Past & Present Secular Evolution in the Host Galaxies of NLS1s*

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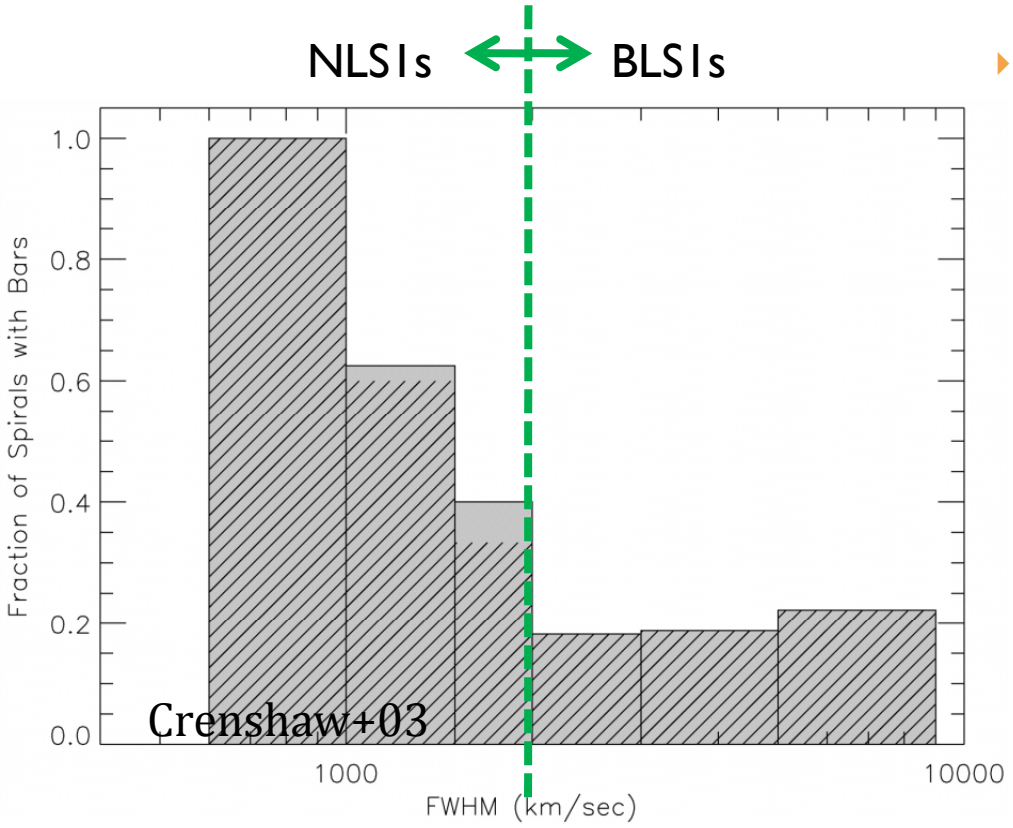
"NLS1s represent a class of AGN in which the black hole growth is, and always has been, dominated by secular processes…"

*see also G. Orban de Xivry et al. 2011, almost submitted to MNRAS

Present

Present Secular Evolution & NLS1 Hosts
Morphological Properties – Bars

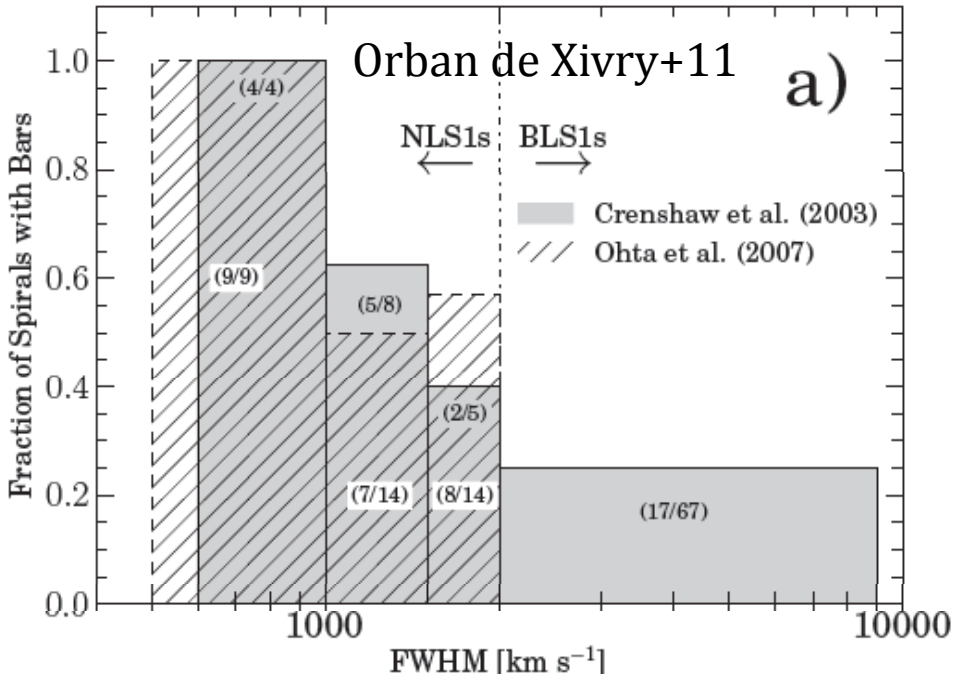
- NLS1 galaxies are likely to be barred



- *Crenshaw+03, visual study HST survey (Malkan+98):*
  - >90% of NLS1s and BLS1s are in spirals.
  - ~65% of NLS1s spirals are barred
  - ~25% of BLS1s spirals are barred

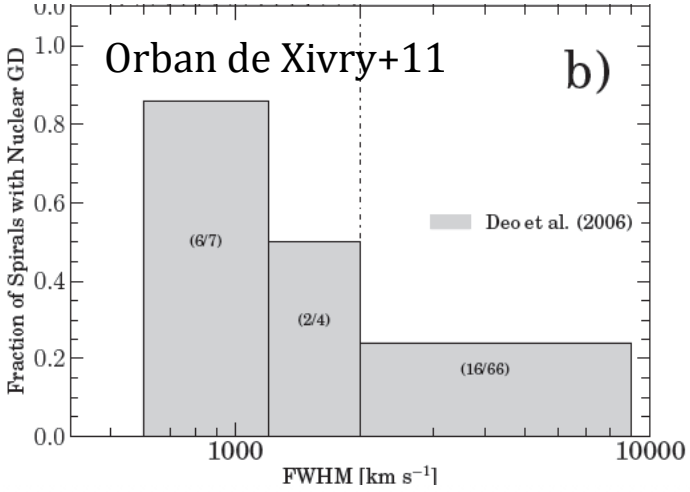
Present Secular Evolution & NLS1 Hosts
Morphological Properties – Bars

- NLS1 galaxies are likely to be *strongly* barred

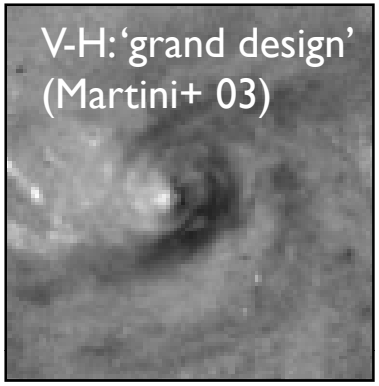


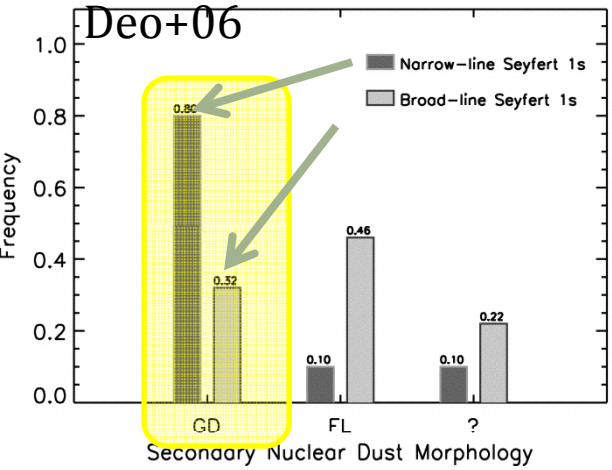
- *Crenshaw+03:*
  - >90% of NLS1s and BLS1s are in spirals.
  - ~65% of NLS1s spirals are barred
  - ~25% of BLS1s spirals are barred
- *Ohta+07, visual and ellipse fitting:*
  - Most NLS1s are in spirals galaxies.
  - ~85% of NLS1 spirals are barred.
  - SB (not SAB) show similar trend with FWHM(Hβ)

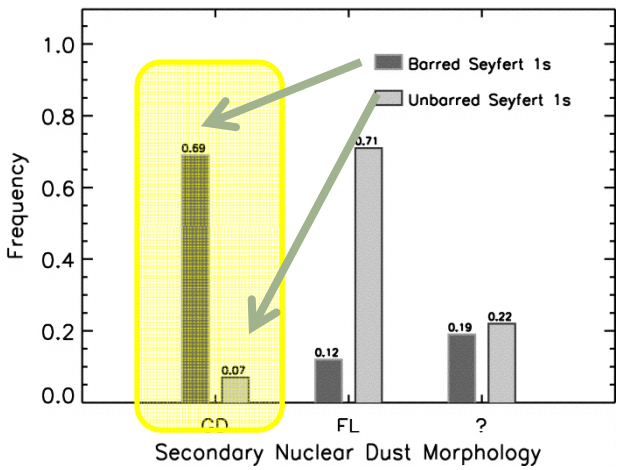
Present Secular Evolution & NLS1 Hosts
Morphological Properties - Circumnuclear



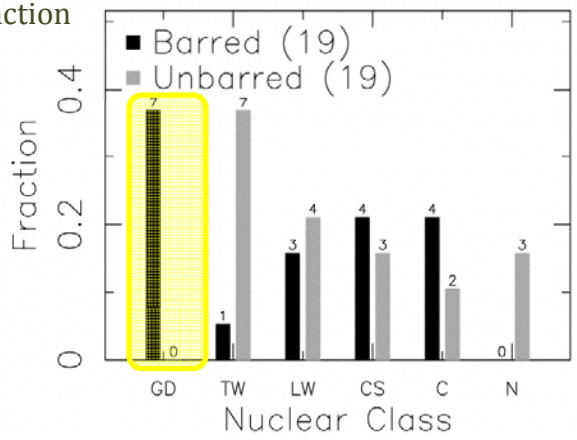
- Deo+ 2006, HST imaging survey from Malkan+ 98:
  - NLS1s likely have 'grand-design' nuclear spirals
- Nuclear grand design spirals are also characteristics of barred galaxies. Martini+03
  - Same trend with FWHM than bars fraction







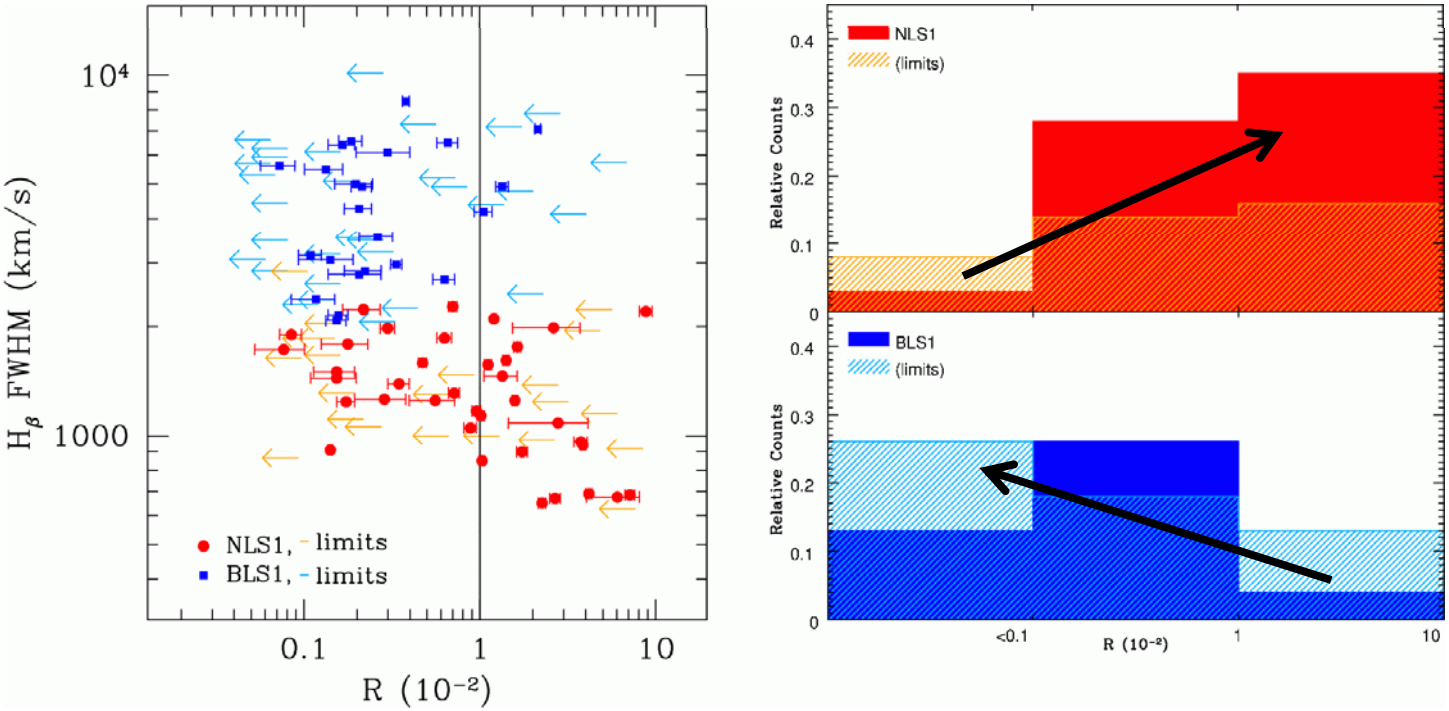
Martini+03



But bars also drives gas inwards …

Present Secular Evolution & NLS1 Hosts
Star Formation

- *Sani+10*, "Enhanced SF in NLS1 AGN revealed by Spitzer"
  - R is ratio of star formation (PAH) to AGN luminosities at 6um
  - significant difference in R between NLS1&BLS1 (checked for bias due to luminosity, distance, etc.)



Present Secular Processes All the Way Down

- *"NLS1 host galaxies are likely to be strongly barred (much more than BLS1 ones) and their nuclear dust morphology is likely to be a grand-design spiral"* (Crenshaw+03,Ohta+07, Deo+06)

- *"NLS1 host bulges have a more intense star formation than BLS1s"* (Sani+10)

- *Also in line with the finding of Ho+97 that nuclear star formation is enhanced in barred galaxies.*

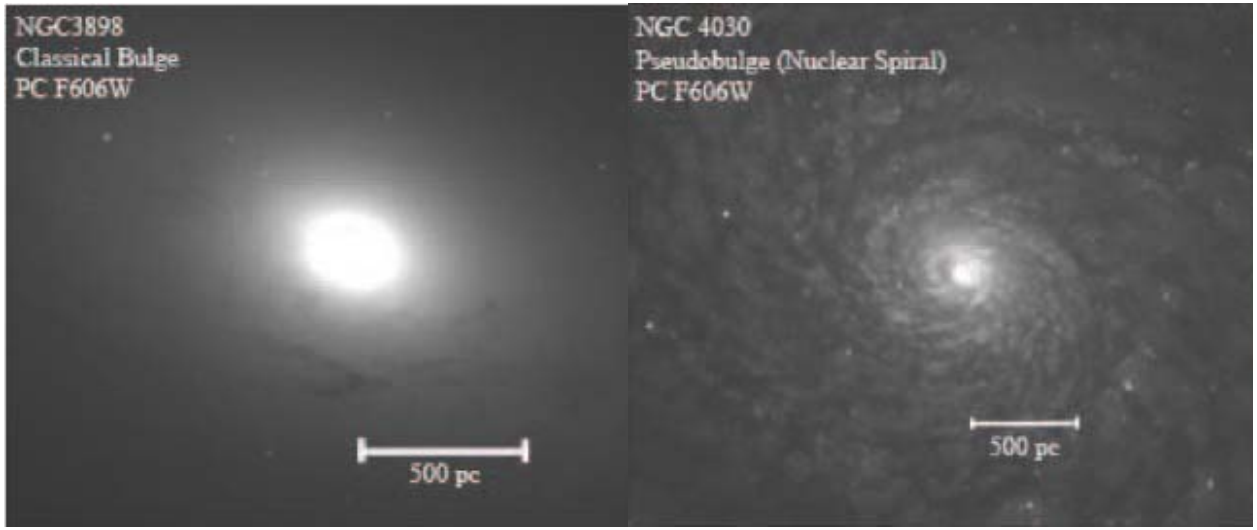
- Secular processes are powerful on all scales

Past

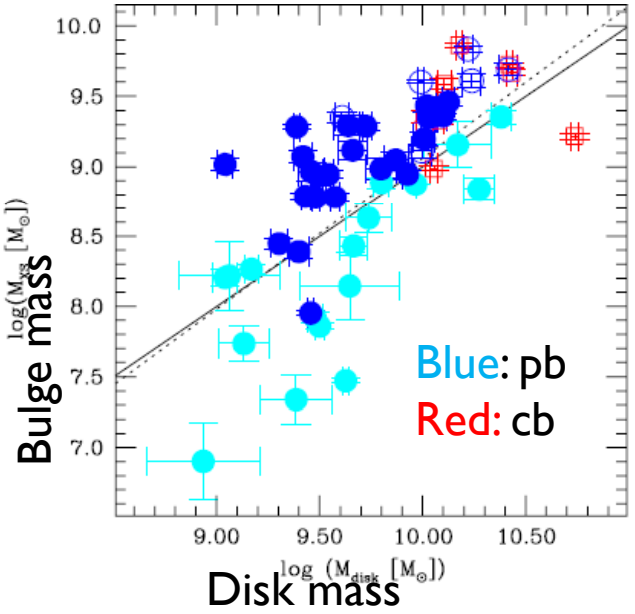
Past Secular Evolution & NLS1 Hosts

Pseudo-bulges and Secular Evolution

- Pseudo-bulges are secular phenomena (Kormendy & Kennicut 2004)
  - They are *bulges* because they are dense central components of galaxies (like classical bulges)
  - They are *pseudo-* because they are made slowly by disks out of disk material. They are formed by internal secular processes (bars, spirals, etc.) > < galaxy mergers or external secular evolution



Fisher&Drory 2008



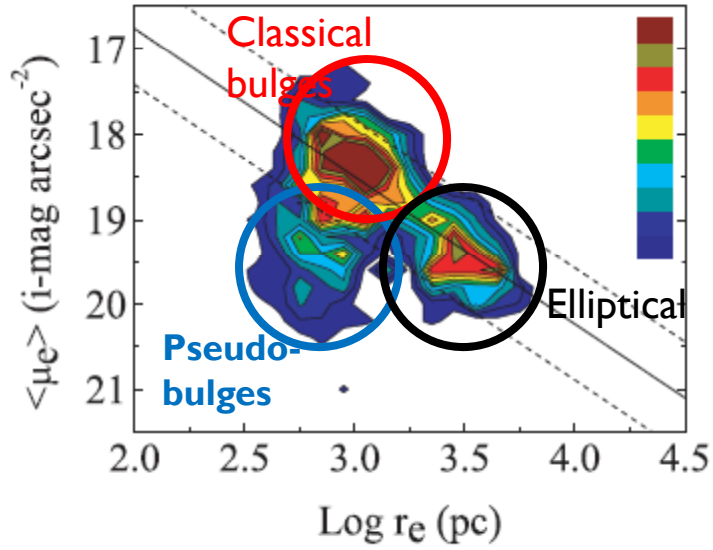
Fisher+09; larger disk makes larger bulges

Past Secular Evolution & NLS1 Hosts
Pseudo- vs. Classical bulges

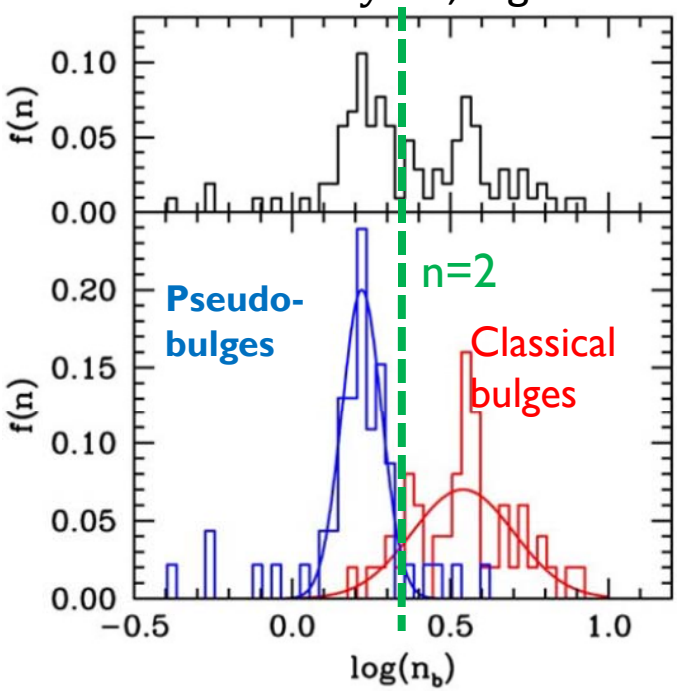
- Pseudo-bulge identification (e.g. KK04, Fisher&Drory08, Gadotti09, FD10)
  - Dynamics are rotation dominated (see later)
  - Structural properties :

    low Sersic index (disk have n~1), bulge scaling relation, bulge morphology
  - Stellar population

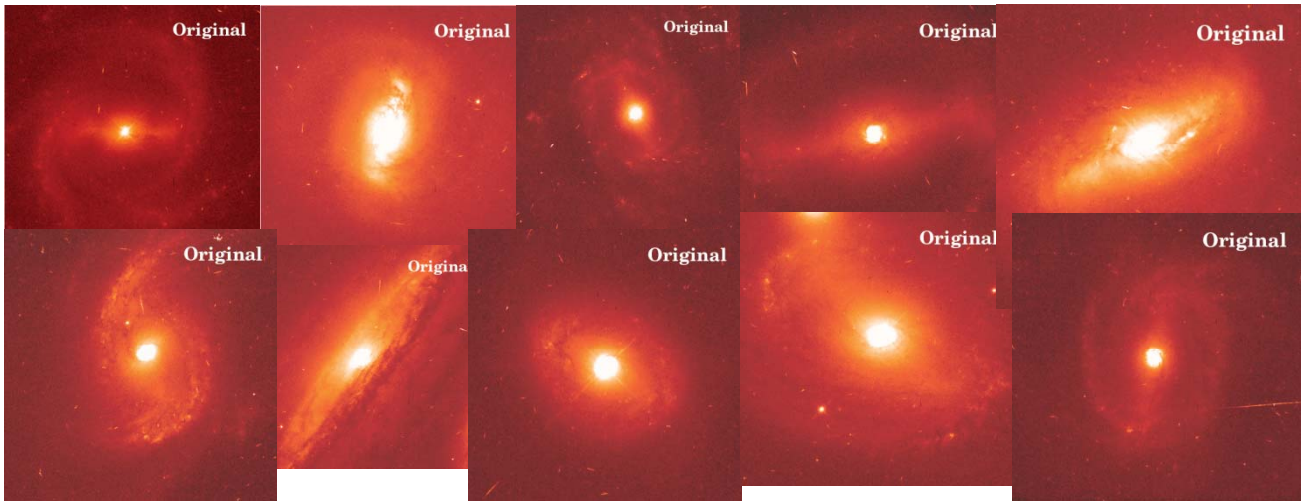
Gadotti 09, SDSS data



Fisher&Drory 08, high resolution data



Past Secular Evolution & NLS1 Hosts
Bulge-Disk decomposition - sample



- WFPC2 F606W images from HST survey of nearby AGNs by Malkan+98 ($z<0.035$)
- Classification is first taken from previous papers using these data and then verify based on spectra.
- Final sample: 10 genuine NLS1s (Veron et al. 2001); 18 BLS1s for comparison
- High resolution images: mean pixel scale ~ 20pc/px

Past Secular Evolution & NLS1 Hosts
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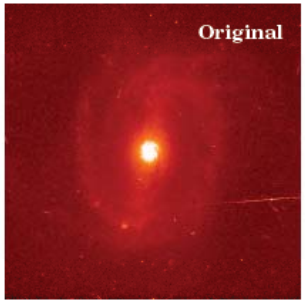
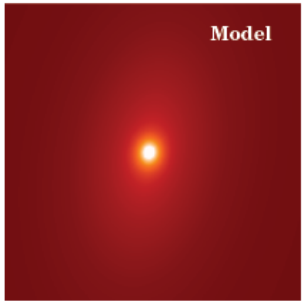
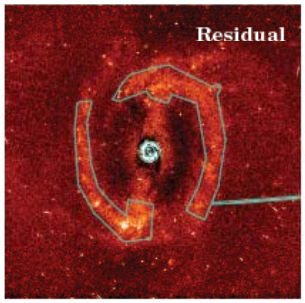
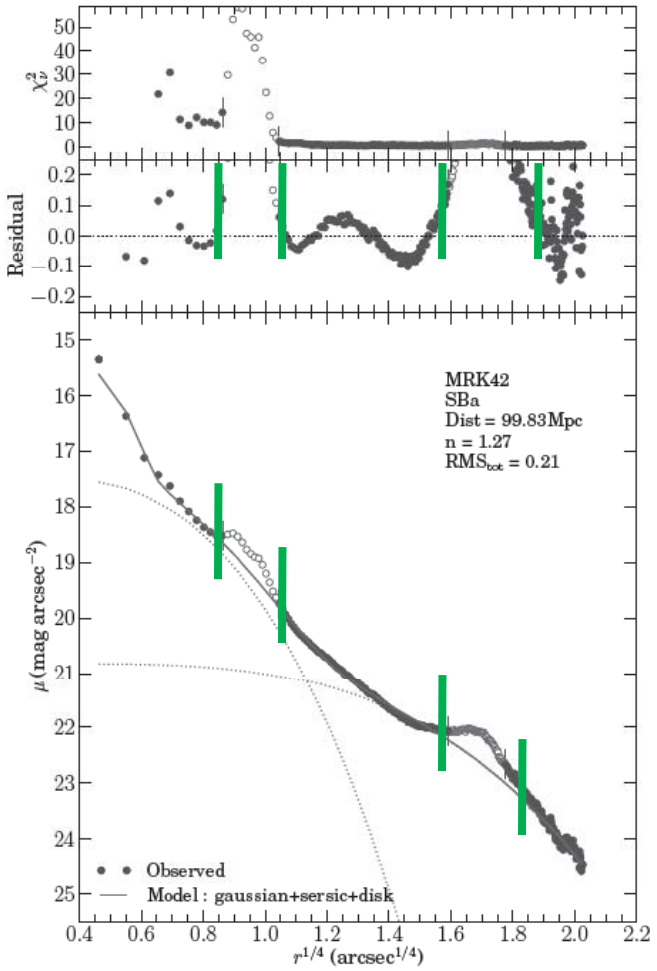
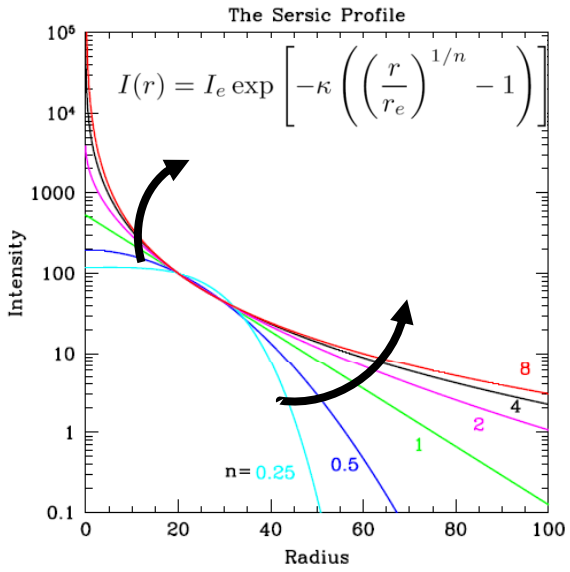








- Components:
  1. Point source
  2. Sersic profile (bulge), *n* index free (*n~4 elliptical, n~1 disk*)
  3. Exponential profile (disk)
- Additional features are masked



Doing this for 28 objects, we obtain…

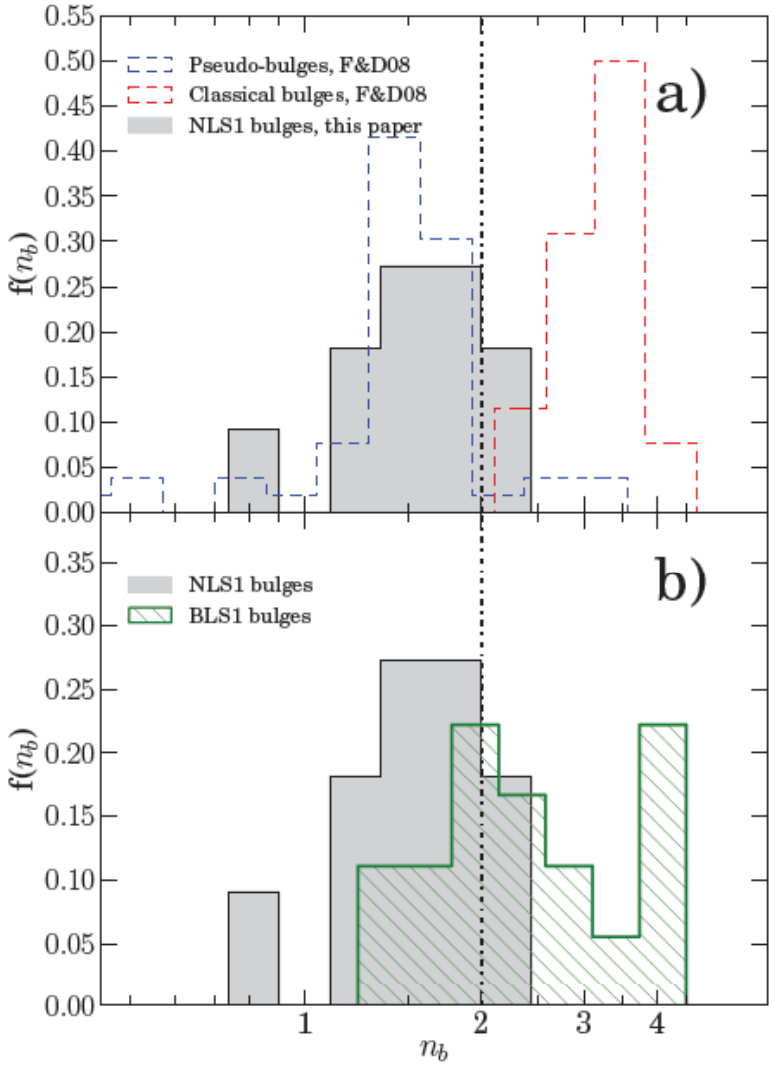
Past Secular Evolution & NLS1 Hosts
Sersic *n* in the bulge of NLS1 and BLS1

NLS1 bulges n is different than the one of BLS1s:

- <*n*>(NLS1) ~ 1.59
- <*n*>(BLS1) ~ 2.54
- FD08 :

<*n*>(pb)~1.69, <*n*>(cb)~3.49

- Laurikainen+07: the mean bulge Sersic index is ~2.5 or less across the Hubble sequence



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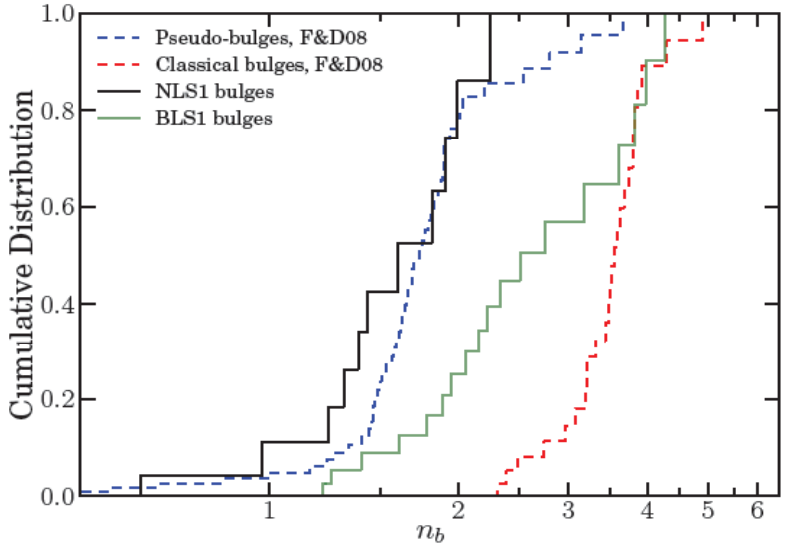

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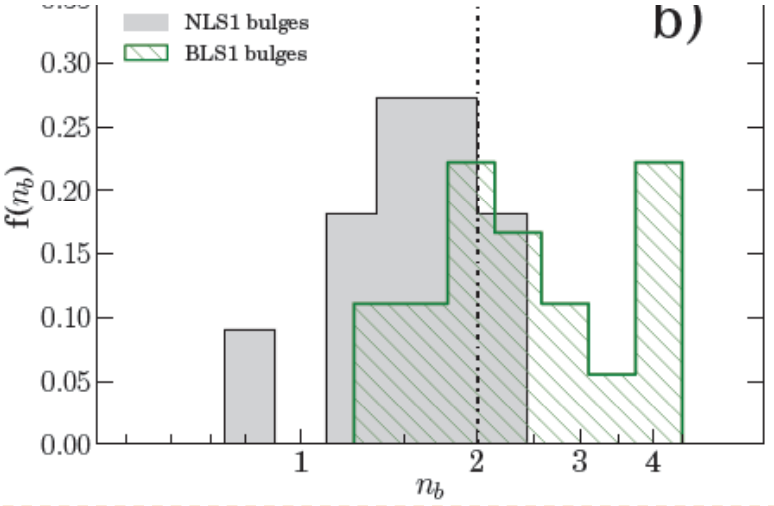
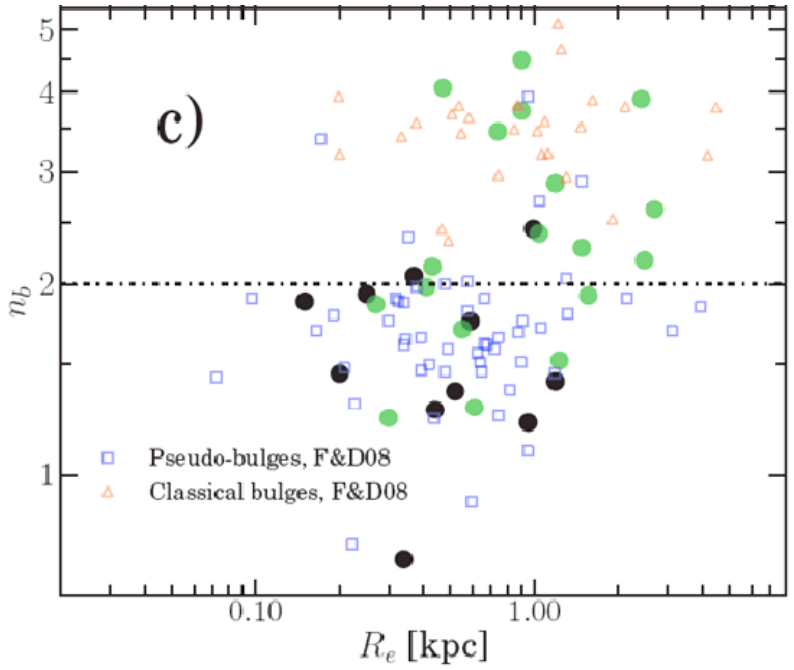
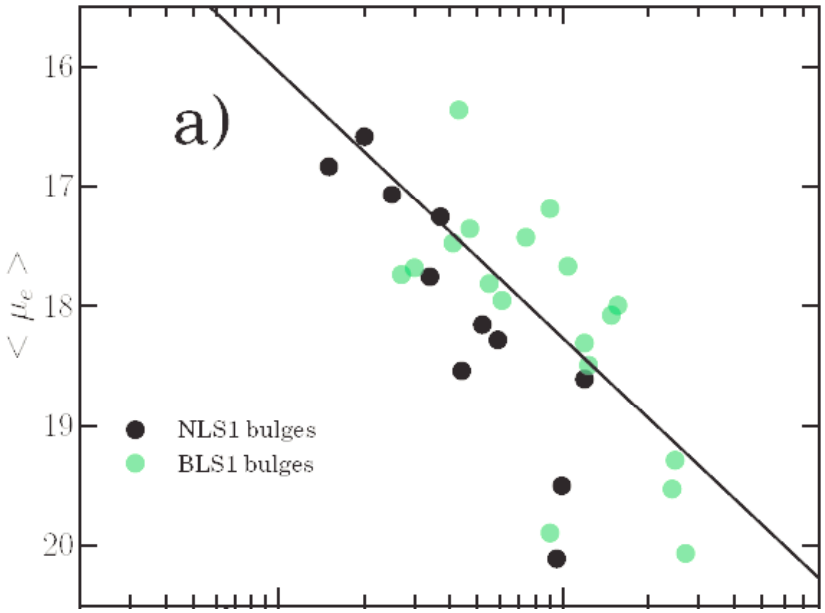


- Dispersion in *n* 2X larger for BLS1 than NLS1
- NLS1 different from the average BLS1.
- BLS1 -> larger bulge range (pb and cb)

Past Secular Evolution & NLS1 Hosts
Bulges Prominence

- NLS1s bulges are less prominent (c)
- Not clearly offset from BLS1 in the FP projection but all on the fainter side (a)

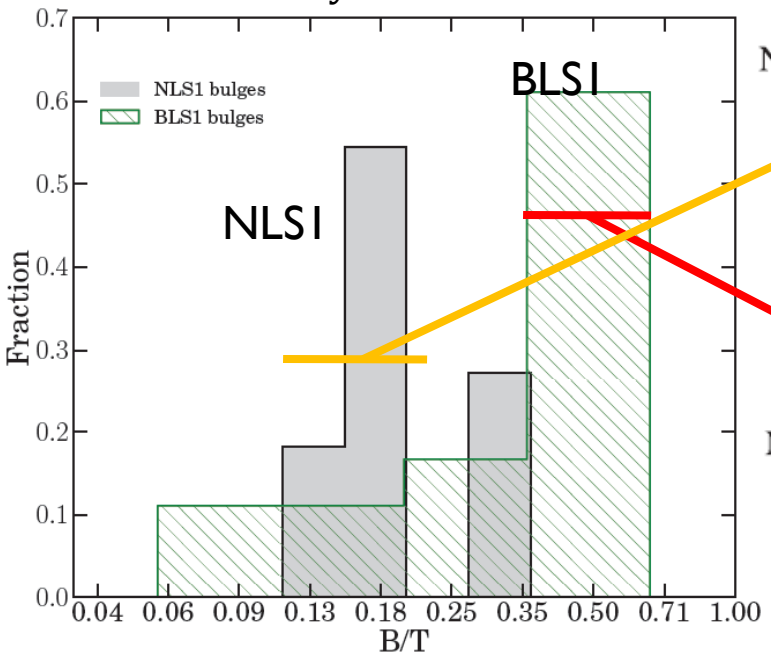




Past Secular Evolution & NLS1 Hosts
Bulges Prominence

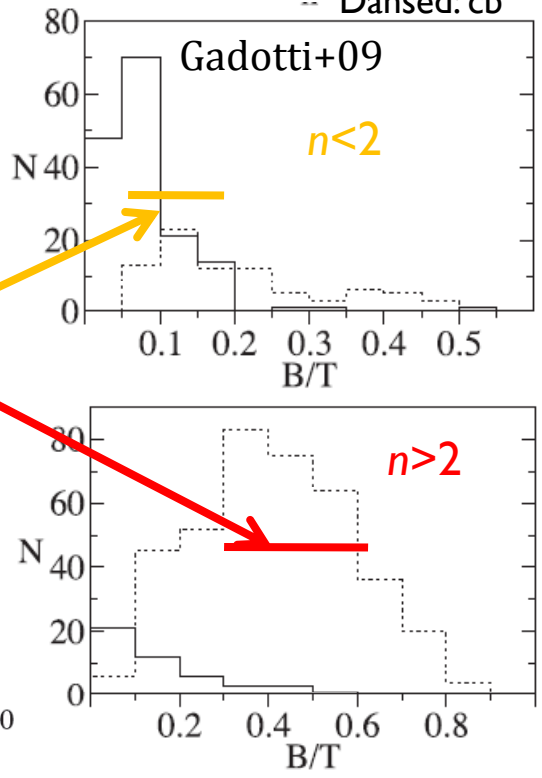
- NLS1 bulges are less prominent than BLS1 bulges as pb and cb.
- NLS1 galaxies are later type than BLS1

Orban de Xivry+2011



Solid: pb
Dahsed: cb

Gadotti+09



Masters+2010

Type	*T*	*B/T*	*B/D*
S0−	−3	0.6	1.5
S0	−2	0.57	1.3
S0+	−1	0.53	1.1
S0/a	0	0.48	0.92
Sa	1	0.41	0.69
Sab	2	0.32	0.47
Sb	3	0.24	0.32
Sbc	4	0.16	0.19
Sc	5	0.094	0.10
Scd	6	0.049	0.05
Sd	7	0.022	0.022

Past Secular Evolution & NLS1 Hosts
NLS1s, pseudo-bulges and secular evolution

- Pseudo-bulges are secular phenomena
- NLS1 bulges have $n<2$. They are less prominent (B/T<~0.2).
- NLS1s have pseudo-bulges and are distinct from the average BLS1 bulges. NLS1s tend to be in later type galaxies than BLS1

  - Internal secular processes have dominated the past evolution of NLS1 hosts.

- Evolutionary scenarios: BH growth is supported by secular processes
  1. NLS1 would be young objects evolving into BLS1s (Mathur 2000, Mathur+ 2011)
  2. NLS1 are not in any special phase of their evolution but are simply growing slower (Ric's talk, Orban de Xivry+11)

Past Secular Evolution & NLS1 Hosts

NLS1s, pseudo-bulges and secular evolution

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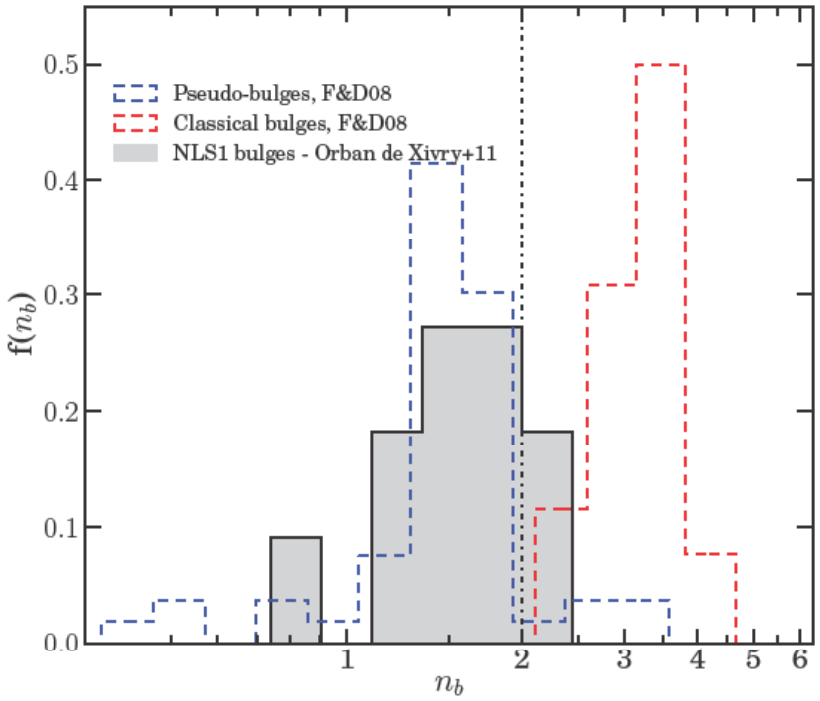
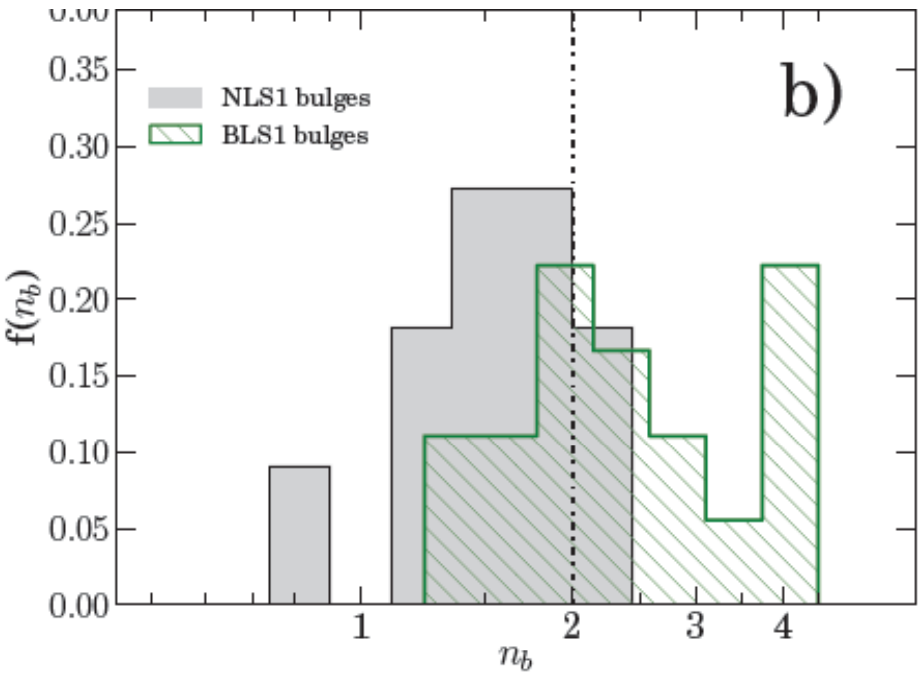
- <*n*>(NLS1) ~ 1.59 <*n*>(BLS1) ~ 2.54





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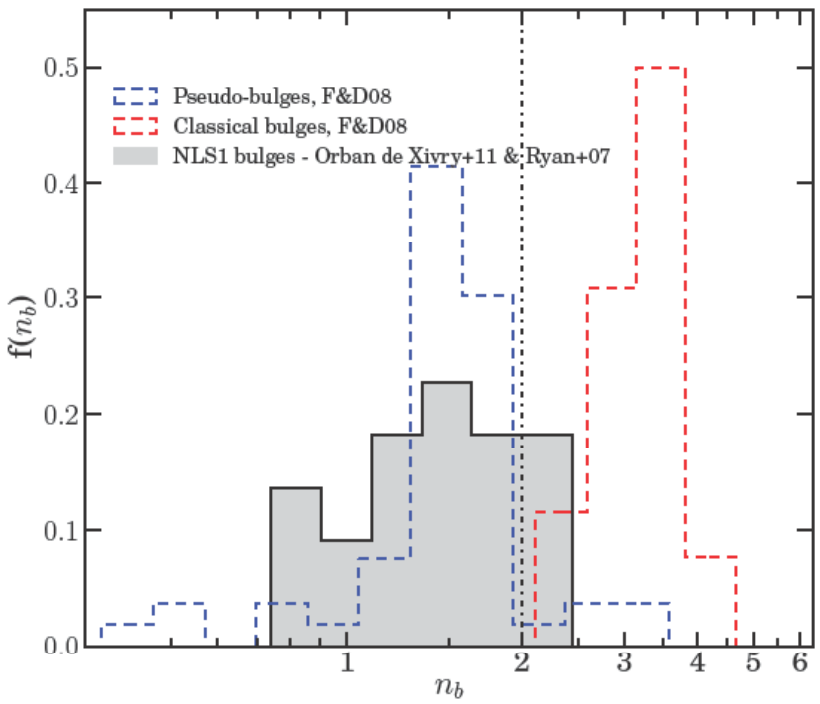

- + Ryan+07, 11 NLS1s AO CFHT data in J and K band:
  - <n_K> ~ 1.4
  - <n_J> ~ 1.5

Past Secular Evolution & NLS1 Hosts
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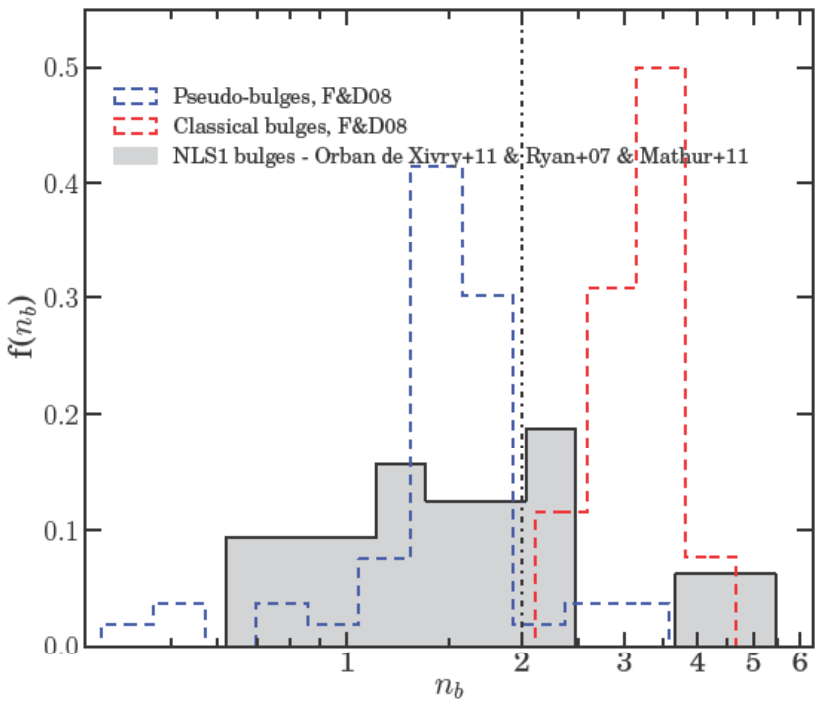
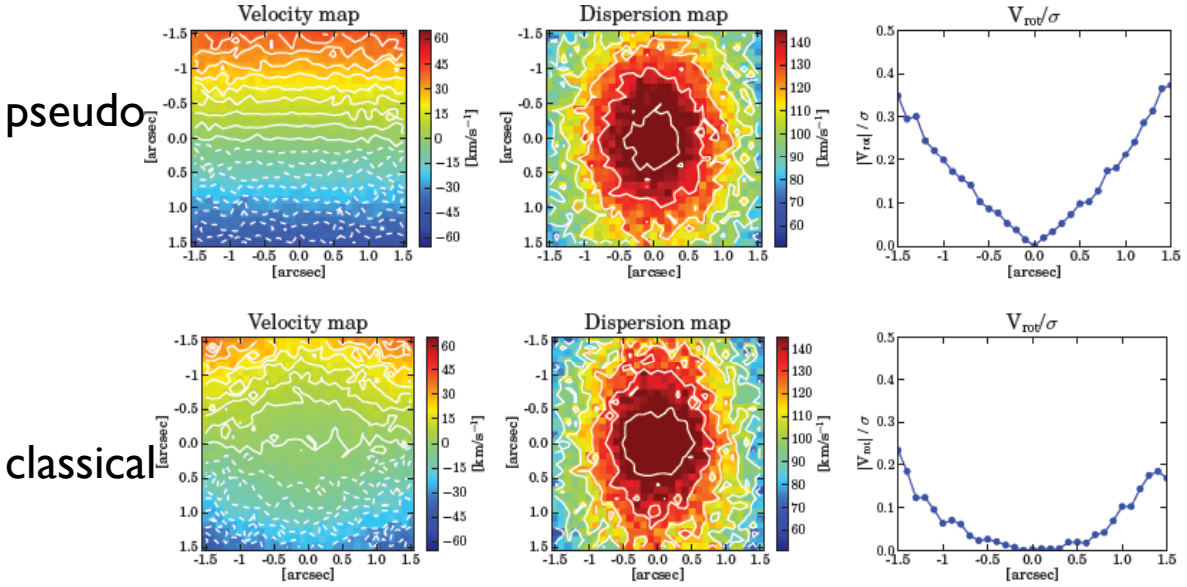


- + Ryan+07, 11 NLS1s AO CFHT data in J and K band:
  - <n_K> ~ 1.4
  - <n_J> ~ 1.5
- + Mathur+11 (updated), 10 NLS1s ACS F625W (6NLS1s have n<2)
  - <n> ~ 2.12

How to challenge this picture?

- Pseudo-bulges are more rotation dominated than classical bulges (KK04)
  - Can we detect it using an IFU?
  - Importance of angular momentum in the fueling of the NLS1 black holes growth?



Using the DYSMAL code, e.g. Davies+09

Conclusions

- NLS1s have strong bars, nuclear GD and enhanced SF,
- Secular evolution is powerful and on-going process on all scales,
- NLS1s host bulges are pseudo-bulges and distinct from BLS1s bulges
- Pseudo-bulges are driven by secular evolution therefore:

- *NLS1 represent a class of AGN in which the BH growth has always been dominated by secular evolution*

- *Ric will present the implications of this results and how it can fit in a cosmological context.*

Thank you!