



ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

The Virtual Observatory

Paolo Padovani

Head, Virtual Observatory Project Office, ESO

EURO-VO Facility Centre Scientist

Chair, International Virtual Observatory Alliance Executive Committee





ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

The way Astronomy works

- Telescopes (ground- and space-based, covering the full electromagnetic spectrum) \Rightarrow Observatories
- Instruments (telescope/band dependent) \Rightarrow Observatories/Consortia
- Data analysis software (instrument dependent) \Rightarrow Observatories/Consortia/Researchers
- *Active* Archives \Rightarrow Observatories/Agencies
- Publications \Rightarrow Journals
- Data curation (metadata + tables & catalogues) \Rightarrow Data curators
- ... and Public Outreach \Rightarrow Observatories/Agencies





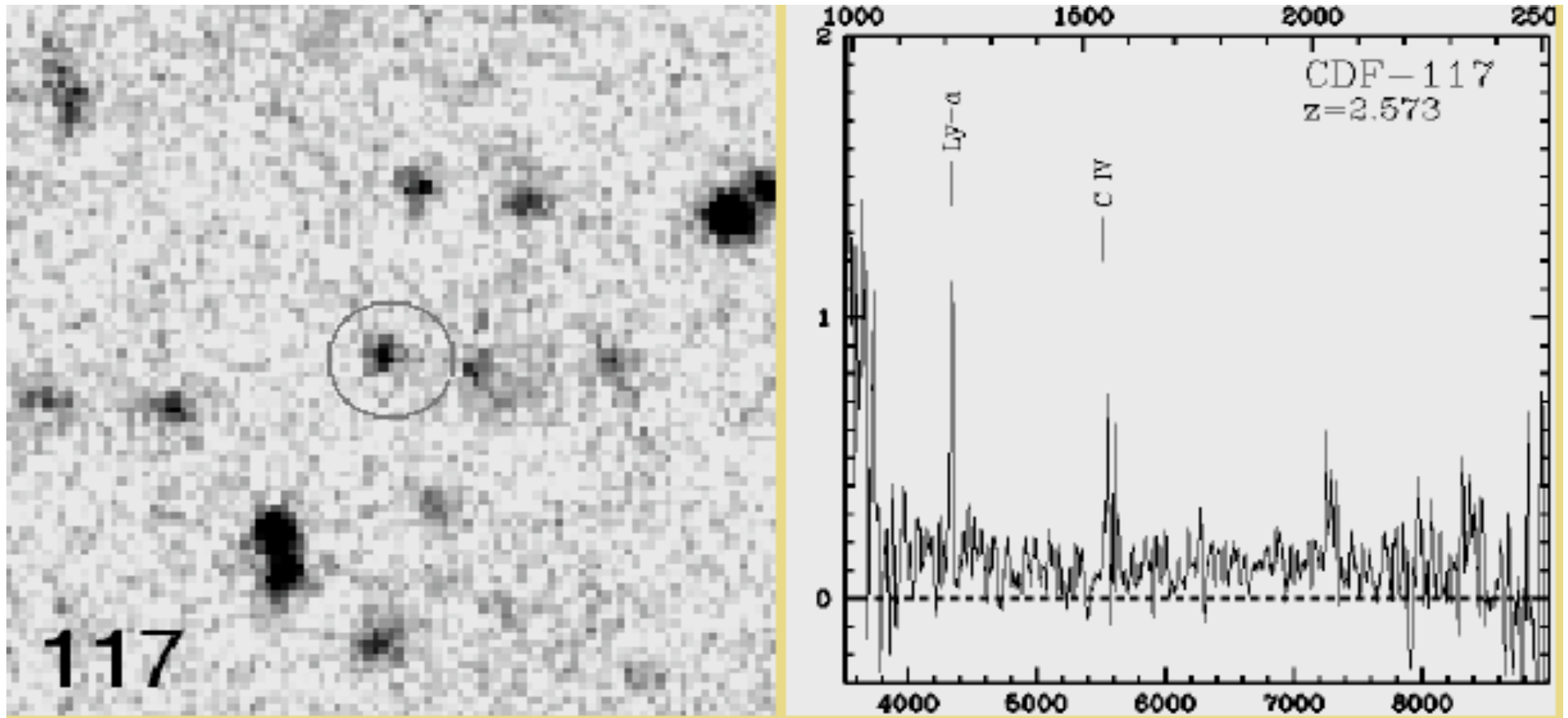
ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

Information Avalanche

- Huge surveys: 100 million sources at < 3000 sources per night \Rightarrow > 100 years to observe them
- Ever fainter sources routinely surpassing the identification limits of 8 - 10m telescopes [$R \approx 25$]
- Huge data collections: download and data analysis on desktop problematic/impossible. Example: downloading Sloan Digital Sky Survey (SDSS) DR7 data:
 - ✓ images (16 Terabytes) $\Rightarrow \sim 5$ months at 10 Mbps (ESO's speed)
 - ✓ catalogues (18 Terabytes) $\Rightarrow \sim 6$ months
 - ✓ on DVDs $\Rightarrow \sim 7,600$ of them
- And data analysis?? (similar size for MACHO, 2MASS etc ...)





$R \sim 25.5$, VLT/FORS2, $t_{\text{exp}} \sim 2.5$ hrs (Szokoly et al. 2004)



ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere



*courtesy of
P. Quinn*





ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

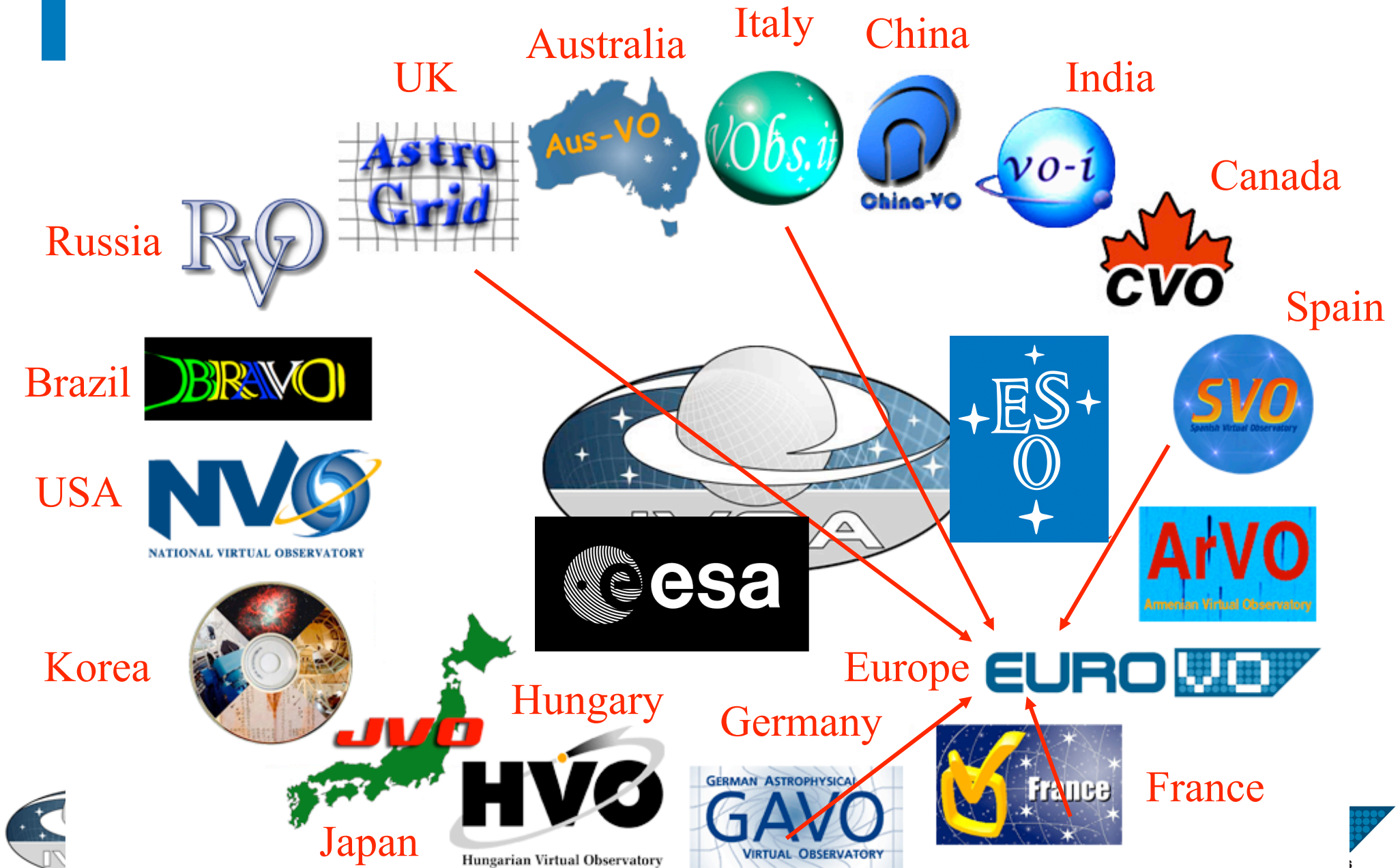
The Virtual Observatory

- The Virtual Observatory (VO) is an innovative, still evolving, system to:
 - take advantage of astronomical data explosion (e.g., use statistical identification to diminish need for a spectrum \Rightarrow multi-wavelength, multi-parameter analysis)
 - allow astronomers to interrogate multiple data centres in a seamless and transparent way and to utilize at best astronomical data
 - permit remote computing and data analysis
 - foster new science
- Web: all documents inside PC; VO: all astronomical databases inside PC
- VO \Rightarrow democratization of astronomy!
- All of the above requires the various players to speak the same language \Rightarrow *VO standards and protocols defined and adopted within the IVOA (International Virtual Observatory Alliance), which includes 17 projects world-wide*



International Virtual Observatory Alliance

17 Member Organizations





ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

The European View: the EURO-VO

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

- Successor to the Astrophysical Virtual Observatory (AVO), which was a 5 M€, Phase A study (2001 - 2004/5) on the scientific requirements and technology for building the VO in Europe, 50% funded by European Community (Fifth Framework Programme [FP5])
- Includes 8 partners: ESO, European Space Agency (ESA), plus six national nodes: INAF (Italy), INSU (France), INTA (Spain), NOVA (Netherlands), PPARC (UK), and RDS (Germany)
- Has three components: Data Centre Alliance, Technology Centre, Facility Centre
- Partly funded by the EC but substantial partner support



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 data, metadata and services to the using VO technology

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. EURO-VO's "public face"

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

@ ESO
managed by
ESO and
ESA

EURO VO

DCA

EURO VO
DATA CENTRE ALLIANCE

EURO VO
TECHNOLOGY CENTRE

EURO VO
FACILITY CENTRE



ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

The EURO-VO Project: AIDA

- The “Astronomical Infrastructure for Data Access (AIDA)” project is funded by the EC FP7 through the Infrastructure call INFRA-2007-1.2.1 “Scientific Digital Repositories”
- AIDA has the same partners as the EURO-VO
- Project started on Feb. 1, 2008, which ensures continuation of European-wide VO activities at least until mid-2010
- AIDA is a combination of DCA, VOTC, and FC activities
- AIDA aims at unifying the digital data collection of European astronomy, integrating their access mechanisms with evolving e-technologies and enhancing the science extracted from these data-sets
- **One of AIDA’s main goals is to support the European astronomical community in their exploitation of astronomical data through VO tools**





ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

The VO and science-ready data

- Astronomical research nowadays needs a variety of multi-wavelength data
- Access to individual archives is time-consuming and not easy: different astronomical archives have widely different access/search interfaces and standards/conventions
- Data reduction requires widely specialized, complex analysis software for various bands (radio, IR, optical, X-ray, etc.)
- Astronomers need and want reduced data!
- The VO provides access to science-ready data. But only if:
 - ✓ they exist!
 - ✓ the data provider has gone through the (often small) effort of “publishing them” to the VO (= following VO standards)





ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

AstroInformatics - VO School

- Goal today: expose attendees to VO tools and services so that they can use them efficiently for their own research; based on our experience, this is the *most effective* way to introduce astronomers to the VO
- Methods:
 - lecture and tutor the participants on the usage of such tools
 - give real life examples of scientific applications
 - hands-on exercises

