eROSITA CalPV phase operational issues: optimizing the scientific efficiency

- General scheduling: start of CalPV observations
- Commissioning Light
- Mini-survey: 6 great circles with scan reversal
- Stars (optical loading)
- Gain monitoring during survey
- Soft X-ray response and contamination monitoring during survey

In-orbit calibration subjects

- Commissioning
- Background (graded shield, calibration and monitoring, “Closed”, etc.)

- Plate scale and boresight of the 7 modules (star-trackers vs. mirror assembly)
- Filter integrity (launch, micrometeorites)
- Soft X-ray response and contamination monitoring
- Gain and CTI (calibration and monitoring, “CalClosed” Fe-55)
- PSF (on-axis, off-axis, survey)
- Power-law type spectrum (cross-calibration)
- Effective area, flat-fielding, and vignetting
- Optical loading by point sources
- X-ray baffle (mosaic, mini-survey in great circles)
- Absolute and relative timing (and operational tests like “mini-survey” in great circles for time-delays between star tracker and X-ray cameras, attitude reconstruction)
- XUV response and contamination monitoring
- Masked mode, etc.

- Performance verification / “early science” (interleaved with calibration observations)

Operational constraints:

- Data handling rate inside camera (buffers)
- Data downlink rate limited
- Only short commanding period during ground contacts
- Number of time-tagged commands to be stored is limited to 80 (ART-XC + eROSITA)
- response time of manual commanding to L2: ∼12 s
  commissioning might require several "real-time" commands
- Closed/CalClosed: only 1 module at a time
  (i.e., 6/7 of exposure to avoid dark regions)
- Monitor health and calibration validity regularly, but do not stop surveys too long:
  after each all-sky survey (6 months): ∼1 day Cal/monitoring campaign:
  1E0102 and RXJ1856
- eROSITA vs. ART-XC programmes
- eROSITA requests for SRG operation (pointing / survey)
- cross-calibration with other operational X-ray missions,
  depends then also on other (external) constraints, e.g. for 3C 273

Background:

- During/after commissioning of all cameras:
  defined mixture of cameras with CLOSED/CALCLOSED filters
  and scientific filter
- as predefined set of commands (macro)
- one camera per day, one after another, for some ks
- joint SRG background study for L2: eROSITA + ART-XC:
  eROSITA MIP counter lightcurves + ART-XC high-channel lightcurves
- no interference with other eROSITA cameras or ART-XC or SRG

General CalPV scheduling: start of observations

- Many CalPV phase obervations have a duration of about $\sim 80\,\mathrm{ks}$ ($\sim$ 1 day), or if raster, e.g., $2 \times 40\,\mathrm{ks}$; in the remaining ~ 1.5 hours SRG could/would slew towards the next target
- If an observation of a CalPV target starts during a ground contact, then real-time data could show whether the observation as such started successfully, and at least a chance of intervention could be possible.
- Is this scheduling possible ?
- Is intervention (stop/command/restart) possible ??

eROSITA Commissioning:

- During/after commissioning of camera:
  closed, calclosed, (gain change TBD),"open" (i.e., filter): "Comm. Light"
- Why as soon as possible: immediate quicklook of :
  background (soft protons !)
  filter integrity, optical loading,
  celestial X-rays: mirror module health, PSF, baffle performance, single-reflections, bore-sight, ...
- helps to optimize set-up for following "open" (filter) scientific CalPV observations (save weeks of time to possibly adapt on-board software, but also eSASS)
- Preferred target: LMC: 30 Dor region / SN1987A (observable at any time)
- Details TBD: what shall be observed during commissioning of other cameras?
  all the time "Comm. Light", same or different position ?
  follow ART-XC and return to "Comm. Light" with next camera ??
- Commissioning phase determines and fixes set-up for CalPV (and survey) phase

Commissioning:

Target name	RA (2000)	Dec (2000)	l (deg)	β (deg)	Remark	Duration (ks)
LMC (SN 1987A)	05 35 28.2	−69 16 11	279.70	−86.446	**for each camera**	**40**

- **commissioning of one camera: CLOSED and CALCLOSED filter**
- **in this phase the SRG/ART-XC pointing is arbitrary**
- **after commissioning of this camera:**
  move to "Commissioning Target" and set to science filter
  make exposure
- **if needed: re-adjust camera parameters**
- **if ready: continue with ART-XC programme**
- **commissioning of next camera**
- **minimum:**
  for first camera with on-chip filter
  for first camera without on-chip filter
  after commissioning of all 7 cameras
- **optimum:**
  after commissioning of each camera

Mini-Survey (in ROSAT terms):

- several full great-circle scans across the ecliptic poles, with a reversal of the scan direction.
- This would be very useful to determine spacecraft parameters like time delays of star tracker relative to CCD cameras (which cannot be retrieved from pointed observations): boresight vs. time delay
- would also be a full end-to-end test in orbit (including data transfer und pipeline processing) of survey mode, and station keeping procedures
- single-reflection stray-light effects, e.g., passing close ($\sim 30' - 190'$) to very bright X-ray sources.
- For eROSITA a time of $3+3$ great circles (i.e., 6×4 h, i.e. 1 day) should be allocated.
- Date: early in CalPV phase
- Procedure: from a stable pointing (some celestial CalPV target) switch to survey mode (3 great-circles), then stop, and switch to survey mode in opposite direction (3 great-circles), then stop to a stable pointing (some celestial CalPV target).
- Is this possible ??

Stars (optical loading)

- Bright optical stars will move through FOV during survey
- will shift X-ray energies and cause spurious events
- Calibrate effect by observing ~ 10 bright optical X-ray dark stars
- Preferred targets: single A-type stars (ROSAT non-detections)
- Procedure:
  offset map calculation/dump + short exposure with this new offset map
  re-load survey offset map + short exposure with this offset map
- This means many short observations on different targets
- This would require many time-tagged commands
- Is it possible to perform 1 such observation during a ground contact, different targets on ~ 10 days during the 7 weeks of CalPV ?

Gain monitoring during survey phase

Target name	RA (2000)	Dec (2000)	l (deg)	β (deg)	Remark	Duration (ks)
1E 0102-72.2	01 04 02.0	−72 01 55	301.558	−65.036		40

- **line positions and line widths (0.3 - 2 keV)**
- **Preferred target: 1E 0102-72.2 (repeat every 6 months)**
- **Approx. visibility: Mar 11 - Jul 01, Sep 13 - Dec 30**
- **Is this possible ??**

Soft X-ray response and contamination monitoring

during survey phase

Target name	RA (2000)	Dec (2000)	l (deg)	β (deg)	Remark	Duration (ks)
1RXS J185635.1−375433	18 56 35.1	−37 54 33	358.600	−15.033	**survey**	**80**
1RXS J214303.7+065419	21 43 03.7	+06 54 19	62.658	+19.419	**CalPV**	**(80)**

- **Verify filter transmission and response in soft X-rays, constant source for contamination monitoring**
- **Preferred targets: Isolated neutron stars (Magnificent Seven): 1RXS J185635.1−375433 (not visible in nominal CalPV phase, but for survey), 1RXS J214303.7+065419 (substitute target for CalPV phase, observe twice), repeat RX J1856 every 6 months**
- **Approx. visibility RXJ1856: Mar 11 - Apr 22, Sep 13 - Oct 25**
- **Approx. visibility RXJ2143: Apr 30 - Jun 13, Nov 01 - Dec 14**
- **Is this possible ??**

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