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Supplementary Materials for

A Conformal, Bio-Interfaced Class of Silicon Electronics for Mapping Cardiac Electrophysiology

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Fig. S22. Screenshot from Cadence simulation environment showing the schematic of one unit cell of the array.
Fig. S23. Screenshot from Cadence simulation environment showing the test setup for two unit cells connected to a common output.
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Movie M2. Unpaced voltage data from all electrodes illustrating the natural activation pattern of the heart.
Movie M3. Voltage data from all electrodes illustrating the paced activation pattern of the heart moving from the left side of the array to the right side.
Movie M4. Voltage data from all electrodes illustrating the paced activation pattern of the heart moving from the right side of the array to the left side.

Other Supplementary Material for this manuscript includes the following:
(available at www.sciencetranslationalmedicine.org/cgi/content/full/2/24/24ra22/DC1)

Movies M1 to M4 (In .mpg format). Files are packaged as a compressed archive, in *.zip format; users should download the compressed file to their machine and decompress the file on their local hard drive, using the instructions below.
3000738_Movies S1_to_S4.zip **(36 MB)**

Instructions for downloading and decompressing files:

1. Create a temporary folder on your machine's hard drive.
2. Save the compressed archive to the temporary folder you created, using the links above.
3. Decompress the compressed file in the temporary folder using decompression software such as WinZip (Windows; www.winzip.com) or StuffIt Expander (Windows and Mac; www.stuffit.com).

Excel files can be opened and viewed using Microsoft Excel, the spreadsheet module of the freely downloadable Open Office suite, or the freely downloadable Excel Viewer available from Microsoft.

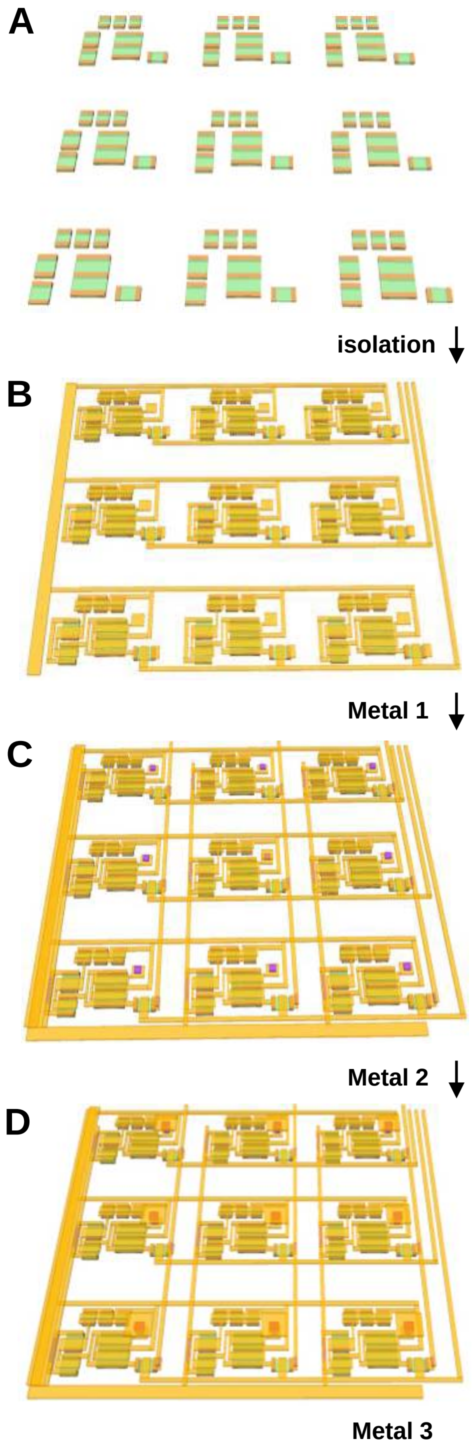

Fig. S1. Schematic illustration corresponding to steps for fabricating active, conformal electronics for cardiac electrophysiology mapping. Nine unit cells are shown to illustrate their interconnection at each metal level.

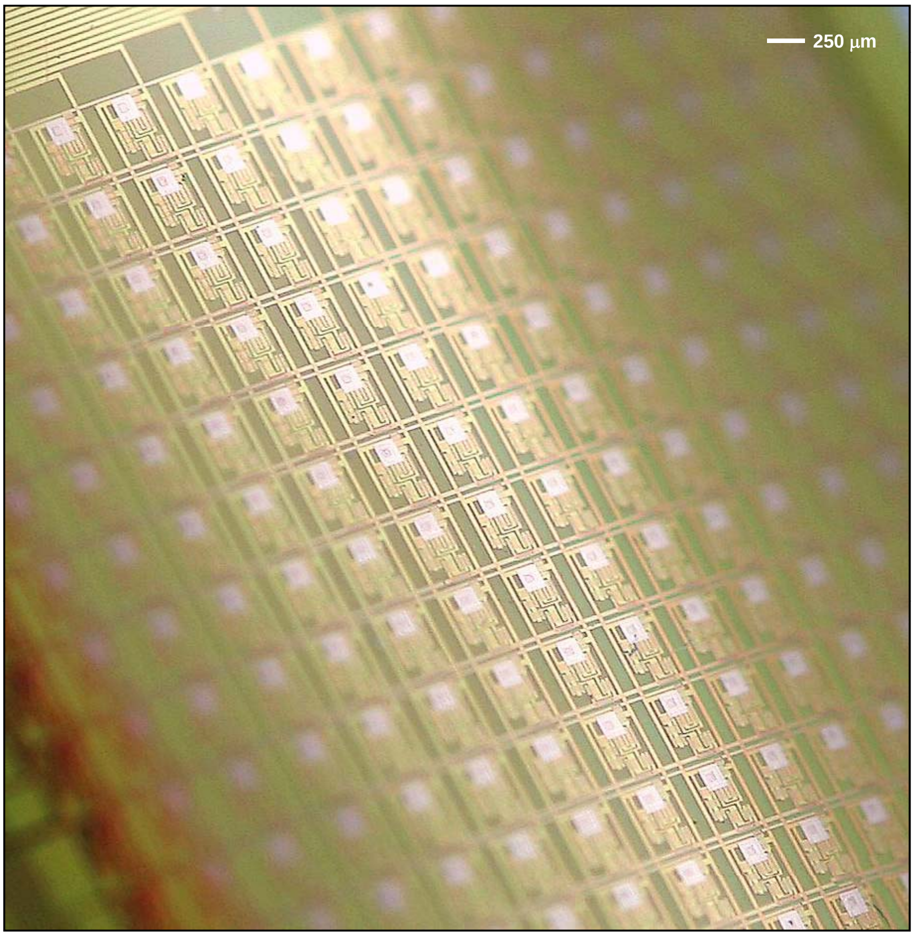

Fig. S2. Magnified view of a completed device, in a slightly bent state to illustrate detail.

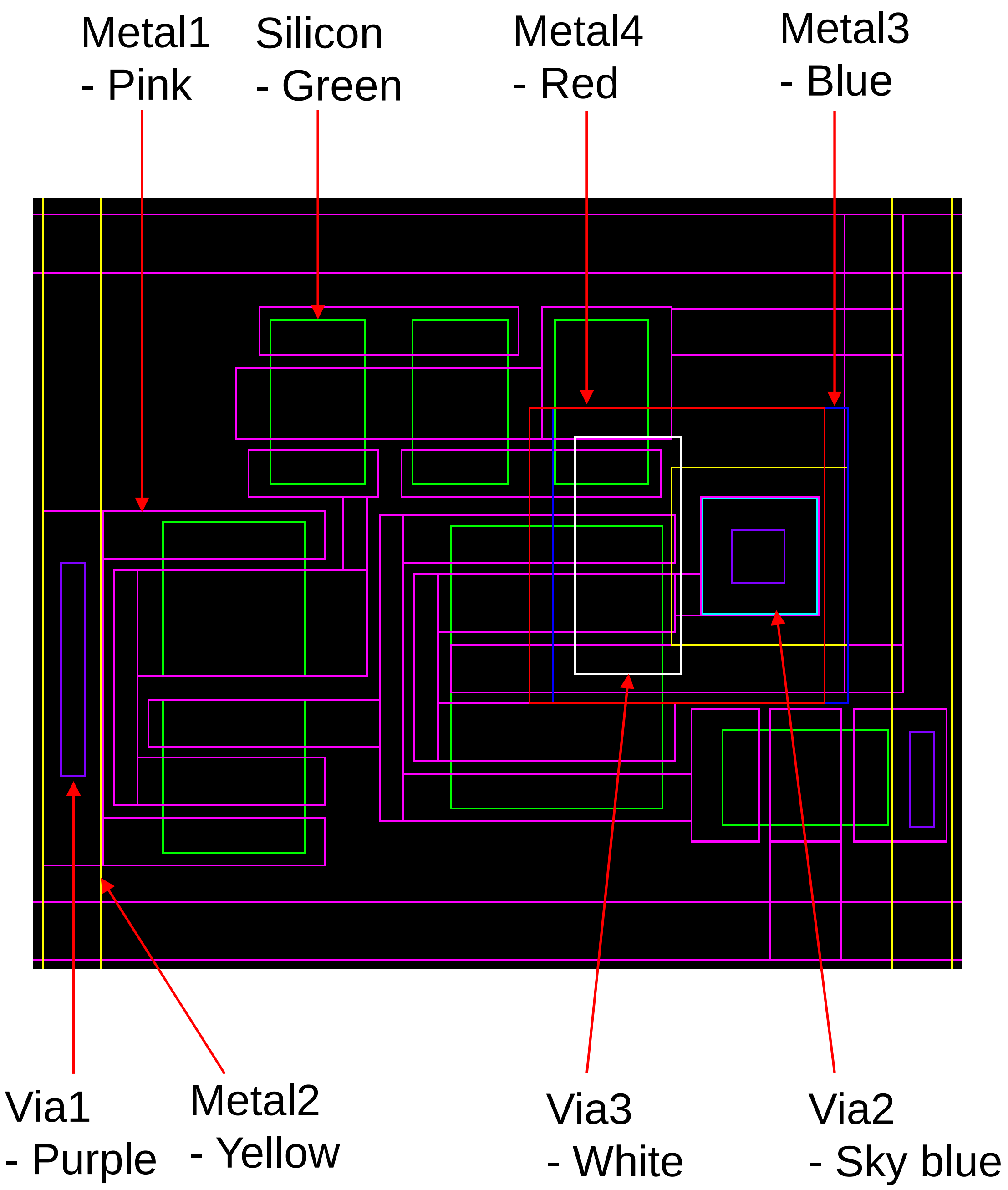

Fig. S3. Physical layout of a single unit cell. Additional insulation layers are added to prevent leakage current in saline solution. The green boxes correspond to the isolated silicon active regions that are connected by a first metal layer, shown in pink.

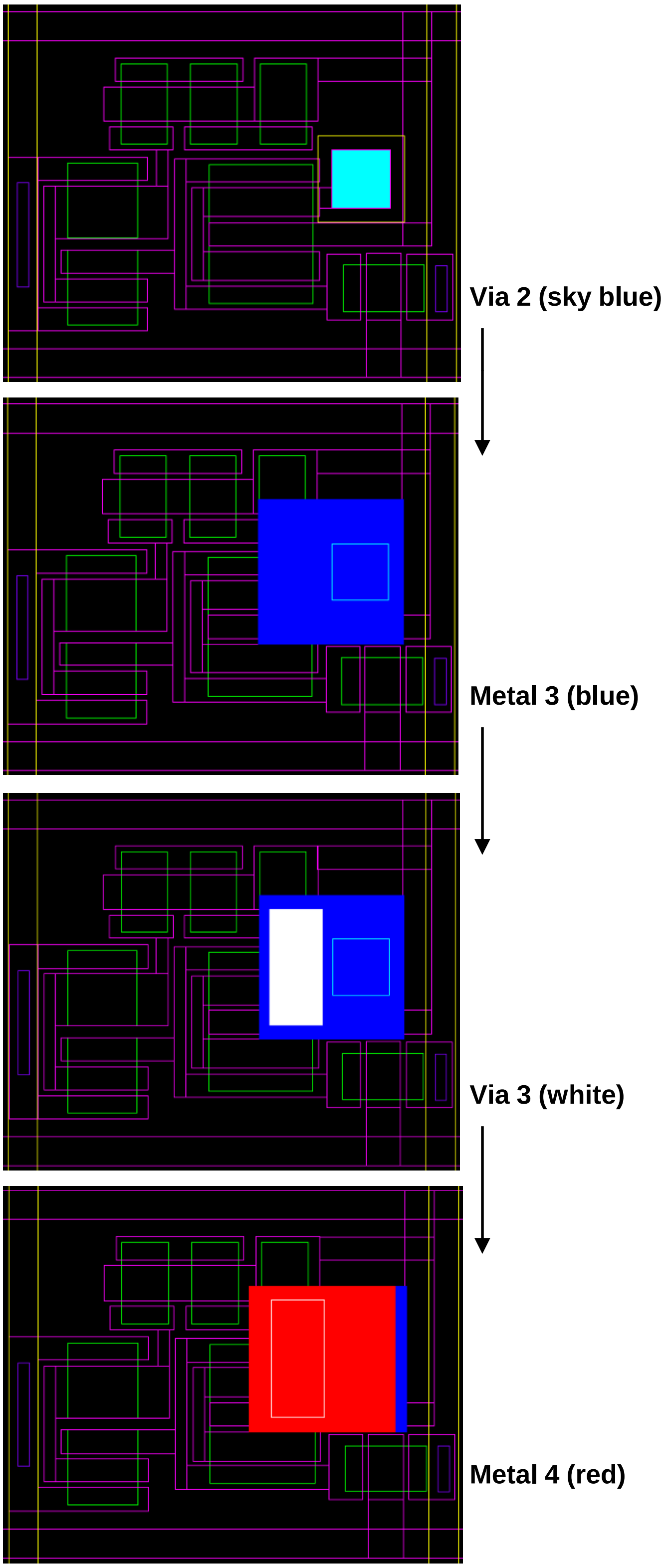

Fig. S4. Sequential process of trilayer organic/inorganic stack fabrication.

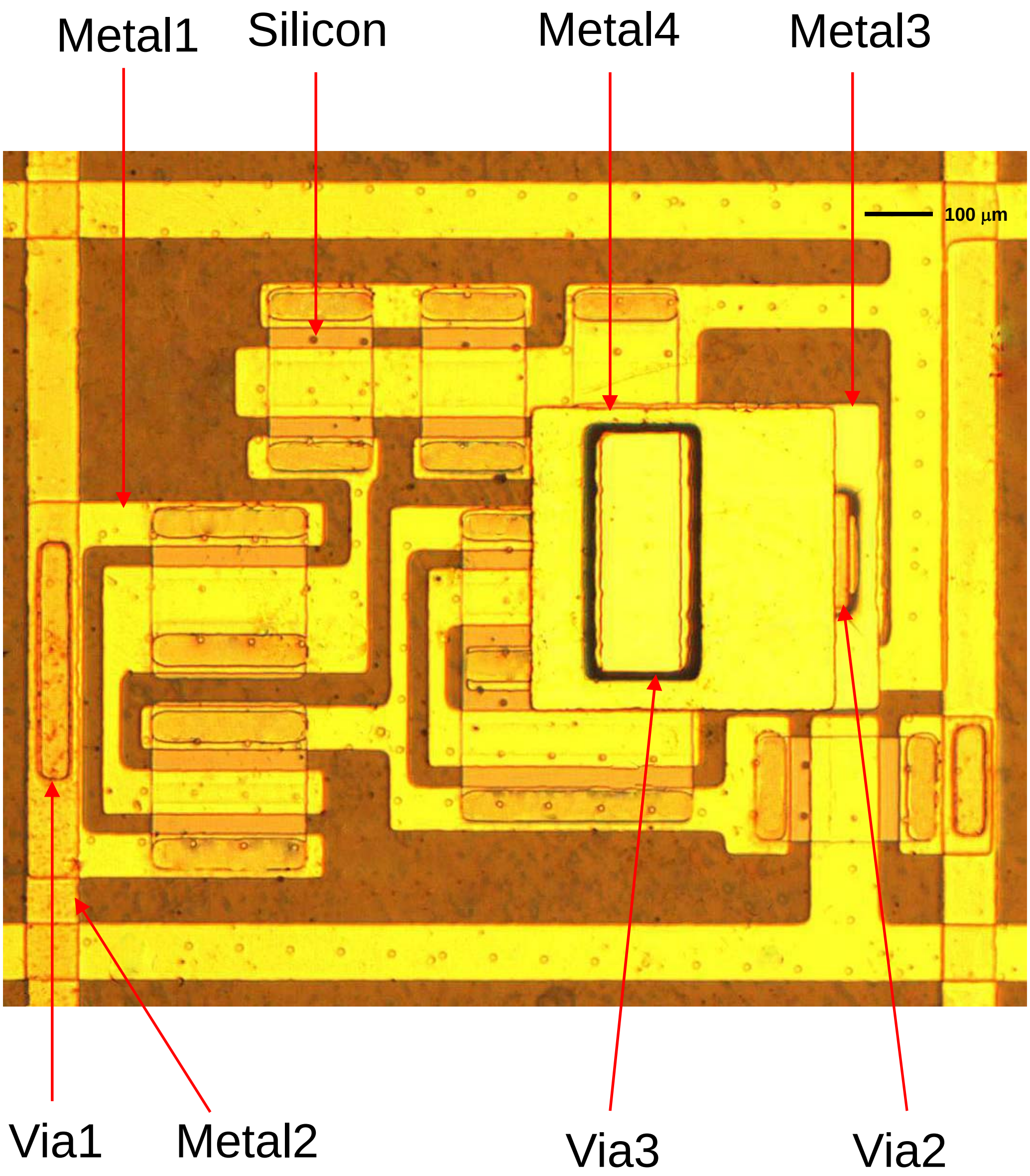

Fig. S5. Optical microscope image of a single unit cell with completed insulation layers.

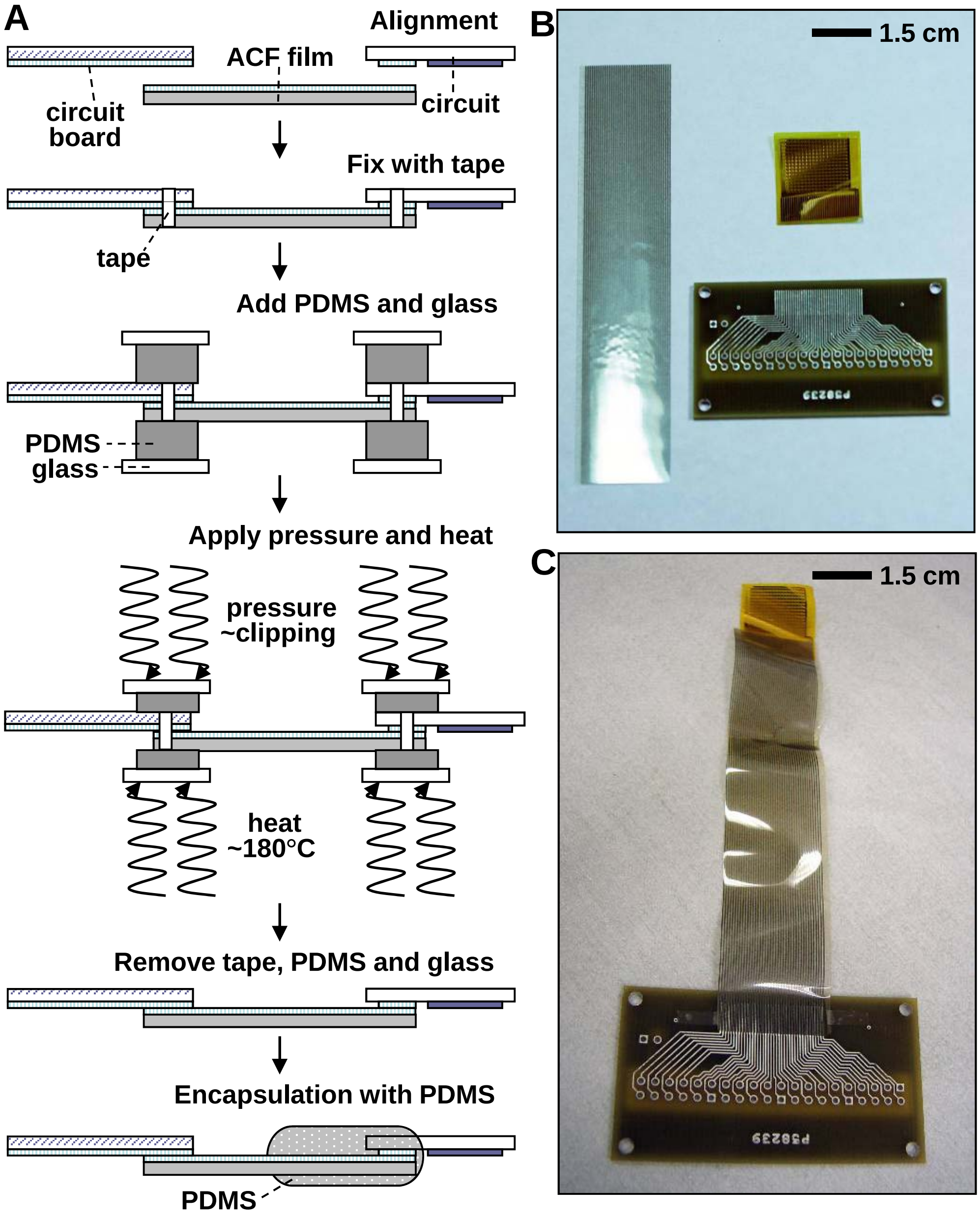

Fig. S6. ACF connection process. **(A)** Schematic diagram. Image of flexible electrode array, ACF film and the circuit board before **(B)** and after **(C)** heat seal connection.

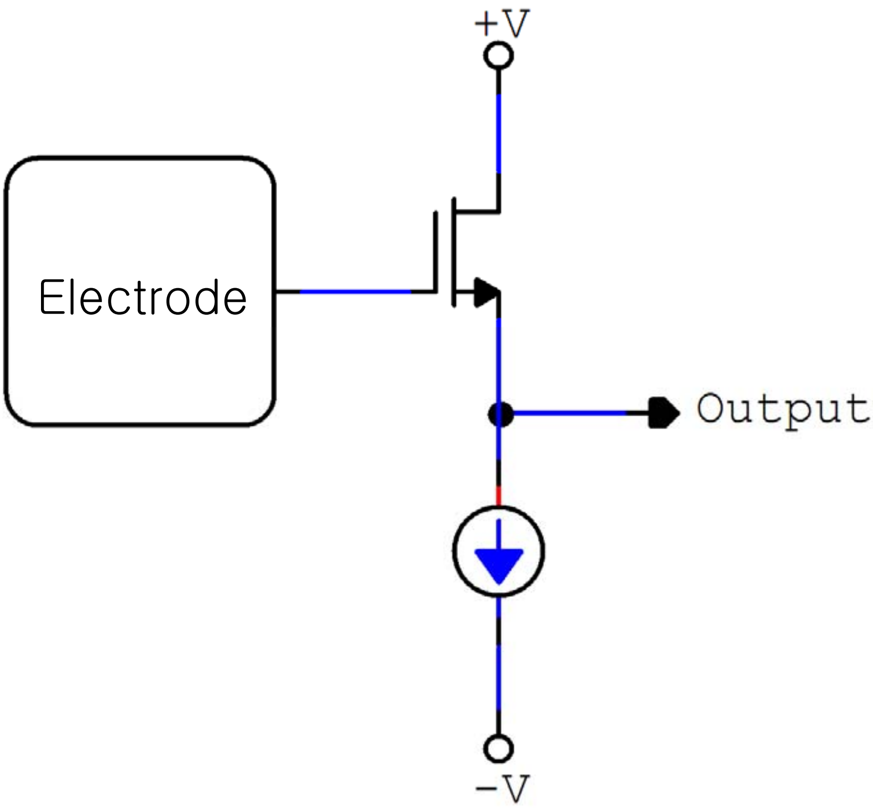

Fig. S7. Simplified schematic diagram of a source-follower buffer amplifier, as utilized in the basic unit cell design.

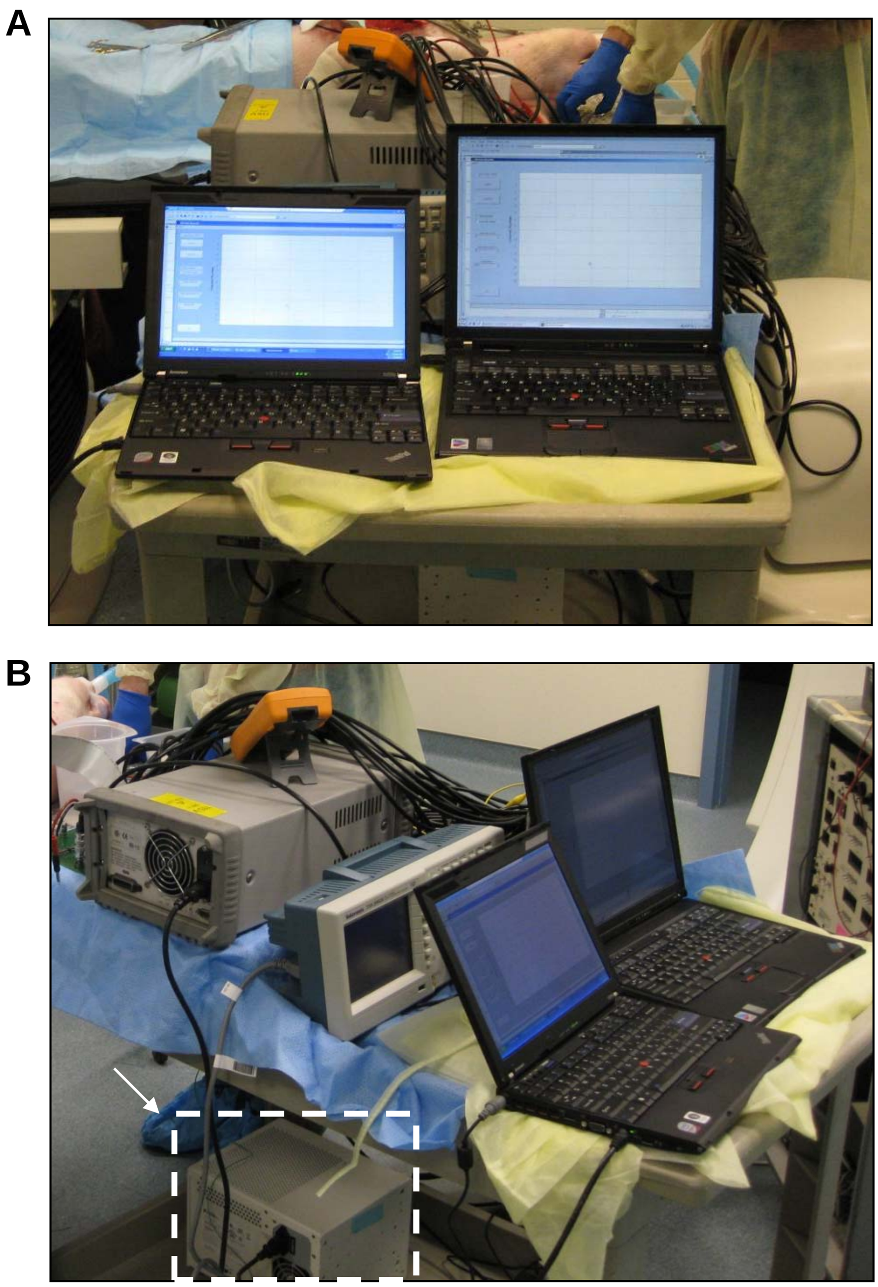

Fig. S8. Image of acquisition system during the animal experiment (National Instruments, USA). **(A)** Front view. **(B)** Side view.

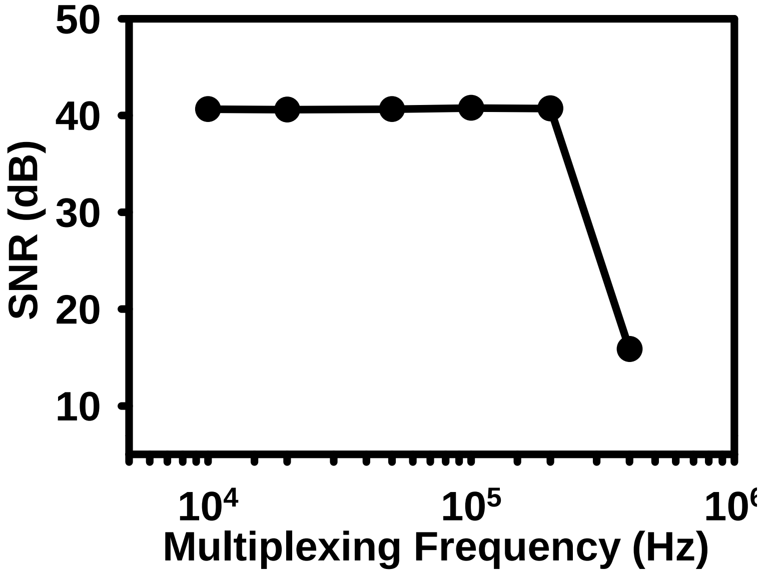

Fig. S9. SNR dependence on multiplexing frequency for a 20 Hz test signal.

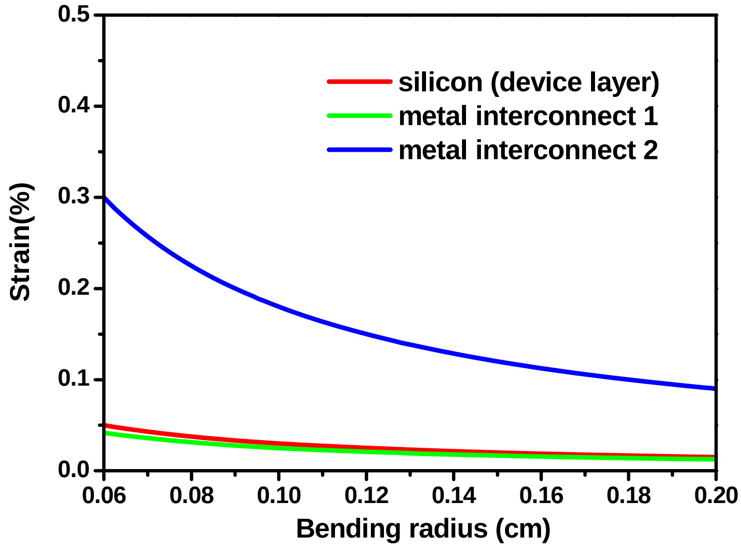

Fig. S10. Calculated induced strain in each layer of the device during tight folding.

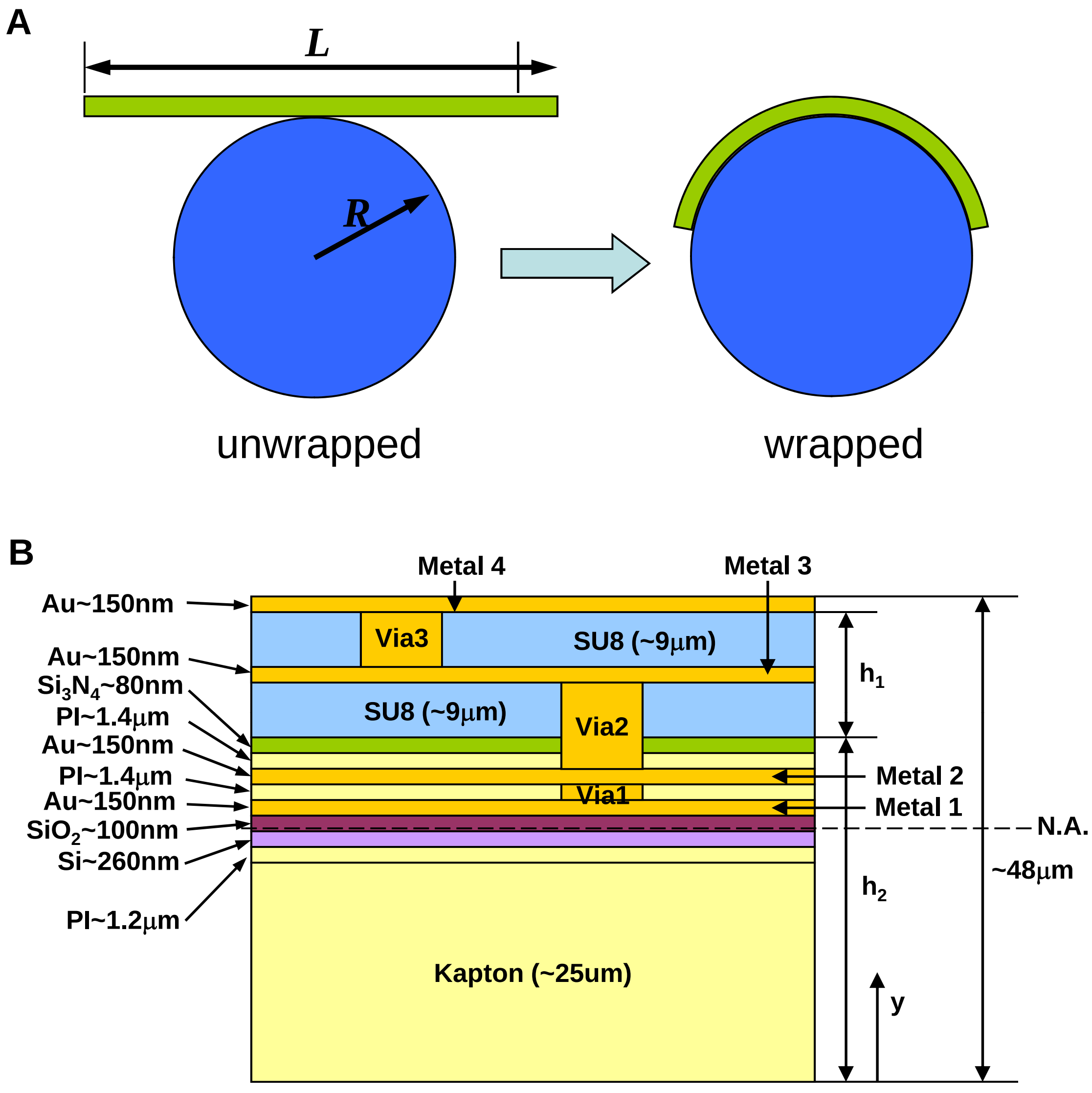

Fig. S11. Schematic diagram of wrapping model **(A)** and cross-sectional view of sensor **(B)**.

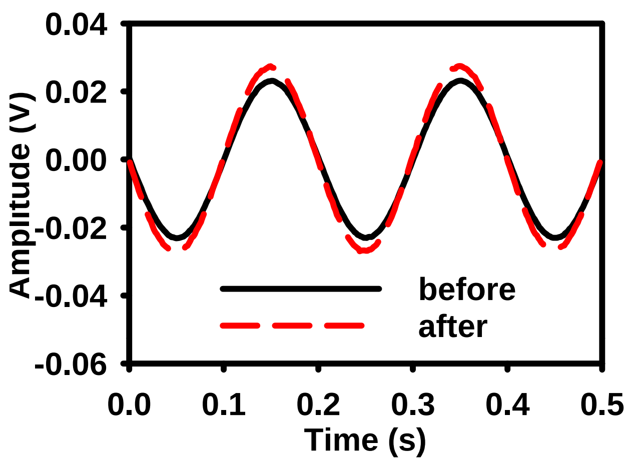

Fig. S12. Sine wave response (at 5 Hz) before and after saline immersion for 3 hours.

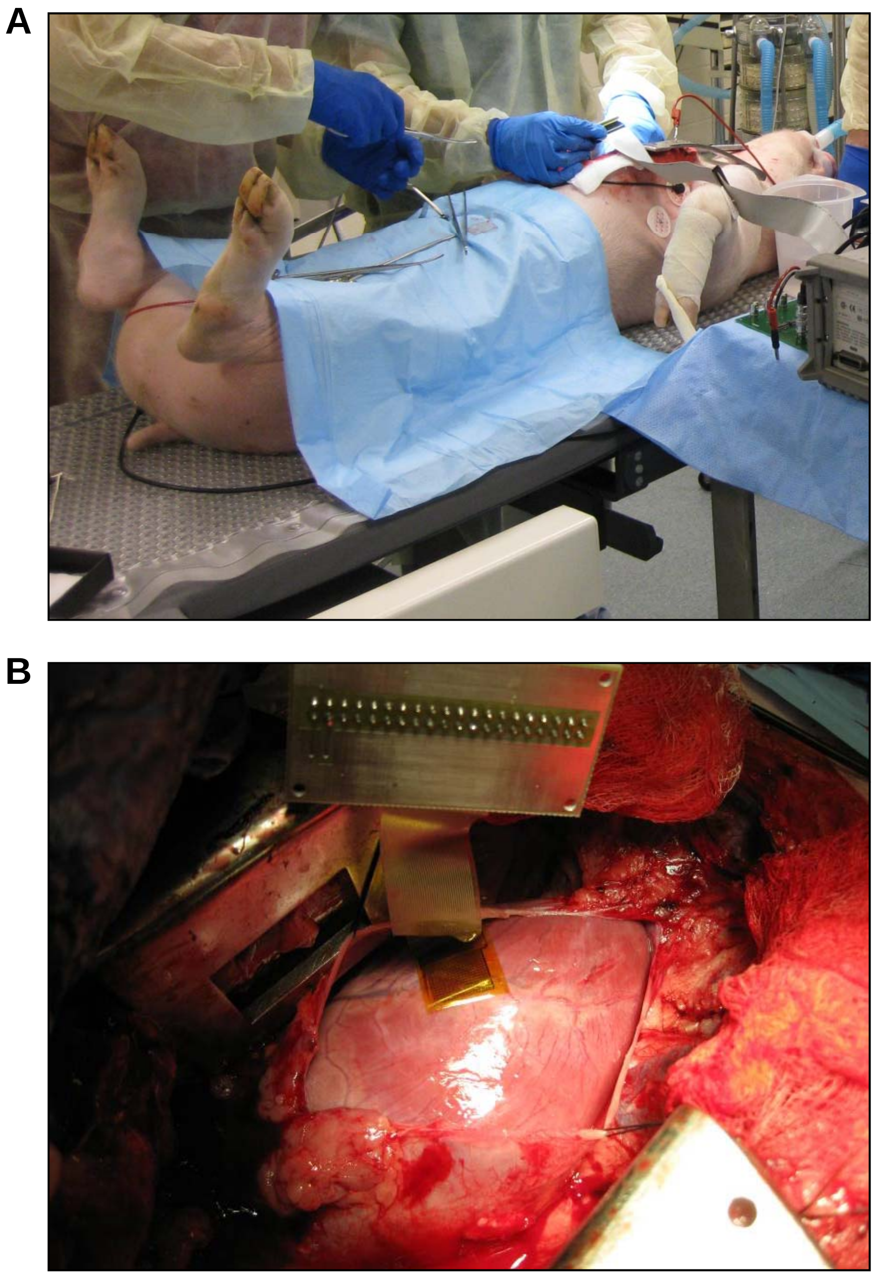

Fig. S13. Images of experiment with porcine animal model. **(A)** Surgical setup and photograph of flexible device conforming to the cardiac tissue via surface tension **(B)**.

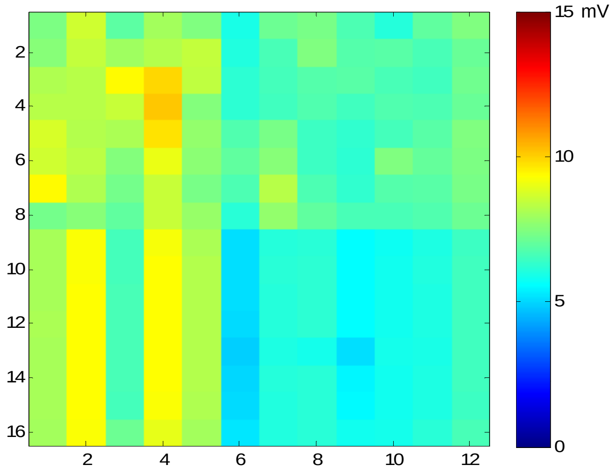

Fig. S14. Color map illustrating the amplitude uniformity of all of the channels. The average peak amplitude of the cardiac activation cycle was plotted.

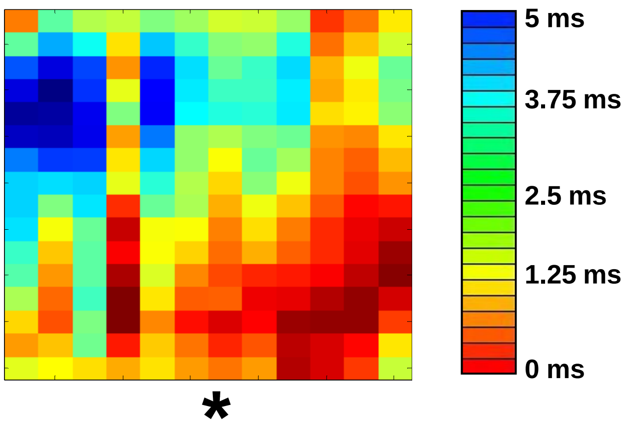

Fig. S15. Isochronal activation map with pacing. The relative pacing electrode location is indicated by an asterisk (*). Data from 3 columns in A and 6 columns in B have been removed due to failures in the metal interconnections.

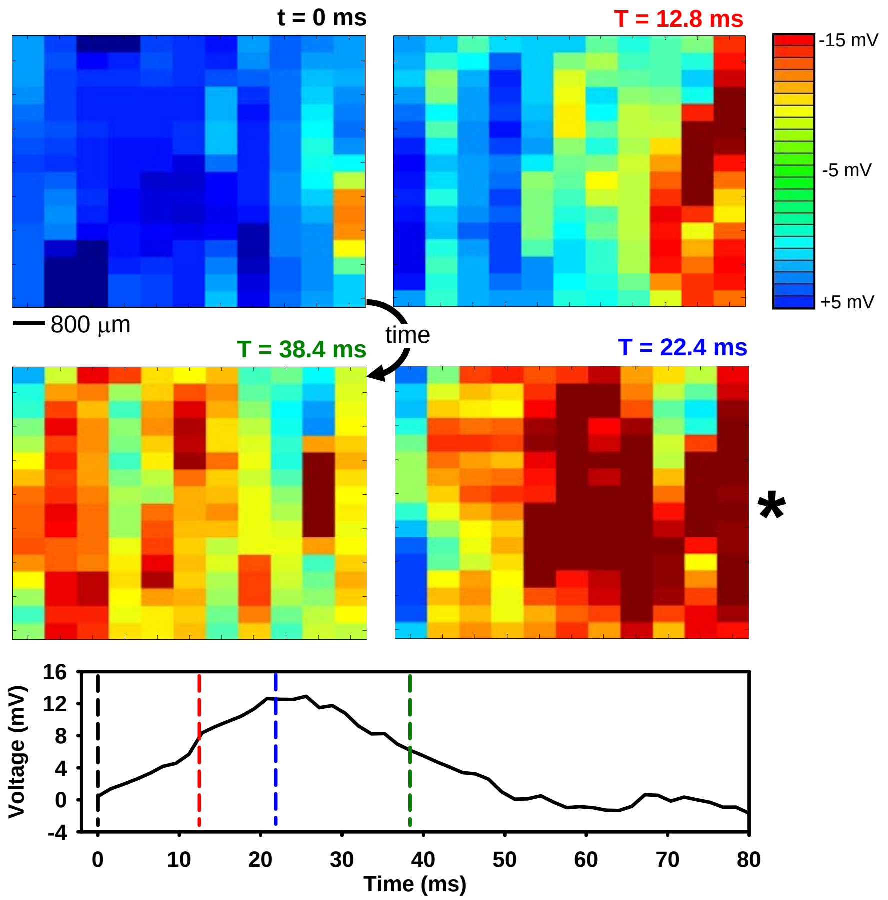

Fig. S16. Representative voltage data for all electrodes at four points in time showing paced cardiac wave front propagation. The relative pacing electrode location is indicated by an asterisk (*). Voltage is plotted using the color scale in the right corner. The bottom frame shows the average voltage from all electrodes. The dashed color lines illustrate the points in time at which each frame was taken. Note that negative is plotted up by convention.

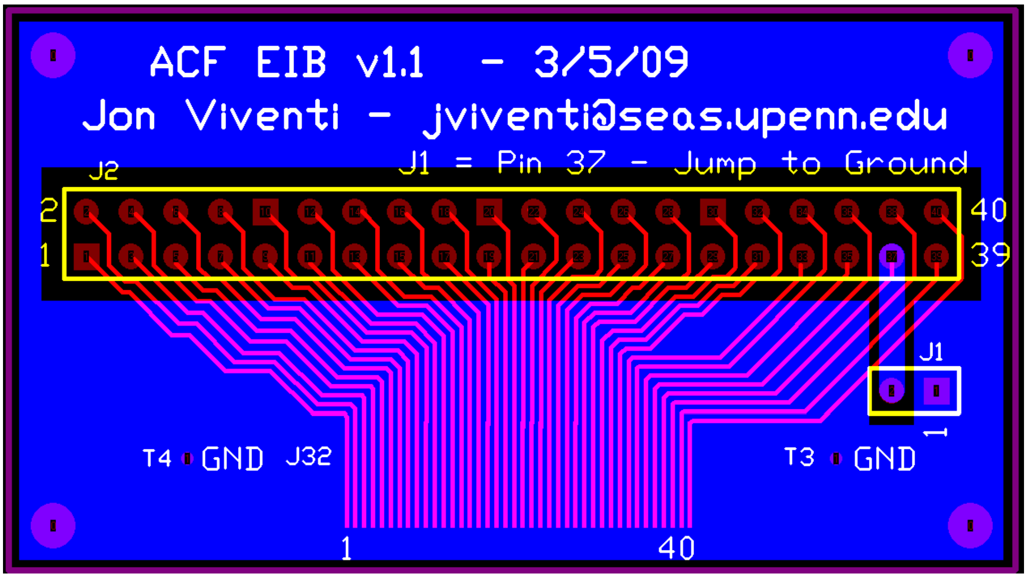

Fig. S17. Design of the adapter circuit board, which adapts the ACF ribbon to a 40 pin connector.

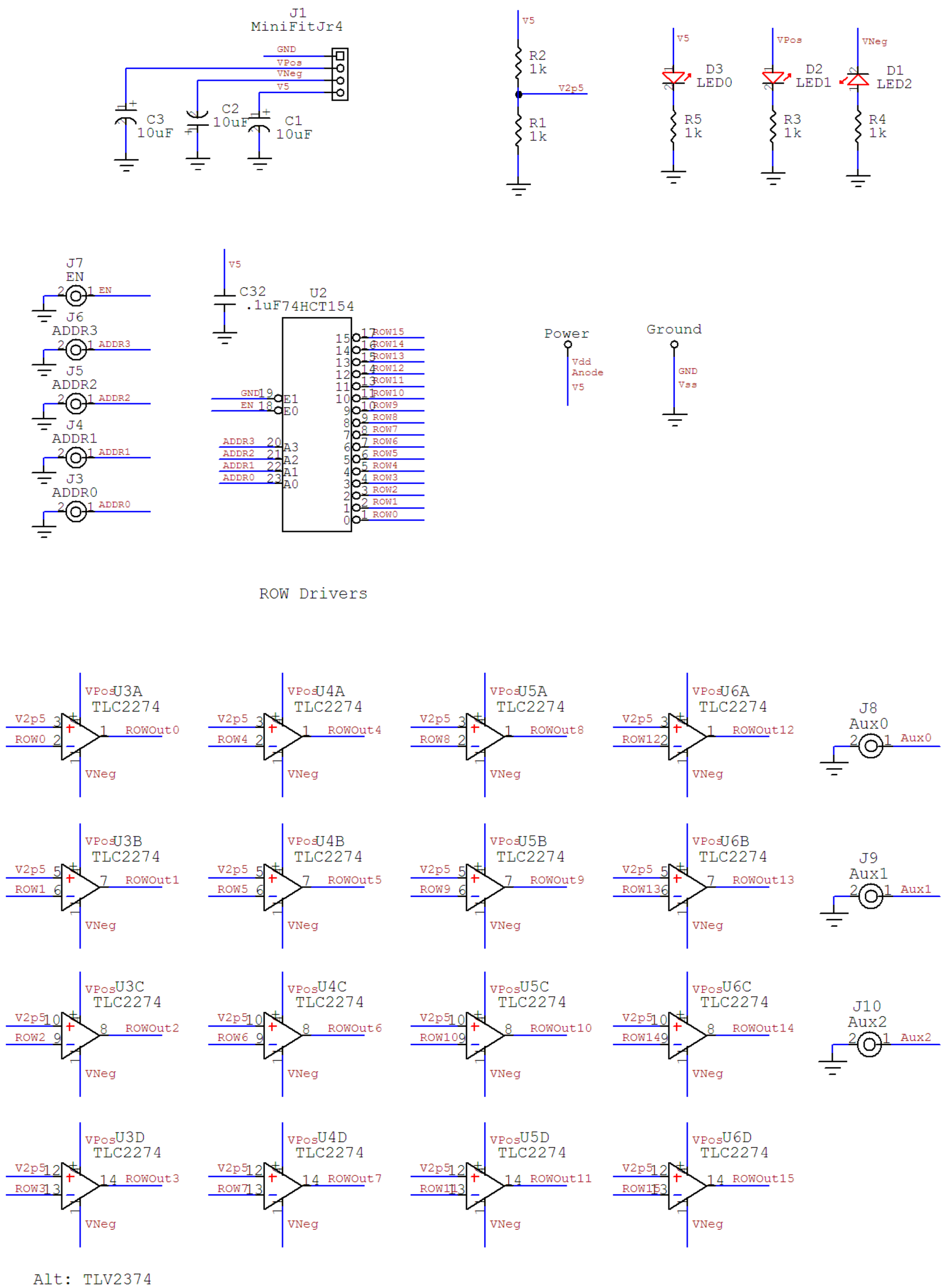

Fig S18. Schematic design and layout of the main interface circuit board, which connects the 40 pin ribbon cable to the acquisition system.

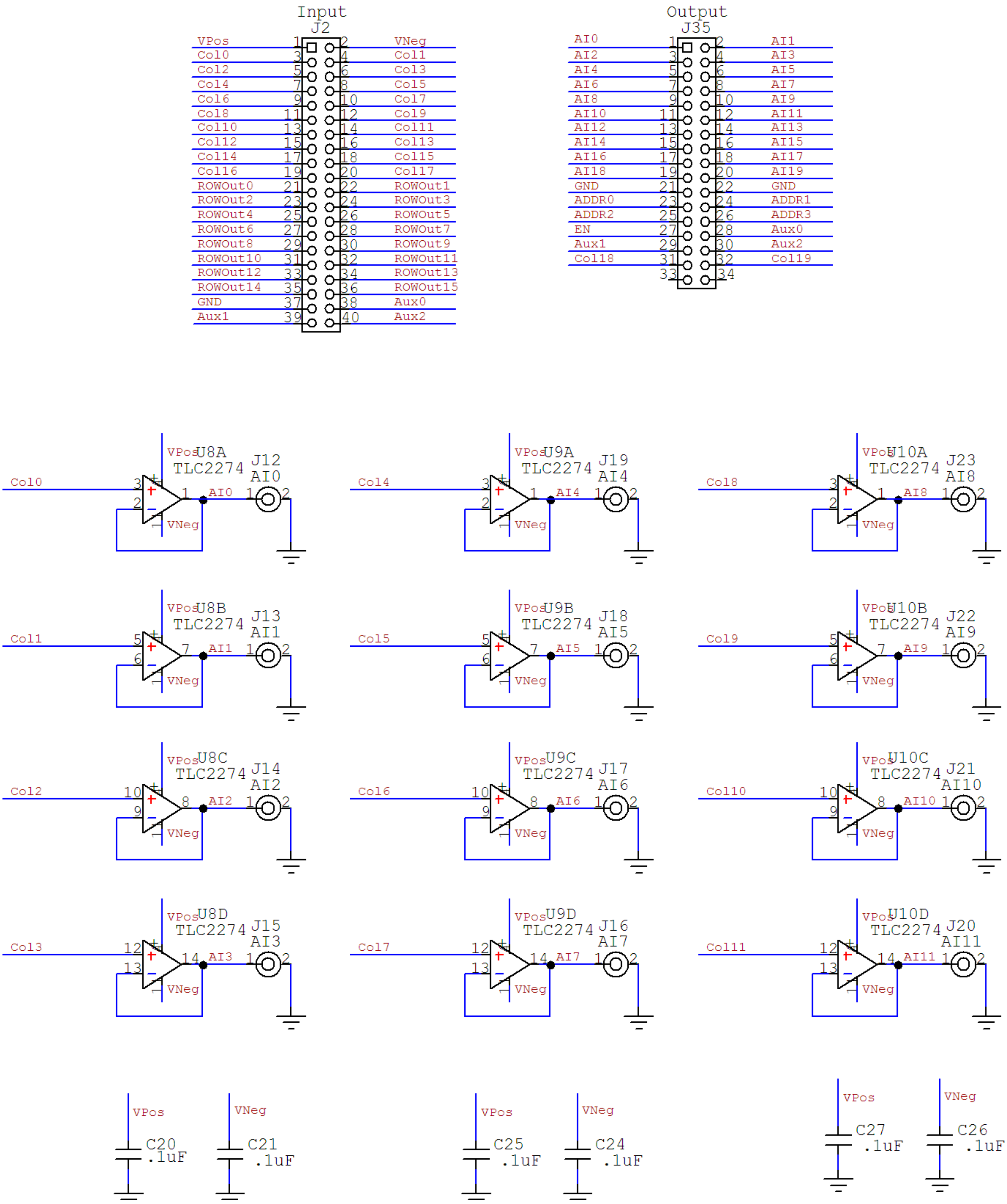

Fig S19. Schematic design and layout of the main interface circuit board, which connects the 40 pin ribbon cable to the acquisition system.

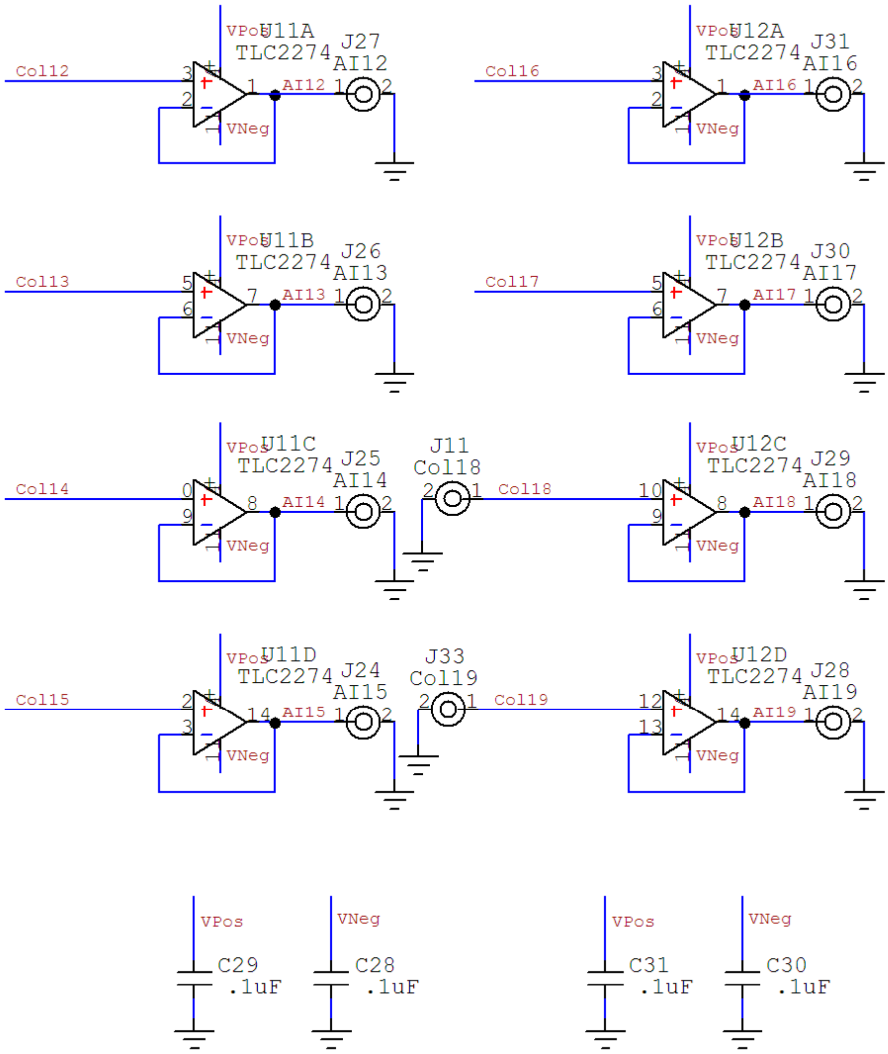

Fig S20. Schematic design and layout of the main interface circuit board, which connects the 40 pin ribbon cable to the acquisition system.

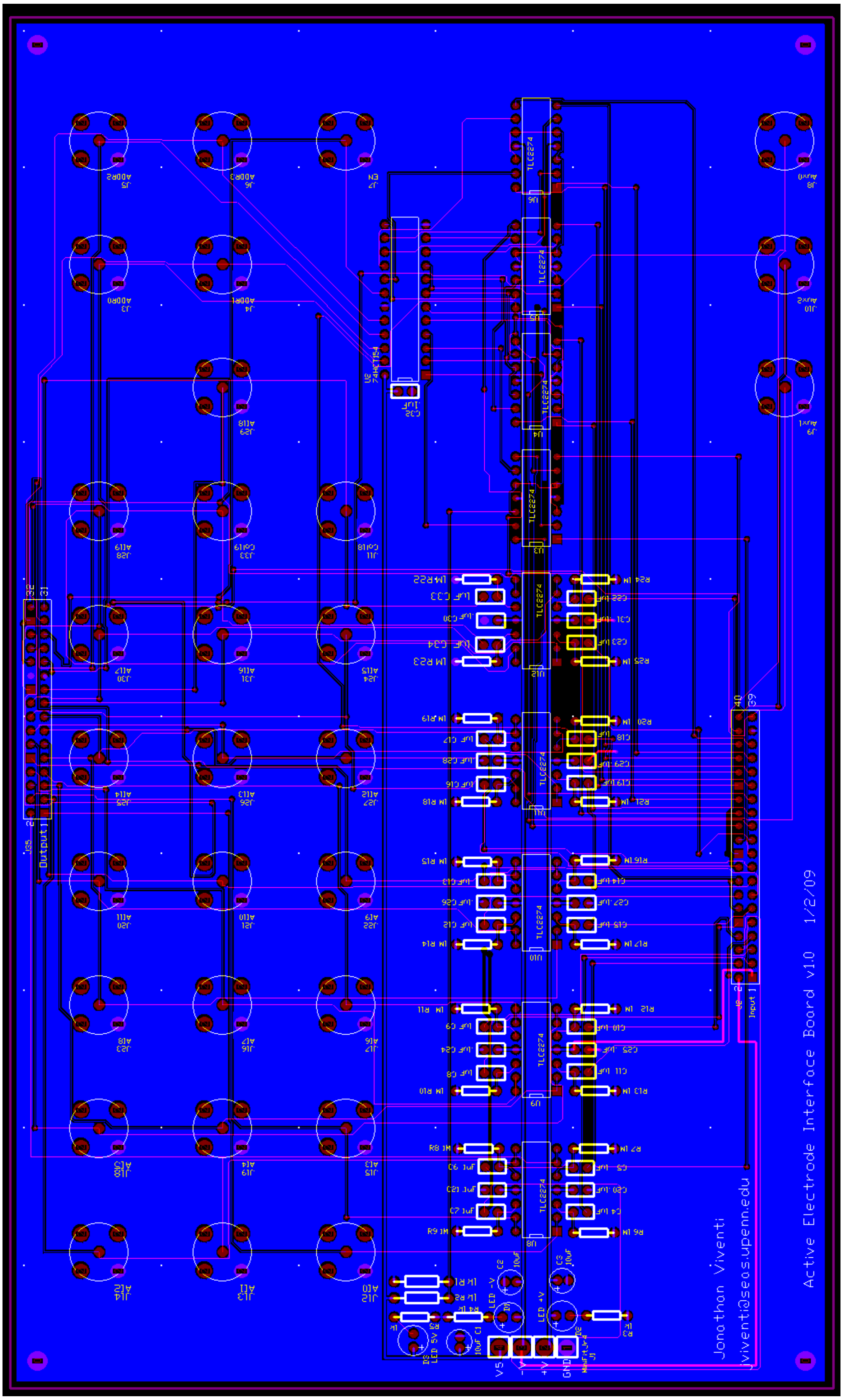

Fig S21. Schematic design and layout of the main interface circuit board, which connects the 40 pin ribbon cable to the acquisition system.

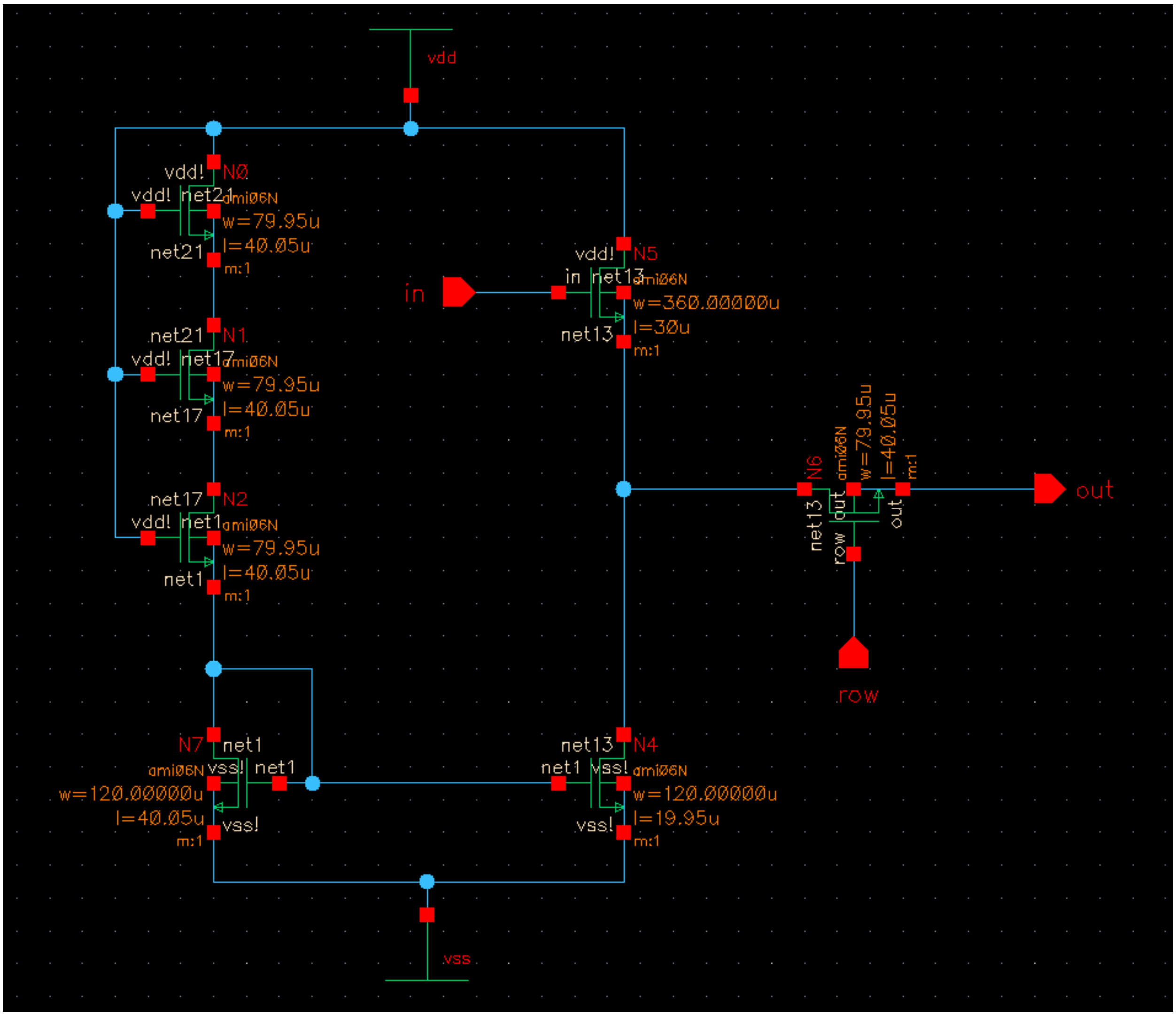

Fig. S22. Screenshot from Cadence simulation environment showing the schematic of one unit cell of the array. The dimensions are labeled for each transistor and match the dimensions of the fabricated array.

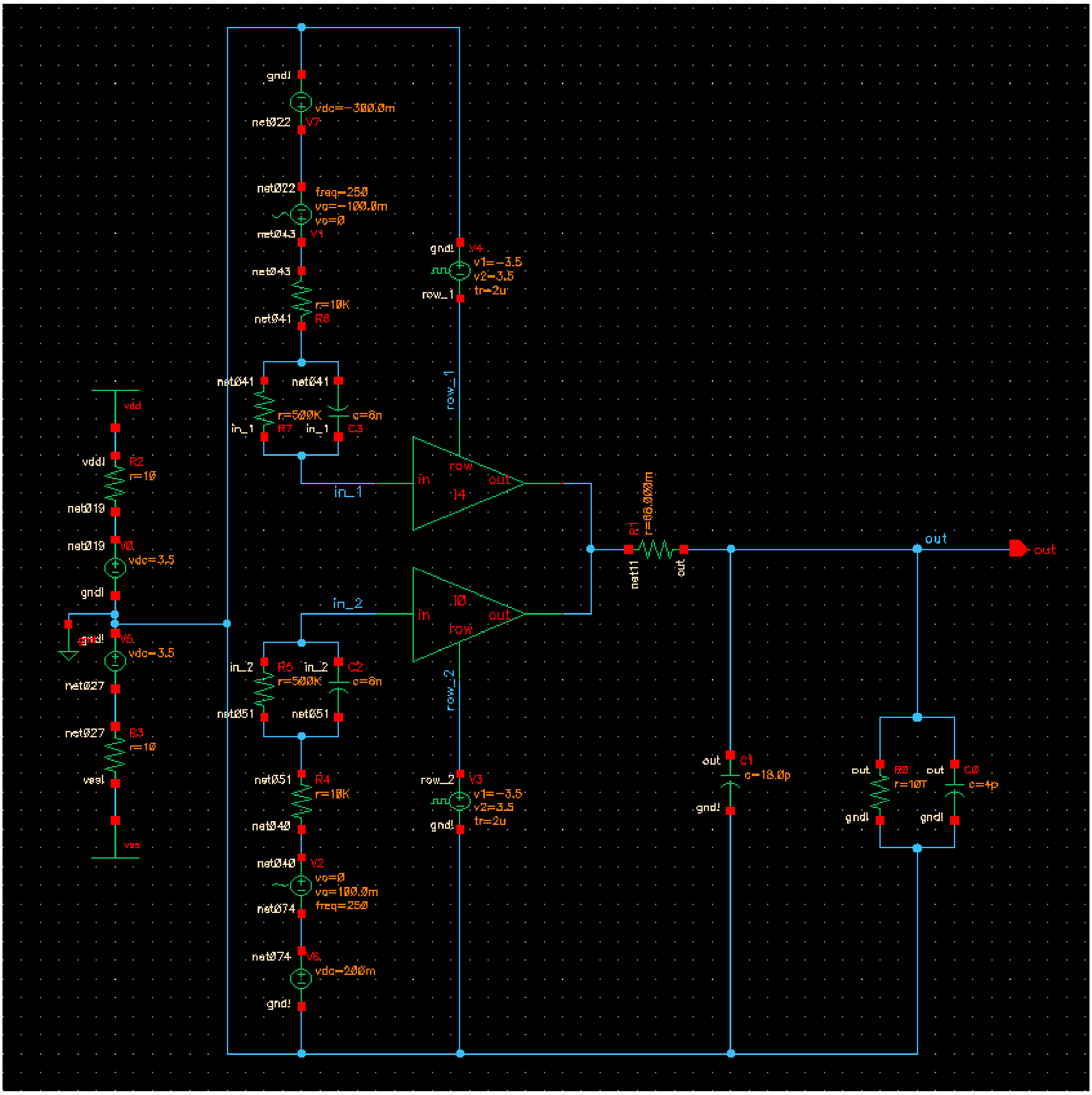

Fig. S23. Screenshot from Cadence simulation environment showing the test setup for two unit cells connected to a common output. The inputs are 200mV peak to peak, 250 Hz sine waves with different offset voltages to measure switching time. The output includes a model of the ribbon cable and the buffer op-amp. The values for the output resistors and capacitors shown in the schematic are 68m ohms, 18 pF, 10T ohms, and 4pF. These values came from specification sheets for the ribbon cable and the TLC2274 op-amp *(3, 4)*. The schematic also includes a model of the electrodes *(5)*. The row select signals alternate with a period of 100us. The rise and fall time for the row select signals are 2 µs.

Figure S24

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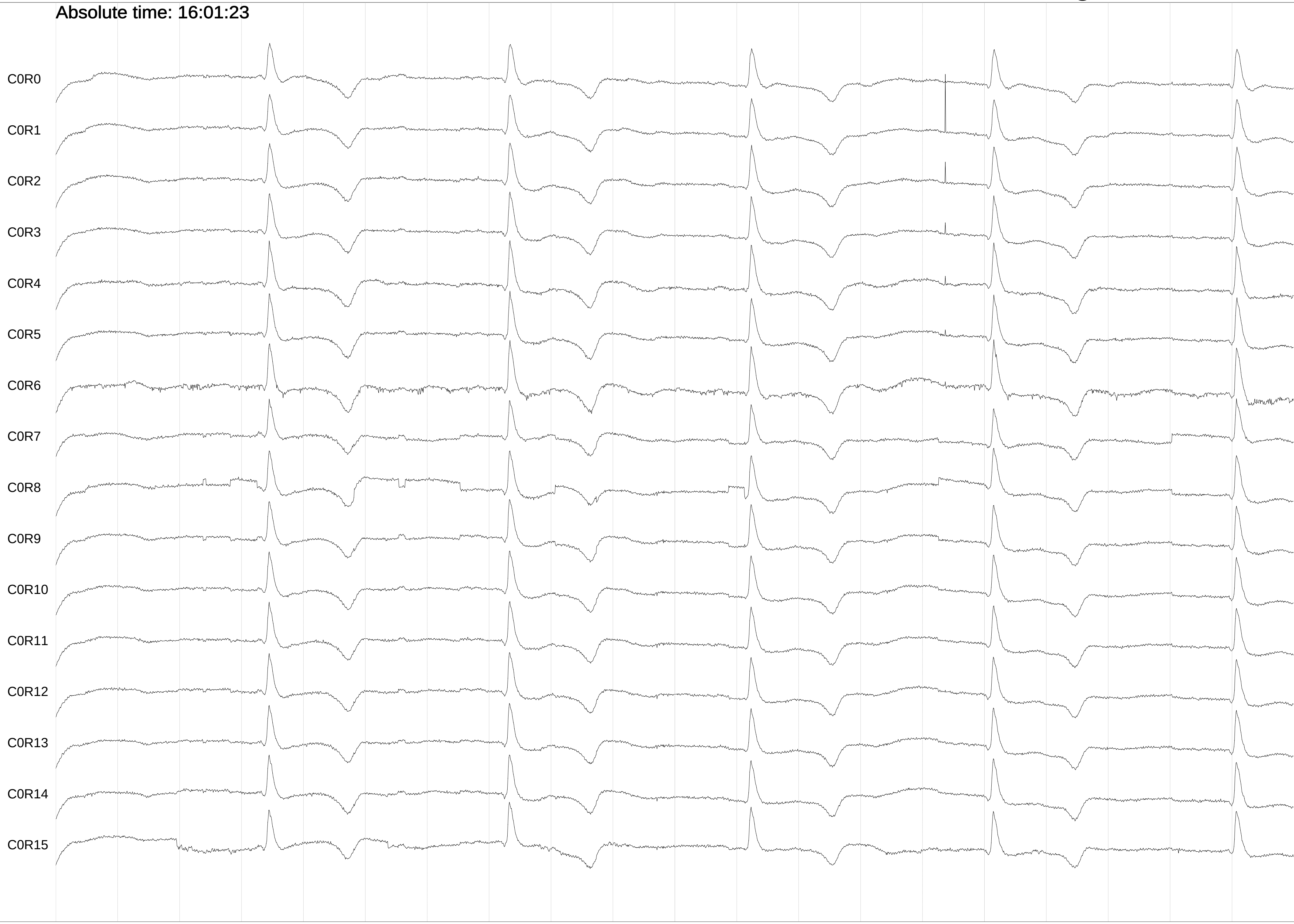

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C1R6
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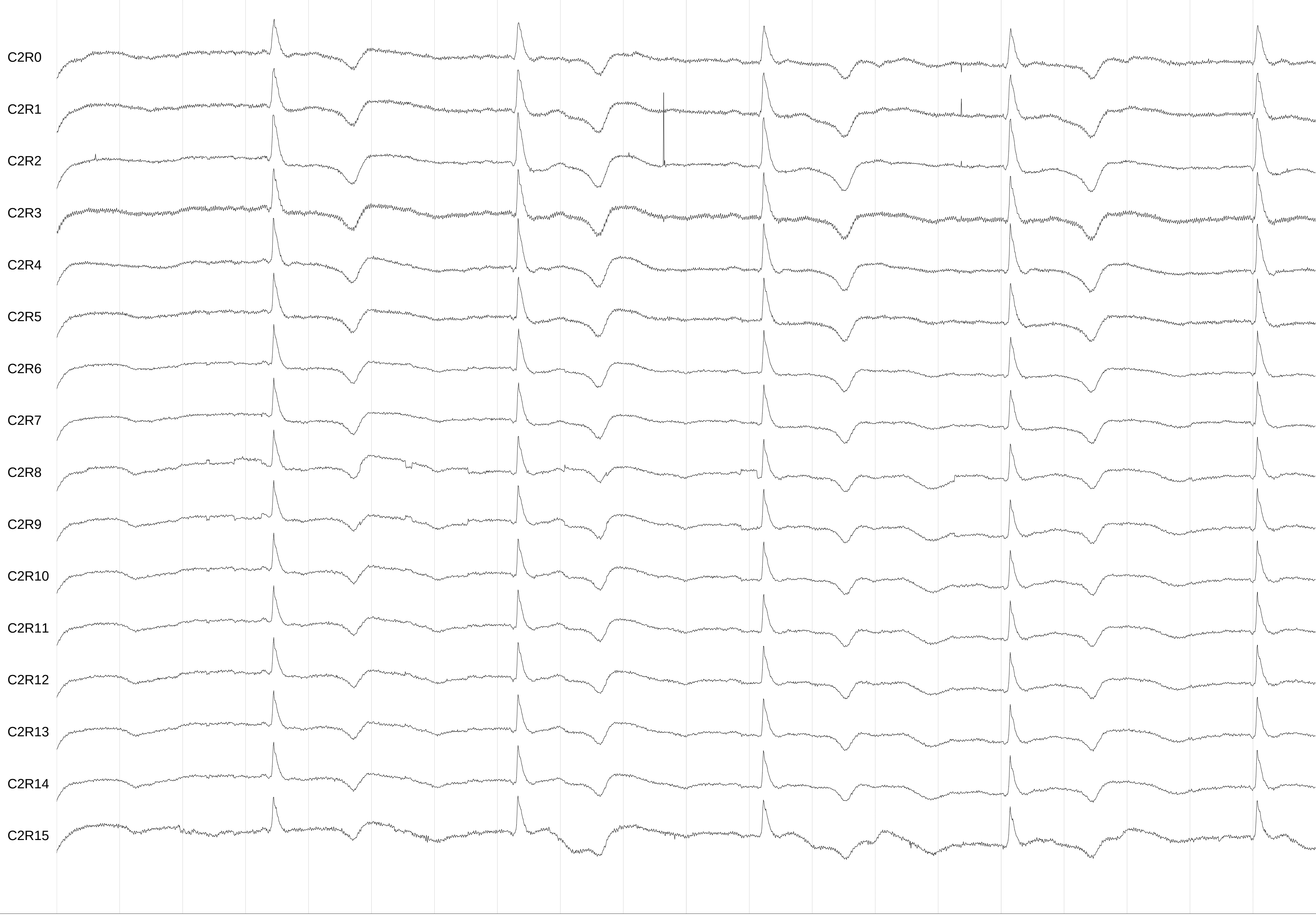

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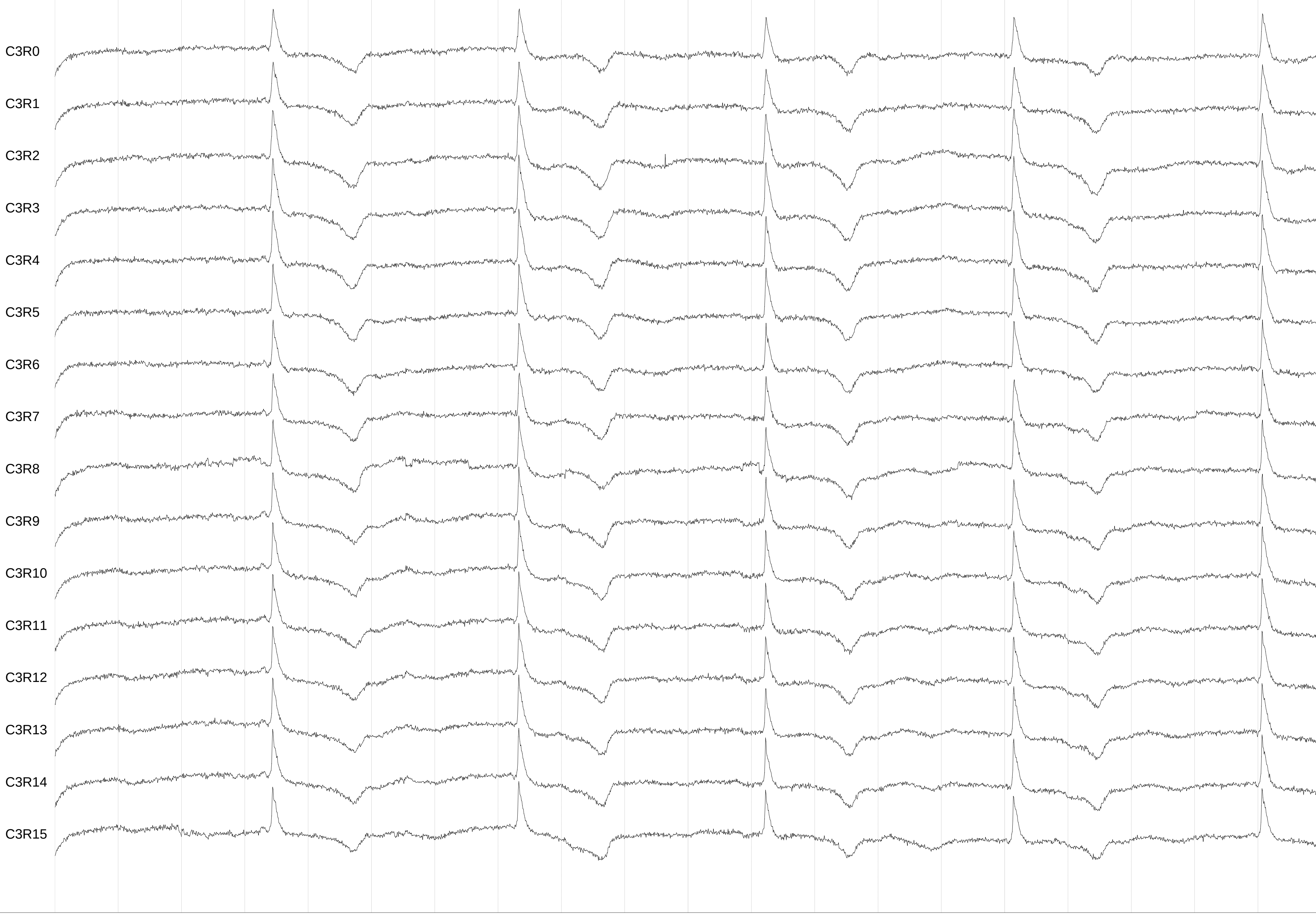

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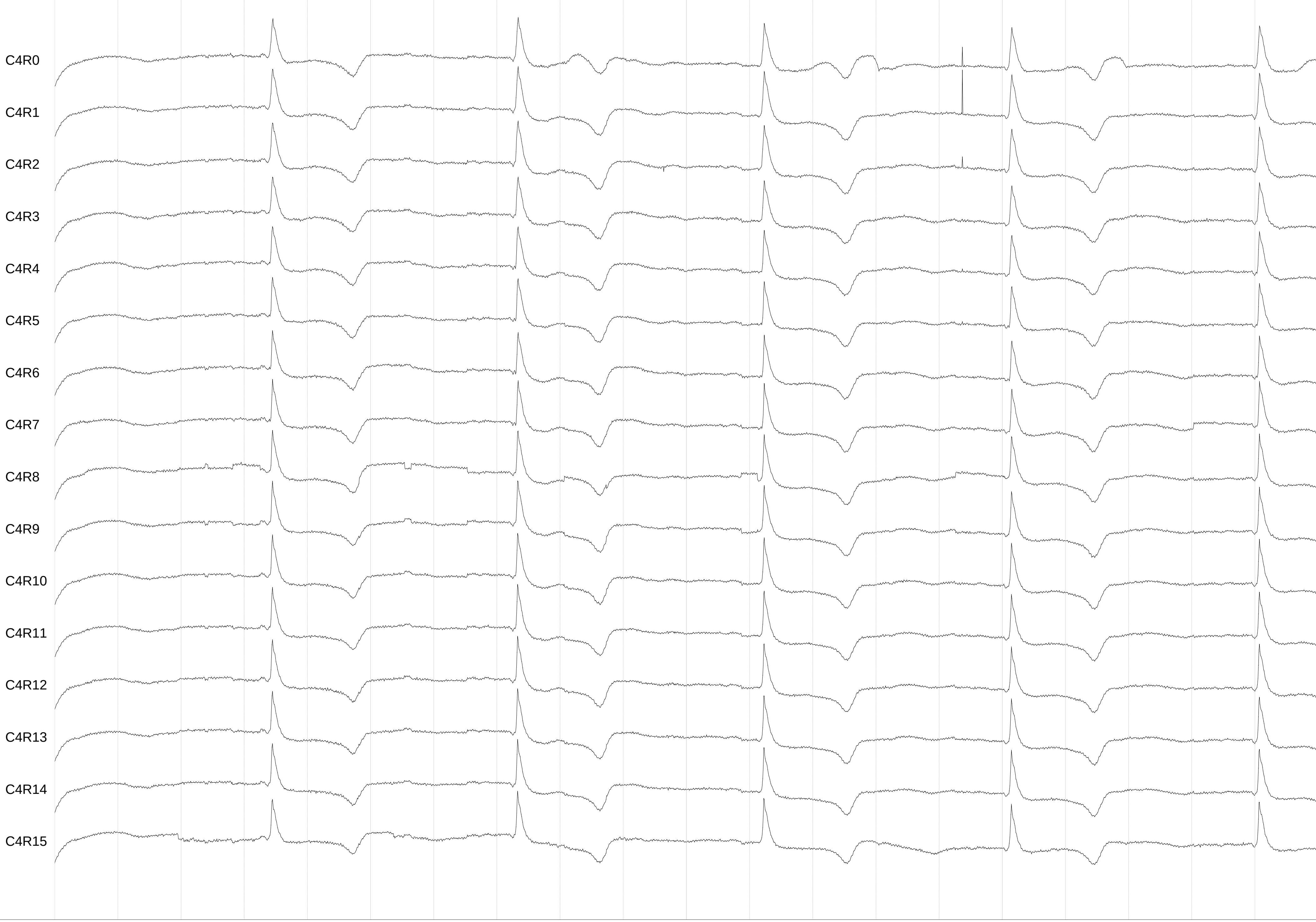

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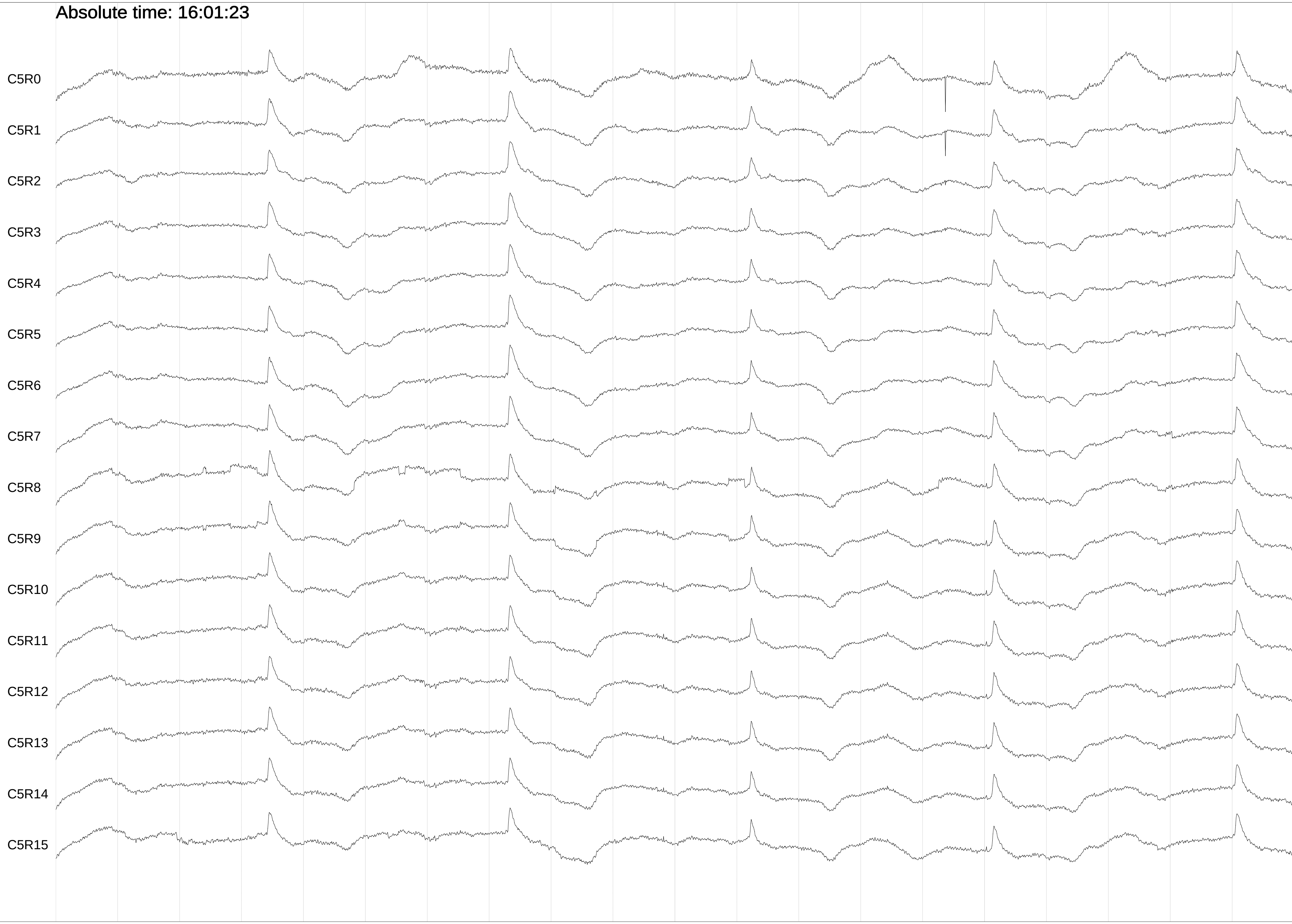

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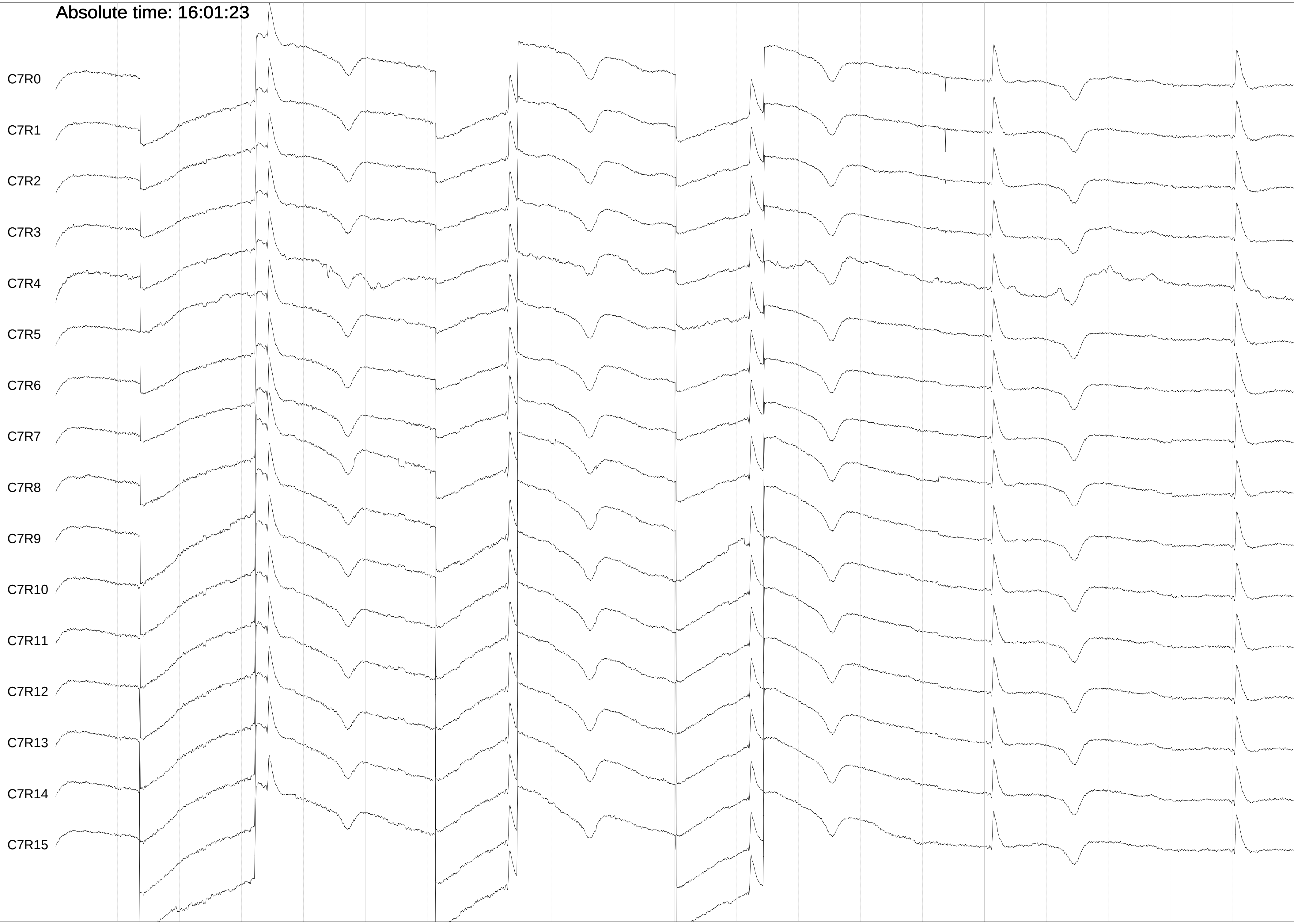

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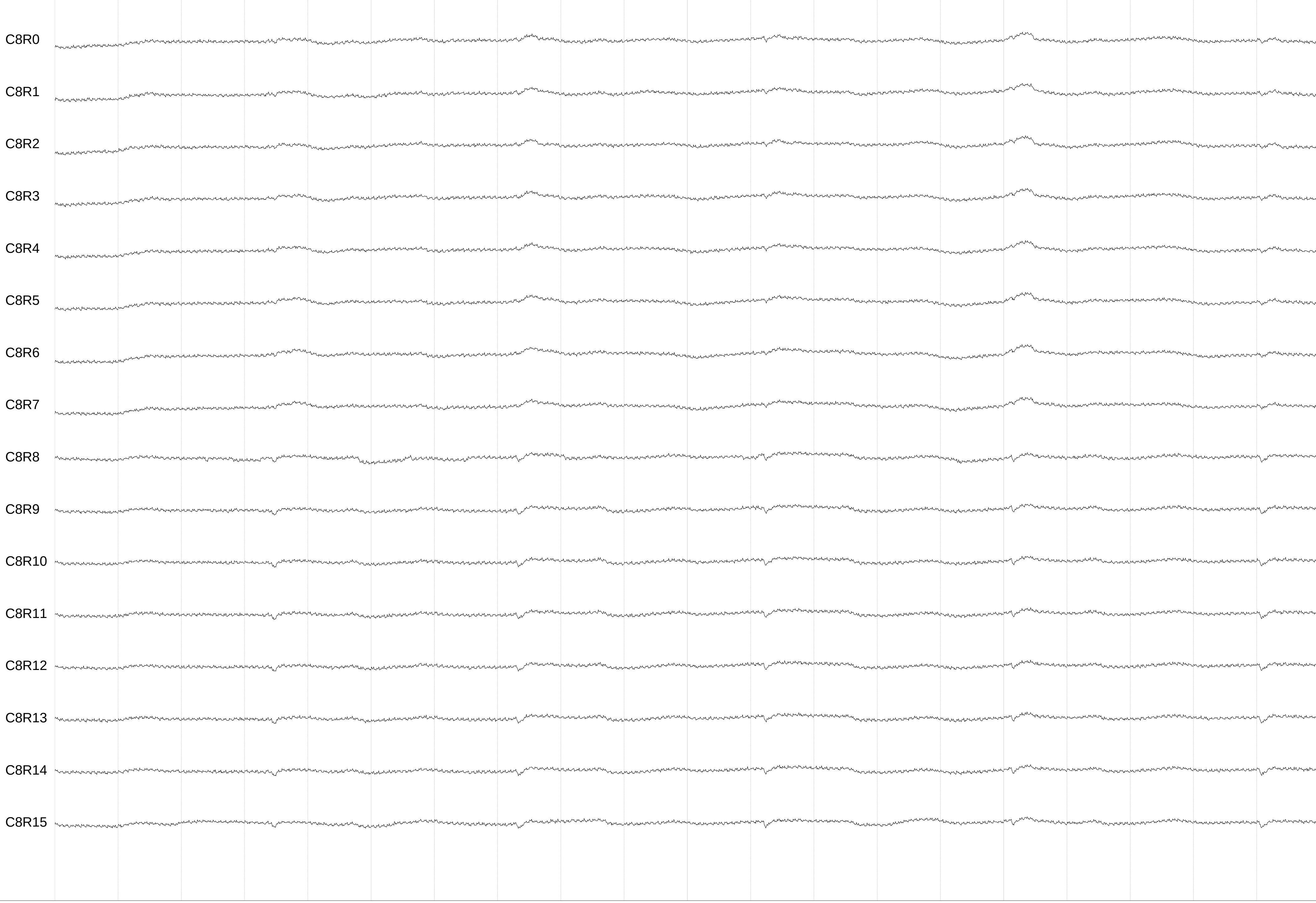

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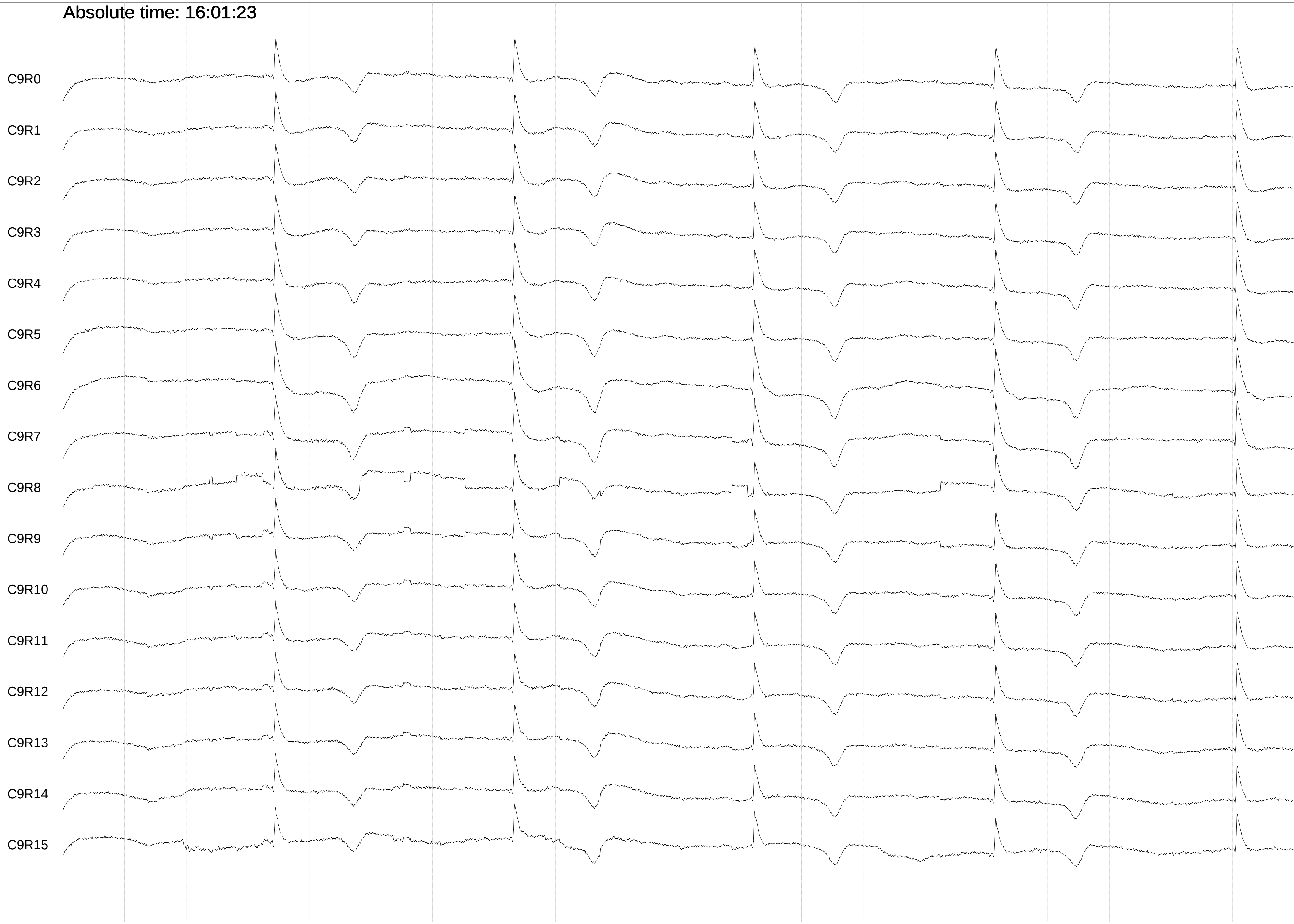

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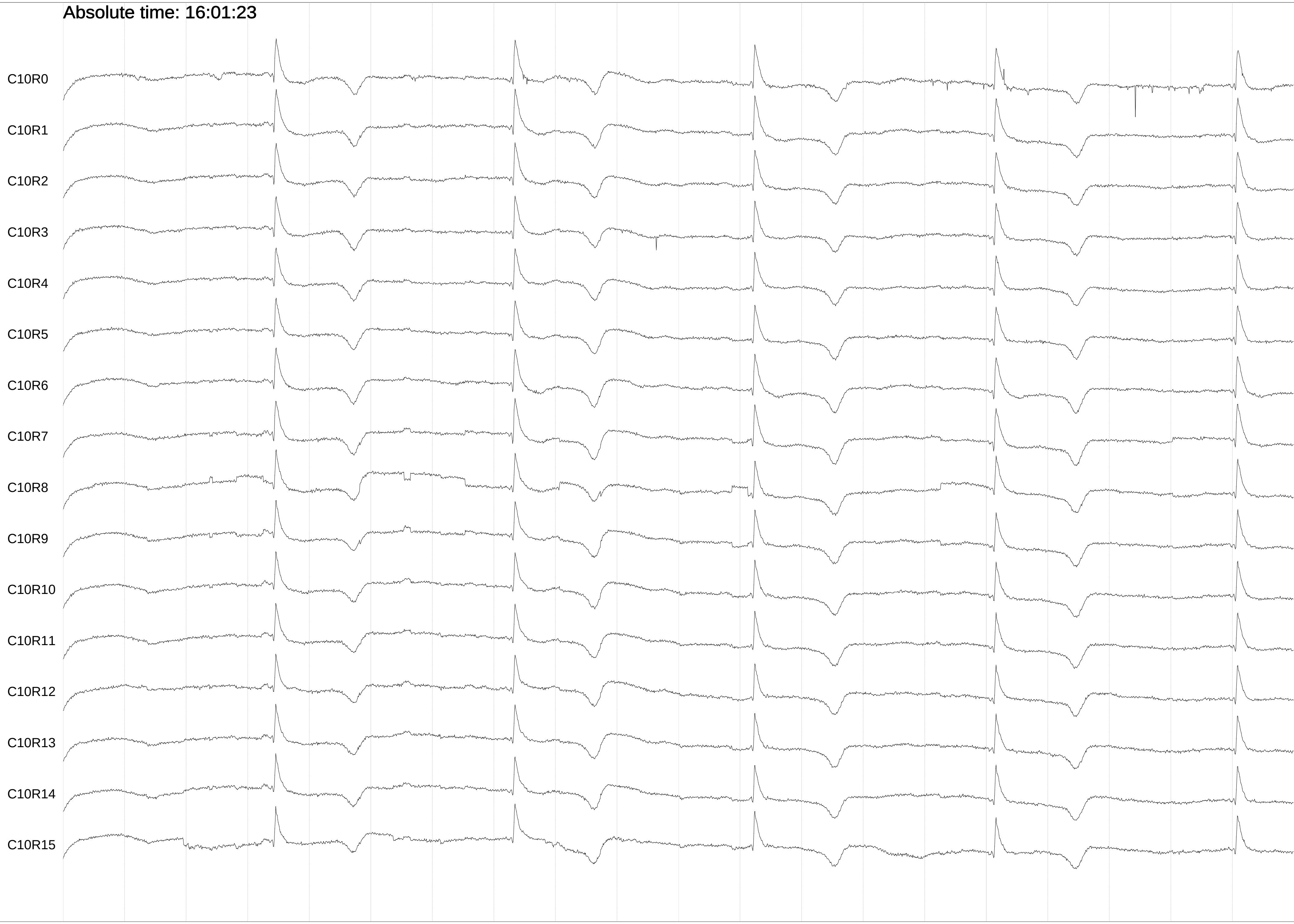

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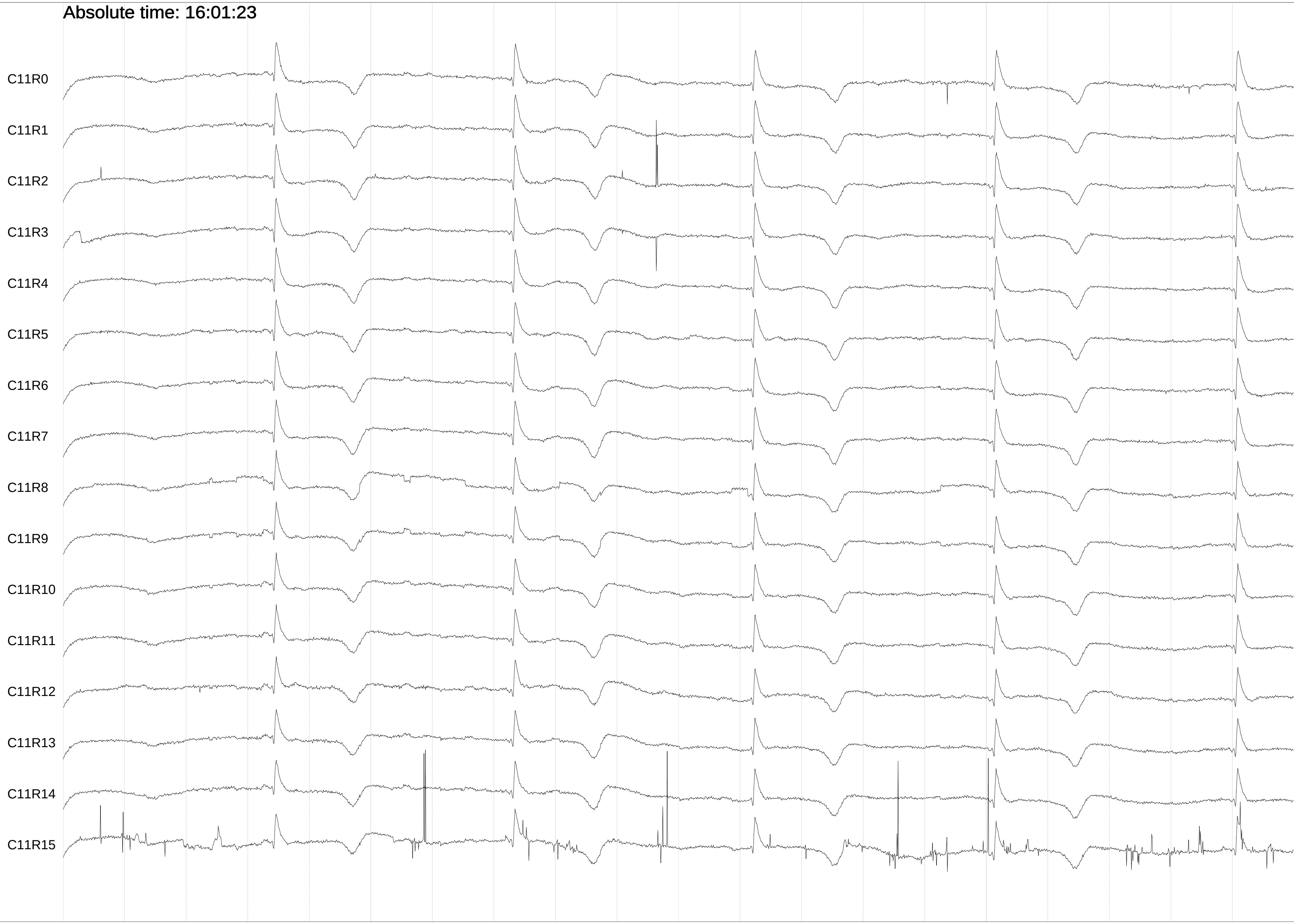

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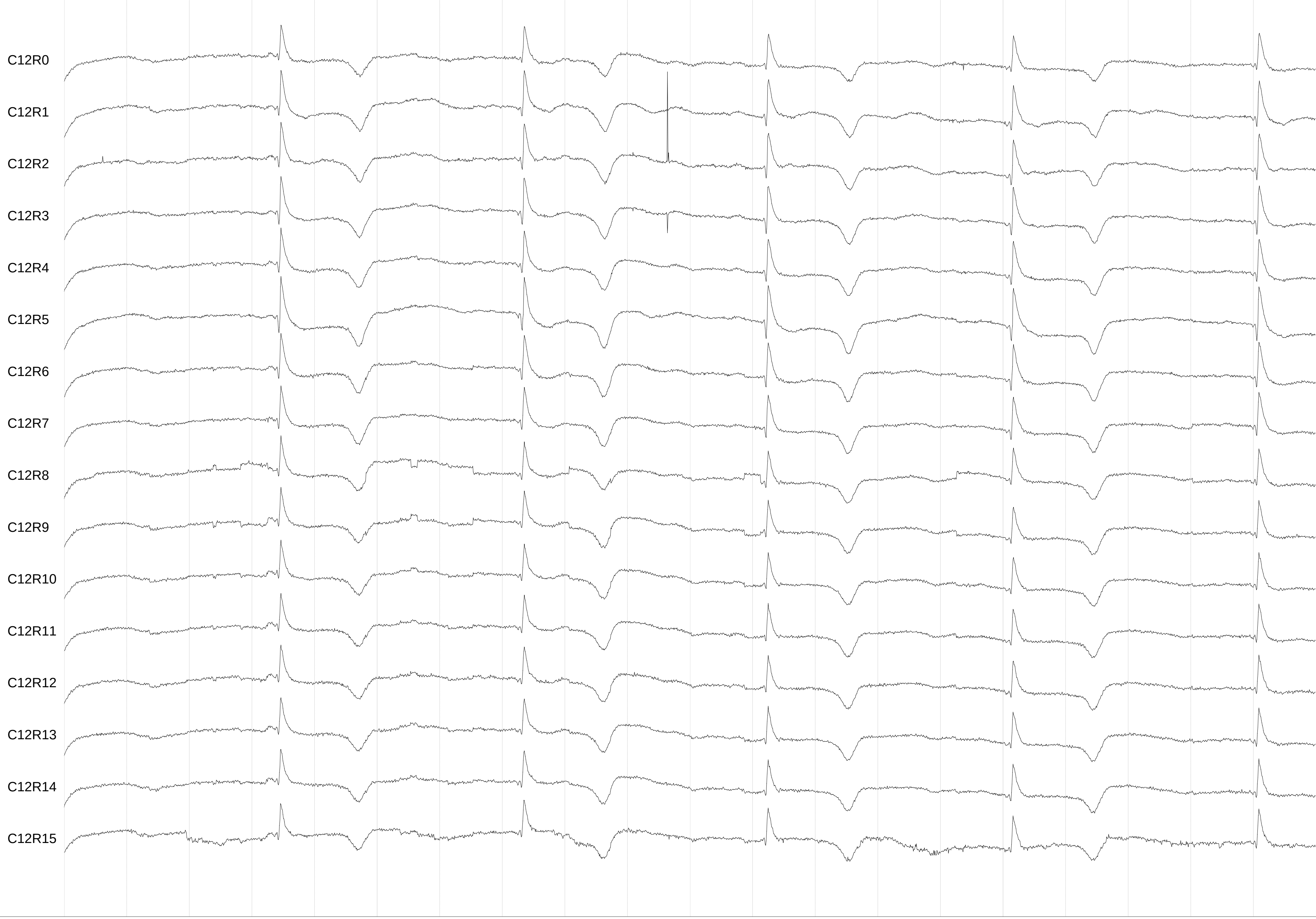

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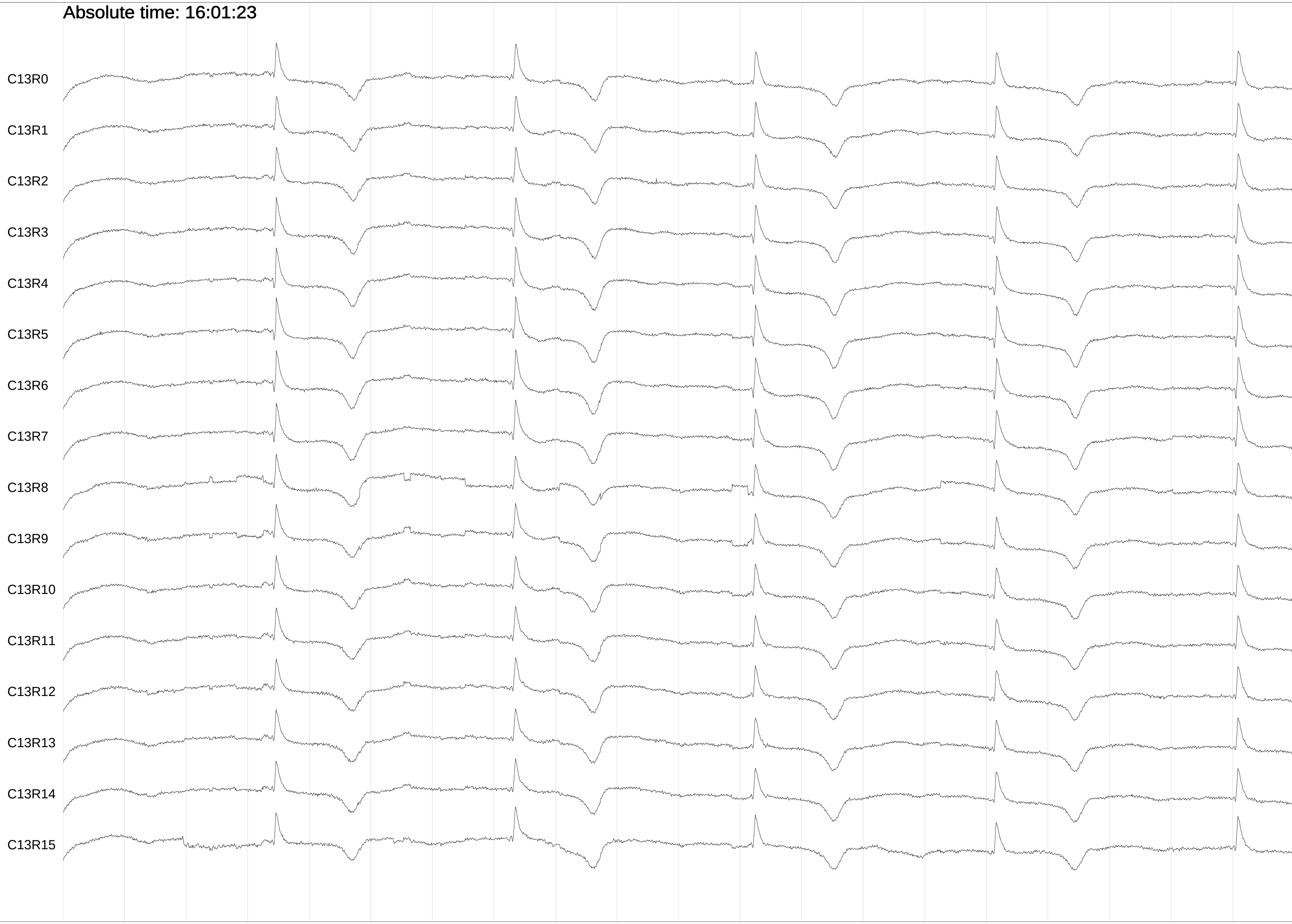
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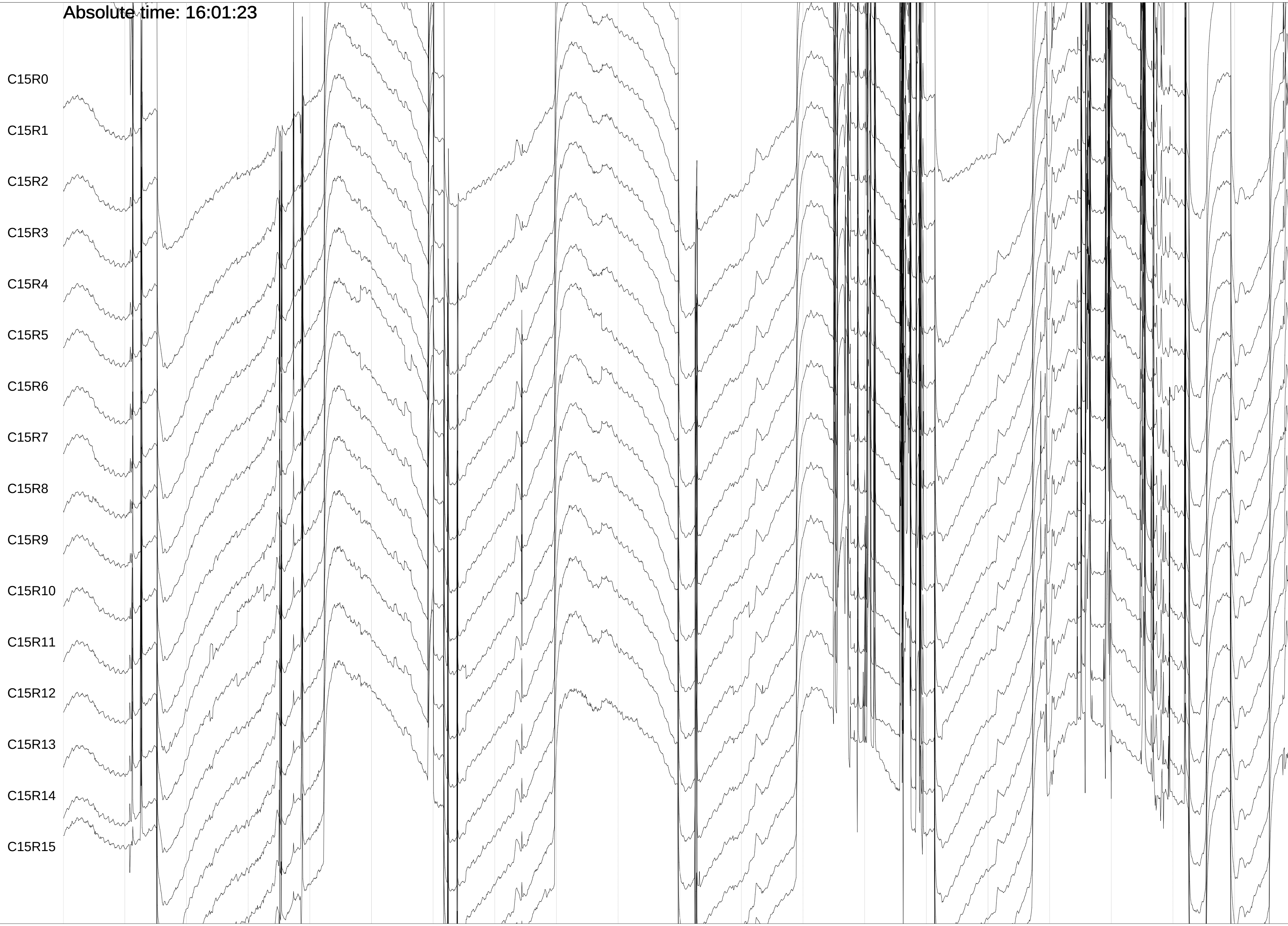

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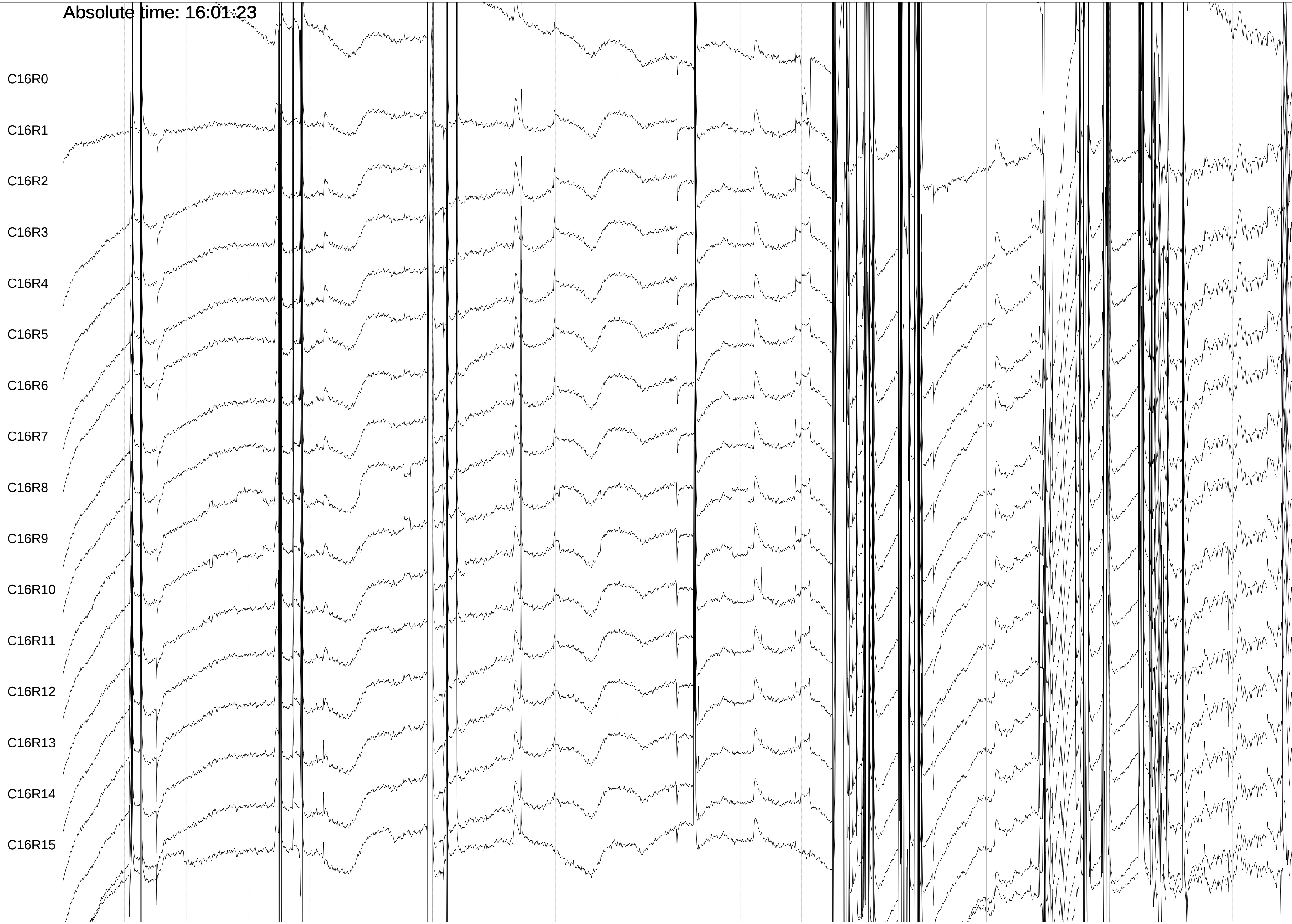

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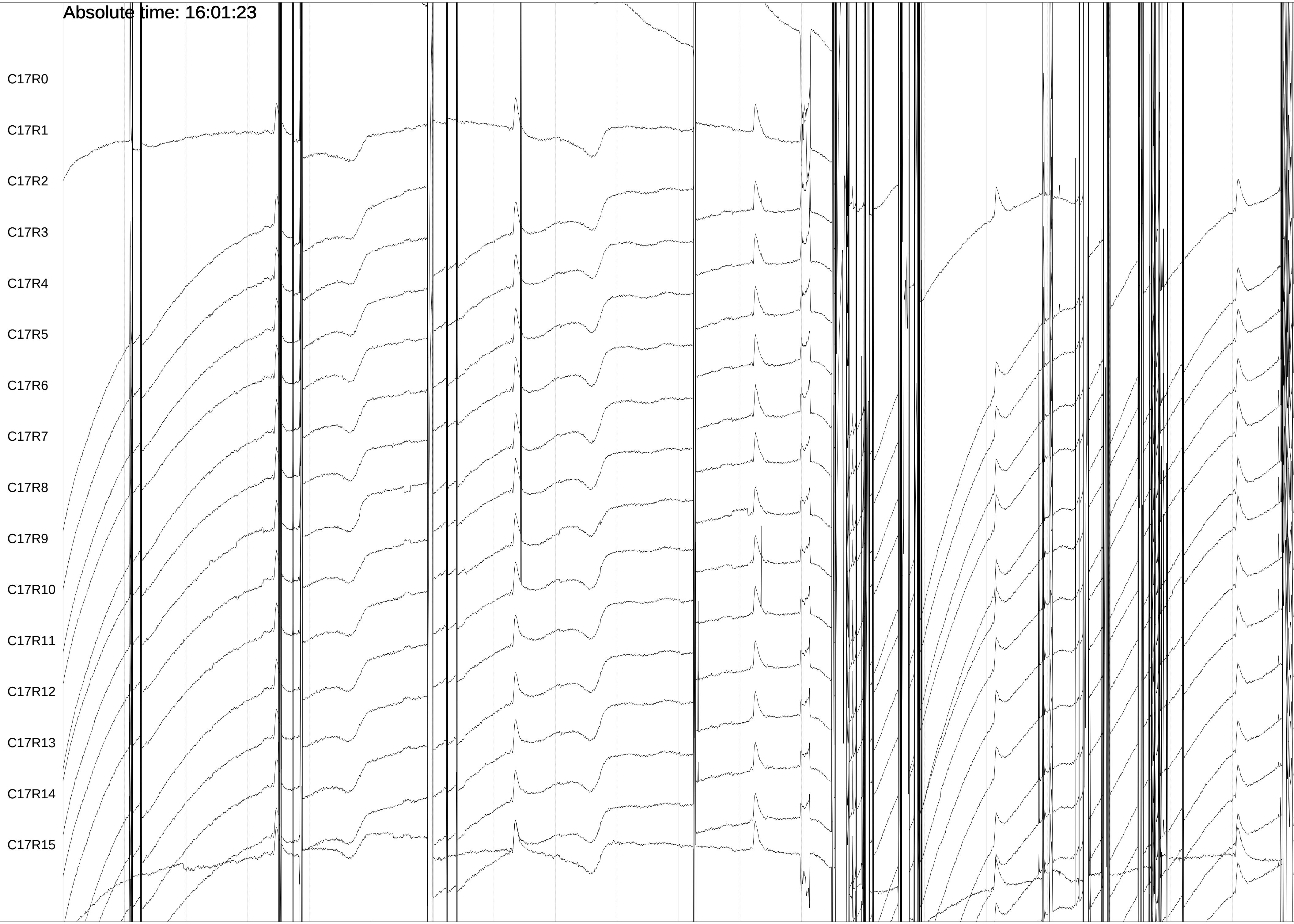

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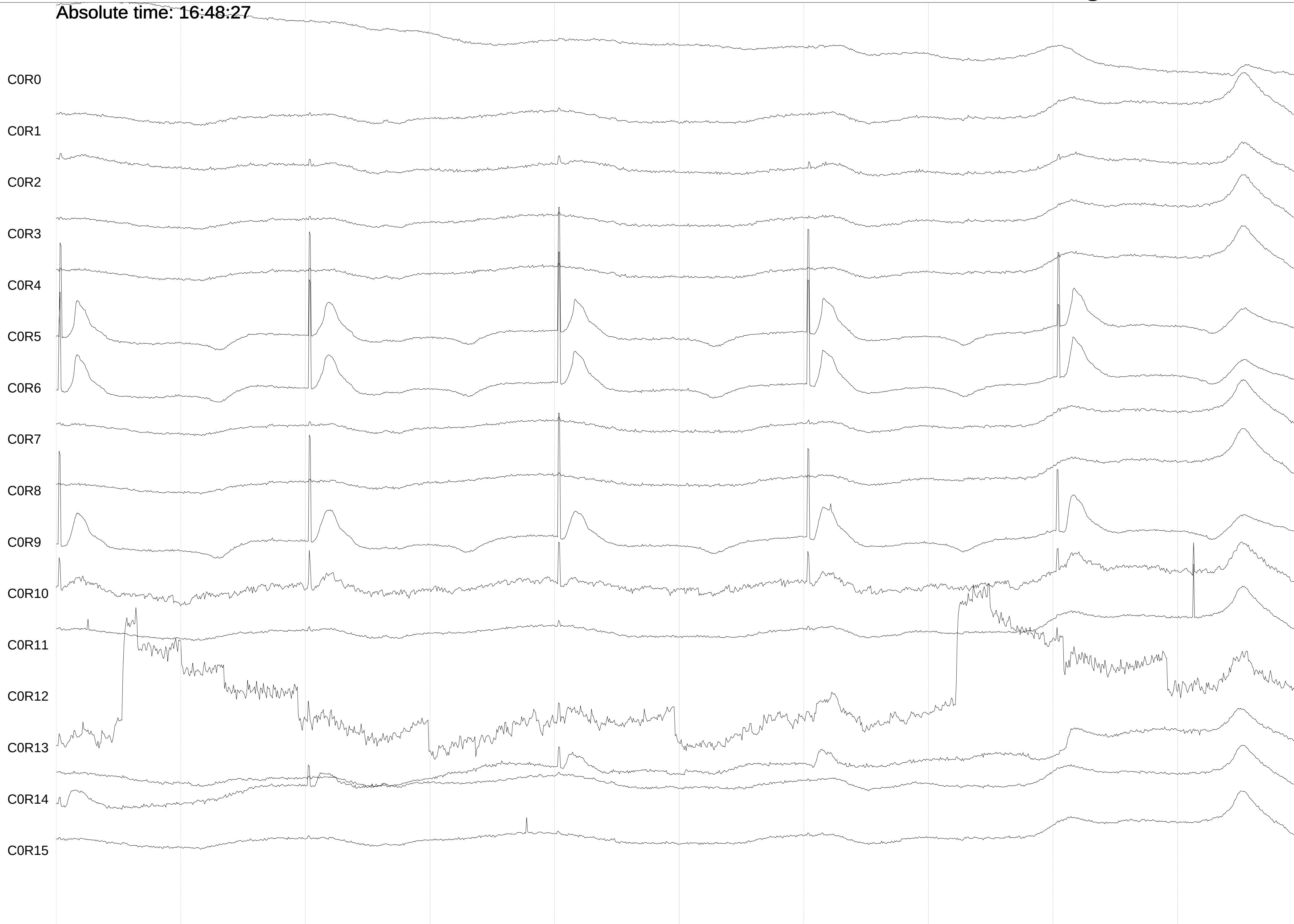
Figure S25



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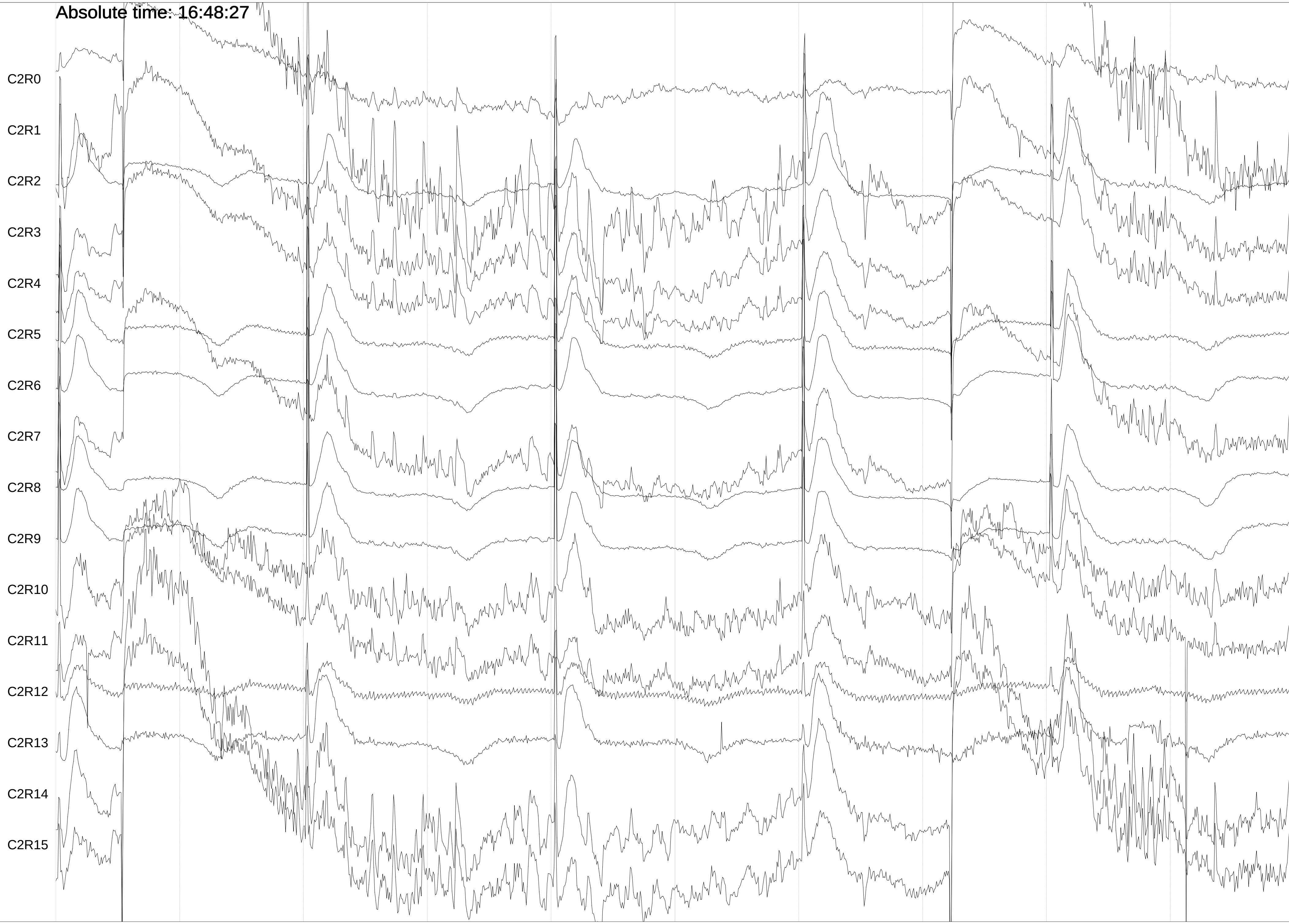

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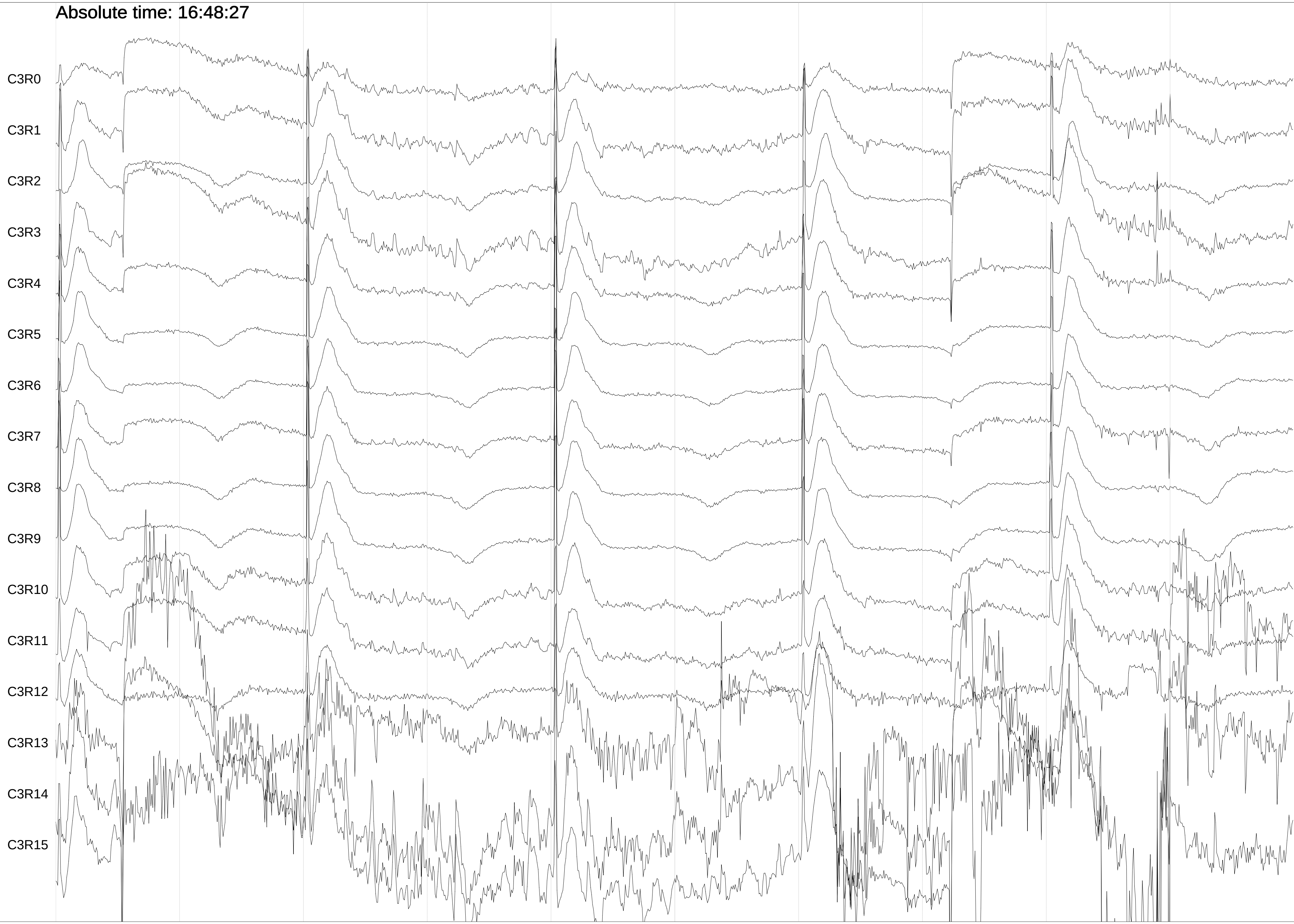

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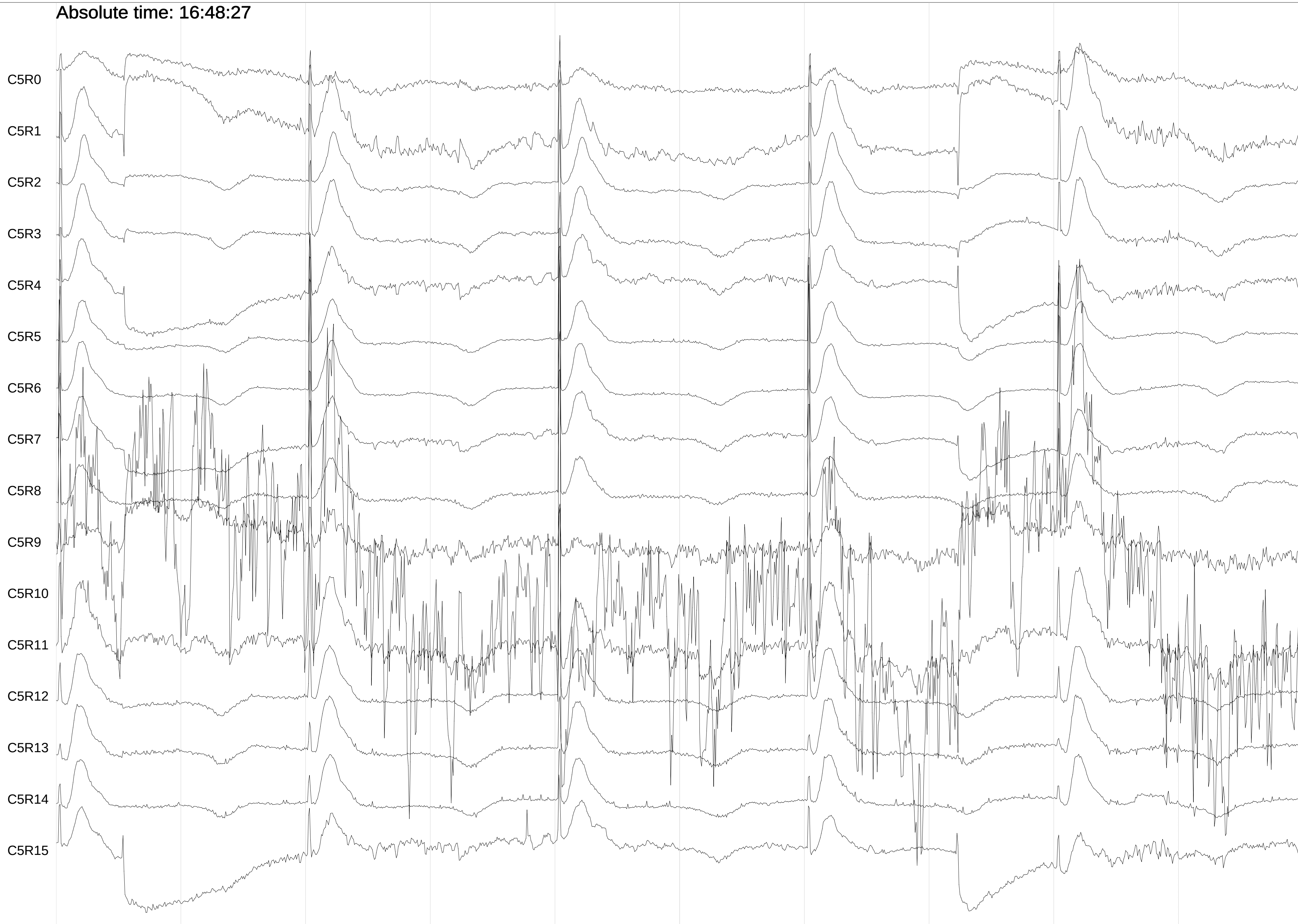

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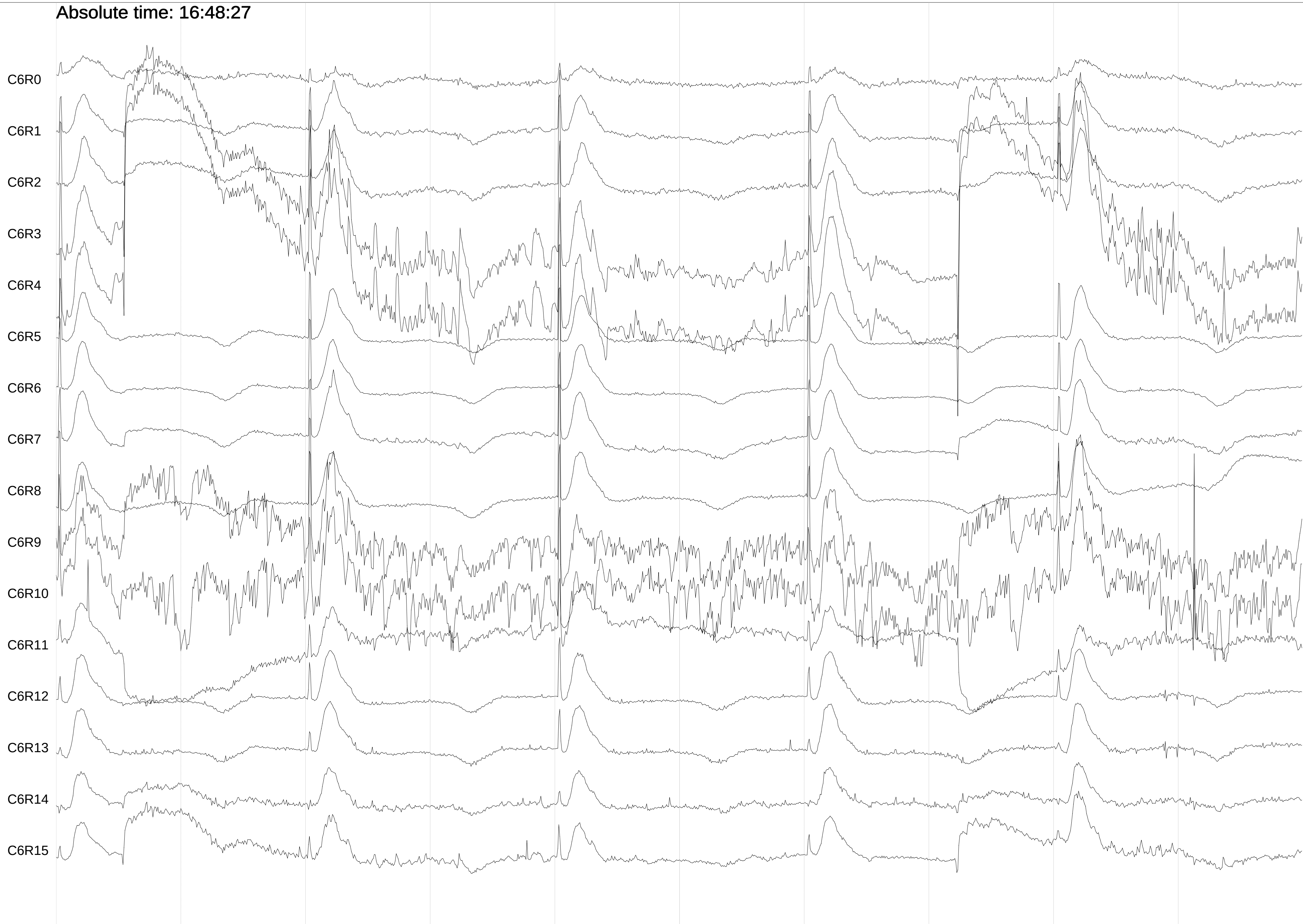

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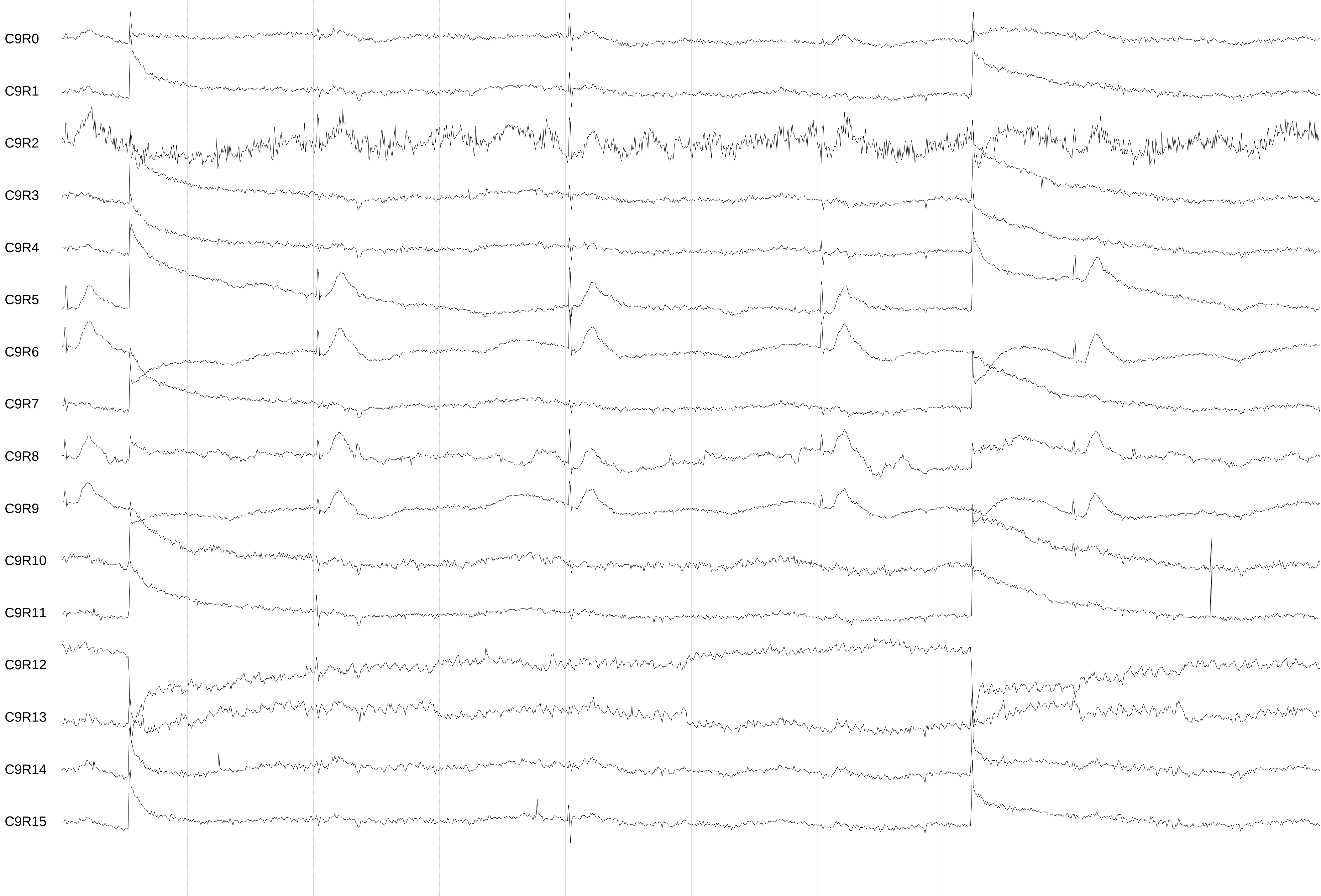

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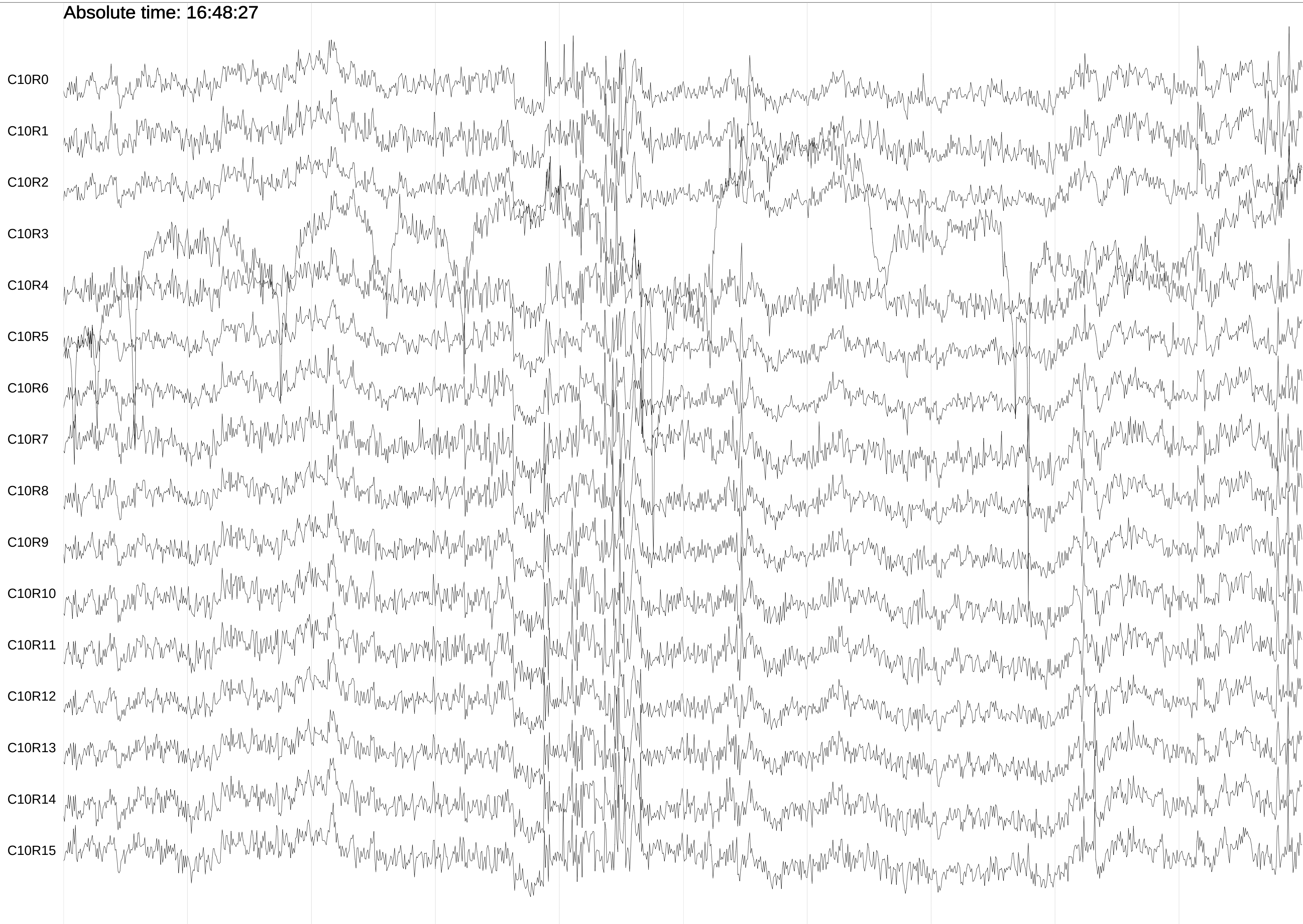

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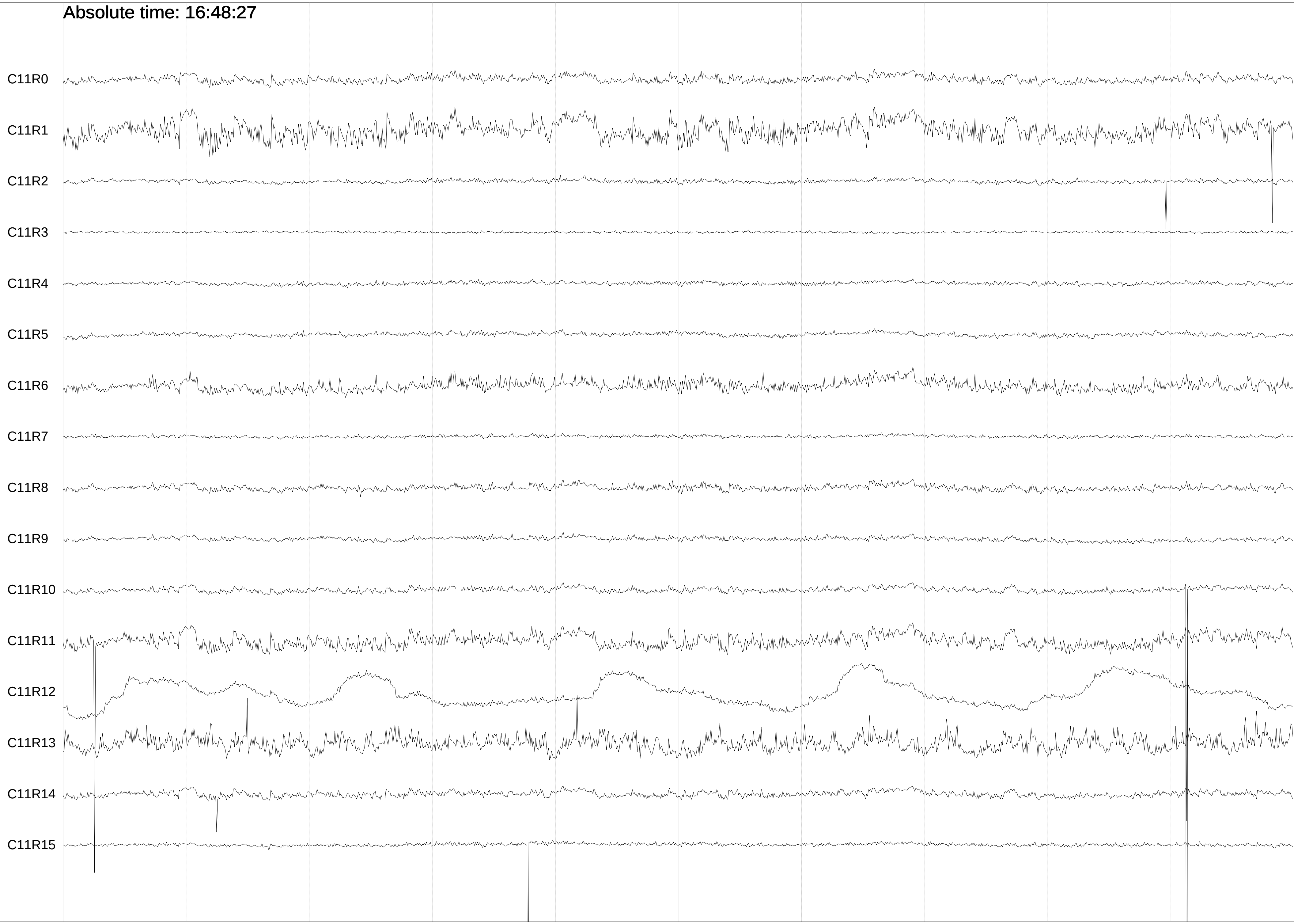

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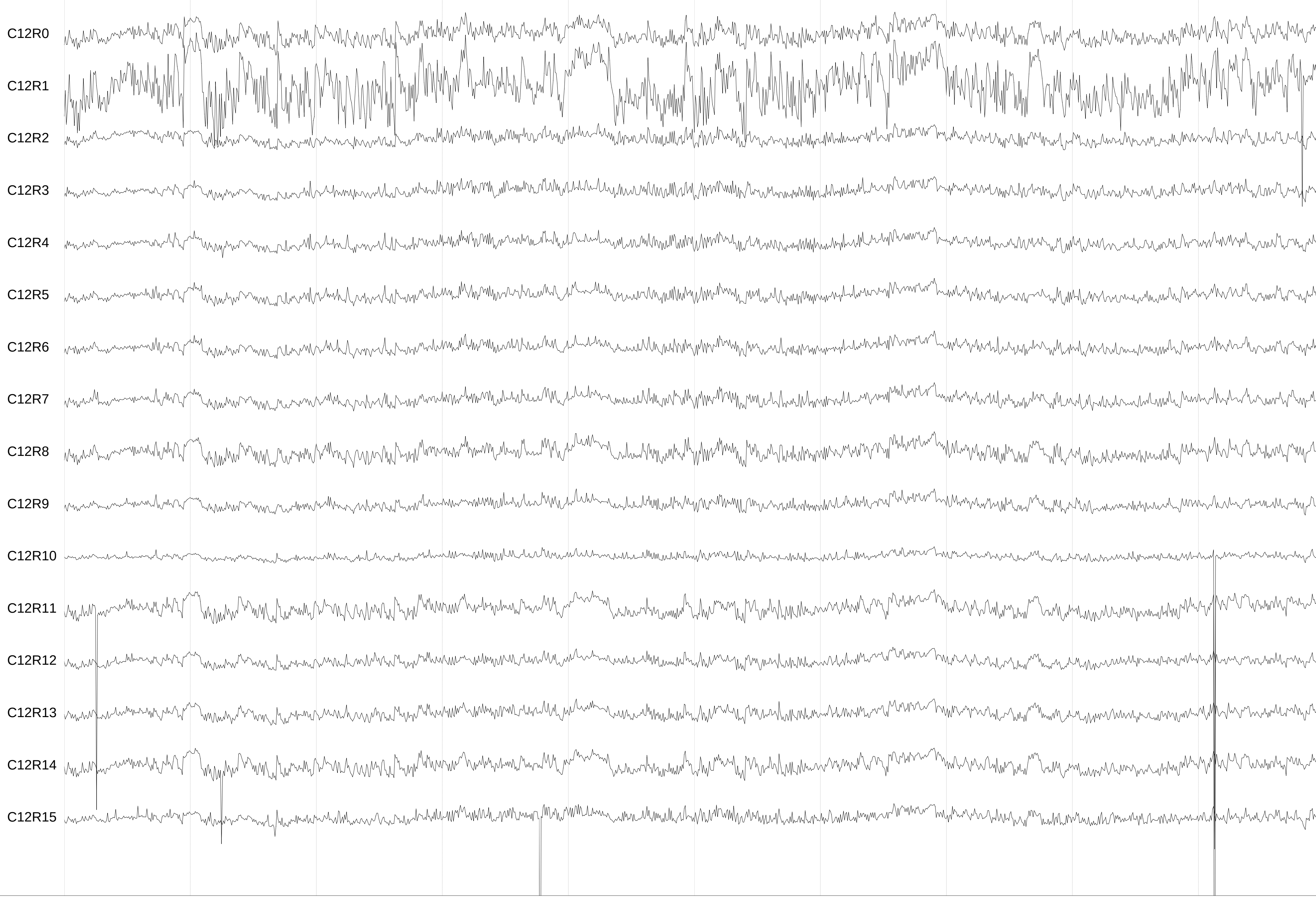

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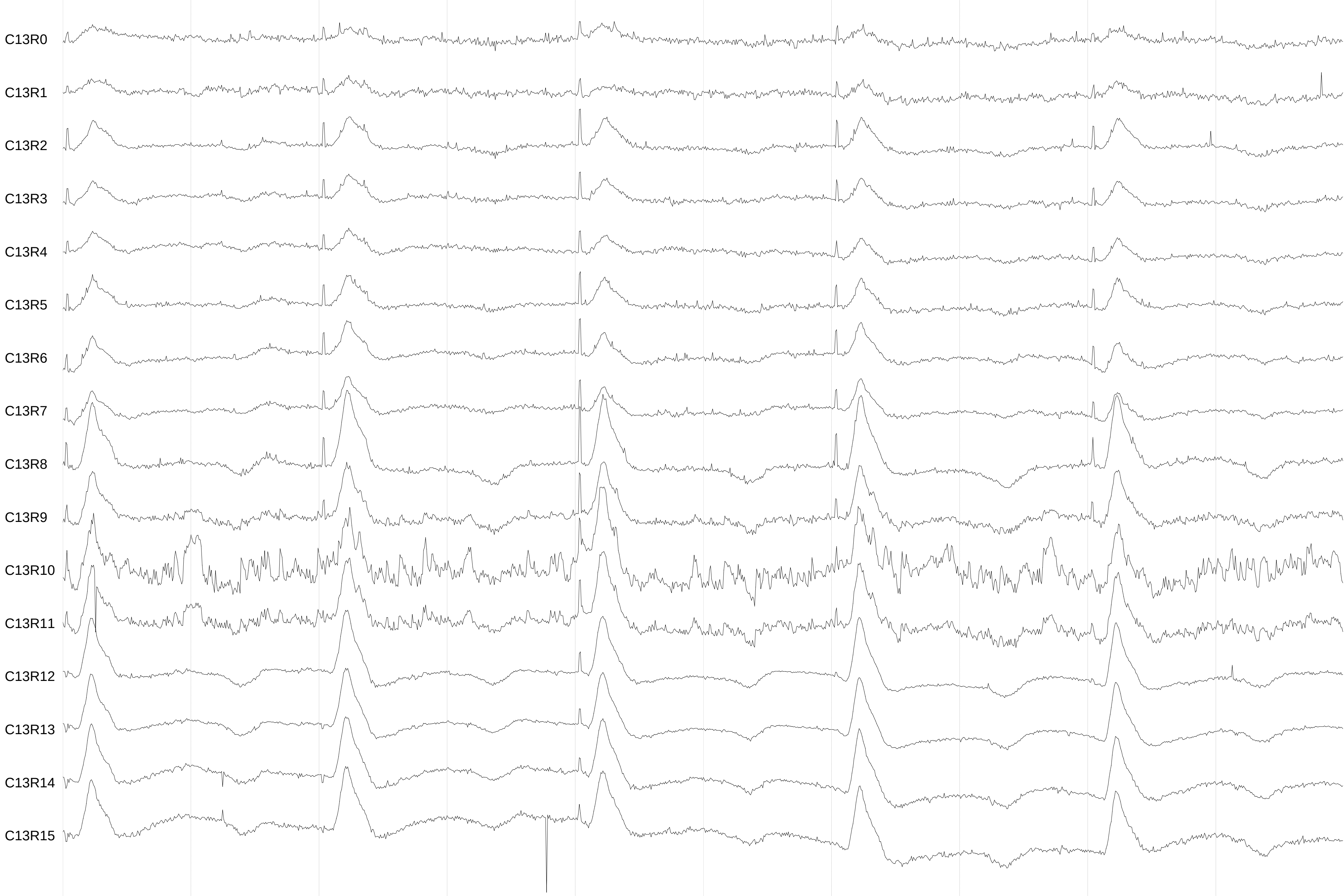

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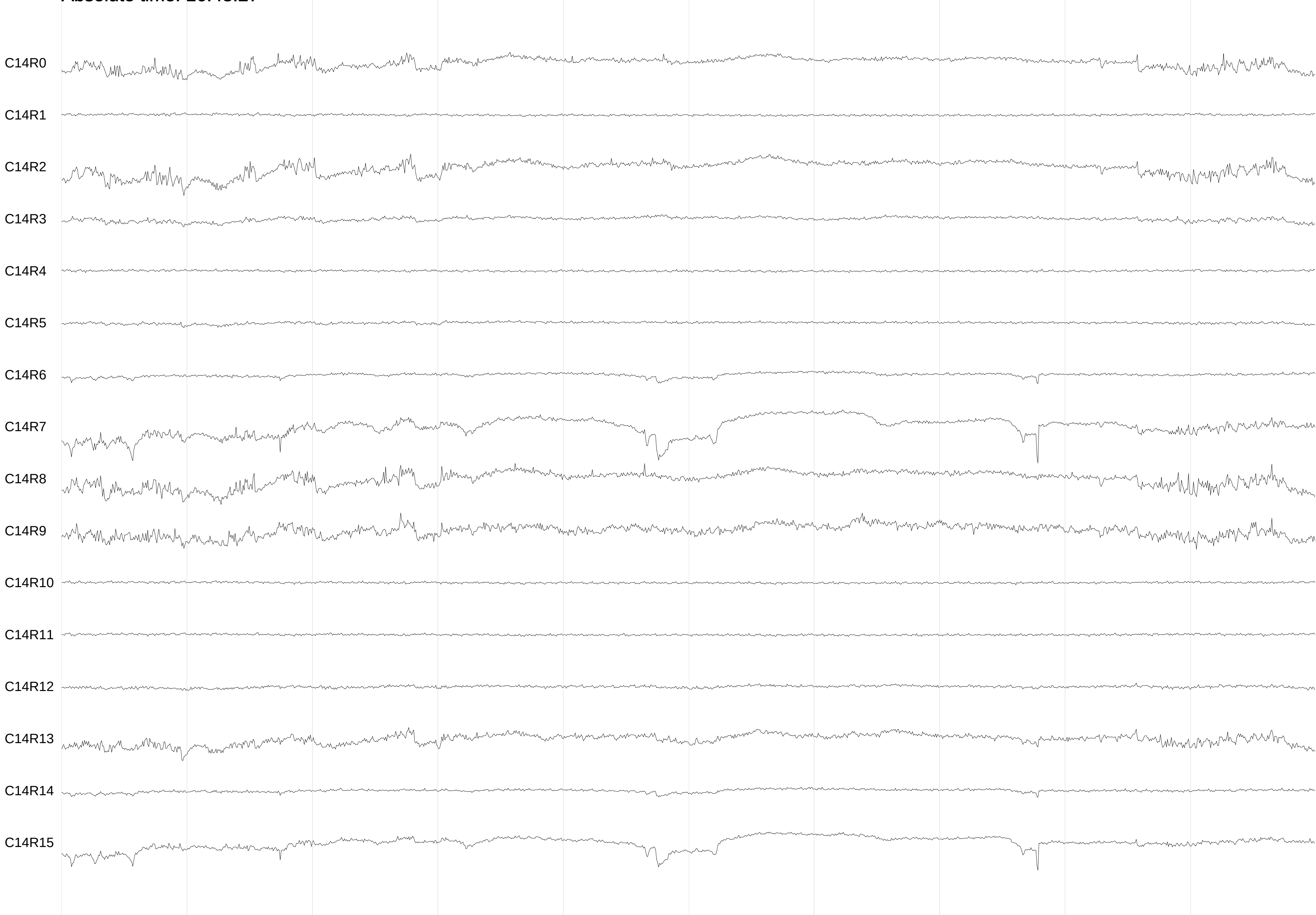

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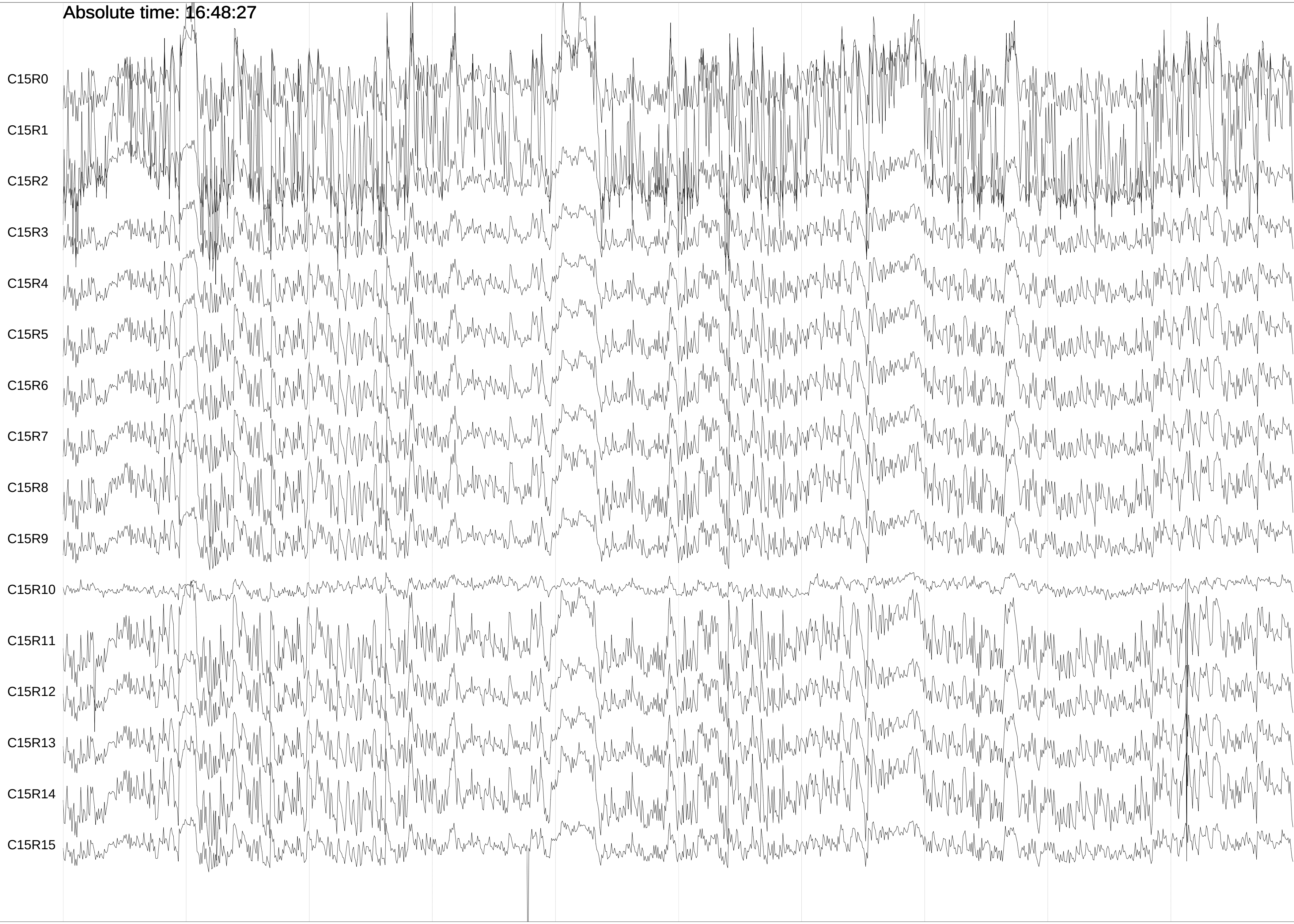

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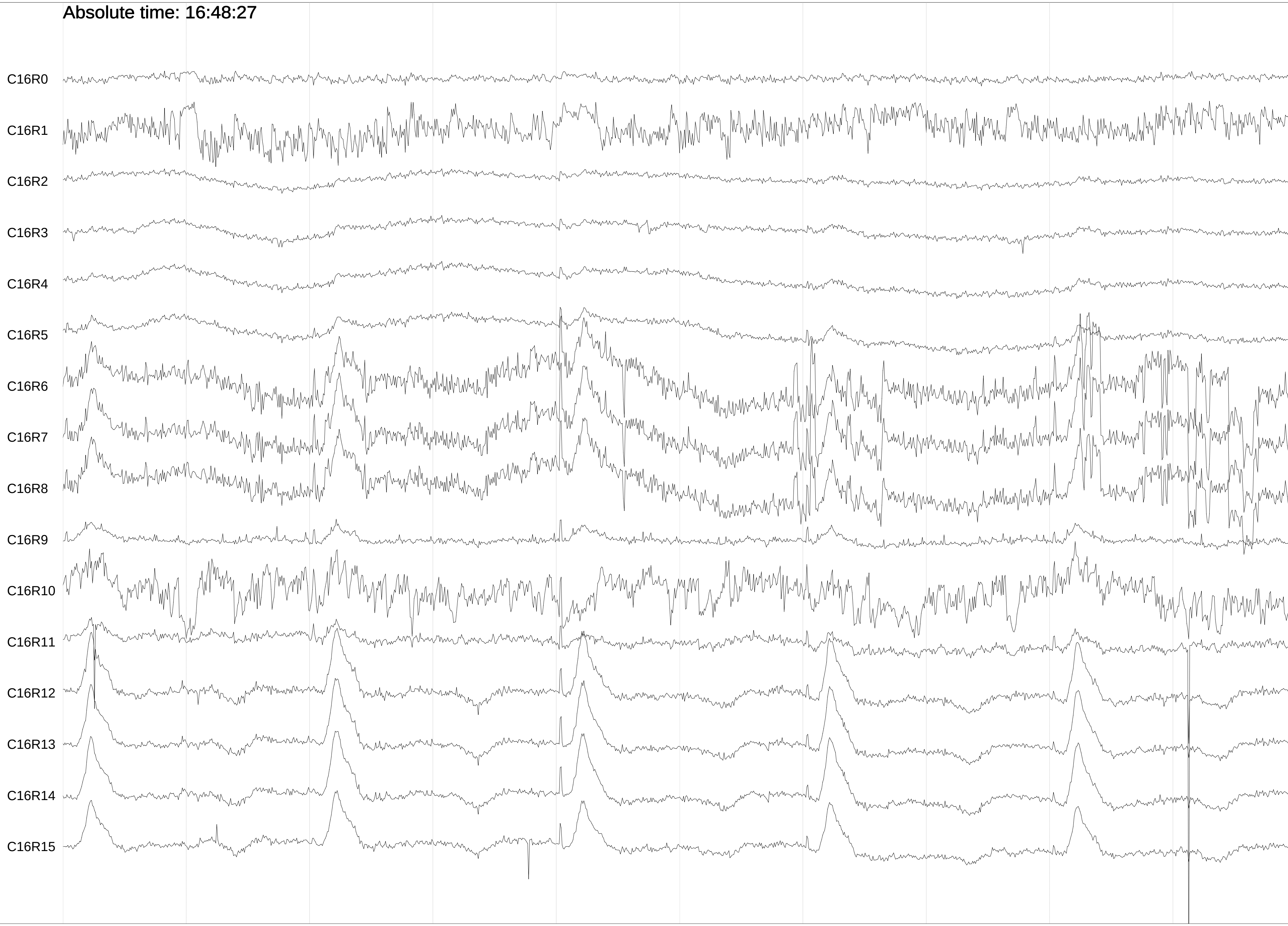

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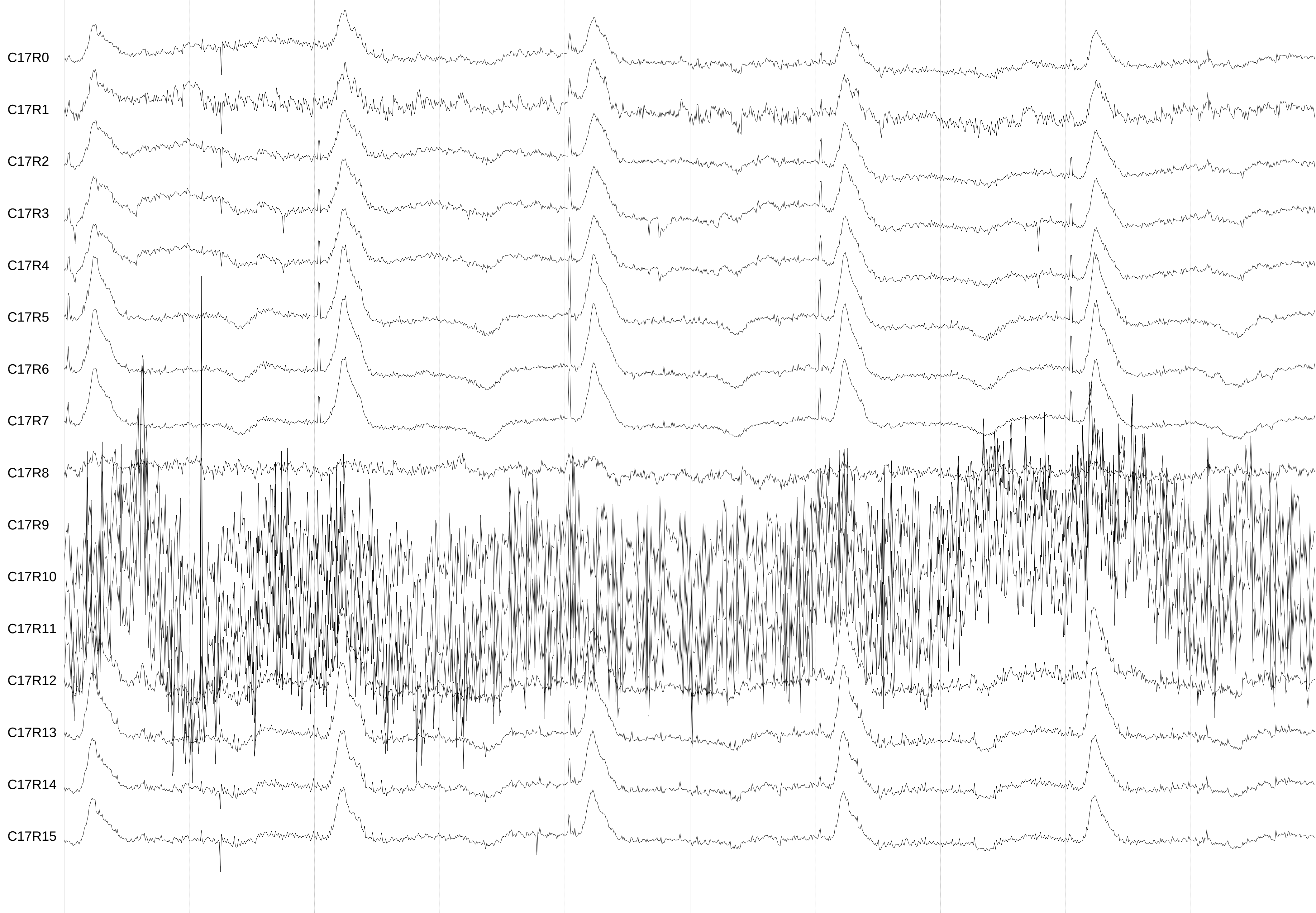

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Figure S26

2sec/page, 1500uV/mm, BNI-1 file format, LoFilter 0.5Hz, HiFilter Off
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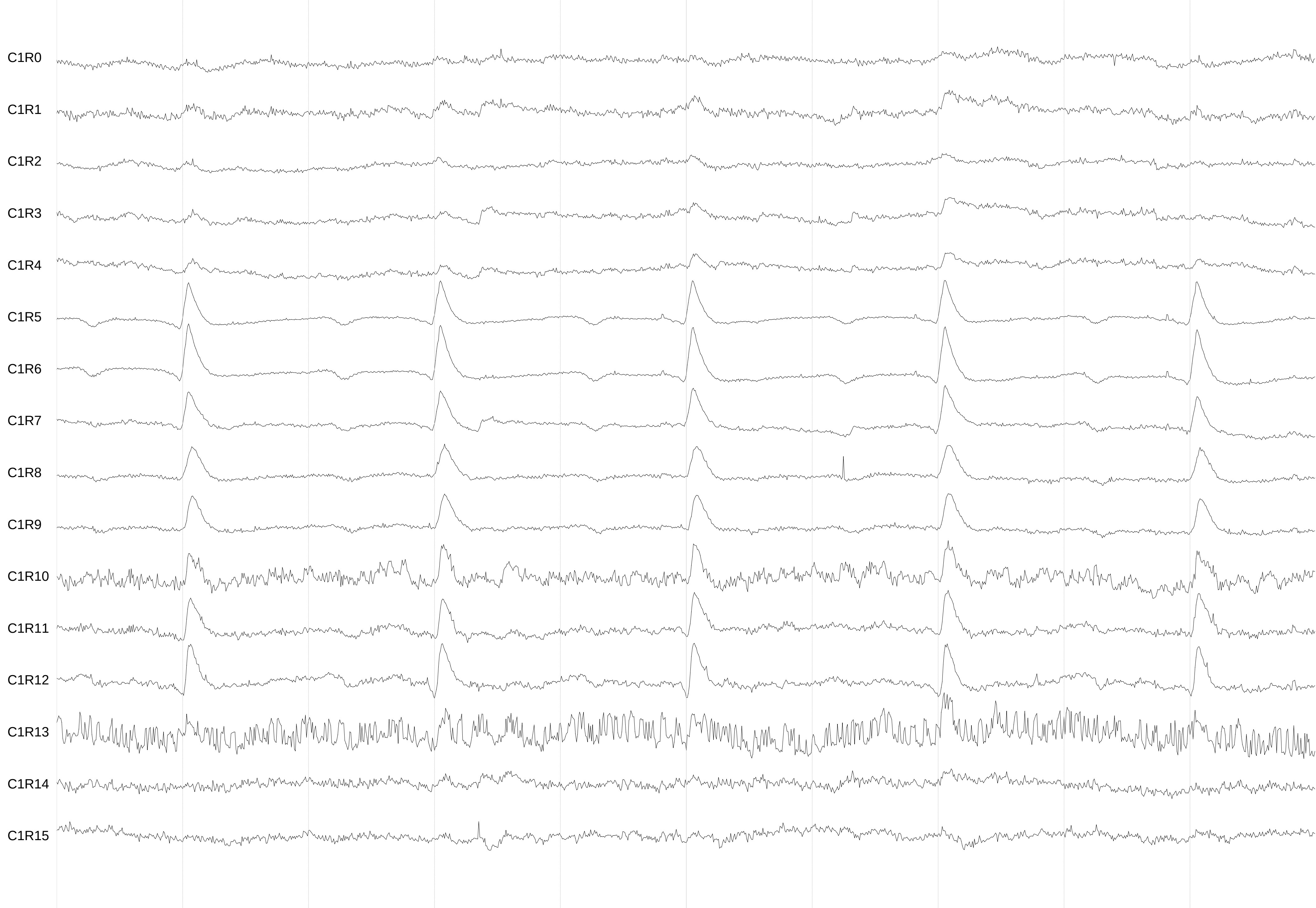

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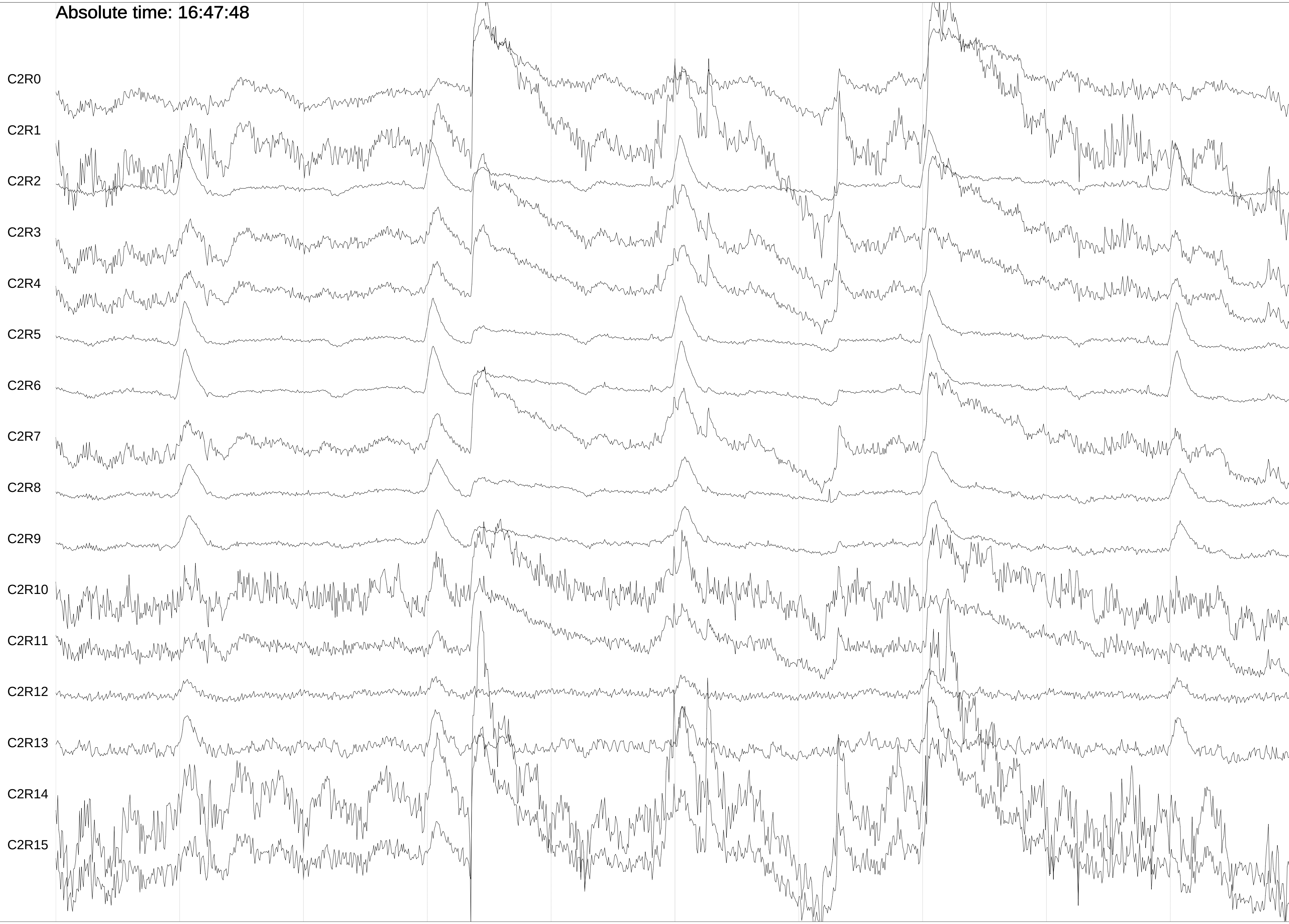

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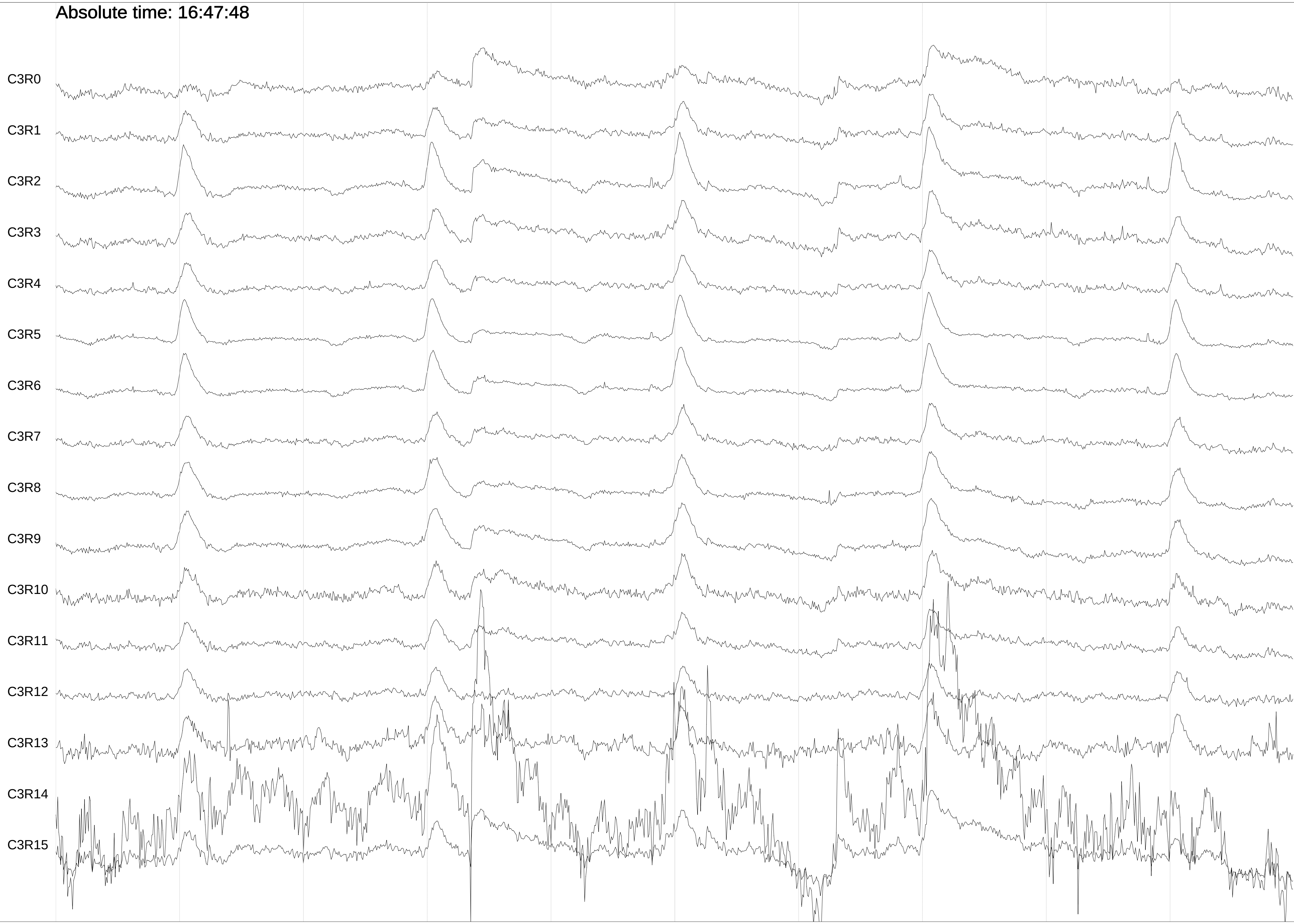

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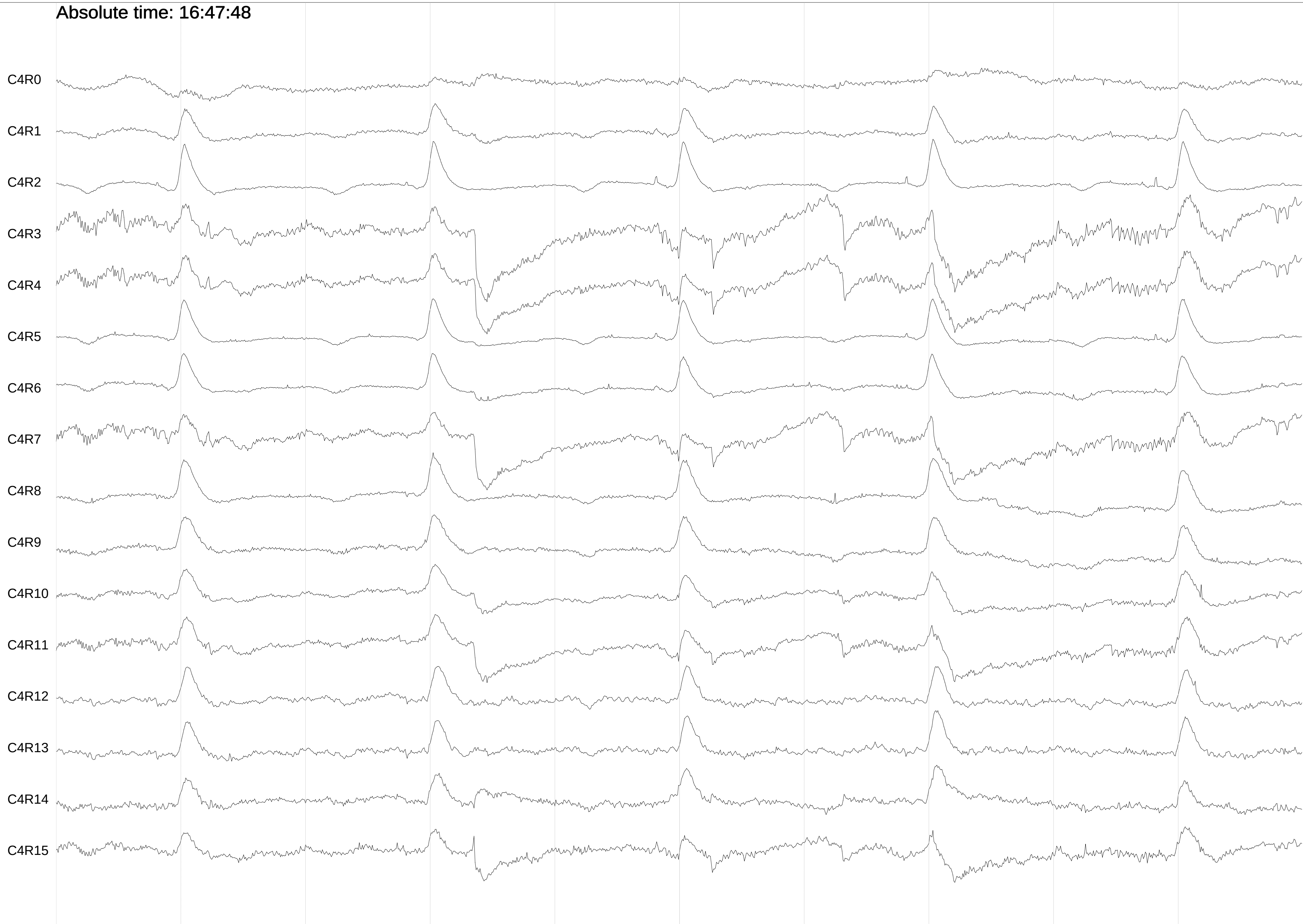
Absolute time: 16:47:48



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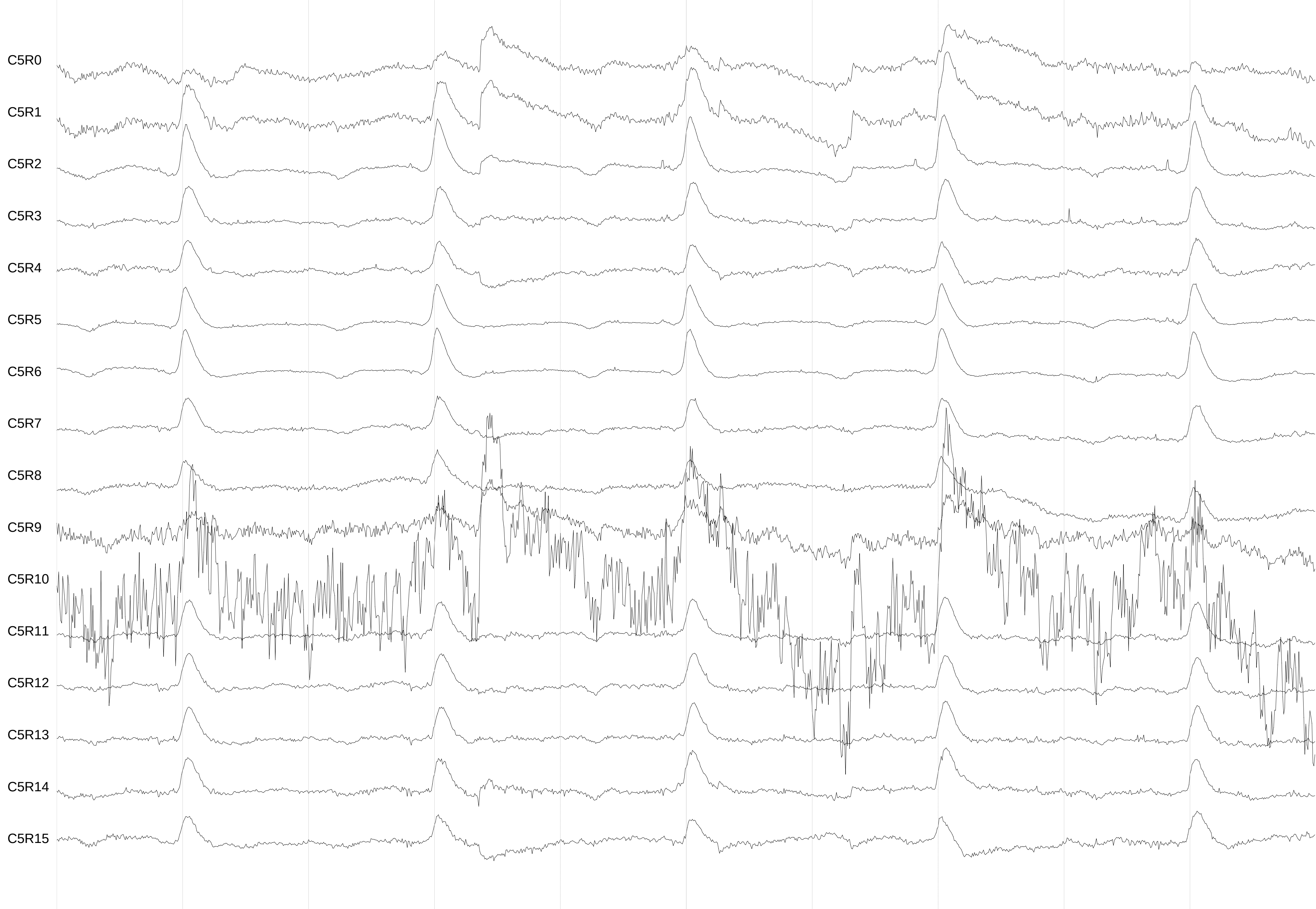

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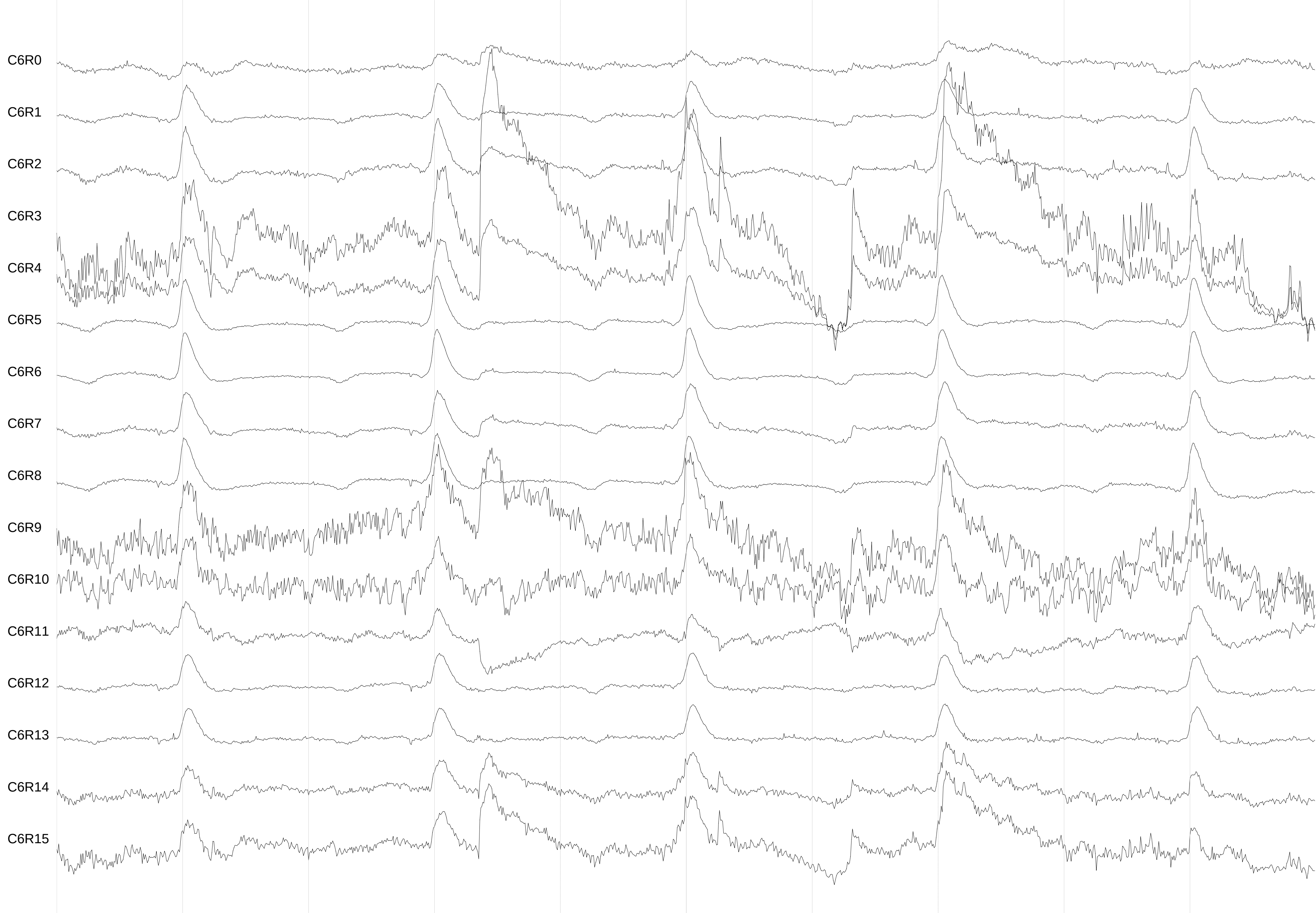
c:\29-apr-2009_16_45_48_p1.eeg

29-Apr-2009_16_45_48_p1 null   04/29/2009

Absolute time: 16:47:48



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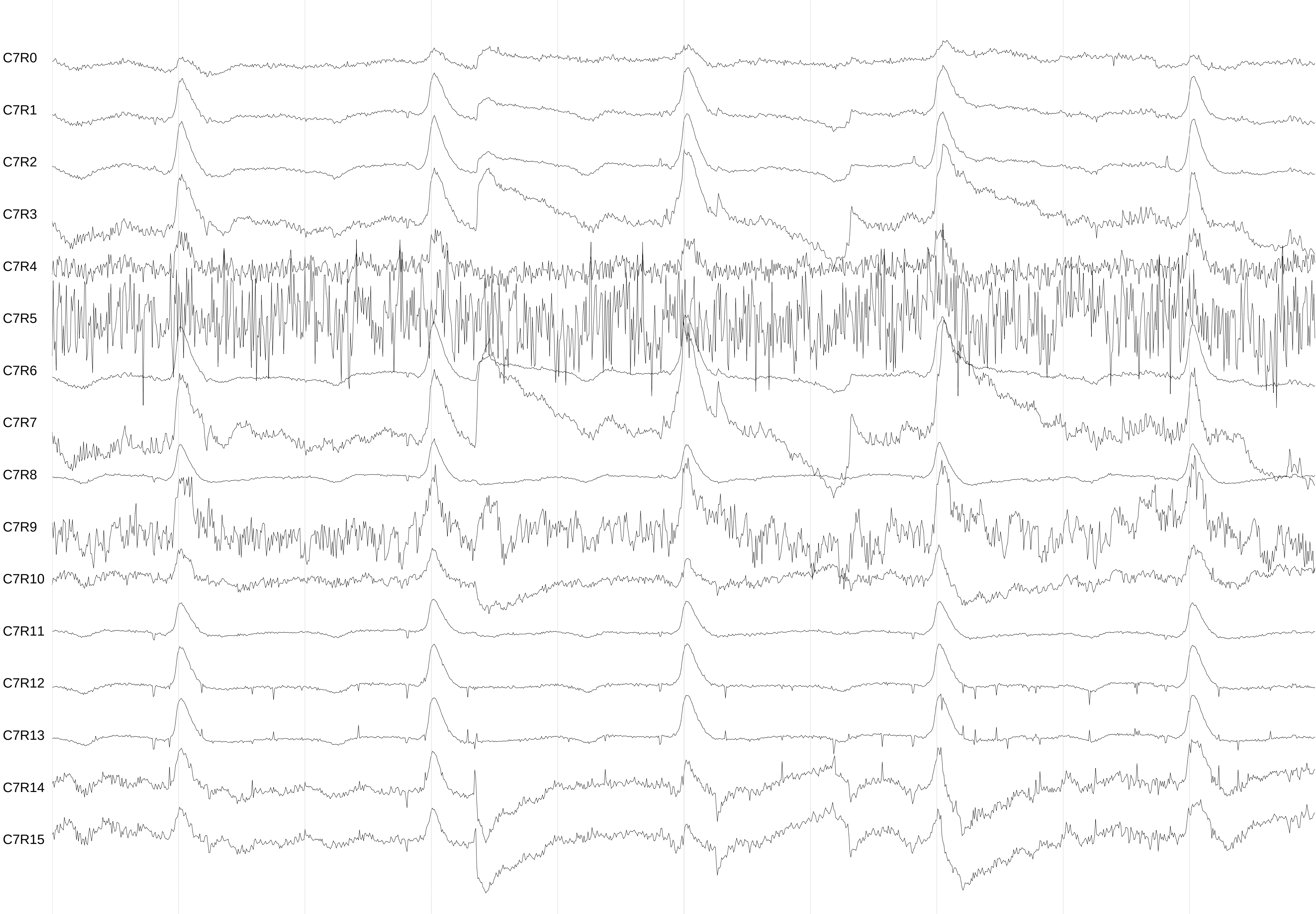
c:\29-apr-2009_16_45_48_p1.eeg

Absolute time: 16:47:48



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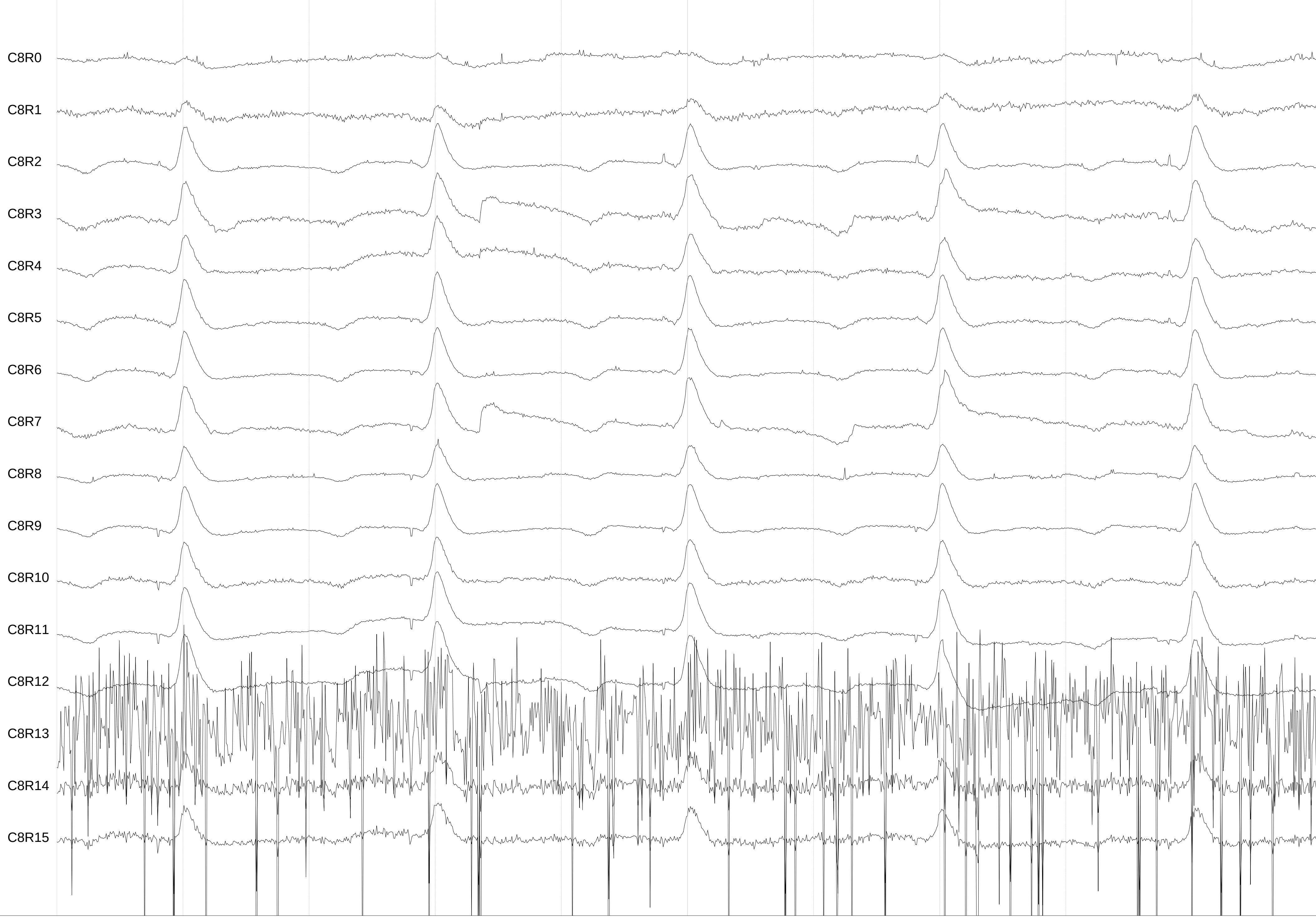
Absolute time: 16:47:48



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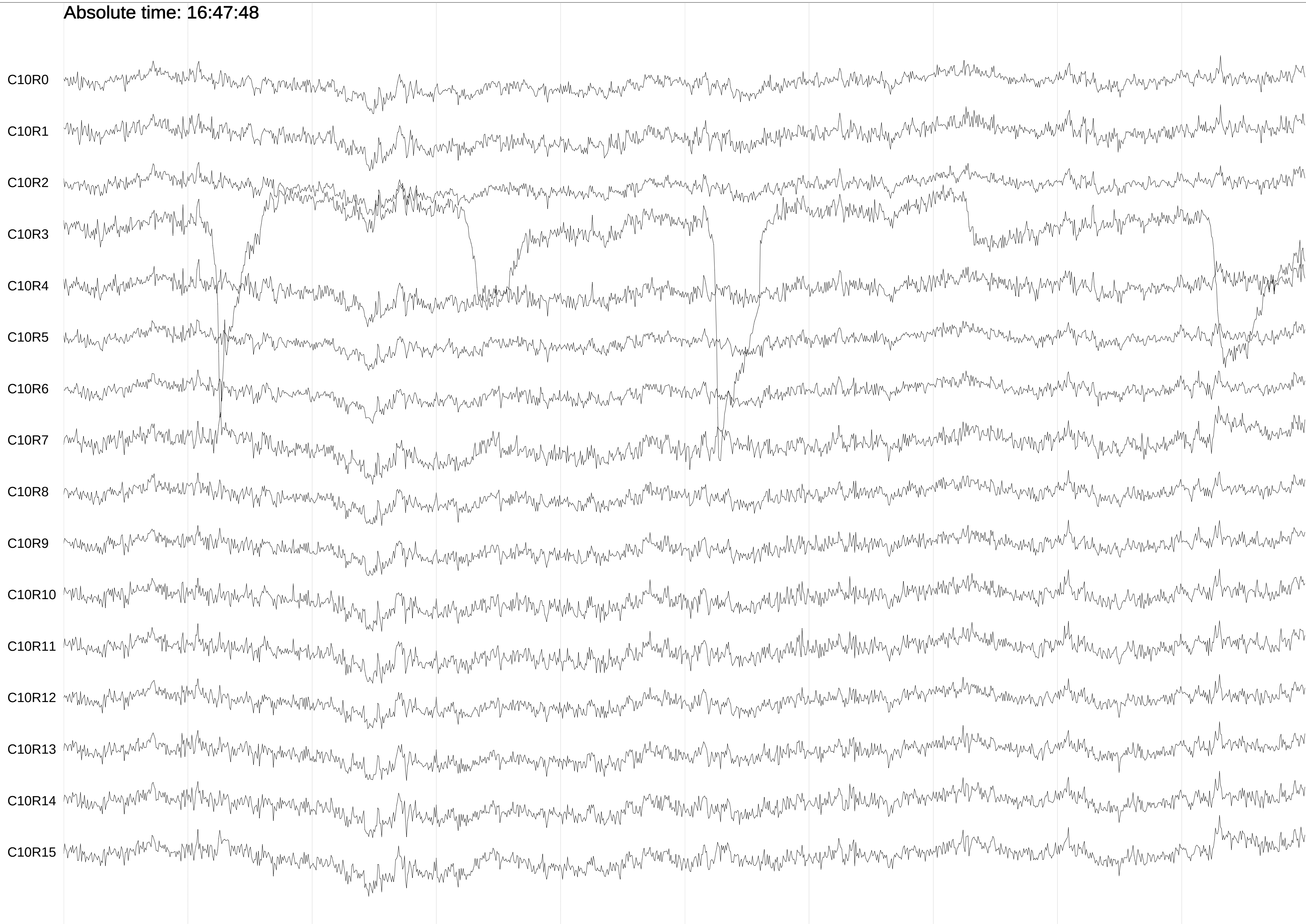
c:\29-apr-2009_16_45_48_p1.eeg

Absolute time: 16:47:48

2sec/page, 1500uV/mm, BNI-1 file format, LoFilter 0.5Hz, HiFilter Off
c:\29-apr-2009_16_45_48_p2.eeg

Absolute time: 16:47:48



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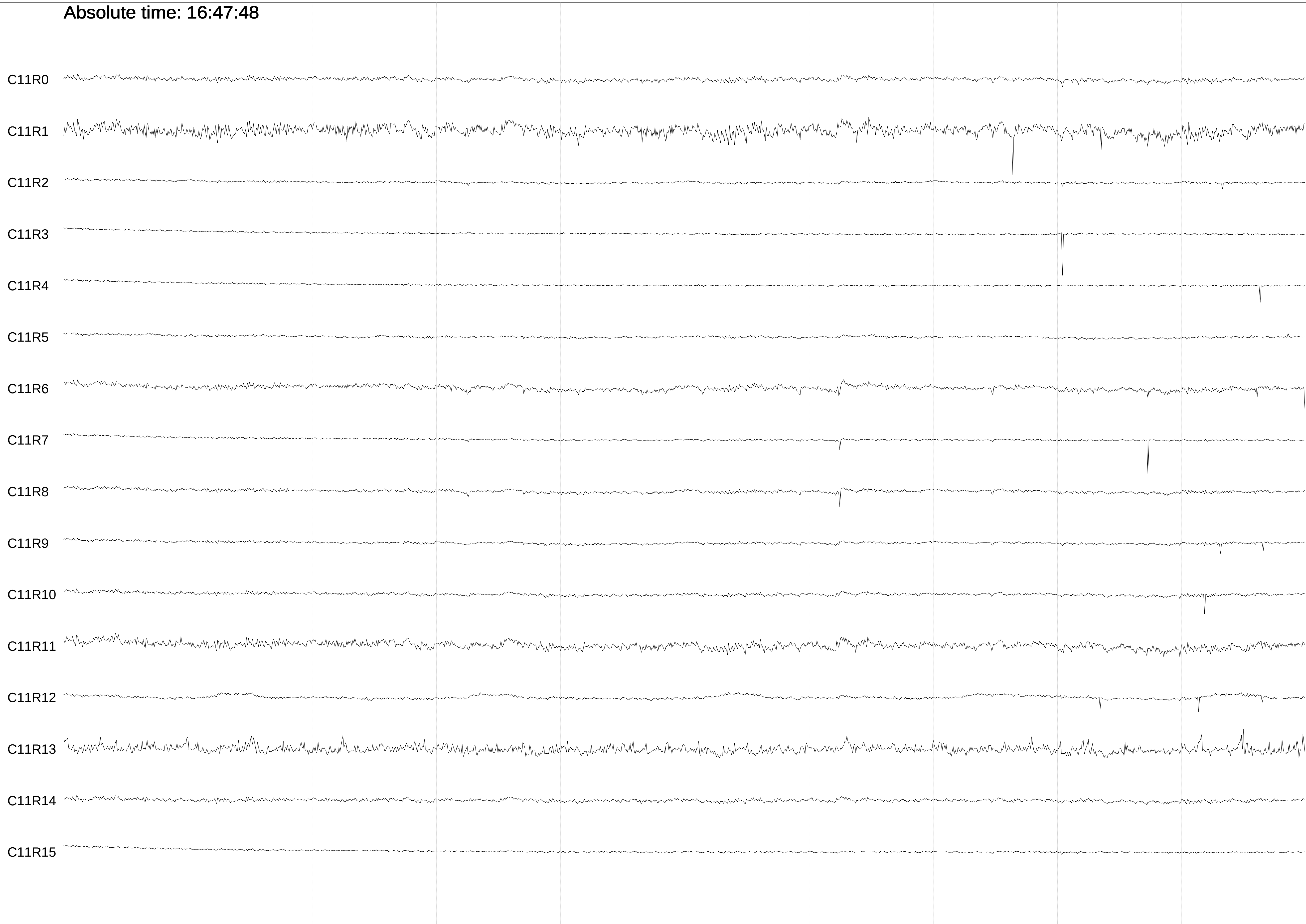
Absolute time: 16:47:48



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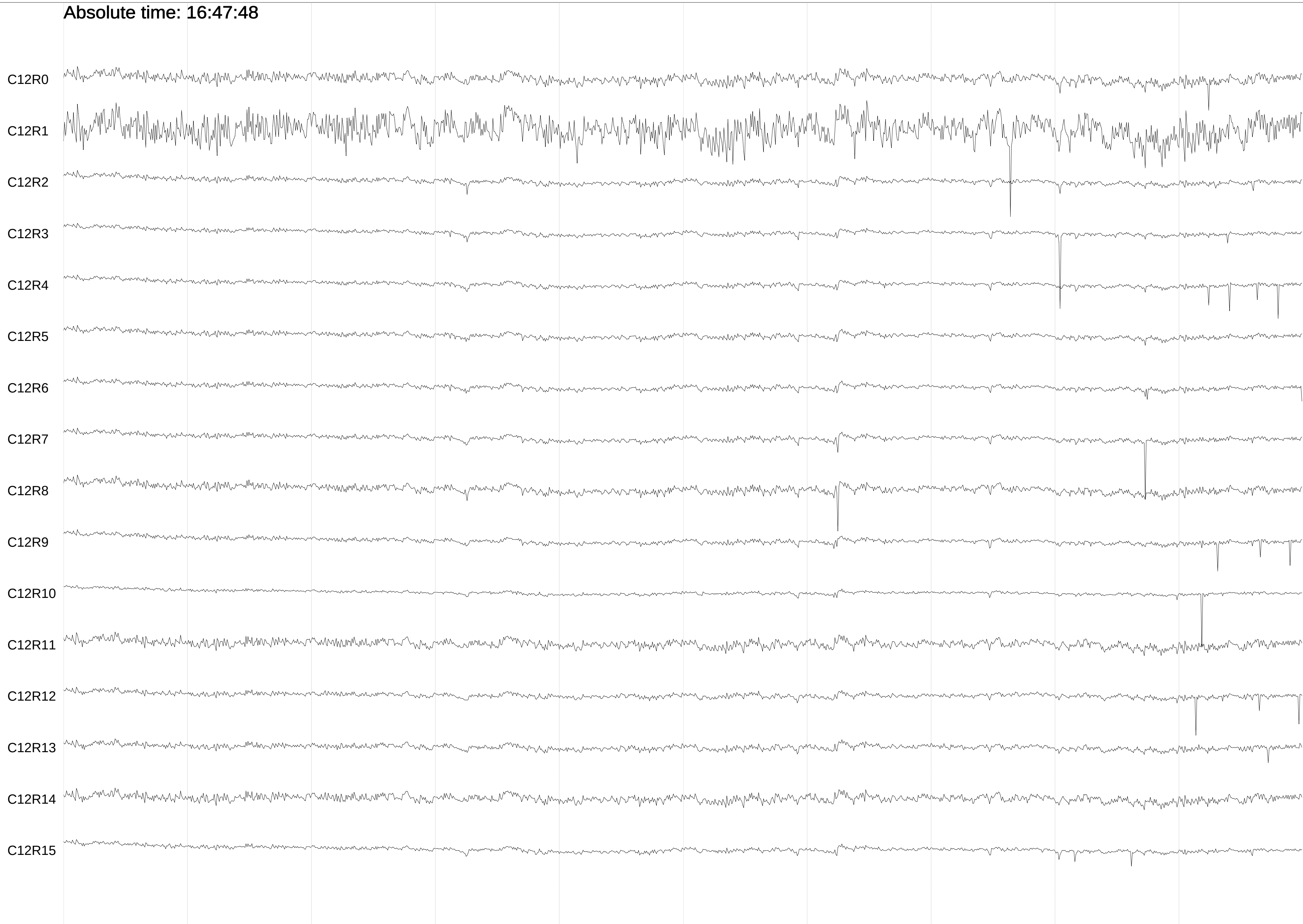

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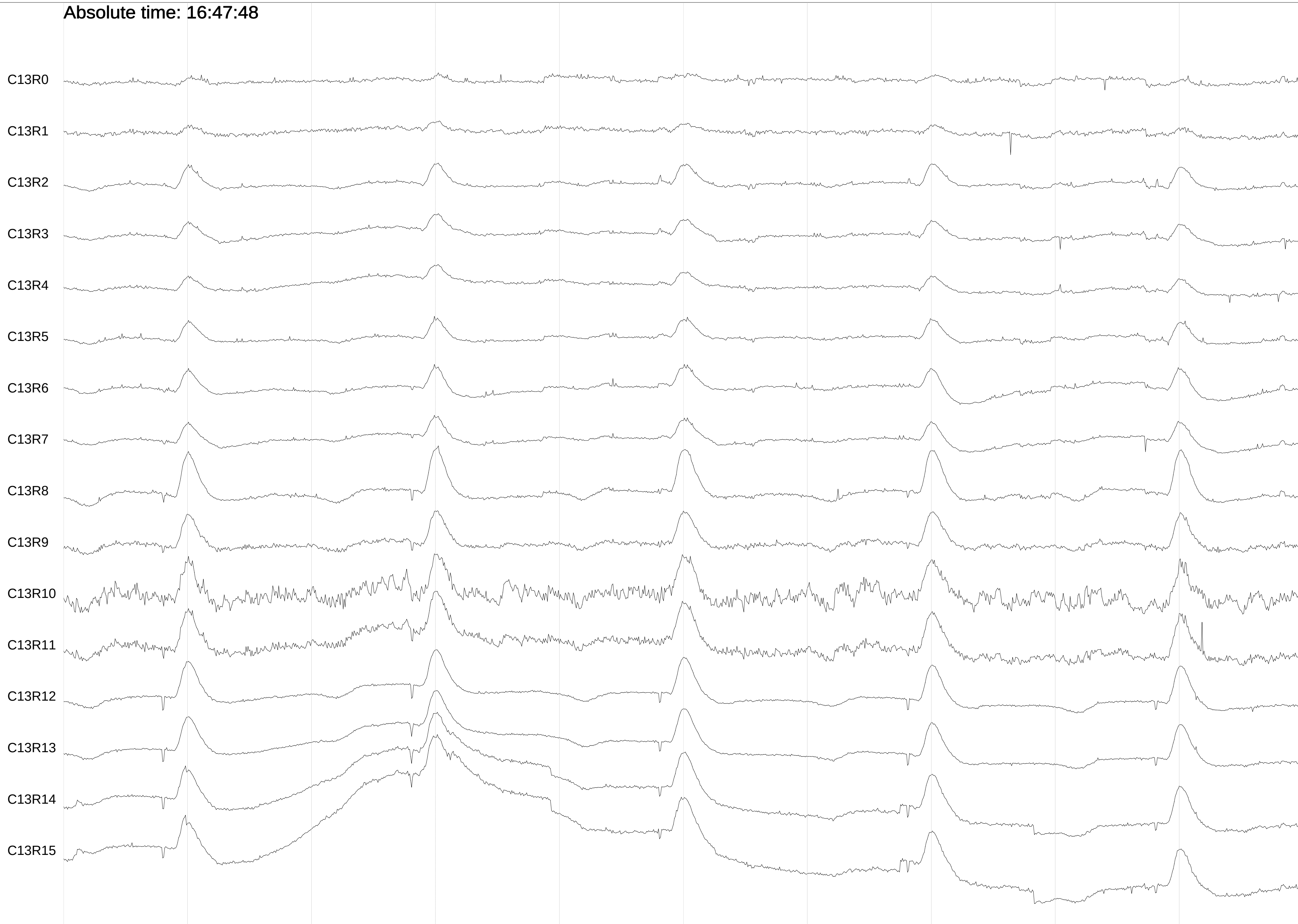

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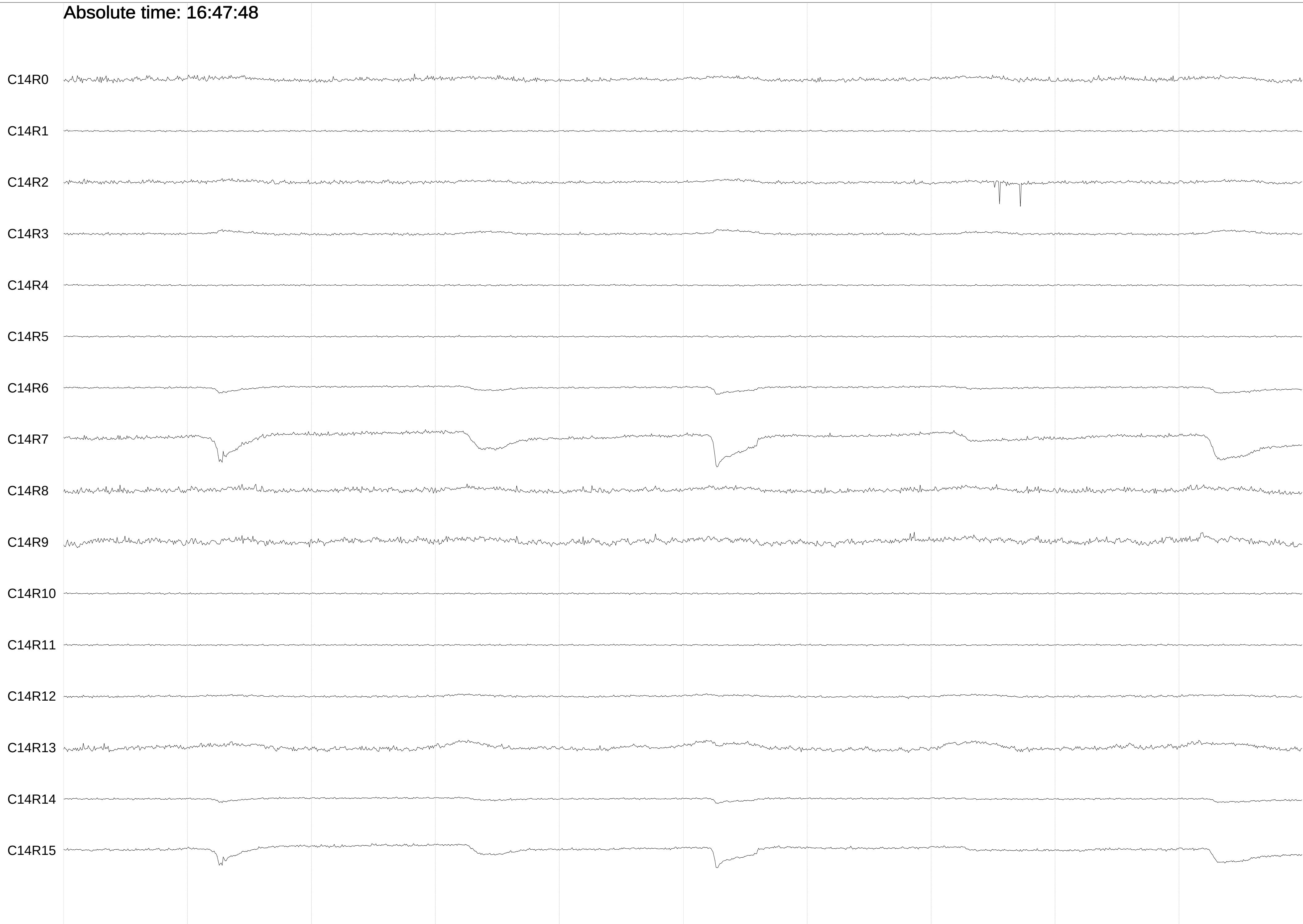

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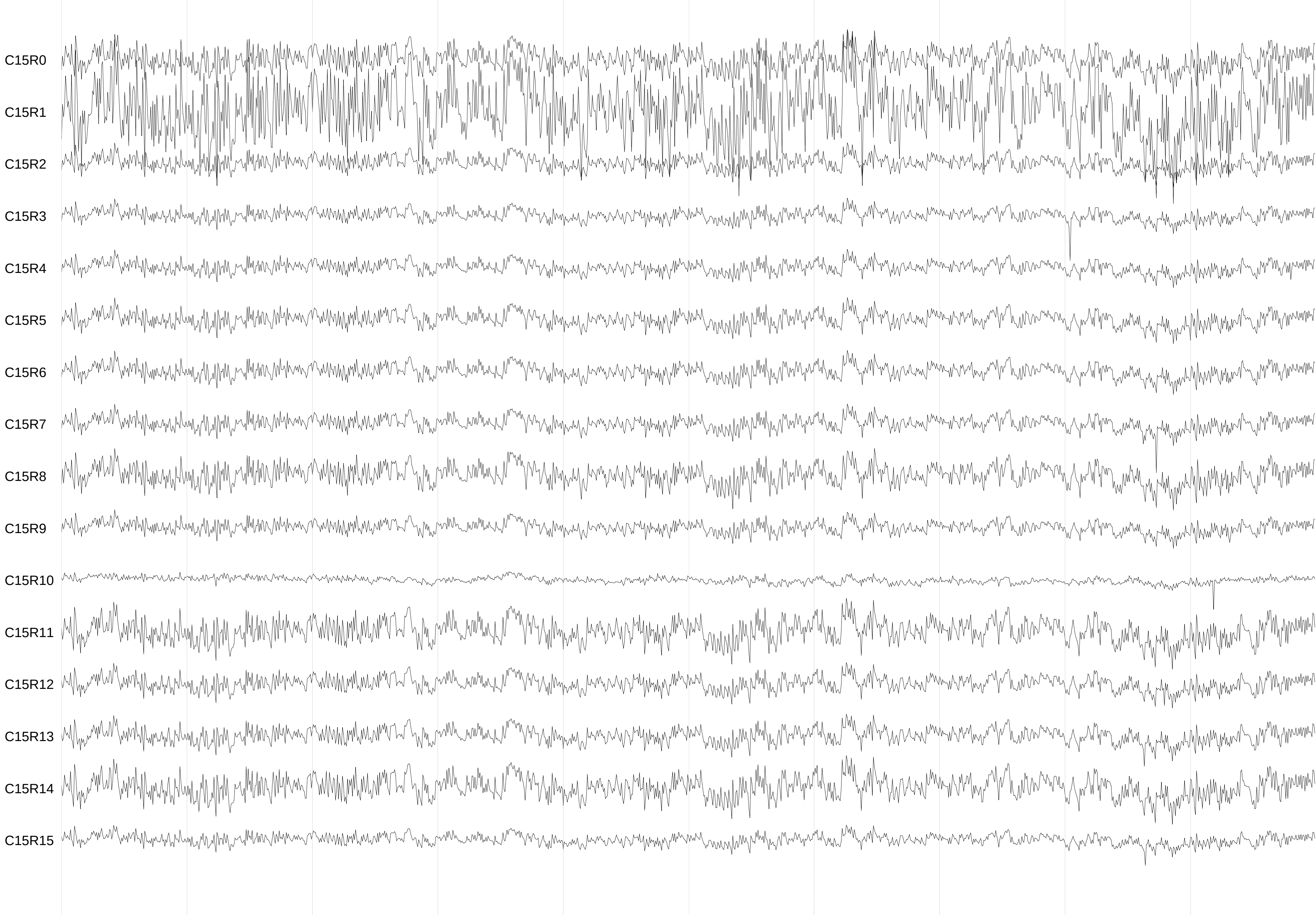

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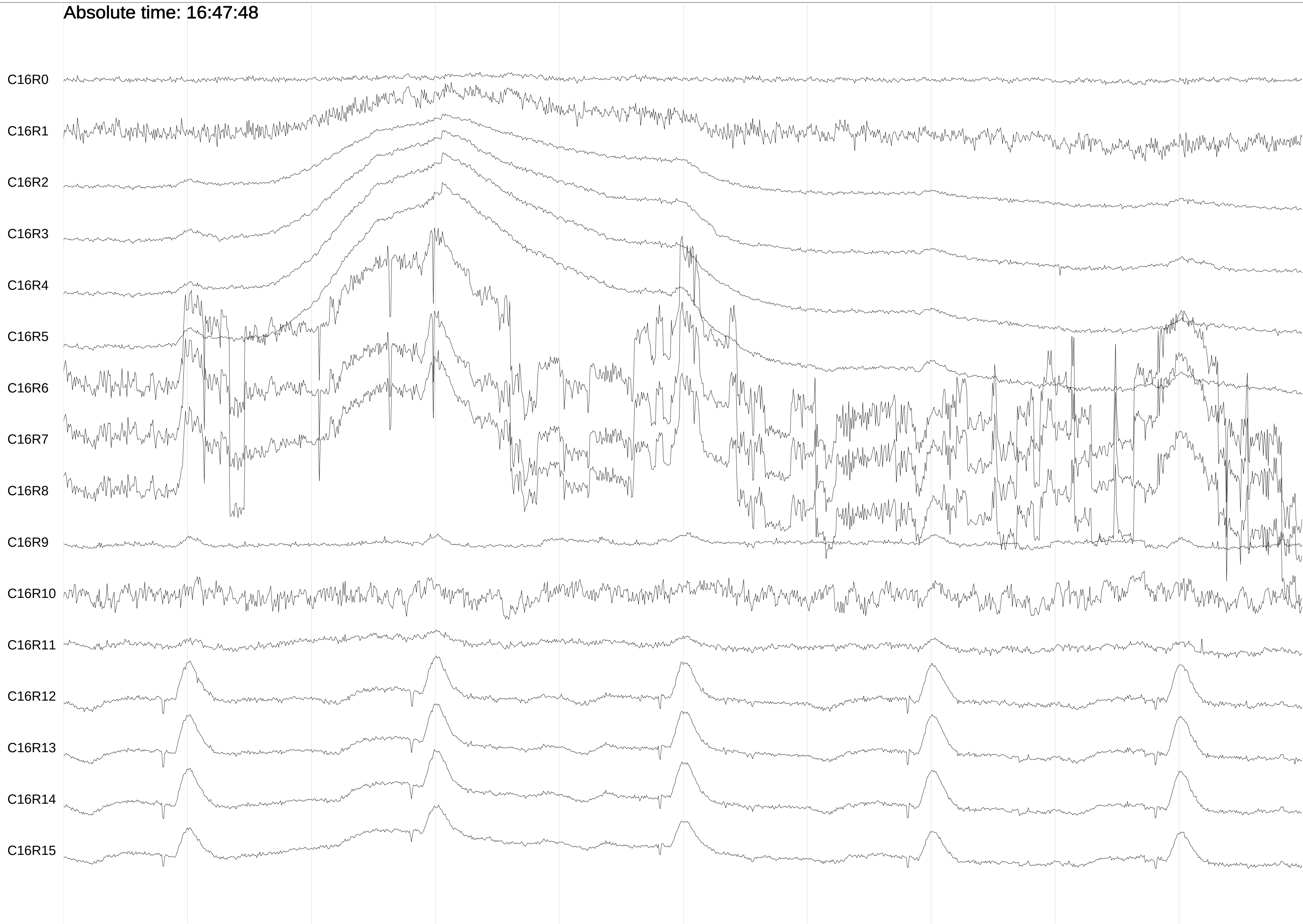
Absolute time: 16:47:48



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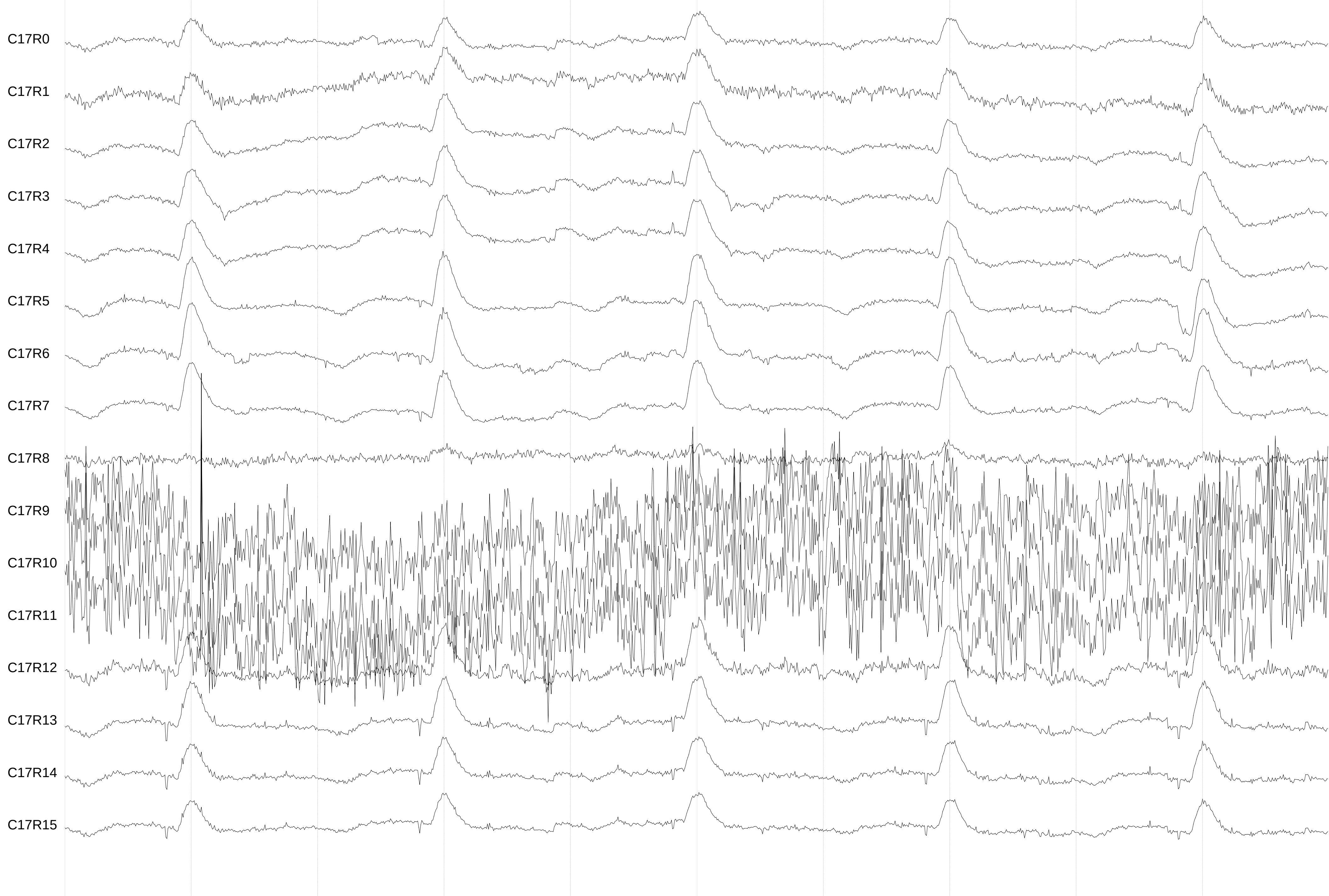
29-Apr-2009_16_45_48_p2 null 04/29/2009

Absolute time: 16:47:48



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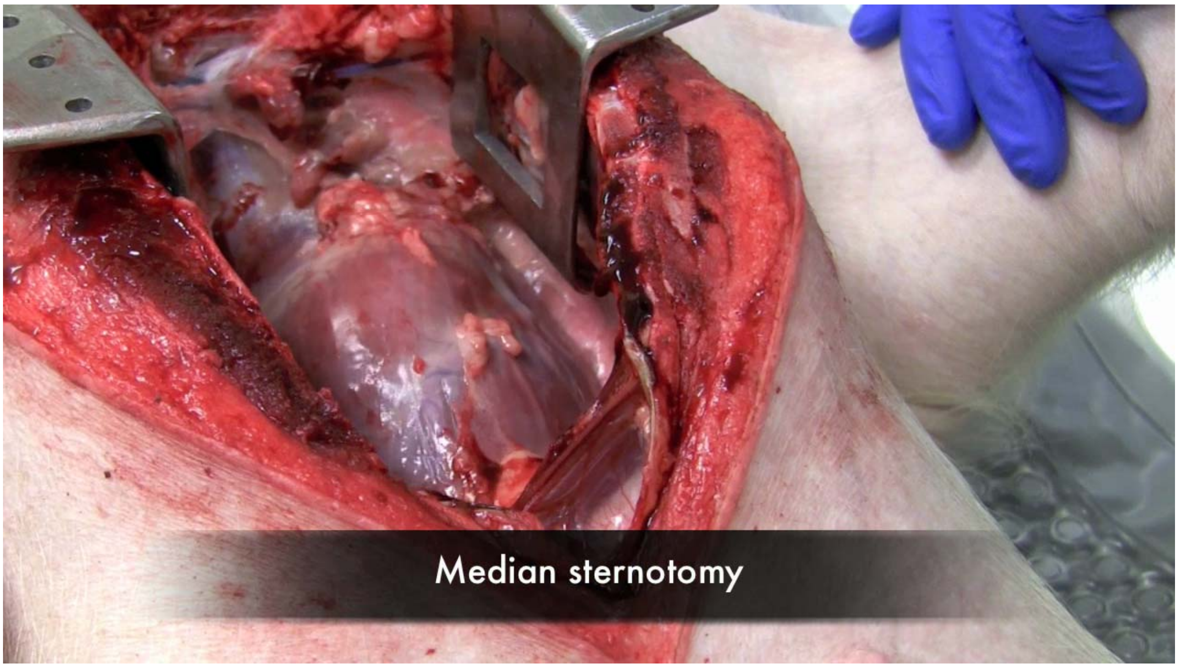
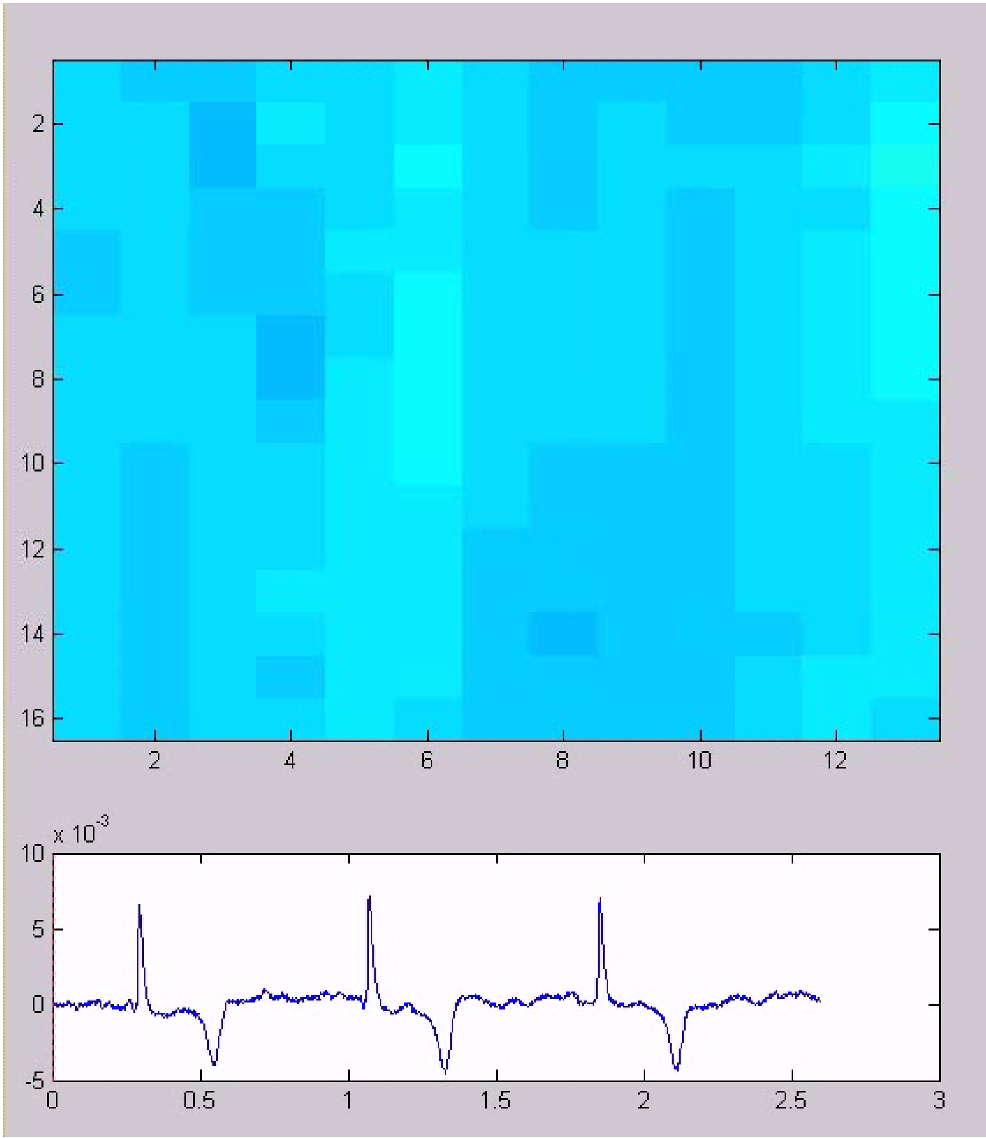
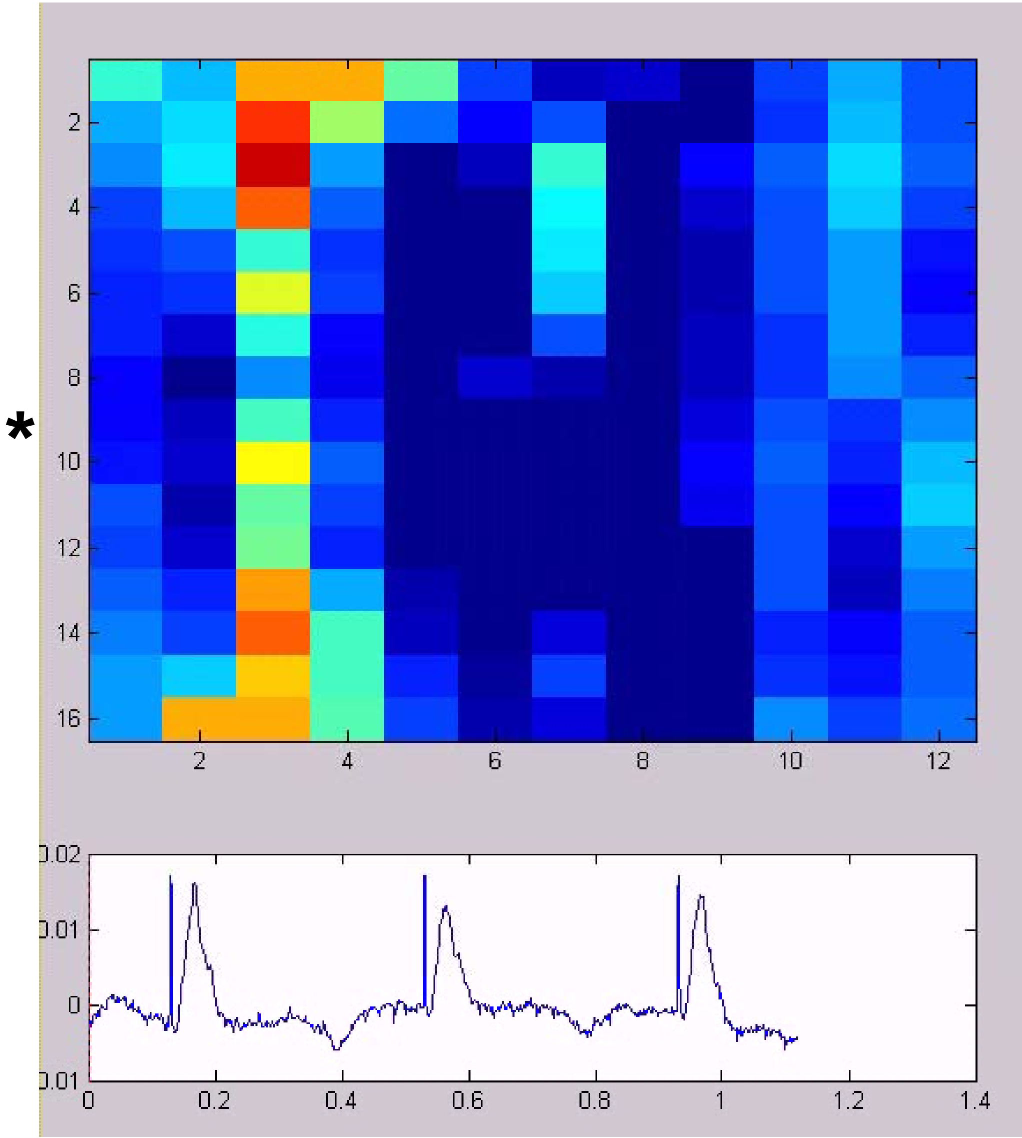


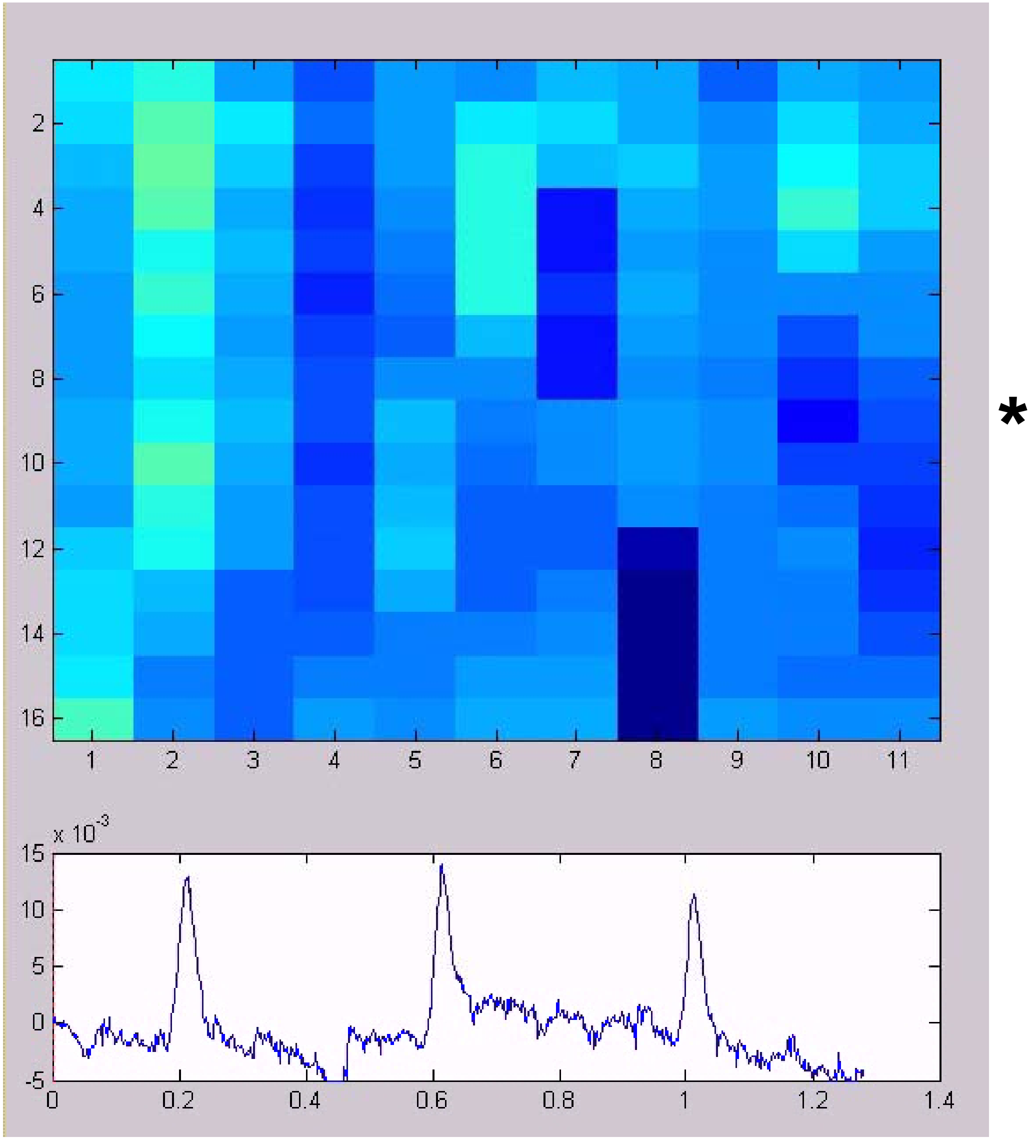
Movie M1. Animal experiment.



Movie M2. Unpaced voltage data from all electrodes illustrating the natural activation pattern of the heart. The bottom frame shows an average ECG signal composed of all of the above channels along with a guide bar to show the current position in the voltage trace. 4 frames from this movie are presented in Fig. 4B.



Movie M3. Voltage data from all electrodes illustrating the paced activation pattern of the heart moving from the left side of the array to the right side. The asterisk (*) indicates the relative position of the pacing electrode. The bottom frame shows an average ECG signal composed of all of the above channels along with a guide bar to show the current position in the voltage trace. Data from this interval in the recording were processed to create the isochronal map shown in the left frame of Fig. 4E.



Movie M4. Voltage data from all electrodes illustrating the paced activation pattern of the heart moving from the right side of the array to the left side. The asterisk (*) indicates the relative position of the pacing electrode. The bottom frame shows an average ECG signal composed of all of the above channels along with a guide bar to show the current position in the voltage trace. Data from this interval in the recording were processed to create the isochronal map shown in the right frame of Fig. 4E. Four frames from this movie are presented in Fig. S14.