

# **The Virtual Observatory: A New Revolutionary Way of Scientific Research**

## **Astroinformatics, e-Science**

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Astroinformatics and VO Summer School  
Faculty of Mathematics, University Belgrade, 30-th June 2010, Serbia

# 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

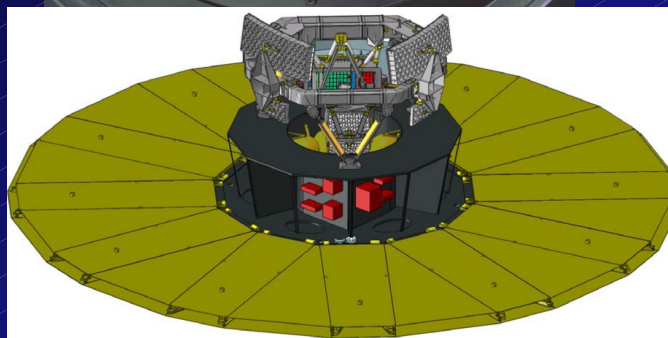
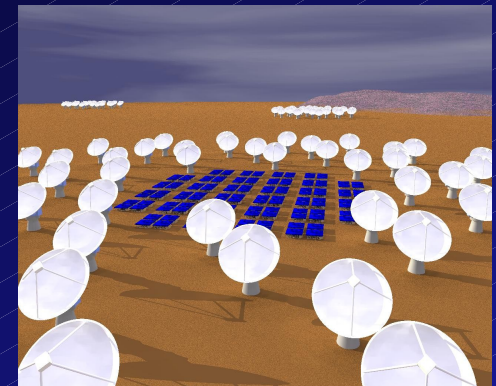
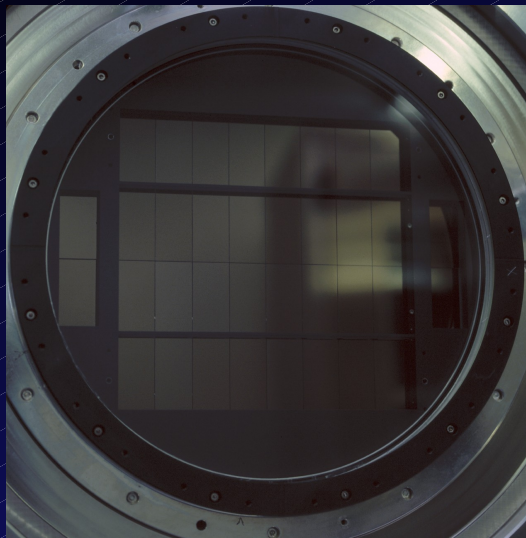
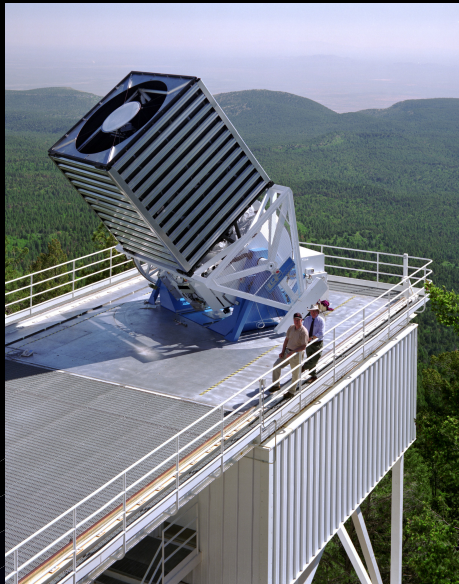
# VO – The Hidden Revolution

- VO is the radical change of the paradigm of the work of the scientists – effectiveness !!!
- Everyday question (what, where, format, units)
- Everyone is using it – but not stated (> 5 years)
  - CDS (Simbad, Aladin, Vizier), NASA, ESA archives
  - All looks like „ONLY“ another WEBs, client apps
- Scientists are conservative (don't like change)
  - The fear of buzzword VO (multispec, large scale)
- Computer literacy – obligatory (part of job)

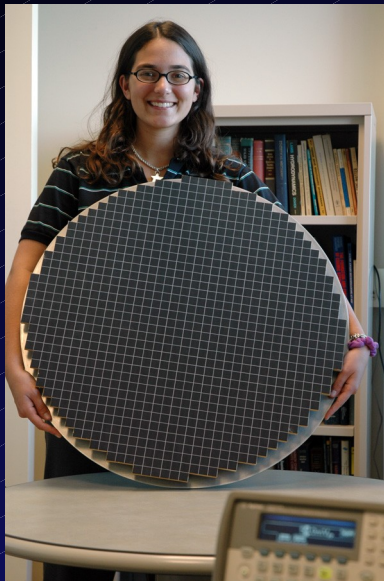
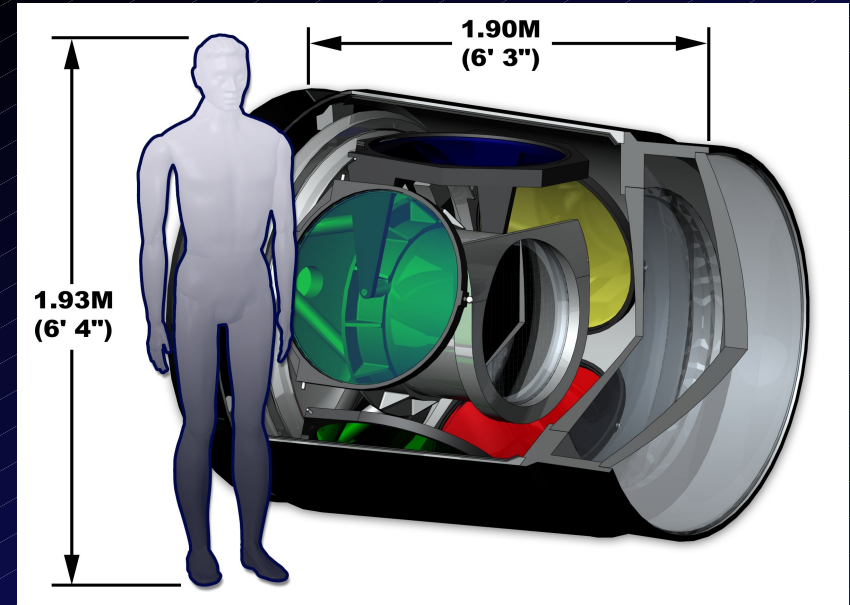
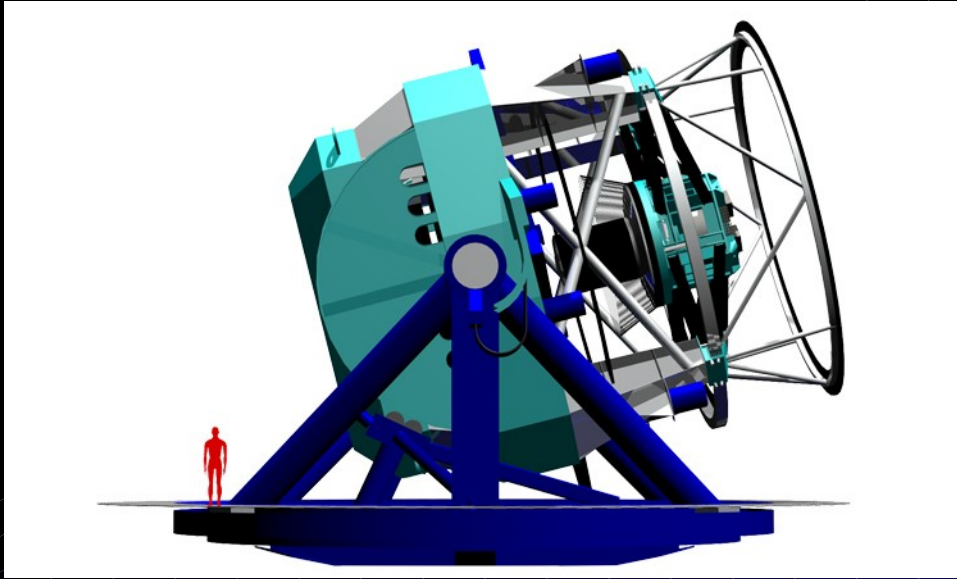
# **Analogy between VO and WWW**

- 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 (usefulness for my field ???)
- Steep Growth – average user can use it without knowledge of principles (effectivity, habits)

# Data Avalanche



# LSST (8.4m)

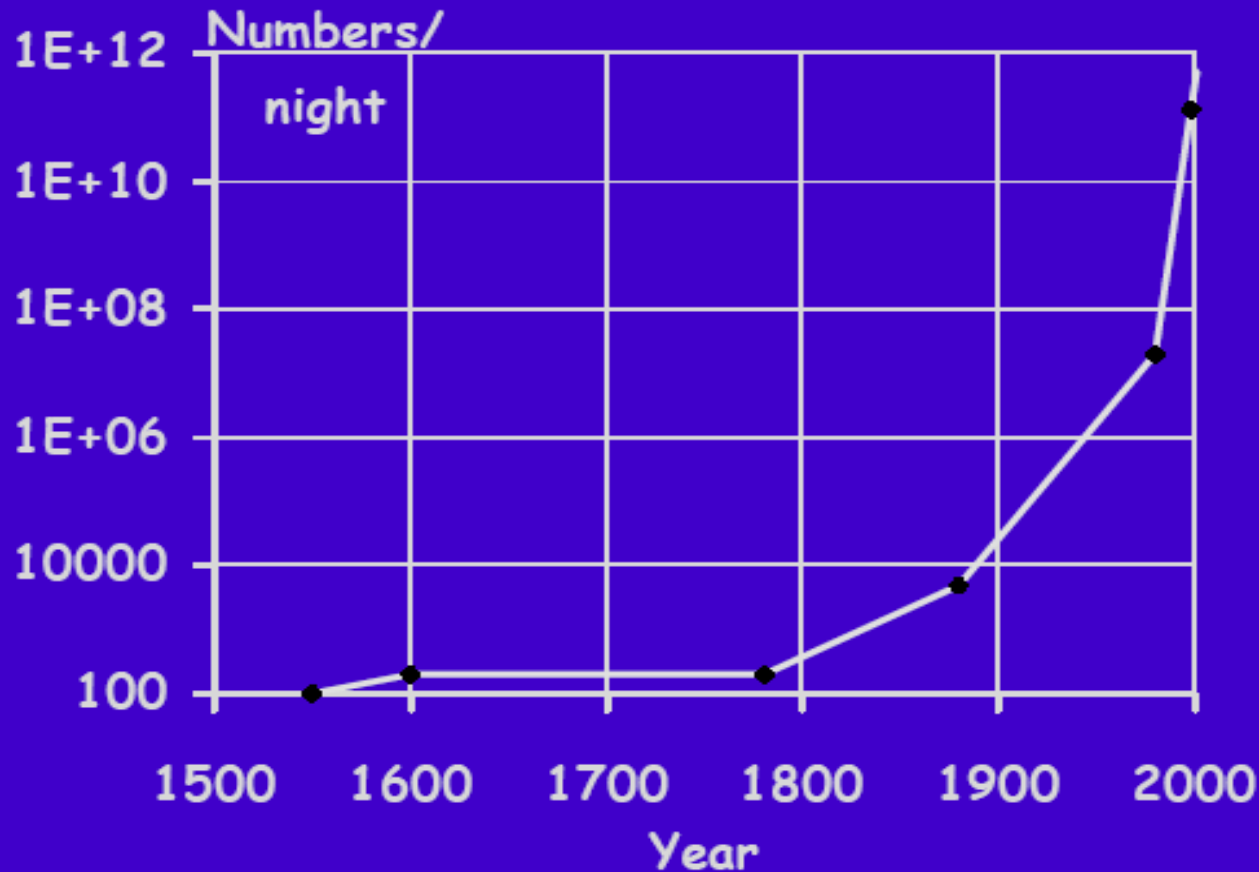


200 CCD 4kx4k,  
32 channels (6400)  
3.2 Gpix every 20 sec  
64cm diameter  
3.5 deg FOV  
30 TB/night  
2 TFLOPS  
detection of changes  
within 60sec

# Data Avalanche

Moore law for chips –doubling 1.5 year

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



$T_2 < 18$  mths  
1990-2000

# 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

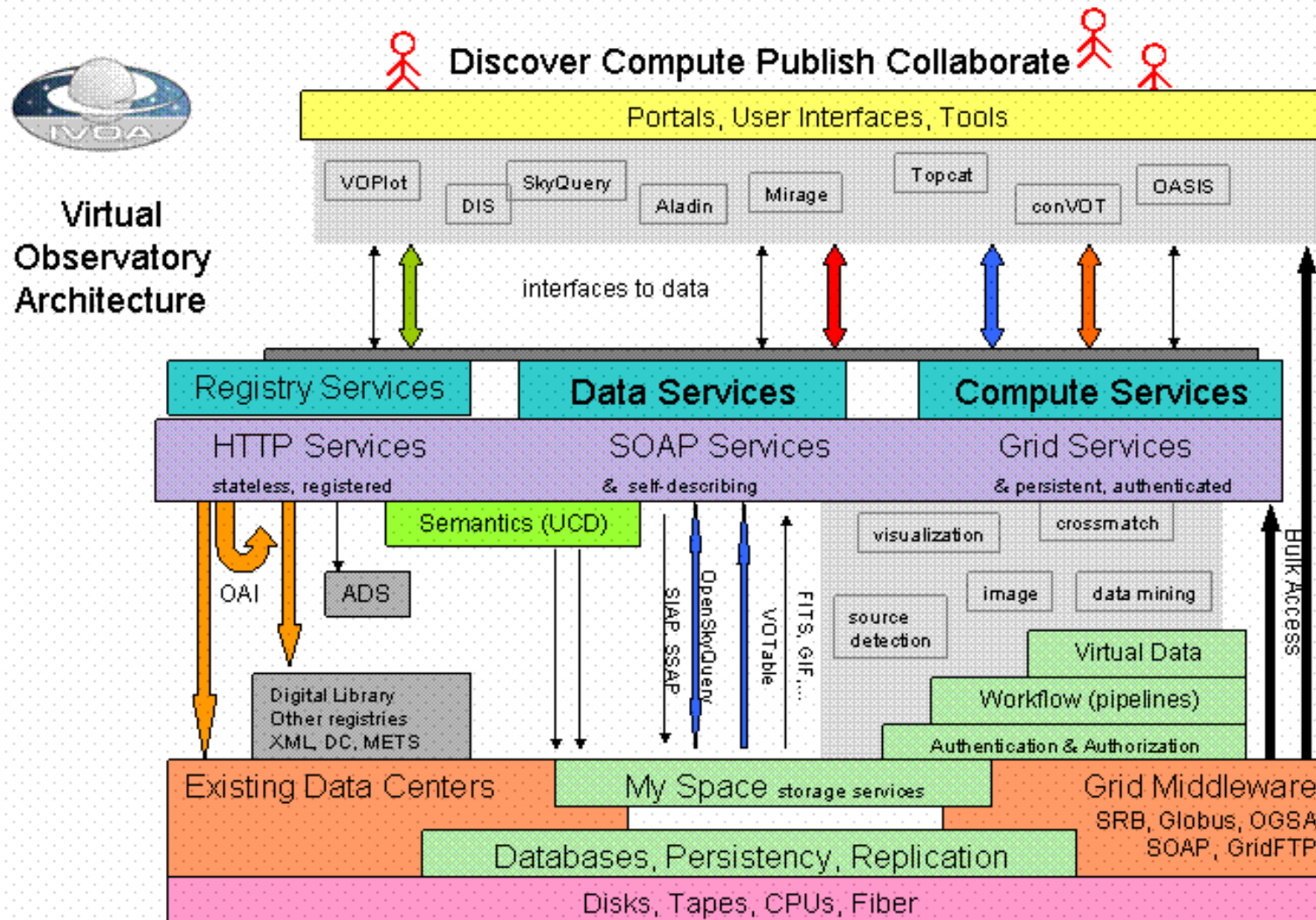
- *“The Virtual Observatory will be a system that allows astronomers to interrogate multiple data centers in a seamless and transparent way, which provides new powerful analysis and visualization tools within that system, and which gives data centers a standard framework for publishing and delivering 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 Paradigm

- 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  $\rightarrow$  nm),  $\text{Wm}^{-2}\text{s}^{-1} \rightarrow \text{Jy}$ )
- Background computing on GRIDS
- Multiwavelength approach (SED)

# 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

HEROS OND CUTOUT: Resource Record Summary - Iceweasel

Soubor Úpravy Zobrazit Historie Záložky Nástroje nápověda

← → ↺ ↻ ↵


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

☆

vo registry vor10

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

VOSpec\_Oct2007.png (PNG obrá... HEROS OND CUTOUT: Resource ...




National Virtual Observatory

NVO Registry

[NVO Home](#) [Search](#) [Publish](#) [Developers](#) [Help](#) [Contact Us](#)

Hosted By



Space Telescope Science Institute

Tip: [What's a "Resource"?](#)

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=11/12 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 0.1Å. 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



Meet the  
Developers



Hotovo

# VO Registry - XML

Iceweasel

Soubor Úpravy Zobrazit Historie Záložky Nástroje nápověda

file:///home/skoda/VO-brno2009/RegistryMetadata.xml vo registry vor10

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

VOSpec\_Oct2007.png (PNG obrá... file:///home/sko...tryMetadata.xml

Tento XML soubor nemá připojeny žádné informace o vzhledu prvků. Strom XML dokumentu je zobrazen níže.

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" xsi:schemaLocation="http://www.ivoa.net/xml/VORegistry/1.0/ivo-registry.xsd" xsi:type="vs:CatalogService">
  <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 CUTOOUT</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=11/12 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>
  </ri:Resource>
</?xml>
```

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# Technology of VO

ADQL (Astronomical Data Query Language)

XMATCH, REGION (2 catalogues - shifted)

Application interoperability – PLASTIC, SAMP

Allows develop applications as bricks

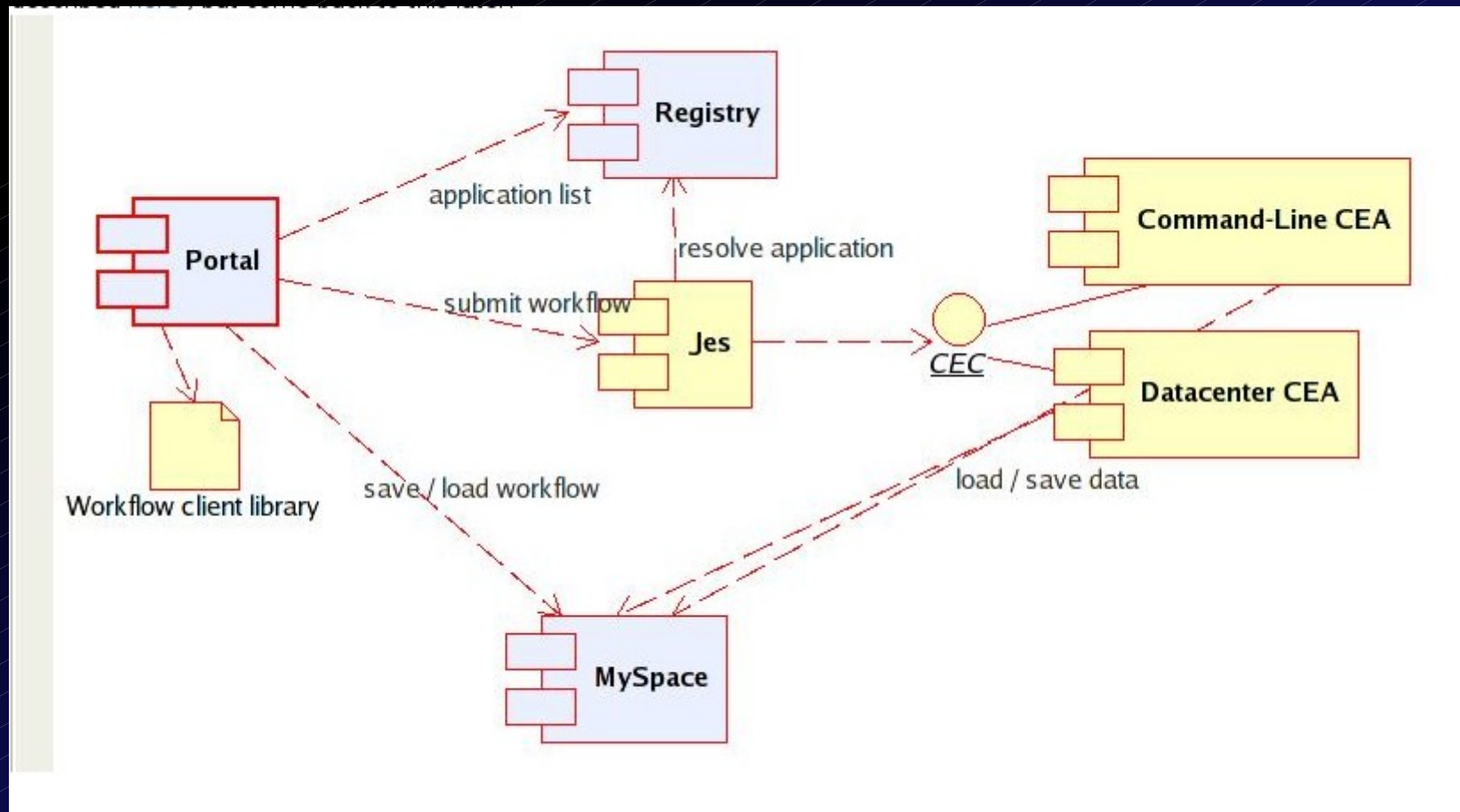
sending VOTABLES (catalogue-spectra-images)

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

SDSS Data Release 3 (AstroGrid DSA)

**Table Columns**

**Table Description**

**Selected table**

**Query being built**

**Dialog to insert selected columns into selected section of the query**

**List of tables in the database**

Chooser  
Query  
Parameter  
XML  
Info  
Security

Tree Adql/s Adql/x

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

SDSS Data Release 3 (AstroGrid DSA)

Maps all primary and secondary objects in the PhotoObjAll table to a view

Name	UCD	Units	Type	Description
intMid	CO...			zU-deep ni...
fieldID	ID_...			Link to the ...
parentID	ID_...			Pointer to p...
specObjID	ID_...			Pointer to t...
u	PH...	mag		Shorthand ...
g	PH...	mag		Shorthand ...
r	PH...	mag		Shorthand ...
i	PH...	mag		Shorthand ...
z				
err_u				
err_g				
err_r	PH...	mag		Error in mo...
err_i	PH...	mag		Error in mo...

**Column References**

Insert 5 references into "Items"

Set Archive Definition..

SpecLineNames  
SpecZStatus  
SpecZWarning  
TiMask  
Tile  
TilingBoundary  
TilingMask  
TiledTarget  
SpecObj  
PhotoFamily  
PhotoObj  
PhotoPrimary  
PhotoSecondary  
SpecLine  
SpecPhoto  
Galaxy

**VOTable :**

```
<?xml version="1.0"?>
<!DOCTYPE VOTABLE SYSTEM "http://us-vo.org/xml/VOTable.dtd">
<VOTABLE >
  <DESCRIPTION>
    VizieR Astronomical Server: urania.iucaa.ernet.in 2002-10-04T05:20:16
    Explanations and Statistics of UCDs: See LINK below
    In case of problem, please report to: question@simbad.u-strasbg.fr
  </DESCRIPTION>
  <DEFINITIONS>
    <COOSYS ID="J2000" equinox="J2000" system="EQ_FK5"/>
  </DEFINITIONS>
  <INFO ID="Ref" name="-ref" value="VOTx11451"/>
  <RESOURCE name="V/105" ID="yCat_5105" >
    <DESCRIPTION>SKY2000 Catalog, Version 3 (Myers+ 2000)
  </DESCRIPTION>
  <TABLE ID="V_105_sky2v3r1" name="V/105/sky2v3r1" >
    <DESCRIPTION>The Sky2000 Version 2 Catalogue
  </DESCRIPTION>
    <FIELD datatype="int" width="6" name="HD" ucd="ID_ALTERNATIVE" >
      <DESCRIPTION>?Henry Draper &lt;III>135&gt; number
    </DESCRIPTION>
    </FIELD>
    <FIELD unit="h:m:s" datatype="char" ref="J2000" name="RAJ2000" ucd="POS_EQ_RA_MAIN" arraysize="13" >
      <DESCRIPTION>Right ascension (J2000) hours
    </DESCRIPTION>
    </FIELD>
    <FIELD unit="d:m:s" datatype="char" ref="J2000" name="DEJ2000" ucd="POS_EQ_DEC_MAIN" arraysize="13" >
      <DESCRIPTION>Declination degrees (J2000)
    </DESCRIPTION>
```

☒ Display Data Of Selected Points

Close

Save As File

# IVOA



# 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
POS	52, -27.8	degrees; defaults to ICRS	string
SIZE	0.05	degrees	double
BAND	2.7E-7/0.13	meters	string
TIME	1998-05-21/1999	ISO 8601 UTC	string
FORMAT	votable	-	string

## 4.1.2 Recommended and Optional Query Parameters

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

The spatial, spectral, and time resolution of the data may all be used as query parameters.

# VO-enabled tools

Aladin

VOPlot

TOPCAT

VOSpec

SpecView

SPLAT

ViSiVO (HPC simulations, cosmology)

VOSED

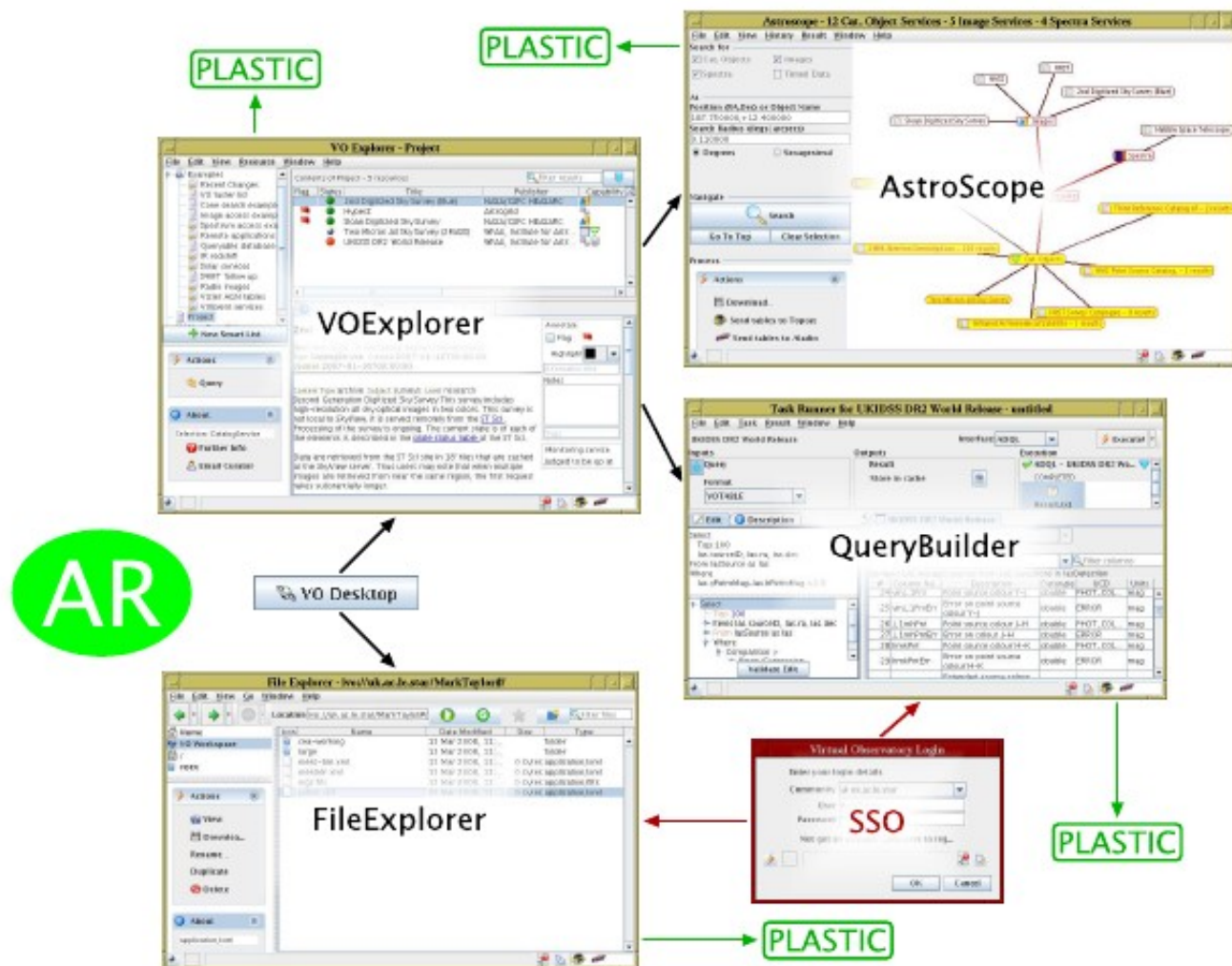
BASTI

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

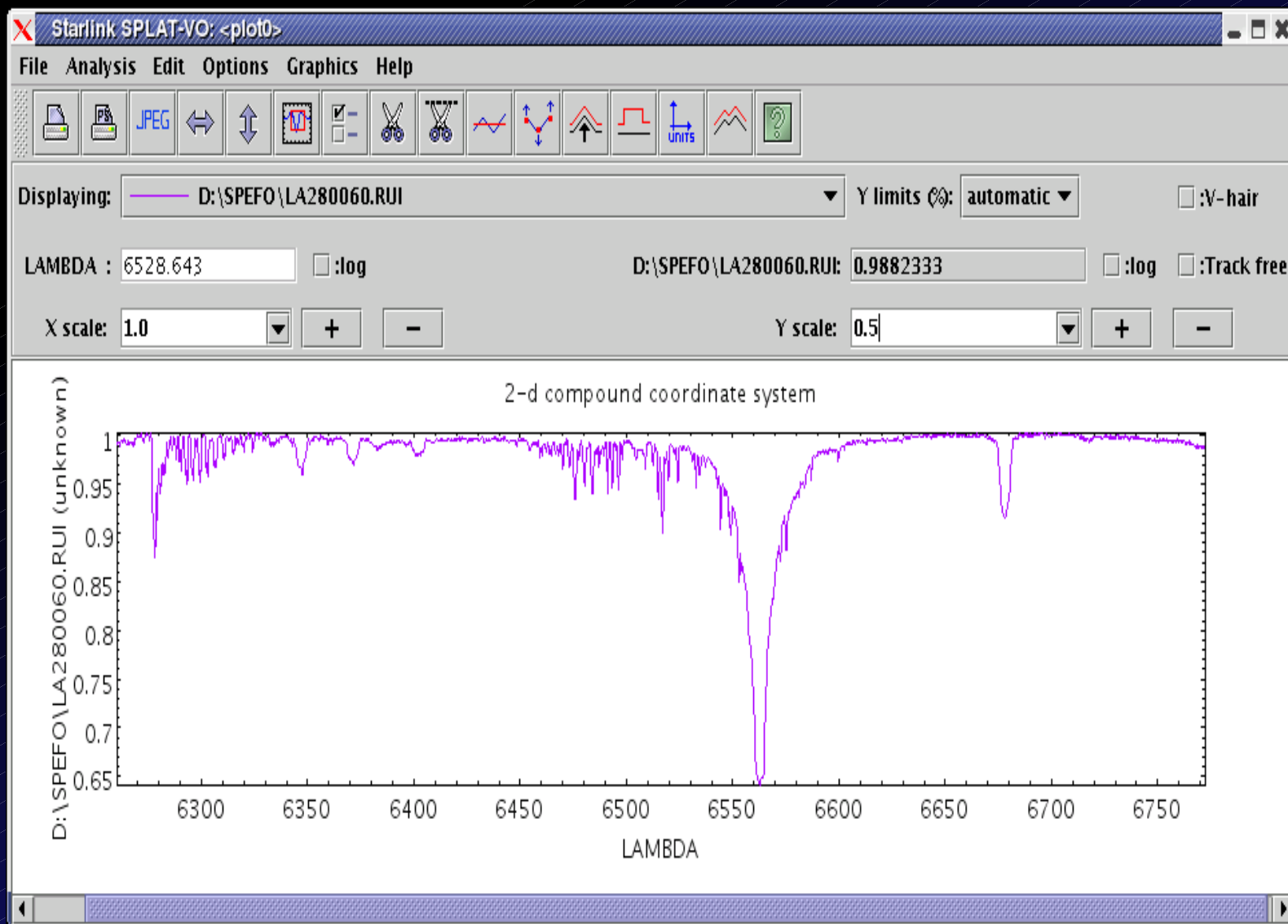
Period04 (since 18.9.08) - PLASTIC

# AstroGRID VODesktop

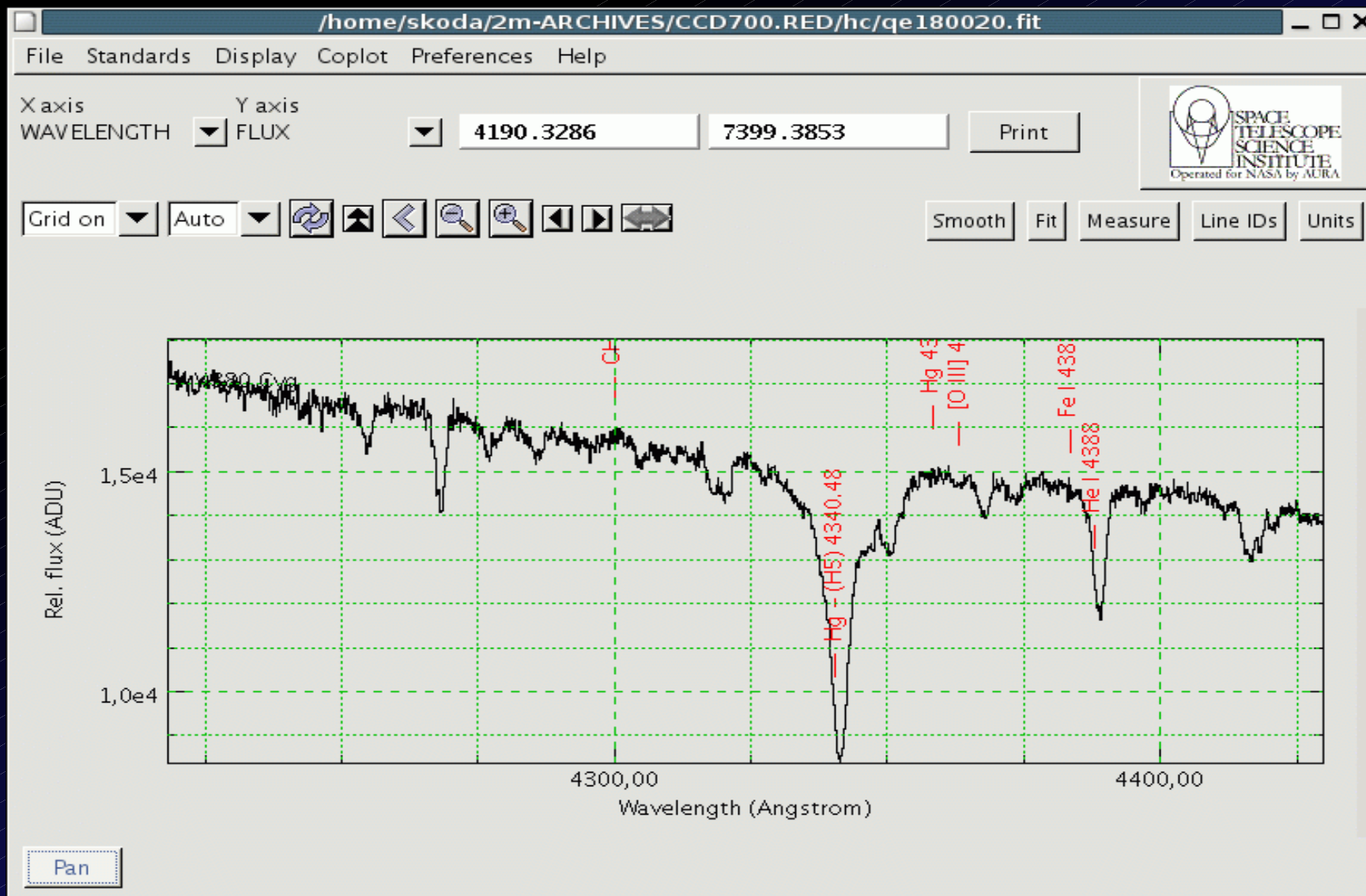
## VODesktop Overview



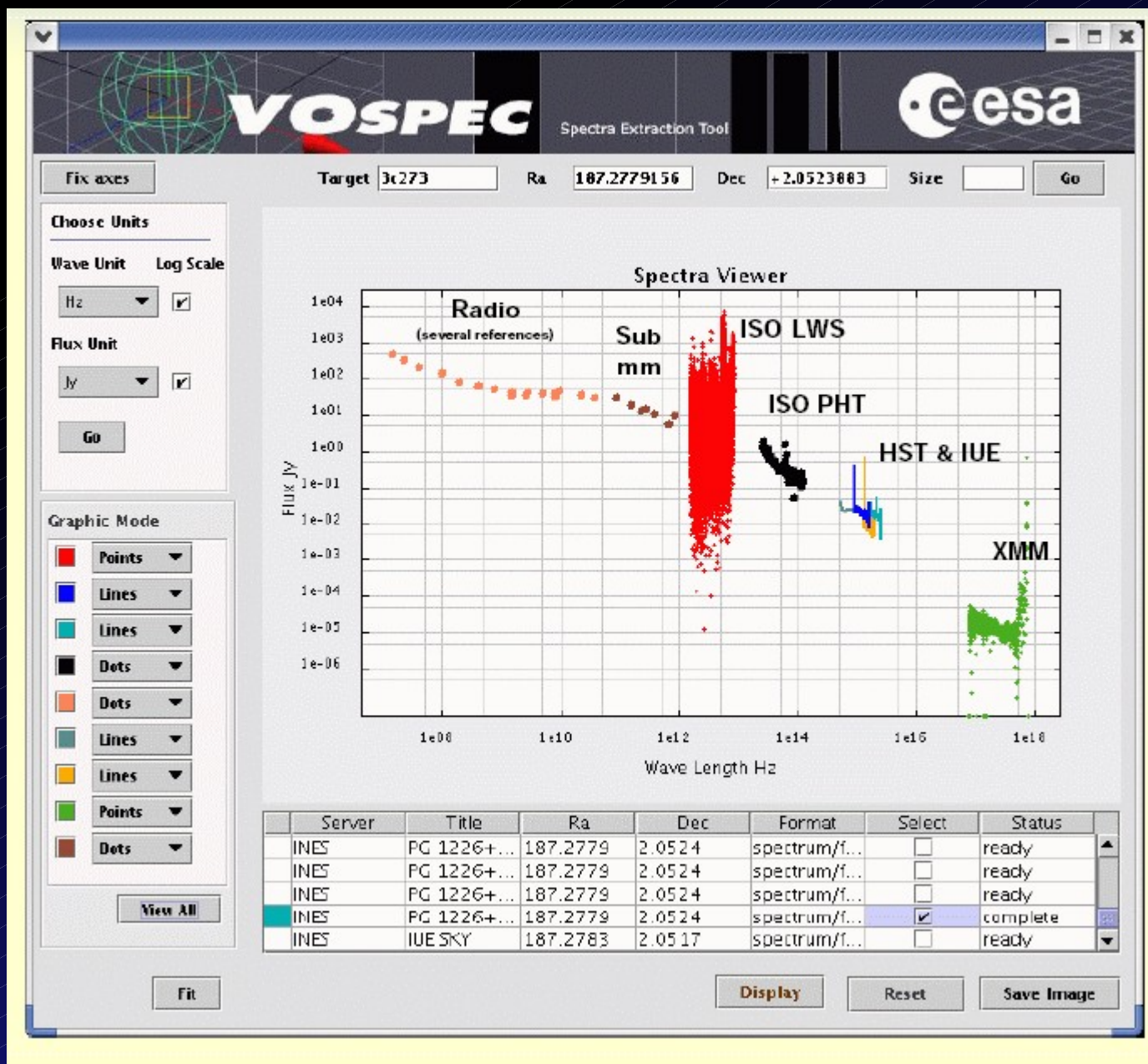
# SPLAT-VO (Starlink, JAC)



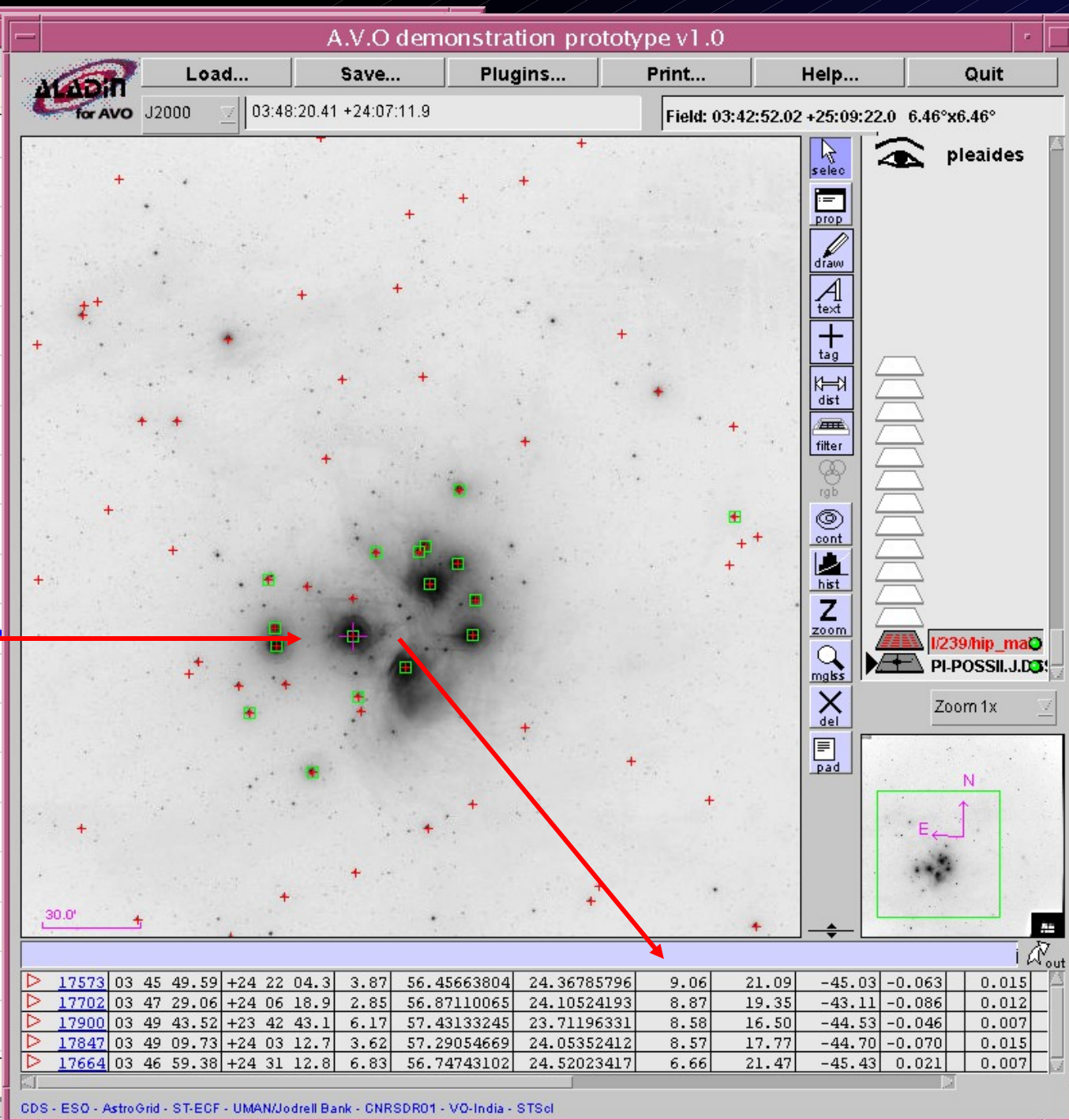
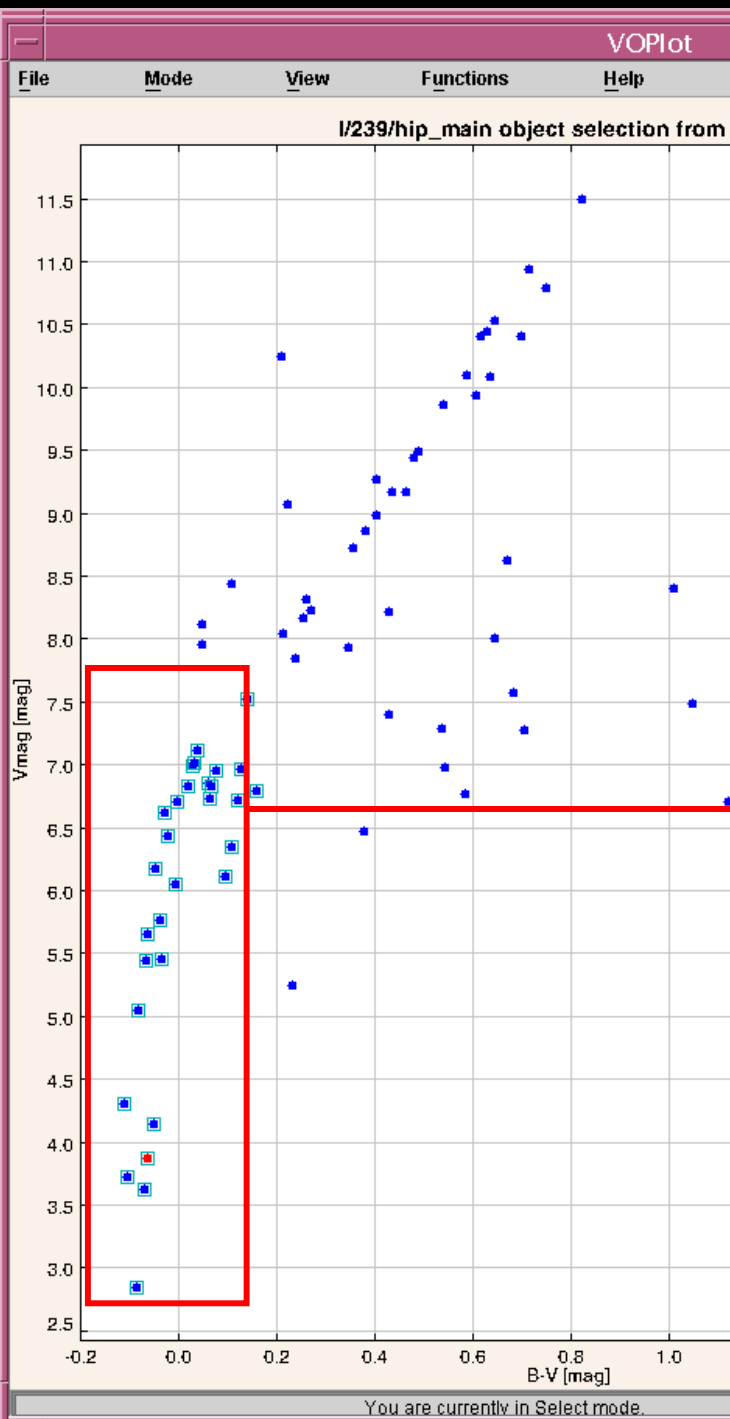
# SpecView (STScI)



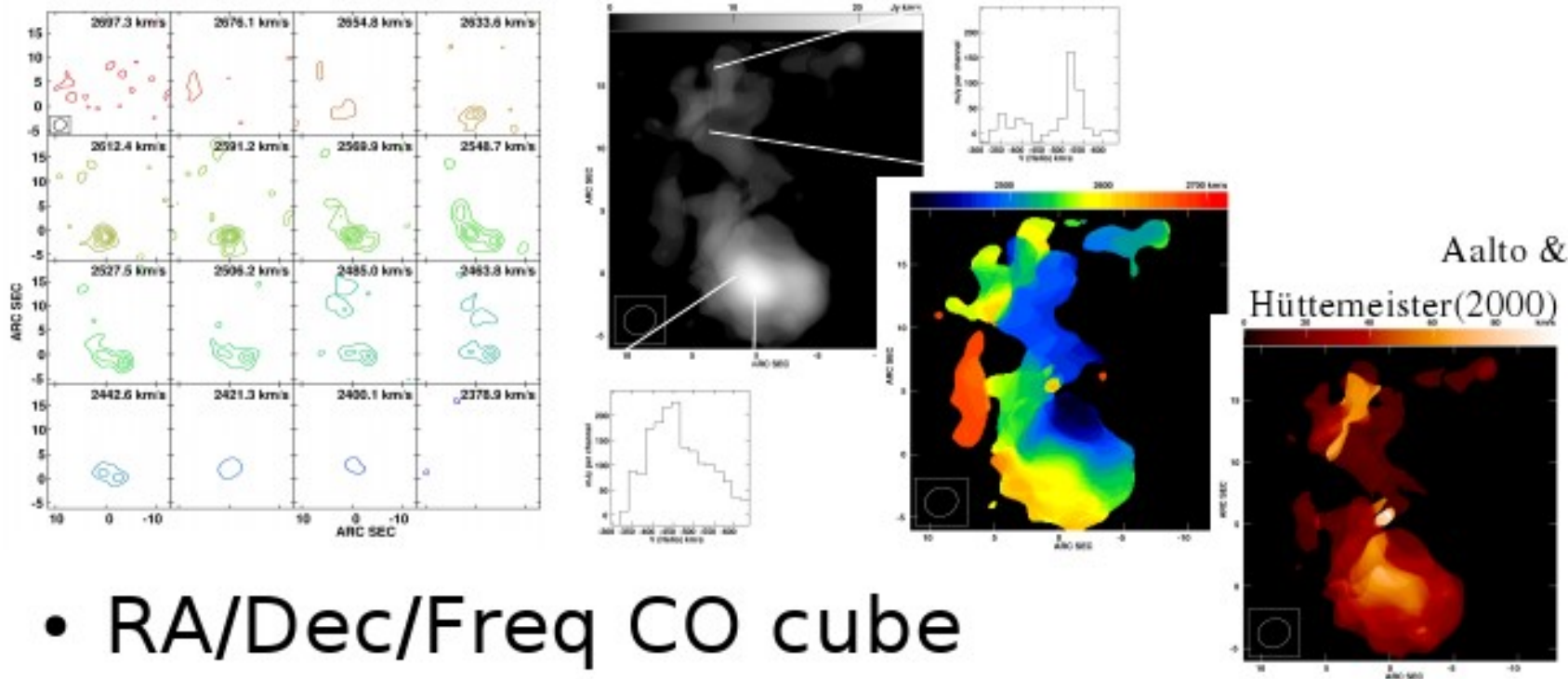
# VOSpec (ESAC)



# Colour-magnitude diagram



# 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

**Molecular line databases**

<http://esavo02:8080/cieloslapToolKit/cieloslap.jsp?>

Select

Range of Search (m)

Wavelength Start  Wavelength End

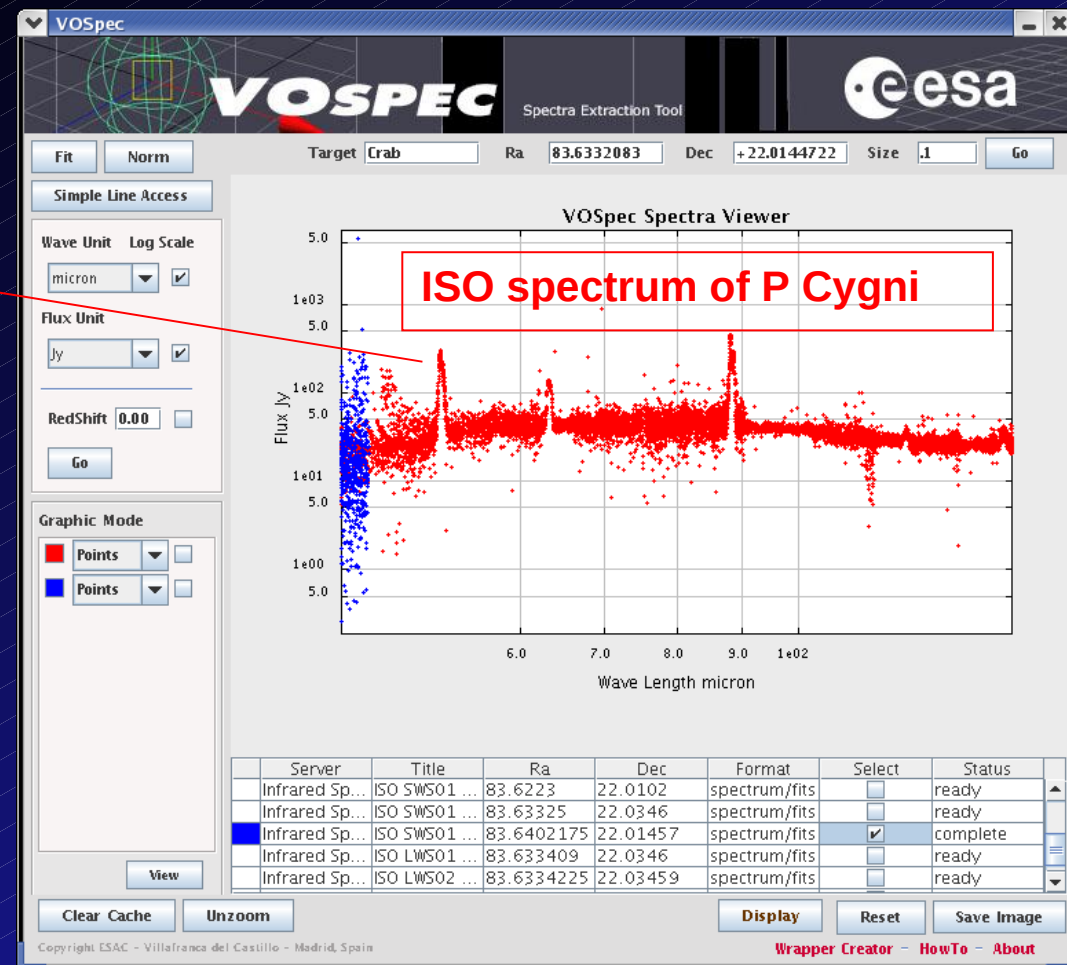
Reset

Slap Services Output

**CIELO SLAP**

Idm:Line.wavelength	Idm:Source...	Source.co...	Source.co...	Idm:Li...	Idm:...	Id...	Id...	Idm:...	I...
1.8627e-09	NGC1068	40.66963	-0.01328	1s_3p	1s2	1P1	1S0	OVII	...
1.7768e-09	NGC1068	40.66963	-0.01328	1s_4p	1s2	1P1	1S0	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	1S0	OVII	...
2.1602e-09	NGC1068	40.66963	-0.01328	1s_2p	1s2	1P1	1S0	OVII	...
2.18071e-09	NGC1068	40.66963	-0.01328	1s_2p	1s2	3P1	1S0	OVII	...
2.1621e-09	NGC1068	40.66963	-0.01328	1s_2p	1s2	3P1	1S0	OVII	...

Close



(IVOA Line Data Model: Dubernet, Osuna et al., in preparation)  
(Simple Line Access Protocol: Salgado et al., in preparation)

# **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, VOSpec)

(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.





Theoretical model services

Documents

Models

Services

Funded by



Services: VOSA Filters TSAP S3if

esm@laeff.inta.es Uploads LogOut

### TSAP Interface

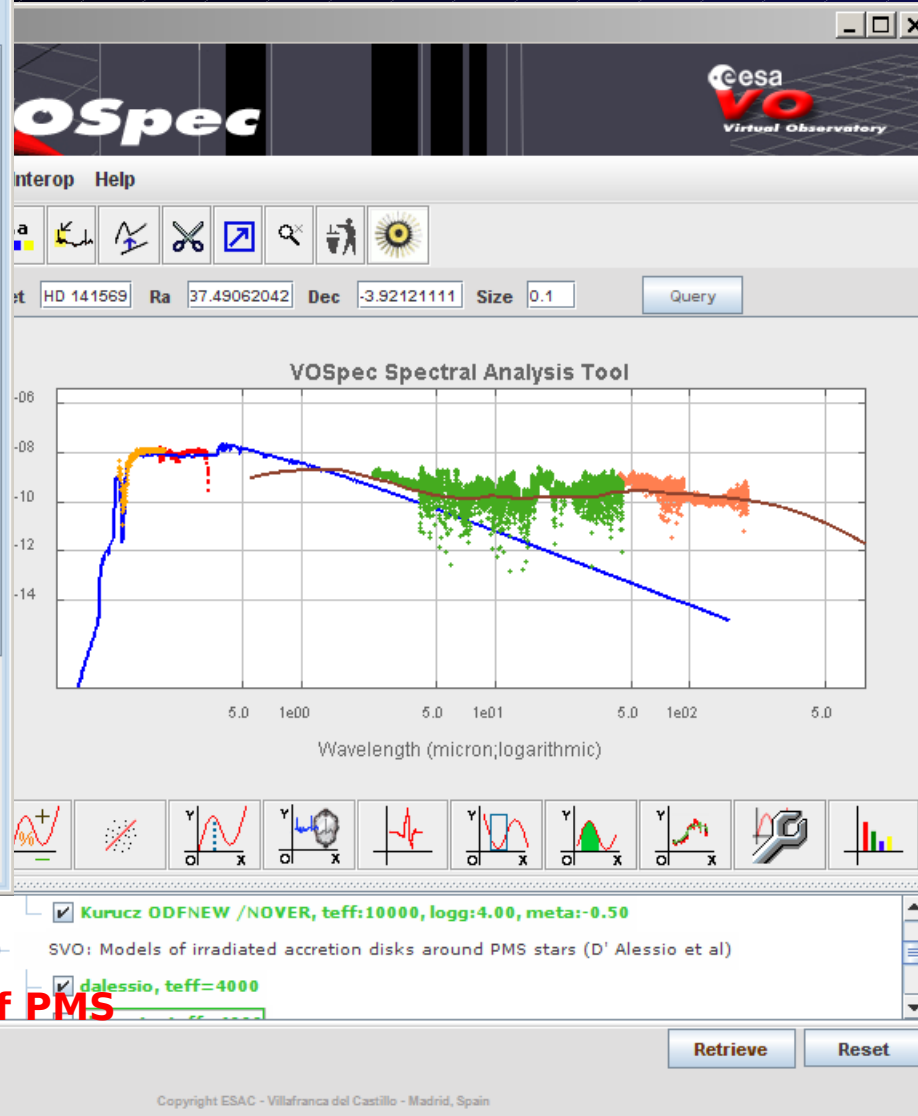
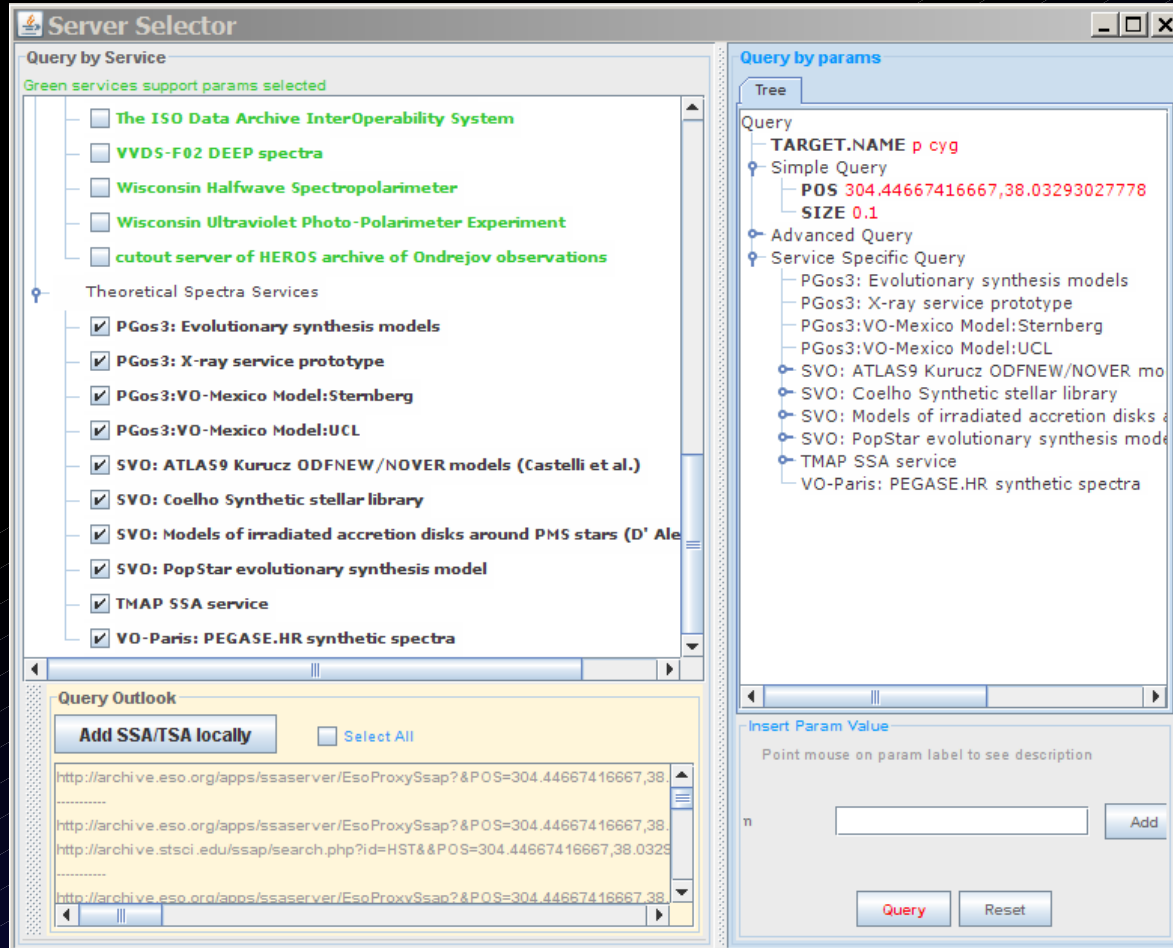
SVO Theoretical Data Access Service: ATLAS9 Kurucz ODFNEW/NOVER models (Castelli et al., 1997, AA, 318, 841)

teff_min:	<input type="text" value="3500"/>	(min value for the effective temperature for the model. Temperatures are given in K)
teff_max:	<input type="text" value="3500"/>	(max value for the effective temperature for the model. Temperatures are given in K)
logg_min:	<input type="text" value="0.00"/>	(min value for Log(G) for the model.)
logg_max:	<input type="text" value="0.00"/>	(max value for Log(G) for the model.)
meta_min:	<input type="text" value="-2.50"/>	(min value for the Metallicity for the model.)
meta_max:	<input type="text" value="-2.50"/>	(max value for the Metallicity for the model.)

Search

See metadata VOTable

# VOSpec - models by TSAP

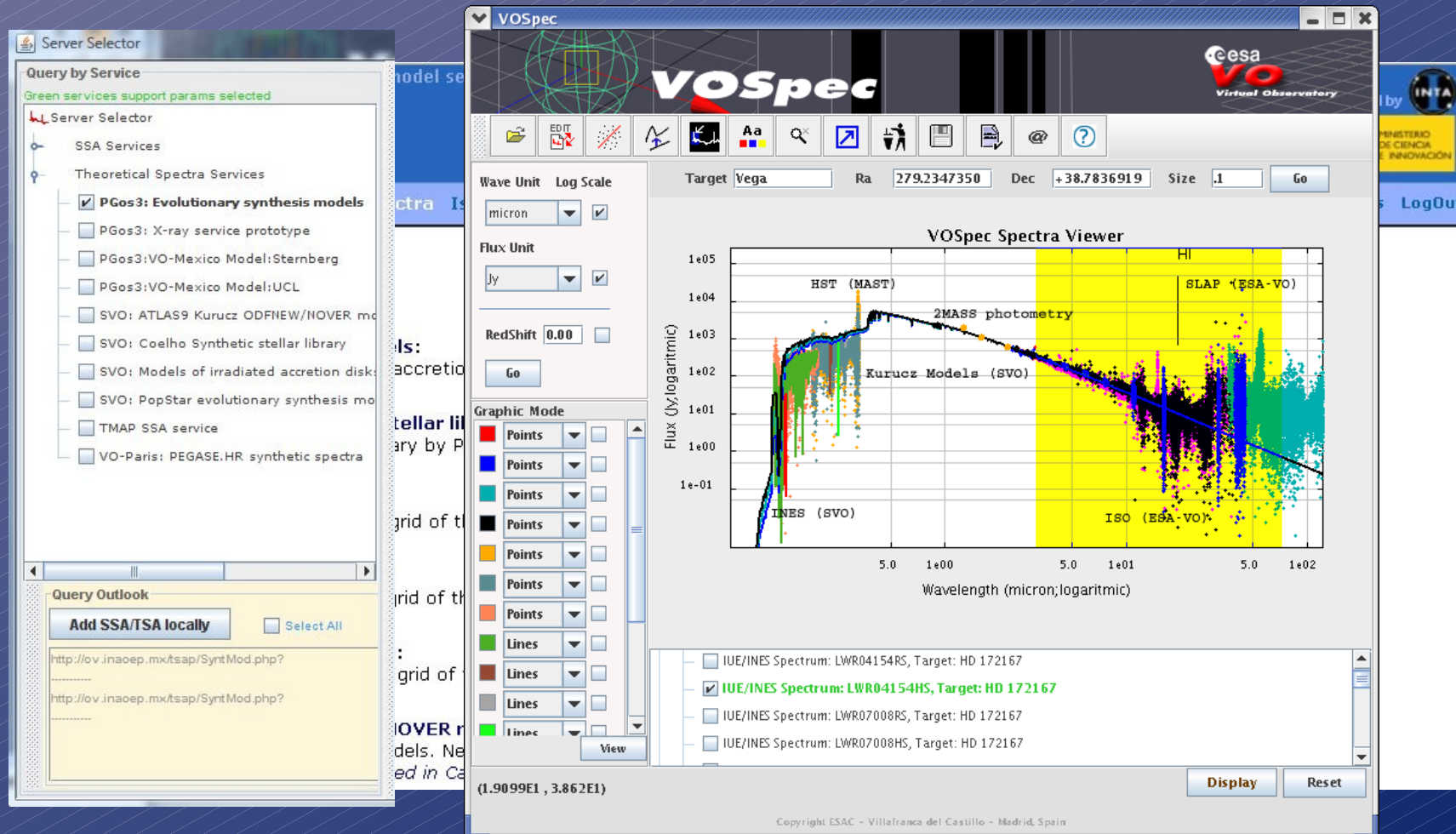


**Kurucz stellar model and D'Alessio model of PMS discs fit to UV and IR spectra of HD 141569**


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

Simple Spectral Access Protocol V1.04

## Appendix A: Theoretical Spectral Access Use Case



- Other VO Data Centres providing theoretical spectra using TSAP



# German Astrophysical Virtual Observatory

Archive:

TMAP Spectra

More information on archive

Effective temperature in K:

120000 +/- 1000

Surface gravity (log g) in cm/s2:

6 +/- 1

Mass fraction 0:

none

0.0 +/- 0.3 dex

Mass fraction 1:

none

0.0 +/- 0.3 dex

Mass fraction 2:

none

0.0 +/- 0.3 dex

Mass fraction 3:

none

0.0 +/- 0.3 dex

Mass fraction 4:

none

0.0 +/- 0.3 dex

Mass fraction 5:

none

0.0 +/- 0.3 dex

Mass fraction 6:

none

0.0 +/- 0.3 dex

Mass fraction 7:

none

0.0 +/- 0.3 dex

Band:

/

m

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

Data format:

all

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.)

Help

Reset

Start search

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

# 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>

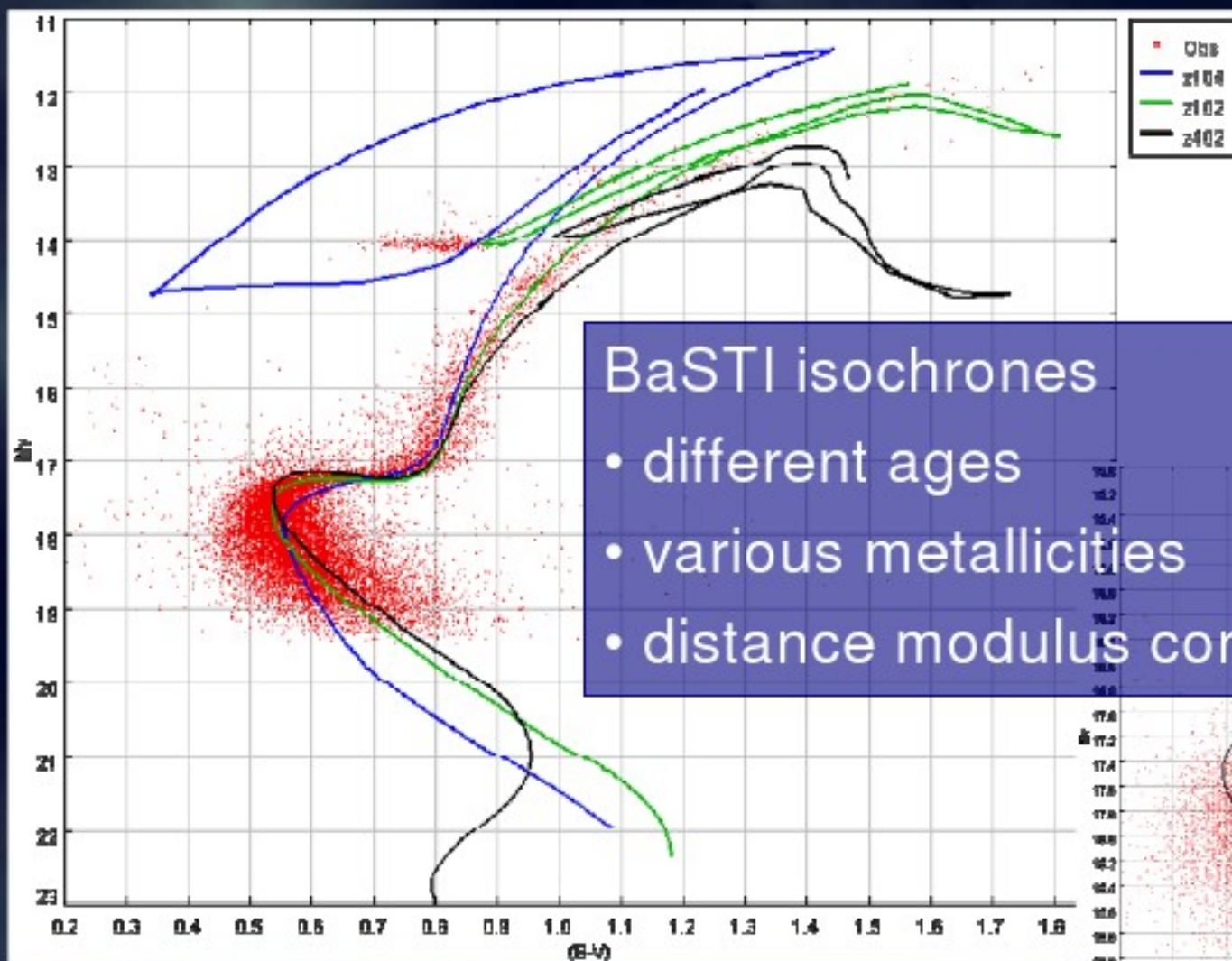
We developed two prototype implementations of S3P for BaSTI: one for isochrones and one for tracks:

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

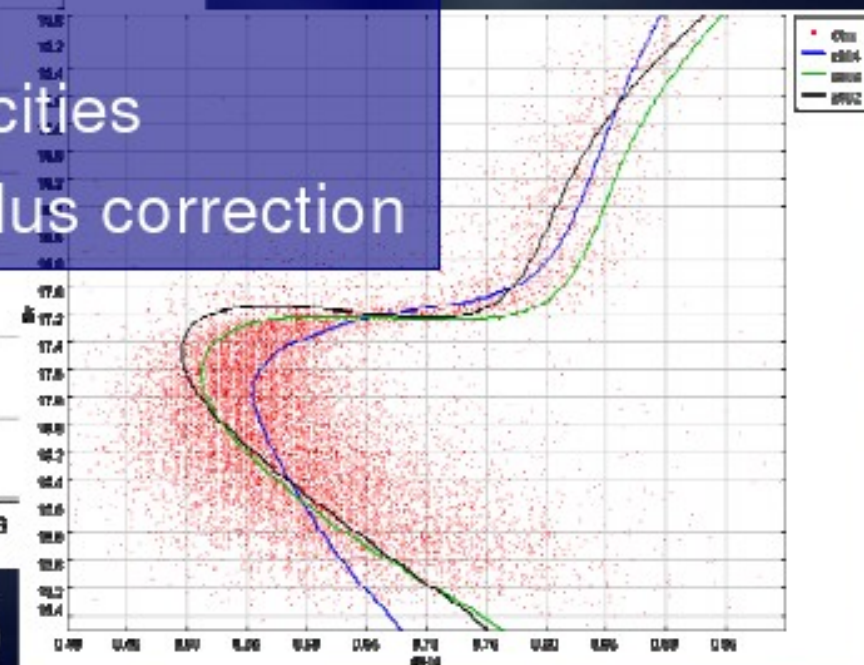
<http://albione.oa-teramo.inaf.it/PHPmetadata/BaSTItrack.php?format=metadata>

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

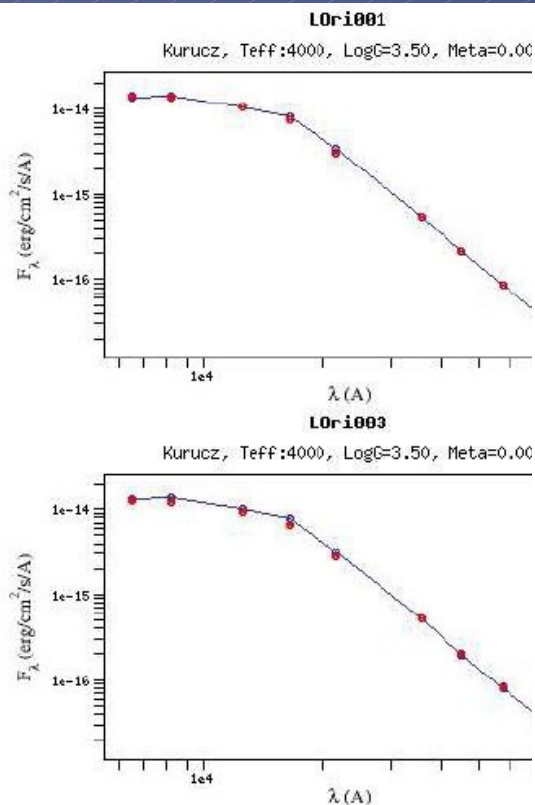


**VOSA: VO Sed Analyzer**

VO SED Analyzer

Services: VOSA Filters TSAP S3if

Object	Model	$T_{\text{eff}}$	$\text{LogG}$	Metallicity	$\chi^2$
LO-i001	Kurucz	4000	3.50	0.00	1.71e
LO-i002	NextGen	3800	4.5	0	1.44e
LO-i003	Kurucz	4000	3.50	0.00	5.05e
LO-i004	Kurucz	3750	4.00	0.00	2.82e
LO-i005	NextGen	4000	4.0	0	9.20e
LO-i006	Kurucz	4000	3.50	0.00	3.36e
LO-i007	Kurucz	4000	4.50	0.00	2.49e
LO-i008	Kurucz	4000	3.50	0.00	4.43e
LO-i009	NextGen	4000	3.5	0	6.22e
LO-i010	NextGen	4200	4.0	0	1.87e
LO-i011	NextGen	3900	4.5	0	1.20e
LO-i012	NextGen	4000	4.5	0	6.58e
LO-i013	NextGen	3700	4.5	0	3.50e
LO-i014	Kurucz	4000	4.50	0.00	4.70e
LO-i015	Kurucz	4000	3.50	0.00	8.73e
LO-i016	Kurucz	3750	4.50	0.00	5.53e
LO-i017	NextGen	4200	4.0	0	7.58e
LO-i018	Kurucz	3750	3.50	0.00	4.31e
LO-i019	Kurucz	3750	3.50	0.00	1.90e
LO-i020	NextGen	3800	4.5	0	2.98e
LO-i021	Kurucz	4000	3.50	0.00	3.08e
LO-i022	Kurucz	3750	4.00	0.00	1.76e
LO-i023	NextGen	4000	4.5	0	2.35e
LO-i024	Kurucz	3750	3.50	0.00	2.22e
LO-i025	NextGen	3700	4.5	0	1.37e
LO-i026	NextGen	3700	4.5	0	4.81e
LO-i027	NextGen	4000	4.5	0	2.35e
LO-i028	Kurucz	3750	4.00	0.00	1.28e
LO-i029	NextGen	3100	4.5	0	7.28e
LO-i030	NextGen	3700	4.5	0	2.15e
LO-i031	NextGen	3800	4.5	0	2.77e
LO-i032	NextGen	3700	4.5	0	1.70e
LO-i033	NextGen	3700	4.5	0	7.12e
LO-i034	NextGen	3000	4.0	0	1.77e
LO-i035	NextGen	3700	4.5	0	1.81e



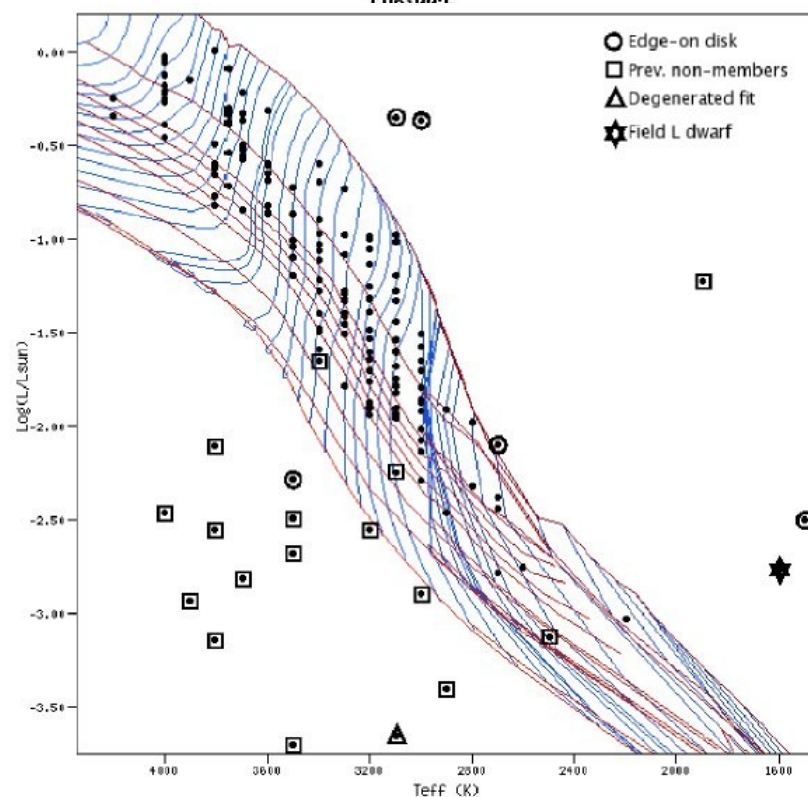
Astronomy & Astrophysics manuscript no. Synth VO PR1 ref format

August 2, 2008

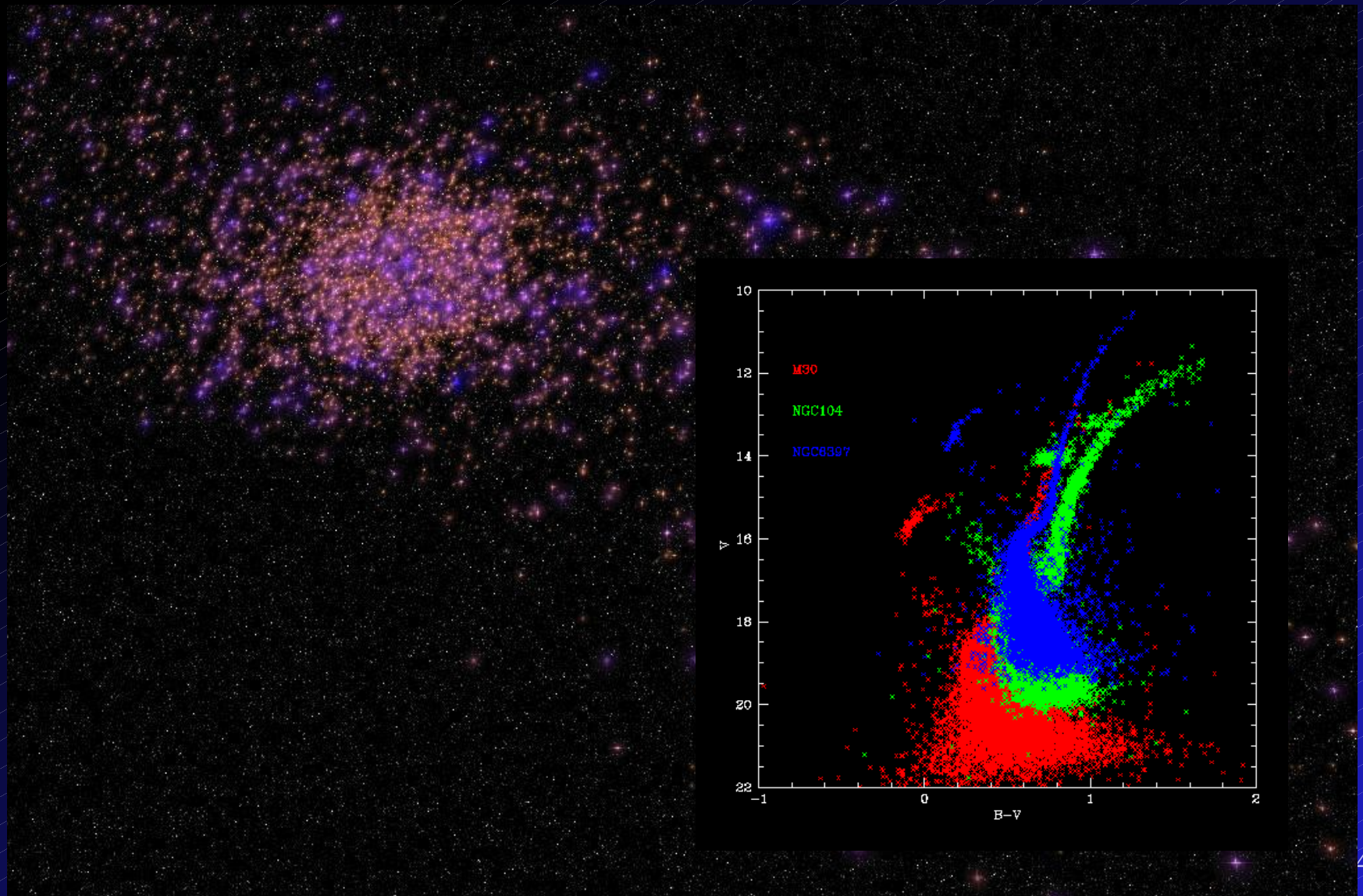
## VOSA: Virtual Observatory SED Analyzer.

### An application to the Collinder 69 open cluster

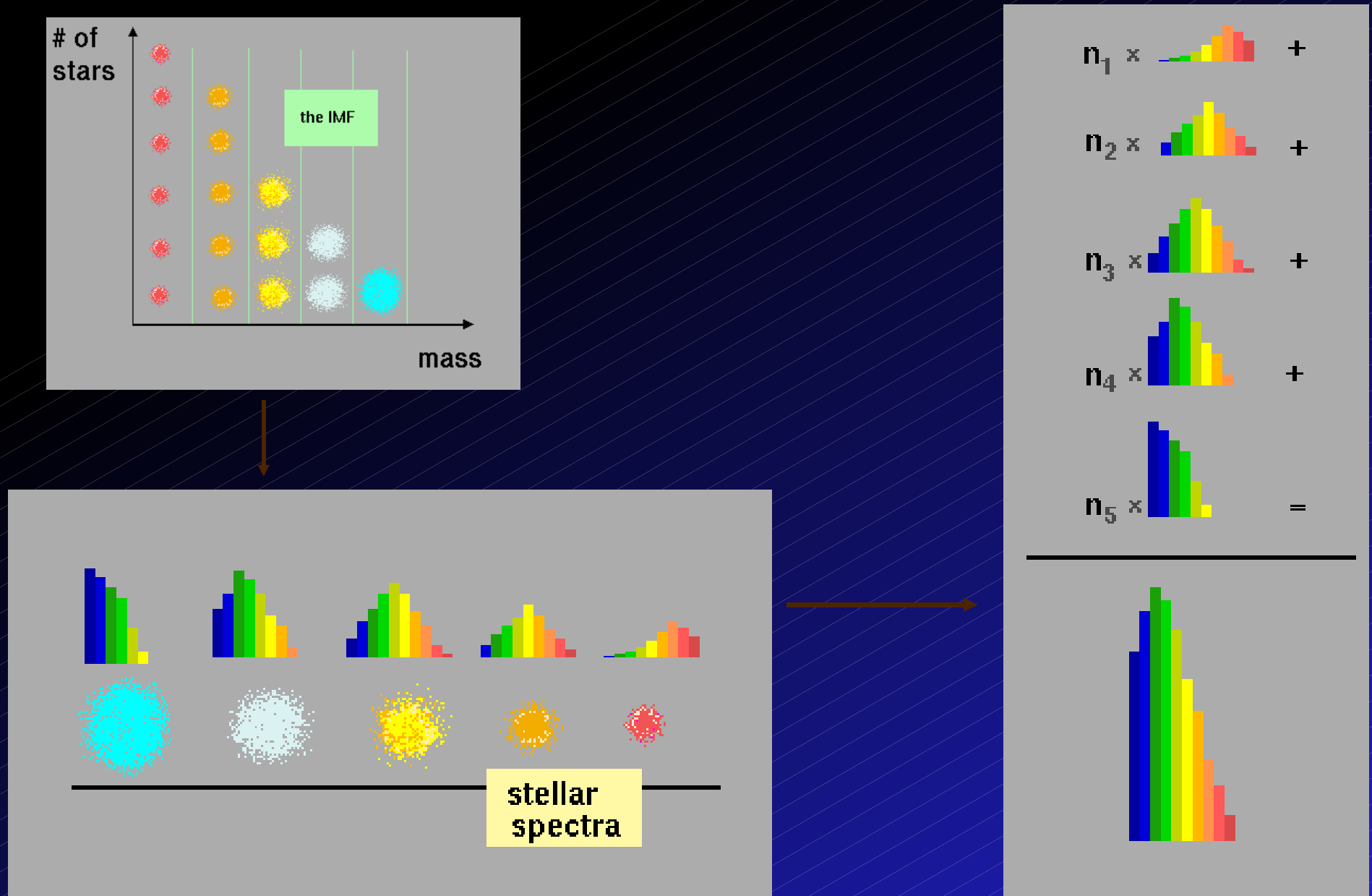
A. Bayo<sup>1,2</sup>, C. Rodrigo<sup>1,2</sup>, D. Barrado y Navascués<sup>1,2</sup>, E. Solano<sup>1,2</sup>, R. Gutiérrez<sup>1,2</sup>, M.



# N Body Simulations of Globular Cluster Evolution



# Stellar populations are modeled with synthesis models



# Using SimDB/SimDAP

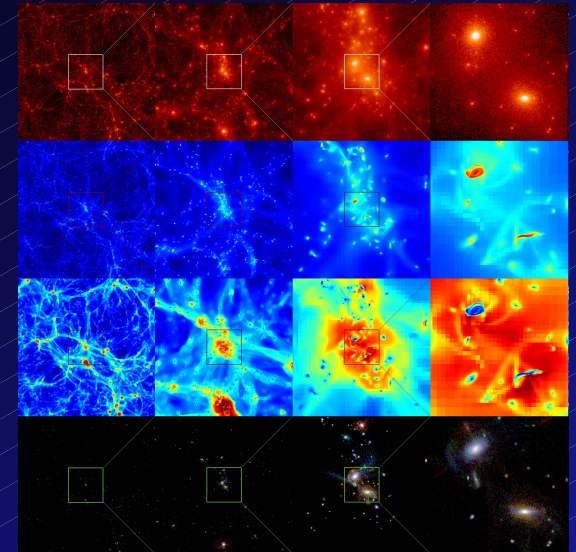
- Cosmological simulations
  - Prototypes for GalMER, Horizon
- PDR simulations
  - test implementation of Meudon PDR code
- Isochrones/evolutionary tracks
  - BaTSI
- Visualization tools
  - VisIVO

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

millimil (context)

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**



# Millennium Run

$10^{10}$  particles

Several Gpc to  
10 kpc

Cube 2 billion ly

One month MPSSC  
25 TB

Evolution of 20 mil  
galaxies

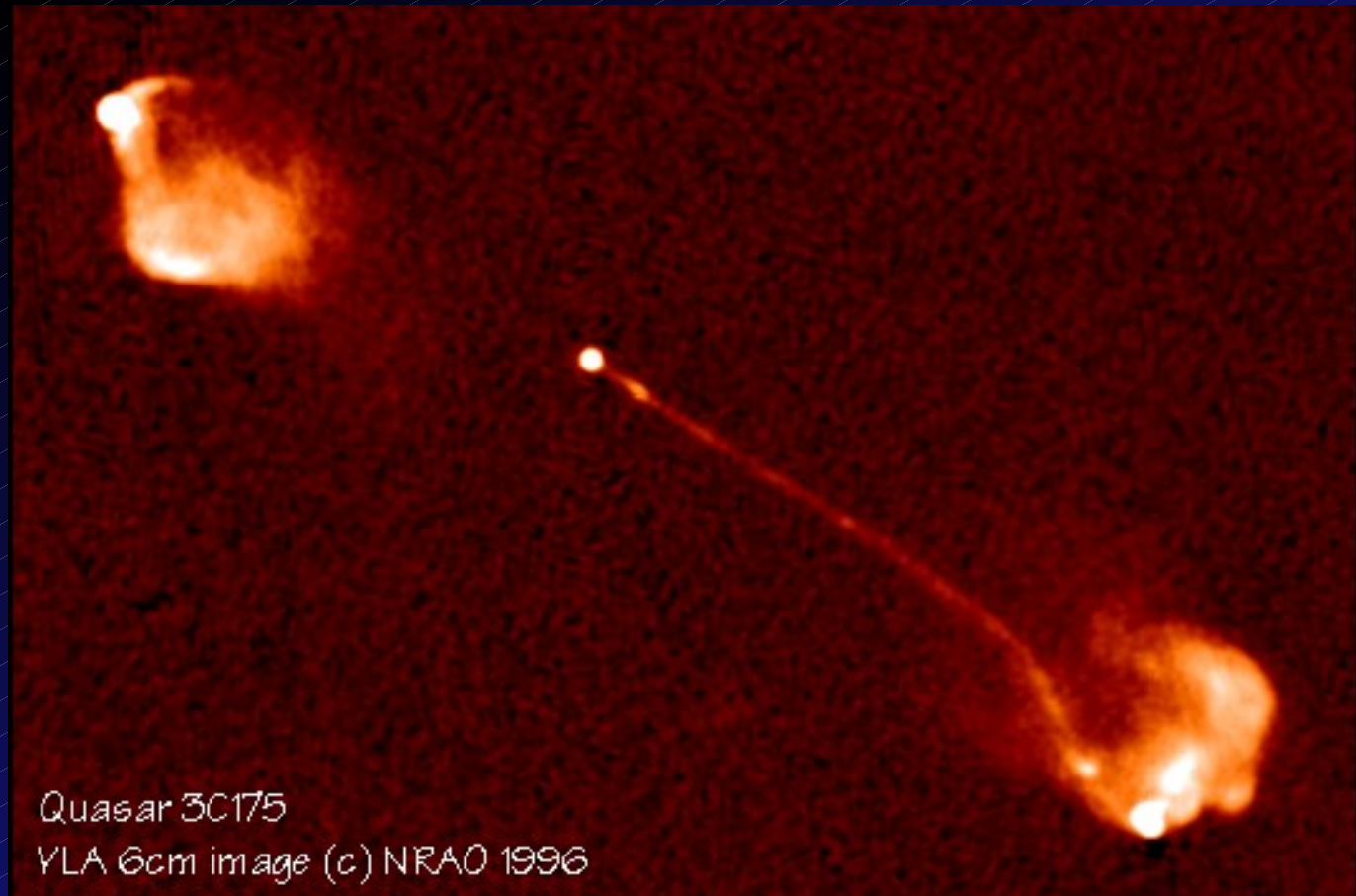
Evolution merger tree

Millennium Run  
10,077,696,000 particles

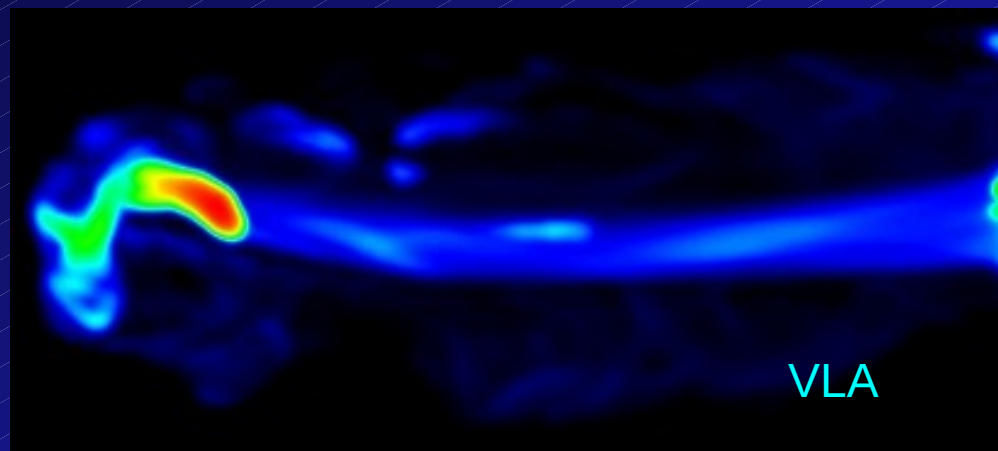
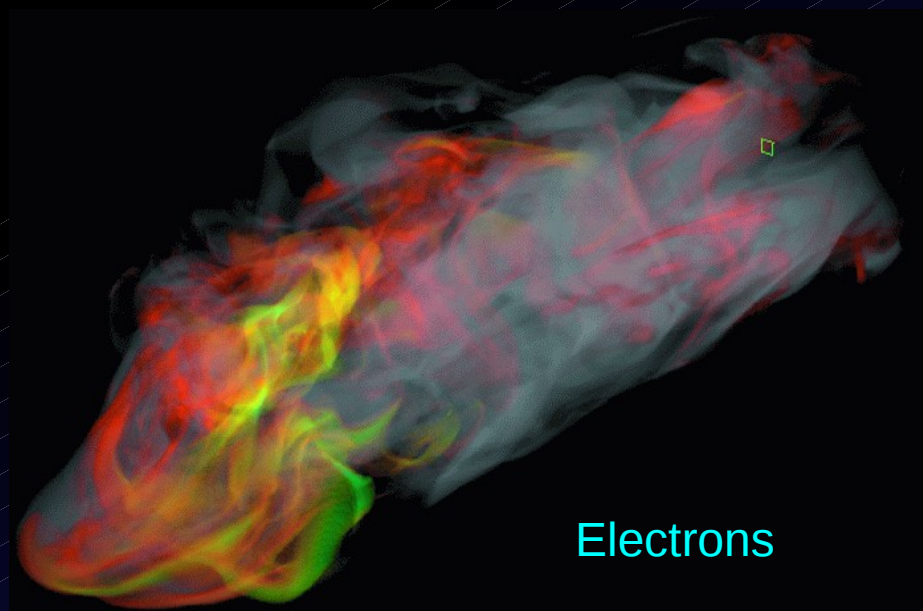


# Collimated Outflows from AGN

- 3C 175

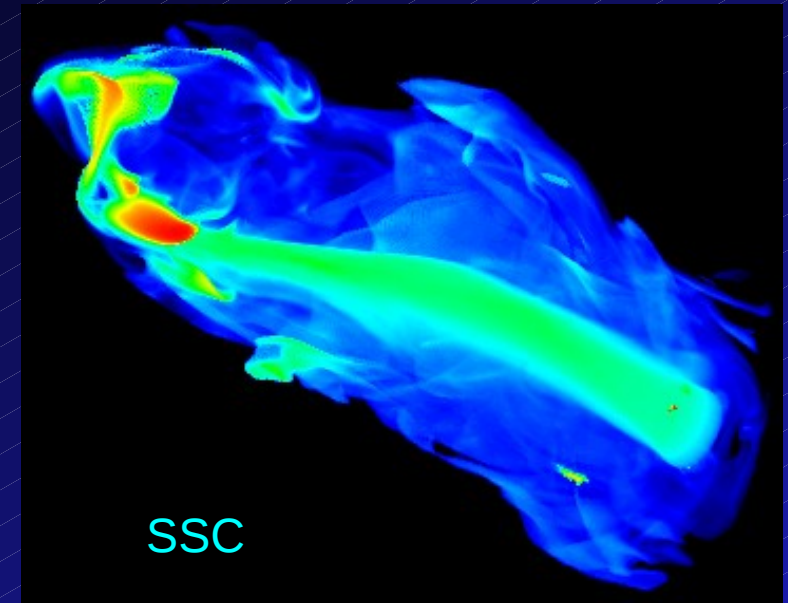
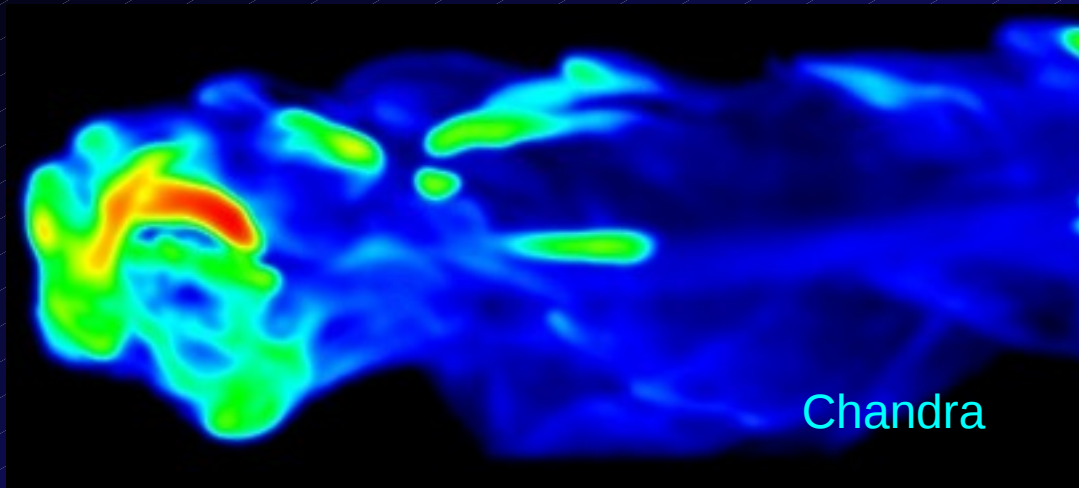
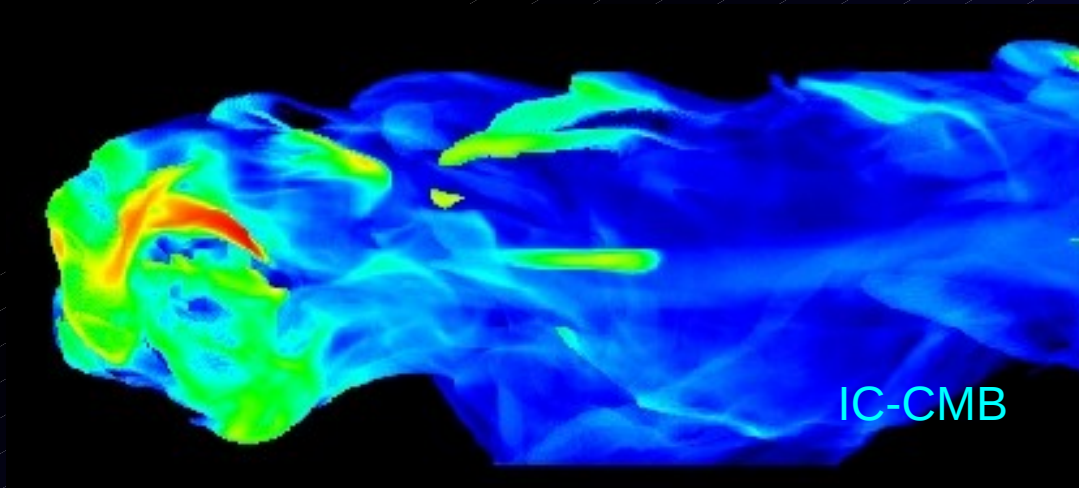


# MHD Simulations of Collimated Outflows from AGN - Virtual Telescope Observations



Compare with  
Radio  
Archives

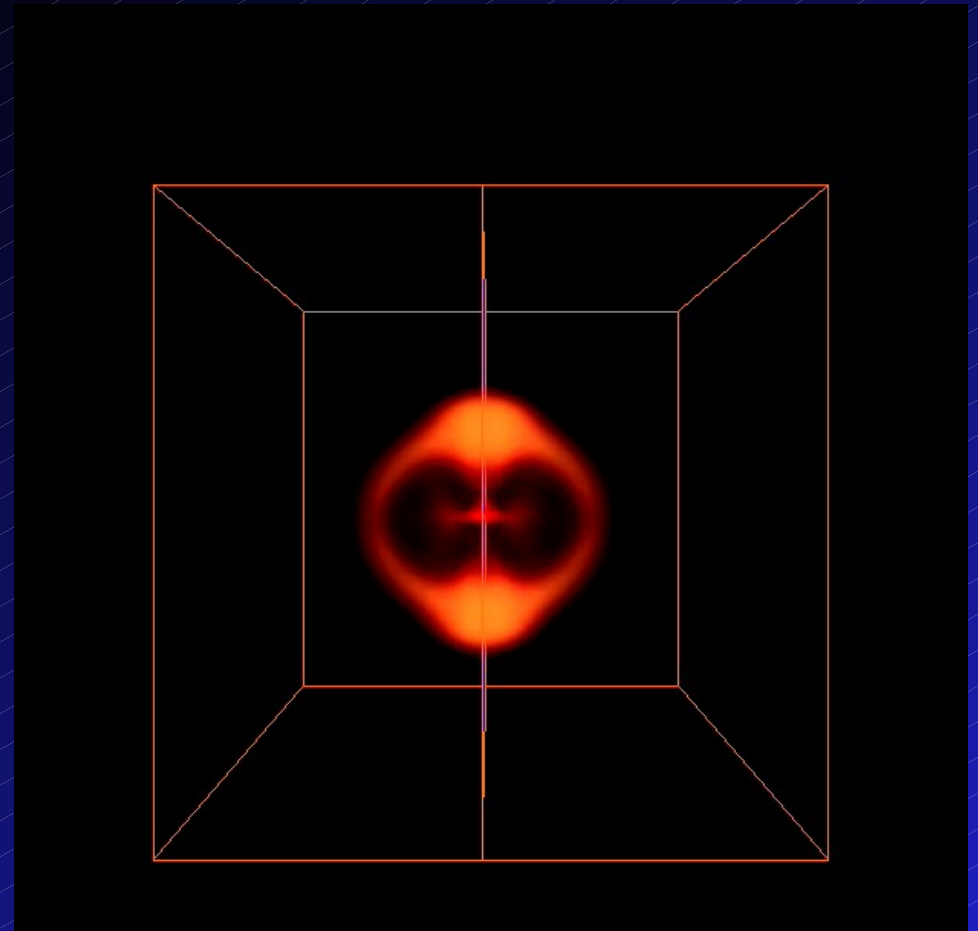
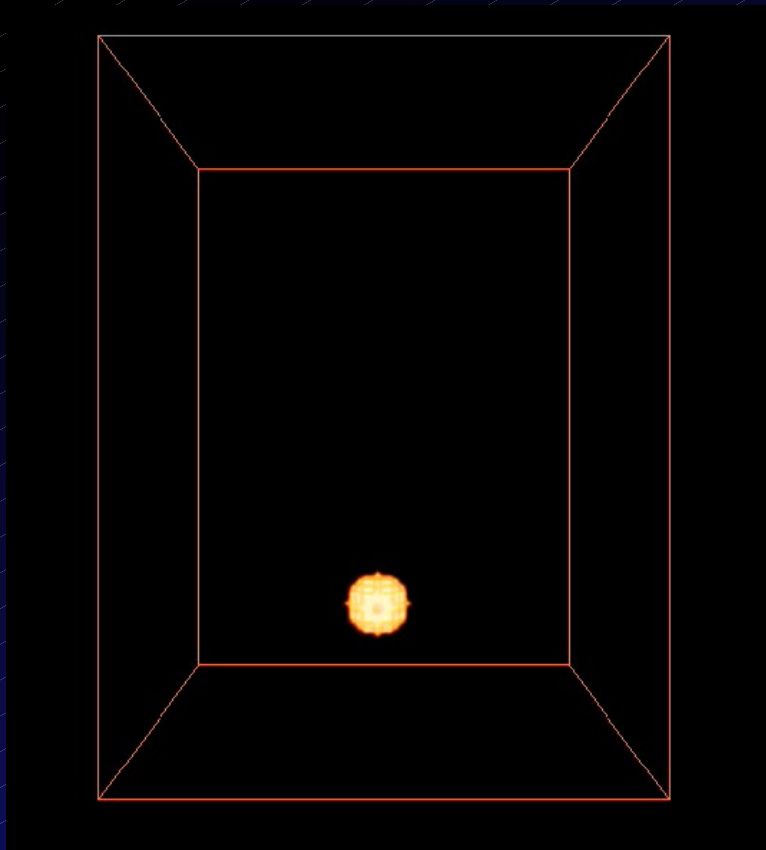
# MHD Simulations of Collimated Outflows from AGN - Virtual Telescope Observations



Compare with  
Chandra Archives

# Three Dimensional MHD Calculations

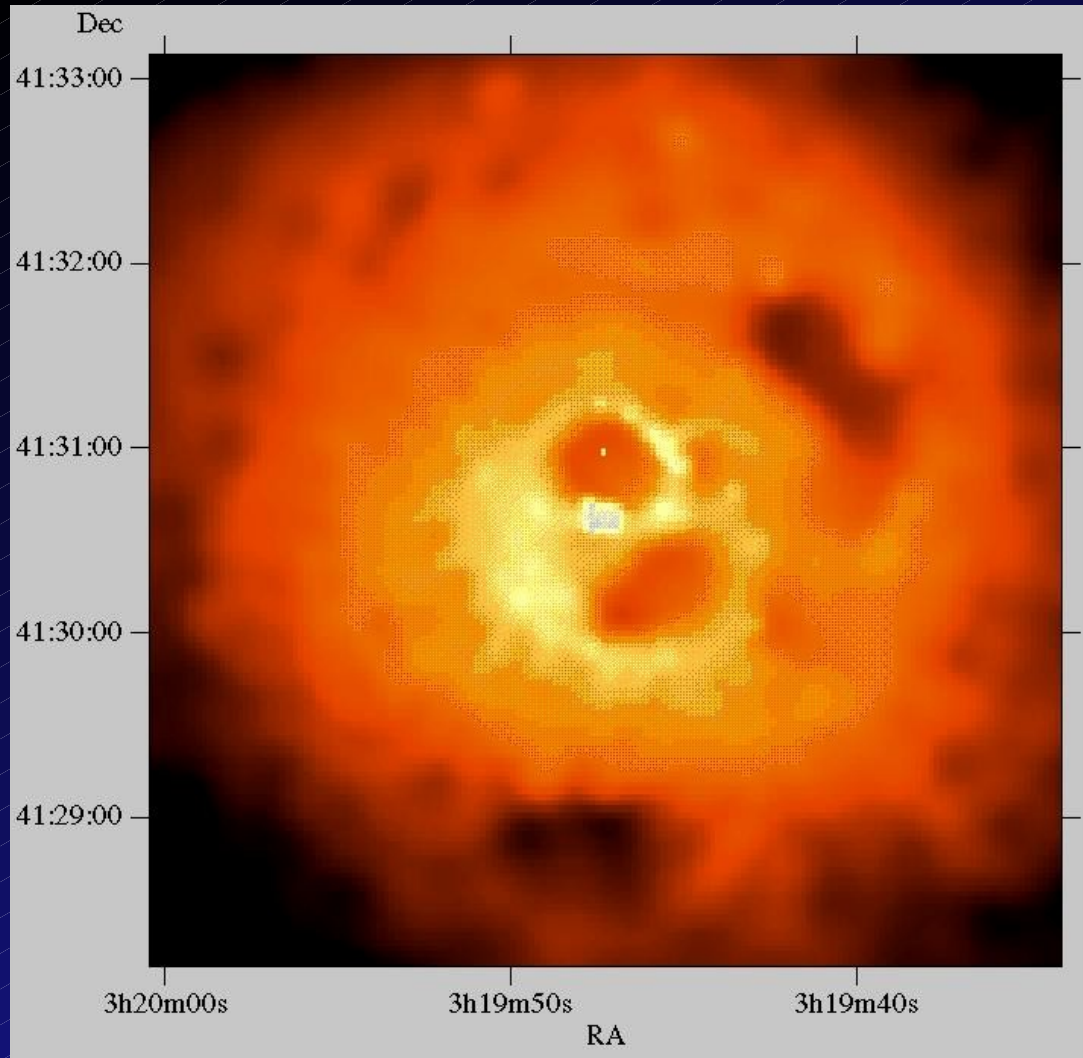
- $\beta = 3000$



# Relic Radio Bubbles in Galaxy Clusters

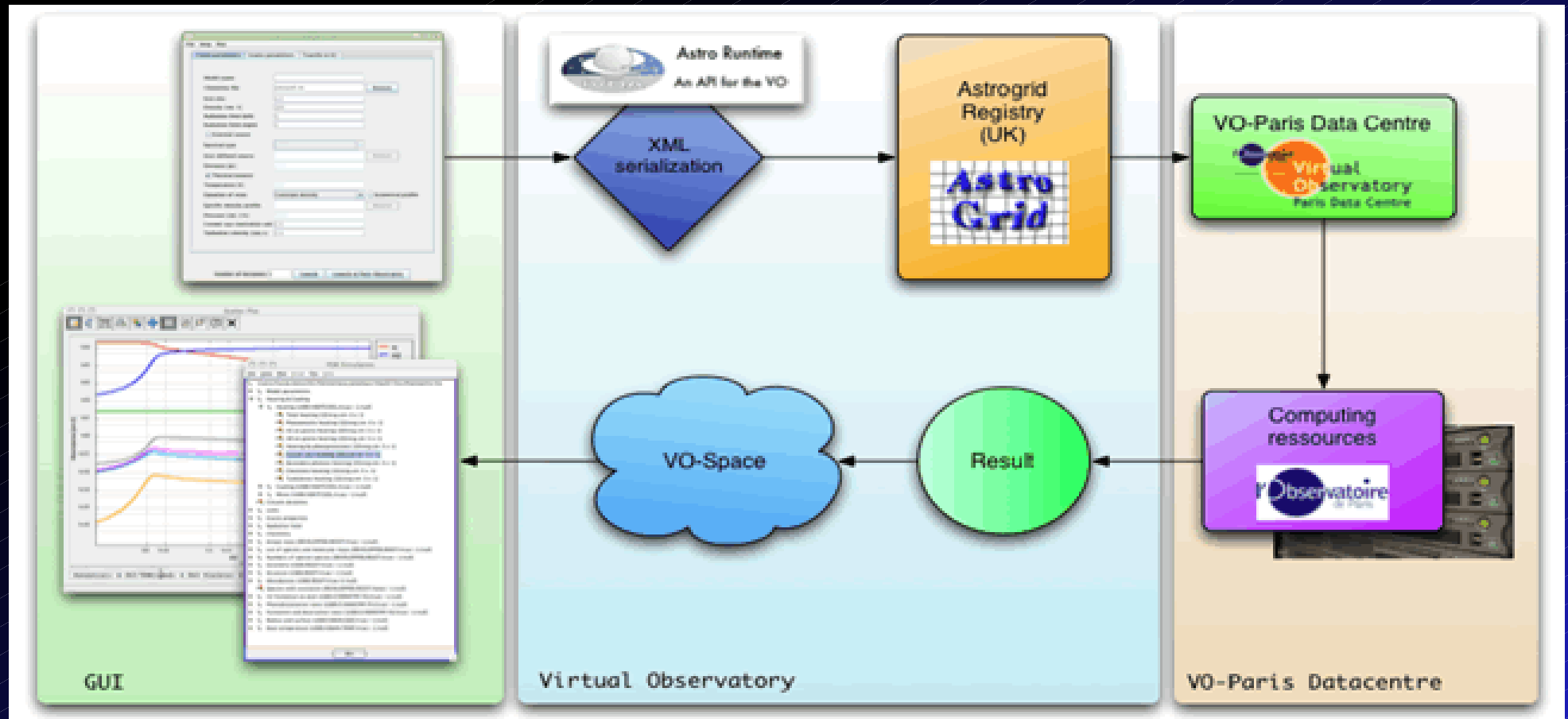
- N1275

Compare  
with  
Chandra  
Archives



Fabian et al. 2000

# PDR VO-infrasctructure



# PDR database and clients

## ❑ PDR Database

### Output Files

Code produces

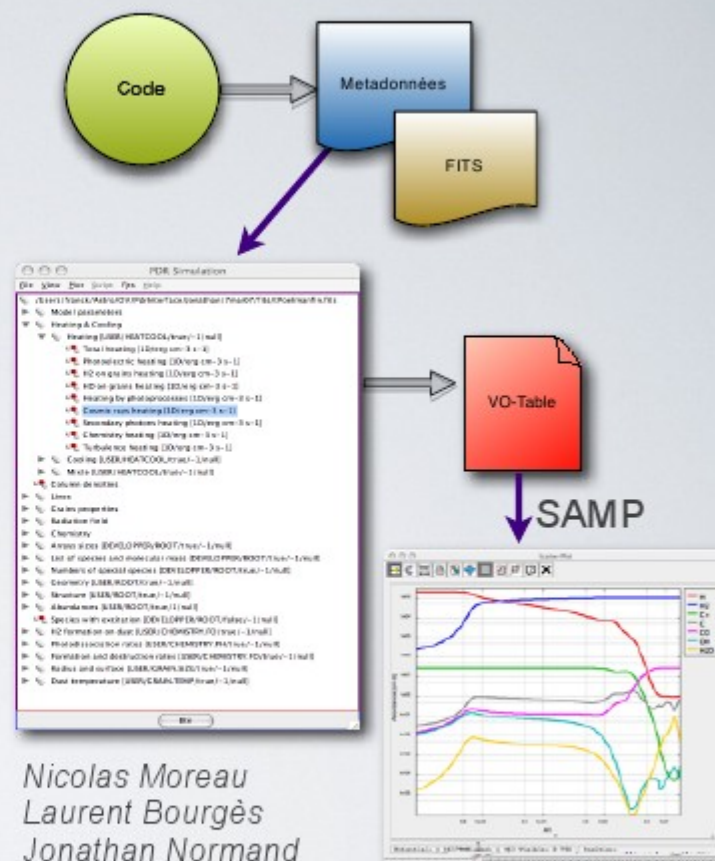
- raw data : FITS File
- XML / VO-TABLE : meta-data (name, description, units, UCD, ...)

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

The screenshot displays the VO Explorer - PDR application window. The interface is divided into several sections:

- Left Panel:** Contains a 'Resource Lists' sidebar with 'Examples', 'PDR', 'CEA', and 'New Smartlist'. Below this are 'Actions' (New Smart List, Execute Task) and 'About' (Selection: CeaApplication, Further Info, Email Curator).
- Top Panel:** Shows 'Contents of PDR - 3 resources' with filters for 'Content - Subject', 'Coverage - Waveband', and 'Resource Type'. The 'Content - Subject' list includes 'unknown', '???', 'chemistry', 'interstellar gas', 'interstellar matter', 'interstellar medium', 'interstellar molecules', and 'models'. The 'Coverage - Waveband' list includes 'unknown', 'infrared', 'millimeter', 'optical', 'radio', and 'uv'. The 'Resource Type' list includes 'CeaApplication', 'DataService', and 'Organisation'.
- Table:** A table with columns 'Status', 'Flag...', 'Title', 'Capability', and 'Date'. It lists three resources: 'Meudon PDR code' (Status: red circle, Title: Meudon PDR code, Capability: icon, Date: 2007-12-14), 'Meudon PDR code' (Status: black circle, Title: Meudon PDR code, Capability: icon, Date: 2007-04-11), and 'VO-Paris' (Status: black circle, Title: VO-Paris, Capability: icon, Date: 2007-04-11).
- Bottom Panel:** Displays detailed information for the selected 'Meudon PDR code' resource. It includes a description of the code, its interfaces, version, and creator. The description states: 'The Meudon PDR code is a tool to model the physics and the chemistry of interstellar gas at stationary state. It considers a stationary 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...](#)'. The interfaces are listed as 'simple'. The version is '1.0' and the date is 'representative : 2006-01-12'. The creator is 'VO Paris'.

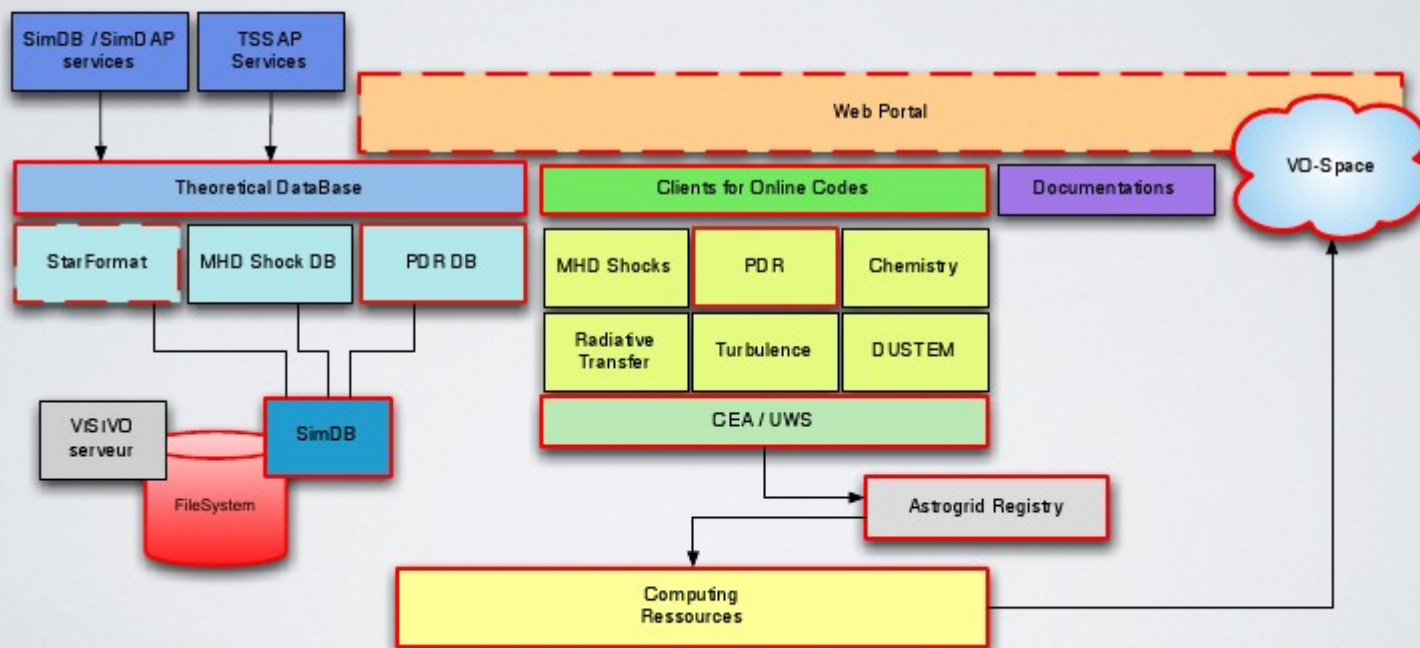
# ISM platform

## □ Interstellar Medium Platform

Bring together expertise in modeling / simulation of the ISM

Provide theoretical services about ISM

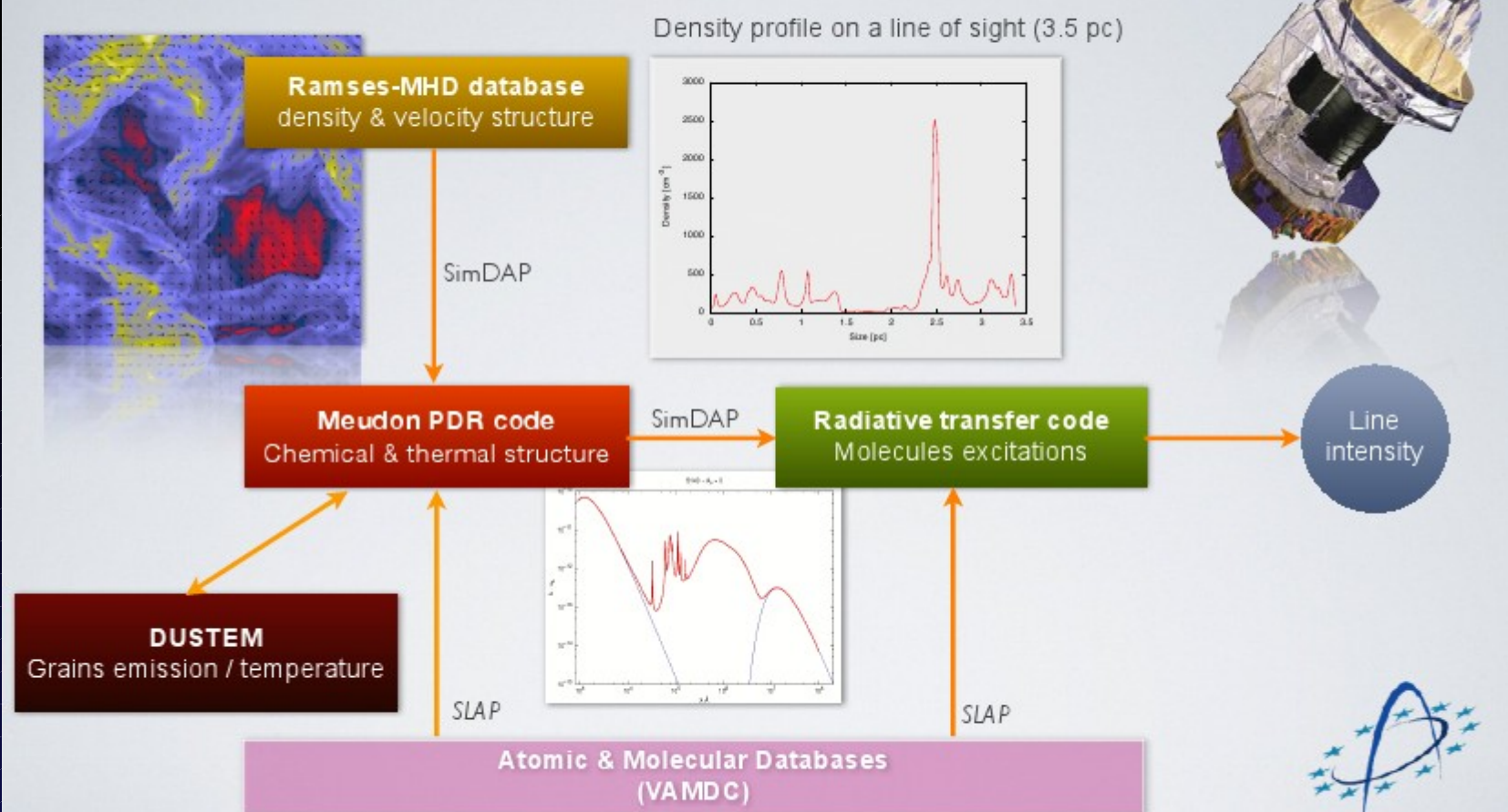
### Codes - Databases - Tools & services



# Complex join of TVO bricks

## Interstellar Medium Platform

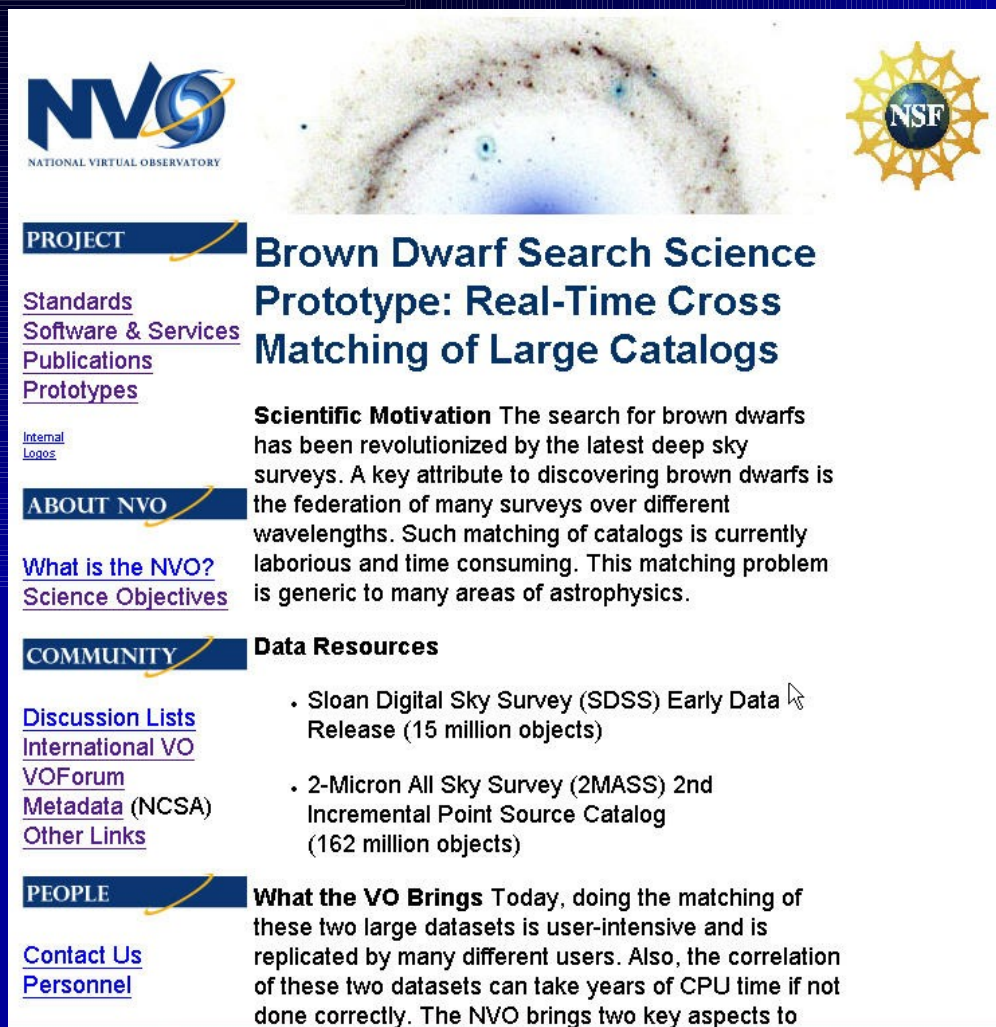
STARFORMAT project (PI: P. Hennebelle)



# 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



The screenshot shows the NVO Project website. At the top left is the NVO logo (National Virtual Observatory) and at the top right is the NSF logo. The main heading is 'PROJECT Brown Dwarf Search Science Prototype: Real-Time Cross Matching of Large Catalogs'. Below this, there are links for 'Standards', 'Software & Services', 'Publications', and 'Prototypes'. A section titled 'ABOUT NVO' contains links for 'What is the NVO?', 'Science Objectives', and 'COMMUNITY'. The 'COMMUNITY' section lists 'Data Resources' including 'Sloan Digital Sky Survey (SDSS) Early Data Release (15 million objects)' and '2-Micron All Sky Survey (2MASS) 2nd Incremental Point Source Catalog (162 million objects)'. A 'PEOPLE' section at the bottom has links for 'Contact Us' and 'Personnel'. A large astronomical image of a spiral galaxy is in the background.

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

[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](#)

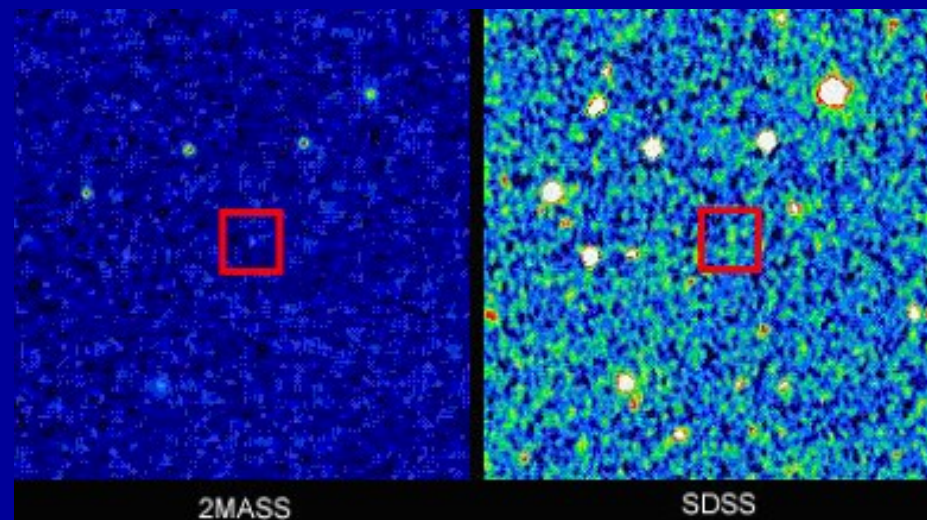
**Scientific Motivation** The search for brown dwarfs has been revolutionized by the latest deep sky surveys. A key attribute to discovering brown dwarfs is the federation of many surveys over different wavelengths. Such matching of catalogs is currently laborious and time consuming. This matching problem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

# 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

# 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)

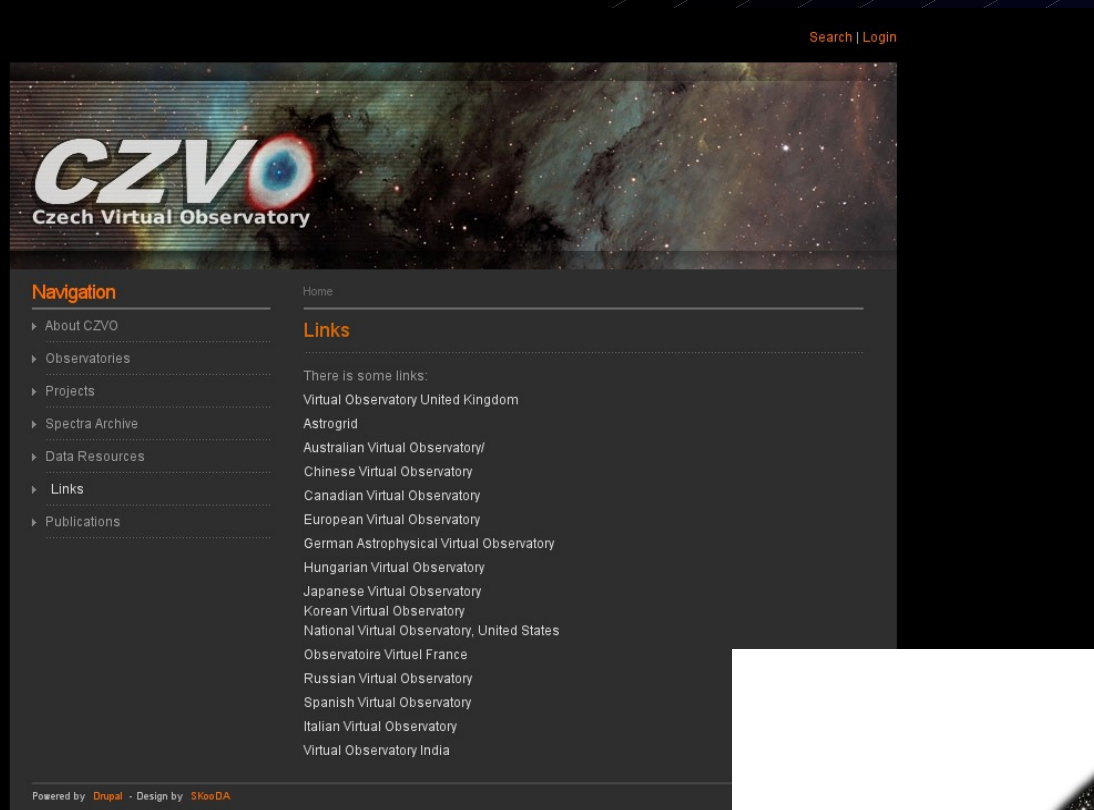
local archive - available data marked

# 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. ”

# Czech VO - CZVO



# CZVO Activities

VO-KOREL (web services)

parallel run of many jobs – more users  
using VO Universal Worker Server (CEA)  
job control, queuing, jobs results polling  
will be integrated in VODesktop

1D spectra cutout server (HEROS)

SSA access to 1D spectra + cutout of regions (lines)  
normalization, (rebinning , convolution on server)

Data mining – AstroNeural + Clustering

# VIRTUAL OBSERVATORY

