# Dynamical interaction of Supermassive Black Holes with the surrounding stellar system:

## *Evolution of the Galactic Centre up to 500 Myr.*



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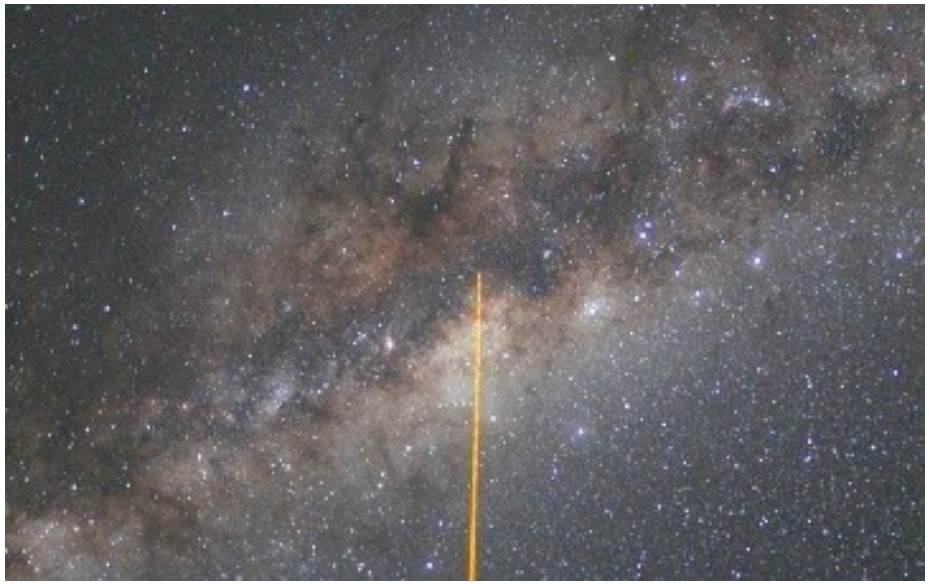
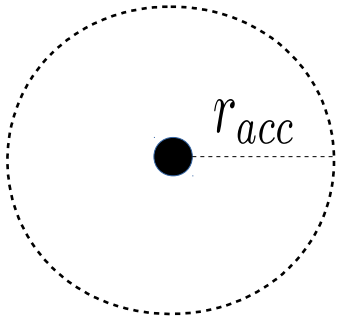
# THE GALACTIC CENTRE

## The direct N-Body code

- Supermassive black hole
- Compact stellar cluster
- Stellar tidal disruption and accretion
- Stellar & binary evolution (Hurley et al. 2000, 2002)






if r < $r_{acc}$ :

tidal disruption

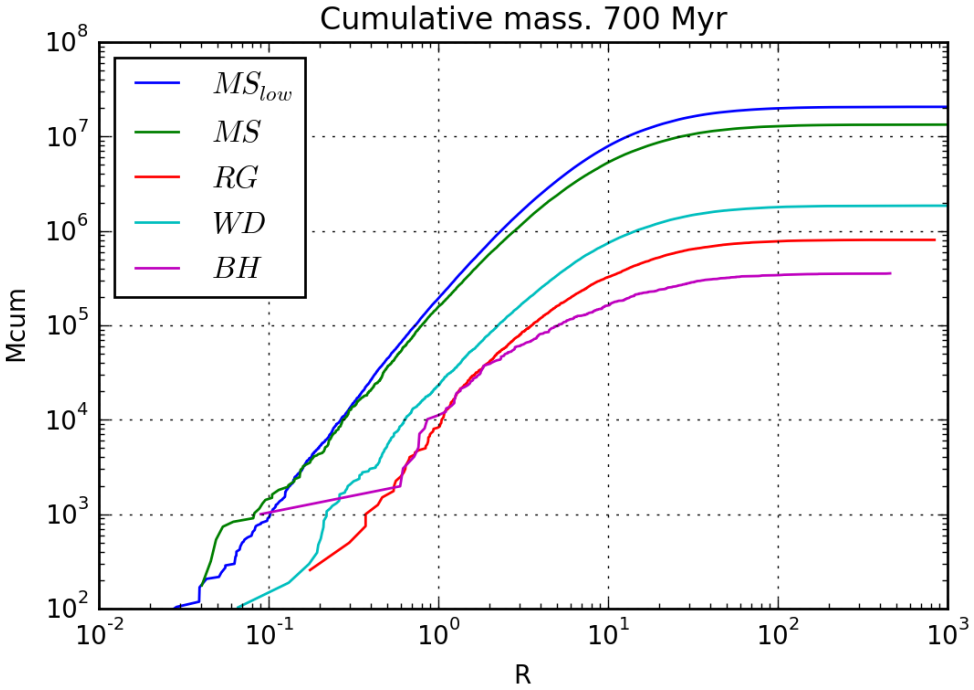
$$r_{acc} = 3.0 \cdot 10^{-4} r_{inf}$$

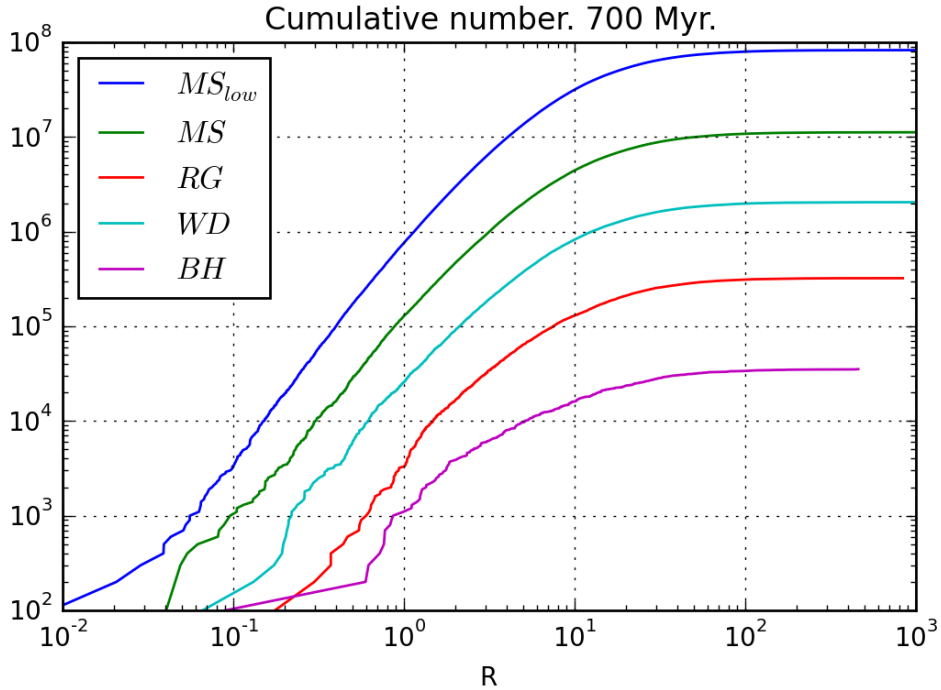
- *NBODY6++GPU (Wang et al. 2015); 96 CPU + 16 GPU on Jureca cluster, Juelich*

# THE INITIAL CONDITIONS

- **N** = 1M ⟶ $\mathbf{N}_{real}$ = 100M
  - $N_{single}$ = 950K;  $N_{binary}$ = 50K
- **Plummer** + point mass potential (MakeHalo, Dehnen 2005)
- **IMF**: Kroupa, 2001; 0.08 – 100 $\mathrm{M}_{\odot}$
- **Binaries**:
  - Uniform in log(a)
  - Thermal eccentricity distribution f(e) = 2e
  - Mass ratios: $f(q) \propto q^{-0.4}$ (Kouwenhowen et al., 2007)
- **Kick**: 256 km/s (Hobbs et al., 2005)
- $\mathbf{M}_{\mathbf{smbh}}$ = 0.1 $M_{tot}$

# Mass profiles

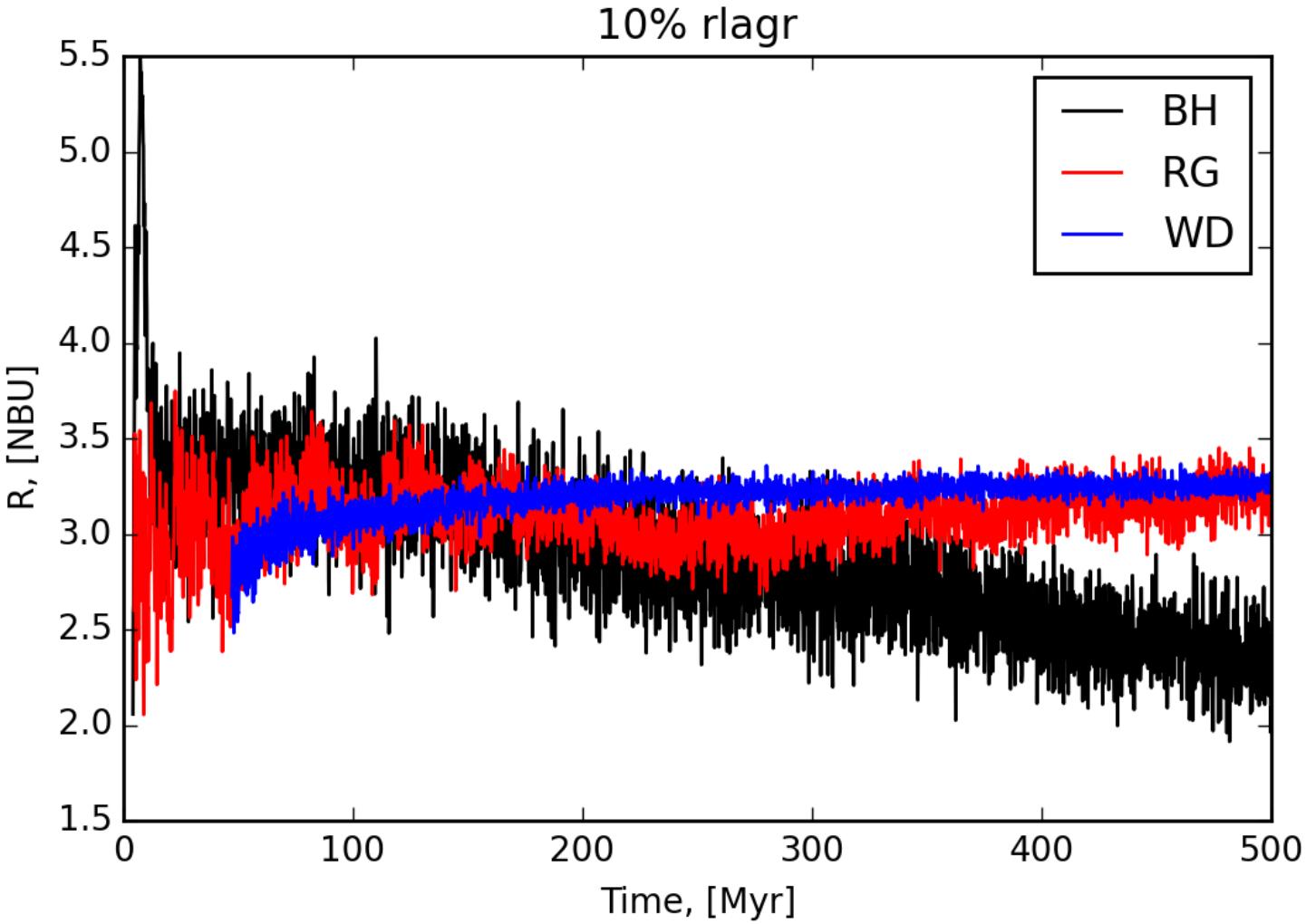



Mass profiles and number counts for different stellar types.

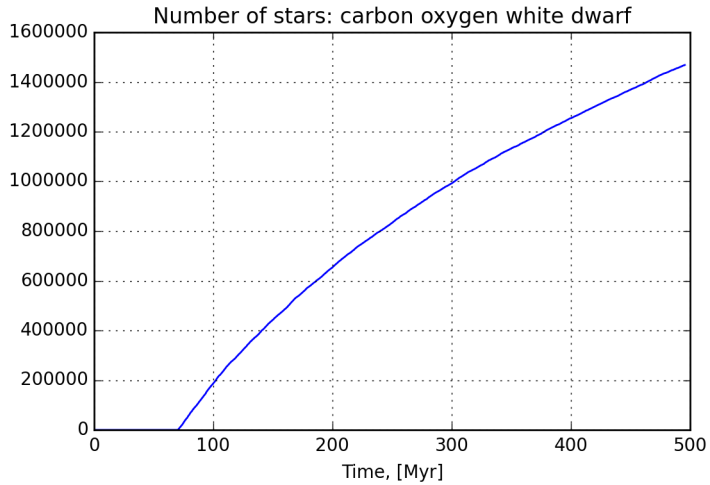
MS – main sequence
RG – red giants
WD – white dwarfs
BH – Black holes

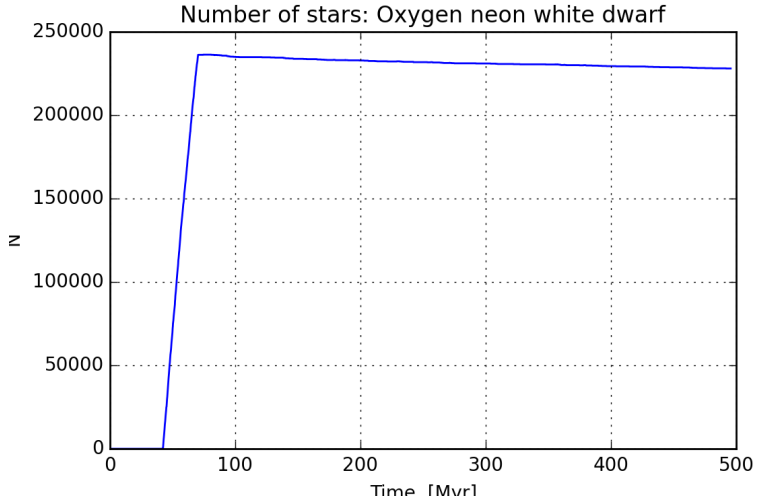
# Lagrangian Radii

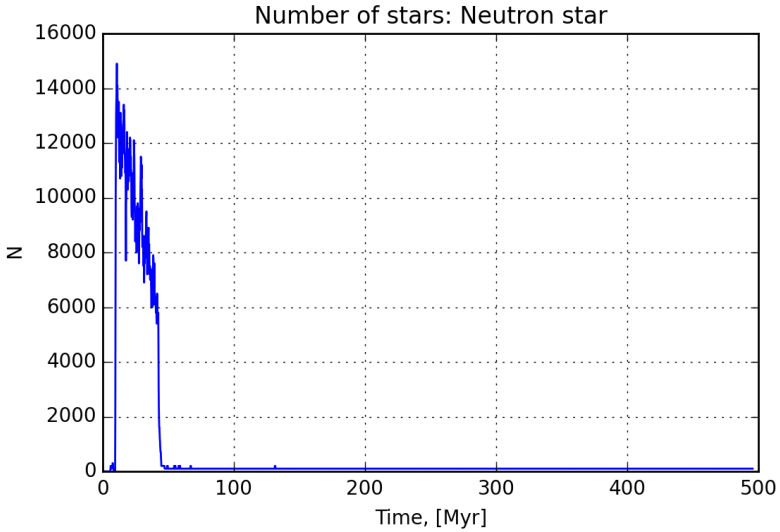


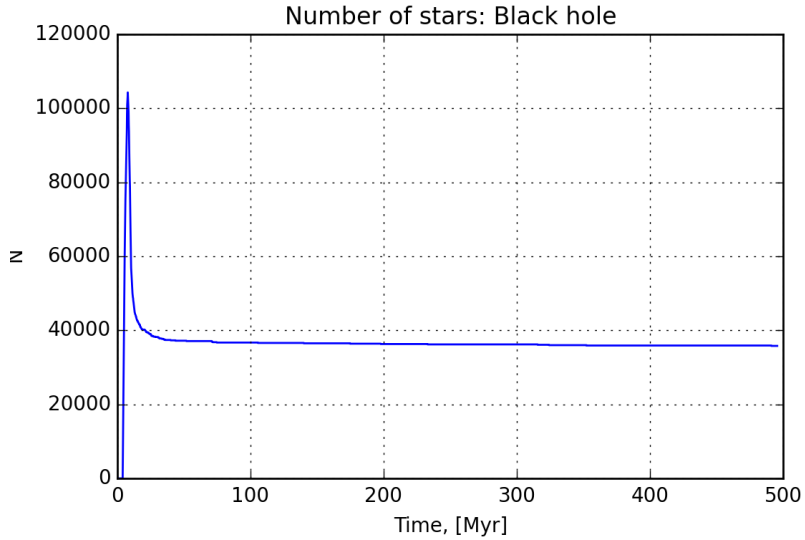

***10% Lagrange radius for black holes shows the mass segragetion***

# Stellar types:



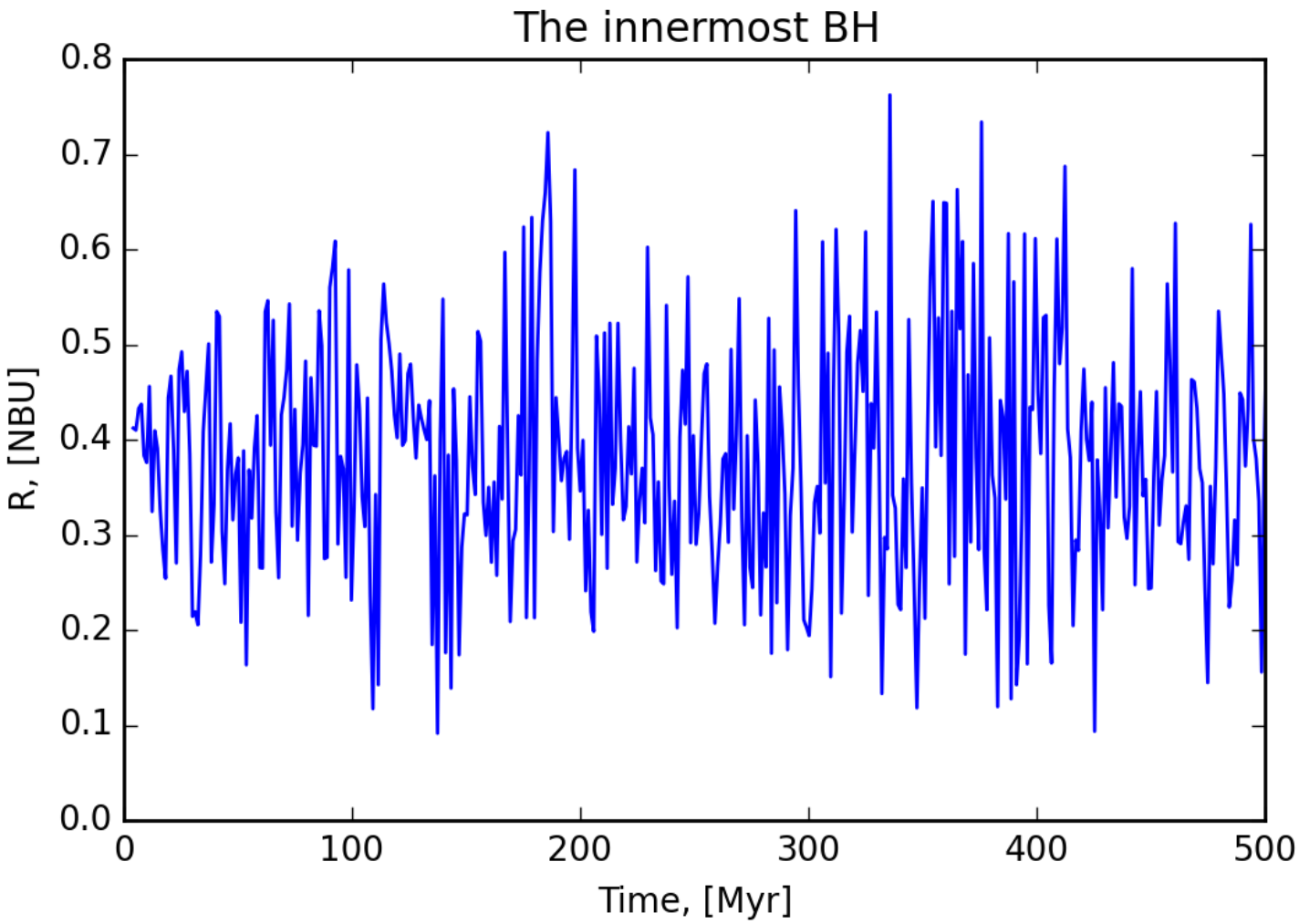




All neutron stars escaped but black holes remain in the system

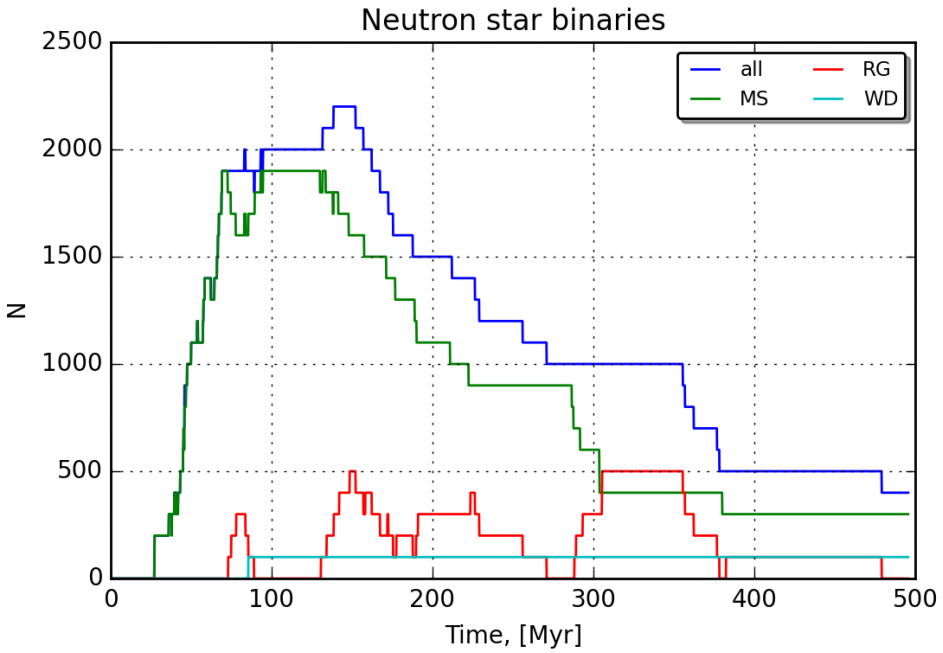
# Compact Objects




*Distance to the nearest black hole as a function of time.*

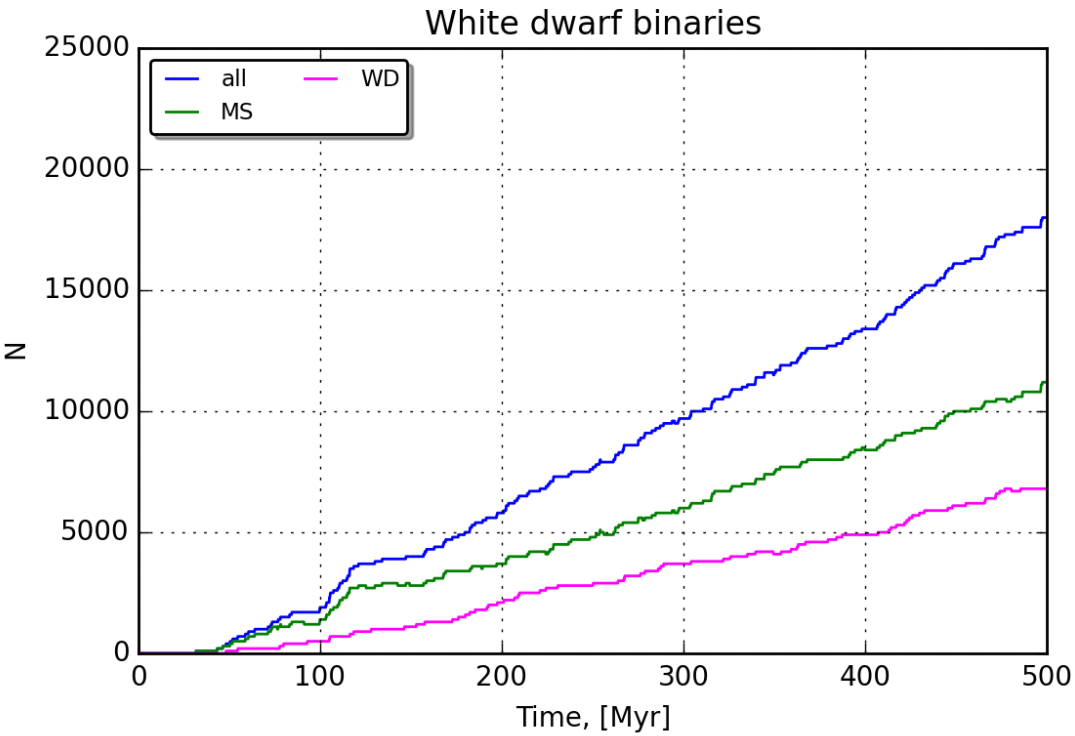
# Compact binaries

**Number of neutron star and white dwarf binaries**

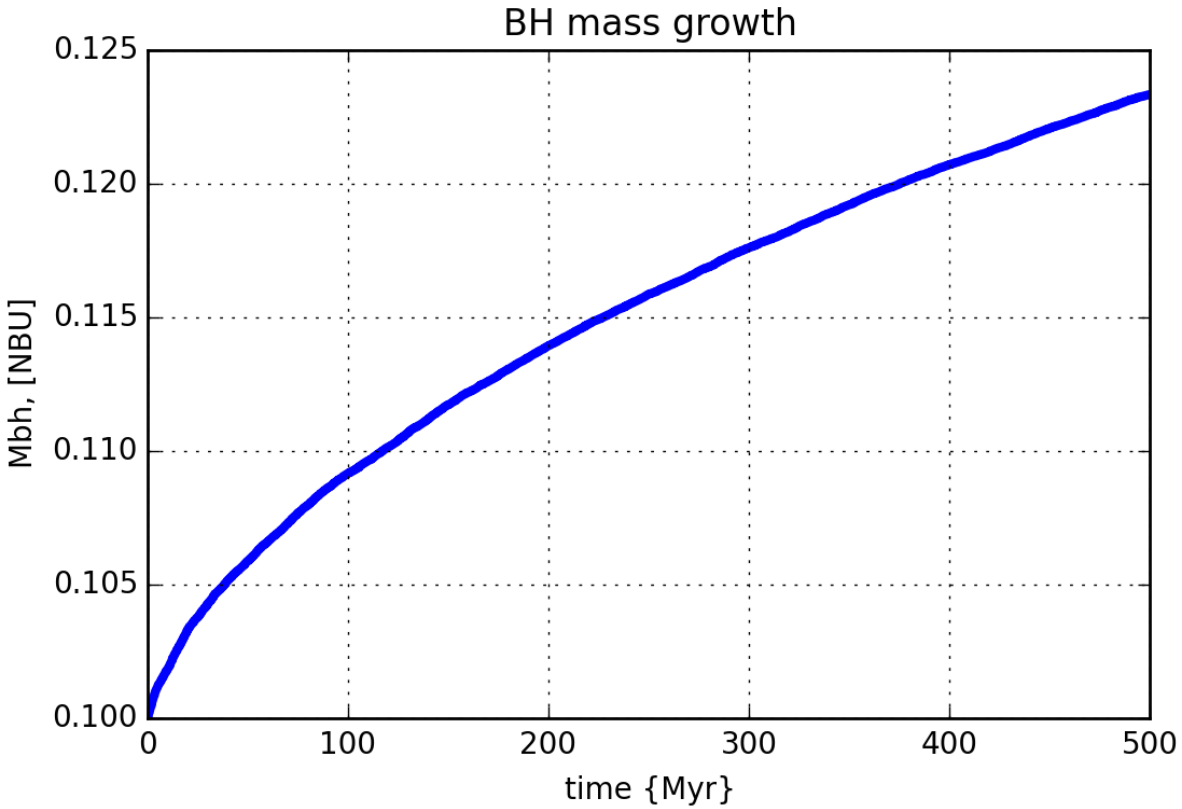



*Neutron star (NS) – main sequence*
*NS – red giant*
*NS – white dwarf*

*White dwarf – main sequence*
*White dwarf – white dwarf*



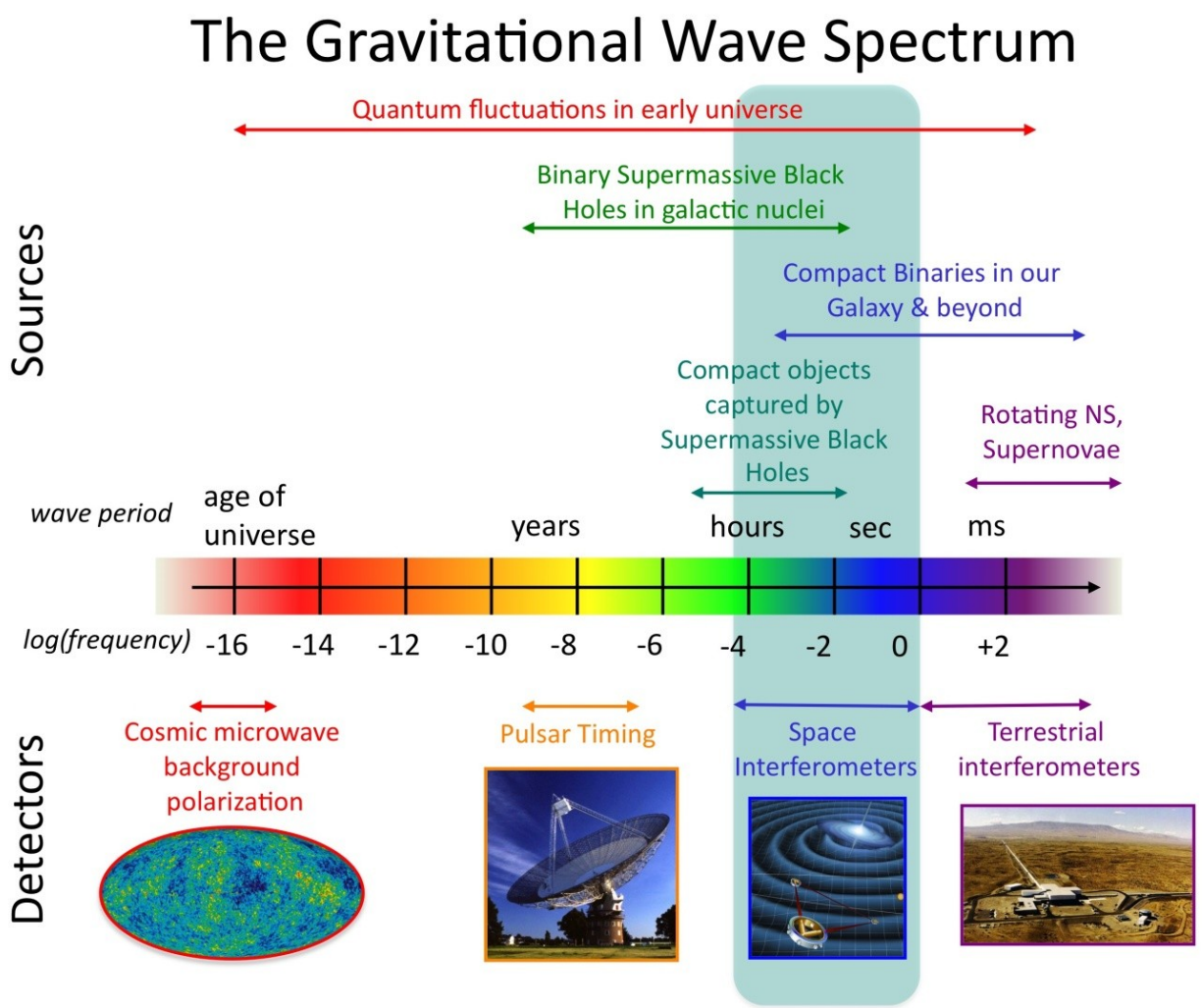
# Tidal disruption




| | |
|---|---|
| $MS_{low}$ | 2872400 |
| MS | 449700 |
| RG | 2800 |
| WD | 26200 |
| BH | 1100 |

**Mass growth of the supermassive black hole and number of accreted stars classified by stellar evolutional type. At 500 Myr.**

# Gravitational Waves




*Credit: NASA Goddard Space Flight Center*

# Conclusions

- SMBH heats the environment
- All Neutron stars escaped
- Black holes slowly segregate towards the center, but they are far away
- ~300 NS binaries → potential millisecond pulsars
- ~7000 WD-WD → low frequency gravitational waves (eLISA band), Supernovae Ia
- TDE events (x-ray)
- ~1100 accreted black holes → GW (eLISA)