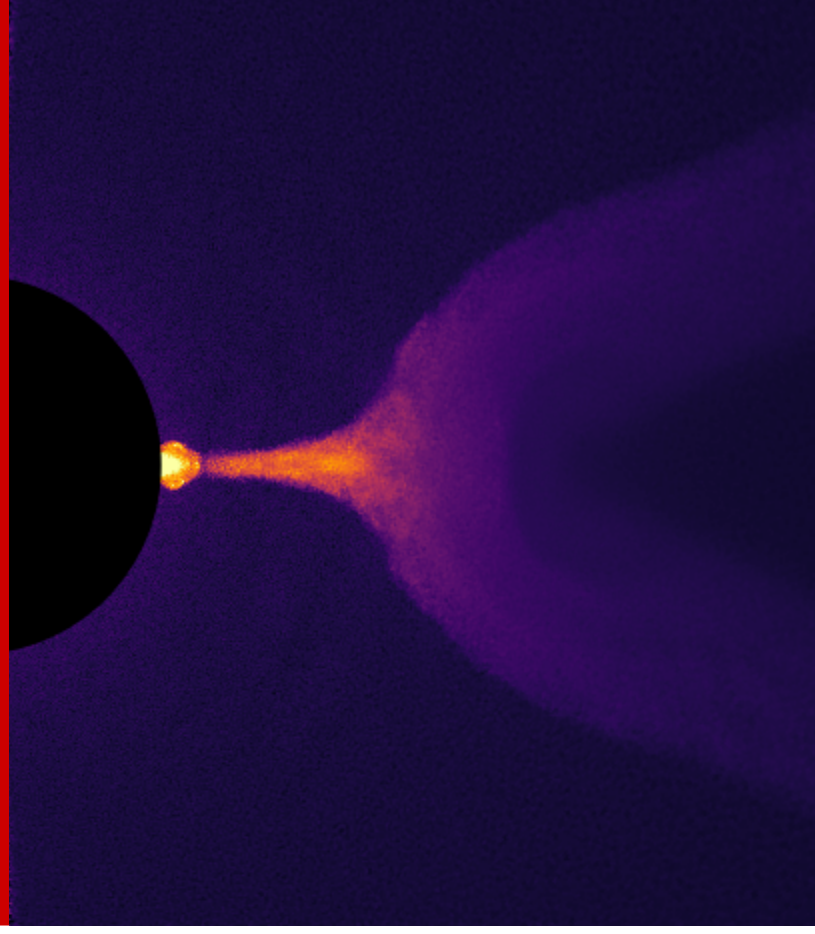
Flaring Activity in a Black Hole Magnetosphere



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erc European Research Council
GENCI Le calcul intensif au service de la connaissance
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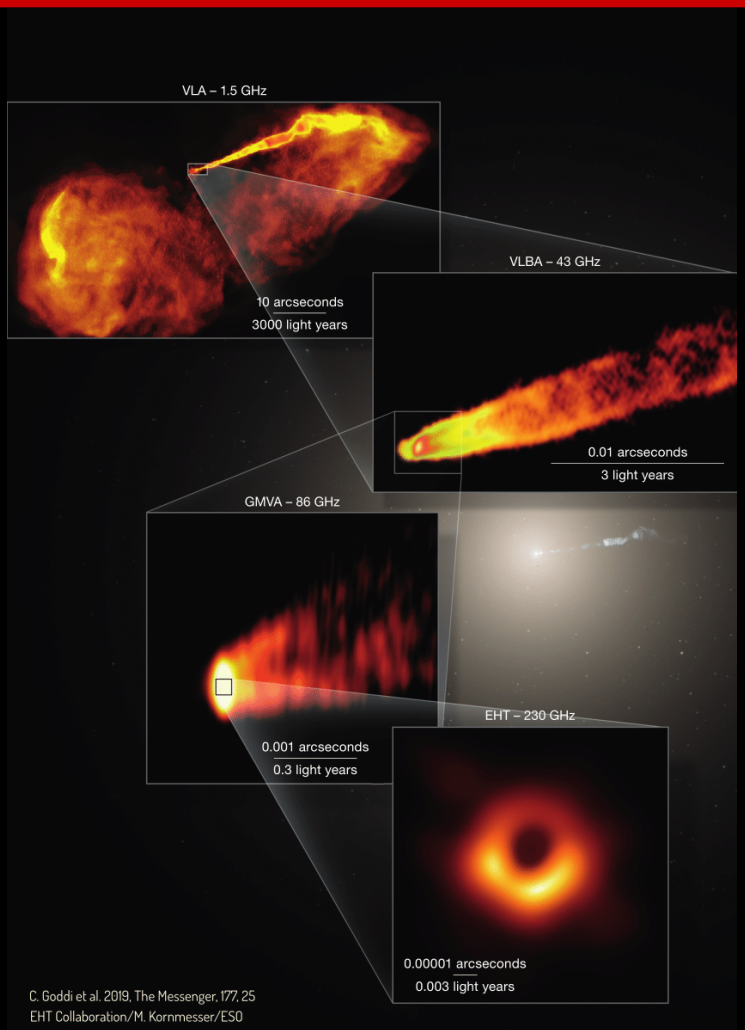
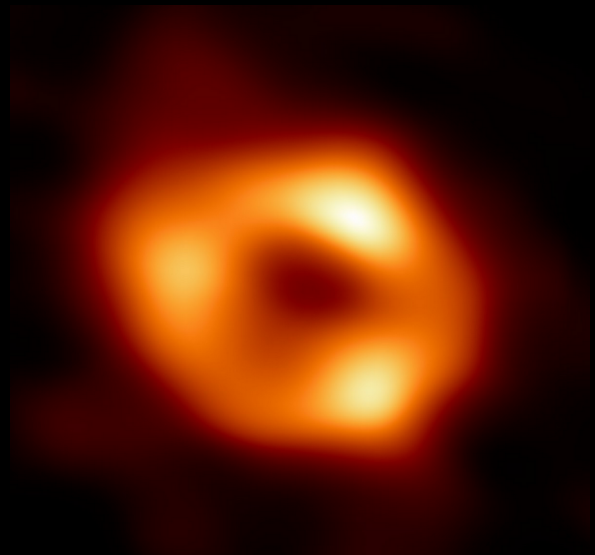
Black holes and jet emission



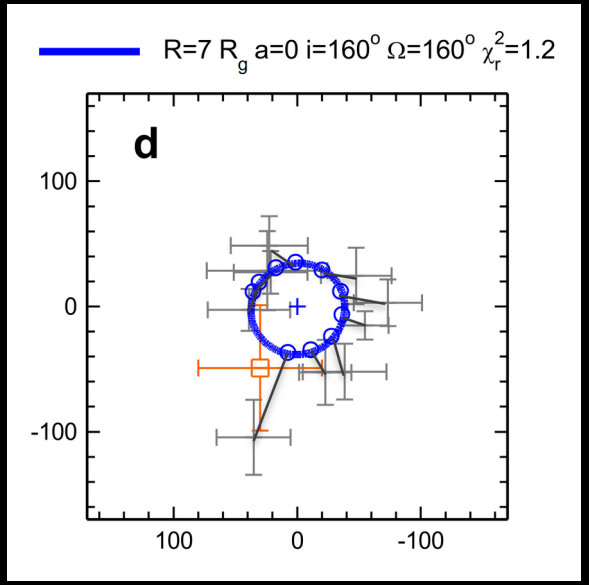
Evidences for a connection between SMBH and galactic jets
Non thermal emission → Particle acceleration

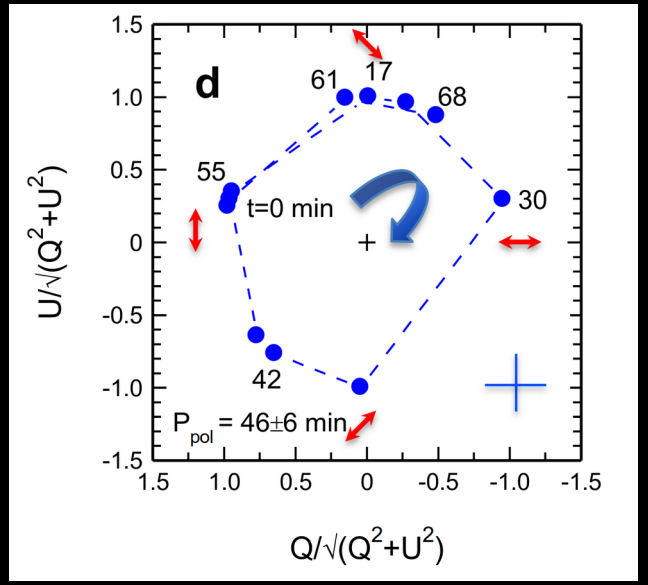


No jet? But flares!

Sagittarius A*: a not-so-quiet black hole

GRAVITY observations:





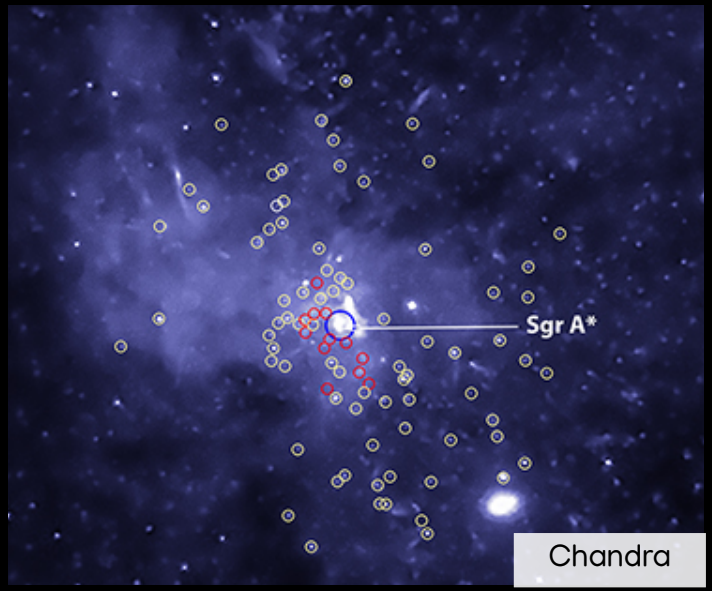
- Time-duration: 30-90 min
- Near-infrared + X-rays

Close to BH (6 r_g)

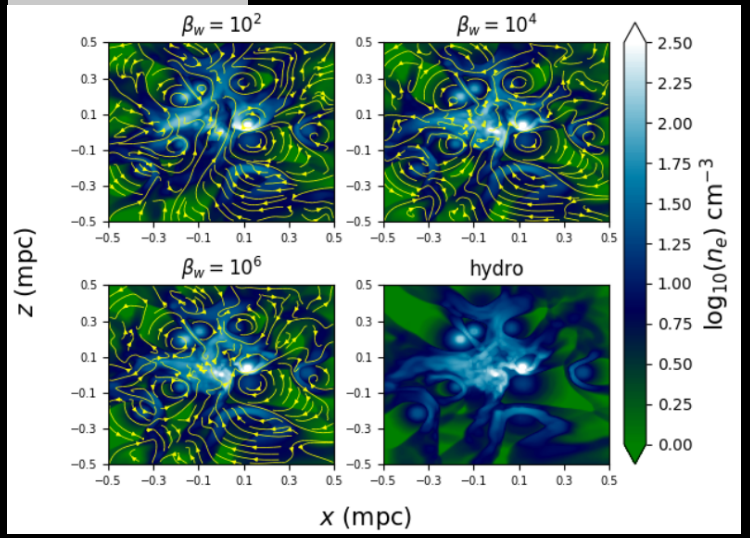
- Large-scale magnetic field (10-15 G)
- Orientation orthogonal to rotation axis

Sagittarius A*: about its environment

Wind-fed accretion from surrounding stars in the Galactic Center



Ressler+2020

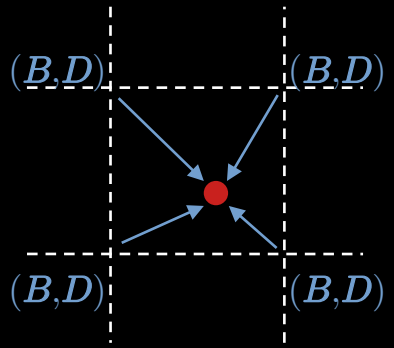


Large-scale simulations predict a low-angular momentum plasma that is highly magnetized! (β = few)

GRZeltron: a GRPIC code (Parfrey+2019)

3+1 formalism (Komissarov, 2004)

Kerr metric, KS spherical coordinates



Field Interpolation

Particle Push

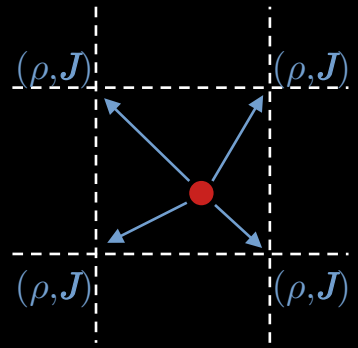
$$\dot{x}^i = \frac{\alpha}{\Gamma}\gamma^{ij}u_j - \beta^i$$

$$\dot{u}^i = \text{Lorentz + Metric}$$

Fields Evolution

$$\frac{\partial B}{\partial t} = -c\nabla \times E$$

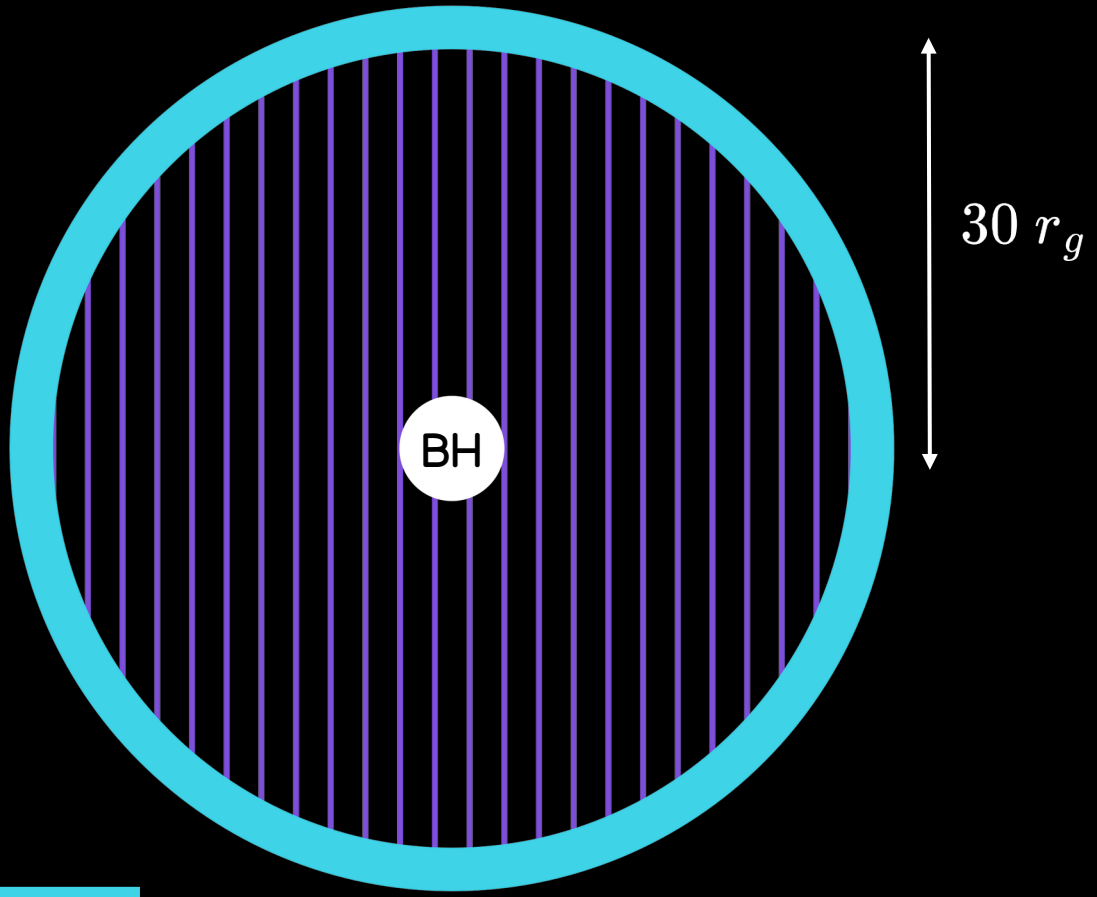
$$\frac{\partial D}{\partial t} = c\nabla \times H - 4\pi \mathbf{J}$$



Charge/Current Deposition

- Full treatment of non ideal phenomena
- Can capture microphysics (e.g. QED processes)
- Acceleration of particles self consistently treated
- Straightforward radiative transfer

Numerical setup



–Schwarzschild black hole

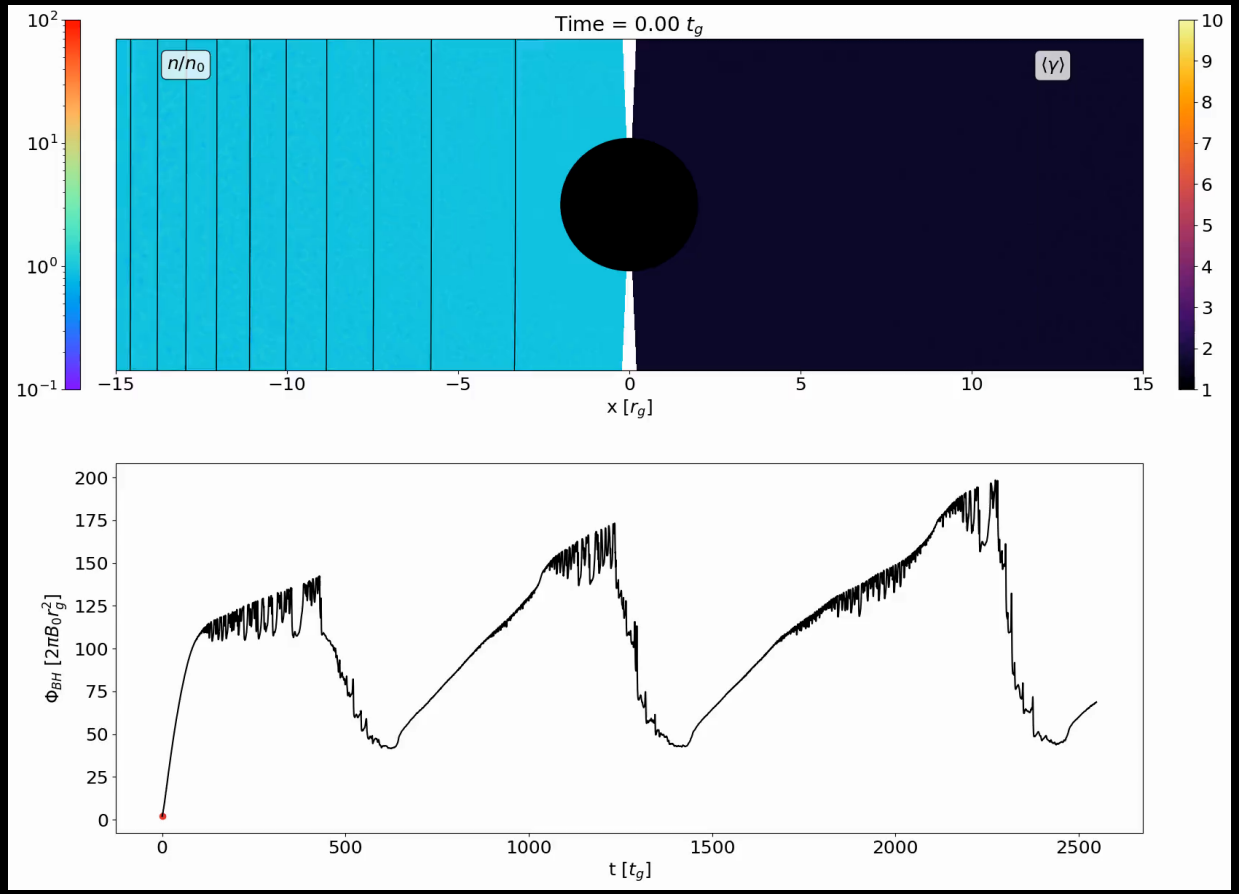
–Axisymmetric setup

–Plasma injected on the outer–edge of the box (free–fall)

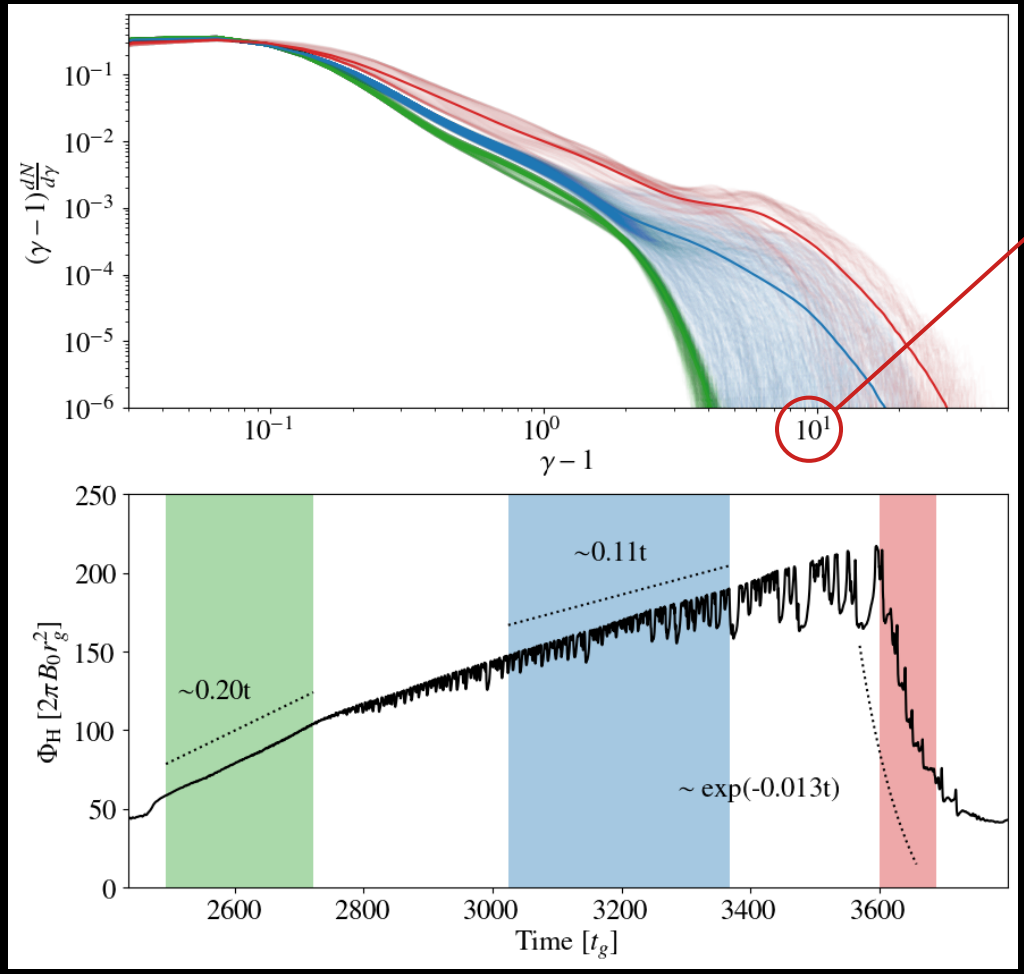
–Pair plasma at “low” magnetization

$$\sigma_0 = \frac{B_0^2}{4\pi n_0 m_e c^2} = 0.1$$

Flux eruptions in the black hole surroundings



Strong particle acceleration at the eruptions

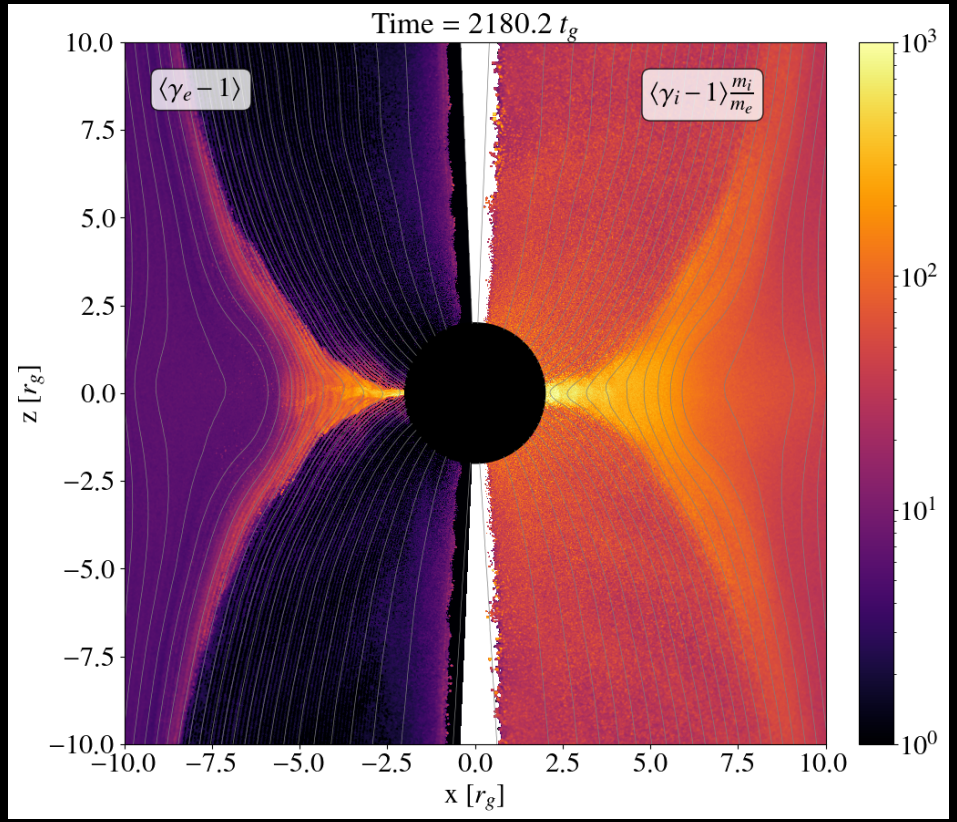


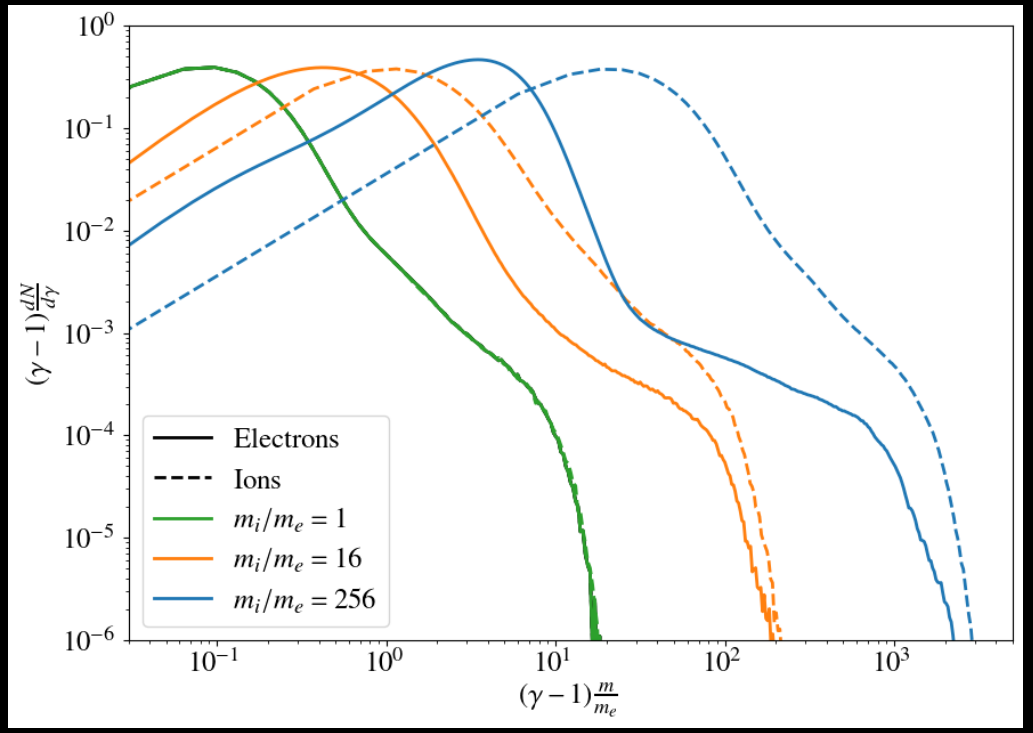
$\sim \sigma$ near the event horizon!

The eruptive phase should correspond to flare of synchrotron emission

Typical timescale: 100 t_g
→ 30 min for Sgr A* mass

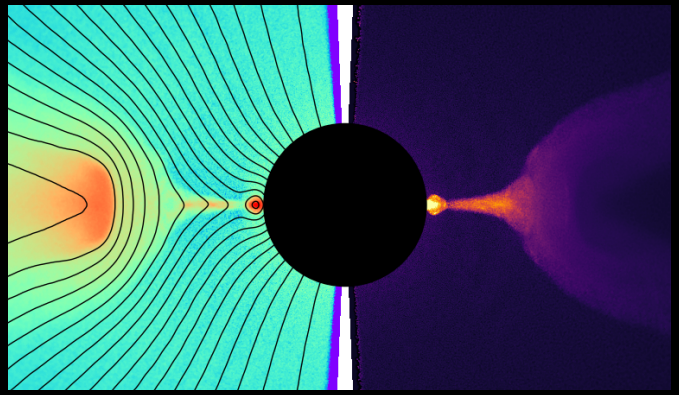
What if we put ions?



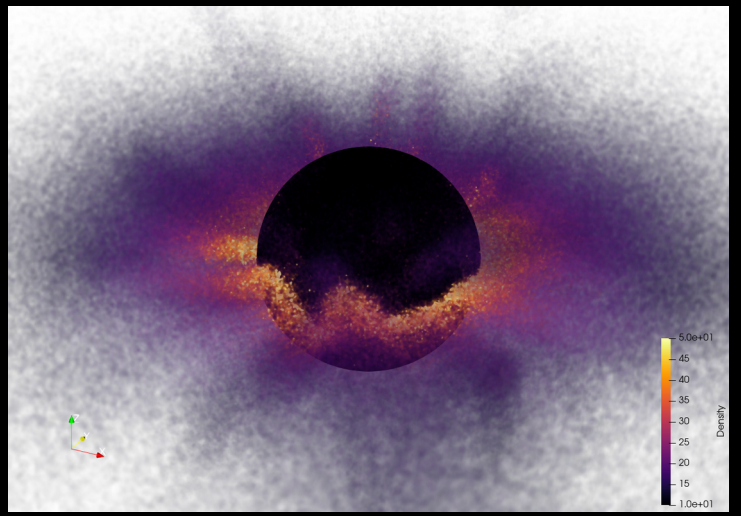


Extrapolating to the real mass ratio: $\langle\gamma_e\rangle \sim 10^4$

Conclusions



–A simple setup can capture flaring activity of a black hole magnetosphere from first principles

–The universality of magnetic reconnection appears to have a central role to explain the eruptions timescales

Incoming 3D simulations!