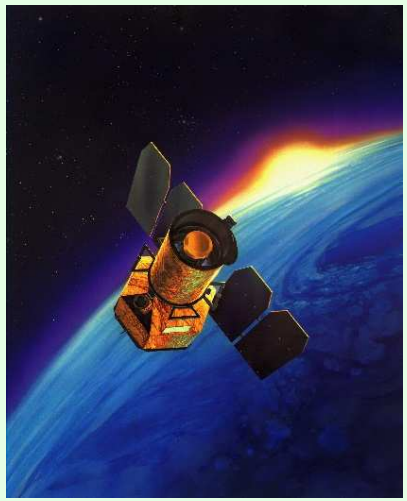
Recent Progress in Building the Virtual Observatories in the World

Masatoshi Ohishi / NAOJ & Sokendai
大石雅寿 / 国立天文台 & 総合研究大学院大学

masatoshi.ohishi@nao.ac.jp

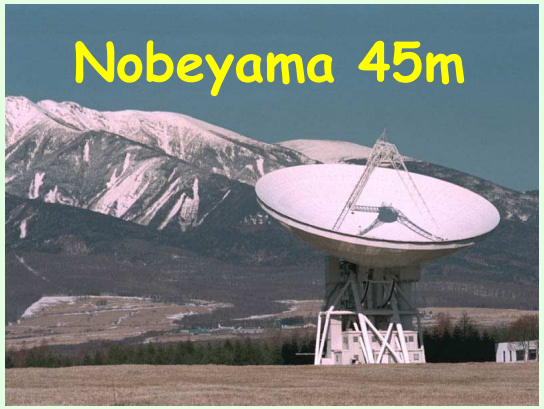
Data Resources in the World

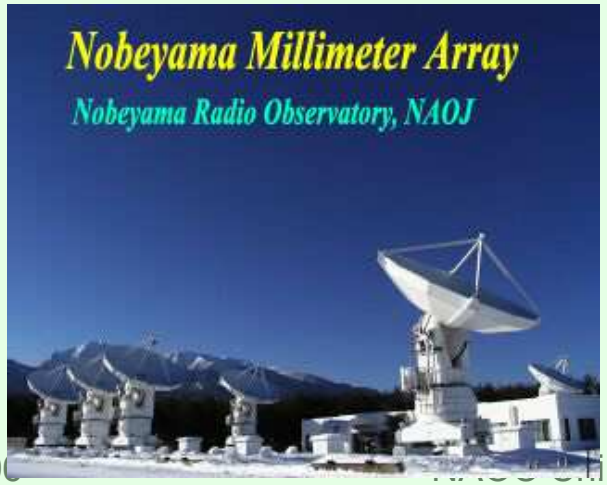
- ESO VLT @ Paranal
- ESO telescopes @ La Silla
- Telescopes in Mauna Kea
  Subaru, Keck, JCMT, CSO, SMA,,,
- Telescopes on board satellites
  HST, GALEX,,,,



Data Resources in NAOJ

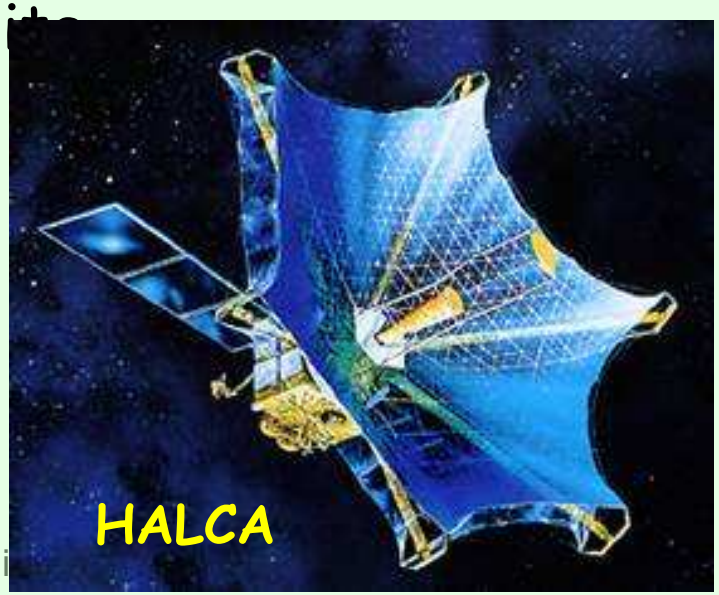
- Subaru 8.2m Optical-Infrared Telescope
- Kiso 105cm Schmidt Camera
- Okayama 188cm Optical Telescope
- Nobeyama 45m Radio Telescope
- Nobeyama Millimeter Array
- Nobeyama Radioheliograph
- VSOP
- VERA
- *ALMA*



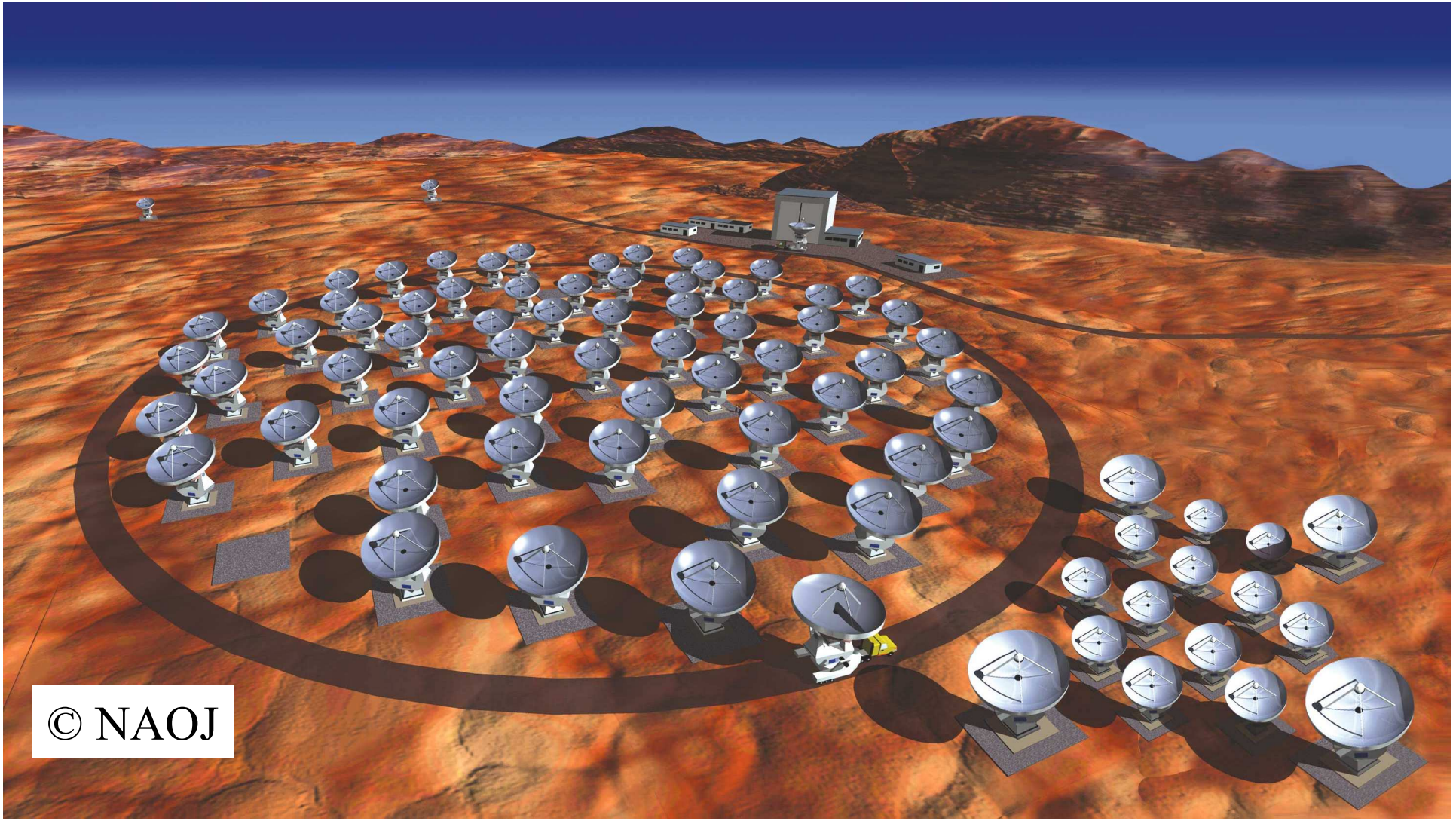


Data Resources in JAXA/ISAS

- ASCA X-ray astronomy satellite
- YOHKO solar physics satellite
- Ginga X-ray astronomy satellite
- HALCA VLBI satellite
- Geotail geomagnetosphere satellite
- Akebono aurora observation satellite
- *ASTRO-F Infrared satellite*
- *ASTRO-E2 X*
- *SOLAR-B*



ALMA Project



Data Productivity

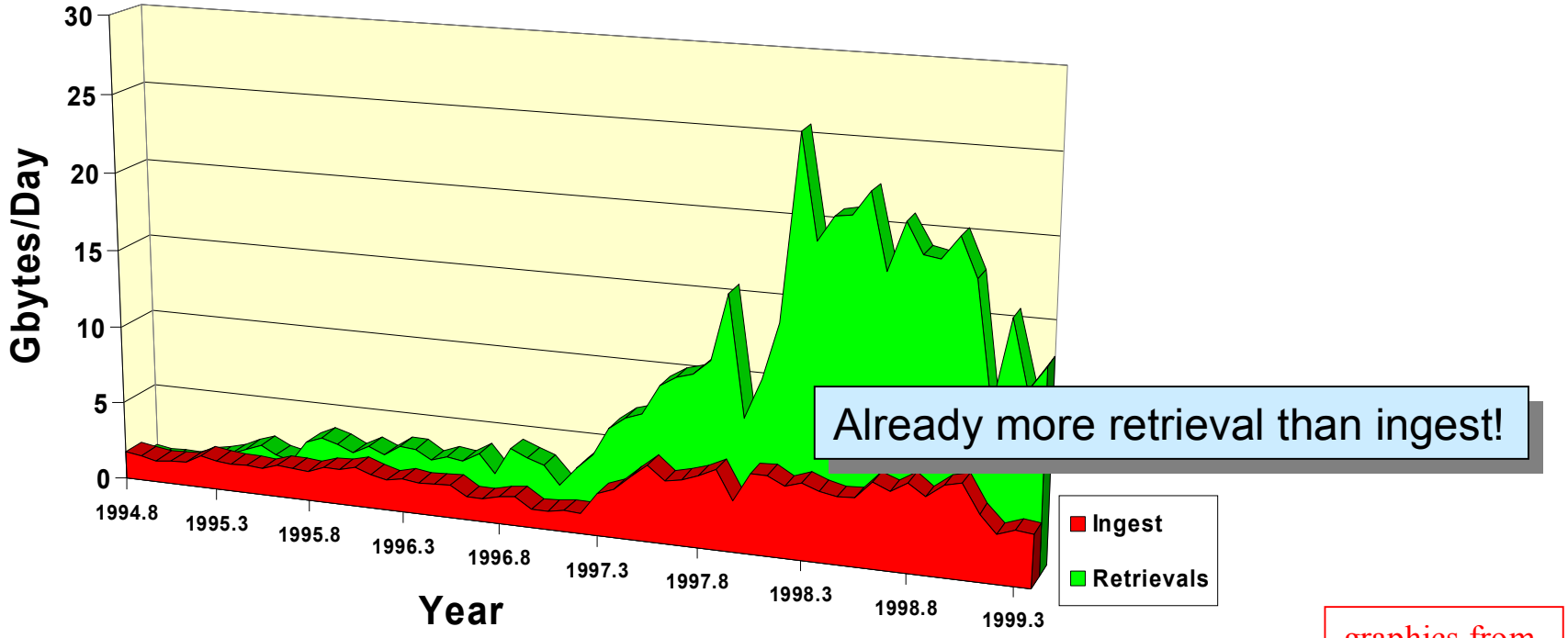
- Nobeyama Radio ：~1TB/yr
- Subaru@Hawaii ：~20TB/yr
- ASTRO-F(will be launched)
  ：several 100 GB in total
- ALMA（planned） ：~PB/yr

Flood of excellent data (survey data)

Digitized & Archived

Astronomy based on Archives

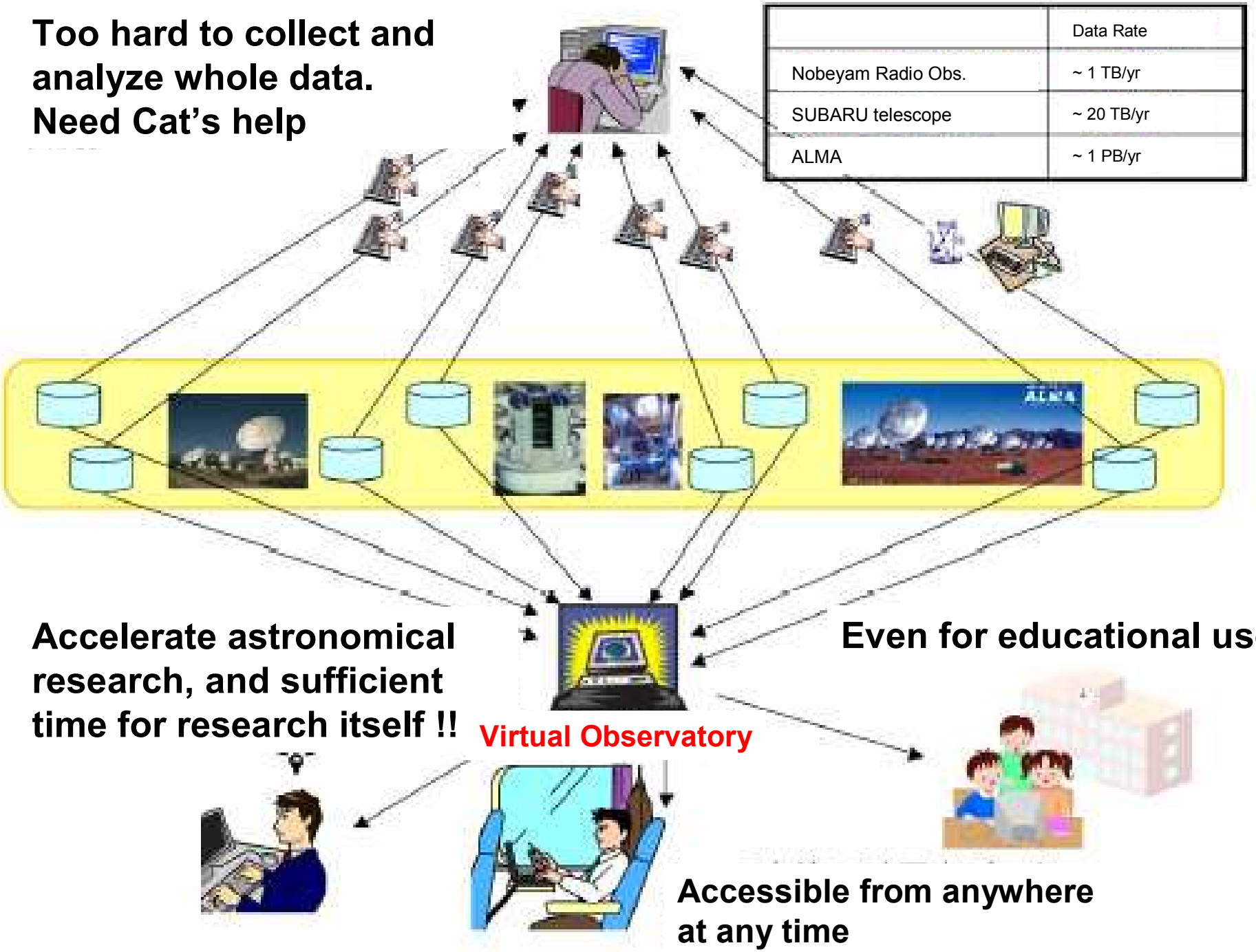
- large fraction of astro-papers based on archives
- HST archive use growing faster than archive



graphics from US NVO project

Too hard to collect and analyze whole data. Need Cat's help

	Data Rate
Nobeyam Radio Obs.	~ 1 TB/yr
SUBARU telescope	~ 20 TB/yr
ALMA	~ 1 PB/yr



Accelerate astronomical research, and sufficient time for research itself !!

Virtual Observatory

Even for educational use

Accessible from anywhere at any time

VO– New Research Infrastructure in the 21st Century

A collection of integrated astronomical data archives and software tools that utilize computer networks to create an environment in which research can be conducted.

http://www.encyclopedia.com/html/v1/virtobserv.asp

International Endorsements

- IAU XXVth GA Res. (2003 Jul.)
- OECD Rec. (‘04 Aug)
  - place archives that may be accessible via internet
  - provide adequate funding as long-term issues

IAU XXVth GA Res. (2003 Jul.)

Recommends

1. that, data obtained at major astronomical facilities should, after a reasonable proprietary period in which they are available only to observers or other designated users of the facility, be placed in an archive where they may be accessed via the internet by all research astronomers. As far as possible, the data should be accompanied by appropriate metadata and other information or tools to make them scientifically valuable,
2. that, such data should not be subject to intellectual property rights. The form in which data are made available, and the subsequent processing of such data, may be appropriately protected by copyright laws, but the fair usage (including educational purposes) of the archive data themselves should not be subject to restrictions,
3. that, funding agencies provide encouragement and support to enable data produced by astronomical research that they fund to be deposited, after some proprietary period as defined above, in recognized data archives which provide unrestricted access to these data.

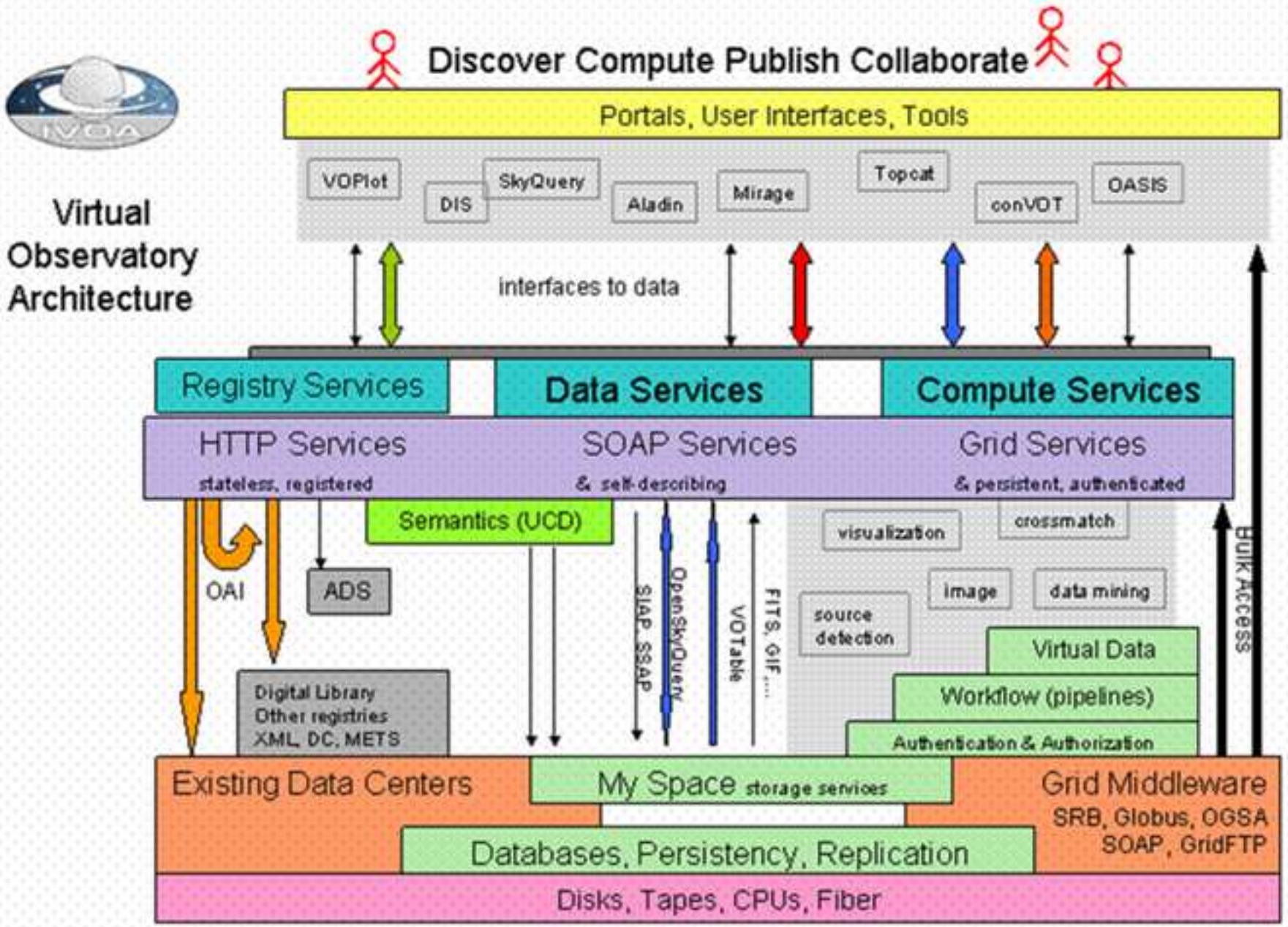
OECD Rec. (‘04 Aug)

Recommendations:

New projects and facilities must take the data management, storage, maintenance, and dissemination into account at the earliest planning stages, consulting potential users in the process. Agencies and governments should consider adopting the IAU resolutions as the basis for progress in this field. Agencies should recognise that this is an important long-term issue and should co-ordinate plans, provide adequate funding on a long-term basis, and support development and maintenance of the needed infrastructure. Agencies should encourage broadening of existing VO collaboration into a fully representative global activity.

VO Projects in the world

- 15 countries and region
- International Virtual Observatory Alliance (IVOA) Standards to interoperate VOs
- Japan – Language to access federated DB


Virtual Observatory Architecture
Discover Compute Publish Collaborate
Portals, User Interfaces, Tools
VOPlot
DIS
SkyQuery
Aladin
Mirage
Topcat
conVOT
OASIS
interfaces to data
Registry Services
Data Services
Compute Services
HTTP Services
stateless, registered
SOAP Services
& self-describing
Grid Services
& persistent, authenticated
Semantics (UCD)
OAI
ADS
Digital Library
Other registries
XML, DC, METS
SIAP, SSAP
OpenSkyQuery
VOTable
FITS, GIF, ...
visualization
crossmatch
image
data mining
source detection
Virtual Data
Workflow (pipelines)
Authentication & Authorization
BULK Access
Existing Data Centers
My Space storage services
Grid Middleware
SRB, Globus, OGSA
SOAP, GridFTP
Databases, Persistency, Replication
Disks, Tapes, CPUs, Fiber

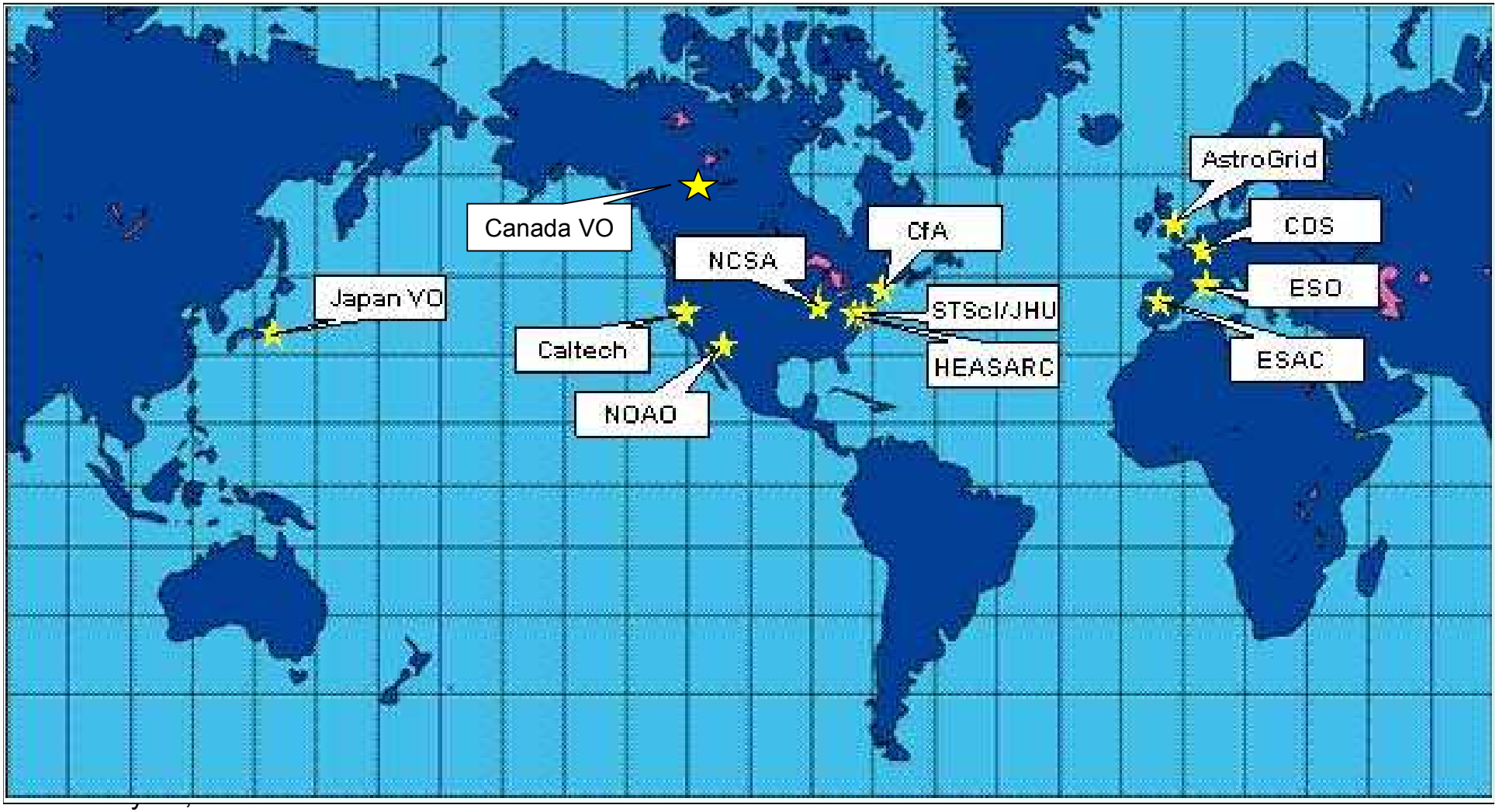
Standardization in IVOA

- Query language to distributed DBs (VOQL)
- Meta-data : contents, protocol to interchange
  based on OAI-PMH
- Protocols to retrieve images, spectra, and so on
  SkyNode, SIAP, SSAP, STC, etc.
- Unified attribute names in DBs
  UCD (Unified Contents Descriptions)
- Output Format : VOTable (XML)
  incorporates FITS
- etc

IVOA Interoperability WS

- Twice a year
- Discussions toward standardization
- Human network as a basis for cyber network

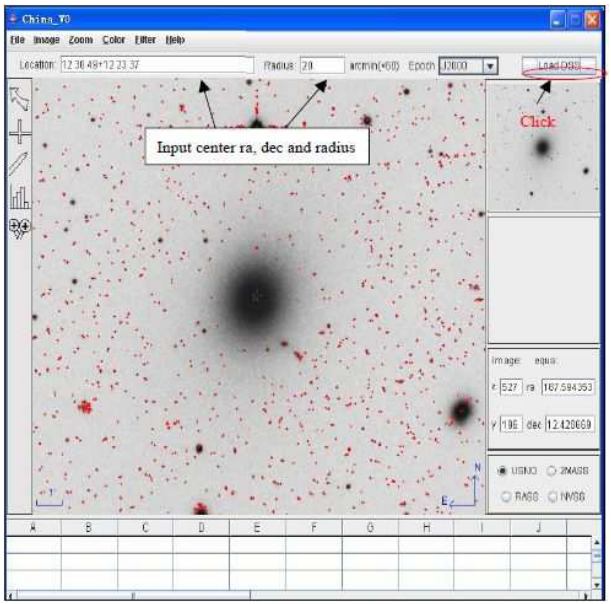
Interconnected VO Data services in the World

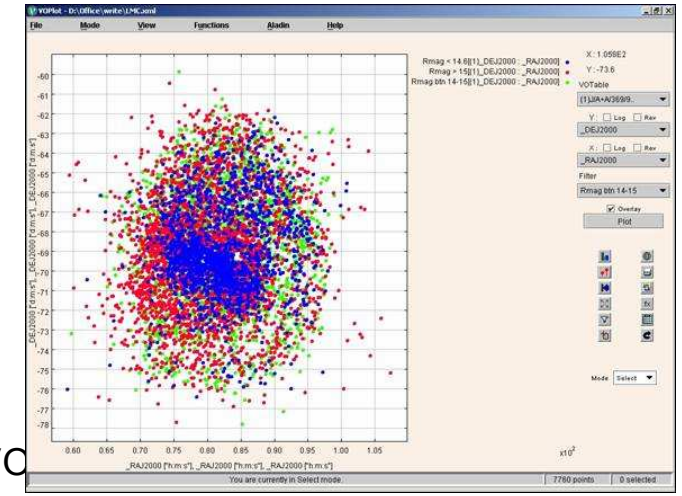



COSPAR2006

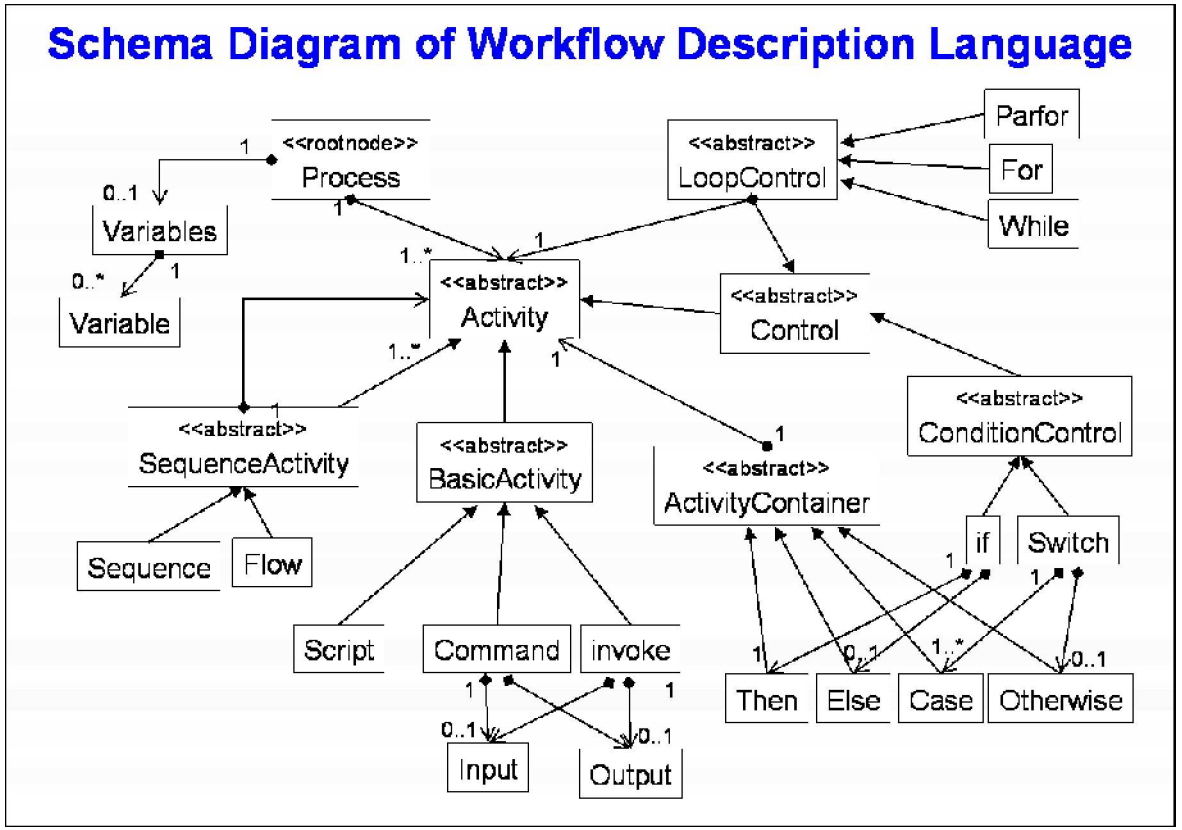
Software Tool providers

- VO-China
  - VOFilter : VOTable → OpenOffice data
  - VOIMPAT : Image processing and analysis tool
  - ,,,
- VO-India
  - VO-Plot: to plot contents in VOTable
  - ,,,





Workflow Description Language



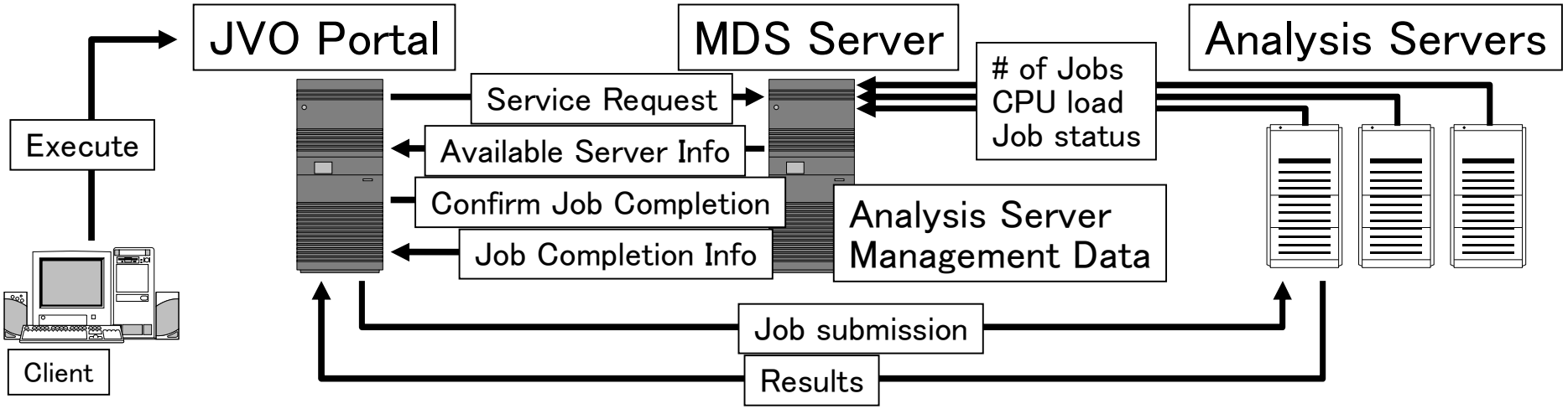
Based on BPEL4WS

- Variable definition
- Controls (Loop, Condition)
- Parallel execution
- Invoke external services
- Invoke built-in Java Classes

Management of Multiple Servers

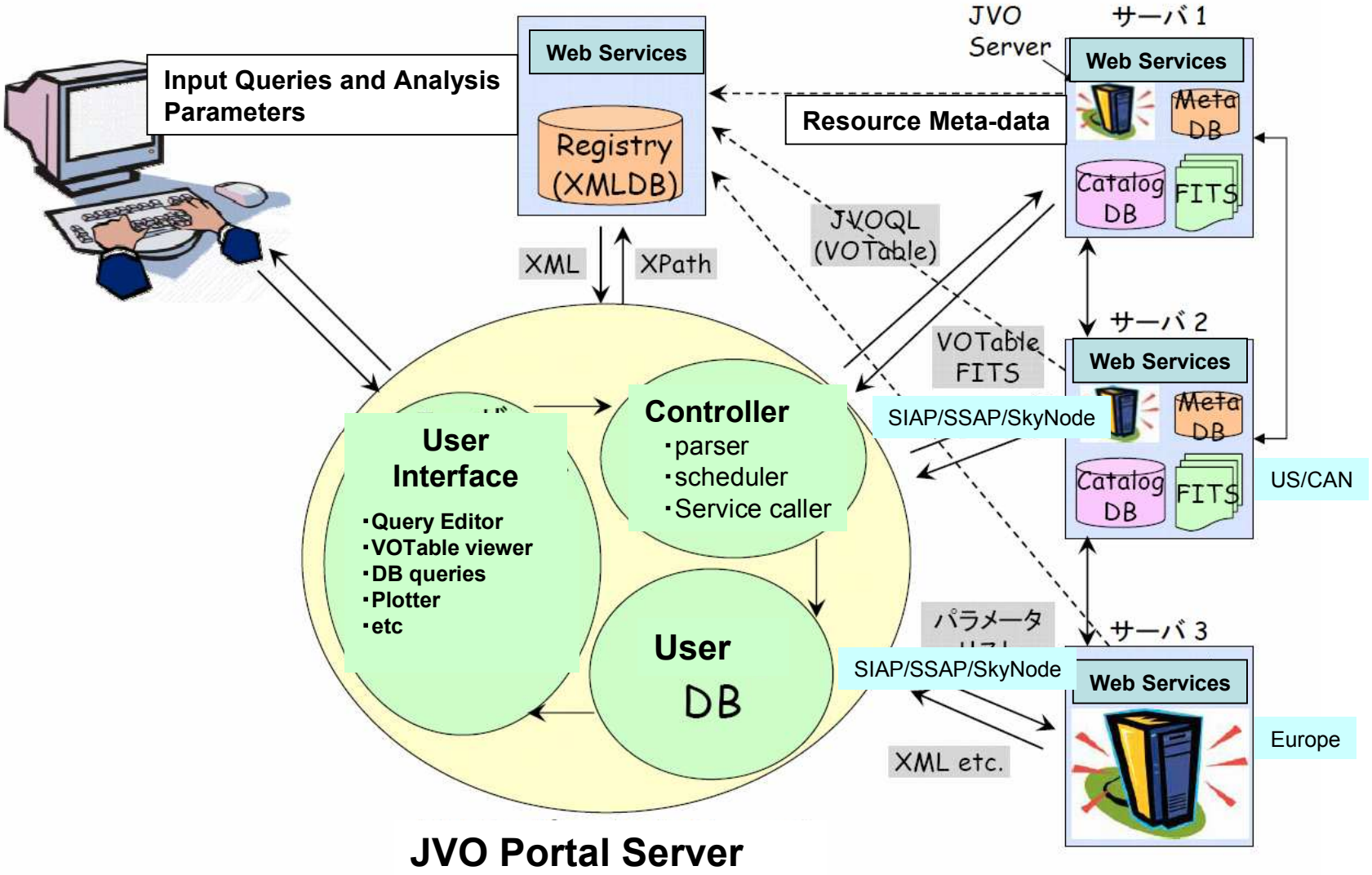
- Data Analysis services under JVO
  - SExtractor (Image → Catalog)
  - HyperZ (Catalog → photometric redshift)
    - In operation on multiple servers

→ Monitor and Discovery Service (MDS) server



Parallel Executions on Multiple Servers are available

Schematic diagram of VOs



JVO Query Language (JVOQL)

JVOQL is designed as a prototype of VO Query Language.

Characteristics of the JVOQL:

- SQL based Query Language
- Query Language for the distributed astronomical DB.
- Can search and retrieve observational data as well as catalog data
- Upward compatible with the ADQL and SIAP syntax.
- Scalable syntax structure. Very simple core syntax and extension syntax packages.

JVOQL Syntax Requirement 1

• Unified query language for both the catalog and observation data such as image data, spectrum, 3D-cube, photon list …

- Parameter query (SIAP) can be replaced by SQL thinking that the parameters are columns of a relational table.

- Observational data or pointer (URL) to retrieve the data is also a column of the relation table.

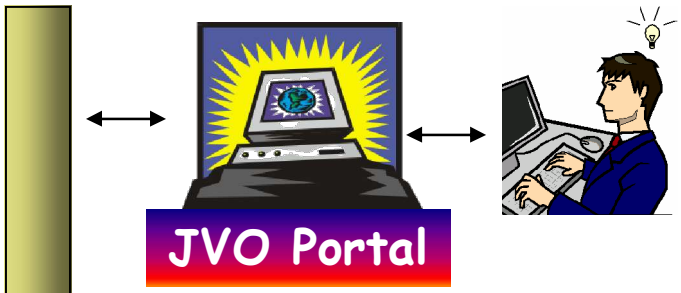
```
http://jvo.nao.ac.jp/imageData?Pos=24,5&Size=0.2&format=VOTable
```

↓

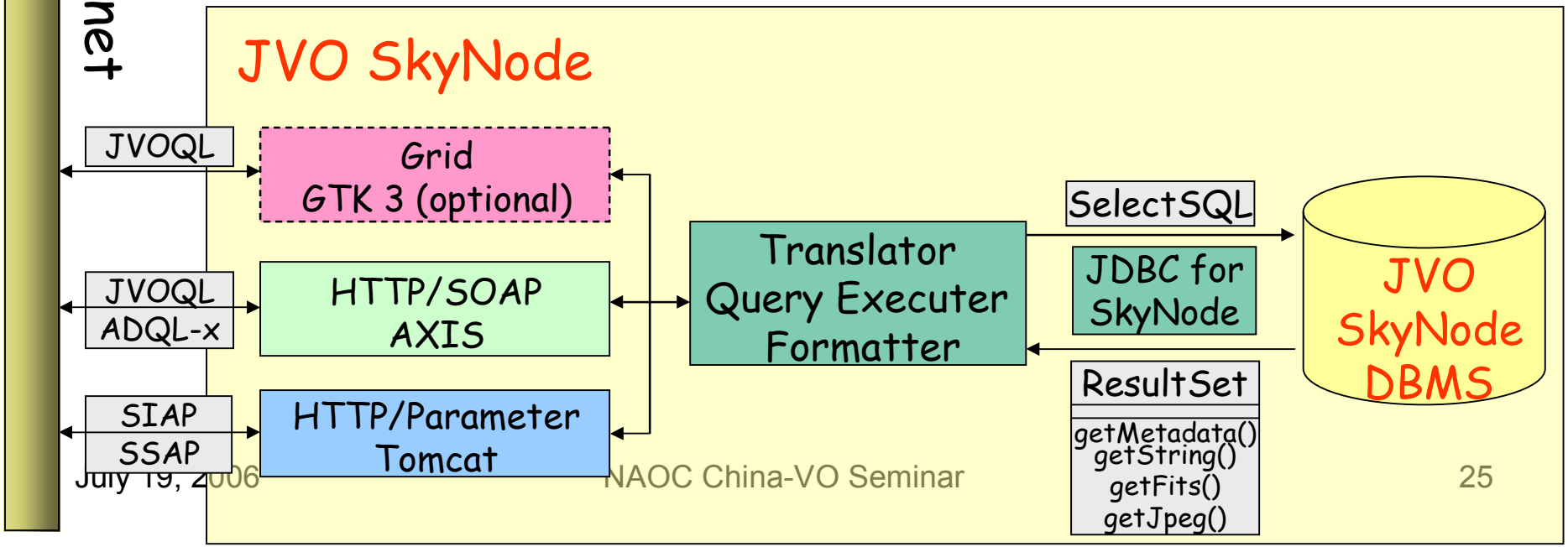
```
Select      imageURL, …
From        naoj:imageData
Where       pos=Point(24,5) and size=0.2 and format='VOTable'
```

"pos" , "size", "imageURL" are virtual columns.

JVO SkyNode Architecture



- Apache Axis and Tomcat are used for implementing the VO standard interface, and Globus Toolkit is used for an optional Grid interface.
- Four kinds of query languages are converted to java class SelectSQL and query is executed through JDBC-like interface.
- Query results is obtained as ResultSet, and table data is formatted to VOTable or CSV file.



Development of JVO Skynode Toolkit

JVO Skynode :

- can accept ADQL-x over HTTP/SOAP, SIAP over HTTP/Parameters → VO compliant,
- can accept JVOQL over HTTP/SOAP and Grid (experimental) . → functionality test of JVOQL,
- returns VOTable, CSV file and FITS file,

The JVO Skynode toolkit is intended to be used as an wrapper for existing data services to become VO compliant → easy and quick implementation of the skynode interface on the existing system.

Resource Metadata

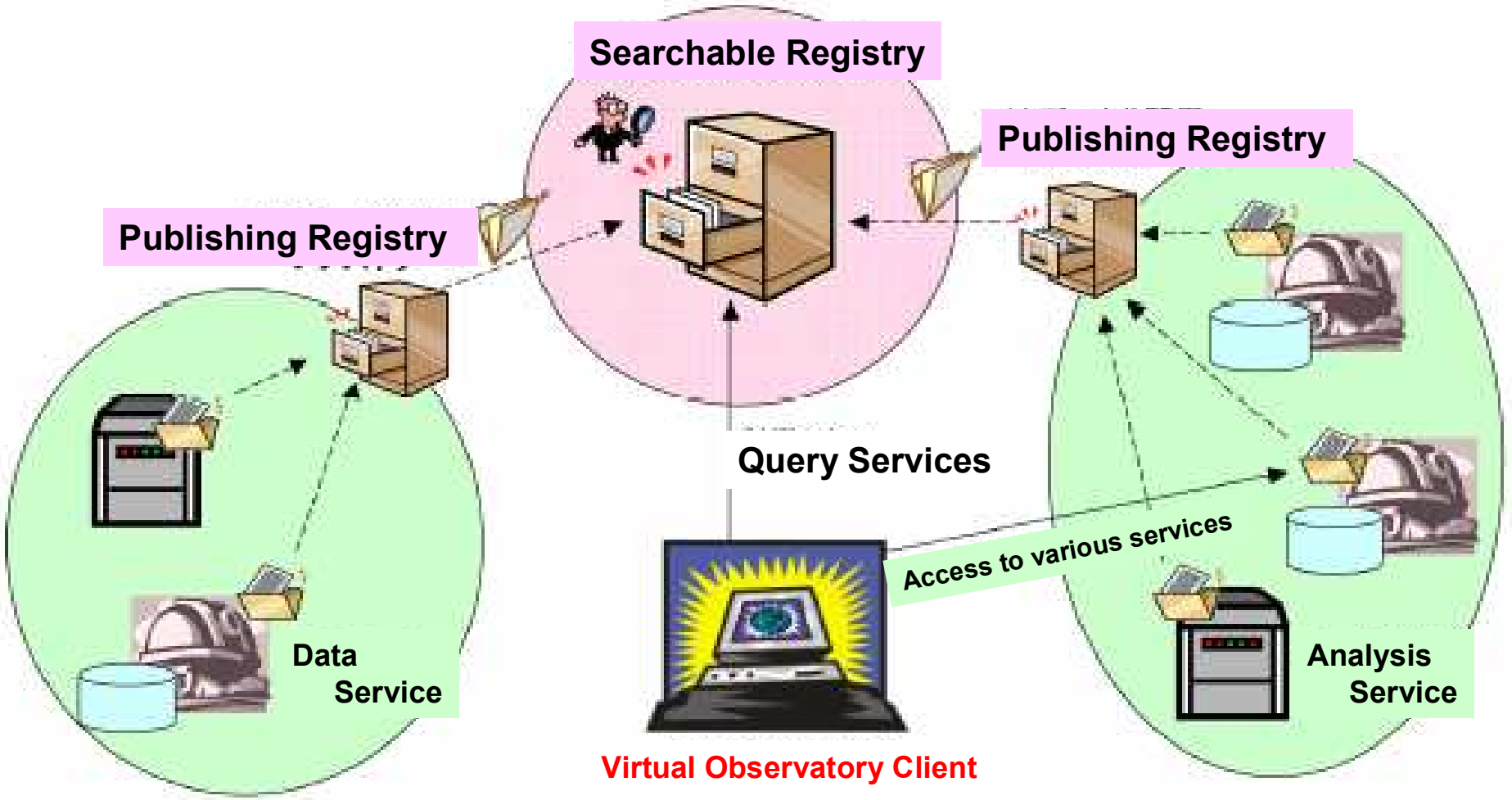
Identity metadata　service metadata　column metadata
curation metadata　content metadata

title	string
short_name	string
identifier	URI
publisher	string
publisher_id	URI
creator	string
creator_logo	URL
contributer	string
date	string
version	string
contact_name	string
contact_email	e-mail address
service_interface_url	URL
service_base_url	URL
service_http_result	MIME type
service_standard_uri	URI
service_standard_url	URL
service_msr	float,decimal degrees
ucd	string
unit	string
datatype	string
width	int
precision	string
arraysize	string

	identity	curation	service	content	column
catalog	○	○	○	○	×
table	○	○	○	○	×
column	○	○	○	○	○

subject	string,list
description	string,free text
source	string
reference_url	URL
type	string,list
coverage_spatial	string
coverage_region_of_regard	float,decimal degrees
coverage_spectral	string,list
coverage_spectral_bandpass	string,list
coverage_spectral_central_wavelength	float
coverage_spectral_minimum_wavelength	float
coverage_spectral_maximum_wavelength	float
coverage_temporal_start_time	string
coverage_temporal_stop_time	string
coverage_depth	float
coverage_depth_unit	string
coverage_object_density	float
coverage_object_count	int
coverage_sky_fraction	float
resolution_spatial	float
resolution_spectral	float
resolution_temporal	float
content_level	string,list
facility	string,list
instrument	string,list
format	string,list
right	string

Exchange of Meta Data:OAI-PMH



JVO is seen from the UK VO

AstroGrid Registry — AstroGrid

Server
- Home
- Admin

Investigate
- IVORN Lookup
- Browse
- Query Keyword Query

Register
- Enter Resource

Registry Browser

Version: 0.9

Find IVORNs including: jvo [List]

Browse for another version 0.9 [List]

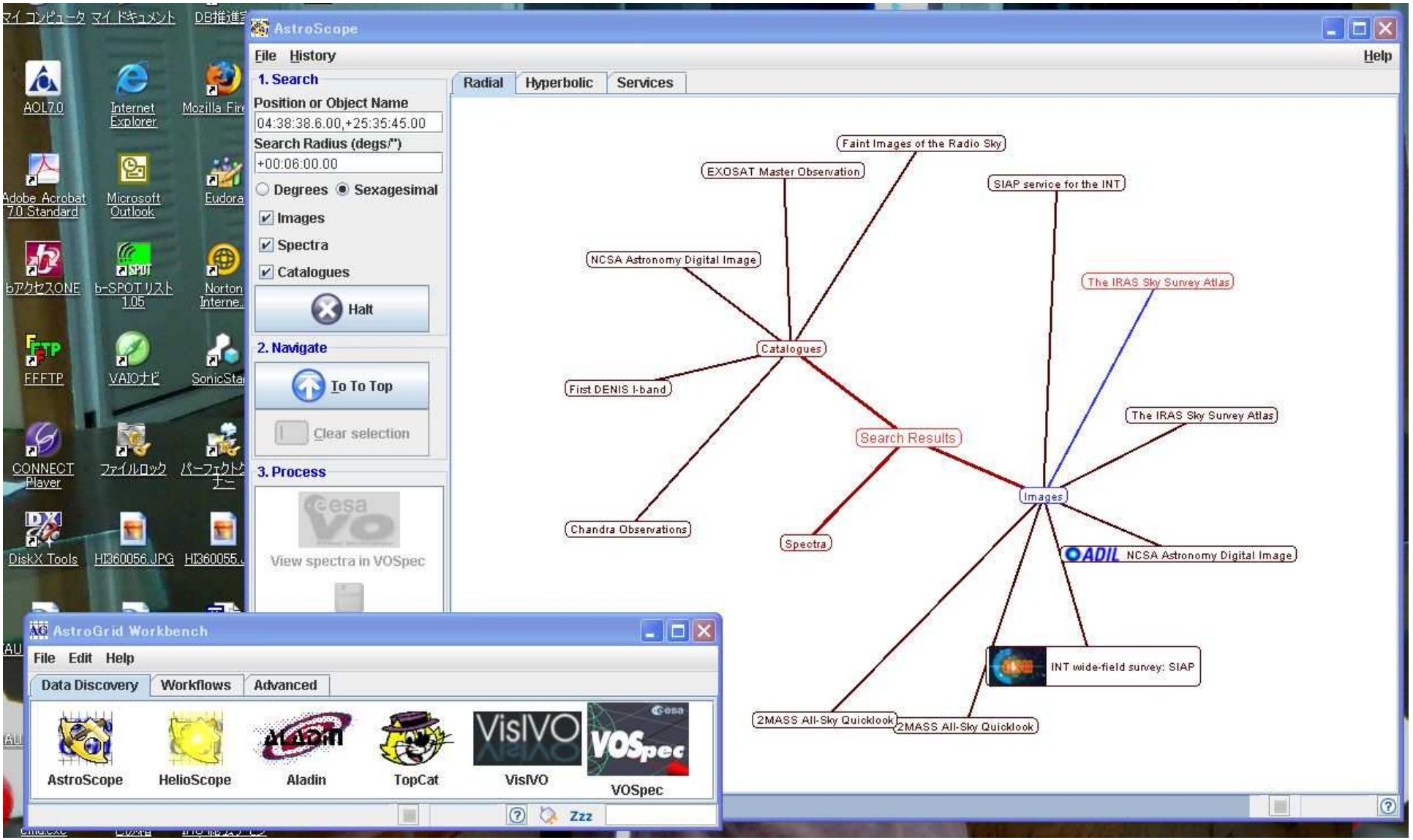
Title	Type	AuthorityID	ResourceKey	Up
JVO Publishing Registry	vg:Registry	o	publishingregistry	200-16
JVO Publishing Registry	vg:Registry	jvo	publishingregistry	200-21
the Subaru/XMM-Newton Deep Survey (SXDS) SkyNode Service	sn:OpenSkyNode	jvo/skynode	sxds	200-20
Subaru/XMM-Newton Deep Survey 01	jsn:OpenSkyNodeJ	jvo/skynodej	sxds	200-20
JVO	vr:Organisation	jvo	jvo	200-18
the Subaru/XMM-Newton Deep Survey (SXDS) SIA Service	sia:SimpleImageAccess	jvo/siap	sxds	200-20
JVO Authority	vg:Authority	jvo	null?!	200-21

Elapsed time to querying US VOs

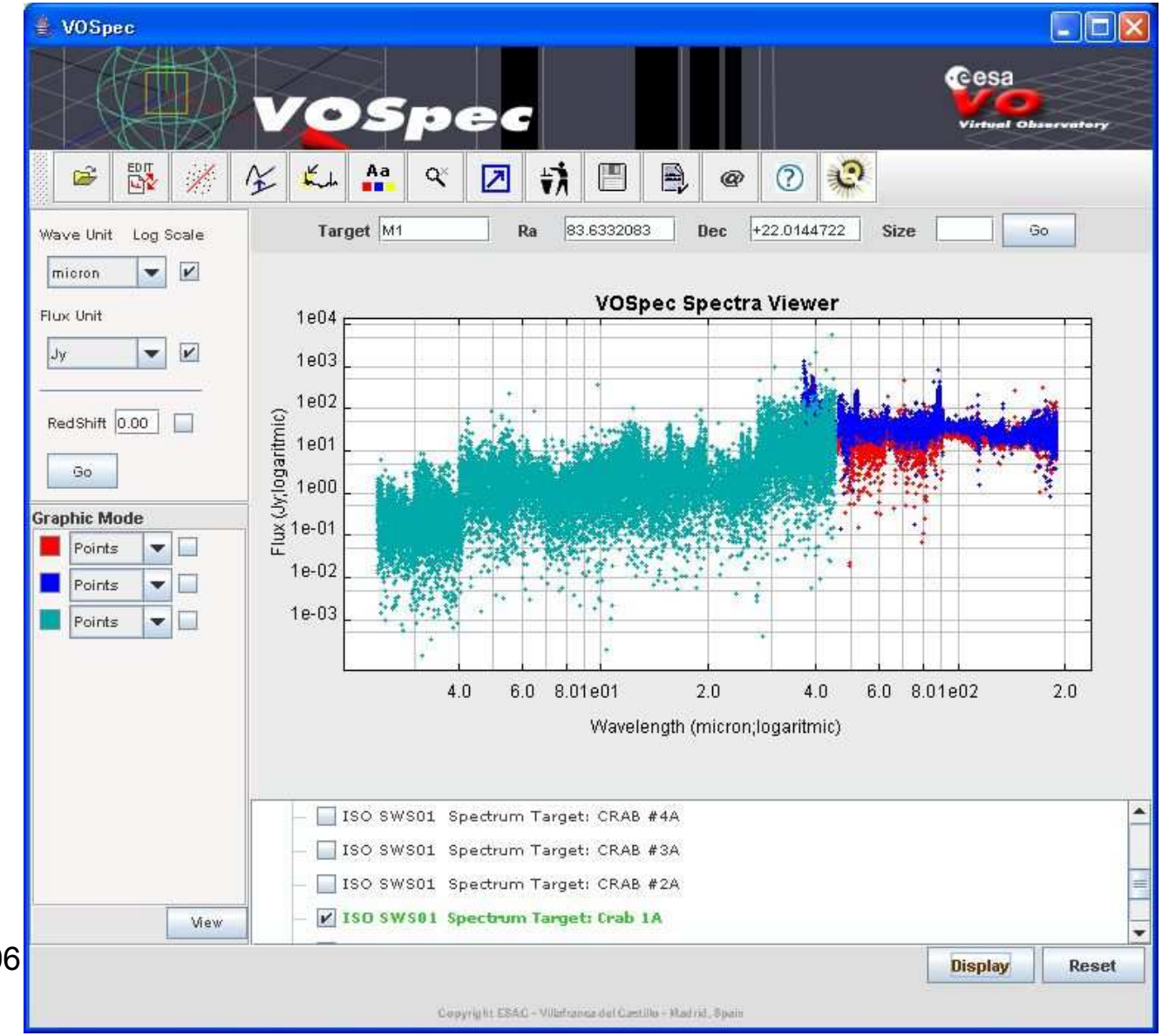
wavelength	Survey name	server	time (sec)
X-ray	Chandra	cda.harvard.edu	1.715
Infrared	2MASS	mercury.cacr.caltech.edu	3.536
Radio	VLA	adil.ncsa.uiuc.edu	7.115

Best Records -- Some servers may be overloaded from time to time

AstroGrid Workbench



VOSpec: SSAP viewer



JVO Searchable Registry (Keyword Search)

Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

⇒ Keyword | Advanced | Admin | Publishing

optical AND Keyword Search Get All

User ID	User Name	Group	Last Login
ohishi	Masatoshi Ohishi	jvo	Mon Jan 23 19:56:18 JST 2006

Total memory = 109363kB Used momory = 40430kB (36%)

JAPANESE VIRTUAL OBSERVATORY

Service Search Result

Select Service[s] Select the checked service and go to the search page.

No.	Check	ID	Title	Type	Access URL	Country
0	☐	More Info	Deep Lens Survey	SkyNode	URL	
1	☐	More Info	Photometric Optical Structure Survey Using Multiwavelengths	SkyNode	URL	
2	☐	More Info	HST trans-Neptunian Objects Search field images	SIAP/SSAP	URL	
3	☐	More Info	HST Hubble Deep Field	SIAP/SSAP	URL	
4	☐	More Info	HST Hubble HELIX Observations	SIAP/SSAP	URL	
5	☐	More Info	The Spitzer Wide-area InfraRed Extragalactic Survey	SIAP/SSAP	URL	

Select Service[s] Select the checked service and go to the search page.

User ID	User Name	Group	Last Login
ohishi	Masatoshi Ohishi	jvo	Mon Jan 23 19:56:18 JST 2006

Total memory = 109363kB Used memory = 42785kB (39%)

JVO Simple Data Search

Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

⇒ Simple | JVOQL

Find Data Service

AND | Search Service

Region Selection Criteria

Object Name
Name Resolver

Coordinate	Frame	Size	unit	Shape
	J2000		deg	box size

Selected Services

service is not selected

User ID	User Name	Group	Last Login
ohishi	Masatoshi Ohishi	jvo	Mon Jan 23 18:28:14 JST 2006

Service Search Result

Select Service[s] Select the checked service and go to the search page.

No.	Check	ID	Title	Type	Access URL	Country
0	☐	More Info	XMM-Newton Science Archive Open SkyNode	SkyNode	URL	esa
1	☐	More Info	Rosat	SkyNode	URL	
2	☐	More Info	Rosat	SkyNode	URL	
3	☐	More Info	XMM-Newton Science Archive Open SkyNode	SkyNode	URL	esa
4	☐	More Info	ASCA SkyNode Service	SkyNode	URL	
5	☐	More Info	Canadian Network for Observational Cosmology Image	SIAP/SSAP	URL	
6	☐	More Info	Chandra X-Ray Observatory Data Archive	SIAP/SSAP	URL	
7	☐	More Info	XMM-Newton Archive Interoperability System	SIAP/SSAP	URL	
8	☐	More Info	ROSAT All Sky Survey	SIAP/SSAP	URL	unknown

Select Service[s] Select the checked service and go to the search page.

JVO Simple Data Search

Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

⇒ Simple | JVOQL

Find Data Service

X-ray AND Search Service

Region Selection Criteria

Object Name				
Crab Name Resolver				
Coordinate	**Frame**	**Size**	**unit**	**Shape**
83.633212 22.014460	J2000	1	deg	box size

Selected Services

Chandra X-Ray Observatory Data Archive

http://cxc.harvard.edu/cda

table name	Data Selection	Query Condition	Submit Query	description
N/A	Data	Condition	Search	

Workflow Status

Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

⇒ All | Detail

Workflow Name : work_20060123185359073

Activity Name	Host	Elapsed Time (s)	Flag	Status
1_executeQuery		0.0		waiting
		0.0		waiting
2_storeVOTable		0.0		waiting

Cancel Results

User ID	User Name	Group	Last Login
ohishi	Masatoshi Ohishi	jvo	Mon Jan 23 18:28:14 JST 2006

Total memory = 91992kB Used momory = 37743kB (41%)

JVO
JAPANESE VIRTUAL OBSERVATORY

Workflow Status

Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

⇒ All | Detail

Workflow Name : work_20060123185359073

Activity Name	Host	Elapsed Time (s)	Flag	Status
1_1_executeQuery	cda.harvard.edu	2.265		success
		0.0		success
2_2_storeVOTable		0.041		success

Results

User ID	User Name	Group	Last Login
ohishi	Masatoshi Ohishi	jvo	Mon Jan 23 18:28:14 JST 2006

Total memory = 91992kB Used memory = 35776kB (38%)

JVO
JAPANESE VIRTUAL OBSERVATORY

Workflow Results

Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

⇒ Workflows | Results

Workflow Name : work_20060123185359073

File Name	File Type	Action
result_votable0	VOTable	Viewer Download

User ID	User Name	Group	Last Login
ohishi	Masatoshi Ohishi	jvo	Mon Jan 23 18:28:14 JST 2006

JAPANESE VIRTUAL OBSERVATORY

Total memory = 91992kB Used memory = 38219kB (41%)

VOTable Viewer

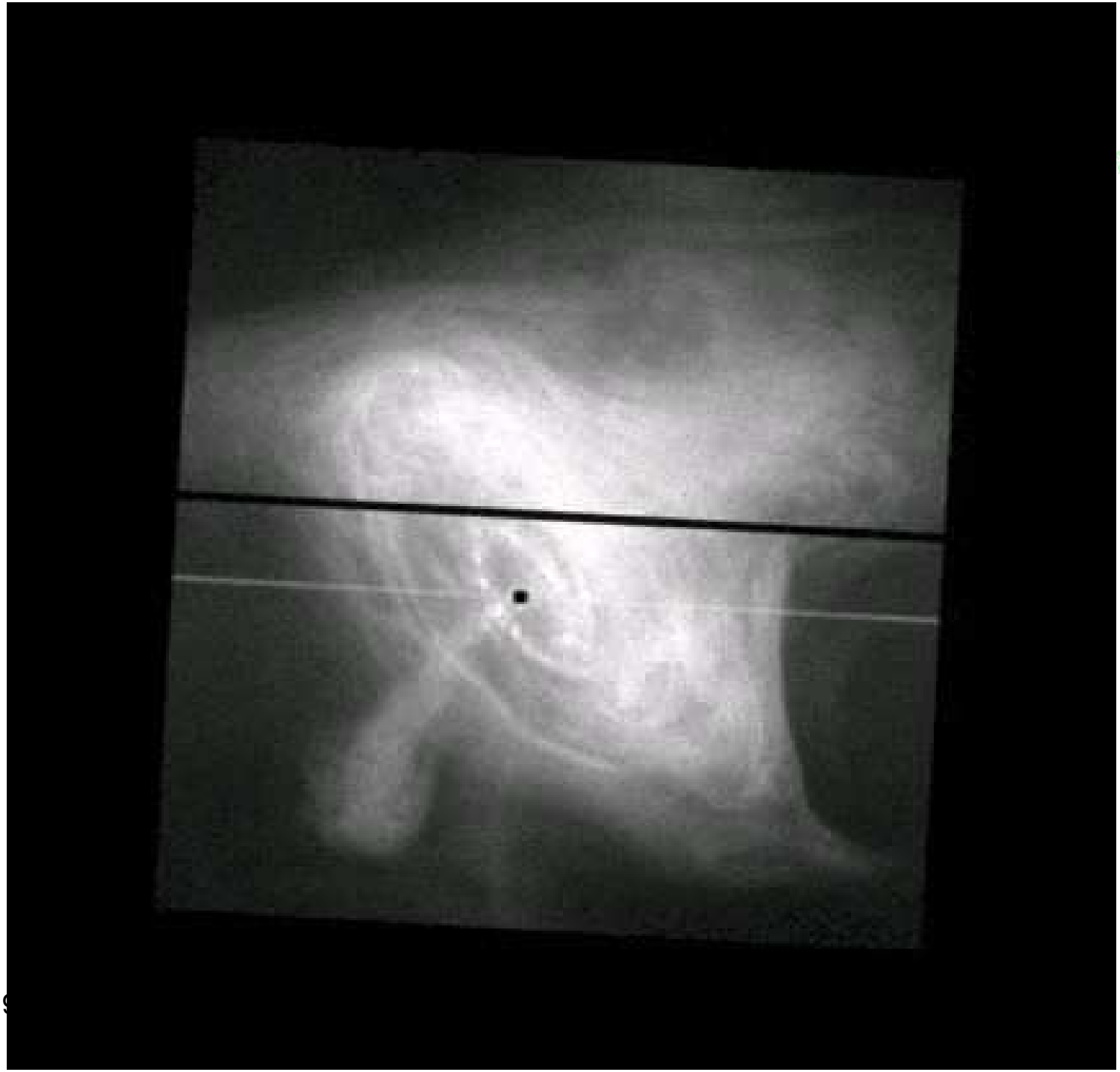
Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

Workflow Name : work_20060123185359073

File Name : result_votable0

data viewer | Reset | VOTable download

#	check	download	VOX:Image_Title	VOX:DateObs	POS_EQ_RA_MAIN	POS_EQ_DEC_
			Object	DATE-OBS(TT)	RA	Dec
0		Download	Crab Nebula	Tue Jan 27 01:11:43 EST 2004	83.63333333333333	22.01444444444
1		Download	Crab Nebula	Tue Jan 27 01:11:43 EST 2004	83.63333333333333	22.01444444444
2	☐	Download	Crab Nebula	Tue Jan 27 01:11:43 EST 2004	83.63333333333333	22.01444444444
3	☐	Download	Crab Nebula	Tue Jan 27 01:11:43 EST 2004	83.63333333333333	22.01444444444
4		Download	Crab Nebula	Tue Jan 27 01:11:43 EST 2004	83.63333333333333	22.01444444444



Workflow

Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

Upload your workflow Upload

参照...

Edit workflow Execute | clear | Sequential Query | Brown Dwarf Search #1 | Brown Dwarf Search #2 | QSO Study

```
<?xml version="1.0" encoding="UTF-8"?>
<Workflow xmlns="http://jvo.nao.ac.jp/workflow/v0.4" xmlns:xsi="http://www.w3.org/2001/XMLSchema-ins
  <!-- ********************************************************** -->
  <!-- Search for Brown Dwarf candidates -->
  <!-- 01. Simplest Case -->
  <!-- ********************************************************** -->
  <name>SequentialQuery</name>
  <author>M.Tanaka</author>
  <identifier>ivo://jvo.nao.ac.jp/workflow/Y.Shirasaki/SequentialQuery</identifier>
  <create_date>2006/01/22 00:20:00</create_date>
  <update_date>2006/01/22 00:20:00</update_date>
  <description>Query to Mutple Data Services</description>
  <status>wating</status>

  <variables>

    <variable name="query1" type="String">
       <value>SELECT * FROM ivo://cxc.harvard.edu:cda WHERE region = BOX( (83.633212,22.014460), 0.2
    </variable>

    <variable name="query2" type="String">
       <value>SELECT ra, dec, dered_z  FROM   ivo://jvo/sdss:photoobjall WHERE  Region('Circle 20. 0
    </variable>
```

Edit workflow Execute | clear | Sequential Query | Brown Dwarf Search #1 | Brown Dwarf Search #2 | QSO Study

```
<command xsi:type="builtin" proc_name="noname" name="executeQuery">
  <activity_status>
    <status>wating</status>
    <elapsed_time>0.0</elapsed_time>
    <log>none</log>
    <error_info>none</error_info>
  </activity_status>
  <input>
    <varRef>query1</varRef>
  </input>
  <output>
    <varRef>result1</varRef>
  </output>
</command>

<command xsi:type="builtin" proc_name="noname" name="executeQuery">
  <activity_status>
    <status>wating</status>
    <elapsed_time>0.0</elapsed_time>
    <log>none</log>
    <error_info>none</error_info>
  </activity_status>
  <input>
    <varRef>query2</varRef>
  </input>
  <output>
    <varRef>result2</varRef>
  </output>
</command>
```

Overview of workflow Update

Workflow Status

Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

⇒ All | Detail

Workflow Name : work_20060123200255167

Activity Name	Host	Elapsed Time (s)	Flag	Status
1_executeQuery		0.0		waiting
		0.0		waiting
2_executeQuery		0.0		waiting
3_executeQuery		0.0		waiting
4_executeQuery		0.0		waiting
5_executeQuery		0.0		waiting

Cancel Results

User ID	User Name	Group	Last Login
ohishi	Masatoshi Ohishi	jvo	Mon Jan 23 19:56:18 JST 2006

Total memory = 109363kB Used memory = 49106kB (44%)

JVO
JAPANESE VIRTUAL OBSERVATORY

Workflow Status

Status | Registry | Search | Workflow | Result | Database | QSO | DataViewer | Link | MemoryMonitor | Logout

⇒ All | Detail

Workflow Name : work_20060123200255167

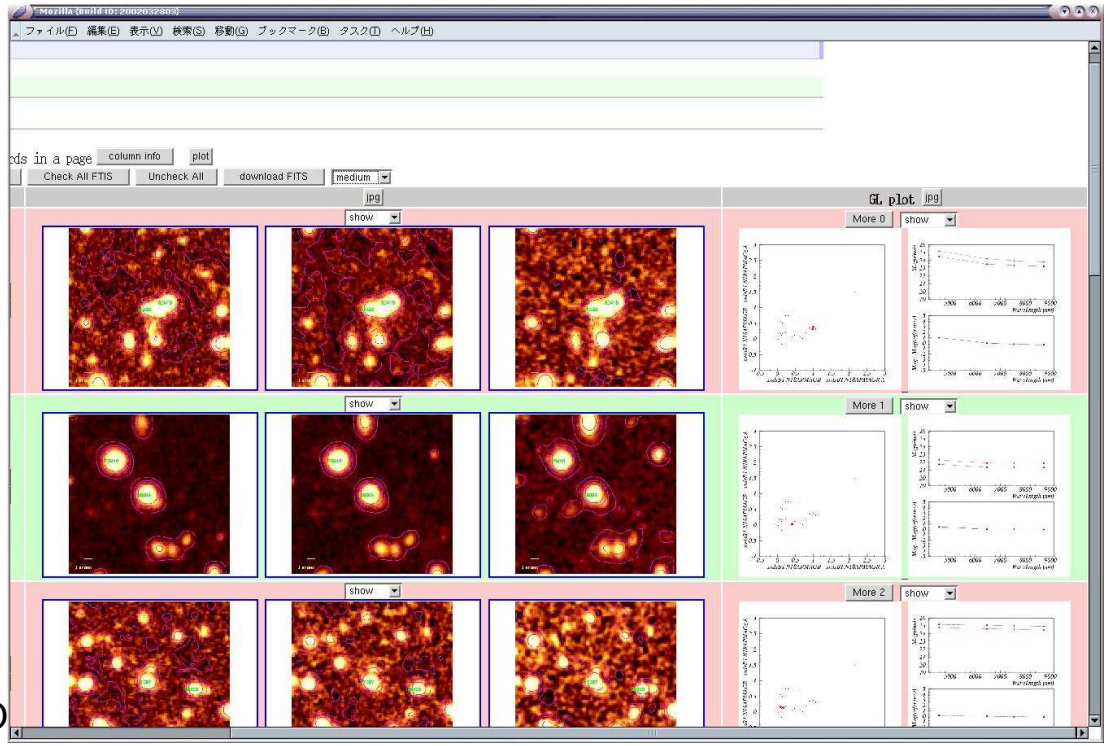
Activity Name	Host	Elapsed Time (s)	Flag	Status
1_executeQuery	cda.harvard.edu	1.93		success
		0.0		success
2_executeQuery	jvo.nao.ac.jp	2.143		success
		0.0		success
3_executeQuery	pma.iso.vilspa.esa.es	4.632		success
		0.0		success
4_executeQuery	www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca	0.0		executing
		0.0		waiting
5_executeQuery		0.0		waiting

Cancel Results

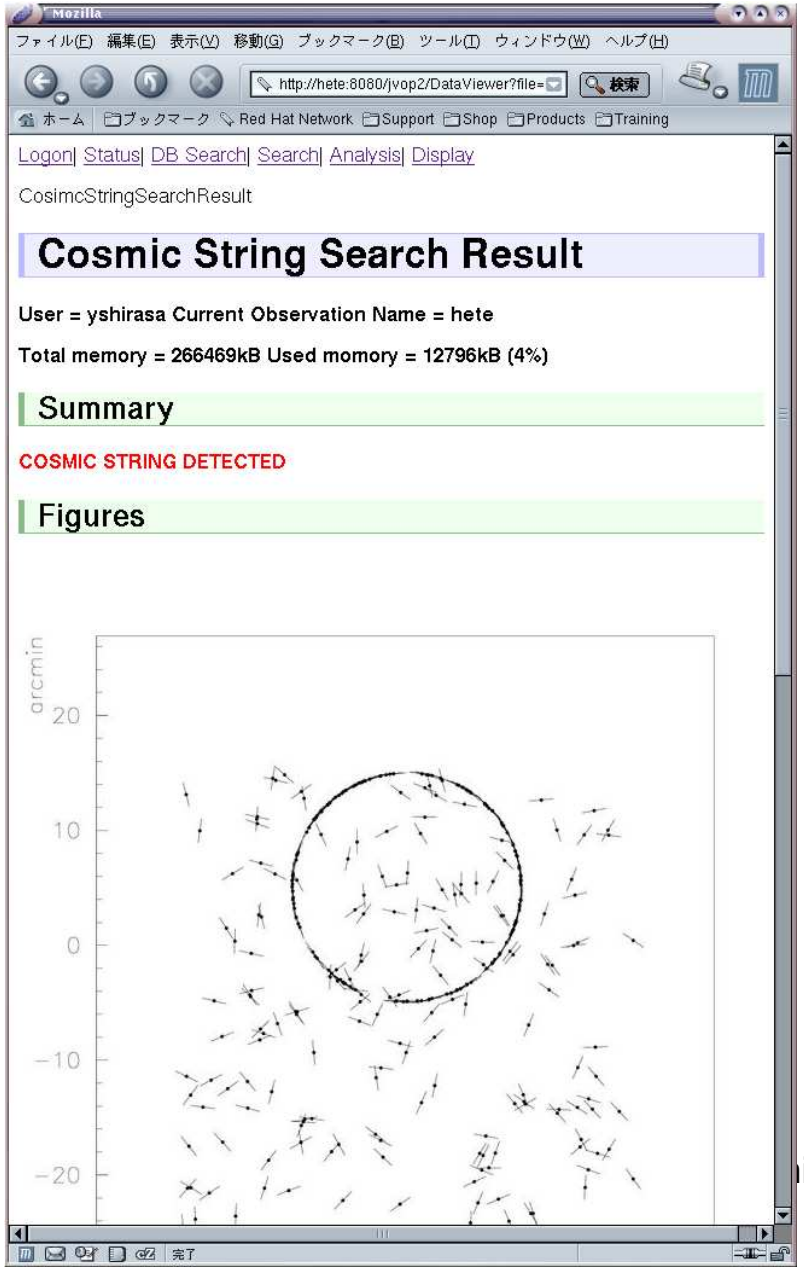
User ID	User Name	Group	Last Login
ohishi	Masatoshi Ohishi	jvo	Mon Jan 23 19:56:18 JST 2006

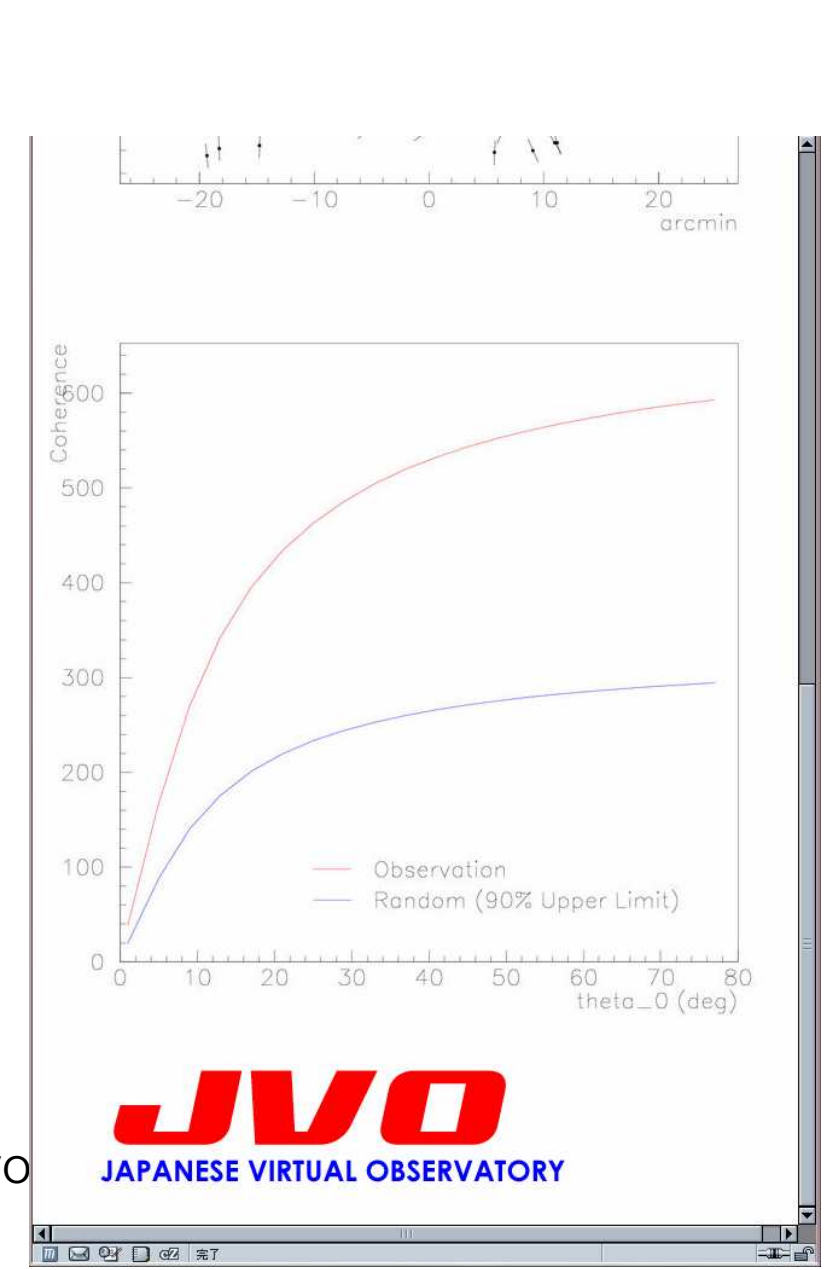
Search for Gravitational Lenses produced (?) by Cosmic Strings

- SXDS data observed by Subaru
- Query results were obtained less than 5 min, displaying SEDs
- It has been proven that VO can accelerate researches.

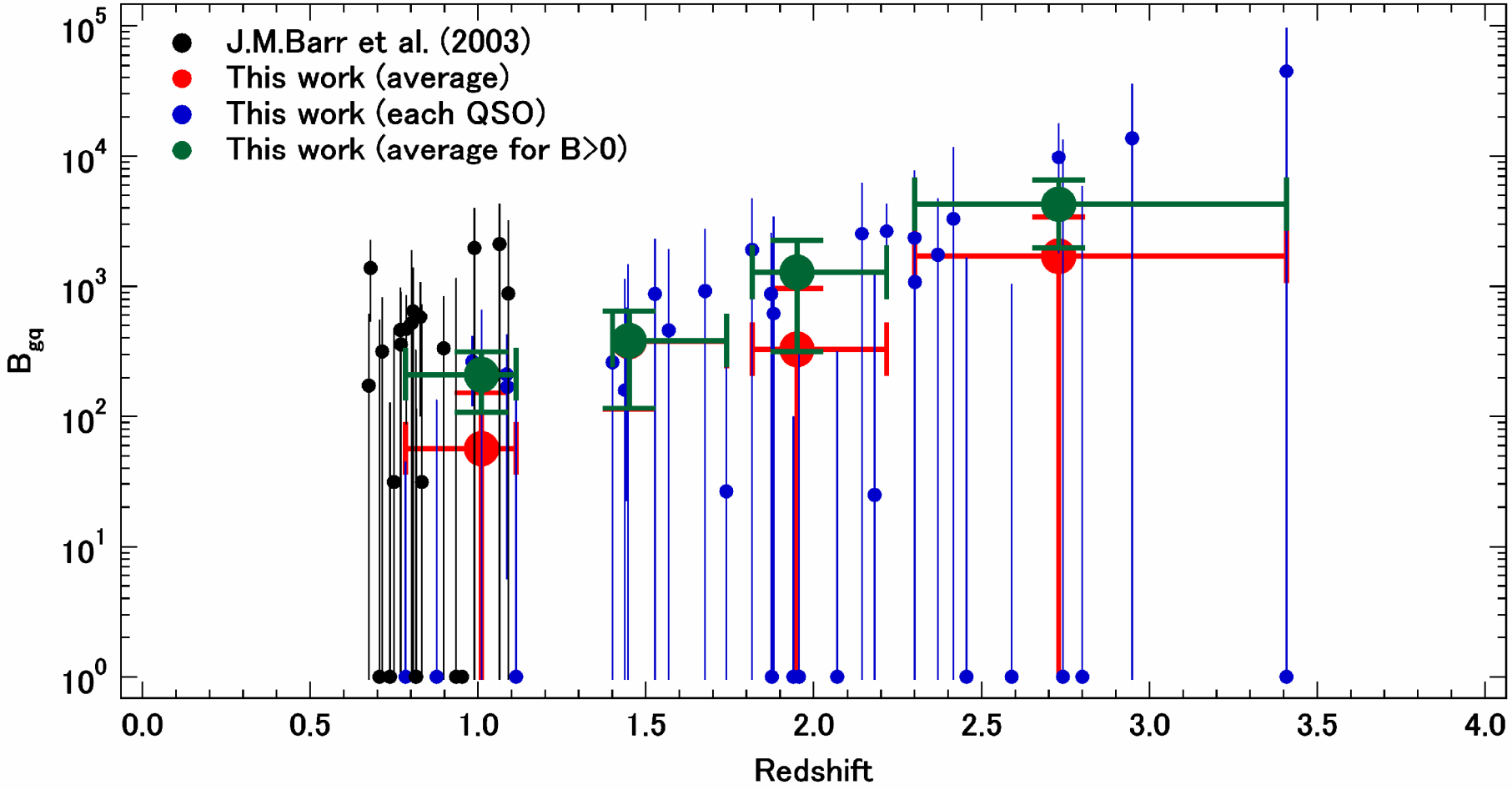


Cosmic String Search Result

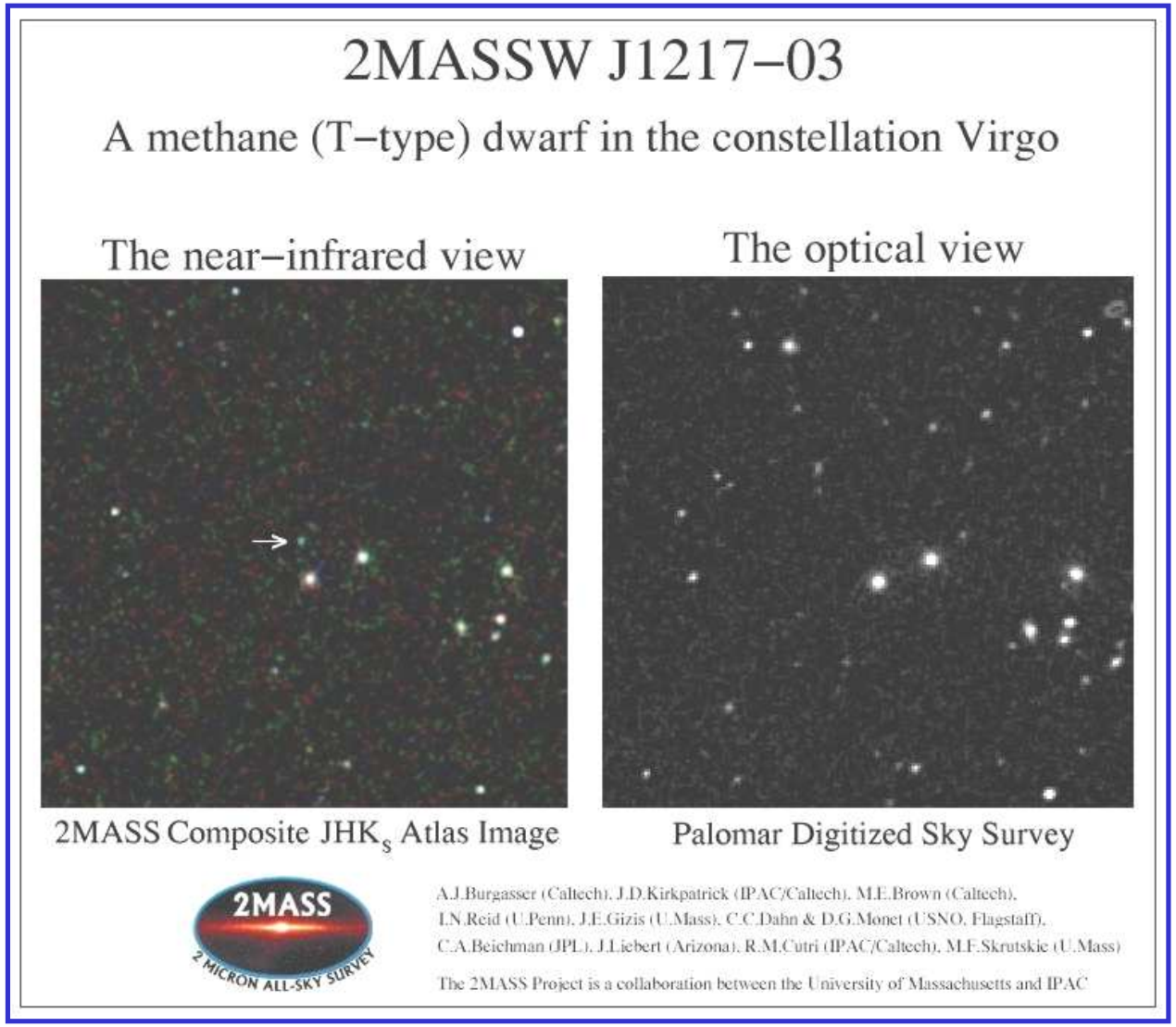




Study on Environment around QSOs

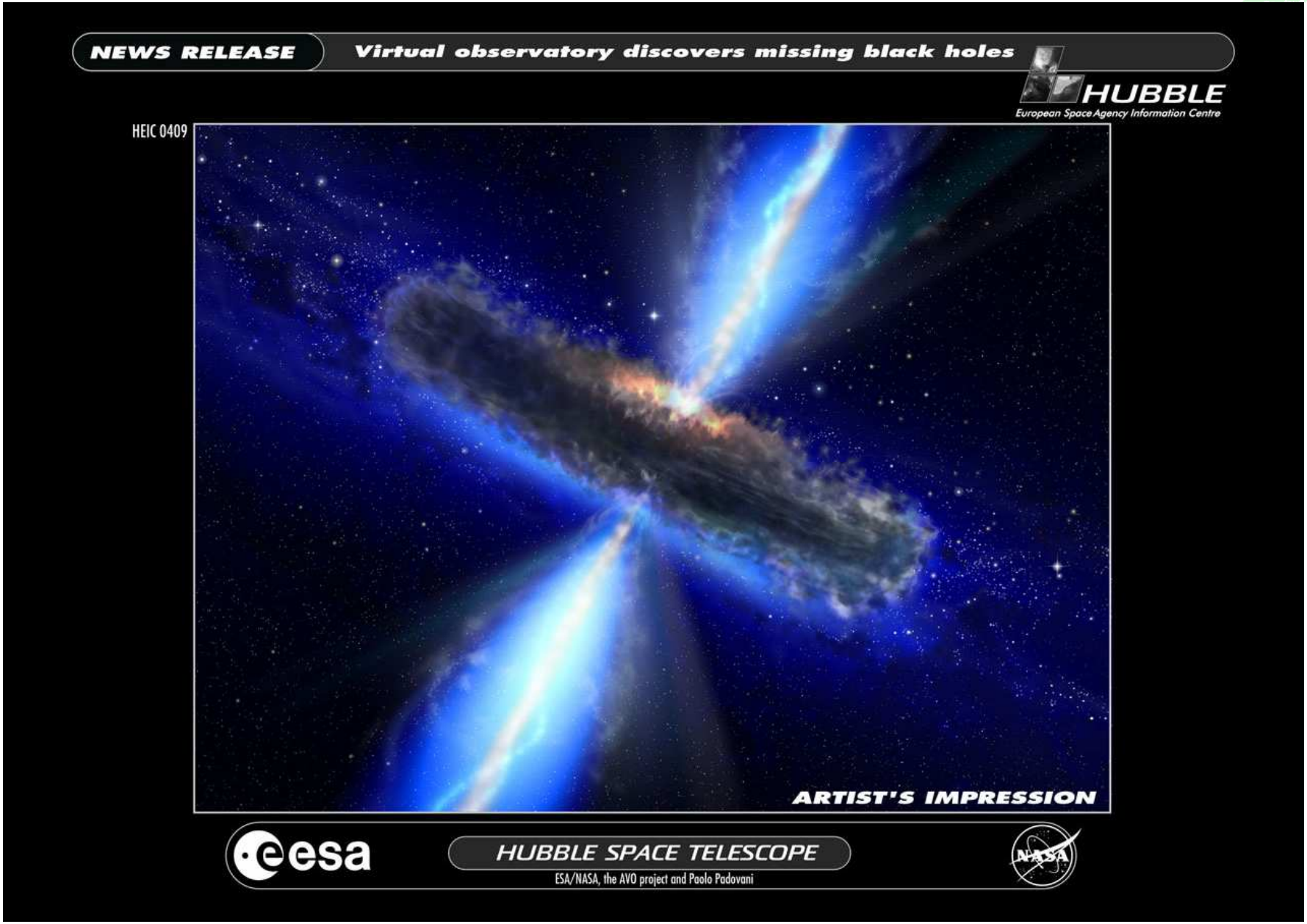


Discovery of a Brown Dwarf: SDSS/2MASS



discoveries like this much easier if databases jointly queryable

Detection of MANY Type II Quasars



Latest Science outputs

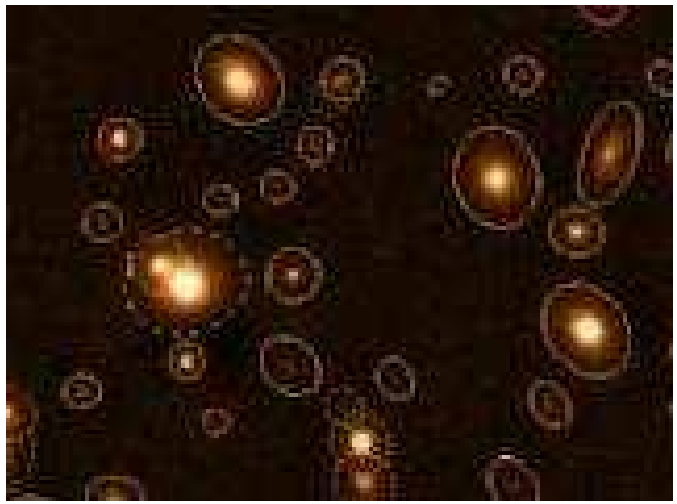
- Aug 2006 – VO Special Session @IAU GA
  - 5 days session
- 200+ participants registered already
  - ~30 science talks out of ~50
  - ~100 posters

New Moves

- Some VO projects move from R&D phase to operations phase
  - UK, Japan, US, EU,,,
- New VO projects
  - Brazil, Chinese Taipei, Blugaria, Tagikistan, Ireland, Czech,,,

Items to be done

- Distributed Storage to store query/analysis results
- Secure access to VOs : single-sign-on
- Other Standardizations
  - Standard application interface
- Advertisement to Data Centers
  - data centers need implement VO interfaces
- VO schools for astronomers



VO : basis for EACOA

http://www.ivoa.net/