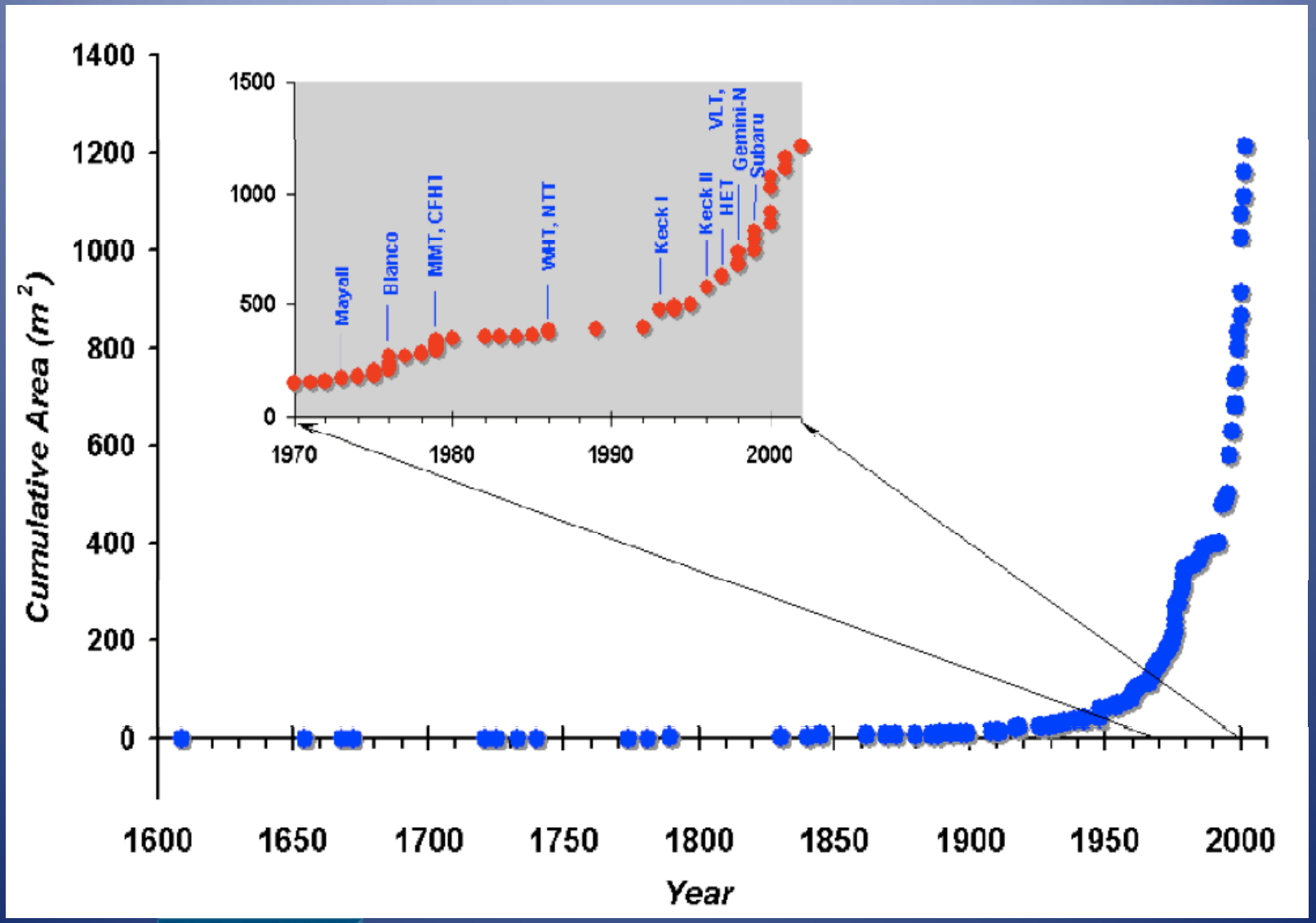
IVOA
International Virtual Observatory Alliance

Fabio Pasian - INAF

ASPERA Workshop

Lyon, 7-8 October 2010

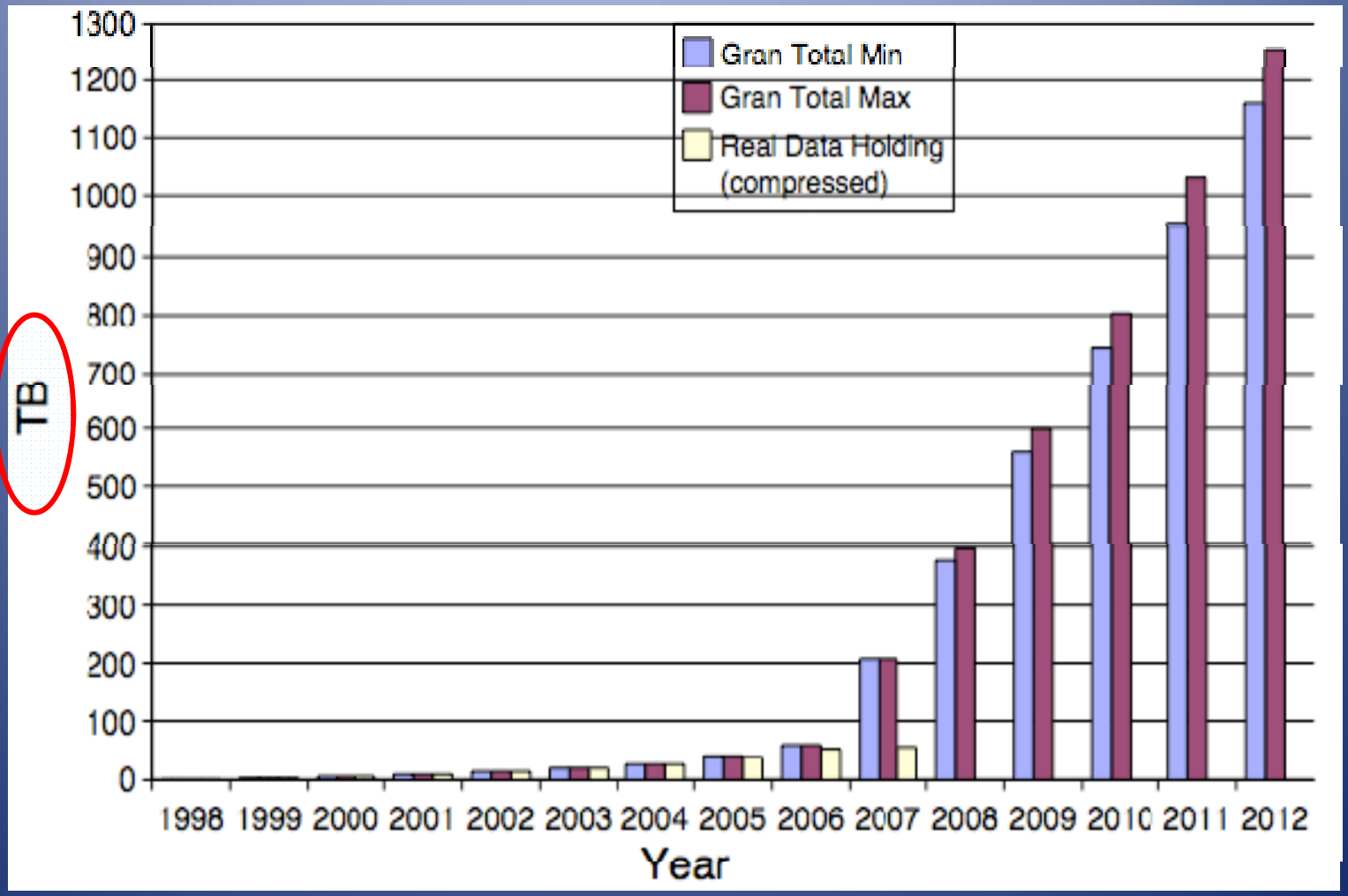
Increase in Telescope Collecting Area



Need for Archives

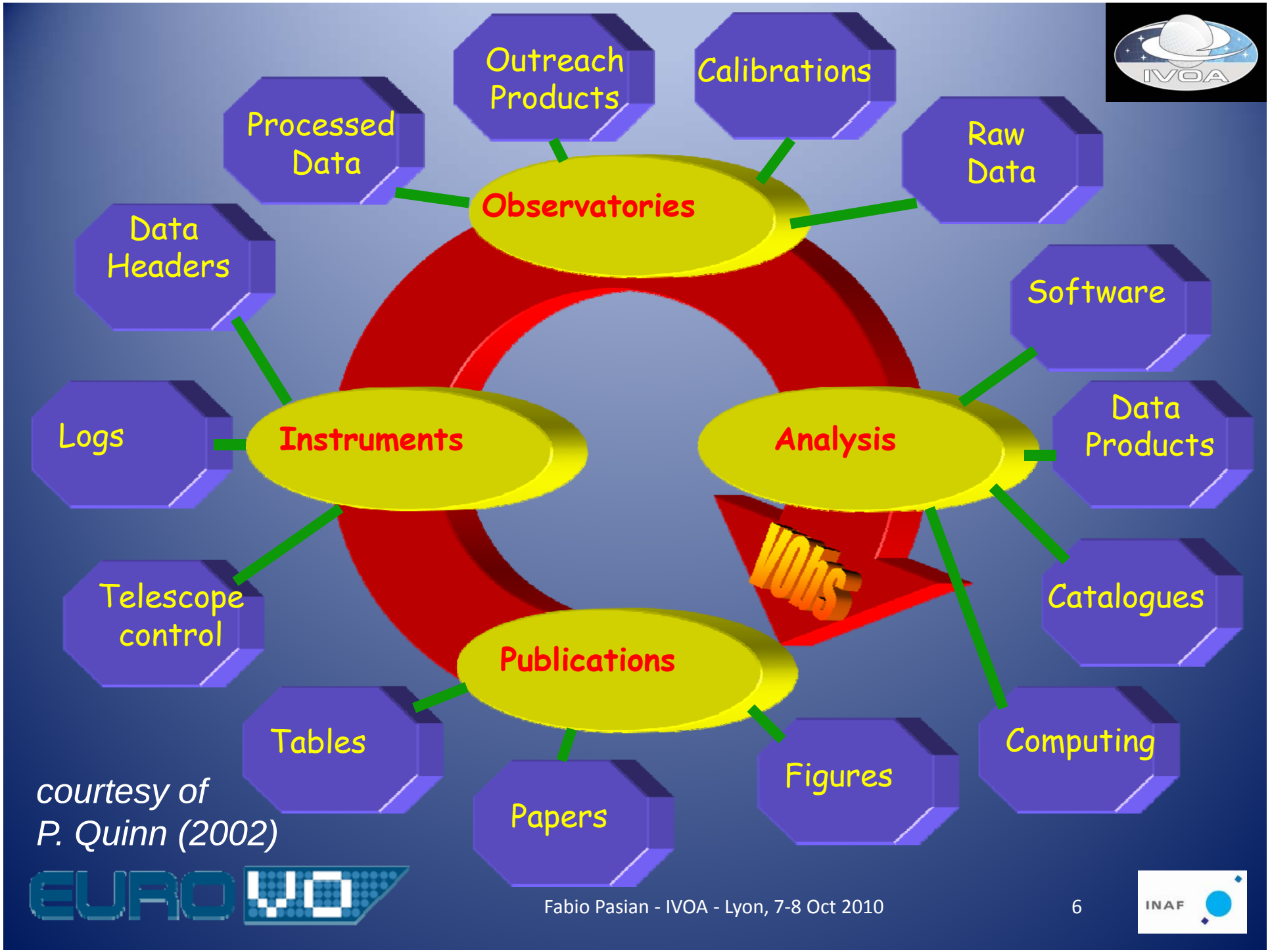
- Need to reprocess raw data given better knowledge of instrumental effects
- Monitor time variability of phenomena (... interest for digitization of photographic plates ...)
- Compare phenomena in different bands (multi-λ astronomy)
- Increase return for investment (data re-use, educational, outreach, ...)
- Statistical analysis / mining of large quantities of data
- Cope with data avalanche

Archive Growth (e.g. ESO)



The way Astronomy works

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



courtesy of
P. Quinn (2002)

The Good News

- Observational data normally stored in *astronomical archives*, freely available *on-line* after ~ 1 year
- Results published in academic journals, all *available on-line* (full content in general freely available after ~ 3 years)
- One *single entry point for journals*: ADS
- Two-way links between most archives and publications
- Data curators (object metadata + catalogues) *on-line*; some links to archives and publications
- Analysis software available from Observatories/Archives *on-line*
- Press release and outreach material (pictures, movies) *on-line*
- There is a *standard format* for data files (FITS)

FITS

- Flexible Image Transportation System
- Born in 1977 for images, later extended for N-dim data arrays, ASCII and bin tables, event lists, ...
- 3 continental committees, IAU WG, permanent FITS office (in GSFC/NASA) maintaining std and s/w
- Standard format
  - ASCII header containing keywords with data description
  - standard record size: 28800 bytes
  - readers available in any astronomical application
- Header non-uniformity issues

The “not-so-Good” News (I)

- Different astronomical archives have *widely different access/search interfaces and standards/conventions*; serving mainly raw data
- Publication - Archive links point to *raw, unprocessed data*
- Object *metadata not homogeneously defined*; links with archives and publications not complete
- Widely specialized, *complex analysis software* for various sub-branches; steep learning curve, but multi-wavelength is now the norm to produce science
- Press release and *outreach material disconnected*

The “not-so-Good” News (II)

- *Preservation policies* depend on the individual data centres
- *Policies on providing science-ready data* depend on the individual data centres

- *Information avalanche*:
  - ✓ *Huge surveys*: 100M sources at <3k/night ⇒ >100 yr to ID them! (Ever fainter sources, routinely beyond limits of 8 - 10m telescopes [R ≈ 25])
  - ✓ *Huge data collections*: download and data analysis on desktop problematic/impossible (TB dataset: ~ 1 week at 10 Mbps)

The Virtual Observatory

The Virtual Observatory (VObs) is an innovative, still evolving, system to:

- take advantage of astronomical data explosion (e.g., use statistical identification to diminish need for a spectrum ⇒ 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

VObs: all astronomical databases inside PC

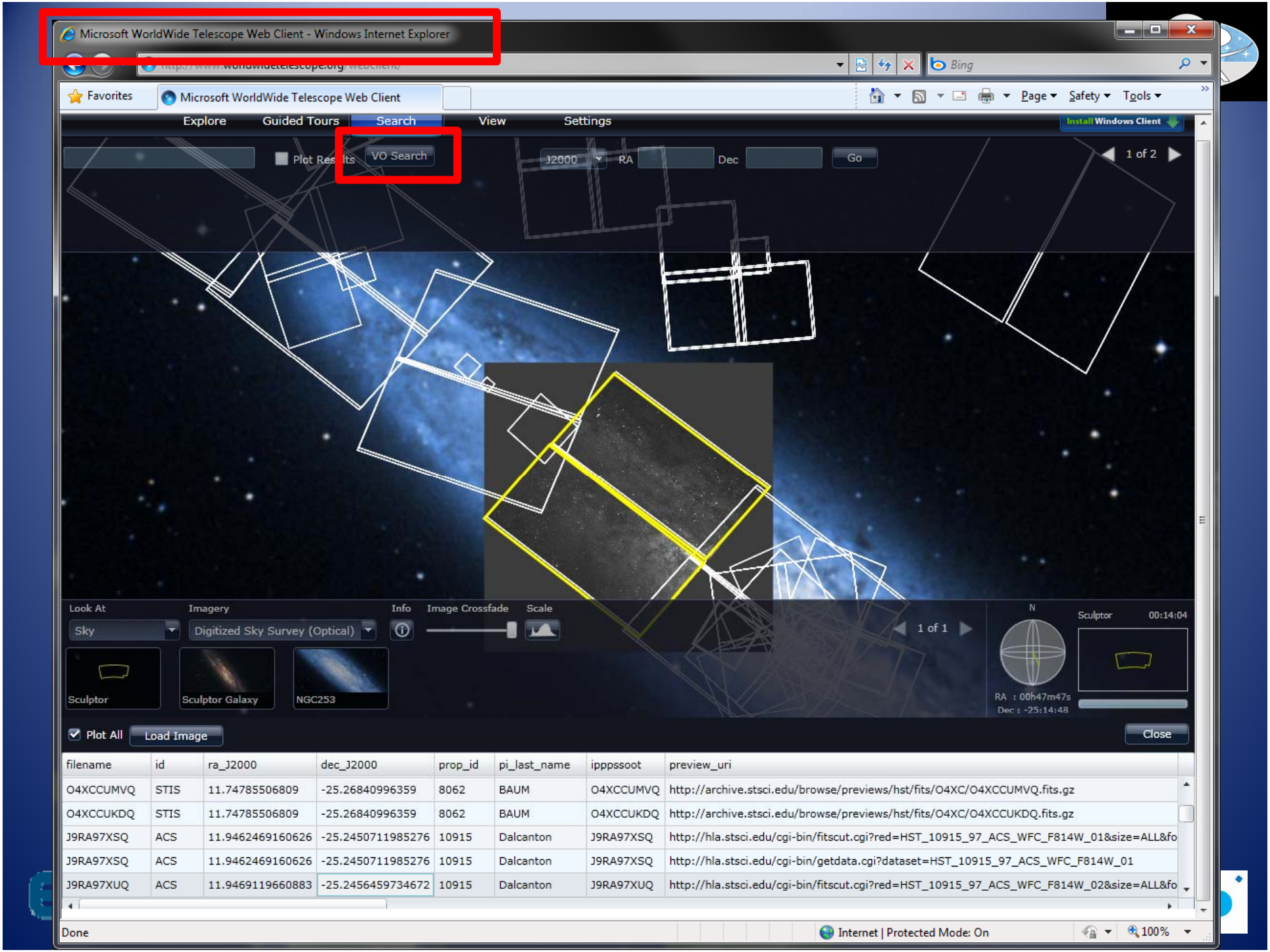
VObs ⇒ democratization of astronomy!

Is this for real ?

Is this stuff worth investing upon ?

ESFRI and ASTRONET statements

- ESFRI (multi-disciplinary)
  - focus on networking, capability & throughput computing, grid architectures, software, data management and curation
- ASTRONET (~ASPERA for Astronomy & Astrophysics)
  - recognised as must-haves to tackle the challenges of the future (priority in assignment of resources):
    - computing (capacity AND capability)
    - theory & simulations
    - virtual observatory
    - laboratories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Favorites
Microsoft WorldWide Telescope Web Client
Explore
Guided Tours
Search
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Settings
Install Windows Client
Plot Results
VO Search
J2000
RA
Dec
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1 of 2
Look At
Imagery
Info
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1 of 1
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IVOA

Implementing the VObs concept requires ALL the various players to speak the same language

↓

VObs standards and protocols are defined and adopted within the IVOA (International Virtual Observatory Alliance) which includes 19 national/supernational partners world-wide

IVOA members

The IVOA: http://ivoa.net

- **Mission:** *"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"*
- Works by telecons, "TWiki" pages, and bi-annual meetings (last one in Victoria [May 2010], next in Nara [December 2010])
- **Needs:** standardization of data/metadata/sw, data interoperability methods, and list of available services (provided by projects)
- **Slow convergence on standards** (there is no direct IVOA funding)
- Structure:
  - ✓ IVOA Executive Board includes representatives from all VObs projects
  - ✓ Working and Interest Groups

IVOA Exec

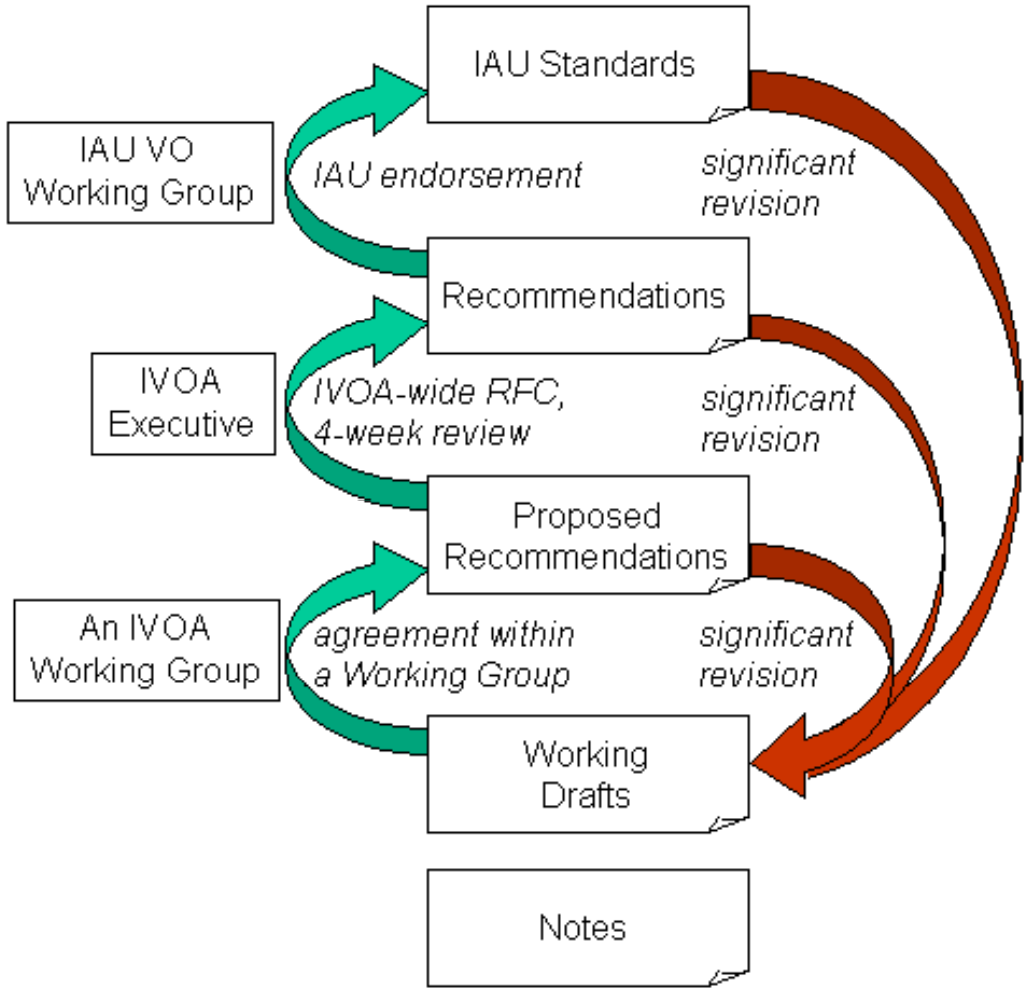
- *Senior representatives from each national and international member VO initiative form the IVOA Executive Committee.*
- *Executive Committee members represent their own project and are expected to be in a position to commit resources targeted at the achievement of common goals.*
- It is understood that Exec members, while representing their national or international initiative, are focused on achieving the common IVOA goals
- *Decisions by the IVOA Executive Committee are reached by consensus only.*

The IVOA: http://ivoa.net

- Organization: working groups to tackle various aspects
  - ✓ Applications (VObs software)
  - ✓ Data Access Layer (VObs standards for remote data access)
  - ✓ Data Modelling (data characterization)
  - ✓ Data Curation and Preservation (long term preservation of data)
  - ✓ Grid and Web Services
  - ✓ Resource Registry (VObs resources: "yellow pages")
  - ✓ Semantics (meaning/interpretation of words, sentences, etc.)
  - ✓ VOEvent (definition of immediate event [e.g., GRB])
  - ✓ VObs Query Language (to be used by applications)
  - ✓ VOTable (XML format for VObs data exchange)
- plus Theory and Data Mining Interest Groups
- plus Standing Committees on Procedures and Scientific Priorities

Technical Coordination Group

IVOA Document Standards Process



International Virtual Observatory Alliance

Documents and Standards

Documents XML Schema Templates Docs Submission

On this page:
Technical Specifications Notes Promotion process Submission Log

Technical Specifications

Group	Title	Most stable	In progress	Versio
App	Simple Application Messaging Protocol	1.11		1.11 1.11 1.10 1.00
DAL	Simple Cone Search	1.03		1.03 1.02 1.01 1.00
	Simple Image Access	1.0	RFC	1.0 1.0 1.01 1.00
	Simple Line Access	1.0	RFC	1.0 1.0
	Simple Spectral Access	1.04		1.04 1.03 1.02 1.01 1.01 1.00
	Table Access Protocol	1.0	RFC	1.0 1.0 1.00
DaM	Space-Time Coordinate Metadata for the Virtual Observatory (STC)	1.33		1.33 1.31 1.30 1.21 1.20 1.10 1.00
	Data Model for Astronomical DataSet Characterisation	1.13		1.13 1.12 1.12 1.11 1.10 1.00
	Simple Spectral Lines Data Model	1.0	RFC	1.0 1.0
	IVOA Spectral Data Model	1.03		1.03 1.02 1.01 1.01 1.01 1.00
GWS	IVOA Single-Sign-On Profile: Authentication Mechanisms	1.01		1.01 1.01 1.00 1.00
	VOSpace service specification	1.15	2.0	1.15 2.0 1.15 1.15 1.14 1.13 1.12
	IVOA Credential Delegation Protocol	1.0	RFC	1.0 1.01 1.01 1.00
	Universal Worker Service	1.0	RFC	1.0 1.0
	IVOA Support Interfaces	1.0		1.0 1.0
	IVOA Web Service Basic Profile	1.00		1.00
ReR	IVOA Identifiers	1.12		1.12 1.11 1.10 1.10 1.10 1.00
	IVOA Registry Interfaces	1.0		1.0 1.0 1.00 1.02 1.01 1.00
	Resource Metadata for the Virtual Observatory	1.12		1.12 1.12 1.10 1.10 1.01 1.01 1.00
	VOResource: an XML Encoding Schema for Resource Metadata	1.03		1.03 1.02 1.02 1.01 1.00
	VODataService: a VOResource Schema Extension for Describing Collections and Services	1.1	RFC	1.1 1.10
Semantics	An IVOA standard for Unified Content Descriptors	1.10		1.10 1.10 1.06 1.05 1.03
	UCD1+ Controlled Vocabulary	1.23		1.23 1.22 1.21 1.20 1.20 1.11 1.11
	Maintenance of the list of UCD words	1.20		1.20 1.20 1.10 1.00
	Vocabularies in the Virtual Observatory	1.19		1.19 1.18 1.16 1.15 1.13 1.00
SDP	IVOA Document Standards	1.0	1.2	1.2 1.2 1.2 1.2 1.1 1.1 1.0 1.0
VOE	Sky Event Reporting Metadata (VOEvent)	1.11		1.11 1.11 1.10 1.01
VQL	IVOA Astronomical Data Query Language	2.00		2.00 2.00 2.00 1.01 1.00
	IVOA SkyNode Interface	1.01		1.01 1.00
VOT	VOTable Format Specification	1.10	1.2 RFC	1.2 1.2 1.20 1.20 1.10 1.00

Maturity level: Recommendation Proposed Recommendation Working Draft

Most stable: New systems should be developed against this version with the highest maturity level.

In progress: Indicates (if any) a new version of the document under development (but with a lower maturity even than its predecessor) and a link to the relevant Request For Comments (RFC).

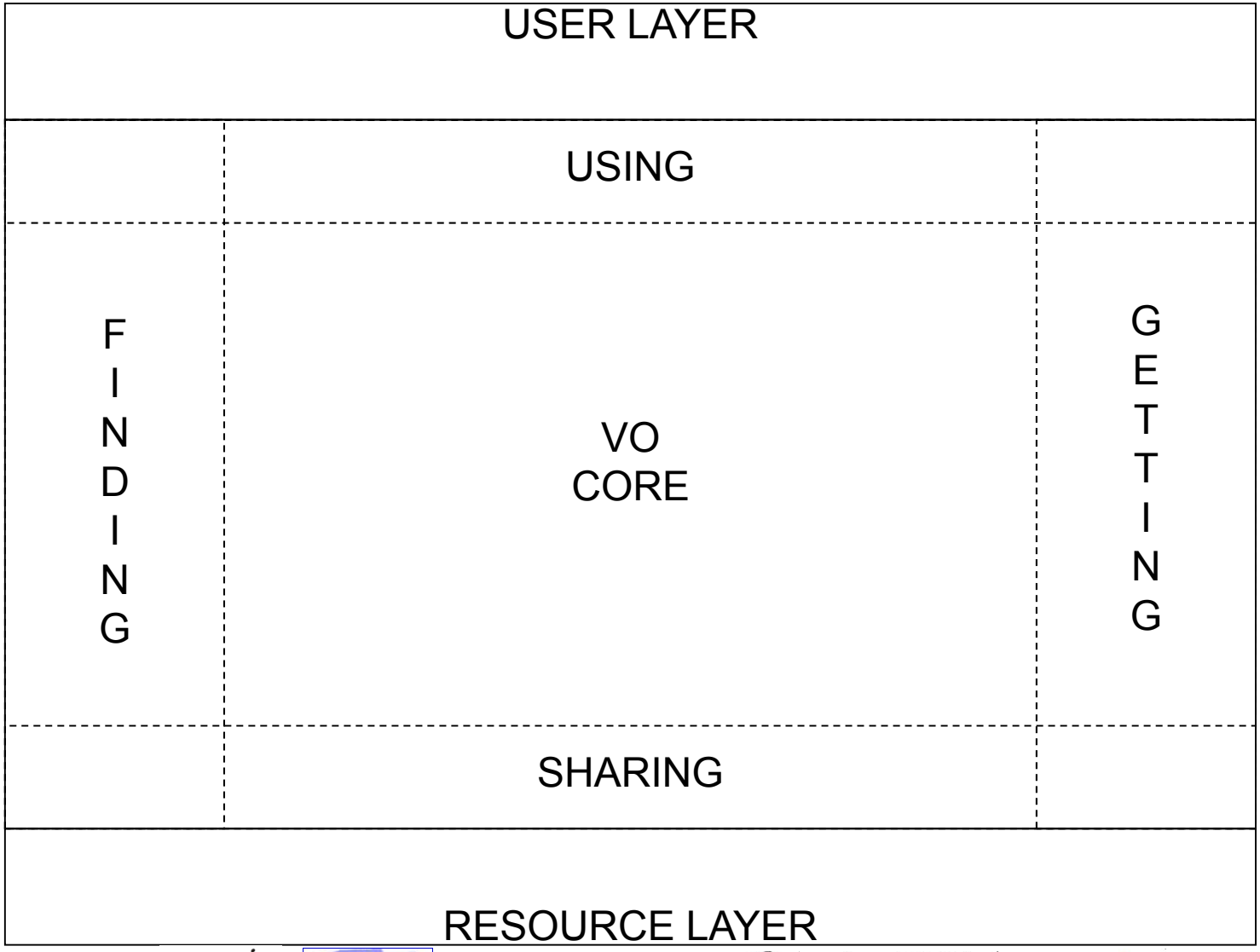
Group: **Apps** Applications WG **DAL** Data Access Layer WG **DaM** Data Modeling WG **GWS** Grid & Web Services WG **ReR** Resource Registry WG **Semantics** Semantics WG **SDP** Standards & Documents Process WG **VOE** VO Event WG **VOT** VOTable WG **VQL** VO Query Language WG **n.a.** not applicable

INAF

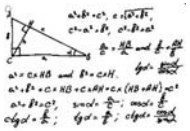
LEVEL 0

USERS

COMPUTERS



PROVIDERS



LEVEL 1

USERS

COMPUTERS

USER LAYER

Browser Based Apps | ***Desktop Apps*** | ***Script Based Apps***

USING

REGISTRY

Semantics

VO Query Languages

VO CORE

Formats

Data Models

DATA ACCESS

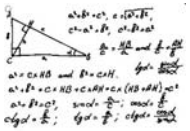
PROTOCOLS

SHARING

RESOURCE LAYER

Storage | ***Data and Metadata Collection*** | ***Computation***

PROVIDERS



LEVEL 2

USERS

COMPUTERS

REC

InProgress

USER LAYER

Browser Based Apps

Desktop Apps

Script Based Apps

SAMP

SSO

USING

UWS

CDP

WS BP

REGISTRY

Registry Interface

Resource Metadata

VOResource

VODataService

ApplicationsRegExt

StandardsRegExt

SimpleDALRegExt

VOSI

ADQL

PQL

VO Query Languages

STC

Utypes

Units

SpectrumDM

UCD

Semantics

Vocabularies

VO CORE

CharDM

ObsCoreDM

ObsProvDM

SSLDM

PhotDM

VOEvent

Formats

Resource Identifier

VOTable

SimDM

DATA ACCESS PROTOCOLS

SIAP

SCS

SSAP

TAP

SLAP

SEAP

SimDAP

FAP

VOSpace

VOPipe

SHARING

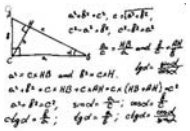
Storage

Data and Metadata Collection

Computation

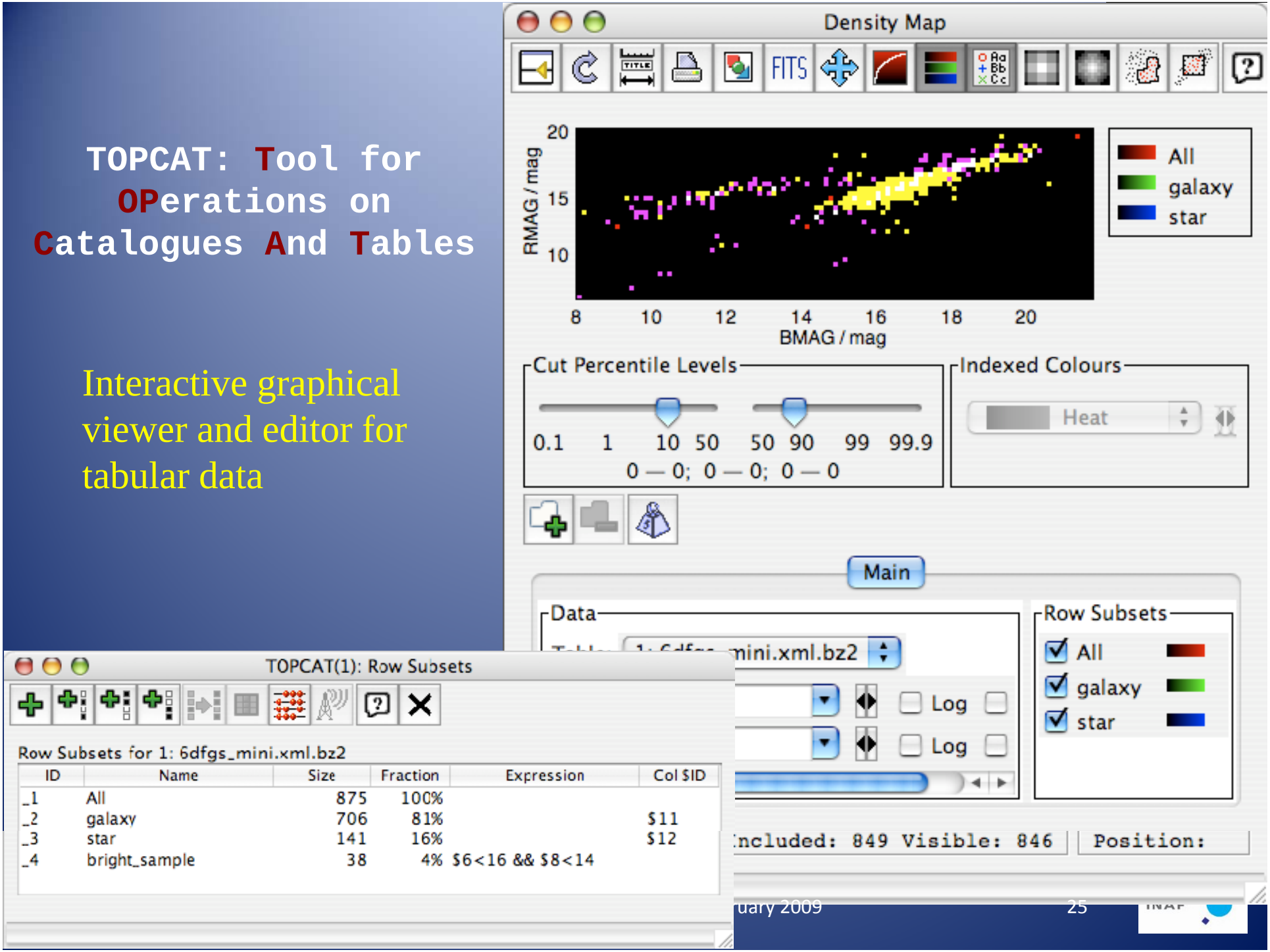
RESOURCE LAYER

PROVIDERS



TOPCAT: Tool for OPerations on Catalogues And Tables

Interactive graphical viewer and editor for tabular data



TOPCAT

USERS

COMPUTERS

USER LAYER

Browser Based Apps

Desktop Apps

Script Based Apps

SAMP

SSO

USING

UWS

CDP

WS BP

REGISTRY

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ObsProvDM

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SimDM

Models

UCD

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Vocabularies

VO CORE

Formats

Resource Identifier

VOTable

DATA ACCESS

SIAP

SCS

SSAP

TAP

SLAP

SEAP

SimDAP

FAP

PROTOCOLS

VOSpace

VOPipe

SHARING

Storage

Data and Metadata Collection

RESOURCE LAYER

Computation

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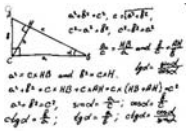
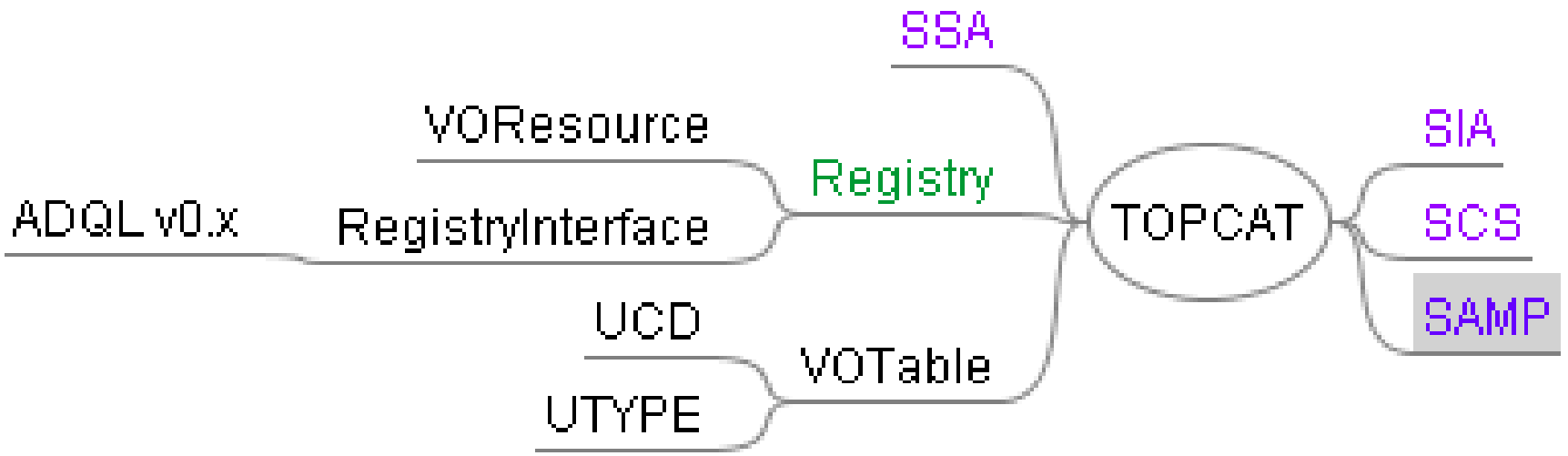
IVOA Architecture

PROVIDERS



TOPCAT


SSA
VOResource
Registry
ADQL v0.x
RegistryInterface
TOPCAT
SIA
SCS
SAMP
UCD
VOTable
UTYPE

Science priorities

- Development of complex technical tools:

  "It-Can-Be-Done does not imply It-Should-Be-Done"

- The IVOA is about enabling research ⟶ science requirements to be kept up front
- "Standing Committee on Science Priorities":
  - collects use cases from the science community and preposes priorities in development of standards ⟶ liaison with TCG
  - nat'l projects agree implementation path in Exec

Education to VObs

- Educating (young) professionals:
  - User Workshops (possibly on one specific subject)
  - "Hands-On" Workshops on VO tools
  - "VO Days"
- Educating "new generations of astronomers":
  - In AIDA-WP5, a number of research projects that can be carried out at high school (13-18 yrs old) and undergraduate levels, using data extracted from the VO and (simplified) VO tools

IVOA Newsletter

http://ivoa.net/newsletter/

Focus on:
- applications highlights
- VO science papers
- VO calendar

IVOA NEWSLETTER

November 2009

Subscribe to email notifications of the IVOA Newsletter

www.ivoa.net

newsletter archives

The International Virtual Observatory Alliance (IVOA) was formed in June 2002 with a mission 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." The IVOA now comprises 17 VO projects from Armenia, Australia, Brazil, Canada, China Europe, France, Germany, Hungary, India, Italy, Japan, Korea, Russia, Spain, the United Kingdom, and the United States. Membership is open to other national and international projects according to the IVOA Guidelines for Participation. You can read more about the IVOA and what we do at http://www.ivoa.net/pub/info/.

What is the VO?

The Virtual Observatory (VO) aims to provide a research environment that will open up new possibilities for scientific research based on data discovery, efficient data access, and interoperability. The vision is of global astronomy archives connected via the VO to form a multiwavelength digital sky that can be searched, visualized, and analyzed in new and innovative ways. VO projects worldwide working toward this vision are already providing science capabilities with new tools and services. This newsletter, aimed at astronomers, highlights VO tools and technologies for doing astronomy research, recent papers, and upcoming events

VO APPLICATIONS HIGHLIGHTS

VO Interoperability in DS9

SAOImage DS9 is a standalone astronomical imaging and data visualization application. DS9 supports FITS images and binary tables, multiple frame buffers, region manipulation, and many scale algorithms and colormaps. It provides for easy communication with external analysis tasks and is highly configurable and extensible via messaging capabilities XPA, and the VO

Liaison with other disciplines

- Formation of Liaison Committee
  - C. Arviset, D. De Young, F. Genova, M. Ohishi, F. Pasian, N. Walton
  - Follow-on to Trieste Interop plenary and special sessions
  - Establish liaison with other disciplines
  - STP, Planetary Science, Particle Physics, Earth Science, ...
  - Explore mutual problems and areas of interest
    - Developing tools, standards, & protocols
  - Communicate results, experience
    - Common or recurrent themes or needs – standards?
  - Up to now "passive" approach ⟶ creation of dedicated groups (Liaison Groups) with interested communities
  - Links to computational Grid communities

VObs-related computing

- Examples:
  - Data processing (reduction, calibration, ...)
  - Astro data on demand (e.g. numerical simulations, MC, theory data, calibration on-the-fly, ...)
  - Data mining
- Need for computing power (!)
  - c/o Data Centres
  - at HPC facilities
  - on the Grid

Data Centres in the VObs Era

- The VObs needs data ⇒ astronomical data centres lie at its foundation
- The VObs is more than a system: also a “frame of mind” ⇒ modern access to better data
- The VObs is “convenient” for data centres as well. Various reasons:
  1. old technology has hard time keeping up with current data volume and complexity
  2. broadens user base
  3. exposes highly processed data in a direct way through VObs protocols

What is a VObs-compliant archive?

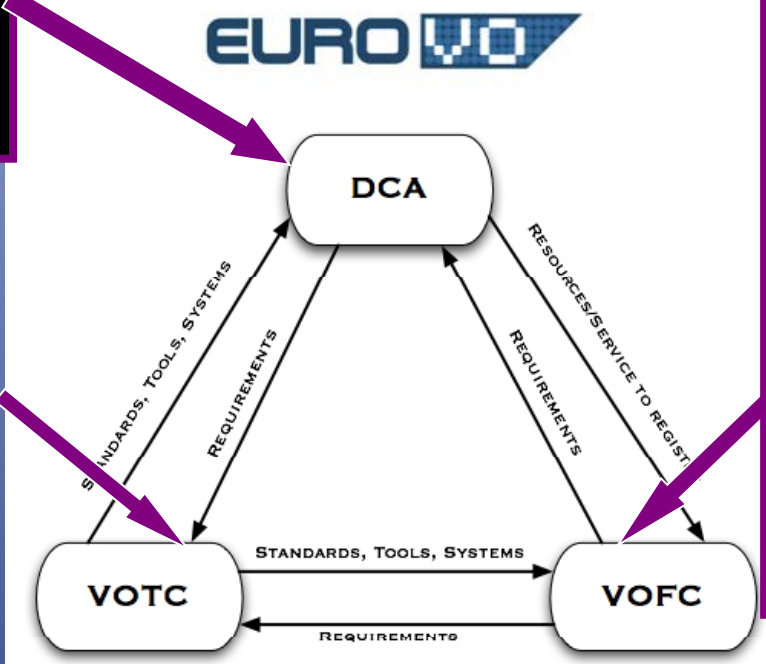
- The VObs cannot (and does not) dictate how to manage archives
- The VObs requires data centres to have a "VObs layer" to:
  - ✓ "translate" any locally defined parameter to the standard (IVOA compliant) ones (e.g., RA can be called in many different ways)
  - ✓ hide any observatory/telescope/instrument specific detail and work in astronomical units: e.g., *wavelength range/band* (not grism or filter name), *spectral resolution, signal-to-noise ratio, field of view, limiting magnitude* ⇒ provide the correct meta-data (i.e. data about data, data description)
- The VObs will work at best with high level "science-ready" data ⇒ data centres should make an effort to provide such data

A project's perspective: 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)
- Includes 8 partners: ESO, European Space Agency (ESA), plus INAF (Italy), INSU (France), INTA (Spain), NOVA (Netherlands), PPARC (UK), and MPG (Germany)
- Partly funded by the EC, with ~ 50% partner support
  - EuroVO-DCA: 1.5 M€ (EU/FP6) Sep.06-Dec.08; led by CDS, France
  - VO-TECH: 3.3 M€ (EU/FP6) Jan. 05-Jun09; led by AstroGrid, UK
  - EuroVO-AIDA: 2.7 M€ (EU/FP7) Feb.08-Jul.10; led by CDS, France
  - EuroVO-ICE: 200 K€ (EU/FP7) 1yr, started Jul.10; lead is CDS, France
- Euro-VO has three components: Data Centre Alliance, Technology Centre, Facility Centre

An alliance of European data centres who populate the EURO-VO with data, provide the physical storage and computational fabric and who publish data, metadata and services to the EURO-VO using VObs 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 VObs technology take-up and scientific programs. EURO-VO's "public face". Should also deal with outreach and education.

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

Summary

- Astronomy has changed and grown considerably
  ⇒ archives needed
- Some work is required to integrate and make the various data archives interoperable ⇒ the Virtual Observatory
- Goal: all astronomical databases "one click away"
  ⇒ democratization of Astronomy!
- To make sense, the Virtual Observatory needs to be an international effort, which requires coordination (IVOA) but also involvement at the *project* at *data centre* level
- The Virtual Observatory concept can be re-used in different domains
- The final goal is **Science**

Thanks to:

- The organisers of this Workshop for the invitation
- P.Padovani (ESO), C.Arviset (ESA/ESAC), F.Genova (CDS), D.DeYoung (US-VAO) ⇒ IVOA + Euro-VO
- U.Becciani, S.Cassisi, A.Preite-Martinez, B.Garilli, R.Smareglia, M.Ramella, P.Manzato, A.Pietrinferni, A.Costa, L.Paioro, M. Molinaro, O.Laurino, G.Iafrate, C.Vuerli, G.Taffoni (INAF), C.Gheller (CINECA), G. Longo (Univ. Napoli "Federico II"), P.Benvenuti (Univ. Padova) ⇒ VObs.it

Thank you for your attention!

pasian@oats.inaf.it


IVOA