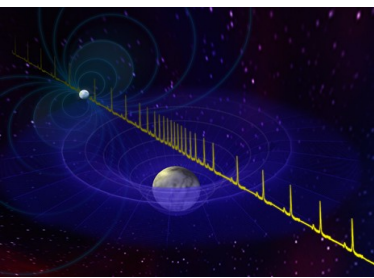


Time evolution of luminosity and spin period of X-ray pulsars in the Small Magellanic Cloud

Jun Yang^{1,2}

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3. University of Southampton, Southampton, United Kingdom



Outline

- ❖ Introduction to the **library** of **pulsars** in the **Magellanic Clouds**

event lists, light curves, periodograms & spectra

- Why study pulsars in Magellanic Clouds:

NSs hold unsolved problems; population-statistical study.

low absorption, minimum foreground contamination, known distance (-> categorize luminosity of the Pulsars). The process of accretion and X-ray emission in HMXB

- ❖ Known pulsars with **combination of 3 satellites, physical parameters**

e.g. SXP 348, SXP 1323

- ❖ **Pulse profile** modeling

e.g. SXP 504

Library of pulsars in the Magellanic Clouds

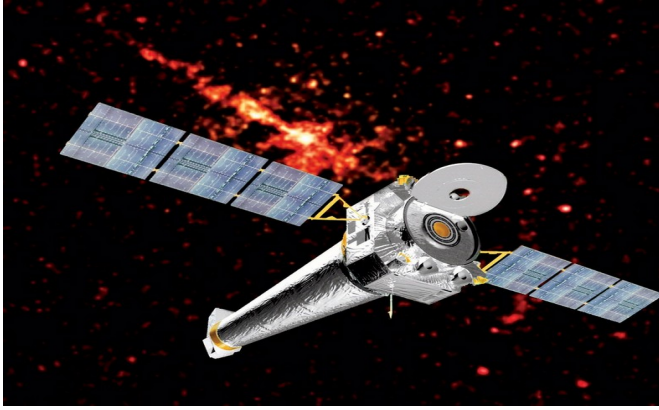
Pulsars in SMC & Model

Intro Library

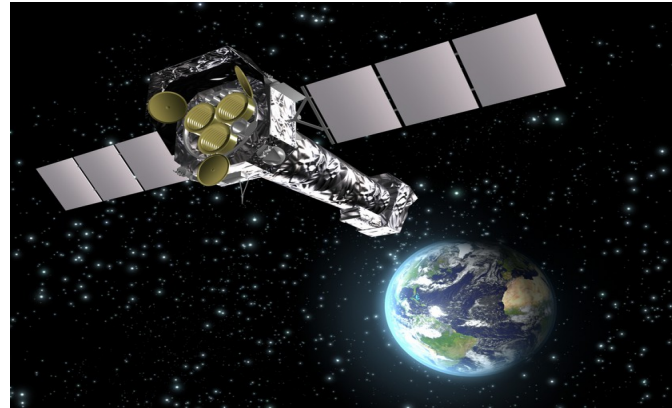
[Pulsar spin up/down](#)

Pulse profile model

In sum



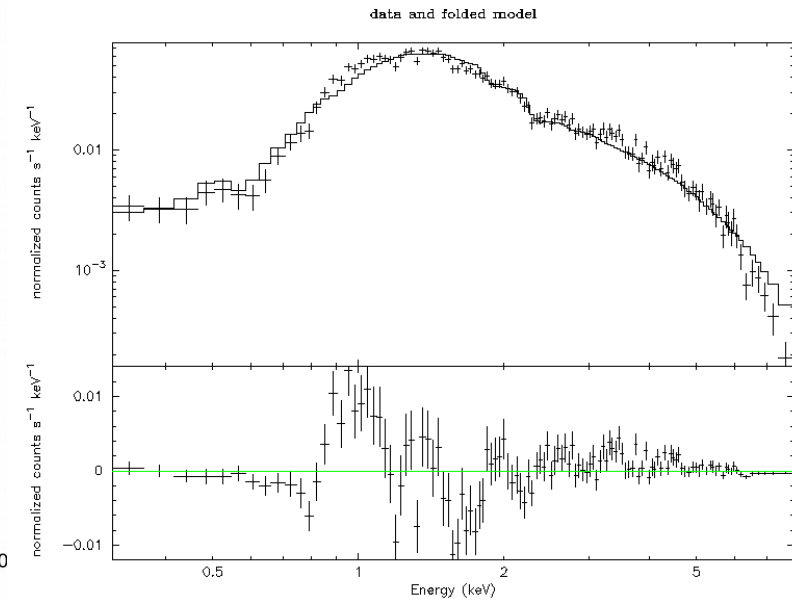
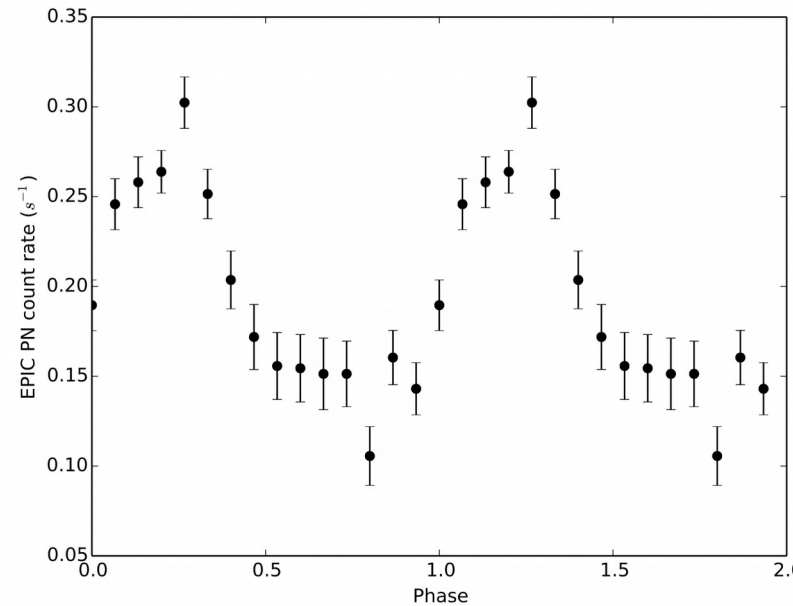
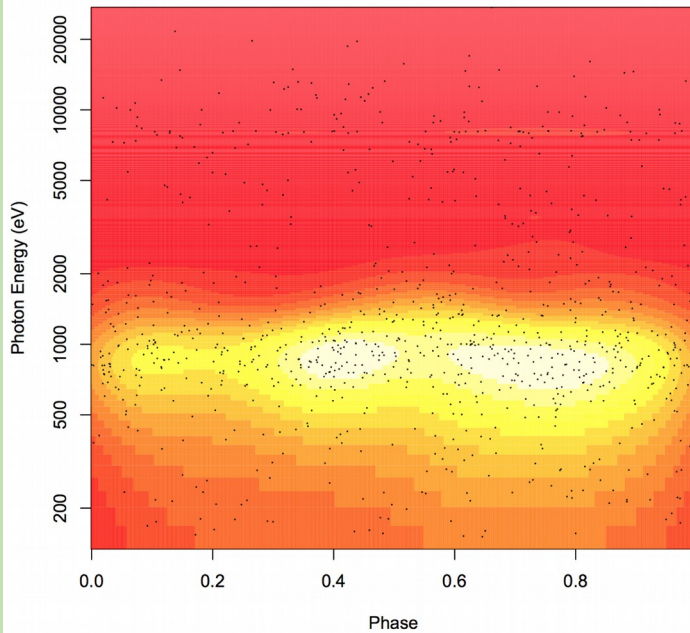
Chandra
155+30 Obs: 2000-2014



XMM-Newton
116+42 Obs: 2000-2014



RXTE
Weekly Obs: 1997-2012



Luminosity of X-ray pulsars in the Small Magellanic Cloud

Pulsars In SMC & Model

Observation overview

Luminosity Range:

10^{31} - 10^{38} erg/s

Intro Library

[Pulsars spin up/down](#)

Pulse profile model

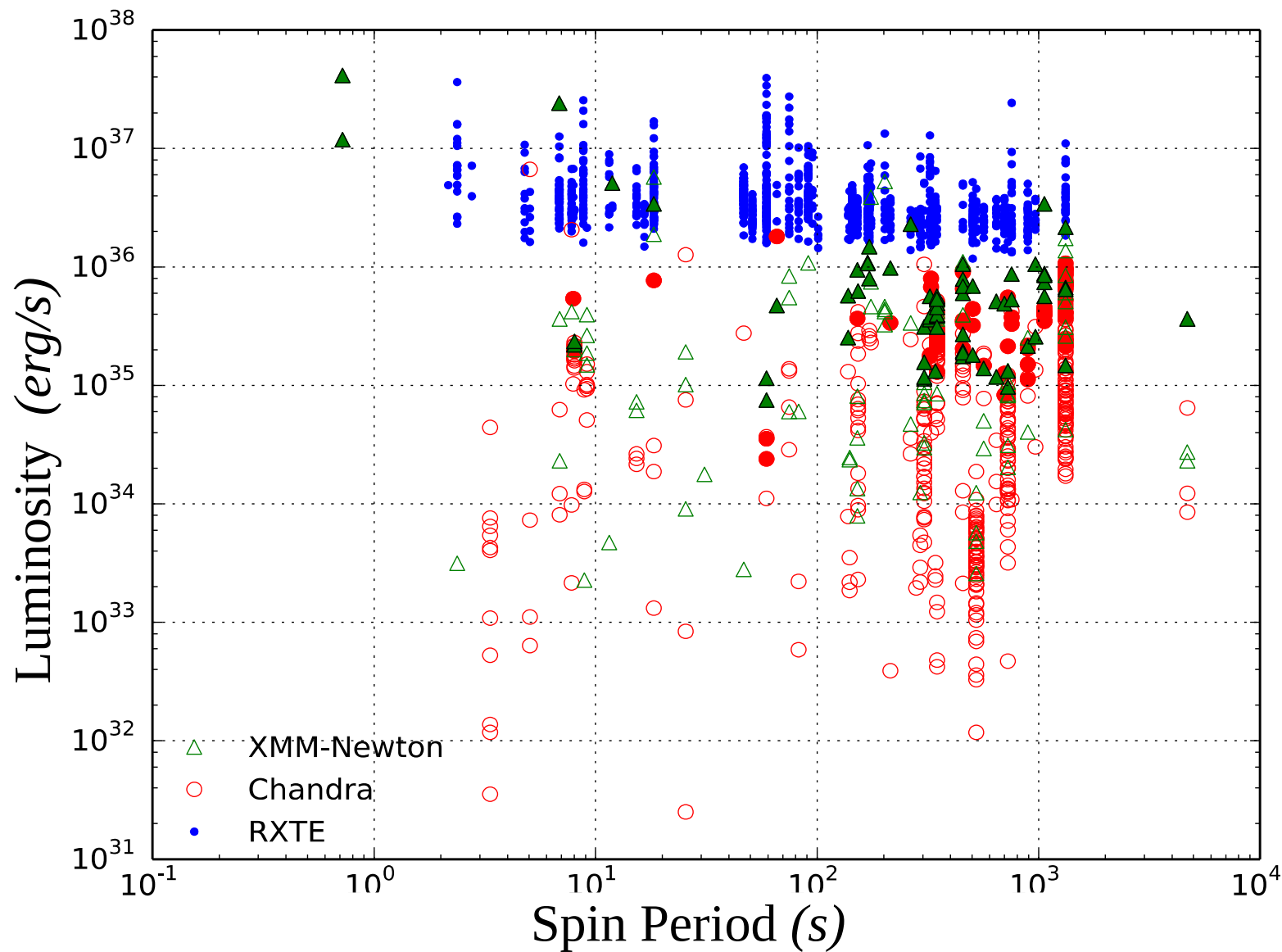
In sum

Fast pulsars

rarely detected

Faint source

Short exposure



Classify:

pulsating & non-pulsating

Luminosity of X-ray pulsars in the Small Magellanic Cloud

Pulsars In SMC & Model

Observation overview

Luminosity Range:

10^{31} - 10^{38} erg/s

Intro Library

[Pulsars spin up/down](#)

Pulse profile model

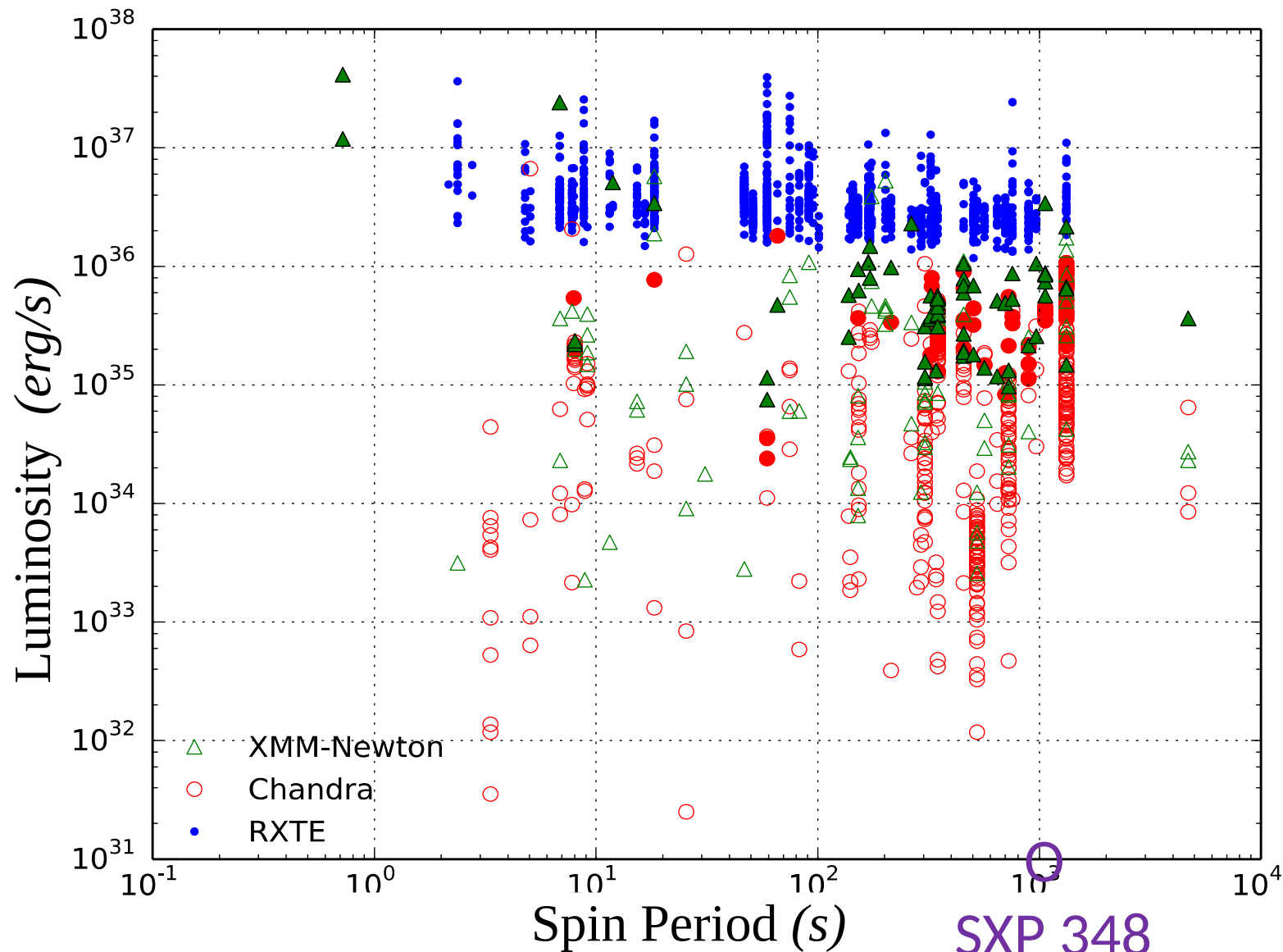
In sum

Fast pulsars

rarely detected

Faint source

Short exposure



Classify:

pulsating & non-pulsating

Time evolution of Source properties with 3 satellite combination

Pulsars
In SMC
& Mode
I

e.g.
SXP 348

Luminosity
(erg/s)

Intro
Library

RXTE does not have Pulse Frac info

Pulse fraction

Pulsars
spin
up
/down

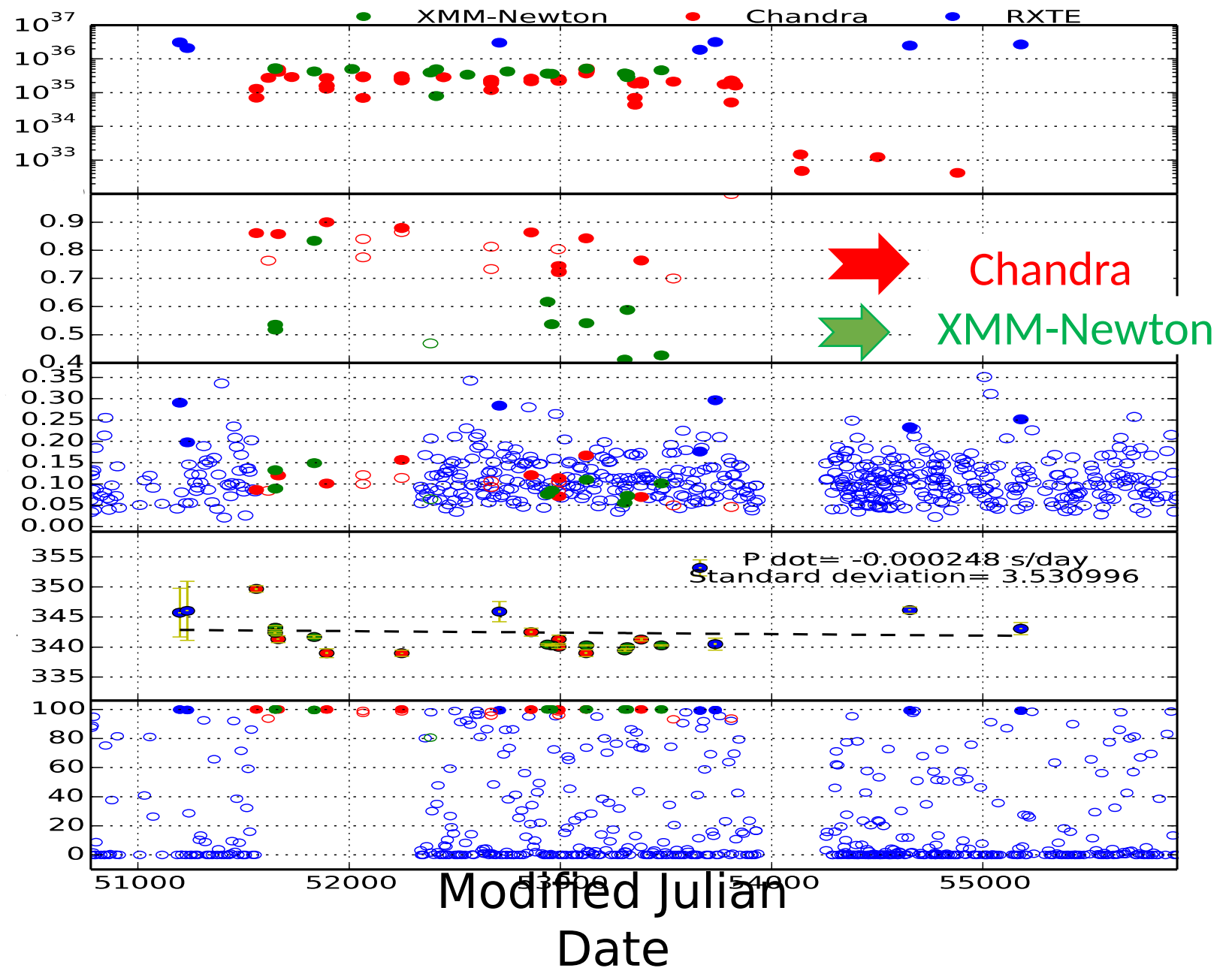
Spin up:
Mass and angular momentum to NS

Spin Period(s)

Pulse
profile
model

Significance (%)

In sum



SMC Pulsar library products

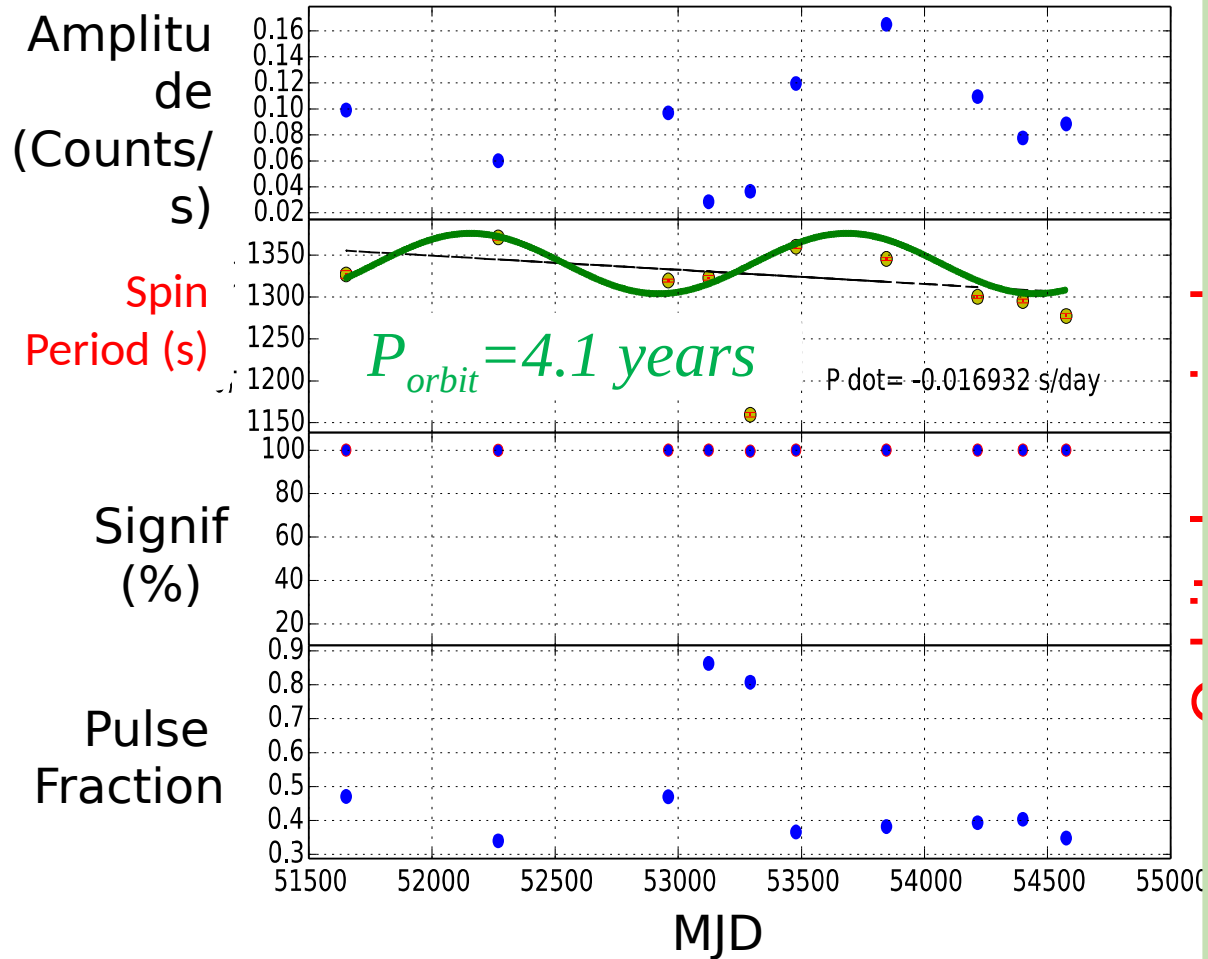
Pulsars
In SMC
& Mode
I

Intro
Library

**Pulsars
spin
up
/down**

Pulse
profile
model

In sum

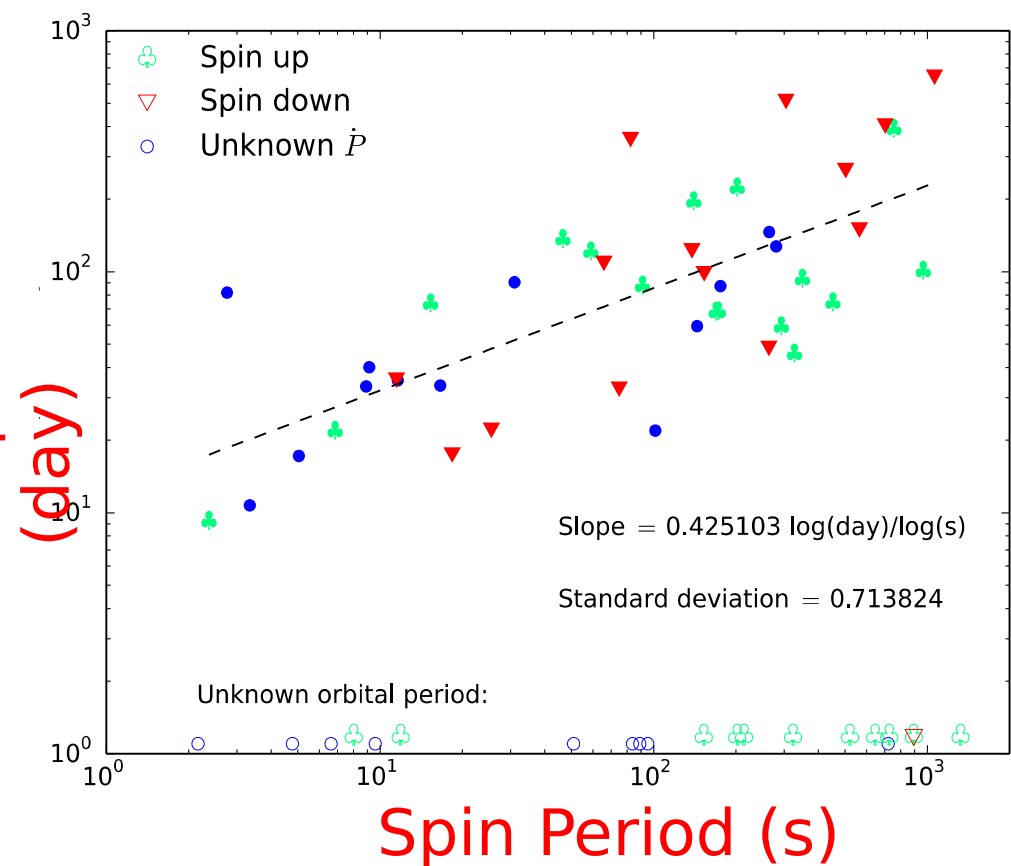


e.g. SXP 1323

Spin up: 0.016932 s/day

Orbital modulation, accretion torque

Orbital period



$$P_{orbit} = 12.0656 \text{ (days)} * P_{spin}^{0.4251}$$

26 spin up 17 spin down

43 out of 65 pulsars have measured orbit period

Model: Off-center magnetic axis with GR effect

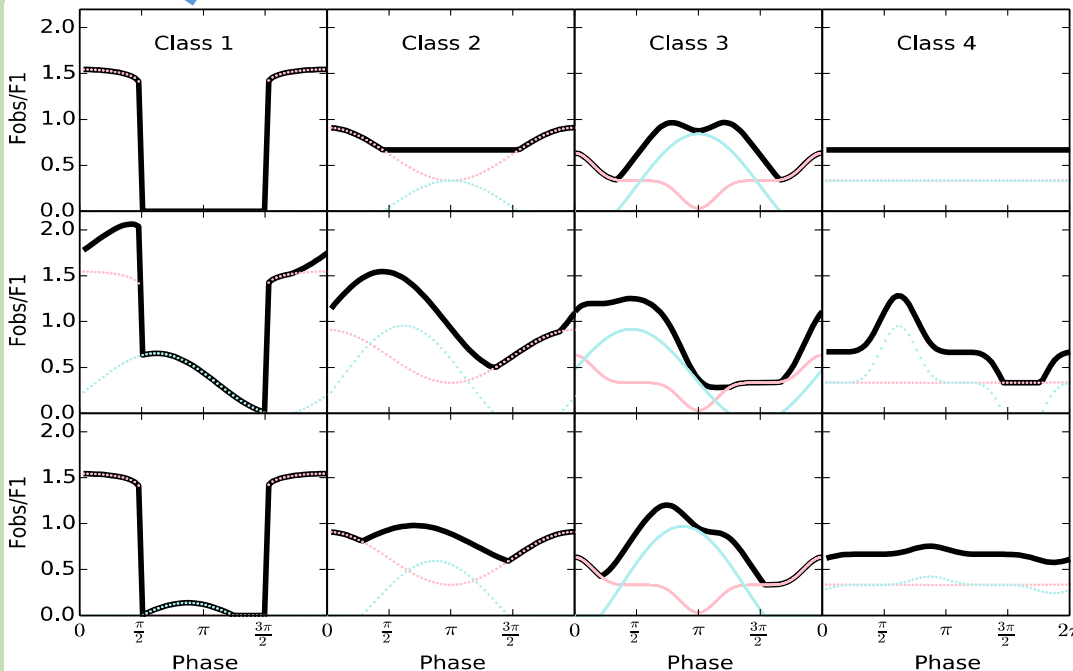
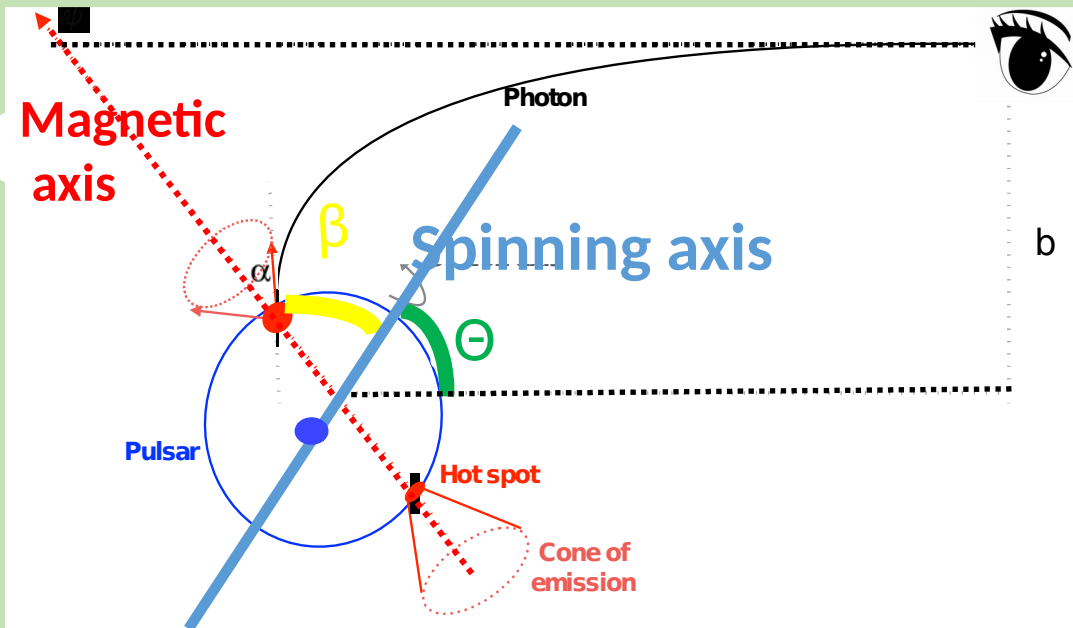
Pulsars
In SMC
& Mode I

Intro
Library

Pulsar
Spin
up
/down

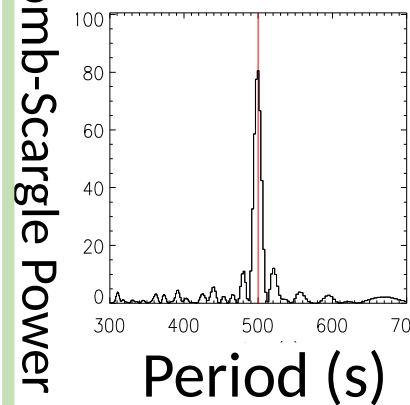
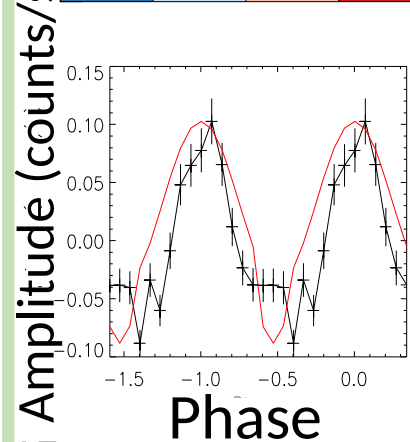
**Pulse
profile
model**

In sum

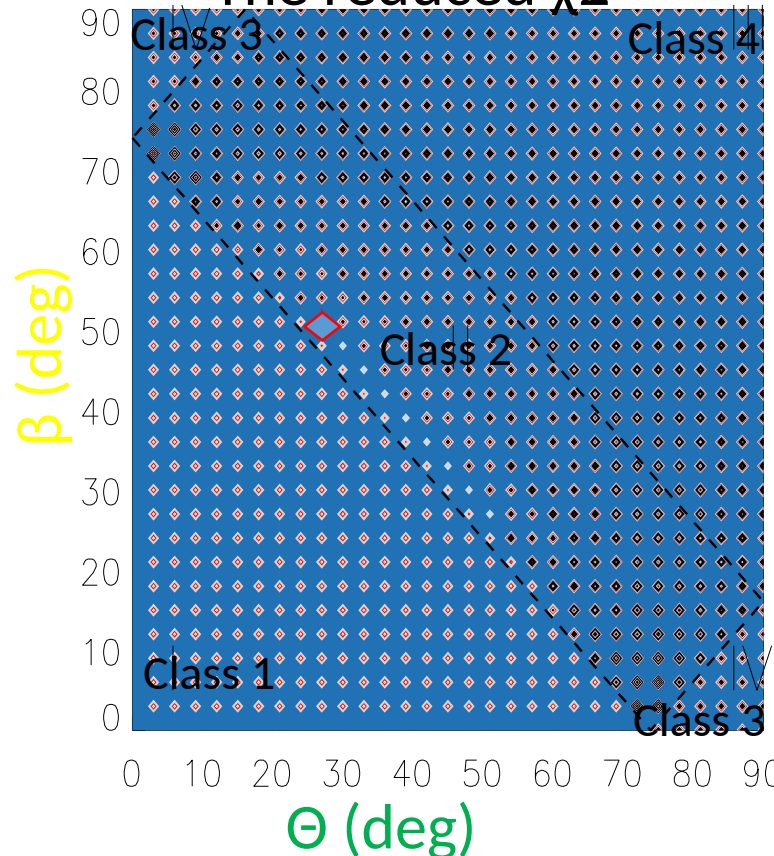


SXP 504 2003-12-14 Observation

0.0 2.3 4.6 6.8 9.1 11.4 13.7 16.0 18.2 20.5 22.8 25.1 27.4



The reduced χ^2



Best fitting angle: $\theta = 28^\circ$ and $\beta = 52^\circ$

θ : angle between spinning axis and B

β : angle between spinning axis and light of sight

Summary & Outlook

❖ Library of 3 satellites combination: **Chandra**, **XMM-Newton**, **RXTE**

Known pulsars in **SMC & LMC** : event lists, pulse profiles, spectra

❖ Time evolution of their luminosities and spin period

26 spin **up** and 17 spin **down**

❖ Modeling

More phenomenon into current model: e.g., flow column geometry including physics of accretion shock, accretion rate and photon energy

❖ **Astrosat & HXMT (Hard X-ray Modulation Telescope)**

Investigate the **hard X-ray sources**; bright galactic pulsars, **expand the period range** of the pulsars

Pulsars
In SMC
& LMC

Into
Library

Pulsars
spin
up
/down

Pulse
profile
model

**In
sum**

Pulsar
s In
SMC
& Mode
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Into
Library

Pulsar
s
spin
up
/down

Pulse
profile
model

In sum

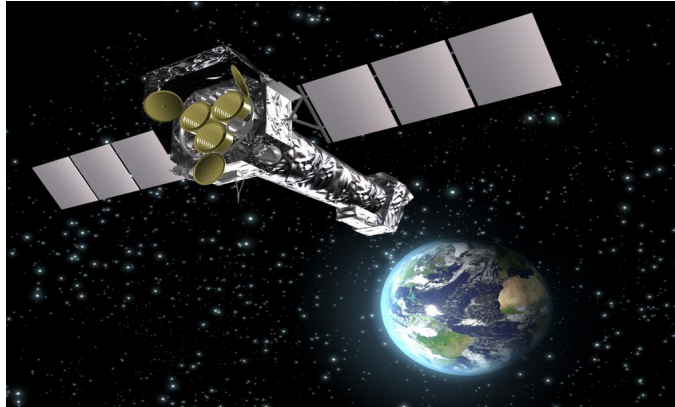
Thank you!



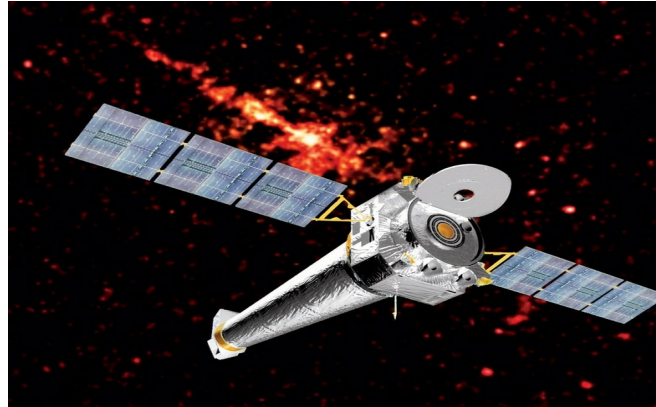
Library of pulsars in the Magellanic Clouds

Pulsars
In SMC
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Intro
Library



XMM-Newton
116+42 Obs: 2000-2014



Chandra
155+30 Obs: 2000-2014

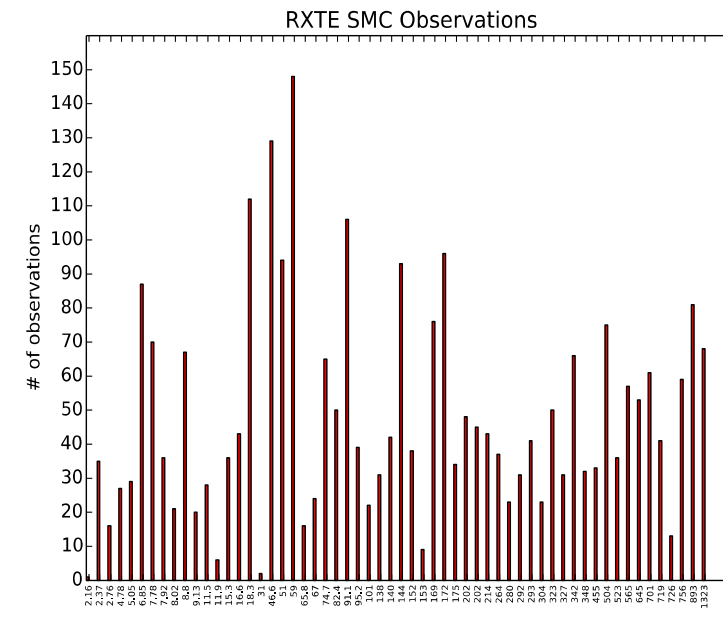
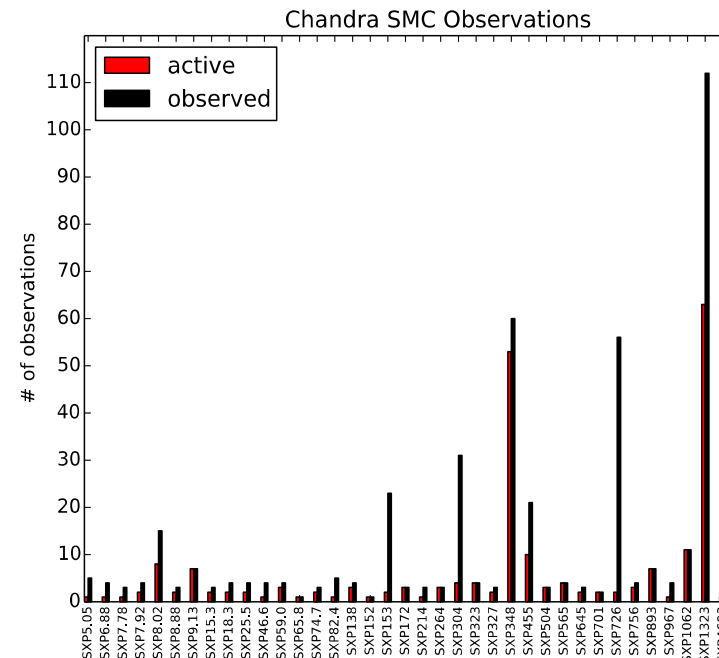
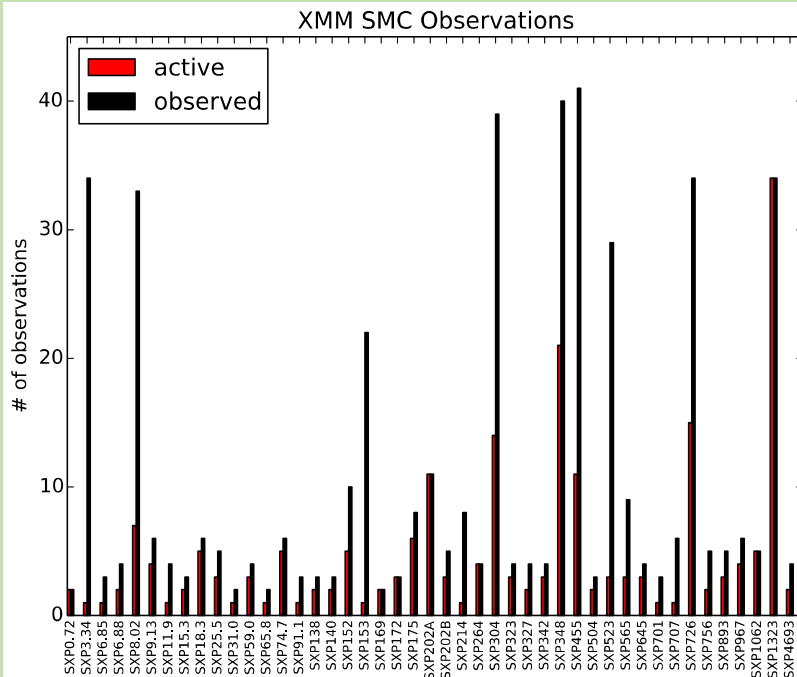


RXTE
Weekly Obs: 1997-2008

[Pulsar
Spin
up/down](#)

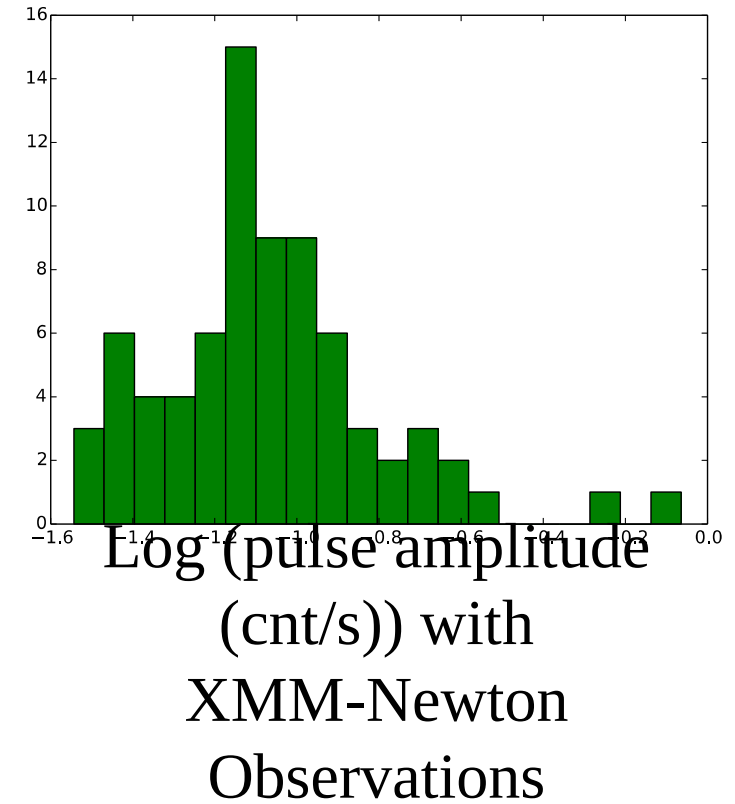
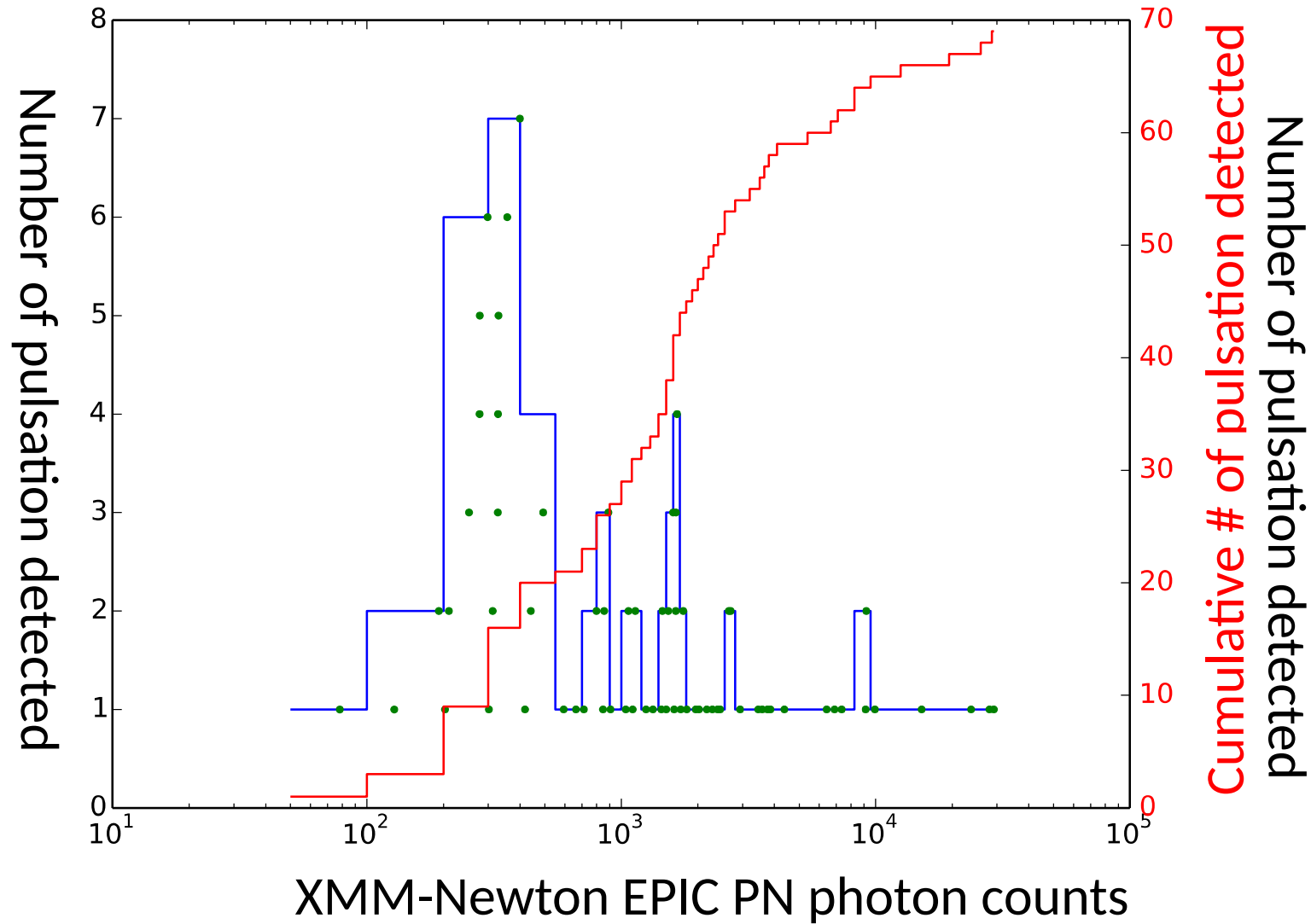
Pulse
profile
model

In sum



Library of pulsars in the Magellanic Clouds

Pulsars
In SMC
& Mode
|
Into
Library
Pulsars
spin
up
/down
Pulse
profile
model
In sum



Library of pulsars in the Magellanic Clouds

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spin
up/down](#)

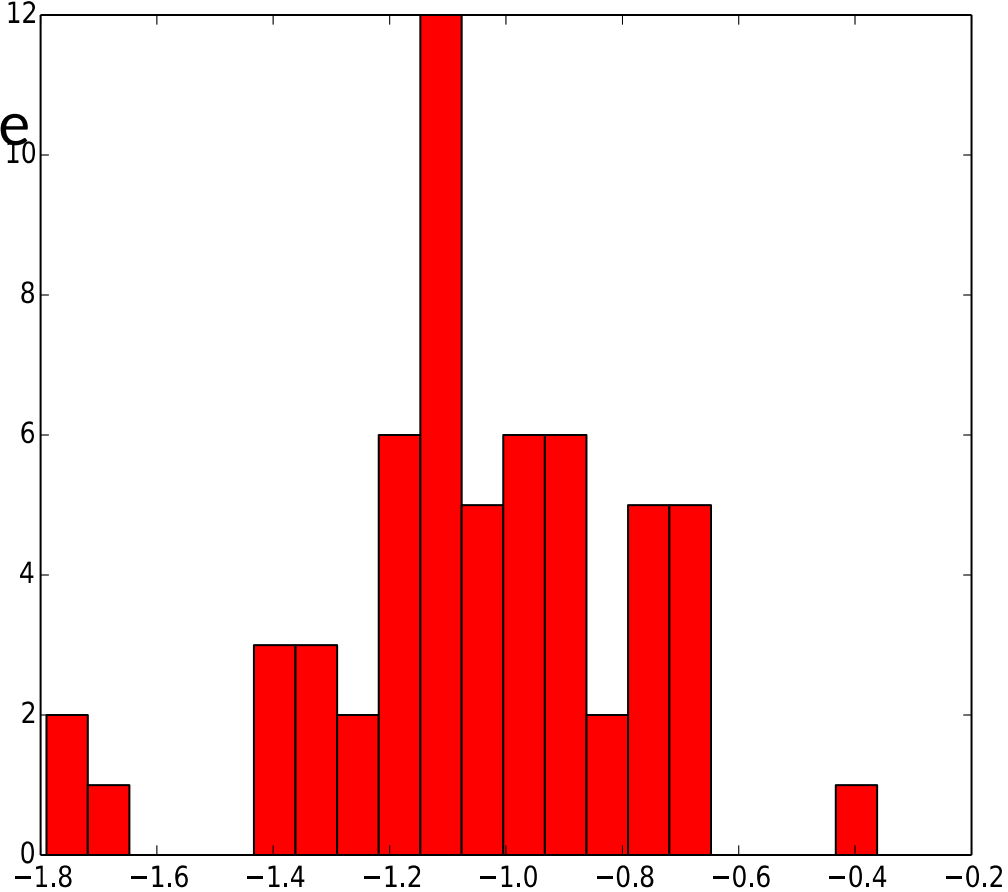
Pulse
profile
model

In sum

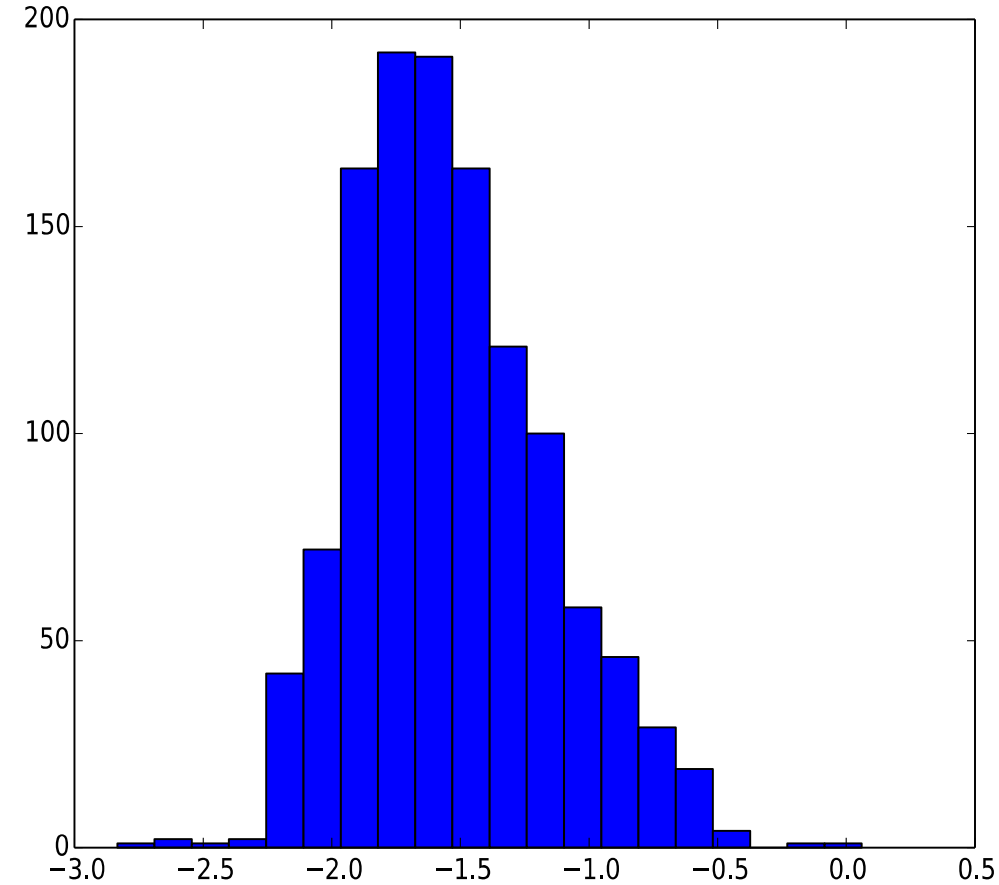
Observation
overview

Amplitude

of observations



Log (pulse amplitude (cnt/s))
with Chandra Observations



Log (pulse amplitude (cnt/s)) with
XMM-Newton Observations

SMC Pulsar library products

Pulsars
In SMC
& Mode

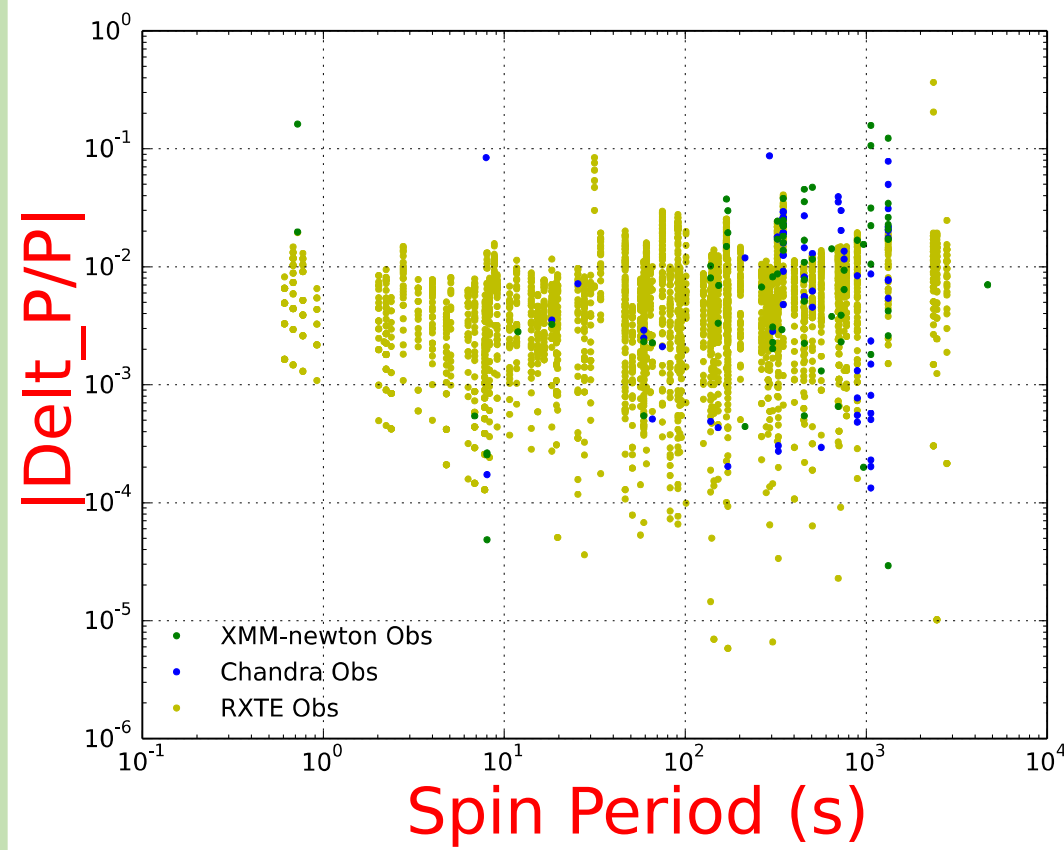
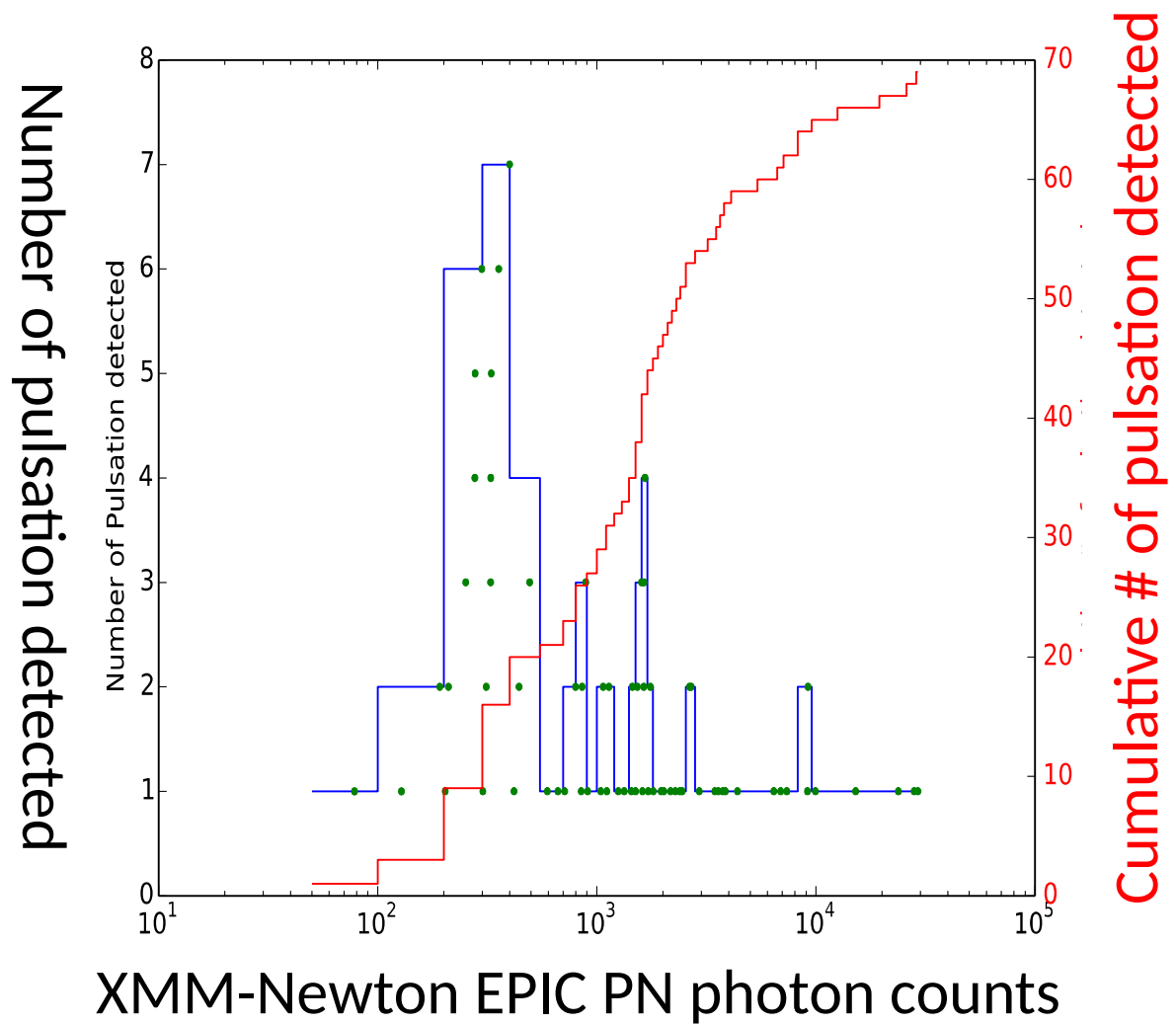
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Intro
Library

**Pulsar
s
spin
up
/down**

Pulse
profile
model

In sum



*Period
deviation*

Library of pulsars in the Magellanic Clouds

Pulsars
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& Mode
I

Observation
overview

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Yang

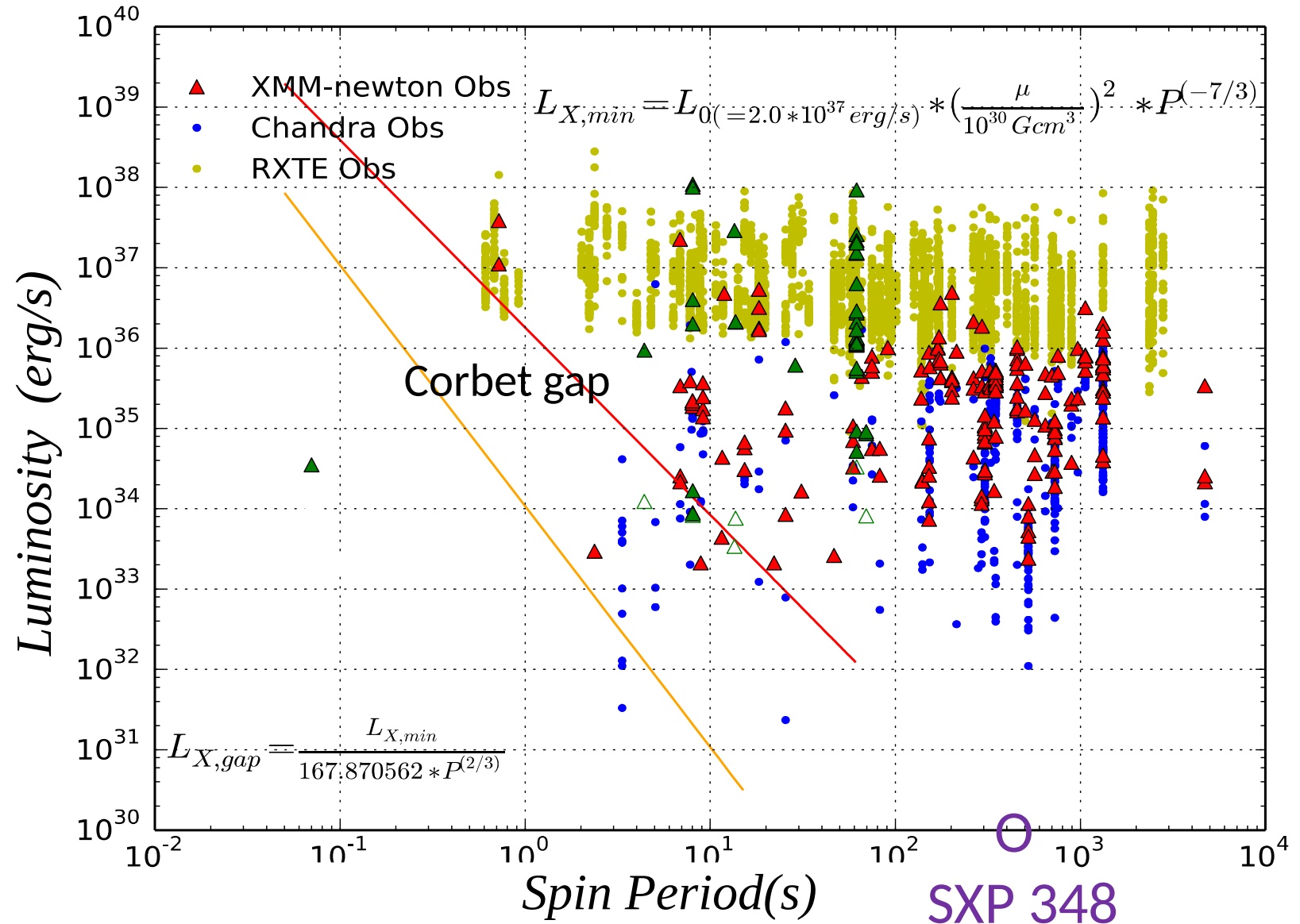
Intro
Library

Propeller line
(P-line) in
Magellanic
high mass X-ray
binaries;

[Pulsar
Spin
up
/down](#)

Did not find
the pulsations
below the
P-line

Pulse
profile
model



Makeup

Pulsars
In SMC
& Model

Jun
Yang

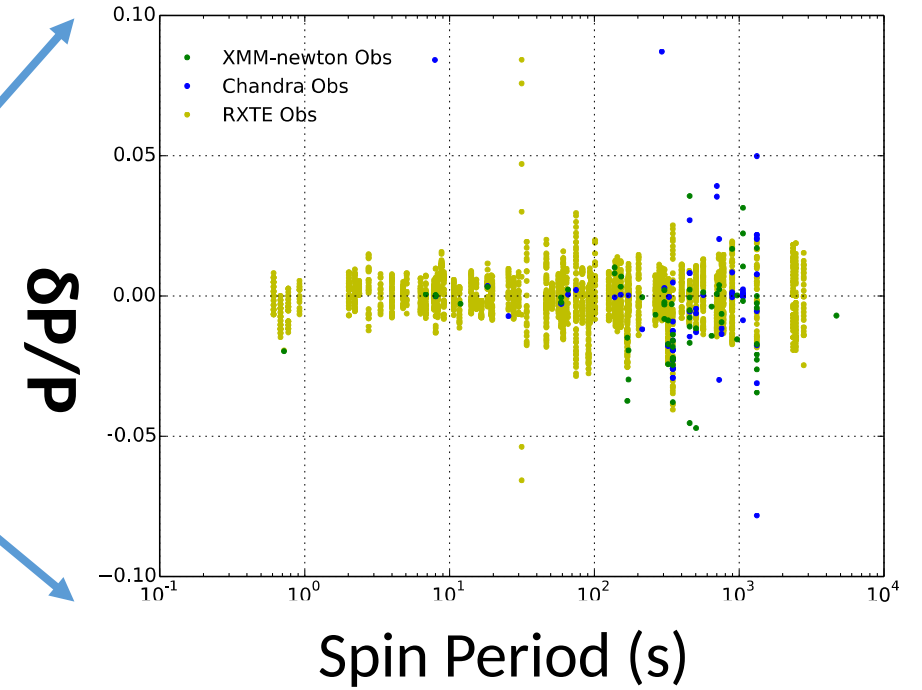
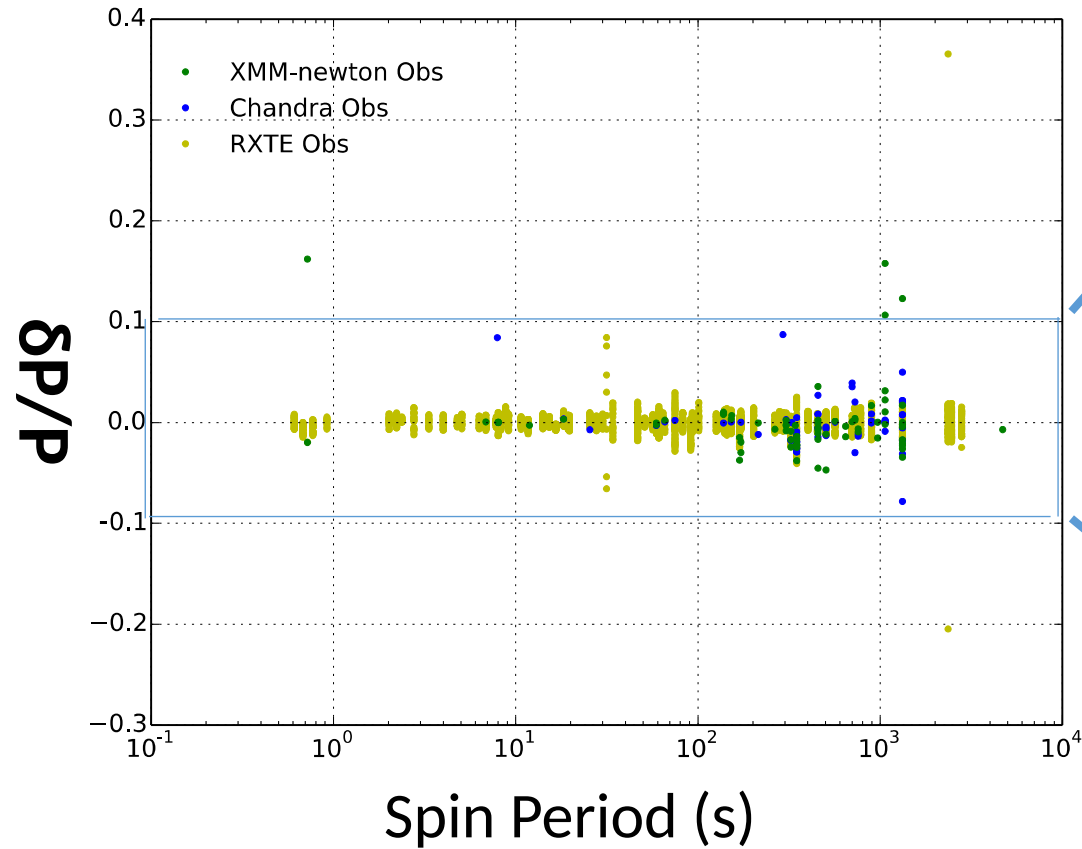
Into
Library

Pulsars
spin up
/down

Pulse
profile
model

In sum

**Make
up**



Makeup

Pulsars
In SMC
& Model

Jun
Yang

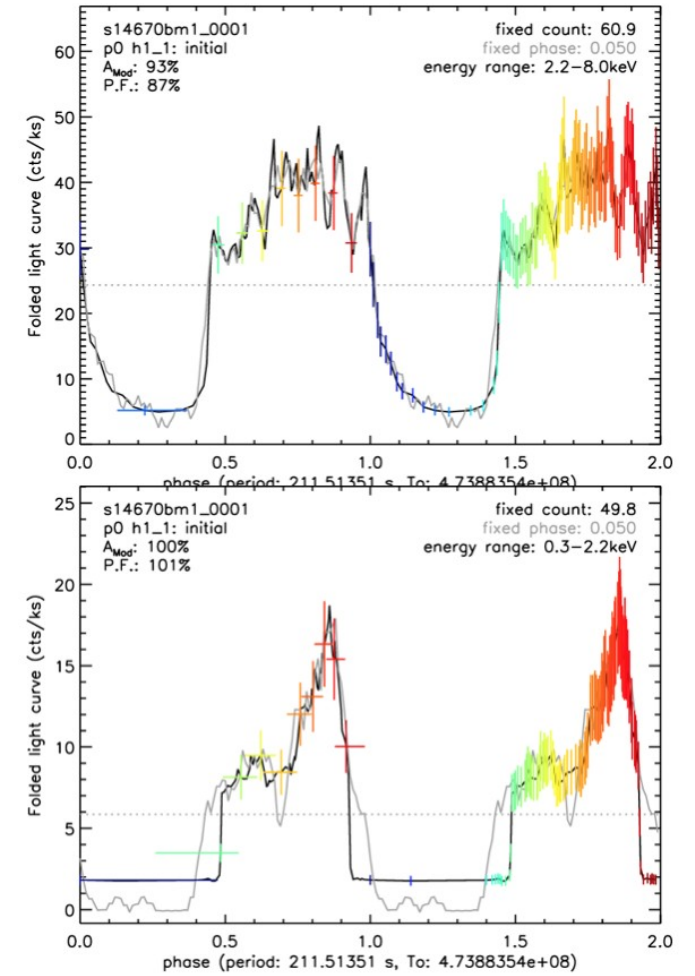
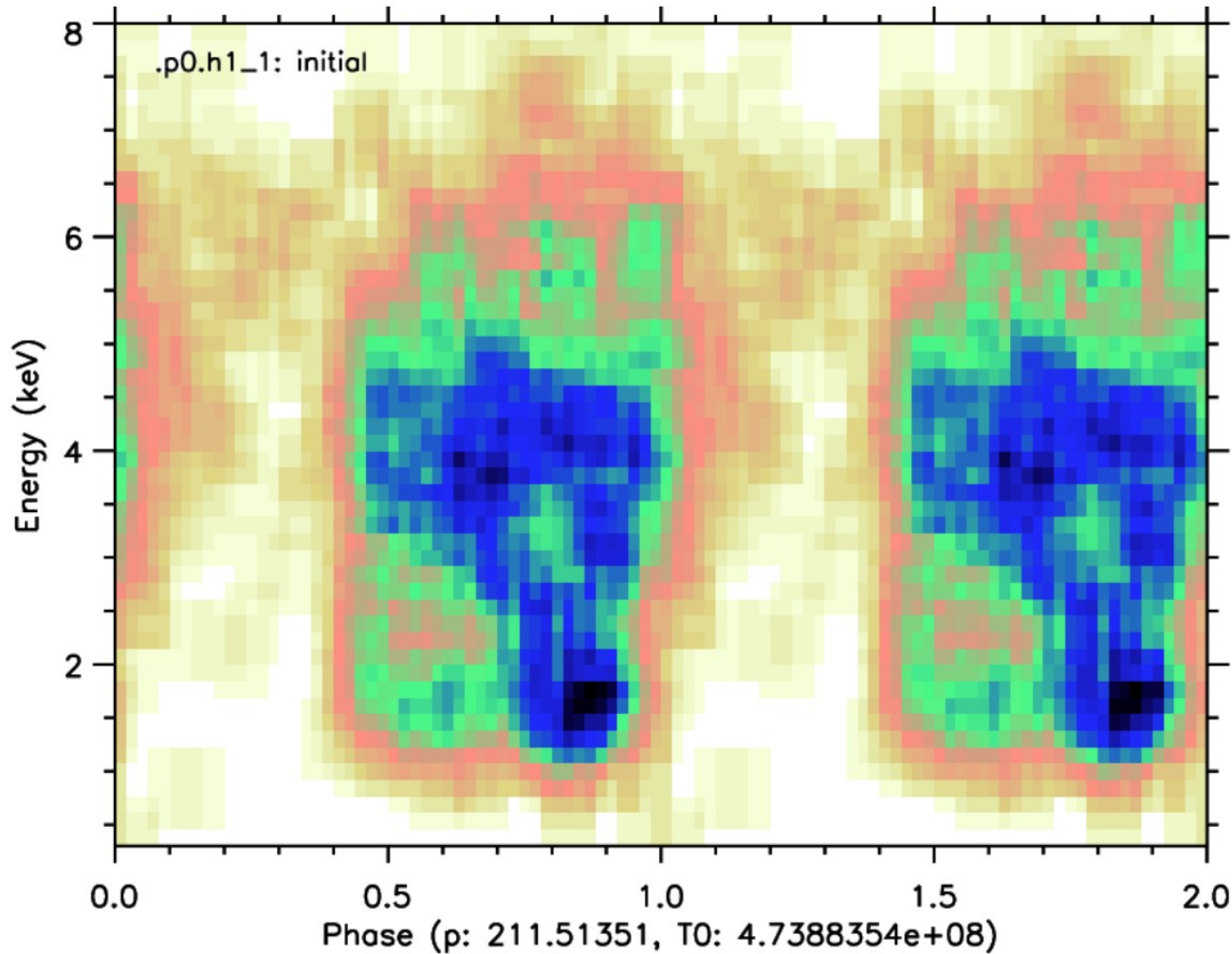
Into
Library

Pulsars
spin up
/down

Pulse
profile
model

In sum

**Make
up**



Makeup

Pulsars
In SMC
& Model

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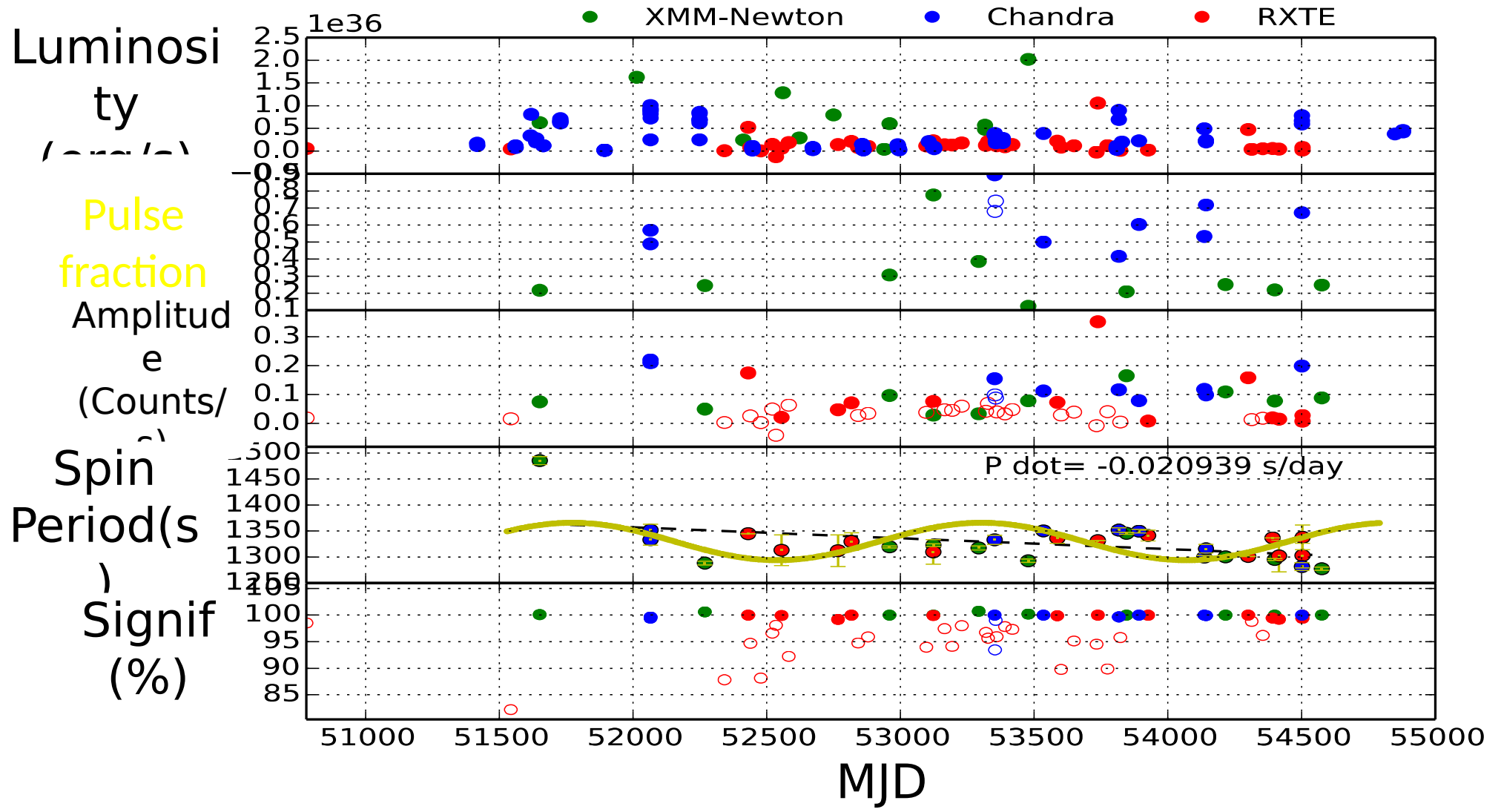
Into
Library

Pulsars
spin up
/down

Pulse
profile
model

In sum

**Make
up**



SXP 1323 Spin up: 0.0209 s/day

Makeup

Pulsars
In SMC
& Model

Jun
Yang

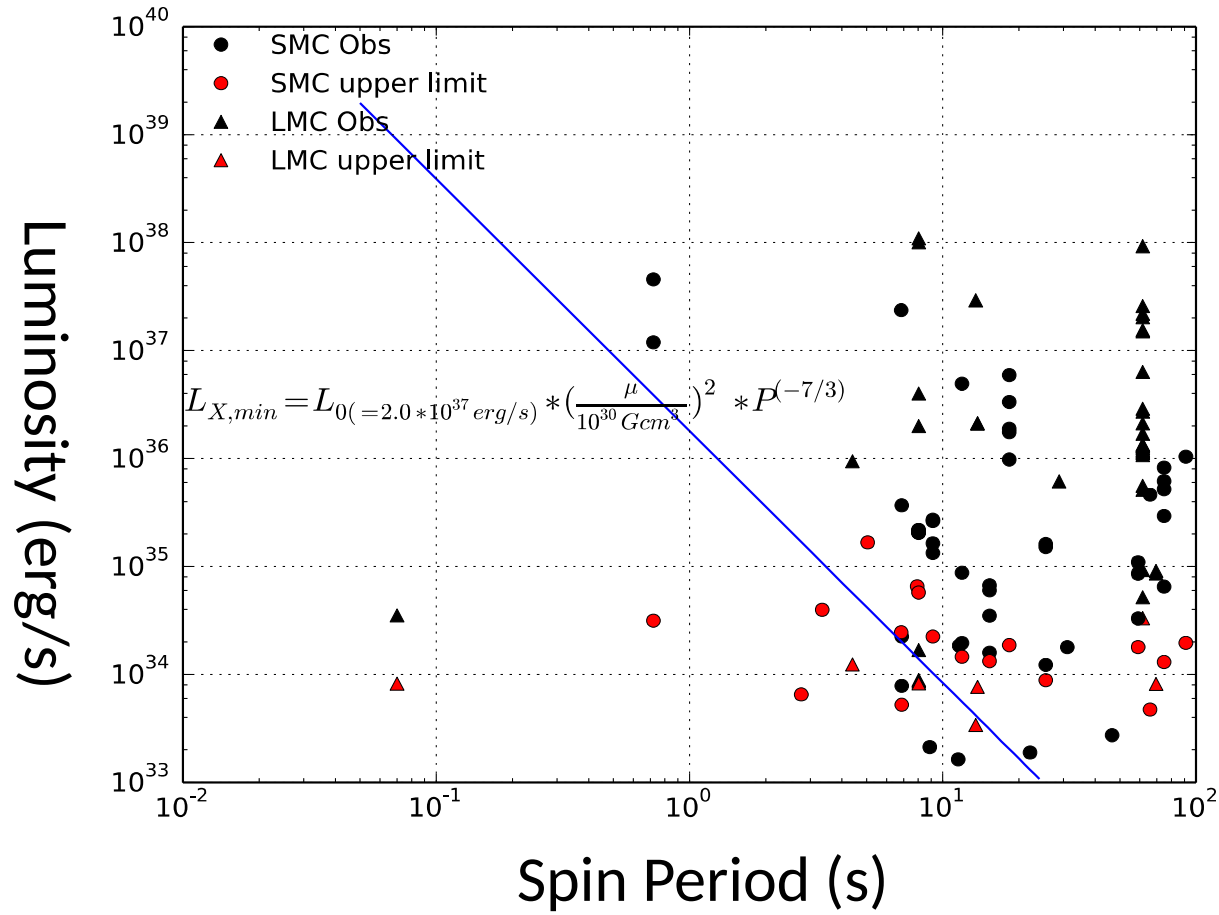
Into
Library

Pulsars
spin up
/down

Pulse
profile
model

In sum

**Make
up**



Astrosat

- Broadband Spectroscopic studies of X-ray sources