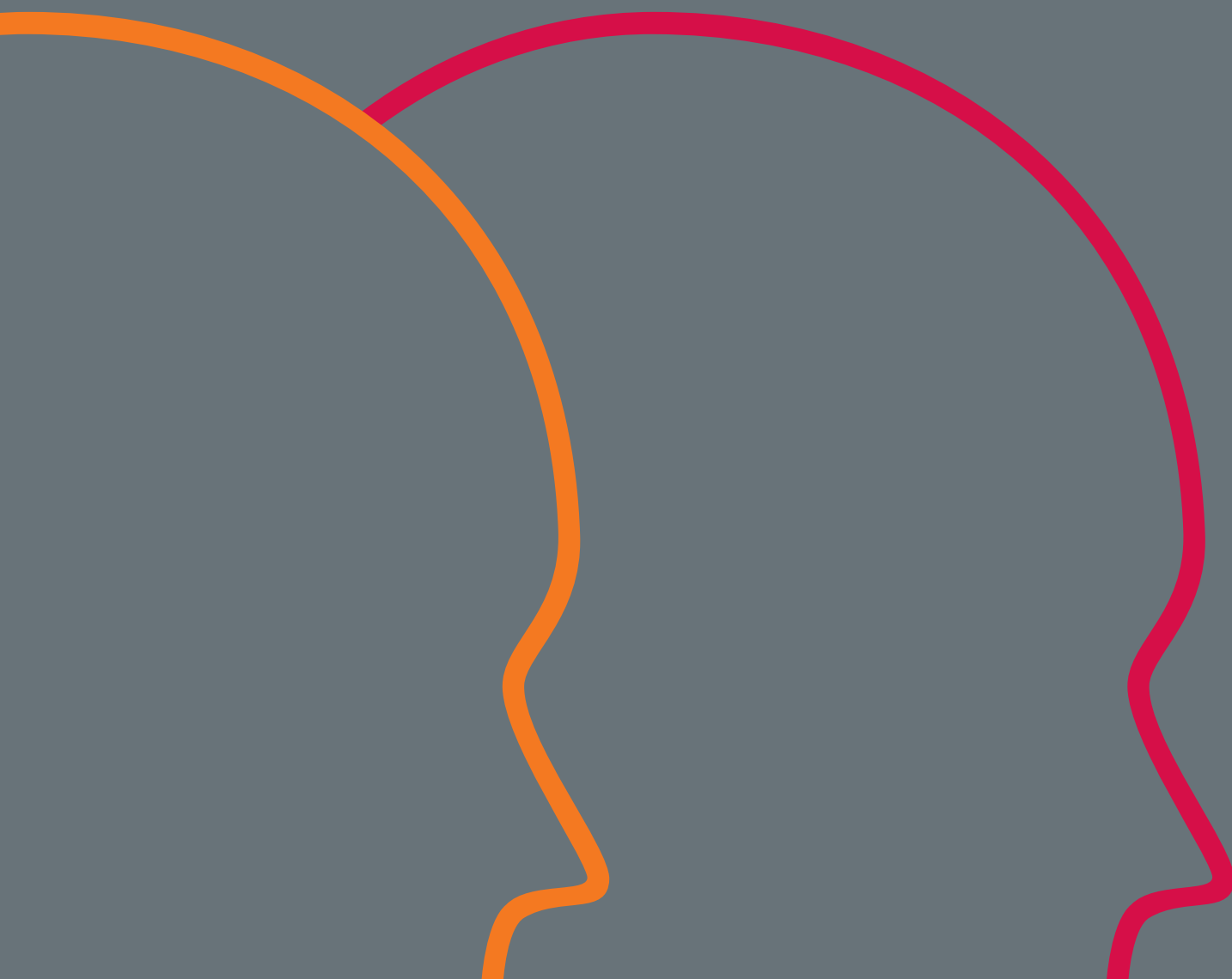




## **BESA Research** Quick Guide





# BESA®

## Research 6.0

# Quick Guide for EEG in Epilepsy

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# 1. Introduction

## 1.1. Purpose

Since BESA Research 5.2.4, the workflow for analyzing epileptiform spikes and seizures has been optimized by using the **F2-F12** function keys for fast processing and remontaging. This easy-to-use workflow is described in detail in the tutorial **Advanced EEG Review and Imaging in Epilepsy** on our website [http://besa.de/tutorials/hands\\_on/](http://besa.de/tutorials/hands_on/).

Please check the downloaded file **BESA-11-Tutorial-on-Advanced-EEG-Review-and-Imaging-in-Epilepsy.pdf** for more details and training.

The optimized batch functions described below are now available for BESA Research 6.0 along with this quick guide. Download the full installation or the upgrade from <http://besa.de/updates/besa/>.

## 1.2. Setting up for optimized EEG review and imaging in epilepsy

1. Start BESA Research (**BESA.exe**) and open the file **Examples\Epilepsy\Spikes\SpikeExamples.fsg**.
2. From the **Options** menu, choose the **Open “Reset Settings” Dialog...** menu item.
3. At the bottom, check the options **Set Options for EEG Review** and **Reset function keys to EEG Review default**.
4. If you prefer to have right EEG channel groups displayed above left channels in the displayed montages, press montage button **Opt** and remove the tick mark in the **Left to Right** menu item. In order to obtain the right-over-left channel order also for the recommended standard user montages (most important: **AV33** and **BiHL**), run the batch **Install.bat** in the **Shared Documents\BESA\Research\_6\_0\Montages\Special Montages\EEG Review\Regional\_Inferior-first\_Right-to-Left\** folder.
5. Restart BESA Research (**BESA.exe**), open the file as before and press **F4** for EEG spike view. Check channel order.

## 2. Features for optimized EEG review

### 2.1. Fast 3D Maps & Top View

By setting the **Options for EEG Review** introduced in chapter 1.2 direct 3D mapping and the display of the top view window at the time of the cursor has been enabled for single click. The 3D map rotates automatically to set the view point close to the center of gravity of the displayed topography. Thus, immediate visual localization can be done. For details on the interpretation of 3D maps, see the lecture **BESA Practical Analysis and Imaging in Epilepsy**.

Please download from <http://besa.de/tutorials/lectures/>.

**Note:** Top view (and 3D mapping) upon single click can be disabled from the **Options** menu. In the **Open "Reset Settings" Dialog...** menu item, you can reset the position of the 3D Map and Top view windows to their default at the right of the EEG window.

### 2.2. Fast Remontaging: Keys F9 - F12

The following montages are pre-assigned to the function keys **F9-F12**:

**F9:** **AV33** - optimized average reference montage based on virtual 10-10 electrode for best spike view

**F10:** **BiHL** - longitudinal bipolar montage preceded by horizontal bipolar channels with 20% distances

**F11:** **TR** – Temporal Region source mon. to view basal, polar, anterior-lateral and posterior TL activities

**F12:** **FR** – Frontal Region source mon. to view radial, anterior and vertically oriented FL activities.

If you have your own preference for a bipolar montage (e.g. to combine longitudinal & transverse channels), you may edit your montage using the Montage Editor, store it under User Montages and press **Shift+F10** to assign function key **F10** to your montage.

For example, after pressing the **Usr** button, you may select the user montage **LBip+SP** (longitudinal bipolar montage extended down to Sp1/Sp2, according to H. Lueders). Then, press **Shift+F10** to assign this montage to function key **F10**.

### 2.3. Fast Processing during EEG Review: Keys F2 - F4

The functions keys **F2-F4** provide optimized settings for standard EEG review, seizure and spike review. Press the button appropriate for your review task to obtain optimized montages and filter settings:

**F2:** Standard EEG review: **BiHL** montage; Time constant 0.3 sec (~ low filter 0.53 Hz);

Epoch: -500 ms : +500 ms (Batch script: F2\_EEG-Epoch\_TimeConst-03\_BiHL.bbat)

**F3:** Seizure review: **TR** source montage for fast check on temporal lobe; Filter 3-20 Hz to view rhythms;

Epoch: -1000 ms : +1000 ms (Batch script: F3\_Seizure-Epoch\_3-20Hz\_TR-mtg.bbat)

**F4:** Spike review: **AV33** montage for complete overview; Filter 2-35 Hz (zero phase)

Epoch: -250 ms : +150 ms (Batch script: F4\_Spike-Epoch\_2-35Hz\_Av33-mtg\_for-search.bbat)

After setting up filters etc. for your task by **F2-F4**, use **F9-F12** to change montage if needed for comparison.

If you have your own preference for a bipolar montage to be used with **F2** (hopefully combining longitudinal with transverse channels), open the Montage Editor to create **MyEEG** montage, store in the **User Montages** folder, copy the batch script **F2\_EEG-Epoch\_TimeConst-03\_BiHL.bbat** to **F2\_EEG-Epoch\_TimeConst-03\_MyEEG.bbat**, and replace the Montage name **BiHL** by **MyEEG** in the batch file. To use the montage **MyEEG** or the montage **LBip+SP** for standard EEG review, press **Shift+F2** to select the related batch.

## 2.4. Fast Processing for Averaging and Imaging: Keys F5 - F8

**F5:** Set optimized forward filter (**F5\_Spike-Set-Forward-Filter-5Hz-40Hz-to-Map-Onset.bbat**). This batch helps to map spike onset by reducing EEG background. Apply to EEG or averaged spike files.

Alternatively, you may use the **F5** key for a batch to localize a single spike in the EEG. This batch (**F5\_Spike-Epoch-in-Raw-EEG\_Fit+CLARA.bbat**) is no longer recommended, because single spike localization can be misleading. You may press **Shift+F5** to associate **F5** with this batch file.

**F6:** Convert tags to triggers and average (**F6\_Spike\_Convert-Tags\_and\_Average.bbat**).

This creates an average file **xxxxx\_av.fsg** from the original EEG file using the tags created by pattern search.

**F7:** Localize and image the first spike (Sp1) in an averaged spike file **xxxxx\_av.fsg**.

(Batch script: **F7\_Spike\_Sp1\_Fit\_Onset\_Manual+CLARA.bbat**).

For more detail on this revised imaging batch, see the next pages.

**F8:** Check the tutorial for more details on the use of the beamformer batch (**F8**) and pattern search.

**Note:** at any time you may select a specific batch file by pressing **R** (= Run Batch).

## 2.5. Use the Left Hand on Keyboard for Fast Working

<b>&lt;Space&gt;</b>	Page forward (one page, 1 sec overlap).
<b>B</b>	Back: Page backward half a page
<b>N</b>	Next: Page forward half a page
<b>S</b>	Select: Tag / Trigger for viewing and checking detected events
<b>D</b>	Delete: delete the tag / event near to the marked block, e.g. during selected view.
<b>E</b>	EEG: Switch back to EEG viewing from selected events or averages
<b>F</b>	FFT: Fast fourier transform over marked block to obtain spectrum and phase maps
<b>G</b>	Goto an event / comment in the EEG. List of events pops up.
<b>R</b>	Run batch. Select the batch from file open list that comes up.
<b>&lt;Tab&gt;</b>	Jump to next event in EEG view. <b>&lt;Shift+Tab&gt;</b> or <b>&lt;Backspace&gt;</b> jump backwards.

### 3. Imaging batch F7: How to interpret and check localization and imaging results.

Dipole localization and imaging accuracy depend on many factors: signal quality, electrode coverage, complexity of spike onset and propagation, etc. In order to obtain a reliable result, at least 2 methods must converge. This is why the **F7** batch always combines an image method with 4 different source localizations:

The CLARA images, based on an iterative application of LORETA, provide smoothed images, with a center often deeper in the brain and, sometimes, artifacts at the base of the brain due to electrode limitations.

Dipole localization leads to point-like equivalent centers of activity. This center can be consistent with the region where the spikes are generated, but it can just as well be an equivalent center between several regions already active at the time when the spike activity appears in the averaged EEG signals.

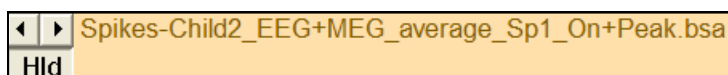
Therefore, in BESA Research the following 4 source localization strategies are combined with CLARA:

- **On+Peak (Sequential strategy):** A regional source is fitted during the user defined onset interval, oriented at the maximum, and converted to a single dipole. In its presence, a 2<sup>nd</sup> regional source is fitted to the peak interval (-20 ms : 0 ms) and converted. A 3<sup>rd</sup> regional source is fitted in the presence of the 2 dipoles to the residue around the peak (-10 ms : +20 ms), oriented, and switched off.
- **On-Bilat (Bilateral strategy):** A symmetric pair of regional sources is fitted to the onset interval, oriented, and converted to dipoles. Then, in addition, a pair of symmetric regional sources is fitted to a prolonged peak interval (-20 ms : +10 ms) and switched off. Switch on to test for propagation.
- **On-Peak (Separate strategy):** A regional source is fitted during the onset interval and oriented. Then, a separate source is fitted and oriented to the peak interval (-20 ms : 0 ms) while the onset source is off. Both sources are switched on to compare location and check for propagation. If sources are close together, there is little or no propagation.
- **RS2 (Background strategy):** Two regional sources (RS2) are fitted simultaneously to a longer interval (-100 ms : +20 ms) comprising EEG background and spike activities. This strategy may separate overlap of EEG background from spike activity. Compare spike source with the onset / peak source in the other strategies.

Using these strategies, the following hypotheses are tested:

1. Spike propagates.
2. Spike onset is already bilateral.
3. Overlapping EEG background activity leads to mislocalization of spike.

Compare the solutions by using the right (left) arrow buttons at the top of the head scheme window:



Press **On / Off** to switch sources 2 and higher on and off. This helps to understand how the peak activity overlaps the onset activity. Later activity must be interpreted with caution, especially if small.

You may press the **Cancel** button in the batch control box when scaling is requested to stop creating screenshots. Then, inspect the solutions, select the best, and set a cursor to create your own onset and peak images. Press the **CLARA** button to recalculate the image at the cursor and scale using the **Scale** buttons.



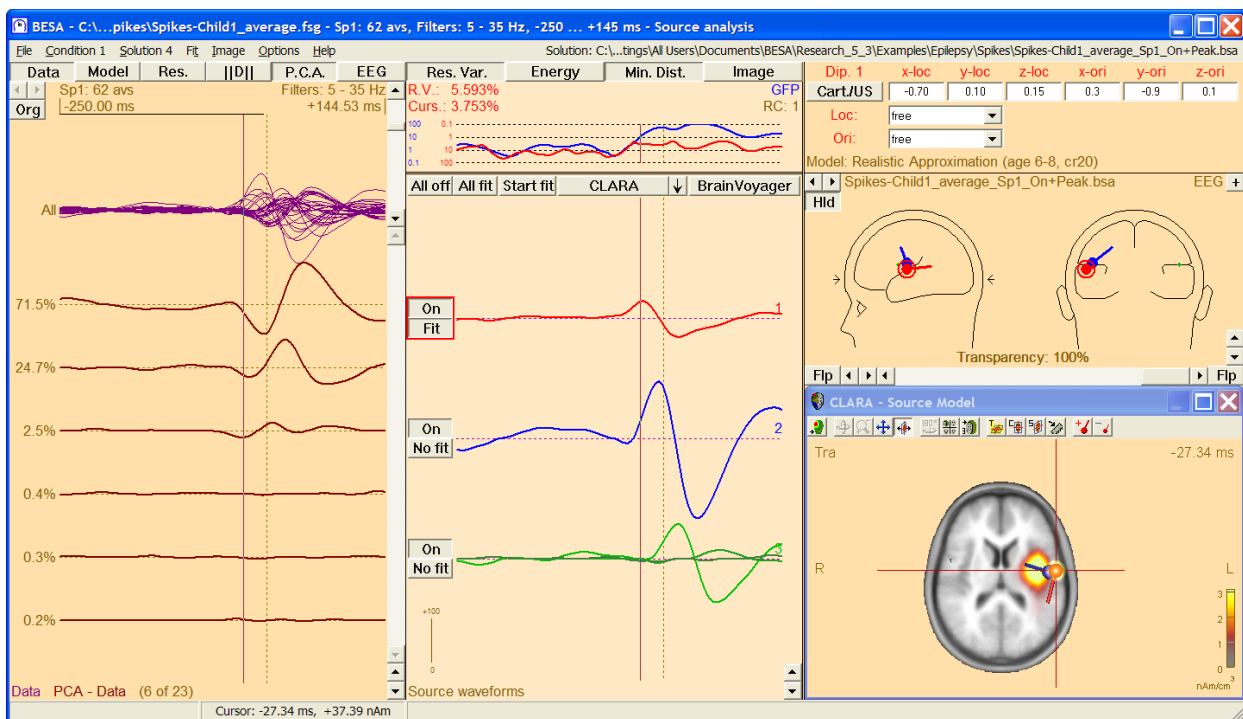
## Learn by Examples

You may analyze the spike files in the folder **Examples\Epilepsy\Spikes\** to learn how to interpret the strategies.

Run the **F7** batch on the averaged spike files using the onset intervals / head model ages indicated below:

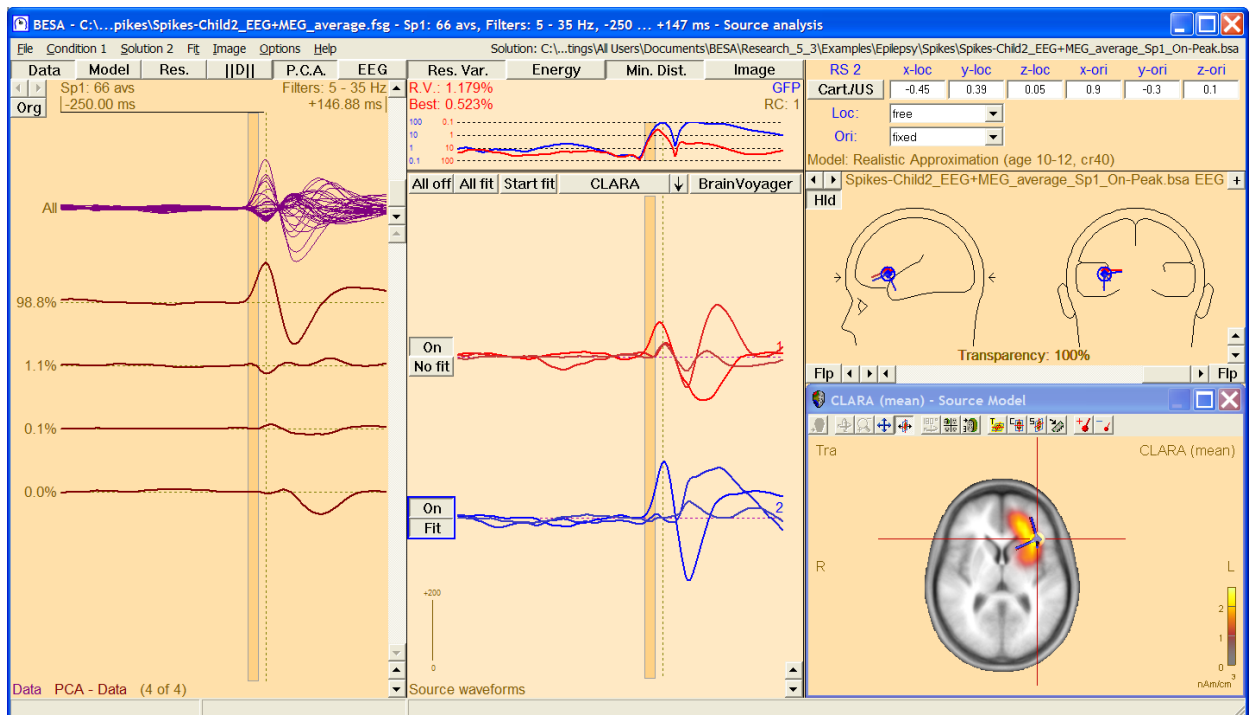
- |   |                                  |            |
|---|----------------------------------|------------|
| 1. <b>Spikes-Child1_average.fsg</b>         | Onset interval: -55 ms : -35 ms. | Age: 6-8   |
| 2. <b>Spikes-Child2_EEG+MEG_average.fsg</b> | Onset interval: -22 ms : -10 ms. | Age: 10-12 |
| 3. <b>Spikes-Child3_GSW_average.fsg</b>     | Onset interval: -70 ms : -20 ms. | Age: 12-14 |
| 4. <b>Spikes-Child4_EEG+MEG_average.fsg</b> | Onset interval: -40 ms : -10 ms. | Age: 12-14 |
| 5. <b>Spikes-Child5_MEG+EEG.fsg</b>         | Onset interval: -63 ms : -38 ms. | Age: 8-10  |
| 6. <b>Spikes-Child6_PL_average.fsg</b>      | Onset interval: -60 ms : -40 ms. | Age: 8-10  |

**Note:** Keep in mind that the CLARA images and at least one fitting strategy should match meaningfully!



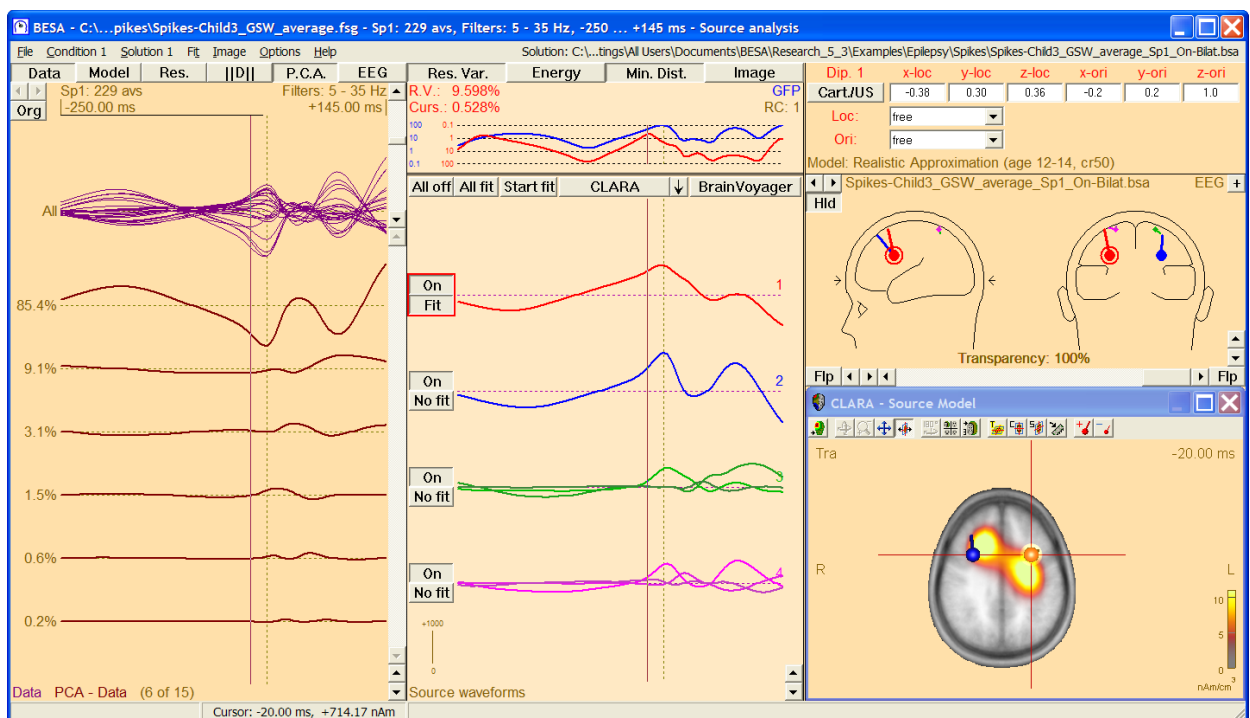
**Child 1:** Rolandic spike. Local and contra lateral propagation. CLARA consistent with onset and peak sources (image deeper due to smoothing).

### 3. Imaging batch F7: How to interpret and check localization and imaging results.

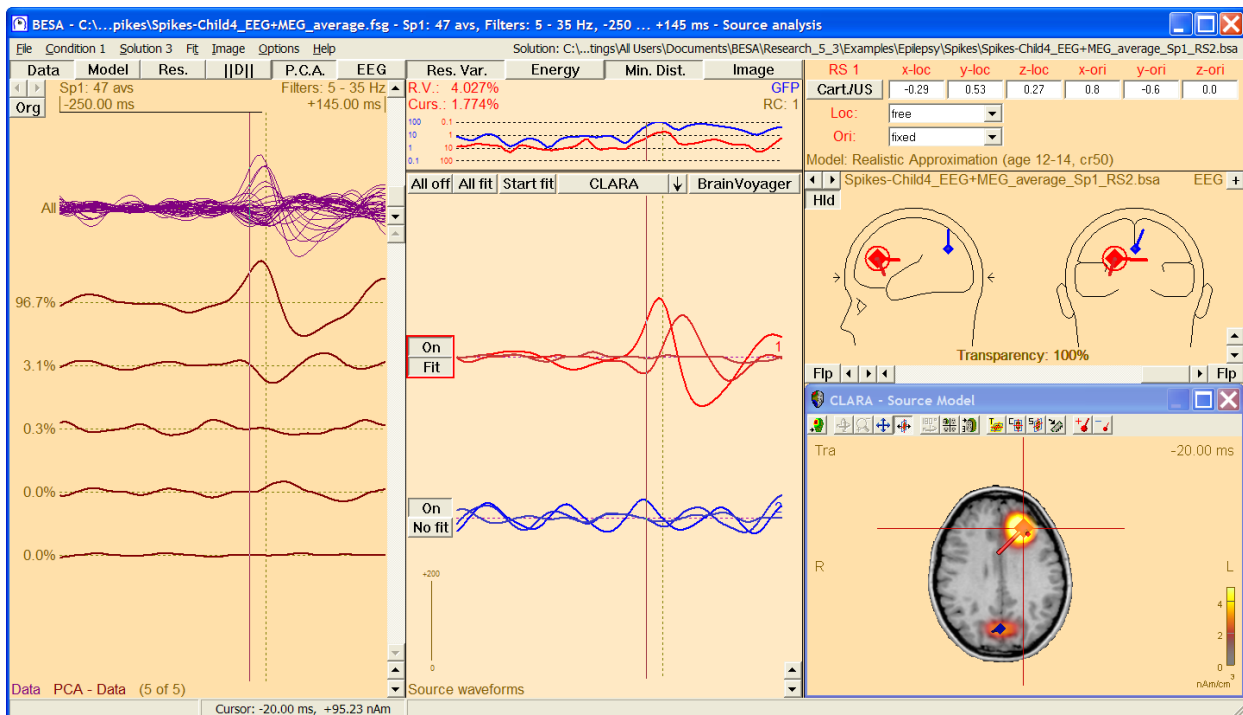


**Child 2:** Left frontal spike, little propagation. CLARA consistent with onset and peak sources.

**Note:** The onset source is the same as in the sequential strategy where it is converted to a single dipole. The 2nd dipole in the sequential strategy is weak and needs to be interpreted with caution. The bilateral onset dipoles confirm the lateralization to the left.

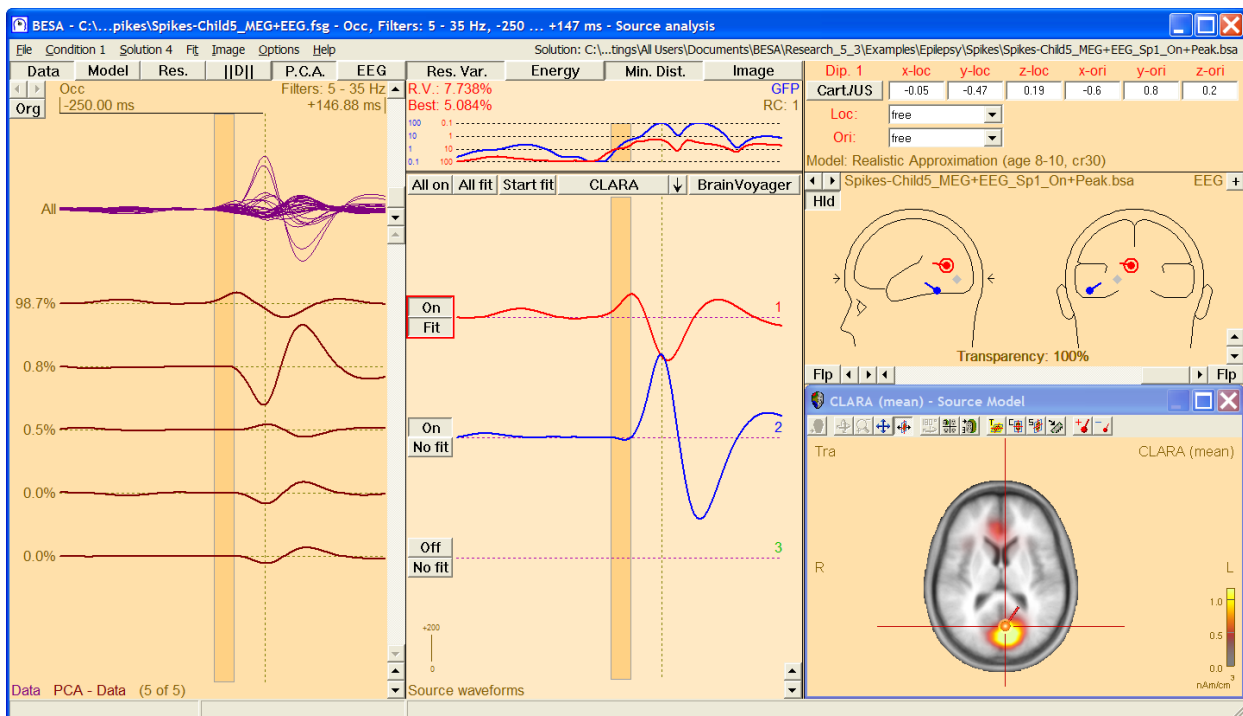


**Child 3:** Generalized spike waves. Bilateral onset and propagation. CLARA shows bilateral activities. Single source hypotheses fit near to midline (incorrect, equivalent locations!)

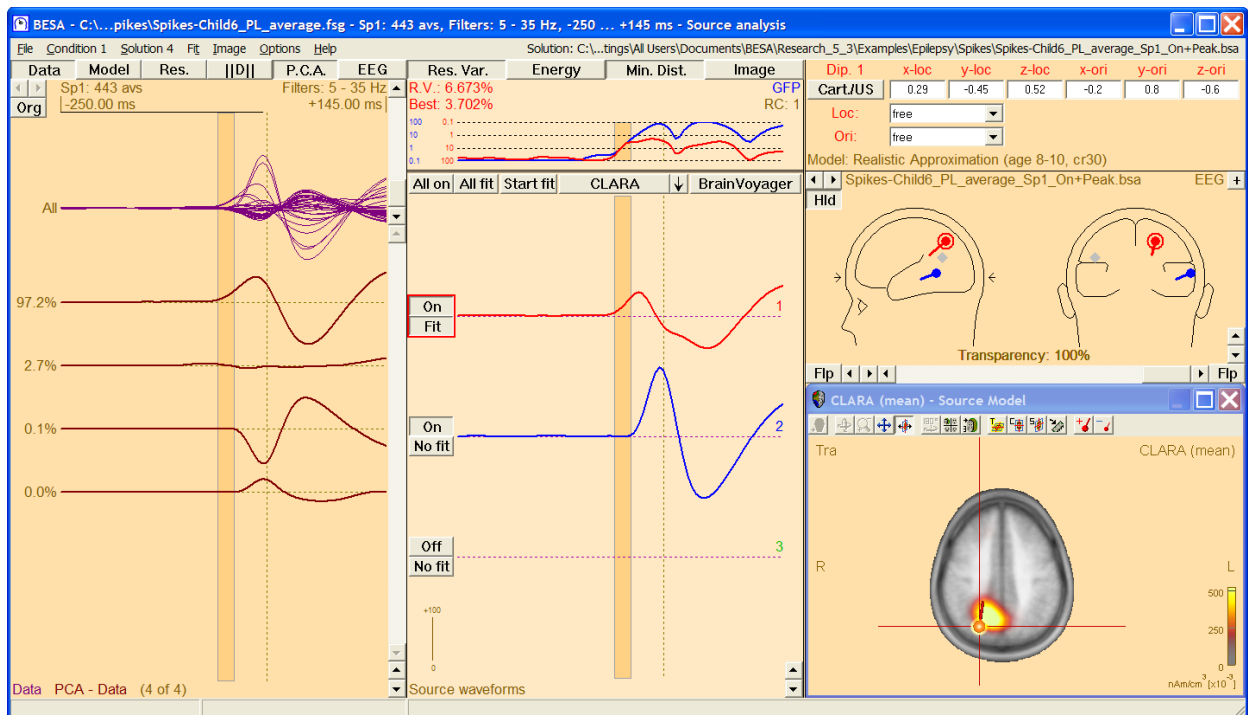


**Child 4:** Alpha background overlaps left frontal spikes (cortical dysplasia). CLARA images consistent with the spike source in the background hypothesis (RS2).

**Note:** Ignoring the alpha-EEG overlap leads to mislocalization of the spike away from the lesion. CLARA and the fitting of 2 sources simultaneously separate both activities.



**Child 5:** Propagating left occipital spike. CLARA images consistent with onset and peak. Lateralization of onset by source orientation using cortex negativity of spikes!



**Child 6:** Propagating right parietal-temporal spike. CLARA images consistent with onset and peak.

## Conclusion

Onset sources consistent with CLARA and bilateral test in all cases except for case 3 (bilateral sources consistent with CLARA) and case 4 (background EEG leads to mislocalization, CLARA confirms RS2 solution).



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