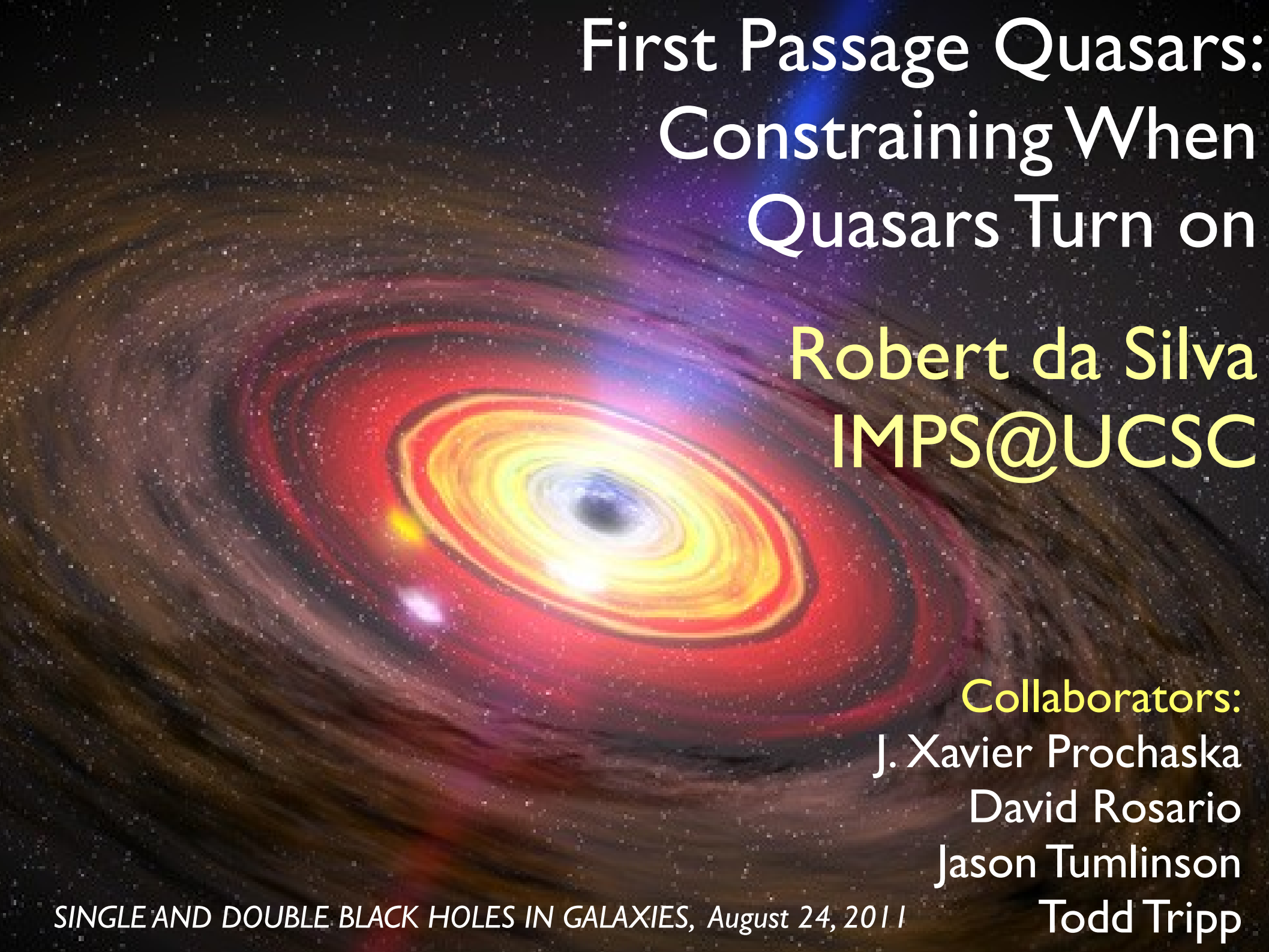

First Passage Quasars: Constraining When Quasars Turn on

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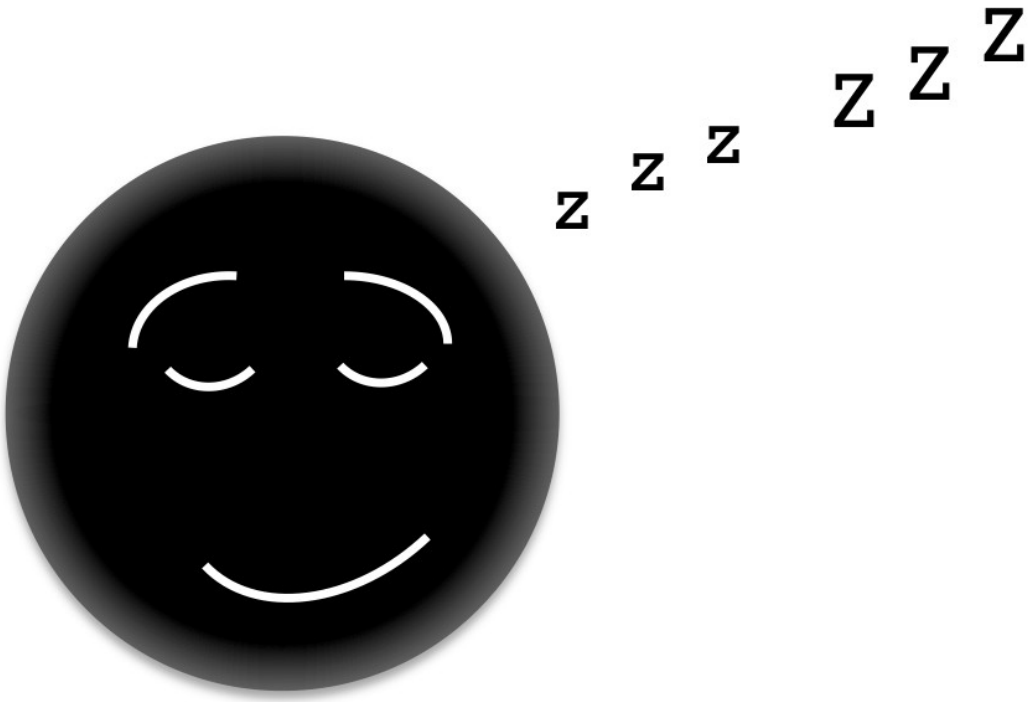
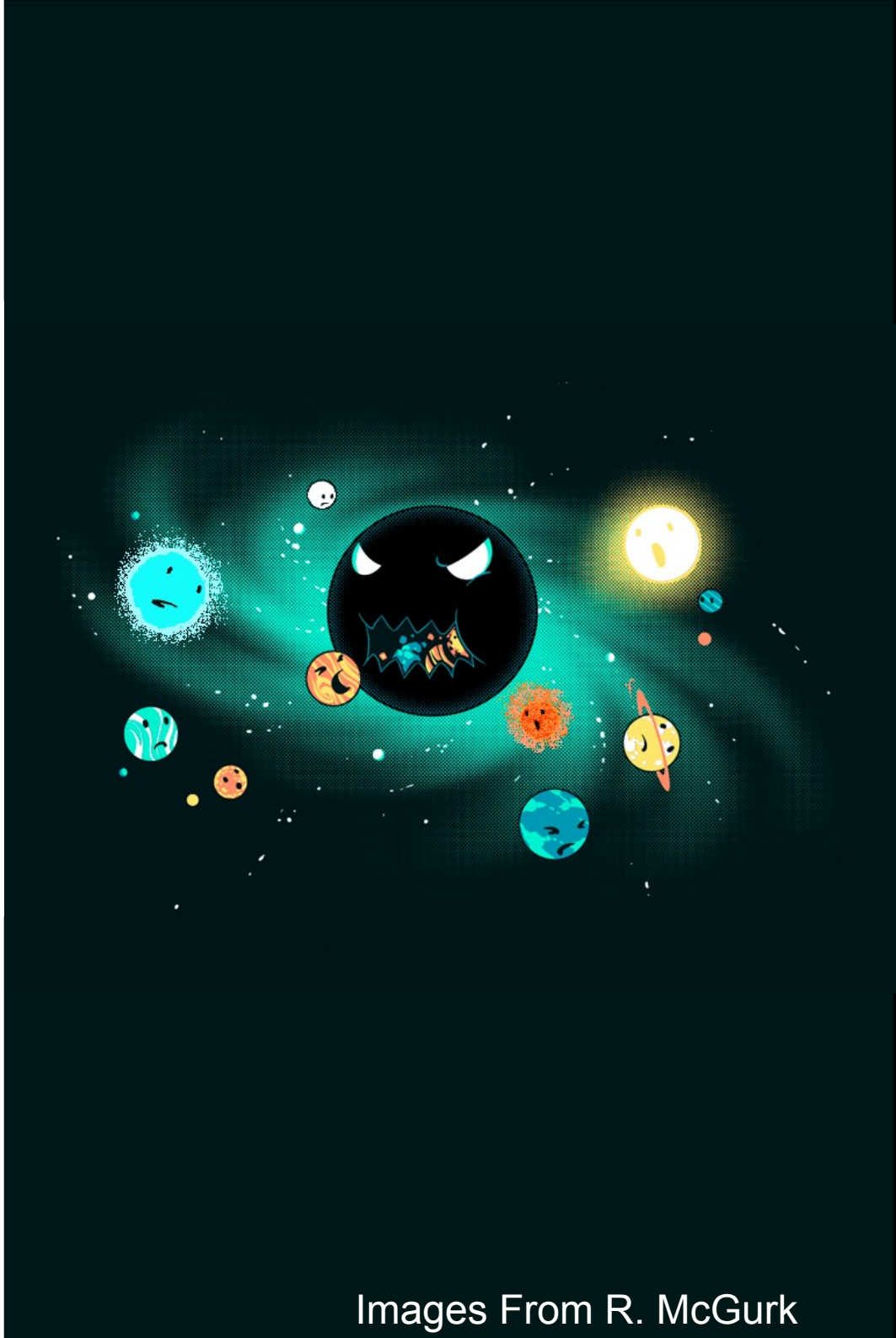
David Rosario
Jason Tumlinson
Todd Tripp

SINGLE AND DOUBLE BLACK HOLES IN GALAXIES, August 24, 2011





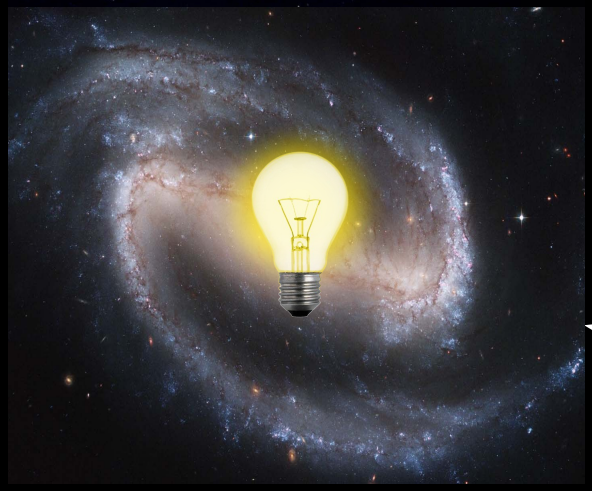
Images From R. McGurk

How/When QSOs Turn on

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

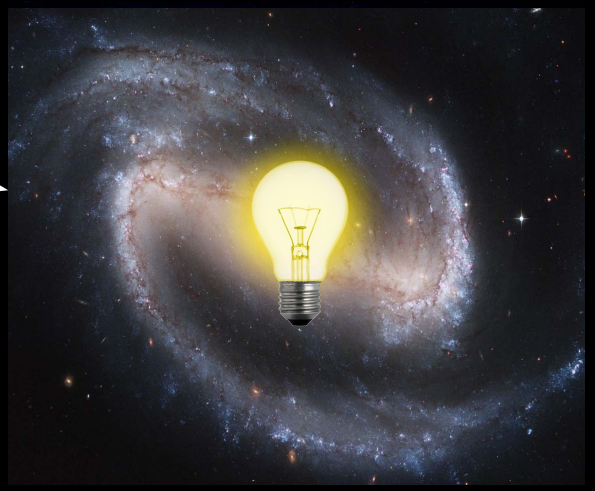
Can occur during two phases

a) After First Passage



Tidal torques → Bar Formation → Gaseous Inflow

≈ 100 kpc



How/When QSOs Turn on

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

Can occur during two phases

a) After First Passage

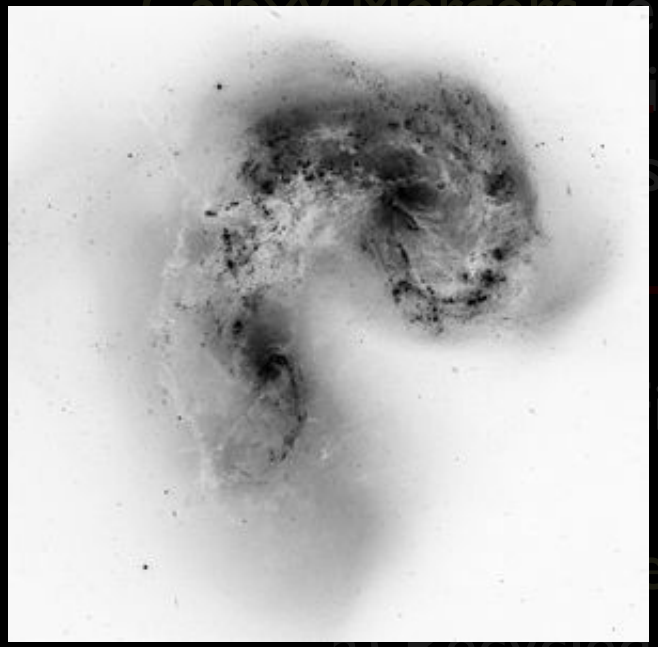
b) During Final Coalescence

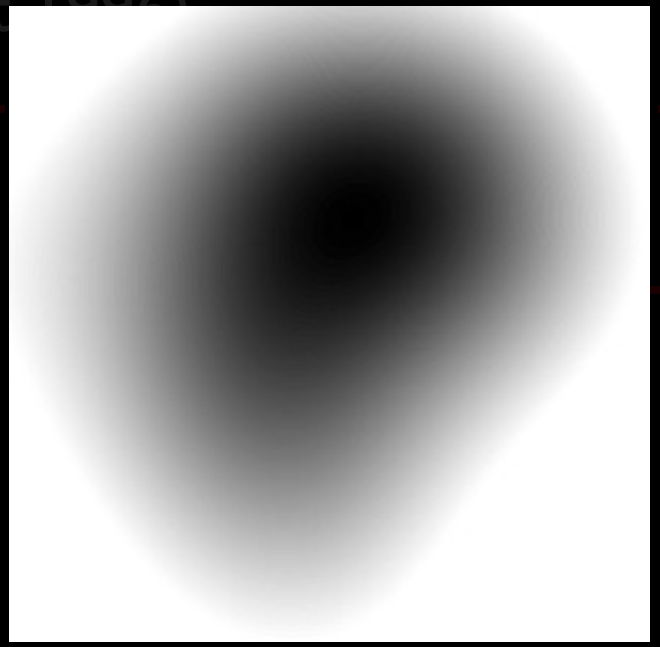
Secular Process: i.e. "Non-Merging"

a) Recycled gas
(Ciotti & Ostriker2007)

b) Wild Disk Instabilities
(Bournaud+2011)

How/When QSOs Turn on





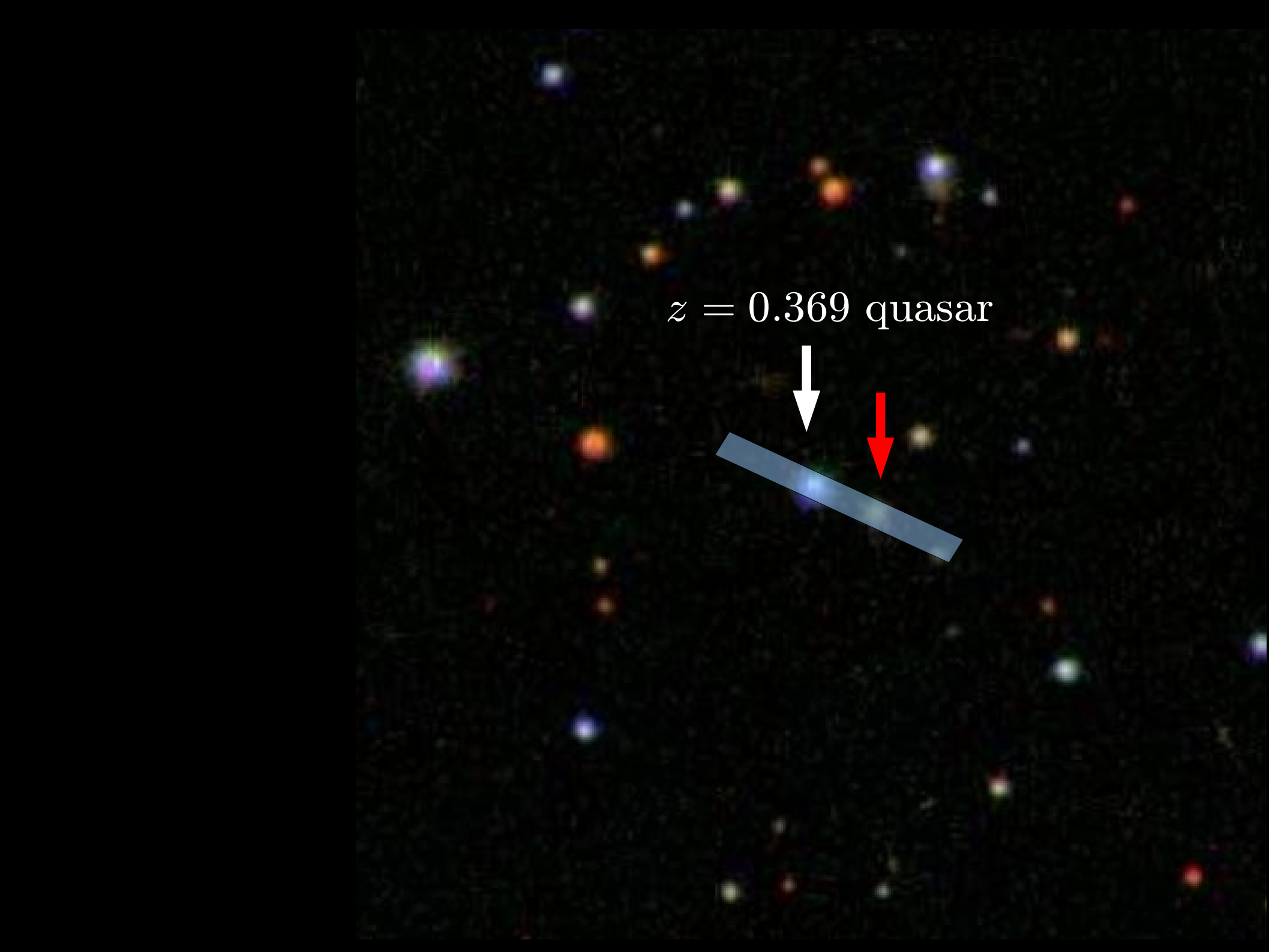
Single Galaxy

First Passage Quasar

- A quasar that has been triggered during the first passage of a merger event

- Expect a companion galaxy at ~50 kpc with comparable mass to quasar host

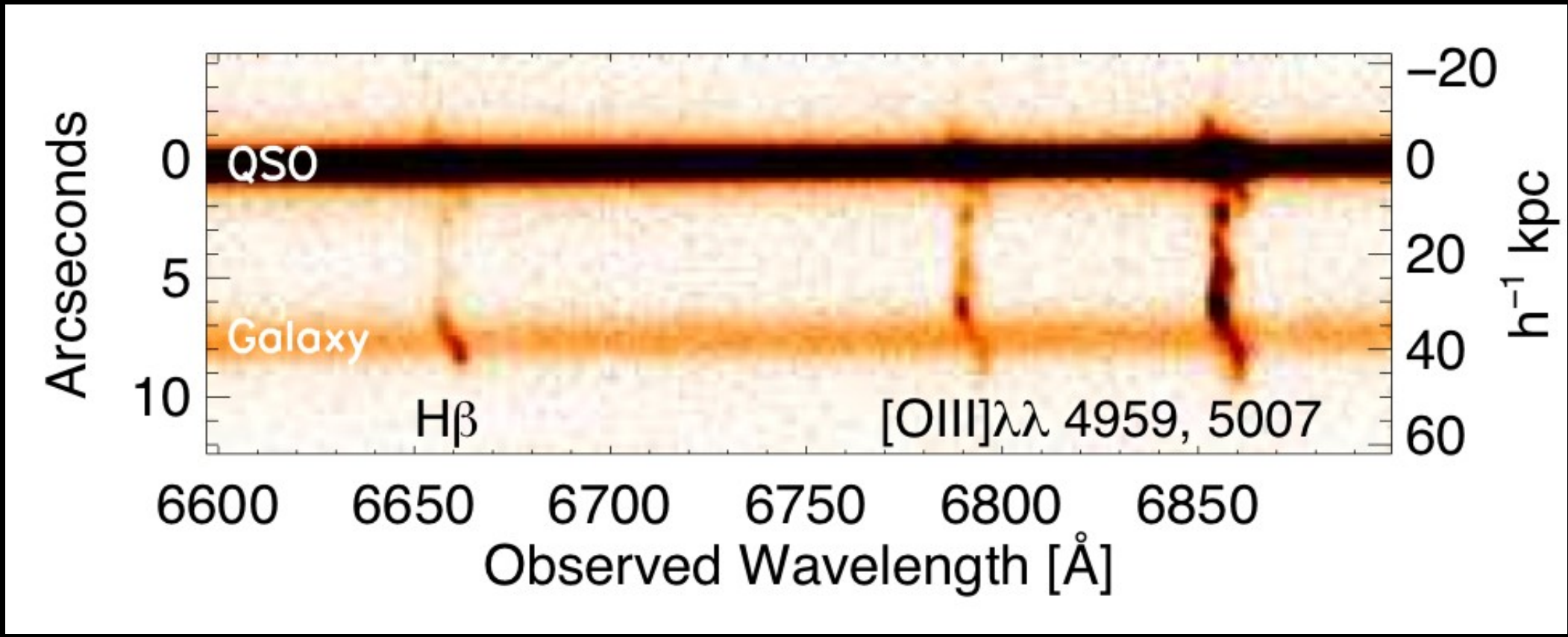
- Companion galaxy does not necessarily have to be a quasar as well


$z = 0.369$ quasar

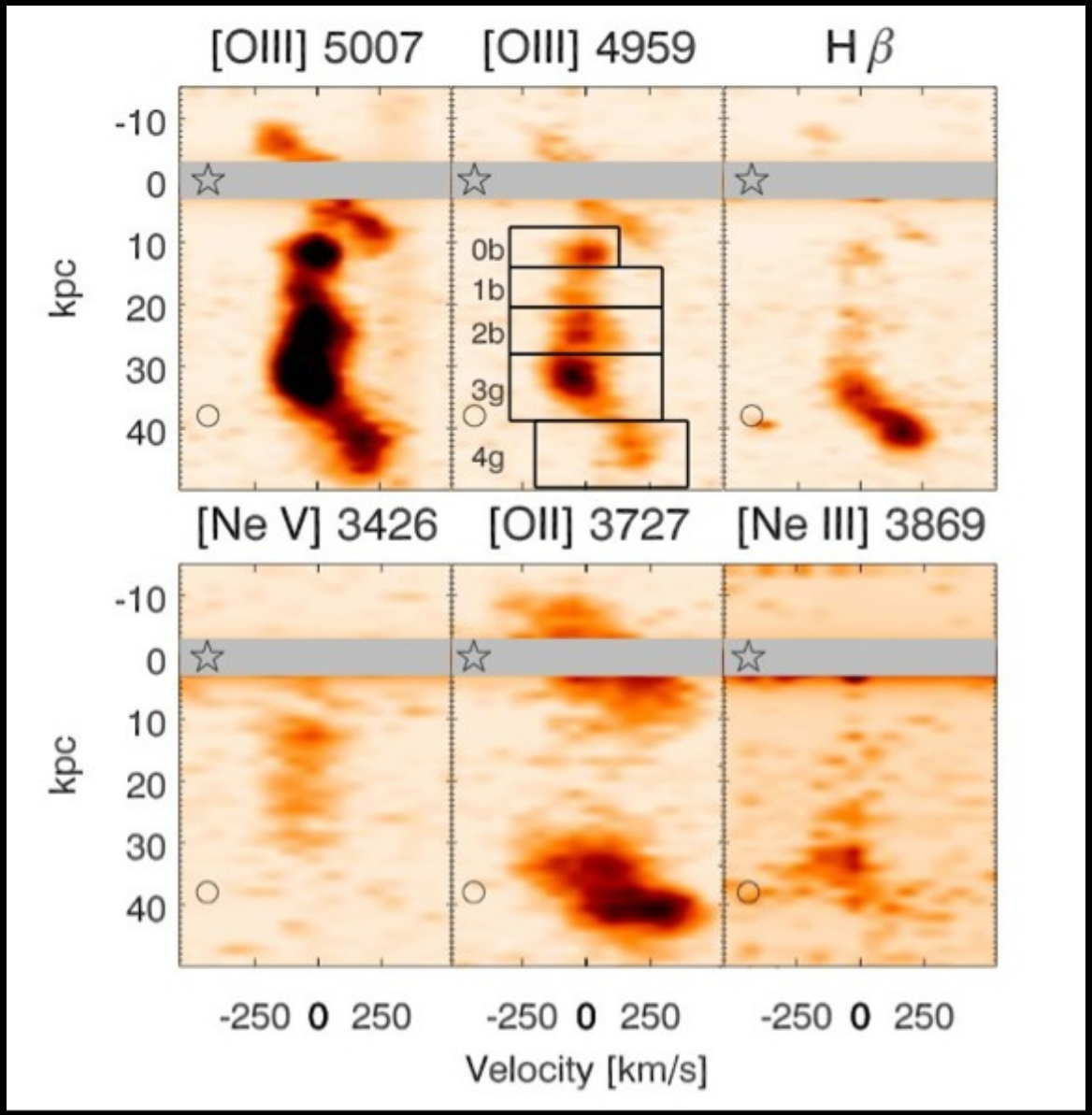
$z = 0.3693$

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

$b = 38$ kpc

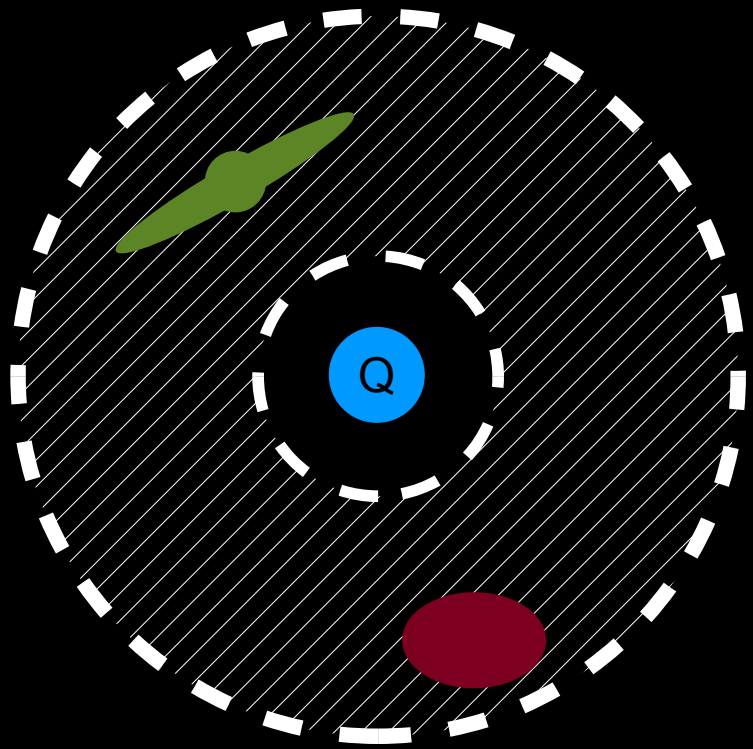


da Silva+2011,ApJ,735,54D

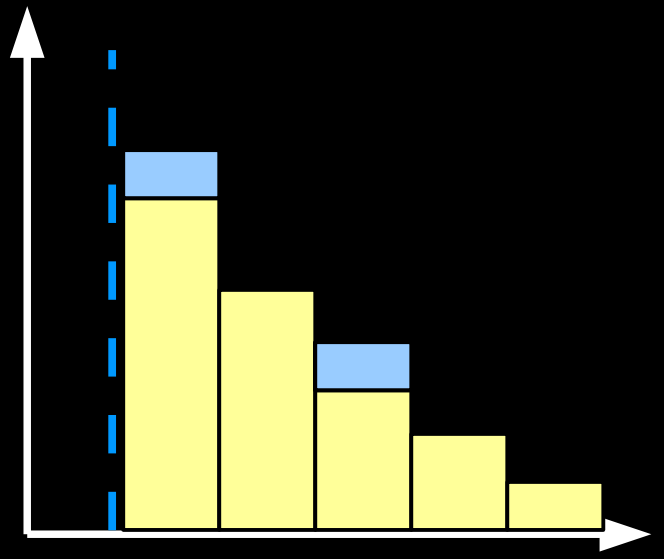


- QSO photoionizing a bridge of material connecting the two galaxies
- Separation & kinematics consistent with a first passage merger
- Inferred companion galaxy SFH is consistent with a burst triggered during first passage of interaction

da Silva+2011,ApJ,735,54D



$\Delta z < 3\sigma_z$



Mass Ratio

Completeness Limit = 1:8

Ingredients

- Need a catalog of quasars where we have large numbers at distances where we can expect to see companions
  - z<0.2 quasars from Schneider+2010 catalog
- Want photometric redshifts and stellar masses of companion galaxies
  - obtainable from SDSS photometry
- Want mass of quasar host galaxy
  - use SMBH mass estimated by Shen+2010 combined with Magorrian Relation

Interlopers

- Generous cut in photometric redshift $(\Delta z < 3\sigma_z)$ results in a large number of interlopers meeting our criteria

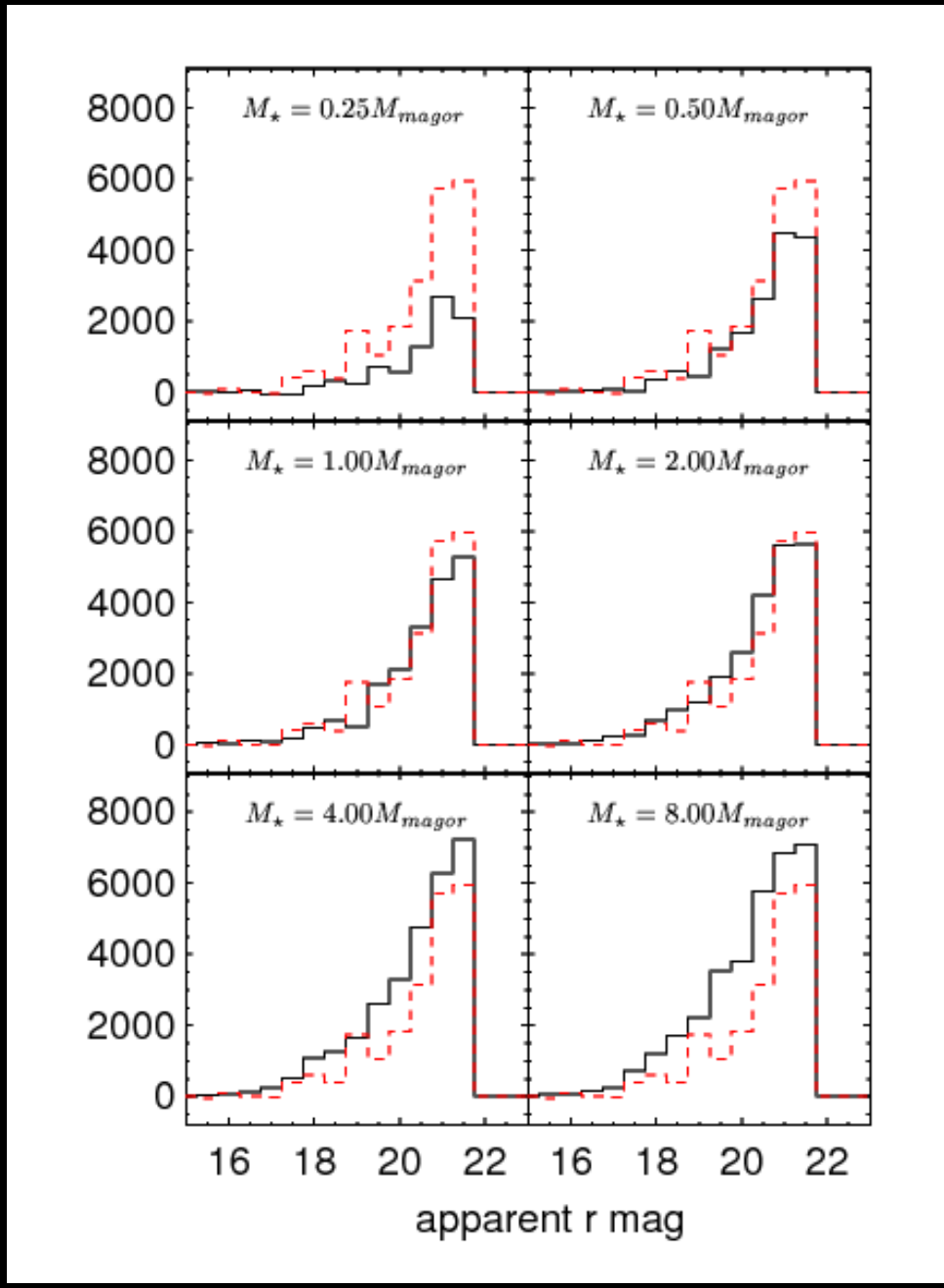
- So we need to compare with a set of control fields to subtract the background

Perform the same experiment on two sets of control fields:

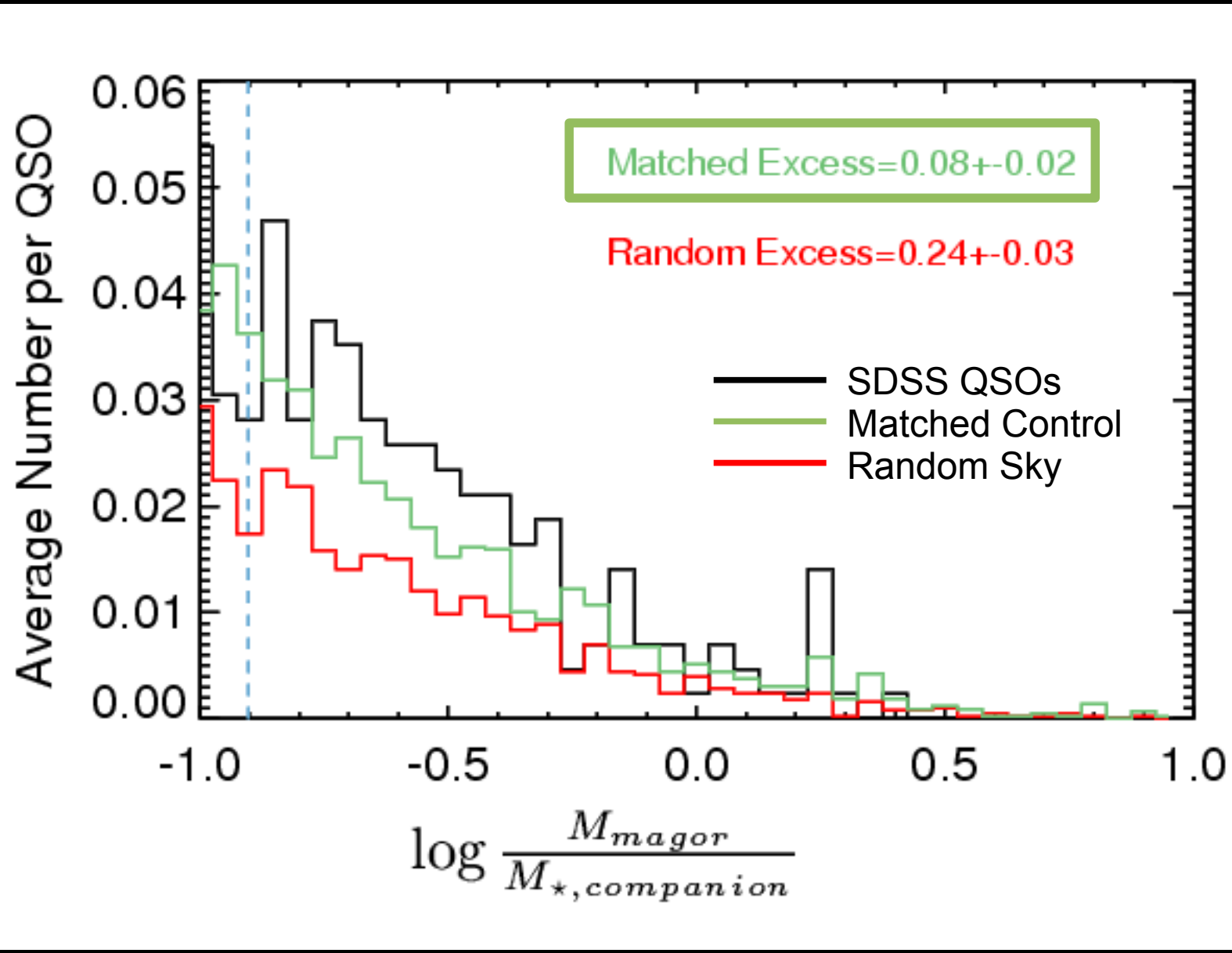
1.) Empty Sky

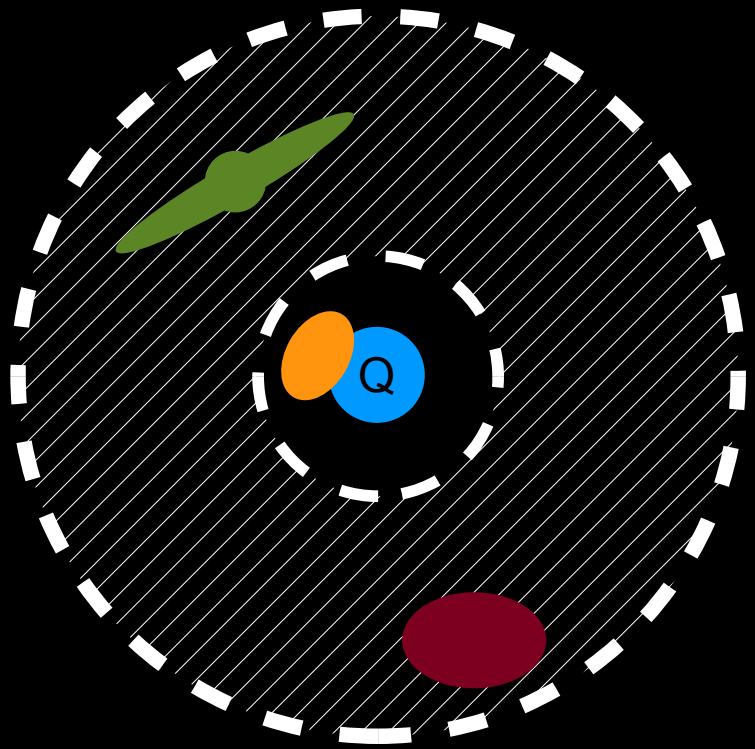
2.) Mass-matched Control Sample

- Magorrian Mass is (M_{magor}) not an ideal proxy for stellar mass
- compare luminosity functions at distance between 1–1.2 Mpc
- Find a factor of 2 correction



Detected Excess

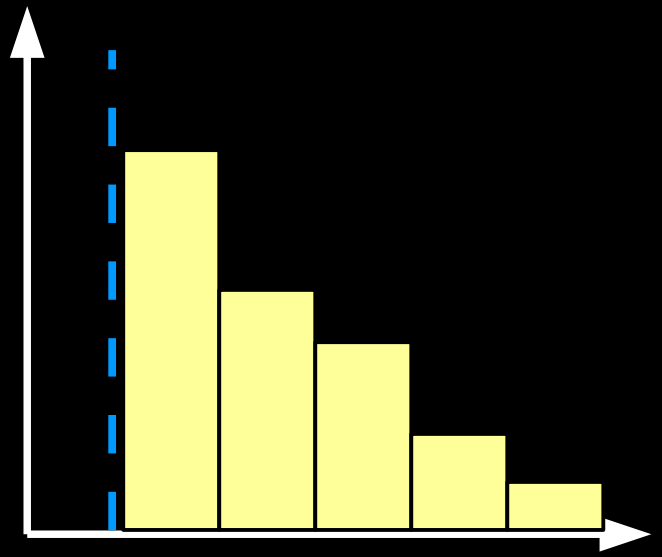




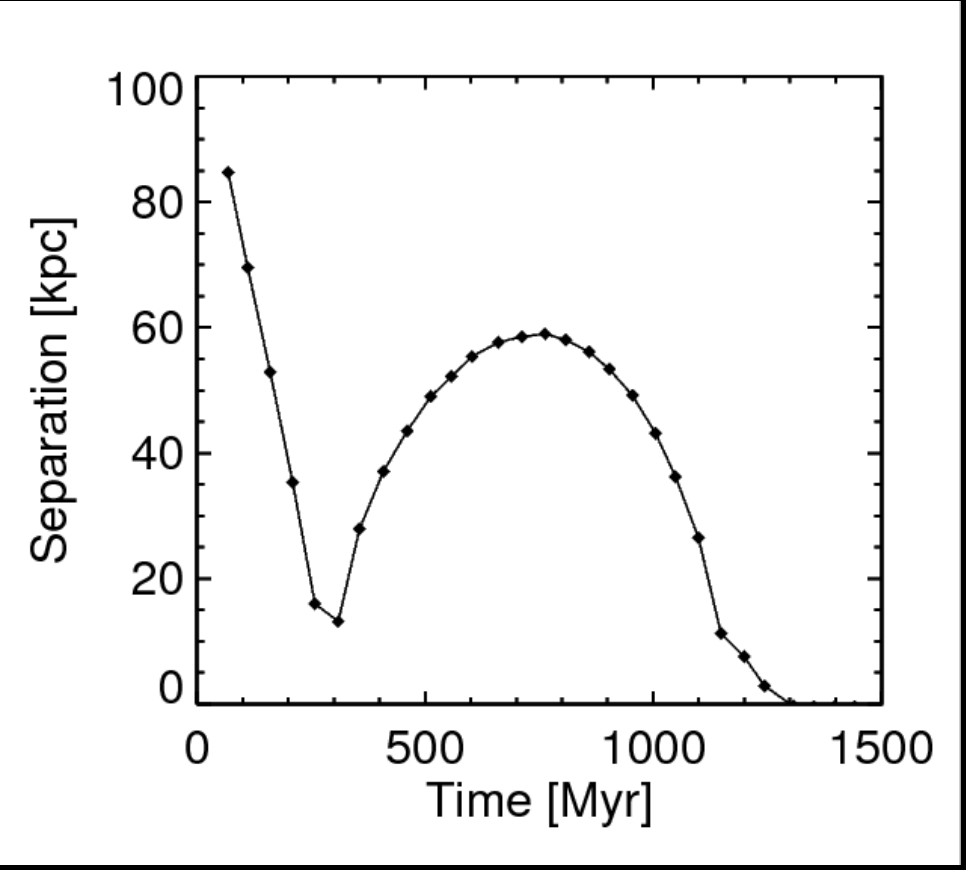
30 kpc

80 kpc

$\Delta z < 3\sigma_z$



Mass Ratio

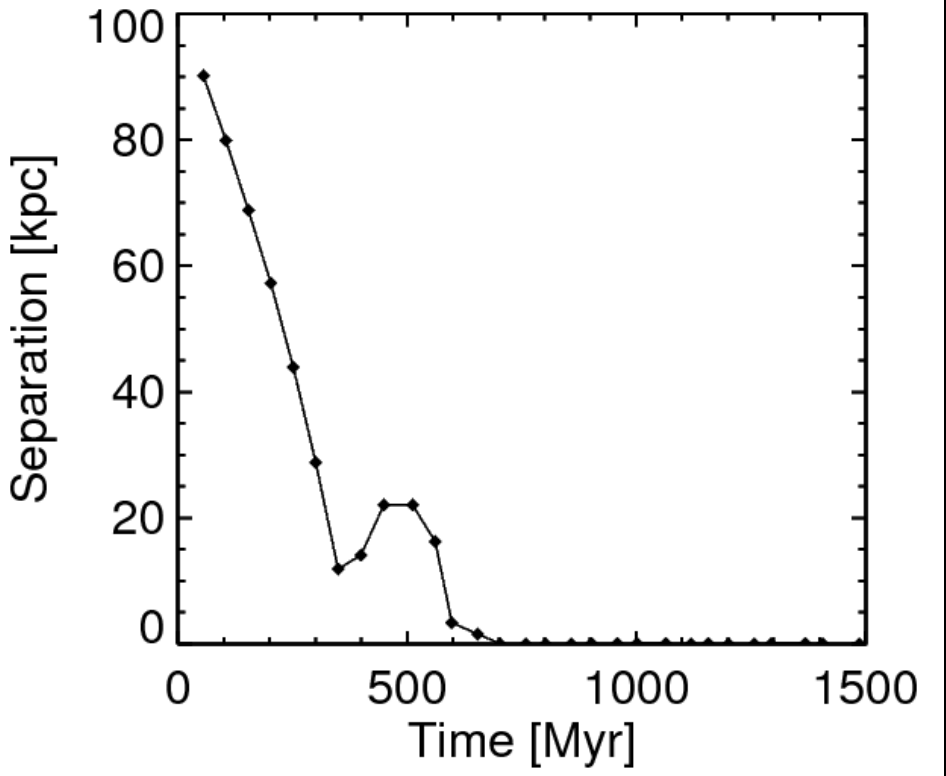

Separation [kpc]
Time [Myr]
0
20
40
60
80
100
0
500
1000
1500

?

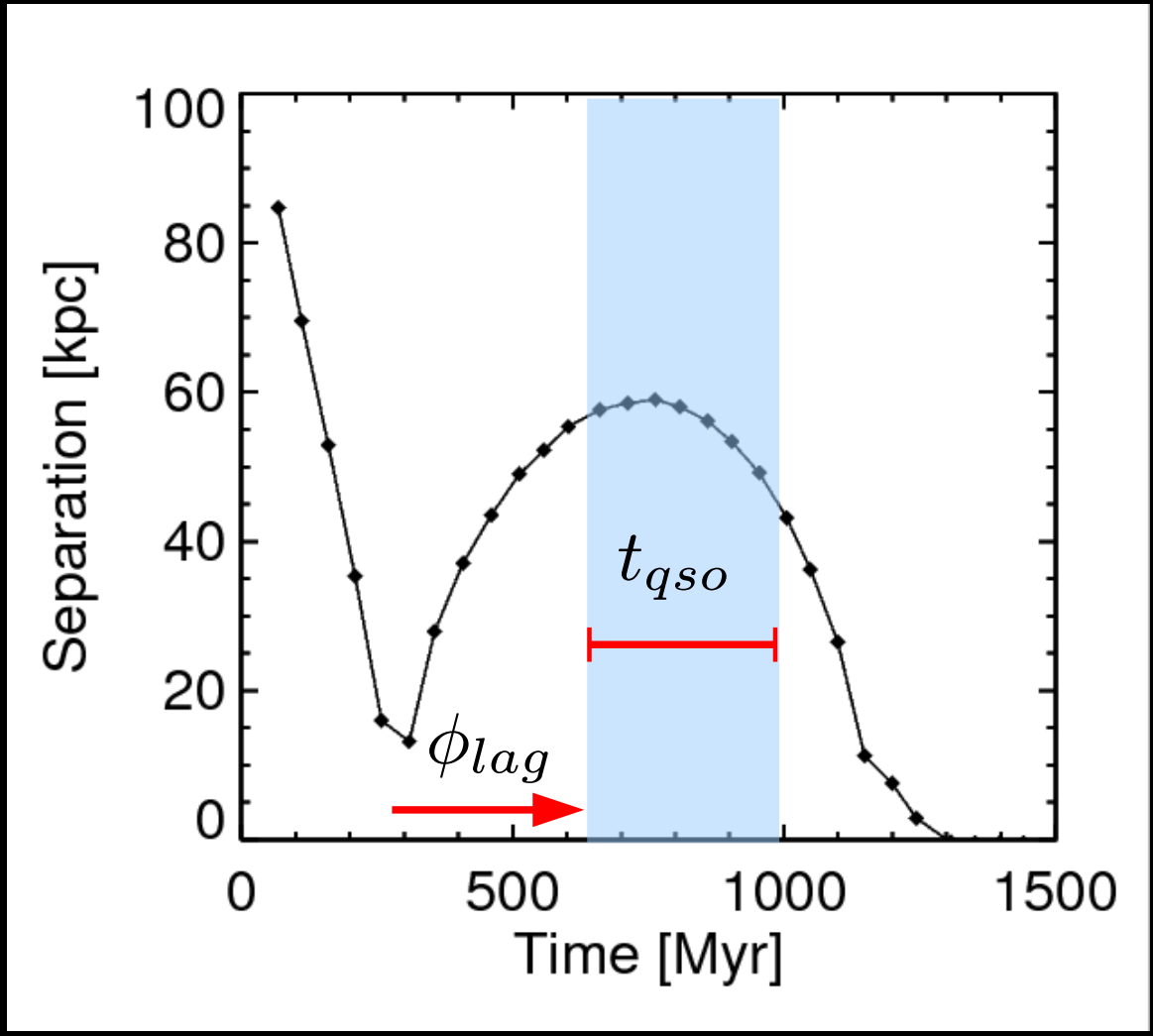
?

?

?


Separation [kpc]
Time [Myr]
0
20
40
60
80
100
0
500
1000
1500

Quasar Triggering Toy Model

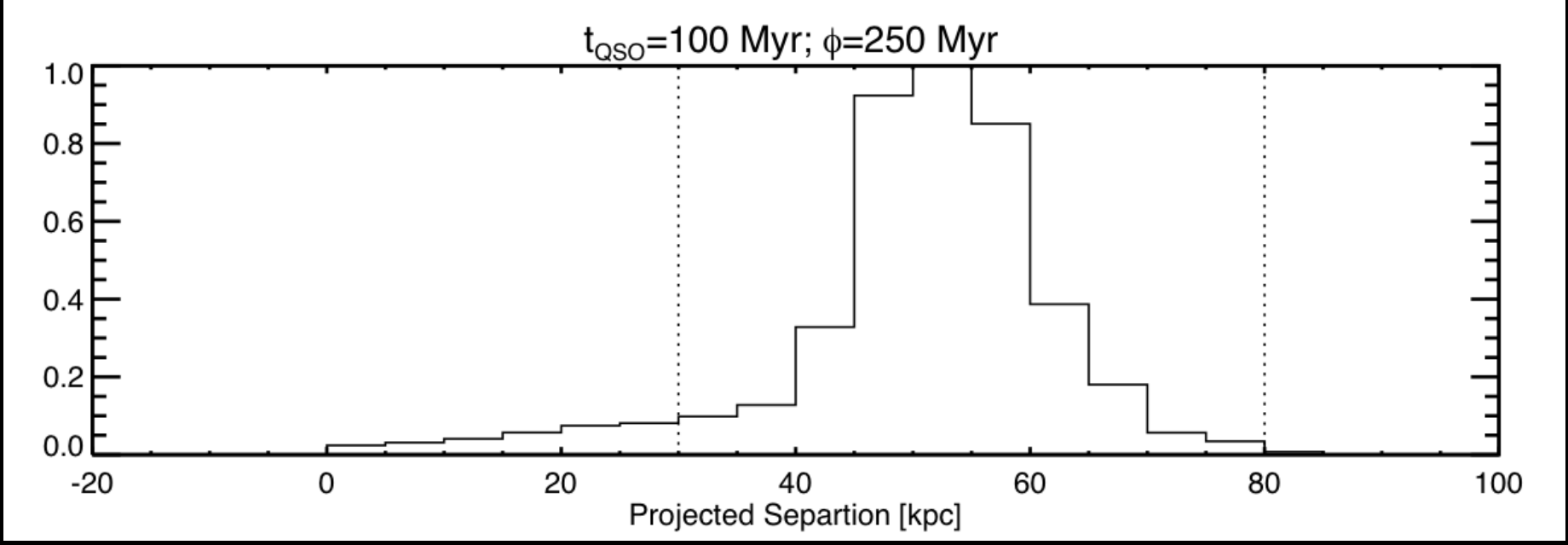


Completeness Correction

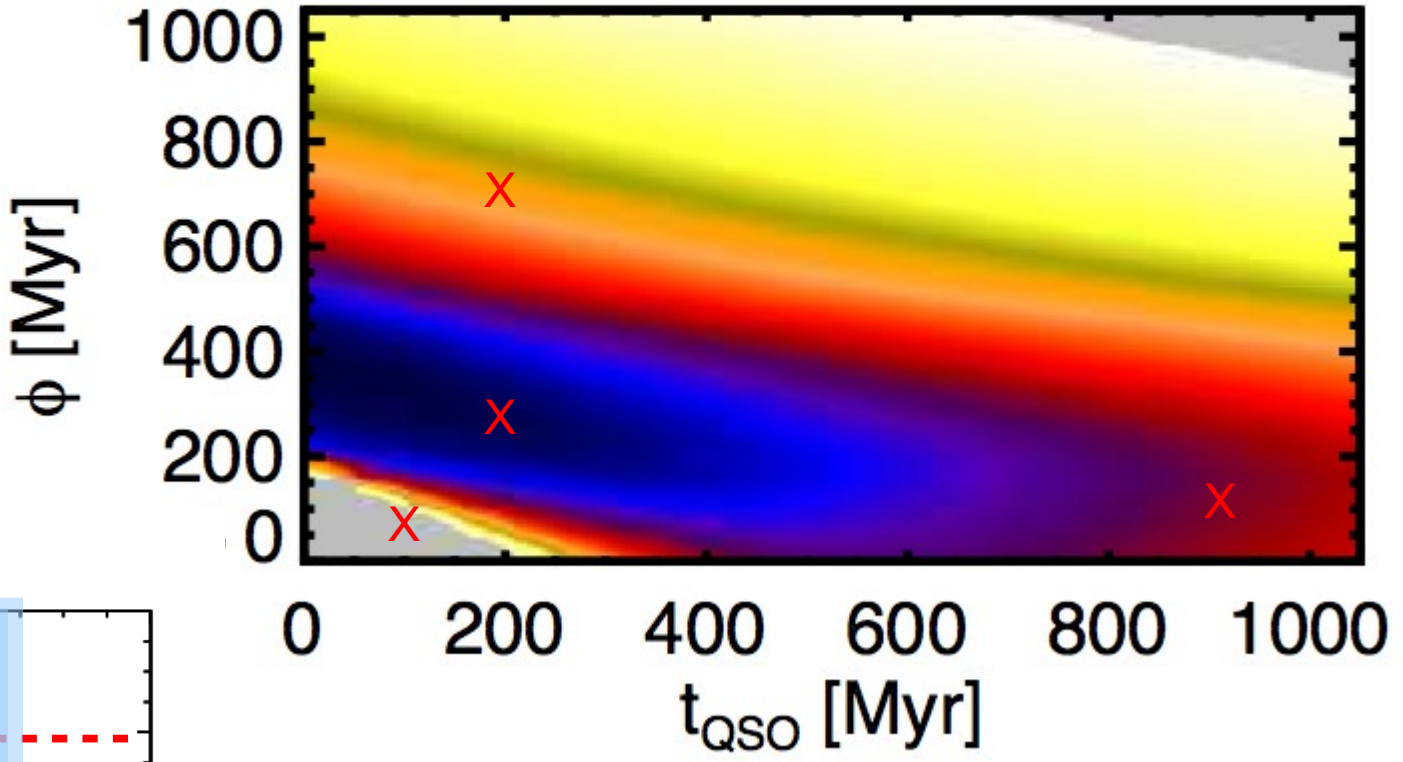
Cosmological Orbit Distribution
(e.g. Wetzel+2010)

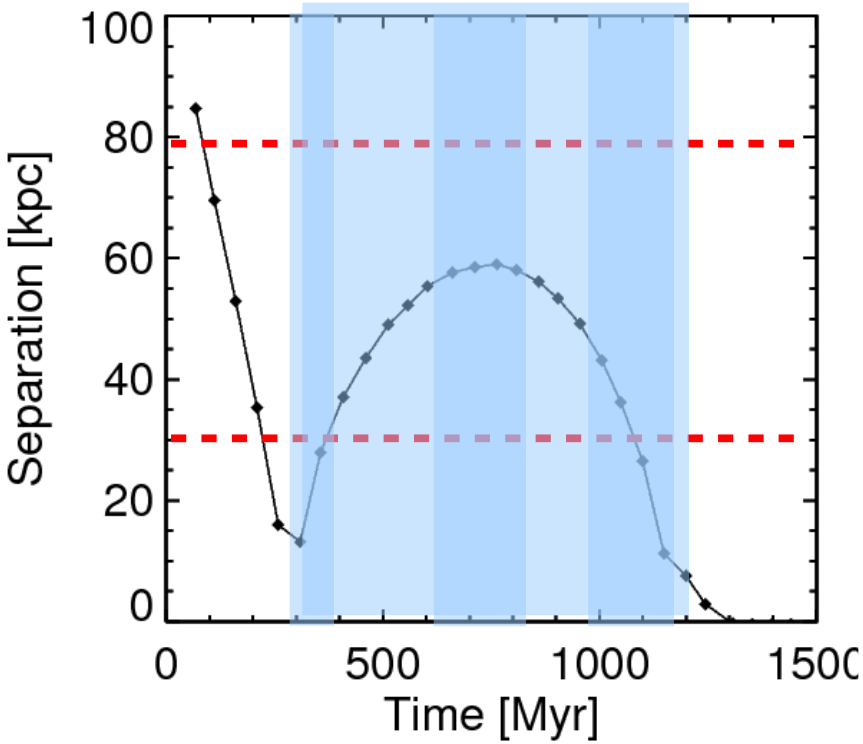
Parameterize a Model for QSO Triggering
t_{QSO} ϕ_{lag}

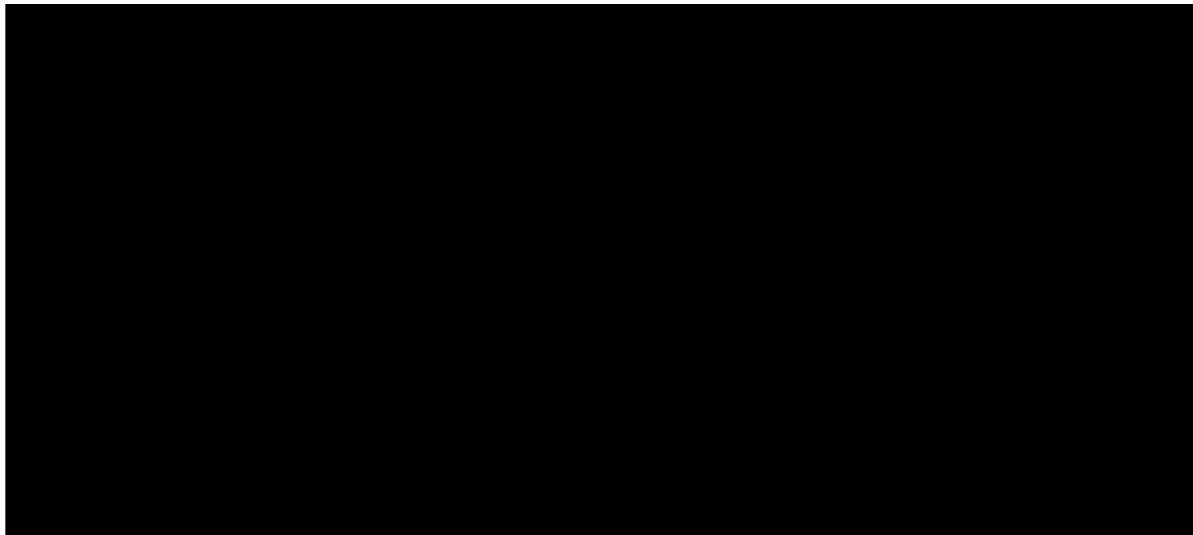
GalMer: Galaxy Merger
Simulation Database



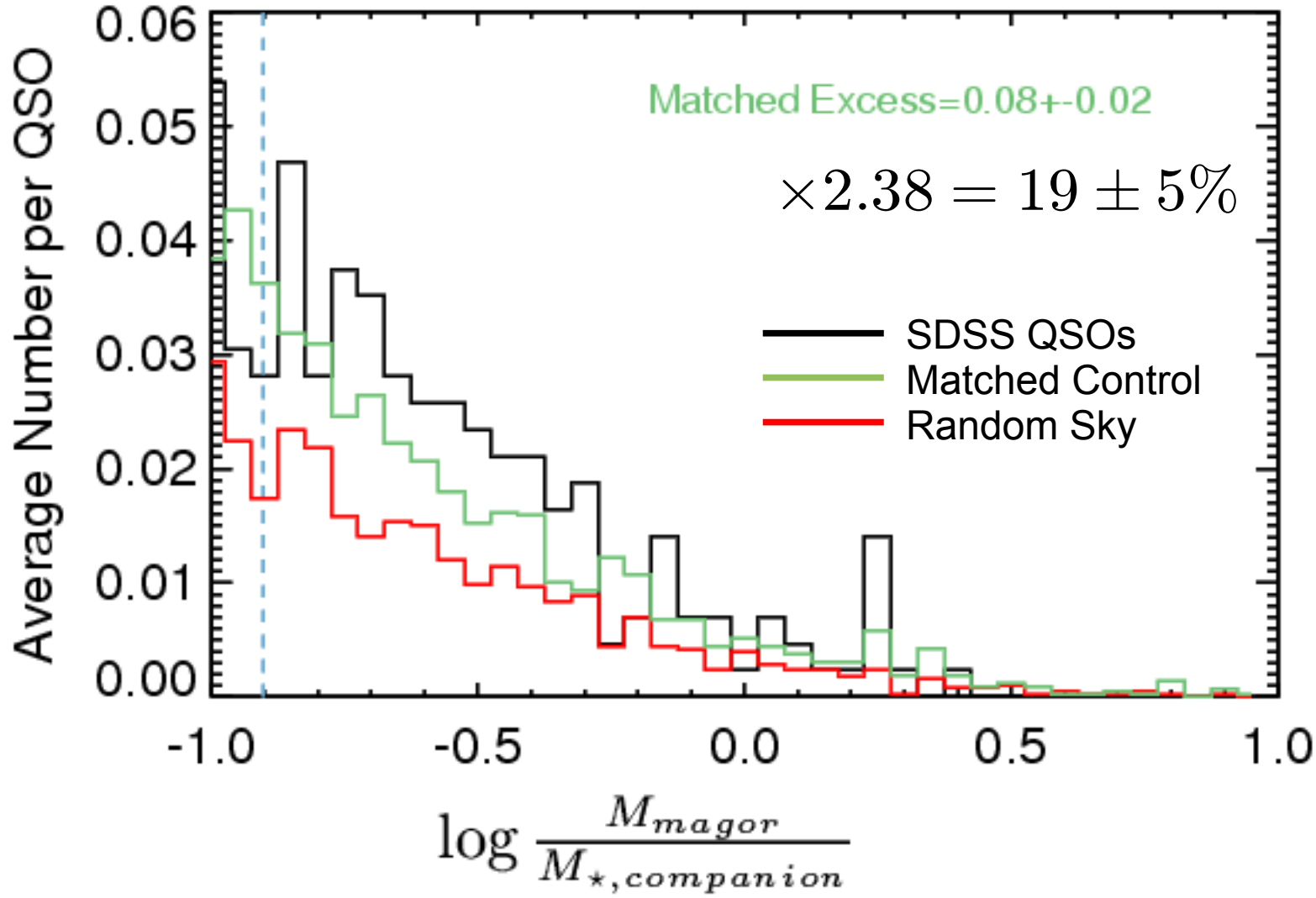
2
4
7
9
11
14
16


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


100
80
60
40
20
0
Separation [kpc]
0
500
1000
1500
Time [Myr]

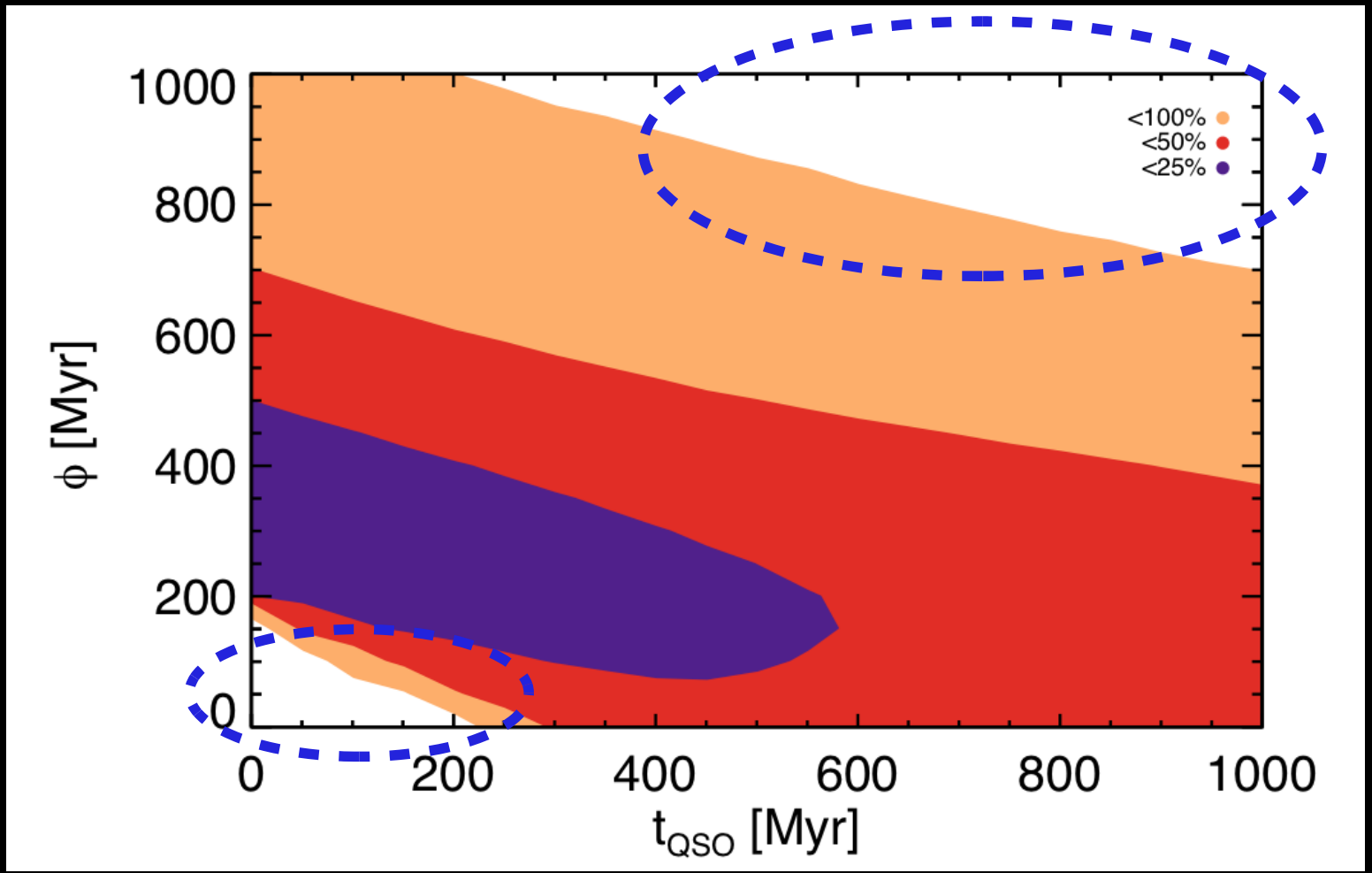


$t_{qso} = 10$ Myr $\phi_{lag} = 250$ Myr



Constraining Triggering Parameters

- Assume a fraction of quasars triggered during first passage $\rightarrow$ infer triggering properties



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
  - -Try to answer the question of why one quasar is on and the other is not
  - -Comparison of SMBH and galaxy masses at this intermediate stage will provide insights on evolution along the Magorrian relation

- Search for more pairs with quasar photoionized extended tidal features
  - -study quasar lifetime, isotropy, and triggering

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 with mass ratio > 1:8 near quasars (30-80 kpc) interpreted as galaxies interacting with quasar hosts

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

Open Questions

- What is the dominant triggering mechanism of quasars?

- What does this teach us about SMBHs and their effect on galaxy evolution?

- What are the key parameters that determine why in these pairs one galaxy is in a quasar phase and the other is not?

Thank You