

Search for Faint AGNs through

Variability

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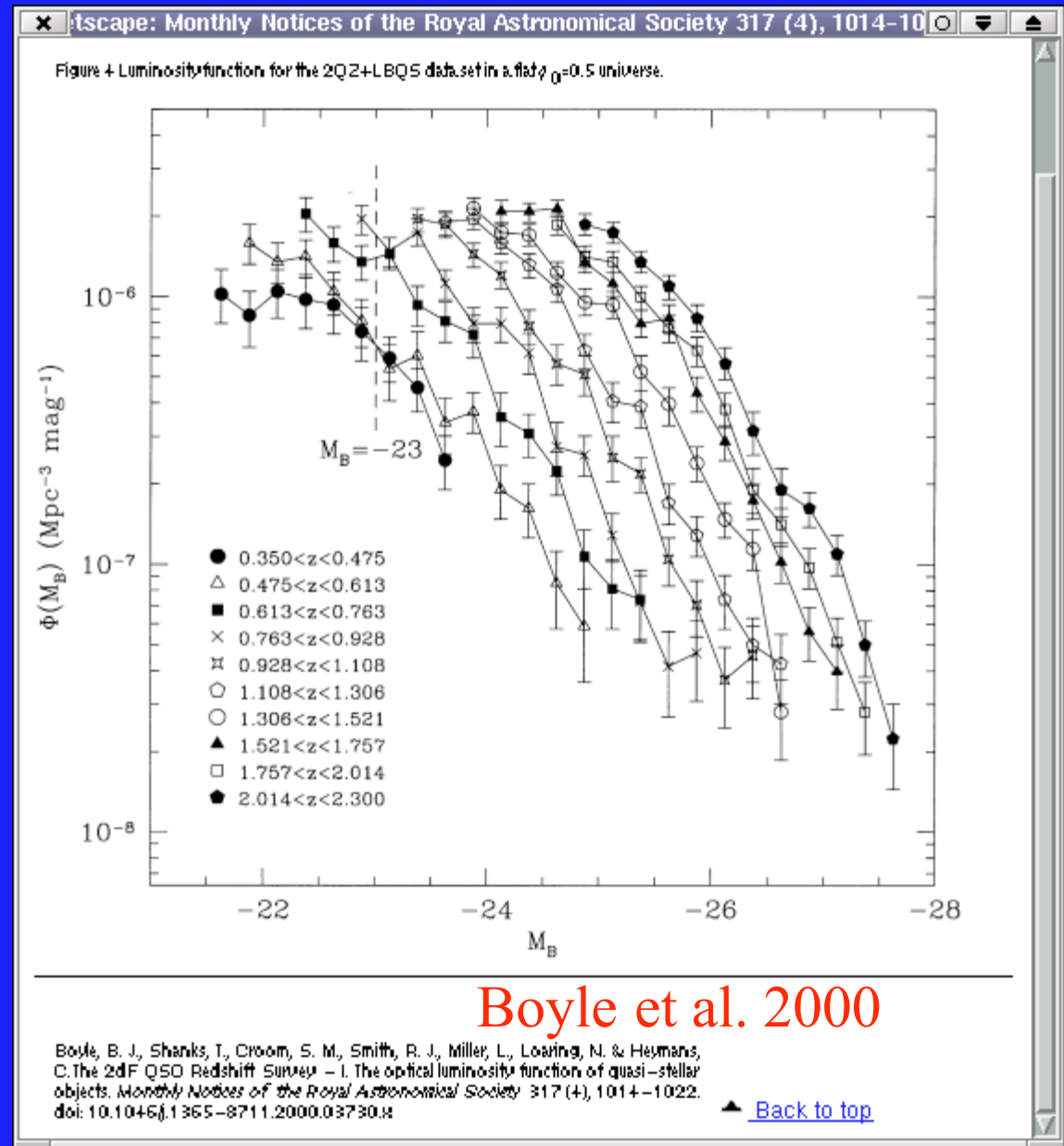
- evolution of AGN luminosity function (LF)
variability as a selection criterion
- origin of AGN variability
repeated multiband observations
- CONCLUSION: “synergic” use of LBC/LBT

Evolution of the LF

LF evolution is well
studied with
6000 QSOs of 2dF
spectral database
for:

$$0.35 < z < 2.3$$

$$-26 < M_B < -23$$



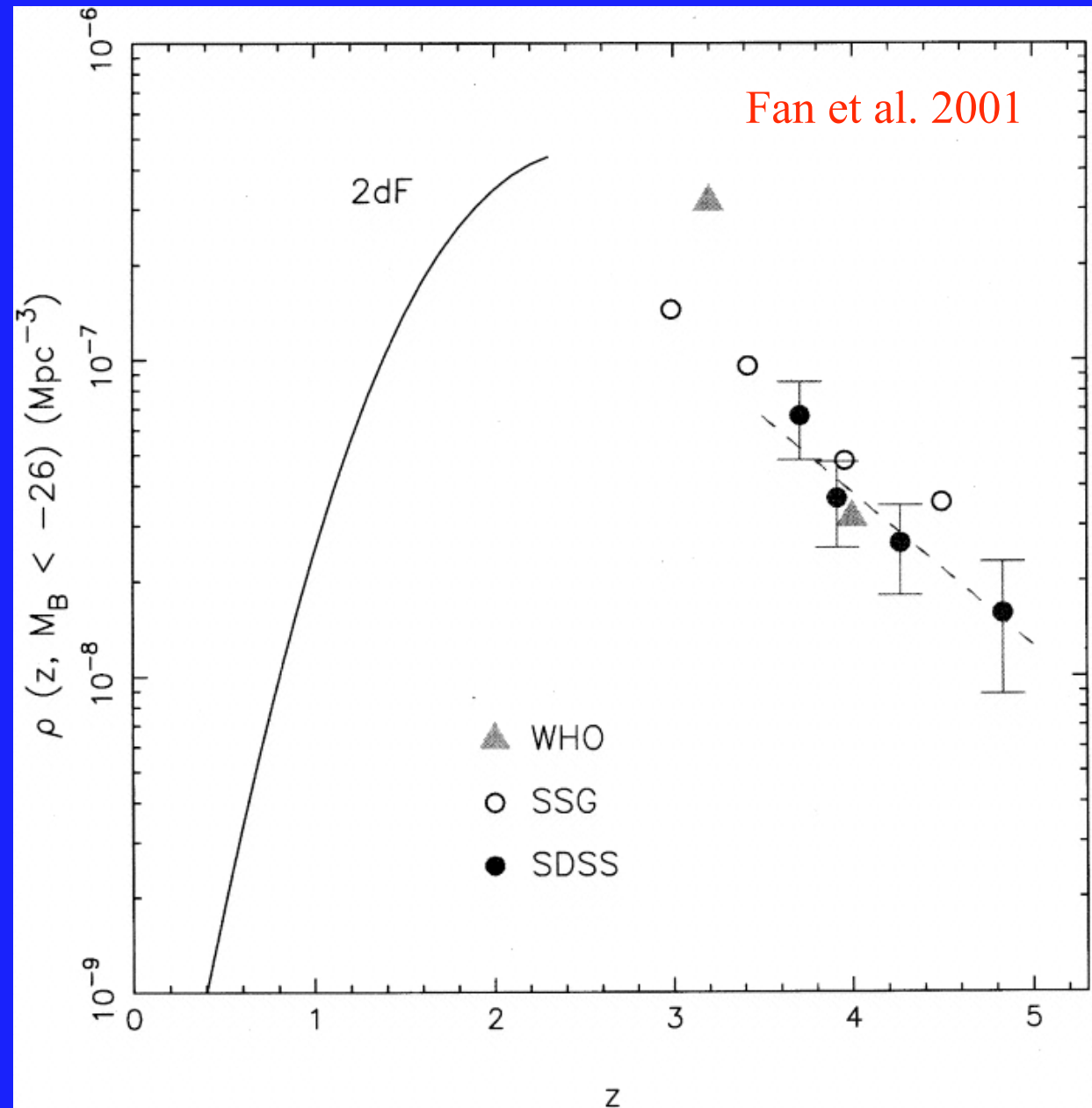
Evolution of the LF

- UKST Warren, Hewett, Osmer 1994 (WHO)
85 QSOs $2.2 < z < 4.5$
- Palomar Transit Grism Survey
Schmidt, Schneider & Gunn 1995 (SSG)
90 QSOs $2.75 < z < 4.75$
the density ($M_B < -26$) drops by 1.7 per unit z at $z > 2.7$
- SDSS Fan et al. 2001
39 QSOs $3.6 < z < 5.0$ $-27.5 < M_{1450} < -25.5$

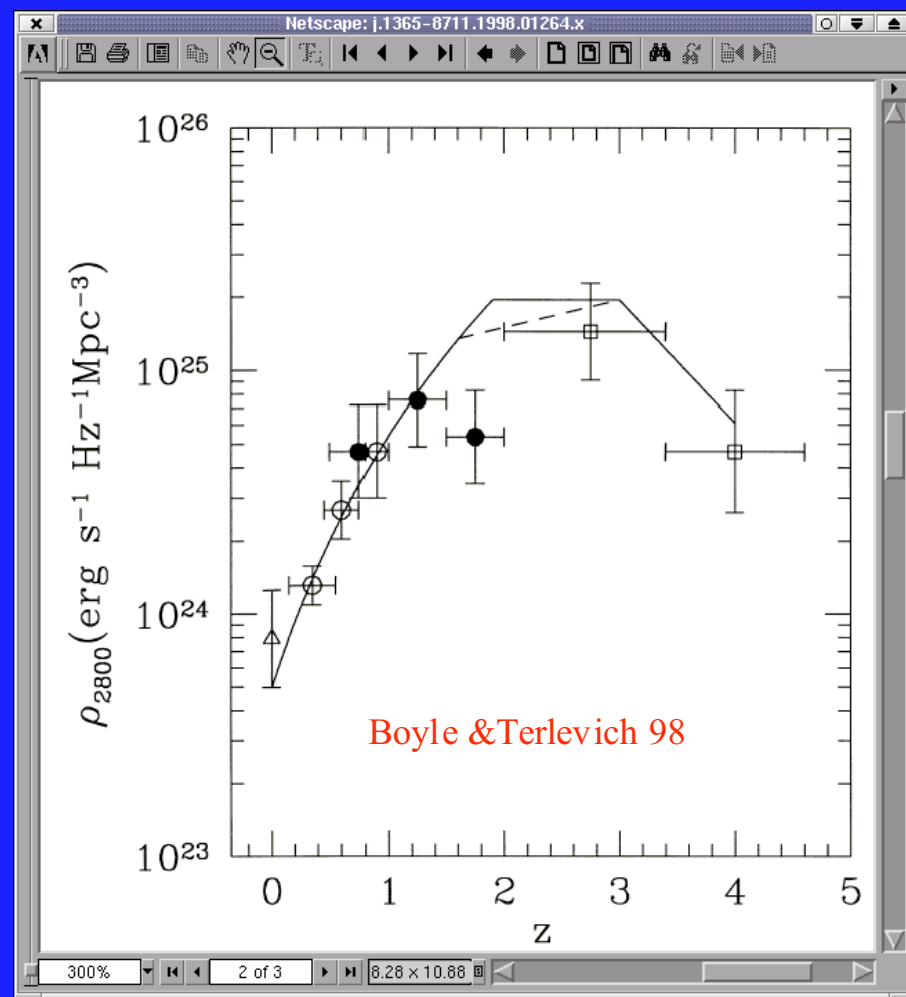
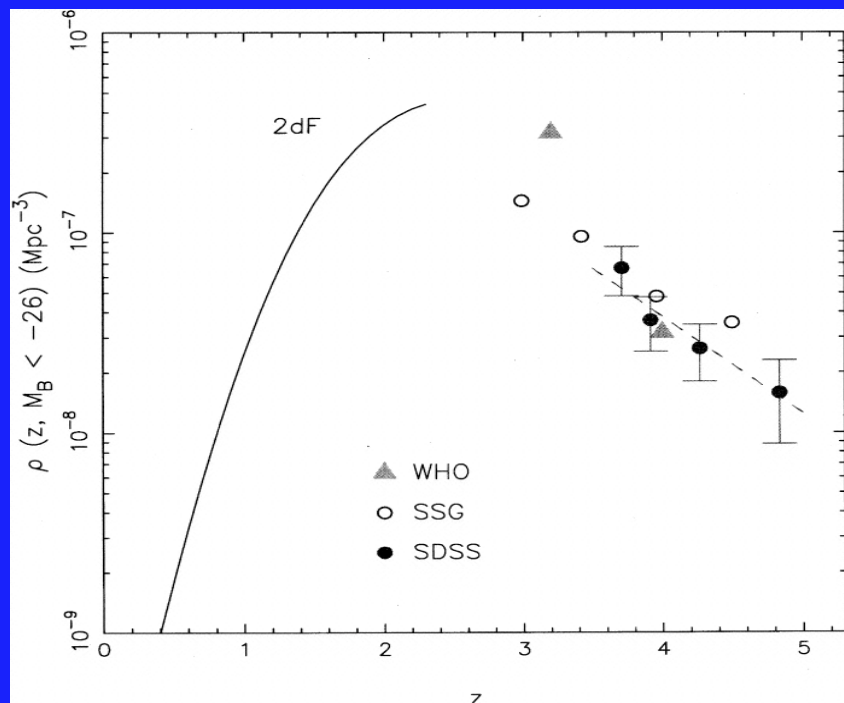
Evolution of the LF

LBT2002 Bertinoro, 7-9/10/2002

The density of
bright quasars
Decreases at
high redshift
 $z > 2.7$



Evolution of the LF



The luminosity densities (LDs) due to QSOs and galaxies evolve in a similar way (they overlap once scaled by a factor 0.025)

→ sincronizzazione di QSO and galaxy formation and evolution processes

Evolution of the LF

LBT2002 Bertinoro, 7-9/10/2002

Open questions

- Faint AGN contribution to LD

at high z QSO UV flux is not sufficient to explain the observed ionization (Madau 99)

- galaxies and AGN contribution to X-ray background (Nandra et al. 02)

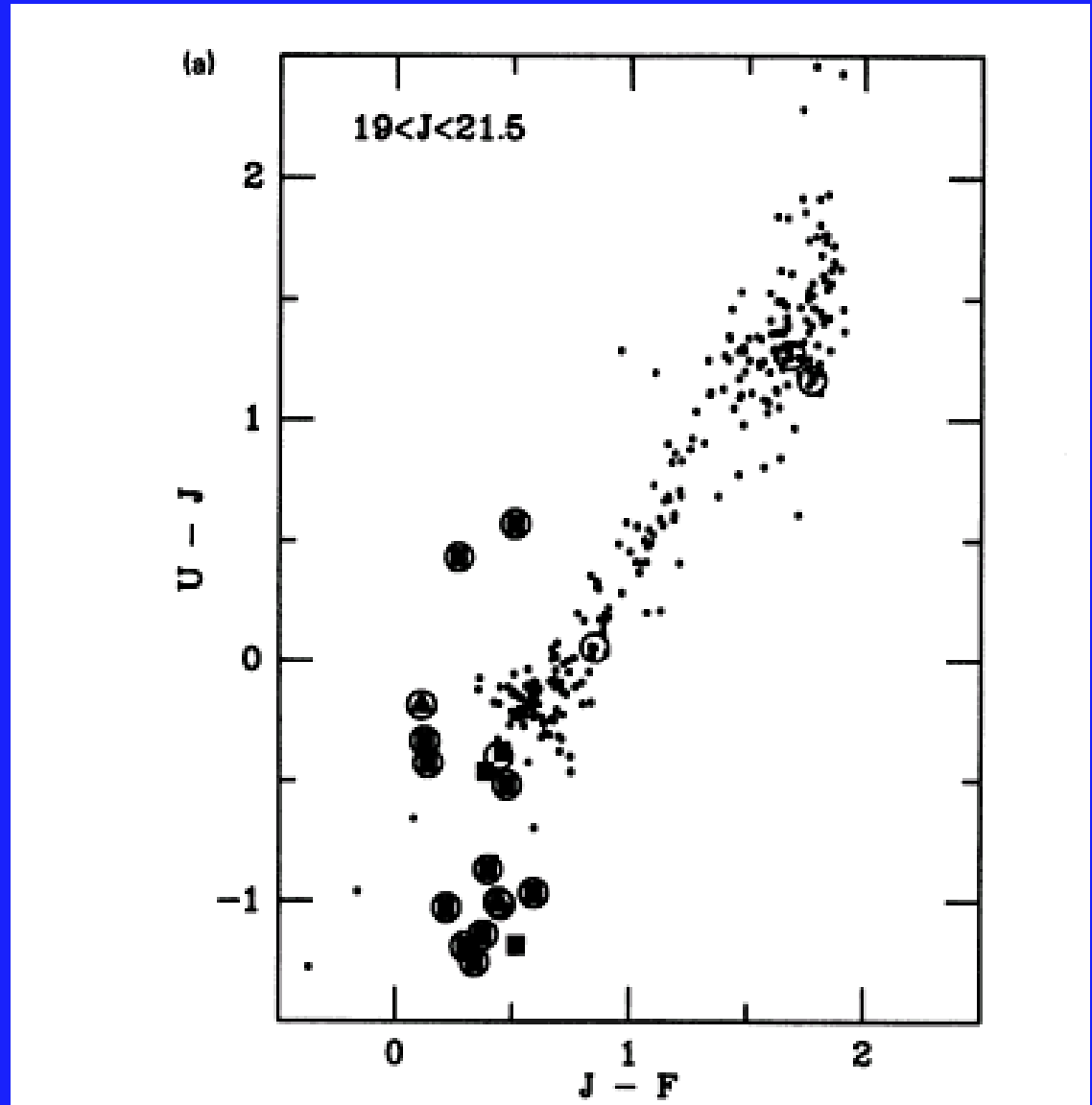
The dominant contributions is due to faint AGN whose evolution is poorly known

→ study of the distribution of optical-X SEDs and its cosmic evolution

Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

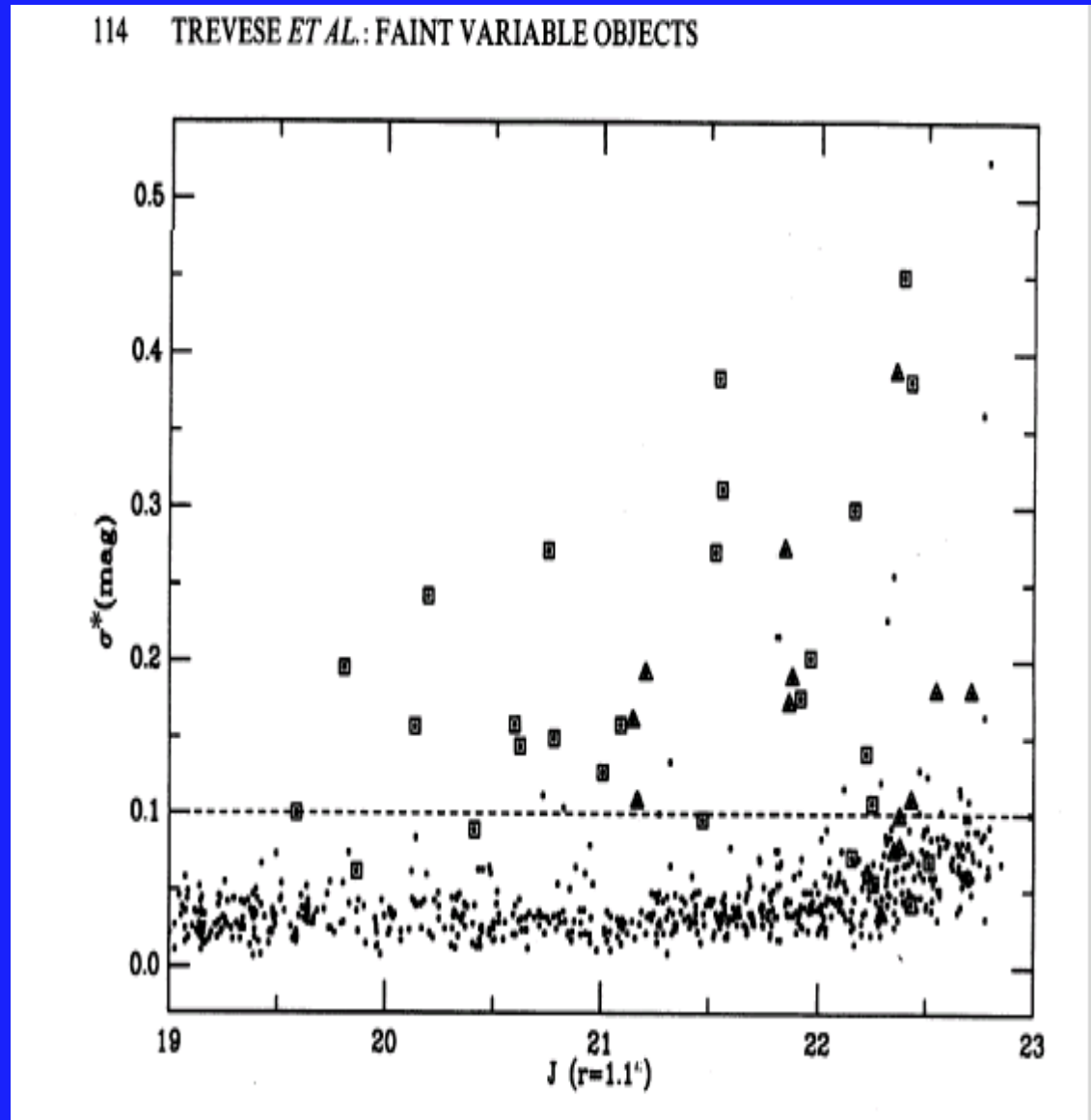
- (non stellar) color selection is limited to point-like QSOs, i.e. so bright to swamp the host galaxy, since galaxies have non-stellar colors



Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

- Selection through variability can be so efficient as color selection
- It allows to assess completeness of color selected samples
(Trevese et al. 89)

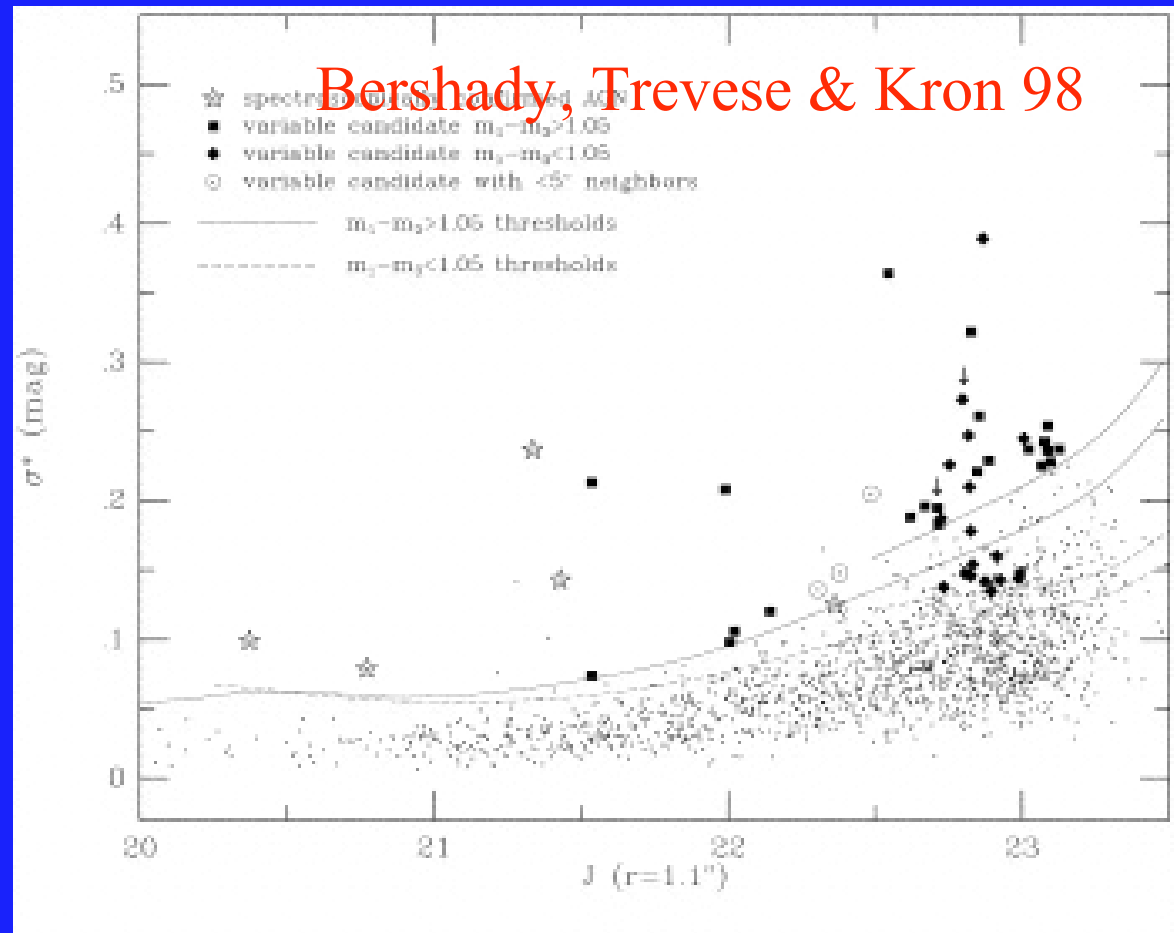


Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

- Variability selection can be applied to “extended” objects, i.e. to search for AGNs which do not dominate the light of the host galaxy

$$M_{B_nucl} < -22$$



Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

- With HDF data is possible to reach

$$M_{B_nucl} < -15, z \sim 1$$

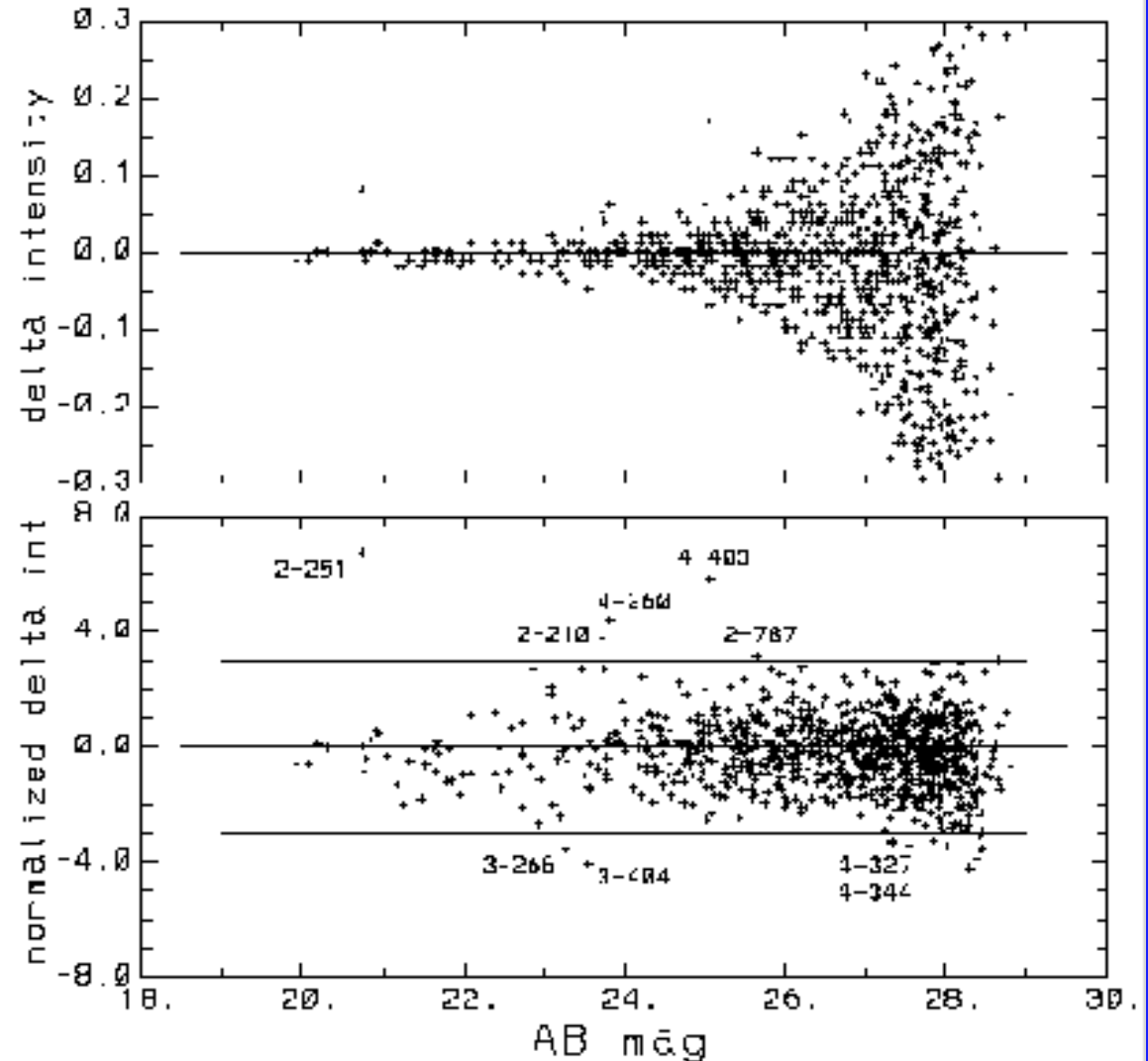
(124 ks + 63 ks exposures)

(3.92 arcmin²)

(Sarajedini et al.2000)

IN THE HDF

28

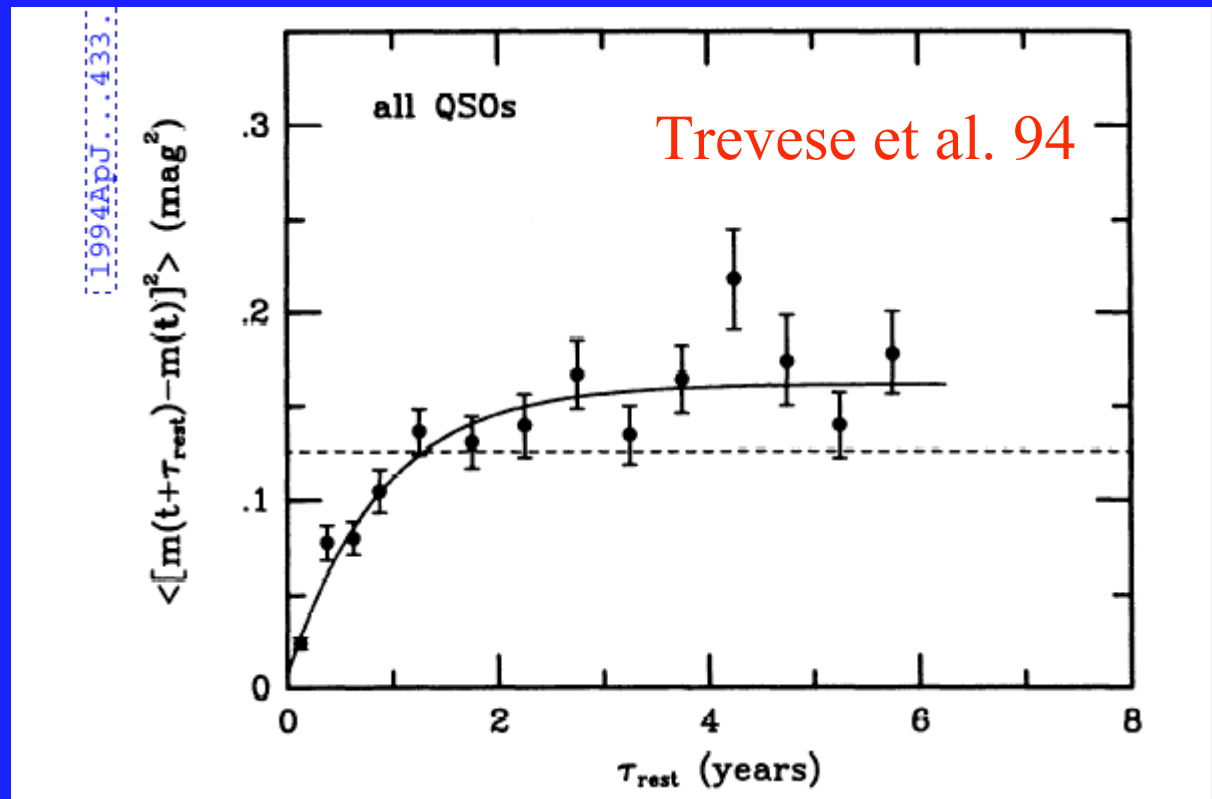


Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

- Variability amplitude depends on time lag

- the characteristic time is $\tau_{\text{rest}} \sim 1$ yr with $\sigma \sim 0.4$ mag



- **Smaller variations are detectable on shorter time lags**

Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

- Repeated observations with the SDSS

(Ivezic 2002 “Variability with Wide Field Imagers”, Lampedusa)

The screenshot shows a PDF viewer window with the title 'Lampedusa.pdf'. The slide content is as follows:

Photometric Variability of Cataloged Point Sources

- Area: $\sim 700 \text{ deg}^2$
- Number of point sources: $\sim 3 \text{ million}$
- Δt from 3 hours to 3 years
- 0.02mag photometry in 5 bands, down to $r \sim 22$

Refs: Ivezić et al., 2002 (in prep.)

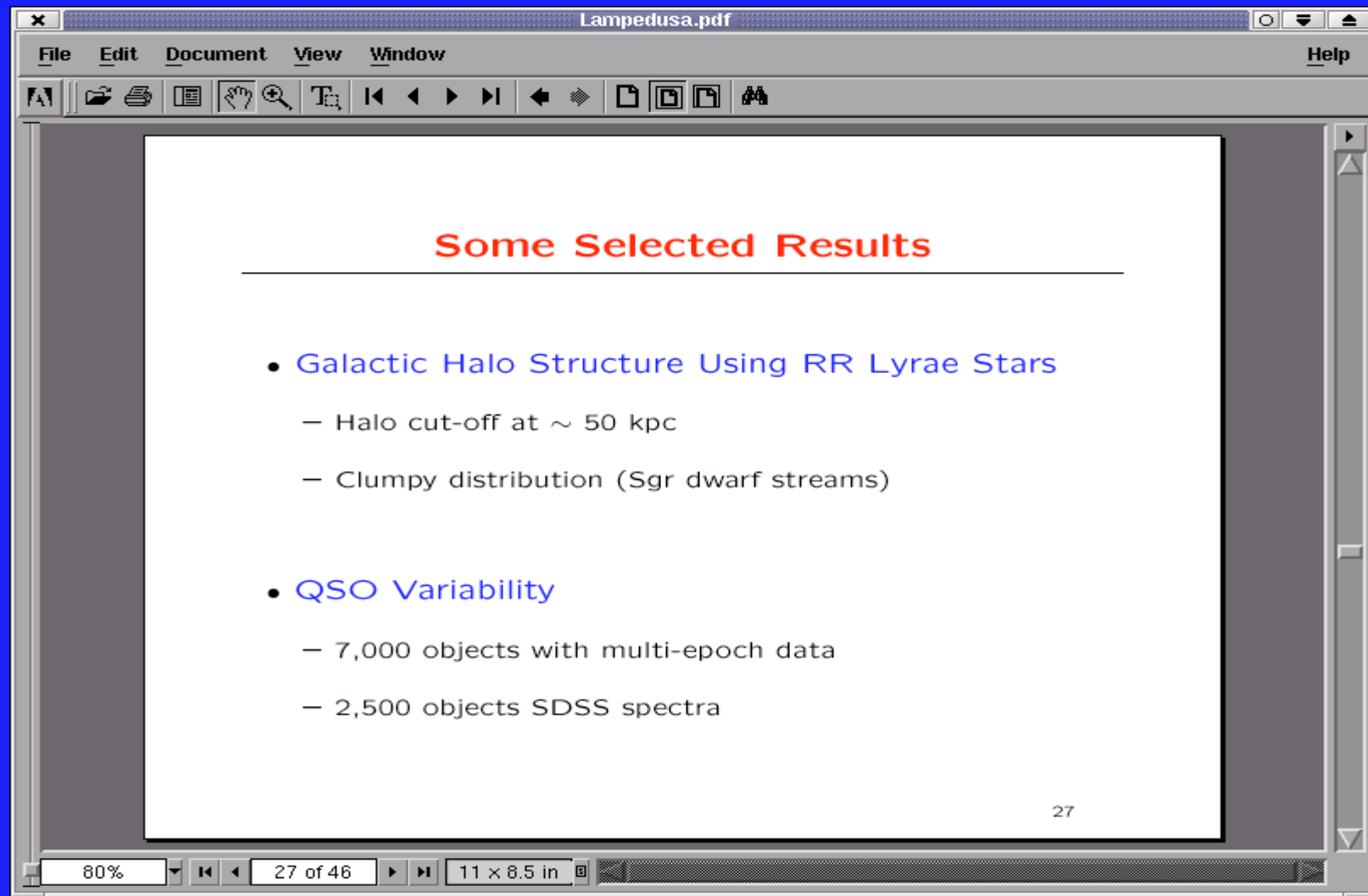
14

96% 14 of 46 11 x 8.5 in

Variable AGN samples

- Repeated observations with the SDSS

(Ivezic 2002 “Variability with Wide Field Imagers”, Lampedusa)



Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

- Repeated observations with the SDSS

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The screenshot shows a PDF viewer window with the title 'Lampedusa.pdf'. The window has a menu bar (File, Edit, Document, View, Window, Help) and a toolbar with various icons. The main content area displays a slide with the following text:

QSO Variability using SDSS Imaging Data

The main results:

- The distribution of Δm follows an exponential distribution,

$$f(\Delta m) \propto \exp(-\Delta m / \Delta_c)$$

with the characteristic amplitude, Δ_c , increasing with time and frequency. While similar and consistent with the structure function analysis ($rms \propto \Delta_c$), note that the whole distribution is determined here, not only its second moment.

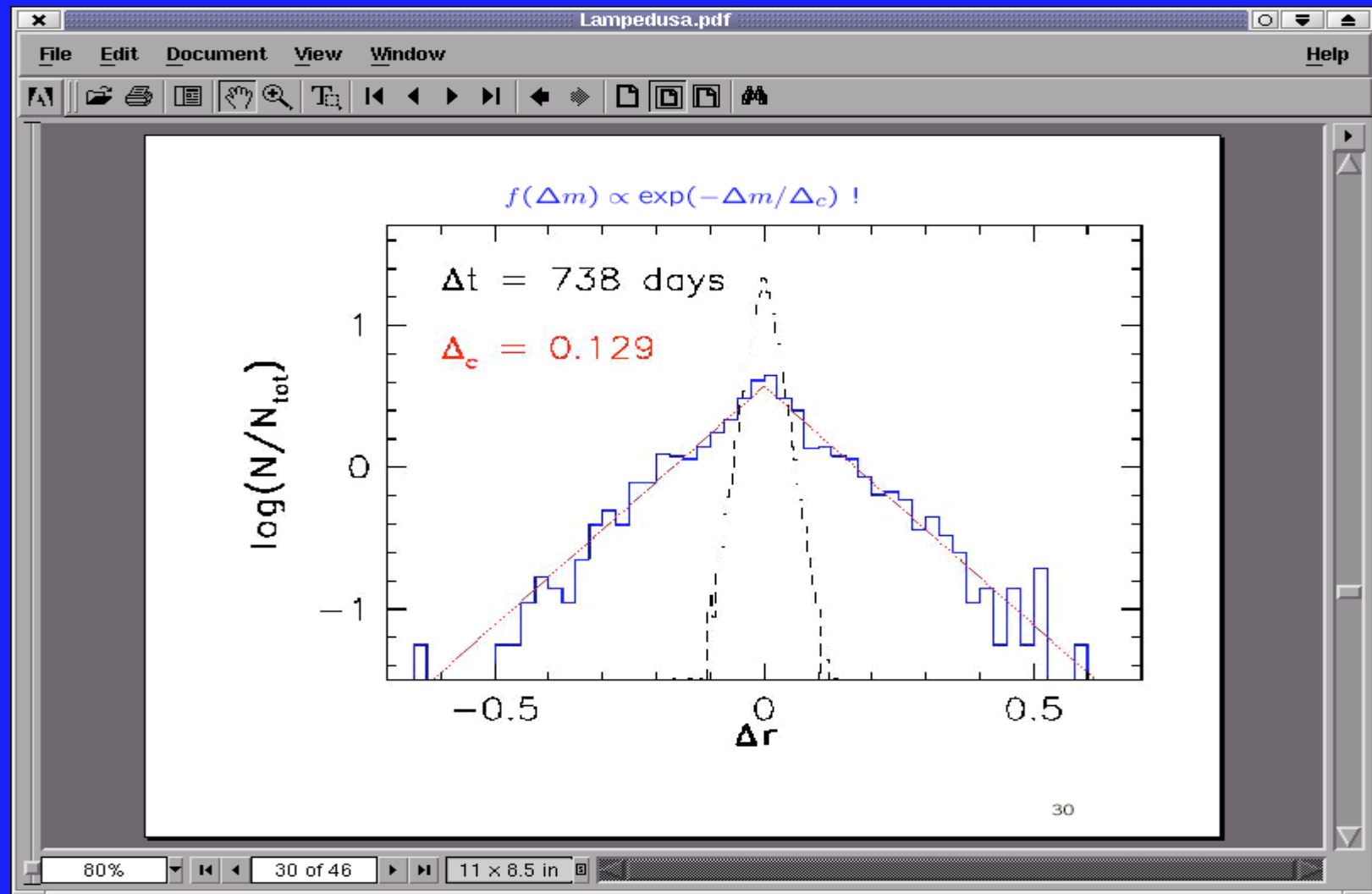
29

80% 29 of 46 11 x 8.5 in

Variable AGN samples

- Repeated observations with the SDSS

(Ivezic 2002 “Variability with Wide Field Imagers”, Lampedusa)

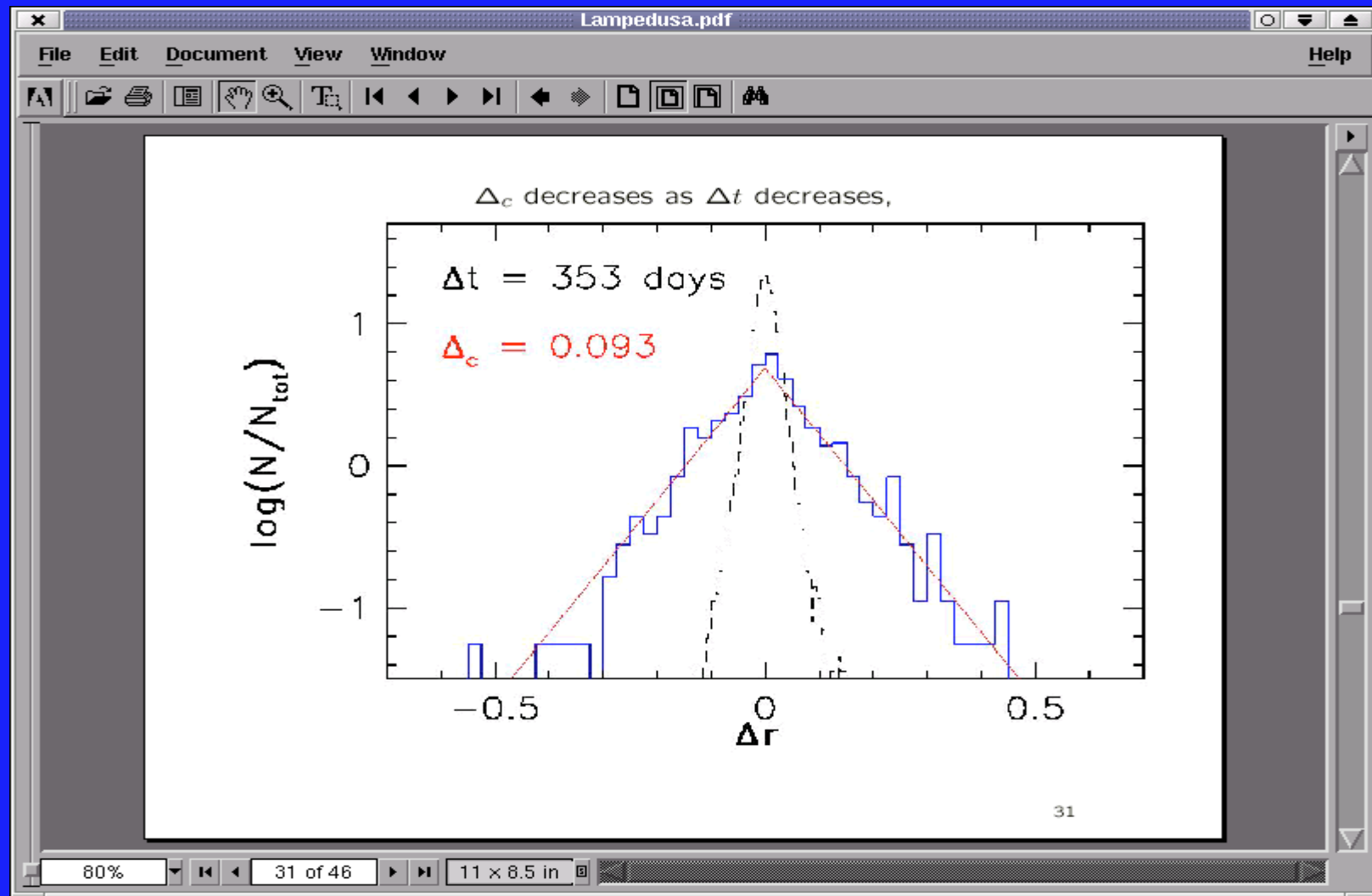


Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

- Repeated observations with the SDSS

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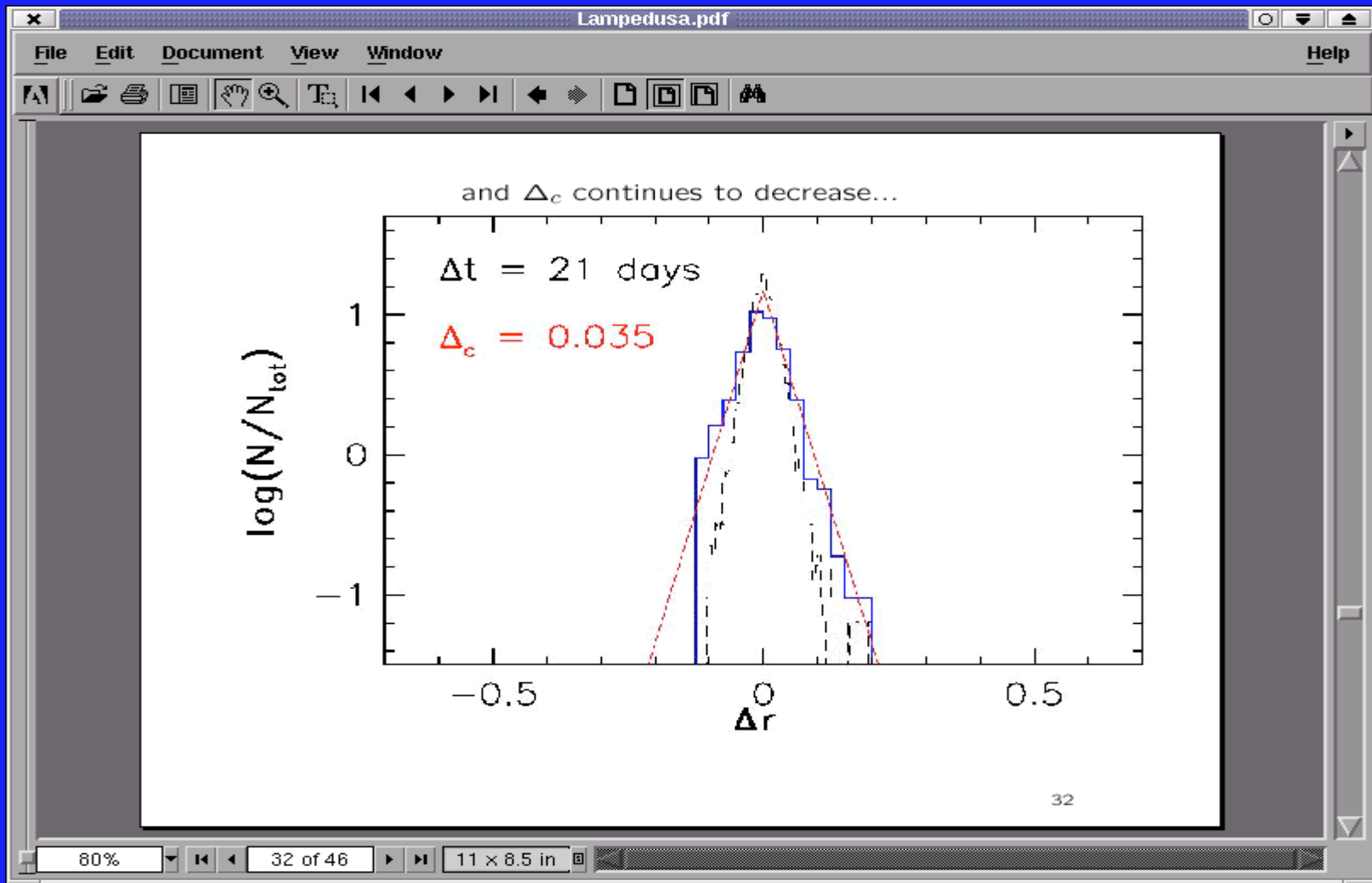


Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

- Repeated observations with the

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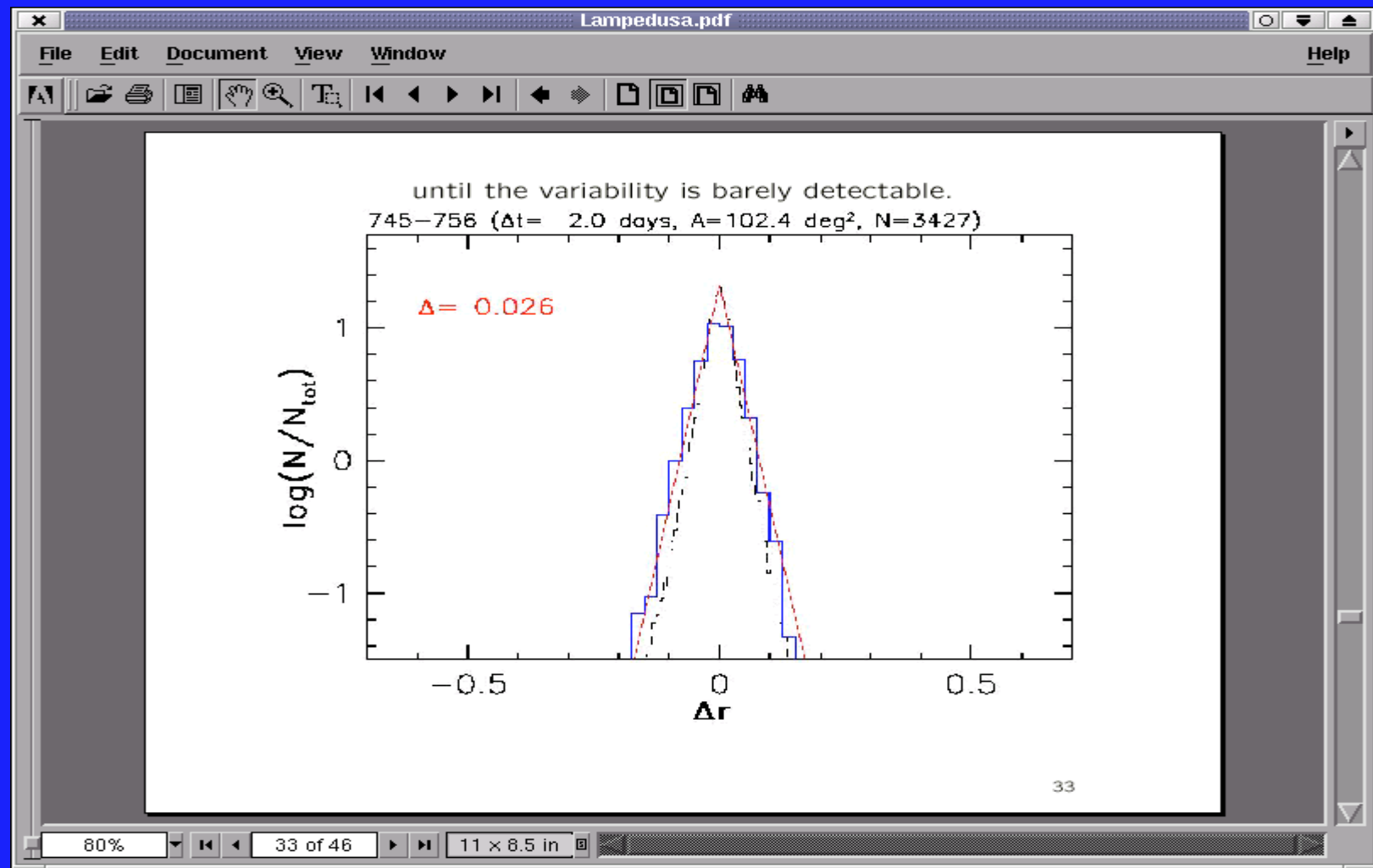


Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

- Repeated observations with the SDSS

(Ivezic 2002 “Variability with Wide Field Imagers”, Lampedusa)



Variable AGN samples

- **Respect to HST, LBC has:**
 - 100 times larger area
 - ... “comparable” limiting magnitude
 - lower angular resolution **BUT** observation in U band
increase BOTH $L_{\text{nuc1}}/L_{\text{Host}}$ AND variability
- **Respect to SDSS:**
 - mag. limit (23 $\rightarrow$ 27) (intrinsically faint AGNs)
 - area $\sim 10^{-3}$
 - systematic time sampling is not included in *present* SDSS plans

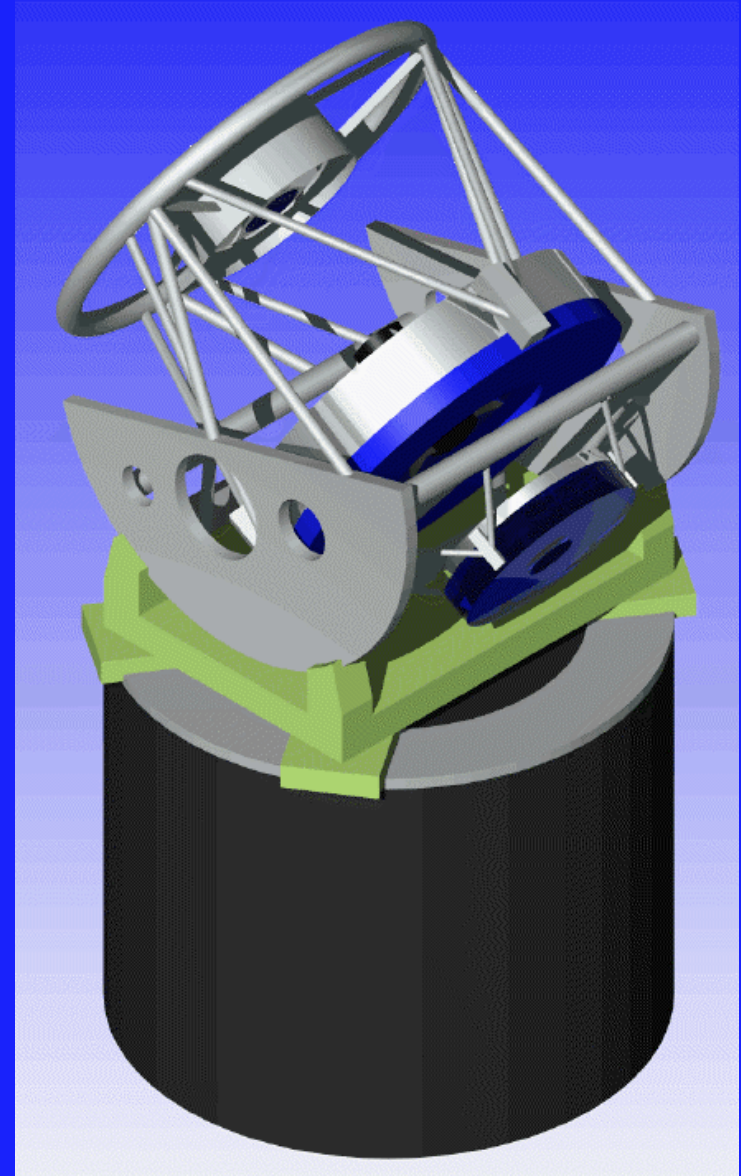
Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002



Variable AGN samples

- 8.4 m mirror
- 7 deg² field
- 20 000 deg² in 3-4 nights
V~24 I~23 a 5 σ
- 7 deg² 50 h
U~27 B,V,R~28 I~27 a 5 σ



Variable AGN samples

LBT2002 Bertinoro, 7-9/10/2002

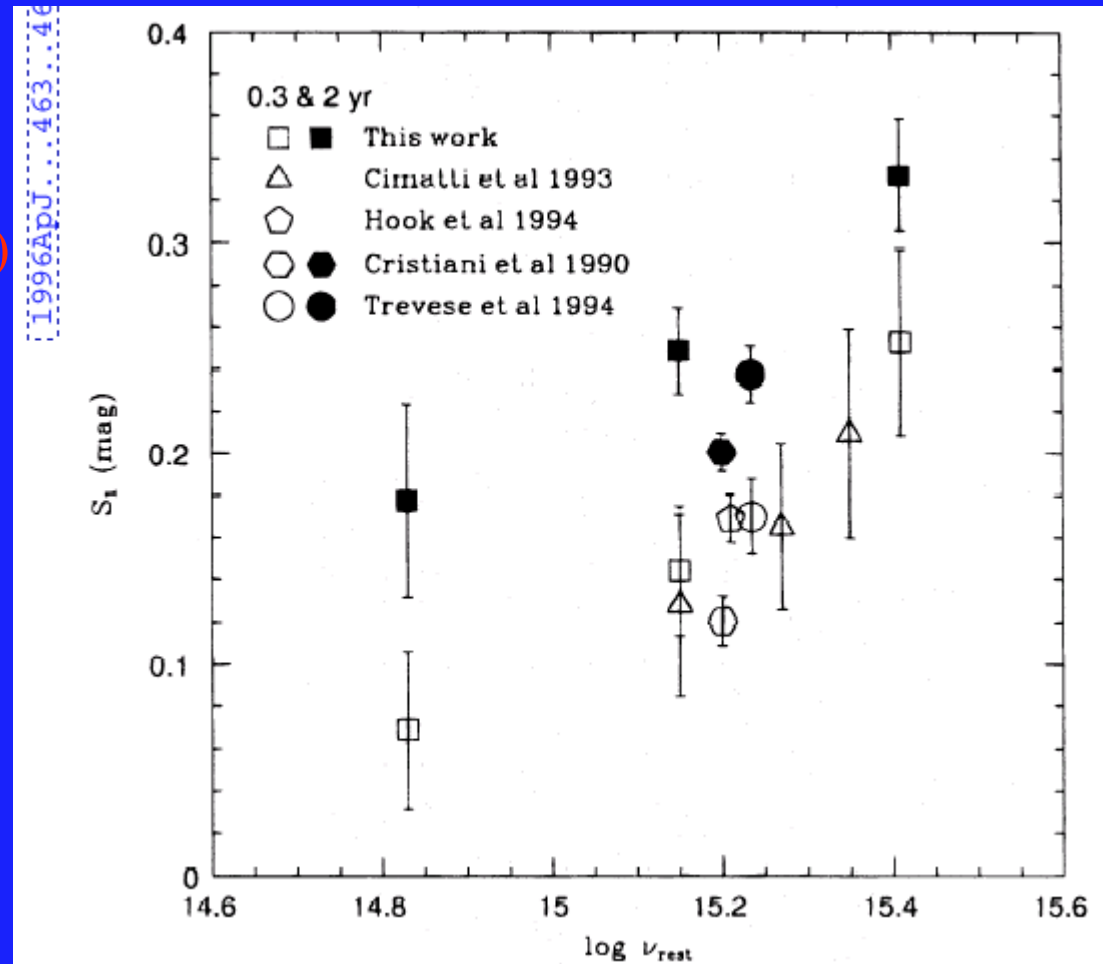
- Variability increases with z

(Giallongo, Trevese & Vagnetti 91)

- Variability increases with ν_{rest}

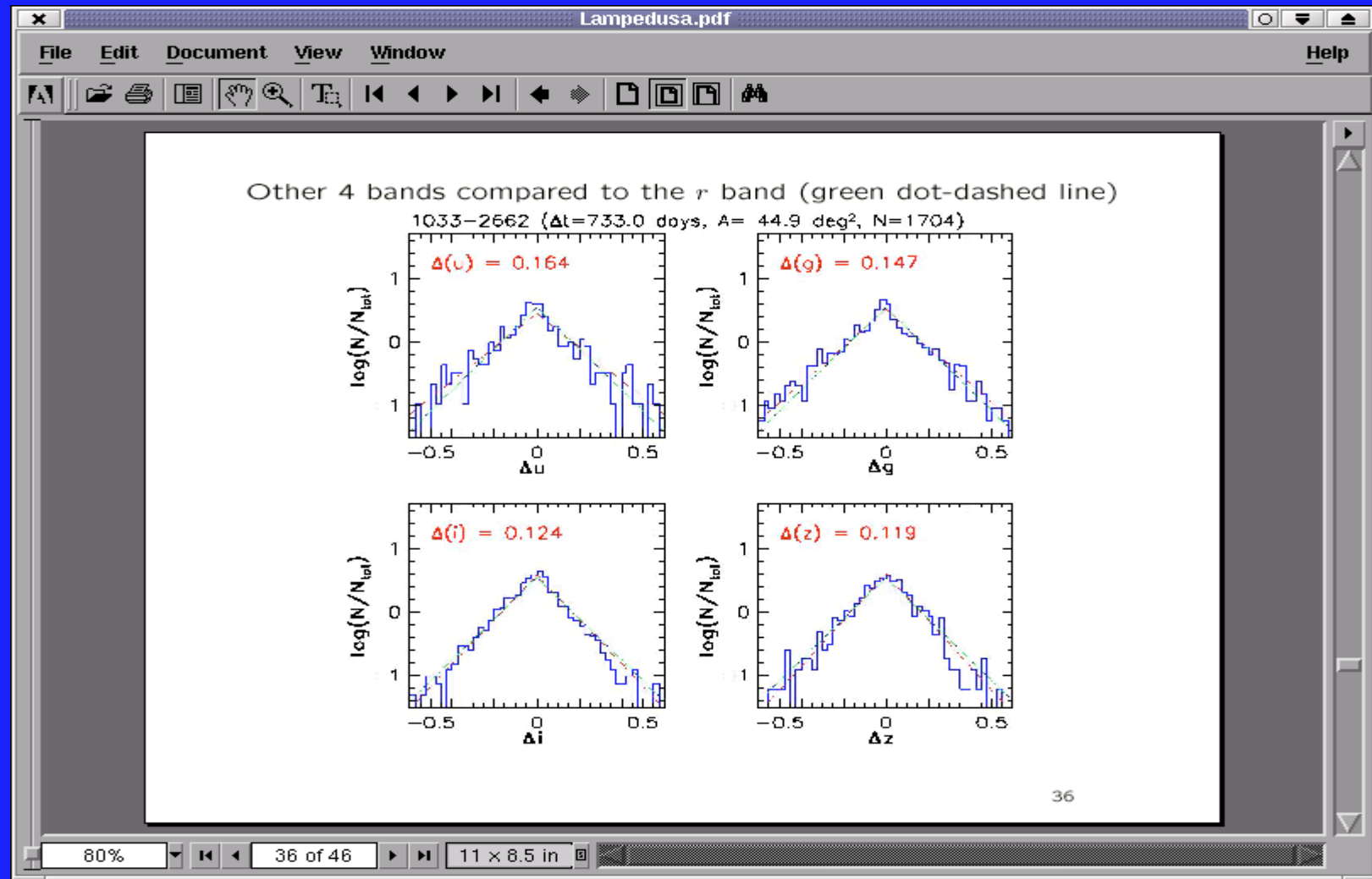
- high z QSOs are more variable since they are observed at higher ν_{rest}

(DiClemente, et al. 96)



Variable AGN samples

- the increase of variability with v_{rest} is confirmed by SDSS
(Ivezic 2002 “Variability with Wide Field Imagers”, Lampedusa)



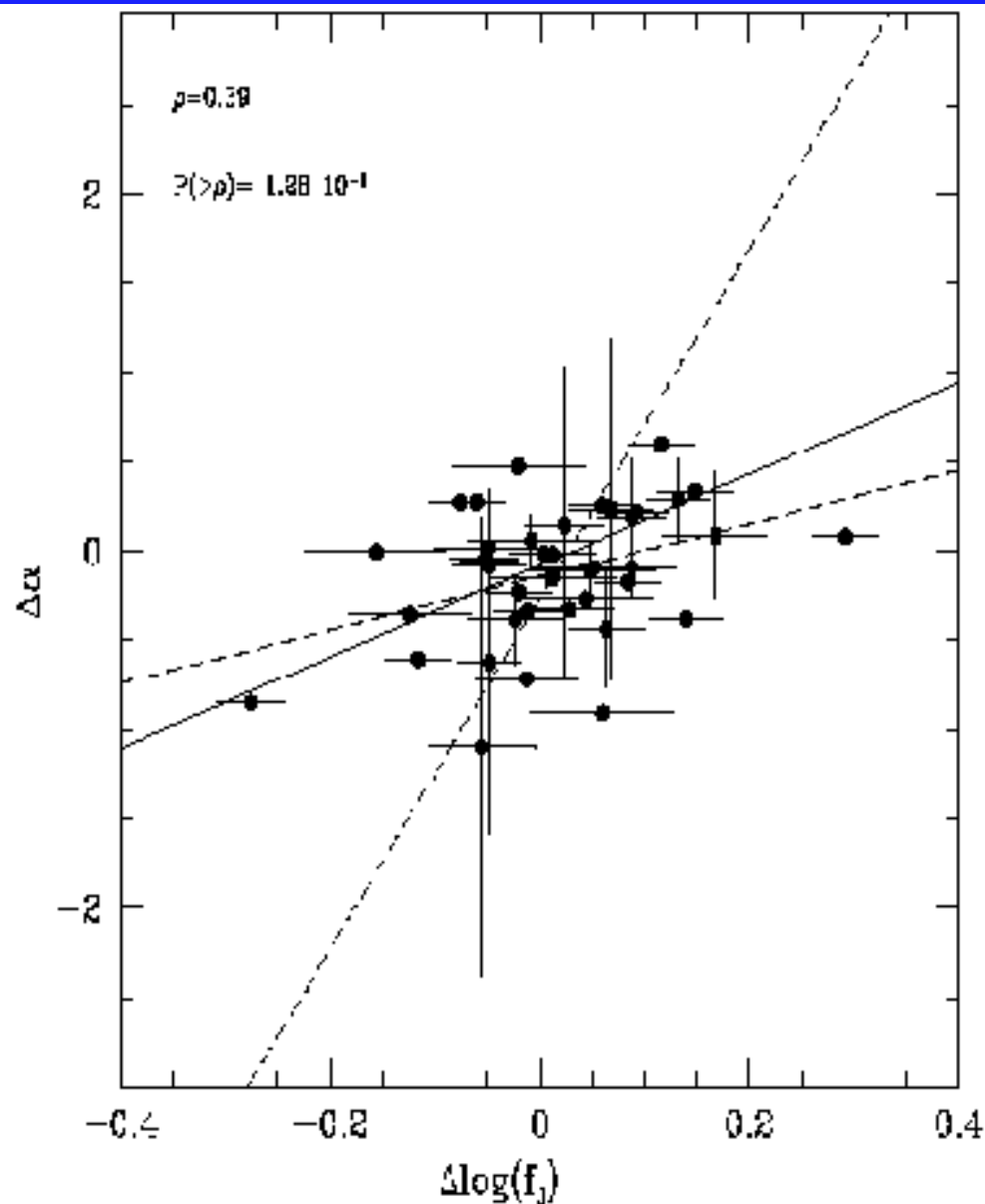
Origin of variability

LBT2002 Bertinoro, 7-9/10/2002

- Are individual QSOs brighter in the brighter phases ?

YES

(Trevese, Kron & Bunone 2000)



Origin of variability

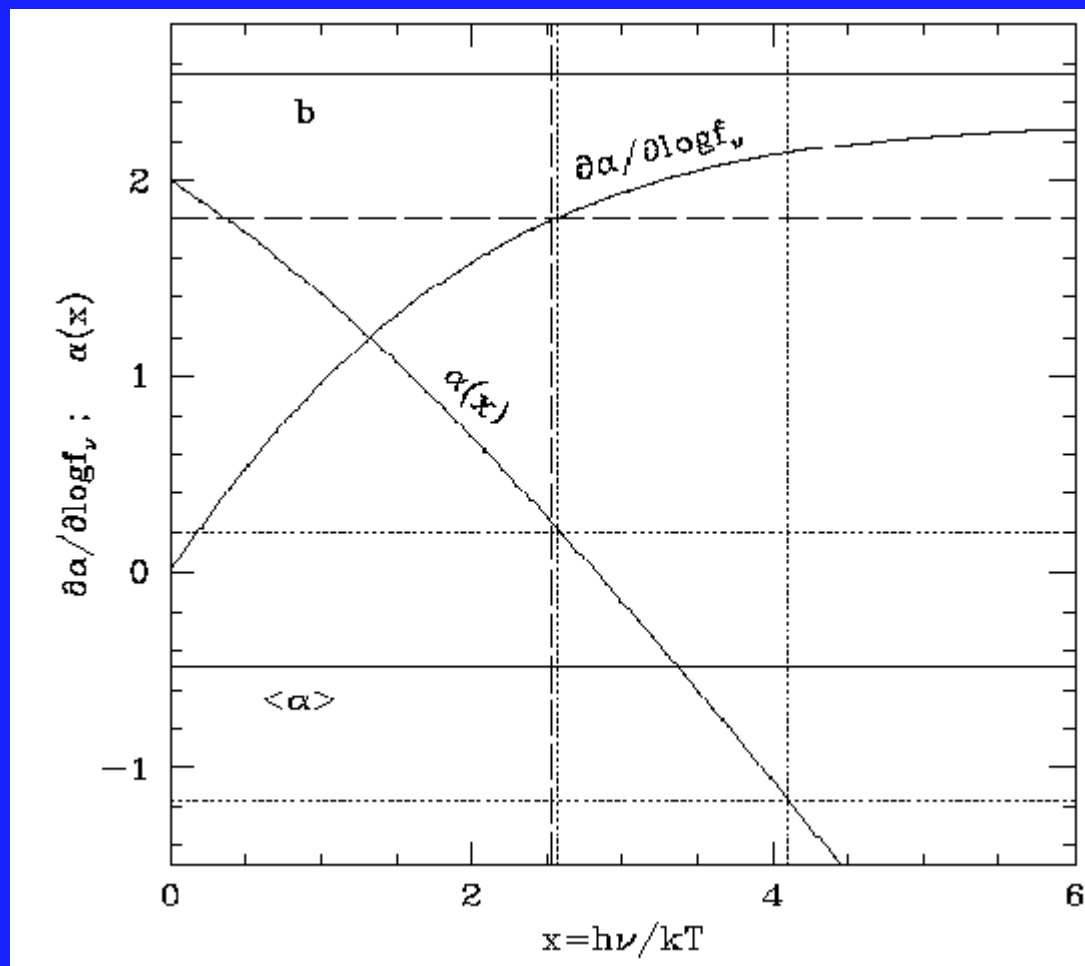
LBT2002 Bertinoro, 7-9/10/2002

- Slope α and spectral variability

$$\beta \equiv \partial \alpha / \partial \log I_\nu$$

are ~ consistent with n
 ΔT of a black body

$$T \sim 2.5 \times 10^4 \text{ K}$$



(Trevese, Kron & Bunone 2000)

Origin of variability

LBT2002 Bertinoro, 7-9/10/2002

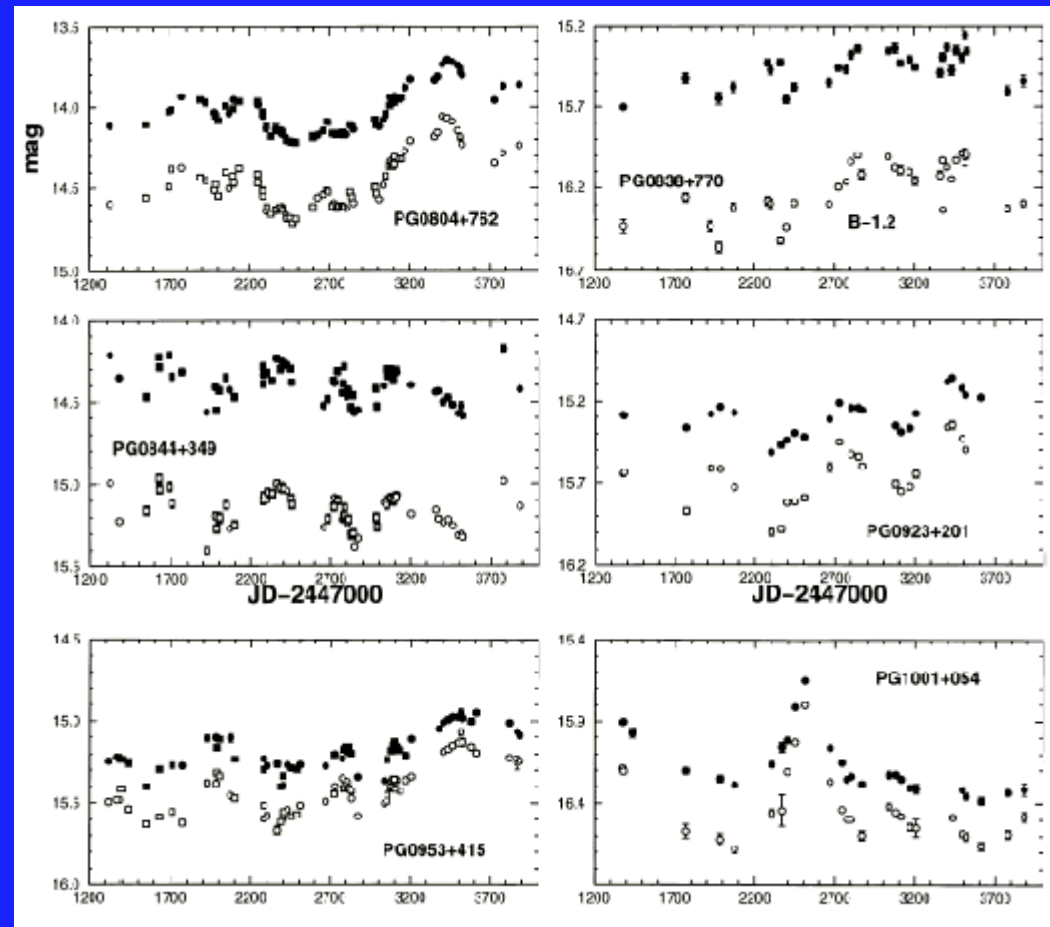
- A unique two band monitoring of a statistical sample:

Wise Observatory, 1 m
B R

7 yr $\Delta t \sim 30$ d

42 PG QSO

(Giveon et al. 99)

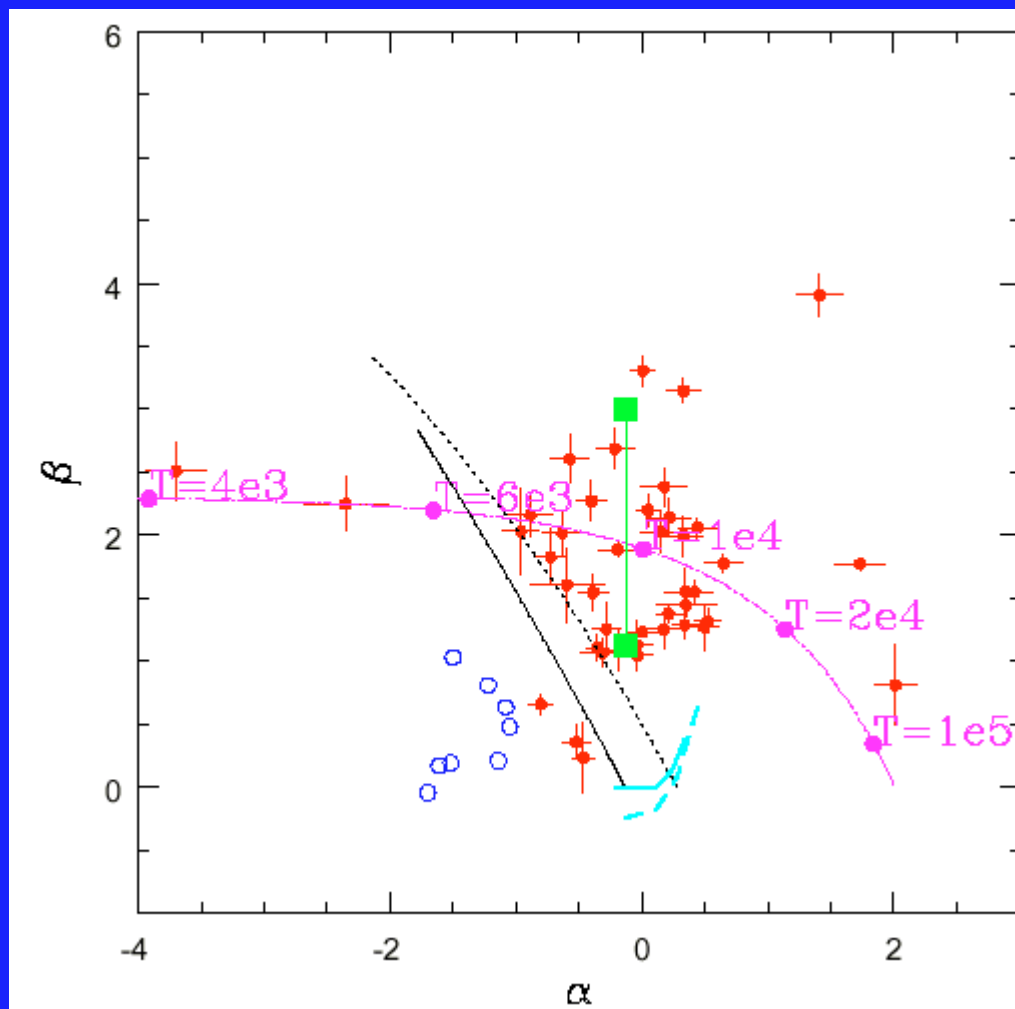


Origin of variability

LBT2002 Bertinoro, 7-9/10/2002

- The analysis of spectral variability allows to discriminate models

(Trevese & Vagnetti 02
; Vagnetti Trevese &
Nesci 02)



CONCLUSIONS

- Search of AGNs through variability with LBC
1 deg² $m_{\text{lim}} \sim 26$, 2 yr $\Delta t \sim 1-6$ months
→ $\sim 10^3$ AGN ($z \sim 1-2$; $M_B \sim -(17-22)$??)

Evolution of the faint end of AGN LF

- Synergy with di SN (and variable stars ?) search
→ **Spectral variability analysis in redshift bins**
(i.e. as a function of v_{rest})
($U(z=2) \rightarrow \sim 1000 \text{ \AA}$)

