CENTRE DE DONNÉES ASTRONOMIQUES DE STRASBOURG

Observatoire Astronomique de Strasbourg

Introduction to the Virtual Observatory

Centre de Données de Strasbourg

Data avalanche in Astronomy

- *Very large surveys:*100 million of sources, less than 3000 sources per night ⇒ > 100 nights to identify them

- *Very large data collections*: downloading and analysing the data on personal computers becomes problematic, or even impossible.
  E.g download SDSS DR6 :
  ✓ images (10 Terabytes) ⇒ ~ 3 months at 10 Mbps
  ✓ catalogues (2 Terabytes) ⇒ ~ 3 weeks
  ✓ On DVDs ⇒ you will need ~ 2100 of them
- How to do *data analysis*??

astronomy & open digital data

- Data has no commercial value
  - Free, open access
  - Simplifies collaborations, data exchange…
- Data volume always at the limit of the technology
- Data become independant from scientific results.
- <u>New knowledge can arise from cross-correlating data from various origins</u>

The Virtual Observatory
(formal definition)

Set of tools, systems, standards, protocols and organisational structures required to allow international usage of astronomical data in an integrated and interoperable manner.

Astronomy (since 2000) and then closeby disciplines (PLASMA Physics, planetology, héliophysics, etc….)

The Virtual Observatory
(operational definition)

- Web: all documents on a personnal computer
- VO: <u>*all astronomical data bases on a personnal computer*</u>

- What the VO is not:
  - A centralized data base that contains all astronomical data
  - A monolithic software
  - A peer-to-peer system

- All this requires that the different parties speak the same language ⇒ VO standards and VO protocols are defined

- But the <u>OV layer</u> remains <u>transparent to the users</u>

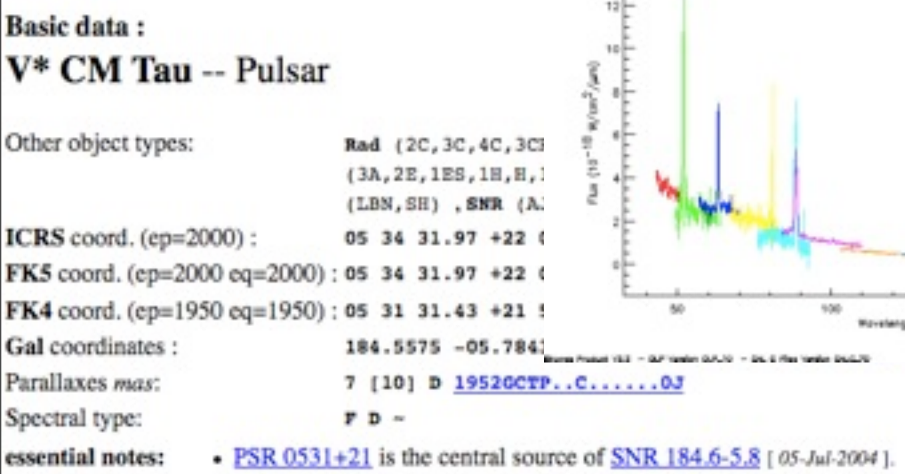
IVOA

International Virtual Observatory Alliance

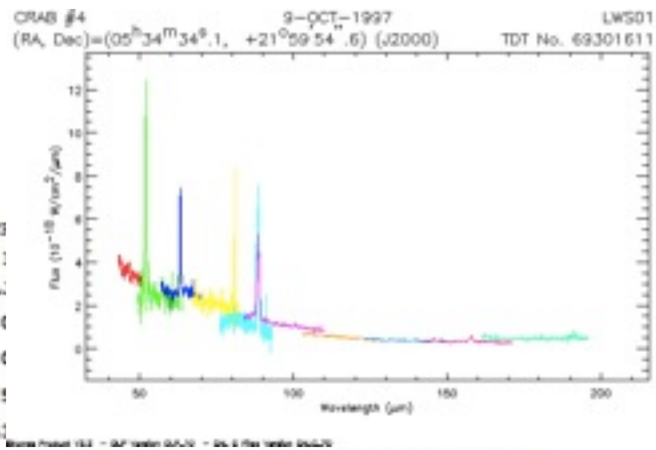
• Created in 2002 to facilitate international coordination and collaboration necessary for development and OV deployment

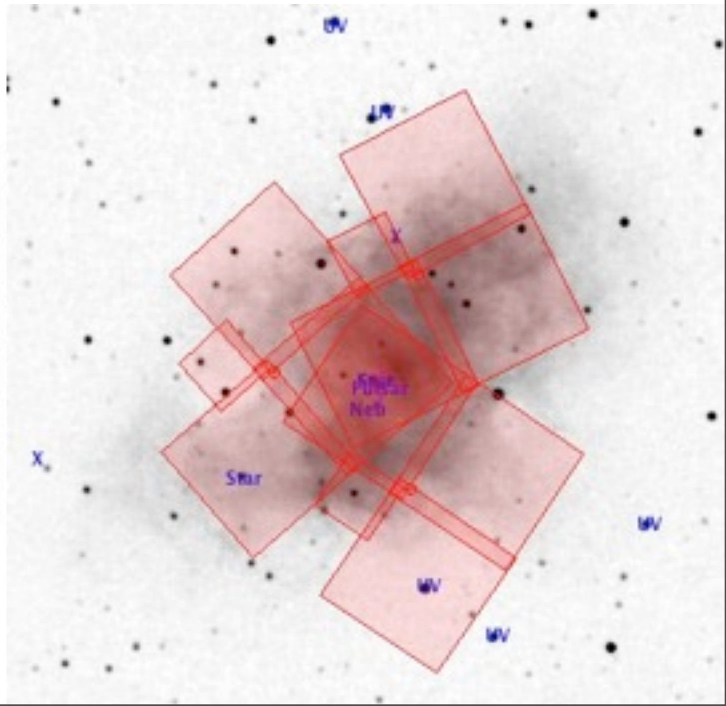
The Virtual Observatory

- Astronomers questions the VO can answer:
  - Are there data that…
  - Where can I find data/tools that…
  - What is the format of…
  - What is the content of…


Basic data :
V* CM Tau -- Pulsar

Other object types:	Rad (2C,3C,4C,3C (3A,2E,1ES,1H,H, (LBN,SH) , SNR (A
ICRS coord. (ep=2000) :	05 34 31.97 +22
FK5 coord. (ep=2000 eq=2000) :	05 34 31.97 +22
FK4 coord. (ep=1950 eq=1950) :	05 31 31.43 +21
Gal coordinates :	184.5575 -05.784
Parallaxes *mas*:	7 [10] D 1952GCTP..C......0J
Spectral type:	F D ~
essential notes:	• PSR 0531+21 is the central source of SNR 184.6-5.8 [*05-Jul-2004*].





Data Centers

- The essential bricks of the VO
- Data centers in the VO can be very different, including very small teams
- Archives data, services with added value, software development,…
- Keywords: user services, quality, sustainability
- In Strasbourg:

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VO core: Standards!

- Protocols to:
  - Access images, access spectra, access tables
  - Exchange messages between applications
- Standard data formats
  - VOTable, FITS
  - UCDs (Unified Content Descriptors)
- Data models & meta-data
  - Describe the data
    - Instrument used, wavelength, epoch, …
  - What makes this dataset different from others?

And now, let us show you how it works!

Give you a flavor of the VO

Half tutorial - half demo

Multi-instrument, multi-wavelength study of high energy sources with the Virtual Observatory

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Goal of this tutorial

This tutorial demonstrates how to use several standard tools of the Virtual Observatory (VO) for data mining and multiple waveband data analysis. The step-by-step application below focuses on towards applications in the gamma-ray and high energy domain, but also involves observational data from other wavebands. The user may explore how to...

- query astronomical catalogues in the gamma-ray and high energy spectral band using OV tools
- cross-correlate catalogues to find an object at different photon energy bands
- apply selection criteria when extracting sources from a catalogue
- use the observational measures of the selected objects to explore possible correlations
- visualize astronomical images from the radio up to the high energy domain
- display spectral energy distributions obtained from different photometric data sets

x-match and analysis of HESS sources observed with the FERMI satellite

Question: How can one use the VO to find counterparts of HESS sources at FERMI-LAT energies ?

Question: How are HESS sources of different astronomical type localized on a "color-color plot" at GeV and sub-GeV energies ?

Note: In stellar astronomy, color-color plots are a very efficient tool for source identification without requiring detailed spectroscopy.

Question: How do HESS sources appear on a broad spectral range in terms of imaging and photometry ?

The broad-band spectrum of the high-energy blazar PKS 2155-304

- AGN with a ballistic, kpc-scale jet directed nearly along the line of sight

- radio to high-energy spectrum explained by synchrotron self-Compton emission originating in the jet plasma (however, details are still to be constrained)