Problems encountered in spatial and timing analysis of AXPs

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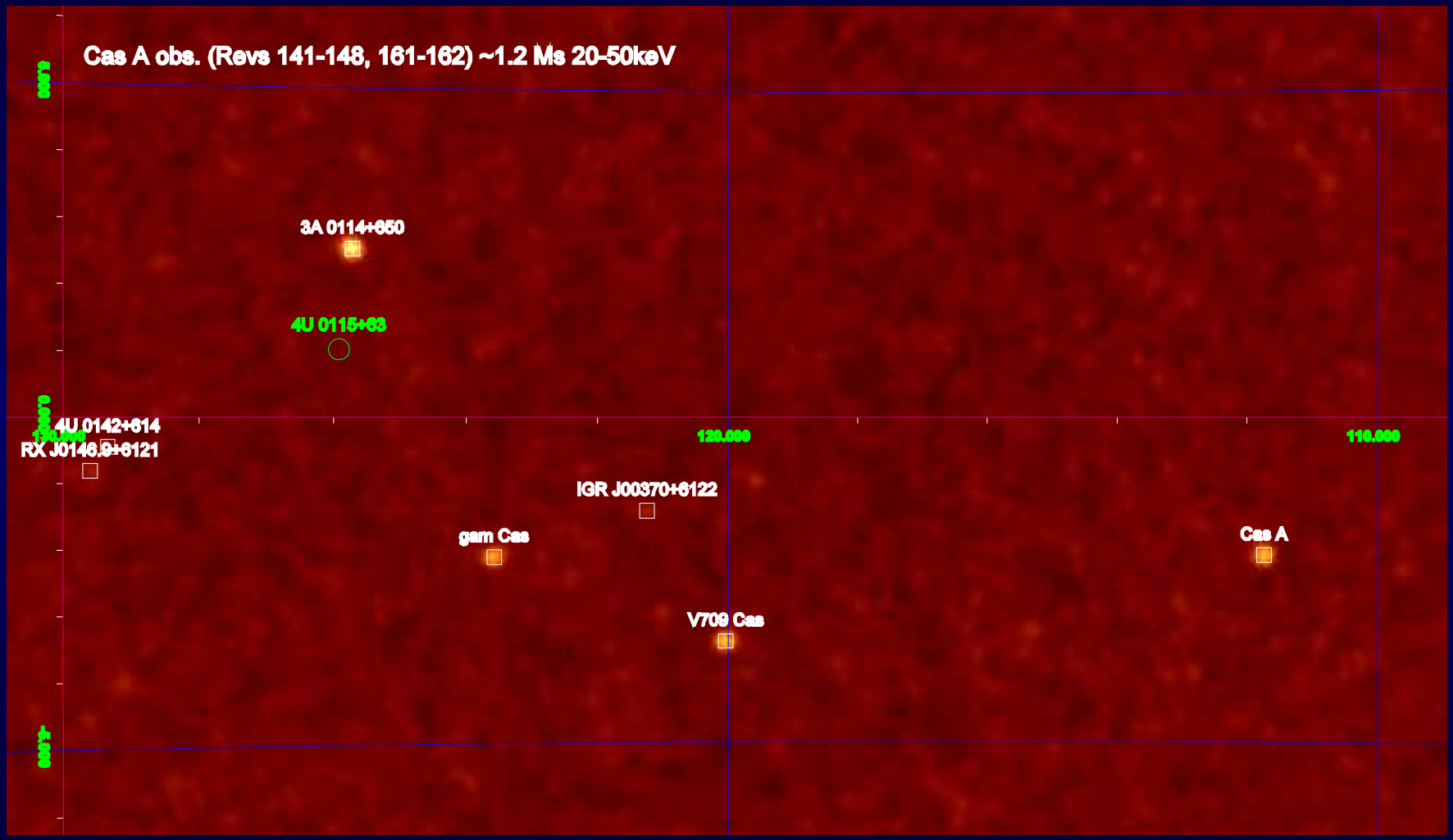
Cassiopeia region



Cassiopeia region

6 known sources

3A 0114+650

RX J01469+6122

γ Cas

V709 Cas

Cas A

3A 2206+543

2 'new' sources

AXP 4U 0142+614

(den Hartog et al 2004 Atel 293)

IGR J00370+6122

(den Hartog et al 2004 Atel 281)

Spatial-analysis problem

OSA 3.0/4.0/4.1 Data products

ISGRI_MOSA_IMA.fits

Intensity (Cts/s)

Variance (Cts^2/s^2)

DETSIG (σ)

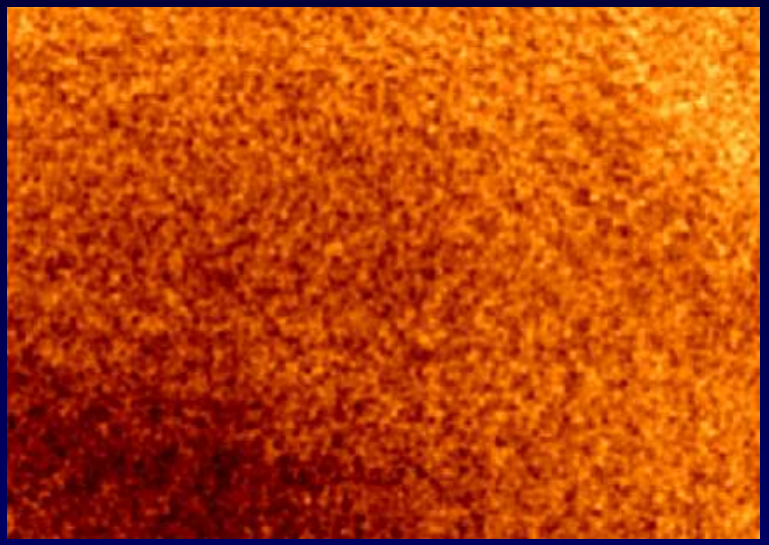
I/sqrt(Var) ≠ DETSIG

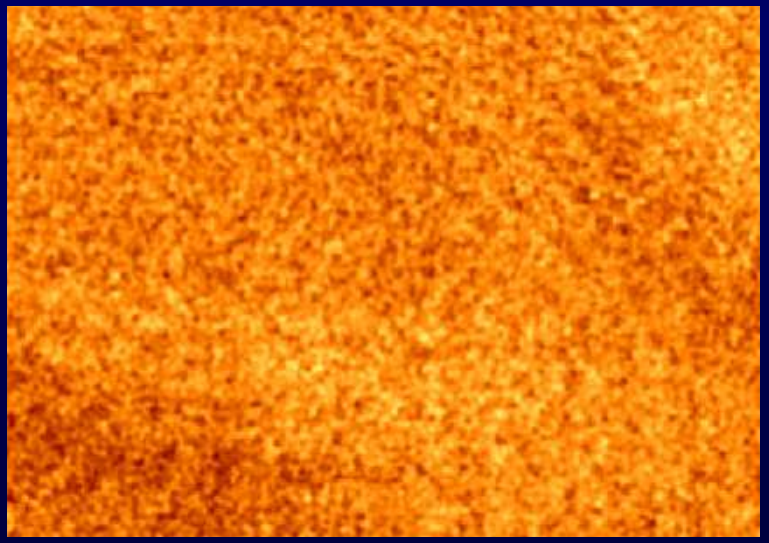
'Bug' is now reported and added to the 'Known issues'

This will be fixed in OSA 4.2

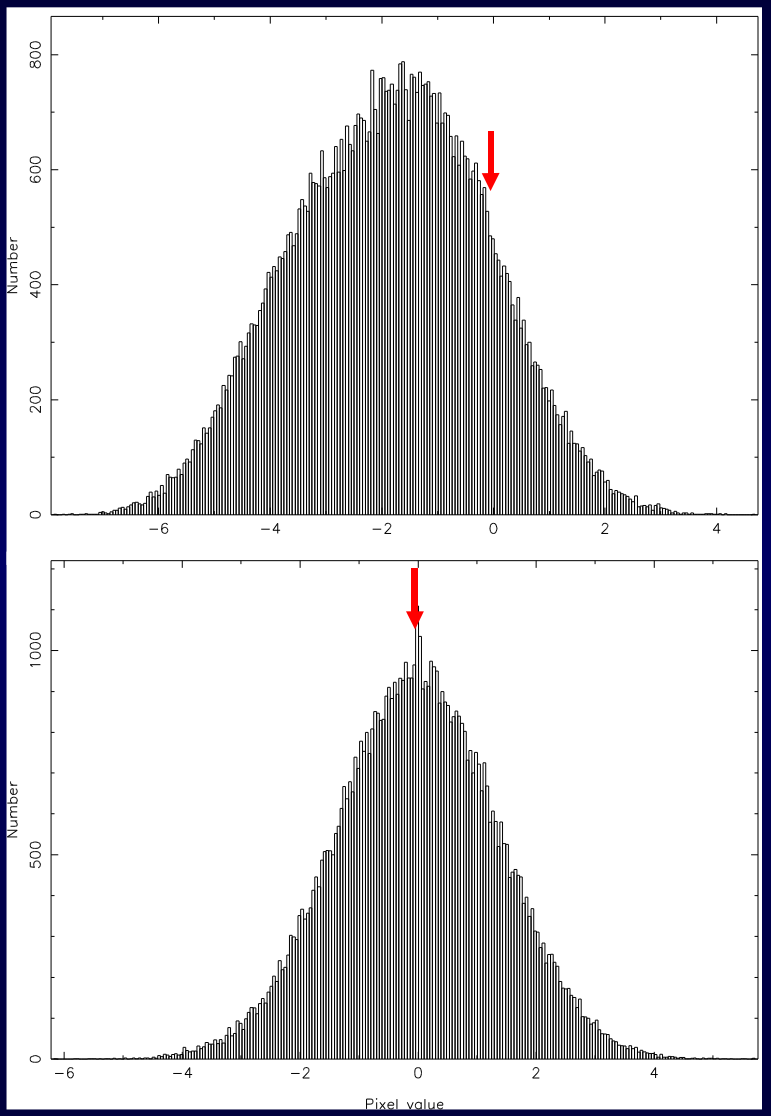
For now use I/sqrt(Var)

DetSig IMA (50-60 keV) and histogram





-10 – 10 'σ'



mean = -2.12

sd = 1.97

mean = 0.06

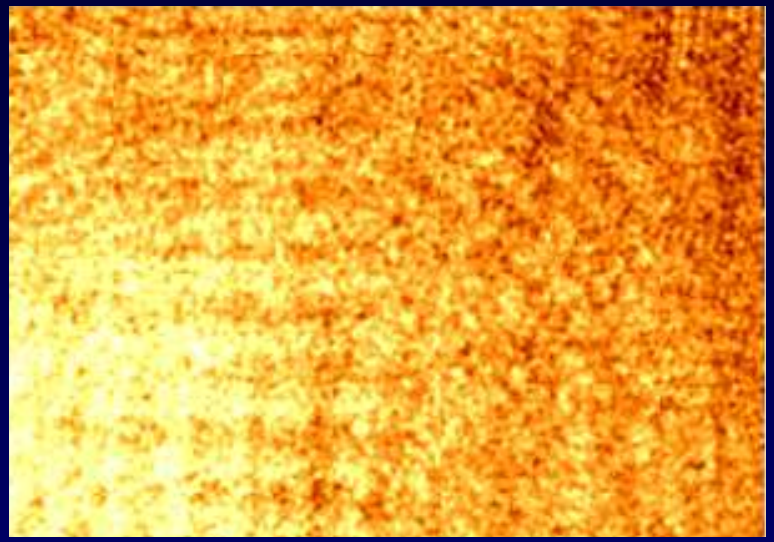
sd = 1.26

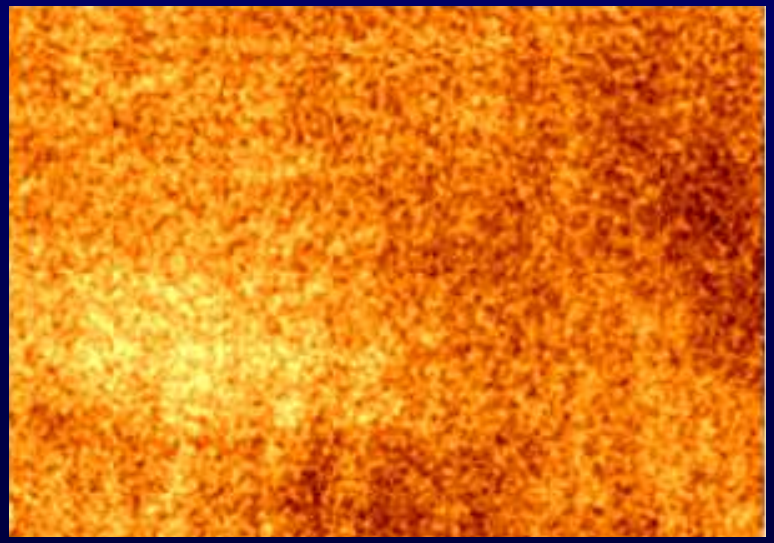
SNR correction needed

I/dI IMA (50-60 keV) & histogram

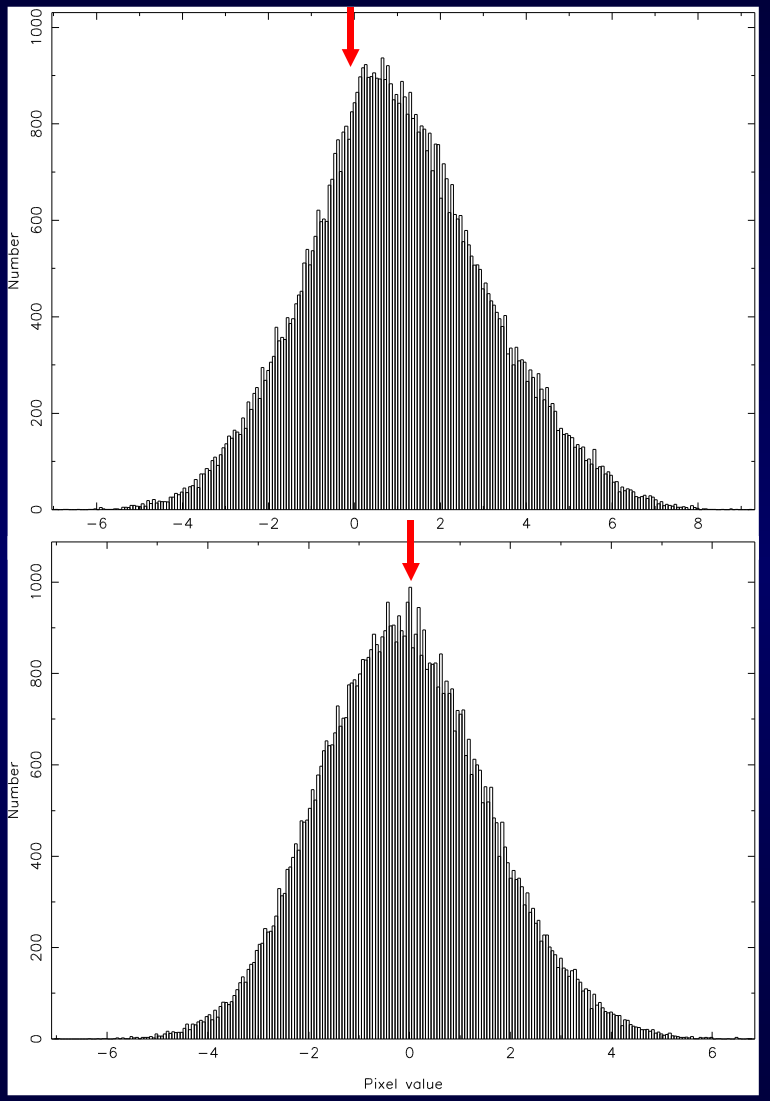
Background subtracted

DetSig IMA (50-60 keV) and histogram





-10 – 10 'σ'



mean = 1.01

sd = 2.07

mean = 0.02

sd = 1.88

I/dI IMA (50-60 keV) & histogram

No background subtraction

Anomalous X-ray Pulsars

X-ray power greater than rotational-energy loss

- 6 established, 2 candidates
- Young characteristic ages (~10-100 kyr)
- Periods in range 5 – 12 s
- Large $\dot{P}$s ~10^{-11} ss^{-1}
- X-ray luminosities in range 10^{34} – 10^{36} erg s^{-1}
- Spectra soft: kT_{BB} ~ 0.35 – 0.6 keV + PL α ~ 2 - 4
- Steady spin-down like radio pulsars

- Magnetars, dipole spin-down B fields 10^{14} – 10^{15} G

Anomalous X-ray Pulsars

CXOU J0110043.1-721134*

4U 0142+614 (den Hartog et al. 2004)

1E1048.1-5937

1RXS J170849-400910 (Revnivtsev et al. 2004)

XTE J1810-197

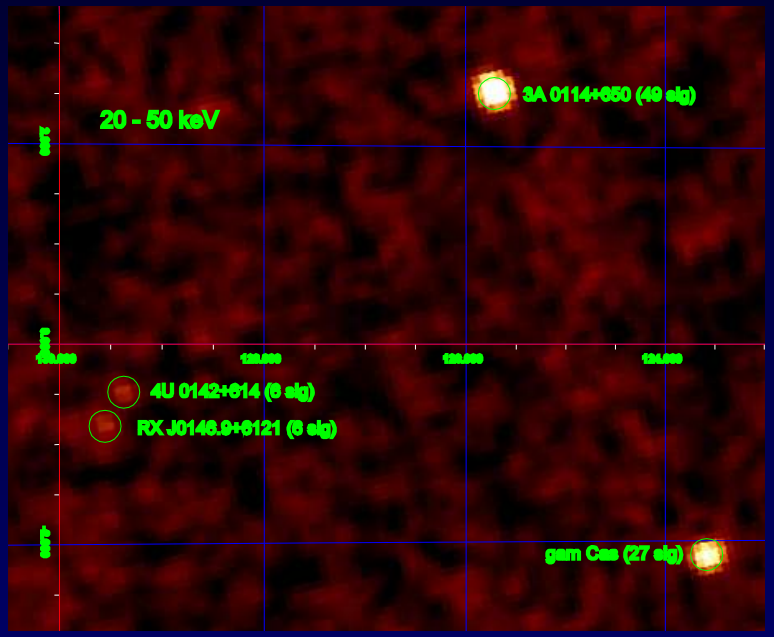
1E 1841-045 (Molkov et al. 2004)

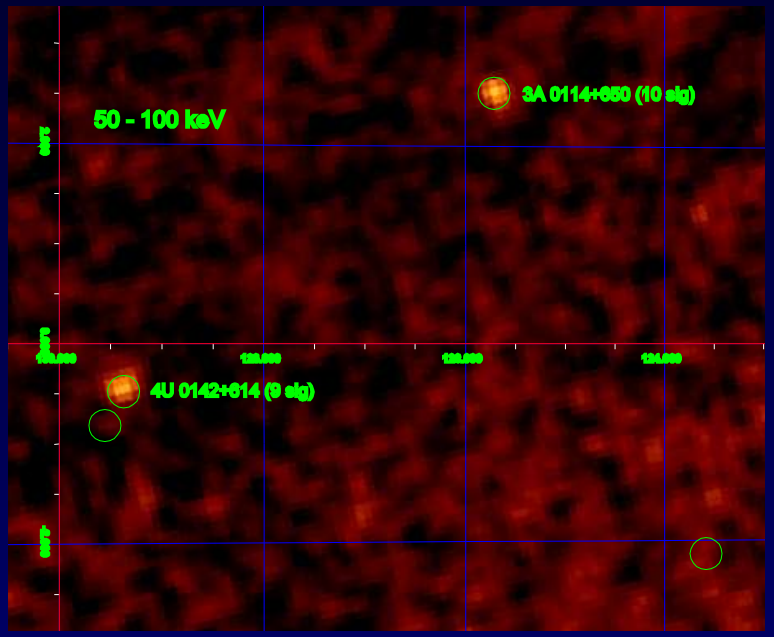
AX J1845.0-0258*

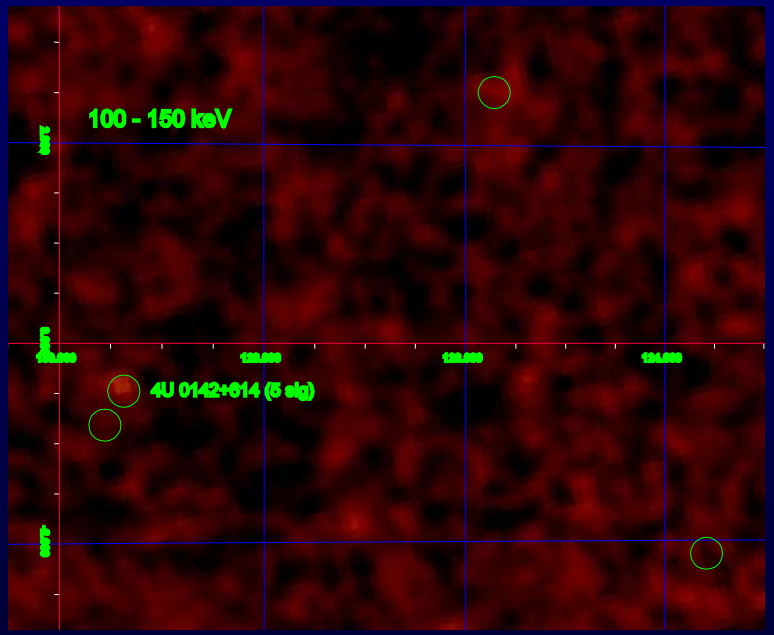
1E 2259+586

Kuiper, Hermsen, Mendez 2004

*: AXP candidate







AXP 4U 0142+614 (IMA)

$P \sim 8.7$ s

$\dot{P} \sim 0.2\ 10^{-11}$ ss^{-1}

$T \sim 69$ kyr

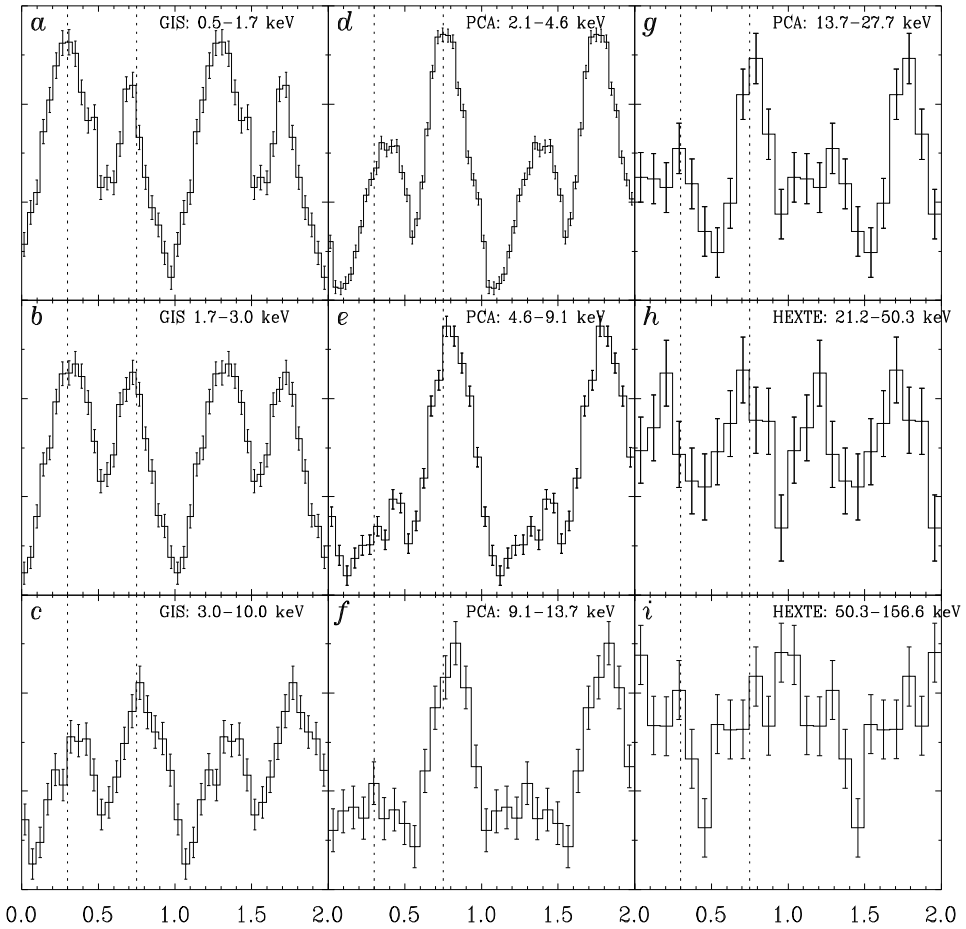
$B \sim 1.3\ 10^{14}$ G

$d \sim 3$ kpc

Stable rotator!!

AXP 4U0142+614

pulse profile as function of Energy



INTEGRAL
very useful

Kuiper, Hermsen & den Hartog AA in prep

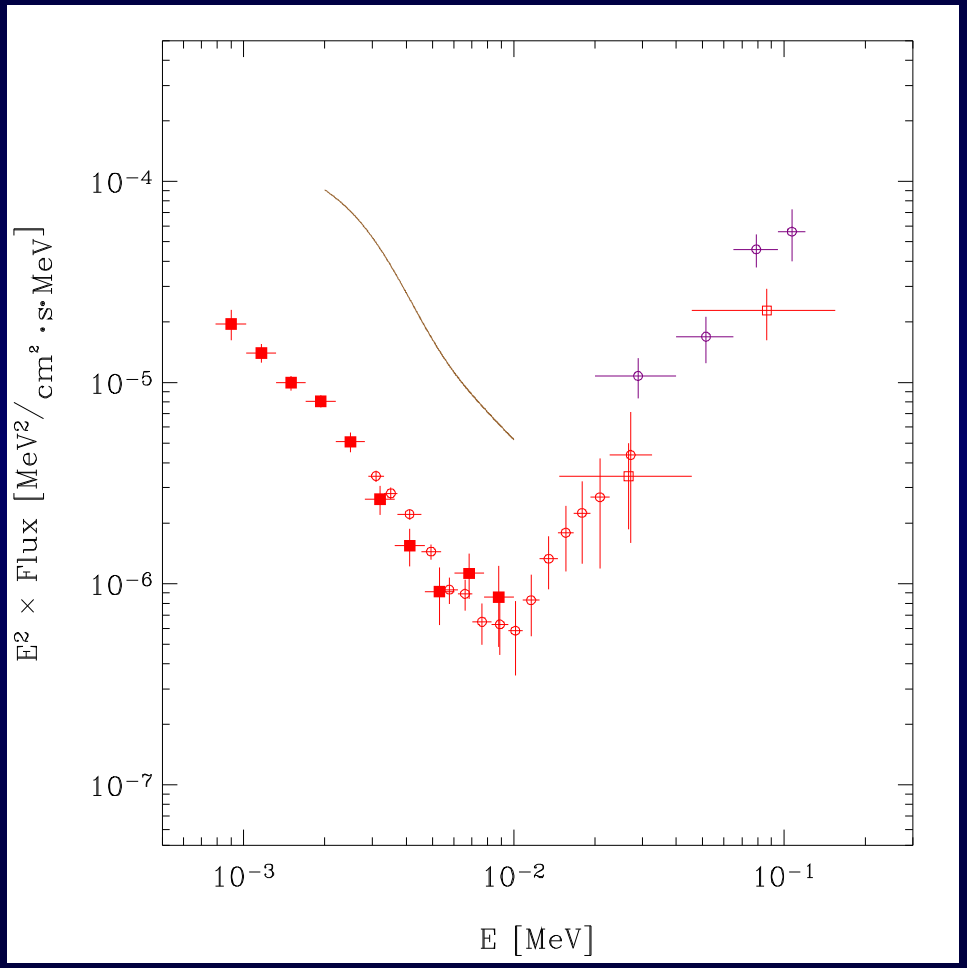
AXP 4U0142+614

spectrum

Pulsed:

ASCA GIS, RXTE PCA, RXTE HEXTE

$\Gamma \sim 0.5$



Total (DC + pulsed):

Chandra,

$kT_{BB} = 0.46$ keV

$\Gamma = 3.4$ (Patel et al 2002)

INTEGRAL

Pulsed-fraction increase as function of energy

INTEGRAL timing of AXP 4U 0142+614

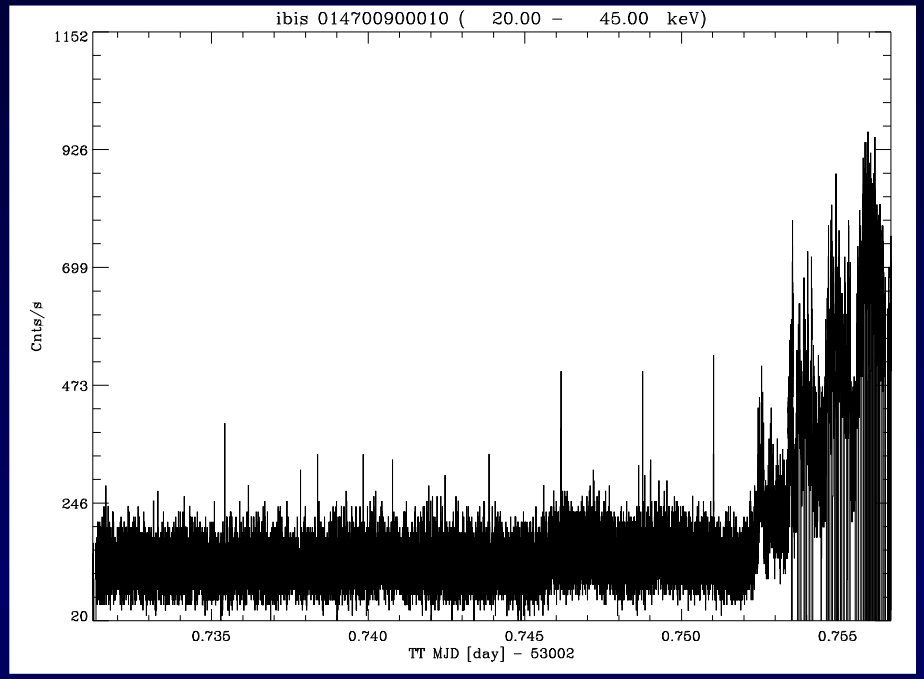
Extrapolated phase-connected ephemeris

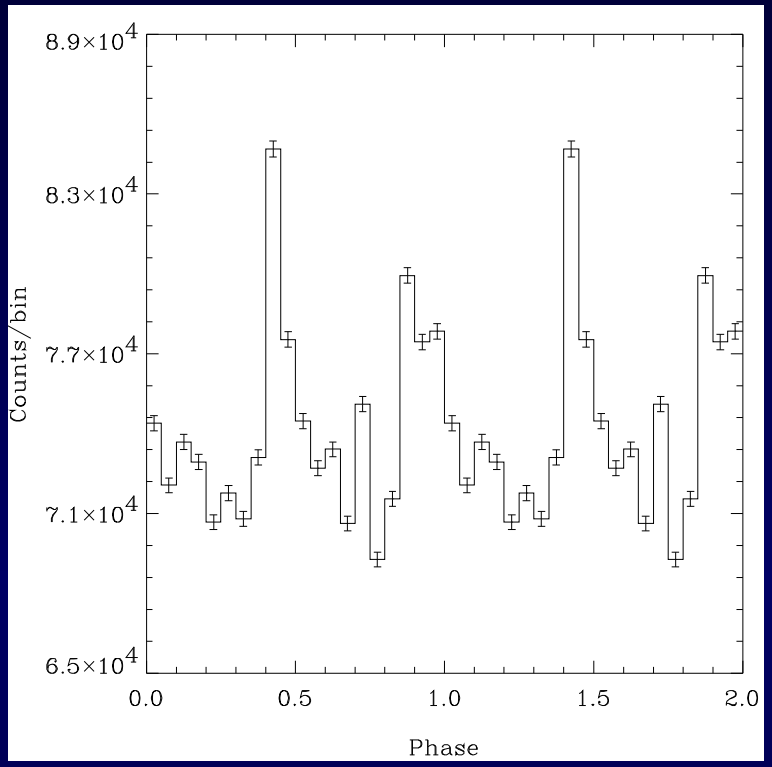
(0.5 yr) from RXTE-monitoring program

INTEGRAL timing verified using Crab data (Kuiper et al. 2004)

Caution: Rise-time selection (Revs < 0039) especially important for short periods <1 s

Caution: Radiation-belt increasing countrates especially important for longer periods >1 s





0014700900010

0014700910010

0014700920010

0014700930010

0014700940010

32 σ 'pulsed' signal

GTI accounts for data gaps, but

not for erratic count rates

Preliminary result

Extrapolated ephemeris

~0.75 Ms exposure

Accounted for erratic count rates

Pixel illumination factor > 25%

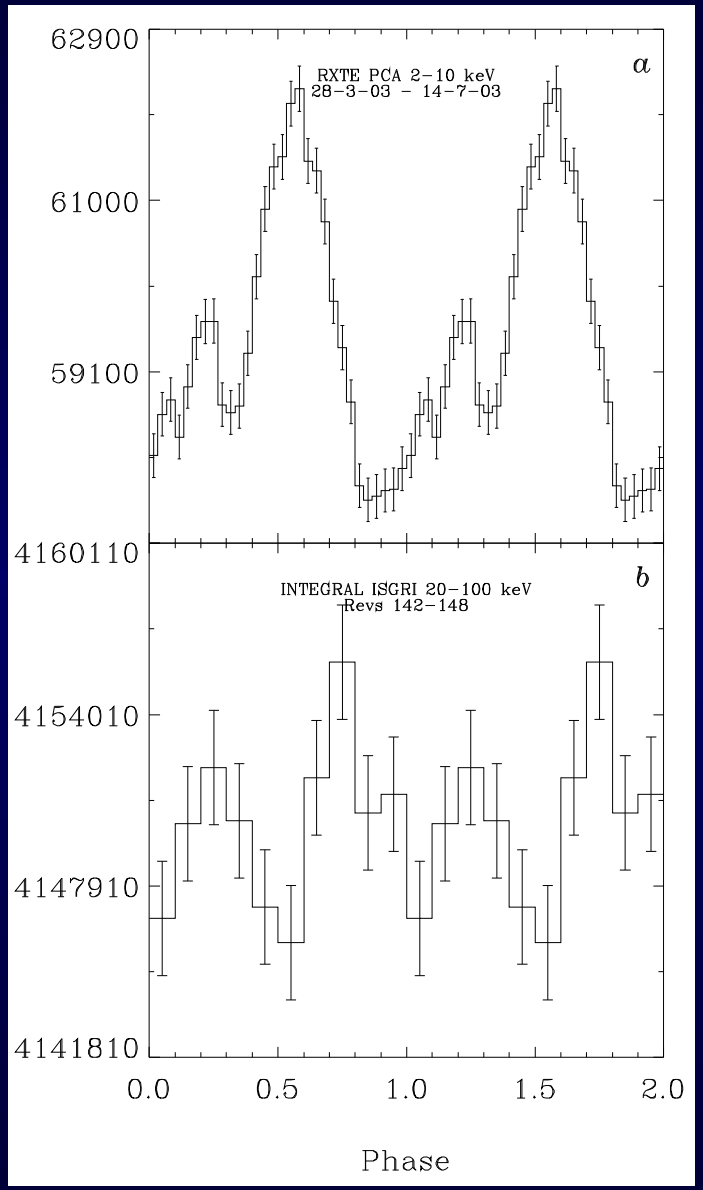
<Off axis> = 11.5°

25% on axis efficiency!

Resulted in a 3.2σ pulsed signal

Similar to HEXTE result

Phase shift (0.15) due to extrapolation



Conclusions

Spatial analysis:

The standard (OSA) DETSIG map should be used with care.
Preferably use the standard Intensity and Variance maps to determine significances (especially for weak sources).

Timing analysis:

Remove erratic count rates due to radiation belts entrance.

This is very important for sources with periods longer than 1 second. (For other cases it should help as background surpression)

Thank you for your attention

Contact: Hartog@sron.nl

IGR J00370+6122: New Supergiant X-ray Binary

~11 σ in Rev 0147

(20-60 keV) 4.5 mCrab

~5 σ in Rev 0142

coincident with

IRX J003709.6+612131

optical counterpart

BD =60 73 (B supergiant)

RXTE-ASM folded light curve shows

15.665 d orbital period