

*GRID 2023*

Distributed modular platform for working with neurocognitive  
experiments data  
(MRI/fMRI)

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# TOPIC OF REPORT

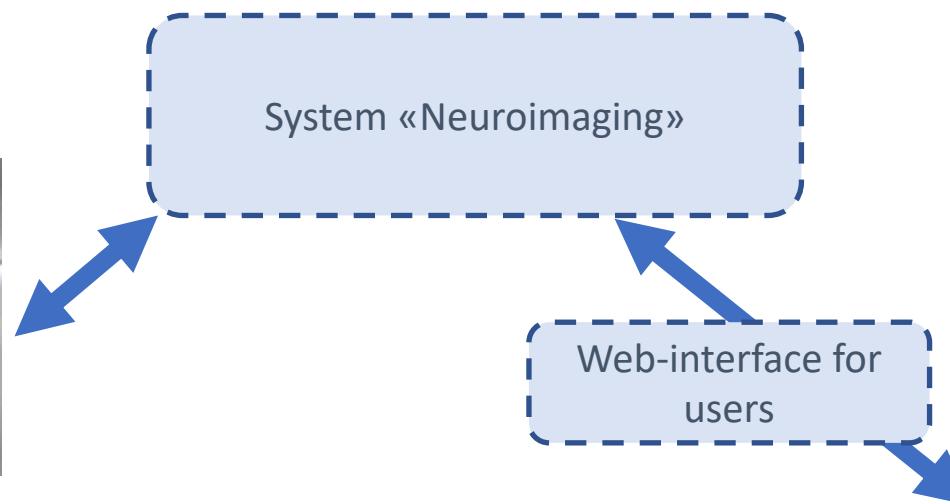
This report presented the project of [Digital Lab Platform](#) implementation to organize storage, processing and analysis of neurocognitive data (MRI, fMRI), obtained at Kurchatov Institute Resource Center of Nuclear Physical Research Methods "Cognimed". To this goal was created a new Digital Lab module - [System "Neuroimaging"](#). System "Neuroimaging" allows to organize the interaction between the [Resource Center «Cognimed»](#), the Computer Center [Complex for Simulation and Data Processing](#) and the [scientists](#) at the Kurchatov Institute (Moscow).



Supercomputer NRC KI



Resource Center



Researches

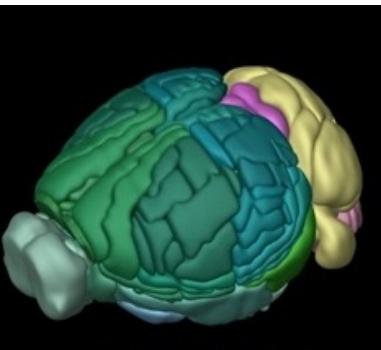




# Scientific field Neuroimaging

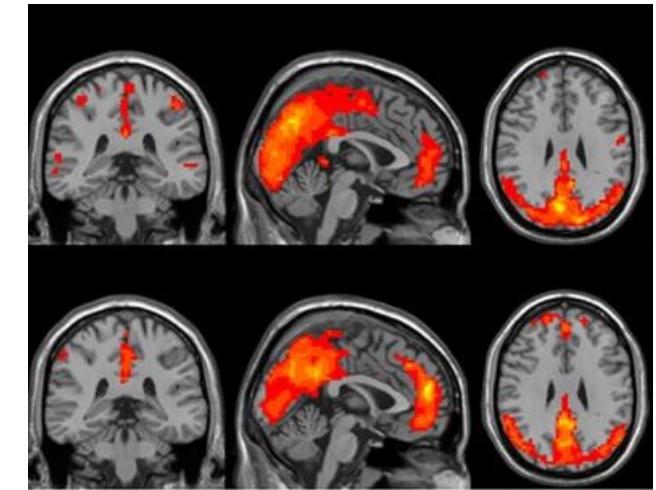
**MRI (anatomical structure)**

human

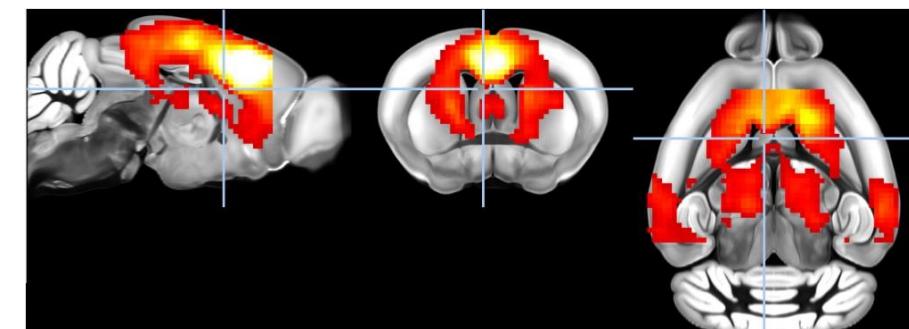


**fMRI (neuron's functional connectivity)**

human

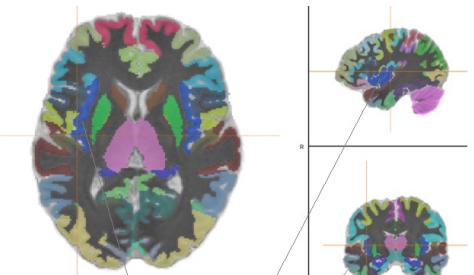
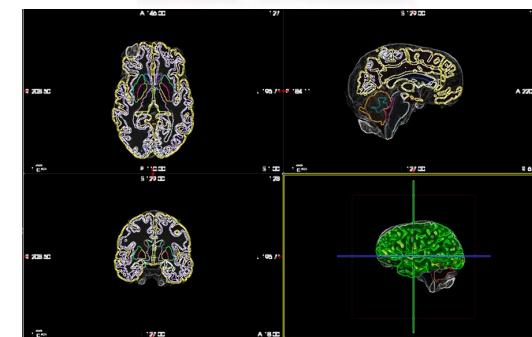
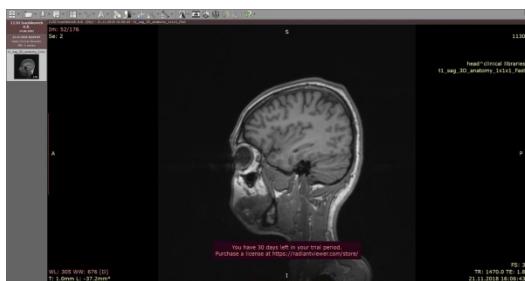
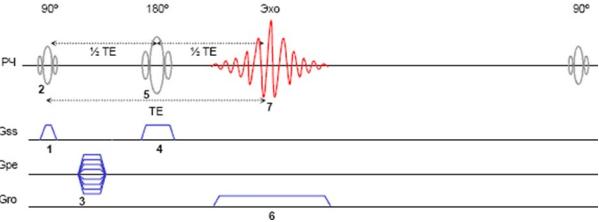
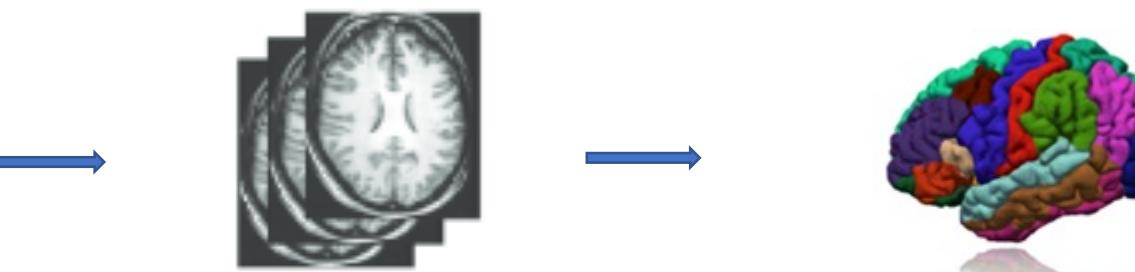
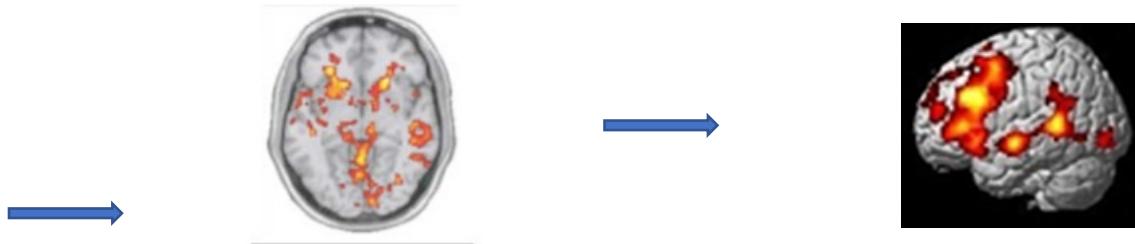


mouse





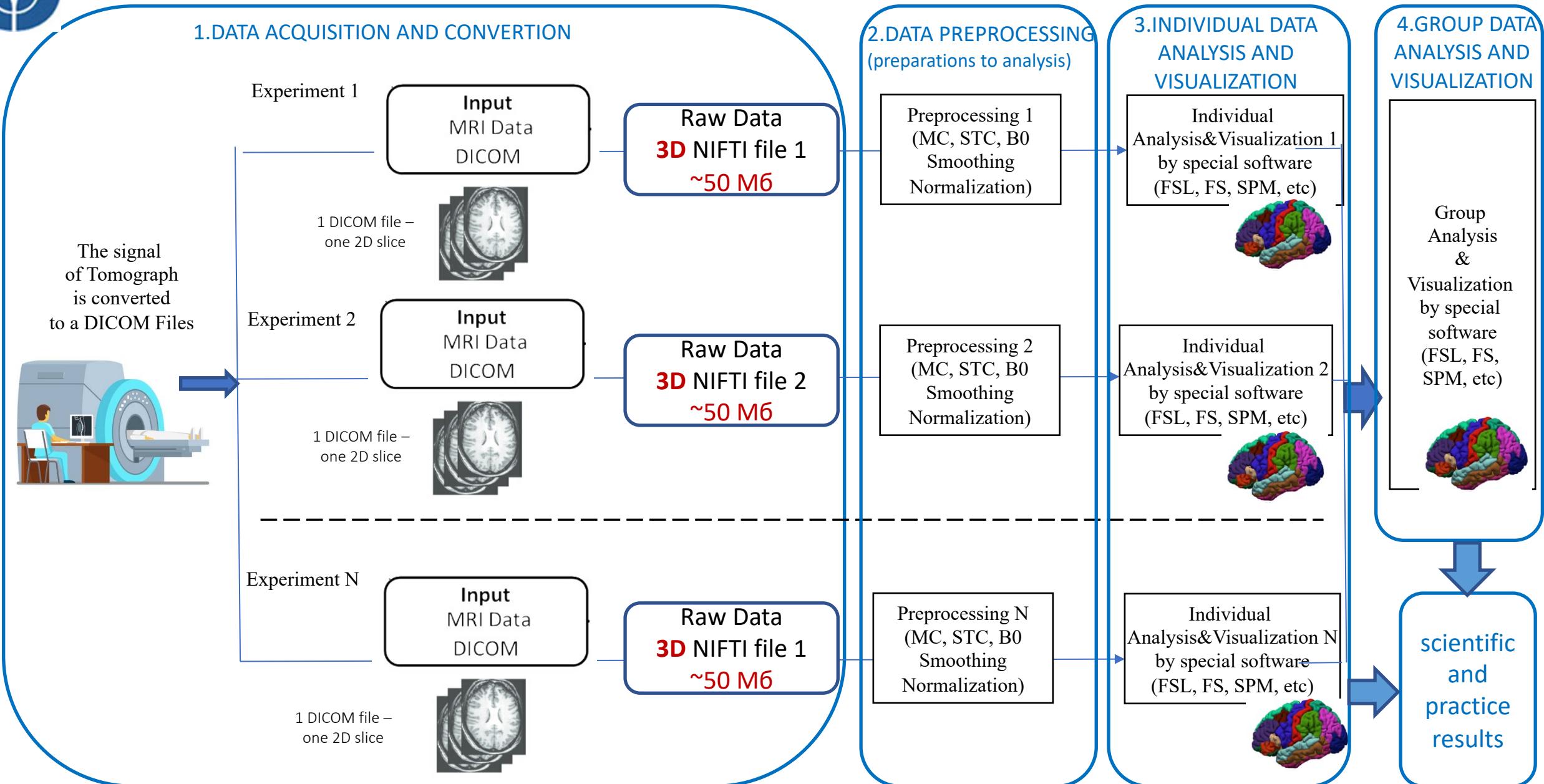
# MRI/fMRI experiments



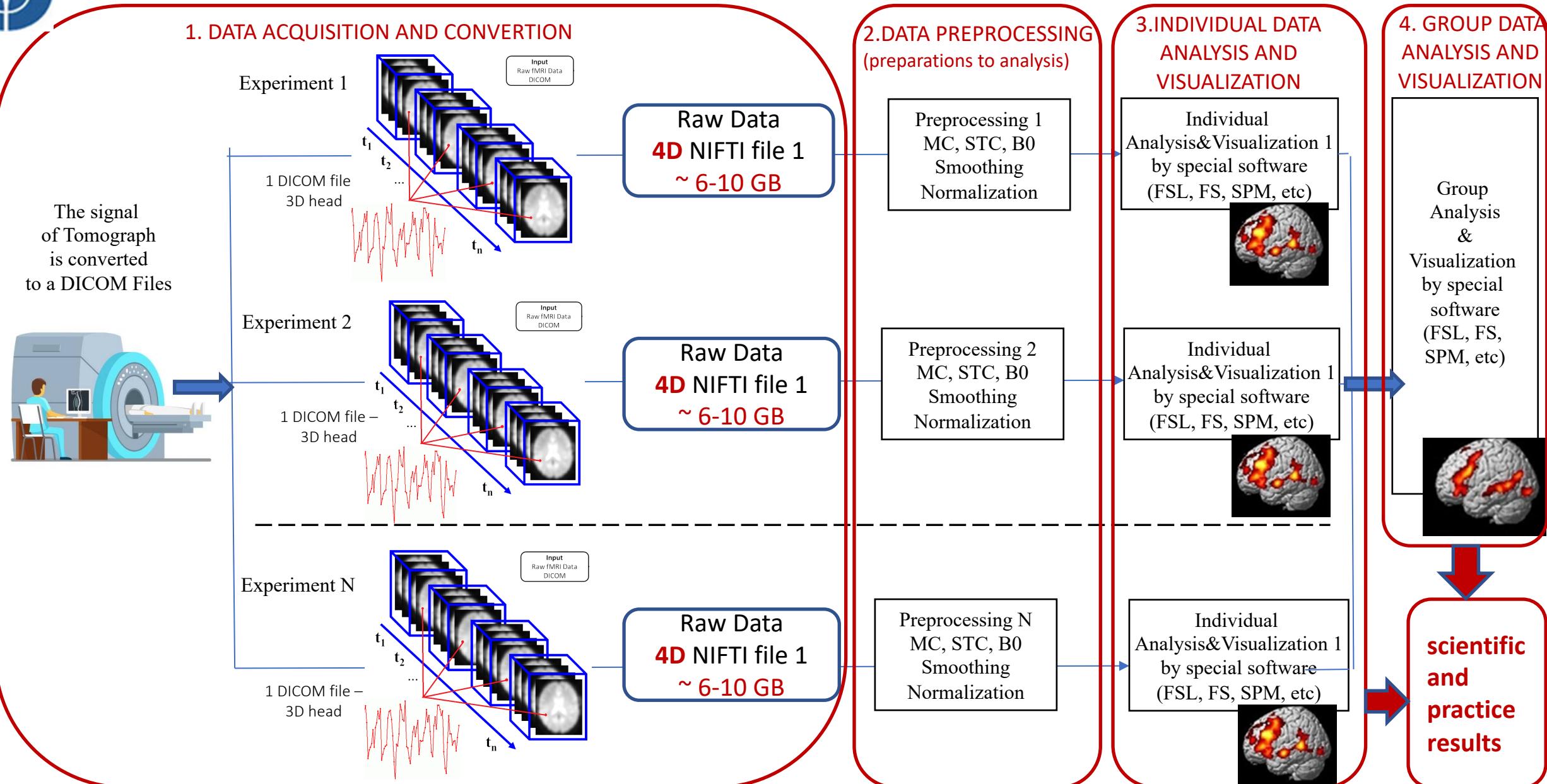
Index	Seed	Vertices	Volume mm <sup>3</sup>	Structures	normDev	normRel	normAbs	normRange	
1	2	12014	12894.4	Left-Cerebellum-White-Matter	88.0657	11.4736	0.0216	86.0000-84.0000	
2	472	512.4	42076.3	Left-Lat-Vent	42.1737	13.6481	0.0000	103.0000-67.0000	
3	23245	4027.4	49.8703	Left-Cerebellum-Cortex	65.8608	10.4574	0.0000	13.0000-99.0000	
4	116550	12290.4	65.8608	Left-Temporal-Insul	65.8608	10.4574	0.0000	13.0000-99.0000	
5	7	3559	3538.4	Left-Caudate	70.6569	7.7235	0.0000	104.0000-68.0000	
6	12	4302.3	90.1354	Left-Putamen	101.3672	8.8674	0.0000	105.0000-49.0000	
7	13	16441	1889.9	Left-Pallium	101.3672	8.8674	0.0000	105.0000-49.0000	
8	14	7521	1693.3	Left-Ventric	27.4703	11.6498	0.0000	85.0000-79.0000	
9	15	1046	1757.2	4th-Ventric	27.4053	11.6211	0.0000	72.0000-66.0000	
10	16	1946	18205.1	Brain-Stem	80.9356	9.4637	0.0000	117.0000-110.0000	
11	17	1046	1757.2	Left-Hippocampus	62.7164	9.0253	0.0000	82.0000-75.0000	
12	18	5487	1427.1	Left-Amygdala	71.8114	9.0790	0.0000	96.0000-46.0000	
13	19	1483	1380.3	CSF	38.7013	14.0183	0.0000	99.0000-92.0000	
14	20	219	337.1	Left-Accumbens-area	77.4463	6.6665	0.0000	49.0000-37.0000	
15	21	219	2104.1	Left-Hippocamp	63.0000	11.2238	0.0000	38.0000-30.0000	
16	22	5	12.2	Left-ventri	65.2000	6.4962	0.0000	76.0000-15.0000	
17	23	754	707.0	Left-chord-plexus	51.4515	12.2652	0.0000	83.0000-68.0000	
18	24	15170	13387.7	Right-Lateral-Ventric	20.0009	11.8744	0.0000	95.0000-89.0000	
19	25	29	41.5	Right-Choroid-Plexus	42.0000	12.5358	0.0000	103.0000-93.0000	
20	26	1057	11683.9	Right-Cerebellum-White-Matter	86.0983	5.6876	0.0000	102.0000-83.0000	
21	27	41983	415217.0	Right-Cerebellum-Cortex	60.0447	10.8931	0.0000	99.0000-84.0000	
22	28	570	84315.5	Right-Thalamus	97.4746	10.3499	0.0000	103.0000-95.0000	
23	29	573	38912.1	Right-Caudate	70.7816	3.1798	0.0000	100.0000-69.0000	
24	30	51	4255	4211.1	Right-Putamen	97.0845	5.9195	0.0000	105.0000-38.0000
25	31	262	1810.9	Right-Pallium	99.3829	4.2403	0.0000	115.0000-47.0000	
26	32	262	1820.9	Right-Hippocamp	68.0000	7.2059	0.0000	38.0000-30.0000	
27	33	1498	1466.5	Right-Amygdala	71.0635	5.6964	0.0000	97.0000-44.0000	
28	34	502	412.1	Right-Accumbens-area	79.0887	5.3949	0.0000	98.0000-46.0000	
29	35	603	3304.8	Right-VentralDG	88.0114	29.0000	0.0000	112.0000-63.0000	
30	36	41	5	Right-Choroid-Plexus	52.0000	10.9793	0.0000	103.0000-56.0000	
31	37	345	124.8	Right-chondro-plexus	46.7423	11.4763	0.0000	21.0000-77.0000	
32	38	72	0.0	5th-Ventric	0.0000	0.0000	0.0000	0.0000-0.0000	
33	39	77	909	742.5	VM-hypointeridies	67.5669	10.5278	0.0000	101.0000-73.0000
34	40	262	1820.9	Left-Choroid-Plexus	2.0000	0.0000	0.0000	0.0000-0.0000	
35	41	79	0.0	Right-VM-hypointeridies	0.0000	0.0000	0.0000	0.0000-0.0000	
36	42	50	0.0	Left-VM-hypointeridies	0.0000	0.0000	0.0000	0.0000-0.0000	
37	43	50	0.0	Right-non-VM-hypointeridies	0.0000	0.0000	0.0000	0.0000-0.0000	
38	44	50	0.0	Left-non-VM-hypointeridies	0.0000	0.0000	0.0000	0.0000-0.0000	
39	45	126	124.8	Optic-Chiasm	75.3810	17.5981	0.0000	37.0000-69.0000	
40	46	121	1042.9	CC_Posterior	101.8186	15.8008	0.0000	123.0000-81.0000	
41	47	111	404.5	CC_Mid	93.0000	12.0935	0.0000	103.0000-61.0000	
42	48	403	403.5	CC_Central	94.5052	10.8743	0.0000	114.0000-81.0000	
43	49	471	405.5	CC_Mid_Anterior	94.7626	17.7985	0.0000	72.0000-41.0000	
44	50	538	417.5	CC_Anterior	101.4512	15.7948	0.0000	140.0000-129.0000	
45	51	1098	1001.3						



# Processing and analyzing MRI data



# Processing and analyzing fMRI data (needs much more resources than for MRI)

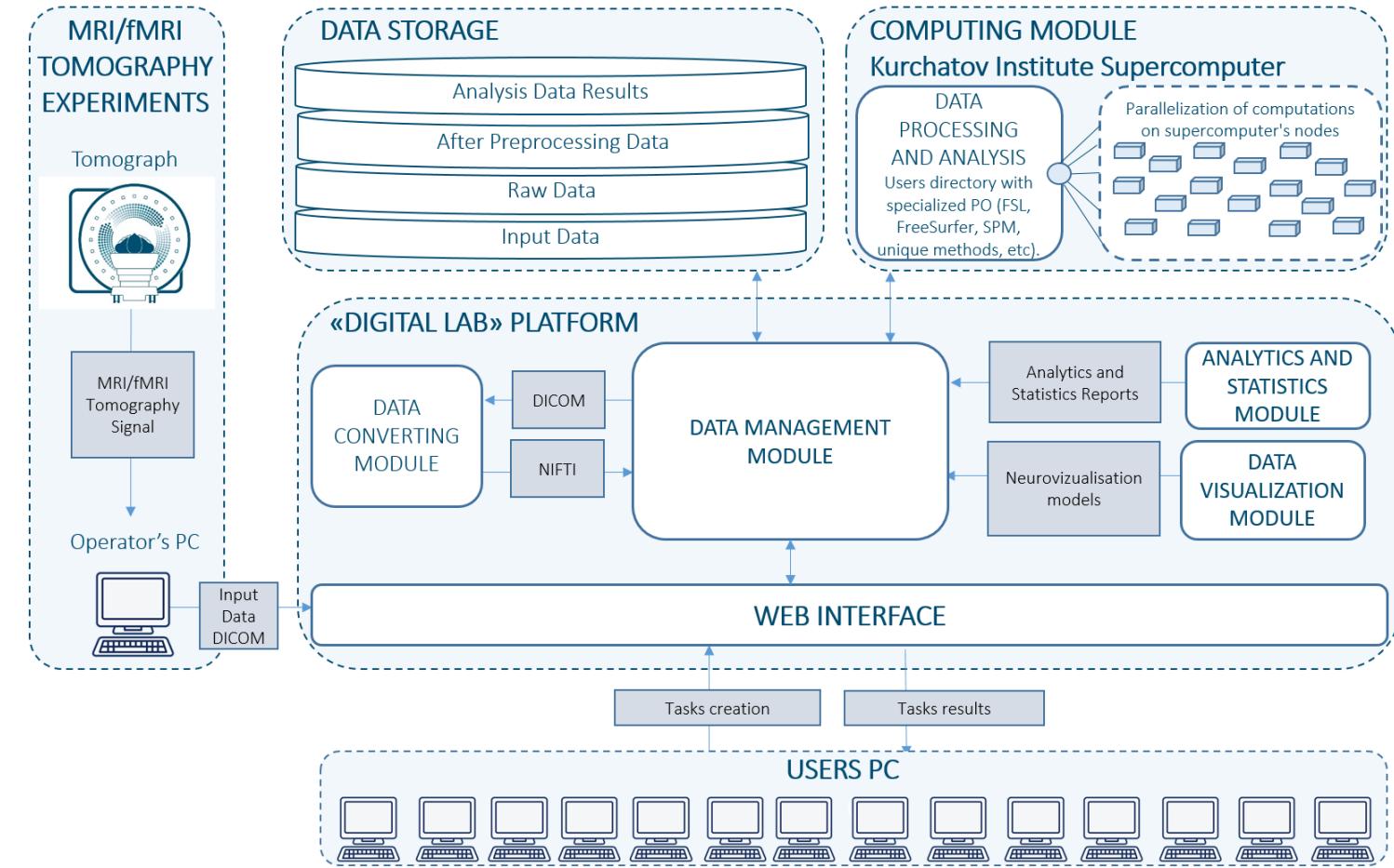




# System «Neuroimaging» Architecture

The System «NEUROIMAGING» has the following structure:

1. **Data Storage**: Unified storage of data and results of their processing and analysis.
2. **Computing Module**: Data processing and analysis using specialized software (standard tools (FreeSurfer, FSL, SPM, etc.) and own developed by Kurchatov Institute researchers tools (unique methods for rest-fMRI, etc.). Parallelization of calculations on supercomputer's nodes.
3. **Analytics and Statistic Module**: Data group's formation by set of parameters; analytics and statistic reports generated.
4. **Data Visualization Module**: Creating the models of data neuroimaging with Viewer Editors (FreeView, etc.).
5. **Data Management Module**: Organizes the exchange of data between Web Portal, Data Storage, Computing Module and other modules of System.
6. **Web interface**: Organization of System interaction with external devices (Tomograph operator's PC, User's PC of medical and scientific organizations, etc.).





# System «Neuroimaging» Web-interface

The image displays five screenshots of the 'System «Neuroimaging» Web-interface' showing various features:

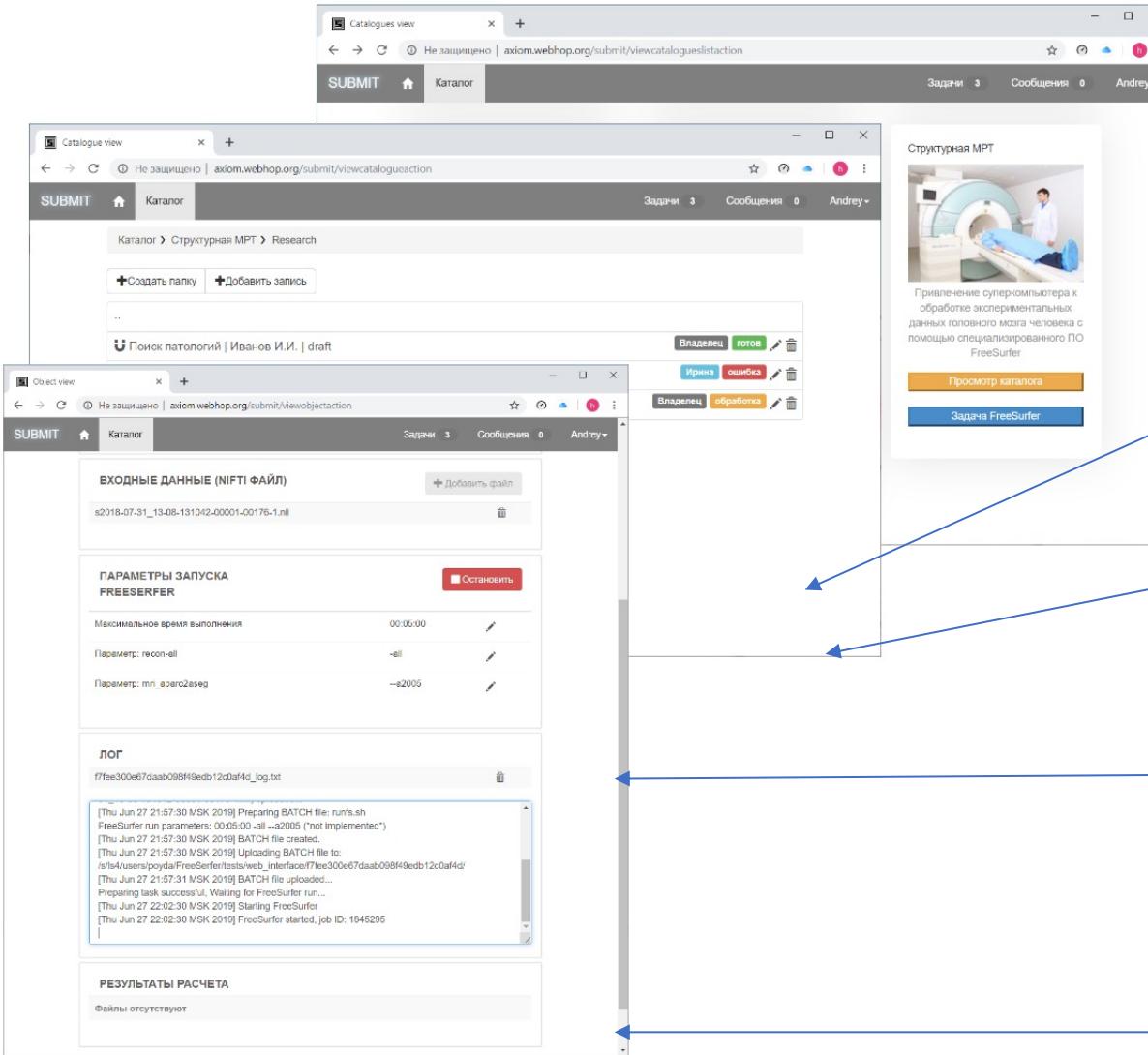
- Catalogues view:** Shows a list of catalog items. One item, 'Структурная МРТ', is highlighted. It includes a thumbnail of an MRI machine, a brief description about using a supercomputer to process experimental brain data, and three buttons: 'Просмотр каталога' (Catalog View), 'Задача FreeSurfer' (Task FreeSurfer), and 'Задача FSL' (Task FSL).
- Catalogue view:** Shows a detailed view of the 'threads test' entry for 'Patient 34'. It includes sections for 'Входные данные' (Input Data) and 'Результаты расчета' (Calculation Results). The 'ДАННЫЕ ПАЦИЕНТА' (Patient Data) section shows: ФИО (patient 34), Пол (Женский), Возраст (43), Идентификатор эксперимента на МРТ (13657), and Дата проведения МРТ (2020-08-27). The 'DICOM ФАЙЛЫ' (DICOM Files) section shows: '+ Добавить файл' (Add file) and 'Файлы отсутствуют' (No files available).
- Object view:** Shows a detailed view of the 'threads test' entry for 'Patient 34'. It includes sections for 'Входные данные' (Input Data), 'Результаты расчета' (Calculation Results), and 'Просмотр' (View). The 'Просмотр' section displays a 3D brain model with a color-coded surface map. Settings for 'SURFACE' (RIGHT HEMISPHERE selected, LEFT HEMISPHERE unselected) and 'COLOR MAP' (Spectral selected) are shown.
- Object view:** Shows a detailed view of the 'threads test' entry for 'Patient 34'. It includes sections for 'Входные данные' (Input Data), 'Результаты расчета' (Calculation Results), and 'Лог' (Log). The 'Лог' section contains a log of command-line activity related to FreeSurfer file downloads and cleaning.
- Object view:** Shows a detailed view of the 'threads test' entry for 'Patient 34'. It includes sections for 'Входные данные' (Input Data), 'Результаты расчета' (Calculation Results), and 'ASEG'. The 'ASEG' section shows a table of measurement results:

Название измерения	Измеренное значение	Единицы измерения
InSurfaceHoles	31	unitless
SubCortGray	50647	mm <sup>-3</sup>



# System «Neuroimaging»

## Algorithm for users



Step 1 Log in to the portal

Step 2 Create new patient record

Step 3 Attach MRI/fMRI data (DICOM files or NIFTI file).

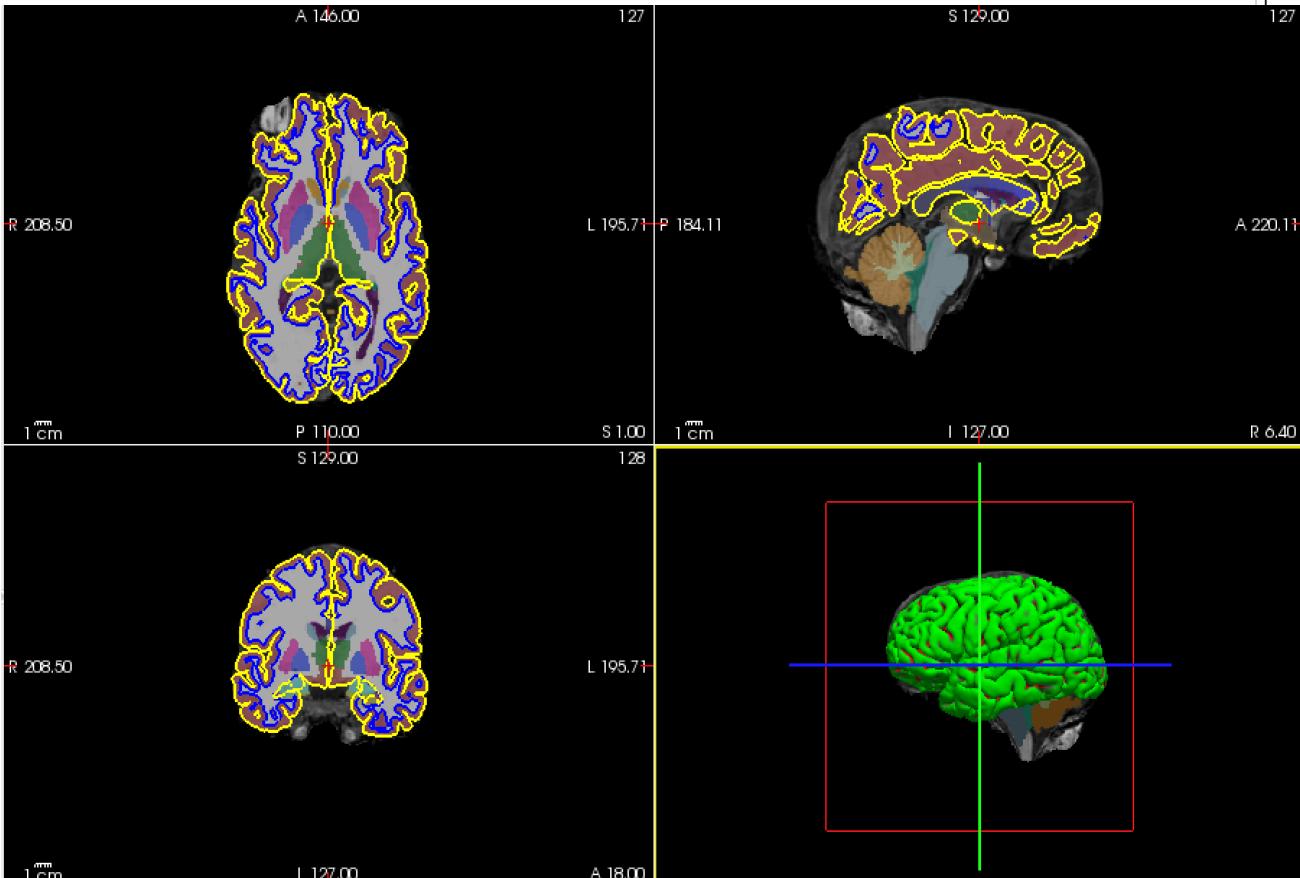
Step 4 Start task by pressing «Start» button

Step 5 Waiting of results  
(interactive log is provided for job status monitoring)

Step 6 Download .rar file with results



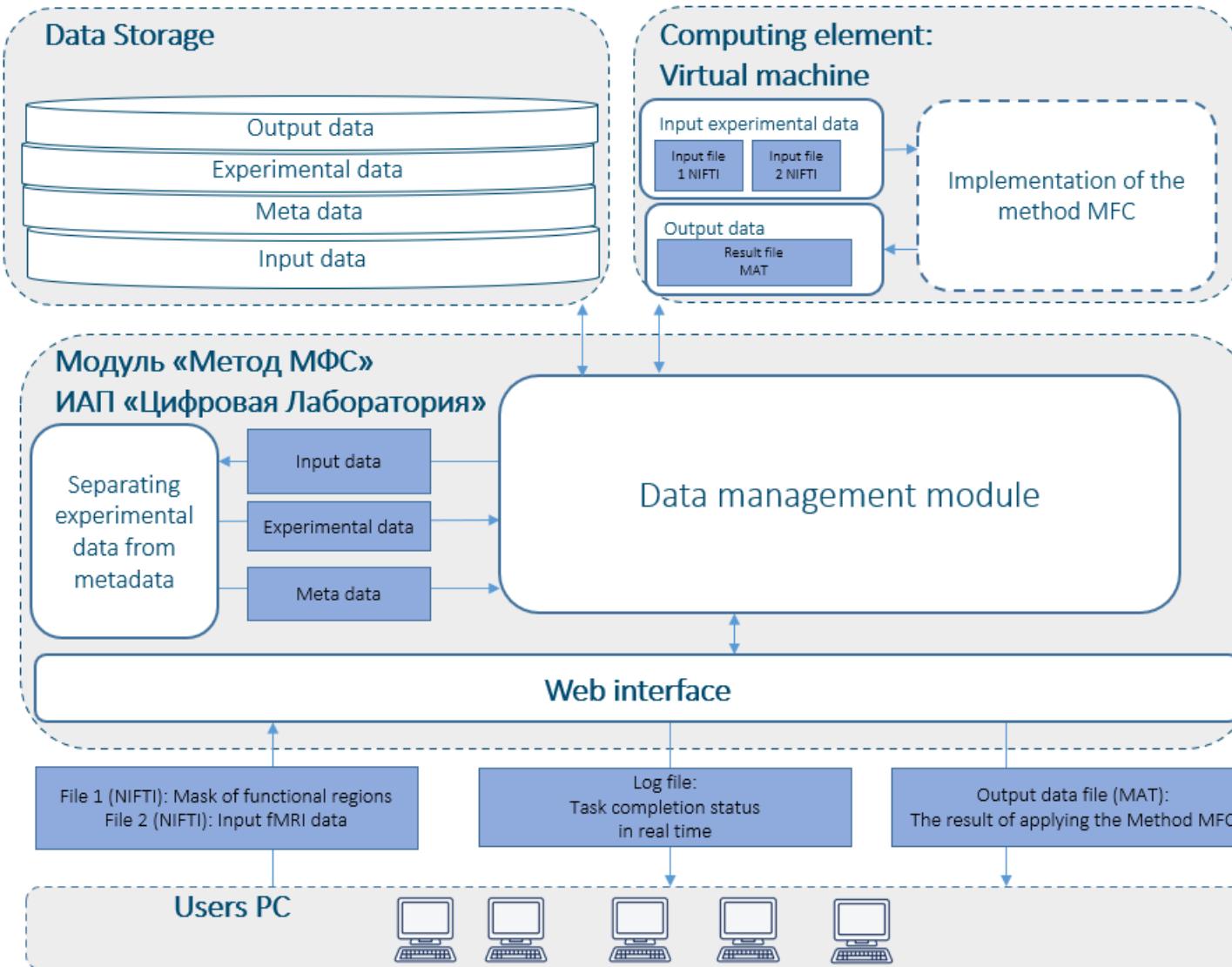
# System «Neuroimaging»: visualization of results



Index	SegId	NVoxels	Volume_m	StructName	normMean	normStdDev	normMin	normMax	normRange
1	4	7599	7932.7	Left-Lateral-Ventrie	40.7429	11.2806	24.0000	85.0000	61.0000
5	123	158.8	158.8	Left-Inf-Lat-Vent	60.1870	11.4529	34.0000	77.0000	43.0000
7	13139	13847.6	13847.6	Left-Cerebellum-White-Matter	93.6948	6.8365	26.0000	110.0000	84.0000
8	58137	57884.6	57884.6	Left-Cerebellum-Cortex	72.9654	10.7339	27.0000	103.0000	76.0000
10	7686	7403.2	7403.2	Left-Thalamus-Proper	93.7050	9.3486	38.0000	114.0000	76.0000
11	2935	2928.3	2928.3	Left-Caudate	83.8589	6.6515	56.0000	106.0000	50.0000
12	3669	3802.0	3802.0	Left-Putamen	92.9635	4.6146	71.0000	107.0000	36.0000
13	1973	1922.4	1922.4	Left-Pallidum	104.0862	4.7881	73.0000	115.0000	42.0000
14	1046	1141.9	1141.9	3rd-Ventricle	42.1080	10.7543	24.0000	89.0000	65.0000
15	2274	2383.5	2383.5	4th-Ventricle	37.0954	10.9126	16.0000	76.0000	60.0000
16	20597	20259.8	20259.8	Brain-Stem	82.7575	10.1114	29.0000	110.0000	81.0000
17	3630	3475.5	3475.5	Left-Hippocampus	78.7689	7.3033	35.0000	107.0000	72.0000
18	1064	1027.9	1027.9	Left-Amygdala	80.1194	5.6961	56.0000	97.0000	41.0000
24	1164	1126.2	1126.2	CSF	54.8763	13.8059	29.0000	107.0000	78.0000
26	261	253.6	253.6	Left-Accumbens-area	82.7203	6.0462	54.0000	97.0000	43.0000
28	3784	3492.6	3492.6	Left-VentralDC	93.4199	11.8571	34.0000	117.0000	83.0000
30	0	0.0	0.0	Left-vessel	0.0000	0.0000	0.0000	0.0000	0.0000
31	276	244.4	244.4	Left-choroid-plexus	53.8841	12.8802	30.0000	84.0000	54.0000
43	8817	9064.1	9064.1	Right-Lateral-Ventrie	40.0640	11.0066	23.0000	87.0000	64.0000
44	215	259.2	259.2	Right-Inf-Lat-Vent	46.0000	10.4331	25.0000	77.0000	52.0000
46	12610	13420.0	13420.0	Right-Cerebellum-White-Matter	85.4273	5.8124	34.0000	105.0000	71.0000
47	58540	58361.7	58361.7	Right-Cerebellum-Cortex	69.0651	9.4873	15.0000	98.0000	83.0000
49	7026	6737.3	6737.3	Right-Thalamus-Proper	90.1658	9.0977	41.0000	112.0000	71.0000
50	3100	3035.9	3035.9	Right-Caudate	83.7655	6.9715	53.0000	104.0000	51.0000
51	4221	4225.7	4225.7	Right-Putamen	90.7197	5.0922	63.0000	106.0000	43.0000
52	1837	1813.6	1813.6	Right-Pallidum	101.4110	4.0582	75.0000	114.0000	39.0000
53	3820	3707.8	3707.8	Right-Hippocampus	76.4639	7.1124	38.0000	99.0000	61.0000
54	1506	1459.9	1459.9	Right-Amygdala	75.9515	6.1383	50.0000	94.0000	44.0000
58	334	329.1	329.1	Right-Accumbens-area	82.7964	5.1102	54.0000	97.0000	43.0000
60	3831	3535.9	3535.9	Right-VentralDC	92.7450	11.4026	31.0000	118.0000	87.0000
62	3	10.4	10.4	Right-vessel	65.6667	4.0415	62.0000	70.0000	8.0000
63	405	351.6	351.6	Right-choroid-plexus	56.4173	12.2299	28.0000	83.0000	55.0000
72	0	0.0	0.0	5th-Ventricle	0.0000	0.0000	0.0000	0.0000	0.0000
77	981	925.3	925.3	WM-hypointensities	73.1947	12.8392	33.0000	108.0000	75.0000
78	0	0.0	0.0	Left-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
79	0	0.0	0.0	Right-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
80	0	0.0	0.0	non-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
81	0	0.0	0.0	Left-non-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
82	0	0.0	0.0	Right-non-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
83	81	65.4	65.4	Optic-Chiasm	73.1481	15.4314	44.0000	116.0000	72.0000
84	251	1165	1057.7	CC_Posterior	98.6695	15.9545	38.0000	117.0000	79.0000
85	661	573.7	573.7	CC_Mid_Posterior	89.9244	15.4868	35.0000	111.0000	76.0000
86	531	462.5	462.5	CC_Central	92.8173	15.7818	41.0000	110.0000	69.0000
87	688	618.6	618.6	CC_Mid_Anterior	94.0116	15.2766	42.0000	112.0000	70.0000
88	904	856.0	856.0	CC_Anterior	103.2489	11.6222	46.0000	117.0000	71.0000



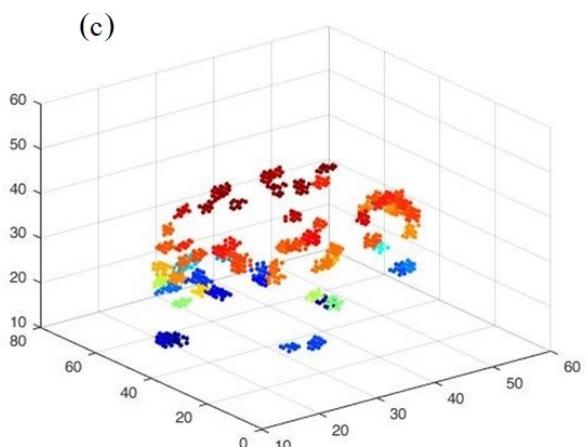
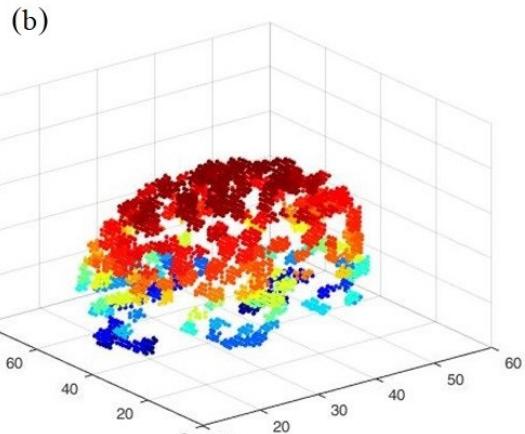
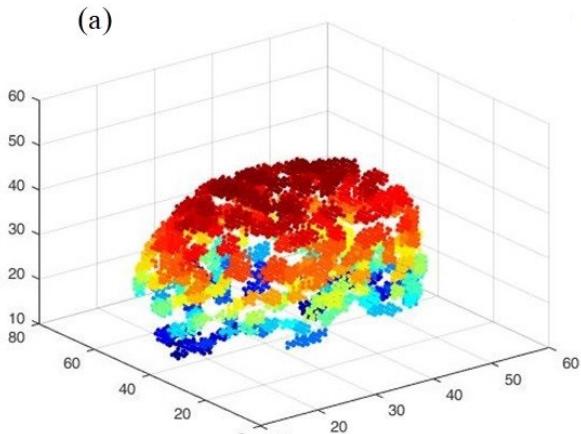
# System «Neuroimaging»: Module «Method MFC»



Automation of work with a program deployed on a virtual machine NRC KI, for implements the Method MFC for identifying homogeneous functional regions based on fMRI data analysis (the method is the author's development of the Kurchatov Institute Research Center).



# Module «Method MFC»: visualization of results



эксперимент 3

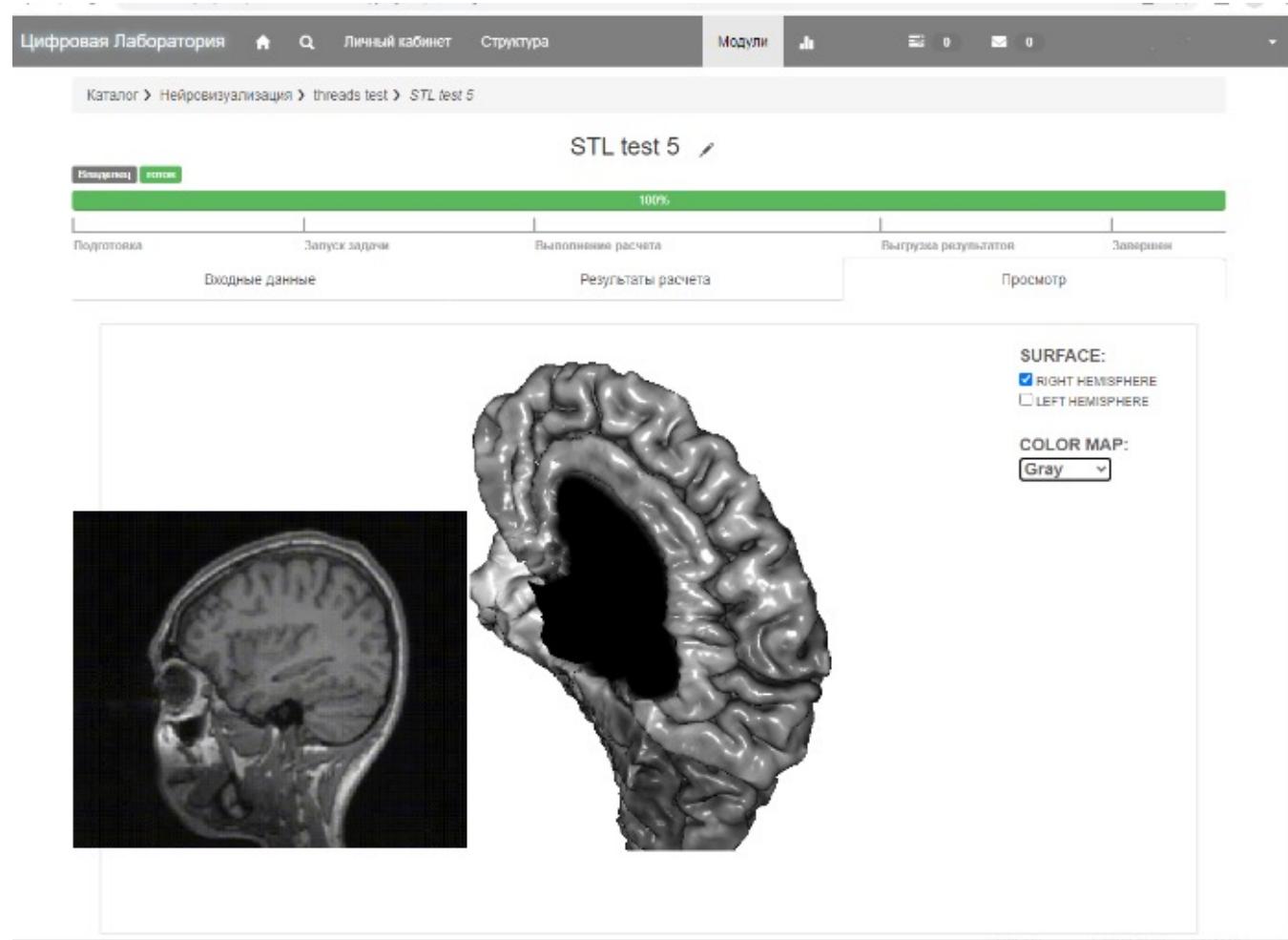
Входные и выходные данные

Визуализация

Volume type:  Panel size:

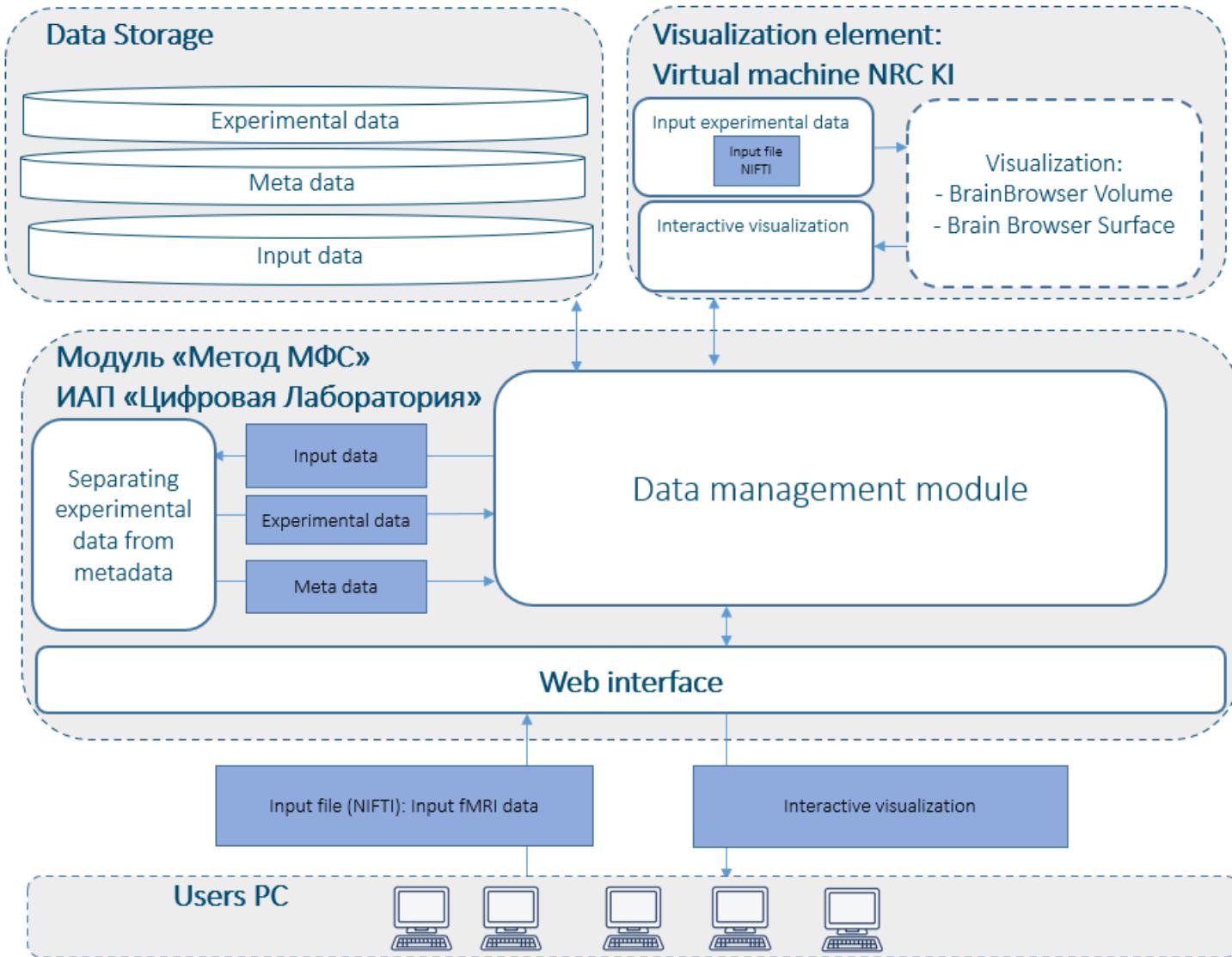


# System «Neuroimaging»: Service «Visualization DICOM»



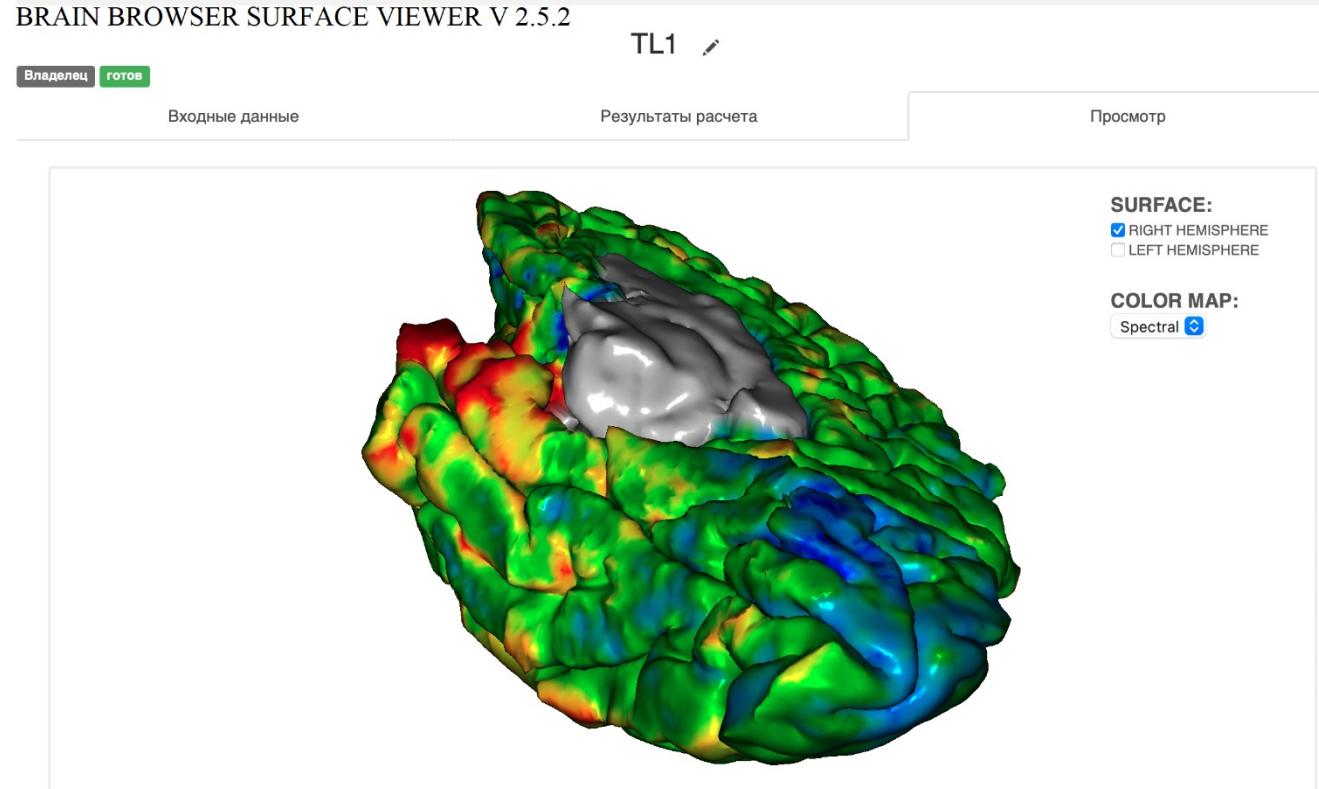


# System «Neuroimaging»: Module «Visualization BB»



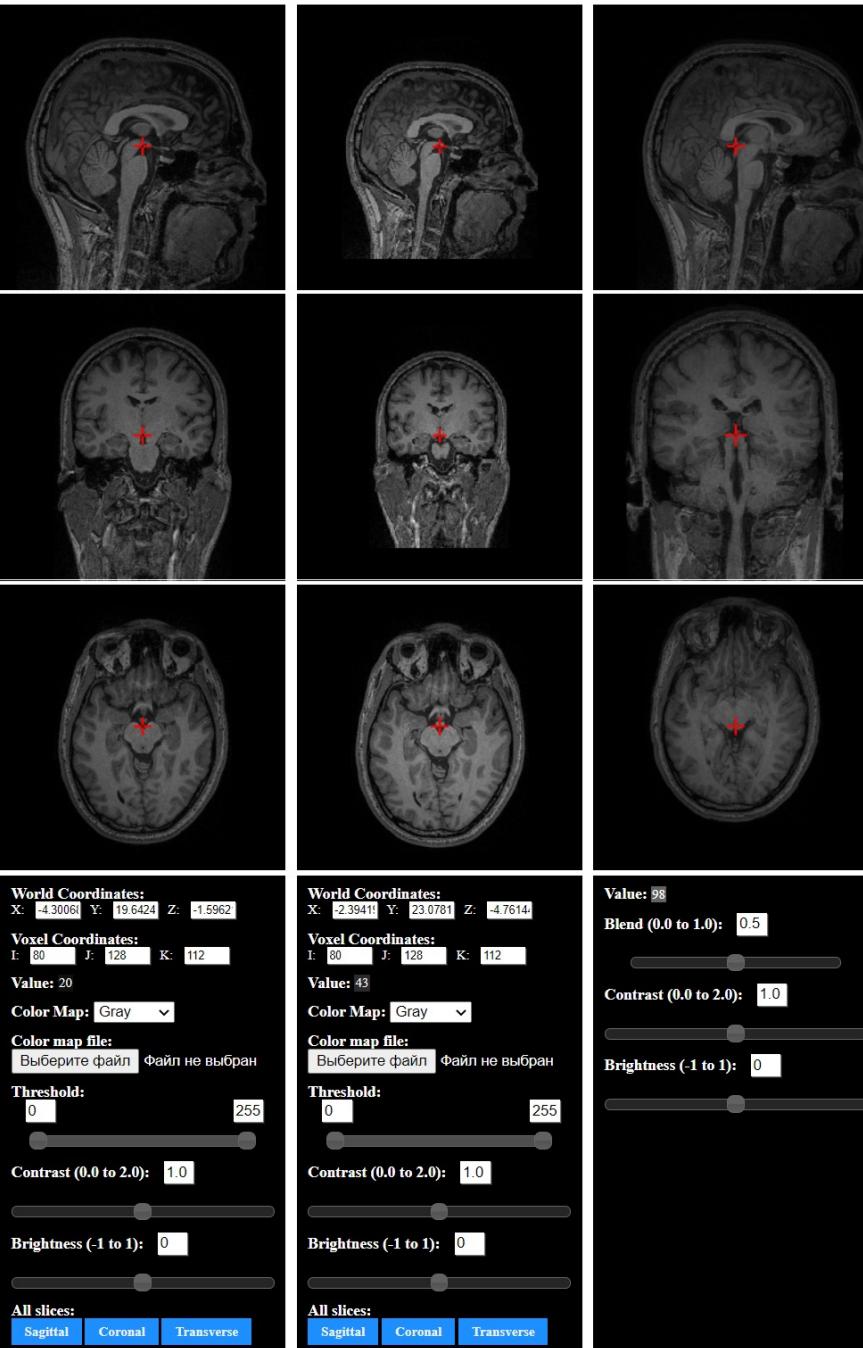


# Module «Visualization BB»: BrainBrowser Surface





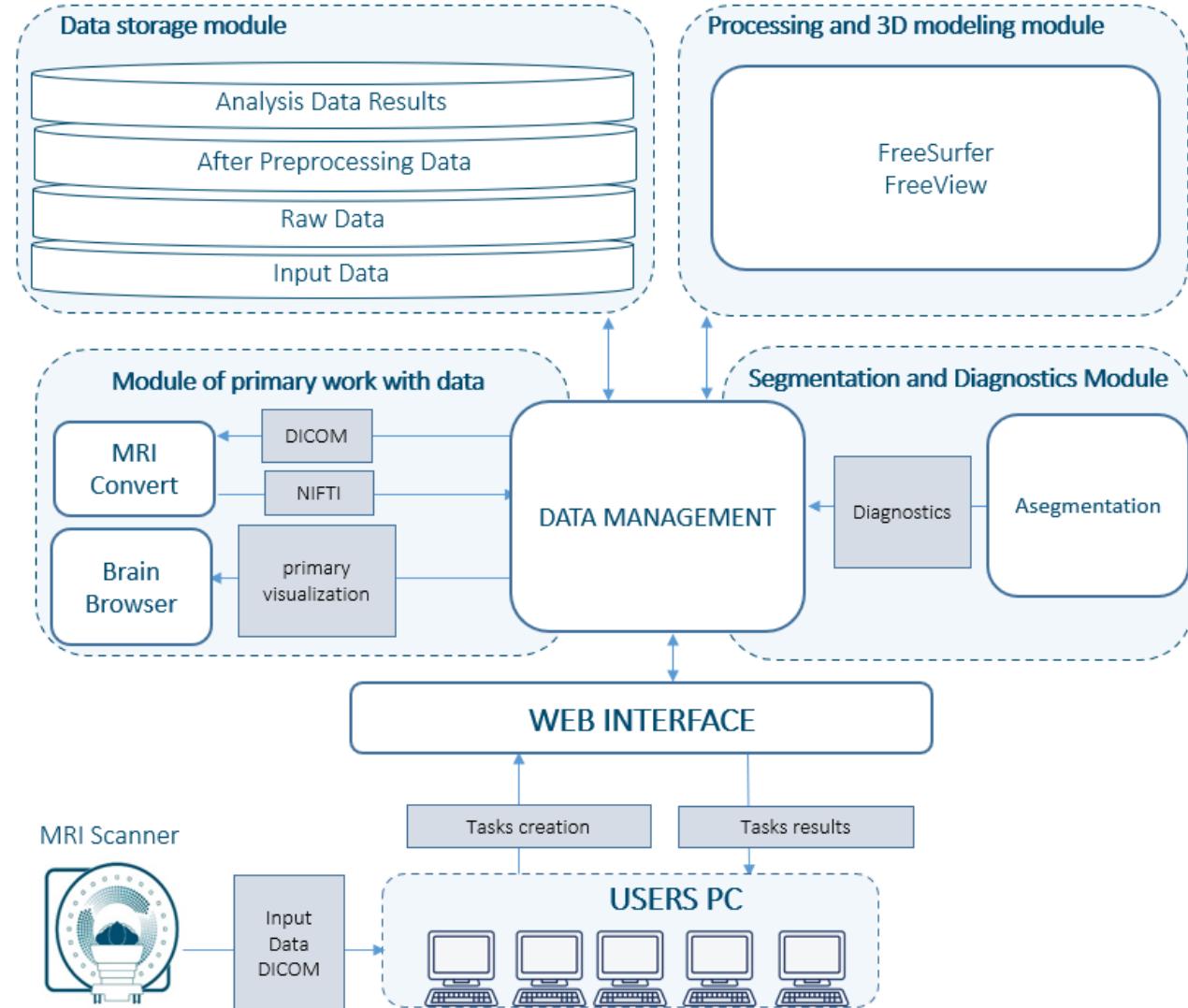
## Module «Visualization BB»: BrainBrowser Surface





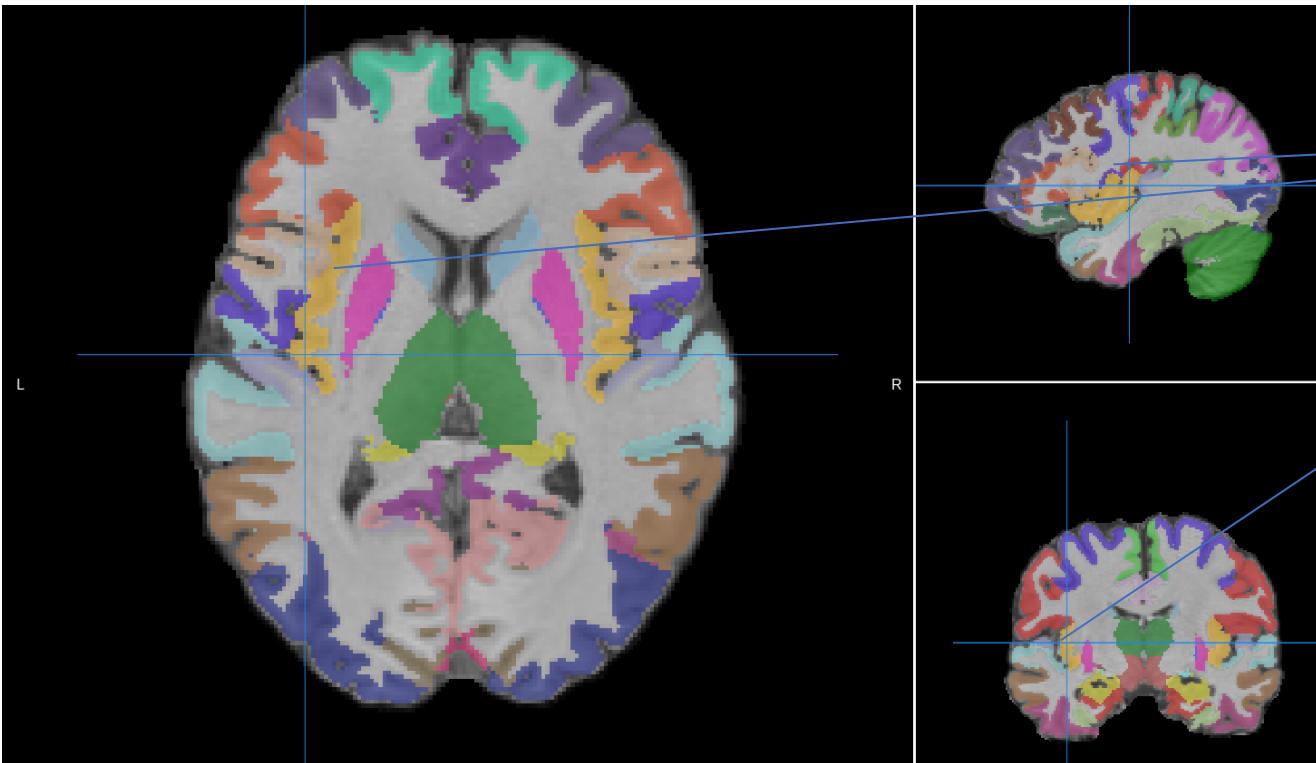
# System «Neuroimaging»: Module «Auto segmentation»

- - The module of primary work with data: loading and unloading of data; primary visualization, conversion.
- Data storage module: primary data, processing and analysis results.
- Processing and 3D modeling module: preprocessing, processing, 3D modeling, 3D visualization, manual data correction.
- Segmentation and diagnostics module: loading and analysis of the results of automatic segmentation, implementation of algorithms for the diagnosis of neurocognitive pathologies.
- User Interaction module: web interface.





# Module «Auto segmentation»



Index	SegId	NVoxels	Volume_mm3	StructName	normMean	normStdDev	normMin	normMax	normRange
1	4	12614	12894.4	Left-Lateral-Ventricle	25.3736	11.4750	1.0000	85.0000	84.0000
2	5	472	513.4	Left-Inf-Lat-Vent	42.1737	13.6481	9.0000	76.0000	67.0000
3	7	11650	12290.4	Left-Cerebellum-White-Matter	88.0567	6.0216	39.0000	103.0000	64.0000
4	8	42416	42076.3	Left-Cerebellum-Cortex	65.8808	10.4574	13.0000	99.0000	86.0000
5	10	6299	6054.6	Left-Thalamus-Proper	89.4036	9.8070	31.0000	110.0000	79.0000
6	11	3559	3538.4	Left-Caudate	79.9598	7.7291	38.0000	104.0000	66.0000
7	12	4440	4362.3	Left-Putamen	90.1354	5.8674	57.0000	106.0000	49.0000
8	13	1981	1989.2	Left-Pallidum	101.2867	4.3412	72.0000	119.0000	47.0000
9	14	1521	1609.3	3rd-Ventricle	27.4793	11.4588	6.0000	85.0000	79.0000
10	15	1646	1757.2	4th-Ventricle	27.4635	11.8721	6.0000	72.0000	66.0000
11	16	19484	19205.1	Brain-Stem	80.5536	9.4537	7.0000	117.0000	110.0000
12	17	3741	3603.6	Left-Hippocampus	69.2392	8.0353	28.0000	102.0000	74.0000
13	18	1487	1427.1	Left-Amygdala	71.8514	6.0786	50.0000	96.0000	46.0000
14	24	1483	1390.3	CSF	38.7013	14.0183	7.0000	99.0000	92.0000
15	26	319	337.1	Left-Accumbens-area	77.4483	5.6665	49.0000	87.0000	38.0000
16	28	3710	3548.4	Left-VentralDC	90.8930	11.2528	38.0000	120.0000	82.0000
17	30	5	12.2	Left-vessel	68.2000	6.4962	61.0000	76.0000	15.0000
18	31	754	707.0	Left-choroid-plexus	51.4151	12.7262	15.0000	83.0000	68.0000
19	43	13170	13387.7	Right-Lateral-Ventricle	26.0699	11.8744	5.0000	94.0000	89.0000
20	44	249	305.9	Right-Inf-Lat-Vent	40.4819	12.3938	16.0000	72.0000	56.0000
21	46	10757	11583.9	Right-Cerebellum-White-Matter	86.0363	5.6876	39.0000	102.0000	63.0000
22	47	41853	41217.0	Right-Cerebellum-Cortex	66.0447	10.3831	15.0000	99.0000	84.0000
23	49	6701	6431.5	Right-Thalamus-Proper	87.4740	10.0949	27.0000	110.0000	83.0000
24	50	3731	3681.2	Right-Caudate	79.3492	8.1789	40.0000	100.0000	60.0000
25	51	4225	4213.1	Right-Putamen	87.8845	5.9106	67.0000	105.0000	38.0000
26	52	1823	1810.9	Right-Pallidum	99.3829	4.2403	68.0000	115.0000	47.0000
27	53	3487	3409.0	Right-Hippocampus	69.9707	7.5291	29.0000	120.0000	91.0000
28	54	1486	1485.5	Right-Amygdala	71.0935	5.6994	43.0000	87.0000	44.0000
29	58	462	442.1	Right-Accumbens-area	79.0887	5.3949	52.0000	98.0000	46.0000
30	60	3539	3304.8	Right-VentralDC	88.1164	11.7193	29.0000	112.0000	83.0000
31	62	36	44.5	Right-vessel	52.9167	10.9763	30.0000	68.0000	38.0000
32	63	815	735.2	Right-choroid-plexus	46.7423	11.7483	21.0000	77.0000	56.0000
33	72	0	0.0	5th-Ventricle	0.0000	0.0000	0.0000	0.0000	0.0000
34	77	909	742.5	WM-hypointensities	67.5699	10.5729	28.0000	101.0000	73.0000
35	78	0	0.0	Left-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
36	79	0	0.0	Right-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
37	80	0	0.0	non-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
38	81	0	0.0	Left-non-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
39	82	0	0.0	Right-non-WM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
40	85	126	124.8	Optic-Chiasm	75.3810	17.5981	37.0000	106.0000	69.0000
41	251	1119	1042.9	CC_Posterior	101.8168	15.8608	42.0000	123.0000	81.0000
42	252	489	423.5	CC_Mid_Posterior	93.3967	17.7805	35.0000	114.0000	79.0000
43	253	471	426.5	CC_Central	94.3652	16.8743	33.0000	114.0000	81.0000
44	254	535	471.5	CC_Mid_Anterior	94.7626	17.7385	42.0000	114.0000	72.0000
45	255	1066	1001.3	CC_Anterior	101.4512	15.7948	11.0000	140.0000	129.0000



# Module «Auto segmentation»

## INDIVIDUAL DATA ANALYSIS

Таблицы `aseg.stats` полученные для испытуемого в режимах `freesurfer` и `anatomy` соответственно

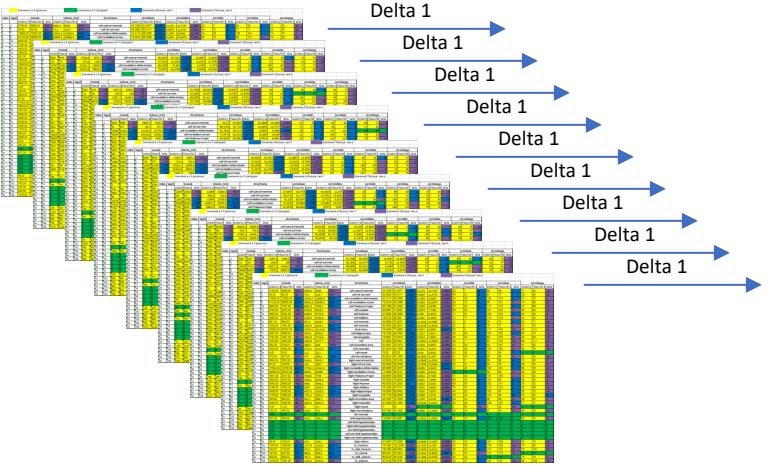
Index	SegId	NVoxels	Volume_mm3	StructName	normMean	normStdDev	normMin	normMax	normRange		
1	4	12614	12894.4	Left-Lateral-Ventrie	25.3736	11.4750	1.0000	85.0000	84.0000		
2	5	472	513.4	Left-Inf-Lat-Vent	42.1737	13.6481	9.0000	76.0000	67.0000		
3	7	11650	12290.4	Left-Cerebellum-White-Matter	88.0567	6.0216	39.0000	103.0000	64.0000		
4	8	42416	42076.3	Left-Cerebellum-Cortex	65.8808	10.4574	13.0000	99.0000	86.0000		
5	10	6299	6054.6	Left-Thalamus-Proper	89.4036	9.8070	31.0000	110.0000	79.0000		
6	11	Index	SegId	NVoxels	Volume_mm3	StructName	normMean	normStdDev	normMin	normMax	normRange
7	12	1	4	12299	12589.0	Left-Lateral-Ventrie	37.0607	10.4816	18.0000	96.0000	78.0000
8	13	2	5	343	400.2	Left-Inf-Lat-Vent	49.2741	12.0751	22.0000	77.0000	55.0000
9	14	3	7	11928	12669.0	Left-Cerebellum-White-Matter	91.2350	5.5721	37.0000	105.0000	68.0000
10	15	4	8	45399	44901.2	Left-Cerebellum-Cortex	73.4197	10.0282	13.0000	97.0000	84.0000
11	16	5	10	7138	6863.5	Left-Thalamus-Proper	91.5979	8.8710	39.0000	109.0000	70.0000
12	17	6	11	3579	3537.4	Left-Caudate	85.0386	6.9977	55.0000	106.0000	51.0000
13	18	7	12	3975	4024.4	Left-Putamen	93.3660	4.7605	66.0000	107.0000	41.0000
14	19	8	13	2033	2009.2	Left-Pallidum	102.1643	3.8446	64.0000	114.0000	50.0000
15	20	9	14	1523	1611.8	3rd-Ventricle	37.2534	10.3213	21.0000	88.0000	67.0000
16	21	10	15	1710	1877.3	4th-Ventricle	39.6281	11.8036	17.0000	81.0000	64.0000
17	22	11	16	20107	19578.7	Brain-Stem	81.2321	9.6734	28.0000	104.0000	76.0000
18	23	12	17	3746	3617.2	Left-Hippocampus	74.9923	7.0177	41.0000	100.0000	59.0000
19	24	13	18	1336	1245.5	Left-Amygdala	77.3278	5.9699	48.0000	94.0000	46.0000
20	25	14	24	1511	1386.1	CSF	50.6155	14.4072	23.0000	103.0000	80.0000
21	26	15	26	235	233.3	Left-Accumbens-area	83.6043	4.5301	61.0000	92.0000	31.0000
22	27	16	28	3681	3469.1	Left-VentralDC	91.3246	10.1825	44.0000	110.0000	66.0000
23	28	17	30	0	0.0	Left-vessel	0.0000	0.0000	0.0000	0.0000	0.0000
24	29	18	31	623	575.1	Left-choroid-plexus	52.4350	11.7163	26.0000	81.0000	55.0000
25	30	19	43	12963	12998.8	Right-Lateral-Ventrie	37.6648	11.4195	20.0000	89.0000	69.0000
26	31	20	44	205	249.5	Right-Inf-Lat-Vent	50.8732	11.8588	27.0000	85.0000	58.0000
27	32	21	45	10985	11185.0	Right-Cerebellum-White-Matter	85.8590	6.6042	25.0000	99.0000	74.0000
28	33	22	47	46812	46697.4	Right-Cerebellum-Cortex	73.2710	10.2500	13.0000	100.0000	87.0000
29	34	23	49	7565	7236.5	Right-Thalamus-proper	86.9856	9.1504	28.0000	105.0000	77.0000
30	35	24	50	4225	4029.8	Right-Caudate	86.9550	7.1947	54.0000	111.0000	57.0000
31	36	25	51	3976	3956.0	Right-Putamen	91.4225	5.0126	70.0000	105.0000	35.0000
32	37	26	52	1798	1797.8	Right-Pallidum	100.7336	3.7413	78.0000	113.0000	35.0000
33	38	27	53	3575	3441.4	Right-Hippocampus	74.5491	6.6634	43.0000	94.0000	51.0000
34	39	28	54	1411	1377.0	Right-Amygdala	75.0135	5.9827	49.0000	91.0000	42.0000
35	40	29	55	407	370.4	Right-Accumbens-area	86.2383	4.3151	60.0000	100.0000	40.0000
36	41	30	60	3463	3171.6	Right-VentralDC	87.8255	10.4204	37.0000	111.0000	74.0000
37	42	31	61	36	50.3	Right-vessel	59.0000	9.6362	39.0000	77.0000	38.0000
38	43	32	63	695	661.8	Right-choroid-plexus	52.7353	10.7325	25.0000	76.0000	51.0000
39	44	33	72	0	0.0	5th-Ventricle	0.0000	0.0000	0.0000	0.0000	0.0000
40	45	34	77	731	692.4	WM-hypointensities	70.3379	14.7827	24.0000	111.0000	87.0000
41	46	35	78	0	0.0	Left-VM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
42	47	36	79	0	0.0	Right-VM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
43	48	37	80	0	0.0	non-VM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
44	49	38	81	0	0.0	Left-non-VM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
45	50	39	82	0	0.0	Right-non-VM-hypointensities	0.0000	0.0000	0.0000	0.0000	0.0000
46	47	35	75	66.6	Optic-Chiasm	72.2400	16.9082	35.0000	100.0000	65.0000	
47	48	36	185	1070.1	CC_Posterior	97.8059	17.0334	38.0000	116.0000	78.0000	
48	49	37	536	444.9	CC_Mid_Posterior	90.4478	19.2091	36.0000	111.0000	75.0000	
49	50	38	500	440.1	CC_Central	93.9740	15.9676	35.0000	113.0000	78.0000	
50	51	39	472	436.3	CC_Mid_Anterior	96.6843	16.1255	34.0000	114.0000	80.0000	
51	52	39	1097	1027.3	CC_Anterior	101.1778	14.5638	30.0000	127.0000	97.0000	

Index	SegId	Значения А и F различны			Значения А и F совпадают			Значение А больше, чем F			Значение F больше, чем А								
		NVoxels	Volume_mm3	StructName	normMean	normStdDev	normMin	normMax	normRange	anatomy	freesurfer	delta	anatomy	freesurfer	delta	anatomy	freesurfer	delta	anatomy
1	4	5739.00	5859.00	Left-Lateral-Ventrie	43.7029	31.0077	12.695	12.135	13.7157	-1.5807	23	7	16	94	90	4	71	83	-12
2	5	54.00	90.00	Left-Inf-Lat-Vent	62.5926	50.5111	12.082	9.8929	11.5761	-1.6832	43	21	22	81	77	4	38	56	-18
3	7	13885.00	12820.00	Left-Cerebellum-White-Matter	91.2114	88.0265	3.1848	6.1898	6.6093	-0.4185	34	29	5	108	104	4	74	75	-1
4	8	61123.00	58630.00	Left-Cerebellum-Cortex	73.4918	65.3396	8.1522	9.4454	10.4875	-1.0421	25	12	13	99	101	-2	74	89	-15
5	10	8305.00	7767.00	Left-Thalamus-Proper	92.1399	87.2063	4.93316	8.7068	9.9769	-1.2701	37	24	13	111	110	1	74	86	-12
6	11	3745.00	3970.00	Left-Caudate	84.2967	77.9081	6.3883	6.6678	7.7409	-1.0731	55	42	13	101	102	-2	46	60	-14
7	12	5403.00	5563.00	Left-Putamen	91.2082	86.2495	4.9584	4.208	4.8222	-0.6142	71	67	8	106	105	1	35	38	-3
8	13	2268.00	2309.00	Left-Pallidum	100.9798	98.388	2.59	4.1942	5.4348	-1.2406	74	71	8	115	116	-1	41	45	-4
9	14	851.00	994.00	3rd-Ventricle	43.6898	33.9547	9.7351	11.25	14.5693	-3.3175	24	2	22	76	73	3	52	71	-19
10	15	1502.00	1491.00	4th-Ventricle	40.4634	42.2515	12.211	10.61	12.6916	-2.072	22	1	21	75	-2	53	76	-23	
11	16	23083.00	22532.00	Brain-Stem	78.4888	77.9988	0.59	8.9331	8.8864	0.0467	28	9	19	117	140	-23	89	131	-42
12	17	4527.00	4599.00	Left-Hippocampus	76.1208	68.7643	7.3565	7.1227	7.6412	-0.5185	43	28	15	106	102	4	63	74	-11
13	18	1727.00	1807.00	Left-Amygdala	73.6821	72.3514	1.3307	6.5024	7.9025	-1.4001	48	38	10	92	100	-8	44	62	-18
14	19	1078.00	1064.00	CSF	57.4462	43.9041	13.542	12.65	14.3828	-1.7327	29	7	22	97	118	-21	68	111	-43
15	20	283.00	419.00	Left-Accumbens-area	81.0601	76.1074	4.9552	5.3149	5.8975	-0.5826	52	39	13	93	101	-8	41	62	-21
16	21	4463.00	4400.00	Left-Ventricular-DT	87.4618	84.7945	2.6673	9.4261	10.551	-1.1249	42	29	13	105	108	-2	83	79	-16
17	22	30.00	40.00	Left-vessel	70.25	62.25	8	3.594	3.8622	-0.2686	65	58	7	66	68	0	0	0	0
18	23	370.00	527.00	Left-chordoid-plexus	60.6243	53.1366	7.4877	10.488	11.667	-1.1786	31	24	7	86	89	-3	55	65	-10
19	24	5304.00	5553.00	Right-Lateral-Ventricle	43.9618	40.5134	5.8152	6.6021	7.9959	-1.3974	48	38	10	96	88	8	56	58	-2
20	25	4478.00	4326.00	Right-Choroid-Plexus	76.0385	72.9769	2.2293	7.0702	7.9703	-0.8986	42	25	17	100	97	3	58	72	-14
21	26	1736.00	1706.00	Right-Cerebellum-White-Matter	86.0066														



# Module «Auto segmentation»

## GROUP DATA ANALYSIS



Delta 1	Значения А и F различны нестабильная разница								Значения А и F совпадают стабильная без изменений								Значение А больше, чем F А стабильно больше F	Значение F больше, чем А F стабильно больше А											
	1236	1238	1242	1230	1234	1220	1221	1229	1217	StructName	1236	1238	1242	1230	1234	1220	1221	1229	1217										
1	-465	-537	-743	-521	-315	-129	-155	-129	Left-Lateral-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Lateral-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217	
2	-23	-45	-1028	-328	-340	-129	-203	-53	-36	Left-Infra-Tent.	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Infra-Tent.	1236	1238	1242	1230	1234	1220	1221	1229	1217
3	-732	6443	518	1532	278	-470	-672	106	Left-Cerebellum-White-Matter	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Cerebellum-White-Matter	1236	1238	1242	1230	1234	1220	1221	1229	1217	
4	4561	895	3524	2536	3250	2983	3531	3335	2593	Left-Cerebellum-Cortex	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Cerebellum-Cortex	1236	1238	1242	1230	1234	1220	1221	1229	1217
5	445	510	1049	1429	500	839	241	723	538	Left-Thalamus-Proper	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Thalamus-Proper	1236	1238	1242	1230	1234	1220	1221	1229	1217
6	-223	31	1225	-22	31	20	62	-162	-22	Left-Caudate	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Caudate	1236	1238	1242	1230	1234	1220	1221	1229	1217
7	-471	263	-245,2	-864	-86	-465	-443	-249	-150	Left-Putamen	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Putamen	1236	1238	1242	1230	1234	1220	1221	1229	1217
8	-156	-198,7	481	149	52	378	-156	-41	-	Left-Pallidum	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Pallidum	1236	1238	1242	1230	1234	1220	1221	1229	1217
9	48	159	-11,4	-31	122	2	-28	-83	-14	3rd-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217	3rd-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217
10	-72	-51	71,5	60	-33	64	26	-126	-72	4th-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217	4th-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217
11	1617	146	275,5	-21	1669	623	1197	858	553	Brain-Stem	1236	1238	1242	1230	1234	1220	1221	1229	1217	Brain-Stem	1236	1238	1242	1230	1234	1220	1221	1229	1217
12	-473	97	247,3	42	27	13	-128	-72	-72	Left-Hippocampus	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Hippocampus	1236	1238	1242	1230	1234	1220	1221	1229	1217
13	-180	208	-183,2	-161	126	154	-92	-126	-72	Left-Amygdala	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Amygdala	1236	1238	1242	1230	1234	1220	1221	1229	1217
14	-36	67	19,3	13	34,3	26	15	55	14	CSF	1236	1238	1242	1230	1234	1220	1221	1229	1217	CSF	1236	1238	1242	1230	1234	1220	1221	1229	1217
15	-35	70	40,2	73	62	84	133	1	120	Left-Accumbens-area	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-Accumbens-area	1236	1238	1242	1230	1234	1220	1221	1229	1217
16	48	14	-55,9	-160	372	-29	-341	-276	63	Left-VentralDC	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-VentralDC	1236	1238	1242	1230	1234	1220	1221	1229	1217
17	-15	0	-5,8	-1	9	-5	4	3	0	Left-vessel	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-vessel	1236	1238	1242	1230	1234	1220	1221	1229	1217
18	-198	109	58,1	-145	167	131	39	-141	-157	Left-choroid-plexus	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-choroid-plexus	1236	1238	1242	1230	1234	1220	1221	1229	1217
19	222	-154	50,6	-369	186	207	-22	46	51	Right-Lateral-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Lateral-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217
20	-124	-74	-35,9	-33	111	44	131	-36	-33	Right-Infrat-Vent.	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Infrat-Vent.	1236	1238	1242	1230	1234	1220	1221	1229	1217
21	-404	364	425	126	2927	228	70	-507	493	Right-Cerebellum-White-Matter	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Cerebellum-White-Matter	1236	1238	1242	1230	1234	1220	1221	1229	1217
22	3739	2843	3613,3	2609	791	4950	2938	3970	895	Right-Cerebellum-Cortex	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Cerebellum-Cortex	1236	1238	1242	1230	1234	1220	1221	1229	1217
23	131	921	91,6	74	747	864	776	68	-70	Right-Thalamus-Prop	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Thalamus-Prop	1236	1238	1242	1230	1234	1220	1221	1229	1217
24	-294	-10	-25,6	74	155	494	104	-55	-378	Right-Caudate	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Caudate	1236	1238	1242	1230	1234	1220	1221	1229	1217
25	-207	-173	-136,9	-133	-128	249	3	-105	-413	Right-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217
26	140	238	126,3	139	-45	-29	192	111	22	Right-Hippocampus	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Hippocampus	1236	1238	1242	1230	1234	1220	1221	1229	1217
27	-314	-267	-174,7	333	137	88	119	-187	132	Right-Accumbens-area	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Accumbens-area	1236	1238	1242	1230	1234	1220	1221	1229	1217
28	187	-14	148,3	199	-7	-75	84	29	29	Right-VentralDC	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-VentralDC	1236	1238	1242	1230	1234	1220	1221	1229	1217
29	-87	34	-36,7	-31	52	52	52	52	52	Right-Vessel	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-Vessel	1236	1238	1242	1230	1234	1220	1221	1229	1217
30	-55	273	-192,4	122	517	517	53	-5	-63	Right-ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217	Right-ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217
31	2	-18,1	5	-1	0	-9	-9	-5	-63	WM-hypointensities	1236	1238	1242	1230	1234	1220	1221	1229	1217	WM-hypointensities	1236	1238	1242	1230	1234	1220	1221	1229	1217
32	-198	-161	-76,7	22	-157	120	-274	-141	-168	Sth-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217	Sth-Ventricle	1236	1238	1242	1230	1234	1220	1221	1229	1217
33	0	2	-2,5	0	0	0	0	0	0	WM-hypointensities	1236	1238	1242	1230	1234	1220	1221	1229	1217	WM-hypointensities	1236	1238	1242	1230	1234	1220	1221	1229	1217
34	-504	-353	147,4	222	156	176	323	-15	-247	Optic-Chiasma	1236	1238	1242	1230	1234	1220	1221	1229	1217	Optic-Chiasma	1236	1238	1242	1230	1234	1220	1221	1229	1217
35	0	0	0	0	0	0	0	0	0	CC_Posterior	1236	1238	1242	1230	1234	1220	1221	1229	1217	CC_Posterior	1236	1238	1242	1230	1234	1220	1221	1229	1217
36	0	0	0	0	0	0	0	0	0	CC_Mid_Posterior	1236	1238	1242	1230	1234	1220	1221	1229	1217	CC_Mid_Posterior	1236	1238	1242	1230	1234	1220	1221	1229	1217
37	0	0	0	0	0	0	0	0	0	non-WM-hypointensities	1236	1238	1242	1230	1234	1220	1221	1229	1217	non-WM-hypointensities	1236	1238	1242	1230	1234	1220	1221	1229	1217
38	0	0	0	0	0	0	0	0	0	Left-non-WM-hypointensities	1236	1238	1242	1230	1234	1220	1221	1229	1217	Left-non-WM-hypointensities	1236	1238	1242	1230	1234	1220	1221	1229	1217
39	0	-65																											

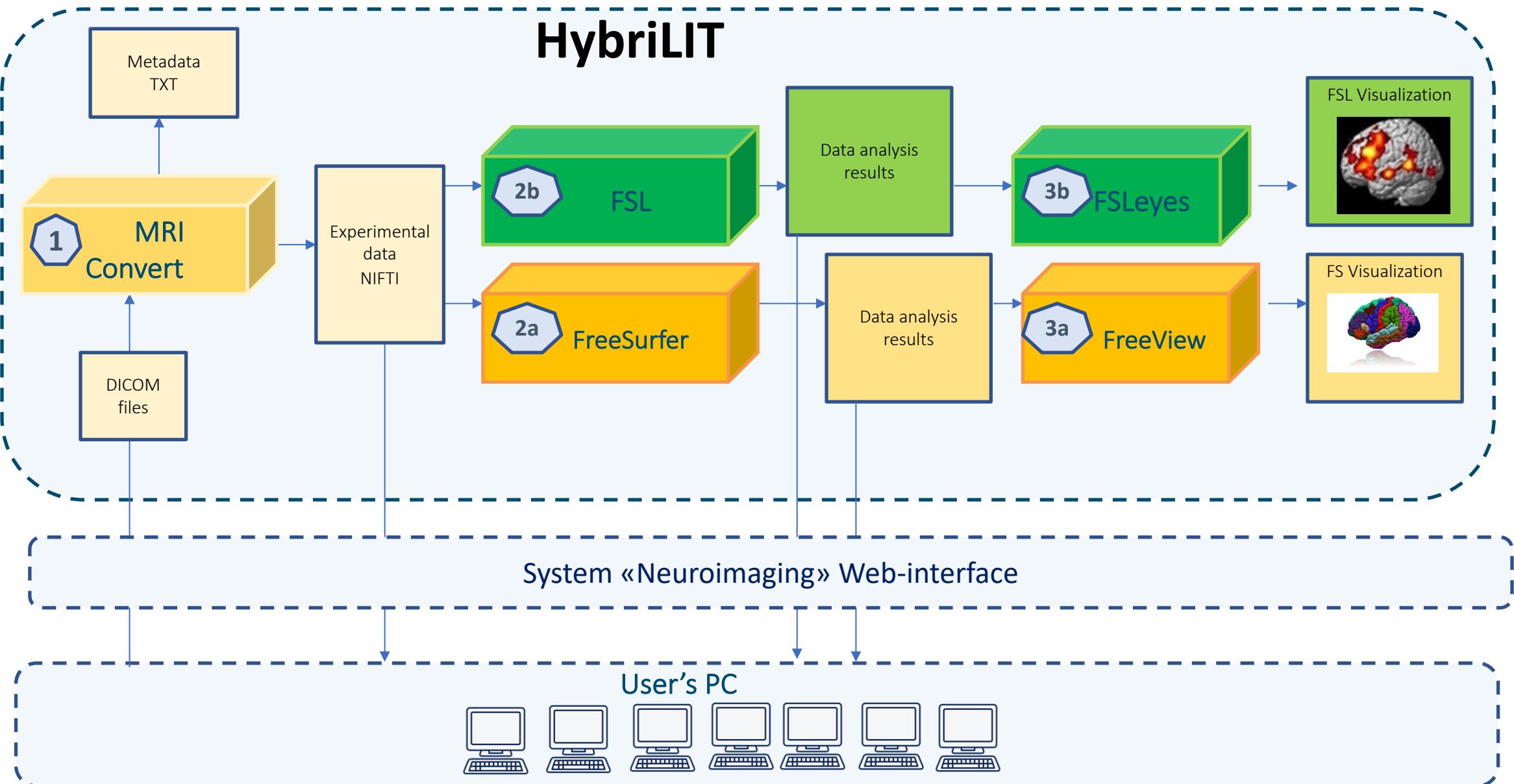


# Benefits of System «Neuroimaging» implementation

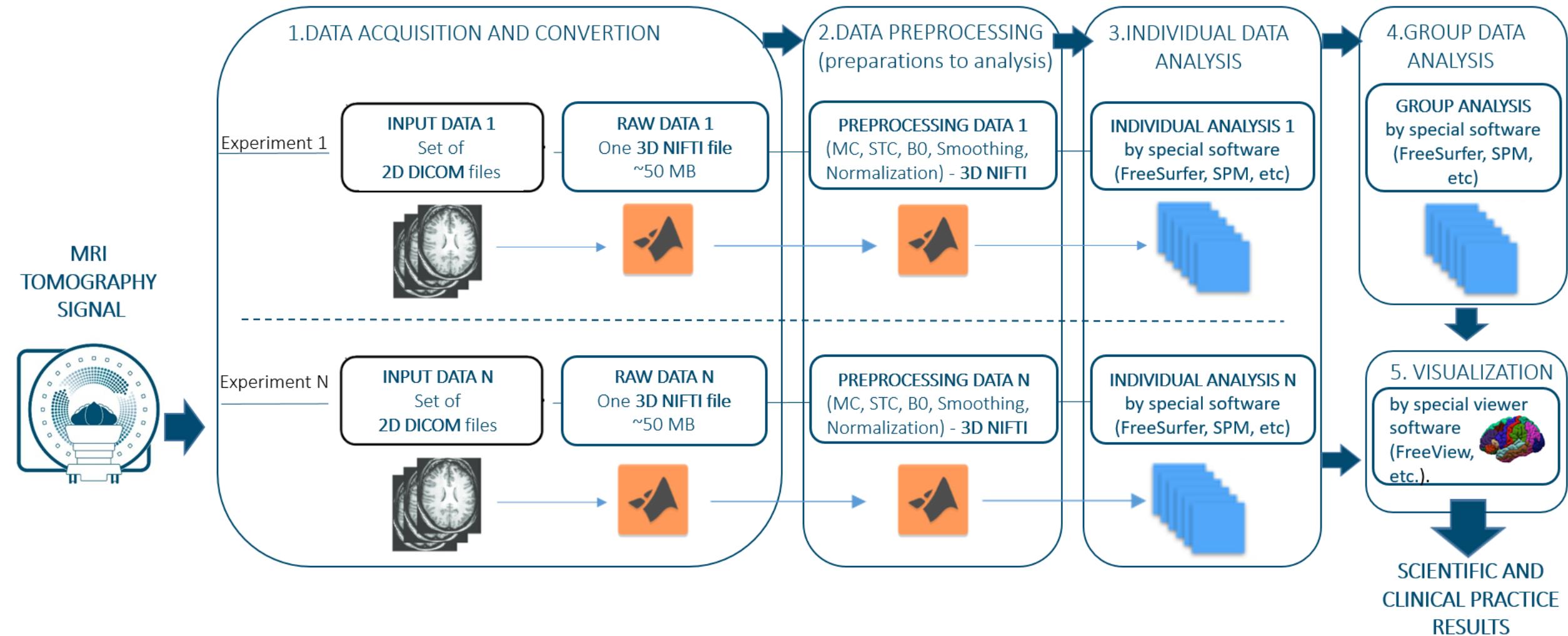
- Many times speed up of processing and analysis MRI and fMRI data due to parallelization of computations on supercomputer nodes.
- Wide choice of tools for processing and analyzing data due to the installation of a set of modern specialized software packages on a supercomputer.
- Centralized data storage, with the possibility of searching on a set of parameters, what make possible in the future to reuse this data for various scientific studies.
- Work with data at any time from any place using web-portal.



# System on the HybriLIT heterogeneous platform for storing and analyzing MRI|fMRI experimental data

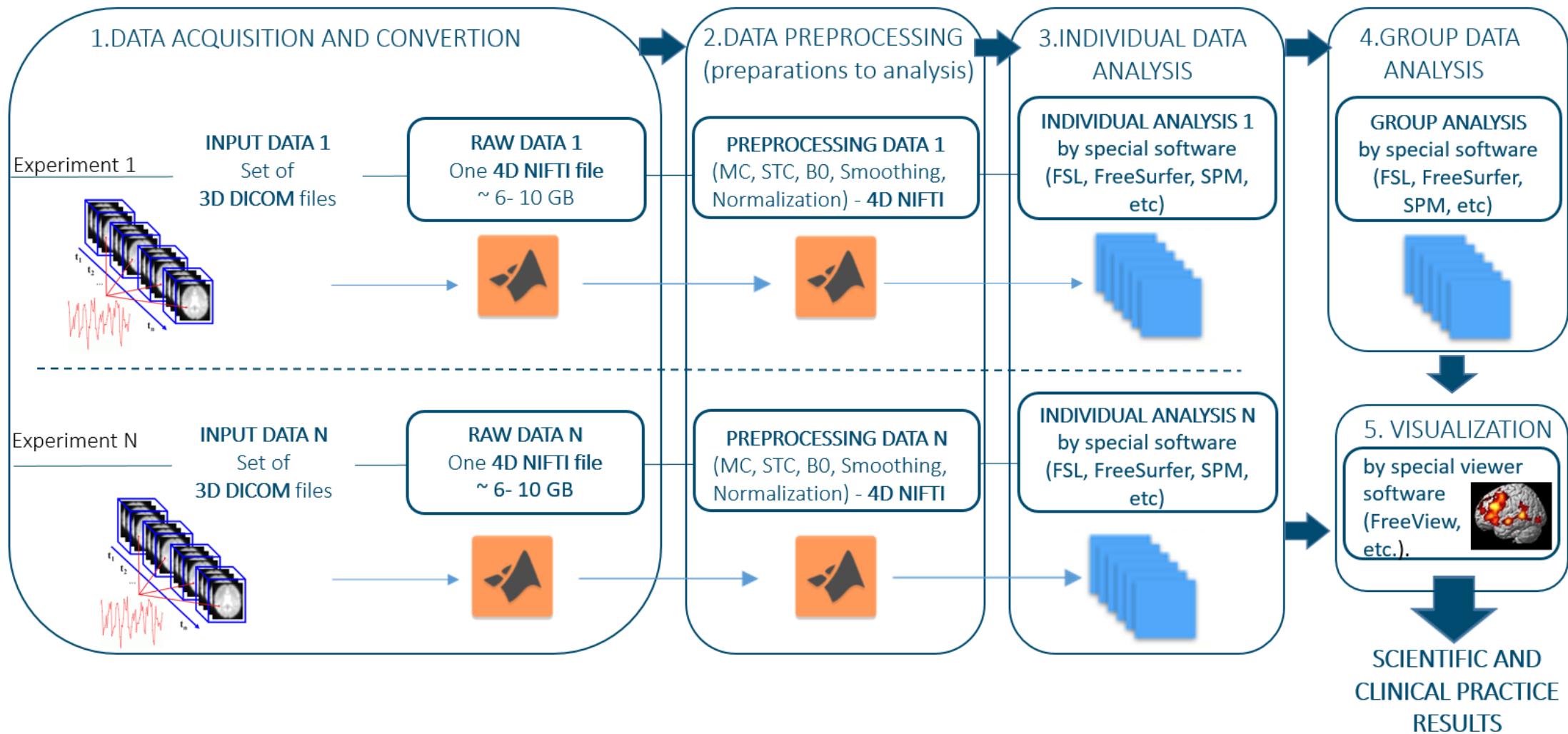
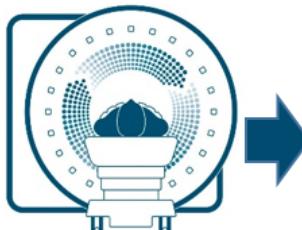


# MRI experiments data work flows



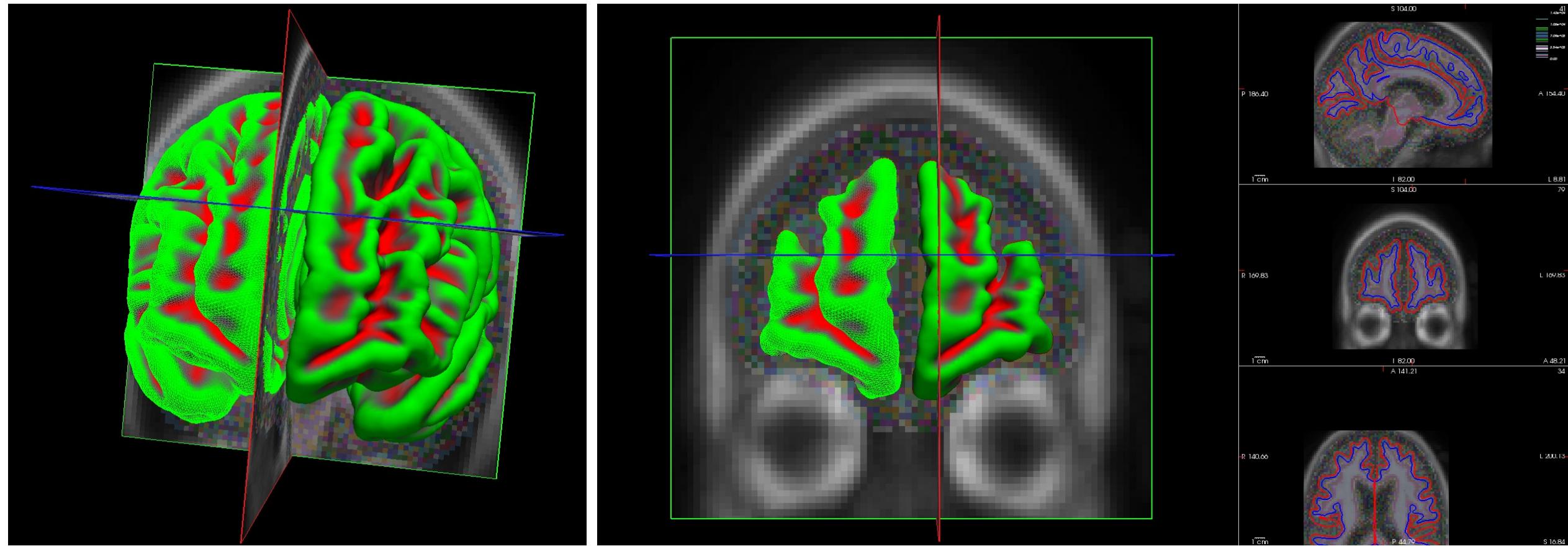


fMRI  
TOMOGRAPHY  
SIGNAL





# Resulting images after processing the initial data



FreeView



## List of installed packages

- MRI Convert for converting the NIFTI file from the original set of DICOM files;
- FreeSurfer for NIFTI file processing;
- FreeView (viewer from the FreeSurfer package) for building images after NIFTI file processing.
- FSL, alternative package for NIFTI file processing;
- FSLeyes ( viewer from the FSL package) for building images after NIFTI file processing

All the software has been installed in the network file system such as CernVM File System (cvmfs), and the corresponding modules have been prepared. Work with it is organized via the Modules package, using which the user can dynamically change the environment variables of the current session.



# Workflow for Analyzing Experimental MRI/fMRI Data on the HybriLIT Heterogeneous Platform

The information system at HybriLIT heterogeneous platform for storing and analyzing magnetic resonance imaging (MRI) and functional magnetic resonance imaging (fMRI) data. The main task of this information system is to create a storage of MRI / fMRI data, as well as to automate the processes of their processing and analysis with the possibility of subsequent visualization of the results. A system module has been created for working with MRI / fMRI of the human brain using specialized software (FreeSurfer, FSL). When deploying the additional specialized software, the module can also be used for processing and analysis of MRI / fMRI data of the brain of laboratory animals (for example, mice).

Thanks for your attention!