

# The first SMBHs Indications from models

*arxiv/1902.07982*

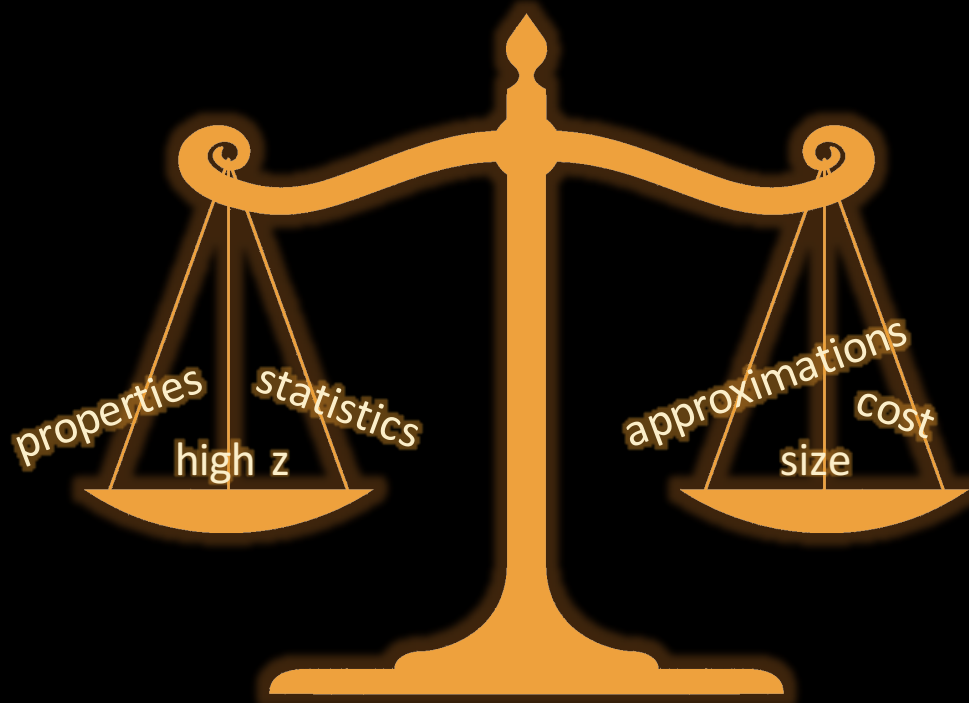
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# Goal of this project

- Study the AGN/SMBH population at EoR
- Predictions for the next generation of telescopes
- Use cosmological galaxy formation and evolution models
- Indications for improvement of the models

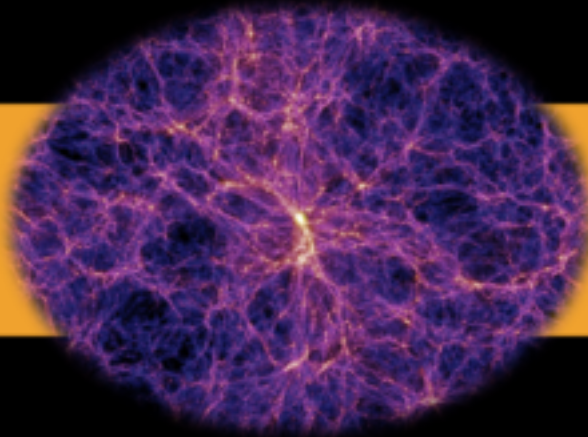
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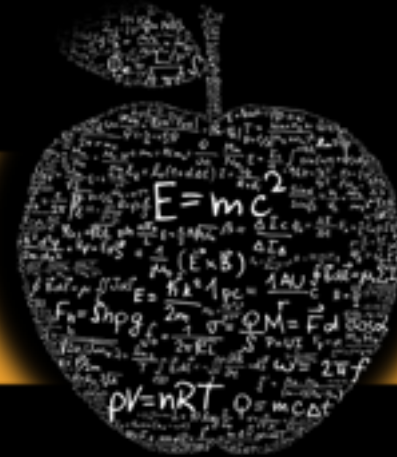


# Galaxy formation models

- Dark matter simulations
- Semi-Analytic Models (SAMs) – 4 models
- Hydro-dynamical simulations (HDSs) – 4 models



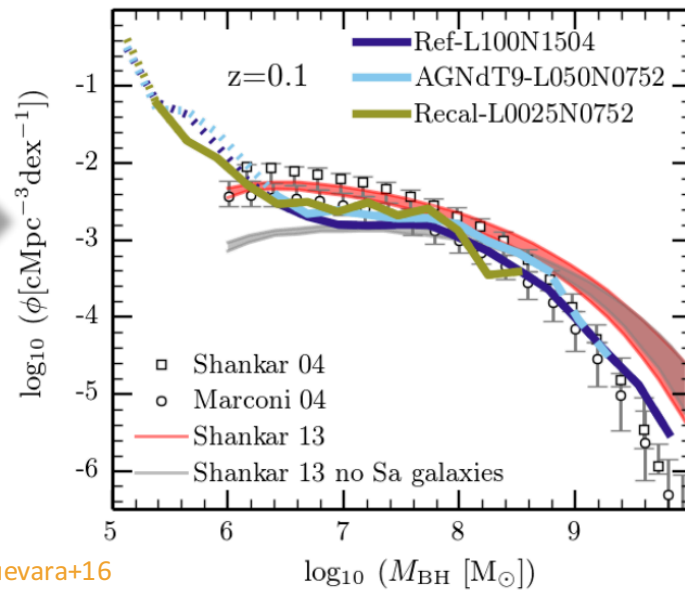
Dark Matter



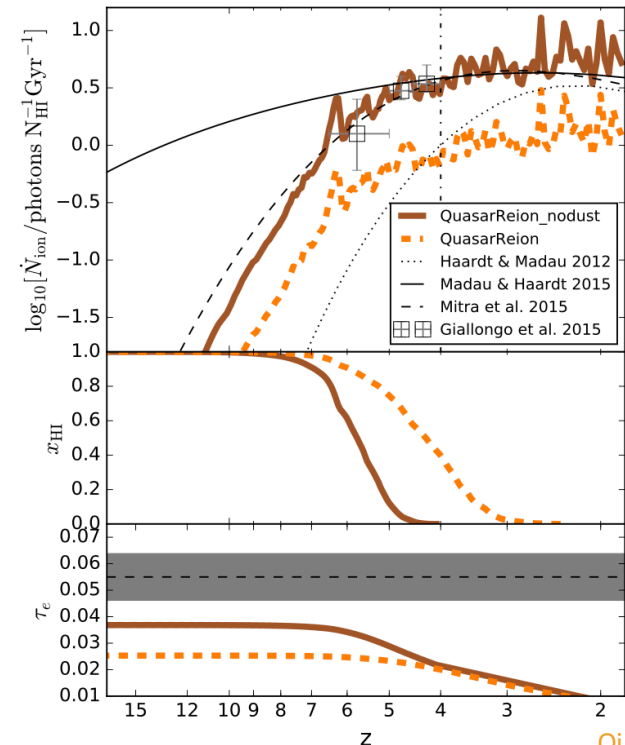
Models

# Galaxy formation models

- Predictions for the local and high z Universe
- Comparison with observations – tuning of parameters
- Future surveys (SKA, Athena, JWST, etc)



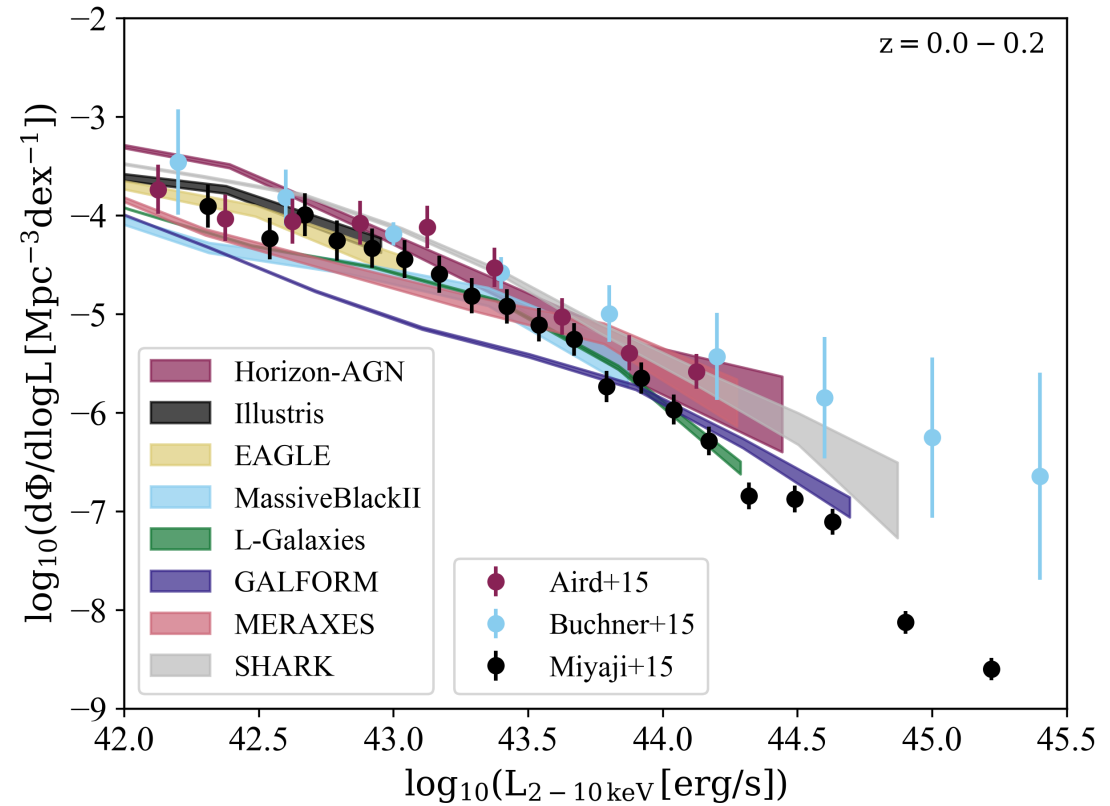
Rosas-Guevara+16



Qin+17

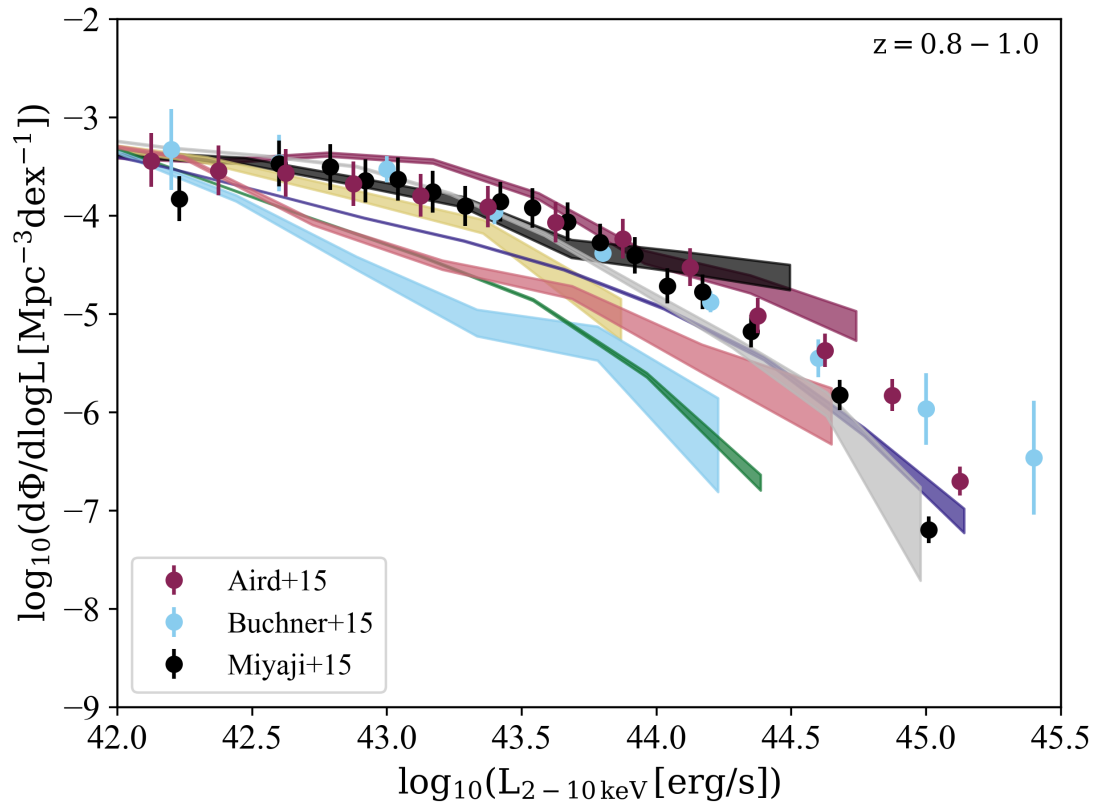
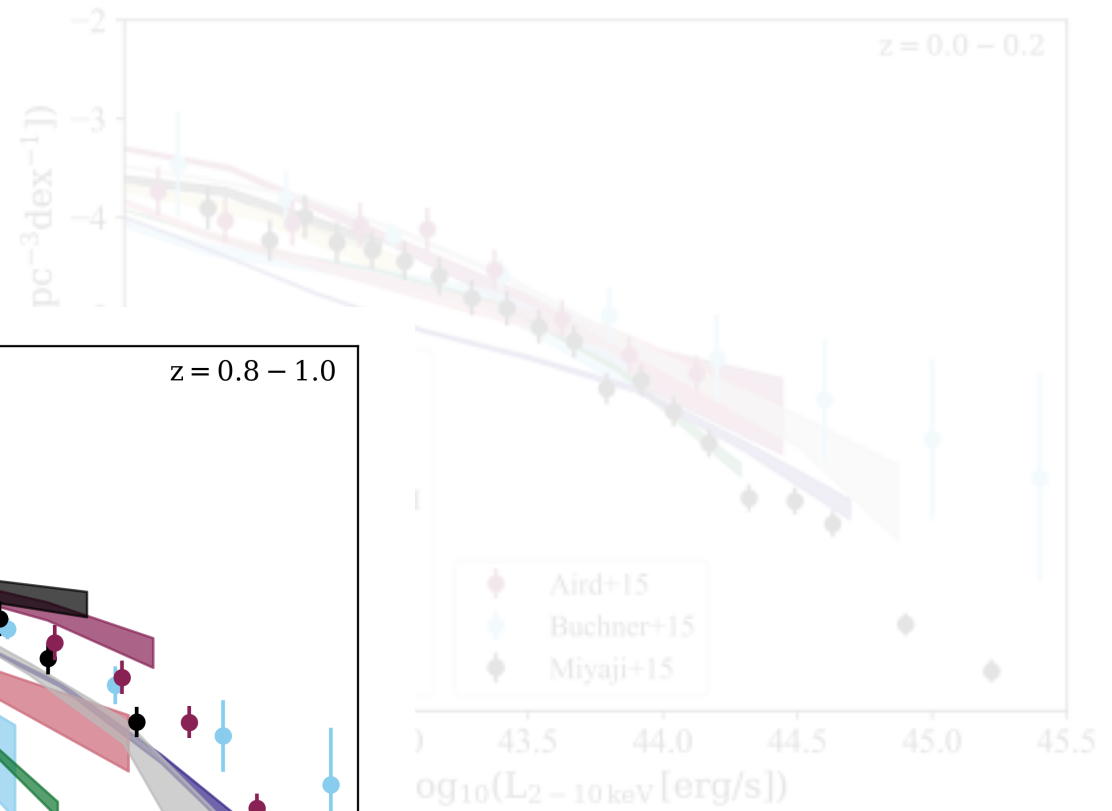
# X-ray LFs: local

- Match with observations
- Tuning of models
- Radiative efficiency



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# Radiative efficiency ( $\epsilon$ )

- Spin parameter

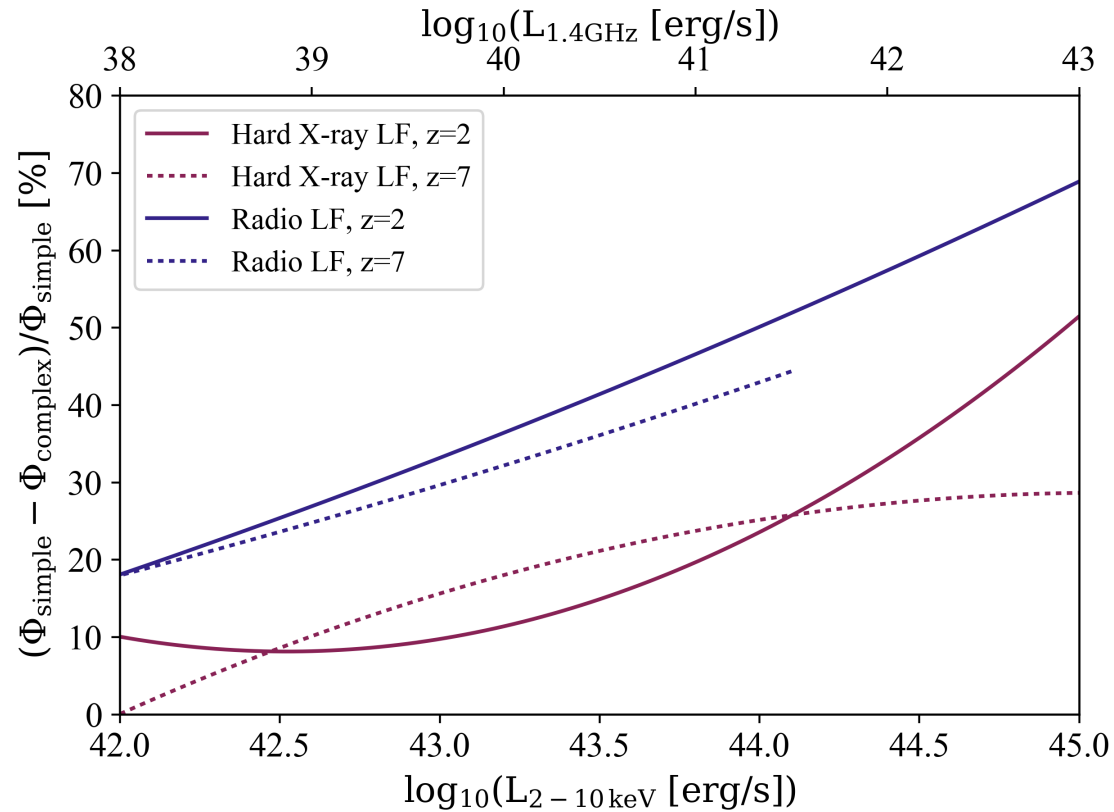
- $\epsilon = 1 - \sqrt{1 - \frac{2}{3} \frac{1}{r_{\text{ISO}}}}$

- $r_{\text{ISO}} = f(a)$  (Bardeen+72)

- $L_{\text{bol}} = \epsilon \dot{M} c^2 \rightarrow L_{2-10\text{keV}}$

- $L_{\text{jet}} \propto a^2 \rightarrow L_{1.4\text{GHz}}$  (Blandford+77)

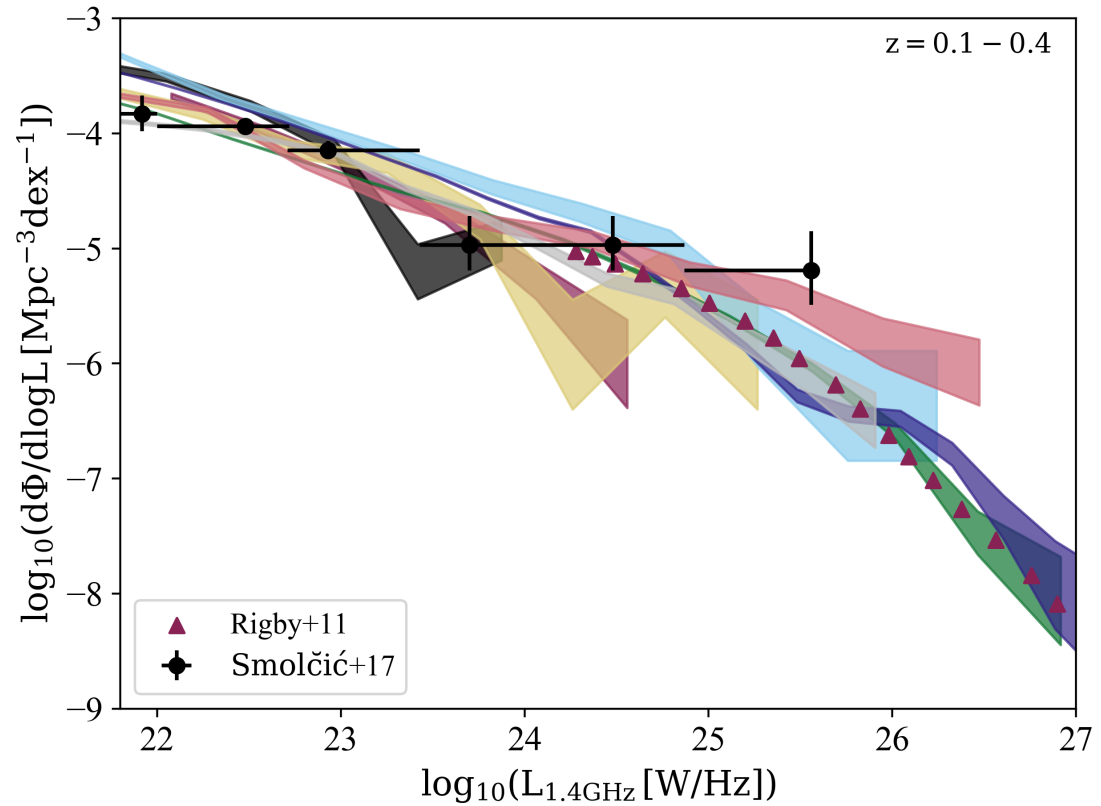
- $\uparrow L \Leftrightarrow \uparrow \Delta\Phi$





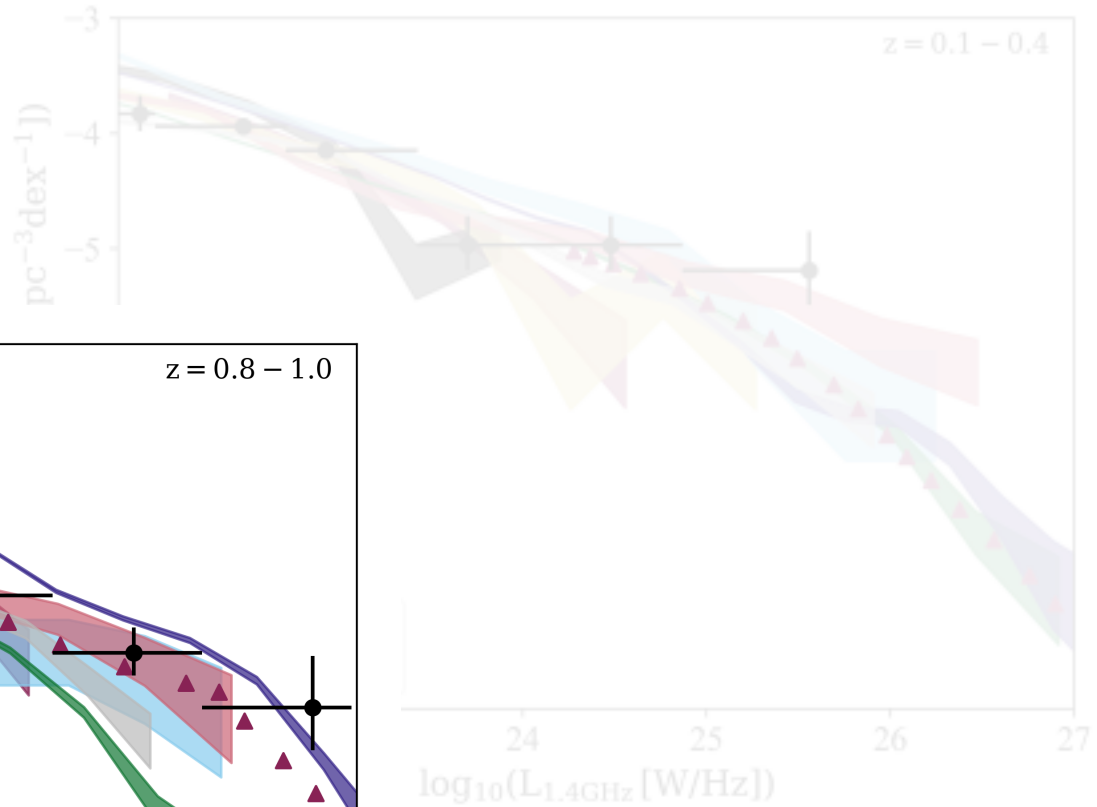
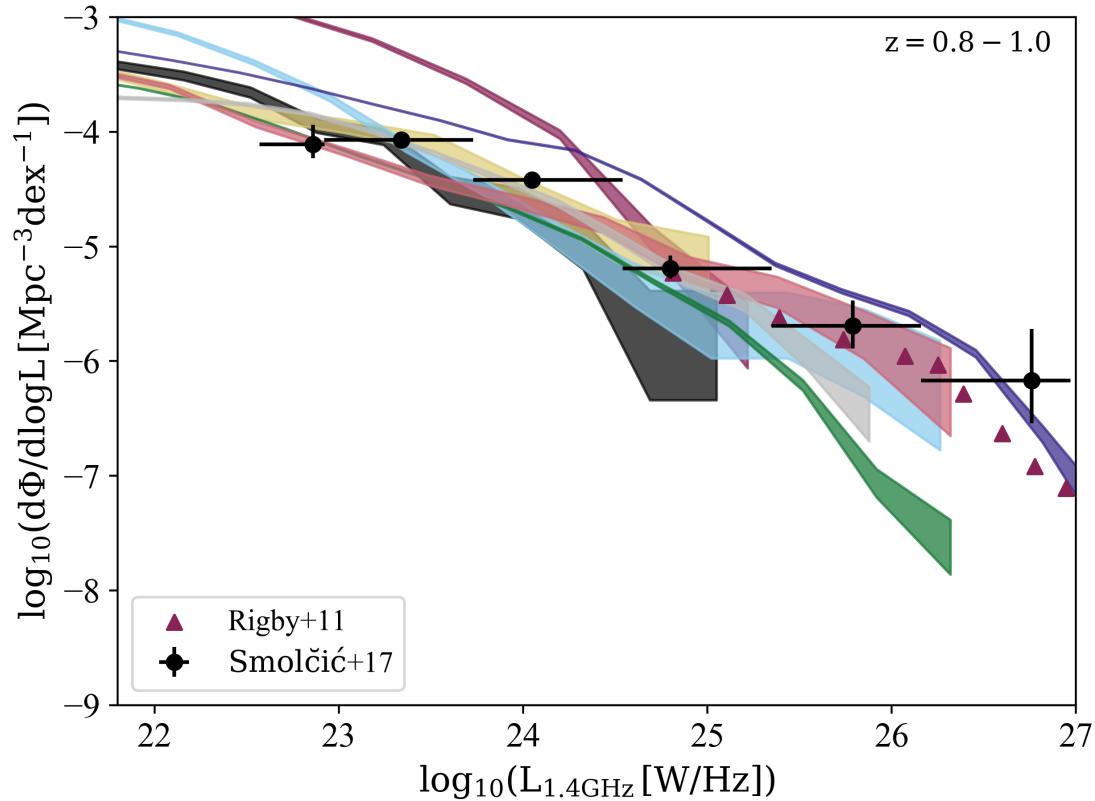
# Radio LFs: local

- Match with observations
- Tuning of models
- Parameters
- Degeneracy



# Radio LFs: local

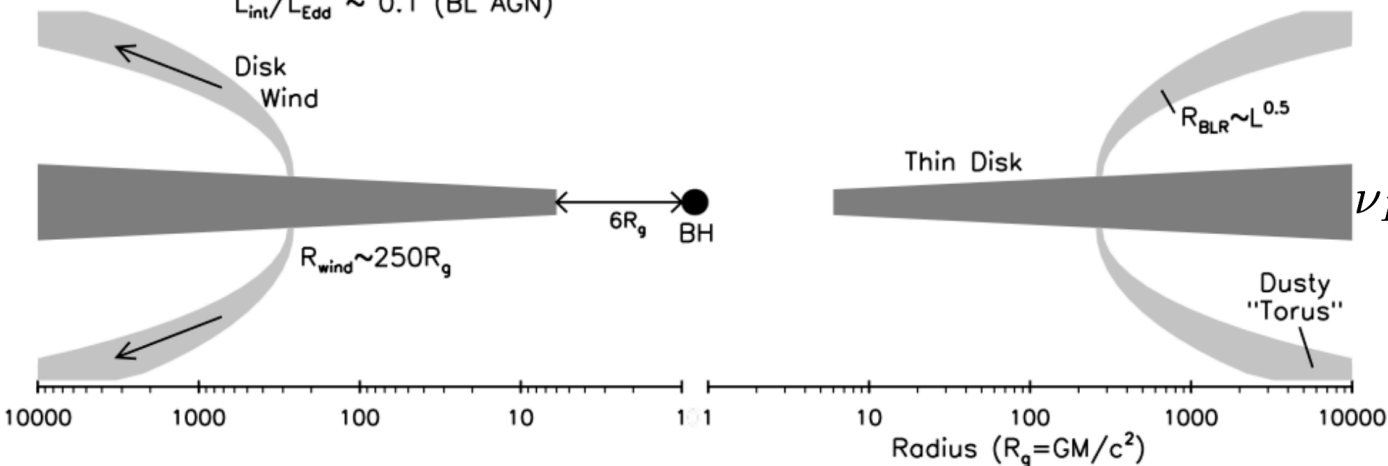
- Match with observations
- Tuning of models
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# Accreting scenarios

## Quasar mode - Thin disc (Shakura-Sunyaev model)

$L_{int}/L_{Edd} \sim 0.1$  (BL AGN)

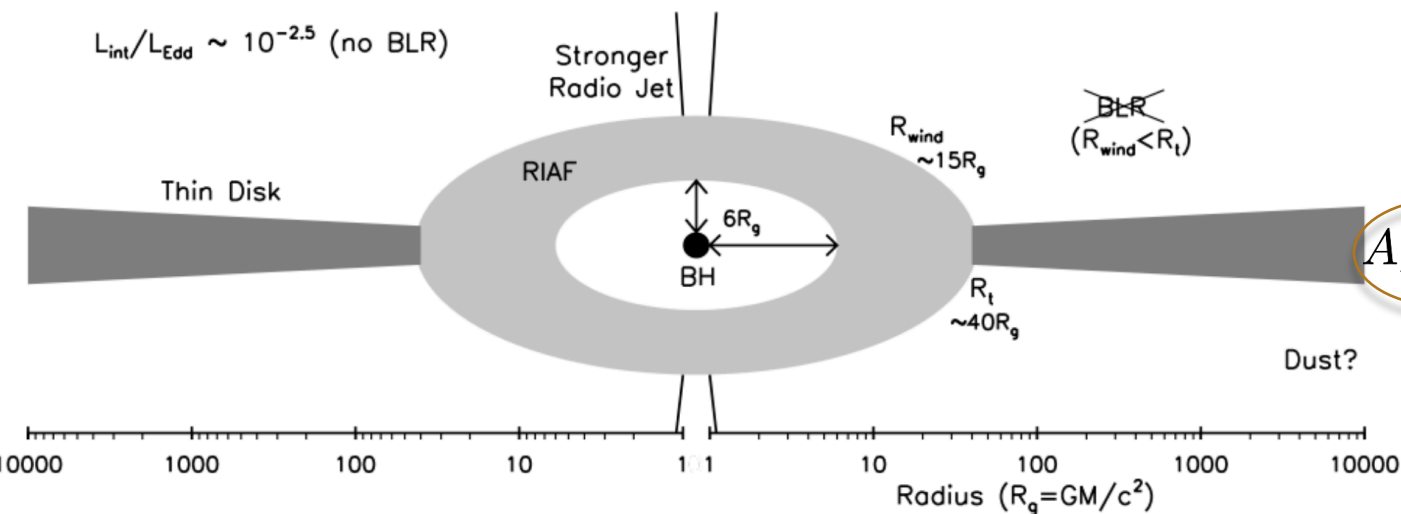


$$\nu_R L_{\nu R} = \frac{A_{TD} L_{jet} M_9^{0.32}}{(\dot{m}/0.01)^{1.2}}$$

$$\dot{m} = \frac{\dot{M}}{\dot{M}_{Edd}} = 0.01$$

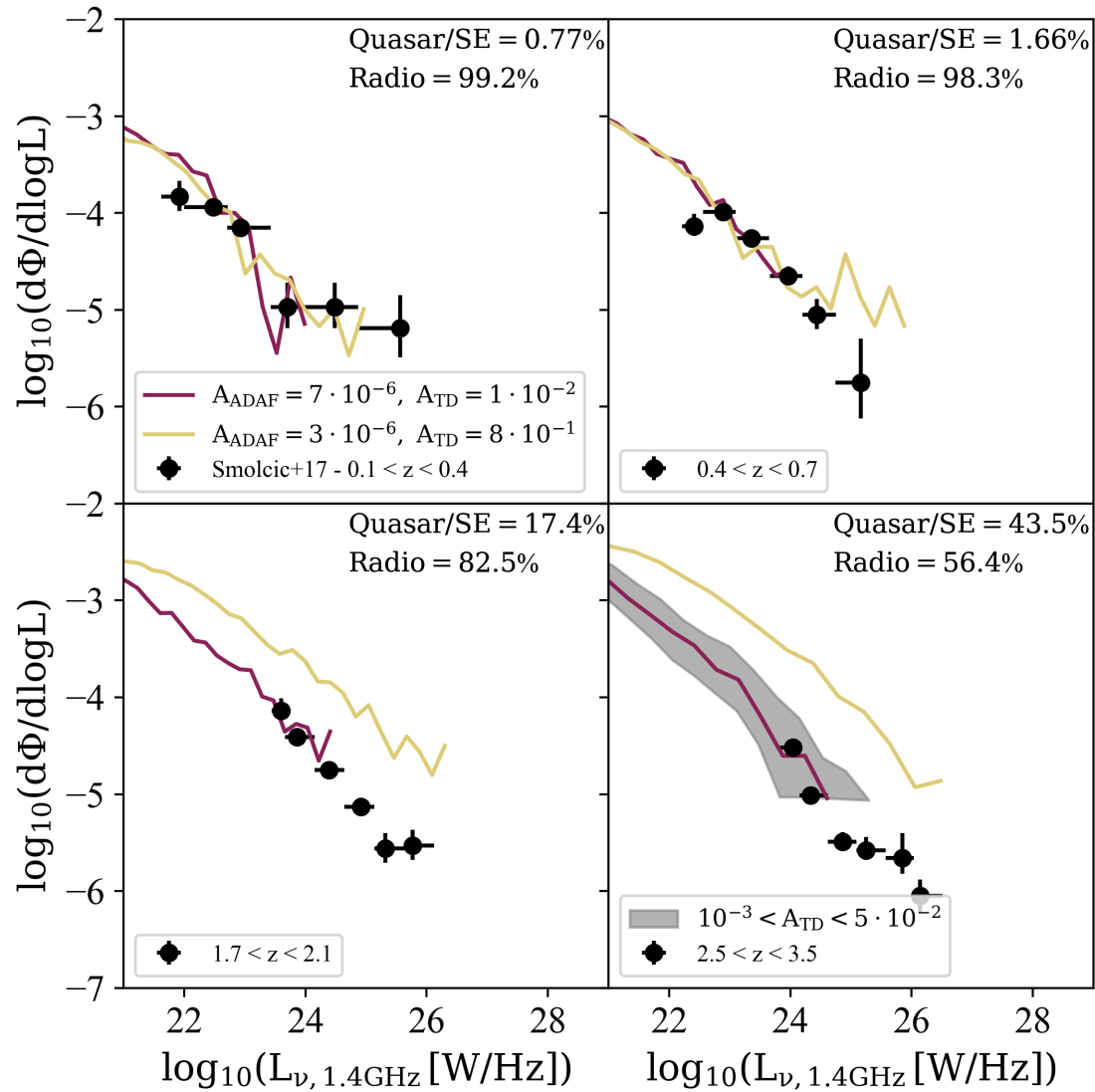
## Radio mode - ADAF disc (advection-dominated accretion)

$L_{int}/L_{Edd} \sim 10^{-2.5}$  (no BLR)



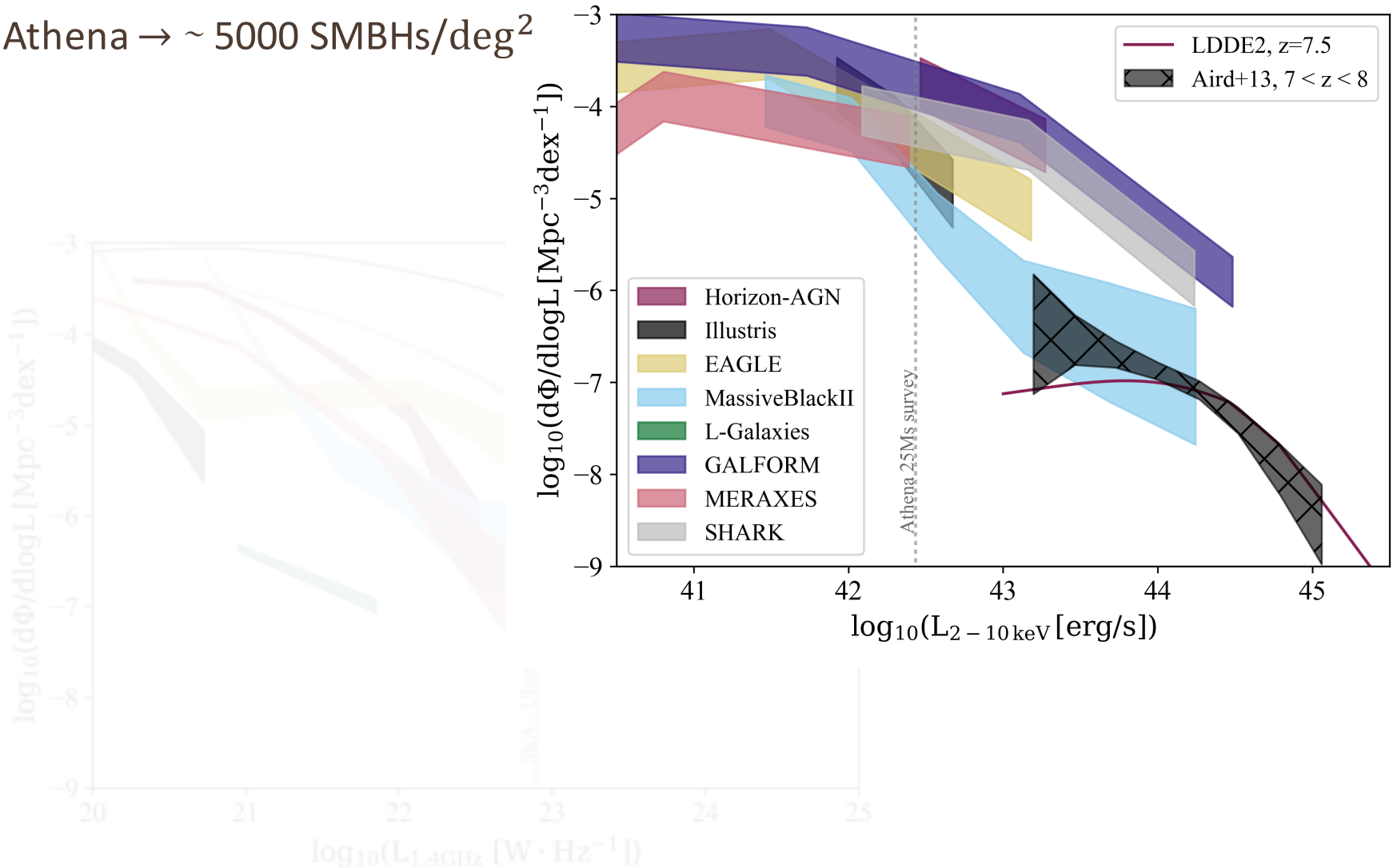
$$\nu_R L_{\nu R} = A_{ADAF} L_{jet} \left( M_9 \frac{\dot{m}}{0.01} \right)^{0.42}$$

# Degeneracy



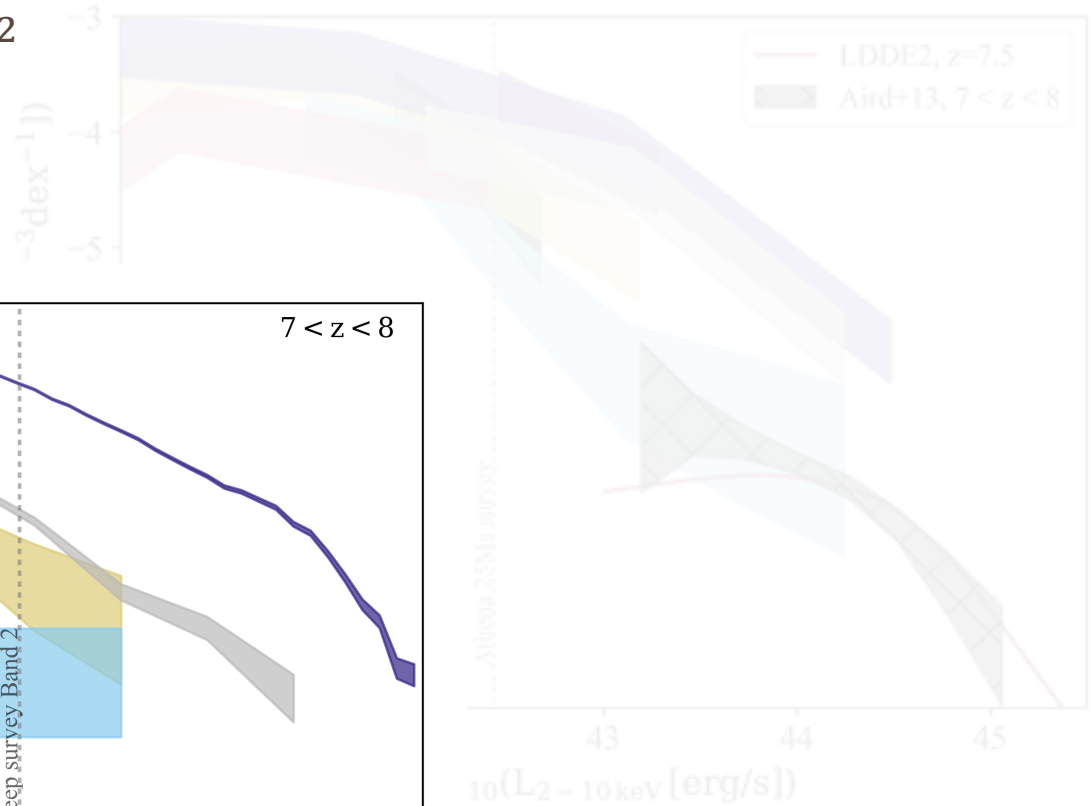
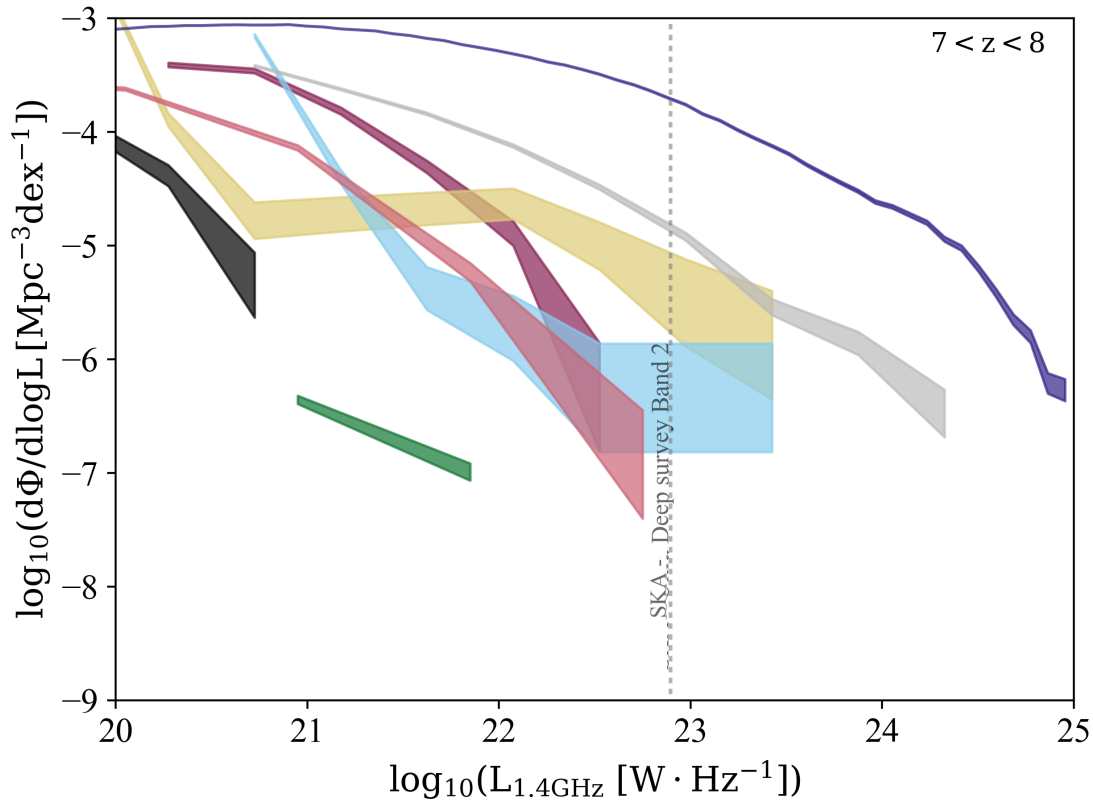
# Results: EoR

- Athena → ~ 5000 SMBHs/deg<sup>2</sup>



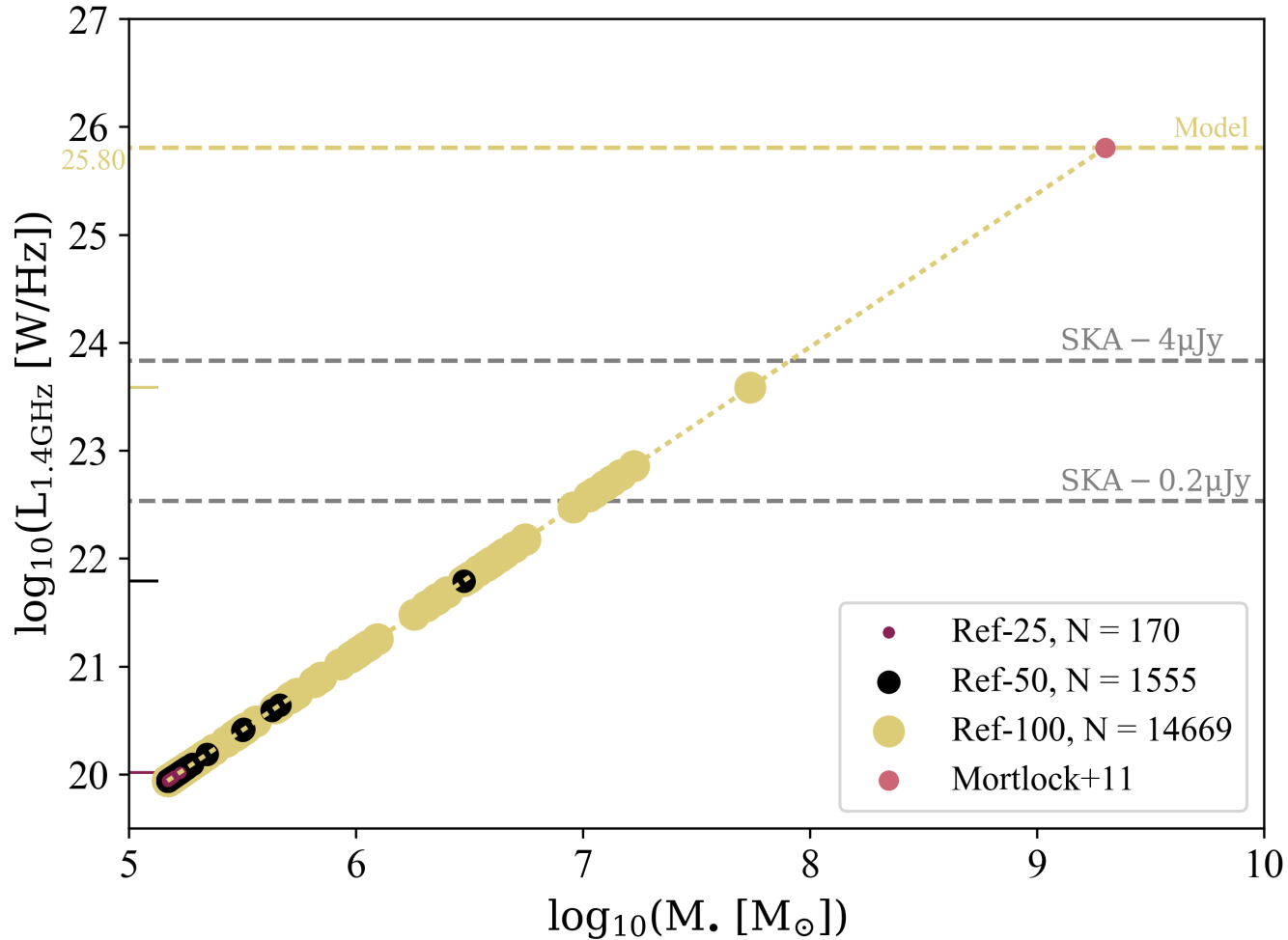
# Results: EoR

- Athena → ~ 5000 SMBHs/deg<sup>2</sup>
- SKA → ~ 400 SMBHs/deg<sup>2</sup>
- Limitations

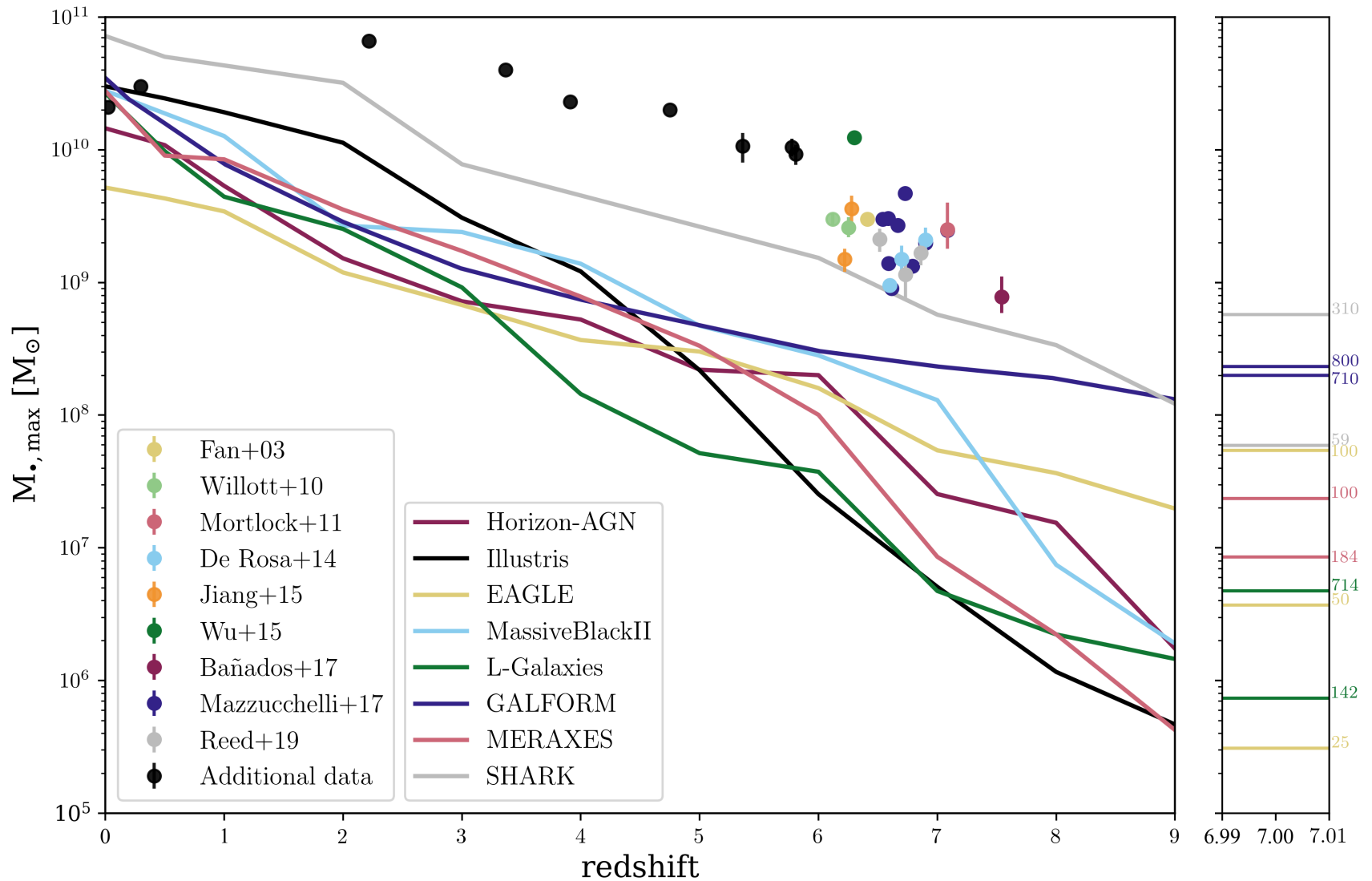


# Results: Indications from models

$$L_{\nu}^{TD} \propto M_{\bullet}^{1.42}$$

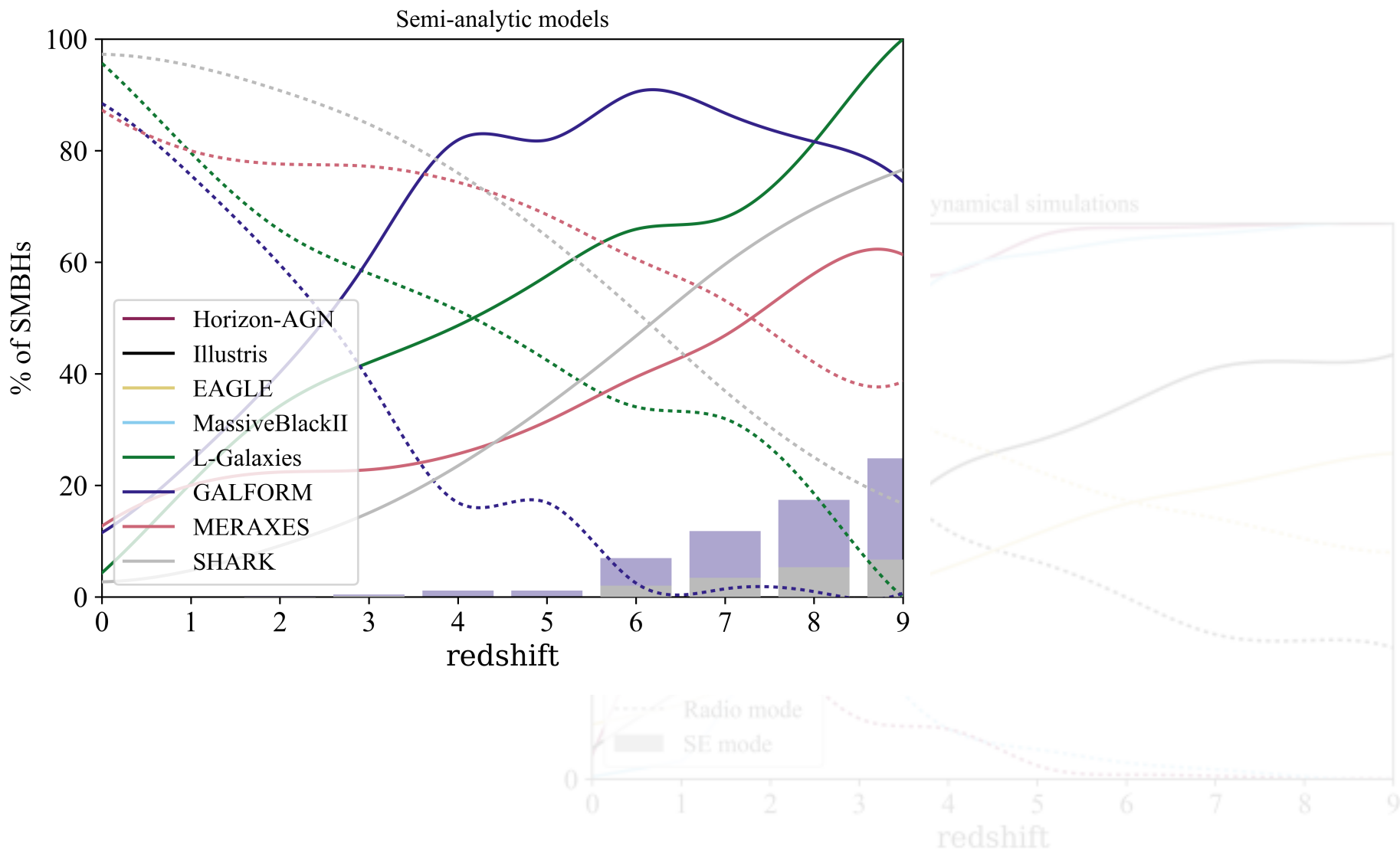


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