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u.s. edition

# **BESA incorporates expert know-how in comprehensive software tools for Neuroscientists**

BESA GmbH was founded as MEGIS Software GmbH in 1995 by Dr. Michael Scherg. It is the leading company in the field of EEG / MEG analysis and a home base for highly skilled people.

Our products have been developed on the basis of 30 years' experience in human brain research. BESA provides state of the art scientific analysis tools covering the complete range of neurophysiological applications.

We strive to bring you the latest methods for advanced EEG and MEG analysis in a user-friendly and optimized implementation.

A handwritten signature in black ink that reads "Tobias Scherg". The signature is written in a cursive, slightly slanted style.

**Dr. Tobias Scherg**  
CEO/General Manager

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# Find the Product That Fits Your Needs

BESA offers four different products which cover many usage scenarios in neurophysiological data analysis in EEG and MEG.

## Data Formats

Manage EEG/MEG data recorded by different systems in one application:

**BESA Research** can read files of more than 40 different EEG/MEG data formats. Exporting whole files or segments to EDF is possible.

**BESA Epilepsy** can read files of more than 10 different EEG data formats. The intuitive patient database is your starting point for study-centered review of routine and long-term EEG.

## ERP/ERF

Use **BESA Research** for complete pre-processing and analysis. It includes artifact correction and rejection, peak finding, paradigm definition and grand averaging.

Use **BESA Statistics** to perform group and/or condition comparisons; it intrinsically solves the multiple testing problem and runs parameter free statistics. F-Test and t-Test are available.

## EP

Use **BESA Research** to perform artifact rejection, averaging, and analysis. Save time with the intuitive, graphical user interface.

## Source Analysis/Source Imaging

**BESA Research** is the most comprehensive toolbox for EEG/MEG source localization. Pattern search and averaging support your discrete and distributed source analysis. Generate source montages for reviewing the data. Fit single dipoles and regional sources, or use volume or cortical imaging methods for distributed source imaging. If you have no MRI data available, simply choose realistic children's and adults' FEM head models.

**BESA MRI** is required for source analysis with individual MRI. The integrated workflow concept makes it very easy to use. Create a 4-layer individual head model and co-register with EEG/MEG sensors.

## Brain Connectivity and Spectral Analysis

Use **BESA Research** to calculate DSA or FFT of your data. Time frequency transforms, coherence and source coherence methods are available in the included Source Coherence module.

## Cross-subject Statistics

Perform cluster permutation statistics on ERPs, source waveforms, images, time-frequency and coherence results with **BESA Statistics**.

## Spikes in Epilepsy Research

Use **BESA Research** to mark spikes manually. 3D Mapping and source montages support evaluation of the interictal activity. Run a pattern search to find similar patterns quickly and reliably. Average spikes for discrete or distributed source analysis. Analyze spike onset and check for propagation.

If you have MRI data available, use **BESA MRI** to create an individual head model for source analysis.

Use **BESA Epilepsy** to run automatic spike detection with subsequent clustering and hyperclustering on children and adults. Obtain an overview of the spikes in a 24h EEG within 5 minutes. A report is generated automatically during evaluation. Finally print the report or save it as PDF.

Use all three products in the **BESA Pipeline** to analyze interictal spikes and seizure onset.

## Seizures in Epilepsy Research

Use **BESA Research** to visualize seizure epochs in DSA. FFT supports your seizure analysis. Localize seizure onset using phase maps and averaged cycles.

If you have MRI data available, use **BESA MRI** to create an individual head model for source analysis.

Use **BESA Epilepsy** to run automatic seizure detection on adults. Detection requires less than 5 minutes for a 24h EEG. Check the result in seizure review using optimized montages and filters. A report is generated automatically during evaluation. Print the report or save it as PDF.

Use all three products in the **BESA Pipeline** to analyze interictal spikes and seizure onset.

## MEG Data Analysis

Use MEG source montages in **BESA Research** to save time and facilitate MEG data review. Search for spikes and perform source analysis in MEG.

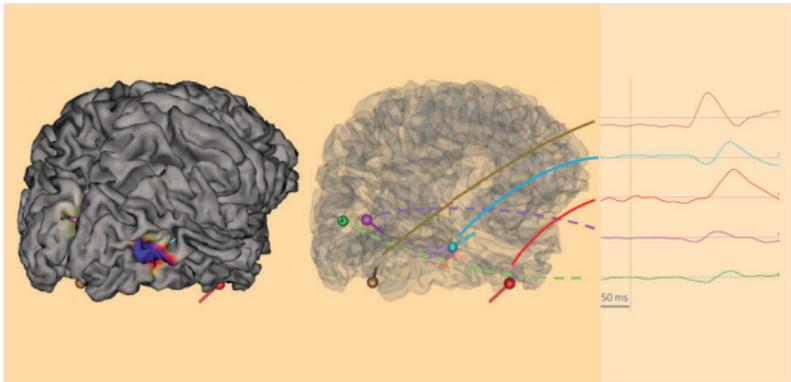


# BESA Research 6.1

## The most comprehensive signal processing toolbox for EEG / MEG source localization

BESA Research has set the standard for state-of-the-art EEG and MEG data analysis for nearly two decades. Then as well as now, the imperative was to provide innovative and tailored analysis methods which go hand in hand with intuitive and easy-to-use data processing and data review tools. The Matlab interface provides a convenient and extremely smooth pathway for following up with your own additional analysis, or with add-on Matlab tools provided by the research community.

Furthermore, detailed tutorials, the BESA Wiki, a Youtube channel with instructive videos, and the customer support supplied by experts in the field contribute to the overall user experience.



### Cortical Map – Cortical CLARA

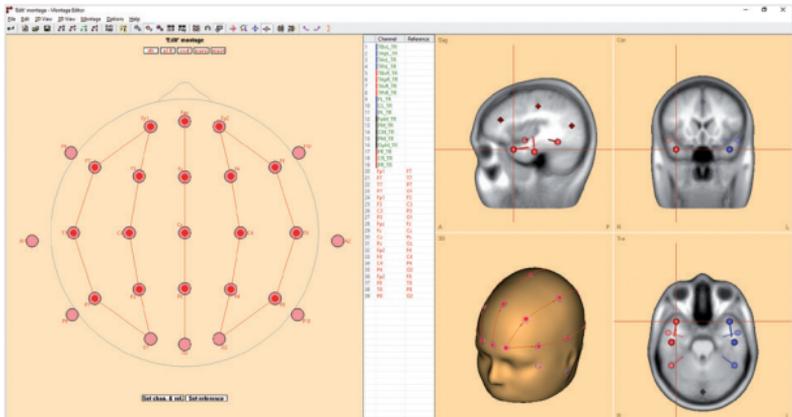
Combined cortical imaging and time course analysis illustrated for a visual motion processing example

## Data Review and Data Processing

- Reading and writing of multiple formats
- Graphical montage editor
- Source montages for
  - standard review, epilepsy review, ERP / ERF
  - resting state networks
- ICA / PCA
- Superior artifact removal tools
- ERP / ERF paradigms and averaging
- Graphical artifact rejection tool
- Co-registration with individual MRI / fMRI
- Grand averaging of subjects and conditions

## Time-Frequency Analysis

- Time-frequency transformation of any montage data
- Coherence in
  - Sensor space
  - source space using DICS or source montages
- TSE, ITPL, Phase-locking value, phase delay computation



## Data review

User montages can be defined easily in the graphical Montage Editor



## Time-frequency analysis

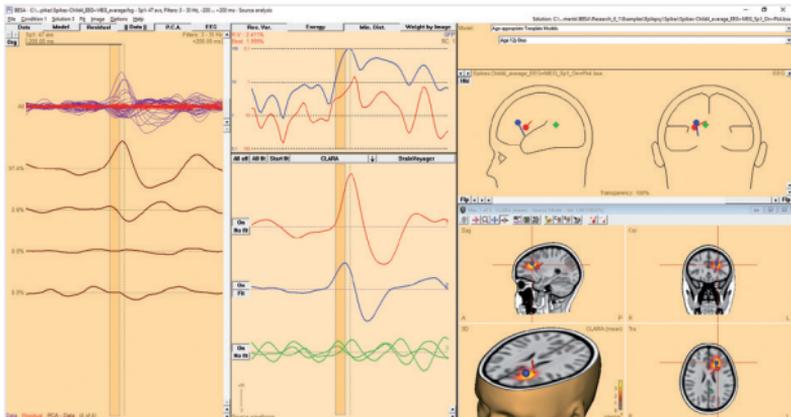
Temporal-spectral evolution of an error-related negativity task using a fronto-parietal task control network source montage

## Source Analysis and Source Imaging

- Dipole fitting / regional, single dipoles
- Volume imaging: (s)LORETA, CLARA, LAURA, SSLOFO, User-defined
- Cortical imaging
  - Minimum Norm
  - Cortical LORETA, Cortical CLARA; computed on individual or standard cortical surface
- Multiple or single source beamforming
- Realistic head models (FEM) in combination with BESA MRI for both EEG and MEG
- Co-registration with individual MRI / fMRI
- Realistic children's and adults' FEM head models for various age groups based on real averaged MRIs  
Kindly provided by John Richards, University of South Carolina, USA

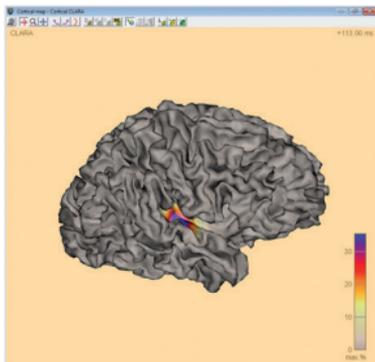
## Tools Available in all Modules

- Comprehensive online help
- Batch processing for multi-subject analysis
- MATLAB® interface
- Result export for further analysis



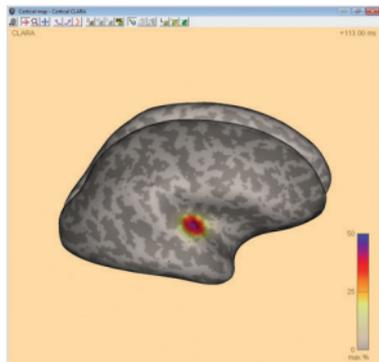
## Source analysis

Combined volume imaging and dipole source analysis using a template head model



## Source Imaging 1

Cortical CLARA using an individual cortex for an auditory task



## Source Imaging 2

Cortex inflation enables viewing all activity while retaining anatomical details

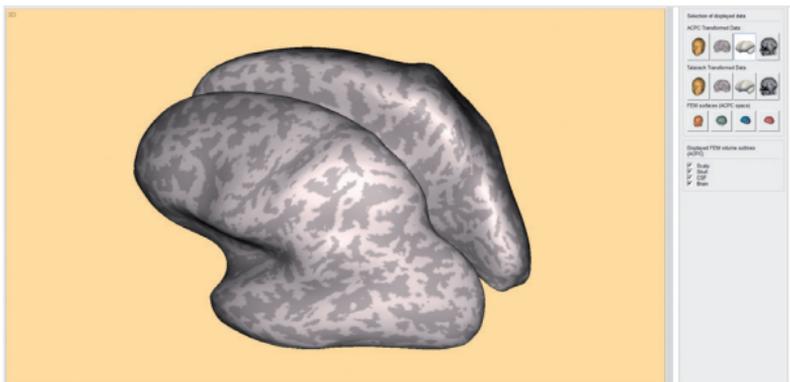


# BESA MRI 2.0

## Creating individual 4-layer FEM models made easy – improving source analysis by considering individual anatomy

BESA MRI is a fully integrated addition to BESA Research which opens up the next generation in both user experience and accuracy in EEG and MEG source modelling.

Streamlined workflows guide through the processes of semi-automated MRI segmentation, and co-registration with EEG and MEG data which includes FEM generation. Batching of several segmentation projects is possible. User interaction is optimized to enable largely automated segmentation. The 64-bit architecture enables simultaneous high-resolution image processing of T1-and T2-weighted MRI data for superior reconstruction results. Context-sensitive help is provided at all steps throughout the workflows.



### Segmentation result review

Display automated segmentation results including brain inflation

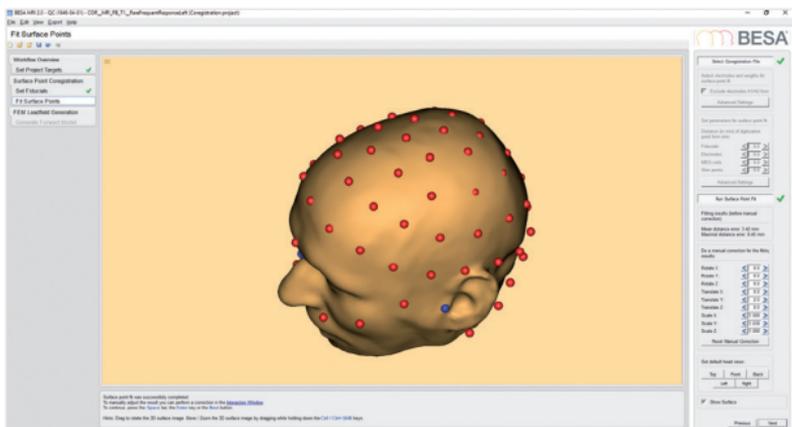
## Workflow-Driven Segmentation and Co-Registration

- **Integrated workflow**
  - Maximally intuitive and user-friendly
  - Context-related help
- **Automatic inhomogeneity correction**
  - For the best segmentation results
- **Automatic segmentation**
  - For superior skull segmentation
- **Automated registration of T1- and T2-images**
  - Scalp, skull, CSF, brain
- **Reconstruction of scalp, cortex, and inflated cortex**  
(used in visualization in BESA Source Analysis)
- **FEM model generation for both EEG and MEG**
  - Automated setup of FEM model including CSF layer
  - Geometry-adapted hexahedral meshes
  - All FEM meshes, surfaces, and lead fields are exportable
- **Coregistration**
  - With individually digitized electrodes and MEG sensors or standard electrodes
- **Using individual anatomy**
  - Individual realistic FEM models sent to BESA Research for source analysis
  - Individual source space for volume-based and cortex-based source imaging



## FEM Model

Automatic setup of 4-layer FEM model



## Electrode Coregistration

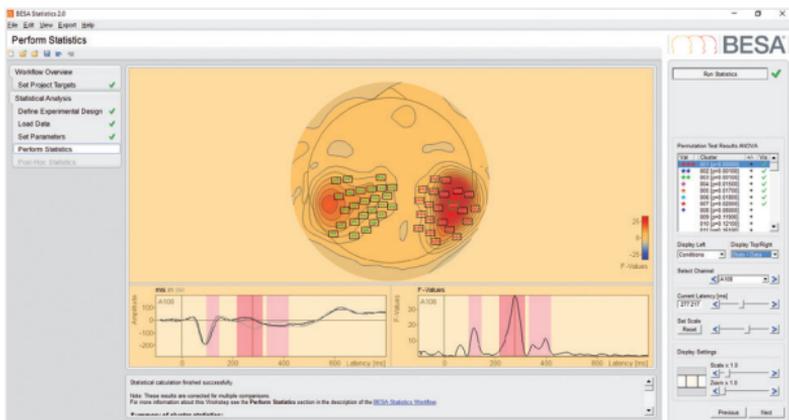
Easy coregistration of standard or digitized electrodes with MRI data



# BESA Statistics 2.0

## State of the art cross-subject cluster permutation statistics for ERPs, source waveforms, images, and coherence results

BESA Statistics enables you to bring together all pieces of the jigsaw: At the end of a group analysis study with several subjects, walk through a largely automated statistical evaluation of your data. The convenient workflow architecture does all the number crunching. BESA Statistics takes care of all multiple testing issues and population statistics questions along the way, presenting you with well-arranged final plots. Of course, these can be exported as high resolution (vector) graphics for use in publications.

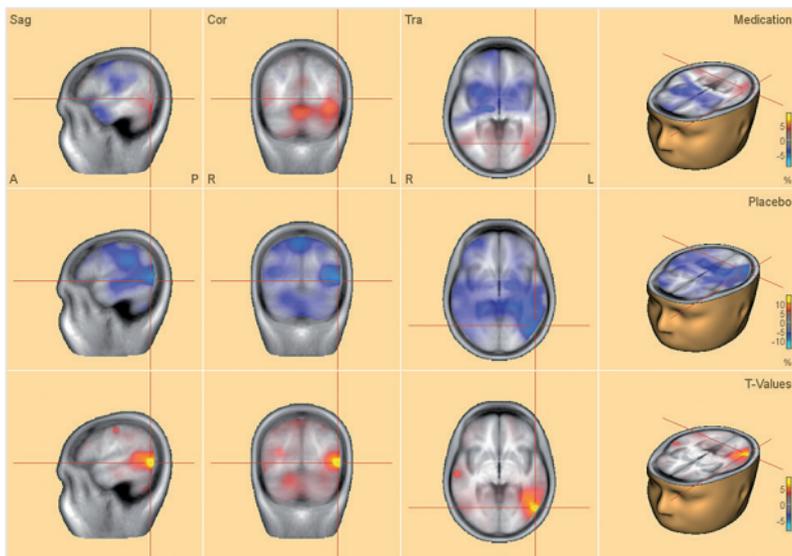


### Perform Statistics

ANOVA of an MEG experiment reveals several clusters where the null hypothesis is rejected

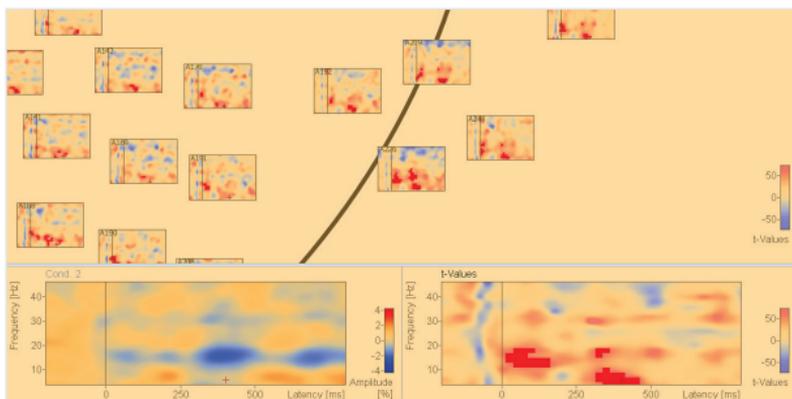
## Tailored Workflows for t-Test, AN(C)OVA, and Correlation

- **Cross-subject statistics of**
  - Event-related potentials / fields
  - Volume image data, e.g. LORETA, beamforming; 4D data also supported (3D+time)
  - Time-frequency data, e.g. temporal-spectral evolution, coherence, intertrial phase-locking
  - Source waveforms
- **t-test for comparing two groups (e.g. patients, controls) or conditions within the same group of subjects (e.g. target, control)**
- **One-way Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA)**
  - within-group or between-group testing
  - post-hoc tests possible
- **Correlation analysis for testing the relationship between covariates of interest and EEG / MEG data**
- **Significant clusters in time and if applicable space and frequency are determined and visualized in categories (highly significant, significant, trend)**
- **Results are corrected for multiple comparisons**
- **Works as a standalone package with BrainVision Analyzer 2 for time and time-frequency data**
- **All statistical parameters can be exported, and pictures saved as vector graphics suitable for publications**



### Cross-Subject Statistics

Cluster permutation testing applied to image data exported from BESA Research



### Visualization of Data

Significant clusters are visualized in time-frequency plots; high resolution export of images possible



# BESA Epilepsy 2.0

## Software for efficient EEG review and automatic detection of spikes and seizures

You can use BESA Epilepsy 2.0 to review EEG data of many different EEG data formats in one program: Alpha-Trace, BESA, Cadwell, Coherence/ ITMed, Compumedics, EBNeuro, EDF/EDF+, EGI MFF, Grass-Telefactor, MEF, Micromed, Nicolet-Nervus, Nihon Kohden, Stellate-Harmonie, XLTEK.

**BESA Epilepsy Review Database [Clinical Edition Complete]**

Patient selection

Det	Rev	Name	Date of birth	Last recording *	Age	Phys.	Tech.
		PatientExample03	1997-07-01	2009-02-25 / 10:45:15	11		
		PatientExample02	1994-05-01	2009-01-15 / 13:51:42	14		
		PatientExample01	1979-09-01	2008-09-19 / 11:05:43	30		

Patients: 3 / 3      Last database update completed at: 2015-04-01/16:02:08

Recording selection

0 2 4 6 8 10 12 14 16 18 20 22 24

Me 2008-09-15  
Di 2008-09-16  
Mi 2008-09-17  
Do 2008-09-18  
Fr 2008-09-19  
Sa 2008-09-20  
So 2008-09-21

Check Electrodes   EEG Review   **Spike Review**   Seizure Review   BESA Research   Close DB

### Intuitive patient database

Your starting point for file-independent review of routine and long-term EEG

## **Automatic Spike Detection**

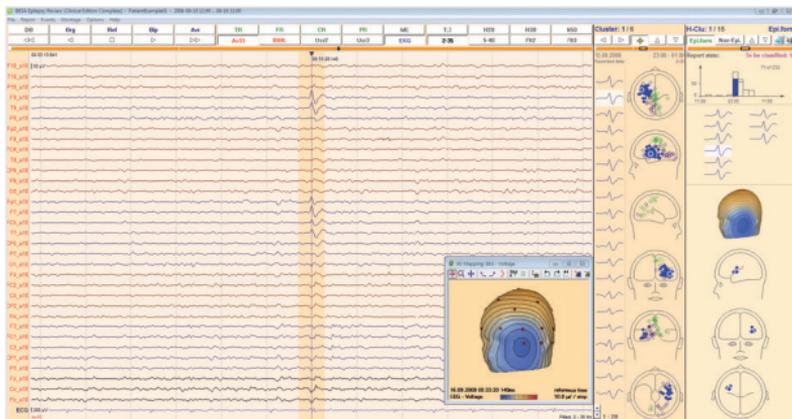
- Detection and clustering on children and adults
- Detection requires less than 3 hours for a 24h EEG
- Easy, intuitive workflow to set up detection

## **Automatic Seizure Detection**

- Detection on adults requires less than 5 minutes for a 24-hour EEG
- Quick navigation to review the findings
- Algorithm has been developed at the Epilepsy Center, Department of Neurology, Universitätsklinikum Erlangen

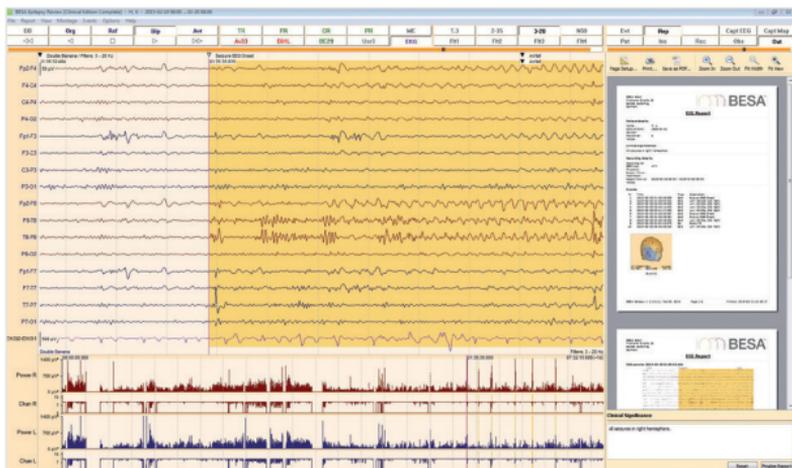
## **EEG Review / EEG Report**

- Many montages, filter settings, 3D Mapping and event list are available for reviewing the EEG
- Add EEG images manually by 1-click to the EEG report
- Print your final EEG report or store it as PDF



### Automatic spike detection

“Fast evaluation of interictal spikes in long-term EEG by hyper-clustering”.  
Find more details in *Epilepsia*, 2012 Jul;53(7):1196–1204



### Automatic seizure detection

“Automatic seizure detection in long-term scalp EEG using an adaptive thresholding technique: a validation study for clinical routine”.  
Find more details in *Clinical Neurophysiology*, 2014 Jul;125(7):1346–52

# BESA Pipeline

## Analyze interictal spikes and seizure onset in EEG and MEG Research

The **BESA pipeline** is the perfect combination of **BESA Epilepsy 2.0**, **BESA Research 6.1** and **BESA MRI 2.0**. Get support in evaluating epileptiform interictal and ictal activity in long-term (LTM) EEG and MEG.

### Interictal activity (spikes)

Use **BESA Epilepsy 2.0** to save precious time in evaluation. Within 5 minutes you can obtain an overview of the interictal activity (spikes) in a 24h EEG. The automated spike detection with subsequent clustering and hyperclustering enables the efficient evaluation of the interictal events detected in the EEG. During evaluation a report is generated automatically. Print the report or save it as PDF.

Use **BESA Research 6.1** to search for more spikes, and to average these and / or the different spike types previously detected in **BESA Epilepsy 2.0**. Finally perform a source analysis using the averaged data to analyze e.g. the onset phase.

Use **BESA MRI 2.0** for the segmentation of MR data and for a coregistration with the EEG. You can calculate an individual head model, which can be used in the source analysis of **BESA Research 6.1** to obtain superior localization results.

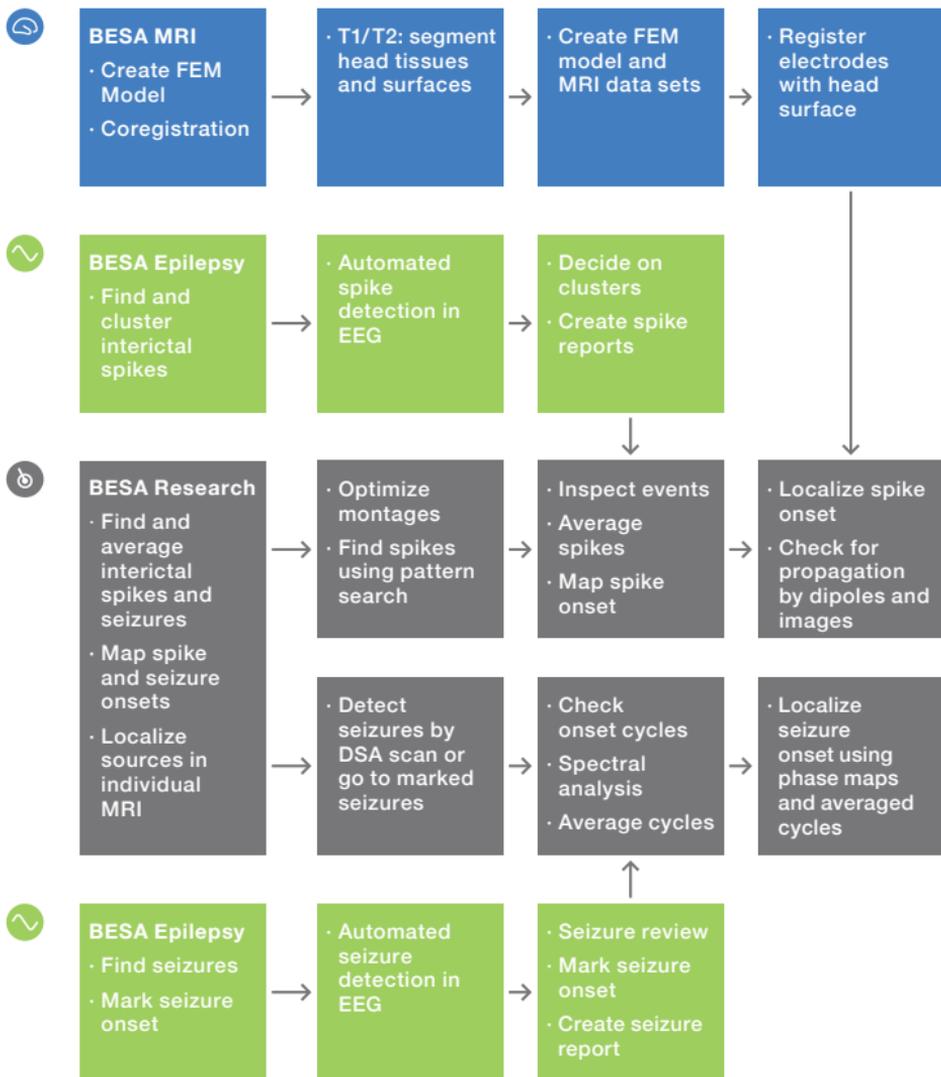
## **Ictal activity (seizures)**

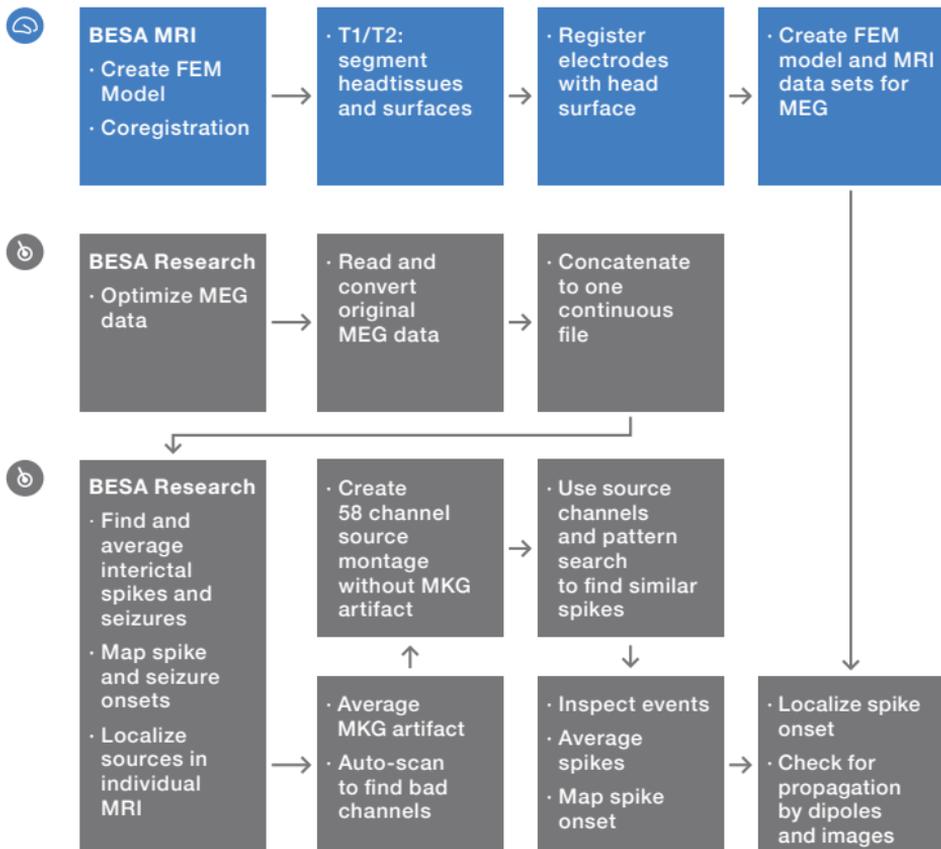
Use **BESA Epilepsy 2.0** to evaluate ictal activity. Within 5 minutes again you can obtain an overview of the ictal activity (seizures) in a 24h EEG.

The automated seizure detection in combination with the efficient seizure review enables the comprehensive evaluation of the ictal activity detected in the EEG. A post hoc-analysis takes at the most 5 minutes for a 24h EEG. During evaluation an EEG report is generated automatically. Print the report or save it as PDF.

Use **BESA Research 6.1** to search for more seizures and to analyze e.g. the onset phase. Send the seizure markers detected previously in **BESA Epilepsy 2.0** to **BESA Research**.

Use **BESA MRI 2.0** in the same way as for the interictal activity.





# BESA Team

BESA GmbH is the leading company in the field of EEG / MEG analysis and a home base for highly skilled people.

Our team is a thriving mixture of researchers from different disciplines, skilled software engineers and highly motivated young professionals.

We believe that the interaction between experienced researchers and young, creative and dedicated people is the key to success. This helps us in developing the most innovative software for data analysis in the field of EEG / MEG.

## Our Team from left to right

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**First row** Tobias Scherg / Theodor Scherg / Dieter Weckesser / Michael Scherg **Second row** Harald Bornfleth / Arndt Ebert / Mateusz Rusiniak / Gudrun Gerber **Third row** Nicole Ille / Robert Spangler / Michael Kornweibel / Olga Kornweibel **Fourth Row** Matthias Asselborn / Soma Sekhar Reddy Yarram / Jae-Hyun Cho / Abinash Pant **Fifth row** Christa Scherg / Patrick Berg



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The CE marking certifies that this product fulfills the essential requirements of the Medical Devices Directive MDD 93/42/EEC.

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