Black hole accretion on 17576 CPUs

Bijia Pang and Ue-Li Pen

Low luminosity of Sgr A*

- Supermassive

Gillessen et al. 2009

$$M_{BH} = 4.3 \times 10^6 M_\odot$$

- Reported luminosity

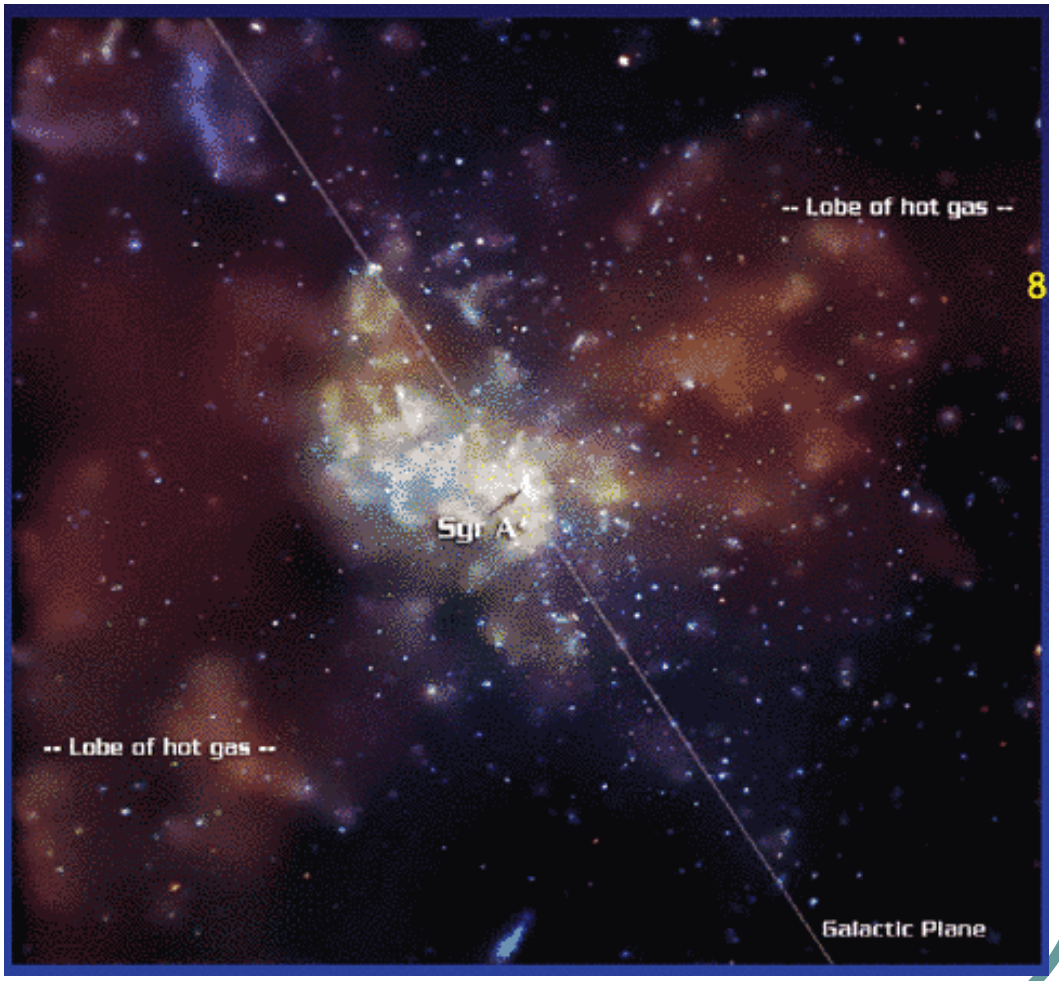
Baganoff et al. 2001ab; Genzel et al. 2003; Ghez et al. 2003

$$2.4 \times 10^{33} ergs^{-1}$$

- Expected luminosity

From Bondi solution

$$10^{39} ergs^{-1}$$



Baganoff, et al. 2001

MHD and simulation setup

- Magneto-hydrodynamics (MHD) describes how conducting fluid evolves under a magnetic field.
- MHD code (3D, time-dependent, finite-difference, finite-volume), was written by Prof. Ue-li Pen, then expanded by Phil Arras, ShingKwong Wong, Hugh Merz, Matthias Liebendoerfer, Stephen Green, Bijia Pang.
- Expanding Cartesian grid, denser center, bigger box
- Inner boundary represents black hole
- Outer boundary far away from accretion radius
- Initial static flow
- Keplerian rotation and magnetic field are added

From small to large

- Double interpolation to attain long term results

- Fixed box size: 8000^3 unit

- 600^3 on 125 nodes (120^3 per node):
  528800 time steps, 20 CT, dx=1

- 585^3 on 125 nodes (117^3 per node):
  30700 time steps, 21.06 CT, dx=1

- 1170^3 on 125 nodes (234^3 per node):
  7600 time steps, 21.14 CT, dx=0.5

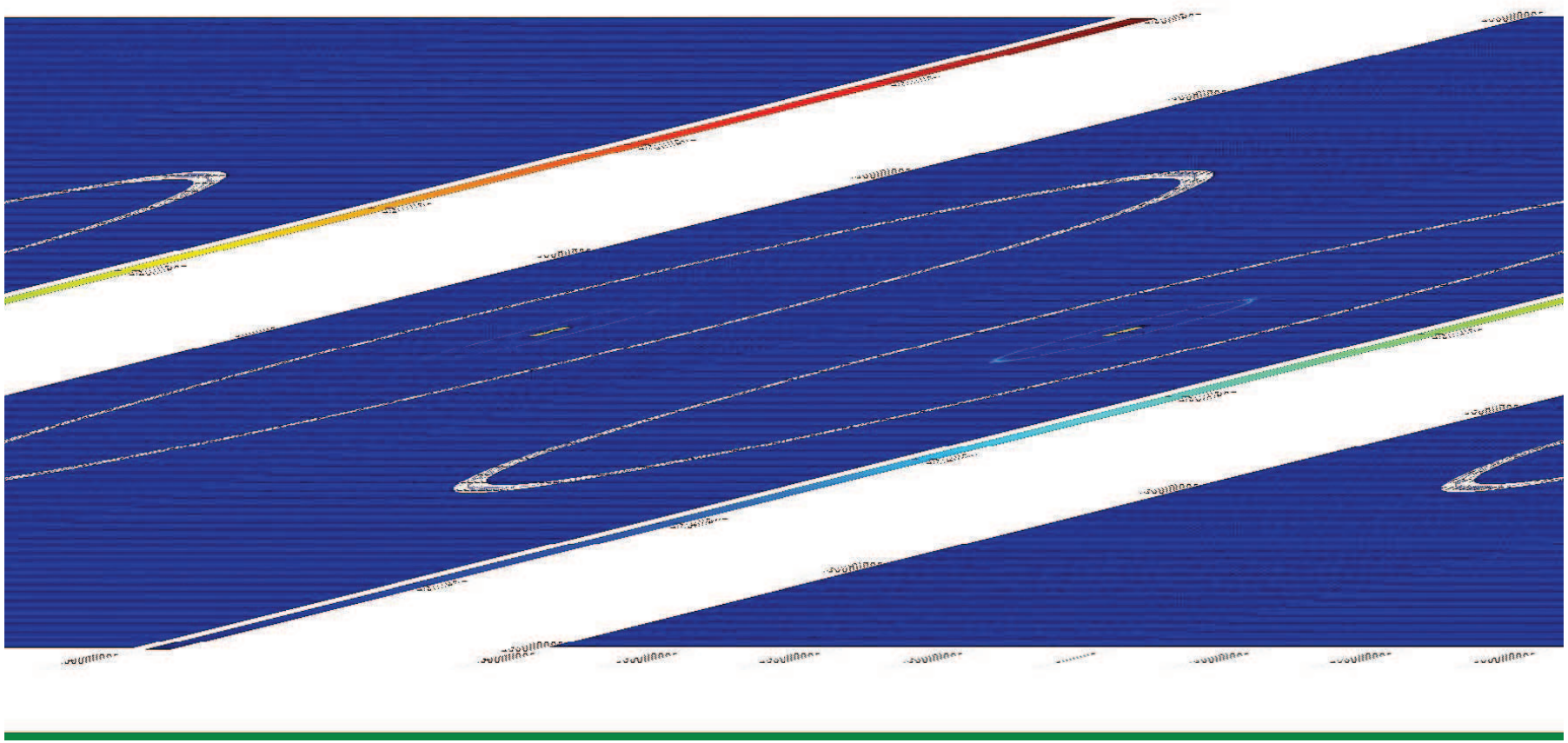
- 2340^3 on 729 nodes (260^3 per node):
  3600 time steps, 21.1459 CT, dx=0.25

- 4680^3 on 2197 nodes (360^3 per node):
  2964 time steps, 21.1465 CT, dx=0.125

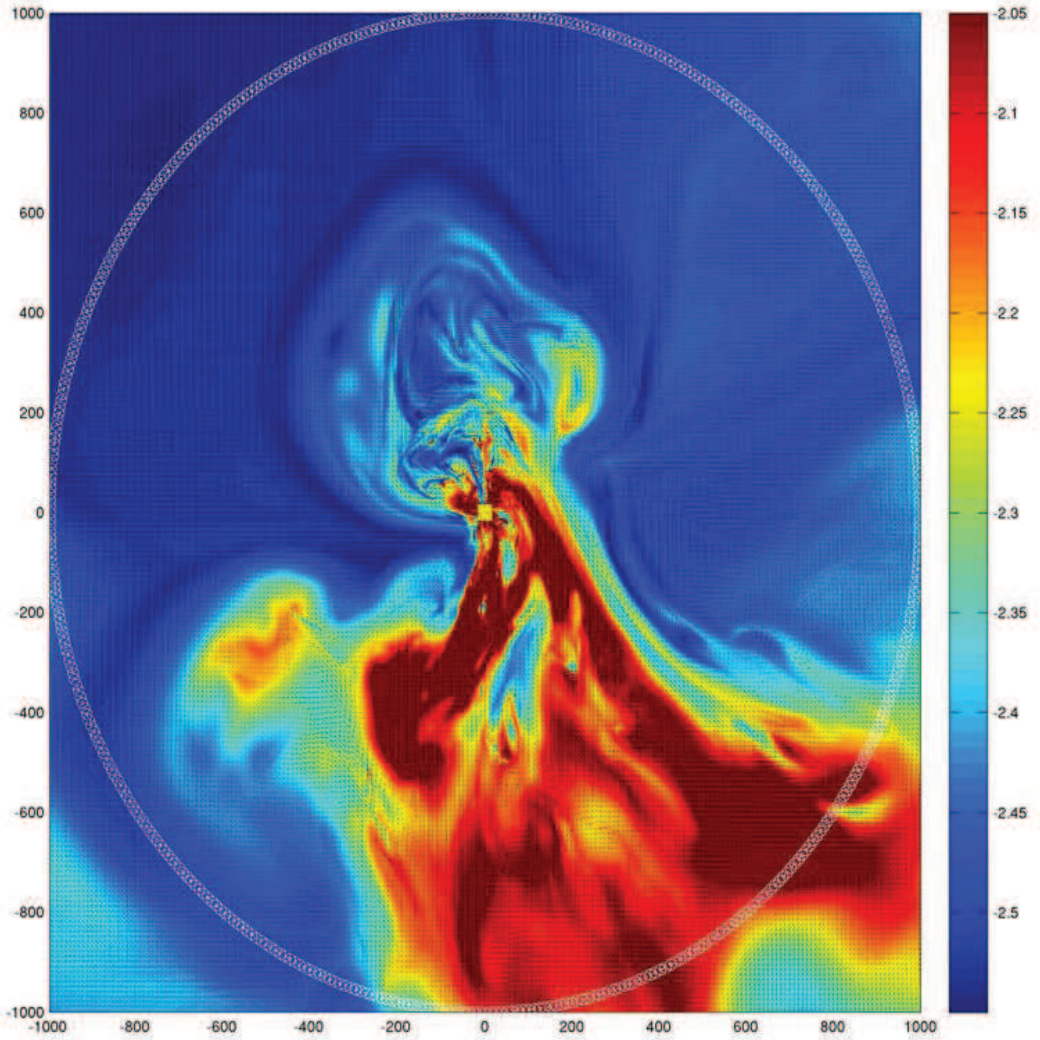
Problems for higher resolution

- CFL time constraint
- Expensive inner boundary subroutine
- 5 layers for loop
- Update inner every 8 time steps in the highest resolution (results proved to be correct)

Small run movie (600^3)



Final 4680^3 plot



Thank you!