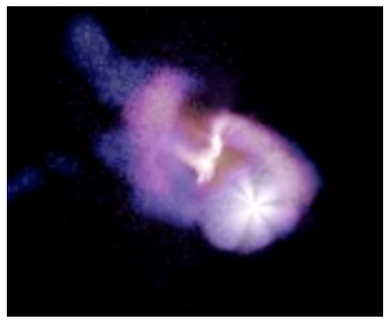
Frontiers of Galaxy Formation:

3D Spectroscopy and Time-Domain Observations

Kasper B. Schmidt (MPIA)
Thesis Advisor: Hans-Walter Rix

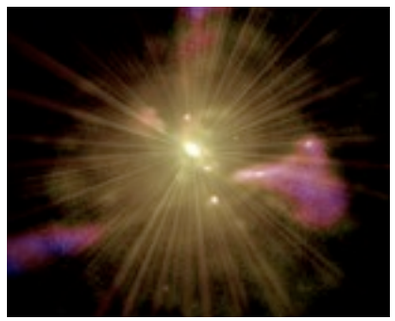
Thesis (and talk) outline

Pics from
Li et al. 2007



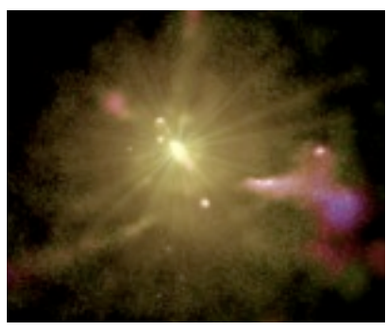
Mergers at z~1.5

Schmidt et al. 2011b
in preparation



Quasar Variability Selection

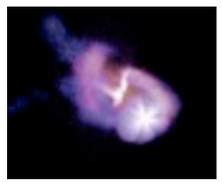
Schmidt et al. 2010
ApJ 714:1194



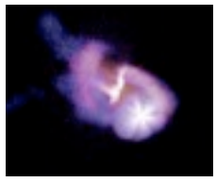
Quasar Color Variability

Schmidt et al. 2011a
ApJ accepted, arXiv/1109.6653

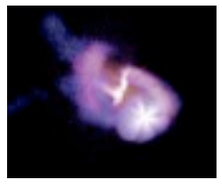
Time...



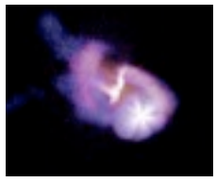
Mergers at z~1.5: The 3D-HST Survey



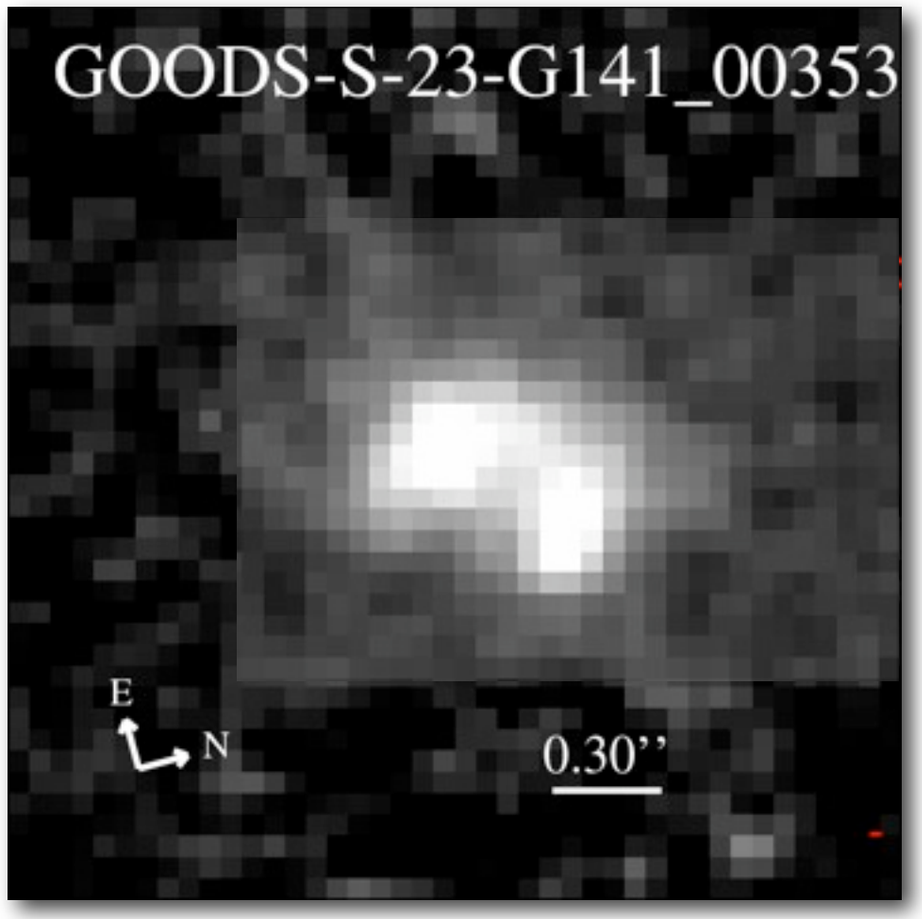
- HST Legacy Survey - PI: P. G. van Dokkum
- ~9000 Galaxies at 1<z<3.5
- From GOODS-S, GOODS-N, AEGIS, COSMOS and UDS
- High resolution (0.1") NIR WFC3 imaging
- Grism (3D) Spectroscopy
- 68 pointings (50% of survey) as of 01.08.2011

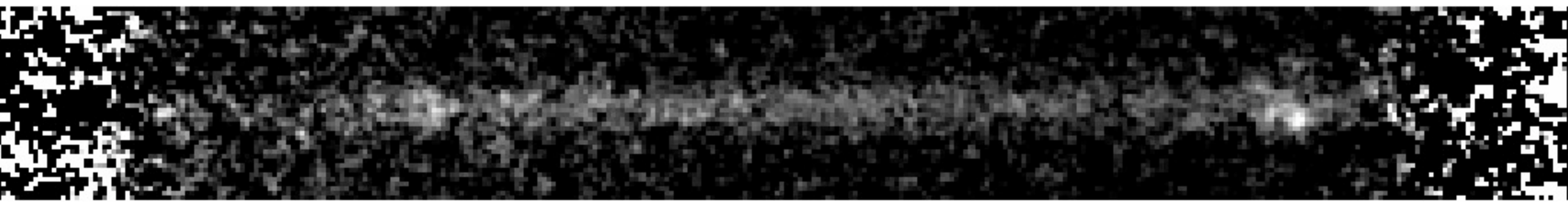


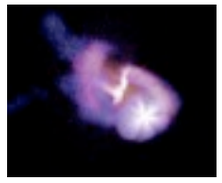
Mergers at z~1.5: Emission Line Maps



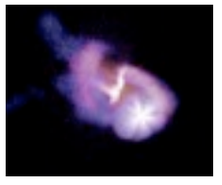
- Grism Spectroscopy
- Spatial Extent of Emission Lines
- Subtract the Continuum



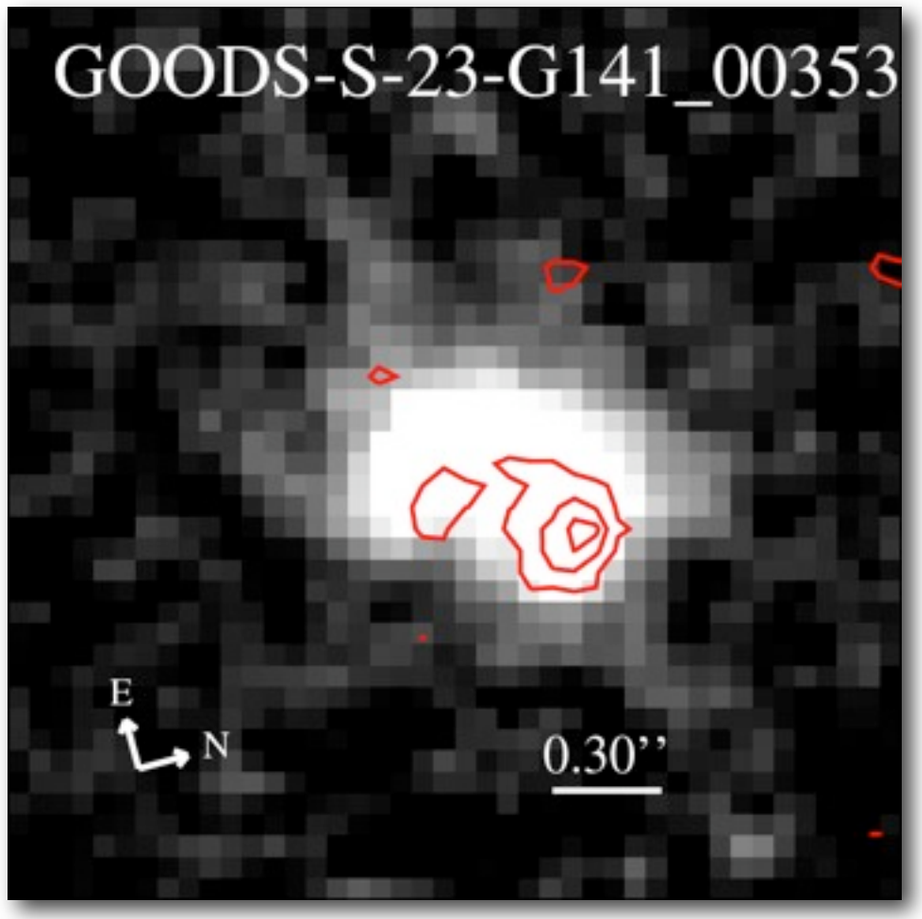


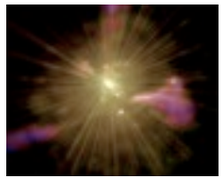


Mergers at z~1.5: Emission Line Maps

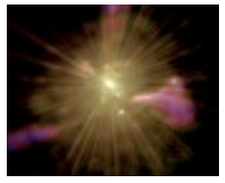


- Grism Spectroscopy
- Spatial Extent of Emission Lines
- Subtract the Continuum
- Map EL Map back on continuum
- Largest samples at z~1.5 with this information

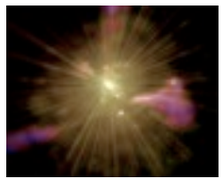




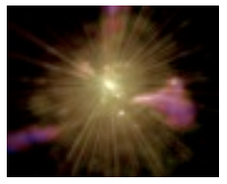
Quasar Variability Selection: Why Another QSO Selection?



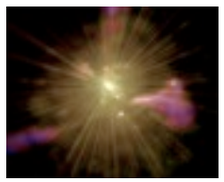
- Need to improve C & P of samples
  - >10^6 QSOs can not all be followed-up spectroscopically
- UV-excess indicator not always available
  - e.g. Pan-STARRS1
- More QSOs → more rare quasar 'configurations'
  - QSO pairs QSO sight-lines QSO Lenses



Quasar Variability Selection:
Selection Based on Variability



see also: MacLeod et al. 2010, 2011; Butler & Bloom 2011; Kim et al. 2011; Palanque-Delabrouille et al. 2011



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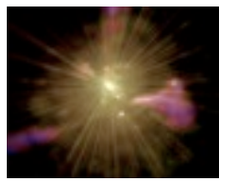
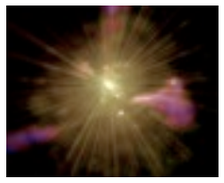


- SDSS Stripe 82 has ~60 epochs over 8 years per QSO
- Model Structure Function as a Power-Law:

$$\mathrm{SF}_{\mathrm{mod}}(\Delta t_{\mathrm{obs}}|A,\gamma) = A\left(\frac{\Delta t_{\mathrm{obs}}}{1\mathrm{yr}}\right)^{\gamma}$$

- Selection on A and γ



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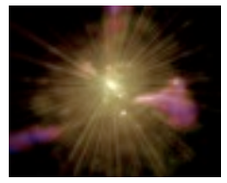

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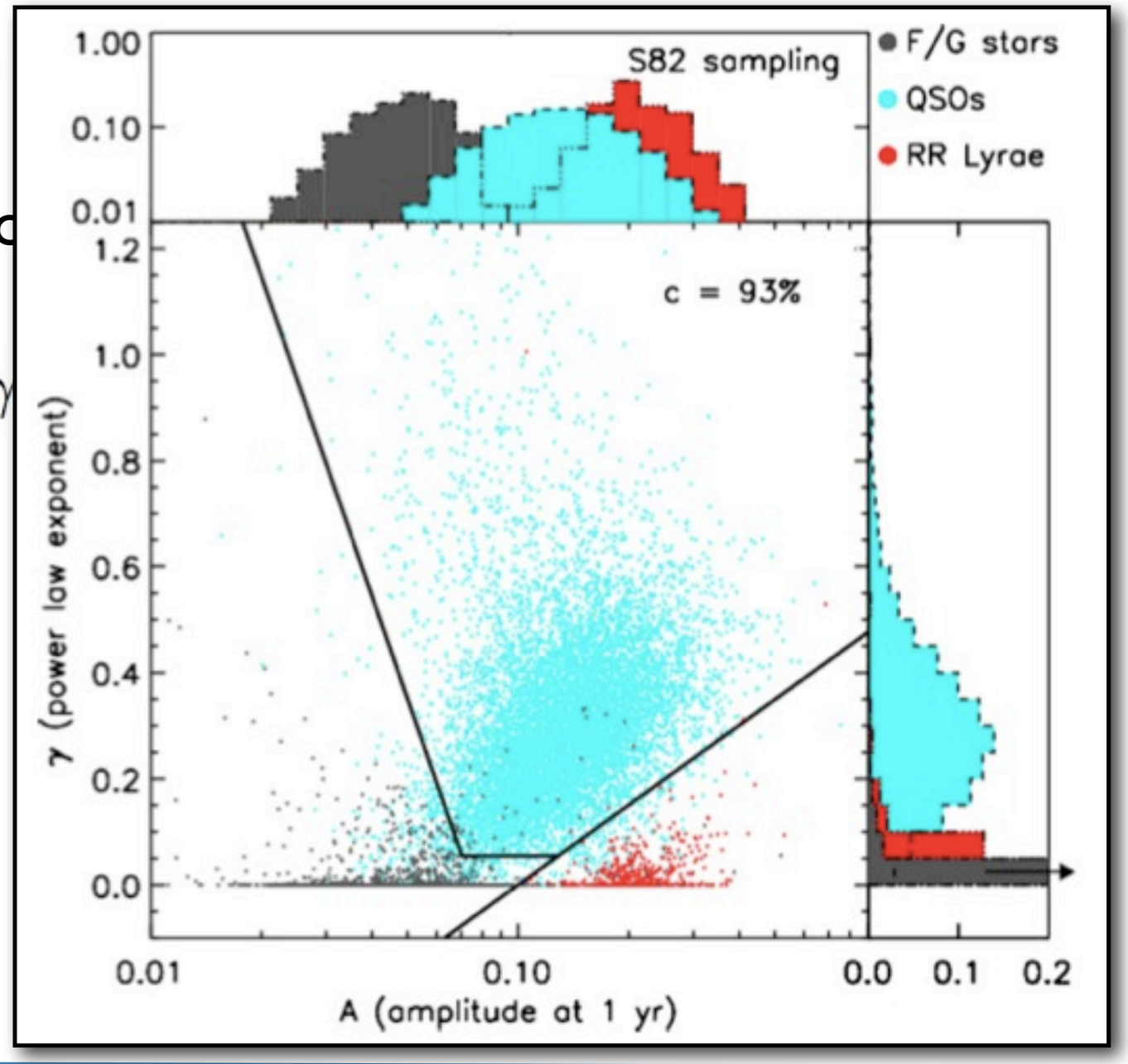

Quasar Variability Selection: Selection Based on Variability

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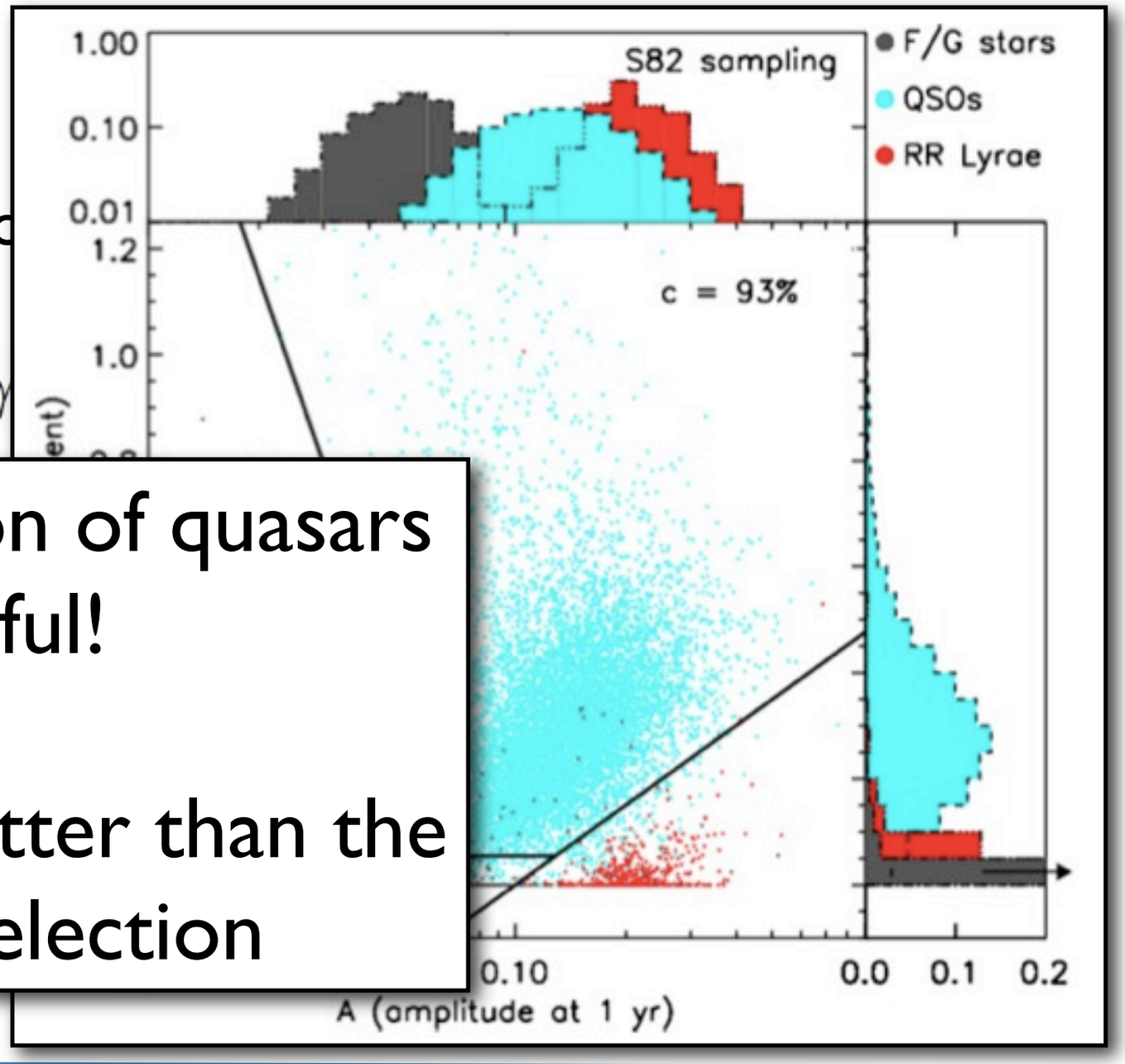
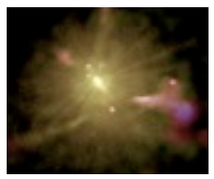
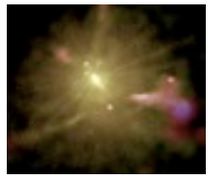


- Variability selection of quasars is powerful!

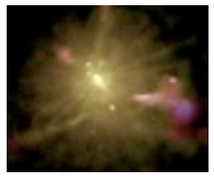
  Up to 10 times better than the usual color selection



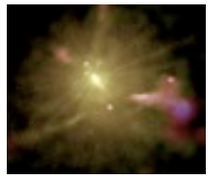
Quasar Color Variability: A Key to Quasars Physics



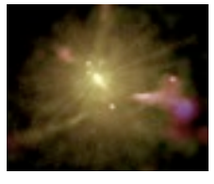
- We know that quasars vary on time-scales of years
- We do not know *why*!
- Change in accretion rate has been proposed
  - e.g. Pereyra et al. 2006 Li & Cao 2008, MacLeod et al. 2010
- Color changes are clues to the underlying physics



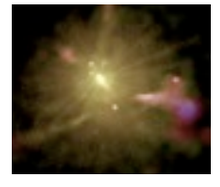
Quasar Color Variability:
Brighter = Bluer



Giveon et al. 1999; Trevese et al. 2001; Trevese & Vagnetti 2002;
Geha et al. 2003; Vanden Berk et al. 2004; Wilhite et al. 2005



Quasar Color Variability: Brighter = Bluer

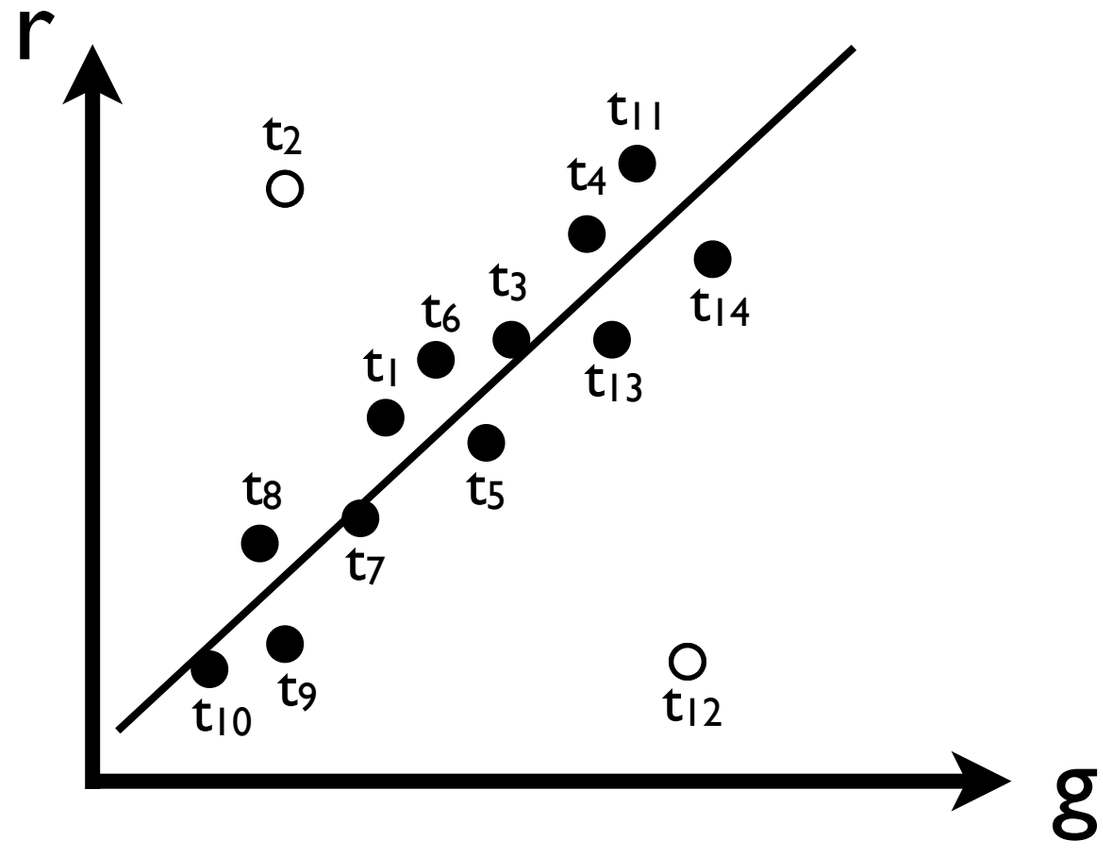


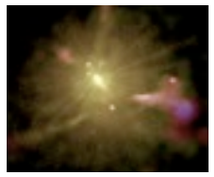
- 9093 Spectroscopic Quasars from SDSS Stripe 82
- Change in color estimated on g-r space
- Color Variability $\equiv S_{gr}$

$S_{gr} < 0$: Brighter = Bluer

$S_{gr} > 0$: Brighter = Redder

$S_{gr} = 0$: No Color Change





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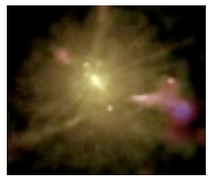

- 9093 Spectroscopic Quasar
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$S_{gr} < 0$: Brighter = Bluer

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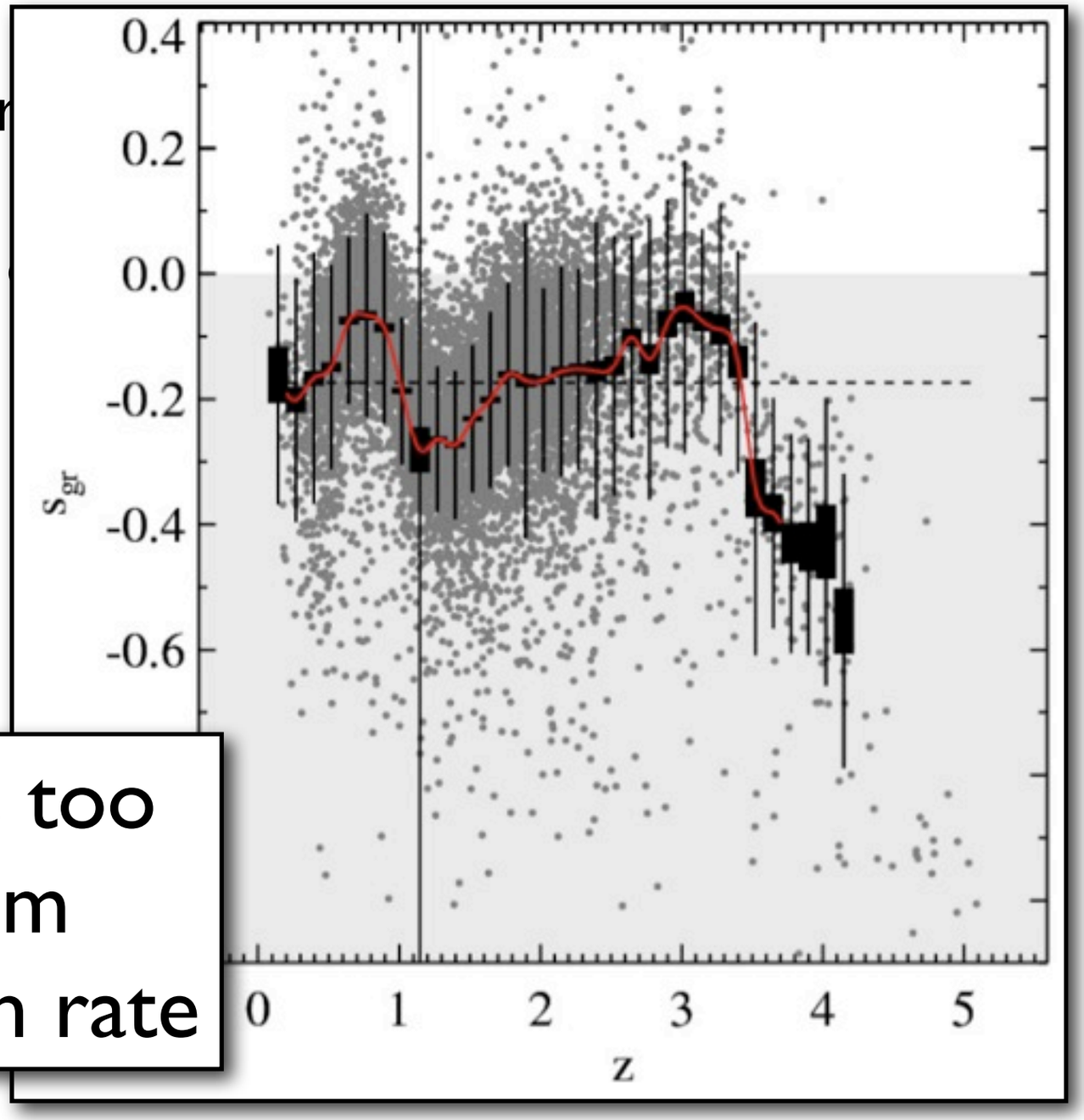
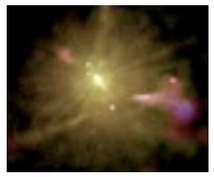
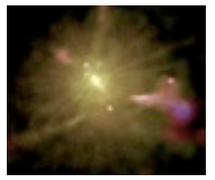
S_{gr}



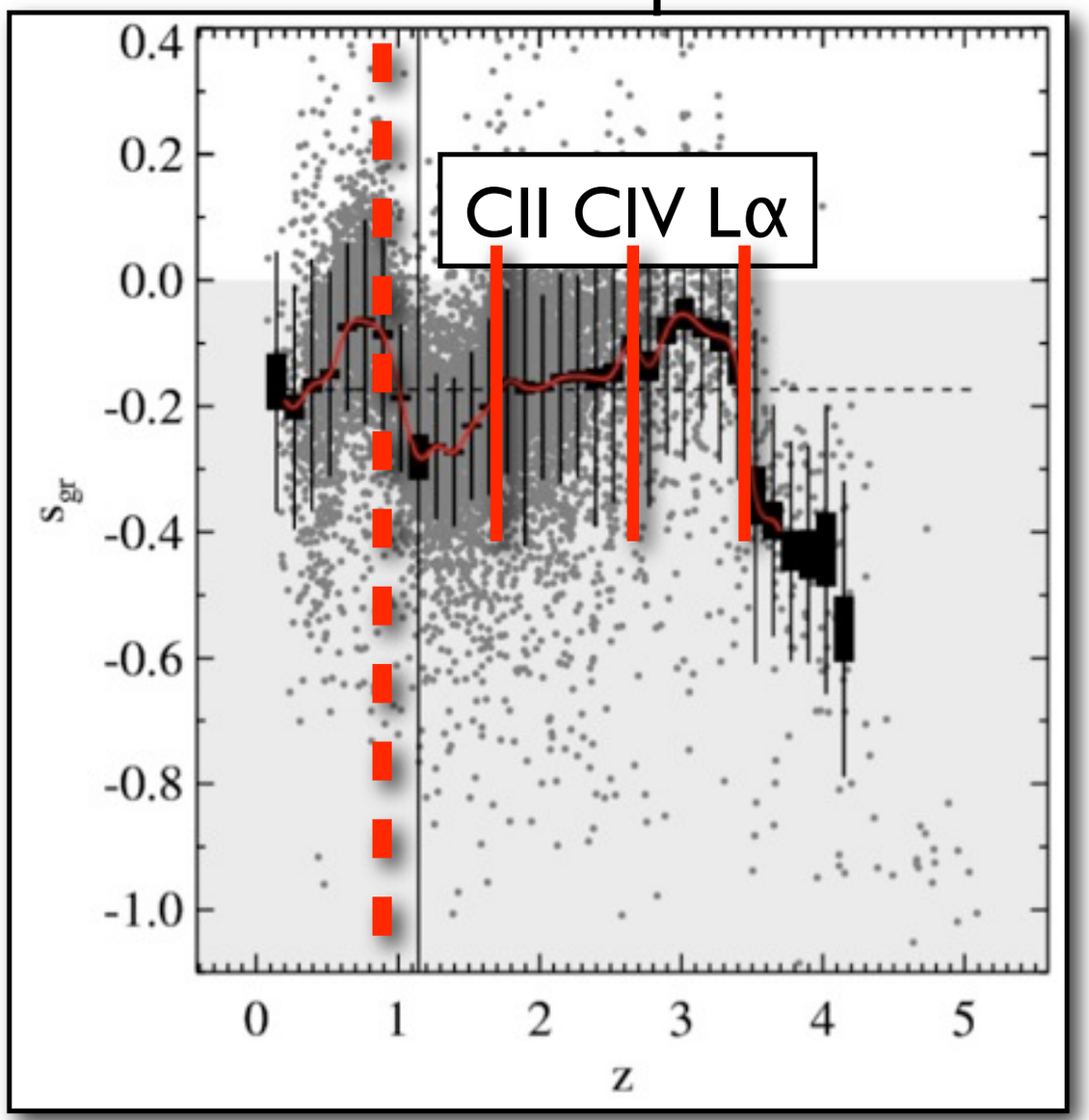
Color variability is too strong to be from changes in accretion rate

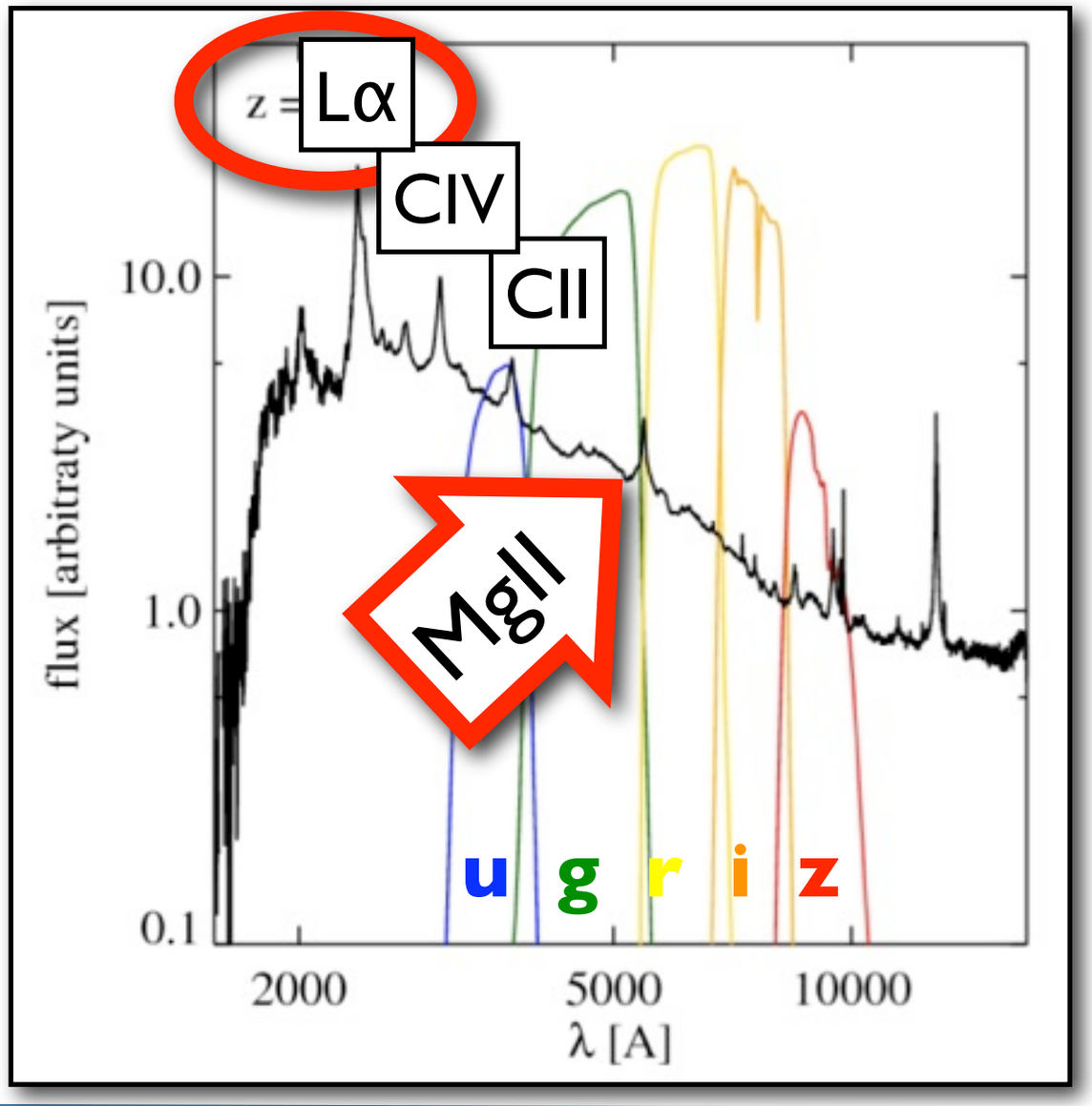


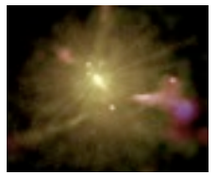
Quasar Color Variability:
Color Variability vs. M & L



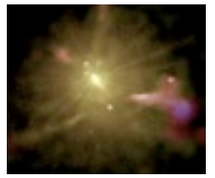
- Redshift dependence due to emission lines





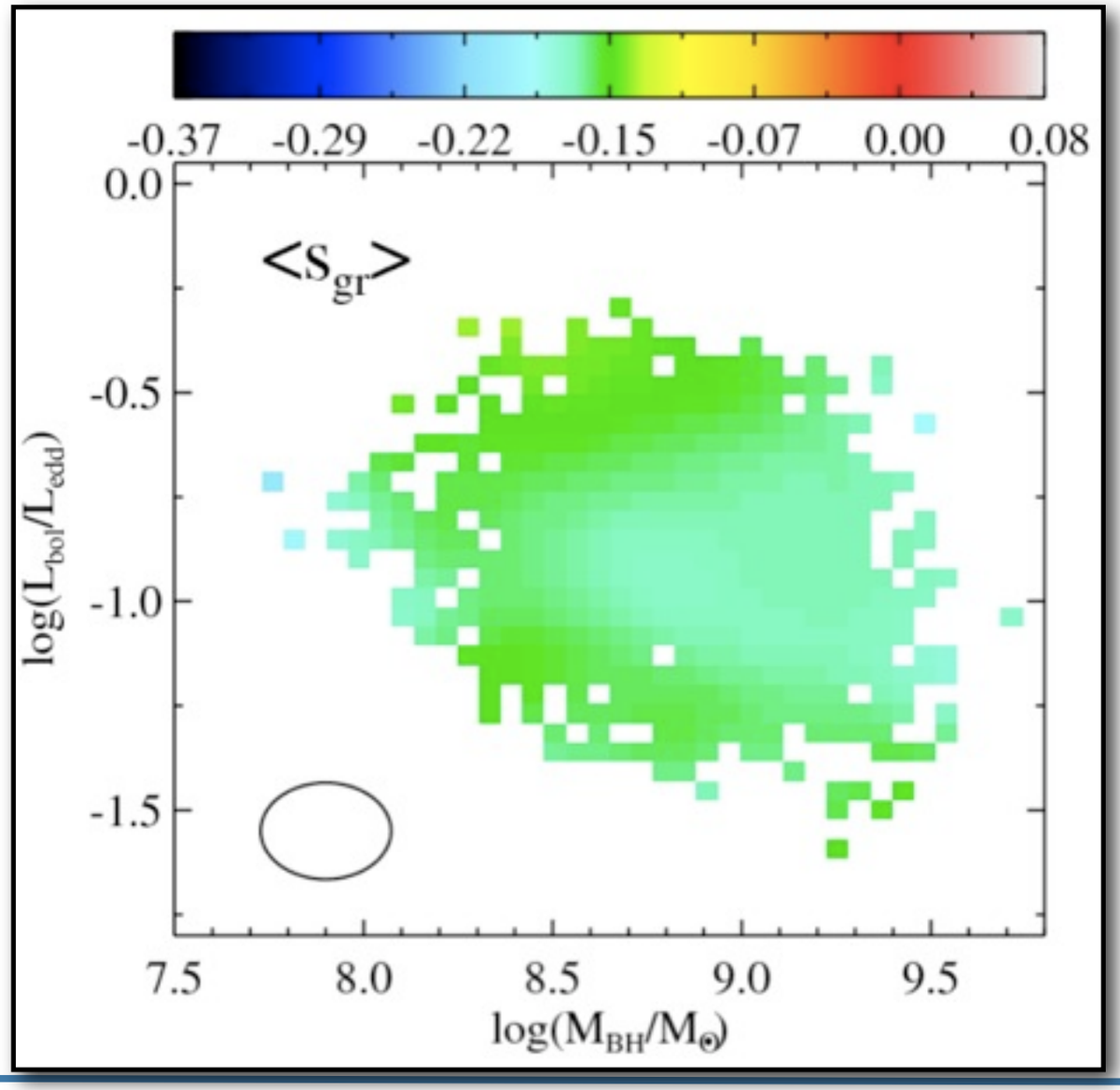


Quasar Color Variability:
Color Variability vs. M & L

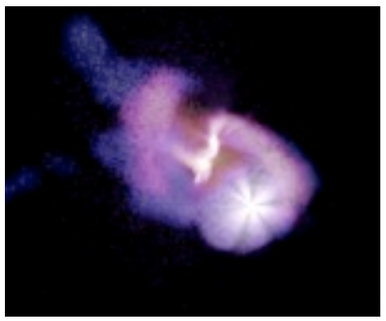


- Redshift dependence due to emission lines
- Correct for z-dep.

Color variability does *not* depend on
M & L

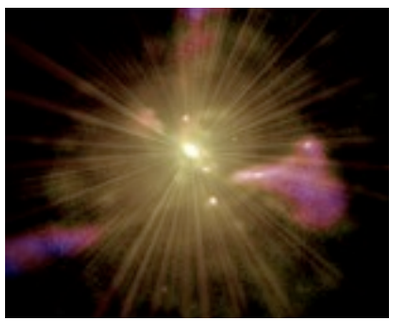


Future Plans



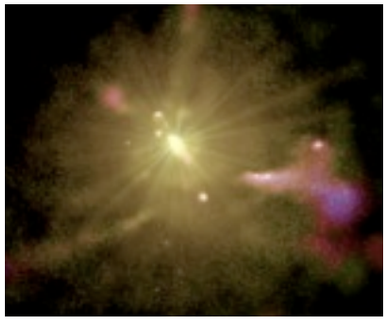
Investigate full sample - where does SF happen?

SINFONI follow-up to obtain kinematics



Combine Variability with Color selection for PS1 and LSST

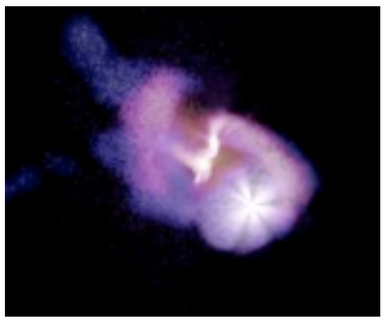
Find quasar lenses via variability - 1st candidates followed up



Model (reverberation) of emission lines

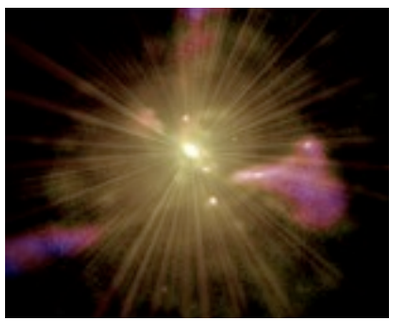
Statistical photometric reverberation mapping of sample

Summary



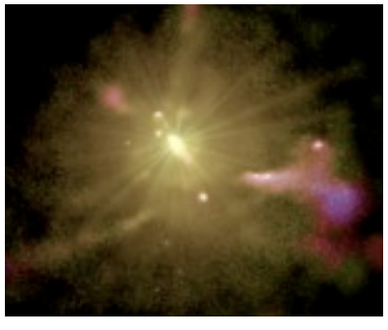
We can make galaxy EL maps at a z~1.5 of large samples

Merger samples are ready to be investigated further.



Variability is a powerfull tool for selecting QSOs!

It can/will improve completeness & purity of future samples



Color variability of QSOs is too strong to be acc. rate changes

Color variability is not dependent on L & M