The long term X-ray variability of quasar

A twenty years (rest-frame) long variability story

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Variability in the X-ray, state of the art

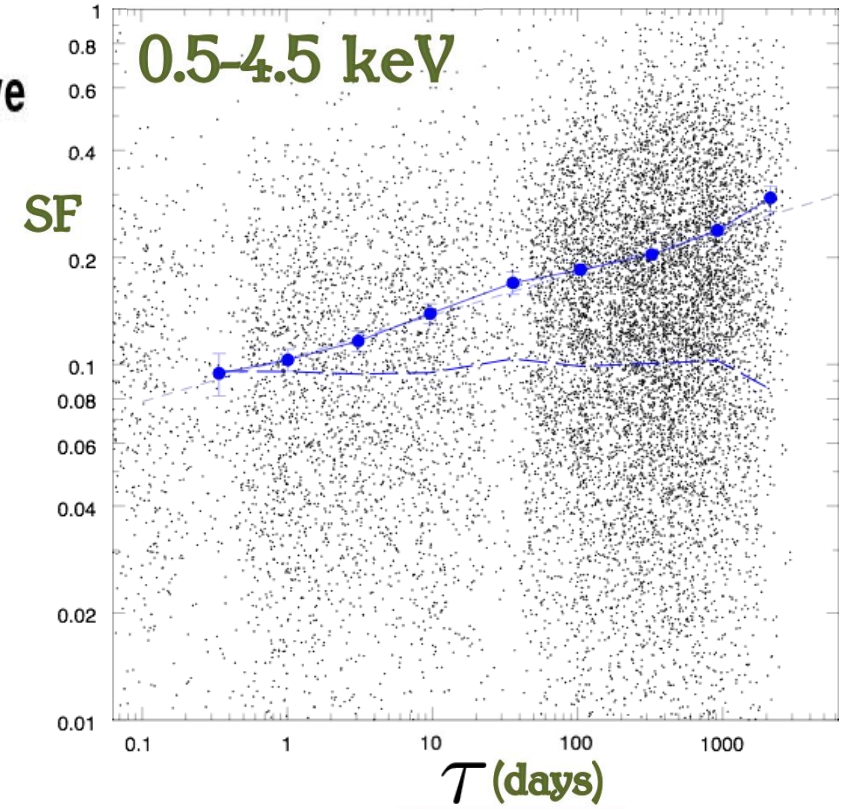
Many time scales

Δt=20, 40, 60, 80 Ks, ~ days, months, years

(e.g. Ponti, Bianchi et al. 2013)

CAIXA: a catalogue of AGN in the XMM-*Newton* archive
III. Excess Variance Analysis

(e.g. Vagnetti, Middei et al. 2016)



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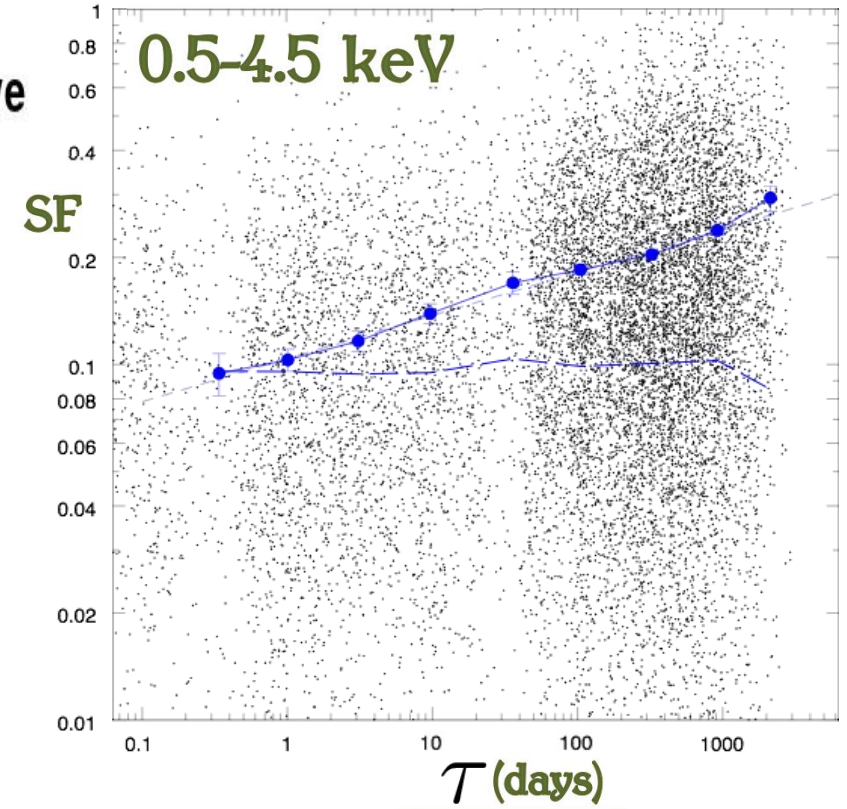
How variability behaves on longer time scales???

(e.g. Vagnetti, Middei et al. 2016)



Building the quasar sample, the recipe

IGIENE * ECONOMIA * BUON GUSTO

LA SCIENZA IN CUCINA

E

L'ARTE DI MANGIAR BENE

MANUALE PRATICO PER LE FAMIGLIE

COMPILATO

DA

PELLEGRINO ARTUSI

Un pasto buono ed un mezzano
Mantengon l'uomo sano

Molto cibo e mal digesto
Non fa il corpo sano e lesto

Piglia il cibo con misura
Dai due regni di natura

Prima digestio fit in ore

IN FIRENZE

PEI TIPI DI SALVADORE LANDI

Direttore dell'*Arte della Stampa*

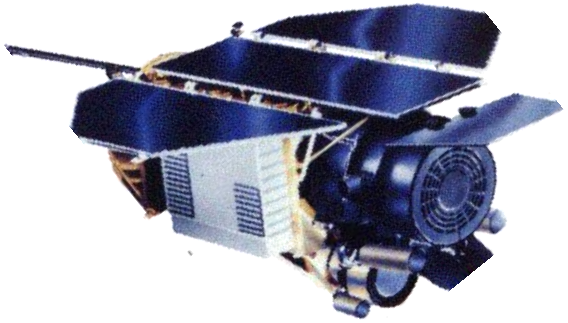
1891

Long term X-ray ensemble flux variations

- **Large number of observations**
- **Large number of sources**
- **Large temporal window**

Building the quasar sample, ingredients

Quasar catalogs
Dr7 & Dr12



3XMMSSC-Dr5

565,962 X-rays det.

239,505 multi epoch

covered time interval

13 years obs. frame

covered time interval

~8 years rest-frame

only type 1 objects

- 105,783 s.c.q.
- 297,301 s.c.q.

RASS BSC & RASS FSC

18,806 X-ray det.

105,924 X-ray det.

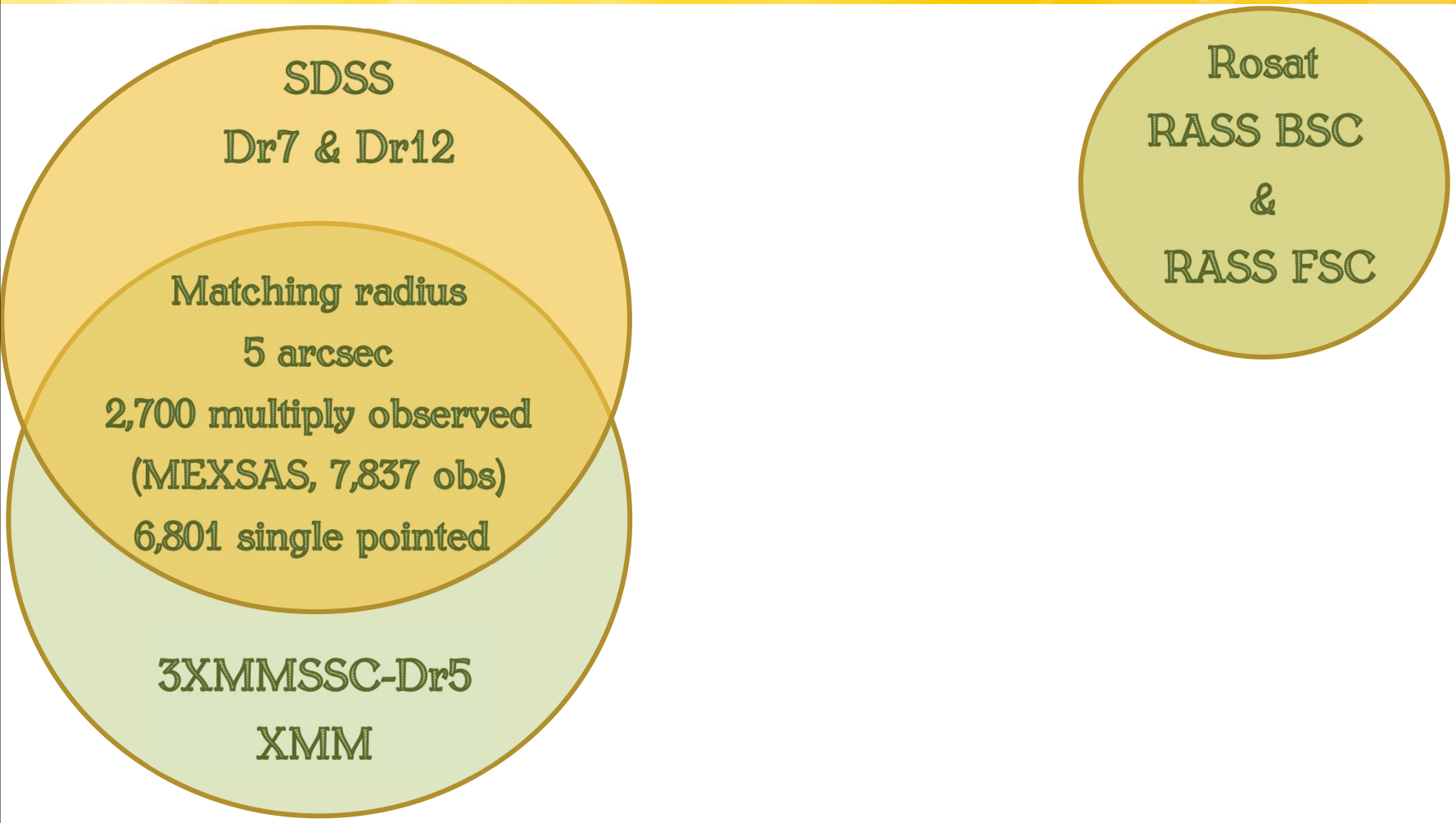
covered time interval

~1 year

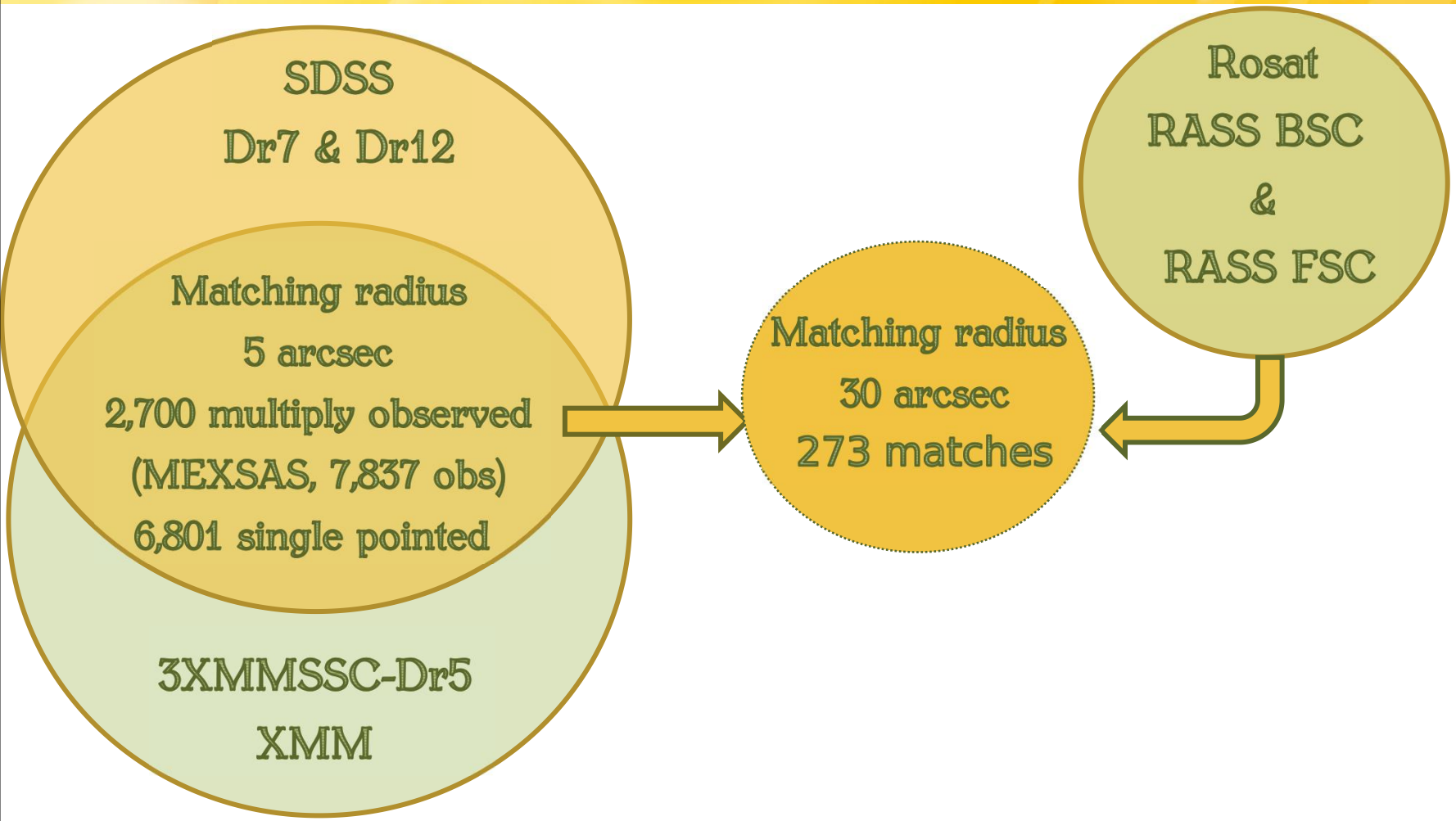
however...it was

1990/1991 (:

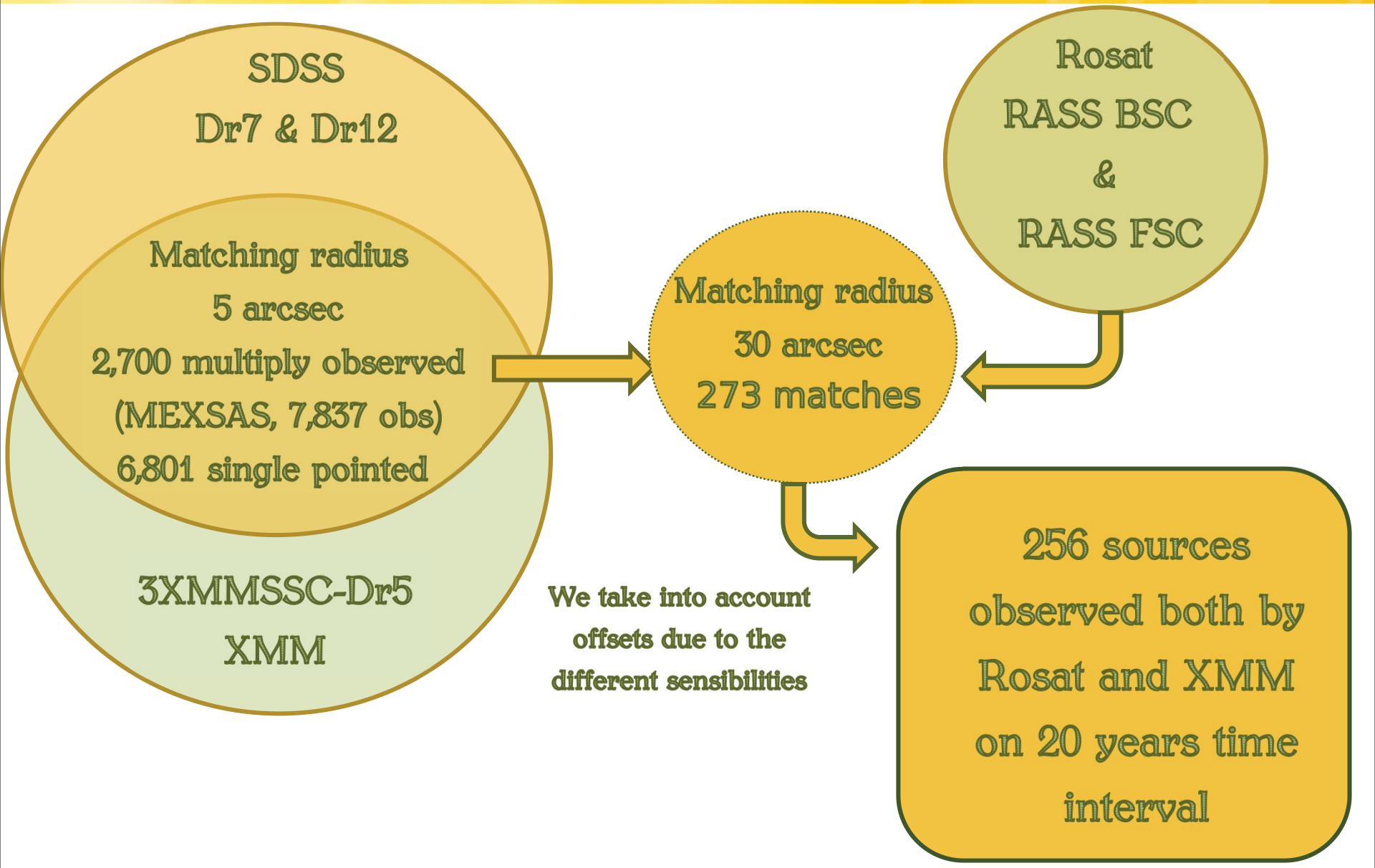
Building the quasar sample, loading



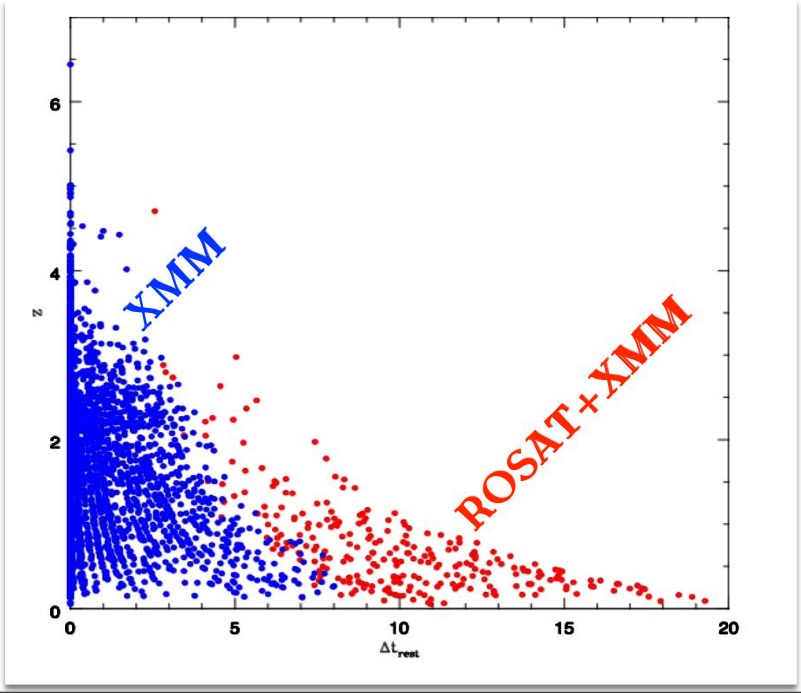
Building the quasar sample, loading



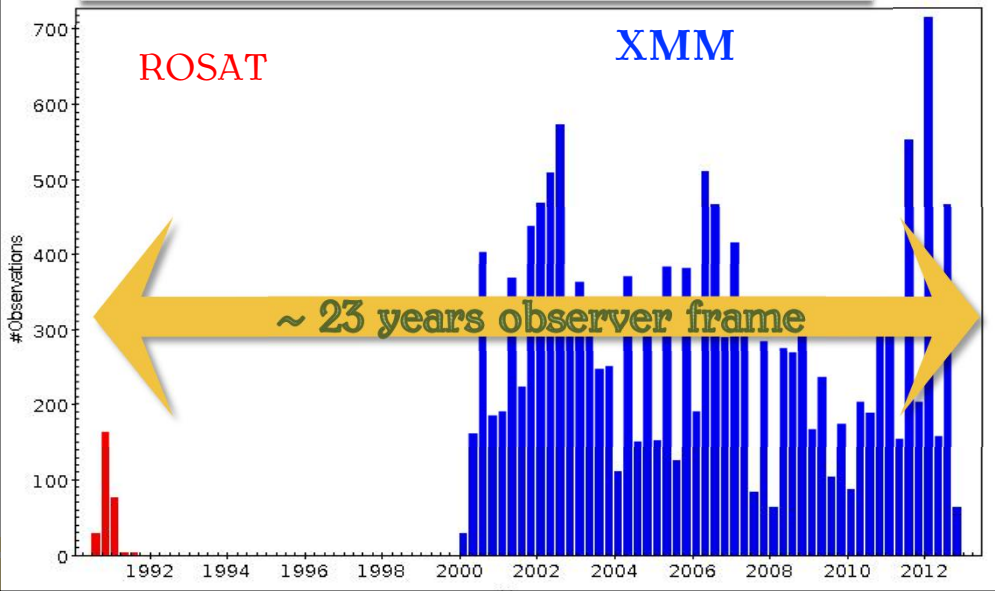
Building the quasar sample, finally

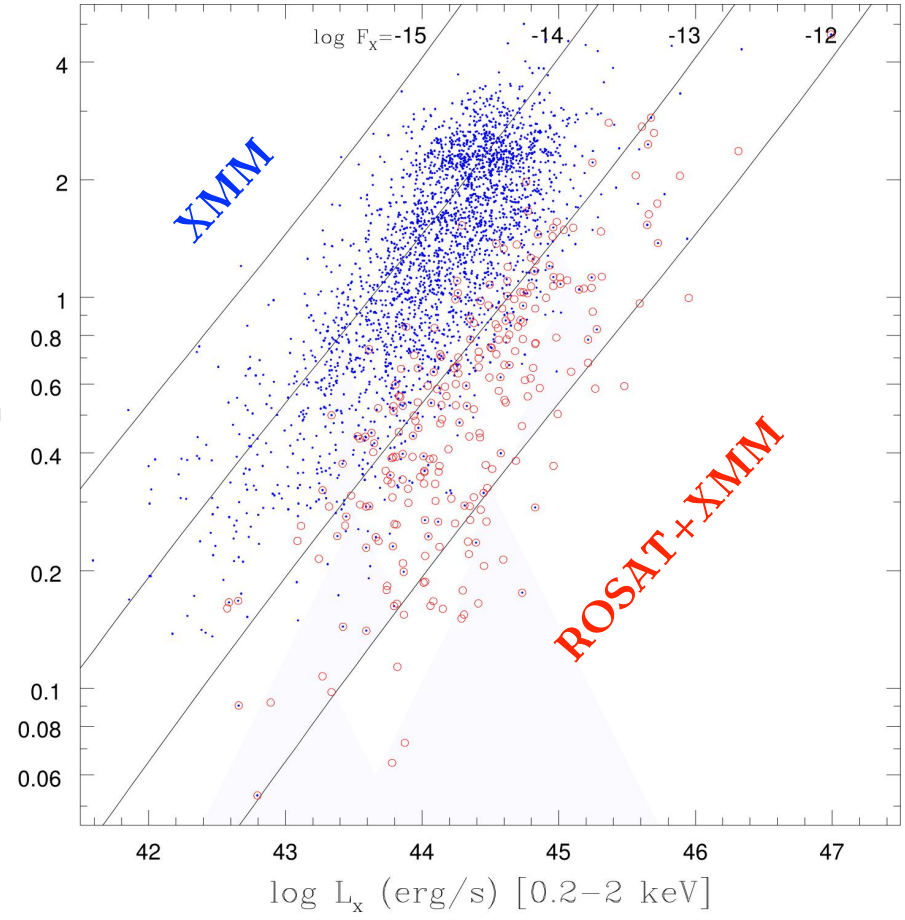


The investigating sample



rich sample of objects!!!





(Middei et al. in prep)

The structure function analysis

the lag between measure i and ii

$$SF(\tau) = \sqrt{< [\log f_X(t+\tau) - \log f_X(t)]^2 - \sigma^2_{noise} >}$$

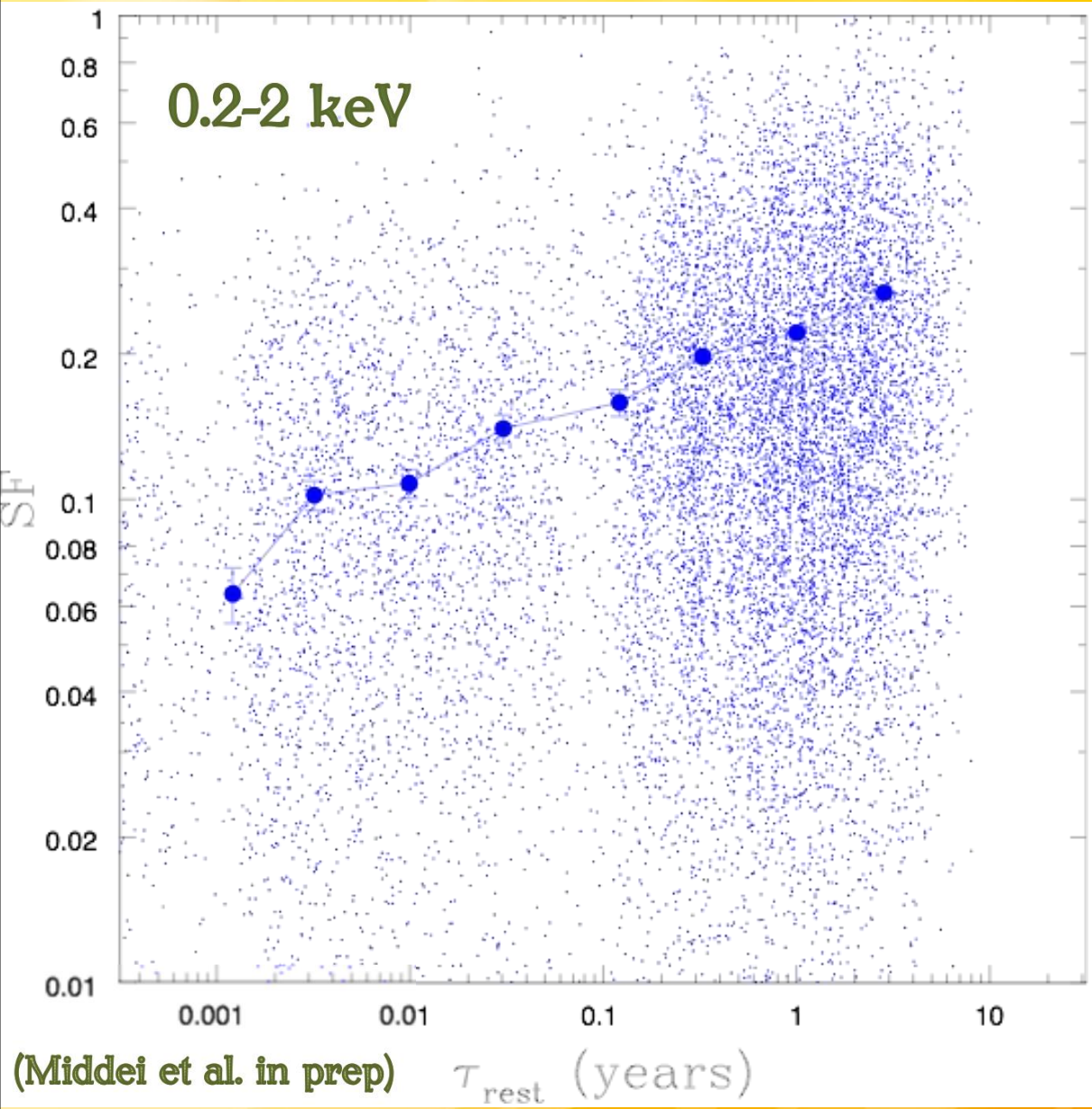
flux measures at epoch i, ii

$$\sigma^2_{noise} =< \sigma^2_n(t) + \sigma^2_n(t+\tau) >$$

photometric errors coming from epochs i, ii

- it works in the time domain
- useful for ensemble studies
- it describes the amount of variability as a function of the lag τ between the observations
- SF increases if flux differences increase

The long term (Soft) X-ray Structure Function...



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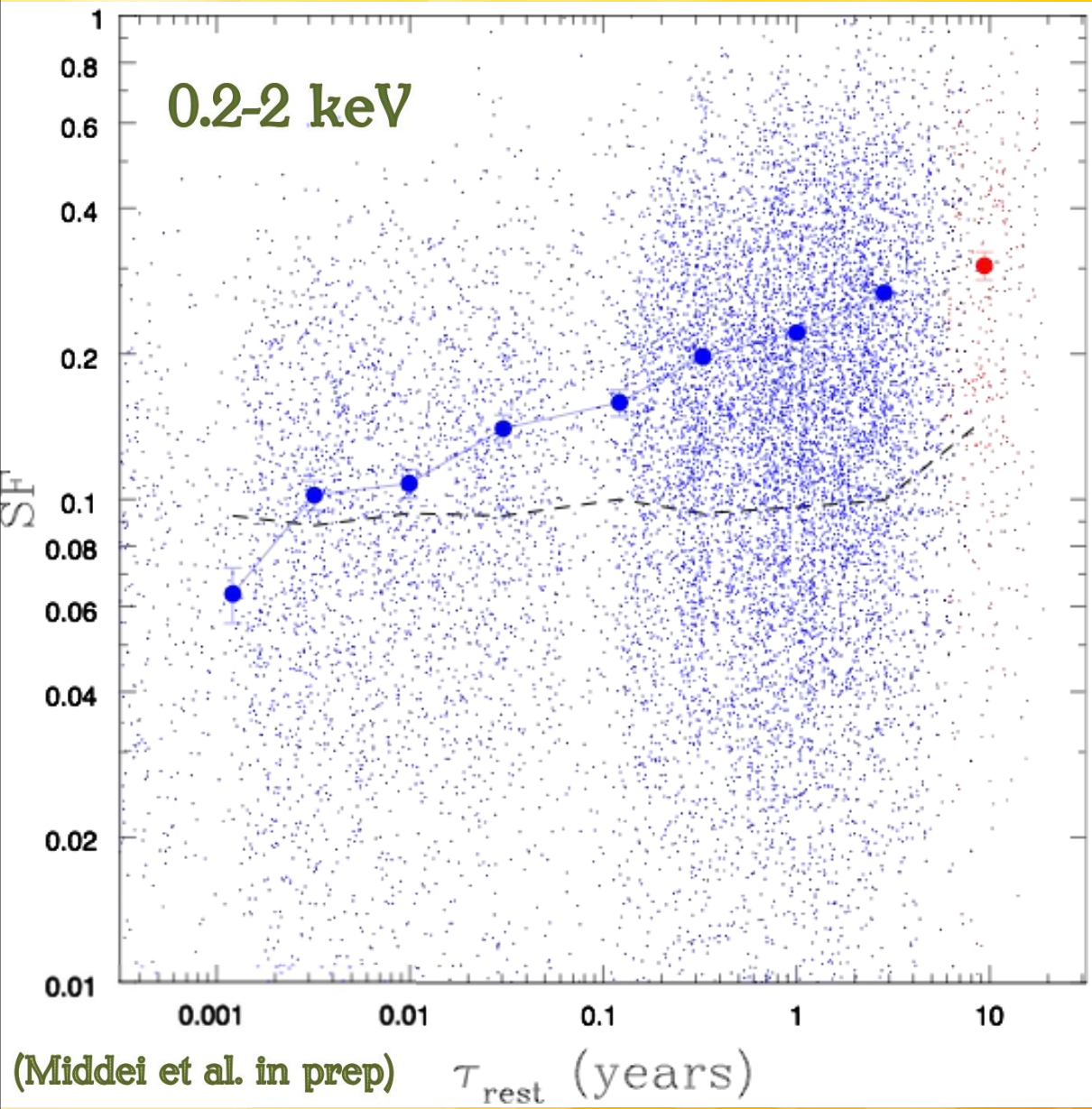


(Middei et al. in prep)

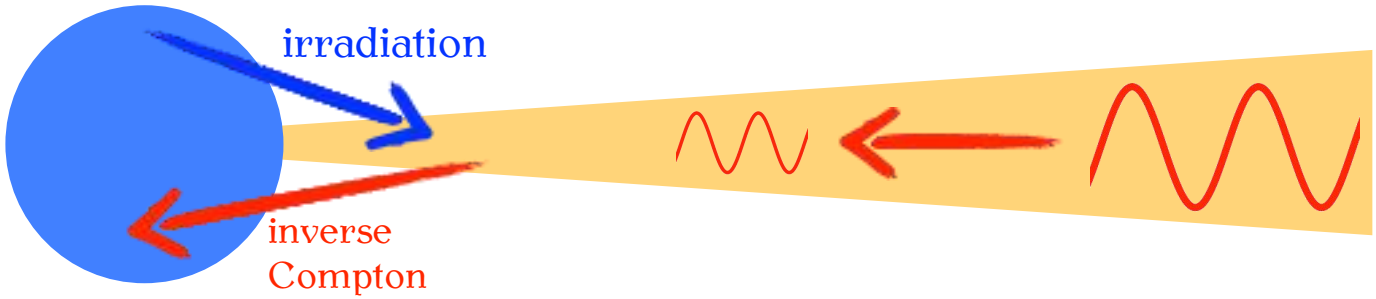
to build the combined SF we use the softer band 0.2-2 keV and XMM data are cut to the brighter ROSAT fluxes to perform the match in the long time lag bin

X-ray SF still increases at 20 years lag

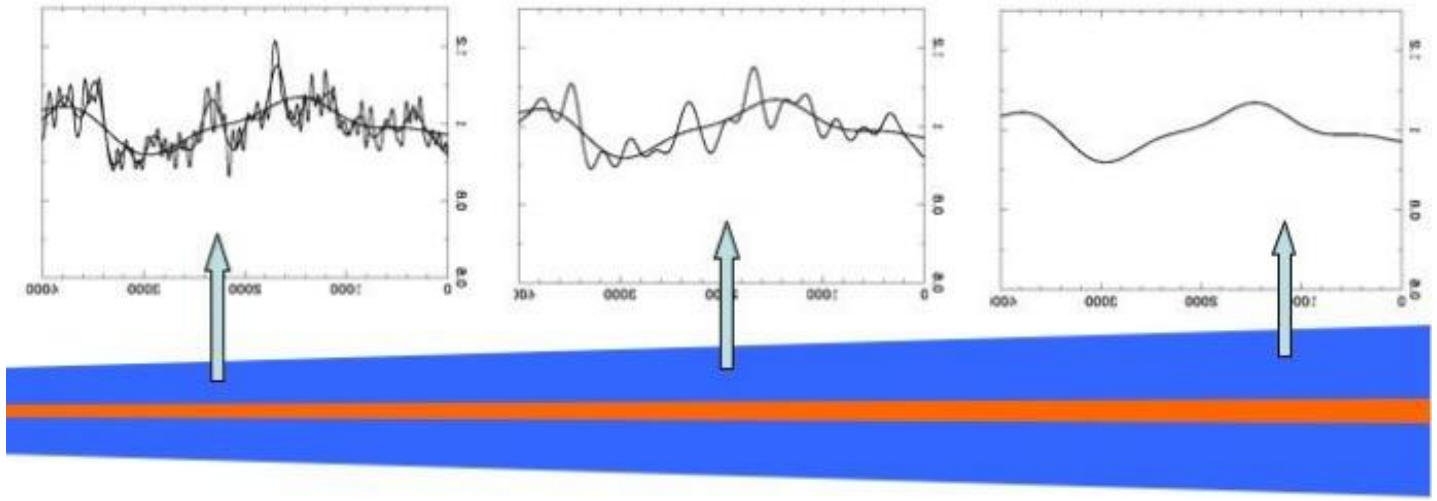
Intriguing (& plausible) scenarios:

The propagating fluctuations model...

(Lyubarskii 1997)



Long term fluctuations propagate through the disk



(Arévalo 2007)

optical variability could lead X-ray flux variations!!!

Comparing with optical structure function

from Collin & Huré 2001,

$$R_{crit}/R_g = 3 \times 10^7 (M/M_{sun})^{-0.46}$$

↓

this corresponds to 10^3-10^4 R_g
for 10^8-10^9 M_{sun} BHs

from e.g. Czerny 2006 we derive
dynamical time scales

$$\tau_{dyn} = 7\ 10^{-5} (R/R_g)^{3/2} M/M_{sun}\ (\mathrm{yrs})$$

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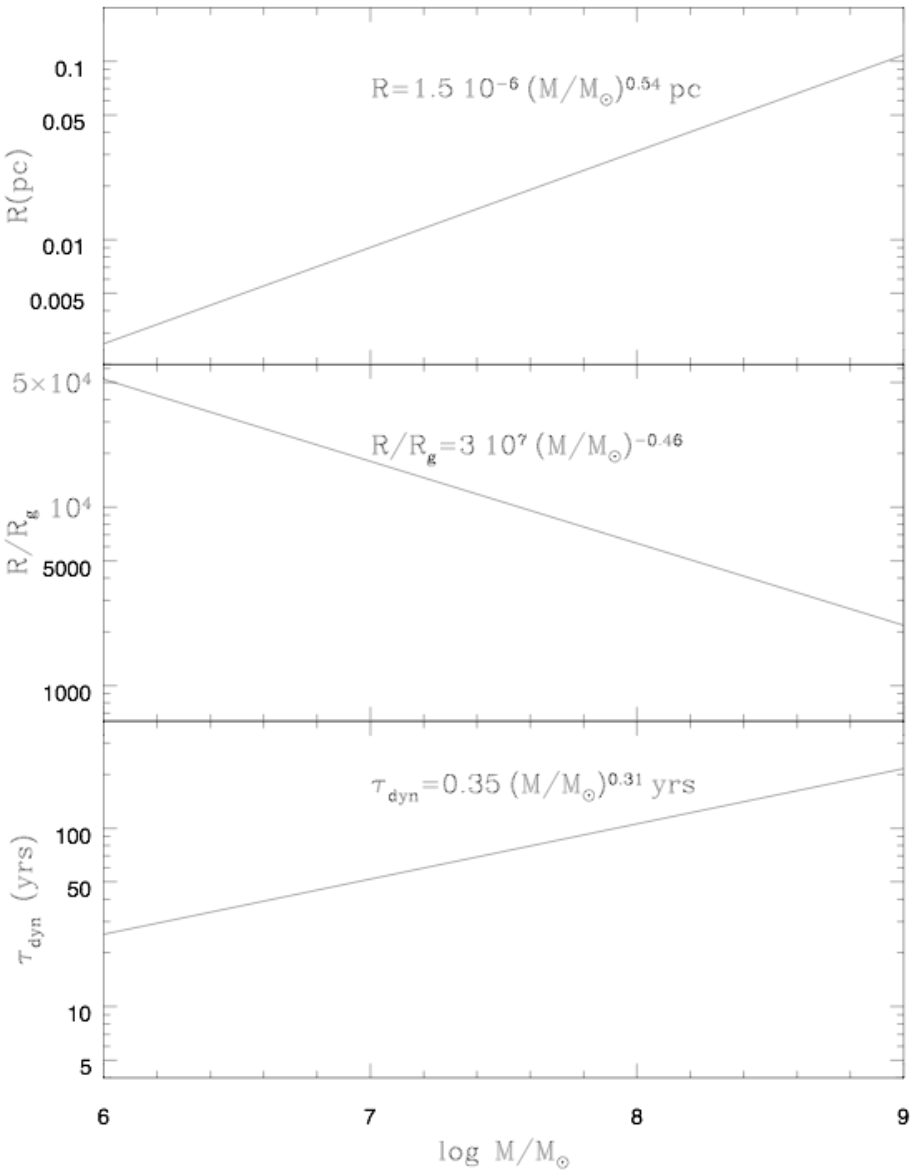

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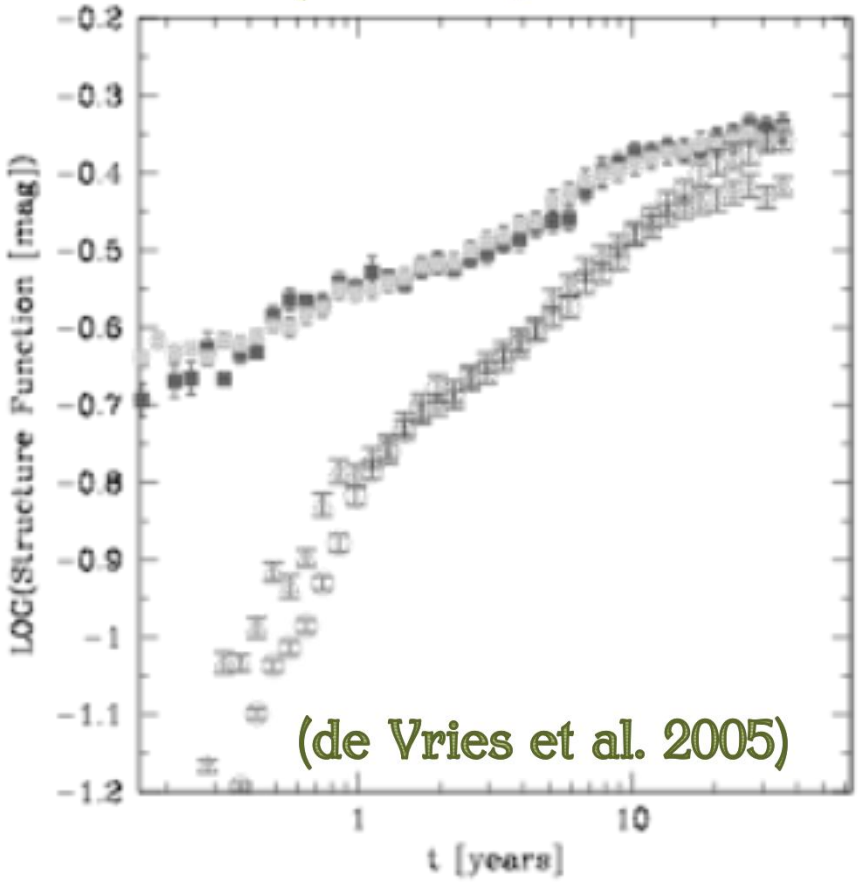
$$t_{dyn} = 0.35 \times (M/M_{sun})^{0.31} \ yrs$$

Variability can occur then on time scales of tenths of years!!!

Comparing with optical structure function

Optical SF increases up to ~40 years



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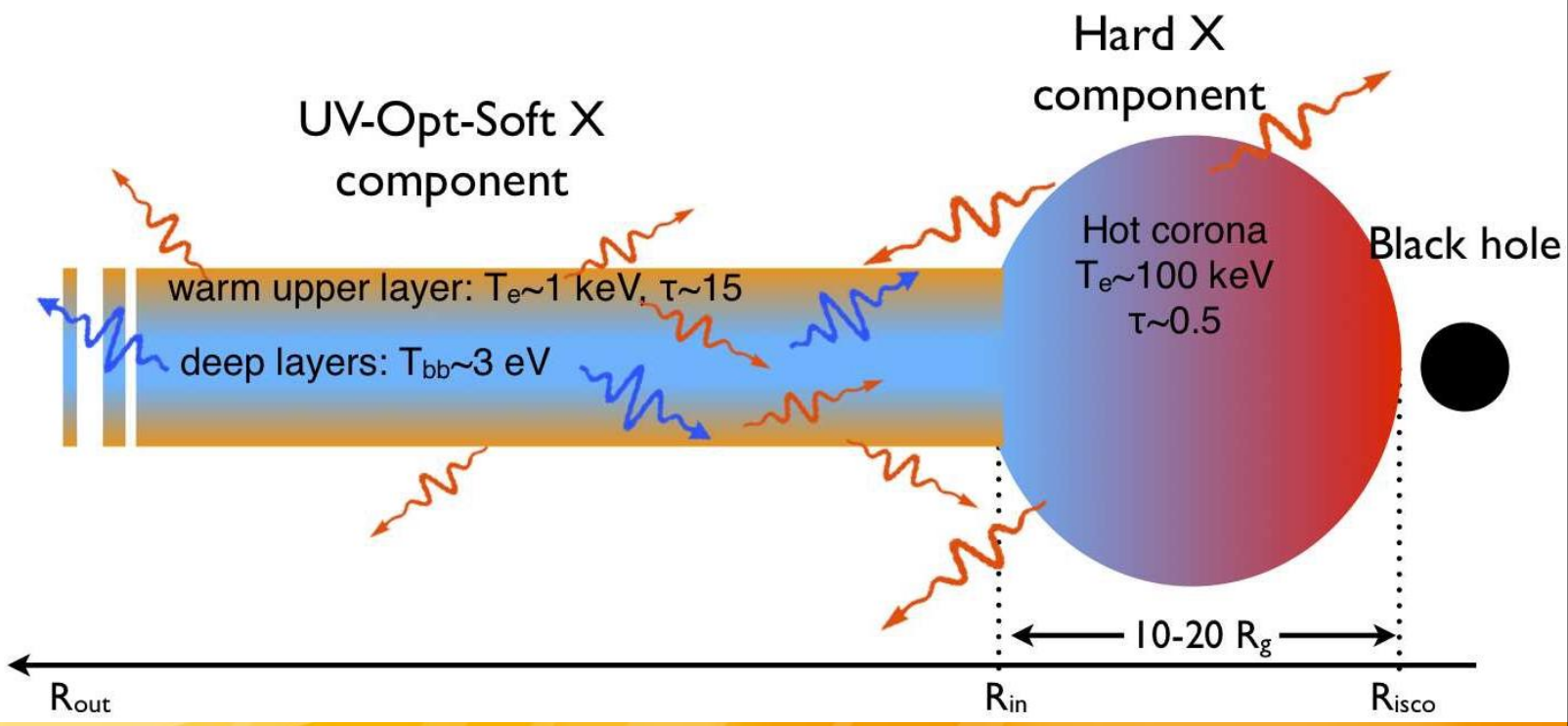
. . . Large size emitting region

. . . as just shown, large size emitting regions allow flux variations on long time scales

(Petrucci et al. 2013)



Thank you
for your
attention