DARTS: JAXA's Multi-disciplinary Space Science Data Archives

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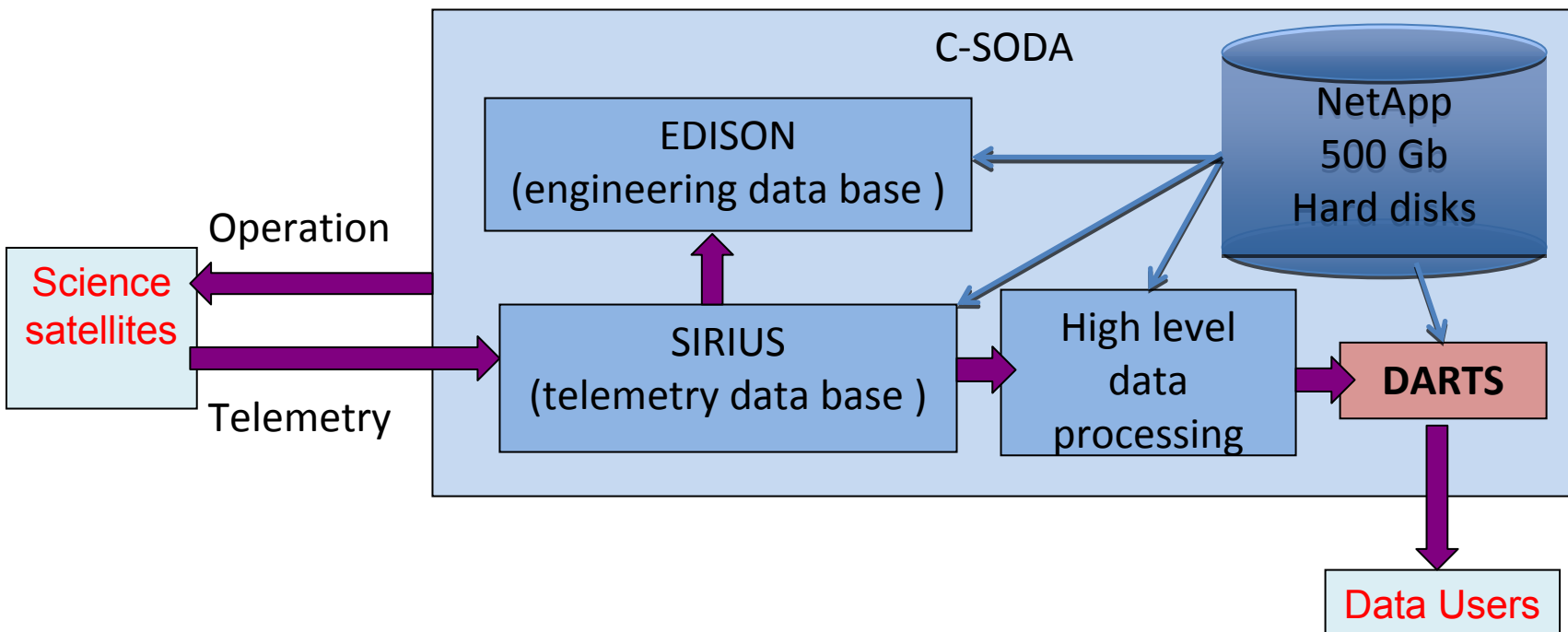Introduction to DARTS

JAXA, ISAS and DARTS

- **JAXA** (Japan Aerospace eXploration Agency)
  - Japan's only public organization for space developments
  - Launch rockets and satellites!
- **ISAS** (Institute of Space and Astronautical Science)
  - A part of JAXA, and a research institute for Space Science.
- **C-SODA** (Center for Science-satellite Operation and Data Archive)
  - Belongs to ISAS. Carry out science-satellite operation, data processing and develop data archives
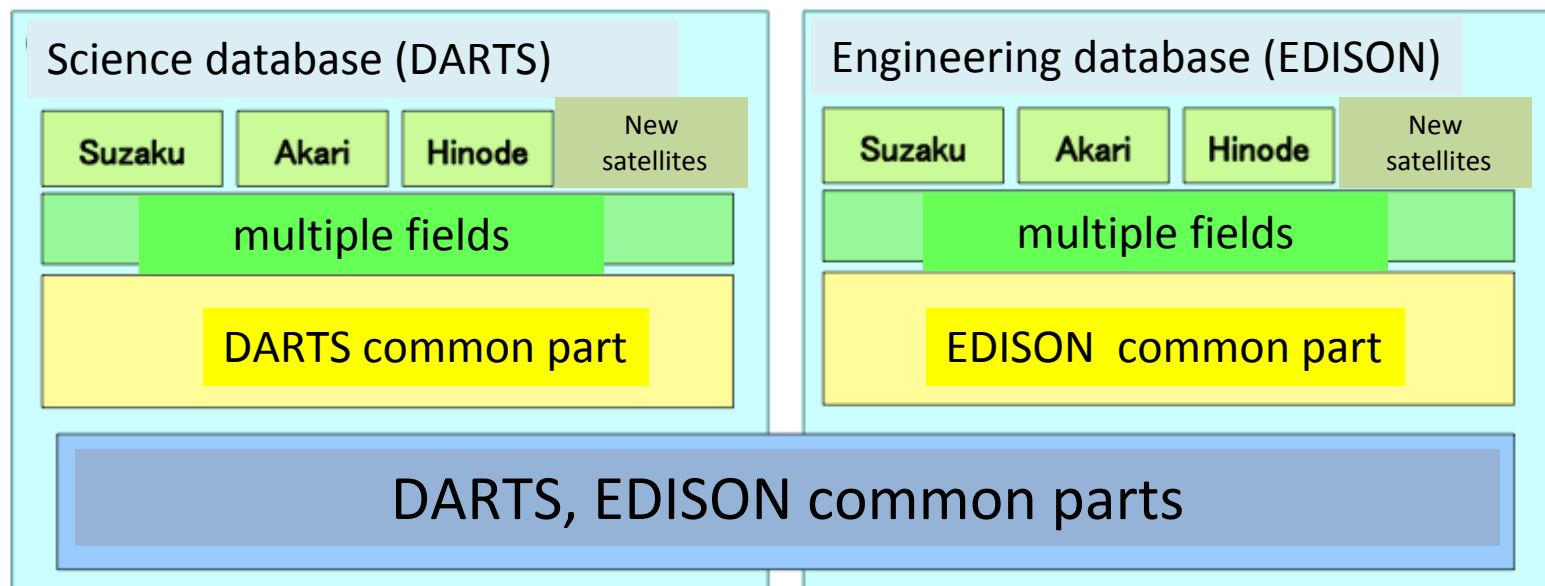 - We develop **DARTS**, JAXA's sole space-science data archives

JAXA	ISAS	C-SODA	JSPEC	EORC
	Space Science	Operation and Data archive	Space Exploration	Earth observation

Introdu

JAXA, ISAS and DARTS

- DARTS (Data Archives and Transmission System; http://darts.jaxa.jp)

- JAXA's sole space science data archives
  - Mostly archive ISAS satellite data, but also JSPEC data
  - In principle, public science data archives
    - Open to anybody via internet, free of charge

- Multi-disciplinary, multi-wavelength data archives
  - Visit "DARTS of the Month"!
    - http://darts.jaxa.jp/month
  - DARTS introduction movie:
    - http://darts.jaxa.jp/month/200708/200708.html

C-SODA and DARTS

- **C-SODA develops and operates ground systems for all the science satellites in "end2end"**
- **From the satellite telemetry to data users**

Introduction to DARTS

Development of DARTS

Science database (DARTS)	Engineering database (EDISON)
Suzaku · Akari · Hinode · New satellites	Suzaku · Akari · Hinode · New satellites
multiple fields	multiple fields
DARTS common part	EDISON common part

DARTS, EDISON common parts

Only ~15 team members in DARTS development
~10 FTE equivalent developers
Adopt common framework
Share common hardware/software as much as possible
Develop various databases efficiently with limited resources

JAXA`s Space Science Data

- Astronomy satellites
  - X-rays：Hakucho、Tenma、Ginga、ASCA、**Suzaku**
  - Radio：HALCA
  - Infra-red：SFU、**Akari**
- STP (Solar-Terrestrial Physics) satellites
  - Jikiken、Kyokkou、Oozora、**Akebono**、**Geotail**、**Reimei**
- Solar satellites
  - Hinotori、Yohko、**Hinode**
- Lunar and Planetary missions
  - Suisei、Nozomi、**Hayabusa**、Kaguya

Blue satellite data are archived at DARTS(http://darts.jaxa.jp)
Blue with underlines are currently operational
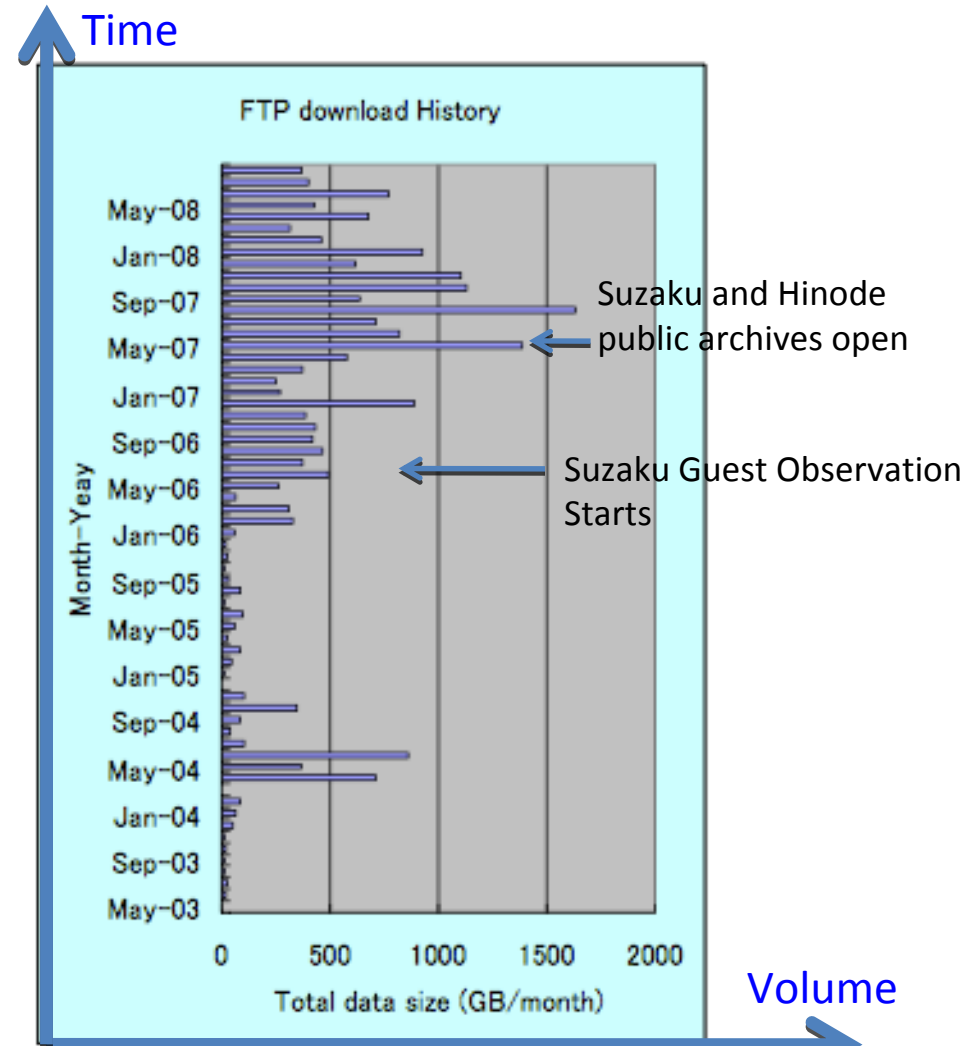Orange：data are currently outside of DARTS

DARTS services

- **Provides high level (calibrated) data to users**
  - ftp, http protocol
- **Data query service**
- **Quick look, simple analysis service**
- **Provides some data analysis software**
  - We do not have resources for serious software development
  - Analysis software is dependent on the fields
    - For example, X-ray data analysis software provided from NASA/GSFC

Data usage of DARTS

DARTS FTP Server Statistics

Month	directory /		directory /pub/suzaku	
2009	Count	Size(GB)	Count	Size(GB)
Jan	13701	345.912	7790	65.605
2008	Count	Size(GB)	Count	Size(GB)
Dec	45508	1164.349	14051	267.375
Nov	421268	1692.924	107078	925.054
Oct	205237	1515.121	47524	477.849
Sep	99634	584.964	30996	273.602
Aug	130994	367.491	9718	96.343
Jul	73310	398.223	11270	153.039
Jun	138446	769.767	28067	354.695
May	55574	426.249	23970	237.450
Apr	70423	674.850	41481	514.657
Mar	166955	317.813	21839	126.335
Feb	70415	457.868	15100	149.815
Jan	411364	929.483	23257	179.194

- More than several hundreds of Gbytes data downloaded per month

Time

FTP download History

Suzaku and Hinode public archives open

Suzaku Guest Observation Starts

Volume

Example of high level data processing of X-ray data

- Each X-ray photon ("event") corresponds to a single line in the Event Table (binary table FITS)
  - Different satellites share similar FITS formats
  - Generic software can be used to analyze multiple satellite data
- Each column of the Event Table corresponds to physical values
  - Photon arrival time, direction, X-ray energy, etc
- DARTS provides "ready to eat" X-ray astronomy data to users (ASCA, Suzaku)
  - Common practice in X-ray astronomy data centers (Chandra, XMM-Newton etc)
- Users download calibrated X-ray event data, make own selections, create histograms:
  - X,Y 2D histogram → X-ray image
  - Time histogram → Light Curve
  - Energy histogram→ Energy Spectrum

System Engineering

In DARTS, we have high-level data products
Not "raw" data, but cooked and "Ready to eat"

Science by DARTS users

Introduction to DARTS

SODA
ISAS/JAXA

DARTS

▶ **DARTS of the Month**

New Findings in the 20th Year — Discovery of X-Ray Transients from the Ginga Archives

Today, we know that there are many X-ray objects in the universe, some of which vary their luminosities significantly. In fact, there are sources which are bright and observable only during short periods of time. Archival data records of such X-ray transients, when and where the X-ray sources appeared at which brightness, are extremely important. Also, when new sources are discovered, we can go back to the old data to investigate for their past activities, as long as the data are archived.

The Ginga satellite, launched in February 1987, observed many parts of the sky and discovered dozens of new X-ray sources, while all the data have not been fully

PASJ: Publ. Astron. Soc. Japan **59**, 1141–1151

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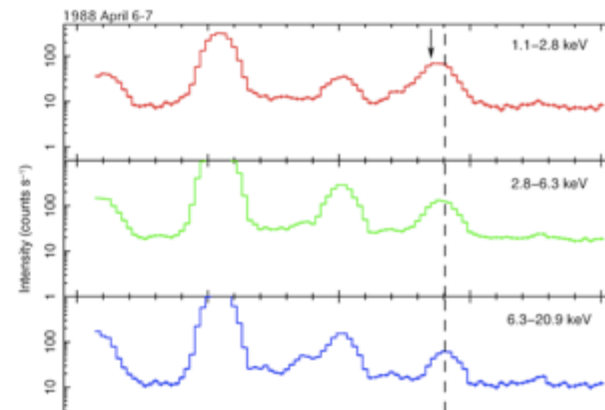
Discovery from 20 year old data！

Near the Galactic Center Found in Archival ▓▓▓▓ Data from ▓▓▓

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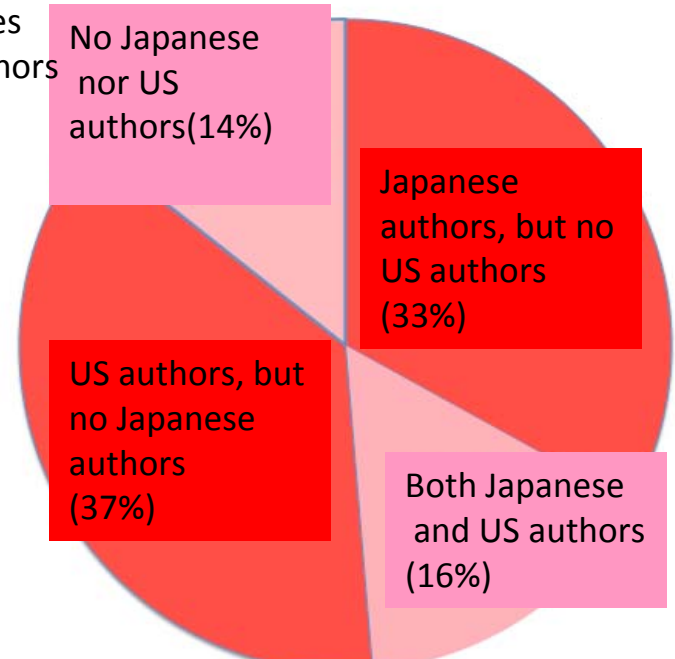
Introduction to DARTS

Papers from ASCA satellite data

- Japan-US collaborative mission
- 1463 refereed journal papers from 1993 10 2007
- ASCA was operational for 2736 days,
  One paper per two day observation

  Japanese papers 1/3, US papers1/3
  Japan-US papers 1/6
  From other countries 1/6

If author list includes Japanese or US authors

No Japanese nor US authors(14%)

Japanese authors, but no US authors (33%)

US authors, but no Japanese authors (37%)

Both Japanese and US authors (16%)

JUDO and UDON

Example of DARTS services for quick look and simple analysis

http://www2.hawaii.edu/~nhiraoka/judo_clipart.jpg

http://www.netlaputa.ne.jp/~ryufuu/udon/image/udon2.jpg

- JUDO and UDON are parts of DARTS (DATA Archives and Transmission System)
- On-line tools developed for DARTS users to access and browse archival data easily
- No need to download software
- Work with standard browsers
- Targeted for professional astronomers using DARTS

Introduction to DARTS

JUDO

JAXA Universe Data Oriented
http://darts.jaxa.jp/astro/judo

- Navigate the entire sky using mouse to search for desired targets/observations
- Browse images easily, zoom-in, zoom-out
- Directly access FITS images in DARTS
  - WCS compliant
- Designed for multi-mission
  - Currently only Suzaku X-ray data available
  - Akari infrared data being implemented
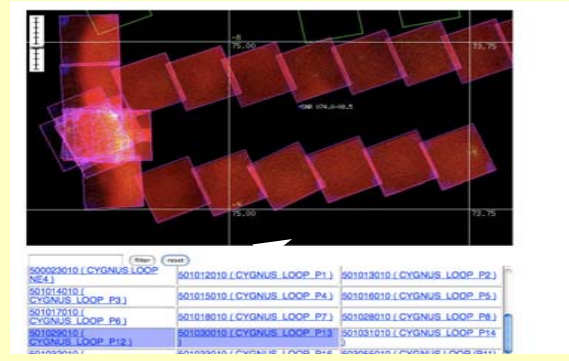- Developed in C and Java script with Ajax technology

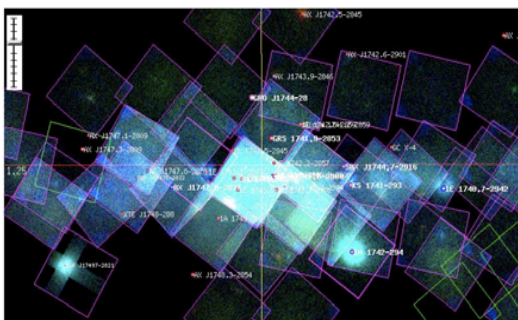**JUDO** ----- *http://darts.jaxa.jp/astro/judo*
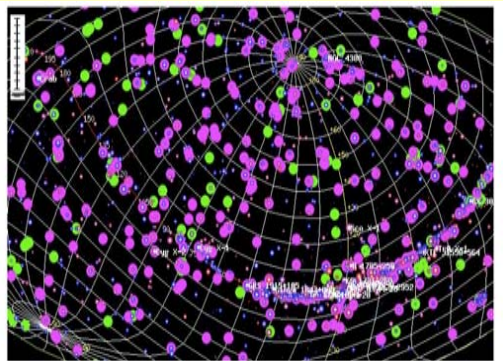
Display the celestial sphere, zoom-in and out with mouse. Different colors tell Suzaku public or proprietary data
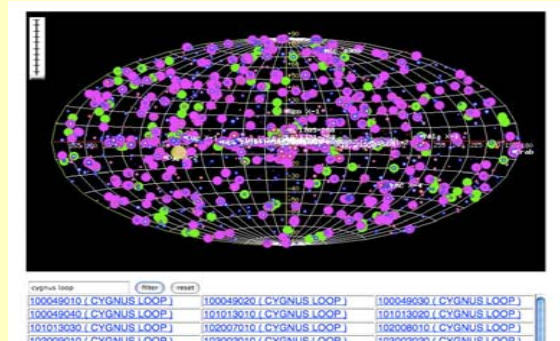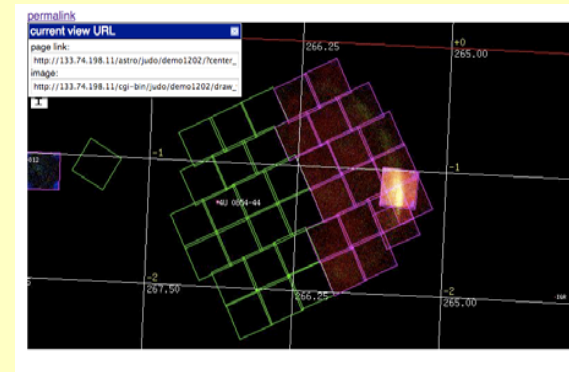

Search your target, and your can see the position on the sky。
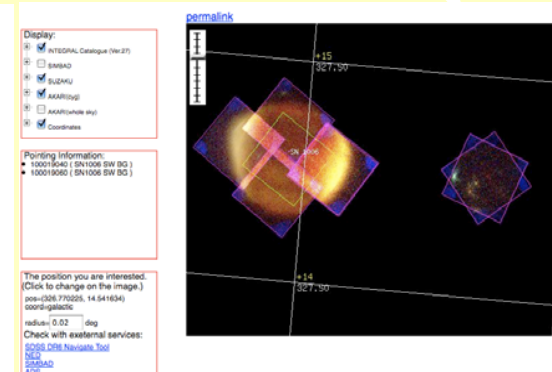

Different colors tell X-ray energies. "Mouse over" the "foot prints" tell the observation sequences

Suzaku observation of the Galactic Center region

Permalink of the displayed image may be obtained

Specify points of interests, and outside databases (SIMBAD, NED etc) are referenced

Introduction to DARTS

UDON

## Universe via DARTS ON-line

http://darts.jaxa.jp/astro/suzaku/udon.html

- Facilitate on-line data analysis
  - Display pseudo-color image, change color, extract X-ray light curves and spectra

- Currently, only Suzaku public data are accessible
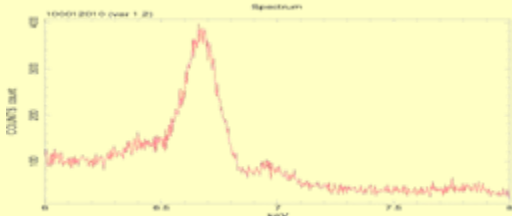
- Developed using IDL ON-the net (ION), Flash, ftools

UDON ----- http://darts.jaxa.jp/astro/suzaku/udon.html

•ION (IDL On-the net)、
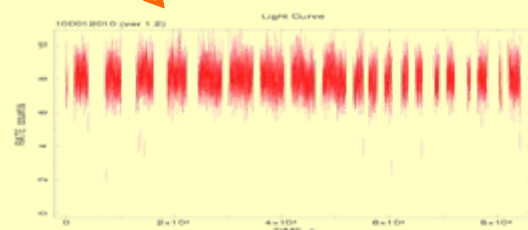Flash、 ftools are used
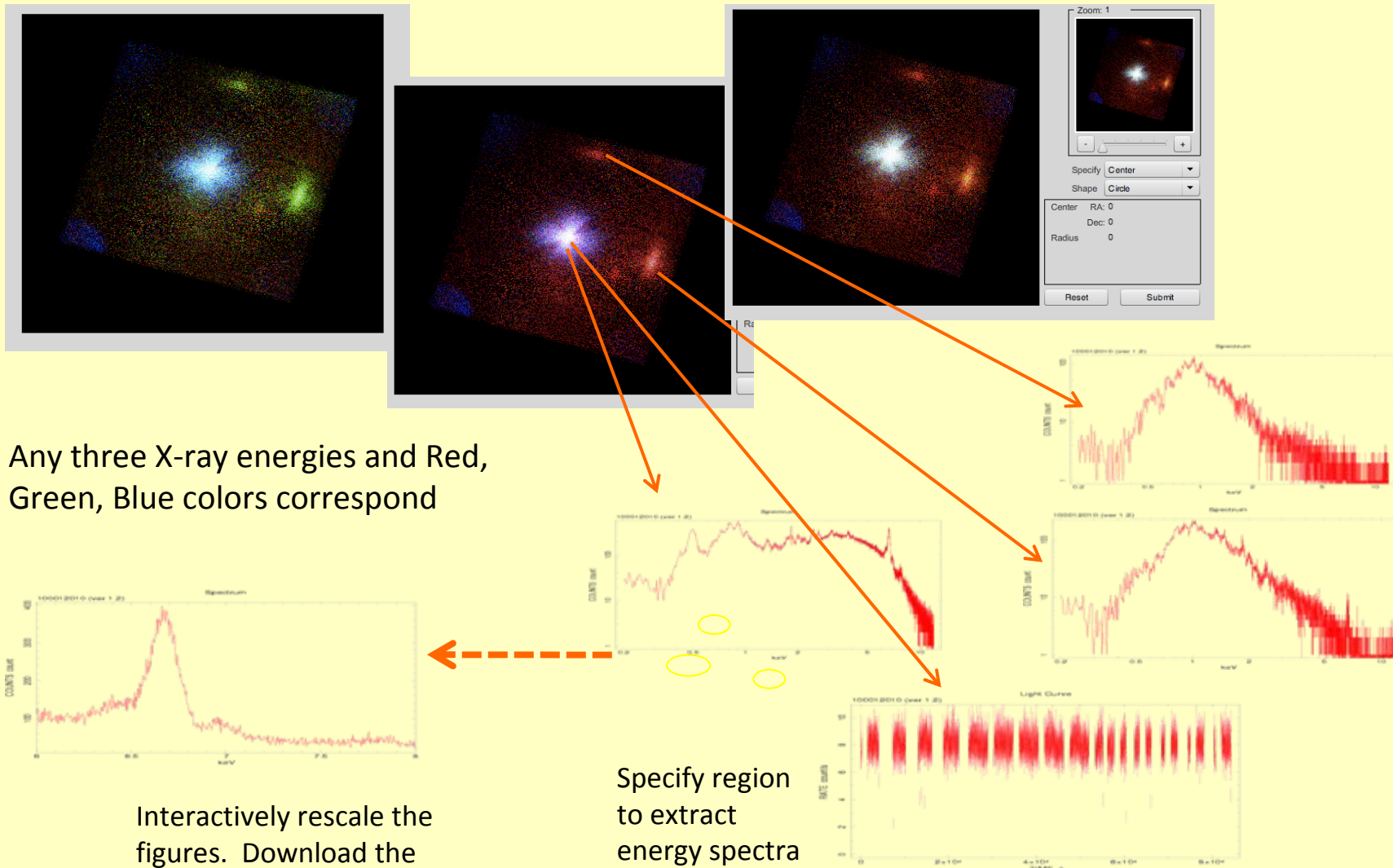
Any three X-ray energies and Red,
Green, Blue colors correspond

Interactively rescale the
figures. Download the
spectra and images.

Specify region
to extract
energy spectra
and light curves

Introduction to DARTS

Future science missions at JAXA and DARTS

- ISS instruments (2009+; already operational)
  - MAXI（X-rays）、SMILES(upper atmosphere)
- Projects (approved)
  - Planet-C (Venus,2010), EXCEED (planetary telescope,2011)、Astro-G(radio, 2012), Astro-H(high energy, 2013), BepiColombo(Mercury, 2014)
- Preprojects (being approved)
  - SPICA(Infrared, 2017+), Hayabusa2（asteroid, 2014+）, SELENE-2(lunar, 2014+)
- Still there are more than 10 Working Groups planning future space science missions
- All these data are planned to be archived at DARTS

Future DARTS plan

•DARTS archives JAXA's science satellite data permanently, and make them publicly available to international science communities
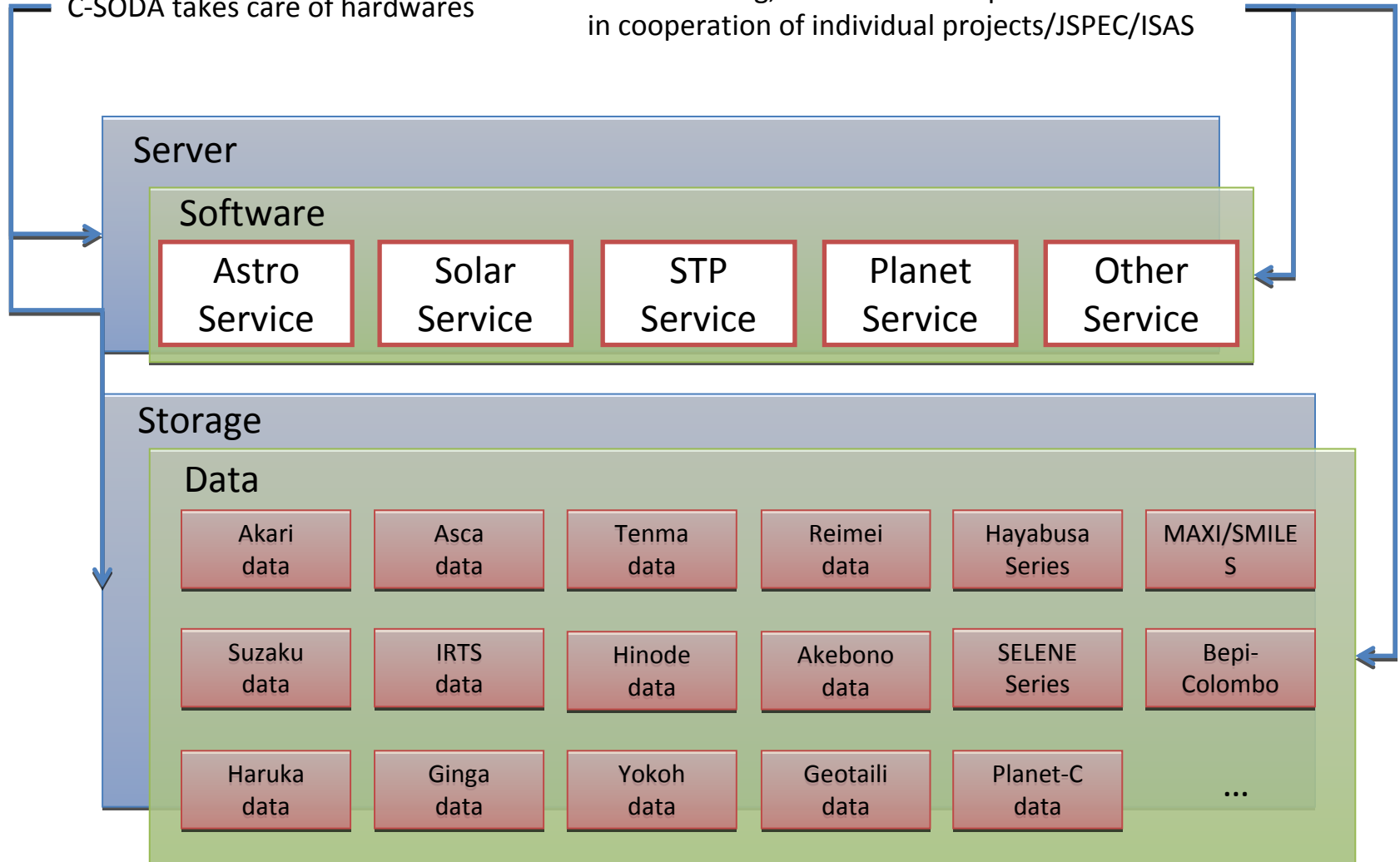•DARTS development and operation resources are dependent on both ISAS and JSPEC

http://darts.jaxa.jp/

Introduction to DARTS
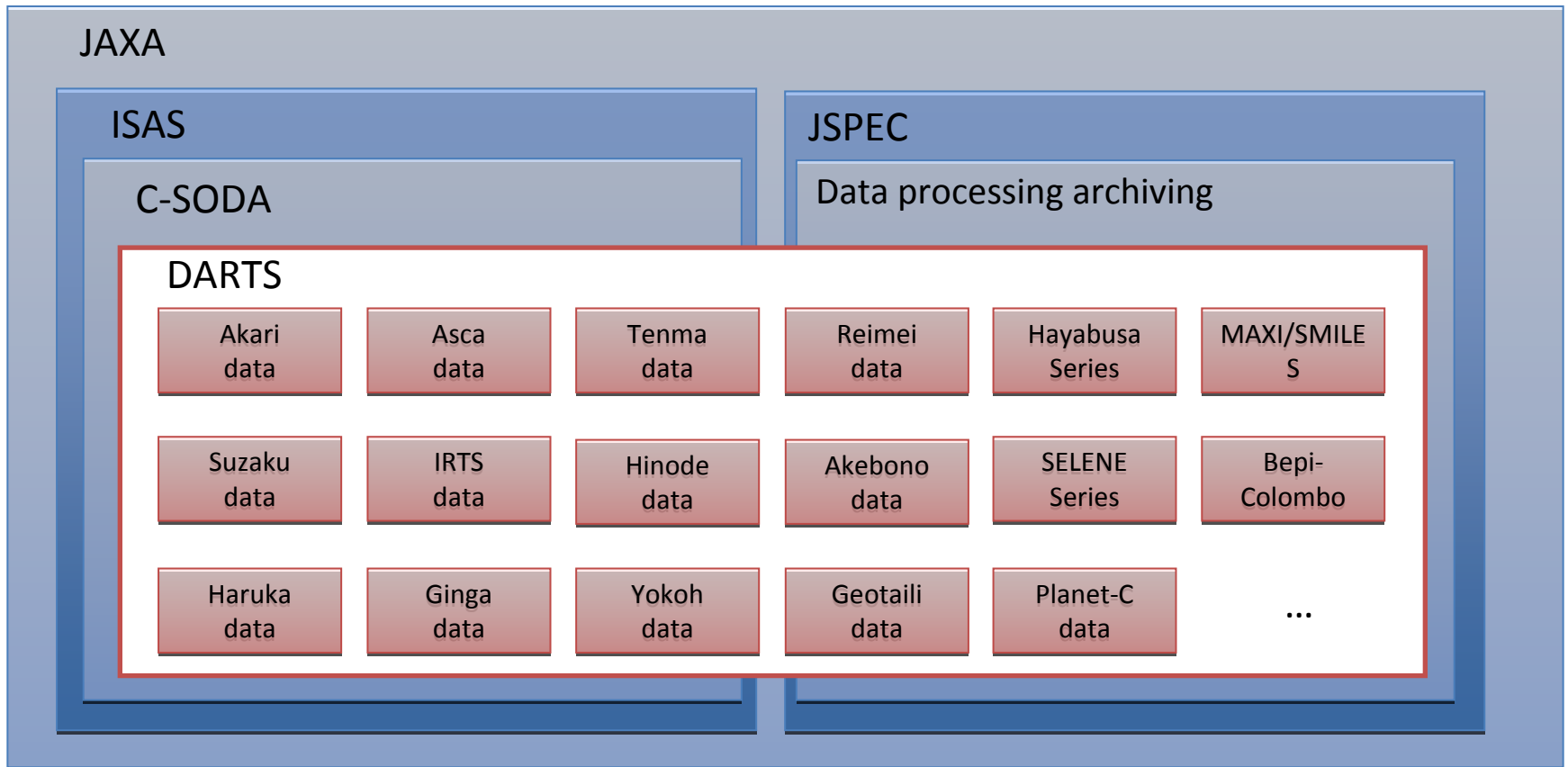
Future DARTS plan

C-SODA takes care of hardwares

Data archiving, software developments are made in cooperation of individual projects/JSPEC/ISAS

Server

Software

Astro Service	Solar Service	STP Service	Planet Service	Other Service

Storage

Data

Akari data	Asca data	Tenma data	Reimei data	Hayabusa Series	MAXI/SMILES
Suzaku data	IRTS data	Hinode data	Akebono data	SELENE Series	Bepi-Colombo
Haruka data	Ginga data	Yokoh data	Geotaili data	Planet-C data	...

Introduction to DARTS

Future plan of DARTS and C-SODA

- Data standardizing activities
  - PDAP (Planetary Data Application Protocol) etc
- Library development
  - FITSCC(FITS I/O in C++) etc
- Define high-level piple-line data processing as C-SODA's task
  - Currently, level of the data products depend on projects
- Develop data analysis software?
  - Currently, most data analysis software packages are from US
  - While individual components are written in Japan (packaged in US)
  - Should we start developing data analysis software packages in Japan?
- Tight collaboration between scientists and engineers
  - Scientists should not spend too much time on technical tasks
  - System engineering is required, nurture data processing engineers in-house and outside
- Collaboration with outside organizations
  - JAXA's resources are limited
  - Pursue more collaborations with universities
  - Data centers may be located outside of JAXA (NASA, ESA model)
- Hire young people
  - There are many good pot-docs
  - Not many positions in JAXA, universities
  - We should utilize those manpower