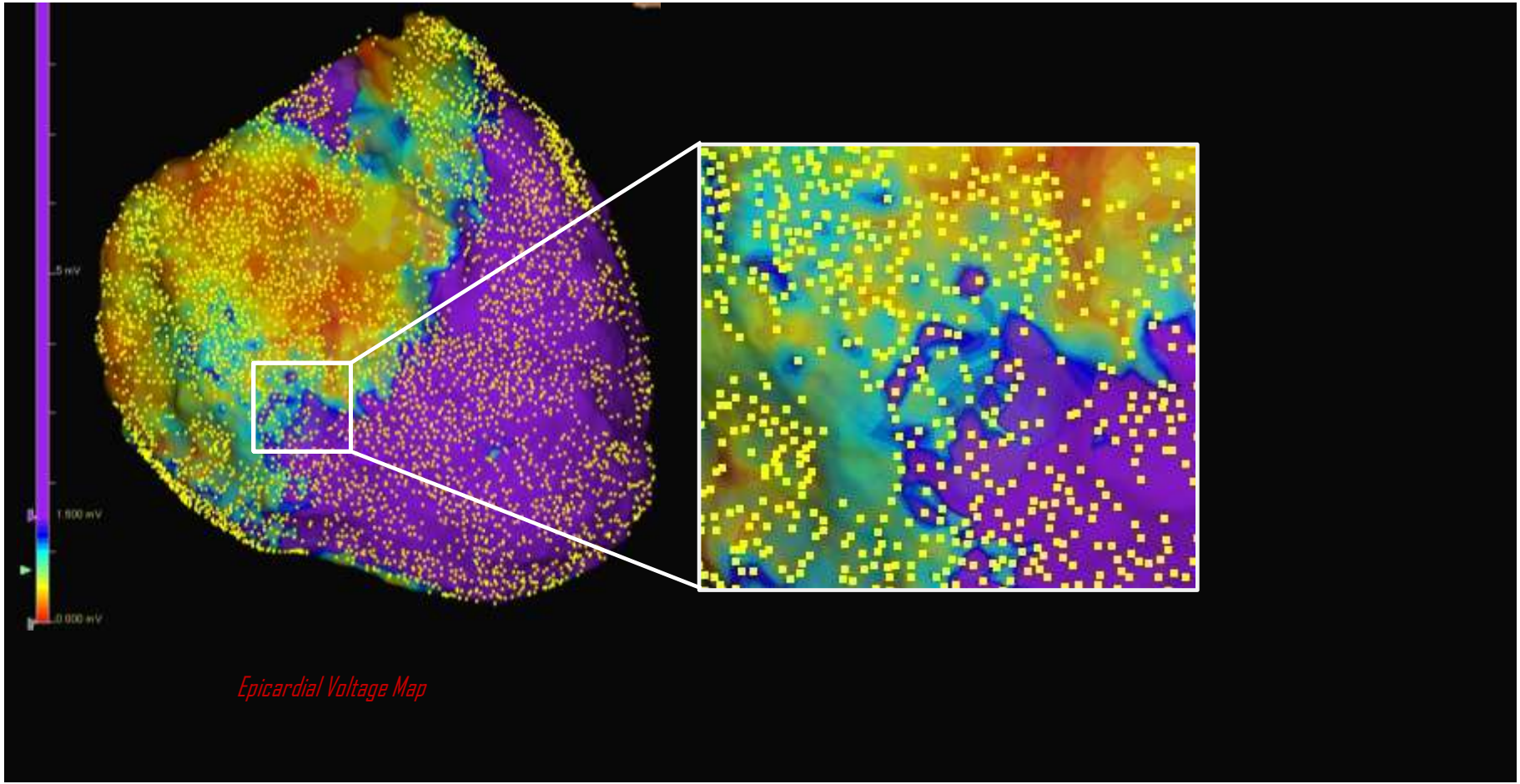
***RF** ablation lesions were applied to the **target area** until the pacing threshold exceeded*

10 mA *at* **2 ms** *pulse width.*

***Target areas** defined by means of*

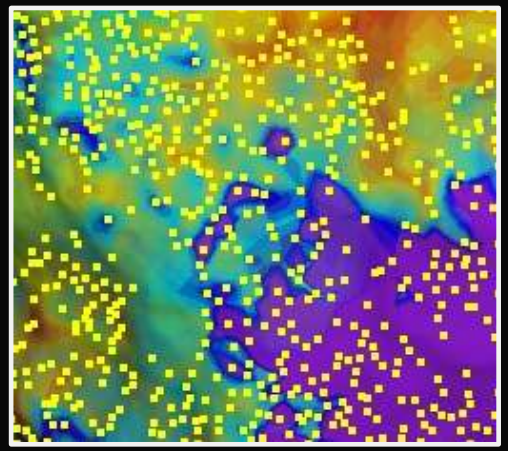
- *Concelaed entrainment in tolerated VTs*
- *Pace-mapping manouvers in unmappable VTs*

High resolution substrate mapping



Epicardial Voltage Map

Scar vs Borderzone vs Healthy



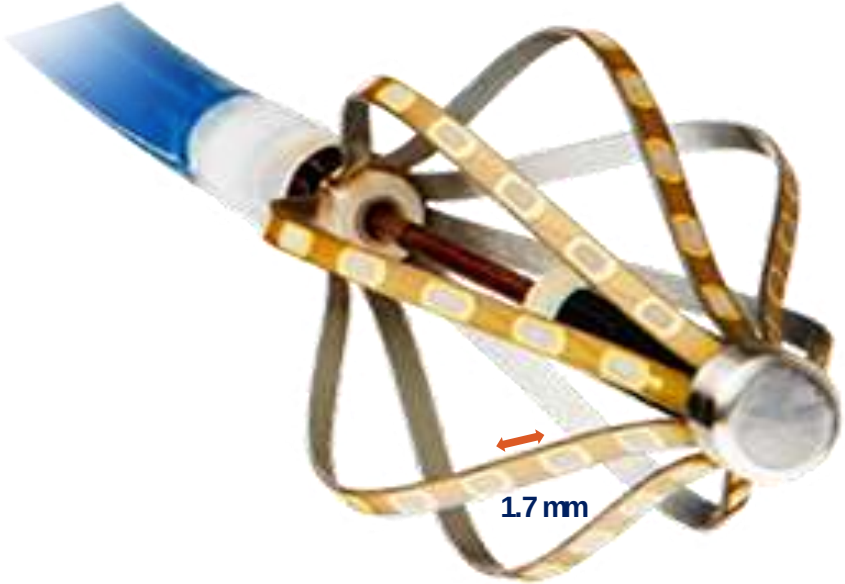
The (HD) definition of scar , «borderzone» is critically **dependent** upon:

- *Activation wavefront*
- *Electrode size*
- *Inter-electrode distance*
- *Contact vs non contact*

The Orion tool

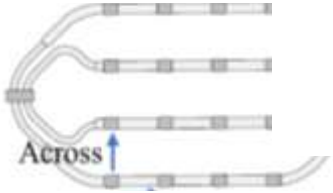
- *Electrode size*

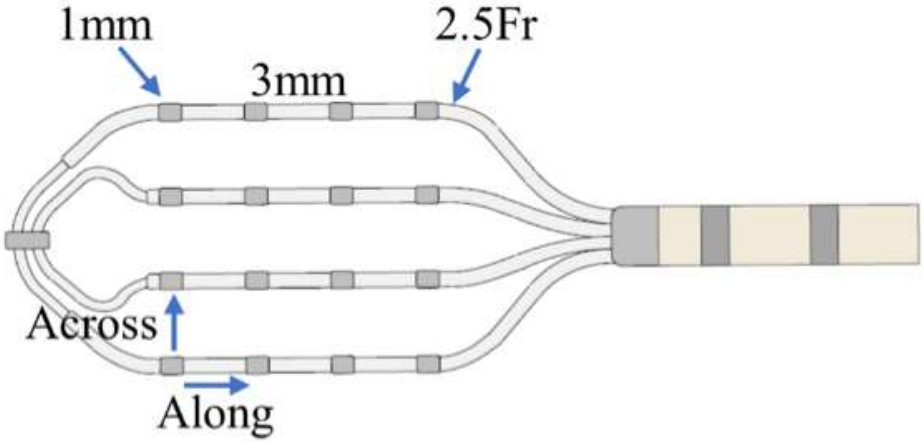
1 mm

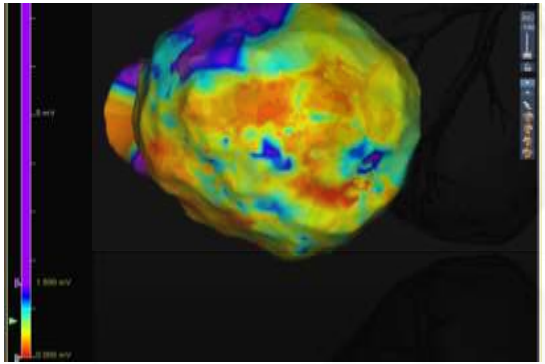


Inter electrode distance

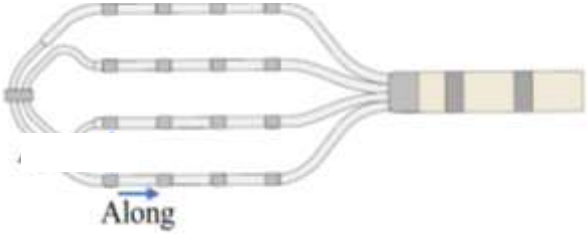
The HD Grid

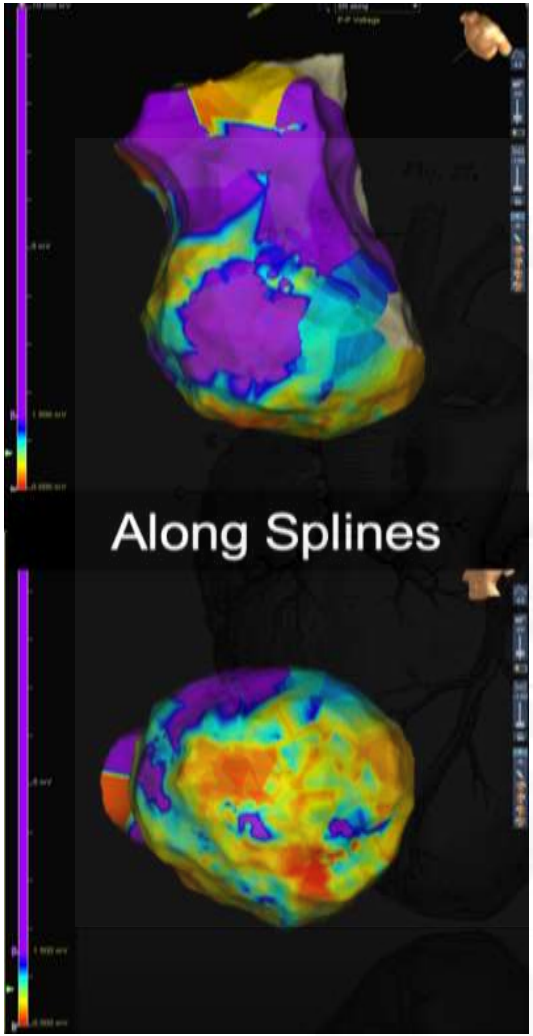




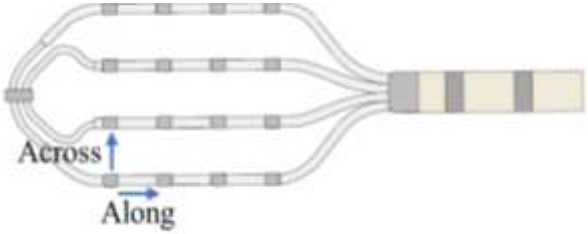


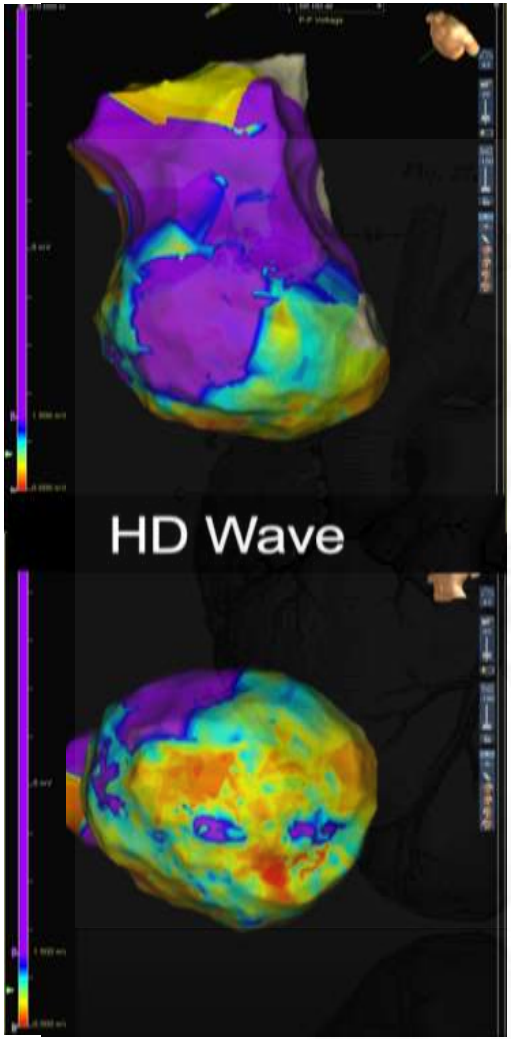
The Activation Front



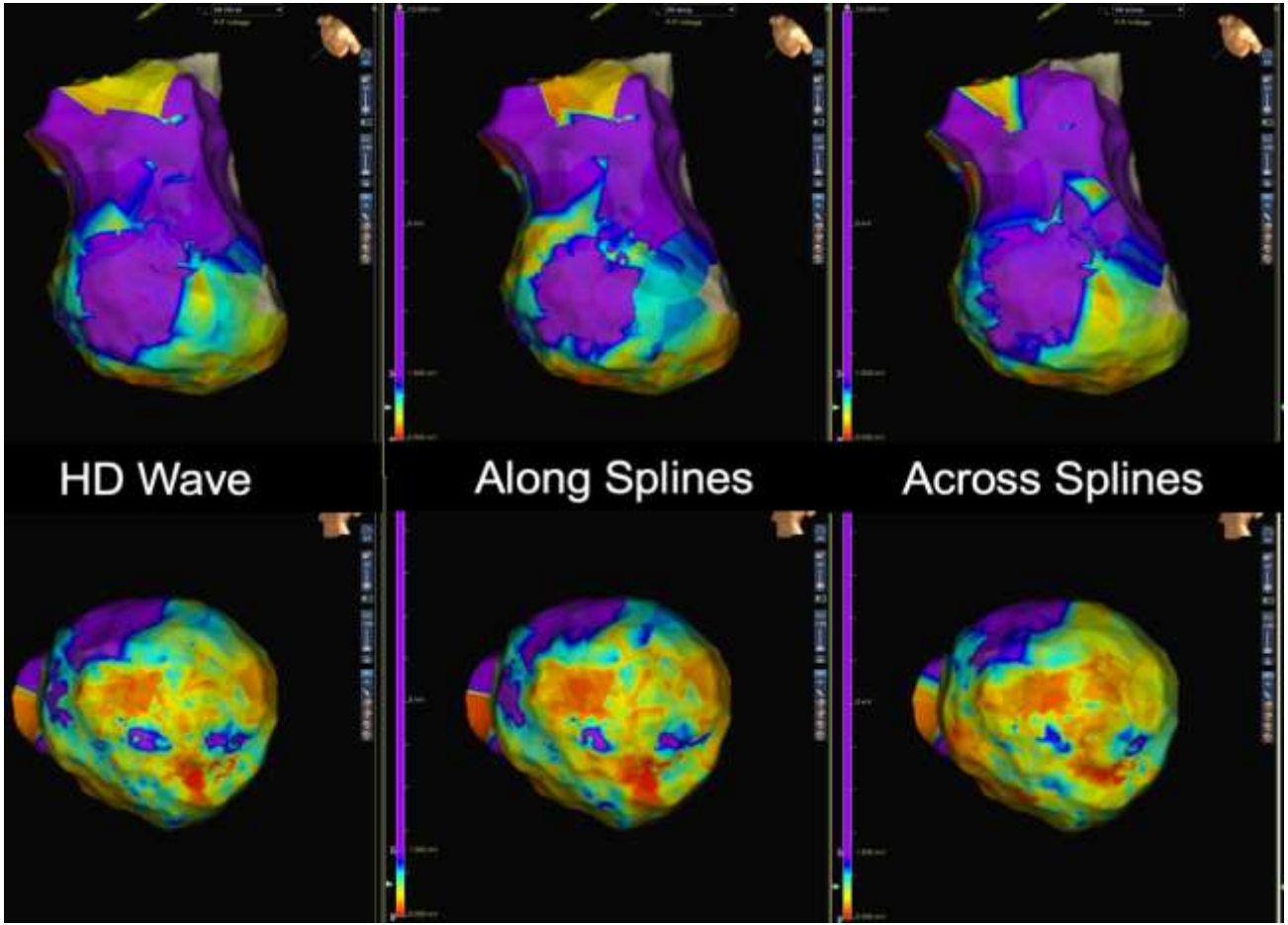


The Activation Front

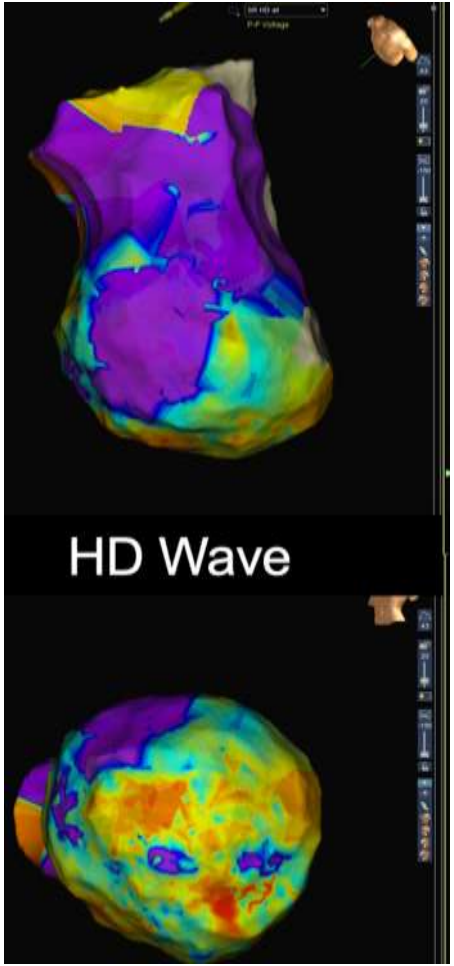


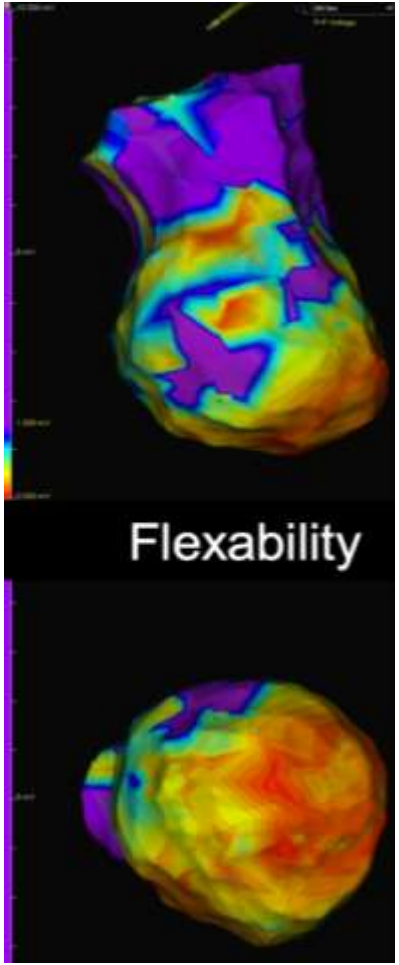


The Activation Front



The inter-electrode distance





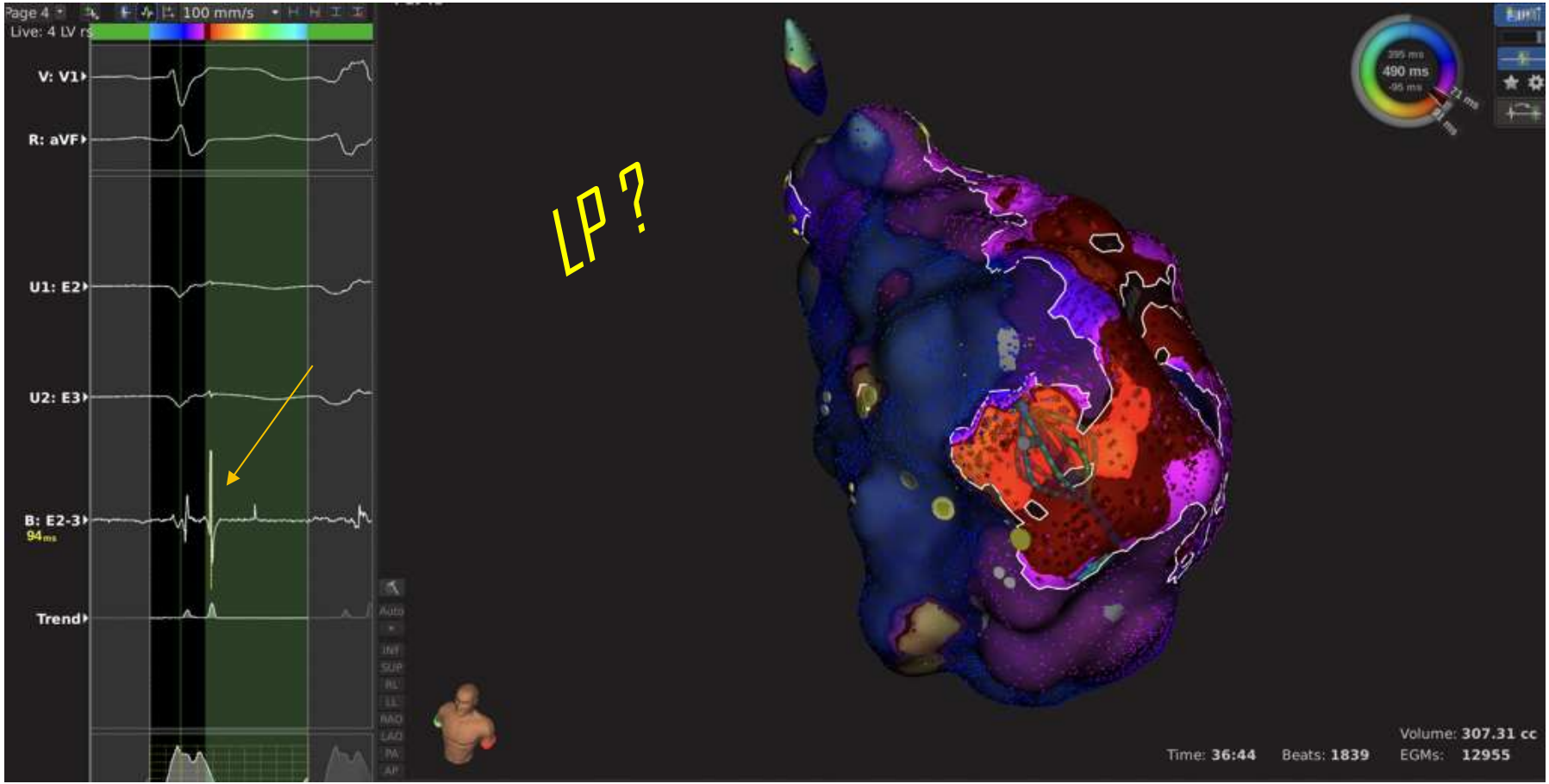
The shorter distance

The best resolution

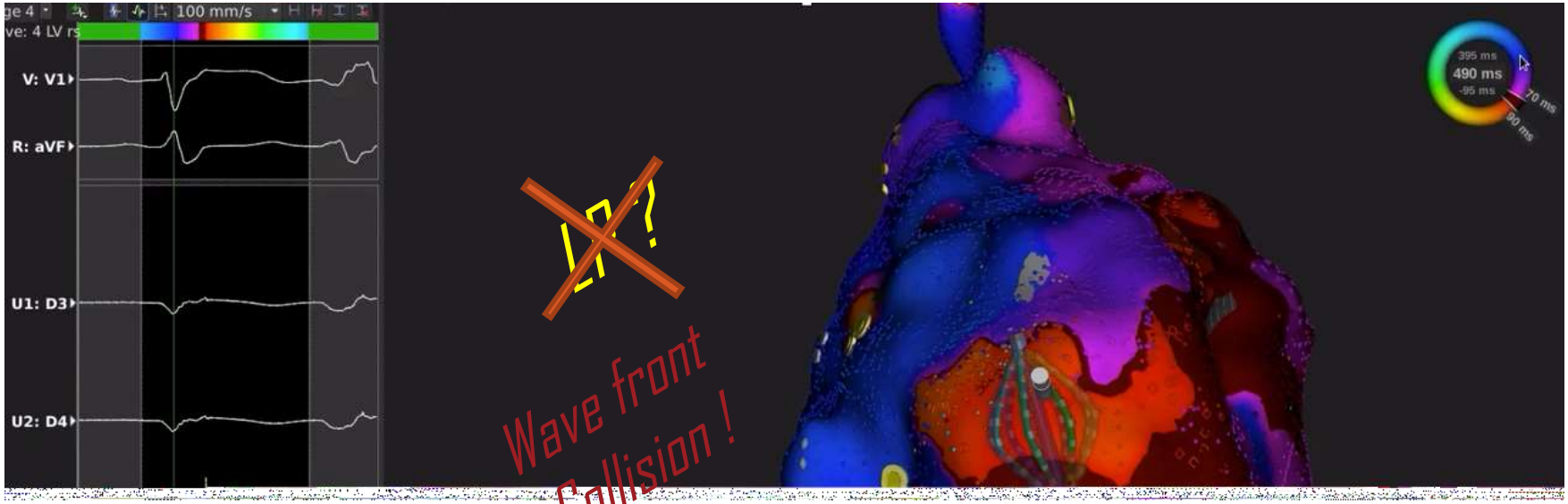
The best characterization

2 EGM characterization during baseline rhythm does not provide a trustworthy evidence of their role into the VT mechanism

LAVA and LPs


100 mm/s
V: V1
R: aVF
U1: E2
U2: E3
B: E2-3
94 ms
Trend
LP ?
490 ms
Volume: 307.31 cc
Time: 36:44
Beats: 1839
EGMs: 12955

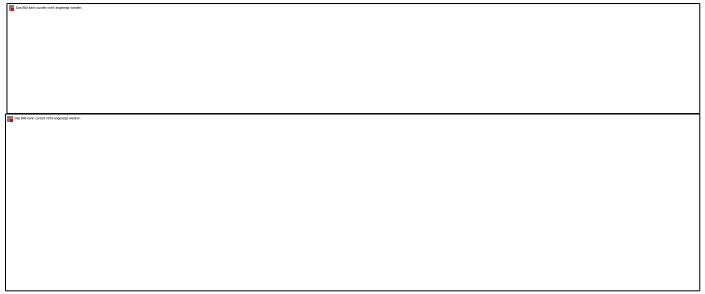
LP = Sometimes bystanders



LAVA and LPs

LAVA and LPs

LAVA vs LP

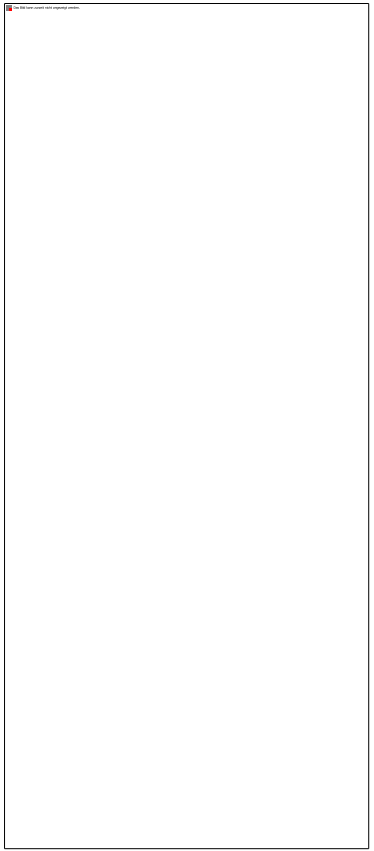


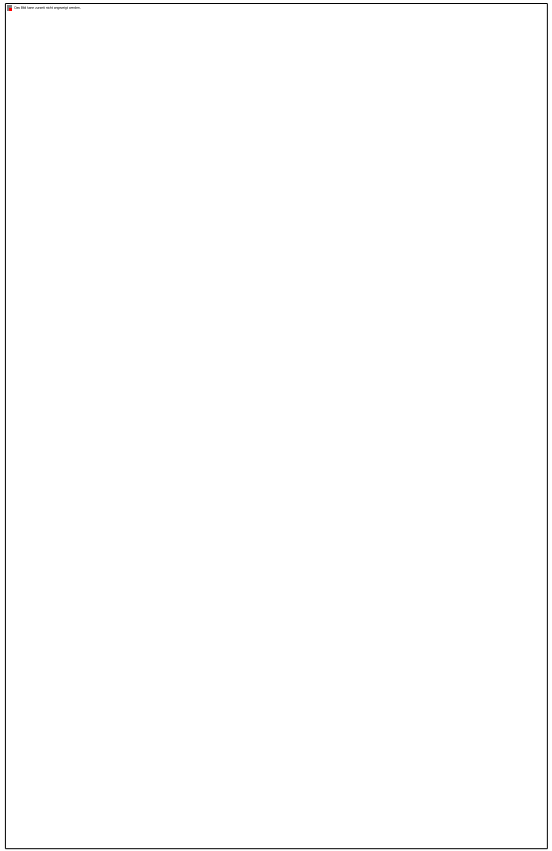
Timing

Morphology = **EGM characterization**

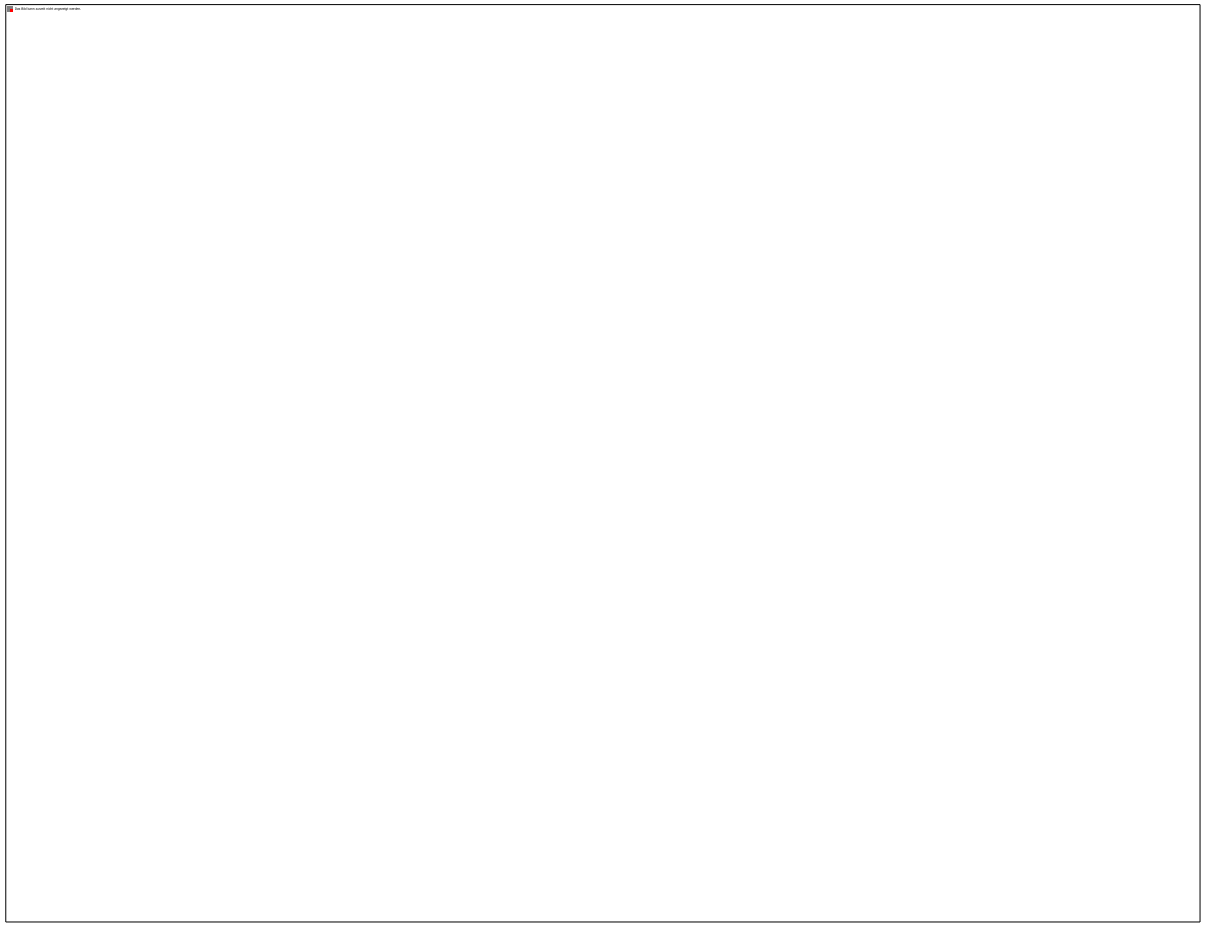
Duration

Bystander vs Critical ?

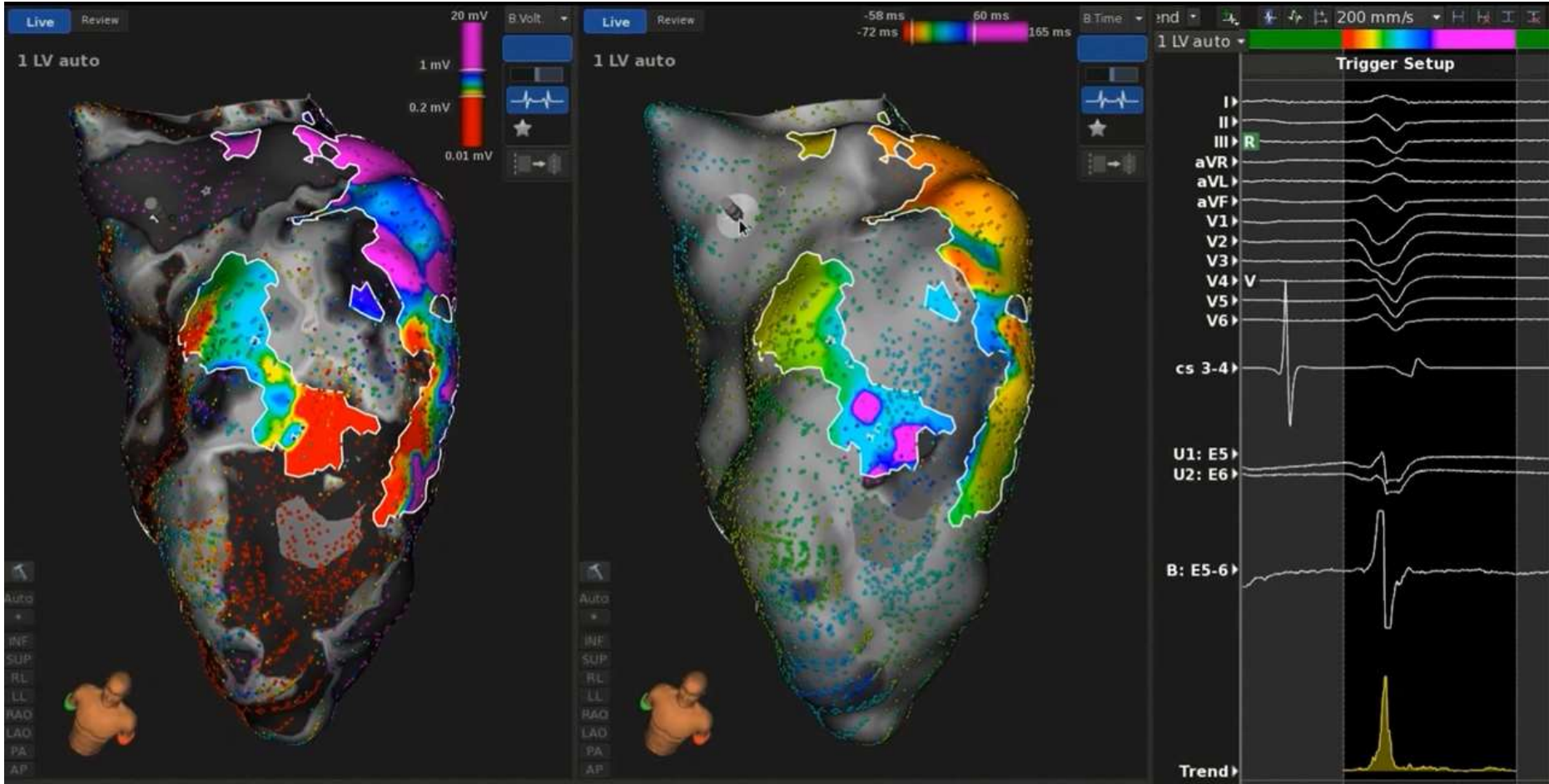




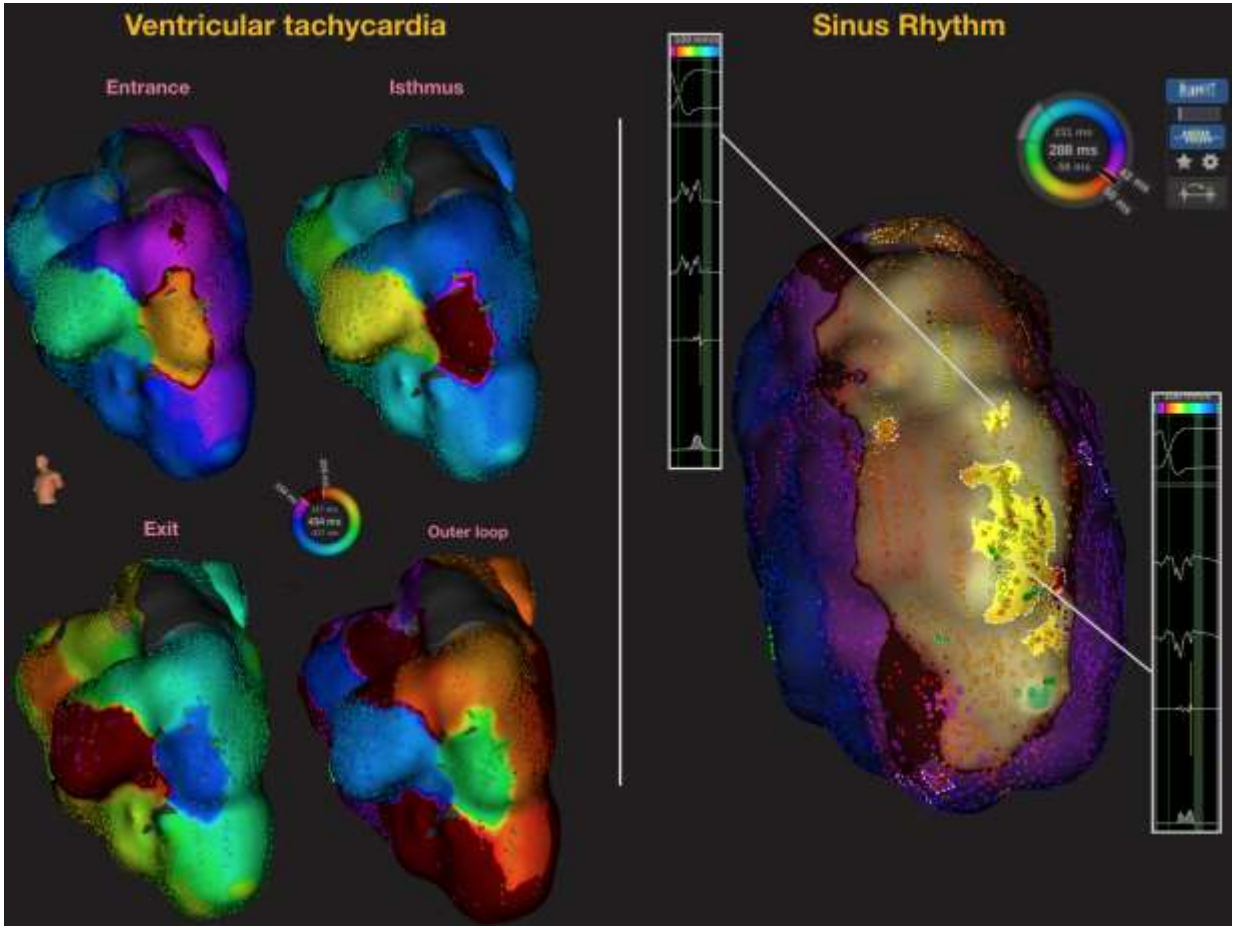
Substrate mapping + software



Substrate mapping + software



Substrate mapping + software



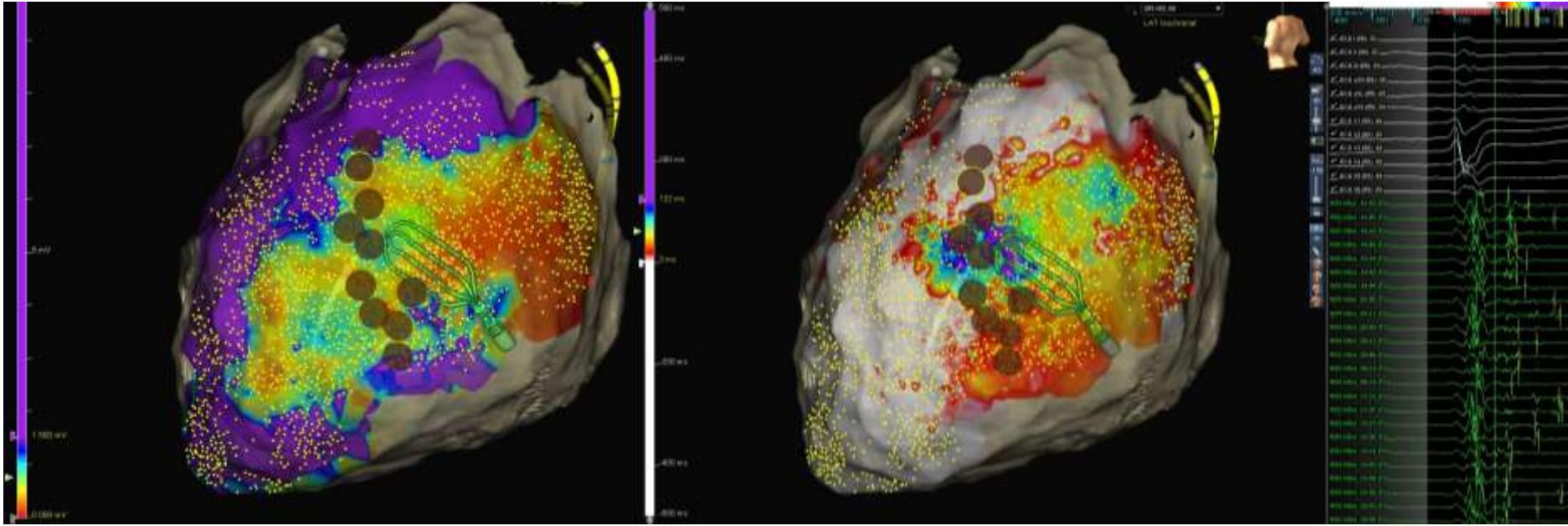
The importance of substrate mapping

3 *Multiple VTs and / or arrhythmic storm.*
In absence of clinical VT (12L) ECG

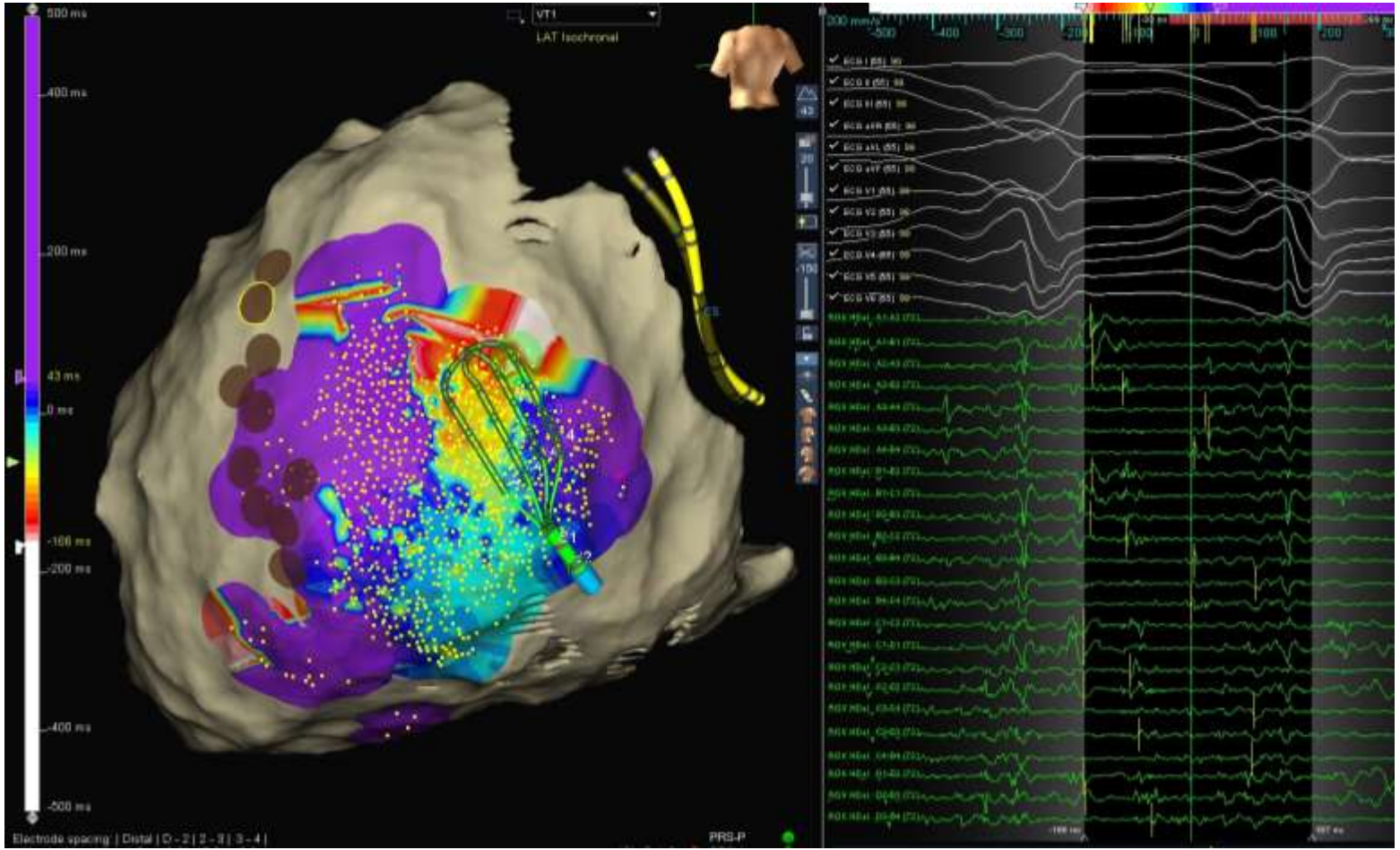
Substrate map!

Voltage Map

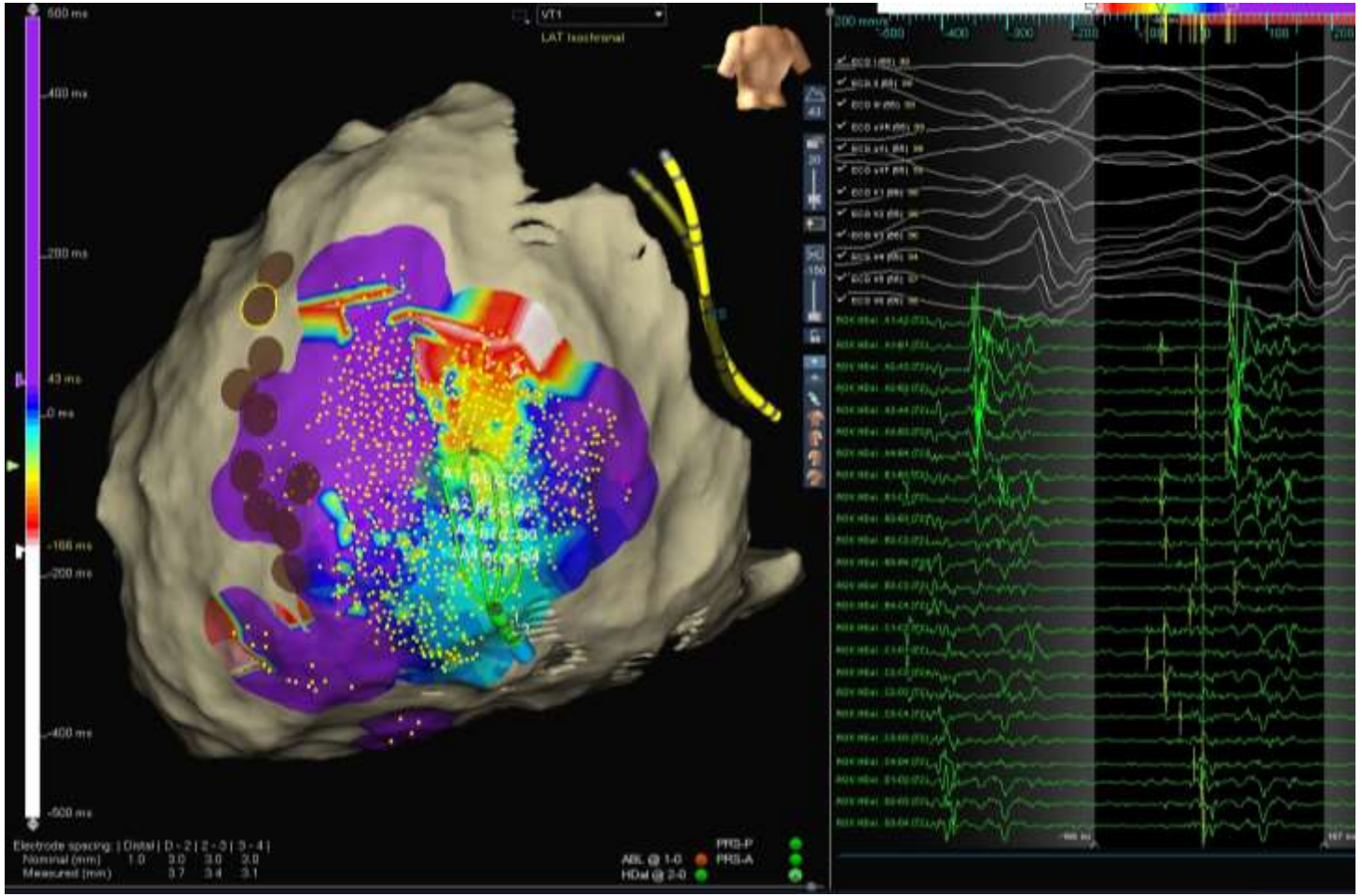
LP map



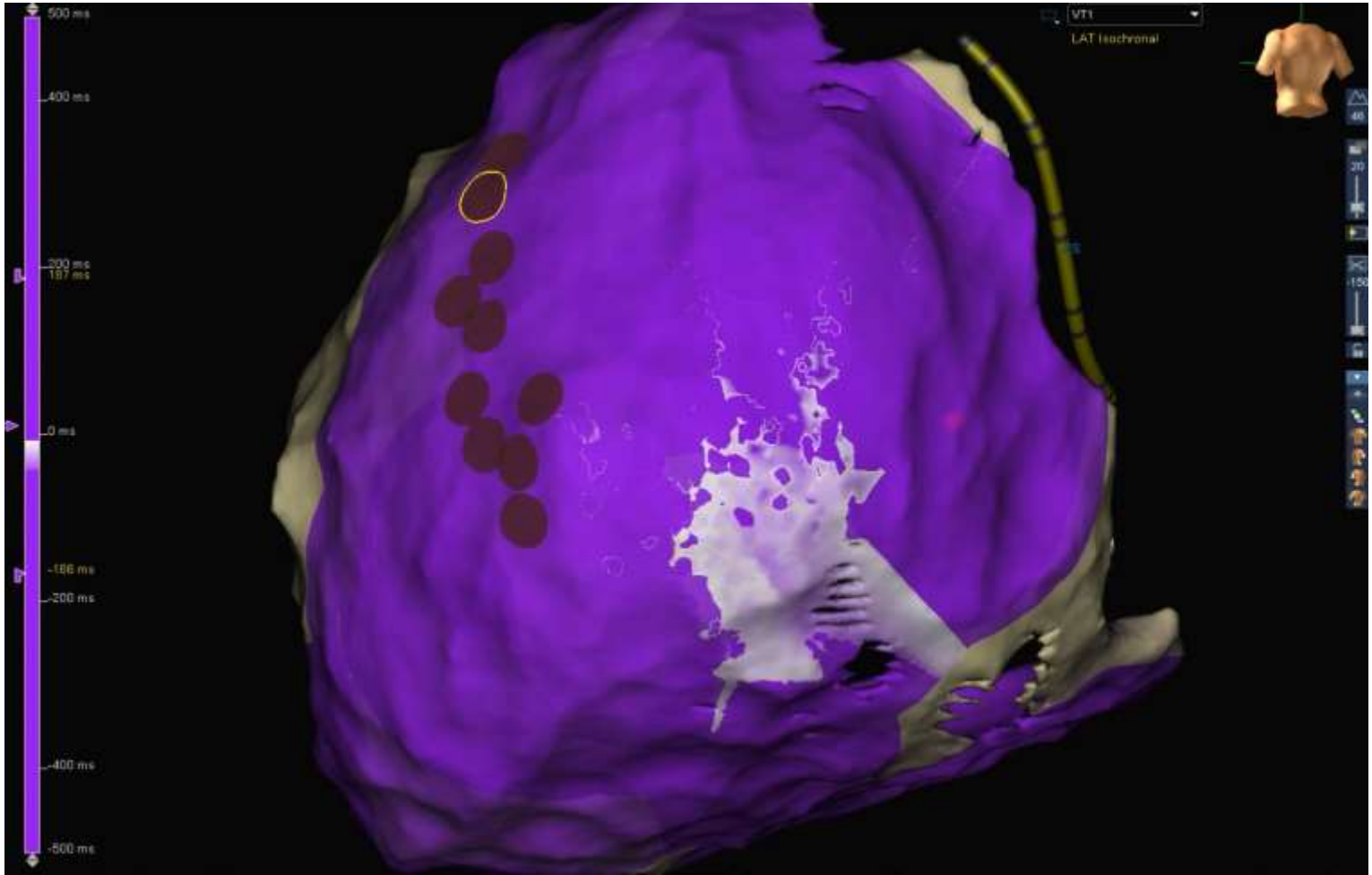
During VT


VT1
LAT Isochronal
500 ms
400 ms
200 ms
43 ms
0 ms
-100 ms
-200 ms
-400 ms
-500 ms
Electrode spacing | Distal | D - 2 | 2 - 3 | 3 - 4 |
PRS-P
Entrance

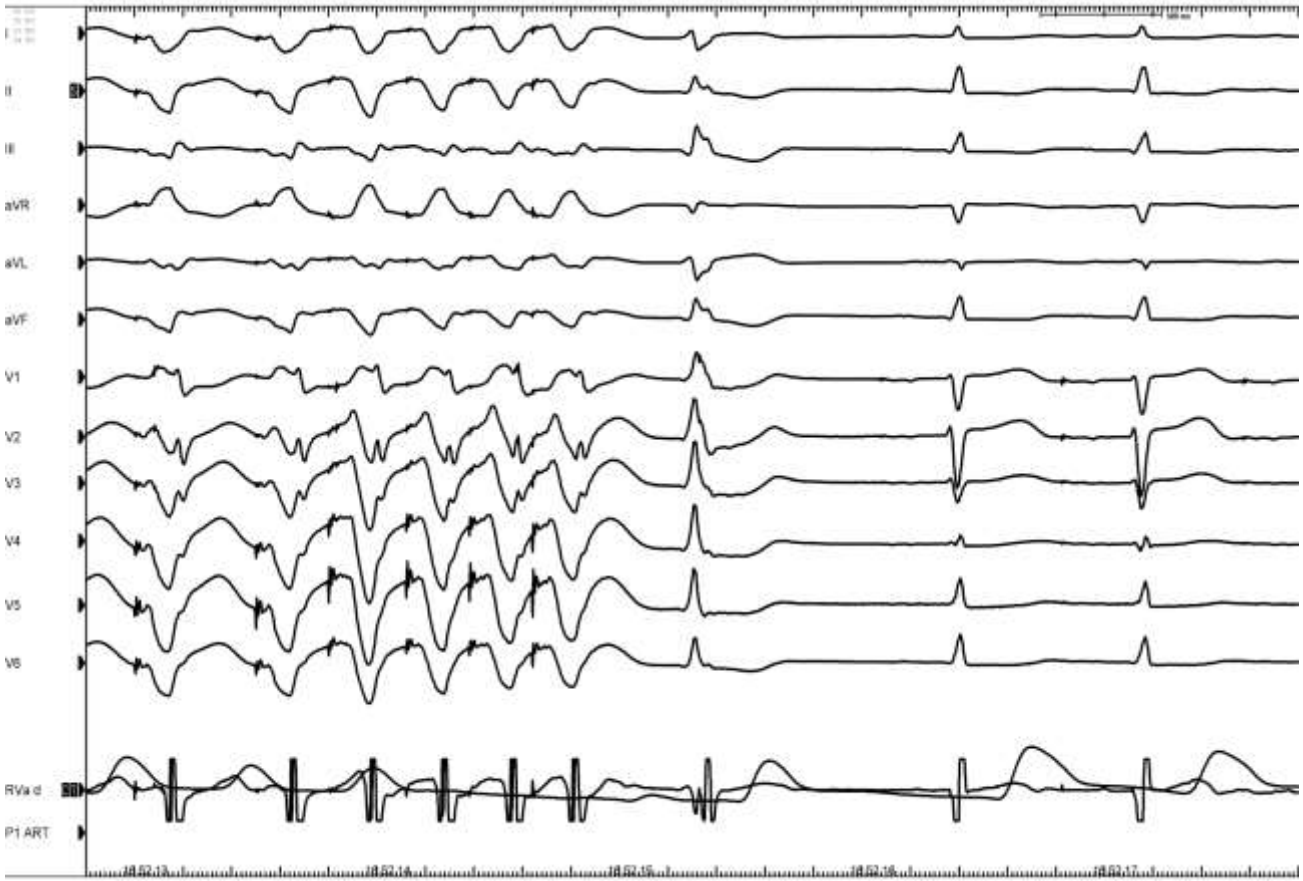
During VT


VT1
LAT Isoforenal
600 ms
400 ms
200 ms
43 ms
0 ms
-186 ms
-200 ms
-400 ms
-600 ms
Electrode spacing | Distal | D - 2 | 2 - 3 | 3 - 4 |
Nominal (mm) 1.0 3.0 3.0 3.0
Measured (mm) 3.7 3.4 3.1
ABL @ 1-0
HDal @ 2-0
PRS-P
PRS-A
200 ms/
Exit

Propagation map



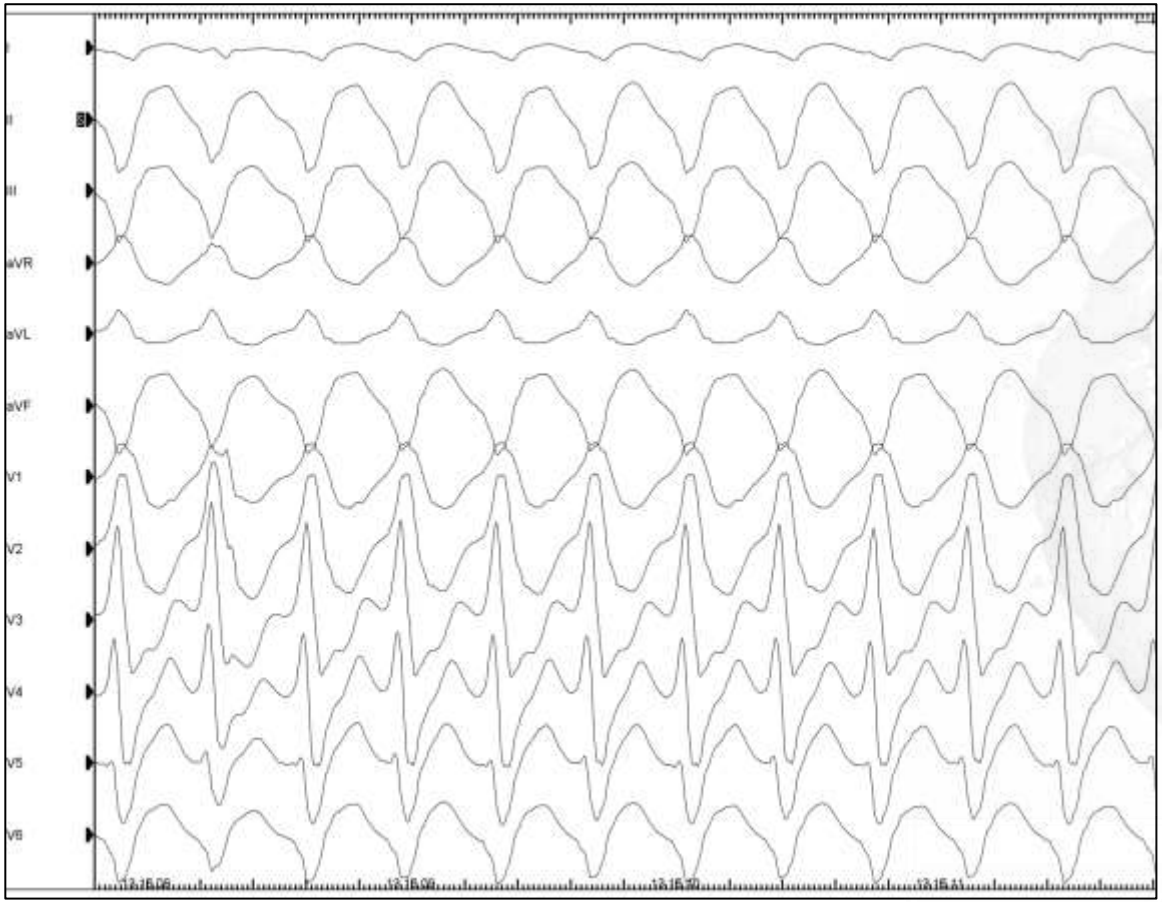
Re-induction



4 *HD substrate mapping but where ?*

EPI vs ENDO

Clinical case



48y

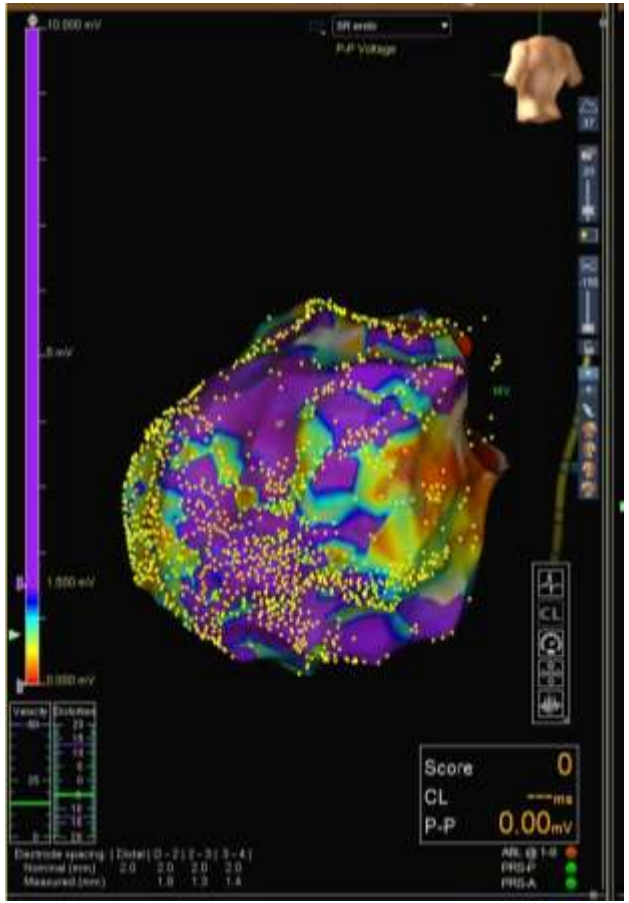
Previous **MI** (2013).

LVEF: 38%

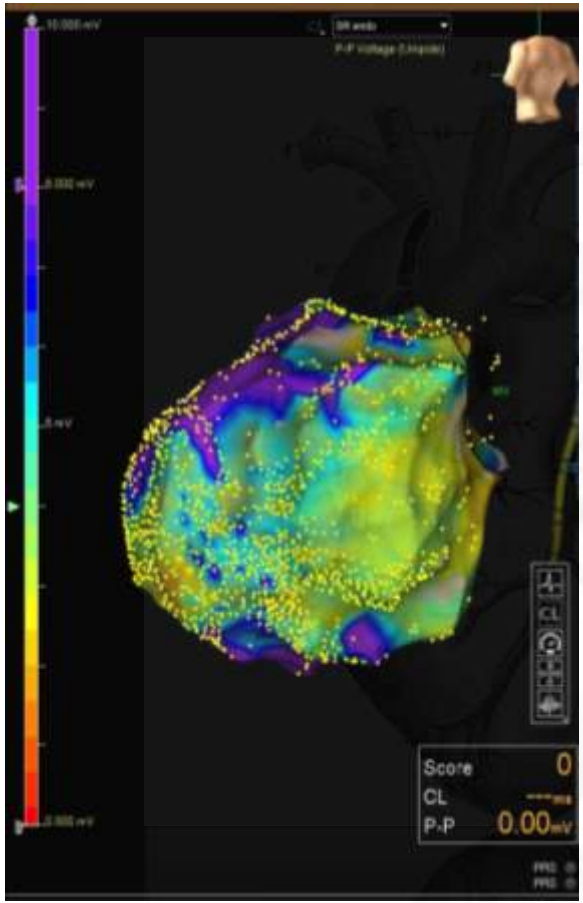
VT recurrences on Amiodarone causing ICD shocks after uneffective ATP delivery.

CMR scar in the infero-lateral wall of the LV

Clinical case

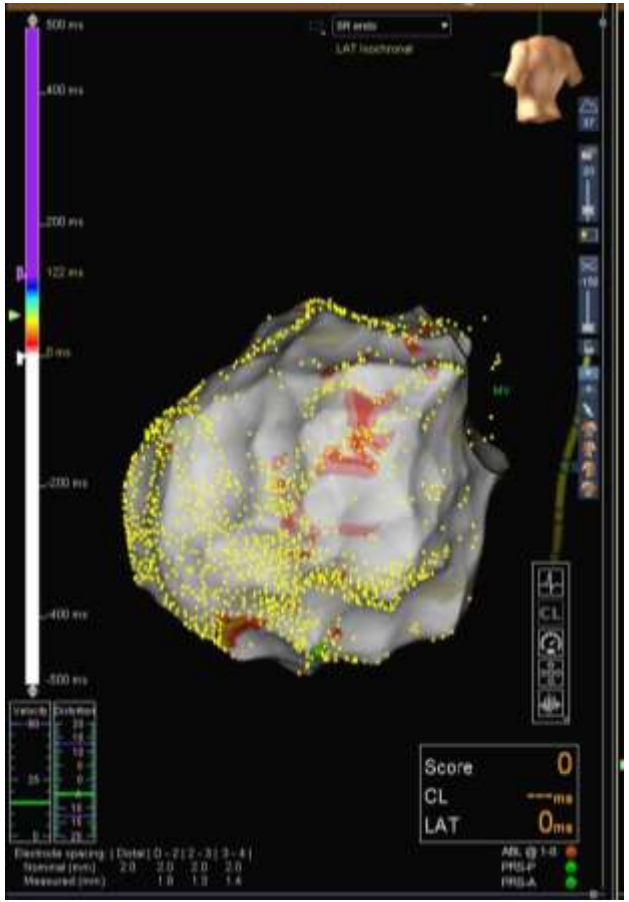


BIPOLAR MAP



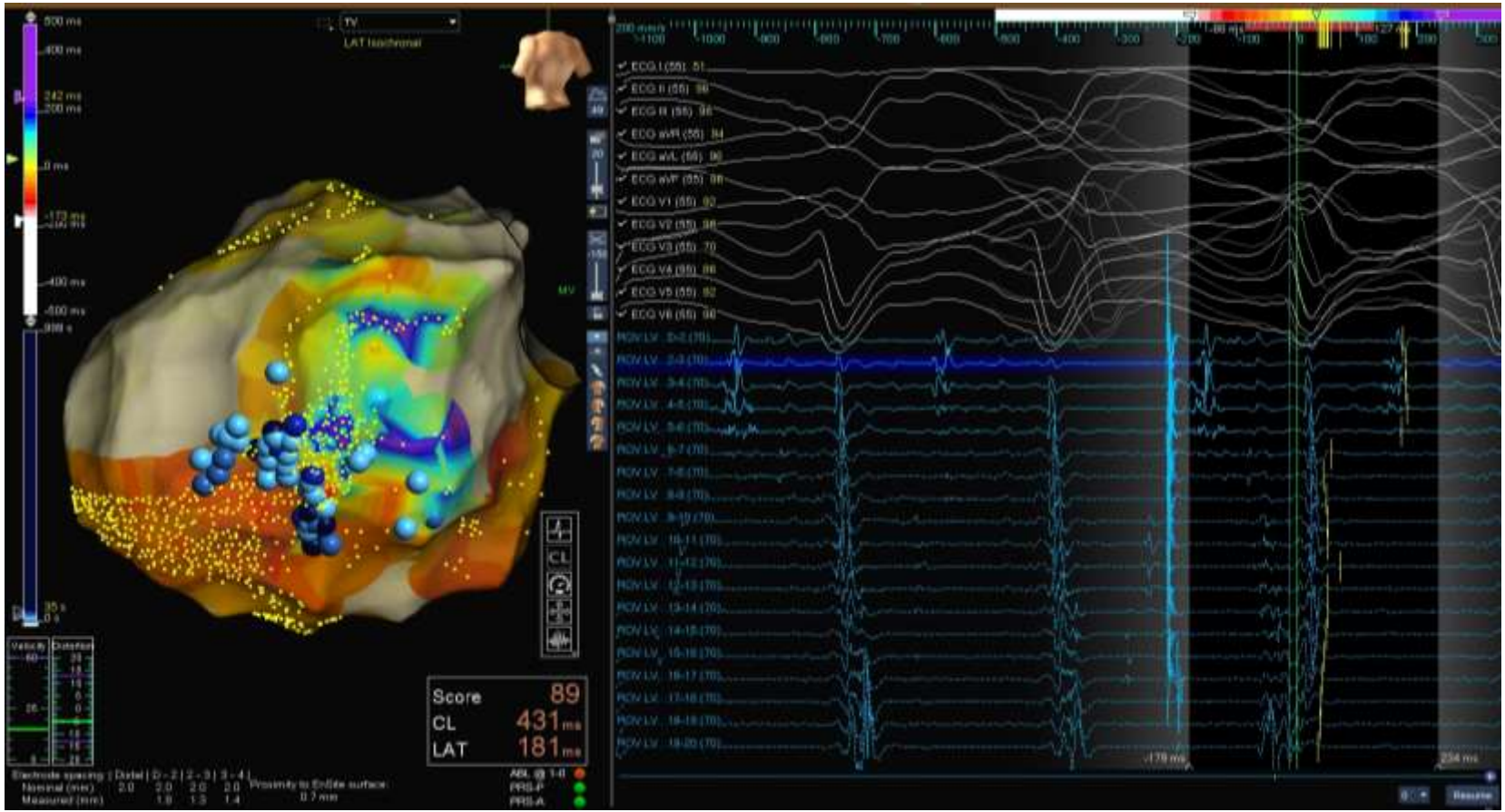
UNIPOLAR MAP

Clinical case

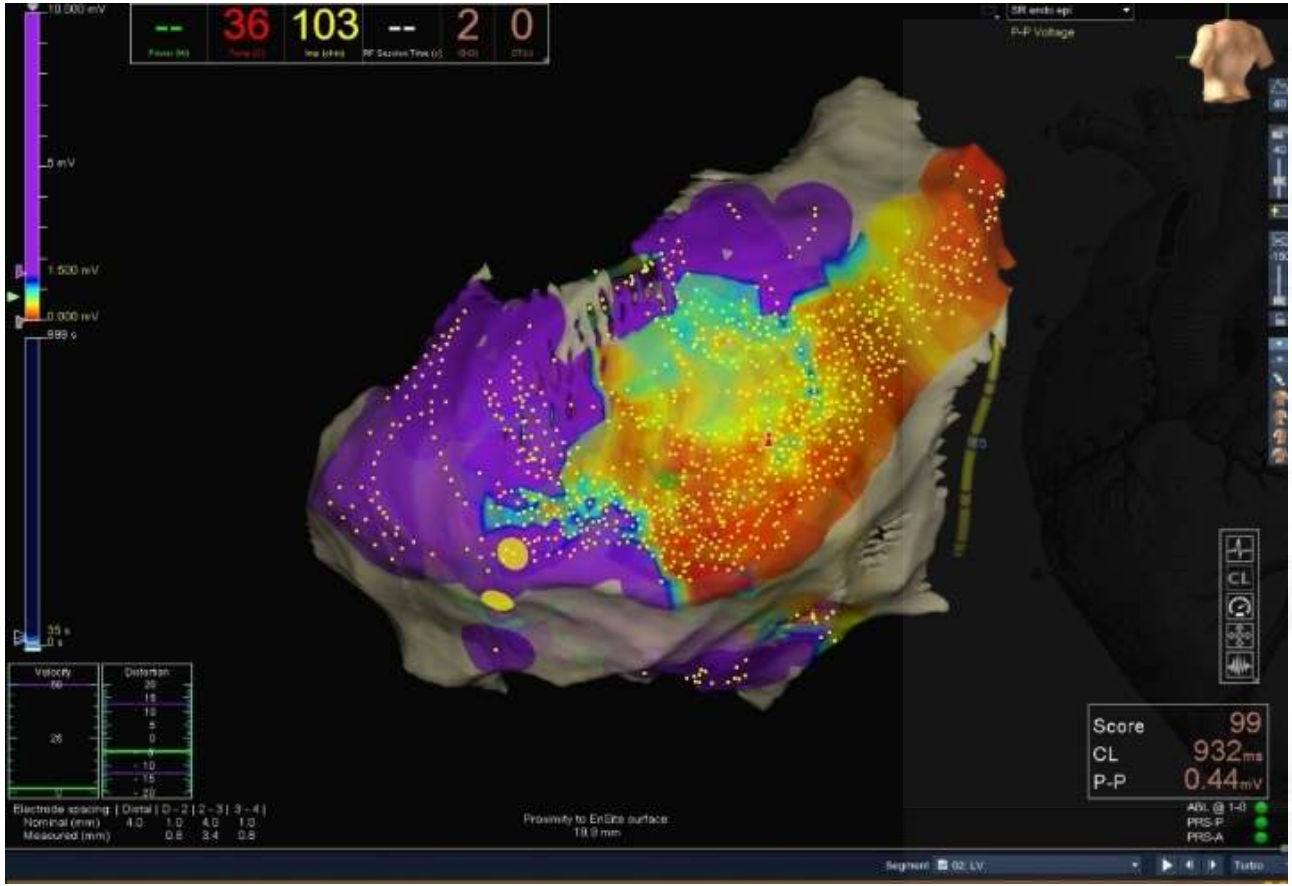


LATE POTENTIAL MAP

During VT (endo)

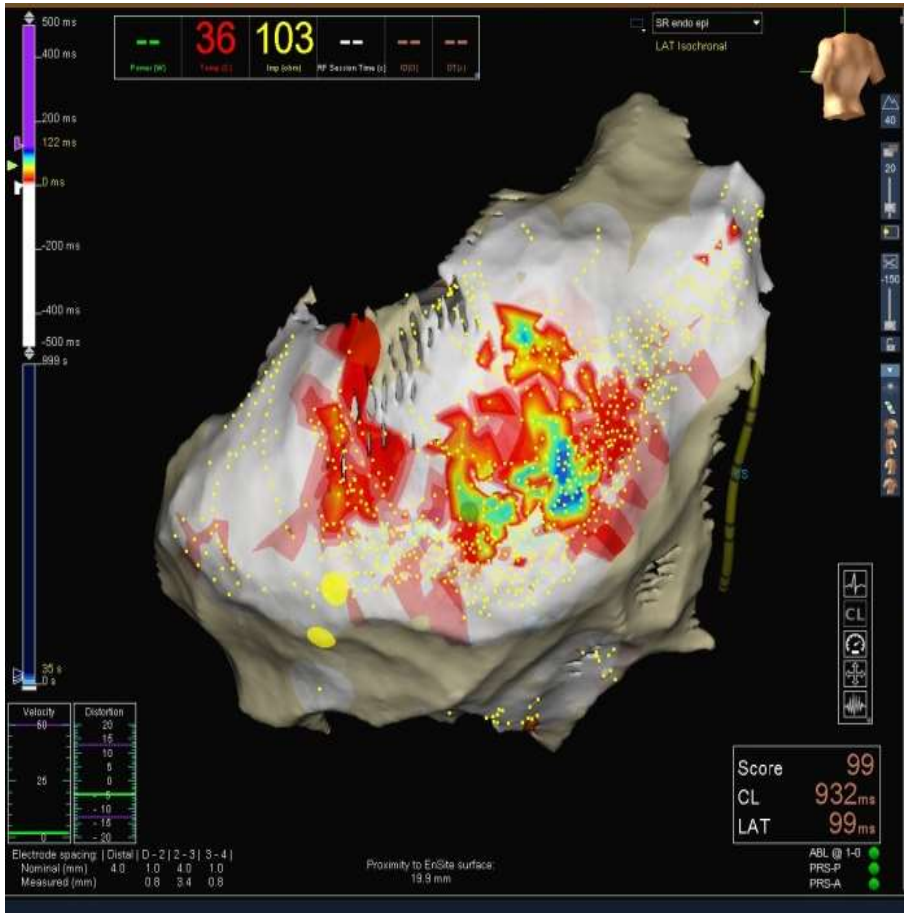


Epicardial Mapping



BIPOLAR MAP

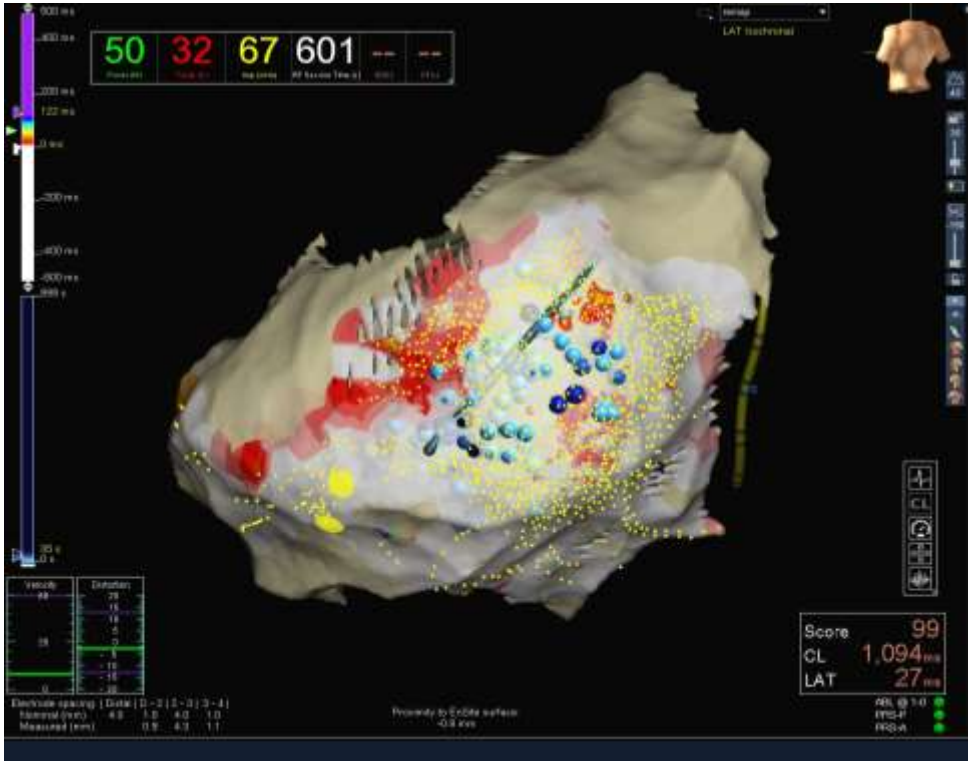
Epicardial Mapping



Late potentials map

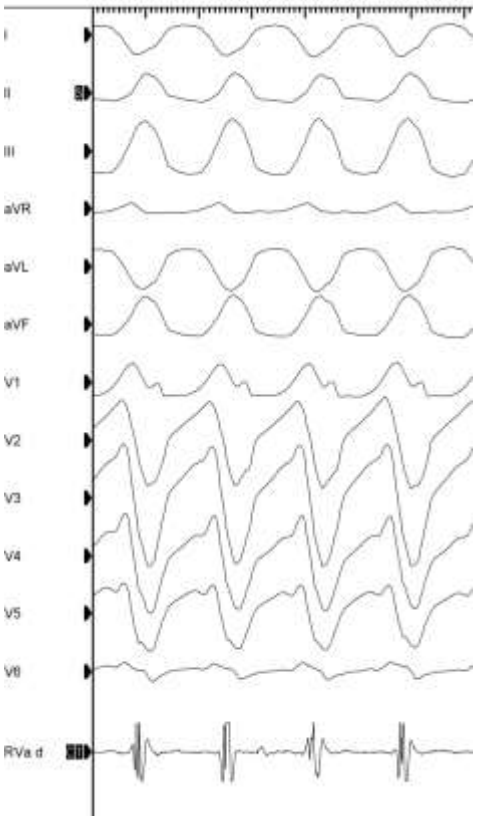
Epicardial (VT) Mapping

ReMap

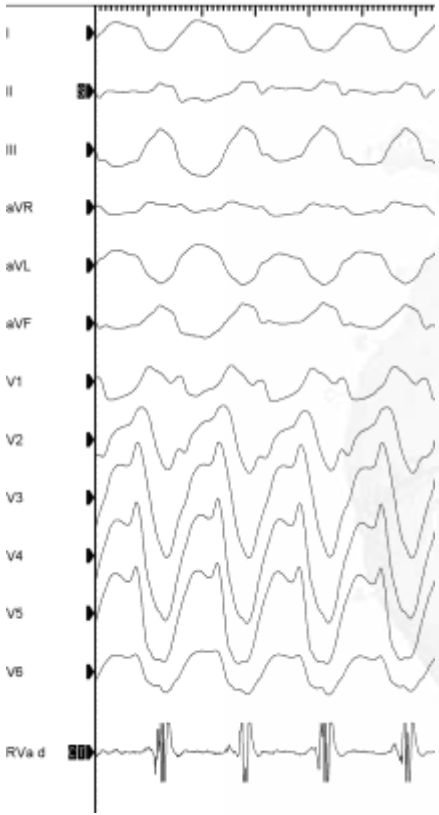


Re-re-Map

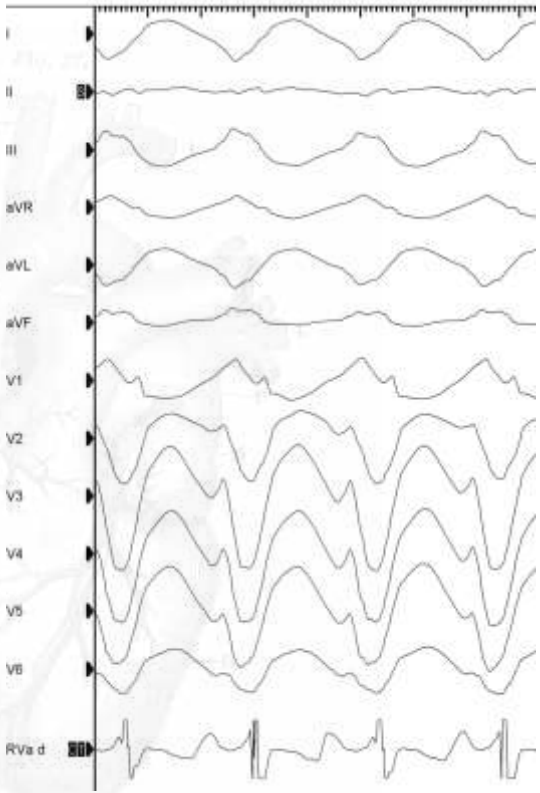
Another case



VT1 360 ms (induced at baseline EP study)

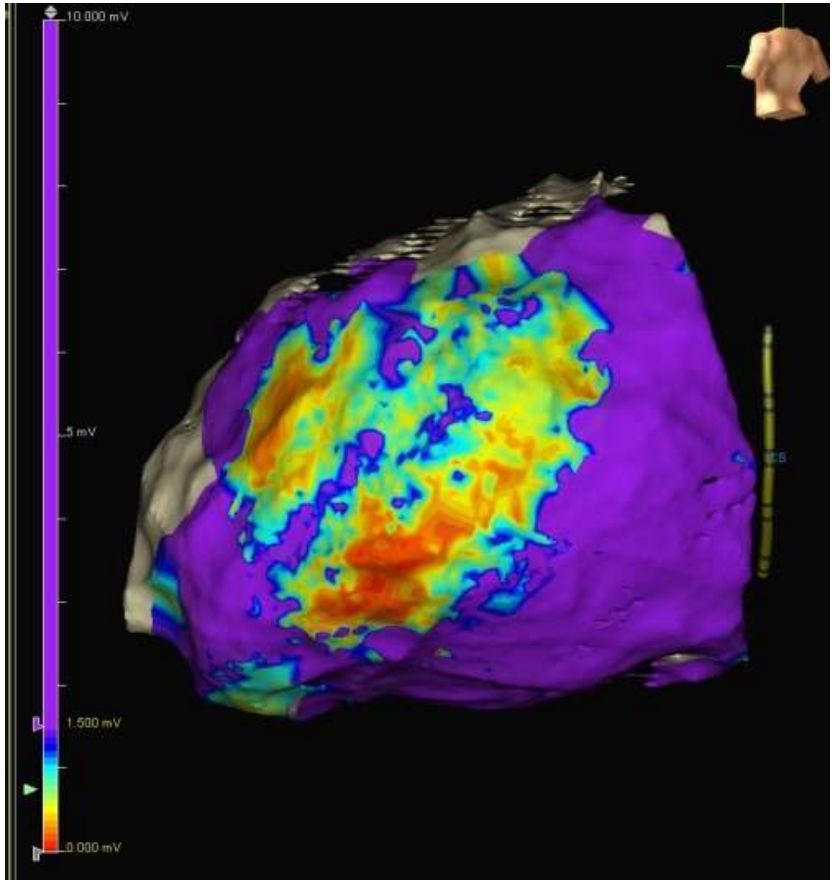


VT2 300 msec



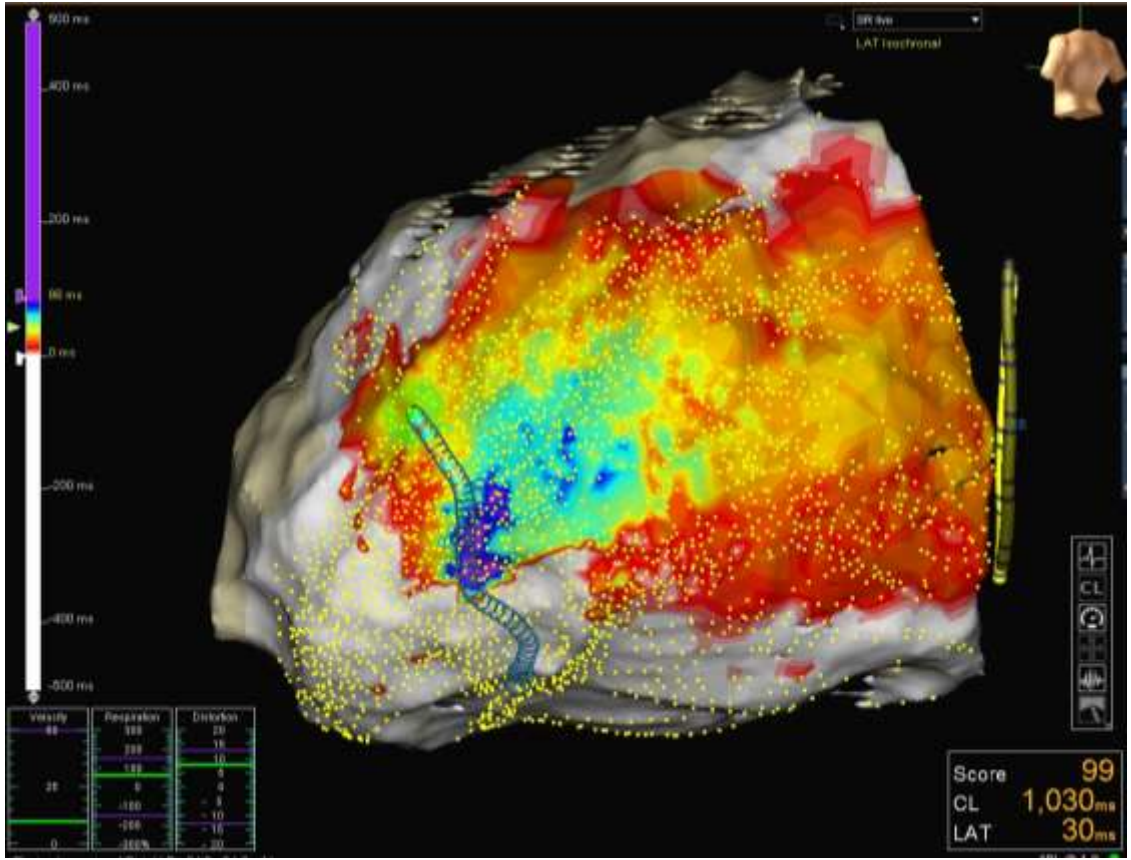
VT2 490 msec

Epicardial map

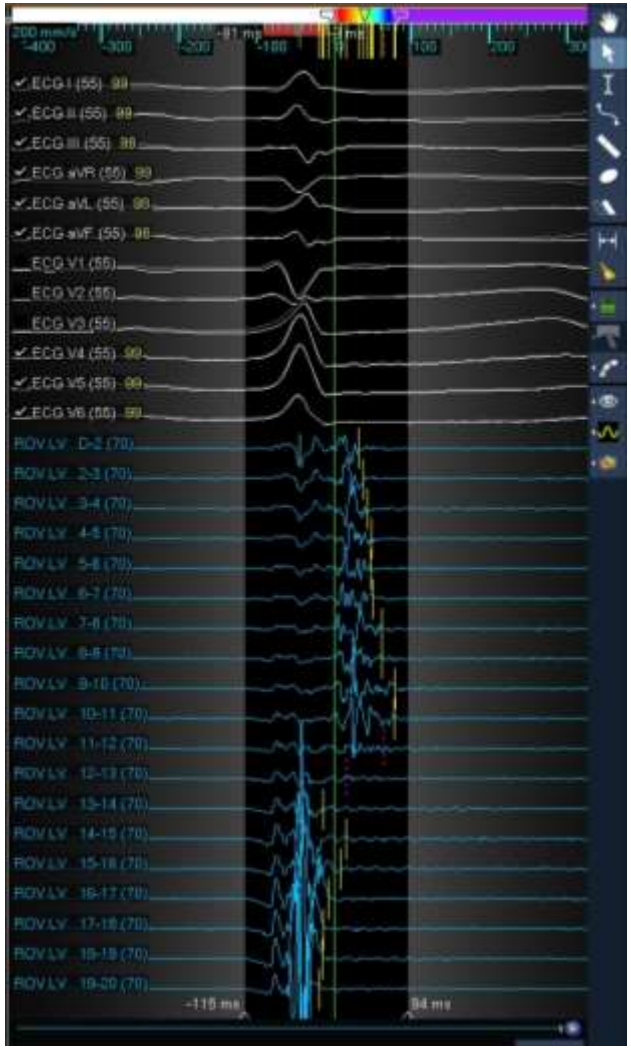


BIPOLAR MAP

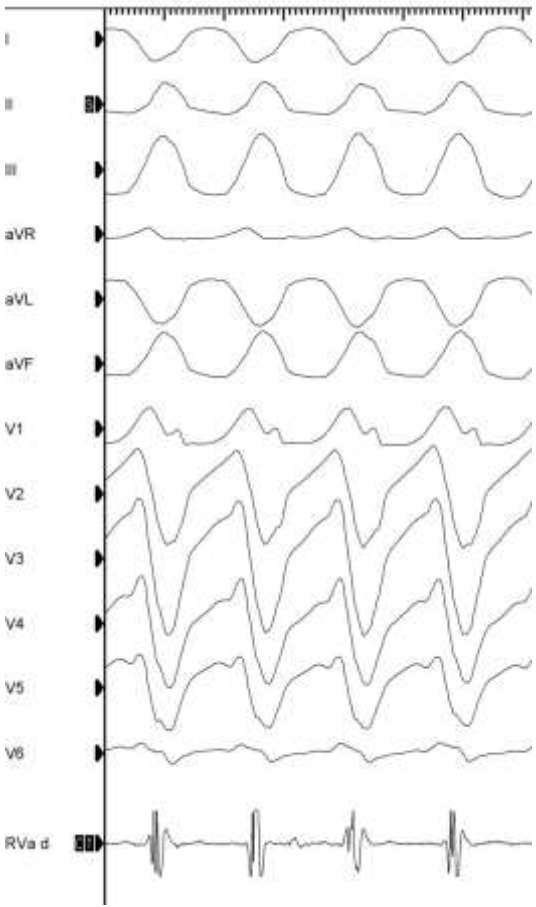
Epicardial map



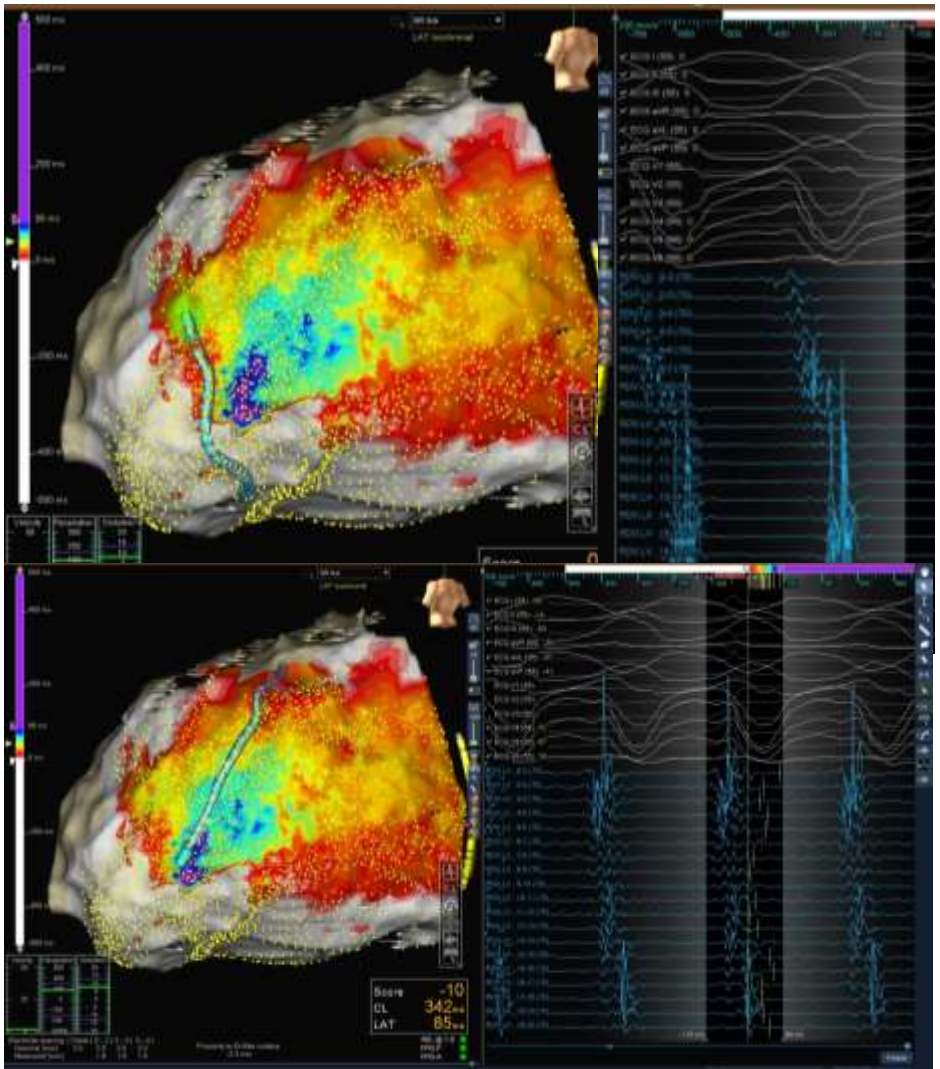
Late potentials map



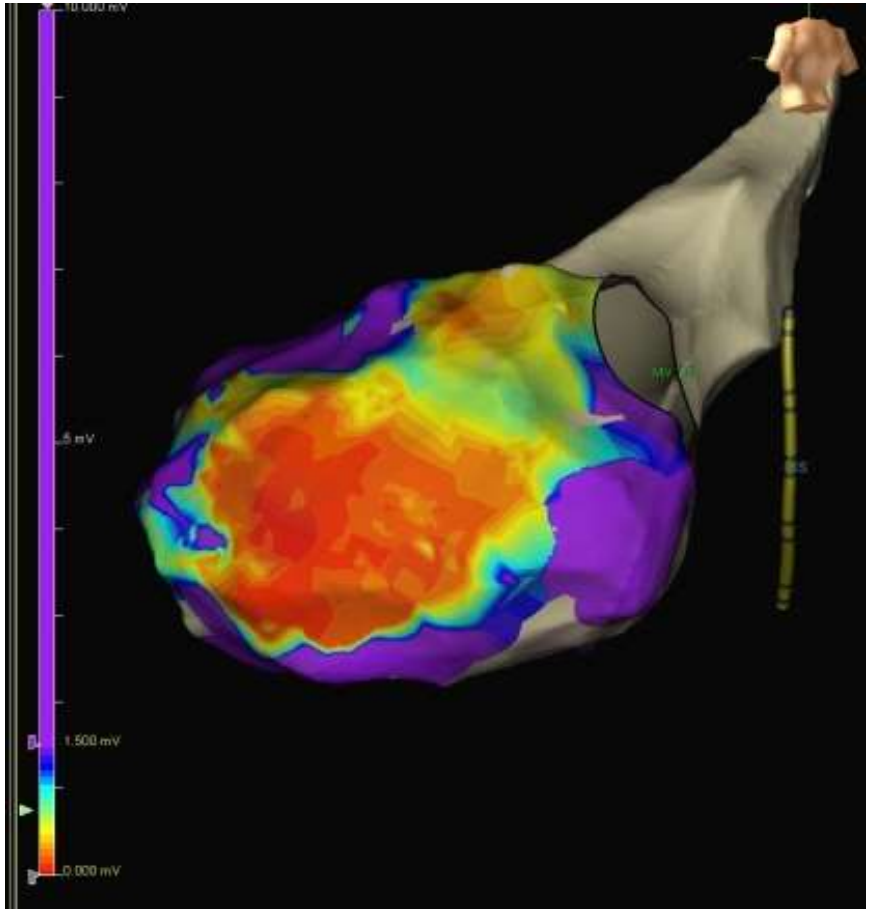
Epicardial map



VT1

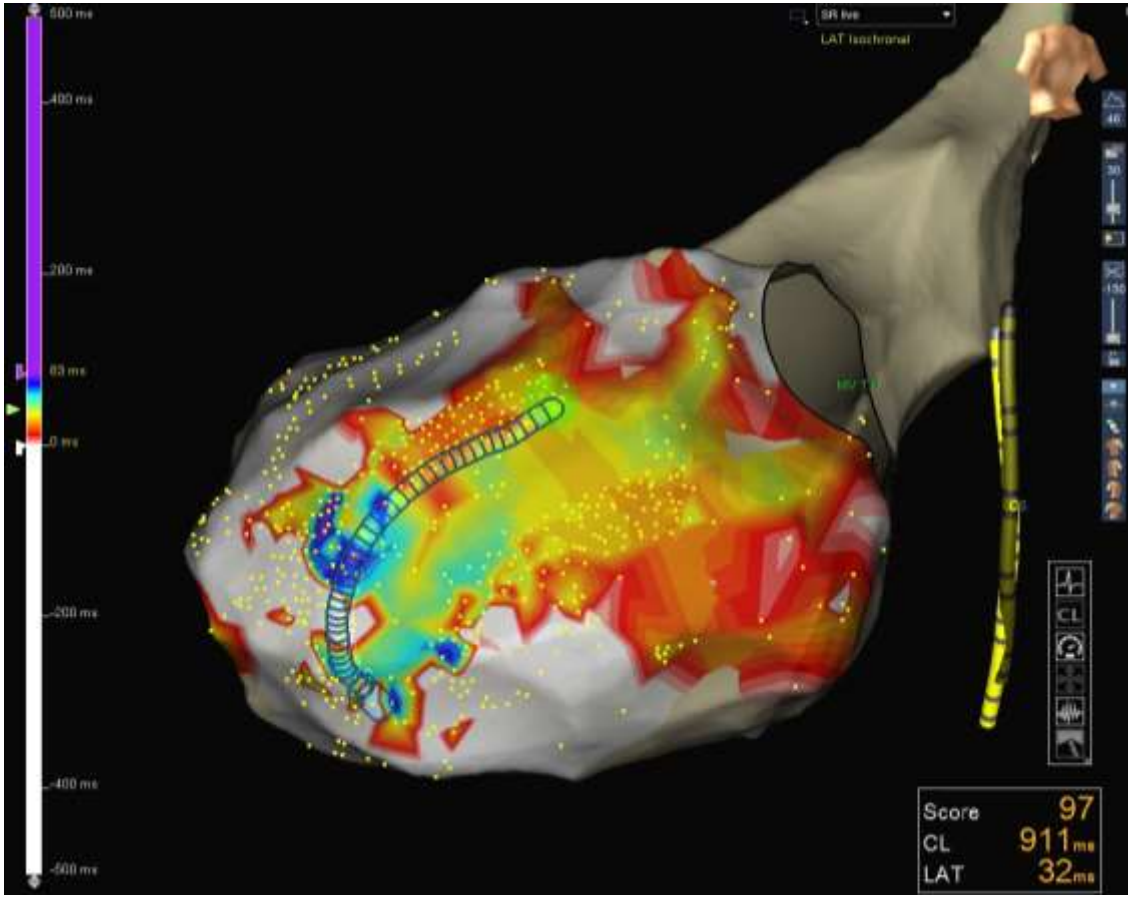


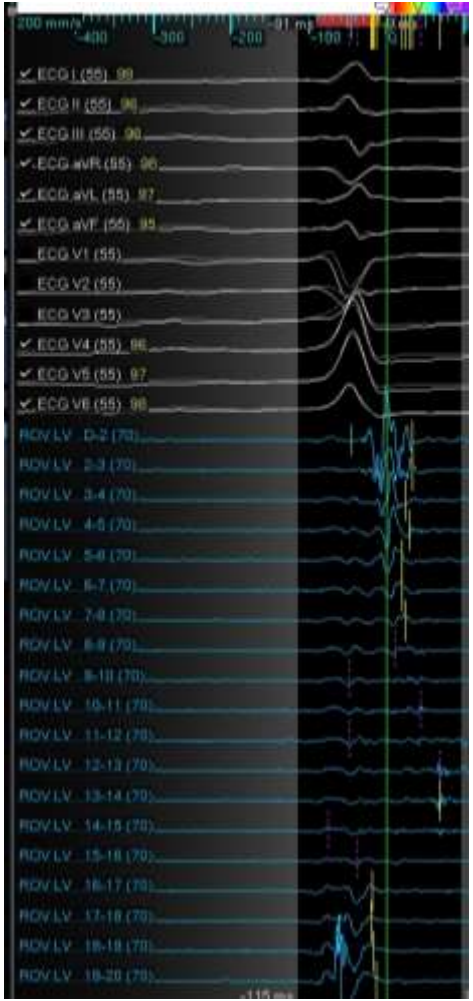
Switch to Endo



BIPOLAR MAP

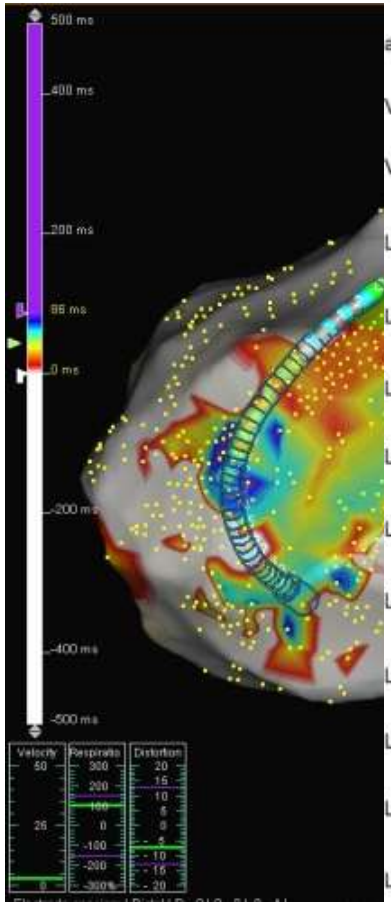
Switch to Endo

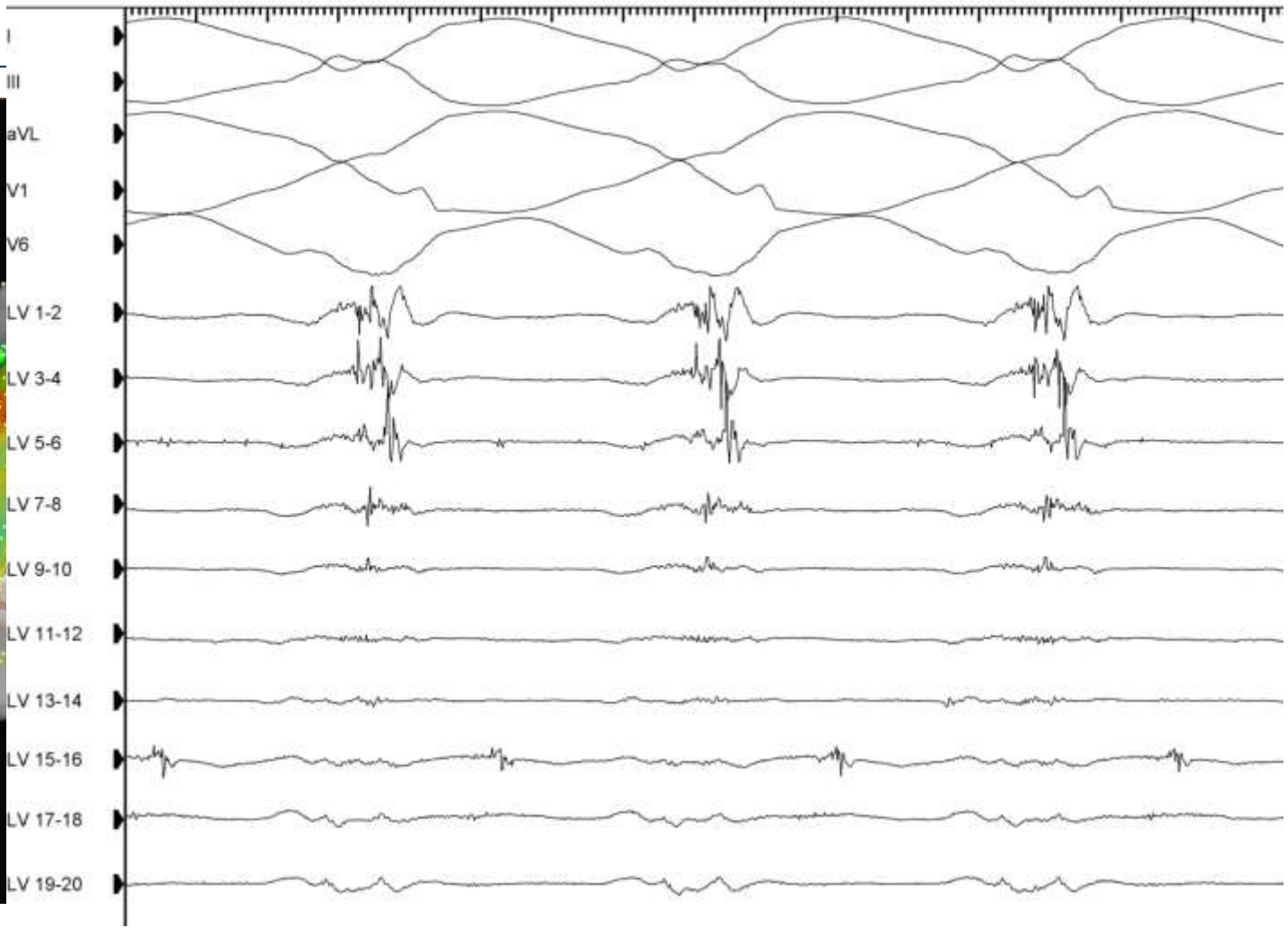




Late potentials map

Switch to Endo

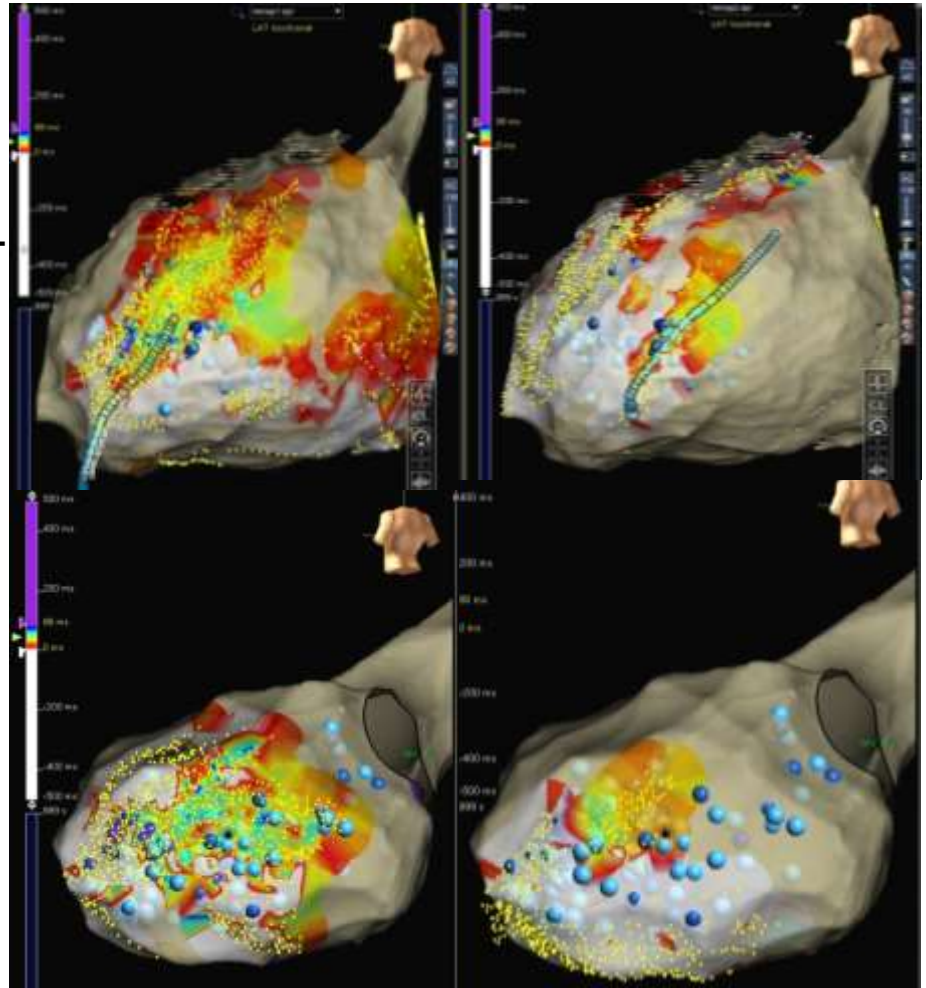




Recap

Epi

Endo

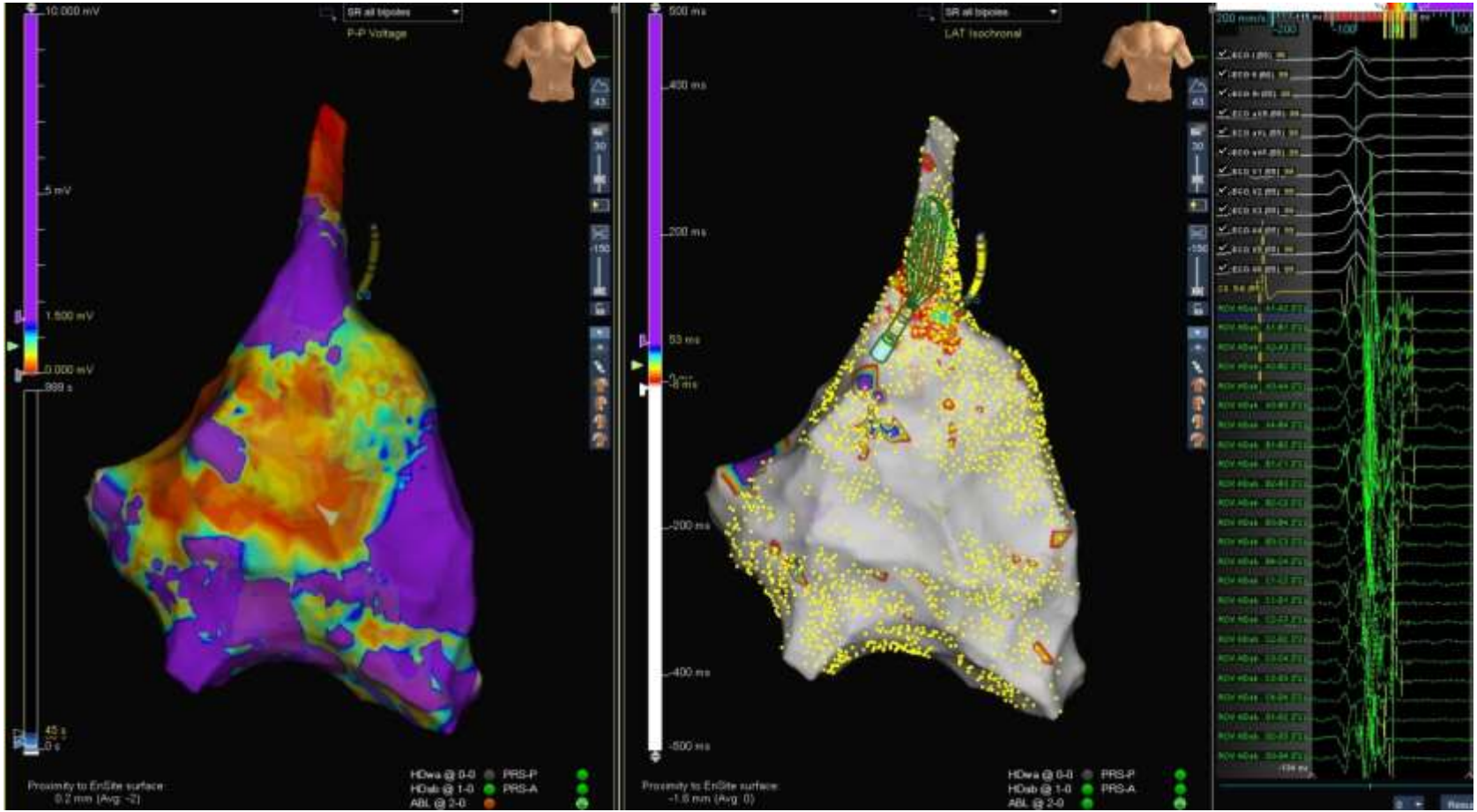


Limitations of substrate mapping

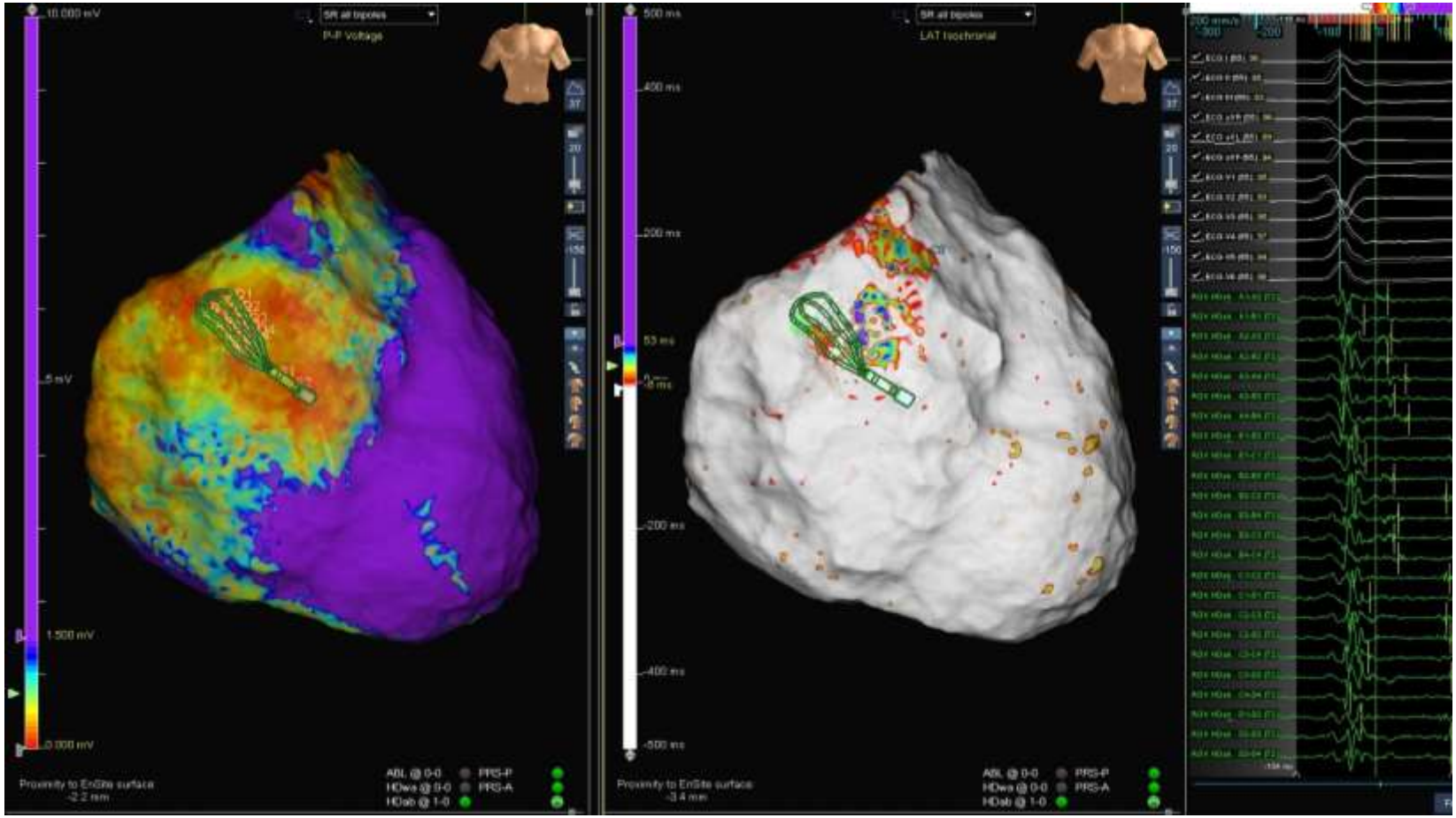
1 **Late potentials.**

Always correlated with the target area?

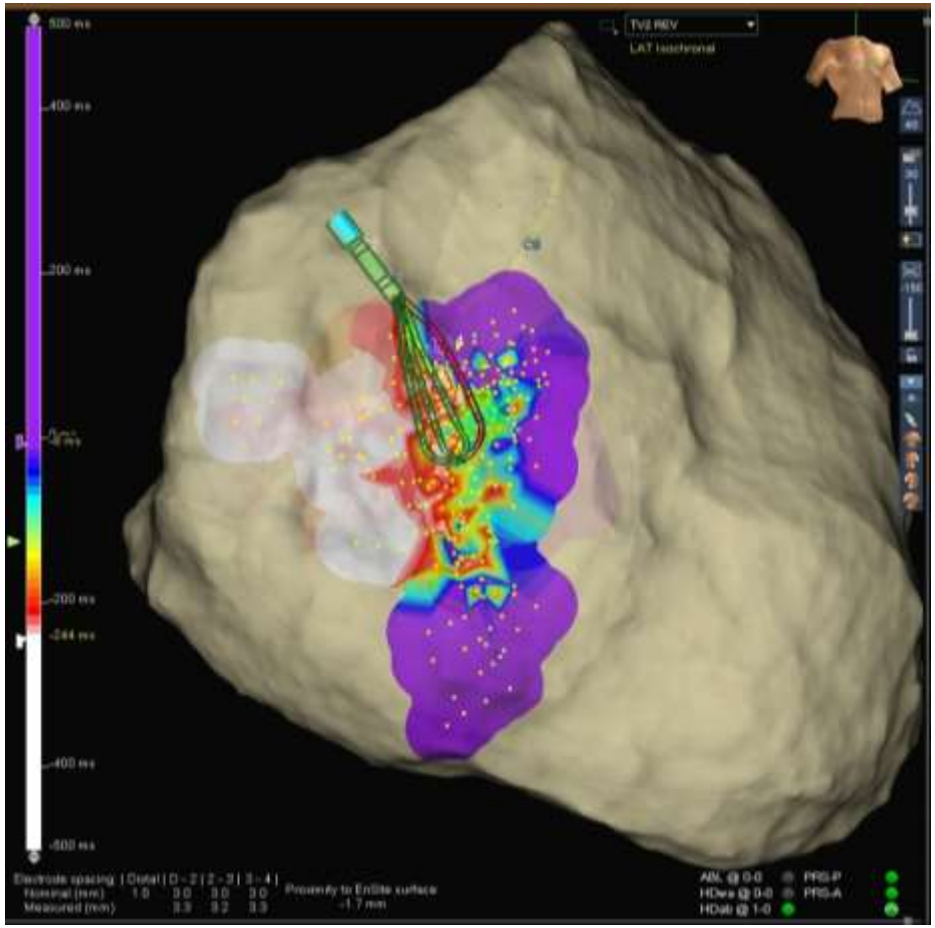
Endo

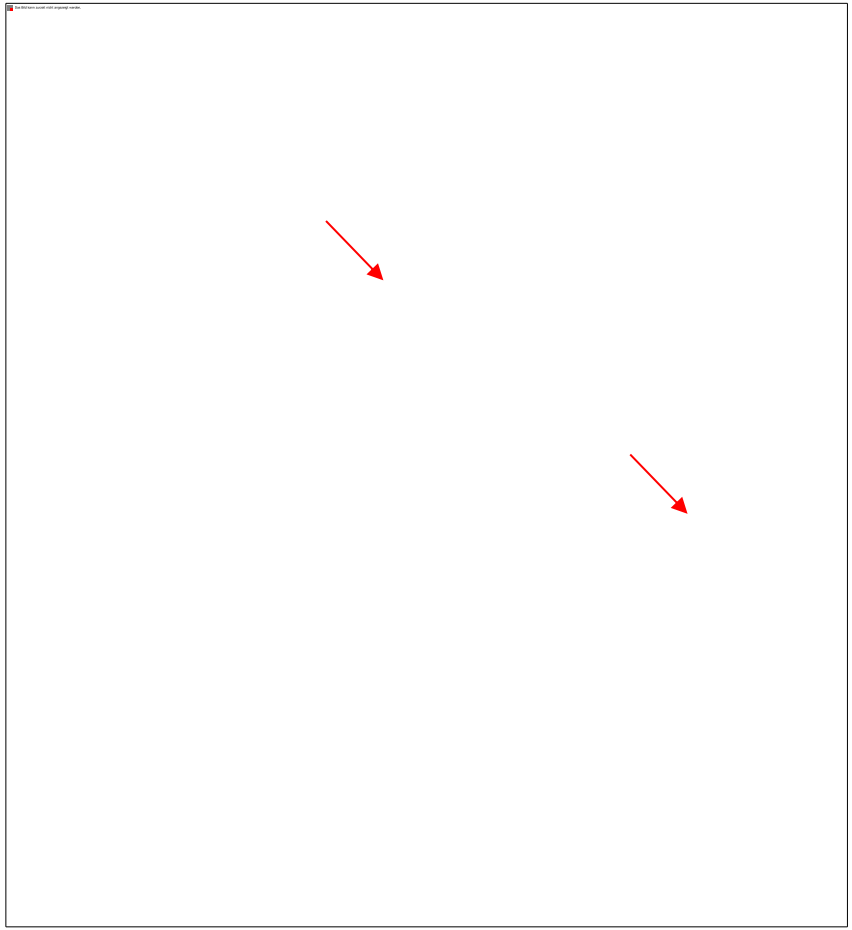

10.000 mV
SR all bipoles
P-P Voltage
5 mV
1.500 mV
0.000 mV
999 s
45 s
0 s
Proximity to EnSite surface
0.2 mm (Avg: -2)
HDwa @ 0-0
HDab @ 1-0
ABL @ 2-0
PRS-P
PRS-A
500 ms
SR all bipoles
LAT Isochronal
400 ms
200 ms
53 ms
-8 ms
-200 ms
-400 ms
-500 ms
Proximity to EnSite surface
-1.0 mm (Avg: 0)
HDwa @ 0-0
HDab @ 1-0
ABL @ 2-0
PRS-P
PRS-A

Epi

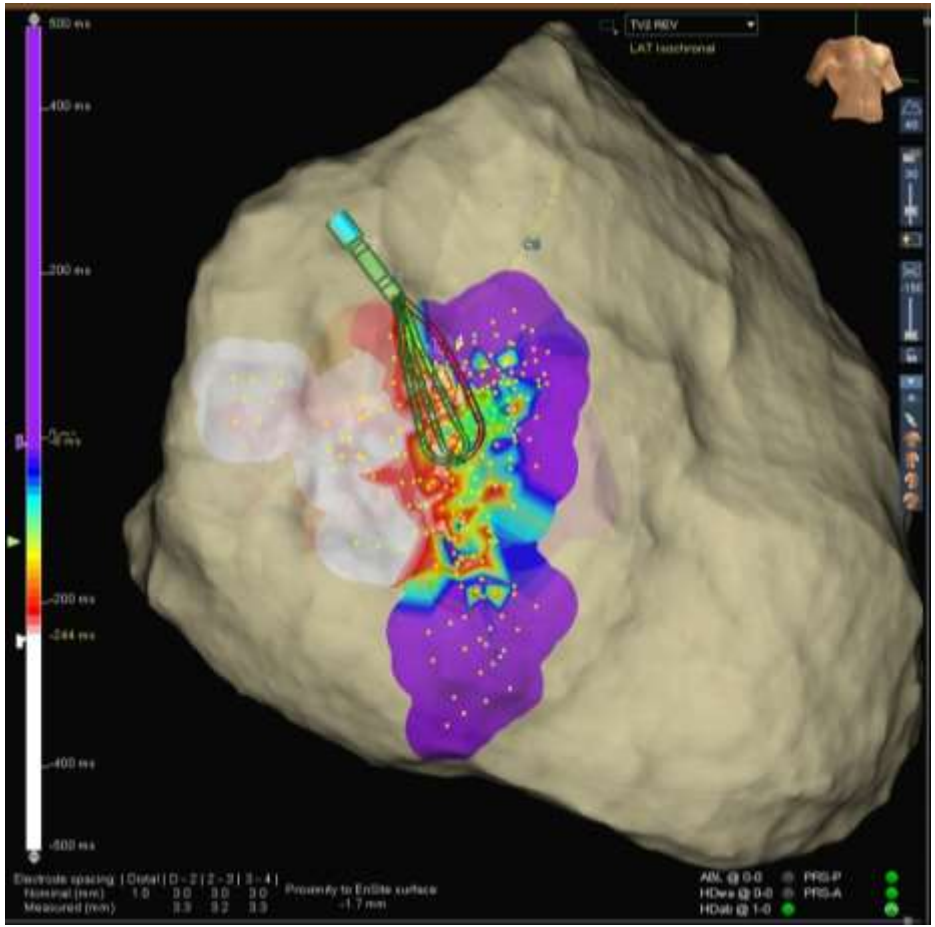

SR all bipoles
P-P Voltage
10.000 mV
1.500 mV
0.000 mV
Proximity to EnSite surface
-2.2 mm
ABL @ 0-0
HDwa @ 0-0
HDab @ 1-0
PRS-P
PRS-A
SR all bipoles
LAT Isochronal
500 ms
400 ms
200 ms
53 ms
-200 ms
-400 ms
-500 ms
Proximity to EnSite surface
-3.4 mm
ABL @ 0-0
HDwa @ 0-0
HDab @ 1-0
PRS-P
PRS-A

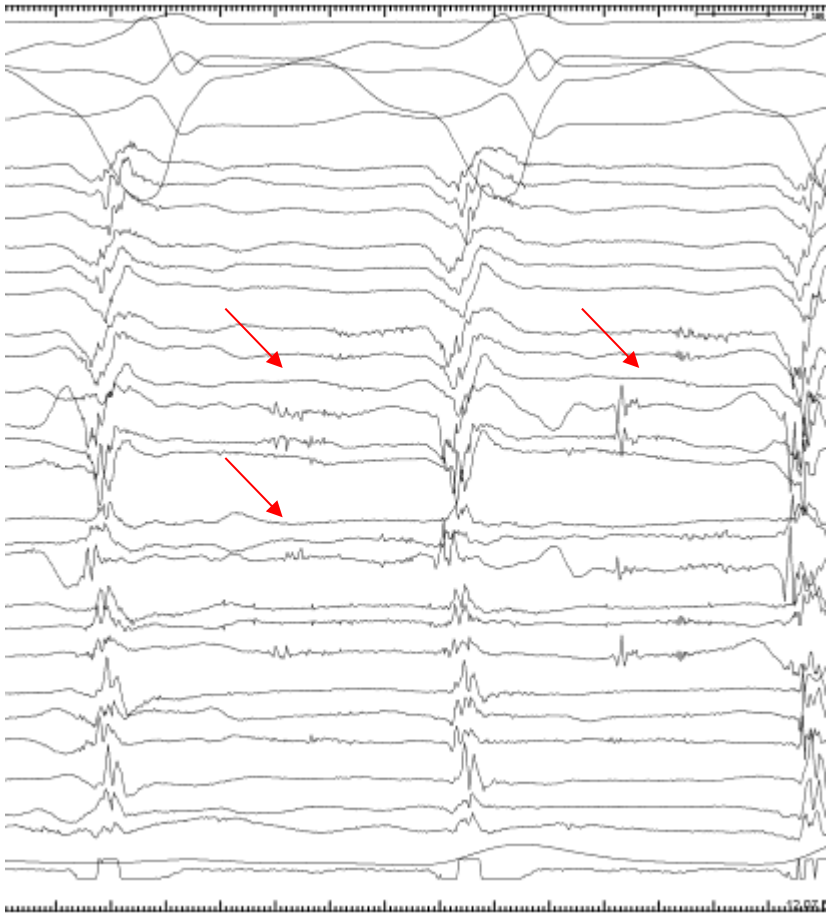
Entrance


TVI REV
LAT Isochronal
500 ms
400 ms
200 ms
-244 ms
-400 ms
-500 ms
Proximity to EnSite surface
-1.7 mm

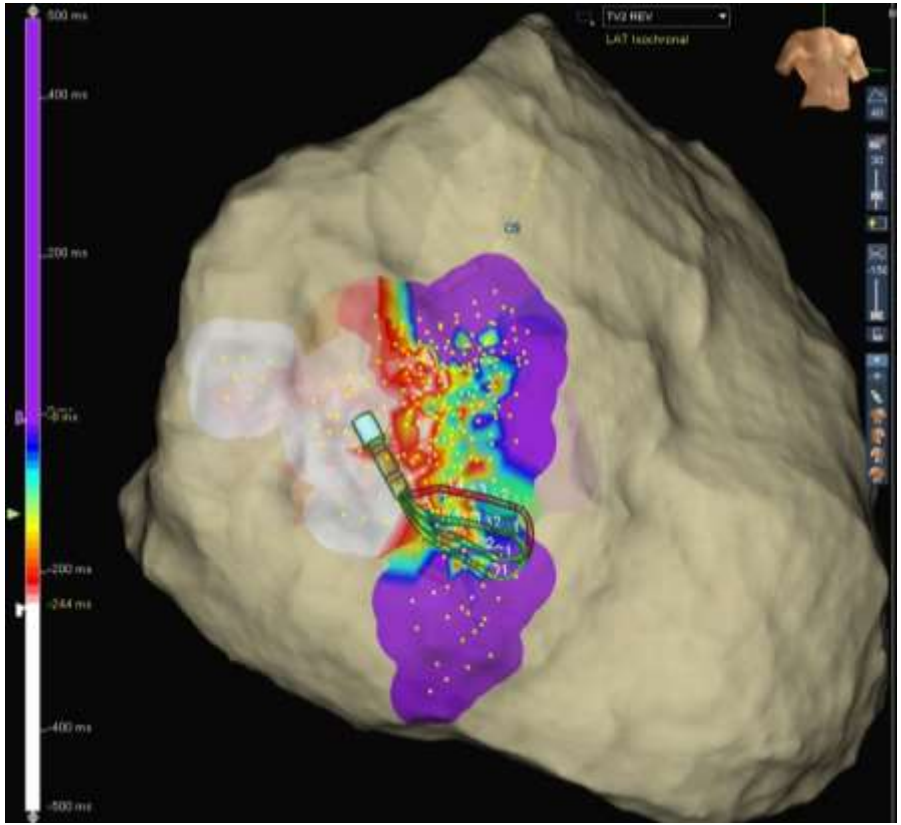


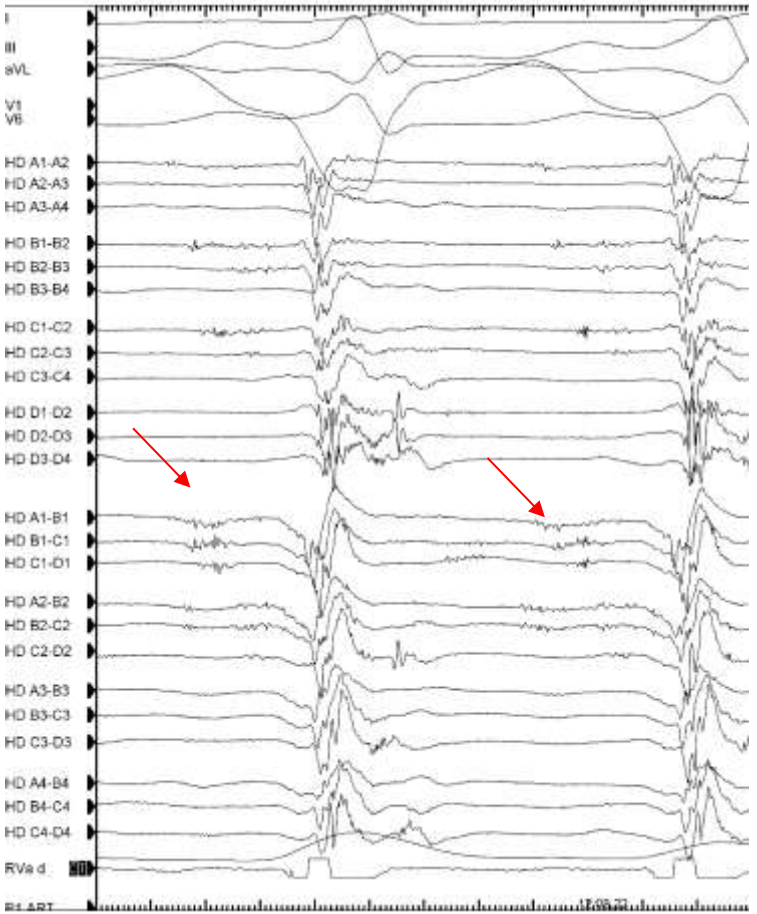
Isthmus



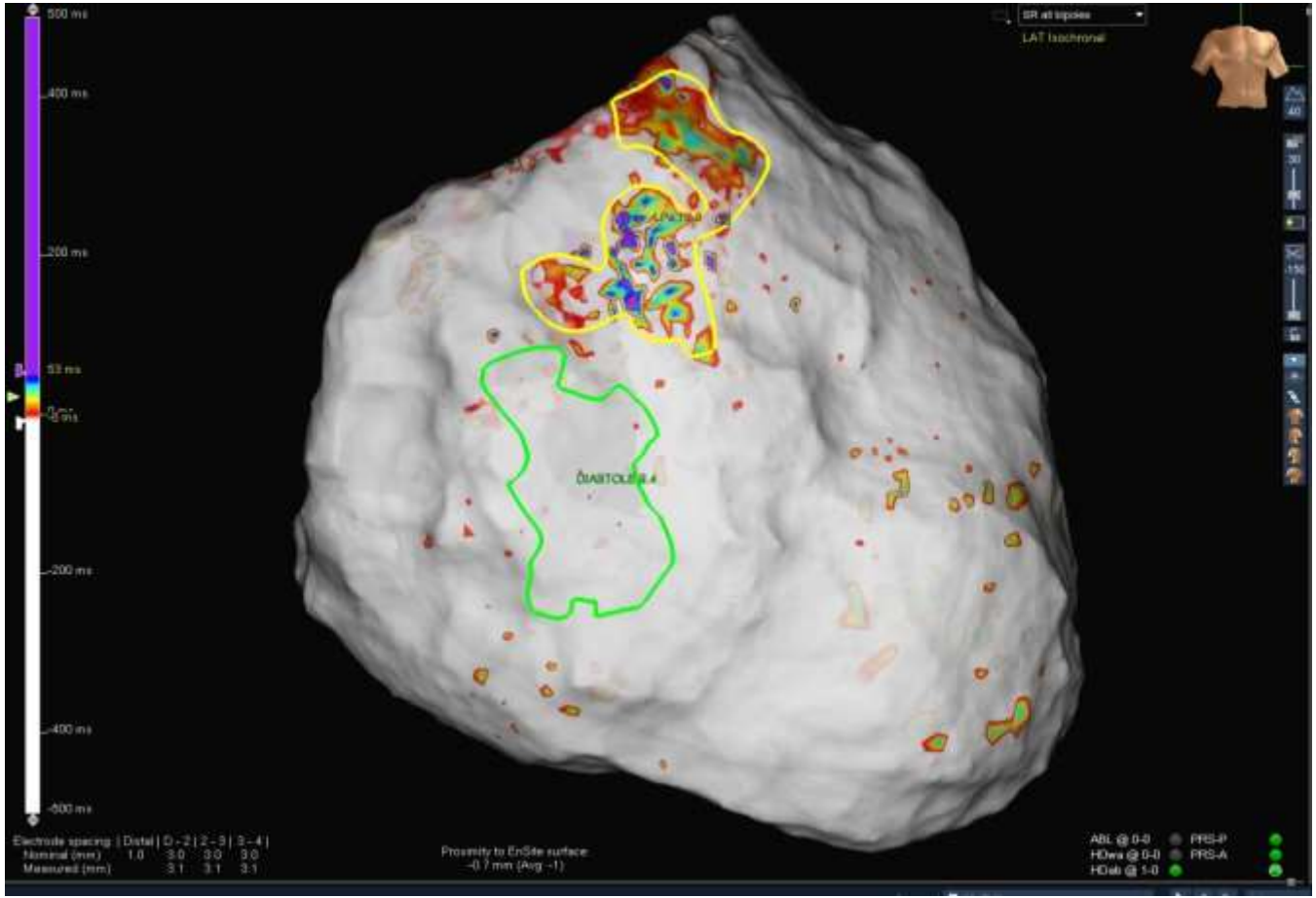


Exit

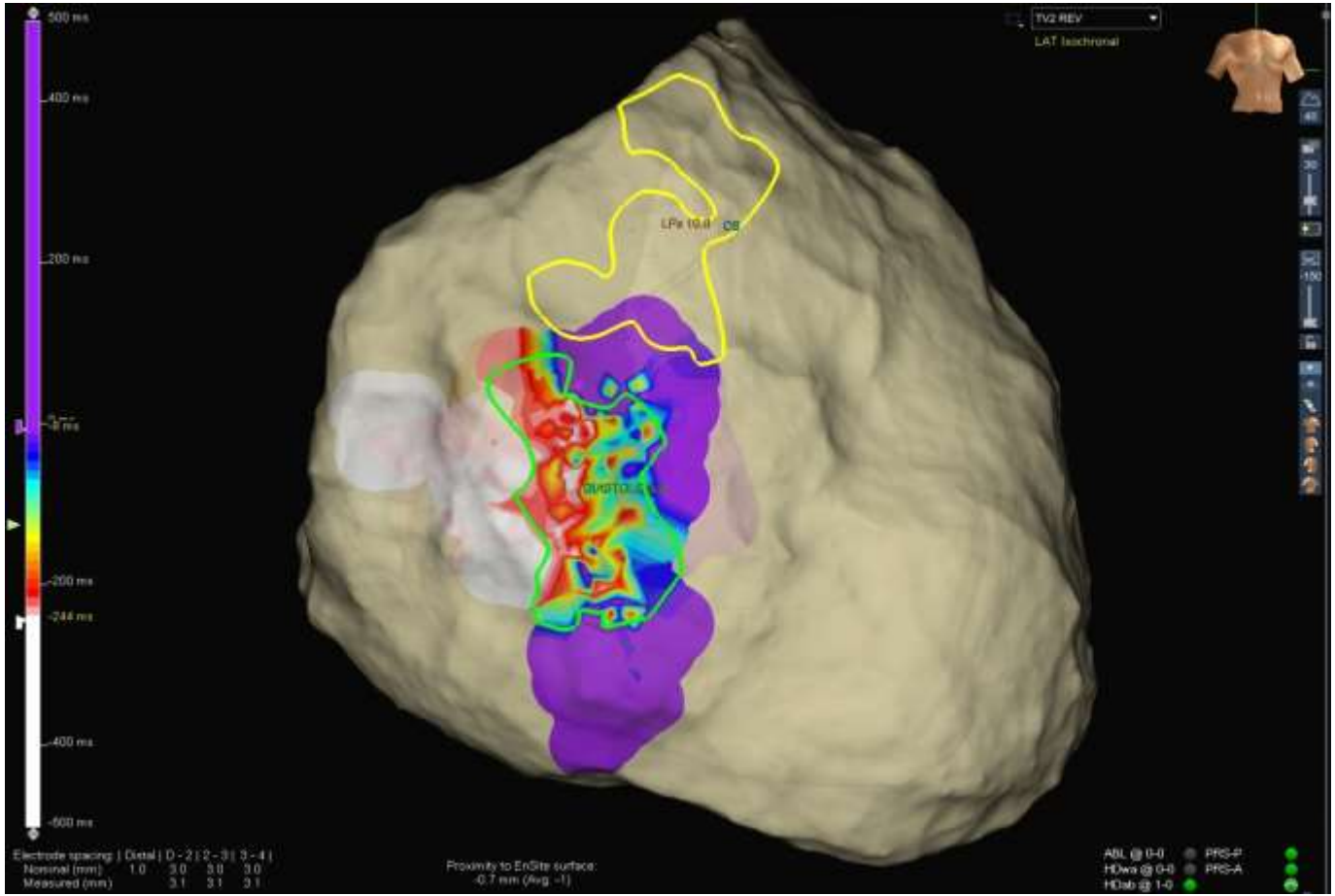

500 ms
400 ms
200 ms
0 ms
-200 ms
-244 ms
-400 ms
-500 ms
TV2 REV
LAT Isochronal


I
II
aVL
V1
V6
HD A1-A2
HD A2-A3
HD A3-A4
HD B1-B2
HD B2-B3
HD B3-B4
HD C1-C2
HD C2-C3
HD C3-C4
HD D1-D2
HD D2-D3
HD D3-D4
HD A1-B1
HD B1-C1
HD C1-D1
HD A2-B2
HD B2-C2
HD C2-D2
HD A3-B3
HD B3-C3
HD C3-D3
HD A4-B4
HD B4-C4
HD C4-D4
RVa d

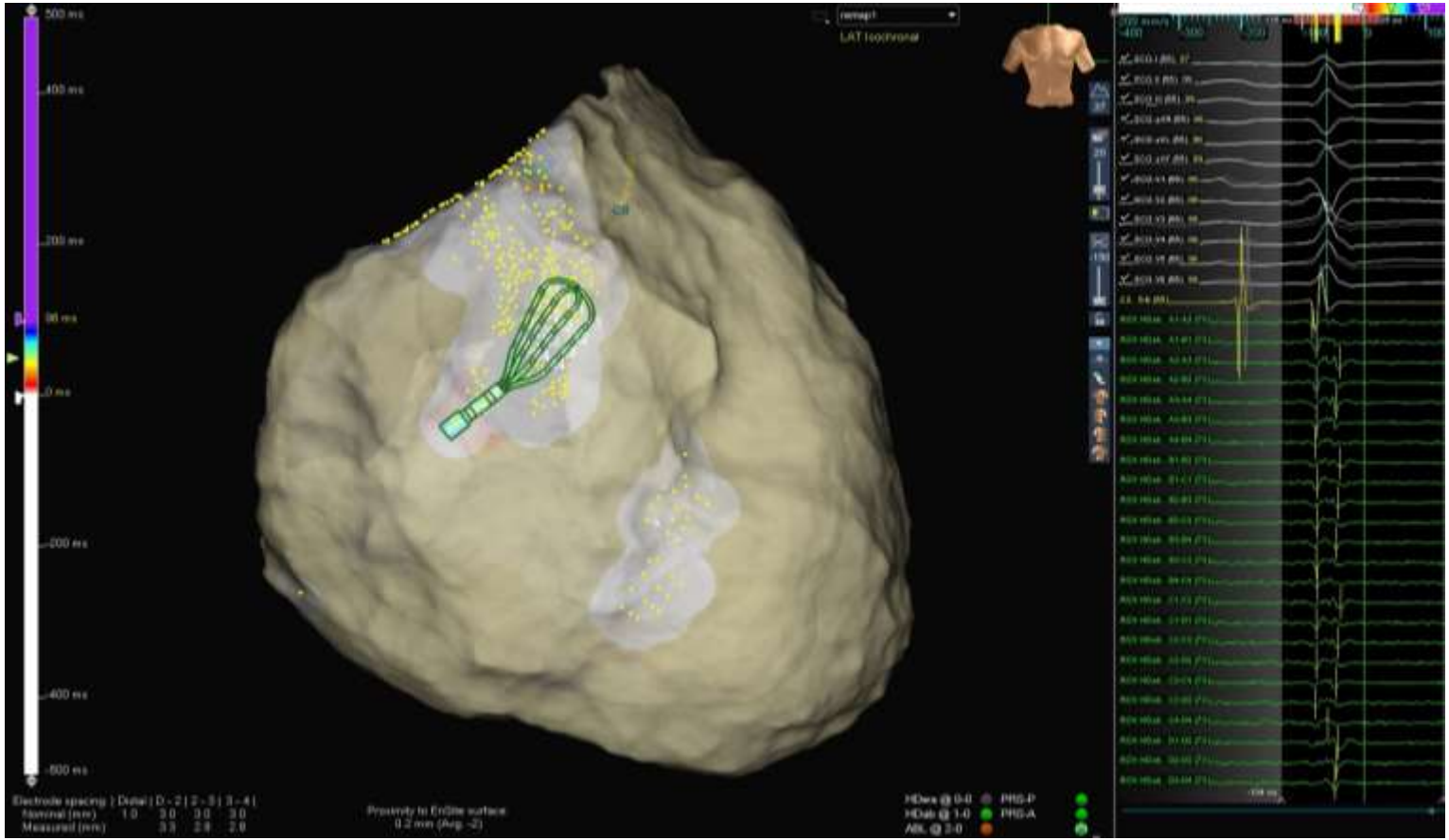
Mismatch


500 ms
400 ms
200 ms
33 ms
0 ms
-200 ms
-400 ms
-500 ms
SR all bipoles
LAT Isochronal
DIASTOLE 4
Electrode spacing | Distal | D - 2 | 2 - 3 | 3 - 4 |
Nominal (mm) 1.0 3.0 3.0 3.0
Measured (mm) 3.1 3.1 3.1
Proximity to EnSite surface:
-0.7 mm (Avg: -1)
ABL @ 0-0
HDwa @ 0-0
HDab @ 1-0
PRS-P
PRS-A

Mismatch


500 ms
400 ms
200 ms
-200 ms
-244 ms
-400 ms
-600 ms
TV2 REV
LAT Isochronal
LPs 10.0
CS
Electrode spacing | Distal | D - 2 | 2 - 3 | 3 - 4 |
Nominal (mm) 1.0 3.0 3.0 3.0
Measured (mm) 3.1 3.1 3.1
Proximity to EnSite surface:
0.7 mm (Avg. -1)
ABL @ 0-0
HDwa @ 0-0
HDab @ 1-0
PRS-P
PRS-A

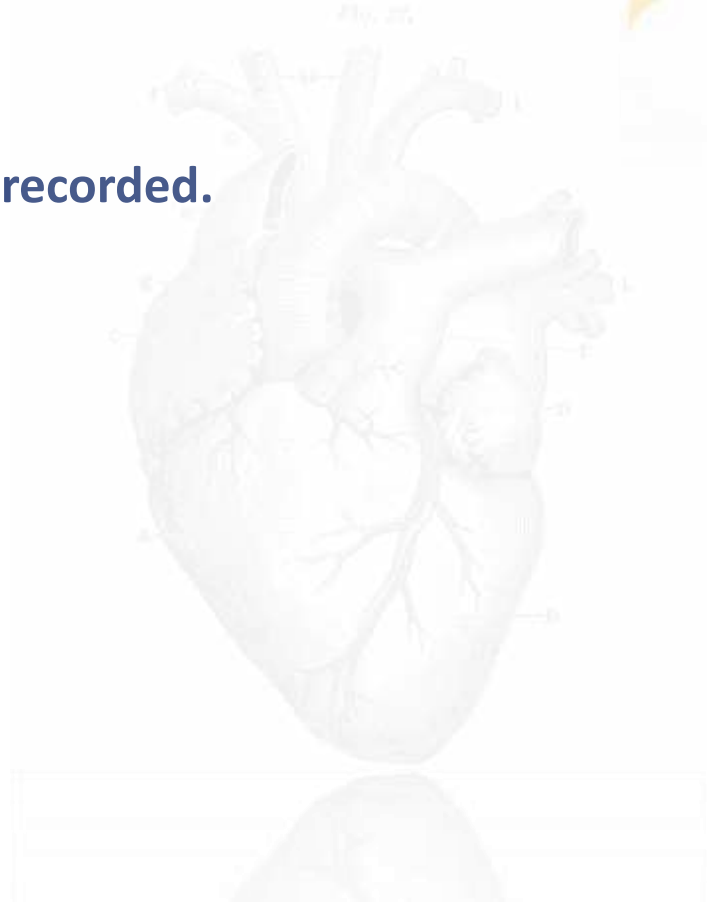
Re Map


500 ms
400 ms
200 ms
0 ms
-200 ms
-400 ms
-500 ms
remap1
LAT isochronal

Limitations of substrate mapping

2 **No late activity could be recorded.**

Sometimes happens!



Clinical case

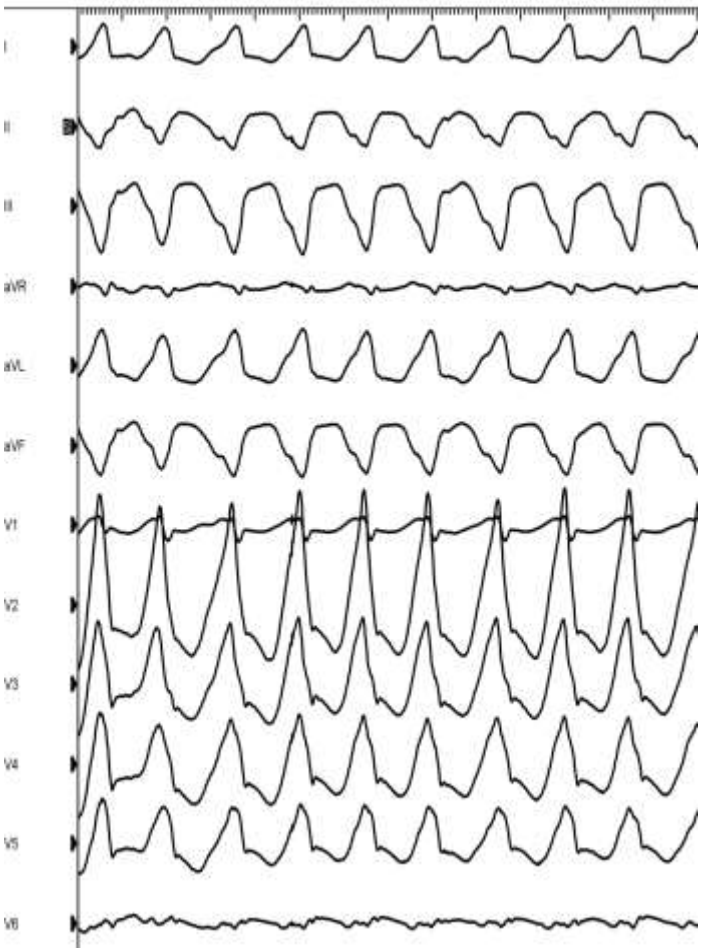
- Male, 75 yo

- Ischemic heart disease (previous inferior MI + CABG)
- Severe LV dysfunction (EF: 27%)
- Previous CRT-D implantation.

- History of post-MI VT refractory to antiarrhythmic therapy. After a first procedure of VT RFCA (2012) the patient was free of VT recurrences for 5 years

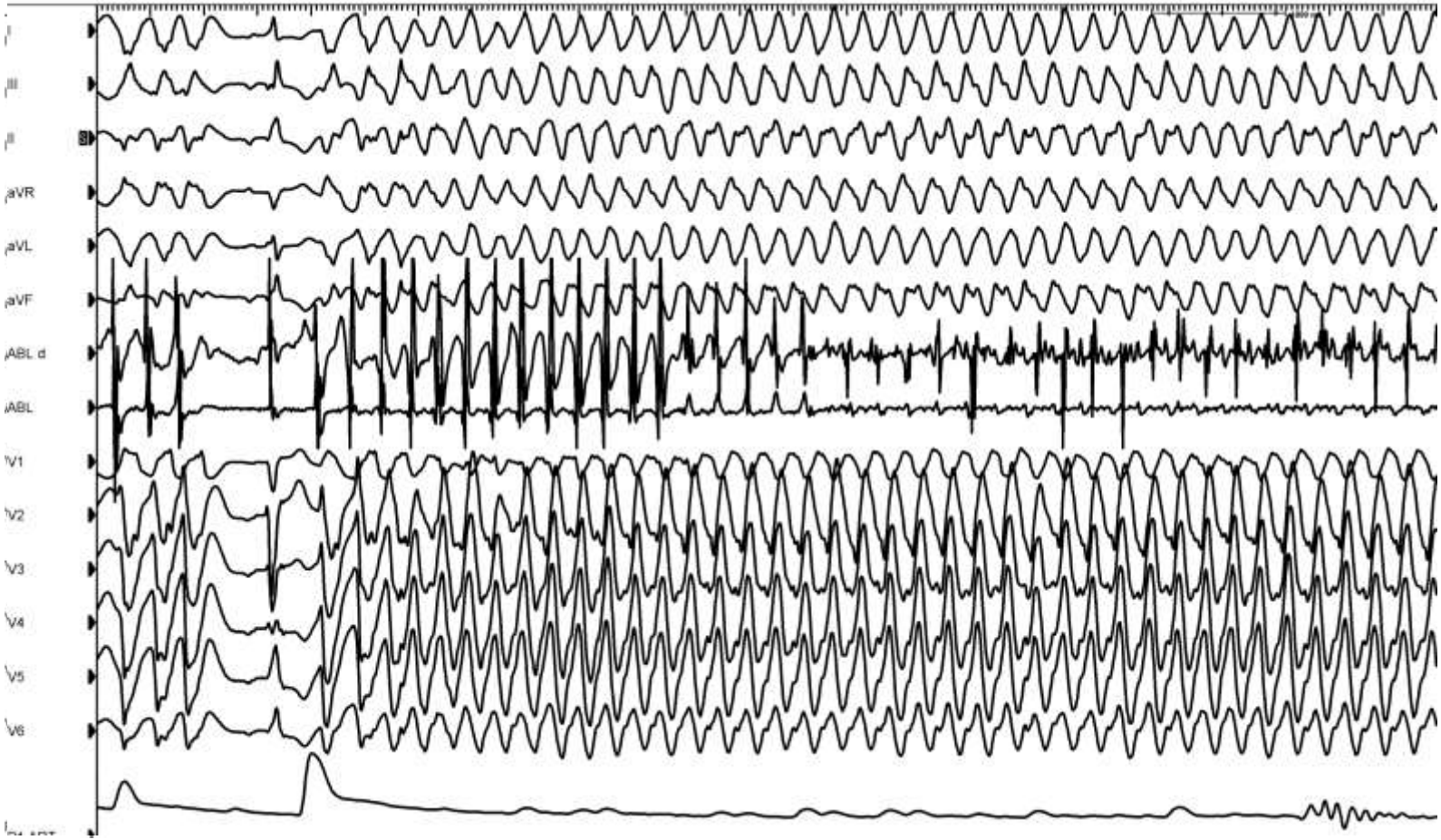
- In the last 8 months the patient had 3 episodes of electrical storm on fast VTs (CL: 280 ms).

- Referred for a second catheter ablation attempt.



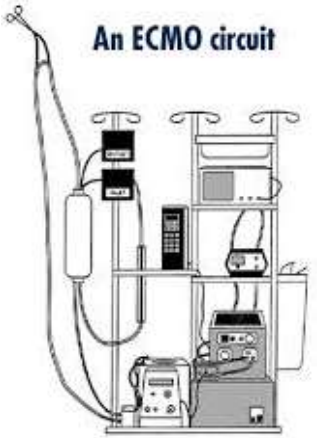
VT I induction

Clinical case

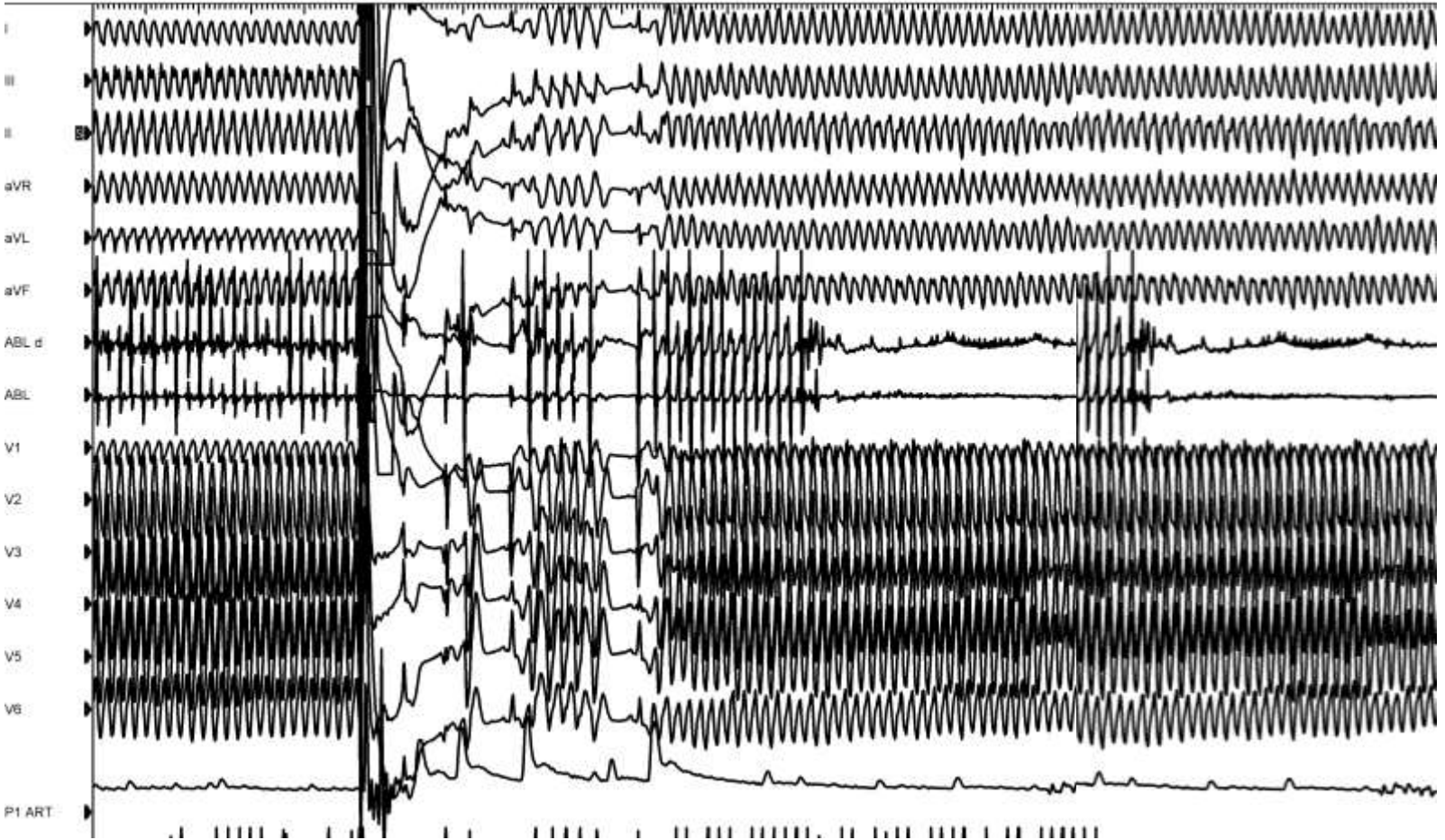


… if you're going through hell

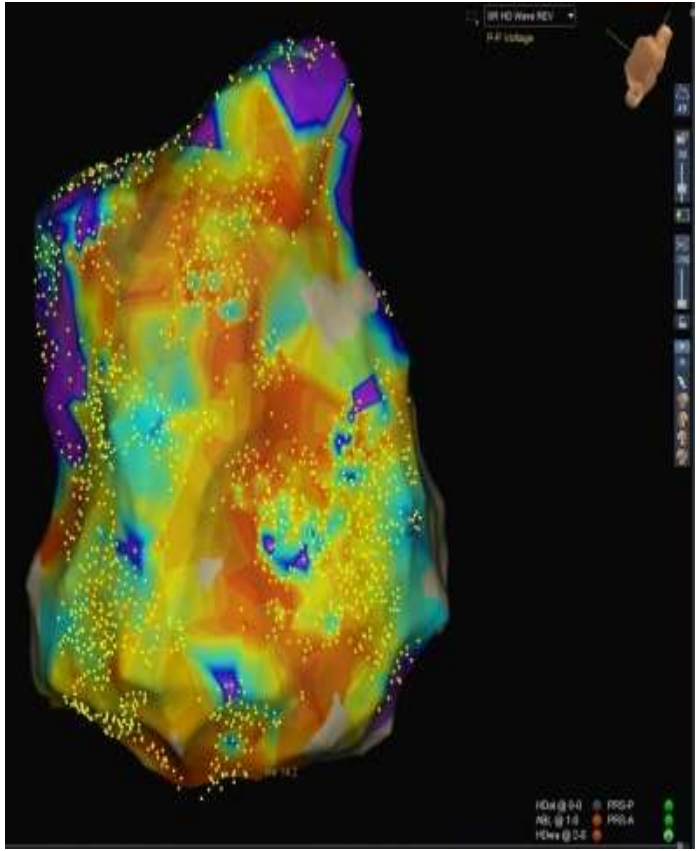
.. keep going ..

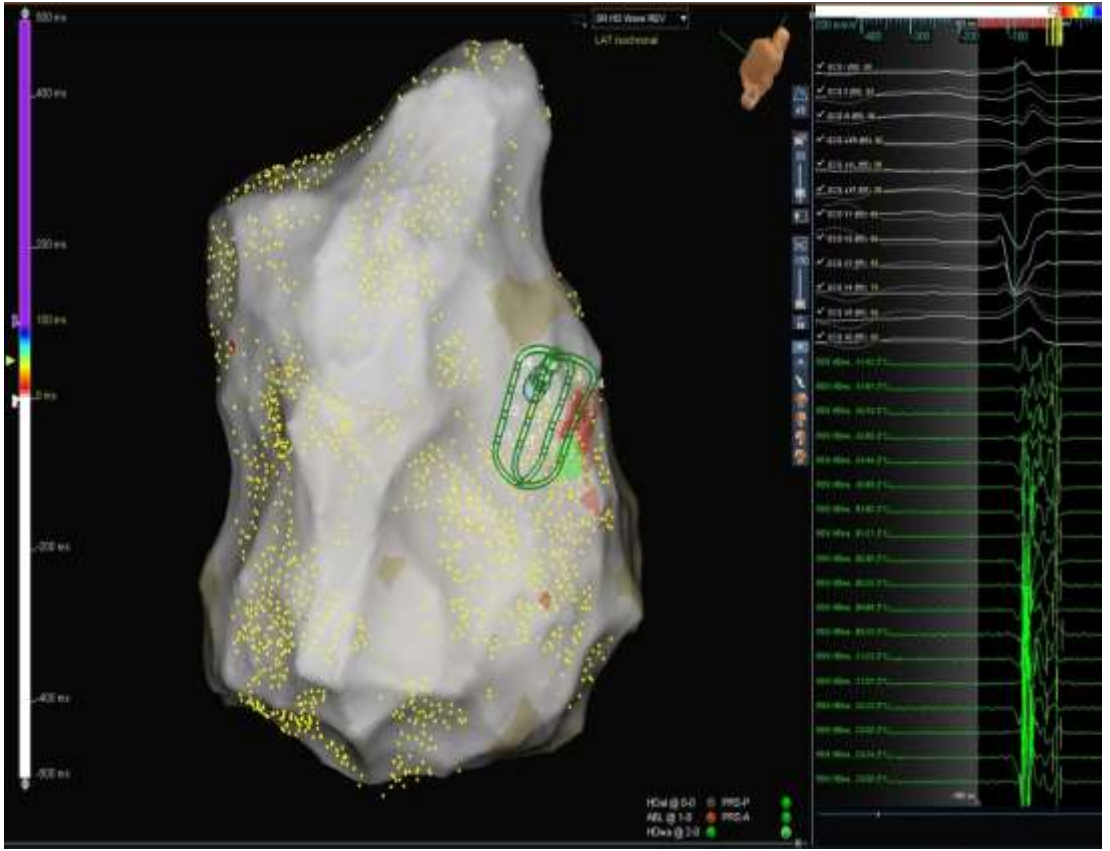


Clinical case

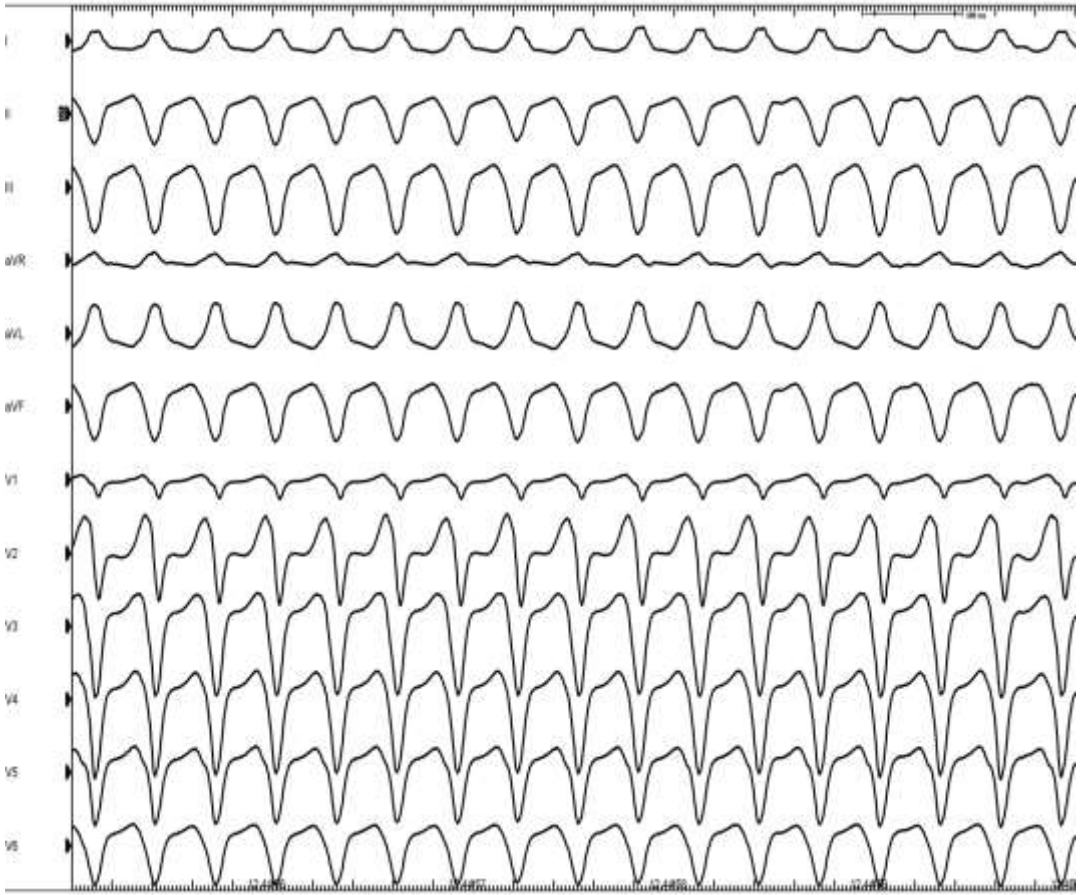


Clinical case



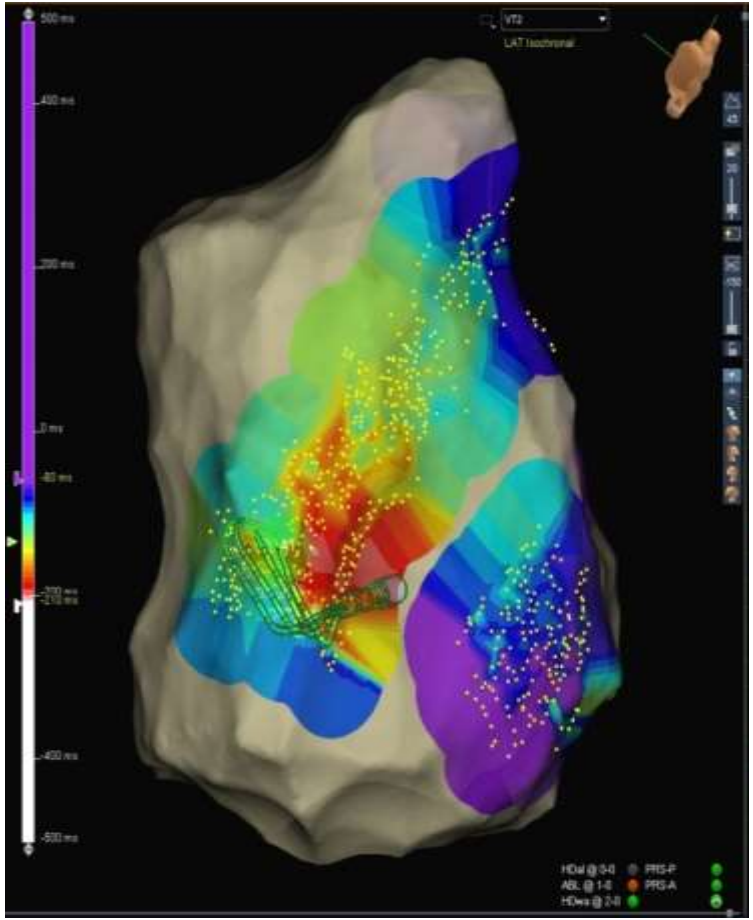


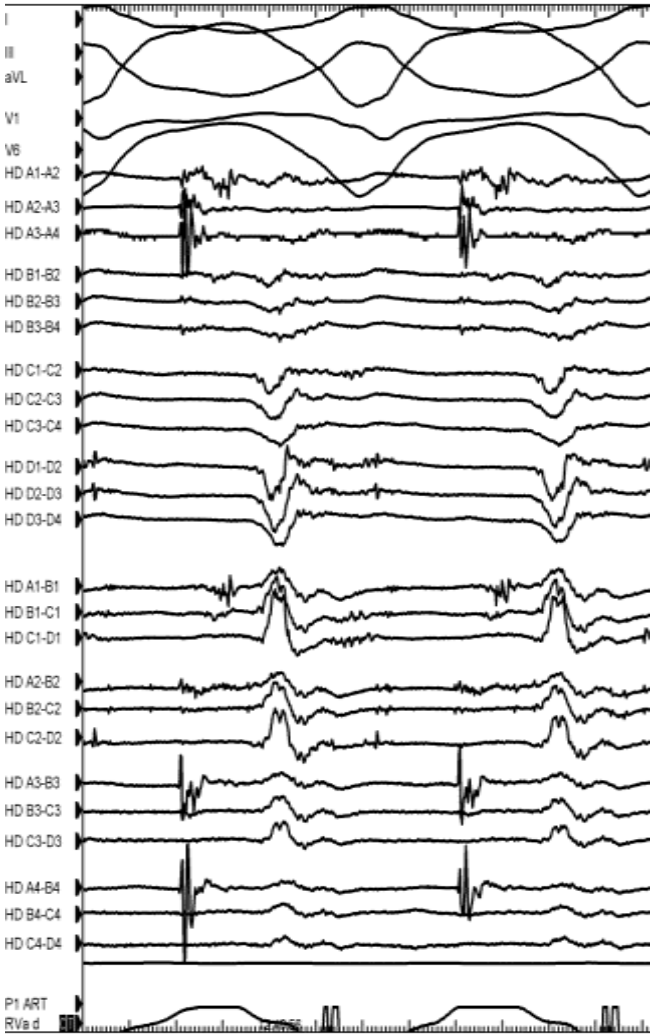
Clinical case



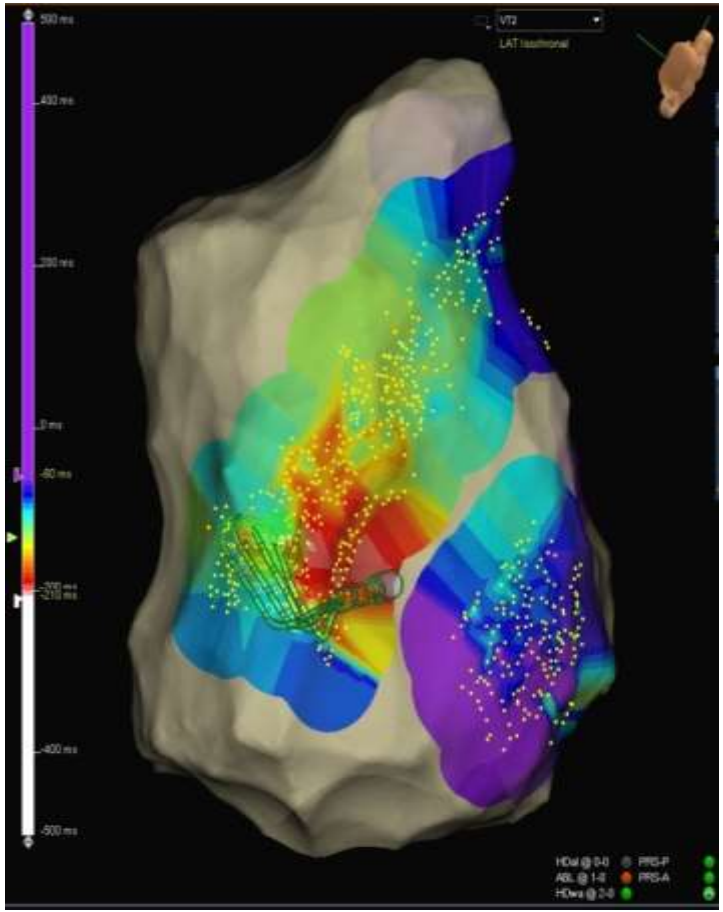
Induction of VT2 after SR map

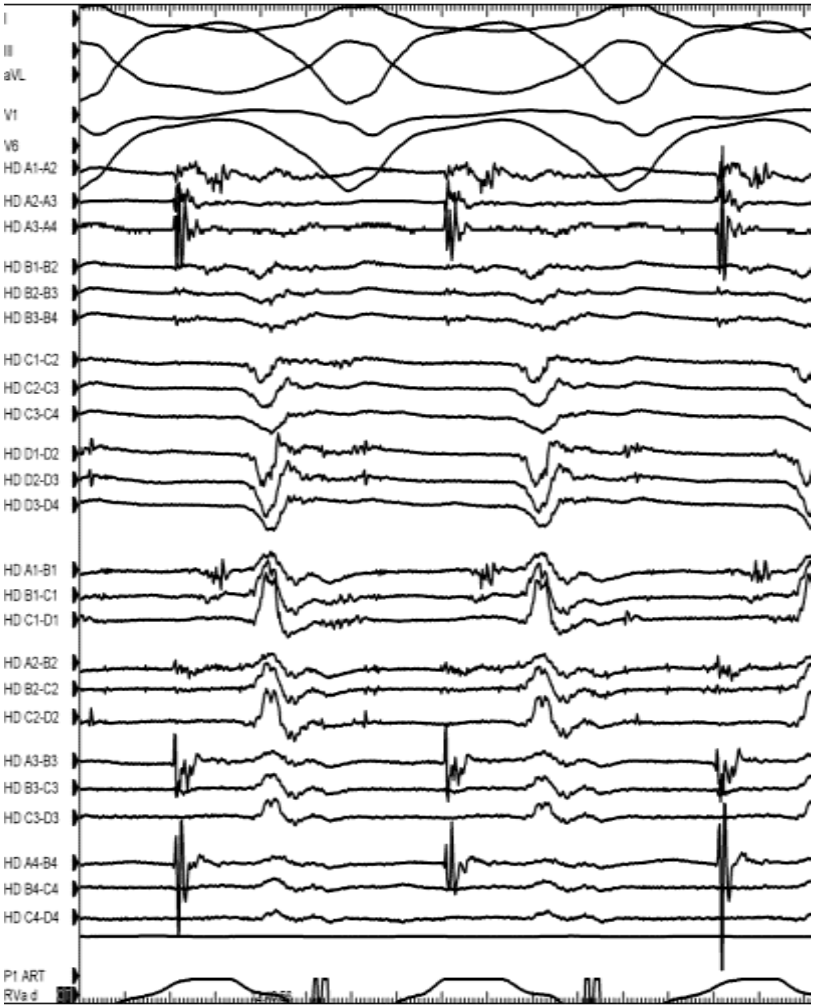
Isthmus


VT2
LAT Isochronal

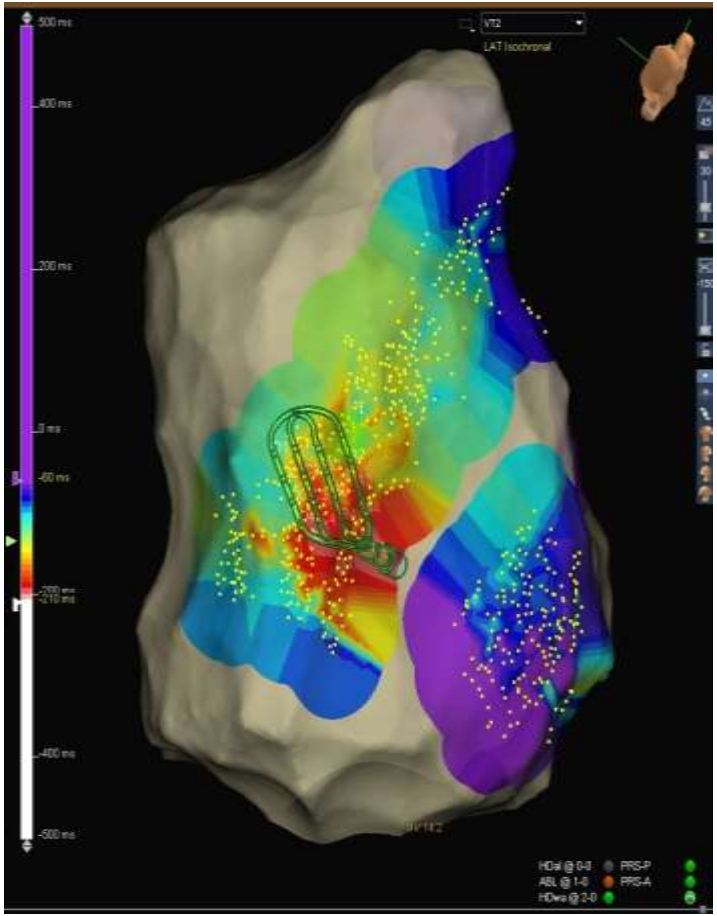

I
II
aVL
V1
V6
HD A1-A2
HD A2-A3
HD A3-A4
HD B1-B2
HD B2-B3
HD B3-B4
HD C1-C2
HD C2-C3
HD C3-C4
HD D1-D2
HD D2-D3
HD D3-D4
HD A1-B1
HD B1-C1
HD C1-D1
HD A2-B2
HD B2-C2
HD C2-D2
HD A3-B3
HD B3-C3
HD C3-D3
HD A4-B4
HD B4-C4
HD C4-D4
P1 ART
RVa d

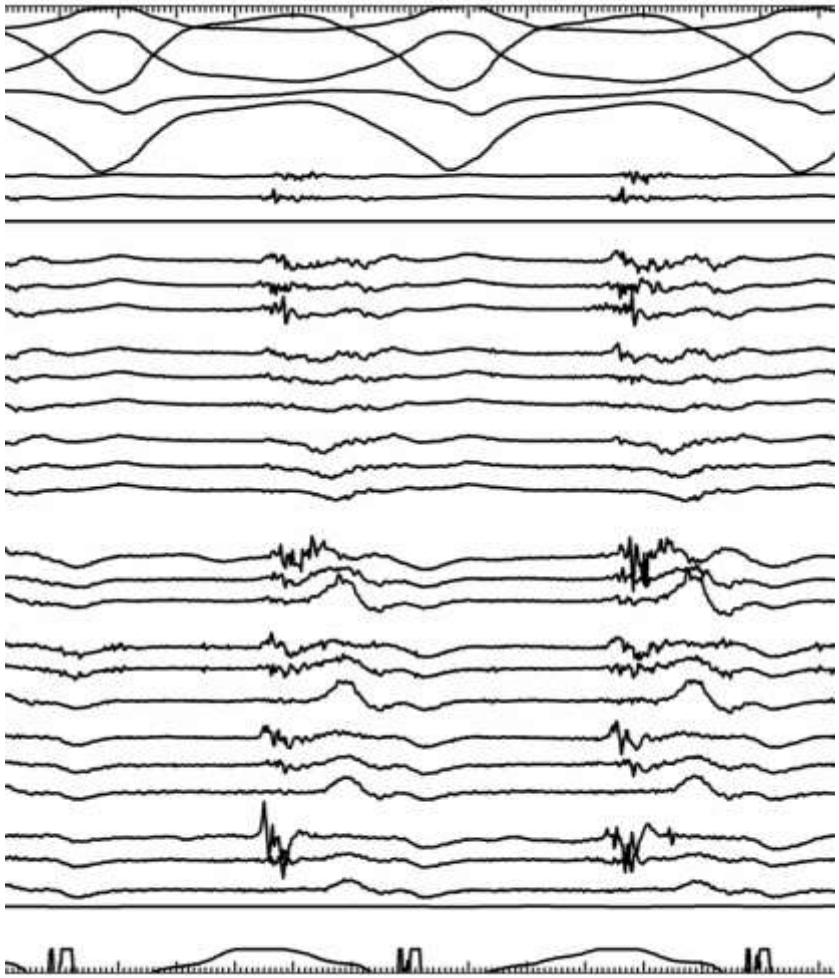
Entrance / Isthmus





Exit

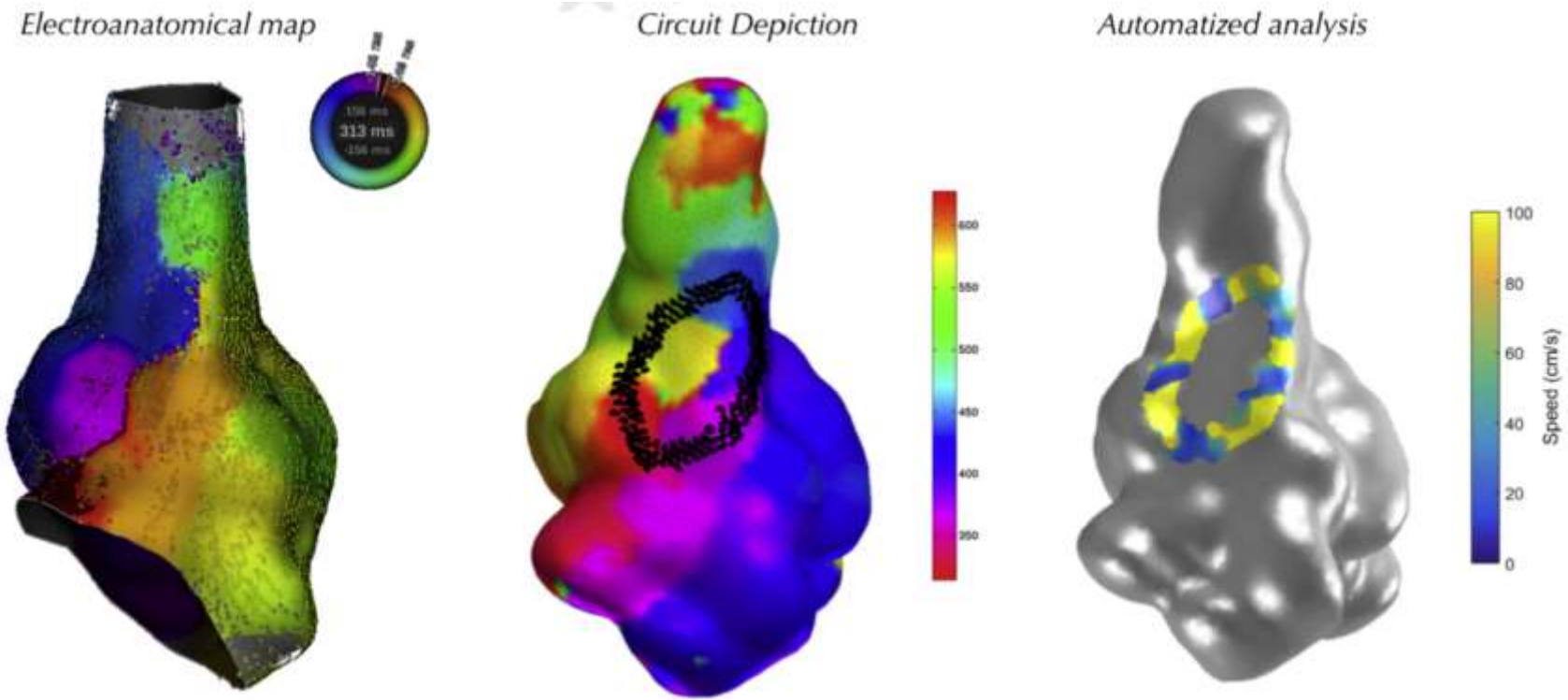

500 ms
400 ms
200 ms
0 ms
-60 ms
-200 ms
-210 ms
-400 ms
-500 ms
VT2
LAT Isochronal
HDal @ 0-0
ABL @ 1-0
HDwa @ 2-0
PRS-P
PRS-A



OSPEDALE SAN RAFFAELE

The future in substrate mapping

The future in substrate analysis



The future in substrate analysis

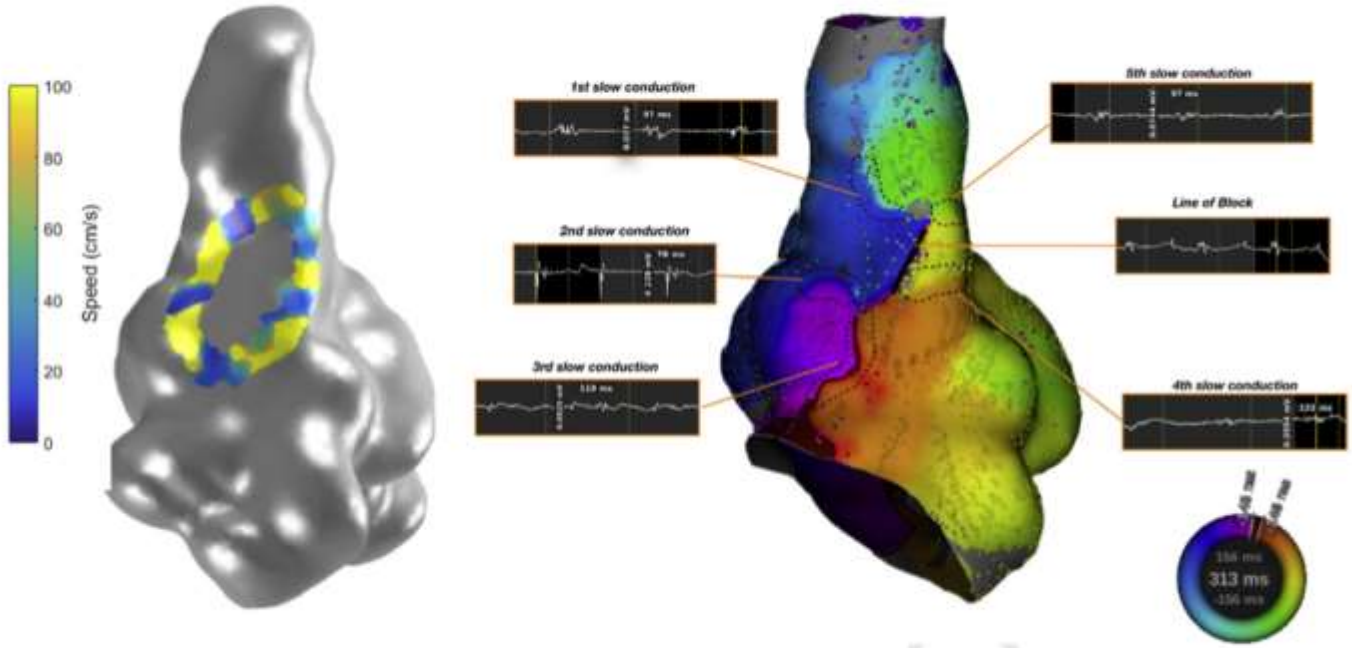
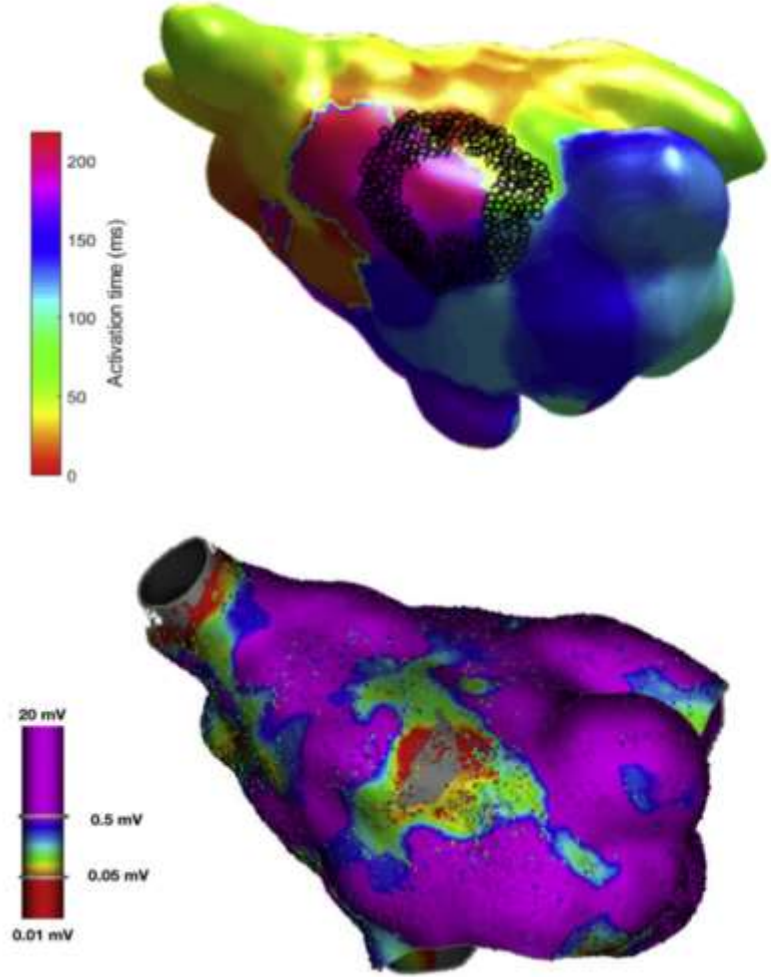
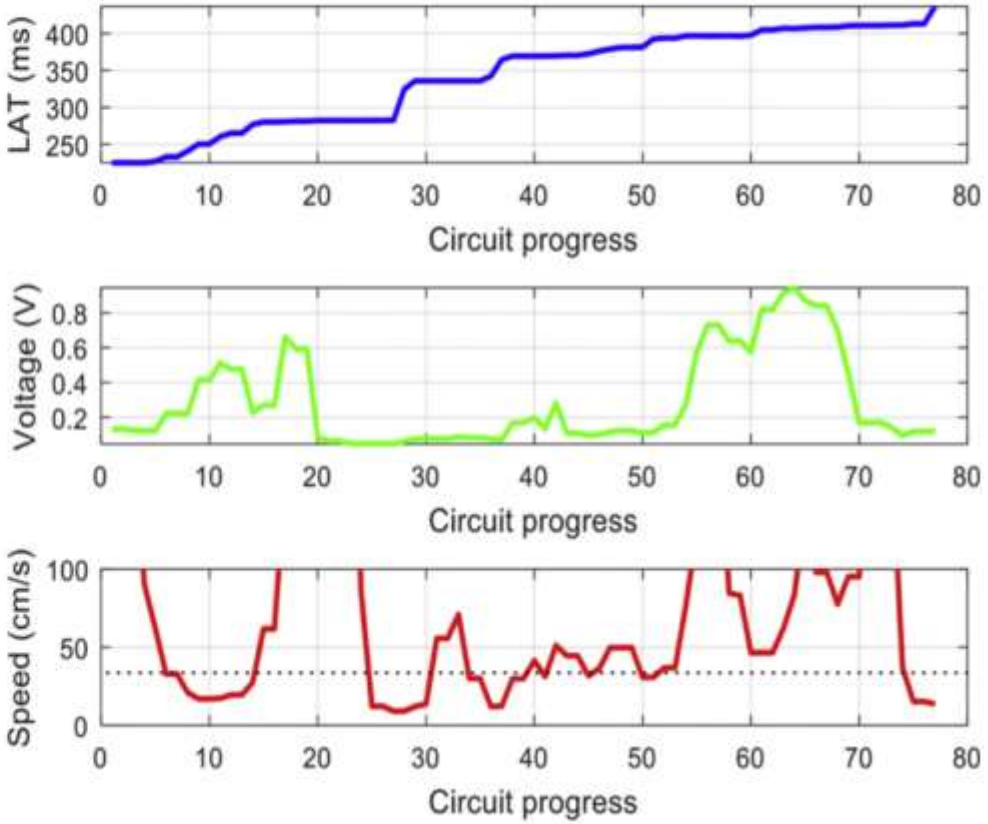


Figure 1 MATLAB automatized analysis of slow conduction. The MATLAB script identifies and analyzes areas of decreased velocity conduction. Electrophysiological characterization of the localized reentrant circuit is shown on the **right**.

The future in substrate analysis





Conclusions

- (HD) **substrate mapping** represents a **crucial step** in the context of VT ablation.
- **Multi polar / Multi electrodes** catheters are the keys in the scenario of VT mapping strategies. *More informations = More knowledge*
- Mapping technologies have improved a lot BUT **few advancements** have been made for **softwares** and **algorithms**.
- New scenarios will be the on-line **analysis** of **conduction velocities** and vector orientations of wavefronts