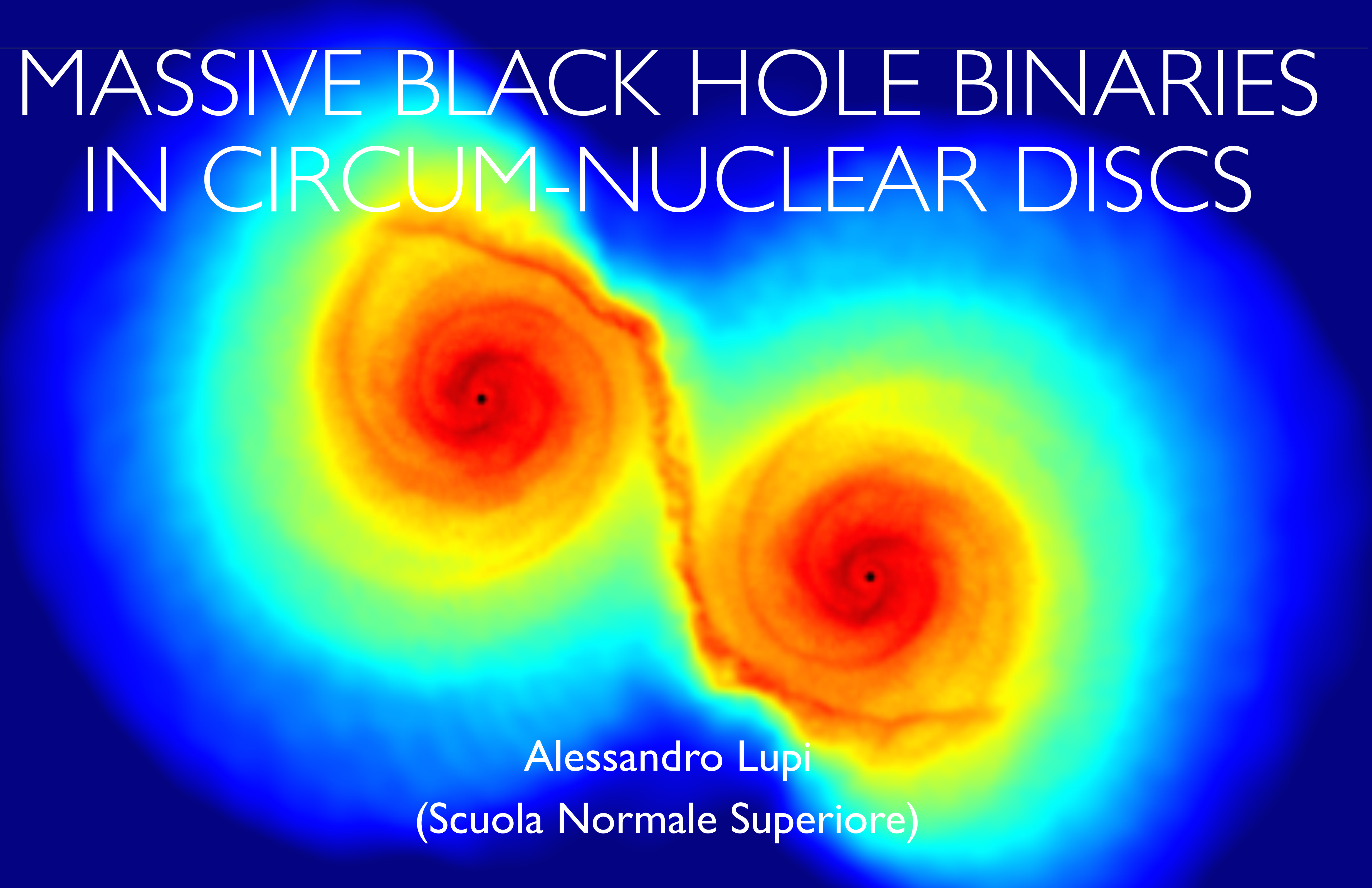
MASSIVE BLACK HOLE BINARIES IN CIRCUM-NUCLEAR DISCS



Alessandro Lupi
(Scuola Normale Superiore)

1st LISA Astrophysics working group workshop
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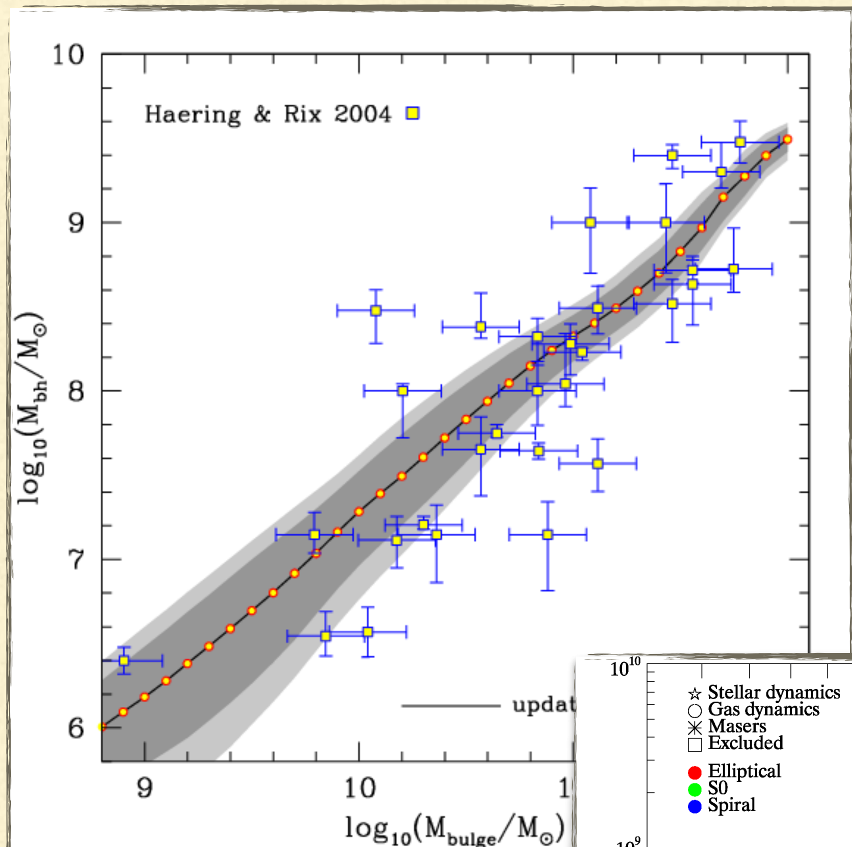
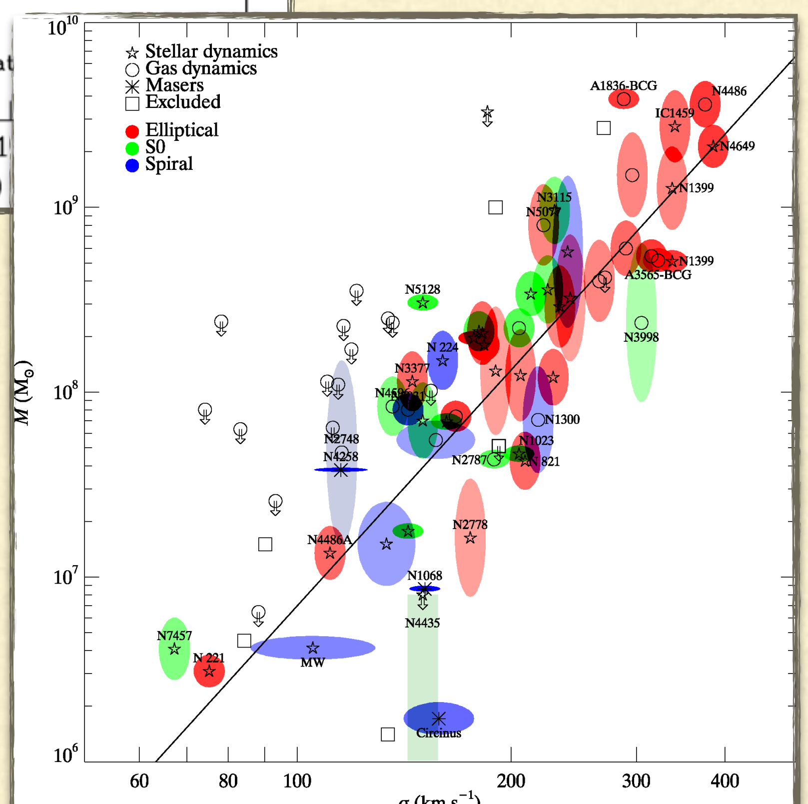
in collaboration with: F. Haardt, M. Dotti, and M. Colpi

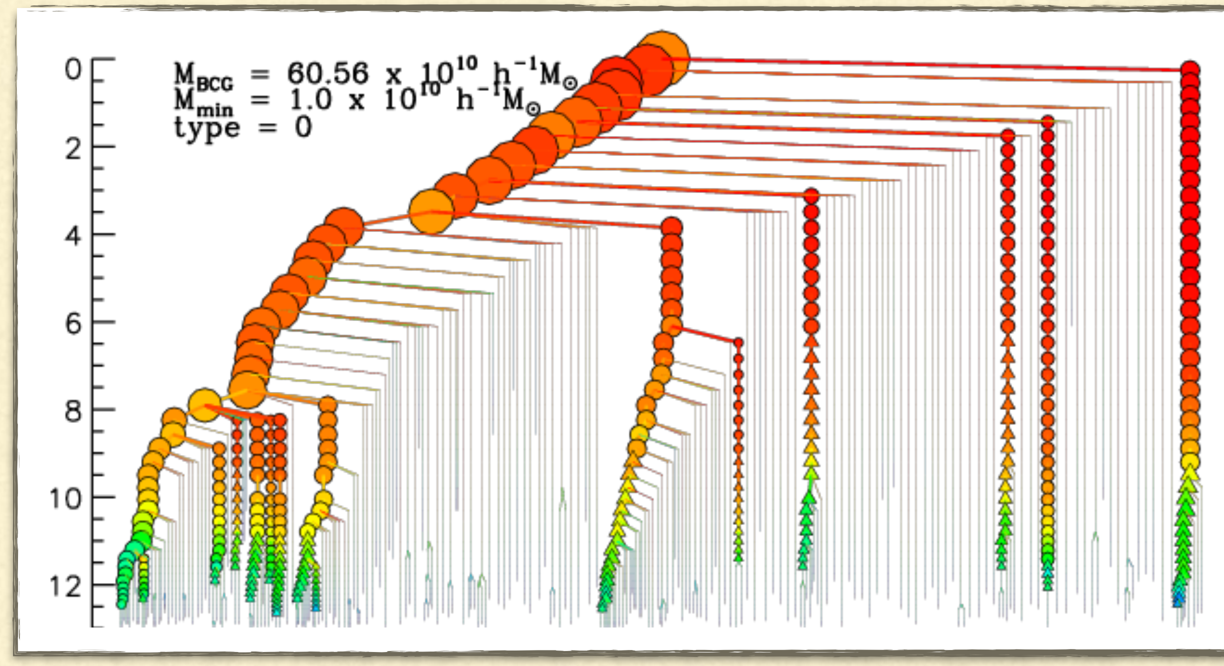
Introduction



Credit:
Bower et al. (2006)



Credit: Gültekin et al. (2009)

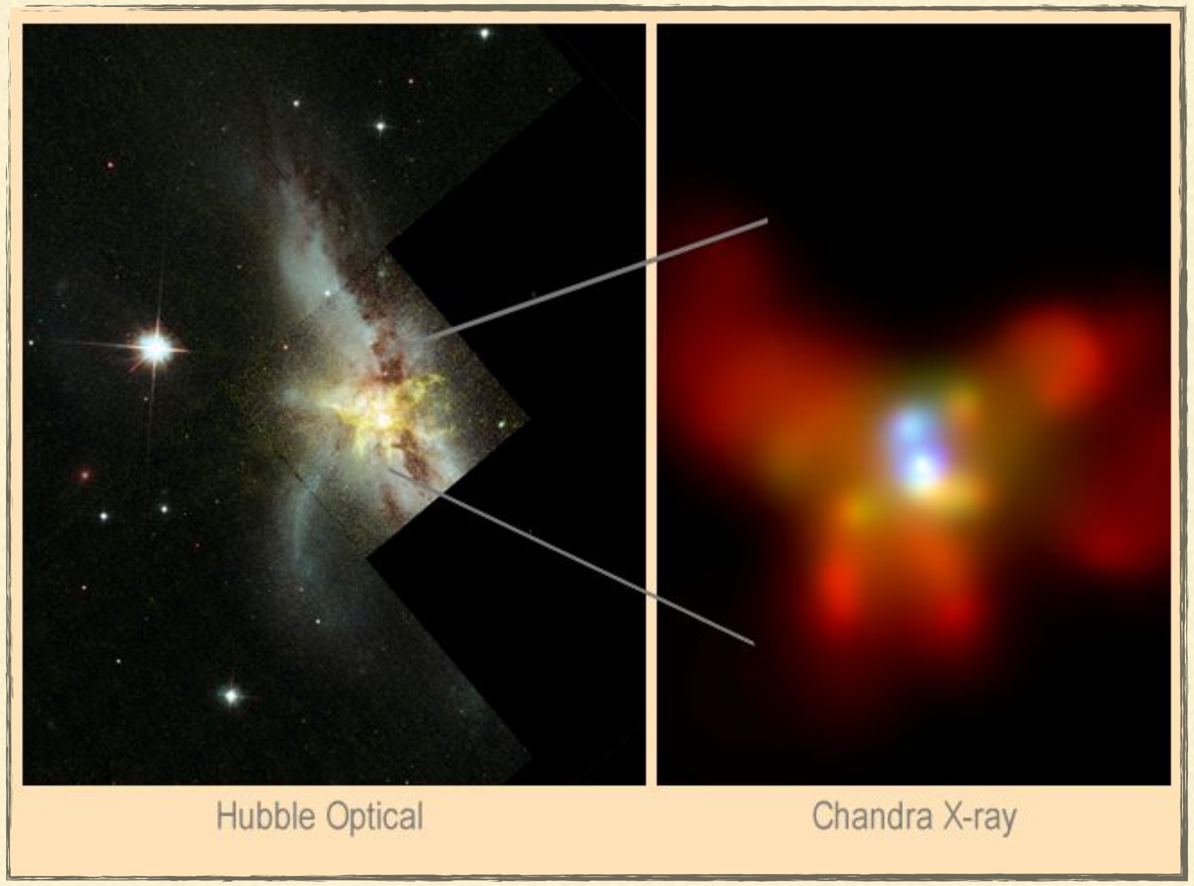


Credit: De Lucia (2007)

When galaxies merge MBHs pair in a MBHB and finally coalesce.

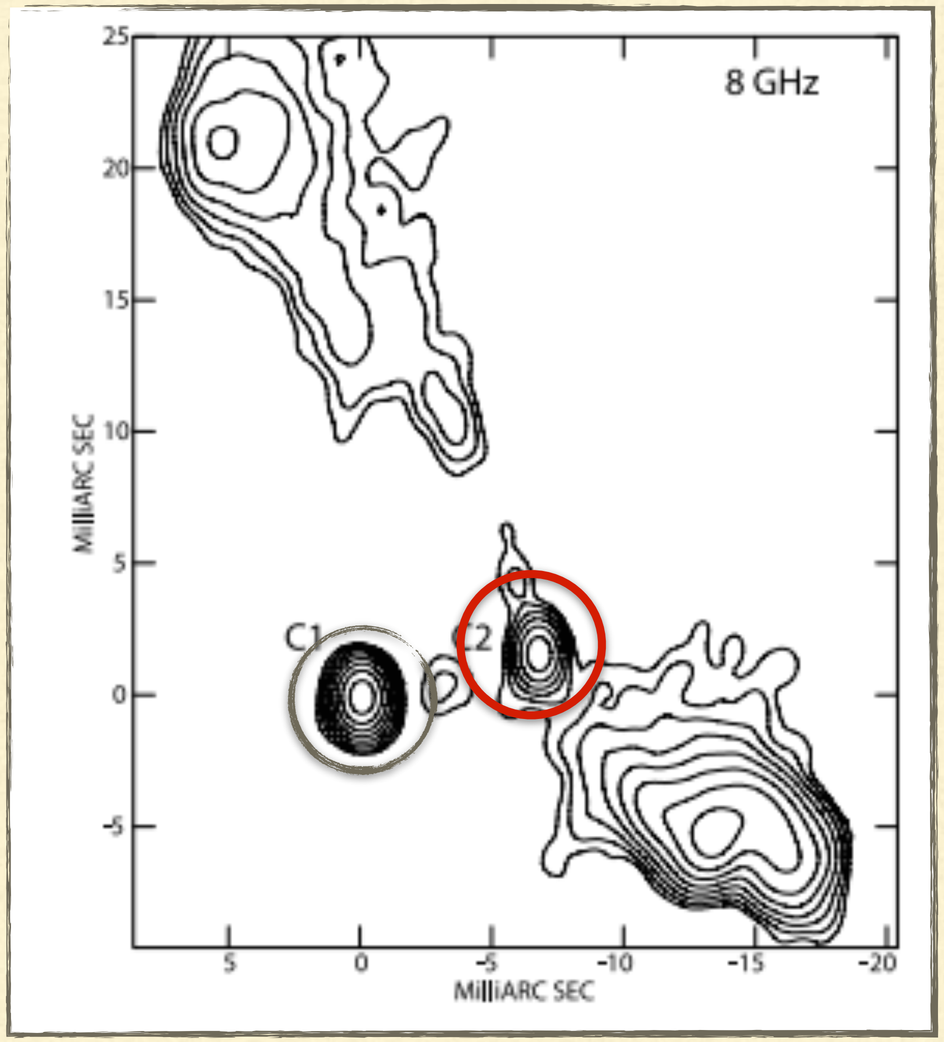
MBH binaries

There is compelling evidence of dual AGNs (e.g. NGC 6240).



Credit: NASA Komossa et al. (2003)

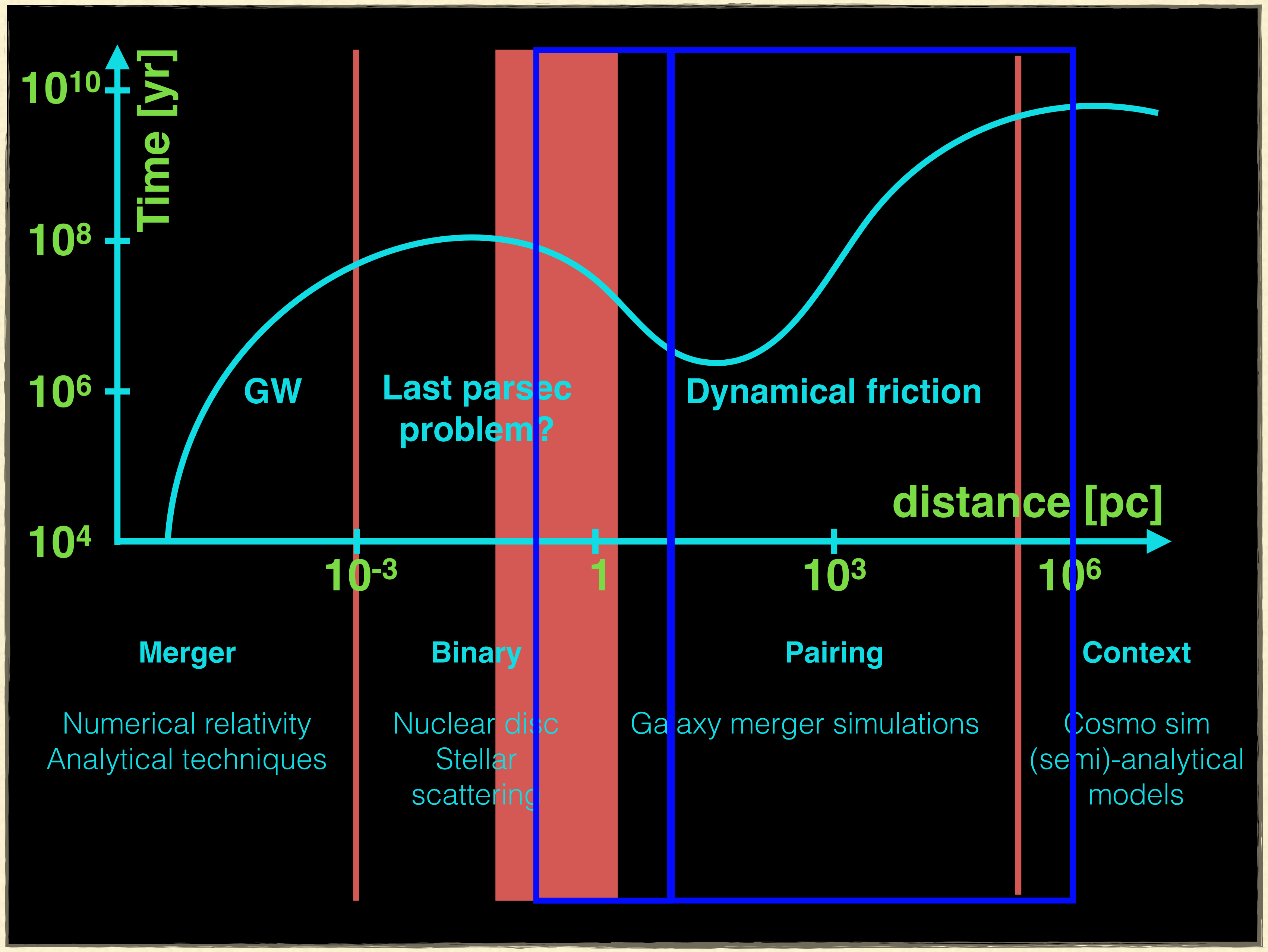
Binaries on pc scales are rare and the clearest evidence is represented by the radio galaxy 0402+379.



Credit: Rodriguez et al. 2006

A recent candidate was found by Kharb et al. (2017) with a separation of 0.35 pc

The path to coalescence



(Begelman, Blandford & Rees 1980)

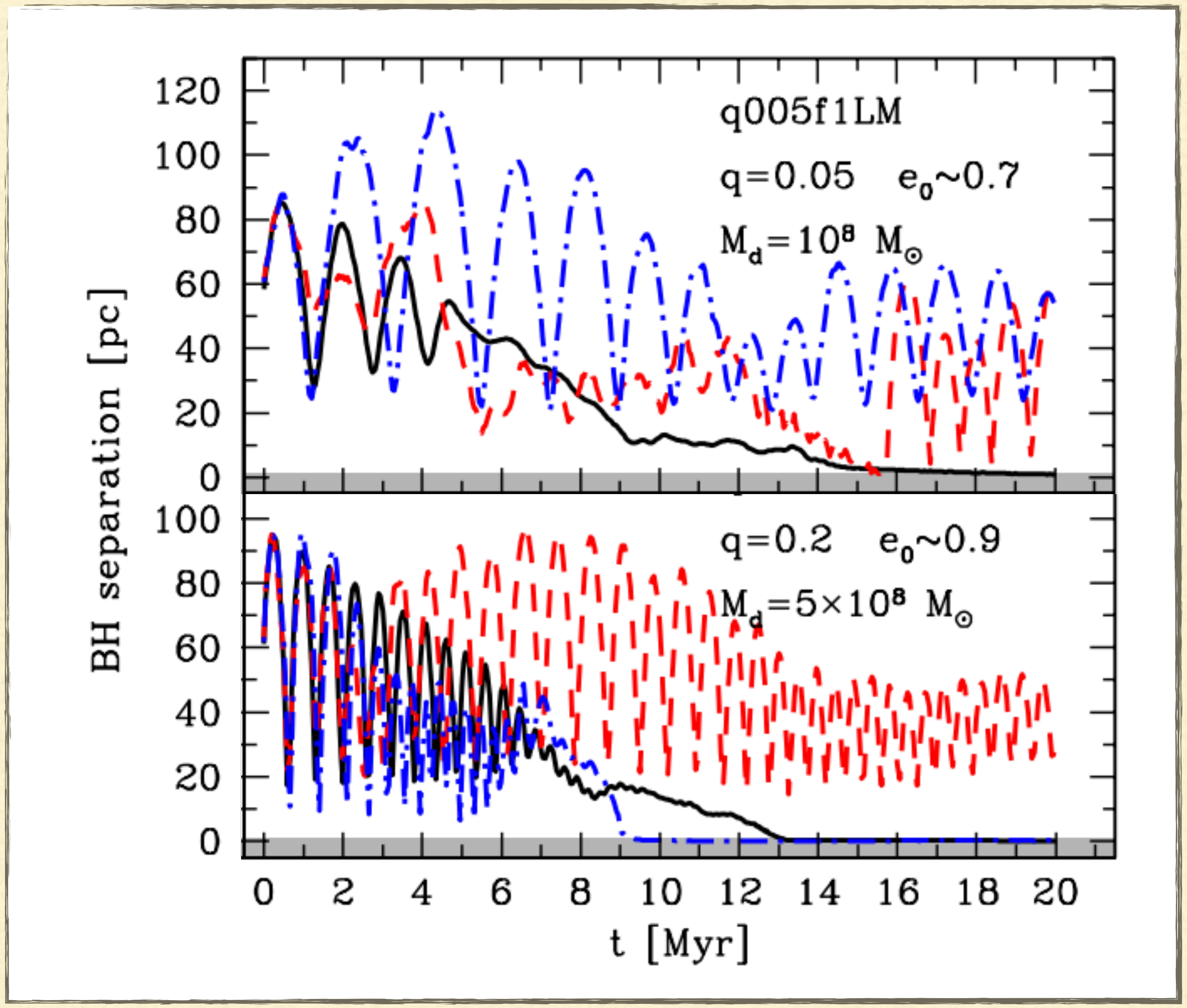
Phase I:
DF (gas/stars/DM)

Phase II:
three-body encounters
DF on gas
…

Phase III:
GW-driven inspiral

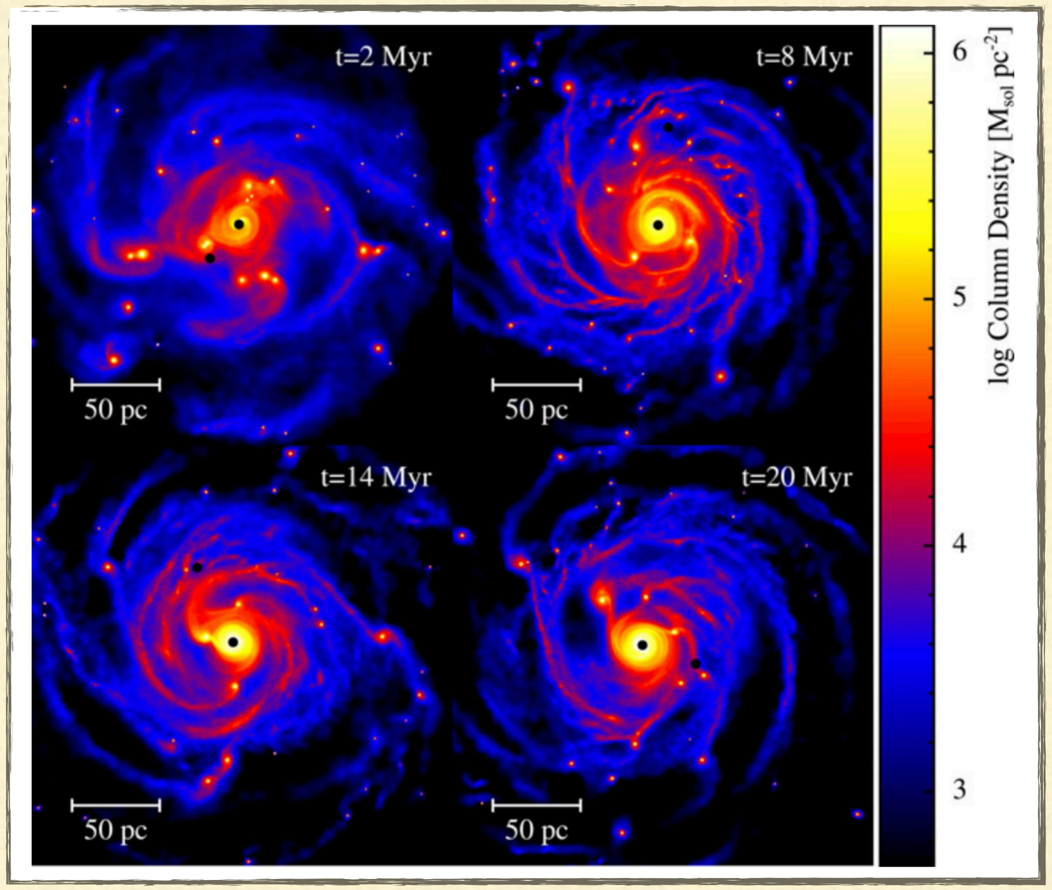
MBHs in circum-nuclear discs

(Fiacconi et al. 2013)



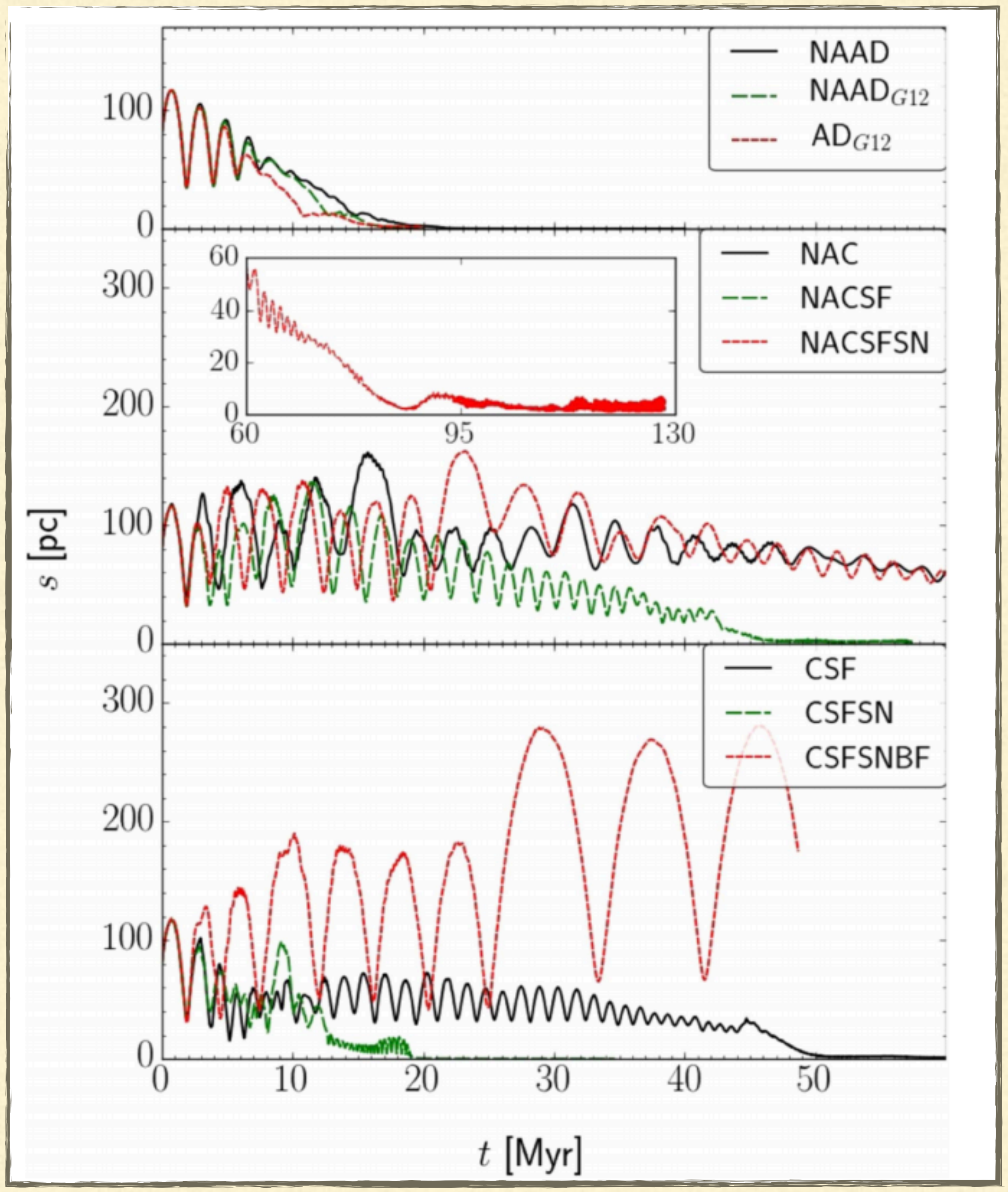
SPH simulations:

0.5 pc resolution
No SF/SN feedback
No cooling during the run



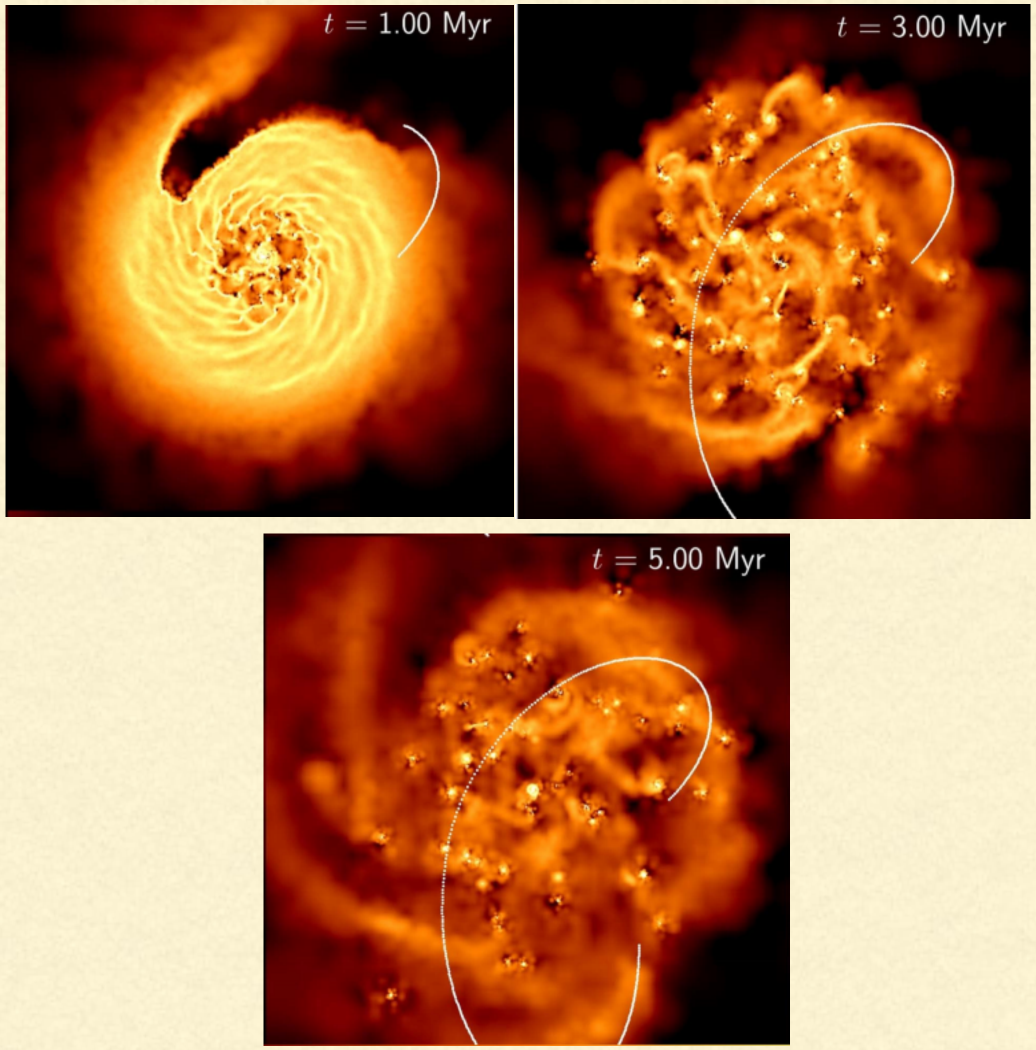
MBHs in circum-nuclear discs

(Souza-Lima et al. 2017)



SPH simulations:

0.5 pc resolution
Cooling/SF/SN feedback
+ BH accretion and feedback

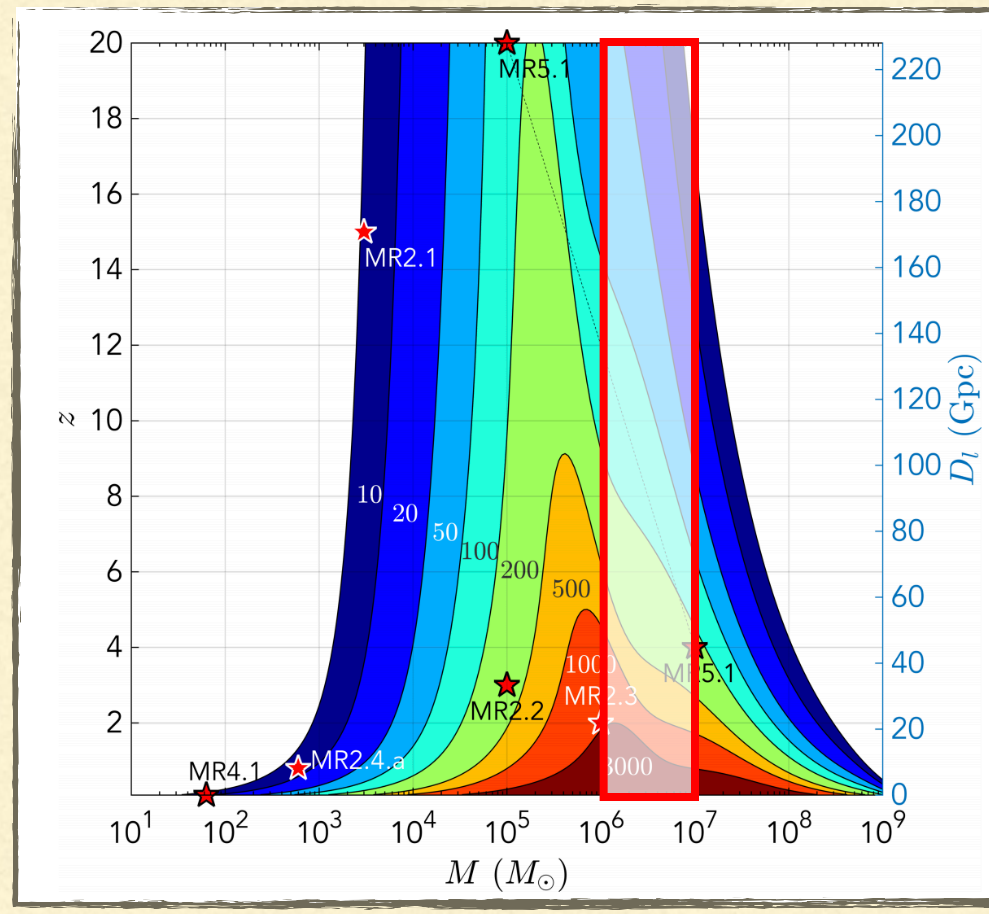


MBHs in circum-nuclear discs

We consider each of the two identical galaxy nuclei composed by:

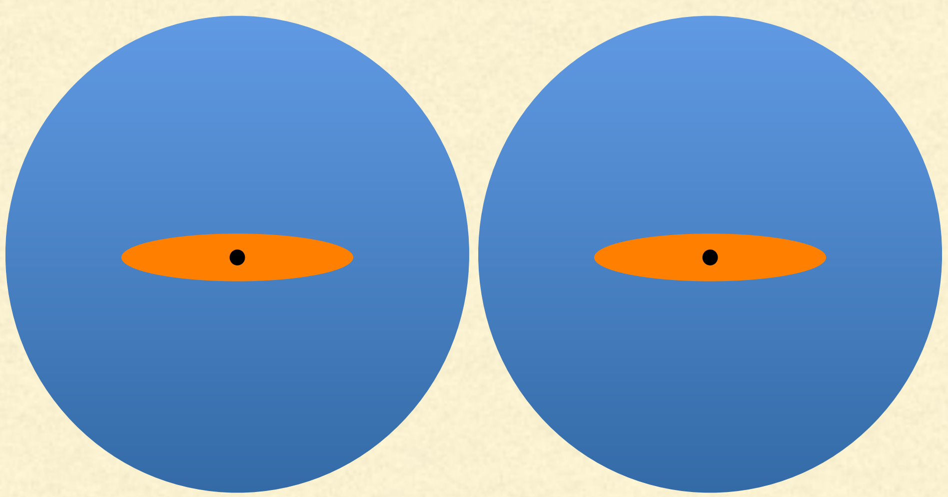
- a gaseous circum-nuclear disc, described by an exponential surface density profile, with *H*/*R* ~ 0.2, scale radius R_{disc}=50 pc and mass $M_{disc}=10^8$ $M_{\odot}$;

- a MBH at the centre of the nucleus, with mass $M_{BH}=10^7$ $M_{\odot}$.



The initial conditions for the merger consist of two equal mass, co-planar co-rotating discs at a distance of 300 pc, placed on an elliptical orbit with eccentricity *e*=0.3.

The orbital angular momentum is antiparallel to the angular momentum of the disc, in order to maximise the gas shocks and thus the gas infall toward the centre.

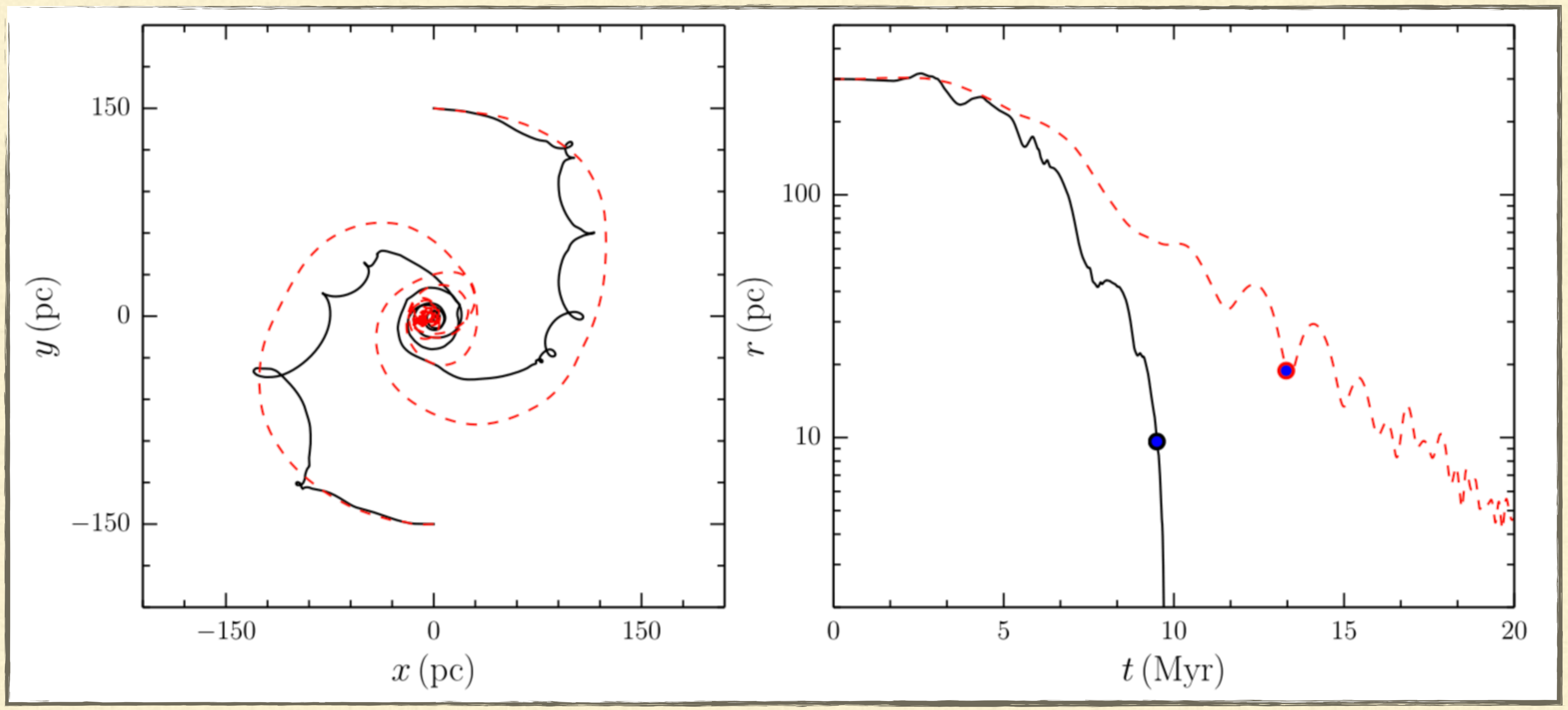


The impact of SN feedback

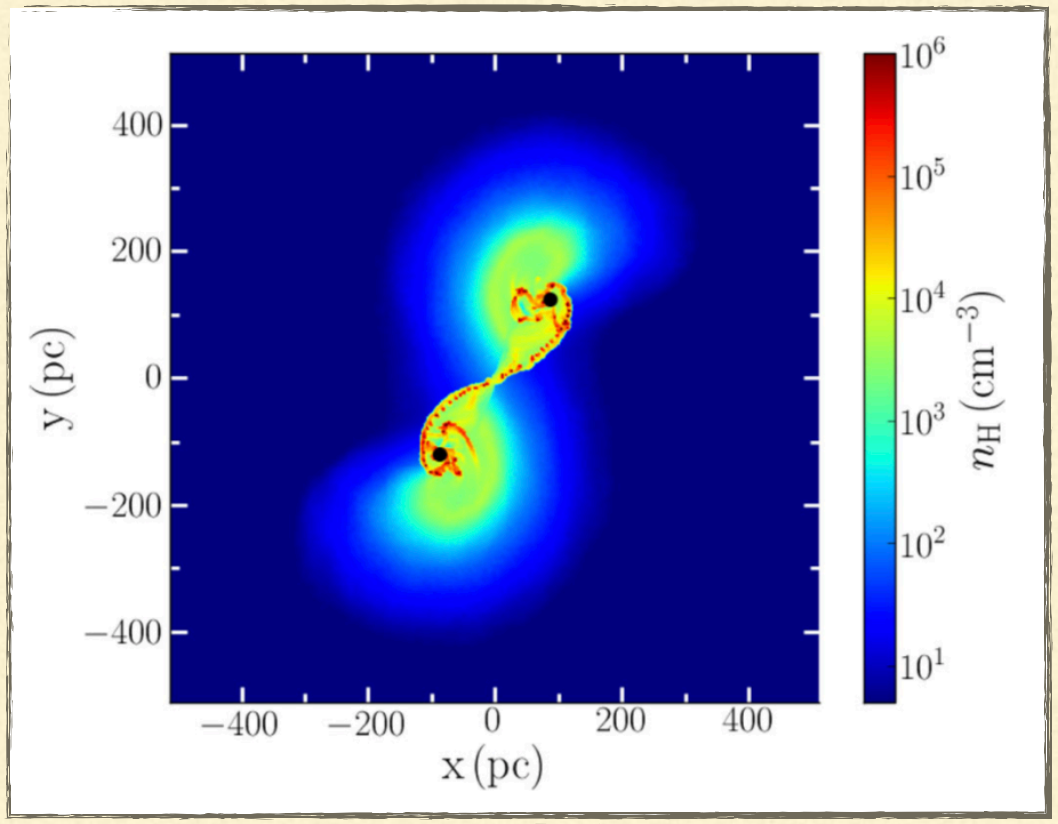
We evolve the two discs with radiative cooling, star formation, and supernova (SN) feedback using the AMR code RAMSES (Teyssier 2002), which better models gas shocks compared to SPH codes, with a resolution of 0.4 pc.

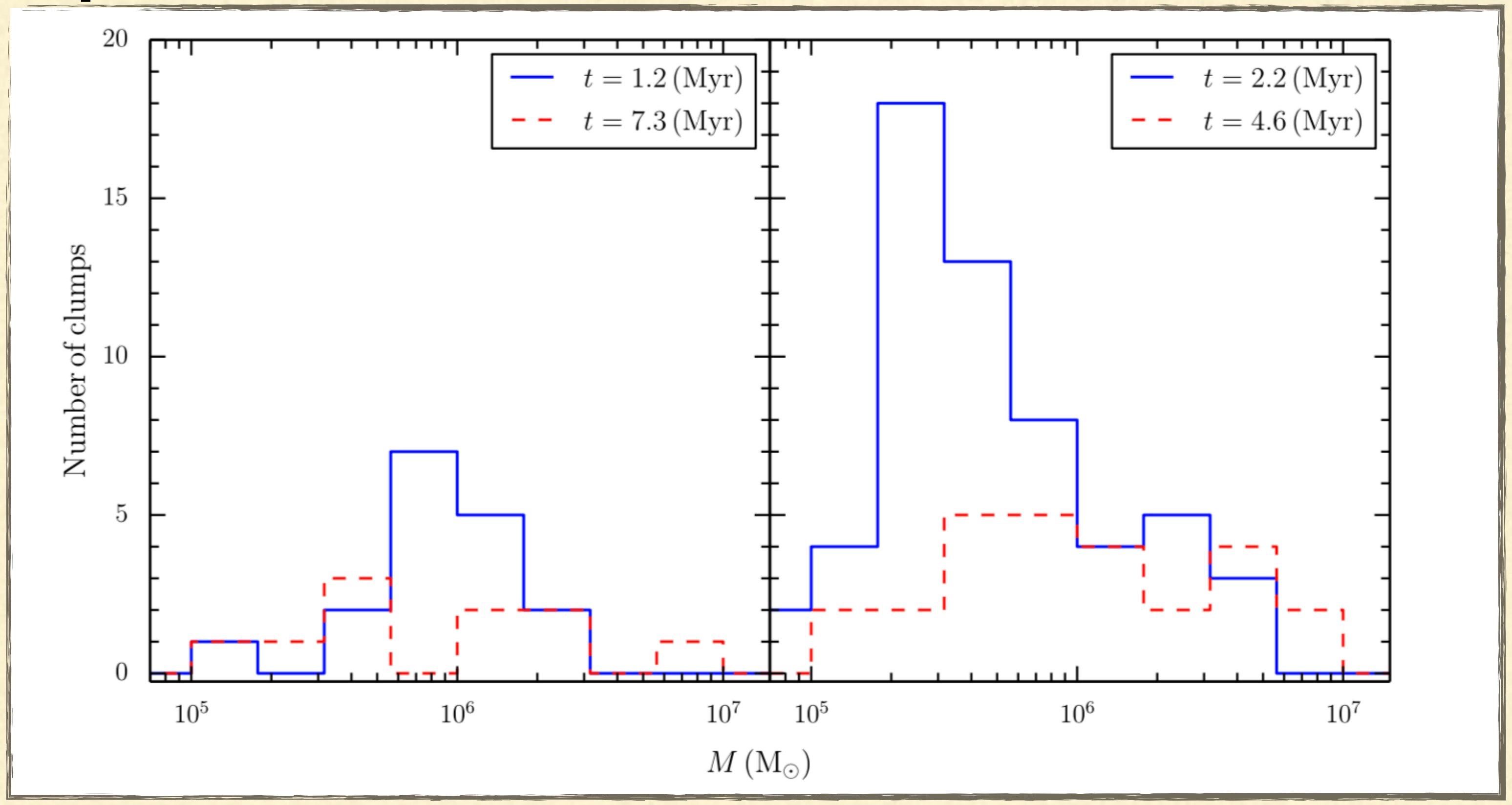
We explore two different cases: weak vs strong SN feedback.

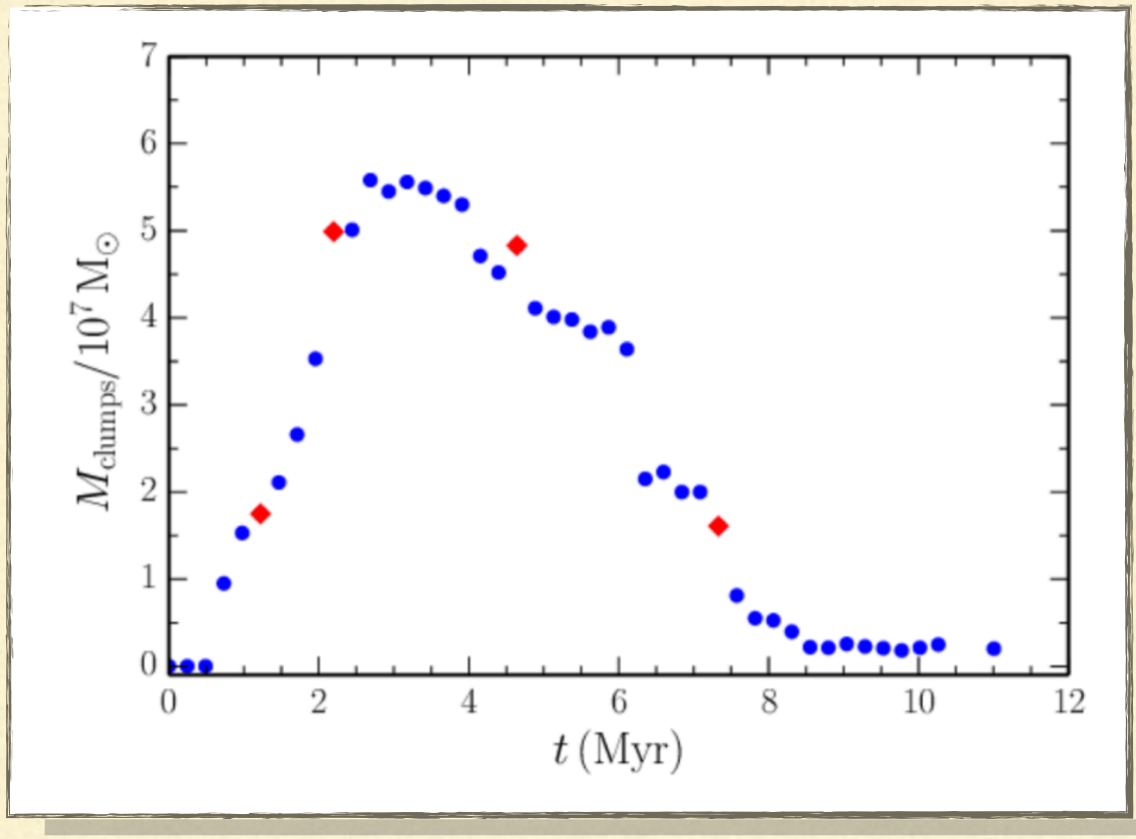
—— Weak - - - Strong

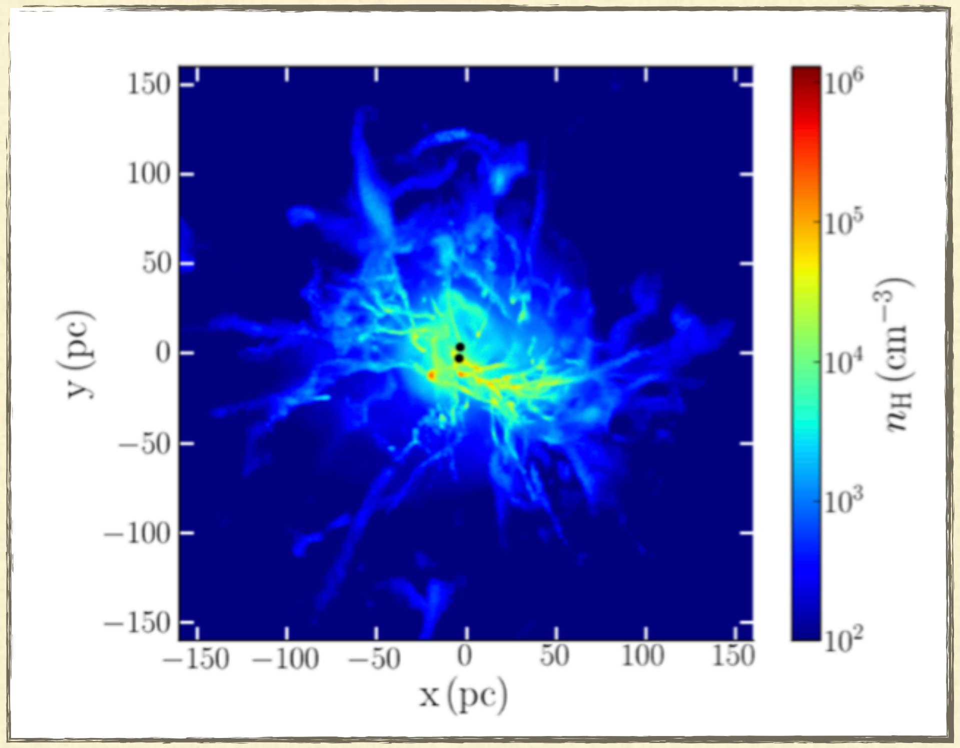


BH-clumps interactions









Conclusions
(Lupi et al. 2015a, 2015b)

We performed 3D hydrodynamical simulations of the MBH pairing during galaxy mergers in an idealised and controlled environment.

We considered cooling, star formation and SN feedback to assess their effect on the MBH dynamics.

Unlike other studies (e.g. Fiacconi et al. 2013, Tamburello et al. 2017), we found that:

1) MBH-clump interactions can also accelerate the pairing, and this strongly depends on the geometry of the interactions and on the physical processes shaping the CND

2) a strong SN feedback can effectively destroy clumps and prevent the scattering of the MBH during the mergers.

3) Accurate merger time-scales (and event rate predictions) are still difficult to assess, because of the huge variety of conditions observed in numerical simulations. We are still far from properly modelling galaxy mergers, and we still need a great effort to properly model all the physical processes involved.