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Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

Updates on Radio U-Net: application to the full LoTSS survey

Chiara Stuardi
INAF-IRA
with
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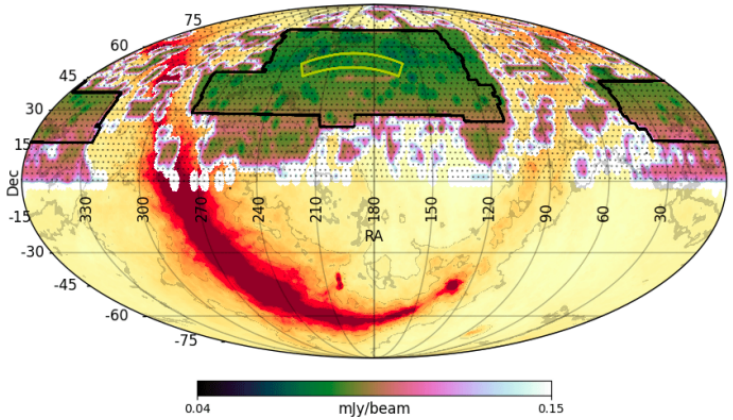
F. Braga (UniBo) F. Vazza (UniBo), A. Botteon (INAF-IRA)

Spoke 3 II Technical Workshop, Perugia May 26-29, 2025

Scientific Rationale

Current radio surveys are challenging our detection and cataloging strategies

- large data size (PB/year)



LOFAR Two Metre Sky Survey DR2
@150 MHz [LOTSS,Shimwell+22]

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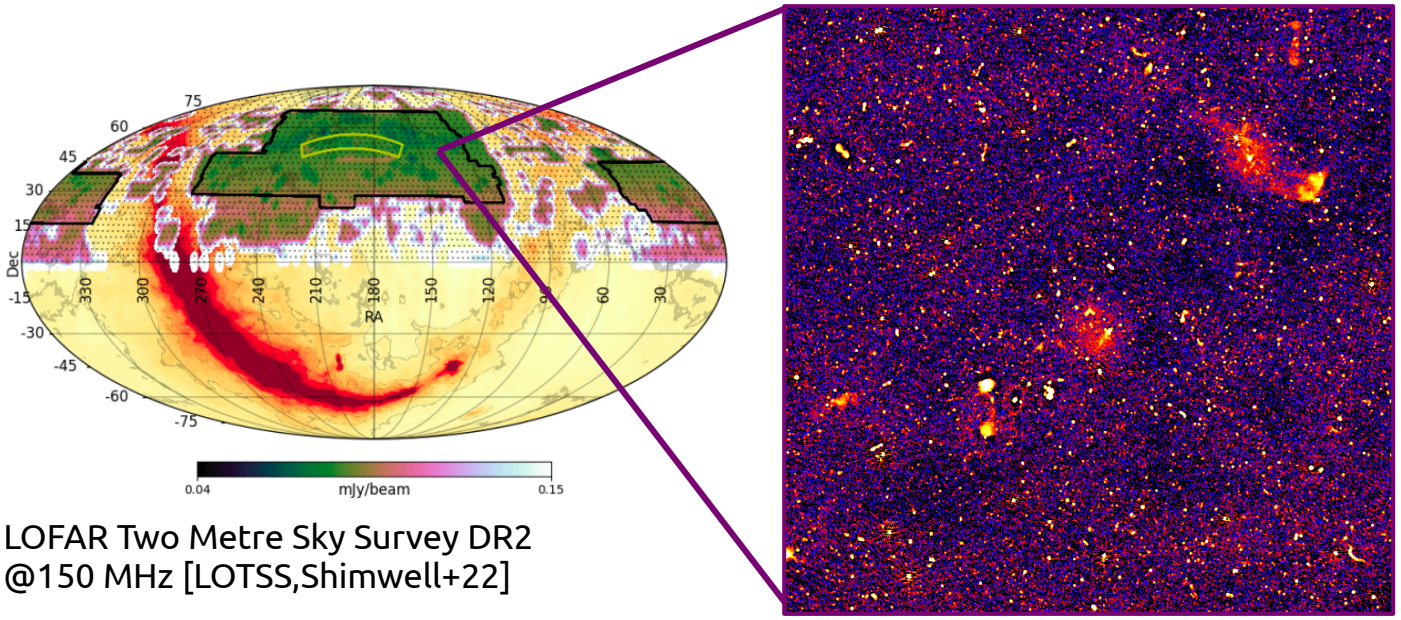
- non-Gaussian noise and imaging artifacts



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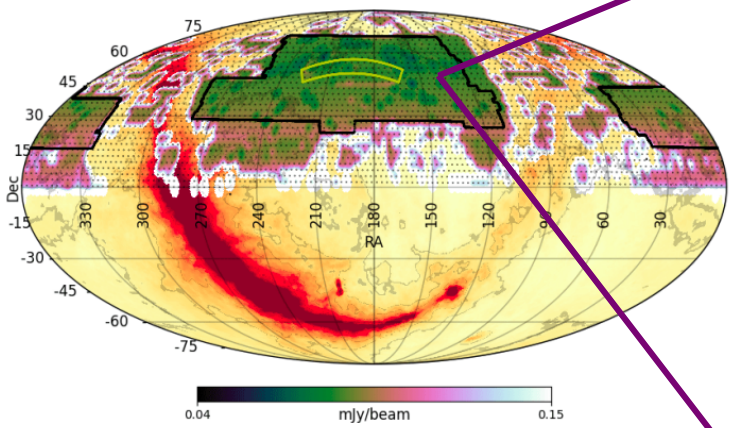

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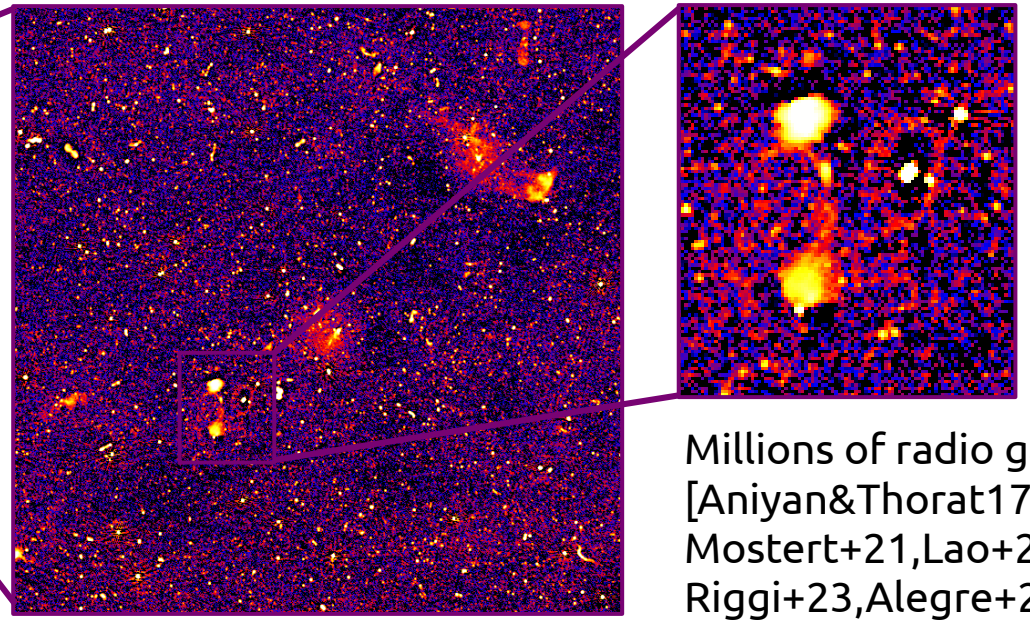

Millions of radio galaxies [Aniyan&Thorat17,Lukic+18, Mostert+21,Lao+23, Riggi+23,Alegre+24,Gupta+24 Riggi+24,Slijepcevic+24]

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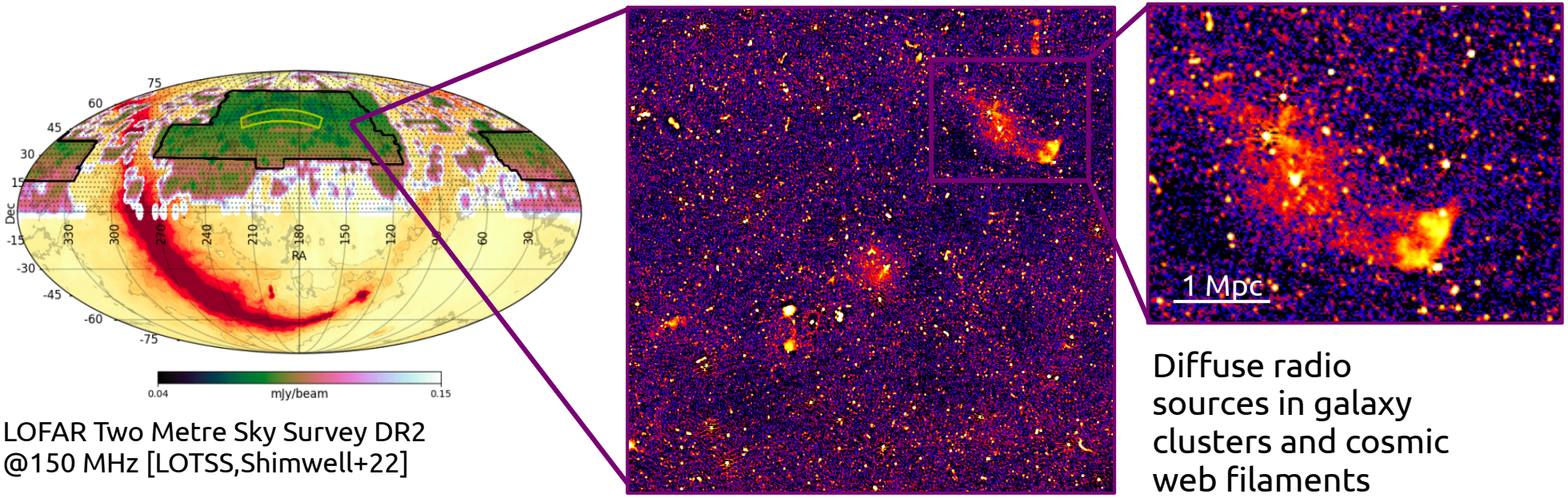

LOFAR Two Metre Sky Survey DR2 @150 MHz [LOTSS,Shimwell+22]

Diffuse radio sources in galaxy clusters and cosmic web filaments

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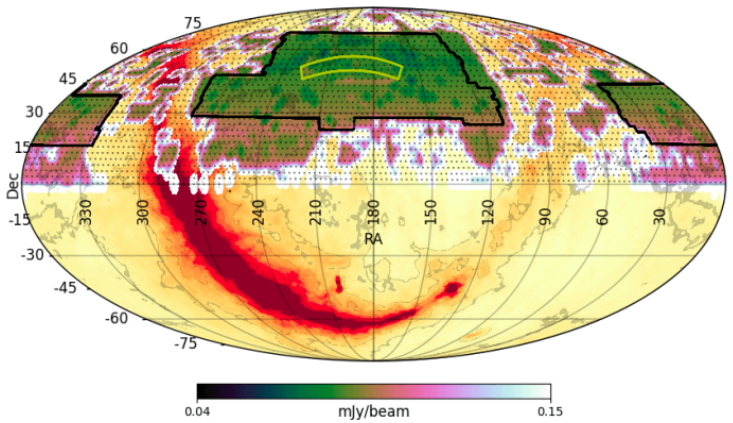
- rare sources with complex and irregular morphology

  → new strategies to minimize human intervention in data processing



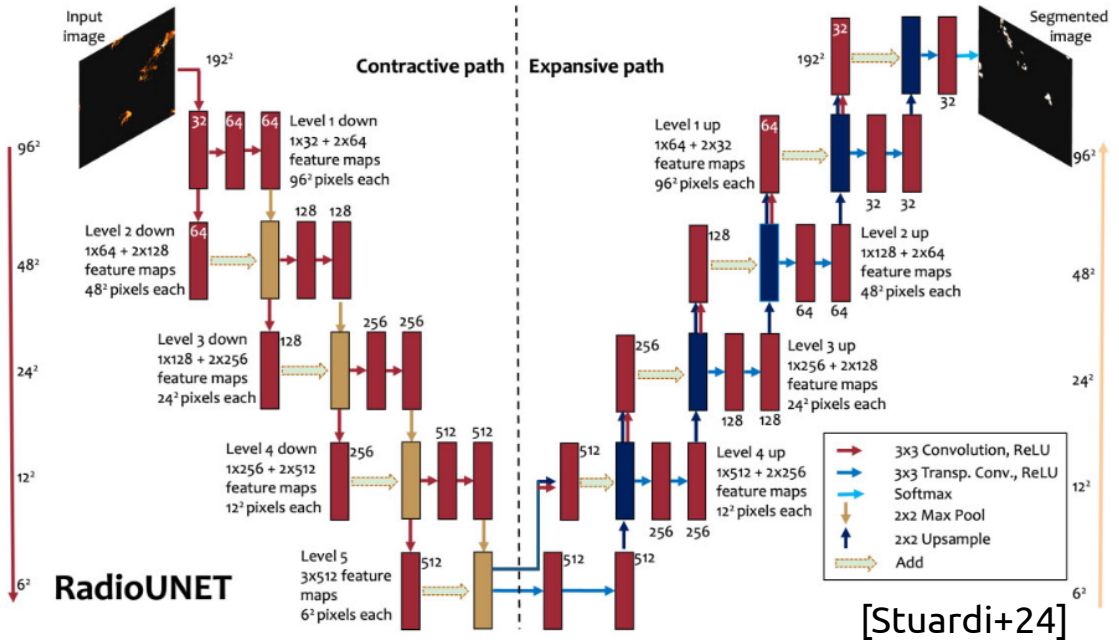
LOFAR Two Metre Sky Survey DR2
@150 MHz [LOTSS,Shimwell+22]

Square Kilometre Array, operational in 2030

Technical Objectives, Methodologies and Solutions

Objective: Developement and distribution of a machine leraning tool for detection of diffuse emission in radio surveys

- **U-Net architecture adopted perform fast segmentation of large datasets**



[Stuardi+24]

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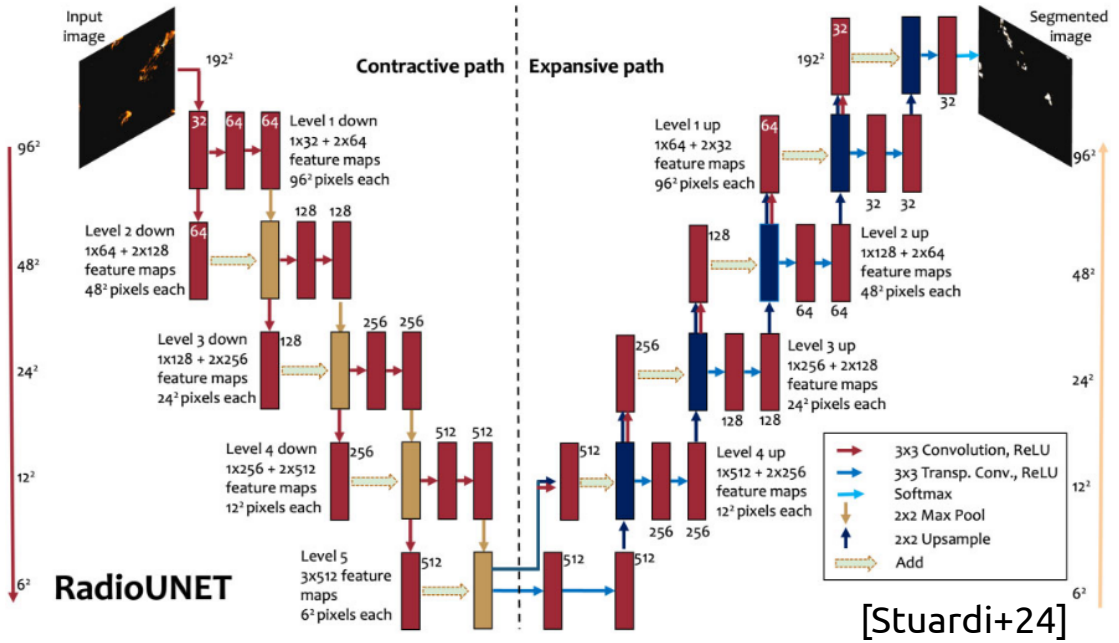

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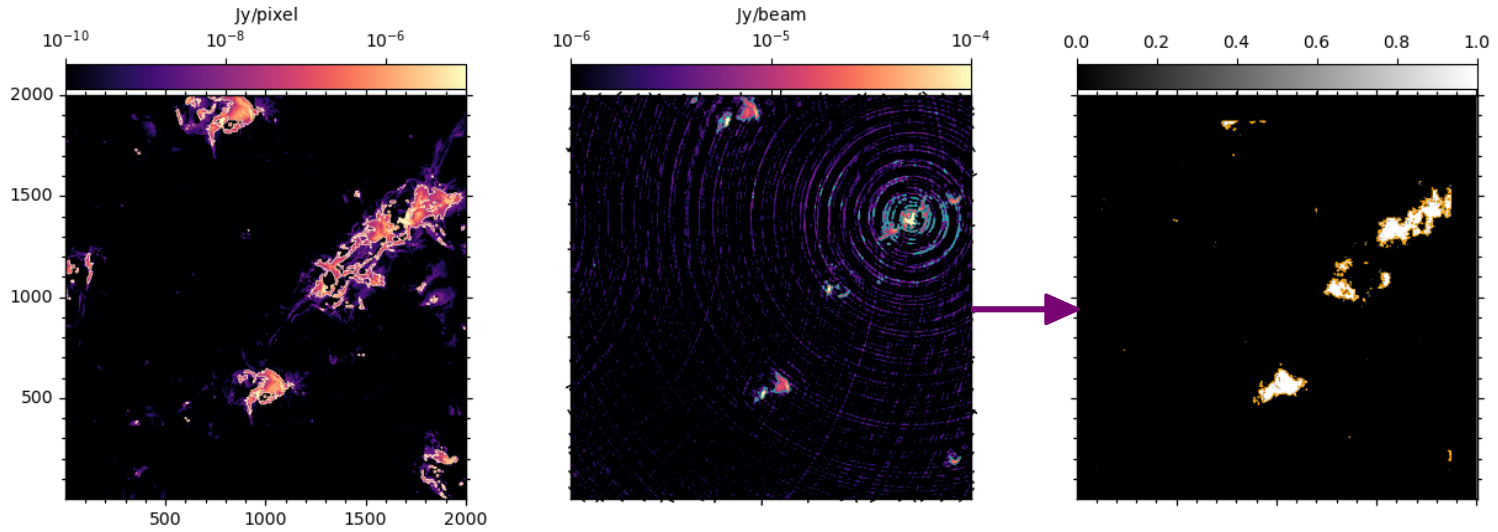
- **Supervised learning with trainig on comological simulations** [Gheller&Vazza22]



Sky image – Reference mask | Input image | Output segmented image

Technical Objectives, Methodologies and Solutions

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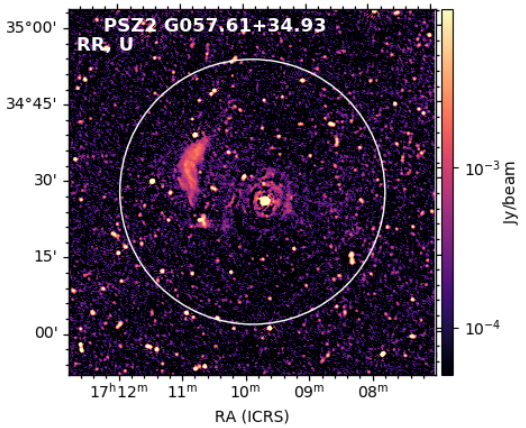
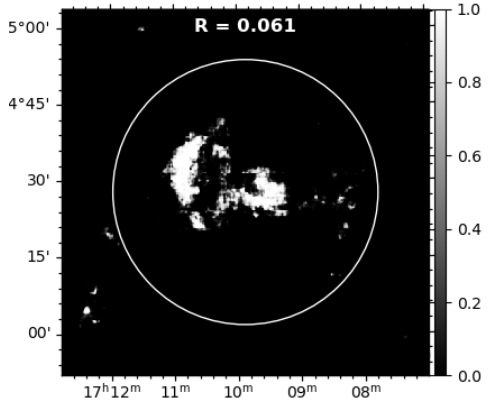
- **Application and performance verification on LOFAR Two Metre Sky Survey (LoTSS)**



LoTSS image



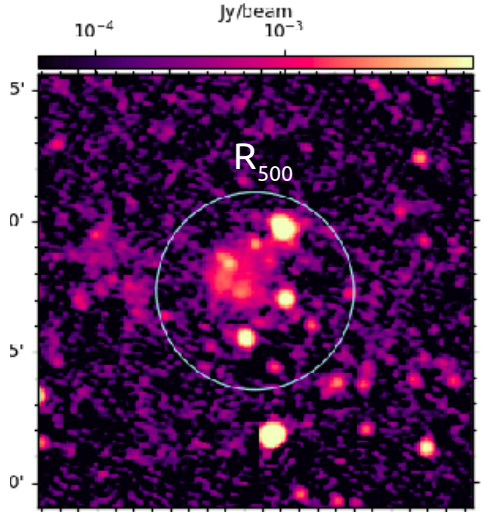
Radio U-Net segmented image

Main Results

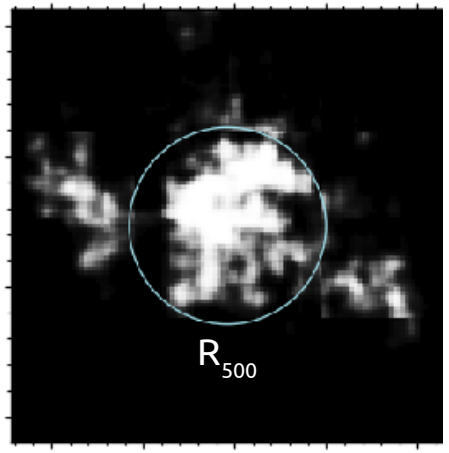
Paper published on MNRAS (KPI) ✓
+ follow-up A&A letter published
Private code on Spoke 3 GitHub 100%

Main Results

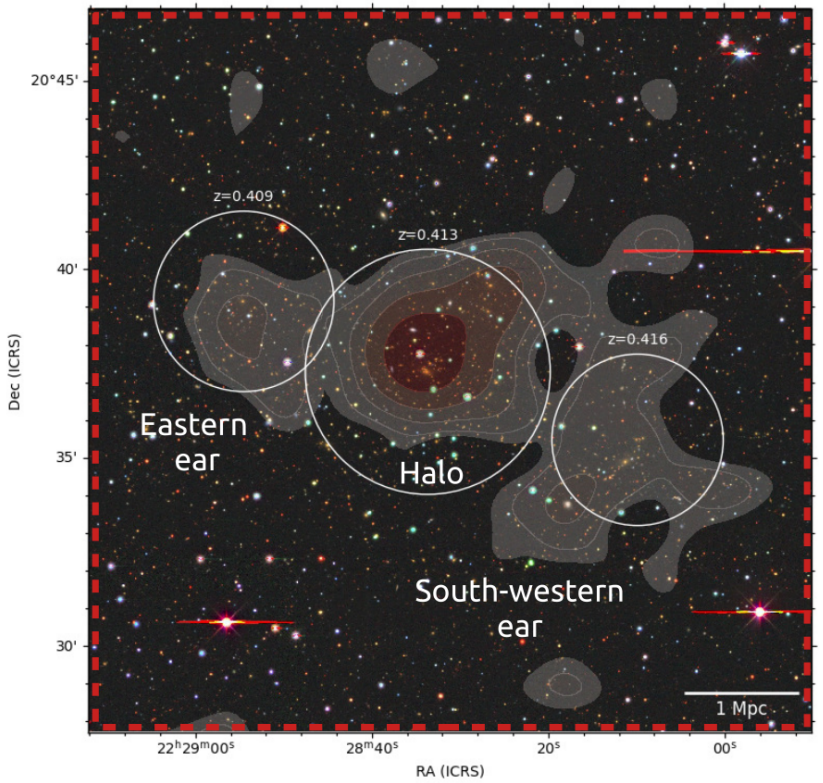
LoTSS data



Radio U-Net segmented

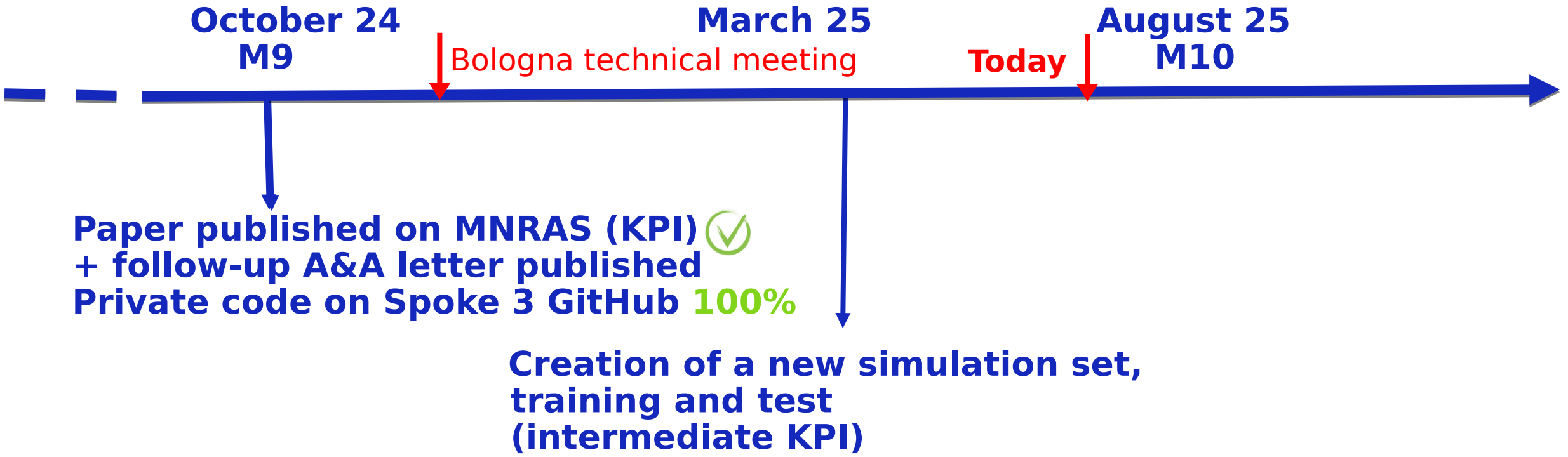


Detection of diffuse radio emission beyond galaxy clusters and below classical detection limits

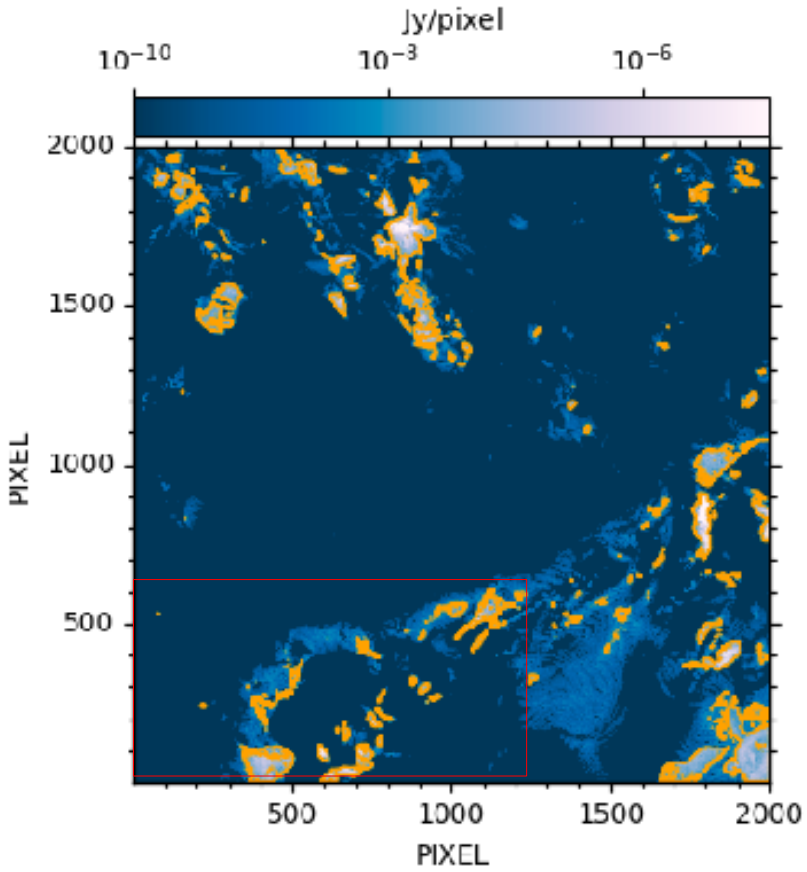


[Stuardi+25]

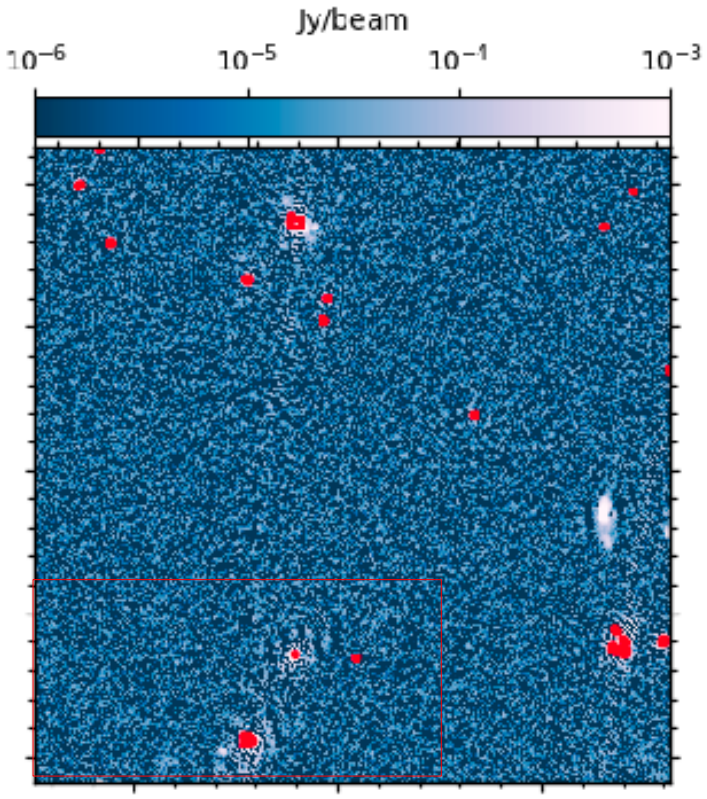
Main Results



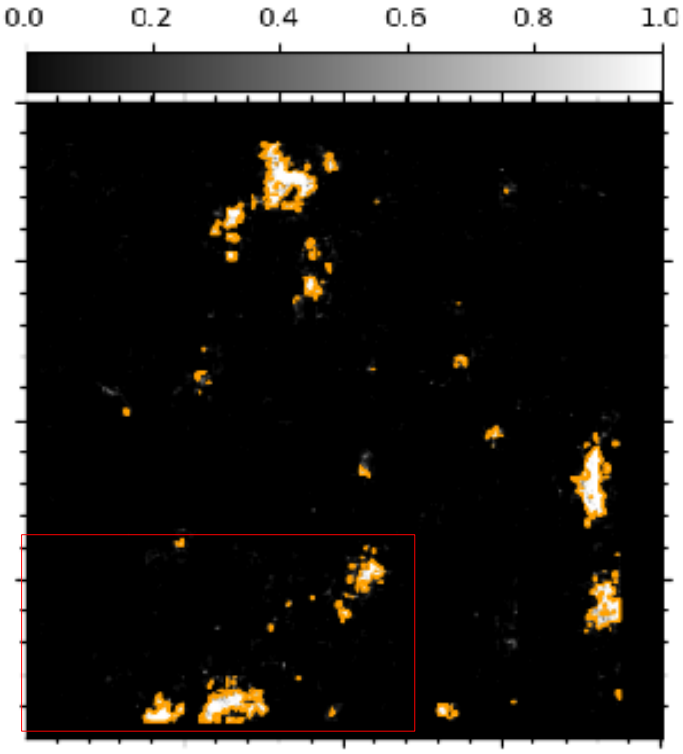
Main Results



Reference mask (no AGN)



Input image (with AGN)



Output segmented image

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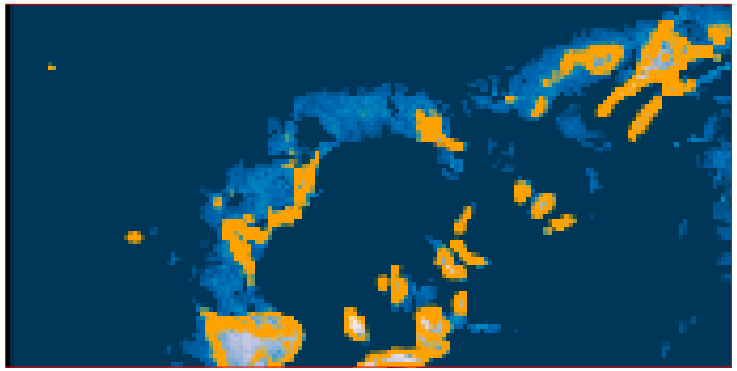

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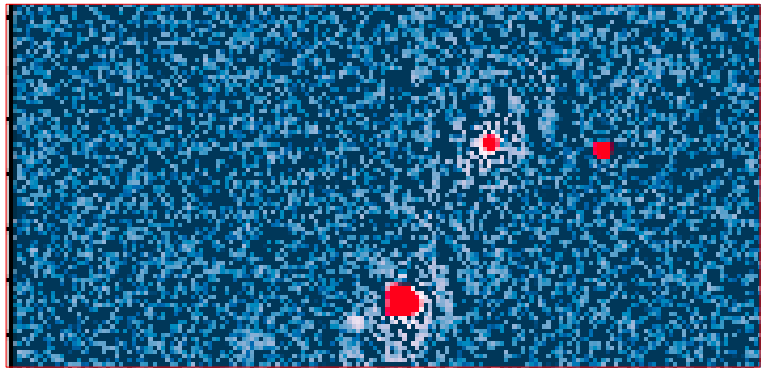

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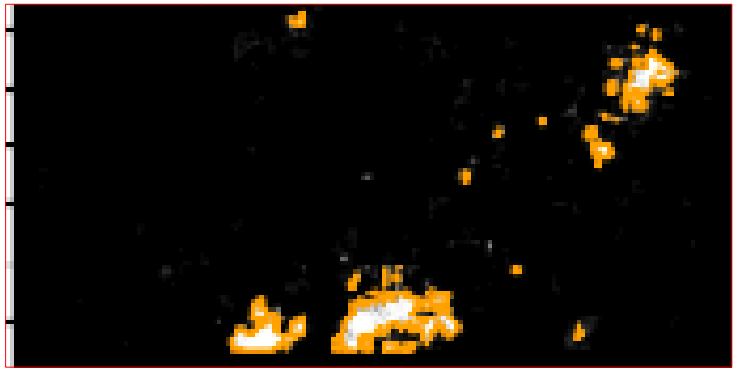

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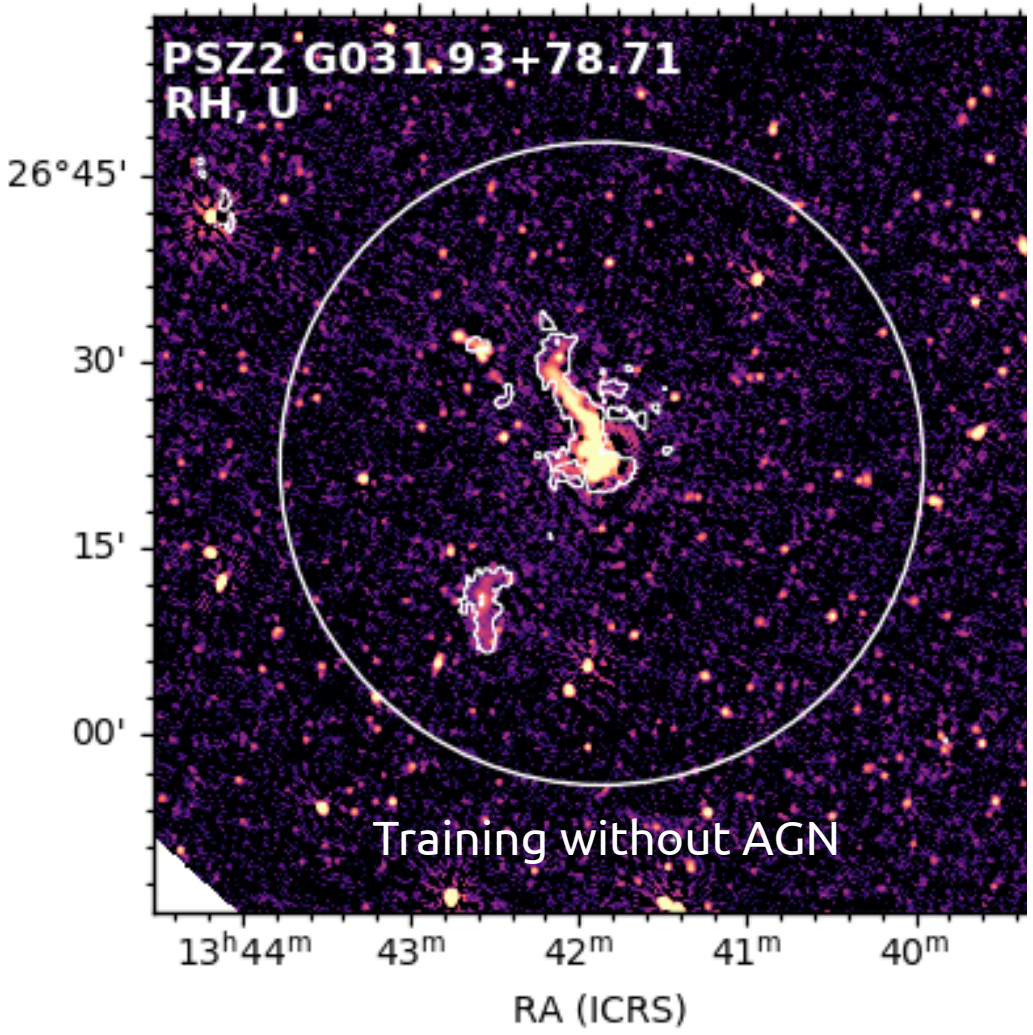

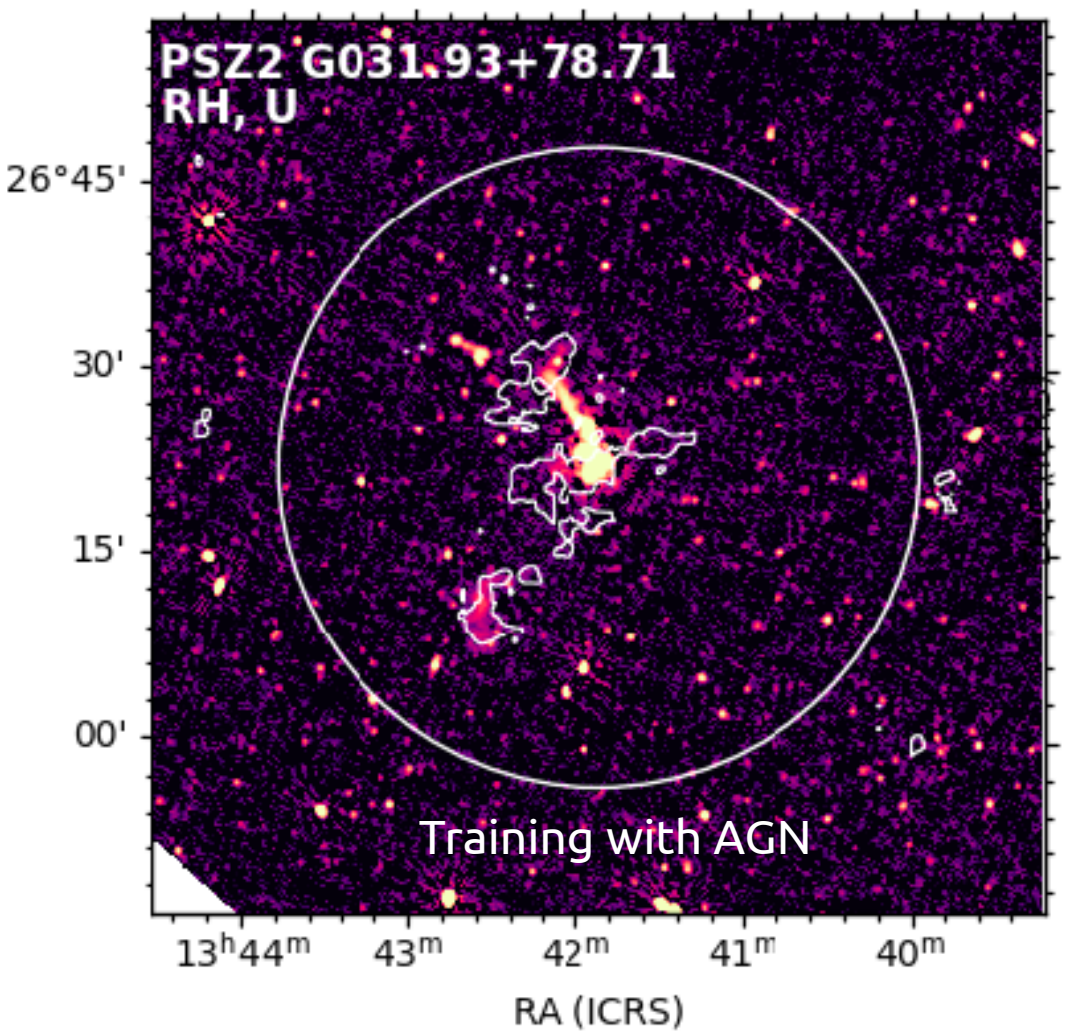

Final Steps

October 24
M9

March 25

Bologna technical meeting

Today

August 25
M10

Paper published on MNRAS (KPI) ✓
+ follow-up A&A letter published
Private code on Spoke 3 GitHub 100%

Creation of a new simulation set
training and test 100%
(intermediate KPI) ✓

Application of the network
to the LoTSS DR3 and submit paper
(KPI)

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Application of the network
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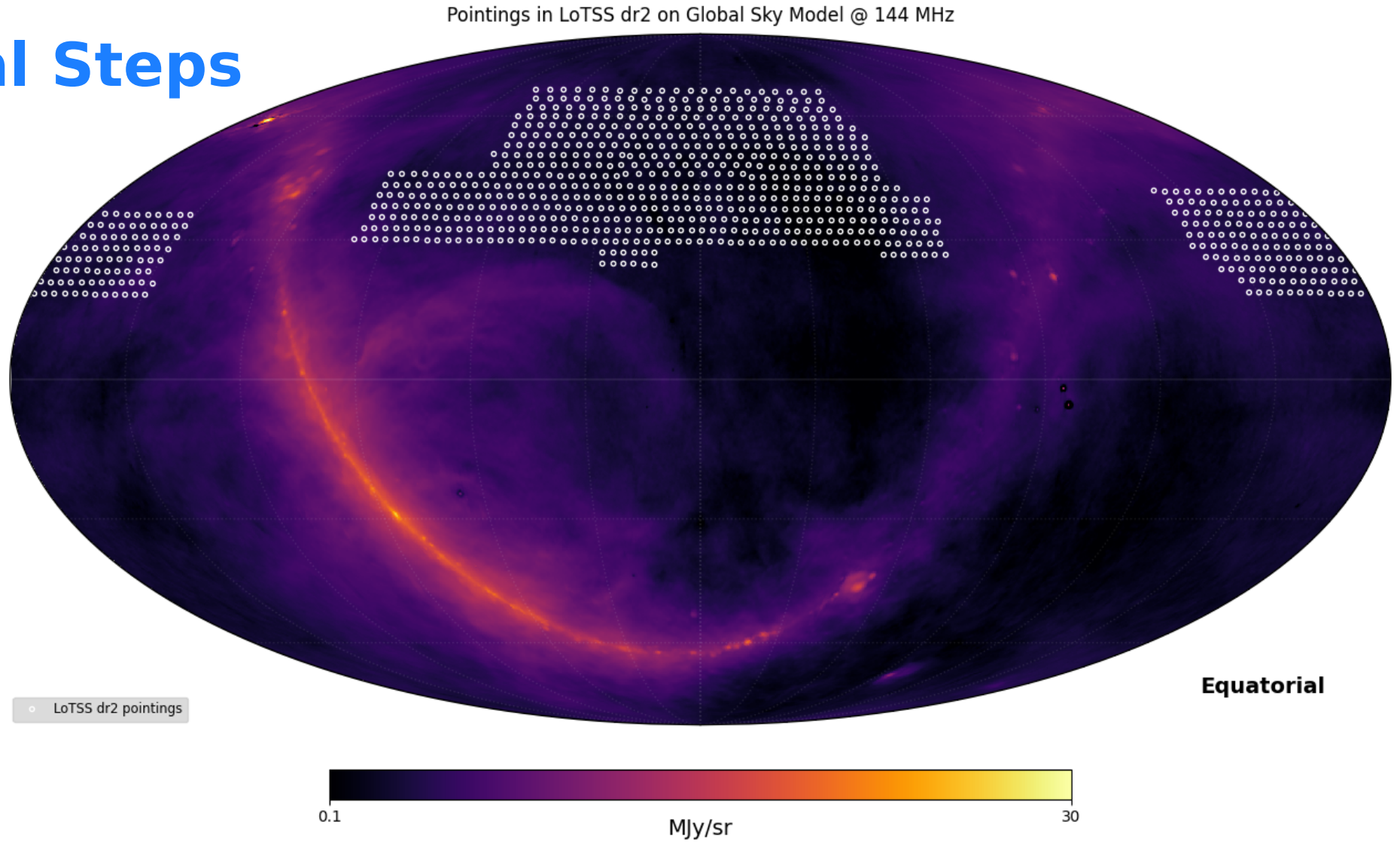
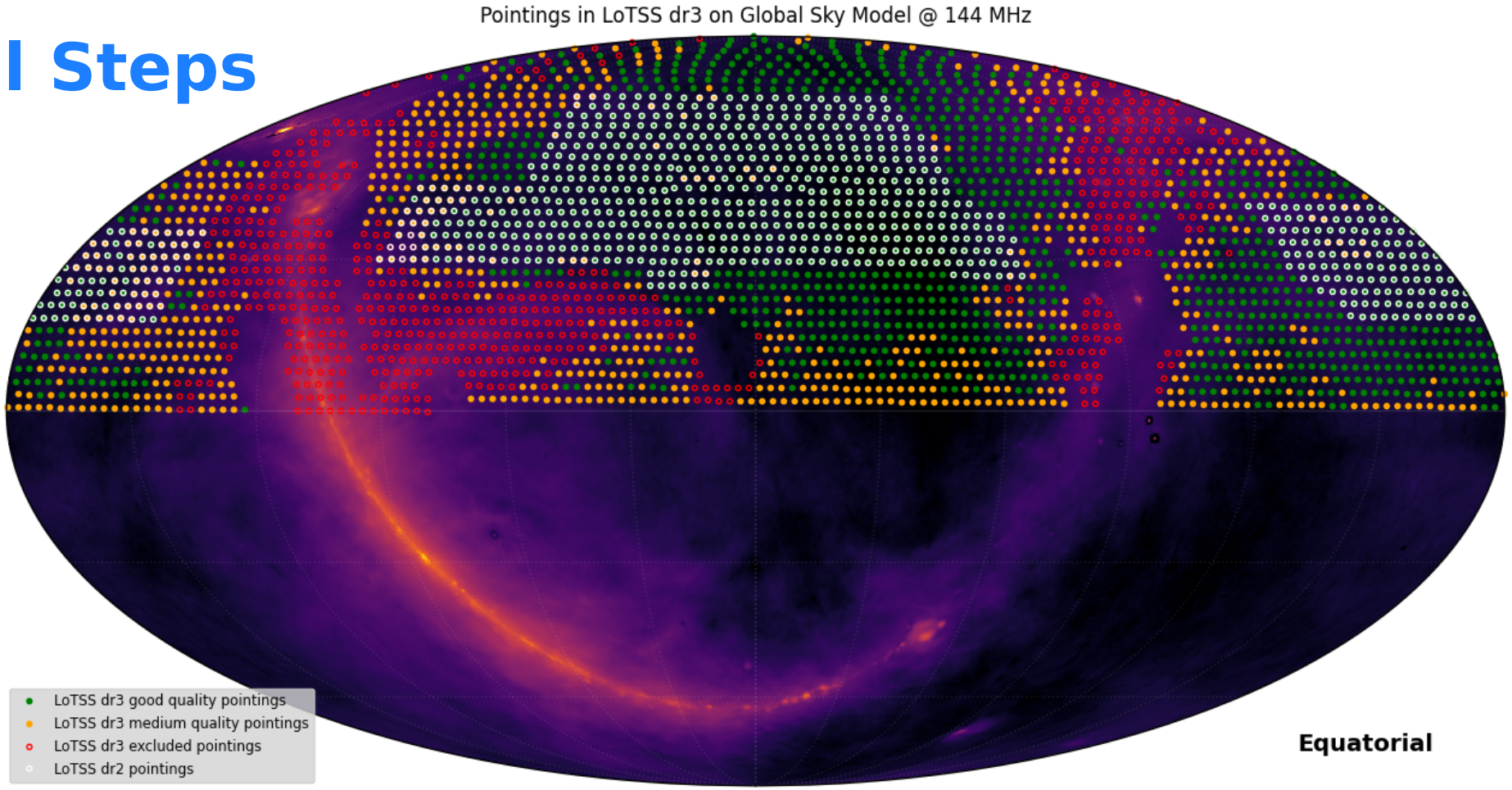
(KPI) 60%

Final Steps

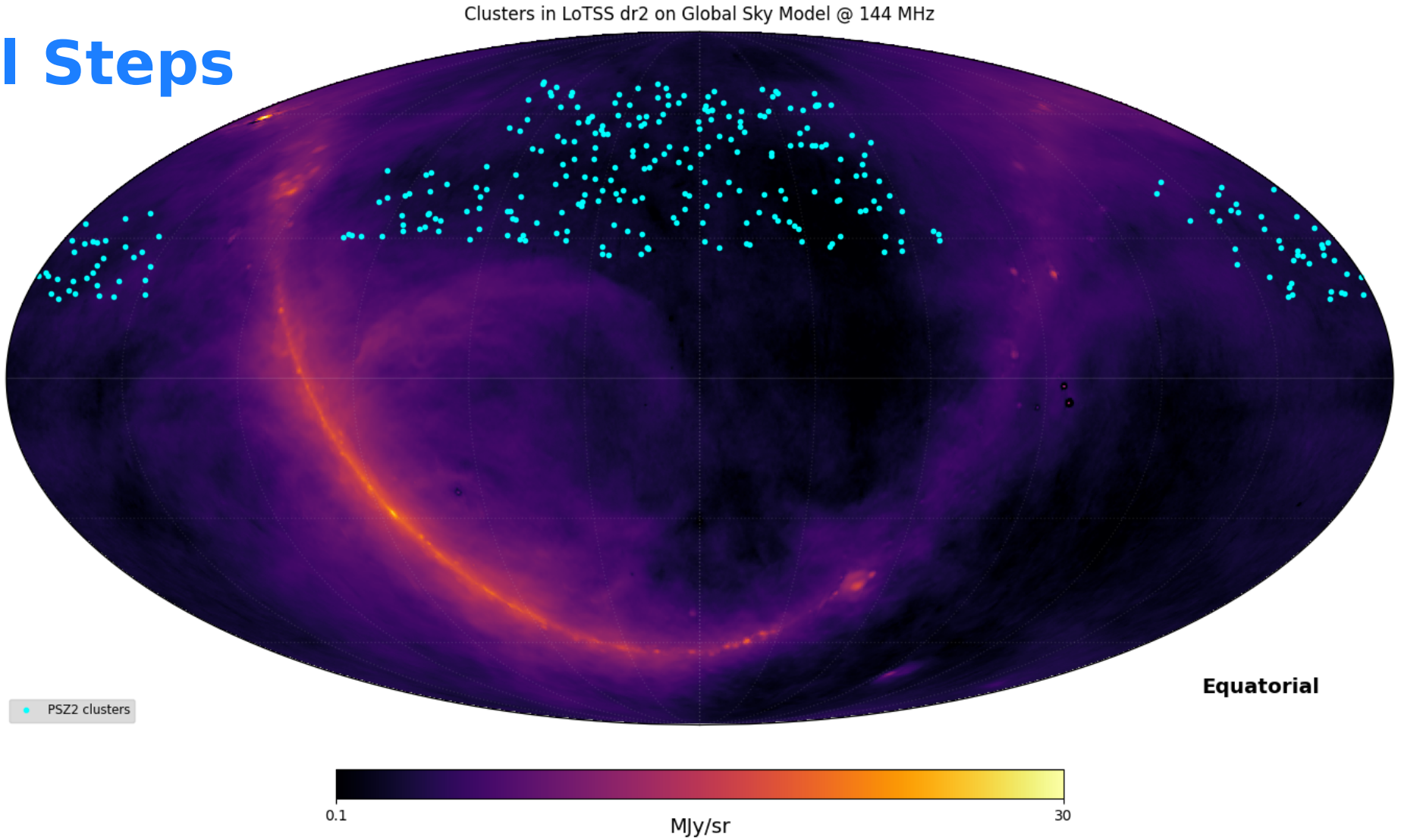

Pointings in LoTSS dr2 on Global Sky Model @ 144 MHz
LoTSS dr2 pointings
Equatorial
0.1
30
MJy/sr

Final Steps

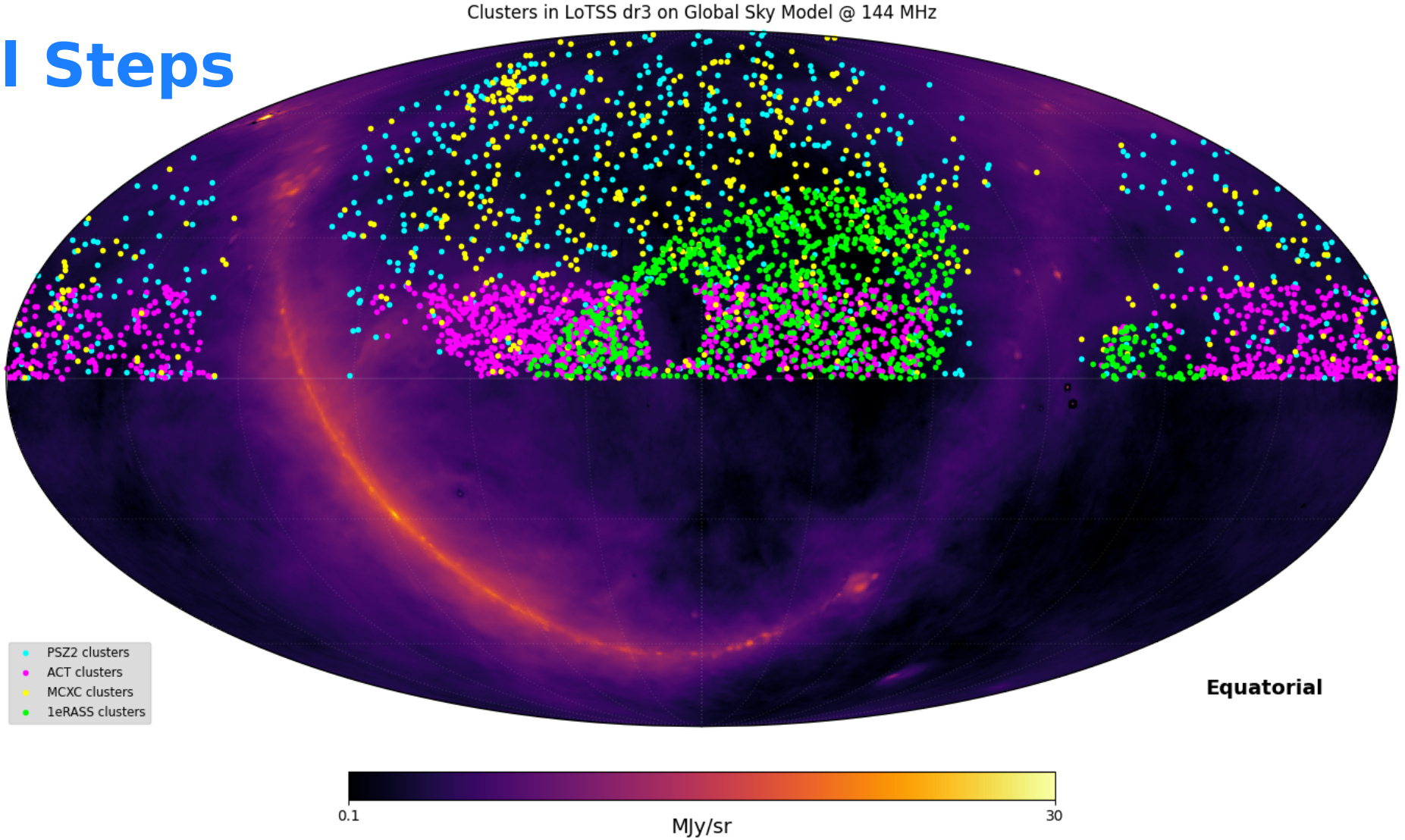


- Adapt the pipeline to process entire pointings
- New problem: Galactic diffuse emission

Final Steps


Clusters in LoTSS dr2 on Global Sky Model @ 144 MHz
PSZ2 clusters
Equatorial
0.1
30
MJy/sr

Final Steps



309 → 3821 clusters

[Stuardi & LoTSS collaboration in prep.]

Final Steps

December 25
M11(?)

Publish the LoTSS dr3 paper, segmentation masks and the code (KPI) 30%

TOTAL: 80%