



ASTROPHYSICAL VIRTUAL OBSERVATORY

## **SCIENCE** with (A)VO Tools

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**AVO Science Manager**

- The Virtual Observatory (VO) and the AVO
- VO-Science: the first VO-based refereed astronomical paper
- The near future

# Astronomy in the XXI century

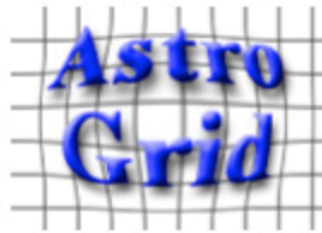
Radical changes are needed!

- Huge surveys: 100M sources at <3k spectra/night  $\Rightarrow$  **>100 yr!**
- Ever fainter sources: surpassed the identification limits of 8 - 10m telescopes ( $R_{\text{mag}} \approx 25$ )
- Huge data collections: downloading Sloan Digital Sky Survey (SDSS) DR3 ( $\sim 1/2$  of total) images (6 Tb)  $\Rightarrow$   **$\sim 2.3$  months** at 1 Mb/s (ESO's speed); catalogs (2.3 Tb)  $\Rightarrow$   **$\sim 1$  month**. On DVDs  $\Rightarrow$   **$\sim 1,300$**  of them. And analysis?? (similar size for MACHO, 2MASS etc ...)
- Ever increasing amount of data ( $\sim 1$  Tb/night)



# The solution: Virtual Observatory

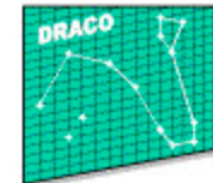
- An innovative, *evolving* system, which takes advantage of astronomical data explosion
- It will allow users to interrogate multiple data centres in a seamless and transparent way and to utilize at best astronomical data
- Data analysis tools (*in-situ*) and models will be made more accessible
- It will allow new *SCIENCE* by moving Astronomy beyond era of "classical" identification by combining **all** available information: data mining (increase obs. efficiency) + statistical identification (less need for spectra)
- Good communication  $\Rightarrow$  common language! Adoption and definition of VO standards and protocols within the International Virtual Observatory Alliance (IVOA: <http://ivoa.net>)
- And it's all happening now: see the many talks and posters [ $> 1/5$ ]



# International Virtual Observatory Alliance



*To facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory*



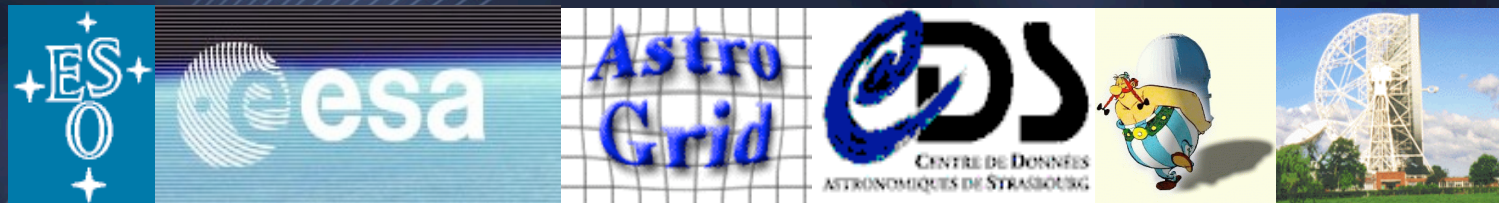




<http://www.euro-vo.org>

# Virtual Observatory in Europe

- R&D on scientific requirements and technology for building a EURO-VO, 50% funded by European Community



- Phase A, 2001 - 2004/5
- Driven by strategy of **scientific VO annual demonstrations**
- Science Working Group established to provide scientific advice to AVO project

# January 2004 SWG Demo Overview

- Two scenarios:
  - Extragalactic: **Obscured (Type 2) Quasars**
  - Galactic: **Classification of Young Stellar Objects (YSO)**
- Multiwavelength, heterogeneous, and complex data: VLA, CGPS, ISO, 2MASS, USNO, 2.2m/WFI, VLT/FORS, HST/ACS, XMM, and Chandra (images, spectra, and catalogues)
- Access to any **VO-compliant** data: seamless and transparent access to ESA ISO & XMM archives and ESO data products
- **AVO: from First Light (2003 demo) to First Science!**



# VO First Science!

- 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, Allen, Rosati, & Walton, 2004, A&A, 424, 545

ESA/ESO Press release May 28



# Relevant Quotes ...

## ■ Slashdot

- “We are using laboratories which don’t physically exist to detect things we can’t actually see ...”
- “It’s official: The Universe Sucks”

## ■ Deutschland Radio

- “The observatory might be virtual but the science is very real!”



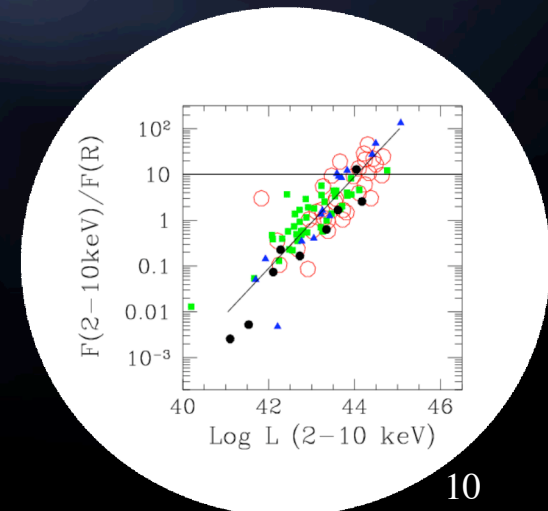
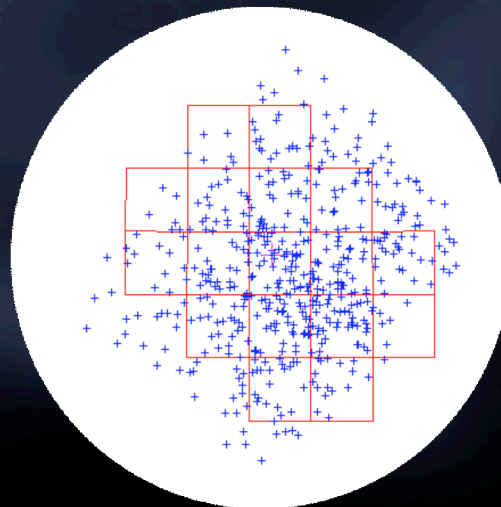
# The AVO Prototype

- Evolution of Aladin (Centre de Donnés astronomiques de Strasbourg [CDS])
- Downloadable Java application  
(<http://www.euro-vo.org/twiki/bin/view/Avo/SwgDownload>)
- Registry of services (Générateur de Liens Uniformes: GLU)
- Extensible toolset with plug-ins which allows easy access to images (manipulation), spectra, catalogues, with overlays, plotting facilities, catalogue extraction, and a cross-correlation utility [ASTROGRID, VOIndia, STScI]
- Interoperable with other VO tools  
(see next talk!)

# Discovery of QSO 2s with VO tools

- GOODS (Koekemoer's talk) HST/ACS data & catalogues
- Chandra X-ray catalogues
- Select absorbed X-ray sources
- Cross-match X-ray and optical
- Check against spectroscopy
- Apply empirical estimator for  $L_x$

$L_x > 10^{44}$  erg/s: QSO 2



Oct. 26, 2004

P. Padovani, ADASS XIV

10



2MASS  
 ESO-WFI  
 Chandra  
 VLT-ISAAC  
 HST-ACS  
 DSS  
 My Data

Tree view

Data Tree

- GOODS-WFI
  - DEEP2C-FV-PREVIEW 38.1 'x37.3' 2000-10-2
  - DEEP2C-FV 8.2 'x8.2' 2000-10-26
- GOODS-ACIS
  - LR-1-10KEV
  - ACISMCDFSN000 1.2 'x1.2' 1999-10-14
  - HR-1-10KEV
- GOODS-ISAAC
  - J
    - GOODS-10 2.5 'x2.5' 08/04/2002
    - GOODS-11 2.5 'x2.5' 08/04/2002
    - GOODS-14 2.5 'x2.5' 08/04/2002
    - GOODS-15 2.5 'x2.5' 08/04/2002
    - GOODS-20 2.5 'x2.5' 08/04/2002
    - GOODS-16 2.5 'x2.5' 08/04/2002
    - GOODS-21 2.5 'x2.5' 08/04/2002
    - GOODS-9 2.5 'x2.5' 08/04/2002
- GOODS-HST-ACS
  - F775W
    - epoch1
    - epoch2
    - epoch3
    - epoch4
    - epoch5
  - version1.0
    - CDF-SOUTH-SECT32-VERSIO
    - CDF-SOUTH-SECT25-VERSIO
    - CDF-SOUTH-SECT23-VERSIO
    - CDF-SOUTH-SECT21-VERSIO
    - CDF-SOUTH-SECT44-VERSIO
    - CDF-SOUTH-SECT14-VERSIO
    - CDF-SOUTH-SECT42-VERSIO
    - CDF-SOUTH-SECT12-VERSIO
    - CDF-SOUTH-SECT35-VERSIO
    - CDF-SOUTH-SECT33-VERSIO
    - CDF-SOUTH-SECT31-VERSIO
    - CDF-SOUTH-SECT24-VERSIO
    - CDF-SOUTH-SECT22-VERSIO
    - CDF-SOUTH-SECT45-VERSIO
    - CDF-SOUTH-SECT43-VERSIO
    - CDF-SOUTH-SECT13-VERSIO
    - CDF-SOUTH-SECT11-VERSIO
    - CDF-SOUTH-SECT34-VERSIO

Data available at selected point are highlighted in tree

Info Frame

CDF-SOUTH-SECT23-VERSION1.0

Observation_Name	CDF-SOUTH-SECT23-VERSION1.0
ObservingProgram_Name	GOODS-HST-ACS
FilterName	F775W
Size_alpha	4.1"
Size_delta	4.1"
Angular Pixel Size	0.029"
Origin	STSCI
OriginalCoding	FITS
Centre(Point)_RA	03:32:38.72
Centre(Point)_DEC	-27:48:18.3
DateAndTime	2002-08-01
Position Angle	0.0°

Cutout Target: 03 32 33.50 -27 47 36. Grab

Stick FoV in stack LOAD Close

Image metadata

A.V.0 demonstration prototype v1.0

ALADDIN for AVO

Load... Save... Plugins... Print... Help... Quit

J2000 03:32:33.50 -27:47:36.9 Field: 03:32:25.77 -27:48:07.4 38.08'x37.2'

cdfs

select, draw, text, tag, dist, filter, rgb, cont, hist, zoom, mglss, del, pad

FoV for epoch2  
 FoV for epoch1  
 GOODS-WFI

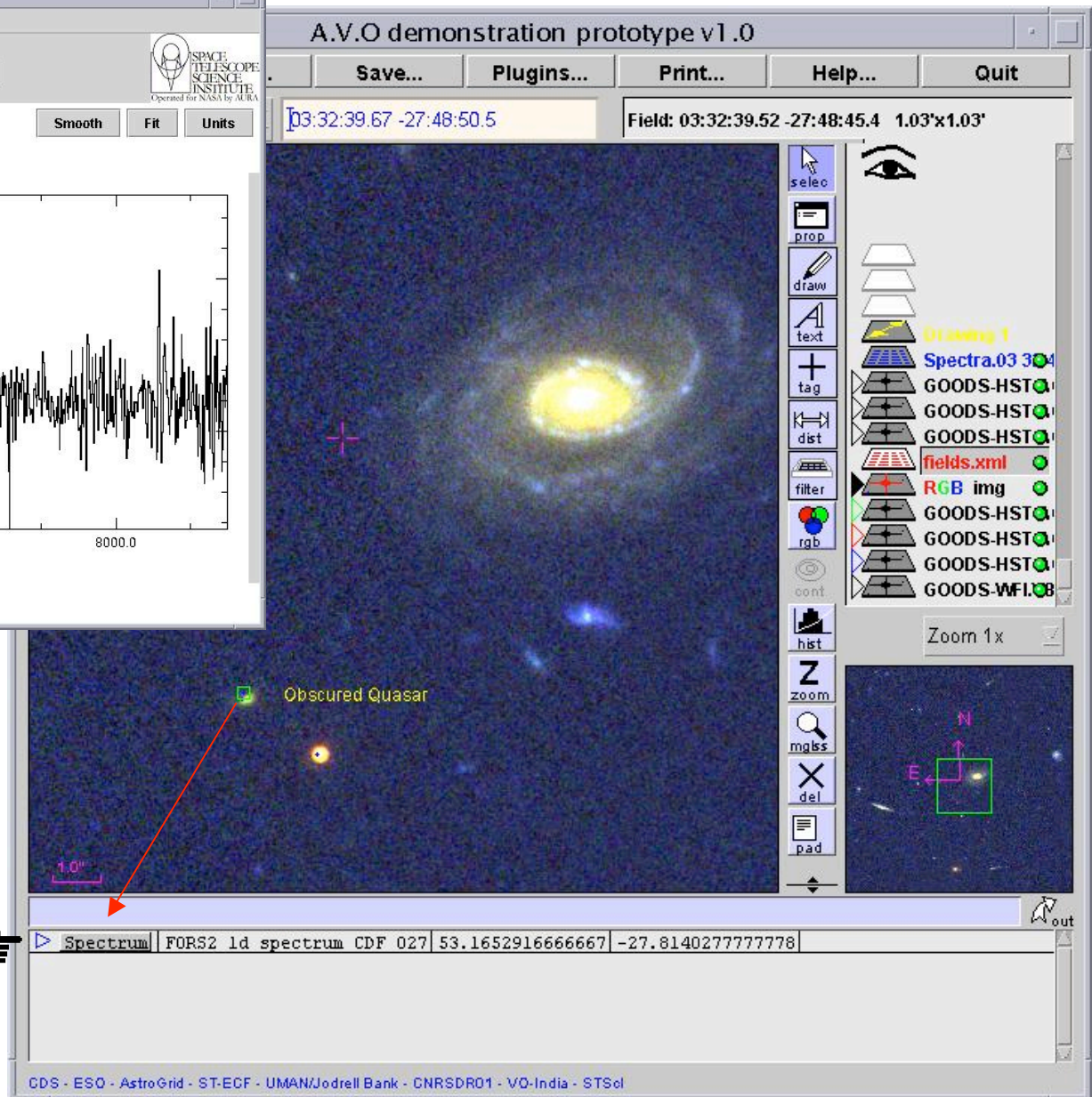
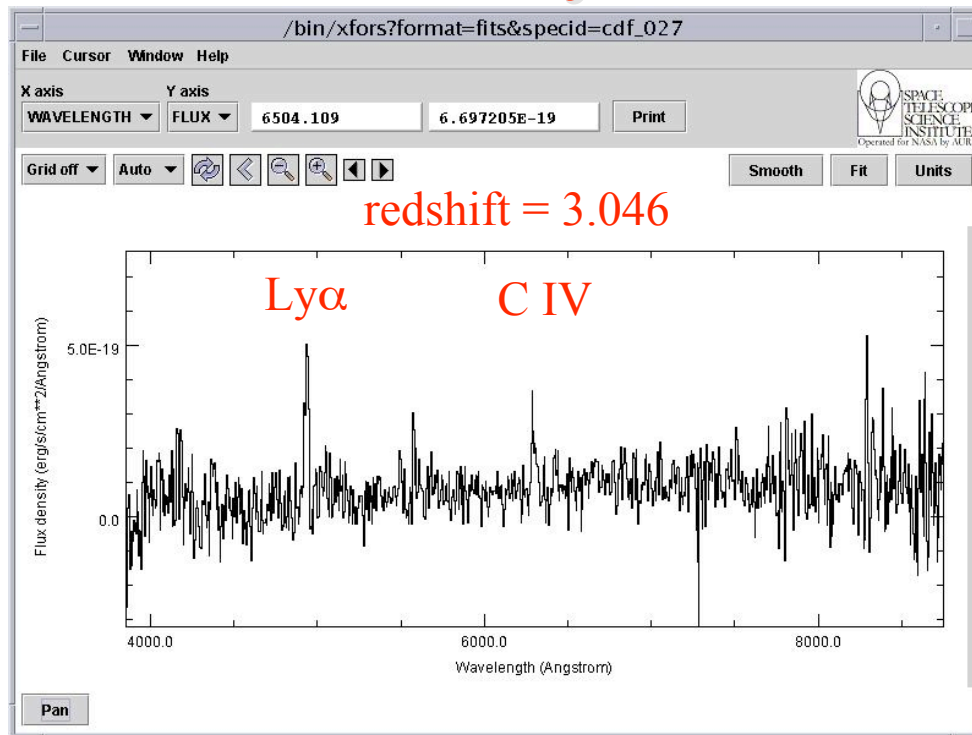
Zoom 1x

1.0"

CDS - ESO - AstroGrid - ST-ECF - UMAN/Jodrell Bank - CNRS/DR01 - VQ-India - STScI

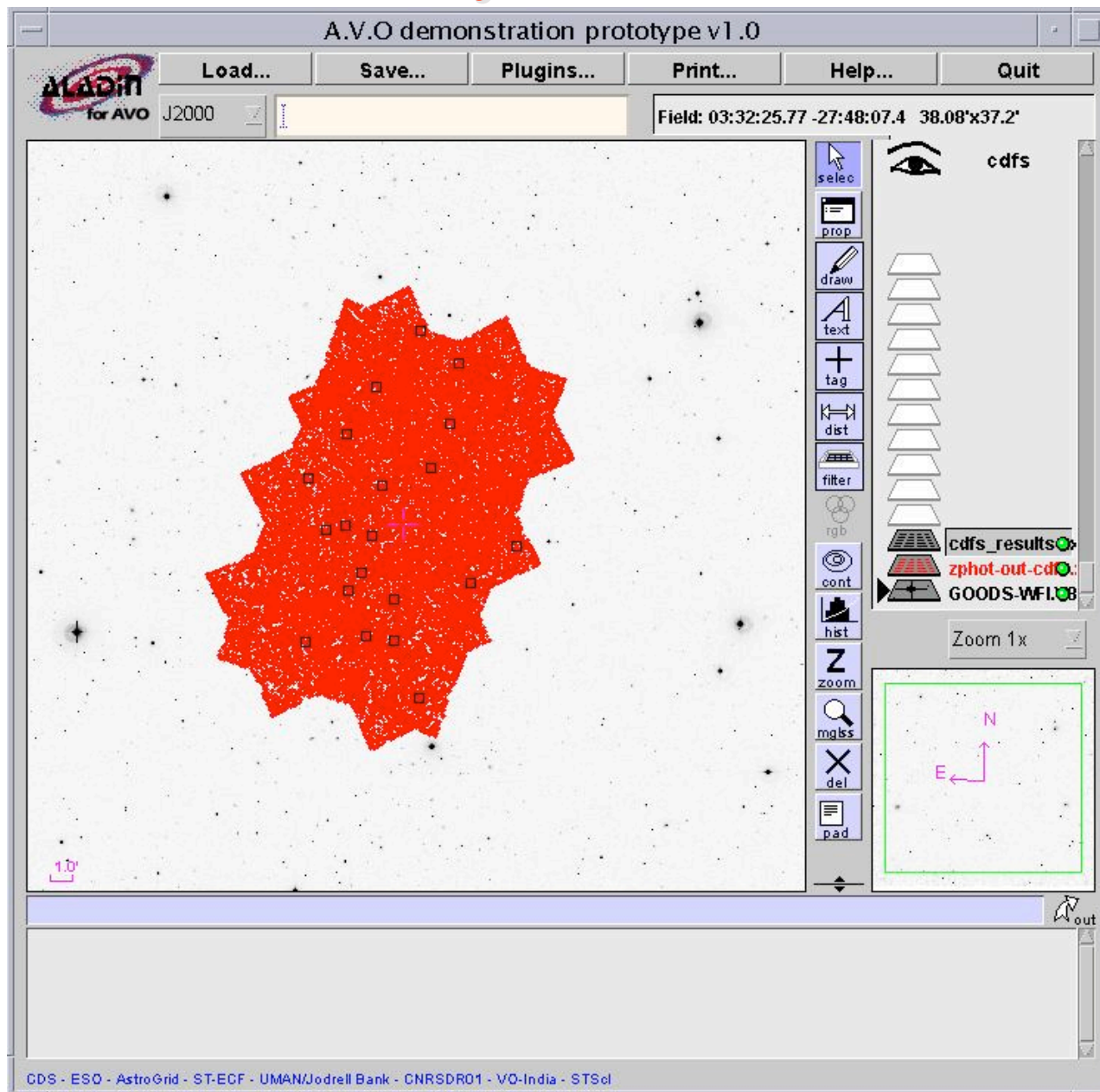
Field of view outlines are plotted automatically

# January 2004: AVO First Science





# January 2004: AVO First Science



~ 30 new  
obscured QSOs  
in GOODS  
CDF5+HDFN

x 4 increase

# VO Science!

- AVO is doing cutting-edge science by exploiting the data beyond “classical” identification limits ( $R > 25$ )
- AVO provides “statistical” identification of sources using multiwavelength information
- VO tools enable astronomers to reach into new areas of parameter space with little effort
- “AVO should enable everyone to compete with the GOODS team (on their data)”  
[G. Gilmore, SWG meeting, June 2002]



# The AVO Science Reference Mission

- The Science Reference Mission (SRM) defines key scientific results that the full-fledged (Phase B) EURO-VO should achieve when fully implemented.
- Will consist of science cases, with related requirements, against which the success of the EURO-VO will be measured.
- Being put together right now, with input from the Science Working Group, final version by January 2005.
- My main message to the SWG: THINK BIG!

# January 2005

## The last AVO Demo

- **Ambitious! Two scenarios being worked on:**
  - Extragalactic: Star Formation Histories in Galaxies (ELAIS fields)
  - Galactic: Transition from Asymptotic Giant Branch (AGB) to Planetary Nebulae (PN)
- **Multiwavelength, heterogeneous, and complex data (images, spectra, and catalogues): VLA, IRAS, ISO, 2MASS, MSX, Spitzer, 2.2m/WFI, INT/WFS, IUE, Chandra**
- **Technical side: distributed workflows, registry harvesting, sophisticated astronomical applications as Web services**
- **AVO  $\Rightarrow$  EURO-VO; VO-TECH: 6.6 M€ from EC, 12 FTEs (+ 12 from partners) for VO development at Edinburgh, Leicester, Cambridge, ESO, CDS, and INAF.**



# Summary

- The Virtual Observatory is happening, because it has to!
- Astronomy IS being done with Virtual Observatory tools!
- AVO (soon to be EURO-VO) is committed to the pursuit of science with VO tools through:
  - Scientific demonstrations
  - Science papers
  - Science Reference Mission
- “Astronomical research with the VO”: Jan. 05 AAS

Astrophysical Virtual Observatory - Netscape

Back Forward Reload Stop <http://www.euro-vo.org/> Go Search Print

Mail Home Search Bookmarks AVO Work Are... DXRBS FSRQ Google MAST la Repubblica Webmail Internet

Astrophysical Virtual Observatory



Virtual Observatory..?

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- [Q & A](#)
- [Movie](#)

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**First VO Paper and Press Release**  
**May 28, 2004** The first major discovery to be made with the Virtual Observatory was announced today to the press. The AVO science team discovered 31 previously undetected powerful supermassive black holes in the so-called GOODS (Great Observatories Origins Deep Survey) fields. The [paper](#) describing these results will be published in an upcoming issue of *Astronomy & Astrophysics*.

[Release Page >](#)

## AVO Web Page



**Interoperability Meeting**  
**May 24-28, 2004** The Spring 2004 IVOA Interoperability Workshop was held in Cambridge, Massachusetts, USA, hosted by the Smithsonian Astrophysical Observatory/Chandra X-Ray Center. There were work sessions for all IVOA Working Groups, plus for two new Interest Groups.

[Meeting Page >](#)



**AVO 1<sup>st</sup> Science**  
**January 27, 2004** A year ago the AVO project had its *first light* and introduced a suite of tools. This year there is the AVO 1<sup>st</sup> Science: the AVO team shows scientific results and the means used to derive them to an advisory committee of Astronomers and international visitors. One highlight: for the first time spectroscopic data were analyzed within the Virtual Observatory framework.

[Event page >](#)



**Interoperability Meeting**  
**October 16-17, 2003** Following the ADASS conference in Strasbourg,

AN EC RTD PROJECT 2002-2004

European Southern Observatory • European Space Agency • UK ASTROGRID Consortium • Centre de Données astronomique de Strasbourg • TERAPIX • Jodrell Bank Observatory

AVO prototype downloadable at  
<http://www.euro-vo.org/twiki/bin/view/Avo/SwgDownload>