The ASI Science Data Center

English language version
DRAFT 9-12-2011

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Abstract

This document presents an overview of the ASI Science Data Center (ASDC), a facility of the Italian Space Agency (ASI) established in November 2000 to support all scientific missions of ASI in the management, and in the long-term preservation of scientific space data, and to provide modern services to the scientific community in the field of scientific data management and archival research.

The ASDC operates in the fields of Astrophysics, Cosmology, Exploration of the solar system and Astroparticle.

The main responsibilities and most important features of the ASDC are reviewed. A synthetic description of all the activities related to the missions currently supported and to possible future projects is also presented.

The ASDC manages the data archives and supports the scientific operations of several space scientific missions with various degrees of involvement. At present full support (including prime responsibility for the data archives, pipeline data reduction software, contribution to high level scientific software development and data distribution) is provided to the *Beppo*SAX and the AGILE missions. The ASDC is also involved in a significant way in the scientific ground segment of the Fermi, Herschel, Gaia, NuSTAR, Planck and Swift astronomy satellites and participates to the AMS astroparticle payload on board the International space station.
At a lower level of involvement the ASDC hosts a copy of the archive of several other space astronomy missions (e.g. EXOSAT, *Einstein*, ROSAT, ASCA, XMM-*Newton*, *Chandra)* and some large astronomical catalogs (including SDSS, WISE, GALEX etc). The ASDC integrates these data sets into a locally developed Multi-Mission Interactive Archive which provides simple and transparent access to data from several other archives hosting ground based astronomy data.

Whenever possible standard formats (FITS/OGIP for astronomy missions) are used to store all processed data. Full compliance with Virtual Observatory (VO) is currently being implemented as a high priority task.

Several examples are given to illustrate the present implementation of the ASDC on-line services which include web access, data distribution, data visualization and on-line interactive analysis of multi-mission archival data.

The ASDC rests on reliable and secure hardware infrastructure that is directly managed by ASI staff in cooperation with industrial personnel.
Following an agreement between ASI and ESA the ASDC is located at the ESA establishment of ESRIN in Frascati, Italy.

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1 Introduction

Over the past several years the issue of the management and long-term preservation of archival of scientific space data has been the subject of recurrent discussions, which resulted in several independent initiatives in a number of countries worldwide. This has occurred in several fields of space science. One of the most significant experiences in terms of data handling, distribution and standardization has been accomplished within the space astronomy community where a long-standing tradition led to the establishment of a number of facilities, albeit following widely different approaches in the USA, Japan and in Europe.

The main motivations behind these initiatives include

- Long term preservation of valuable space scientific data;
- Significant cost savings through re-utilization of past experience and infrastructures;
- Efficient support to the scientific community;
- Simplified integration of data from different experiments.
- Enhance data exploitation though research with archival data
- Promote new types of studies, including data intensive research?

This international experience led to the availability of vast amounts of high-quality data from past and present space missions. Scientists have now a much better chance to exploit the increasing volumes of existing data and to follow new research avenues by studying and comparing large data sets from different experiments. The world-wide initiatives promoting virtual archives (VO) are a concrete sign of a trend that will dominate the future approach to the archiving and the scientific utilization of large and distributed data sets.

The 2008 ASTRONET roadmap report on a "*Strategic plan for European Astronomy*" clearly recognized that systematic archiving of observational data in standardized internationally recognized formats is essential to preserve the precious information obtained with public funds. The report recommended the implementation of a Virtual Observatory (VO) and that any new astronomical facility should produce a long-term VO-compliant archive.

The 2010 report of the NASA/NSF/DOE Committee for a Decadal Survey of Astronomy and Astrophysics further underlined the role of scientific archives stressing that "*data archives are central to astronomy today and their importance continues to grow"* and that *"the science impact is large and is increasing rapidly*". The report recommends that any new major astronomical facility should be required as a matter of policy to be properly funded so as to ensure data acquisition, processing, and archiving. The report also strongly recommends that "*NSF, NASA, DOE and NSF should plan for effective long-term curation of, and access to, large astronomical data sets after completion of the mission or projects that produced these data, given the likely future scientific benefit of the data*."

In late 2000 the Italian Space Agency (ASI), capitalizing on the experience acquired with the management of the *Beppo*SAX Science Data Center, established a long-term facility to manage, archive and distribute data from current and future ASI scientific missions, and to host mirror copies of data from non-ASI satellites for which there is an interest within the Italian scientific community.
This facility, named ASI Science Data Center, (ASDC), is currently part of ASI's technical directorate- *Unità Applicativa Esplorazione ed Osservazione dell'Universo* (EOS), and is fully operational since early 2001.

ASDC Responsibilities

The ASDC primary responsibilities are

- Provide support to ASI scientific missions for all matters concerning the management and archival of scientific space data;

- Generate and maintain a permanent data archive (including data, software calibration and scientific expertise) of all ASI scientific missions. This ensures that a similar approach is followed for similar missions thus allowing the re-use of past experience and the exploitation of a common hardware infrastructure that leads to significant costs reduction;

- Act as the interface between ASI's scientific missions and the users' community and support the Italian scientific community (both remotely and as a visiting guests facility) in data analysis and archival research;

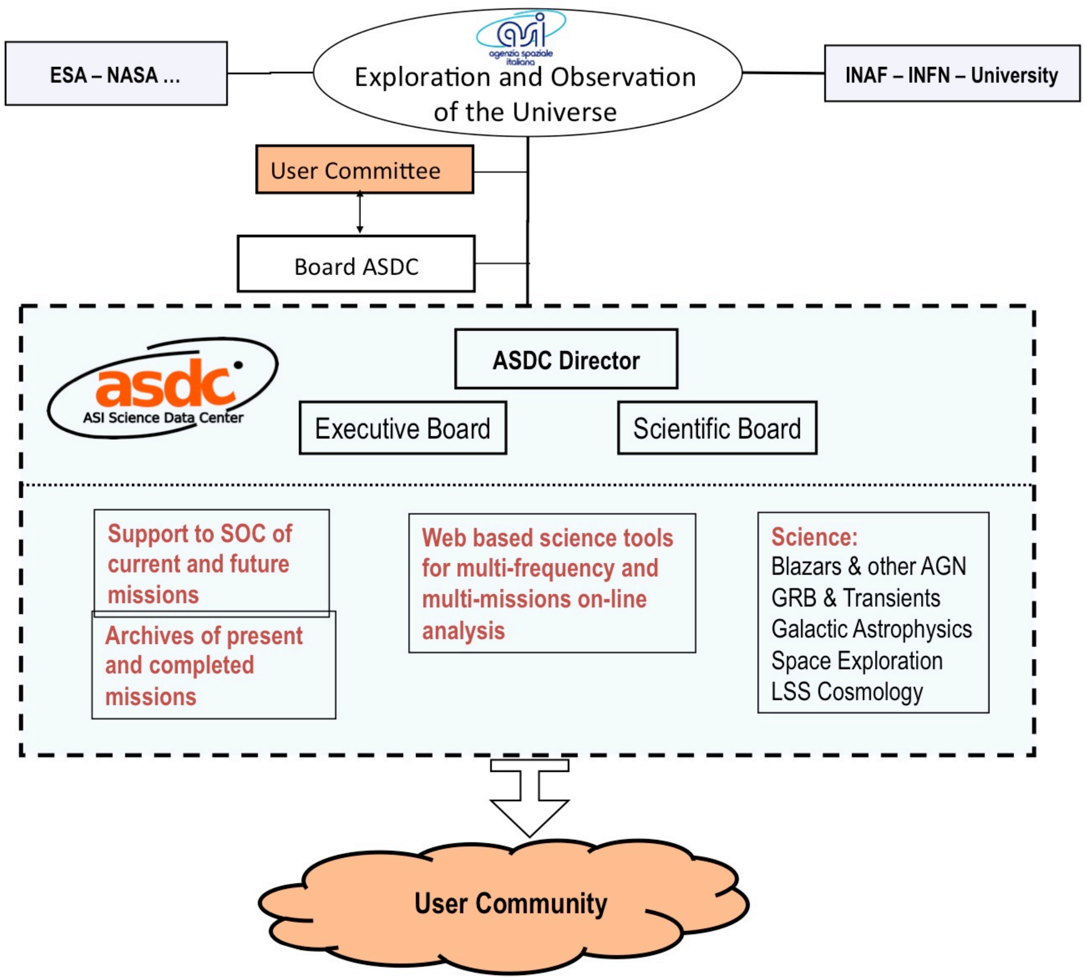
- Provide on-line access to archival data, analysis software, calibration files and documentation both produced and maintained by the Hardware teams and locally;

- Host a copy of the data archive of international missions for which there is an interest in the Italian scientific community;

- Develop and maintain (also in cooperation with other institutions) modern software for the efficient access, analysis and comparison of locally resident or remotely accessible archival data. These activities will be based on international standards and, whenever possible, will be carried in accordance with international initiatives like the NVO and AVO;

- Establish collaborations and links with other data centers and scientific institutions for the exchange of data, software and expertise.

In order to fulfil its duties, ASDC is structured as in the following figure, where is shown how ASDC interacts with the users and with the funding agency (ASI) and participating agencies and institutes (ESA, NASA, INAF, INFN, University etc)



1.1 ASDC Supported Missions

The ASDC hosts the data archive of several past and present scientific missions as described in detail in chapter 3.

The ASDC can provide support to the design, operational and post-operational phases of all future scientific missions for which there is interest in the ASI, INAF and INFN reference communities. For these missions the ASDC can provide support to the proposing teams in term of design and implementation of scientific data analysis systems, pipeline processing, archive generation and management.

These activities will be based on the extensive existing infrastructure and of a long-standing expertise, an approach that ensures significant costs, development times and risks reductions.

In addition, the ASI scientific program foresees a strong participation to the activities of the European Space Agency (ESA) and other projects carried out either as national initiatives or as collaborative efforts with other agencies.

In principle a copy of the data archive of all scientific space projects, directly or indirectly, funded by ASI should be hosted at the ASDC.

1.2 The ASDC in the International Context

All major nations and agencies operating scientific satellites have set up stable data centers to archive and distribute space data and to support their community of users.
In the USA a number of major data centers have been active for several years. These include

- The NASA High Energy Astrophysics Science Archive Research Center (HEASARC) (http://heasarc.gsfc.nasa.gov/) dedicated to high energy space data;

- The *Chandra* Science Center, mostly dedicated to the *Chandra* X-ray Astronomy Observatory launched in 1999 (http://asc.harvard.edu/);

- The Hubble Data Archive (http://archive.stsci.edu/) for near Infra-Red, Optical and UV data;

- The NASA/IPAC Extragalactic database (http://nedwww.ipac.caltech.edu/) and the Infrared Processing and Analysis Center (IPAC) (http://www.ipac.caltech.edu/) for catalogued data, bibliography, and Infrared space data;

- Several other data archives exist to support ground based astronomy data. Examples are the NRAO/VLA Sky Survey (http://www.cv.nrao.edu/~jcondon/nvss.html, the Sloan Digital Sky Survey (http://www.sdss.org/) etc.

The situation in Europe is somewhat different since ESA does not have a general data archive facility, but a number of archives (in ESTEC, ST-ECF, VILSPA) each dedicated to one or a small number of missions.

Several relatively large facilities exist in most European countries involved in scientific space activities. The following is a list of the major existing groups:

- The Leicester Database and Archive Service (LEDAS), which hosts a copy of the archive of several past and current X-ray astronomy missions, and is the base of the XMM-*Newton* Survey Science Centre. University of Leicester, Leicester, UK;

- The Centre de Donnees astronomique de Starsbourg (CDS), which supports large amounts of astronomical data, catalogs and bibliographic information (http://cdsweb.u-strasbg.fr/); Strasbourg, France;

- The Data Center at the X-ray Astronomy group at MPE, Garching (http://wave.xray.mpe.mpg.de/rosat/), and the X-ray data archive at the Astrophysikalisches Institut Potsdam (AIP), Potsdam, Germany;

- The INTEGRAL Science Data Centre (ISDC) (http://obswww.unige.ch/isdc/), in Geneva, Switzerland;

- The European Southern Observatory (http://archive.eso.org/) provides access to archival data from its telescopes and from several other ground and space based observatories.

A very active data center in Canada is the Canadian Astronomy Data Centre (http://cadcwww.dao.nrc.ca/) which provides access to Hubble Space Telescope data and several other data sets, catalogues and information.

The Anglo Australian Observatory provides a service to access data mostly from ground based observatories that are very useful for space astronomy data.

Data archives and related services for Japanese missions are provided by the Institute of Space and Astronautical Science (ISAS) (http://xray.astro.isas.ac.jp/).

In addition, there is a growing consensus in developing a common infrastructure that allows distributed data centers to use each other's data through projects that promote Virtual Observatories. At the moment there are several collaborations and initiatives in various countries:

- The National Virtual Observatory in the USA (www.us-vo.org/)
- The European Astrophysical Virtual Observatory (www.euro-vo.org/)
- The Australian Virtual Observatory (www.atnf.csiro.au/people/morris/AVO/)

1.3 The Structure and High Level Architecture of the ASDC

As most other data centers, the ASDC provides its services mainly through computer networks. Other

services include on-site support to Guest Observers, and data distribution via traditional media like magnetic tapes, CDs etc.
To fulfil its many tasks the ASDC is linked to several data archives and includes software systems.

Seen from the users' viewpoint the ASDC appears as a single web page providing access to various services and distributed data archives through its software systems. The data is partly resident at the ASDC and partly is remotely accessed by the ASDC systems through the internet.

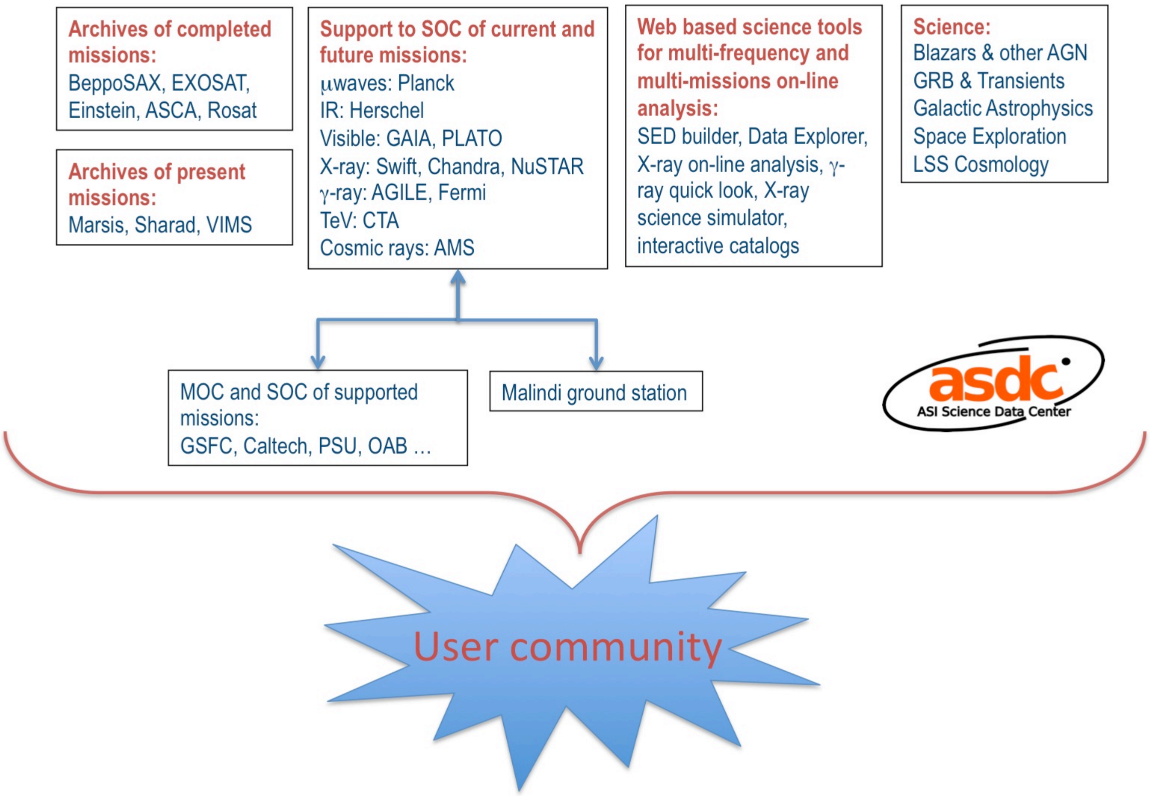
The resident archives include:

- a copy of several public data sets from past missions (e.g. *Einstein*, EXOSAT, ROSAT, ASCA etc.);
- data that is processed at the ASDC like those from the ASI scientific missions;
- public data from active missions like *Chandra*, and that are copied at the ASDC as they become available.

For the projects in which there is a major involvement (*Beppo*SAX in the past, AGILE, Swift and NuSTAR) the ASDC receives the data from the mission control centers, the ground station, or from other data processing centers via internet or via ASINet. The data are then archived, processed and validated as foreseen in the data management plans of each mission. At the end of the process the archives are made available to the users.

Typically the user connects to the ASDC Web page (www.asdc.asi.it) where all the data retrieval services are accessible. All the requests are processed by the ASDC web software that provides transparent and interactive access to local and remote archival data with a single interactive interface based on up to date software technology.
Appropriate software modules allow data downloading, visualization, on-line analysis, data comparison, multi-wavelength searches etc.

In the following figure are sketched the main activities on going at ASDC and their interconnections with the users.


Archives of completed missions:
BeppoSAX, EXOSAT, Einstein, ASCA, Rosat
Archives of present missions:
Marsis, Sharad, VIMS
Support to SOC of current and future missions:
μwaves: Planck
IR: Herschel
Visible: GAIA, PLATO
X-ray: Swift, Chandra, NuSTAR
γ-ray: AGILE, Fermi
TeV: CTA
Cosmic rays: AMS
Web based science tools for multi-frequency and multi-missions on-line analysis:
SED builder, Data Explorer, X-ray on-line analysis, γ-ray quick look, X-ray science simulator, interactive catalogs
Science:
Blazars & other AGN
GRB & Transients
Galactic Astrophysics
Space Exploration
LSS Cosmology
MOC and SOC of supported missions:
GSFC, Caltech, PSU, OAB …
Malindi ground station
asdc
ASI Science Data Center
User community

2 ASDC Activities

The ASDC is currently involved in several projects at various levels:

- **MAJOR INVOLVEMENT**

*Beppo*SAX, Swift, AGILE, Fermi, GAIA and NuSTAR: for these projects the ASDC has, or will have, the direct responsibility in part of the data reduction and analysis software development, will play a major role in the design and implementation of the scientific data archive, will run the routine pipeline processing, and will be a primary site for users' support.

- **DATA ARCHIVE AND SCIENTIFIC SUPPORT**

It is a specific duty of the ASDC to host a copy of the available data of all the missions for which there is a sufficient interest in the Italian community. These missions can be divided into projects with direct (or indirect) ASI involvement (such as ESA missions or international missions where ASI contributes part of the funding) and missions with no ASI involvement.
For Herschel, AMS, *Chandra*, ROSAT, ASCA, EXOSAT, *Einstein* etc the ASDC hosts (or will host) a copy of the public data archive and includes it in the ASDC Multi-Mission Interactive Archive. In some cases some pipeline scientific processing is also carried out.

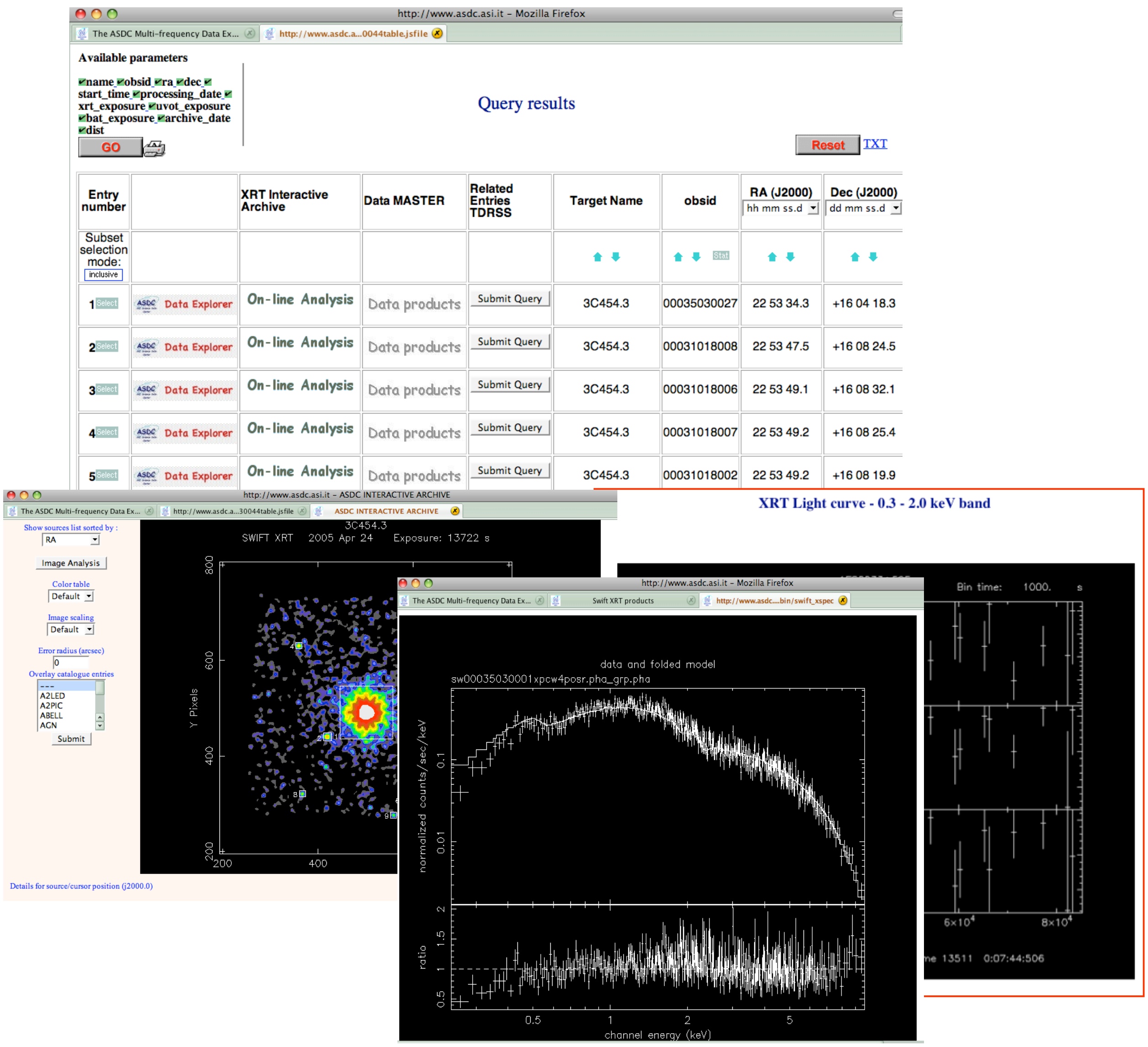
- **MINOR INVOLVEMENT**

In this case the ASDC activities are limited to hosting a copy of part of the archive if appropriate, to host source catalogues, or to establish links to other archive sites.

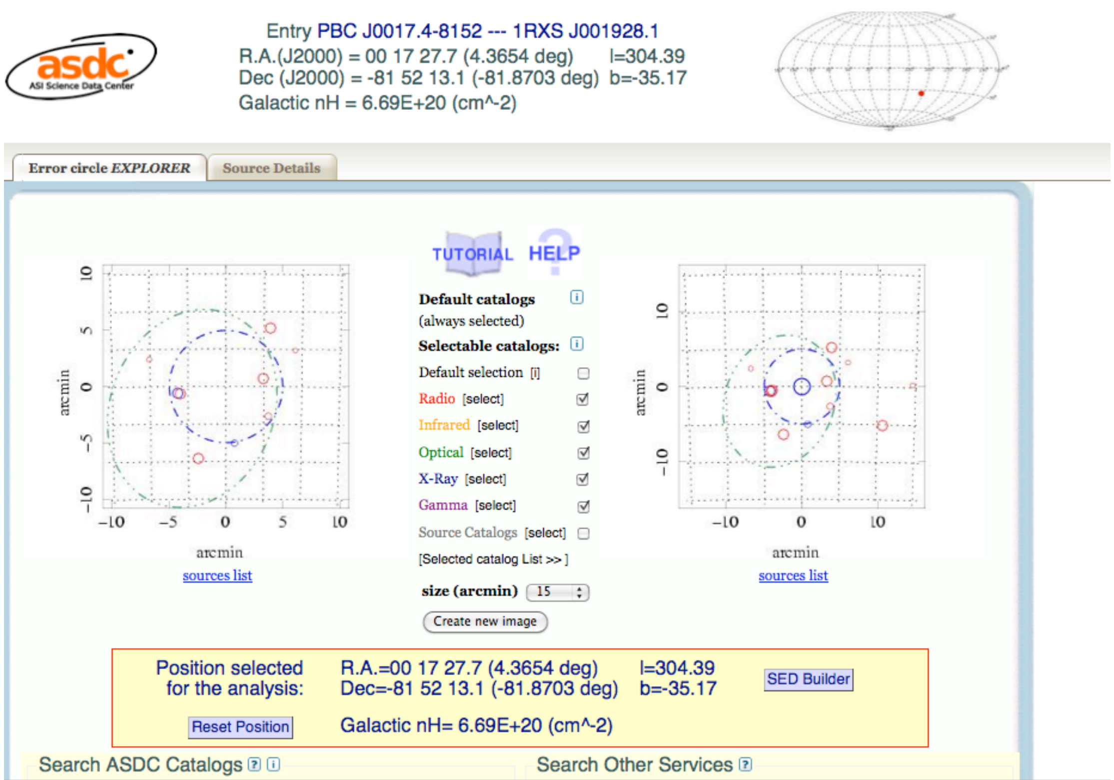
2.1 Multi Mission Interactive Archive (MMIA) and Virtual Observatory

The ASI Science Data Center offers to the scientific community an easy access to several astronomical data taken in different energy bands and allows their scientific analysis and comparison using on-line tools.

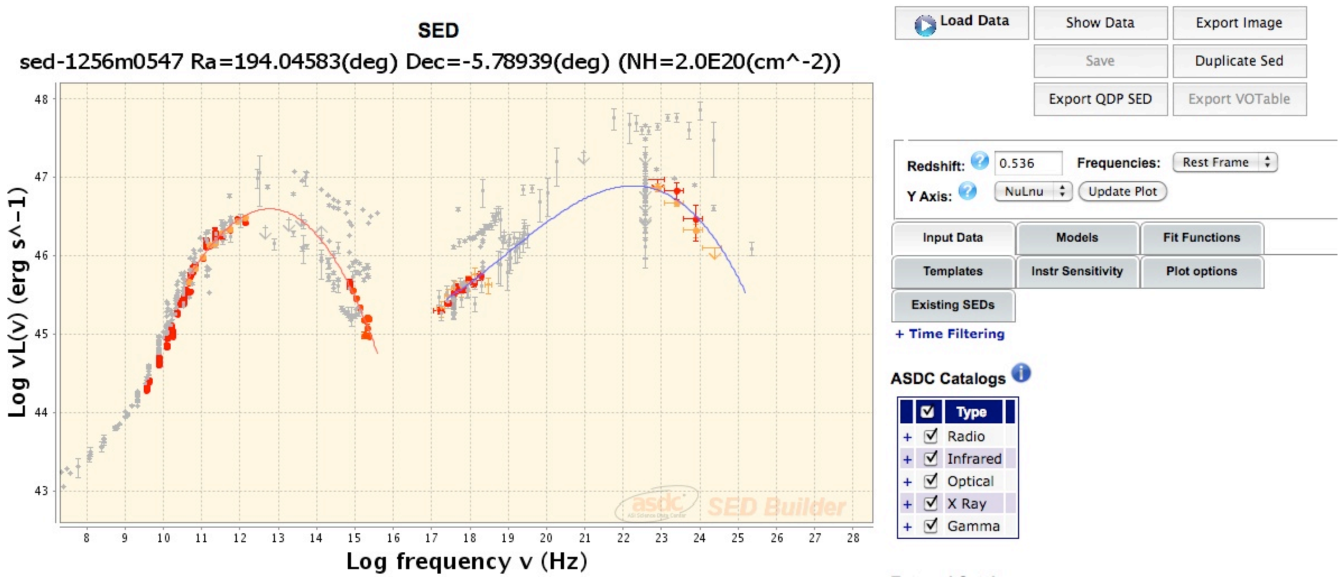
Data of different space missions are archived and made available through the Web interface of the ASDC Multi-Mission Interactive Archive (MMIA). Moreover, the user can easily perform the on-line analysis of the archive data without the need to install specific software locally and to download huge amount of data.



In addition to the on-line data analysis, ASDC provides to the users dedicated tools (the 'Data Explorer' and the 'ASDC SED Builder') for a multi-wavelength analysis. It is possible to easily access the data of archives and catalogs internal or external to the ASDC and combine multi-wavelength and multi-epoch data exploiting the rich and complex information stored in different databases.



The ASDC Data Explorer is a graphical tool designed to allow users to get a quick and efficient overview of a given region of the sky by querying a large number of astronomical catalogs and many data archives. The Data Explorer is particularly useful for the association and identification of sources with some positional uncertainty, like Gamma-ray or hard X-ray sources. The tool plots the source error region and all the detections obtained by instruments in different energy ranges from Radio to TeV. Additional information and data can be obtained by querying in a simple and transparent way many archives or external services as NED, NRAO, SDSS, Vizier, SIMBAD and many others.



The ASDC SED Builder tool (tools.asdc.asi.it/SED) allows users to produce the Spectral Energy Distribution of any astronomical object, by combining the measurements performed by different instruments operating on-orbit and on-ground and collecting data of different wavelength. The tool is designed also to study the SED e.g. by comparing the data to physical models, or to a set of templates and fitting the data to polynomial functions.

The ASDC is working for the integration of its resources in the Virtual Observatory (VO) . The objective of the VO is to facilitate data discovery and access allowing the users to query all the archives in a uniform and transparent way. Moreover the VO provides discovering and analysis tools to enable science with massive and complex datasets.

Following the indications of the International Virtual Observatory Alliance (IVOA), the ASDC resources (archive and catalog data and the software tools for their analysis) are going to become VO compliant: catalogs and archive data will be remotely accessible from any VO clients; the tools will export the output in a VO format, will perform queries to the VO registry to discover data published by other providers all over the world and will be interoperable with other VO tools. The work is on-going to implement the standards and protocols defined by the IVOA.

2.1.1 Mirror Copies of Public Archives

A key factor in astronomical archival research is the ability to compare fresh data with those of past missions. The now consolidated technological capability of comparing very large amounts of data from different archives has opened new and very promising lines of research. To pursue these objectives it is necessary for the ASDC to host mirror copies of public archives of past missions, and to establish links with other data centers providing on-line access to public data.

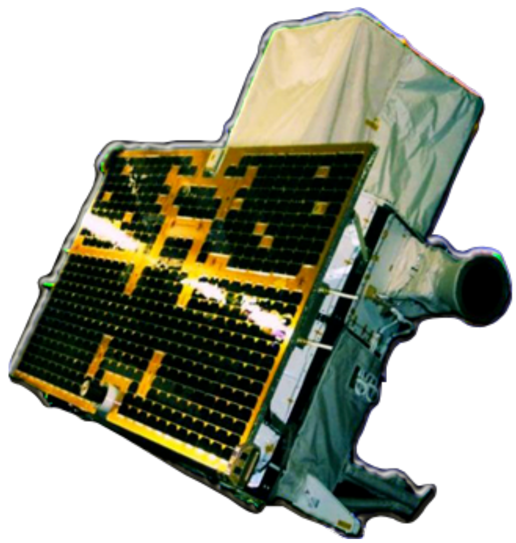
The mirror copies of public archives will be used to provide fast access to these data to the local community.

An agreement between ASI and NASA foresees the exchange of BeppoSAX public data with ROSAT and ASCA archival data. The ASDC has already received about 200 CD-ROMs with ROSAT and ASCA data in the form of clean and calibrated event lists and has provided NASA with a complete set of CD-ROMs including all BeppoSAX NFI public data. A complete set of BeppoSAX WFC data will be shipped in the near future.

The ROSAT and ASCA data have been made available on-line, together with the *Beppo*SAX and XMM-*Newton* public data, through the ASDC Multi-Mission Interactive Archive.

2.2 AGILE

2.2.1 Mission description



The AGILE satellite is designed to detect and image photons in the 30 MeV - 30 GeV and 20-60 keV energy bands, with excellent spatial resolution, timing capability, and a very large field of view covering ~3 sr (~ 60 degrees radius) of sky at energies above 30 MeV. Primary scientific goals include the study of AGNs, gamma-ray bursts, Galactic sources, unidentified gamma-ray sources and diffuse Galactic gamma-ray emissions (M. Tavani et al. , *"The AGILE Mission",* A&A 502, 2009, arXiv:0807.4254).
In June 1997, the AGILE space program was proposed to ASI (for the Program for Small Scientific Missions) by a Team of scientists from INAF (former CNR) institutes[1], INFN laboratories[2], and several Italian Universities[3] (hereafter, the AGILE Team). The mission was selected in December 1997 for a Phase A study that ended in October 1998. Subsequently, ASI selected AGILE in June 1999. The Mission is part of the ASI Piano *Aero-Spaziale Nazionale* formulated in mid-2002 and approved by the Italian Ministry of Research. The satellite was successfully launched on April 23rd, 2007 from the Indian Space Center in Sriharikota ISRO (Chennai-Madras) by the PSLV-C8 rocket. AGILE has been operated in the nominal pointing mode until October 18th, 2009 when the spacecraft reaction wheel failed, making pointed observations no longer possible. Science operations were resumed on November 4th, 2009 with AGILE operating in "spinning mode". The payload is operating nominally producing scientific data of quality equivalent to that obtained before October 2009.
The AGILE scientific instrument is very compact and consists of a combination of two imaging detectors and other subsystems. The Gamma-Ray Imaging Detector (GRID, composed of a Silicon Tracker and a Calorimeter) covers the 30 MeV - 30 GeV energy range with a large field of view (~3 sr). A hard X-ray imaging detector (Super-AGILE) is coaxial with the GRID and operates in the hard X-ray range (20-60 keV) with a ~1 sr field of view. The instrument is completed by the Anticoincidence system, the Data Handling system and power supply. AGILE has been injected in a low-inclination (2.5 degree), quasi-equatorial and nearly circular orbit at 540 km altitude. A brief summary of the AGILE scientific performance is given in section 1 and Table 1. A more detailed description is given in the AGILE User's Manual.
Since October 2009, AGILE will continue to operate in spinning mode for the rest of the mission,

1 INAF/IASF-Milano, INAF/IASF-Bologna, INAF/IASF-Roma.
2 INFN-Trieste, INFN-Roma 1, INFN-Roma 2.
3 Università di Trieste, Università di Roma La Sapienza, Università di Roma Tor Vergata, Consorzio Interuniversitario per la Fisica Spaziale.

observing a large fraction of the whole sky each day. AGILE Science Program is primarily focused on a systematic observation of the gamma-ray sky also providing a prompt response to gamma-ray transients and alerts for follow-up multi-wavelength observations. AGILE is providing crucial information complementary to the many space missions that are currently operational (INTEGRAL, XMM-*Newton*, *Chandra*, RXTE, *Swift*, *Suzaku* and *Fermi*). Furthermore, it can support ground-based investigations in the radio, optical, and TeV bands. Quick-look data analysis and fast communication of new transients are implemented as an essential part of the AGILE Science Program and is carried out by a dedicated AGILE Data Center located at the ASI Science Data Center (ASDC) within the European Space Agency's establishment of ESRIN in Frascati (Italy). Part of the AGILE Science Program is open to Guest Investigators on a competitive basis.

A complete description of the mission can be found at the AGILE Team website

http://agile.mi.iasf.cnr.it/Homepage/index.shtml

2.2.2 ASDC Activities for AGILE

As reported in the AGILE Science Management Plan:

*"**2.4 The AGILE Science Group (ASG)***
The AGILE Science Group (ASG) is composed by the AGILE Team, a few qualified Scientists of the ASI Science Data Center (ASDC), and by the AGILE Project Scientst. The ASG will operate under the coordination of the AGILE PI.

4.1 AGILE Pointing Program Committee (APPC)
The APPC is appointed by the AMB and determines the AGILE satellite Pointing Program.
The APPC is composed of:
- 2 ASI representatives;
- 2 AGILE Team representatives.

The Pointing Program will be prepared before issuing the AGILE AO's for each Observing Cycle, and the overall planning will be made publicly available to the scientific community. Planned exposures and source availability will be made available through the ASI Science Data Center (ASDC, see below).

The AGILE Data Center (ADC) is the scientific part of the AGILE ground segment. For practical, economical and efficiency reasons the ADC will be part of the multi-mission ASI Science Data Center

The low earth equatorial orbit of the AGILE satellite requires that the scientific data is collected at a ground station close to the equator (Malindi) and quickly relayed to the AOCC in Italy. The data is subsequently sent to the ADC where it is processed, quality checked, archived and delivered to the scientific community as required.

5.2 The AGILE Data Center (ADC) at ASDC
The ADC, which will be based at the ASI Science Data Center (ASDC), is in charge of all the scientific oriented activities related to the use of AGILE data. These include the monitoring of the correct functioning of the instruments, the Quick-Look Analysis, the routine data reduction to derive Standard Products, the distribution

and archiving of AGILE data, etc. As shown in Fig. 2, the ADC will consist of two entities: the AGILE Team Processing Group (ATPG) and the AGILE Science Support Center (ASSC). The more instrument-related tasks will be carried out by the AGILE Team Processing Group. This group, belonging to the AGILE Team and under the AGILE PI responsibility, will assure at the ADC the technical expertise required to make the best use of the AGILE data. The ATPG will work in close collaboration with the AGILE Team to develop the instrument specific software. The AGILE Team Processing Group will operate at the ASI Science Data Center premises in collaboration with the ADC staff provided by ASI. Some overlap between the ATPG and the ASSC staff is necessary in order to provide the required functionalities, therefore a few members of the ASSC might also operate within the ATPG (and report to the AGILE PI for their ATPG related activities).

5.4 Tasks of the AGILE Science Support Center (ASSC)

The ASSC will be in charge of the following tasks:

• ***Provide the formal interface between the project and the scientific community.***

• ***Provide scientific support to the astronomical community*** *through a set of WEB pages, by providing data analysis software, exposure maps and assistance in the data reduction and an on-line Helpdesk. The ASSC will also support visiting observers.*

• ***Manage the Announcements of Opportunity (AOs)*** *for the Guest Observation Program and provide AO support to the scientific community. The ASSC will develop and provide the proposal submission tools for the Guest Observers. It will also provide technical support during the data allocation process.*

• ***Support to the AGILE Pointing Program****. The ASSC will provide technical support for the determination of the AGILE Pointing Program by the APPC.*

• ***Standard software support****. AGILE data analysis software, provided by the ATPG to the ASSC, to be used by Guest Observers and general users will be supported by ASSC personnel. Analysis software will be supported with the development of proper interfaces to be used with standard packages (such as FTOOLS, etc.).*

• ***Contact point for follow-up multi-wavelength observations.*** *Results of the AGILE Quick-Look analysis will be available at the ASSC to any interested scientist. The ASSC will be the contact point for the organization of follow-up observations.*

• ***Archive and distribute all scientific data.*** *This activity will take into strict account the proprietary rights of the data.*

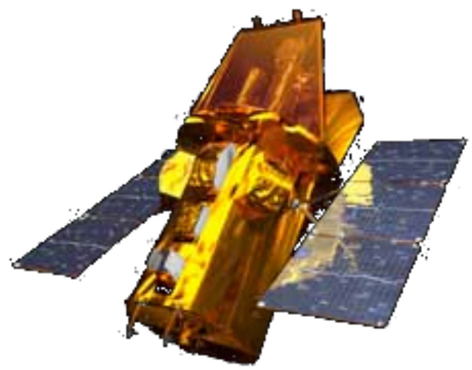
• ***Manage the AGILE public archive*** *which will include all data after the end of the proprietary period. The ASSC will be the only public archive of AGILE data for the duration of the Mission."*

AGILE Telemetry raw data (Level-0) are down-linked every □ 100 min to the ASI Malindi ground station in Kenya and transmitted first to the Telespazio Mission Control Center at Fucino, and then to the AGILE Data Center (ADC). Raw data are routinely received at ADC within □ 5 min after the end of each contact. The ADC is the scientific component of the AGILE ground segment and is part of the ASI Science Data Center (ASDC).

ADC is in charge of all the scientific oriented activities related to the analysis, archiving and distribution of AGILE data. Its main tasks are:
preliminary data analysis (Quick Look Analysis), data processing and production of the data archives (from raw data to scientific level data through calibration level data), management of the Guest Observer Program and of the Announcements of Opportunities, management of the Mission Planning (Long Term Plan preparation and emission), data and software distribution to the scientific community.

2.3 Swift

Swift is a fast-reaction high-energy astronomy satellite dedicated to the study of Gamma-Ray Bursts (GRB) and of other transient and steady cosmic sources. Swift was launched on November 20, 2004 and its scientific payload includes a wide angle coded mask high energy detector called the Burst Alert Telescope (BAT), one X-ray Telescope with CCD detector (XRT) with good spatial resolution, and one Optical-UV Telescope (UVOT).



Swift is a NASA/MIDEX mission led by NASA and other institutions in the USA in collaboration with Italy and the United Kingdom. A full description of the mission can be found at the following link: http://swift.gsfc.nasa.gov.

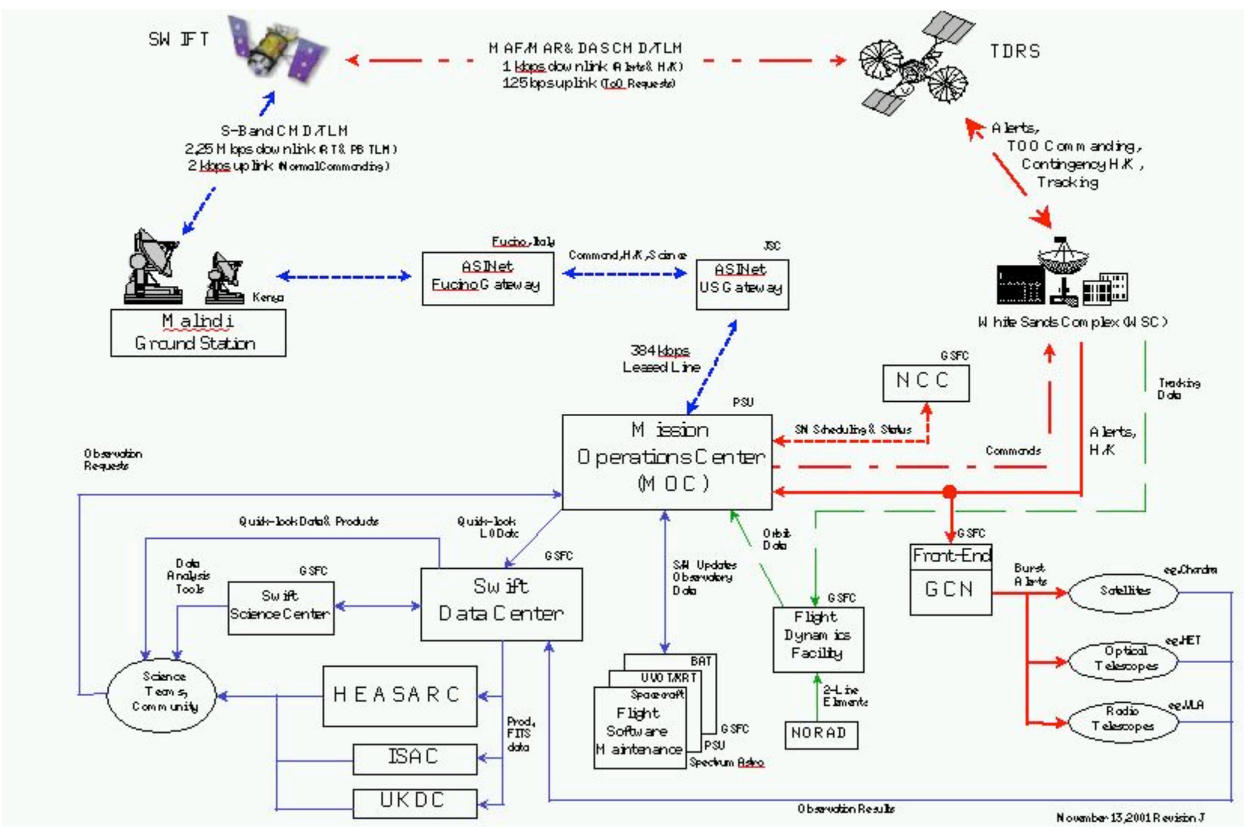


Figure 3.4.1 Swift Ground Segment Architecture

The italian participation to Swift includes the provision of the Malindi ground station (ASI), the X-ray mirror (INAF-OAB) and the ASDC which has the responsibility of the development of the XRT Data Reduction Software (XRTDAS) and hosts an official mirror of the Swift scientific data archive. As shown in Fig. 3.4.1 Italy provides and operates important parts of the ground segment. A copy of all Swift data are hosted at the Italian Swift Archive Center (ISAC) which has two major components: one at the ASDC and the other at the Brera Observatory (OAB) in Merate (see figure 3.4.2).

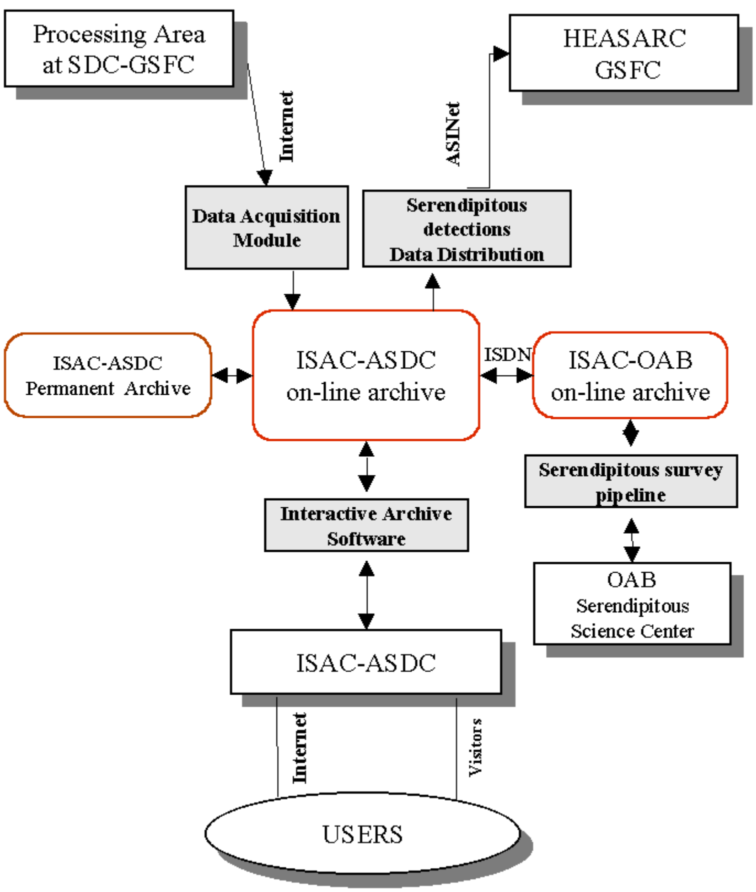


Figure.3.4.2 Swift data flow involving the Italian Swift Archive Center (ISAC) in Rome (ASDC) and Merate (OAB) and two other scientific parts of the ground segment at NASA/GSFC.

2.3.1 The roles and responsibilities of each ISAC component

ASI (ASDC)

- host and maintain a copy of the Swift science archive including data for all Swift instruments, to be made publicly accessible via computer networks;
- lead the design and development of the basic data reduction software to reduce the XRT raw data and produce clean and calibrated scientific data files (FITS-OGIP compliant) (XRT Data Reduction Software, XRTDAS);
- technical and scientific quality check of data.

OAB

- lead the development of the XRT calibration software and maintain the XRT calibration database;
- run the high level scientific pipelines to generate final data products and scientific results (scientific standard analysis) for serendipitous XRT sources;
- organize follow-up observations.

ASI-OAB collaboration

- include the Swift scientific archive (BAT, XRT, UVOT) within a multi-mission interactive archive;
- Build value added information through correlation and comparison of Swift data with other astronomical data sets.

2.3.1.1 Pipeline software development

One of the main responsibilities of ASDC is to develop the data reduction software of the XRT instrument (XRT Data Reduction Software (XRTDAS)). Level 1 data of the CCD detector (telemetry in FITS format) are processed to produce cleaned and calibrated, Level 2, data. Calibrated event lists are then processed to generate high-level data products including images, spectra and light curves.
The software modules needed to process the data have been developed after a systematic study of the characteristics of the hardware, the electronics flight software and the telemetry of the XRT instrument (see fig. 3.4.3).
The software modules that are part of the XRTDAS package are listed below:

- Hot pixels identification
- PHA computation (Photon Counting readout mode)

- PHA to PI conversion (gain correction)
- Coordinates transformation
- Housekeeping processing
- Filter file generation
- Good Time Intervals (GTI) generation and data screening
- Exposure Map computation
- ARF file computation (in collaboration with INAF-OAB)
- Light-curve correction
- Events time tagging (Timing readout modes)
- Events recognition (Timing readout modes)
- Correction of spacecraft attitude using TAM information
- Creation of high-level scientific products
- Bias subtraction
- TDRSS data processing
- Processing pipeline (all modules)

The software is written in ANSI C, Fortran and PERL under the HEASoft system, the software environment designed to manipulate FITS files mantained at HEASARC. Expertise acquired supporting other missions has been used to adapt existing software written for similar projects, when possible. Code reuse improves reliability and significantly cuts development costs.

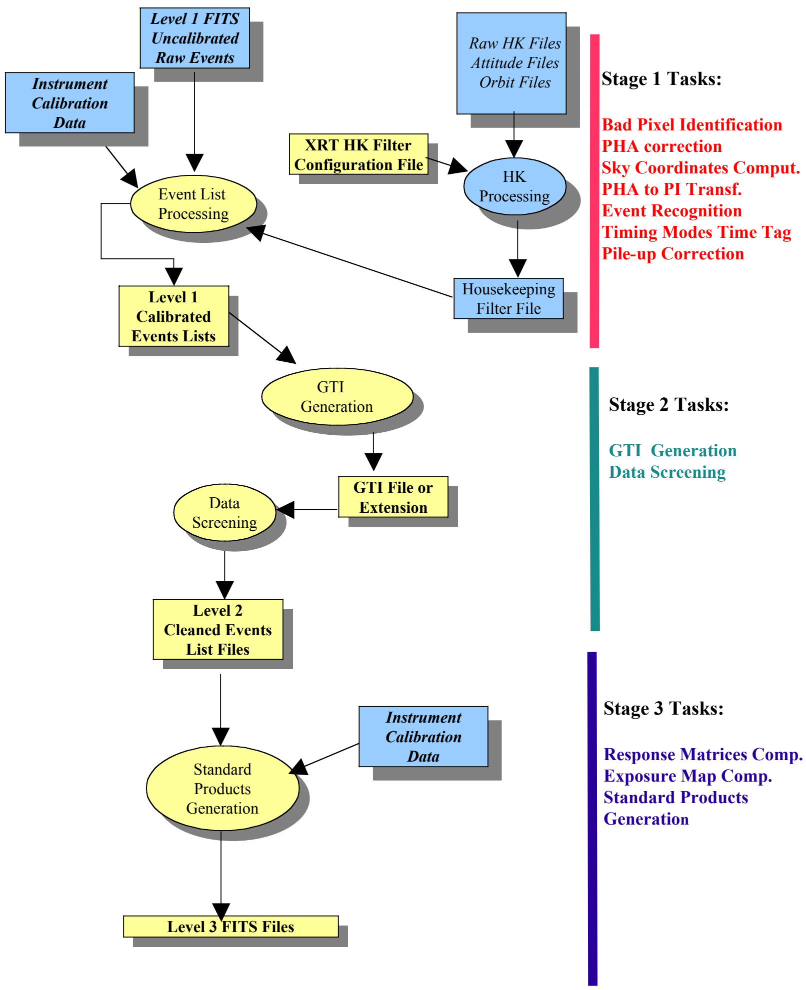


Figure 3.4.3 XRT Data Reduction Software Flow Chart

2.3.1.2 *Swift Archive at ASDC*

The XRTDAS software modules are first run at the Swift Data Center (SDC) in USA to generate the XRT archive and then the data are delivered in few hours to the ASDC.

HEASARC has provided ISAC with the following packages adopted by the project to transfer and archive data:

- Data Transfer System (DTS) - transfer protocol
- Data Archive System (DAS) - system developed by HEASARC to move data from the DTS staging area to the final archive location
- Database System Ingest (DBSI) - system developed by HEASARC to ingest the database tables in the database system.

DTS is a protocol of data transfer originally developed for XMM-*Newton* mission and generalized for multimission use by HEASARC. It is designed to be operated automatically and also be highly reliable, it is a Perl script combined with e-mail server and Secure File Transfer Program (SFTP) server that performs the bi-direction secure transfer of data sets from one site to another.

The overall archive procedure as currently implemented at ISAC consists of three steps (see figure 3.4.4):

- The first step is the data transfer achieved via DTS. The data arrive in a staging area of the receiving site.
- The second step is to move data from the staging area into the final archive location. This is achieved via the DAS software which moves the data into the appropriate directory. If the incoming data set is a newer revision of the same data set already present in the archive, it replaces the latter with the newer version and move the older version into a directory in the backup location. DAS keeps logs of all these activities.
- The third step is to ingest the database tables in the database system and to connect the data to the entries in the database tables which is done by the database system ingest (DBSI). This creates tables suitable for the browse DBMS system, ingests the tables, saves the incoming tables to a backup directory and keeps logs of the overall operation.

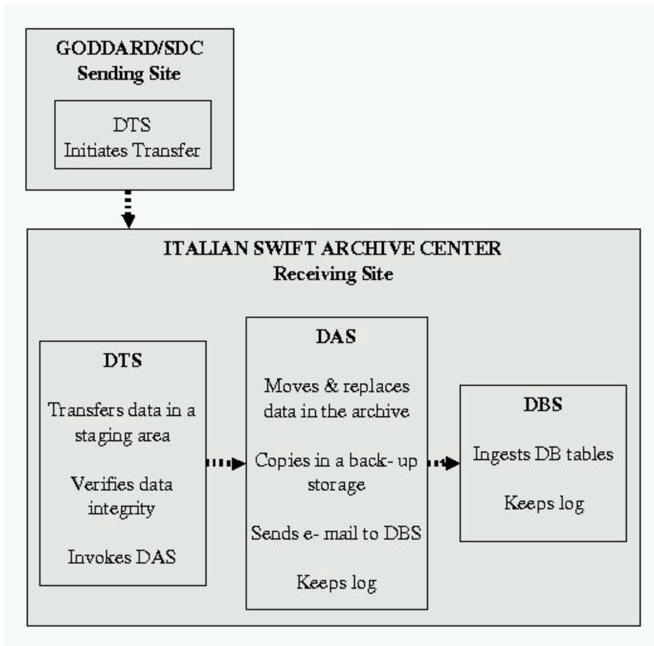


Figure 3.4.4 - Swift Archive Software Flow

The ASDC Swift archive contains all the products present at SDC, but additional analysis is performed. In particular the Swift data archive is integrated into the ASDC Multi-Mission Interactive Archive (see Chapter 6) allowing the scientific community to perform on-line analysis and comparison of Swift data with those of other missions. For this purpose a specific WEB interface to the Swift Archive has been developed.

2.3.1.3 XRT Serendipitous survey

A serendipitous survey of XRT data is performed in collaboration with INAF-OAB.
While pointing the GRBs and other targets, the XRT field of view includes serendipitous sources mainly from objects constituting the X-ray background. Therefore, in addition to the main goal of the Swift mission, the scientific project of the XRT survey has the aim to collect positions, intensities and data products of these serendipitous sources.
The Swift Serendipitous Survey in deep XRT GRB fields (SwiftFT), reaching a sensitivity of ~ 7 10^{-16} erg cm^{-2} s^{-1} in the 0.5-2.0 keV band, includes all X-ray sources detected in 370 Swift-XRT fields centered on gamma ray bursts detected between 2004 and 2008. It was obtained summing data from the same position in the sky collected in different observations. Only data taken in Photon counting mode were considered. The results have been published in Puccetti et al. 2011 (*Astronomy & Astrophysics*, 528, 122).
The ASDC is generating also the catalog of all X-ray sources detected in all XRT single fields.
The catalogs containing the Serendipitous Surveys results are archived at ASDC for public on-line access.

2.4 Fermi

The newest major space observatory for high-energy astrophysics, the Fermi Gamma-ray Space Telescope mission, studies the cosmos in the energy range between 20 MeV and 300 GeV, driving out to the full maturity the studies already begun with the American Compton Gamma ray Observatory (CGRO) and continued with ESA mission INTEGRAL and ASI Italian AGILE satellite. The Fermi satellite (previously known as GLAST and renamed Fermi after the launch from NASA as recognition of the fundamental Italian contribution to the mission) was successfully launched on 11 June 2008 from the NASA base of Cape Canaveral. The operating phase is foreseen to be 5 years (10 years extendible).

The mission is currently funded until August 2013 but a possible 5 year extension may be granted by NASA. Fermi is composed of two instruments: the Large Area Telescope (LAT, operating in the energy range 20MeV-300GeV) and the Gamma-ray Burst Monitor (GBM).
Fermi is working in all-sky scanning and survey mode to monitor and unveil the mysteries of the high-energy universe, looking at the most energetic photons travelling undeflected from the emitting sources to us, and observing high-energy physical processes and conditions far beyond the capabilities of earthbound laboratories.
The main instrument, the Large Area Telescope (LAT), operates more like a particle detector than a conventional telescope. From within its 1.8-meter cube housing, the LAT uses 880000 silicon micro-strip detectors to detect high-energy gamma rays with unprecedented resolution and sensitivity, filling in gaps in understanding left by previous missions, and pushing new boundaries in particle physics, astrophysics, atroparticle physics and multifrequency and multi-messenger physics..
Currently the LAT scientific collaboration includes more than 400 scientists and students at more than 90 universities and laboratories in 12 countries. The collaboration has published papers on pulsars, active galactic nuclei, globular clusters, cosmic-ray electrons, gamma-ray bursts, binary stars, supernova remnants, diffuse gamma-ray sources and other subjects.
Italy participated to the instrumental part thanks to expertise of INFN supplying 18 towers (16 flight towers and two spare towers for calibrations) that constitute the LAT tracker, and thanks to the services, tools and expertise of the ASDC like a centre of record, distribution, quicklook online analysis of the scientific data of the mission. In exchange for these contributions Italy obtained a copy of the data archives in a way similar to what is arranged for the Swift mission.
The Italian Fermi collaboration, in particular ASDC has participated and is actively participating to the service activities, like those for the release, publication and maintaining of Fermi source catalogues (all sources in periodic releases, AGNs, GRBs, pulsars, hard, transient sources, etc.), the collection of simultaneous multiwavelength (MW) data, the duty of the Flare Advocate (also known as Gamma-ray Sky Watcher), the development of high level analysis tools. An example of these Fermi software tools realized, maintained, supported or in construction with the ASDC participation are the Automatic Science Processing, ASP, LAT Data Viewer, the download interface of LAT data at the ASDC servers, the LAT data preview, and some basic quicklook analysis tools placed online.

The exploration, exploitation and scientific analysis of the Fermi LAT data, also in relation to the other multi-frequency data and multi-mission tools based at the ASDC archives is a characterizing, mandatory, demonstrative and founding pillar of the ASDC vocation.
In order to maximize the scientific return of the Fermi mission and the level of international cooperation of the worldwide scientific community with this space mission is important to study gamma-ray photons from cosmic sources in conjunction to simultaneous data obtained from ground-based and space-borne observatories and instruments operating in other electromagnetic wavebands (radiowaves, millimeter, infrared, optical UV bands, X-ray and TeV energies). This modern field of research, involving many and various technologies and scientific communities (also non professional as the amateur communities devoted to optical variability and transient monitoring with small-size telescopes) is characterized by a very high level of internationalization and is commonly named "Multiwavelength (MW, or multifrequency) astrophysics" or, more general, "Multi-messenger astrophysics" (also called astroparticle physics). On top of that the future of astrophysics, cosmology and astroparticle physics will be more and more the domain of survey observations (i.e. synoptic, sum-up and summary surveys monitoring, watching and patrolling all the sky) at multifrequency wavebands.
The Fermi space mission turns out to be a unique protagonist of this promising future, observing the sky in survey mode all the gamma-ray sky every 3 hours in a wide energy range (MeV-GeV) with sensibility and performances never reached before, for all the days of the year. At the present moment it is not expected or thought an instrument and mission successor of Fermi and it is not clear how it the successor might be realized with a jump in performances and a contraction in costs comparable to the transition from CGRO-EGRET to Fermi LAT.
According to the "Memorandum of Understanding" ASI-NASA concerning the GLAST/Fermi Gamma-ray Large Area Space Telescope, signed by ASI and NASA and regulating all the operating phase (therefore at least till 14 August 2013), the role of ASDC in the Fermi mission is reported in the following way:

- *"Establish and maintain a mirror data site of the LAT science database, participate in the development of the GLAST/LAT data analysis software, and lead the development of and make available for the use of the GLAST LAT collaboration, the software for the publication of LAT catalogs and the distribution of high level data products via the World Wide Web".*
- *"Provide for the necessary interfaces to allow the ASDC to serve as a mirror site for the LAT data at the LIOC*". (note: LIOC now is renamed ISOC, at SLAC-Stanford, USA)

In general the tasks of the Fermi Team in ASDC are:

- To participate and support to the software development of the LAT instrument;
- To lead and support the software development for archiving, distribution (also by the Web), and quicklook analysis of the high level data (i.e. ready for scientific analysis);
- To lead and support the software development for analysis, publication and distribution of the Catalogs of the sources of interest and detected by the LAT;
- To receive and maintain the archive of the high level data (i.e. ready for scientific analysis);

- To participate, as members of the LAT science team, to the scientific analysis, exploit of the LAT data, and science investigations, in accordance with the LAT Collaboration data use policy and the Program Data Management Plan (PDMP).

The ASDC activities for the Fermi Subproject and Fermi Team for this Working Package (WP) come from institutional obligations (international agreements between ASI and NASA) and set up, at the same time, a support to the national and international scientific community.

The ASDC activities for the Fermi subproject includes the creation and maintenance of Fermi catalogues, web analysis tools and web pages, development of scientific software for the Fermi and multifrequency data analysis, support and helpdesk to external users, the Flare Advocate (Gamma-ray Sky Watcher) service duty, the Data Quality Monitor (DQM) service duty, participation to Fermi LAT meetings and conferences, contribute to the public outreach activity, possible contribute to the study of new missions and scientific research though the Fermi data.

The data and source archives of the mission are created, updated and maintained (about on a one-month base), with the dedicated web pages and interfaces and links to the other multifrequency-multimission archives (MMIA) at ASDC. Fermi source catalogs includes the DC2, SC, LBAS, 1FGL, 1LAC, 2FGL, 2LAC, GRB (LAT and GBM), transient, hard-sources, catalogs.
Part of the archives and tools are stored on the ASP system at ISOC-SLAC, USA, as services for the LAT Collaboration.

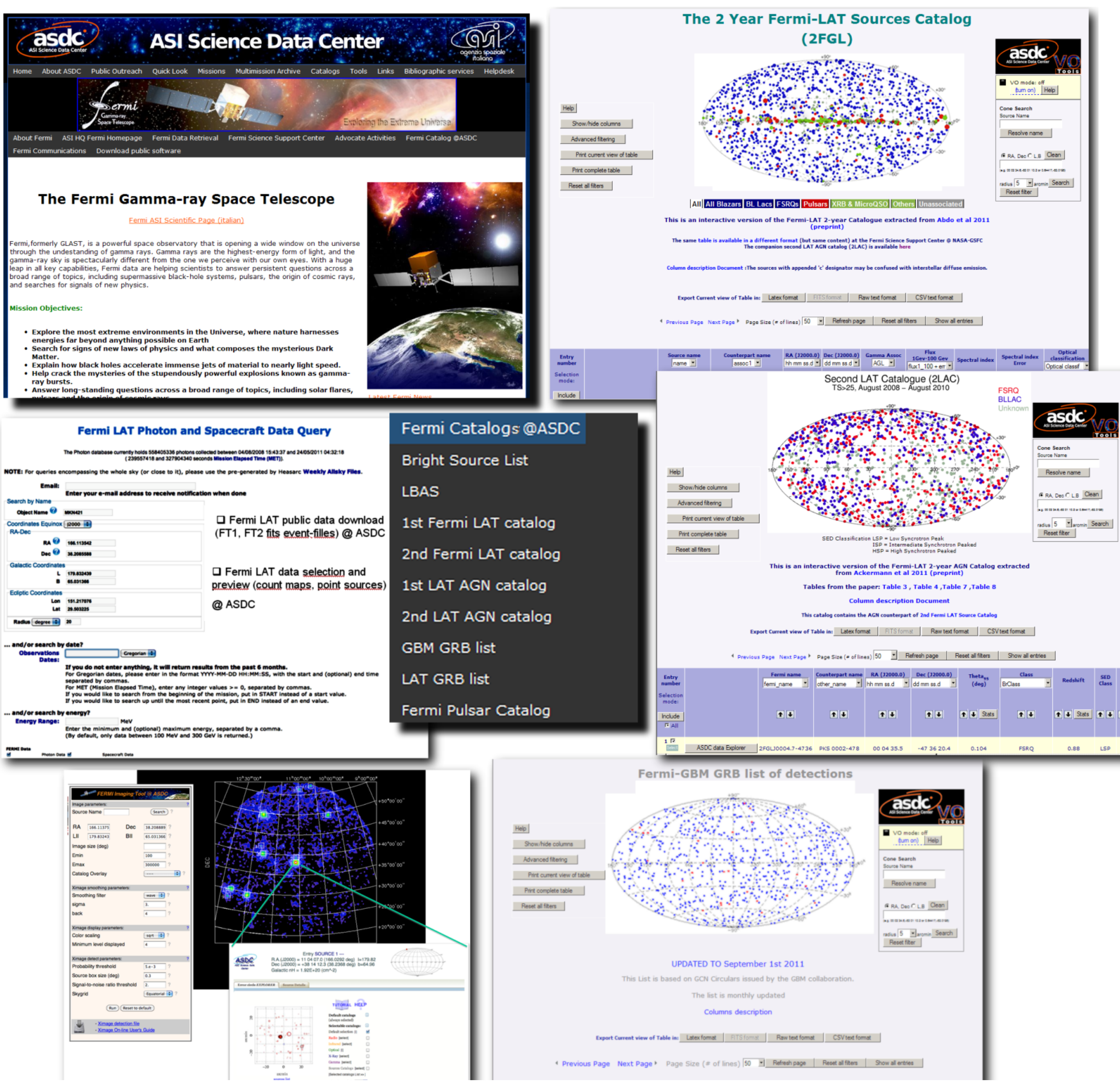
Fermi web-based and dedicated software tools for the data retrieval and quicklook inspection and scientific analysis contain an all sky tool for variability test of simulated data (DC2), the implementation of a detection method based on the minimum spanning tree, the web interface for data retrieval, the data interactive preview, a tool to calculate and extract the energy spectrum in energy bins of a selected source, an interactive light curve display and explorer, the interface of catalogs with the Virtual Observatory (VO), an aitoff projector. The Fermi data preview tool allows to outlook the downloaded data, with an interactive count map and an automatic and fast source guess-detection based on the HEASOFT software XImage.

The main hardware and software systems of the Fermi Data center at ASDC is composed of a data acquisition and archiving subsystem, a data access and distribution subsystem, a data management subsystem. The Fermi LAT high level data (FT1/FT2 files in standard, OGIP, format FITS) are periodically retrieved from the ISOC center at SLAC-Stanford, USA. The data are then organized in a MySQL database to allow a flexible retrieval, and are distributed to the community via a web interactive interface. The data file are archived after controls and checks for updates are made every hour in a database with tables separated by file type. The base software infrastructure for the Fermi data archive is based on FITS standard (NASA OGIP), HEADAS, HEASOFT, and cfitsio programs and libraries, scripting languages (Perl, Javascript, Java, Python), Starlink Tables Infrastructure Library, LHEA HEAdas Software suite, FTOOLS; XANADU software, the MySQL database. The software is both operative (libraries, compilers, programming languages, applications) and specific (development environments). A central role is the monitoring of the data retrieval, acquisition, and optimization of the archive, the monitoring of the data alignment with ISOC-SLAC and monitoring of the data preview and scientific analysis tools performances. Several procedures of data recovery are also implemented.

The scientific FITS files FT1 e FT2 have to be aligned in number, size and event type, with the data released from the center ISOC-SLAC (identical in event number and mandatory keywords following the OGIP standards).

The support to the user, (mainly addressed to the tutorial and help about the management of the software tools) has periodic updated of the documentation at ASDC, and a helpdesk web service.

The Flare Advocate – Gamma-ray Sky Watcher (FA-GSW) service and the Duty-Scientist Data Quality Monitor (DS-DQM) of the LAT instrument is an outlook analysis addressed to search for flares, transients and new gamma-ray source of interest for the LAT science collaboration, and monitor of the instrument performances, data quality and alarms. Software tools for automatic analysis are implemented for these services. Teleconferences, management of this activity, documents, and tutorials are also foreseen.



2.5 *Chandra*

The *Chandra* X-ray Observatory is the third in NASA's family of Great Observatories that includes the Hubble Space Telescope and the Compton Gamma Ray Observatory. It was launched on 23 July 1999 and carries on board a powerful high spatial resolution X-ray telescope with High Resolution Camera (HRC) and high spectral resolution grating detectors ACIS (Advanced CCD Imaging Spectrometer).

The high spectral resolution of spectrometers, the very large collecting area of XMM-*Newton*, the *Chandra* high spatial resolution and unprecedented X-ray image quality, offer a unique opportunity for detailed spectroscopic investigations of faint and distant sources, an invaluable diagnostic tool in detailed investigations of the dynamics and physical structure of X-ray sources.

The ASDC involvement consists of:

- host a mirror copy of the Chandra ftp archive

The ASDC has agreements to host a copy of the public data as it becomes available. In particular, for *Chandra* the ASDC, in collaboration with the *Chandra* Science Center, is setting up a complete mirror of the *Chandra* ftp archive.
Finally the ASDC hosts an up-to-date copy of the calibration files of *Chandra*.

The *Chandra* X-ray Center (CXC) produces a set of standard data products for every *Chandra* observation. These products are also available from the ASDC mirror of the Chandra ftp archive through the ASDC multi-mission interactive archive.

2.6 NuSTAR

The Nuclear Spectroscopic Telescope Array (NuSTAR) is a NASA Small Explorer mission that will carry the first focusing hard X-ray (5-80 keV) telescope to orbit, opening the hard X-ray sky for sensitive study for the first time.

After launch, in early 2012, NuSTAR will carry out a two-year primary science mission focused on studying the evolution of massive black holes, understanding the population of compact objects and the nature of the massive black hole in the center of the Milky Way, constraining explosion dynamics and nucleosynthesis in supernovae, and probing the nature of particle acceleration in relativistic jets in active galactic nuclei.

A full description of the mission can be found at the following link:

http://www.nustar.caltech.edu/

The Italian participation includes the provision of the Malindi ground station (ASI), the ASI Science Data Center (ASDC) which contributes to the development of the NuSTAR Data Reduction Software and will host an official mirror of the NuSTAR scientific data archive and a team of scientists of the Istituto Nazionale di Astrofisica (INAF) to collaborate on the primary scientific mission goals.

2.6.1 The roles and responsibilities of the ASDC

- host and maintain a copy of the NuSTAR science archive to be made publicly accessible via computer networks;
- develop, in collaboration with the NuSTAR Team of the California Institute of Technology (Caltech), the data reduction software to reduce the NuSTAR telemetry data in FITS format to produce clean and calibrated scientific data files (FITS-OGIP compliant) (NuSTAR Data Reduction Software, NuSTARDAS);

- develop, in collaboration with the NuSTAR Team of the California Institute of Technology (Caltech), the NuSTAR calibration software and maintain the NuSTAR calibration database;

- include the NuSTAR scientific archive within the ASDC Multi-Mission Interactive Archive (MMIA);

- technical and scientific quality check of data.

2.6.1.1 Pipeline software development

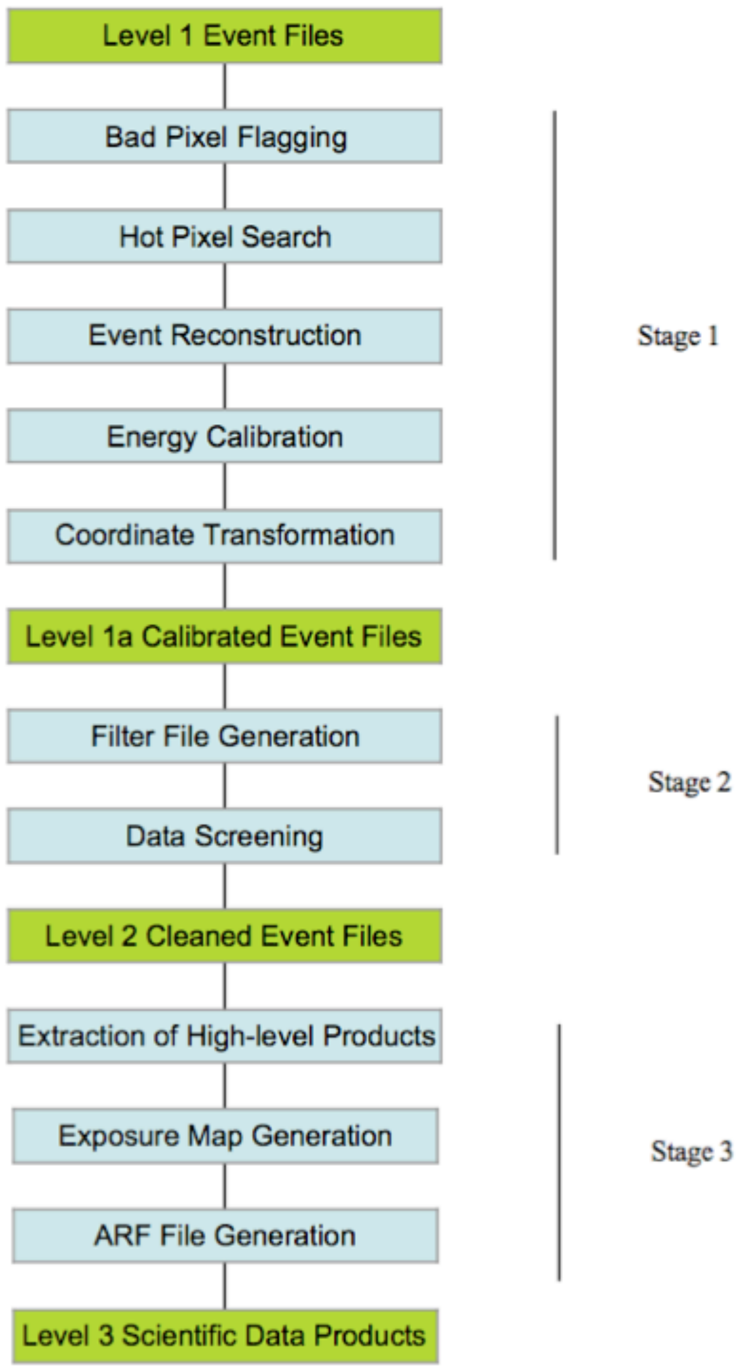
One of the main role of ASDC for the NuSTAR mission is to develop the data reduction software (NuSTAR Data Reduction Software, NuSTARDAS). Level 1 data of the detectors (telemetry in FITS format) are processed to produce cleaned and calibrated, Level 2, data. Calibrated event lists are then processed to generate high-level data products including images, spectra and light curves.
The software modules needed to process the data have been developed after a systematic study of the characteristics of the hardware, the electronics flight software and the telemetry of NuSTAR.

The software modules that will be part of the NuSTARDAS package are listed below:

- Bad pixel flagging
- Hot pixels identification
- Event reconstruction and PHA computation
- PHA to PI conversion (gain correction)
- Processing of metrology information
- Coordinates transformation
- Filter file generation
- Good Time Intervals (GTI) generation and data screening
- Exposure Map computation
- ARF file computation
- RMF file computation
- Creation of high-level scientific products
- Processing pipeline (all modules)

The software is written in ANSI C, Fortran and PERL under the HEASoft system, the software environment designed to manipulate FITS files mantained at HEASARC. Expertise acquired supporting other missions has been used to adapt existing software written for similar projects, when possible. Code reuse improves reliability and significantly cuts development costs.

The data processing steps for each of the two NuSTAR instrument units are illustrated in the figure below:



NuSTAR Data Reduction Software Flow Chart

2.6.1.2 NuSTAR Archive at ASDC

The NuSTARDAS software modules will be first run at the NuSTAR Science Operation Center (SOC) in USA (Caltech) to generate the NuSTAR archive for the NuSTAR Team. It is foreseen that the data will be delivered to the ASDC after validation by the NuSTAR SOC.
Caltech and ASDC will make use of the following packages to transfer and archive data:

- Data Transfer System (DTS) - transfer protocol
- Data Archive System (DAS) - system developed by HEASARC to move data from the DTS staging area to the final archive location
- Database System Ingest (DBSI) - system developed by HEASARC to ingest the database tables in the database system.

DTS is a protocol of data transfer originally developed for XMM-*Newton* mission and generalized for multimission use by HEASARC. It is designed to be operated automatically and also be highly reliable, it is a Perl script combined with e-mail server and Secure File Transfer Program (SFTP) server that performs the bi-direction secure transfer of data sets from one site to another.

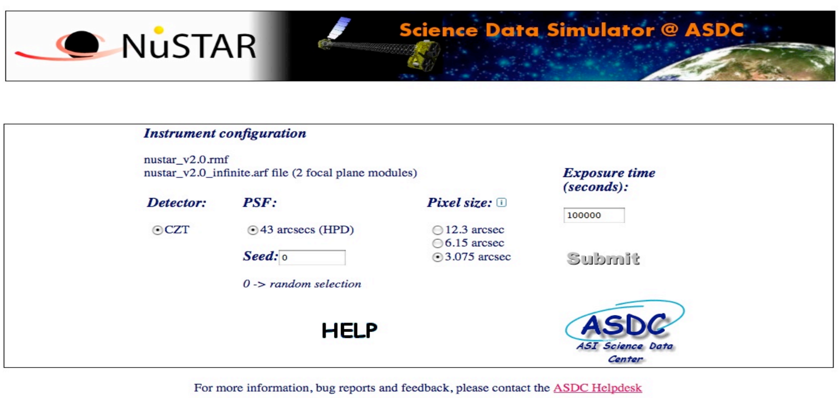
The archive procedure that will be implemented at ASDC will consist of three steps:

- The first step is the data transfer achieved via DTS. The data arrive in a staging area of the receiving site.
- The second step is to move data from the staging area into the final archive location. This is achieved via the DAS software which moves the data into the appropriate directory. If the incoming data set is a newer revision of the same data set already present in the archive, it replaces the latter with the newer version and move the older version into a directory in the backup location. DAS keeps logs of all these activities.
- The third step is to ingest the database tables in the database system and to connect the data to the entries in the database tables which is done by the database system ingest (DBSI). This creates tables suitable for the browse DBMS system, ingests the tables, saves the incoming tables to a backup directory and keeps logs of the overall operation.

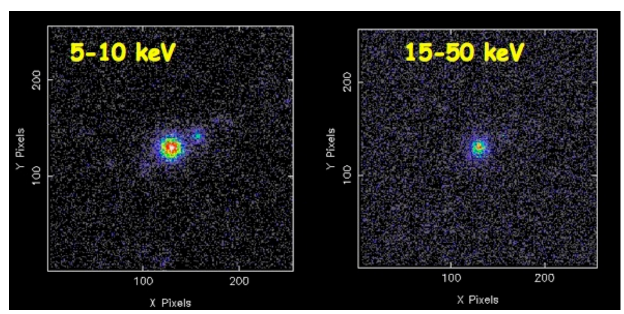
The ASDC NuSTAR archive will contain all the products present at the Caltech NuSTAR SOC, but additional analysis will be performed. In particular the NuSTAR data archive will be integrated into the ASDC Multi-Mission Interactive Archive (see Chapter 6) allowing the scientific community to perform on-line analysis and comparison of NuSTAR data with those of other missions. For this purpose a specific WEB interface to the NuSTAR archive will be developed.

2.7 ASDC X-ray event simulator

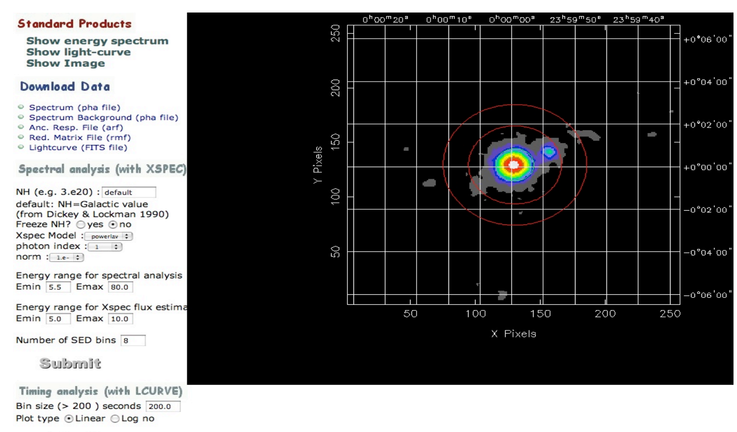
The ASI Science Data Center has developed a multi-mission X-ray event simulator, based on a fortran code, which includes some routines of the HEADAS package. The simulator was originally developed by P. Giommi and F. Fiore for BeppoSAX and extensively used for other missions like Swift and Simbol-X, and recently for NuSTAR. The code is not designed to support extreme calibration details as other ray-tracing simulators can do, calculating for each ray the path through the telescope optics. In spite of this, it guarantees a good accuracy in the X-ray event reconstruction using parametric calibration, it is very fast and it is extremely flexible. As matter of fact the simulator is easily adaptable to any new telescope by changing the a few parameters that describe the telescope performance like Instrumental Background, Response matrix, Vignetting, PSF, FOV, pixel size.
The web version of the ASDC NuSTAR Simulator is available at www.asdc.asi.it/simulator/nustar. This web page allows users to generate NuSTAR events files (level-2 FITS files) and carry out extensive imaging, timing and spectral analysis directly from the web browser.

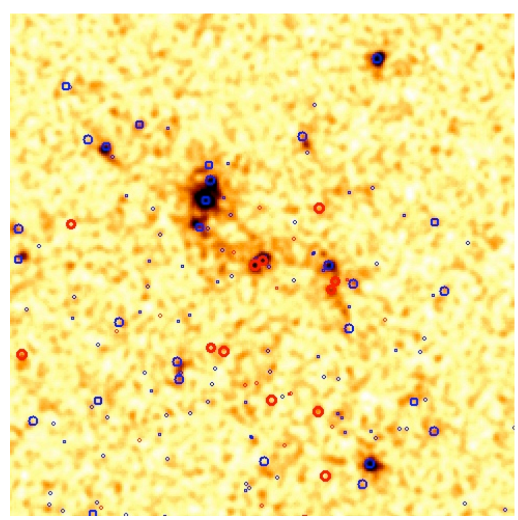


On-line Image processing: allows a quick analysis of features by comparing images in different energy ranges.



On-line spectral analysis: allows to extract the source and of background spectrum, source light curve and image.
The simulated spectrum files, light curve file and response file can be downloaded.

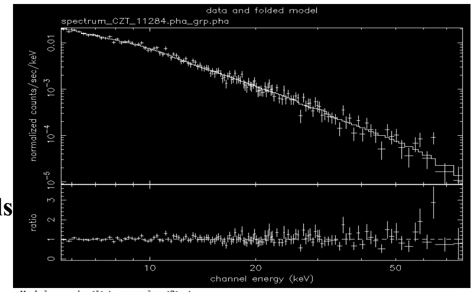




The blue circles are sources detected by Chandra in the 2-10 keV band (Luo et al. 2008). The large circles are sources with flux(10-30 keV) > 5X10^{-15} c.g.s.

The red circles are the candidate highly obscured AGN selected in the mid-infrared by Fiore et al. (2008). The large circles are sources with flux(10-30 keV) > 5X10^{-15} c.g.s..

On-line Analysis of the simulated spectrum file is also available (XSPEC supported spectral models




```
Model:  wabs<1>( powerlaw<2> )
Model Fit Model Component  Parameter  Unit     Value
par   par comp
  1    1    1   wabs       nH         10^22     3.280000E-02 frozen
  2    2    2   powerlaw   PhoIndex              1.75114     +/-  0.225991E-01
  3    3    2   powerlaw   norm                 4.795318E-04 +/-  0.339502E-04
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Chi-Squared =       134.3551     using   131 PHA bins.
Reduced chi-squared =      1.041512     for    129 degrees of freedom
Null hypothesis probability = 0.356

Model flux  7.7299E-05 photons ( 8.6705E-13 ergs)cm**-2 s**-1 (  5.000- 10.000)
```

2.8 Planck

Planck is an ESA cornerstone mission that was lifted off in a dual launch with Herschel in 2009.

Planck looks back at the dawn of time, close to the Big Bang, and observes the most ancient radiation in the Universe, known as the 'cosmic microwave background' (CMB). Planck analyses it for clues about how cluster of galaxies and even individual galaxies formed. This mission follows other similar NASA satellites (COBE and WMAP) but with more sensitivity and more resolution. In addition to the detection of CMB fluctuations Planck measures the microwave emission of many foreground sources like Blazars and Radio Galaxies.

To perform its tasks Planck carries a telescope with a 1.5-metre primary mirror that focuses the radiation from the sky onto the payload, two highly sensitive detectors called the Low Frequency Instrument and the High Frequency Instrument.

The Low Frequency Instrument (or LFI) is an array of 56 tuned radio receivers that is operated at –253°C. These receivers work grouped in four frequency channels, centred between 30 and 100 GHz. They are based on devices called 'HEMTs' (High Electron Mobility Transistors), and work just like transistor radios. The transistors amplify the signal collected by the antenna (the telescope), and the amplified signal is then converted to a voltage. In a normal radio, the detected signal would then be passed on to a speaker, but in Planck it is instead stored in a computer for later analysis.

The High Frequency Instrument (or HFI) is an array of 48 bolometric detectors, which works by converting radiation to heat. The amount of heat is then measured by a tiny electrical thermometer, the signal from which is converted to a temperature by a computer. The HFI detectors works in six frequency channels centred between 100 and 857 GHz. They are operated at –272.9°C (only one tenth of one degree above absolute zero). To achieve that temperature a complex system of on-board refrigerators is used, each of which uses a different technology to provide a successively colder temperature.

Some of the key questions Planck will answer are:

- Will the Universe continue its expansion forever, or will it collapse into a 'Big Crunch'?
- What is the age of the Universe?
- What is the nature of the so-called 'dark matter' (which may account for more than 90% of the total amount of matter in the Universe but that has never been detected directly)?

ASDC will host a copy of the scientific data when these will become available. Other activities are:

- Provide algorithms and software/hardware systems for the cleaning of the Planck data from foreground sources based on multi-wavelength data.
- Use of the Planck foreground sources data for multi-frequency scientific analysis analysis using data from other archive hosted by the ASDC, e.g. Fermi, Swift etc.

2.9 Herschel

Herschel Space Observatory was launched on the 14 May 2009 and represents the fourth `cornerstone' mission in the ESA Science Programme.
The Herschel telescope was designed to observe the Universe in the infrared spectrum region never observed before by previous facilities, at the wavelength range from 55 up to 671 μm. In this spectrum range the cosmos appears 'cool' and, at Galactic and Extragalactic scales, new features can be investigated. To reveal the infrared radiation the space telescope is equipped with three instruments (SPIRE, PACS and HIFI) cooled up to ~0.3 K, whose capabilities permit the acquisition of both photometric and spectroscopic data.
According to its potentiality the main Herschel scientific goals are the study of the composition of the Solar System objects (planets, comets and asteroids), the physics and chemistry of the interstellar medium and molecular clouds, and the formation and the evolution of early epoch galaxies. Herschel also provides important constrains on the mechanisms governing the late stages of the star evolution and on the gap between the local universe and the primordial galaxies.
The Herschel mission lifetime is expected to last about three years, owing to the fact that the superfluid helium stored in the cryostat is slowly evaporating. Before the mission will end, Herschel will be open new exciting scenarios for the comprehension of the Universe.

2. Science with Herschel

Thanks to the Herschel telescope new science investigations are available. According to the Herschel instrumental sensitivity, is possible to study the coldest regions of the Universe at different distance scales. One of the goals of the mission is to investigate the physics and chemistry of the Solar System objects (comets and asteroids) and, in the Galaxy, Herschel provides essential constrains on the star forming regions, on the interstellar medium and on the molecular clouds. The satellite also reveals the composition of the late evolutionary star phases, i.e. asymptotic giant branch and planetary nabulae. Moreover, it provides important information on the early universe (by resolving the far infrared cosmic background), on the evolving AGN-starburst symbiosis and on the galaxy evolution.

3.Technical capabilities of the on board instruments

With its 3.5 m primary mirror, Herschel is the largest space telescope ever launched up to date. The technical capabilities of Herschel permit to acquire both photometric and spectroscopic data in a spectrum region never explored before, in the wavelengths range from 55 to 671 μm.
On board of the space telescope three instruments are available and they are SPIRE (Spectral and Photometric Imaging Receiver), PACS (Photodetector Array Camera and Spectrometer) and HIFI (Heterodyne Instrument for the Far Infrared). More in detail, SPIRE and PACS are based on an imaging camera and a - low or medium - spectrometer while HIFI is an high resolution spectrometer based on the heterodyne tecnique. These detectors are cooled by the presence of a cryostat containing more than 2000 liters of superfluid Helium, which attains extremely low temperatures up to ~0.3 K. The evaporation of Helium is related to the cooling system operation and it affects the mission lifetime, which is expected to last about three years.

Following a brief description of the three instruments is listed:

- SPIRE comprises a three-band photometer, operating in spectral bands centered on 250, 350 and 500 µm, and an imaging Fourier-Transform Spectrometer (FTS) which provide low resolution spectra over the 195-670 µm band. The photometer and the spectrometer are not designed to operate simultaneously. SPIRE photometer operates in three different modes which differentiate in the observation of a point source, a small map and a large map. To observe point source or to make an image sampling the spectrometer has 24 observational modes with several different spectral resolution.

- PACS consists on two mutually exclusive sub-instruments, a bolometric camera planned to perform photometry in three spectral bands (70, 100 and 160 µm) and an integral field unit grating spectrometer operating over the spectral range from 57 to 210 µm. The photometer provides three observing modes each designed to observe a point source, a scan map, and to realize a scan map by using PACS and SPIRE in parallel mode. For the spectrometer two modes are available, i.e. the use of a single line and the scan in a spectral region.

- HIFI was designed to obtain spectra with very high resolution (up to R~107) in the far-infrared and sub-millimetre wavelengths. This detector is an heterodyne receiver which provides spectroscopy in two frequency ranges, from 480 to 1250 GHz (625-240 microns) and from 1410 to 1910 GHz (213-157 micron). HIFI operates in 11 different observing modes grouped in three main class, in order to observe a point source, to realize a map and to acquire a spectral scan map.

All data acquired by the Herschel telescope are automatically processed by the standard pipeline and stored in the Herschel Science Archive (HSA).

4. ASI Data Center (ASDC) Herschel Team activities

The Herschel mission short lifetime introduces a high competition level in the selection of observing programmes.

About 57% of the observing time was allocated before the mission start to execute the Key Programmes, while the remaining Open Time has been available for the worldwide scientific community through Announcement of Opportunity (AO). The first in-flight AO occurred in the summer 2010, while the second (and last) occurred in the summer 2011. In this context, the ASDC Herschel Team provided an individual support to the astronomers for the preparation of scientific observations and for the proposal submission.

To achieve a scientific goal, the ASDC Team studied the most suitable observing mode by using dedicated tools and software. In particular, to prepare and to submit a new proposal, Hspot (Herschel

Observation Planning Tool) tool is available, which permitted to design the observation requirements and to calculate the observing times. Likewise other two useful tools are HDC (Herschel Duplication Checker) and HROST (Herschel Reserved Observations Search Tool), which permit to search a duplication of an Astronomical Observation Request (AOR).

The ASDC provides tutorial to download and to handle data, by using the specific tools and the official interface HIPE (Herschel Interactive Processing Environment). This latter program is a manifold software coded in Jython (Java and Python) language, which enables to interact directly with the Herschel Science Archive (HSA) and to require the desired data. By using HIPE is possible to visualize data and to perform the data reduction and analysis, from the raw level up to the standard pipeline outputs. In this context, the ASDC Team also supports the scientific community in the data reduction through the numerous and useful HIPE tasks.

At the ASDC, dedicated modules for data reduction and specific tools for data analysis are constantly developed. Wide contributes are provided to the development and to the update of a Key Programme (Hi-GAL) pipeline. Useful tools will be released online to help the scientific community in the data processing. In this scenario, the Herschel Team develops and updates
web pages dedicated to several science online utilities.

An important goal of the Team is to provide an archive of the standard pipeline outputs on the ASDC web pages, and where it is possible, to archive optimized data obtained by using ASDC tools.

Further goals are to provide science driven catalogs, i.e. to release online databases grouped for astronomical objects and science interests. The Team aims also to match Herschel data with other infrared catalogs provided by several missions (AKARI, Spitzer, etc), in order to distribute the most complete photometric and spectroscopic data available in the infrared wavelengths. Finally, this work will be a part of the framework of the Multi-Mission Interactive Archive (MMIA) that contains all the data of the mission in which ASDC is involved.
The purpose is to distribute optimized final products in formats (FITS files or ASCII table) that can be easily used by the scientific community.

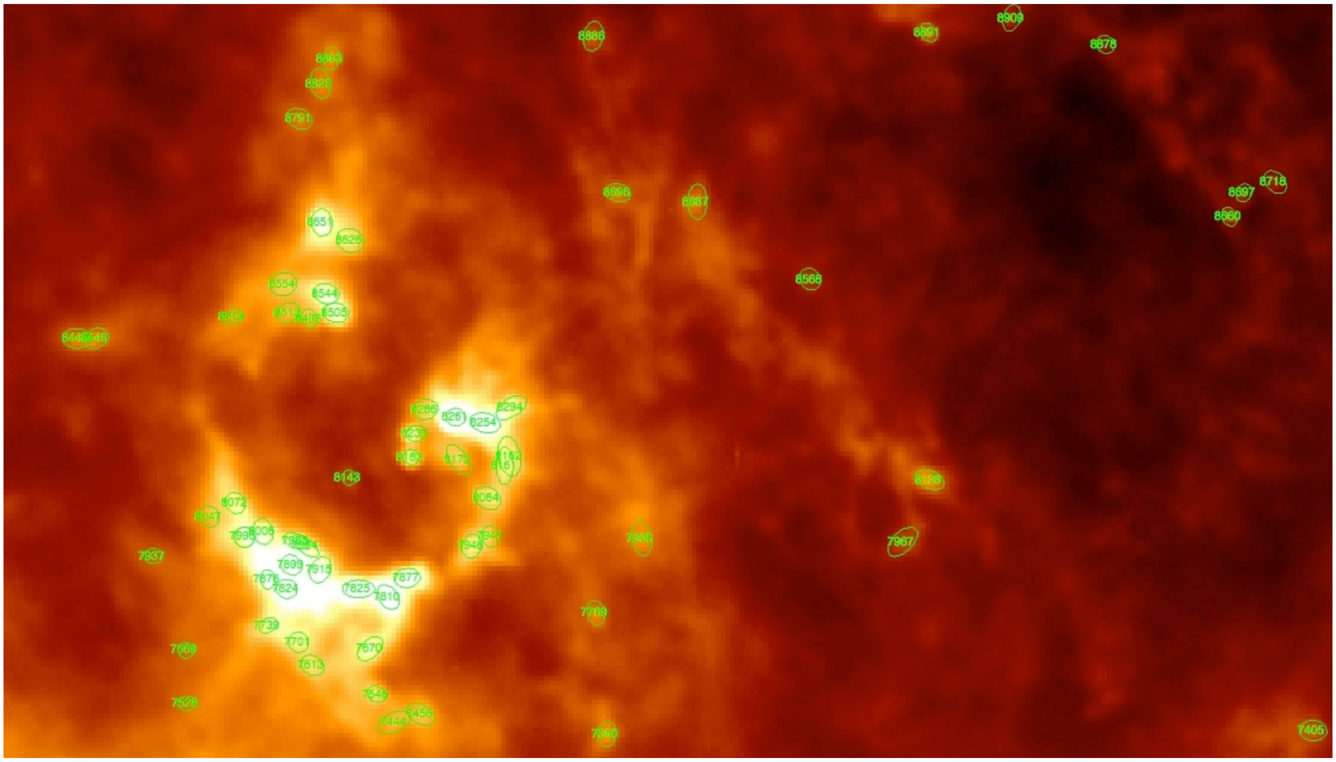


Figure: An example of the ASCD extended source detection tool. The green ellipses over a 500 micron SPIRE image of the Galactic Plane represent the source detections provided with the CuTEx algorithm (Molinari et al. 2011). This task is well suited to detect sources over sky images with high variable background. The tool will be soon available on line.

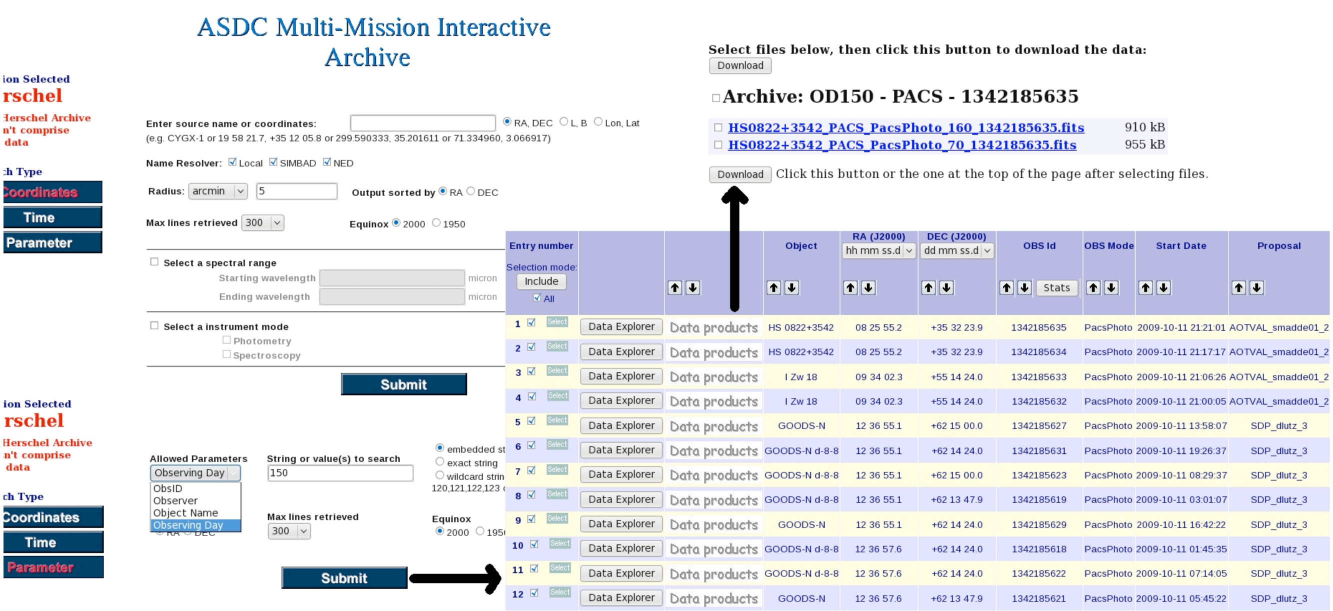
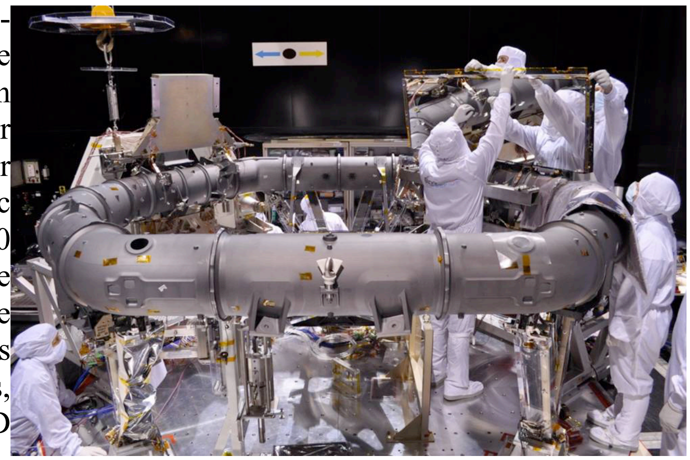


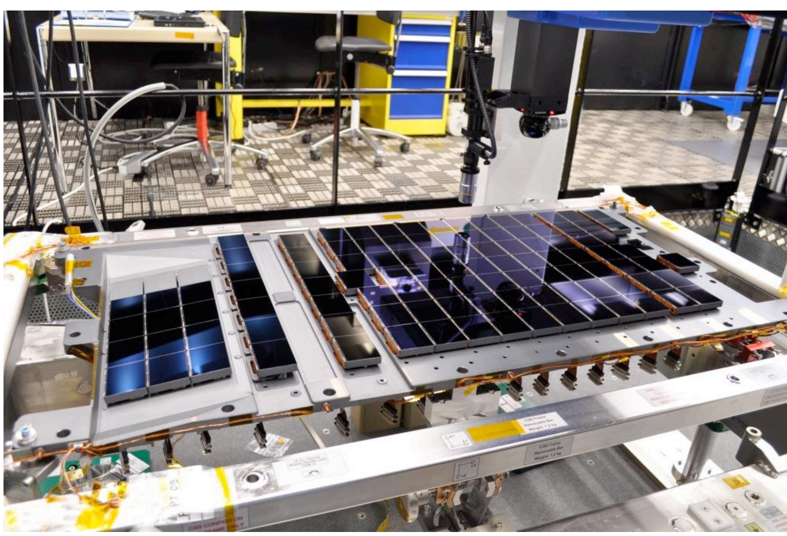
Figure: A screen shot of the web pages of the Multi-Mission Interactive Archive dedicated to the Herschel Mission. The users search for public data by defining either sky coordinates or the parameters that identify the observations (Observation Identifier, Observing Day, etc..).
The results are level 2 products provided in standard formats (FITS, ASCII), that can be directly used for scientific purposes.

2.10 GAIA

Gaia is the ESA satellite conceived to follow the path traced by Hipparcos.

Gaia will perform micro-arcsecond (μas) global astrometry for all ~1 billion stars down to G ≈ 20 mag - except for the ~6,000 brightest stars in the sky - by linking objects with both small and large angular separations in a network in which each object is connected to a large number of other objects in every direction. Over the five-year mission lifetime, a star transits the astrometric instrument on average ~70 times, leading to ~630 CCD transits. Gaia will not exclusively observe stars: *all* objects brighter than G ≈ 20 mag will be observed, including solar-system objects such as asteroids and Kuiper-belt objects, quasars, supernovae, multiple stars, etc. The Gaia CCD detectors feature a pixel size of 10 μm (59 milli-arcsecond) and the astrometric instrument has been designed to cope with object densities up to 750,000 stars per square degree. In denser areas, only the brightest stars are observed and the completeness limit will be brighter than 20th magnitude.





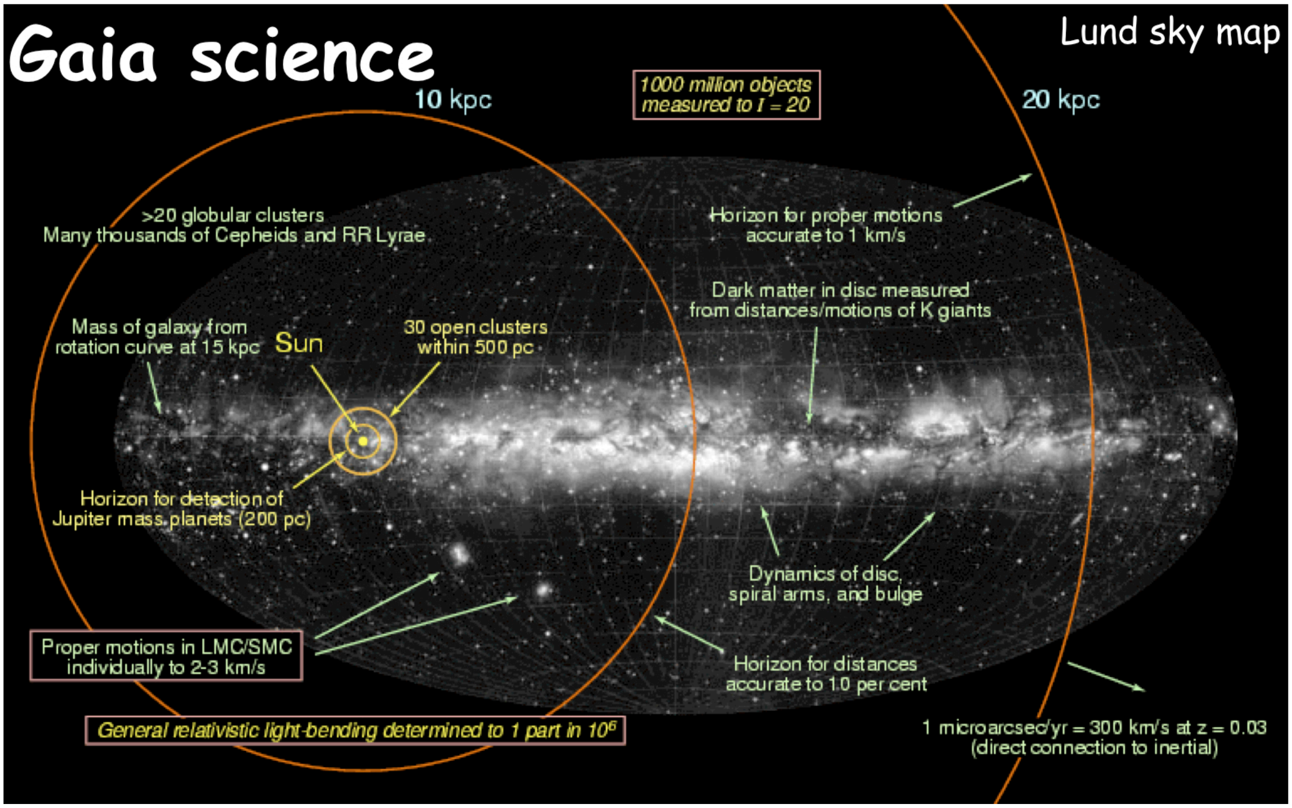
Gaia's photometry comprises:

- broad-band white-light G-band fluxes obtained in the astrometric instrument, and
- low-resolution spectro-photometry obtained in the Blue and Red Photometers (BP and RP).

The wavelength coverage of the astrometric instrument, defining the white-light G band, is ~330-1050 nm. The spectral dispersion of the photometric instrument is a function of wavelength and varies in BP from ~3 to ~27 nm pixel-1 covering the wavelength range ~330-680 nm. In RP, the wavelength range is ~640-1050 nm with a spectral dispersion of ~7 to ~15 nm pixel-1. Over the five-year mission lifetime, a star transits the photometric instrument on average ~70 times, leading to ~70 transits in both BP and RP.

Photometric observations will be collected with the photometric instrument, at the same angular resolution as the astrometric observations and for all objects observed astrometrically, to:

- enable chromatic corrections of the astrometric observations, and
- provide astrophysical information for all objects, including astrophysical classification (for instance object type such as star, quasar, etc.) and astrophysical characterization (for instance interstellar reddenings and effective temperatures for stars, photometric redshifts for quasars, etc.).



Gaia's spectroscopic instrument, the Radial-Velocity Spectrometer (RVS), is an integral-field spectrograph with resolving power ~11,500 covering the wavelength range 847-874 nm. Over the five-year mission lifetime, a star transits the spectroscopic instrument on average ~40 times, leading to ~120 CCD transits.

Spectroscopic observations will be collected with the spectroscopic instrument for all objects down to GRVS ≈ 16 mag, to:

- provide radial velocities through Doppler-shift measurements using cross-correlation (~150 million stars);
- provide astrophysical information, such as interstellar reddening, atmospheric parameters, and rotational velocities, for stars brighter than GRVS ≈ 12 mag (~5 million stars); and
- provide element abundances for stars brighter than GRVS ≈ 11 mag (~2 million stars).

The spectroscopic instrument has been designed to cope with object densities up to 36,000 stars per square degree. In denser areas, only the brightest stars are observed and the completeness limit will be brighter than 16th magnitude.

Gaia's archive will thus contain astrometric, photometric, spectroscopic data for ~1 billion objects, not only stars, but also 107 galaxies, 105 quasars, 105 supernovae, 106 asteroids e 50,000 extrasolar planetary systems.

The satellite's launch is planned for june 2013, the first data release is foreseen by 2015, while the final catalogue release would be available to the scientific community by 2020-2021.

Gaia activities in ASDC

Gaia activities in ASDC are integrated within the italian participation to the Gaia mission, given the mission is of strategic interest for the italian astrophysical community.

Gaia activities in ASDC are on one side a response to institutional duties to DPAC and on the other side in support to the italian scientific community.

GAP/CU9 Gaia Archive Access

The Gaia Data Processing and Analysis Consortium (DPAC) is a consortium of more than 400 european scientists and software engineers organized to perform the satellite data reduction and analysis. As specified in the DPAC Proposal, the consortium is organized in 9 Coordination Units, each responsible for a specific part of the data reduction and analysis. Following is the list of DPAC CUs:

- CU1: System Architecture
- CU2: Data Simulations
- CU3: Core Processing
- CU4: Object Processing
- CU5: Photometric Processing
- CU6: Spectroscopic Processing
- CU7: Variability Processing
- CU8: Astrophysical Parameters
- CU9: Catalogue Access (to be activated in 2012)

The activities related to the Gaia archive implementation and archive access were excluded from the ESA AO concerning the Data Processing, with the agreement that a specific AO for Catalogue Access (CU9) activities would be issued later.

The Gaia Archive Preparation Working Group (GAP) was organized to define the DPAC approach to the Gaia Archive definition and access. The GAP group should work until the CU9 activation through the ESA AO.

In April 2011, ASDC coordinated an italian response (involving several INAF institutes, Naples University and Tor Vergata University) to the ESA AO for the GAP group. Since then we started our GAP related activities in collaboration with both the italian and the international GAP groups.

The ESA AO for CU9 is foreseen by june 2012. We would then coordinate the participation of our italian GAP group to the response to the AO, in order to be involved in the CU9 activities.

The final goal of our GAP/CU9 activities is to contribute to the definition and implementation of the Gaia archive and to collaborate to the implementation of the tools needed to access the archive.
This activities are of strategic importance because, as the Gaia Archive will be released to the international community without any proprietary phase, the italian community would acquire an advantage for the scientific exploitation of the data through the participation to the Gaia archive preparation activities.

GAP/CU9 Activities:

I. Interrogation system:
   A) Archive system:
      - Physical and logical design
      - Indexing and searchability
      - Development of typical queries (interactive and batch)

per source, spatial, temporal, variability, kinematic, per source type, involving a combination of the quantities derived by Gaia (e.g. magnitudes, parallaxes, proper motions), combinations of the above

   B) VO interface

II. Advanced applications:

Development of:

   A) Visualization tools in the parameter space (parameter=astrophysical quantities derived by Gaia), Hyperdimensional visualization
   B) Cross-match facility with external catalogues (multi□wavelength)
   C) Data mining and scientific analysis tools:
      - clustering analysis
      - classification
      - outlier/anomaly searches
      - regression
      - association rule learning
      - dimension reduction (principal component analysis, non□negative matrix)

III. Documentation:
   A) Contribute to the detailed explanation of all quantities provided in the archive
   B) Preparation of statistical plots, histograms and error maps derived from the archive

content.

Gaia ancillary data:
ASDC collaborates with the italian Gaia community and the DPAC group GBOG to host part of the Gaia ancillary data, in particular the photometric and spectroscopic data useful for Gaia calibration and classification.

Gaia Pipeline Development:
A non negligible fraction (~10%) of source transits will be crowded in the BP/RP channels. In principle, the high spatial resolution (58.933 mas along scan and 176.798 mas across scan) should guarantee a low crowding even at high source densities, however the along scan dispersion significantly increases the overlapping of the fluxes. Due to telemetry limitations, full CCDs will never be read and sent to the ground: only small areas (windows) around detected objects will be fed to the data processing pipeline. It is extremely important to know which objects are crowded (i.e. nearby objects contribute to the flux within an object assigned window), both for calibration issues and to correctly disentangle the fluxes of different sources.
ASDC is working within CU5 to the crowding evaluation, decontamination and deblending of BP/RP low resolution spectra.

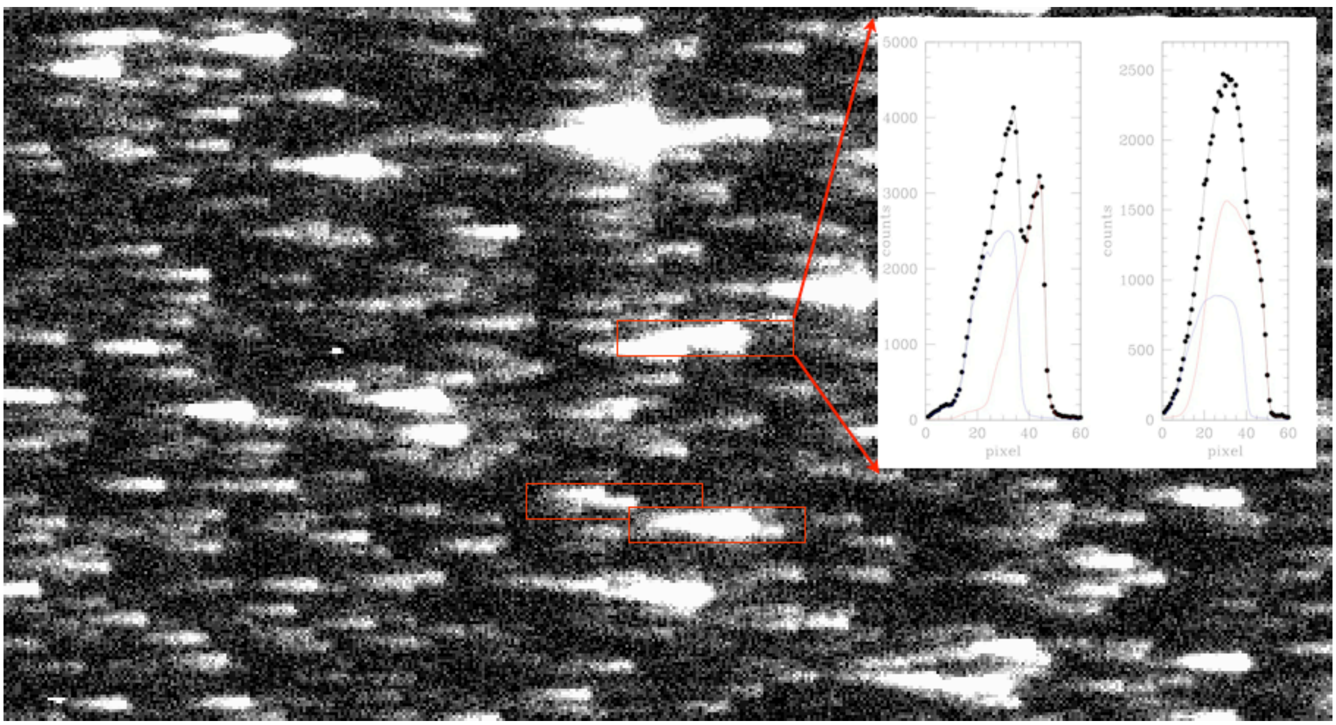


Figure: simulated Bp field in a crowded region. Gaia will collect the sources with magnitude 6 < G < 20 in 60 × 12 pixel (Along Scan × Across Scan) windows. Sources will be transmitted to the ground with these samplings:
1 × 1(AL × AC) pixel for G= 6 ÷ 13 stars
1 × 12(AL × AC) pixel for G=13 ÷ 20 stars.
Meaning that data will be sent mostly in 1d windows.
Bp and Rp spectra for two crowded sources are visible to the right, together with the fit obtained using our software.

2.11 CTA

The present generation of Imaging Atmospheric Cherenkov Telescopes (IACTs) like the MAGIC, HESS and VERITAS experiments, increased the number of known TeV sources of a factor ~10 in the last 8 years. This implies that ground-based very high energy (VHE) astronomy is entering in a "golden age" characterized by both the maturity of the technical instruments and a large scientific breakthrough in many sectors of the astrophysical research. The Cherenkov Telescope Array (CTA) will be a new worldwide facility for VHE astronomy which will consist in two arrays (one for each hemisphere) of about 100 telescopes for the investigation of the sky in the 10 GeV – 100 TeV energy range. CTA will improve the present experiments sensitivity by a factor ~10, allowing significant extension of our current knowledge in high-energy astrophysics. The CTA scientific case is focused in the non-thermal component of our Universe including both galactic (Pulsar physics, Supernova Remnant, X-rays binary and microquasar) and extragalactic (Blazars, EBL models, GRB and Galaxy Clusters) studies. At the same time, more exotic tasks related to particles and fundamental physics (CR physics, Dark matter search, Quantum Gravity effect) will be investigated using CTA capabilities. CTA has been included in the European roadmap of very important scientific infrastructures by ESFRI and it has also been considered among the most important projects by both the ASPERA and ASTRONET Consortia.

ASDC IN CTA

For the first time in VHE astronomy, CTA will be operated as an open, proposal-driven observatory. This implies that a large amount of data will be published, accessible and available for analysis to the entire astrophysical community. To this end, new data archive and dedicated set of analysis software should be developed in the next years. In this context, ASDC expertise can be successfully used in the Cherenkov astronomy field in order to provide both new facilities for high-level data archive and tools for analysis, maximizing the scientific return of this kind of data . In more detail, the activities which are currently performed at the ASDC can be summarized as follows:

- The already existent GeV and TeV data from the present experiments (like HESS, MAGIC and VERITAS) are used in order to build a prototype of the future CTA VHE catalog for high-level scientific data. This catalog can be accessible via the standard ASDC web interface and cross-correlated with the other archives in ASDC using browse. This will improve and make easier the multiwavelenght approach and the integration with satellite observations of both the already existent and future TeV data.

- The existent ASDC tools like the Error Circle Explorer (ECE), the SED-builder tool are being modified in order to accept the GeV and TeV data and for the identifiction of the future CTA discovery. In particular, the existent TeV data have been used in the SED-builder facility in order to prove the capability of this kind of tool in the scientific interpretation of the available data (complete description of the emission in the VHE regime)

- Support to the software development and the web interface needed for the distribution of the future CTA data within the ASDC Multi-Mission Interactive Archive

- Support to the definition of a standard FITS format for TeV data which are produced, until now, only in ROOT format and publishing those data compliant to the Virtual Observatory (VO) standards.

Since the CTA activities are strictly linked to the progresses and the evolution of the whole project (still in a preparatory phase), more activities at ASDC are scheduled and planned in the next future. Basically, these activities will concern technical support to the national and international community involved in CTA in archiving and analyzing high-level data. They can be listed as:

- Participation to the first CTA data challenge (CTA-DC1) in 2012. This will provide a first publication of high-level simulated data for the CTA array.

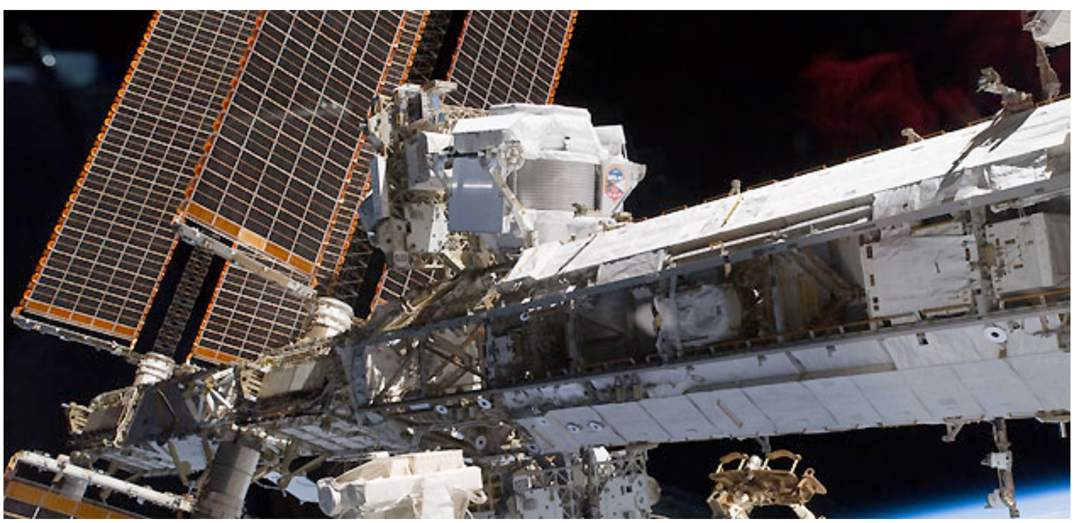
- Production of the complete data archive for the Small Size Telescope prototype which will be built by the INAF group involved in CTA within the ASTRI project.

- Organization of the CTA general meeting in Rome in 2012.

2.12 AMS-02. The Alpha Magnetic Spectrometer Experiment

AMS-02 is a large acceptance magnetic spectrometer conceived to perform precise measurements of the composition and the energy spectrum of the cosmic radiation in space in the GeV-TeV energy range. The experiment has been successfully installed on board the International Space Station on May 19th, and is steadily taking data in low earth orbit since then, gathering ≈1010 events per year.
The scientific objectives of the AMS-02 experiment are :

- the search of primordial anti-matter, i.e. anti-nuclei, as clue for a deeper understanding of the baryogenesis;
- the search of dark matter through the measurement of its annihilation products, i.e. light anti-matter (positrons, antiprotons, deuterons) and high energy photons;
- the study of the composition and energy spectrum of the cosmic radiation in the GeV-TeV energy range for a deeper understanding of its origin, acceleration and propagation in the galaxy;



The Italian collaboration, jointly supported by INFN and ASI, has been respon- sible for the design, construction and integration of five out the six AMS sub-detector systems: the Silicon Tracker, the Star Tracker, the Time of Flight, the Ring Imaging Cherenkov, the Electron Calorimeter, and has contributed to the electronics of the TRD gas system. The operation and calibration of the sub-detectors is the key milestone towards the physics analysis and is currently on-going under the Italian collaboration responsibility.
The raw data collected by AMS is transferred in real time from the MSCF NASA center to CERN, where the AMS Payload Operation Control Center (POCC) and the AMS Science Operation Center (SOC) are located. In the SOC, the raw data are first processed to generate the reconstructed data stream (STD stream) to be analyzed for detector calibration. As the calibrations are released, the second processing is performed to generate the calibrated data stream for analysis (PASS2 streams).

Dedicated PASS2 streams to select reduced samples of data suitable to specific analyses are generated as well, with a size of 10-20% of the full sample.
A master copy of the whole raw data set (35 TB/year) and STD stream (130 TB/year) are transferred in nearly real time to CNAF, the INFN National Center for Research and Development into the field of Information Technologies, as security copy of the data and for privileged access point to data for the Italian collaboration. CPU resources for Monte Carlo production (≈20% of the AMS data set) and data analysis (calibration) are also allocated in CNAF in the AMS funding by the INFN Scientific Committee for Astro-Particles (CSN2).
The AMS-ASDC team is fully integrated in the AMS-02 operation and data analysis activities of the Italian and International Collaboration, with the goal of developing an analysis data center focused on the study of the CR electromagnetic components (electrons and gammas) and low energy particles sensitive to solar modulation and magnetospheric effects.
A computing farm, adequate to store the electromagnetic and low energy PASS2 streams is being setup and will allow on-site data analysis and dedicated MonteCarlo productions, as the AMS commissioning data phase will be terminated.
Regular contacts with the international Collaboration, involving the participation of the AMS-ASDC team in the AMS-02 operation and control as well as in the analysis Collaboration meetings, insure the coordination of the ASDC data center activities within the Collaboration.
The competences of other scientific teams and databases at the ASDC will be then synergic to a full exploitation of the AMS physical potential and the dissemination in a wider community of the AMS results.

Current activities of the AMS/ASDC team are:

- data taking operation of the AMS02 Tracker following the share of the Italian Collaboration (25%) and report to the daily run coordination meetings in the AMS POCC.

- silicon tracker alignment: two independent tracker alignment teams are evaluating the alignment of the 9 layers of silicon microstrip detectors of the tracker and its stability in time with different techniques. Development of alignment test criteria is carried specifically in ASDC, with monthly reports in the Collaboration.

- electron/proton separation: the electron/positron components are identified in AMS by the combined measurements performed in the TRD, ECAL and Tracker. Definition of the best selection criteria in the ECAL and TRD versus the on-flight performance of the detectors are being studied within the Collaboration and specifically in ASDC.

- low energy particles: the selection of a reduced stream of components with energies under the geomagnetic cutoff is under study in synergy with the SISMI project

2.13 Seismic activity/particle correlation

The main purposes of this activity are:
- to study the seismic induced disturbances on the charged particles trapped in the geomagnetic field;
- to contribute to the understanding of the mechanism generating those disturbances.

Tentative observations of ionosphere disturbances which are associated to high intensity earthquakes were reported in the past. Seismic events have been shown to be able to cause seismo-electromagnetic emissions (SEM) consisting of broad band (from DC to a few tens of MHz) electromagnetic (EM) waves, via many mechanisms.
LEO satellite observations have provided information of ionospheric and magnetosphere perturbations possibly caused by pre-seismic EM-waves and capable of inducing the so-called “radiation belt particle precipitations” and many other disturbances to the ionosphere components. Specifically, these “precipitations” are observed as anomalous particle fluxes detected by space detectors, e.g. as a short-term and sharp increase in high energy particle counting rates. This phenomenon is also referred to as “particle burst”. Past studies which have been done with russian or US satellites, provided limited statistical evidence of correlation between the seismic events and the particle bursts: scope of this analysis is to enlarge the database of satellite data which could be studied, including data from x-ray and gamma-ray satellites as well as low energy particle data of the AMS-02 detector on the ISS.

The current activities at ASDC are the following:
- characterization of the X and gamma-ray satellite data, which are hosted at the data center, and evaluation of their relevance for the “particle bursts” detection and the correlation study with the seismic events;
- reduction and analysis of the relevant data (ongoing);
- development of new analysis methods and tools, on the base of the recent advances of the studies in this field and the availability of new data;
- contribution to the preparation of new missions, providing data to the Italian and the international community involved in these studies.

2.14 Research Activities at the ASDC.

It is widely recognized that, to ensure a professional service and to guarantee data integrity, it is mandatory that the scientific staff of a data center be actively involved in scientific research related to the data hosted at the center.

The scientists working for the ASDC are therefore expected to spend a significant fraction of their time in research activities both of their own or in collaboration with colleagues from other institutions.

The scientific staff of the ASDC is currently involved in several research activities, especially in the field of surveys of high energy cosmic sources, in Blazar research, GRB studies, Galactic transients, etc. In addition, the ASDC periodically organizes International scientific workshops and local meetings on a variety of research topics in archival research.

ASDC staff was awarded three times the Rossi Prize of the High-energy division of the American Astronomical Society, in 1998 as part of the BeppoSAX team, in 2007 as part of the Swift team, and in 2011 as part of the Fermi team.

2.15 ASDC Collaborations with Scientific Institutes

2.15.1 Italian institutions

One of the important activities of the ASDC is the establishment of stable collaborations with Italian scientific institutions. This ensures an effective utilization of the vast expertise in data analysis and data management that has been accumulating over the past years in Italy.

These collaborations will minimize duplications and will be essential for reaching that critical minimum size and level of competence that is necessary for Italy to be competitive and influential in this rapidly evolving field.

2.15.2 International institutions

It is important that the ASDC is actively involved in collaborative efforts with the major international data centers.
Currently the ASDC has a long-standing and very fruitful collaboration with the NASA/HEASARC for the development, exchange and distribution of software for the analysis of astronomical X-ray data. Frequent contacts are also kept with several other major data centers, including the Chandra Science Center, ESA-ESTEC, the XMM-Newton Survey Scientist Centre, the Space Telescope Science Institute etc.

2.16 Education and public outreach

The advent in the 1990's of new telecommunication computer technology (Internet and the WWW) combined with the recent developments in data standardization, management and analysis is providing an unprecedented opportunity to expose complex scientific space data to students and more in general to any interested person.

The ASDC is a particularly appropriate infrastructure to take advantage of such an opportunity. This is achieved through dedicated web pages (in collaboration with other data centers, scientific institutes and PR) and direct access to dedicated hardware and educational material.

ASDC Public Outreach foresees a newsletter which has the purpose to provide users with practical information about our activities and services, including multi-mission data access and associated analysis and visualization tools.
The ASDC's main task is to support astronomy space missions with strong ASI involvement like Swift, AGILE, Fermi, Herschel, Planck, NuSTAR and Gaia.
Our purpose is to explain this hard and special work to the public.
The ASDC Outreach, sometimes in collaboration with major Italian research Institutes aims to let the young public to discover the value of scientific research, with exhibition and some Scientific Cafè that try to explain high energy phenomena of the universe and the recent discoveries of these satellites.
During the year ASDC, in collaboration with ESA-Esrin and IFSI-INAF, hosts people for tours in its headquarters.

3 ASDC Staff

The ASDC human resources include a mixture of ASI staff, who manage the Center, of scientific personnel provided by the Istituto Nazionale di Astrofisica (INAF), Istituto Nazionale di Fisica Nucleare (INFN) and of technically qualified industrial staff. The exact team organization depends on the number of projects supported, on the project phase, and on the collaborations that the ASDC has with other institutions.

The ASDC staff composition as of December 20011 is as follows:

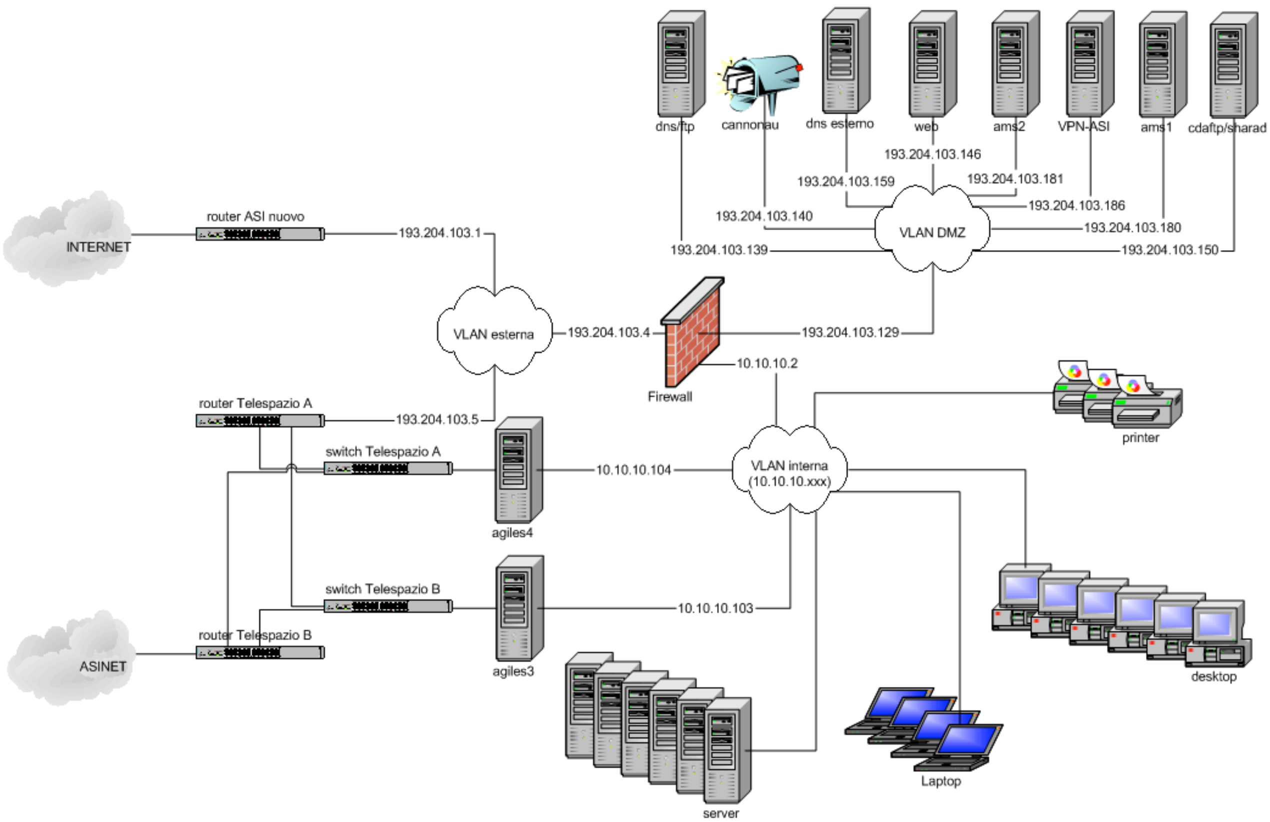
ASDC Management	
Paolo Giommi (ASI)	Director
Elisabetta Cavazzuti (ASI)	Project Coordinator
Massimo Ricci (ASI)	System Manager
Maria Rosaria D'Antonio (ASI)	Public Outreach ASI
Angelo Antonelli (INAF)	INAF Project Scientist
Bruna Bertucci (INFN)	INFN Project Scientist
Secretary and Data Assistants	
Cristina Leto (INAF)	
Maria Elena Pennisi (INAF)	
Multi-frequency and VO Team	
Milvia Capalbi (INAF)	Coordinator
Bruce Gendre (INAF)	
Giulia Stratta (INAF)	
Cristina Leto (INAF)	
Swift Team	
Matteo Perri (INAF)	Coordinator
Milvia Capalbi (INAF)	
Valerio D'Elia (INAF)	
AGILE Team	
Carlotta Pittori (INAF)	Coordinator
Fabrizio Lucarelli (INAF)	

Patrizia Santolamazza (CIFS)	
Edoardo Striani (INAF)	
Francesco Verrecchia (CIFS)	
Fermi Team	
Stefano Ciprini (INAF)	Coordinator
Elisabetta Cavazzuti (ASI)	
Sara Cutini (INAF)	
Dario Gasparrini (INAF)	
Herschel Team	
Luca Calzoletti (INAF)	Coordinator
Alessandra Di Cecco (INAF)	
Fabiana Faustini (INAF)	
GAIA Team	
Giuliano Giuffrida (INAF)	
Paola Maria Marrese (INAF)	
Planck Team	
Gianluca Polenta (INAF)	
NuSTAR Team	
Matteo Perri (INAF)	
Simonetta Puccetti (CIFS)	
CTA Team	
Alessandro Carosi (INAF)	
AMS Team	
Francesco Nozzoli (INFN)	
Cecilia Pizzolotto (INFN)	
Seismic activity/particle correlation	
Vincenzo Vitale (INFN)	
Engineering Team	

Giuseppe Avellino (TELESPAZIO)	software developer
Paolo D'Angeli (TELESPAZIO)	software developer
Giorgio Fanari (TELESPAZIO)	software developer
Antonio Guerra (TELESPAZIO)	software developer
Arturo Montieri (TELESPAZIO)	software developer
Roberto Primavera (TELESPAZIO)	senior analyst
Antonella Raia (TELESPAZIO)	software developer
Nino Spagnuolo (TELESPAZIO)	software developer
Sandra Stellato (TELESPAZIO)	senior analyst
Part time Senior Scientist	
Roberto Buonanno (Univ. Tor Vergata)	senior scientist (Gaia and PLATO Missions)
Marco Castellani (INAF-OAR)	senior scientist (PLATO Mission)
Paola Grandi (INAF-IASFBO)	senior scientist (High Energy Astrophysics Missions)
Paolo Natoli (Univ. Tor Vergata)	senior scientist (Planck Mission)
Maurizio Paolillo (Univ. Federico II, Napoli)	senior scientist (X-ray variability in AGNs)

4 ASDC Hardware infrastructure

The current ASDC Hardware infrastructure is shown below.



Text still to be translated from the Italian version of the document.