# eROSITA Working Group

## Solar System:

~~Planets,~~ Comets, Heliosphere

# Mars

eROSITA CalPV proposal: **Mars** (K. Dennerl)

**Note:** Because of visibility constraints, this proposal is only relevant if the CalPV phase overlaps with the time interval **2018-Oct-15 to 2019-Jan-26**. Mars will afterwards be unobservable for eROSITA until April 2020.

**1. Scientific justification**

X–rays from Mars contain information about its atmosphere and exosphere which are difficult or impossible to obtain by any other means. Thanks to observations with Chandra and XMM–Newton we know that they are a superposition of two different components, caused by scattered solar X–rays and by solar wind charge exchange. The first component originates predominantly at heights of 100 – 140 km above the surface (Dennerl 2002) and thus contains information about atmospheric layers which are difficult to study in other wavelengths. Also in–situ measurements by space probes are facing severe problems, because the atmospheric drag is too high at such low altitudes to allow stable orbits. The challenge in studying the second component is the very low particle density. Here X–rays have opened up a completely new window, because the charge exchange process is characterized by very high cross sections, which makes them the perfect means for studying the distribution of tenuous amounts of gas. XMM–Newton observations have already demonstrated that it is possible to trace the exospheric X–ray emission out to a height of 8 Martian radii, proceeding into regions beyond those which had been observationally explored before (Dennerl et al. 2006). In contrast to in–situ observations, which can only be done at one particular location and time, remote X–ray observations give us a global, instantaneous picture. In view of the temporal variations which

Mars: no CalPV target anymore

# eROSITA and Planets

Mars: eROSITA visibilities 2018 - 2025

| | | | |
|---|---|---|---|
| ~~2018-Feb-05~~ | ~~..~~ | ~~2018-Feb-23~~ | ~~MPE~~ |
| ~~2018-Feb-24~~ | ~~..~~ | ~~2018-May-06~~ | ~~IKI~~ |
| ~~2018-Oct-17~~ | ~~..~~ | ~~2019-Jan-29~~ | ~~IKI~~ |
| 2020-Mar-29 | .. | 2020-Jul-30 | IKI |
| 2020-Dec-27 | .. | 2021-Mar-19 | IKI |
| 2022-Jun-22 | .. | 2022-Sep-20 | IKI |
| 2022-Sep-21 | .. | 2022-Oct-04 | MPE |
| 2023-Feb-13 | .. | 2023-Mar-07 | IKI |
| 2023-Mar-08 | .. | 2023-Apr-27 | MPE |
| 2024-Aug-29 | .. | 2024-Nov-15 | MPE |
| 2025-Mar-21 | .. | 2025-Jun-01 | MPE |

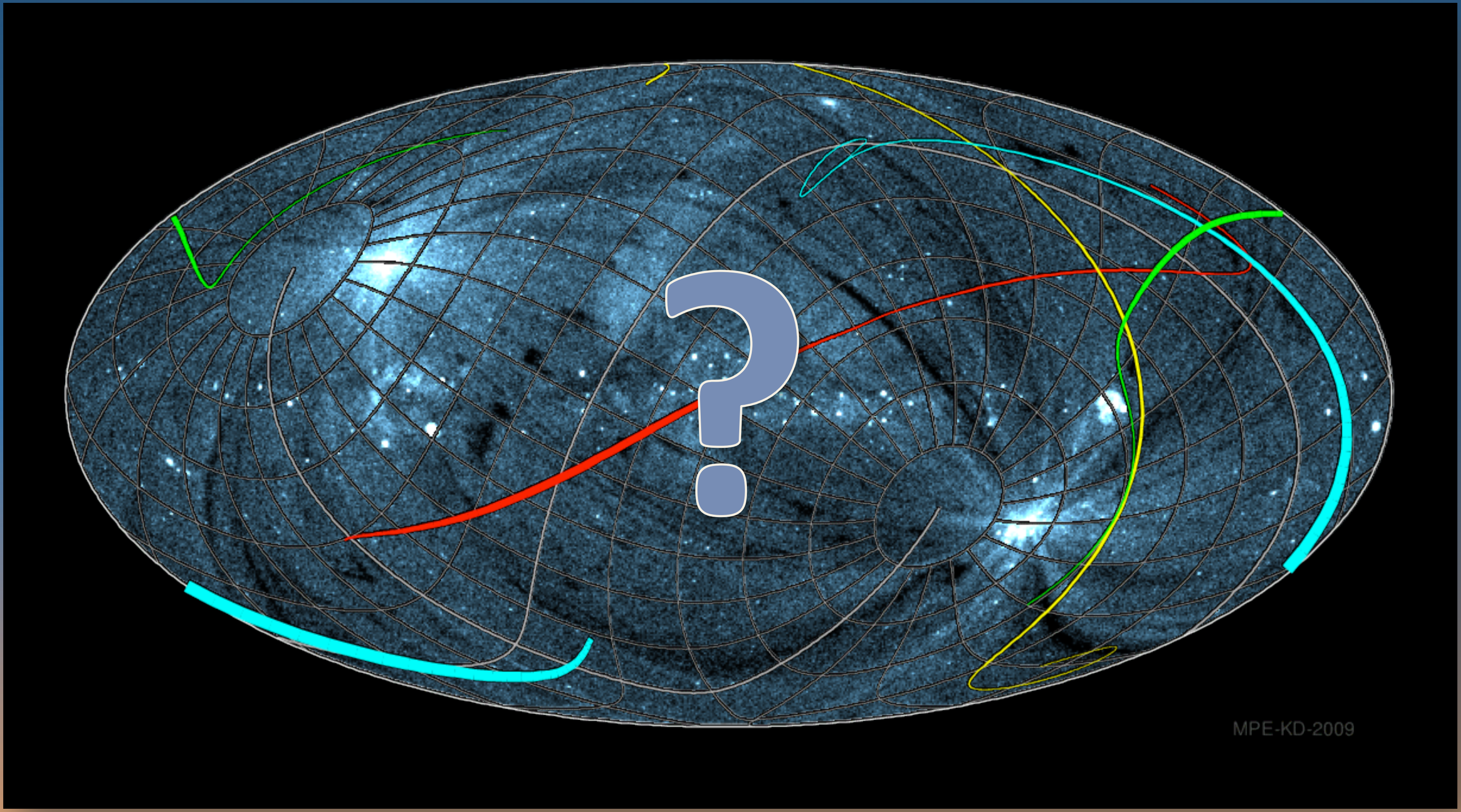
# eROSITA and Planets

Jupiter: eROSITA visibilities 2018 - 2025

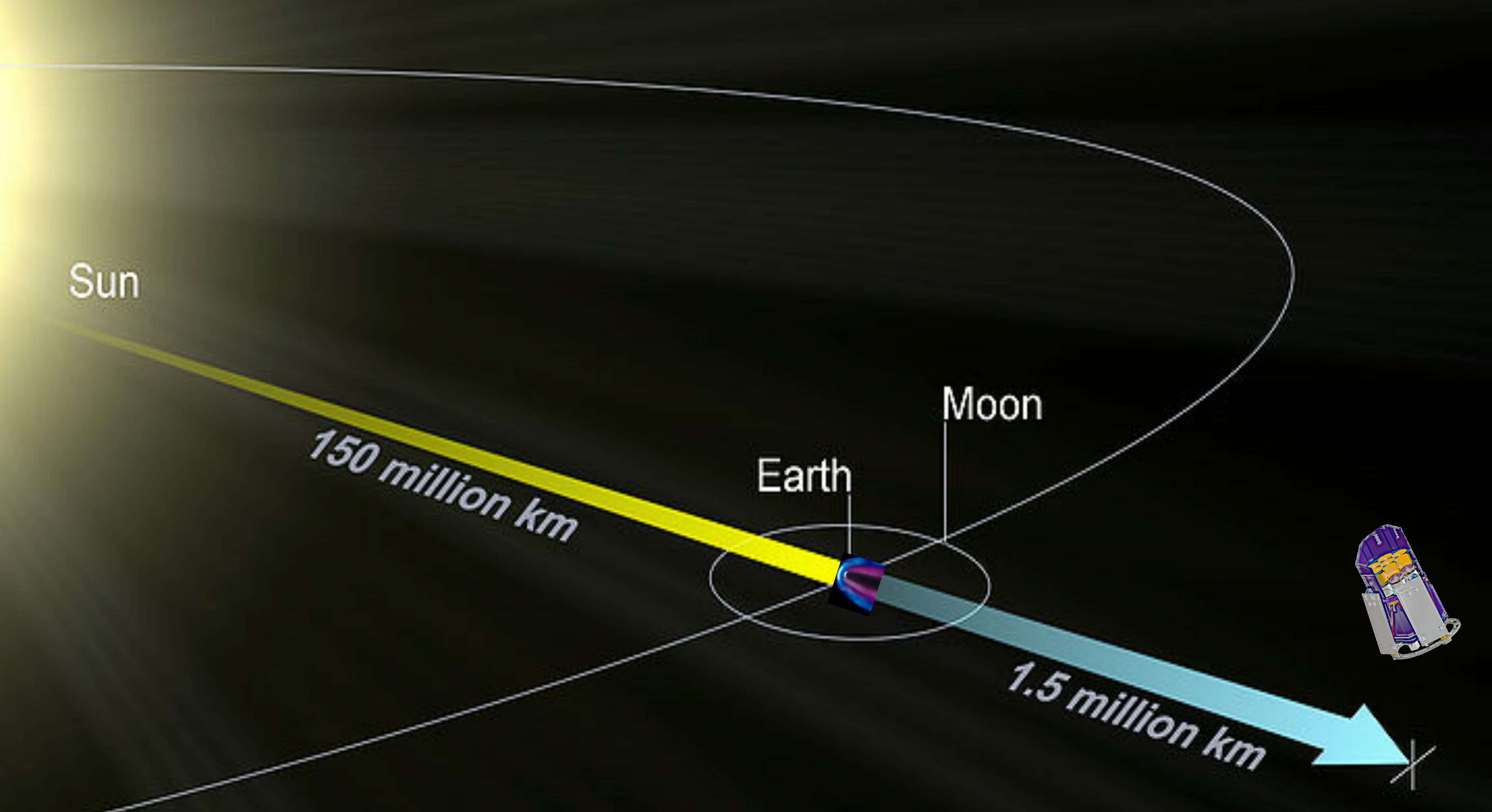
| | | | |
|---|---|---|---|
| ~~2018-Jan-20~~ | ~~..~~ | ~~2018-Mar-03~~ | ~~MPE~~ |
| ~~2018-Jul-16~~ | ~~..~~ | ~~2018-Aug-30~~ | ~~MPE~~ |
| ~~2019-Feb-20~~ | ~~..~~ | ~~2019-Apr-04~~ | ~~IKI~~ |
| 2019-Aug-18 | .. | 2019-Sep-22 | MPE |
| 2019-Sep-23 | .. | 2019-Oct-01 | IKI |
| 2020-Mar-24 | .. | 2020-May-07 | IKI |
| 2020-Sep-20 | .. | 2020-Nov-03 | IKI |
| 2021-Apr-28 | .. | 2021-Jun-12 | IKI |
| 2021-Oct-26 | .. | 2021-Dec-08 | IKI |
| 2022-Jun-06 | .. | 2022-Jul-21 | IKI |
| 2022-Dec-02 | .. | 2023-Jan-13 | IKI |
| 2023-Jul-15 | .. | 2023-Aug-29 | IKI |
| 2024-Jan-07 | .. | 2024-Feb-18 | IKI |
| 2024-Aug-20 | .. | 2024-Oct-04 | MPE |
| 2025-Feb-10 | .. | 2025-Mar-25 | IKI |

# eROSITA and Comets

**plans for early science**

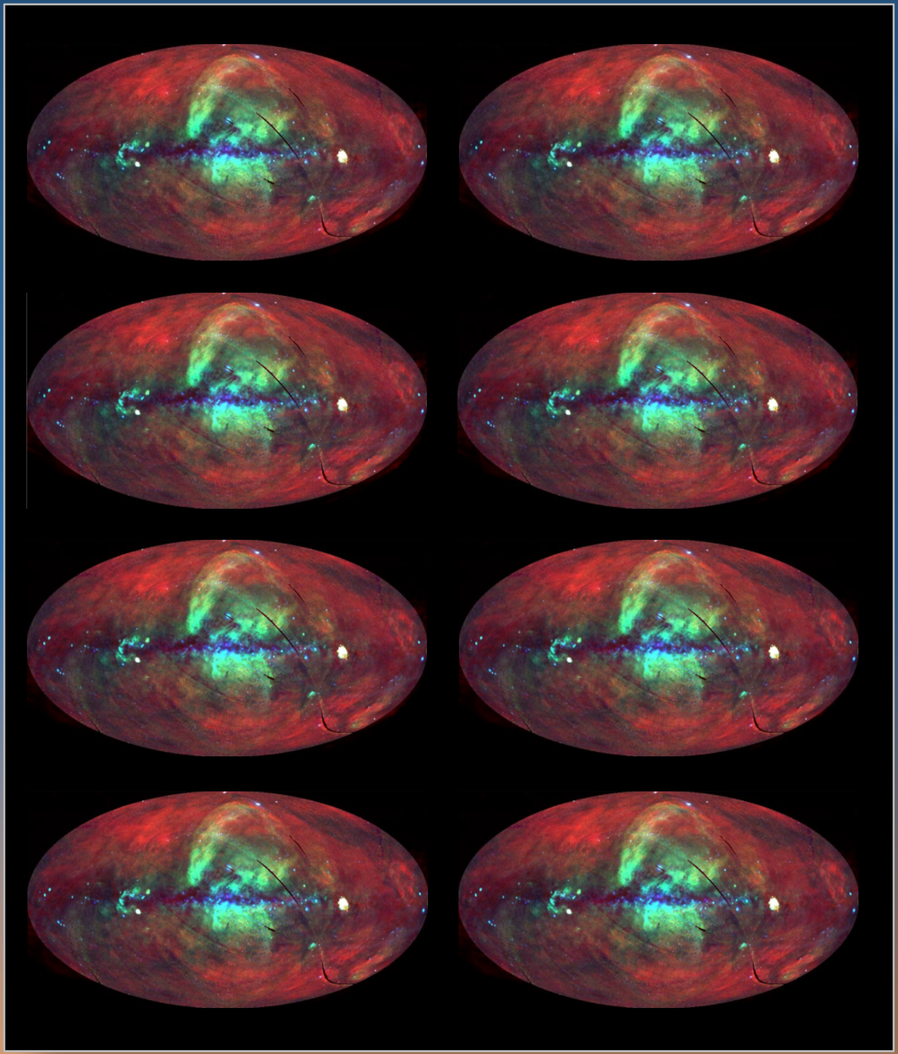


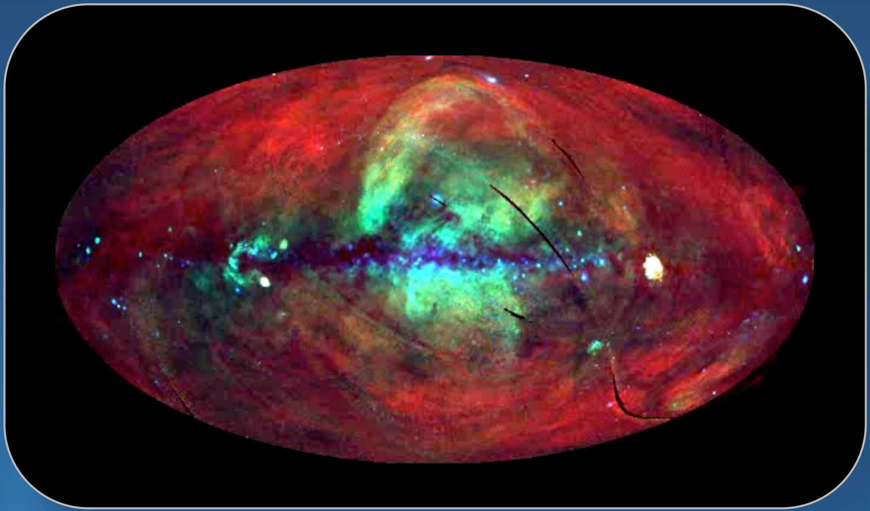
# eROSITA and the Heliosphere




L2: CX contribution from geocorona negligible
8 all-sky surveys in 4 years (1/3 solar cycle)
→ possibility to disentangle heliospheric CX emission from diffuse galactic emission

# Heliospheric Charge Exchange Emission





- ✓ L2: CX contribution from geocorona negligible
- ✓ 8 all-sky surveys in 4 years (1/3 solar cycle)
- ✓ X-ray CCD spectral resolution
- → **possibility to disentangle heliospheric CX emission from diffuse galactic emission**

reduced sensitivity with „5+2“ filter choice

# eROSITA Working Group
## *Solar System*

Group membership

List of ongoing projects

Priorities for the activities of the next few months, especially for PV program exploitation and eRASS:1 science

# eROSITA WG Solar System

https://wiki.mpe.mpg.de

KonradDennerl | Einstellungen | Abmelden

Suche | Titel | Text

EROSITAwiki: erosolar_members

erosita_con...ing_Mar2019 » erostars_so...ing_mar2019 » FrontPage » EroSolar » erosolar_members

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Editieren | Info | Abonnieren | Verweis hinzufügen | Dateianhänge | Weitere Aktionen:

## eROSITA Solar System Group Membership

**Chair: Konrad Dennerl (kod@mpe.mpg.de)**

| erosolar members (Feb 5, 2019) | | | |
|---|---|---|---|
| **Name** | **First name** | **Institute** | **email** |
| Burwitz | Vadim | MPE | burwitz@mpe.mpg.de |
| Dennerl | Konrad | MPE | kod@mpe.mpg.de |
| Freyberg | Michael | MPE | mjf@mpe.mpg.de |
| Robrade | Jan | Hamburger Sternwarte | jrobrade@hs.uni-hamburg.de |

EROSITAwiki: erosolar_members (zuletzt geändert am 2019-02-05 14:01:55 durch KonradDennerl)

Editieren | Info | Abonnieren | Verweis hinzufügen | Dateianhänge | Weitere Aktionen:

# eROSITA WG Solar System

- List of ongoing projects
- Priorities for the activities of the next few months, especially for PV program exploitation and eRASS:1 science

① Comet in the CalPV phase
② Comets in eRASS:1
③ Comets in eRASS:2-8
④ Heliosphere

eROSITA CalPV proposal: Comet (K. Dennerl)

**Note:** This proposal is only relevant if a suitable comet will be observable with eROSITA during the CalPV phase. Due to uncertainties in the time of the CalPV phase and the fact that bright comets are typically discovered only a few months before closest approach, it is not yet possible to provide specific details here.

**1. Scientific justification**

The discovery of cometary X–rays has revealed the importance of a process which was known before, but not realized in its high efficiency as a 'standalone' mechanism for generating X–rays under appropriate conditions. This process, charge exchange between highly charged heavy ions and neutrals, is fundamentally different from all the other X–ray emission processes in that the X–rays are not produced by hot electrons but by 'cold' ions. Since that discovery, evidence for charge exchange induced X–ray emission has been found at various locations throughout the Universe.

Comets represent an ideal laboratory for studying charge exchange interactions, because their X–ray emission is the direct result of this process: highly charged solar wind ions interact with cold neutrals at low density and in the absense of a major magnetic field, and there are no other major emission components (like electron bremsstrahlung, scattered solar X–rays or thermal emission) present in the observed X–ray flux. Thus, X-ray observations of comets make it possible to investigate not only the specific properties of the interactions with the solar wind, but to deduce also fundamental properties about the charge exchange process itself. Furthermore, because comets are not confined to the ecliptic plane, they can be utilized as natural space probes for sampling the heavy ion content of the solar wind at various heliographic latitudes and over the solar cycle, because the heavy ion content leaves a characteristic spectral fingerprint.

**Main scientific goals:**

The unprecedented combination of grasp (Figs. 1, 2) and energy resolution (Figs. 3, 4) make eROSITA well suited for pursuing the following main scientic goals:

- improve our knowledge about the charge exchange process itself: derive/constrain fundamental properties of atomic physics (e.g., velocity dependent state–selective emission cross sections)
- deduce the properties of the heavy ion content of the solar wind from the X–ray spectrum
- derive the gas production rate of the comet and compare it with the values from other measurements
- study the interaction between the solar wind and the comet, e.g., by reconstructing the cometary bow shock from photometrically calibrated maps and by investigating morphological changes over time

**2. Technical feasibility**

The most important question here is whether a suitable comet will be observable with eROSITA during the CalPV phase. Unfortunately, this question cannot be answered at the time of writing, because potentially bright comets may be discovered only a few months before closest approach and because the precise time of the CalPV phase is not yet known. Experience with XMM–Newton observations of comets has shown that essentially all comets brighter than $\sim 8$ mag are rewarding targets, and that $\sim 40$ ks is a reasonable compromise between getting data of sufficient quality and not requesting too much of valuable satellite time.

**3. Relevance for and impact on the eROSITA all–sky survey science**

The main impact on the eROSITA all–sky survey science will be on the calibration: with its well defined, sharp low energy emission lines (Fig. 3), comets are perfectly suited for benchmark tests of the quality of the eROSITA low energy calibration.

**4. Justification of use of eROSITA and uniqueness of eROSITA for the proposed investigation**

X–ray observations of comets make full use of all the unique capabilities of eROSITA: the high sensitivity below 1 keV, the high spectral resolution below 1 keV, the large field of view, and the orbit (absence of diffuse soft X–ray background from the geocorona).

**5. Special requirements on the available calibration at the time of data delivery**

Good energy calibration below 1 keV.

**6. Additional science that may be enabled by the observations beyond that proposed**

Spectroscopic observations of comets may be used to improve the energy calibration of eROSITA, from which many other eROSITA observations will benefit. Furthermore, they will help in getting a better understanding of the physics of the charge exchange process, which has already been found to occur at many other places throughout the Universe, and will thus be beneficial for remote X–ray plasma diagnostics in general. With an extent of several 100 000 km, the tenuous cometary gas, exposed to the solar wind, provides an ideal laboratory for deducing key parameters of atomic physics like the velocity dependent, state-selective emission cross sections, where our knowledge from laboratory measurements and theoretical computations is still far from complete.

**7. Relevant Working Group that approved the proposal:**

This proposal is submitted with the consent of the EroSolar chair.

**8. List of eROSITA_DE scientists who plan to work on the project:**

TBD

**9. List of External Collaborators, if any, who will work on the project:**

Currently none.

**10. Any other resource requirements for the scientific exploitation of the data**

None.

**11. Plan for data analysis**

Over the last decades, with the analysis of ROSAT, Chandra, and XMM–Newton data of comets (including their discovery as X–ray sources), considerable experience has accumulated. The data analysis will utilize essentially the same, well tested methods.

**12. Requirement for ancillary data or availability thereof**

Contacts with solar wind experts have already been established.

**References**


Bodewits, D. et al., "Spectral analysis of the Chandra comet survey", 2007, A&A 469, 1183

Dennerl, K., "Charge Transfer Reactions", 2011, 157, 1–4, 57


eROSITA CalPV proposal

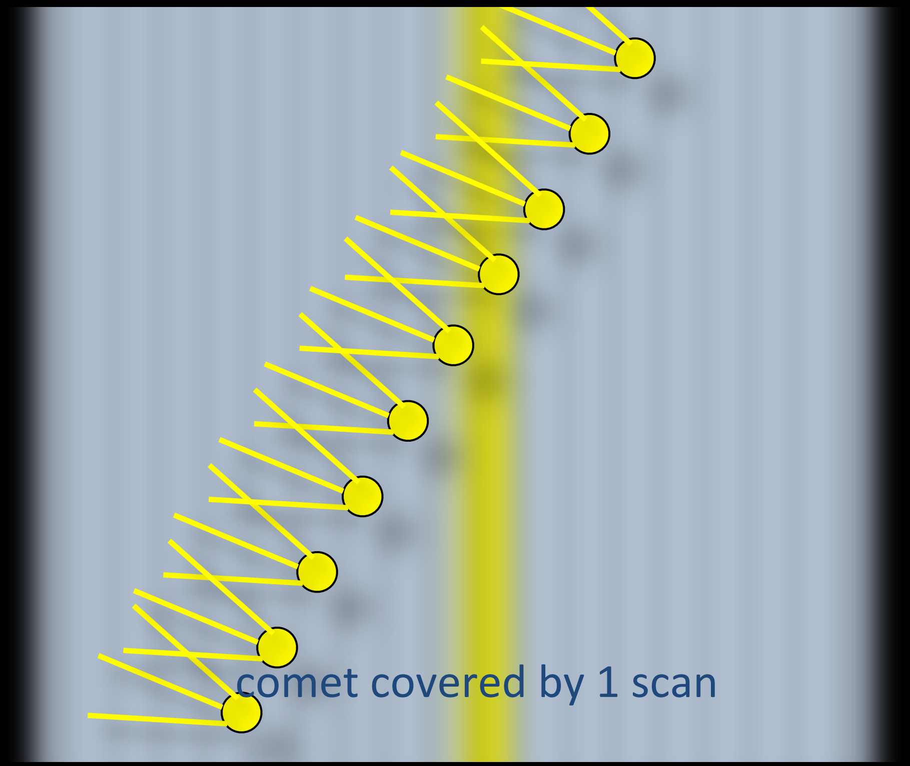
# eROSITA WG Solar System

- List of ongoing projects
- Priorities for the activities of the next few months,
  especially for PV program exploitation and eRASS:1 science

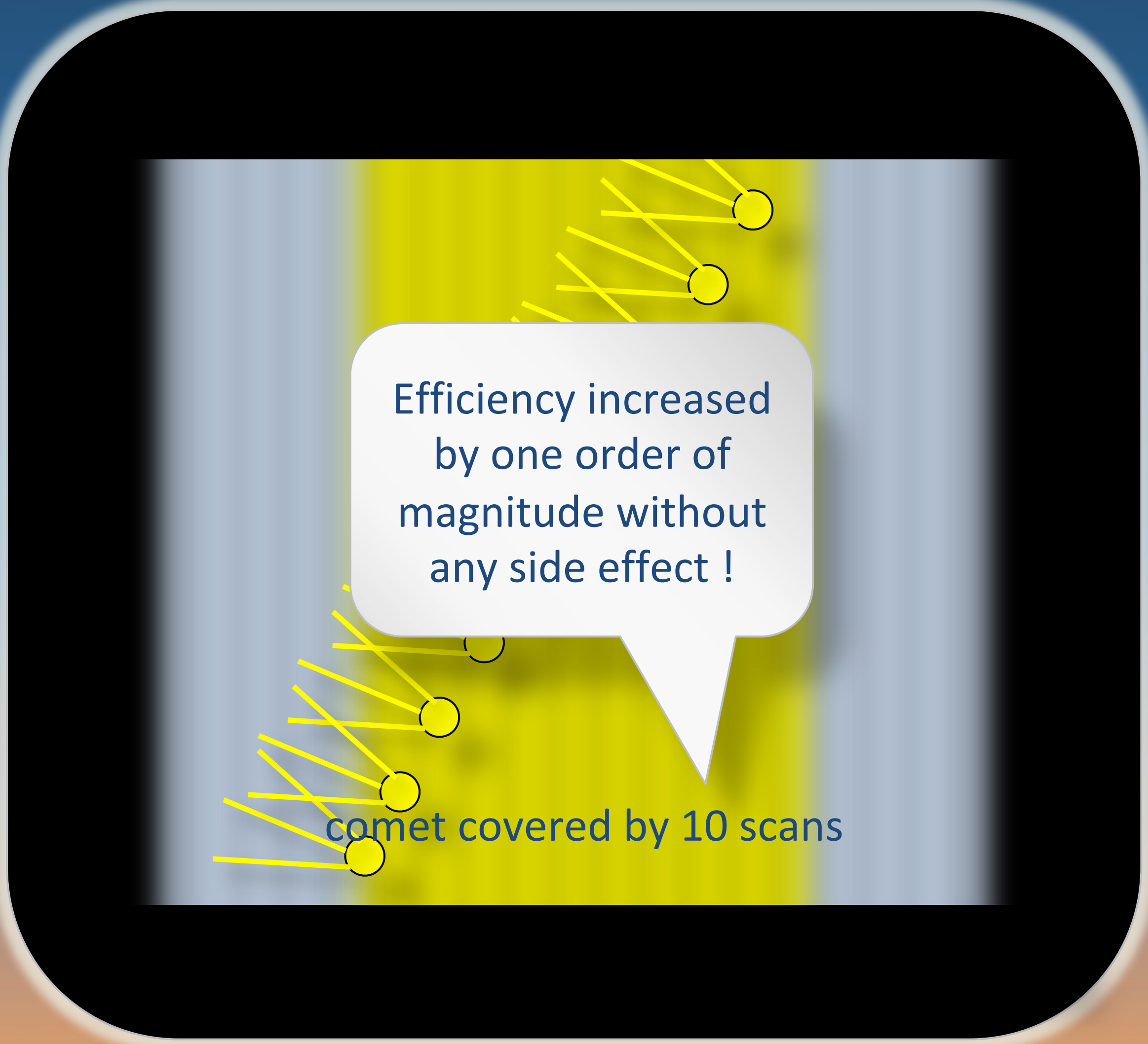
① Comet in the CalPV phase
② Comets in eRASS:1
③ Comets in eRASS:2-8
④ Heliosphere

Renewal of an old (2011) proposal: improve the sensitivity and temporal coverage by re-arranging the sequence of the eRASS slews

# Improving the eROSITA Survey Strategy



# Improving the eROSITA Survey Strategy



# eROSITA Working Group

## Solar System