TIMING ANALYSIS OF GX 1+4 WITH INTEGRAL

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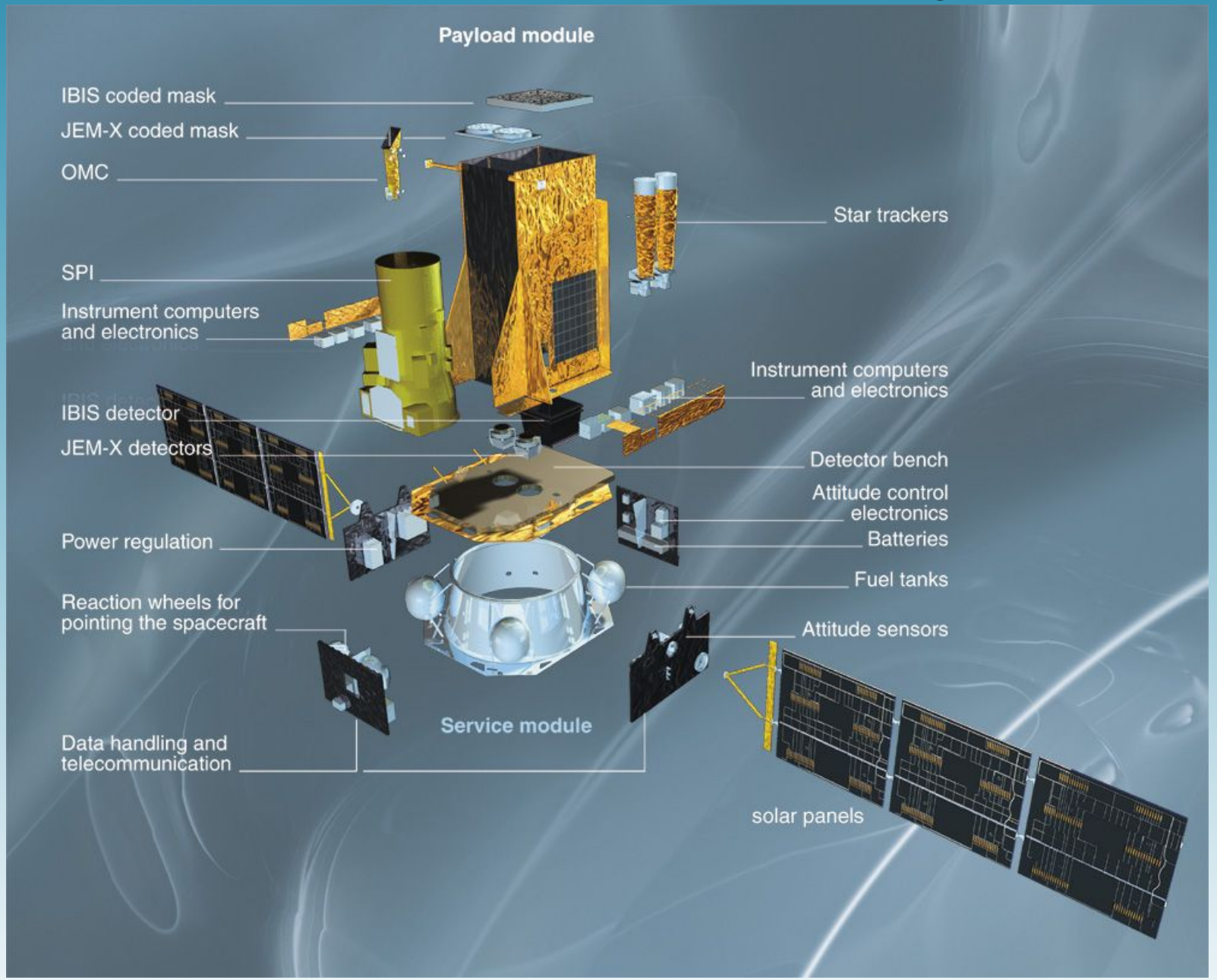
Menu

- INTEGRAL:
  - IBIS coded mask
  - Galactic bulge monitoring program
- The accreting pulsar GX 1+4
- Analysis of the period of GX 1+4:
  - *OSA 6.0*
  - Lightcurve resolution: *ii_light*
  - Period extraction: *efsearch*
- Variation of the period of GX 1+4 with time
- Future

INTEGRAL (INTErnational Gamma Ray Astrophysics Laboratory)



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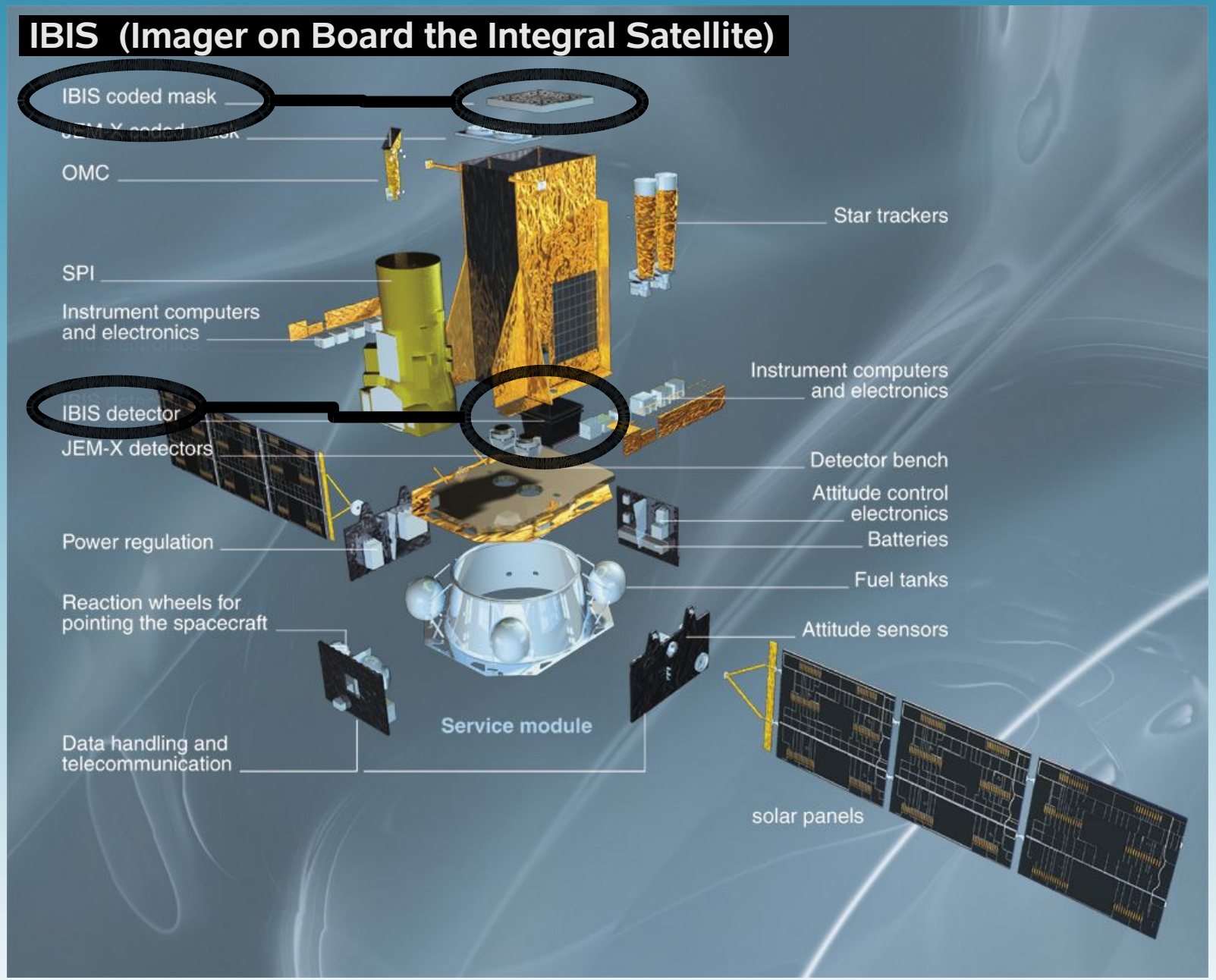


INTEGRAL: IBIS coded mask

Energy range: 15 keV to 10 MeV

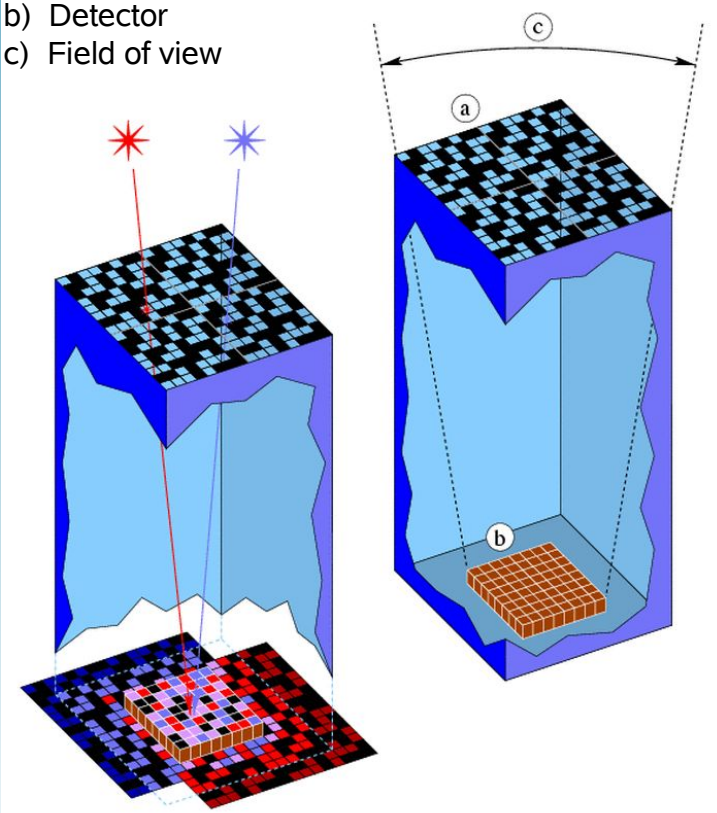
IBIS coded mask

Opaque plates and holes optimally distributed.
(Pattern of holes)

Gamma rays can:
- be blocked by the coded mask itself
- pass through these holes and fall onto the detector recording a shadow pattern

SIMPLIFIED SECTION OF IBIS IMAGER

a) Coded mask
b) Detector
c) Field of view



Gamma rays from different directions cast different shadows in different positions of the detector

↓

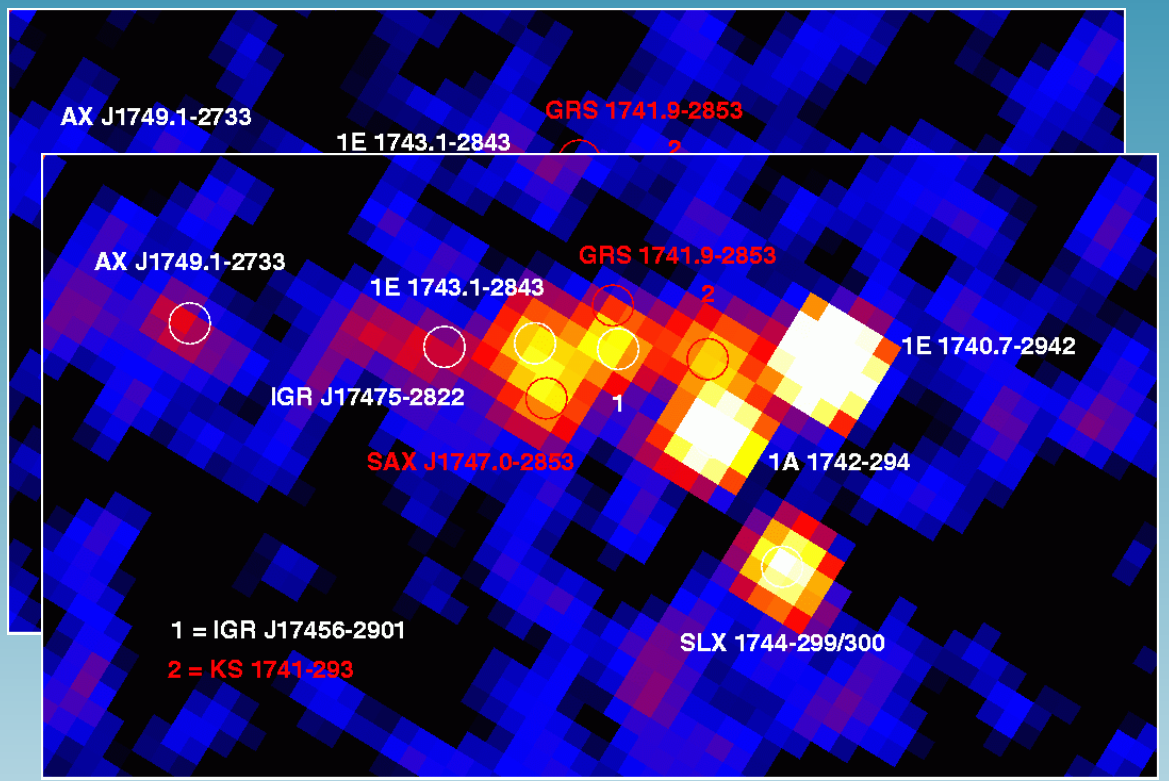
A computer program which knows the shape of the mask is used to convert these shadows into an image of the gamma ray sources

INTEGRAL: Galactic bulge monitoring program

Galactic bulge hosts many ***X-ray*** and ***gamma ray point sources***.

There are ***many transient sources*** in this region, then, it never looks the same.

From February 2005, when this region is visible by INTEGRAL, ***it is monitored every 3 days***.



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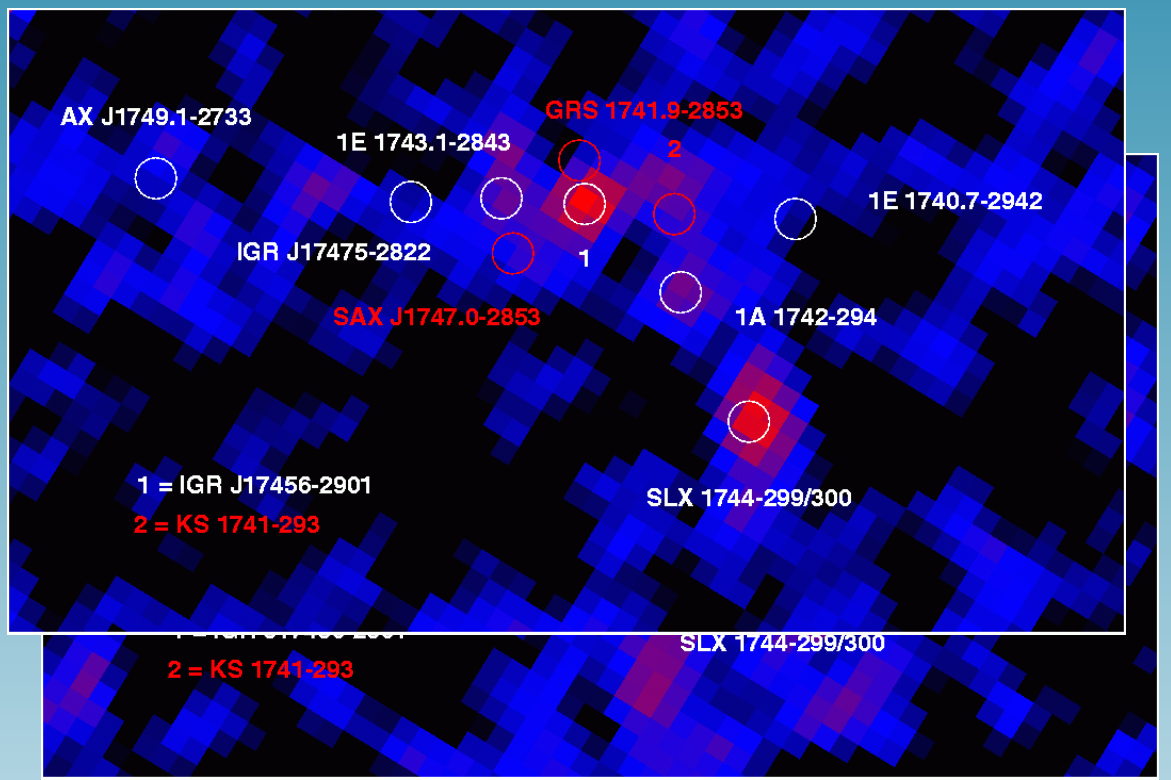

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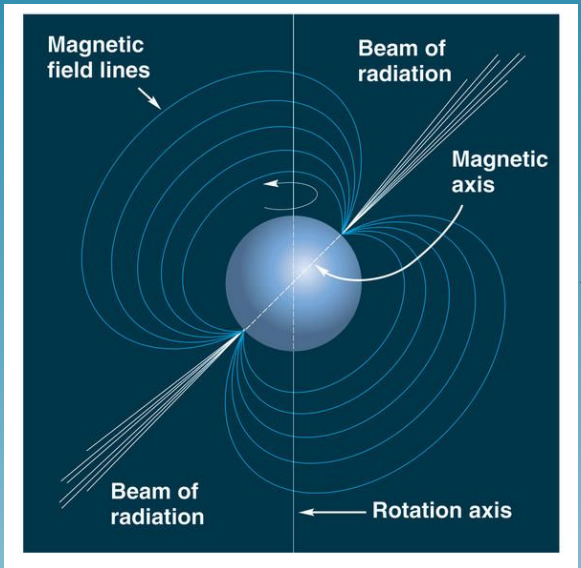
GX 1+4



Symbiotic low mass X-ray binary accreting pulsar

Giant star + Neutron star

Pulsar: Neutron star which
- has a strong magnetic field
- is spinning

Spin axis and magnetic axis not aligned → Pulsed emission period = Spin period

P (GX 1+4) ~ 140s

Binary accreting pulsar:

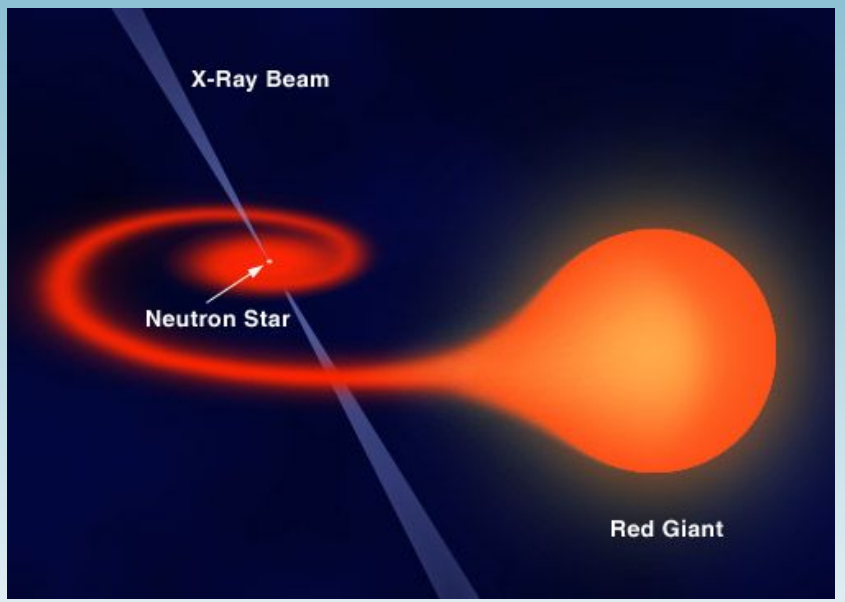
- Revolving in orbit around their common centre of gravity

Orbital period (GX 1+4) ~ 308 days

- Pulsar accretes material from the giant star (accretion disk):

Accretion disk angular momentum $\neq$ ***Pulsar angular momentum***

Pulsar angular momentum changes → **Pulsar spin period changes**



Analysis of the period of GX 1+4:
OSA 6.0

I use the version 6.0 of the INTEGRAL off-line standard analysis software OSA 6.0

1. **Create an image**:

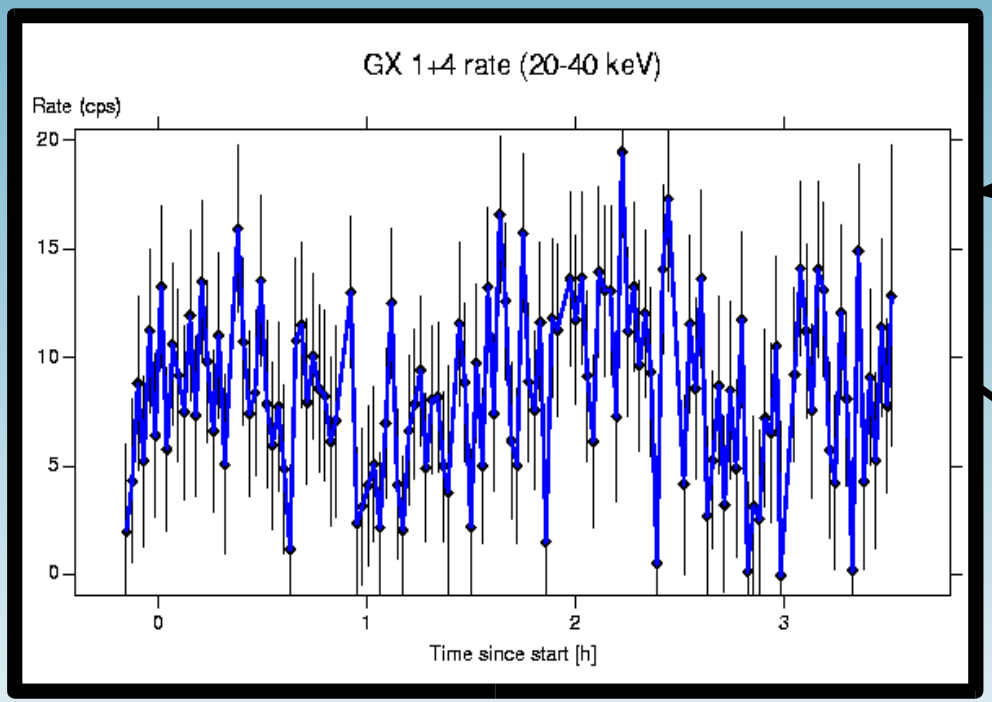
   Background maps.
   Is my source detected?

2. **Spectral extraction**:

   Take into account sources brigther than the one I'm interested in.
   Shadowgram for each energy bin is created.
   Create PIF (Pixel Illuminated Fraction).

3. **Lightcurve extraction**:

   For sources which a spectrum has been created.
   Performed by building shadowgrams for each energy bin.
   Time bin ~ 100s.



P ~ 140s
Lightcurve resolution ~ 100s

A better resolution is needed

Analysis of the period of GX 1+4:
ii_light

ii_light (PIF instead of shadowgrams)

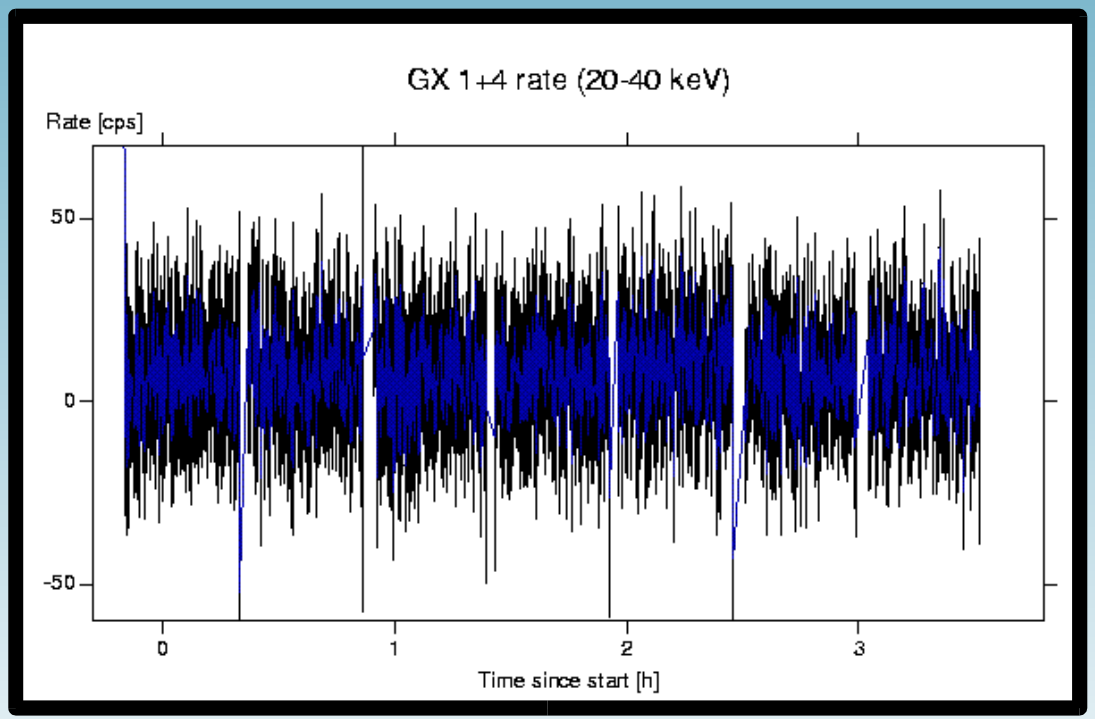
Pixel Illuminated Fraction (PIF) is the fraction of illumination of each detector pixel for a given source

Different approach

Flux values should be compared with those obtained using the other method

No limits on the size of time bin!!

Time bin of 10s



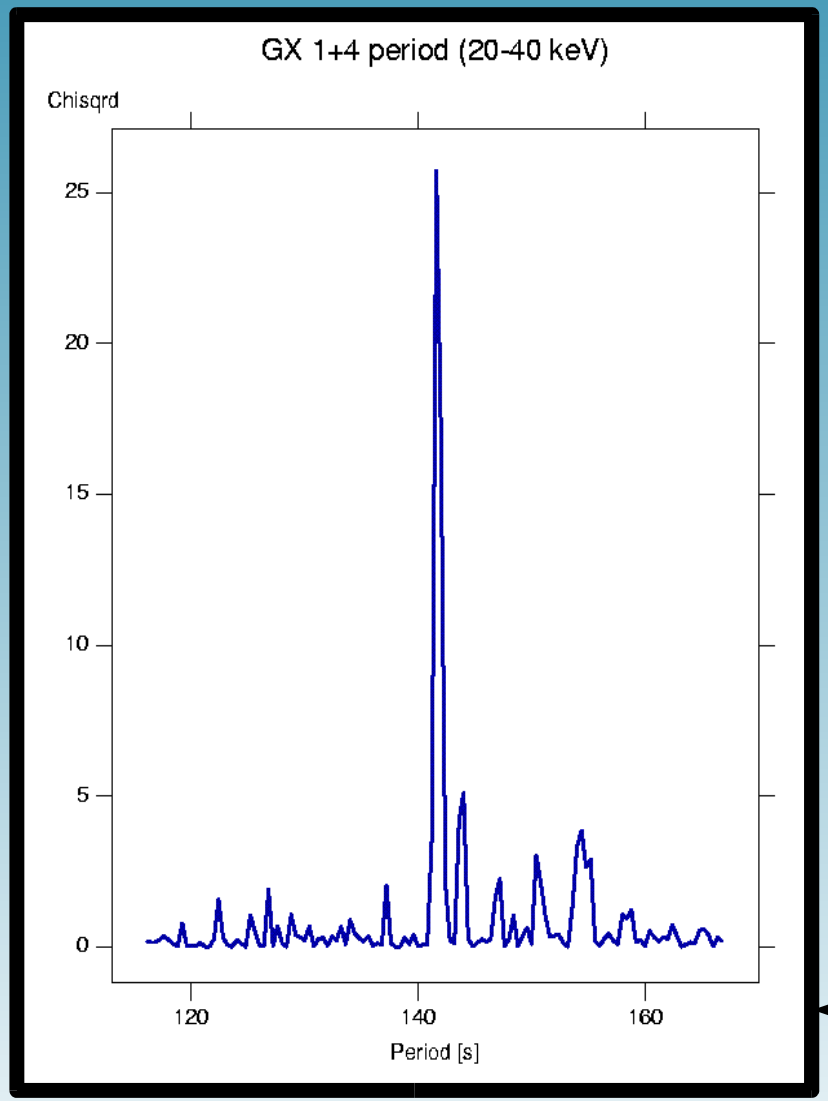
Now it is possible to extract the period

Analysis of the period of GX 1+4: *efsearch*

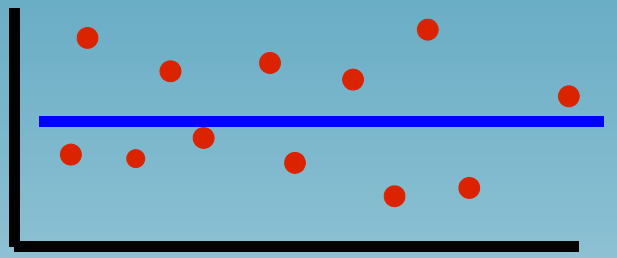
efsearch **to extract the period**

It folds the lightcurve for different test periods

It fits each folded lightcurve to a flat line

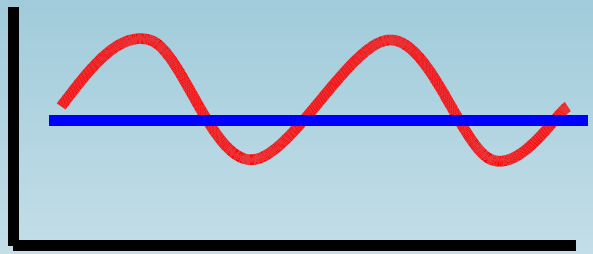


Bad period → Random points



→ Low χ^2

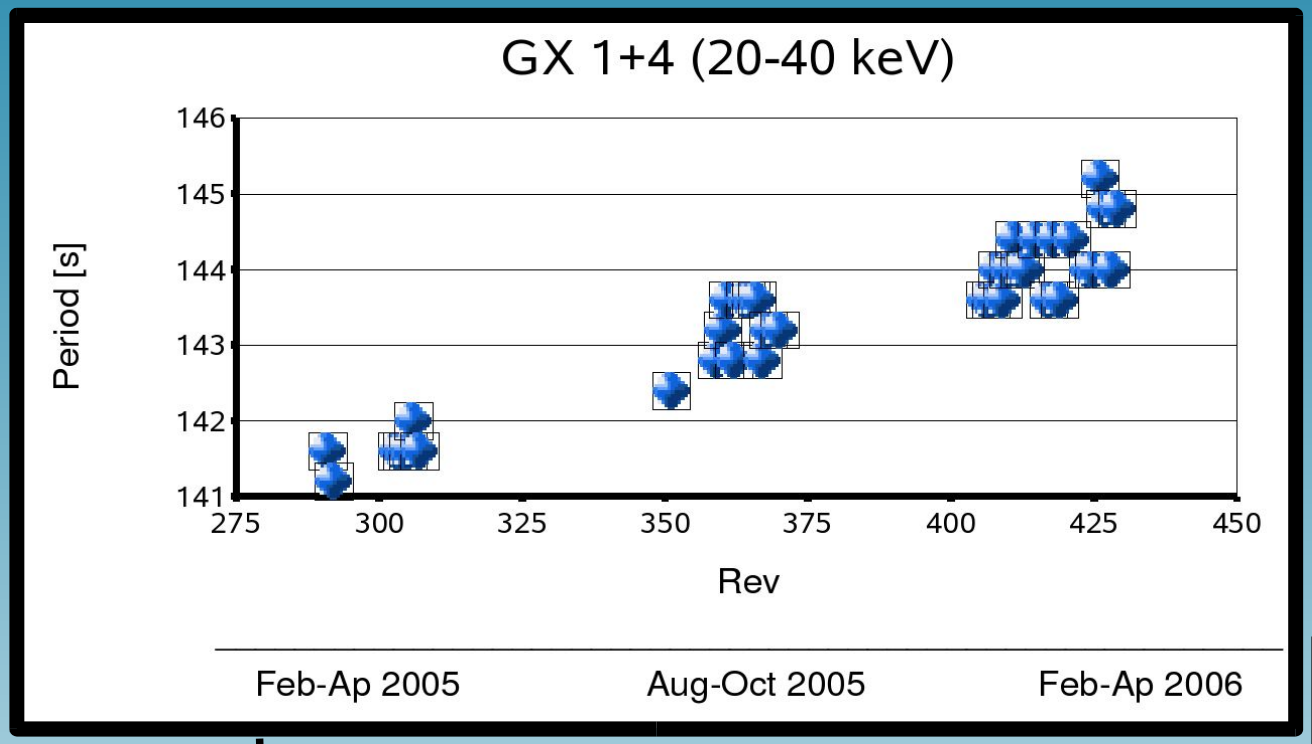
Good period



→ High χ^2

Good period
P = 141.6s

Variation of the period of GX 1+4 with time



GX 1+4 → *Binary accreting pulsar*

Spin period could change due to the accretion disk

Rev 0287 – 0307 ---> 2005, February 18 – April 19

Rev 0347 – 0370 ---> 2005, August 16 – October 26

Rev 0406 – 0429 ---> 2006, February 9 – April 21

Period is increasing

~1.5 years
Δ P ~ 3s

→ **Accretion disk is spinning down the pulsar**

Future

- **Ensure these periods using other methods.**

- **Apply the same analysis to other similar sources of the Galactic bulge:**

~ IGR J18027-2016	(High-mass X-ray binary pulsar)
~ XTE J1807-294	(Low-mass X-ray binary pulsar)
~ AX J1749.2-2725	(High-mass X-ray binary pulsar)
~ 3A 1822-371	(Low-mass X-ray binary pulsar)
~ IGR J17252-3616	(High-mass X-ray binary pulsar)
~ OAO 1657-415	(High-mass X-ray binary pulsar)