THE **GALACTIC CENTER** SUPER-MASSIVE **BLACK HOLE'S** **PAST ACTIVITY** STUDIED FROM ITS **REFLECTION** ON SURROUNDING **MOLECULAR CLOUDS**

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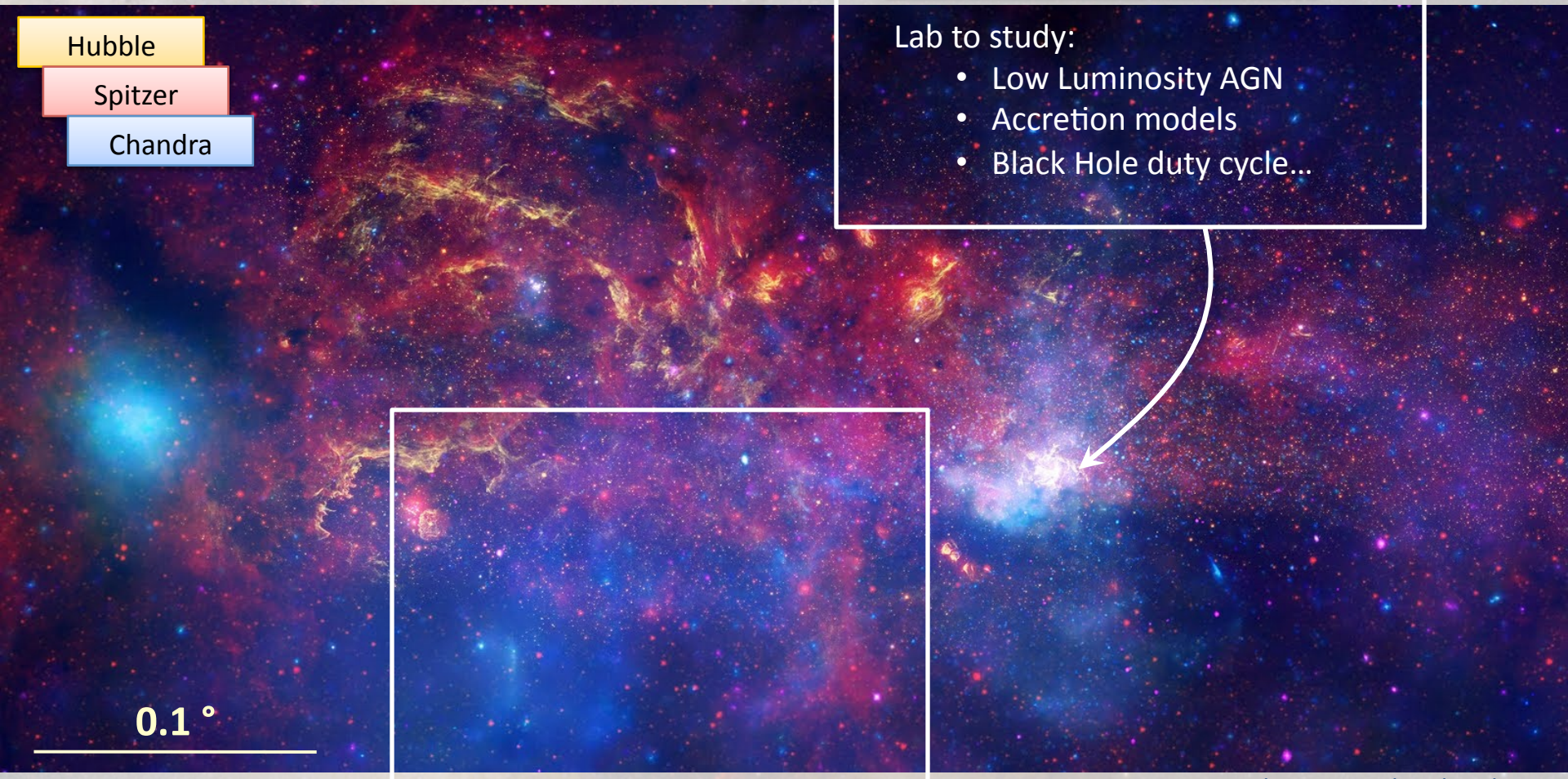
The Galactic Center



Sagittarius A*

Lab to study:

- Low Luminosity AGN
- Accretion models
- Black Hole duty cycle…

Diffuse Emission

Credits: NASA/JPL-Caltech/ESA/CXC/STScI

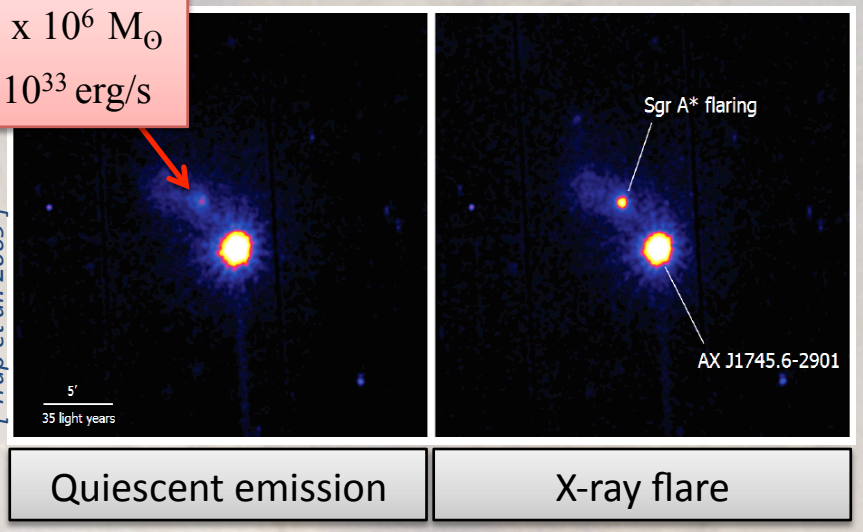
Sagittarius A* - Present Activity

One of the least luminous known super-massive black hole

Sgr A*

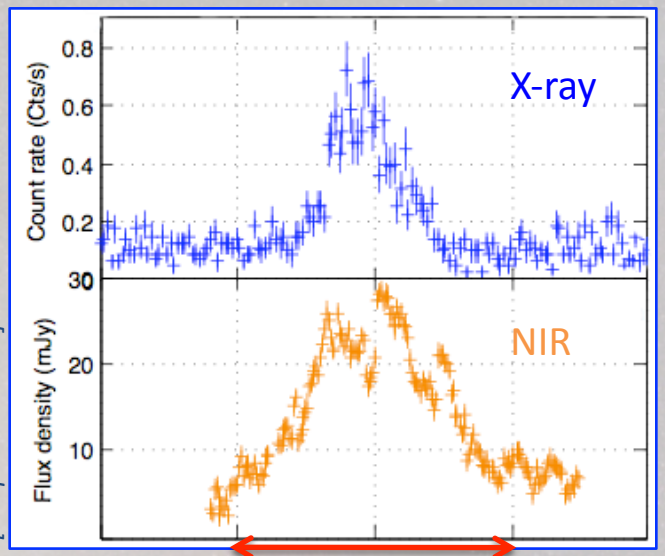
$M \sim 4 \times 10^6 M_\odot$

$L_X \sim 10^{33}$ erg/s



[Trap et al. 2009]

Quiescent emission | X-ray flare



[Trap et al. 2009]

Flaring emission processes not constrained

Part of my PhD

XMM / VLT observation campaign in March 2012

To characterize the flaring spectrum in both IR and X-ray

IR data analysis in progress, results to be published

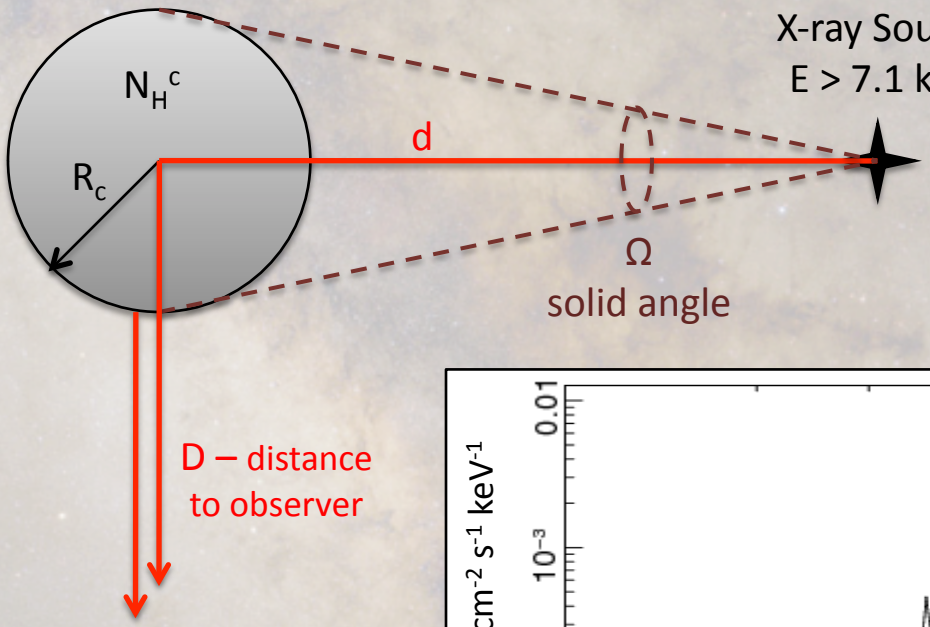
Sagittarius A* - Past Activity

Evidences for a higher level of activity in the past

Molecular clouds: Mirrors of the black hole's past activity

X-ray Radiation Reflection on Molecular Clouds

Molecular cloud



Fluorescence

&

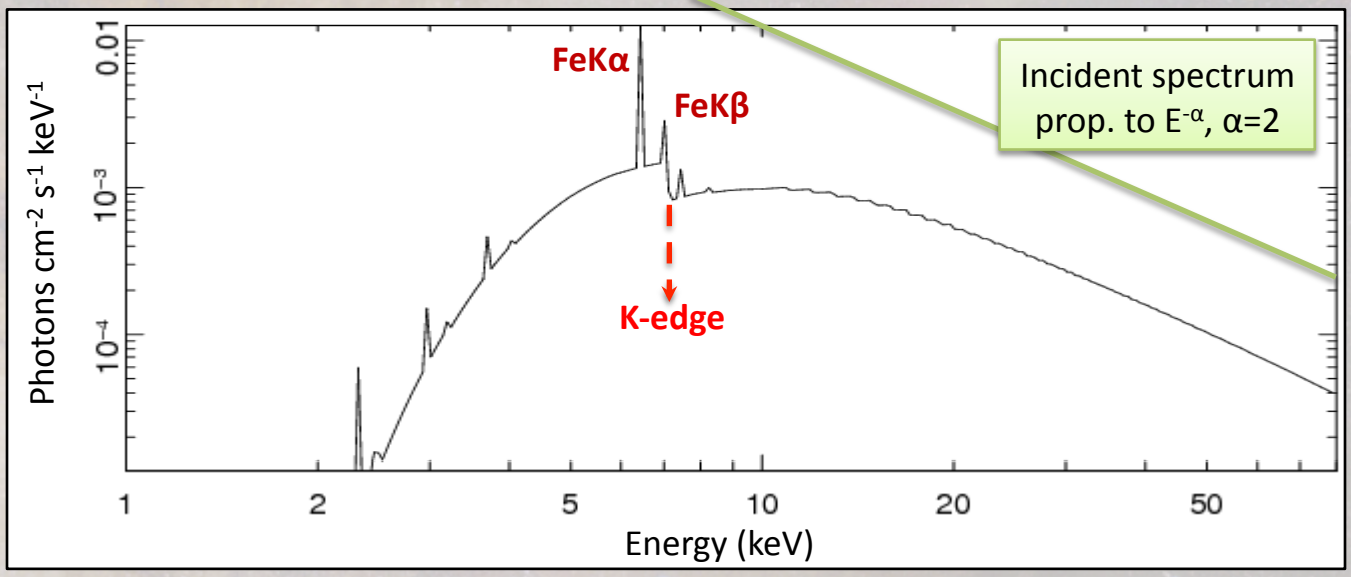
Scattered X-rays

Reflected signal

Time delay due to longer path

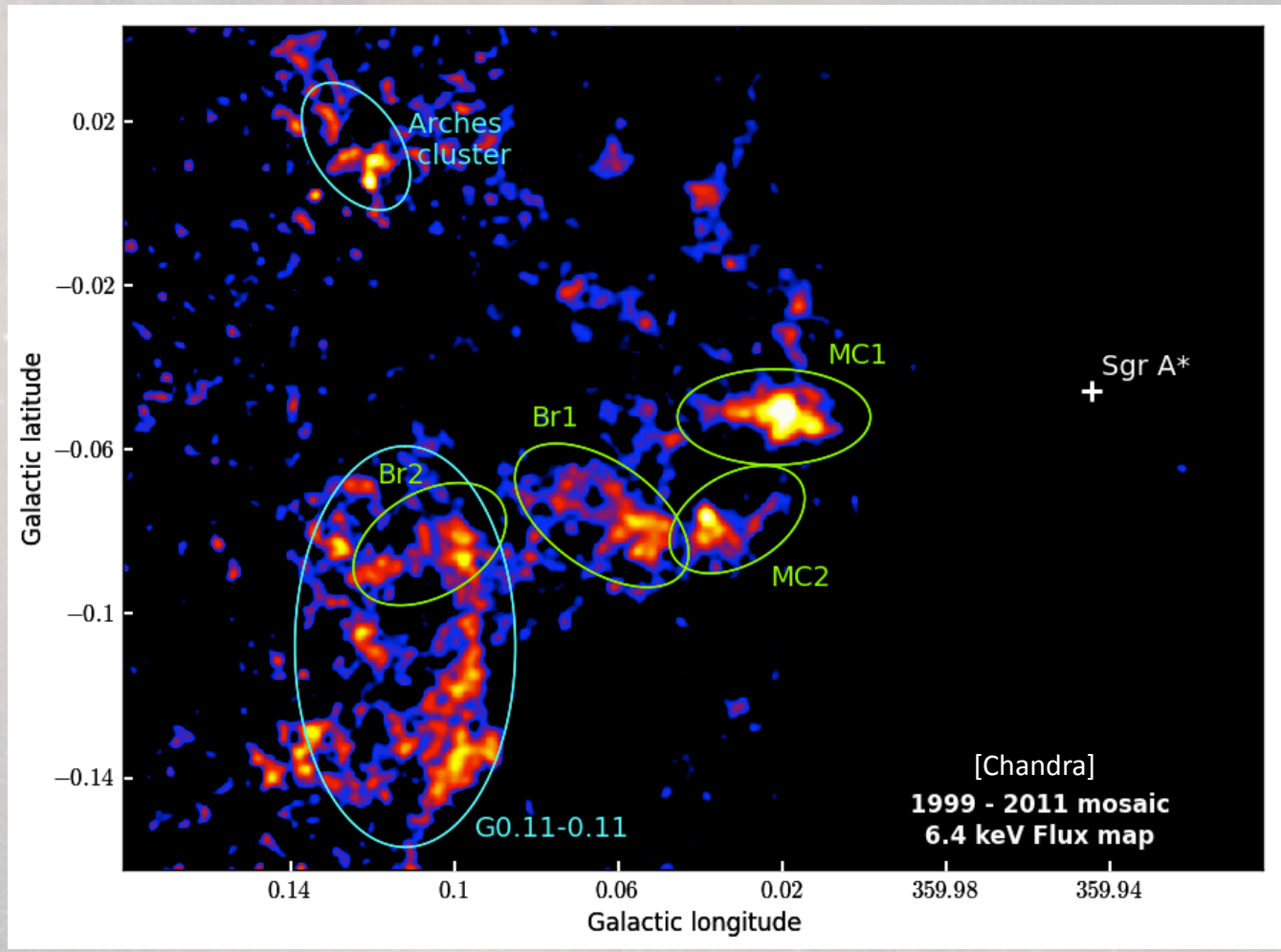
Direct link to Sgr A* past luminosity

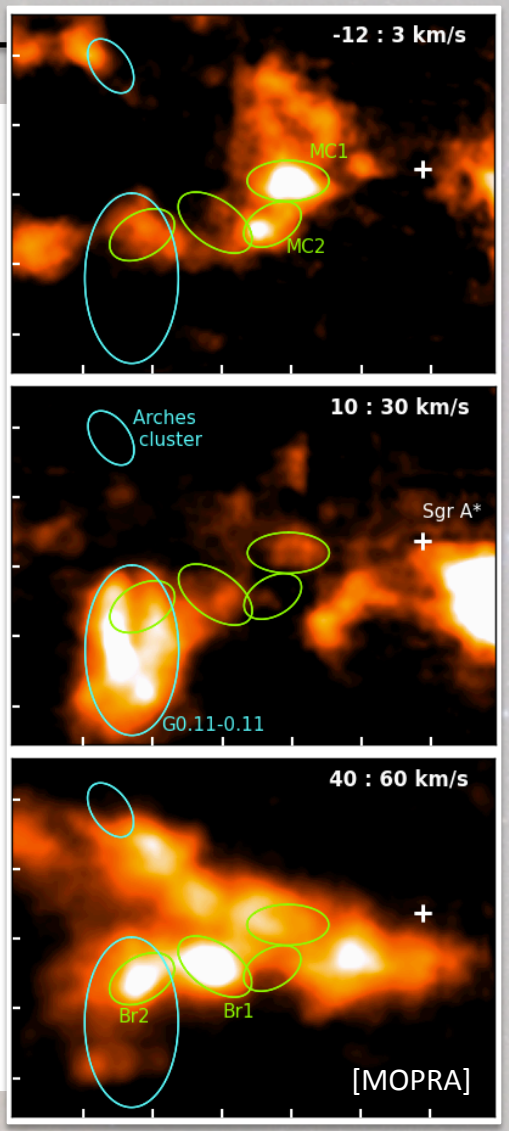
$$F_{6.4keV} \propto L_X \times \frac{R_c^2}{d^2} \times \frac{N_H^c}{D^2}$$



Molecular Clouds emission at 6.4 keV

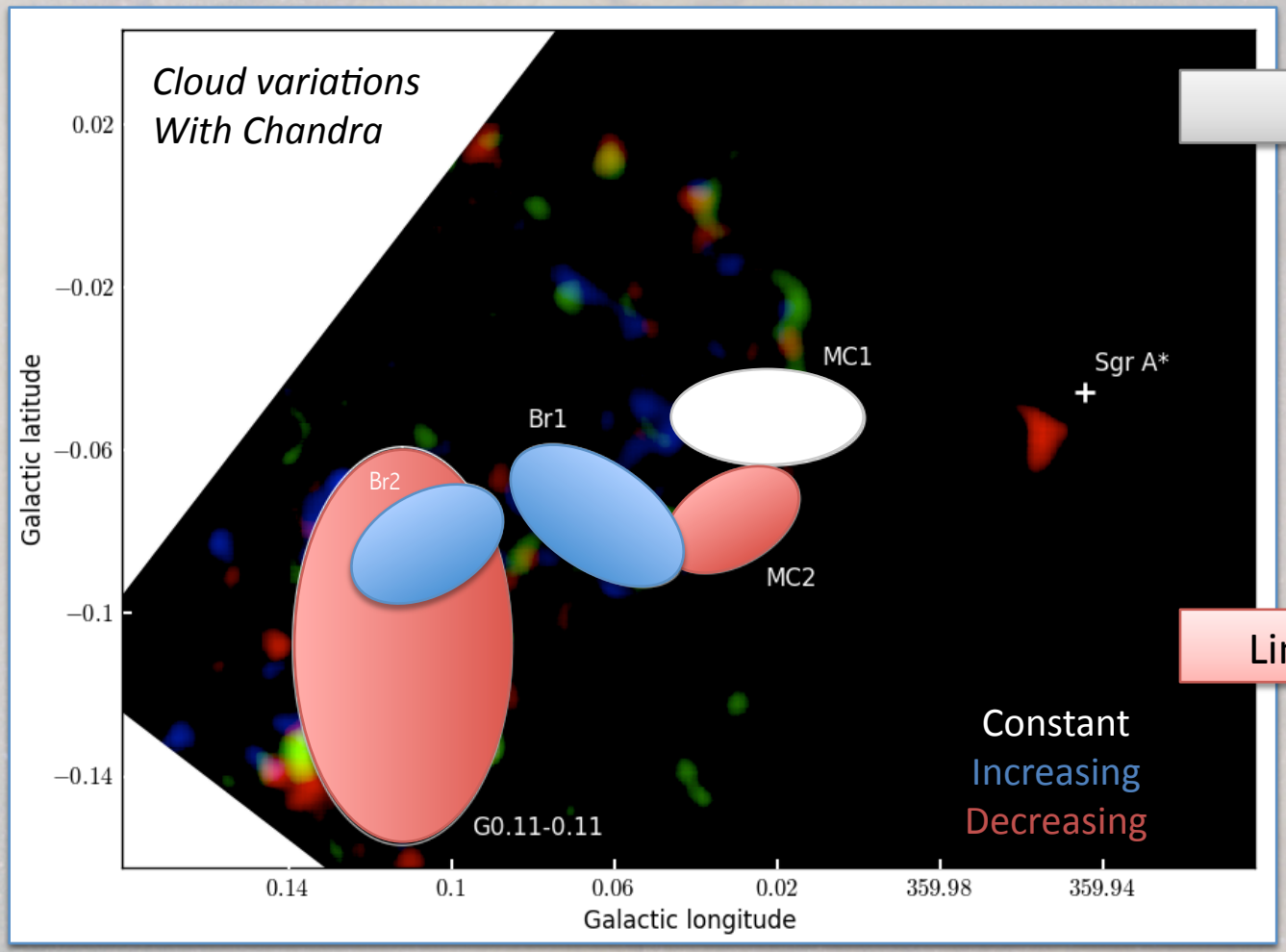
Strong diffuse emission correlated with molecular structures





Molecular clouds 6.4 keV emission variations

Strong variations in a 10-year time scale



Previous works

Large region trends:

Ponti et al. 2010
Capelli et al. 2012

→ Spectral analysis

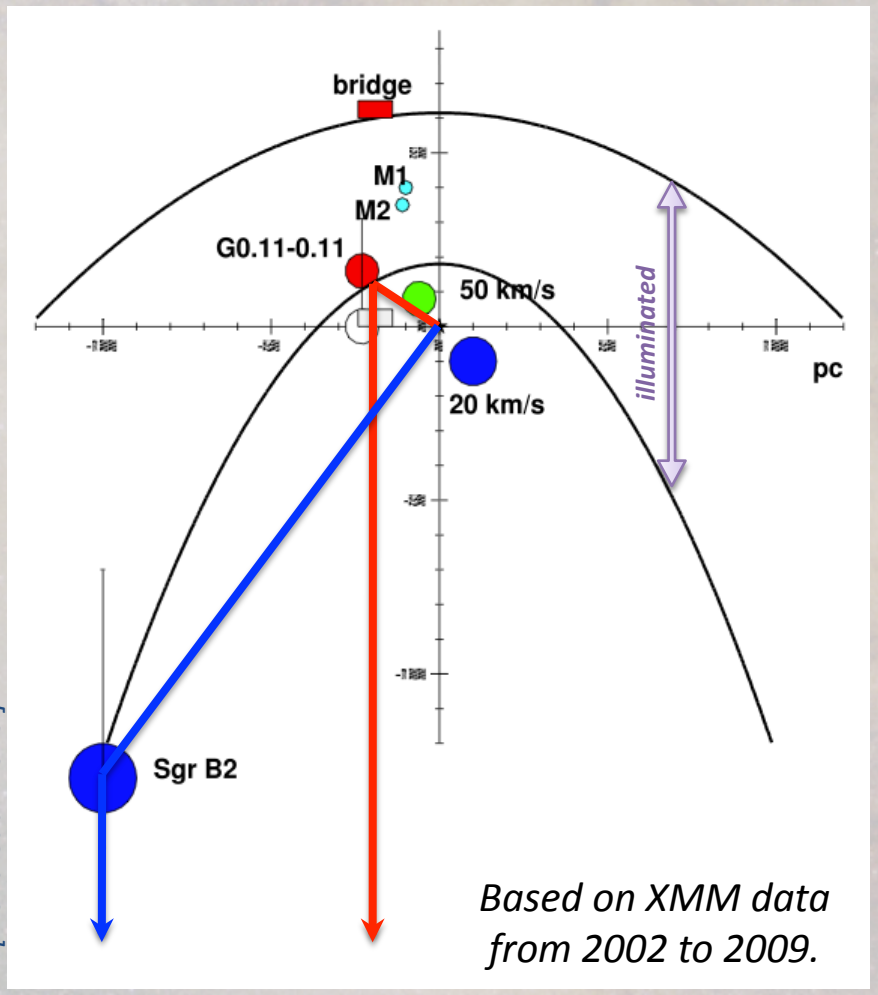
→ Reflection process

Link to Sgr A* past activity?

→ Need a 3D model for the cloud distribution

Studying Sgr A* past activity - Current issues

Previous illumination model



[Ponti et al. 2010]

Known

Part of the emission is due to **Reflection**

The emission is **Varying** / **Propagating**

Unclear

Molecular cloud parameters

Characteristics of the **Flare(s)**

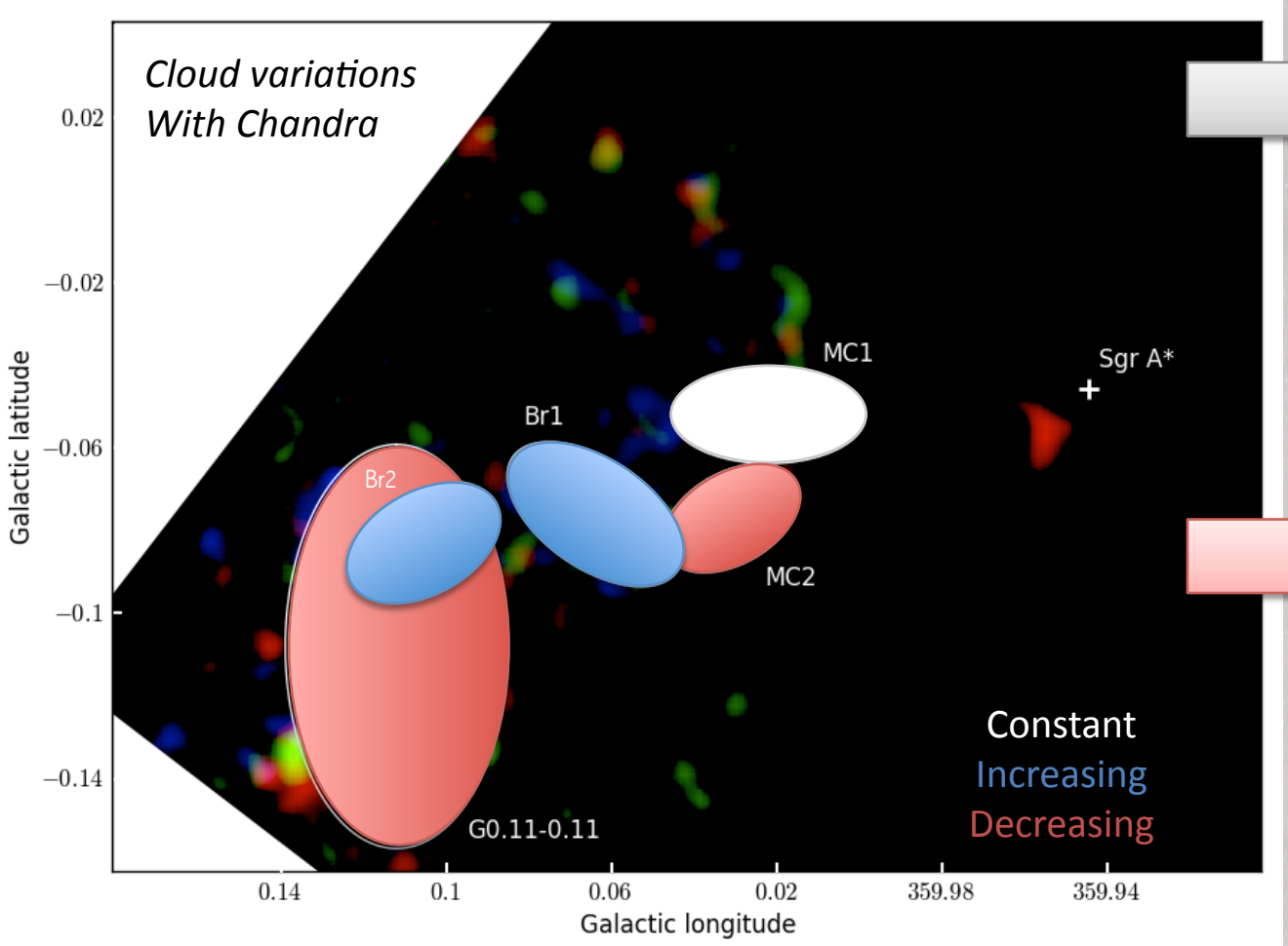
Aim of my work

To use **Chandra** high resolution capability to highlight the **illumination fine structure**

To obtain a **more accurate profile of Sgr A* past activity**

Molecular clouds 6.4 keV emission variations

Strong variations in a 10-year time scale



Previous works

Large region trends:

Ponti et al. 2010
Capelli et al. 2012

→ Spectral analysis

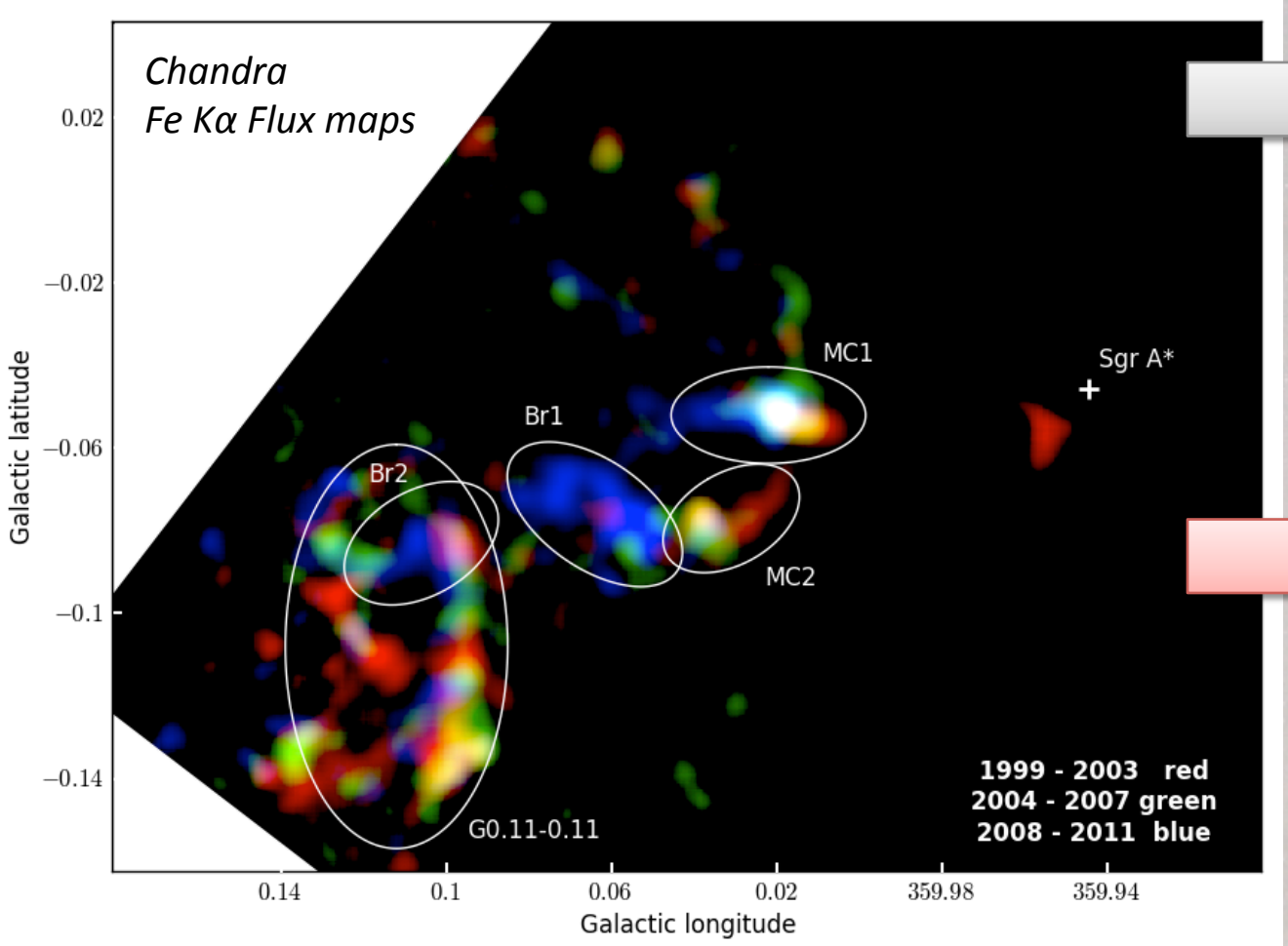
Limitation

→ Different clouds along the line of sight

→ Sub-regions with different variation pattern

6.4 keV Diffuse Emission – Small scale variations

Strong variations in a few year time scale



Previous works

Large region trends:

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→ Spectral analysis

My work

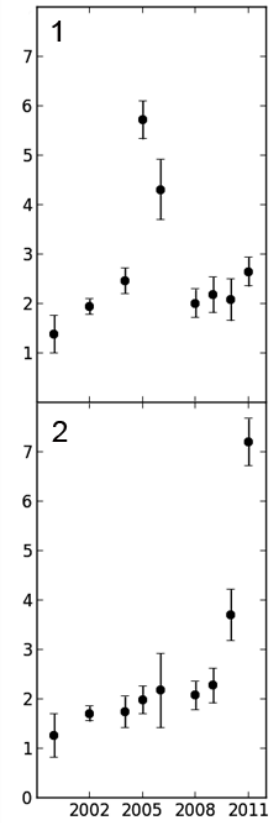
→ To characterize variations on small scales

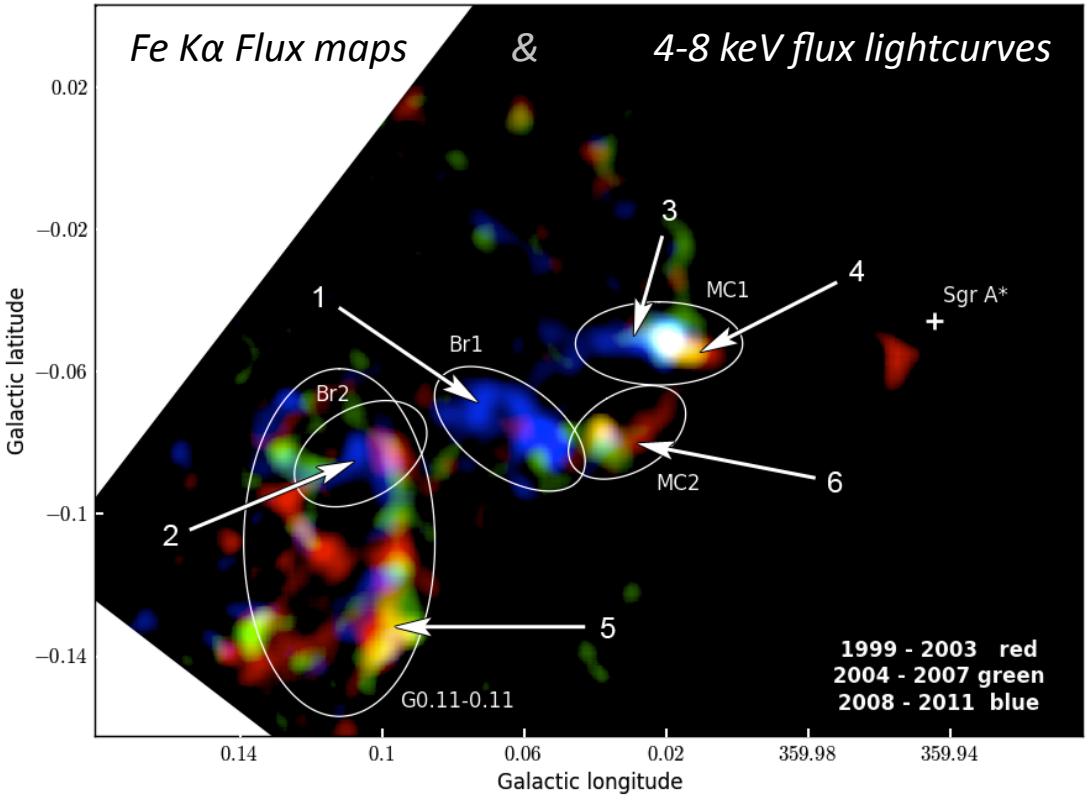
→ To identify simultaneity in the cloud behaviors

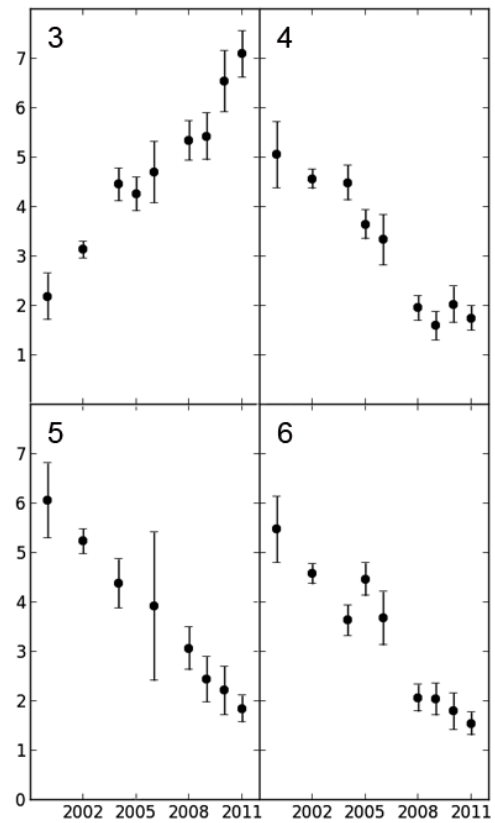
Molecular clouds: Two distinct variation behaviors

2-year peak

10-year linear variation



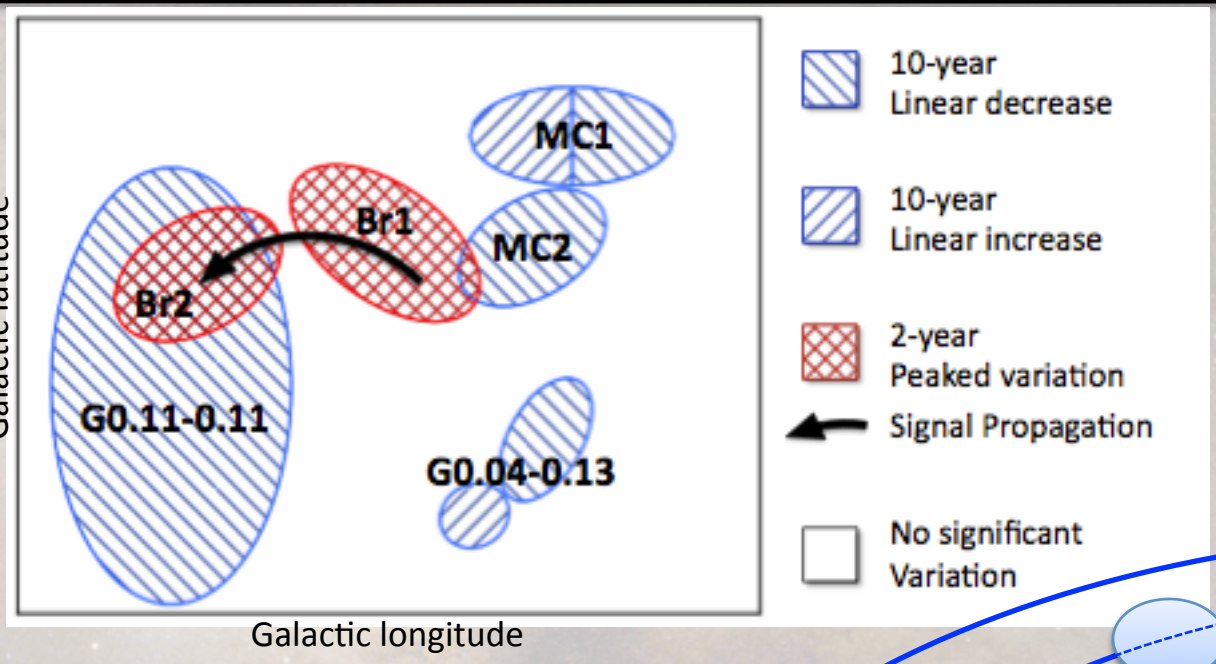




Different cloud structures?

Different illuminating events?

Interpretation: Two illuminating events



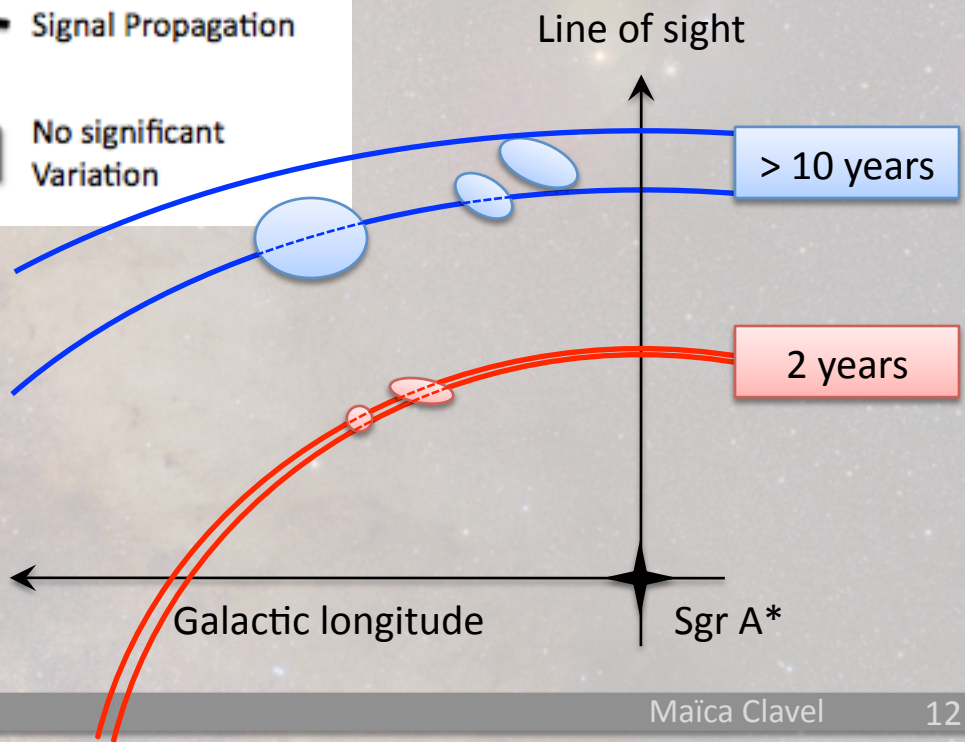
Single-flare scenario:

Excluded by molecular cloud parameters

Two-flare scenario:

$L_X > 10^{39}$ erg s^{-1} but **different durations**

Unknown: *Date*, *Order*, *Underlying level*



Conclusions and Perspectives

Characterization of **Sgr A* past activity** from Molecular Clouds at the Galactic Center

- Clavel et al. 2013 (**submitted** to A&A) - Scenario with two distinct illuminating events
- Characterization of the 6.4 keV emission variations using **XMM-Newton**
- **Proposal** for Chandra 2014 observation campaign to follow the echo
- **Proposal** for CARMA 2013b to better characterize some of the molecular clouds

Direct characterization of **Sgr A* present activity**

- Monitoring the observation campaign from the VLT - Data analysis in progress

Interpretation

- Work on a **model** for the Galactic Center illumination

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Merci !