Low-Luminosity AGN Feedback

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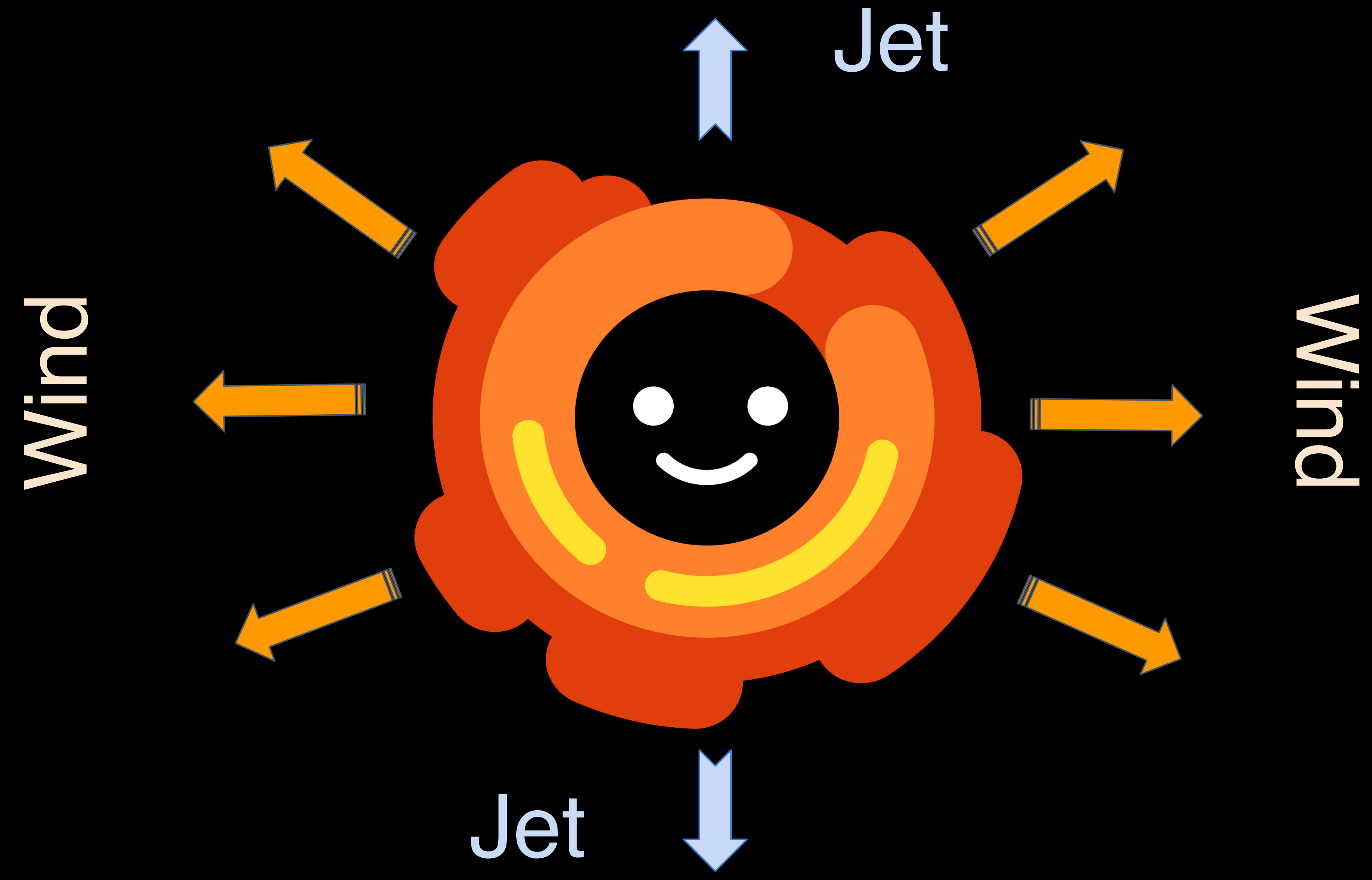
AGN

The universe is populated by supermassive black holes (SMBH) accreting their surrounding gas

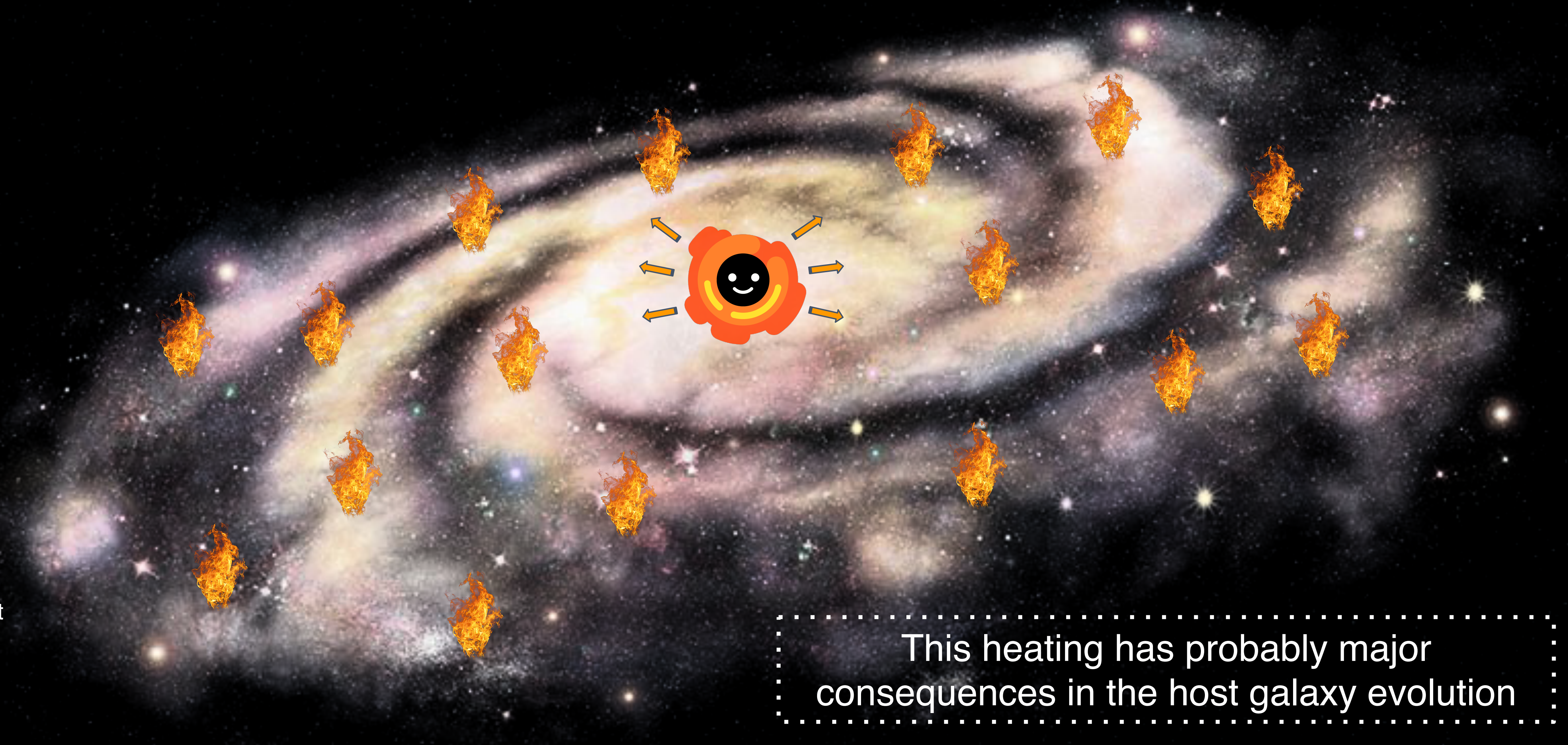
We call this phenomenon Active Galactic Nuclei (AGN), most galaxies does not present an active nucleus

Accreting SMBHs also eject material

(blame the conservation of momentum angular, BH spin, and magnetic fields)



The *outflows* interact with the galaxy, heating the environment

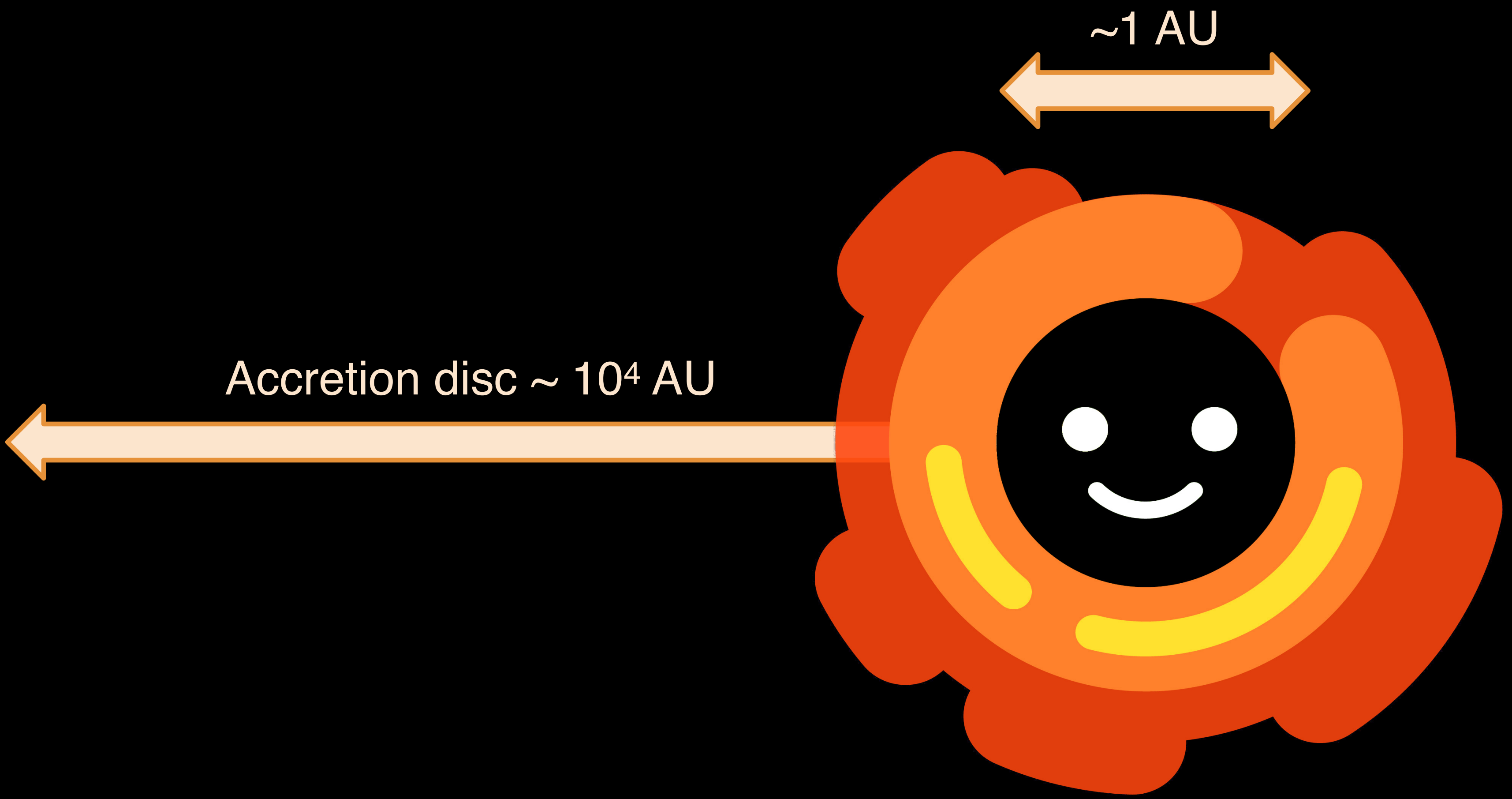


*Totally out of scale

This heating has probably major consequences in the host galaxy evolution

SMBHs are very small

(considering galaxy scales)



In parsecs:
BH (10^8 M_{Sun}) = 5×10^{-6} pc
Disc = 5×10^{-2} pc

Can something so small have a noticeable effect on kpc scales?

M-σ relation

Star formation rate

BCG size

Bubbles in Clusters

The cooling flow problem

What are the mechanisms behind this AGN feedback

AGN feedback is efficient enough to suppress star formation and change the appearance of the galaxy

Accretion Disc scales

GRMHD numerical simulations of RIAFs

Galactic scales

Theoretical modelling of the outflow energetics and interaction with the galaxy's gas

Target: Low-Luminosity AGN (low accretion rates)

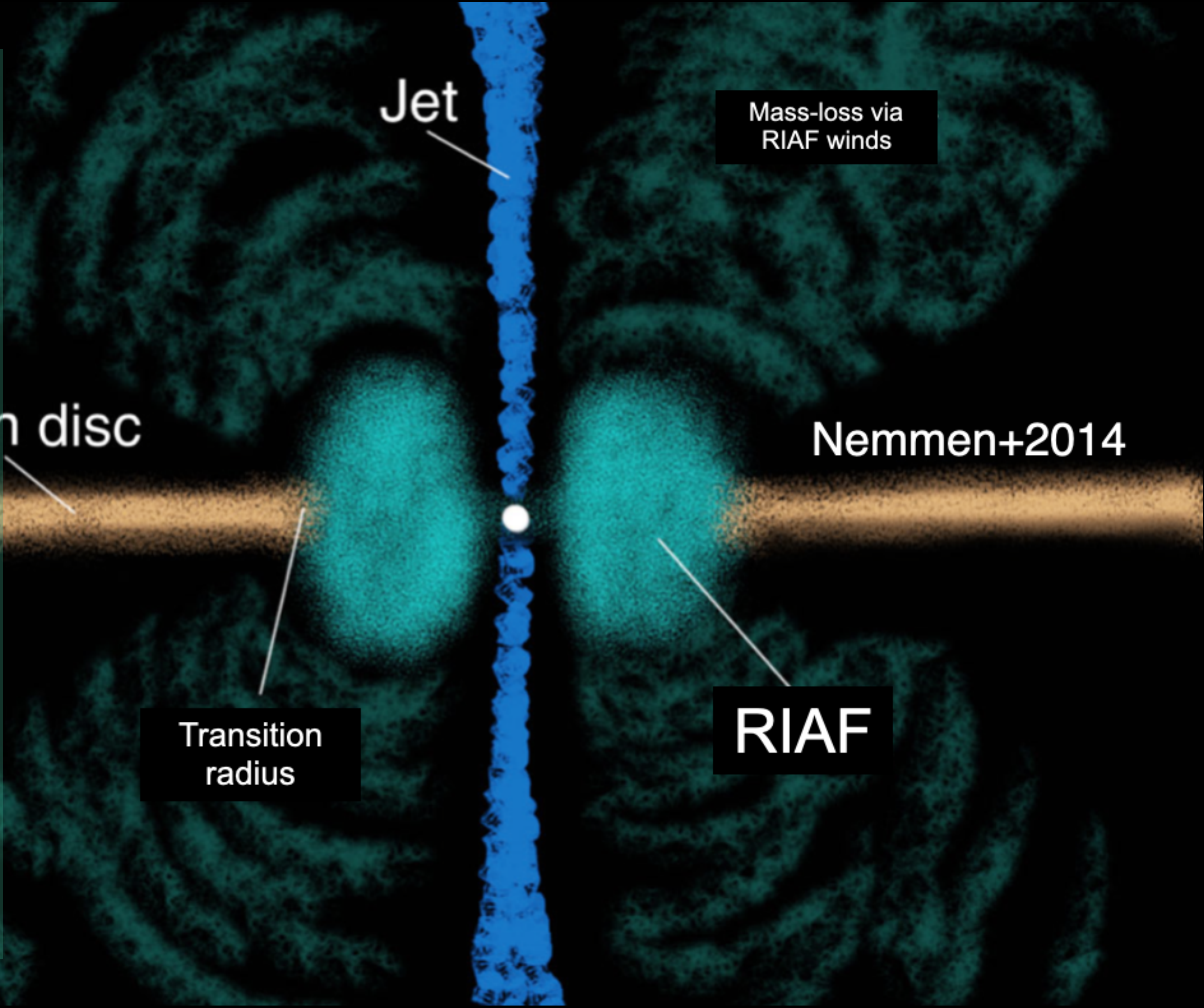
SED modelling

SEDs carry important information about the LLAGN

Radiatively inefficient accretion flows (RIAFs)

- *Geometrically thick*
- *Optically thin*
- *Extremely hot*
- *Extremely low radiative efficiency*

Observations support that in the local universe the AGNs are in RIAF mode



RIAF outflows - Numerical simulations

Winds and feedback from supermassive black holes accreting at low rates: Hydrodynamical treatment

Published on MNRAS

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Winds and feedback from supermassive black holes accreting at low rates: General Relativistic Magnetohydrodynamic treatment

Ivan Almeida[1,2]⋆, Pedro Motta[1], Rodrigo Nemmen[1,3], Matthew Liska[4], Alexander Tchekhovskoy[5,6]

In preparation

H-AMR

The state-of-art GRMHD numerical code

Formation of Precessing Jets by Tilted Black Hole Discs in 3D General Relativistic MHD Simulations

M. Liska[1], C. Hesp[1,2], A. Tchekhovskoy[3,4,5,6], A. Ingram[1], M. van der Klis[1], S. Markoff[1,2]
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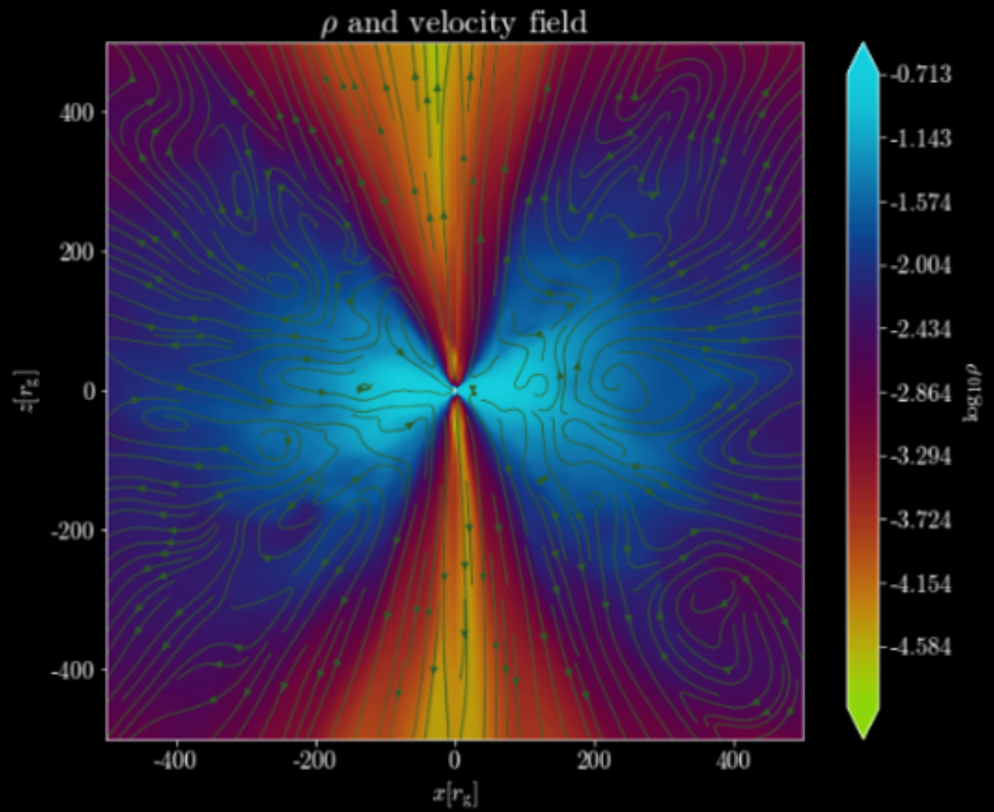
Based on HARM Code and optimized to run on GPUs

In Almeida & Nemmen 2020, we used 400 CPU-cores, for 14 days for each 2D simulation

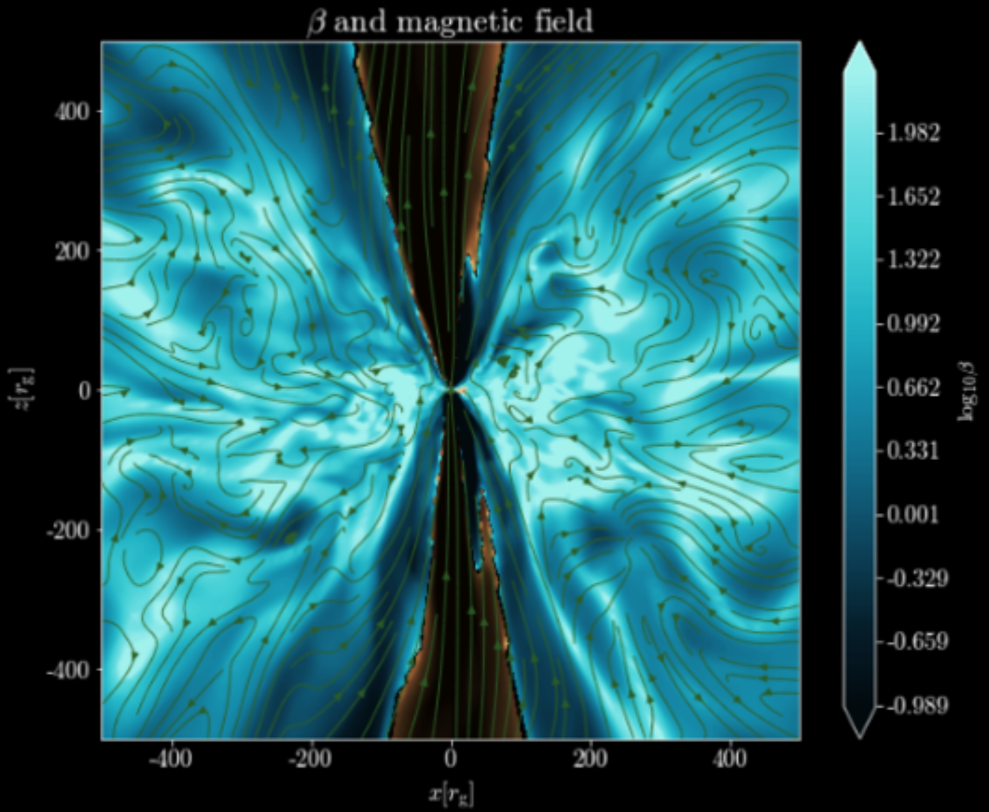
H-AMR simulations using the Nvidia P100 graphics card for 30 days for each 3D simulation (64x more cells), it would increase in a V100

Working together with Pedro Motta
MSc student in our group

GRMHD simulations – Results

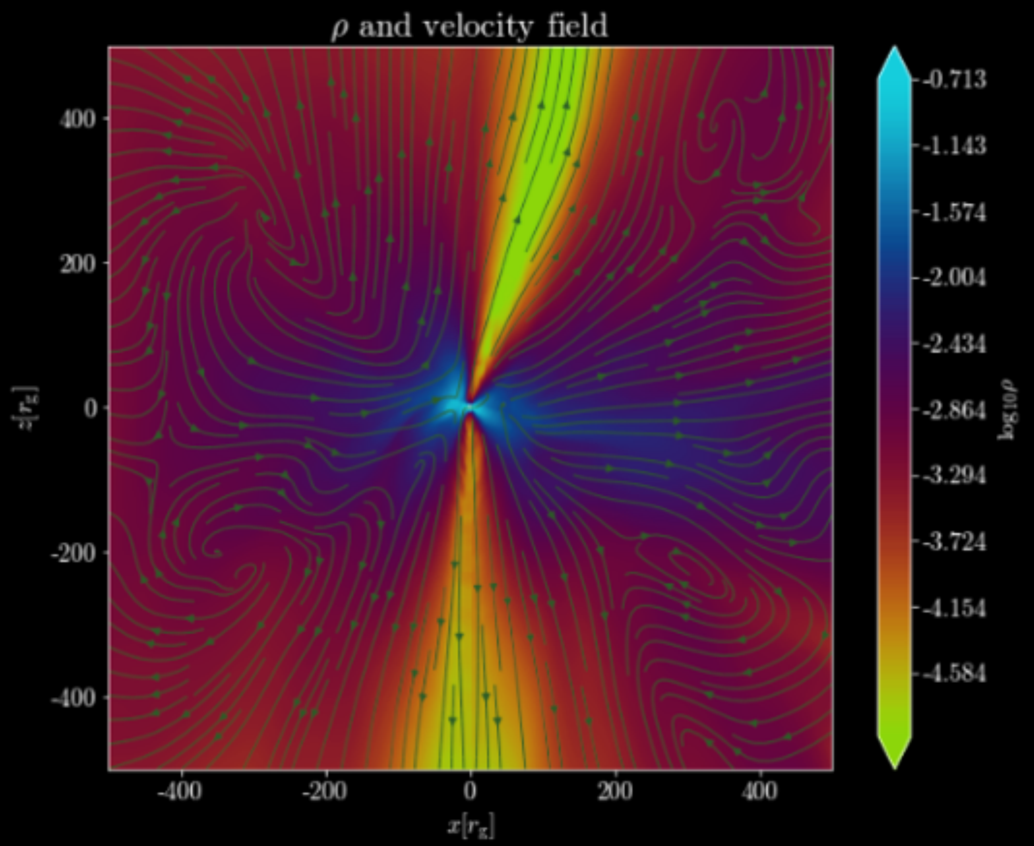


(c) Density map and velocity field lines for simulation `1b100a0`.

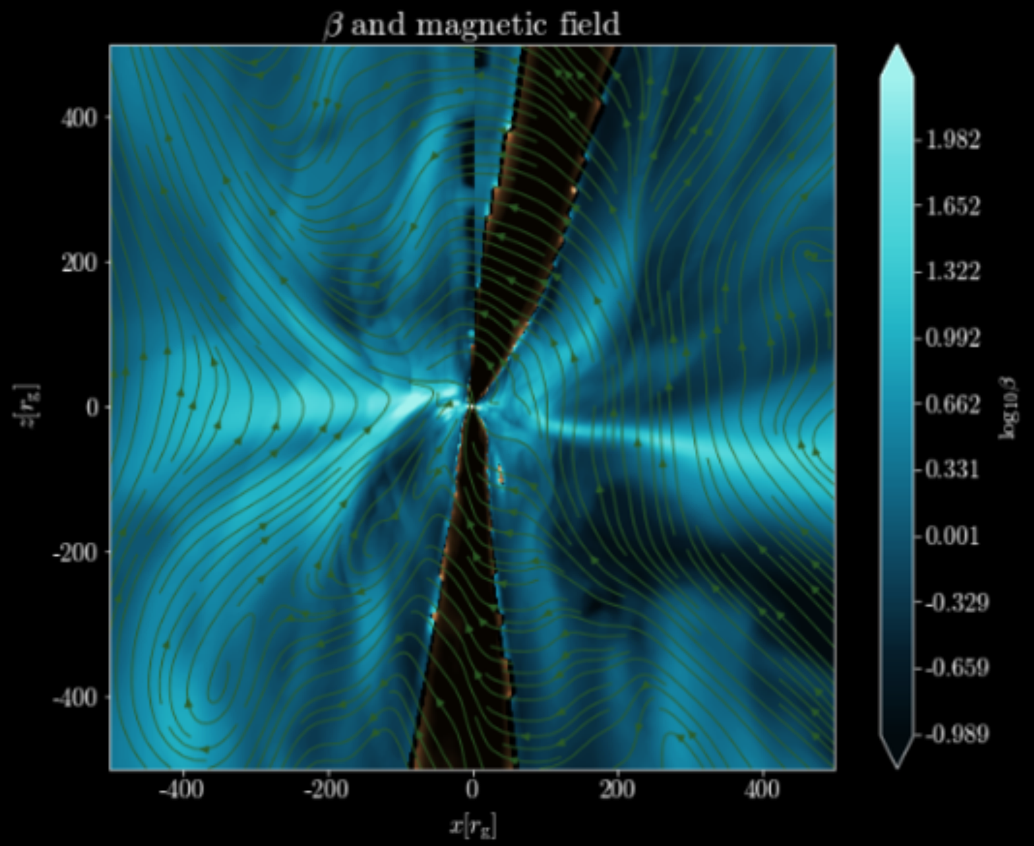


(d) β map and magnetic field lines for simulation `1b100a0`.

GRMHD simulations – Results



(a) Density map and velocity field lines for simulation `ib20a9`.



(b) β map and magnetic field lines for simulation `ib20a9`.

Accretion Disc scales

GRMHD numerical simulations of RIAFs

Galactic scales

Theoretical modelling of the wind energetics and interaction with the galaxy's gas

SED modelling

SEDs carry important information about the LLAGN

Quenching star formation with low-luminosity AGN winds

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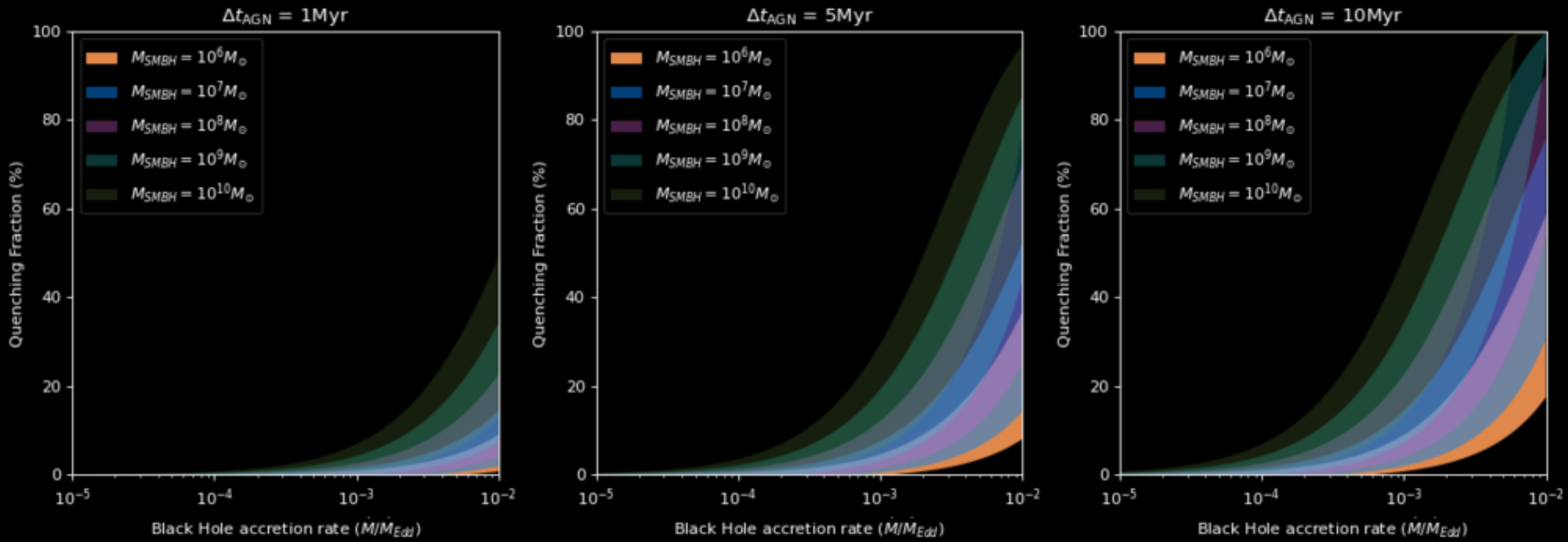
Submitted to MNRAS



Accretion Disc scales

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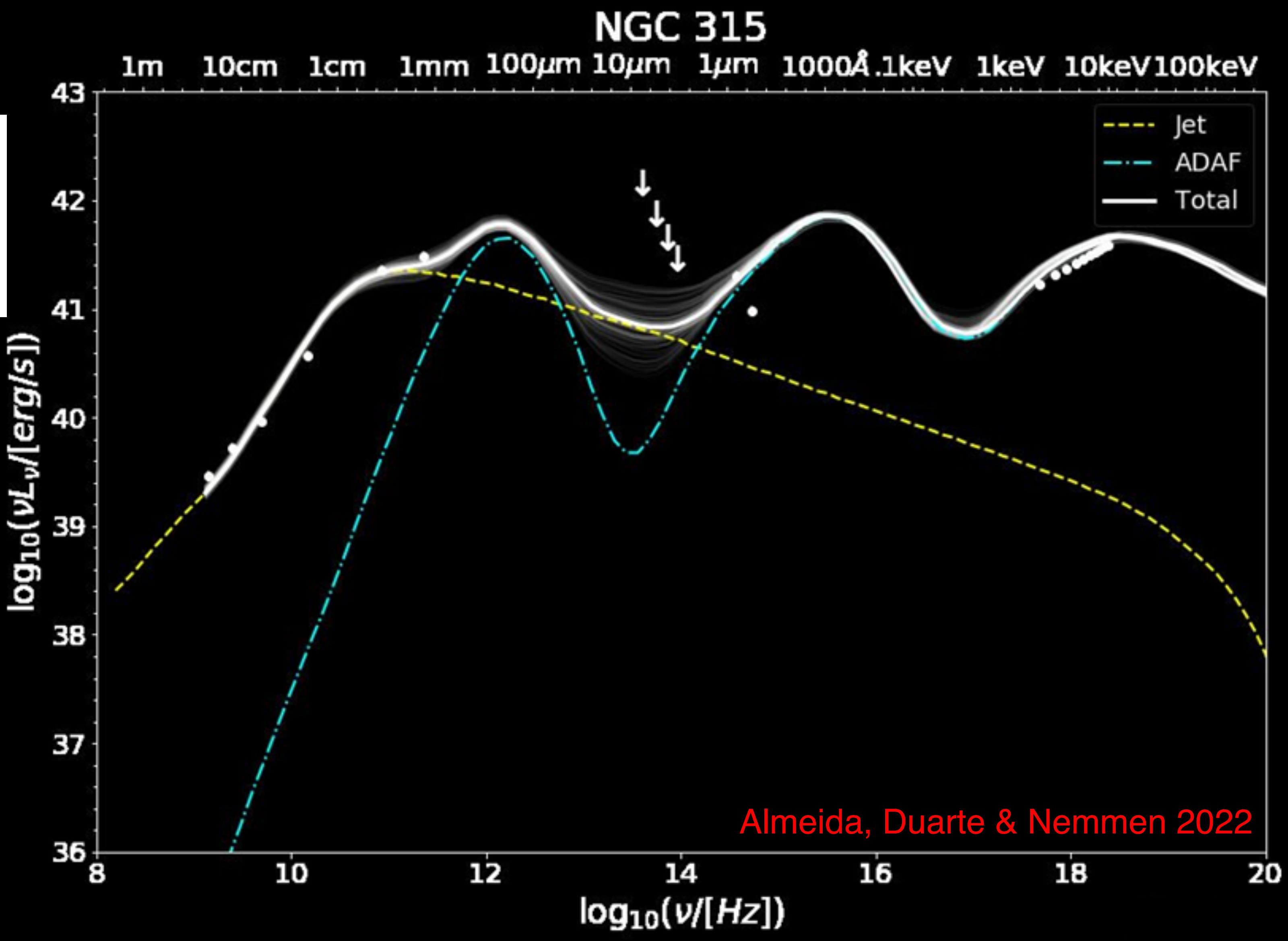
SED modelling

SEDs carry information about the LLAGN physics (Nemmen+06, Almeida+18)

- ❖ Black Hole mass
- ❖ Accretion rate
- ❖ Mass density profile
- ❖ Magnetic Fields
- ❖ Much more



SED modelling using AI - AGNNES

Deep learning Bayesian inference for low-luminosity active galactic nuclei spectra

Published on MNRAS

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AGNNES
(**AGN Ne**ural network **S**ED generator)

Jet SED: **0.4ms**

RIAF SED: **0.3ms**

VS

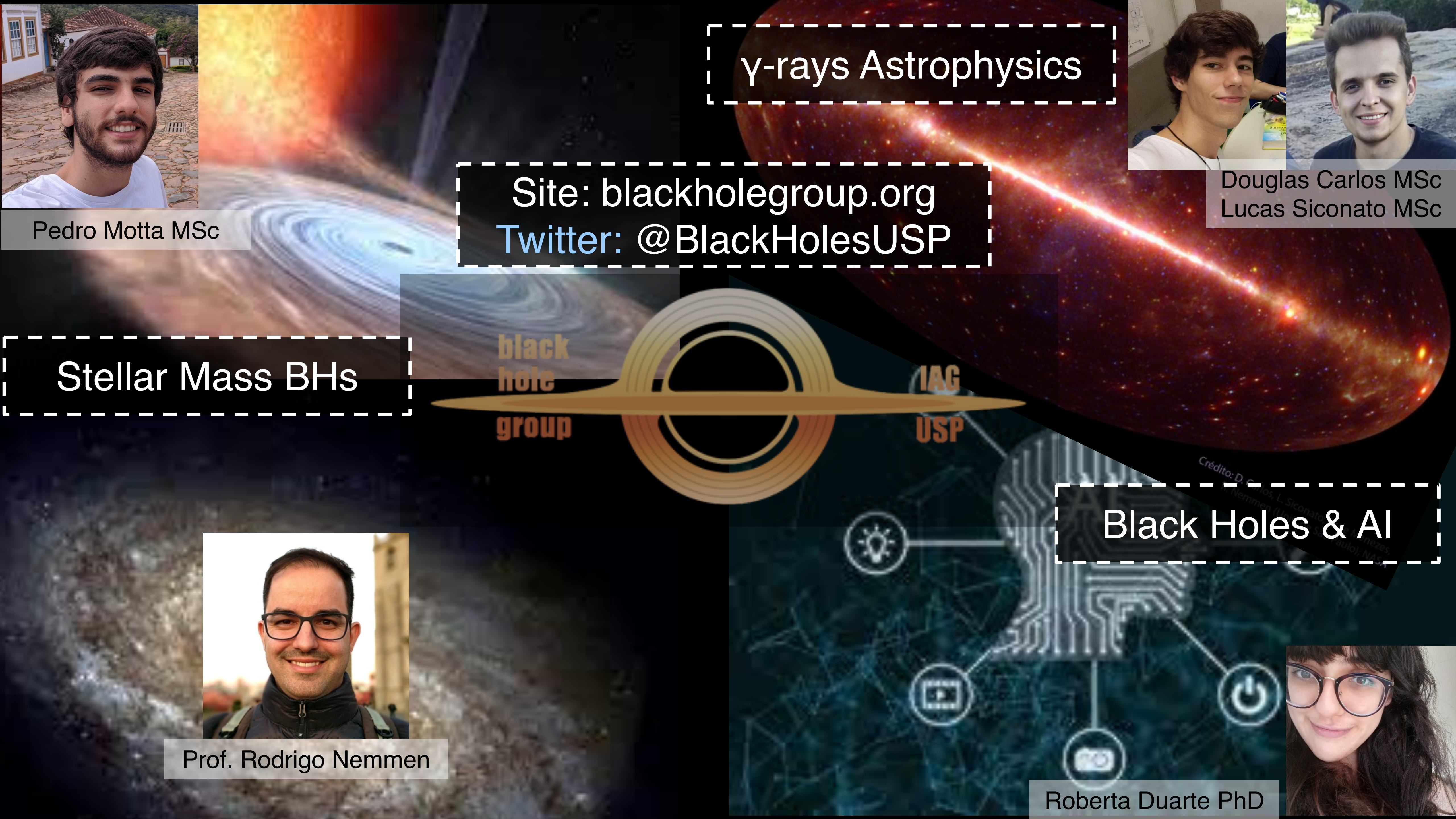
Original Code

Jet SED: **200ms**

RIAF SED:**0.5-2min**

500x faster for jet, and **400000x** for the RIAF

Roberta Duarte, our AI expert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