X-ray activity from SgrA*

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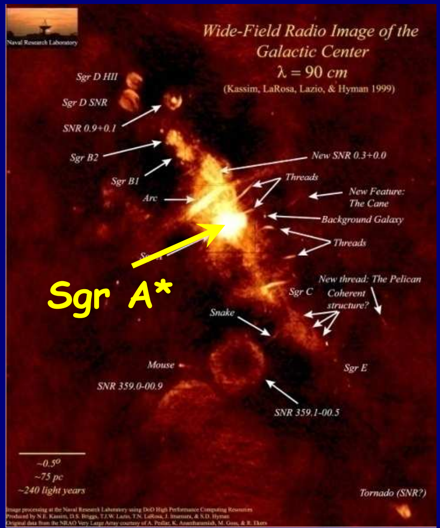
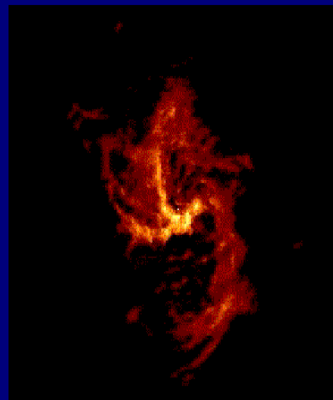
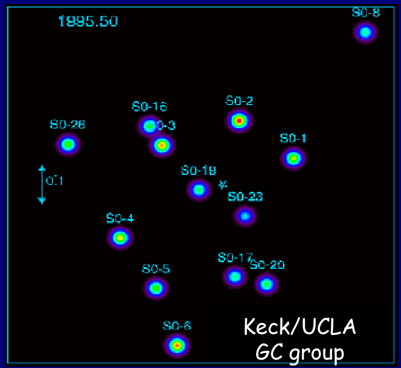
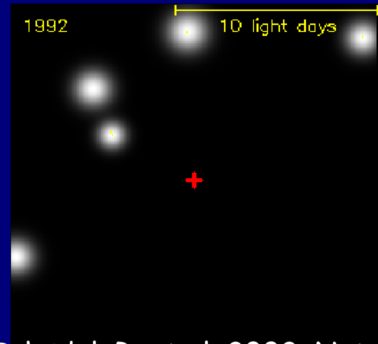




I. Our current knowledge of Sgr A* and its X-ray activity.



Sgr A*



Schödel, R. et al. 2002, Nature

- First detected as a non-thermal radio source (Balick & Brown 1974)
  with a proper motion of 15±11 km/s (Reid et al. 1999)
- Closest supermassive black hole (D ~ 8 kpc)
  M_{BH} ~ 3-4 x 10^6 solar masses (e.g., Ghez et al. 2003, Schödel et al. 2003)
- Bolometric luminosity: $L_{bol} \sim 10^{36}$ erg.s^{-1} ~ x 100 $L_{\odot}$!
  10^{-8}-10^{-9} times weaker than the Eddington luminosity
  (L_{Edd}= 1.26 x 10^{38} $M/M_{\odot}$ ~ 4-5 x 10^{44} erg/s)
- Chandra: X-ray luminosity: ~ 2.4 x 10^{33} erg s^{-1} (Baganoff et al. 2003)
  << Active Galactic Nuclei (≥ 10^{42} erg s^{-1})

⇒ Extremely low radiative efficiency ?

⇒ Low accretion rate ? (extremely low density ? Dynamically ejected prior to accretion ?)

⇒ Anisotropy and/or strong absorption of the emission ?

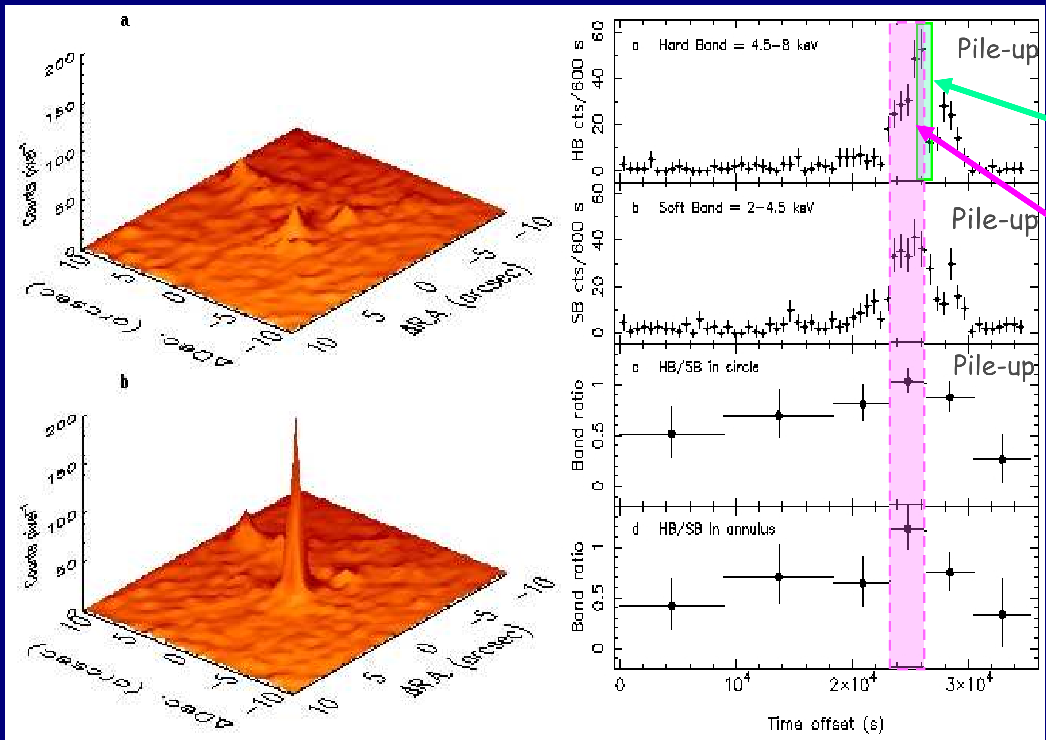
SgrA*: X-ray flaring activity

October 2000:

First detection of a (X-ray) flare from SgrA*

new perspectives for the understanding of the processes at work in the Galactic nucleus

Chandra : Baganoff et al. (2001)



- Sgr A* flared by a factor 45 during about 3 hours
- The shortest time scale is 600 sec → 20 R_s.
- The spectrum at the peak hardens: Γ= 1.3 (+0.5,-0.6)

  Note: Γ(quiescent) ~ 2.5-3.0

⇒ X-rays come from near the black hole.

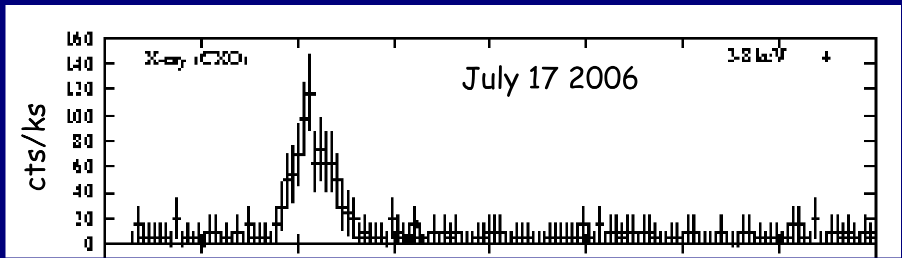
Chandra and XMM-Newton:

Observations of a several weak (amplitude < 20) to moderate (up to an amplitude of 50) X-ray flares (e.g., Baganoff et al. 2001; Baganoff 2003; Belanger et al. 2005; Eckart et al. 2004, 2006, 2008; Hornstein et al. 2007; Marrone et al. 2008; Porquet et al. 2008)

<Frequency>: 0.6 - 1 flare per day (1-5% of the observing time) but could be higher.

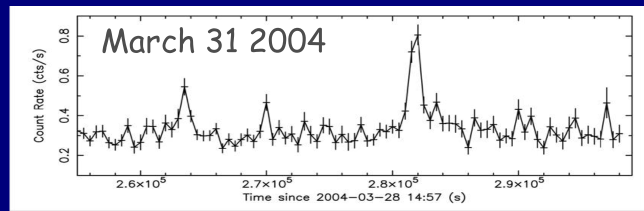
Duration: ~ 5 min – 2 hours

Marrone et al. (2008)



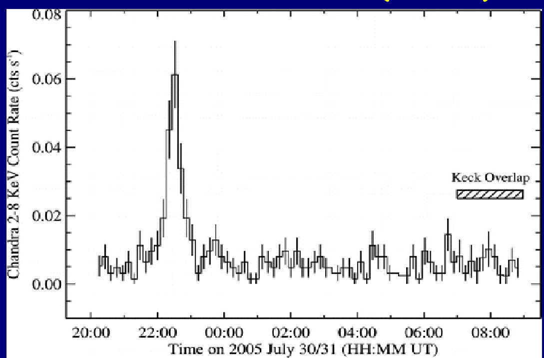
Lx = 40 x 10^{33} erg/s
Amplitude ~ 20

Bélanger et al. (2005)

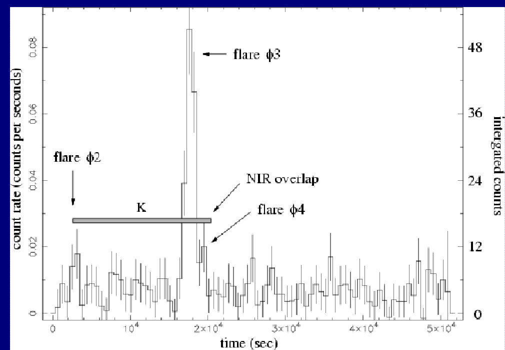


L_x~ 9 x 10^{34} ergs/s
peak/quiescent ~ 40

Hornstein et al. (2007)

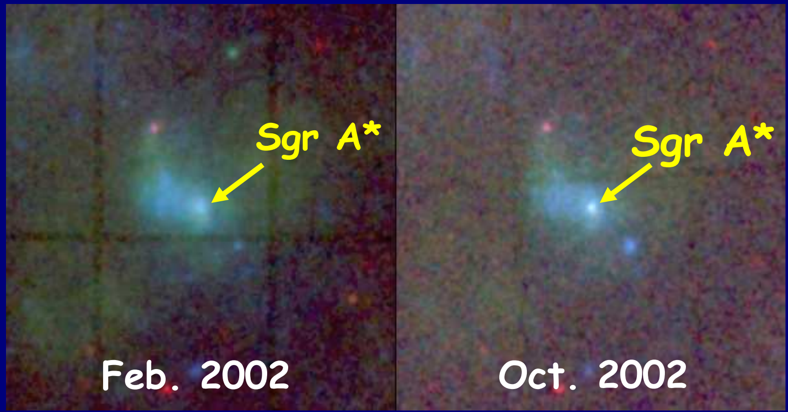


Eckart et al. (2006)



$L_{2\text{-}8keV}$ ~33 x 10^{33} erg/s
Amplitude ~ 15

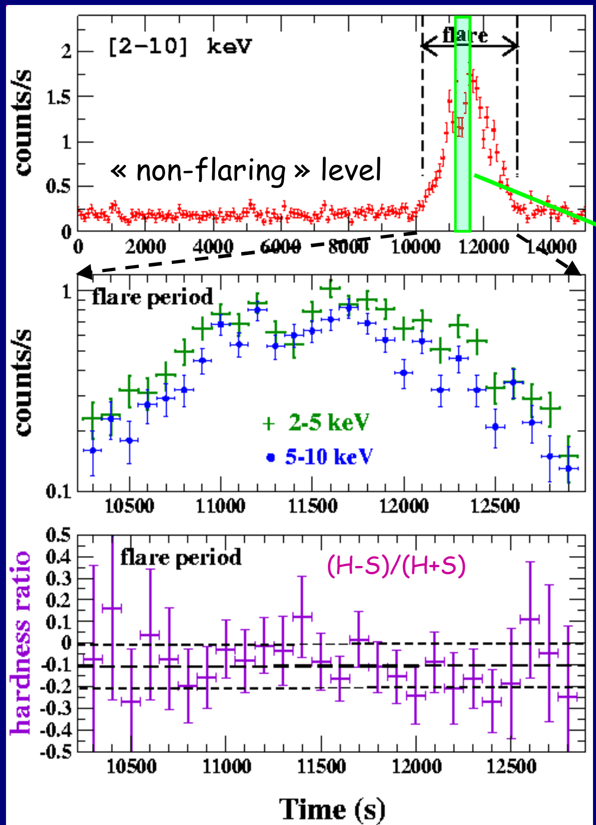
The brightest X-ray flare from Sgr A* (XMM-Newton)



Porquet et al. (2003)

October 3, 2002:

- duration: less than 1 hour (~46 min)
- amplitude: ~ 160 (flare peak / quiescent level)
  (~ x 3.5 October 2000, Chandra)



Peak Luminosity (2-10keV)= 3.6×10^{35} erg.s^{-1}

≈ Bolometric luminosity of the quiescent state

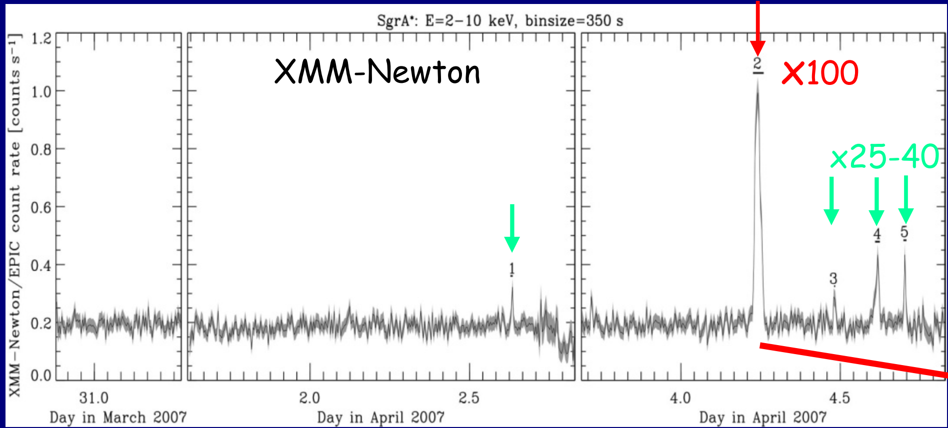
- almost symmetrical light curve
- shortest time-scale: 200 s (3σ) → 7 R_s

  ($R_s \sim 8 \times 10^{11}$ cm): very small region !

- similar soft (2-5 keV) and hard (5-10 keV) light curves.
- no significant spectral variability between the rising and decreasing phases.
- $\Gamma = 2.5 \pm 0.3$ for the whole flare (90% conf. level)

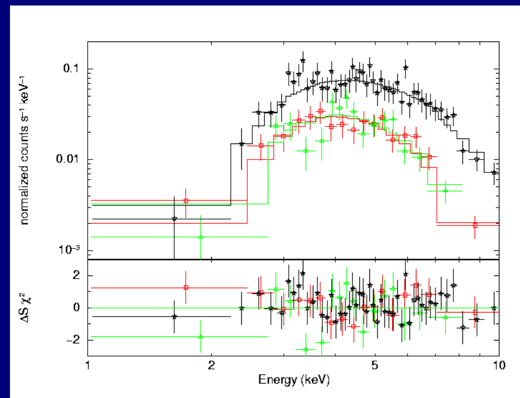
X-ray hiccups from SgrA* on April 4th 2007

Porquet et al. (2008)



4 flares detected within 12 hours with different amplitudes !

Detection of the second brightest X-ray flare from SgrA* followed by 3 moderate X-ray flares.



Bright flare (the second brightest X-ray flare from SgrA) :

- Duration: ~ 2.9 ks ~ 48 min (≅ brightest flare, i.e ~2800s)
- Power-law fit taking into account dust scattering (A_V=25):

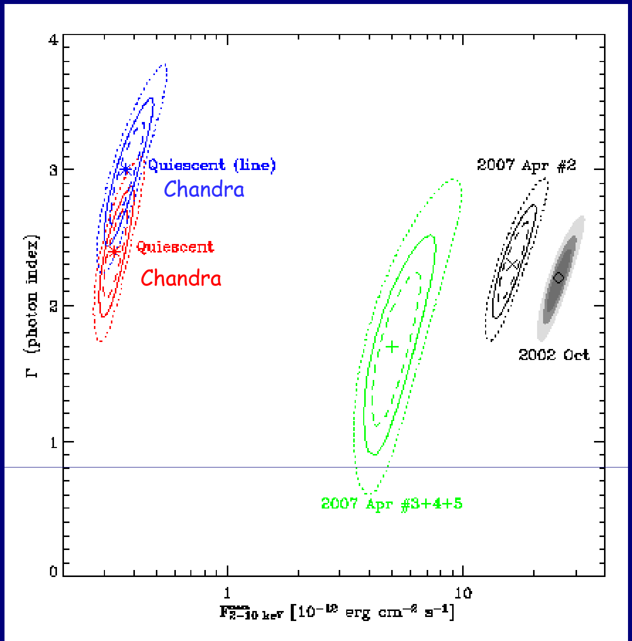
  N_H= 12.3 (+2.1,-1.8) x 10^{22} cm^{-2} and $\Gamma = 2.3 \pm 0.3$
- L_{peak} (2-10 keV) ~ 2.5 x 10^{35} erg/s → Amplitude: ~ 100

Following 3 moderate X-ray flares:

- Durations: 0.3-1.3 ks (~5-21 min)
- Fit (sum of the 3 moderate flares): N_H= 8.8 (+4.4,-3.2) x 10^{22} cm^{-2} and Γ = 1.7 (+0.7,-0.6)
- L_{peak} (2-10keV) ~ 6-9 x 10^{34} erg/s → Amplitude: ~25-40

Confidence regions of the spectral parameters

Porquet et al. (2008)



⇨ the two brightest flares have well constrained soft X-ray spectra $\Gamma \sim 2.2\text{-}2.3\ (\pm 0.3)$

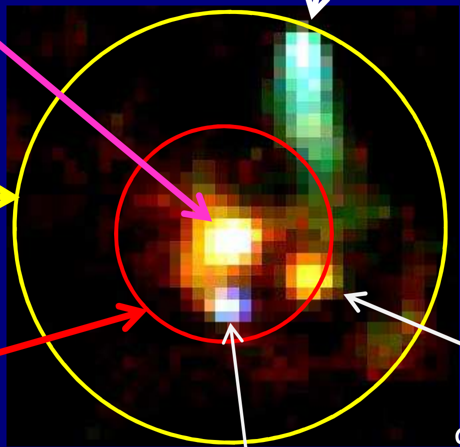
⇨ 2 types of X-ray flares ? weak moderate/hard and bright/soft ?
If yes, two different physical processes ?

II. IXO era

Angular resolution and extraction regions

Pulsar Wind Nebula candidate
(L_x ~ 1.1 x 10^{34} erg/s)
(~0.3-0.4 pc)

Sgr A*



Chandra/ACIS-I
1 Ms

Extraction regions:

XMM-Newton: R = 10"
The "non flaring level" for R=10 "
= 90% (diffuse emission + other point sources)
+ 10% Sgr A* quiescent level.

IRS 13:
cluster of young
and massive stars

IXO extraction region of R=5"

Transient X-ray source
(~0.1 pc)

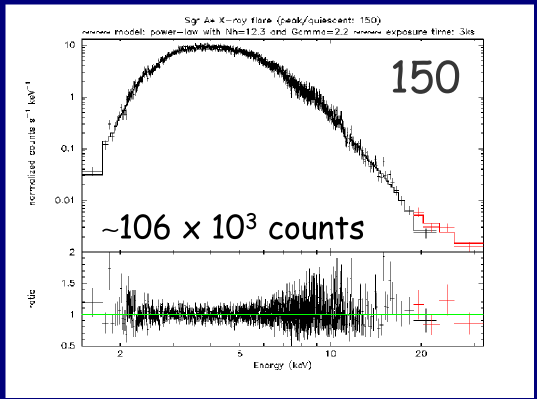
Importance of the spatial resolution to decrease the contamination by other X-ray sources during the non-flaring time interval and to detect weak flares from SgrA*.

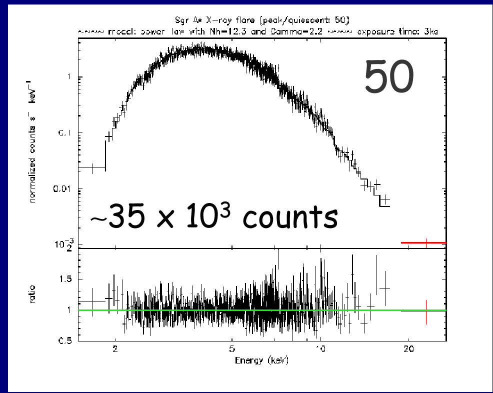
Image Credit:
NASA/CXC/MIT/Frederick K. Baganoff et al.

Sensitivity and energy coverage

IXO simulations : WFI + HXI

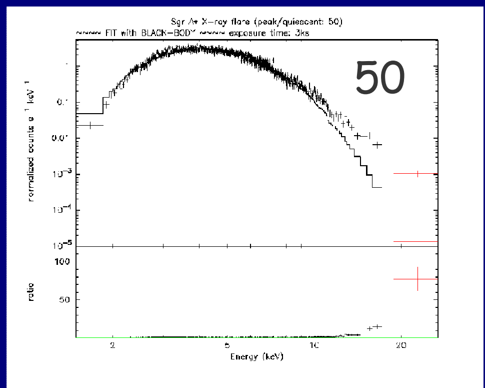
- XEUS_IrC_ML_WFI.rsp, XEUS_IrC_ML_CdTe.rsp
- Power-law model: N_H= 12.3 x 10^{22} cm^{-2} and Γ=2.2 (fit parameters of the brightest flare)
- For amplitude (flare peak to quiescent level)= 150, 100, 50, and 20
- Exposure time ~ 3ks (~50 min)

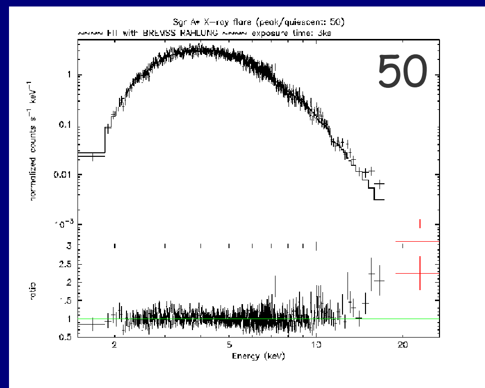




FIT with BB

FIT with brems





Discrimination between models ⇨ physical process

Sensitivity and energy coverage (II)

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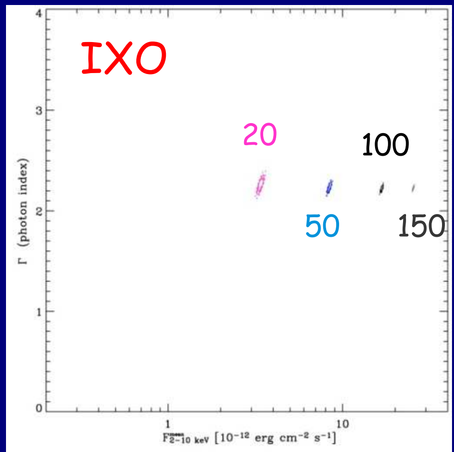
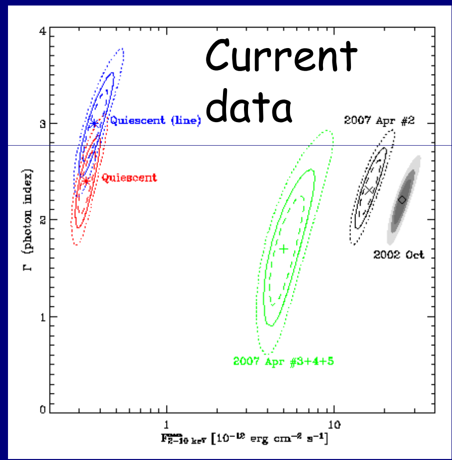
Confidence regions





We will be able to strongly constrain the whole flare spectral properties, as well as time-resolved spectroscopy during flares.

Requirements for SgrA*

1. Good angular resolution: $\leq 5''$ to detect weak to bright flares

2. High sensitivity for time-resolved spectroscopy

3. Energy coverage: WFI + HXI to discriminate between emission models

+4. Wide FOV for the study of serendipitously observed transient X-ray binaries

Thank you for your attention