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Paris Cité

# Polarization properties of the high-energy emission of X-ray binaries with INTEGRAL

Studies of MAXI J1535–571, MAXI J1820+070 & MAXI J1348–630

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*Journées PNHE*

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# X-ray binaries

Black hole or neutron star

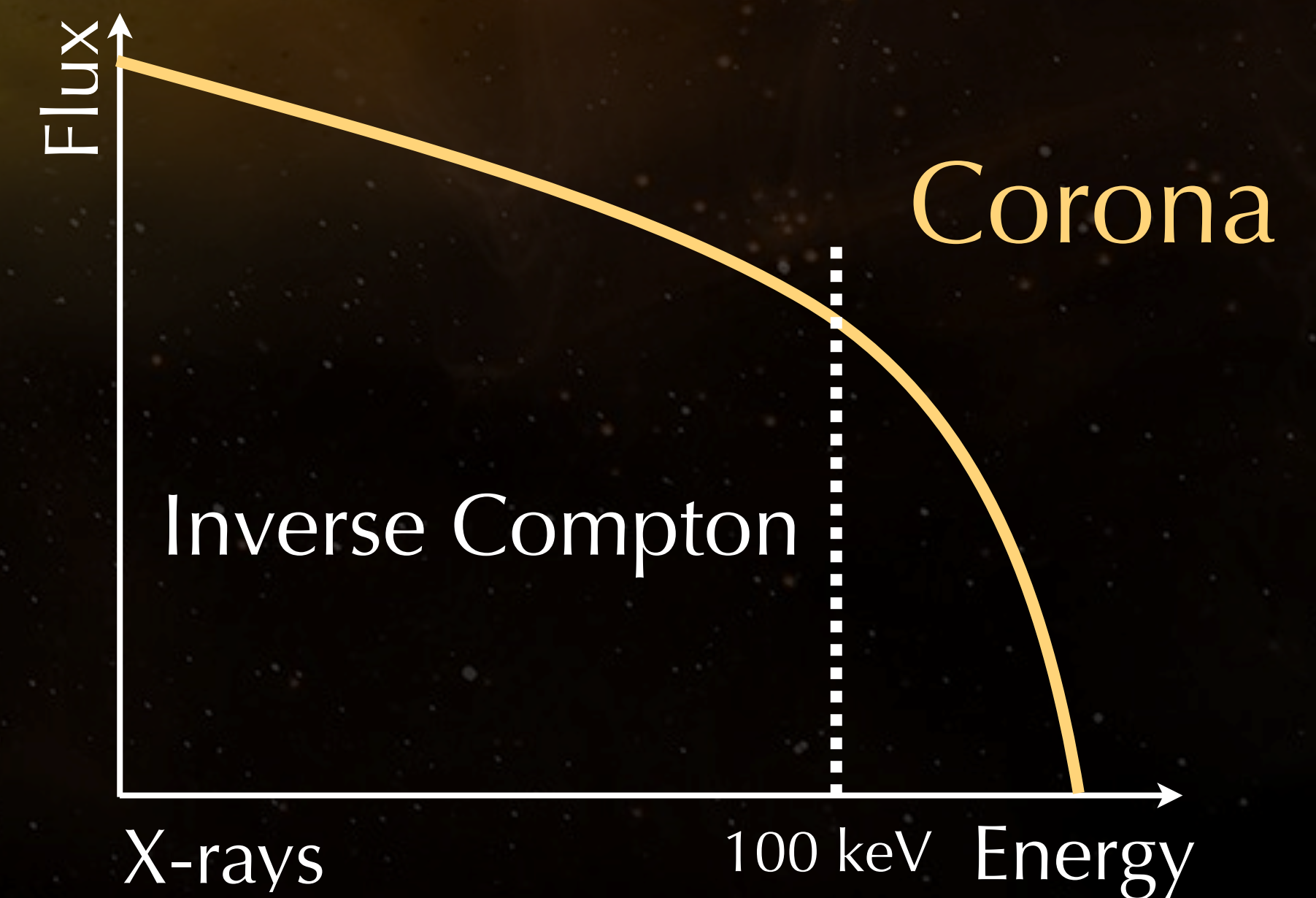
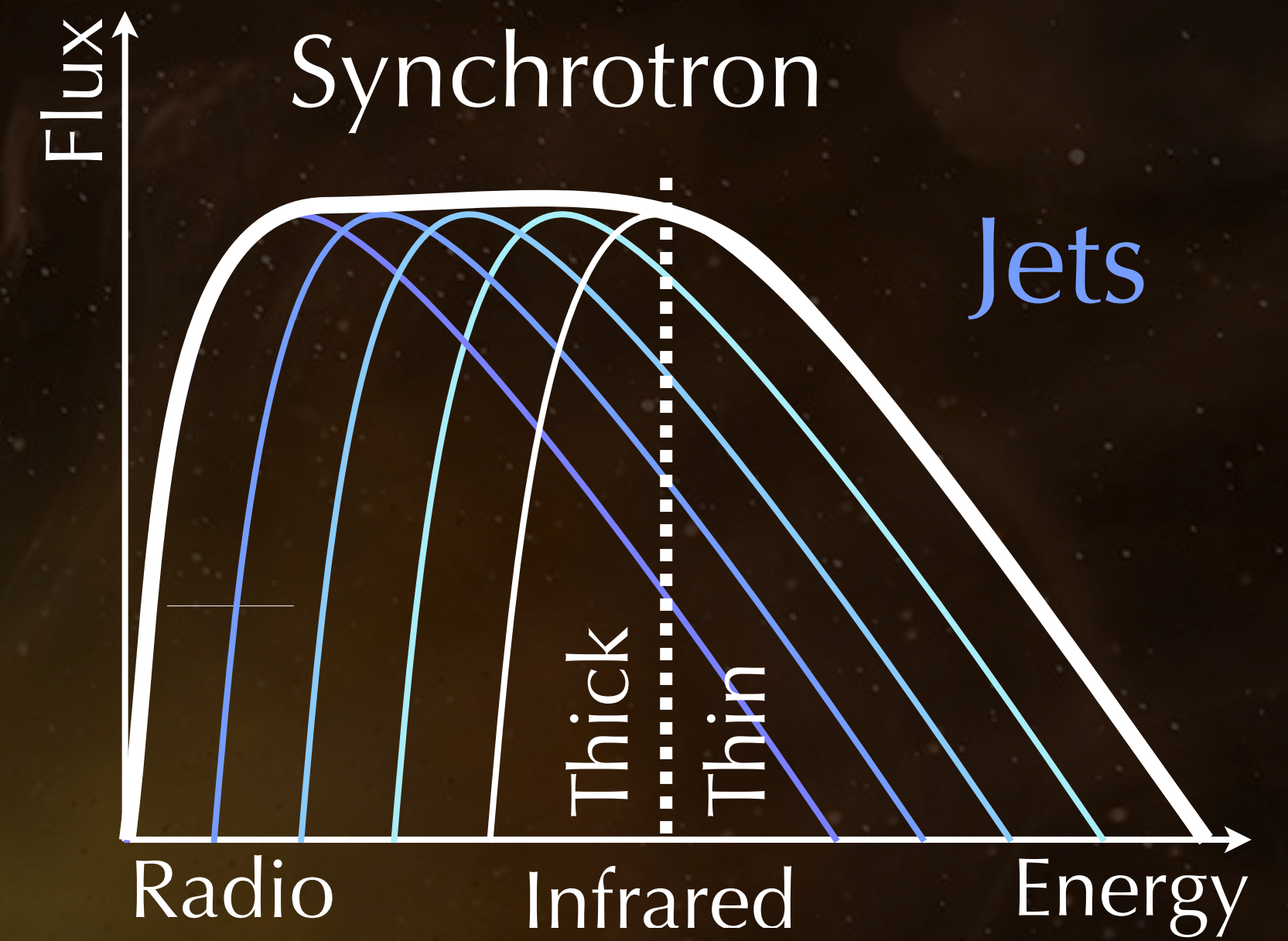
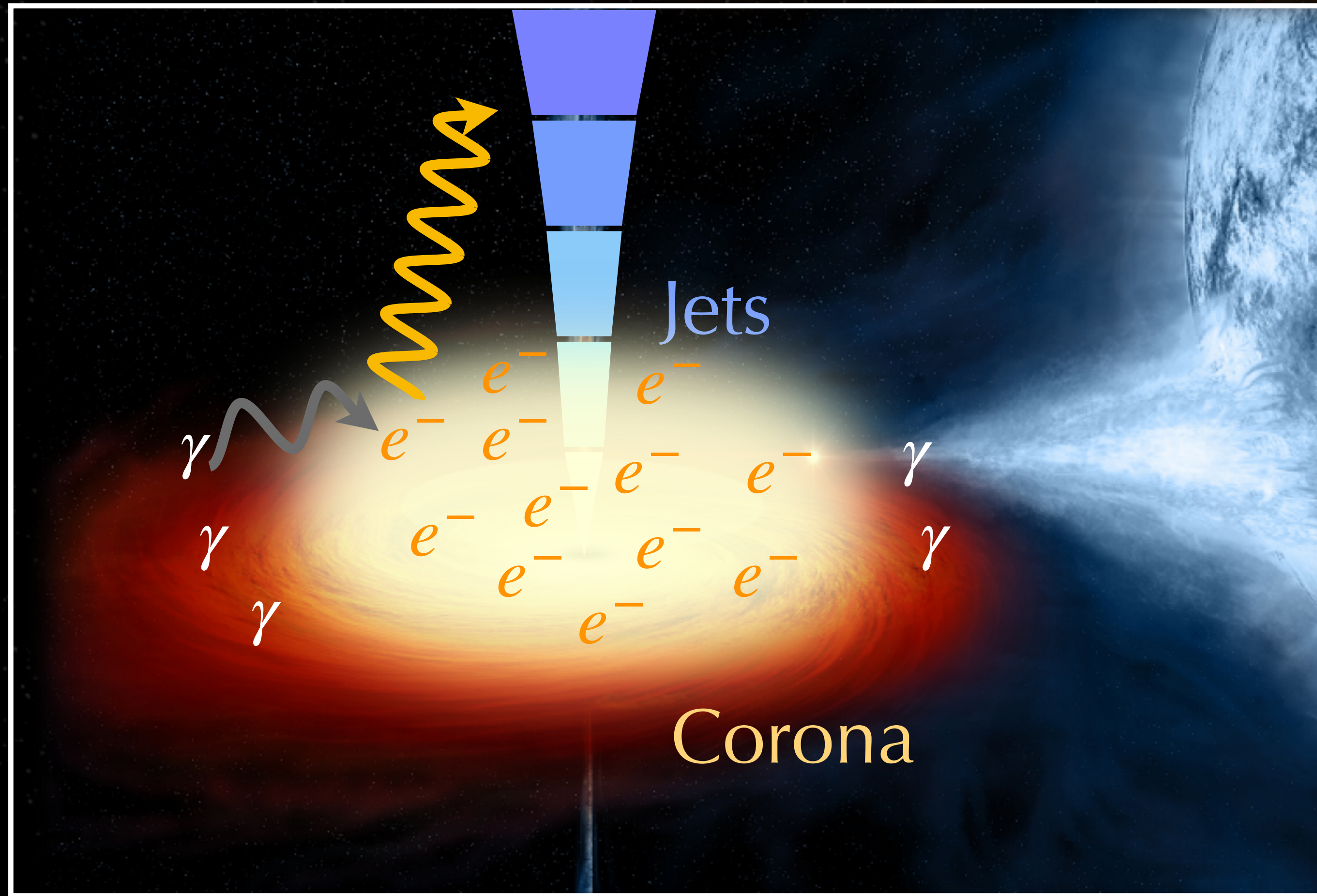
Ejection phenomena

Heating and X-ray emission



# X-ray binaries spectral states

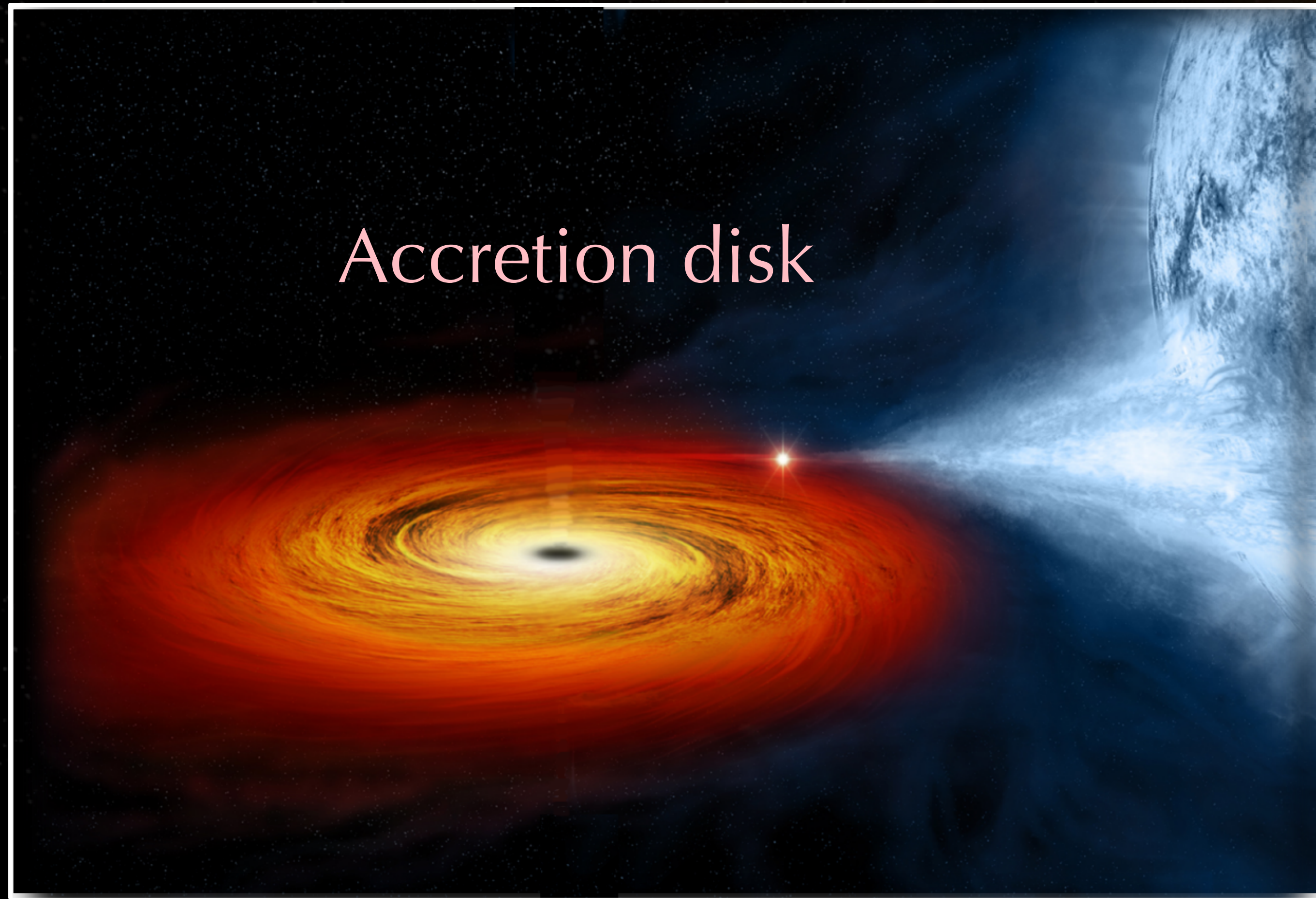
## *Hard state*



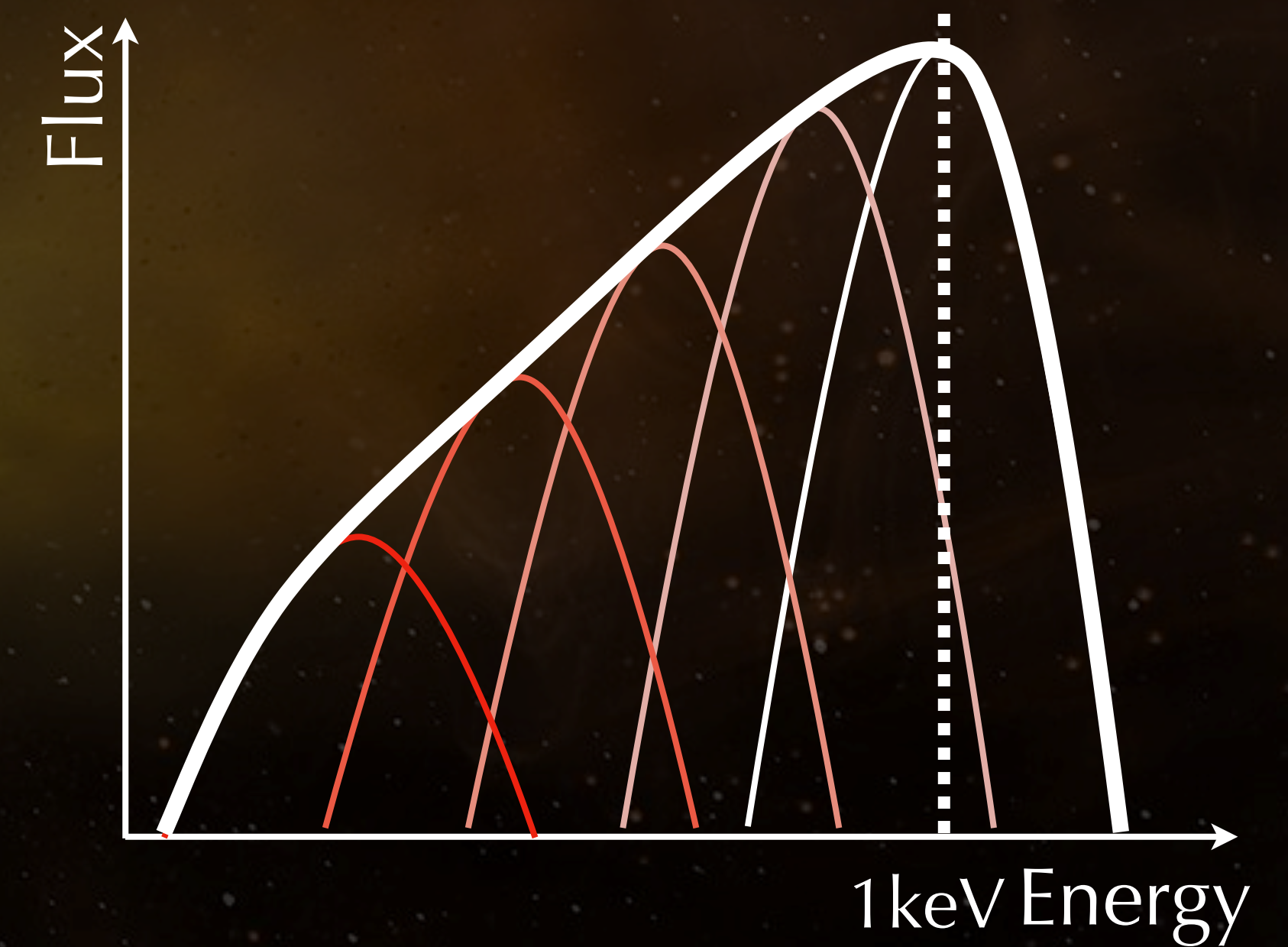


# X-ray binaries spectral states

## *Soft state*



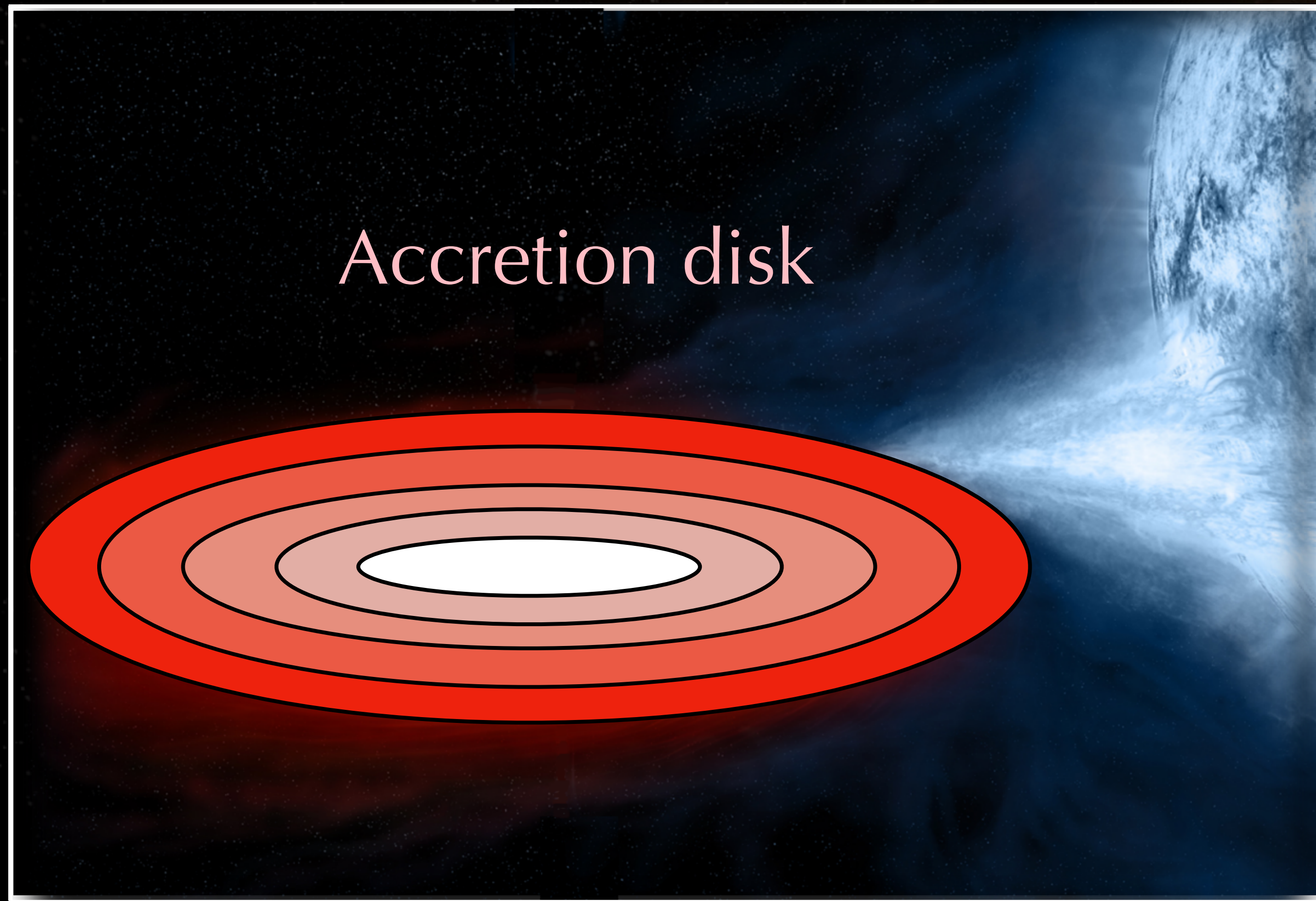
## Multicolor black-body



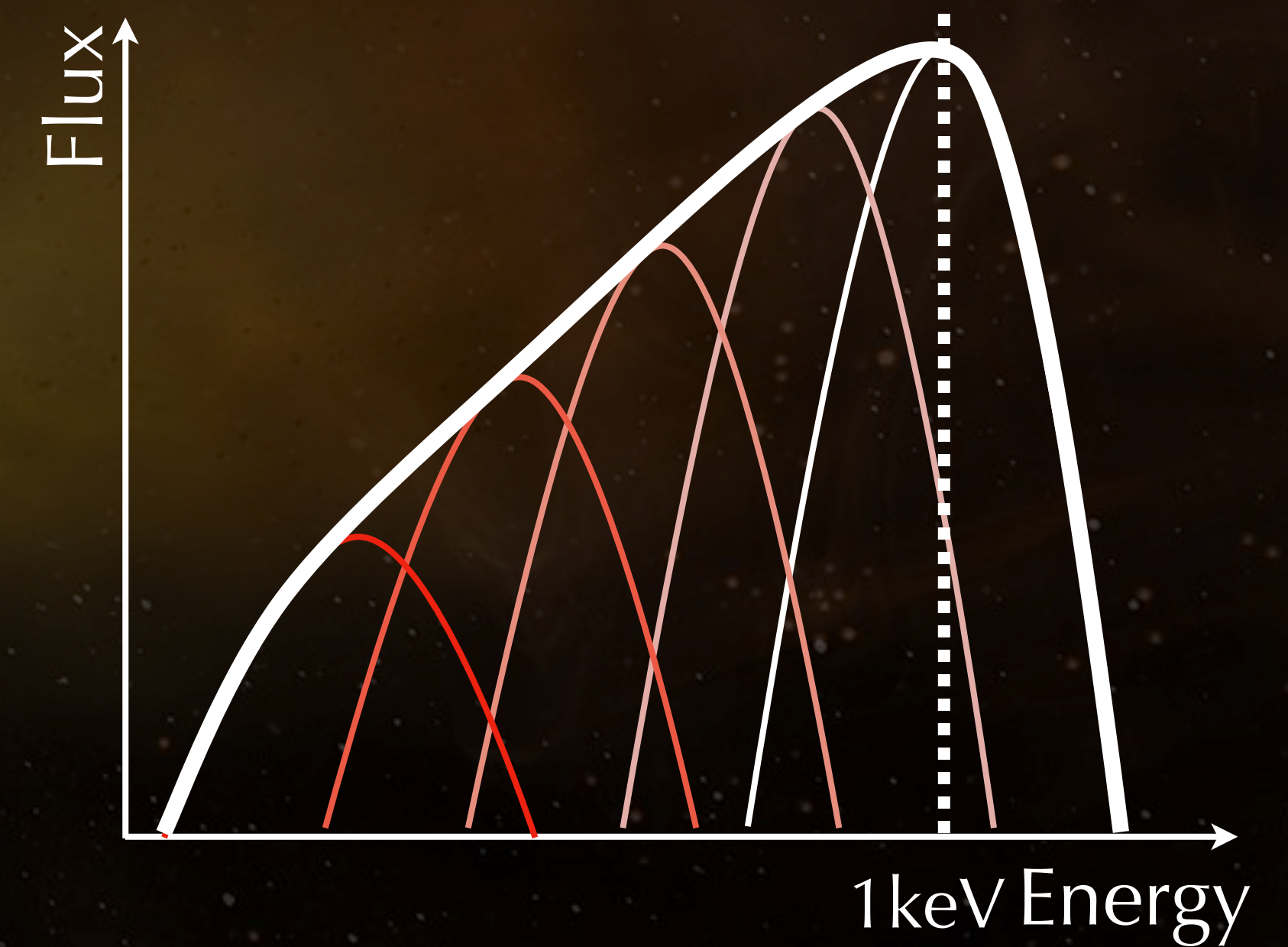


# X-ray binaries spectral states

## *Soft state*

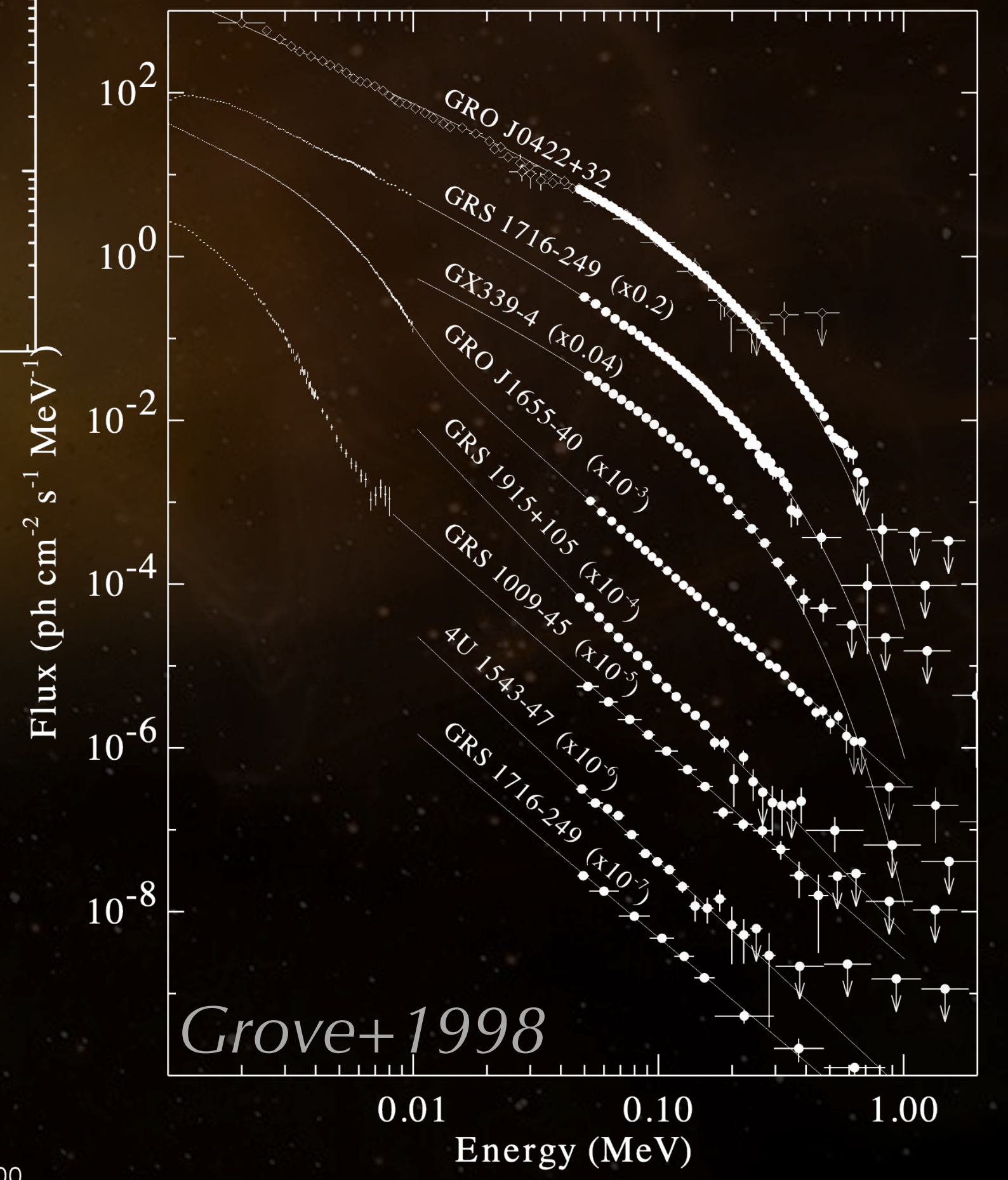
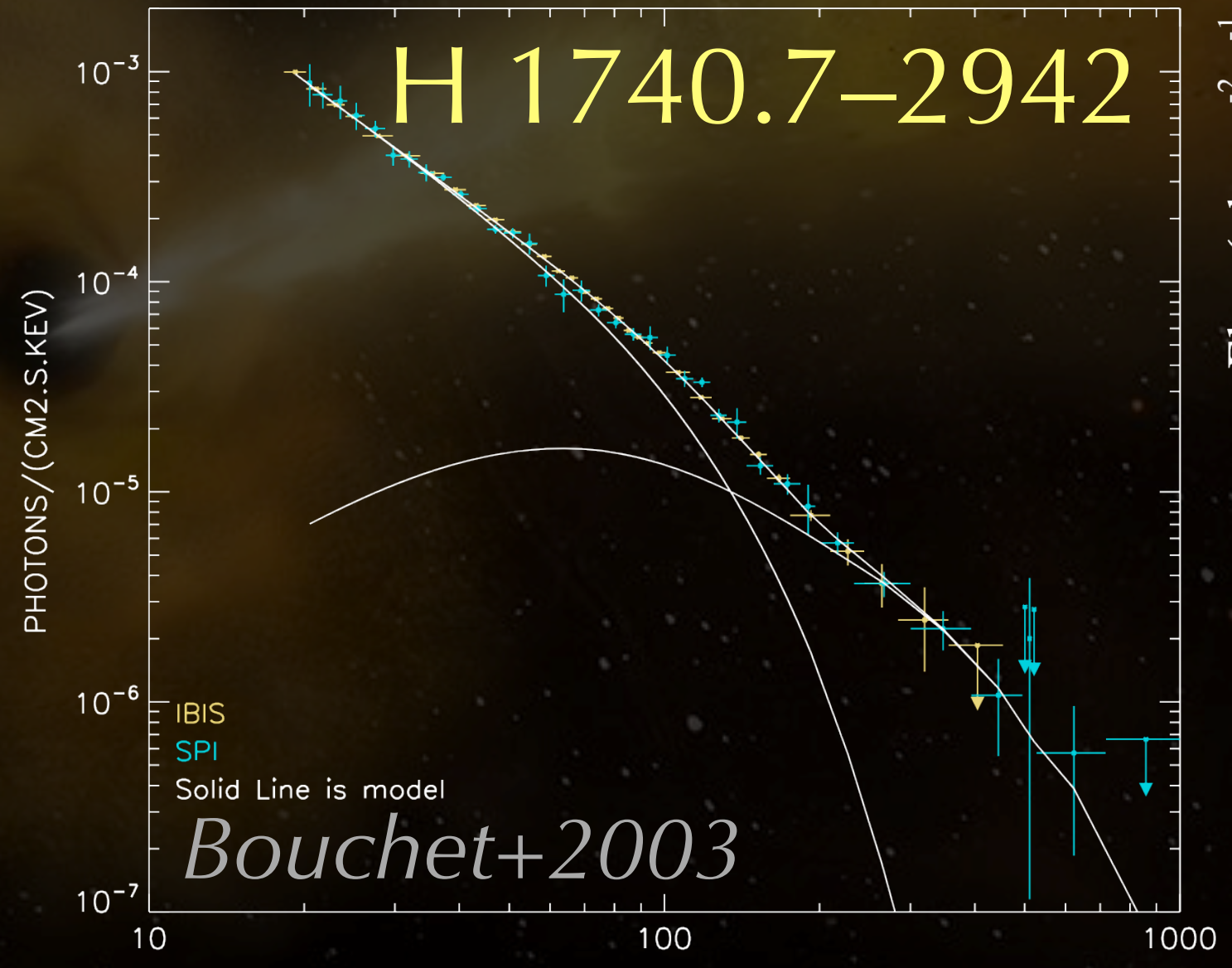
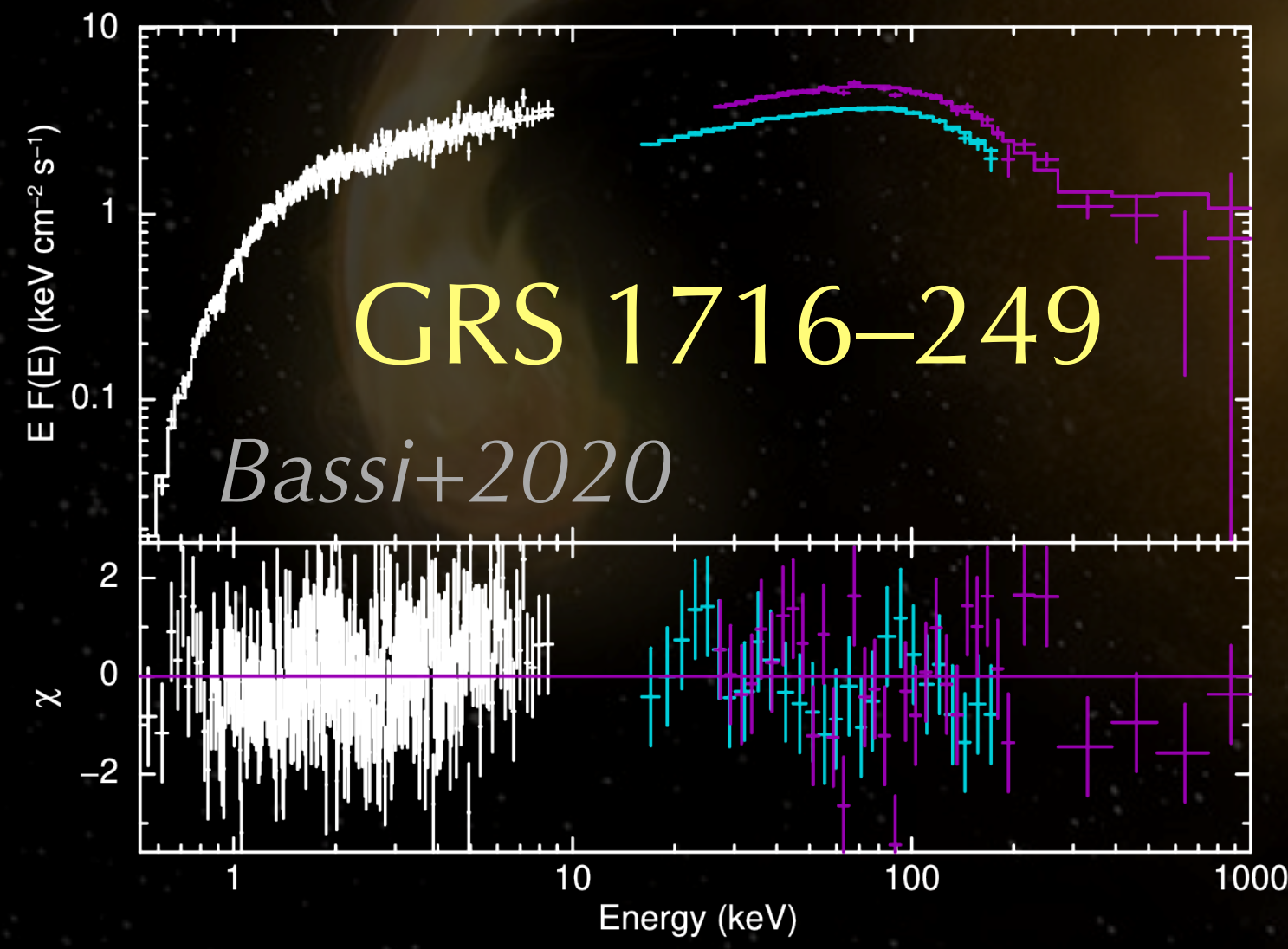
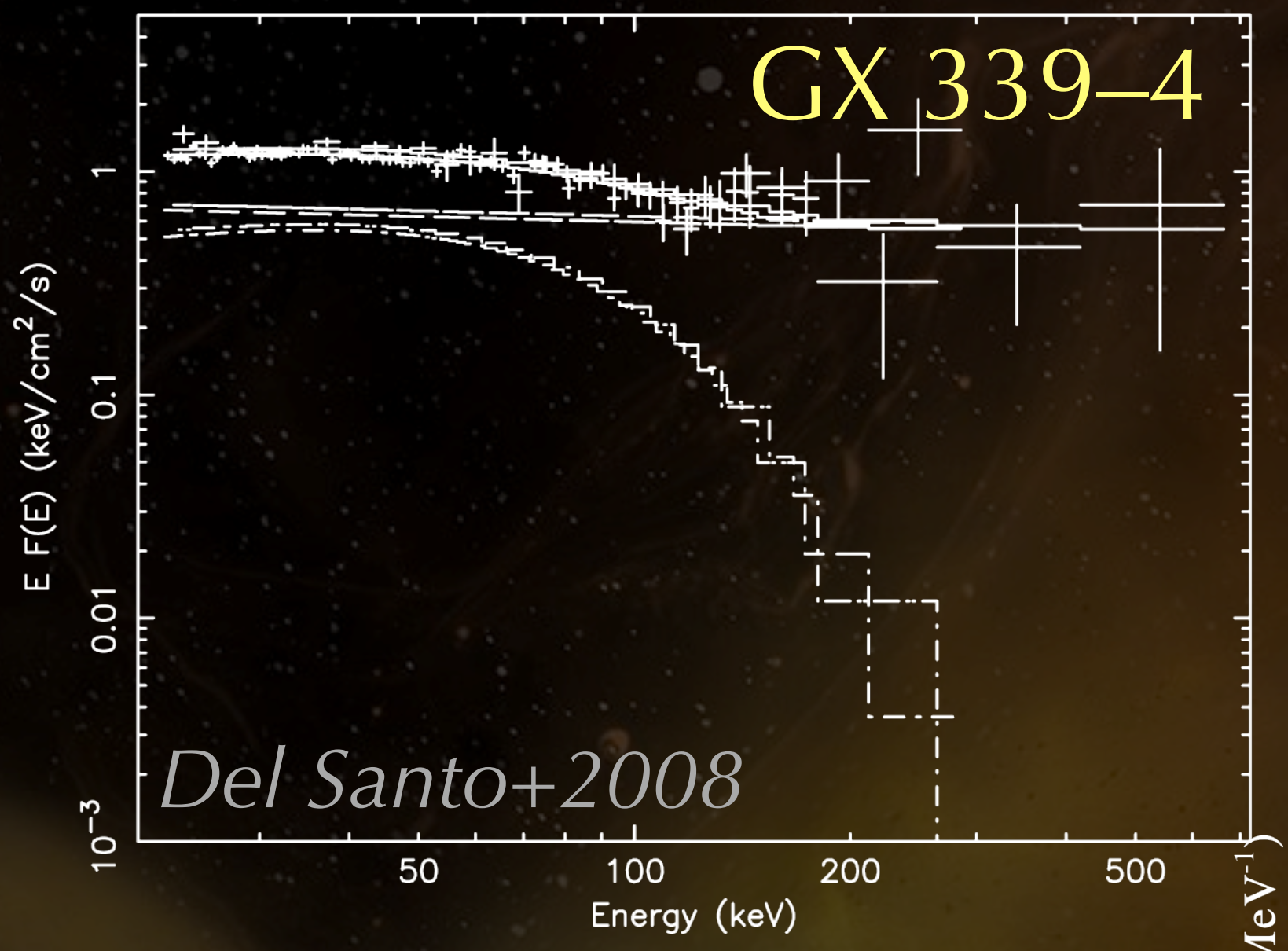
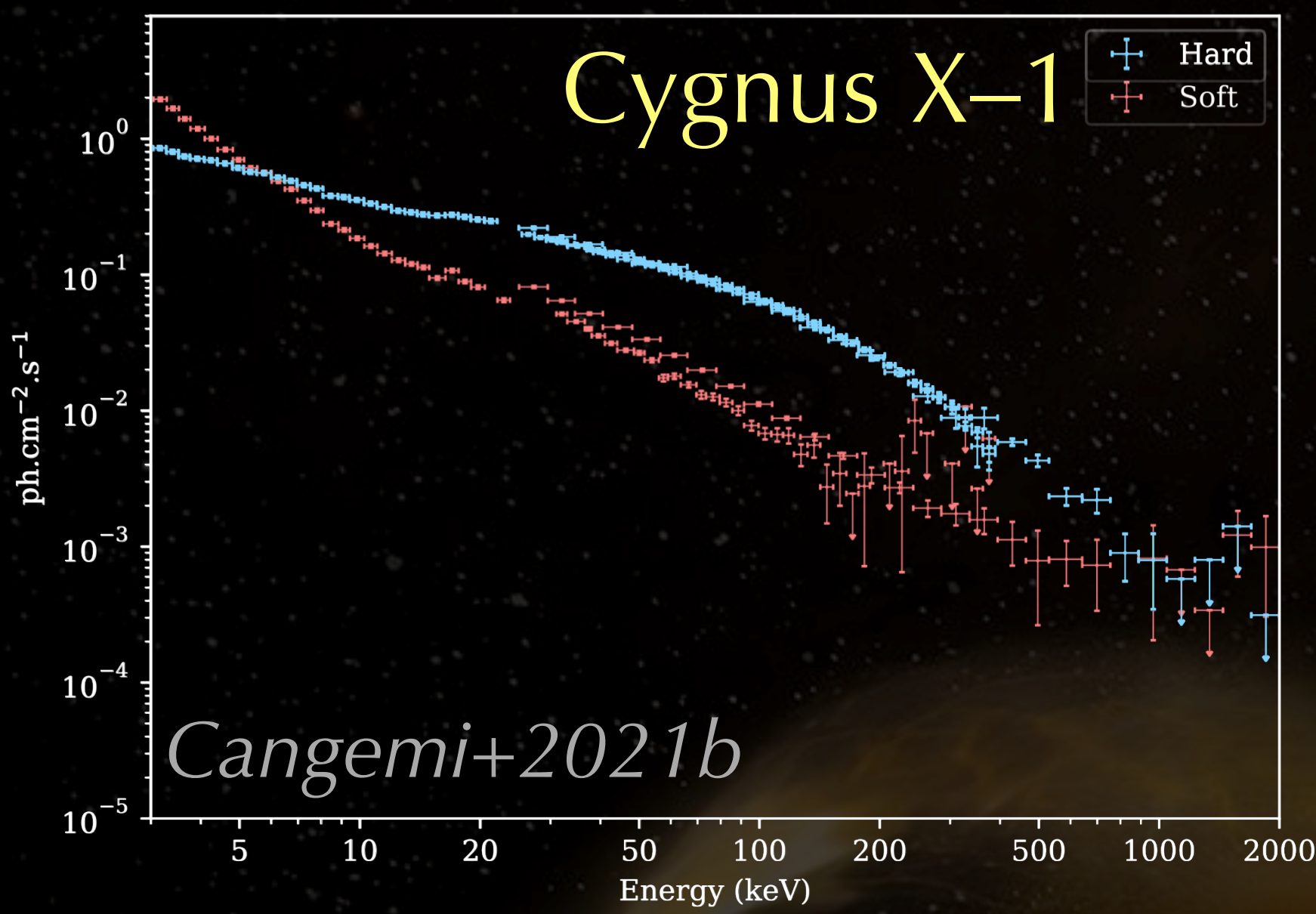


## Multicolor black-body





# Emission above 200 keV





# Emission above 200 keV

*What is the nature of the high-energy emission?*

*From which medium does it come from?*

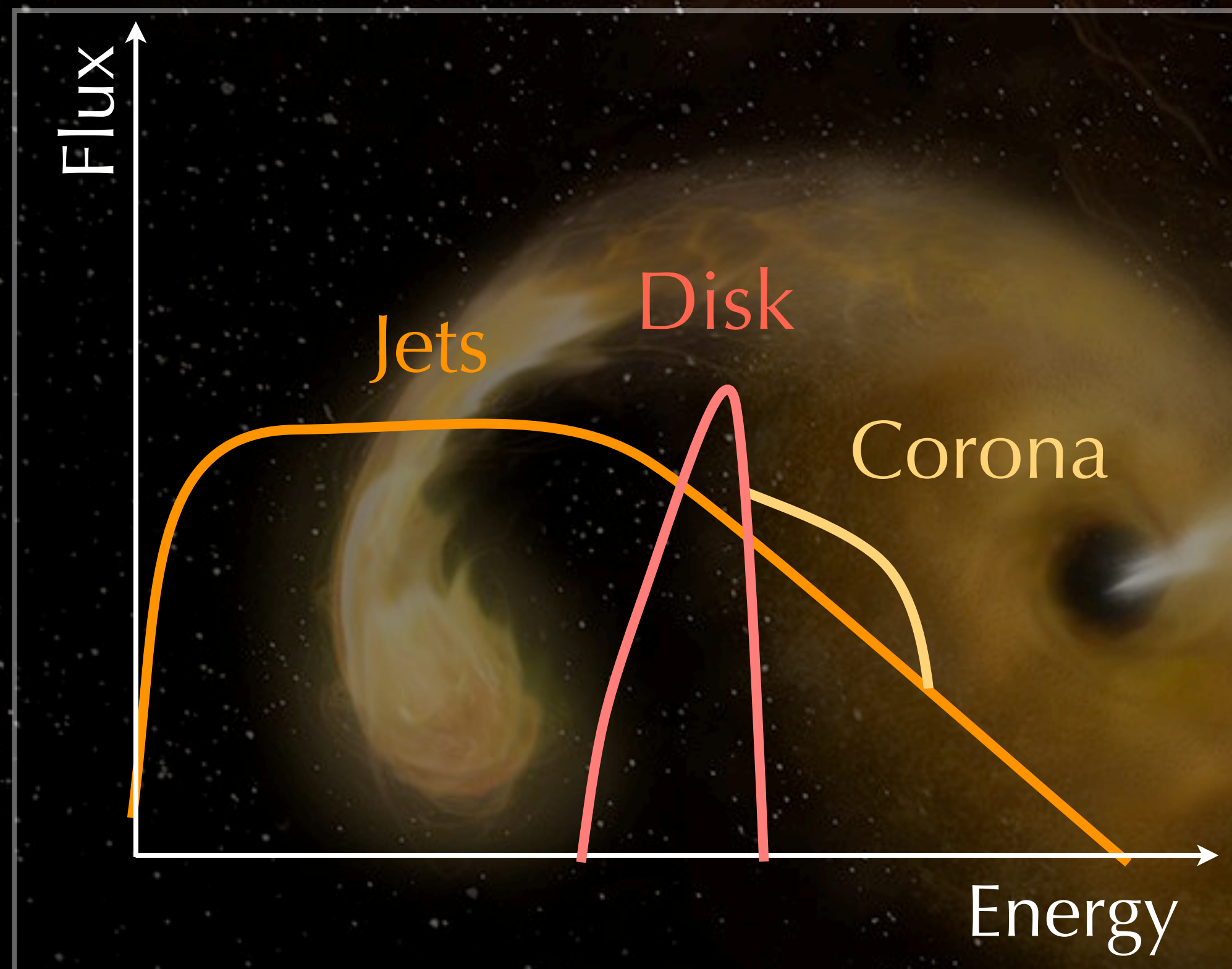




# Emission above 200 keV

*What is the nature of the high-energy emission?*

*From which medium does it come from?*



1. Synchrotron émission from the jets base

Polarization fraction expected

$\Pi \sim 75\%$  for a very ordered magnetic field

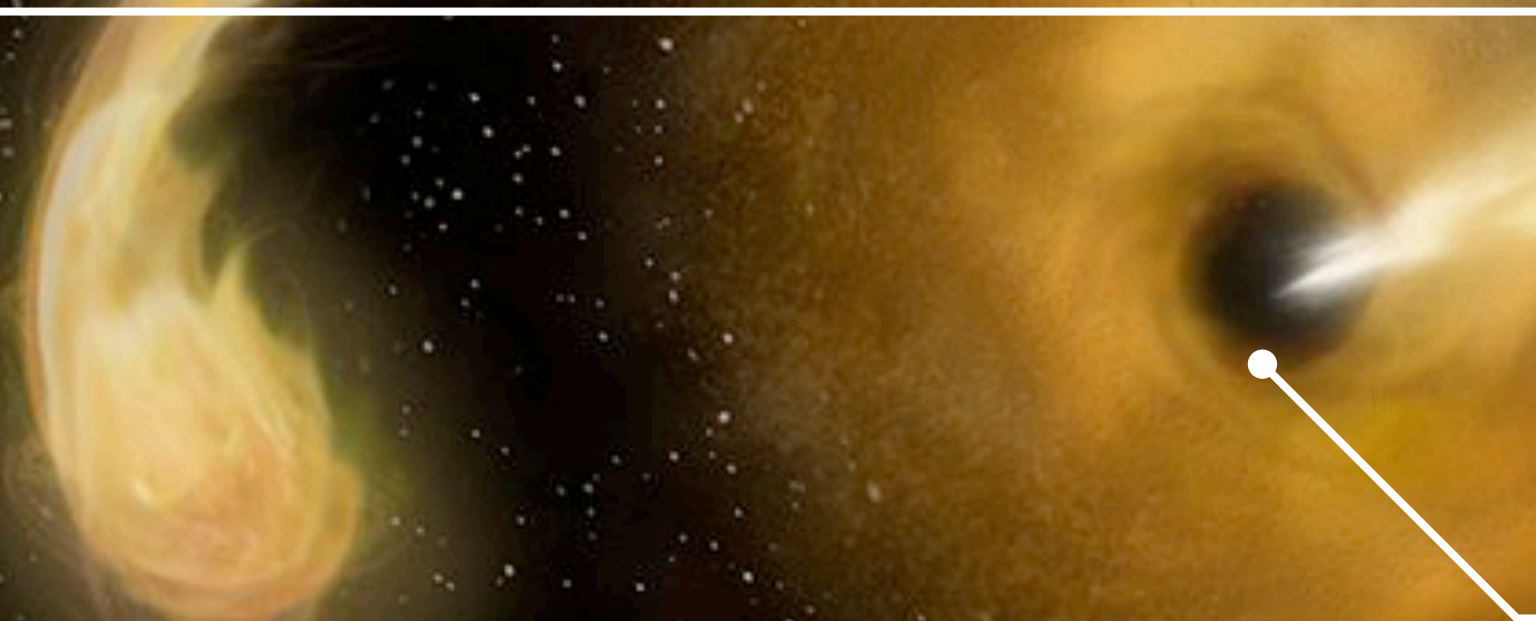
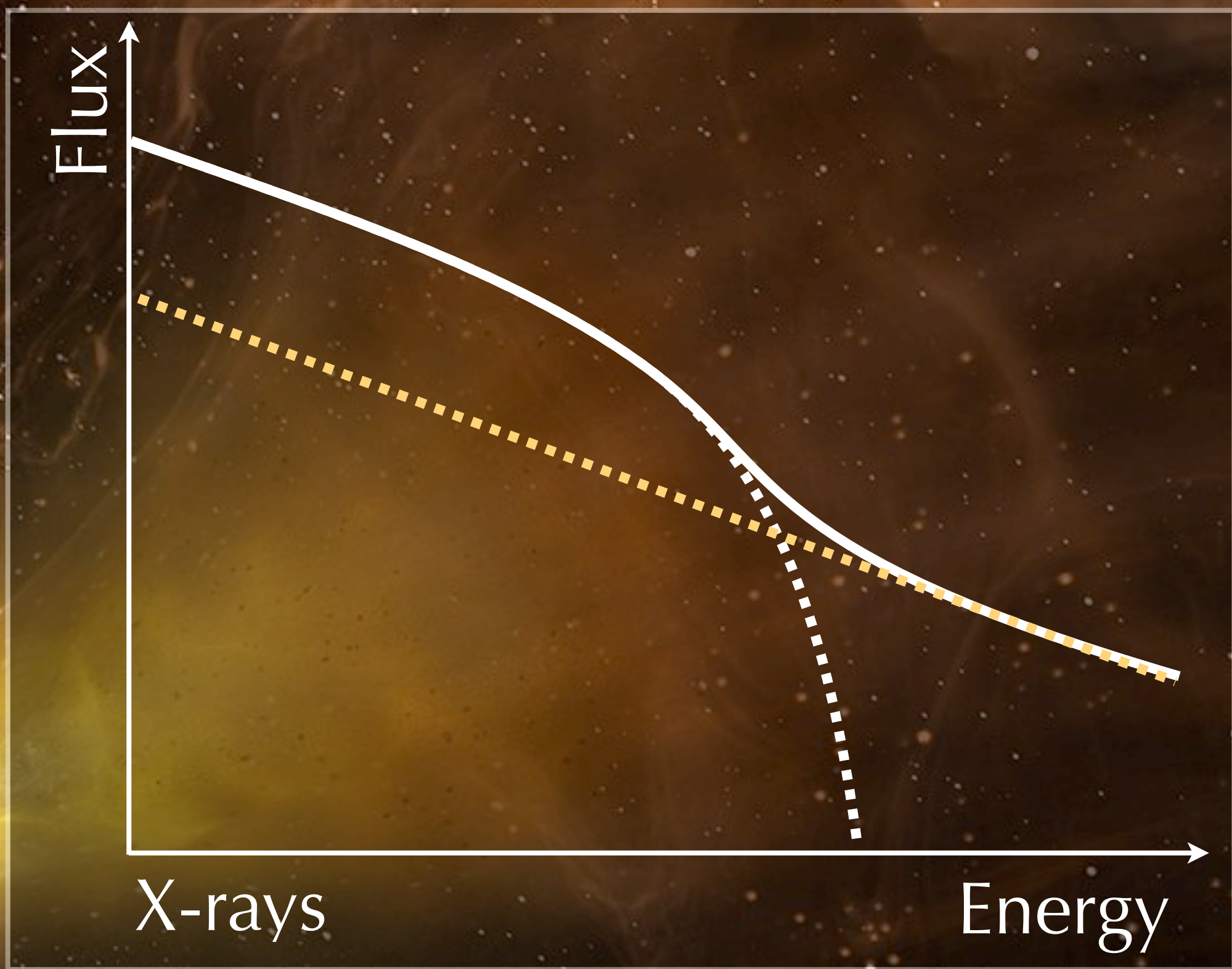
*Rybicki & Lightman 1986*



# Emission above 200 keV

*What is the nature of the high-energy emission?  
From which medium does it come from?*

**Polarization fraction expected**  
Hybrid distribution of electrons:  $\Pi \sim 5\%$   
Non-thermal distribution of electrons:  $\Pi \sim 20\%$   
*Beheshtipour+2017*



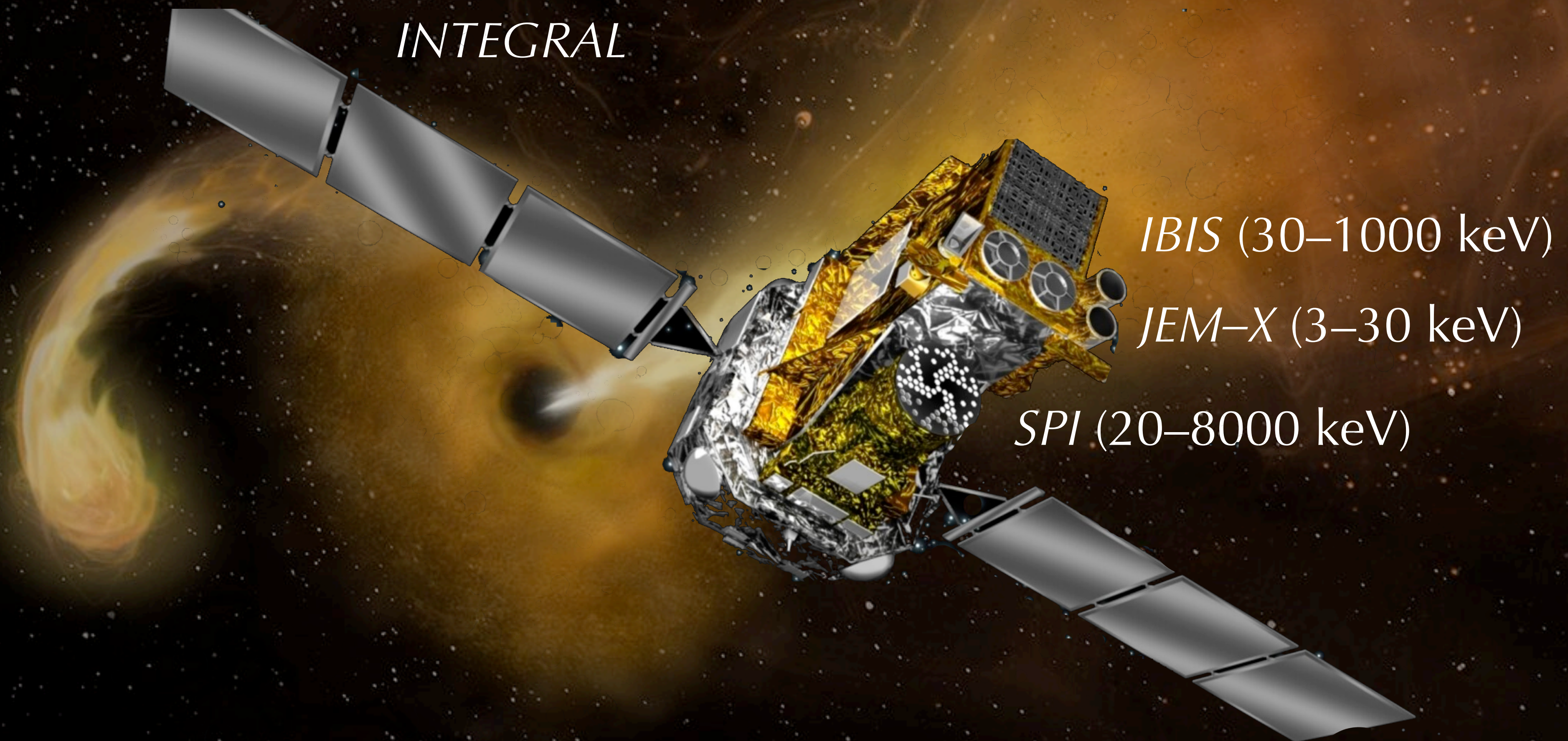
2. Non-thermal electrons from the corona



# Emission above 200 keV

*What is the nature of the high-energy emission?*

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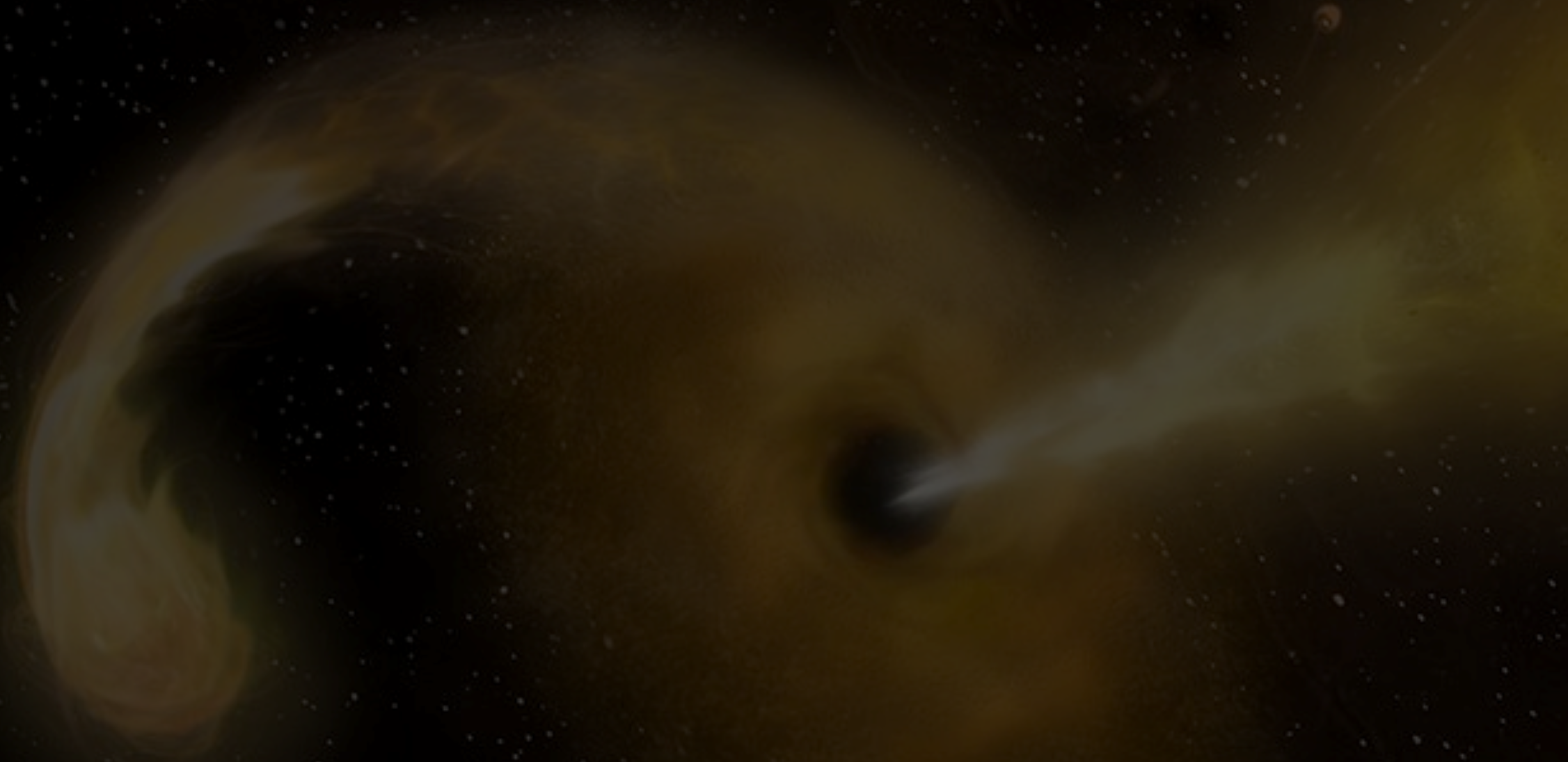
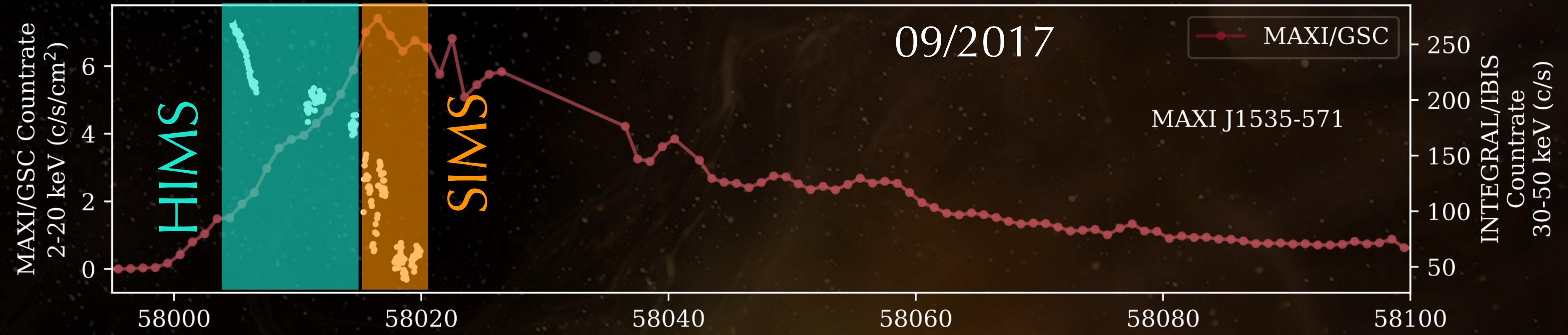




# Observations

## MAXI J1535-571

Cangemi+2023

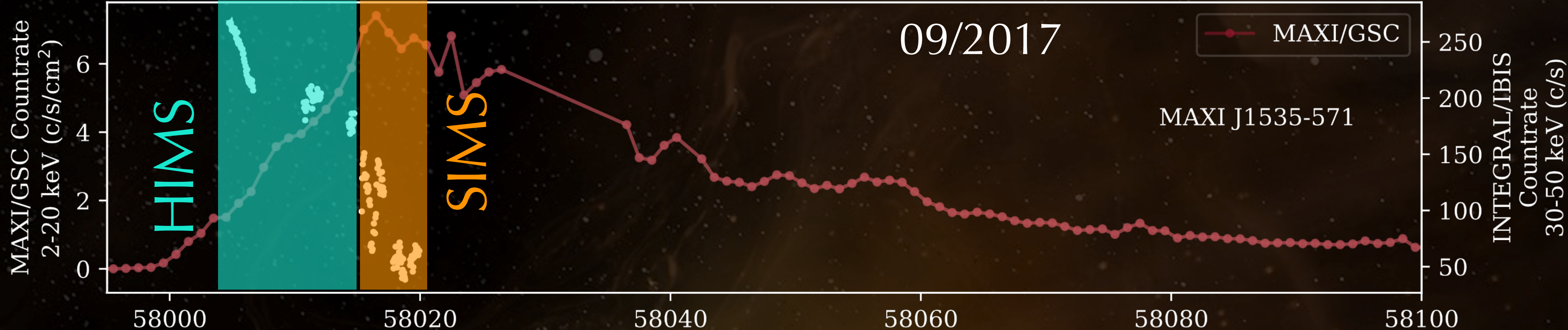




# Observations

Cangemi+2023

## MAXI J1535-571



## MAXI J1820+070

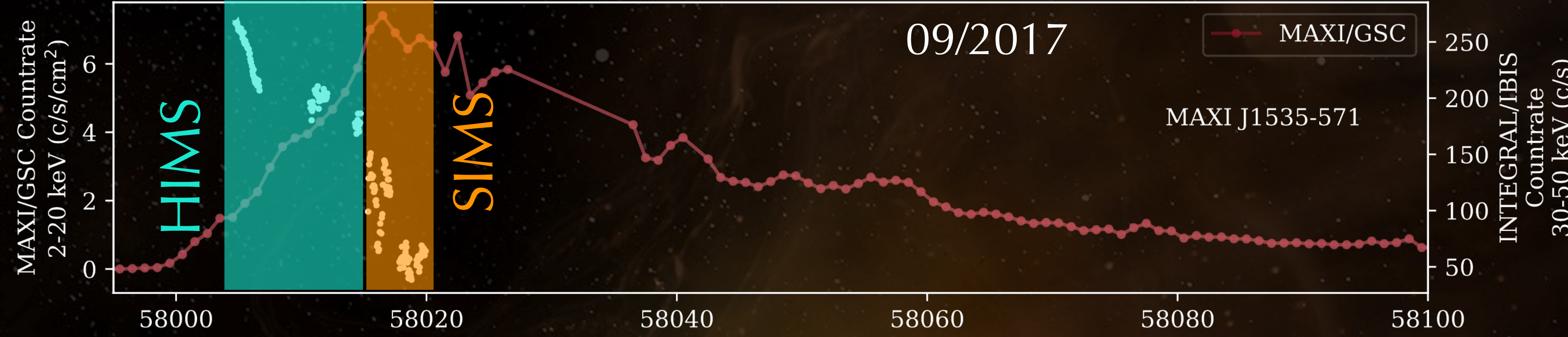




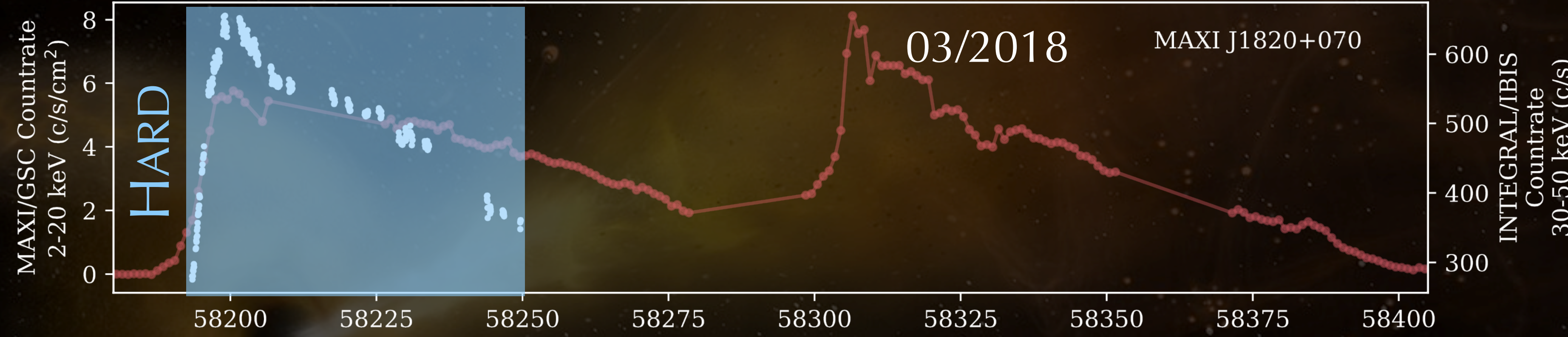
# Observations

Cangemi+2023

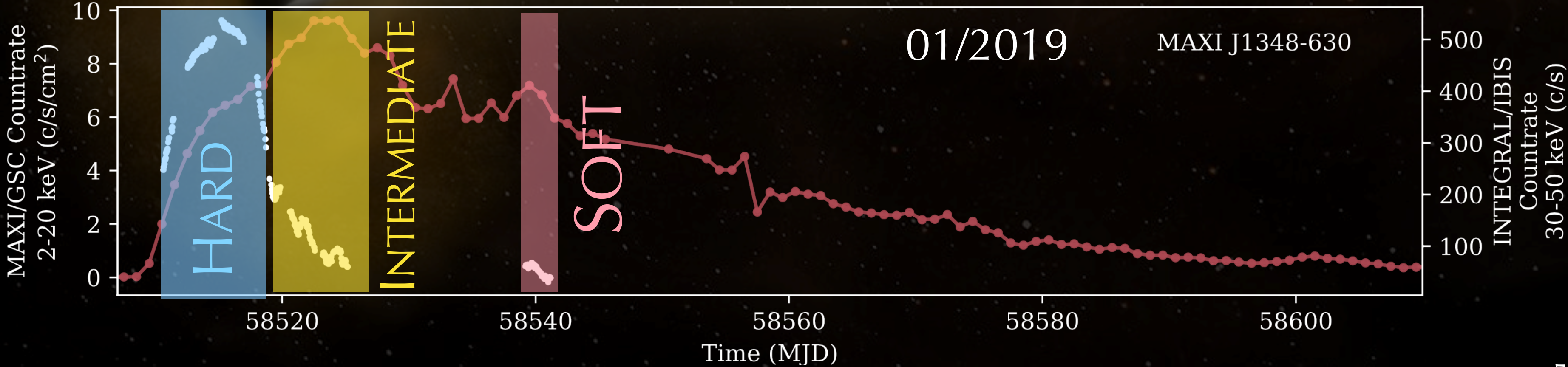
## MAXI J1535-571



## MAXI J1820+070



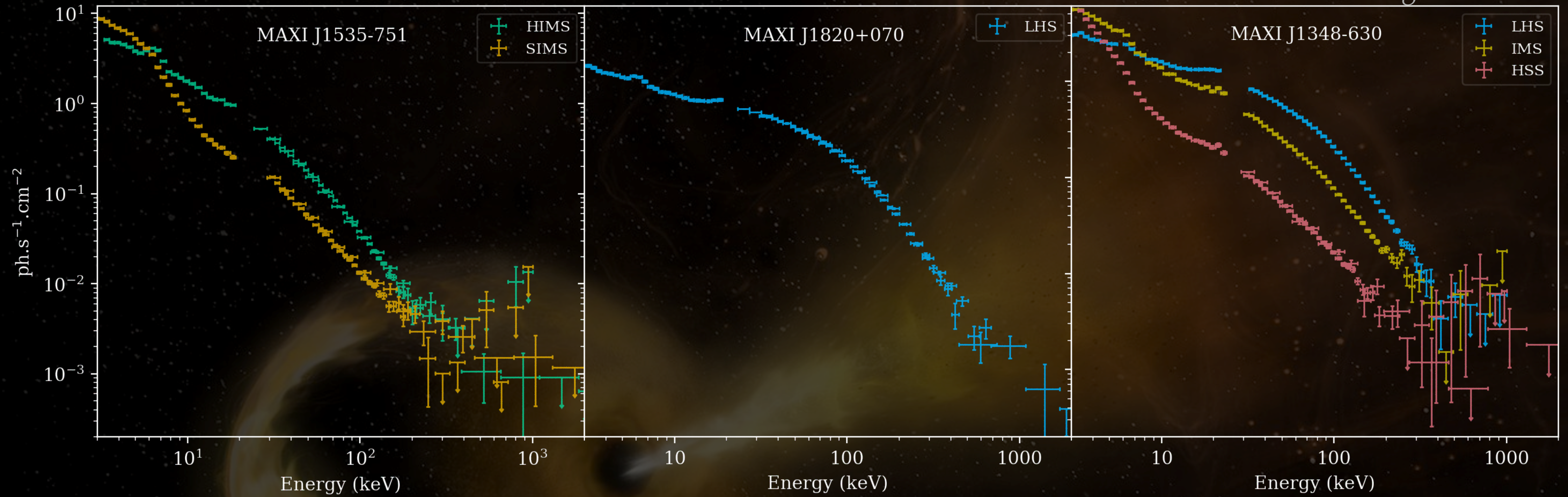
## MAXI J1348-630





# Spectral analysis

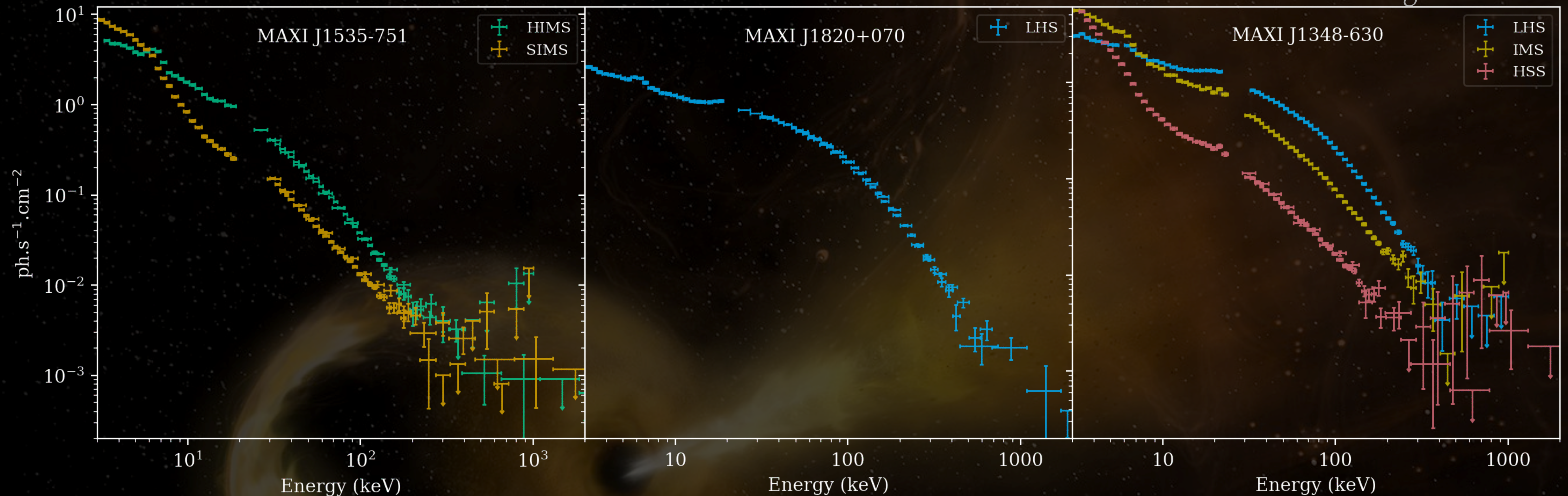
Cangemi+2023





# Spectral analysis

Cangemi+2023

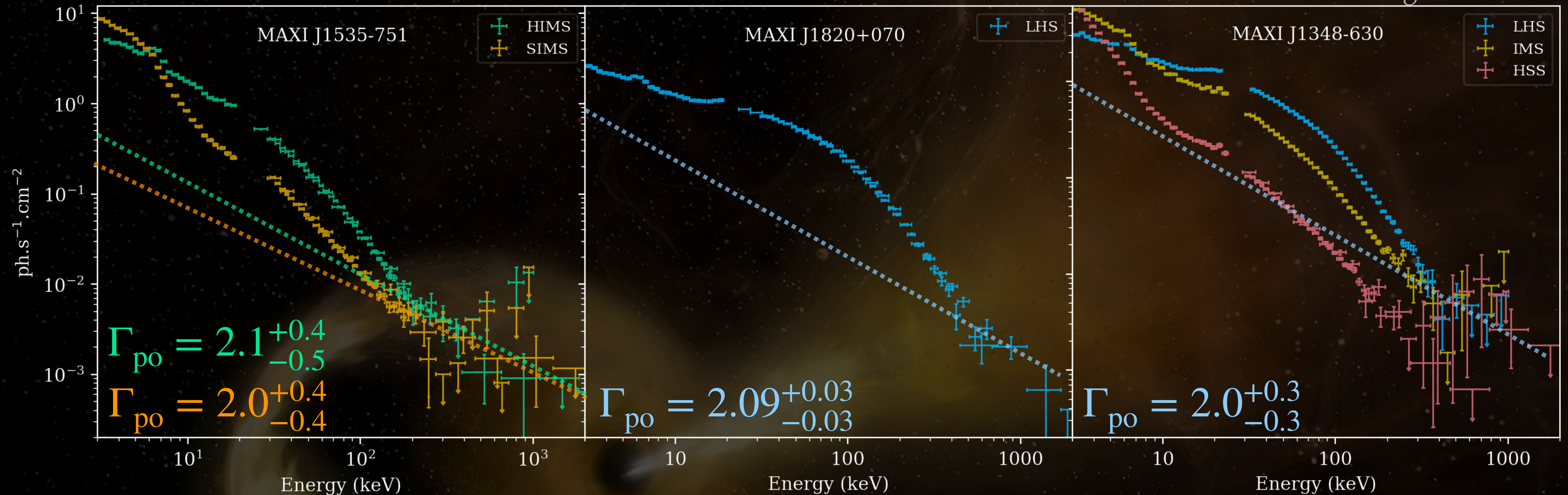


1. We fit data with reflected thermal comptonization model between 3—100 keV (including absorption, and thermal disk black body emission when needed)
2. We add data  $> 100$  keV and let the parameters vary freely.
3. Search for the presence of residuals at high energy.



# Spectral analysis

Cangemi+2023



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# Polarization with INTEGRAL/IBIS

ISGRI



PICsiT



Distribution of the **detected photons**

$$N(\phi) = C[1 + a_0 \cos(2(\phi - \phi_0))]$$

For a source **polarized at an Angle**

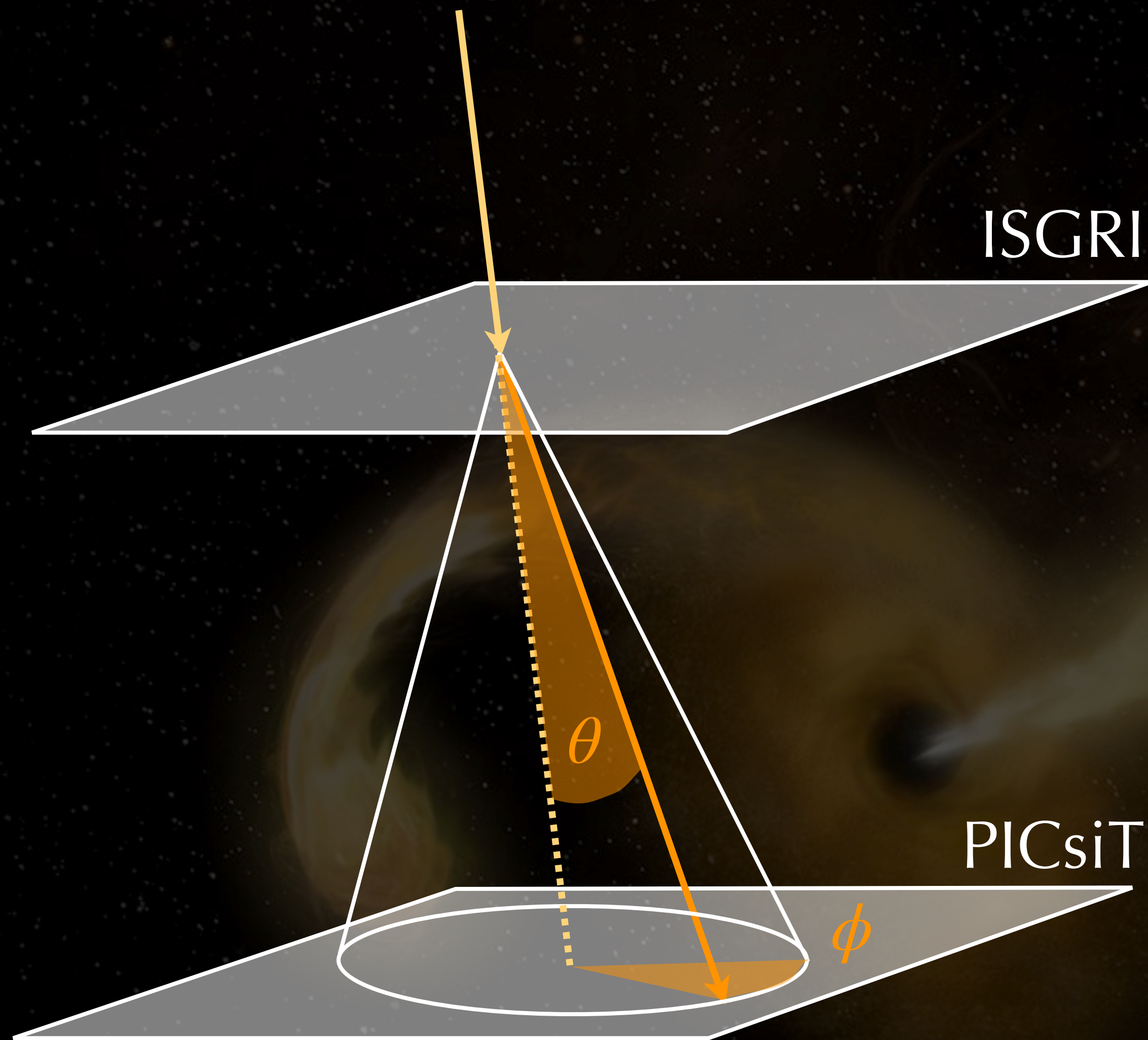
$$PA = \phi_0 - \pi/2$$

And a **Polarization Fraction**  $\Pi \propto a_0$

Signal to noise higher than 12



# Polarization with INTEGRAL/IBIS



Distribution of the detected photons

$$N(\phi) = C[1 + a_0 \cos(2(\phi - \phi_0))]$$

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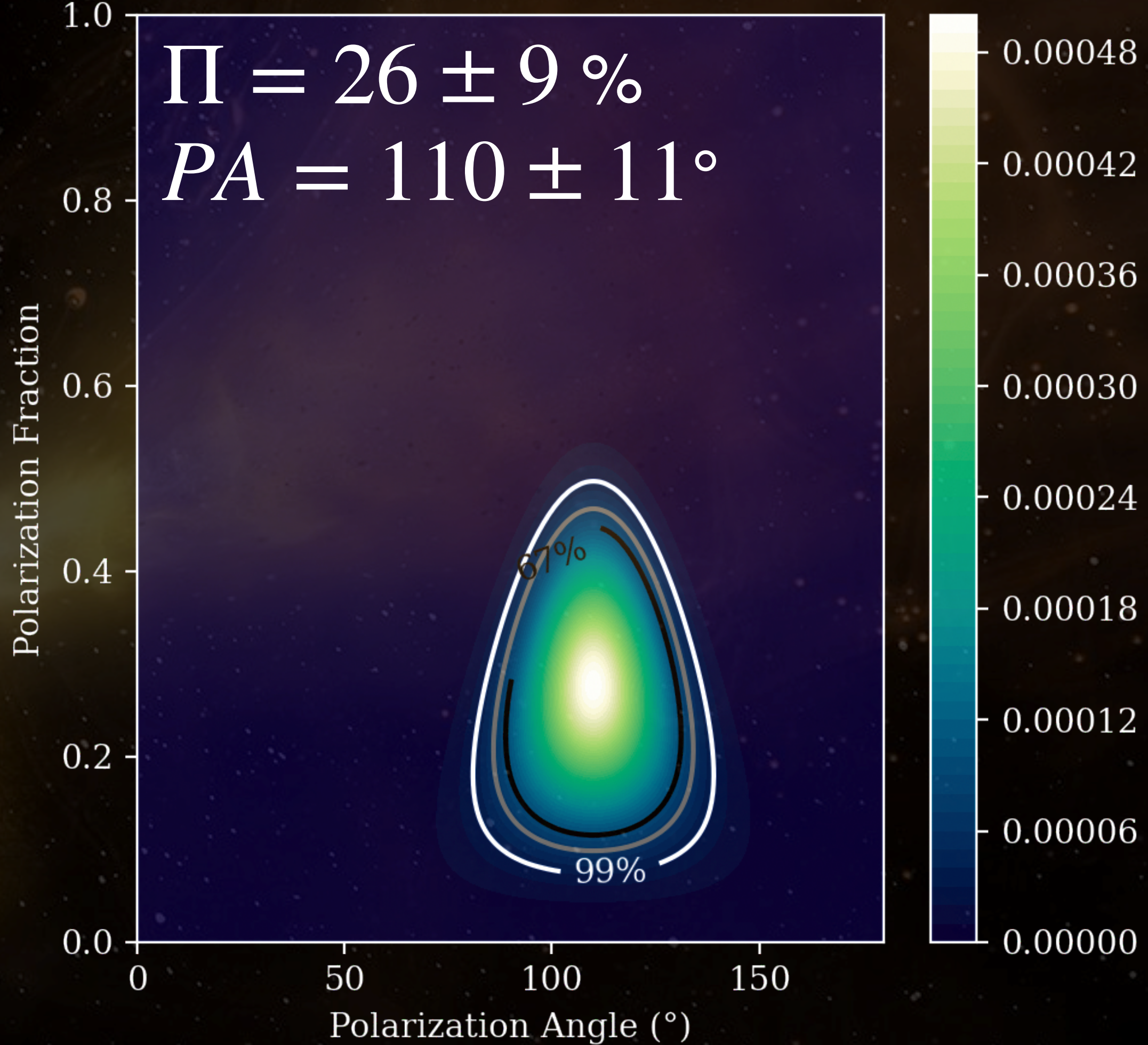
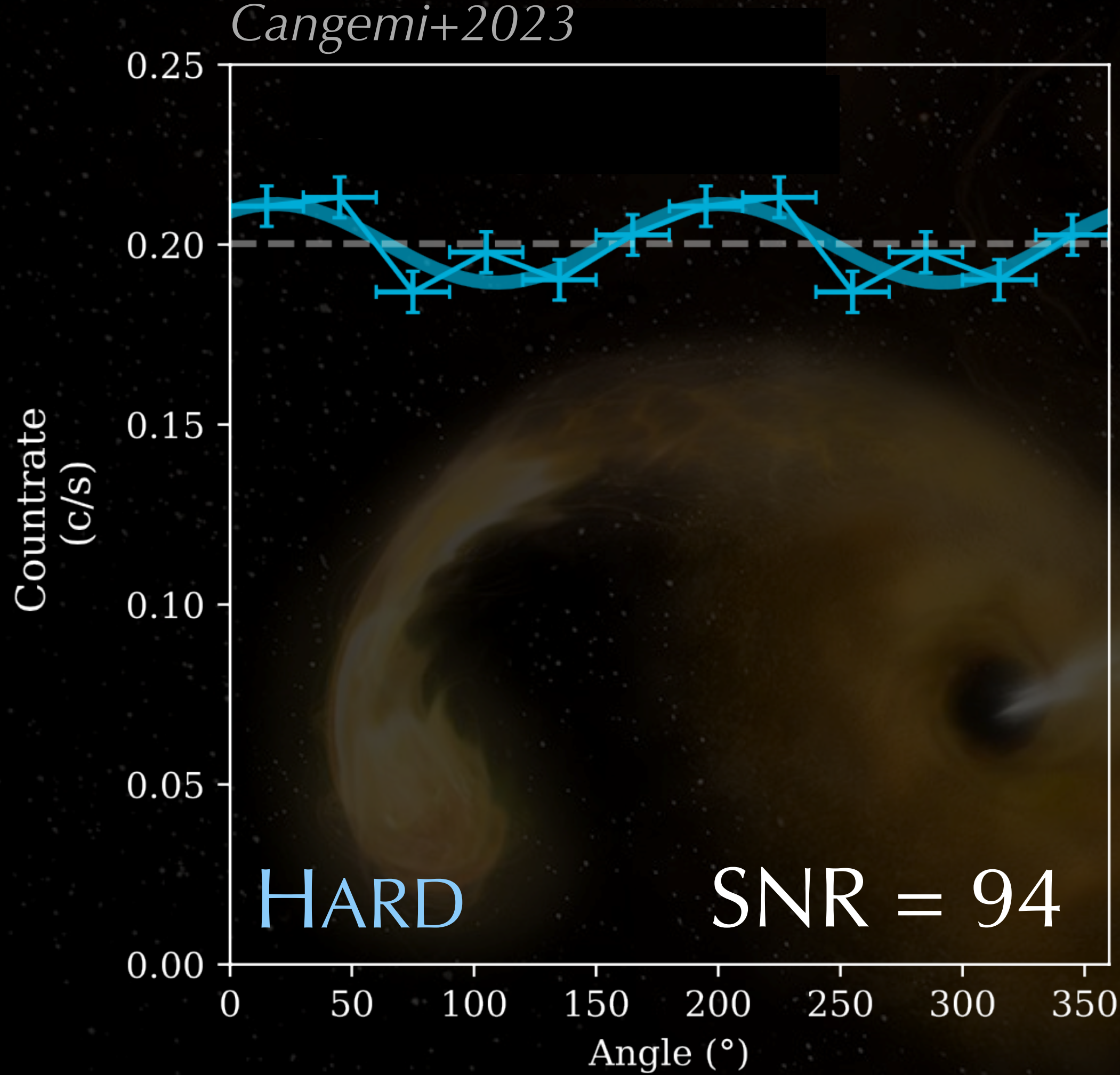
# Results

	State	SNR (300–1000 keV)
MAXI J1535–571	HIMS SIMS	8.7 4.9
MAXI J1820+070	HARD	94.1
MAXI J1348–630	HARD INTERMEDIATE SOFT	30.7 10.4 4.1



# Results — MAXI J1820+070

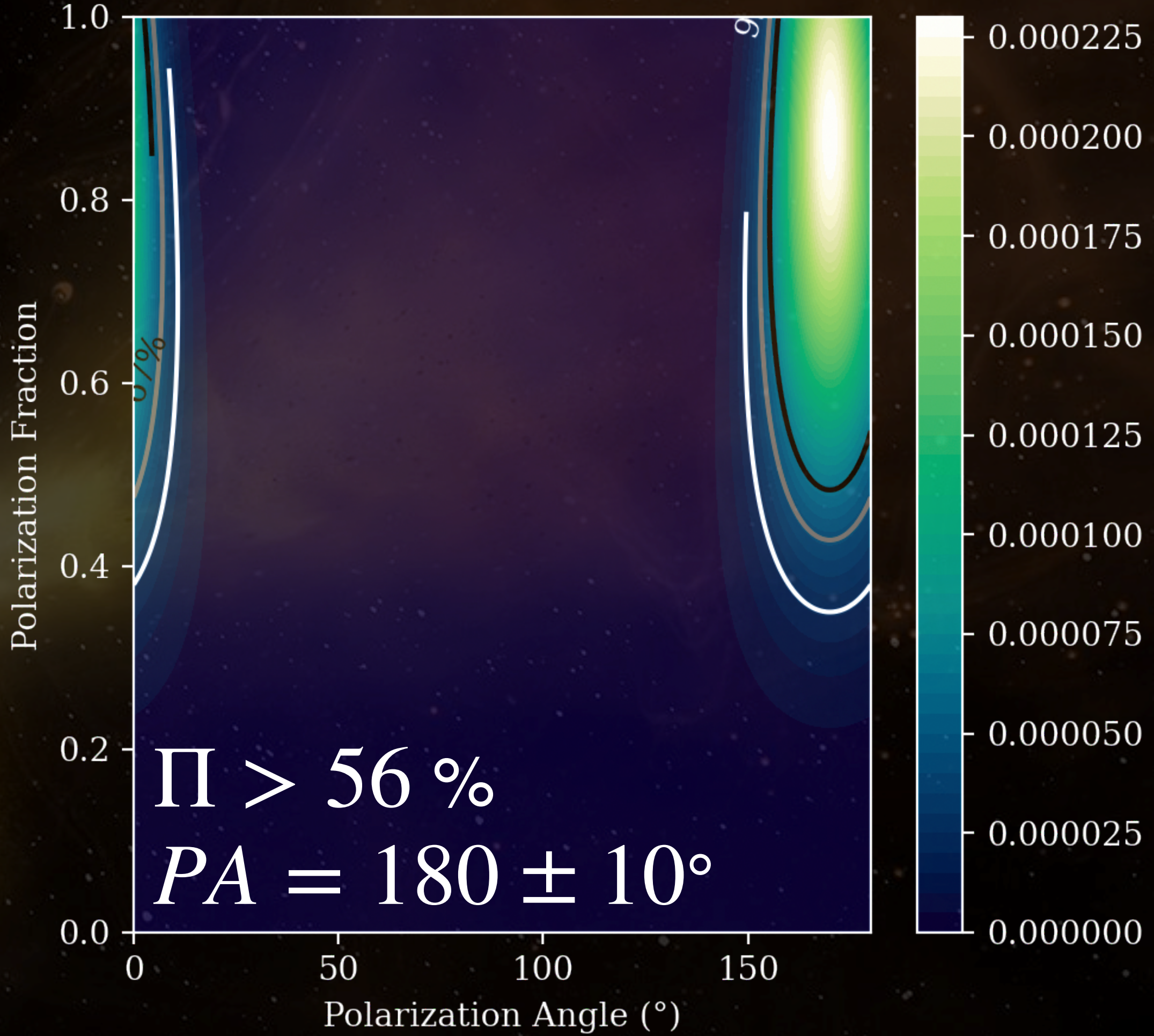
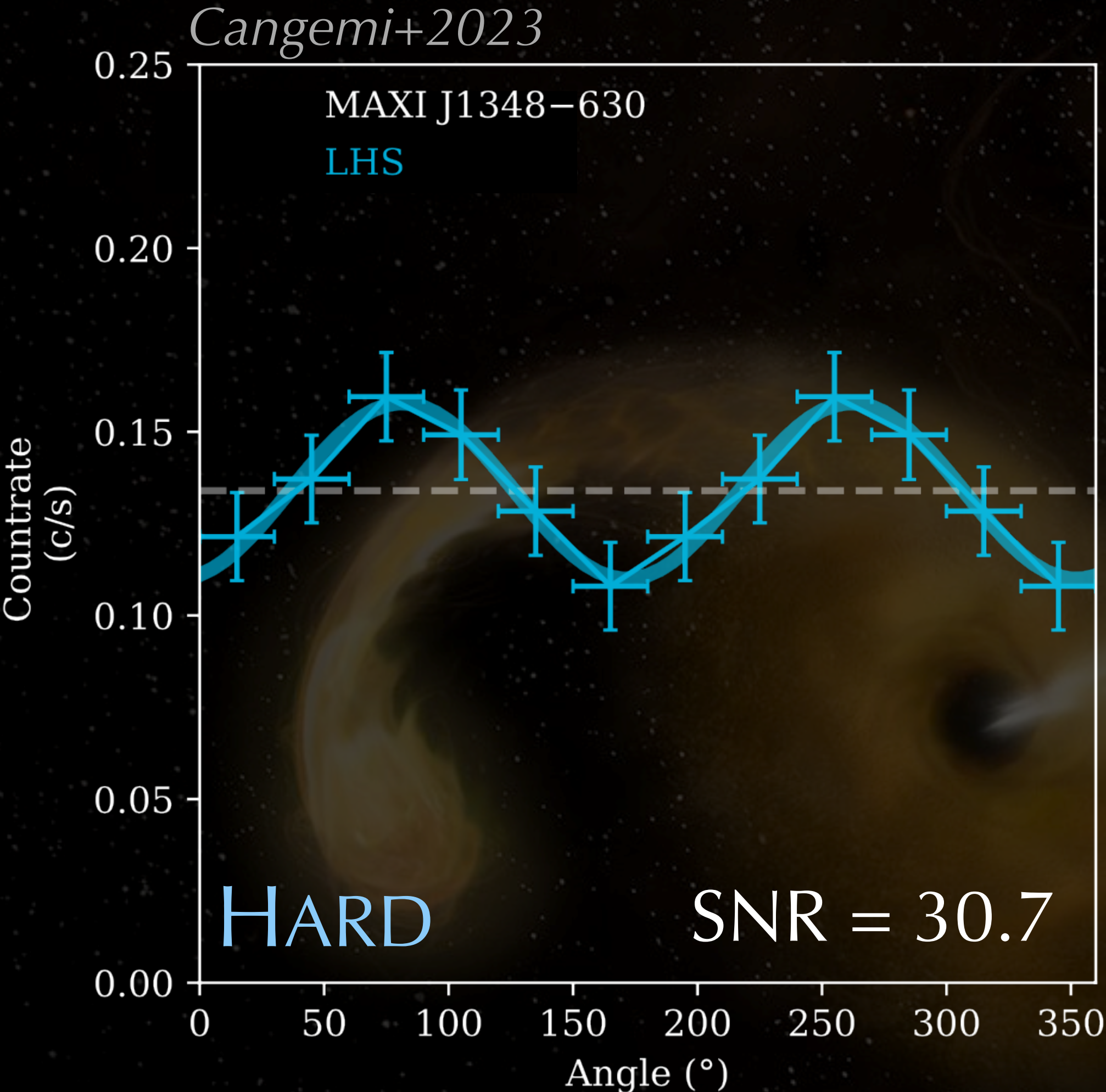
300—1000 keV





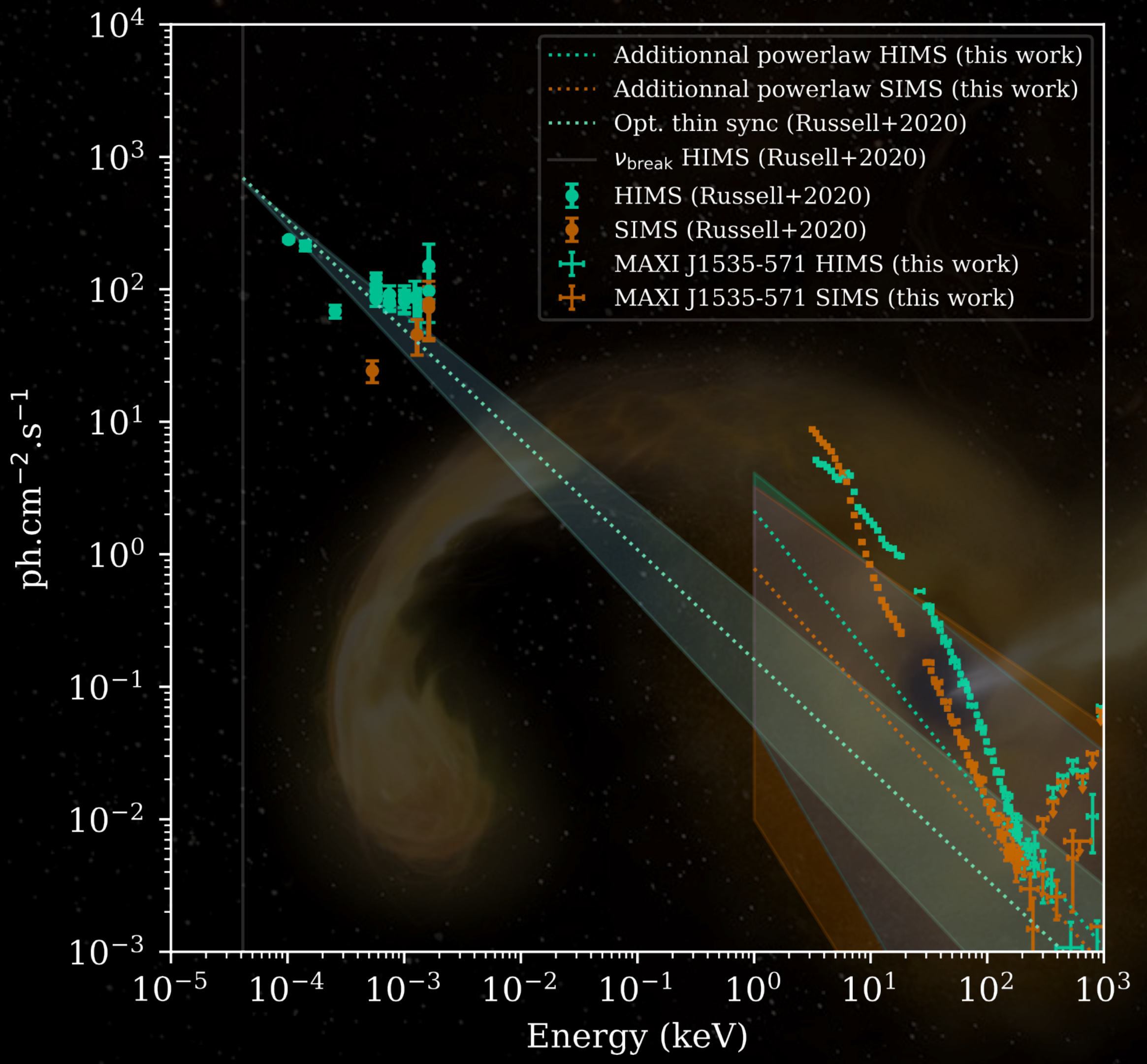
# Results — MAXI J1348–630

300—1000 keV





# Interpretation



## MAXI J1535–571

High-energy tail detected

HIMS  $\Gamma = 2.1^{+0.4}_{-0.5}$   
 SIMS  $\Gamma = 2.0^{+0.4}_{-0.4}$

Polarization

too few signal  
 too few signal

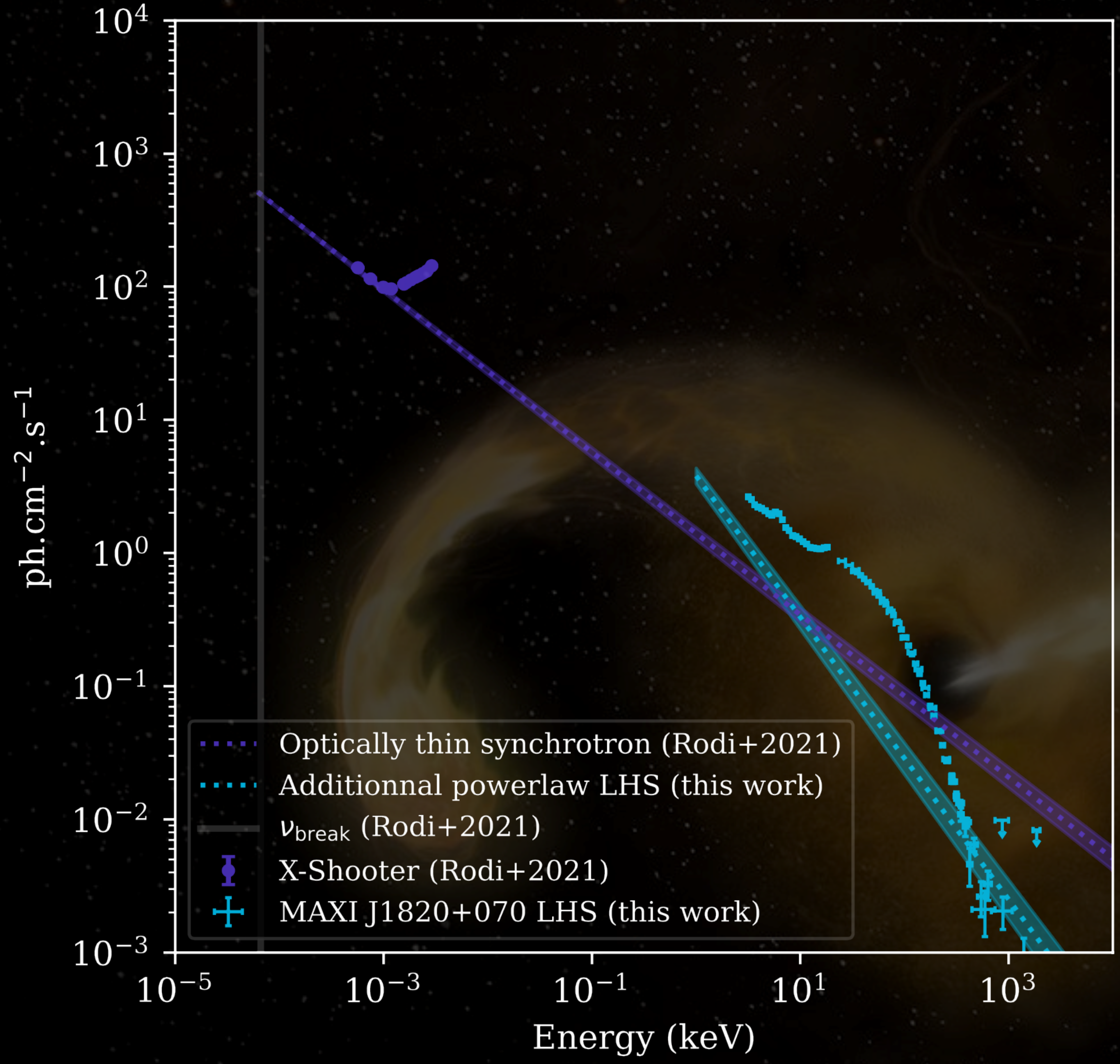
Synchrotron spectrum from *Russell+2020*

$\alpha = 0.83 \pm 0.09$

X-ray data consistent with synchrotron emission  
 BUT  
 Large uncertainties + no polarization information  
**Cannot firmly conclude...**



# Interpretation



MAXI J1820+070

High-energy tail detected

HARD  $\Gamma = 2.09^{+0.03}_{-0.03}$

Polarization

$\Pi = 26 \pm 9 \%$

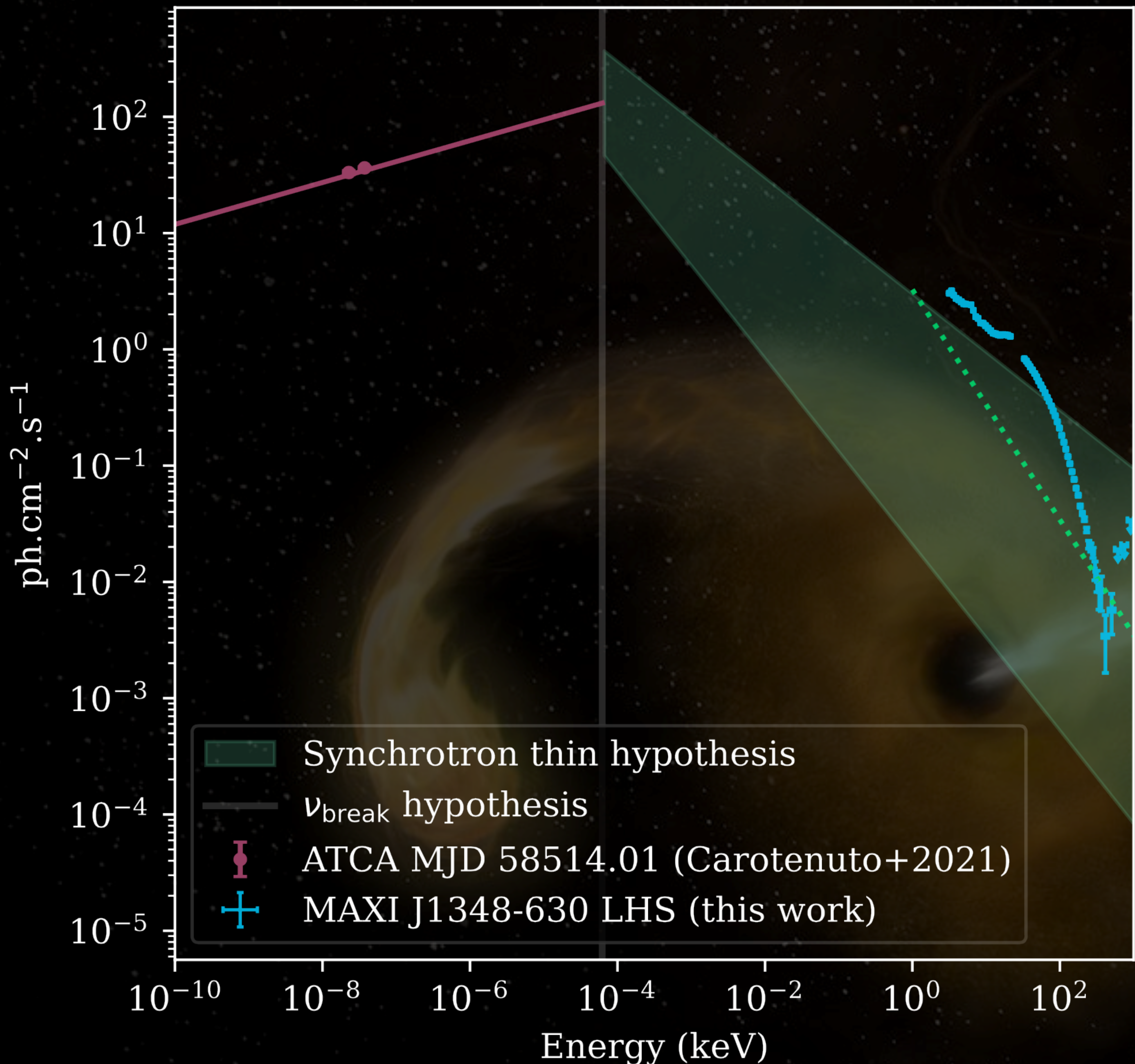
X-shooter data from *Rodi+2021*

Simple extrapolation not consistent with synchrotron emission

Polarization fraction consistent with **either the corona or the jets**



# Interpretation



## MAXI J1348-630

High-energy tail detected

**HARD**  $\Gamma = 2.0^{+0.3}_{-0.3}$

Polarization

$\Pi > 56\%$

Radio data from *Carotenuto+2021*

Hypothesis on the synchrotron break and thin part

X-ray data consistent with synchrotron hypothesis  
**AND**  
 Large polarization fraction  
**Point towards jets origin**



# Conclusion and perspectives

## MAXI J1535–571

Could be consistent with jets but we **cannot conclude** without solid polarization measurements.

## MAXI J1820+070

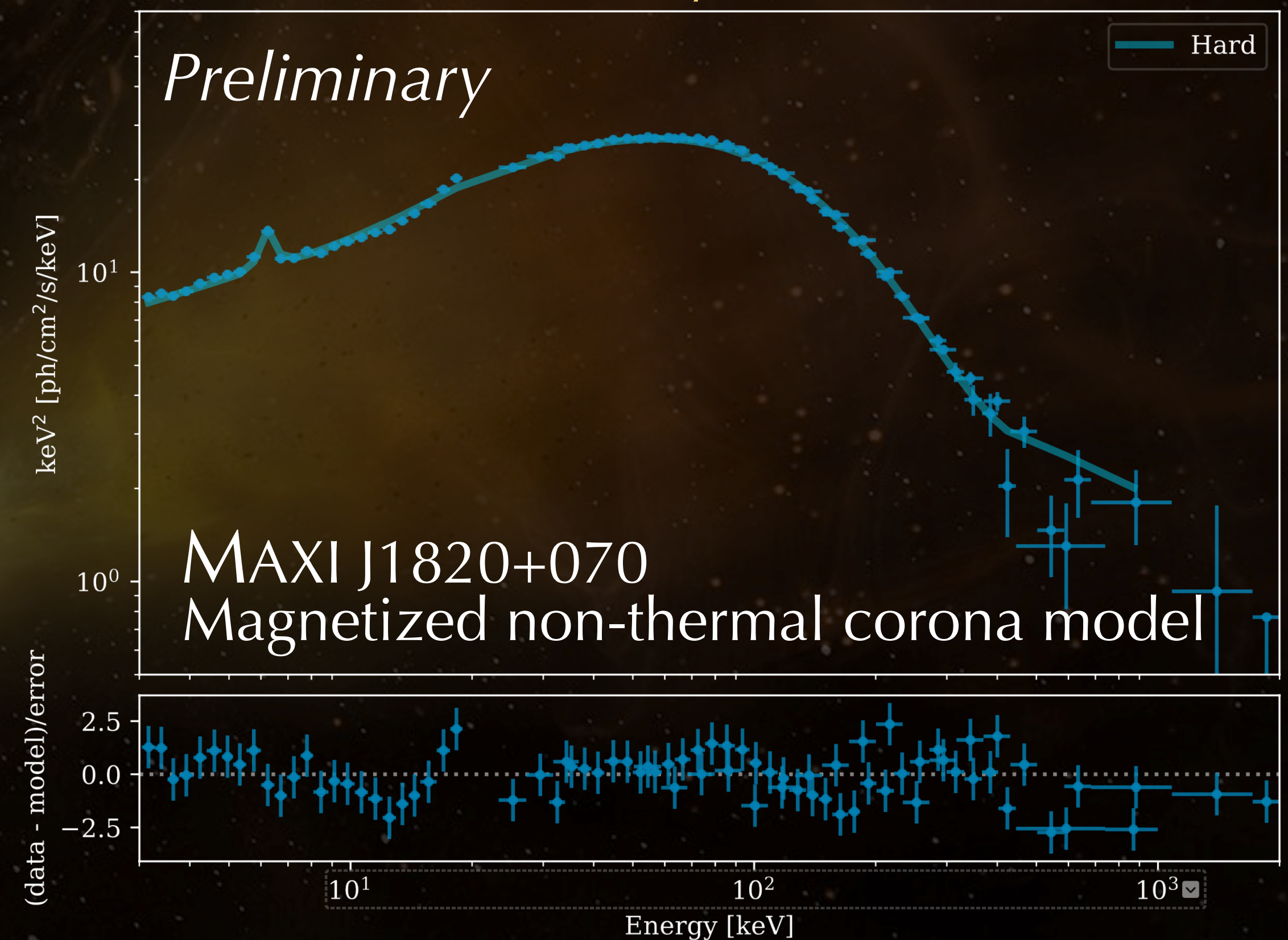
Could be consistent with **jets or corona**, need **further investigations** with physical modelizations.

## MAXI J1348–630

High fraction of polarization **consistent with jet synchrotron emission**.

Modelizations with **jets models**

Modelizations with **hybrid corona models**





# Conclusion and perspectives

## MAXI J1535–571

Could be consistent with jets but we **cannot conclude** without solid polarization measurements.

## MAXI J1820+070

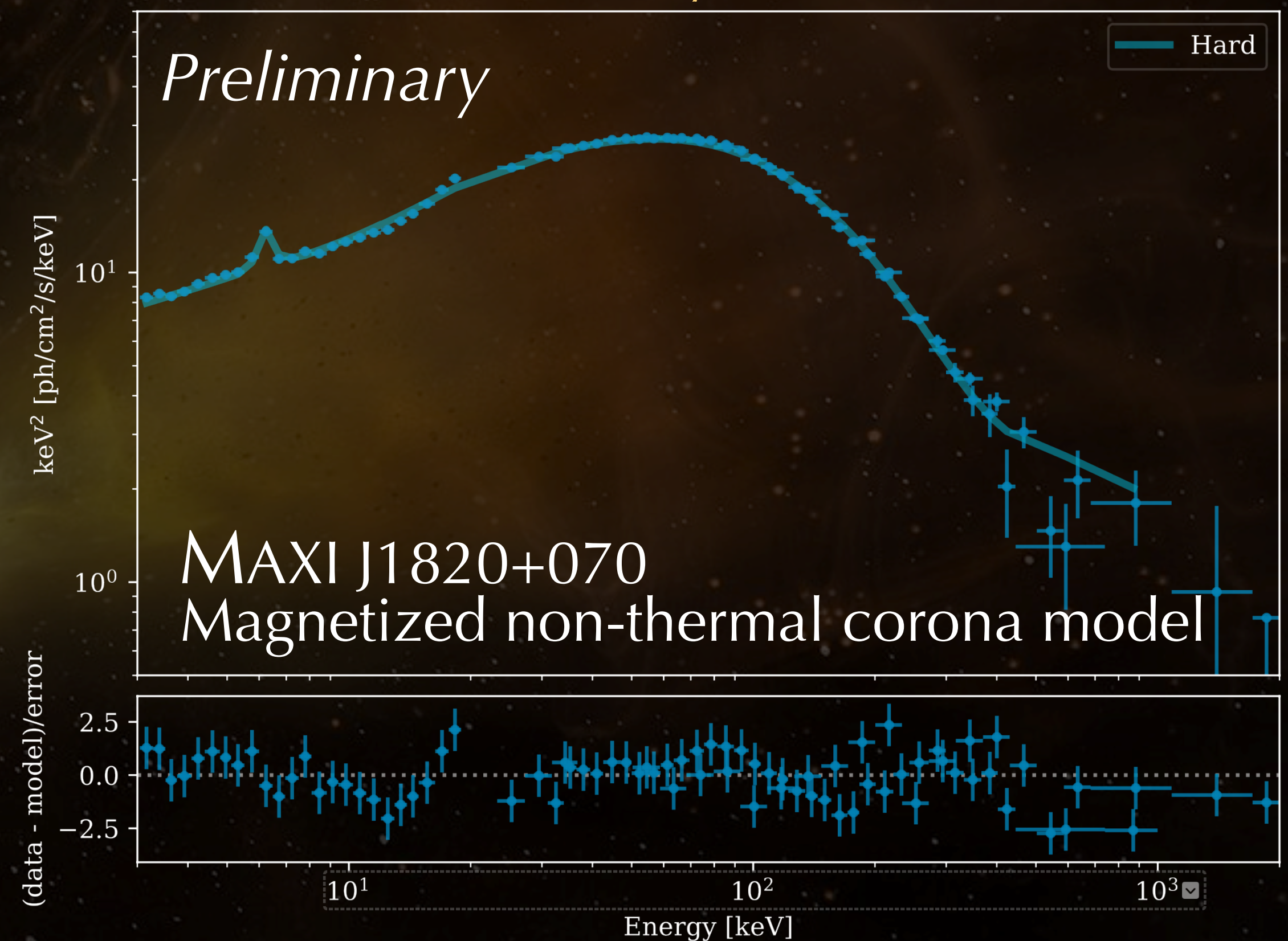
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## MAXI J1348–630

High fraction of polarization **consistent with jet synchrotron emission**.

Modelizations with **jets models**

Modelizations with **hybrid corona models**

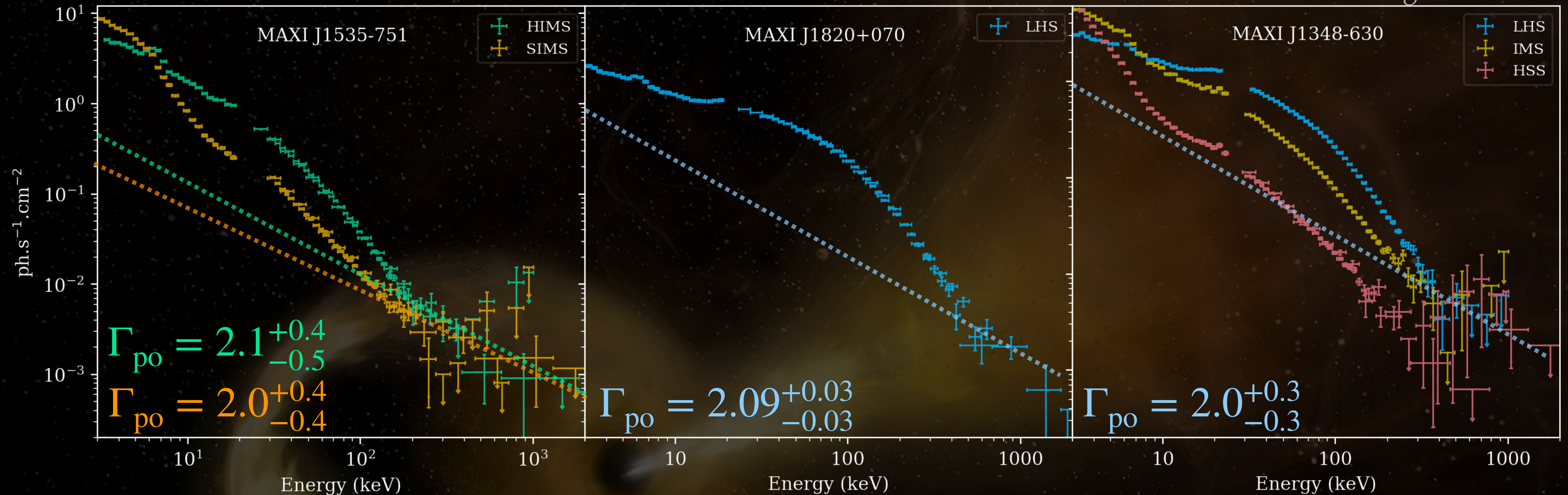


*Thank you!*



# Spectral analysis

Cangemi+2023



1. We fit data with reflected thermal comptonization model between 3—100 keV (including absorption, and thermal disk black body emission when needed)
2. We add data > 100 keV and let the parameters vary freely.
3. Search for the presence of residuals at high energy.



# Search for an additional non-thermal component

Cangemi+2023

