ISO and the Virtual Observatory

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Konkoly Observatory
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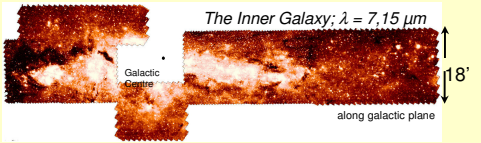
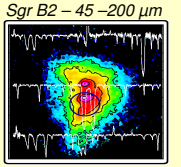
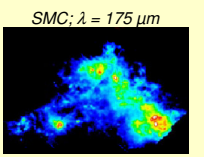
A brief introduction to ISO….

Infrared Space Observatory (ISO)

- Launched in November 1995, operational until May 1998.
- 1st true infrared observatory in space
- 30,000 observations covering all areas of astronomy
- Capabilities
  - Photometry and imaging (some polarisation) in broad and narrow bands from 2.5 - 240 μm with resolutions/fields of view from diffraction-limited to 3'.
  - Full spectroscopic coverage (low - high resolution) from 2.5 - 200 μm,
    - wealth of diagnostics for physical/chemical conditions in many regimes,
    - dust continua; solid state features; atomic, ionic and molecular lines.
- ISO has produced more than 1340 refereed papers so far.

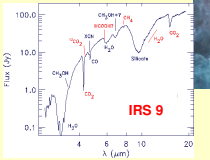


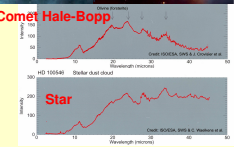


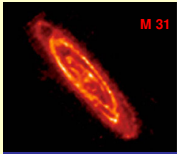


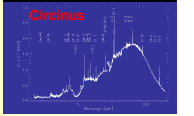
Some ISO science breakthroughs

- ISO was able to explore regions of the Universe obscured in visible light.
- Study of asteroids and planet atmospheres
- Detailed study of star formation regions
  - Inventory of ices
  - Detection of hundreds of young stars
- Astromineralogy
  - Crystalline silicates allow for classification of dust
  - Seen in comet Hale-Bopp and young & old stars
- Astrobiology
  - Water and organic molecules are ubiquitous in the cosmos
  - Detection of carbon-bearing molecules in interstellar space
- Cold dust in galaxies and in between
- Understanding the power source of Ultra Luminous Infrared Galaxies (ULIRGs)
  - Star formation vs. inner black hole as source of energy
- Unveiling a very intense star formation in primordial galaxies
  - Serving to explain diffuse background light









ISO Active Archive Phase (2002-2006)

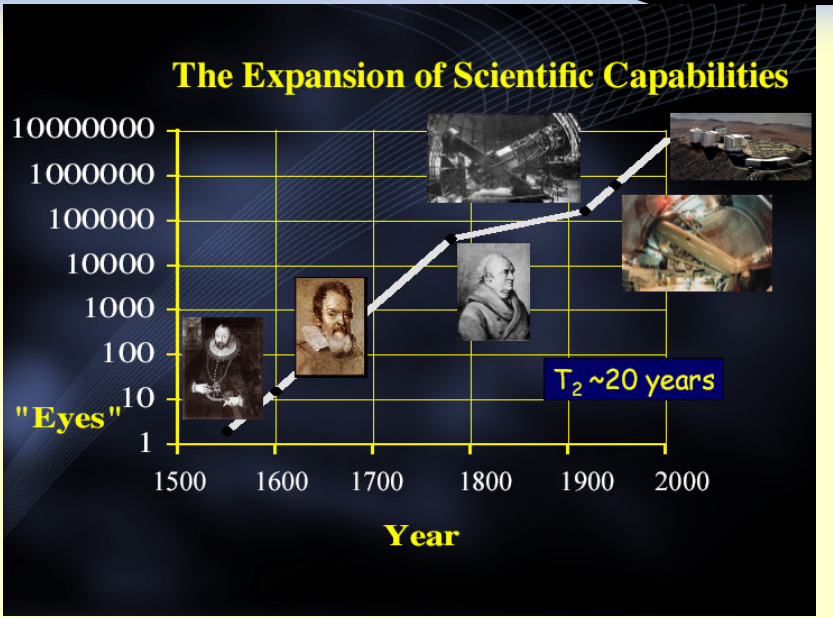
- Archive maintenance and improvements:
  - Stimulating **systematic data reduction** and capturing the resulting data products into the archive
  - Ingestion of new ISO **catalogues** and **atlases**
  - Continuing the process of increasing the **inter-operability of archives** by linking to other data sets. This implies **flagging of problems or uncertainties**, for use by the "innocent" external user
  - **Tracking of refereed ISO publications** and incorporating this information
  - Maintaining the archive, especially the **user interface** to maximise its usefulness and ease of use.
- **Support in data usage**
  - provision of advice
  - support for data reduction either remotely or via visits to the centre
  - supply of, and assistance with, software for detailed data analysis

Highly Processed Data Products (HPDP)

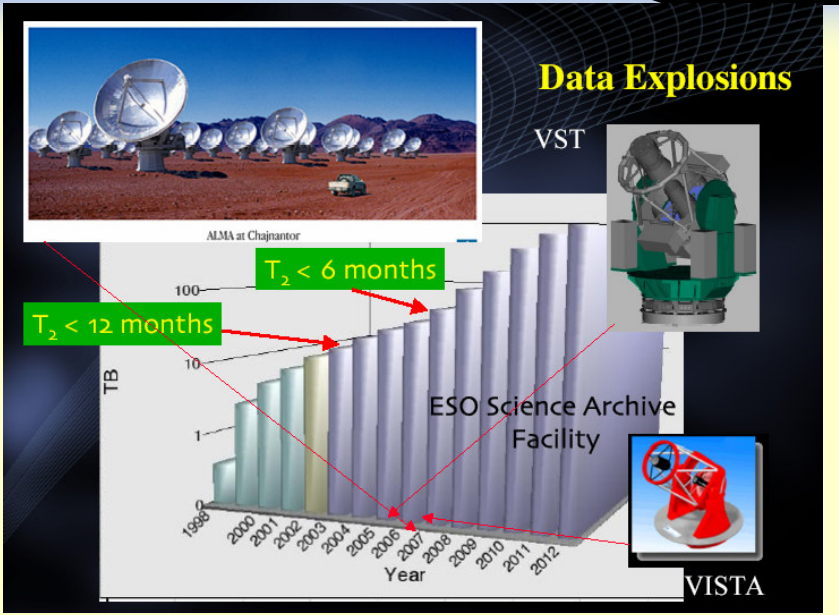
ISO Active Archive Phase Tasks

- Supply of general information
  - Helpdesk and WWW services
  - Handbooks
  - Explanatory Library
- Promotion of awareness of ISO data
  - conferences, workshops
- Continuation of the cooperation between the ESA ISO Data Centre and the National Data Centres, responsible for:
  - Maintenance and improvement of interactive data analysis packages,
  - Instrument-specific calibration,
  - Focussed reduction of specific data sets for ingestion into archive.
- Retention of core skills and knowledge at the ISO Data Centre, which additionally build a bridge in ESA's planning towards other ESA astronomical space missions.

The Virtual Observatory

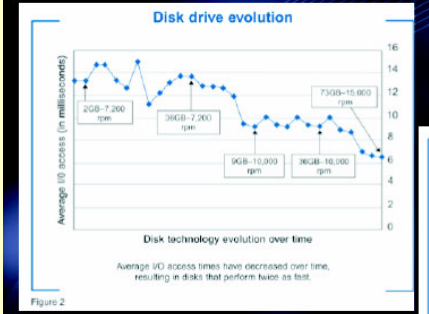

The Expansion of Scientific Capabilities
10000000
1000000
100000
10000
1000
100
10
1
"Eyes"
1500
1600
1700
1800
1900
2000
Year
T2 ~20 years

Why a Virtual Observatory?



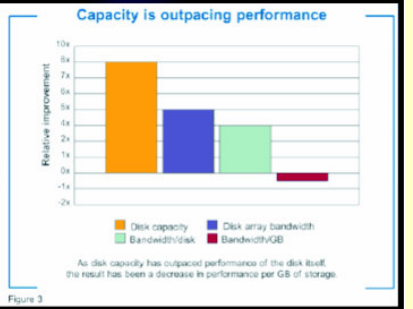
The Data Challenges

Accessing Data:



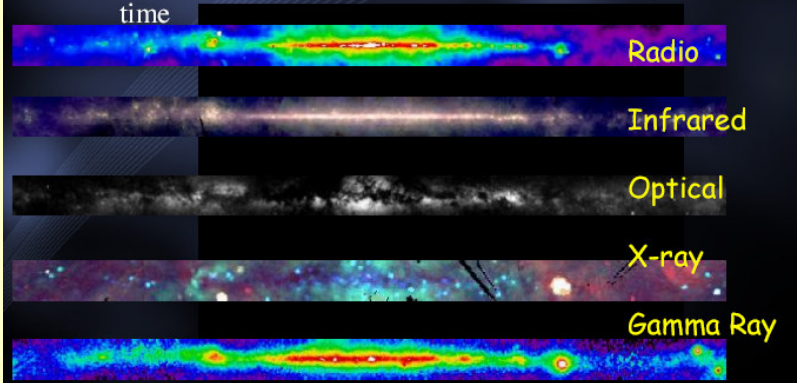
$T_2 \sim 10$ years

1990 - 2000



Further Challenges : interoperability

- **Joining Data from different experiments**
  - To form a complete physical picture of an object it has to been seen in different wavelengths and over a period of time



The solution?

- Data mining to increase observing efficiency ⇒ intelligent pre-selection
- Statistical identification ⇒ multi-wavelength, multi-parameter analysis
- In-situ analysis to avoid download
- Easy and smart access to **all** archives and data providers

The Virtual Observatory

- The power of the World Wide Web is its transparency - it feels as if all the documents in the world are inside your PC. The idea of the Virtual Observatory (VO) is to achieve the same transparency for astronomical data.

- The Virtual Observatory is a collection of integrated astronomical data archives and software tools that utilize computer networks to create an environment in which research can be conducted

15 Member Organizations

In Europe: 1st Step: AVO

- Astrophysical Virtual Observatory Project: R&D on scientific requirements and technology for building the VO in Europe, 50% funded by European Community

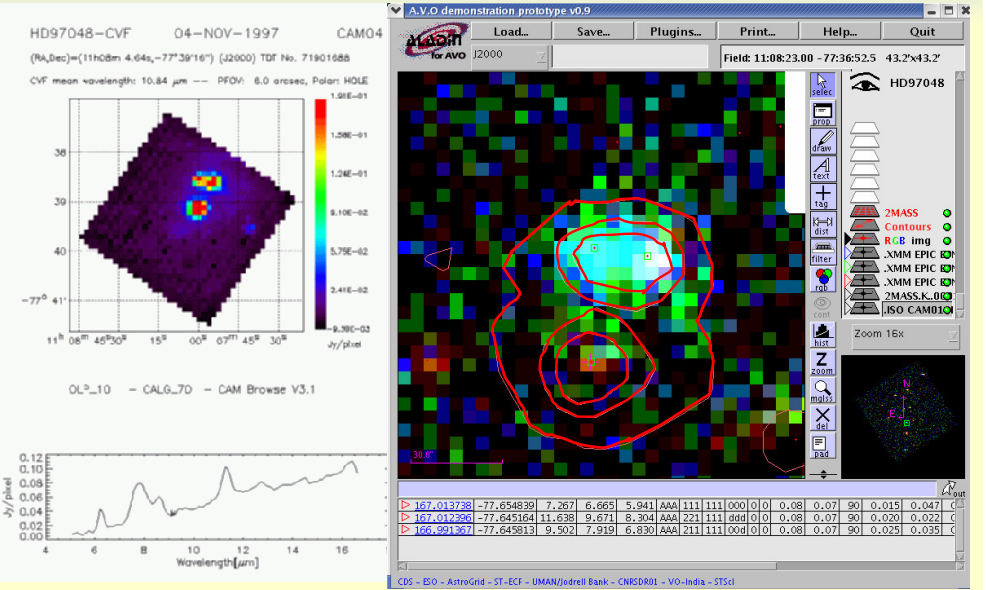
- Phase A, 2001 - 2004/5 (*http://www.euro-vo.org*)
- Driven by strategy of **scientific VO annual demos**
- Science Working Group established to provide scientific advice
- Project completed

AVO's main achievements

- Three science demonstrations
- *First* refereed astronomical paper enabled via end-to-end use of VO tools and systems: "*Discovery of optically faint obscured quasars with Virtual Observatory tools*" (Padovani etal, 2004)

- The AVO prototype, a VO tool that can be used NOW for the day-to-day work of astronomers
- A Science Reference Mission

AVO 2004 demo: ISO presence



AVO 2005 demo

- Two scenarios:
  - Galactic: **Asymptotic Giant Branch to Planetary Nebulae Transition** (strong science case, Spectral Energy Distribution building from archival data)
  - Extragalactic: **Star Formation Histories in Galaxies** (new VO computing concepts: towards the Grid; access to theoretical models)
- Multiwavelength, heterogeneous, and complex data: VLA, MERLIN, Spitzer, ISO (spectra and images), MSX, IRAS, 2MASS, WFS, HST/WFPC2, FUSE, IUE, plus Vizier catalogues
- Another VO paper to be written (Bayo, Garcia-Lario, Sierra, et al.)!

AGB to PNe transition phase

Late evolutionary stages of low- and intermediate mass stars (1 - 8 M_o)

- Short transition times ($\sim 10^3$ - 10^4 yr)
- Recent AGB mass loss (up to 10^{-4} M_o/yr)

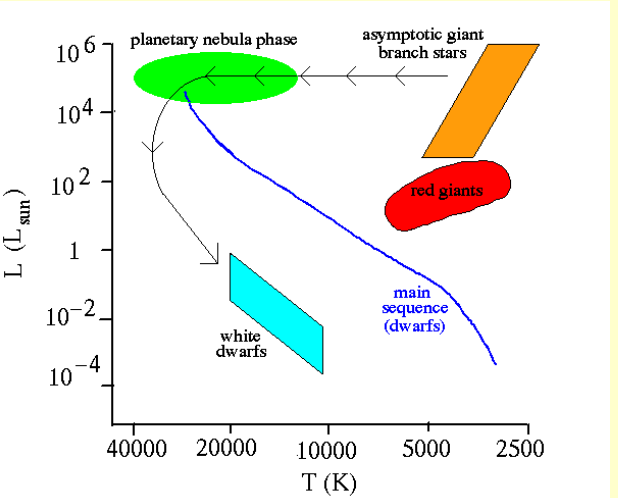
⇓

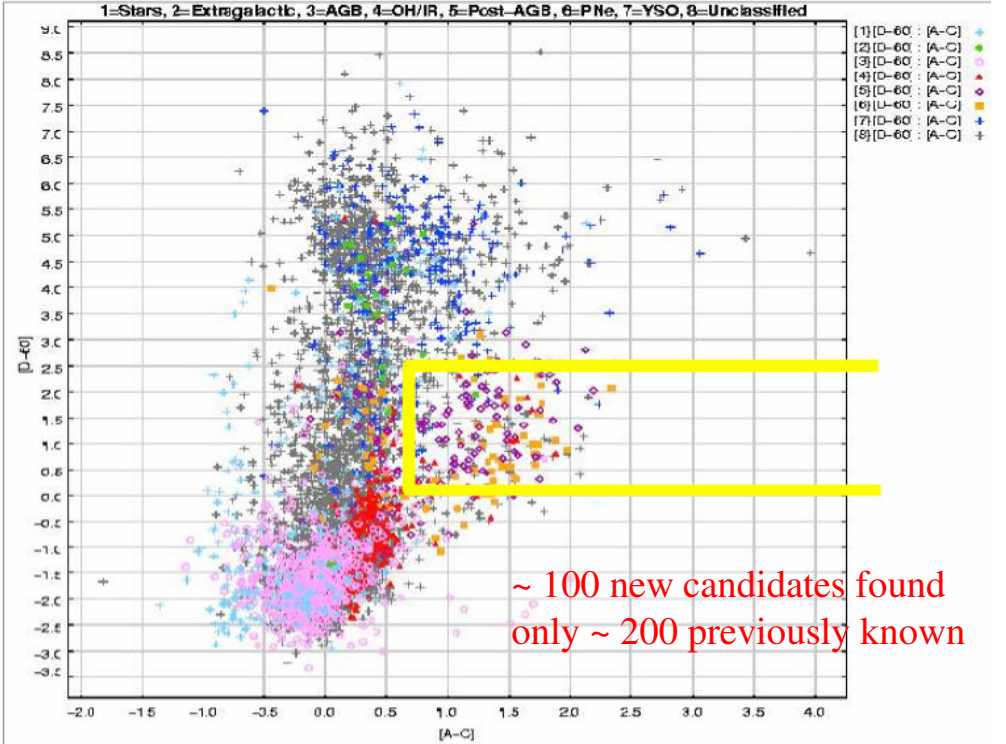
- Few objects in this phase (≈1/1,000,000)

- Many are heavily obscured in the optical

⇓

- Need for systematic surveys using infrared data




1=Stars, 2=Extragalactic, 3=AGB, 4=OH/IR, 5=Post-AGB, 6=PNe, 7=YSO, 8=Unclassified
[1] [D-60] : [A-C]
[2] [D-60] : [A-C]
[3] [D-60] : [A-C]
[4] [D-60] : [A-C]
[5] [D-60] : [A-C]
[6] [D-60] : [A-C]
[7] [D-60] : [A-C]
[8] [D-60] : [A-C]
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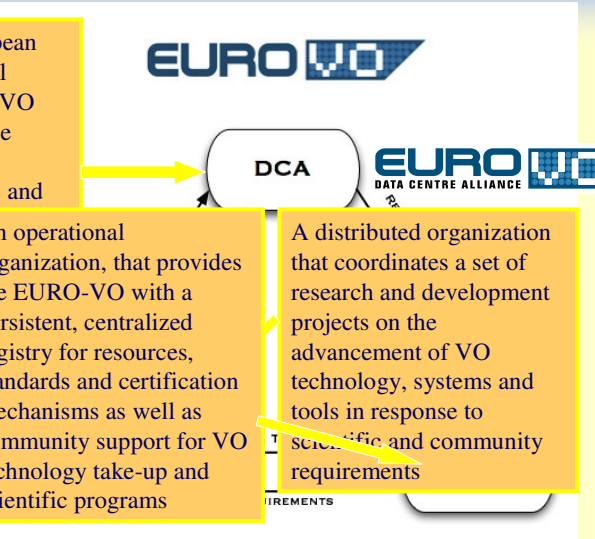
[A-C]
~ 100 new candidates found
only ~ 200 previously known

From AVO to EURO-VO

An alliance of European data centres who will populate the EURO-VO with data, provide the physical storage and computational fabric and who will publish metadata and ser the EURO-VO u technologies



An operational organization, that provides the EURO-VO with a persistent, centralized registry for resources, standards and certification mechanisms as well as community support for VO technology take-up and scientific programs

A distributed organization that coordinates a set of research and development projects on the advancement of VO technology, systems and tools in response to scientific and community requirements

EURO VO TECHNOLOGY CENTRE

EURO VO FACILITY CENTRE

EURO-VO Facility Centre

- Funded by ESA and ESO

- EURO-VO Science Advisory Committee
  - Providing Scientific guidelines to the EURO-VO

- WebPortal, user friendly for Scientists
  - VO tools, User recipes and User manuals, …

- WebPortal, user friendly for Technical people
  - VO development tools, tutorials, links to VO standards, …

- Support for VO technology take-up in Europe
  - Scientific and technical VO Workshops

- Registry of VO resources

Active Member of EURO-VO

- Member of EURO-VO Data Centre Alliance
  - Development of the ESAC Astronomical Archives
  - Make these archives accessible through VO standards
  - VO Support to other European Data Centre
  - Data Processing Centre, through the ESA-VO GRID
    - Processing the data where they reside, instead of moving the data around

- Member of EURO-VO Technology Centre
  - Technology research and prototyping on VO standards
  - Link with VOTECH project
  - Link with IVOA corresponding working groups

Archives at ESAC

- ESA to host final archives of science projects at ESAC, Madrid, Spain
  - ISO, since December 1998, http://iso.esac.esa.int/ida/
  - XMM-Newton since April 2002, http://xmm.esac.esa.int/xsa/
  - Integral since December 2003, http://integral.esac.esa.int/isda/
  - Herschel, Planck, GAIA in the future
  - Except HST in ST-ECF @ Garching

- Same team developing Astronomy Archives at ESAC and working on ESA-VO
  - Ensure VO is in mind from the beginning of Archives development

- All ESA Planetary missions into a single archive (PSA)
  - Available since March 2004, http://www.rssd.esa.int/PSA
  - Mars Express, Smart-1, Giotto, Rosetta, Huygens, Venus Express data

ESAC Archives to be VO compliant

- Simple Image Access Protocol (SIAP)
  - Available for ISO and XMM-Newton, part of AVO demos 2004-2005
  - Accessible from Aladin, other Archives

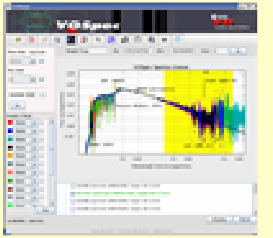
- Simple Spectra Access Protocol (SSAP)
  - Available for ISO, part of AVO demos 2005
  - Accessible from Aladin, Astroscope, other Archives

- Simple Line Access Protocol (SLAP)
  - Available for ISO Spectroscopic Database

- ISO and XMM-Newton Archives as Basic SkyNodes
- XMM-Newton point source catalogue as a Full SkyNode

VOSpec application (I)

- First ever VO application to make use of all VO standards for spectral access: Registry, SSAP (Simple Spectrum Access Protocol), VOTable, SLAP (Simple Line Access Protocol) standards



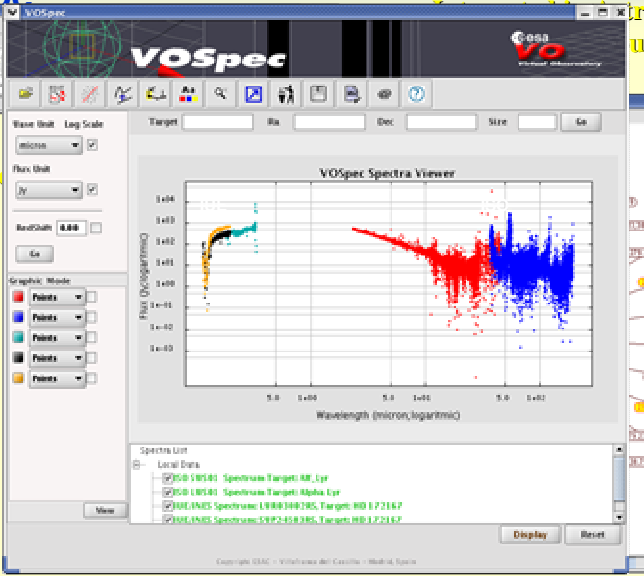
- Connects to all available SSA servers in the VO registry (currently more than 10 different projects) and all available theoretical spectra servers

- Integrated as spectral displayer in Astrogrid Workbench, Aladin, NVO registry and AVO prototype

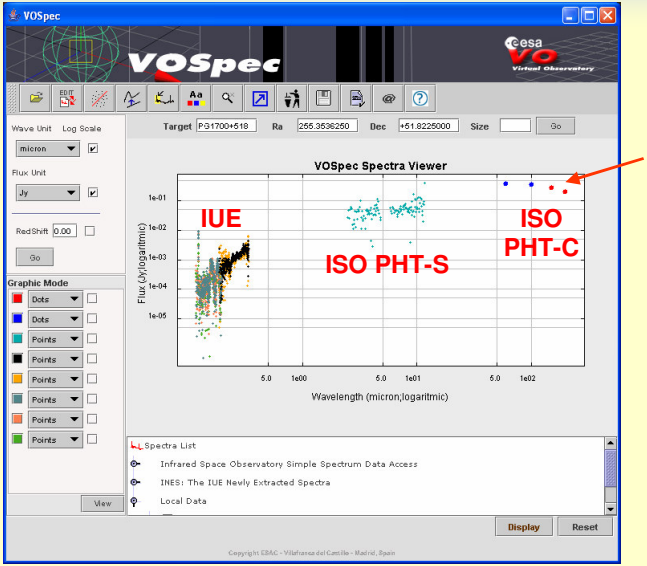
VOSpec application (II) - Astroscope

Enter object and select spe
IUE & ISO

View Spectra In VOSpec



Konkoly catalogues are already in VO



PG1700+518

From the Catalogue of Far-Infrared ISOPHOT observations of extragalactic objects

Summary:
ISO and the Virtual Observatory

- ISO has played a key role in the definition of standards for interoperability within the International Virtual Observatory Alliance
- ISO has provided access to its spectral data through the IVOA Simple Spectrum Access Protocol (SSAP) for the first time ever in the VO world, becoming a reference implementation and test bed for the proper specification and improvement of the protocol.
- ISO image data have been provided through the IVOA Simple Image Access Protocol (SIAP).
- ISO has also been pioneer in Europe by implementing Basic SkyNode (another IVOA standard) access to the ISO products.

Summary:
ISO and the Virtual Observatory

- The ESAVO-VOSpec tool has been used over the ISO spectral data to become the first ever VO compatible tool fuelled by IVOA standards. Through this tool, the ISO spectral data have been exposed to the world in an unprecedented manner.
- The quality and availability of the ISO data through the VO standards led to the inclusion of the ISO image and spectral data at the latest Astronomical Virtual Observatory demonstrations in 2004 (ESO) and 2005 (ESAC)
- The ISO project has also contributed to the definition of a completely new standard, the Simple Line Access Protocol (SLAP), by giving access through the VOSpec to the Infrared Astronomical Spectroscopic Database (IASD) based on ISO spectral line data findings
- ISO Data Centre will continue the integration of its data into the VO, together with the ESAC VO & Science Archive Team as part of the EURO-VO project

Acknowledgements

- Peter Quinn

  EURO-VO Exec Chair

- Paolo Padovani

  Head, ESO VO Systems Department, EURO-VO Facility Centre Scientist

- Christophe Arviset

  ESA VO Project Manager, ESAC

More info…

- http://www.euro-vo.org/
- http://esavo.esac.esa.int/