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University of Warmia and Mazury and the Poznan Supercomputing and Networking Center collaboration

High-resolution mapping of compact galaxies using the LOFAR-VLBI pipeline – test results

Poznań Supercomputing and Networking Center

Poznan Supercomputing and Networking Center (PSNC) affiliated with the Institute of Bioorganic Chemistry of the Polish Academy of Sciences has been operating since 1993 with a mission: “Integration and development of information infrastructure for science”.

It is an internationally known node of the European Research Area in the field of IT infrastructure of science and an important R&D center in the field of information and communication technologies (ICT). As a development centre of e-Infrastructure, PSNC designed and built the Metropolitan Network POZMAN, High Performance Computing Center and the national broadband network PIONIER, maintained and still developed by PSNC.

Poznań Supercomputing and Networking Center

The virtual environment we use has the following parameters:
- vCPU: 32
- RAM: 256 GB
- block storage: 100 TB
- file storage: 60 TB

We can run such environments on virtualized service infrastructure consisting of over 100 servers equipped with 2TB RAM each, 2 x 32/64 CPUs (AMD and Intel) each and a total of 50 A100/H100 cards with 80GB RAM each. The servers are connected via 100 GB links with storage infrastructure (block, file and object) with a capacity of approximately 40 PB.

Pipeline run – thanks to the amazing team

For basic and easy LOFAR-VLBI data processing you can use automated scripts without the need for manual configuration of various CWL workflow files.

Download singularity/apptainer container from:
https://tikk3r.github.io/flocs/

And the flocs github archive to get access to bash scripts that automate configuration and running the pipeline
https://github.com/tikk3r/flocs.git

Pipeline run – thanks to the amazing team

Calibrate core LOFAR stations with LINC

$ bash flocs/runners/run_LINC_calibrator_HBA.sh -b path_to_directory_with_data -s your_singularity_container.sif -d path_to_calibrator_data -r path_to_results_catalogue

This will produce solutions for calibrator

$ bash flocs/runners/run_LINC_target_HBA.sh -b path_to_directory_with_all_data -s your_singularity_container.sif -d path_to_target_data -r path_to_results_catalogue -c path_to_solutions_from_calibrator.h5

This will calibrate target data for core LOFAR, you can use it to make 6” images

Calibrate international stations:

$ bash flocs/runners/run_lofar-vlbi-delay-calibration.sh -b path_to_directory_with_data -s your_singularity_container.sif -d path_to_target_data -r path_to_results_catalogue -c linc_target_solutions.h5

This will produce solutions for delay in international antennas, will automatically find delay calibrators (for fields in LoTSS DR) you can use chose calibrators with additional option:

-e”- -delay_calibrator=calibrators.csv”

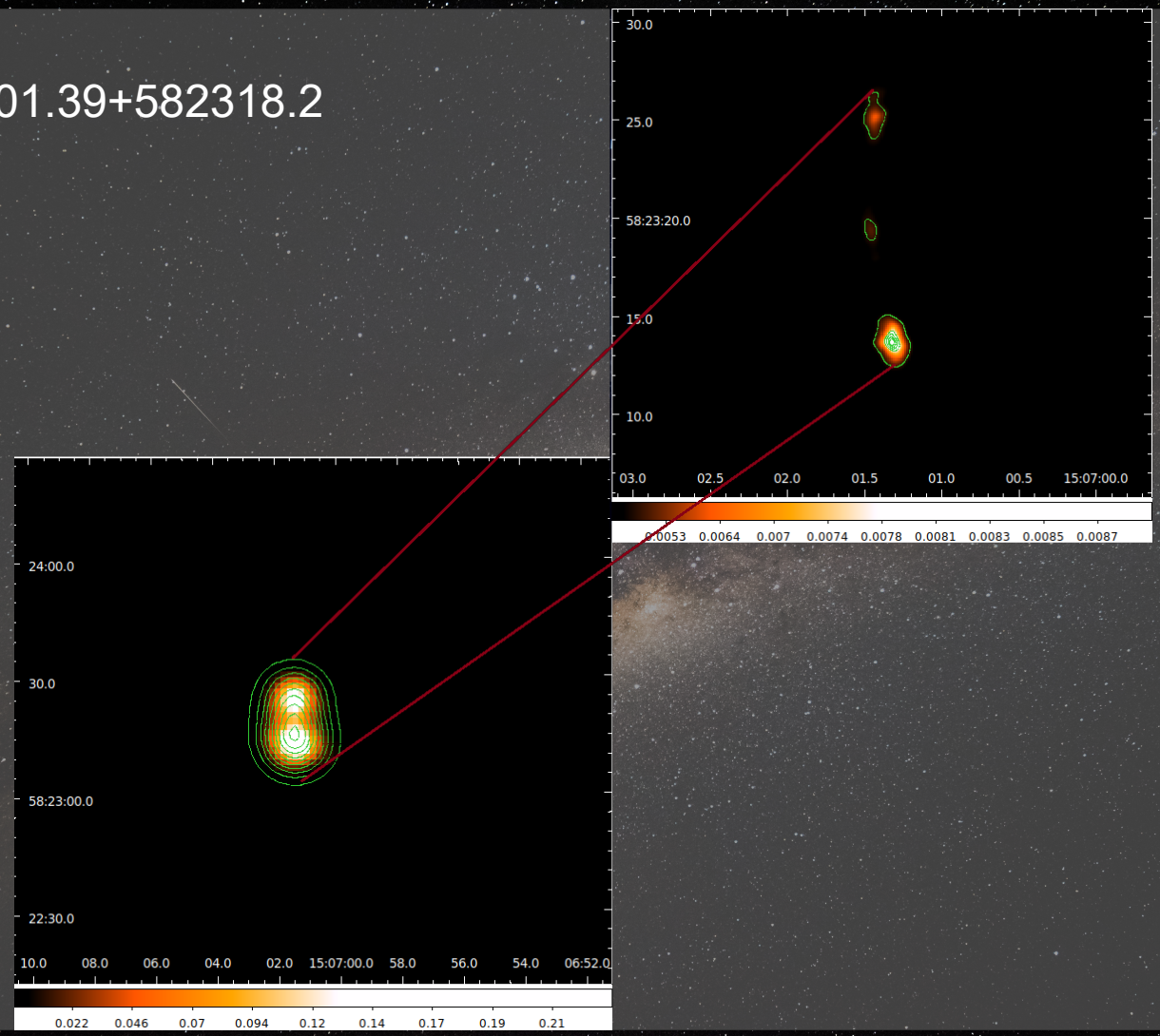
$ bash flocs/runners/run_lofar-vlbi-split-directions.sh -b path_to_directory_with_all_data -s your_singularity_container.sif -d path_to_target_data_from_delay_calibrations -r path_to_results_catalogue -c path_to_solutions_from_delay.h5 -i image_catalogue.csv

Creates final MS file with calibrated visibilities for target that you can image and self calibrate if needed

The first test run:

LT5_007 - LOFAR surveys: Opening up a new window on the Universe

ILTJ150701.39+582318.2



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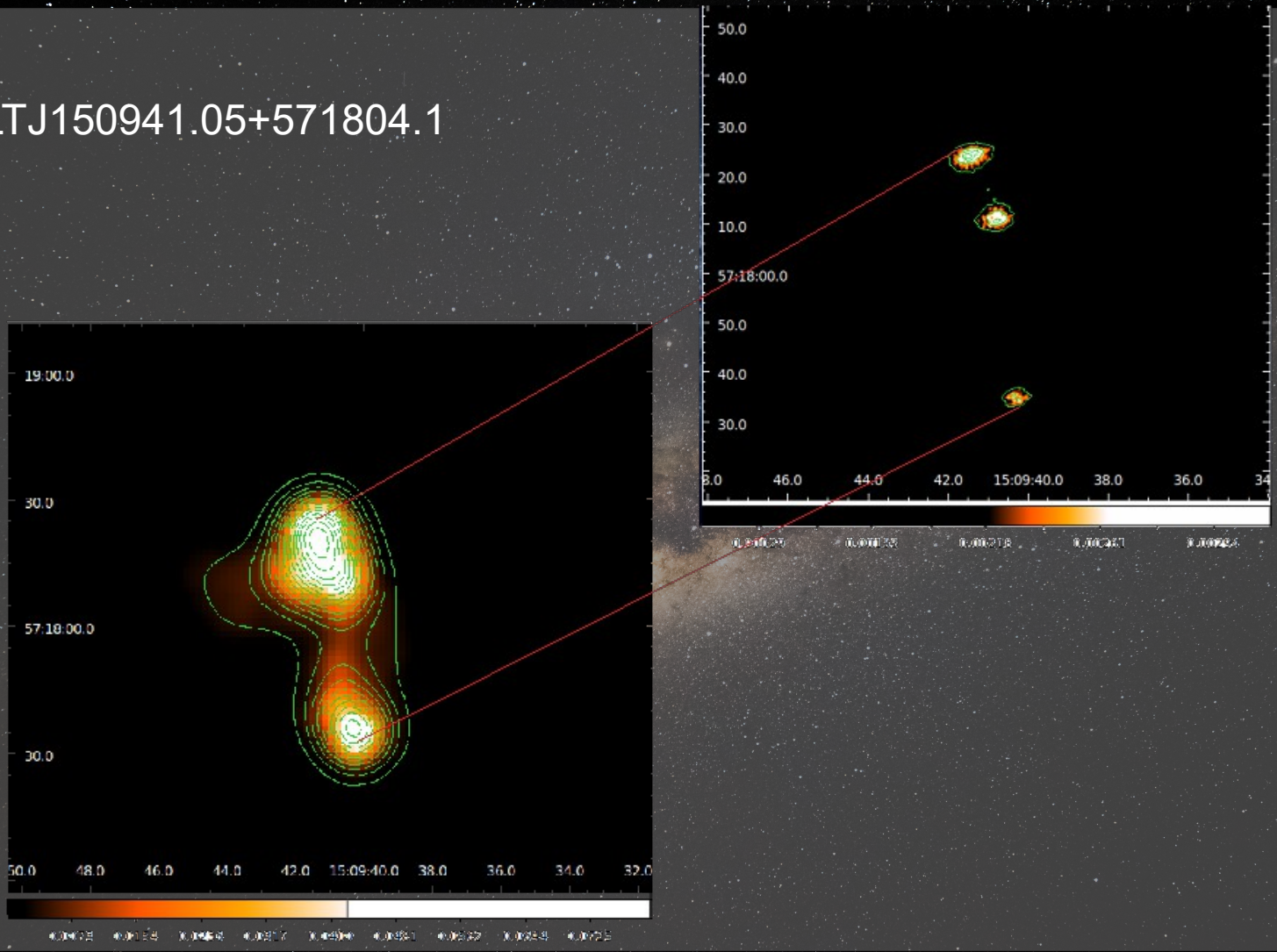

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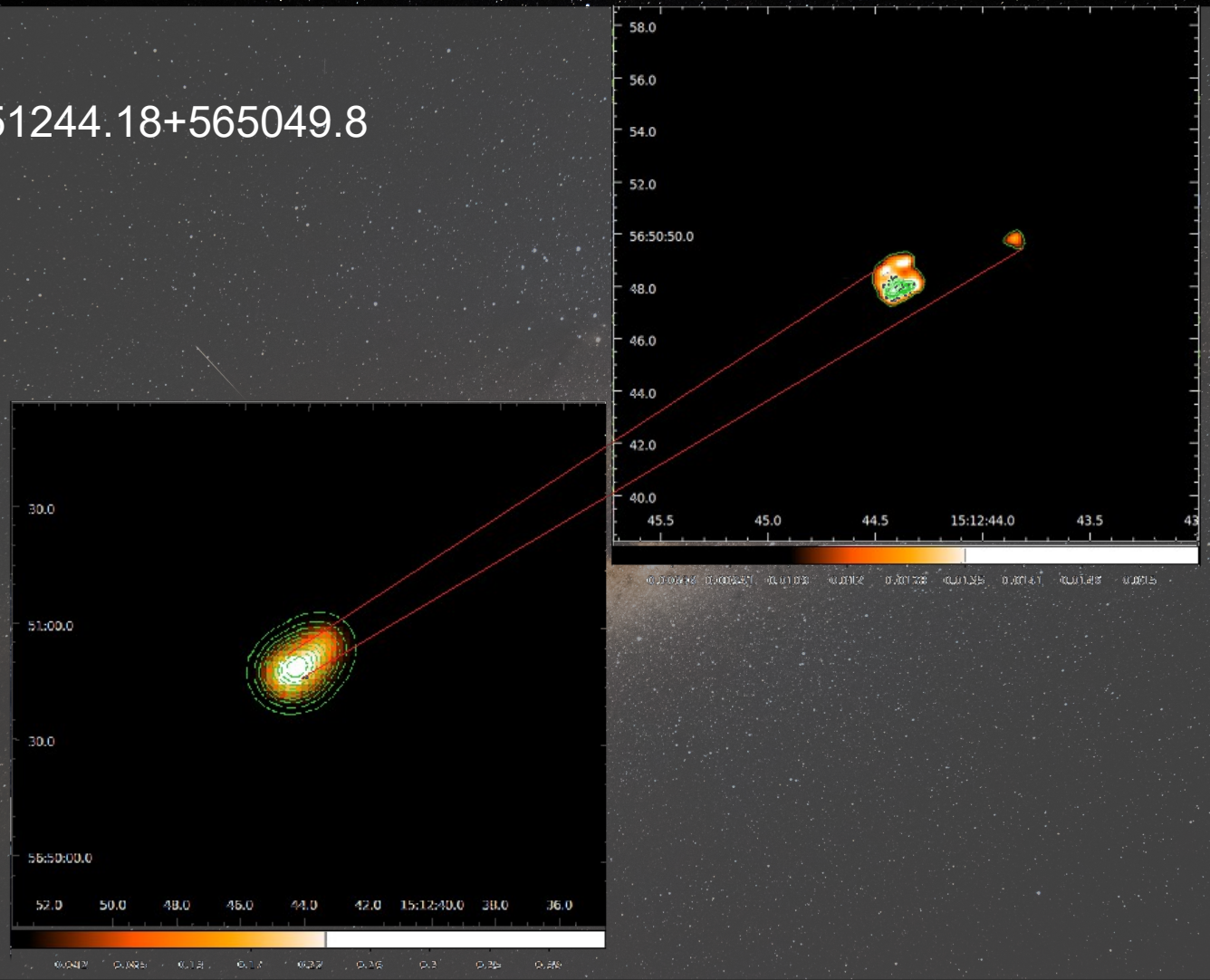

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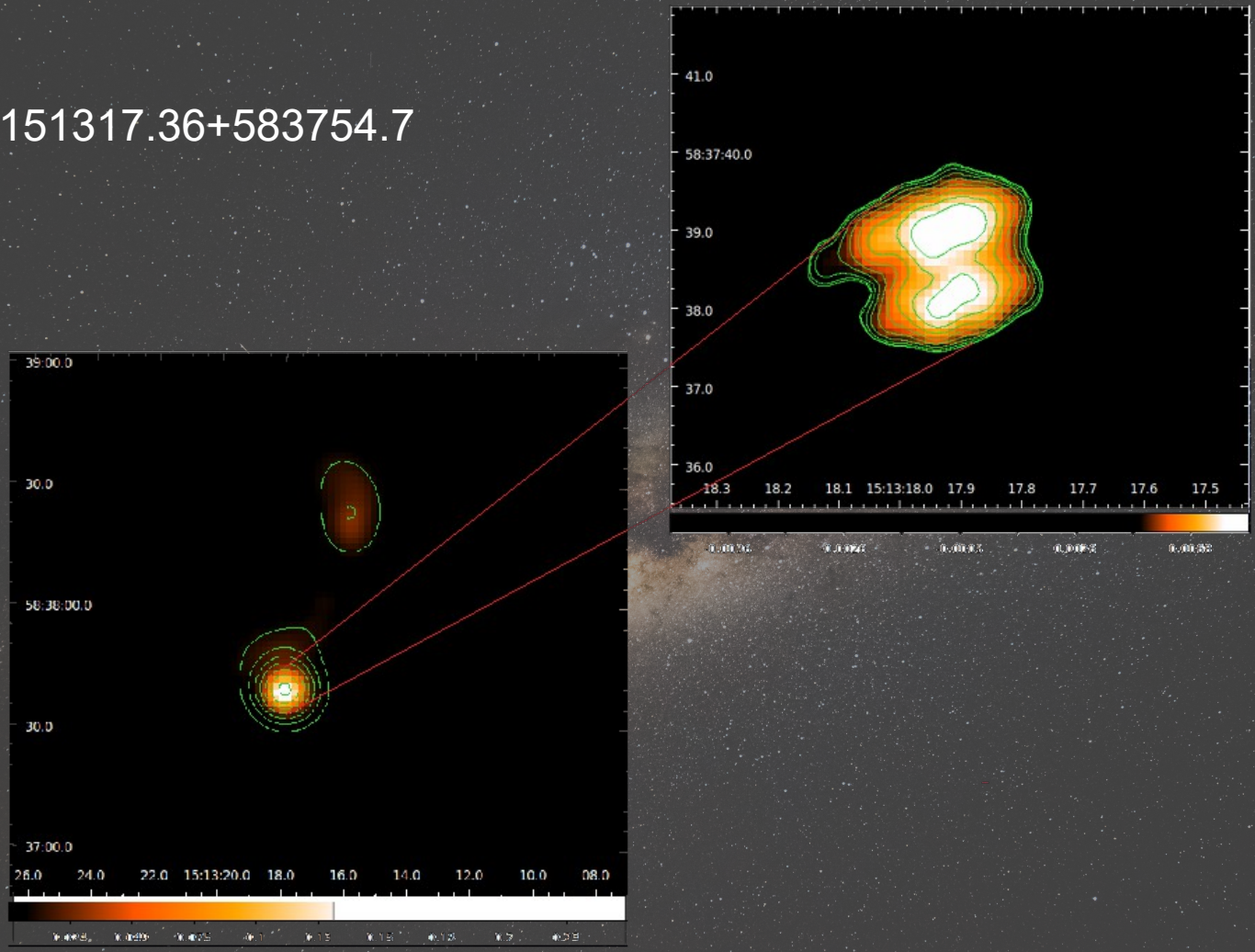
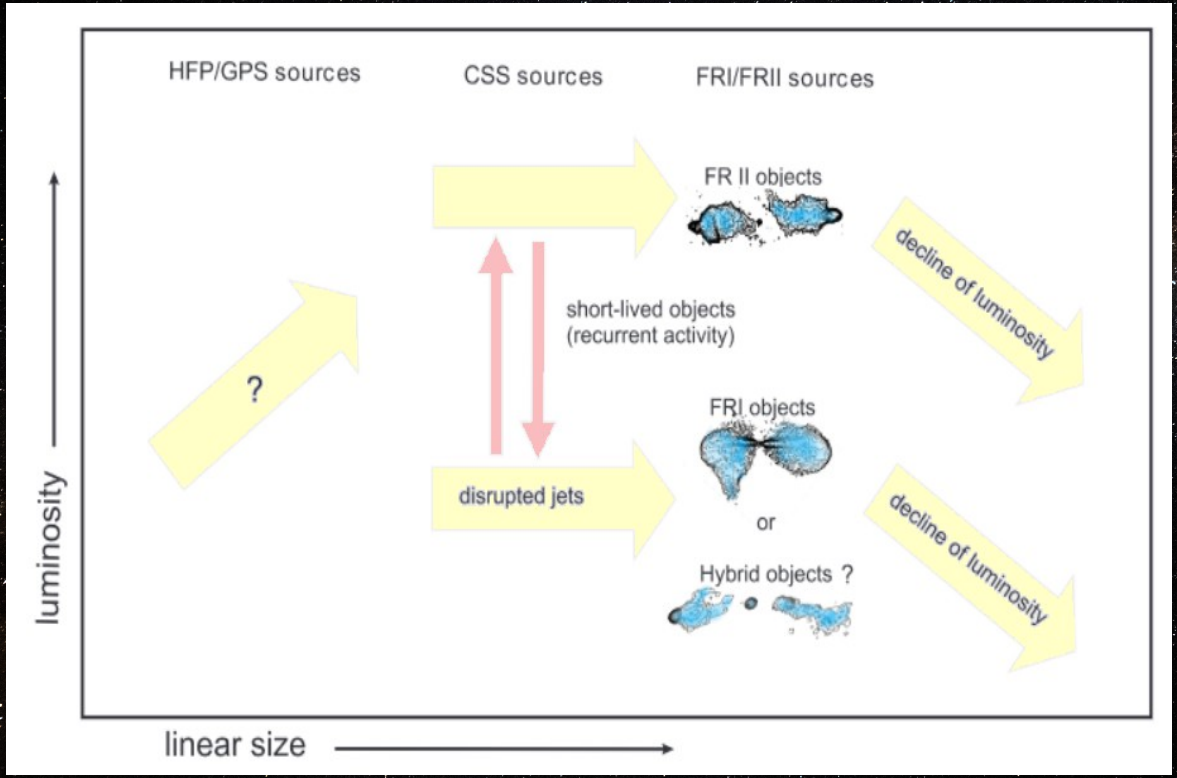
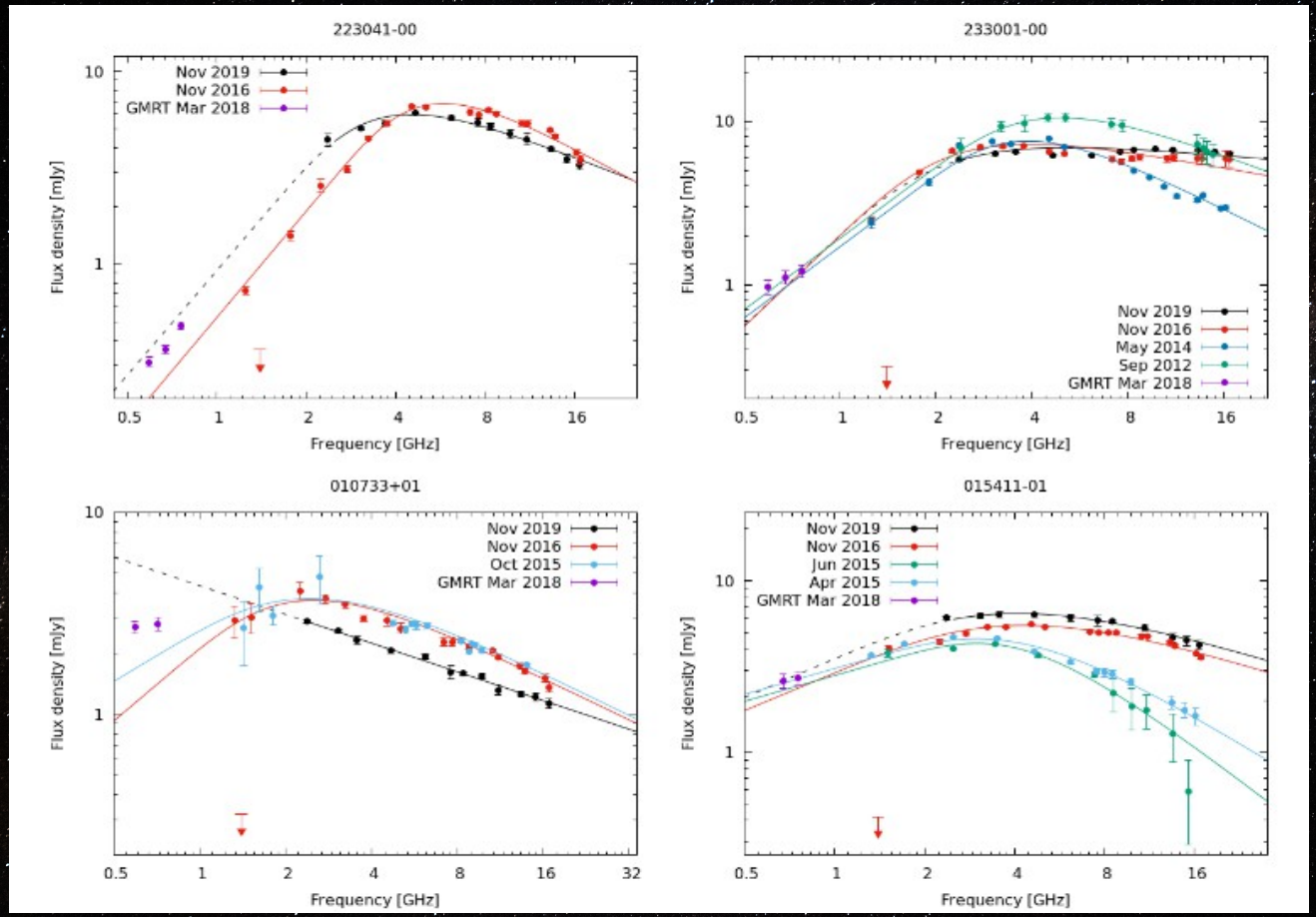


LC8_030 - Study of the evolution of compact radio sources



Kunert-Bajraszewska+ 2010

LC8_030 - Study of the evolution of compact radio sources



Wołowska+ 2021

- Young galaxies with jets developing in dense environments may be more vulnerable for disruption
- Such interactions may change the morphology of the radio souce or even halt the je propagation
- Some of them can fade away and come back after soem quiescent period

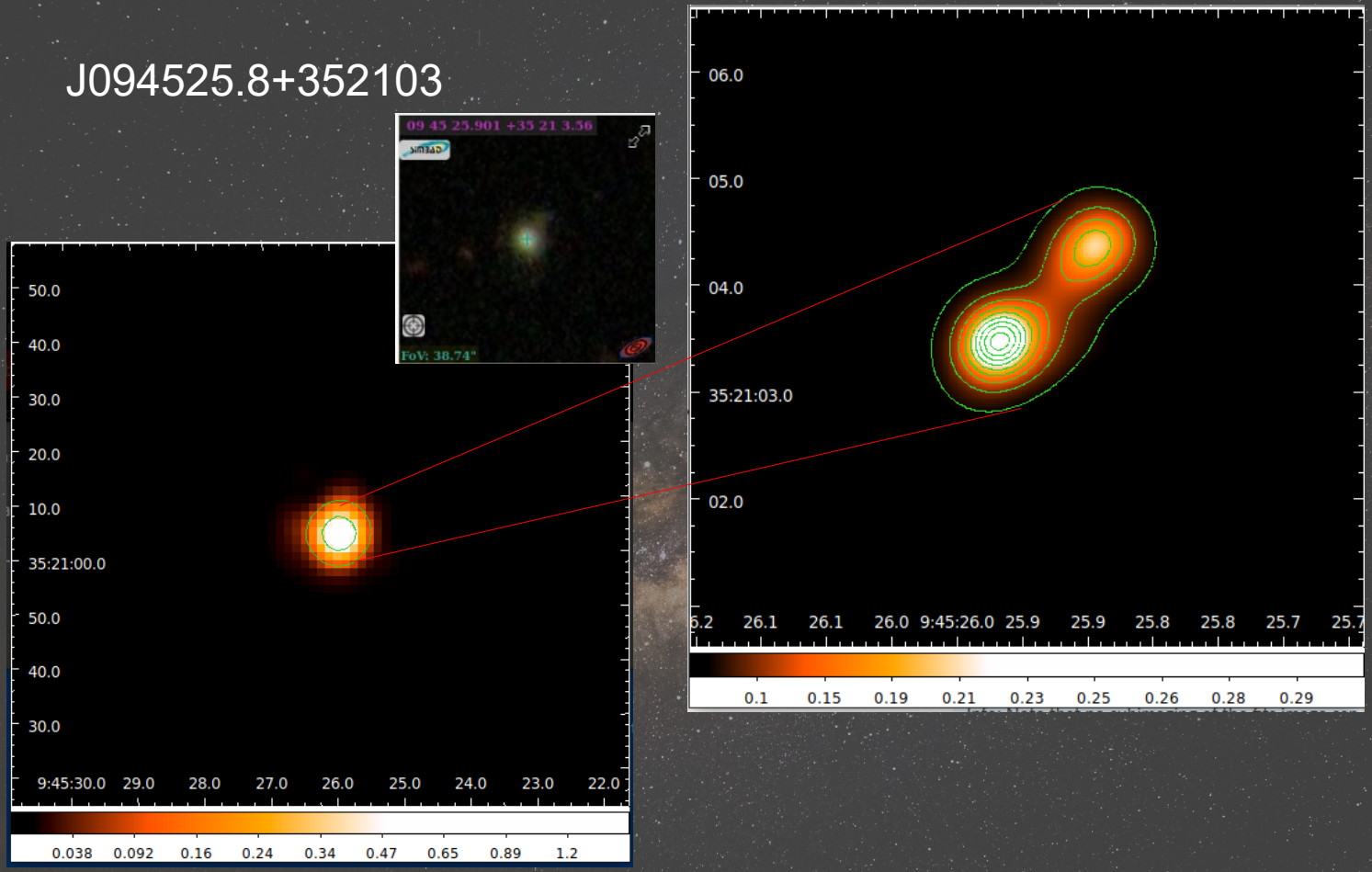
Capabilities of LOFAR can allow ut to look for the impact of shock from the early phases of radio source evolution – in case of some young AGNs faint diffuse emission should be present on arcsecond scales.

If found – such extended emission could mean that the young CSS/GPS sources are recurrent with jet propagation halted on small scales (tens of pc).

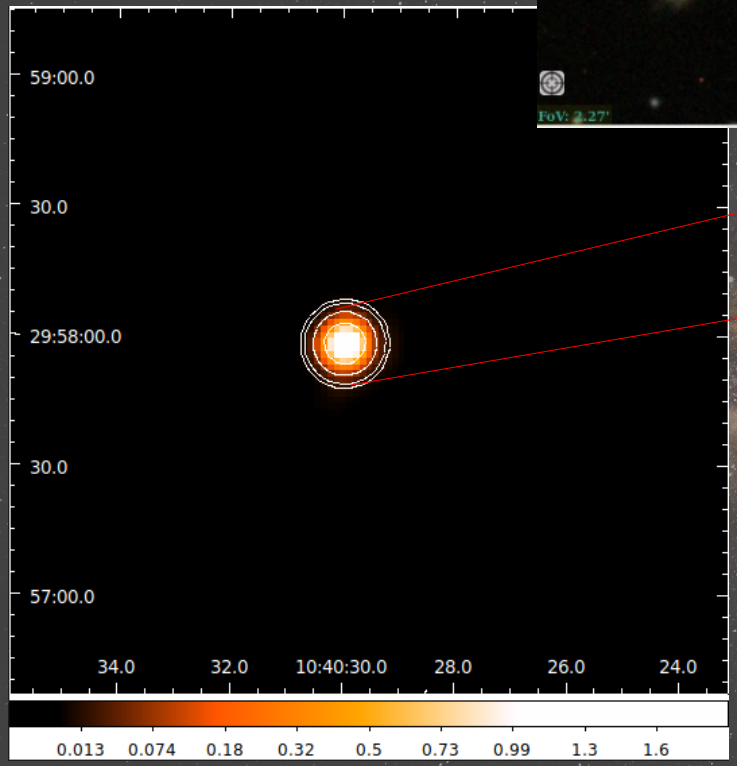
3 Compact Steep Spectrum sources proposed, 2 observed.

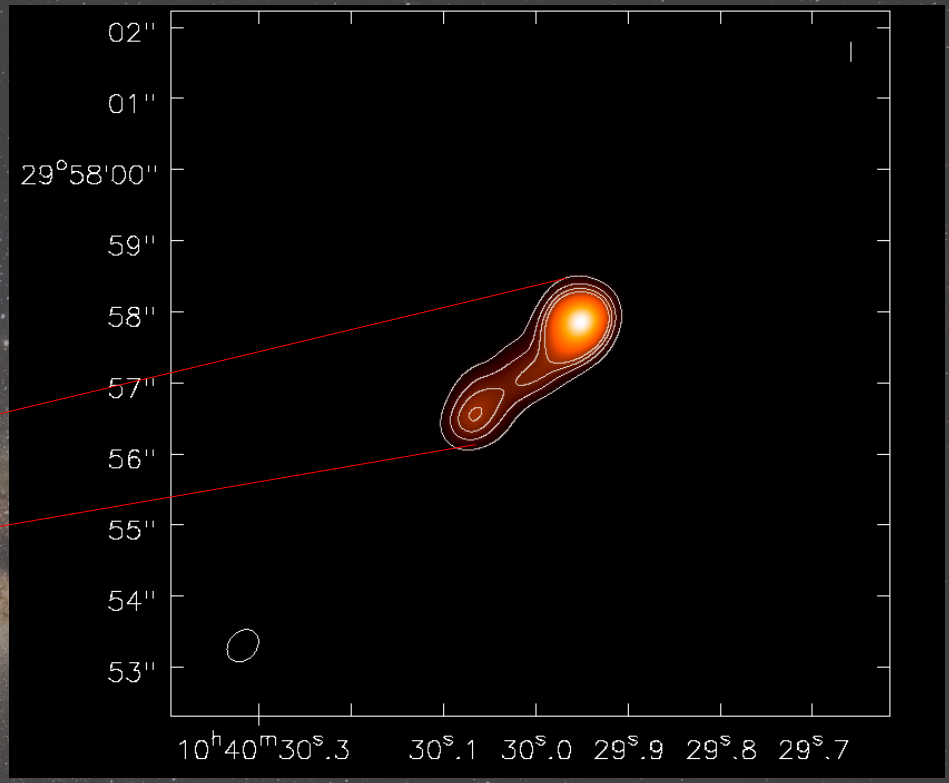
	Source Name	RA h m s	Dec ° ′ ″	ID	z	S_{74MHz} Jy	S_{365MHz} Jy	α_{74}^{365}	LAS ″	Class
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
*	**0945+3521**	09 45 25.902	35 21 03.602	G	0.208	1.4	0.489	0.66	2	HEG
	1040+2957	10 40 29.949	29 57 57.747	G	0.091	3.51	1.293	0.62	3	LEG
	1544+3208	15 44 48.395	32 08 45.11	G	0.468*	3.35	2.16	0.27	2.4	-

J094525.8+352103

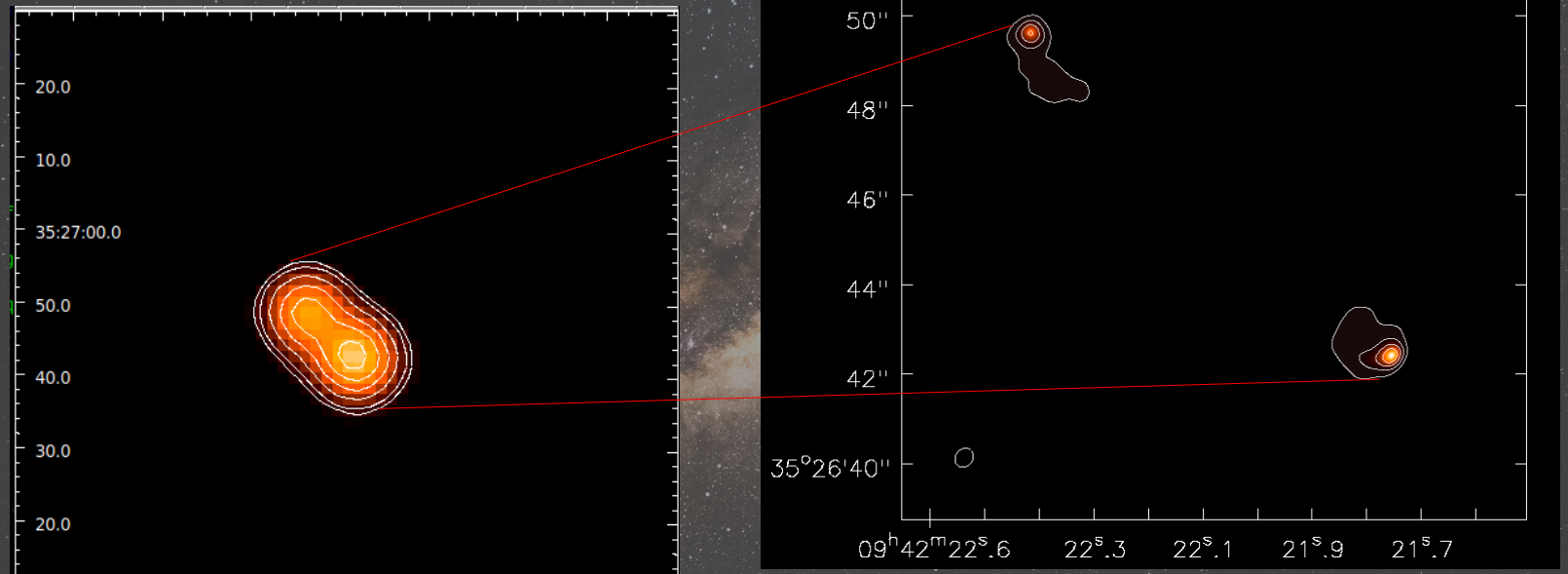


J104029.9+295757





Accidental gem found while looking through LC8_030 data: J094222+352644



Summary and future plans:

- We were able to succesfully run the newest pipeline using Poznan Supercomputer Center machines (not without extensive help of the team – thank you!)
- The newest software makes obtaining data for desired objects and imaging them much easier than it used to be!
- We would be happy to share computational resources with anyone interested in LOFAR data processing

As for personal scientific goals:

- Definitely follow-up for proposed compact sources!
- New project on NGC5905 LC20_036 – data almost ready – hope to present it at LFM2025

Thank you!