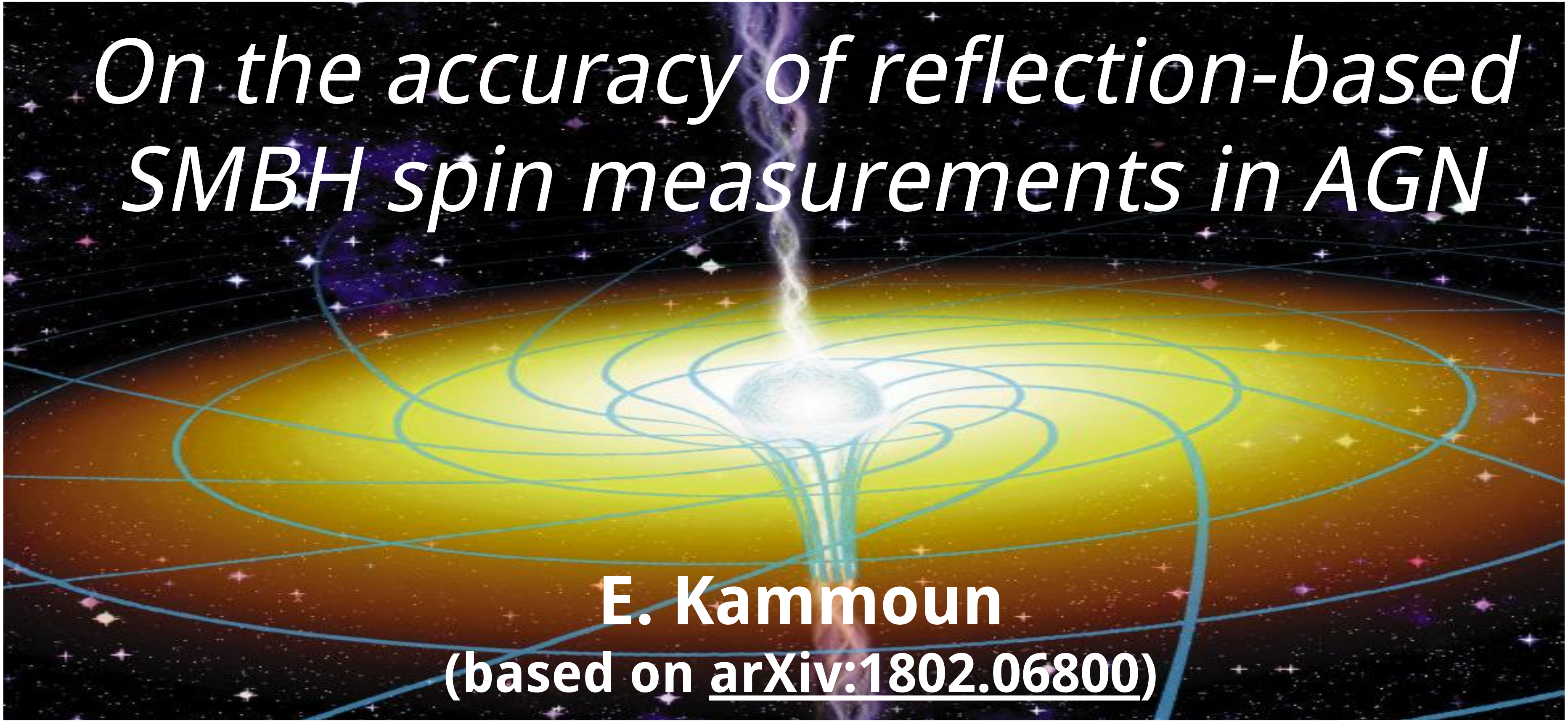


On the accuracy of reflection-based SMBH spin measurements in AGN

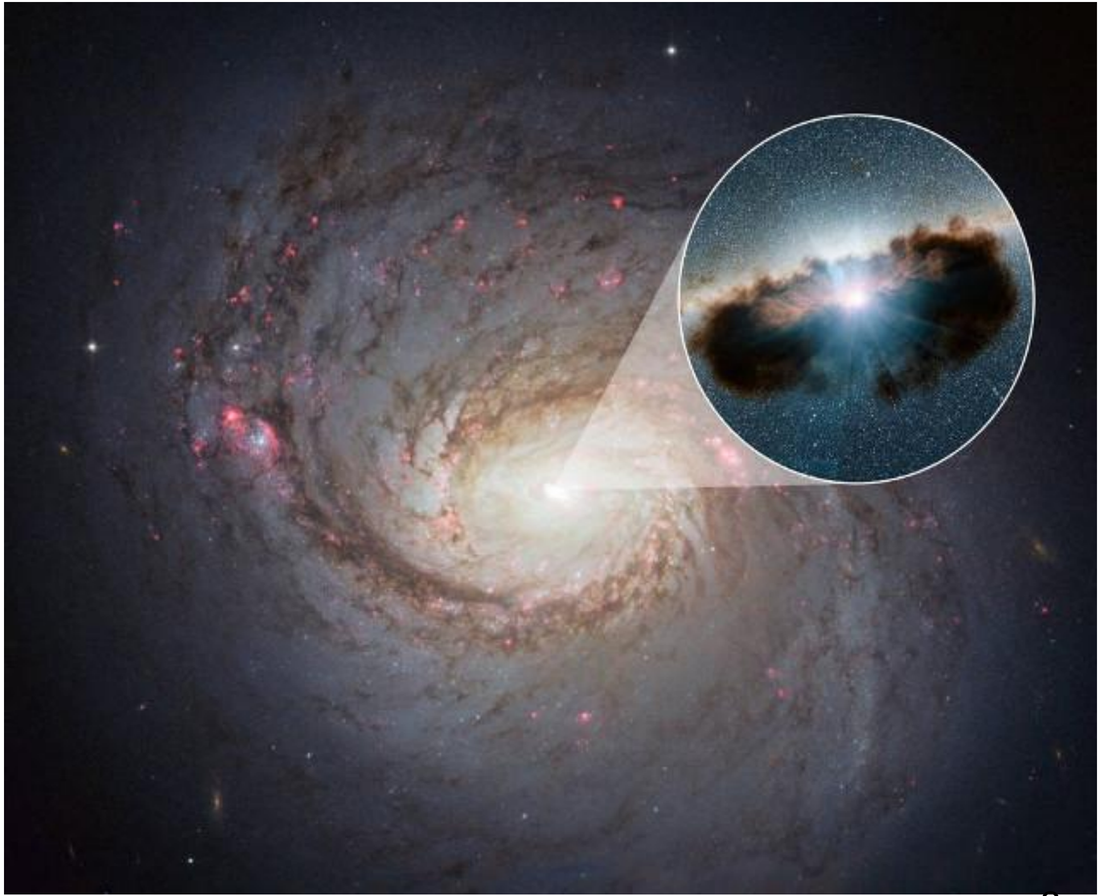
E. Kammoun

(based on arXiv:1802.06800)

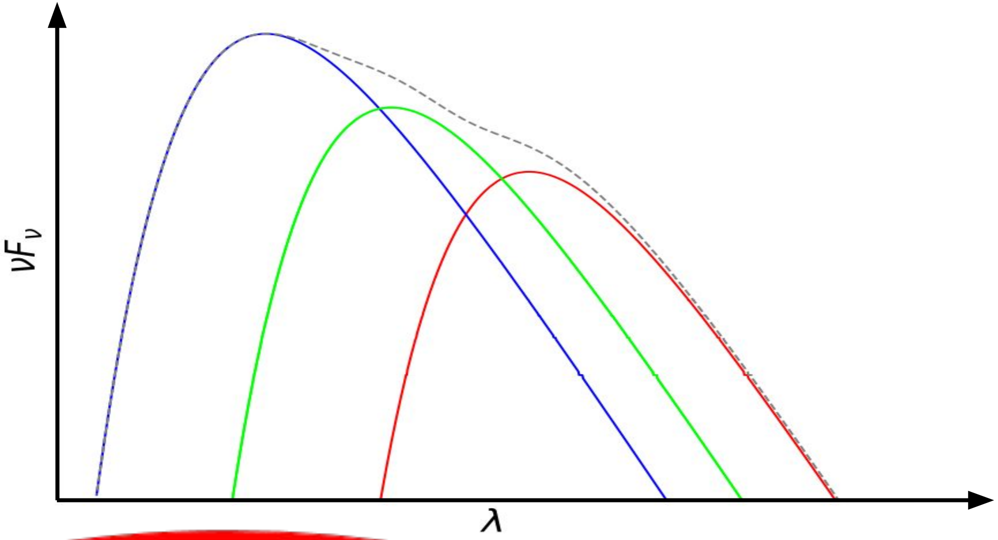
In collaboration with: E. Nardini (INAF - Arcetri)
G. Risaliti (Uni of Florence)

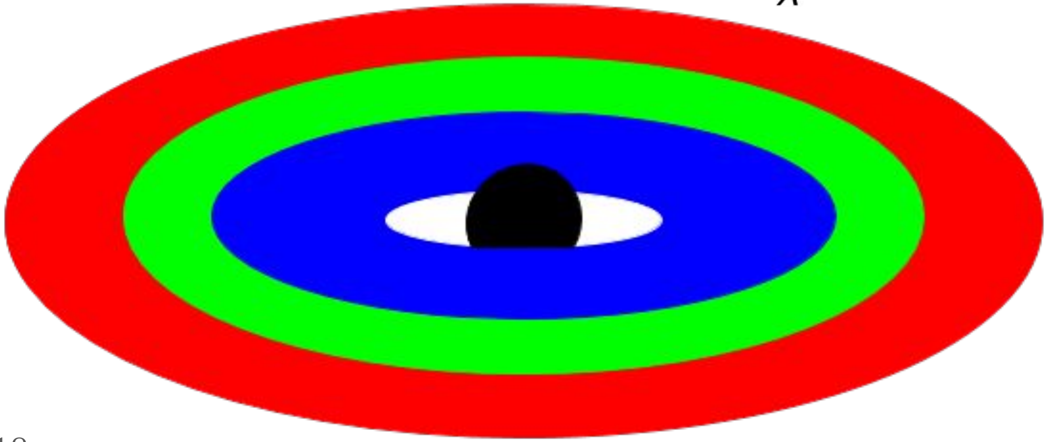
ICYAA - Padova, 08 June 2018

Active Galactic Nucleus
→ Supermassive Black Hole ($\sim 10^6$-10^{10} Msun)

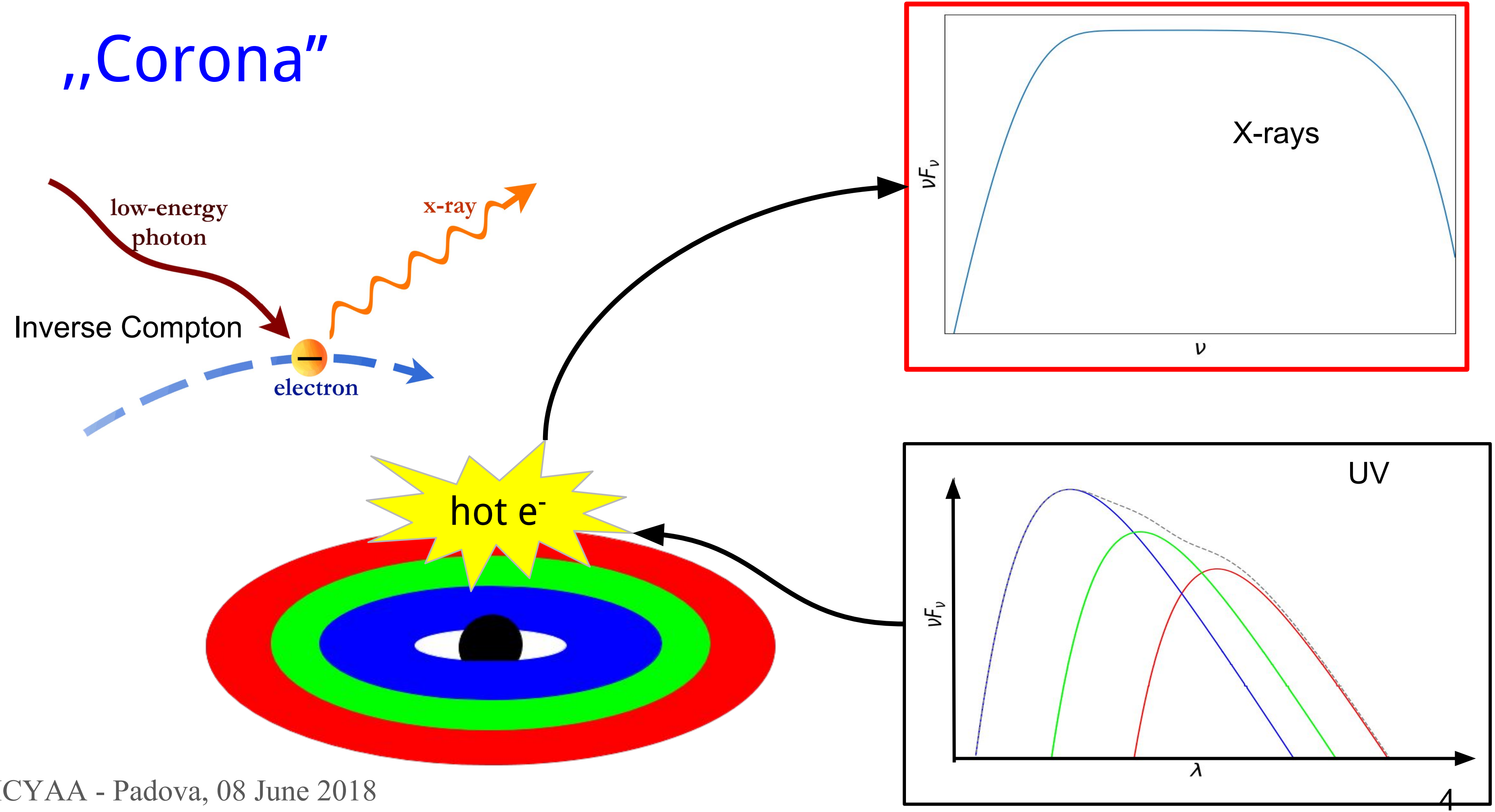


Accretion Disc

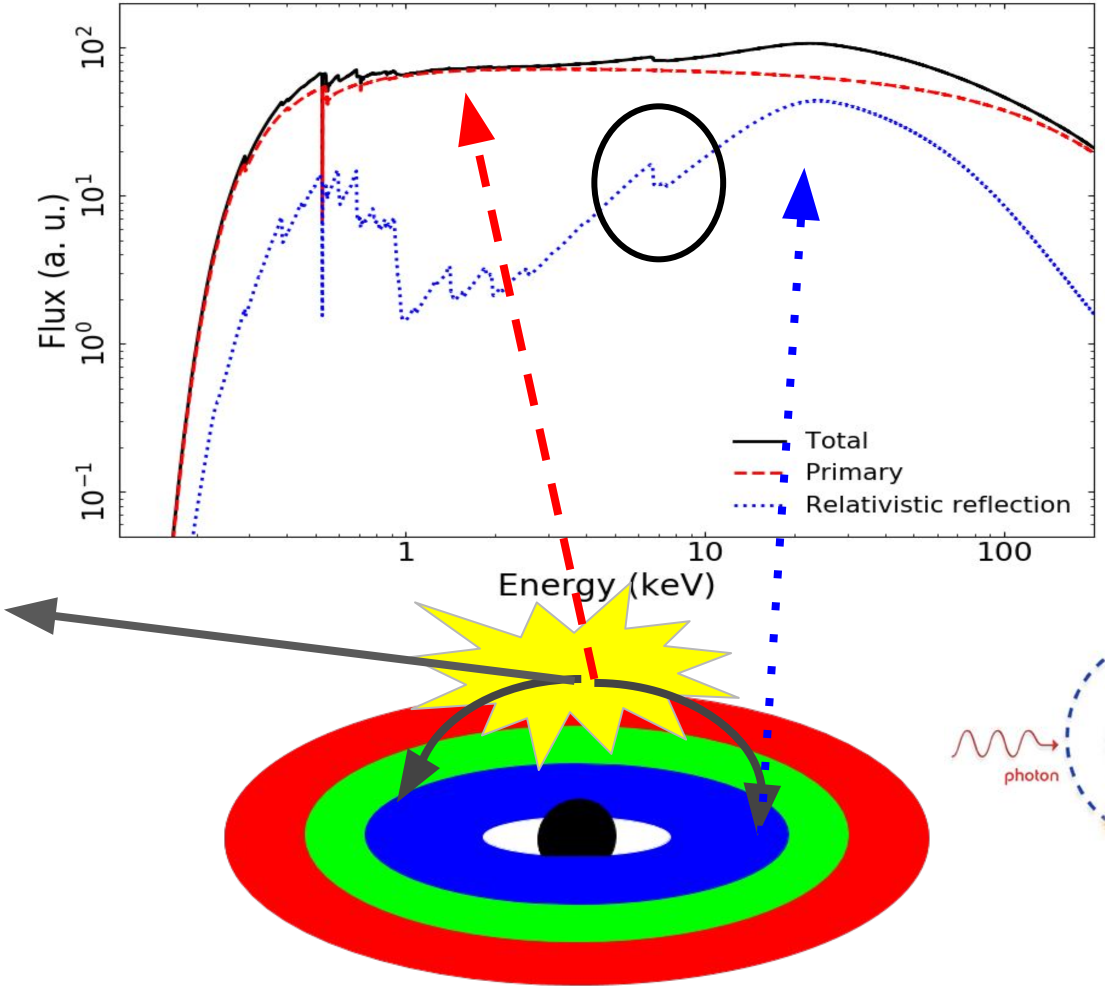




„Corona"

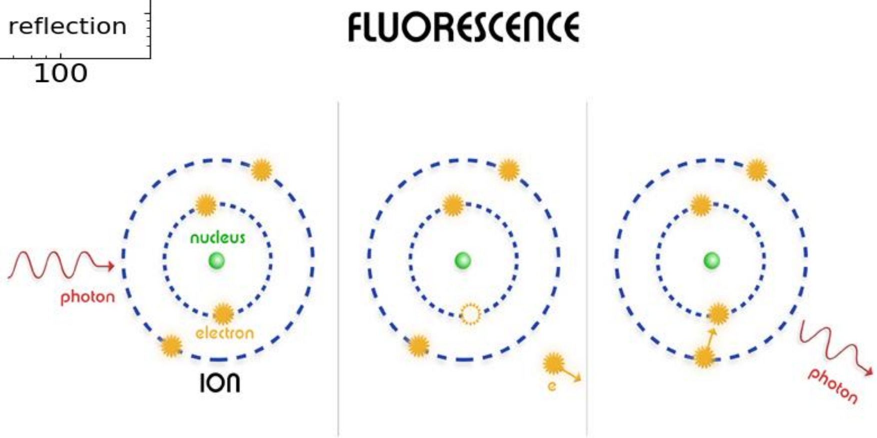


low-energy photon
x-ray
Inverse Compton
electron
hot e⁻
X-rays
νF_ν
ν
UV
νF_ν
λ

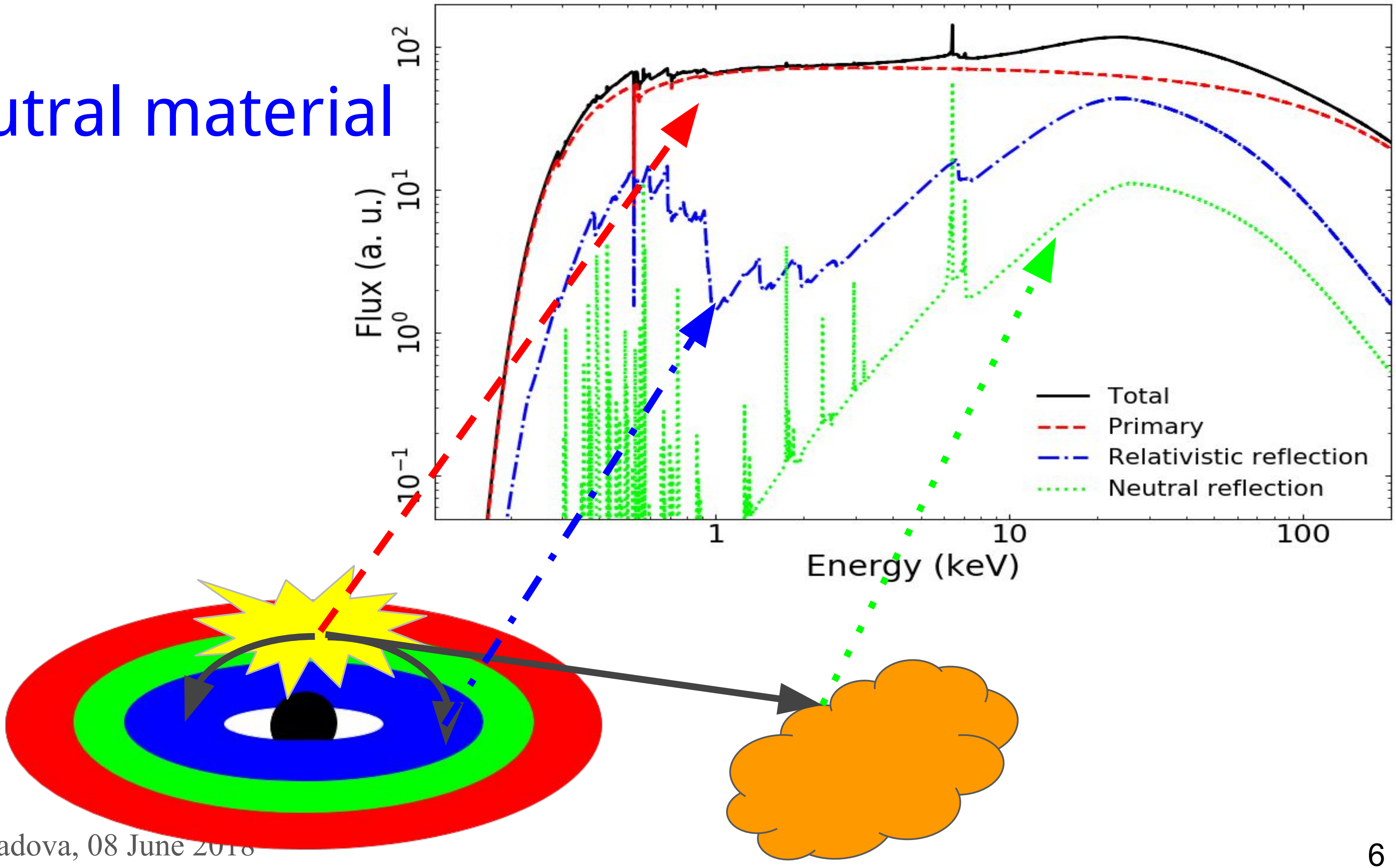


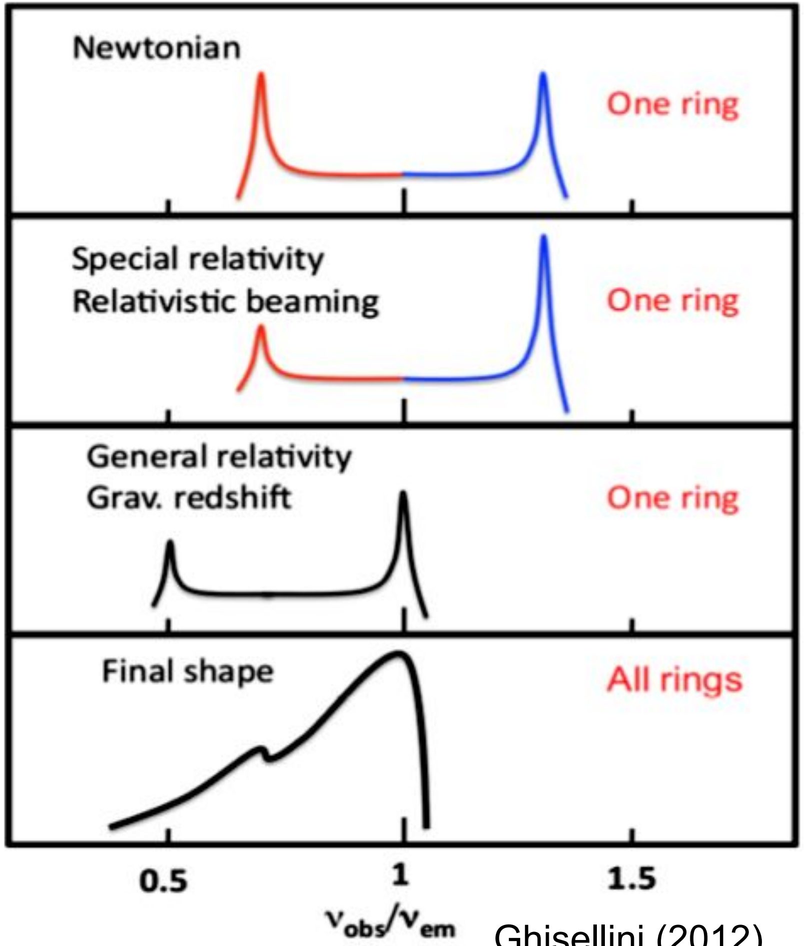
Corona ↔ Disc

⇒ „Reflection"

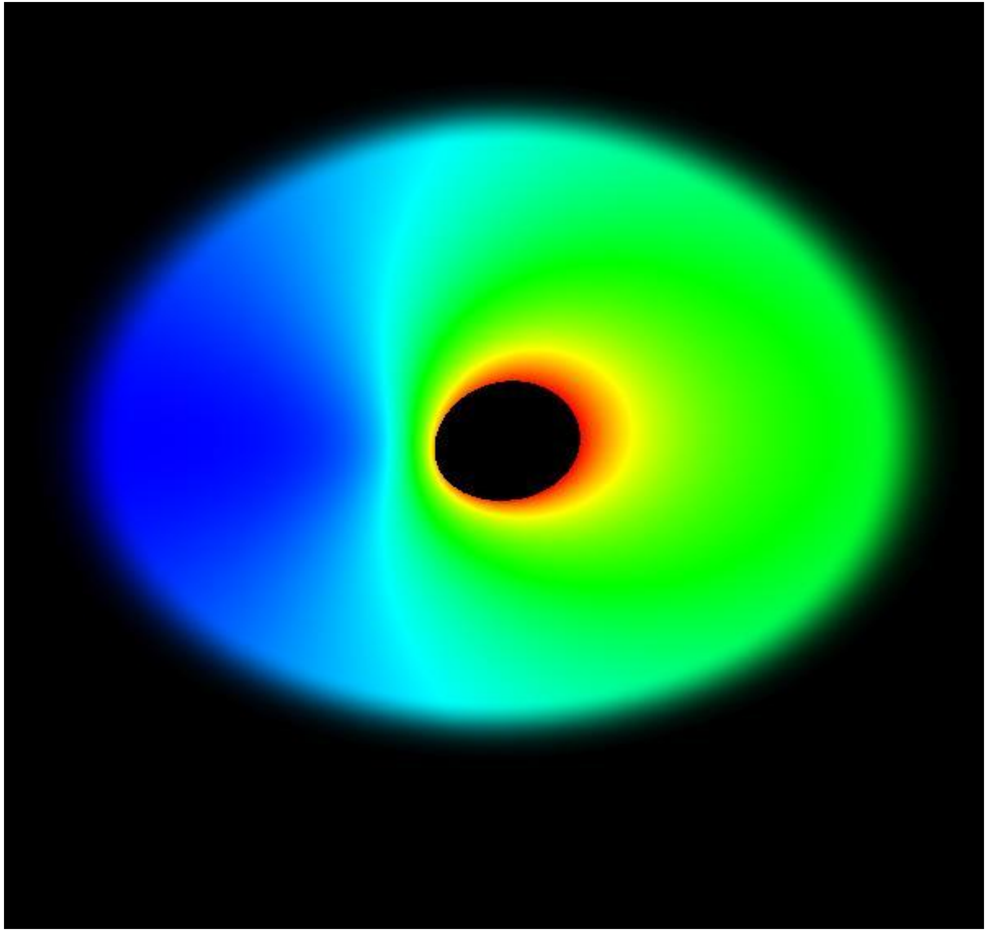


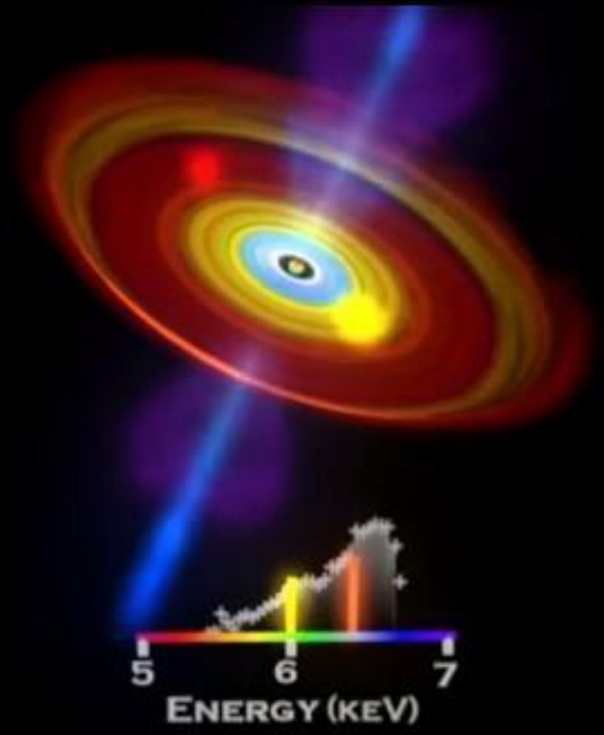
Neutral material



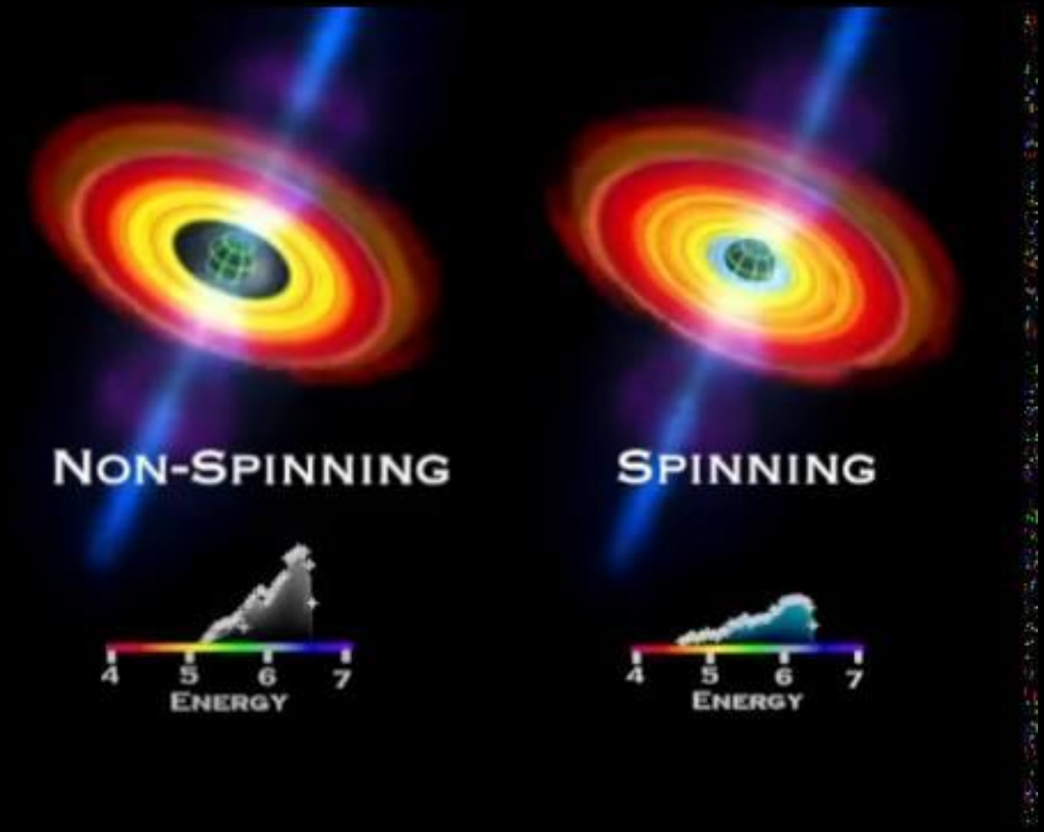


Ghisellini (2012)



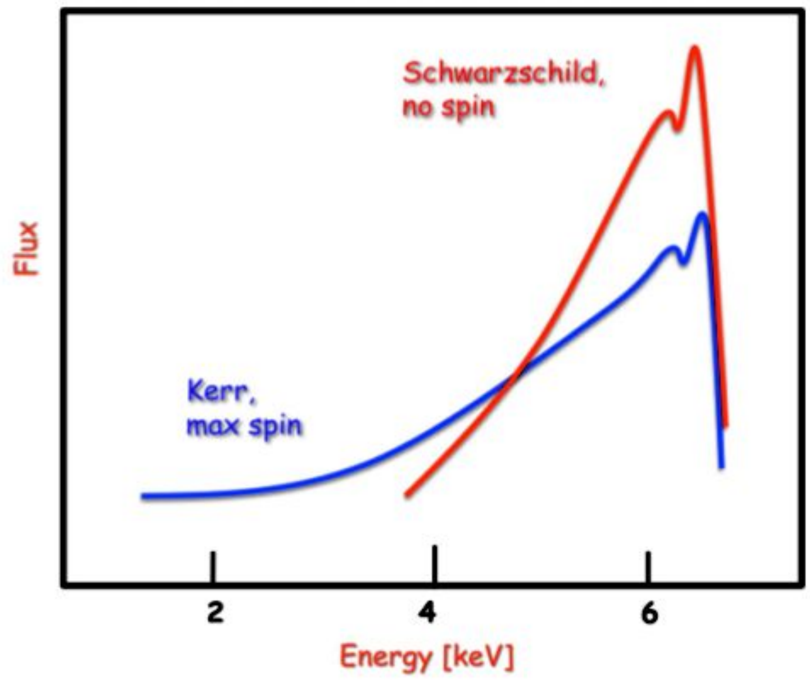


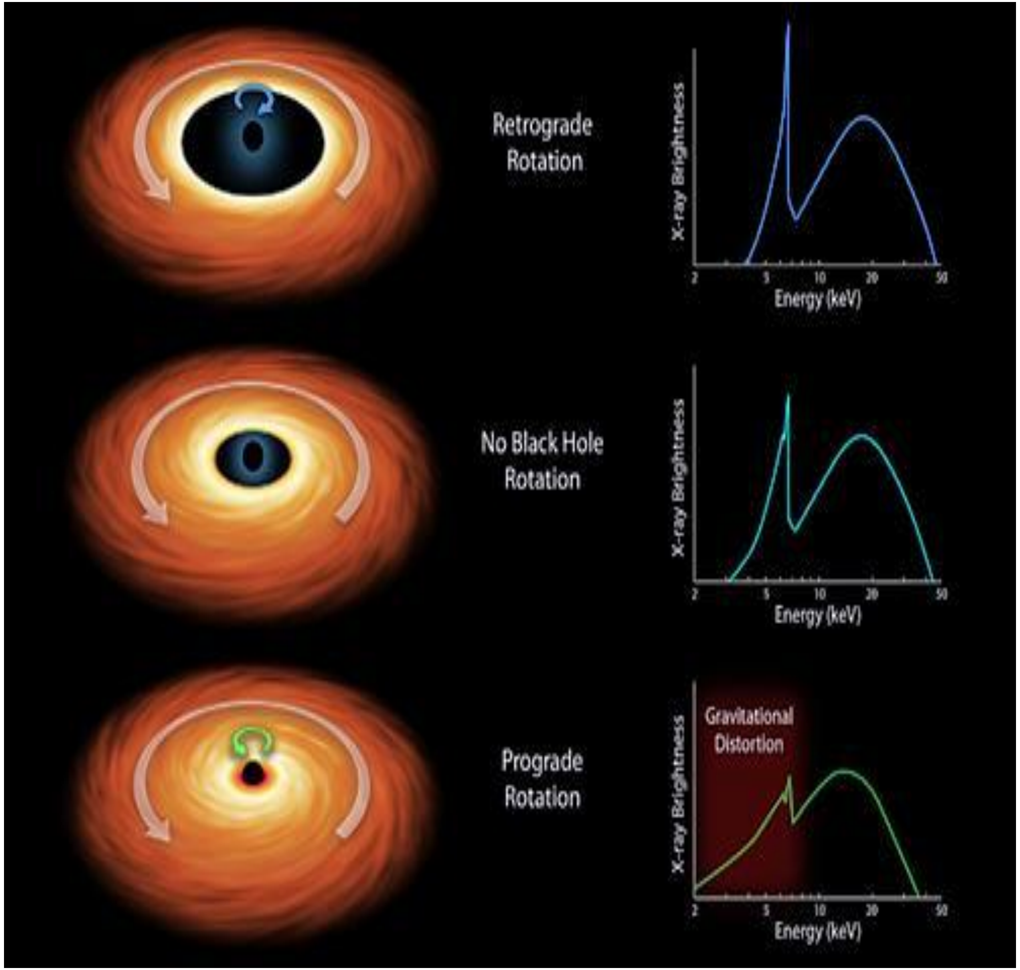
Credits: NASA



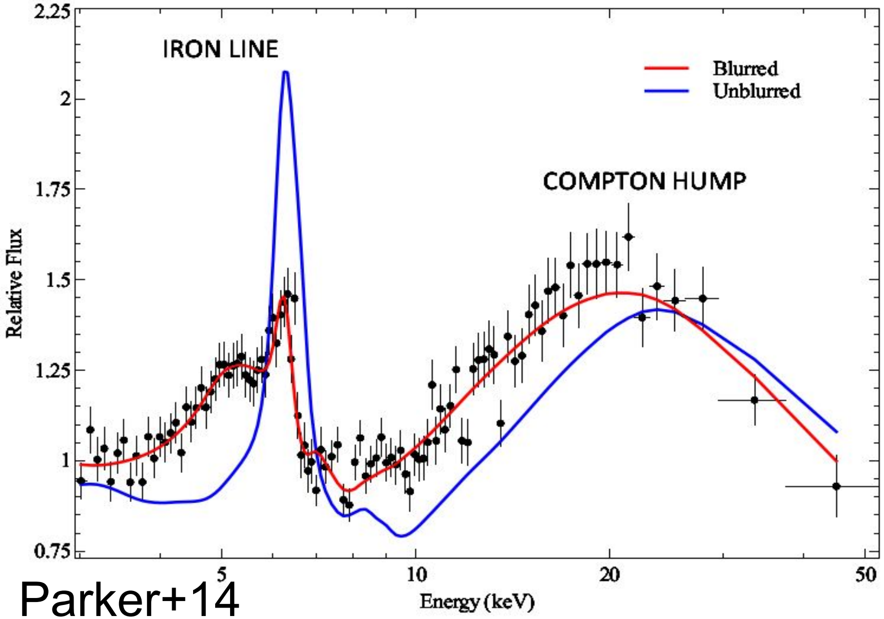
Credits: NASA

Relativistic effects on the reflection features
→ <u>one possible way</u> to measure the spin

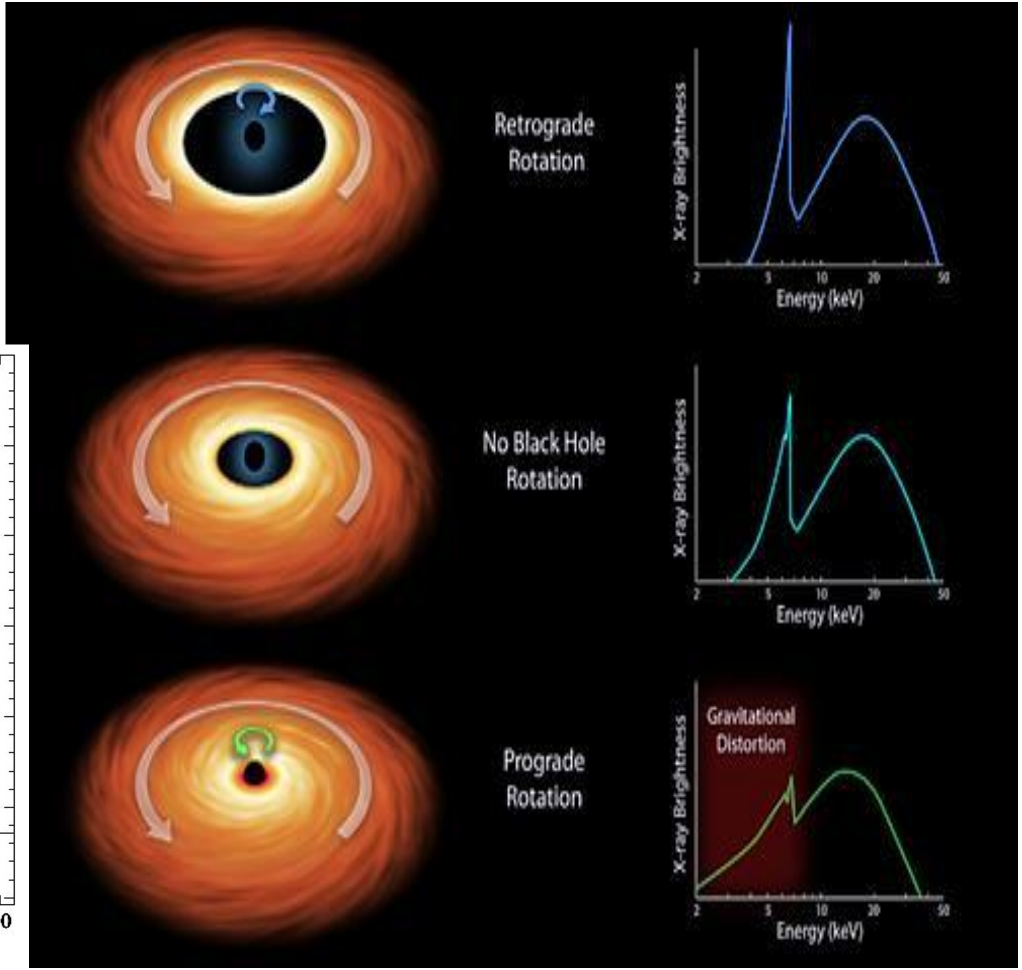




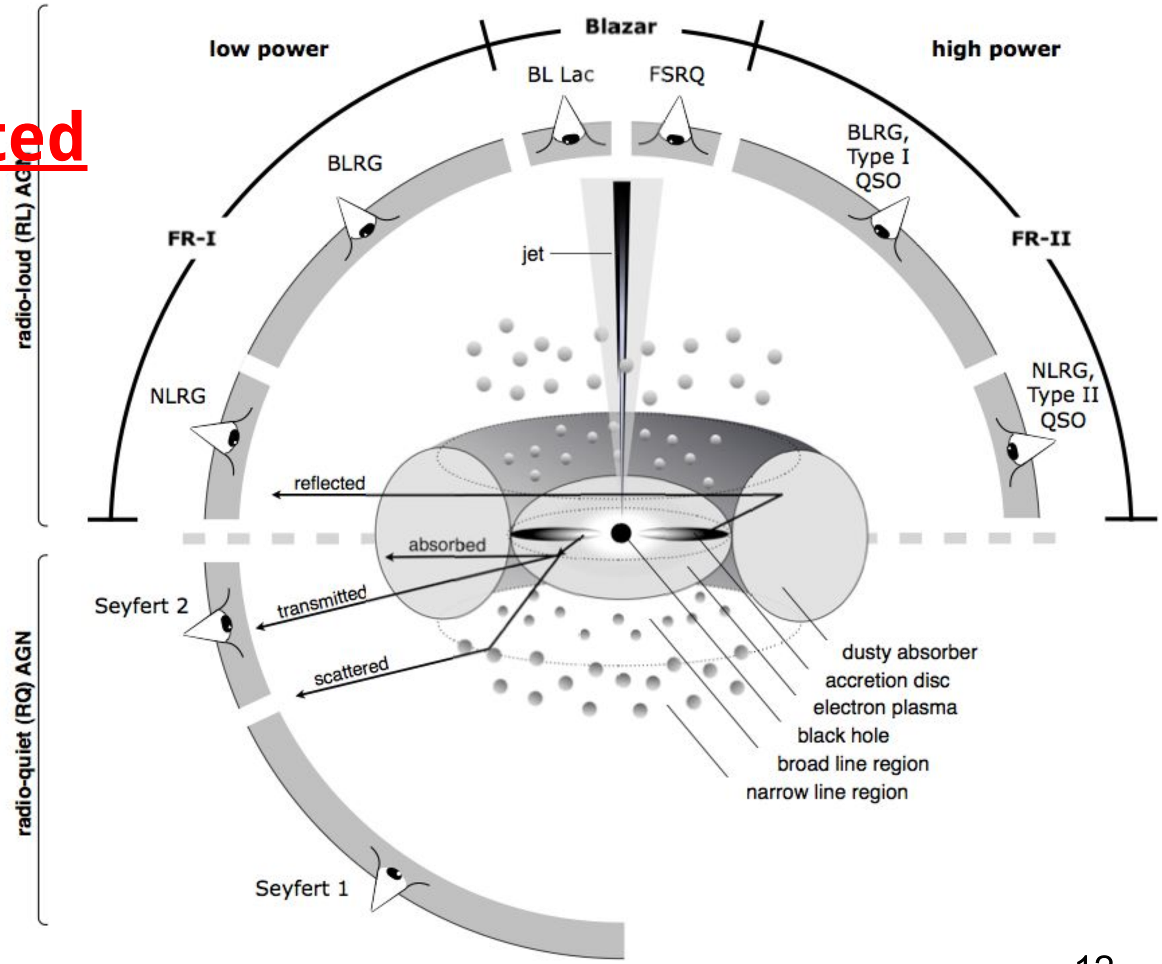
Relativistic effects on the reflection features → <u>one way</u> to measure the spin



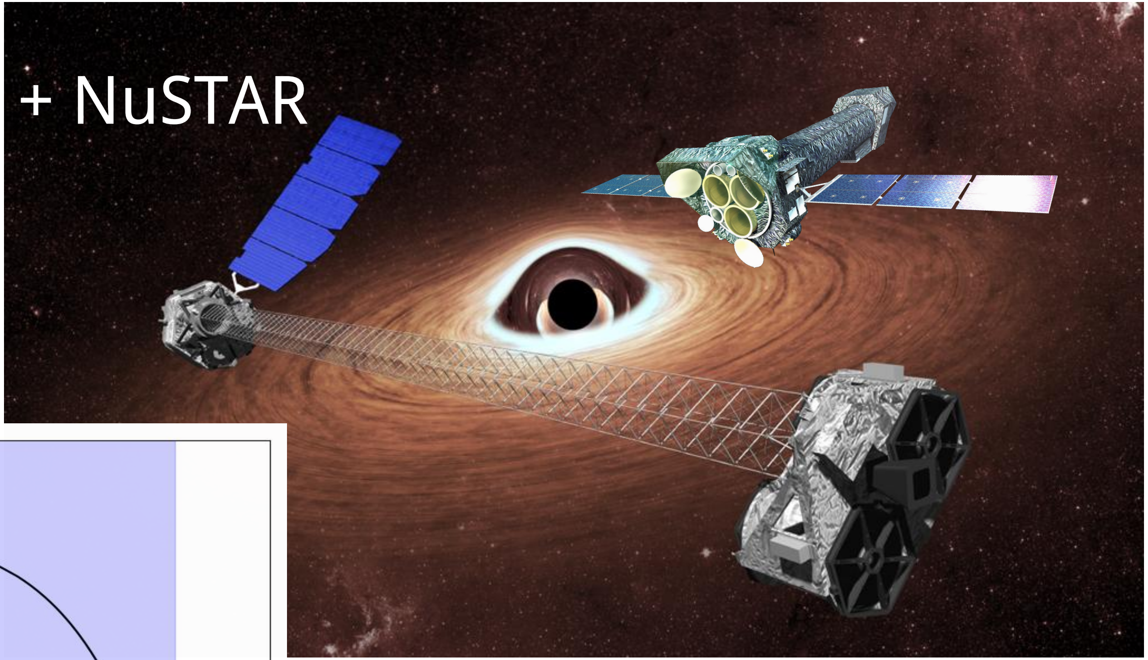
Parker+14

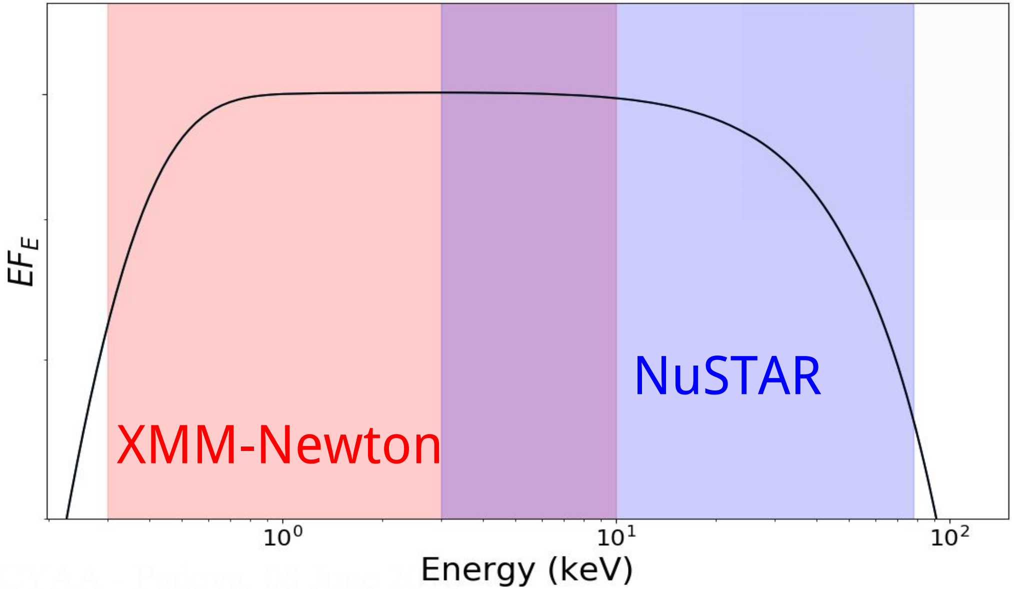


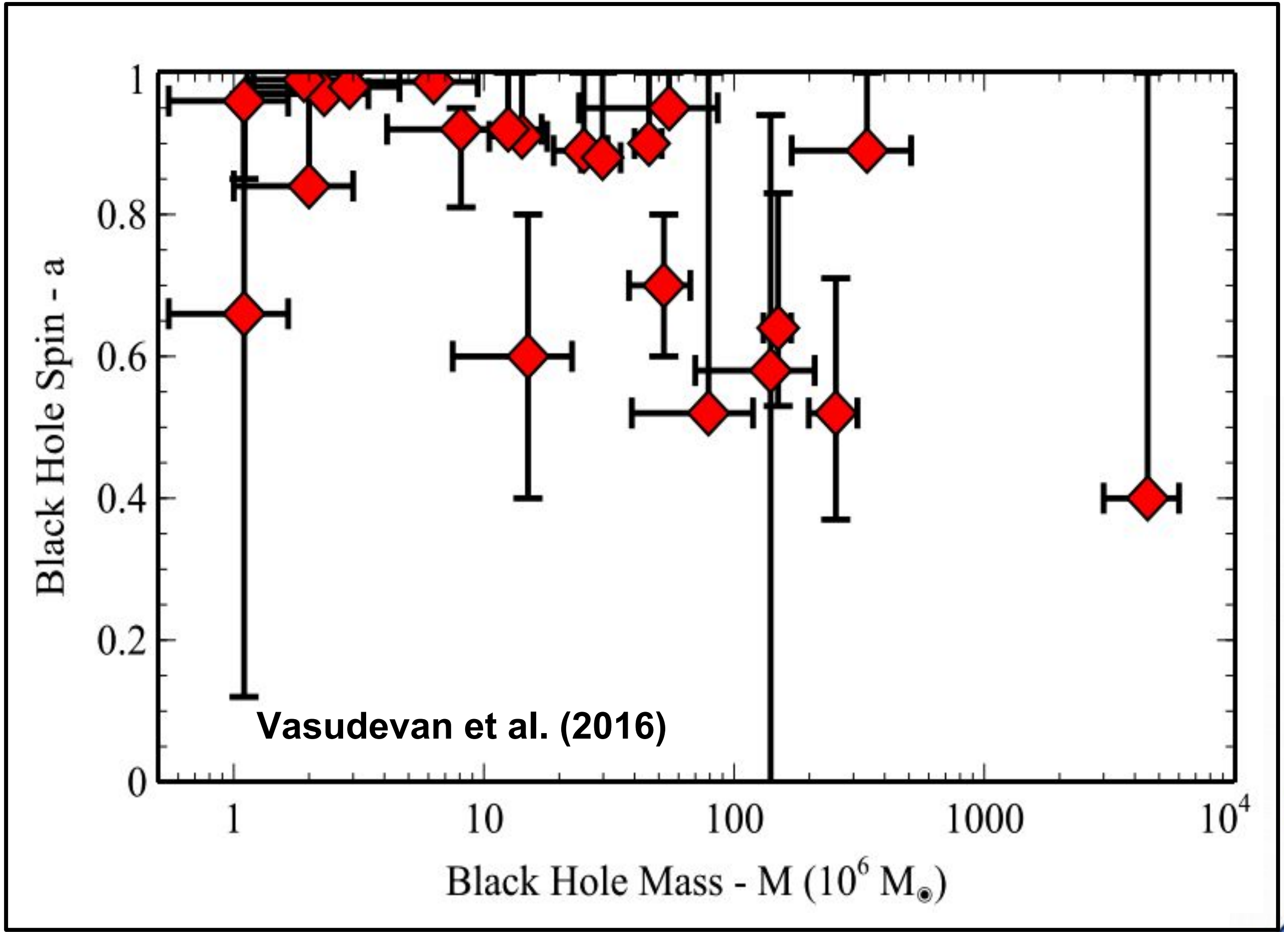
… However, the AGN environment is **much more complicated**



The era of XMM-Newton + NuSTAR






1
0.8
0.6
0.4
0.2
0
Black Hole Spin - a
1
10
100
1000
10^4
Black Hole Mass - M (10^6 $M_\odot$)
Vasudevan et al. (2016)

Preliminary answer: spectral simulations

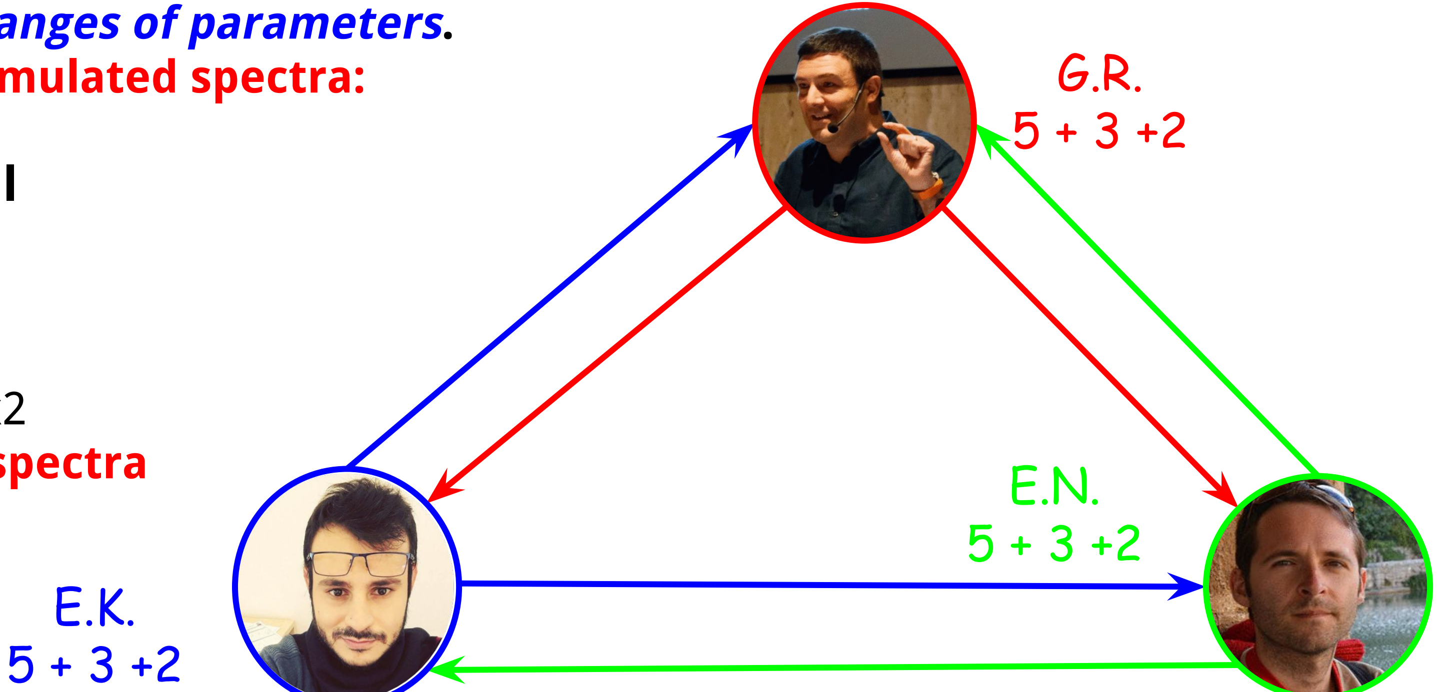
1) Simulation of high-quality *XMM+NuSTAR* spectra:

   -***single-epoch*** observation of **low-redshift bright (1-3 mCrab)** AGN,
   - ***observed ranges of parameters*.**

   Total of **30 simulated spectra:**

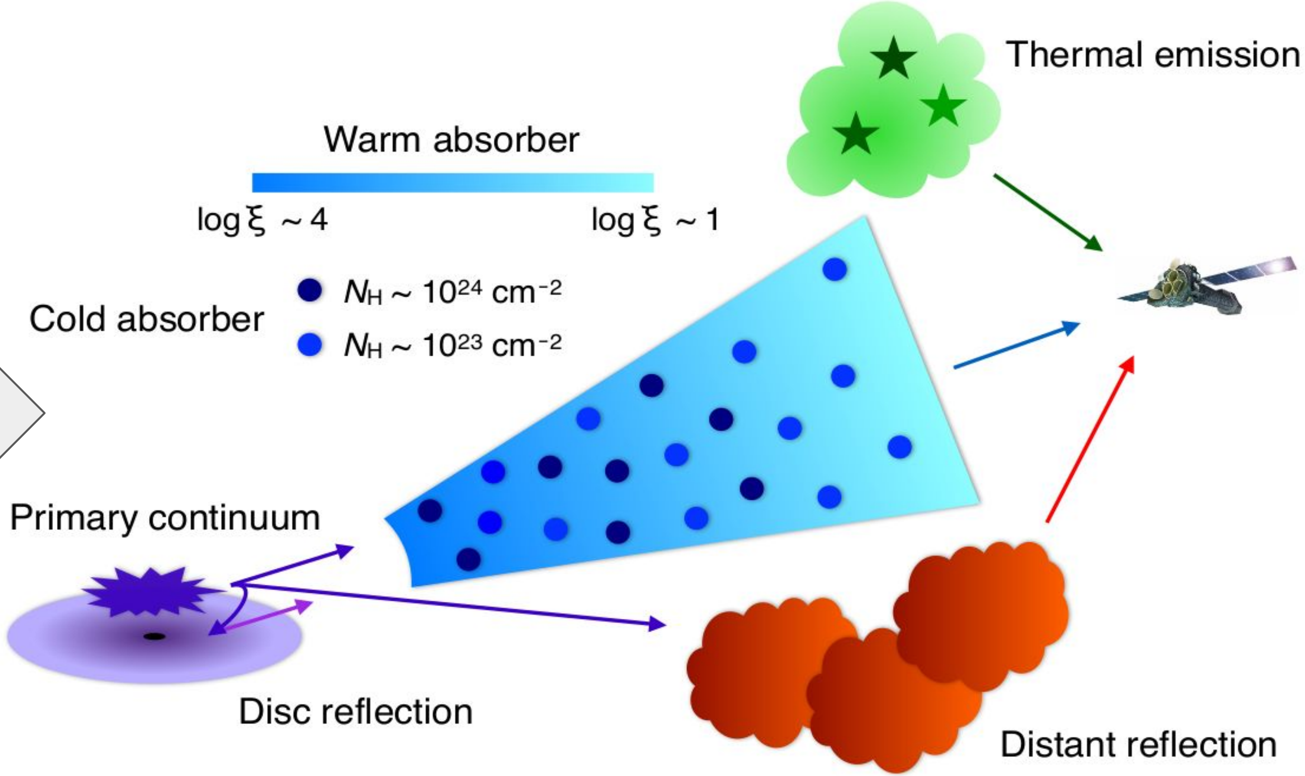
   15 x **General**
   9 x **Bare**
   6 x **Kerr**

2) Blind fitting x2
   ⇒ **60 fitted spectra**
3) Fit vs Input



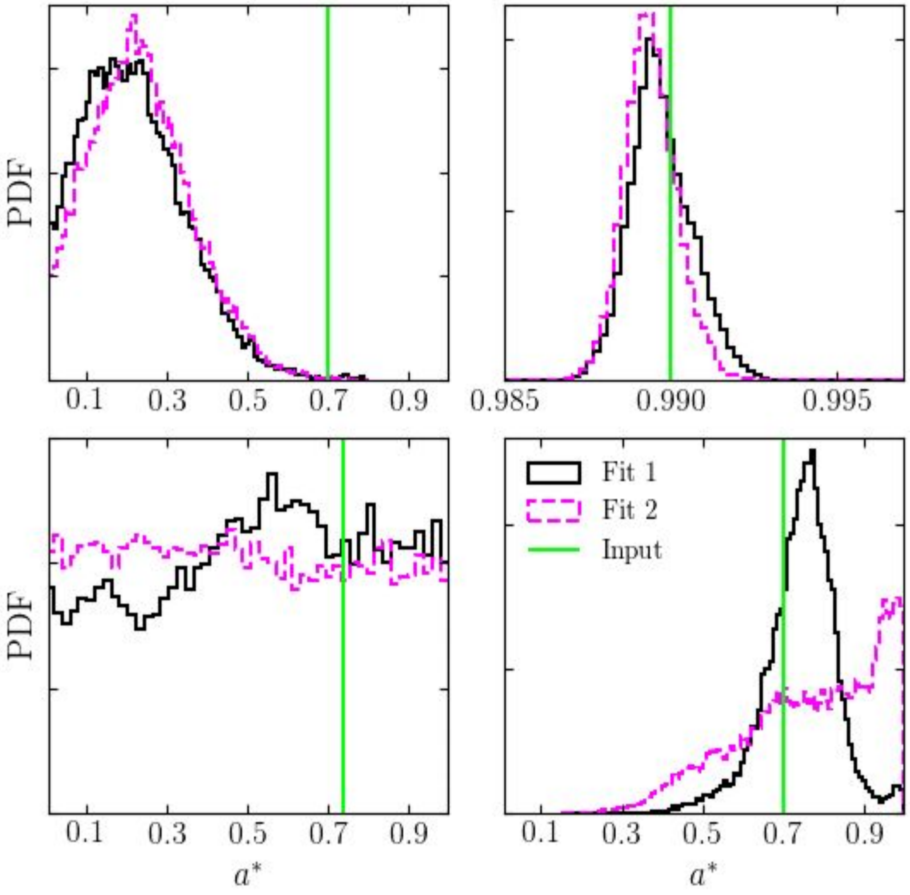
Preliminary answer: spectral simulations

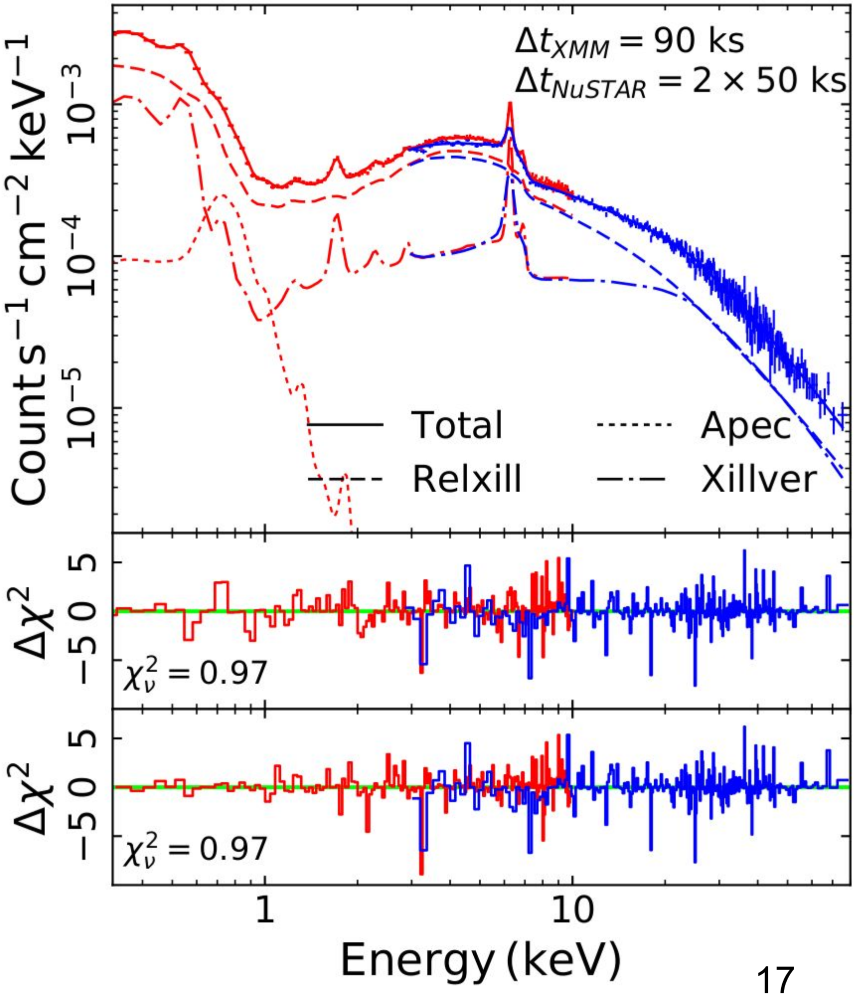
NGC 1365



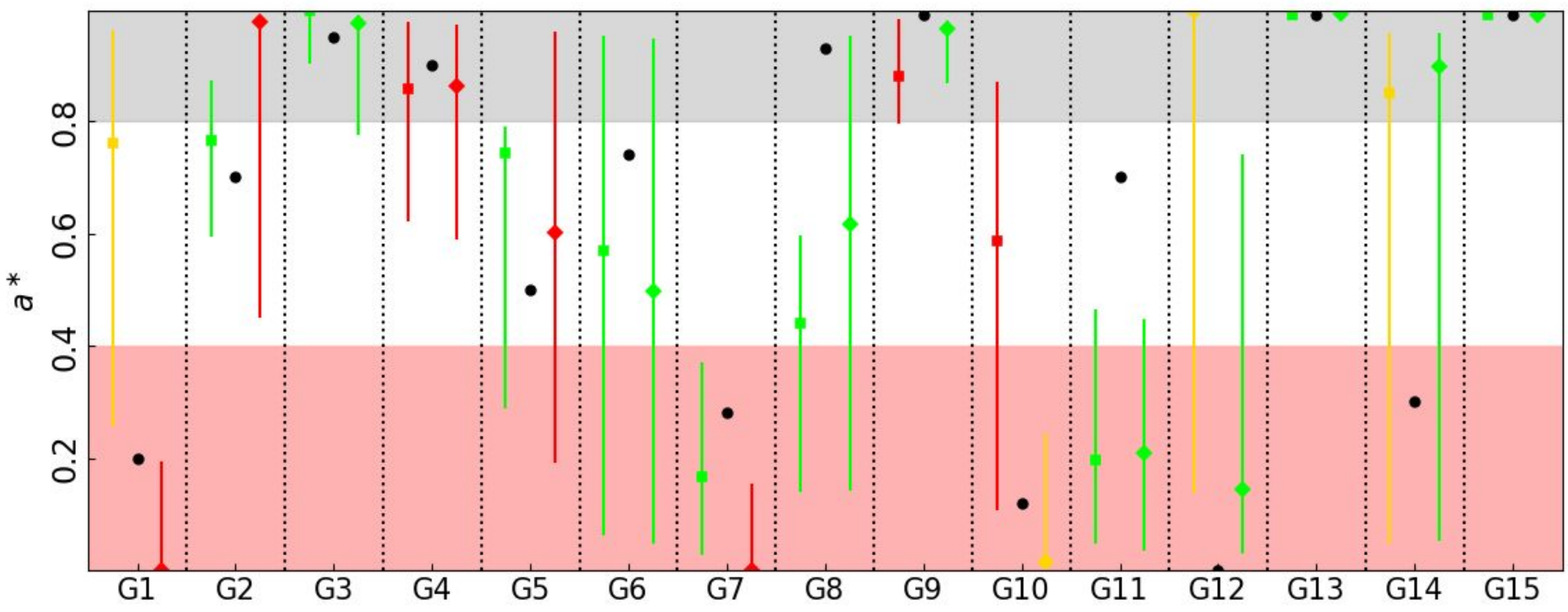
model = XSTAR × zpcfabs × zpcfabs × Relxill_LP + Xillver + Apec

Results

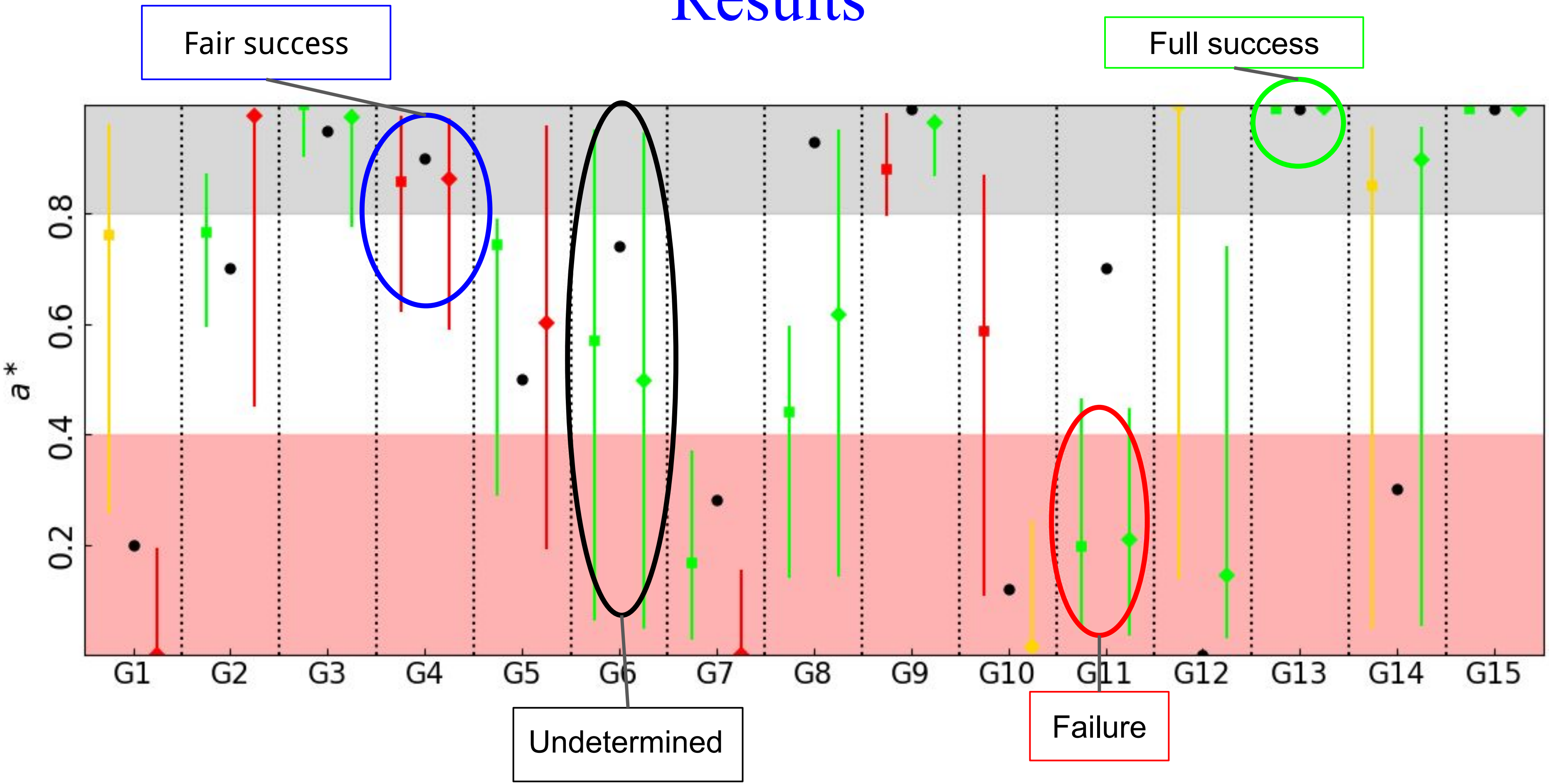

PDF
PDF
0.1 0.3 0.5 0.7 0.9
0.985 0.990 0.995
Fit 1
Fit 2
Input
a^*
a^*


$\Delta t_{XMM} = 90$ ks
$\Delta t_{NuSTAR} = 2 \times 50$ ks
Total
Apec
Relxill
Xillver
Counts s^{-1} cm^{-2} keV^{-1}
$\Delta\chi^2$
$\chi^2_\nu = 0.97$
$\Delta\chi^2$
$\chi^2_\nu = 0.97$
Energy (keV)

Results

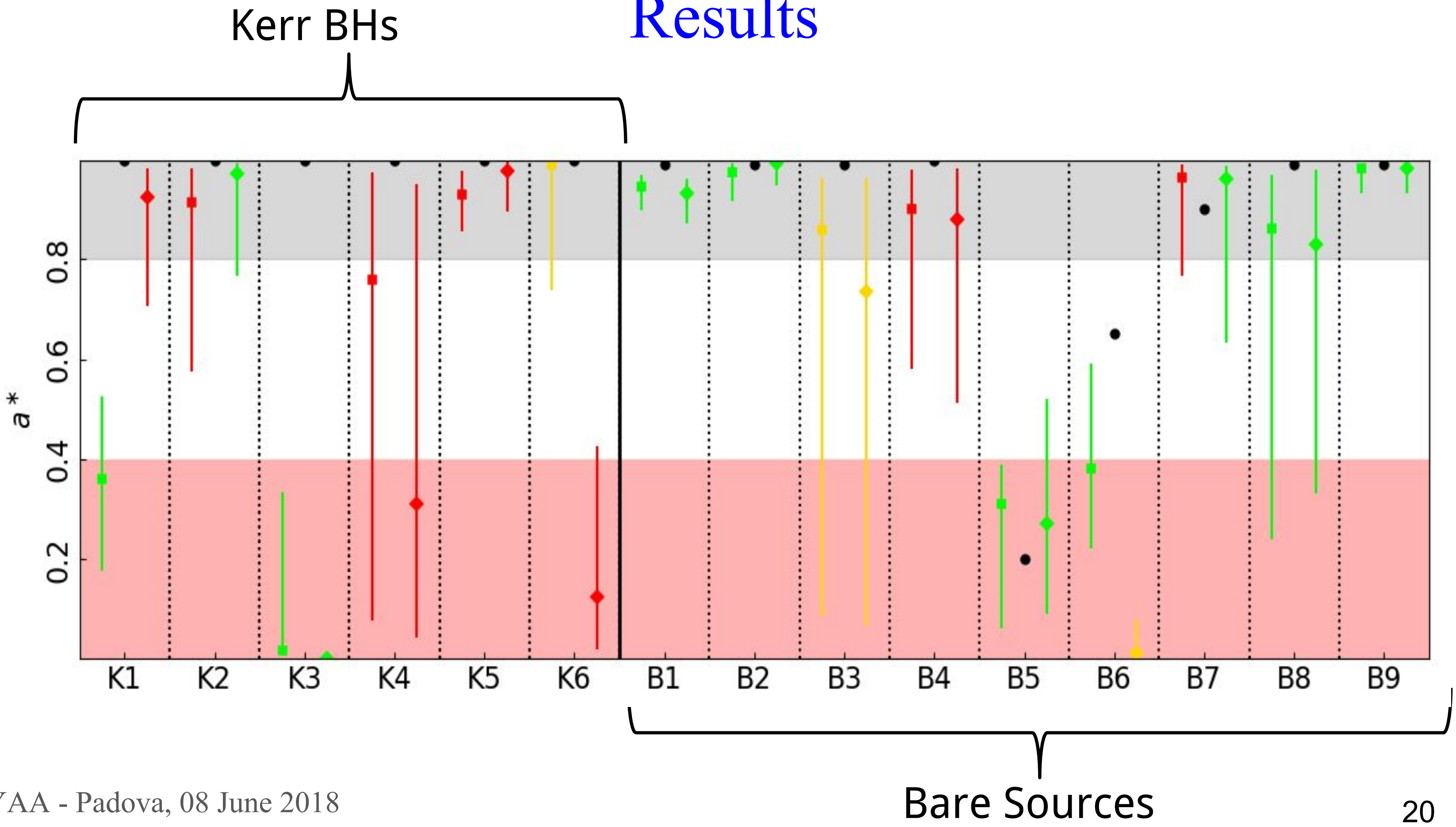


Results



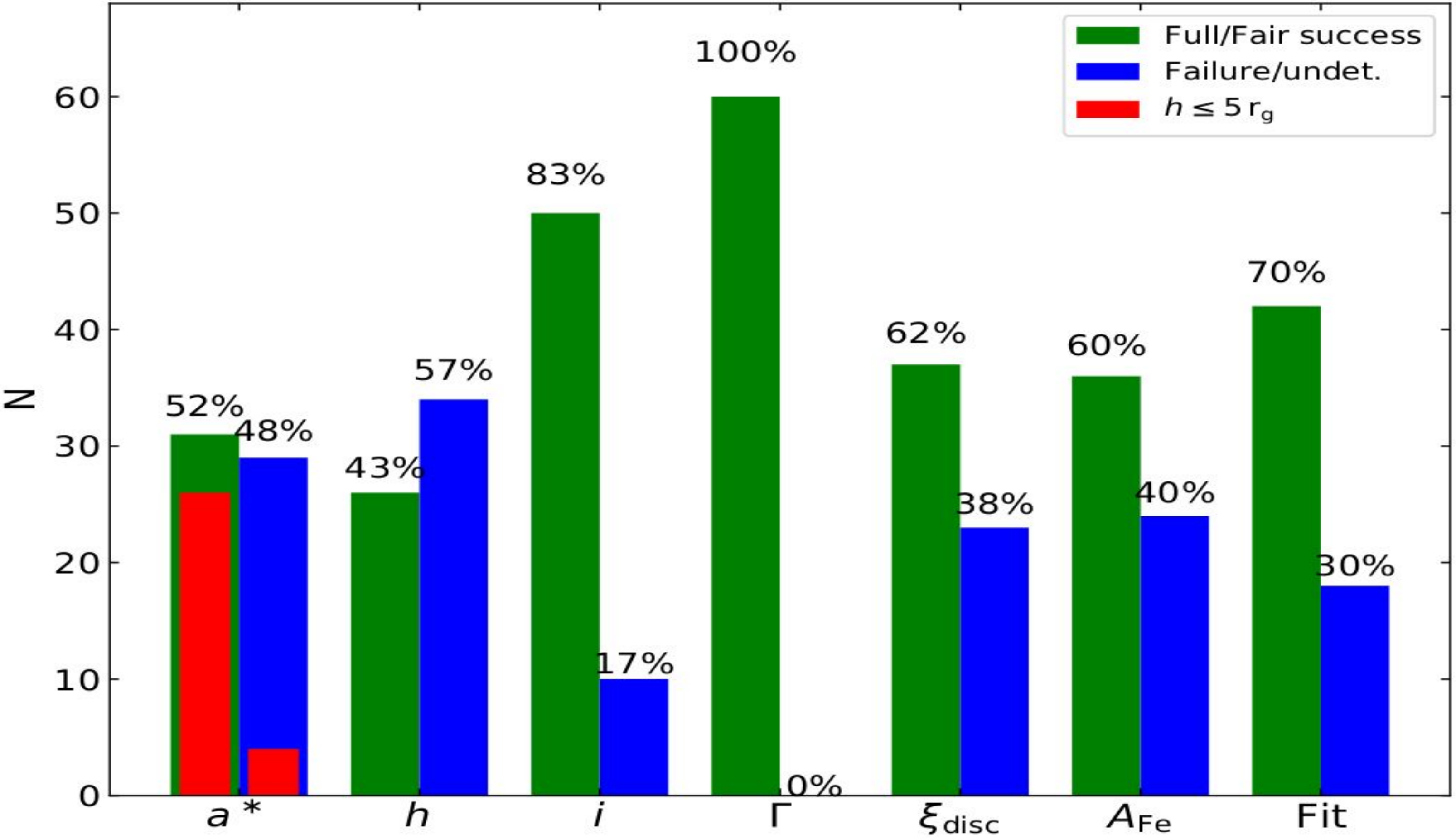
Fair success
Full success
0.8
0.6
0.4
0.2
a*
G1
G2
G3
G4
G5
G6
G7
G8
G9
G10
G11
G12
G13
G14
G15
Undetermined
Failure

Results



Kerr BHs
a*
0.2
0.4
0.6
0.8
K1
K2
K3
K4
K5
K6
B1
B2
B3
B4
B5
B6
B7
B8
B9
Bare Sources

Results



Full/Fair success
Failure/undet.
$h \leq 5\,r_g$
N
0
10
20
30
40
50
60
52%
48%
43%
57%
83%
17%
100%
0%
62%
38%
60%
40%
70%
30%
$a*$
h
i
Γ
ξ_{disc}
A_{Fe}
Fit

Conclusions

Low/intermediate spin: 22 cases

- Full: 3/18
- Fair: 6/22
- Undetermined: 6/22
- Failure: 7/22

High spin: 38 cases

- Full: 9/38
- Fair: 13/38
- Undetermined: 1/38
- Failure: 15/38

h < 5 rg: 30 cases

- Full: 10/30
- Fair: 16/30
- Undetermined: 0/30
- Failure: 4/30

h > 5 rg: 30 cases

- full: 2/30
- Fair: 3/30
- Undetermined: 7/30
- Failure: 18/30

Conclusions

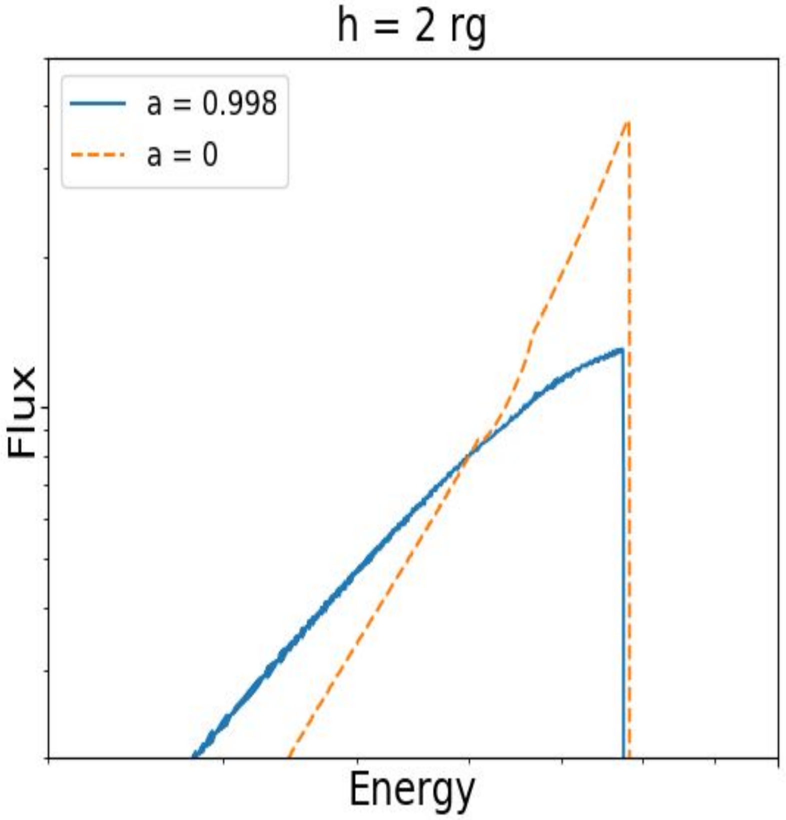
High spin & h < 5rg: 24 cases
- Full: 9/24
- Fair: 13/24
- Undetermined: 0/24
- Failure: 2/24

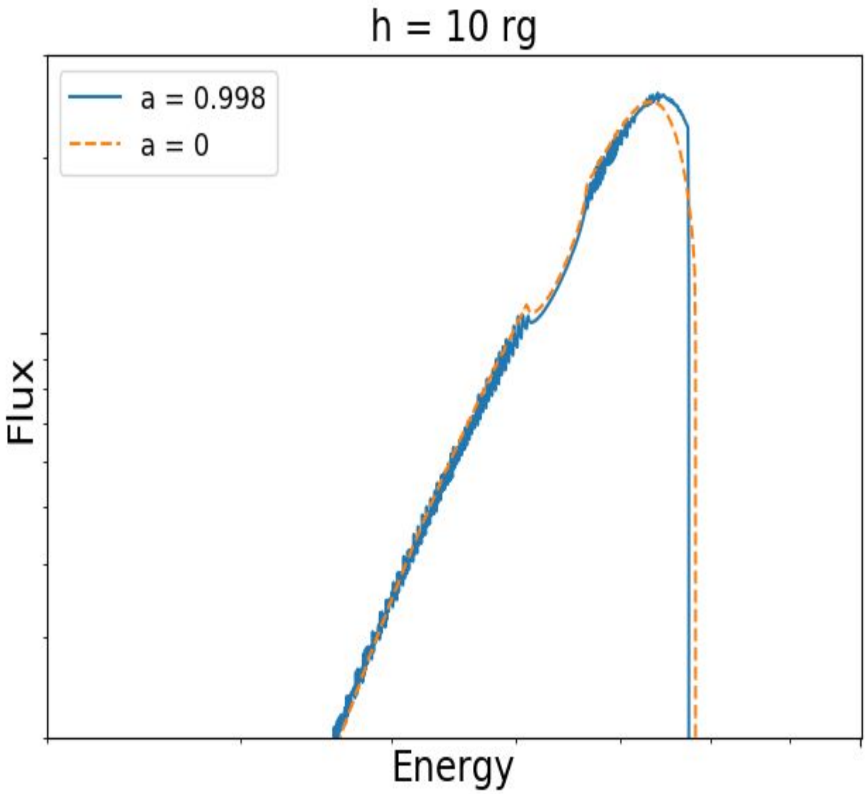
High spin & h > 5 rg: 14 cases
- **Full: 0/14**
- **Fair: 0/14**
- Undetermined: 1/14
- Failure: 13/14

Low/Intermediate spin & h < 5rg: 6 cases
- full: 1/6
- Fair: 3/6
- Undetermined: 0/6
- Failure: 2/6

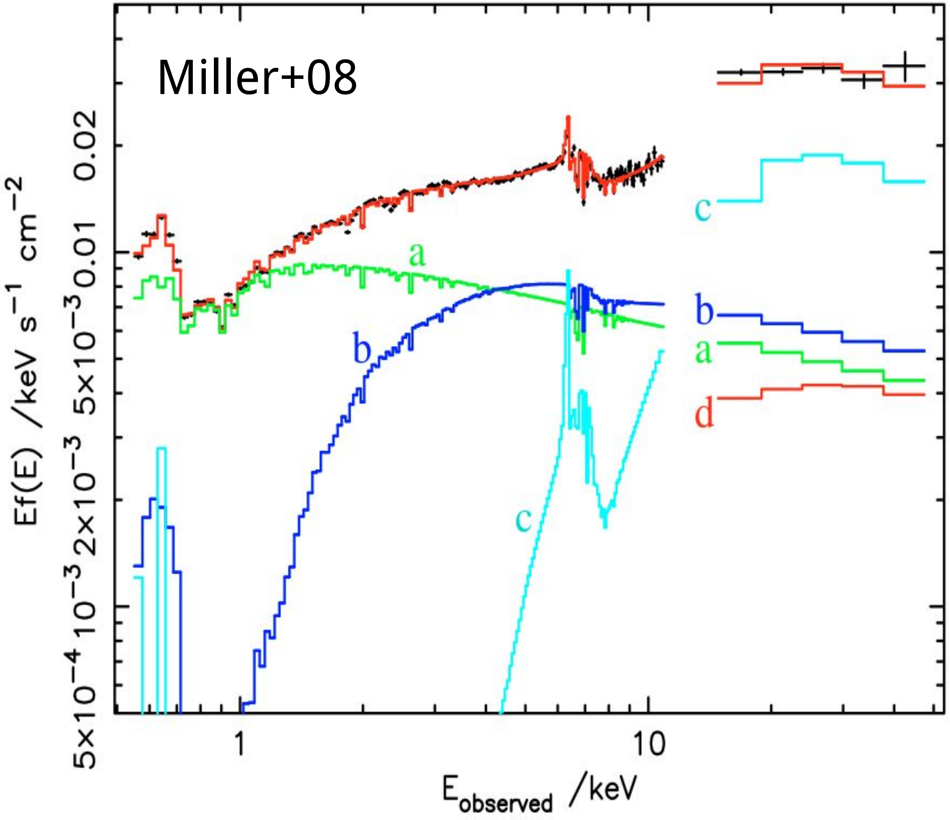
Low/Intermediate spin & h > 5rg: 16 cases
- Full: 2/16
- Fair: 3/16
- Undetermined: 6/16
- Failure: 5/16

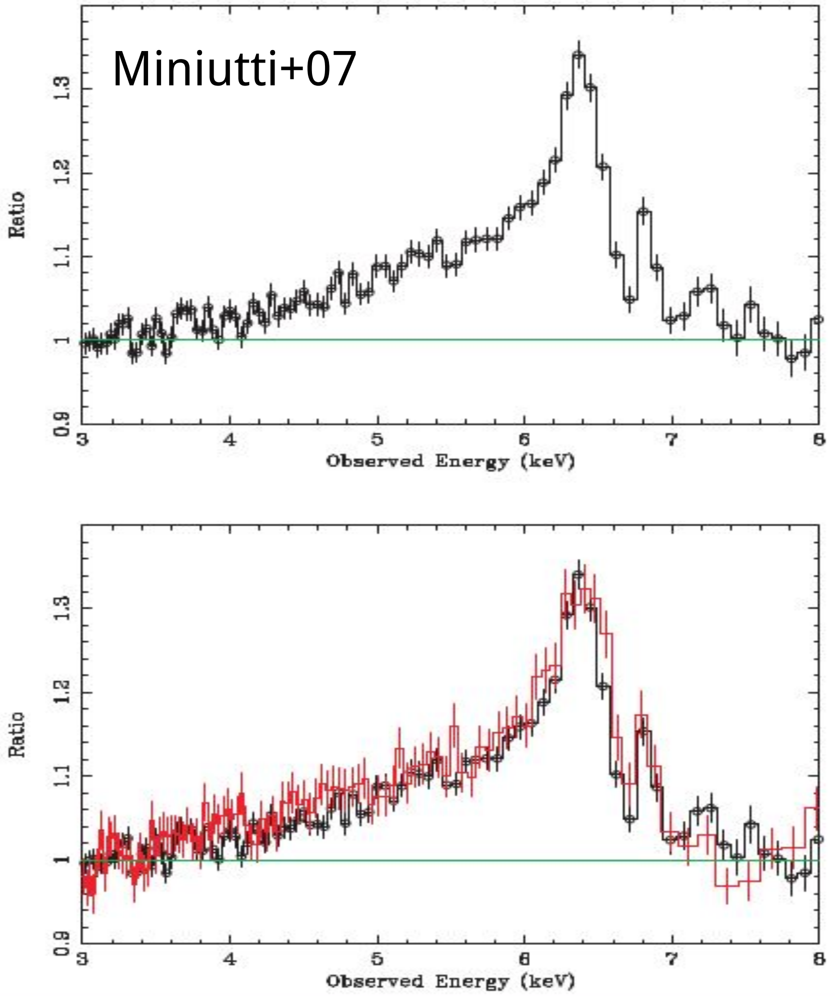
⇒ General trend: the extreme cases, i.e. **high spin + small height**, are more likely to be a success.


h = 2 rg
a = 0.998
a = 0
Flux
Energy

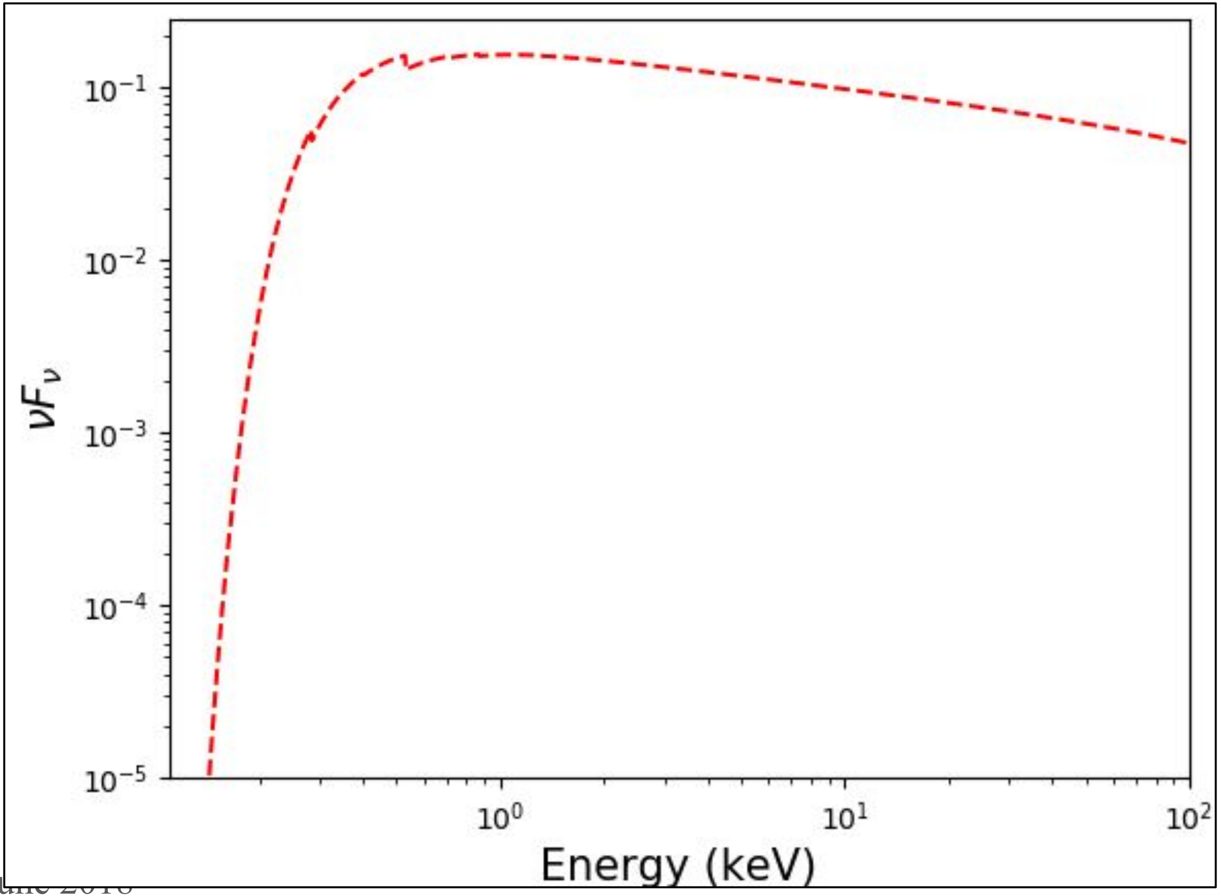

h = 10 rg
a = 0.998
a = 0
Flux
Energy

Absorption vs Reflection

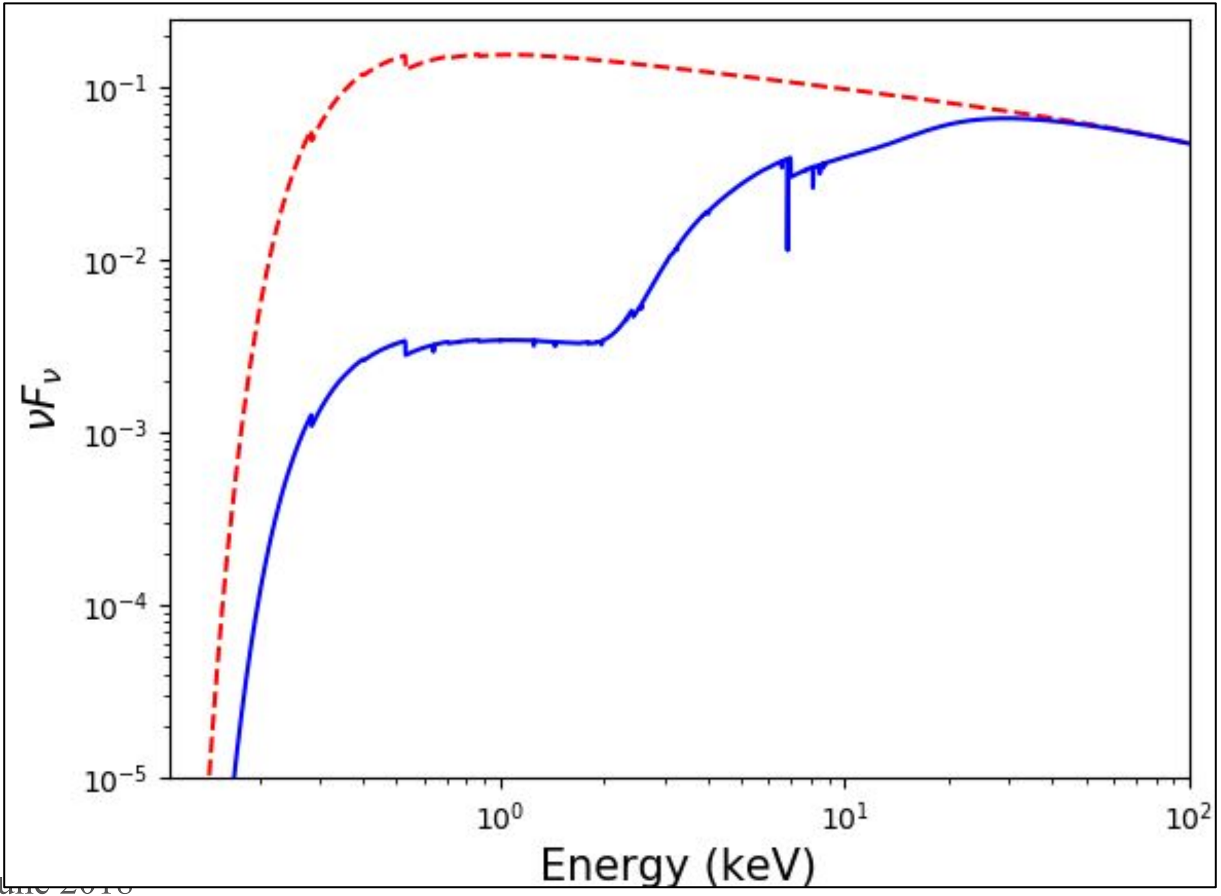




Absorption vs Reflection



Absorption vs Reflection



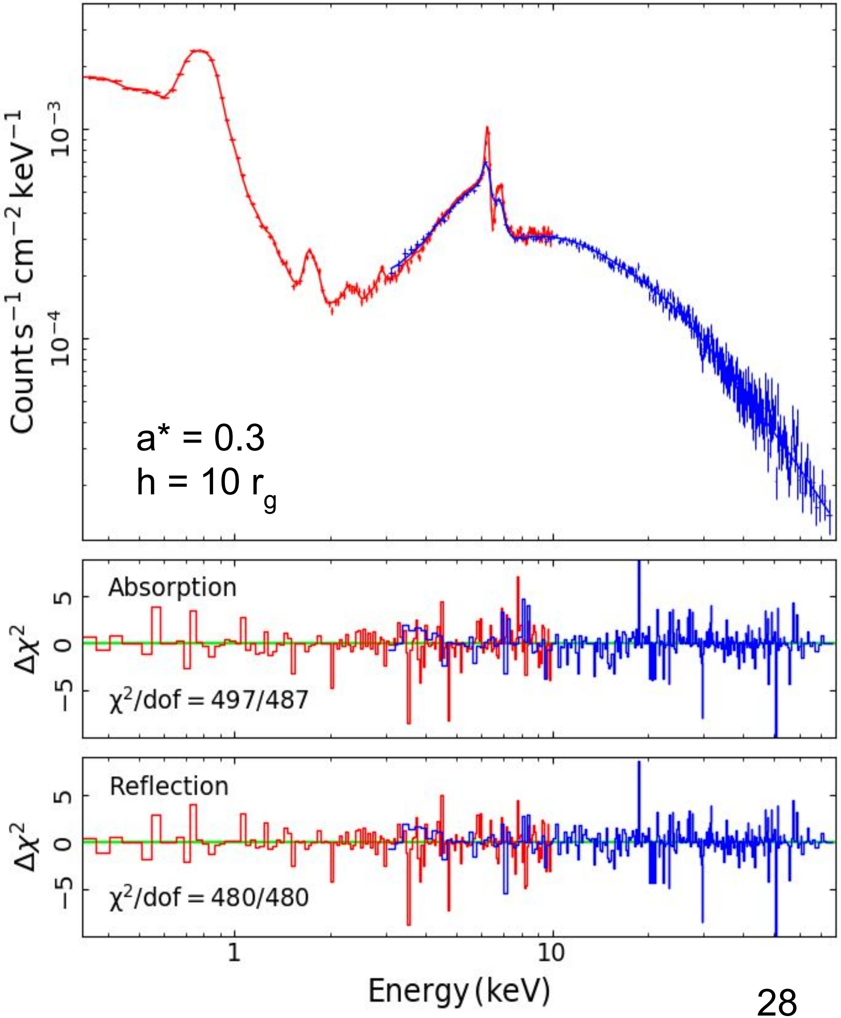
Absorption vs Reflection

- Only <u>**4/30**</u> cases could be fitted with a model consistent of 2-3 partial covering absorption with **no relativistic reflection.**

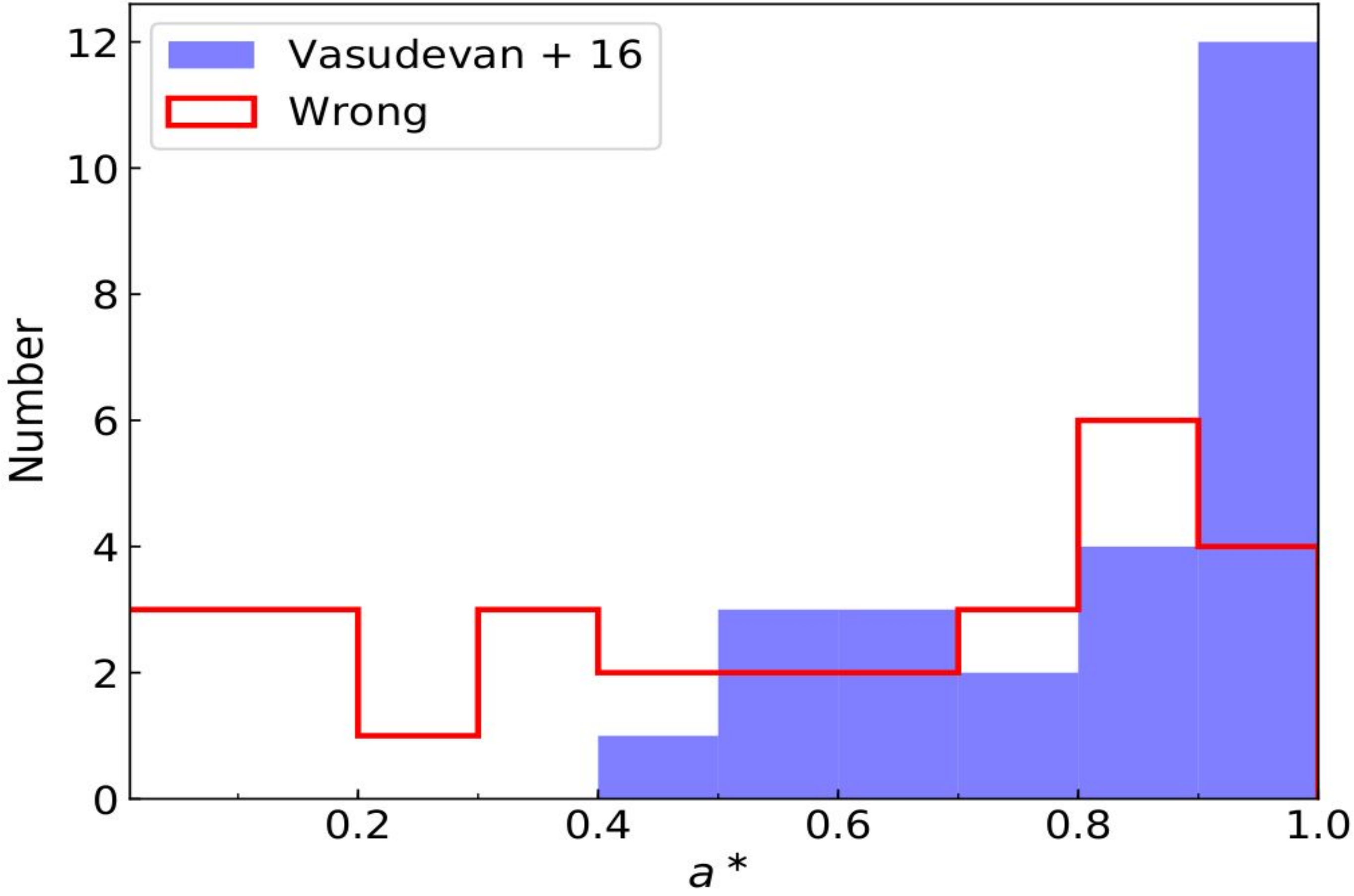
- All of the 4 cases:
  - **not bare**
  - with **h > 5 rg.**

- Things become tricky for **lower S/N** or when the reflection spectrum is **smooth**.

⇒ <u>How to break the degeneracy ?!</u>



Failure vs Observations



Some questions and potential next steps

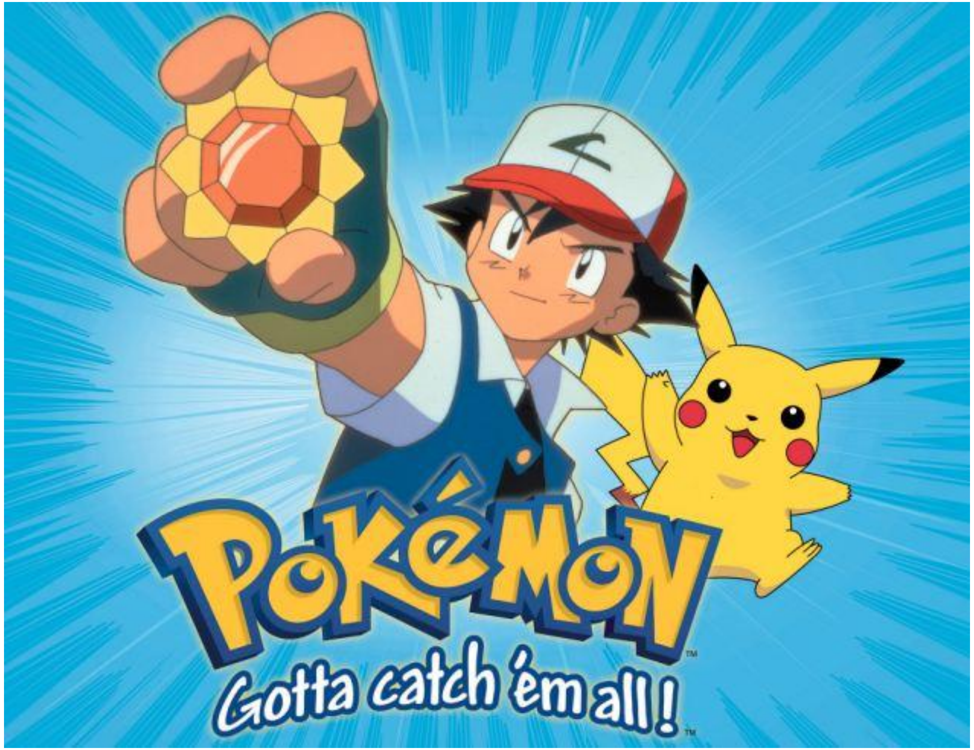
★ Is there degeneracy within the reflection models themselves?
→ We re-fitted the "failed" cases with reflection by fixing A_{FE} and ξ_d ⇒ nothing changed!

★ What about **variability**?
→ Step 2, maybe…

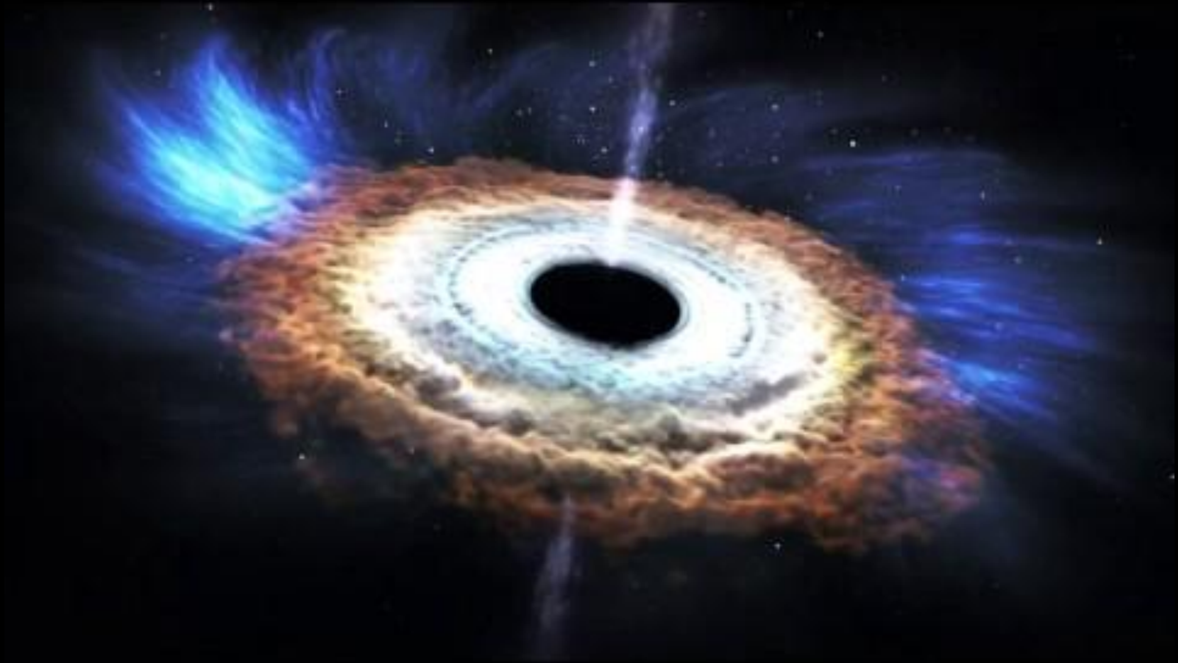
★ More with ***ATHENA !***

★ Should we throw away all spin measurements?
→ Of course ***NO, but one has to be a bit careful, you know…..***

Would you like to join the game?!



Backup slides



	Warm absorption	
N_H (cm^{-2})		10^{18} - 3×10^{24}
log xi		0-5
	Reflection	
h (Rg)		2-300
spin		0-0.998
inclination		3-89 deg
log xi		0-4.7
A_{Fe} (solar)		0.5-10
	Partial covering absorbers	
N_{H1} /N_{H2} (10^{22} cm-2)		0.01 - 20 / 0.01-500
	Thermal emission	
kT (keV)		0.1-15

Conclusions

Missing a component: 7 cases (** **Only one case with high spin & low height** **)

- Full: 1/7
- Fair: 0/7
- Undetermined: 1/7
- Failure: 5/7

Extra component: 11 cases (** **four of them with high spin & low height** **)

- Full: 0/8
- Fair: 6/8
- Undetermined: 1/8
- Failure: 4/8

⇒ General trend: the extreme cases, i.e. **high spin + <u>small height</u>**, are more likely to be a success.

High-resolution spectroscopy with ATHENA