eROSITA NRTA

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The NRTA



- conversions for other missions, e.g., lab development for Jem-EUSO balloon
- have also converted various other mission formats
- \implies prepared for last minute changes, add ons





Single scan sensitivity (T. Dauser)



One eRASS scan sensitivity (T. Dauser)

Sensitivity during individual scans: O(0.1 mCrab)

- \implies better than MAXI,
- \implies comparable to *RXTE*-PCA slews

1 Crab: 2-10 keV: $2.05 \times 10^{-8} \text{ erg cm}^{-2} \text{ s}^{-1}$ (3.2 ph); 0.3-2 keV: $1.01 \times 10^{-8} \text{ erg cm}^{-2} \text{ s}^{-1}$ (5.5 ph)



Single scan sensitivity



One eRASS scan sensitivity

Variability:

- ⇒ Variability between individual scans (one "ero-day" to the next)
- \implies Variability on 0.5 yr scales
- \implies Variability during survey phase



Counts per single (!) telescope and per single visit as function of flux (T. Hain, MSc thesis)

Bright sources (>0.1 mCrab) will allow spectroscopy and variability analysis in a single slew

NRTA Detection



Strategy for variability detection during survey phase:

- 1. Directly after downlink: Near Real-Time Data Analysis (NRTA)
- 2. NRTA triggers on potentially interesting sources See next slides for examples
- 3. eSASS run on fields containing interesting sources
- 4. Initial fast analysis by scientist on duty in collaboration w/scientists to be named by working groups Need more volunteers for this job
- 5. If phenomenon interesting: ATEL, special email lists, papers,...

Criteria for "interesting sources":

- *must* be quantitative
- trigger criteria can be matched against following:
 - source is/is not in a well specified catalogue
 - source is at a given position
 - i.e., always extract fields around list of sources
 - count rate range ("cps above", "cps below"), in E-band or total eROSITA
 - bright sources: Bayesian block trigger
 - unknown sources: type from machine learning
 - hardness in a given hardness band (expect ~4 HR values)
 - eSASS ML likelihood
 - relative change in count rate wrt previous eRO-Day (or later: eSASS)

Need "trigger criteria" from all WGs.

Note: It is the job of all WGs to ensure that the science in their remit can be done. BUT: just because you formulated a trigger criterion *does not* mean that you get to do the science! – that's up to the WGs to decide!

High Mass X-ray Binaries in the LMC and SMC:

Sources with ≥ 0.1 counts s⁻¹ (\sum all 7 cameras) and

- LMC: circle with radius 4.5° centred on $\alpha_{J2000.0}=05:22:15,\,\delta_{J2000.0}=-68:04:30$
- SMC: circle with radius 2.5° centred on $\alpha_{J2000.0}=01:07:00,\,\delta_{J2000.0}=-73:18:00$
- Bridge: 01 : 30 : 00 $\leqslant \, \alpha_{J2000.0} < 05 : 30 : 00$ and $-75^\circ < \delta_{J2000.0} < -72^\circ$

Ultraluminous X-ray Sources

Known ULX:

- extract all sources with EP8LMax > 10³⁹ erg s⁻¹ in Earnshaw et al. (2019), and
- Flag $F_{eROSITA} > 3 \times \text{SFluxEP9} \text{ or}$
- Flag F_{eROSITA} < SFluxEP9/3 SFluxEP9: average 3XMM-Flux

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New ULX:

• Source w/10³⁹ erg s⁻¹ (equiv. eROSITA cps) within D₂₅ ellipse of Galaxy in Catalog of Neighboring Galaxies (Karachentsev et al.) *or* HECATE catalogue (Zezas et al., to be submitted)

Brightening X-ray Binaries in other galaxies

- extract all sources with EP8LMax $< 10^{39}$ erg s⁻¹ in Earnshaw et al. (2019) binary catalogue, and
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Blazar Flares

- measure fluxes \forall blazars > 0.01 mCrab in the Frascati catalogue and
- trigger if fluxes are $3 \times$ above average flux

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Blazar Flares

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Bright X-ray Sources

- known sources: Extract at all positions of 4U-catalogue sources or transients from RXTE-ASM, Swift-BAT, MAXI
- unknown sources: Extract wherever Bayesian Block Analysis yields significant excess count rate

Bright Transients



Fast identification of bright transients w/Bayesian blocks (P. Weber) (*really* bright ones: single scatterings)

Bright Transients



Fast identification of bright transients w/Bayesian blocks (P. Weber) (*really* bright ones: single scatterings)

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display eSASS detected src in Aladin w/eROSITA sources



display eSASS detected src in Aladin known source info



change base image and add other source catalogues (will also match w/all earlier X-ray missions)



overlay Aladin sources onto eROSITA image

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plot source spectrum in detector space (log-log) [will provide fits to standard spectral models]

Work Area 4 🛞		Unknown Source Unknown Sou	Ger Ger	118.9 30998.9	0.3 <mark>463.</mark>	17:58:0 4 18:01:0	+50:24: -25:04:4	Ingo Kreykenb Not assigned	22.39
Work Area 5		Unknown Source Unknown Source Unknown Source	Ger Ger Ger Ger	29080.2 82.2 41.7 48097.1	363.0 1.1 0.1 505.	18:01:1 18:02:1 7 18:03:2 2 18:01:3	-25:44:2 -24:52:0 -25:15:5 -20:31:4.	Not assigned Not assigned Not assigned Not assigned	17.78 - 15.85 - 14.13 -
	Discu	Unknown Source	Ger	39544.0	256.	Info on scien	tific alert	00002 +224 00003	
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						Info:	1	Alert-ID: 00002-t234 Source: Unidentified Position: RA = 18:01:08.32	-00003 (NRTA J180100.1-250443) DEC = -25:04:43.19 Error: 0.43 arcsec
	Alert Sour Con	ID: 0000 rce: <u>Unic</u> figuration: t23)2-t234-0000 [°] dentified (NR	3 <u>(TA J180100.1</u>	 <u>-250443</u>) C			I = 5.08 b = -1.02 Time of alert: Seconds: 21492.80 eroDay (center): 2.4 MJD (center): 5154	- 21601.05 9631 .12439
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IJD: 8542.5806 roday: 1992.2334		- KKI				D		DDI	1.12 1.00 1.00 1.58 2.51 3.98 6.31 10.00 15.85 25.12 39.81 63.10 100.00 158.49 25 Channels [PHA]
ist eroday:	4								

display further alert information (summary text), can also be other informative text from other NRTA modules ("bots")



can browse all products from eSASS run



Alerts can be assigned to scientist for further inspection

	V	Unknown Sou.	Ger	32.4	0.6	18:08:4	-26:00:4	Not assigned
Work Area 4		Unknown Sourc	e Ger	78.0	3.9	18:08:2	-23:09:1	Ingo Kreykenb
Work Area 5 🛛 🛎		Unknown Sourc	e Ger	1349.9	17.0	18:08:4	-20:24:4	Not assigned
		Unknown Sourc	e Ger	419.0	19.6	18:09:5	-19:43:5	Not assigned
		Unknown Sourc	e Ger	820.5	23.7	18:10:2	-19:04:1	Not assigned
		Unknown Sourc	e Ger	2019.9	20.5	18:07:2	+19:42:	Not assigned
		Unknown Sourc	e Ger	1948.3	18.3	18:05:4	+21:26:	Not assigned
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	2019-0	02-01	kreyken	Backgi	ound event			
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ast eroday:								

Alerts can be blacklisted, hidden,...

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Work Area 4 🛛 🛎	Unki	nown Sou	Ger	32.4	0.6	18:08:4	-26:0	0:4	Not assigned			
Work Area 5 🛞		Iown Source	Ger	1240.0	3.9	18:08:2	-23:0	9:1	Not accigned			
			Ger	1349.9	19.6	18:09:5	-20.2	3.5	Not assigned			
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roday: 1992.6322												
ist eroday:												

Trigger info can be emailed to known users

Work Area 4 🛛 🛎	Unknown So	u Ger	32.4	0.6	18:08:4	-26:0	00:4	Not assigned						
Work Area 5 🛛 🛎		ree Ger	1240.0	3.9	10:00:2	-23.0	J9.1	Not accigned						
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Trigger info can be emailed to known users

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Work Area 5	Unknown So	urce Ger	78.0	3.9	18:08:2	23:09:1	Ingo Kreykenb						
	Unknown So	ource Ger	1349.9	17.0	18:08:4	20:24:4	Not assigned						
	Unknown So	ource Ger	419.0	19.6	18:09:5	19:43:5	Not assigned						
	Unknown So	Ger	820.5	23.7	18:10:2	19:04:1	Not assigned						
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Discussion on alert can be accessed

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Work Area 5 🛛 🛎		Unknown Sou	Irce Ger	1575.4	19.9	18:05:4	+2	1:26:	Not assigned					
		Unknown Sou	irce Ger	693.7	24.4	18:08:1	+2	9:41:	Not assigned					
		Unknown Sou	irce Ger	34.3	0.6	18:06:5	+2	9:31:	Not assigned					
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Summary

Science:

- There is a large number of sources to follow
- Survey science: end stages of stellar evolution, stellar flares, AGN events,...
- Timing: Sampling not ideal, but eROSITA will probably be one of only a few monitors <10 keV available in 2020ff.
- $\sim 1-2$ transients per day to follow up

Software:

- NRTA interface allows initial studies of triggered sources
- Many tools in backend finalized
- Input on triggers, interface from potential users urgently needed
 ⇒ please communicate trigger criteria & science projects to the TDA WG!
- Interested scientists: please come the TDA WG sessions for further information.