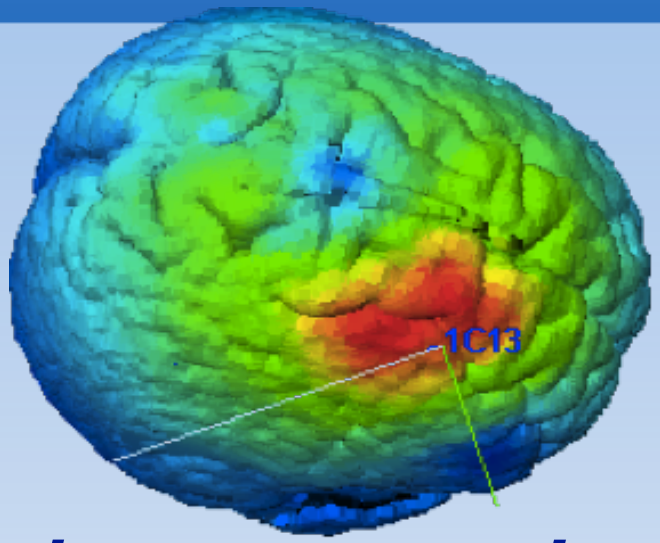
SofTaxic Optic 2.0



MRI-guided frameless neuronavigation system

for TMS and integrated EEG-TMS

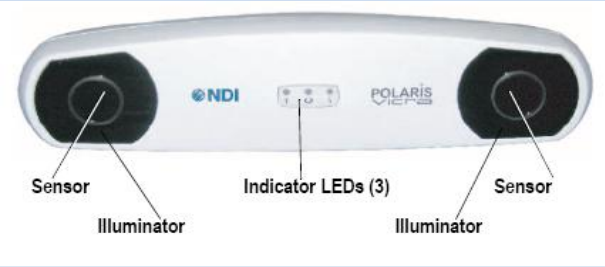
http://www.emsmedical.net - sales@emsmedical.net

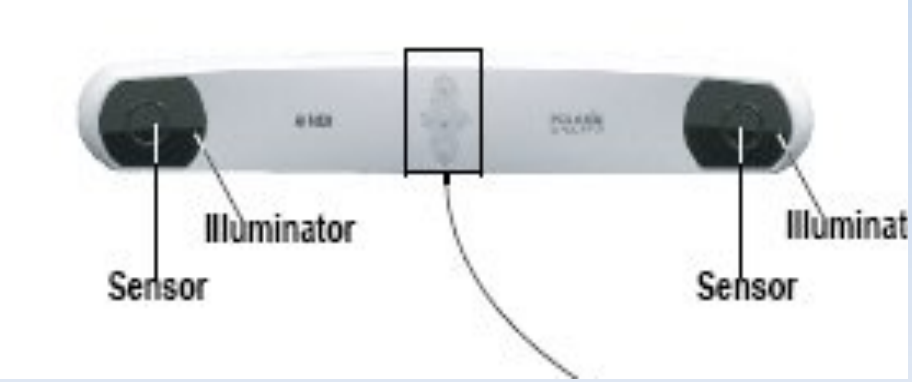
Introduction

- The SofTaxic neuronavigation system is a tool used in conjunction with a Magnetic stimulator by researchers in order to guide the direction of the stimulating coil over an area of interest.
- The system works with the majority of focal stimulating coils available on the market.

Introduction

- It's based on an optical digitizer that tracks in realtime the position in space of several tools
- It can be used with 2 different models of digitizer: Polaris Vicra and polaris Spectra from NDI
- The main difference between the two is the acquisition volume and the frame rate

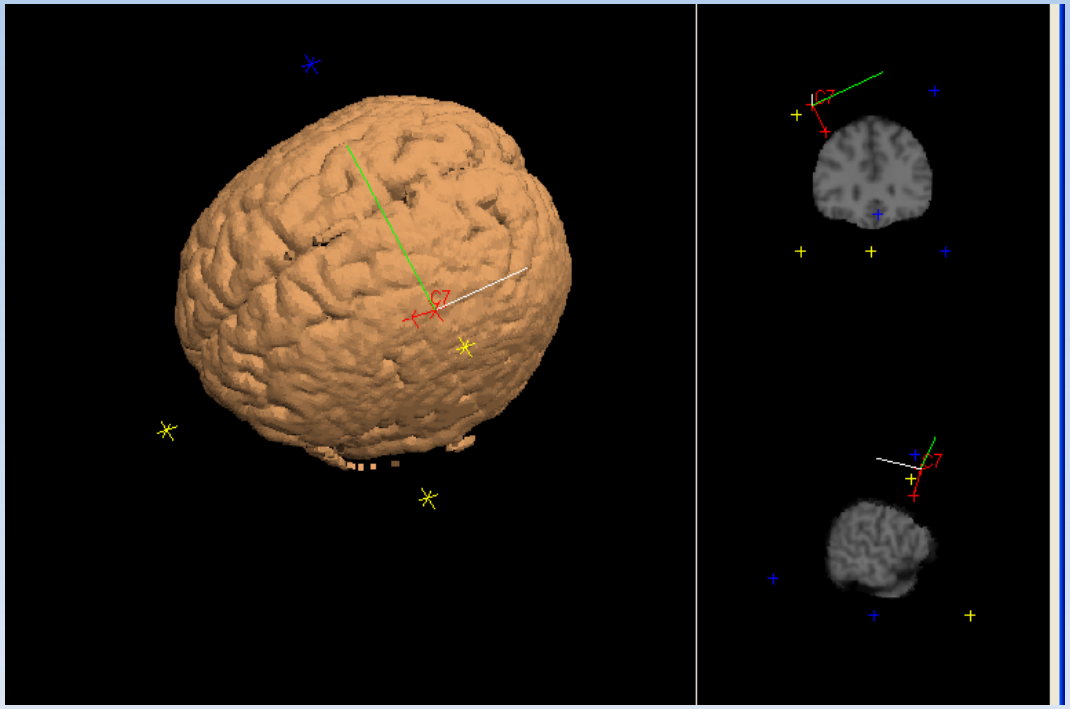




Why Neuronavigation ?

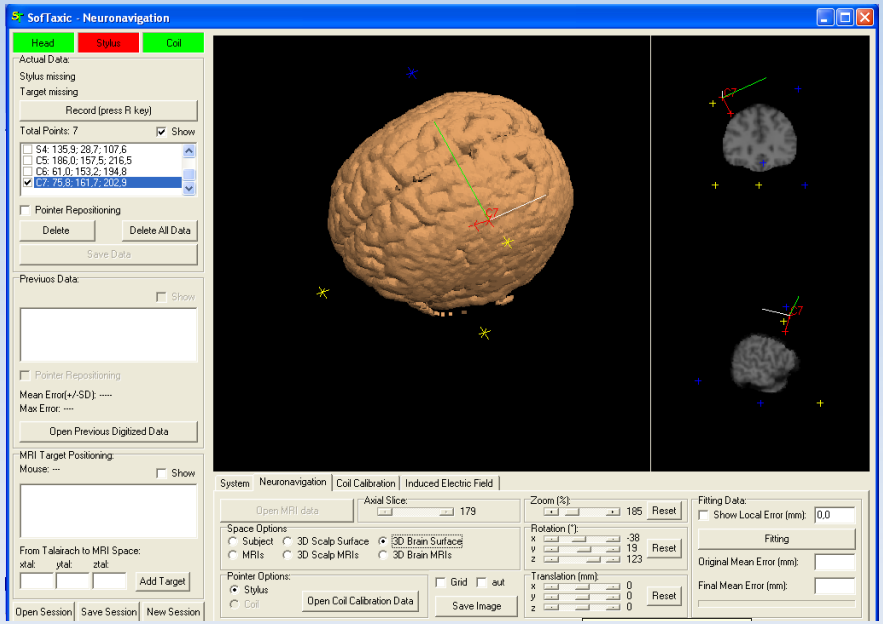
It gives you information about your stimulation's cortical target with high accuracy (2-3 mm) in real time.

By using a navigation system users can achieve better acurracy and repeatability for their experiments



MRI-guided coil positioning

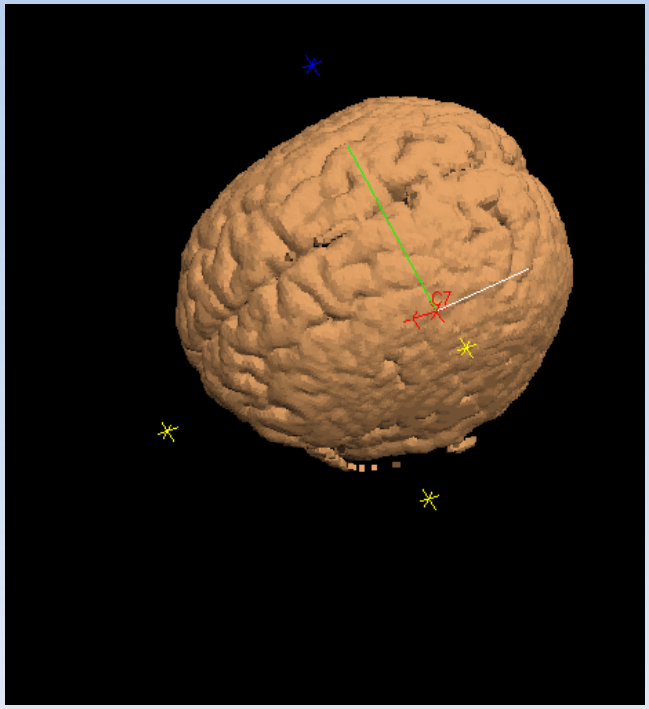
- The SofTaxic system is able to guide accurately the TMS coil positioning, by using MRIs
- The TMS stimulation brain site can be localized on to the 2D MRIs and on to the 3D realistic MR-constructed brain model
- Furthermore, spatial coordinates of the stimulated sites are referred to the PAN*, stereotaxic Talairach and MRIs coordinate systems



Localization

Localization is by far the most important feature that every navigation system implements, it allows:

- ✓ Easiness of target's search thanks to the visual feedback
- ✓ Repositioning to a previous target with high accuracy

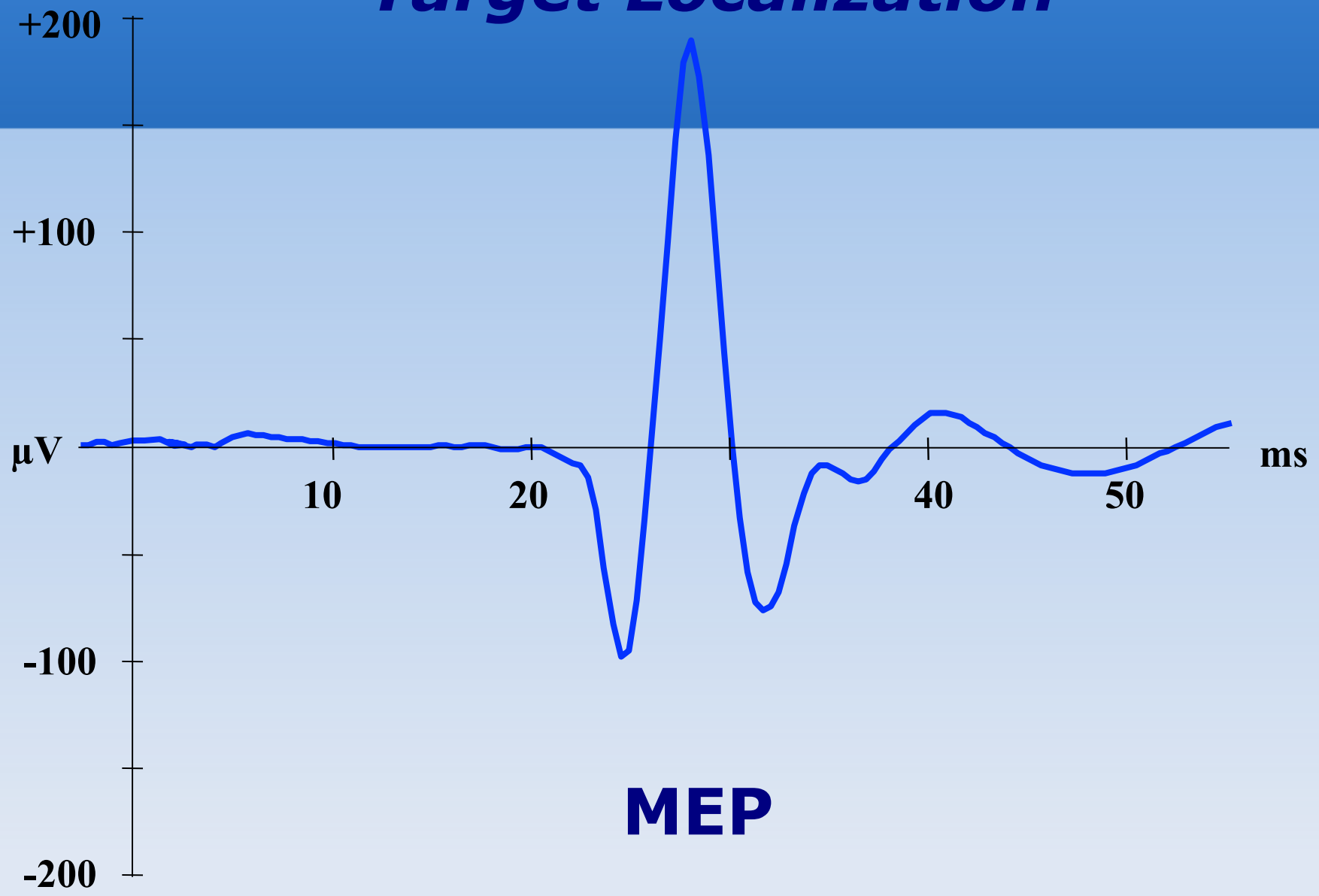


Is that important ?

- Why bother using a navigation system ? It's yet another tool you have to learn !
- How do users use TMS without a Neuronavigation system ?
- Alternatives ?

Motor Cortex

Target Localization

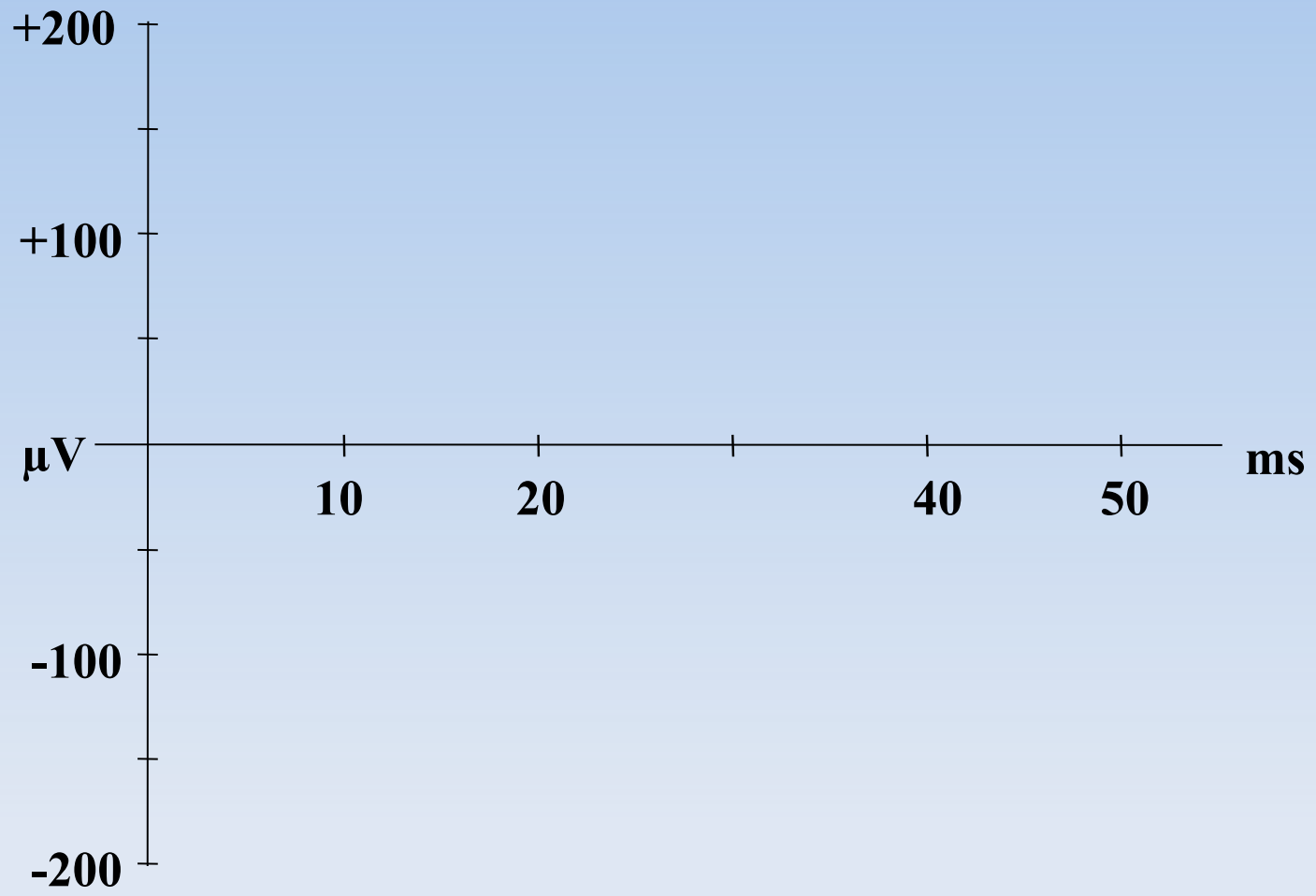


MEP

Other areas ?

Target localization

Problem: what if we need to hit an area other than the motor cortex / spine ?

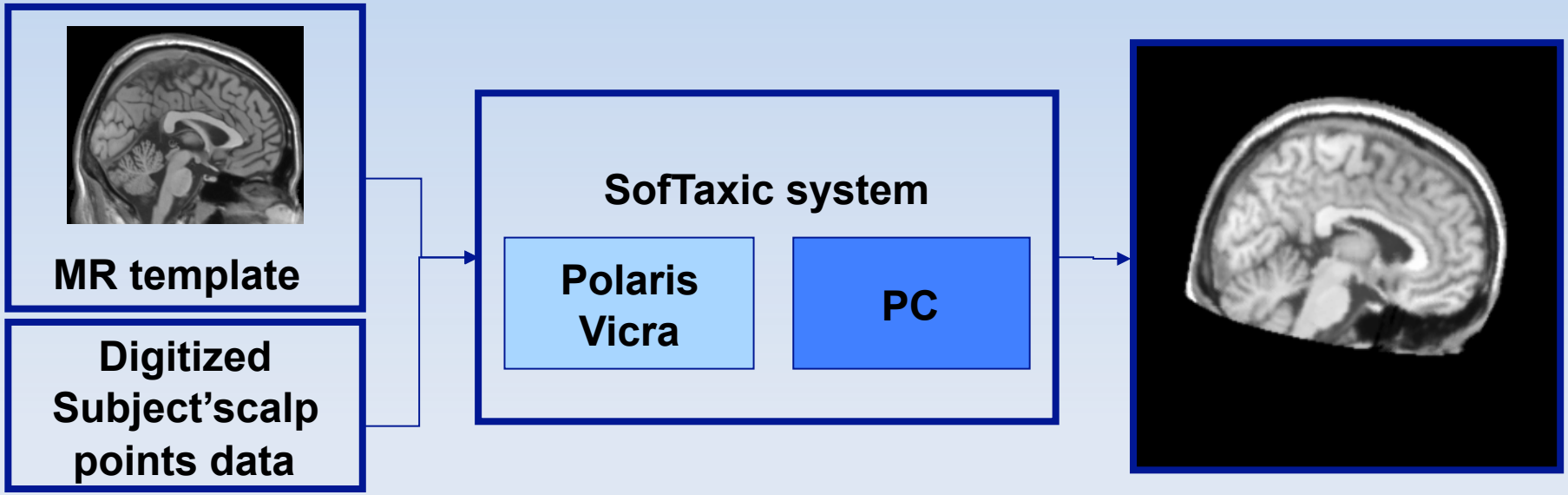


What if my subject's no MRI ?

- We provide a solution for the problem: it's called MRIs estimation.
- This feature makes the system appealing to researches (e.g. psycologist) that have no access to an MRI scanner, but they still want to investigate brain functionality by means of TMS.
- Nobody else can do the same, not with our level of accuracy.

MRIs Estimation

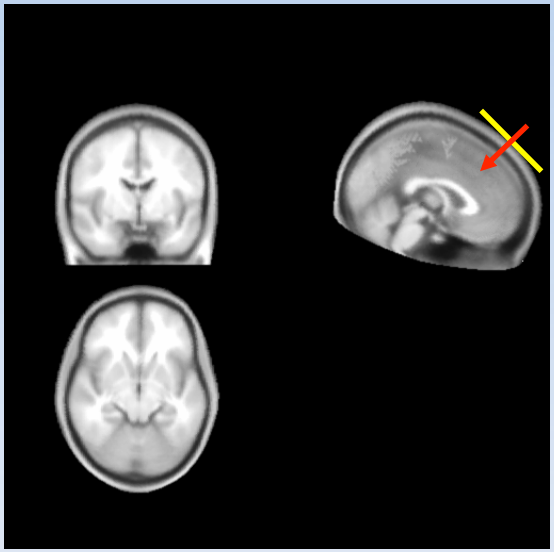
- If the subject does not have his MRIs, the TMS stimulation can be guided by using an estimated set of MRIs
- The estimated set of MRIs is calculated using an innovative and accurate 3D warping procedure, able to preserve anatomical scalp-brain correlates of an MR template.
- The 3D warping procedure works on a set of points, digitized from the subject's scalp by mean of a computer-assisted procedure.



MRIs Estimation

- The accuracy of the estimation procedure was evaluated on 28 healthy adults (mean age 35 ys) having own MRIs used as gold standard
- In this evaluation, the TMS stimulation brain site was localized using both own and estimated MRIs, while the position of the TMS coil was kept fixes onto the subject's scalp overhanging one of the 64 S.I.10-10 sites

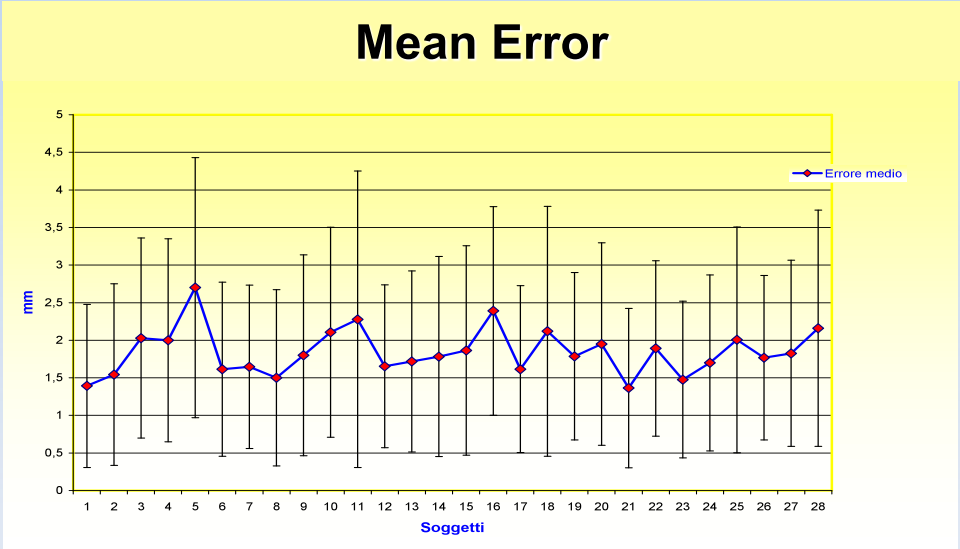
Own MRIs



Estimated MRIs

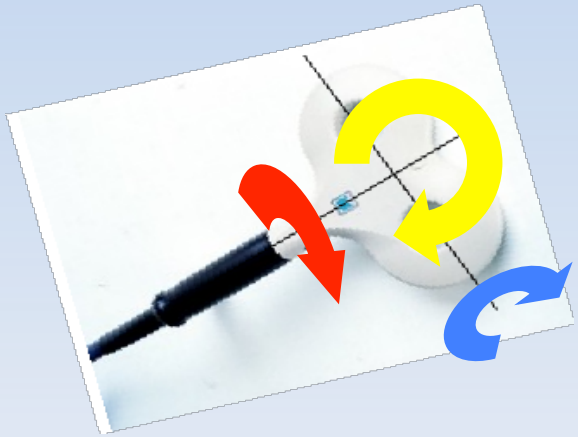
MRIs Estimation

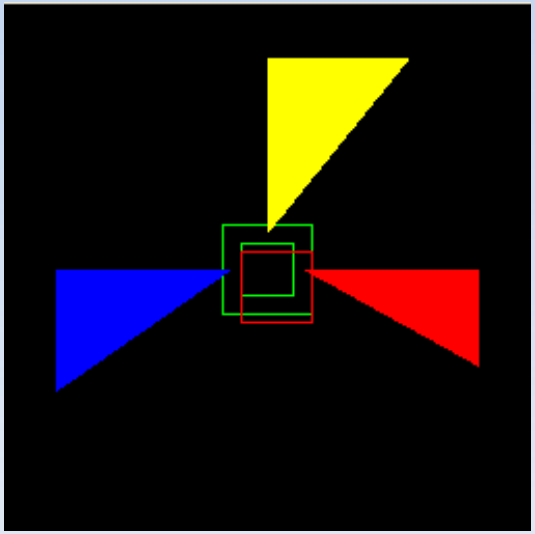
- In order to evaluate the accuracy of the estimated MRIs respect to the own images, for each one of these 64 scalp sites we calculated the difference (Euclidean distance - Talairach space) between the stimulation brain site localized used the own and the estimated MRIs, respectively
- The results indicate a mean error of 1,84 mm, with a maximum error of 4,32 mm, lower than TMS spatial resolution



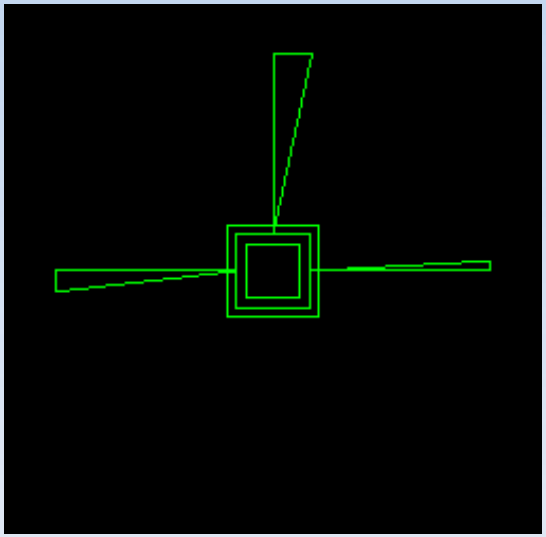
COIL repositioning and stability

- **Stability: it is a tool that enable us to quantify the coil shifts from the stimulation target during the experiment**
- **Repositioning: we are able to hit again the very same target on the subject, even during different sessions.**
- **Foundamental for studies that needs to check pre/post conditions (e.g. farmaceutical studies)**
- **<u>Up to 2 coils can be tracked simultaneously</u>.**





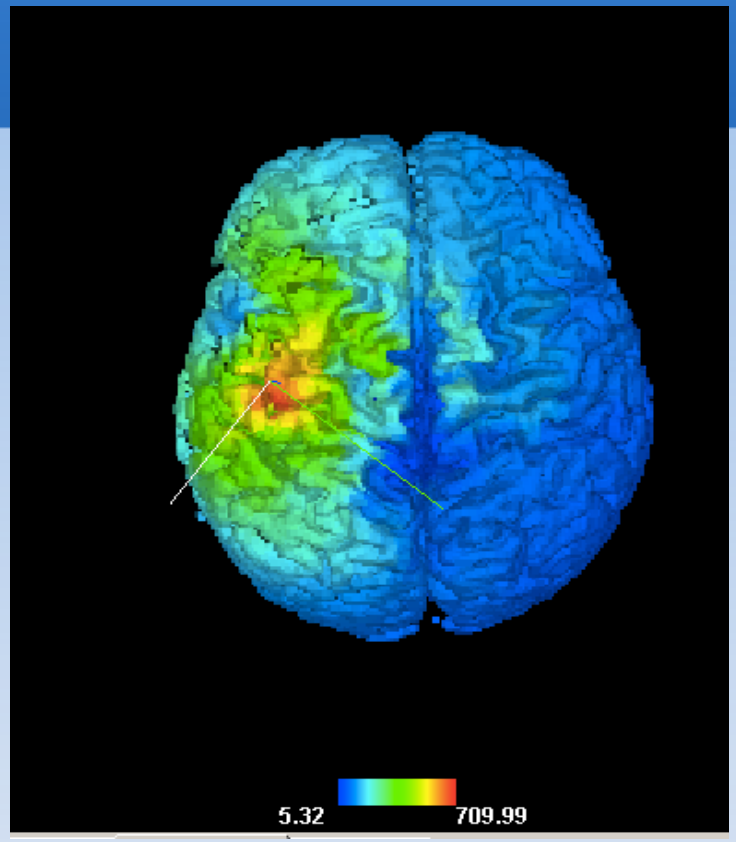
Bad overlapping



Good overlapping

TMS Induced Electrical field

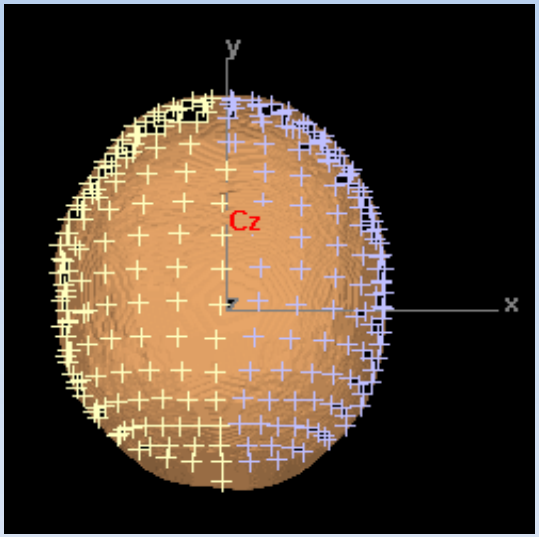
- In order to fully characterized a TMS brain stimulation, it is very important not only to know the stimulated area, but also the magnitude and the effective direction of the TMS induced E-field over the brain tissue
- This induced E-field depends on many factors, like stimulator settings, geometry and orientation of the TMS coil, local brain geometry, brain electrical conductivity
- The SofTaxic system calculates on-line the TMS induced electrical field onto the 3D realistic MR-constructed brain model of the subject by means of the BEM mathematic method (Boundary Element Method)



Assisted electrodes placement

- SofTaxic is able to calculate the locations of 249 scalp electrode sites of the Standard International 10-5 system (S.I.10-5) onto a virtual reconstruction of the subject's scalp
- These locations can be used to assist EEG electrode placement onto the subject's scalp by using digitizer facility

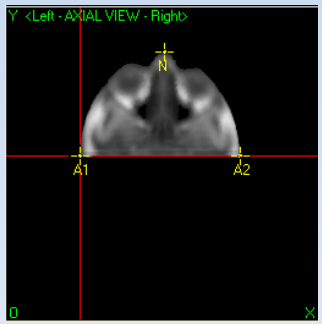
253			
N	3.884976	84.941986	-0.000006
I	-2.185060	-86.409782	51.890289
A1	-65.383720	-0.000002	-0.000002
A2	65.383720	0.000001	-0.000004
Fpz	4.127801	101.731209	30.729733
AFpz	2.771171	106.126831	48.297249
AFz	2.416262	107.021057	65.858231
AFFz	1.981065	104.021355	84.451828
Fz	1.174894	96.854942	100.050934
FFCz	1.099663	85.298119	113.909233
FCz	-0.297144	70.909943	124.513435
FCCz	-1.896418	53.945255	133.132339
Cz	-2.512669	38.376381	141.521774
CCPz	-2.506457	21.050310	147.810272
CPz	-3.341788	3.253401	150.158936
CPPz	-4.949323	-13.582659	148.321899
Pz	-5.446433	-31.293465	141.485962
PPOz	-4.673426	-44.992039	131.673538
POz	-3.414007	-57.672745	118.443680
POOz	-3.376748	-68.416130	103.474998
Oz	-2.197857	-75.972664	87.657990
T7	-74.944054	6.722118	36.381363
T7h	-76.606163	13.265292	54.224861
C5	-78.578629	18.789509	73.391212
C5h	-76.167648	24.849007	91.751579
C3	-69.359642	31.092134	108.512436
C3h	-56.721863	35.270924	123.819954
C1	-40.993370	38.413918	133.691940
C1h	-21.983002	39.174778	139.467987
C2h	16.671219	38.298779	140.933350
C2	35.069553	37.073898	136.088913
C4h	51.815205	33.434864	125.807922
C4	63.779594	27.867832	111.766800
C6h	70.929077	21.317623	94.389999
C6	73.552917	14.887579	77.097687

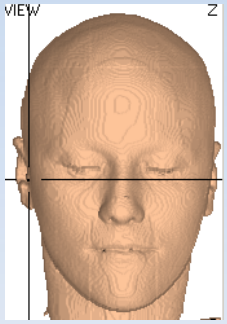


Electrode sites of the S.I.10-5

MRI subject head registration

- In the MRI-guided TMS neuronavigation, the main potential source of low accuracy takes place during the registration procedure, which is made in order to co-register the subject's head and his MRIs in a common coordinate system
- This procedure uses two analogous set of craniometrical landmarks (i.e. left and right preauricular points and nasion) digitized from the subject and localized onto his MRIs, respectively
- The SofTaxic system uses an automatic best-fit surface procedure, to define the best MRI-subject's head registration

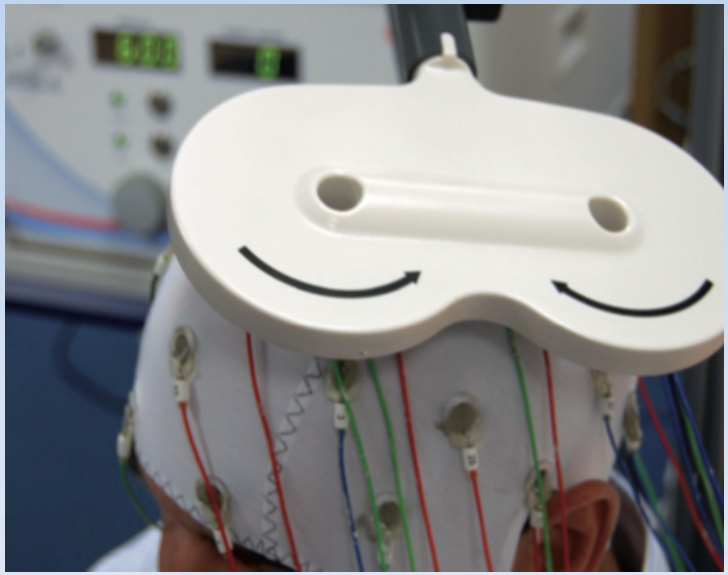




EEG - TMS

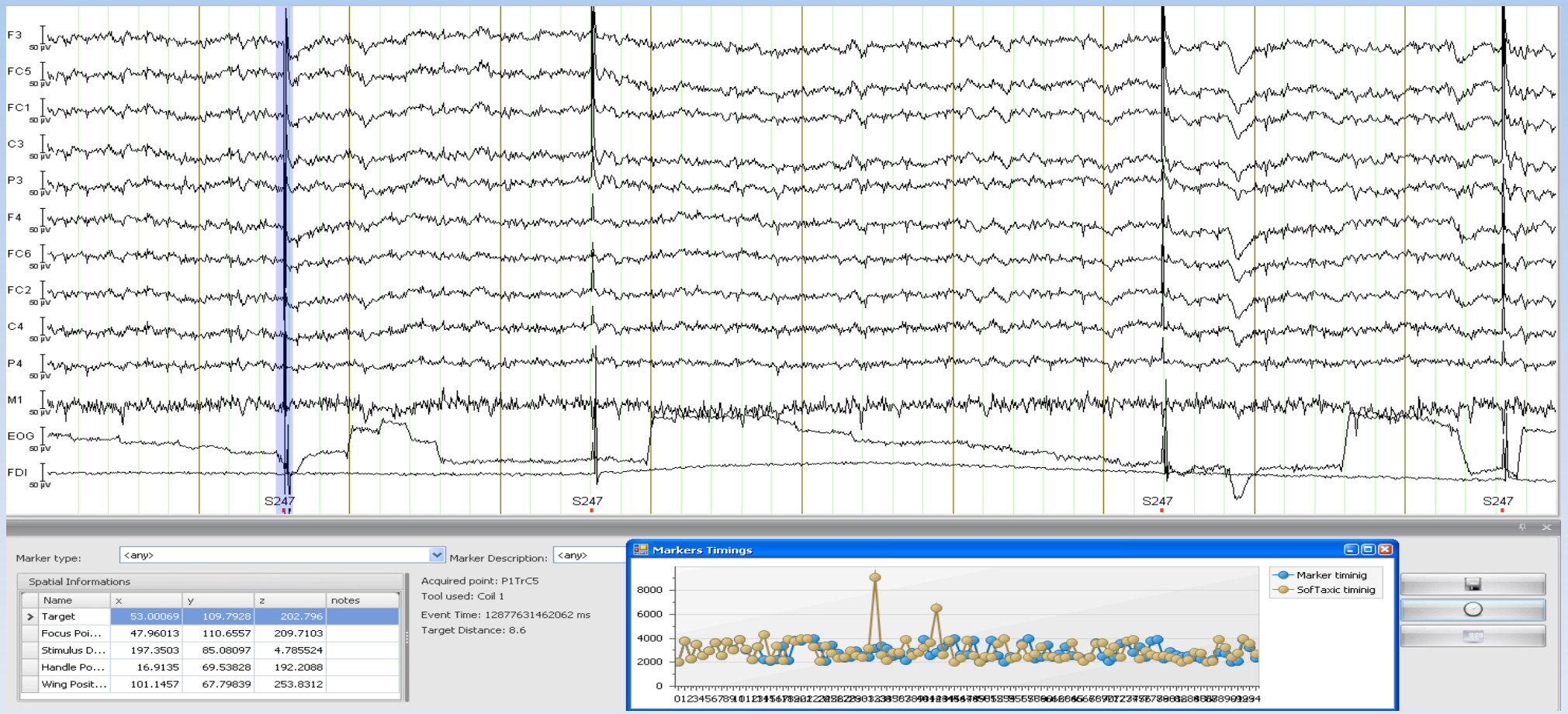
- The most advanced TMS applications involves the use of combined EEG-TMS recordings.
- We provide to users the tools they need for today's and tomorrow's applications needs.
- By using the SofTaxic system + BrainAmp amplifiers we can enable the simultaneus recording of EEG + Coil positions.

SofTaxic



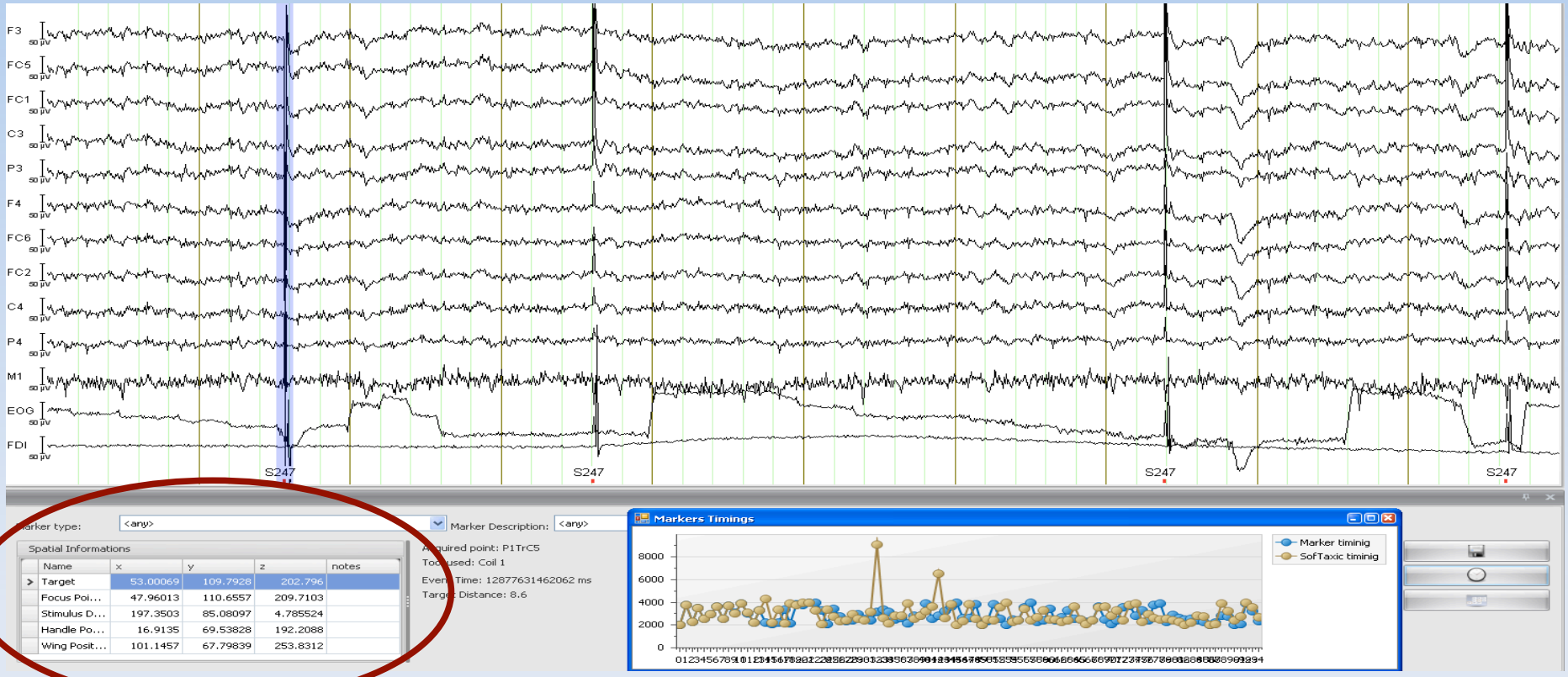
EEG - TMS

The ability to synchronize the stimulation with EEG data acquisition allows us to do combined data recording EEG-TMS and MEPs-TMS:



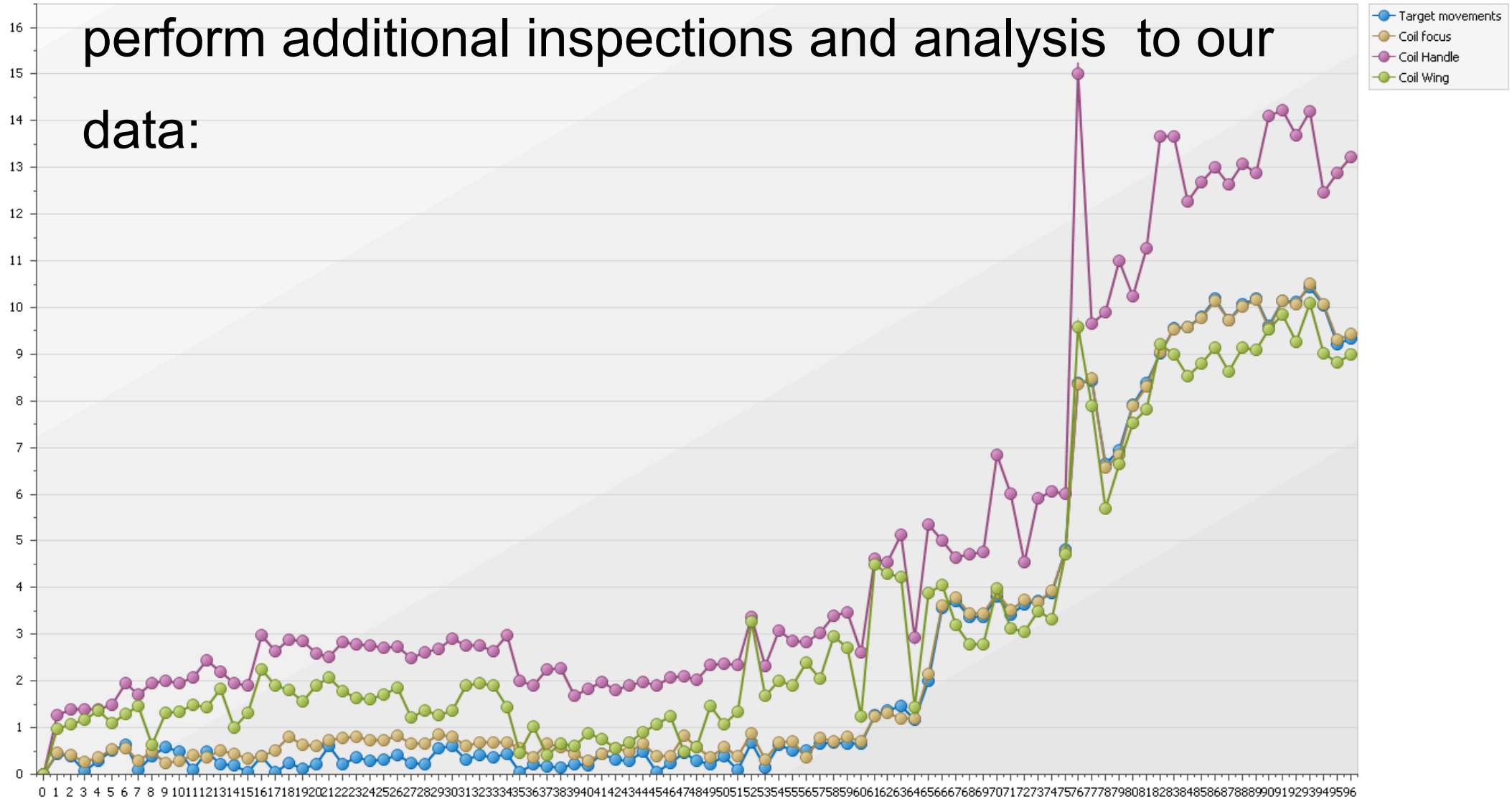
EEG - TMS

The neuronavigation system stores the coil positions inside the EEG data as “User properties” that can be analyzed by users with their own macros or our built-in facilities



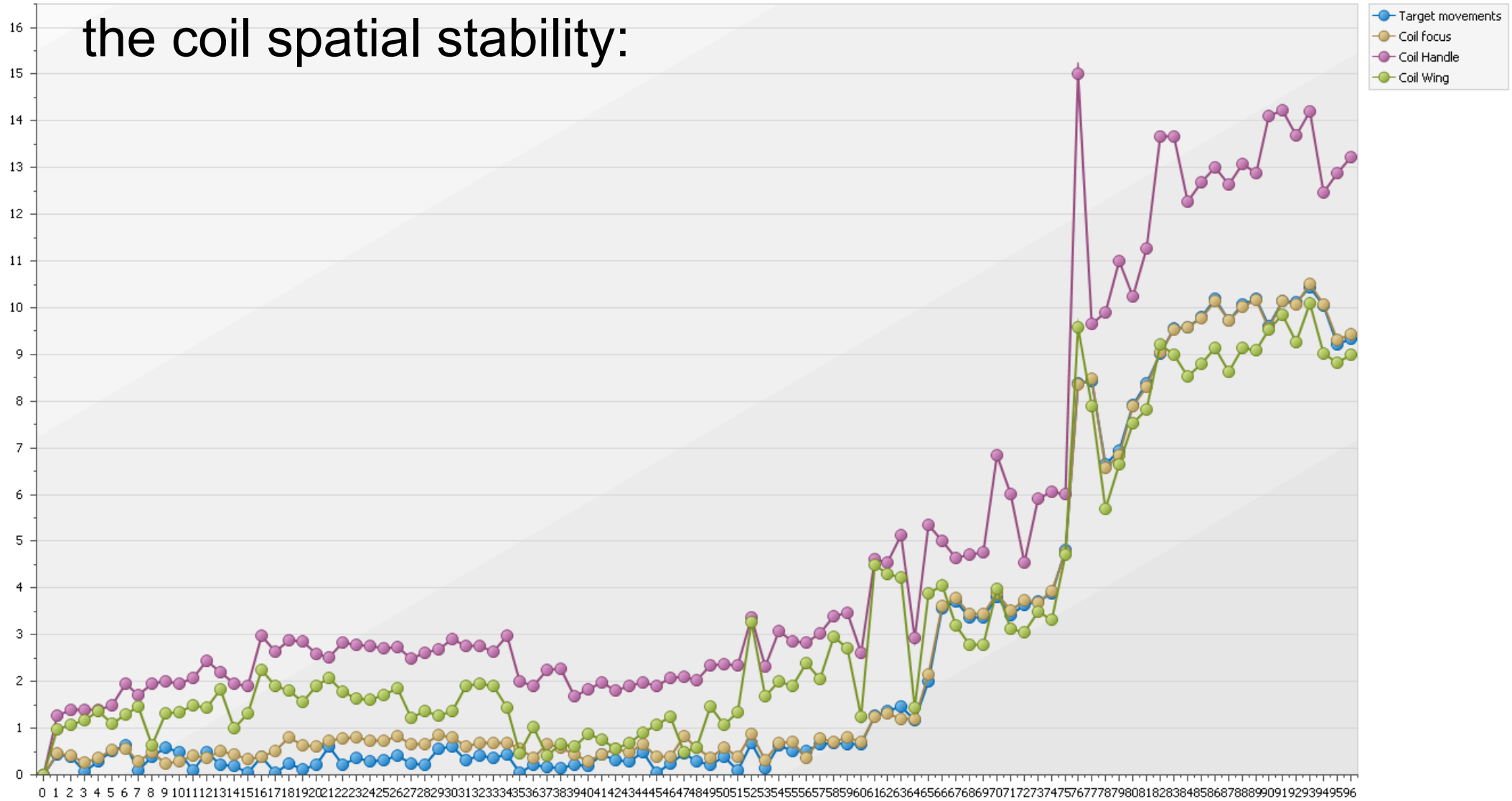
Coil movements

The open architecture of Analyzer 2 gives us the ability to perform additional inspections and analysis to our data:



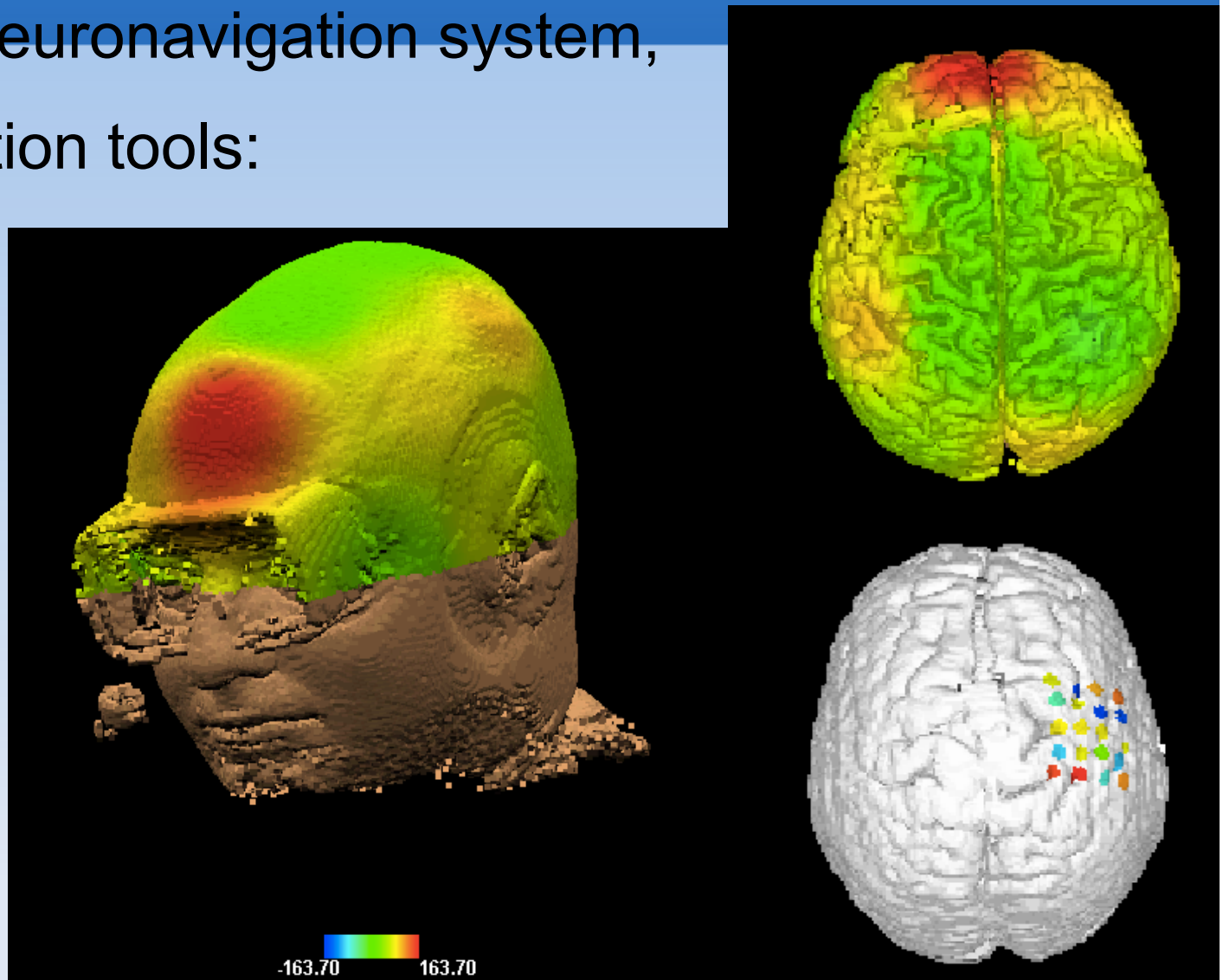
Coil movements

We can do a rejection of artifacts using criteria based on the coil spatial stability:



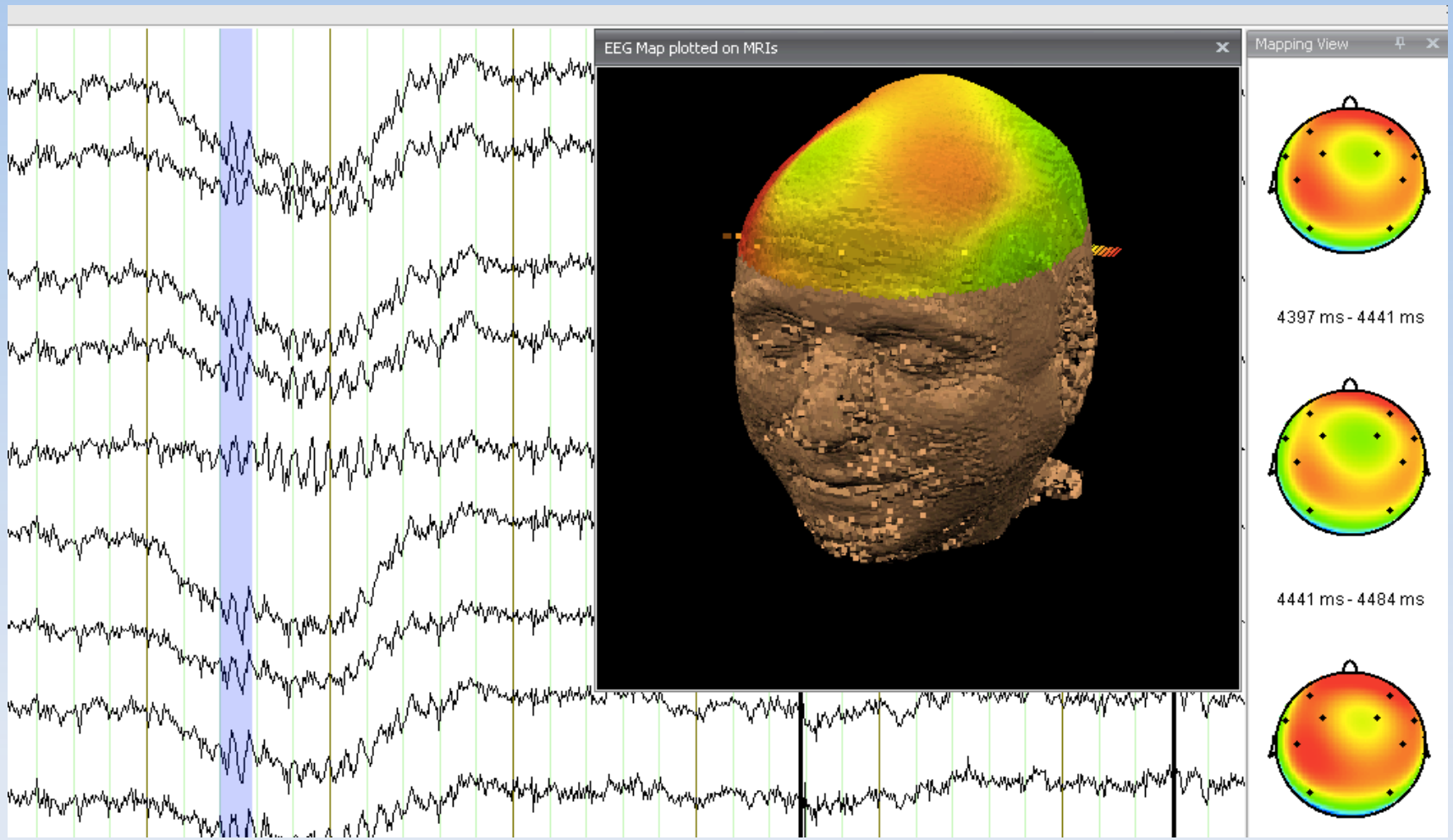
EEG Maps and MEPs

We can send the information about the EEG data back to the neuronavigation system, using its visualization tools:



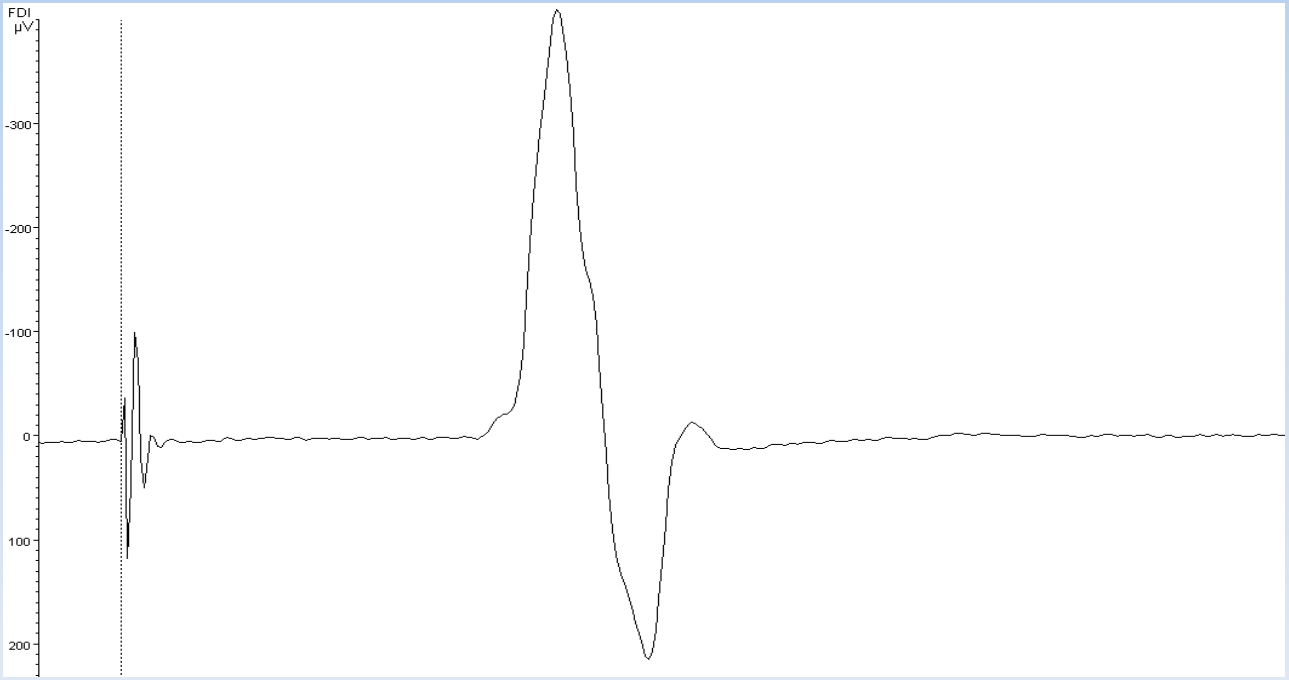
EEG Maps and MEPs

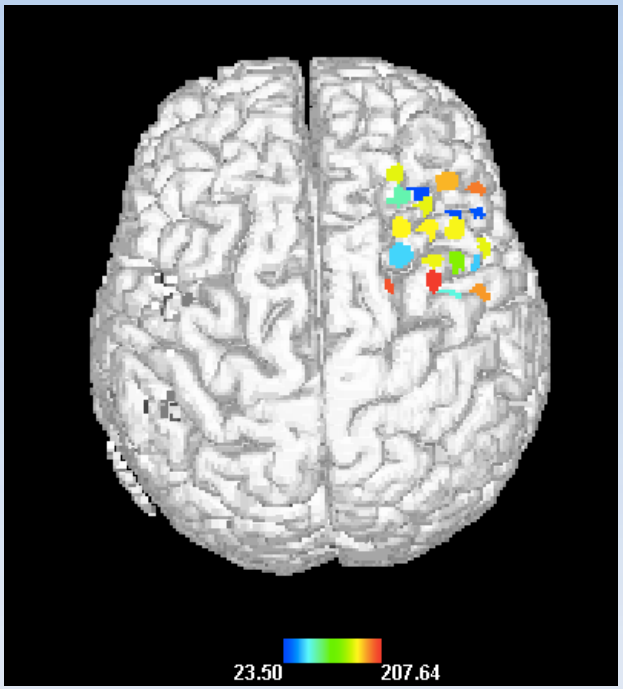
Here we can see an example of a EEG MAP plotted on 3D reconstruction of a real subject's head inside Analyzer 2.0



EEG Maps and MEPs

MEPs maps are built by using the amplitude values of motor responses to TMS stimuli, each different stimulation site evokes a different amplitude of the motor response thus it's plotted with a different color:





Highlights:

- ✓ Optical digitizer: 2 models from NDI are supported
- ✓ Tight integration with Analyzer 2
- ✓ Doesn't need subject's MRIs for TMS: high accuracy MRIs estimation
- ✓ MR Volume export with target points
- ✓ Automatic coil calibration
- ✓ 2 Coils tracking

Comments ?