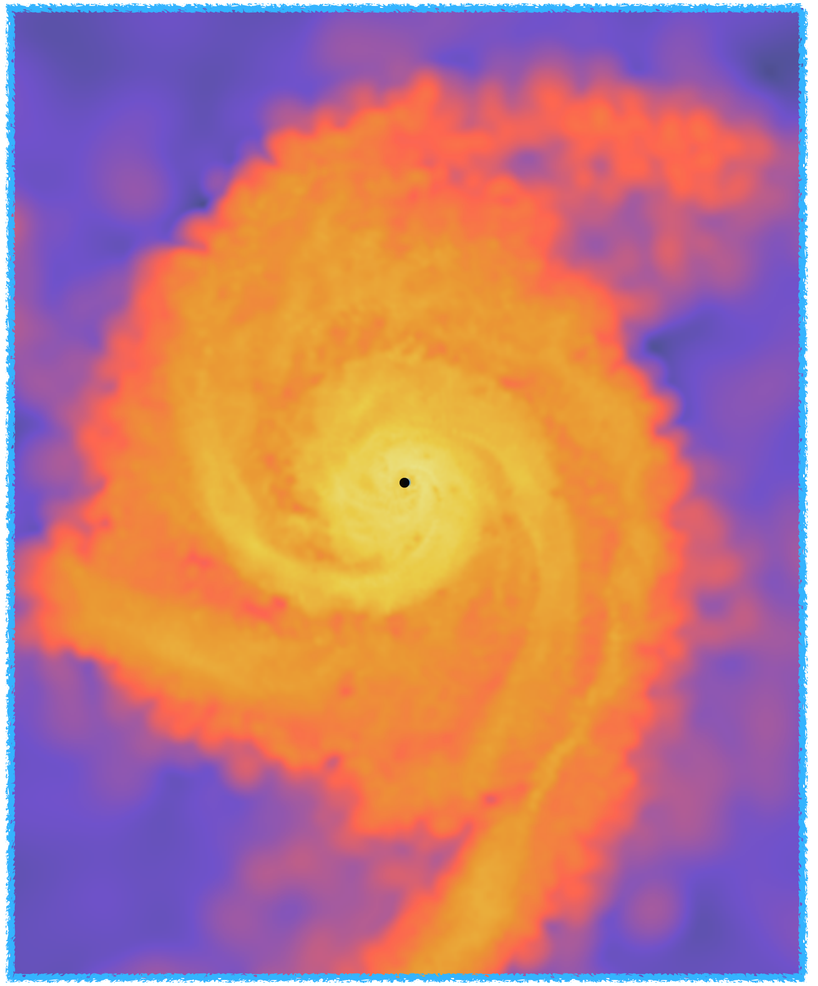
On the connection between AGN feedback and MBH spin

Francesco Bollati

Leibniz-Institut für Astrophysik Potsdam

UNIVERSITÀ DEGLI STUDI DELL'INSUBRIA

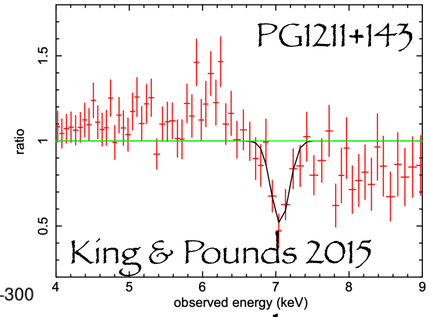
Collaborators: R. Weinberger, A. Lupi, M. Dotti, F. Haardt, M. Volonteri



AGN Feedback

- = Release of energy and momentum

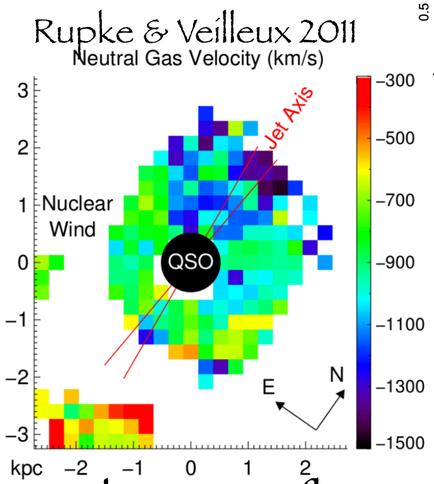
Radiation,



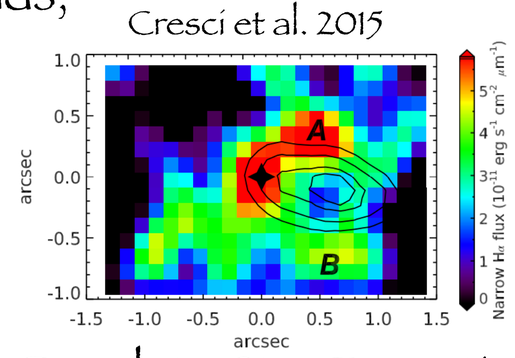
Winds,

jets …

- Observational evidence



Galactic outflows



H_α map

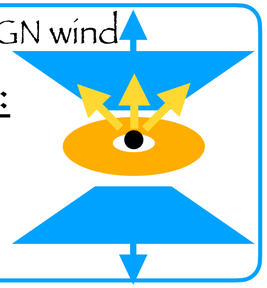
Regulate Star Formation

- Theoretical evidence

i) Galaxy stellar mass function,
ii) "cooling flow" problem,
iii) galaxy color bimodality,
iv) MBH-bulge scaling relations …

- This work → <u>Radiation-driven winds:</u>

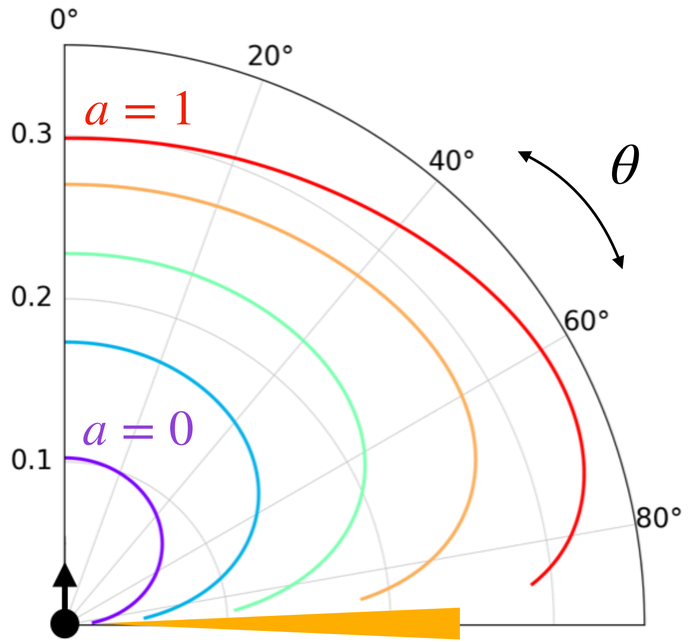
  Impact on <u>isolated disc galaxy</u>

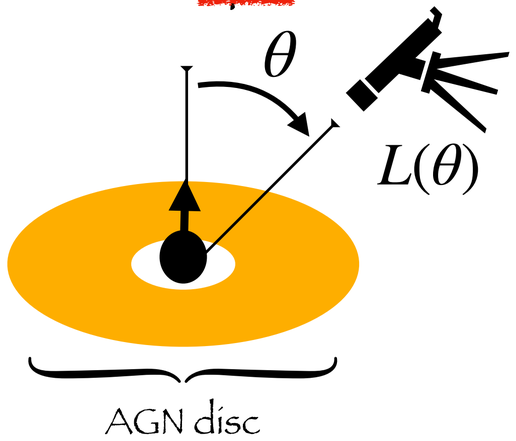


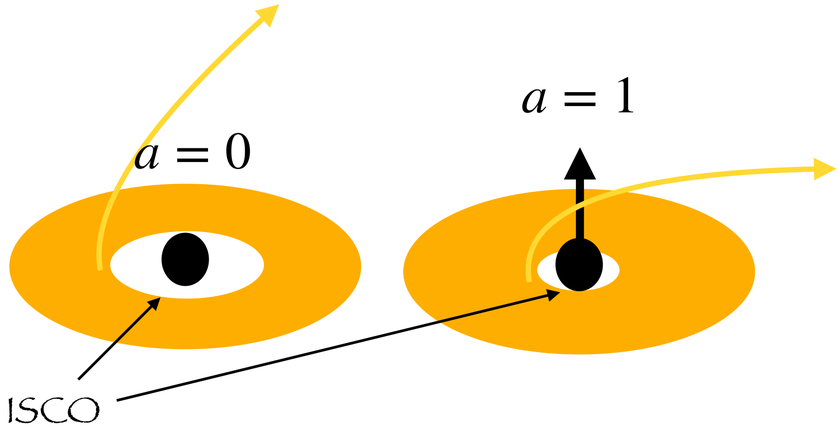
Radiative Feedback and Spin

- Why is feedback anisotropy linked to the MBH spin?

$$L(\theta) = \dot{M}c^2\eta(a)f(\theta, a)$$

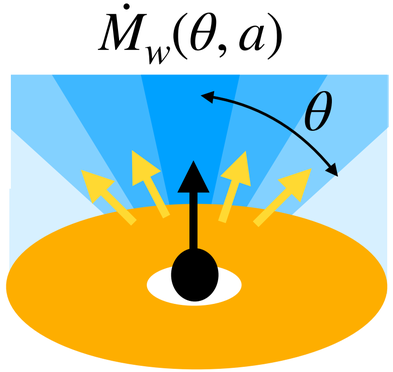






Anisotropic wind $\dot{M}_w(\theta, a) = \dfrac{L(\theta, a)}{v_w c}$

(See Ishibashi et al. 2019, Ishibashi 2020)

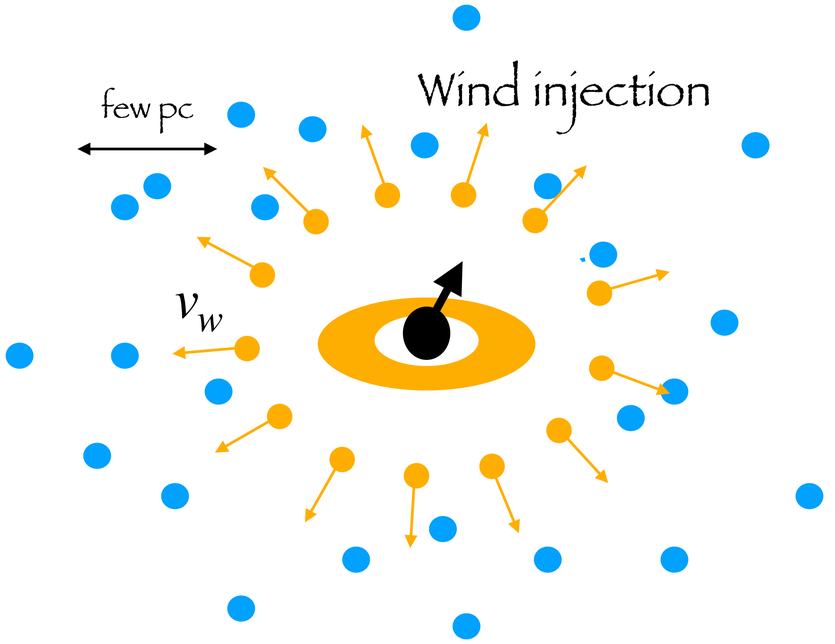


Numerical implementation

- A subgrid model for radiative feedback in  **GIZMO** :

Self-consistently tracks:

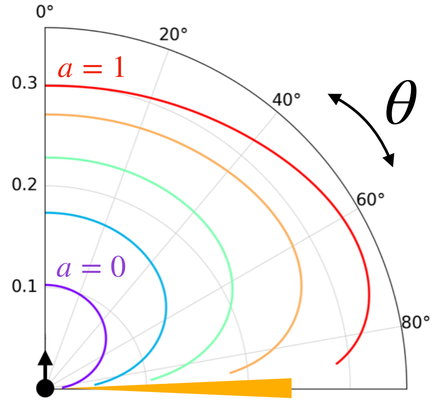
- Resolved accretion
- MBH mass and spin evolution
- Wind launching
- Wind anisotropy



(Tremmel et al. 2017)

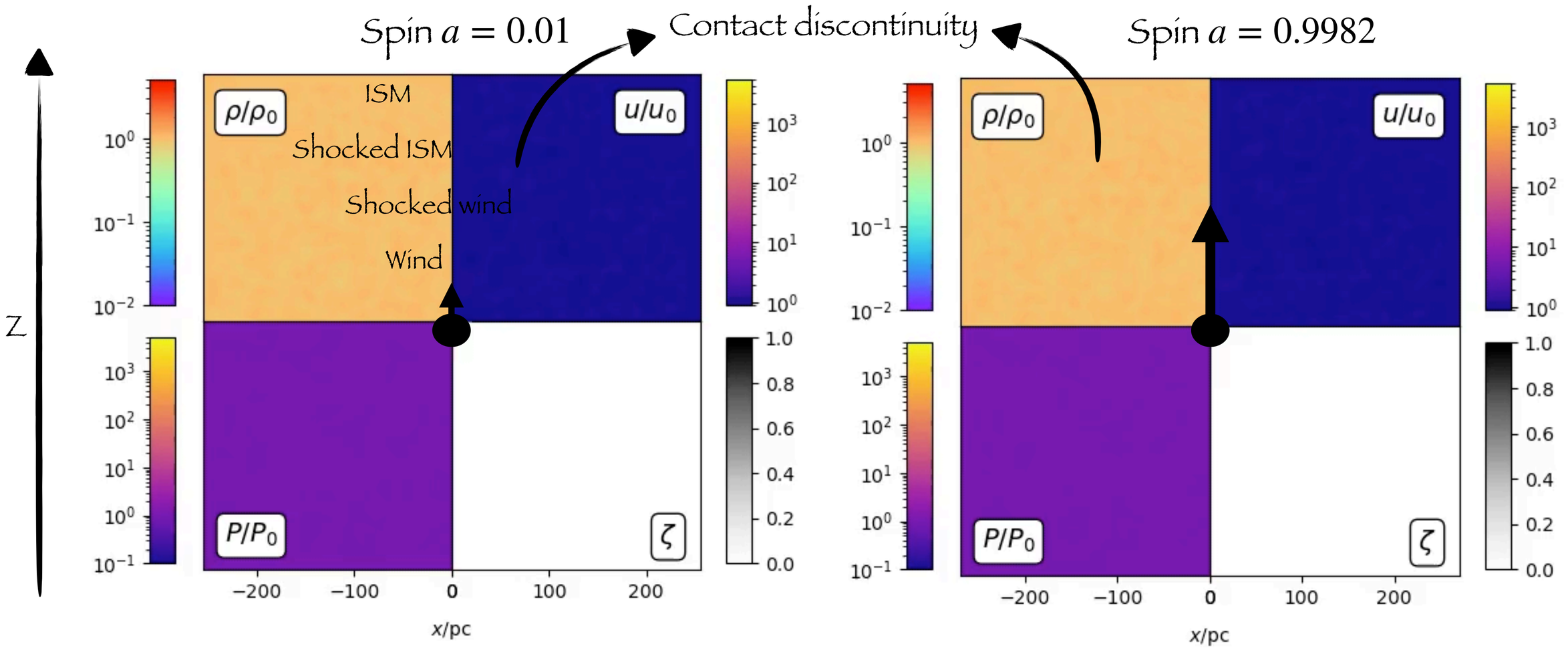
$$\dot{M}_{in} = \frac{4\pi(GM)^2\rho c_s}{(v_\varphi^2 + c_s^2)^2}$$

$$\dot{M}_w(\theta, a) = \frac{L(\theta, a)}{v_w c}$$



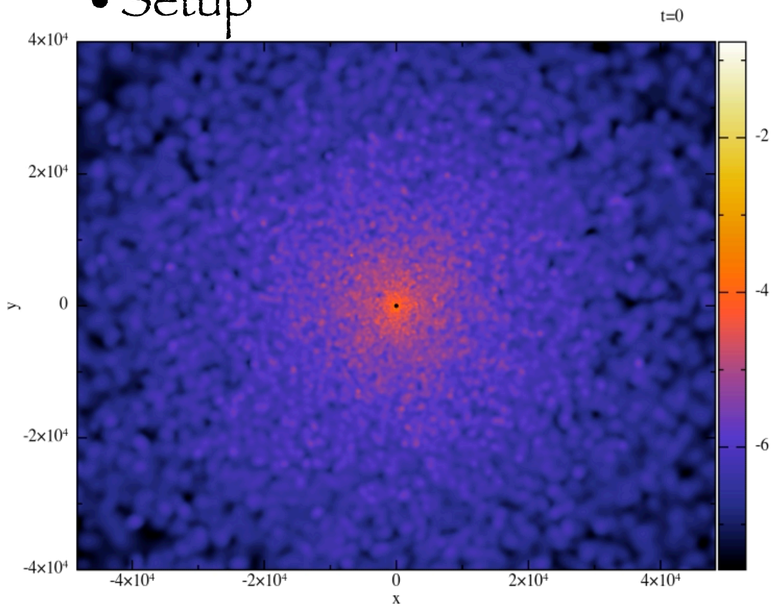
Tests

- Outflow propagation in homogeneous background: $n_H = 1\,cm^{-3}$, $T = 2 \cdot 10^4\,K$



MBH-galaxy host coevolution

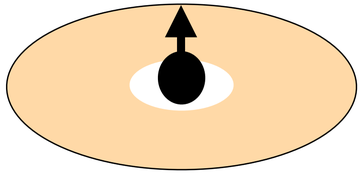
- Setup



- Simulations suite:

Constant accretion rate

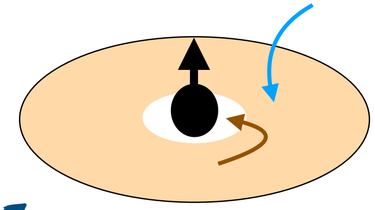
$$f_{Edd} \equiv \frac{\dot{M}_\bullet}{\dot{M}_{Edd}} = 1$$



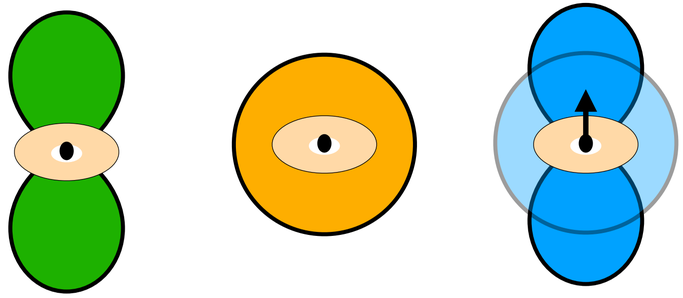
$M_\bullet = 10^8 M_\odot$

Evolving disc properties

$f_{Edd}(t)$



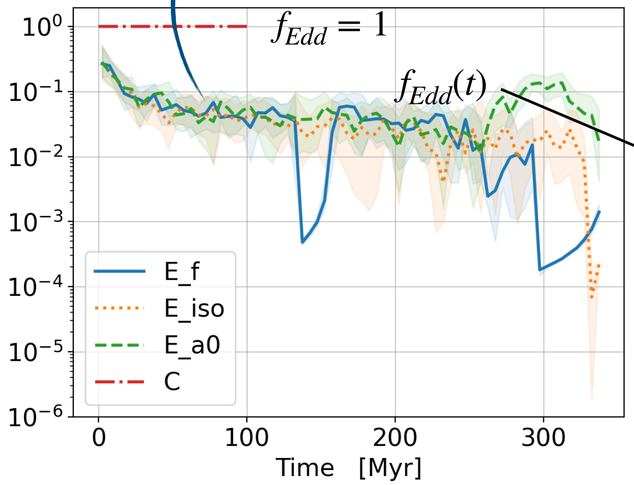
$\neq$ Angular patterns



$f(\theta, a = 0)$ $f(\theta) = 1$ $f(\theta, a(t))$

- Results:

1. AGN disc and winds form a complex self-regulated system

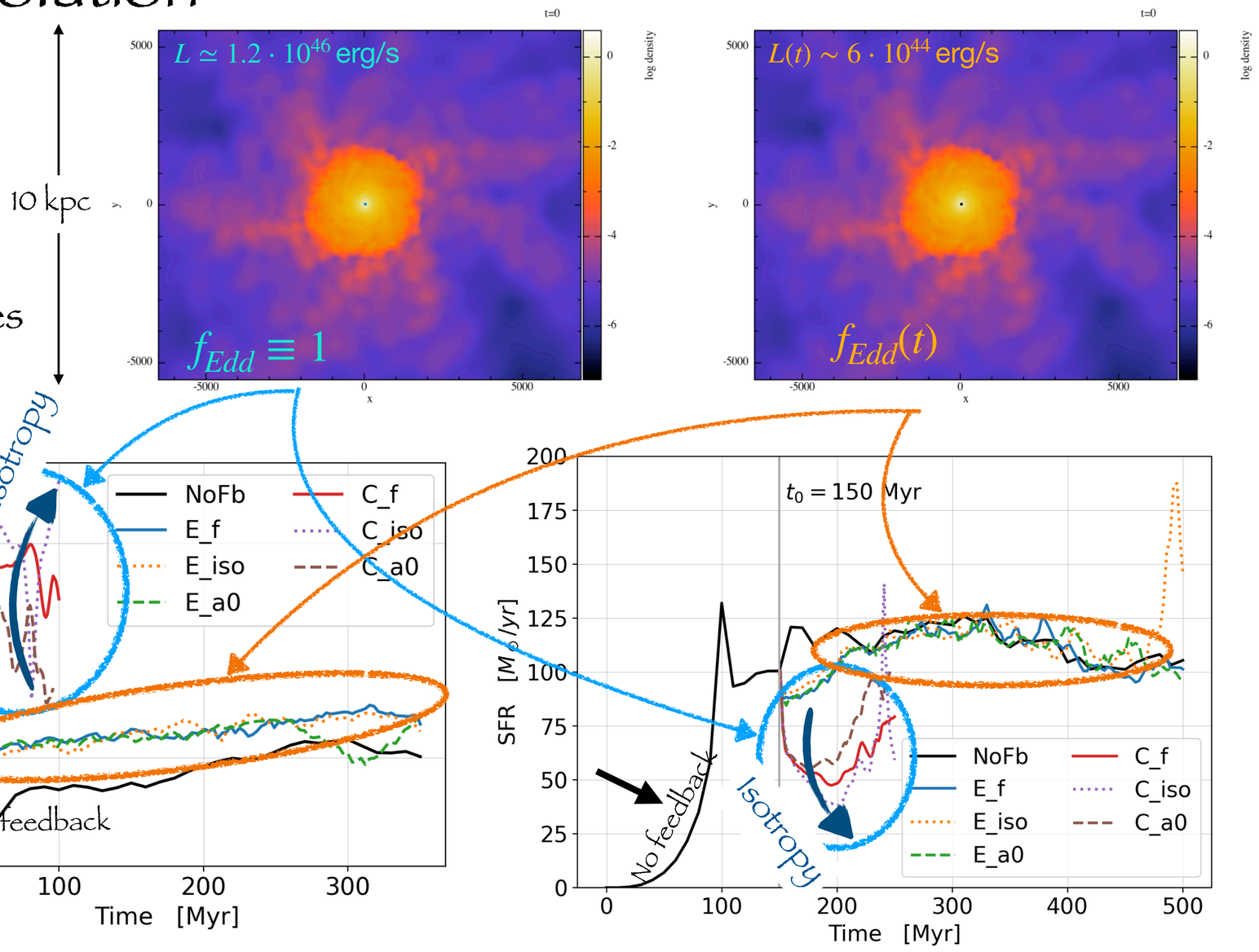


$f_{Edd} \sim 0.05$
Seyfert galaxy (Ho 09)

MBH-galaxy host coevolution

2. Limited impact on host galaxy

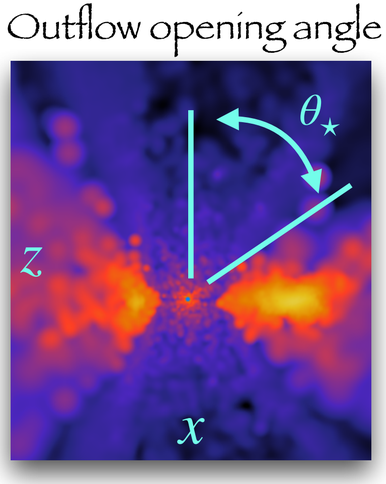
3. At $f_{\rm Edd} = 1$, more isotropic feedback yields wider central cavities and more SFR suppression

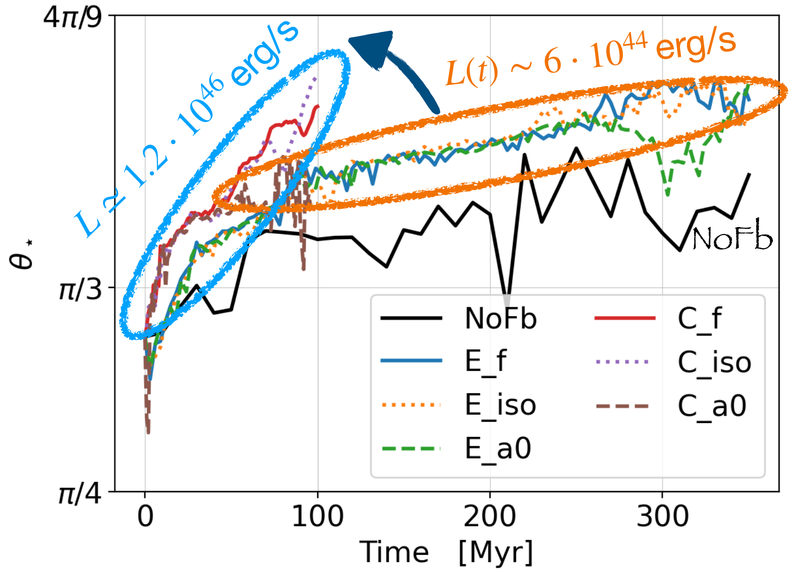


MBH-galaxy host coevolution

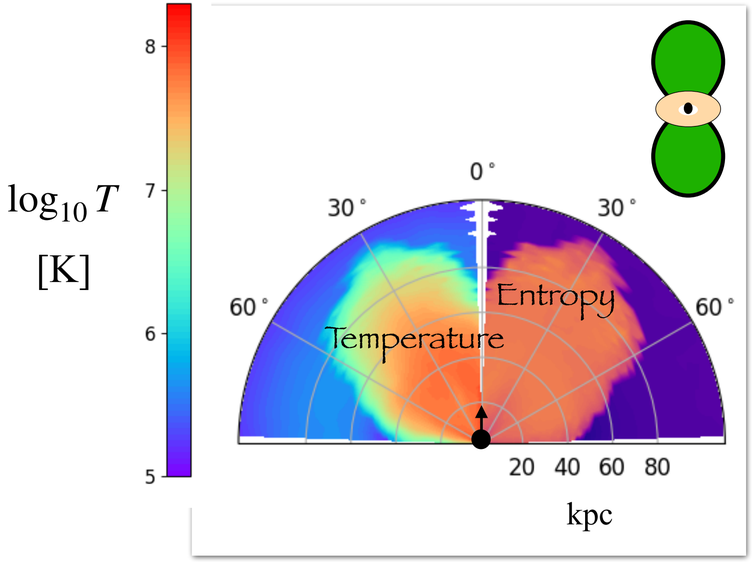
4. Outflow shape

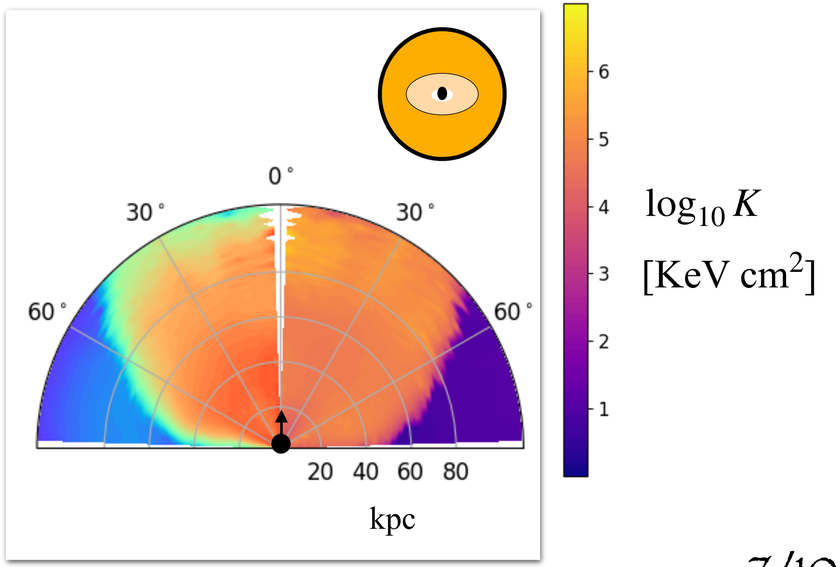
- At $\lesssim$ 10 kpc, Galactic scale





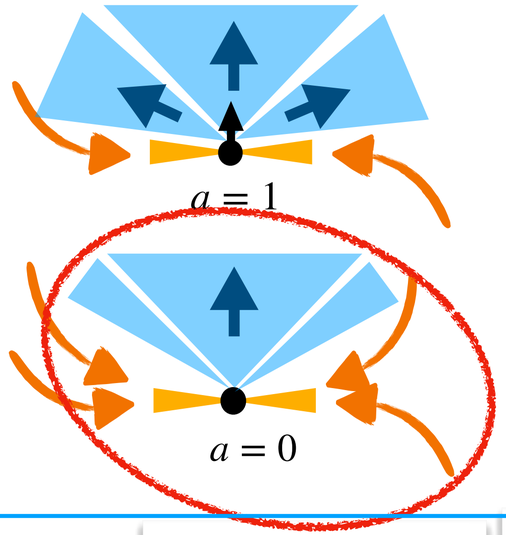
- At $\lesssim$ 100 kpc, CGM scale

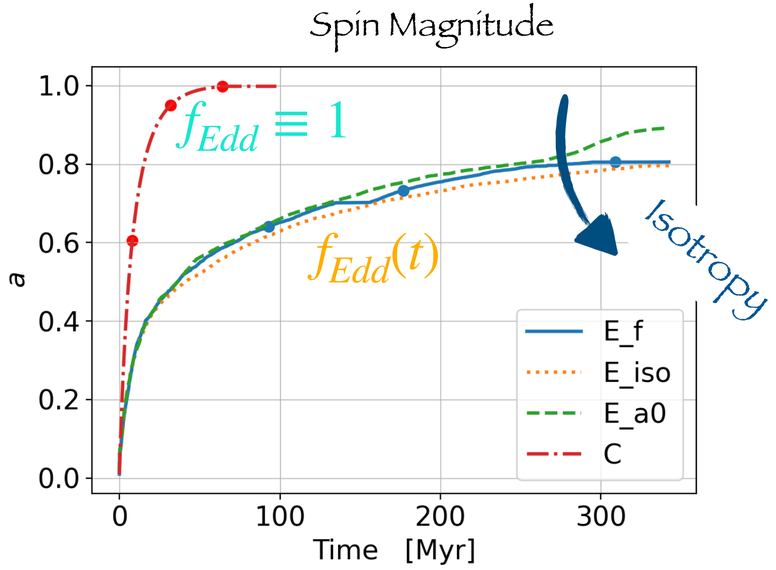




MBH-galaxy host coevolution

5. More isotropic winds -> slower mass and spin growth





arXiv:2311.07576

- Higher spin → more isotropic $L(\theta)$

⇒

- Higher SFR suppression
- More CGM heating
- Slower MBH growth

superEddington regime

CONDITIONS

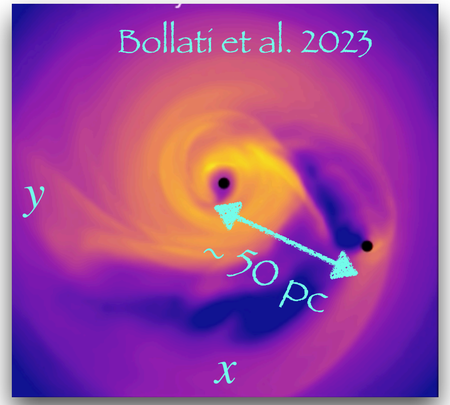
- i) High f_{Edd}
- ii) Thick galaxy

e.g. Post-merger and high-redshift galaxies

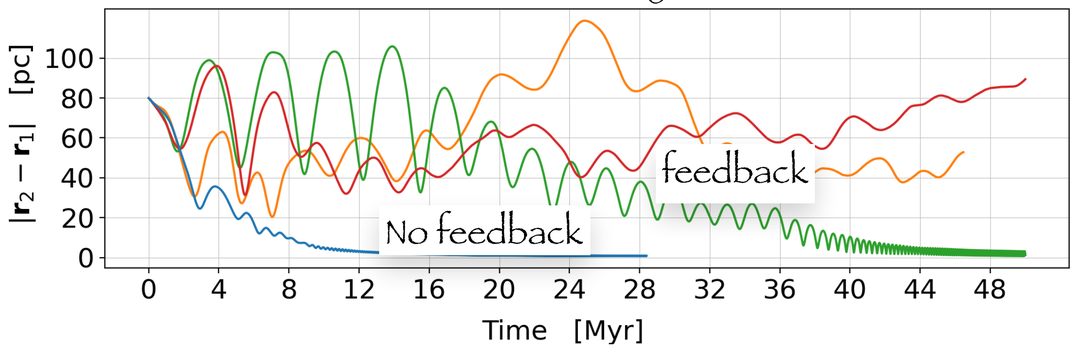
MBH pairs and binaries

Feedback anisotropy influences …

- … Dynamical-Friction driven inspiral of MBH pairs

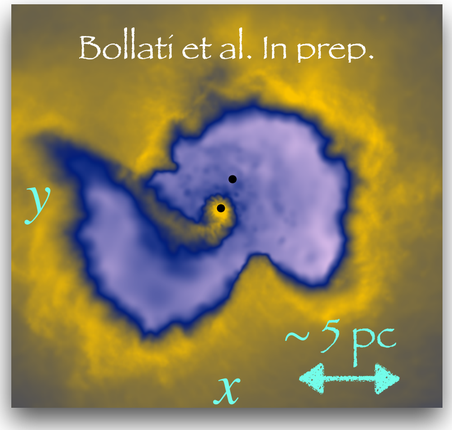


Orbital decay



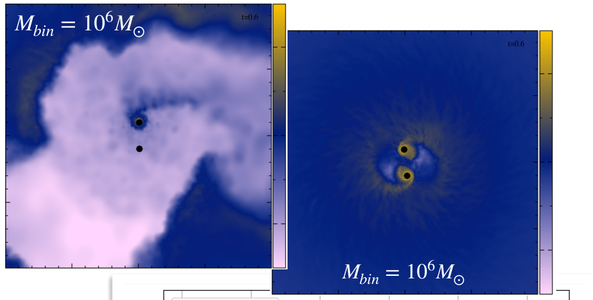
≠ anisotropy → decay timescale eccentricity

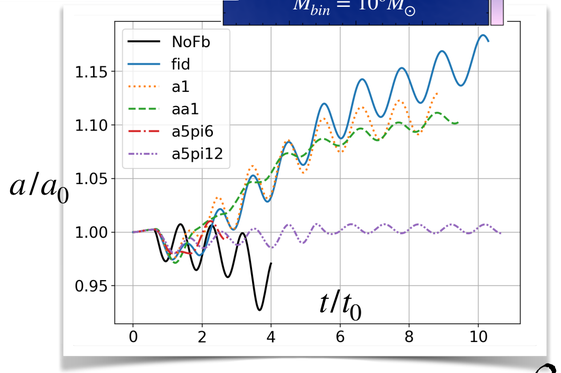
- … MBH binaries hardening phase



≠ anisotropy →

- disc structure
- migration rate
- mass and spin growth





Conclusions

A new sub-grid model for MBH accretion, feedback and spin-evolution:

MBH-galaxy coevolution

- The impact of an AGN on the host is primarily driven by its luminosity, rather than its angular pattern
- Highly spinning MBHs more easily suppress the host SF and hinder the MBH growth
- Feedback angular pattern is more relevant for highly accreting MBHs in thick/spherical galaxies

Thank you for your attention