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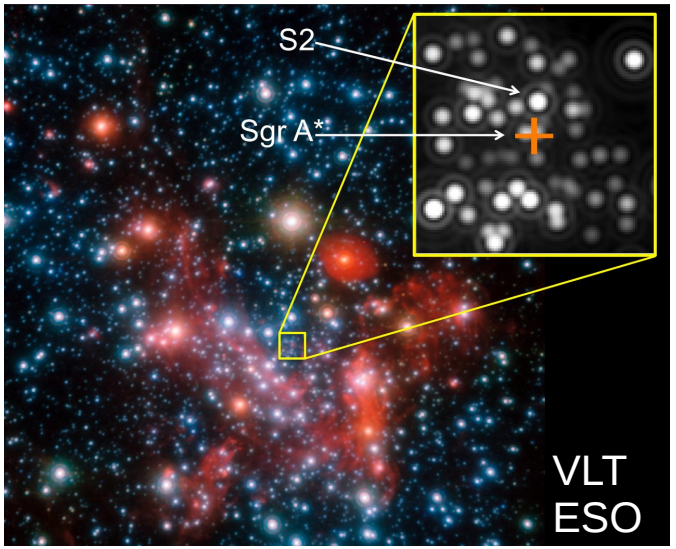
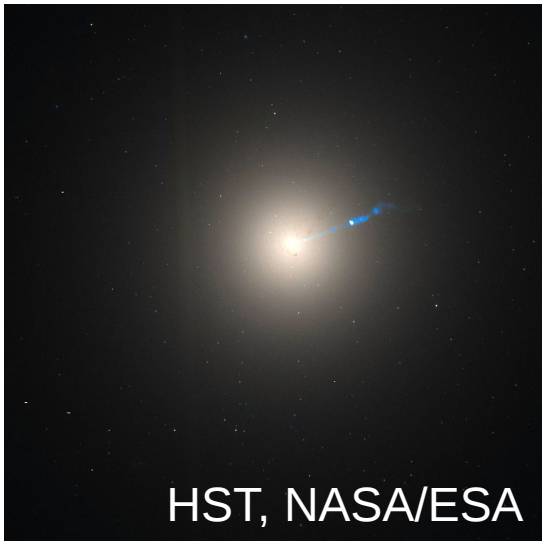


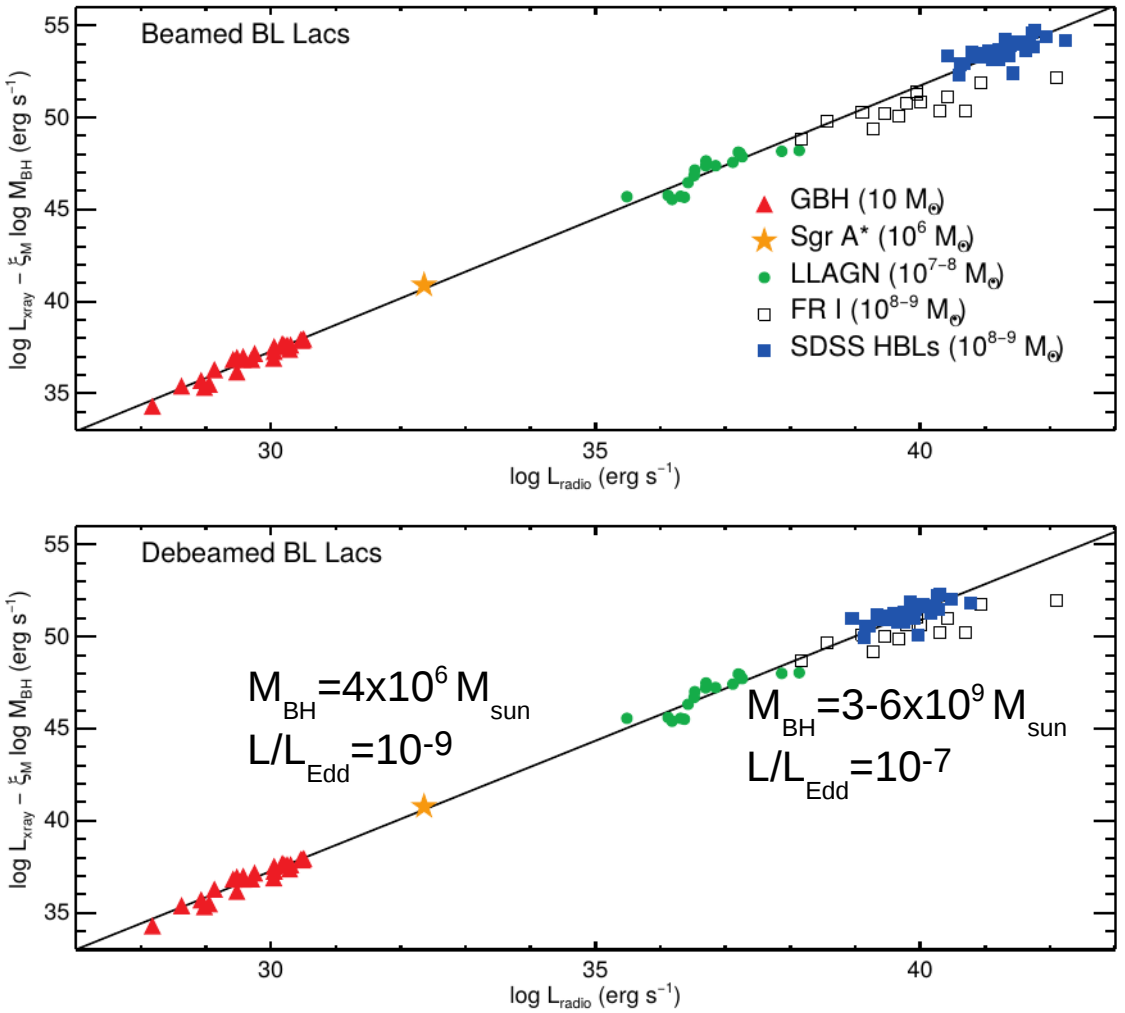


MHD Theory: Accretion Disks, Jets, Radiation

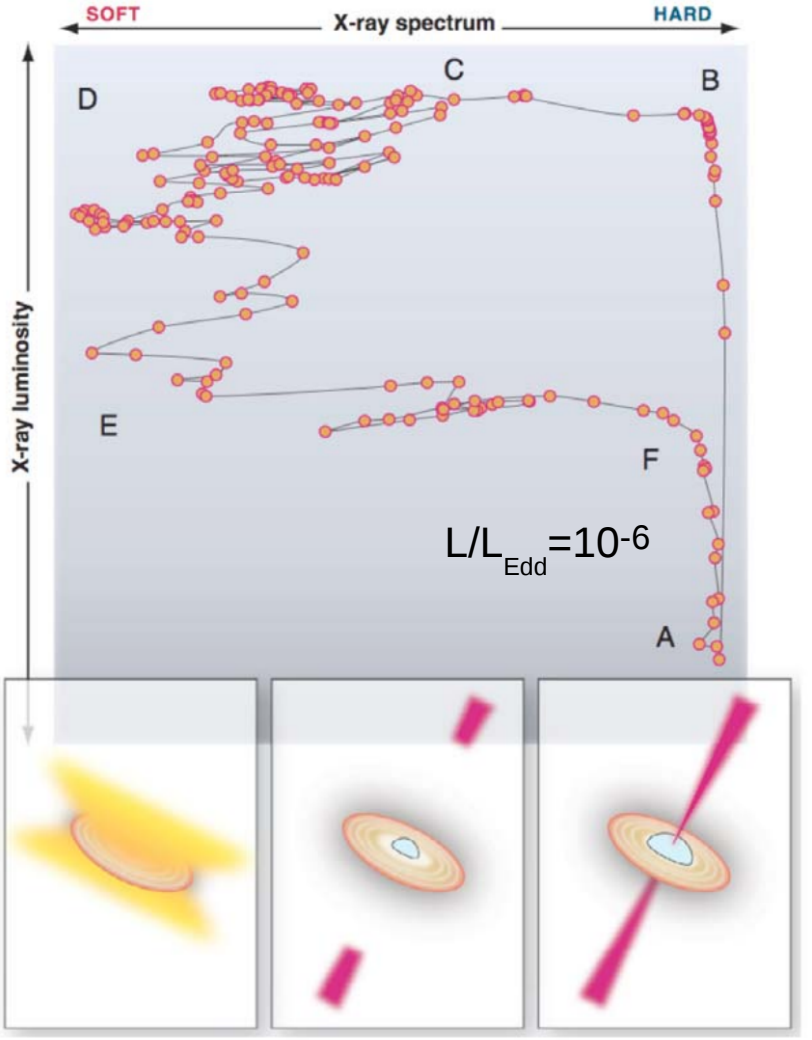
Monika Moscibrodzka
Radboud University Nijmegen Netherlands

26 Sept. 2017

Disk – jet symbiosis in low states

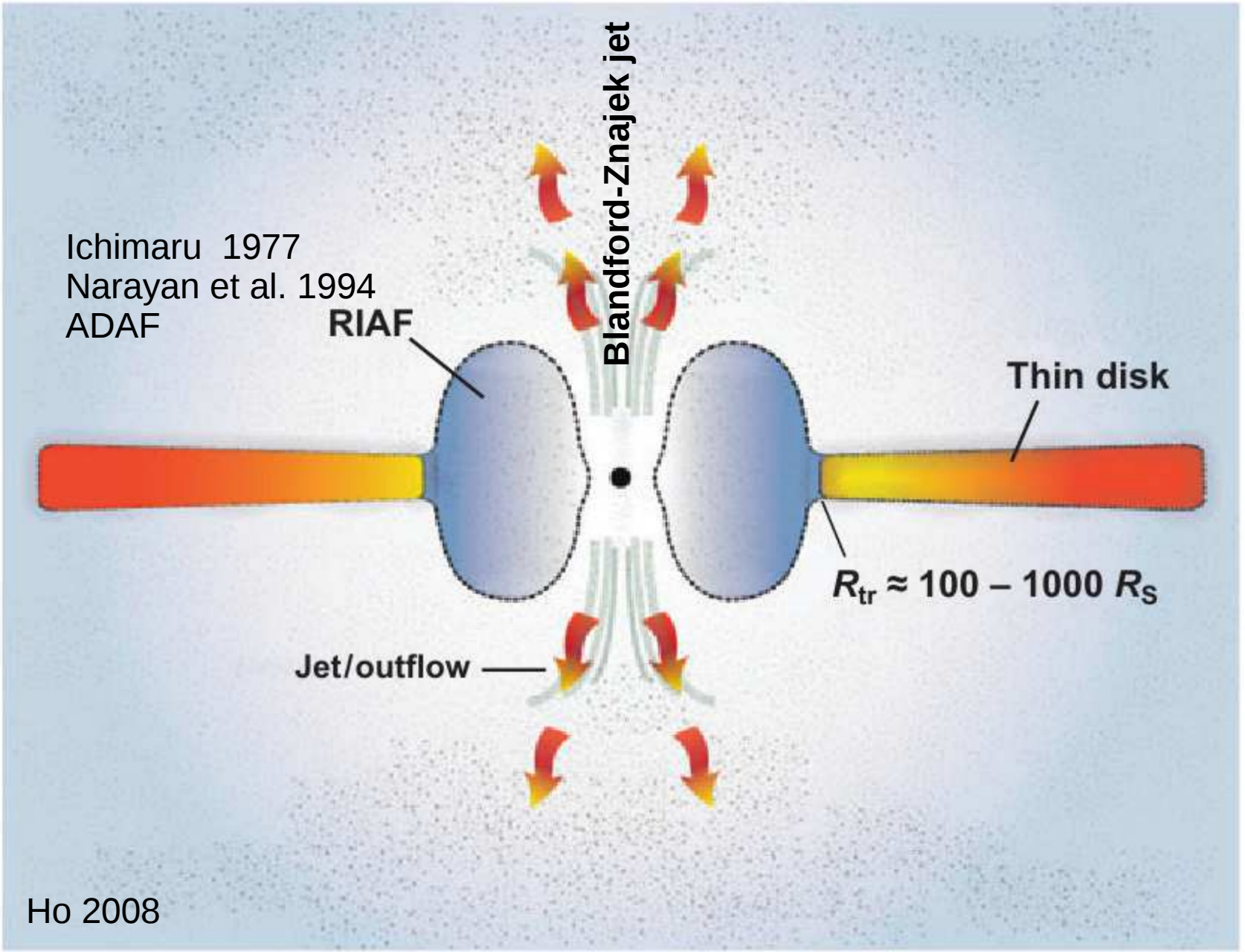


Plotkin et al. 2011

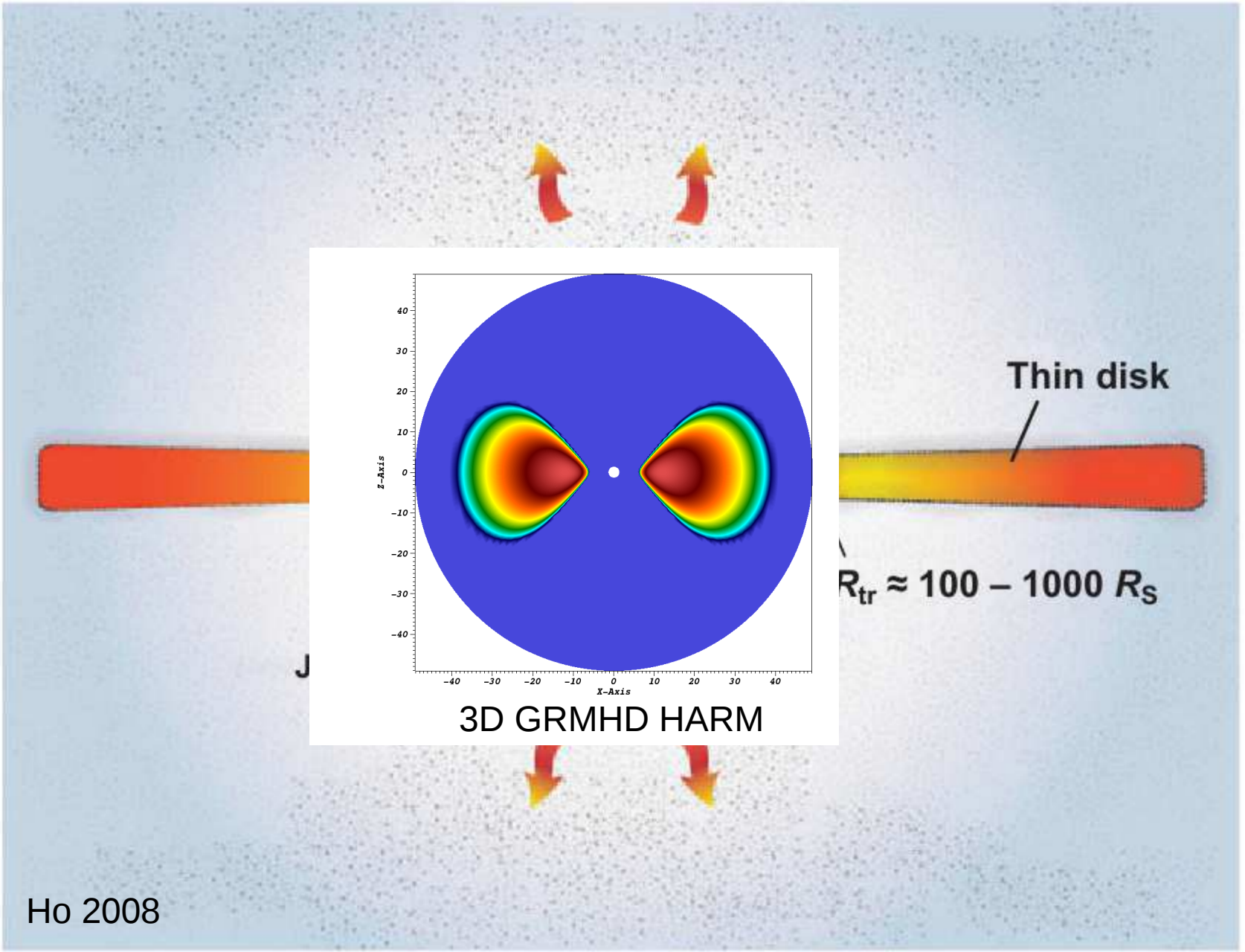


Fender 2016

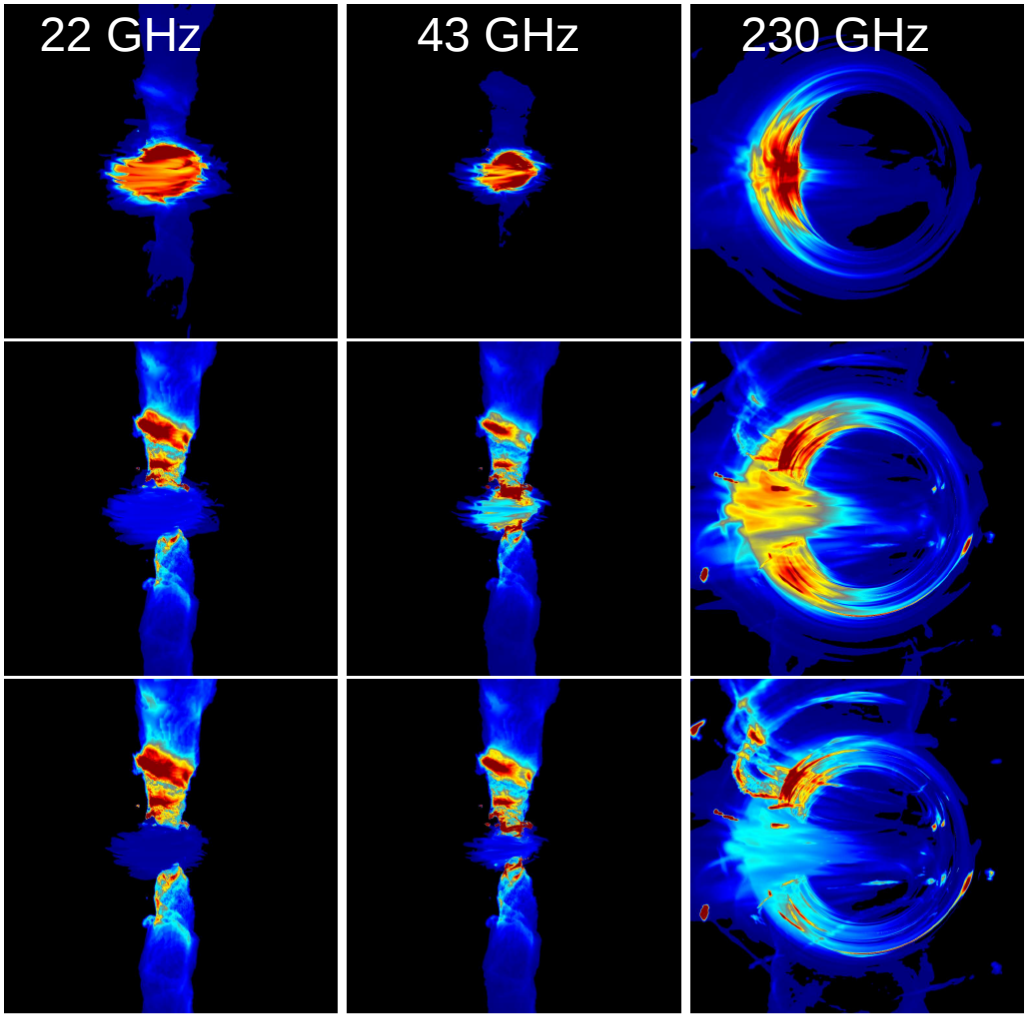
Quiescent state?



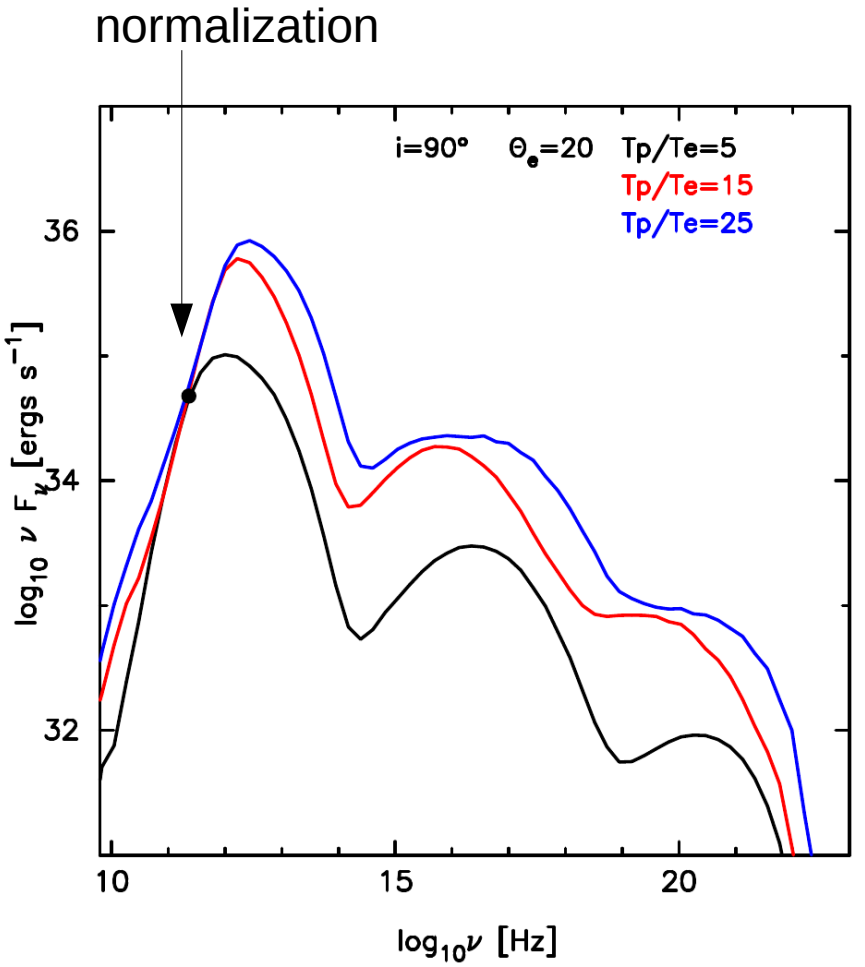
Numerical models of black hole accretion



„Painting simulations with hot electrons“

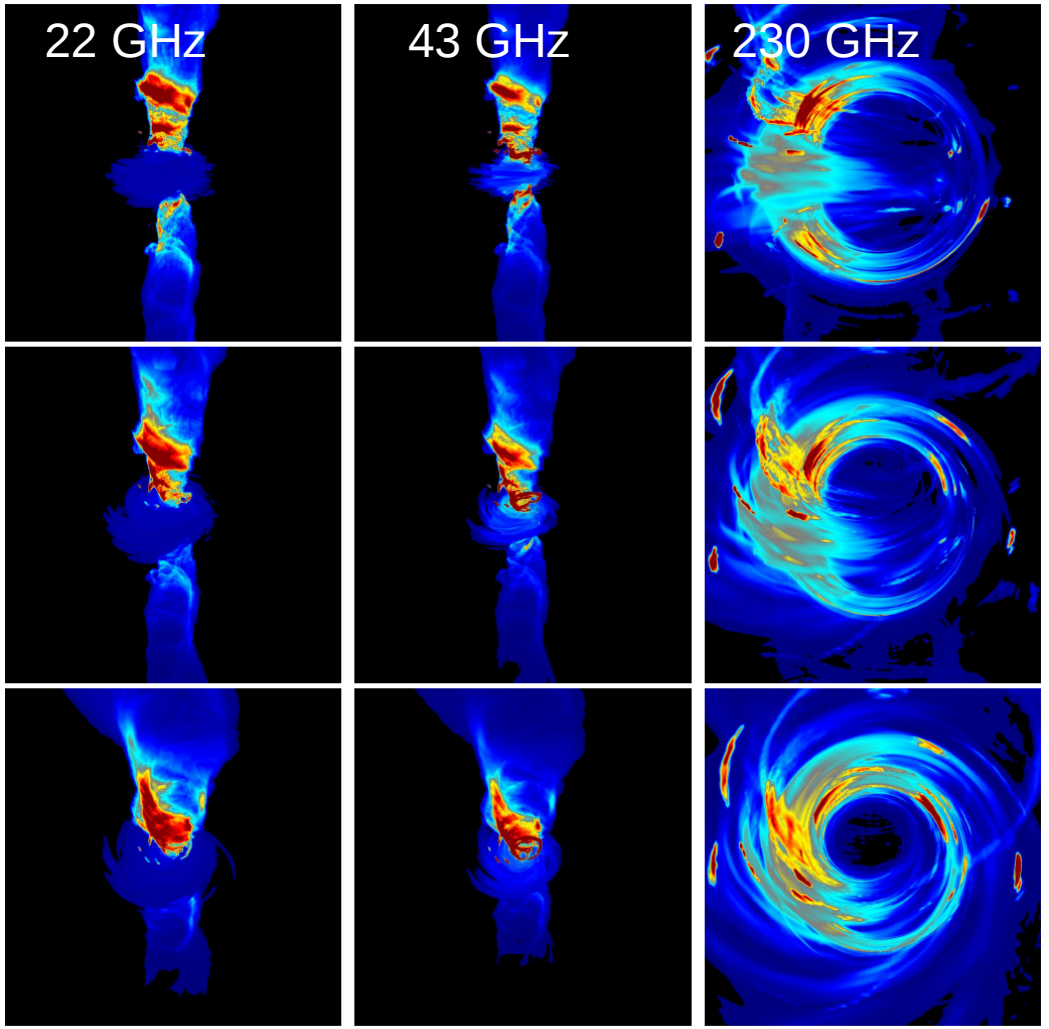


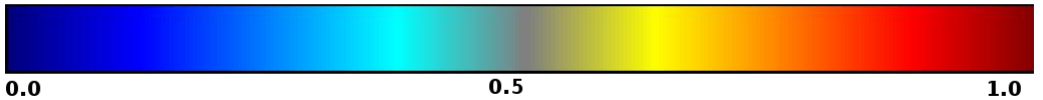
Hot disks vs. cool disks+hot jets



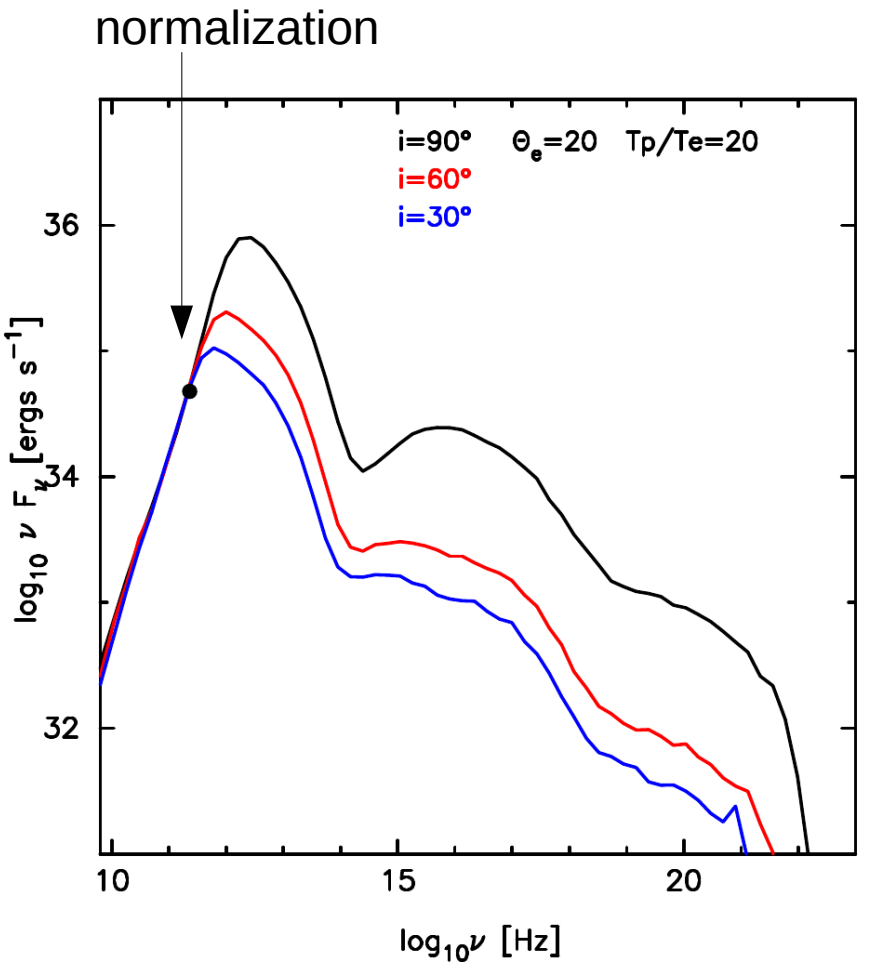
MM et al. (2014)

„Painting simulations with hot electrons“



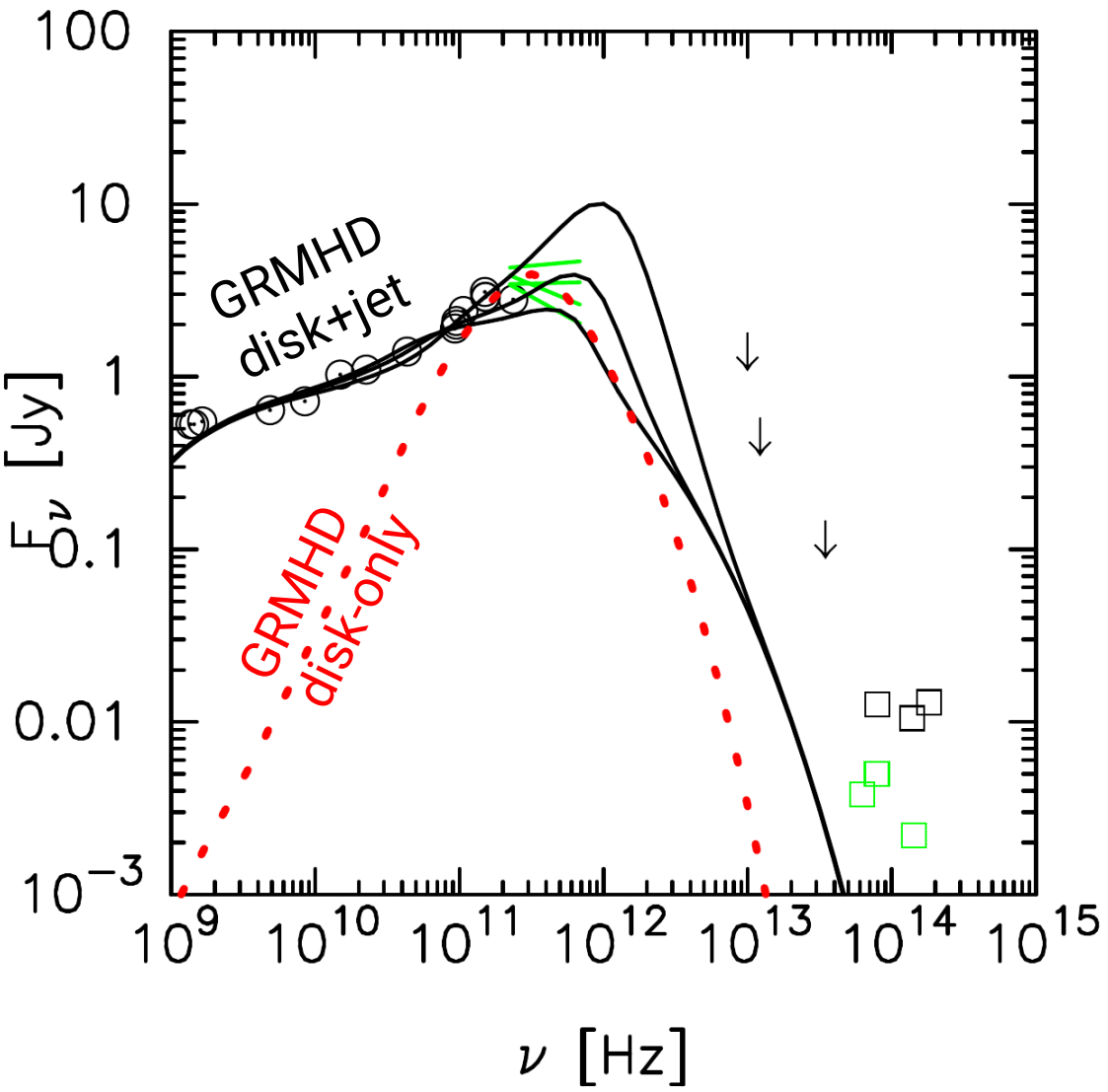


Jet-sheath (disk jet) model at different viewing angles



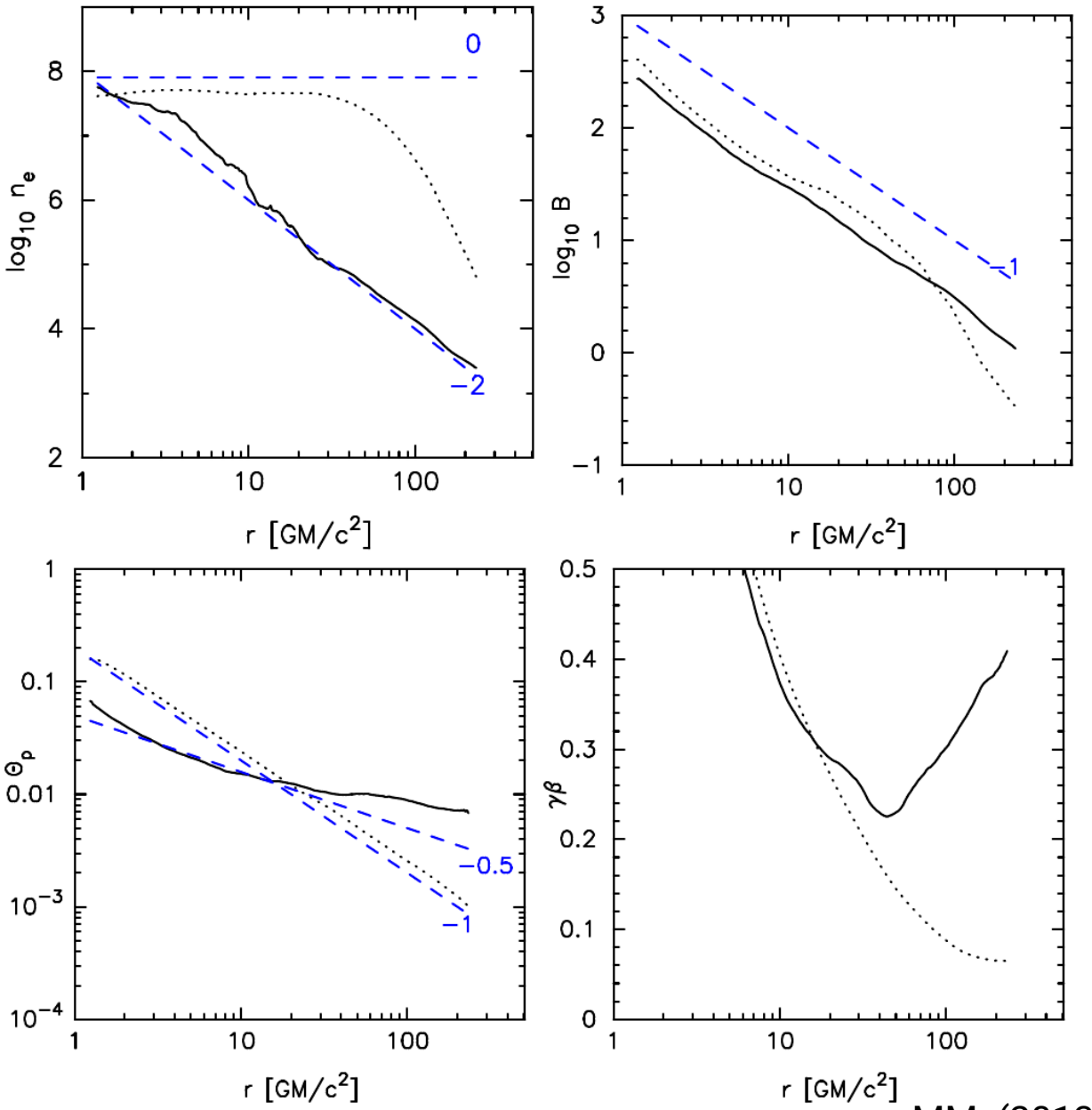
MM et al. (2014)

Hot jet-sheath naturally explains the nearly flat radio SED



MM (2013, A&AL)

GRMHD jet-sheath = Blandford & Konigl 1979



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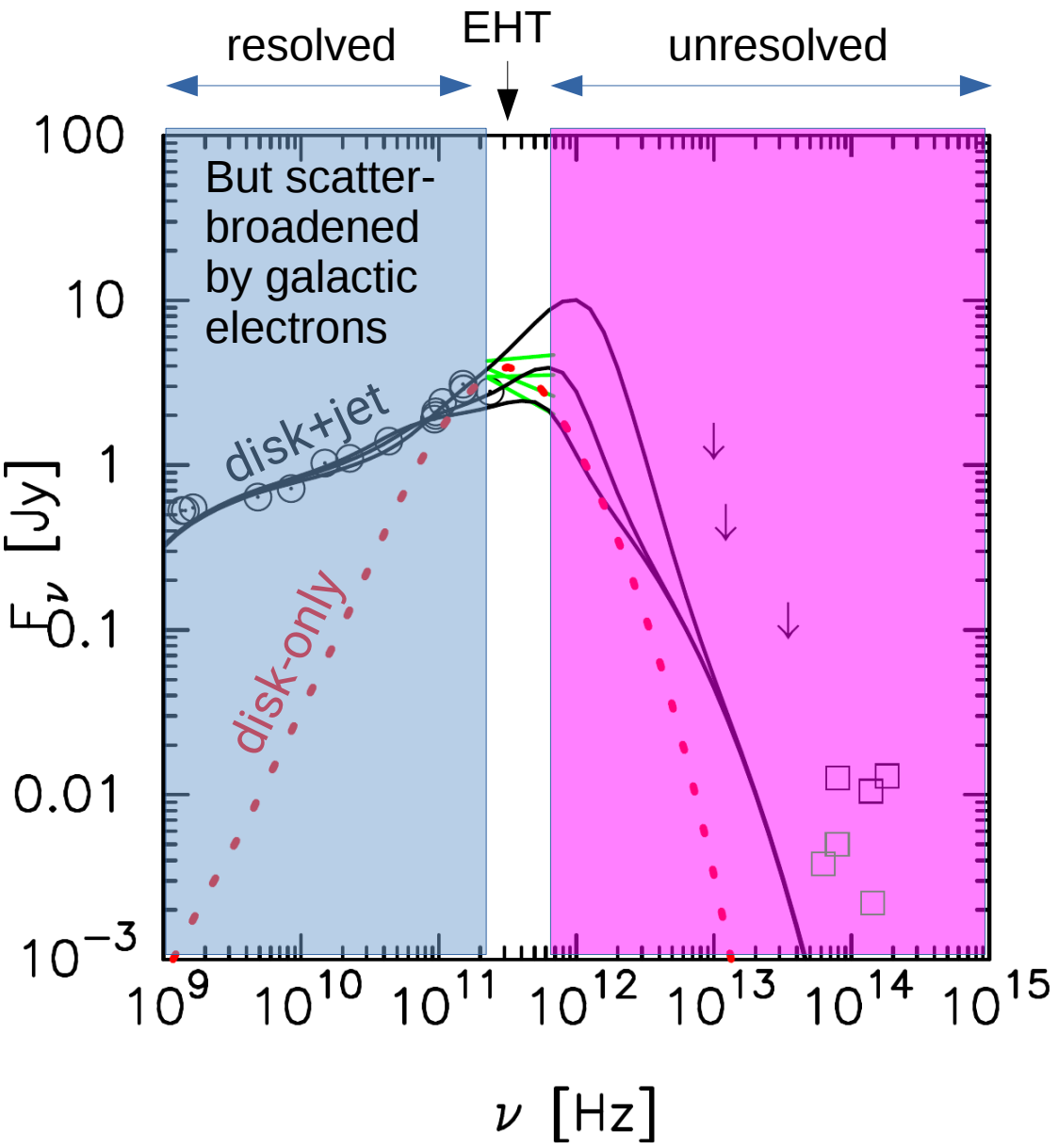
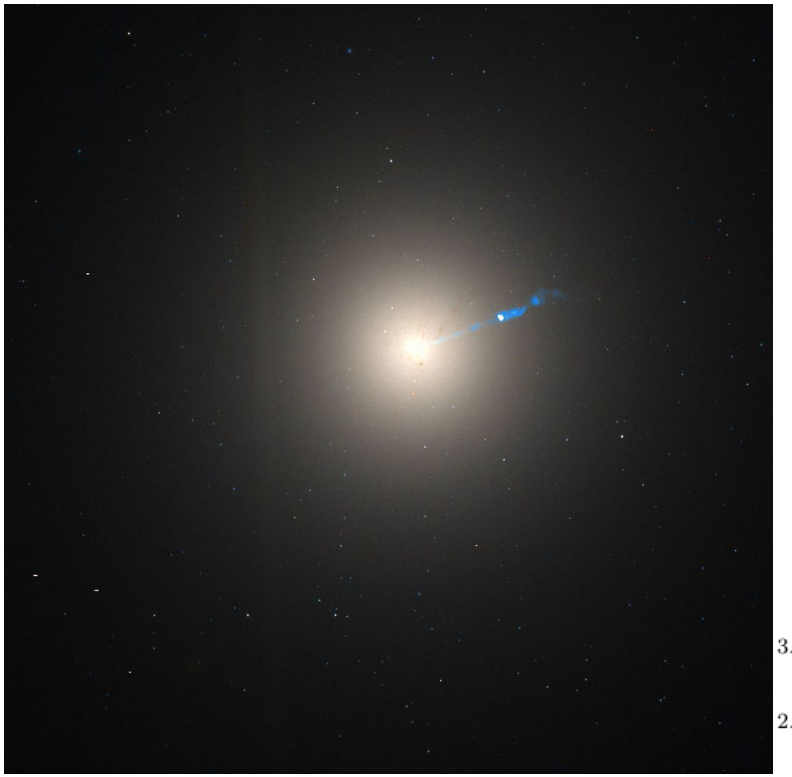


MM (2013, A&AL)

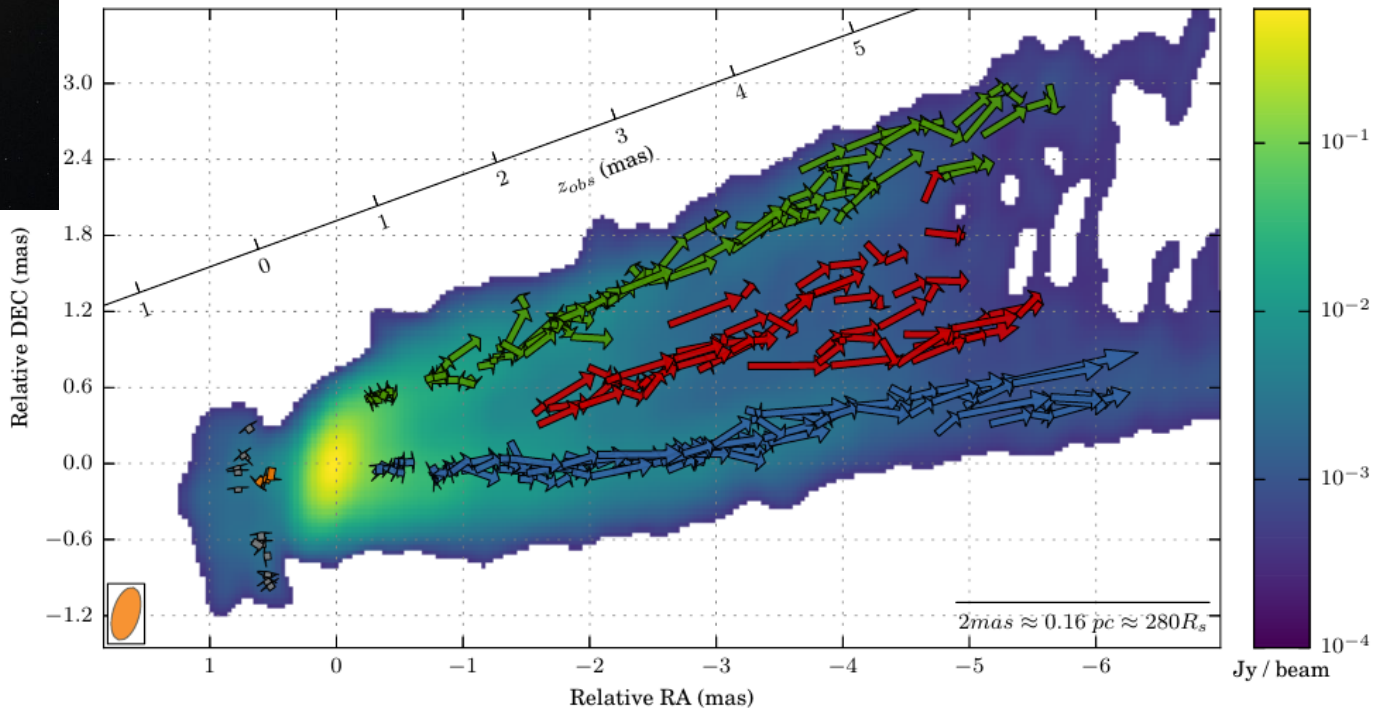
Plasma physics during quiescent state



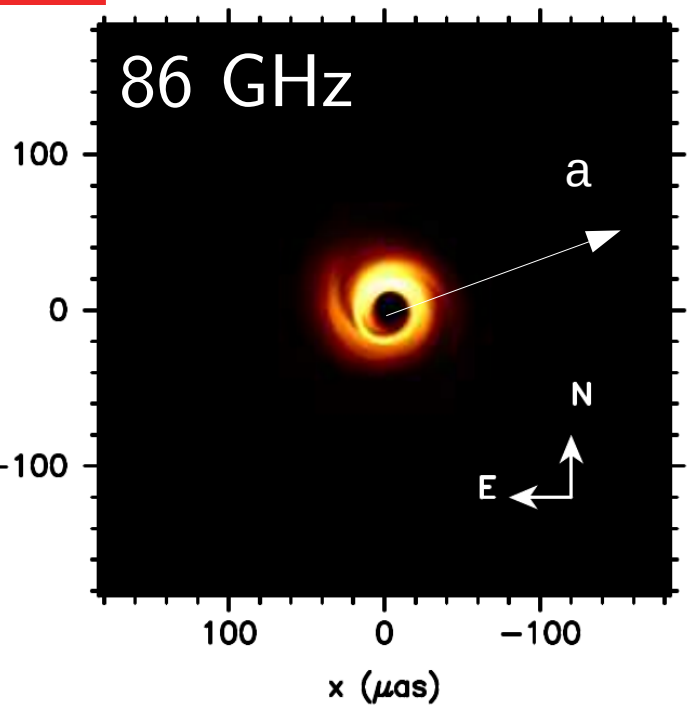
HST, NASA/ESA

- No scattering
- Orientation contrained by large scale jet
- Scaling the model – interesting excercise

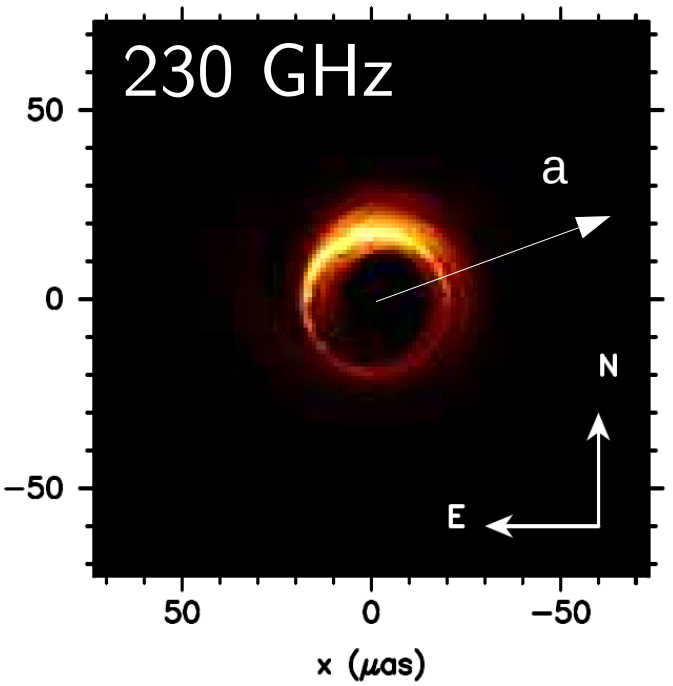
Mertens+2016



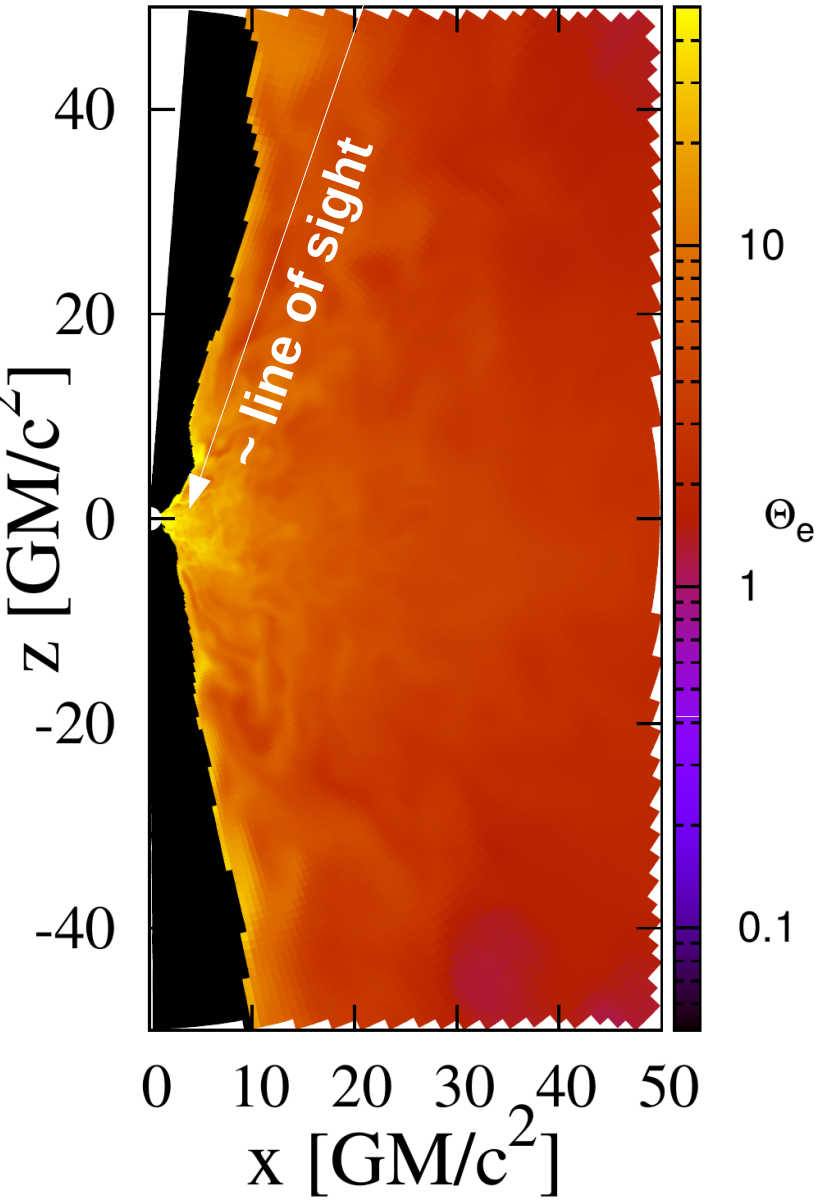
Plasma physics during quiescence – hot disk ?



$M_{acc} = 10^{-4}\ M_{sun}/yr$

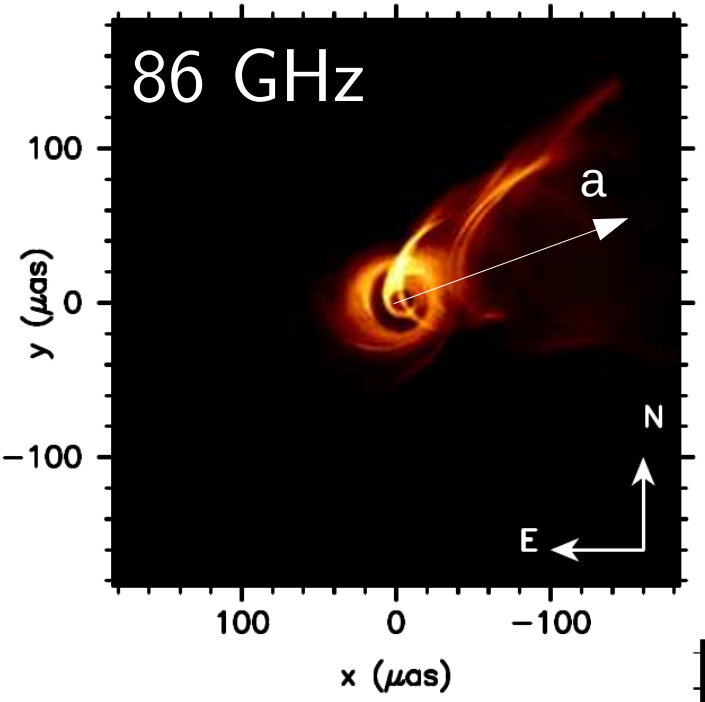


Disk emission dominated images

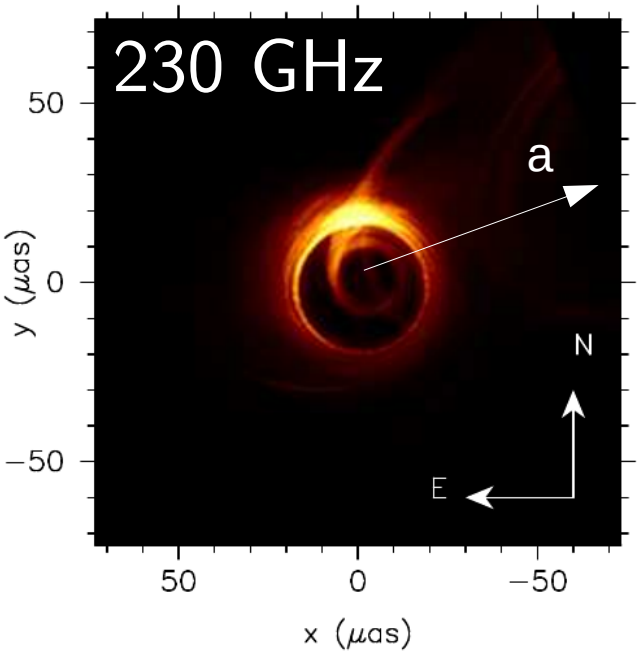


MM et al. (2016)

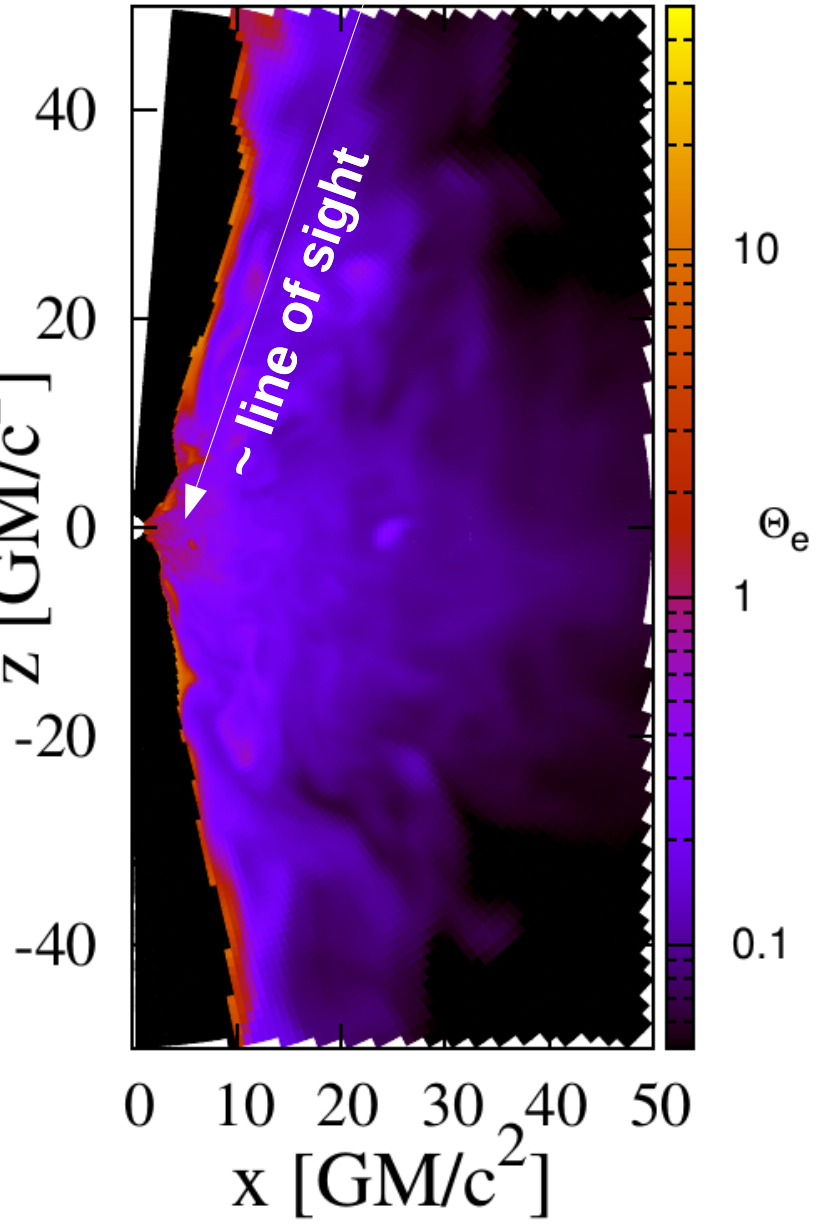
Plasma physics during quiescence – cool disk+hot jet



$M_{acc} = 9 \times 10^{-3}\, M_{sun}/yr$

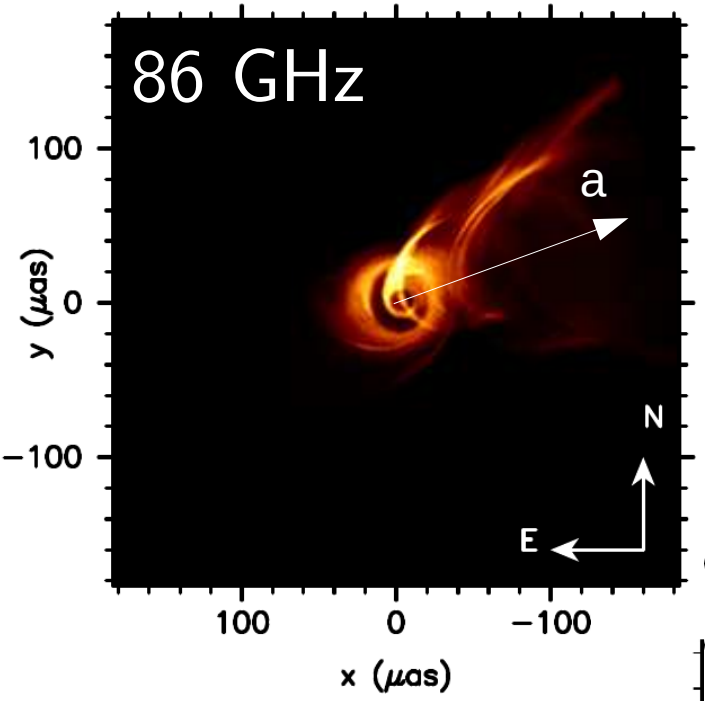


Jet-sheath emission dominated images



MM et al. (2016)

Plasma physics during quiescence – cool disk+hot jet



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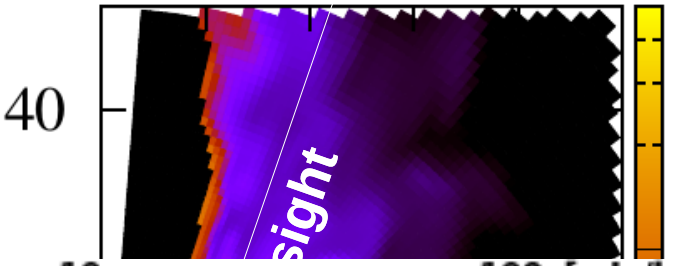

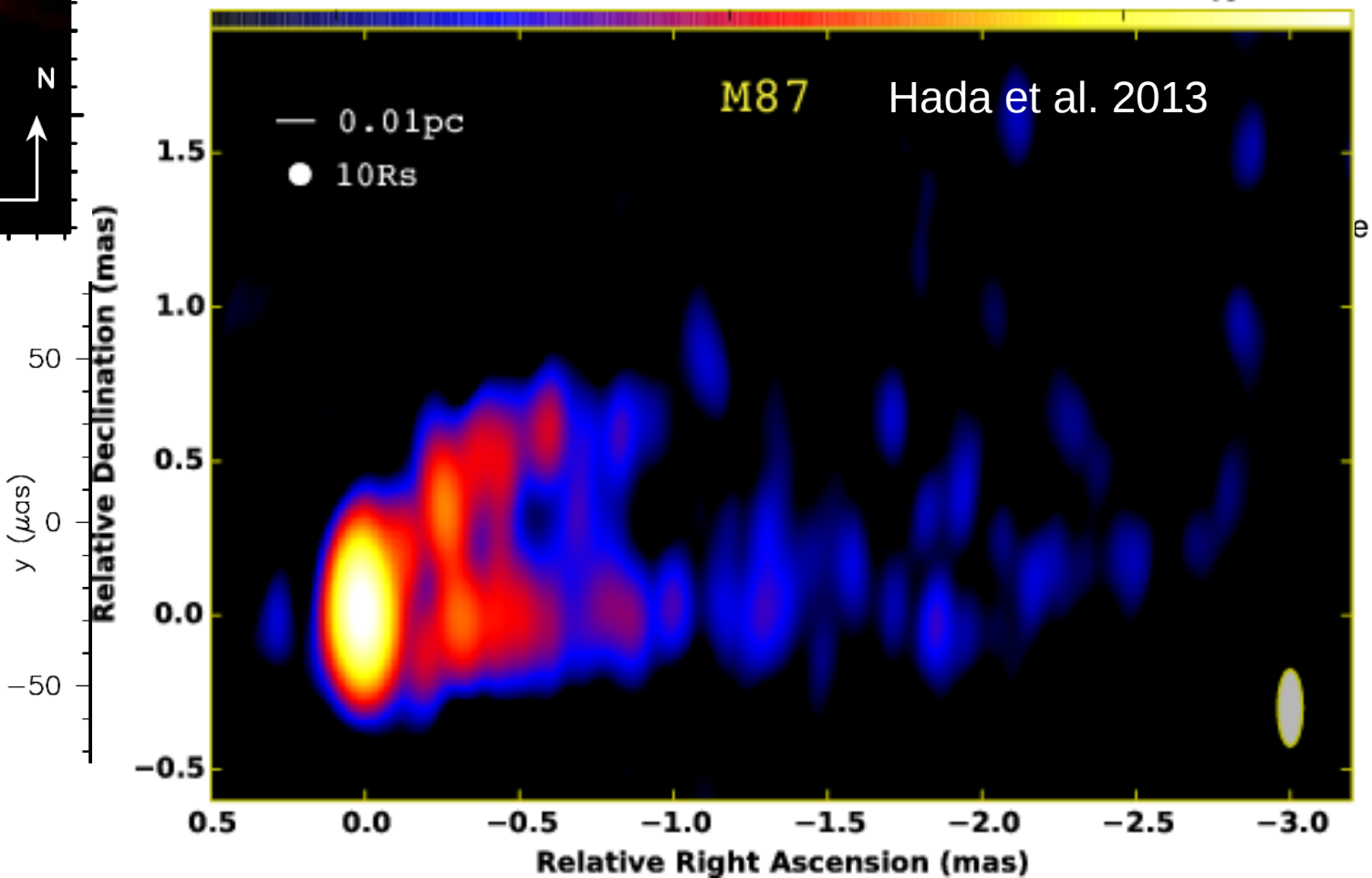

Jet-sheath emission dominated images

MM et al. (2016)

Polarization of accreting black holes

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- Sgr A*: LP $\sim$ 5-7 %, RM = - 5.6($\pm$0.7)x10^5 rad/m^2 (Marrone+2007)
- M87: LP $\sim$ 1%, |RM| $<$ 7.5x10^5 rad/m^2 (Kuo+2014)

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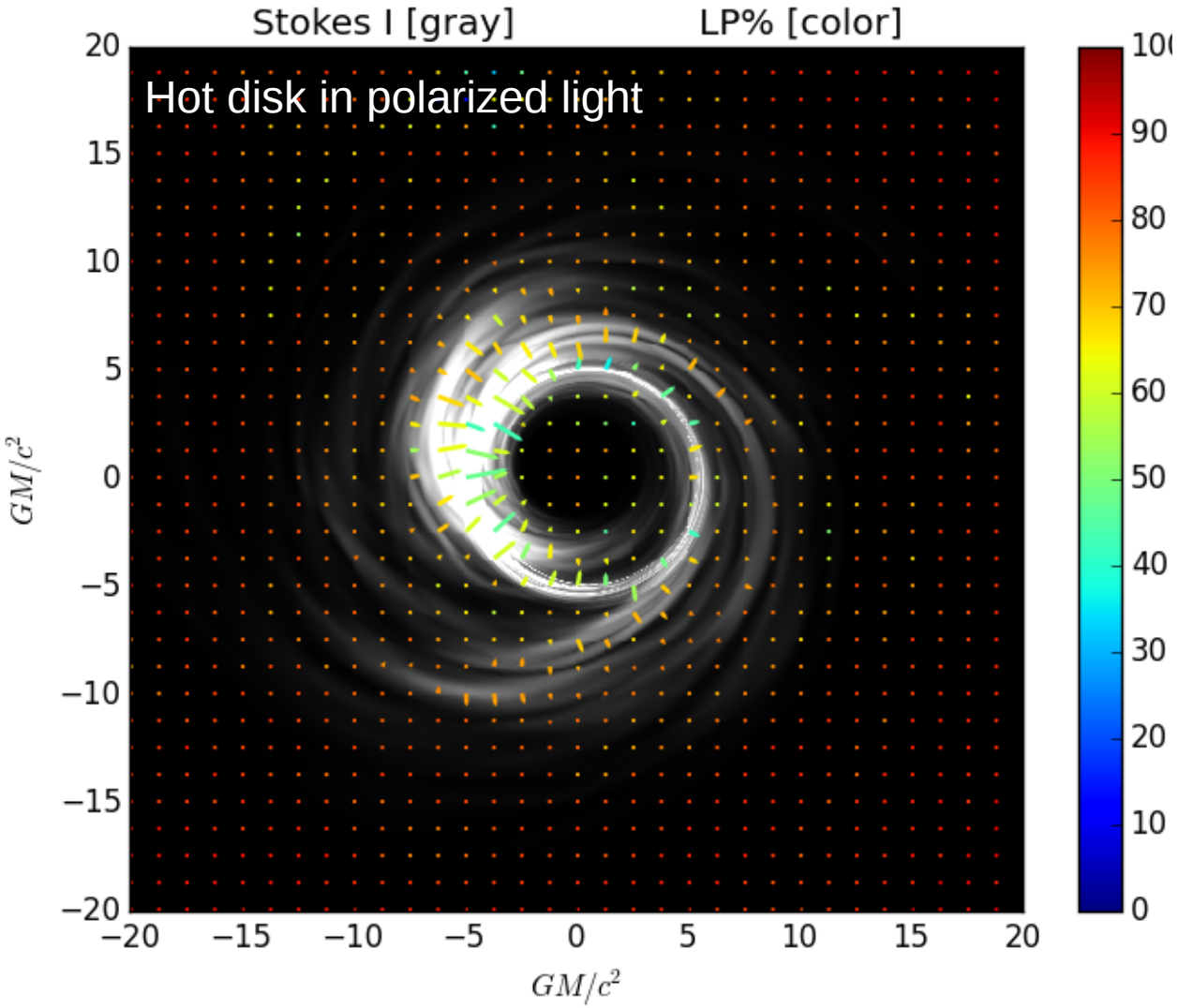
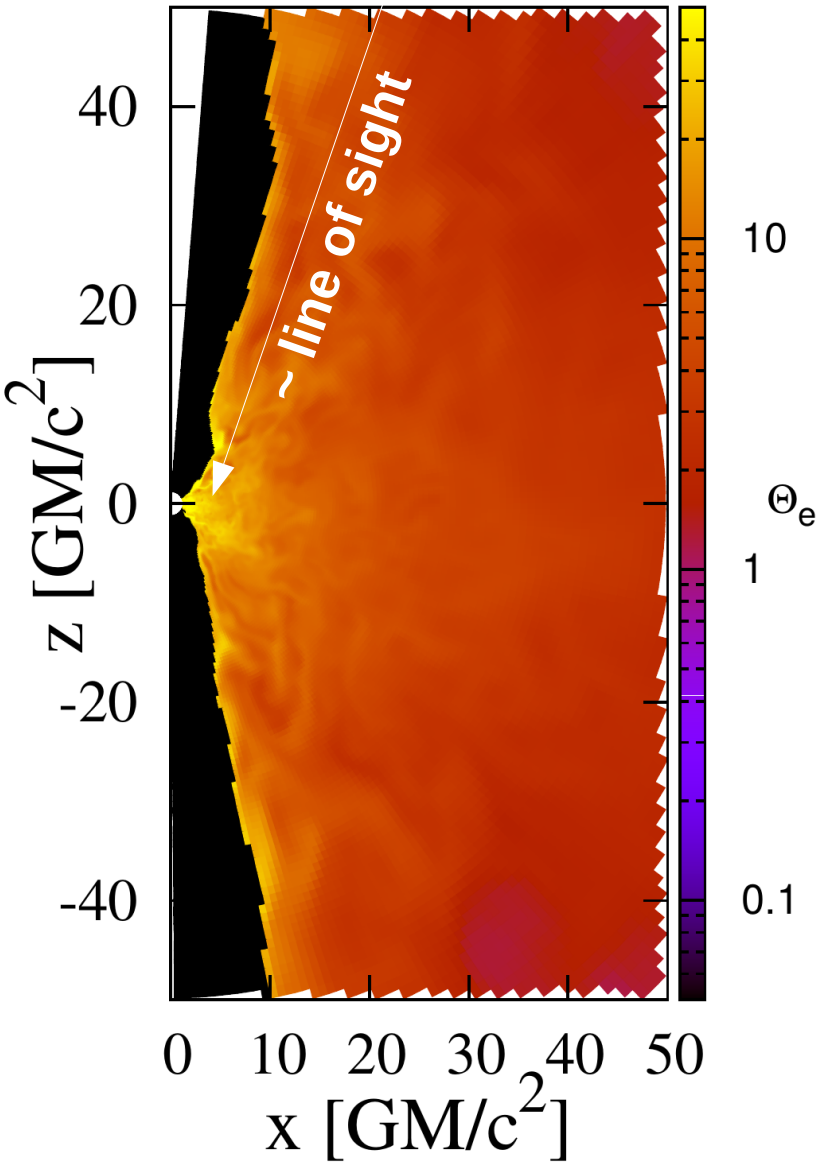
  - Gravitational lensing, gravitational redshift, doppler boosting, gravitational Faraday rotation (all contribute at order of unity to radiative properties of a model)
- ipole code (Moscibrodzka, Gammie 2017, submitted)
  - ***analytic (!)*** solutions to transfer equations (synchrotron contunuum, no scattering)
  - ***super-fast*** and *very* compact
  - ***covariant***: non-Kerr spacetimes can be selfconsistently tested
  - to be ***publicly*** realsed
  - ray-tracing scheme (images and spectra) for relativistic polarized RT in arbitrary: spacetimes, optical thickness, and Faraday thickness

„Painting simulations with hot electrons“ Polarimetric properties of quiescent jet (launching point)

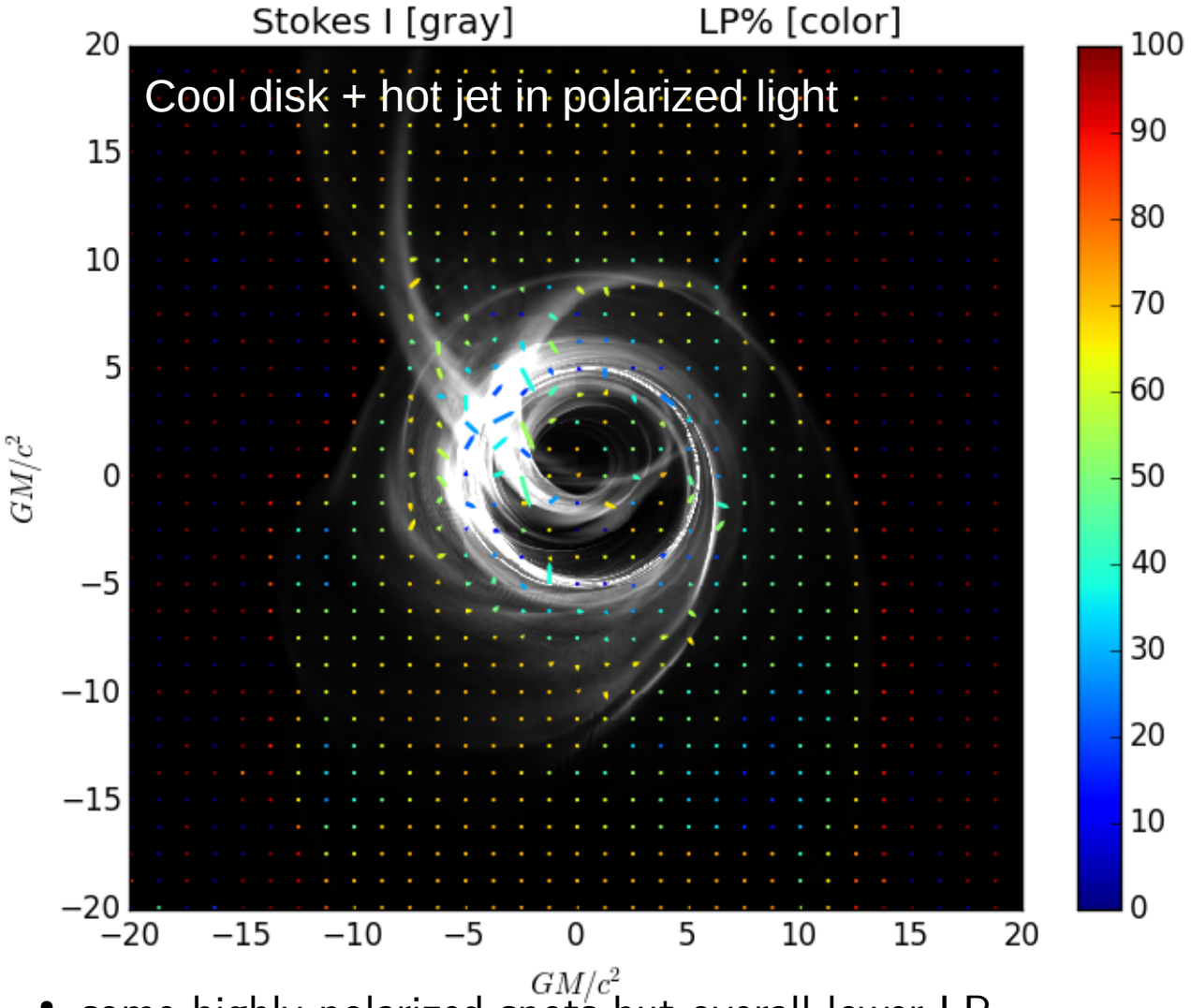


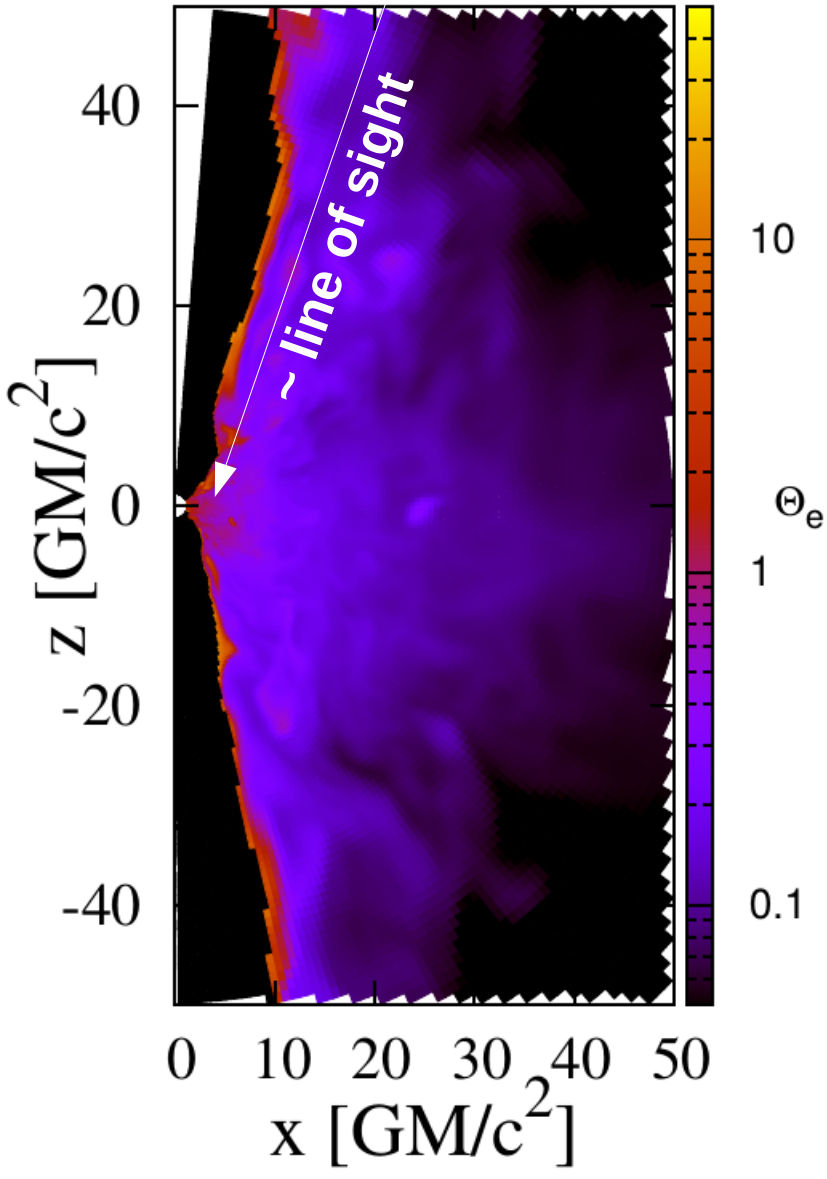


- EVPA organized, radiation mostly strongly polarized
- in non-VLBI beam depolarized down to LP=5%

MM, Dexter, Davelaar, et al 2017

„Painting simulations with hot electrons“
Polarimetric properties of quiescent jet (launching point)

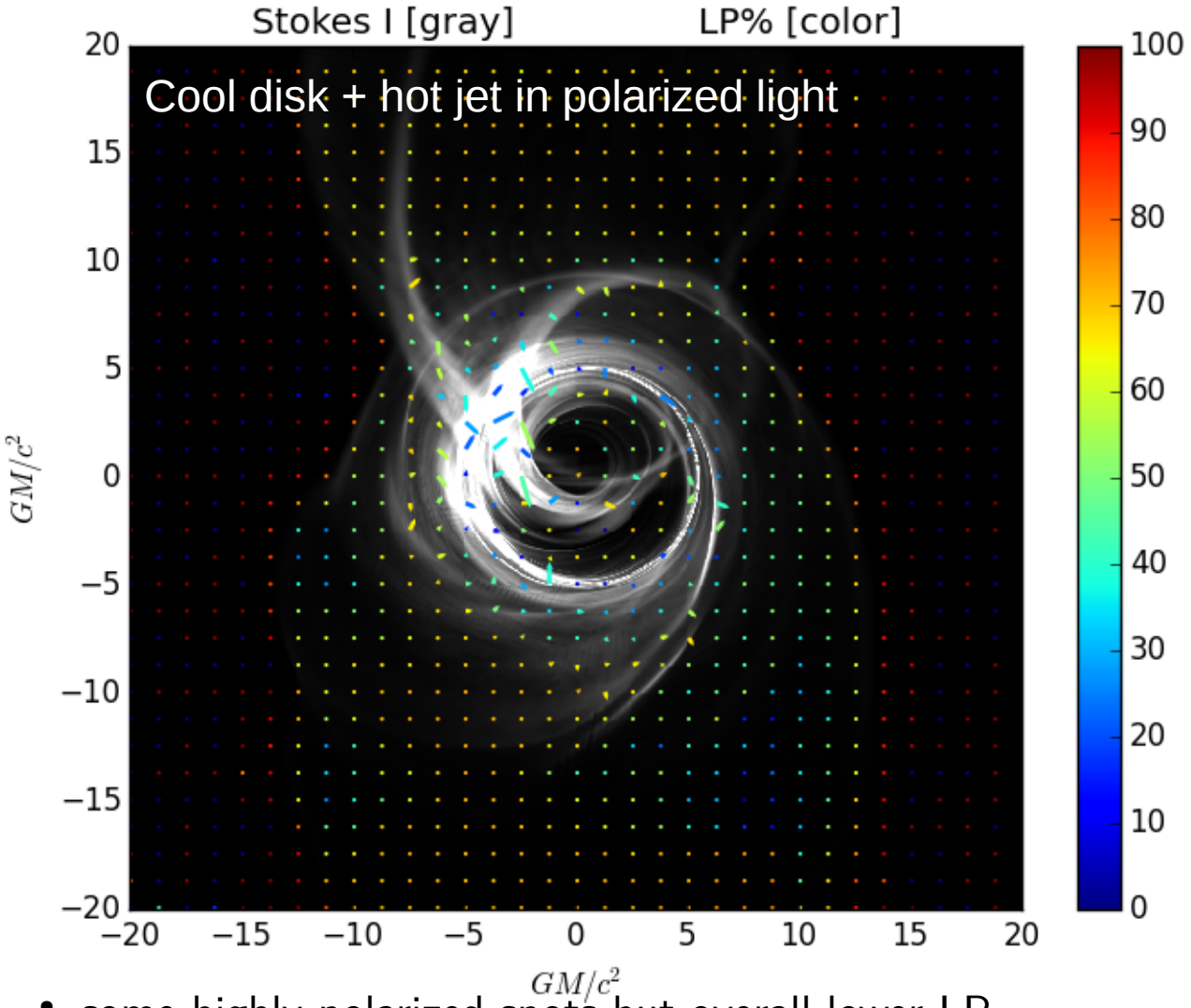


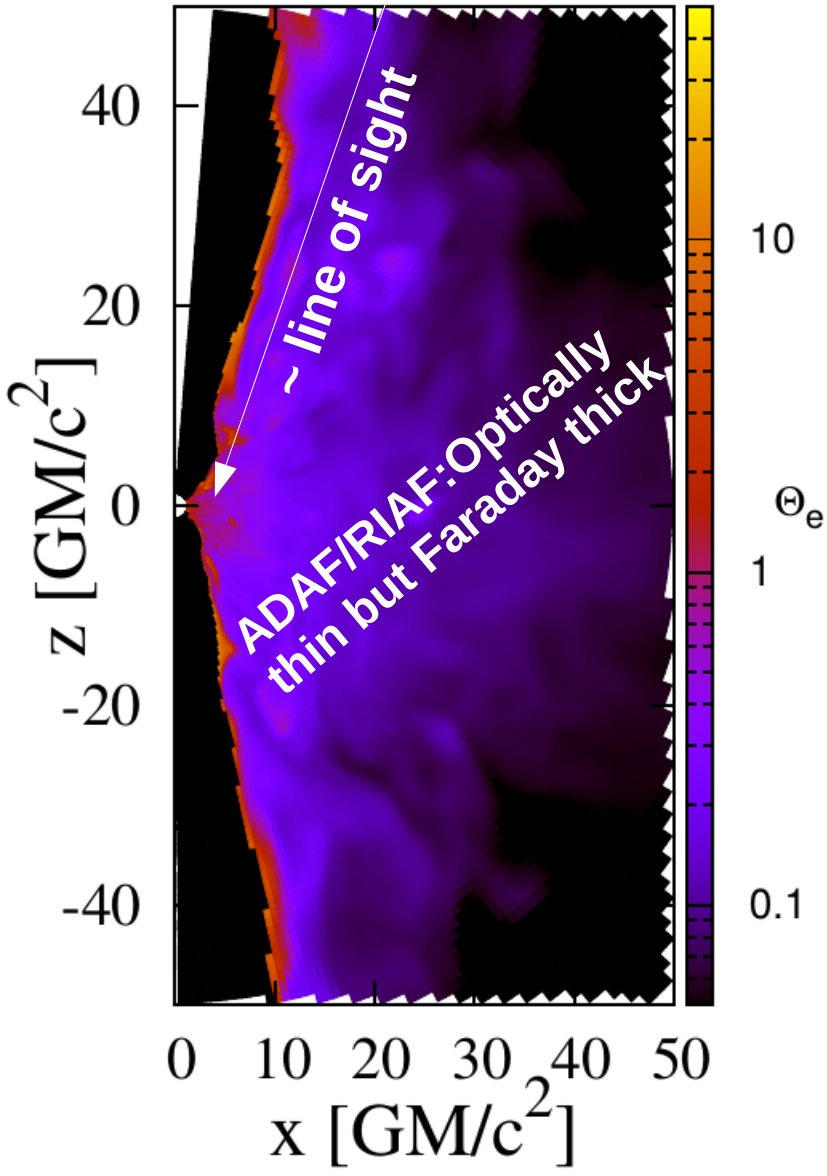


- some highly polarized spots but overall lower LP
- in non-VLBI beam depolarized down to 1%
- strong internal Faraday rotation: scrambling EVPA

MM, Dexter, Davelaar, et al 2017

„Painting simulations with hot electrons“
Polarimetric properties of quiescent jet (launching point)





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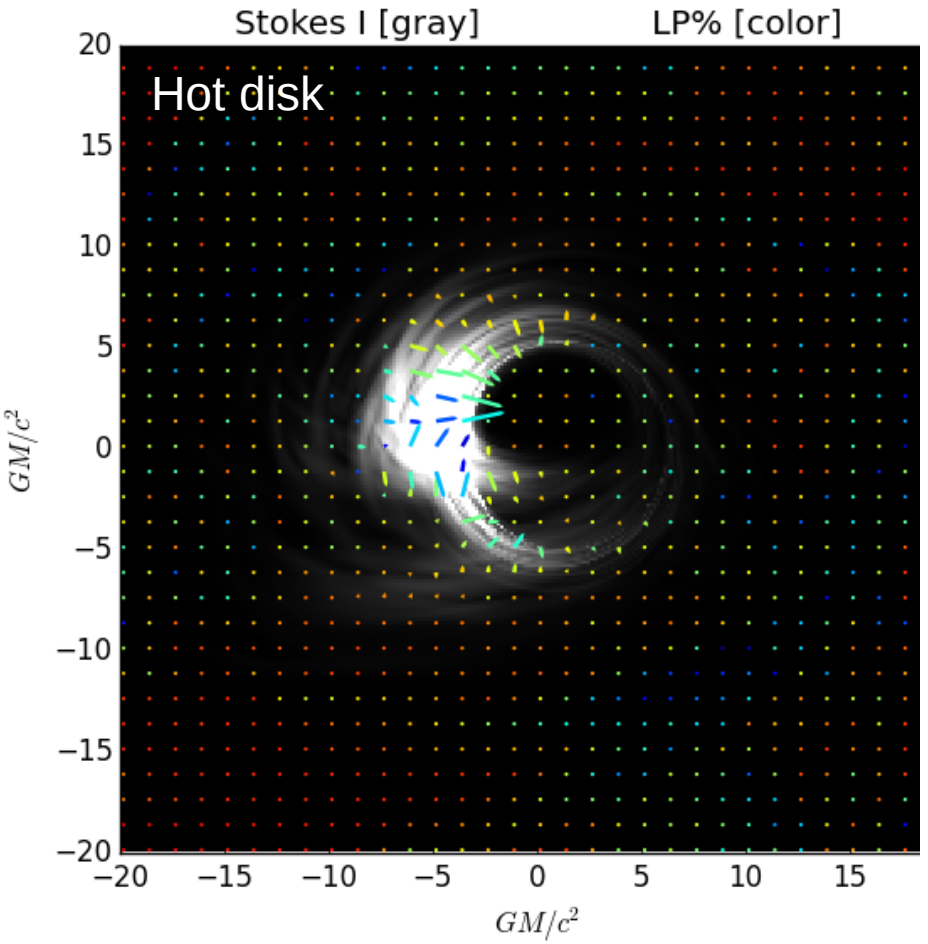

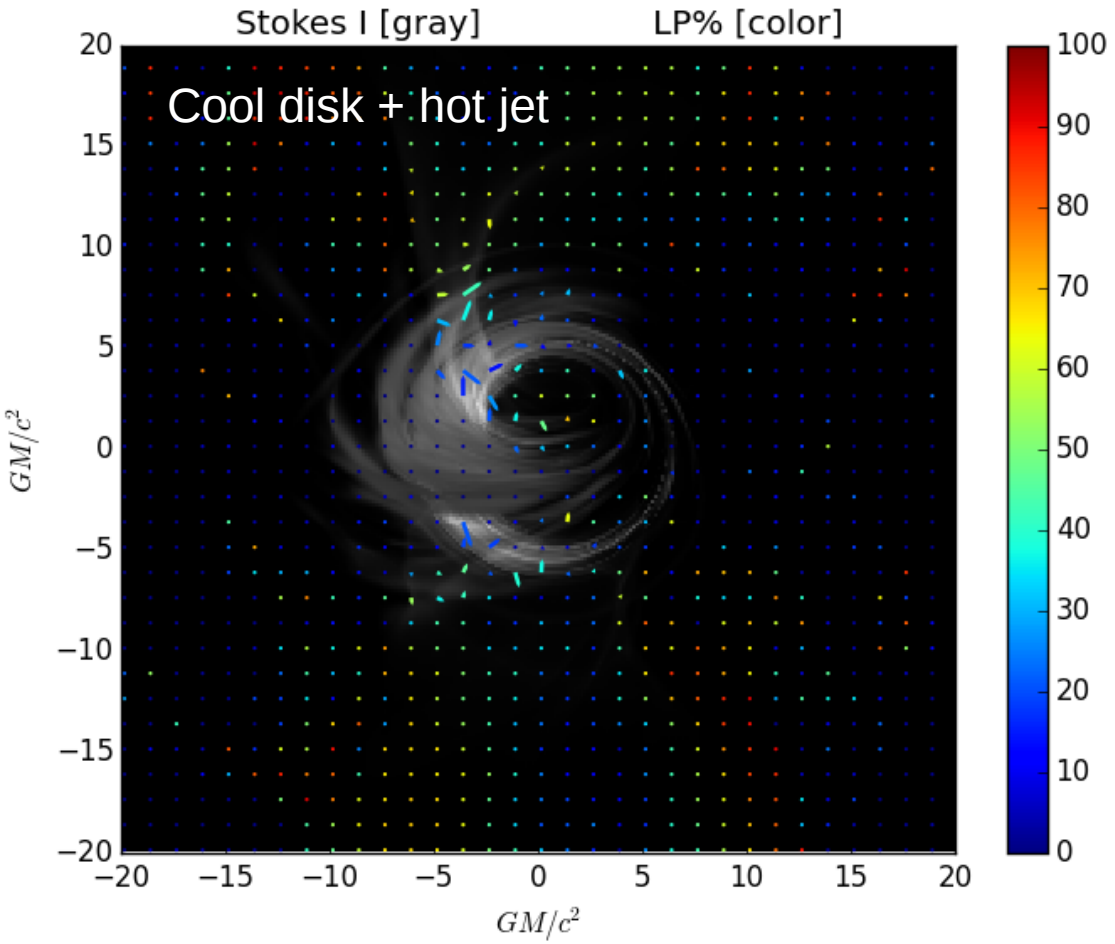

Disk emission model LP = 9%

Jet emission model LP < 1 % !
Non-thermal component in the jet-sheath ?

Summary, future steps

- MHD models do not resolve detailed electron physics which is the biggest problem
- Current model/observations of LLAGN lean toward jet but there maybe details to work out (more detailed electron model e.g. w/ particle acceleration may be unavoidable)
- We will test our quiescent states scenarios in 2xLLAGN with EHT
- More models with different magnetizations, spins will be tested along (EHT collaboration is making a huge effort)
- Modeling radiative MHD (selfconsistently) is being developed but progress in this direction would be faster if electron physics in the quiescent state is better understood
- Here only steady jets, no ejections due to B-reconnections because no explicit physical resistivity (ideal MHD)
- I talked about jet-sheath models – jets that are in symbiosis with the disk, issue of the jet-spine (may also become bright at softer states) dynamics, radiative properties, and interactions with jet-sheath remains unsolved (Moscibrodzka et al. 2011, O' Rodrian talk)
- Polarimetry is a crucial diagnostic tool – should be done carefully
- We plan to expand the polarized models to include Compton scattering in Monte Carlo framework to make the radiative models applicable to observations of broader range of objects (stellar-mass BH)
- Any suggestions welcome