# HOW DOES GALAXY ENVIRONMENT INFLUENCE AGN ACTIVITY?

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**08/28/2013 @ Kavli IPMU**

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# Introduction

- Black holes are important yet poorly understood. How can we study black holes? **Look at AGN**
- How can we study AGN? **Look at environment**
  - Mergers: Delivery
  - Clusters: Availability
- **Key questions**
  - What is the general picture of environment's role in triggering AGN?
  - How far does environmental influence extend?
  - How are AGN driven?

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# Dataset

- Sloan Digital Sky Survey (SDSS)
- Value-added catalogs
  - Pairs by Ellison et al.
  - Groups by Yang et al.
- **Unprecedentedly large, newly available dataset**

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# Measuring AGN Activity

- Very hard problem
- **Criteria for our measure**
    1. AGN-specific
    2. Continuous
    3. Comparable across all SDSS galaxies
- **D parameter**
    - Distance from star-forming locus on BPT
    - Correlates with spectrum hardness and intensity
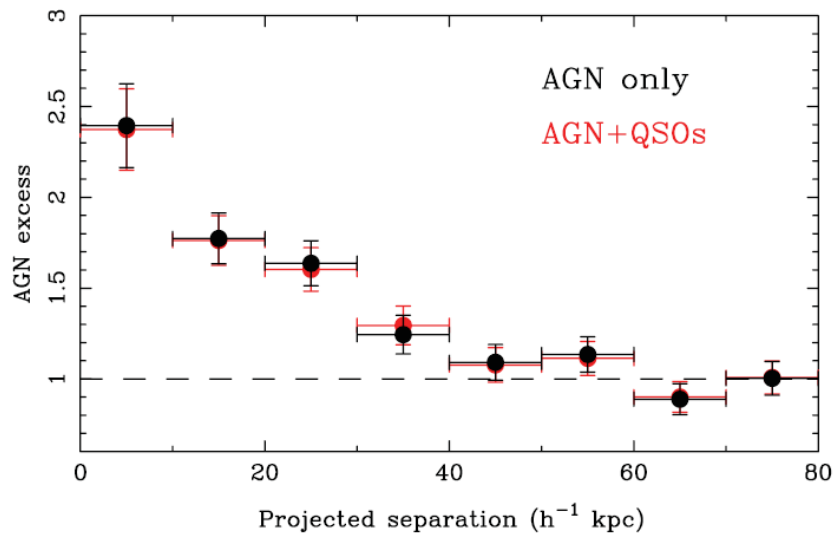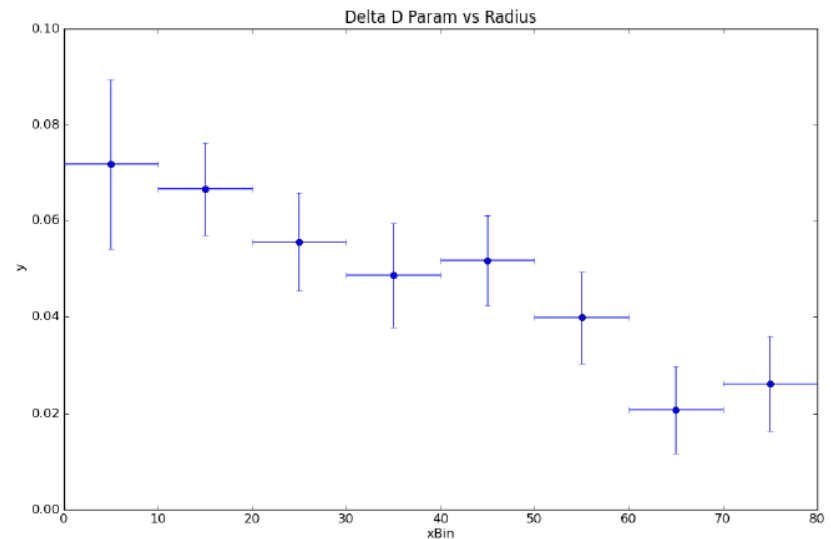- Any problems?
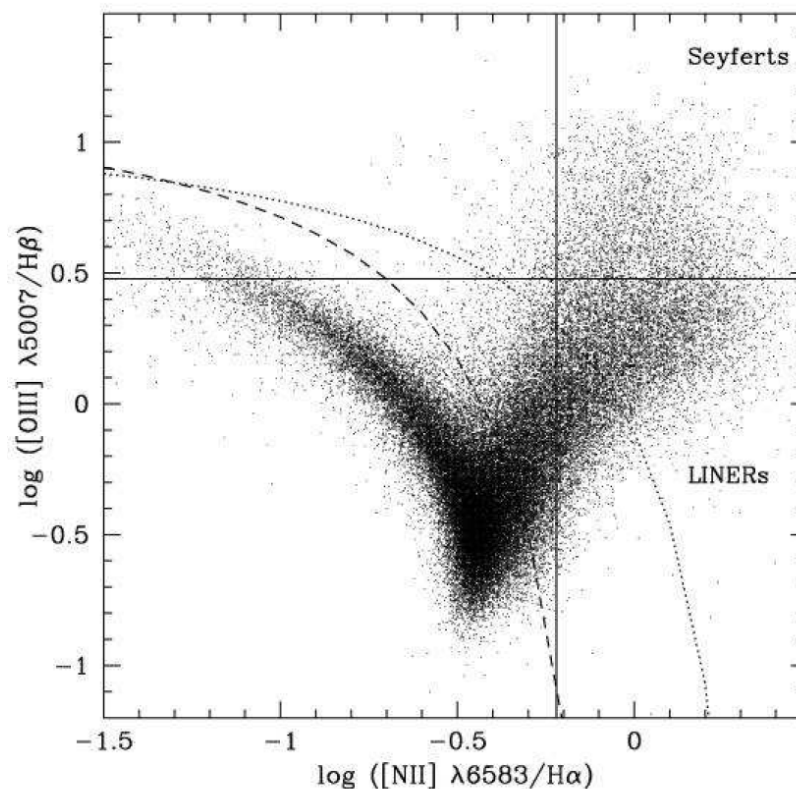


Kauffmann et al., 2003

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# Measuring AGN Enhancement

- **ΔD**
  - Difference between D of sample galaxy and median D of all matched control galaxies
  - Takes care of problems with D
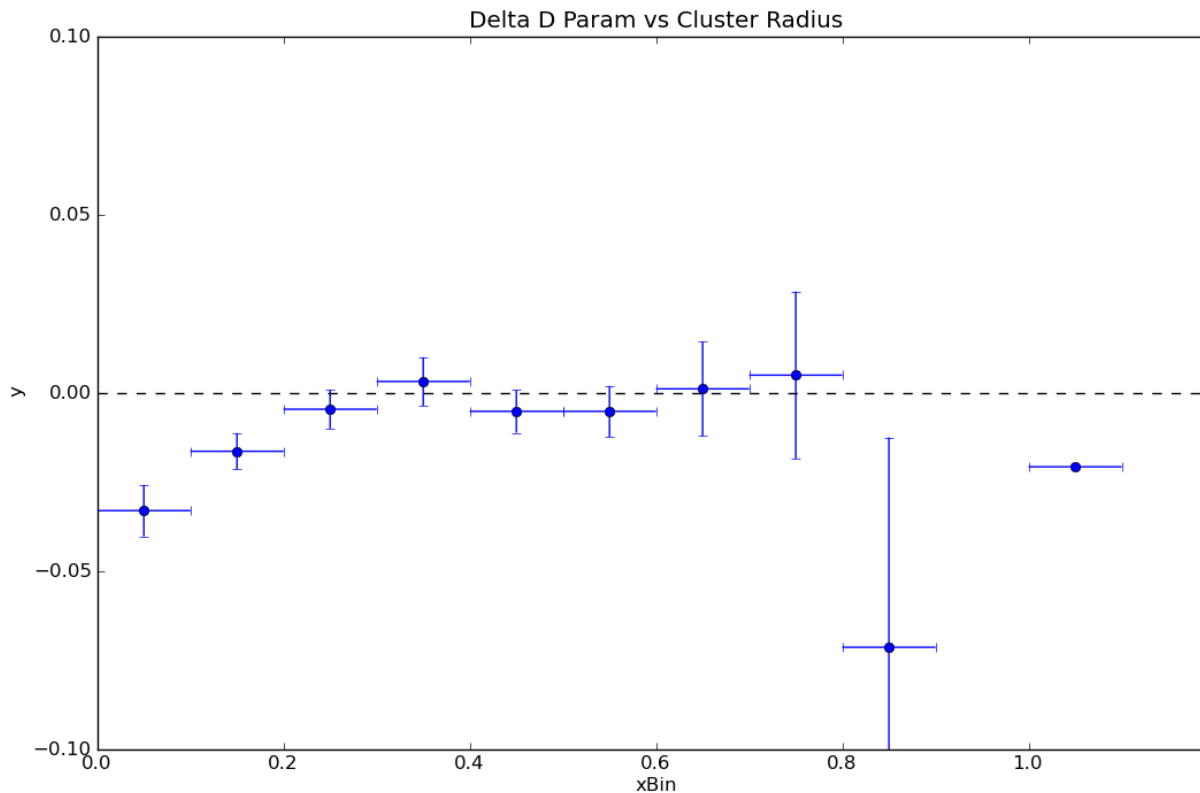  - Measures enhancement/triggering
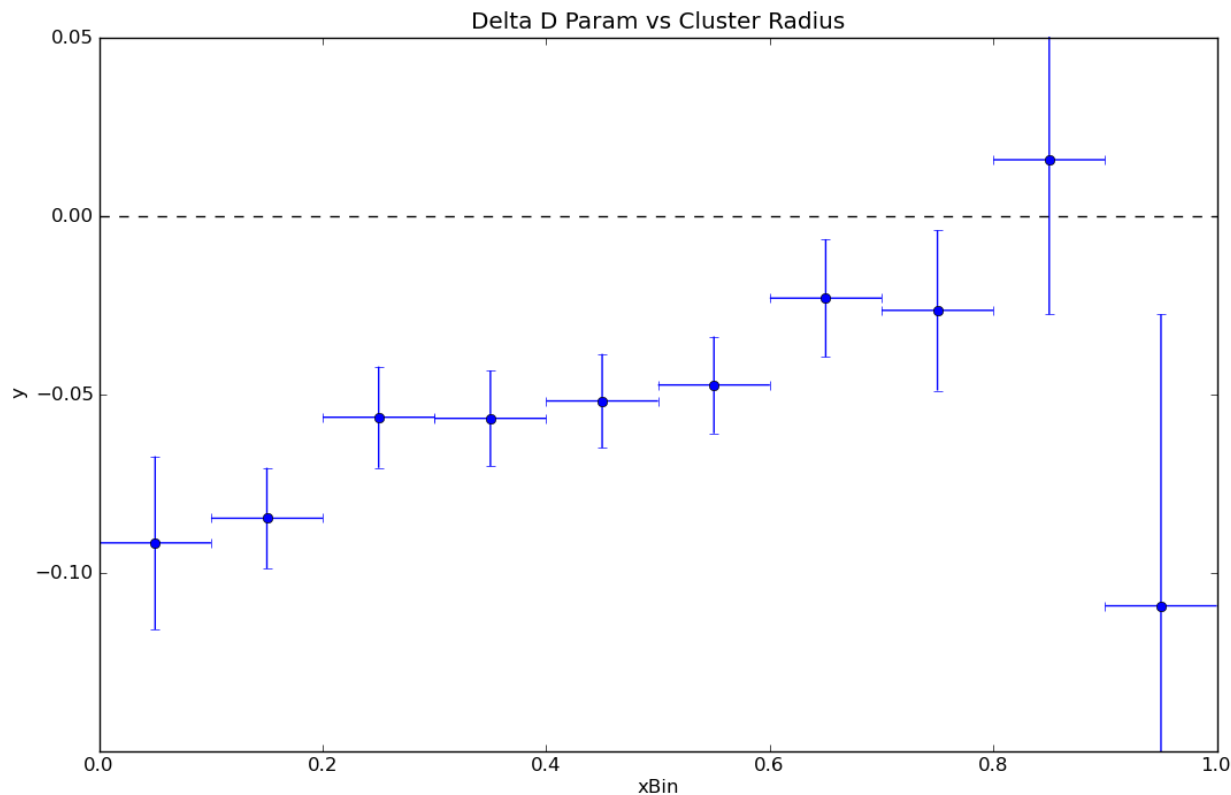  - Any problems?



Ellison et al., 2011

# Availability: **Small** Clusters

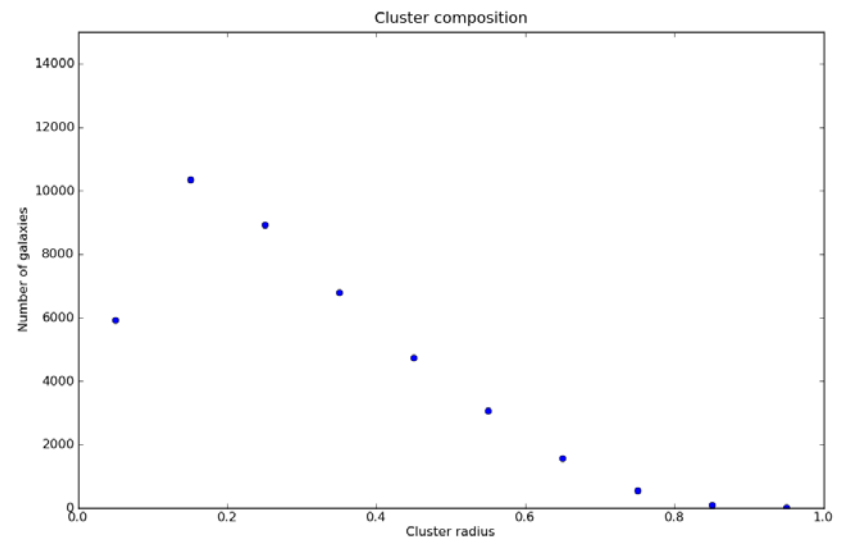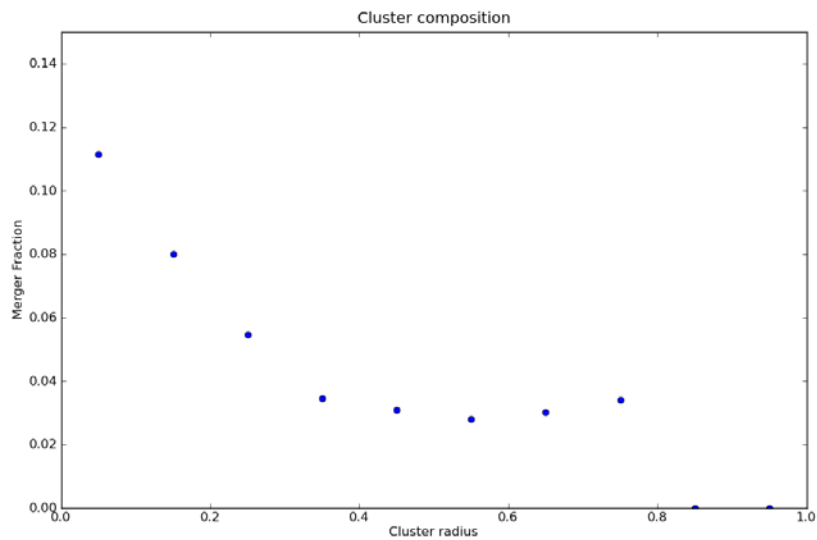- What is the general effect of being in a cluster?

# Availability: **Large** Clusters

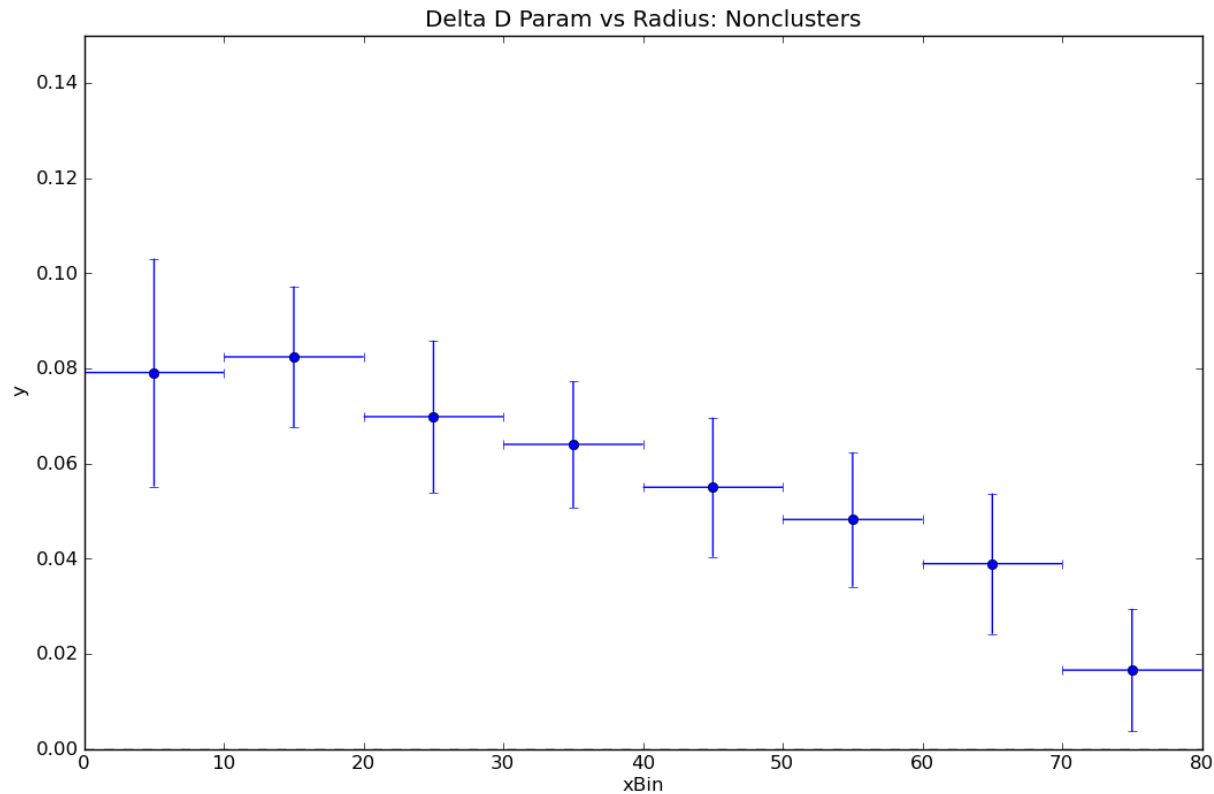- What is the general effect of being in a cluster?

# Mergers in Clusters

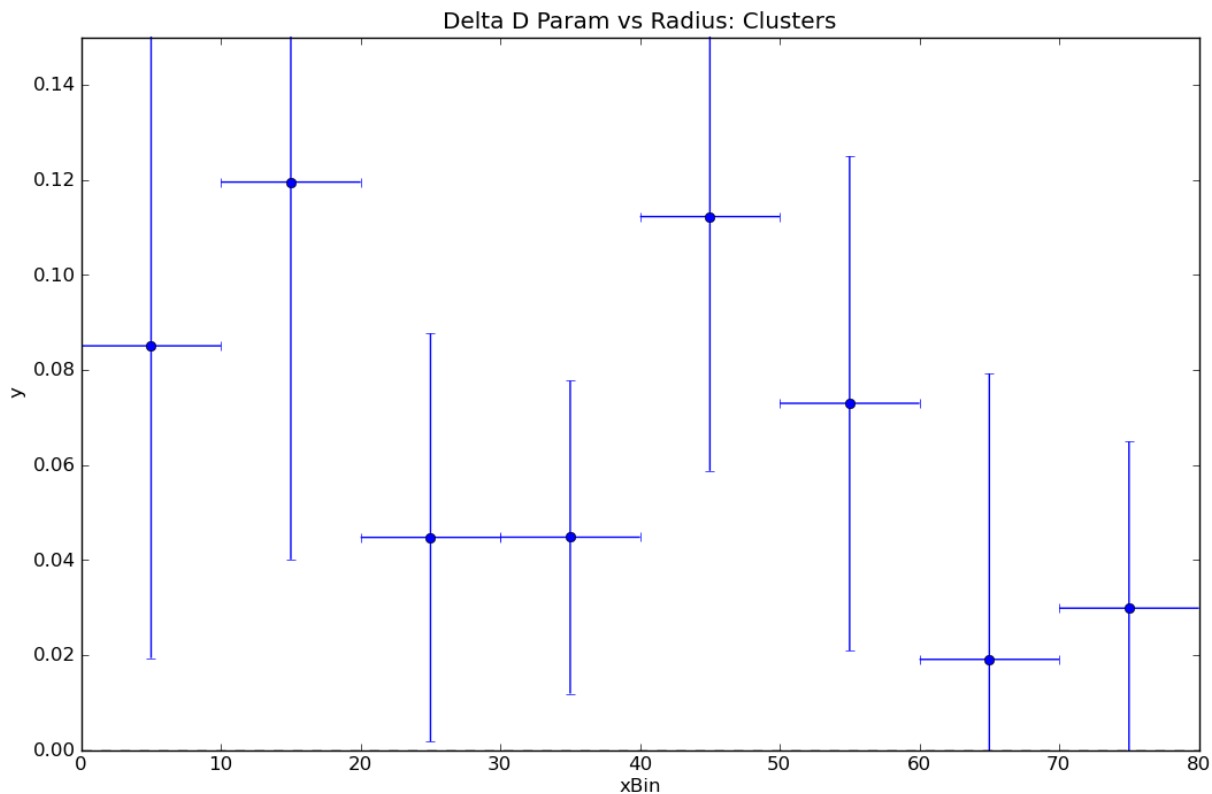- How are mergers distributed in clusters?

# Delivery: **Outside** Clusters

- We now consider mergers in the context of clusters

# Delivery: **Inside** Clusters

- We now consider mergers in the context of clusters

# Contradiction?

- Suppression in clusters yet more pairs which should give enhancement
- **No contradiction. Both results can be consistent**
  - We have a 2-dimensional space (mergers, clusters) while our plots are 1-dimensional projections
  - Most galaxies are not in the center of the cluster and behave more like the field
  - **Additional suppression mechanism in clusters may override merger enhancement**
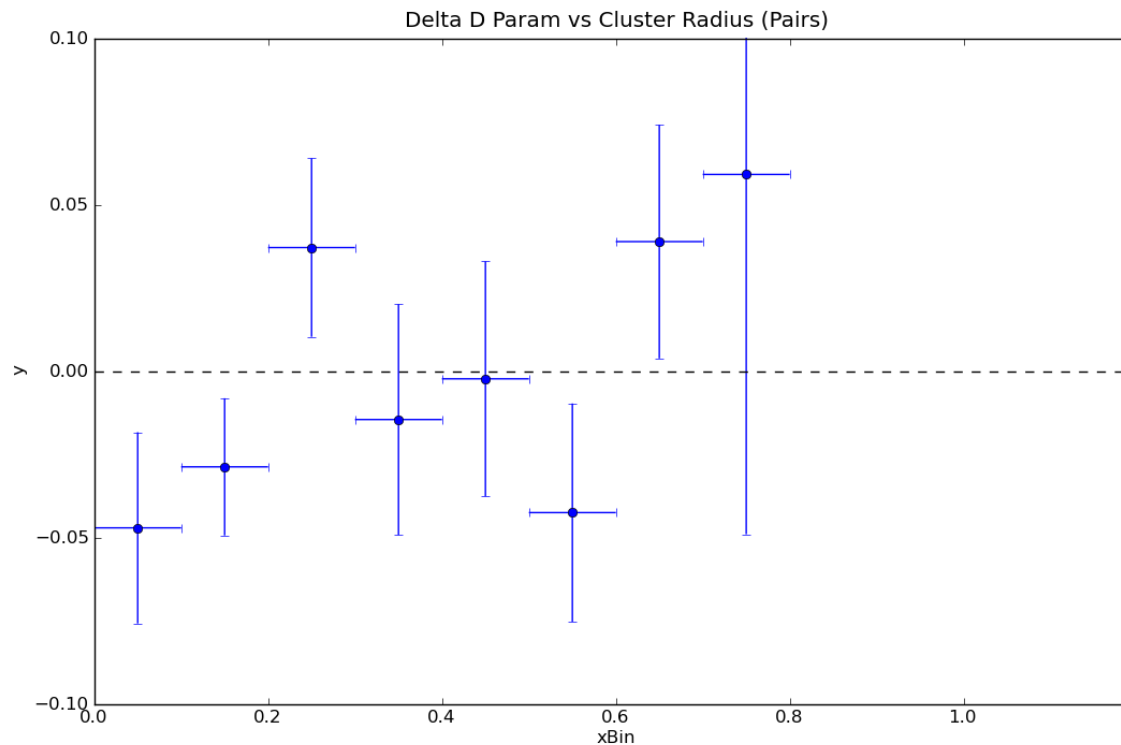
# Availability + Delivery: **Nonmergers**

- Strict matching procedure prevents comparing populations selected on both dimensions but it is possible to compare a specific sample to a broader control



Delta D Param vs Cluster Radius (Nonpairs)
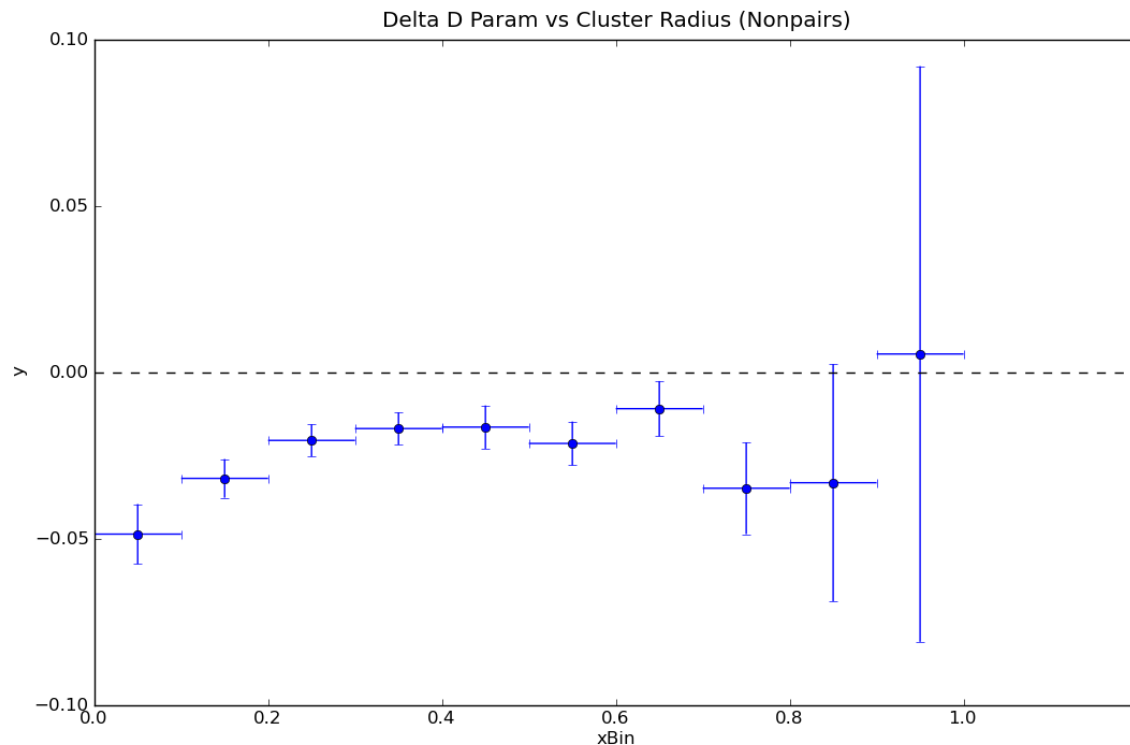
# Availability + Delivery: **Mergers**

- Strict matching procedure prevents comparing populations selected on both dimensions but it is possible to compare a specific sample to a broader control



Delta D Param vs Cluster Radius (Pairs)

# Conclusions & Discussion

- **Mergers (delivery)** cause **enhancement**
  - By mixing gas and sending it toward the center
- **Clusters (availability)** cause **suppression**
  - Gas at centers of clusters is rapidly depleted
  - Higher gas density at centers of clusters causes gas stripping that starves the accreting AGN
- **Availability dominates delivery**
  - Intrinsic availability of gas is more important than delivery

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# Future Directions

- Polish this **preliminary** analysis
  - D and ΔD
  - Quality control
  - Use data to understand physics better
- **New** analyses
  - Different types of activity
  - Internal galaxy properties
  - Local merger dynamics
- Answer question of what drives the galaxy-black hole system and reveal underlying physics

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# Thank You

- Charles Steinhardt and John Silverman
- Sara Ellison and Trevor Mendel
- Surhud More, Steve Bickerton, Josh Speagle, etc.
- Caltech and Kavli IPMU

**Questions?**

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