BEPICOLOMBO DATA ANALYSIS ECOSYSTEM: QUICK-LOOK AND SCIENCE ANALYSIS FORUM

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Introduction:

The ESA-JAXA BepiColombo mission to Mercury is currently in its cruise phase and will start its science orbit phase in 2026, with a planned mission lifetime of 1(+1) year in Mercury's harsh environment [1,2]. Comprising two spacecraft, the ESA Mercury Planetary Orbiter (MPO) [1] and the JAXA Mercury Magnetospheric Orbiter (MMO or Mio) [2], the mission has a large number of instruments that will monitor the interior, surface and the close environment of the planet [3,4,5].

In order to optimise the science return of the mission and support collaboration between teams, the MPO Science Ground Segment (SGS) team is developing a data analysis ecosystem composed of (1) a Quick-Look Analysis (QLA) web-interface (used for data analysis and instrument monitoring), coupled with (2) a Science Analysis Forum (SAF) (to capture scientific discussions between teams). The cruise phase science opportunities (e.g. planetary flybys) offer the possibility to test the interfaces in the context of real operations for a subset of the payload [6]. Here we present the status and plans for development of the interfaces.

Quick-Look Analysis (QLA):

Objective. The QLA aims to providing a user-friendly, centralised and access-protected way of (1) monitoring the BepiColombo instrument science and operations based on the data acquired, with rapid feedback into the mission planning process when necessary, and (2) improving science collaboration and coordination between teams. To perform these tasks, the QLA includes visualisation of both operational data (e.g. platform and instrument housekeeping) and scientific data. The interface development is performed in close collaboration with the BepiColombo instrument teams, who are the main users.

Data Workflow. The QLA is at the end of the BepiColombo data acquisition and processing chain, which generates PDS4-compliant data from telemetry within a few hours of a ground station pass [7]. Products are immediately made available in the QLA for analysis, and are ingested in the Planetary Science Archives (PSA), accessible only to the instrument teams [8]. Additional data sources such as telemetry packets and parameters (extracted in near real-time), commanding information, planned resources information, or data processing logs, are accessed by the QLA to provide a complete view of the planned and actual operations.

Interactive data visualisation. The data visualisations are organised in topical "dashboards" (e.g. operations, science, housekeeping monitoring). Dashboards consist of interactive components for representing data, known as "widgets", following a grid layout. The widgets display the actual data read from the PDS4 products, and handle many data types commonly used in planetary science such as tables, time-series, histograms, spectrograms, spectral cubes, or images. The interactivity with actual data usage is essential to support the data analysis and allows plots to be linked together, query/refine specific time ranges, zoom in/out, toggle on/off data in the charts, or extract subsets of data (e.g. spectrum).

Sharing and Customisation. The overall dashboard and widget configuration/layout is agreed between the instrument teams and the SGS. Most instrument team dashboards display proprietary science and housekeeping data, and by default are set private to the team. Nevertheless, each team possesses a "shared" dashboard where science data plots are available to the BepiColombo science team as a whole. In addition to the predefined dashboards, the QLA offers the possibility to create customised dashboards, by combining the available widgets, and to set their privacy. Topical shared science dashboards, collecting shared science plots from various instruments, can therefore easily be created to foster active collaborations between teams. Supporting such a collaborative approach is at the heart of the Science Analysis Forum.

Science Analysis Forum (SAF):

Objective: Cross-instrument (and multi-spacecraft) scientific data analysis is needed to fulfill the BepiColombo mission science objectives and requires interactions between scientists. For this purpose, the SGS is currently implementing the Science Analysis Forum, a centralised and access-protected forum-based interface to host and preserve scientific discussions triggered based on science "events" detected in data via the QLA.

The SAF will be based on the Discourse open source forum software, augmented by plugins. It will host Working Group level discussions open to the science team, in addition to more restricted Instrument

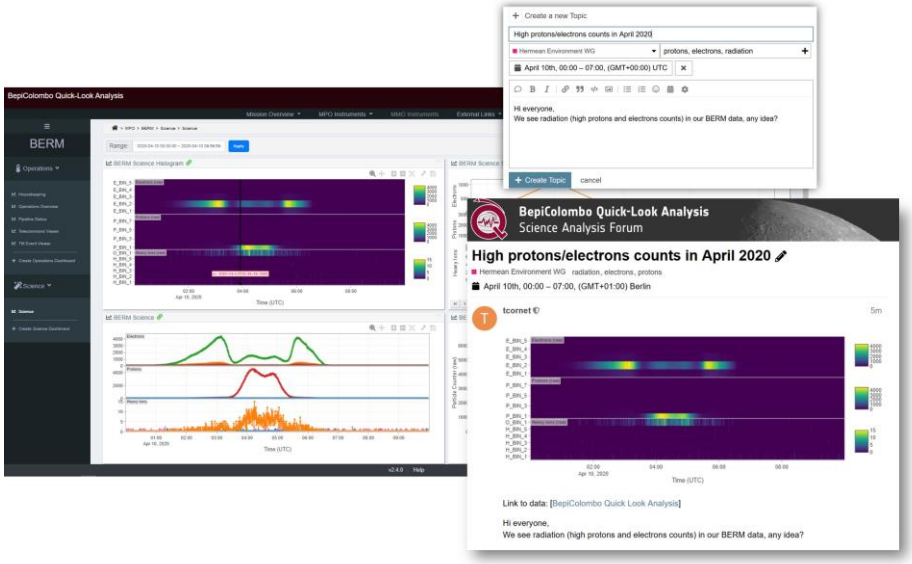

Figure 1: Concept of the interaction between the QLA and the SAF from the MPO radiation monitor (BERM) science dashboard, spotting a period of interest in a spectrogram widget. The post is created (topic, category, keywords, event time, …) and made available to the SAF, with a snapshot of the data and a URL pointing back to the original data.

Teams level discussions, configured via user groups in the system.

The coupling between the two interfaces is a key aspect of the development in order to allow users to create forum posts directly from the QLA, when looking at the data, and automatically generating snapshots of the data plots relevant to the post. Users will be informed of recent activities via notifications in the interfaces. Additional metadata are associated to the posts and include the widget used, time range or event time, location, parameter used, instrument, links back to the QLA original dashboard etc. These metadata will be available to search for posts/events in the SAF, and identify time periods or locations when and where science events of interest were identified in the QLA. The concept of the coupling is illustrated in Figure 1.

Status and future plans:

The QLA currently supports 8 MPO instruments operating during cruise and planetary flybys (particles and X-ray sensors, magnetometer, monitoring cameras, thermal infrared spectrometer). In the near future, we will consolidate the existing implementation of the QLA by incorporating, for instance, additional science views, along with geometry information that will provide context to the measurements. We will incorporate the remaining MPO instruments whose science measurements are not possible given the spacecraft configuration during cruise (e.g. imagers, spectrometers, altimeter). Many of these instruments include mapping capabilities, which will drive the implementation of mapping functionalities. Shared science plots from the MMO/Mio instruments will also be added to the QLA in order to support rapid multi-spacecraft data analysis. We will also explore the usage of ESA DataLabs [10] for enhanced analysis of the BepiColombo data.

In addition, a major challenge of the QLA resides in optimising the data retrieval and display performance when dealing with large amounts of data and users. For this purpose, several approaches have been implemented or are being considered, including online down-sampling [4], offline down-sampling (quick-look products), and data caching.

The SAF development started recently with the aim of releasing a first operational version in 2021 to support instrument team collaboration during, for example, planetary flyby events. Its development will continue with a particular emphasis on the interplay with the QLA, in order to become fully operational and tested before the end of the cruise phase.

References:

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