Synthetic Jets – from models to observations and back

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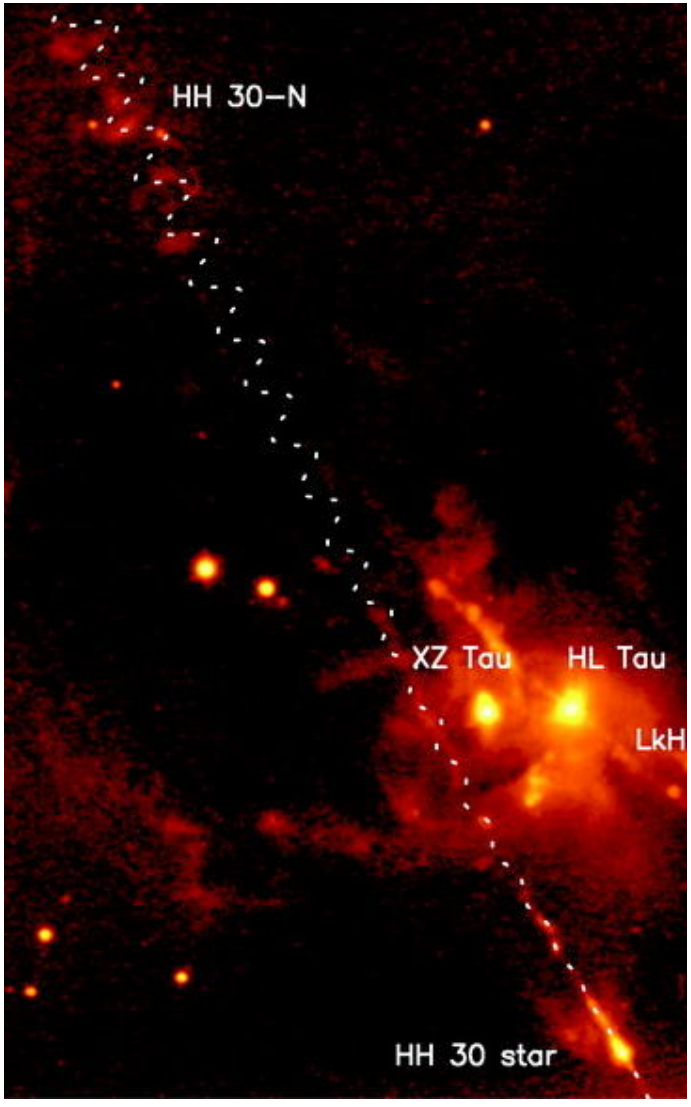
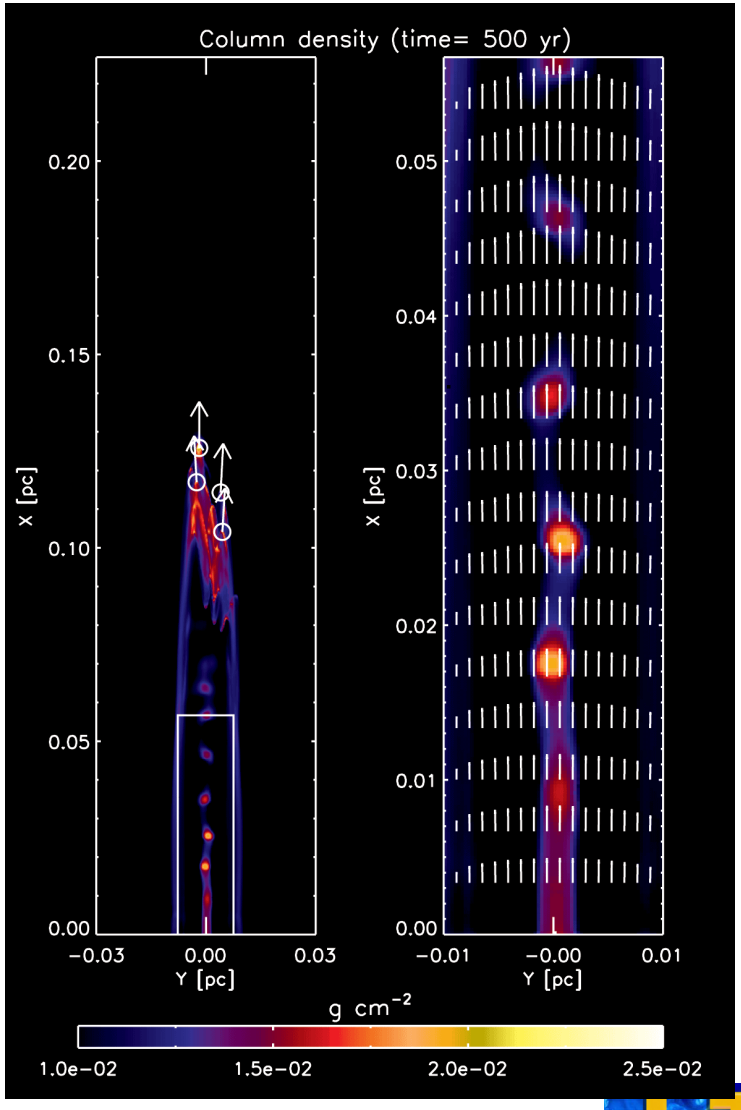
Thanks to: I. Agudo, D. Coffey, F. De Colle, G. Murphy, J. O'Sullivan, M. Stute, K. Tsinganos, N. Vlahakis

Outline

Observations vs simulations



Anglada et al. (2007)



Esquivel et al. (2007)

Observations vs simulations

Simulations

predict plasma state, eg density, magnetic/velocity field, etc, for a given set of initial and boundary conditions

Observations

meassure photon flux in a detector far away from the source

However

- emissivity is **not** a simple function of the plasma state
- radiation may be **re-processed** on its way to the telescope
- telescopes are **non-perfect** detectors

Forward modelling vs backward modelling

Forward modelling

- given a set of boundary & initial conditions run simulation
- calculate emission and project along line-of-sight
- convolve with detector characteristics

huge parameter space, microphysics

Backward modelling (Inversion of obs data)

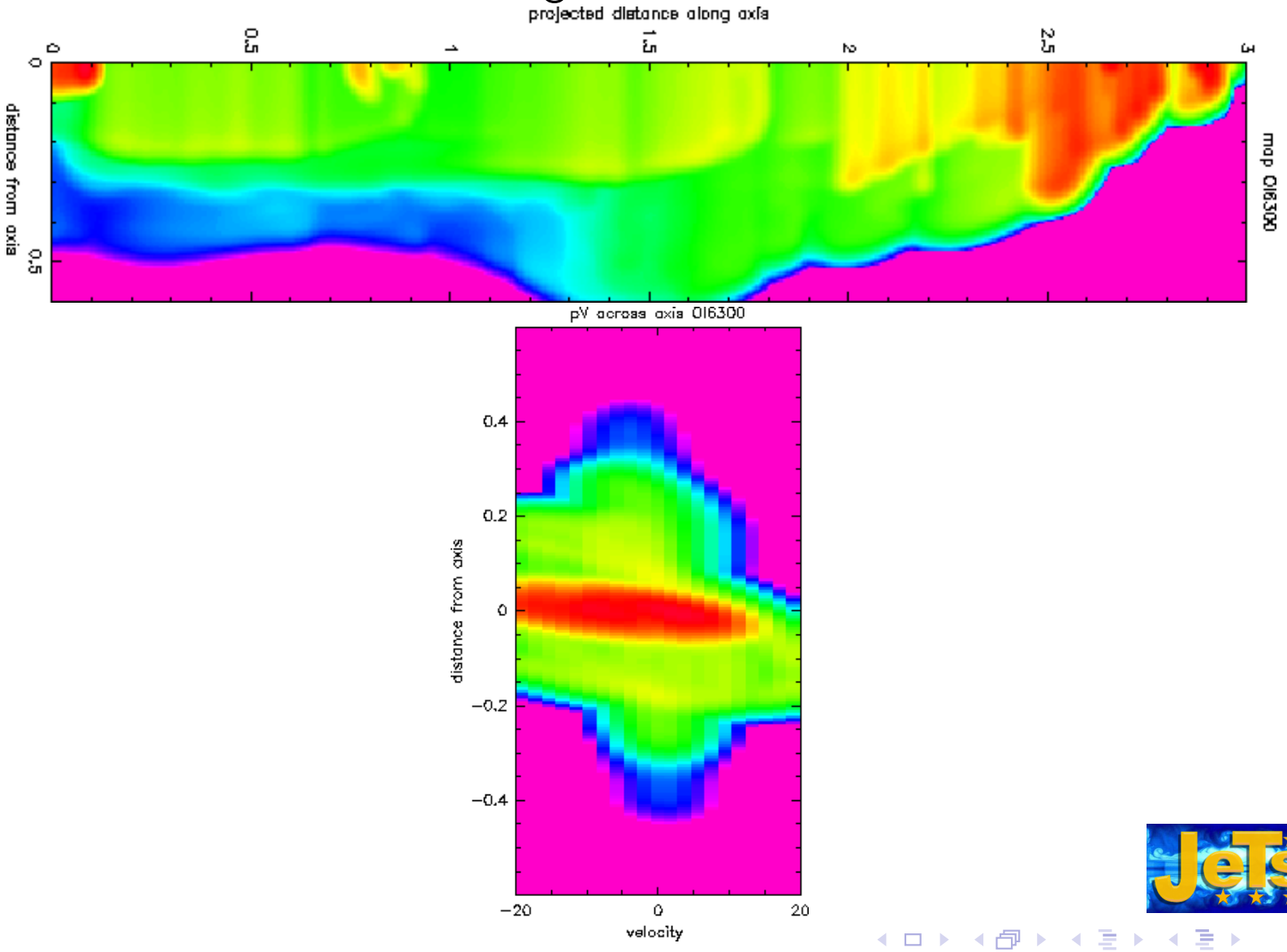
- deconvolve observations
- deproject along LoS
- infer physical quant from emission (diagnostic)

deprojection: photons don't have an 'origin' tag

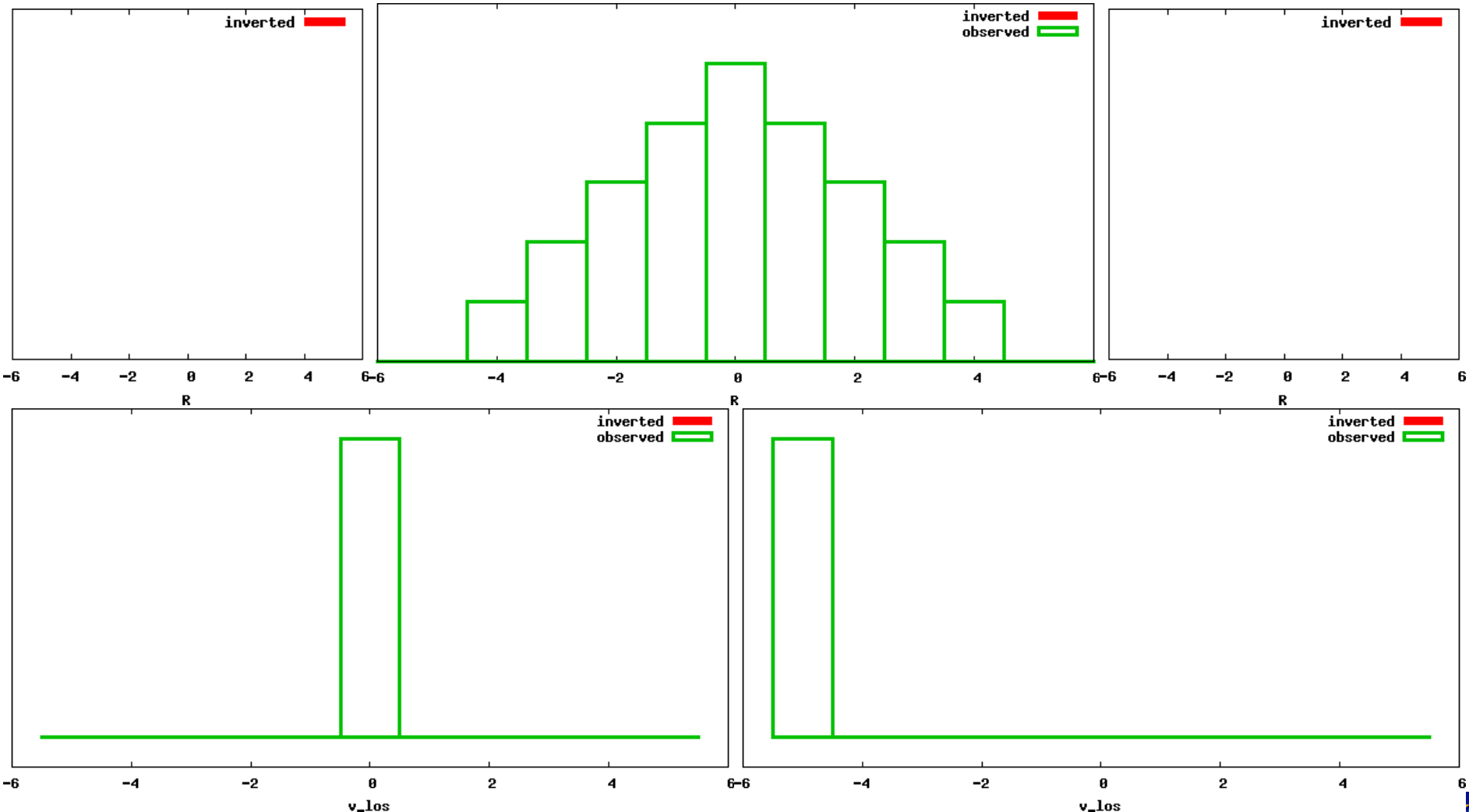
Inversion of pV diagrams for stellar jets

Synthetic maps & position-velocity diagrams

simulation: J. O'Sullivan, Heidelberg



Onion peeling



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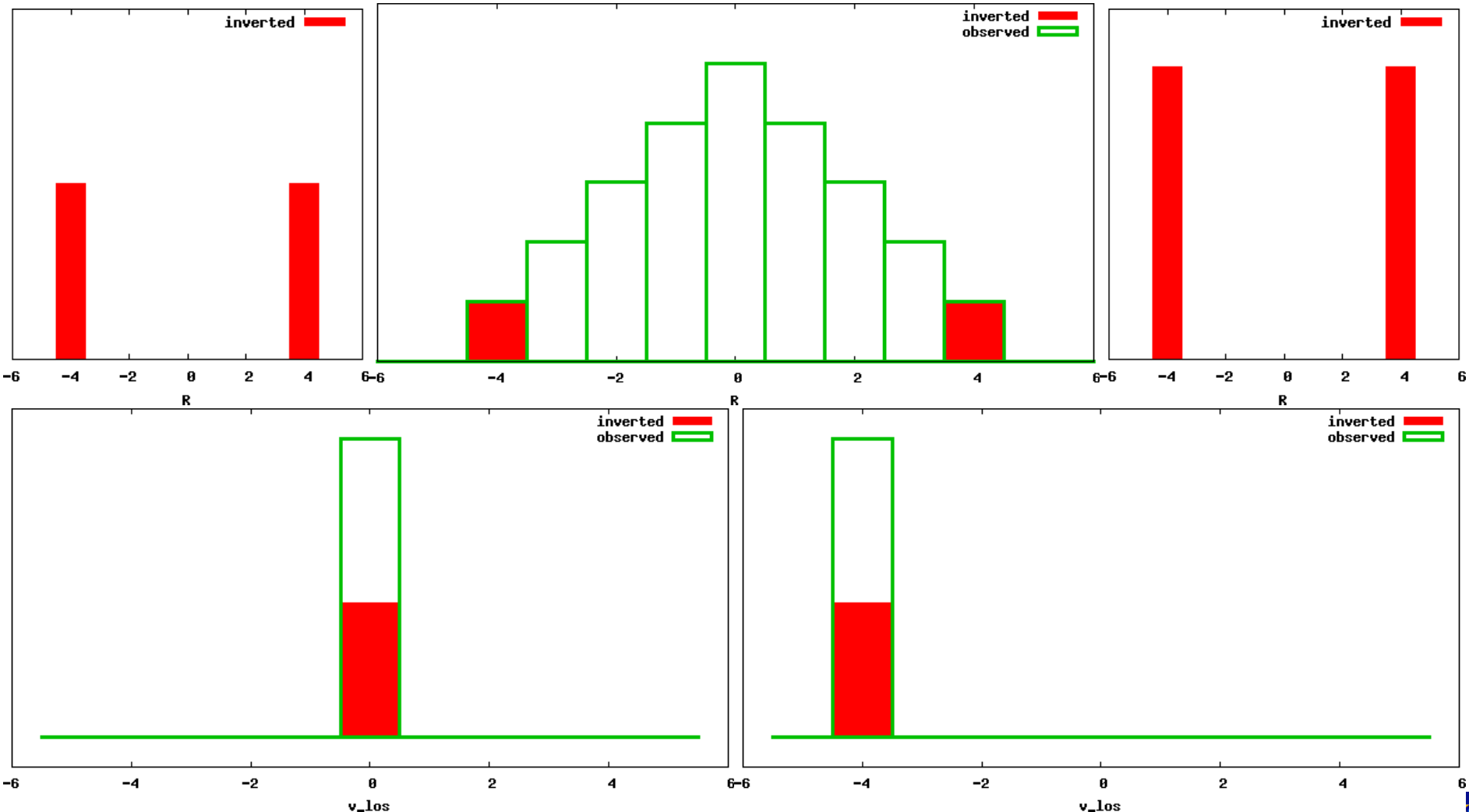

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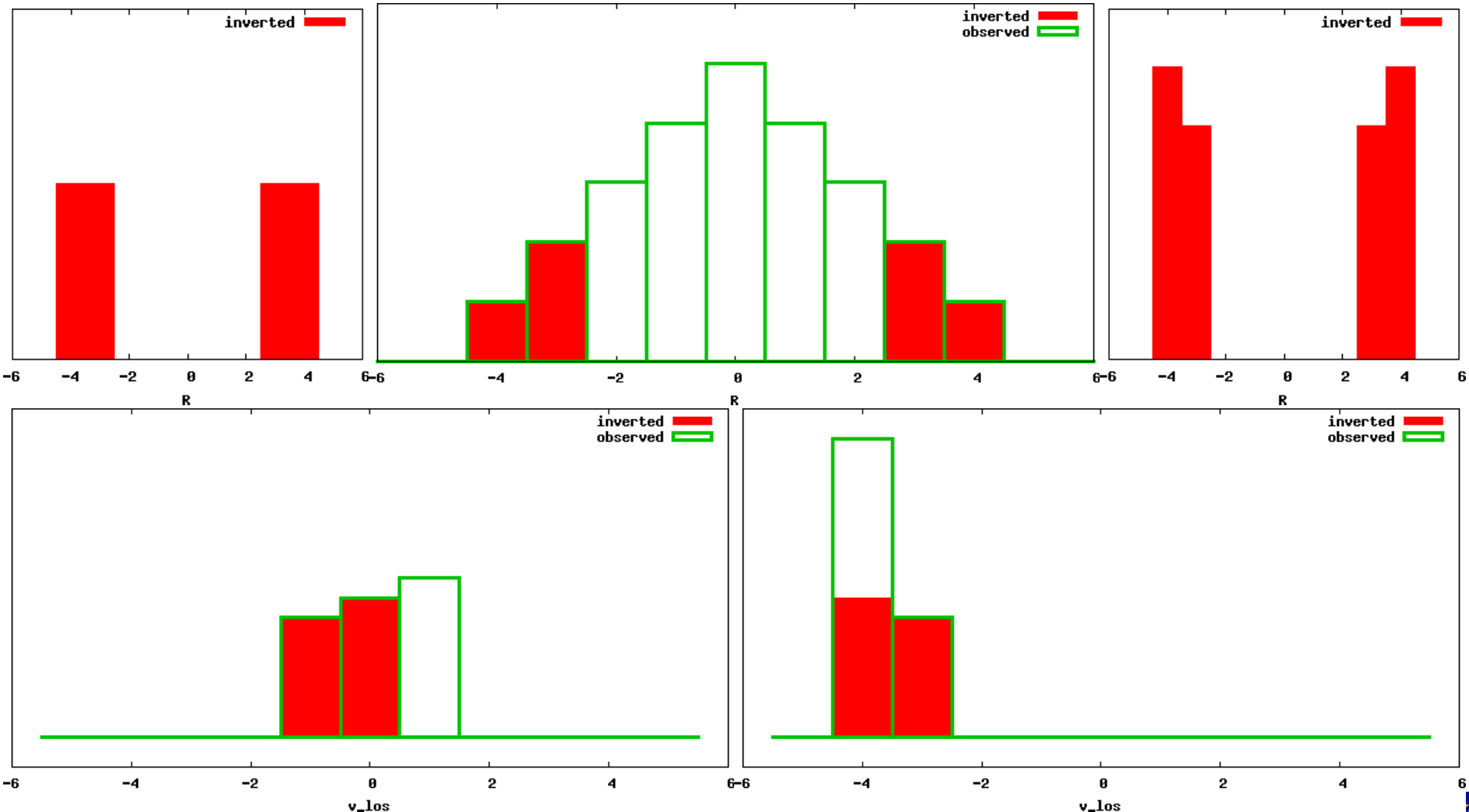

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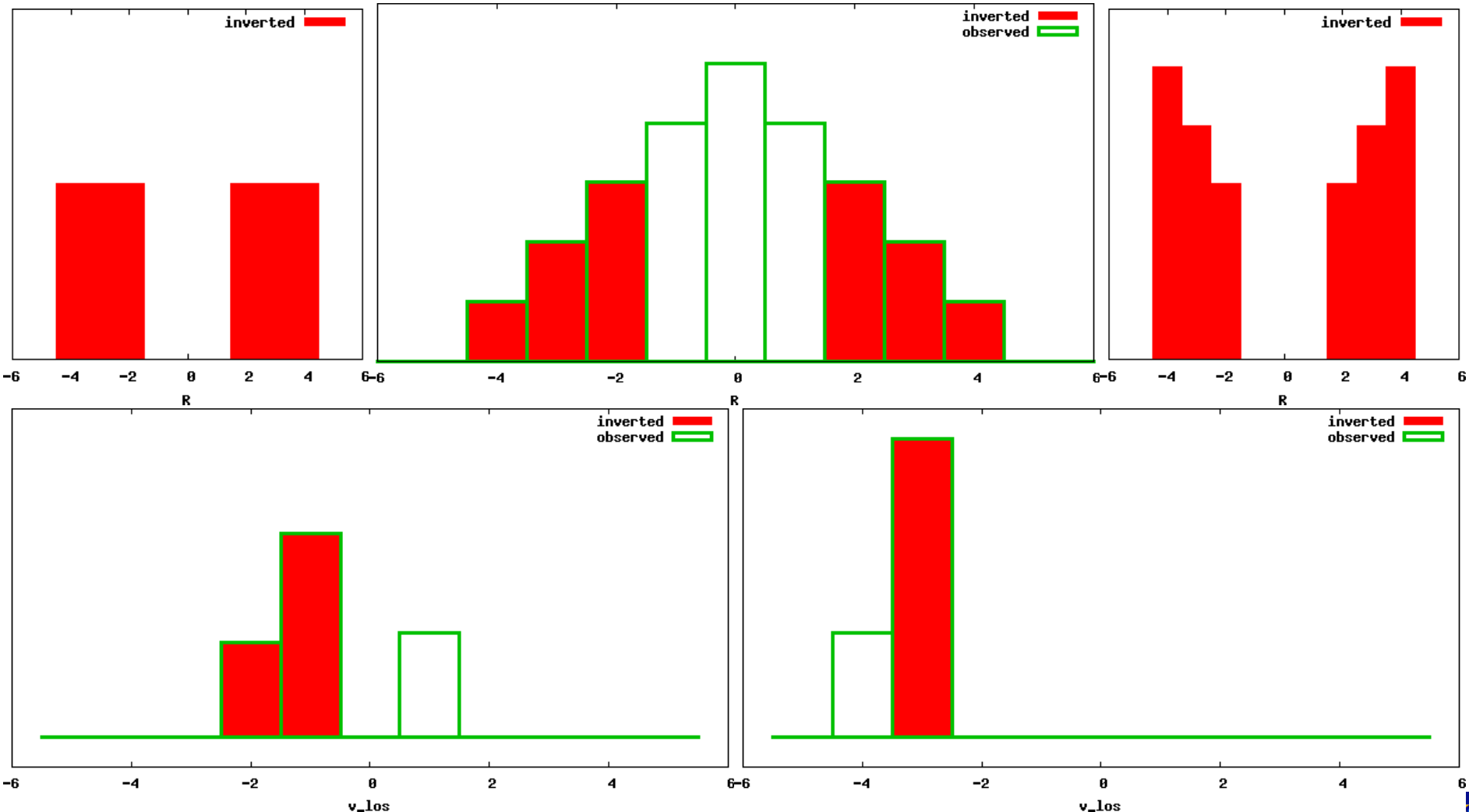

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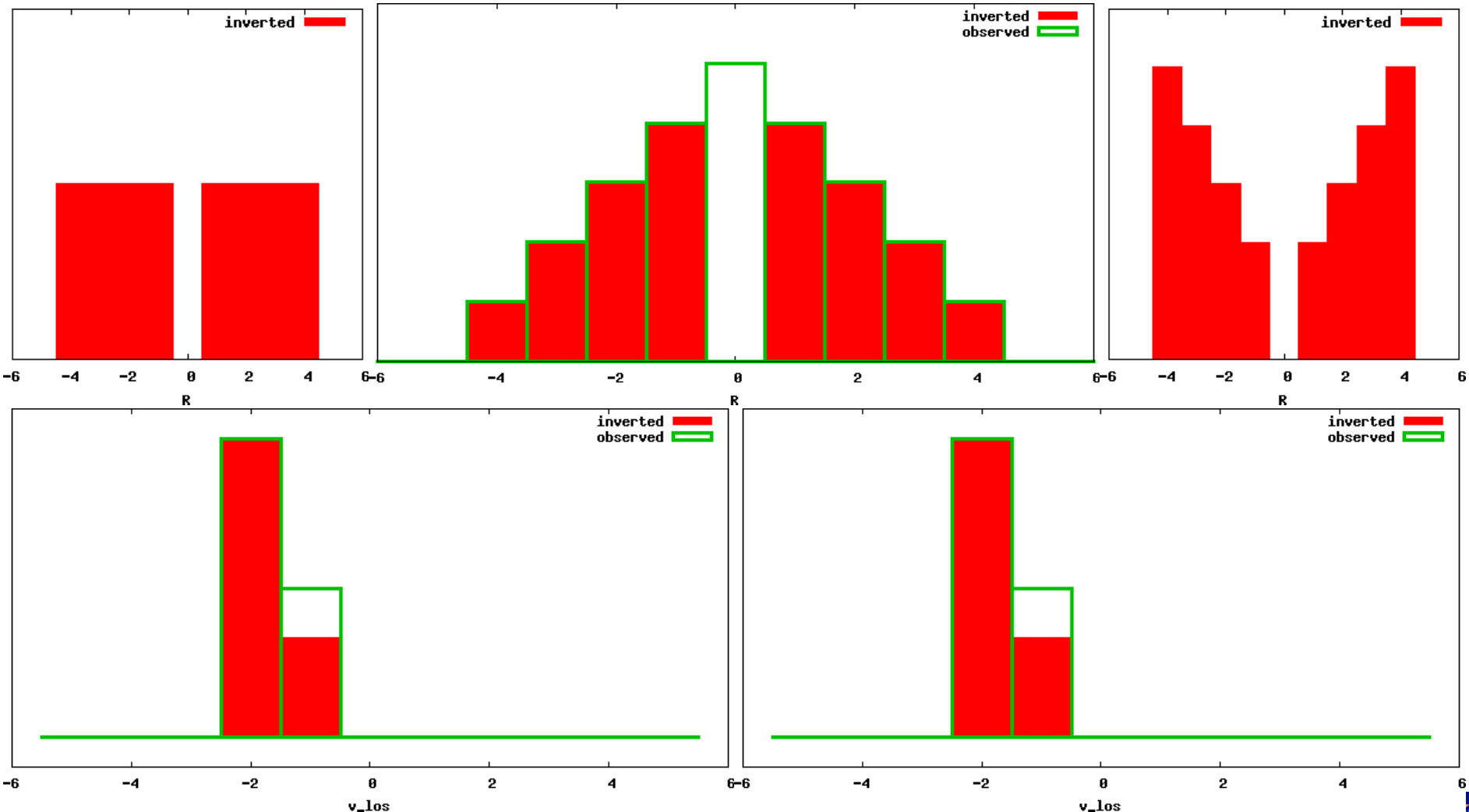
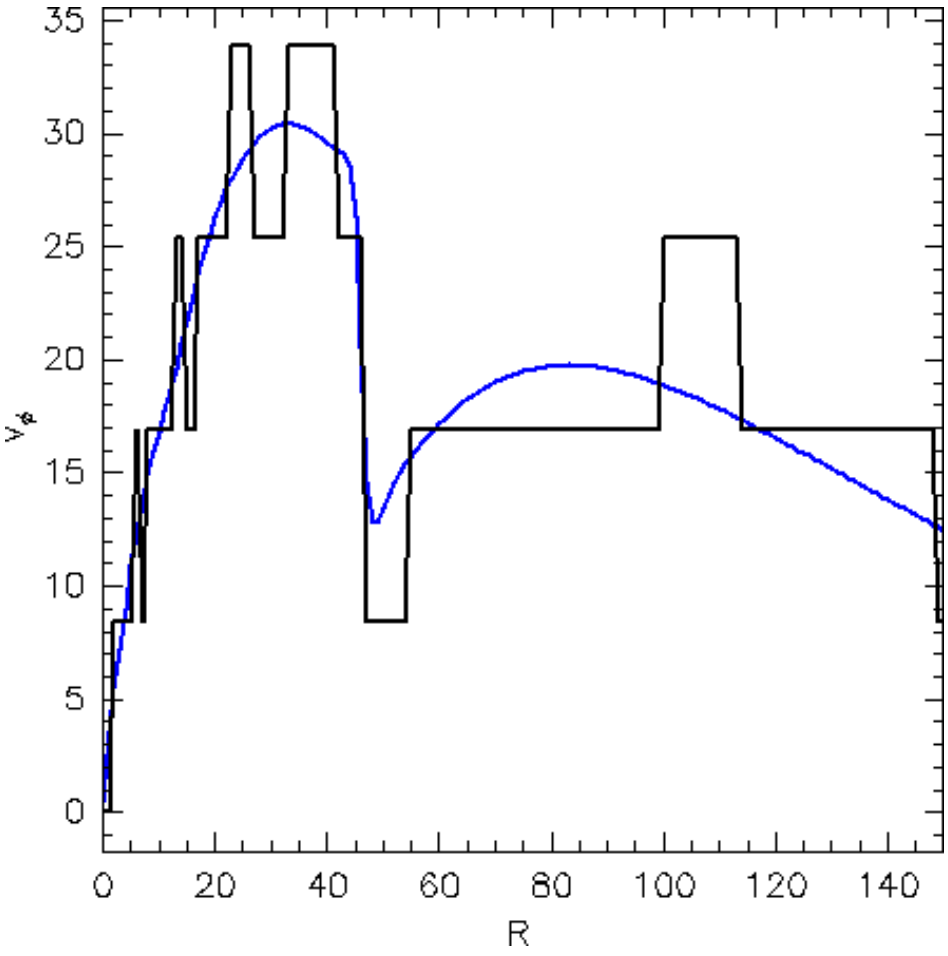
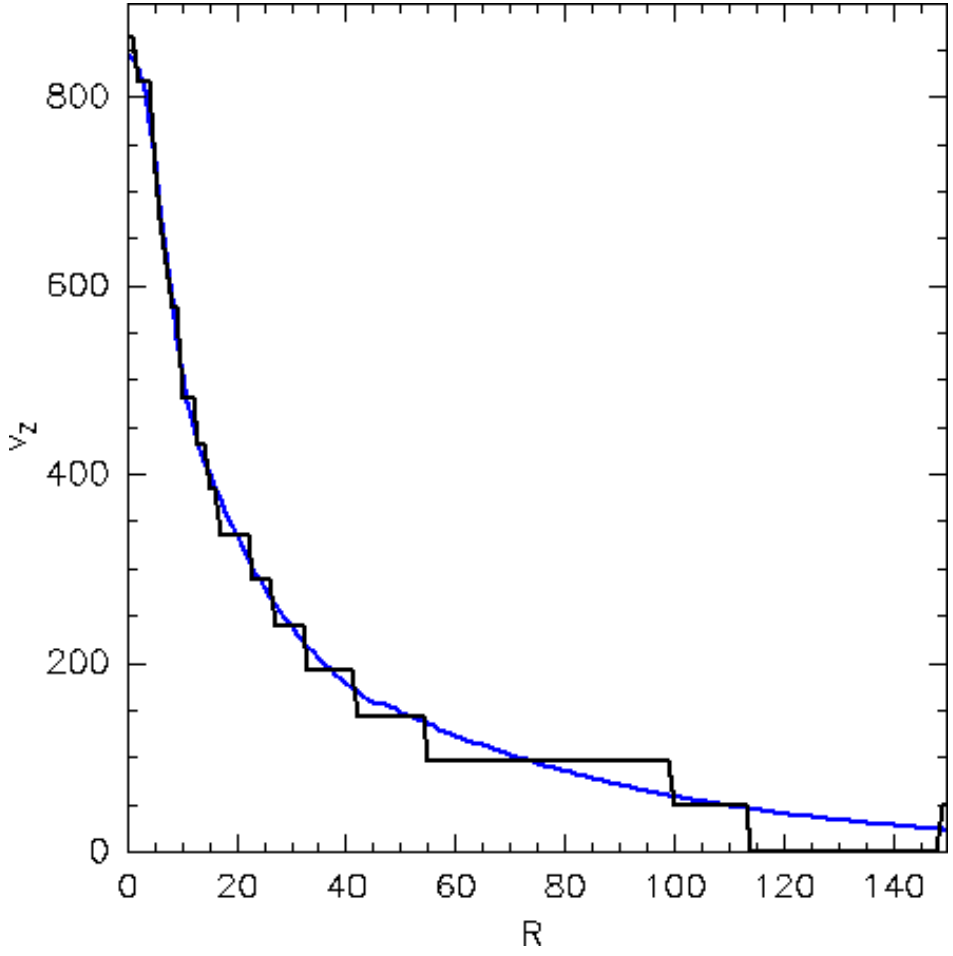


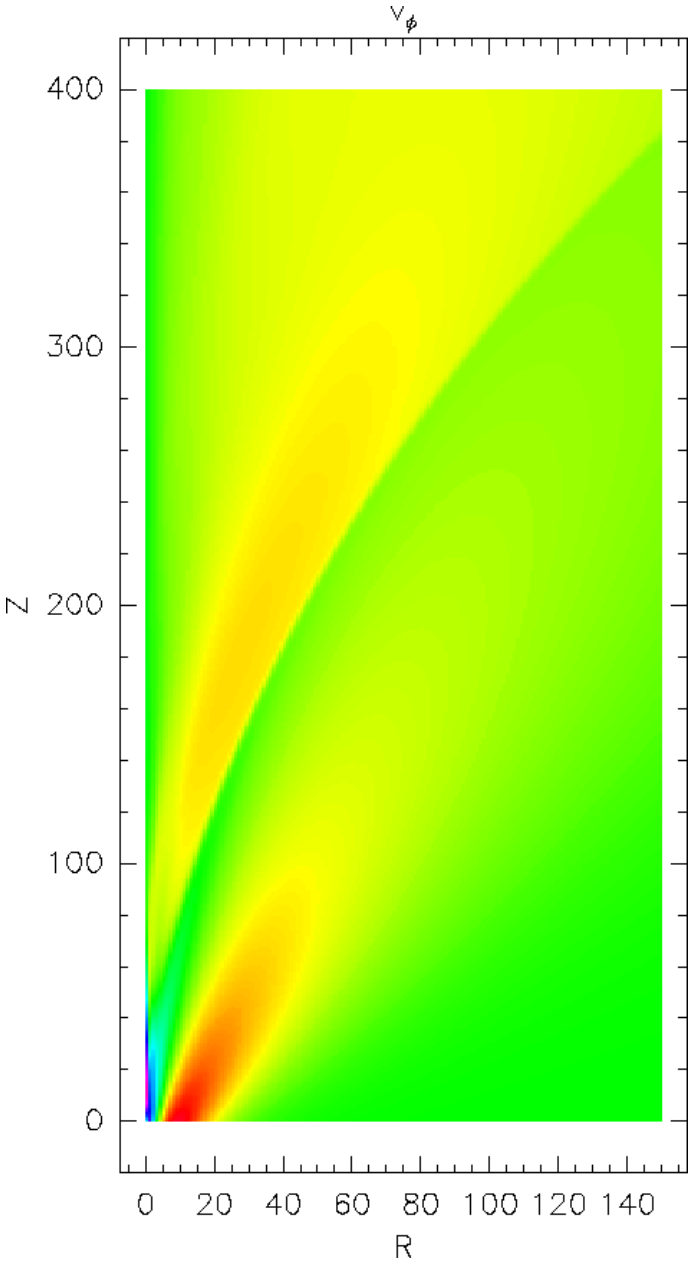
Onion peeling simulated data

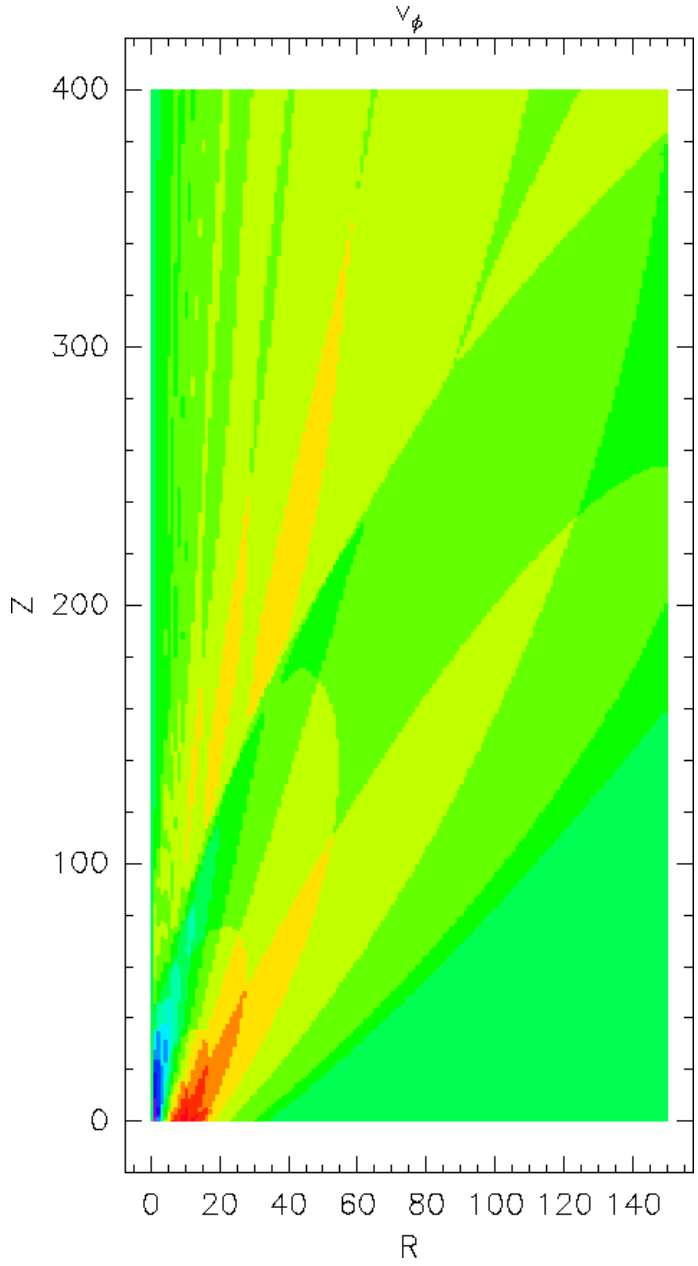




simulation: M. Stute et al 2008

Onion peeling simulated data





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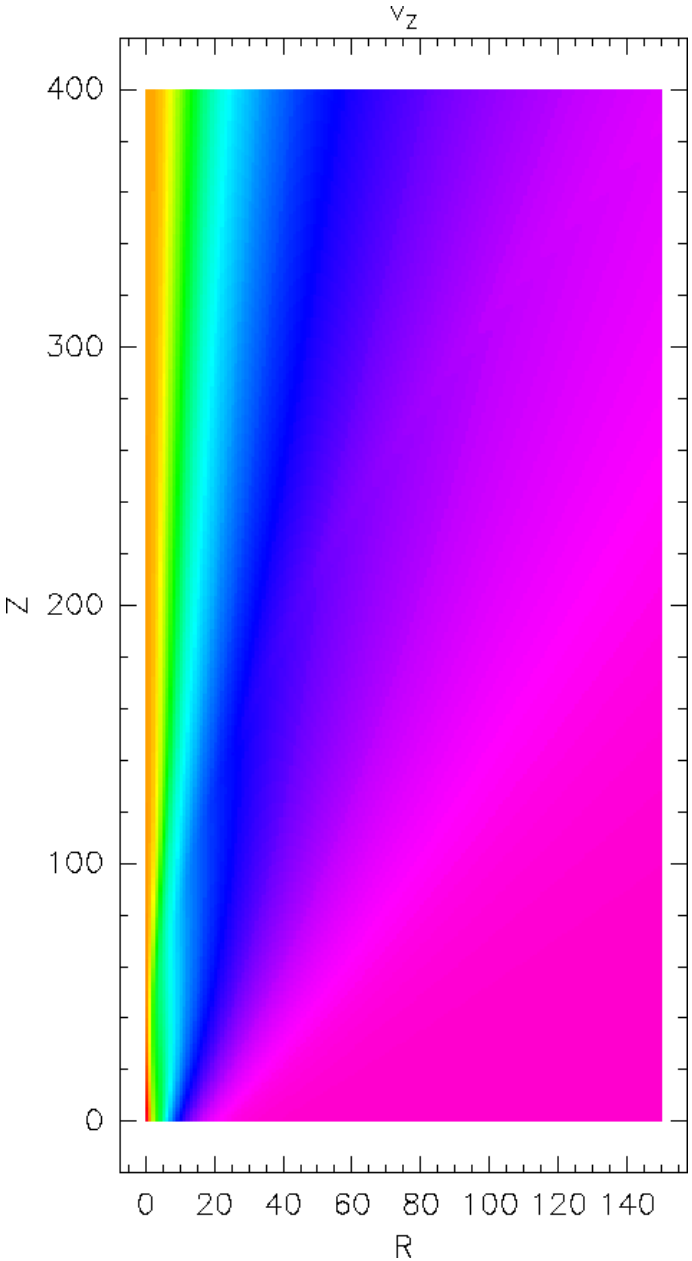
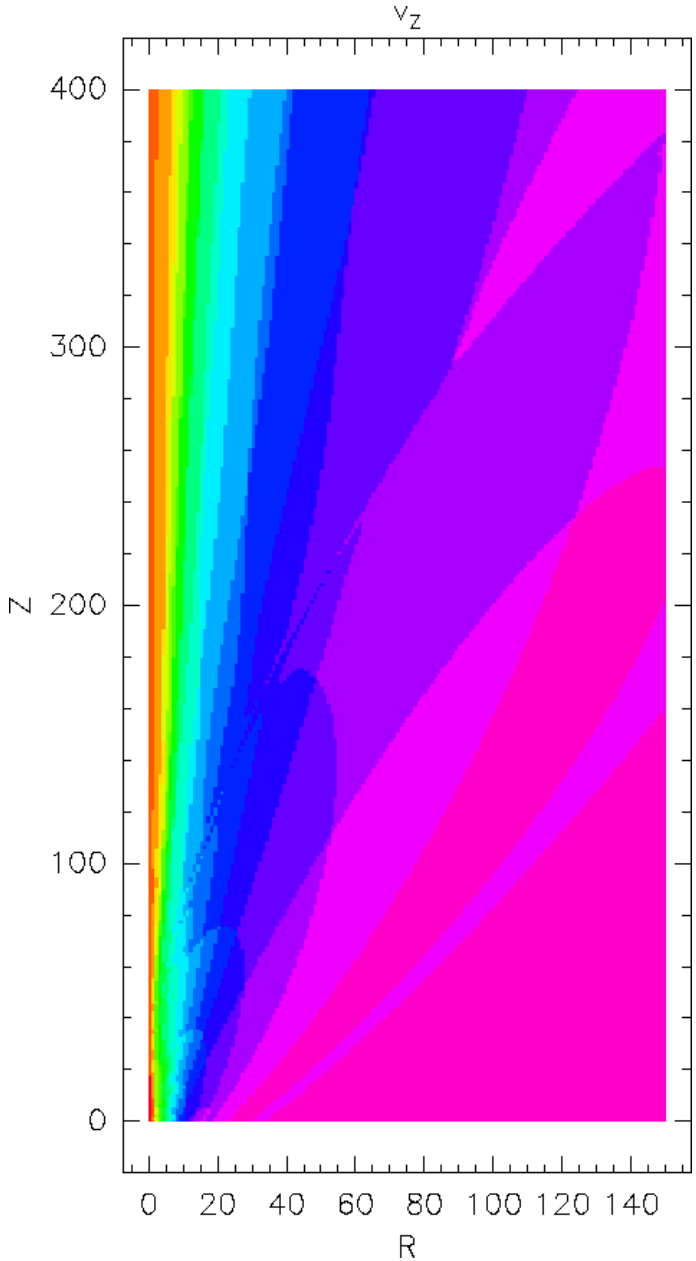
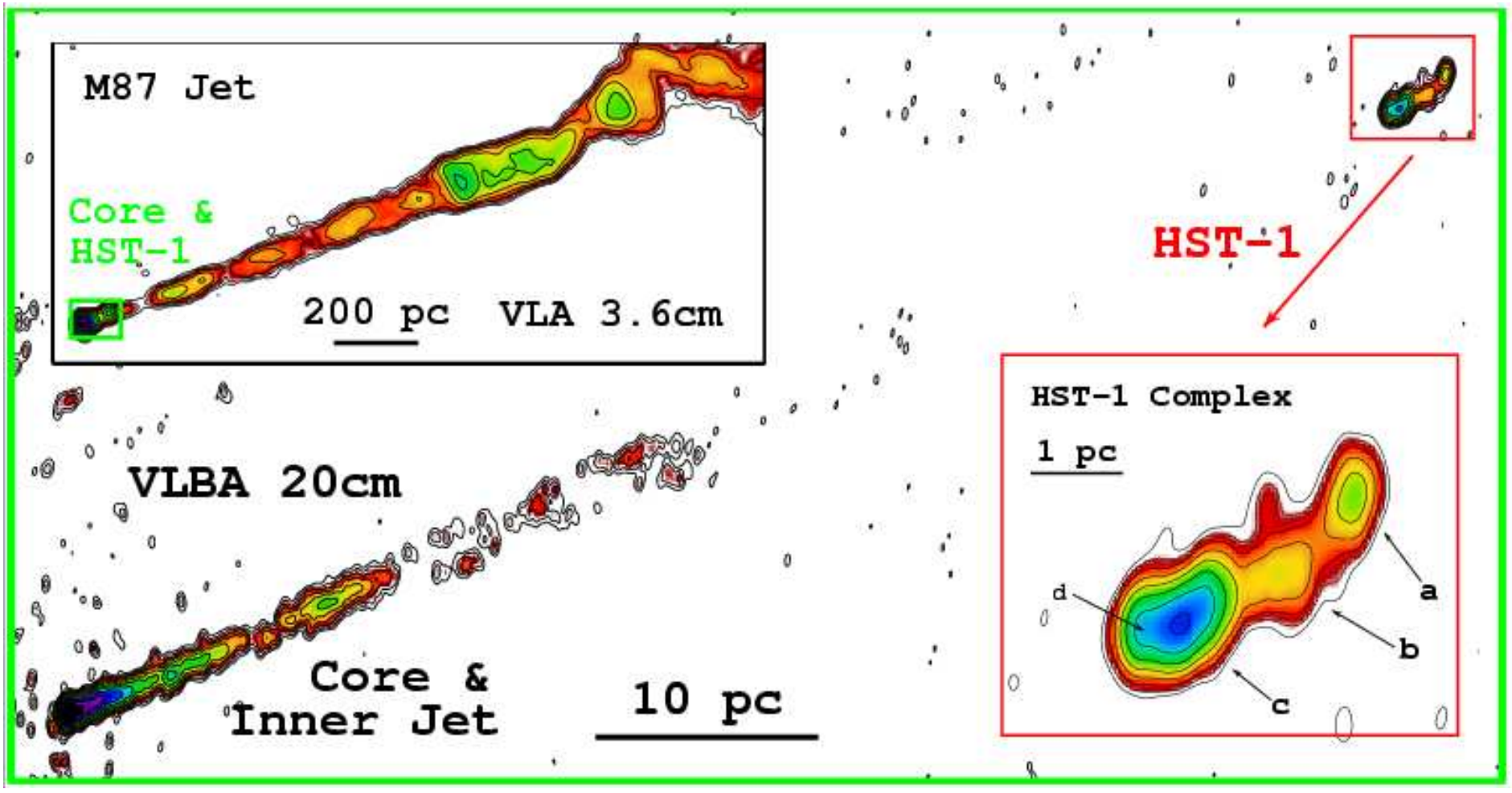




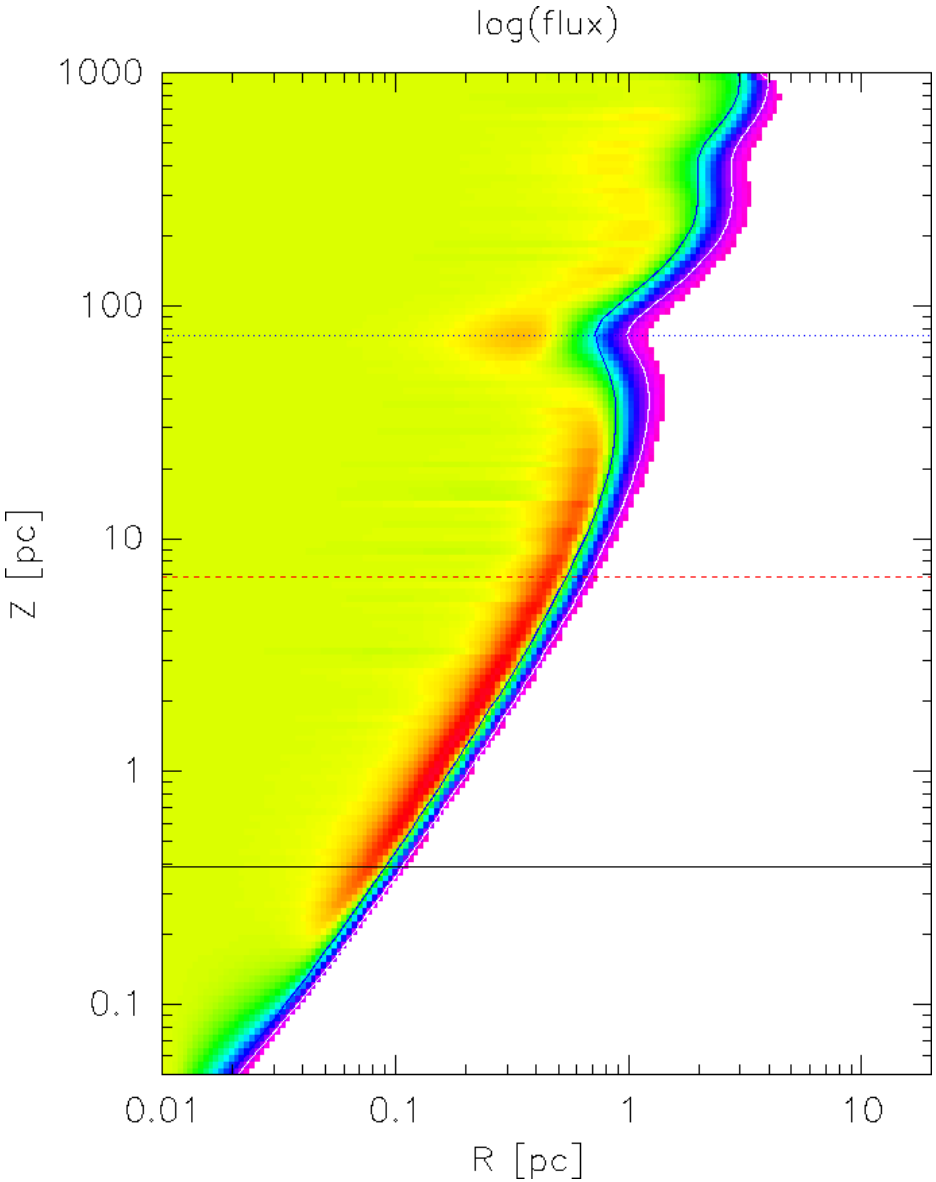
Inversion of synchrotron emission in AGN jets

M87: synchrotron emission, observed



Cheung et al (2007)

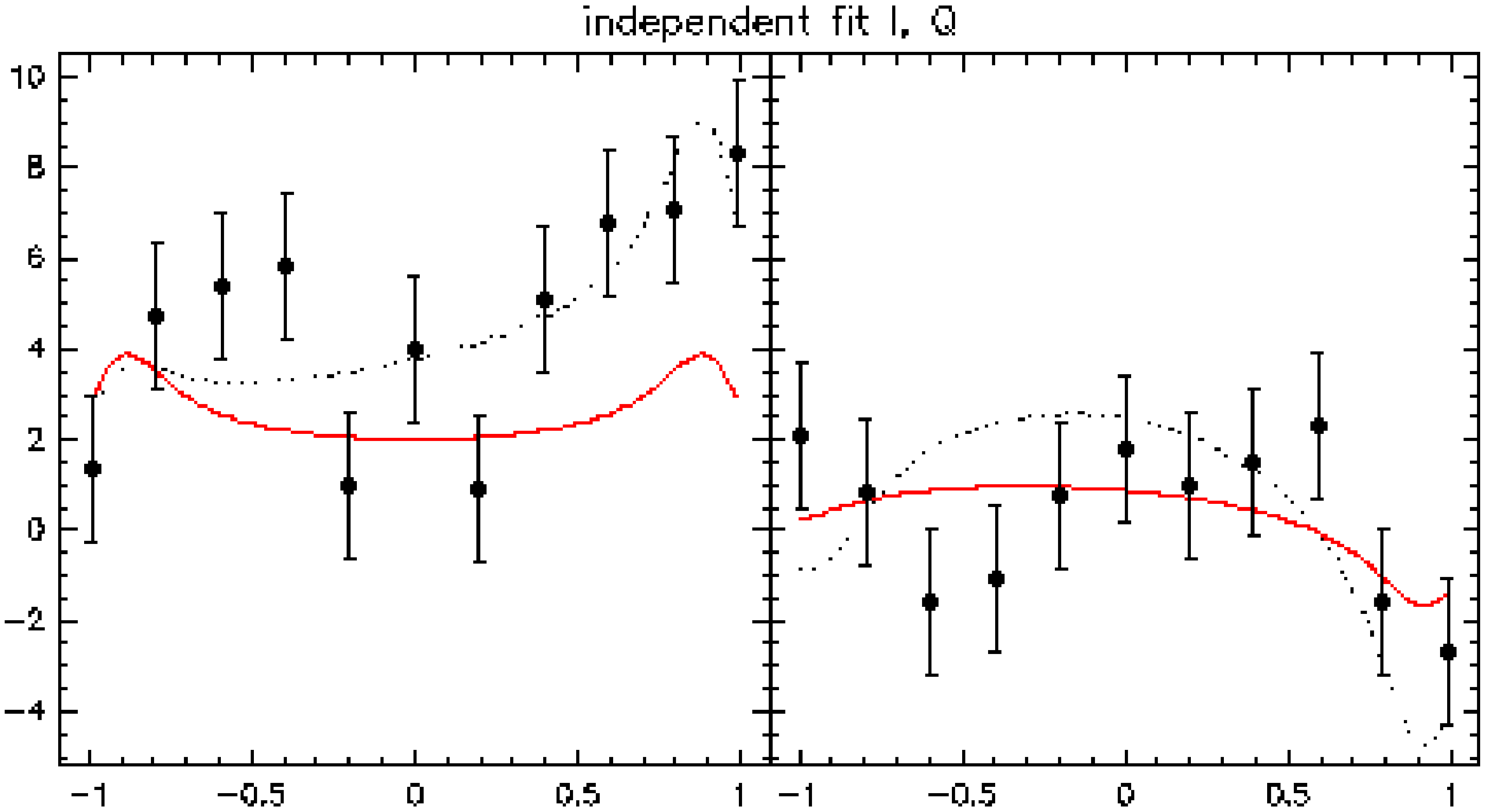
M87: synchrotron emission from a thin shell



J. Gracia et al, to be submitted

jet in M87 emits synchrotron radiation only in a thin shell
$\longrightarrow$ apply thin-shell models
(eg Laing 1981; Vlahakis et al, in prep)

Fitting I, Q independently

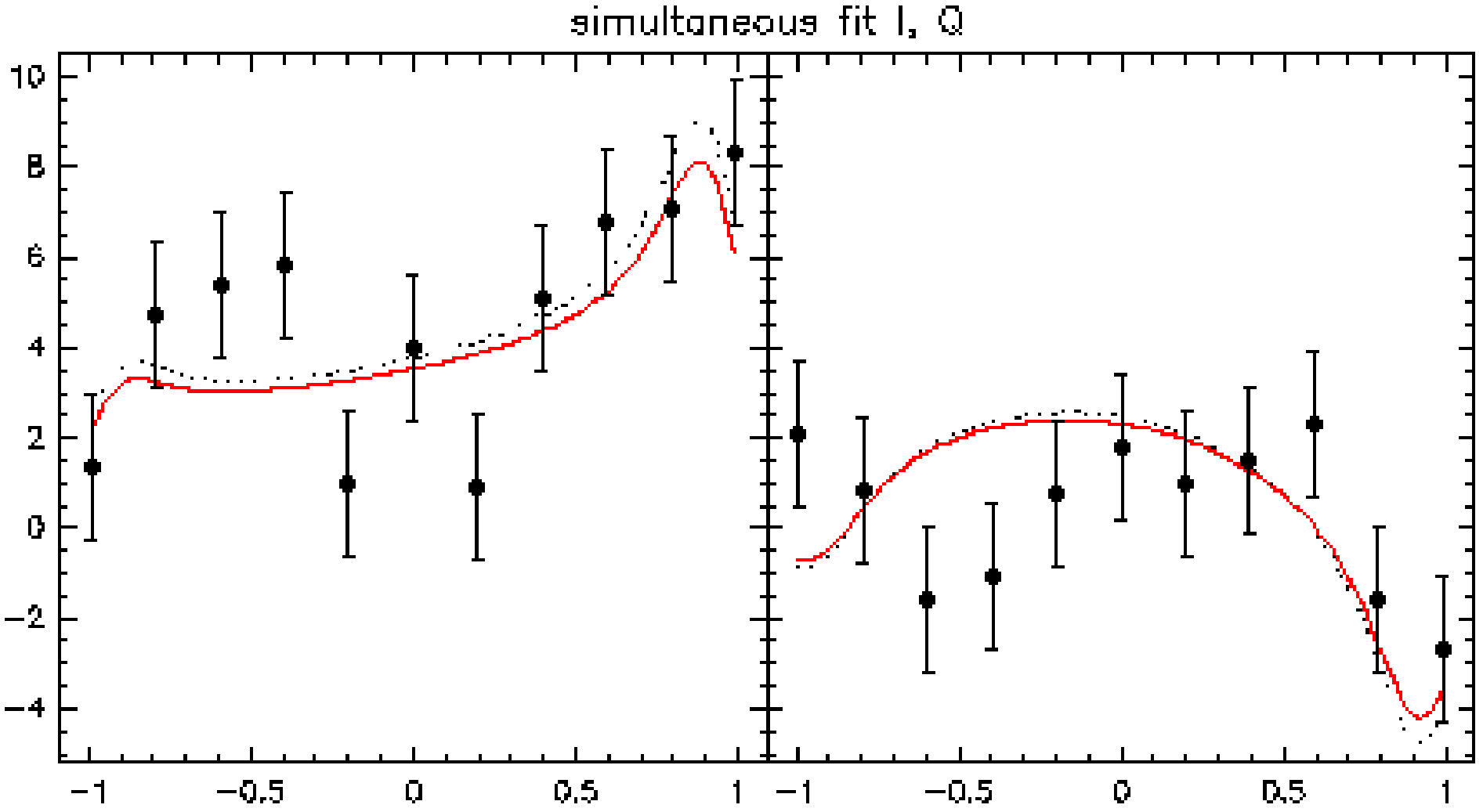


data = model + noise (S/N=5)

Stokes I: viewing angle $\delta \sim 90°$, pitch angle $\gamma \sim 1°$

Stokes Q: viewing angle $\delta \sim 60°$, pitch angle $\gamma \sim 60°$

Fitting I&Q simultaneously

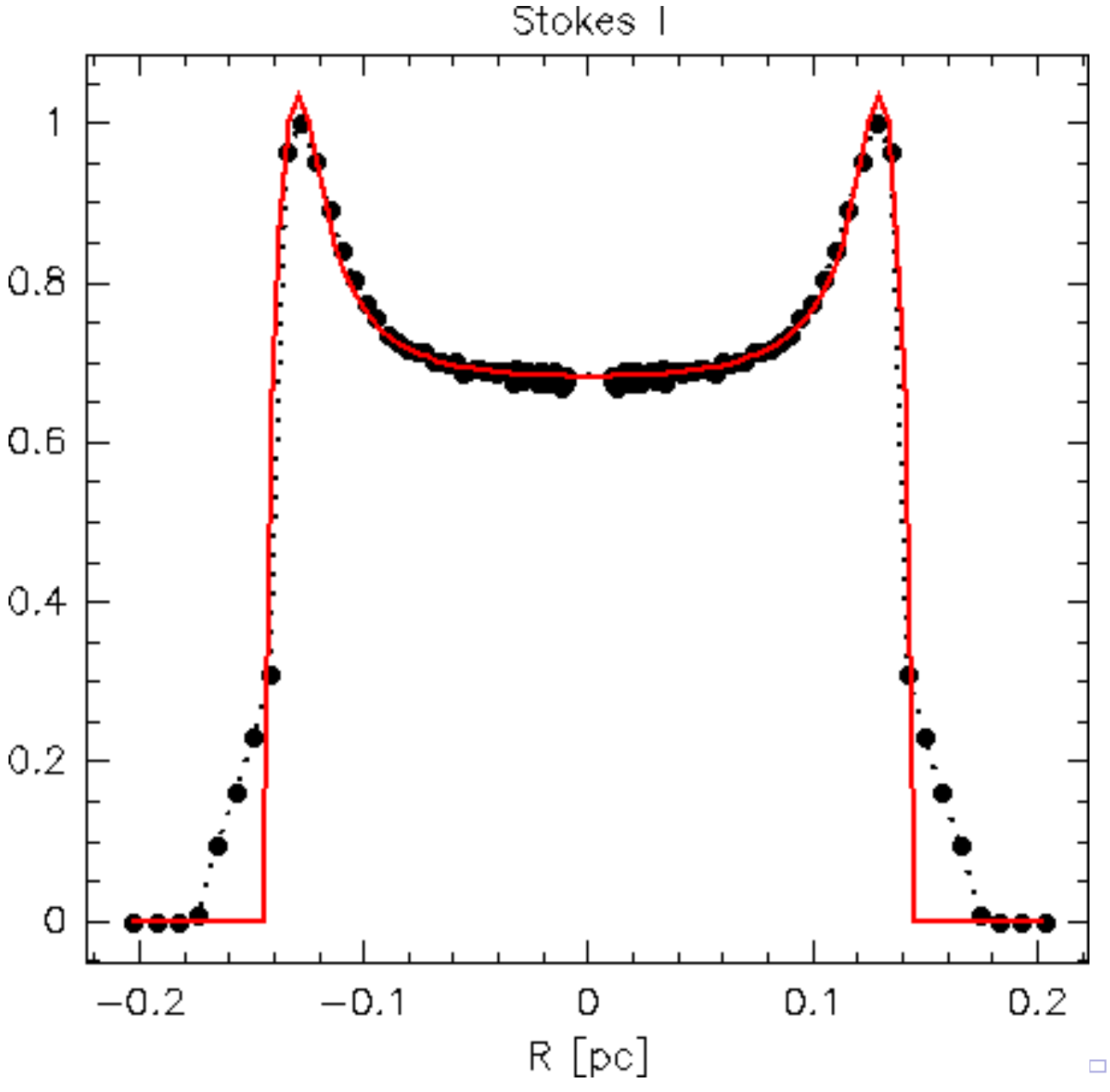


data = model + noise (S/N=5)

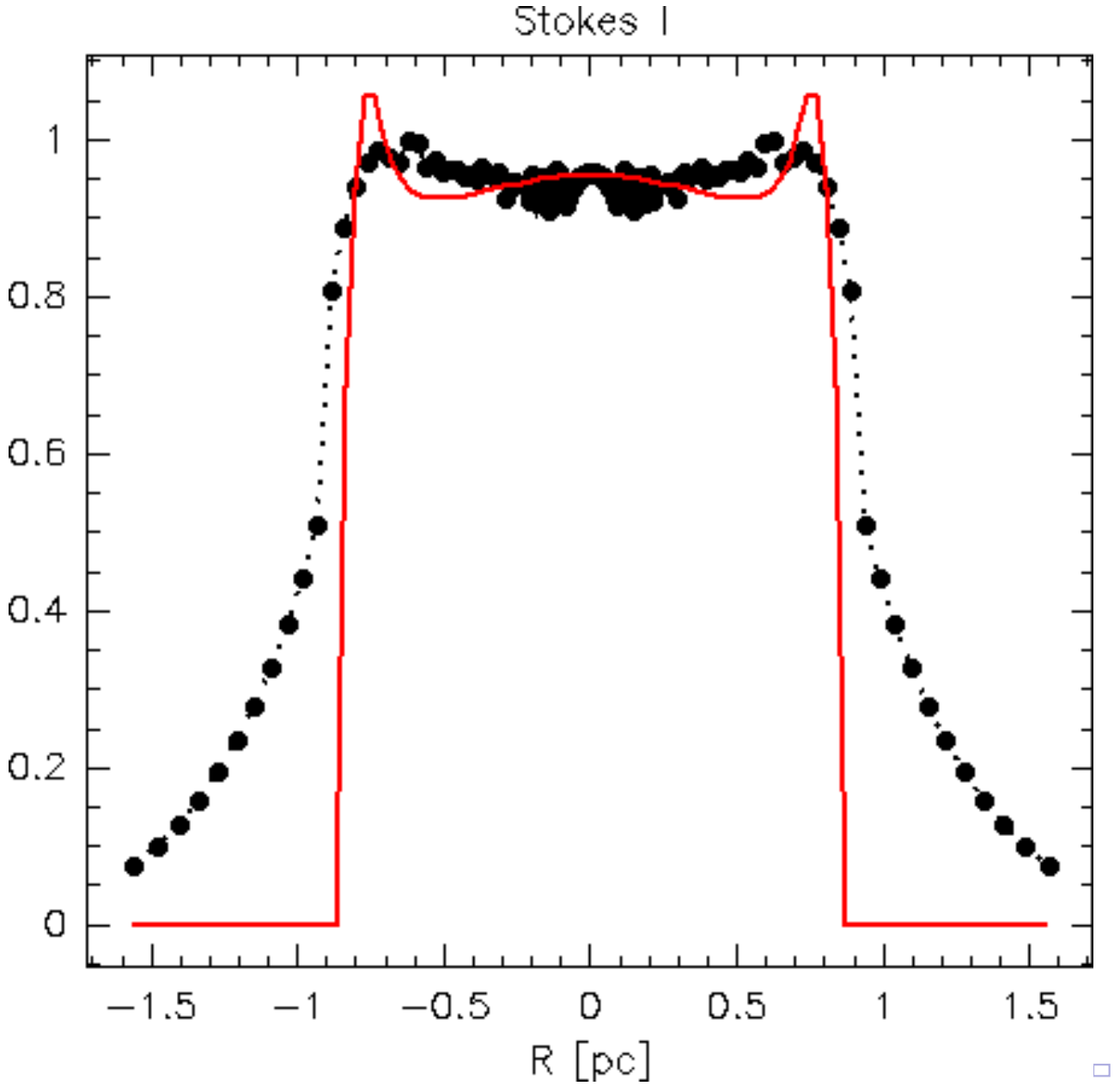
Stokes I&Q: viewing angle $\delta \sim 28°$, pitch angle $\gamma \sim 63°$

true parameters: viewing angle $\delta \sim 25°$, pitch angle $\gamma \sim 60°$

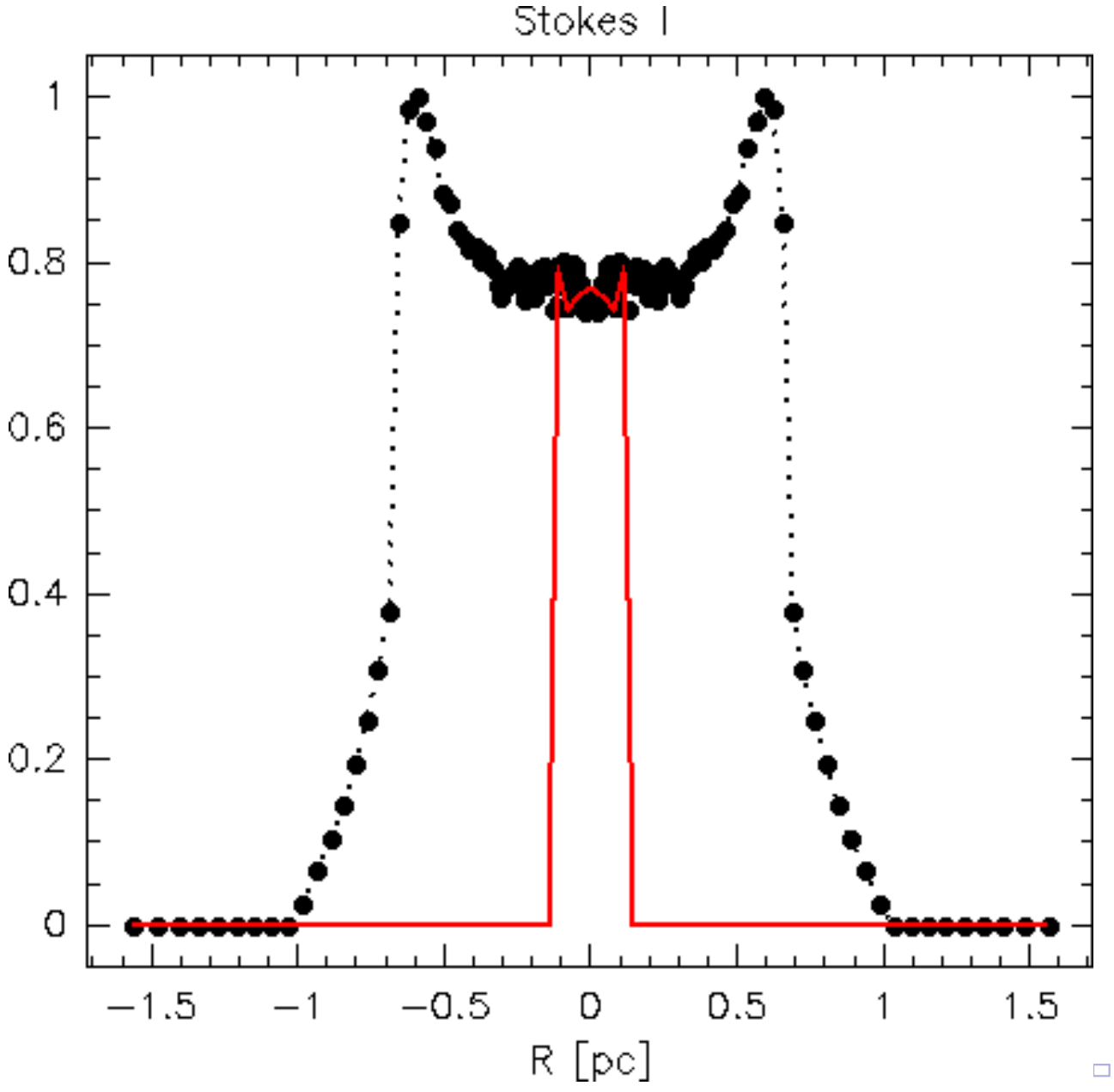
Proof-of-concept



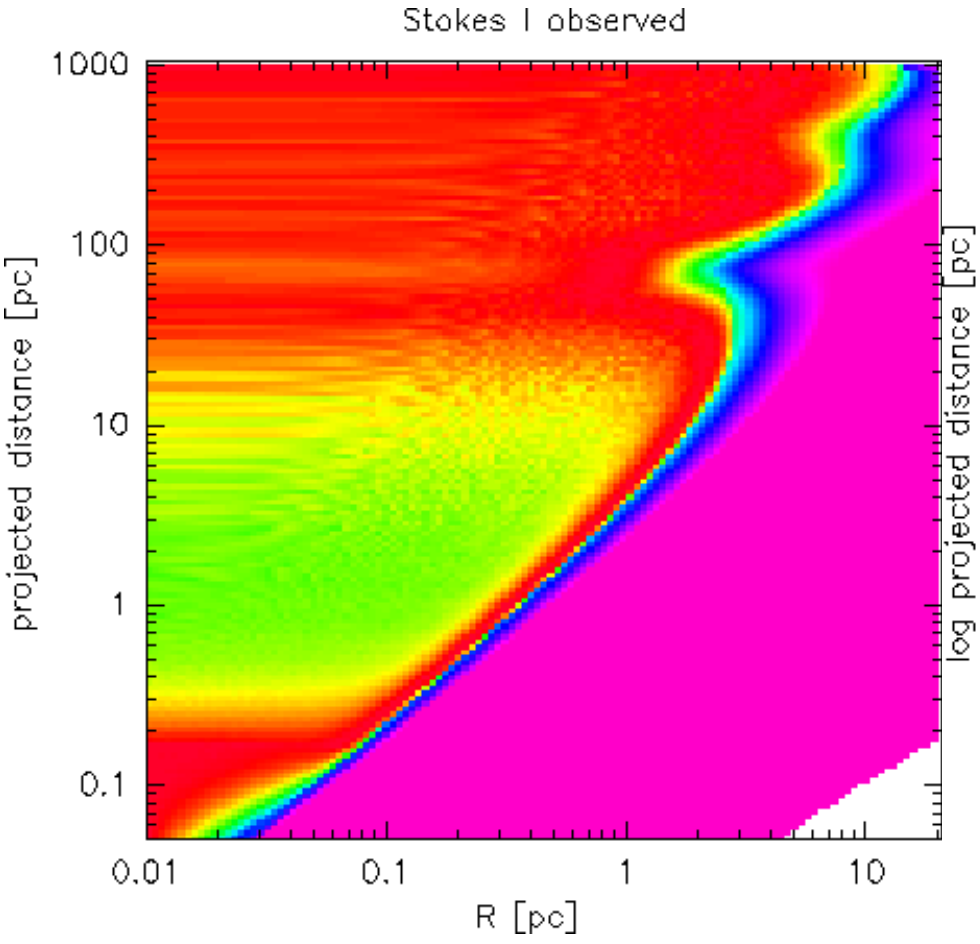
Proof-of-concept

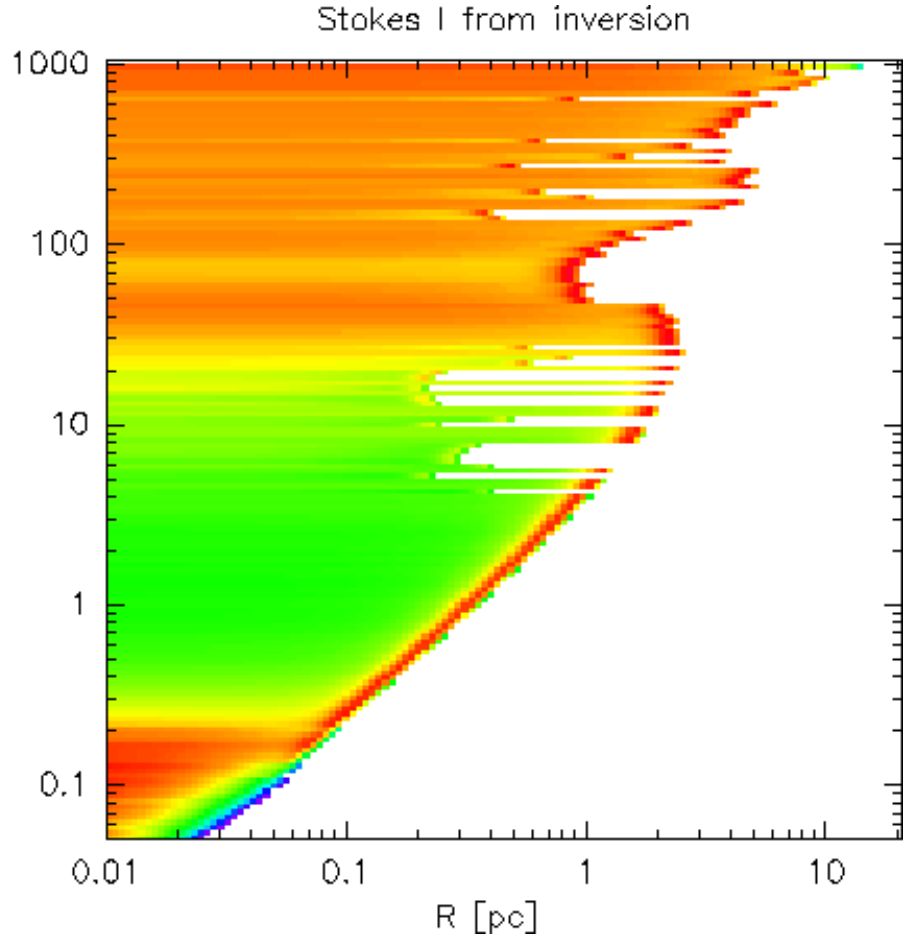


Proof-of-concept



Inversion of the synthetic radiomaps





Summary

Stellar jets:

- given high-quality data and assuming axisymmetry, it is possible to infer the intrinsic, non-parametric, deprojected emissivity and velecity field in YSO jets
- simulataneous inversion of several line profiles may improve the results dramatically
  $\longrightarrow$ use as much info as available
- better input for diagnostics
- very valuable input for global MHD jet models

AGN jets:

- given Stokes I and Stokes Q and assuming that a homogeneous shell dominates the synchrotron emission, it is possible to infer the intrinsic, non-parametric, deprojected magnetic field structure in AGN jets
- simultaneous inversion of I & Q dramatically improves the results