Technical Note:
The SRG/eROSITA Deep Field South

Edited by A. Merloni. Draft v1, July 18, 2018

1. Scope

This Technical Note summarizes the current discussion within the eROSITA_DE team regarding the location and depth of the SRG/eROSITA deep fields. This document describes a baseline plan that was proposed to the SRG Joint (Russian/German) committee. A final decision on the scanning strategy will only be taken after the final SRG orbital profile have been fixed by the SRG ballistic engineers.

2. SRG Scanning law

2.1 *General Considerations*

The 4 years eROSITA all-sky survey (eRASS) consists of eight sky scans with duration of half a year each. The accumulated data builds the consecutive versions of the all-sky survey (eRASS:1 – eRASS:8). Survey strategies have been adapted over the years to various modifications in the eROSITA/SRG mission design; see e.g. the eROSITA Science Book (Merloni et al., 2012, arXiv1209.3114) for a development history.

A survey strategy defines the time-dependent orientation of the spacecraft and thereby determines the exposure distribution over the sky. The main constraints to be taken into account are: (i) maximum separation between the antenna (and scanning) axis and the Earth for continuous downlink capability; (ii) maximum angle between the viewing axis and the sun for instrument and spacecraft safety and thermal balance; (iii) angular separation between the earth and the sun as seen from the spacecraft during its evolving orbit around L2.

2.2 *Survey strategy: basics*

The SRG/eROSITA survey strategies are mainly characterized by two time-dependent parameter sets that define:

a) the pole of the survey, i.e. the plane in which the rotation axis is moving;
b) the orientation and angular movement of the rotation axis within this plane.

Each survey strategy defines a survey pole and thereby the plane in which the spacecraft rotation axis is moving around the Sun, the 'survey plane'. In addition, it defines the initial orientation and the angular velocity of the rotation axis within

this plane. These parameters are typically time dependent, and a strategy has to define the time intervals where a specific set of control parameters is valid.

The overall shape of the all-sky survey exposure distribution is governed by the fact that the rotation axis is oriented almost parallel to the ecliptic plane. This survey geometry results in a latitudinal distribution, with lowest exposure values close to the ecliptic plane and highest exposures at its poles. Survey poles that do not coincide with the ecliptic pole, introduce a tilt of the survey coordinates with respect to the ecliptic plane, thereby the chosen survey poles mainly influence the exposure distribution at highest (or lowest) latitudes around the ecliptic poles.

In general, three main choices drive the overall design of the survey:

a) **The location of the center(s) of the deeply exposed areas:** In the survey geometry, the ecliptic pole (EP) is the natural centre, but a shift to nearby regions at <10 degrees away from the pole is possible.
b) **The extent of the deeply exposed area (and, consequently, the maximal depth reachable)**: To some extent, the choice of how large and deep should the deeply exposed area(s) is largely independent from the choice of centres. Here the options are more numerous, but, in summary, the decisions we have to take are: what is the minimum and/or maximum exposure of the deep fields and the minimum/maximum number of survey poles.
c) **The survey rate, i.e. the movement of the spacecraft rotation axis in the survey plane, which determines the large-scale longitudinal exposure distribution on the all-sky maps.**

In this Technical Note, we describe the current baseline plan regarding point a) and b) above.

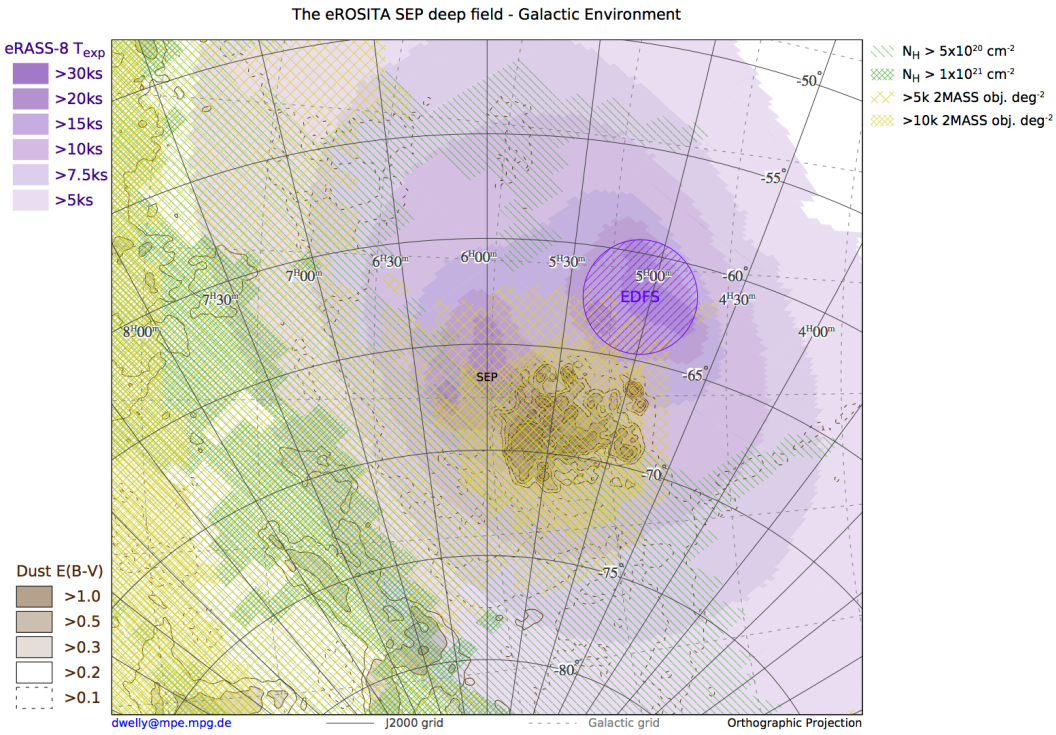

Figure 1: Detailed map of the South Ecliptic Pole area for the "baseline" eROSITA_DE survey strategy. The purple shaded areas mark the eRASS:8 exposure (in units of on-axis exposure, calculated assuming a 1.0deg circular FoV, and not corrected for vignetting), brown shaded areas dust extinction levels, green shaded areas the intervening hydrogen column density, N_H, and yellow shaded areas the 2MASS stellar density.

3. SRG/eROSITA baseline survey plan

3.1 *General Considerations*

In the discussion within the German eROSITA Consortium, because of the importance of the Euclid/LSST synergy for distant clusters study (one of the the key science drivers of eROSITA), we favored a solution having *two distinct deep fields*, one centered on the SEP (and thus with large overlap with the LMC) and the other in a region of low foreground N_H and stellar density (and thus as close as possible to the final EDFS). In particular, we adopt as baseline an option that concentrate the deeper exposure in two areas, one centered on the ecliptic poles, and one on a possible location of the Euclid ~20 deg^2 calibration field, which was tentatively located (at the time of the exercise, i.e. June 2016) about 7.5 degrees away from the EP, to avoid the high stellar density area surrounding the LMC (see Figure 1).

As far as the extent of the deeply exposed regions is concerned, an almost general consensus was expressed that maximizing the area with ~20ks exposure was preferred to having small regions with high (>40ks) exposure. Confusion limit was regarded as potentially critical issue here.

To address this, with the aid of Figure 2, we evaluate confusion in the hard and soft bands for two FoV-averaged HEW: 30" (dashed lines) and 26.4" (solid). Confusion is defined by having a source density of one per 40 telescope beams (= HEW). This

corresponds to ~460 deg^{-2} for 30" HEW and ~590 for 26.4" HEW. The blue lines mark the confusion limit for the nominal 26.4" option (close to what will be implemented), which is reached at about 38ks exposure.

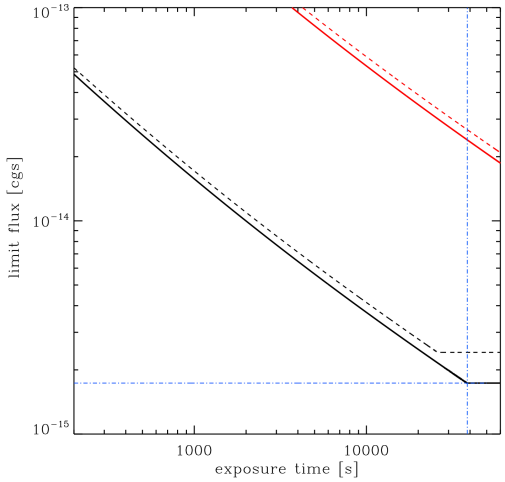

Figure 2: eROSITA limiting flux vs. exposure for two FoV averaged HEW: 30" (dashed) and 26.4" (solid). Black lines are for 0.5-2 keV, red for 2-10 keV.

On the basis of this analysis the eROSITA_DE team recommend the following baseline survey strategy:

3.2 *Location of the deep polar regions:*

Pending a decision of the location of the Euclid (and possibly LSST) southern deep field(s), we recommend the SRG/eROSITA deep polar regions to be split in two disjoint areas. One will be centered on the Ecliptic poles, and the other will be offset from the EP by an amount to be defined, in order to allow maximal overlap with the Euclid deep field, still preserving all safety constraints for the SRG operations (i.e. provided this will fall with <10 degrees from the SEP). The main criteria in the final definition of the second SRG/eROSITA (and Euclid/LSST) deep field will be: minimal N_H, minimal stellar density and absence of bright stars. The SRG/eROSITA mission planning team will define the best possible solution according to the above principles, in coordination with the Euclid (And LSST) Survey strategy teams.

3.3 *Extent and depth of the deep polar regions*

Within the above defined geometrical setup, we should strive to maximize the area covered at ~20ks (net) exposure, while limiting the maximal exposure to ~40ks (net), in order to avoid confusion. Current plans foresee an area of about 100 deg^2 around each deep field with >20ks exposure, and area of about 200 deg^2 around each deep field with >15ks exposure (roughly comparable to the soft X-ray depth of the XMM-XXL survey).