



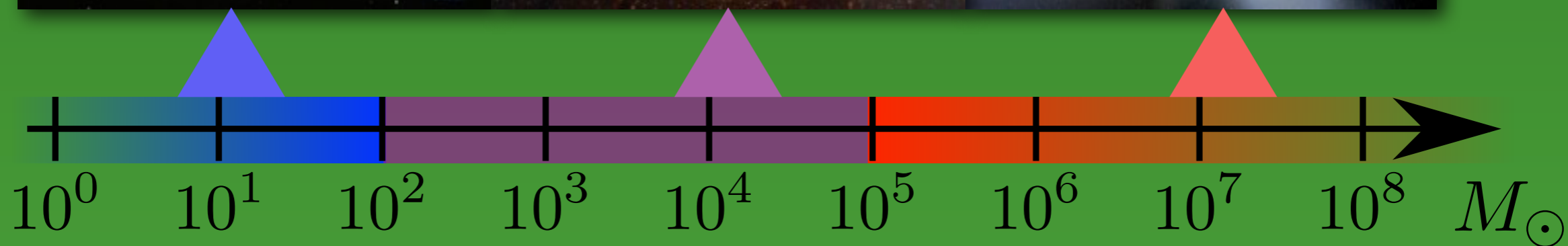
- BODY

SIMULATIONS OF GLOBULAR CLUSTERS IN TIDAL FIELDS

Effects of Intermediate-Mass Black Holes

INTERMEDIATE-MASS BLACK HOLES

ESO



STELLAR

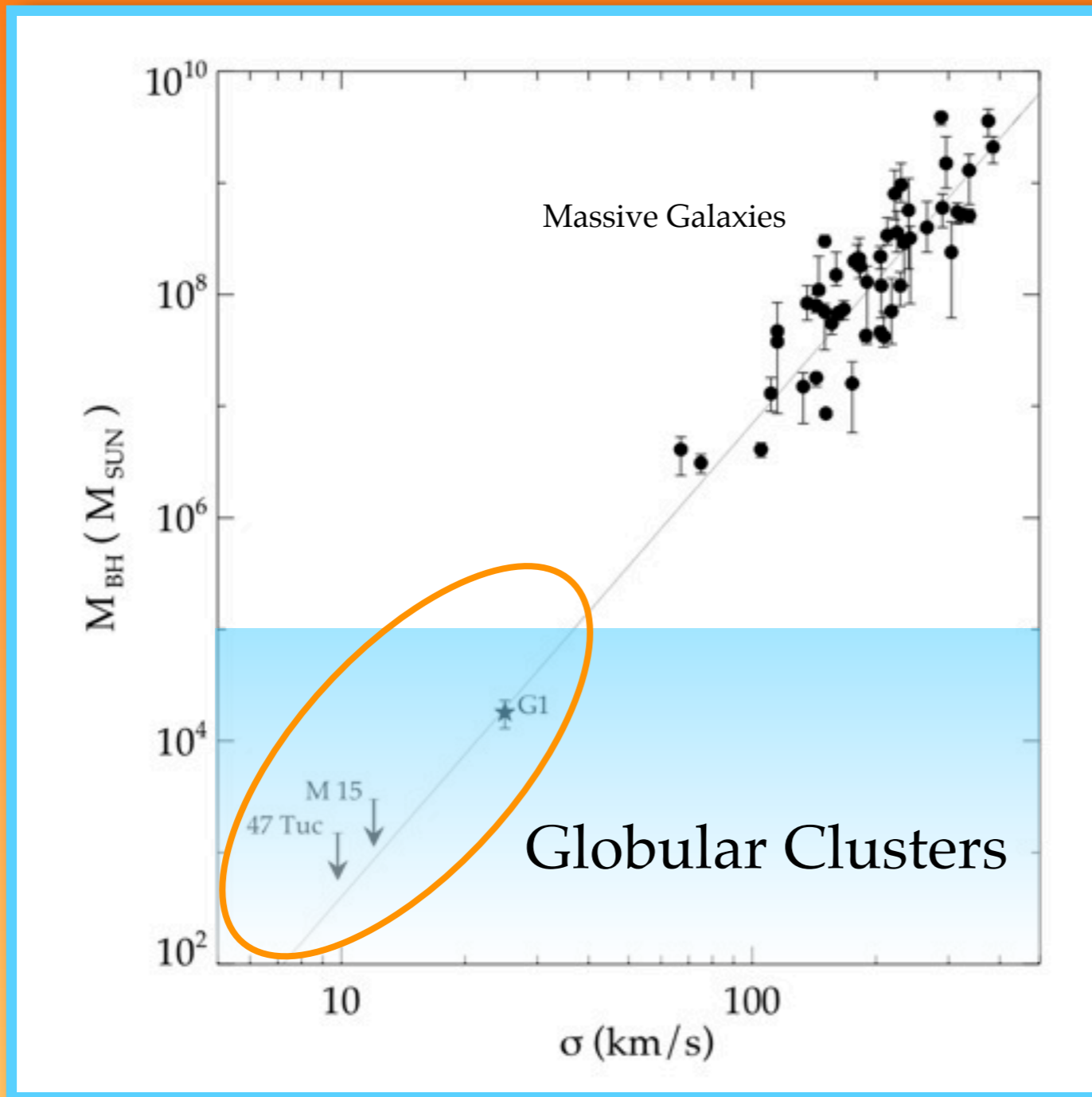
- Gravitational Collapse of Massive Star
- Supernovae
- Compact X-ray Binaries
- ...

IMBH

SUPER-MASSIVE

- Centers of Massive Galaxies
- Active Galactic Nuclei
- Quasars
- Center of the Milky Way
- ...

INTERMEDIATE-MASS BLACK HOLES



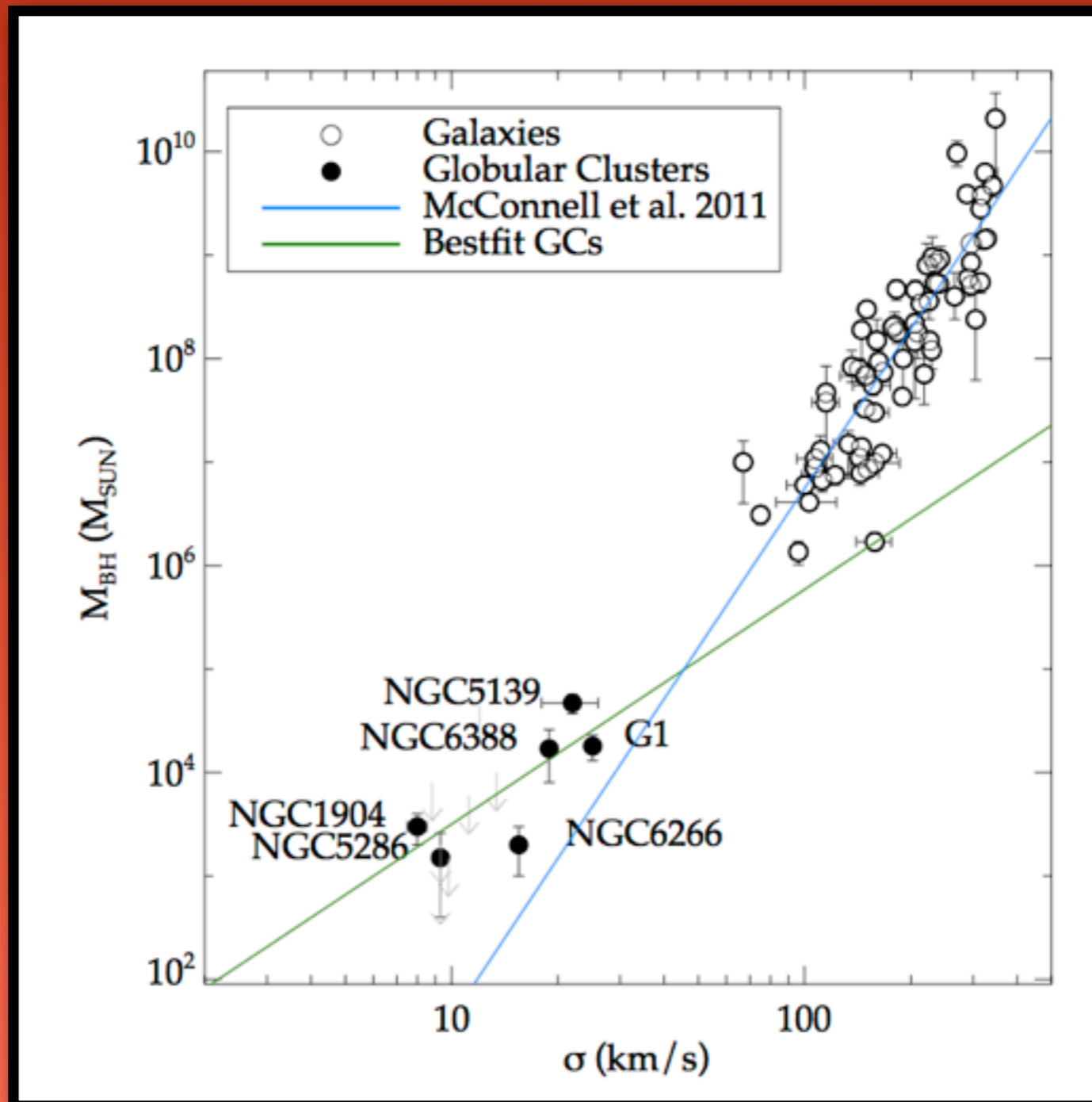
1. Relation at lower Masses?



2. Growth of Supermassive Black Holes?

➔ **Seeds:** IMBHs

INTERMEDIATE-MASS BLACK HOLES



STARTPARAMETERS



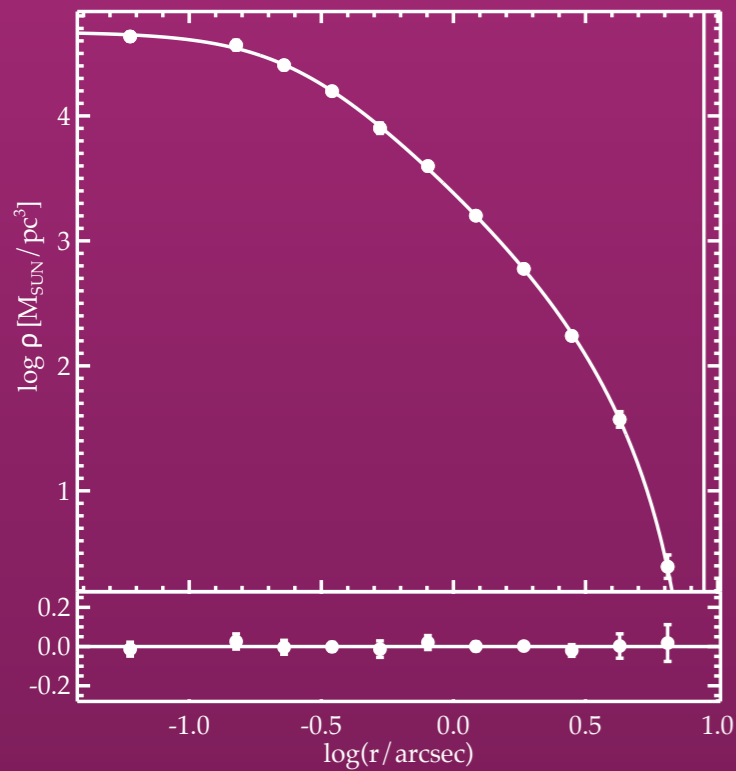
- NBODY6 (Aarseth 1999) on GUPs
- $N = 32k - 128k$
 - ✓ Stellar Evolution
 - ✓ External Tidal Field

We vary:

- ▶ **Black-Hole Retention Fraction** - 0%, 30%, 50%, 100%
- ▶ **Intermediate-Mass Black Hole** - 0%, 1%, 3%
- ▶ **Primordial Binary Fraction** - 0%, 10%, 30%

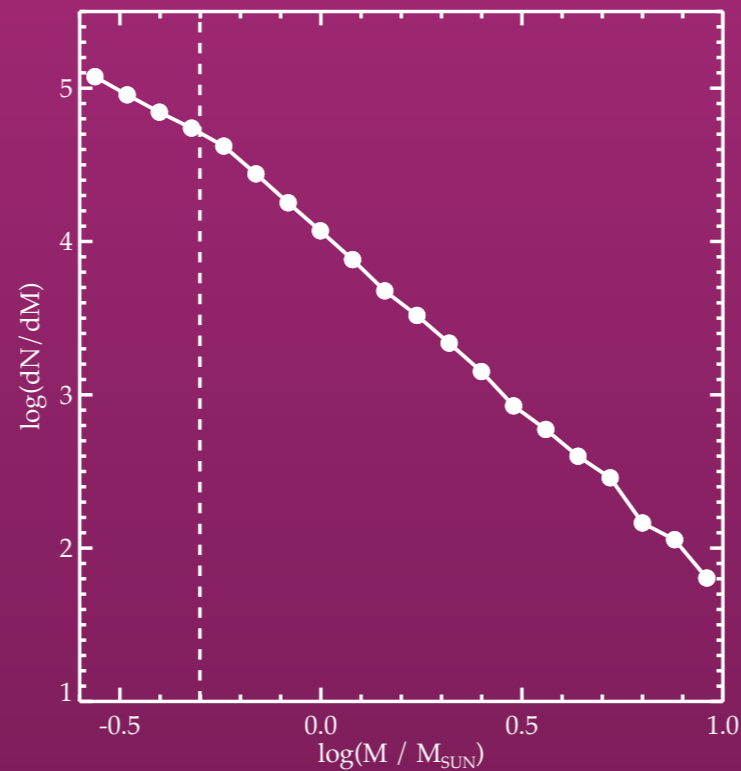


STARTPARAMETERS

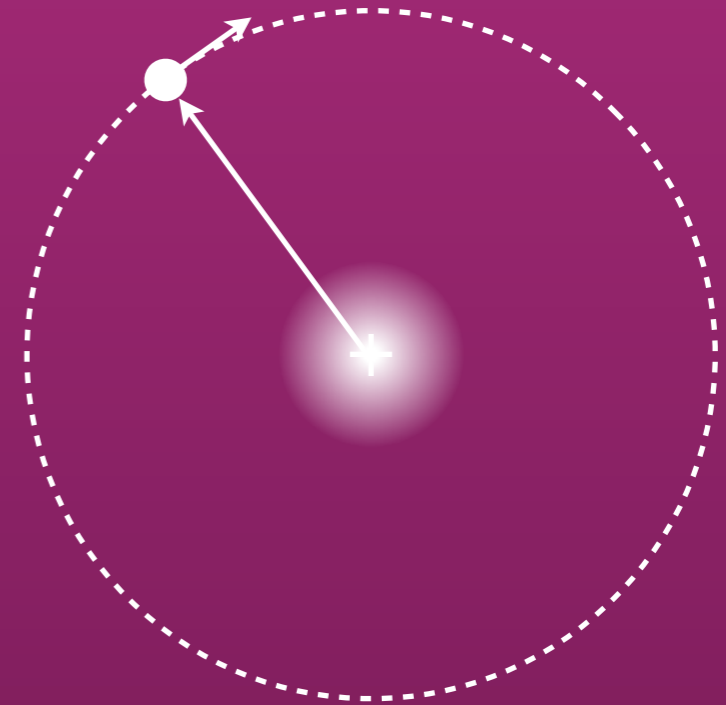


KING PROFILE

- ▶ $W_0 = 7$
- ▶ $r_h = 1 \text{ pc}$



KROUPA MASS FUNCTION



TIDAL FIELD

- ▶ Isothermal Sphere
- ▶ Circular Orbit
- ▶ $r_{gc} = 8.5 \text{ kpc}$

STARTPARAMETERS



- NBODY6 (Aarseth 1999) on GUPs
- $N = 32k - 128k$
 - ✓ Stellar Evolution
 - ✓ External Tidal Field

We vary:

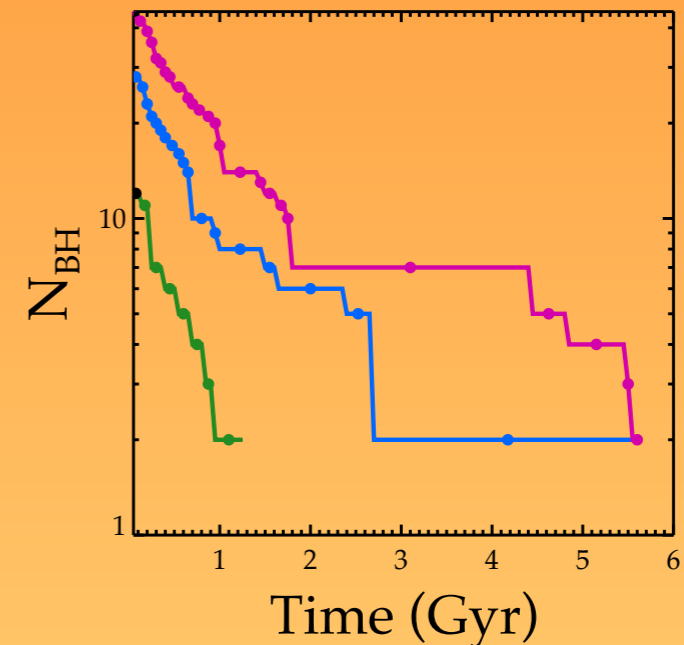
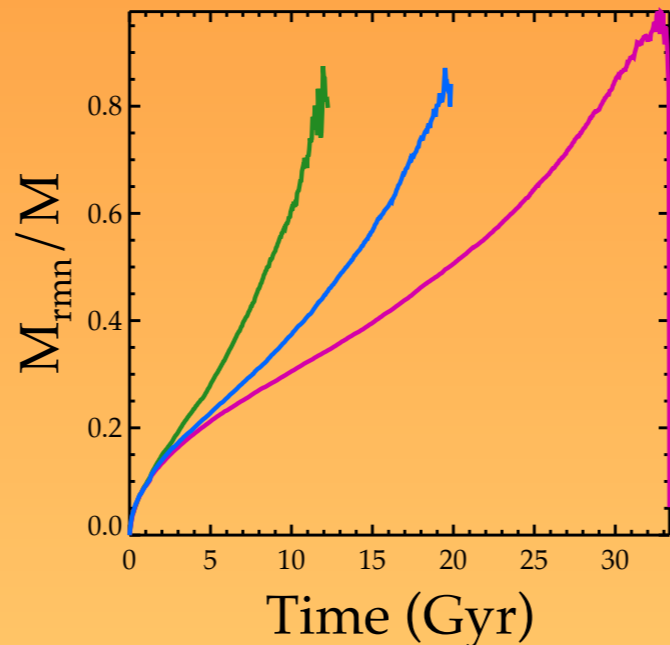
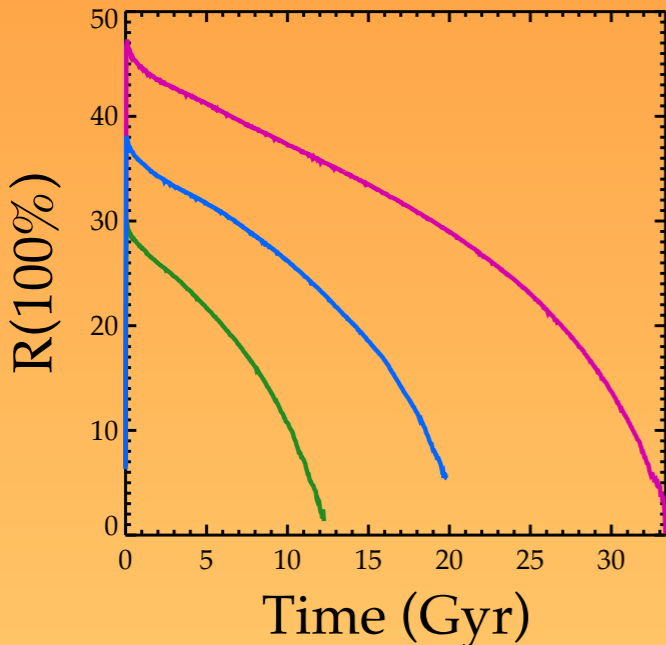
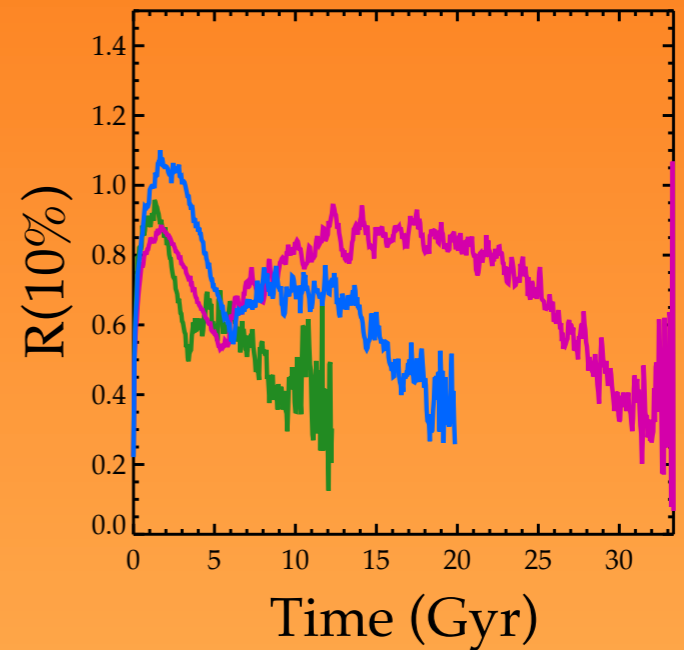
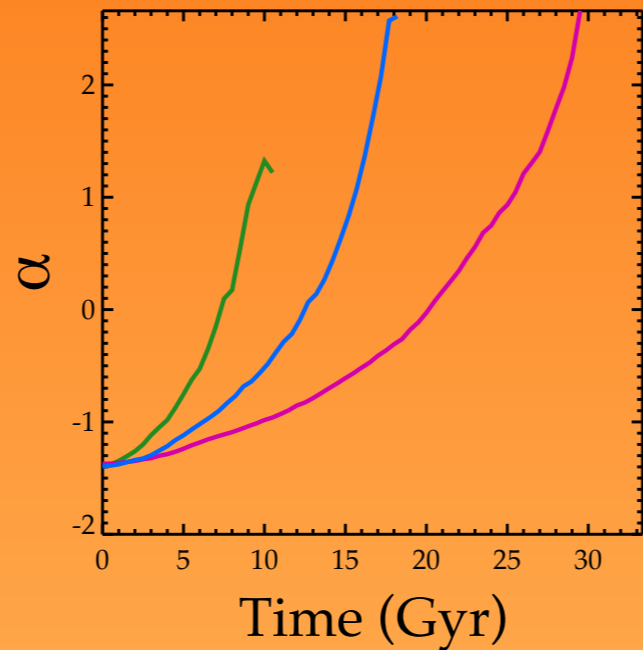
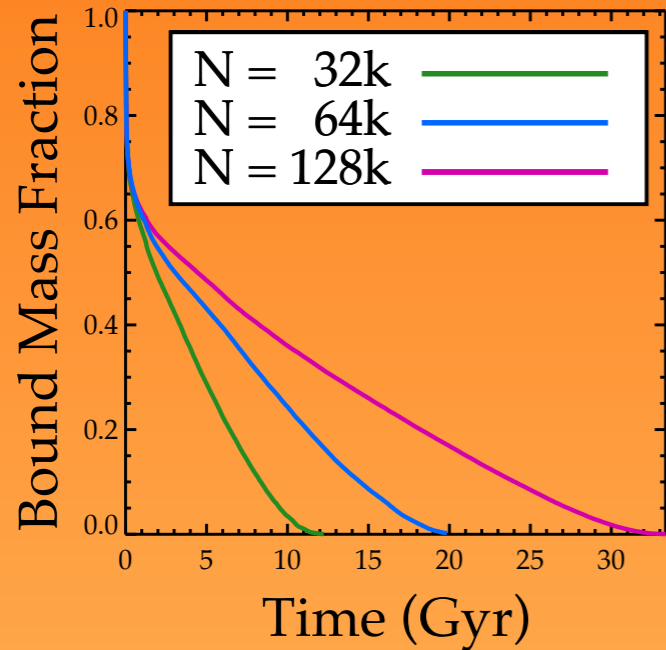
- ▶ **Black-Hole Retention Fraction** - 0%, 30%, 50%, 100%
- ▶ **Intermediate-Mass Black Hole** - 0%, 1%, 3%
- ▶ **Primordial Binary Fraction** - 0%, 10%, 30%



REFERENCE MODELS



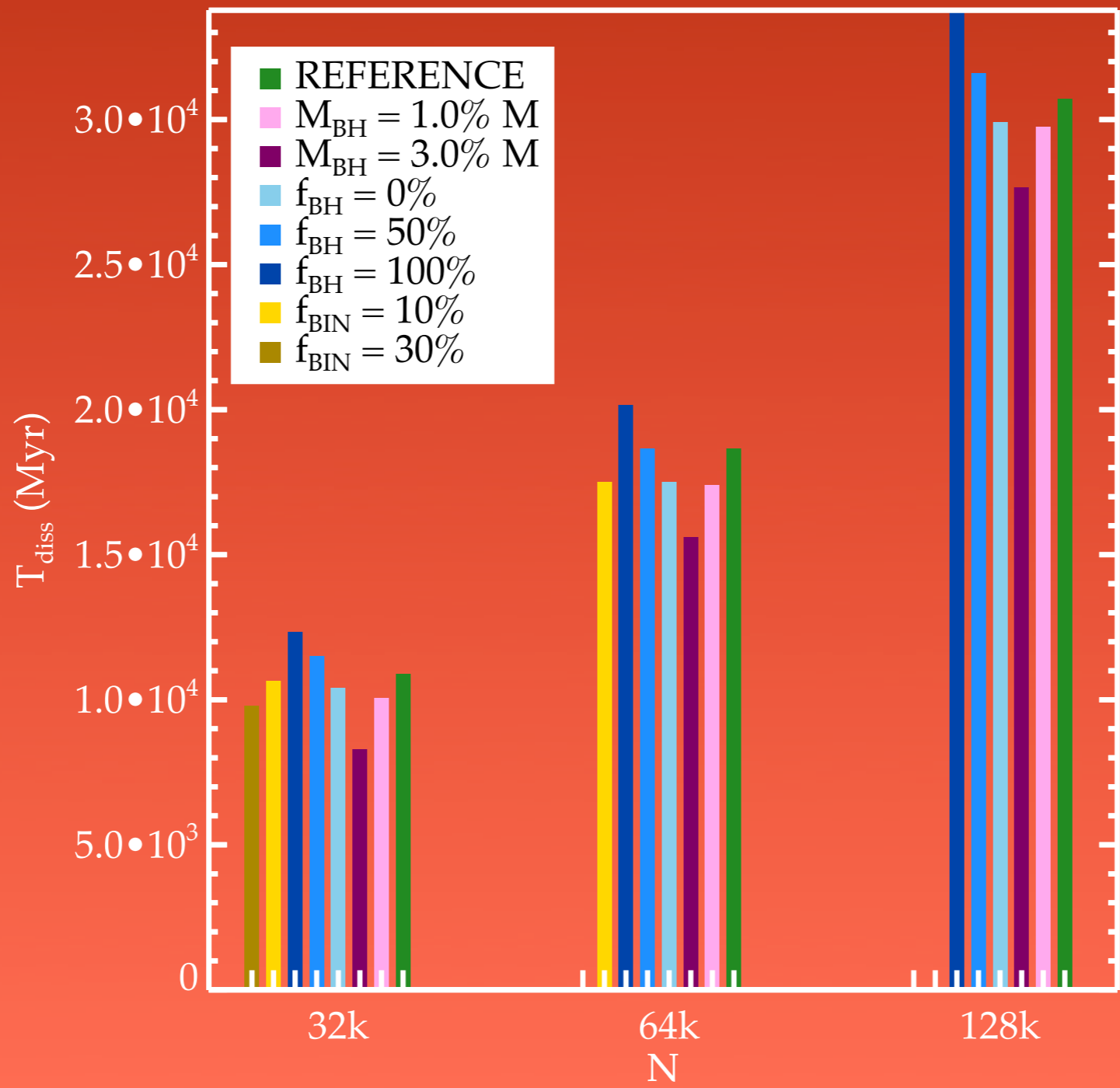
BH-Retention: 30%, IMBH: 0%, Binaries: 0%





OBSERVABLES

1. LIFETIMES





OBSERVABLES

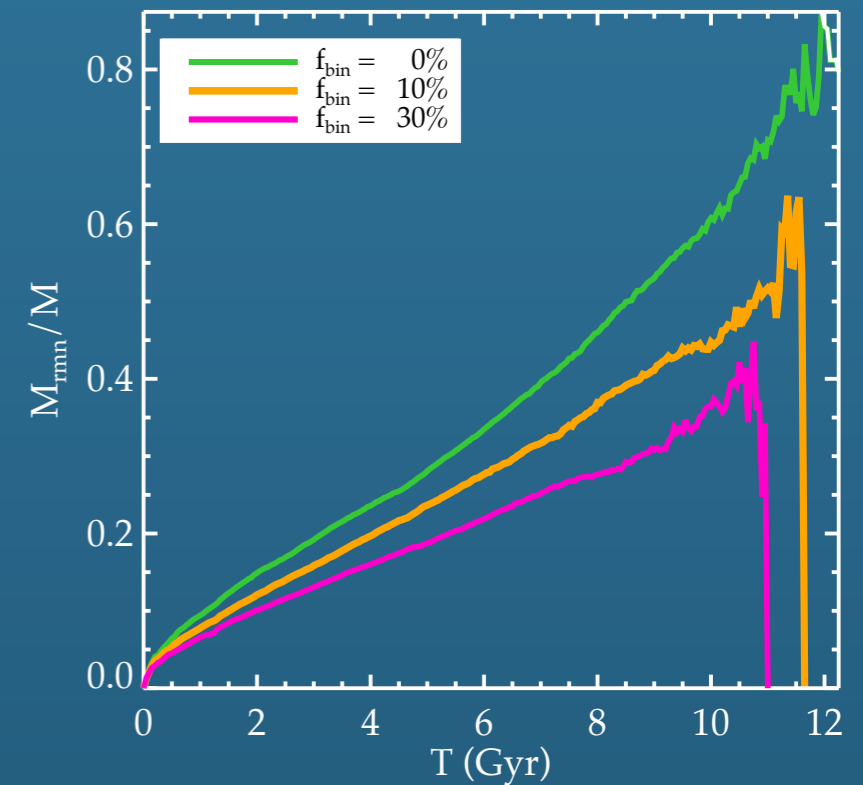
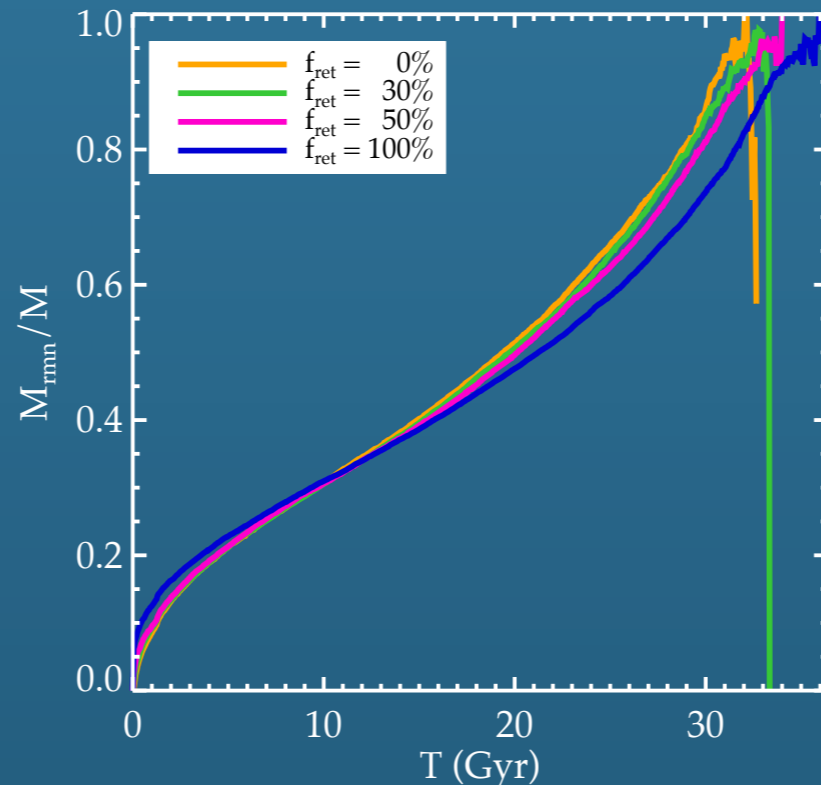
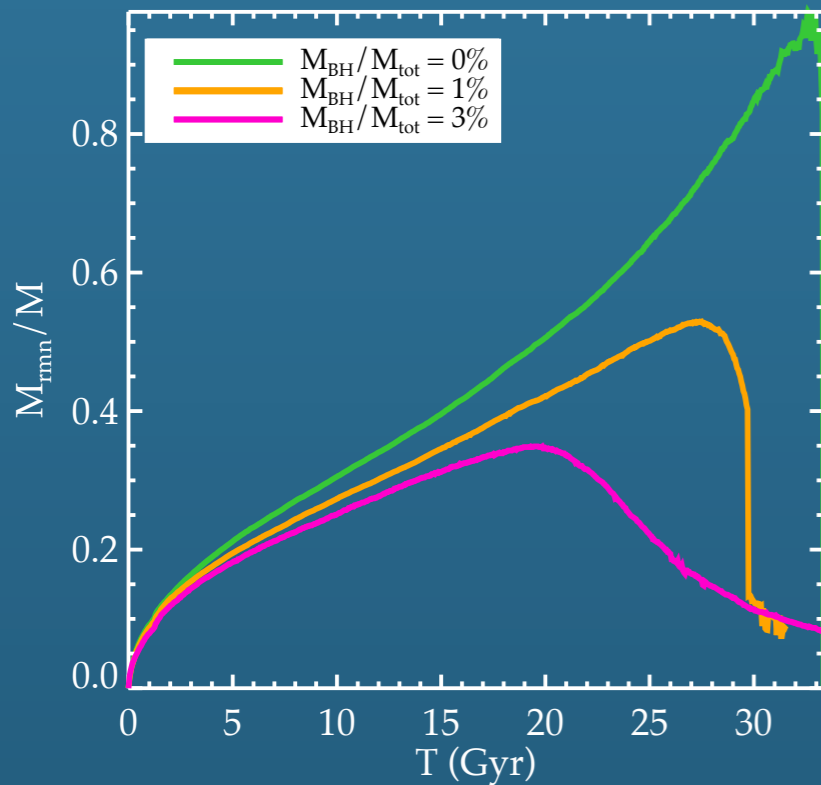
2. REMNANT FRACTIONS

$$M_{\text{rmn}}/M$$

IMBH

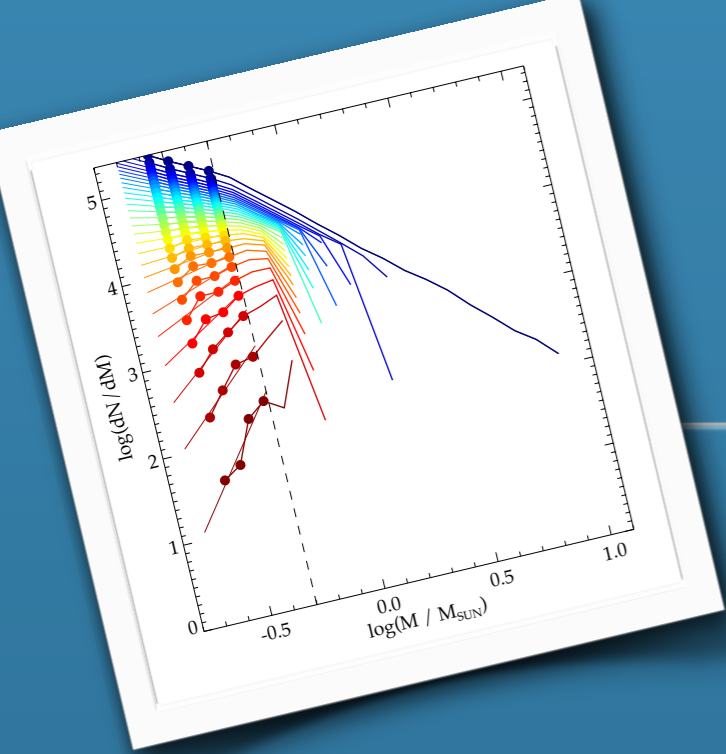
STELLAR-MASS
BLACK HOLES

BINARIES



OBSERVABLES

3. MASS-FUNCTION SLOPE

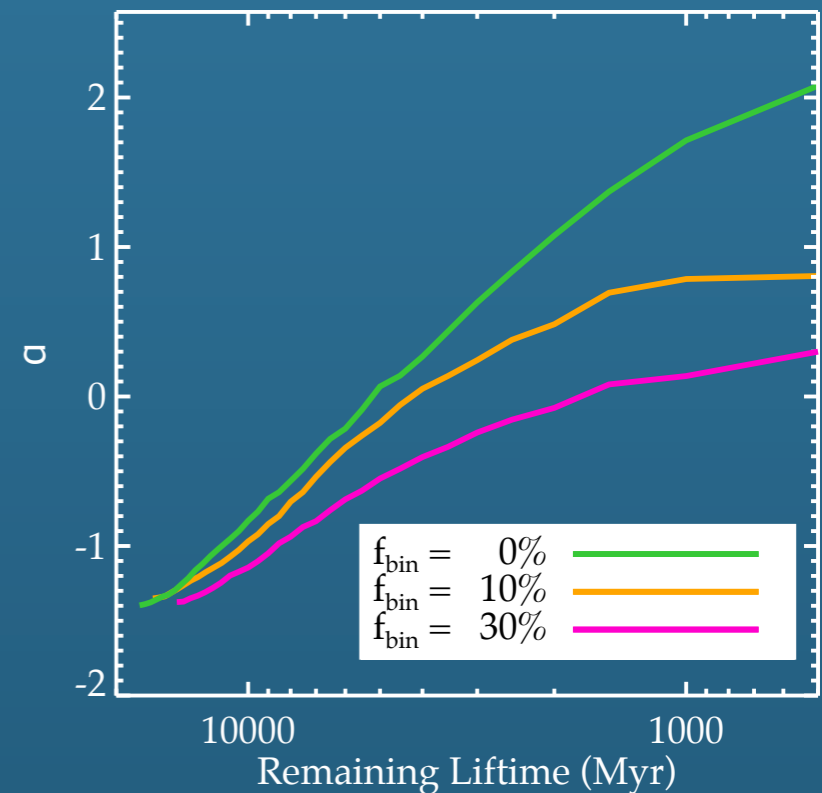
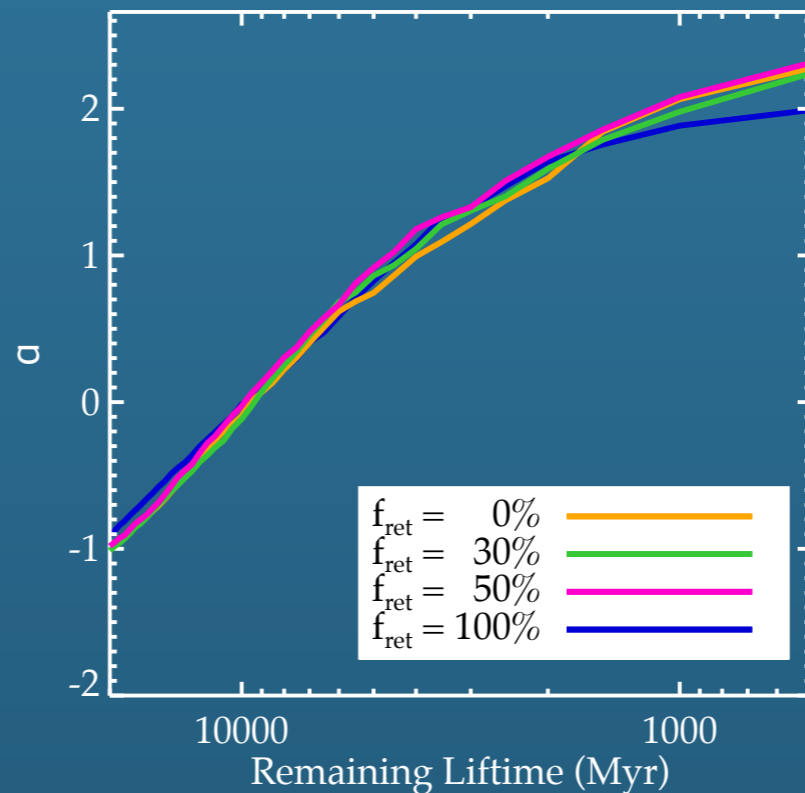
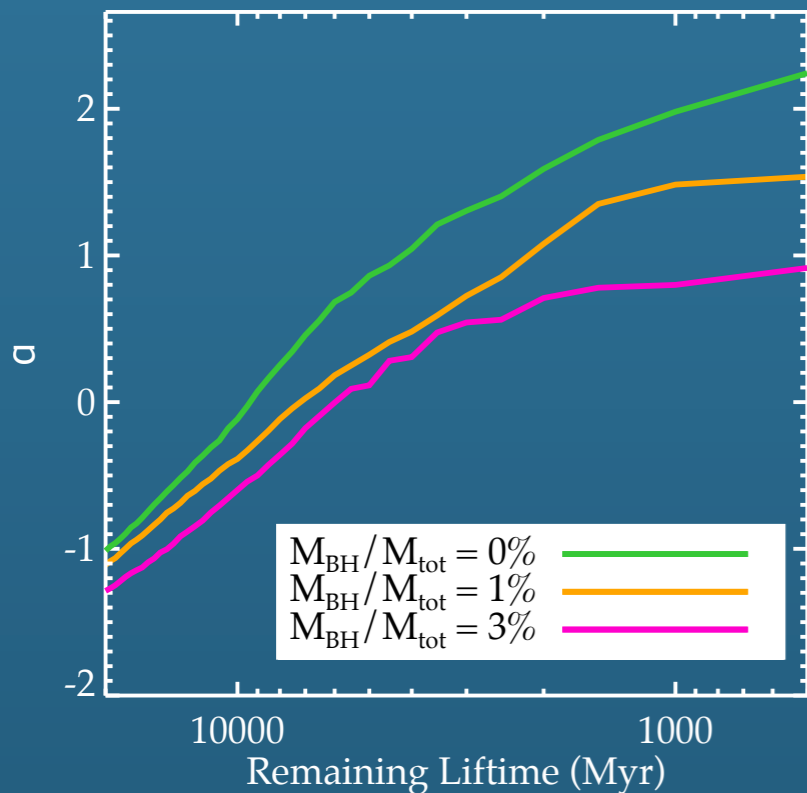


$$\alpha_{MF}$$

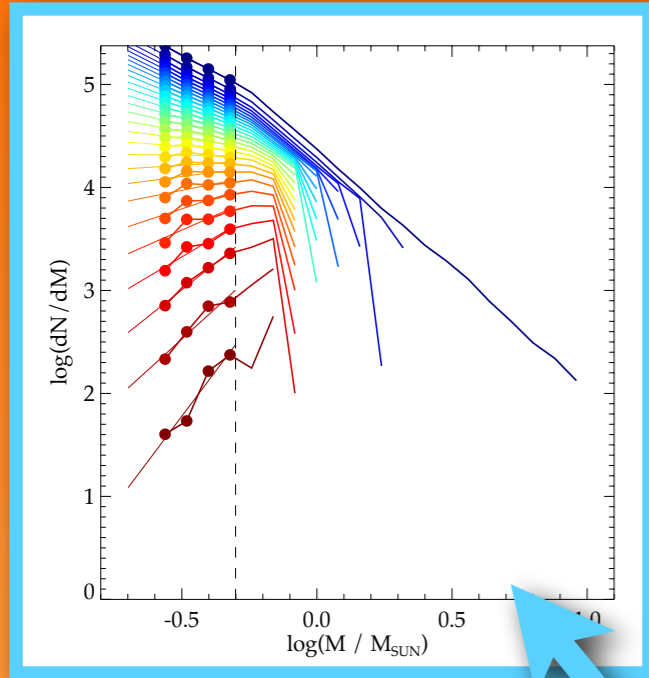
IMBH

STELLAR-MASS
BLACK HOLES

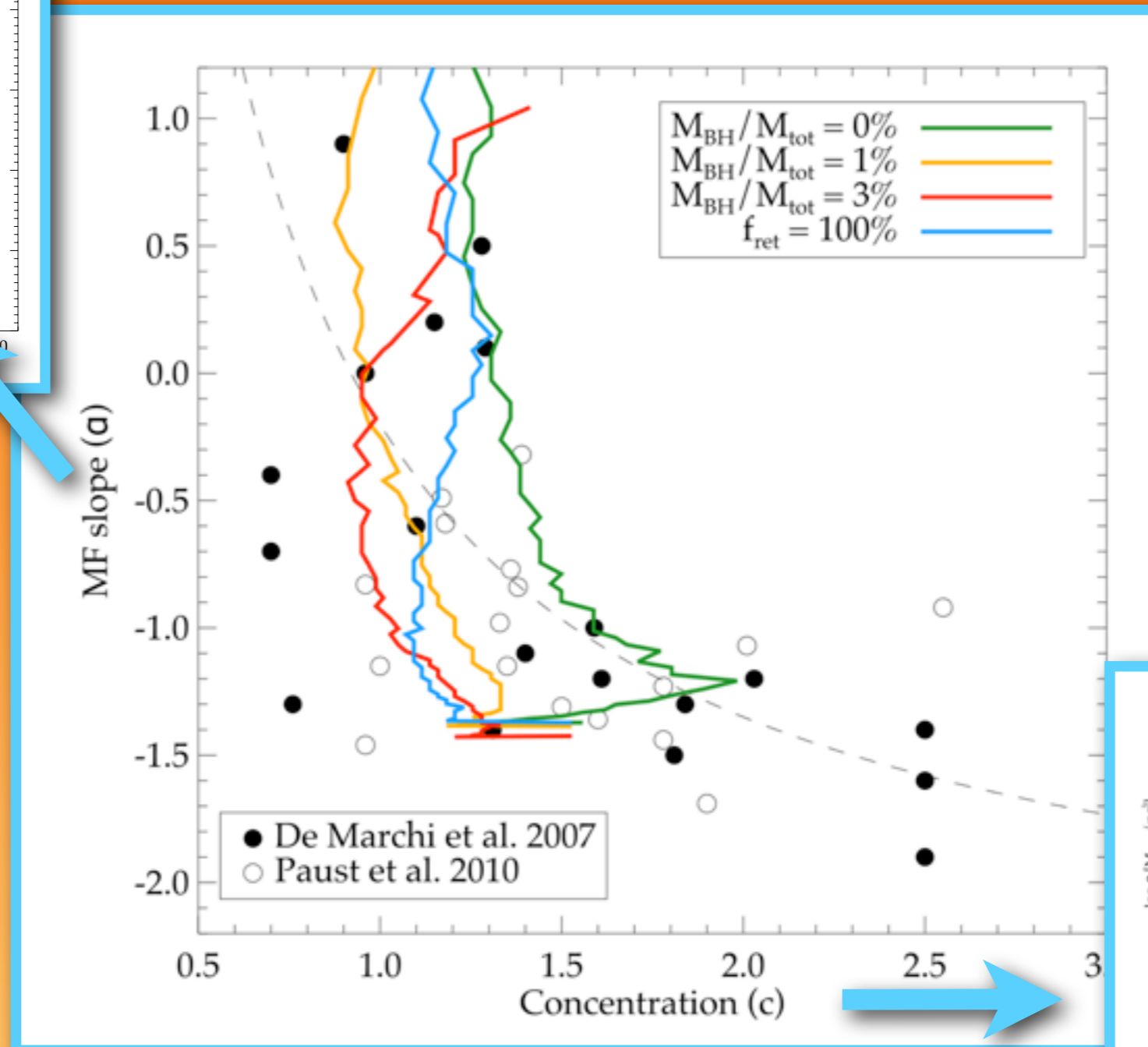
BINARIES



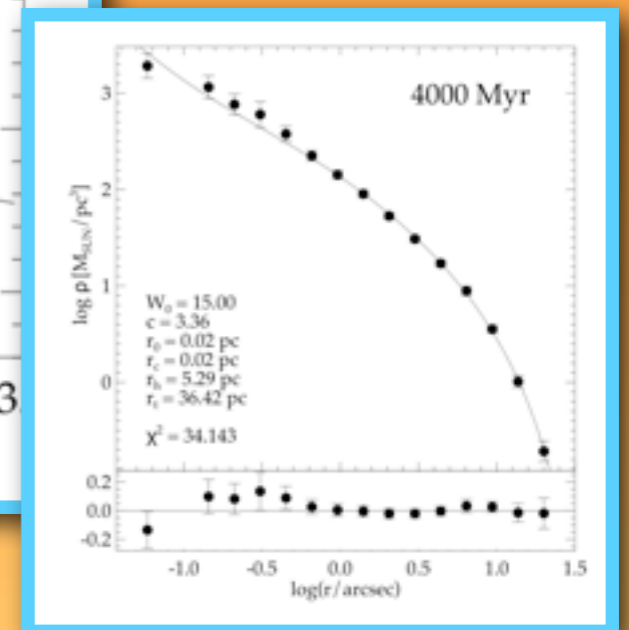
COMPARISON TO OBSERVATIONS



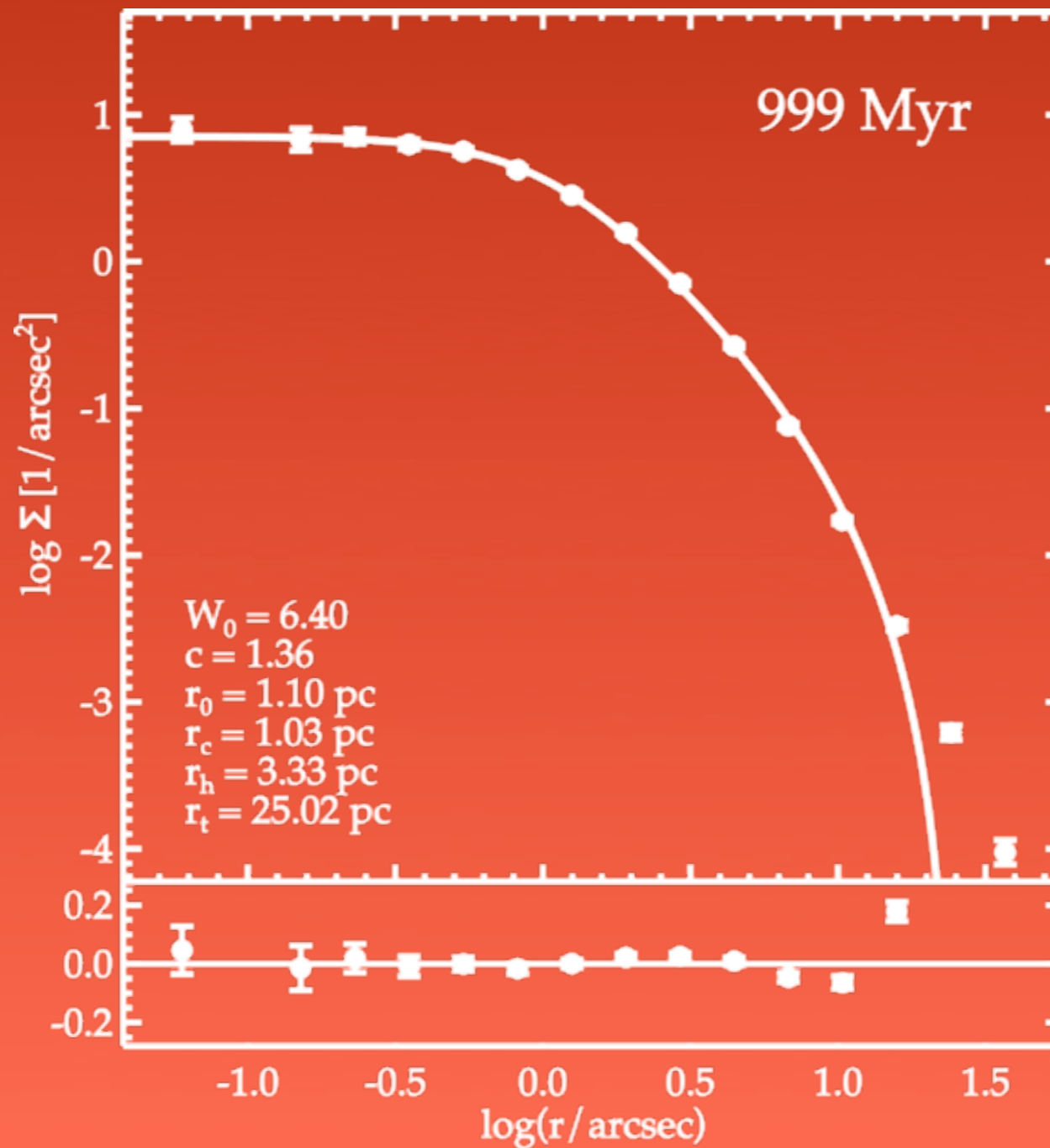
Mass Function



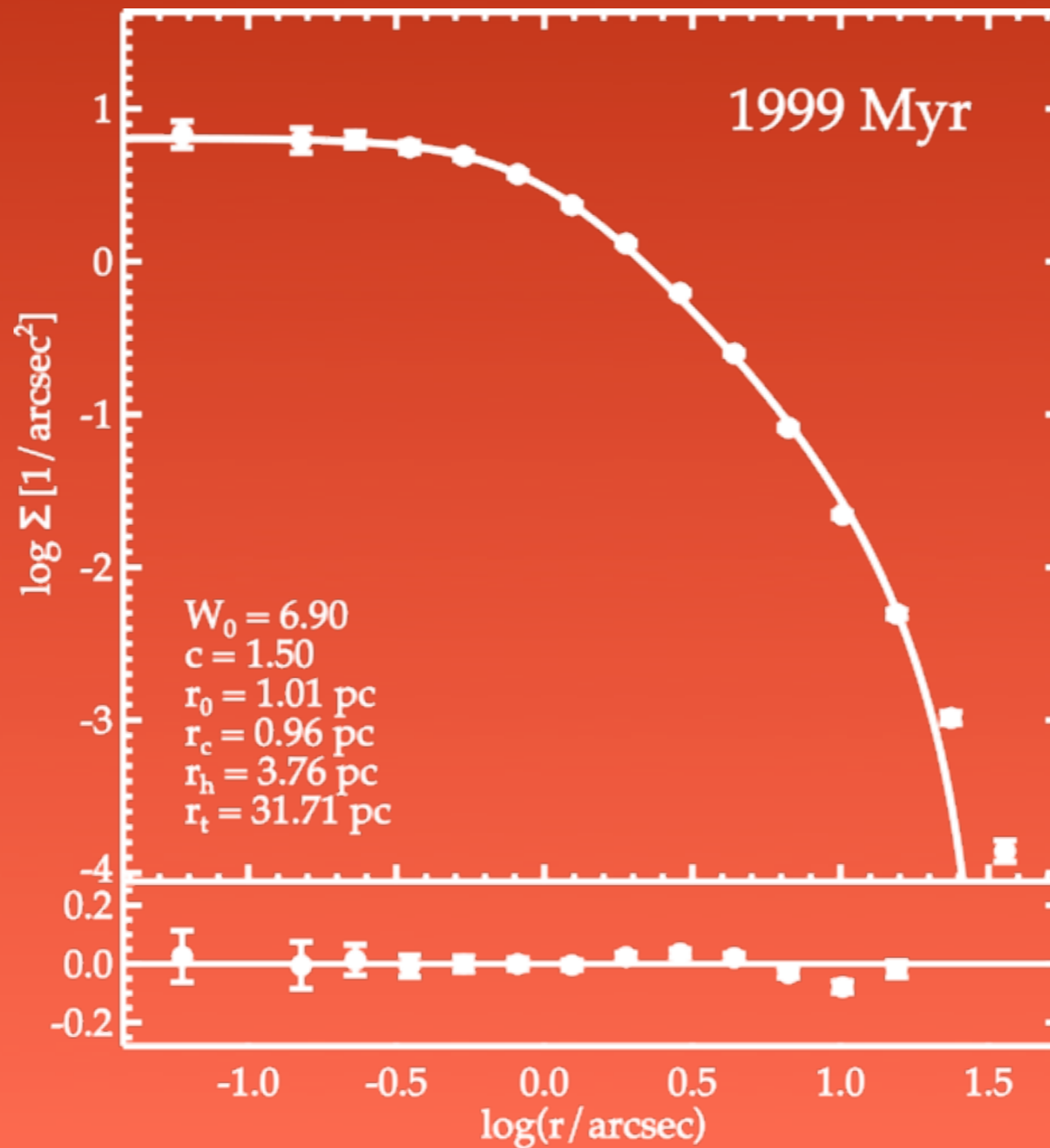
King Fit



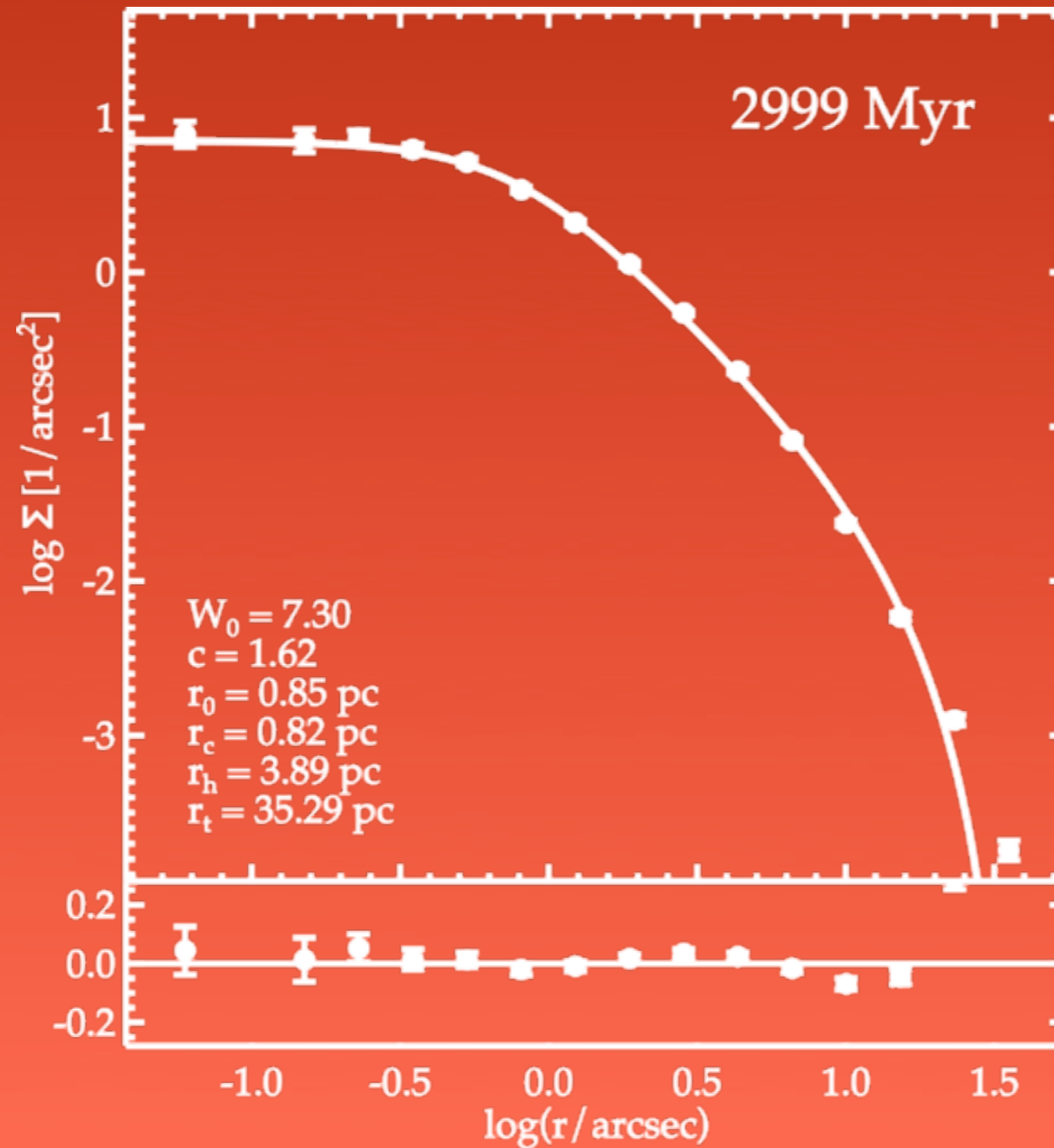
PROBLEMS WITH KING FITS



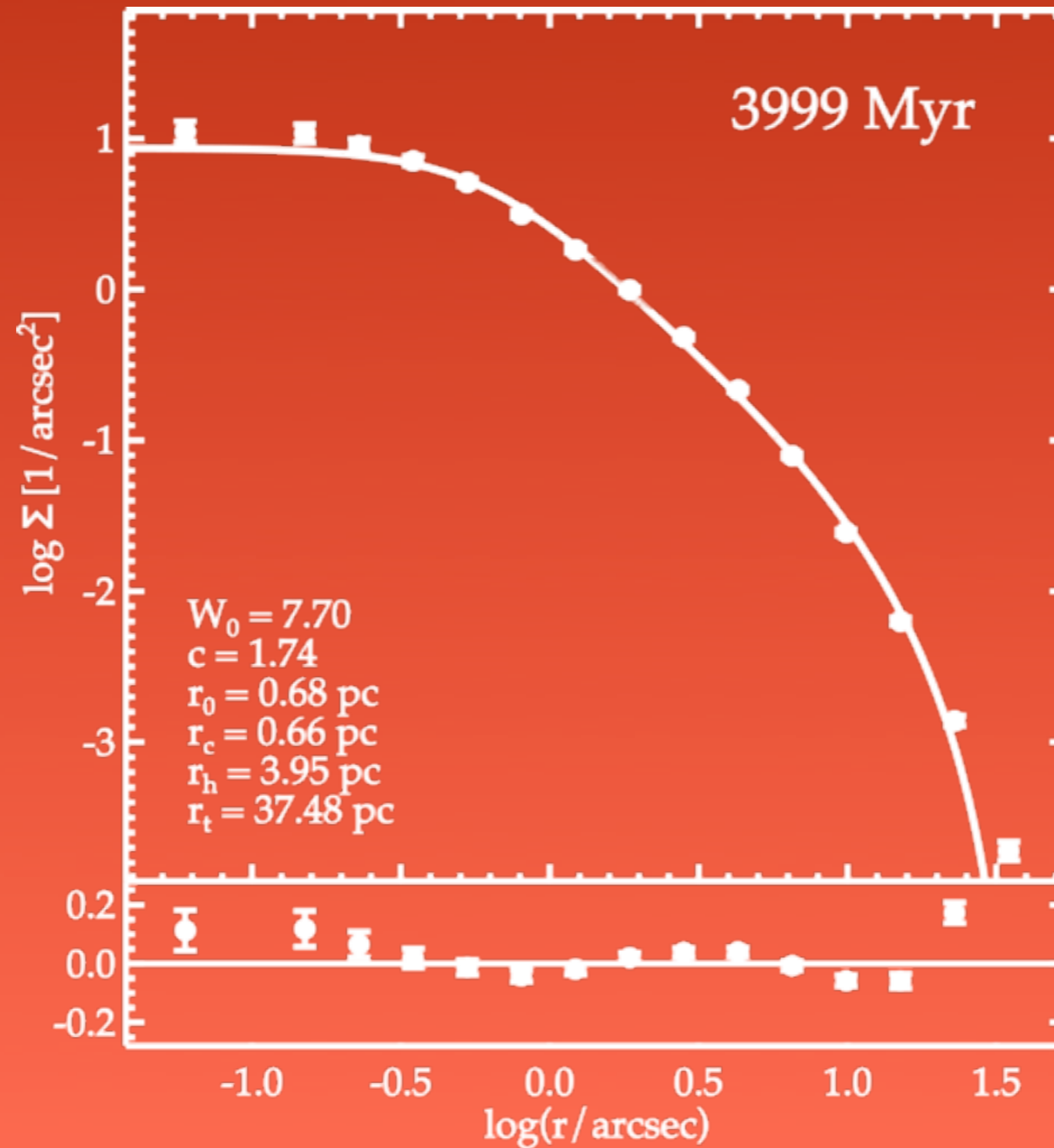
PROBLEMS WITH KING FITS



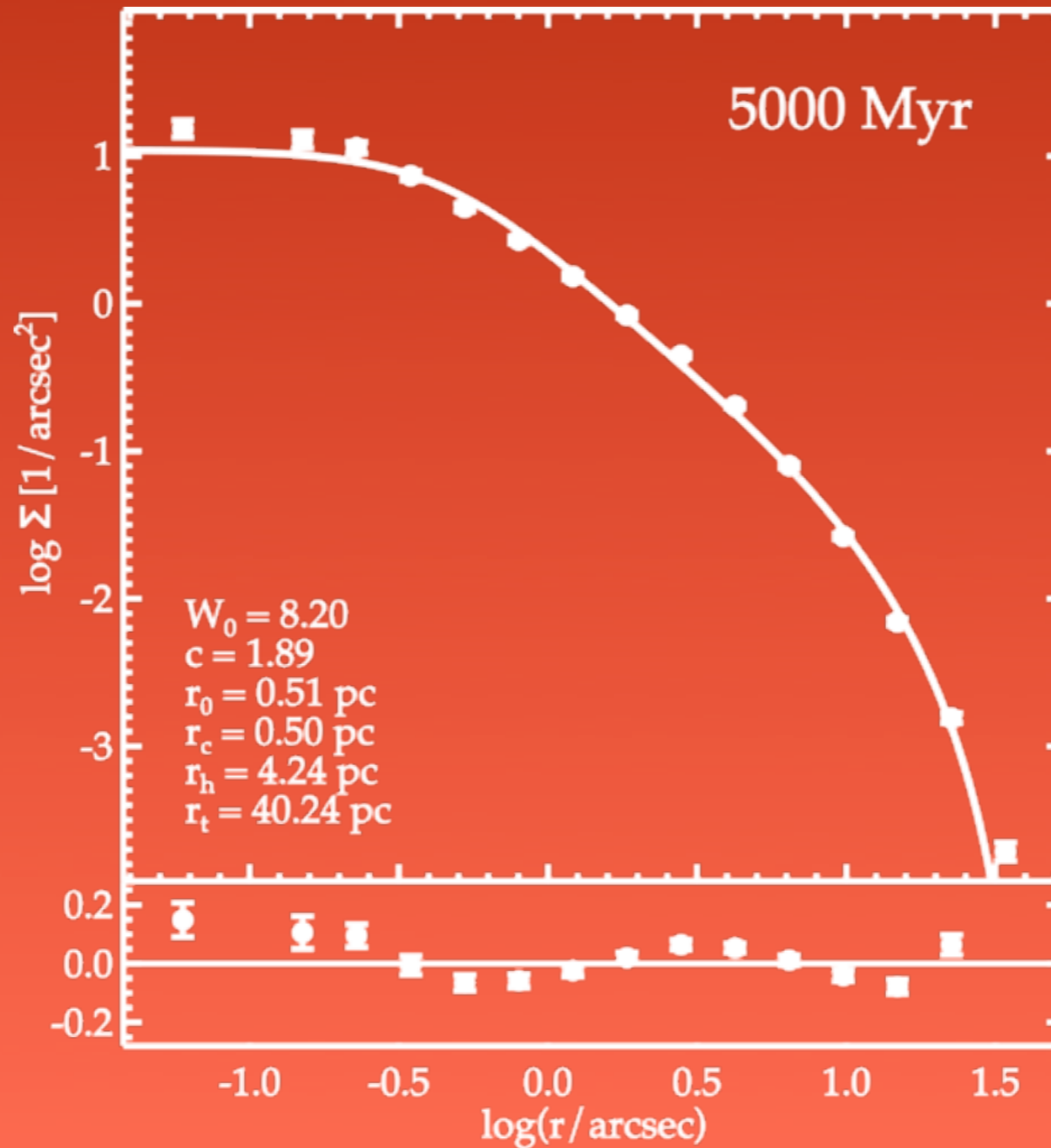
PROBLEMS WITH KING FITS



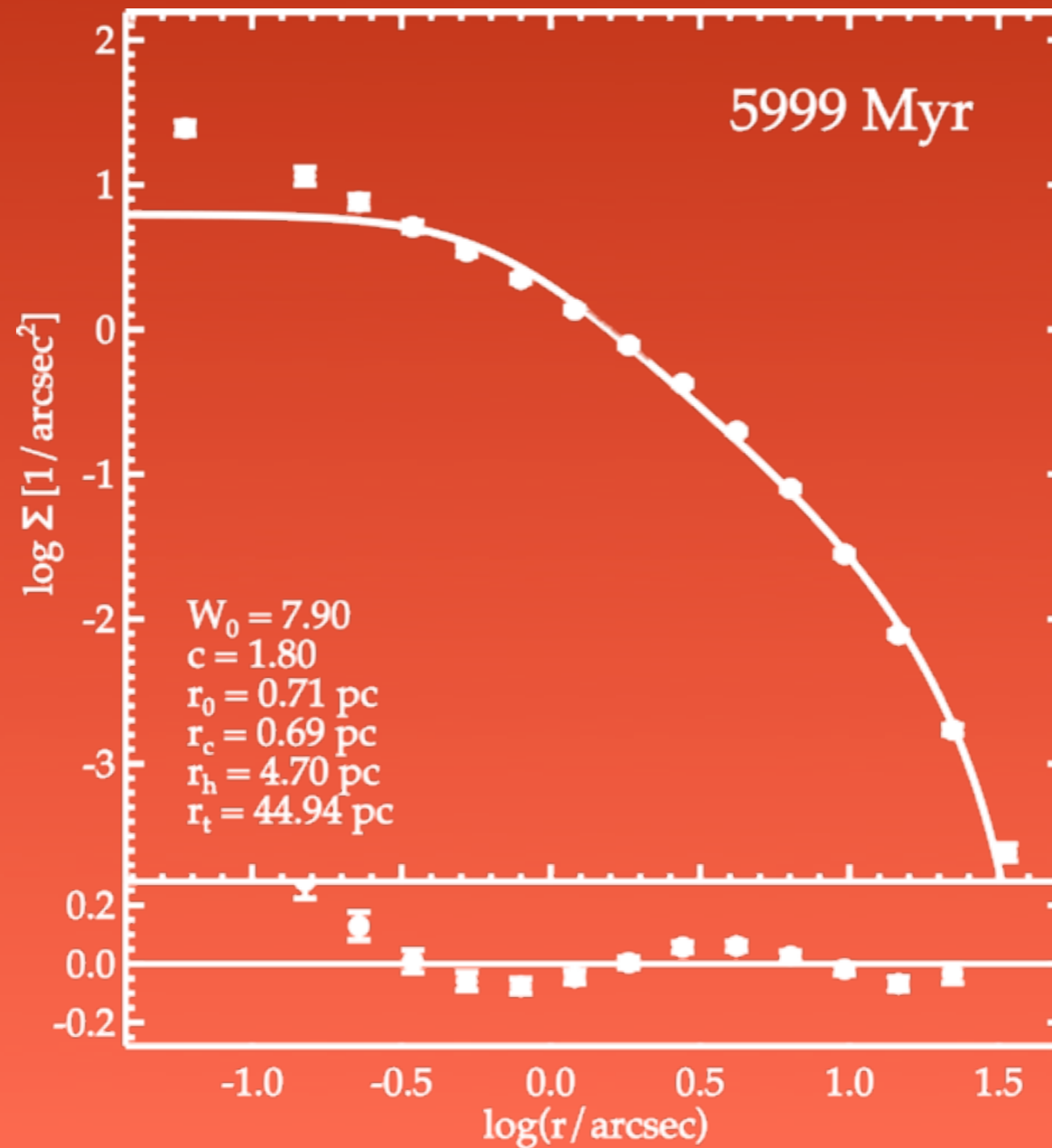
PROBLEMS WITH KING FITS



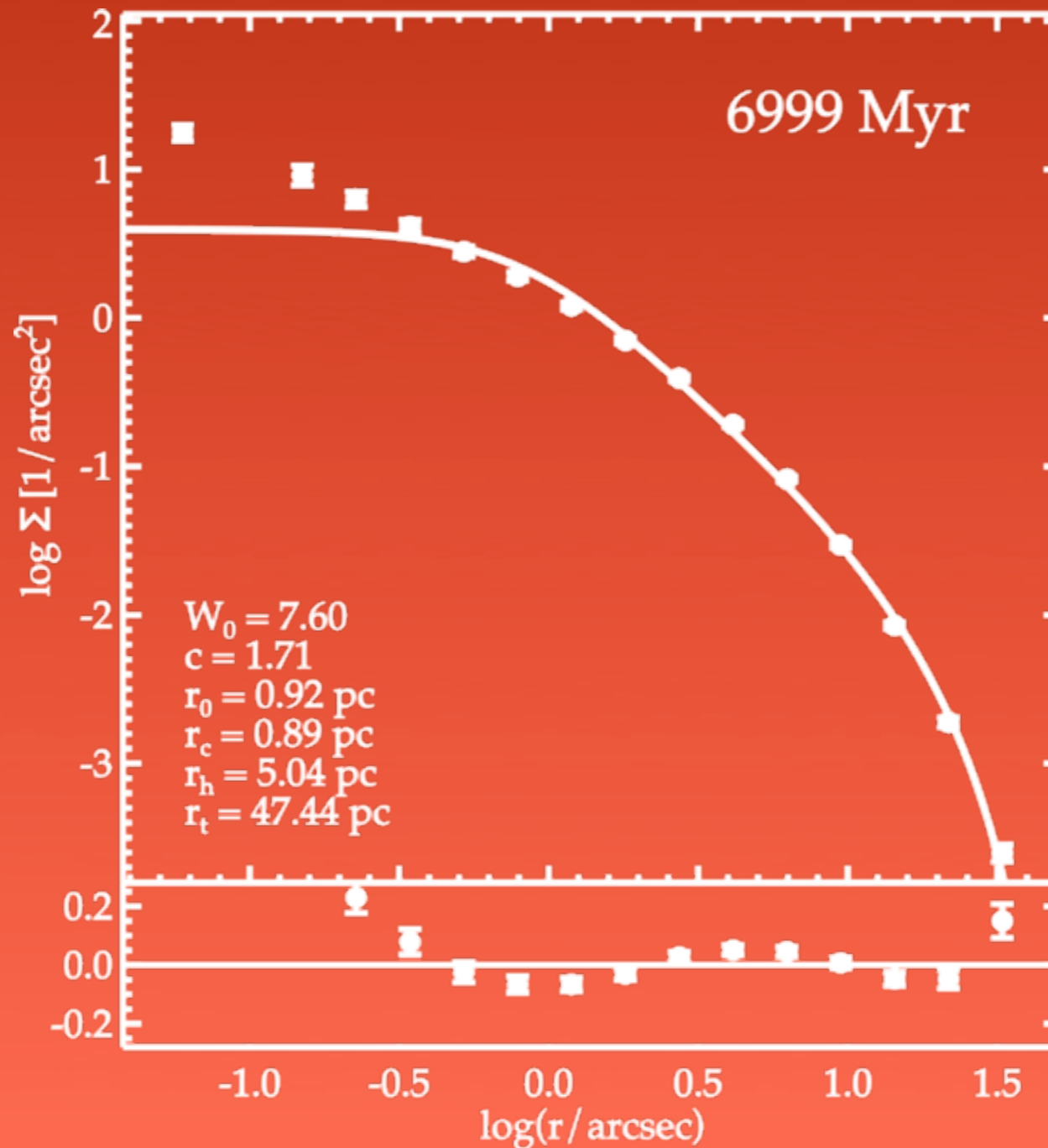
PROBLEMS WITH KING FITS



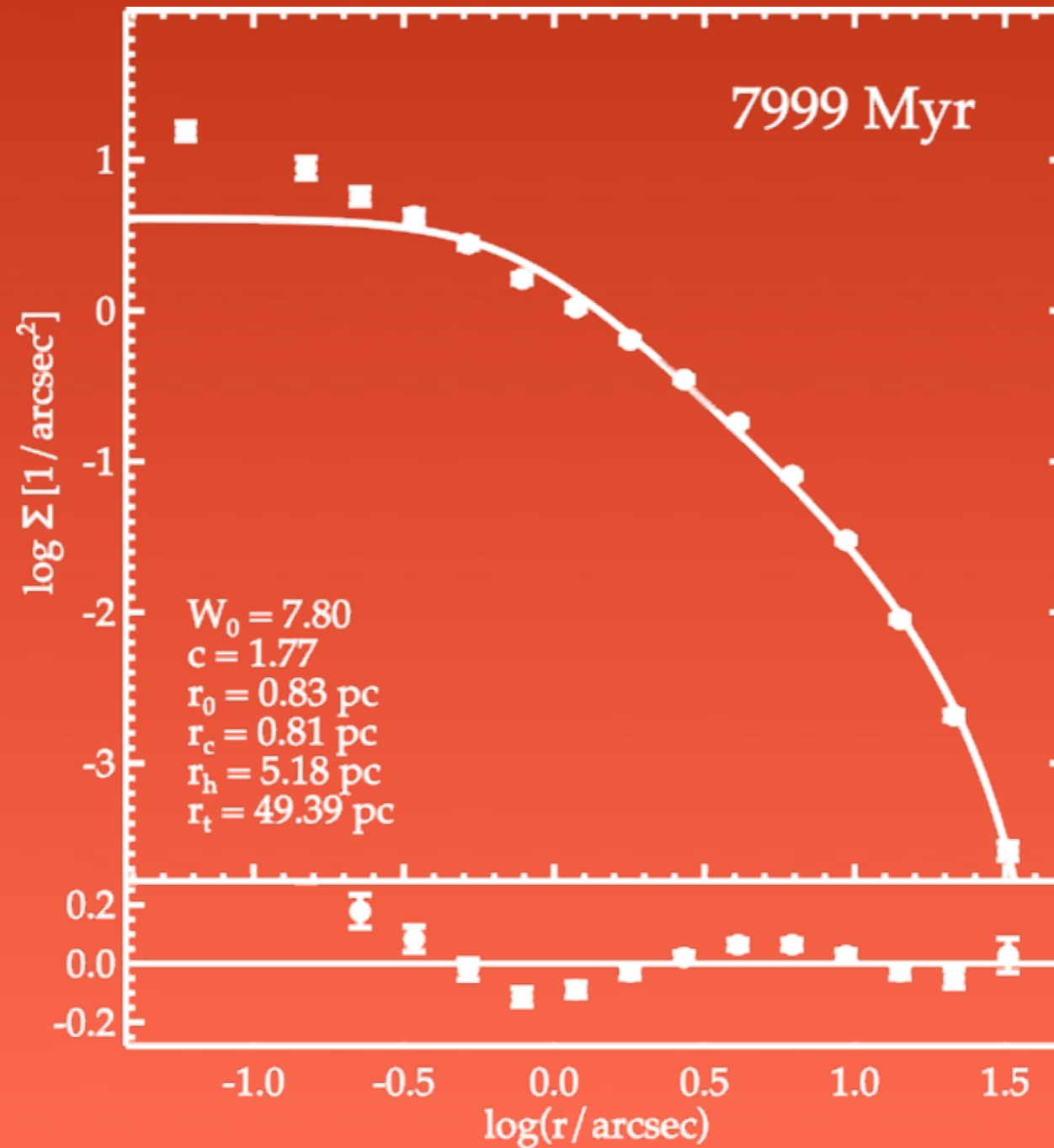
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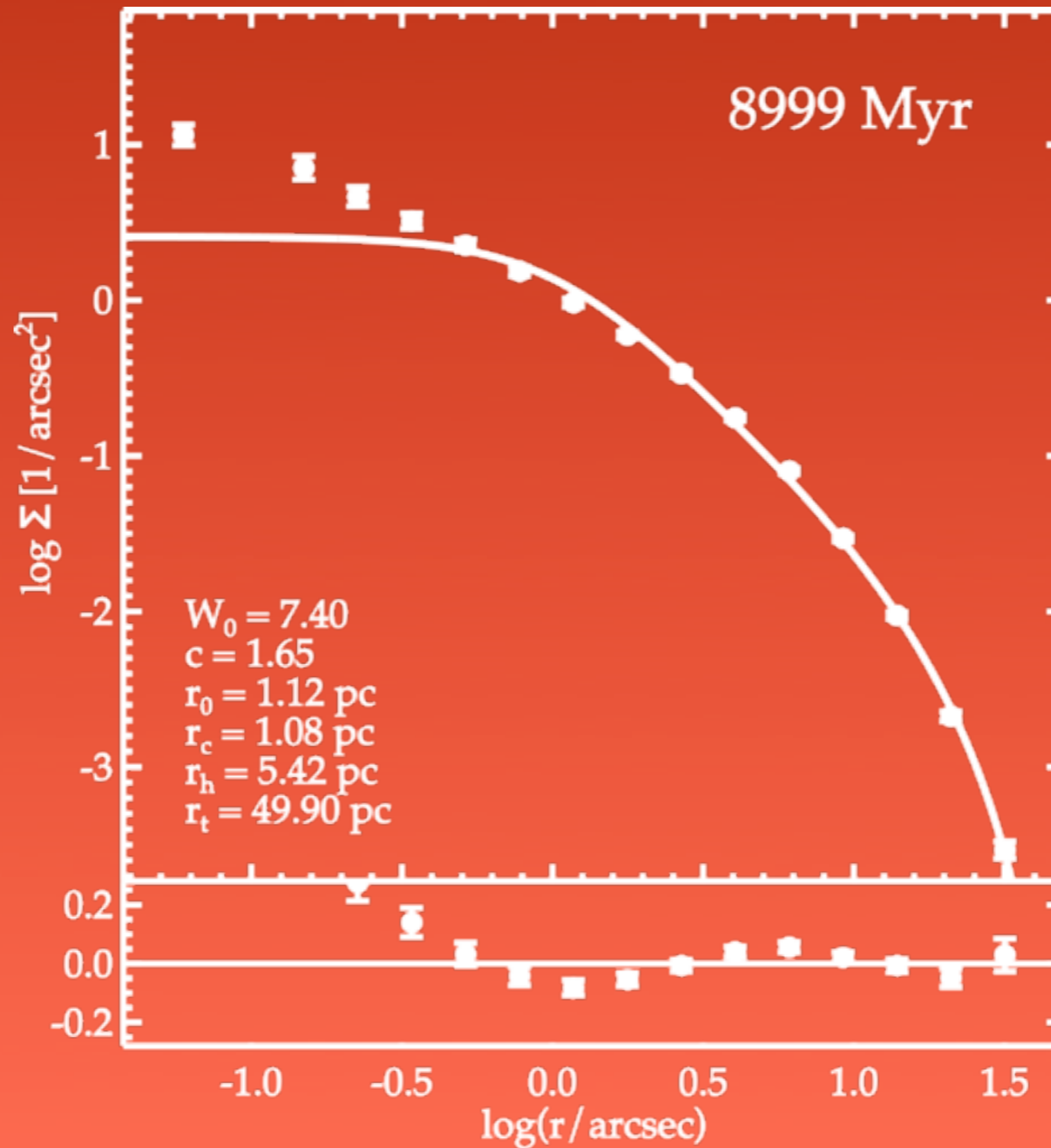
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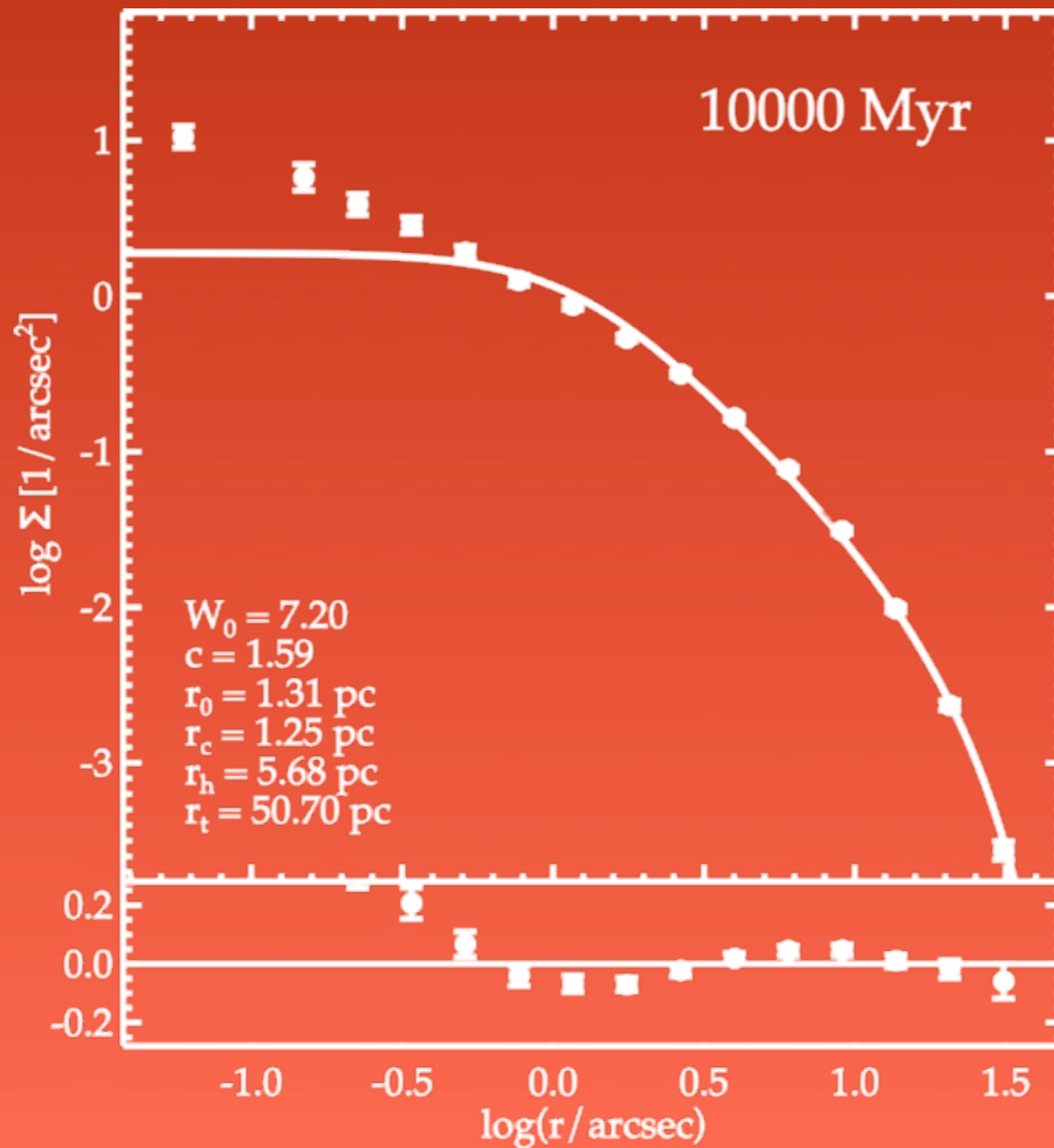
PROBLEMS WITH KING FITS



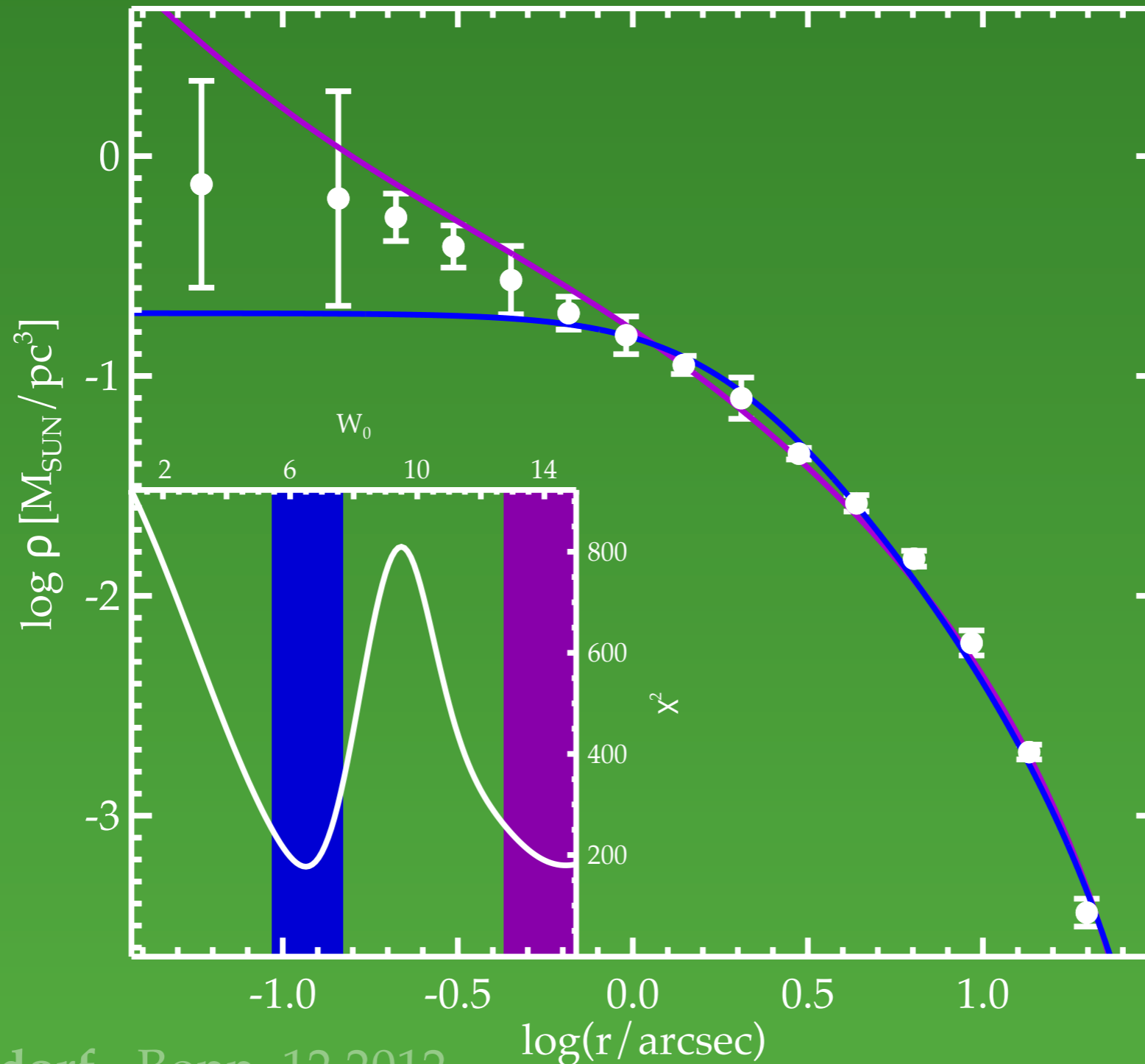
PROBLEMS WITH KING FITS



PROBLEMS WITH KING FITS

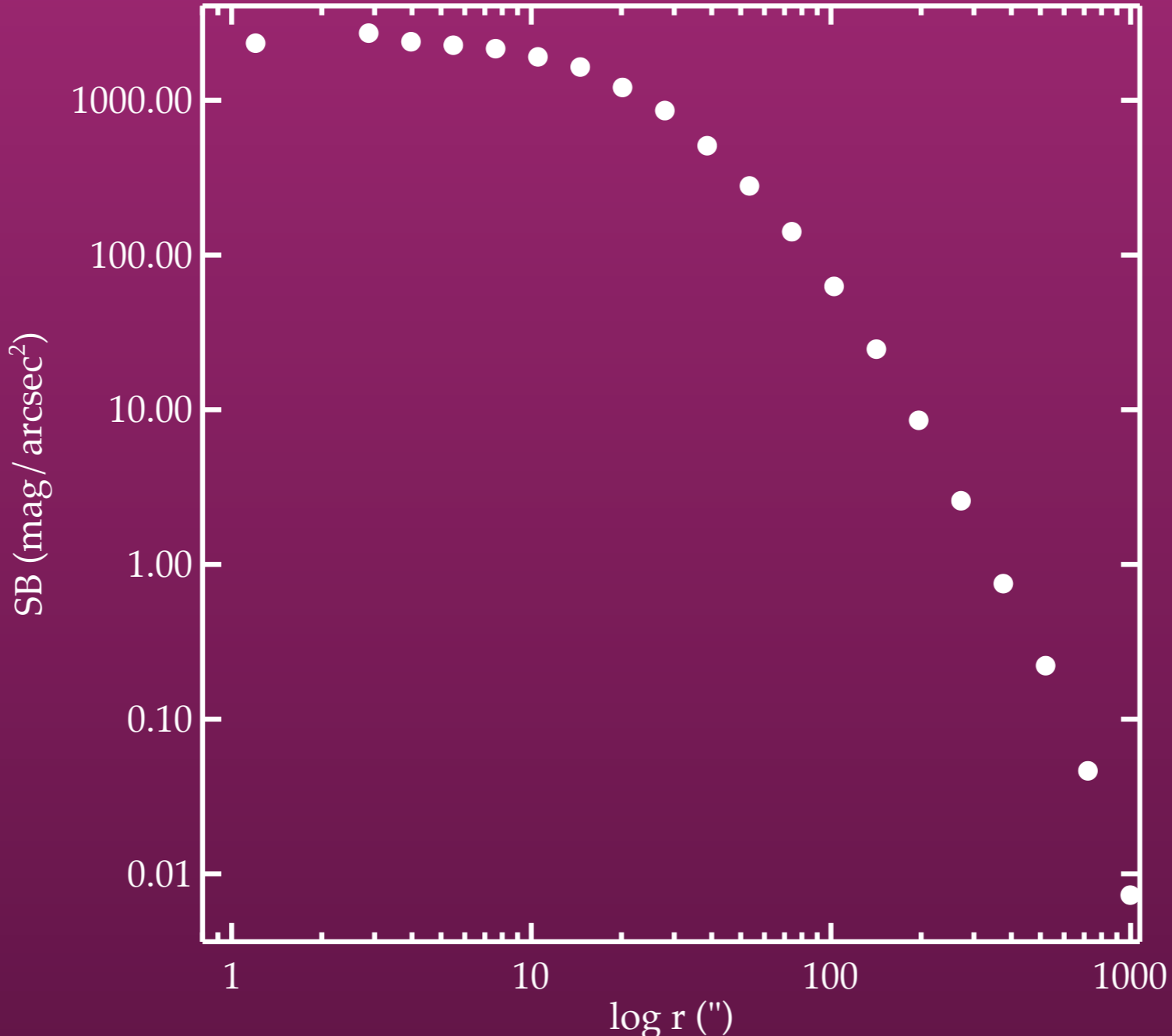


PROBLEMS WITH KING FITS





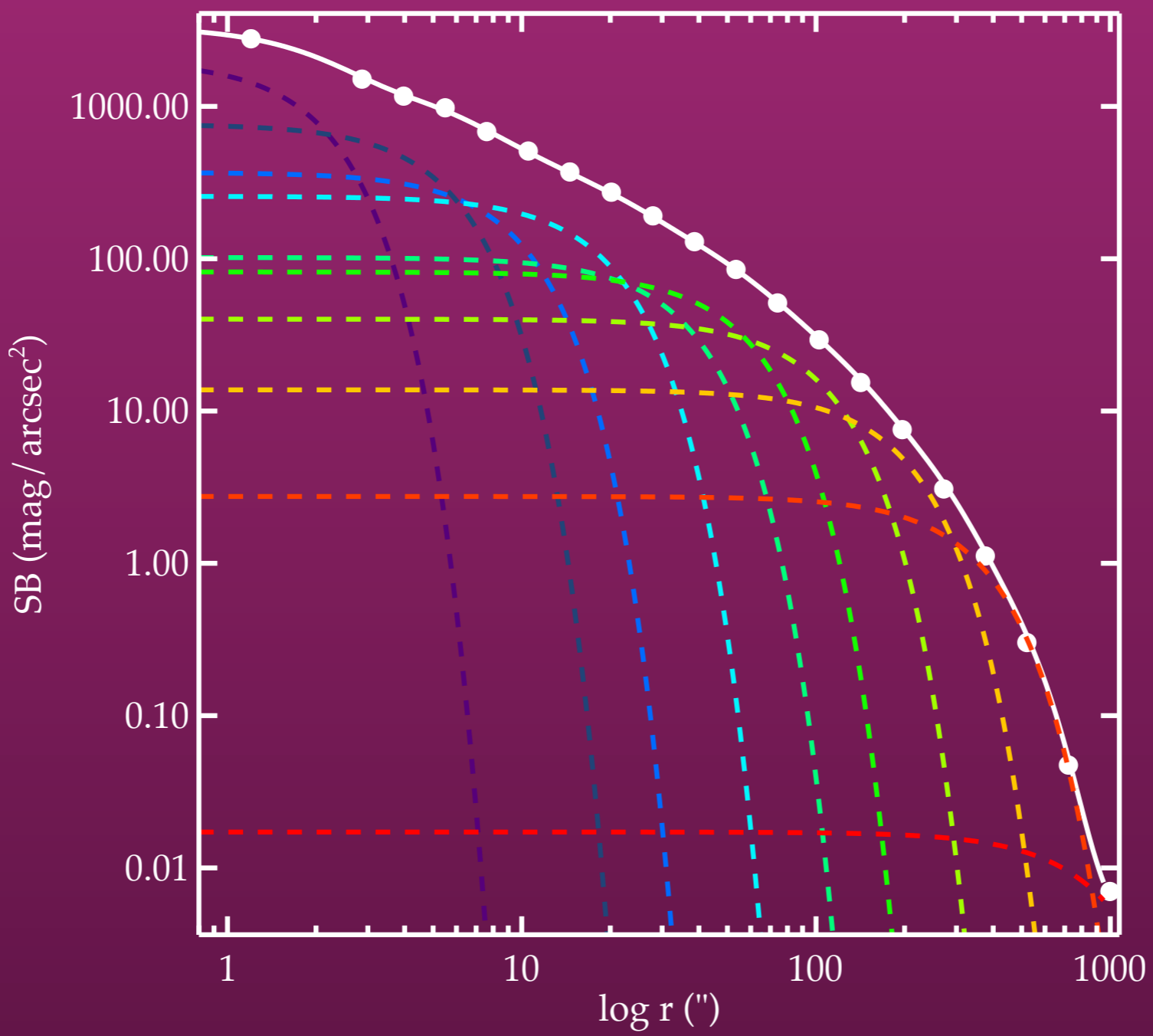
ALTERNATIVES





ALTERNATIVES

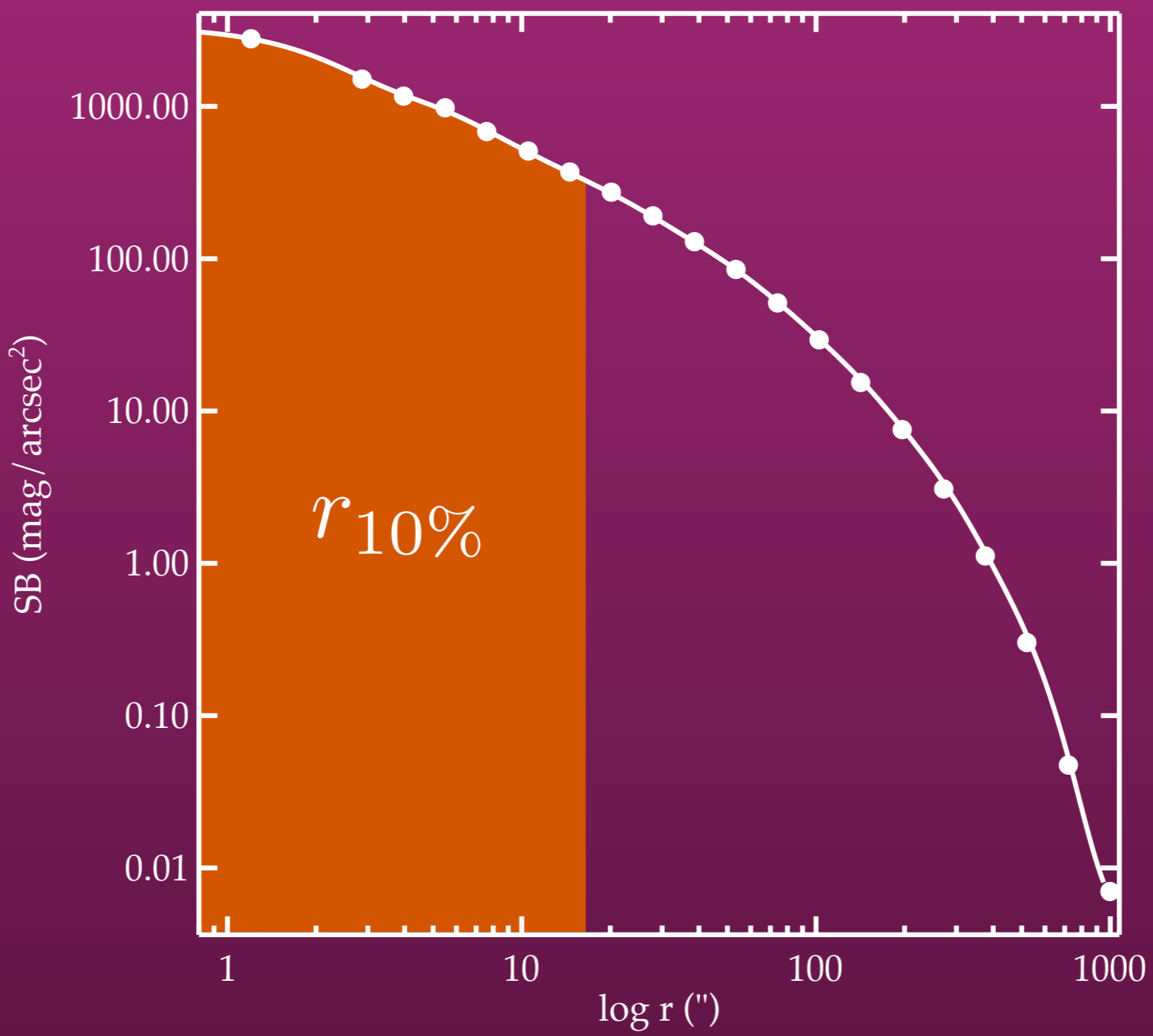
Multi Gaussian Expansion





ALTERNATIVES

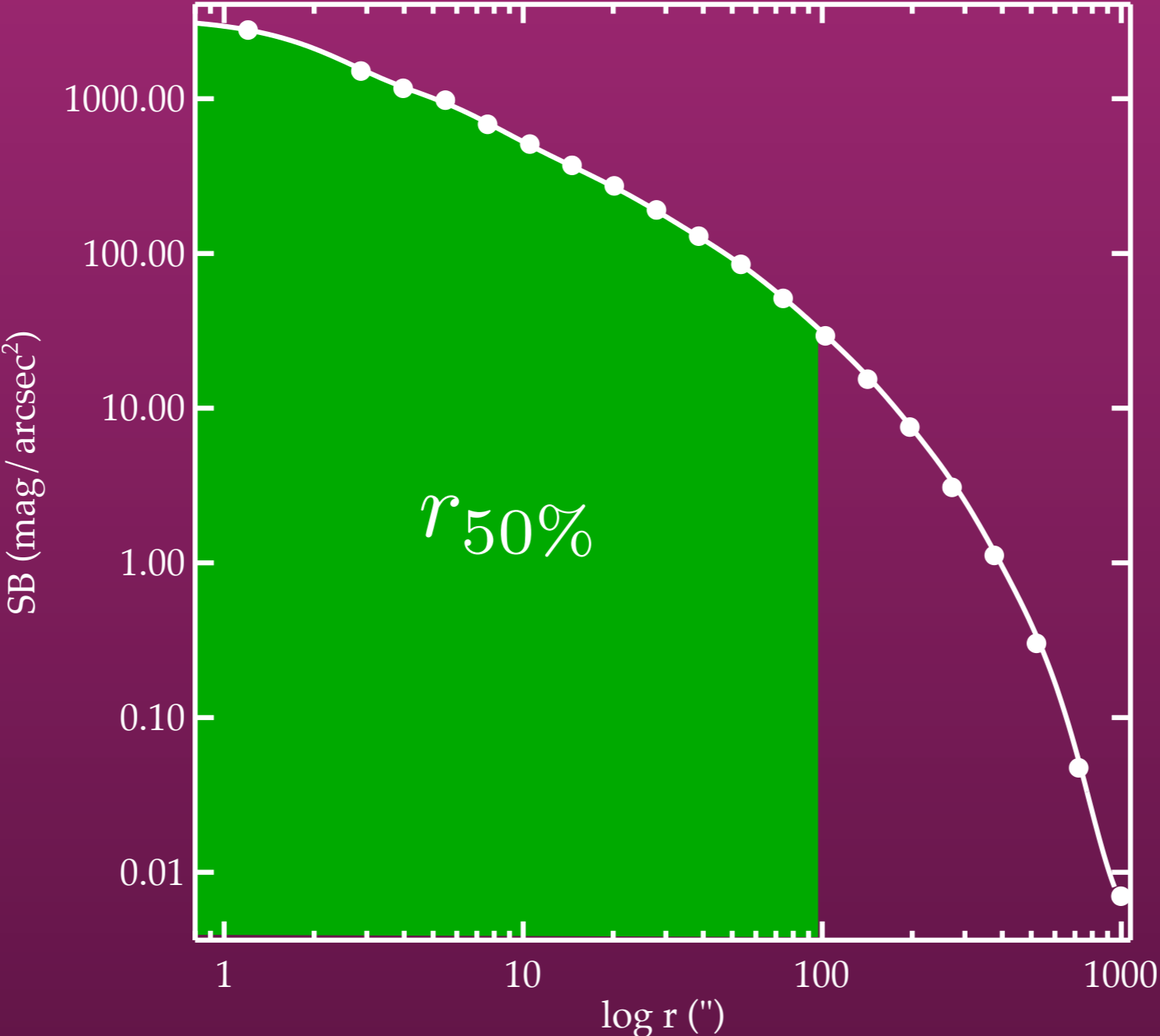
Multi Gaussian Expansion





ALTERNATIVES

Multi Gaussian Expansion





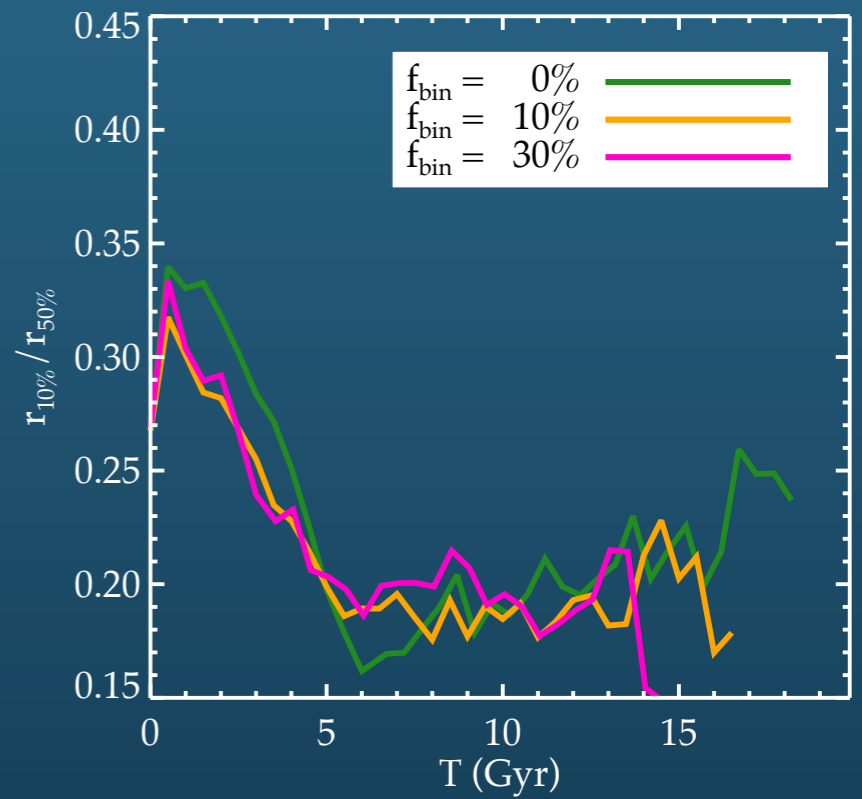
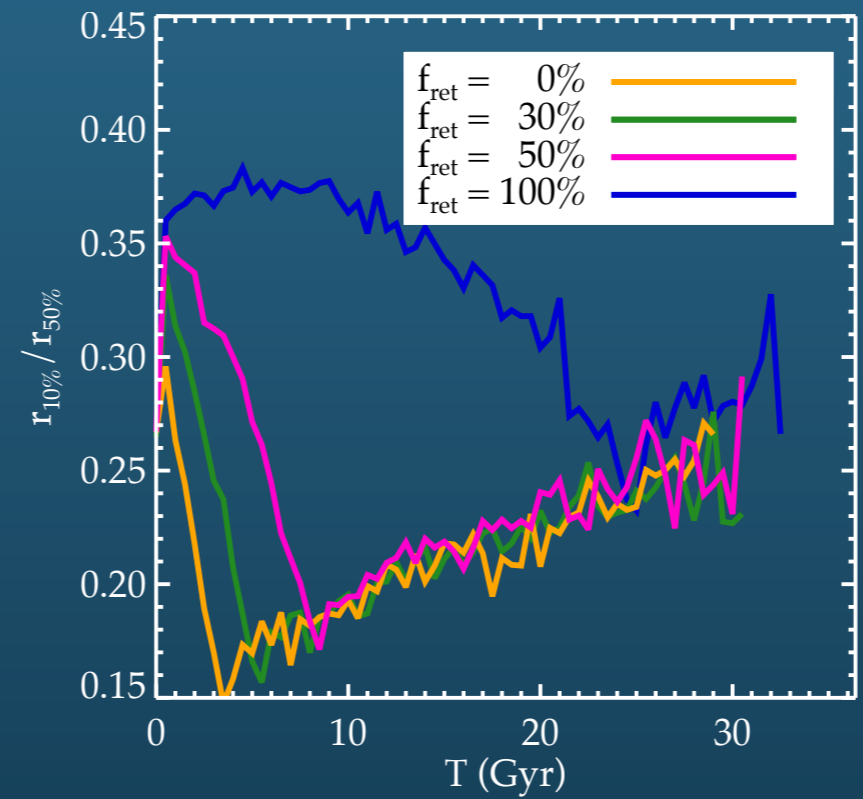
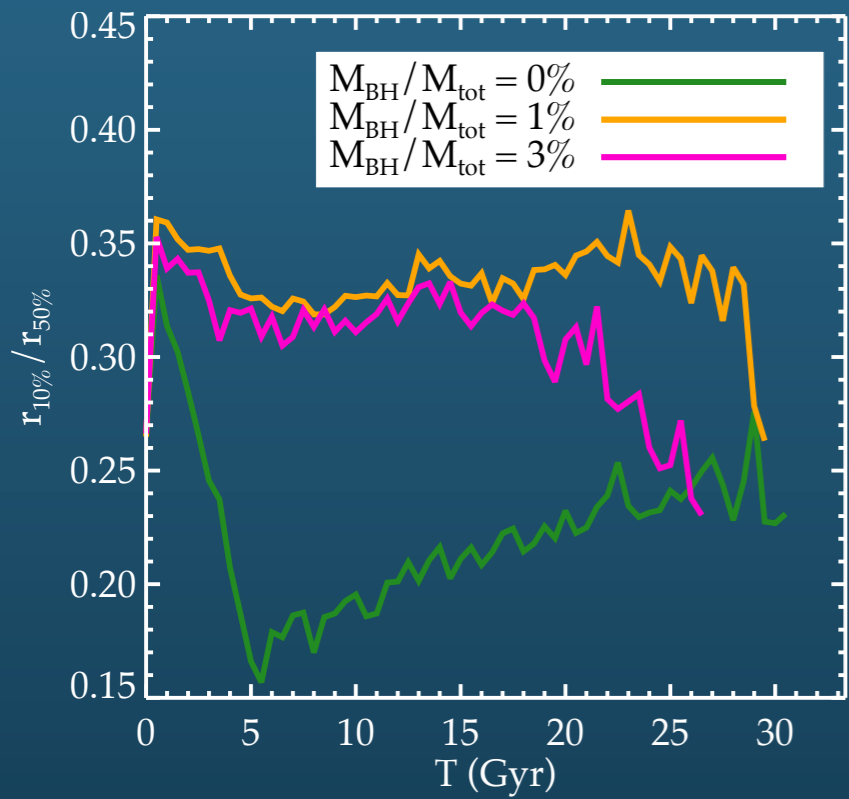
ALTERNATIVES

$$r_{10\%}/r_{50\%}$$

IMBH

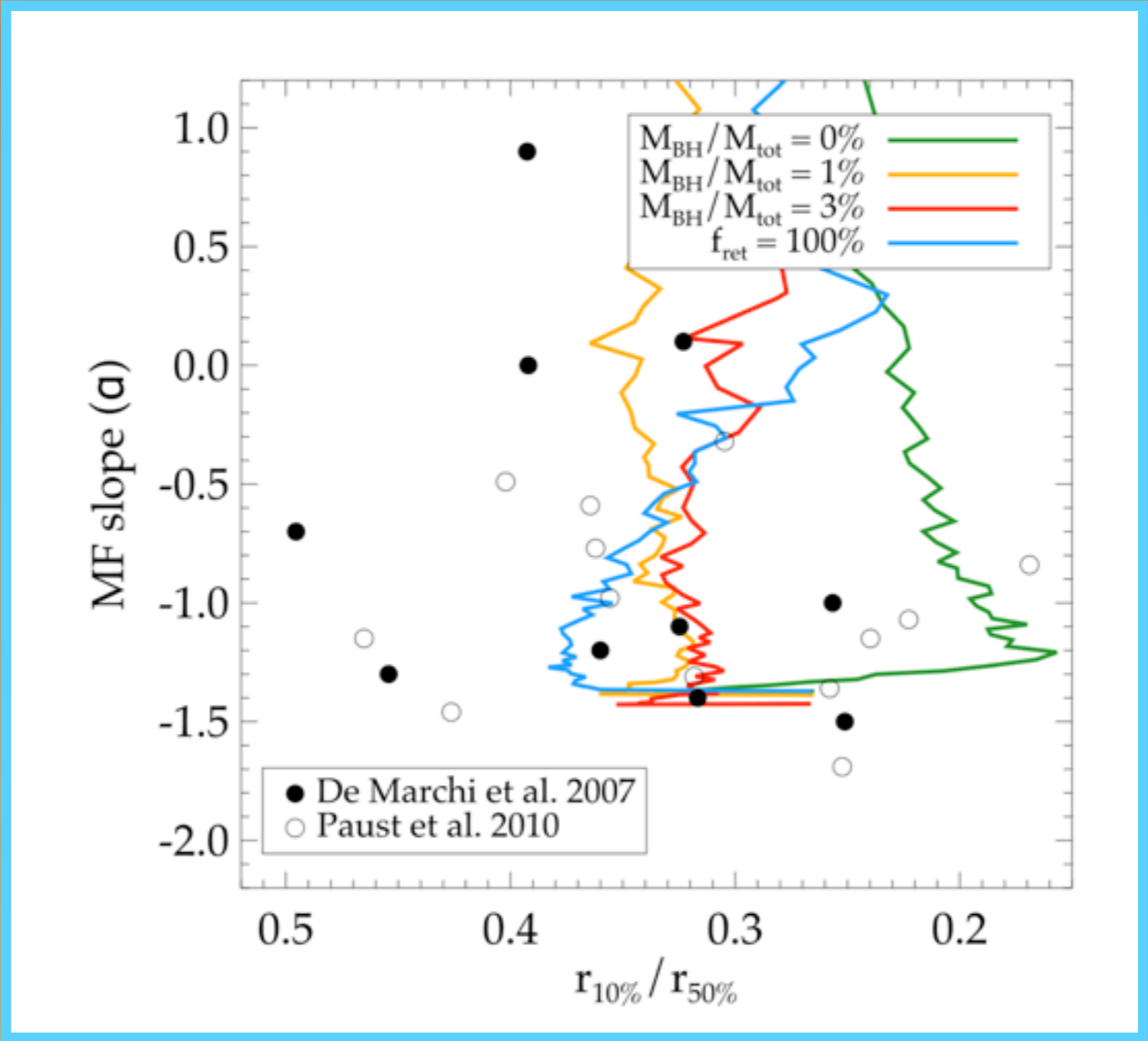
STELLAR-MASS
BLACK HOLES

BINARIES



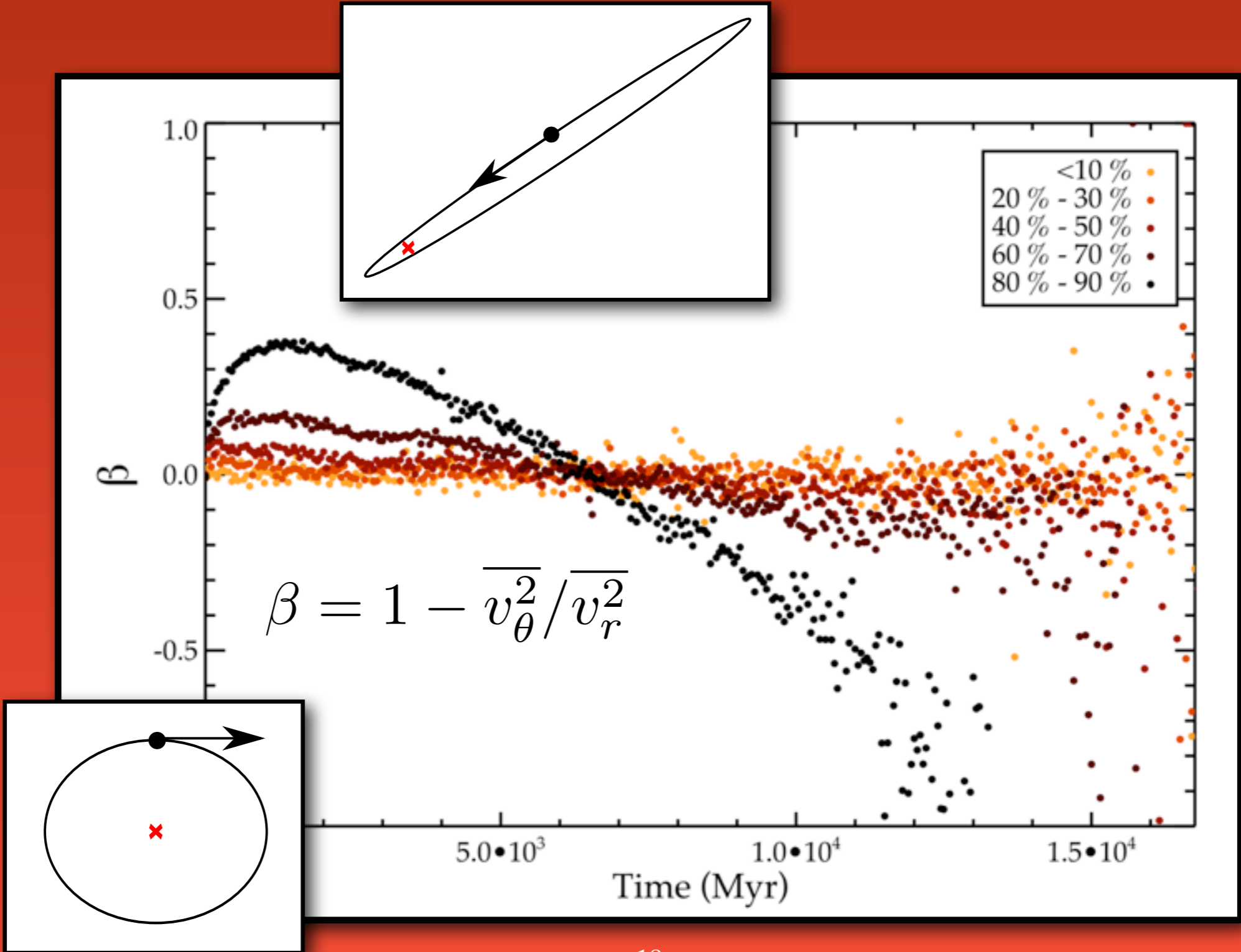


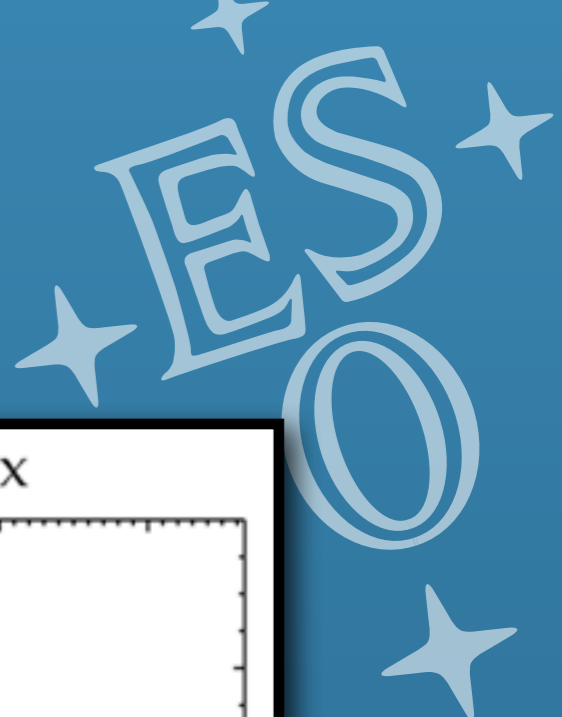
ALTERNATIVES



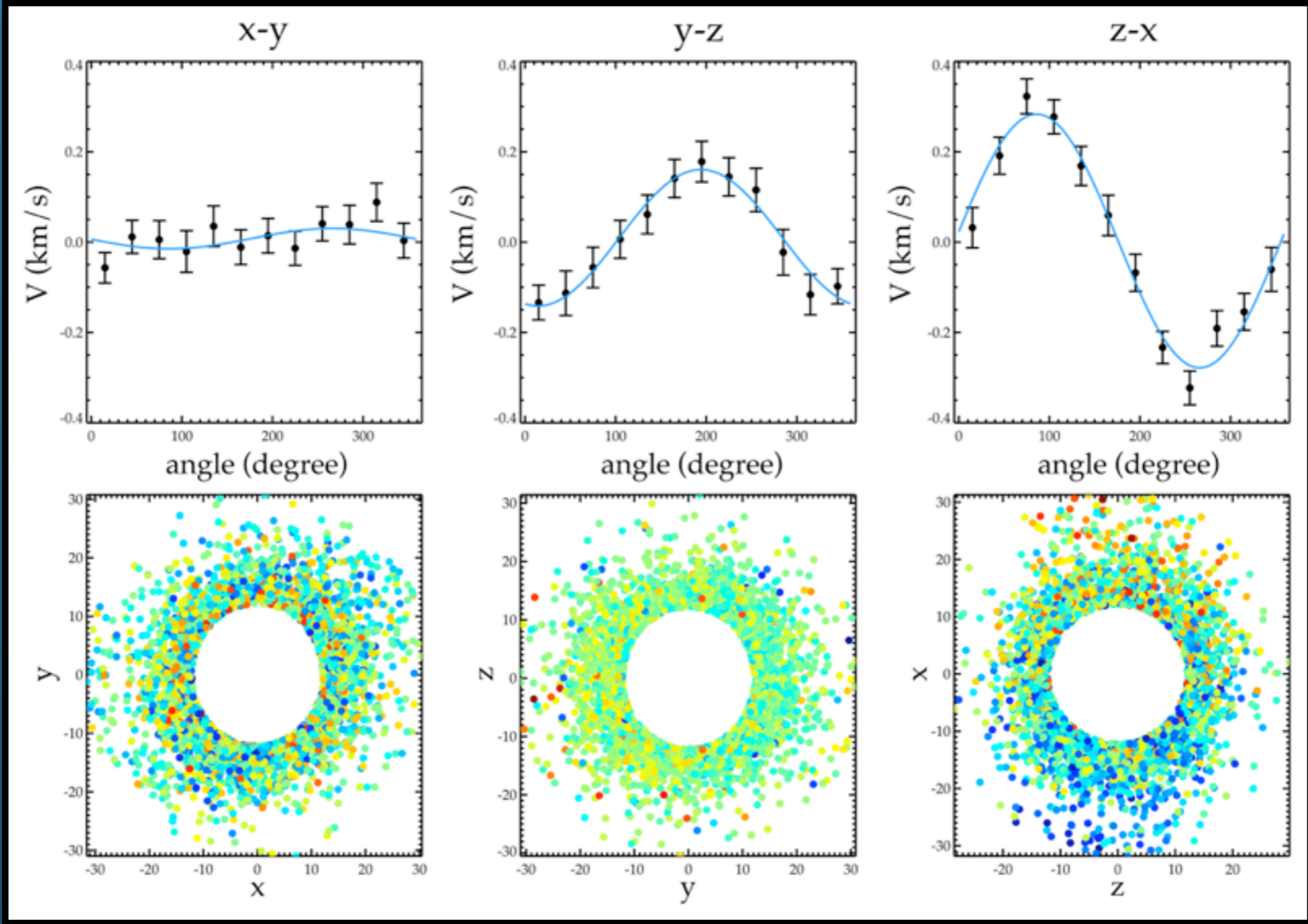


ROTATION

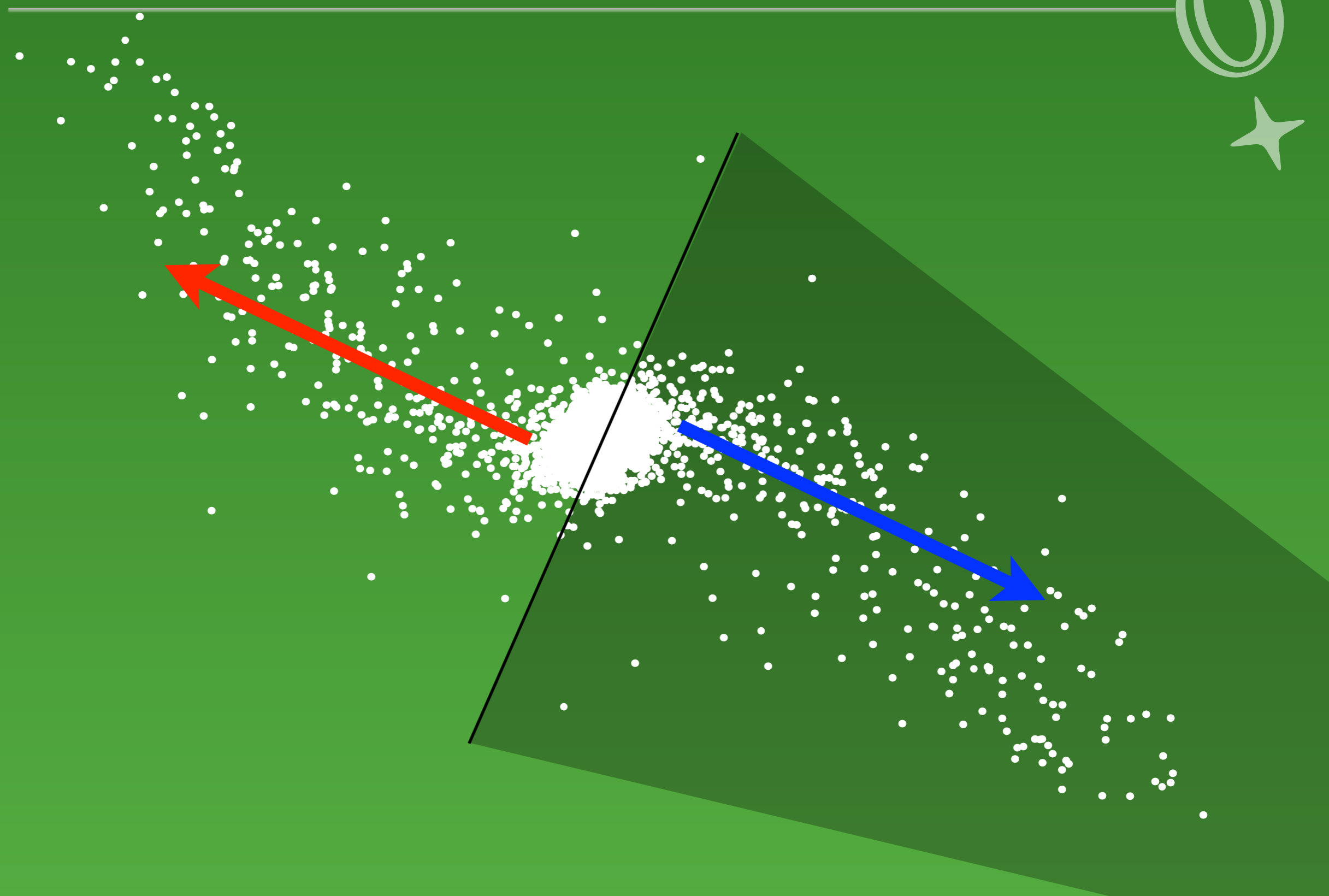




ROTATION



ROTATION



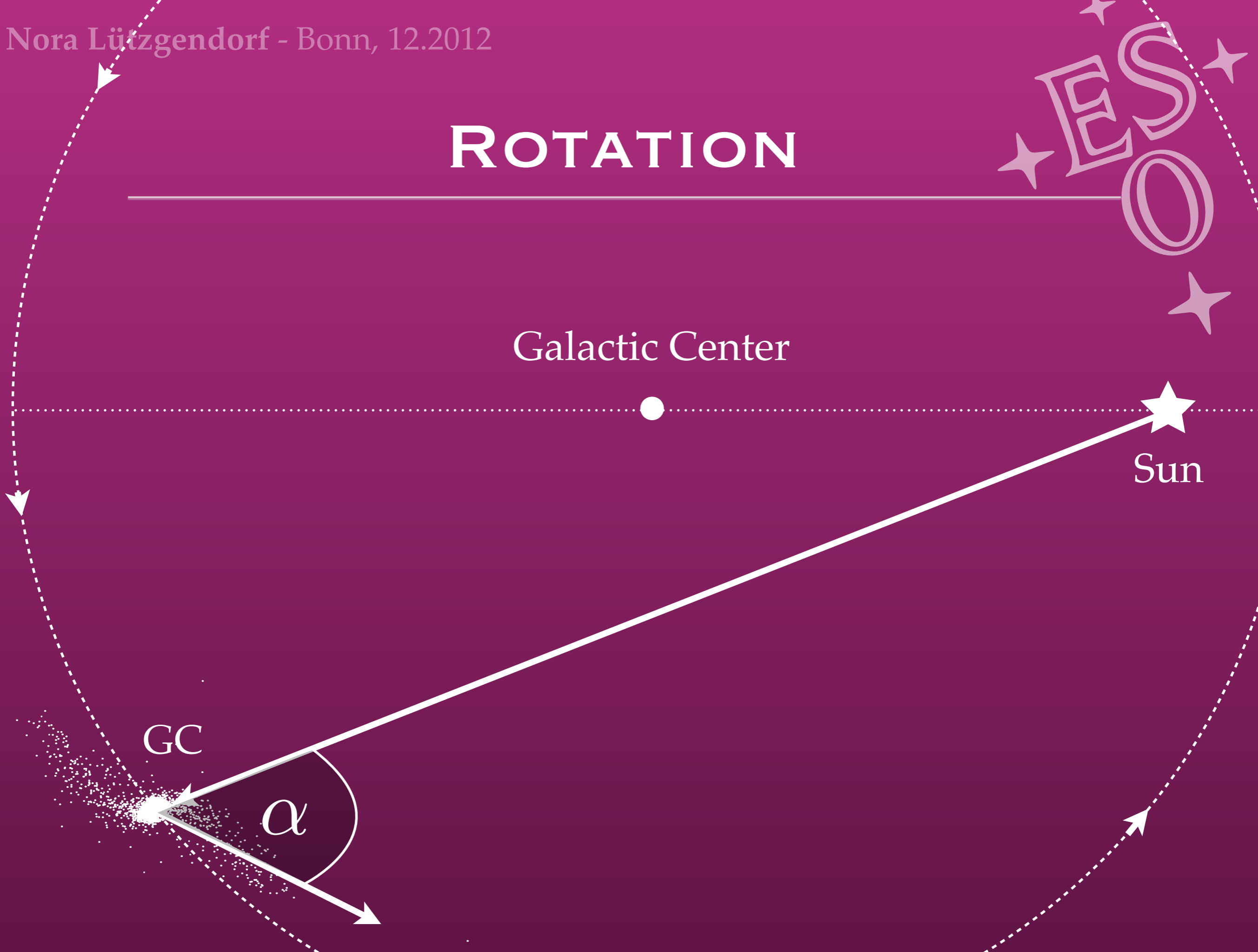
ROTATION



Galactic Center

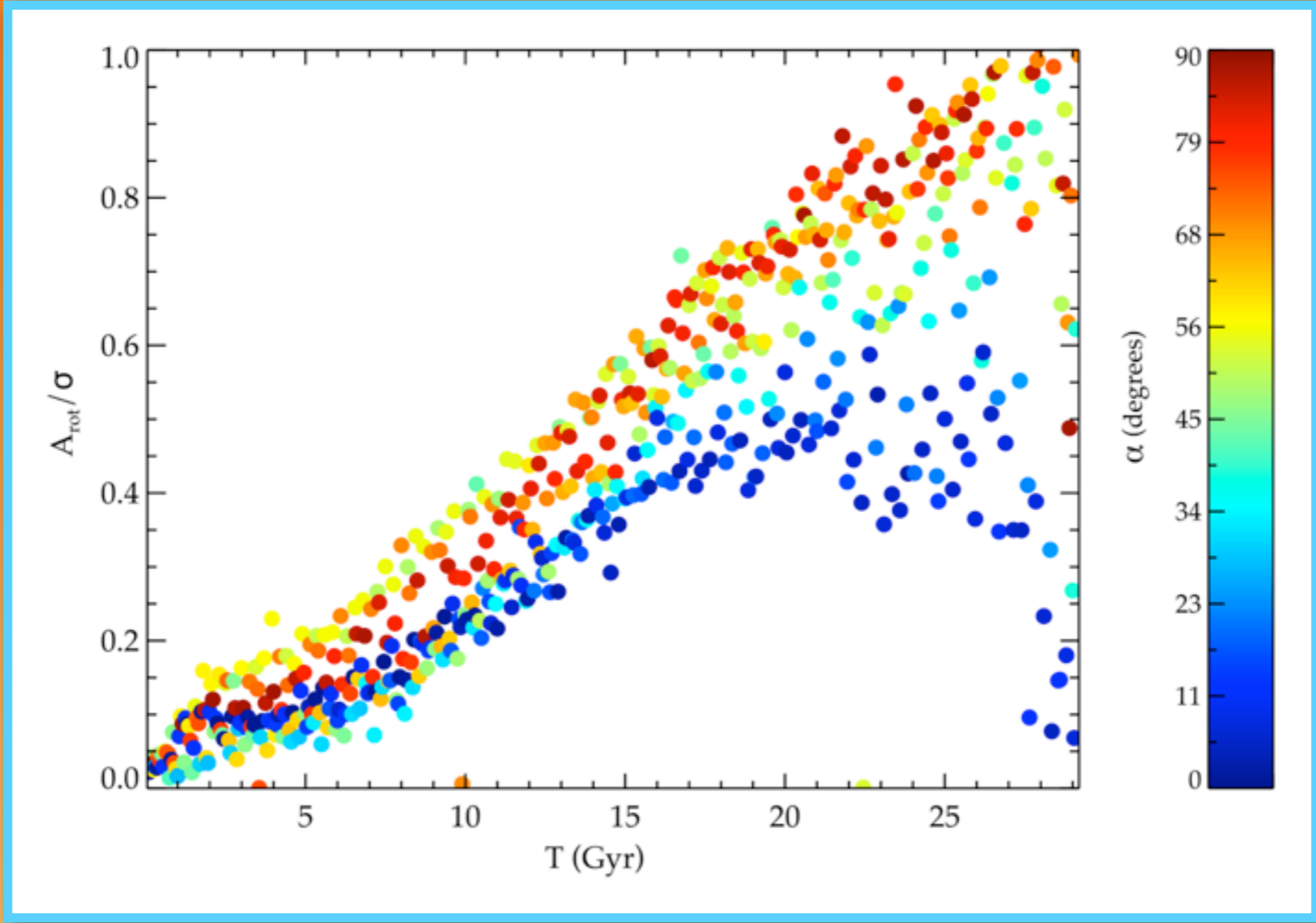


Sun





ROTATION





SUMMARY

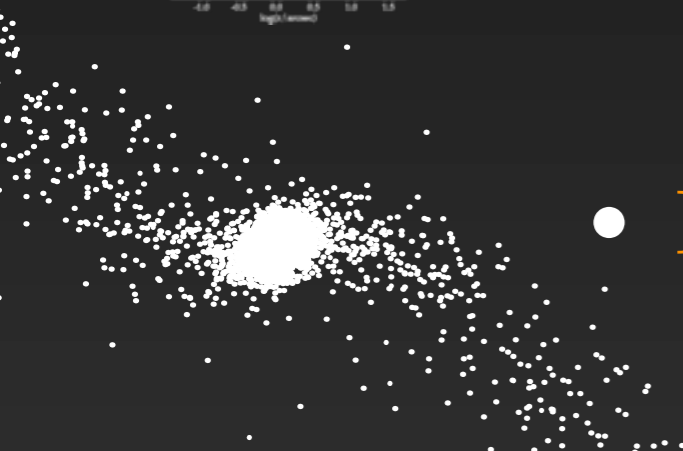
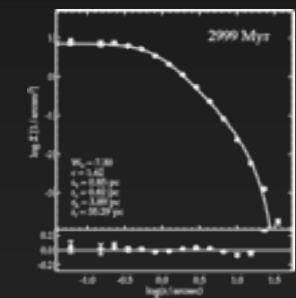
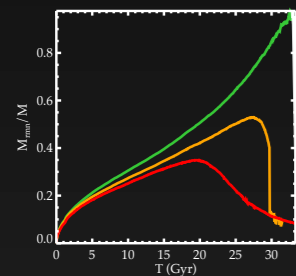
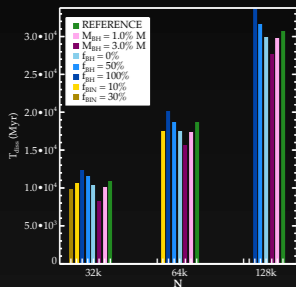
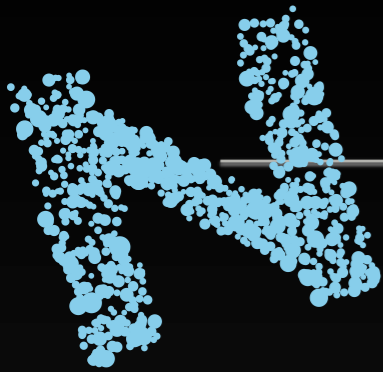
- **N-Body Simulations in Tidal Fields**

- ▶ **Black-Hole Retention Fraction** - Long Lifetimes
- ▶ **Intermediate-Mass Black Hole** - Ejection of Remnants
- ▶ **Binary Fraction** - Less Mass-Function Depletion (?)

- **King Models** - not a good Representation

- ▶ Better: **Non-parametric Values**

- **Rotation** - Tidal Streams



THANK YOU!

