

The Virtual Observatory: What is it and how can it help me?

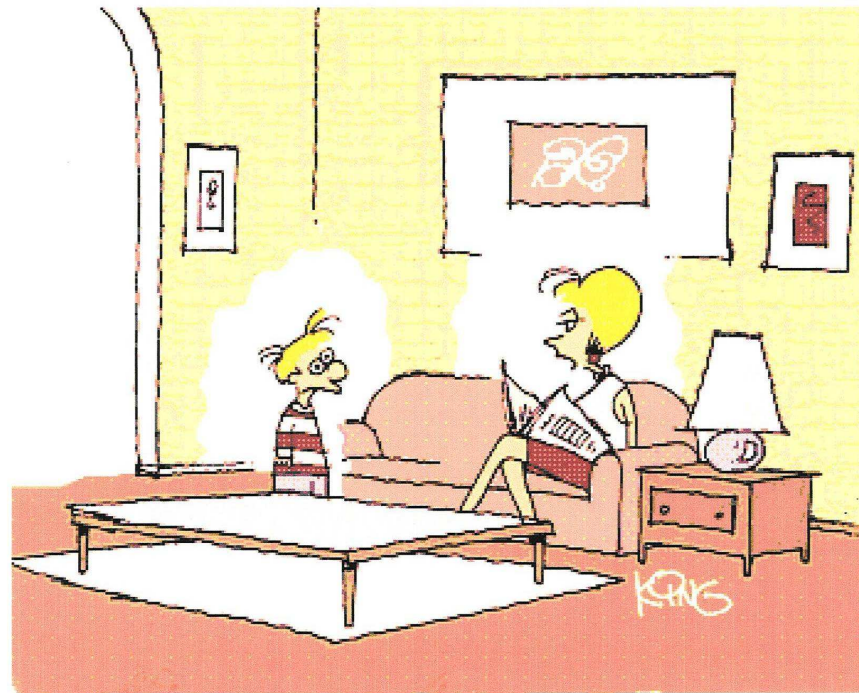
Enrique Solano
LAEFF / INTA

Spanish Virtual Observatory



Astronomy in the XXI century

- The Internet revolution (the "dot com boom") has transformed the way we live...



**"No, no te bajamos de la red;
naciste."**



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Astronomy in the XXI century

... and work

- The availability of huge amounts of “on-line” information has drastically transformed the astrophysical research.

esa

The INES Archive Data Server

This data server provides access to IUE Final Archive data, processed with the INES system. It was developed by the ESA IUE project at WILSPA and is maintained and distributed by LAEFF, the Principal Centre for INES data. LAEFF is part of the Space Science Division of INTA.

Resources (Version 3.0)

- ▶ Archive search and data retrieval
- ▶ System Overview
- ▶ Help Desk
- ▶ Project documentation
- ▶ INES Principal Centre Home Page
(News, General Information, Usage examples ...)

IUE Observations

IUE performed UV spectrophotometry at resolutions of ~0.2Å and ~6Å from 1150Å to 3350Å, acquiring more than 104000 spectra of some 9600 objects.

Figure courtesy of MAST, at STScI

Smithsonian/NASA ADS Astronomy Query Form for Wed Apr 5 09:36:12 2006

[Sitemap](#) [What's New](#) [Feedback](#) [Preferences](#) [FAQ](#) [HELP](#)

Full Text Search: You can now search the complete text of all scanned articles in the ADS (see link below).

Send Query Return Query Form Store Default Form Clear

Databases to query: Astronomy Physics arXiv e-prints

Authors: (Last, First M, one per line) SIMBAD NED LPI IAUC Objects

Exact name matching Object name/position search

Require author for selection Require object for selection

(OR AND simple logic) (Combine with: OR AND)

Publication Date between (MM) (YYYY) and (MM) (YYYY)

Enter Title Words Require title for selection

(Combine with: OR AND simple logic boolean logic)

Enter Abstract Words/Keywords Require text for selection

(Combine with: OR AND simple logic boolean logic)

Return items starting with number

[Full Text Search: Search OCRd text of scanned articles](#)

Astronomy in the XXI century

- **The advances in technology** (telescope design and fabrication, large-scale detector arrays,...) are now permitting to explore the Universe in a multi-parameter space.
- **The advances in computational capabilities** have provided the means to make, for the first time, direct comparisons between complex theoretical calculations and large, statistically significant observational databases.

BUT...

Astronomy in the XXI century (II)

- The progress in the scientific exploitation has not kept pace with the exponential growth of these vast new datasets.
- This new scenario is demanding changes in the “classical” methodology.



Astronomical research: the classical way

I. Get the data

New data



Archive data

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IUE Observations

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Figure courtesy of MAST @ STScI

II. Reduce and analyze the data locally.



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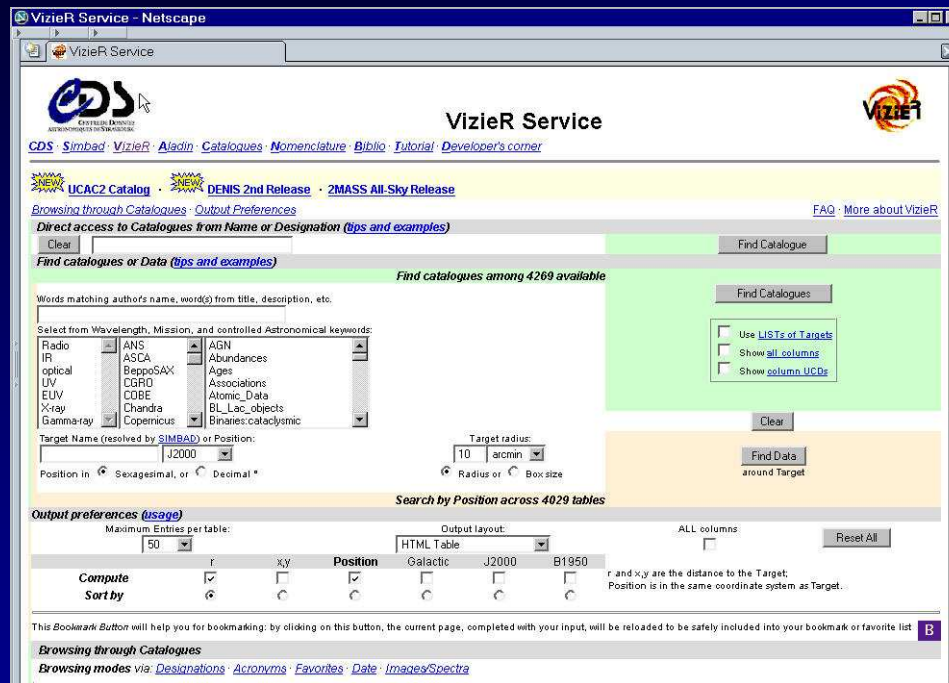
VO: a complementary approach

- The classical method has demonstrated to be quite inefficient when dealing with problems that require either:
 - ✓ Interoperability among data service and/or
 - ✓ Management of large volumes of data.



Interoperability problems: Easy questions with non-easy answers

➔ "Give me all objects in VizieR with V-Johnson."



➔ **VizieR**: Contains more than 4000 astronomical catalogues consisting of one or several tables.

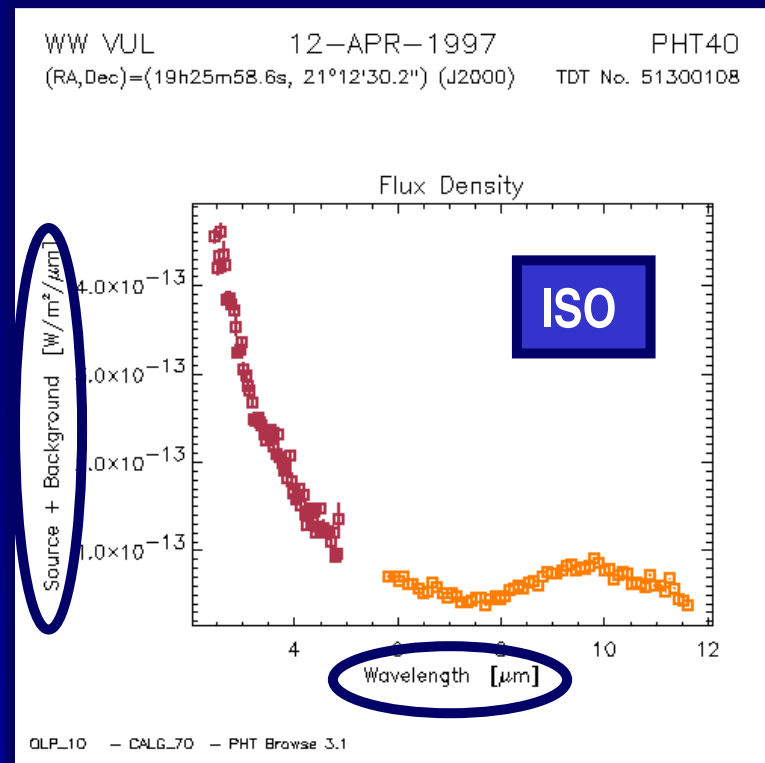
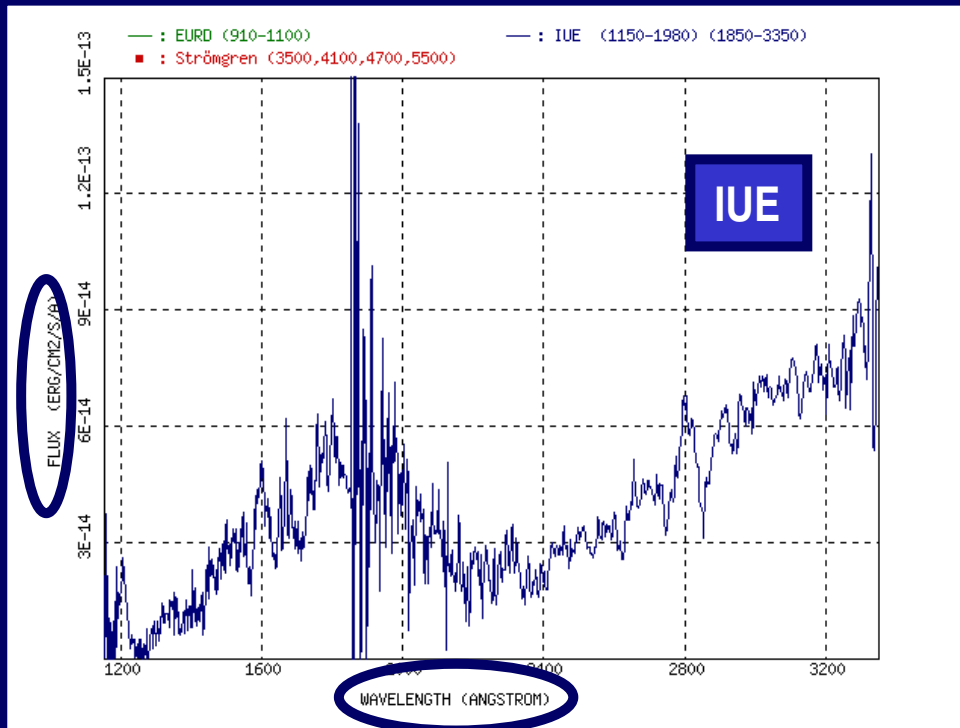
➔ Problem: as the catalogues come from many different sources, the original descriptions are very heterogeneous: "Give me all tables containing the V magnitude in the Johnson system: **144 different names for V Johnson.**"

Frequency: column name	Frequency: unit
956 Vmag	1263 mag
62 V	4 ---
21 V0	1 10-17W/m2/nm
11 Vmax	
8 Vmag2	
7 <Vmag>	
6 mag	
4 <V>	
4 Vmagph	
4 A0	
4 Vcs	
4 Vmagav	
3 V91	
3 V(HB)	
3 VMAGp	
3 Vpred	
3 Vmin	
3 Vmag1	
3 V2mag	
2 V42	

Result was truncated to 20 lines (out of 144).
Reload with 10 lines.

In the pre-VO era

- ✓ Different units both in wavelength and flux.
- ✓ Flux calibration of the photometric systems.



UBVRIJHK

• Wavelength: Å + μ

Magnitudes!!!

Radio

• Wavelength: mm

Flux: mJy

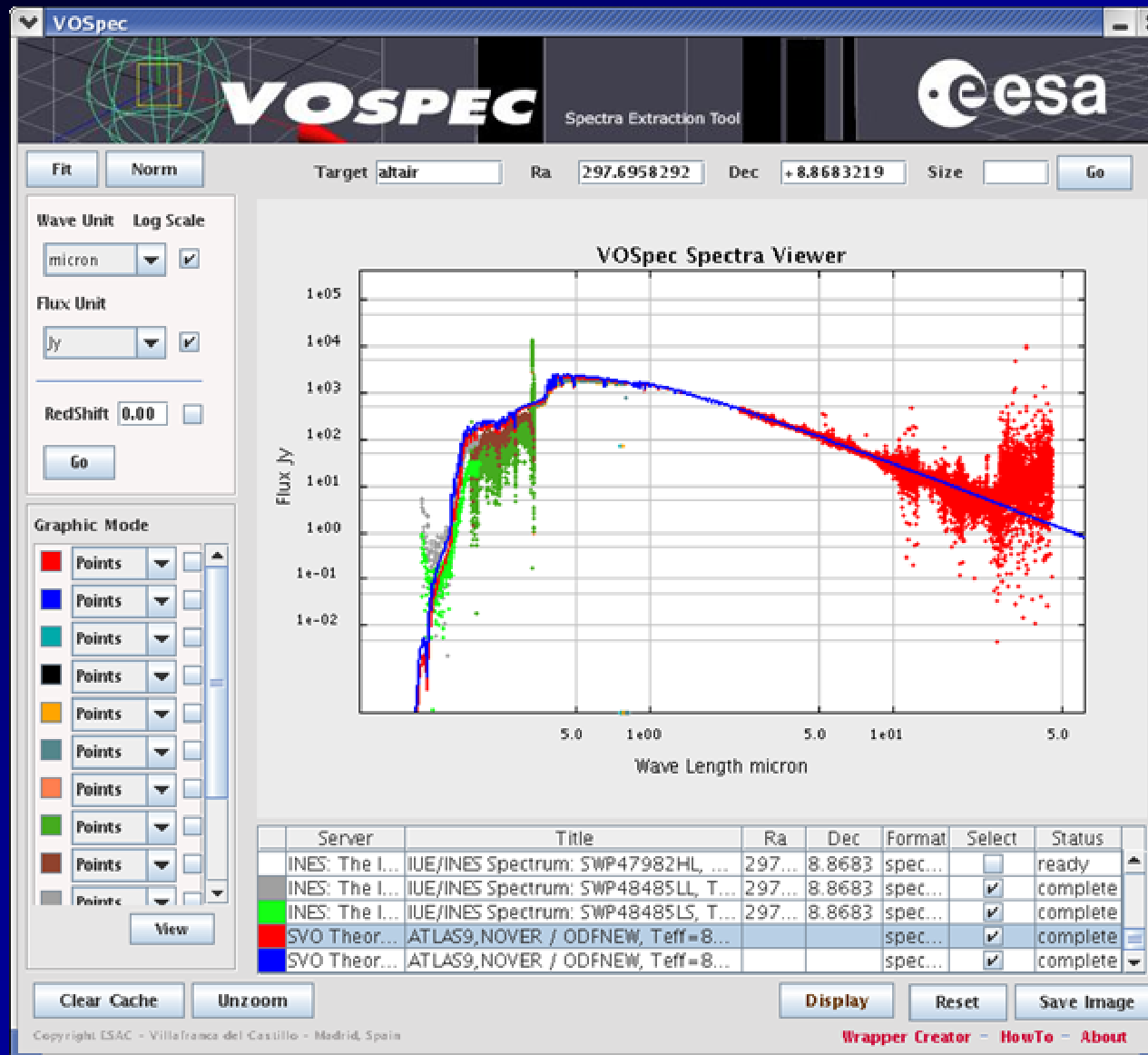


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Using VO capabilities



The solutions provided by VO to solve the interoperability problem

- Agree and build standards.
 - Standard semantic: UCDs
 - Standard access protocols
 - Standard output formats
 - Standard data models
 - Automated discovery tools (registries)
- Uptake of standards by the data services.
- Development of a federation of astronomical data centres (“data grid”).



VO: a complementary approach

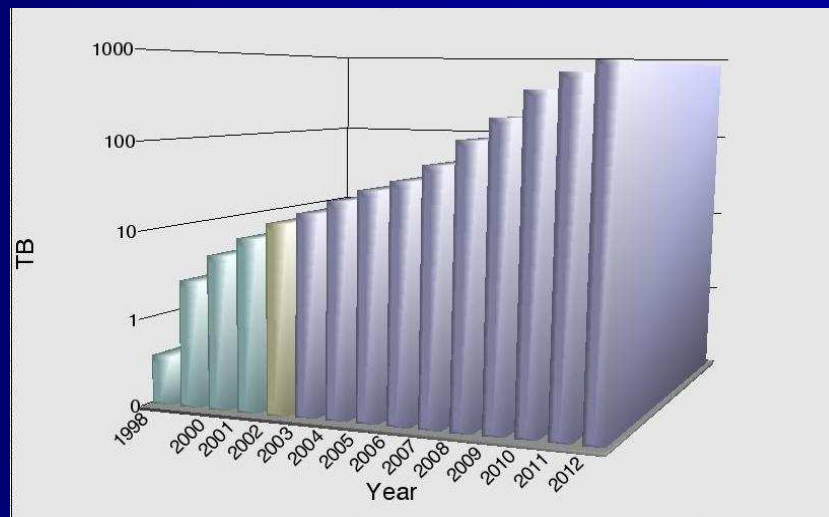
- The classical method has demonstrated to be quite inefficient when dealing with problems that require either:
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“large” really means LARGE

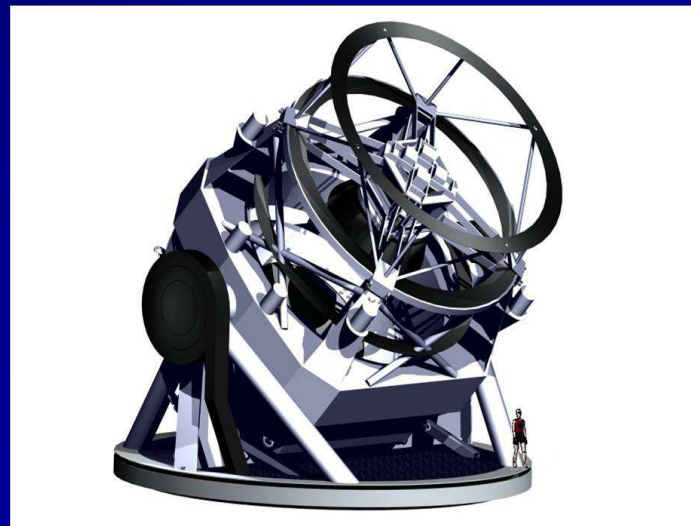
➤ Archive data are dramatically increasing.

✓ *ESO/ST-ECF Science Archive Facility holdings (x100 increase in the next 7 years)*



✓ *LSST*

- It will scan the visible sky every few nights.
- Few TB/night. A factor of 1000 larger than current surveys.



Is it necessary to work with all this amount of information?



PROJECT

Brown Dwarf Search Science Prototype: Real-Time Cross Matching of Large Catalogs

[Standards](#)
[Software & Services](#)
[Publications](#)
[Prototypes](#)

[Internal Logos](#)

ABOUT NVO

[What is the NVO?](#)
[Science Objectives](#)

COMMUNITY

[Discussion Lists](#)
[International VO](#)
[VOForum](#)
[Metadata \(NCSA\)](#)
[Other Links](#)

PEOPLE

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Scientific Motivation The search for brown dwarfs has been revolutionized by the latest deep sky surveys. A key attribute to discovering brown dwarfs is the federation of many surveys over different wavelengths. Such matching of catalogs is currently laborious and time consuming. This matching problem is generic to many areas of astrophysics.

Data Resources

- Sloan Digital Sky Survey (SDSS) Early Data Release (15 million objects)
- 2-Micron All Sky Survey (2MASS) 2nd Incremental Point Source Catalog (162 million objects)

What the VO Brings Today, doing the matching of these two large datasets is user-intensive and is replicated by many different users. Also, the correlation of these two datasets can take years of CPU time if not done correctly. The NVO brings two key aspects to

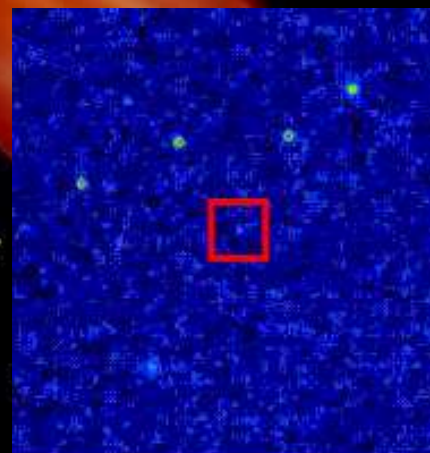
➤ **Criterio de filtrado:**

Detecciones solamente en z y J con $z - J > 2.75$

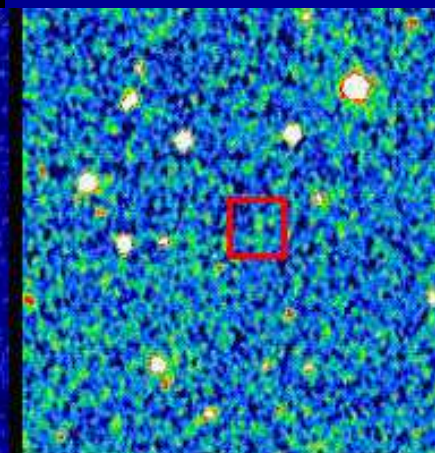
➤ *SDSS: 15M obj.*

➤ *2MASS: 160M obj.*

➤ *300000 objetos en común.*



2MASS



SDSS



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How to solve the problem of the data avalanche?

➤ Move from download to service paradigm

- Leave the data where it is.
- Operations on data (search, cluster analysis, etc) as services.
- Ship the results not the data.

Requirements on data centres: computing

- Local resources:
Supercomputers,
PC farms

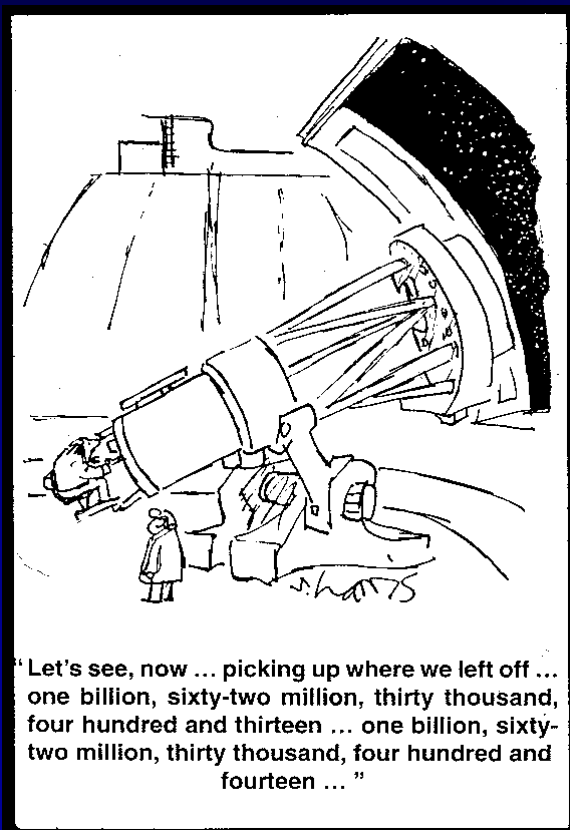


- Distributed computing:
the GRID



Requirements on data centres: analysis tools

- Allow remote functionality as if they were local.
- **Data mining:** Key issue for VO and where the greatest scientific benefits are expected to come from.

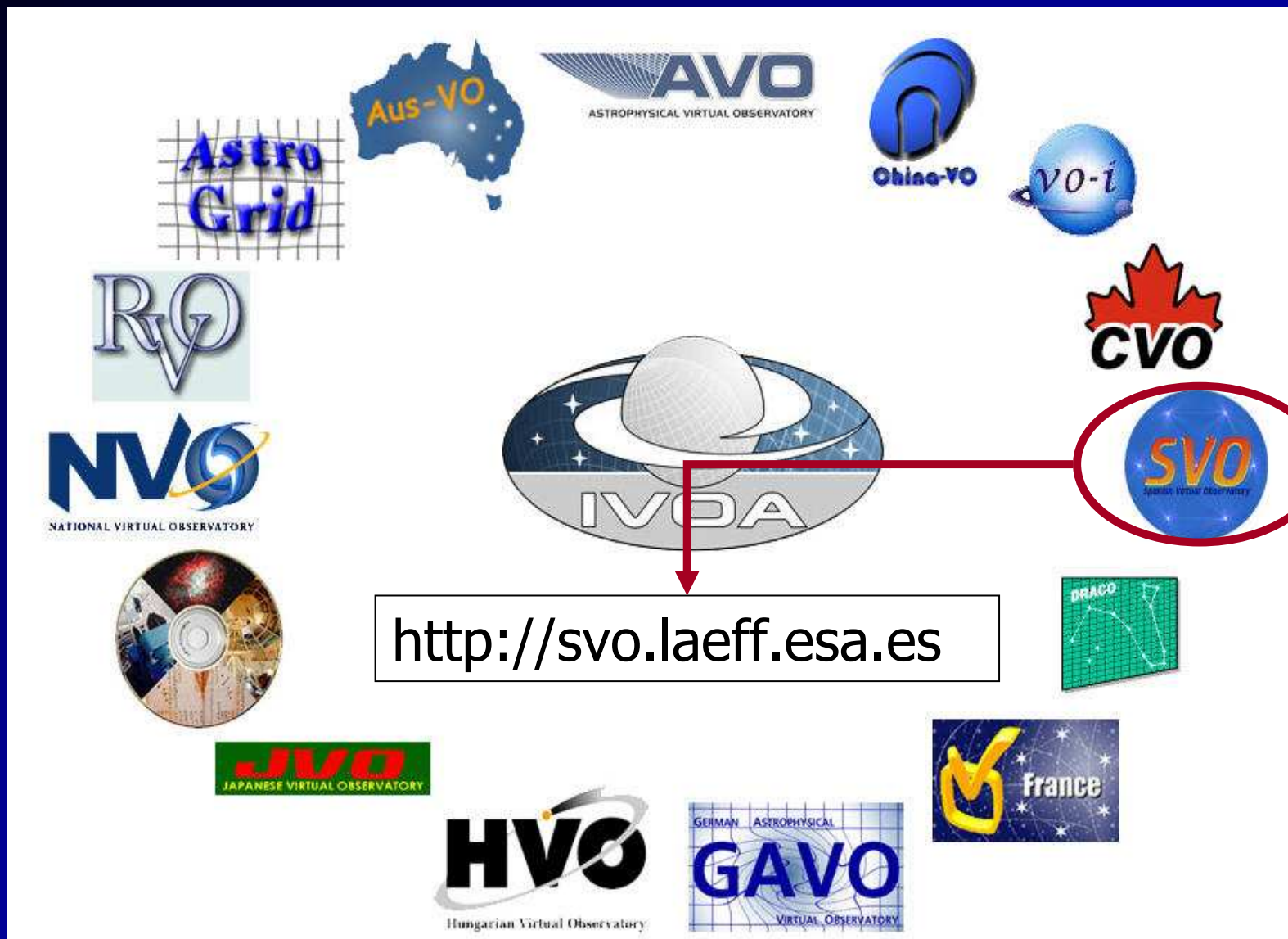


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How is the VO structured?



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The Spanish Virtual Observatory

The screenshot shows the homepage of the Spanish Virtual Observatory (SVO). At the top, there is a navigation bar with the SVO logo on the left, the text "SPANISH VIRTUAL OBSERVATORY" in the center, and the date and time "JUN 01, 2006 - 11:36 AM" on the right. Below the navigation bar, the main header features the SVO logo, the text "Spanish Virtual Observatory", and logos for the "MINISTERIO DE EDUCACION Y CIENCIA" and "INTA".

The main content area is divided into several sections:

- About SVO**
 - Home
 - Gral Info (Spanish)
 - Gral Info (English)
 - Participating Centres
 - Meetings
 - Distribution Lists
- Internal Information**
 - Project Documentation
- SVO Projects**
 - Astronomical Data Centres
 - Data Analysis/Data Mining Tools
 - Theory in the VO
- Publications**
 - Papers
 - Posters
 - Press Releases
 - SVO in the Media

The central text area contains the following information:

The Spanish Virtual Observatory

Although astronomical archives constitute basic tools for modern Astrophysics as revealed by their intensive usage, it is also true that the efficiency in the information retrieval is seriously limited by the lack of interoperability among them. The Virtual Observatory is a project designed to provide the astronomical community with the data access, research tools and systems, research support, data interoperability standards, data-flow practices and data centre coordination, necessary to enable the exploration of the digital, multi-wavelength universe resident in the astronomical data archives.

The **Spanish Virtual Observatory (SVO)** officially started in June 2004 and it is supported by the Spanish Plan of Astronomy and Astrophysics (project AYA2004-00253). Its purpose is to provide an efficient coordination among the different national initiatives in the framework of the Virtual Observatory and to achieve an effective integration of all the expertise in this research domain.

First Meeting of the SVO Thematic Network: Madrid, April 6-7, 2006

On the right side of the page, there is a **Login** form with fields for "User name" and "Password", a "Remember me" checkbox, and a "Log in" button. Below the login form, there are links for "Log in Problems?" and "New User? Sign Up!".

- More than 60 people from 17 centres.

Conclusions

- VO is not science-fiction. It's a reality. →
- VO is an essential tool for multi- λ astronomy.
- VO is not only for people interested in handling large volumes of data. (e.g. "give me all spectra of A-type stars in a given range and with resolution $> R$).
- VO has crossed the non-return point: The biggest data providers (NASA, ESA, ESO, ...) have understood the importance of this initiative and are already adapting their contents to VO requirements.
- The successfulness of VO from the scientific point of view strongly depends on the interaction with the scientific community.



From Demo to Real Science

- **Extragalactic case:** Discovery of 30 type 2 QSOs.

→ First refereed astronomical paper enabled via end-to-end use of VO tools and systems:

A&A 424, 545–559 (2004)
DOI: 10.1051/0004-6361:20041153
© ESO 2004

**Astronomy
&
Astrophysics**

Discovery of optically faint obscured quasars with Virtual Observatory tools

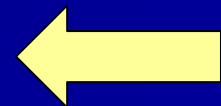
P. Padovani¹, M. G. Allen², P. Rosati³, and N. A. Walton⁴



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VO misconceptions



VO misconceptions



Discovering type 2 quasars

- Seyfert 2's high-power counterparts. Characterized by narrow lines and hard X-ray emission ($L_x > 1e44$ erg/s).

- **Data:** X-ray catalogue for the two GOODS fields

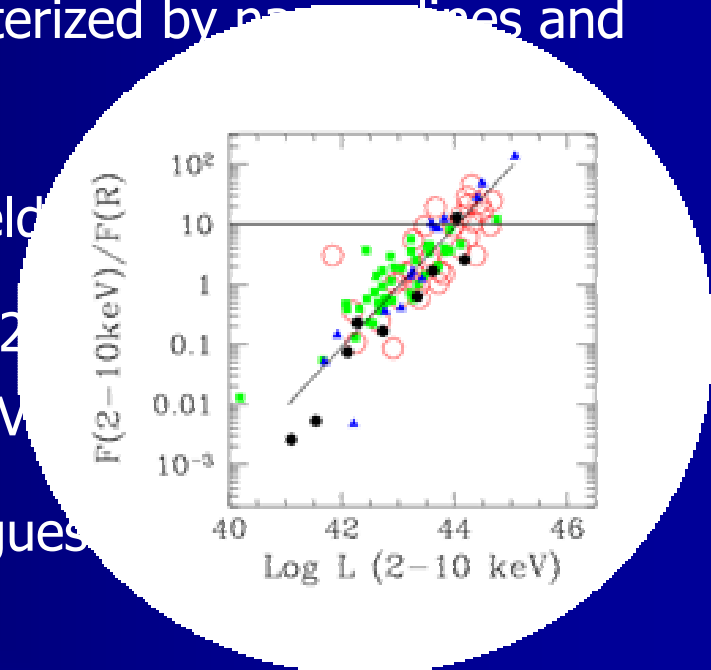
- **Filtering:** $HR \geq -0.2$ for absorbed sources \rightarrow 2
 $HR = (H+S) / (H-S)$; $H = (2.0 - 8.0$ keV)

- **Cross-matching** with the GOODS ACS catalogues
counterparts \rightarrow 168 matches.

- **Data manipulation:** X-ray power for unidentified sources derived from:

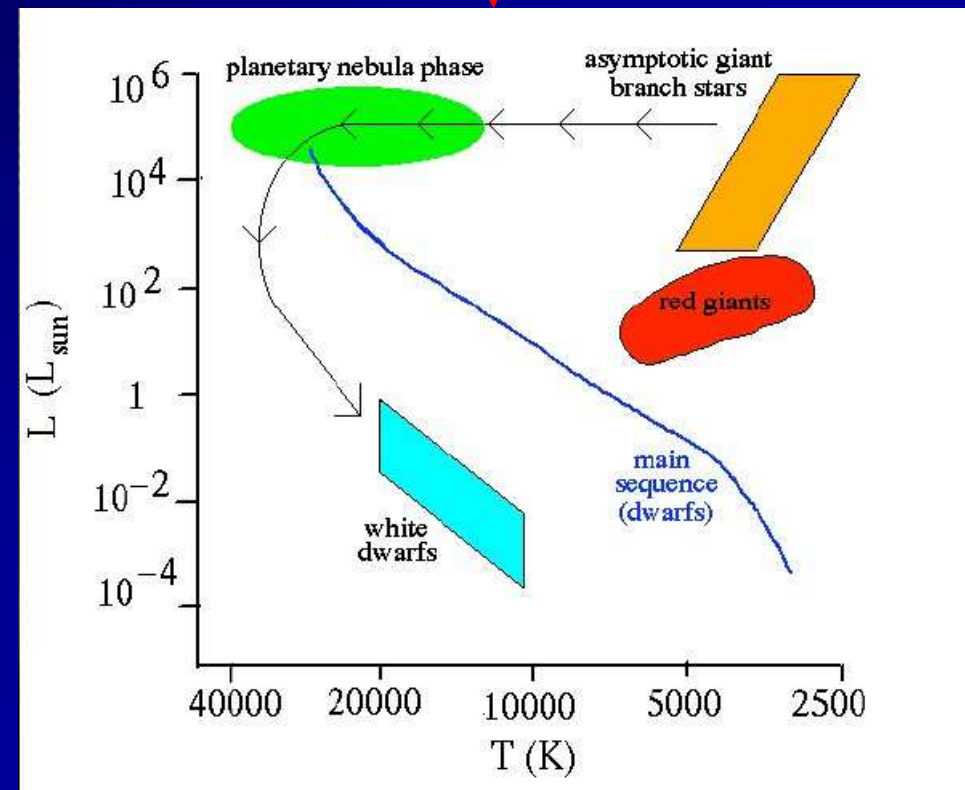
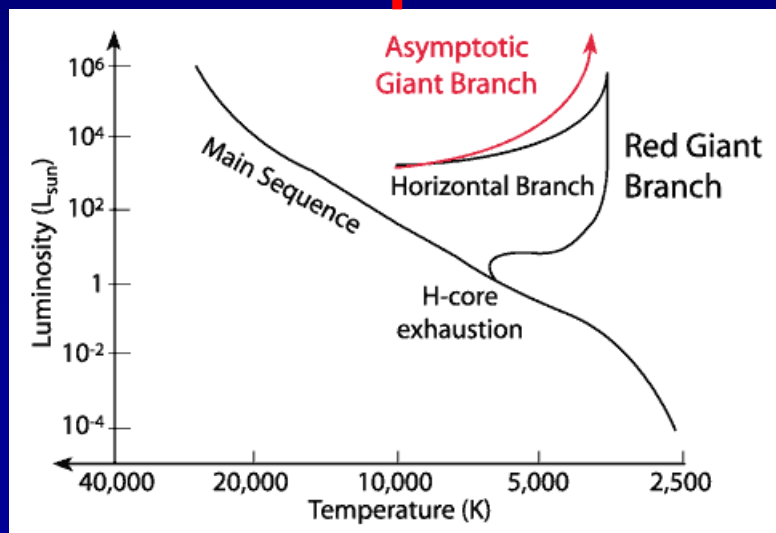
$$\text{Log } L(2-10) = \log f(2 - 10 \text{ keV}) / f(R) + 43.05 \text{ (Fiore 2003).}$$

- **Results:** 31 new QSOs 2 (only 9 sources previously known).



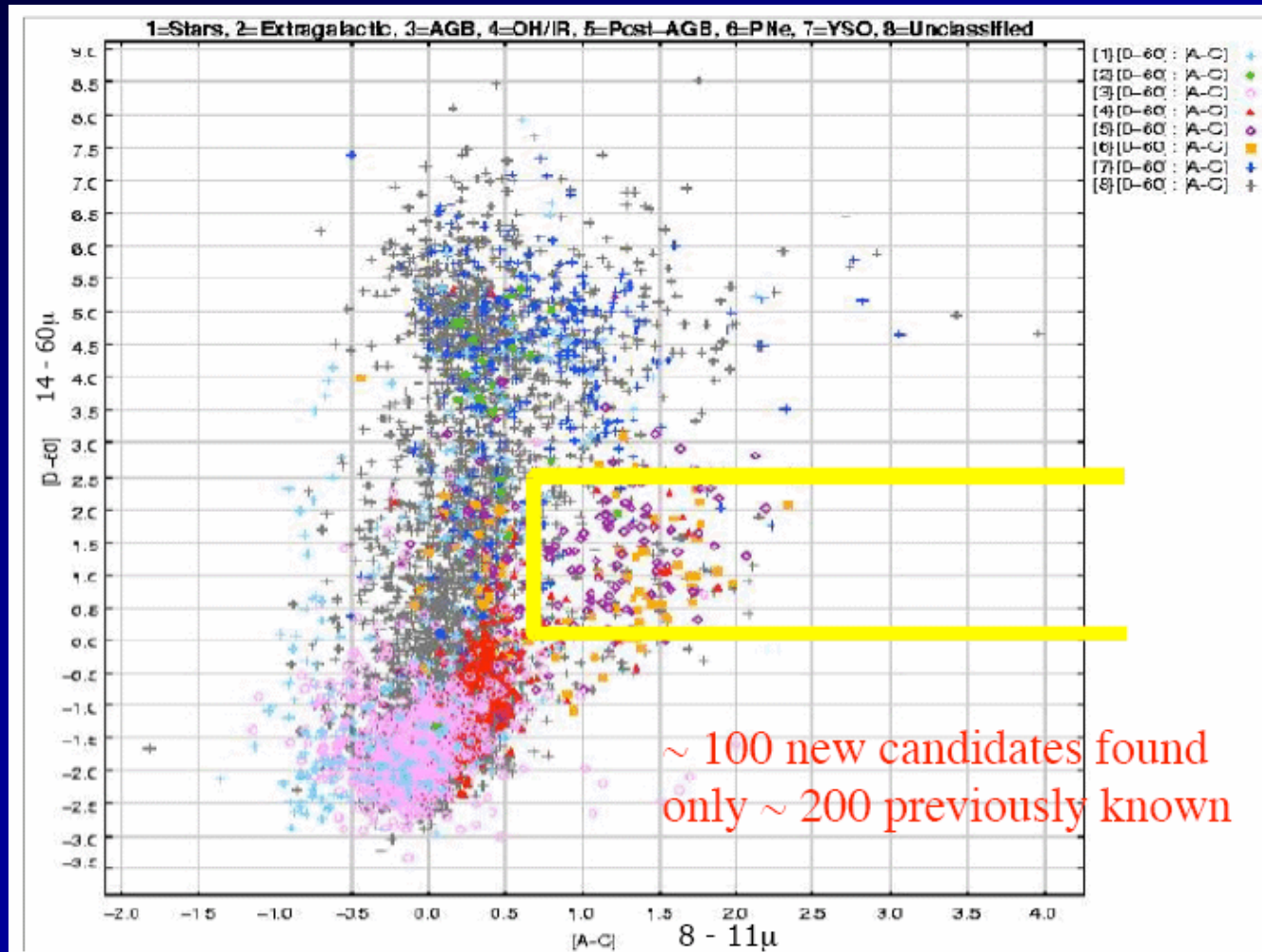
Scientific Demos: AGB stars to PNe

- Short transition times \rightarrow Few objects in this phase.
- Stellar case for the AVO Demo 2005 (García Lario, Bayo, Sierra)
- **GOAL: Identification of new candidates in the transition source.**
- Many are heavily obscured in the optical by thick CS envelopes
 consequently to many stages of low-mass intermediate mass stars
 IR data: MSX and IRAS catalogues.



AGB stars to PNe (II): Workflow

- Selection criteria: $|b| \geq 2$ deg.
- Column manipulation
- Cross-matching with SIMBAD.
- Cross-matching with IRAS



AGB stars to PNe

VO gain: Efficiency

A spectroscopic atlas of post-AGB stars and Planetary Nebulae selected from the IRAS Point Source Catalogue. *

O. Suárez¹, P. García-Lario², A. Manchado^{3,4}, M. Manteiga⁵, A. Ulla⁶, and S.R. Pottasch⁷

Abstract. We present low-resolution optical spectroscopy, finding charts and improved astrometric coordinates of a sample of 254 IRAS sources showing far infrared colours similar to those of well-known planetary nebulae. 106 sources are classified as post-AGB stars, 21 as “transition sources”, and 36 as planetary nebulae, some of them strongly reddened. The large majority remained unidentified in the literature or were poorly known by the time when this spectroscopic survey started, some 15 years ago. Among the rest of sources in the sample, we were also able to identify 38 young stellar objects, 5 peculiar stars and 2 Seyfert galaxies. Up to 46 sources in our spectroscopic sample were found to show no optical counterpart, most of them are suggested to be heavily obscured post-AGB stars, rapidly evolving in their way to become planetary nebulae. A preliminary analysis of the distribution of post-AGB stars and PNe in the IRAS two-colour diagram is presented, as well as of their galactic latitude distribution. We also analyse the spectral type distribution of the post-AGB stars observed.

Key words. Planetary nebulae – stars: AGB and Post-AGB – infrared radiation – stars: mass loss



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