

# **Astroinformatics - The New Paradigma of Astronomy in the Epoch of Petabyte-Scaled Archives**

Petr Škoda

Astronomical Institute of the Academy of Sciences  
Ondřejov  
Czech Republic

Institute of Astronomy, Wroclaw University  
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# Credits

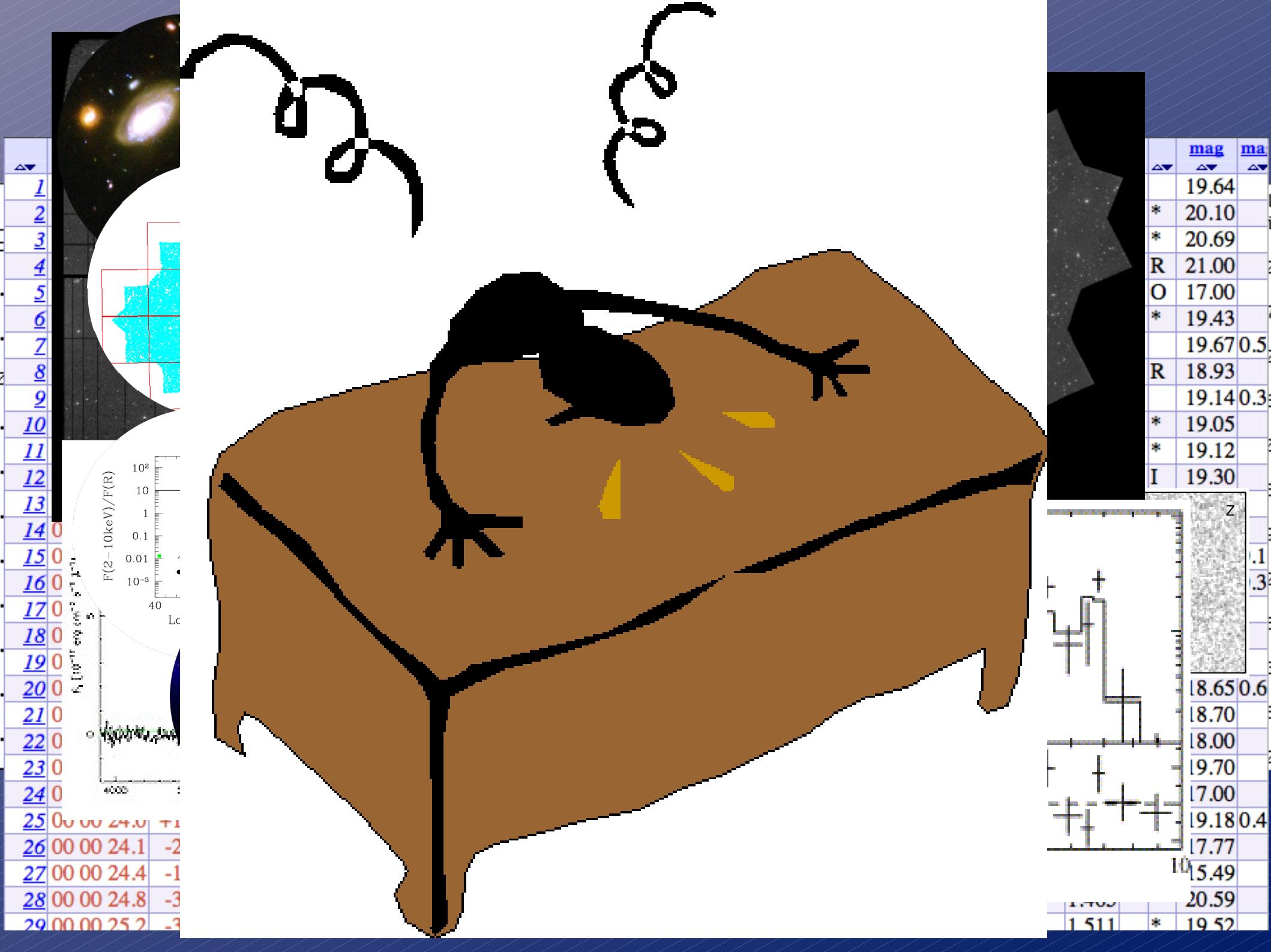
- The presentation is based on many different sources – mainly the on-line published slides from IVOA meetings, slides from Astroinformatics 2010 workshop or pictures found on internet.
- We acknowledge namely materials of E. Solano, D. De Young, F. LePetit, B.Hanish, G. Djorgovski, O. Laurino, L. Fortson, M. Graham, G. Longo, R. D'Abrusco, T.Hey and many others

# **Outline of the Talk**

- VO – the hidden revolution in astronomy
- Data Avalanche in astronomy
- History of VO
- Basic principles of technology
- VO Tools
- Theory in VO
- VO Science
- VO and Society
- Astroinformatics (Citizen Science, 4<sup>th</sup> Paradigm)

# VO - The Hidden Revolution

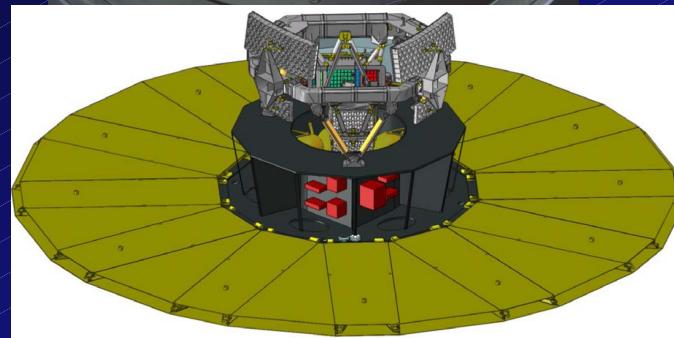
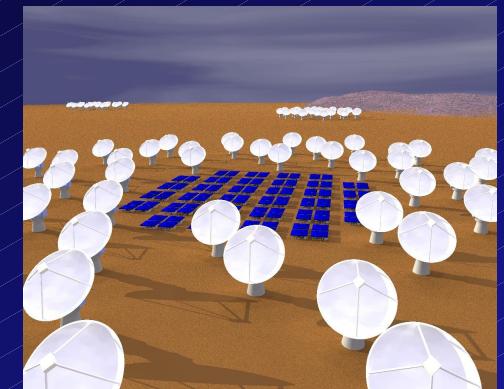
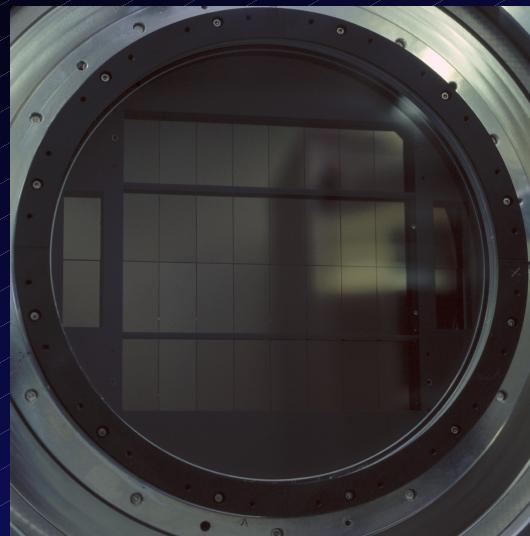
- VO is the radical change of the paradigm of the work of the scientists – effectiveness !!!
- Everyday question (what, where, format, units)
- Scientists are conservative (don't like change)
  - The fear of buzzword VO (multispec, large scale)
- Computer literacy – obligatory (part of job)
- **Evanthia Hatsiminaoglou – cartoon !**



## **Analogy between VO and WWW**

- Linking HYPERTEXT/DATA among servers
- Synergy effect of GLOBAL NET (Gopher,WAIS)
- Powerfull SEARCH (VERONICA – GOOGLE)
- DISTRIBUTED but CENTRAL Steering Organisation (W3C/IVOA)
- Recommendations = „Obligatory“ Standards
- Astronomers in forefront of development
- Scepticism (usefullness for my field ???)
- Steep Growth – average user can use it without knowledge of principles (effectivity, habits)

# Data Avalanche



# Large Scale Data

- Huge surveys: 100 million sources at < 3000 sources per night  $\Rightarrow$  > 100 years to identify them
- Huge data collections: download and data analysis on desktop problematic/impossible.
- Example: downloading Sloan Digital Sky Survey (SDSS) DR6 data:
  - images (10 Terabytes)  $\Rightarrow$  ~ 3 months at 10 Mbps
  - catalogues (2 Terabytes)  $\Rightarrow$  ~ 3 weeks
  - on DVDs  $\Rightarrow$  ~ 2,100 of them
- And data analysis?? (similar size for MACHO, 2MASS etc)

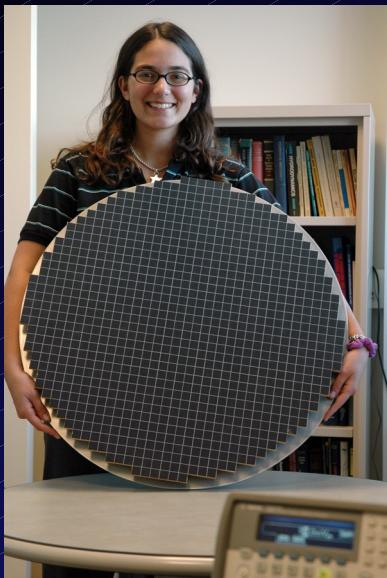
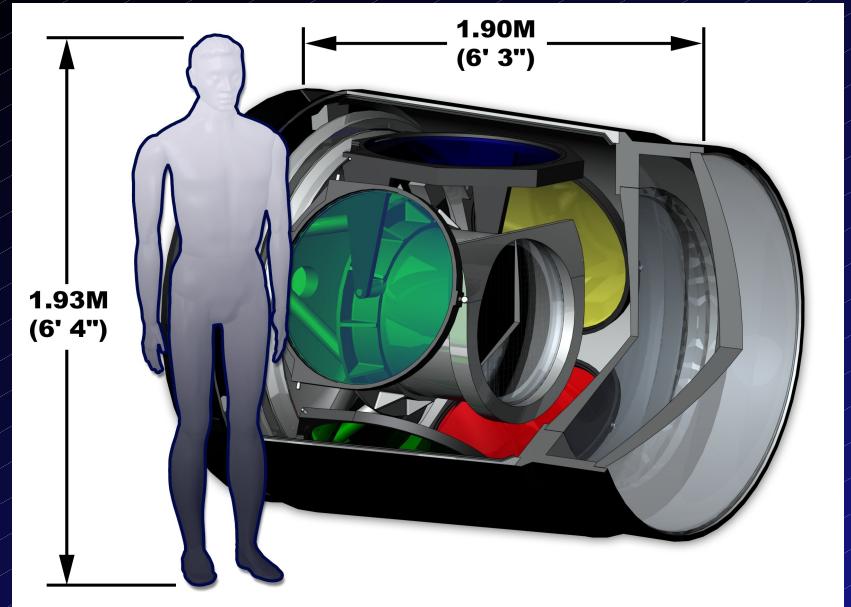
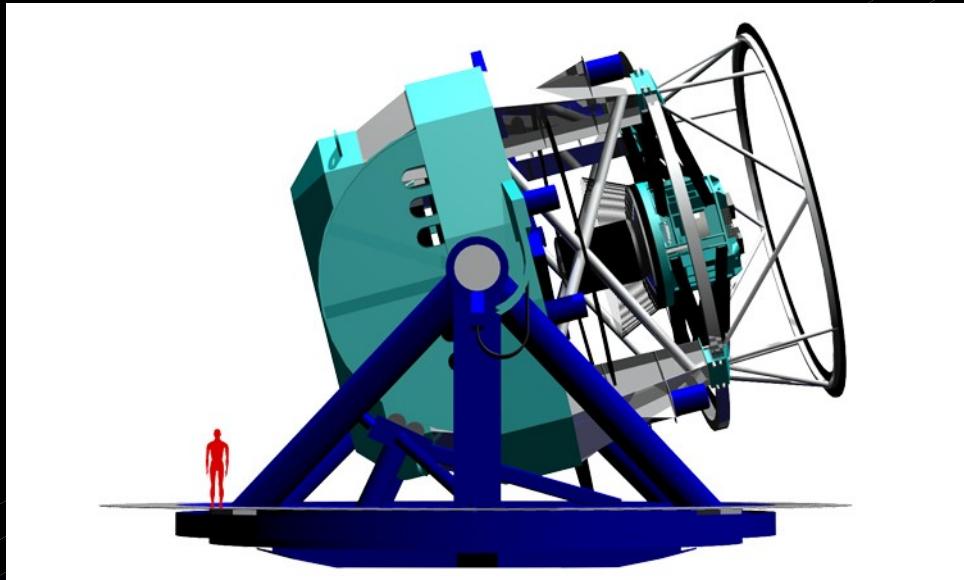
# CD Sea



600 000 CD = 372 TB (CD 650MB)  
600 000 DVD = 2.5 PB (DVD=4.5GB)

Bruce Monro  
Kilmington UK

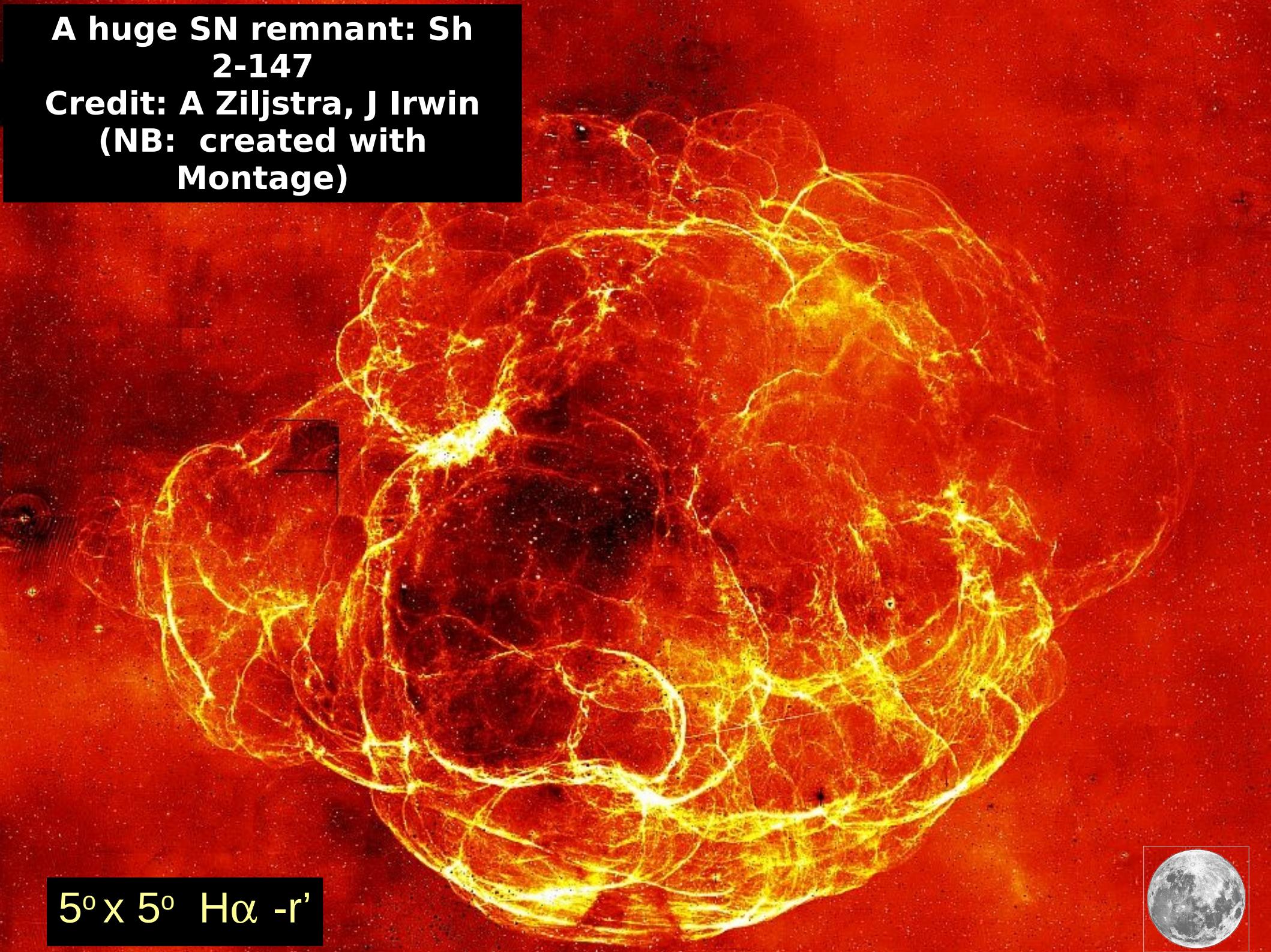
# LSST (8.4m)



200 CCD 4kx4k,  
32 channels (6400)  
3.2 Gpix every 20 sec  
64cm diameter  
3.5 deg FOV  
30 TB/night  
2 TFLOPS  
detection of changes  
within 60sec

# A huge SN remnant: Sh 2-147

Credit: A Zijlstra, J Irwin  
(NB: created with  
Montage)

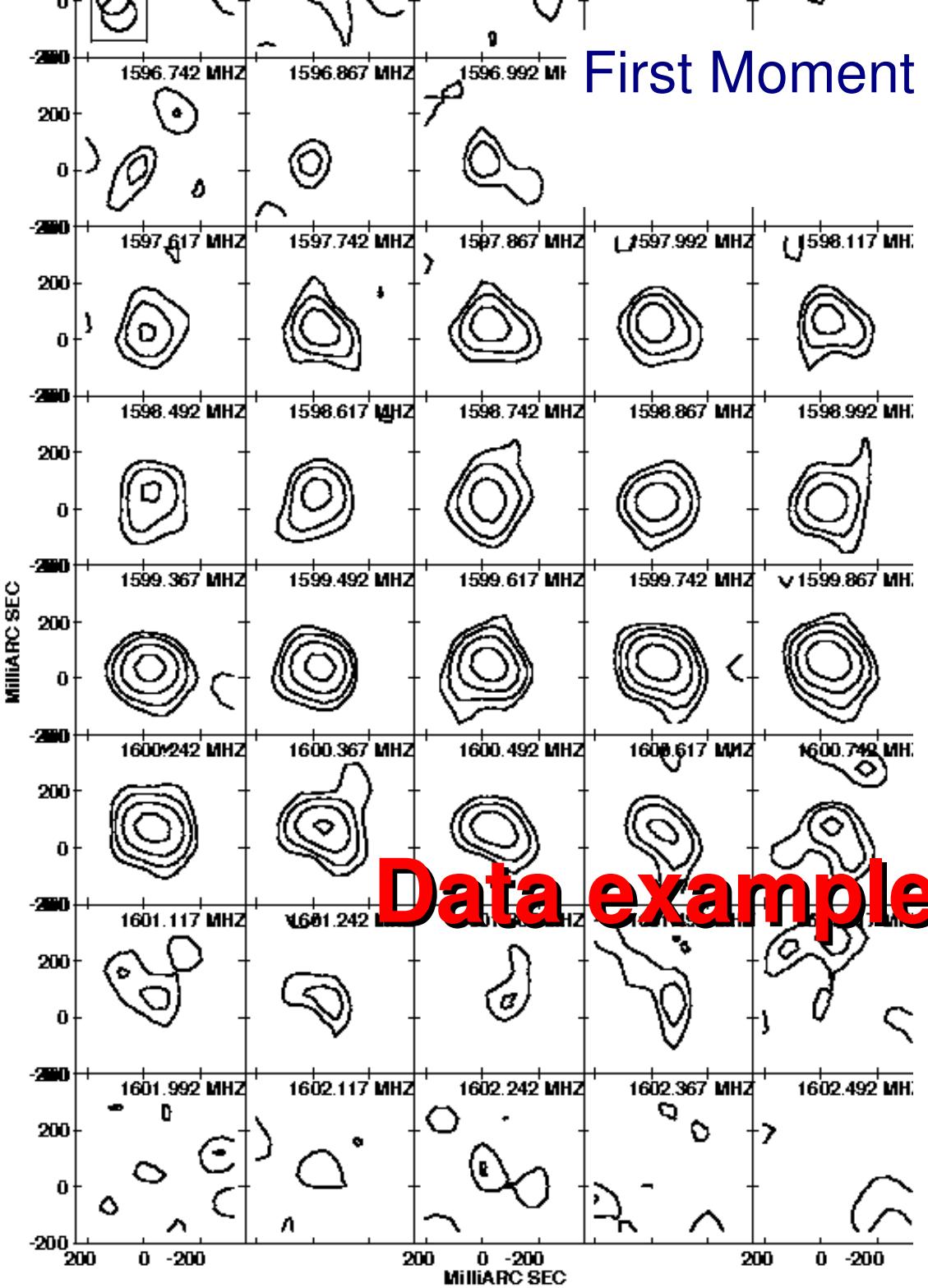


5° x 5° H $\alpha$  -r'

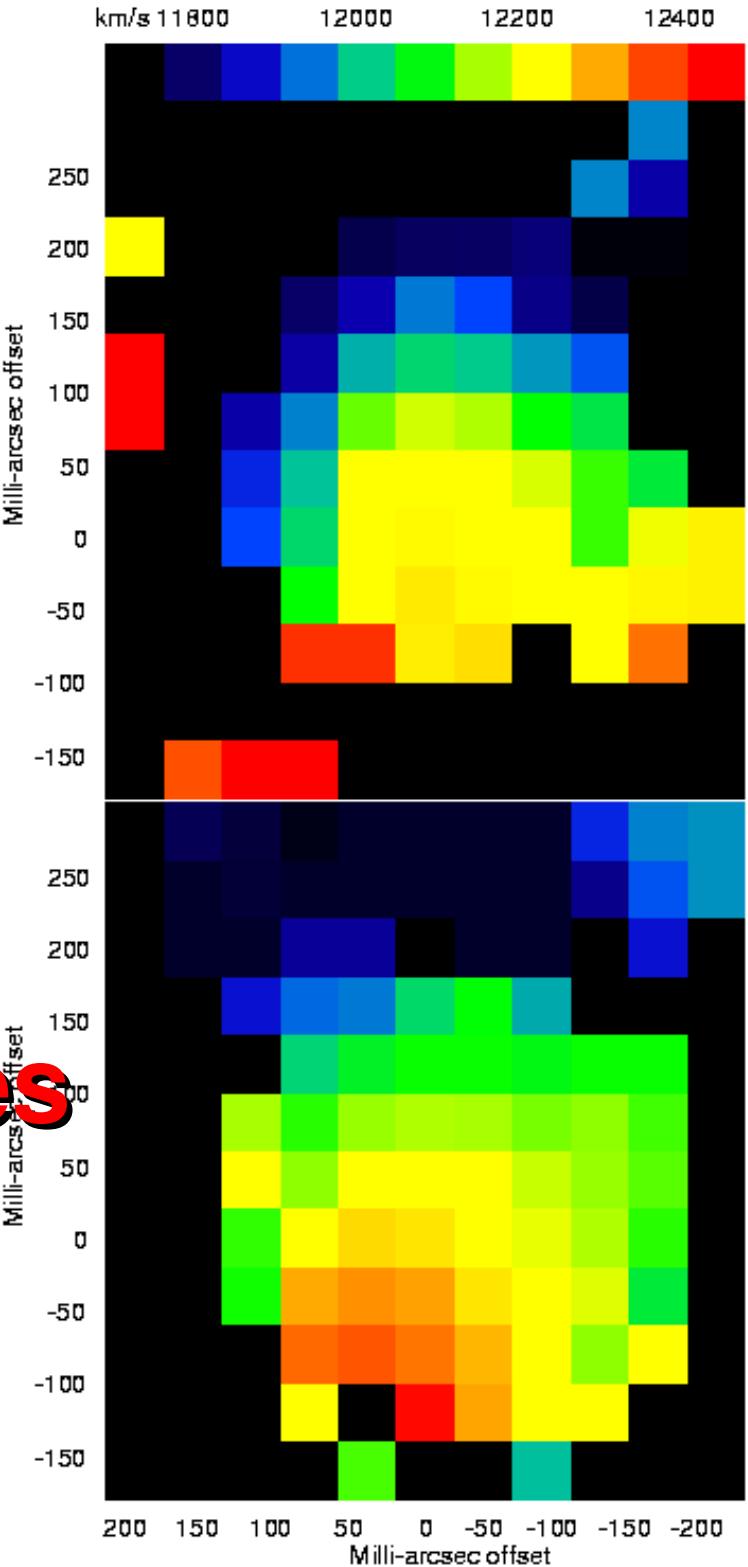


# First Moment

DECINRATION (J2000)



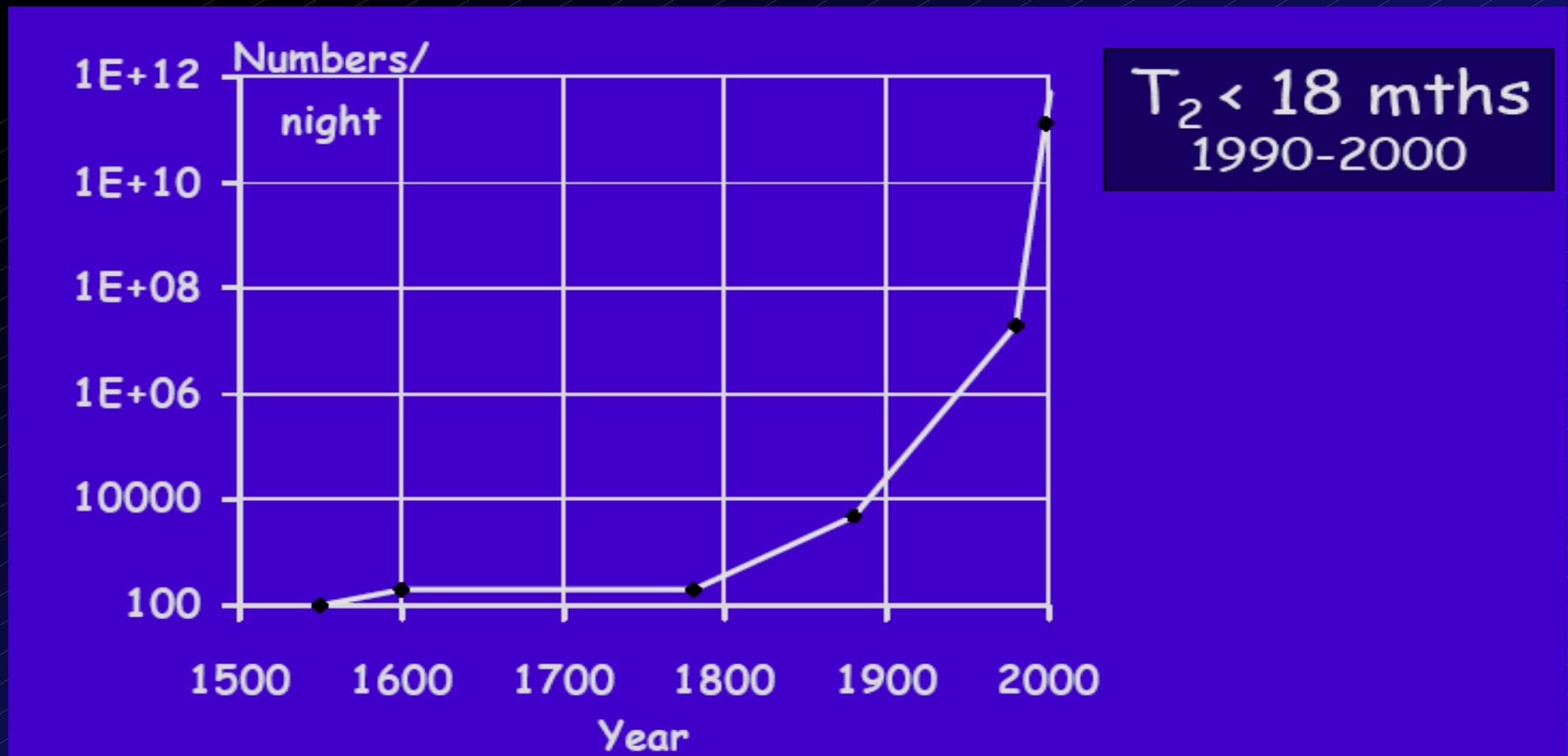
Data examples



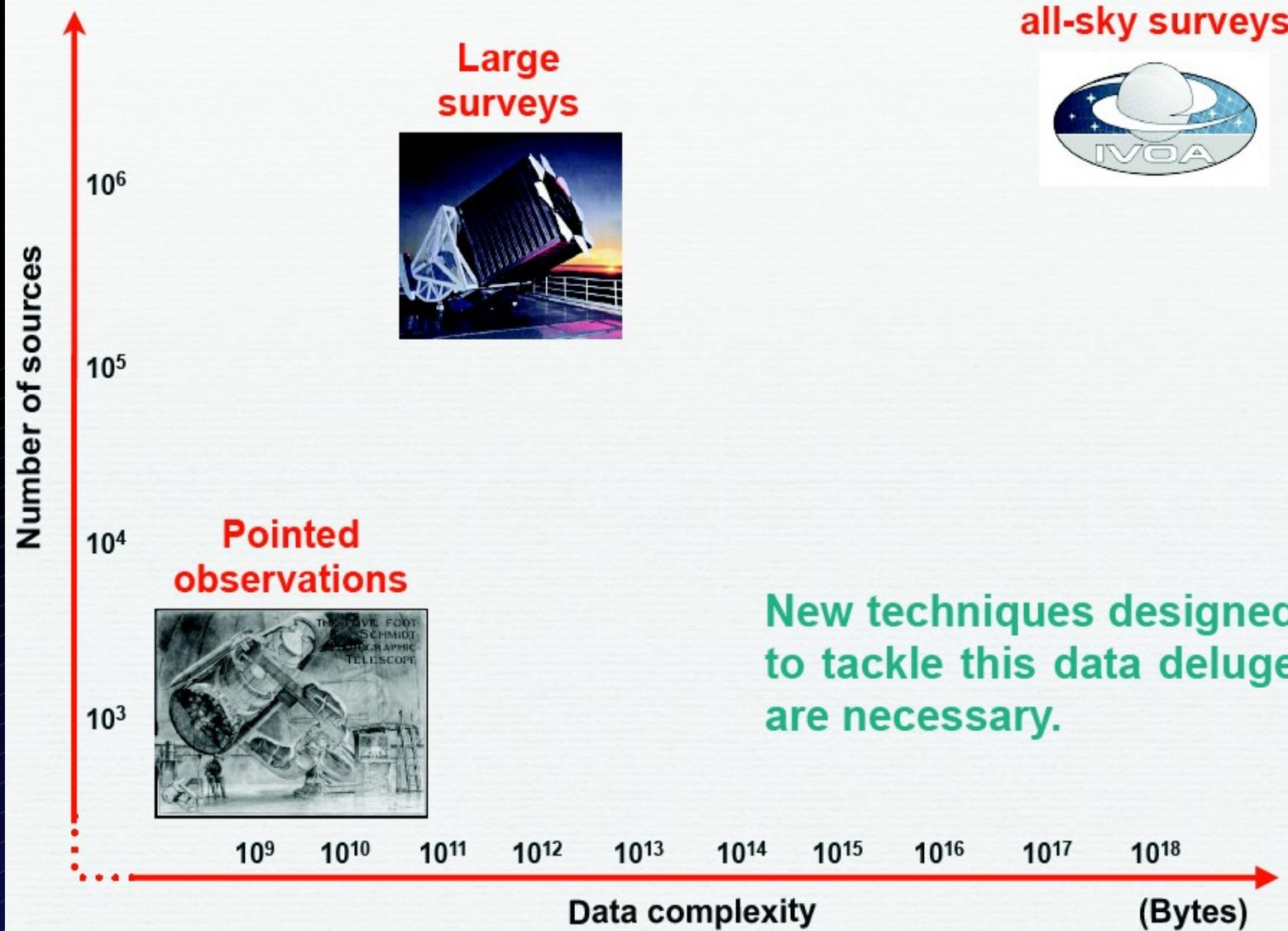
# Data Avalanche

Moore law for chips –doubling 1.5 year

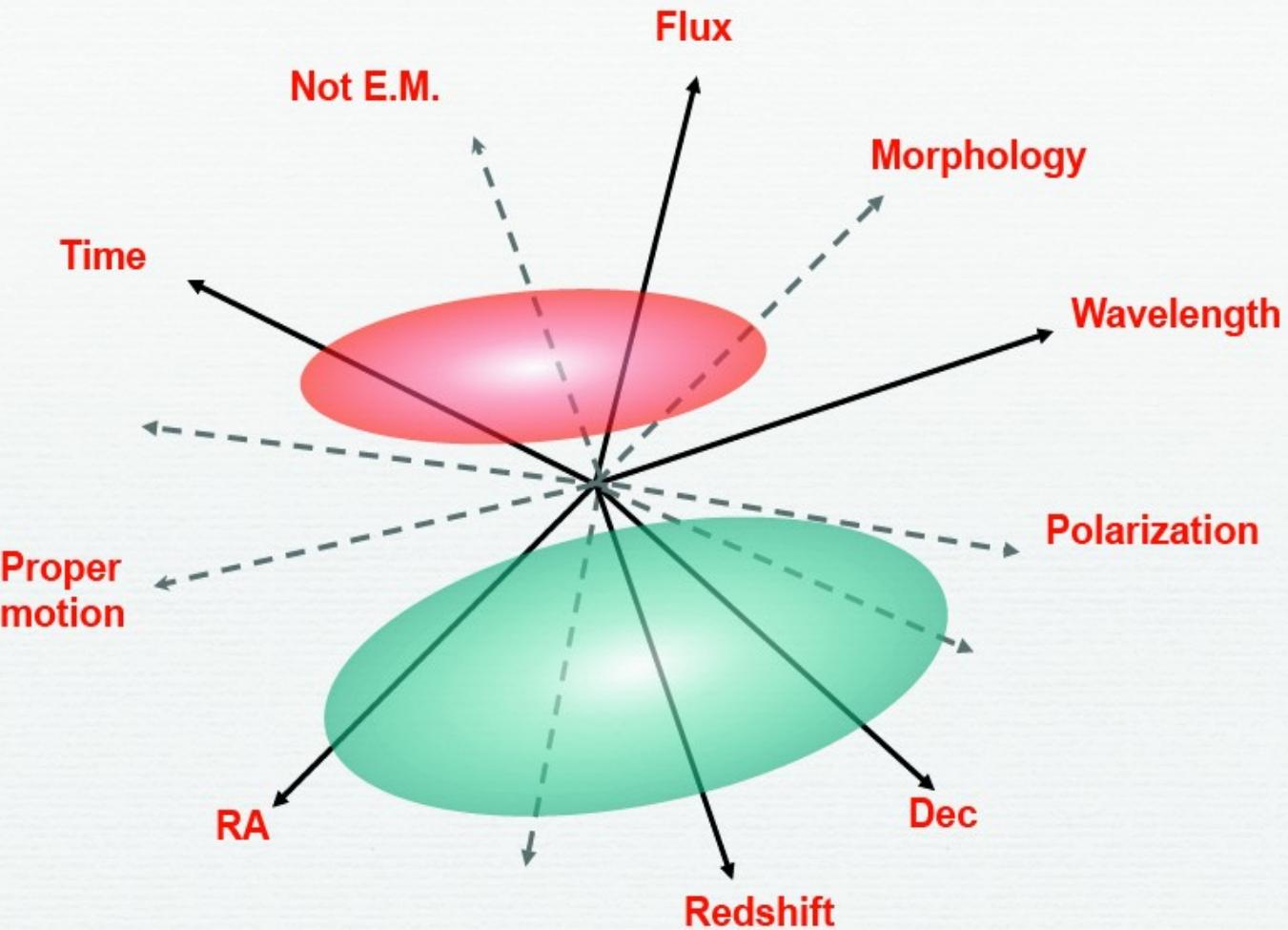
Data in astronomy – doubling < 1 yr ! (1000/10 yr)



# A paradigm shift

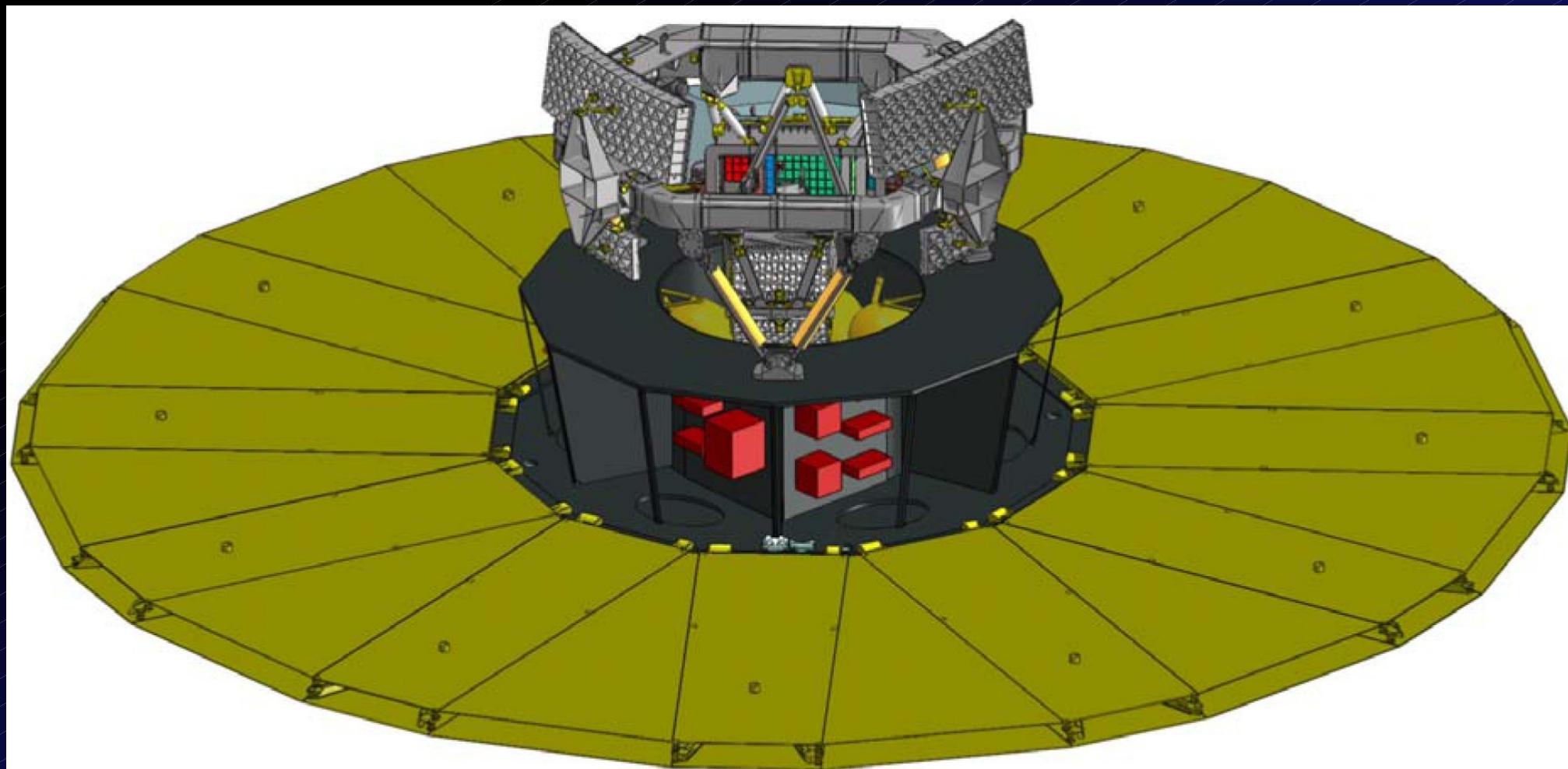


# A growing parameter space



**Most discoveries were made in small regions  
of subspaces or along some of these axes**

# GAIA (2012)

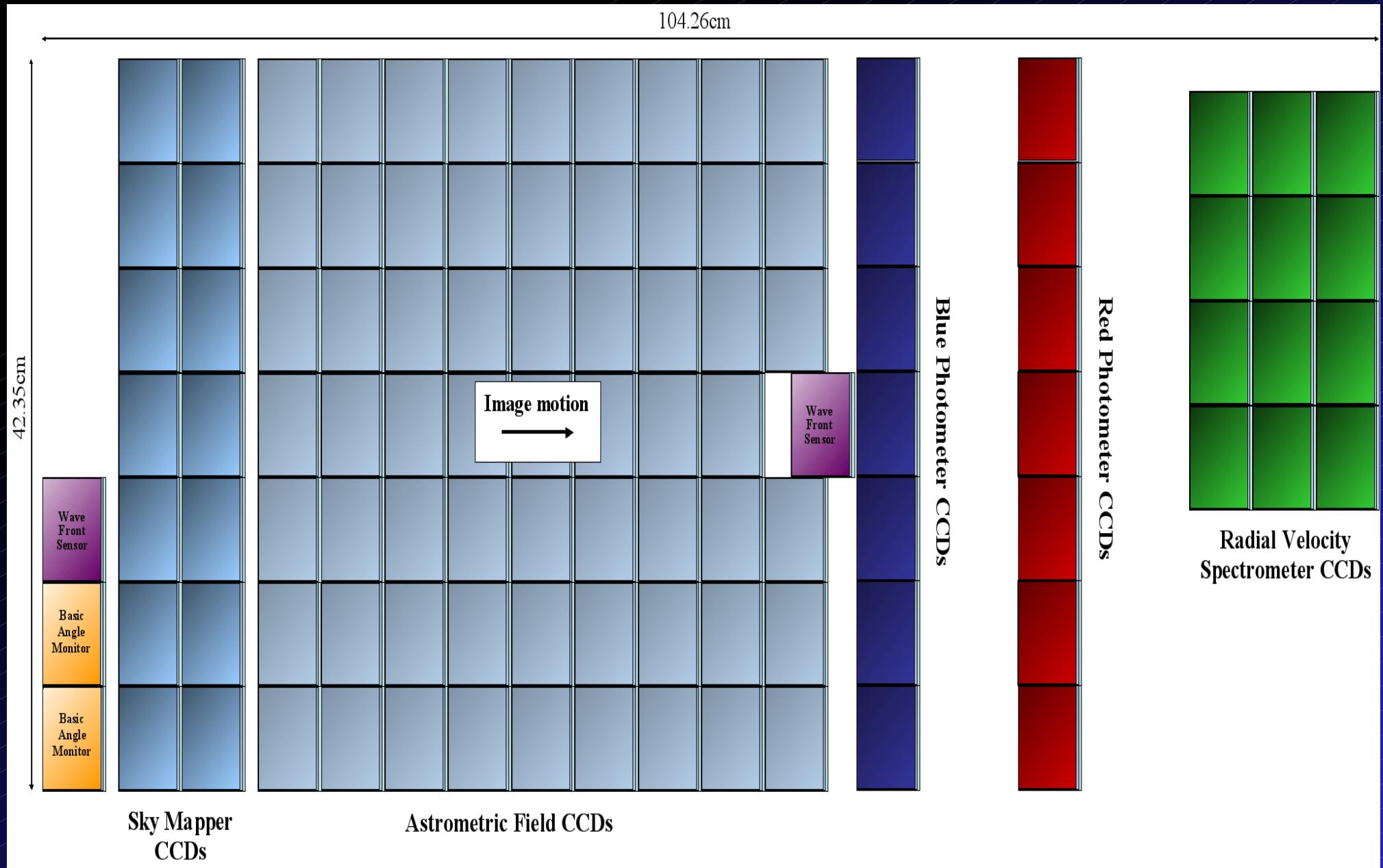


106 CCDs

938 Mpix

2800cm<sup>2</sup>

# GAIA CCDs



# **History of VO**

Success of IUE/HST archives

idea of the VO - end 2000

Federation of archives (MAST, NED)

- unified IF, data format for transport

Huge data – distributed processing

GRID - started in HEP (accelerator science)

Multispectral research : radio---gamma

- Virtual Universe (UK), AstroVirTel (ESO)

Data for SDSS, SIMBAD, NED – key research

# **Virtual Observatory : Key Definitions**

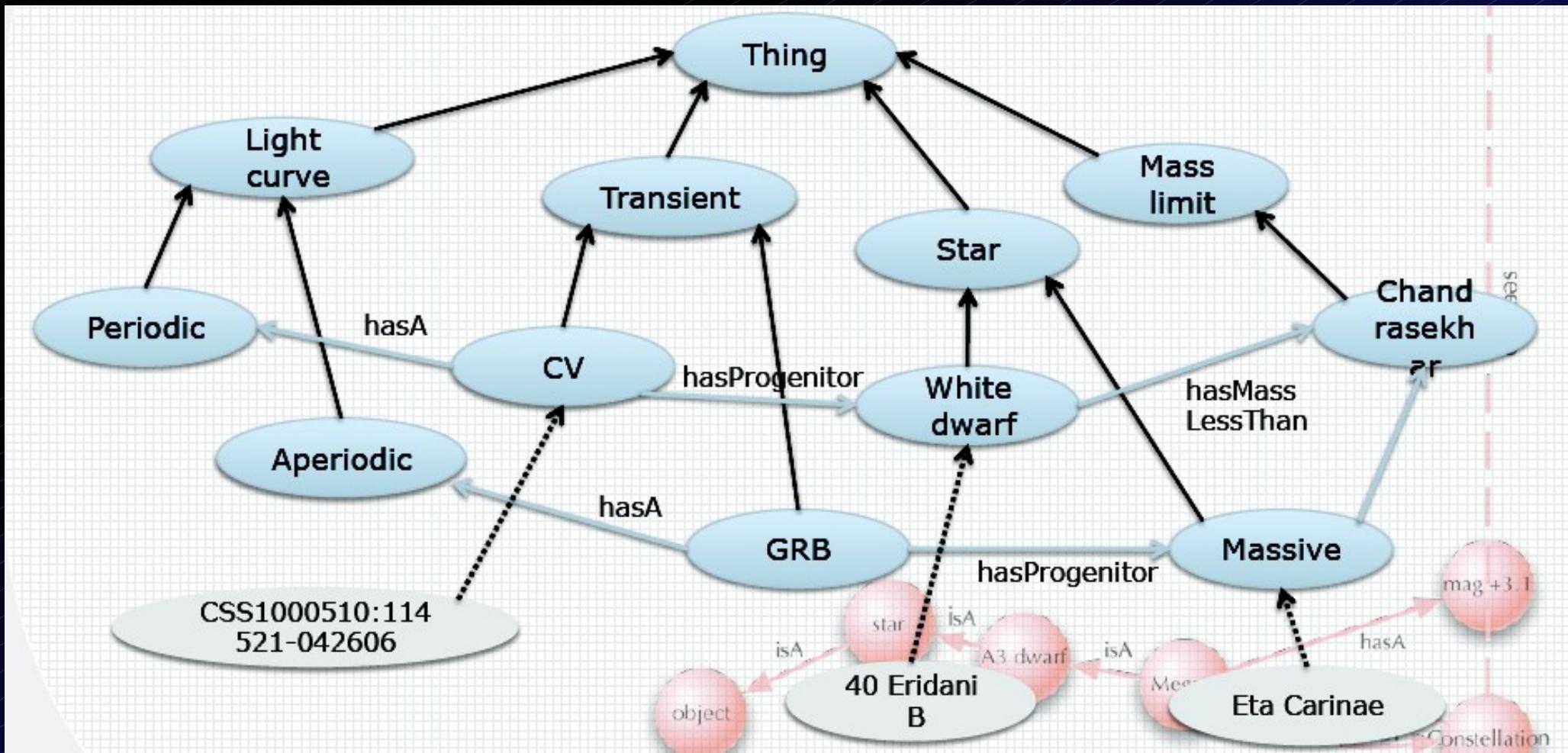
- “*The Virtual Observatory will be a system that allows astronomers to interrogate multiple data centers in a seamless and transparent way, which provides new powerful analysis and visualization tools within that system, and which gives data centers a standard framework for publishing and delivering services using their data*”.
- Standardization of data and metadata, and of data exchange methods.
- Registry, listing available services and what can be done with them.

*R.J.Hanisch, P.J.Quinn, in “IVOA – Guidelines for participation”*

# VO Paradigma

- METADATA (name of column), ontologies (name)
- Unique format (VOTable – e.g Vizier)
- Transparent search, download, conversion
- Query for data – processing done on servers
- Federation of astronomical archives (protocols)
- Unified presentation – automatic units conversion  
(A,MeV,MHz->nm),  $\text{Wm}^{-2}\text{s}^{-1}$  → Jy)
- Background computing on GRIDS
- Multiwavelength approach (SED)

# Ontologies in Astronomy

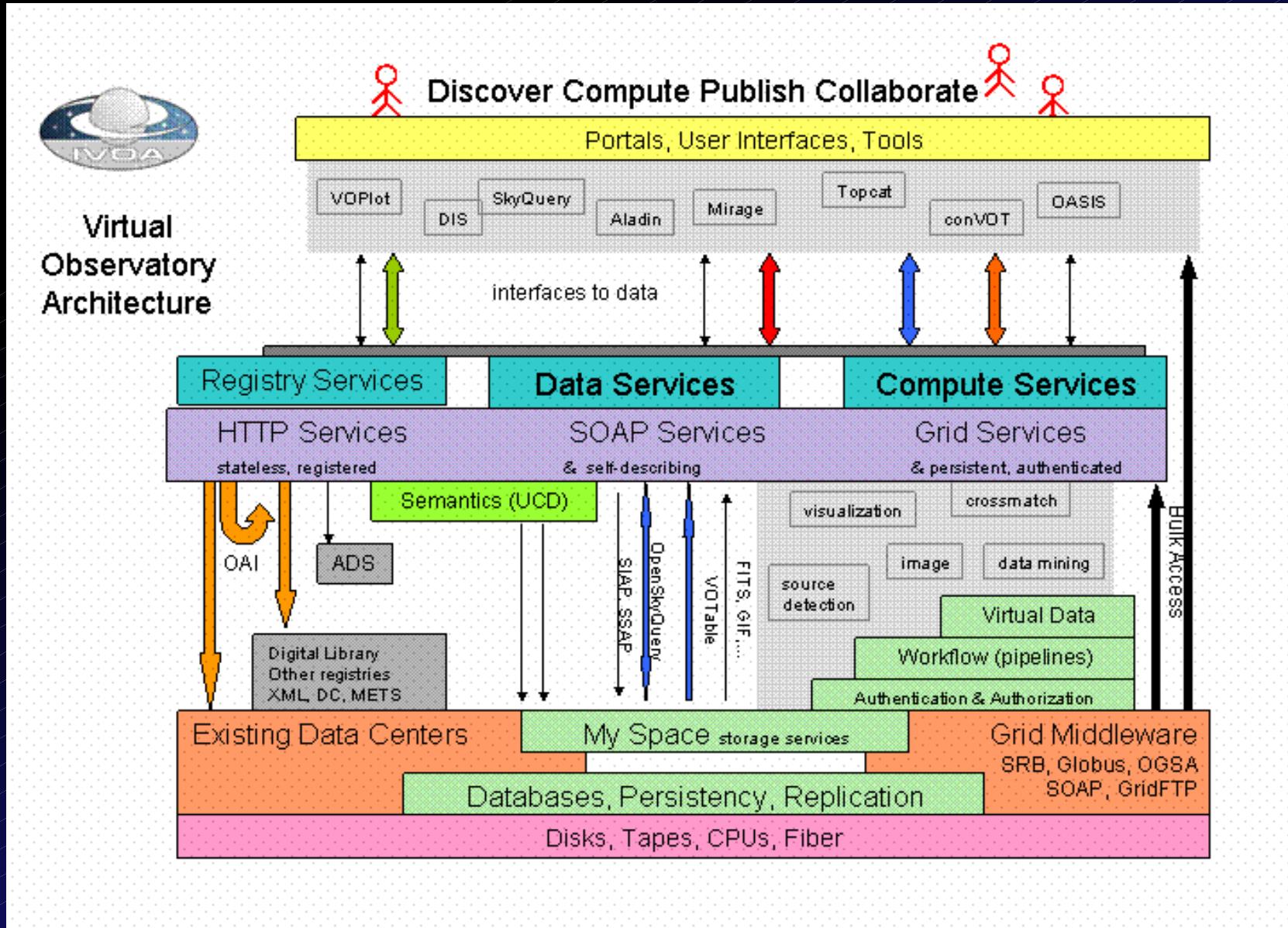


# VOTable

```
<TABLE name="SpectroLog">
<FIELD name="Target" ucd="meta.id" datatype="char" arraysize="30*"/>
<FIELD name="Instr" ucd="instr.setup" datatype="char" arraysize="5*"/>
<FIELD name="Dur" ucd="time.expo" datatype="int" width="5" unit="s"/>
<FIELD name="Spectrum" ucd="meta.ref.url" datatype="float" arraysize="*"
      unit="mW/m2/nm" type="location">
<DESCRIPTION>Spectrum absolutely calibrated</DESCRIPTION>
<LINK type="location"
      href="http://ivoa.spectr/server?obsno="/>
</FIELD>
<DATA><TABLEDATA>
<TR><TD>NGC6543</TD><TD>SWS06</TD><TD>2028</TD><TD>01301903</
TD></TR>
<TR><TD>NGC6543</TD><TD>SWS07</TD><TD>2544</TD><TD>01302004</
TD></TR>
</TABLEDATA></DATA>
</TABLE>
```

Serialization (metadata first, end of data unknown, tree structure)

# Architecture of VO



# Technology of VO

Unified data format– VOTable, UCD (Vizier)

Transparent transport (SOAP , REST<sub>(youtube)</sub>)

Web services (WS) e-commerce, B2B, J2EE, .Net

VOregistry (DNS like) Google for data+WS  
protocols (CGI)

- ConeSearch (searching in circle on sky)
- SIAP (Simple Image Access Protocol)
- SSAP(Simple Spectral Access Protocol)
- SLAP(Simple Line Access Protocol)
- TAP (Table Access Protocol)
- VOEVENT (transients, robotic telescopes,Sun)

# VO Registry - web

Soubor Úpravy Zobrazit Historie Záložky Nástroje Nápověda

http://nvo.stsci.edu/vor10/getRecord.aspx?id=ivo://asu.cas.cz/stel/heros/cutout

Nejnavštěvovan... Getting Started Latest Headlines ELIAV, a.s. - Firmy.cz

VOSpec\_Oct2007.png (PNG obrázek) HEROS OND CUTOUT: Resource Record Summary

## NVO Registry

Hosted By Space Telescope Science Institute

Resource Record Summary

### Catalog Service:

#### cutout server of HEROS archive of Ondrejov observations

**Short name:** HEROS OND CUTOUT  
**IVOA Identifier:** ivo://asu.cas.cz/stel/heros/cutout  
**Publisher:** Stellar Department of Astronomical Institute of the Academy of Sciences of the Czech Republic [+] [Pub. ID]  
**More Info:** <http://stelweb.asu.cas.cz/vo-archives/heros>

**Status:** active  
**Registered:** 2008 Oct 24 21:13:08Z  
[Get XML](#)

#### Description

This is the cutout server for the content of HEROS archive. Using the parametr BAND=I1/I2 prepares on the fly spectra extended only over given range of wavelengths. This archive contains about 6000 high resolution (R=2000) echelle spectra obtained by the HEROS spectrograph installed at the 2m telescope of the Ondrejov observatory since August 2000 to March 2003. The spectra exposed simultaneously in two channels (red 580-840nm, blue 370-560nm) were reduced by MIDAS HEROS pipeline including the merging of echelle orders, heliocentric correction and rebinning to steps of 0.1A. The intensities are in instrumental flux (not normalized).

#### More About this Resource

[+] **About the Resource Providers**  
This section describes who is responsible for this resource.

[+] **Status of This Resource**  
This section provides some status information: the resource version, availability, and relevant dates.

[+] **What This Resource is About**  
This section describes what the resource is, what it contains, and how it might be relevant.

#### Available Service Interfaces

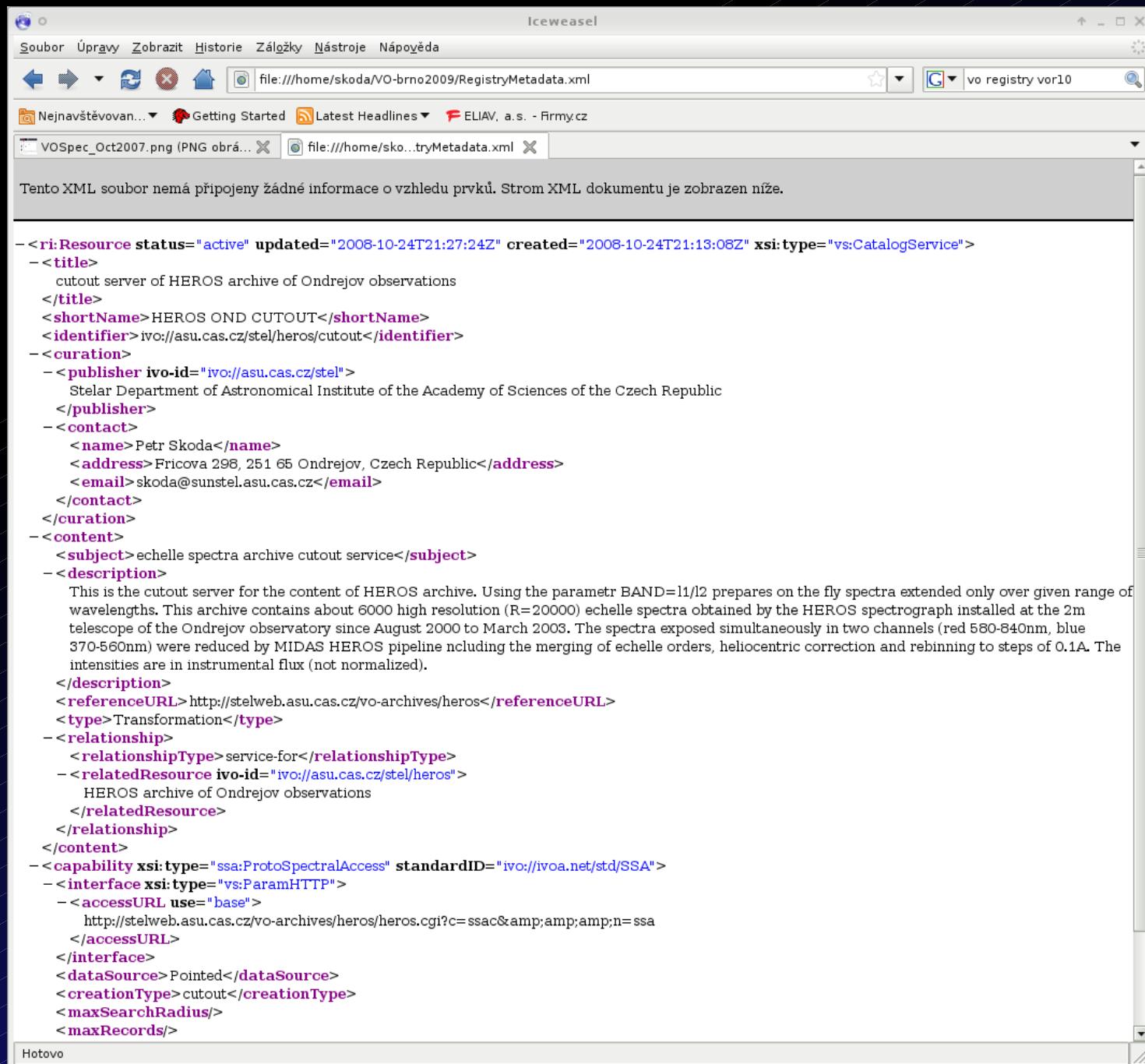
[+] **Simple Spectral Access**  
This is a standard IVOA service for searches for spectra from this resource that were observed within a specified region of the sky.

Developed with the support of the National Science Foundation under Cooperative Agreement AST0122449 with the Johns Hopkins University. The NVO is a member of the International Virtual Observatory Alliance. This NVO Application is hosted by the Space Telescope Science Institute.

Member

Hotovo

# VO Registry - XML



The screenshot shows the Iceweasel web browser displaying the XML content of a VO Registry resource. The title bar reads "Iceweasel". The address bar shows the URL "file:///home/skoda/VO-brno2009/RegistryMetadata.xml". The main content area displays the XML code for the "HEROS OND CUTOUT" service.

```
<ri:Resource status="active" updated="2008-10-24T21:27:24Z" created="2008-10-24T21:13:08Z" xsi:type="vs:CatalogService">
  <title>
    cutout server of HEROS archive of Ondrejov observations
  </title>
  <shortName>HEROS OND CUTOUT</shortName>
  <identifier>ivo://asu.cas.cz/stel/heros/cutout</identifier>
  <curation>
    <publisher ivo-id="ivo://asu.cas.cz/stel">
      Stelar Department of Astronomical Institute of the Academy of Sciences of the Czech Republic
    </publisher>
    <contact>
      <name>Petr Skoda</name>
      <address>Fricova 298, 251 65 Ondrejov, Czech Republic</address>
      <email>skoda@sunstel.asu.cas.cz</email>
    </contact>
  </curation>
  <content>
    <subject>echelle spectra archive cutout service</subject>
    <description>
      This is the cutout server for the content of HEROS archive. Using the parametr BAND=l1/l2 prepares on the fly spectra extended only over given range of wavelengths. This archive contains about 6000 high resolution (R=20000) echelle spectra obtained by the HEROS spectrograph installed at the 2m telescope of the Ondrejov observatory since August 2000 to March 2003. The spectra exposed simultaneously in two channels (red 580-840nm, blue 370-560nm) were reduced by MIDAS HEROS pipeline including the merging of echelle orders, heliocentric correction and rebinning to steps of 0.1A. The intensities are in instrumental flux (not normalized).
    </description>
    <referenceURL>http://stelweb.asu.cas.cz/vo-archives/heros</referenceURL>
    <type>Transformation</type>
    <relationship>
      <relationshipType>service-for</relationshipType>
      <relatedResource ivo-id="ivo://asu.cas.cz/stel/heros">
        HEROS archive of Ondrejov observations
      </relatedResource>
    </relationship>
  </content>
  <capability xsi:type="ssa:ProtoSpectralAccess" standardID="ivo://ivoa.net/std/SSA">
    <interface xsi:type="vs:ParamHTTP">
      <accessURL use="base">
        http://stelweb.asu.cas.cz/vo-archives/heros/heros.cgi?c=ssac&amp;amp;n=ssa
      </accessURL>
    </interface>
    <dataSource>Pointed</dataSource>
    <creationType>cutout</creationType>
    <maxSearchRadius/>
    <maxRecords/>
  </capability>

```

# Technology of VO

ADQL (Astronomical Data Query Language)

XMATCH, REGION (2 catalogues - shifted)

Application interoperability – PLASTIC, SAMP

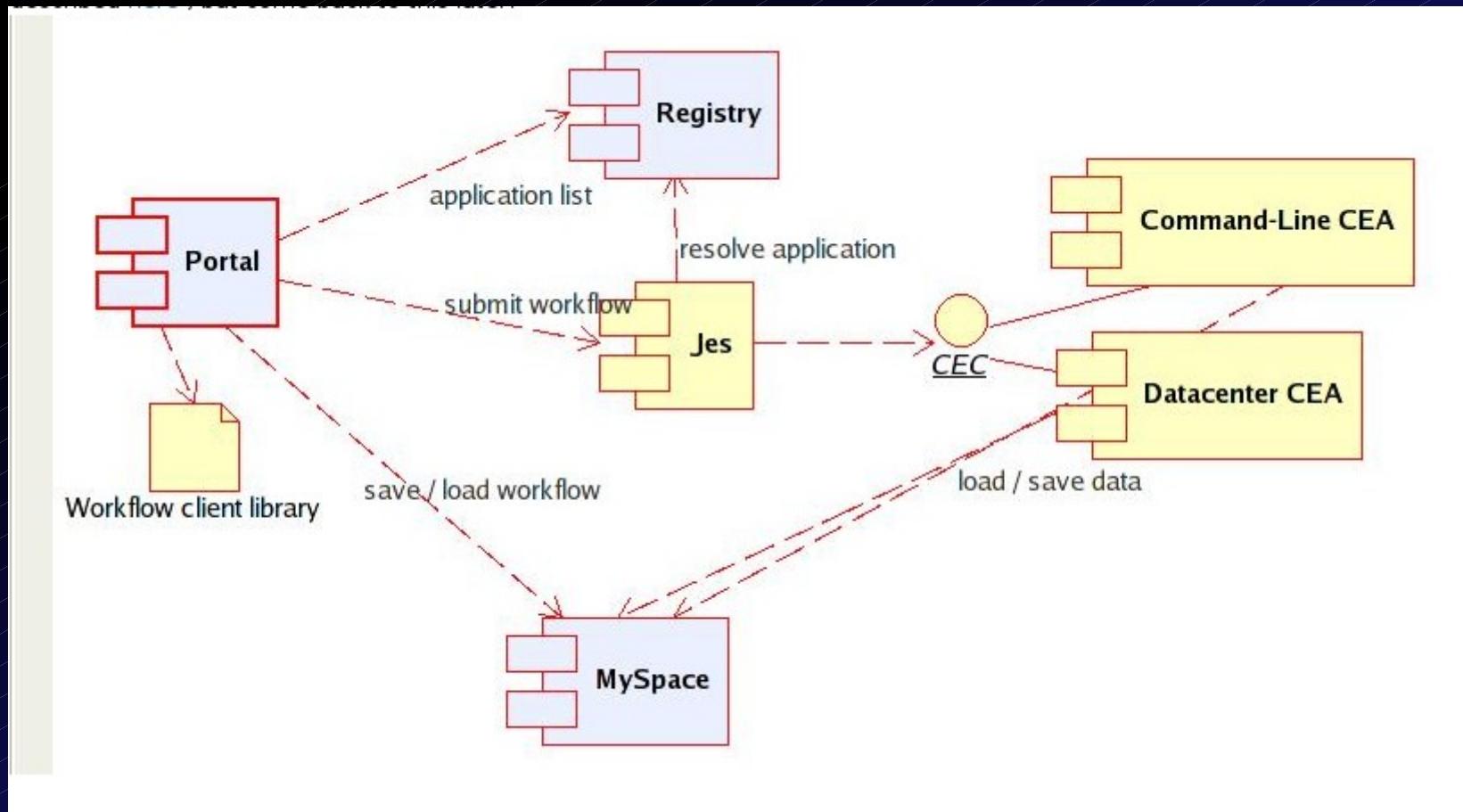
- Allows develop applications as bricks
- sending VOTABLES (catalogue-spectra-images)

Commercial interest (GoogleSky, MS WWT)

Planetariums, Outreach (Stellarium)

# Workflows - Astrogrid

Running remote services – e.g. Sextractor, CASJobs, AstroNeural MLP....



# Building a query

## AstroGrid Query Builder

The screenshot illustrates the AstroGrid Query Builder interface for SDSS Data Release 3 (AstroGrid DSA). The interface is divided into several panels:

- Top Bar:** SDSS Data Release 3 (AstroGrid DSA)
- Left Sidebar:** Chooser, Query, Parameter, XML, Info, Security.
- Central Area:**
  - Table Columns:** Shows the structure of the PhotoObjAll table, listing columns like ntmID, fieldID, parentID, specObjID, u, g, r, i, z, err\_u, err\_g, err\_r, and err\_i with their UCD, Units, Type, and Description.
  - Table Description:** Provides a brief description of the PhotoObjAll table: "Maps all primary and secondary objects in the PhotoObjAll table to a view".
  - Selected table:** A list of tables in the database, with PhotoObj highlighted.
  - Query being built:** Displays the current query tree:
    - Select
      - Items: a.ra, a.dec, a.u, a.g, a.r, a.i, a.z, a.err\_u, a.err\_g, a.err\_r, a.err\_i, a.err\_z, a.type
    - From: PhotoObj as a
    - Where
      - And
        - a.ra Between 242.0 And 243.6
        - a.dec Between 54.1 And 55.1
  - Column References:** A dialog box showing "Insert 5 references into 'Items'".
- Diagnostics:** A panel at the bottom left.
- Bottom Bar:** Set Archive Definition..

Annotations highlight specific features:

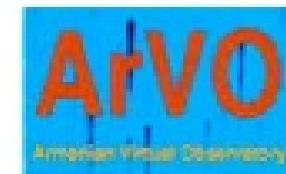
- Table Columns:** Points to the "Table Columns" panel.
- Table Description:** Points to the "Table Description" panel.
- Selected table:** Points to the "Selected table" list.
- Query being built:** Points to the "Query being built" panel.
- Dialog to insert selected columns into selected section of the query:** Points to the "Column References" dialog.
- List of tables in the database:** Points to the "Selected table" list.

# IVOA

Astro  
Grid



EUROVO



# Simple Spectra Access Protocol Spectral Data Model

Simple Spectral Access Protocol V1.04



*International  
Virtual  
Observatory  
Alliance*

**Simple Spectral Access Protocol**  
**Version 1.04**  
**IVOA Recommendation Feb 01, 2008**

**This version:**  
<http://www.ivoa.net/Documents/REC/DAL/SSA-20080201.html>

**Latest version:**  
<http://www.ivoa.net/Documents/latest/SSA.html>

**Previous version(s):**  
Version 1.03, December 2007  
Version 1.02, September 2007  
Version 1.01, June 2007  
Version 1.00, May 2007  
Version 0.97, November 2006  
Version 0.96, September 2006  
Version 0.95 May 2006  
Version 0.91 October 2005  
Version 0.90 May 2005

**Editors:**  
D.Tody, M. Dolensky

**Authors:**  
D.Tody, M. Dolensky, J. McDowell, F. Bonnarel, T.Budavari, I.Busko, A. Micol, P.Osuna, J.Salgado, P.Skoda, R.Thompson, F.Valdes, and the data access layer working group.



*International  
Virtual  
Observatory  
Alliance*

**IVOA Spectral Data Model**  
**Version 1.03**  
**IVOA Recommendation 2007-10-29**

**This version (Recommendation Rev 1)**  
<http://www.ivoa.net/Documents/REC/DM/SpectrumDM-20071029.pdf>

**Latest version:**  
<http://www.ivoa.net/Documents/latest/SpectrumDM.html>

**Previous versions:**  
<http://www.ivoa.net/Documents/PR/DM/SpectrumDM-20070913.html>

**Editors:**  
Jonathan McDowell, Doug Tody

**Contributors:**  
Jonathan McDowell, Doug Tody, Tamas Budavari, Markus Dolensky, Inga Kamp, Kelly McCusker, Pavlos Protopapas, Arnold Rots, Randy Thompson, Frank Valdes, Petr Skoda, and the IVOA Data Access Layer and Data Model Working Groups.

# SSAP Parameters

## 4.1.1 Mandatory Query Parameters

The following parameters **must** be implemented by a compliant service:

Parameter	Sample value	Physical unit	Datatype
<b>POS</b>	52,-27.8	degrees; defaults to ICRS	string
<b>SIZE</b>	0.05	degrees	double
<b>BAND</b>	2.7E-7/0.13	meters	string
<b>TIME</b>	1998-05-21/1999	ISO 8601 UTC	string
<b>FORMAT</b>	votable	-	string

## 4.1.2 Recommended and Optional Query Parameters

Parameter	Sample value	Unit	Req	Datatype
<b>APERTURE</b>	0.00028 (=1")	degrees	OPT	double
<b>SPECRP</b>	2000	$\lambda/d\lambda$	REC	double
<b>SPATRES</b>	0.05	degrees	REC	double
<b>TIMERES</b>	31536000 (=1yr)	seconds	OPT	double
<b>SNR</b>	5.0	dimensionless	OPT	double
<b>REDSHIFT</b>	1.3/3.0	dimensionless	OPT	string
<b>VARAMPL</b>	0.77	dimensionless	OPT	string
<b>TARGETNAME</b>	mars		OPT	string
<b>TARGETCLASS</b>	star		OPT	string
<b>FLUXCALIB</b>	relative		OPT	string
<b>WAVECALIB</b>	absolute		OPT	string
<b>PUBDID</b>	ADS/col#R5983		REC	string
<b>CREATORDID</b>	ivo://auth/col#R1234		REC	string
<b>COLLECTION</b>	SDSS-DR5		REC	string
<b>TOP</b>	20	dimensionless	REC	int
<b>MAXREC</b>	5000		REC	string
<b>MTIME</b>	2005-01-01/2006-01-01	ISO 8601	REC	string
<b>COMPRESS</b>	true		REC	boolean
<b>RUNID</b>			REC	string

# Universal Worker Service

RESTfull (PUT/GET/POST/DELETE)

URI	Description	Representation
/jobs{}	the Job List	the <jobs> element in the UWS schema
/jobs{}/(job-id)	a Job	the <job> element in the UWS schema
/jobs{}/(job-id)/phase	the Phase of job (job-id)	one of the fixed strings
/jobs{}/(job-id)/executionduration	the maximum execution duration of (job-id)	Integer number of seconds
/jobs{}/(job-id)/destruction	the destruction instant for (job-id)	<a href="#">[std:iso8601]</a>
/jobs{}/(job-id)/error	any error message associated with (job-id)	any representation appropriate to the implementing service
/jobs{}/(job-id)/quote	the Quote for (job-id)	Integer number of seconds
/jobs{}/(job-id)/results	any parameters for the job (job-id)	the <results> element in the UWS schema
/jobs{}/(job-id)/parameters	any parameters for the job (job-id)	the <parameters> element in the UWS schema
/jobs{}/(job-id)/owner	the owner of the job (job-id)	an appropriate identifier as discussed in <a href="#">3.</a>

# **VO-enabled tools**

Aladin

VOPlot

TOPCAT

VOSpec

SpecView

SPLAT

ViSiVO (HPC simulations, cosmology)

VOSED

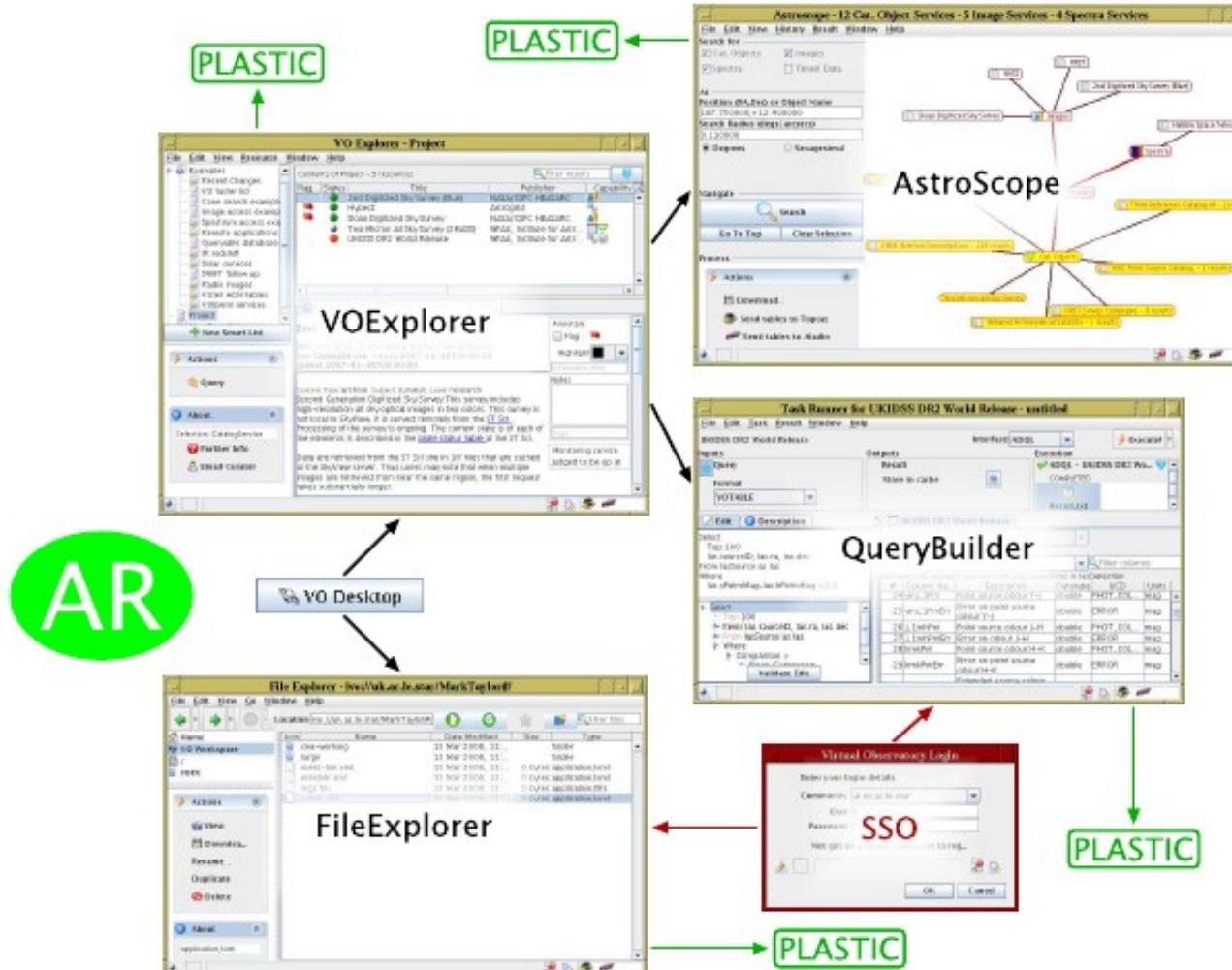
BASTI

SExtractor – WESIX (Web Enabled Source Identification with  
Cross Matching)

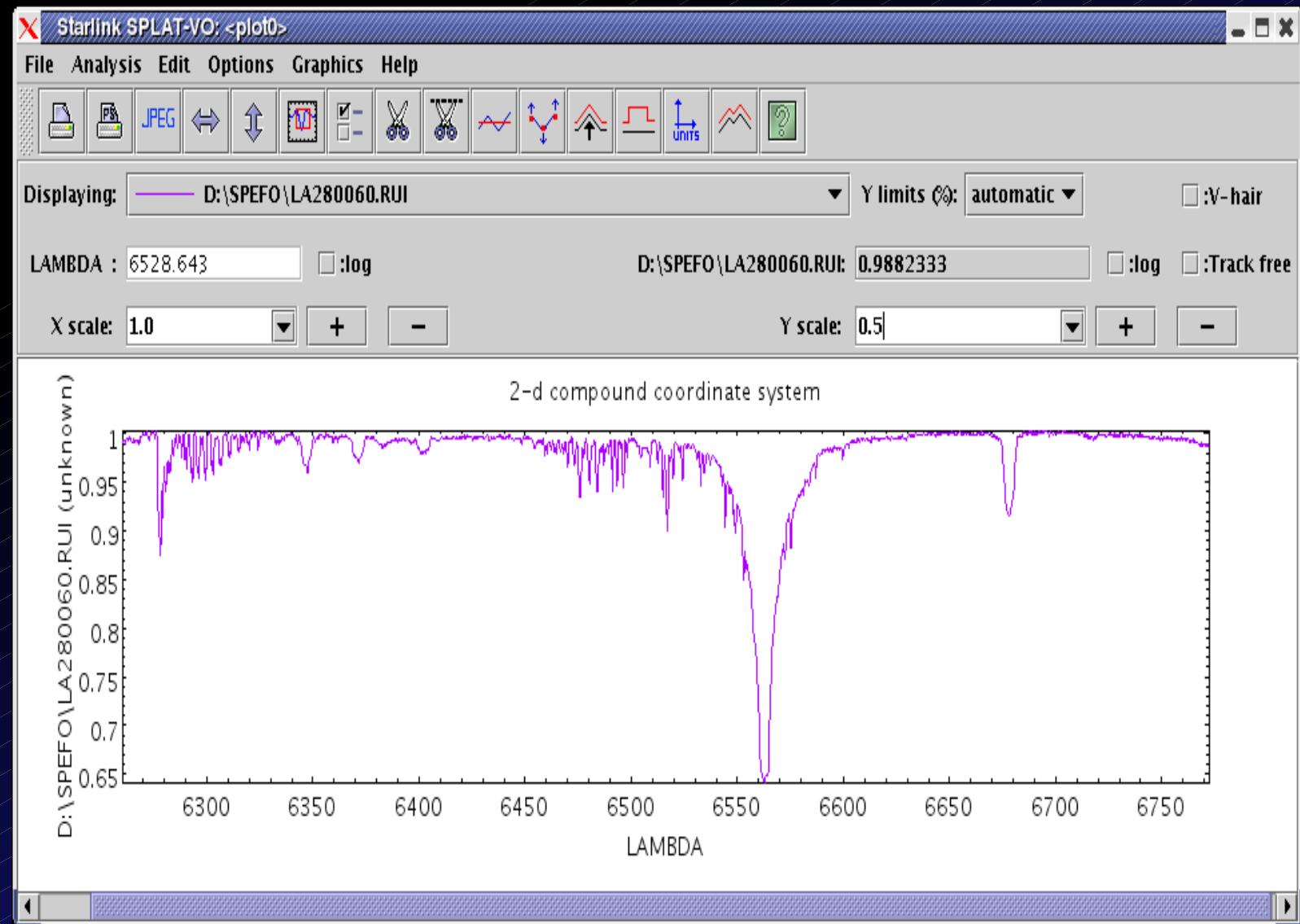
Period04 (since 18.9.08) - PLASTIC

# AstroGRID VODesktop

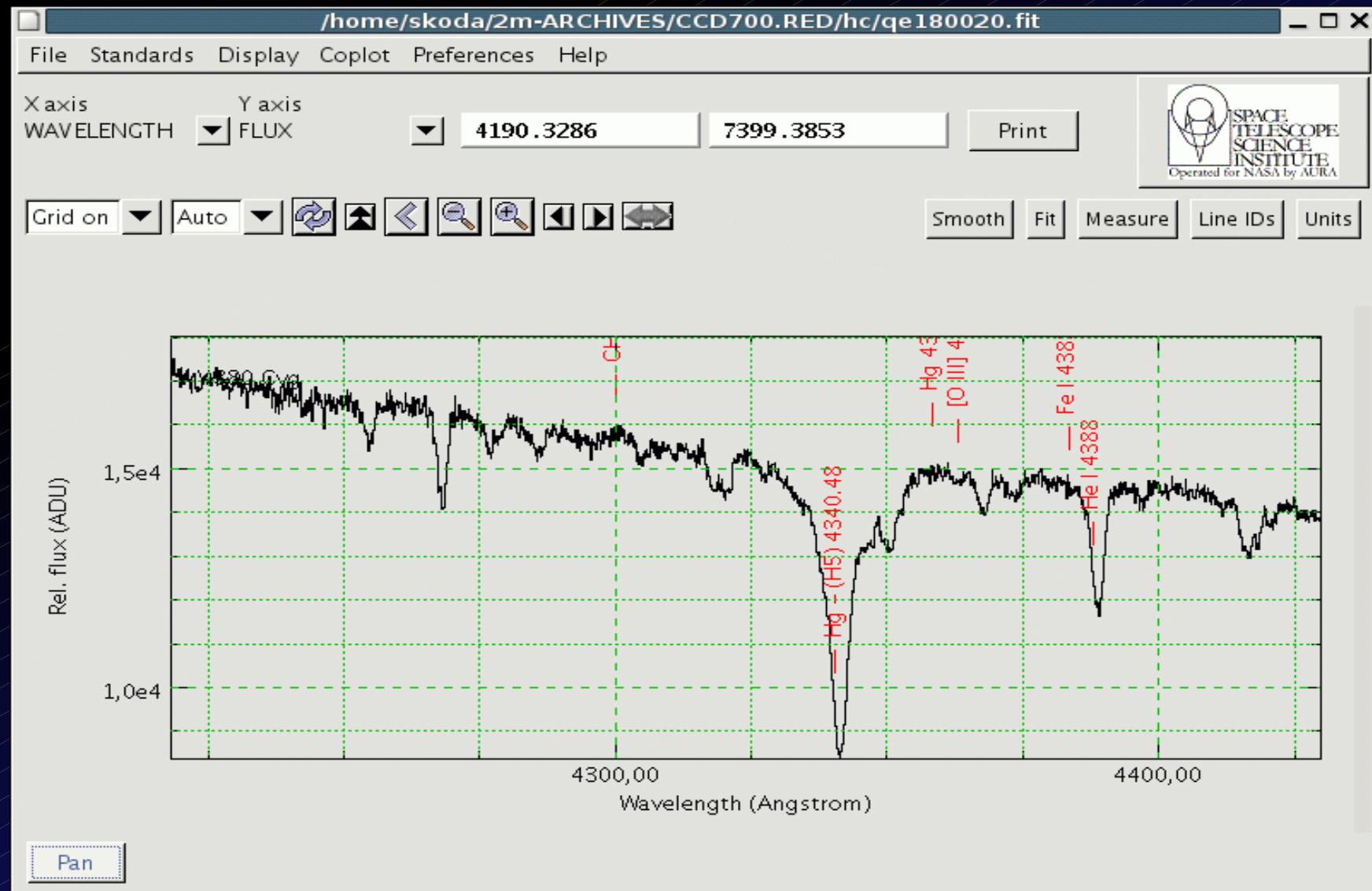
## VODesktop Overview



# SPLAT-VO (Starlink, JAC)



# SpecView (STScI)



Spectrum Services for the VO - Microsoft Internet Explorer

Back Search Favorites File Edit View Favorites Tools Go

Address http://voservices.net/spectrum/search\_list.aspx?search=cone&view=graph&page=0

NVO National Virtual Observatory

## Spectrum Services

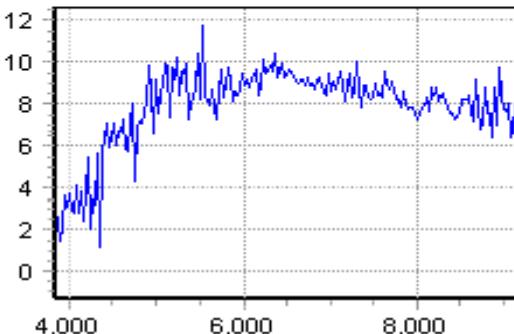
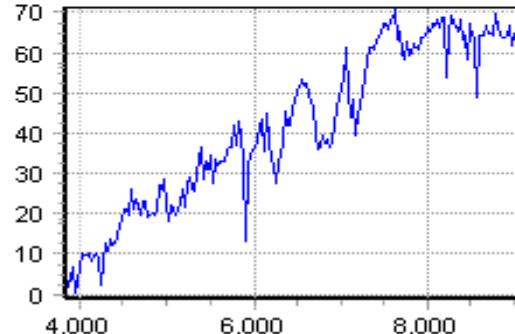
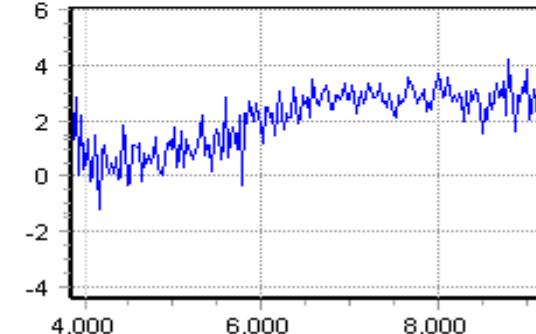
home docs search MySpectrum collections webservices user not logged in login | register

### Search Results

Found 12 objects. Displaying from 1 to 3

List mode Image mode First Prev Next Last

	1 . SDSS J115944.85+000000.00	2 . SDSS J120008.29+016000.00	3 . SDSS J115923.80+000000.00		
<input type="checkbox"/>	ivo://jhu/sdss/dr4#80443408212033536   ivo://sdss/dr4/spec#80443408212033536 details class: Galaxy , Z = 0.1009 ra = 179.936874 , dec = 0.941241	<input type="checkbox"/>	ivo://jhu/sdss/dr4#80443408262365184   ivo://sdss/dr4/spec#80443408262365184 details class: Galaxy , Z = 0.0000 ra = 180.034561 , dec = 1.146855	<input type="checkbox"/>	ivo://jhu/sdss/dr4#80443407863906304   ivo://sdss/dr4/spec#80443407863906304 details class: Galaxy , Z = 0.4517 ra = 179.849167 , dec = 0.984768

Select All Clear All What do you want to do with the results?

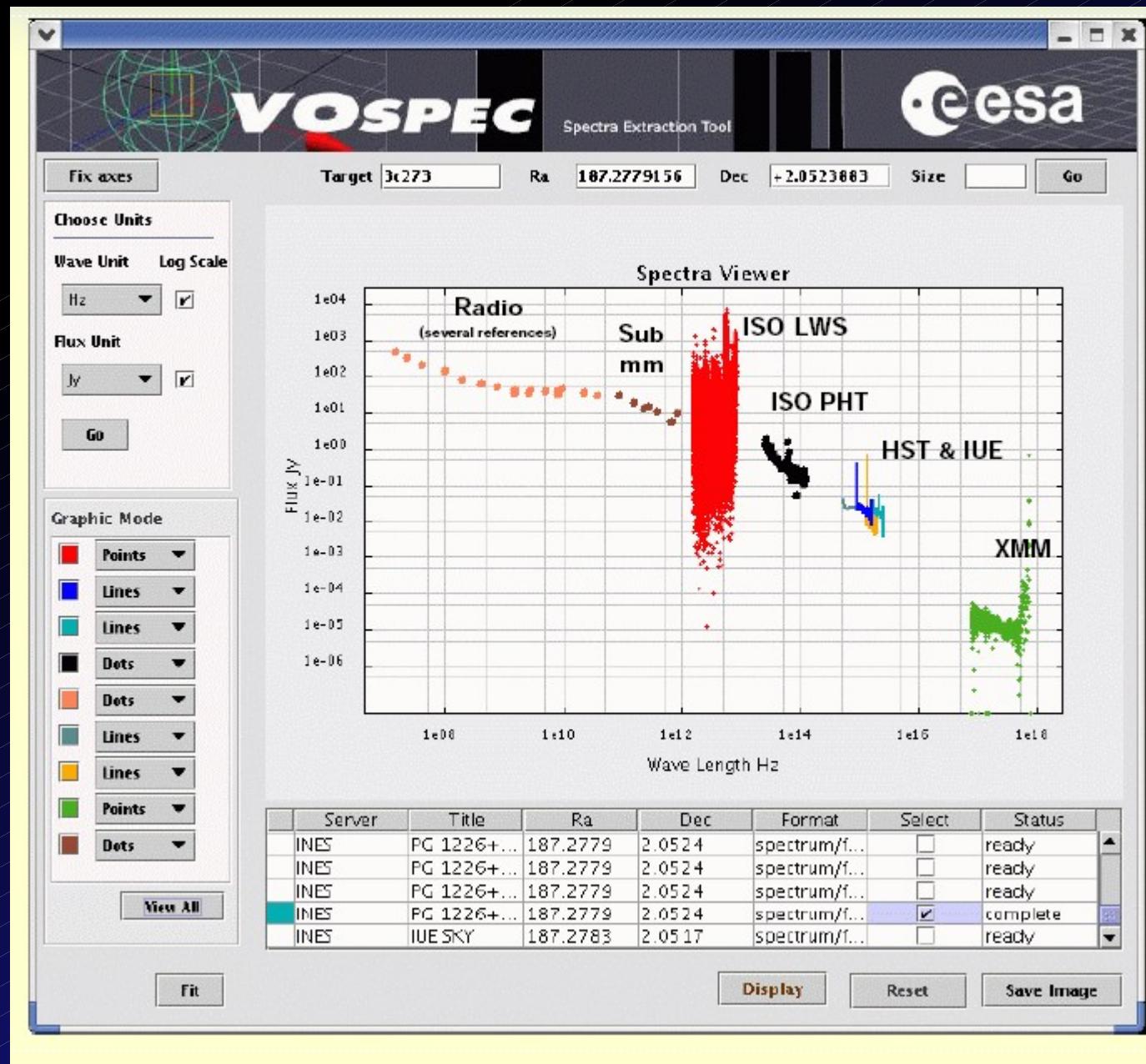
Download data

- Download data
- Save to MySpectra
- Plot on a graph
- Calculate composite
- Calculate synthetic magnitudes
- Fit continuum & lines

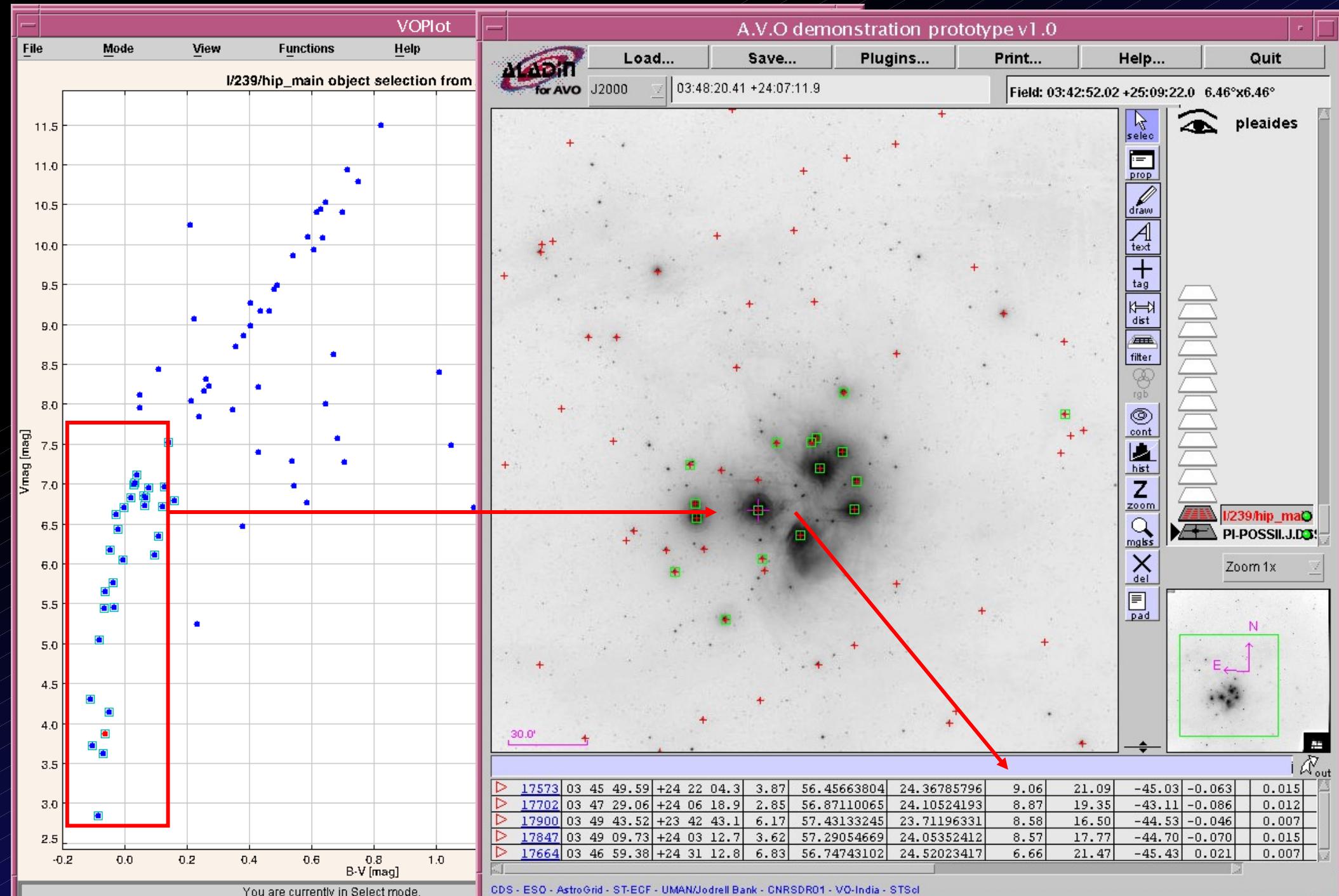
<< Results < Back Next > Finish >>

Internet

# VOspec (ESAC)



# Colour-magnitude diagram



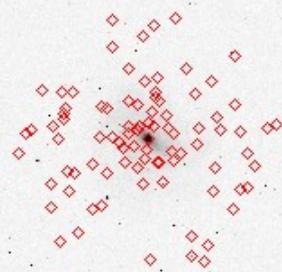
Aladin v5.0

Location

ICRS



2MASS Large Galaxy Atlas (LGA)



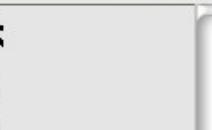
NGC 5236 (M83)

select

pan

zoom

3D



VOSpec

esa  
vo  
Virtual Observatory

File Edit View Operations Interop Help



Target M83 Ra 204.25325 Dec 6627777778 Size 0.2 Query

34.27' x 33.87'

E

GALEX NUV.h\_m83-nd-int.fits.gz

E

12.85' x 12.7'

E

grid multiview match

[View A1]

Graphic Mode

Li... Li...

Li... Li...

Li... Li...

Li... Li...

Po... Po...

Po... Po...

Po... Po...

Po... Po...

(c)1999-2008 ULP/CNRS - Centre de Donnees astro

11 0.09034

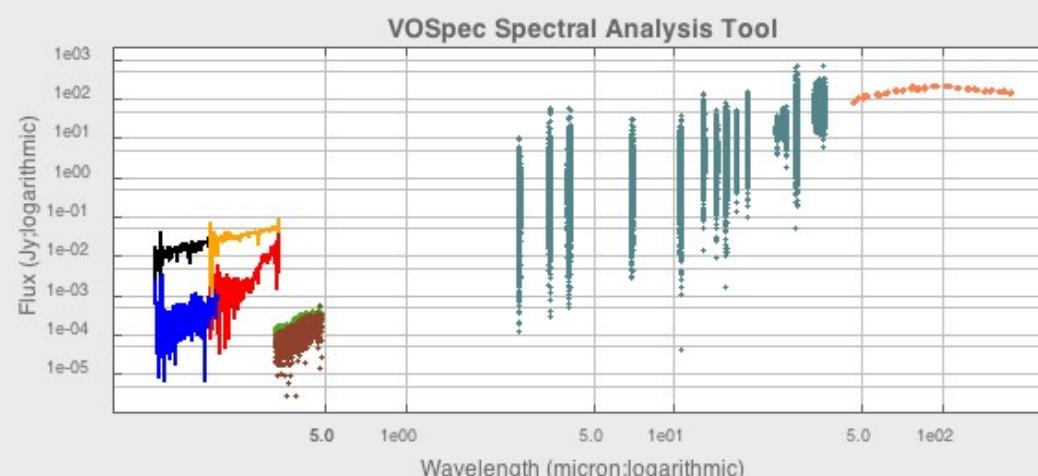
12 0.09083

13 0.09169

View

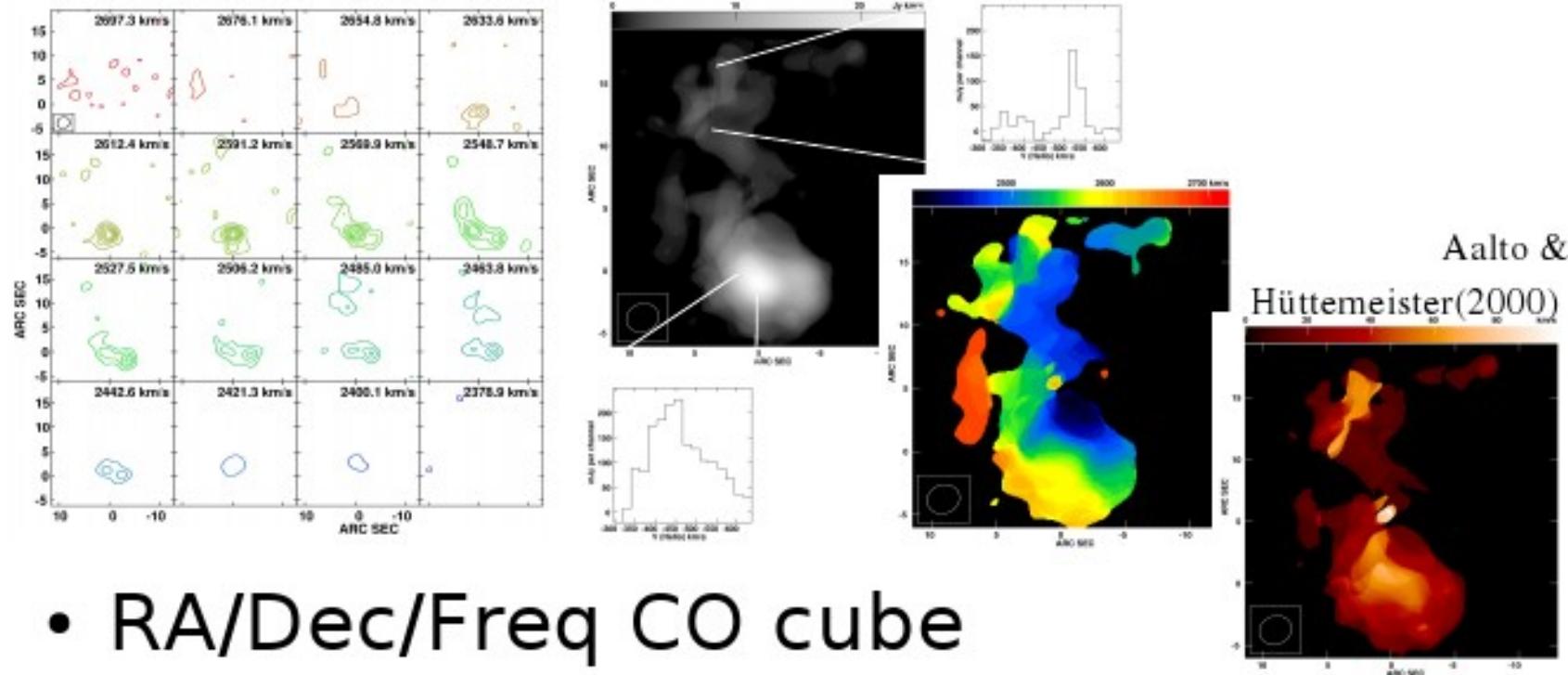
Retrieve

Reset



- NGC 5236
- Infrared Space Observatory Simple Spectrum Data Access
- ISO LWS01 Spectrum Target: NGC 5236P1
- ISO SWS02 Spectrum Target: NGC 5236 M83

# ALMA/IRAM use case



- RA/Dec/Freq CO cube
  - Convert to velocity (LSR, radio convention)
  - Cutouts, simple squashes - VO tools?
  - Smoothed spectra, moments with noise cut-off
    - Specialised server-side pipeline controlled via UWS

## Other VOs

Virtual Solar Observatory

Virtual Solar-Terrestrial Observatory

Virtual Magnetospheric Observatory

Virtual Space Physics Observatory

Virtual Meteor Observatory – not proper - XML

SKYBOT – Minor planets ephemerides (1840-2019)

Interest of climatology, meteorology

New branch of Science = e-Science

# Theory VO (TVO)

- Methods of VO (parameters in DB, SQL...) for study of results of simulations , catalogues of simulated objects like SDSS...(PCA)
- Browsing of simulation space along different axes – parameters, regions...
- Evolutionary tracks, Photo Dissociation Regions
- Formation of artificial galaxies, clusters – N body models (Millenium Run 10 billions, 25TB)
- Theoretical Spectra (GAVO – Rauch, GRID)

# CIELO VO - line catalogue SLAP

**SLAP Viewer Copyright ESAC, Spain**

**Server Selector**

- SLAP Services
  - IASD
  - LERMA
  - NIST ATOMIC SPECTRA
  - CIELO SLAP
    - <http://esav02:8080/cieloslapToolKit/cieloslap.jsp?>

**Molecular line databases**

Range of Search (m)

Wavelength Start  Wavelength End

**Select**

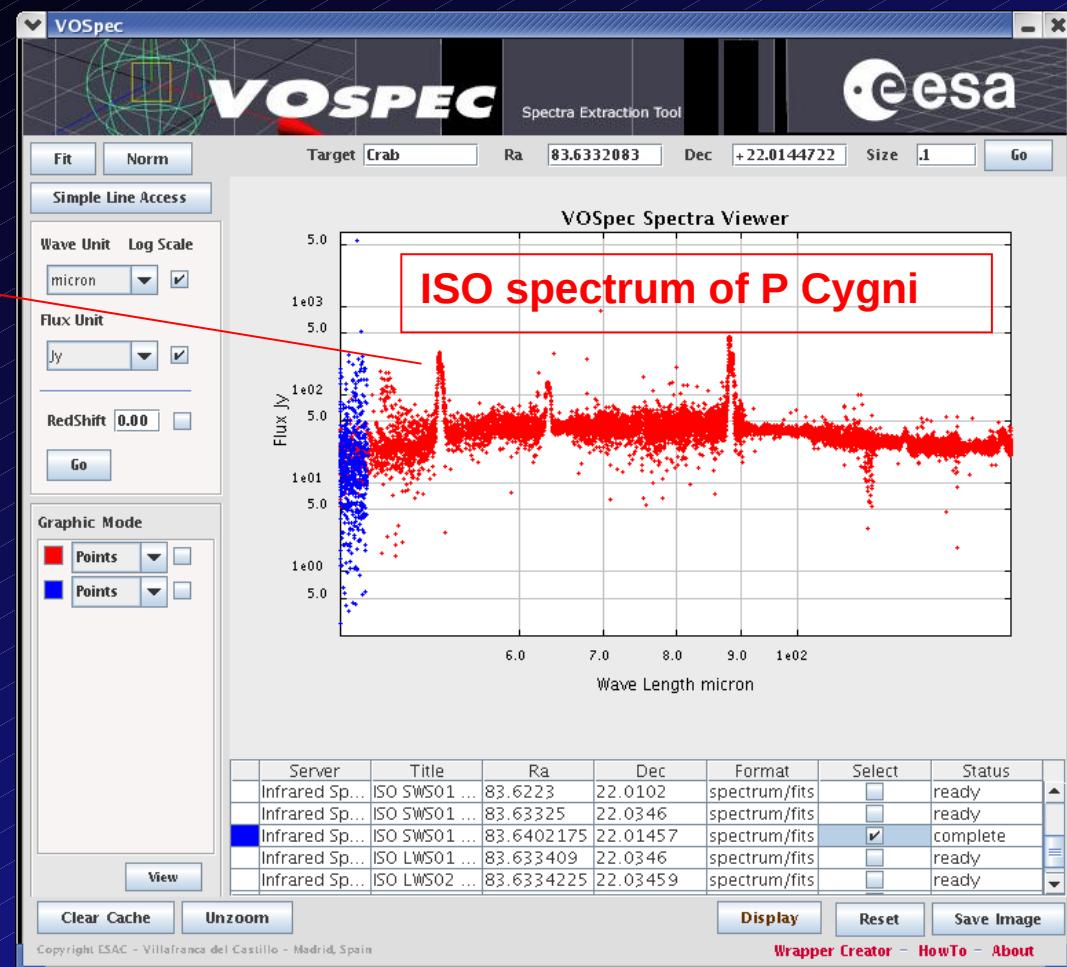
**Reset**

Slap Services Output

**CIELO SLAP**

Idm:Line.wavelength	Idm:Source...	Source.co...	Source.co...	Idm:Li...	Idm:...	Id...	Id...	Idm:...	Id...	
1.8627e-09	NGC1068	40.66963	-0.01328	....	1s_3p	1s2	1P1	150	OVII	....
1.7768e-09	NGC1068	40.66963	-0.01328	....	1s_4p	1s2	1P1	150	OVII	....
1.89671e-09	NGC1068	40.66963	-0.01328	....	2p	1s	2...	2...	OVIII	....
2.47793e-09	NGC1068	40.66963	-0.01328	....	2p	1s	2...	2...	NVII	....
2.21012e-09	NGC1068	40.66963	-0.01328	....	1s_2s	1s2	3S1	150	OVII	....
2.1602e-09	NGC1068	40.66963	-0.01328	....	1s_2p	1s2	1P1	150	OVII	....
2.18071e-09	NGC1068	40.66963	-0.01328	....	1s_2p	1s2	3P1	150	OVII	....
2.16210e-09	NGC1068	40.66962	0.01279	....	1s_2p	1s2	3P1	150	OVII	....

**Close**



# VO for Atomic and Molecular Data

VAMDC (06/2009-12/2012 FP7)

13 organizations

Virtual Atomic and Molecular Data Centre

VO principles (web services, integration, registry,  
SAMP, VODesktop, TOPCAT, VOSSpec)

(includes VALD extractor, NIST)

extended citation system (all providers acknowledged)

# Access protocols in VO: TSAP

## Theoretical models in the VO

### • Theoretical spectra: TSAP

- Included in the SSAP standard (use case for theoretical spectra)
- A simple protocol.
- Dialog server-application.

The screenshot shows the SVO TSAP Interface web page. At the top, there is a navigation bar with links for 'Theoretical model services', 'Documents', 'Models', 'Services', and 'Funded by INTA'. Below the navigation bar, there is a logo for 'SVO Spanish Virtual Observatory' and a link to 'MINISTERIO DE CIENCIA E INNOVACIÓN'. The main content area is titled 'TSAP Interface' and describes it as 'An interface to test TSAP services'. It lists 'Services: VOSA Filters TSAP S3if' and provides email contact information 'esm@laeff.inta.es'. On the right side of the main content area, there is a 'Logout' link. Below the main title, there is a section titled 'TSAP Interface' with a brief description of the service: 'SVO Theoretical Data Access Service: ATLAS9 Kurucz ODFNEW/NOVER models (Castelli et al., 1997, AA, 318, 841)'. This section also contains several input fields for parameters: 'teff\_min:' with a dropdown menu set to '3500' (min value for effective temperature), 'teff\_max:' with a dropdown menu set to '3500' (max value for effective temperature), 'logg\_min:' with a dropdown menu set to '0.00' (min value for Log(G)), 'logg\_max:' with a dropdown menu set to '0.00' (max value for Log(G)), 'meta\_min:' with a dropdown menu set to '-2.50' (min value for Metallicity), and 'meta\_max:' with a dropdown menu set to '-2.50' (max value for Metallicity). A 'Search' button is located at the bottom of this parameter section. At the very bottom of the page, there is a link 'See metadata VOTable'.

# VOSpec - models by TSAP

**Server Selector**

Query by Service  
Green services support params selected

- The ISO Data Archive InterOperability System
- VVDS-F02 DEEP spectra
- Wisconsin Halfwave Spectropolarimeter
- Wisconsin Ultraviolet Photo-Polarimeter Experiment
- cutout server of HEROS archive of Ondrejov observations

Theoretical Spectra Services

- PGos3: Evolutionary synthesis models
- PGos3: X-ray service prototype
- PGos3:VO-Mexico Model:Sternberg
- PGos3:VO-Mexico Model:UCL
- SVO: ATLAS9 Kurucz ODFNEW/NOVER models (Castelli et al.)
- SVO: Coelho Synthetic stellar library
- SVO: Models of irradiated accretion disks around PMS stars (D' Alessio et al.)
- SVO: PopStar evolutionary synthesis model
- TMAP SSA service
- VO-Paris: PEGASE.HR synthetic spectra

**Query Outlook**

Add SSA/TSA locally    Select All

- <http://archive.eso.org/apps/ssaserver/EsoProxySsap?&POS=304.44667416667,38.03293027778>
- <http://archive.eso.org/apps/ssaserver/EsoProxySsap?&POS=304.44667416667,38.03293027778>
- <http://archive.stsci.edu/ssap/search.php?id=HST&&POS=304.44667416667,38.03293027778>

**Query by params**

Tree

Query

- TARGET.NAME p cyg
- Simple Query
  - POS 304.44667416667,38.03293027778
  - SIZE 0.1
- Advanced Query
- Service Specific Query
  - PGos3: Evolutionary synthesis models
  - PGos3: X-ray service prototype
  - PGos3:VO-Mexico Model:Sternberg
  - PGos3:VO-Mexico Model:UCL
  - SVO: ATLAS9 Kurucz ODFNEW/NOVER models
  - SVO: Coelho Synthetic stellar library
  - SVO: Models of irradiated accretion disks around PMS stars
  - SVO: PopStar evolutionary synthesis model
  - TMAP SSA service
  - VO-Paris: PEGASE.HR synthetic spectra

**OSpec**

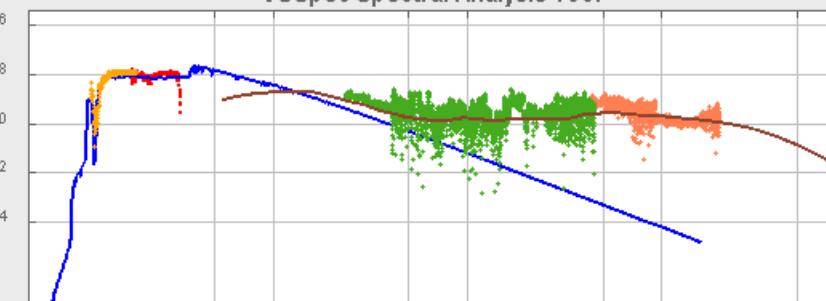
Interop Help

a           

HD 141569 Ra 37.49062042 Dec -3.92121111 Size 0.1 Query

**VOSpec Spectral Analysis Tool**

Wavelength (micron; logarithmic)



Points Points

Kurucz ODFNEW / NOVER, teff:10000, logg:4.00, meta:-0.50

SVO: Models of irradiated accretion disks around PMS stars (D' Alessio et al)

dalessio, teff=4000

Retrieve Reset

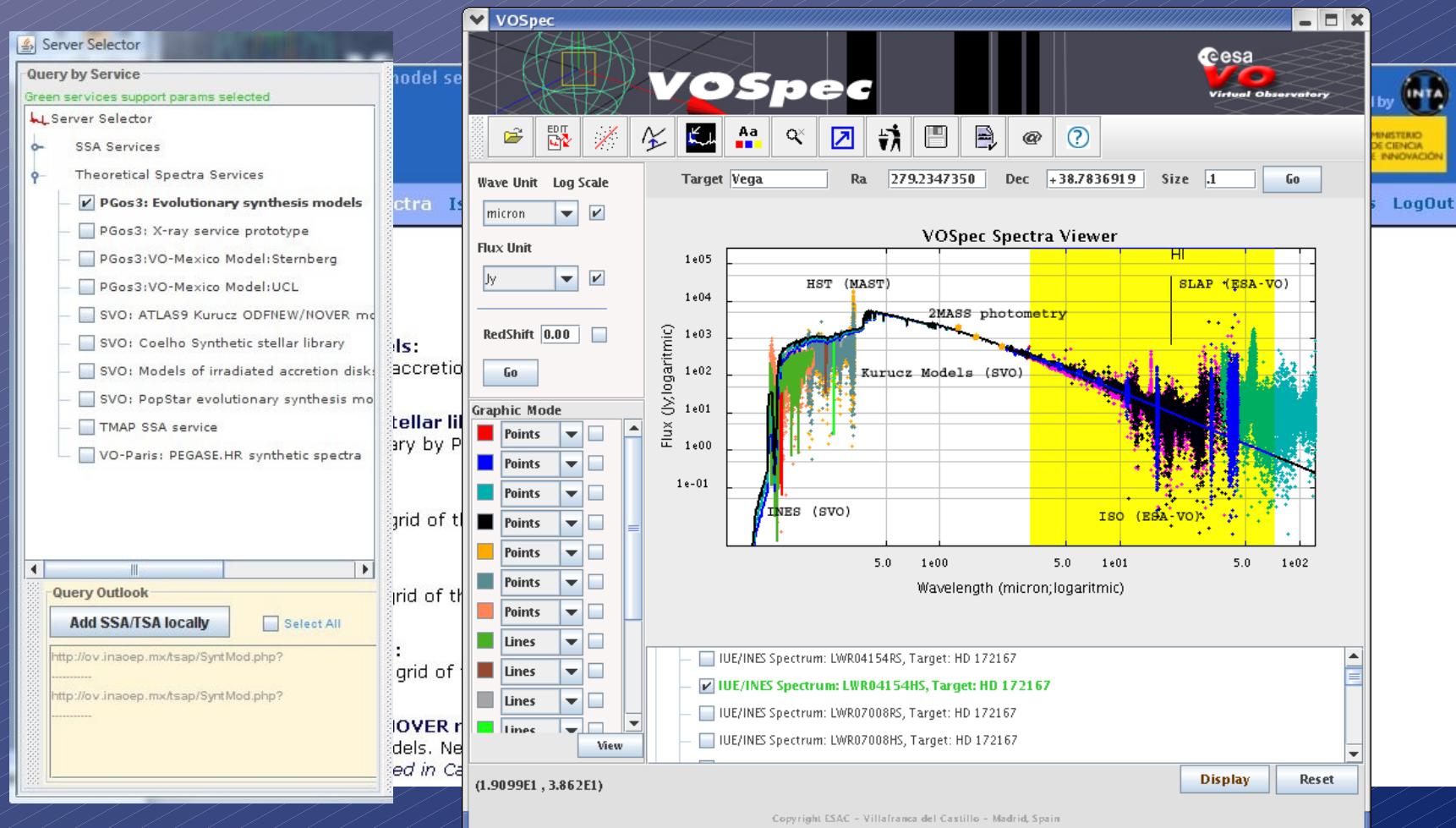
Copyright ESAC - Villafranca del Castillo - Madrid, Spain

**Kurucz stellar model and D'Alessio model of PMS discs fit to UV and IR spectra of HD 141569**

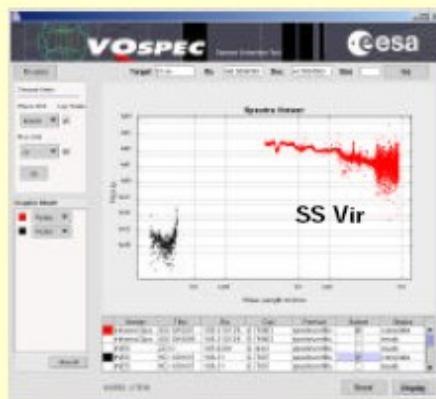
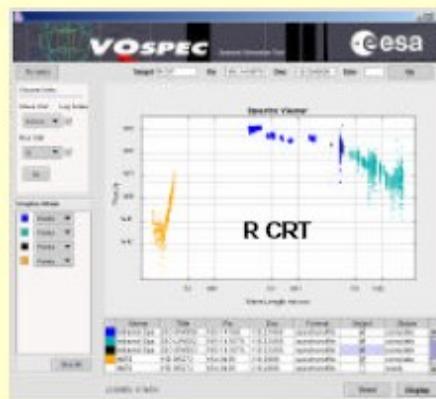
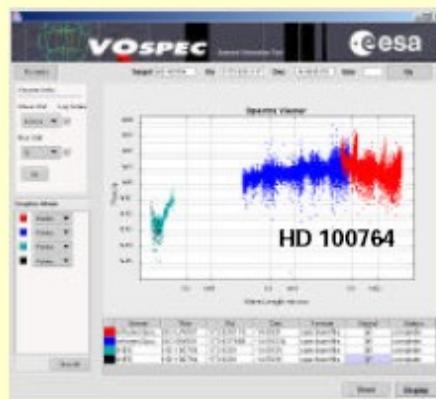
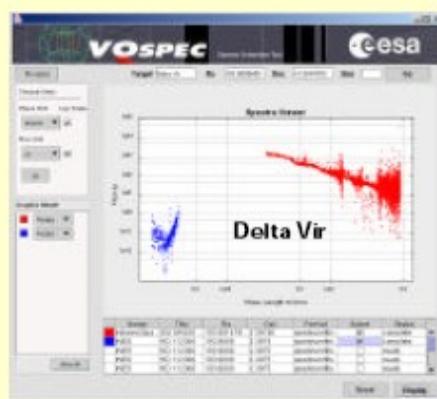
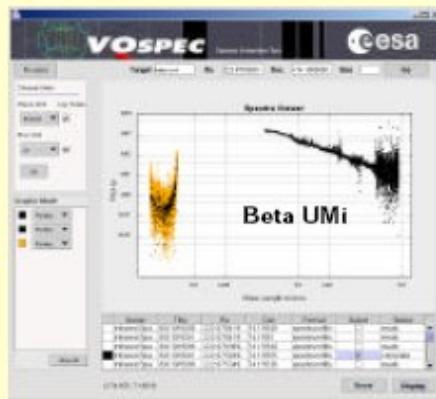
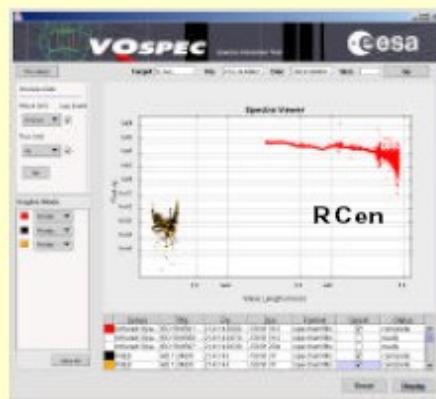
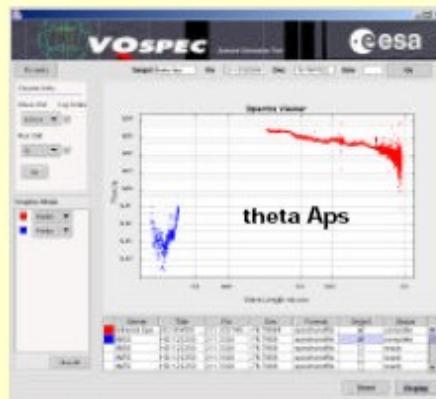
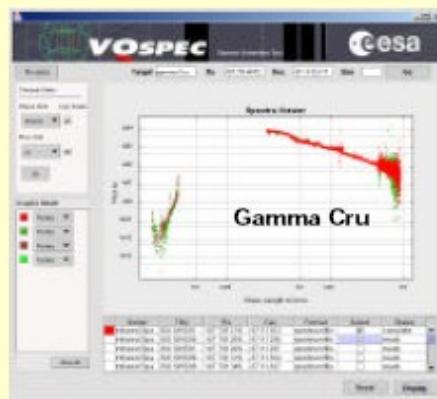
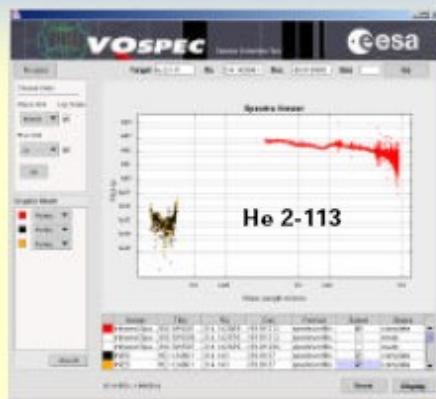
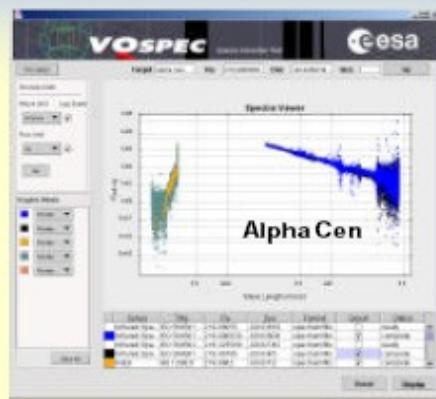
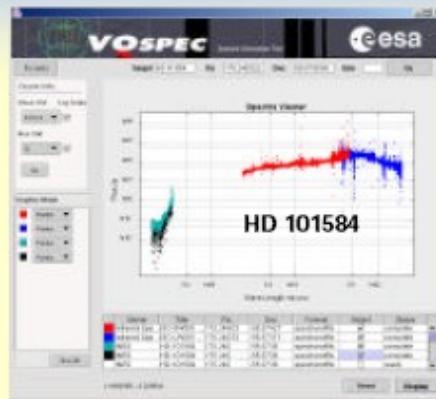
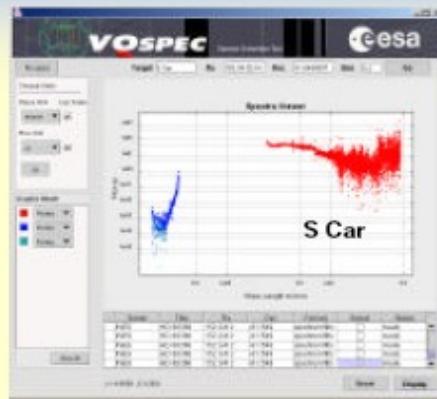
# Archives, Theory, VO-Science, DataMining, E&O

Simple Spectral Access Protocol V1.04

## Appendix A: Theoretical Spectral Access Use Case



# VOspec working example: Sampling AGBs



- Other VO Data Centres providing theoretical spectra using TSAP

**GERMAN ASTROPHYSICAL  
GAVO  
VIRTUAL OBSERVATORY**

## German Astrophysical Virtual Observatory

Archive: **TMAP Spectra** [More information on archive](#)

Effective temperature in K:  +/-

Surface gravity (log g) in cm/s<sup>2</sup>:  +/-

Mass fraction 0:	<input type="button" value="none"/>	<input type="text" value="0.0"/>	<input type="text" value="+/- 0.3"/>	<input type="text" value="dex"/>
Mass fraction 1:	<input type="button" value="none"/>	<input type="text" value="0.0"/>	<input type="text" value="+/- 0.3"/>	<input type="text" value="dex"/>
Mass fraction 2:	<input type="button" value="none"/>	<input type="text" value="0.0"/>	<input type="text" value="+/- 0.3"/>	<input type="text" value="dex"/>
Mass fraction 3:	<input type="button" value="none"/>	<input type="text" value="0.0"/>	<input type="text" value="+/- 0.3"/>	<input type="text" value="dex"/>
Mass fraction 4:	<input type="button" value="none"/>	<input type="text" value="0.0"/>	<input type="text" value="+/- 0.3"/>	<input type="text" value="dex"/>
Mass fraction 5:	<input type="button" value="none"/>	<input type="text" value="0.0"/>	<input type="text" value="+/- 0.3"/>	<input type="text" value="dex"/>
Mass fraction 6:	<input type="button" value="none"/>	<input type="text" value="0.0"/>	<input type="text" value="+/- 0.3"/>	<input type="text" value="dex"/>
Mass fraction 7:	<input type="button" value="none"/>	<input type="text" value="0.0"/>	<input type="text" value="+/- 0.3"/>	<input type="text" value="dex"/>

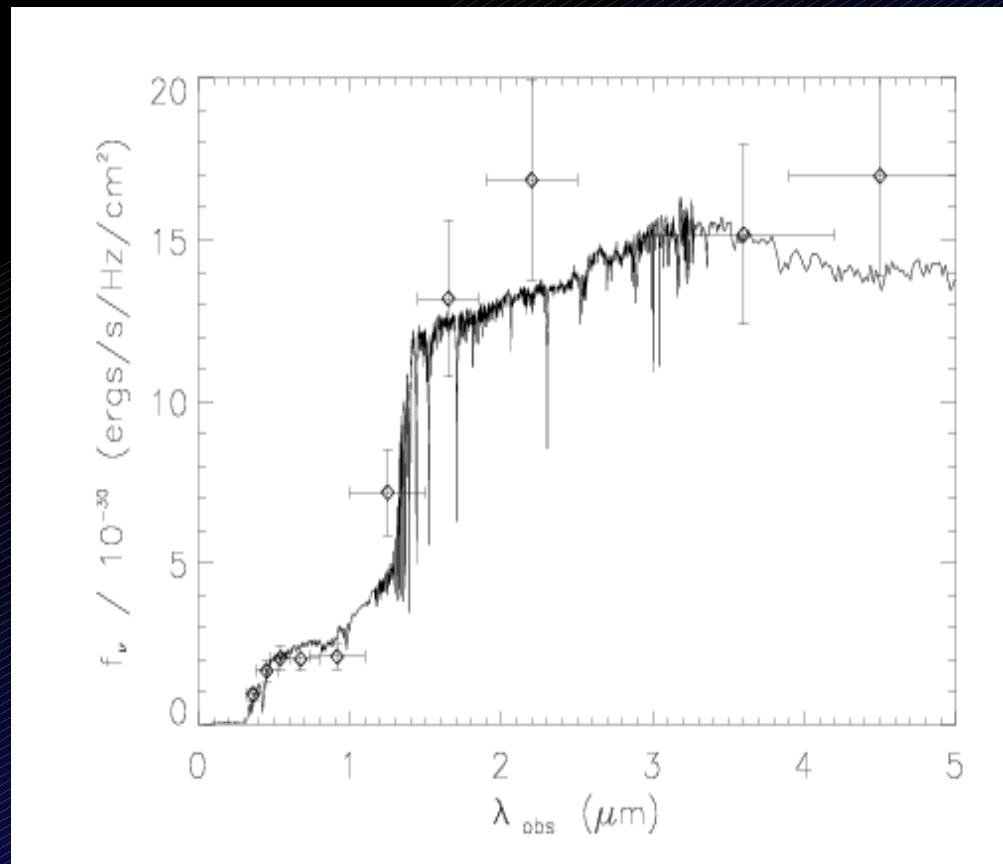
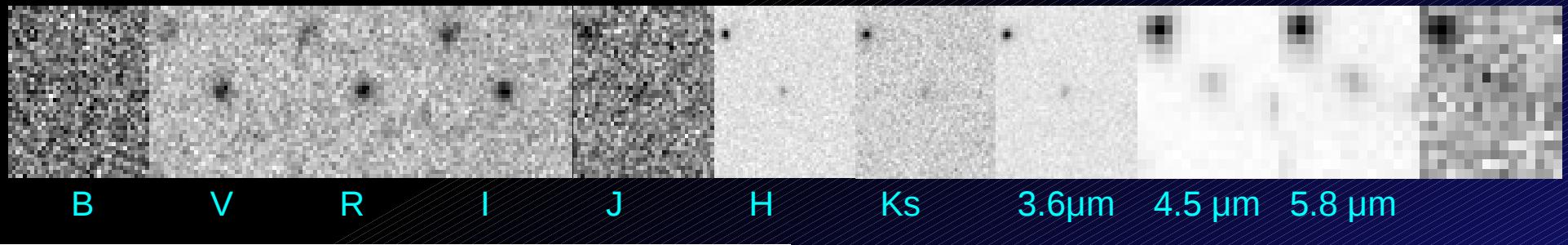
Band:   The wavelength range in format "wavelength<sub>1</sub>/wavelength<sub>2</sub>" in the selected unit.

Data format:  Format of the individual spectra. (No need to select, if return format is html.)

Return Format:  votable  html The format in which to present the metadata. (If html is selected, no further selection of data format is necessary, since links to all available formats will be created anyways.)

- PGos3 (Mexico), PEGASE (VO-Paris)

# SED from photometry



$z_{\text{phot}} = 2.52$   
Age = 500 Myr  
Stellar mass =  $9.9 \times 10^9 M_{\text{sun}}$   
Reduced chi-sq = 1.04  
SFR current =  $0.79 M_{\text{sun}} \text{ yr}^{-1}$

# BaSTI database



## Micro-simulations inside the VO: the BaSTI case



P. Manzato<sup>(1)</sup>, M. Molinaro<sup>(1)</sup>, F. Gasparo<sup>(1)</sup>, F. Pasian<sup>(1)</sup>, A. Pietrinferni<sup>(2)</sup>, S. Cassisi<sup>(2)</sup>, C. Rodrigo<sup>(3)</sup>, M. Cerviño<sup>(4)</sup>, E. Solano<sup>(3)</sup>  
INAF - SI / Trieste Astronomical Observatory; (2) INAF – Teramo Astronomical Observatory; (3) LAEFF-INTA / Spanish VO; (4) Instituto de Astrofísica de Andalucía – CSIC / Spanish VO

### S3P (Simple Self-described Service Protocol) implementations

In collaboration with SVO (the Spanish Virtual Observatory) we presented S3P in the last IVOA Interoperability Meeting. S3P (Simple, Self-described Service) is a protocol oriented to handle theoretical data in the VO framework. It is based in the ability of the data server to describe itself in a simple standardized way.

This is a step by step protocol:

1 step: the service described it self (input and output parameters);

<http://myservice.com/s3.php?format=metadata>

2 step: http query and response in VOTable format;

<http://myservice.com/s3.php?param1=value1&param2=value2...>

3 step: retrieve the simulated files of interest via http GET;

<http://myservice.com/s3.php?id=12>

We developed two prototype implementations of S3P for BaSTI: one for isochrones and one for tracks:

<http://albione.oa-teramo.inaf.it/PHPmetadata/BaSTIisochron.php?format=metadata>

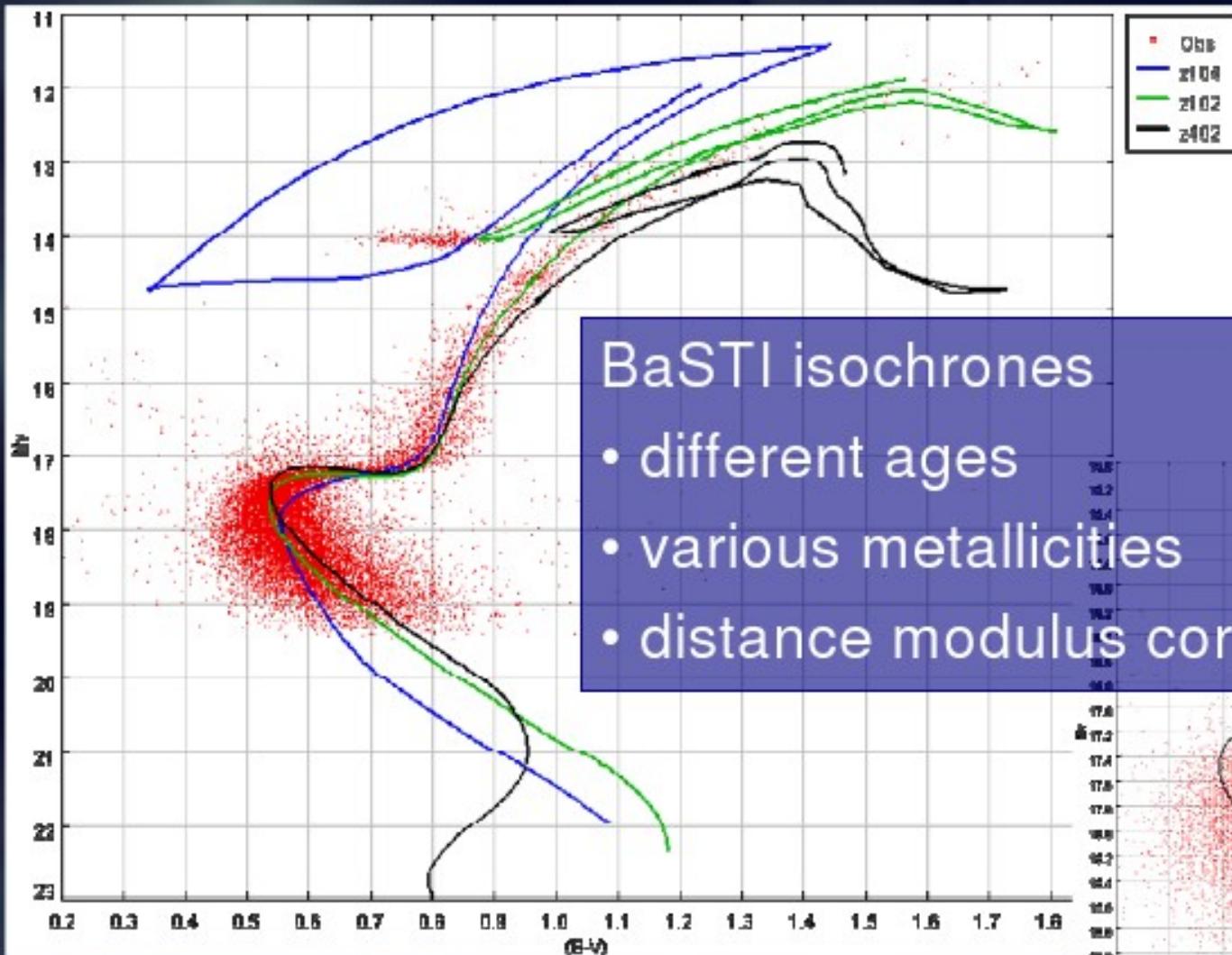
<http://albione.oa-teramo.inaf.it/PHPmetadata/BaSTItrack.php?format=metadata>

Param	UCD	Description
<i>INPUT:age_min</i>	<i>time.age</i>	Min. age of the isochron in Gyr (min value 0.03 Gyr)
<i>INPUT:age_max</i>	<i>time.age</i>	Max. age of the isochron in Gyr (max value 19 Gyr)
<i>INPUT:meta_min</i>	<i>phys.abund.Z</i>	Min. mass fraction of the initial heavy elements abundance for stellar isochron model (min value 0.0001)
<i>INPUT:meta_max</i>	<i>phys.abund.Z</i>	Max. mass fraction of the initial heavy elements abundance for stellar isochron model (max value 0.4)
<i>OUTPUT:age</i>	<i>time.age</i>	value for the stellar Age for the model. Age is given in Gyr
<i>OUTPUT:meta</i>	<i>phys.abund.Z</i>	value of mass fraction of the initial heavy elements abundance for the model.
<i>OUTPUT:[M/H]</i>	<i>phys.abund.Z</i>	The metal abundance in the spectroscopic formalism.
<i>OUTPUT:[Fe/H]</i>	<i>phys.abund.Fe</i>	The iron abundance in the spectroscopic formalism.
<i>OUTPUT:Y</i>	<i>phys.abund.T</i>	value of mass fraction of the initial helium abundance. Actually calculated as $Y = 1.44 * (Z - 0.0001)$ .
<i>OUTPUT:MassLoss</i>	<i>phys.mass.loss</i>	value of mass loss according to the Reimers (1975) law.
<i>OUTPUT:title</i>	<i>VOX.Image_Title</i>	Title.

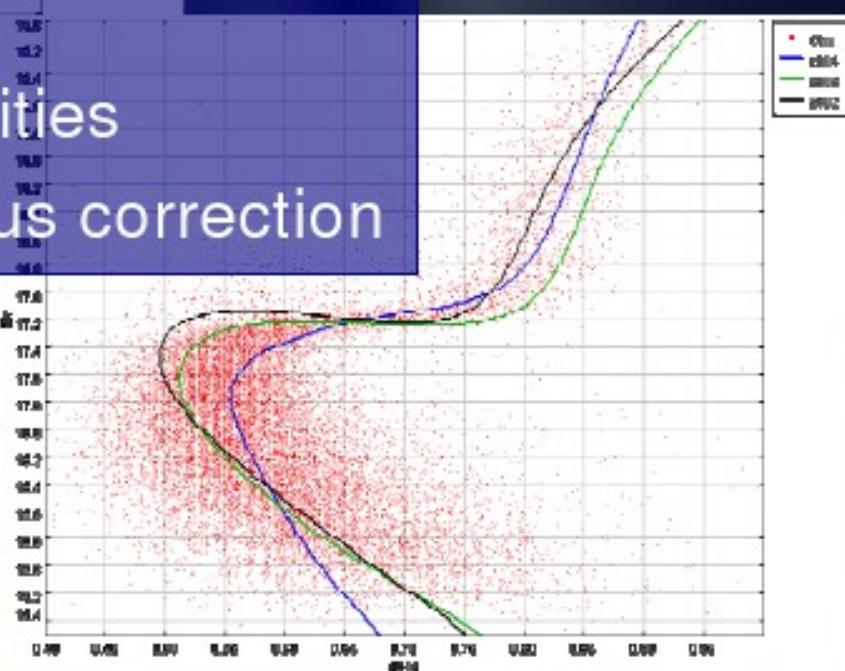


# BaSTI Isochrones

step 1  
metallicity



$z = 0.01$  ( $\alpha$ -enh) ; 0.008 (scaled solar)



# Archives, Theory, VO-Science, DataMining, E&O

Theoretical model services

**VOSA: VO Sed Analyzer**  
VO SED Analyzer

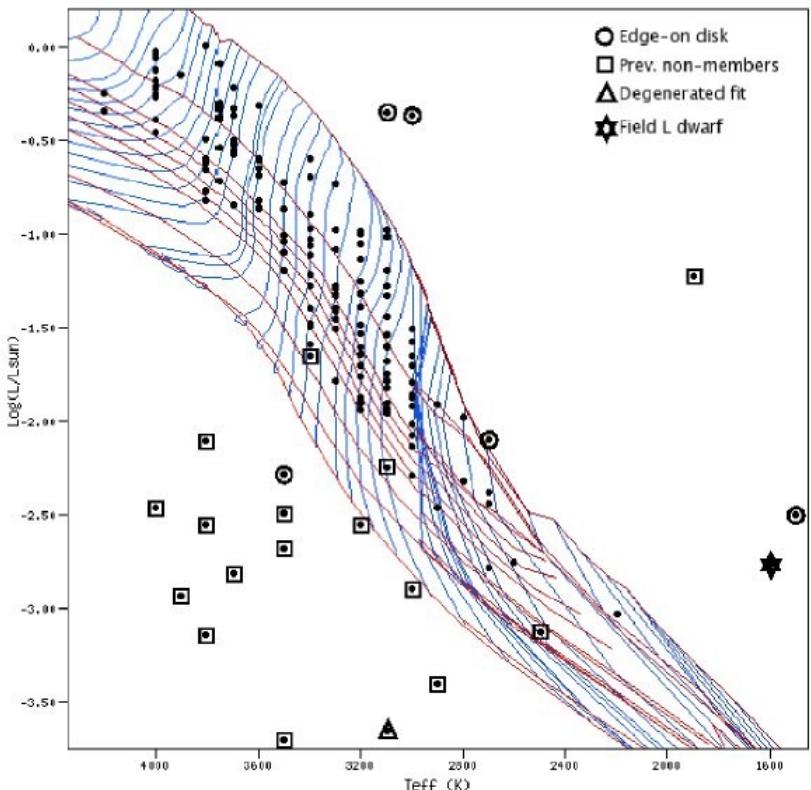
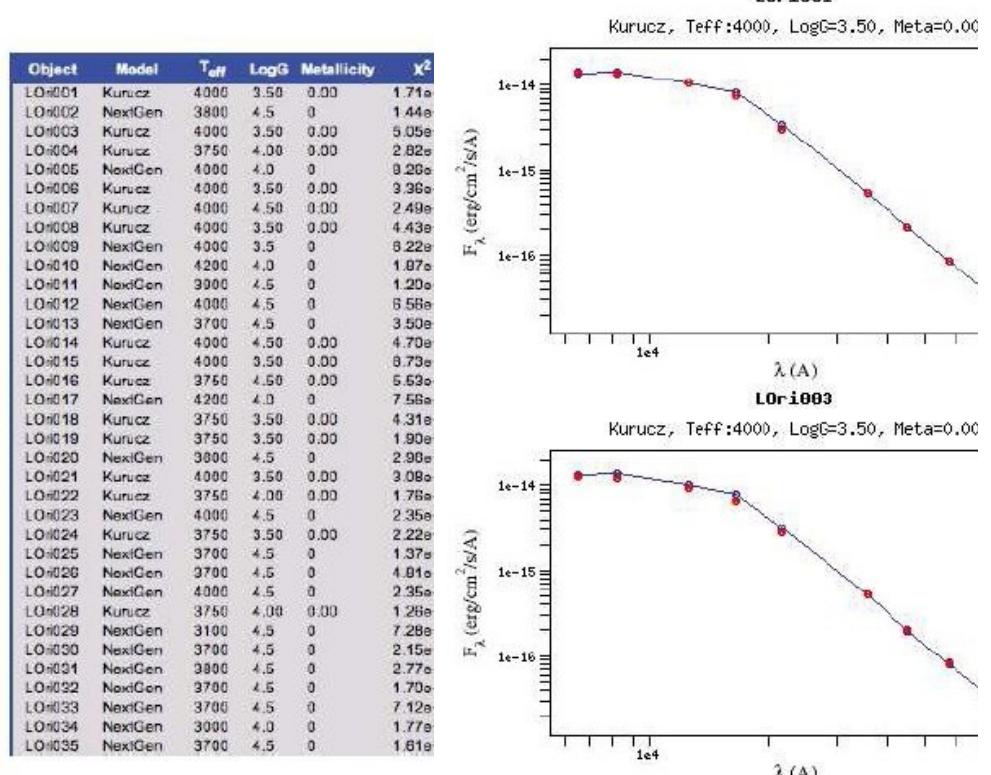
Services: VOSA Filters TSAP S3if

Astronomy & Astrophysics manuscript no. Synth'VO'PRI'ref format  
August 2, 2008

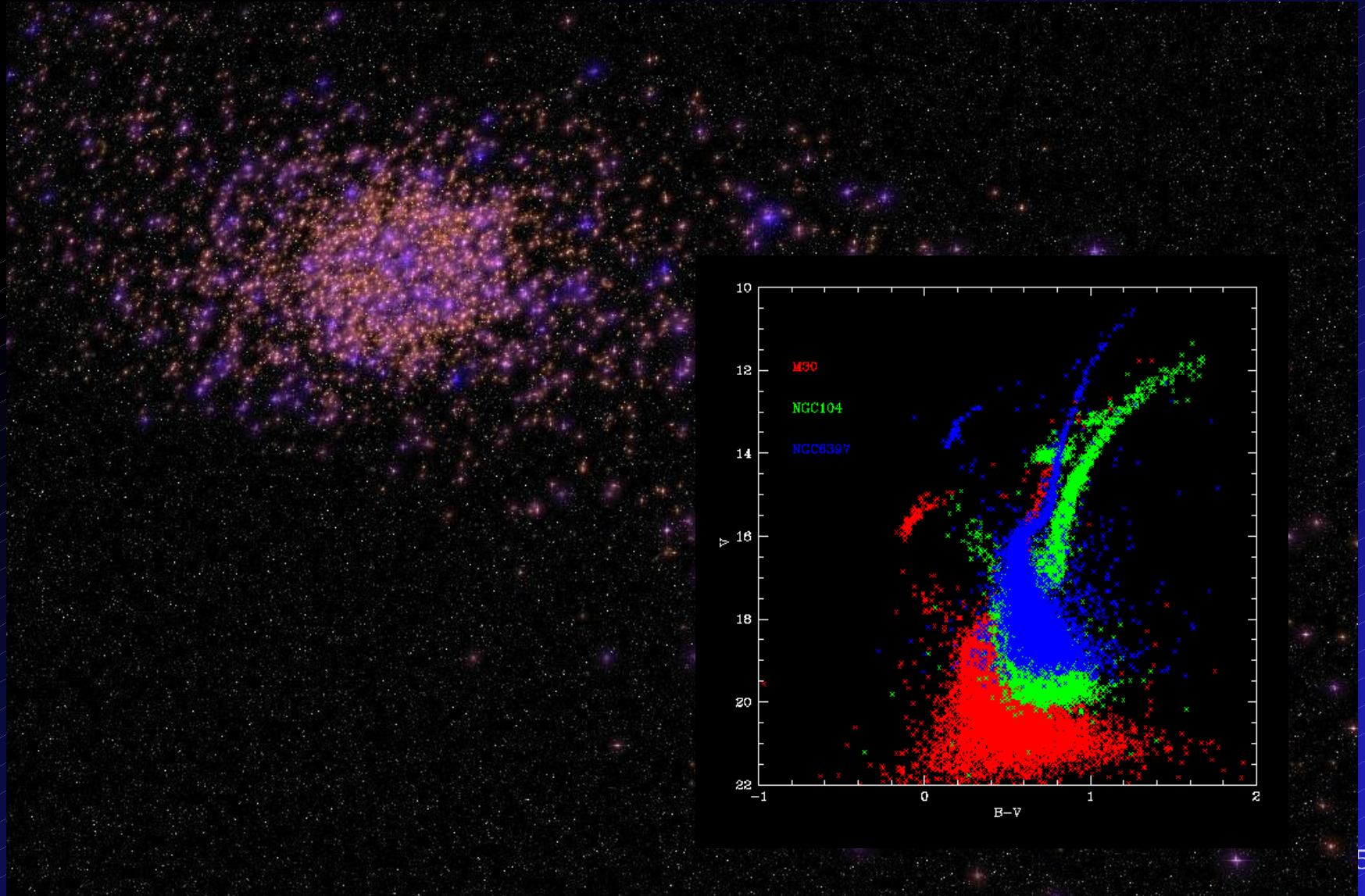
## VOSA: Virtual Observatory SED Analyzer.

### An application to the Collinder 69 open cluster

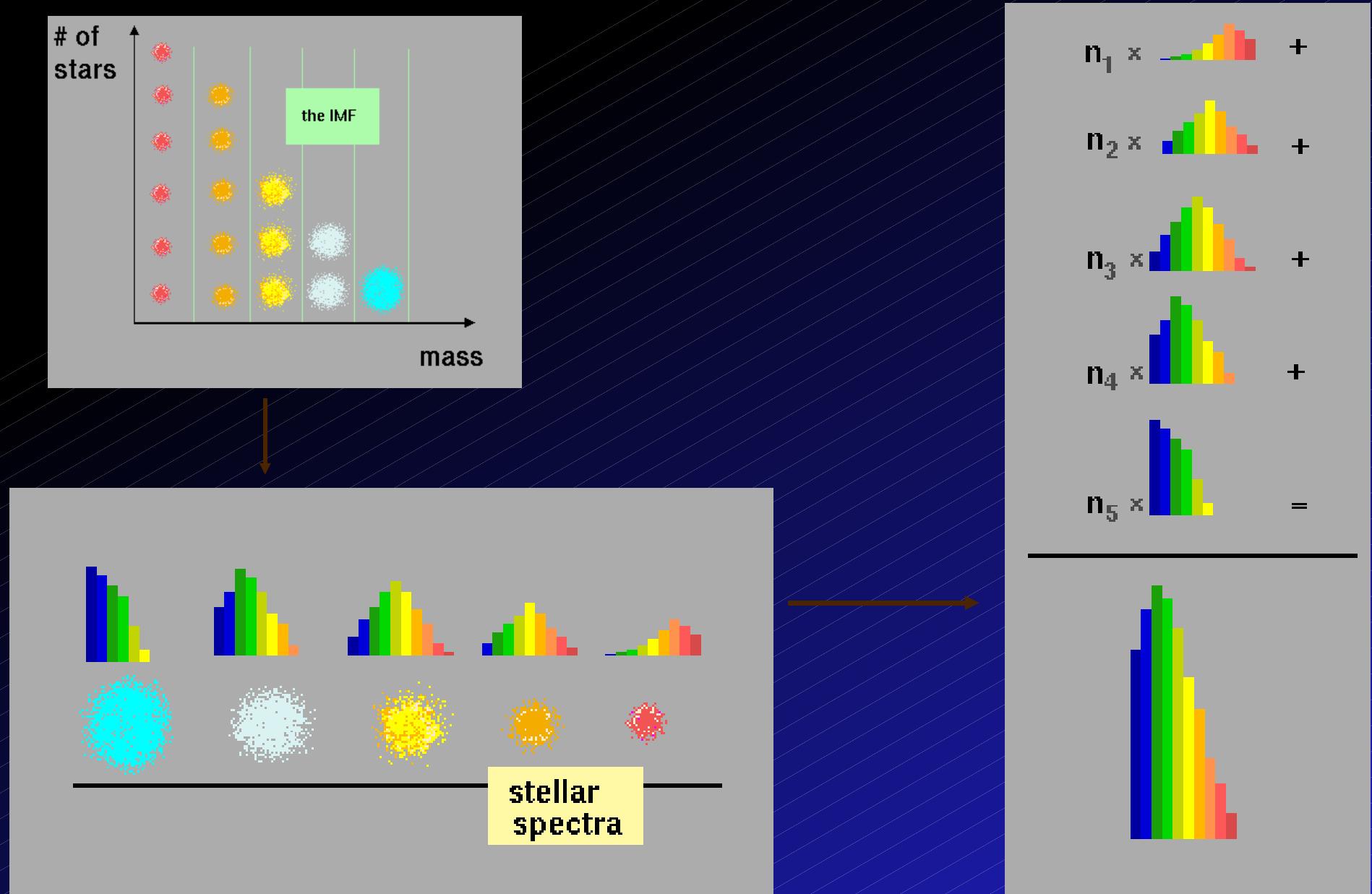
A. Bayo<sup>1,2</sup>, C. Rodrigo<sup>1,2</sup>, D. Barrado y Navascués<sup>1,2</sup>, E. Solano<sup>1,2</sup>, R. Gutiérrez<sup>1,2</sup>, M.



# N Body Simulations of Globular Cluster Evolution



# Stellar populations are modeled with synthesis models



(Available as *Theoretical Simple Access Protocol* server :<http://ov.inaoep.mx>)

# Using SimDB/SimDAP

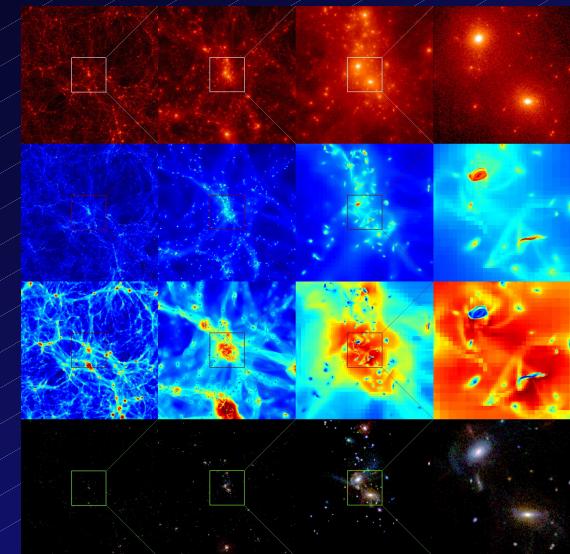
- Cosmological simulations
  - Prototypes for GalMER, Horizon
- PDR simulations
  - test implementation of Meudon PDR code
- Isochrones/evolutionary tracks
  - BaTSI
- Visualization tools
  - VisIVO

GalMer

DB Query Query Results Experiment Snapshot Description

Select Input Parameters

Galaxy #1	Galaxy #2	Query
gE0 ▲ gSa gSb gSd ▾	gE0 ▲ gSa gSb gSd ▾	Orbit type 1 ▾ Spin Prograde ▾ Inclination 0 deg ▾



Virgo - Millennium Database

Documentation CREDITS/Acknowledgments Registration News Databases millenium (context) VIRGO GAVO

Check out the latest news about the release of the Millennium-II database.

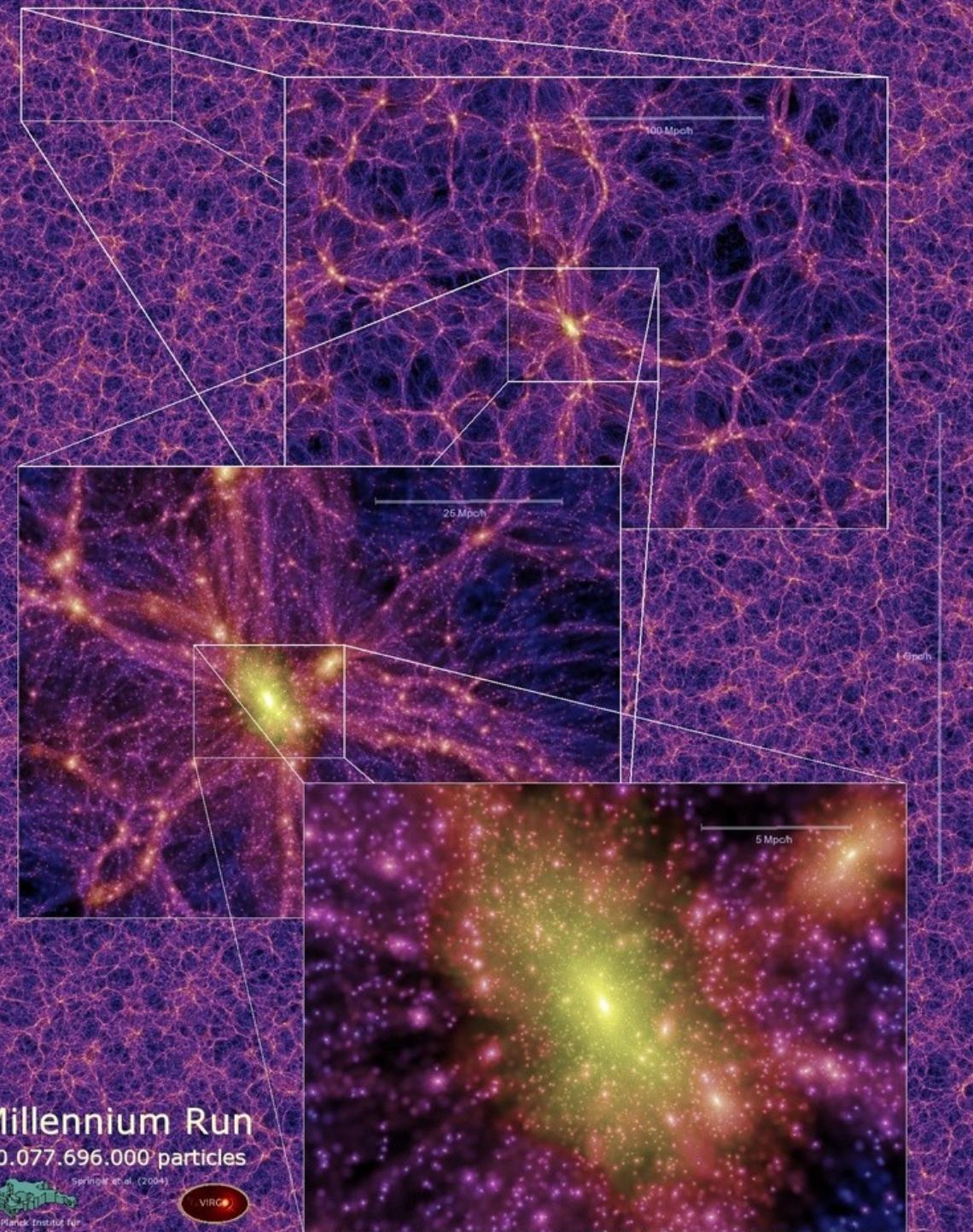
Streaming queries return unlimited number of rows in CSV format and are cancelled after 30 seconds. Browser queries return maximum of 1000 rows in HTML format and are cancelled after 30 seconds.

Query (stream)  
Query (browser)  
Help

Maximum number of rows to return to the query form: 10 ▾

GADGET-2: Galaxies with dark matter and gas interact

A code for cosmological simulations of structure formation



# Millenium Run

$10^{10}$  particles

Several Gpc to

10 kpc

Cube 2 billion ly

One month MPSSC

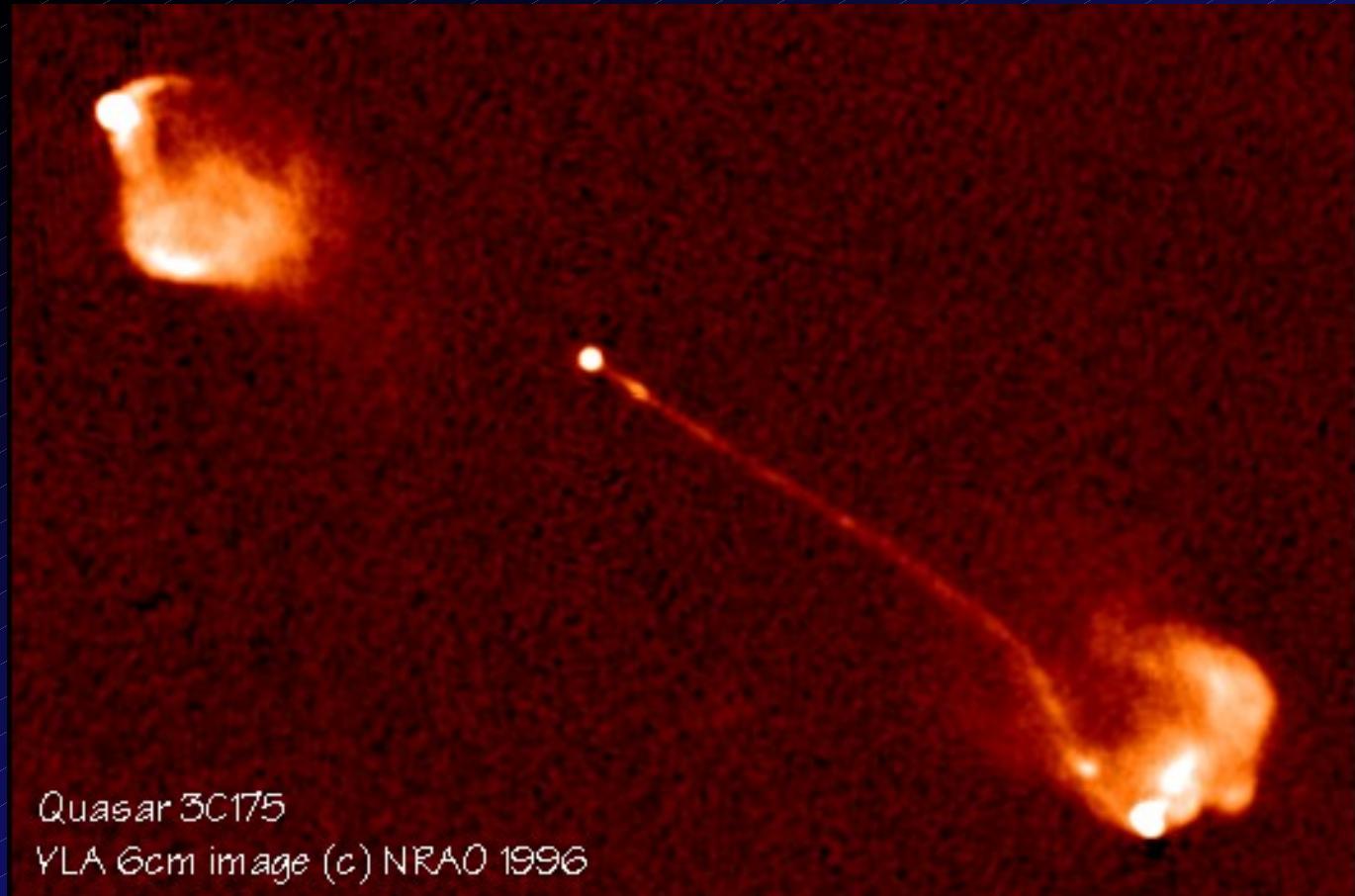
25 TB

Evolution of 20 mil  
galaxies

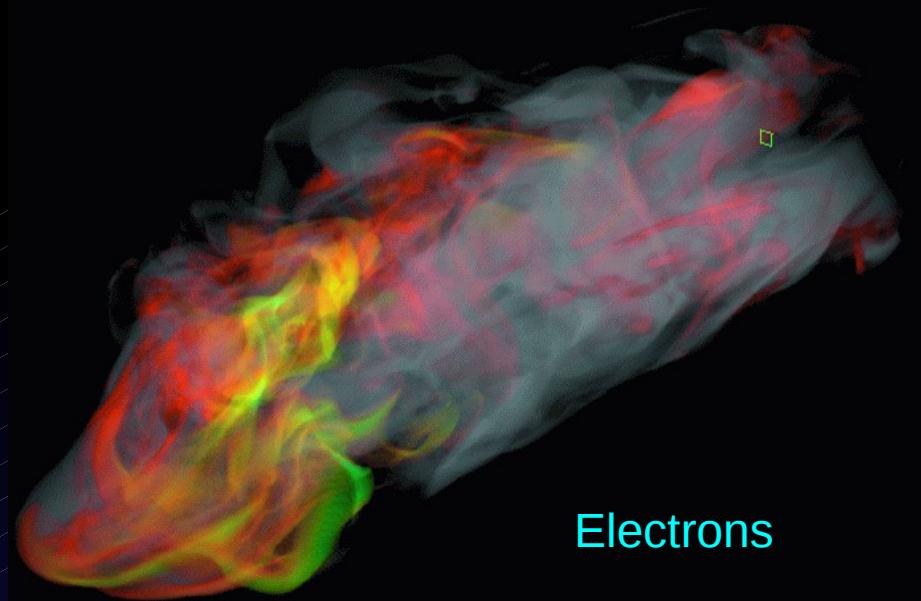
Evolution merger tree

# Collimated Outflows from AGN

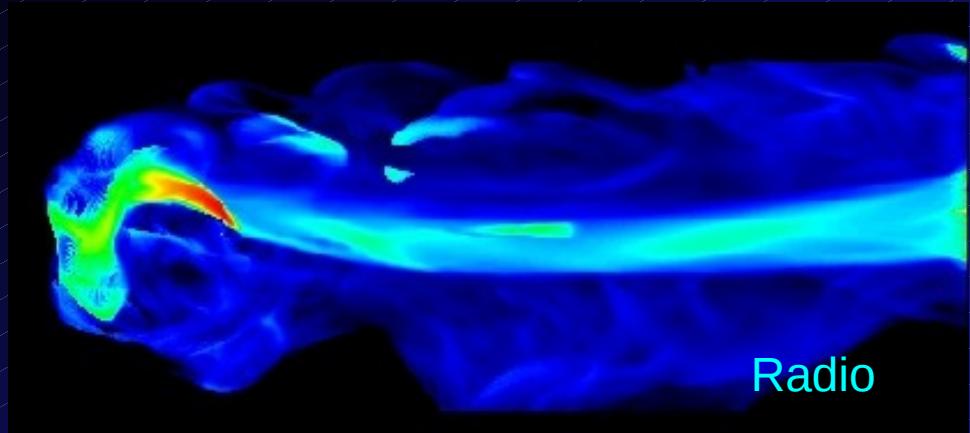
- 3C 175



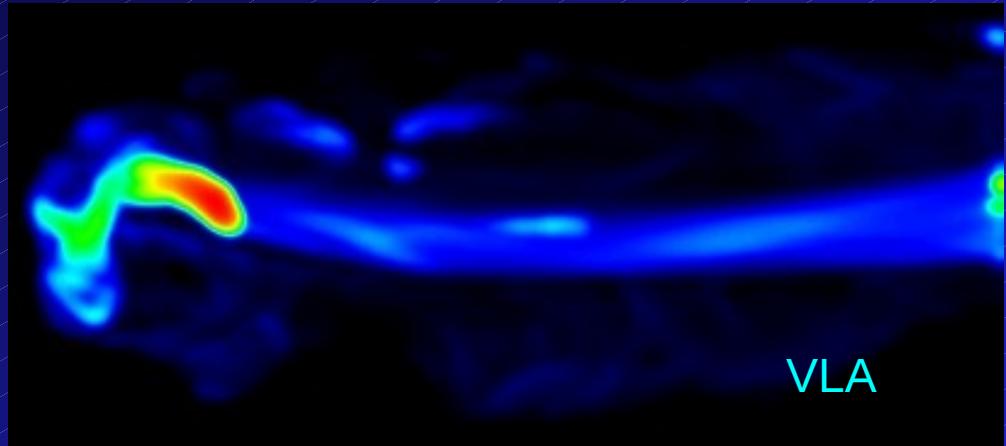
# MHD Simulations of Collimated Outflows from AGN - Virtual Telescope Observations



Electrons



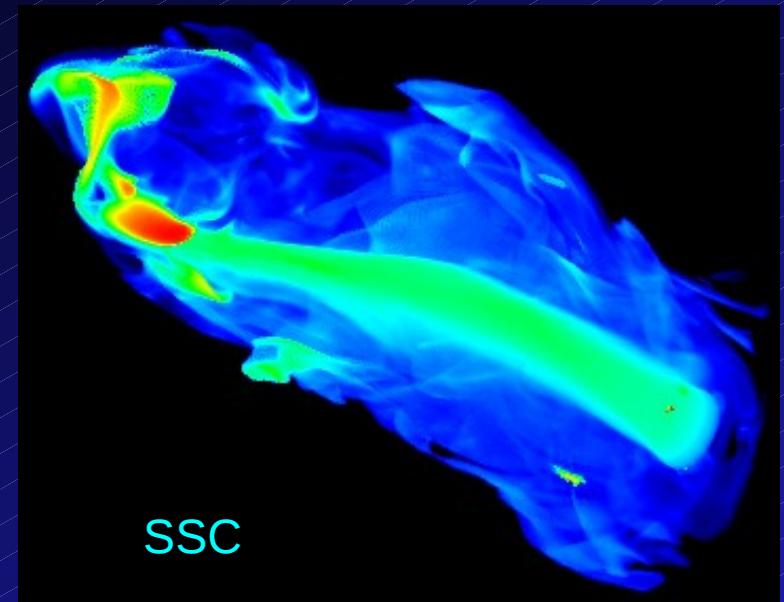
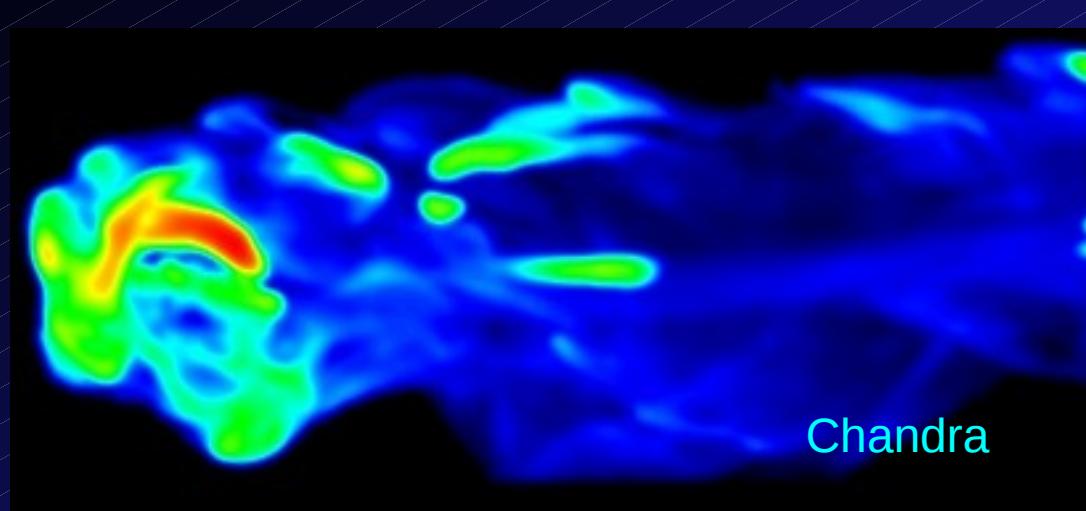
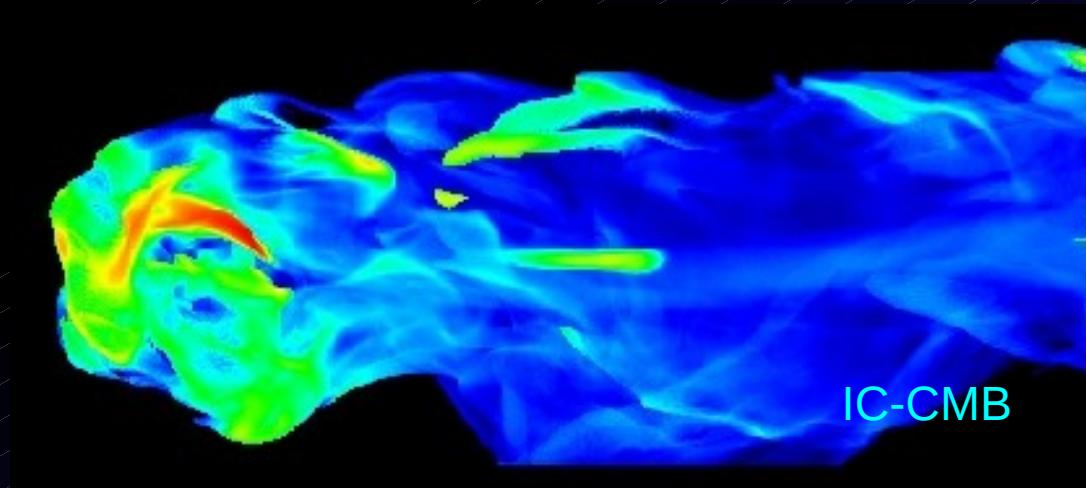
Radio



VLA

Compare with  
Radio  
Archives

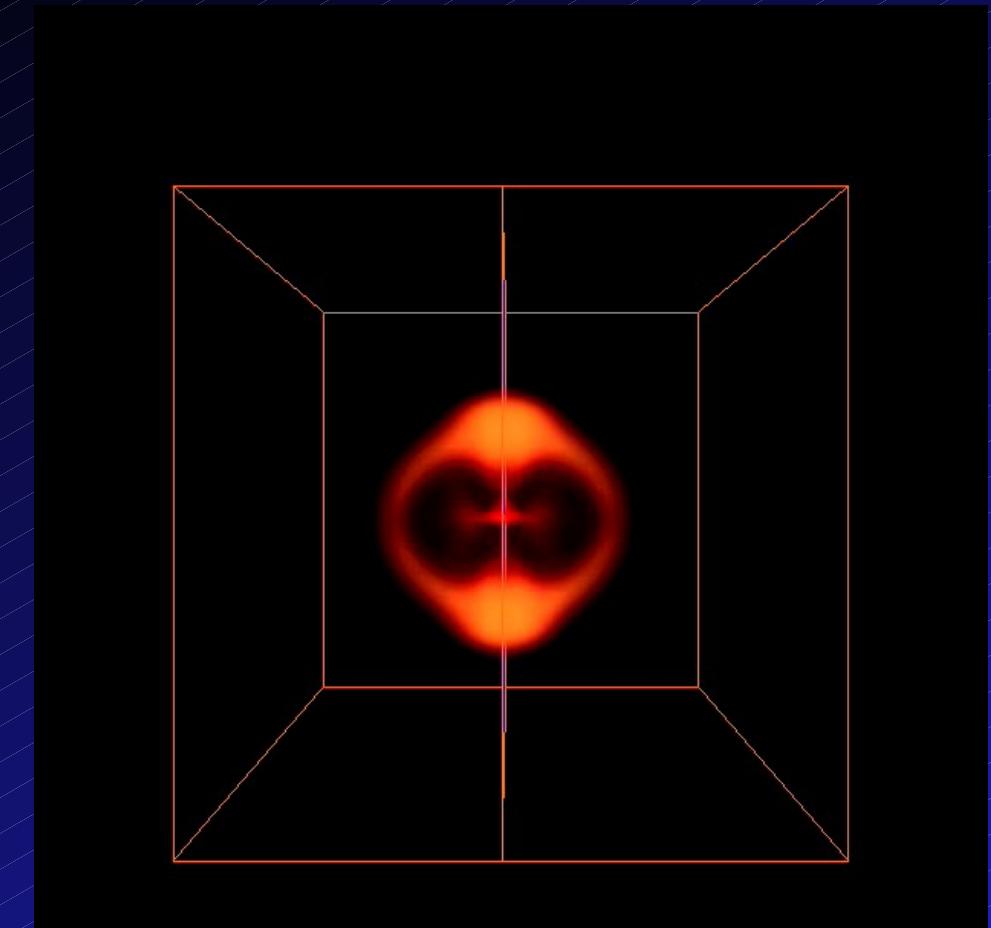
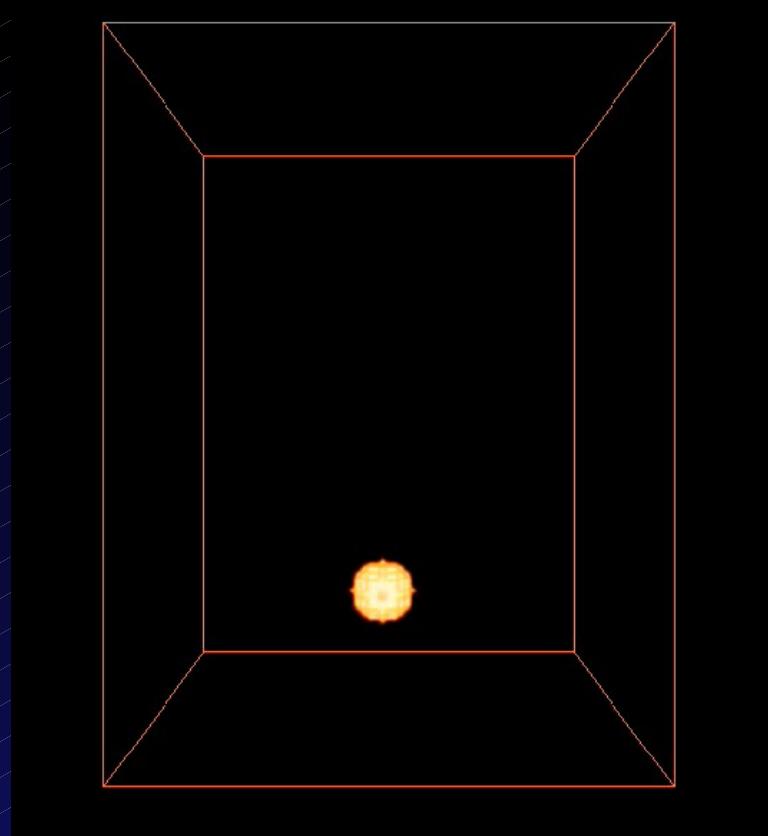
# MHD Simulations of Collimated Outflows from AGN - Virtual Telescope Observations



Compare with  
Chandra Archives

# Three Dimensional MHD Calculations

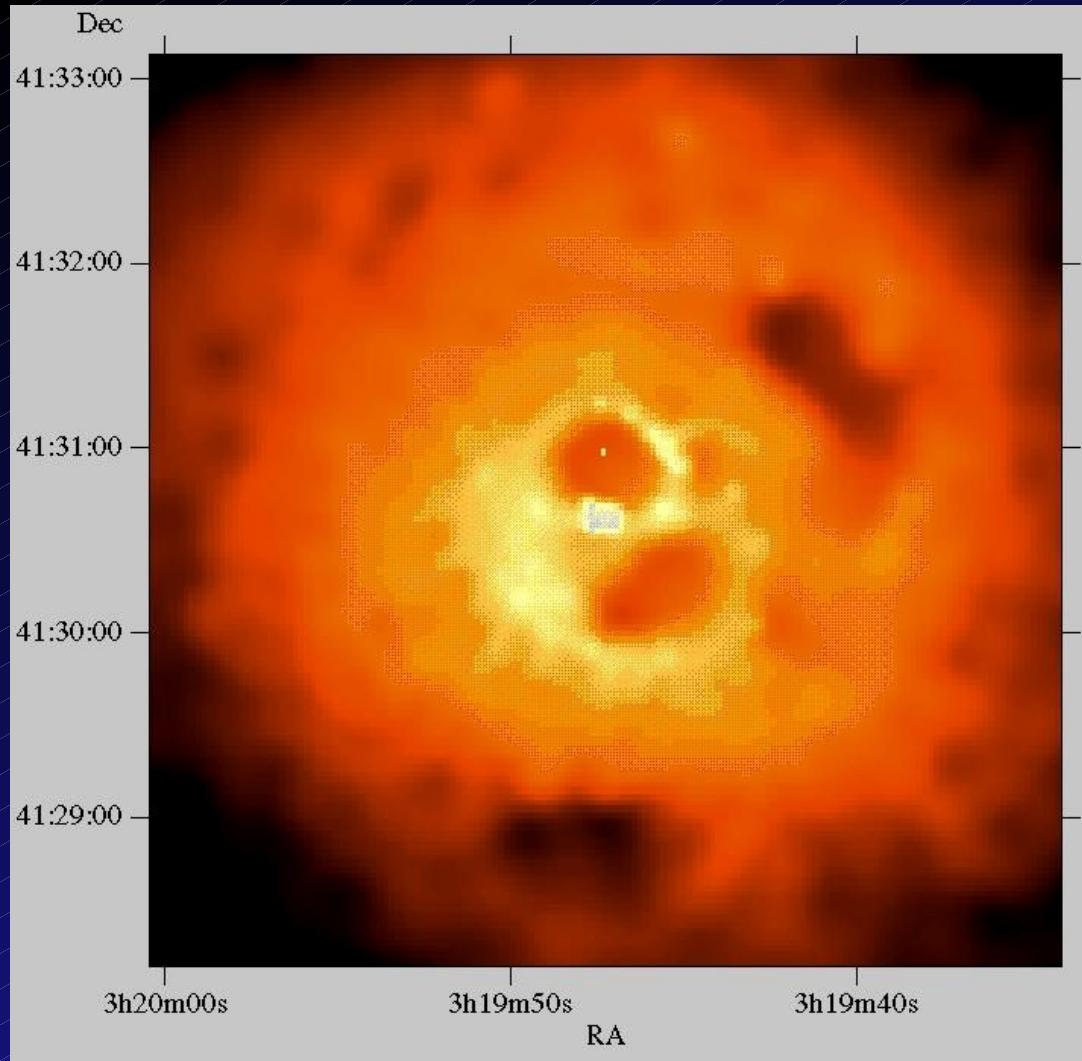
- $\beta = 3000$



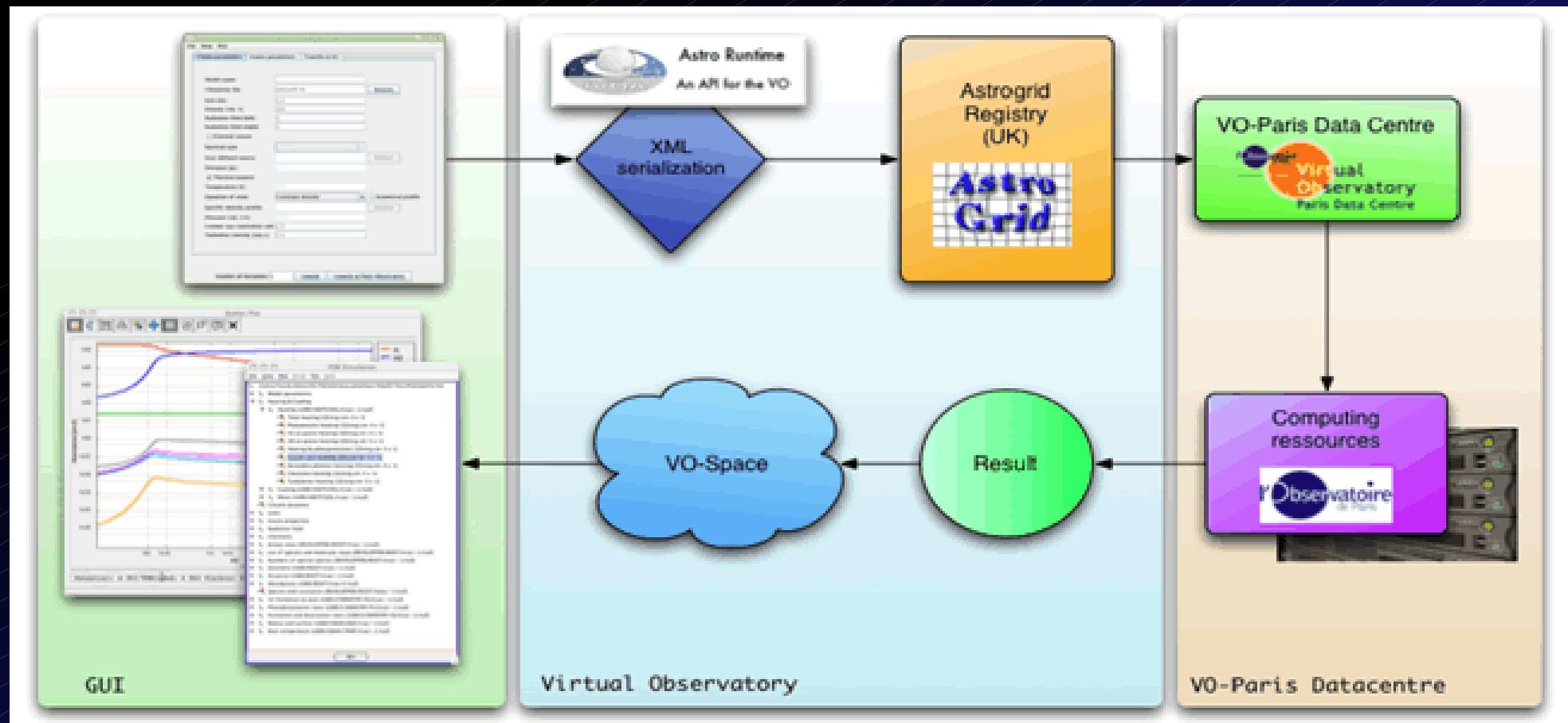
# Relic Radio Bubbles in Galaxy Clusters

- N1275

Compare  
with  
Chandra  
Archives



# PDR VO-infrasctructure



# PDR database and clients

## PDR Database

### Output Files

Code produces

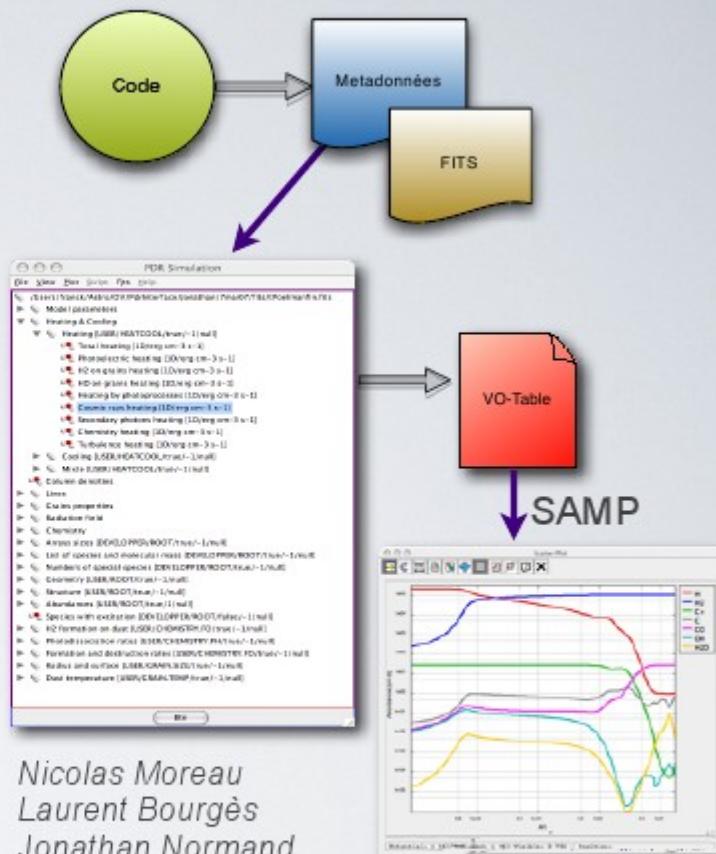
- raw data : FITS File
- XML / VO-TABLE : meta-data  
(name, description, units, UCD, ...)

Provide all quantities computed by the code

- observables
- theoretical quantities

### PDR Analyser

- browse the computed quantities
- extraction (ASCII, VO-Table)
- SAMP
- Download data from VO-Space
- Scriptable



# PDR code via VODesktop

VO Explorer – PDR

Contents of PDR – 3 resources

Content – Subject: unknown, ???, chemistry, interstellar gas, interstellar matter, interstellar medium, interstellar molecules, models

Coverage – Waveband: unknown, infrared, millimeter, optical, radio, uv

Resource Type: CeaApplication, DataService, Organisation

Filter results:

Status	Flag...	Title	Capability	Date
●		Meudon PDR code	Meudon PDR code	2007-12-14
●		Meudon PDR code VO-Paris		2007-04-11
				2007-04-11

New Smart List

Actions: Execute Task

About: Selection: CeaApplication, Further Info, Email Curator

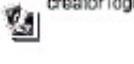
Information | Table Metadata

**Meudon PDR code**

Short Name: Meudon PDR code, ID: ivu/obspm.fr/pdr  
Type: CeaApplication, Created: 1999-01-01T00:00:00, Updated: 2007-12-14T00:00:00

Content Type: other, Subject: ???  
The Meudon PDR code is a tool to model the physics and the chemistry of interstellar gas at stationnary state. It considers a stationnary plan-parallel slab of gas and dust illuminated by a UV radiation field and solves radiative transfer, thermal balance and chemistry. It is then possible to deduce column densities and emissivities to compare to observations. The exact physics in the code is described on our website. [Further Information...](#)

This resource describes a Remote Application (CEA)  
Interfaces: simple

Version 1.0, Dates: representative: 2006-01-12  
Creator: [VO-Paris](#), creator logo: 

Annotate: Flag, Highlight, Alternative title, Notes, Tags, Monitoring service, No known providing services

-Paris Datacentre

Franck Le Petit  
LUTH - Paris Observatory

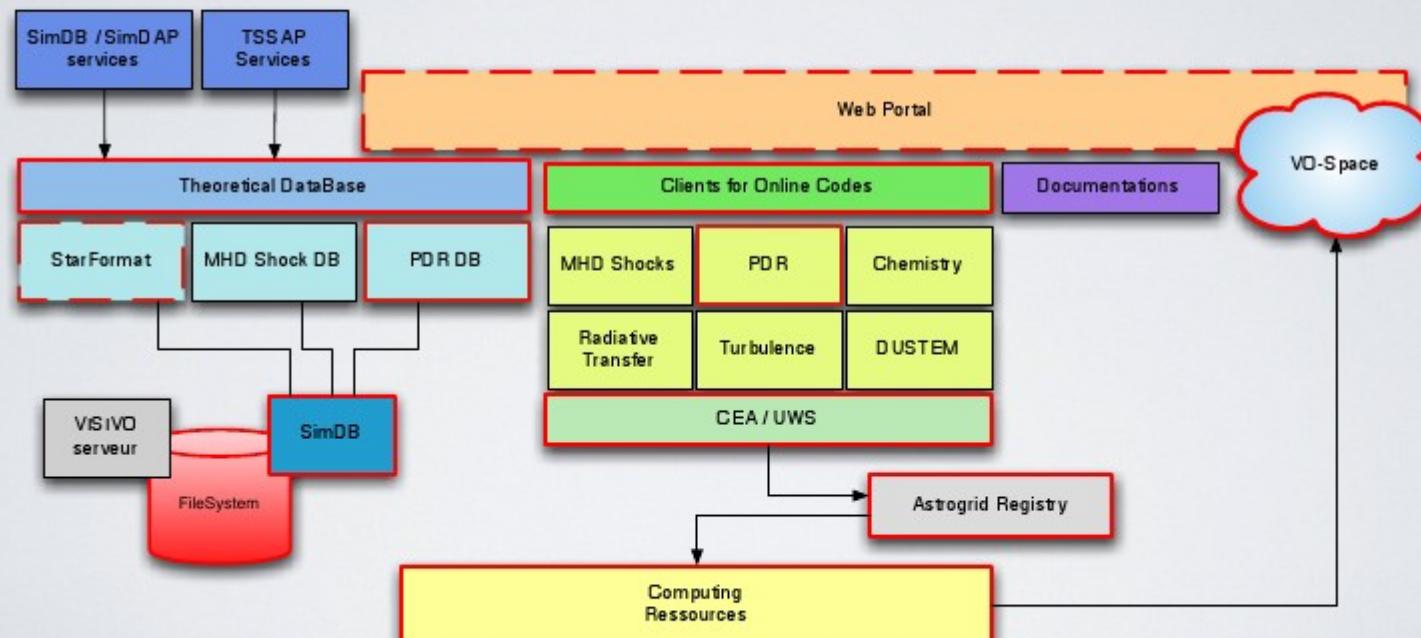
# ISM platform

## □ Interstellar Medium Platform

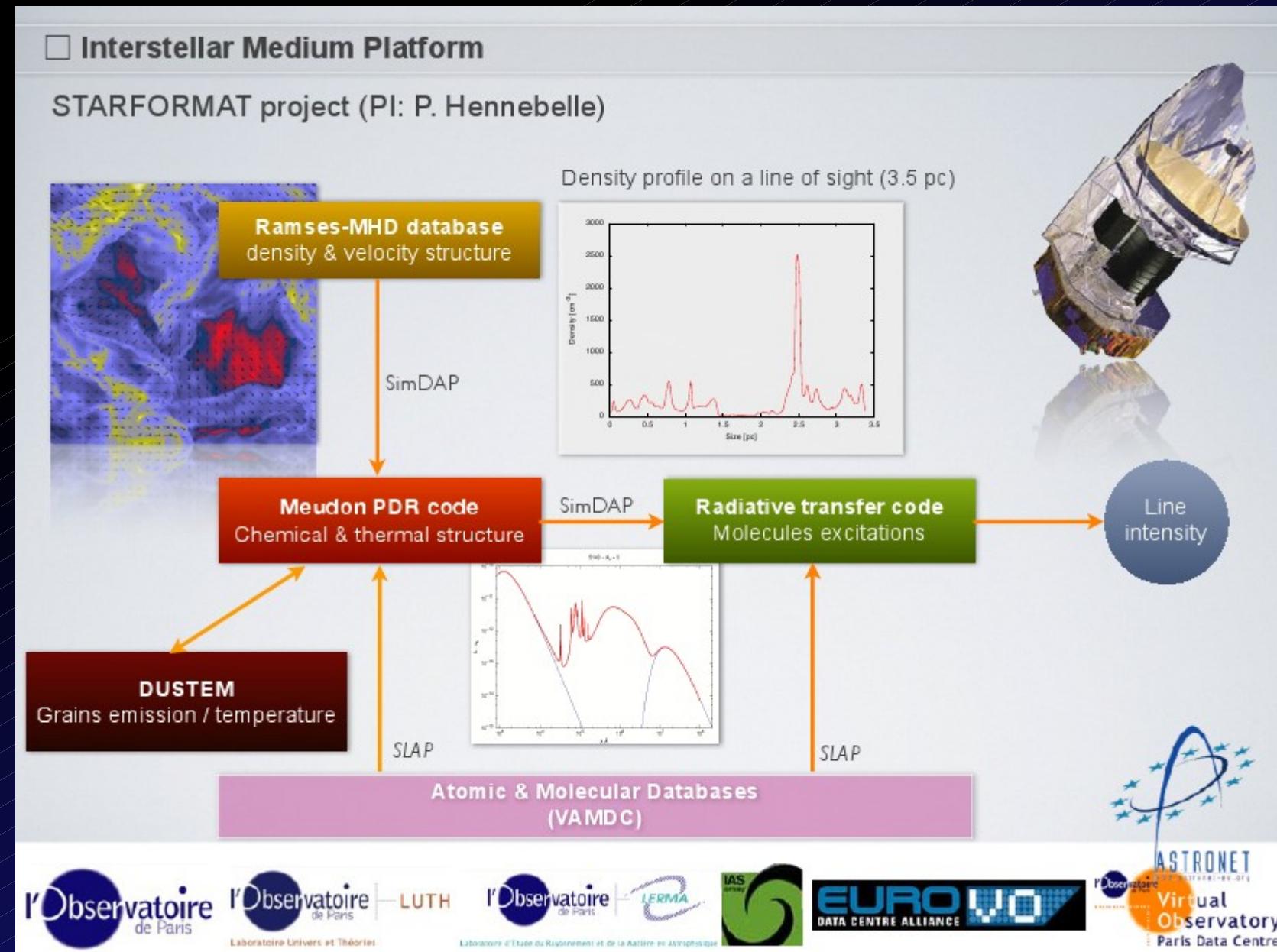
Bring together expertise in modeling / simulation of the ISM

Provide theoretical services about ISM

### Codes - Databases - Tools & services



# Complex join of TVO bricks



# VO Science

- 31 (9) new obscured type 2 QSO (Padovani 2004)
- Brown dwarfs (about 20 candidates)
- Brightest (WD?) Albus-1 (Cabalero et al. 2008)
- Widest CPM binaries
- AGB to PNe - 100 new (200) with VO
- SED (Spectrum Energy Distribution)
- Bolometric magnitude
- VOEvent – robotic telescopes (GRB, transits,)
- Outreach , Education (MS WWT, GoogleSky)

# BDs discovered using VO



**PROJECT**

Standards  
Software & Services  
Publications  
Prototypes

Internal Logos

**ABOUT NVO**

What is the NVO?  
Science Objectives

**COMMUNITY**

Discussion Lists  
International VO  
VOForum  
Metadata (NCSA)  
Other Links

**PEOPLE**

Contact Us  
Personnel

**Brown Dwarf Search Science Prototype: Real-Time Cross Matching of Large Catalogs**

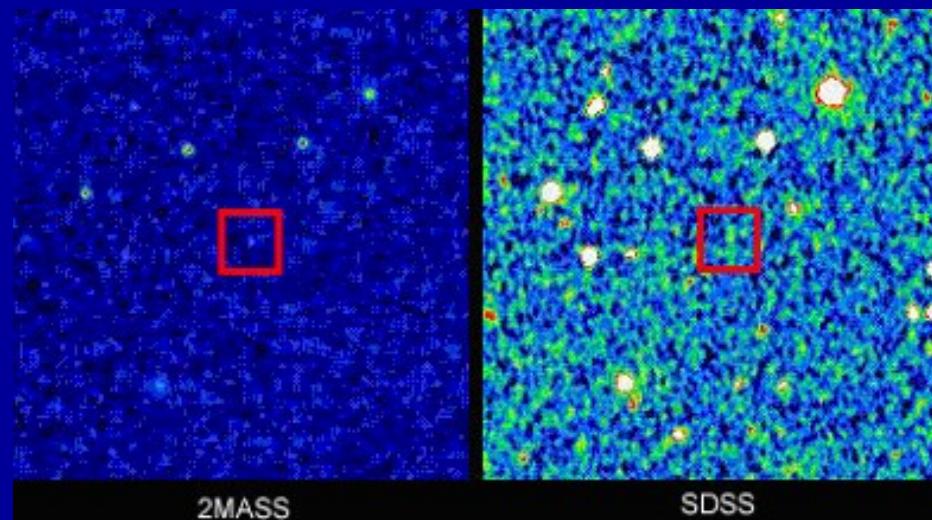
**Scientific Motivation** The search for brown dwarfs has been revolutionized by the latest deep sky surveys. A key attribute to discovering brown dwarfs is the federation of many surveys over different wavelengths. Such matching of catalogs is currently laborious and time consuming. This matching problem is generic to many areas of astrophysics.

**Data Resources**

- Sloan Digital Sky Survey (SDSS) Early Data Release (15 million objects)
- 2-Micron All Sky Survey (2MASS) 2nd Incremental Point Source Catalog (162 million objects)

**What the VO Brings Today**, doing the matching of these two large datasets is user-intensive and is replicated by many different users. Also, the correlation of these two datasets can take years of CPU time if not done correctly. The NVO brings two key aspects to

- **Filtering criteria:** z & J-only detections with  $z-J > 2.75$
- *SDSS: 15M obj.*
- *2MASS: 160M obj.*
- *300000 objects in common.*



✓ *However, systematic searches using a VO methodology have not been performed so far.*

# **Democratization of Science**

- **Digital Divide**  
technological barrier, data access free, access to journals
- **International Council for Science CODATA**  
Committee on Data for Science and Technology – UNO ICS
- **CASPAR**  
Cultural, Artistic and Scientific knowledge for Preservation, Access and Retrieval  
Digital curation centers
- **ADS and VO**  
links to ivo://, metadata, ontologies – semantic web
- **Archive importance:**  
5x IUE , 3x HST results from archives than PI articles
- **Effectiveness**  
50% of published data appears in Journals, links to data automatic ?

# Objections to VO

Data quality – garbage in - garbage out

How and whom to give credit ? (button)

embedded ivo:// data in ApJ

VO for dissemination only

- technology for OPTICON, nextgen
- Virtual science – VO technology

VO only for public data ! Proprietary ?  
(data jealousy)

- local archive - available data marked

# The Astronomer's Data Manifesto

at 26 IAU GA Prague SPS3

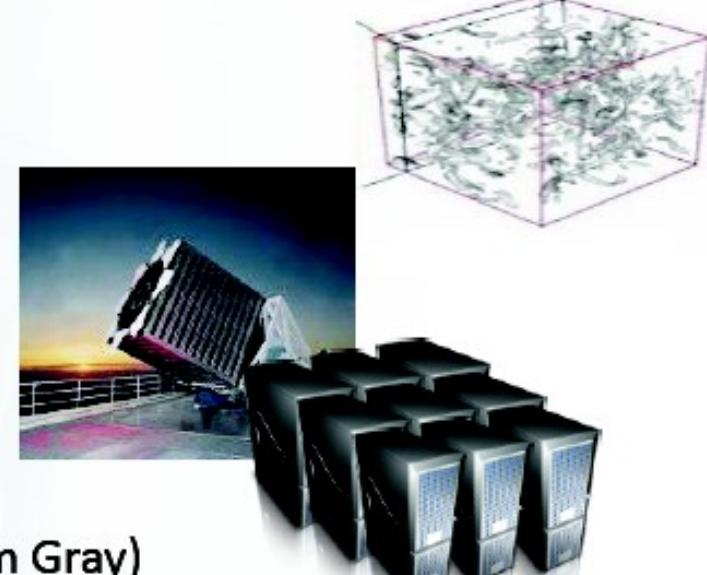
- (a) All significant tables, images, and spectra published in journals should appear in astronomical data centres.
- (b) All data obtained with publicly-funded observatories should, after appropriate pro-prietary periods, be placed in the public domain.
- (c) In any new major astronomical construction project, the data processing, storage, migration, and management requirements should be built in at an early stage of the project plan, and costed along with other parts of the project.
- (d) Astronomers in all countries should have the same access to astronomical data and information.
- (e) Legacy astronomical data can be valuable, and high-priority legacy data should be preserved and stored in digital form in the data centres.
- (f) The IAU should work with other international organisations to achieve our common goals and learn from our colleagues in other fields. ”

# Emergence of a Fourth Research Paradigm

1. Thousand years ago – **Experimental Science**
    - Description of natural phenomena
  2. Last few hundred years – **Theoretical Science**
    - Newton's Laws, Maxwell's Equations...
  3. Last few decades – **Computational Science**
    - Simulation of complex phenomena
  4. Today – **Data-Intensive Science**
    - Scientists overwhelmed with data sets from many different sources
      - Data captured by instruments
      - Data generated by simulations
      - Data generated by sensor networks
- eScience is the set of tools and technologies to support data federation and collaboration
- For analysis and data mining
  - For data visualization and exploration
  - For scholarly communication and dissemination



$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{4\pi G\rho}{3} - K \frac{c^2}{a^2}$$



(With thanks to Jim Gray)

# X-informatics



*The*  
**F O U R T H  
P A R A D I G M**

DATA-INTENSIVE SCIENTIFIC DISCOVERY

EDITED BY TONY HEY, STEWART TANSLEY, AND KRISTIN TOLLE

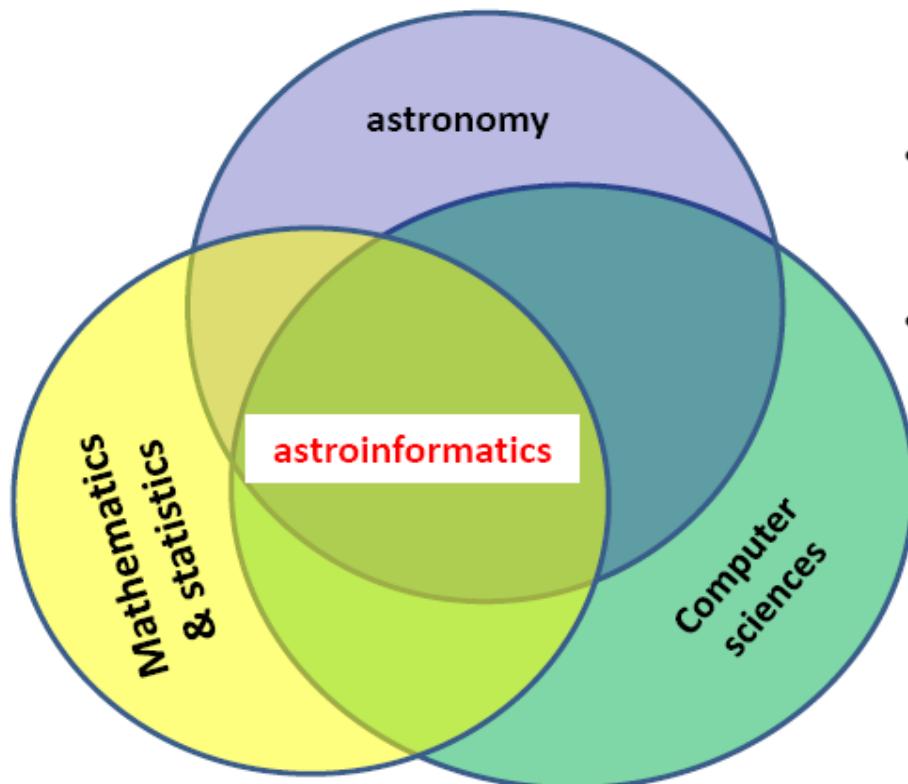
*Downloadable at Microsoft Research site*

Changing methodology of  
the Science

Synergy between different  
worlds

Sociological aspects  
(net-based research  
communities)

# Experimental astronomy has become a three players game



- **astronomy:** problems, data, understanding of the data structure and biases
- **mathematics:** evaluation of the data, falsification/validation of theories/models, etc
- **computer science:** implementation of infrastructures, databases, middleware, scalable tools, etc

- Astroinformatics: AAS n. 215, Washington, December 2009, chairperson: K. Borne
- Astroinformatics 2010: Caltech (USA) June 16-19 2010;co-chairpersons: S.G. Djorgovski, G. Longo
- Astroinformatics 2011: UNINA – Sorrento, co-chairpersons: S.G. Djorgovski, G. Longo

# Astroinformatics

- Analogy – Bioinformatics (Genome analysis with GRIDS, ATB)
- e-Science in Astronomy - using informatics (computer science)
- 4-th Paradigma of science (observation, experiment, modeling, knowledge)
- Data mining, Knowledge discovery - VO-NEURAL, DAME
- Clustering
- Classification
- Supervised learning (Neural Networks, SVM)
- Examples
  - Photometric RedShift
  - Searching for QSO
  - Automatic Light curves classification (GAIA, LSST)
- Very NEW – emerging discipline

# The answer is Data mining .... matching Donald Rumsfeld's epistemology

*There are known knowns,  
There are known unknowns, and  
There are unknown unknowns*

## Classification

Morphological classification of galaxies  
Star/galaxy separation, etc.

## Regression

Photometric redshifts

## Clustering

Search for peculiar and rare objects,  
Etc.

Donald Rumsfeld's  
about Iraqi war



"There are known knowns.  
These are things we know that we know.  
There are known unknowns.  
That is to say, there are things that we know we don't know.  
But there are also unknown unknowns.  
There are things we don't know we don't know."

# Need for a new science: Astroinformatics

## *Knowledge Discovery in Databases*

Data Gathering (e.g., from sensor networks, telescopes...)

→ Data Farming:

- Storage/Archiving
- Indexing, Searchability
- Data Fusion, Interoperability, ontologies, etc.

→ Data Mining (or Knowledge Discovery in Databases):

- Pattern or correlation search
- Clustering analysis, automated classification
- Outlier / anomaly searches
- Hyperdimensional visualization

→ Data understanding

- Computer aided understanding
- KDD
- Etc.

→ New Knowledge



Database technologies

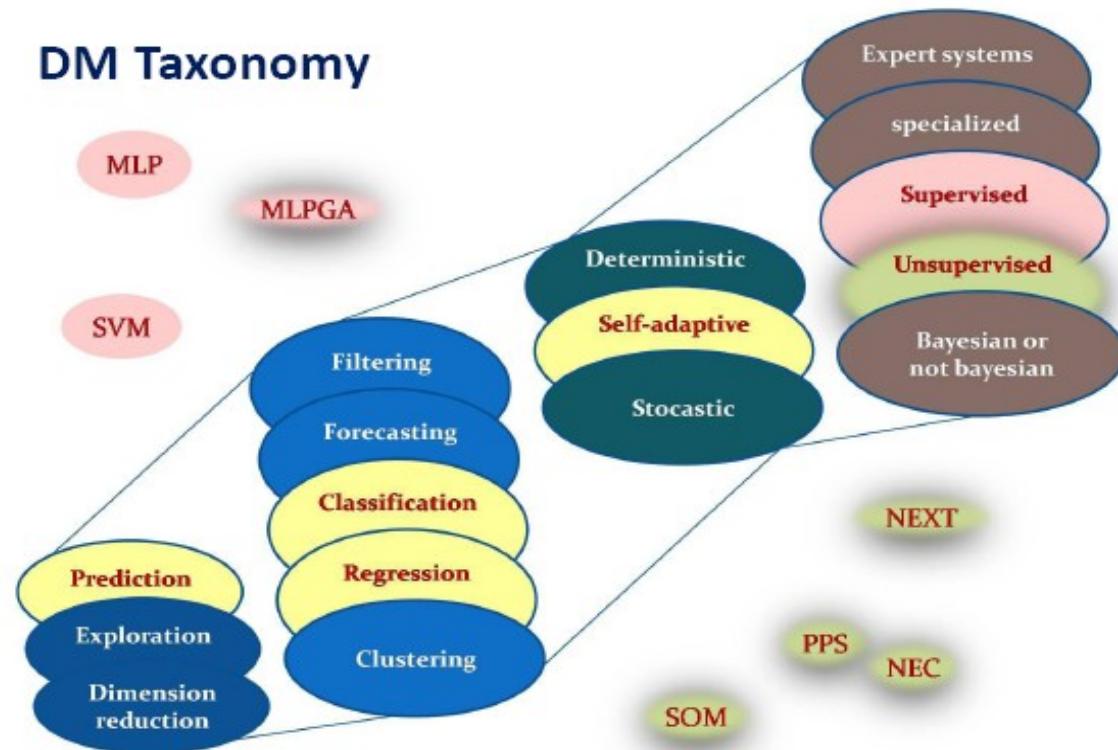
Key mathematical issues

Ongoing research



Data Mining is the activity of extracting **USEFUL** information from **COMPLEX** data using Statistical Pattern Recognition and Machine Learning methods.

## DM Taxonomy



### Supervised Methods

Patterns are learnt from extensive set of templates (Base of Knowledge = BoK)

### Unsupervised Methods

Patterns are discovered using the data themselves

# Scientific Communities

“The co-authorship network of scientists represents a prototype of complex evolving networks. In addition, it offers one of the most extensive database to date on social networks.”<sup>a</sup>

---

<sup>a</sup>Barabàsi et al., “Evolution of the social network of scientific collaborations”

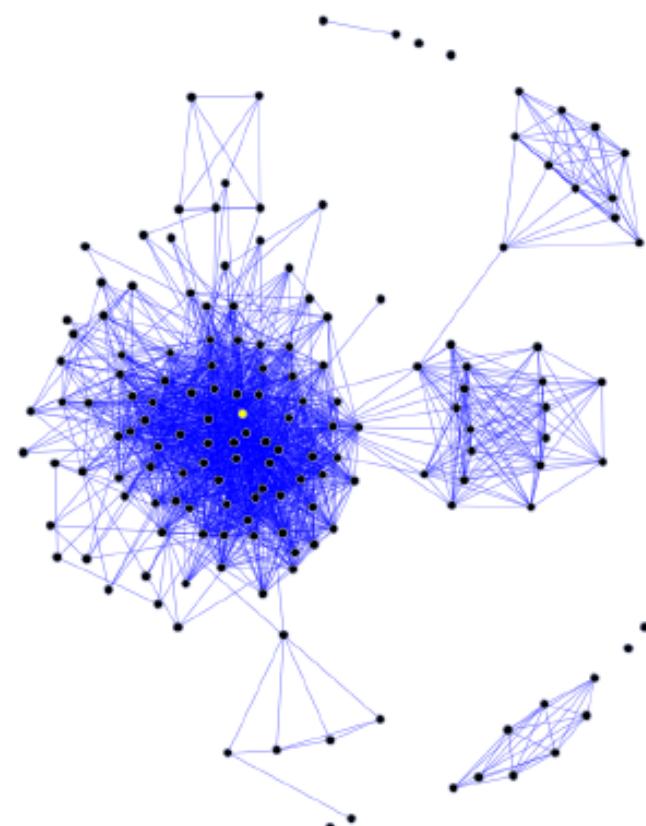
“Social scientists have long recognized the importance of boundary-spanning individuals in diffusing knowledge (Allen 1977; Tushman 1977), and recently, several papers have rigorously demonstrated that technological knowledge diffuses primarily through social relations, not through publications.”<sup>a</sup>

---

<sup>a</sup>Sorenson, and Singh, “Science, Social Networks and Spillovers”

## Motivations of a social networking IT platform for science

- The importance of boundary-spanning individuals in social networks might be what X-informatics is all about;
- we break scientific *cliques* and create new, unexpected, effective links across the science community's network;
- an effective scientific social network platform may be an effective step towards *seamless astronomy*. Seamless not only in terms of data and applications access, but also in terms of social interactions between people in the scientific network.



### Integrated Collaborative Environment



### Distributed Scientific Social Websites

- Each institution could develop its website (e.g. OpenSocial);
- institutions/developers could also provide interoperable web applications;
- researchers could customize their UI/preferred applications (custom portals!);
- researchers social data would be accessed from the web;
- social features (ranking, sharing, discussing, discovering);
- collaborative software (e.g. Google Wave).

If the social communication is effective, applications can spread and compete, new links can form in the network, and new collaborations can start!



<http://mica-vw.org/>

Search

Go

Log in / create account

## Navigation

- » Main Page
- » Charter
- » Events
- » Research
- » Organization
- » People
- » How to Join
- » MICA blog
- » Publications
- » Links

## Meta Institute for Computational Astrophysics

The Meta Institute for Computational Astrophysics (MICA) is a professional scientific and educational, non-profit organization based in virtual worlds [VWs] (currently in Second Life [SL], but with an intent to expand its presence in other venues as the VWs evolve). The goals of MICA include:

- ▶ Exploration, development and promotion of VWs and virtual reality [VR] technologies for professional research in astronomy and related fields.
- ▶ Providing and developing novel social networking venues and mechanisms for scientific collaboration and communications, including professional meetings, effective telepresence, etc.
- ▶ Use of VWs and VR technologies for education and public outreach.
- ▶ Exchange of ideas and joint efforts with other scientific disciplines in promoting these goals for science and scholarship in general.

***MICA is an experiment in the scholarly use of VWs technologies***

- Currently ~ 50 professional members and > 100 affiliates
- Regular schedule of events: seminars, workshops, public lectures, etc.

# Virtual Worlds (2<sup>nd</sup> Life for Science)



Now migrating to the *OpenSim*-based  
VWs, e.g., Intel's *ScienceSim*

Djorgovski



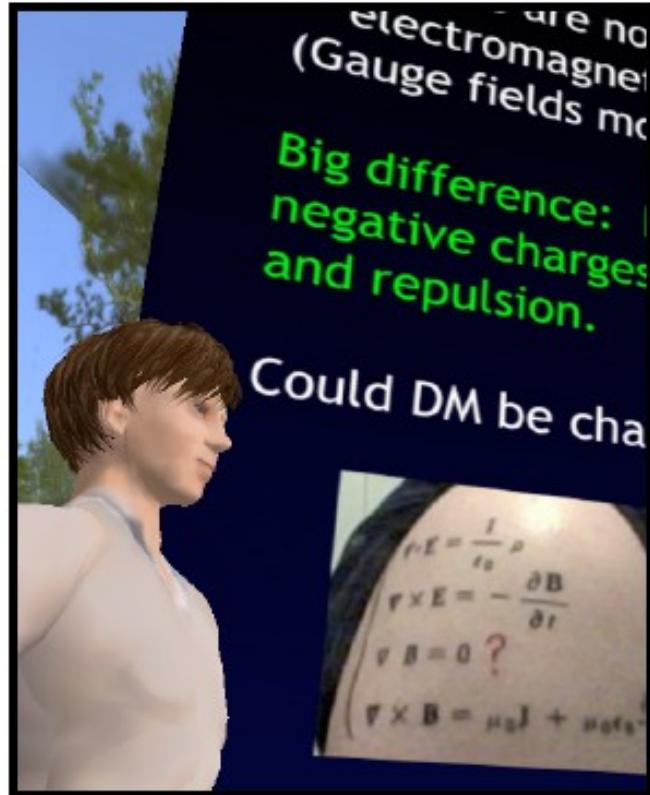
# Virtual Conferences

Virtual conferences at zero cost

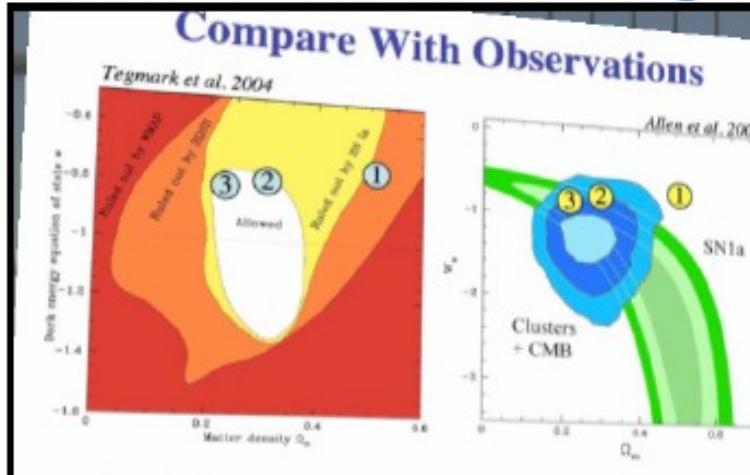
Problem with time zones

Outreach, education

## Professional seminars



## Collaboration meetings

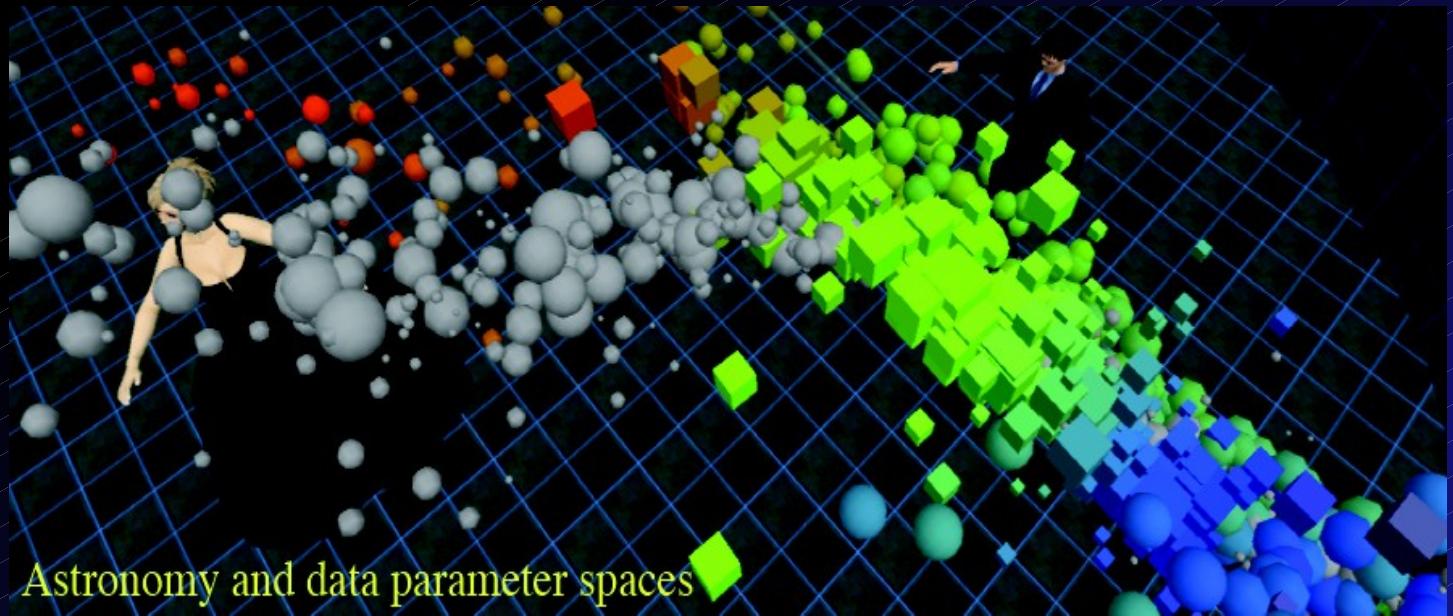


## Public outreach

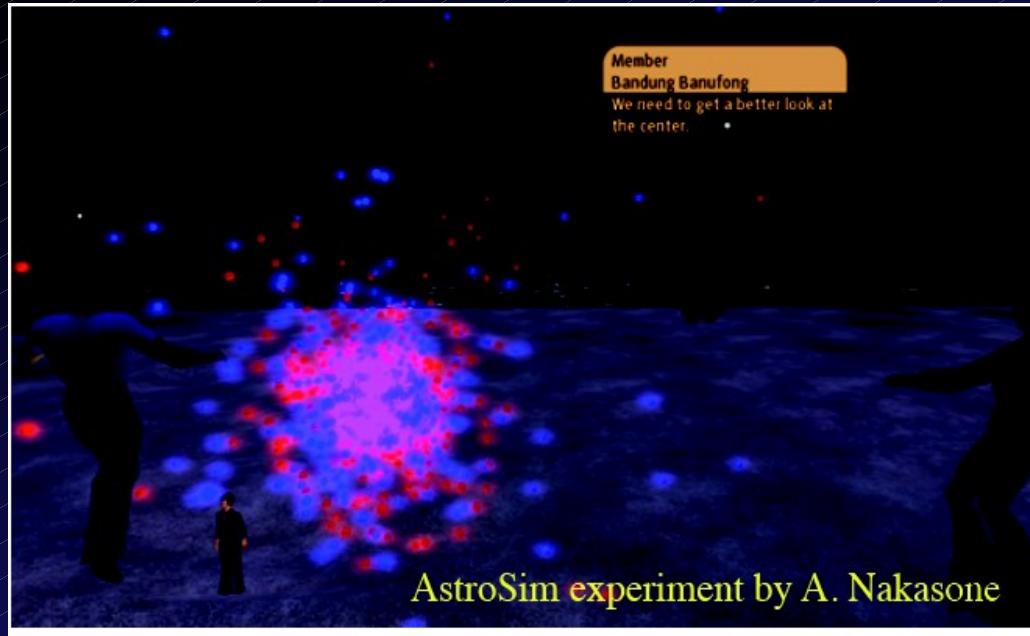


Nobel laureate  
John Mather

# Immersive VR Experiments



Astronomy and data parameter spaces



AstroSim experiment by A. Nakasone

Scientists  
immersed in,  
and  
interacting  
with,  
numerical  
simulations  
of star  
clusters

# **U-Science, Carbon Computing**

**e-Science** emerged ~10 yrs ago using the web protocols that were common at that time:

- web services, XML-based information exchange, registries, distributed data access, distributed computing (Grid) = **machine-to-machine communication**

**U-Science** is now emerging from today's web protocols:

- social networking, ubiquitous devices, user-centric experiences, user-led activities, user-generated content, wikis, blogs, mashups, tagging, annotation, ontologies (semantic web), folksonomies, knowledge-sharing, user recommendations = **user-to-user communication**

- The emergence of **Citizen Science**:
- Anybody can participate in the science discovery process
- Anyone can annotate, tag, and label scientific results:
- scientists, students, and citizen scientists

# Galaxy ZOO

The screenshot shows the Galaxy Zoo website interface. At the top, the logo "GALAXY ZOO.org" is displayed, with a small thumbnail image of a galaxy next to the word "ZOO". Below the logo is a navigation menu with links: Welcome, Home, The Science, How to Take Part, Galaxy Analysis, Forum, Press & News, FAQ, Links, Contact Us, Login, and Register. On the left side, there is a sidebar with links to Galaxy Tutorial and Galaxy Analysis. The main content area features a large image of a spiral galaxy with a prominent central bulge and two smaller galaxies in the background. To the right of the image, the text "Galaxy Ref: 588010880371851294" is shown, followed by the instruction "Choose the Galaxy Profile by clicking the buttons below". Below this text are four buttons representing different galaxy profiles: "Spiral Galaxy" (clockwise and anti-clockwise spirals), "Elliptical Galaxy" (an oval shape), "Star / Don't Know" (a star icon), and "Herrgers" (a curved arrow). At the bottom left of the main image area, there is a checkbox labeled "Show Grid Overlay on the next Image".

Welcome to Galaxy Zoo's view of the Universe. If you're here you should already have seen the [Tutorial](#), but feel free to go and remind yourself. There's no need to agonise for too long over any one image, just make your best guess in each case.

Galaxy Ref:  
588010880371851294

Choose the Galaxy Profile by clicking the buttons below

Spiral Galaxy

Elliptical Galaxy

Star / Don't Know

Herrgers

Show Grid Overlay on the next Image

> 20 Science papers published so far

# www.zooniverse.org

The screenshot shows the Zooniverse homepage with the URL <http://www.zooniverse.org/home> in the browser address bar. The page features the Zooniverse logo and navigation links for HOME, PROJECTS, ABOUT, EDUCATION, BLOGS, RESEARCHERS, and CONTACT. A prominent section for the "SOLAR STORMWATCH" project is displayed, featuring a large image of the Sun with solar flares and a "JOIN IN" button. Below this, a section for "The Zooniverse Community" shows statistics: "254,817 people just like you...". A profile box for Nathaniel Taylor Winston III is shown, detailing his age (57), occupation (Retired and disabled), and joining date (July 2007). He describes Zooniverse as a place to help advance science and meet friends. To the right, there are sections for "Live Projects" (Galaxy Zoo, Solar Stormwatch, Galaxy Zoo: Understanding Cosmic Mergers, Galaxy Zoo: The Hunt for Supernovae) and "Zooniverse Activity" (Total Volunteers: 254,815).

zooniverse - Home

http://www.zooniverse.org/home

astro-ph NASA ADS Login to meal bookin Apple Amazon UKS Organics - Org eBay TinyURL Yahoo News ACS morphology cut Other Bookmarks

LOGIN

ZOONIVERSE REAL SCIENCE ONLINE

HOME PROJECTS ABOUT EDUCATION BLOGS RESEARCHERS CONTACT

SOLAR STORMWATCH

Solar Stormwatch

Help spot explosions on the Sun and track them across space to Earth. Your work will give astronauts an early warning if dangerous solar radiation is headed their way.

JOIN IN

The Zooniverse Community

254,817 people just like you...

Name: Nathaniel Taylor Winston III  
Age: 57  
Occupation: Retired and disabled  
Joined Zooniverse: July 2007  
Nathaniel's Zooniverse: "A chance for me to help advance science and improve myself with NEW discoveries to increase our knowledge. I also love to meet and bond with people of similar interests. It's probably the BEST website I ever joined and I have made many friends that are like family to me."

Nathaniel

I'd like to be featured here too!

Live Projects

GALAXY ZOO

SOLAR STORMWATCH

GALAXY ZOO

GALAXY ZOO

Zooniverse Activity

Total Volunteers: 254,815

# Examples ZOOiverse

Moon Zoo - Crater Survey X http://moon.zooniverse.org/craters

Moon Zoo is a ZOO-NIVERSE project

## MOON ZOO

YOUR CHANCE TO EXPLORE

Your Moon Tools

- Crater Survey
- Boulder Wars
- My Moon Zoo
- Layout
- Home
- How to take part
- About

image credit: NASA/GSFC/Lunar Science Institute

Dimension: Color | Moon

**Galaxy Zoo Irregular Checking**

Galaxy Ref 587356620850

If it is the same as the last image click on Not irregular. If it is clearly & regular spot don't know. Otherwise select properties as Irregular button

Clarity:  Clearly defined,  Faint

Shape:  Compact,  Sprawling

Star Forming:  None,  1-3,  4-10,  11-20,  20+,  Not clear

Champr:

Friends:  On its own,  involved in a merger,  another irregular nearby,  another galaxy nearby

Bar:  Yes,  Possibly,  None

Arms:  Yes,  Possibly,  None

Core:  Yes,  Possibly,  None

Any Spiral:  Yes,  Possibly,  None

Irregular Structure

Zoom In Lots | Zoom In | Zoom Out | Zoom Out Lots | Invert

Back to Previous | Advanced Display | English | Deutsch | Español | Polski | Français

## GALAXY ZOO MERGERS

Home | How To Take Part | Contact Us | Profile | Logout

SIMULATIONS Viewed: 8 Selected: 1 Enhanced: 0 Evaluated: 0 Level: 0 Animate

Explore | Enhance | Evaluate | More

Selected Sims

**Explore**

Click on "More" to see 8 randomly generated simulations. Click on ones that you think show similarities to the image in the center. As you do this, the ones that you selected are saved on the right-hand side for later review. help

**Enhance**

Maybe you found a simulation on the Explore tab that is similar to the image in the center. help

Solar Stormwatch : Spot X http://solarstormwatch.com/spot\_and\_track/spot

HOME WHY SCIENTISTS NEED YOU MISSION BRIEFING SPOT & TRACK STORMS TALK ABOUT IT

**SPOT**

**QUESTION** Can you spot a solar storm?

**INSTRUCTIONS**

Watch this pair of video clips from the STEREO Behind and STEREO Ahead spacecraft cameras. Do you see a solar storm? Is it in just one camera, or both?

STEREO BEHIND | STEREO AHEAD | PLAY | PAUSE | SCAN | ADD CLIP TO FAVORITES | Time - 16.00

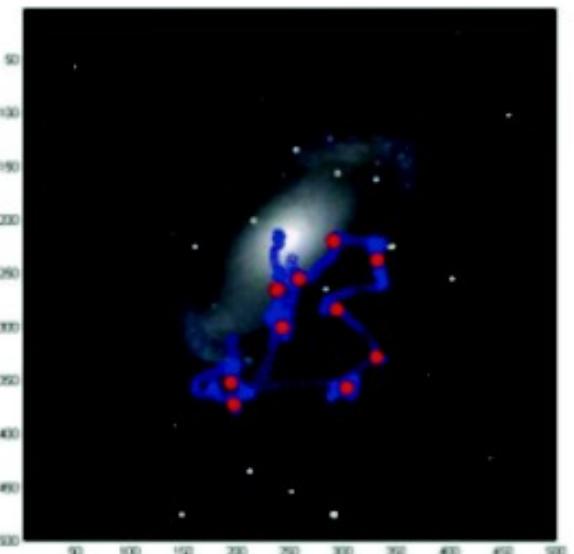
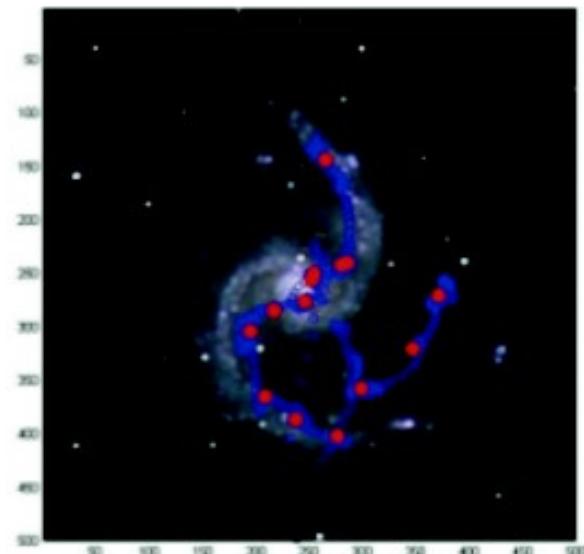
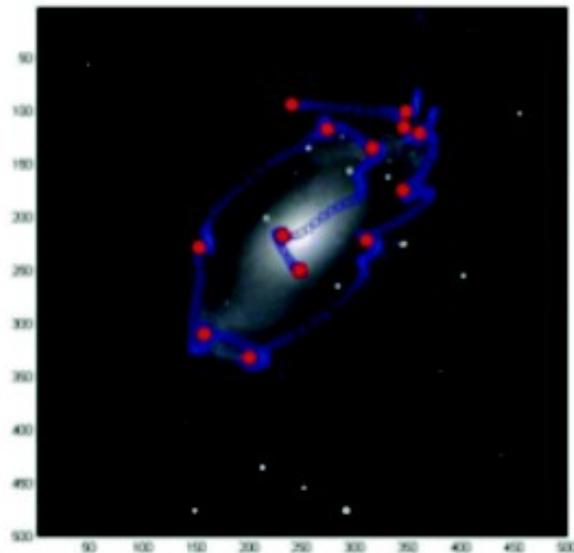
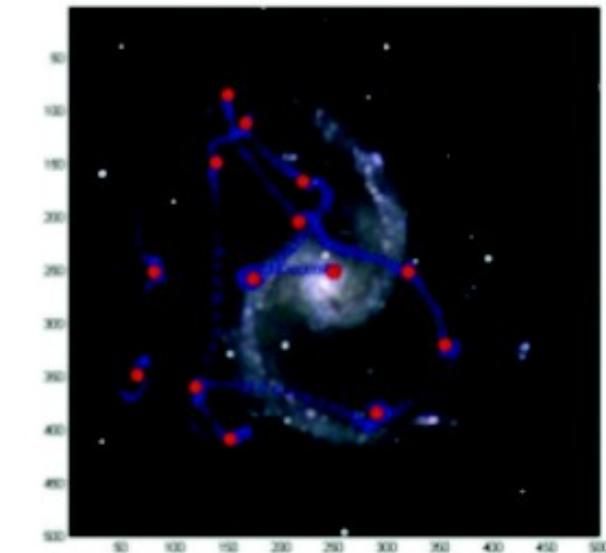
Hints & tips

- Here's a reminder of what a solar storm looks like. See more examples on Flickr.
- Use the SCAN button to play the video at double speed.
- If you spot a solar storm there are two more steps to complete. If not, that's it for this challenge.
- There's always a lot going on at the outside edge of the video. But solar storms expand and then fade as they cross the frame. You will need to follow them at least half way across.
- There might be more than one solar storm per video, but at this stage that doesn't matter. Pick one now, and you'll be able to come back to the rest at the end.
- Watch a How to... screencast.

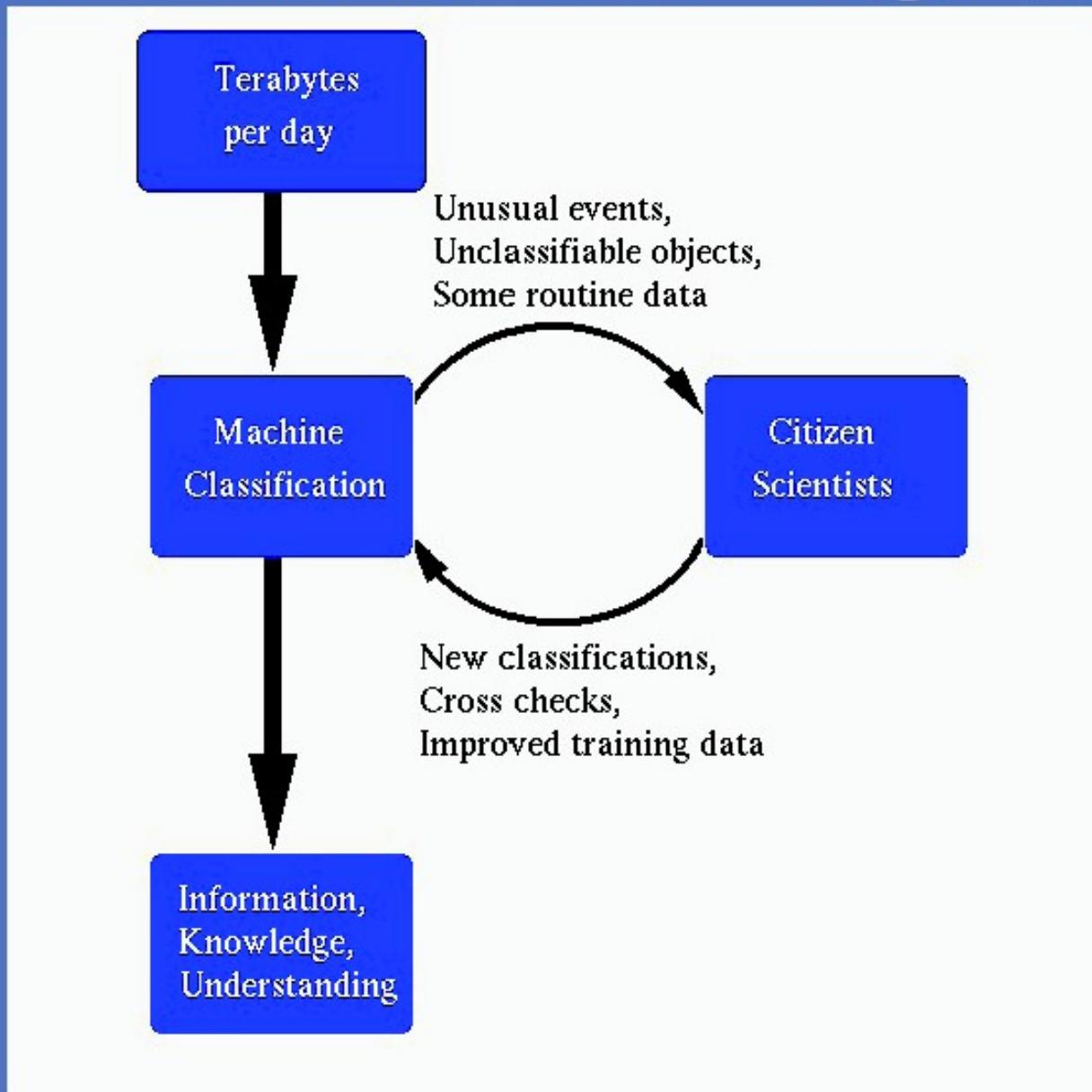
Log out | My Solar Stormwatch



# Expert vs Non-expert Classifier



# Machine-Human Learning Cycle

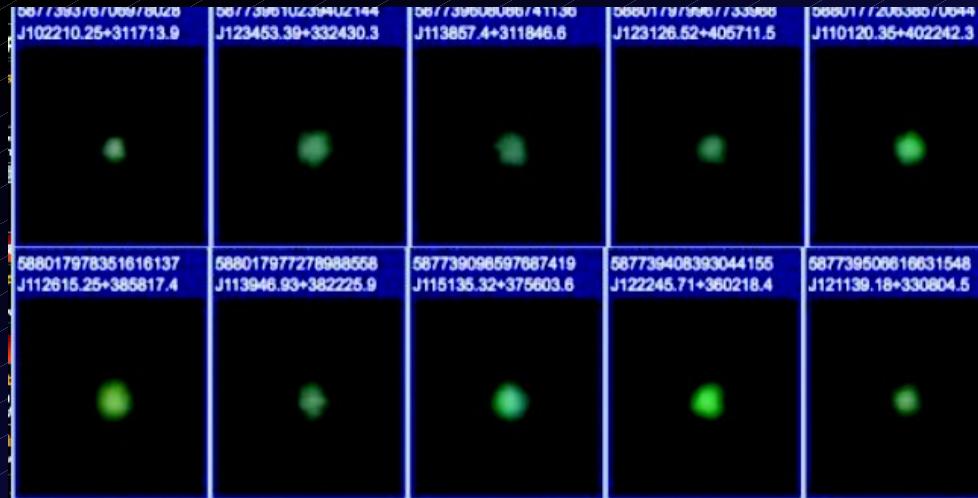


# Citizen Science x Expert Science

Verified by human – training sets

Independent answers=estimate of error

Serendipitous discovery



Galactic Peas

Scale - complexity

# Knowledge Discovery in U-Science



Hanny van Arkel - Voorwerp

Light echo of quasar?

**Known knowns :**

Primary task. Data reduction by science team.

**Known unknowns :**

Related to primary task. Results funneled to specific researchers.

**Unknown unknowns :**

Serendipity. Currently rely on forum moderators to filter.

# Czech VO - CZVO

Search | Login



**CZVO**  
Czech Virtual Observatory

**Navigation**

- ▶ About CZVO
- ▶ Observatories
- ▶ Projects
- ▶ Spectra Archive
- ▶ Data Resources
- ▶ Links
- ▶ Publications

**Home**

**Links**

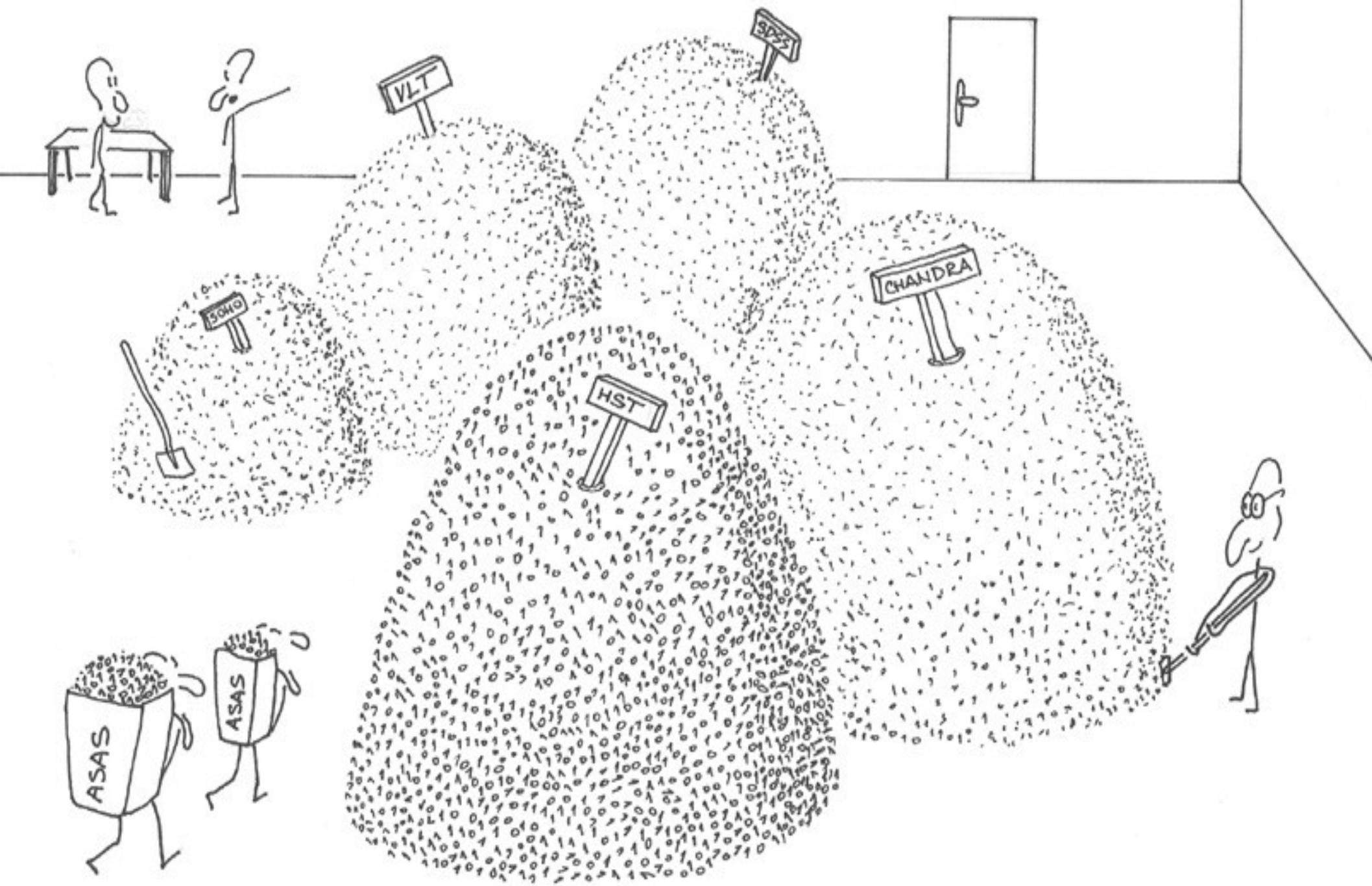
There is some links:

- Virtual Observatory United Kingdom
- Astrogrid
- Australian Virtual Observatory/
- Chinese Virtual Observatory
- Canadian Virtual Observatory
- European Virtual Observatory
- German Astrophysical Virtual Observatory
- Hungarian Virtual Observatory
- Japanese Virtual Observatory
- Korean Virtual Observatory
- National Virtual Observatory, United States
- Observatoire Virtuel France
- Russian Virtual Observatory
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- Italian Virtual Observatory
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