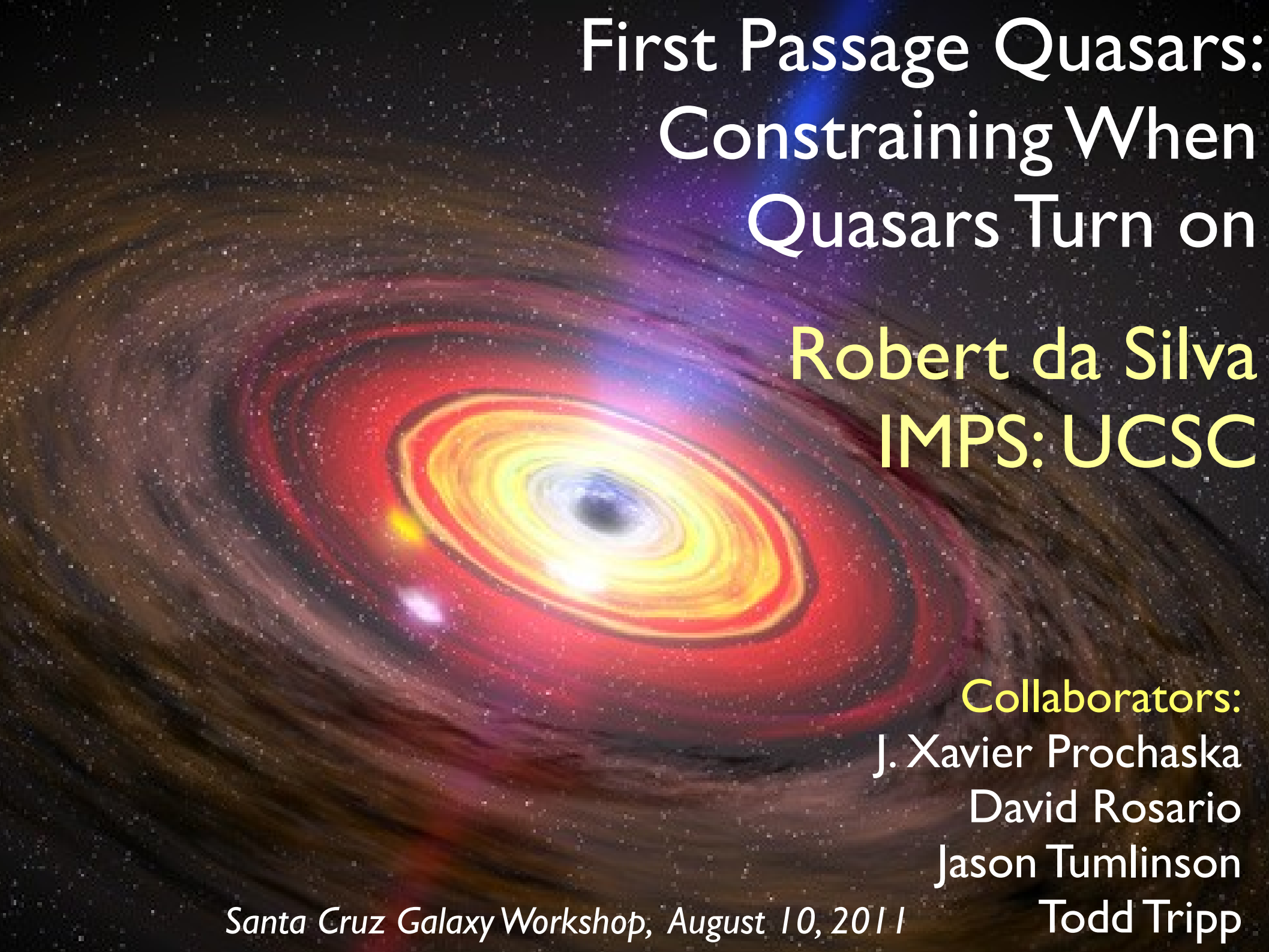


First Passage Quasars: Constraining When Quasars Turn on

Robert da Silva
IMPS: UCSC

Collaborators:
J. Xavier Prochaska
David Rosario
Jason Tumlinson
Todd Tripp

Santa Cruz Galaxy Workshop, August 10, 2011

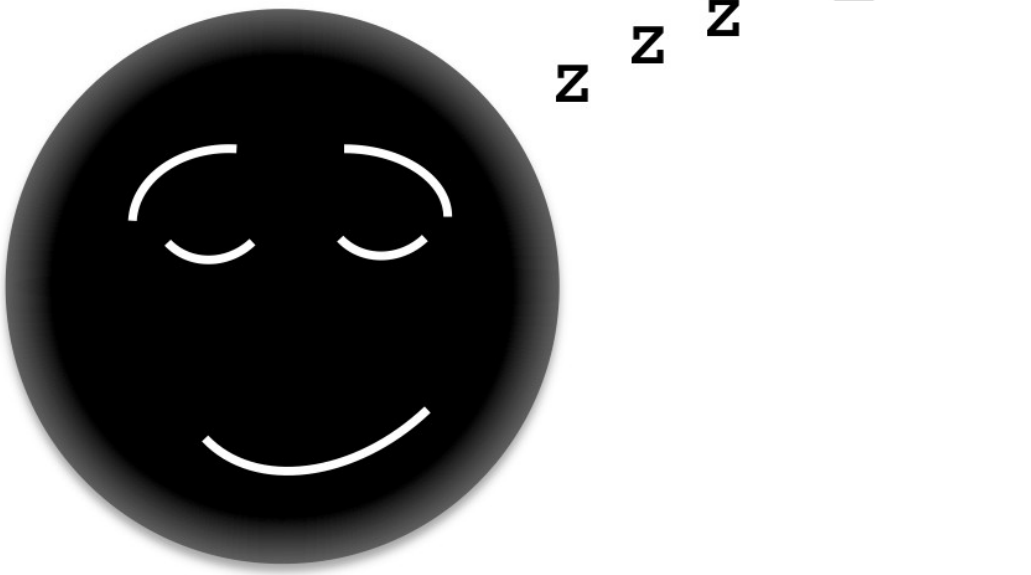
Why Bother With Quasars?

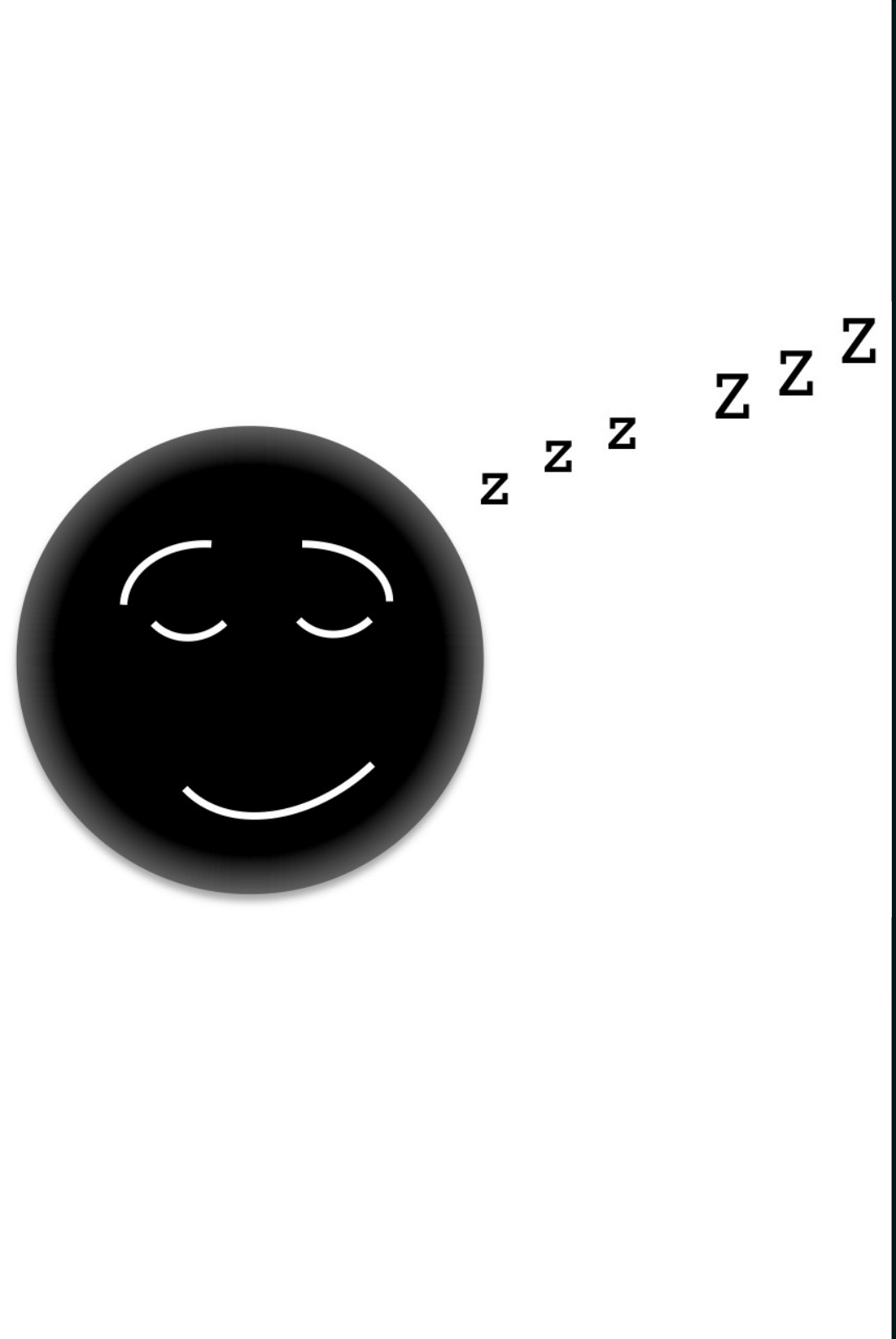
- Most if not all galaxies harbor a supermassive black hole (SMBH) in their centers (e.g., Kormendy & Gebhardt 2001)

- SMBH mass is correlated with host properties such as mass, velocity dispersion and morphology

  Magorrian+1998; Gebhardt+2000; Ferrarese & Merritt 2000; Graham+2001

- SMBH growth thought to be dominated by "quasar mode" accretion (e.g., Soltan 1982)




z
z
z
z
z
z

How/When QSOs Turn on

Galaxy Mergers (e.g., Mihos & Hernquist 1996)

Can occur during two phases

a) After First Passage

How/When QSOs Turn on

Galaxy Mergers (e.g., Mihos & Hernquist 1996)

Can occur during two phases

a) After First Passage

Tidal torques → Bar Formation → Gaseous Inflow

How/When QSOs Turn on

Galaxy Mergers (e.g., Mihos & Hernquist 1996)

Can occur during two phases

a) After First Passage

b) During Final Coalescence

How/When QSOs Turn on

Galaxy Mergers (e.g., Mihos & Hernquist 1996)

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Secular Process: i.e. "Non-Merging"

e.g. Ciotti & Ostriker 2007

How/When QSOs Turn on

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Secular Process: i.e. "Non-Merging"

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Single Galaxy

How/When QSOs Turn on

Galaxy Mergers (e.g., Mihos & Hernquist 1996)

Can occur during two phases

a) After First Passage

b) During Final Coalescence — Single Galaxy

Secular Process: i.e. "Non-Merging" — Single Galaxy

e.g. Ciotti & Ostriker 2007

How/When QSOs Turn on

Galaxy Mergers (e.g., Mihos & Hernquist 1996)

Can occur during two phases

a) After First Passage

Two Galaxies Separated by ~50 kpc

b) During Final Coalescence

Single Galaxy

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Single Galaxy

How/When QSOs Turn on

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Single Galaxy

Secular Process: i.e. "Non-Merging"

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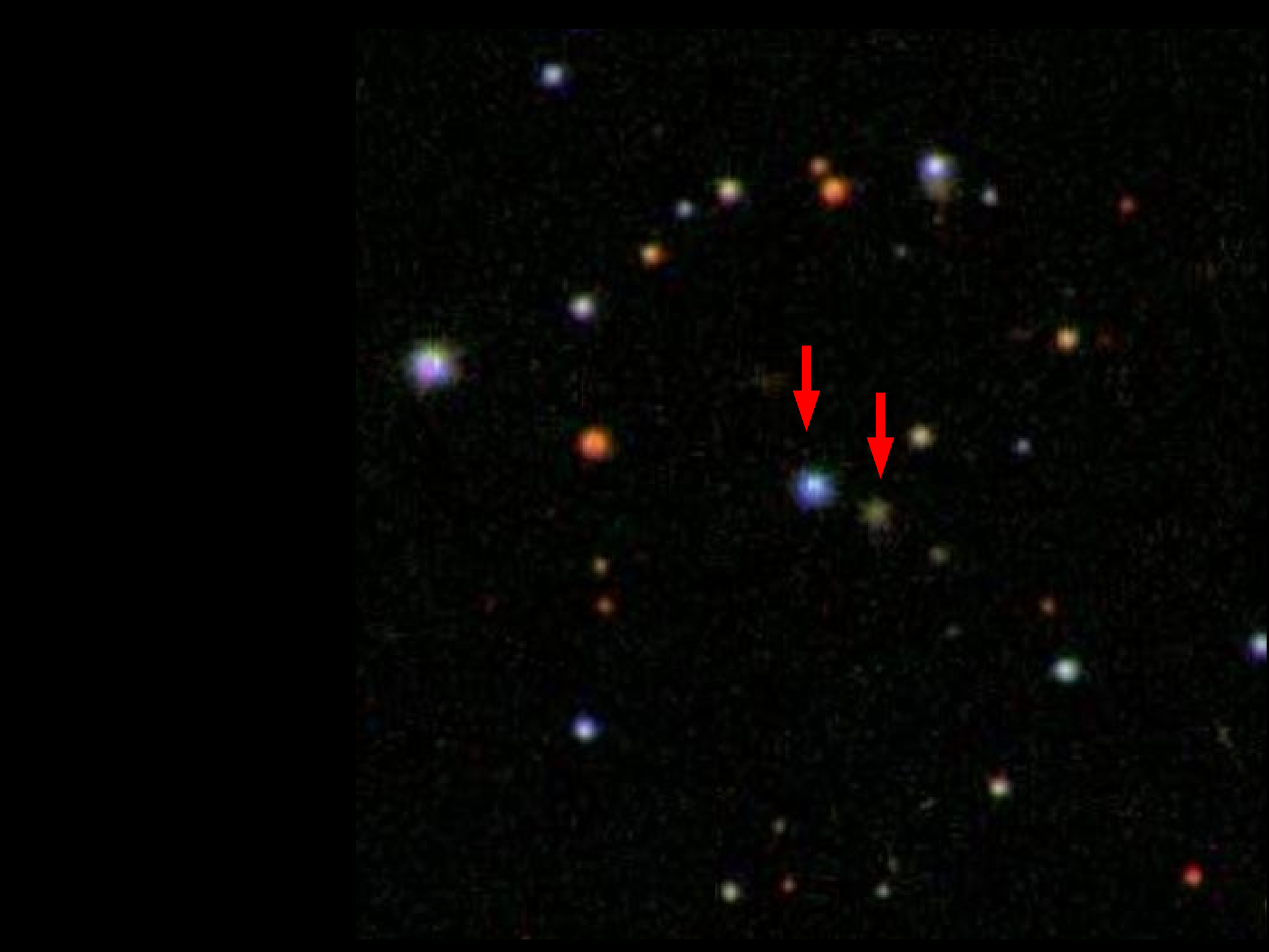
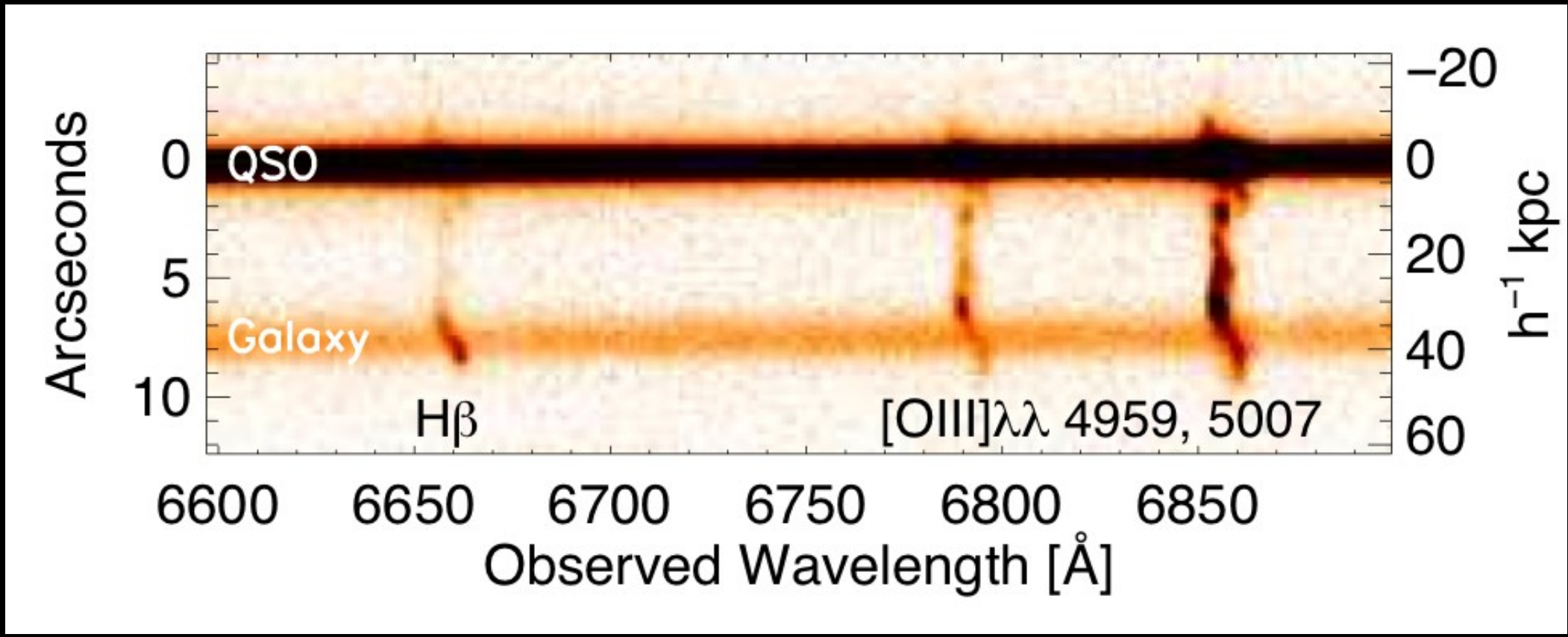
Single Galaxy



$z = 0.3693$

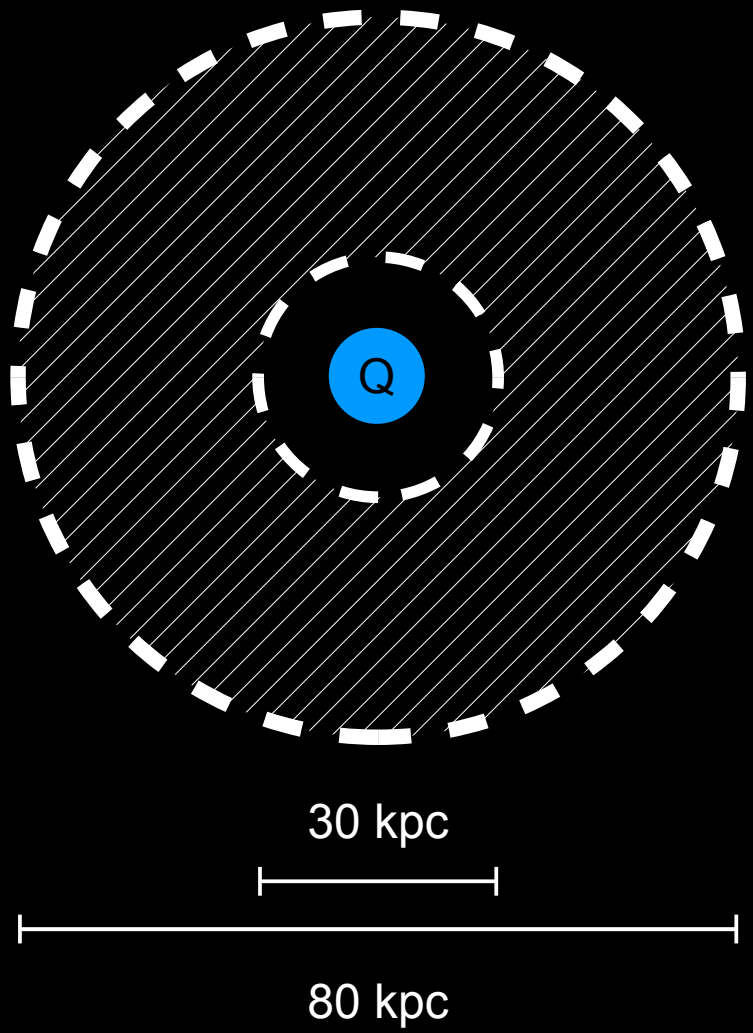
$\Delta v = 159 \pm 20$ km/s

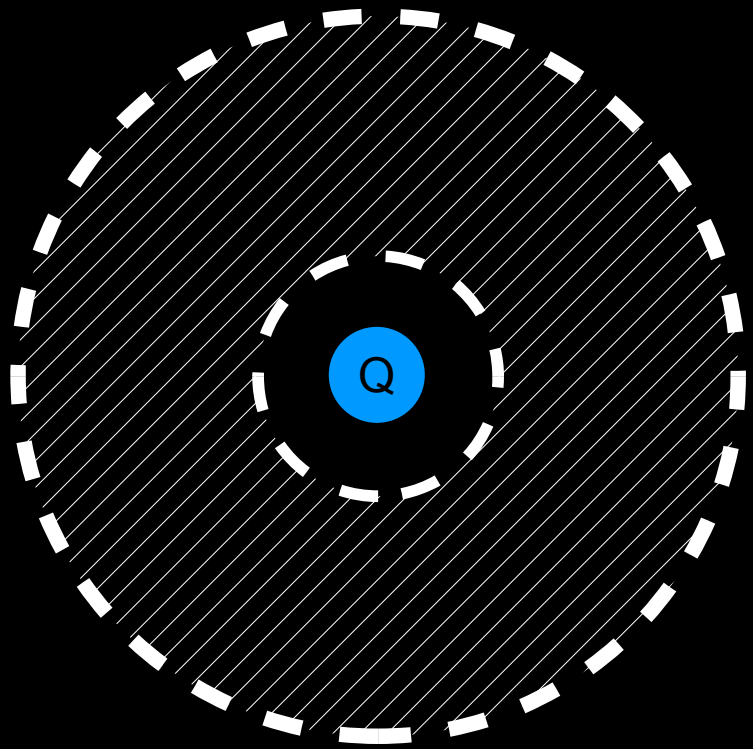
$b = 38$ kpc



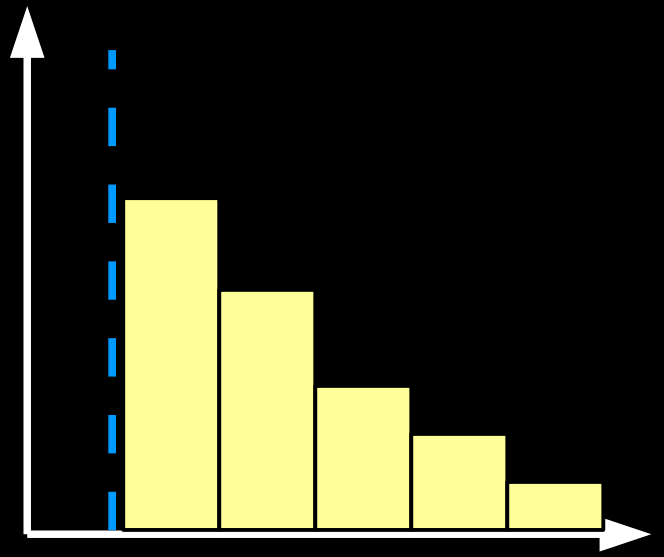
da Silva+2011,ApJ,735,54D

Q

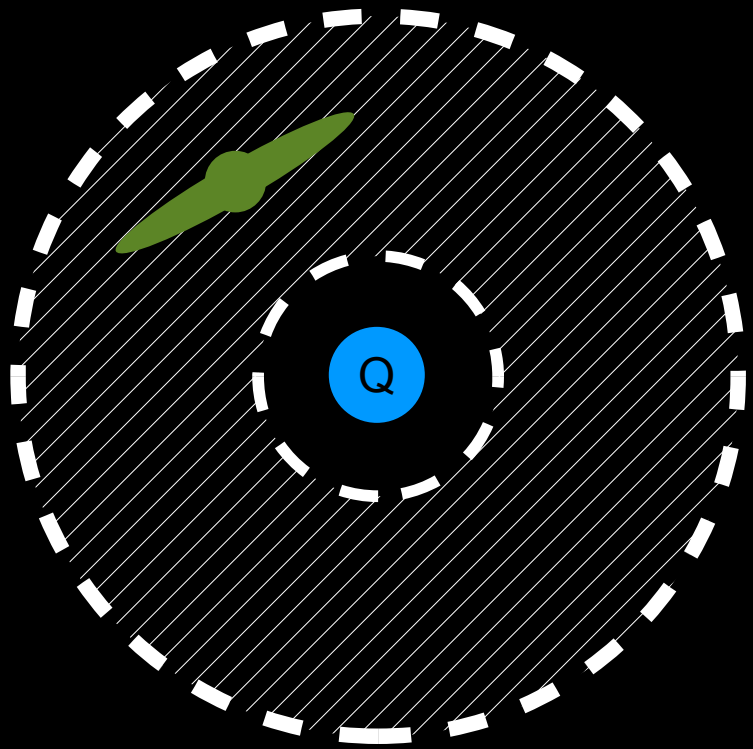

Q
30 kpc
80 kpc



$\Delta z < 3\sigma_z$



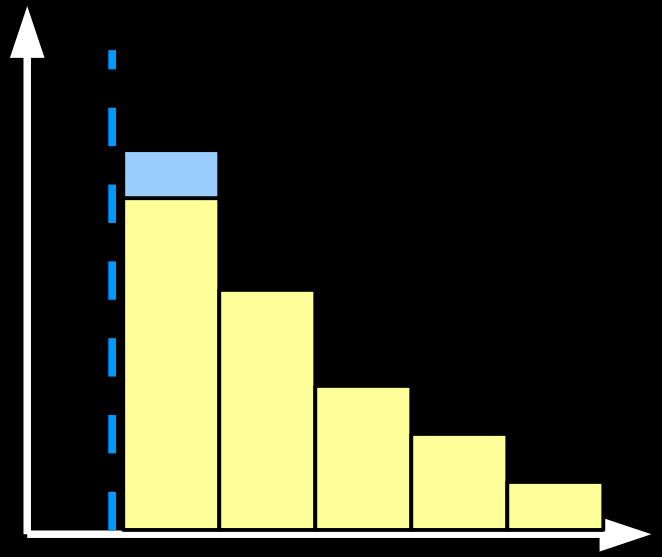
Mass Ratio



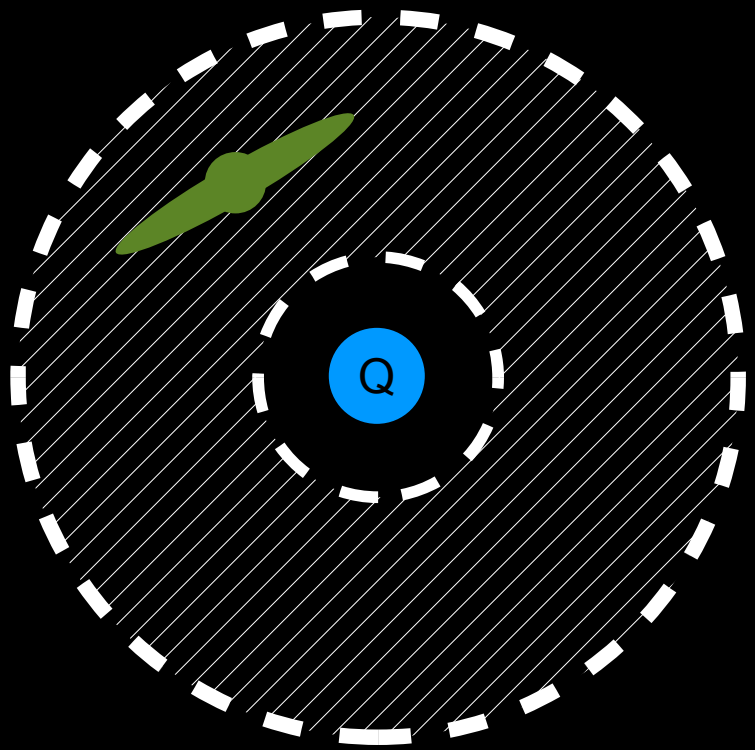
30 kpc

80 kpc

$\Delta z < 3\sigma_z$



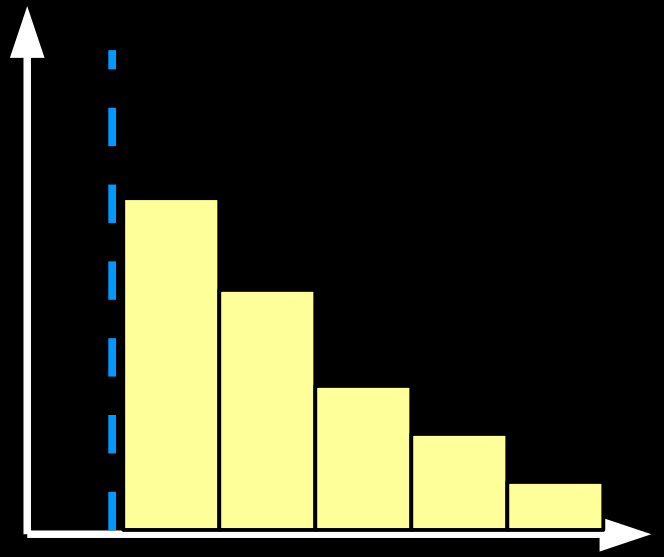
Mass Ratio



30 kpc

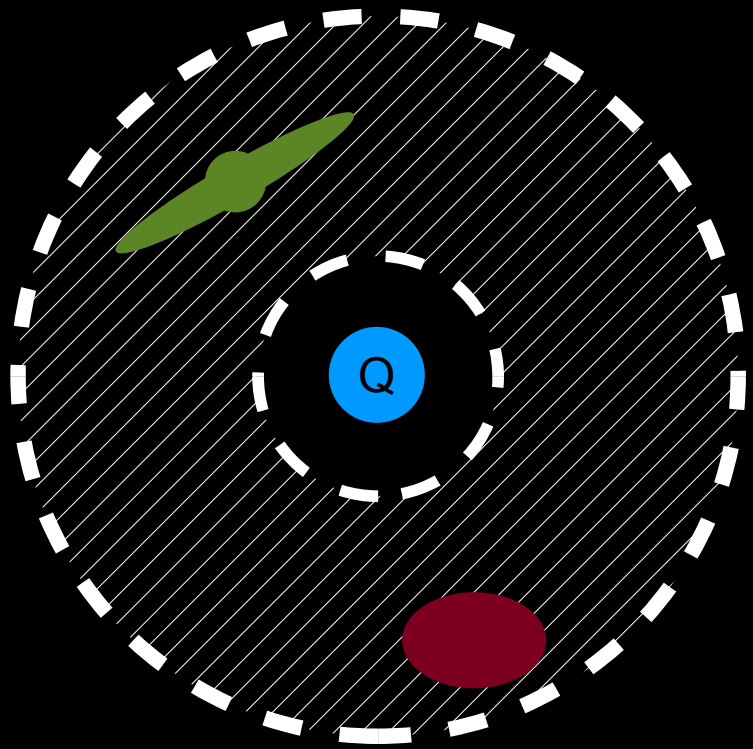
80 kpc

$\Delta z < 3\sigma_z$

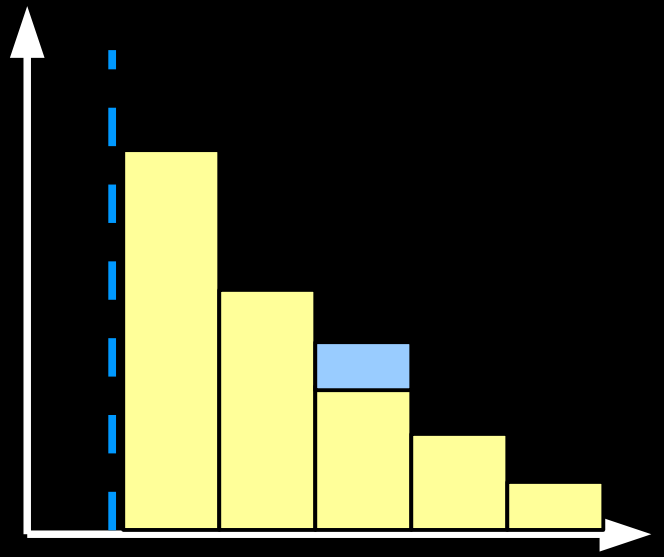


Mass Ratio

Completeness Limit

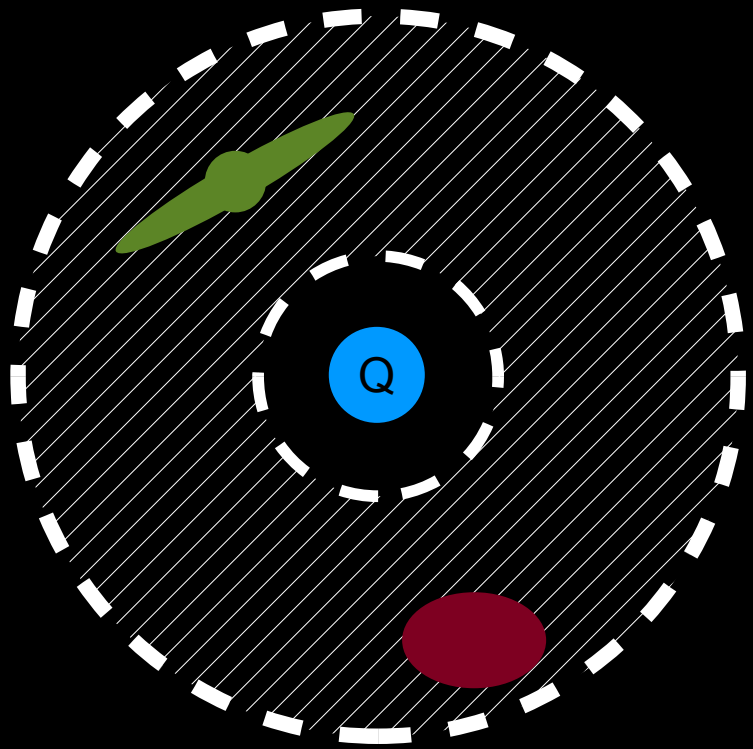


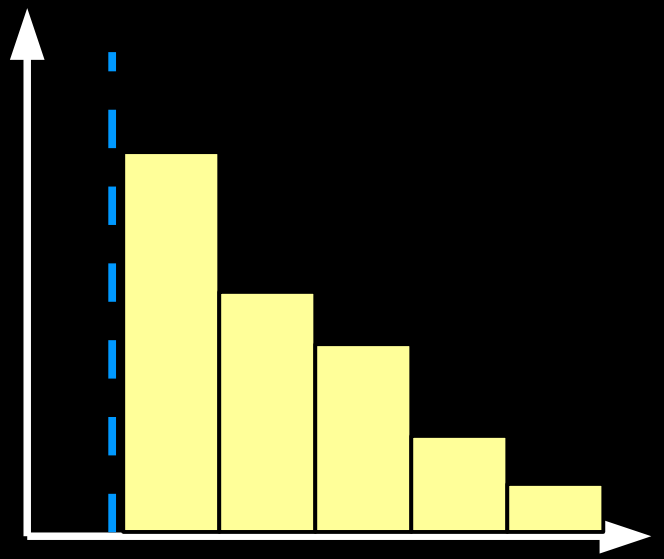
$\Delta z < 3\sigma_z$



Mass Ratio

$\Delta z < 3\sigma_z$





Mass Ratio

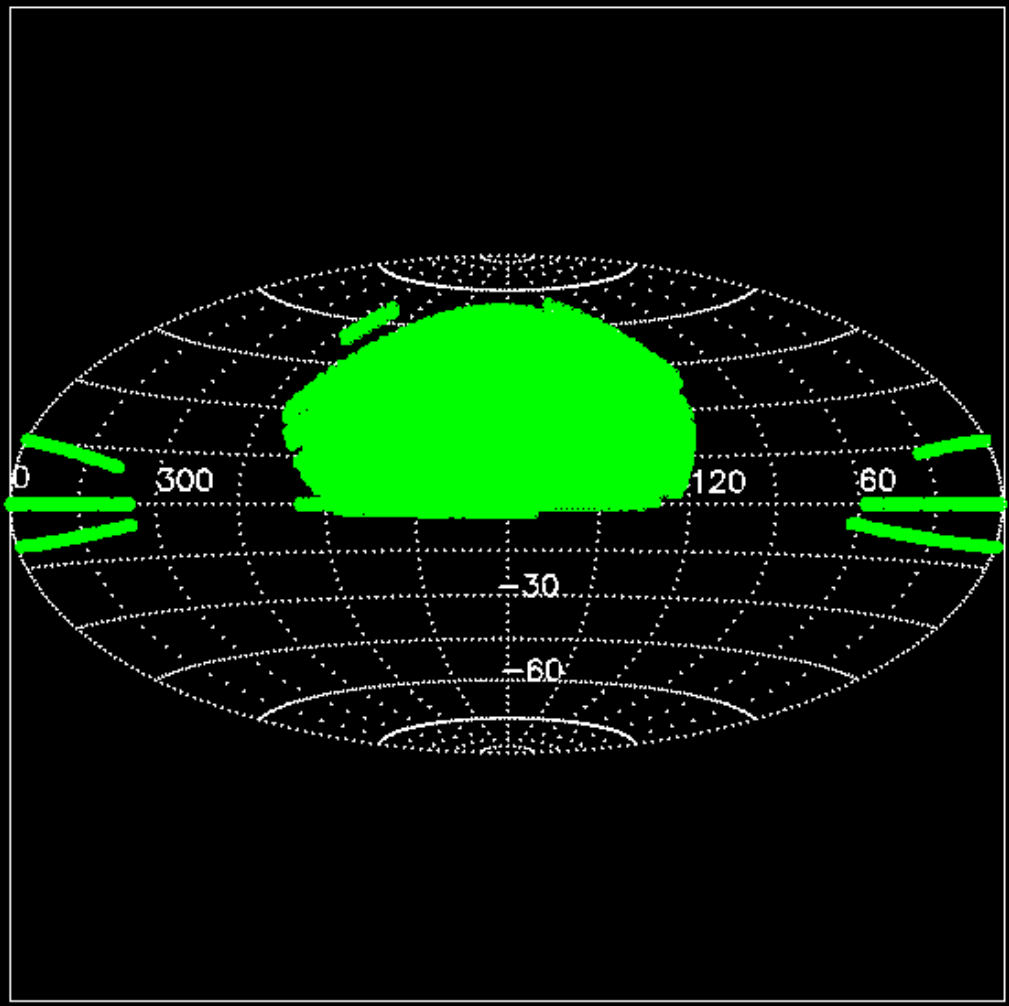
Our Sample

- We have a catalog of SDSS z<0.2 quasars with estimated BH masses (Shen+ 2010)

- The Magorrian relation tells us

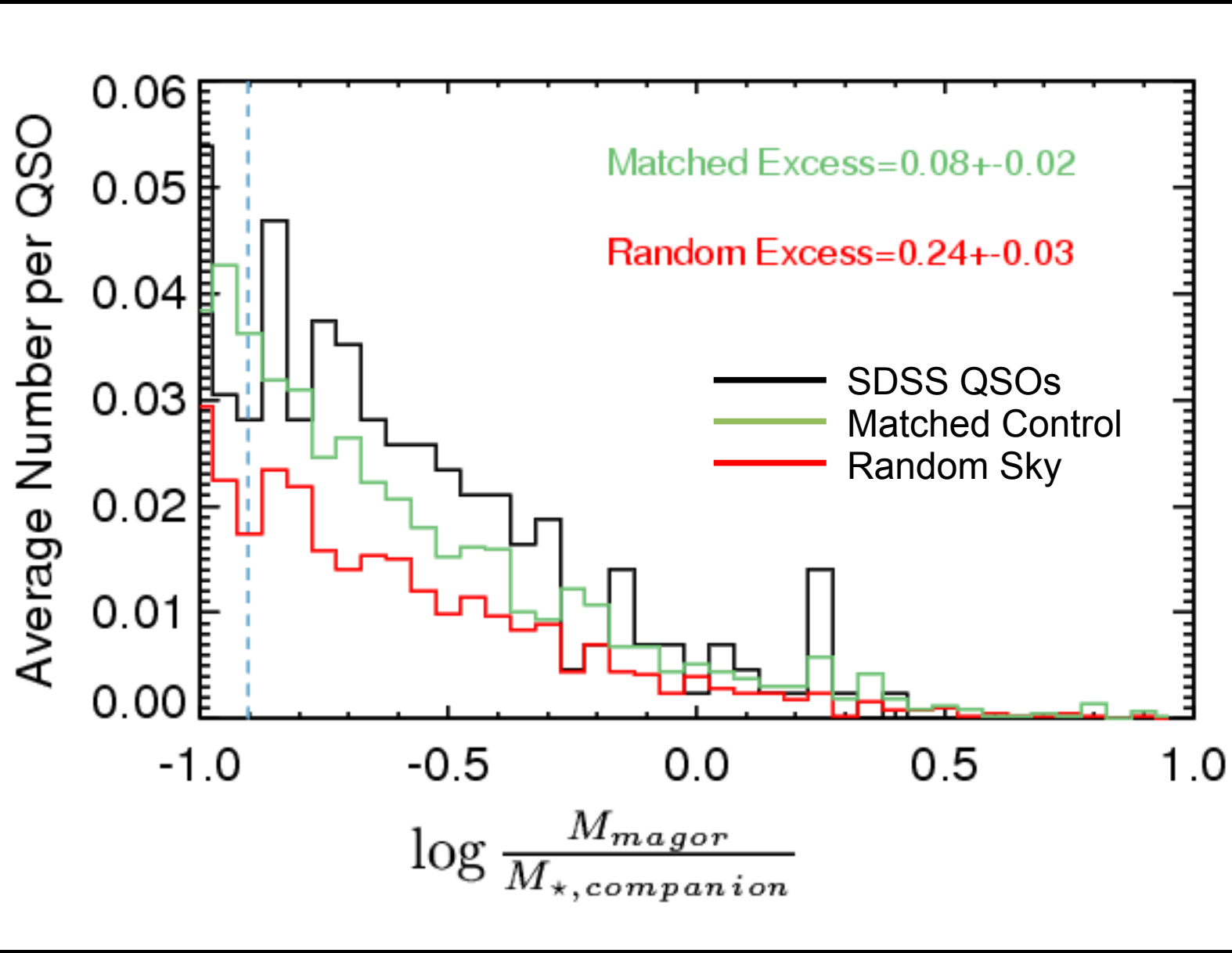
$$M_\star \sim 167 M_{BH}$$

- We can use *ugriz* photometry to estimate stellar masses of nearby projected galaxies as well as their photometric redshifts

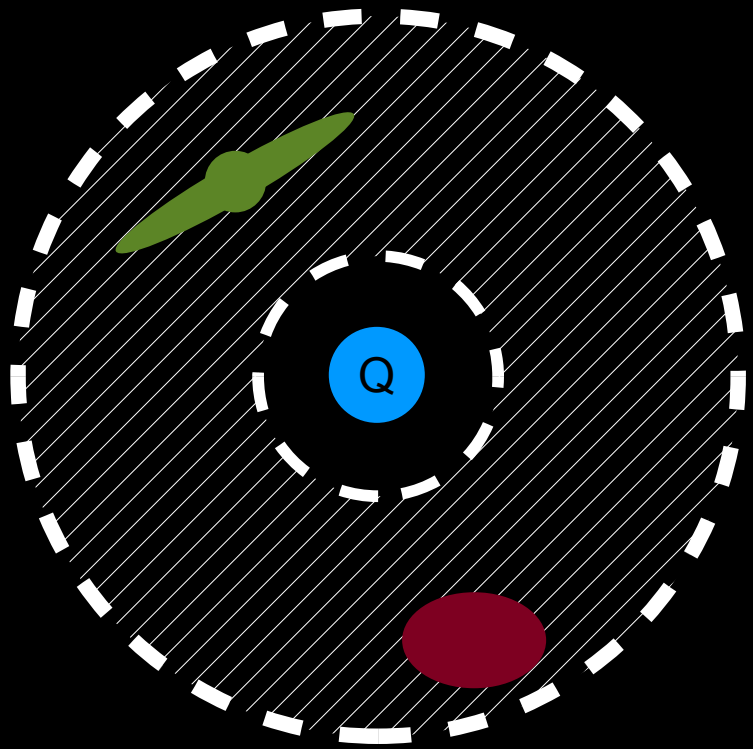


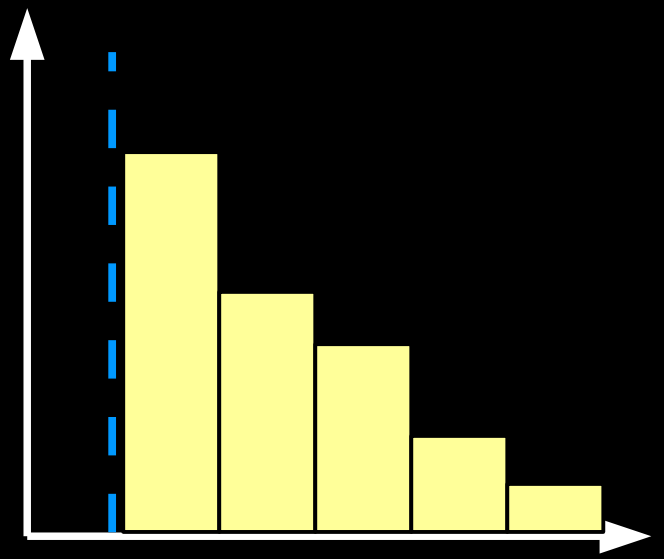
SDSS DR7 Spectral Footprint

Detected Excess

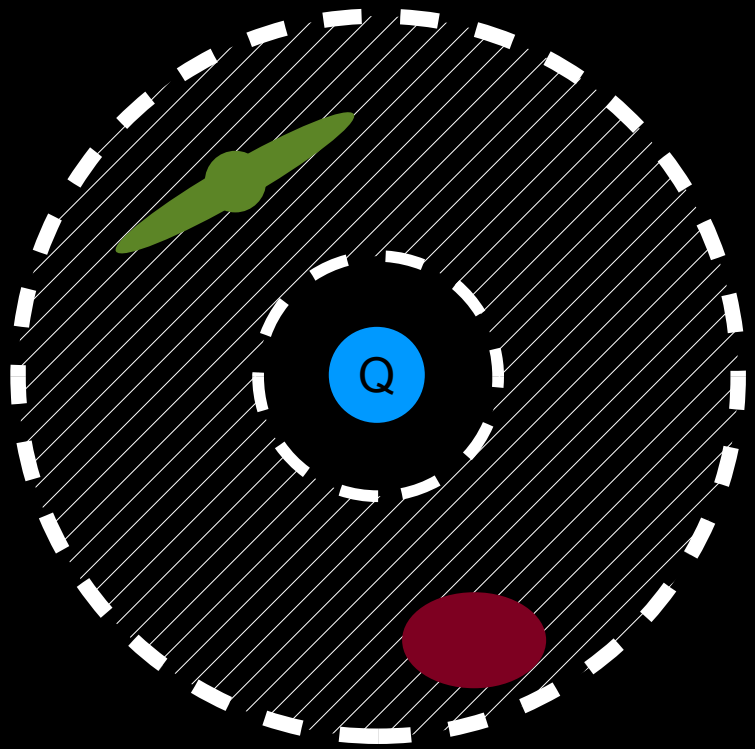


$\Delta z < 3\sigma_z$

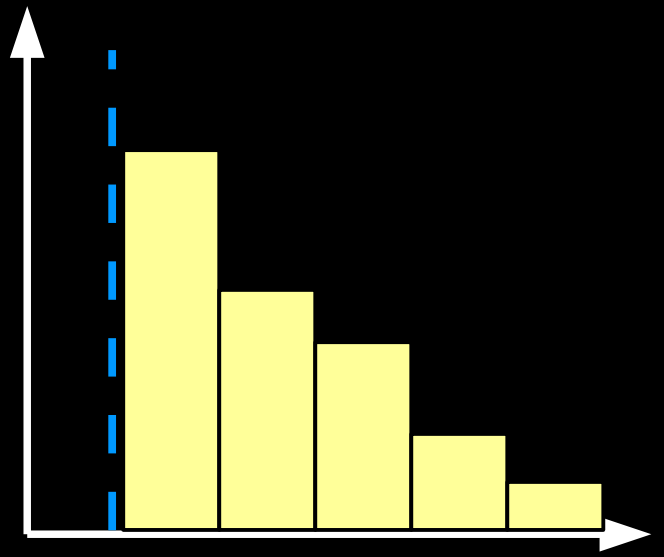




Mass Ratio



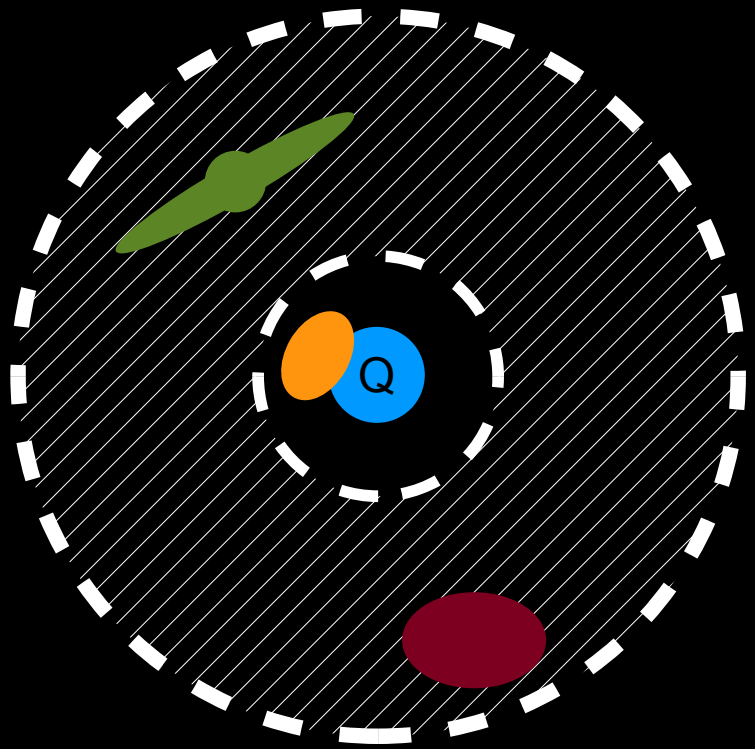
$\Delta z < 3\sigma_z$



Mass Ratio

30 kpc

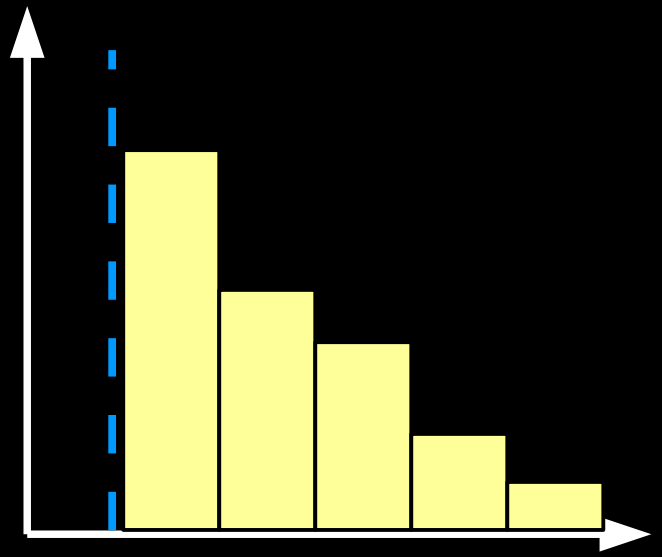
80 kpc



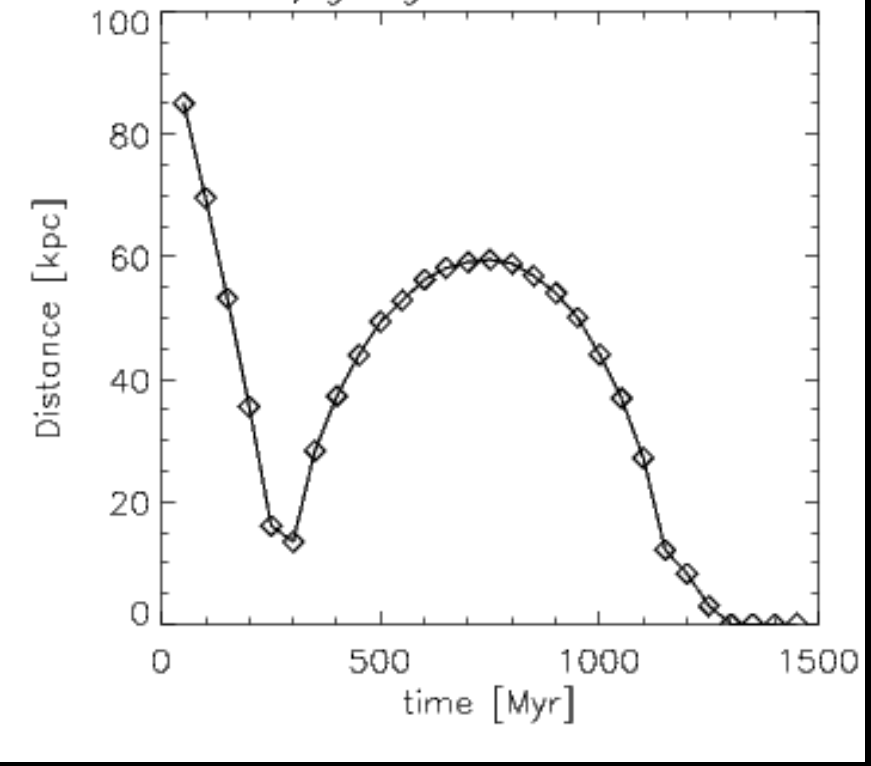
30 kpc

80 kpc

$\Delta z < 3\sigma_z$



Mass Ratio

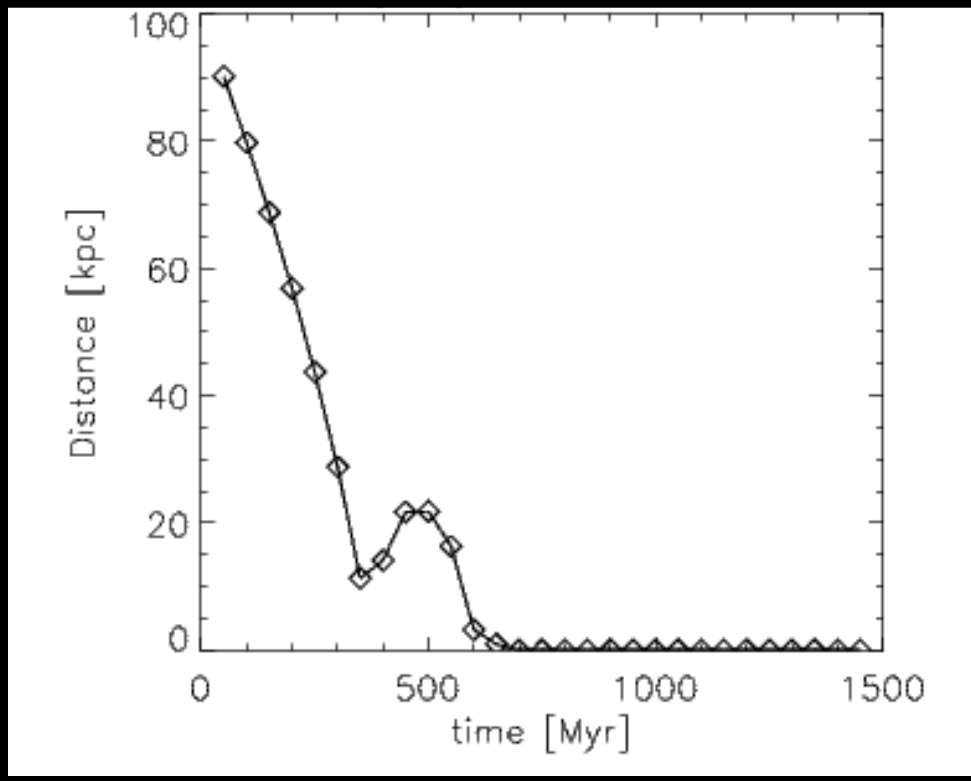

Distance [kpc]
time [Myr]
0
20
40
60
80
100
0
500
1000
1500

?

?

?

?


Distance [kpc]
time [Myr]
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20
40
60
80
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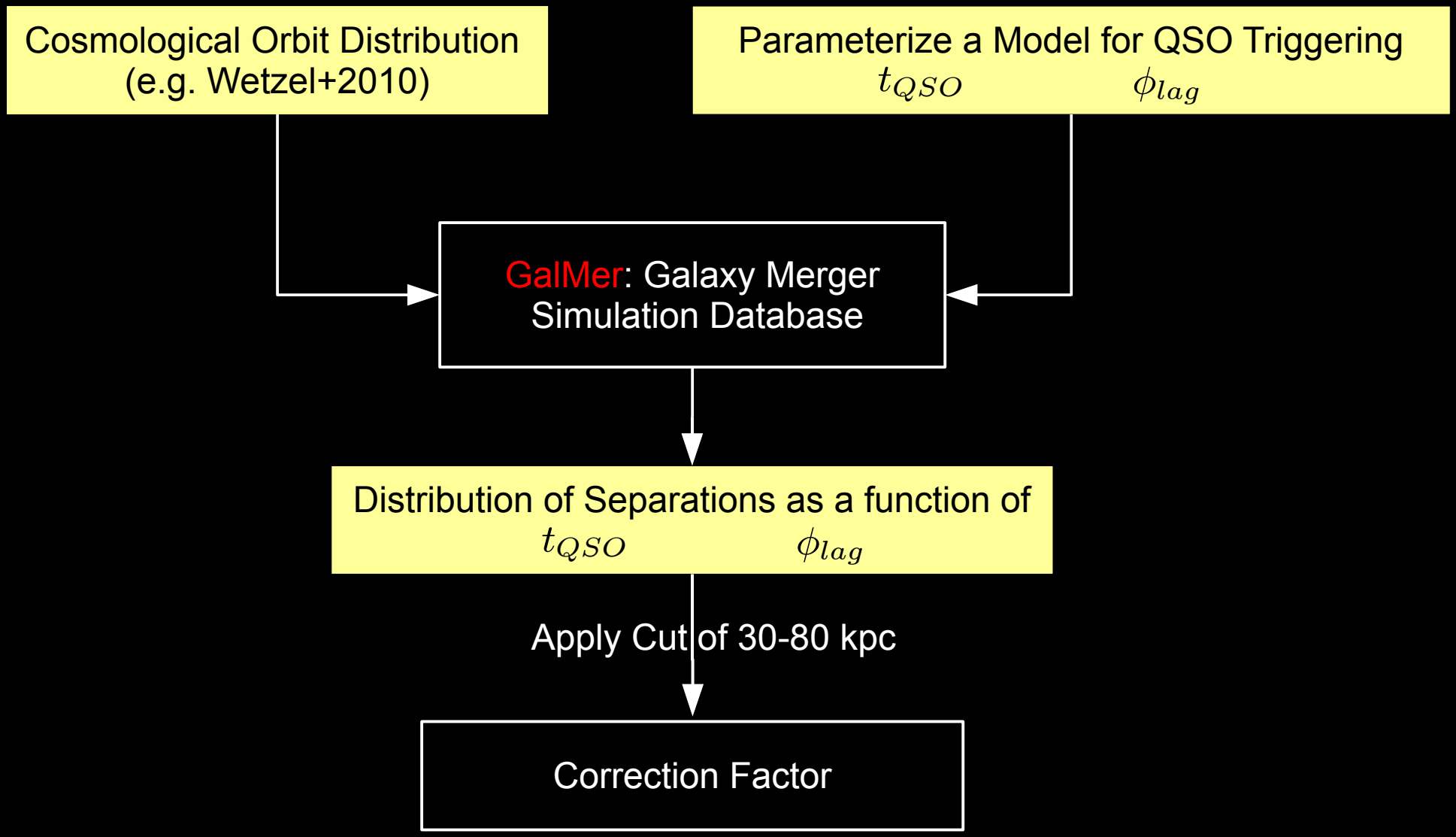
0
500
1000
1500

Completeness Correction

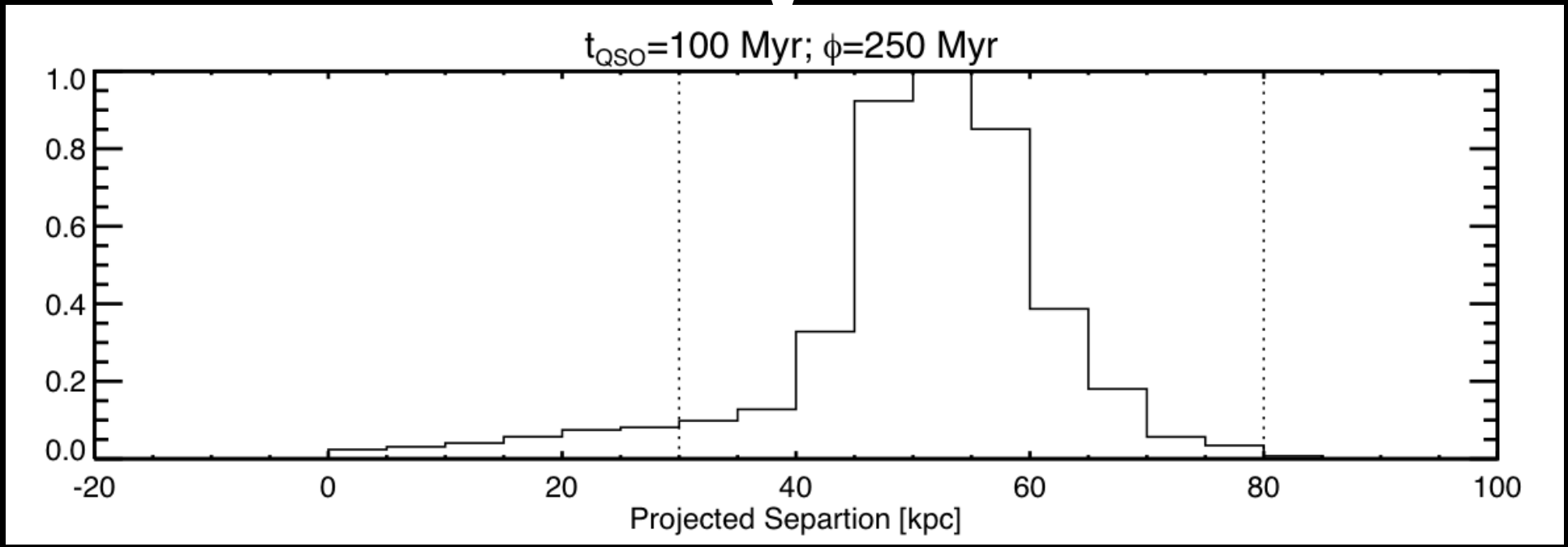


Completeness Correction

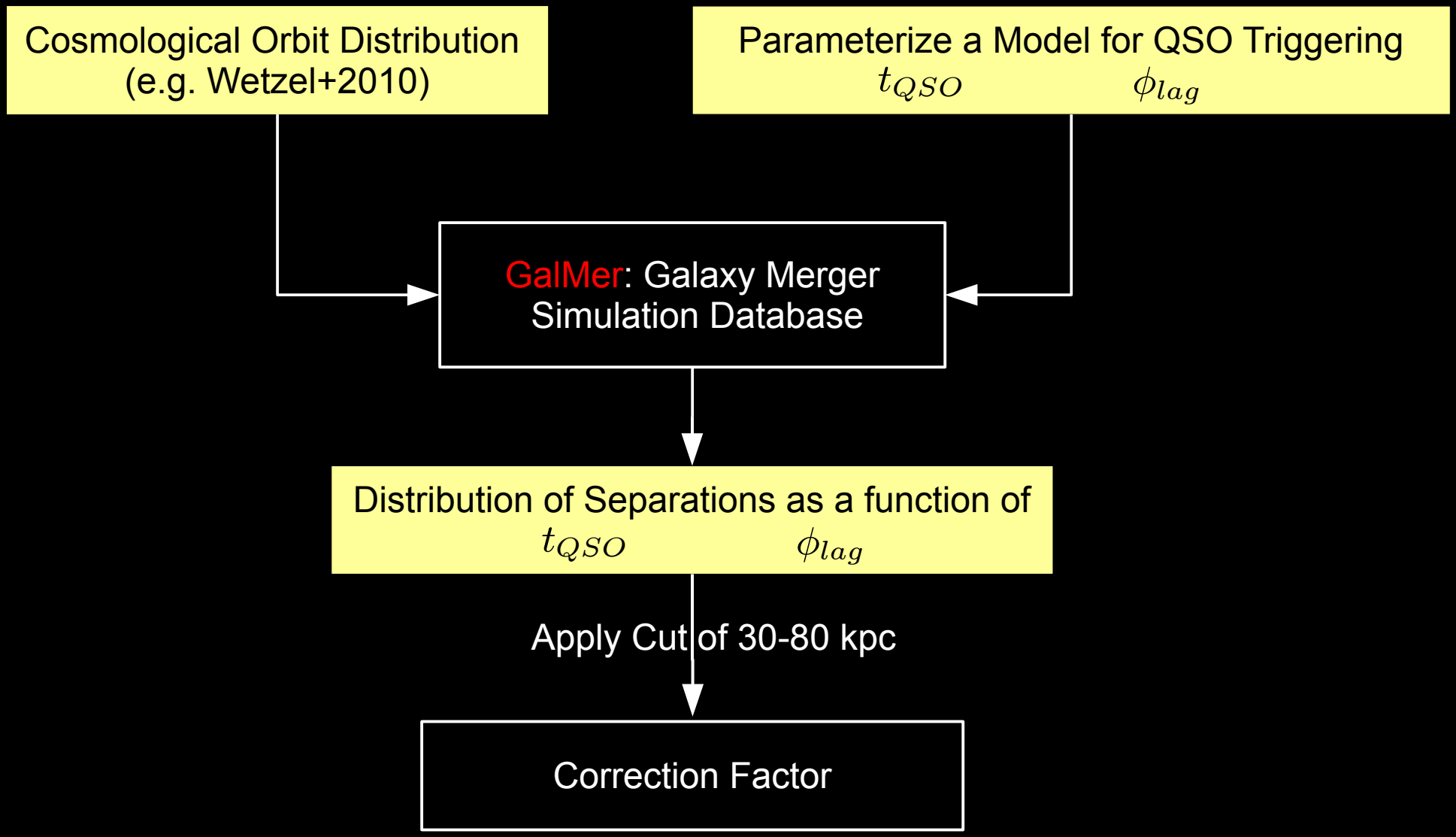
Cosmological Orbit Distribution
(e.g. Wetzel+2010)

Parameterize a Model for QSO Triggering
t_{QSO} ϕ_{lag}

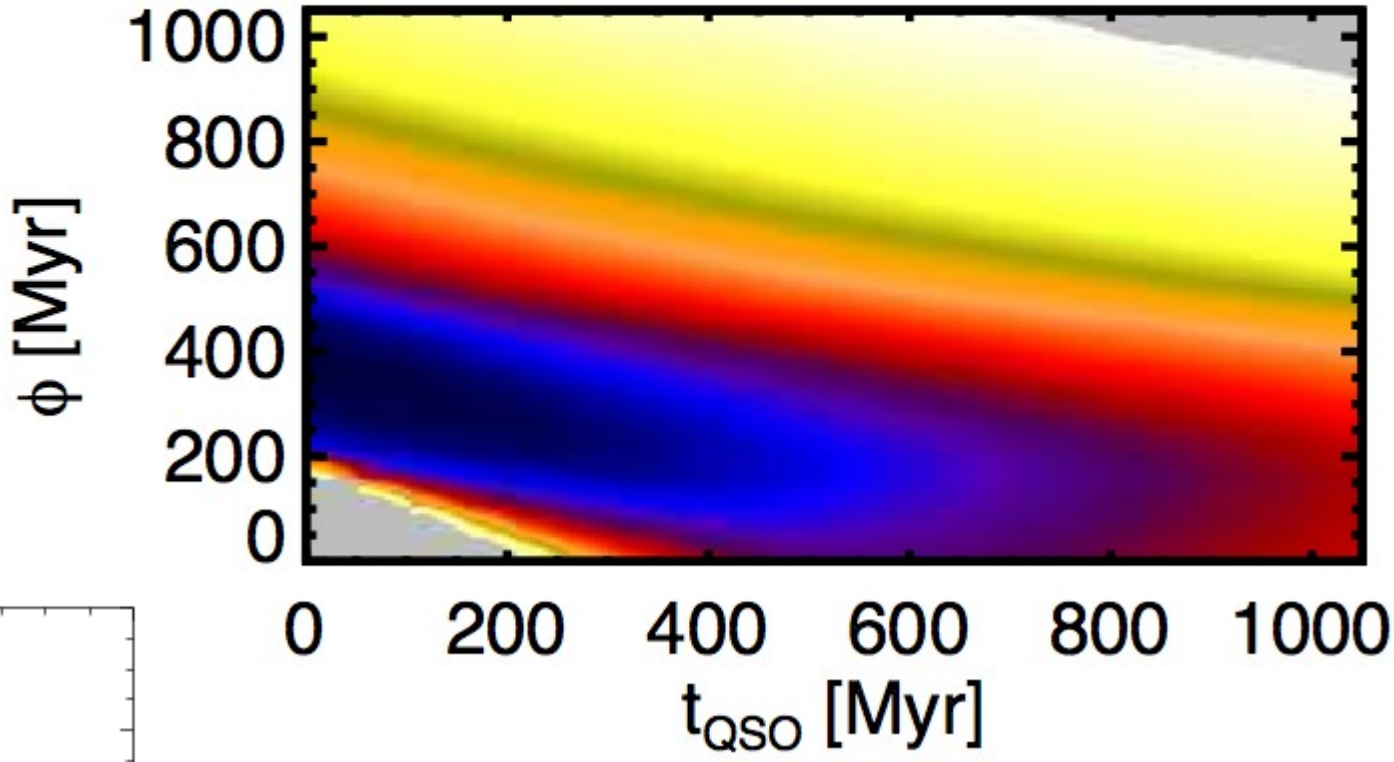
GalMer: Galaxy Merger
Simulation Database



Completeness Correction



2
4
7
9
11
14
16


1000
800
600
400
200
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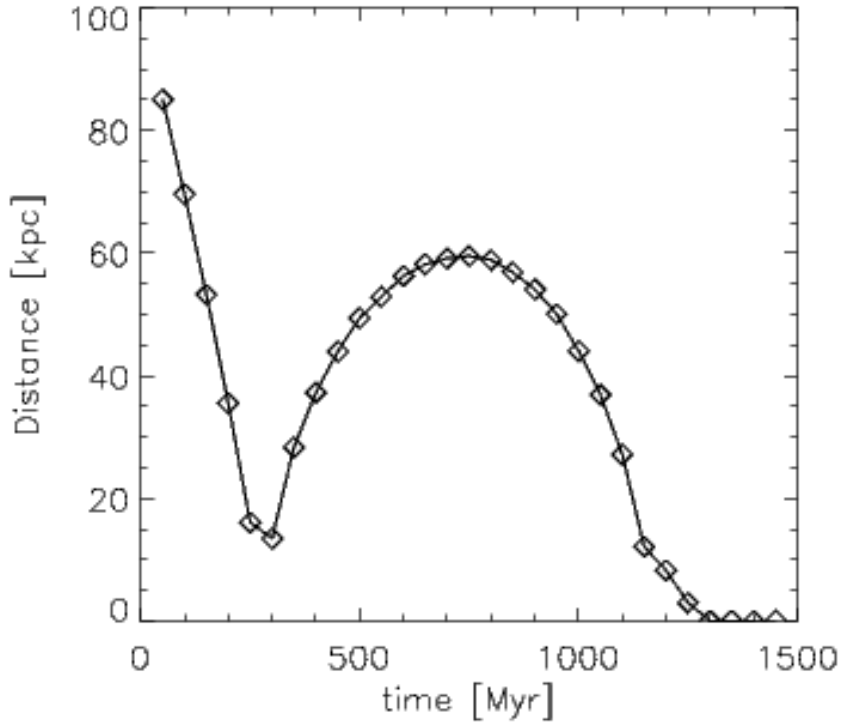
ϕ [Myr]
0
200
400
600
800
1000
t_{QSO} [Myr]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Distance [kpc]
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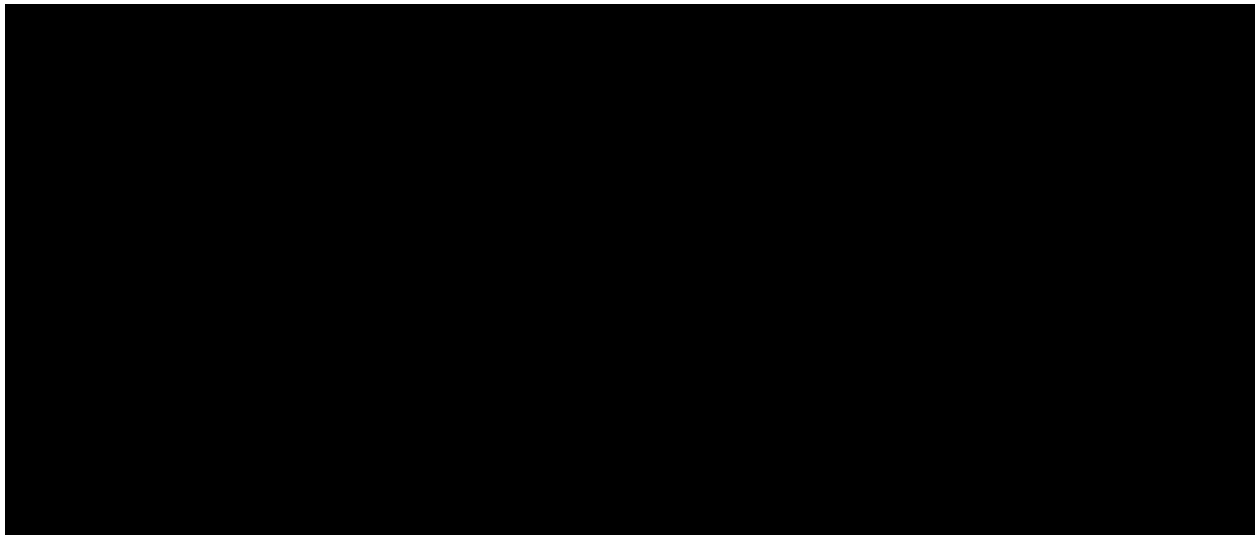
time [Myr]



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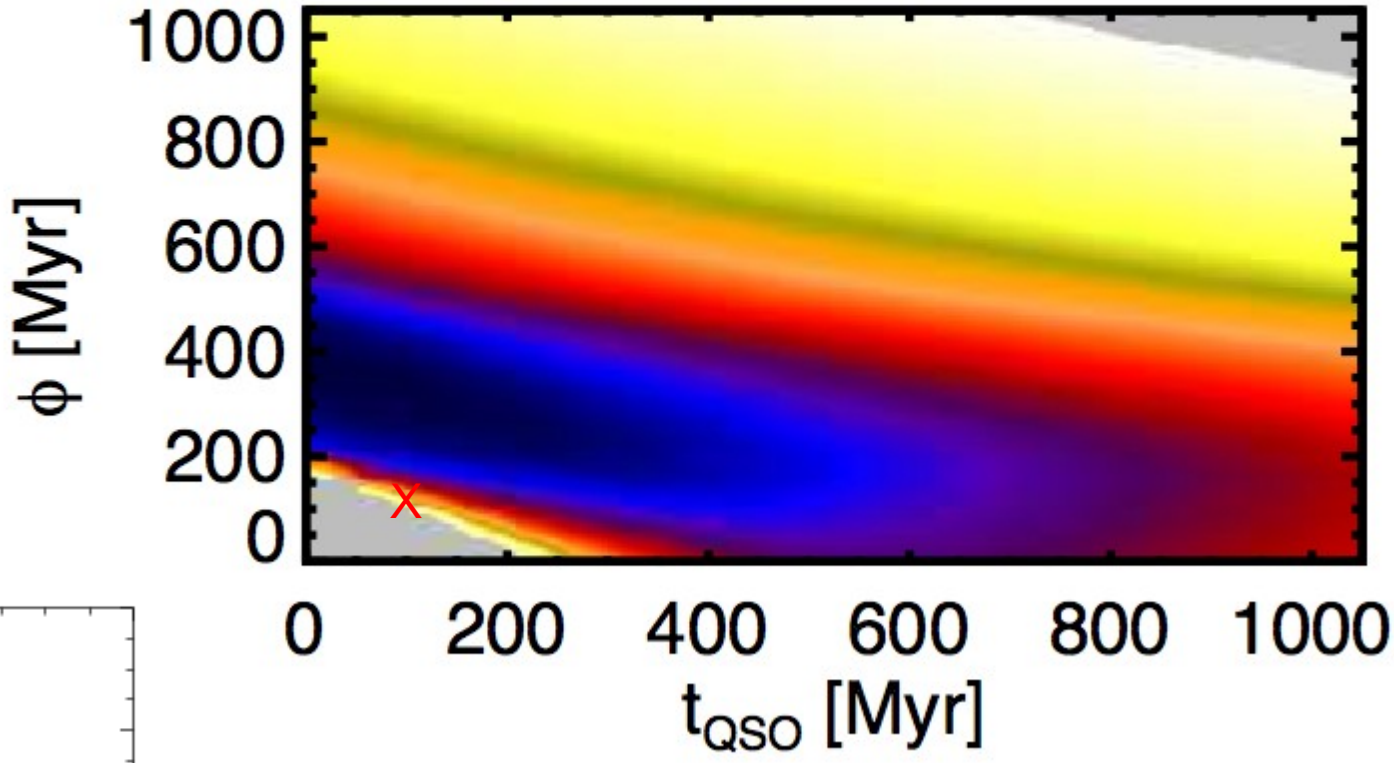
1000
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ϕ [Myr]
0
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600
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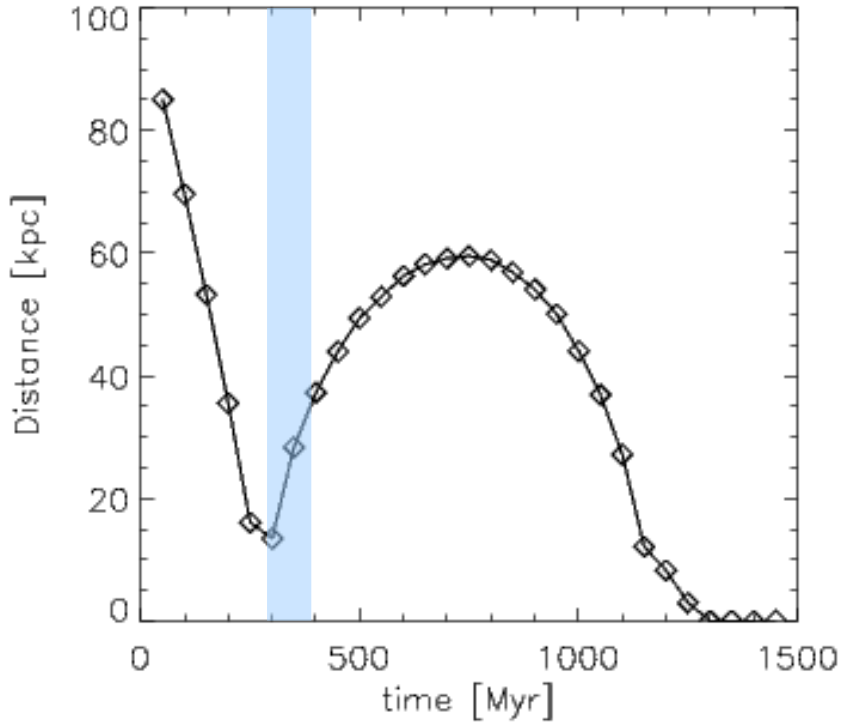
t_{QSO} [Myr]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Distance [kpc]
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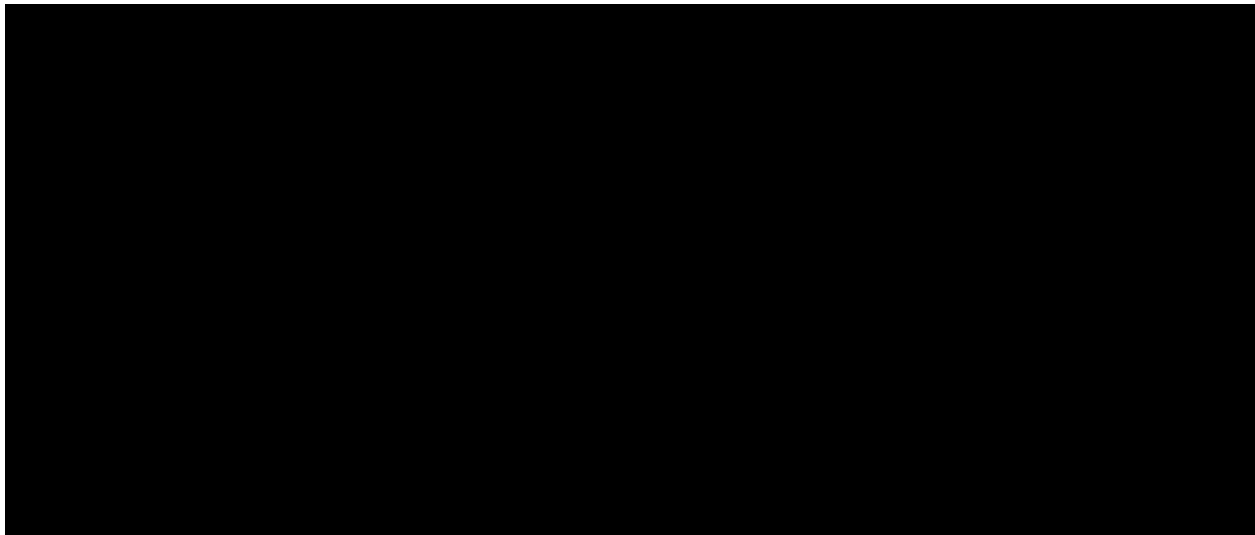

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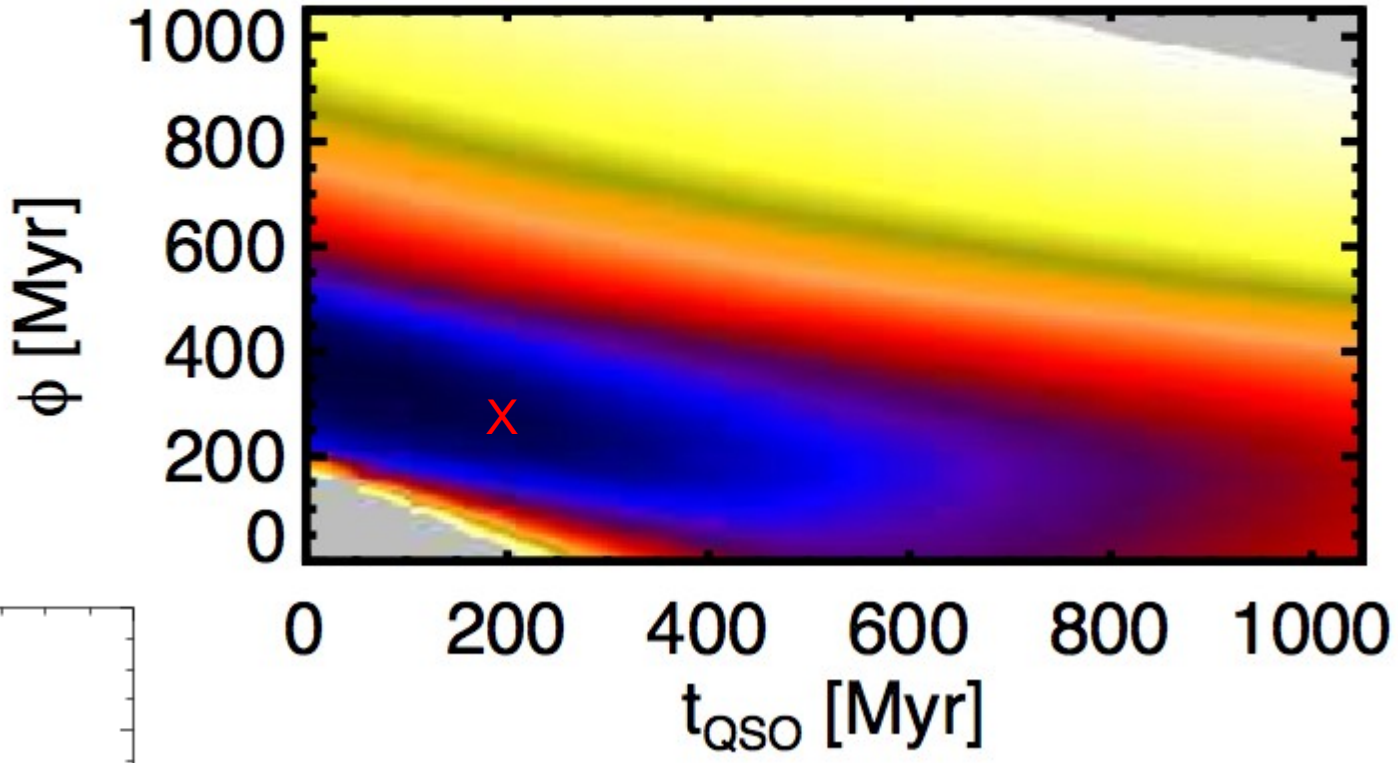
1000
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ϕ [Myr]
X
0
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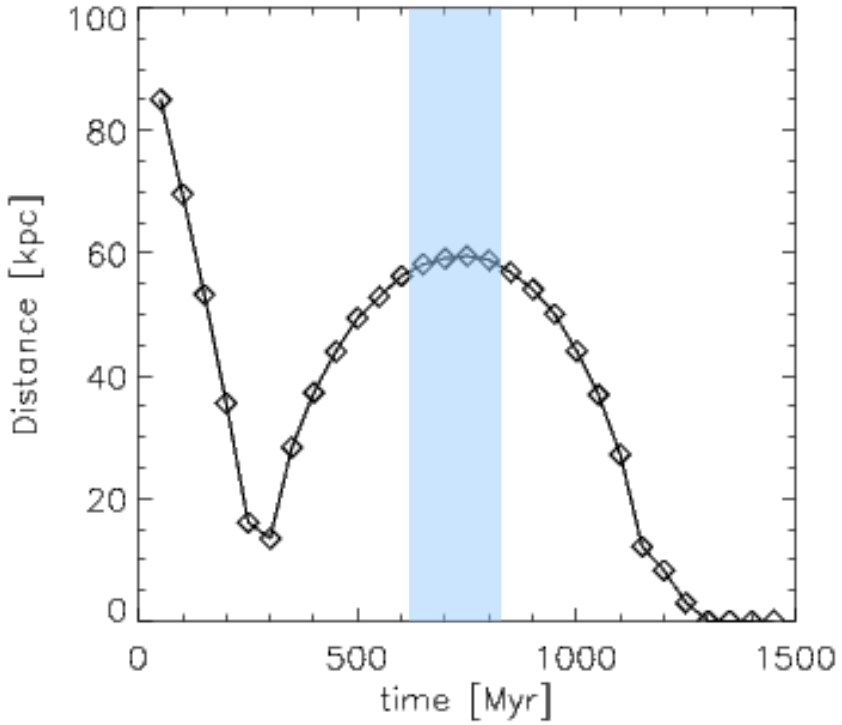
t_{QSO} [Myr]


100
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Distance [kpc]
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1000
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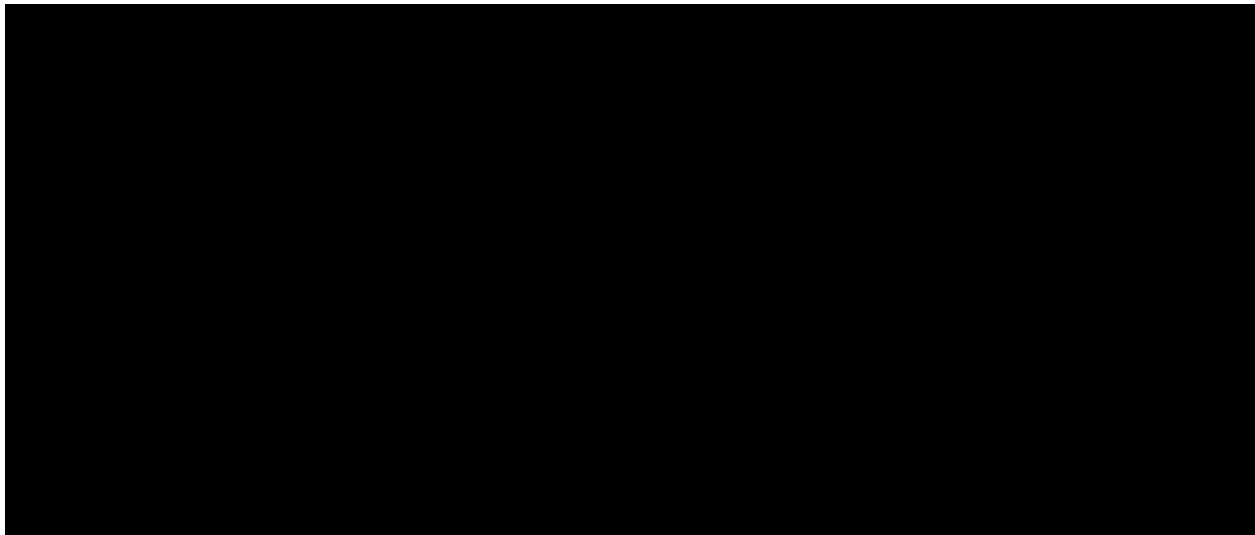
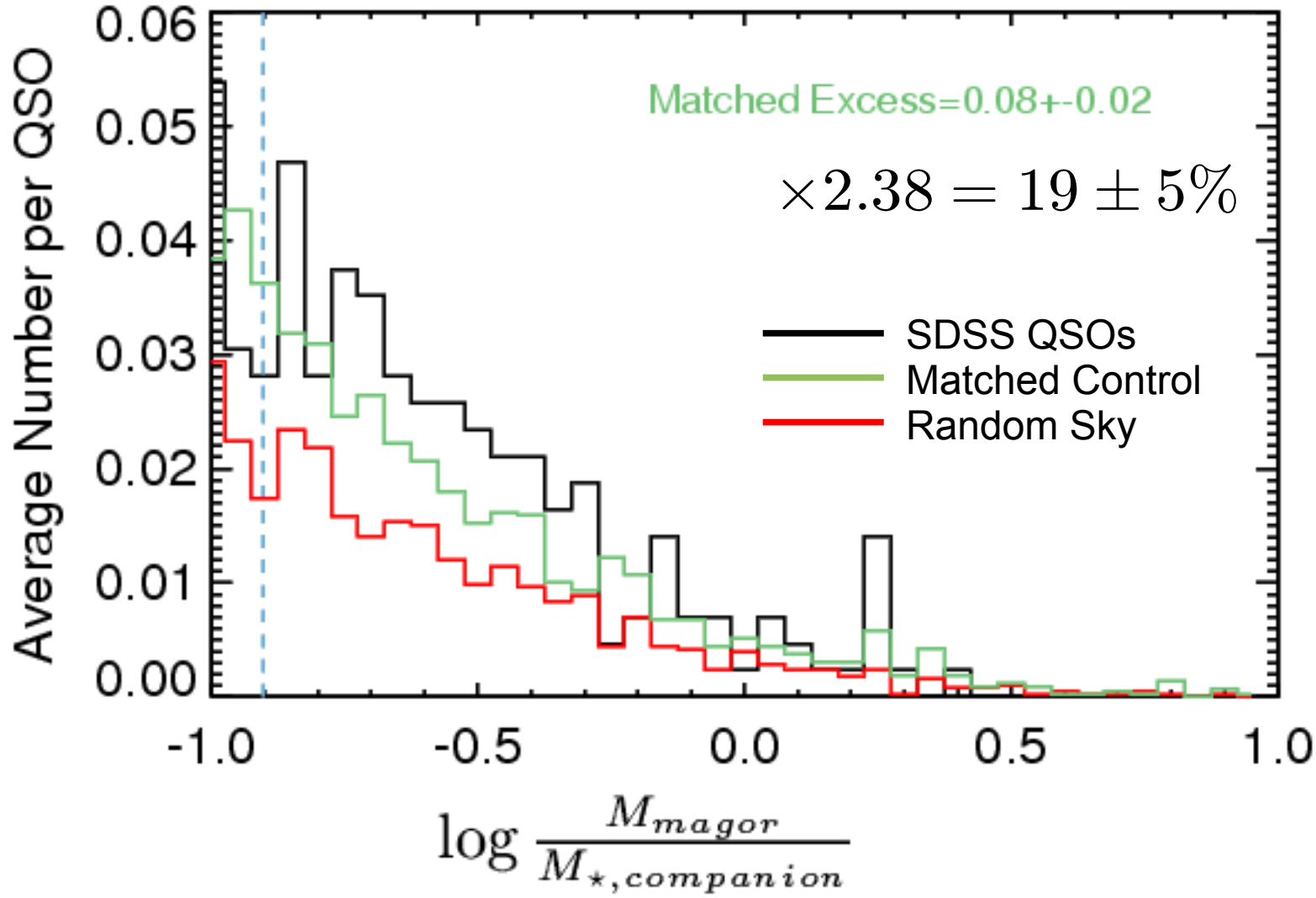
time [Myr]



$t_{qso} = 10$ Myr $\phi_{lag} = 250$ Myr



Future Work

- Study interacting pairs where one galaxy is in a quasar phase
  -Awaiting HST data from successful proposal to study morphologies of galaxies in same merger stage

- Search for more pairs with quasar photoionized extended tidal features

- Comparison of SMBH and galaxy masses at this intermediate stage will provide insights on evolution along the Magorrian relation

Summary

- Statistical study performed studying companions near z<0.2 SDSS QSOs to determine which fraction of quasars are triggered during the first passage stage of a merger

- Determined a significant excess (>8±2 %) companions near quasars (30-80 kpc) interpreted as galaxies interacting with QSO hosts

- Used simulations to estimate a completion correction which increases fraction to ~ 20%

Thank You

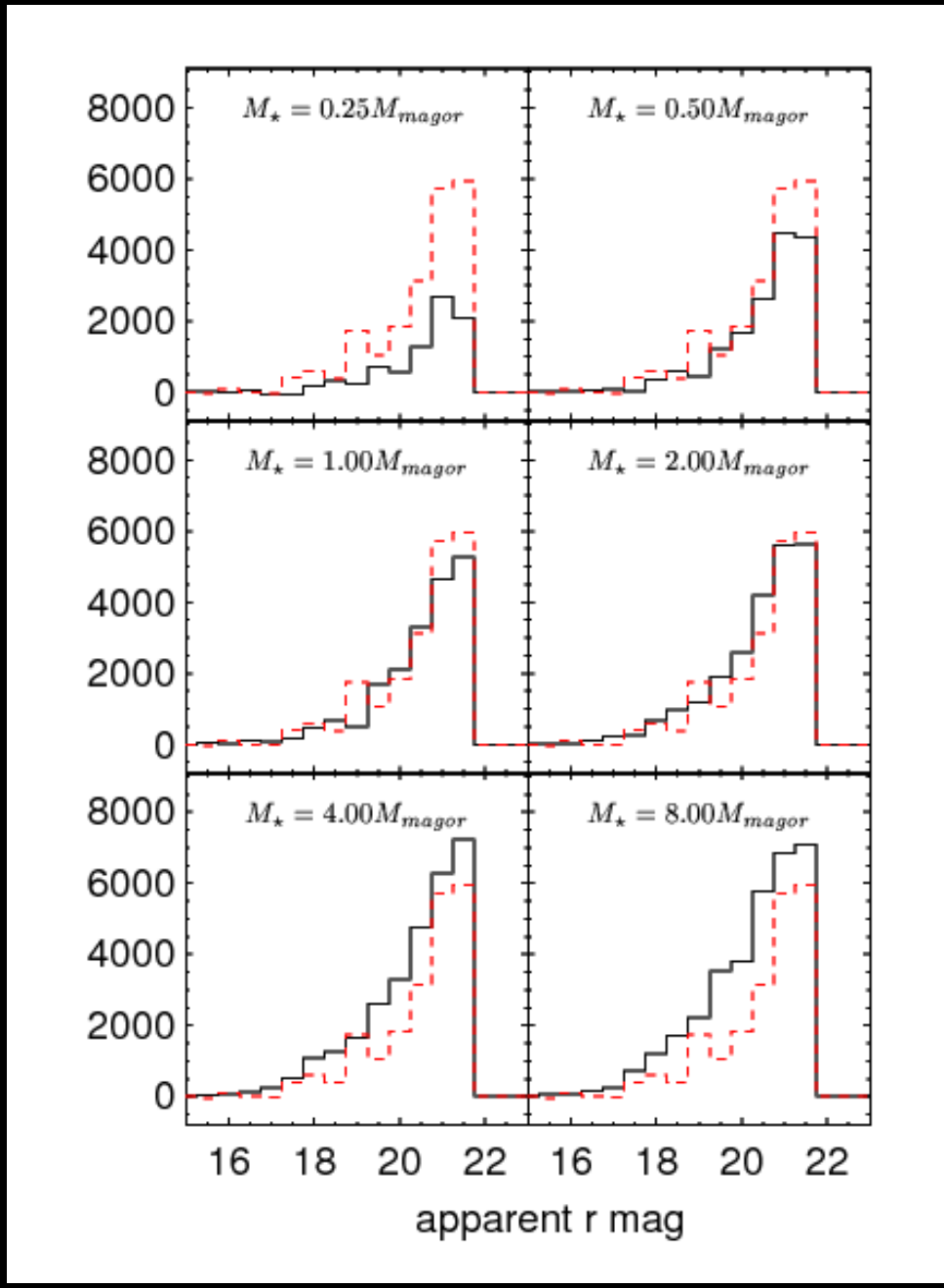
Perform the same experiment on two sets of control fields

1.) Empty Sky

2.) Mass-matched Control Sample

-Magorrian Mass is not an ideal proxy for stellar mass (M_{magor})

- compare luminosity functions in an interval of 1-1.2 Mpc

-Find a factor of 2 correction

Expect the accurate background to be bracketed by these two cases