Radiative signature of large scale magnetized jets

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European Research Council

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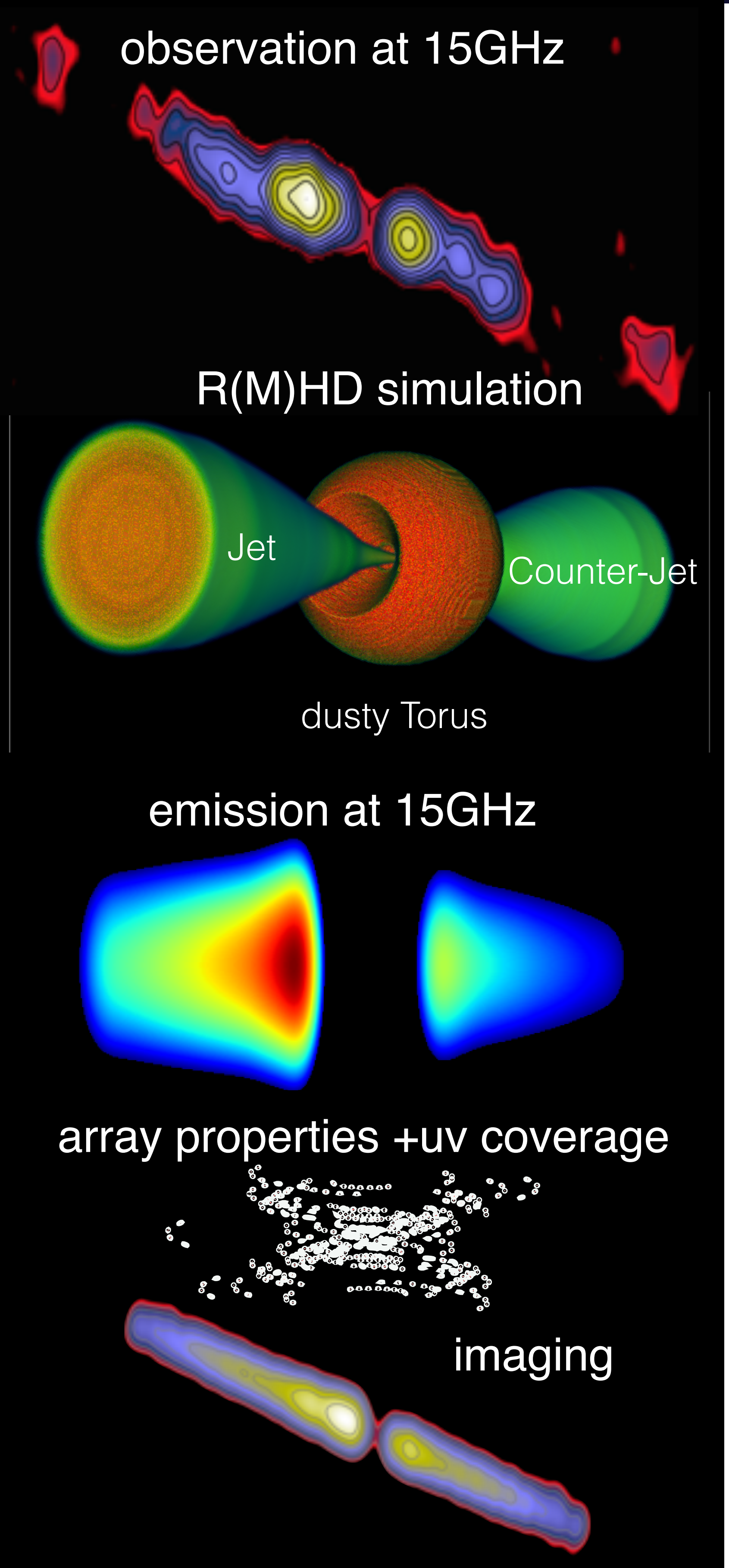
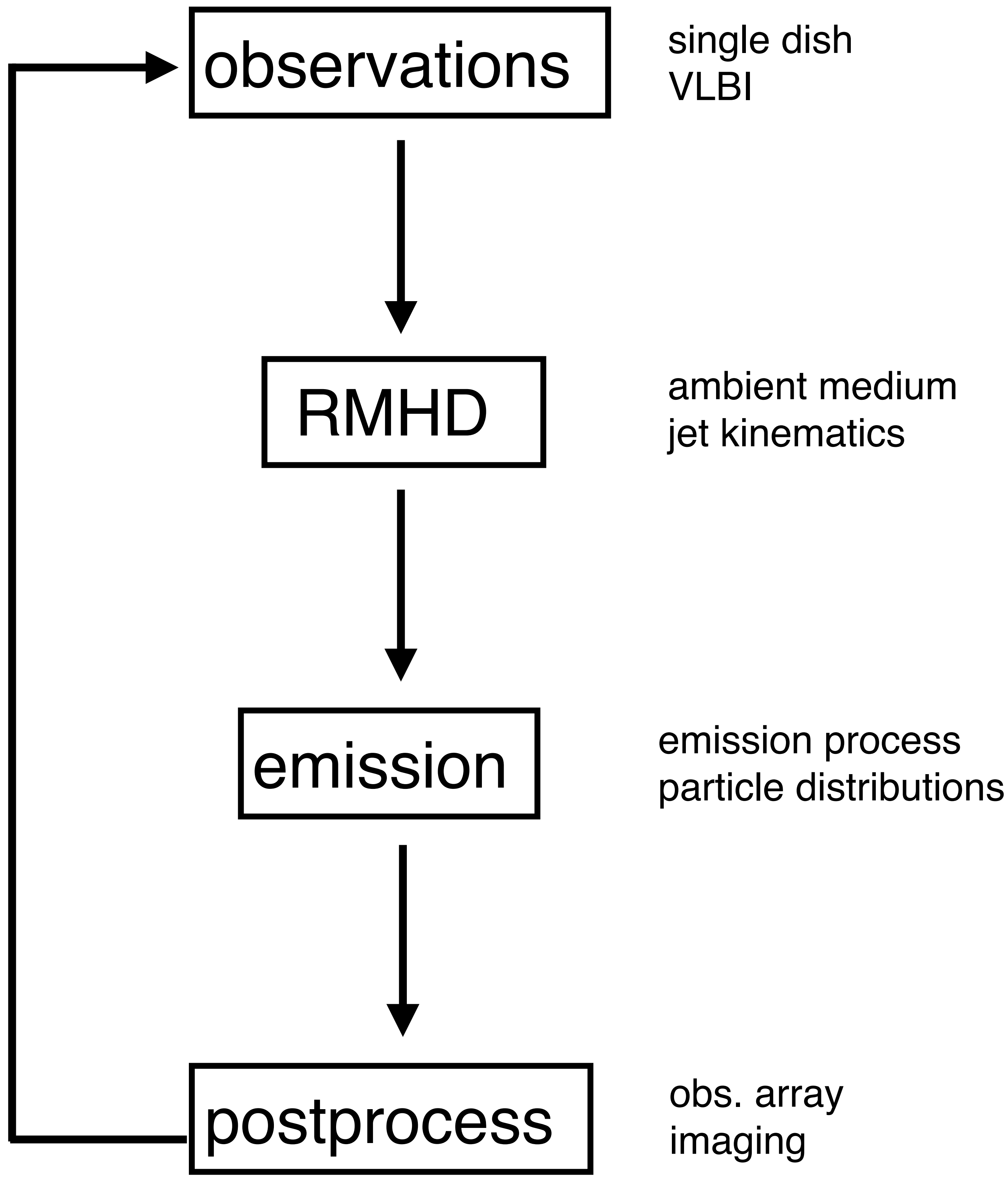
Outline

- Simulation pipeline
- RMHD simulation
- Emission simulation
- Synthetic observation
- Summary/Outlook

Simulation pipeline





Simulations

Ingredients for jet simulations:

Jet model	emission model	synthetic image
(G)RMHD AMR-VAC, BHAC	thermal, non-thermal synchro.py	obs. array & imaging synchro.py

$$
\begin{aligned}
\rho_j &= \text{jet density} \\
\rho_a &= \text{ambient density} \\
\vartheta &= \text{viewing angle} \\
\Gamma &= \text{jet Lorentz factor} \\
\hat{\gamma} &= \text{adiabatic index} \\
B &= \text{jet magnetic field}
\end{aligned}
$$

$$
\begin{aligned}
\epsilon_e &= \text{number ratio} \\
\zeta_e &= \text{energy ratio} \\
\epsilon_b &= \text{mag. field} \\
\epsilon_\gamma &= \text{e}^-\gamma - \text{ ratio} \\
s &= \text{spectral slope}
\end{aligned}
$$

array config

source position

imaging algorithm

Simulations

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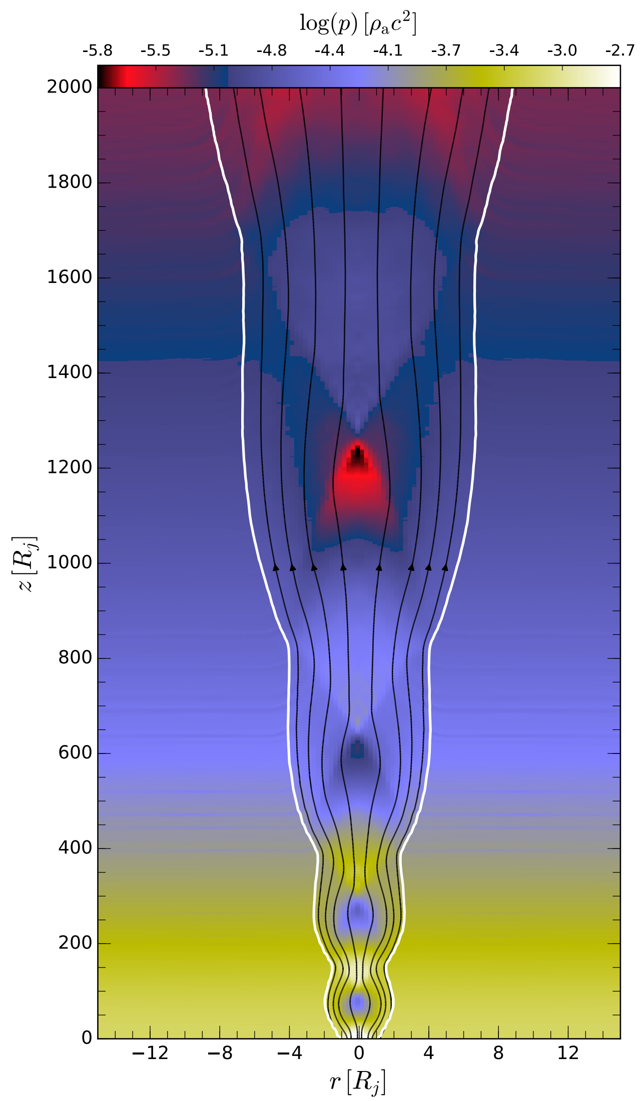
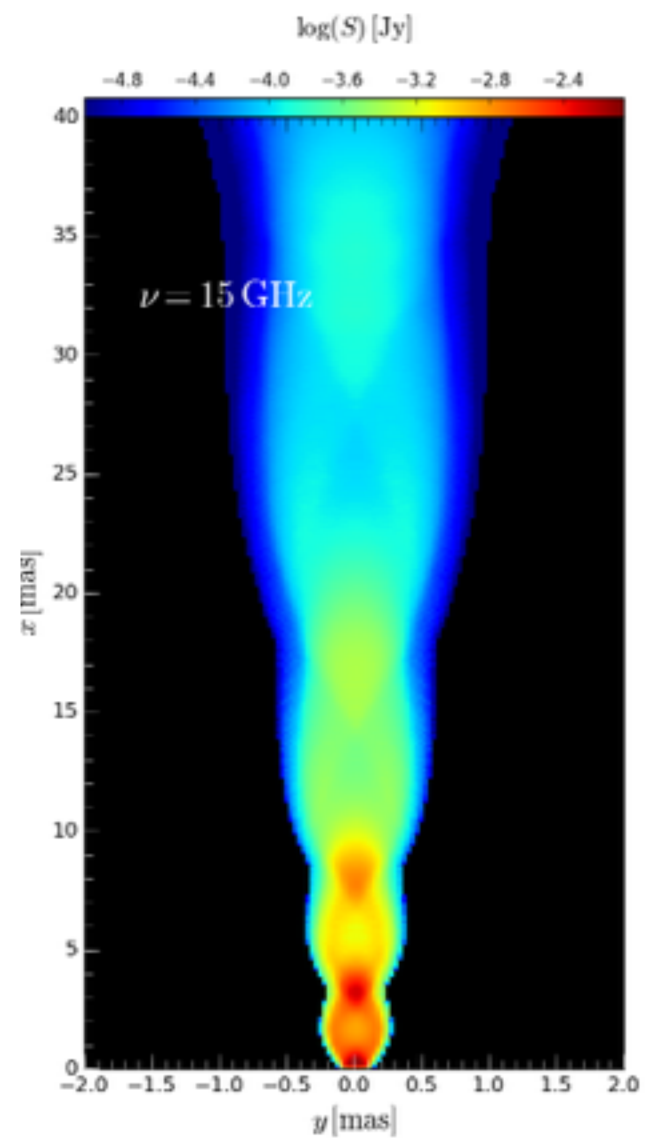
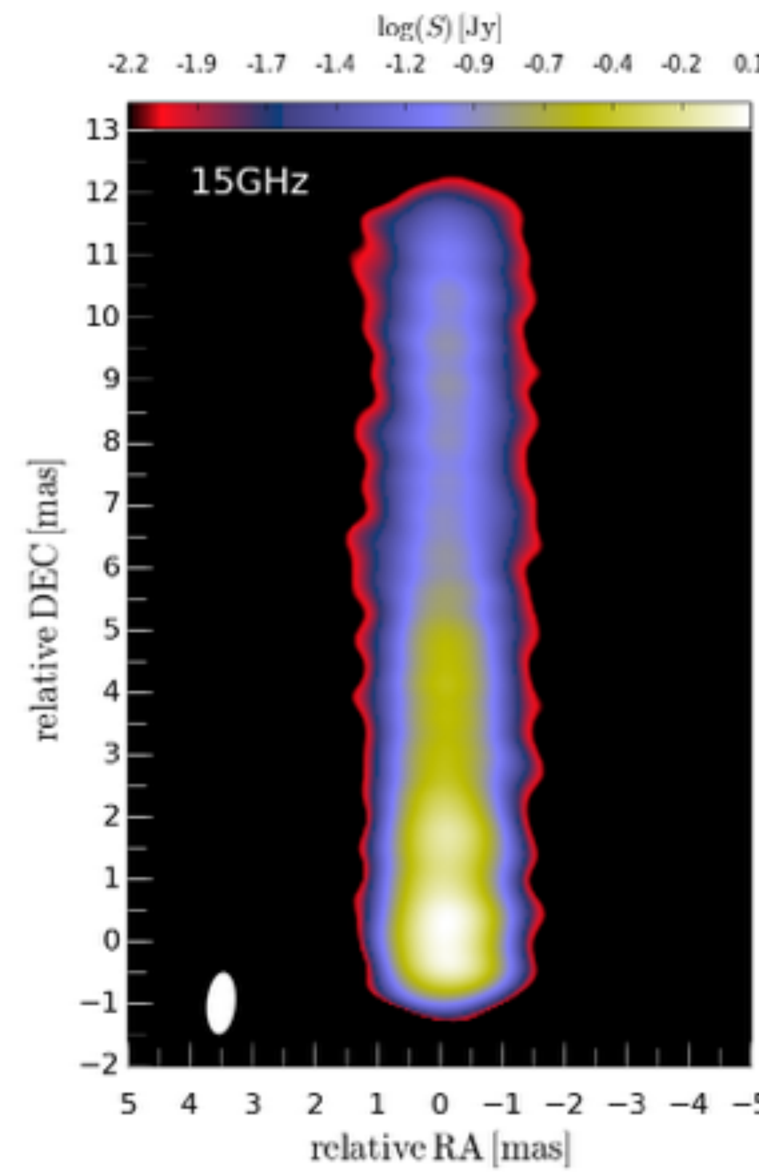
Jet model	emission model	synthetic image
(G)RMHD AMR-VAC, BHAC	thermal, non-thermal synchro.py	obs. array & imaging



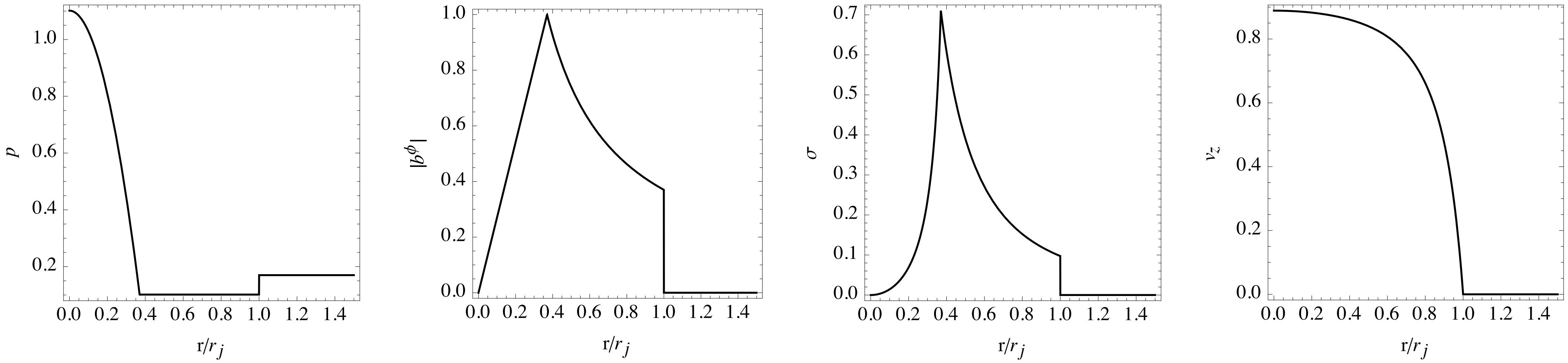




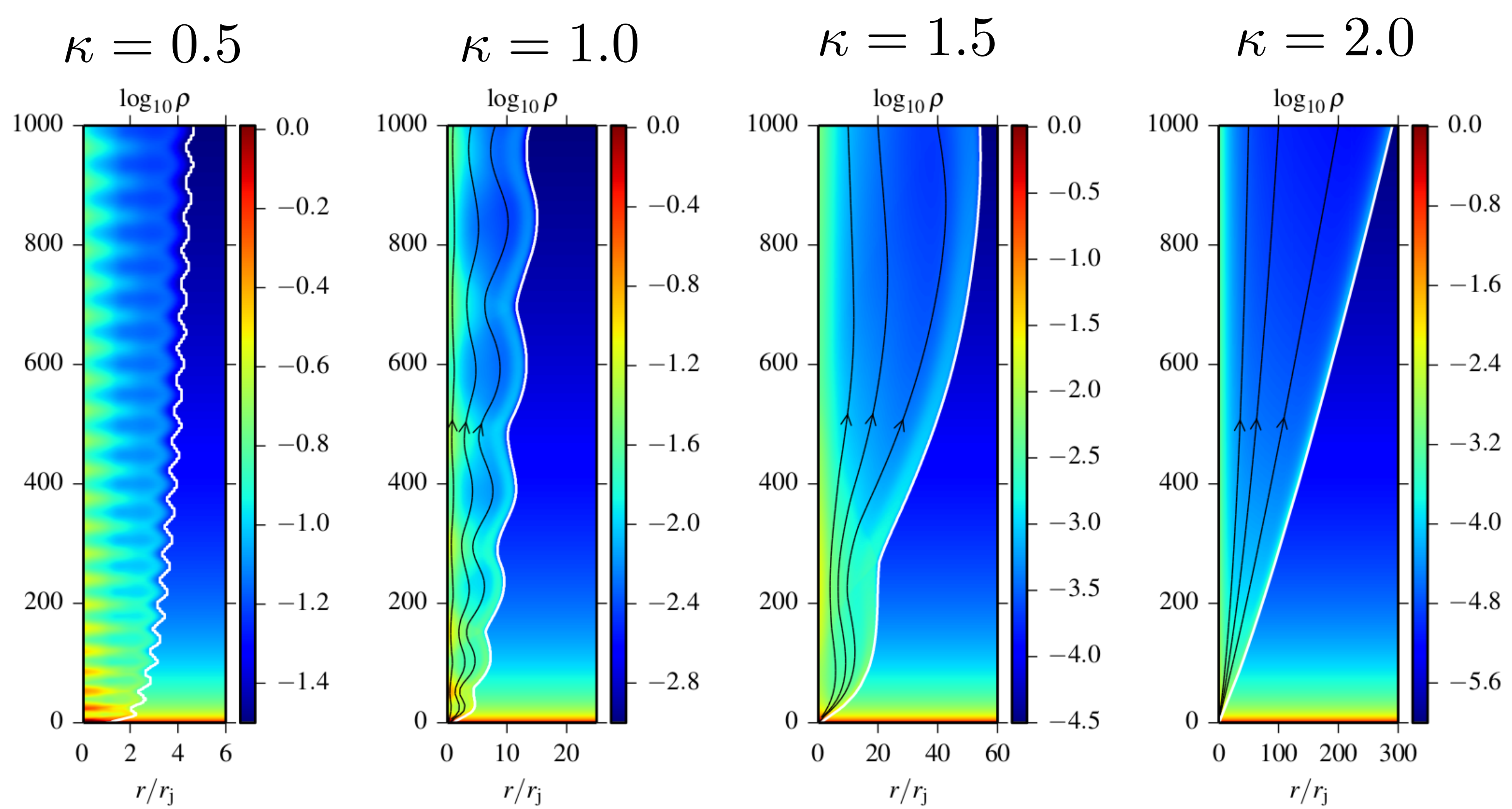
Ref: Fromm et al. 2016

RMHD setup

Spine-Sheath-Jet



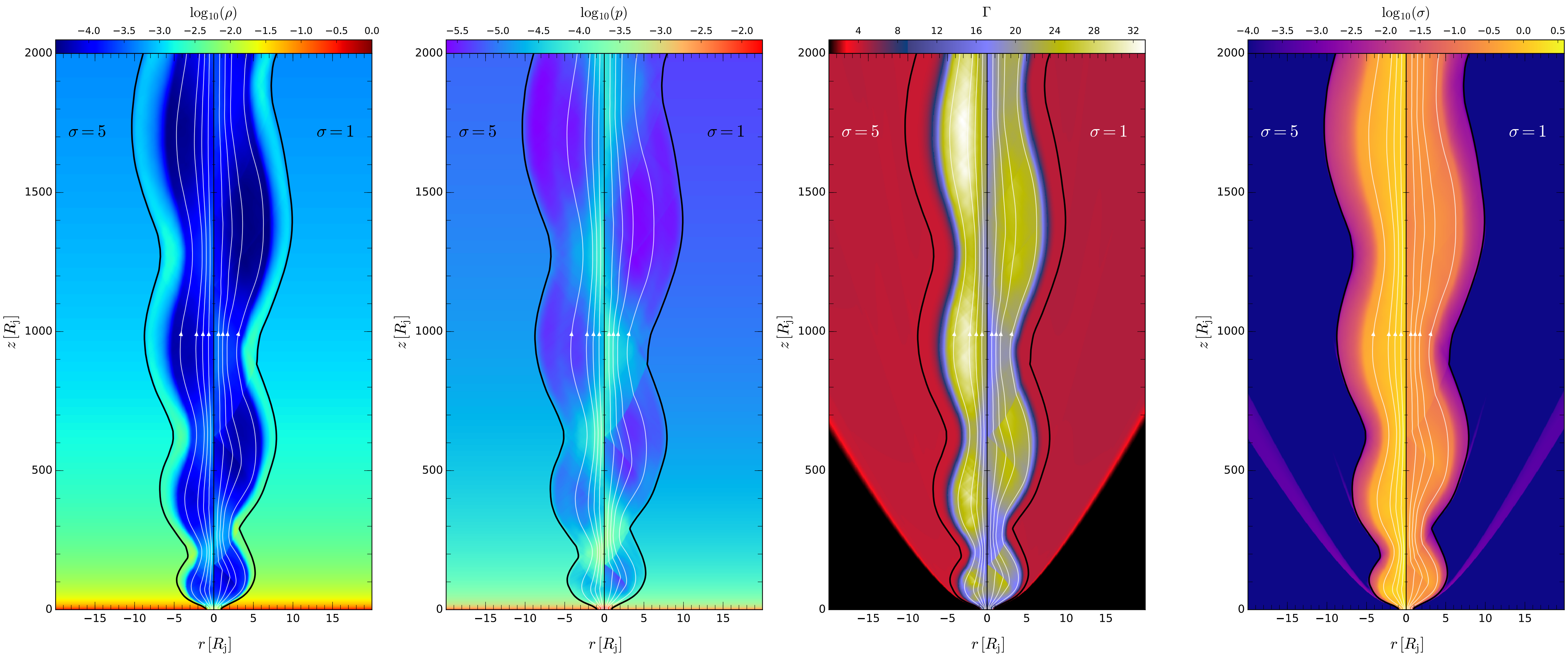
Power-law atmosphere $p \propto r^{-\kappa}$



Ref: Porth & Komissarov 2014, Komissarov et al. 2015

RMHD results

values at jet nozzle $\rho_j = 0.01\rho_a \quad \Gamma = 8 \quad \hat{\gamma} = 13/9 \quad \kappa = 1.0$



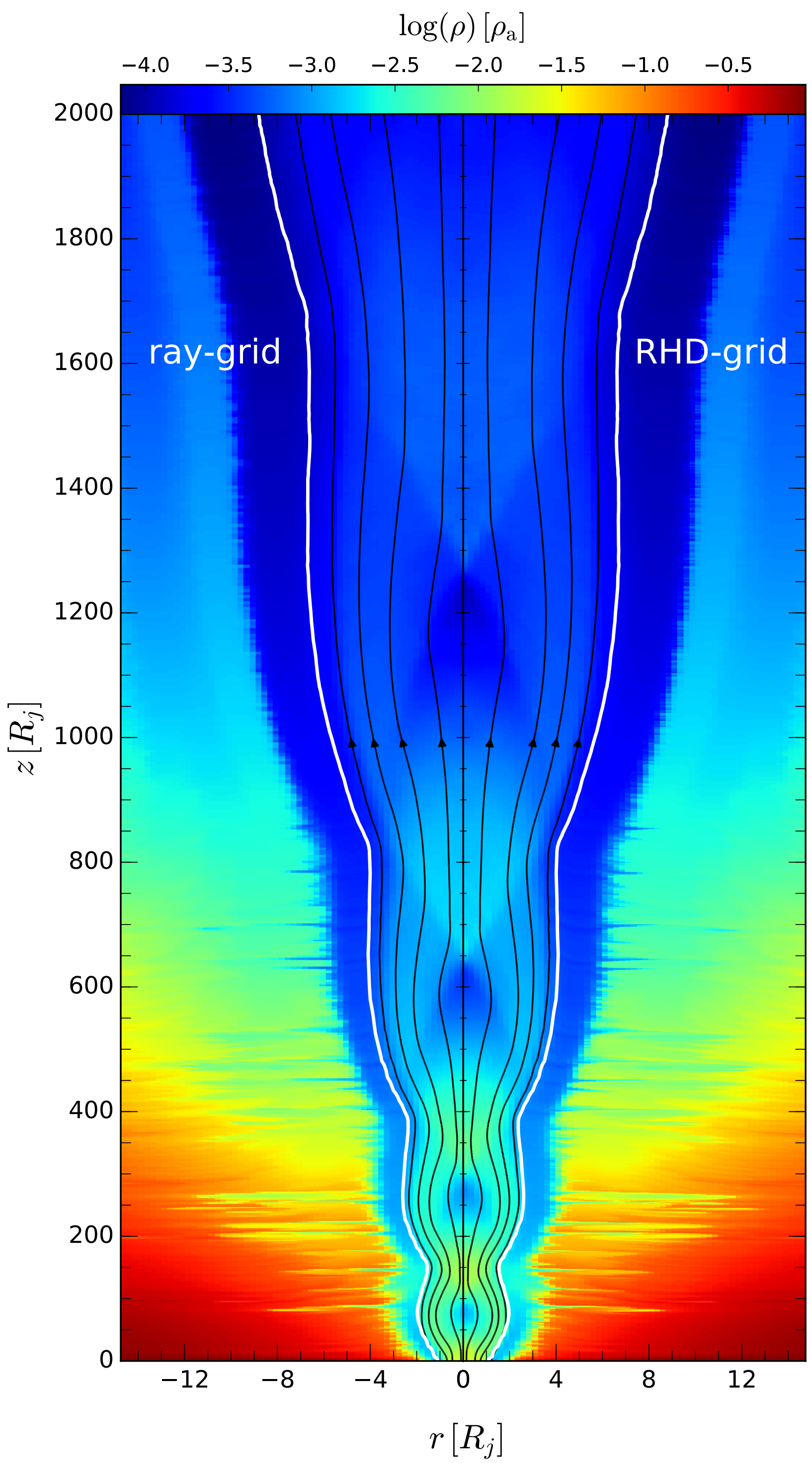
$$\sigma \uparrow \quad \Rightarrow v_a \uparrow \quad \Rightarrow r_{\rm jet} \downarrow \qquad \sigma = b^2/w$$

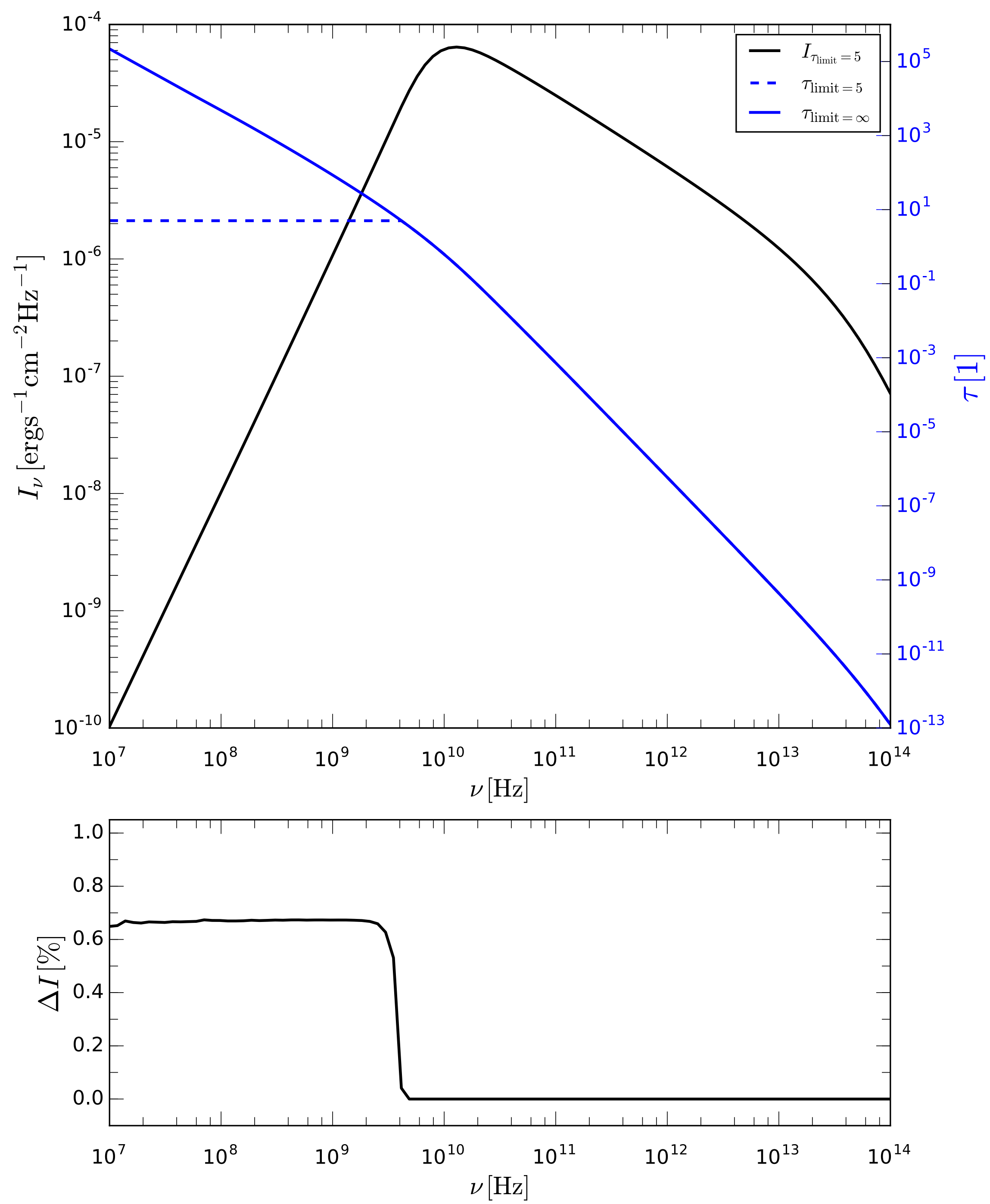
$\sigma \uparrow \quad \Rightarrow$ less recollimation shocks

Emission simulation

re-construct non-thermal particle distribution

3D geometry and radiative transfer (adaptive grid) —> intercell interpolation

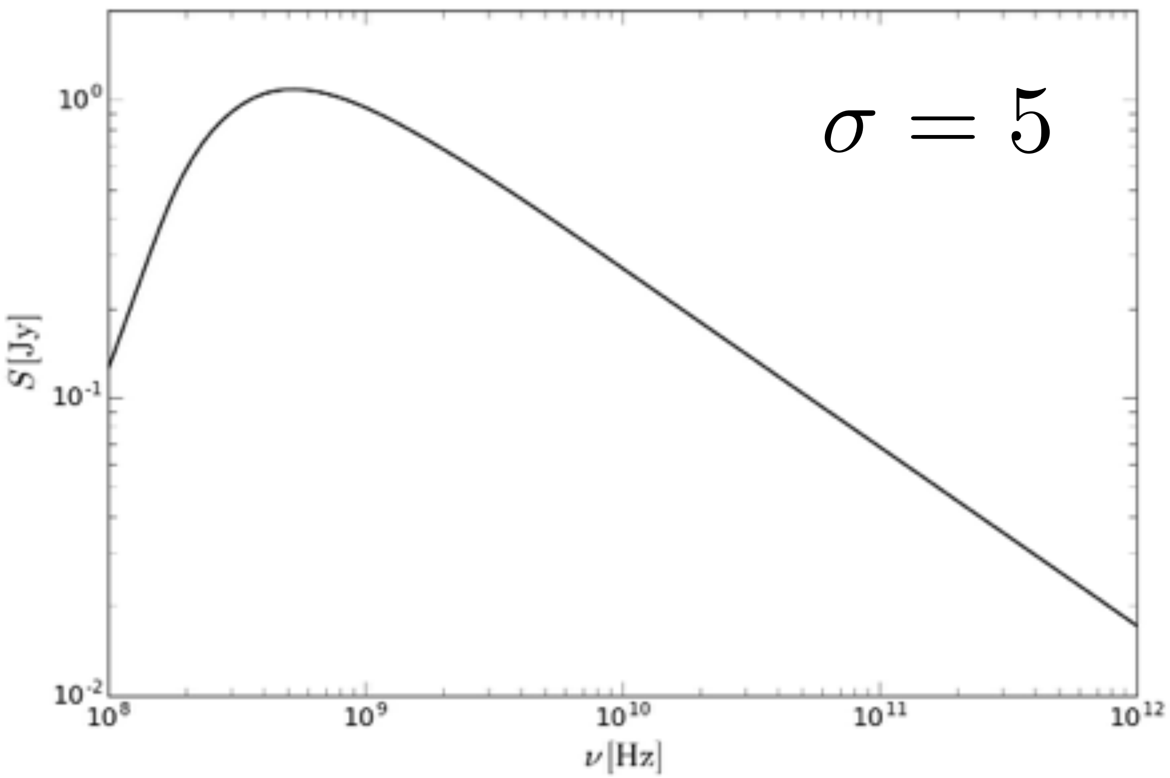


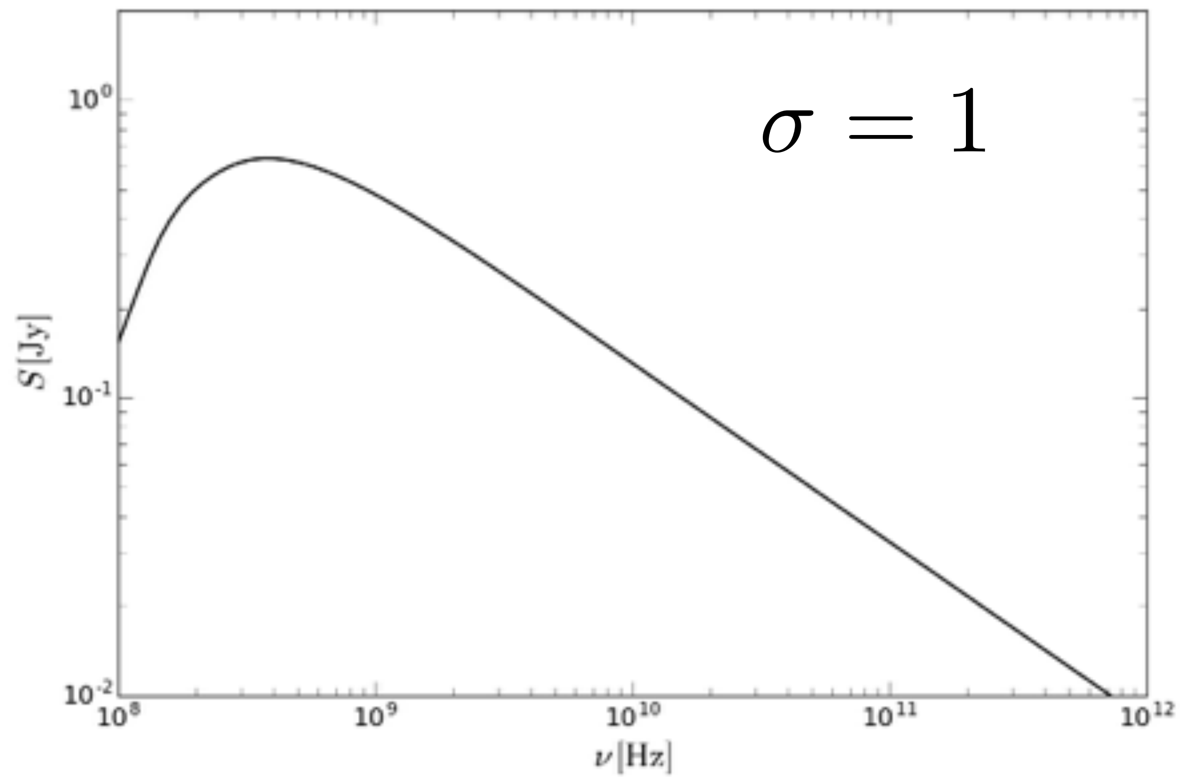


Emission results

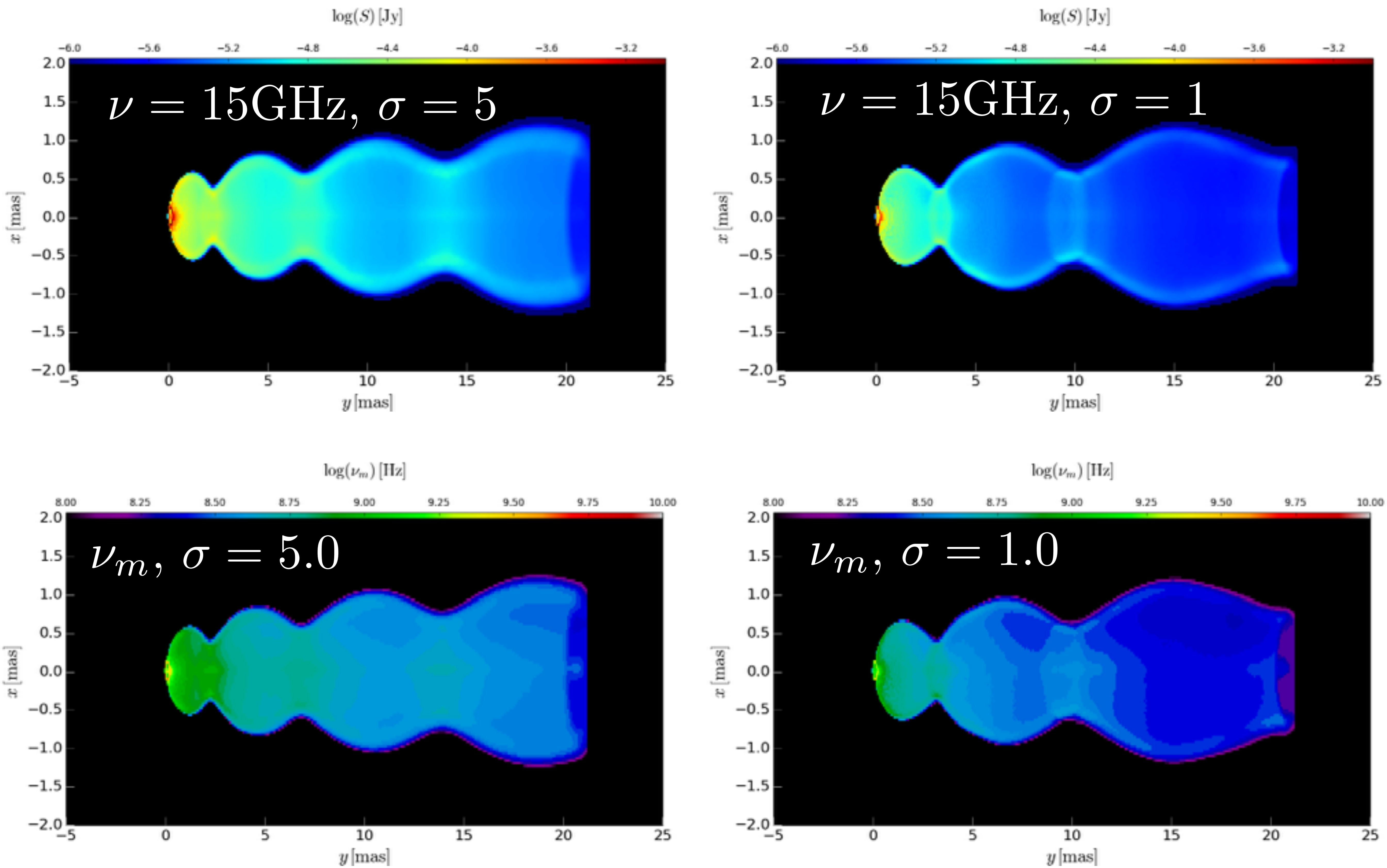
emission parameters used

$$\vartheta = 5^\circ \qquad a_{cc} = 10^6$$
$$\epsilon_e = 0.3 \qquad p = 2.2\,(\alpha = 0.6)$$
$$\epsilon_b = 0.1 \qquad \rho_a = 1.0 \times 10^{-23}\,\mathrm{g/cm^3}$$
$$\zeta_e = 1.0 \qquad R_j = 3 \times 10^{18}\,\mathrm{cm}$$
$$z = 1$$



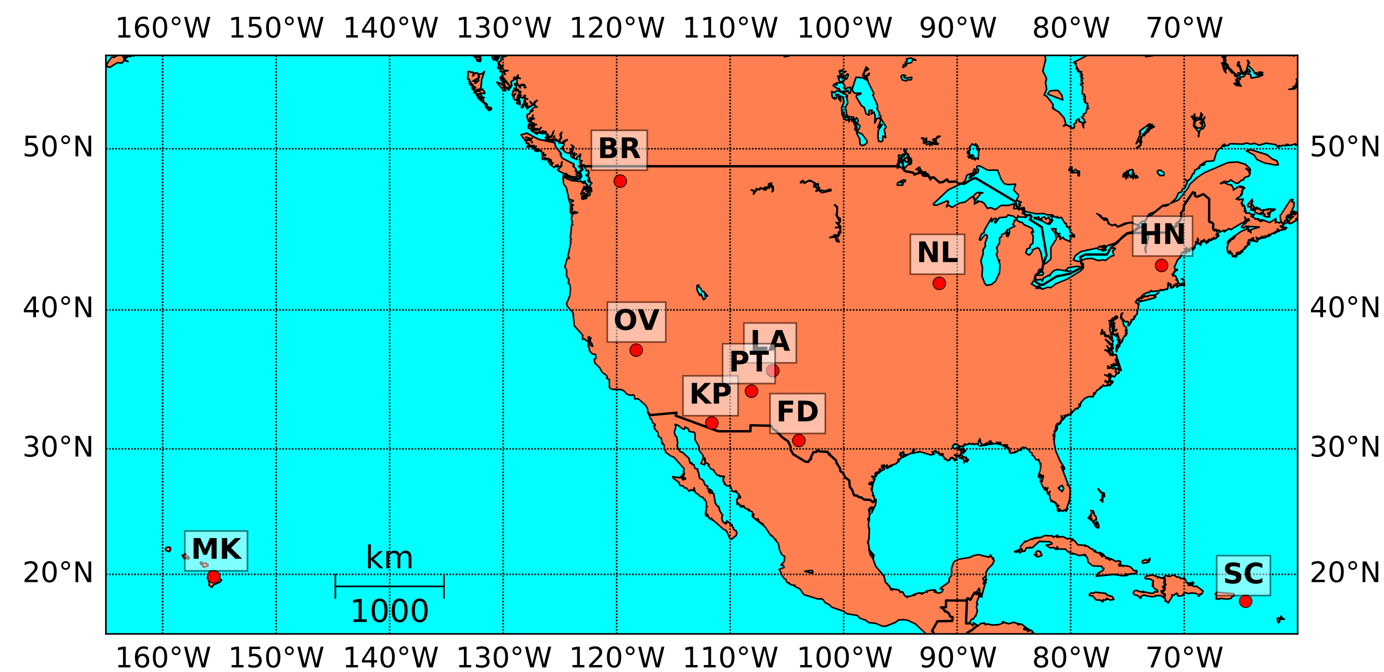


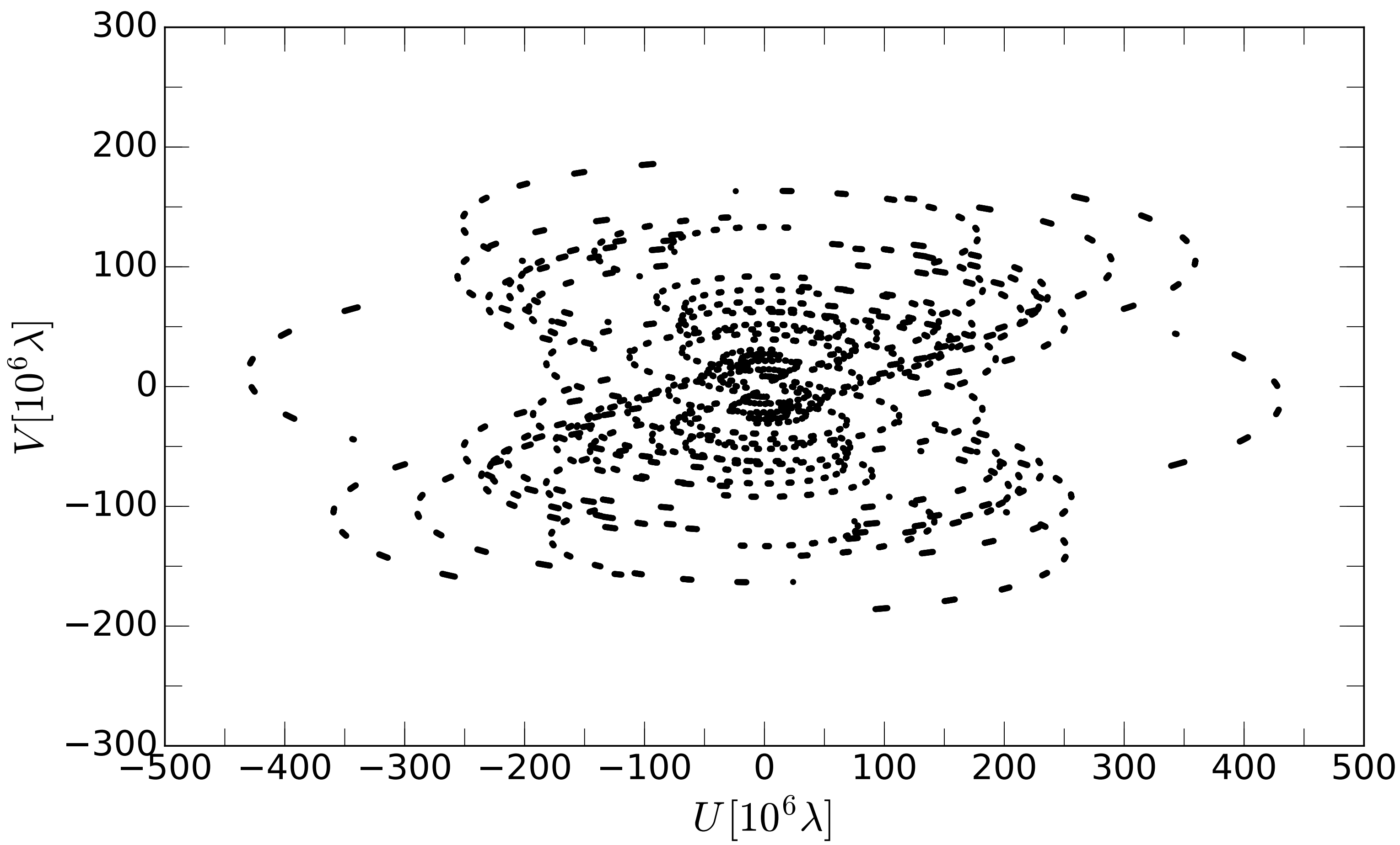
Emission results



Synthetic images

Observing array:	Very Long Baseline Array (VLBA)
Date of observation:	27/03/2017
Observing frequency:	5GHz - 86GHz
On-Off-source:	10min/50min
Antenna diameter:	25m
System temperature:	55K - 65K





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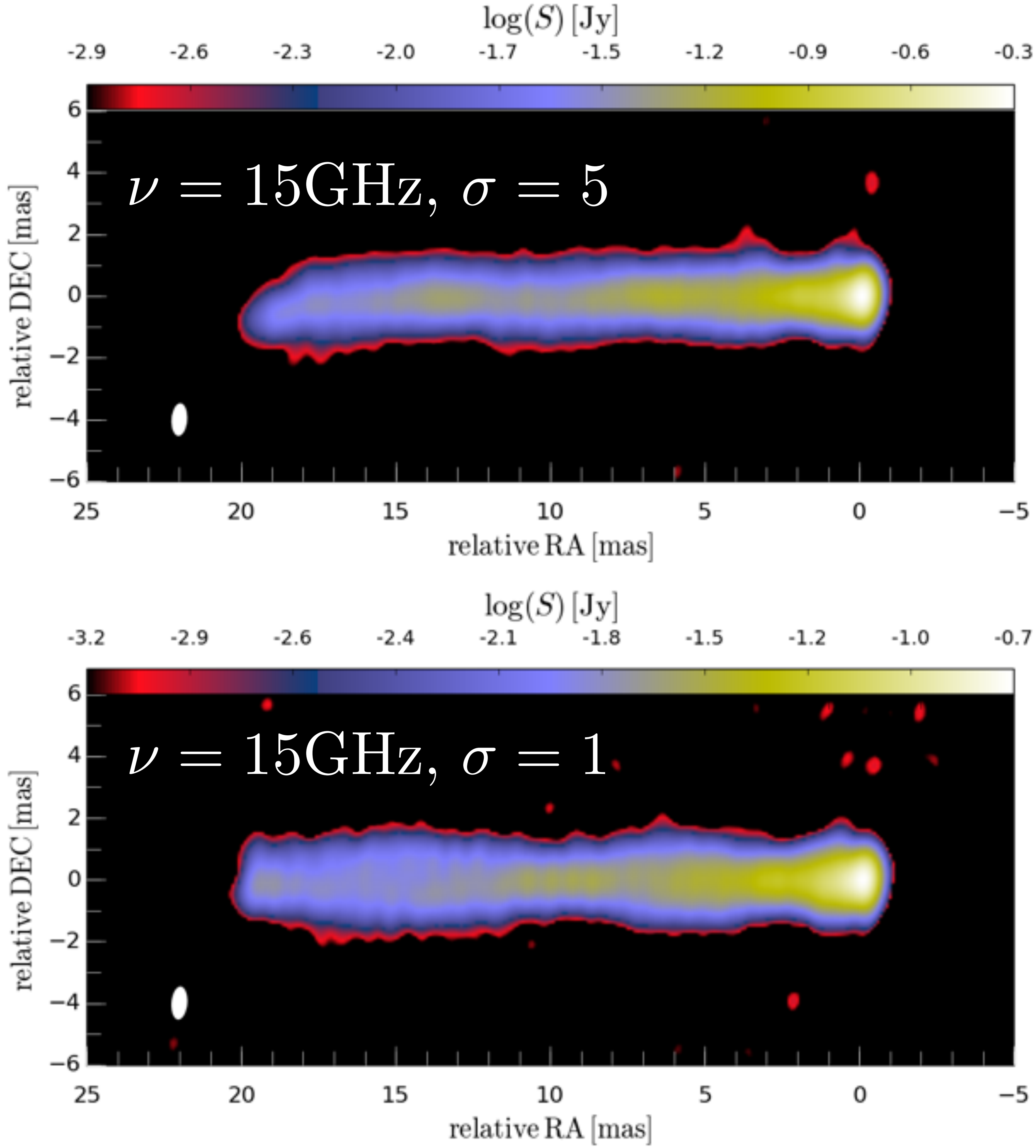

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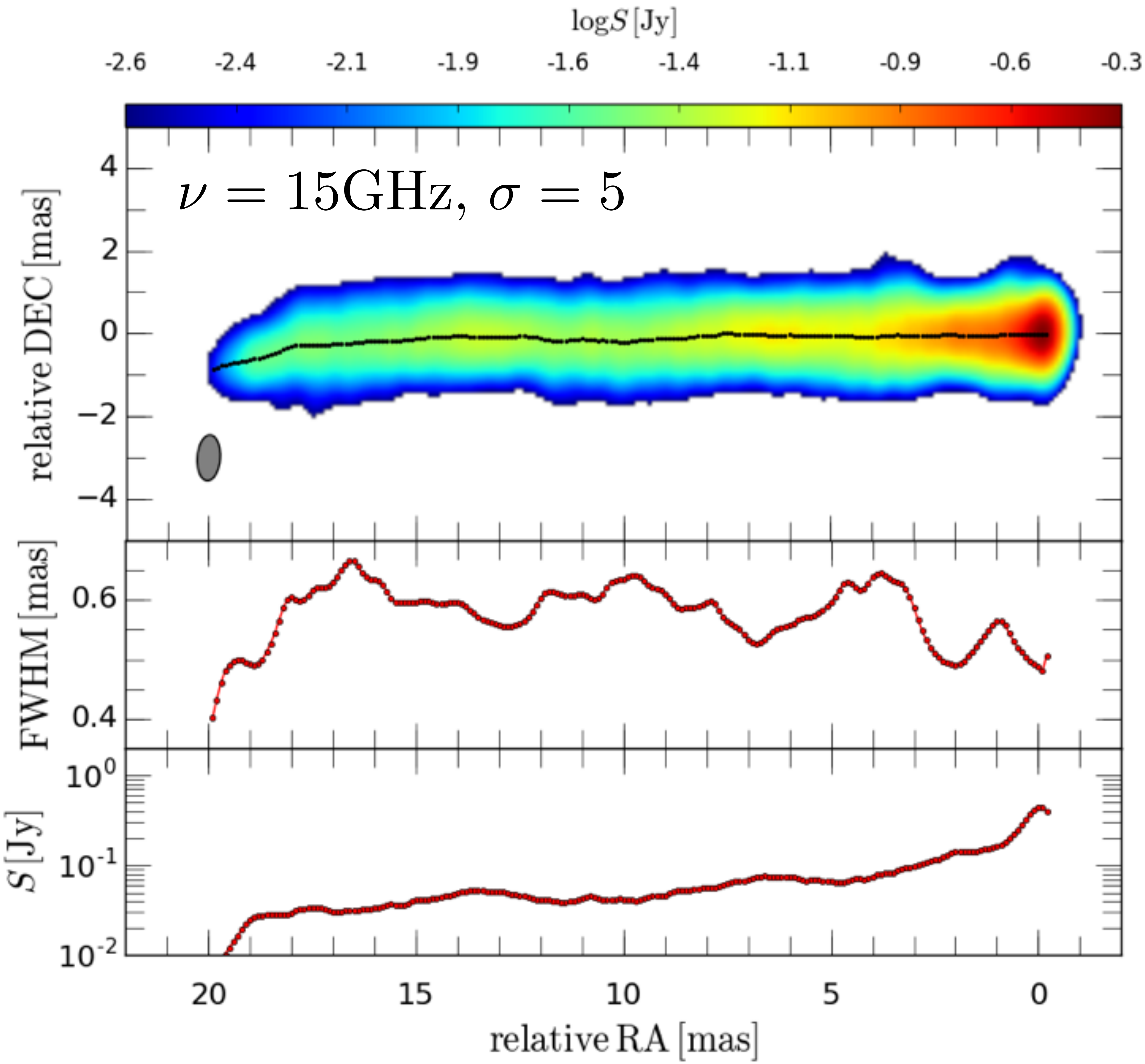

Summary & Outlook

Summary:

- perform RMHD simulations
- compute non-thermal emission
- create synthetic observations
- simulation-to-synthetic observations pipeline

Outlook:

- apply observers analysis technique (spectral index maps, core-shifts, …)
- direct modelling of observations via GA
- compute polarisation
- include radiative losses