Technical University of Denmark

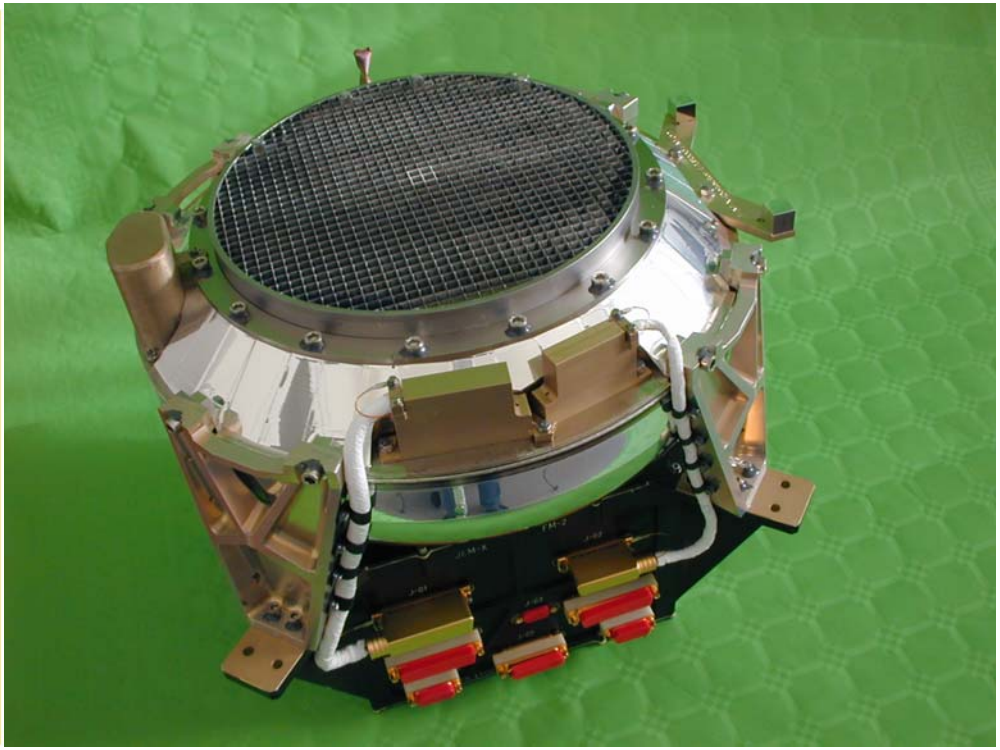
# JEM-X Status, December 2010

Søren Brandt


DTU Space
National Space Institute

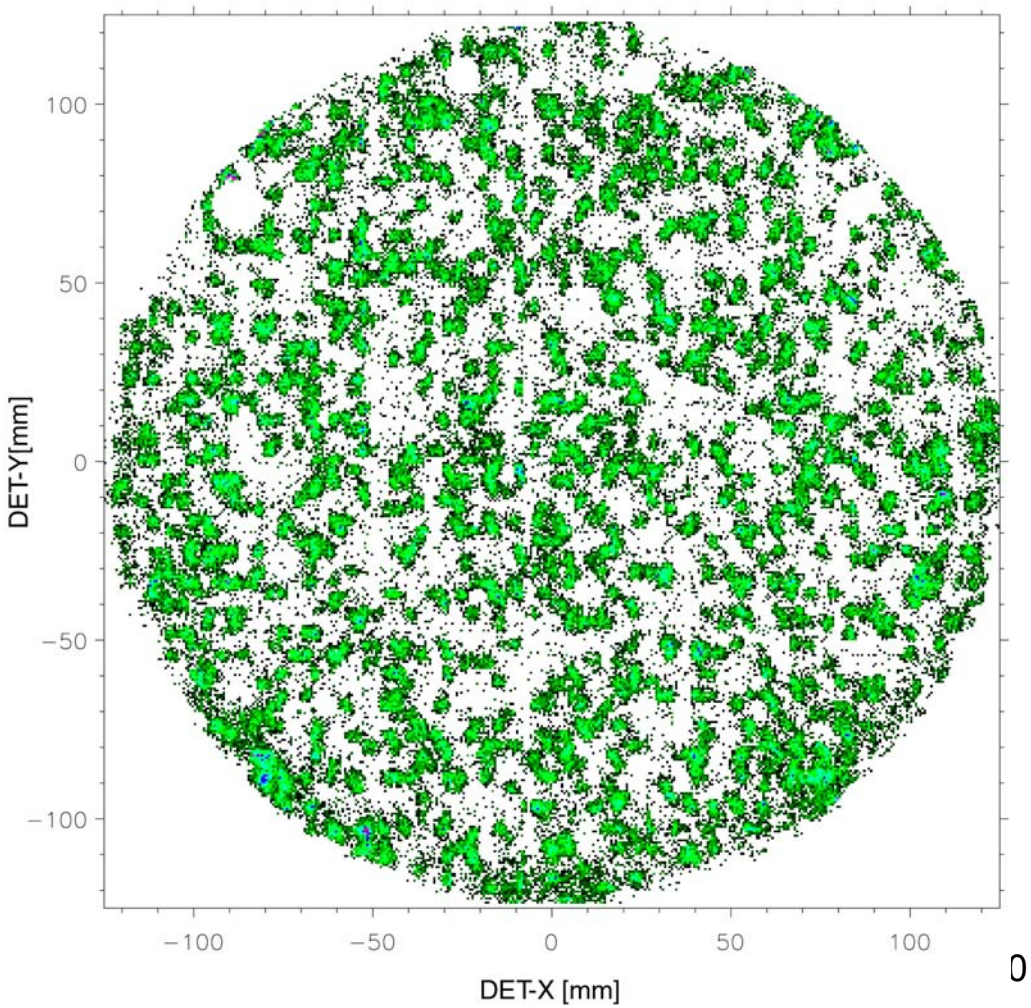
# JEM-X X-Ray Telescope on INTEGRAL

- Coded mask camera with ~5000 holes (1/4 open mask)
- Distance between mask and detector: 360 cm
- Energy range: 3-40 keV
- Micro-strip plate and Xenon gas filled proportional counter
  - Analog detector with ”pixels” determined by software

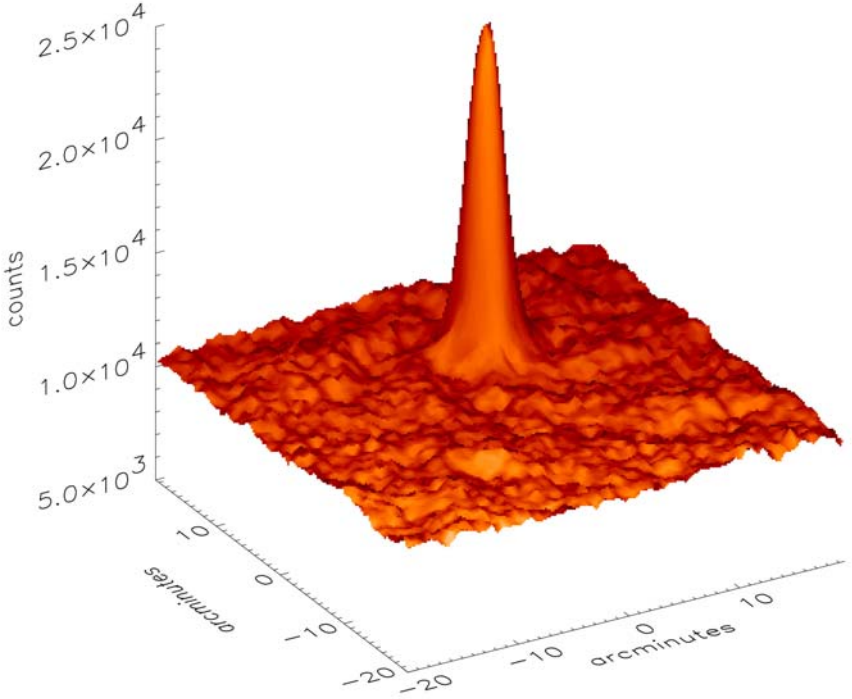


# JEM-X Imaging

JEM-X Shadowgram




JEM-X PSF




- 2D Gaussian, σ = 1.5’

# Both JEM-X units new default configuration

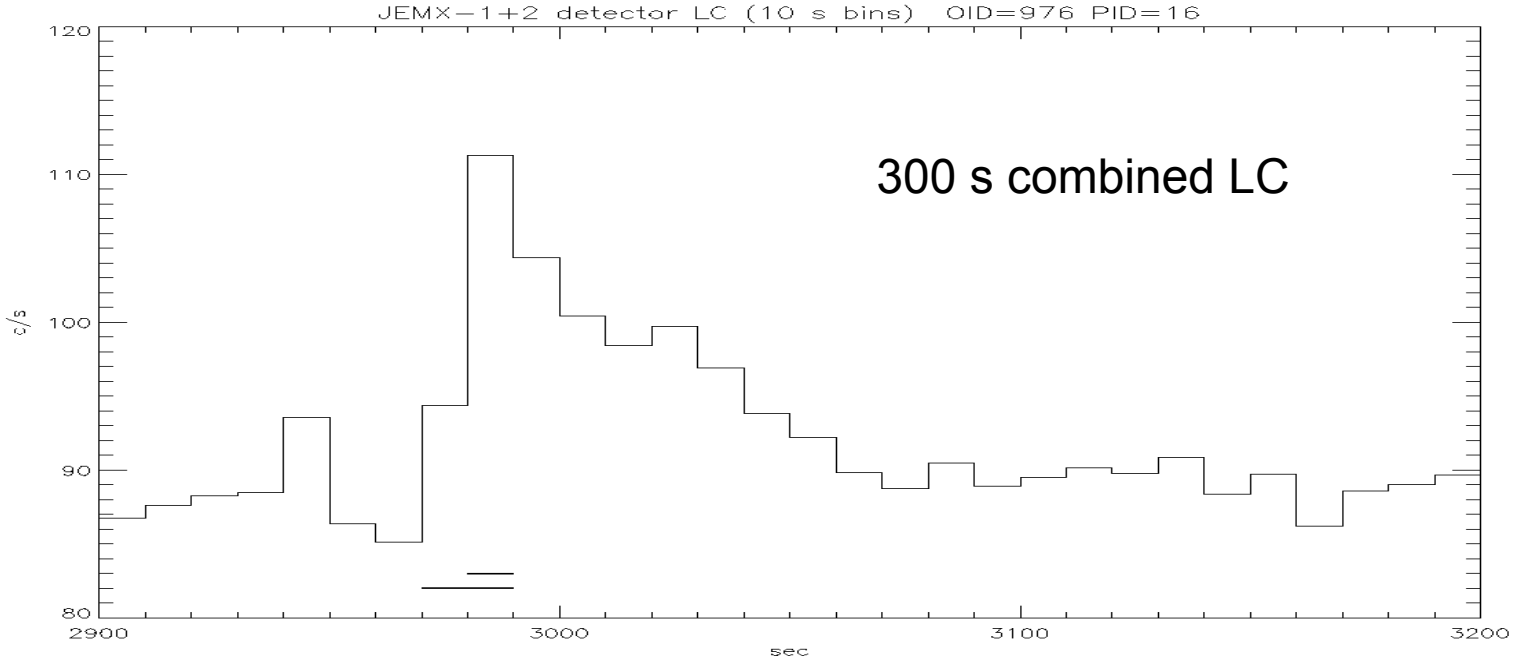
- JEM-X1 was used from rev. 170-855 and has now been used for ~720 revolutions (~6 years of use)
- During revolution 862-975 (Oct 16, 2009) JEM-X2 was the default JEM-X unit
- Since revolution 976 (Oct 10 2010) both JEM-X units have been used (8+8 tm packets allocation)
- JEM-X2 had been used for ~330 revolutions
- Both units have been used for all Crab calibrations
- Both units were used during SPI annealing, as TM allocation allowed
- S/N ratio improved by ~sqrt(2) with both units

DTU Space
National Space Institute

# Example:Recent Transient in Terzan 5

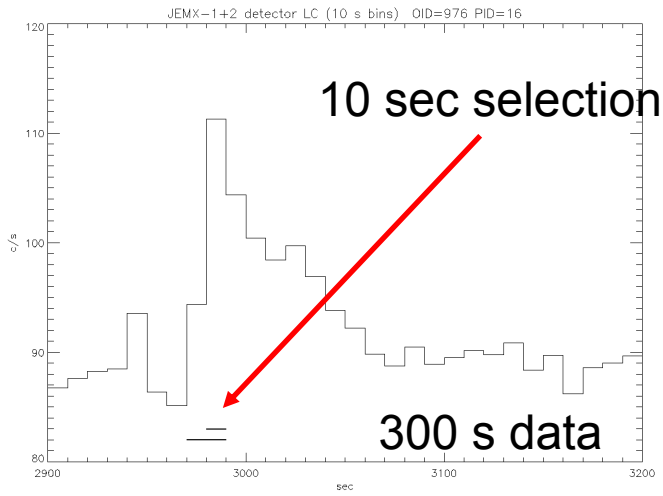
## *IGR J17480-2446*

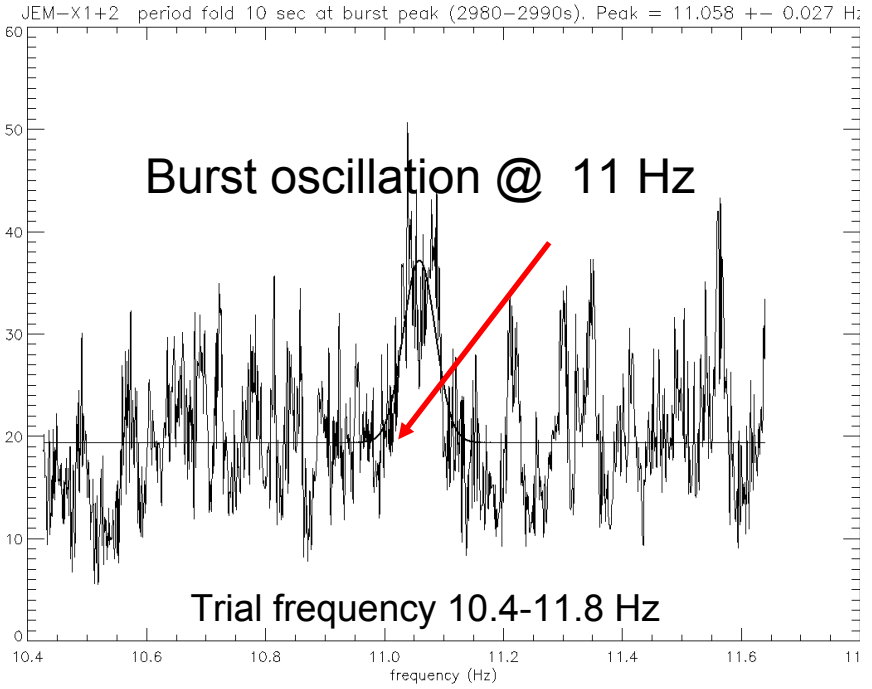
- **“A hard X-ray transient in the direction of Terzan 5 detected by INTEGRAL”, ATEL#2919**, Bordas et al. Oct 10, 2010
  - **Rev. 976, first orbit with both JEM-X units on as default**
- Followed up by 15 other ATELs 2920, 2922, 2924, 2929, 2932, 2933, 2935, 2937, 2939, 2940, 2946, 2952, 2958, 2974, 3000, 3044)
- Long discussions on issue if this source is EXO 1745-248, elclipse? Etc.
- Type I X-ray burst discovered by JEM-X on Oct 11 (ATEL 2924)
  - Both JEM-X units were active, adding to statistics



# *IGR J17480-2446 cont.*

- Shown by XTE to be 11 Hz pulsar
  - Slowest spinning bursting neutron star
- Most X-ray burst neutron star systems do not show pulsations
- Neutron star spin period only revealed very briefly during burs
- Observed by JEM-X




December 16-17 2010

# Anode status

- ~So far – on average 2-3% loss per year (256 anodes in total), but now about 1% per year
- However, no loss during ~12 months period in 2007-08
  - Two strips lost in 2008, one in March 2009, one in Aug 2010
- JEM-X1 (~720 orbits of use)
  - 62 of 256 anodes affected (almost 25% of area)
    - 38 dead (4 pre-launch, 1 lost during 2009, 1 lost during 2010)
    - 13 neighbor
    - 11 unstable or low
- JEM-X2 (~330 orbits of use)
  - 60 of 256 anodes affected (almost 25% of area)
    - 31 dead (9 pre-launch) (+2 since Oct 2009)
    - 18 neighbor
    - 11 unstable or low (+3 since Oct 2009)



DTU Space
National Space Institute

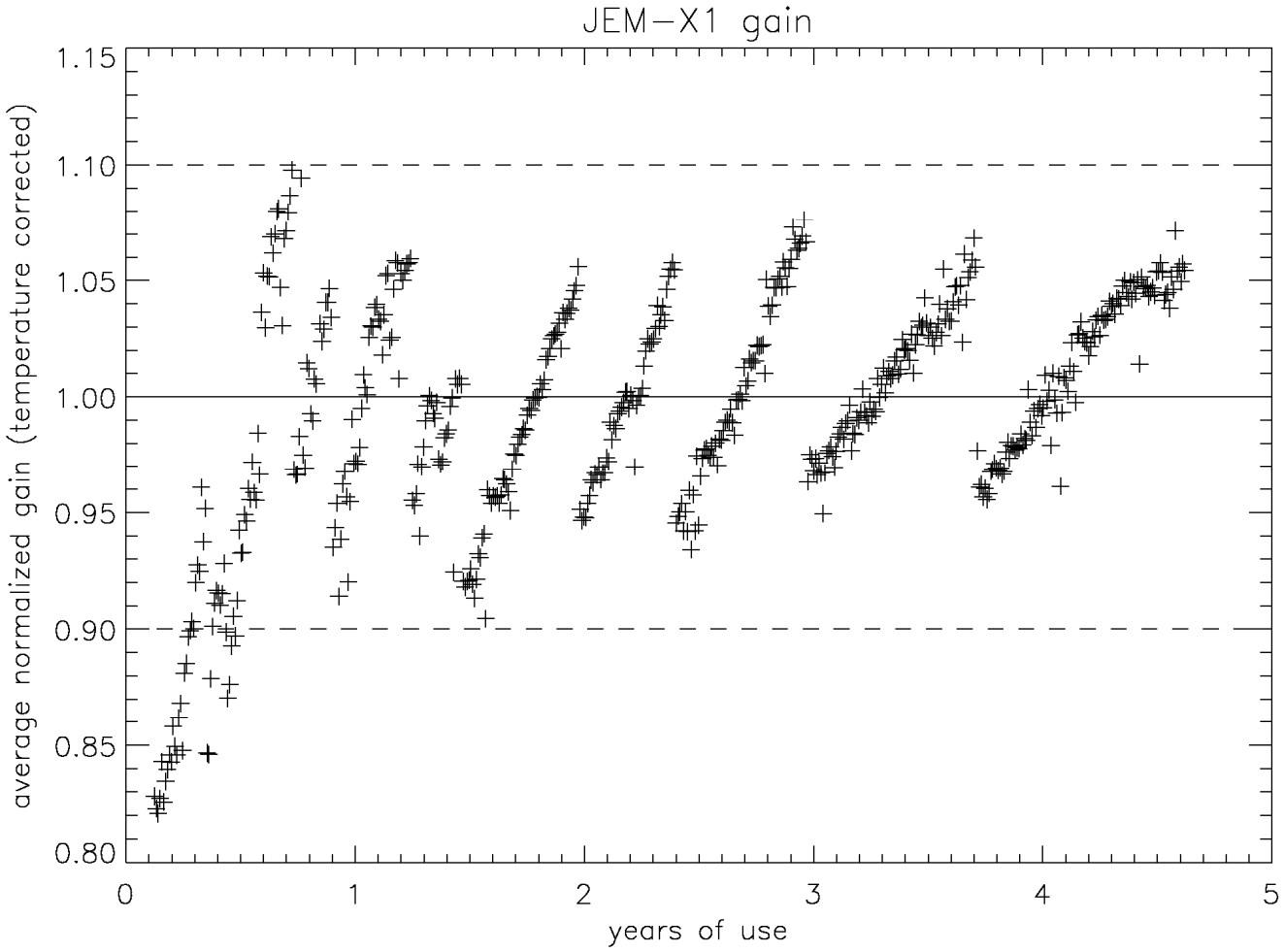
# Gain evolution

- JEM-X1 DV setting was lowered in orbit 978 to DV=70 (~700 Volts)
- When JEM-X1 started as default instrument in orbit 170, we had DV=81 (~810 Volts)
- Gain (at constant HV) has increased by a factor of ~4
- Gain dependence on detector temperature has increased from 1% per degree to ~4% per degree
- JEM-X2 DV setting is was lowered to DV=71 in rev. 967
- Gain evolution is caused by ion conducting glass substrate of the micro-strip plate



DTU Space
National Space Institute

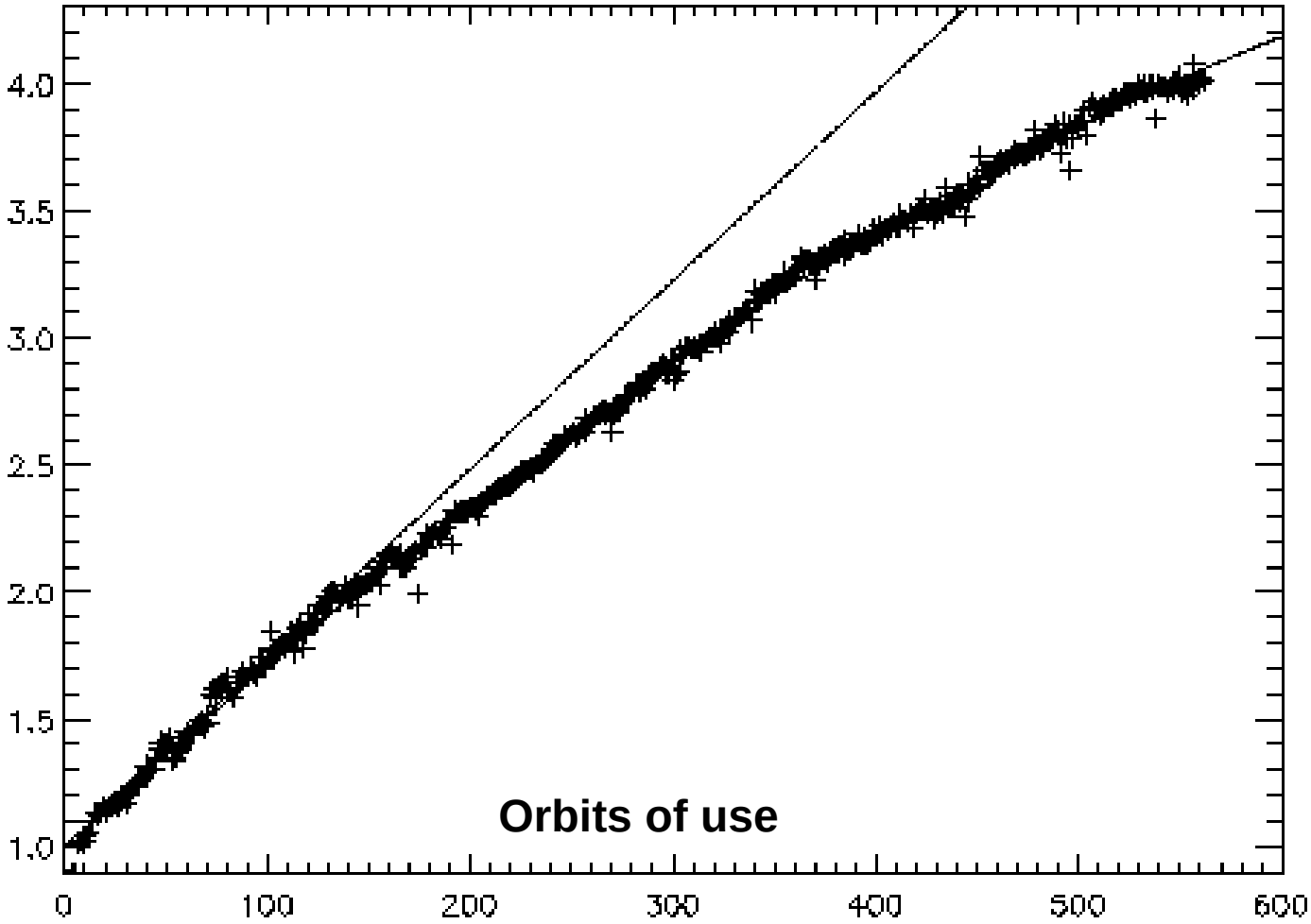
# Gain evolution to orbit 735




DTU Space
National Space Institute

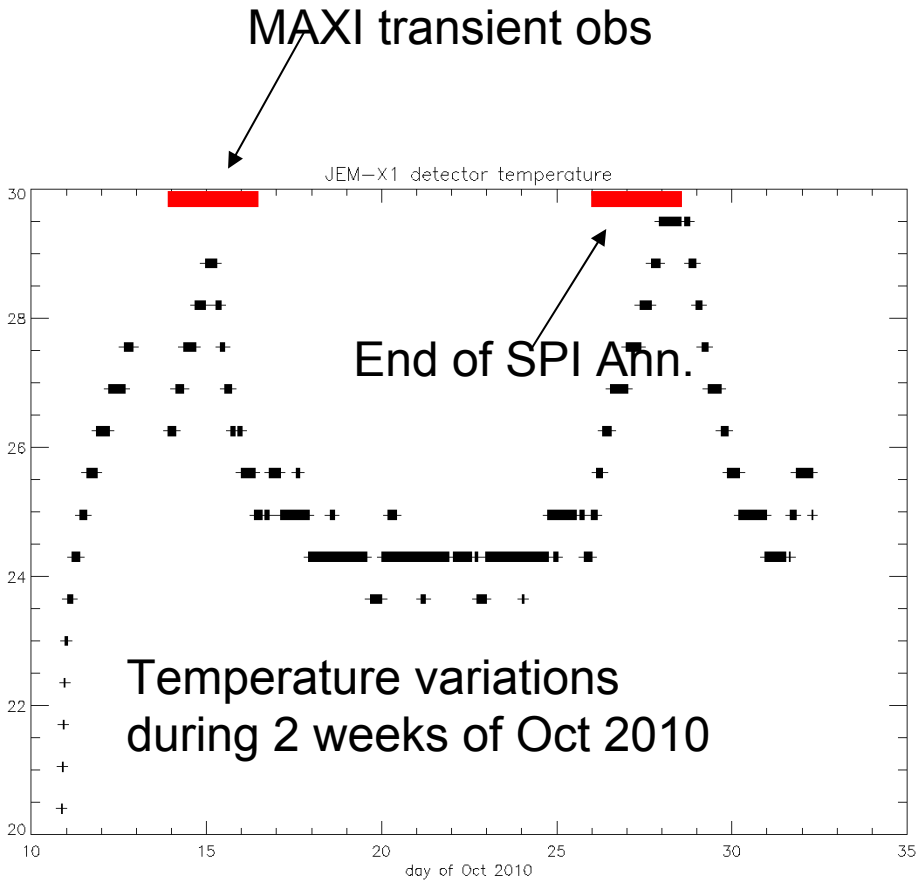
# Total gain increase

- Increase is slowing down from 0.8% to 0.4% oer orbit



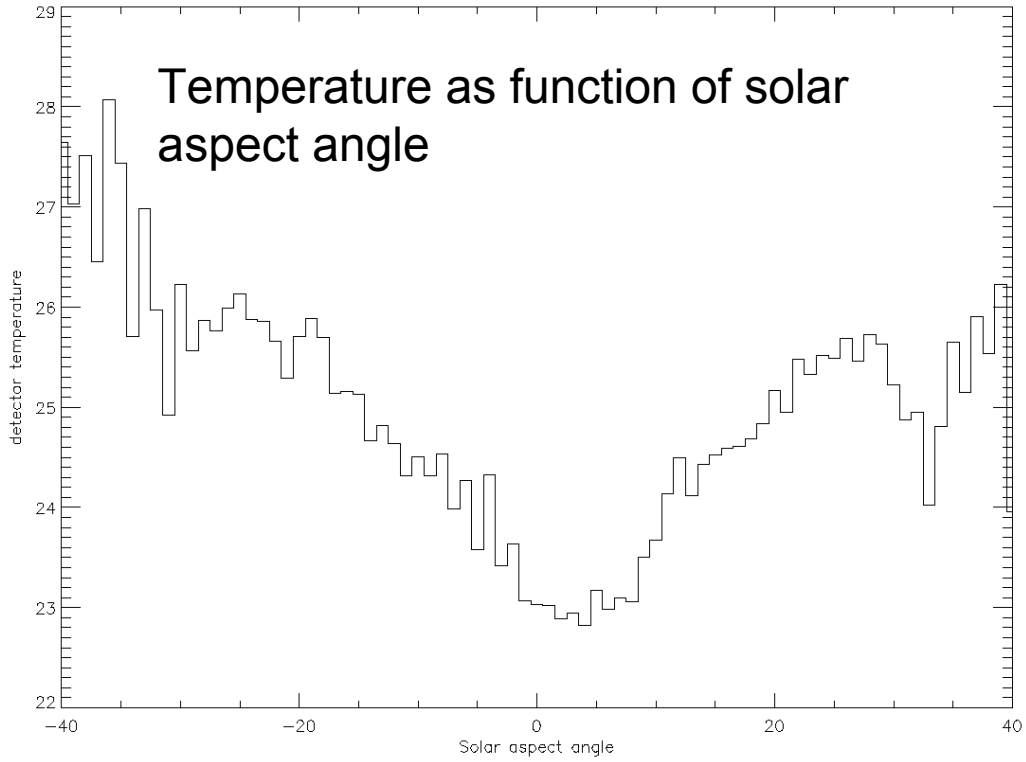
# Gain dependence on temperature

- Gain varies as function of temperature
  - ~1%/°C pre-launch
  - JEM-X1 now: ~4%/°C
  - JEM-X2 now: ~2.5%/°C
- ~5°C amplitude
  - 20% gain variation



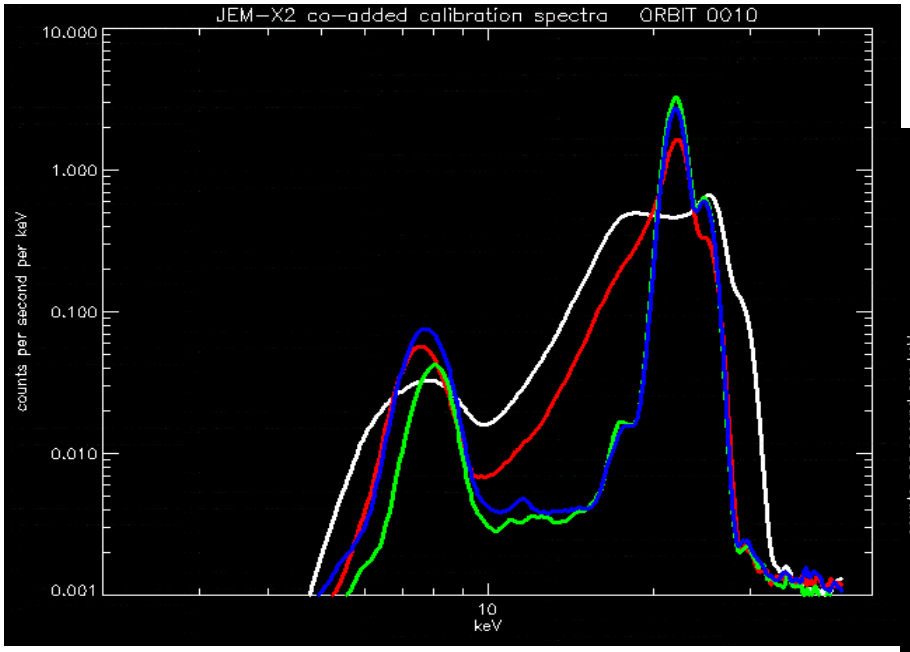
# Detector temperature variation

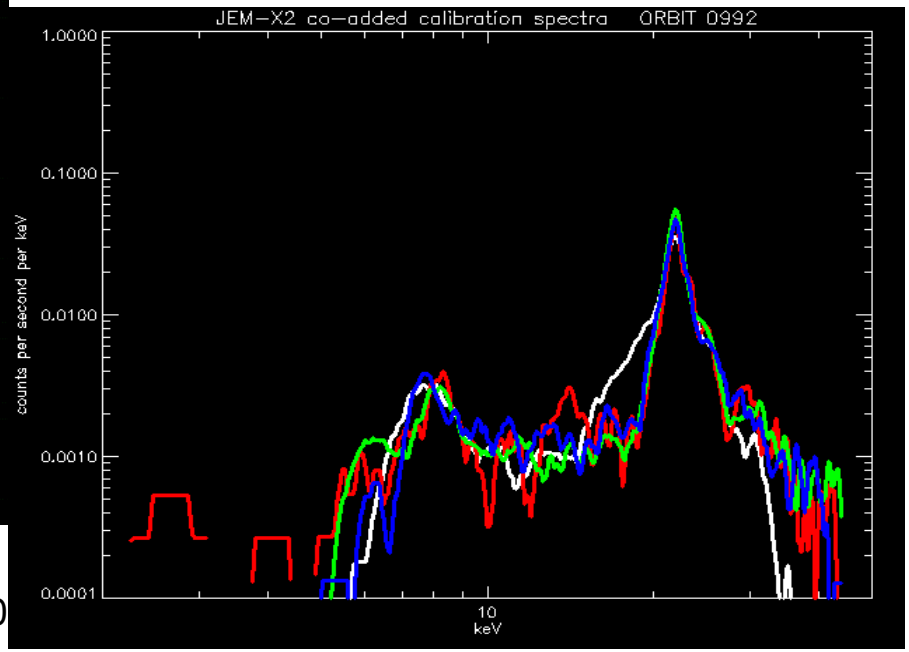
- The JEM-X detector temperature depends on the solar aspect angle
  - +5° to +3° when toward and away from Sun



# JEM-X2 calibration spectra (rev. 10 and 992)

- JEM-X2 has 4 Cd sources, which are down by a factor of ~90 since launch
- Calibration spectra integrated over longer time to fit the line
- Xe fluorescent line from detector gas at 29.6 keV also used



# JEM-X Gain calibration in OSA

- Gain calibration requires continued efforts because of the decaying calibration sources
- data must be collected in increasing time periods
- offline analysis of gain to ensure correct results
- Calibration provided by “Instrument Characteristics” tables delivered to ISDC for each revolution
- Eventually the gain calibration will rely on the Xe fluorescence background line at 29.6 keV



DTU Space
National Space Institute


the cosmic ray flux is coming down…. slowly

# JEM-X software – OSA 9

- OSA 9 includes new version of imaging sw, j_ima_iros
  - Electronic efficiency as function of gain implemented for better flux determination at low energy
  - Improved off-axis response corrections
  - Improved model of evolution of response over time (but Crab not constant)
- OSA 9 also includes
  - Better gain fitting
  - Updated mosaic software
- Note: Source detection limit in deep mosaics is determined by systematics (detailed model of collimator and effects of lost anode strips)
- Better light curve software based on the imaging software in the works
- Imaging based on direct fitting (as opposed to back-projection) is under development (see examples)

DTU Space
National Space Institute

# Calibration

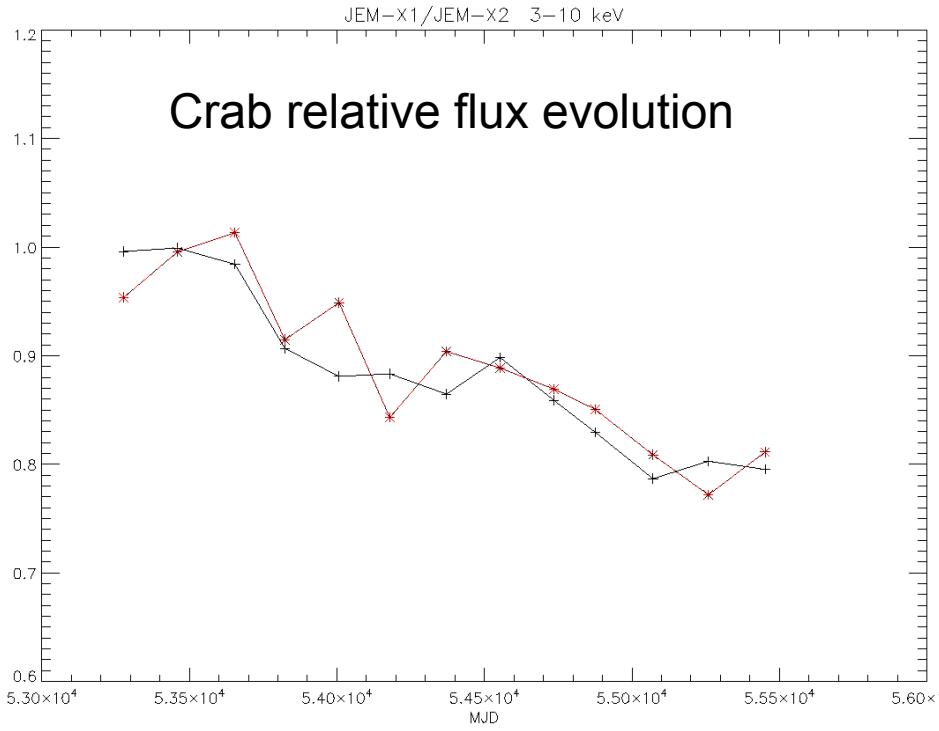
- Circle of 4 degree off axis completed in 774 and 839 Crab calibrations
  - Systematics in light curves on the order of 5% due to the collimator
- In 902 Crab staring during start of orbit to check the gain correction and electronic efficiency after HV activation
- Recent Crab calibration (966): JEM-X request for checking electronic efficiency by stepping the HV settings failed due to ISOC planning errors

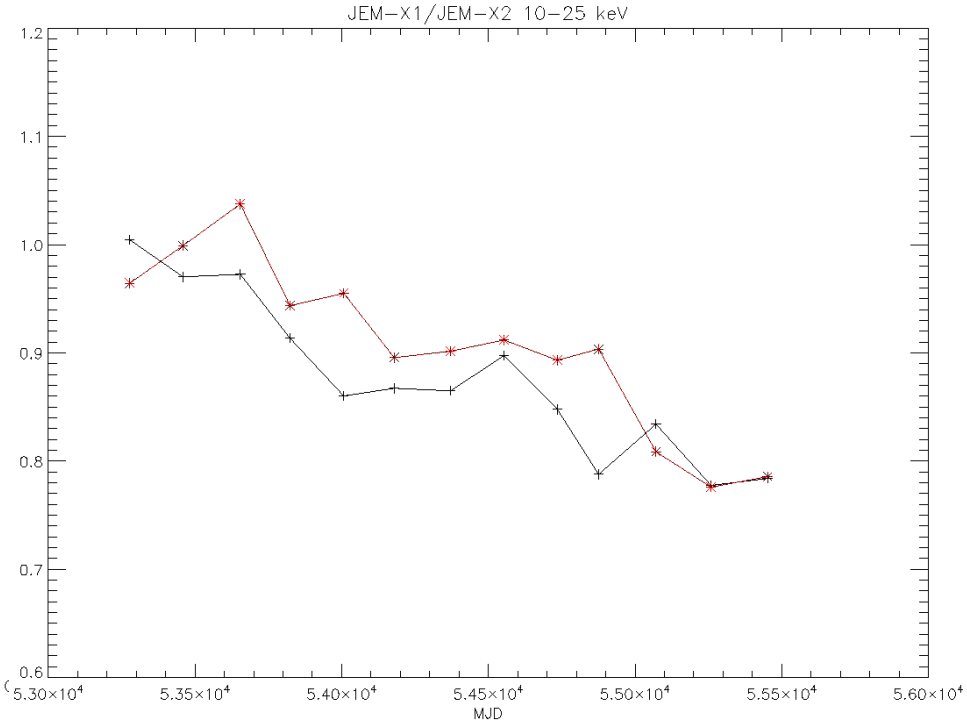


DTU Space
National Space Institute

# JEM-X1+2 Crab offline analysis

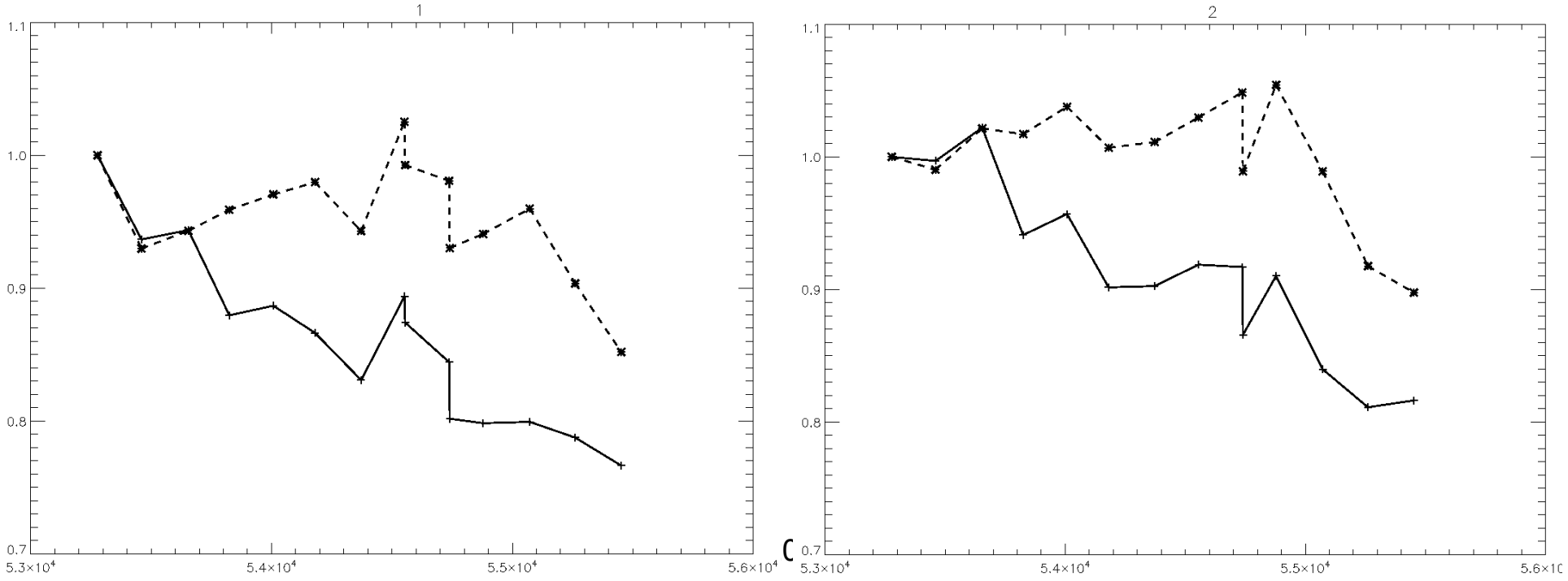
- Standard analysis generally confirm the Crab variability results
- First attempt at “first principle” analysis show general decay trend with variability
  - correlation with cosmic ray flux



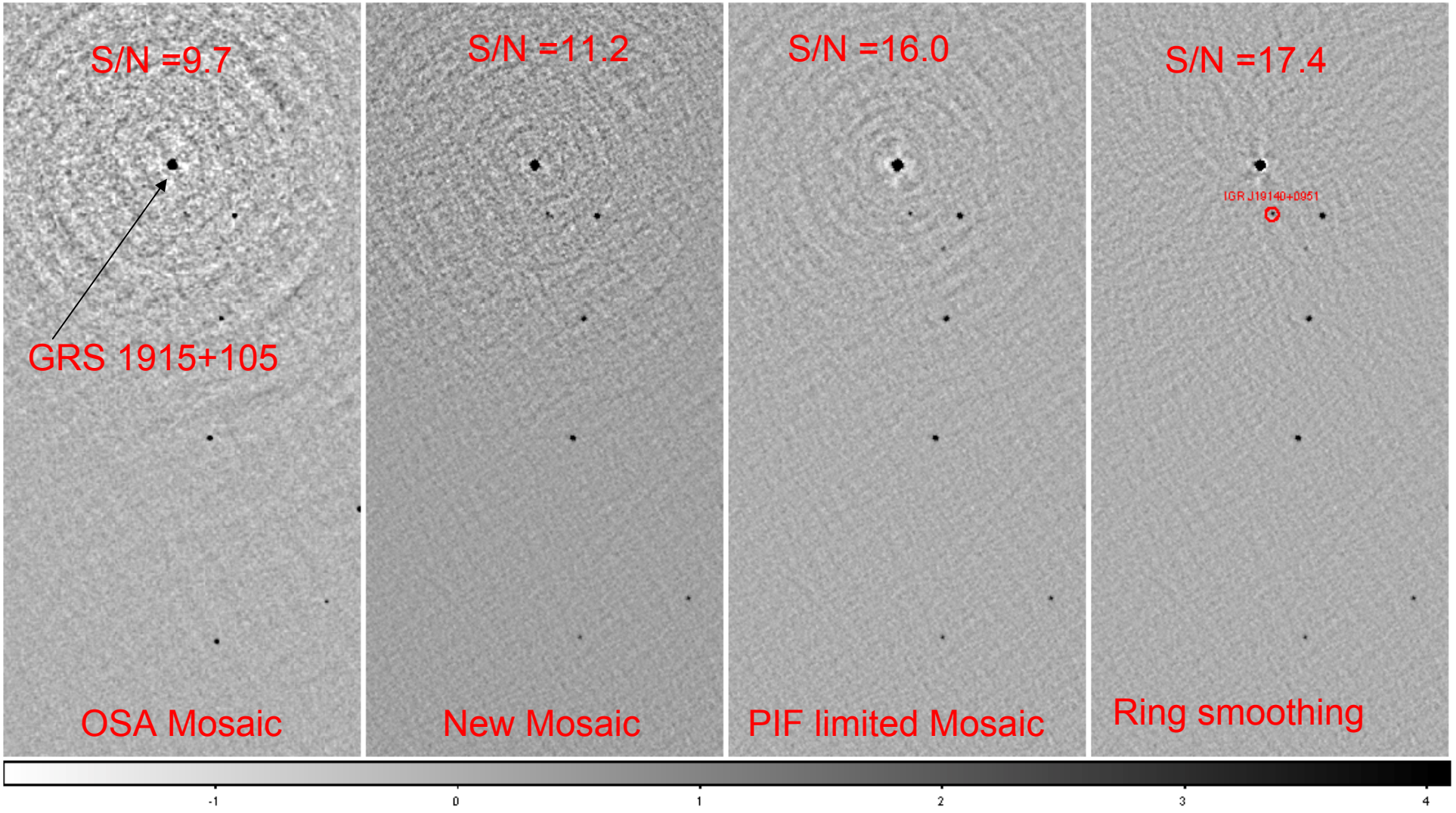
# JEM-X Crab trend

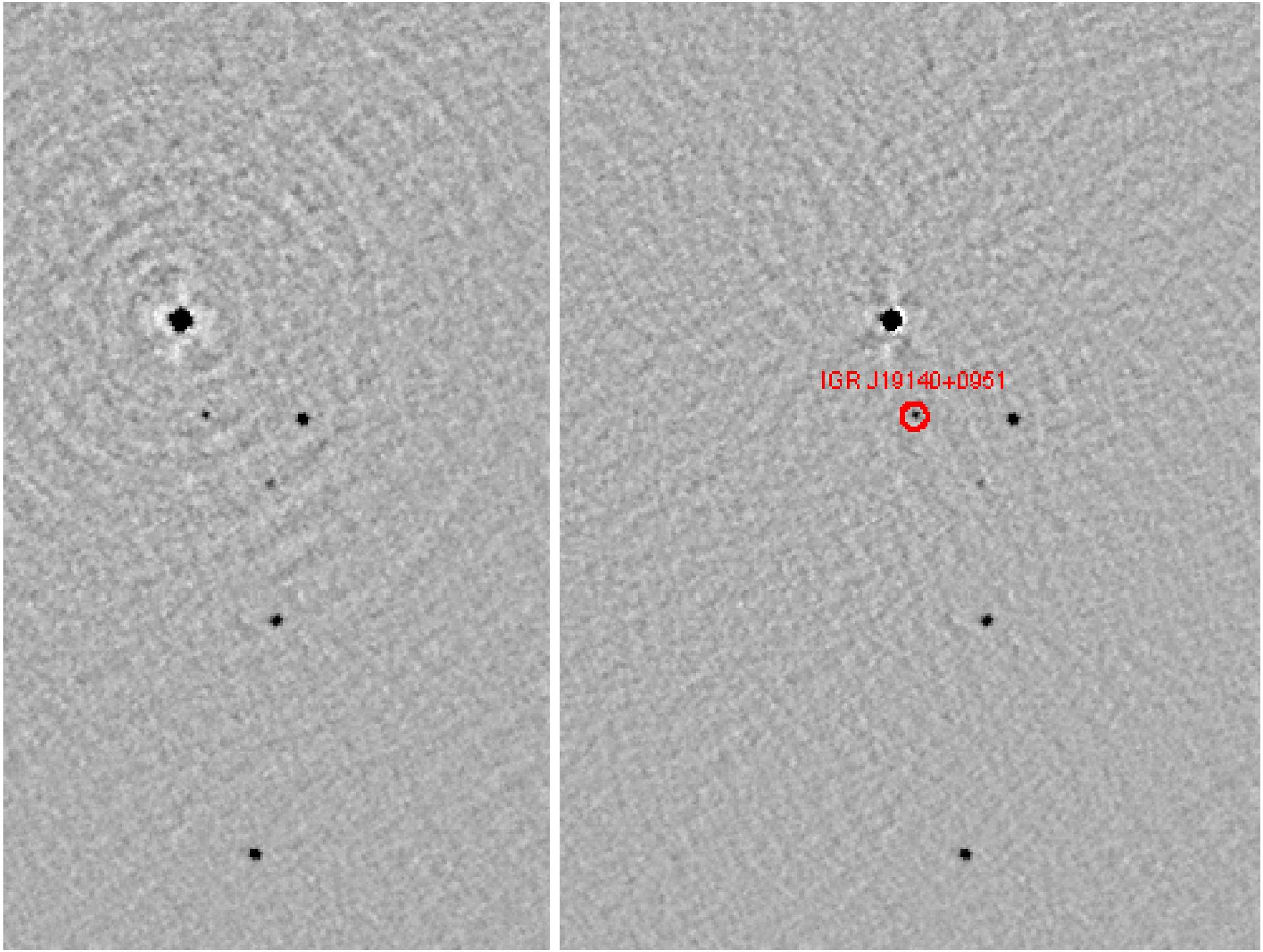
- Work in progress: The overall trend may include unknown dead-time effects due to increased particle rate?



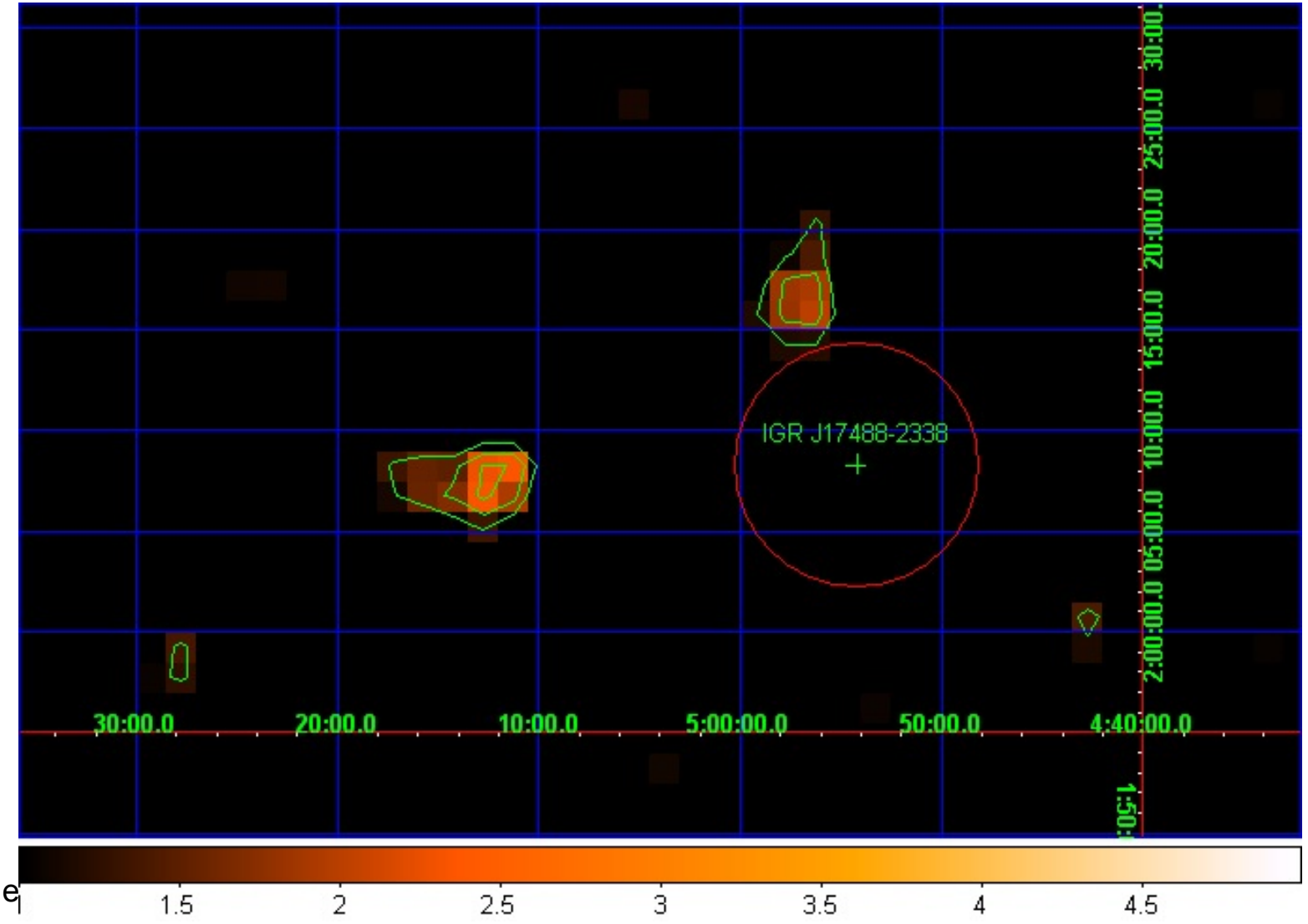
# Improving imaging – direct fitting

- GRS 1915+105 field example (8°x16° field), 3-7 keV band
- JEM-X1 1800, science windows (rev 170-735)
- IGR J19140+0951 as example of weaker source close to strong




IGR J19140+0951

# New Sources in deep exposures



# Conclusion

- JEM-X is running smoothly
- JEM-X is not affected by lowered perigee
- Gain evolution is progressing (as expected)
- Switch from JEM-X1 to JEM-X2 was implemented by start AO7 (Oct 2009) to even the “wear” on the detectors
- Running both JEM-X1 and JEM-X2 was implemented in Oct 2010, as sufficient telemetry became available
  - Improved statistics and reduction of systematics
- OSA 9 has improved flux stability
- Team is still intact (Silvia Matinez, UA, re-joining)
- We expect JEM-X and INTEGRAL to operate through 2014 (and longer?)
  - Performance is monitored to ensure that running both units will not endanger the future use

DTU Space
National Space Institute