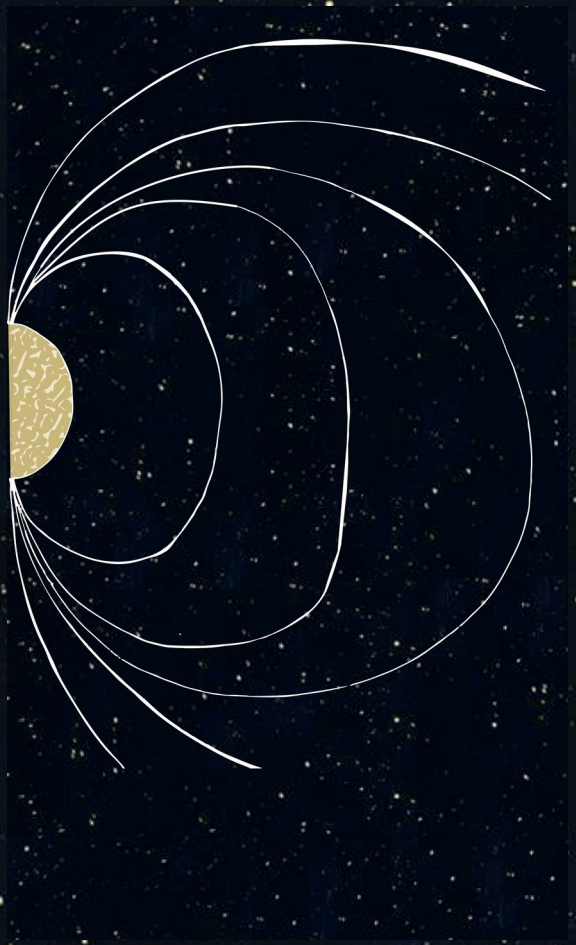
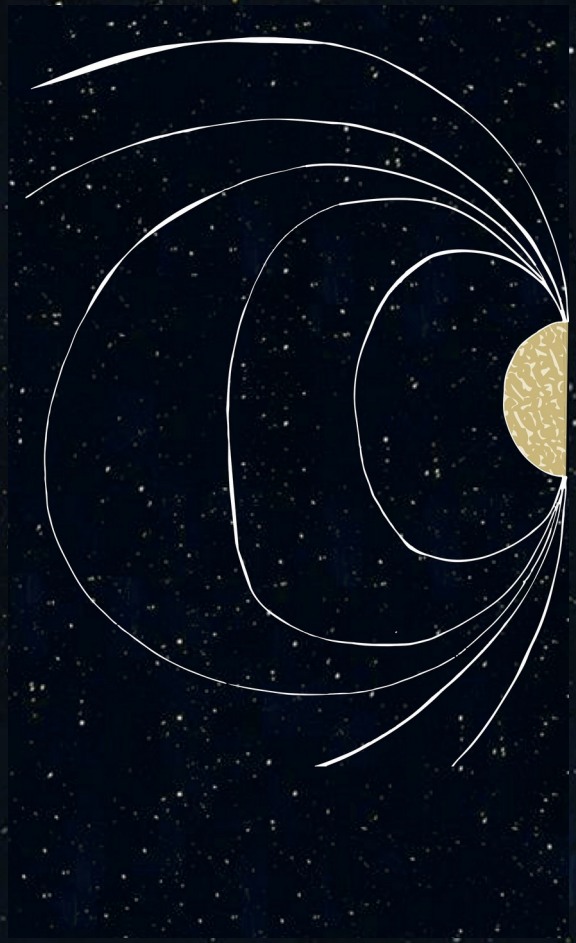


Latest outbursts from radio magnetars



Alice Borghese

MAGNESIA

MAGNETAR CENSUS

The Impact of Highly Magnetic Neutron Stars in the Explosive and Transient Universe

CNOC XII CONGRESSO NAZIONALE OGGETTI COMPATTI

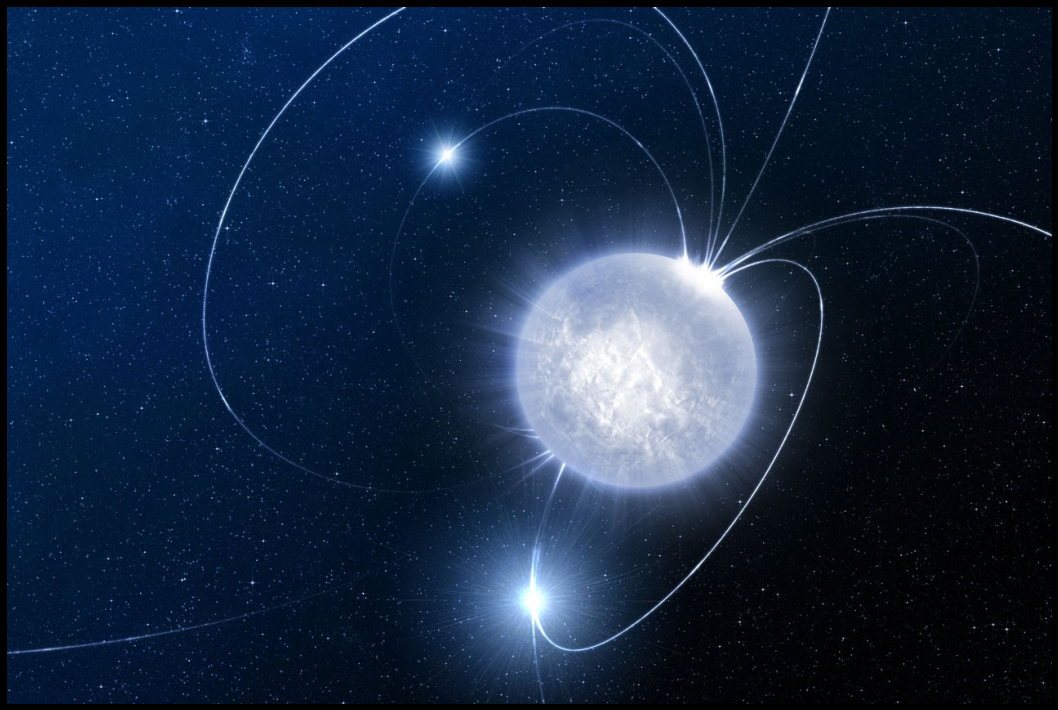
Institute of Space Sciences

CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

IEEC

XTE J1810–197: ID



Discovered in 2003 with *RXTE*

First magnetar to show pulsed emission in the radio band

$P \sim 5.5$ s

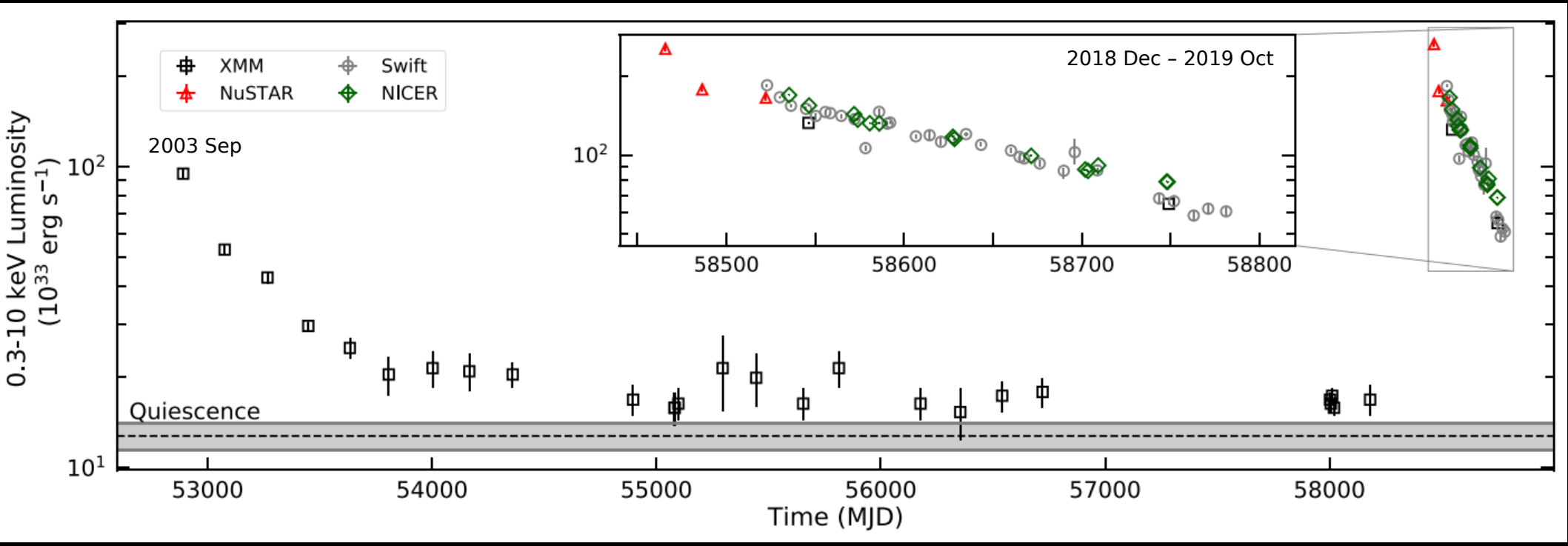
$\dot{P} \sim 2.8 \times 10^{-12}$ s s^{-1}

$B_{dip,eq} \sim 1.3 \times 10^{14}$ G

$\tau_c \sim 31$ kyr

Ibrahim+ 2004; Gotthelf+ 2004; Halpern+ 2005; Camilo+ 2006

XTE J1810–197: outburst history

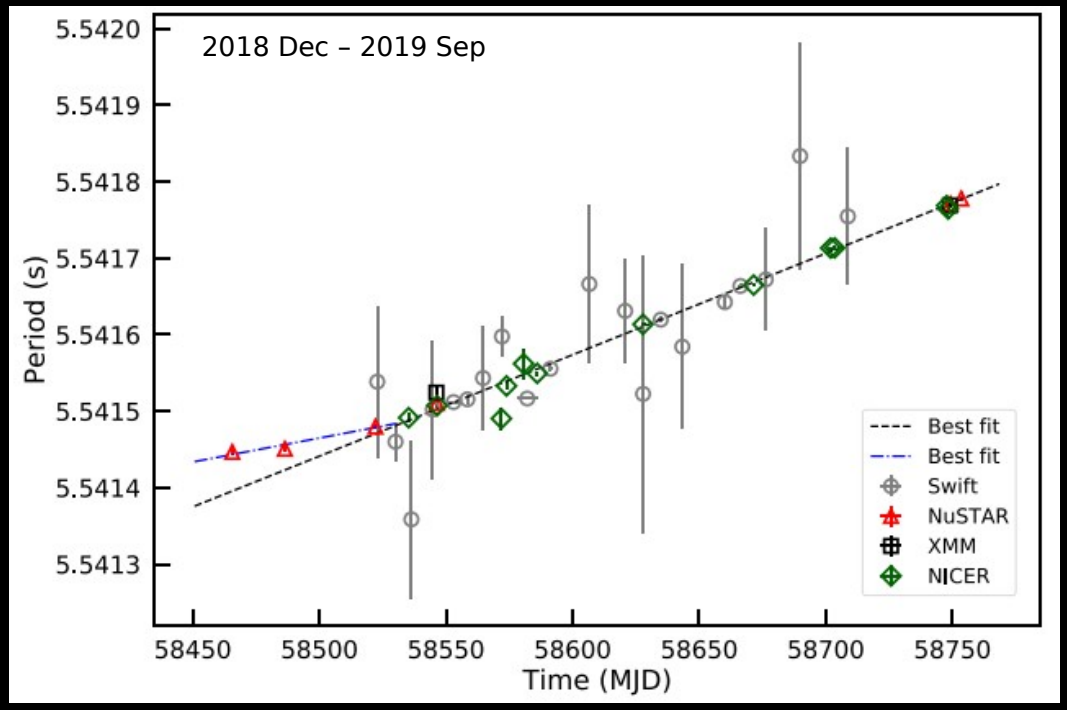


$L_q \sim 1.3 \times 10^{34}$ erg s^{-1} measured with ROSAT in 1993 April

Bernardini+ 2009; Pintore+ 2016, 2019; Gotthelf+ 2019; Borghese+ 2021

Timing analysis

X-rays



Pdot (all sample) ~ 1.5 x 10^{-11} s s^{-1}

Pdot (first two months) ~ 7.2 x 10^{-12} s s^{-1}

$Pdot_q$ ~ 2.8 x 10^{-12} s s^{-1}

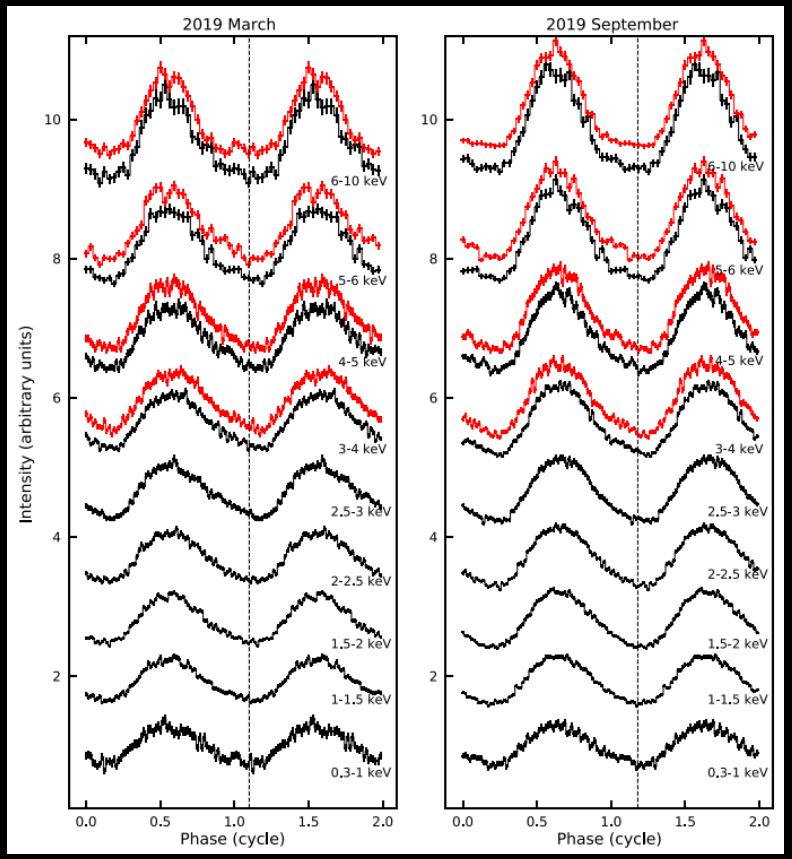
Spin-down rate variations explained in terms of the untwisting bundle scenario

Delayed increase in the spin-down torque consistent with a progressive growth of a small twist

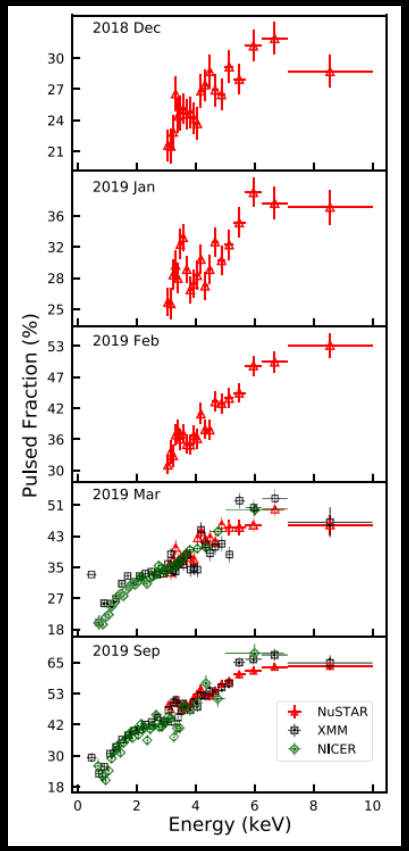
Borghese+ 2021

Timing analysis

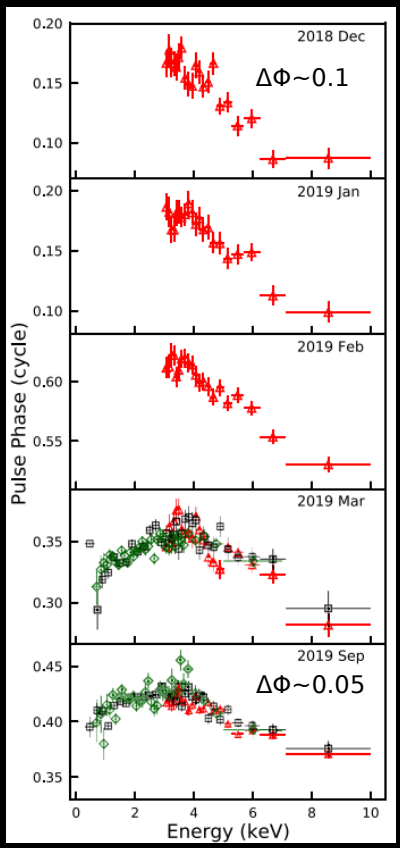
X-rays



Single-peaked pulse profile



PF increases with energy & in time in the same energy band

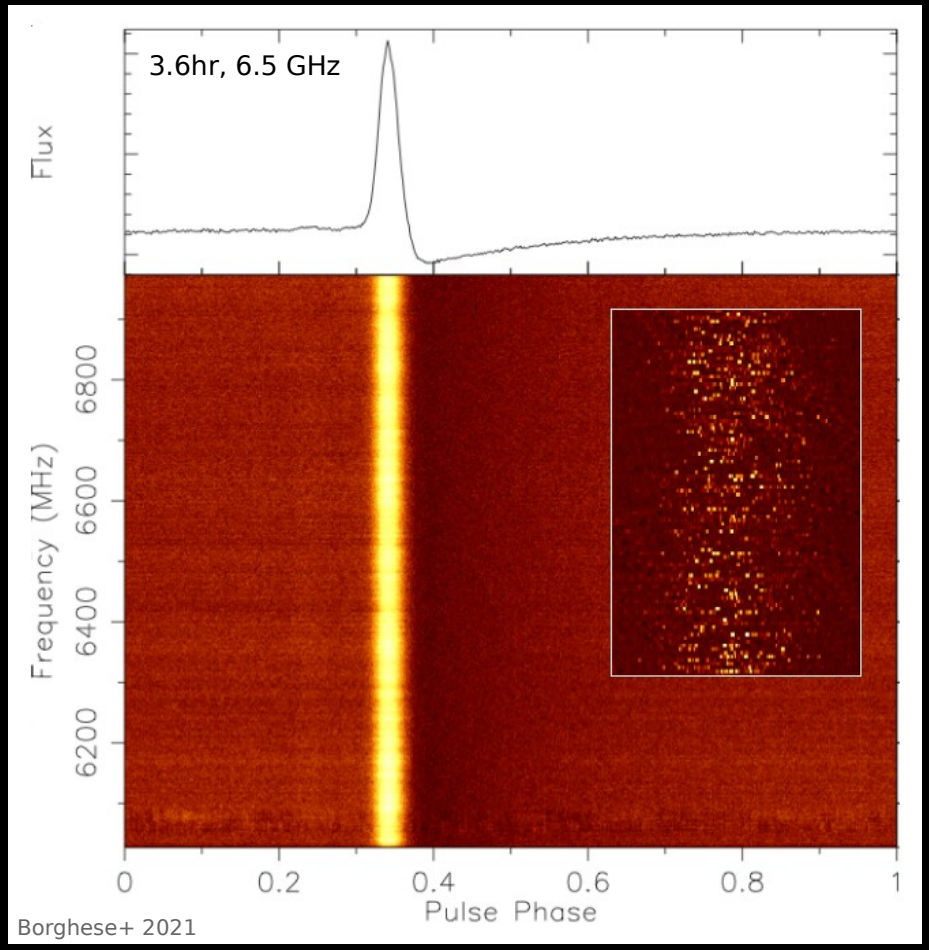


Slippage in phase in the ~3.5–10 keV band

Borghese+ 2021

Timing analysis

Radio



Borghese+ 2021

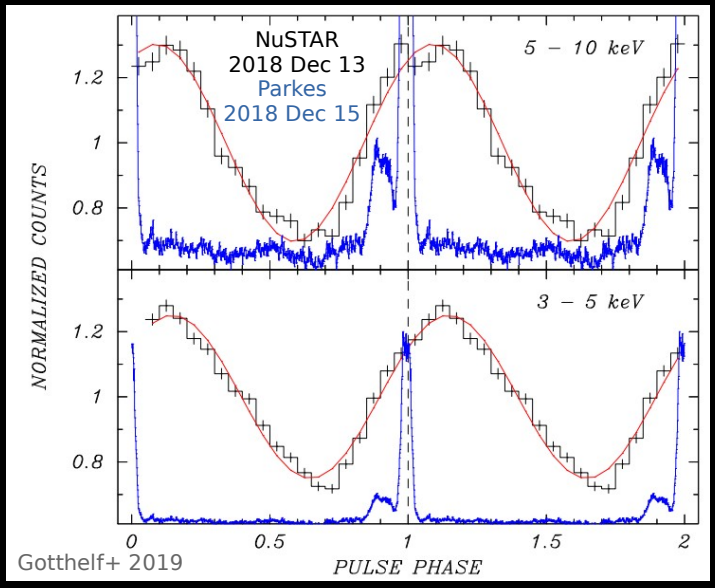
Sardinia Radio Telescope

Simultaneous with *NuSTAR* on 2019 Feb 8

Flux density ~ 2.5 mJy

Bright radio emission → pulses at every rotation

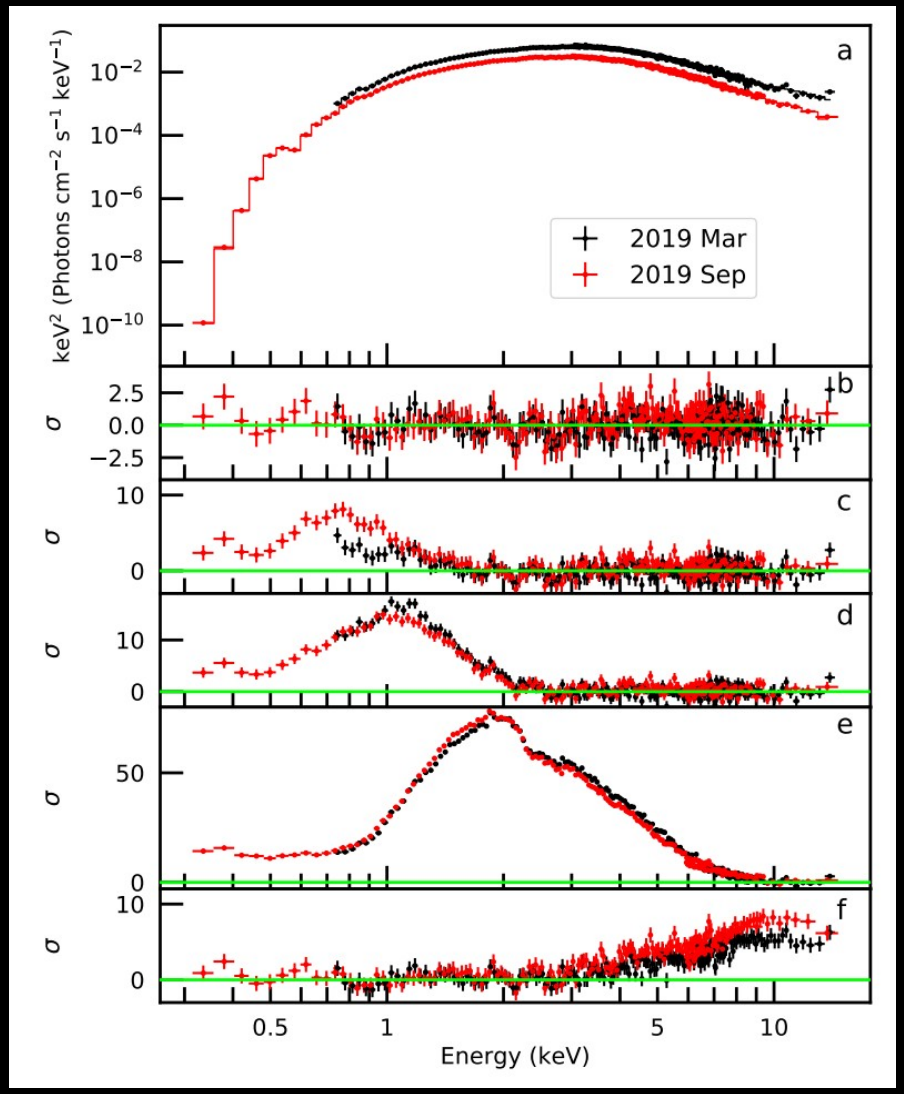
X-ray peak lags the radio one by ~0.08 cycle



Gotthelf+ 2019

Spectral analysis

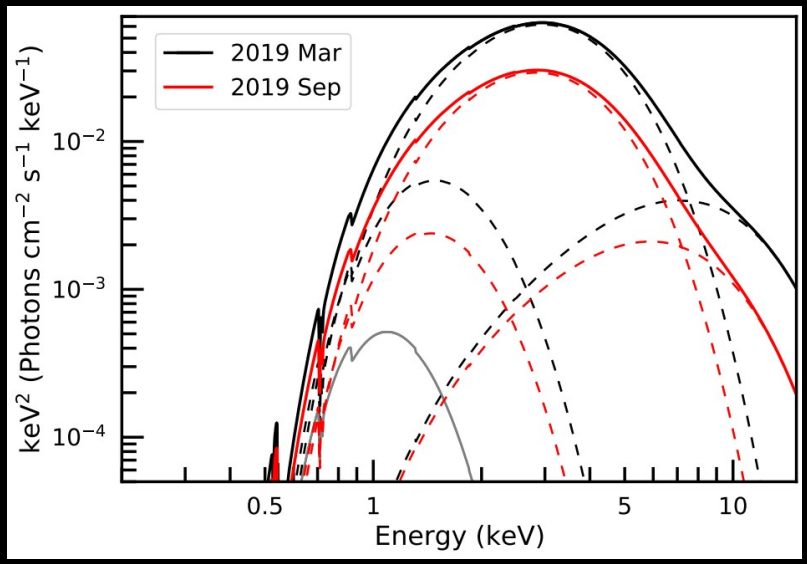
XMM+NuSTAR



Model: 4 blackbody components

BB: Emission from the entire stellar surface (grey)

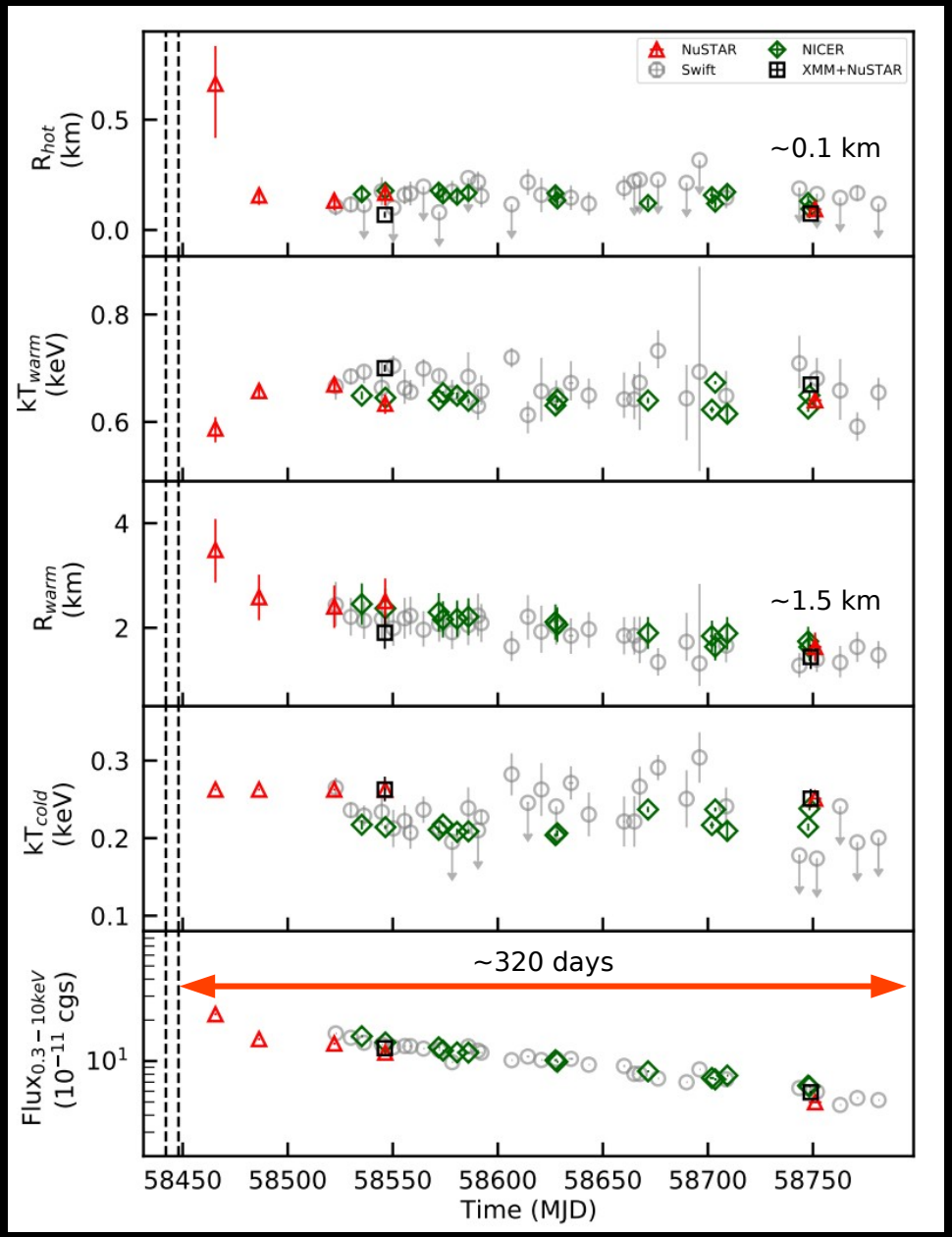
R_{NS} = 12.8 km & kT_{NS} = 0.144 keV



Borghese+ 2021

XTE J1810–197: 2018 outburst

Spectral analysis



X-ray outburst onset: 2018 Nov 20–26

Flux evolution:

$Flux_{2018Dec13} \sim 2 \times 10^{-10}$ erg s^{-1} cm^{-2}

$Flux_{2019Oct25} \sim 5 \times 10^{-11}$ erg s^{-1} cm^{-2}

Versus

$Flux_{q} \sim 5 \times 10^{-13}$ erg s^{-1} cm^{-2}

XMM+NuSTAR

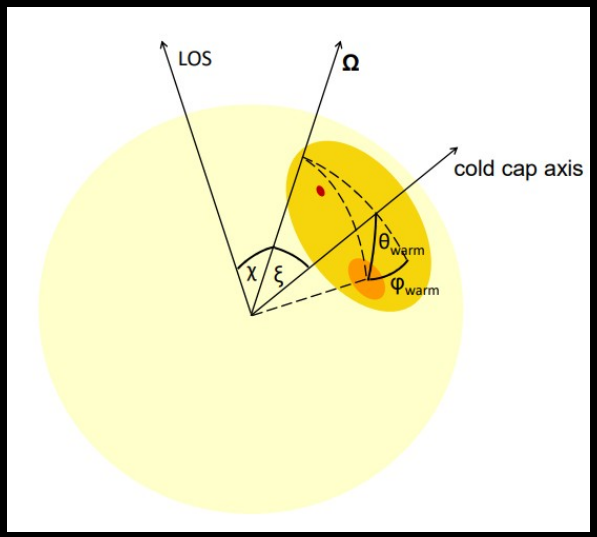
Epoch	kT_{cold} (keV)	R_{cold} (km)
2019 Mar	0.26±0.01	5.9±1.1
2019 Sep	0.25±0.01	4.5±0.9

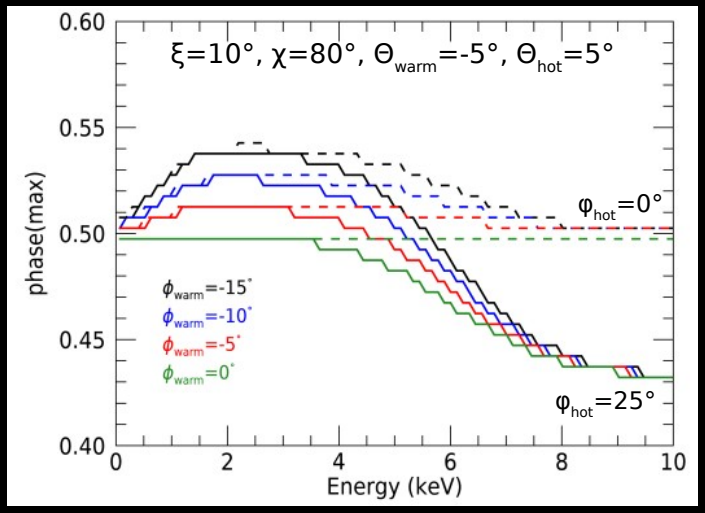
NuSTAR

Epoch	kT_{hot} (keV)	R_{hot} (km)
2019 Jan	1.49±0.05	0.16±0.03
2019 Feb	1.50±0.06	0.14±0.03
2019 Mar	1.38±0.06	0.17±0.04
2019 Sep	1.40±0.05	0.09±0.02

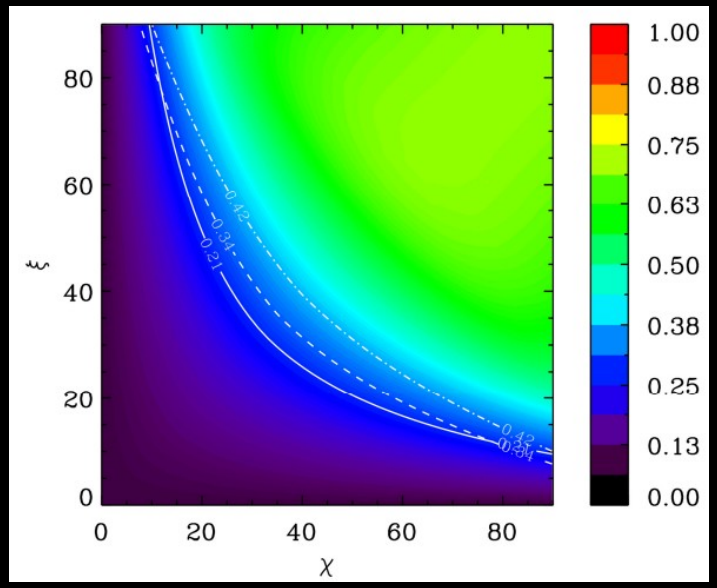
Borghese+ 2021

Physical model





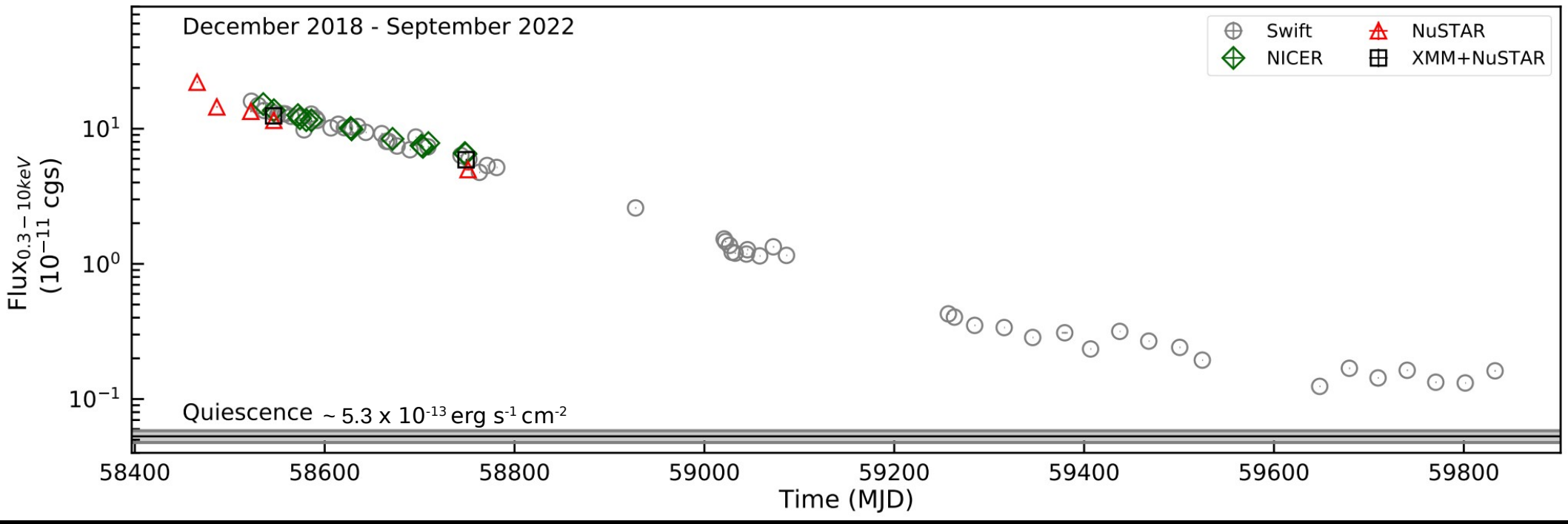
Slippage in phase reproduced if hot cap precedes the warm one (i.e. $\varphi_{hot} > 0$ and $\varphi_{warm} < 0$)



Pulsed fraction contours indicate that small χ and large ξ (or viceversa) are favoured

Borghese+ 2021

XTE J1810–197: future plans



$Flux_{2022} \sim 1.5 \times 10^{-12}$ erg s^{-1} cm^{-2} (~3x higher than $Flux_q$)

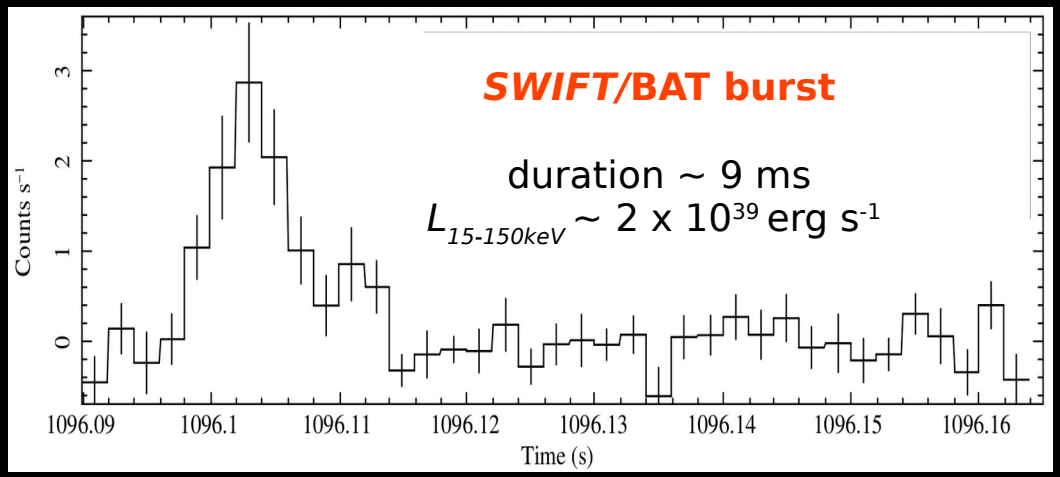
Future plans

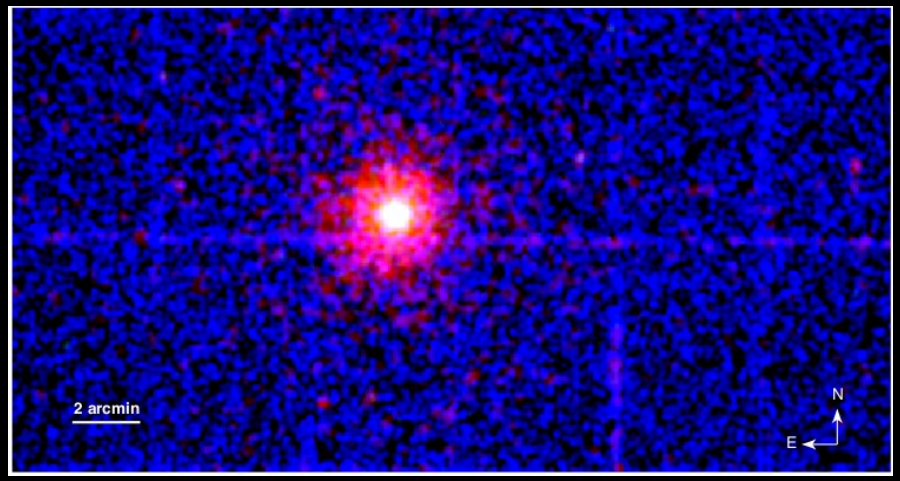
Keep monitoring the source with monthly observations

New quiescent state?

Swift J1818.0–1607: a very young magnetar

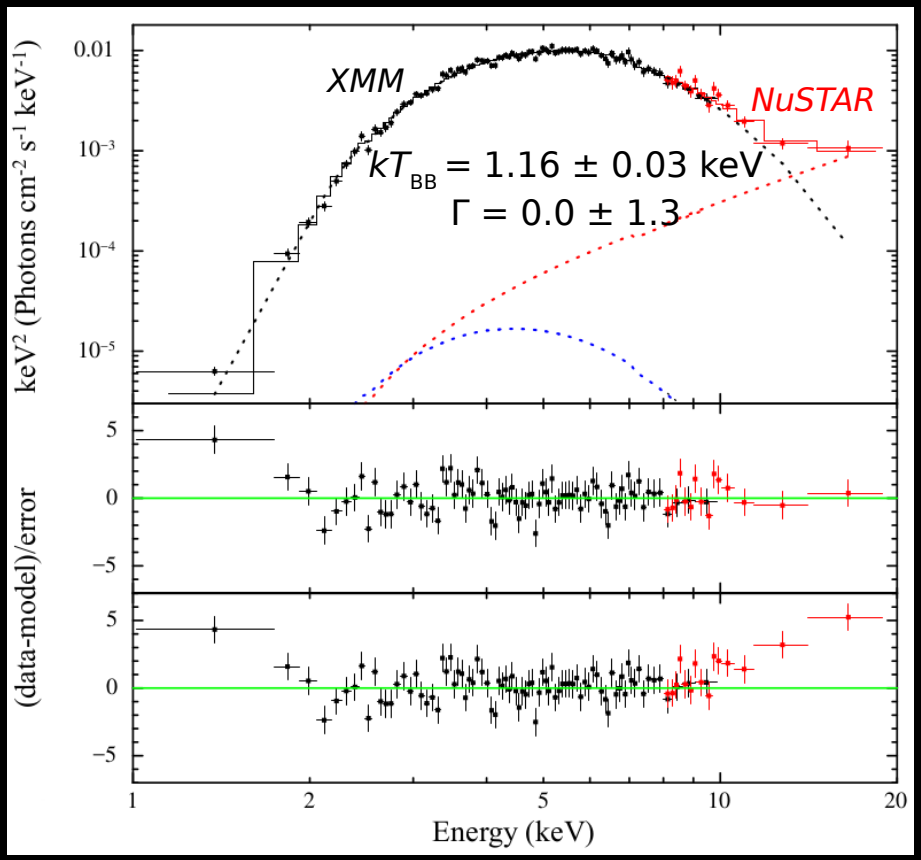
Discovered on 2020 March 12





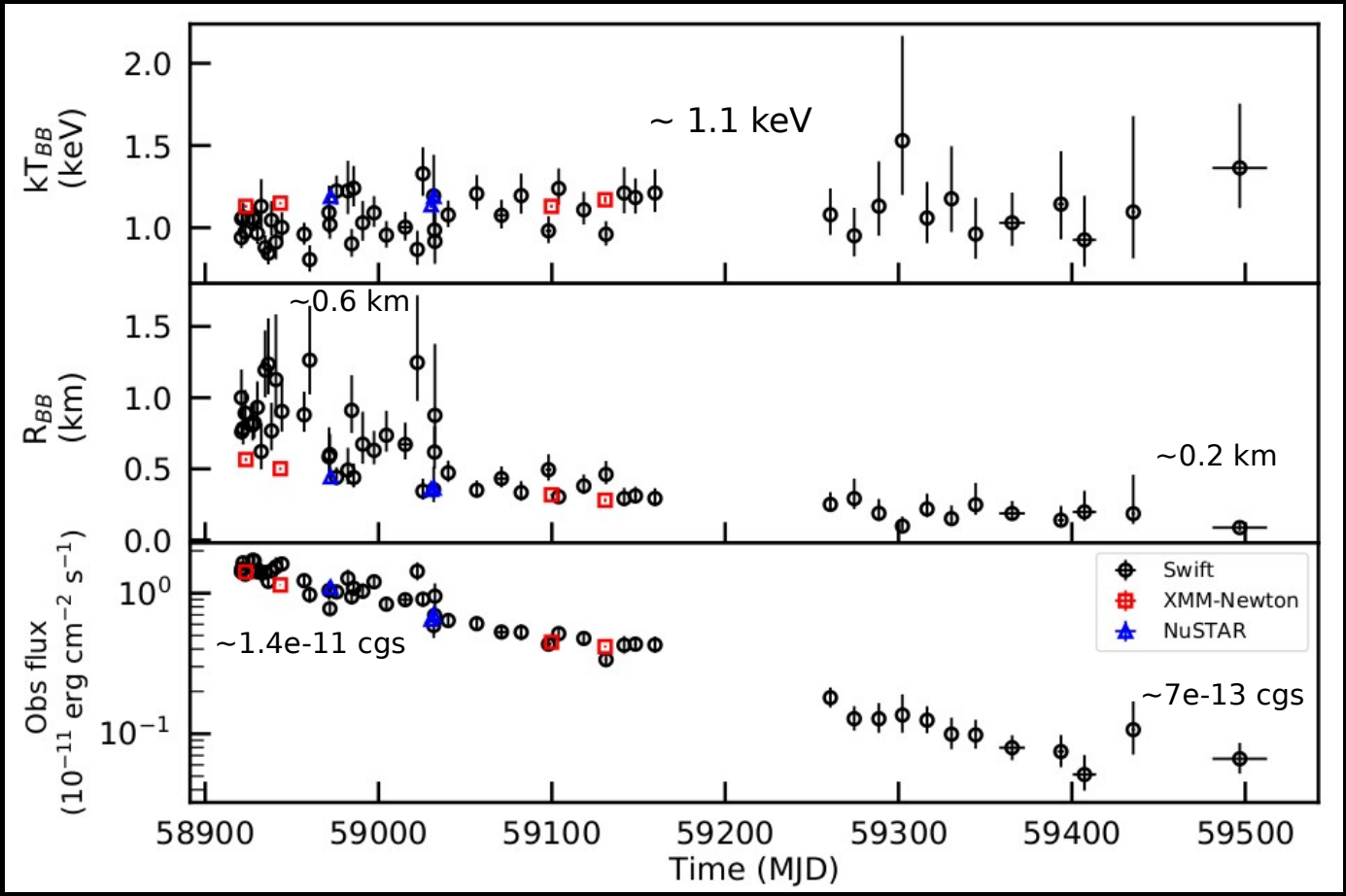
Diffuse emission extending between 50 and 100 arcsec

3 days after the outburst onset



Esposito+ 2020; Ibrahim+ subm.

Long-term monitoring campaign
2020 March – 2021 October

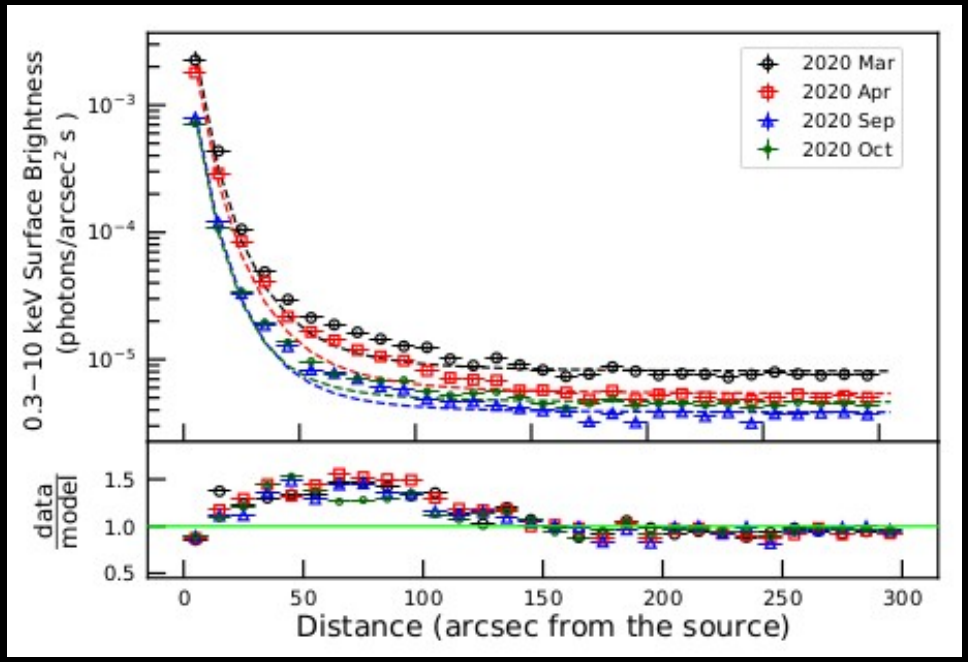


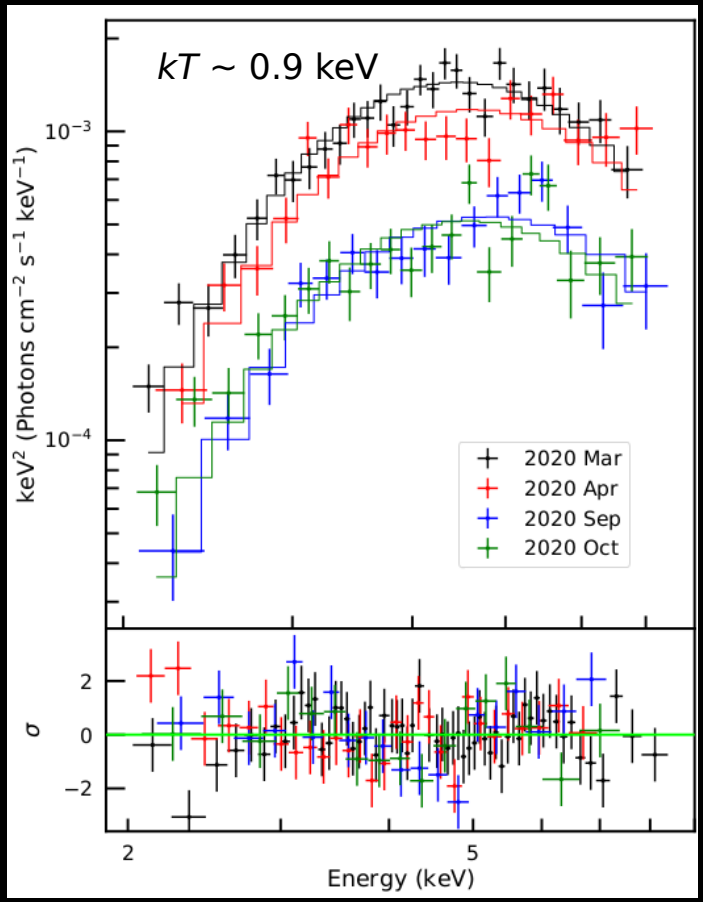
Outburst decay timescale
$\tau \sim 150$ d

Energy released
$E \sim 10^{42}$ erg

Ibrahim+ subm.

Long-term monitoring campaign
Diffuse emission





Flux decreased of about 35% between 2020 March and October

Dust scattering halo

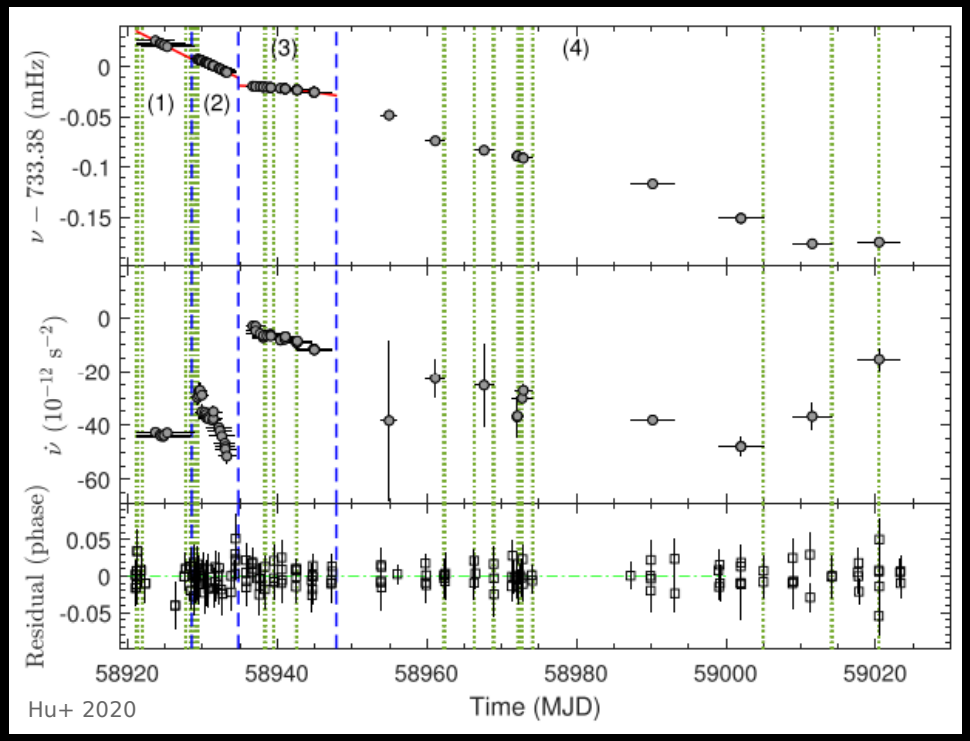
Ibrahim+ subm.

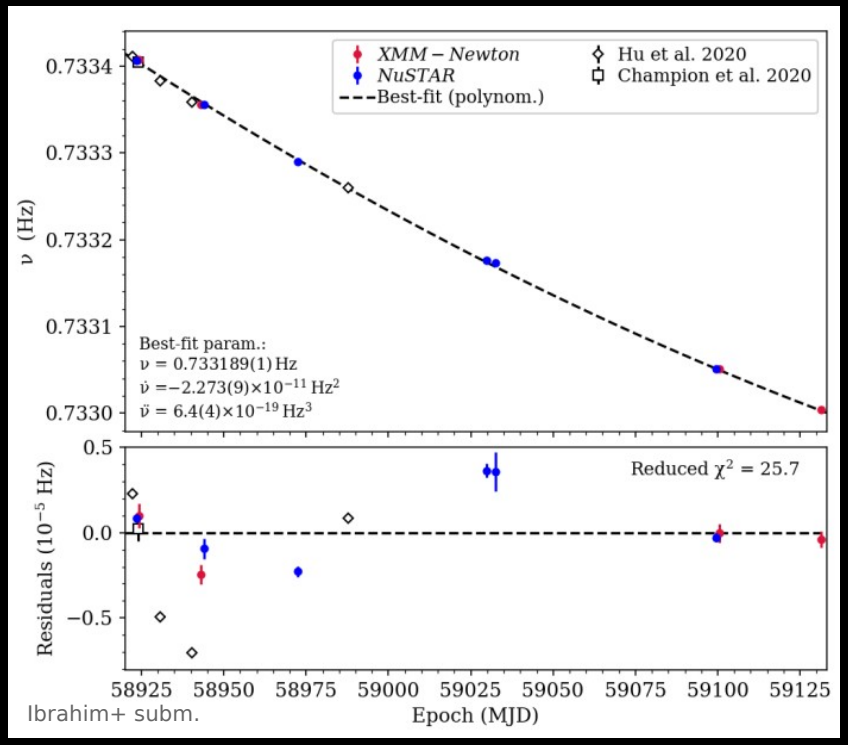
Timing analysis

NICER campaign for the first 100 days

XMM+NuSTAR over the first 7 months

Erratic timing behaviour



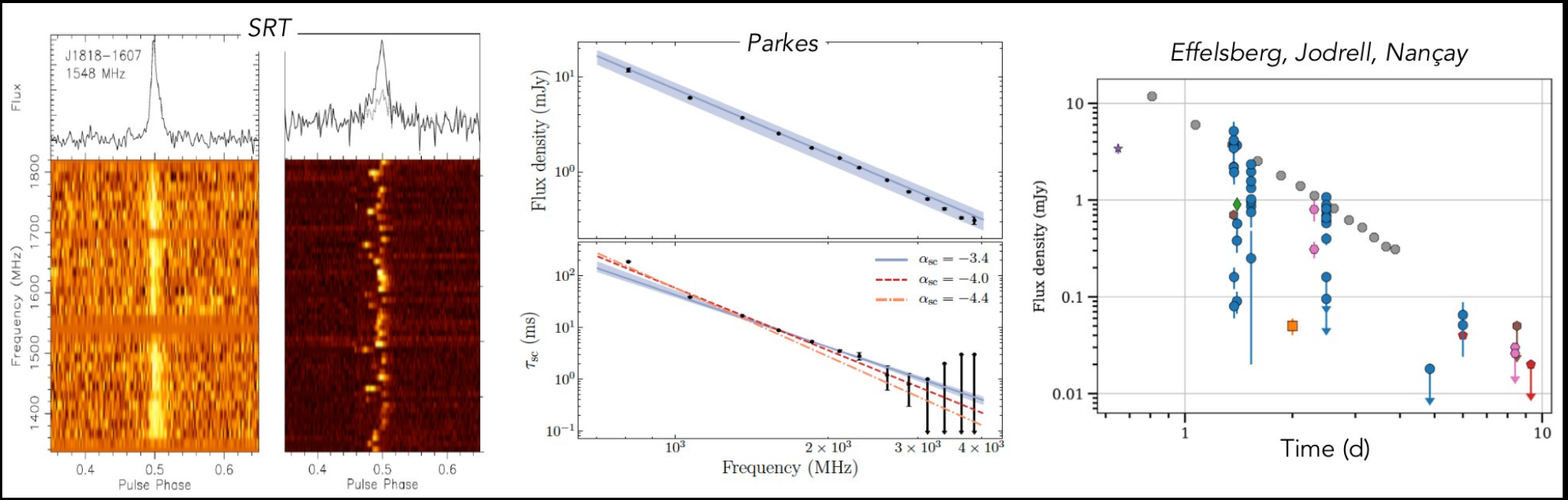


One of the youngest NSs in our Galaxy: $\tau_c \sim 500$ yr

More reliable estimate in quiescence

Swift J1818.0–1607: a very young magnetar

Soon confirmed to be a radio-loud magnetar



Bright single pulses

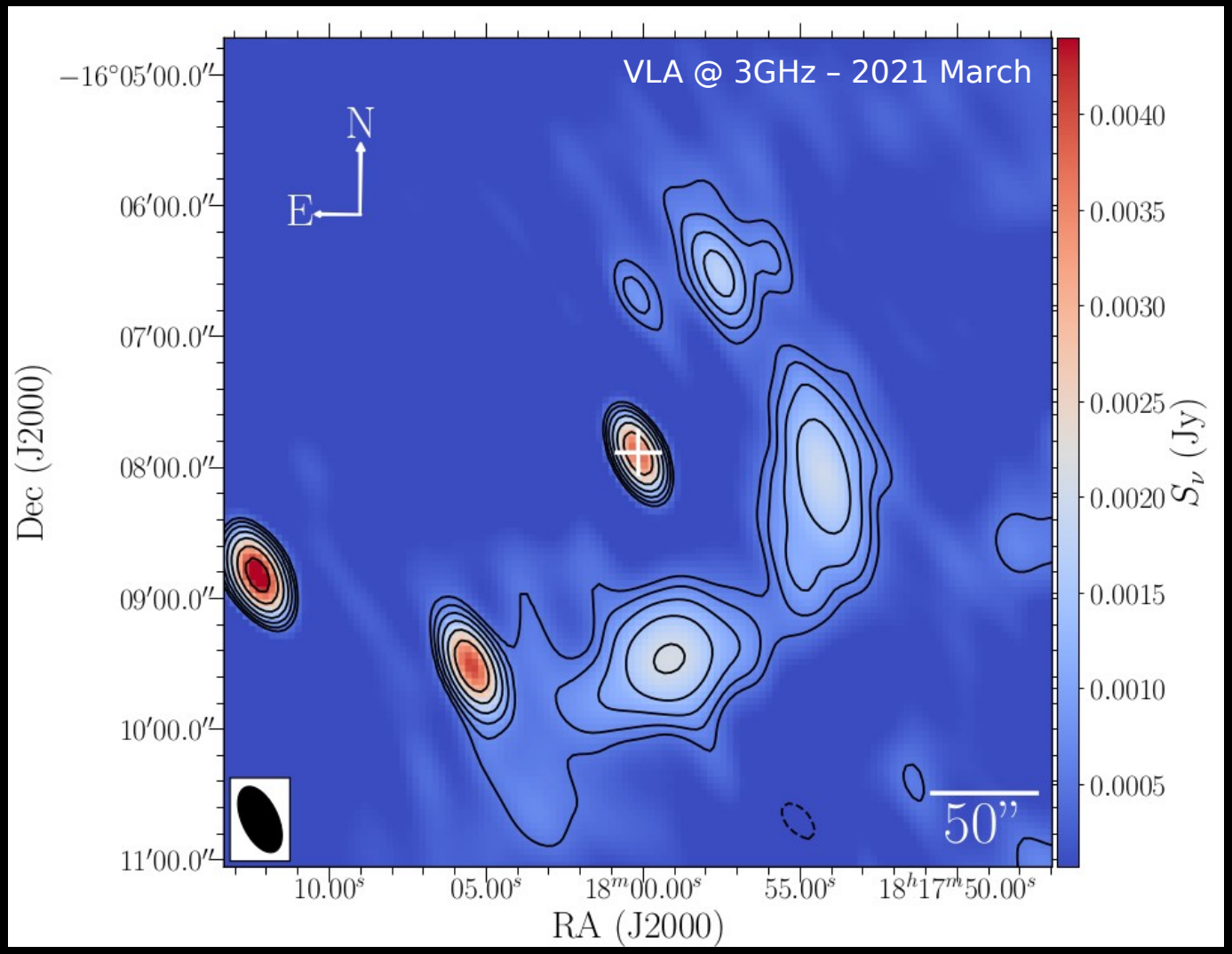
Peculiar steep spectral slope

Rapid radio flux decay

The young age, the high spin-down luminosity and the steep radio spectrum resembles the high-*B* pulsar PSR J1119–6127

Esposito+ 2020; Champion+ 2020; Lower+ 2020, 2021; Huang+ 2021

Search for the supernova remnant

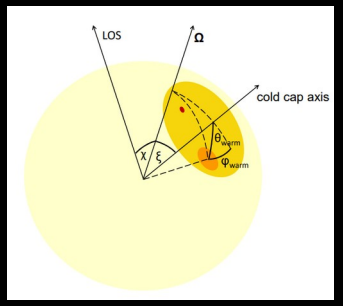


Half ring-like structure at 90’’ to the West of Swift J1818

More observations are planned

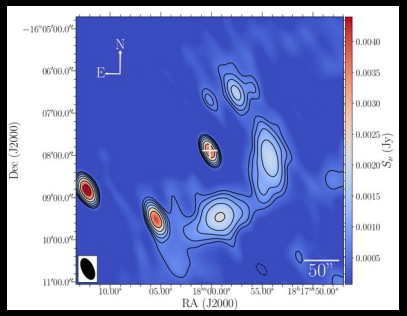
Ibrahim+ subm.

Conclusions



XTE J1810–197

Thanks to an 1yr-long monitoring campaign, we constrained the viewing and surface emission geometry



Swift J1818.0–1607

A prompt follow-up of a short burst allowed the discovery of one of the youngest NSs in our Galaxy.

Phase-resolved spectral analysis & dynamical spectral profile