The X-ray lightcurve of Sgr A* over the last 200 years inferred from Fe Ka reverberation in Galactic Centre molecular clouds

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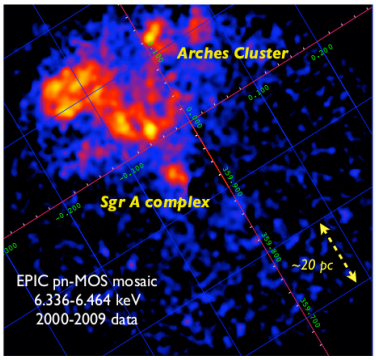
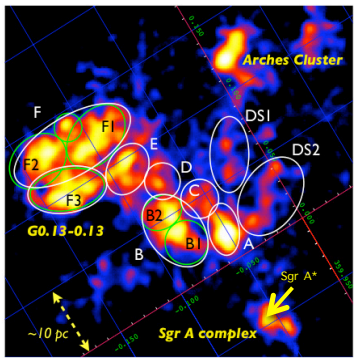
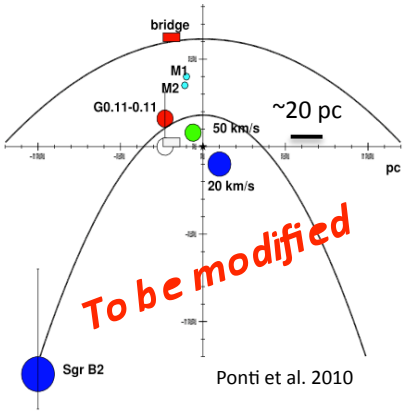
The Fe-Ka line emission at 6.4 keV from molecular clouds (MCs) in the Galactic Centre (GC) region is due to ***fluorescence***, produced by hard X-rays and/or high energy particles hitting the cold molecular gas. The total Fe-Ka flux requires an X-ray luminosity of the ionising source of ~10^{39} erg s^{-1}. Currently, ***no X-ray source*** in the GC has been observed to be so bright. Therefore, the favoured interpretation is that this peculiar line emission is a ***6.4 keV echo*** of the radiation produced by a past giant flare (≥10 years) of Sgr A*. (Sunyaev et al. 1993, Koyama et al. 1996).



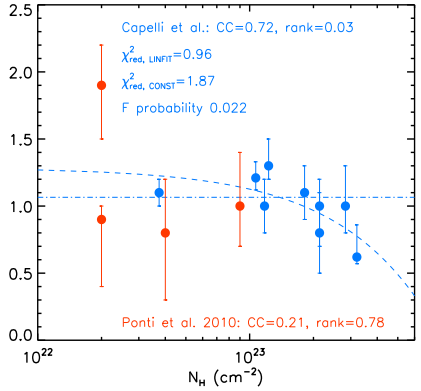




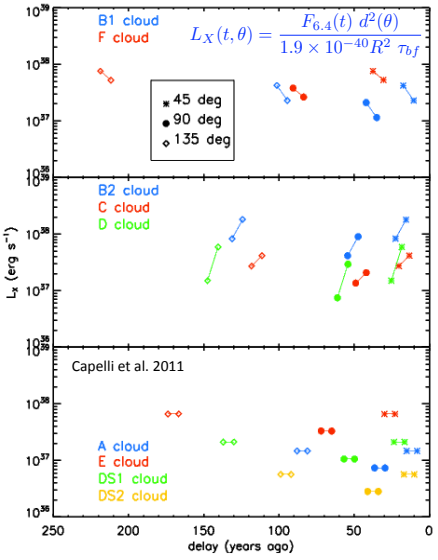
Ponti et al. 2010

Recently, Ponti et al. 2010 showed that the Fe-Ka line flux from the MCs within 30 pc from Sgr A* exhibit a complex pattern of variability.
Assuming that ***the same flare*** illuminated these MCs, it is possible to infer their distance along the line of sight (left), dependent on the assumed Fe abundance (Z_{Fe}) and cloud density (N_H). However, by measuring in the X-ray spectrum ***the optical depth τ_{bf} of the absorption at the Fe-K edge*** (7.1 keV), we obtain the relevant factor directly.

$$\tau_{bf} = N_{Fe}\ \sigma_{bf(Fe)} = 3 \times 10^{-5}\ Z_{Fe}\ N_H\ \sigma_{bf(Fe)}$$

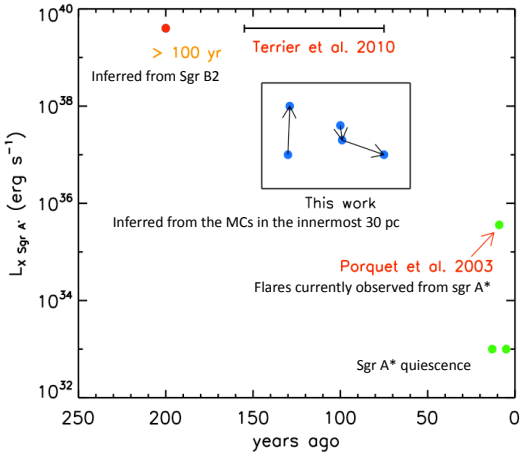


The cloud column densities inferred by our measurements of τ_{bf} ***are significantly larger*** than the values estimated by Ponti et al. (2010) from radio data, and are in much better agreement with the theoretical prediction of an ***inverse proportionality*** between the cloud density and the slope of the reflected continuum. As a consequence, the 3D distribution of these MCs previously proposed ***must be severely revised***. We converted the lightcurves of the 6.4-keV line of the selected MCs into a lightcurve for the putative source Sgr A*; the delay of the Fe-Ka signal with respect to the direct radiation Sgr A*-observer is function of the geometry (θ). We divided the MCs in sub-groups depending on the displayed variability of the 6.4-keV line (increase, decrease, constant). The goal is to find regions of the L_X-delay plot where these sub-groups of clouds cluster.



- ❑ B1,F. They well reflect the same ***drop in the L_X*** occurred 100 years ago - 4 to 2x10^{37} erg s^{-1}.
- ❑ B2,C,D. The increasing Fe-Ka flux in these MCs might be due to a ***burst*** occurred around 130 years ago, with an L_X excursion from 10^{37} to 10^{38} erg s^{-1}.
- ❑ Others. ***Constant level of activity*** at 10^{37} erg s^{-1} around 70-80 years ago.

Plotting all the results in a lightcurve (right) gives the view of the ***X-ray activity of Sgr A* over the last ~400 years***. Starting with a L_X~10^{39} erg s^{-1} required by the Sgr B2 MC (Terrier et al. 2011), whose end can be dated back to 155 years ago, the Sgr A* X-ray activity shows a ***decreasing trend staggered by sudden episodes of brightening.*** We cannot model the real shape of the lightcurve because of the lack of MCs shining in the 6.4 keV line flux in the blank region. We can only assume either a continuum decreasing trend, or sharp outbursts (whose duration decreases with time).



Conclusions. The Fe-Ka line emission from MCs in the GC region strongly supports the hypothesis of a ***past illumination by a low AGN activity of Sgr A****. However, we show that this past activity had to be more ***highly variable*** than the recently suggested L_X~10^{39} erg s^{-1} constant for 400 years; the MCs close to Sgr A* require an ionising X-ray luminosity between 10^{37} and 10^{38} erg s^{-1}.

References: Capelli R. et al. 2011[c], in preparation; Terrier et al. 2010 (and references therein)