

# **Einstein Probe**

## **Science management scheme principles**

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## APPROVAL

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## 1. Scientific data produced by the EP mission

### 1.1 Definitions

The scientific operational time will be composed of two parts:

- Regular Operational Time (ROT), comprising:
  - Survey Mode: The basic operational mode of EP designed to monitor the full sky. EP will operate in this mode unless a follow-up observation or Target of Opportunity (ToO) is issued. The Survey Mode comprises:
    - WXT pointed observations: WXT observations of pre-planned sky regions during the routine survey mode.
    - FXT Survey Target Observations (FSTO): Observations of targeted sources by FXT during WXT pointed observations. FSTO are based on projects prepared by the STPs, endorsed by SMC. Their execution cannot be guaranteed during ROT, as they can be interrupted by a Target of Opportunity or EP-triggered transient in the Follow-up Observation Mode. Interrupted observations may not be restored to the ongoing mission timeline.
  - Follow-up Observation Mode: Following an internal (on-board) EP trigger, EP will autonomously slew to the given target source to be observed by FXT for between 10-20ksecs exposure time (TBD). These sources are known as EP alert sources. During FXT follow-up observations, WXT will be operating in the survey mode and the data, exclusive of the targeted source, is treated as survey data.
- Targets of Opportunity (ToO): These are not autonomously generated targets, but require to be commanded from the ground. For normal ToOs the command will be uplinked via the regular S-band T/C route within 24 hours, while for time-critical ToOs the uplink commands will be sent via the Beidou system with a short latency time, e.g. within 10 minutes as a goal. ToOs fall into the following classes:
  - Internal normal ToOs: Observations following-up alerts issued from EP detections of transients/outbursts on the ground (not on-board); extended follow-up observations of EP sources in addition to the default follow-ups;
  - External normal ToOs: Observations following-up alerts issued by other facilities or EP Science Team members;
  - Time-critical ToOs: Proposals for time-critical ToOs require justification for the use of the Beidou network.
  - Exceptional ToOs: ToOs of extremely high scientific significance and demanding substantial observing resources of the mission, and in some cases also requiring use of the Beidou system for uplink. Exceptional ToOs can only be triggered by the mission PI or PI representatives. Examples of exceptional ToOs include:
    - ToOs for Multi-Messenger (ToO-MM): Specifically, gravitational wave or neutrino events follow-up observations;
    - ToOs triggered by, e.g. supernovae in our, or a neighbouring, galaxy.

During internal and external ToO observations with FXT, WXT will be operating in the survey mode and the data is treated as survey data.

In addition, there will be calibration and/or engineering observations for WXT and FXT for instrument calibration, performed regularly and also on request.

The types of observation/data and apportionment between CAS, MPE and ESA are shown in Figure 1.

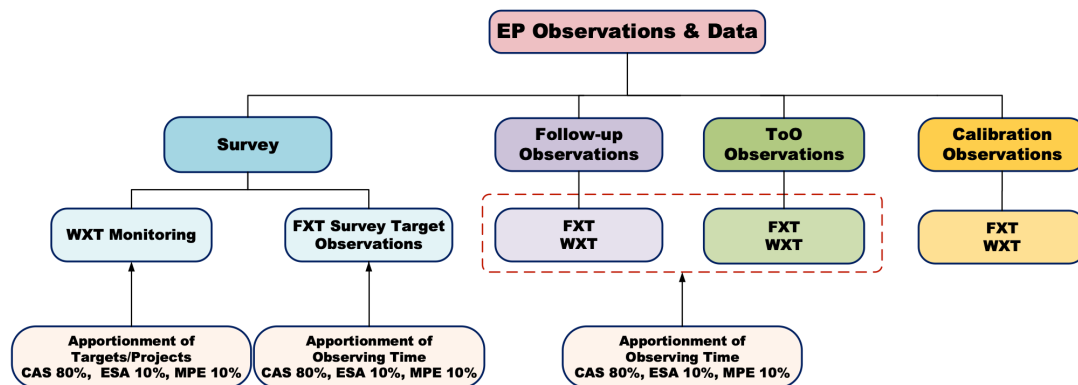


Figure 1: EP observations and associated data

## 1.2 Science data

### Survey Mode data

- WXT Survey Mode data
- FXT Survey Mode data

### EP Triggers

- Alert message: the basic properties of transient/outburst sources triggered to call for prompt multi-wavelength follow-up observations and identification (including triggering time, significance of detection, source position, fluxes, spectral shape, timescale, etc.)
- FXT prompt follow-up observational data

### Target of Opportunity (ToO)

- FXT ToO data
- WXT ToO data

## 1.2 Instrument-specific data

- Calibration data
- Spacecraft and Instrument House Keeping data

## 2. Data levels and products

### 2.1 Data levels

- Level 0: raw data
- Level 1: event files, HK files, AUX files and log files
- Level 2: calibrated and screened event files
- Level 3: images, light curves, spectra, exposure maps, ...

A more detailed, preliminary, definition of the EP data levels is as follows:

- Level 0: Raw spacecraft telemetry
- Level 1: Level 0 data is de-commutated and split into functionally independent parallel streams, i.e., event files, HK files, AUX files and log files, for both the FXT and WXT.
- Level 2: Apply corrections (such as aspect correction, time calibration, barycentric corrections) and instrument-specific calibrations (such as detector gain and good-timing information) to Level 1 data to produce cleaned (i.e., calibrated and screened) event files for both the FXT and WXT.
- Level 3: Level 2 data from multiple observation intervals that constitute an observation are combined to create uniform sets of data for the FXT and WXT: images, light curves, spectra, exposure maps, etc.

### 2.2 Other Data Products

Quick-look data (QLD) products:

- Representative, preliminary high-level products (images, light-curves and spectra) automatically generated from segments of WXT and FXT data by the EP Science Operations Centre (EPSOC, see Section 3.3.1), for the purpose of assessment of source detection, classification and identification, alert triggering, as well as preliminary scientific discussions in the STPs. QLD are generated directly from Level 1 data or, if certain corrections or calibrations are known already at the time the data are taken and telemetered, by using those corrections and/or calibrations done within Level 2.

Long-term data products:

- These include catalogues and mosaics, and products like long-term light-curves of individual sources, and time-resolved spectra
- All-sky X-ray source catalogues
- All-sky X-ray images and spectra-images of diffuse emission

The data release policy is covered in Section 4

### 3. Science Management Committees

Basic Principle for Science Management are:

- Ensure clear decision making and conflict resolution
- Provide well-defined responsibilities and interfaces
- Provide accountability and suitable reporting

The following bodies are envisaged:

1. Steering Committee (see Section 3.1)
2. EP Science Team (see Section 3.2)
  - a. Science Management Committee (see Section 3.2.1)
  - b. Science Topical Panels (see Section 3.2.2)
3. EP Science Centre (see Section 3.3)
  - a. EP Science Operations Centre (see Section 3.3.1)
  - b. Instrument Centres (see Section 3.4.2)
  - c. EP Data Centre (see Section 3.3.3)
  - d. Science Support Centre (see Section 3.4.4).

Figure 2 shows the relationships between the aforementioned bodies.

#### 3.1 Steering Committee

Membership:

- Agency-level representatives from CAS/NSSC, ESA and MPE (hereafter called Parties)

Responsibilities:

- Responsible for the inter-agency coordination and high-level science management strategy definition
- Conflict resolution entity for any science management issues

#### 3.2 EP Science Team (EPST)

The EPST will be composed of scientists, appointed by the Parties, that will form a single science team in 80-10-10 proportion (CAS-ESA-MPE).

The EPST will include a Science Management Committee and various lower-level Science Topical Panels.

##### 3.2.1 Science Management Committee (SMC)

The Science Management Committee (SMC) includes members appointed by the Parties to manage the overall science exploitation of the EP mission.

The SMC will consist of an Executive Board and up to 10 members.

The Executive Board comprises the mission Principal Investigator (Chair), the ESA Project Scientist (co-Chair), the MPE team lead (co-Chair), and one additional scientist proposed by CAS. The Executive Board oversees and manages the SMC activities, approves topics of the Science Topical Panels (STPs), and approves the STP chairs and co-chairs.

The other members of the SMC will consist of Science Topical Panel chairs (max 8), one independent scientist appointed by MPE and one independent scientist appointed by ESA<sup>1</sup>.

CAS shall maintain the majority (>60%) of the members of the SMC.

Responsibilities of the SMC are:

- Manages the activities of the Science Team overall;
- Advises the EP Science Centre on operations aspects related to science performance;
- Monitors science projects proposed by the STPs to ensure 80-10-10 split of the EP operational time (ROT + ToO);
- Monitors the long-term average proportion of EP science return (based on operational time during the proprietary period) to evaluate whether this is satisfactory with respect to the 80-10-10 model, taking corrective action if necessary;
- Defines science management policies on publications, data rights, duration of proprietary period, exploitation strategies, etc.;
- Establishes agreements with external facilities for follow-up activities. The agreements are to be signed by the EP PI;
- Decisions within the SMC should be taken by consensus; in case of disagreement, issues shall first be discussed by the Executive Board, before being escalated to the Steering Committee.

### 3.2.2 Science Topical Panels (STPs)

Science Topical Panels report to the Science Management Committee. STPs will be focussed on specific science topics, with the activities coordinated by one Chair and up to two co-Chairs.

The themes for the STPs will be defined by the SMC, as well as the actual number of STPs; the number of STPs should not exceed eight.

Globally, the number of members of the STPs and the number of Chairs and co-Chairs for the various STPs will be in the 80-10-10 proportion (CAS-ESA-MPE).

Examples of STPs may include, but are not limited to, the following fields:

- Fast extragalactic transients
- Multi-messenger astronomy
- Tidal Disruption Events & SMBH
- Galactic & nearby universe
- Observatory Science (possibly split into thematic TPs)
- Follow-up activities (including relations with entities outside the EP mission team)

CAS appoints members of the Science Topical Panels at the level of 80% of the total team composition. ESA appoints<sup>2</sup> (through open call for scientists in ESA's Member States) members of the Science Topical Panels at the level of 10% of the total STP composition. MPE

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<sup>1</sup> The ESA appointed member (through open call for scientists in ESA's Member States) has the task to represent the science management views and interests of scientists in ESA's Member States. ESA supports the ESA-appointed member for participation in the committee activities.

<sup>2</sup> ESA will not fund the activities of the Science Topical Team members (travel costs to attend meetings, etc.) and each appointed member is responsible for securing his/her own funding.



appoints members of the Science Topical Panels at the level of 10% of the total STP composition.

Tasks (TBC):

- Developing and promoting the EP science case in each of the STP areas;
- Proposing the top science requirements, providing advice to, and overseeing, the observing strategies;
- Proposing, and coordinating input, to the SMC on science projects.
- Proposing to the SMC, and implement after approval, policies to coordinate the research programmes and to assign projects/data to the EPST members. The leadership of the projects will be assigned to guarantee the agreed share (i.e., 80% of the EP operational time is guaranteed to CAS, and 10% to ESA and 10% to MPE);
- Providing advice to the SMC on publication policy (including scientific paper authorship), data rights, duration of proprietary period, exploitation strategies, etc.;
- Monitoring the science performance of the mission and evaluating the impact of any changes on the science return associated with the relevant STP field;
- Providing advice to the EPSC on the development of the calibration plan and monitoring its implementation and outcome; the formal involvement in the calibration work from STP members should be endorsed by the SMC.
- Identifying external facilities for triggers and follow-up for each area of science.

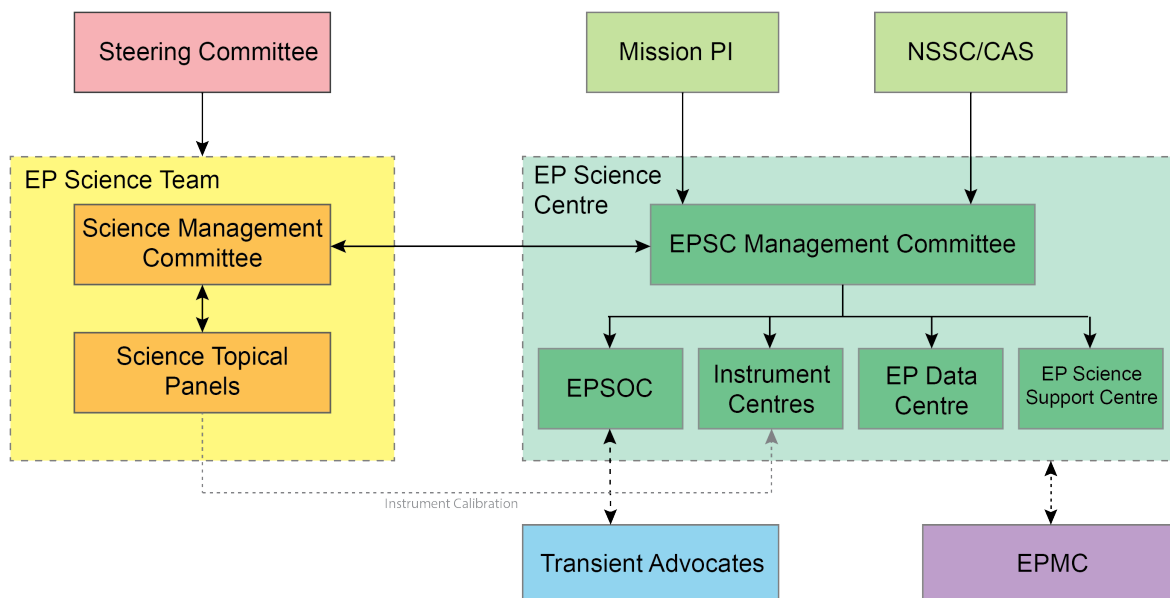


Figure 2: Organigramme of the EP Science Ground Segment.

### 3.3 EP Science Centre

The EP Science Centre (EPSC), in conjunction with the EP Mission Centre (EPMC), constitute the ground segment of the mission. EPSC is responsible for the science ground segment, and comprises four main entities: the EP Science Operations Centre (EPSOC), Instrument Centres, EP Data Centre (EPDC), and the EP Science Support Centre. Details of each entity can be found below. The EPSC is managed through the EPSC Management Committee (EPSCMC), comprising of the leaders from each of the sub-centres. The EPSCMC coordinates the activities

of the science ground segment, and acts as the interface to the SMC. The structure and main tasks of the EPSC is shown in Figure 3.

The EPSC is under the responsibility of CAS, and is located at CAS.

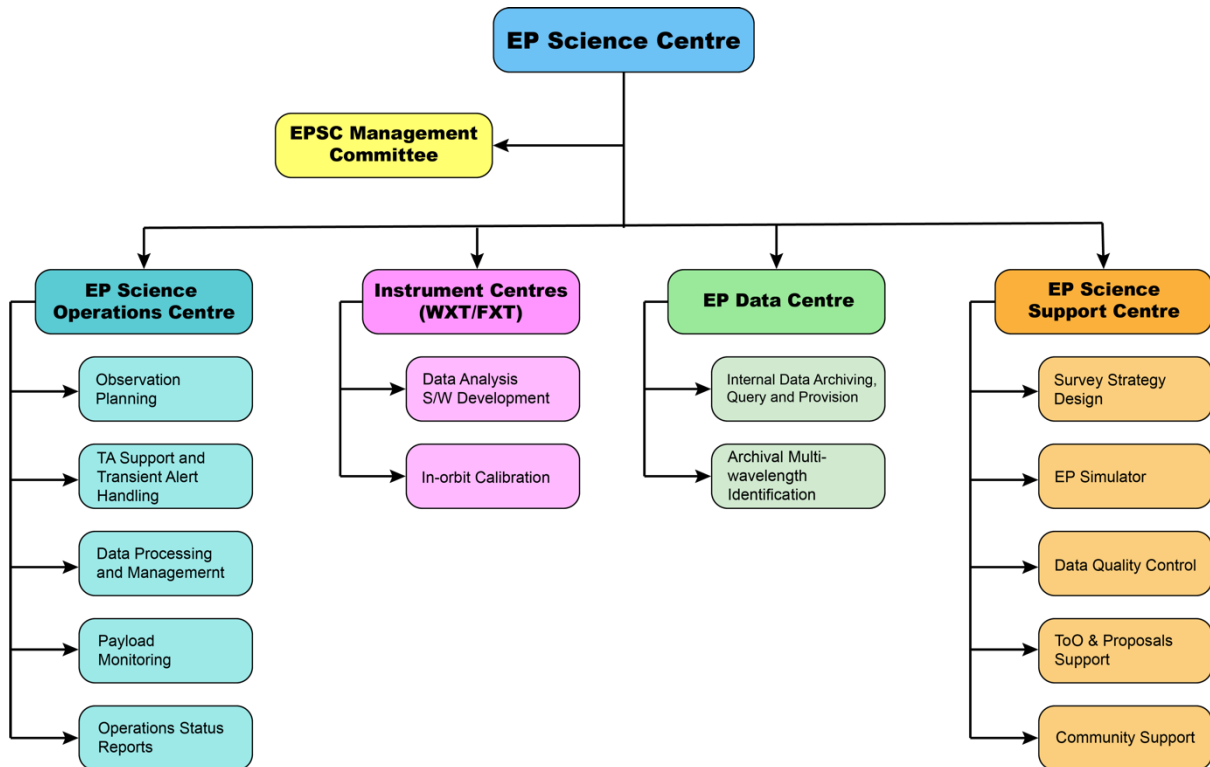


Figure 3: Organigramme of the EP Science Centre

### 3.3.1 EP Science Operations Centre (EPSOC)

The EP Science Operation Centre (EPSOC), hosted at NAOC, is a subordinate component of the EPSC and is responsible for the science operation of the mission. EPSOC will host Transient Advocates (TA), a team of on-duty scientists, providing 24x7 coverage during the science operations of EP. The EPSOC activities include:

- observation schedule planning;
- developing tools needed to facilitate survey planning, alert handling, ToO, quick-look analysis, data management and archiving;
- management of the TA team and its activities;
- quick response to transient alerts triggered both on-board and on-ground by WXT, including analysing the quick-look data;
- data processing and the production of Quick-look and L1-L2-L3 data products;
- preliminary classification of EP triggered transients, if possible;
- issuing public alerts of EP triggered transients;
- triggering and coordinating of quick multi-waveband follow-up observations;
- handling of urgent ToO observation requests; and,
- daily reporting of the observational status and results.

European scientists are encouraged to contribute to the TA activity to support the EP science operations.

### 3.3.2 EP Instrument Centres

The EP Instrument Centres comprise two separate teams, with each responsible for the operation and monitoring of the WXT and FXT instruments, respectively. The activities of the Instrument Centres include:

- developing and monitoring the outcome of the calibration plan;
- developing data reduction pipelines for both instruments;
- developing the scientific analysis tools;
- supporting the science operations;
- monitoring the performance of the scientific instruments;
- in flight instrument calibration and management of calibration data.

### 3.3.3 EP Data Centre (EPDC)

The EP Data Centre (EPDC), as another subordinate component of the EPSC, is responsible for:

- data management and distribution to the EPST before delivering validated data to NSSDC for permanent archiving and release within a time period;
- provision and maintenance of EP data analysis software for end users.

The permanent archiving and public release of screened and validated EP science data and software to the scientific community are the responsibility of National Space Science Data Center (NSSDC), hosted by NSSC, CAS.

### 3.3.4 EP Science Support Centre

The EP Science Support Centre, as well as being the interface to the wider scientific community, will also provide support to the development of the science ground segment. Activities of the EP Science Support Centre include:

- design of the survey strategy;
- development of the EP simulator in conjunction with the full EP ground segment and instrument teams, and performing end-to-end simulations;
- support ToO proposals;
- user/community support.



## 4. Data Release Policy

The Data Release Policy (DRP) for the nominal science phase of the EP mission should comply with the data policy of the CAS's Strategic Priority Space Science Programme, the Agreement between ESA and CAS, and the Agreement between MPE and CAS on the EP project.

All data of level 1-3 will be made available to the EPST from the EP Data Centre, built and maintained under the responsibility of the CAS. Data will be made public after the proprietary period by the NSSDC.

### 4.1 Public release of transient information

Alert information (containing as a minimum sky location, timescale, and source flux) regarding transient/outburst sources generated from WXT and FXT data for the purpose of quick follow-up observations and identification will be released to the community by the EP Science Centre as early as possible, but ideally not later than 1 day of the reception of spacecraft telemetry.

### 4.2 Scheduled release of proprietary data

The proprietary period for data acquired during the Regular Operational Time (ROT) and Internal ToOs is set to be a maximum of **one year** after generation of the Level-3 data products (available approximately 1 week from reception of the spacecraft telemetry at the EPSC), after which data will be publicly available. ROT data includes all WXT and FXT observational data resulting from the survey phase (including FSTO data).

The one year of proprietary time comprises an initial 6 months of exclusive use by the PI of the assigned project (and his/her team), after which the data is made available to all members of the EPST for a further 6 months. EPST members wishing to publish scientific papers during this period must firstly receive permission from the associated STP Chair. Permission to publish will only be granted, if the proposed publication is not in direct conflict with the research project assigned to the PI team.

The proprietary period for Exceptional Targets of Opportunity (see Section 1.1) observational data will be decided by the SMC on a case-by-case basis, up to a maximum of **12 months**, after generation of the Level-3 data products (available approximately 1 week after reception of the spacecraft telemetry at the EPSC).

The proprietary period for external Targets of Opportunity (see Section 1.1) observational data is set to be a maximum of **6 months**, after generation of the Level-3 data products (available approximately 1 week after reception of the spacecraft telemetry at the EPSC).

The six months of proprietary time comprises an initial 3 months of exclusive use by the leader of the assigned project (and his/her team), after which the data is made available to all members of the EPST for further 3 months, before being made publicly available.

Both for ROT and for ToO data, the observational metadata of the EP operation will be accessible to all EPST members within 1 week of being processed by the EPSC.

After expiration of the proprietary period, WXT Level-3 and FXT Levels 1-2-3 data products will be made public via the NSSDC.

WXT Levels 1-2 data products will be made publicly available after the release of the first EP source catalogues produced from those WXT data.

Level 0 data are not planned to become publicly released.

#### 4.3 Long-term legacy scientific products

Scientific products/results obtained from data accumulation over years of mission operation will be published as scientific papers and/or data base when appropriate. These include, e.g. all-sky source catalogues, variable and transient source catalogues, the long-term light curves and spectral variations of monitored sources, the images and spectra of all-sky diffuse emission.

After publication of relevant papers, data products from long-term scientific analysis (see definition in Section 1.2) will be made public via the EP Data Centre.

## 5 Apportionment of scientific return

Only members of the EP Science Team comprising scientists nominated by CAS, ESA and MPE (see Section 3.2) will have access to EP proprietary data for scientific exploitation by their research group, generally by approved proposals or by collaboration. All data of level 1-3 will be made available to the EPST from the EP Data Centre, in compliance with the data publication policies.

The apportionment of the scientific return to CAS, ESA and MPE is to follow a proportion of 80%, 10% and 10%, respectively.

In order to have a clear and implementable data apportionment policy, the following approach will be implemented:

- In order to acquire EP data, and be assigned PI of a scientific investigation, within the proprietary period, EPST members are requested to submit proposals to the STP (co-) Chairs, describing their research plans of EP data exploitation. Regular scientific investigation proposals shall be submitted prior to launch, and later on a yearly basis (TBC) during the operative phase of the mission. Proposals of opportunity may also be submitted by STP members at any time during operations, to reflect new developments in the fields.
- Assignment, by STP Chairs/co-Chairs and approval by the SMC, of the PI of the scientific investigation making use of proprietary EP data will be based on the scientific merits and, if applicable, following assessment of feasibility of proposals from EPSC. The assignment of the PI to projects/data will have to guarantee the agreed shares of the 80-10-10 proportion over the mission lifetime.
- For proprietary WXT data, only the WXT module or the detector chips with which the sources of interest for the projects are observed will be made available to the project PI, exclusive of the rest of the WXT modules/detector chips.
- The observing time spent on all the follow-up and ToO observations of projects led by each of the Parties will be summed up to count the total observing time for each Party. The total observing time spent for the Parties should guarantee the agreed shares of the 80-10-10 proportion.
- Joint scientific data exploitation is encouraged among scientists of the EP Science Team. Members of the EPSC have the right to take part in scientific exploitation of the data of projects led by other members regardless of the Parties – if approved by the STP chairs and the project PIs – and can co-author the publications if significant contributions are made, following the common practice of research. Author lists of all EP collaborative papers will be proposed by the STPs, and approved by the SMC.

### 5.1 ROT observation apportionment

The observations during the ROT will be apportioned differently depending on the observation types (see definitions in Section 1.1):

- The WXT and FXT survey data will be shared by all the Parties, as reflected by the assignment of the leadership to projects/data in the STPs following the 80-10-10 proportion. How the data apportionment is done exactly may differ from one STP from another, depending on the way of research typically conducted in the fields (e.g., transient and non-transient science topics), but will be endorsed by the SMC.

- FXT and WXT follow-up observations: For transients triggered by EP and followed-up by FXT, the assigned research projects normally include investigations of both FXT/WXT follow-up data of those transients. This also holds for EP transient events triggered on the ground and followed-up by FXT via command uplink (internal ToOs). During follow-up observations, the WXT/FXT data exclusive of the targeted source are treated as survey data. The total observing time available for FXT and WXT follow-up observations will be apportioned, and later adjusted, in the 80-10-10 proportion for CAS, ESA and MPE.
- FXT targeted observations of non-transient science projects (“FSTO”) to be implemented during the ROT will be proposed by the relevant STPs, reviewed and ranked by STP chairs/co-chairs, endorsed by the SMC and implemented by EPSOC. Data acquired exclusive of the targets and irrelevant to the proposed science is treated as survey data. The total observing time available for FSTO will be apportioned, and later adjusted, in the 80-10-10 proportion for CAS, ESA and MPE.

## 5.2 Target of Opportunity observations apportionment

The observations of ToOs will be apportioned according to the following criteria (see definitions in Section 1.1):

- ToO observations are open to EPST members appointed by CAS, ESA and MPE only.
- EPST members of each Party may propose ToOs based on internal or external triggers. ToO proposals will be evaluated by EPSC for feasibility and by STP chairs/co-chairs, and in urgent cases, approved by the mission PI or PI representative.
- The scientists awarded ToO observations will co-ordinate (and have the right to lead) papers based on these ToOs, with possible participation of members from the other Parties, proposed by the STPs, and approved by the SMC.
- If EPST members from more than one Party request similar ToO observations, the SMC will encourage that the requests are merged into a single ToO, with a project leader.
- WXT and FXT data exclusive of the ToO targets and irrelevant to the proposed science are treated as survey data.

## 5.3 Open access and Director Discretionary Time

A small portion of the EP operation time or data (taken from the CAS’s share) may be made openly accessible to scientists worldwide outside the EP Science Team, through scientific proposals in the form of Director Discretionary Time (DDT). Currently the total DDT time is set to be no more than 5% of the EP operation time or data. The data of DDT observations will be made public immediately after data processing and delivery of the data product to PI of the proposed observations. Whether and when to implement the DDT programme will be decided by CAS at a later time.

## 5.4 Associated scientists

A number of scientists in fields outside the EP STPs may be appointed by each Party to be EP associated scientists (following approval by the SMC), if their joining can help increase significantly the scientific impact of the mission. The associated scientists can participate in the projects led by the Party that has appointed them. Associated scientists cannot be project leaders.



### 5.5 Collaboration and data sharing with other agencies/facilities

The three Parties may further consider possible collaborations with other partners and major facilities, by exchange of data, for the purpose of maximising the science return. Potential collaboration may include that with CNES (via provision of the VHF network), or large ground-based optical/IR telescopes for follow-up observations for X-ray transients discovered by EP.

Any collaboration with additional partners will be considered as part of the apportionment of scientific return assigned to the partner (CAS/ESA/MPE) who established the collaboration.

## 6 Publication policy

Unless otherwise stated, the following applies to all publications which use EP proprietary data, as well as data taken during the commissioning, calibration or performance verification periods.

Members of the EPST making use of proprietary EP data are required to report periodically (twice per year, TBC) to the relevant STP the status and results of the research projects. Submission of corresponding papers is subject to approval by the relevant STP Chair/co-Chairs and SMC. Any reports on scientific results from EP proprietary data before formal publication will be approved by the relevant STP Chair and SMC.

### 6.1 Authorship

Papers will generally follow standard scientific practice with leadership and authorship based on scientific contribution.

Co-author lists of scientific and technical papers will be proposed by the corresponding science project lead. Any publication using proprietary data will include in the author list any EPST members who have contributed to the scientific idea, data analysis, and/or paper writing and discussion. Any members of the EPST, EPSC, associated scientists, or builder list (see Section 6.4), at any stage of a science project, can request that their name be added to the list of authors, with the presumption that permission will be granted if they have made any significant contribution to the science project. Any conflict regarding the co-authorship of scientific or technical publications should be resolved by the SMC, or, if the conflict cannot be resolved, by the Steering Committee.

### 6.2 Privilege for claiming major discoveries

For a limited number of exceptionally high impact major scientific discoveries that are generated dominantly from or significantly contributed by EP data, CAS may propose the privilege to claim the dominant role in the analysis of the data and the publishing of the results. The assignment of privilege will be managed by the SMC, eventually under control/approval of the Steering Committee. The 80-10-10 balance for CAS-ESA-MPE will be enforced also in respect to the claim of these major discoveries. The identification of such a publication will be made at the appropriate time, and in any case early enough before substantial amount of work has been made towards the completion of the paper. The author list of such papers is expected to be expanded to include those individuals who have made critical contributions to the overall success of EP.

### 6.3 Papers on long-term legacy data products

Papers reporting long-term data products (resulting from the accumulation of data over long periods of mission operation, e.g. including all-sky source catalogues, catalogues of transient and variable sources, the long-term light-curves and spectral variations of sources, the images and spectra of all-sky diffuse emission) will be led by CAS and endorsed by the SMC; participation by ESA and MPE as co-authors will be guaranteed.

#### 6.4 Builders

A list of builders of the mission including a number of key members of the EP project will be generated by the SMC; these key members will have the privilege of being included as co-authors for a subset of papers published during the nominal EP mission, to be defined by the SMC. The builder lists include key members from the CAS, ESA and MPE sides.

## Acronyms:

CAS	Chinese Academy of Sciences
EP	Einstein Probe
EPDC	EP Data Centre
EPMC	EP Mission Centre
EPSC	EP Science Centre
EPSOC	EP Science Operations Centre
EPST	EP Science Team
ESA	European Space Agency
FSTO	FXT Survey Targeted Observation
FXT	Follow-up X-ray Telescope
IHEP	Institute of High-Energy Physics (CAS)
MPE	Max Planck Institute for Extraterrestrial Physics
NAOC	National Astronomical Observatories of China (CAS)
NSSC	National Space Science Center (CAS)
NSSDC	National Space Science Data Center (NSSC/CAS)
ROT	Regular Operation Time
PI	Principal Investigator
PV	Performance Verification
QLD	Quick Look Data
SMC	Science Management Committee
STP	Science Topical Panels
TA	Transient Advocate
ToO	Target of Opportunity
ToO-MM	Target of Opportunity for Multi-Messenger
WXT	Wide-field X-ray Telescope