CDS and the VO

Virtual Observatory

- Framework for interoperable and efficient access to astronomical data and services
- e-Science for Astronomy
- Based on global standards
  - co-ordination via IVOA

Vision

- Archives and databases form a 'digital sky'
- New possibilities via data discovery, efficient data access and interoperability

Driven by:

- Exploding data rates
- Multi-λ science

V*x*Os

Astronomical

Solar

Heliophysics

Planetary Science

Geoscience

Magnetosphere ...

- each one focused on domain specific needs

CDS involvement

- Development of VO standards
- Leadership role in IVOA, EuroVO, VOFrance
- VO science tools and services
- VO science
- Science tutorials, outreach/education
- Assisting the Data Centre community to publish to the VO

CDS approach to VO

- Participation in development of standards helps the CDS services
- As a major content provider we need to be involved
- Careful implementation of VO in CDS services alongside other access modes
- Use VO to foster innovation and collaboration

Projects

- EURO VO - European co-ordination
    - VOTech
    - DCA
    - AIDA
    - ICE

IVOA

- Leadership roles:

  Genova - Chair 2006-7, Vice-Chair 2005-6, DCP IG Vice chair 2004-7

  Ochsenbein - VOTable Chair 2003-9

  Allen - Apps IG/WG Chair 2005-8, CSP 2009-, Newsletter Editor, Secretary 2009-

  Preite-Martinez - Semantics WG Chair 2005-8

  Derriere - Semantics WG Chair 2008-

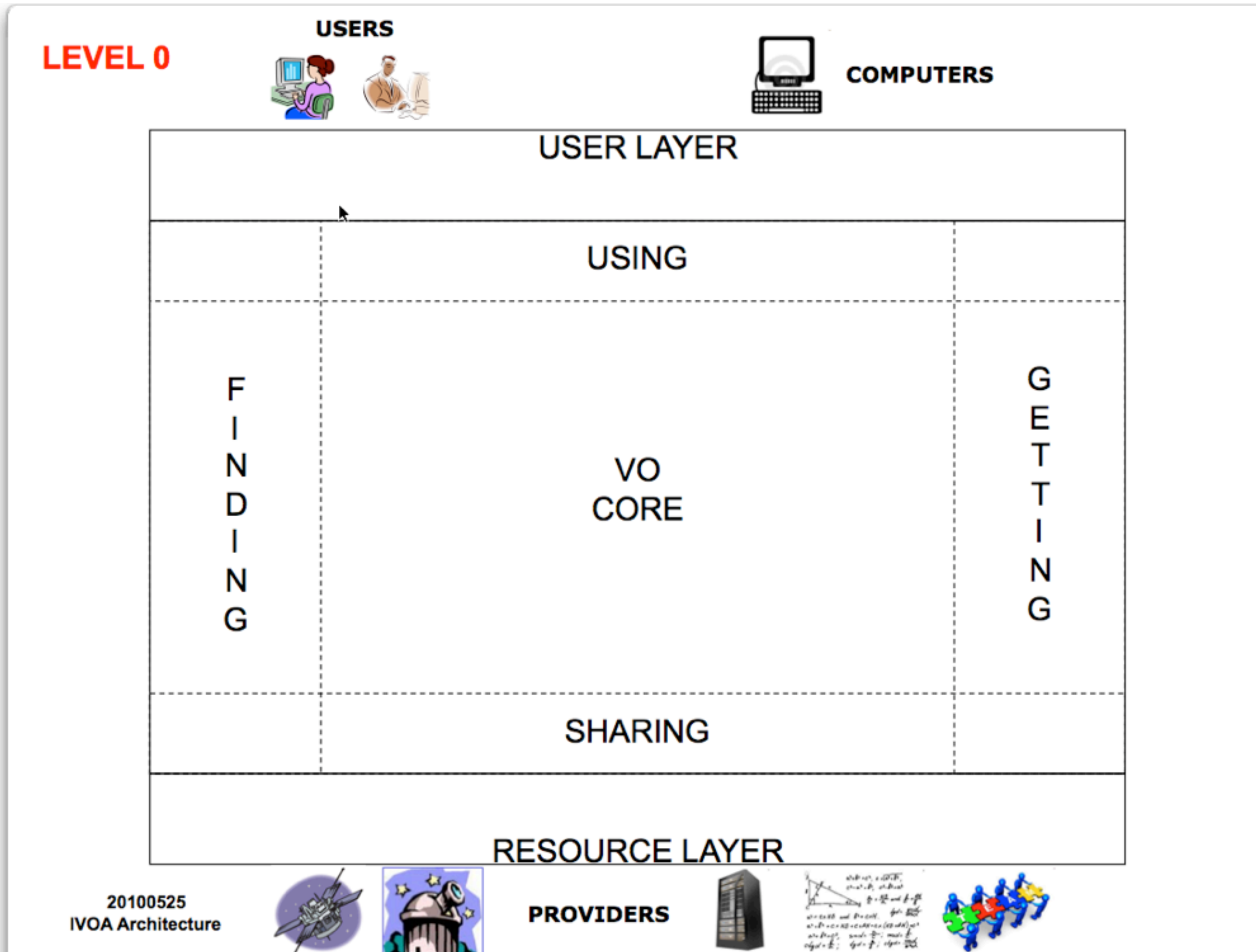
  Louys - DM WG Chair 2007-11

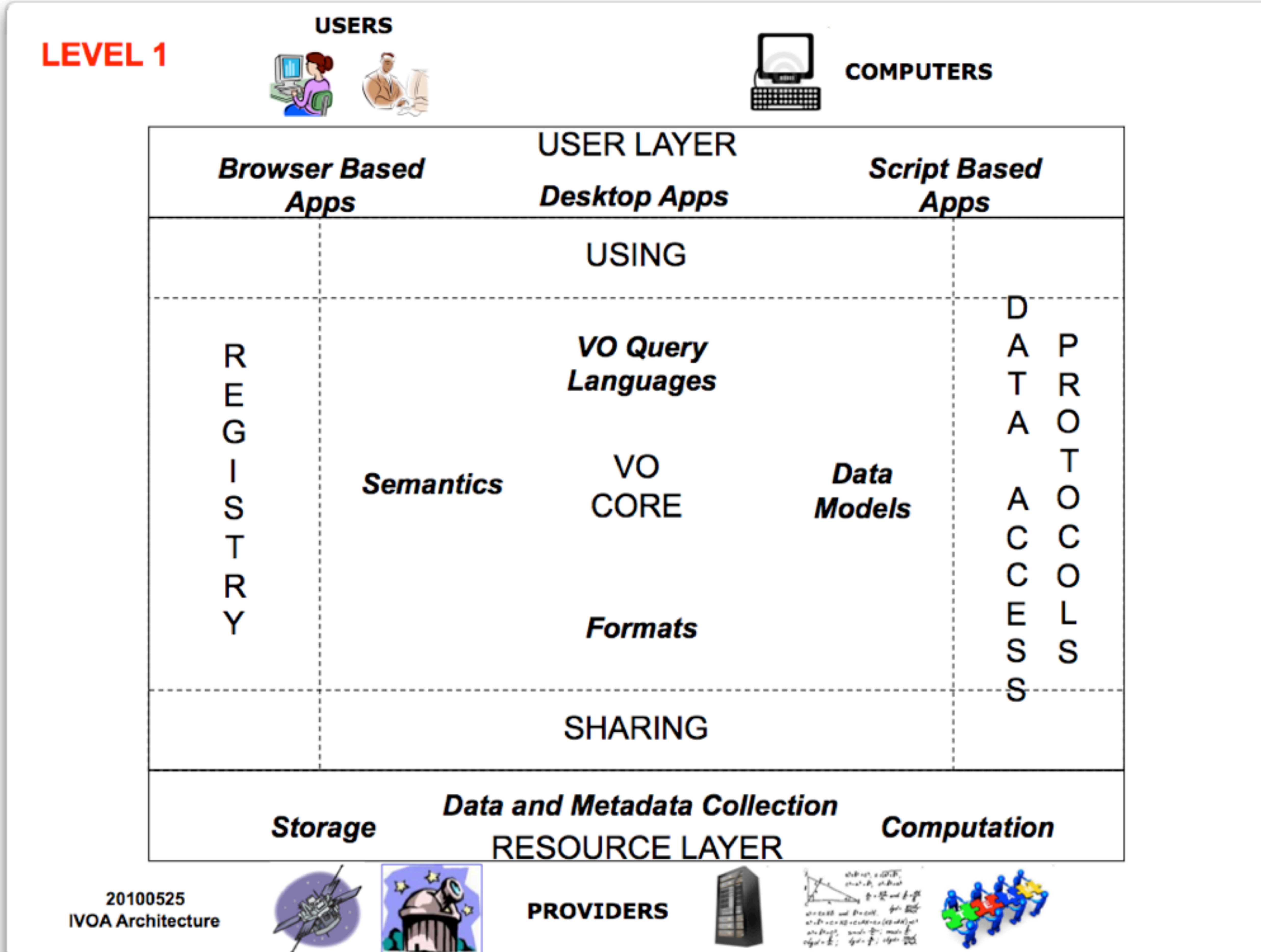
  Wozniak - Theory WG Chair 2008-11

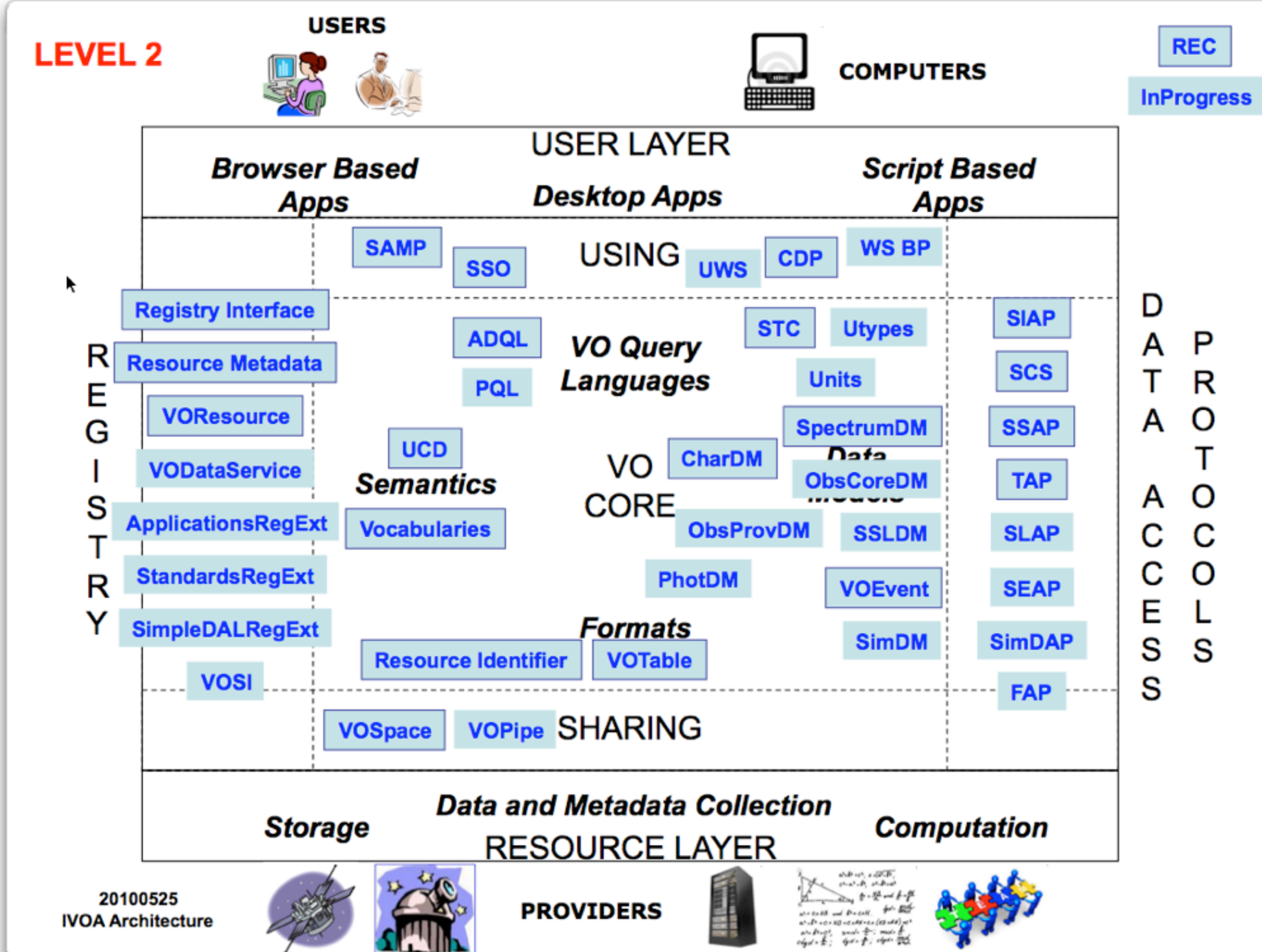
  Schaaff - GWS WG Vice Chair 2011-

IVOA - Architecture

Multi-level structure for understanding each component of the VO




LEVEL 1
USERS
COMPUTERS
USER LAYER
Browser Based Apps
Desktop Apps
Script Based Apps
USING
REGISTRY
VO Query Languages
Semantics
VO CORE
Data Models
DATA ACCESS PROTOCOLS
Formats
SHARING
Storage
Data and Metadata Collection
RESOURCE LAYER
Computation
20100525
IVOA Architecture
PROVIDERS



LEVEL 2
USERS
COMPUTERS
REC
InProgress
USER LAYER
Browser Based Apps
Desktop Apps
Script Based Apps
USING
SAMP
SSO
UWS
CDP
WS BP
Registry Interface
Resource Metadata
VOResource
VODataService
ApplicationsRegExt
StandardsRegExt
SimpleDALRegExt
VOSI
R E G I S T R Y
ADQL
PQL
VO Query Languages
STC
Utypes
Units
SpectrumDM
CharDM
ObsCoreDM
UCD
Semantics
Vocabularies
VO CORE
ObsProvDM
SSLDM
PhotDM
VOEvent
SimDM
Formats
Resource Identifier
VOTable
SIAP
SCS
SSAP
TAP
SLAP
SEAP
SimDAP
FAP
DATA ACCESS PROTOCOLS
VOSpace
VOPipe
SHARING
Storage
Data and Metadata Collection
Computation
RESOURCE LAYER
20100525
IVOA Architecture
PROVIDERS

Specific CDS contributions to IVOA standards

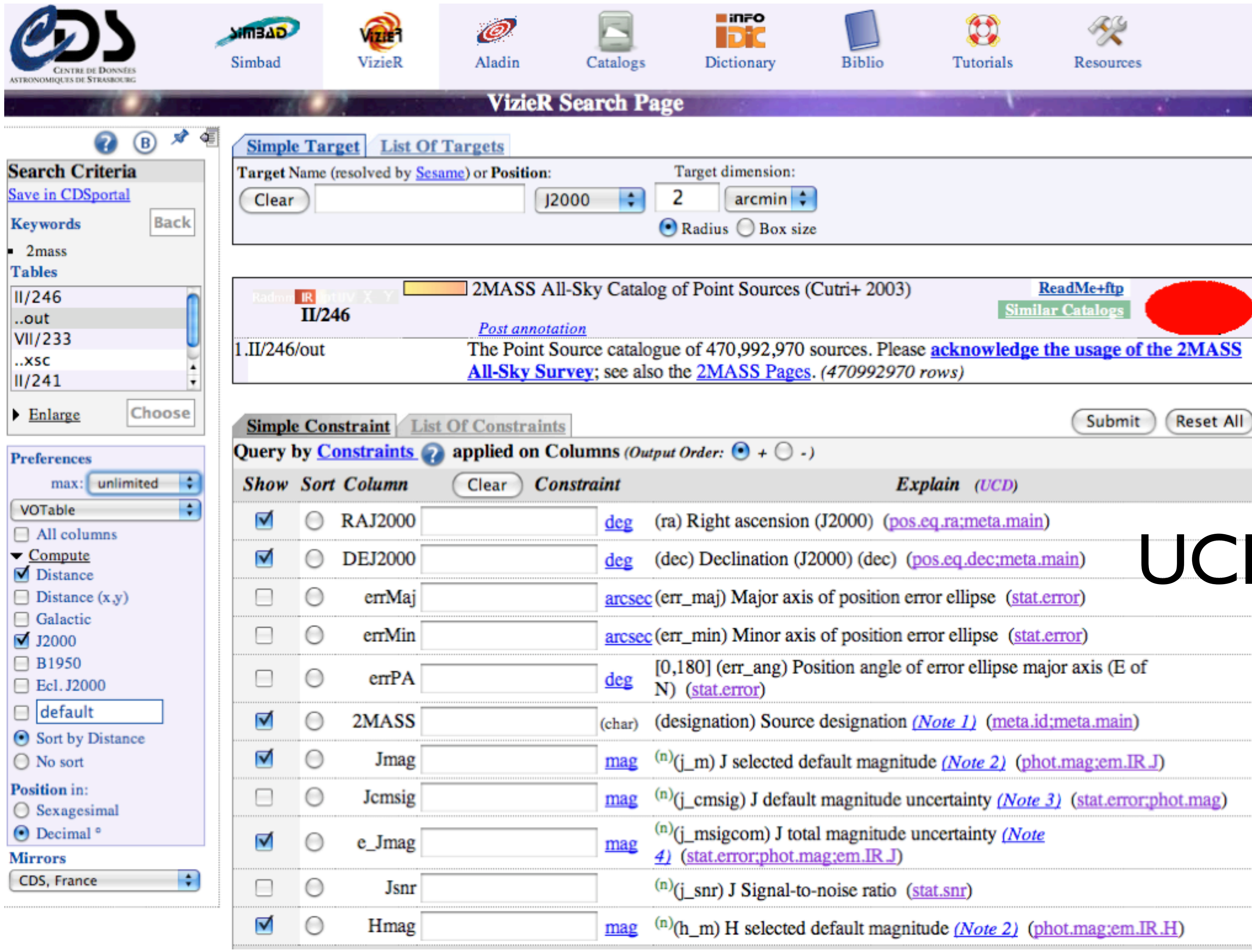
- VOTable
- Data models - Characterisation
- SAMP
- GWS
- ...
- see - list of IVOA standards ‘signed’ by CDS members

- One important aspect of CDS participation: test implementation alongside of standards development
  - ensures relevant and useable standards

VO in CDS services

- VO Compliance in services
  - VO access alongside existing modes (Vizier example to follow)
- VO interoperability of tools (SAMP)
- Innovation (e.g. CDS Portal)

VO standards used in VizieR web page interface

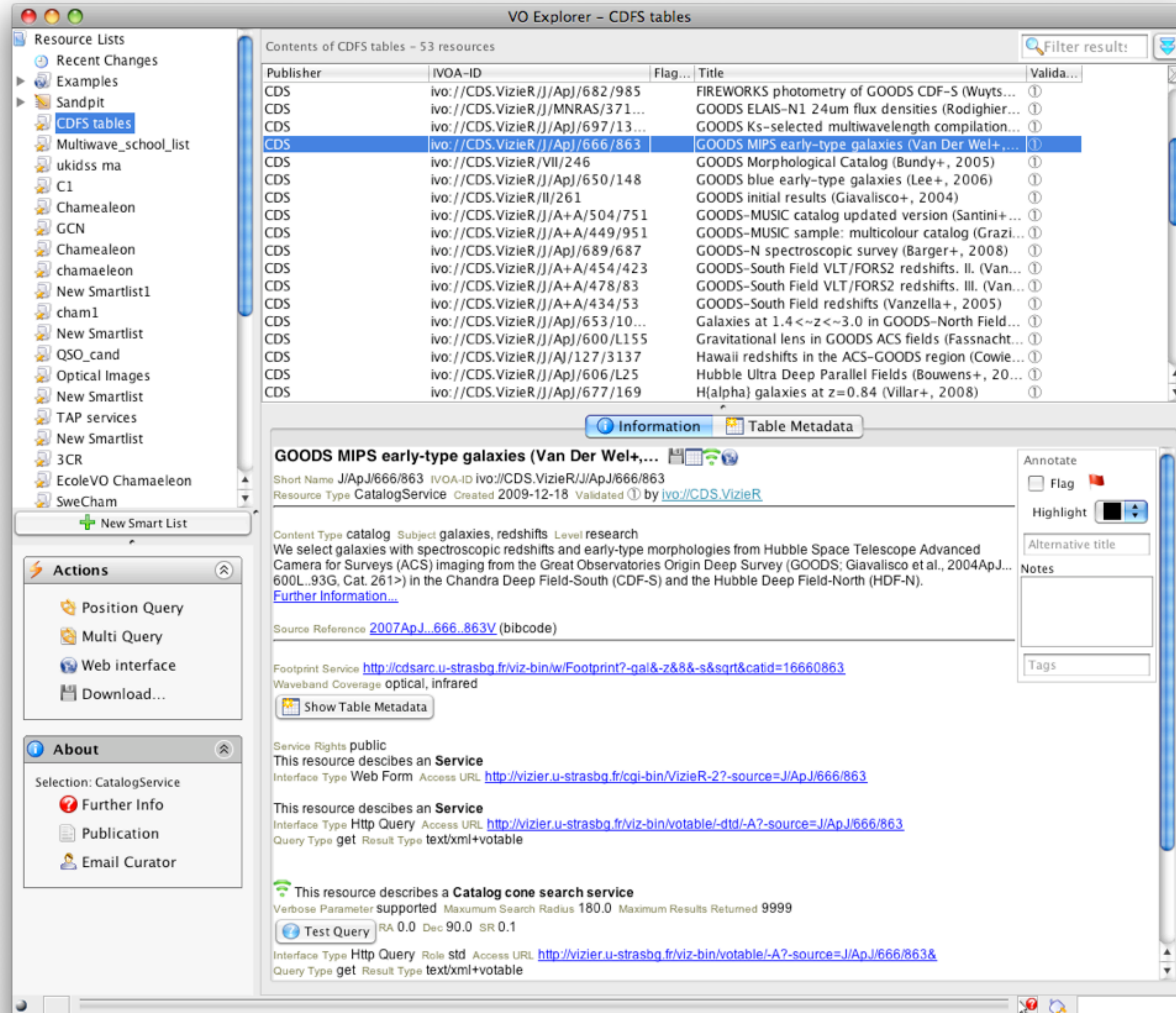


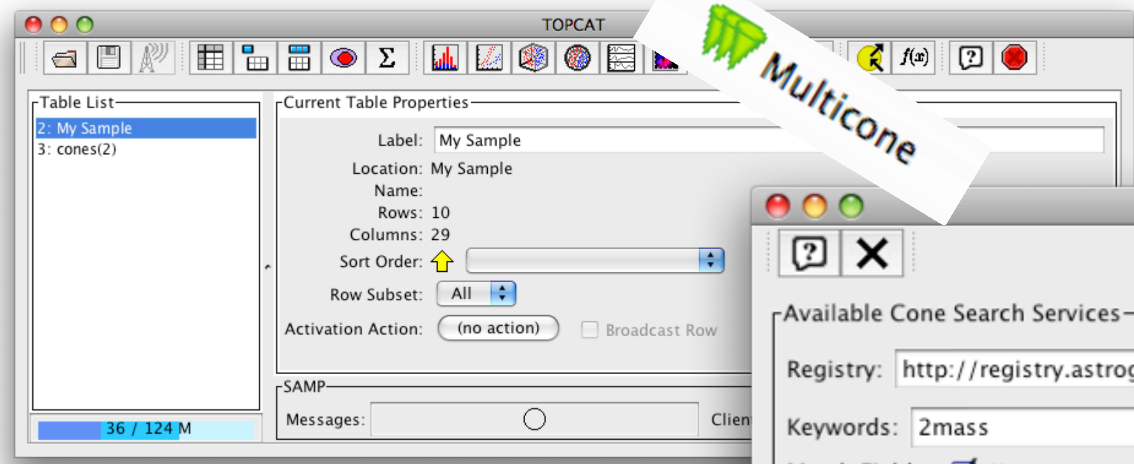
VOTable

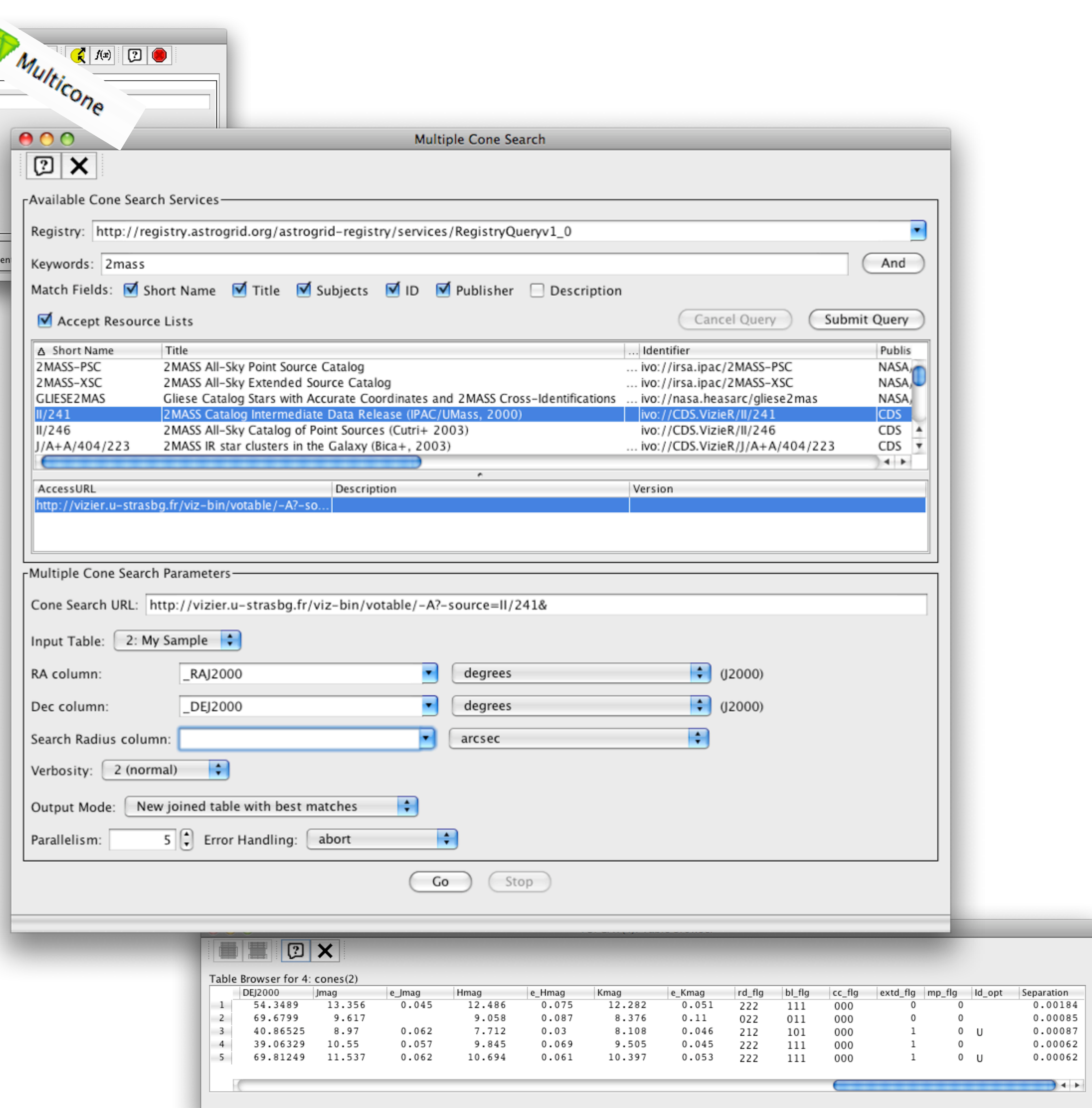
UCDs

VizieR catalogues described in the Registry

VizieR catalogues accessible via VOExplorer







	DEJ2000	Jmag	e_Jmag	Hmag	e_Hmag	Kmag	e_Kmag	rd_flg	bl_flg	cc_flg	extd_flg	mp_flg	Id_opt	Separation
1	54.3489	13.356	0.045	12.486	0.075	12.282	0.051	222	111	000	0	0		0.00184
2	69.6799	9.617		9.058	0.087	8.376	0.11	022	011	000	0	0		0.00085
3	40.86525	8.97	0.062	7.712	0.03	8.108	0.046	212	101	000	1	0	U	0.00087
4	39.06329	10.55	0.057	9.845	0.069	9.505	0.045	222	111	000	1	0		0.00062
5	69.81249	11.537	0.062	10.694	0.061	10.397	0.053	222	111	000	1	0	U	0.00062

My Sample of objects

Registry: 2MASS from VizieR

Cone Search for each object

Interactive Sky Atlas

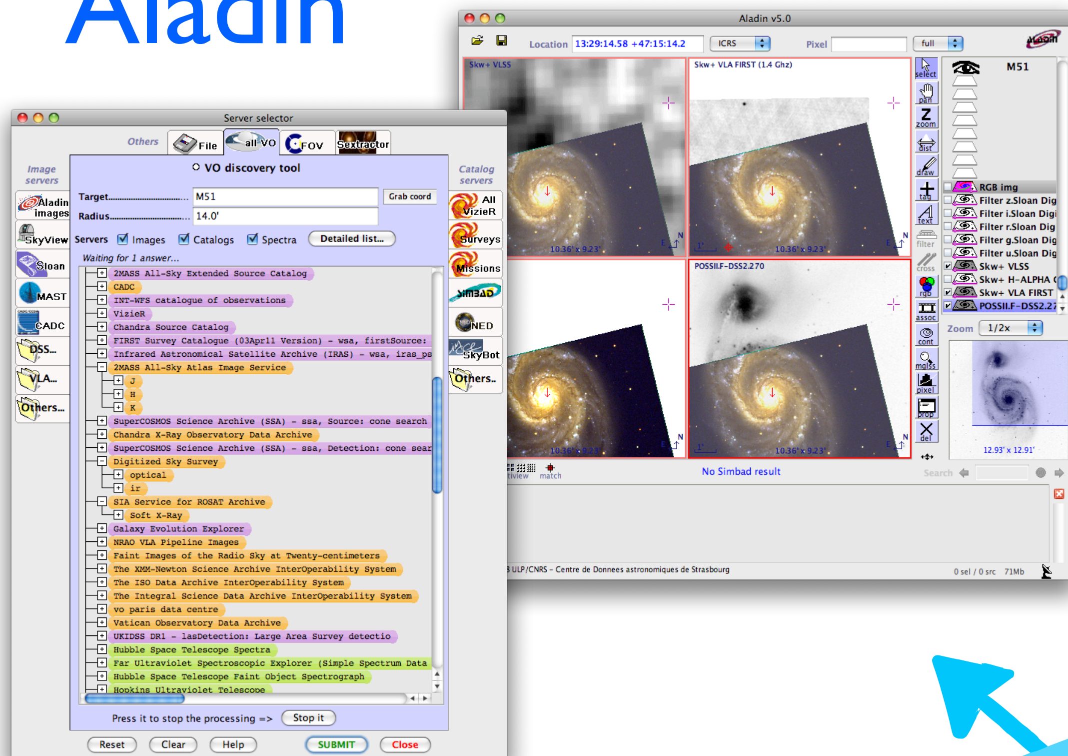
- Images
- Catalogues
- VO Access
- All Sky
- Scripting
- and more...

Some details on the access methods

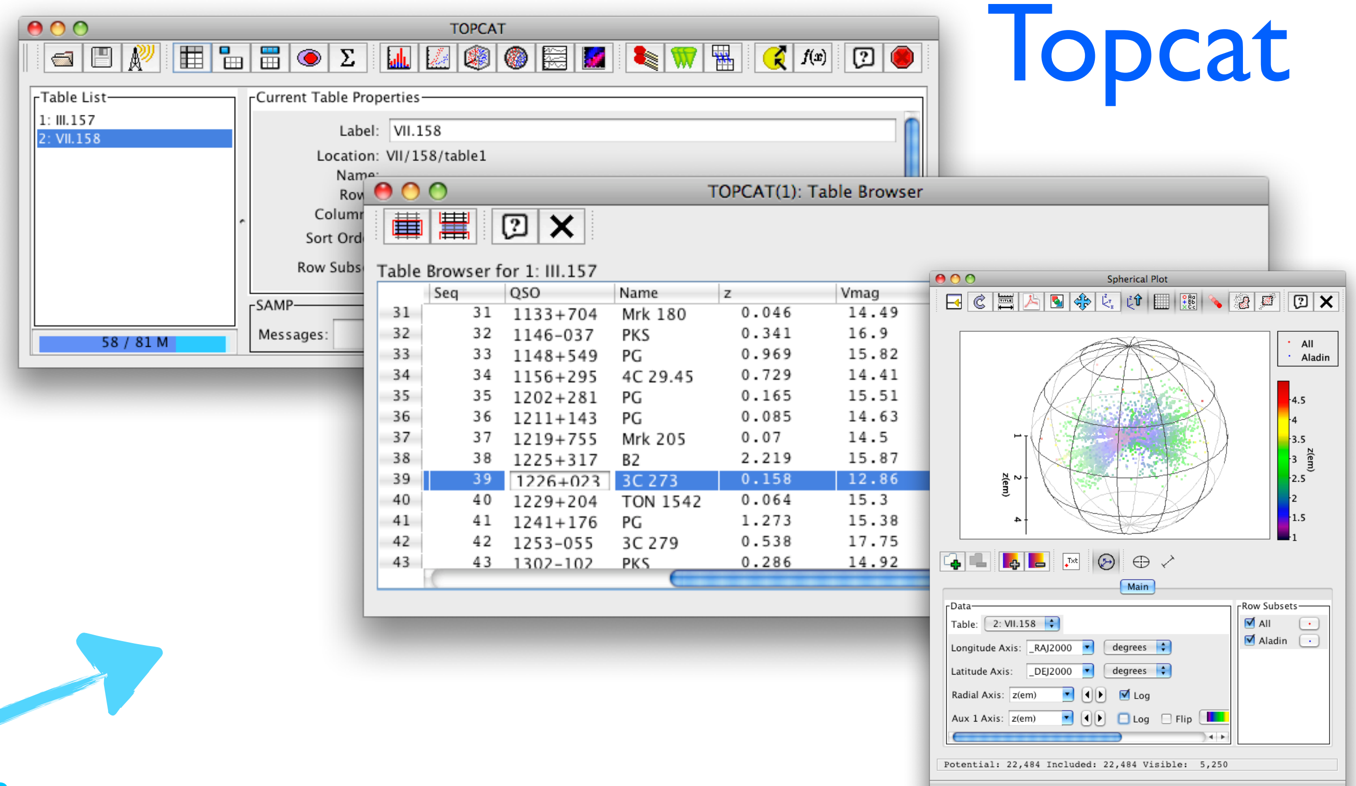
- Web interface
- SOAP
- ... ?

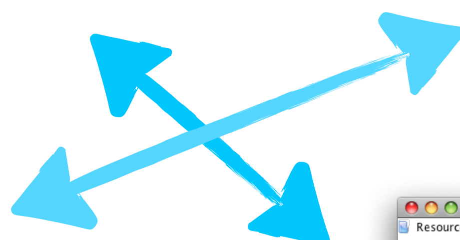
SAMP tool interoperability

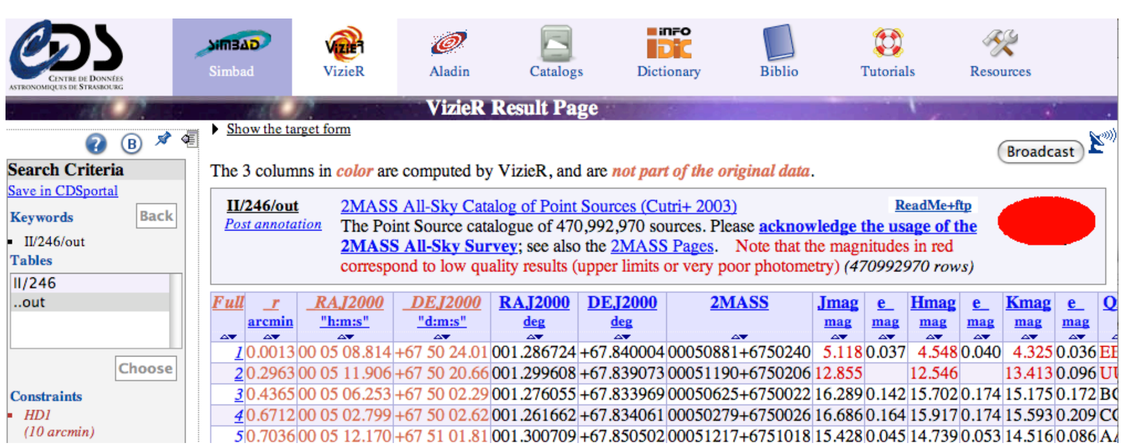
Aladin

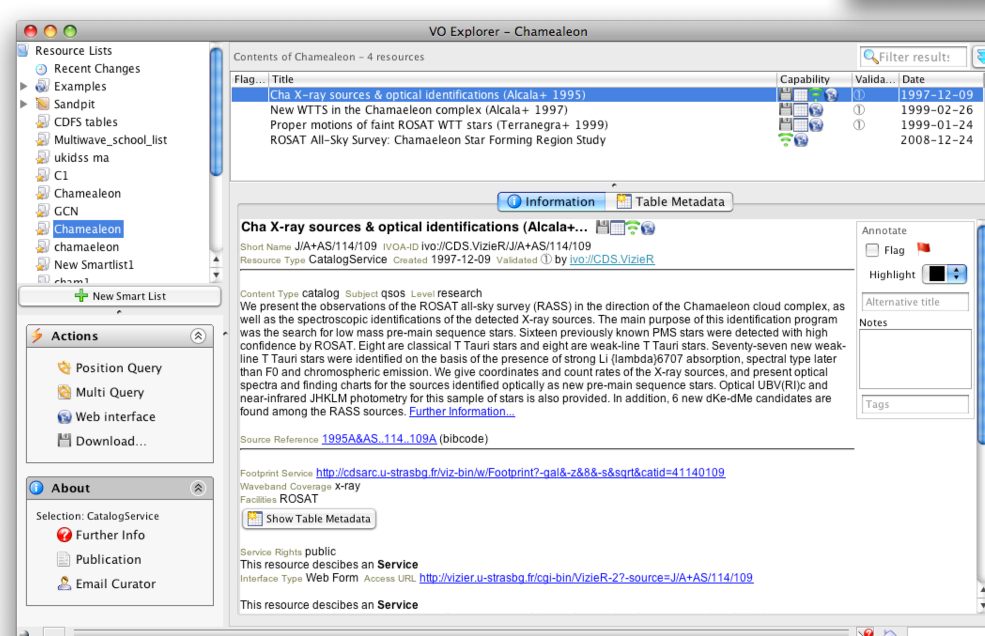


Topcat





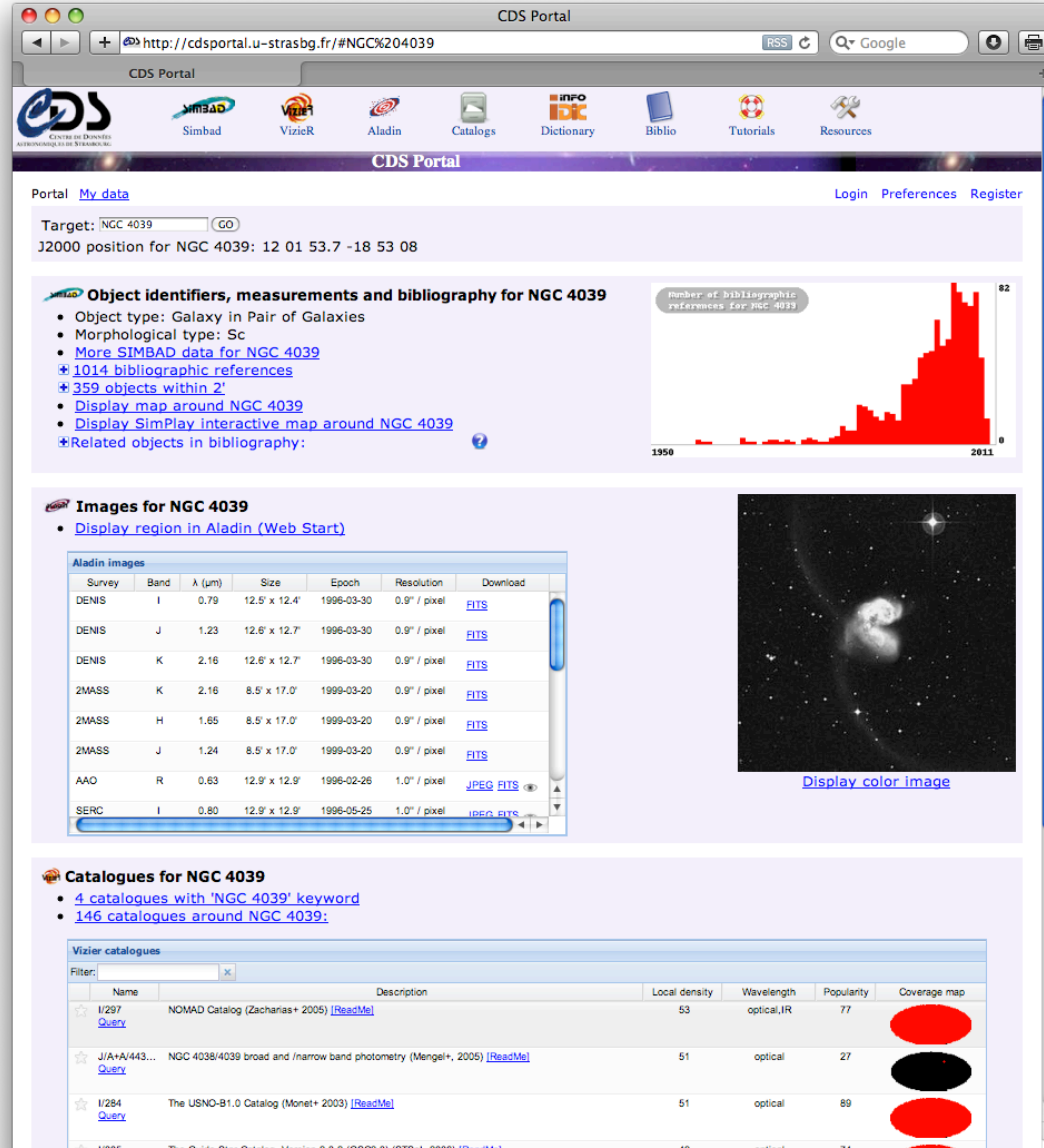




Web pages (VizieR)

VODesktop

Innovation: CDS Portal



CDS Tools in VO schools/tutorials

- Heavy use of CDS tools/services in Euro-VO Science tutorials (VO Schools, VO Days)

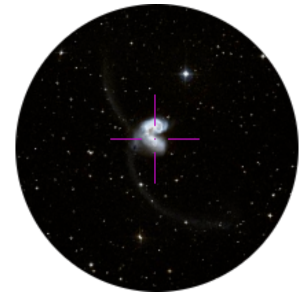
Euro-VO Scientific Tutorials

Fully developed example Science Cases

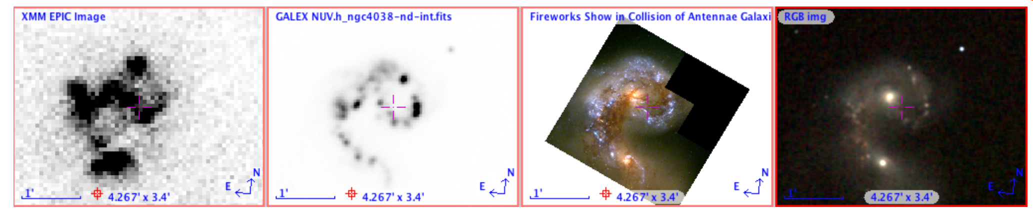
- NEW CDS Tutorial, (step-by-step) **[Mar 2011]** *Uses the CDS Portal and Aladin*
- NEW Study of the Coma Cluster, with a ster-by-step description and a more expanded presentation; **[Mar 2011]** *Uses Aladin and TOPCAT* **VizieR**
- NEW A TOPCAT tutorial, with a section on multi SSA queries (step-by-step) **[Mar 2011]** *Uses TOPCAT, SPLAT-VO*
- H-alpha emitters in X-ray surveys (ster-by-step) **[June 2010]** *Uses Aladin and TOPCAT*
- Proper motion of unstudied open clusters (ster-by-step) **[June 2010]** *Uses Aladin and TOPCAT*
- A study of NGC1068 using TOPCAT for data retrieval (step-by-step) **[Apr 2010; UPDATED Mar 2011]** *Uses Aladin, TOPCAT and SPLAT-VO*
- Quasar candidates in selected fields (step-by-step) **[Mar 2009; UPDATED Mar 2010]** *Uses VODesktop, TOPCAT, VO services, VOSED and VOSpec*
- Classifying the SEDs of Herbig Ae/Be stars (step-by-step) **[Jan 2010]** *Uses TOPCAT, VOSpec and VOSED* **VizieR**
- The nature of a cluster of X-ray sources near the Chamaeleon star-forming region(step-by-step) **[Jan 2010]** *Uses VODesktop, TOPCAT and Aladin* **VizieR**
- Confirmation of a Supernova candidate (step-by-step) **[2009, UPDATED Jan 2010]** *Uses Aladin, TOPCAT, SPLAT-VO or VOSpec* **VizieR**
  - And a lighter version for undergraduate students **[Apr 2010]**
- Search for ULX sources(step-by-step) **[Mar 2009; UPDATED Mar 2011]** *Uses Aladin and TOPCAT* **VizieR**
- Study of Exoplanets(step-by-step) **[Oct 2009]** *Uses the VizieR and Simbad services and TOPCAT*
- Searching for Data available for the bright galaxy M51 (step-by-step) **[Mar 2009, UPDATED Sep 2009]** *Uses Aladin, Simbad, VizieR, TOPCAT and VOSpec*
- Discovery of Brown Dwarfs mining the 2MASS and SDSS databases (step-by-step) **[Mar 2009]** *Uses Aladin, VizieR and TOPCAT*
- The Pleiades open cluster (step-by-step) **[Mar 2009]** *Uses Aladin and TOPCAT*
- Using VOSpec: a VOSpec typical session (movie) **[2009]**
- From SED fitting to Age estimation: The case of Collinder 69 (step-by-step, includes illustrations) **[2008]** *Uses VOSA*
- Individual objects: 3C295 (step-by-step, includes illustrations) **[2007, OUT OF DATE]**
- IMF of massive stars (step-by-step, includes illustrations) **[2007, OUT OF DATE]**

CDS VO Tutorial

Single object search



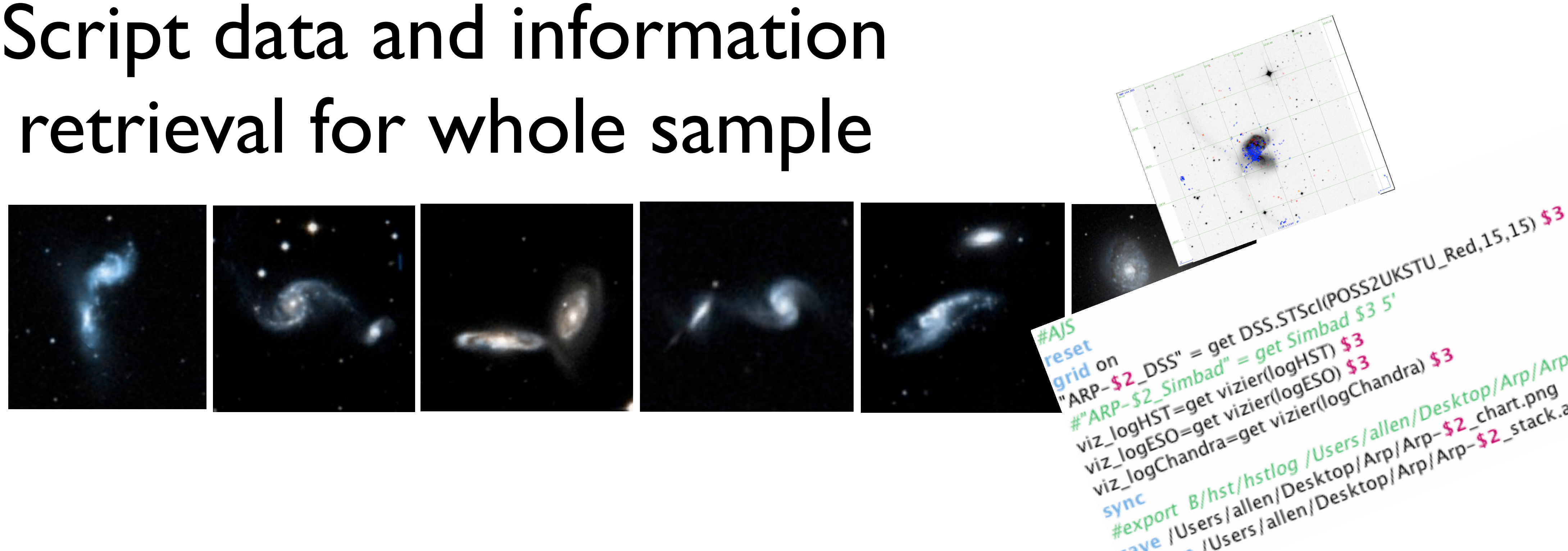
Find Multi-λ data



Use catalogues to select a sample

Full	_RAJ2000 deg	_DEJ2000 deg	Arp	Name	RA2000 "h:m:s"	DE2000 "d:m:s"	Size arcmin
1	141.158	+49.357	1	NGC 2857	09 24 38	+49 21.4	5.2
2	244.075	+47.047	2	UGC 10310	16 16 18	+47 02.8	3.5
3	339.143	-2.905	3	MCG-01-57-016	22 36 34	-02 54.3	5.2
4	027.108	-12.382	4	MCG-02-05-50+A	01 48 26	-12 22.9	3.5
5	171.103	+3.327	5	NGC 3664	11 24 25	+03 19.6	2.6
6	123.310	+45.992	6	NGC 2537	08 13 14	+45 59.5	2.6
7	132.573	-16.577	7	MCG-03-23-009	08 50 17	-16 34.6	2.6
8	020.598	-0.875	8	NGC 0497	01 22 23	-00 52.5	3.5
9	123.748	+73.580	9	NGC 2523	08 14 59	+73 34.8	3.5
10	034.610	+5.653	10	UGC 01775	02 18 26	+05 39.2	2.6

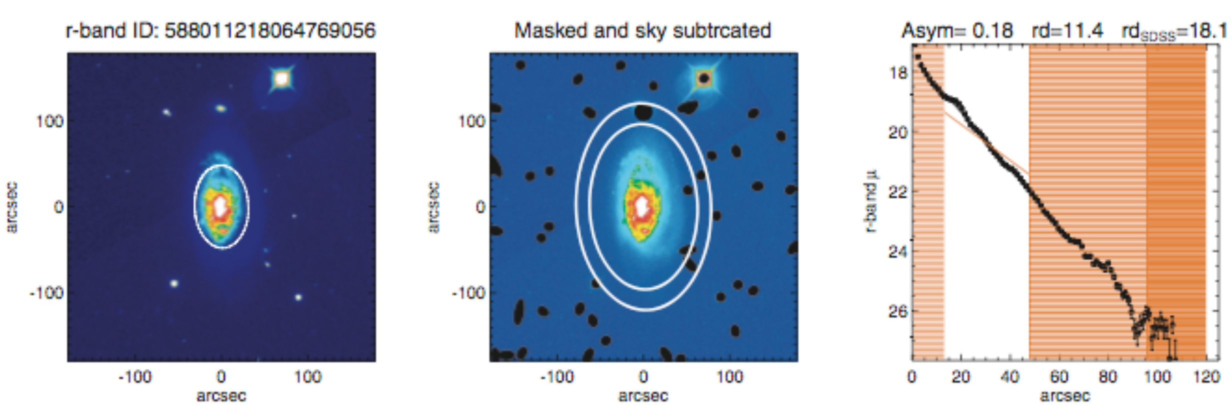
Script data and information retrieval for whole sample



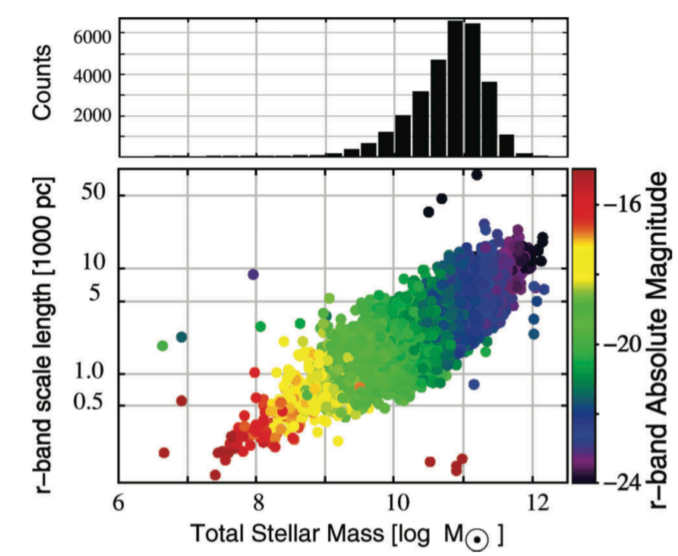
VO Science

e.g. 1.) Euro-VO Research Initiative

- SDSS, Skyview, Aladin, Topcat, IDL/GDL, VOSpace + Cluster System at CDS



×30374 ➡



Freeman law of galaxy disks confirmed for large sample out to z=0.3

Supported at CDS by Allen, Boch, Schaaff

Monthly Notices of the Royal Astronomical Society
Mon. Not. R. Astron. Soc. **406**, 1595–1608 (2010)
doi:10.1111/j.1365-2966.2010.16812.x

Scalelength of disc galaxies

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[2]Oskar Klein Centre for Cosmoparticle Physics, Stockholm University, 106 91 Stockholm, Sweden
[3]Observatoire de Strasbourg, UMR 7550, Strasbourg 67000, France
[4]European Southern Observatory, Karl-Schwarzschild-Str. 2, 85748 Garching bei München, Germany
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ABSTRACT

We have derived disc scalelengths for 30 374 non-interacting disc galaxies in all five Sloan Digital Sky Survey (SDSS) bands. Virtual Observatory methods and tools were used to define, retrieve and analyse the images for this unprecedentedly large sample classified as disc/spiral galaxies in the LEDA catalogue. Cross-correlation of the SDSS sample with the LEDA catalogue allowed us to investigate the variation of the scalelengths for different types of disc/spiral galaxies. We further investigate asymmetry, concentration and central velocity dispersion as indicators of morphological type, and are able to assess how the scalelength varies with respect to galaxy type. We note, however, that the concentration and asymmetry parameters have to be used with caution when investigating type dependence of structural parameters in galaxies. Here, we present the scalelength derivation method and numerous tests that we have carried out to investigate the reliability of our results. The average *r*-band disc scalelength is 3.79 kpc, with an rms dispersion of 2.05 kpc, and this is a typical value irrespective of passband and galaxy morphology, concentration and asymmetry. The derived scalelengths presented here are representative for a typical galaxy mass of $10^{10.8\pm0.54}$ $M_\odot$, and the rms dispersion is larger for more massive galaxies. Separating the derived scalelengths for different galaxy masses, the *r*-band scalelength is 1.52 ± 0.65 kpc for galaxies with total stellar mass 10^9–10^{10} $M_\odot$ and 5.73 ± 1.94 kpc for galaxies with total stellar mass between 10^{11} and 10^{12} $M_\odot$. Distributions and typical trends of scalelengths have also been derived in all the other SDSS bands with linear relations that indicate the relation that connect scalelengths in one passband to another. Such transformations could be used to test the results of forthcoming cosmological simulations of galaxy formation and evolution of the Hubble sequence.

Key words: galaxies: structure.

1 INTRODUCTION

The exponential scalelength of a galaxy disc is one of the most fundamental parameters to determine its morphological structure as well as to model its dynamics, and the fact that the light distributions are exponential makes it possible to constrain the formation mechanisms (Freeman 1970). The scalelength determines how the stars are distributed throughout a disc, and can be used to derive its mass distribution, assuming a specific M/L ratio. Ultimately, this mass distribution is the primary constraint for determining the formation scenario (e.g. Lin & Pringle 1987; Dutton 2009, and referenced therein), which dictates the galaxy's evolution. As the galaxy evolves, substructures such as bulges, pseudo-bulges, bars, rings and spiral arms may build up, and this will then considerably change the morphology of the host discs (Combes & Elmegreen 1993; Elmegreen et al. 2005; Bournaud, Elmegreen & Elmegreen 2007). The scalelength value is intimately connected to the circular velocity of the galaxy halo, which in turn relates closely to the angular momentum of the halo in which the disc is formed (Dalcanton, Spergel & Summers 1997; Mo, Mao & White 1998). Up to the last few years, cosmological simulations were limited to rather low resolution, were discs and spheroids were barely resolved, and generally limited to high redshifts, so reproducing realistic disc scalelengths for modern galaxies was clearly out of reach. The current simulations reach resolutions that allow resolving the discs from high redshift down to redshift zero, and subtle mechanisms changing the disc masses and scalelengths can be studied

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doi:10.1088/2041-8205/722/1/L120

REVISITING THE SCALE LENGTH–μ_0 PLANE AND THE FREEMAN LAW IN THE LOCAL UNIVERSE

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Received 2010 May 20; accepted 2010 September 13; published 2010 September 24

ABSTRACT

We have used Virtual Observatory technology to analyze the disk scale length r_d and central surface brightness μ_0 for a sample of 29,955 bright disk galaxies from the Sloan Digital Sky Survey. We use the results in the *r* band and revisit the relation between these parameters and the galaxy morphology, and find the average value $\langle\mu_0\rangle = 20.2 \pm 0.7$ mag arcsec^{-2}. We confirm that late-type spirals populate the lower left corner of the r_d–μ_0 plane and that the early and intermediate spirals are mixed in this diagram, with disky ellipticals at the top left corner. We further investigate the Freeman Law and confirm that it indeed defines an upper limit for μ_0 in bright disk galaxies with $r_{mag} < 17.0$, and that disks in late-type spirals ($T \geqslant 6$) have fainter central surface brightness. Our results are based on a volume-corrected sample of galaxies in the local universe ($z < 0.3$) that is two orders of magnitudes larger than any sample previously studied and deliver statistically significant implications that provide a comprehensive test bed for future theoretical studies and numerical simulations of galaxy formation and evolution.

Key words: galaxies: evolution – galaxies: formation – galaxies: structure

Online-only material: color figures

1. INTRODUCTION

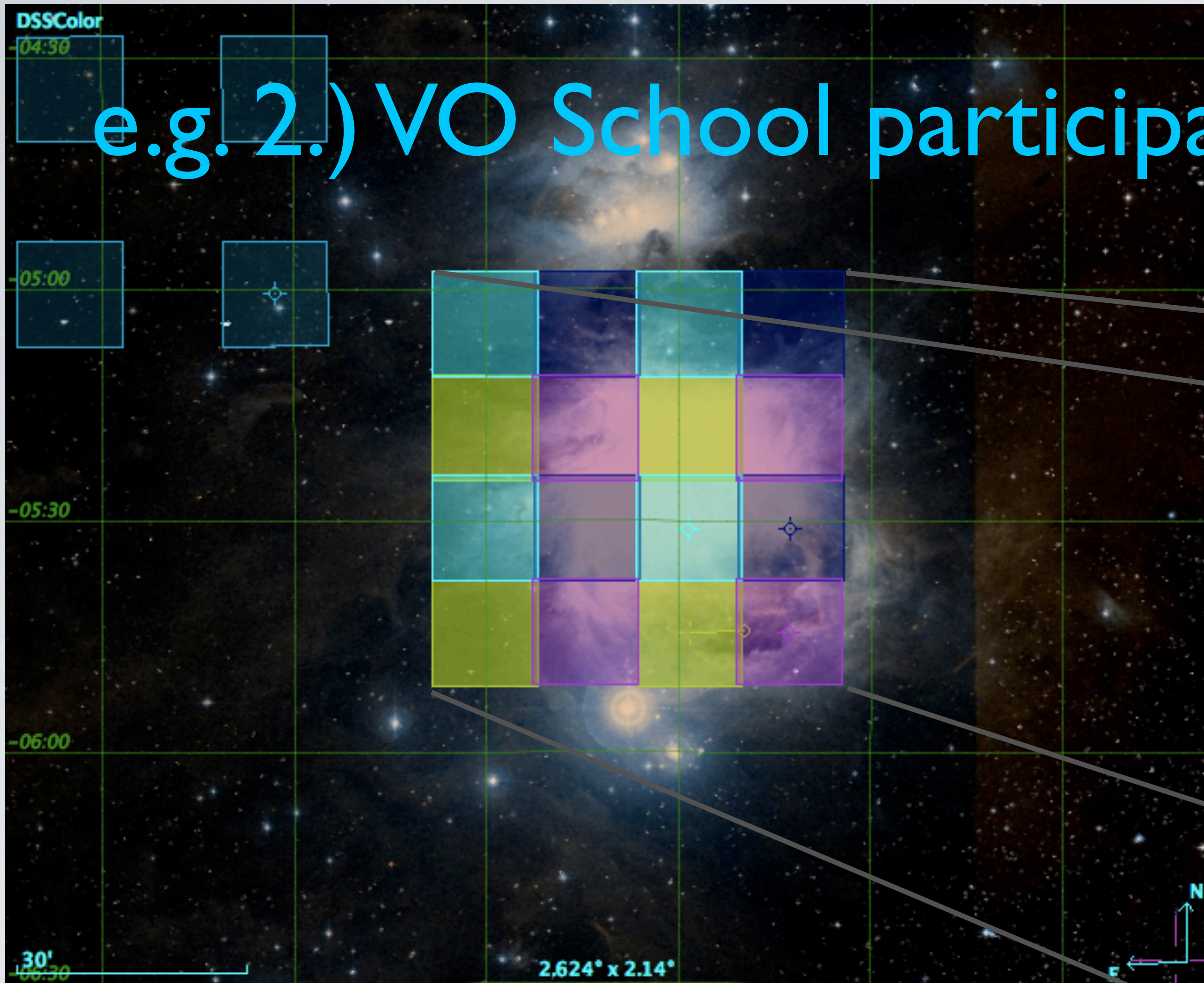
The current mainstream galaxy formation paradigm states that galaxy disks form within dark matter halos and that there is an intimate relation between the scale length r_d of the disk and that of the halo. The mass distribution of the disk is entirely set by the r_d and, for example, in the exponential case, 60% of its total mass is confined within two scale lengths and 90% within four scale lengths. Moreover, the angular momentum of the disk is set by r_d and the mass distribution of its host halo, and the fact that the angular momentum vectors are aligned suggests that there is a physical relation between the two. During the formation process, galaxy mergers and associated star formation and feedback processes play a crucial role in the resulting structure, however, the observed sizes of disks suggest that the combination of these physical processes indicate that galactic disks have not lost much of the original angular momentum acquired from cosmological torques (e.g., White & Rees 1978; Fall & Efstathiou 1980). The hierarchical and infall models predict comparable r_d, and in a cold collapse scenario (Vand 1959) since angular momentum is conserved, immediately after the collapse the gas is supported by rotation so that it quickly collects in the region where a disk forms with substantially higher rotation velocity than the halo is to form. A large r_d disk forms when the disk mass is smaller than the halo mass over the disk region, and vice versa: a small r_d disk forms when the mass of the disk dominates the mass of the halo in any part of the disk. The self-gravitating disk will also modify the shape of the rotation curve near the center of a galaxy (Gelato & Sommer-Larsen 1999) and the disk is then set to undergo secular evolution. The natural implication of this scenario is that the r_d dictates the life of a disk, and consequently, is a prime factor which determines the position of a galaxy on the Hubble sequence.

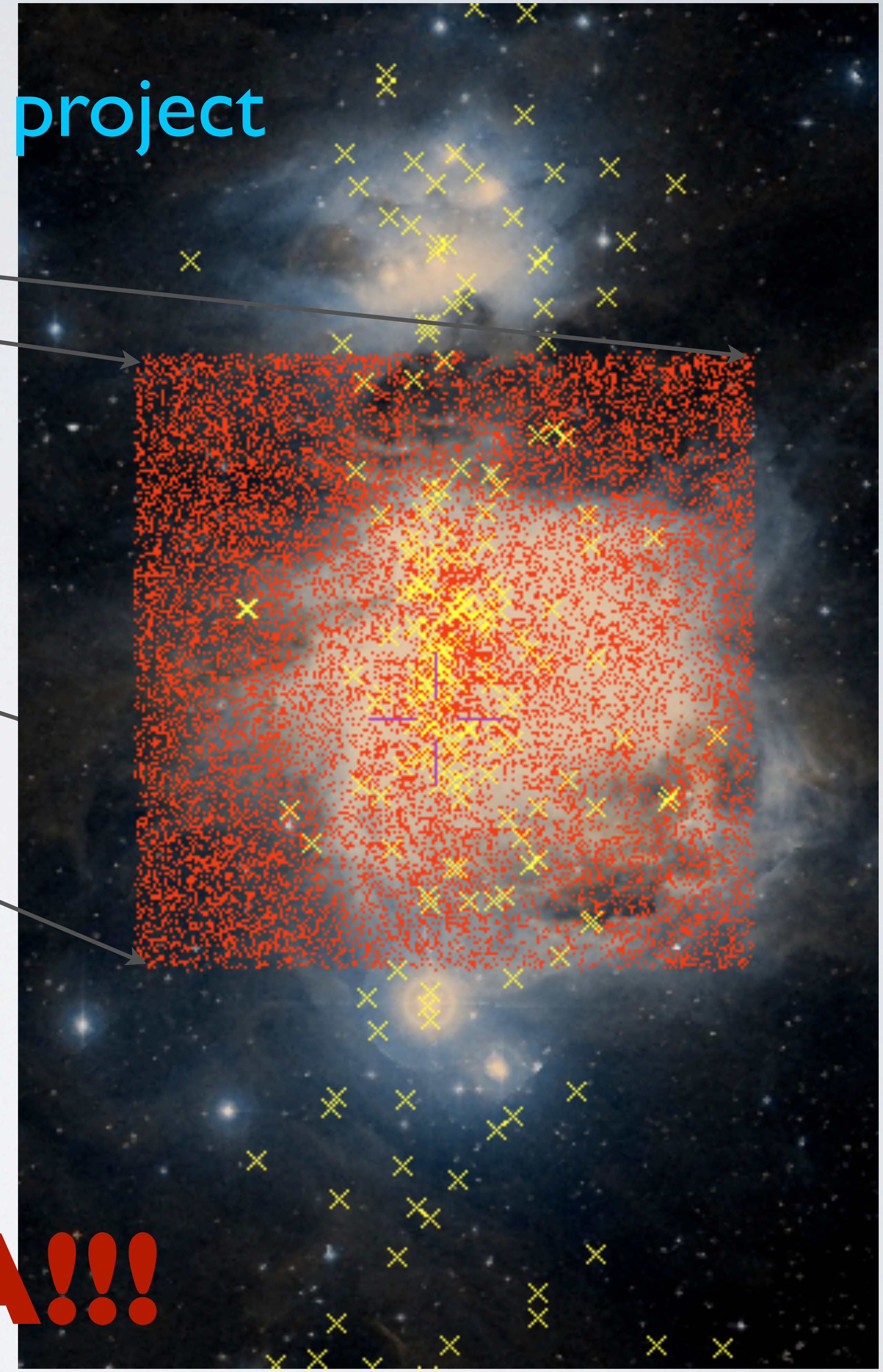
One prominent indicator for a smooth transition from spiral toward S0 and disky ellipticals is provided by the r_d–μ_0 diagram, where μ_0 is the central surface brightness of the disk, where spirals and S0s are mixed and disky ellipticals populate the upper left corner of this diagram (Kent 1985; Scorza & Bender 1995). Another instructive relation is the Freeman Law (Freeman 1970) which relates μ_0 to the galaxy morphological type. Although, some studies have found that the Freeman Law is an artifact due to selection effects (e.g., Disney 1976; Bothun 1981; Scorza & van den Bosch 1998), recent work has shown that proper consideration of selection effects can be combined with kinematic studies to explore an evolutionary sequence (e.g., van der Kruit 1987, 2002; de Jong 1996; Koda et al. 2000).

In the comparison between theory and observations, two issues complicate matters. On the theory side, mapping between initial halo angular momentum and r_d is not trivial, partly due to the fact that commonly the initial specific angular momentum distribution of the visible and dark component favors disks that are more centrally concentrated than exponential (e.g., de Jong & Lacey 2000; van den Bosch 2001). Observationally, comprehensive samples have yet not been studied, and the mixture of different species such as low and high surface brightness galaxies complicate the measurements of disk parameters (McGaugh et al. 1995; Graham & de Blok 2001).

Here, we analyze the r_d and μ_0 from an unprecedentedly large sample of bright disk galaxies in the nearby universe ($z < 0.3$) using the Sloan Digital Sky Survey (SDSS) Data Release 6 (York et al. 2000; Adelman-McCarthy et al. 2008). As detailed in Fathi et al. (2010, hereafter F10), both parameters were robustly determined for 30,374 galaxies in the *r* band (only 29,955 used here as described in Section 2), whereas in other SDSS bands, the derived parameters are valid only for subsets of this sample. In the *g*, *i*, and *z* bands (≈27,000–30,000 galaxies), the sample sizes are comparable to the one presented here. In the *u* band, r_d and μ_0 were robustly derived for a few hundred objects and therefore, not considered here. Throughout this Letter, unless otherwise stated, we use disk parameters in the *r* band and investigate the two relations mentioned above, in order to provide a comprehensive test bed for forthcoming cosmological simulations (or analytic/semi-analytic models) of galaxy formation and evolution.

e.g. 2.) VO School participant project





1 fits file with 4 extensions x 4 points on sky x 2 filters x 13 epochs

= 416 tables

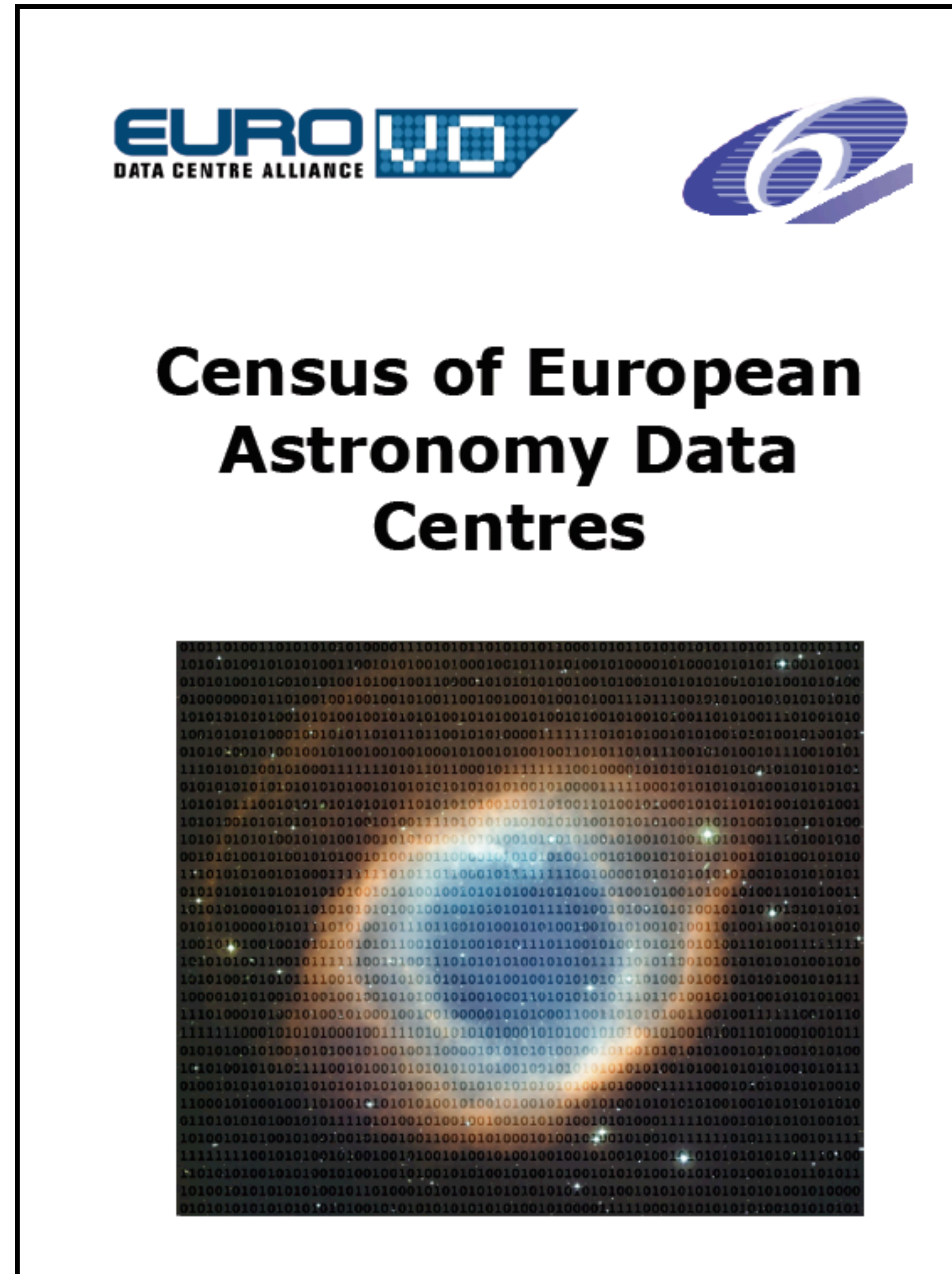
= **ALOT OF DATA!!!**

which sat on my laptop for more than 1 year... until... the VO School 2010!

Assisting VO uptake

CDS contributions to Data Centre Alliance project

- Workshop tutorials
  - Scientific rationale
  - SAADA (w/L. Michel)
  - UCD tools
- Census



Allen & Depretz 2009

Census summary

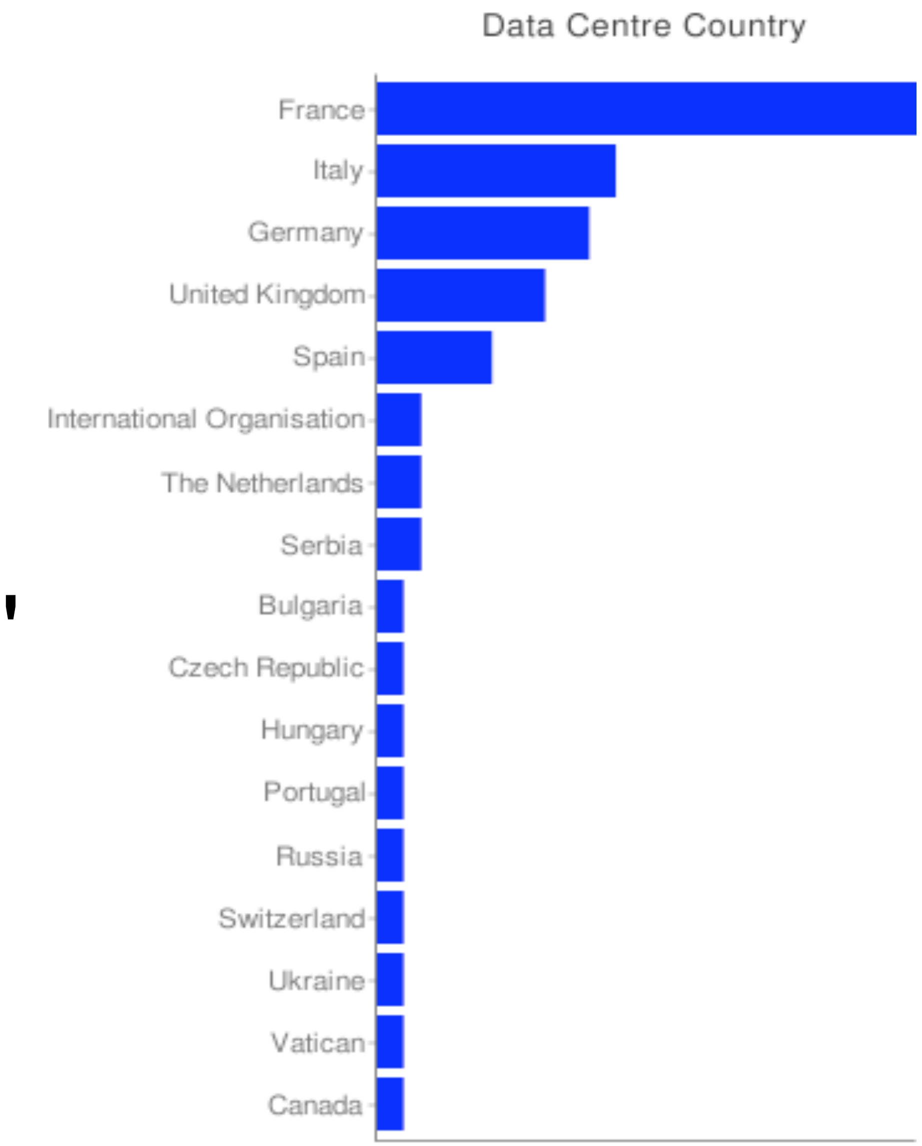
68 Data Centres

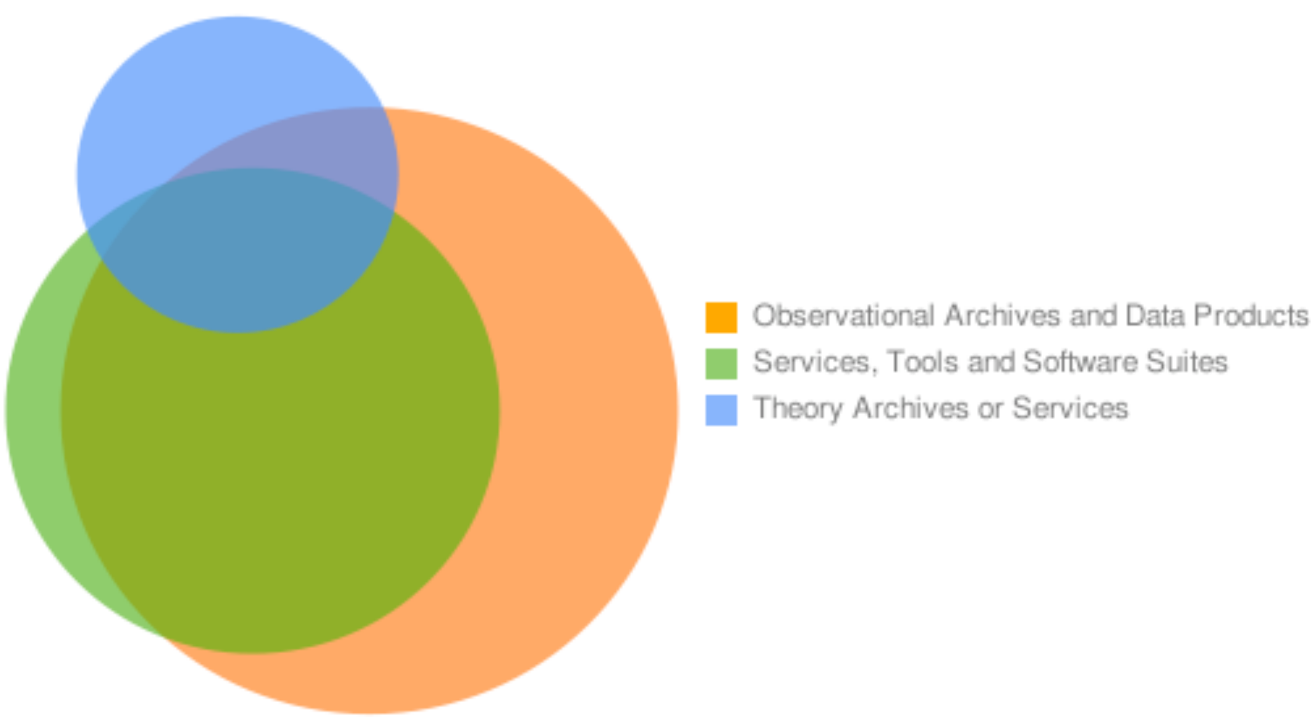
134 Observational Archives

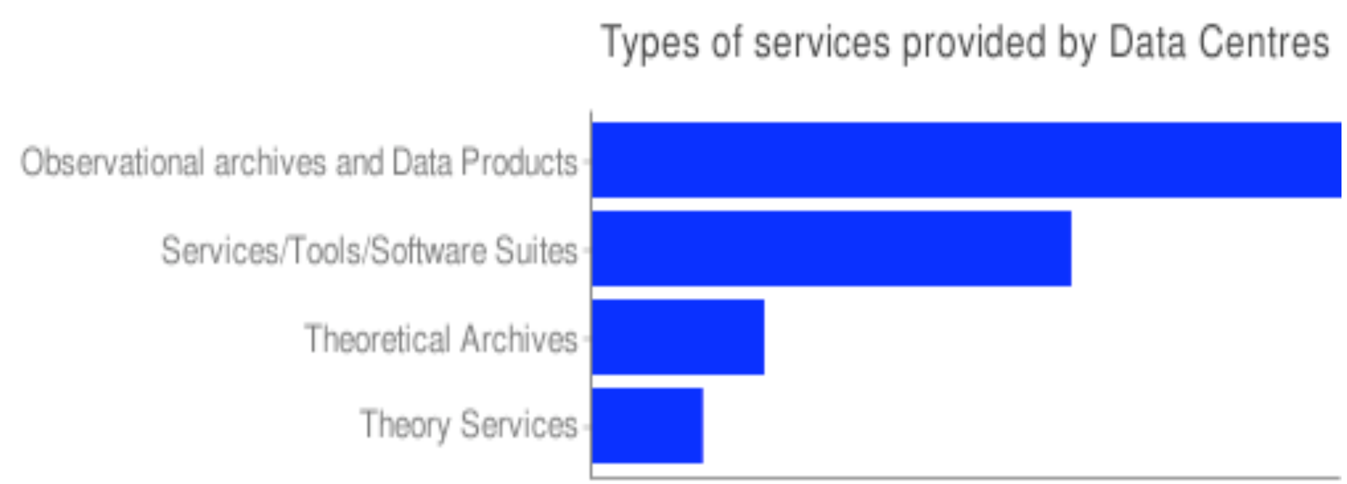
66 'Service/Tool/Software Suite'

24 Theory Archives

8 Theory Services







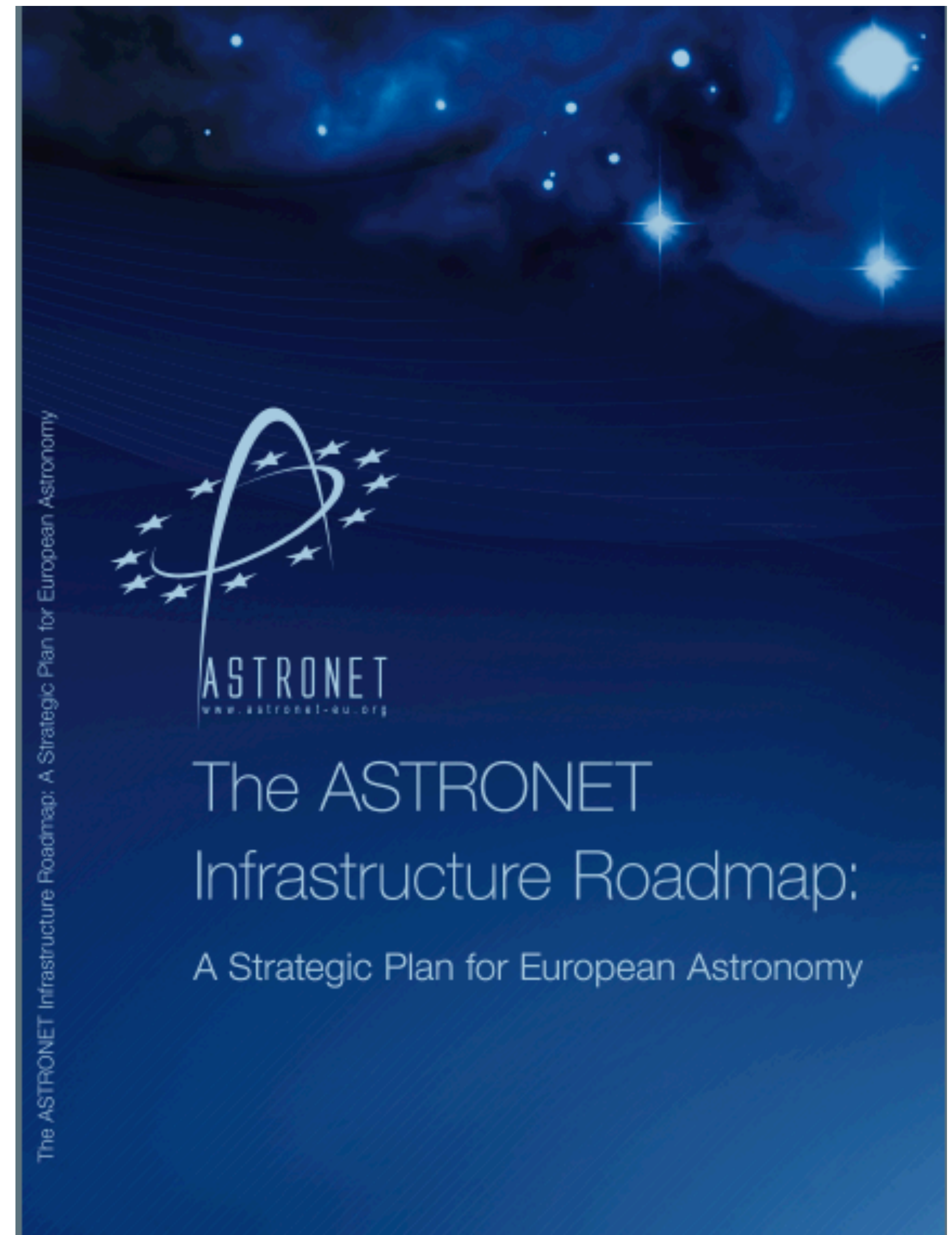
Diversity in terms of 'scale, content and function'

Implications for VO

- Maintain coordination of VO developments with Data Centres
- Ensure VO publishing is not significantly more difficult than web publishing
- Accommodate diversity
- Increase emphasis on 'Science ready data'
- The census identifies Data Centres who will lead up-take of VO as Euro-VO moves into operational phase

VO as Infrastructure

- VO in the ASTRONET Infrastructure roadmap
- recommendations for VO compliance
- community validation of VO approach



Panel D members: Allen, Padovani