The electroencephalogram (4)

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A plan for today

- Finish skimming EEG analyses
- Introduce a set of tools and equipment that you may want to deal with
- ~~Start the course section on Electromyography~~
- Start a hands-on minicourse on signal processing
  - Frequency analyisis
  - Filtering

Time-frequency analysis

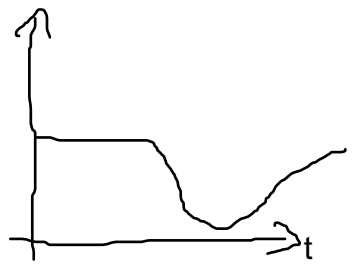
It's able to make the analysis of the spectrum of the singal in a time varing meter

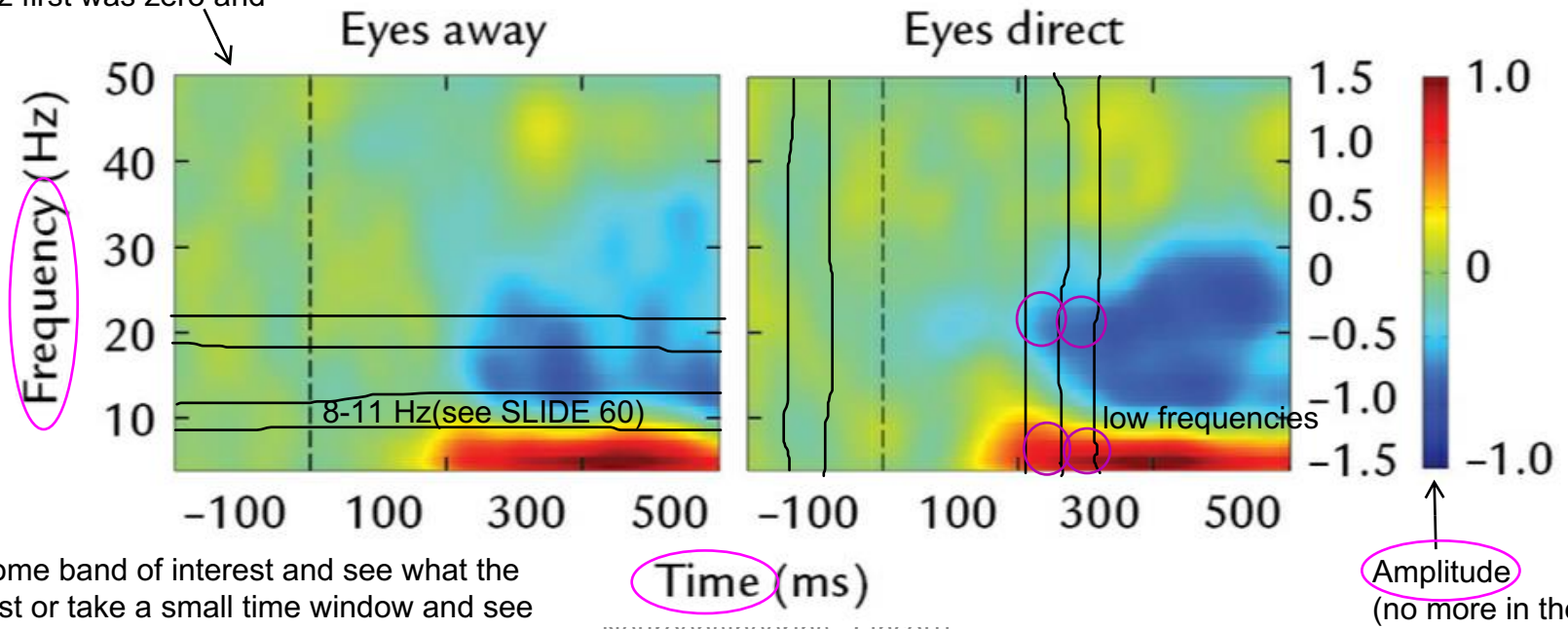
- Time–frequency analyses go one step further by computing and visualizing the spectral or amplitude content of the signal as a function of time simultaneously for all frequencies of interest.
- Fourier transforms, Hilbert transforms, and wavelet-based approaches can be used to calculate MEG/EEG signal power (amplitude
- Using this procedure, features in MEG/EEG data can be visualized in both time and frequency.

Short time

the x axes(that previously was the amplitute), now is used for another domain(frequency)

In the range 8-11 Hz the frequency was first zero and then it increases(yellow), at 20Hz first was zero and then it decreases(blue)





For analize that you can take some band of interest and see what the time course in this band of intrest or take a small time window and see what the spectrum of the signal is in this window

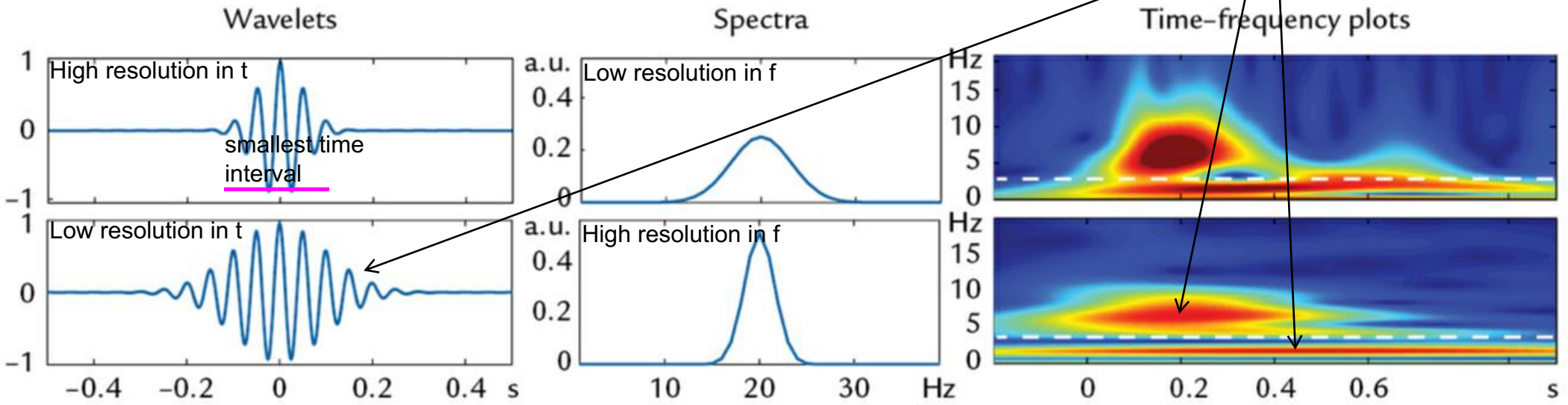
Amplitude (no more in the vertical axis)

Time-frequency analysis – «indetermination principle»

- Improving time resolution worsens spectral resolution (and vice versa)

il fatto che il segnale sia lungo in t, permette che a basse frequenze, le due frequenze di banda siano separate

This two panels analyze the same signal



You can't have high time resolution and high frequency resolution at the same time (you can achieve tools but you will have a marginal improvement)
In the upper panel you will have a better resolution n the orizontal axis, in the lower panel you will have a better resolution in the vertical axis

Further reading

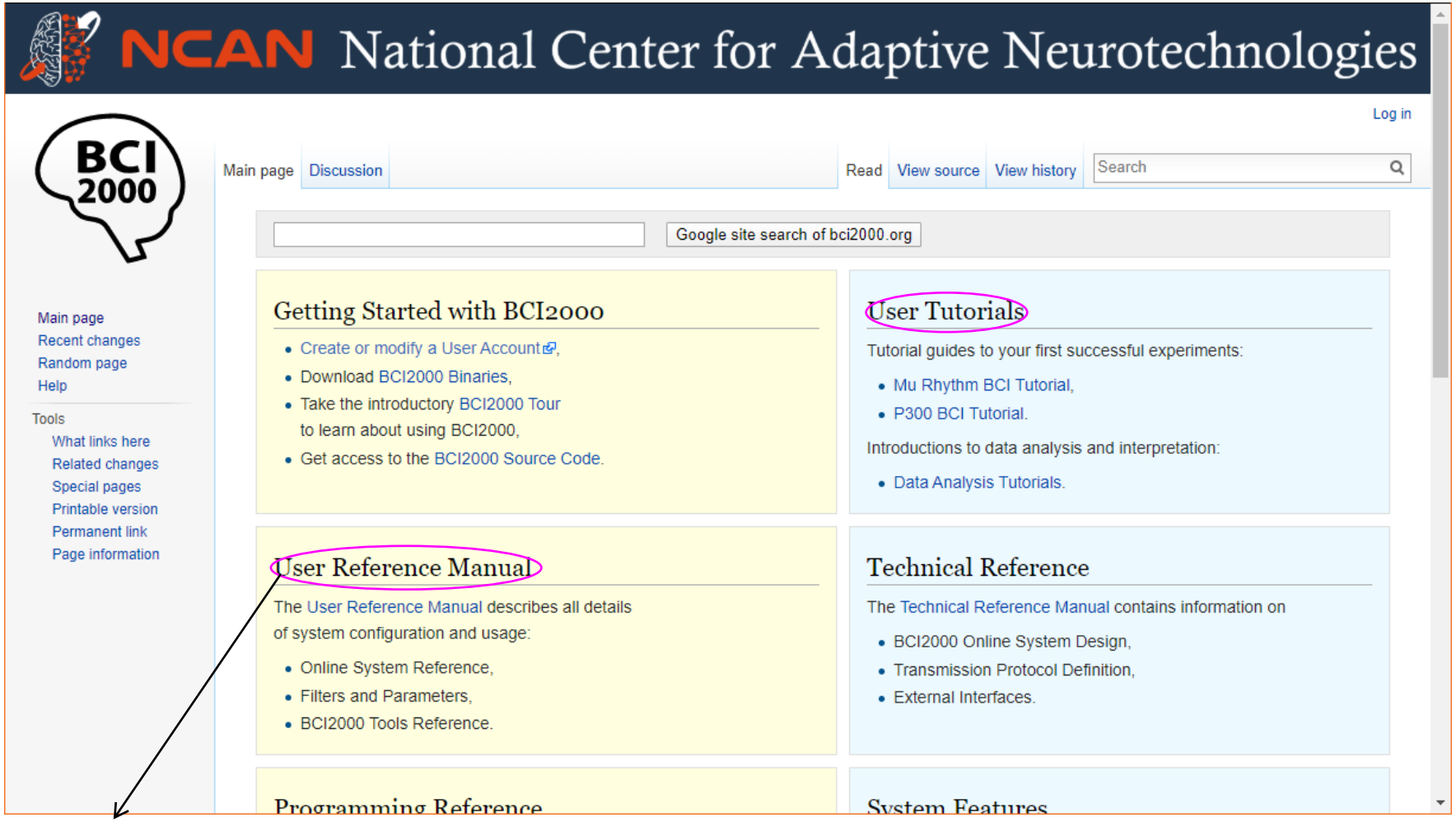
Project related readings

Not necessary to read

- Ch 12. auditory responses, including steady-state
- Ch 13. visual responses, including steady-state
- Ch 14. somatosensory responses
- Ch 16. motor function
- Ch 17. change detection (CNV, MMN, P300, ErrN, …)

Software tools

BCI2000

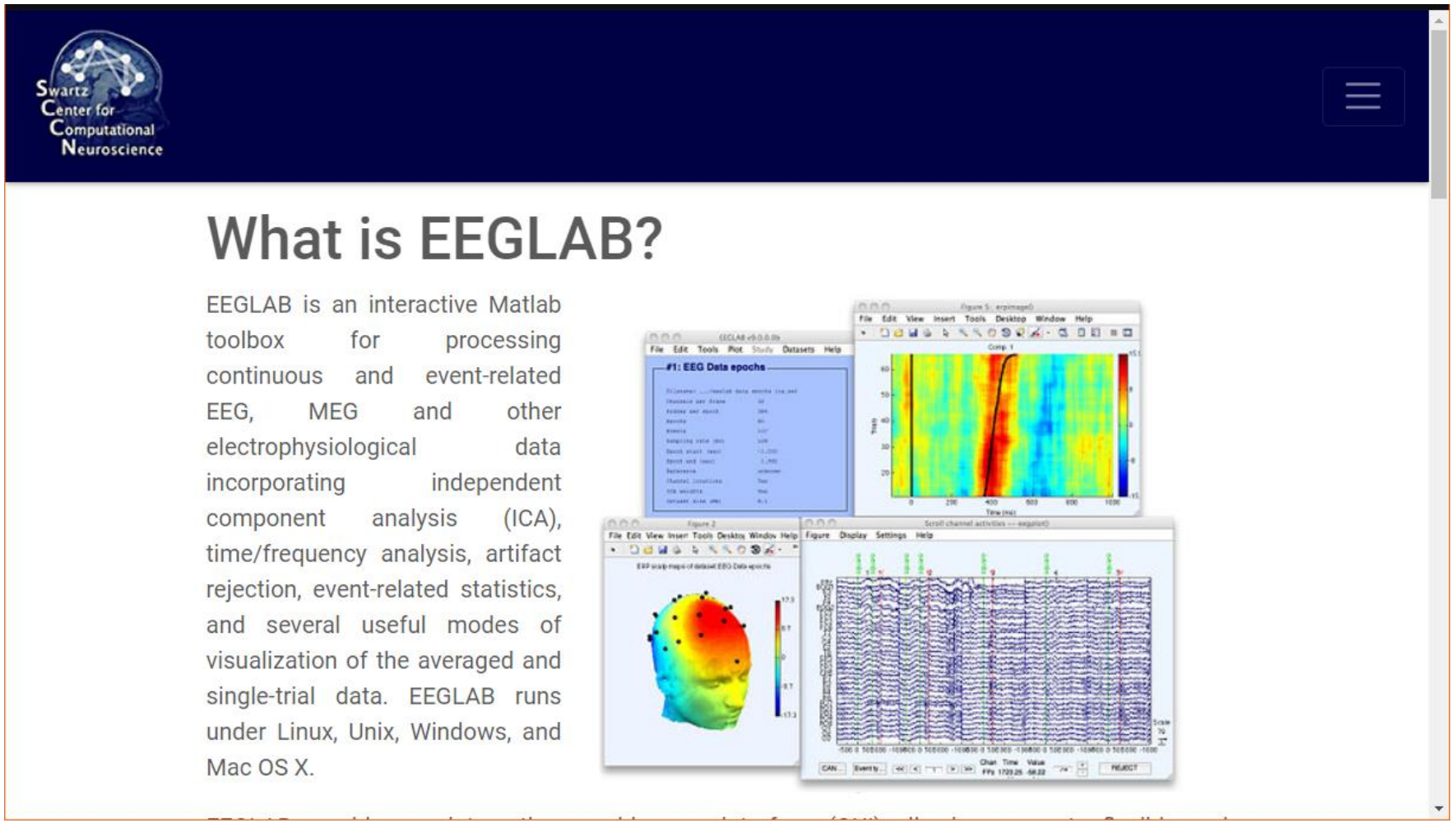


For more advanced tools that are not in the "User Tutorials"

https://www.bci2000.org

EEGLab

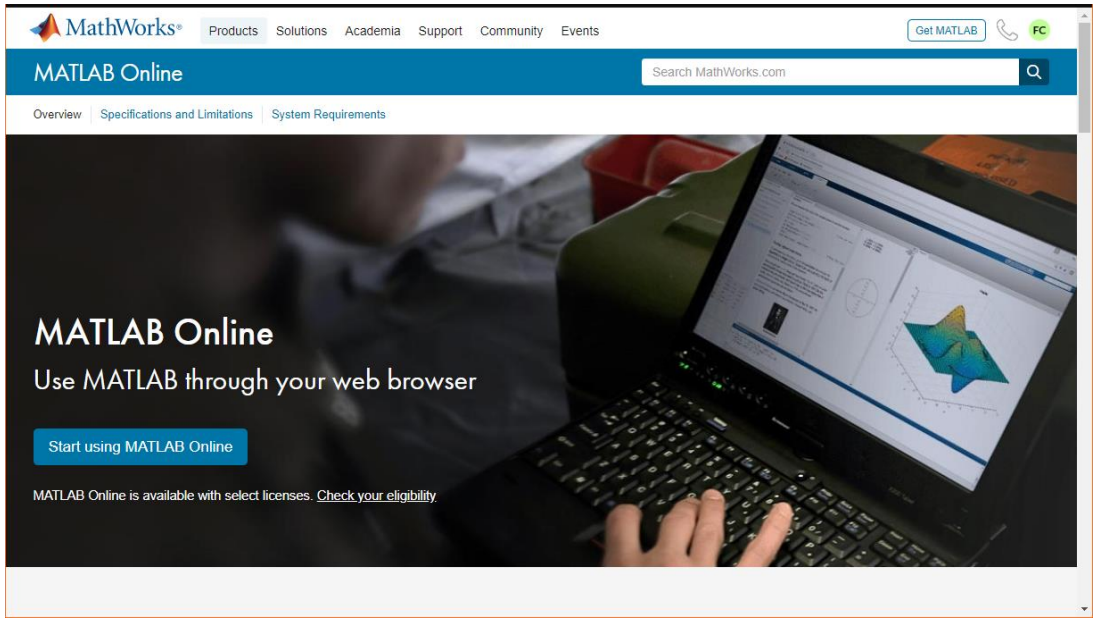
Is a toolbox for MatLab



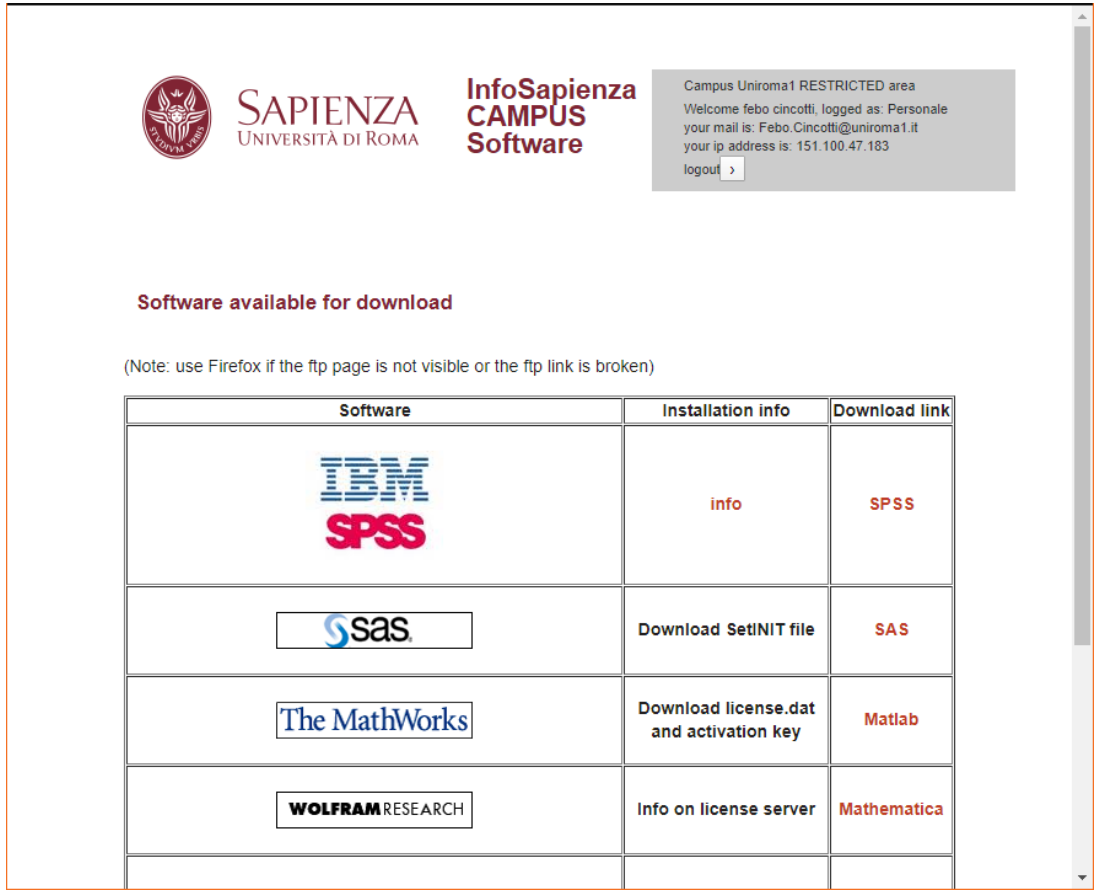
https://sccn.ucsd.edu/eeglab/index.php

Matlab

We will use it to learn very basic signal process



https://www.mathworks.com/products/matlab-online.html

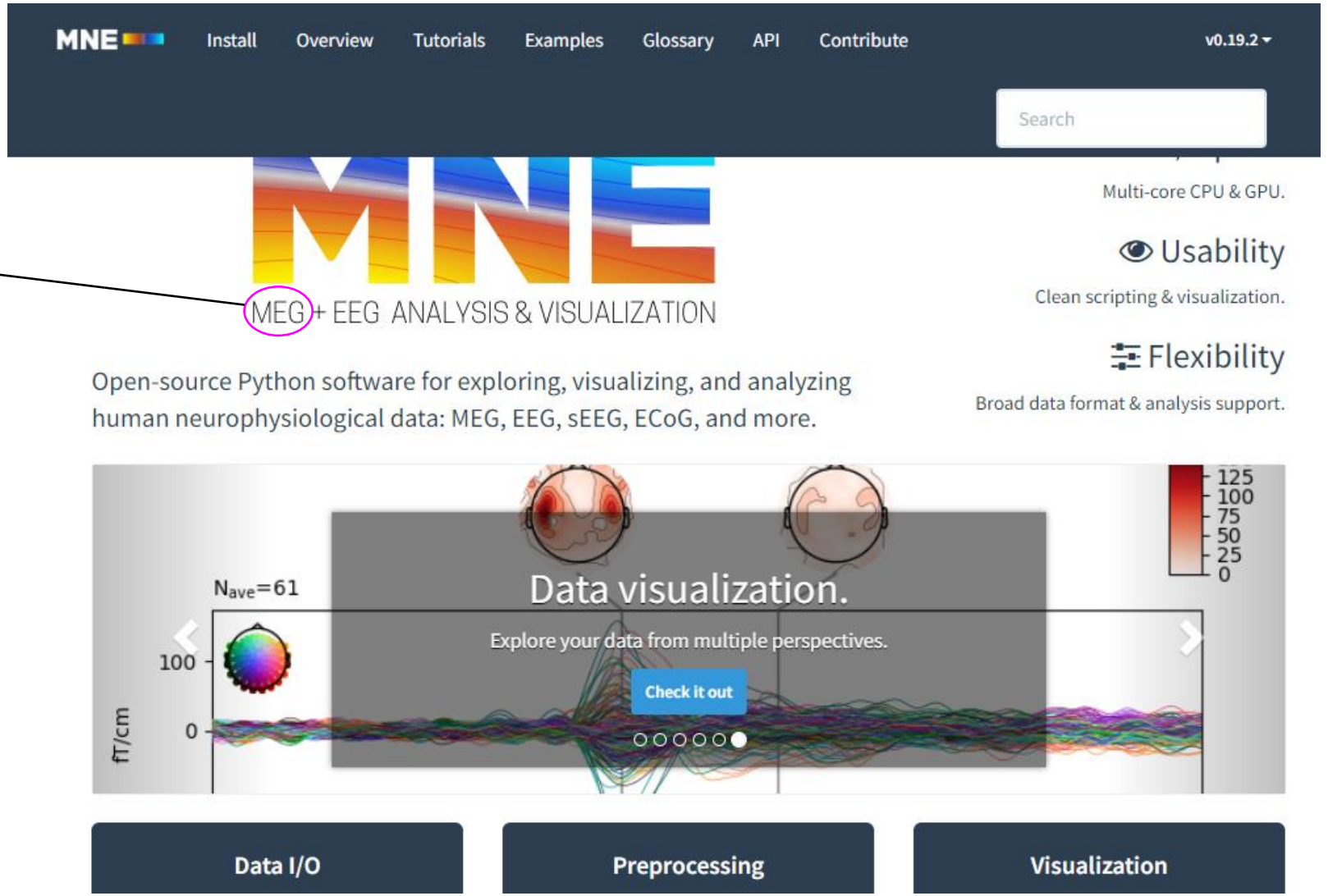


http://bit.ly/install-matlab-sapienza

It is developed in Pyton

Magnetoencelography (you do not mesure potencial but magnetic fields)

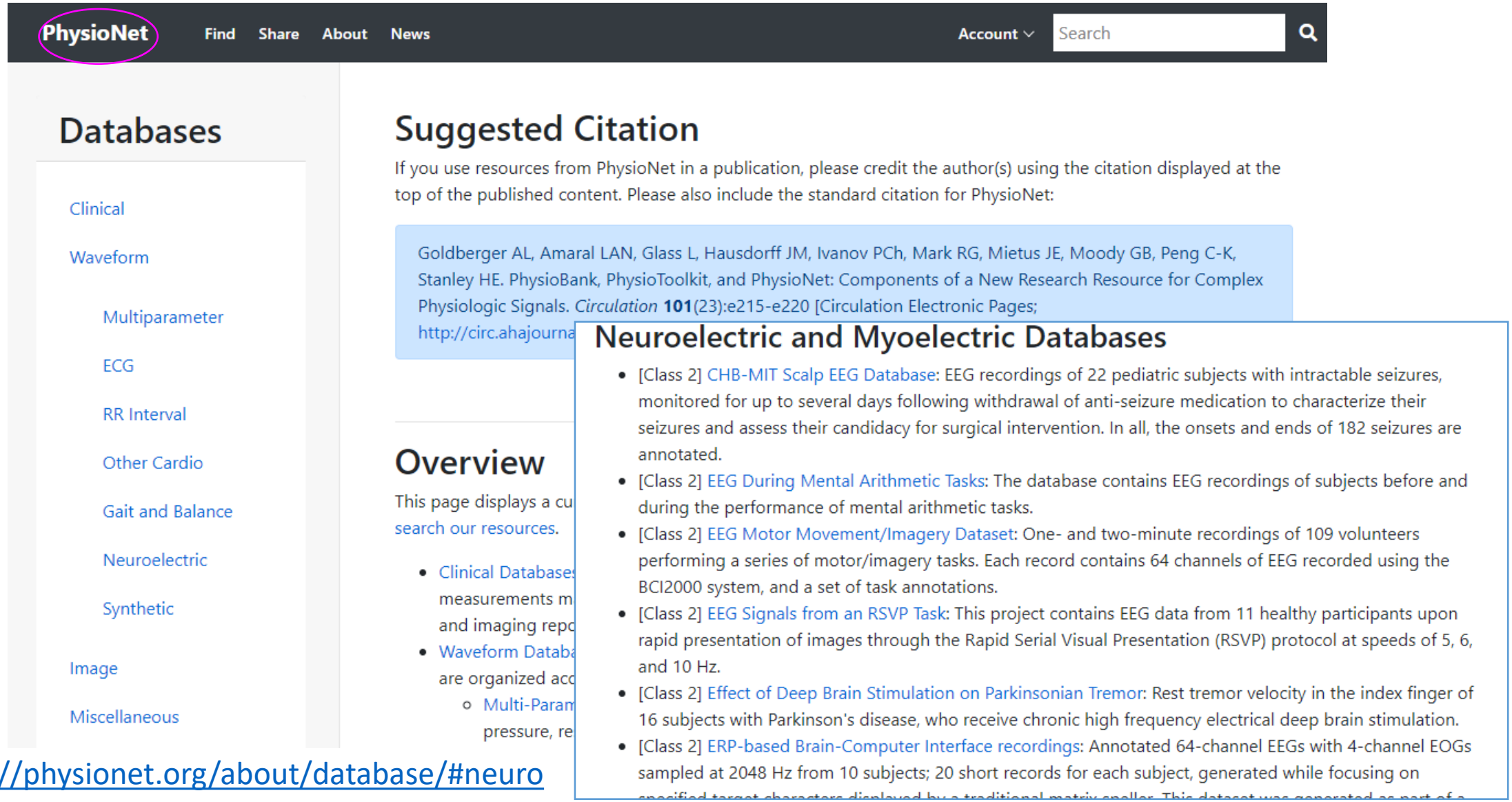
This is more strong for MEG and not so much for EEG



https://mne.tools/

Freely available datasets

The database of EEG is not so large
PhysioNet is a database for physiological signals including electro physiological signals



https://physionet.org/about/database/#neuro

This dataset is public avayable

BCI Competitions

Here there are varius type of stimulation or spontaneus activity

- BCI Competition I
- BCI Competition II (also called BCI Competition 2003)
- BCI Competition III → Have been used by various paper to test a signal processing tool change so a classification tool change
- BCI Competition IV →

References

Please help us to make the list of references complete and keep it up to date by reporting unlisted papers to ‹benjamin.blankertz@tu-berlin.de›, preferably PubMed ID (PMID) or in BibTex format.

- **B. Blankertz, K.R. M€ller, D.J. Krusienski, G. Schalk, J.R. Wolpaw, A. Schl€gl, G. Pfurtscheller, J.d.e.l. R. Mill€n, M. Schr€der, and N. Birbaumer**. The BCI competition. III: Validating alternative approaches to actual BCI problems. *IEEE Trans Neural Syst Rehabil Eng*, 14:153-159, Jun 2006. [pdf]
- **B. Blankertz, K.R. M€ller, G. Curio, T.M. Vaughan, G. Schalk, J.R. Wolpaw, A. Schl€gl, C. Neuper, G. Pfurtscheller, T. Hinterberger, M. Schr€der, and N. Birbaumer**. The BCI Competition 2003: progress and perspectives in detection and discrimination of EEG single trials. *IEEE Trans Biomed Eng*, 51:1044-1051, Jun 2004. [pdf]
- **P. Sajda, A. Gerson, K.R. M€ller, B. Blankertz, and L. Parra**. A data analysis competition to evaluate machine learning algorithms for use in brain-computer interfaces. *IEEE Trans Neural Syst Rehabil Eng*, 11:184-185, Jun 2003. [pdf]

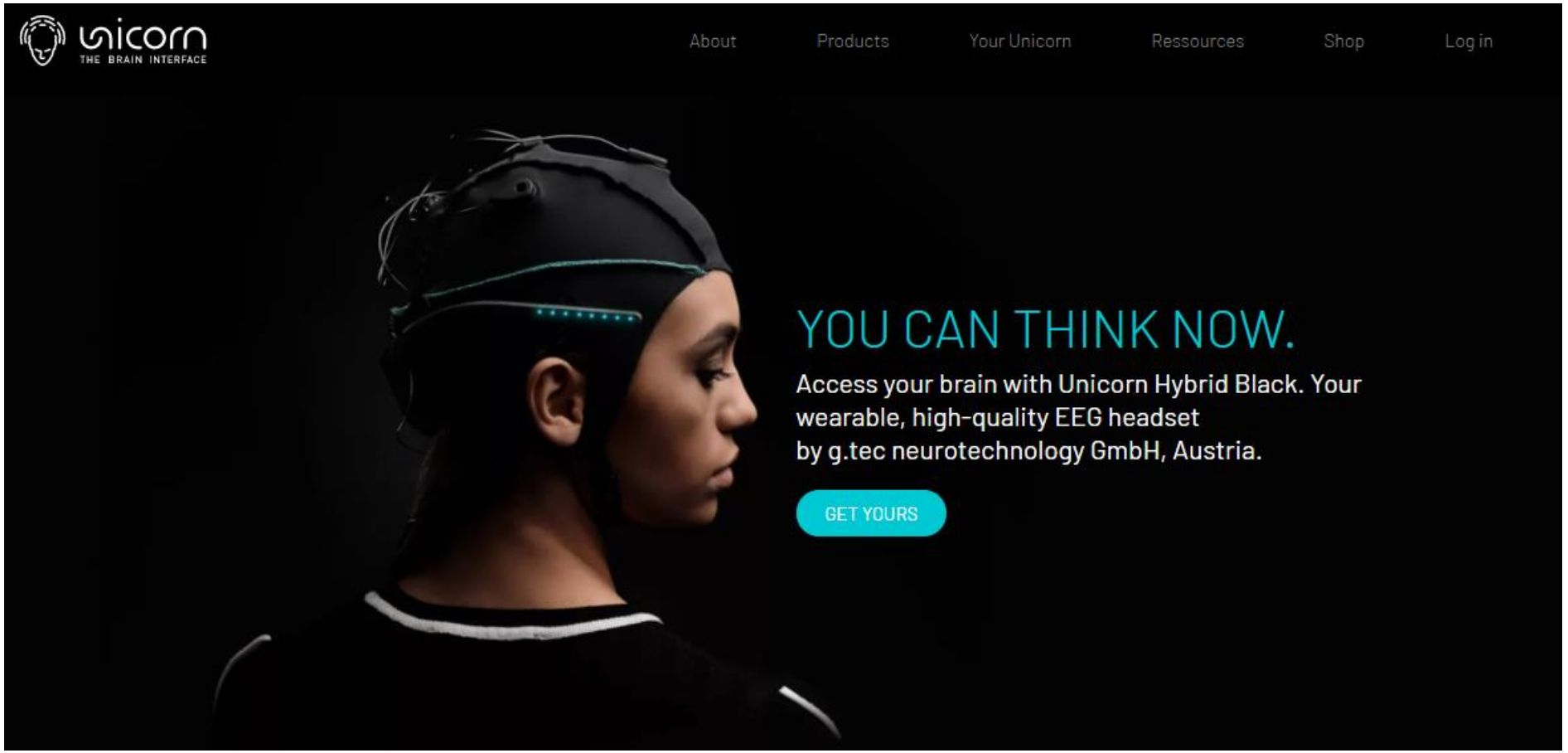
3 references, last updated Tue, Jun 24 18:03:58 2008

https://www.bbci.de/competition/

- Many more …

Devices

https://openbci.com/



new

https://www.unicorn-bi.com/

It is usefull for projects but is so expensive
They have it at the hospital

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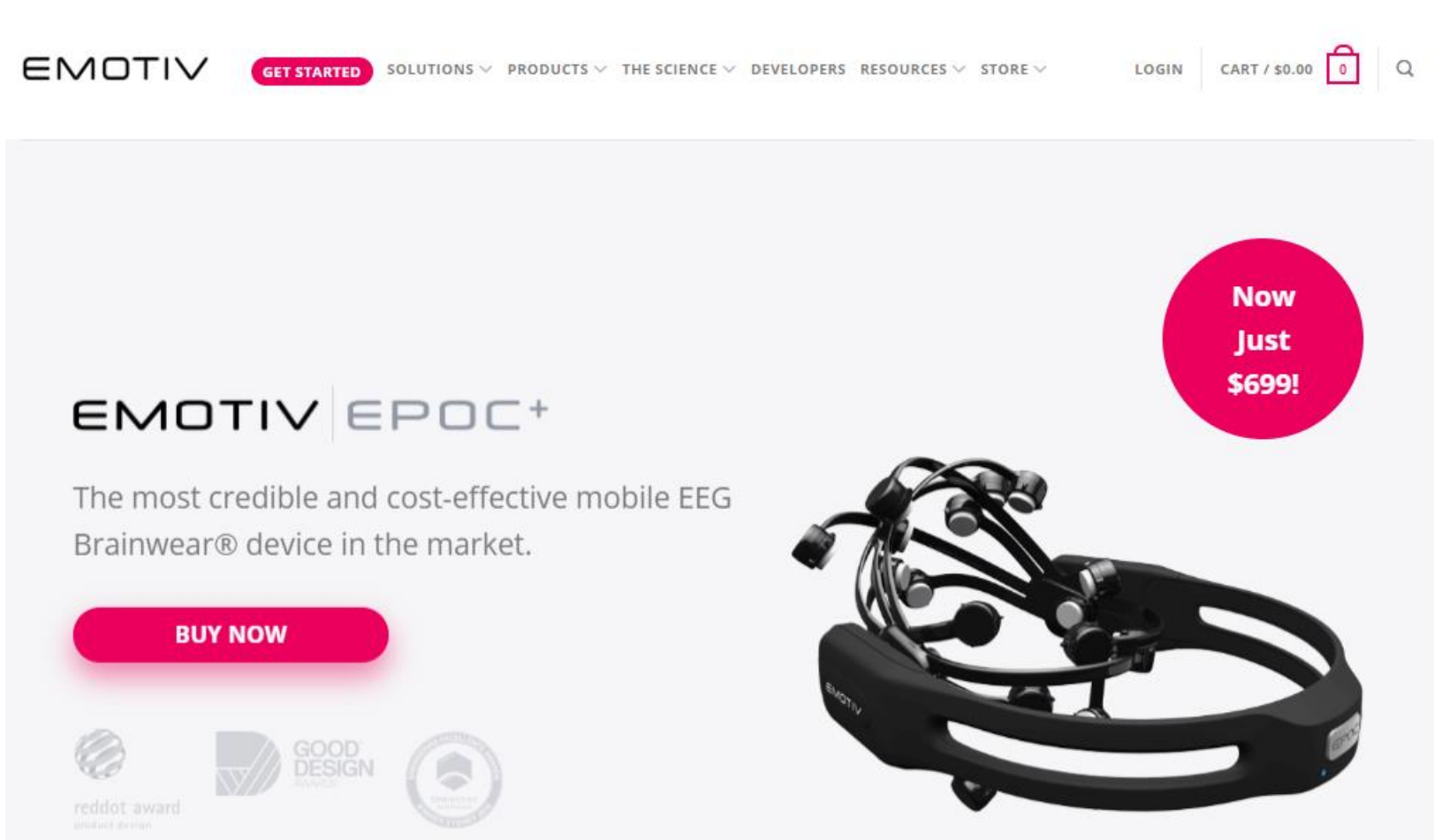
https://www.gtec.at/product/gnautilus-research/

It have 14 channels and works wetting the electrods
It is cheap but it is not so satisfying



https://www.emotiv.com/epoc/