

# Exploiting the Wealth of Theoretical Models in Astronomy with Virtual Observatory

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# Outline of the Talk

- VO – the hidden revolution in astronomy
- Data Avalanche in astronomy
- History of VO
- Basic principles of technology
- VO Tools
- VO and Society
- Theoretical Models in VO
- VO Science
- Demos



# VO – The Hidden Revolution

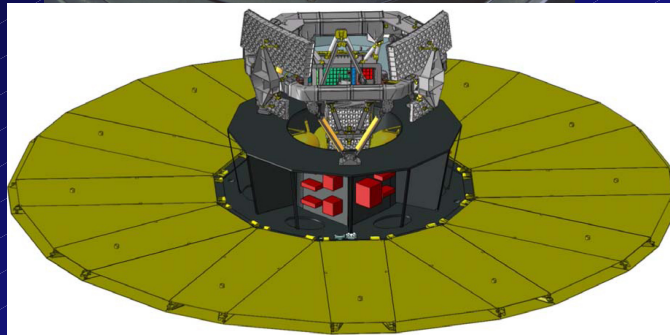
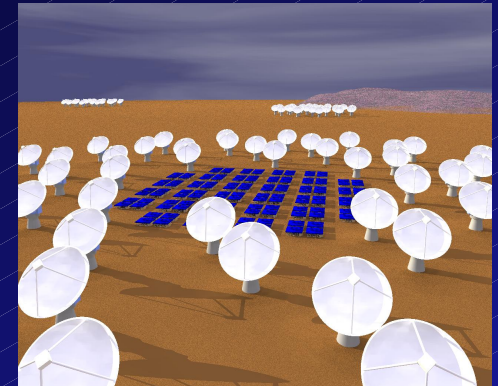
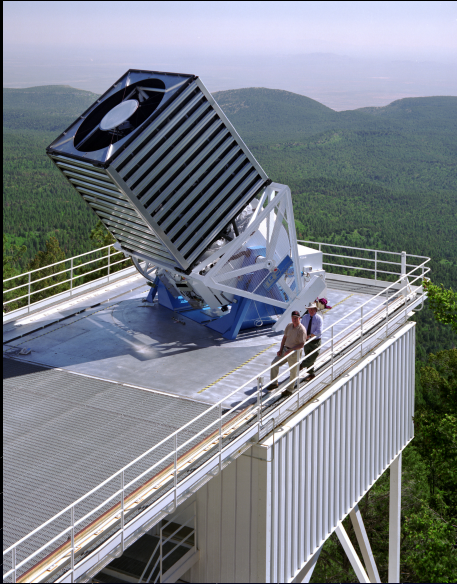
- VO is the radical change of the paradigm of the work of the scientists – effectiveness !!!
- Everyday question (what, where, format, units)
- Everyone is using it – but not stated (> 5 years)
  - CDS (Simbad, Aladin, Vizier), NASA, ESA archives
  - All looks like „ONLY“ another WEBS, client apps
- 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**

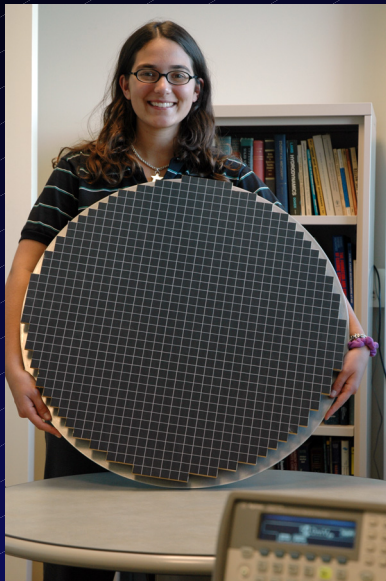
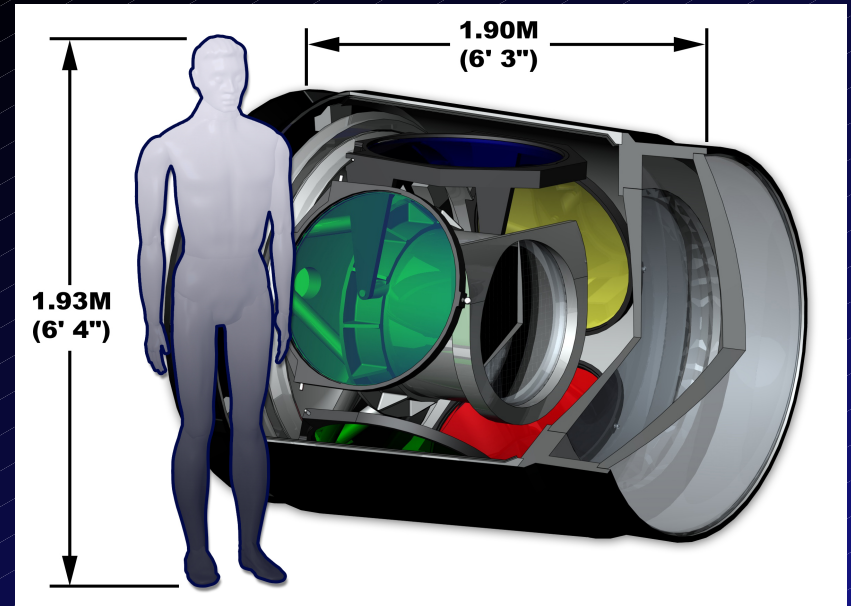
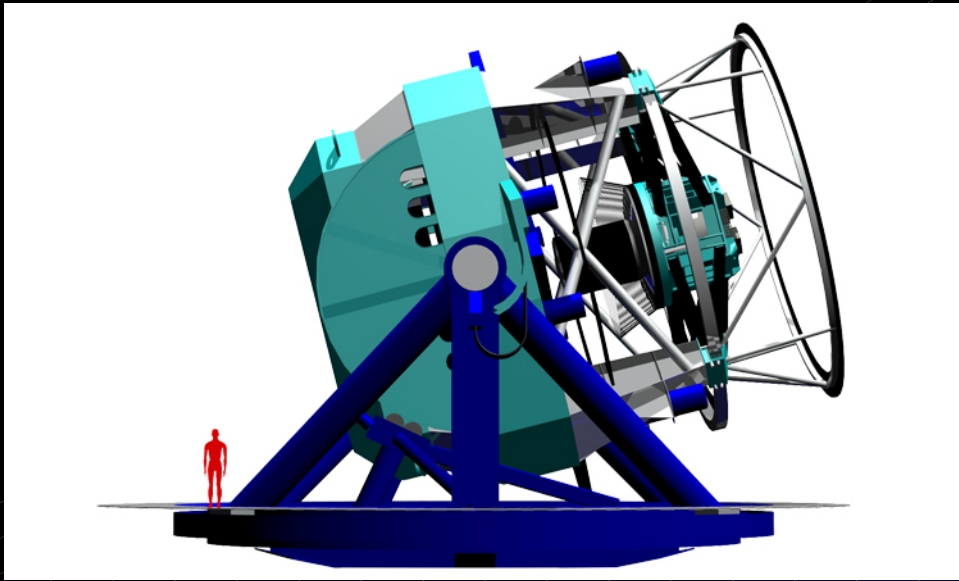
- Linking HYPERTEXT/DATA among servers
- Synergy effect of GLOBAL NET (Gopher, WAIS)
- Powerfull SEARCH (VERONICA – GOOGLE)
- DISTRIBUTED but CENTRAL Steering Organisation (W3C/IVOA)
- Recommendations = „Obligatory“ Standards
- Astronomers in forefront of development
- Scepticism (usefulness for my field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



# Data Avalanche



# LSST (8.4m)



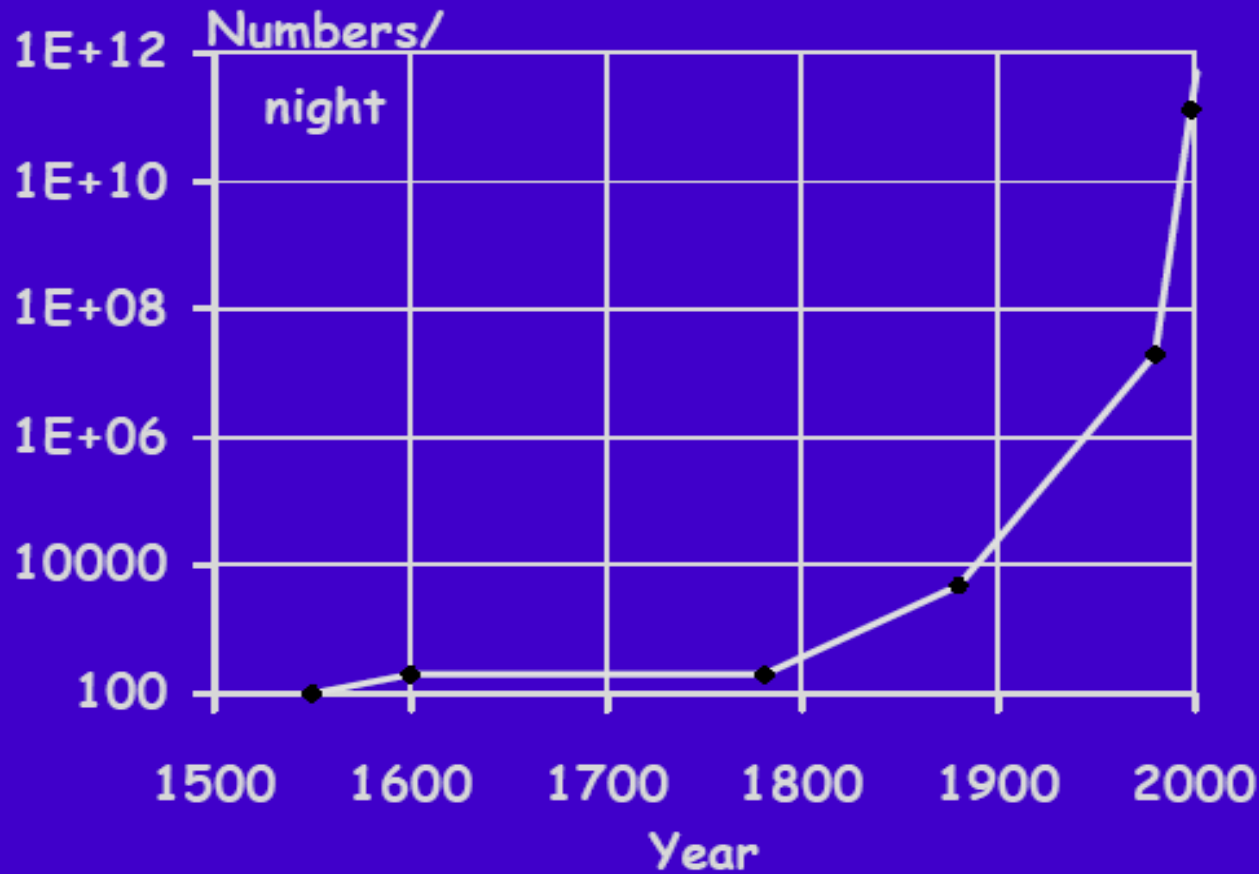
200 CCD 4kx4k,  
32 channels (6400)  
3.2 Gpix every 20 sec  
64cm diameter  
3.5 deg FOV  
30 TB/night  
2 TFLOPS  
detection of changes  
within 60sec



# 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

# 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)



# 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”*

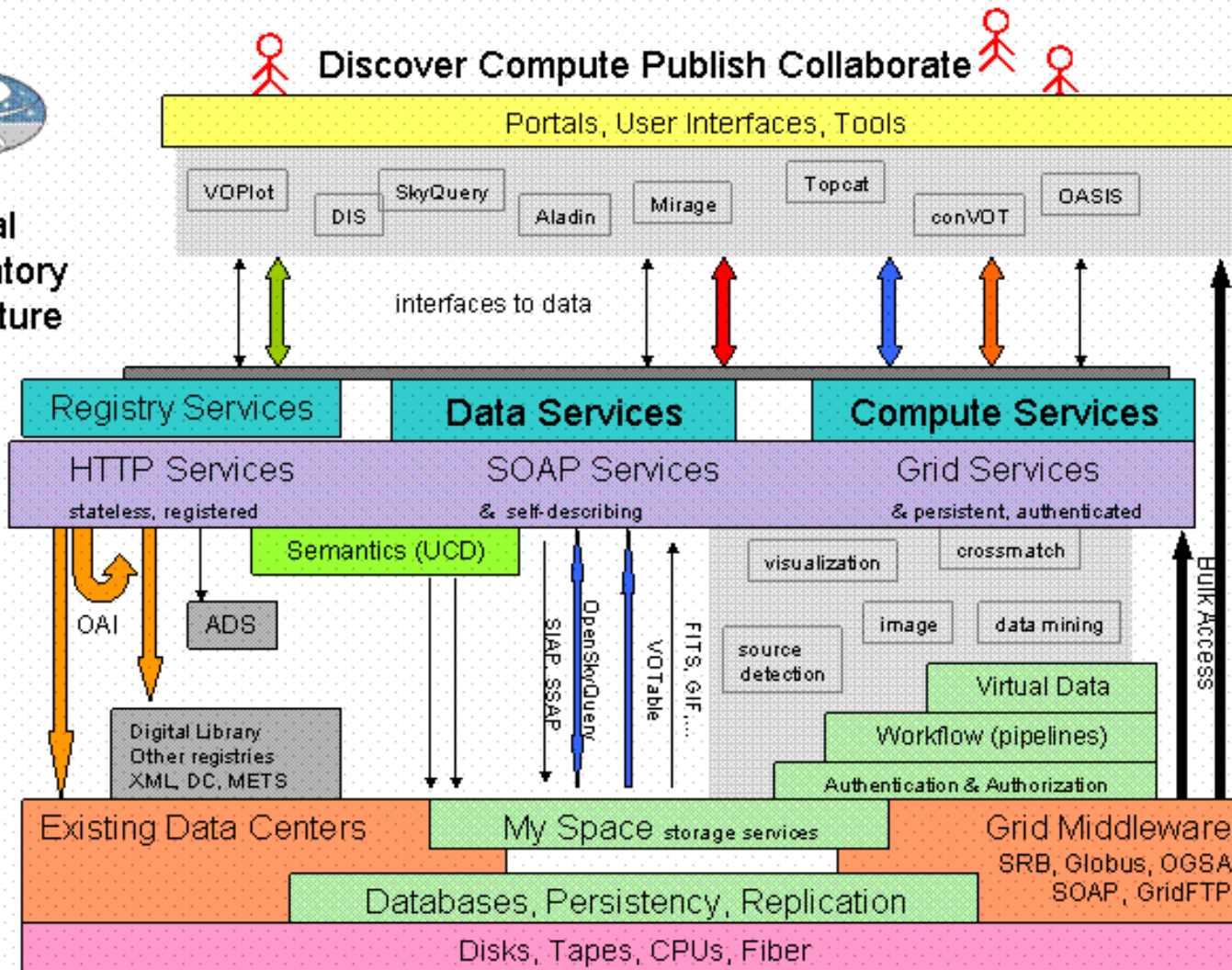
# VO Paradigma

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

# Architecture of VO



Virtual Observatory Architecture





# 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)

# 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)

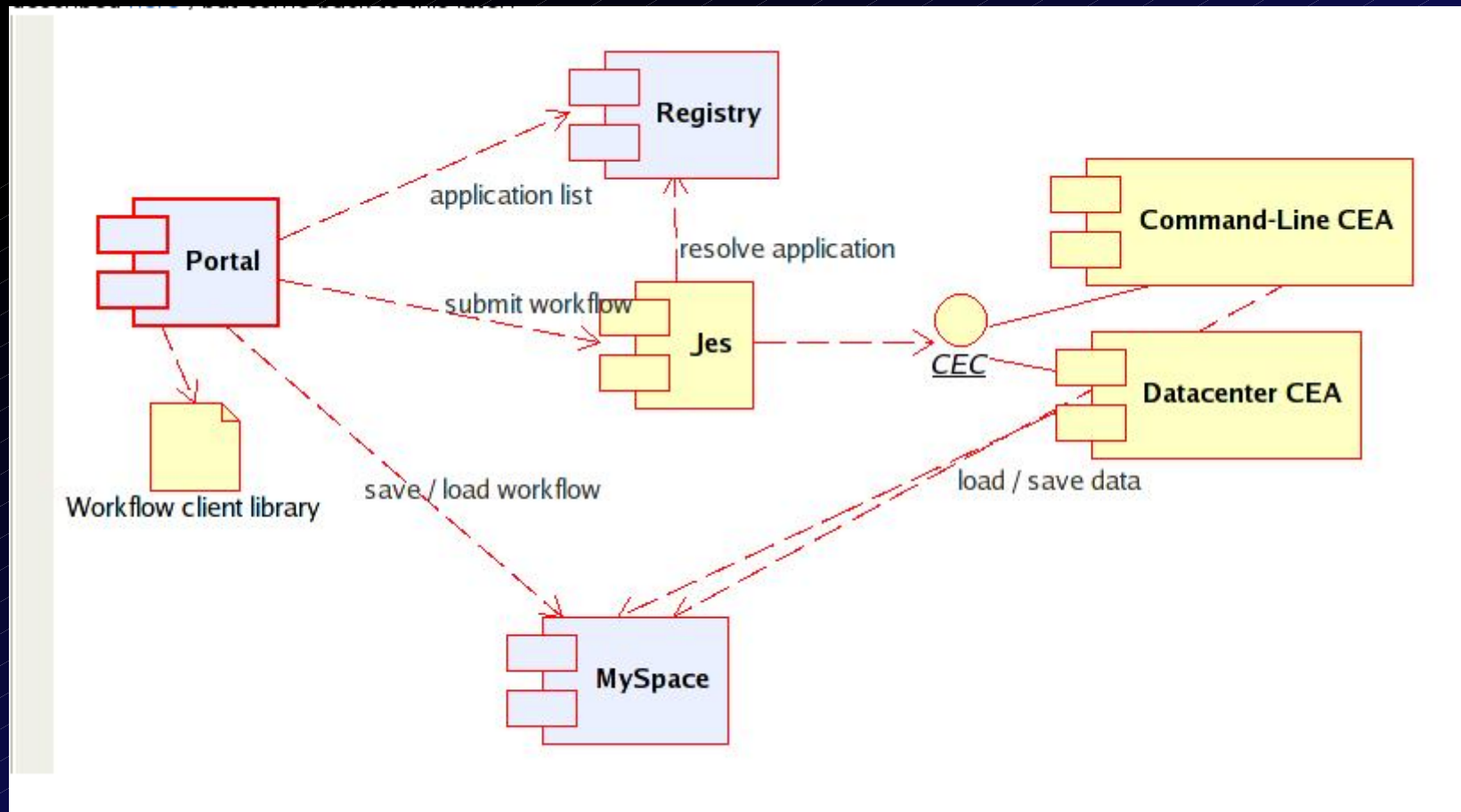
Commercial interest (GoogleSky, MS WWT)

Planetariums, Outreach (Stellarium)



# Workflows - Astrogrid

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





**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>
  </TABLE>

```

Display Data Of Selected Points

Close

Save As File

# 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:

<i>Parameter</i>	<i>Sample value</i>	<i>Physical unit</i>	<i>Datatype</i>
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 must all be used as query parameters.

# IVOA





# VO-enabled tools

Aladin

VOPlot

TOPCAT

VOSpec

SpecView

SPLAT

ViSiVO (HPC simulations, cosmology)

VOSED

BASTI

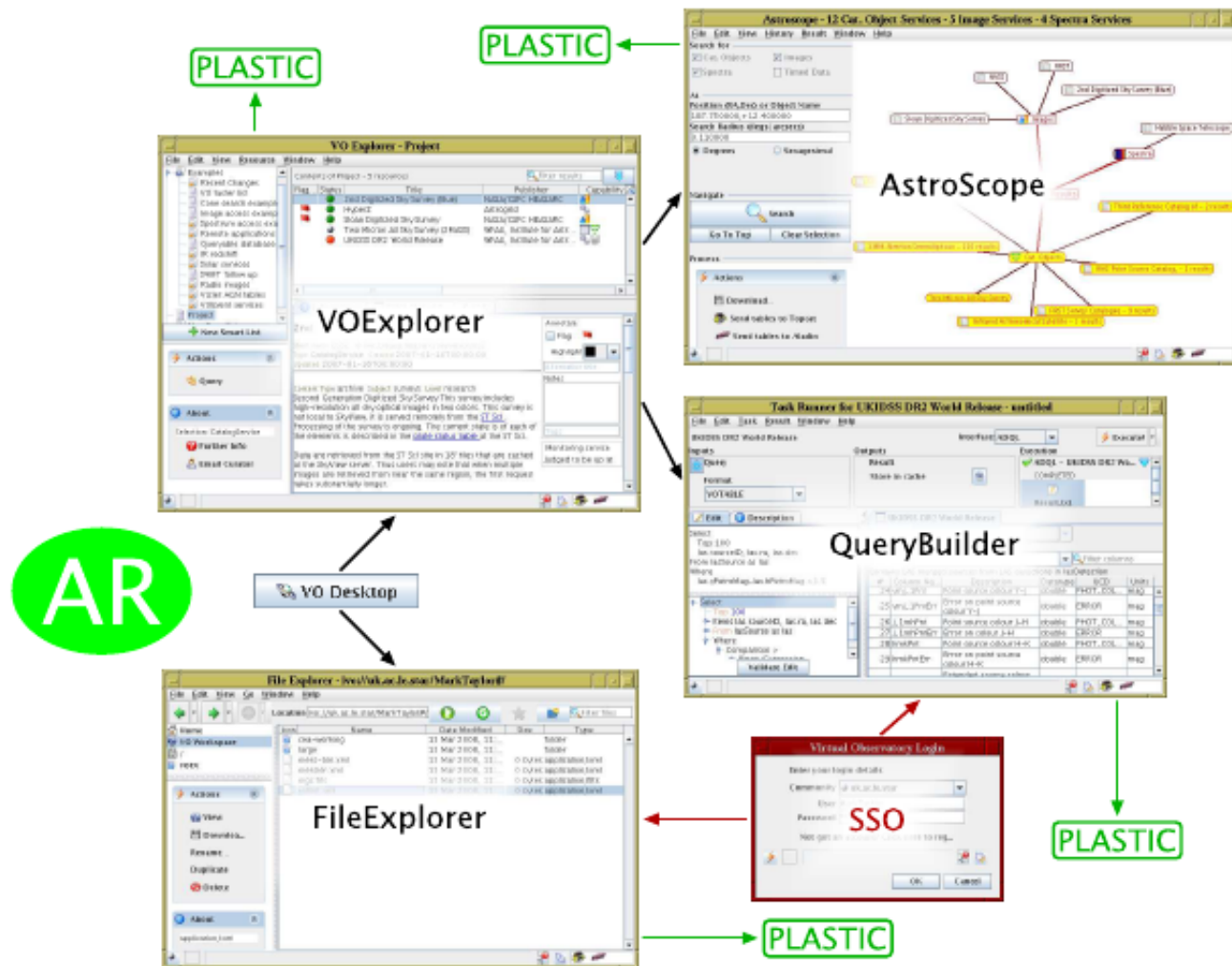
SExtractor – WESIX (Web Enabled Source Identification with Cross Matching)

Period04 (since 18.9.08) - PLASTIC

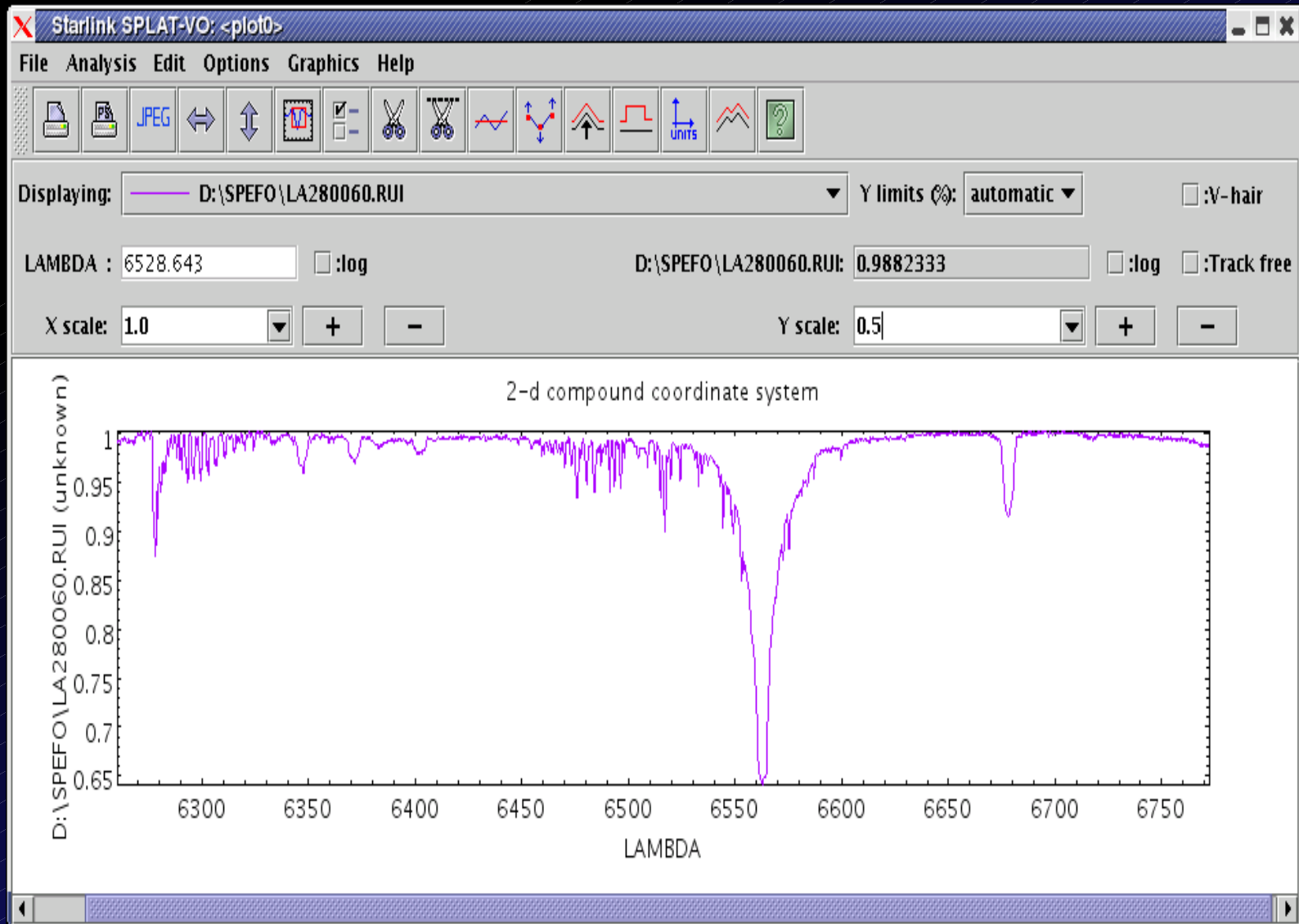


# AstroGRID VODesktop

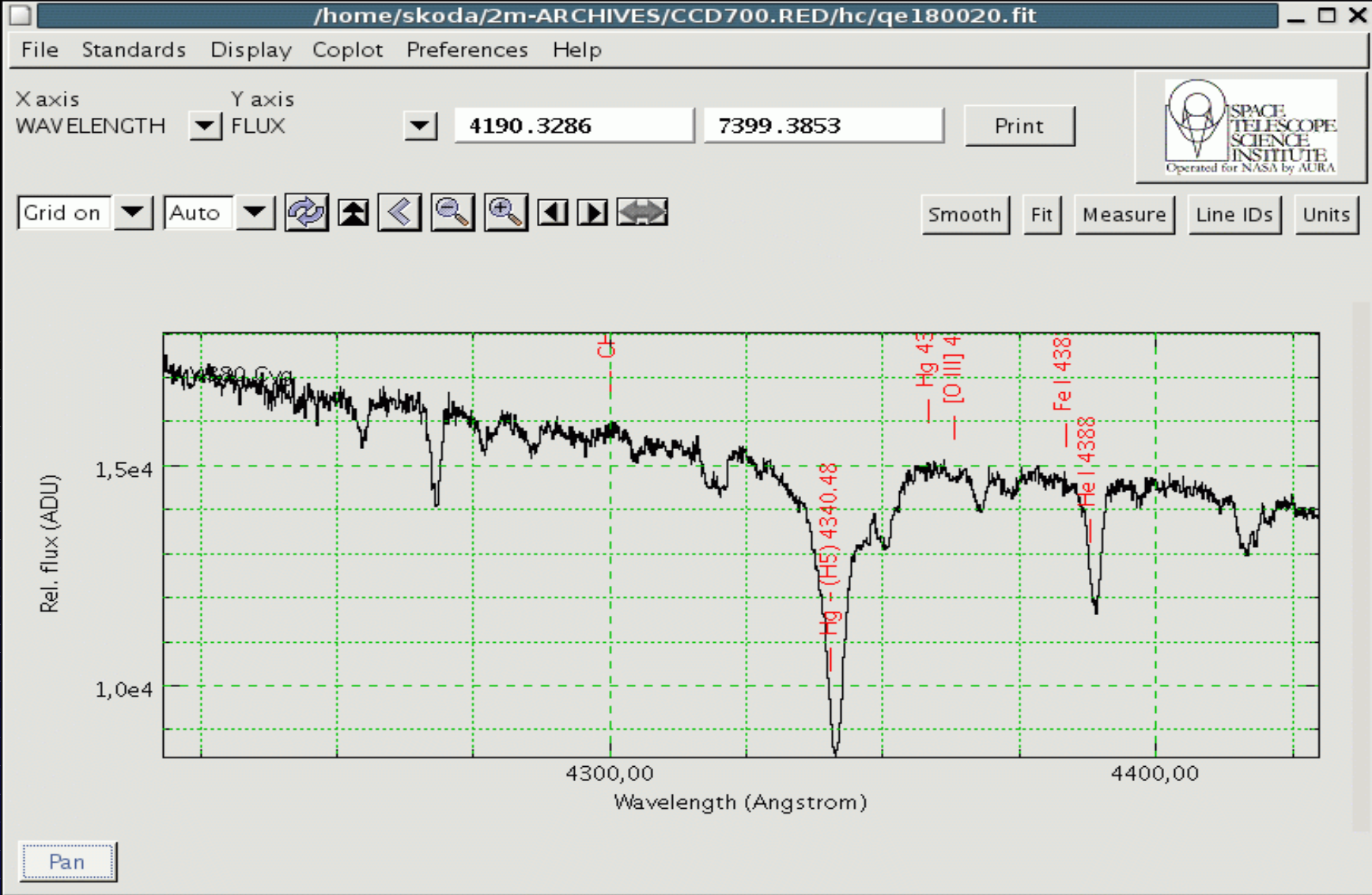
## VODesktop Overview



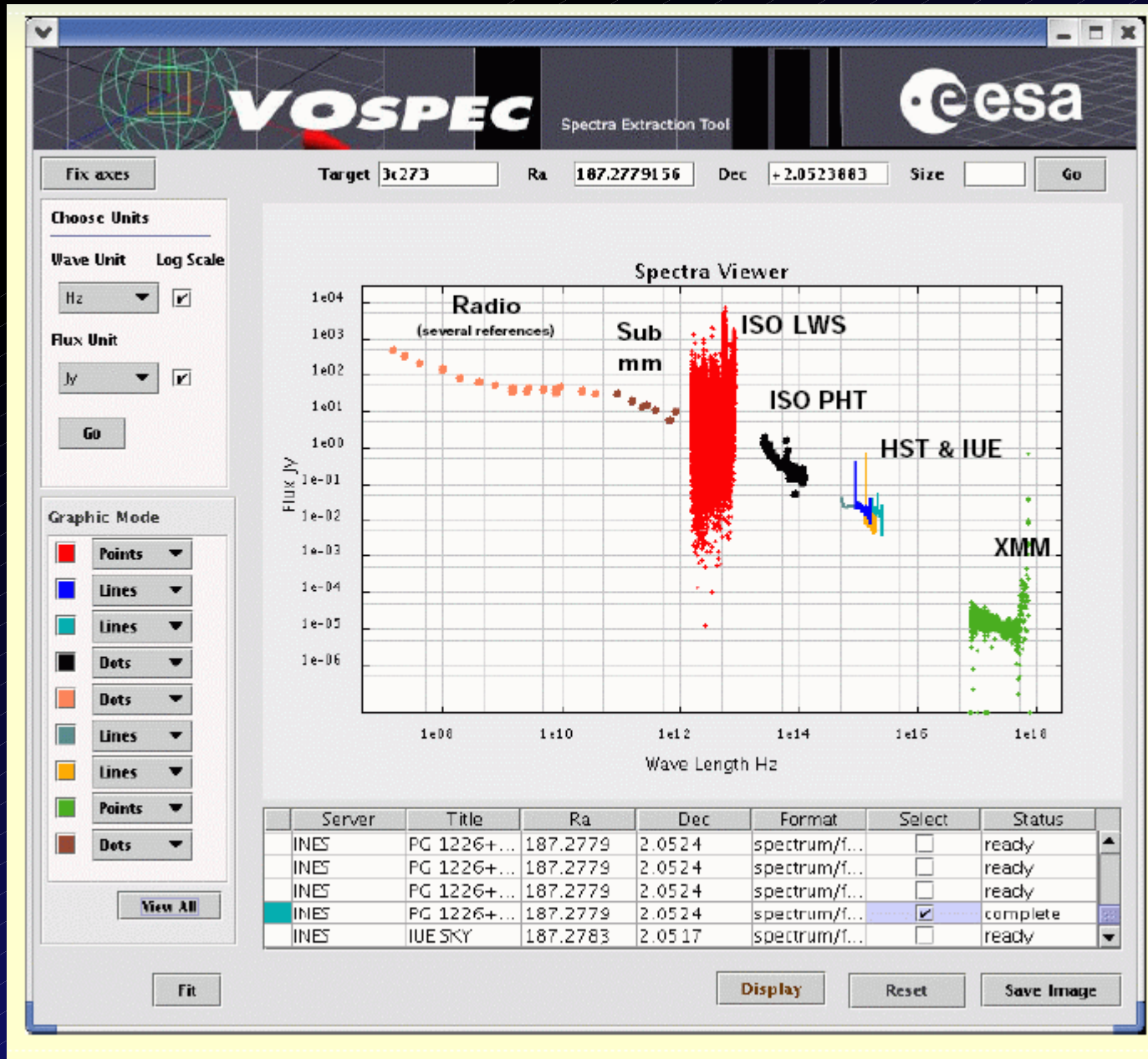
# SPLAT-VO (Starlink, JAC)



# SpecView (STScI)

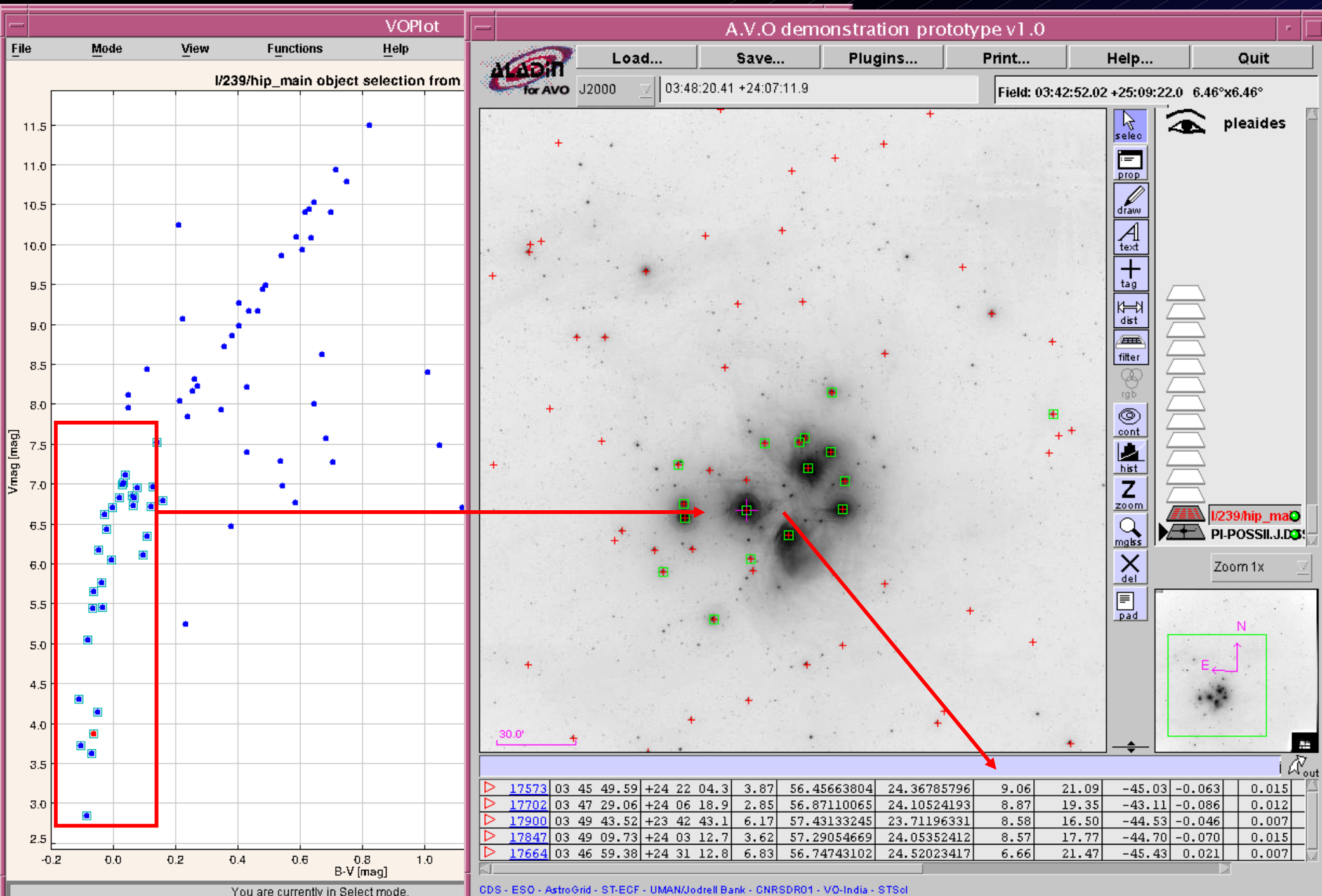


# VOSpec (ESAC)





# Colour-magnitude diagram



# Tools

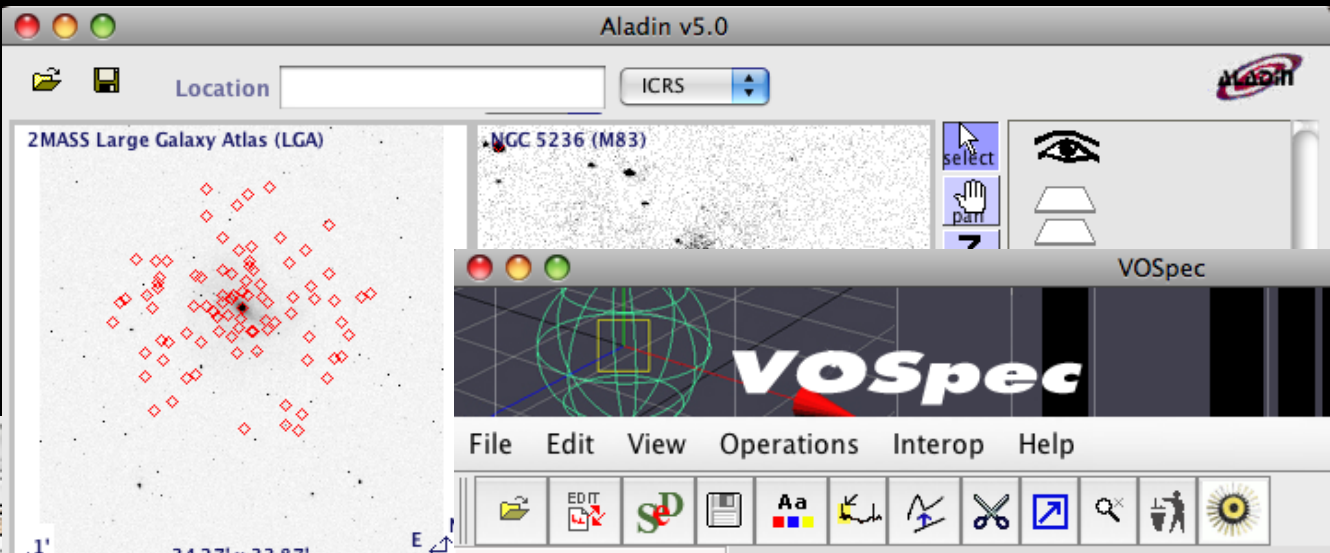
Aladin v5.0

Location  ICRS

2MASS Large Galaxy Atlas (LGA)

NGC 5236 (M83)

select  
pan  
7



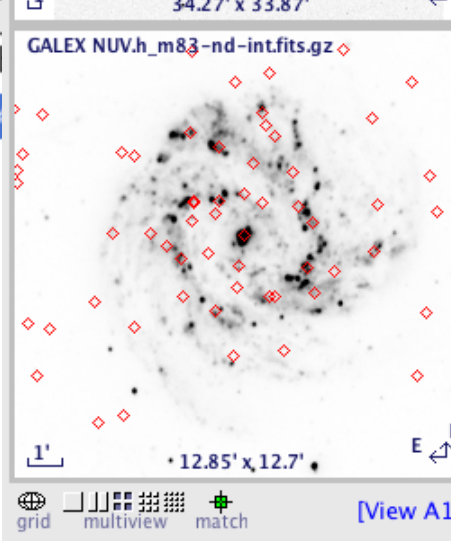
GALEX NUV.h\_m83-nd-int.fits.gz

34.27' x 33.87'

12.85' x 12.7'

grid multiview match

[View A1](#)



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

11	0.09034
12	0.09083
13	0.09165

VOSpec

esa VO Virtual Observatory

File Edit View Operations Interop Help

Wave Unit: micr... Log:

Flux Unit: Jy

RedShift: 0.00

De-reddening:

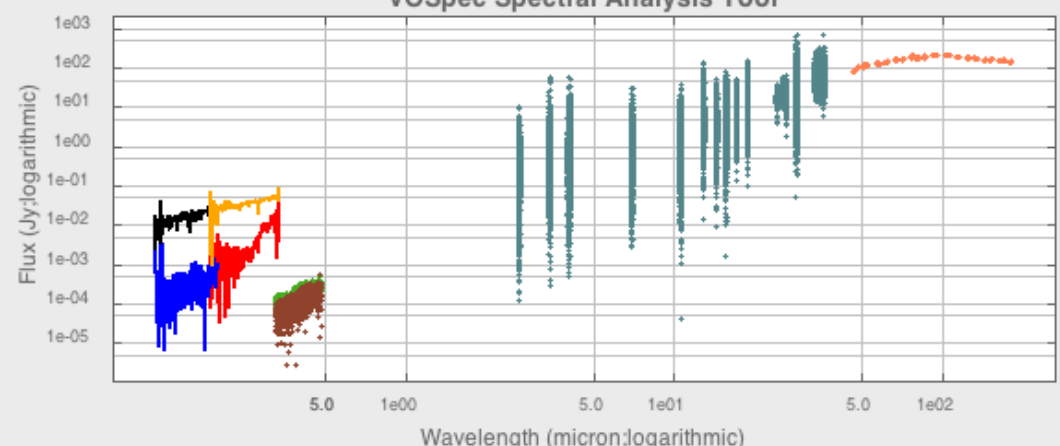
$\lambda_{\text{AV}}$ : 0.00

Graphic Mode

- Li...
- Li...
- Li...
- Li...
- Li...
- Po...
- Po...
- Po...
- Po...

Target: M83 Ra: 204.25325 Dec: 662777778 Size: 0.2 Query

### VOSpec Spectral Analysis Tool



Flux (Jy, logarithmic)

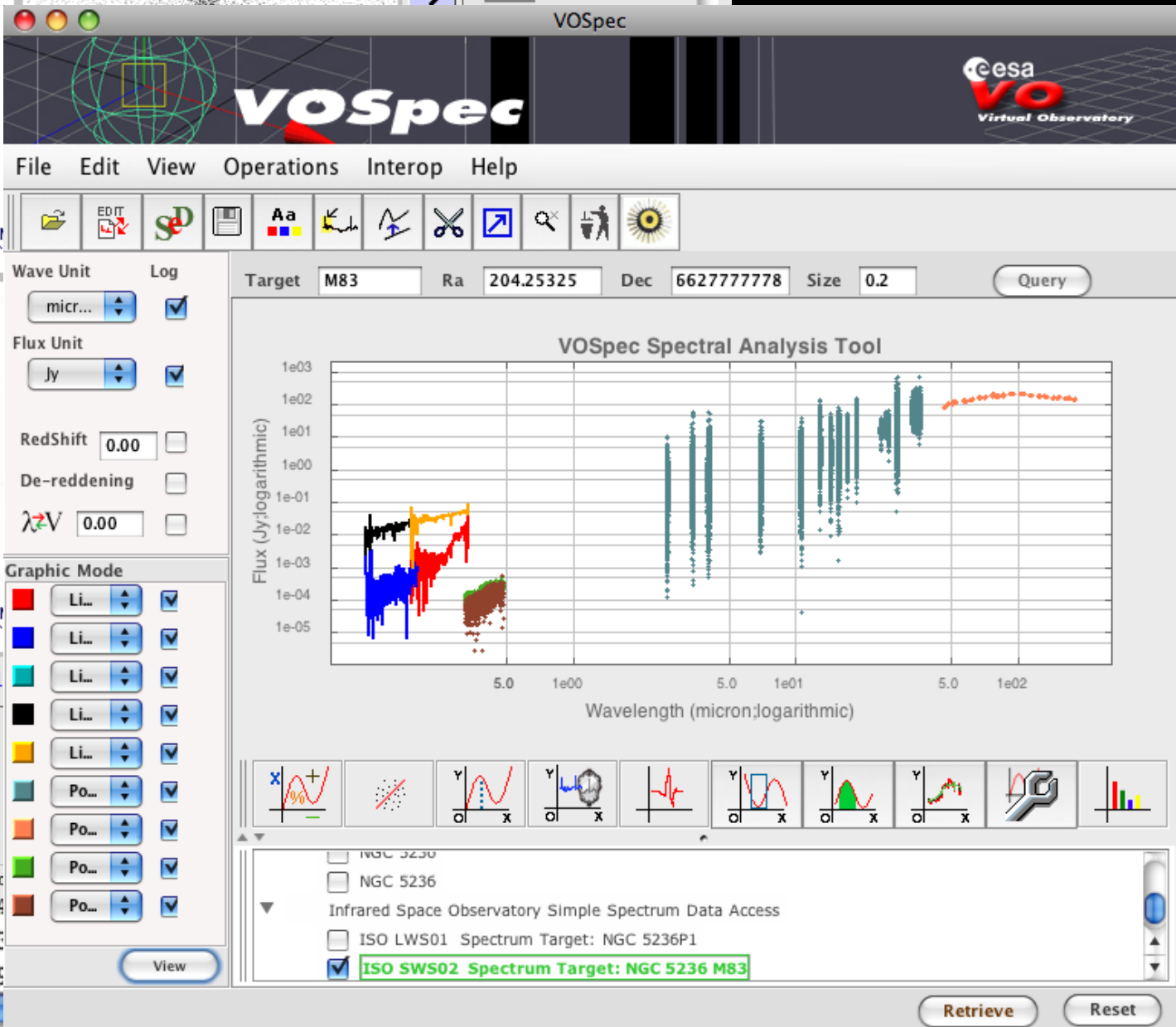
Wavelength (micron, logarithmic)

Flux

3.52
2.86
2.91
1.26
9.57
1.67
3.93
5.34
5.82
3.31
2.27
2.22
1.78

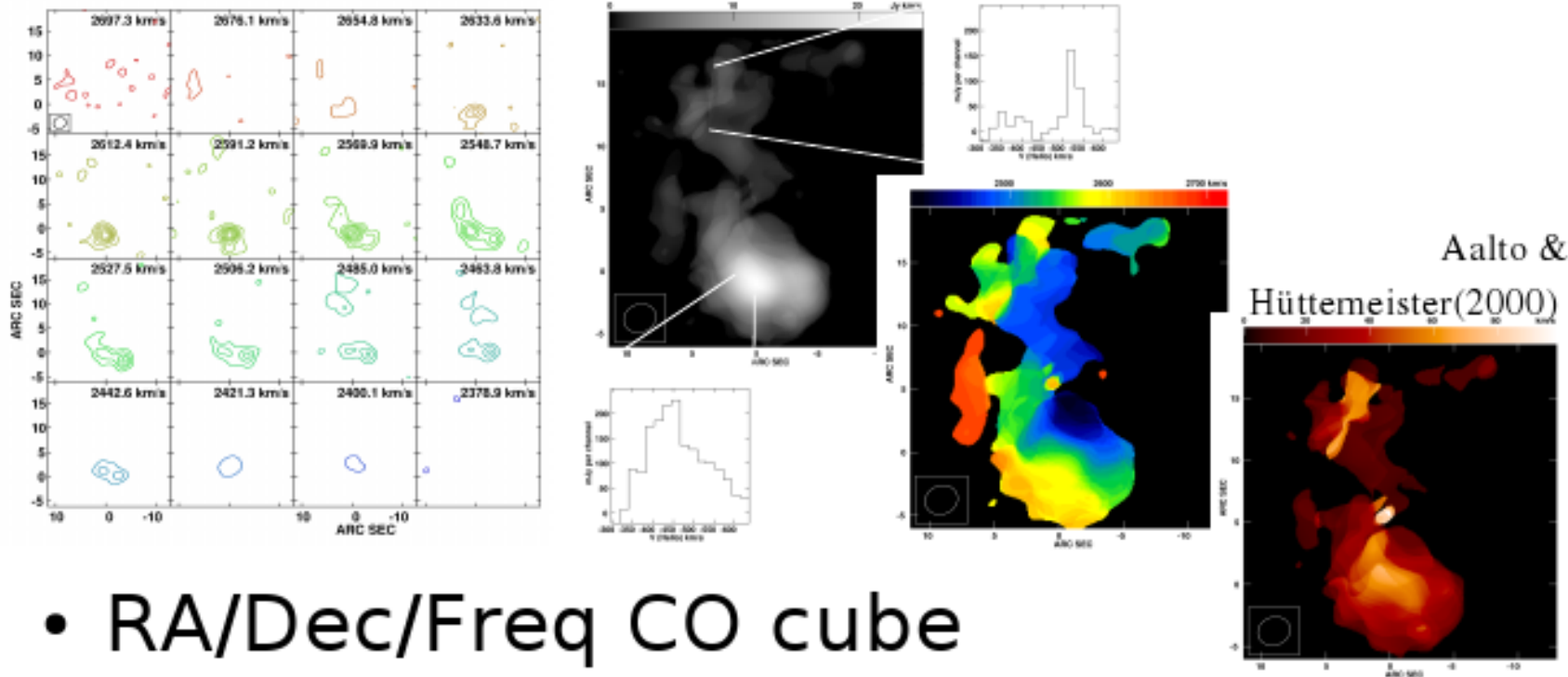
NGC 5230  
 NGC 5236  
Infrared Space Observatory Simple Spectrum Data Access  
 ISO LWS01 Spectrum Target: NGC 5236P1  
 ISO SWS02 Spectrum Target: NGC 5236 M83

Retrieve Reset





# 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

# 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	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	...	...
2.1621e-09	NGC1068	40.66963	-0.01328	1s_2p	1s2	3P1	150	OVII	...	...

Close

VOSpec Spectra Extraction Tool

Target  Ra  Dec  Size  Go

Simple Line Access

Wave Unit  Log Scale

Flux Unit

RedShift

Go

Graphic Mode

Points

Points

View

Clear Cache Unzoom Display Reset Save Image

Copyright ESAC - Villafranca del Castillo - Madrid, Spain

Wrapper Creator - HowTo - About

VOSpec Spectra Viewer

ISO spectrum of P Cygni

Server	Title	Ra	Dec	Format	Select	Status
Infrared Sp...	ISO SWS01 ...	83.6223	22.0102	spectrum/fits	<input type="checkbox"/>	ready
Infrared Sp...	ISO SWS01 ...	83.63325	22.0346	spectrum/fits	<input type="checkbox"/>	ready
Infrared Sp...	ISO SWS01 ...	83.6402175	22.01457	spectrum/fits	<input checked="" type="checkbox"/>	complete
Infrared Sp...	ISO LWS01 ...	83.633409	22.0346	spectrum/fits	<input type="checkbox"/>	ready
Infrared Sp...	ISO LWS02 ...	83.6334225	22.03459	spectrum/fits	<input type="checkbox"/>	ready

(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)

## 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



# Democratization of Science

- Digital Divide (data access free, journals ?)
- International Council for Science (ICS UNO) CODATA (Committee on Data for Science and Technology)
- OECD, UNESCO
- CASPAR  
Cultural, Artistic and Scientific knowledge for Preservation, Access and Retrieval  
Digital curation centers
- ADS and VO (links to ivo://, metadata, ontologies – understanding, semantic web)
- Archive importance: 5x IUE , 3x HST results from archives than PI articles
- Effectivity – 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.”

# 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)

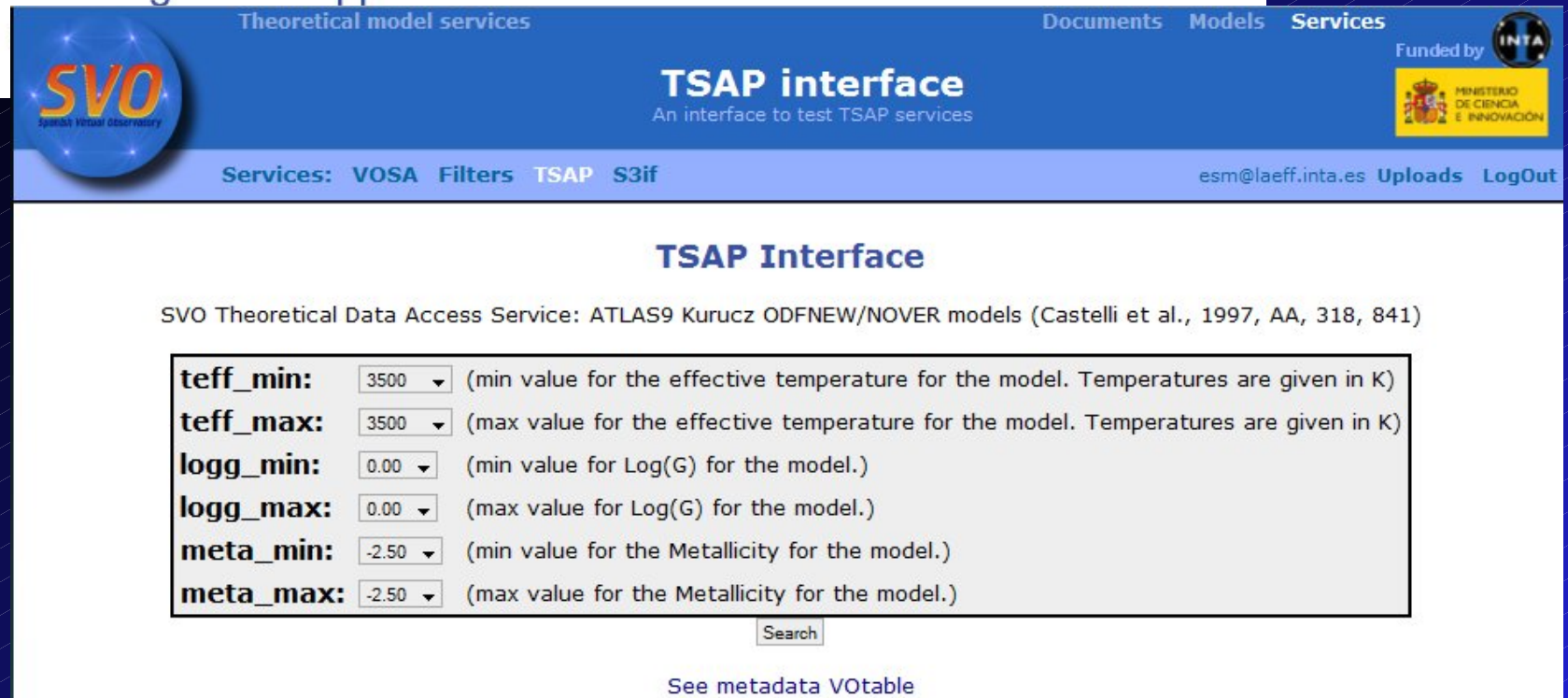


# Access protocols in VO: TSAP

## 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

**SVO** Spanish Virtual Observatory

**TSAP interface**  
An interface to test TSAP services

Funded by INTA  
MINISTERIO DE CIENCIA E INNOVACIÓN

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)

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

See metadata VOTable

# VOSpec – models by TSAP

The **Server Selector** window is divided into two main sections: **Query by Service** and **Query by params**.

**Query by Service:** Lists various services under 'Green services support params selected' and 'Theoretical Spectra Services'. Theoretical services are checked, including: 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, and VO-Paris: PEGASE.HR synthetic spectra.

**Query by params:** Shows a tree structure for a query with parameters: **TARGET.NAME p cyg**, **POS 304.44667416667,38.03293027778**, and **SIZE 0.1**. The tree includes categories like Simple Query, Advanced Query, and Service Specific Query.

**Query Outlook:** Contains a list of URLs for SSA/TSA services and a 'Select All' checkbox.

The **VOSpec Spectral Analysis Tool** interface displays a spectral plot for star **HD 141569** with parameters: **Ra 37.49062042**, **Dec -3.92121111**, and **Size 0.1**. The plot shows flux density versus **Wavelength (micron, logarithmic)** from 5.0 to 5.0e2. The plot features observed data points (green and orange) and several model fits (blue, red, and brown lines).

Below the plot, a list of selected models is shown:

- 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**

Buttons for **Retrieve** and **Reset** are visible at the bottom right.

**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

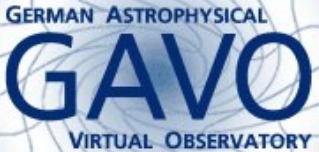
The image displays the VOSpec interface, a web-based tool for accessing and viewing theoretical spectra. The interface is divided into several sections:

- Server Selector:** A panel on the left allows users to query by service. It lists various theoretical spectra services, with "PGos3: Evolutionary synthesis models" selected. Below this, a "Query Outlook" section shows the URL for the selected service: `http://ov.inaoep.mx/Asap/SyntMod.php?`.
- VOSpec Main Window:** The central window displays the "VOSpec Spectra Viewer". It shows a plot of Flux (Jy, logarithmic) versus Wavelength (micron, logarithmic). The plot includes data points from various sources: HST (MAST), 2MASS photometry, Kurucz Models (SVO), INES (SVO), and ISO (ESA-VO). The plot is overlaid with a blue line representing the model fit.
- Target Information:** The top of the VOSpec window shows the target name "Vega" and its coordinates: Right Ascension (Ra) 279.2347350 and Declination (Dec) +38.7836919. The size is set to .1.
- Graphic Mode:** A panel on the left of the plot allows users to select the graphic mode for the data points. The "Lines" mode is selected for the "INES (SVO)" and "ISO (ESA-VO)" data series.
- Spectral Model List:** A list of spectral models is shown at the bottom of the VOSpec window. The selected model is "IUE/INES Spectrum: LWR04154HS, Target: HD 172167". Other models listed include "IUE/INES Spectrum: LWR04154RS, Target: HD 172167", "IUE/INES Spectrum: LWR07008RS, Target: HD 172167", and "IUE/INES Spectrum: LWR07008HS, Target: HD 172167".

The VOSpec interface is powered by the CESA Virtual Observatory and is hosted by INTA (Ministerio de Ciencia e Innovación). The copyright information at the bottom indicates it is developed by ESAC in Villafranca del Castillo, Madrid, Spain.



- Other VO Data Centres providing theoretical spectra using TSAP



GERMAN ASTROPHYSICAL  
**GAVO**  
VIRTUAL OBSERVATORY

## German Astrophysical Virtual Observatory

---

Archive: **TMAP Spectra**

Effective temperature in K:  +/-

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

Mass fraction 0:  +/-  dex

Mass fraction 1:  +/-  dex

Mass fraction 2:  +/-  dex

Mass fraction 3:  +/-  dex

Mass fraction 4:  +/-  dex

Mass fraction 5:  +/-  dex

Mass fraction 6:  +/-  dex

Mass fraction 7:  +/-  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.)

[More information on archive](#)

- 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>

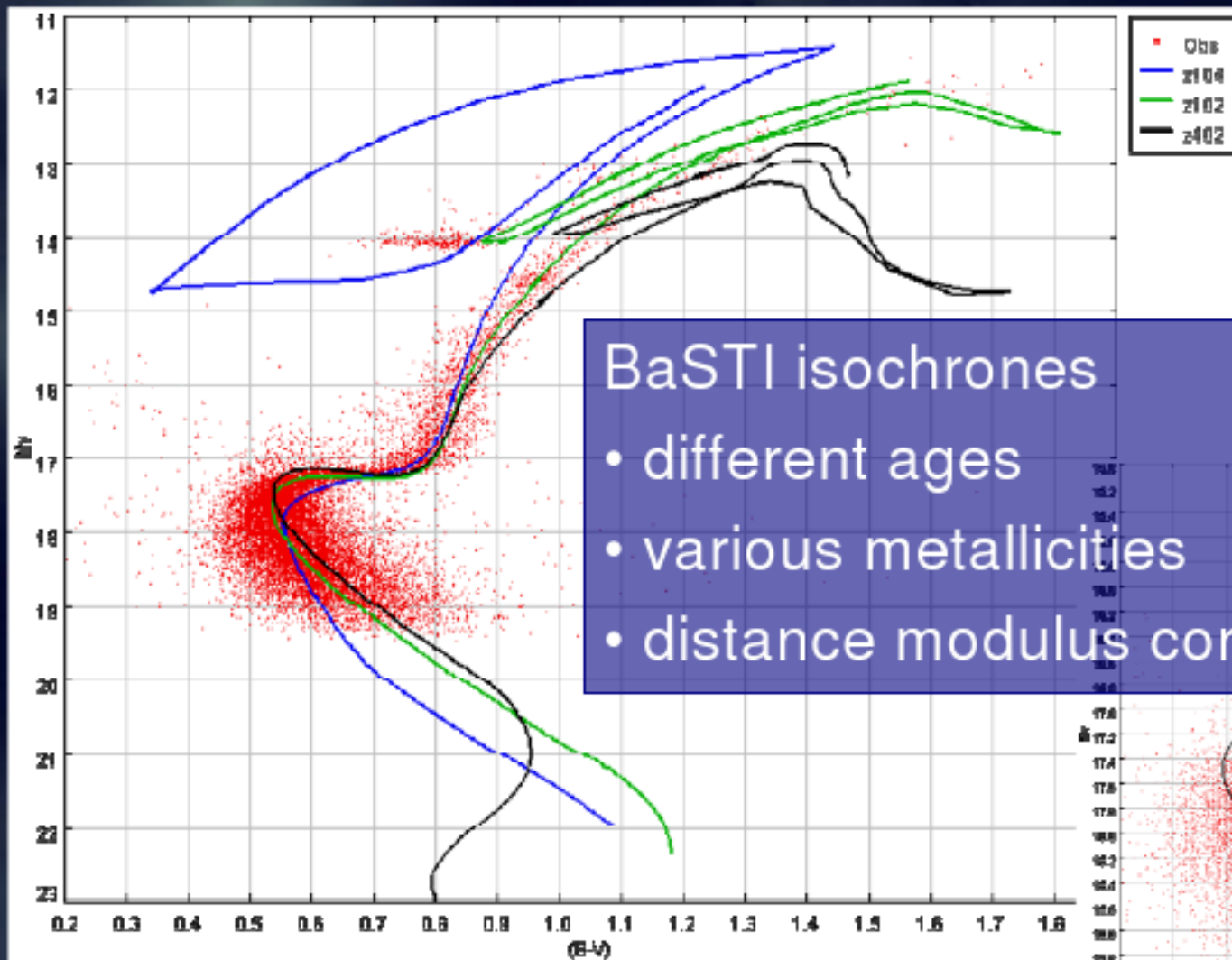
We developed two prototype implementations of S3P for BaSTI: one for isochrones and one for tracks:

<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:[FeH]	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.

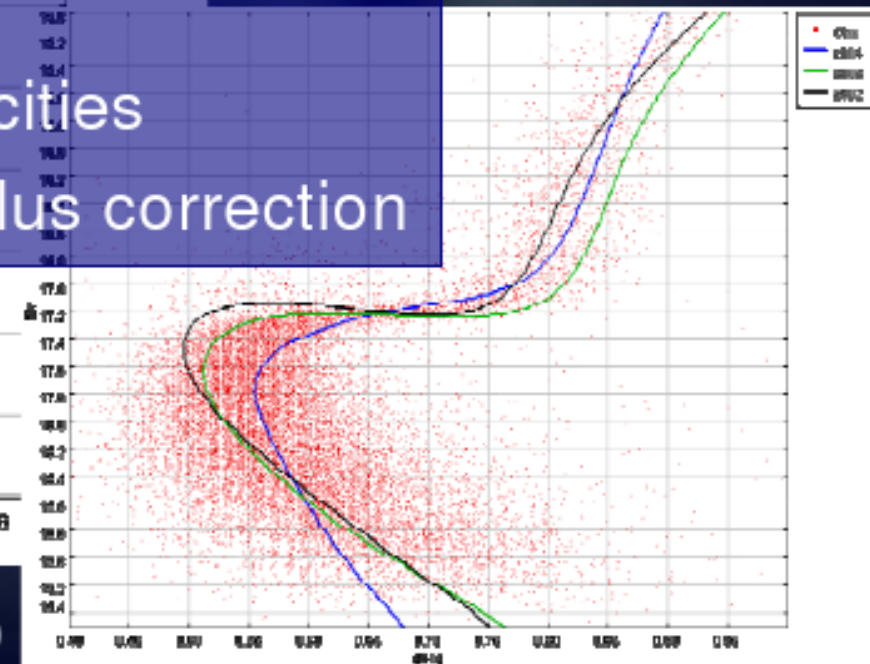
# BaSTI Isochrones



step 1  
metallicity

BaSTI isochrones

- different ages
- various metallicities
- distance modulus correction



$z = 0.01$  ( $\alpha$ -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

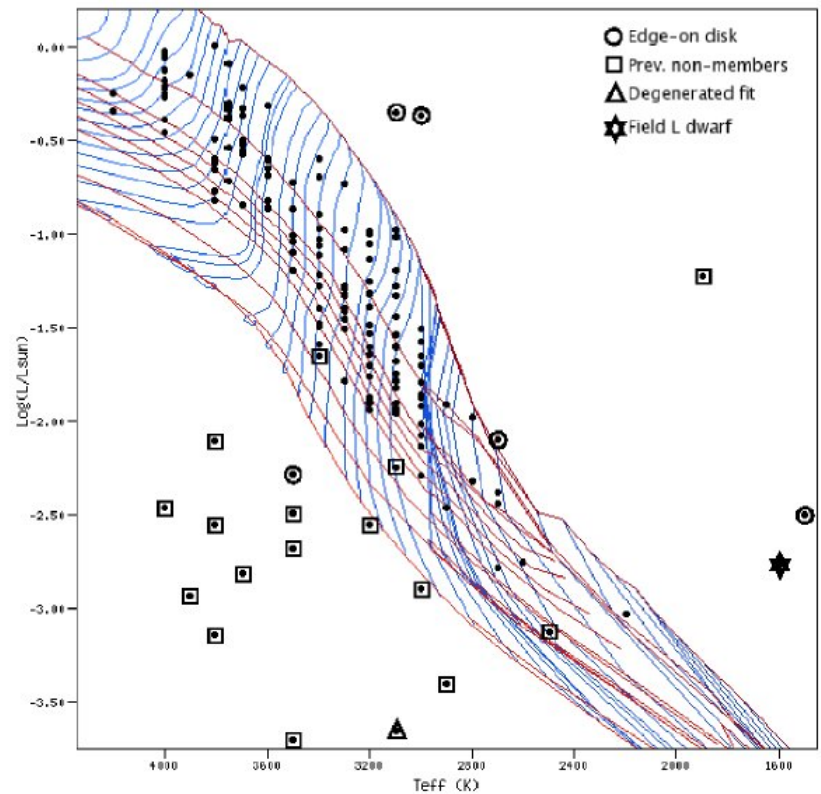
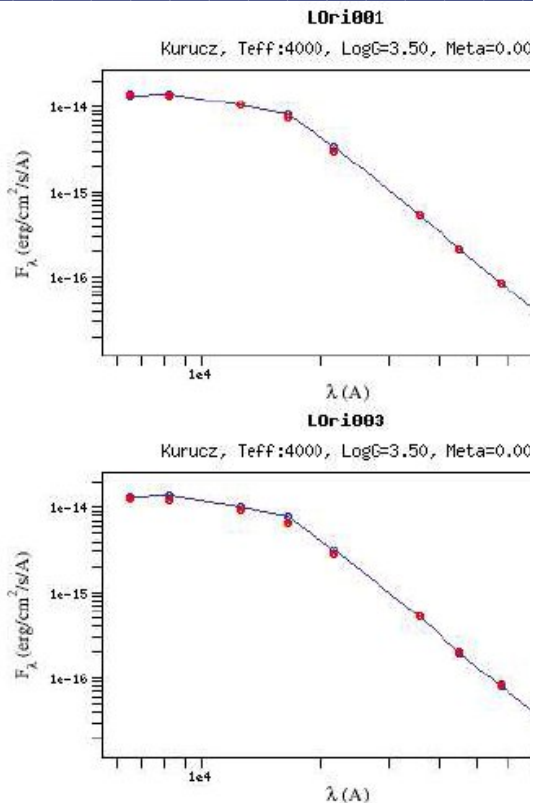
Astronomy & Astrophysics manuscript no. Synth 'VO-PR1' ref format  
August 2, 2008

## VOSA: Virtual Observatory SED Analyzer.

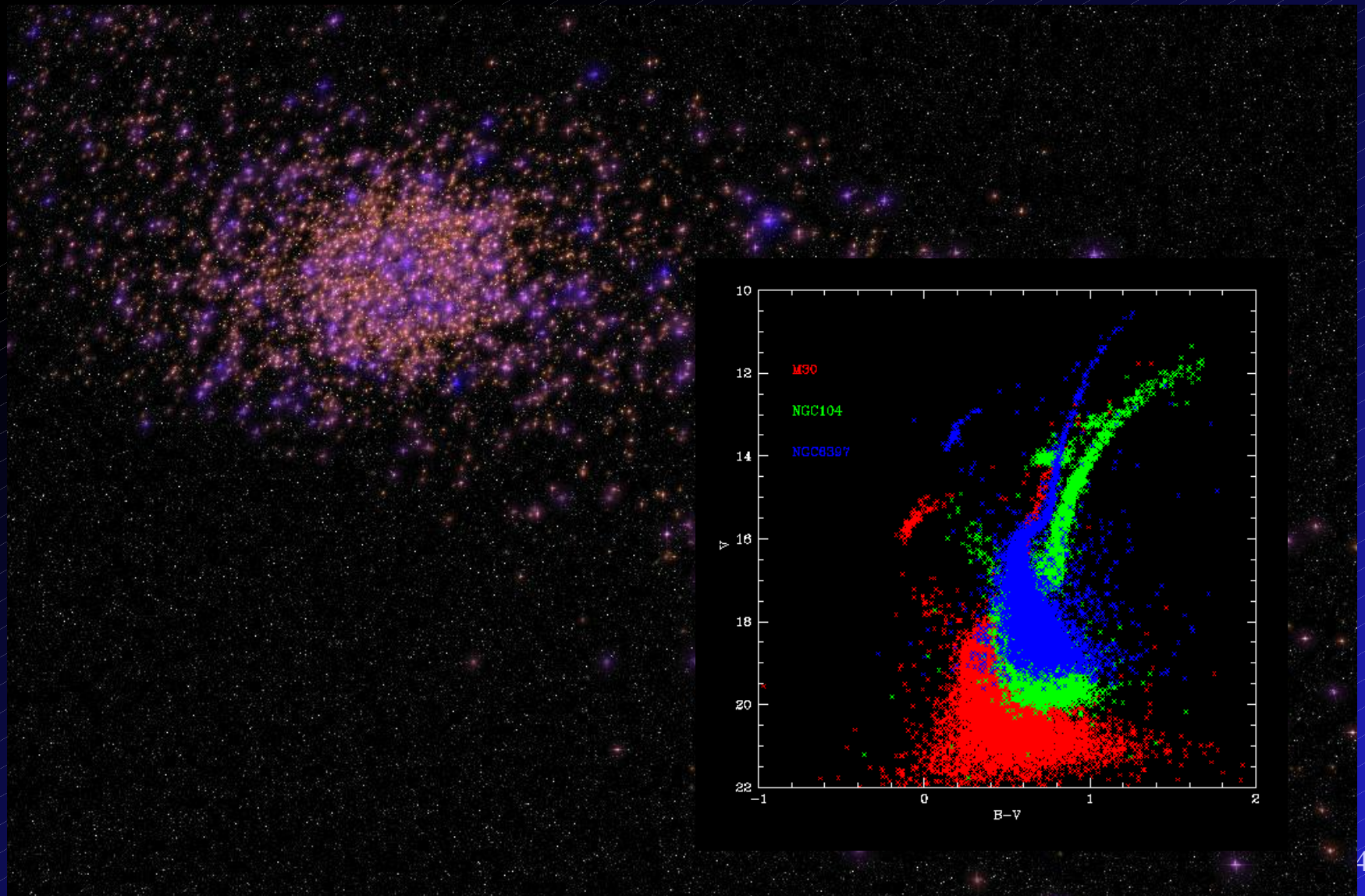
### An application to the Collinder 69 open cluster

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.

Object	Model	T <sub>eff</sub>	LogG	Metallicity	χ <sup>2</sup>
LO#001	Kurucz	4000	3.50	0.00	1.71e
LO#002	NextGen	3800	4.5	0	1.44e
LO#003	Kurucz	4000	3.50	0.00	5.05e
LO#004	Kurucz	3750	4.00	0.00	2.82e
LO#005	NextGen	4000	4.0	0	9.26e
LO#006	Kurucz	4000	3.50	0.00	3.36e
LO#007	Kurucz	4000	4.50	0.00	2.49e
LO#008	Kurucz	4000	3.50	0.00	4.43e
LO#009	NextGen	4000	3.5	0	8.22e
LO#010	NextGen	4200	4.0	0	1.87e
LO#011	NextGen	3900	4.5	0	1.20e
LO#012	NextGen	4000	4.5	0	8.58e
LO#013	NextGen	3700	4.5	0	3.50e
LO#014	Kurucz	4000	4.50	0.00	4.70e
LO#015	Kurucz	4000	3.50	0.00	8.79e
LO#016	Kurucz	3750	4.50	0.00	5.53e
LO#017	NextGen	4200	4.0	0	7.58e
LO#018	Kurucz	3750	3.50	0.00	4.31e
LO#019	Kurucz	3750	3.50	0.00	1.90e
LO#020	NextGen	3800	4.5	0	2.98e
LO#021	Kurucz	4000	3.50	0.00	3.08e
LO#022	Kurucz	3750	4.00	0.00	1.76e
LO#023	NextGen	4000	4.5	0	2.35e
LO#024	Kurucz	3750	3.50	0.00	2.22e
LO#025	NextGen	3700	4.5	0	1.37e
LO#026	NextGen	3700	4.5	0	4.81e
LO#027	NextGen	4000	4.5	0	2.35e
LO#028	Kurucz	3750	4.00	0.00	1.28e
LO#029	NextGen	3100	4.5	0	7.28e
LO#030	NextGen	3700	4.5	0	2.15e
LO#031	NextGen	3800	4.5	0	2.77e
LO#032	NextGen	3700	4.5	0	1.70e
LO#033	NextGen	3700	4.5	0	7.12e
LO#034	NextGen	3000	4.0	0	1.77e
LO#035	NextGen	3700	4.5	0	1.61e

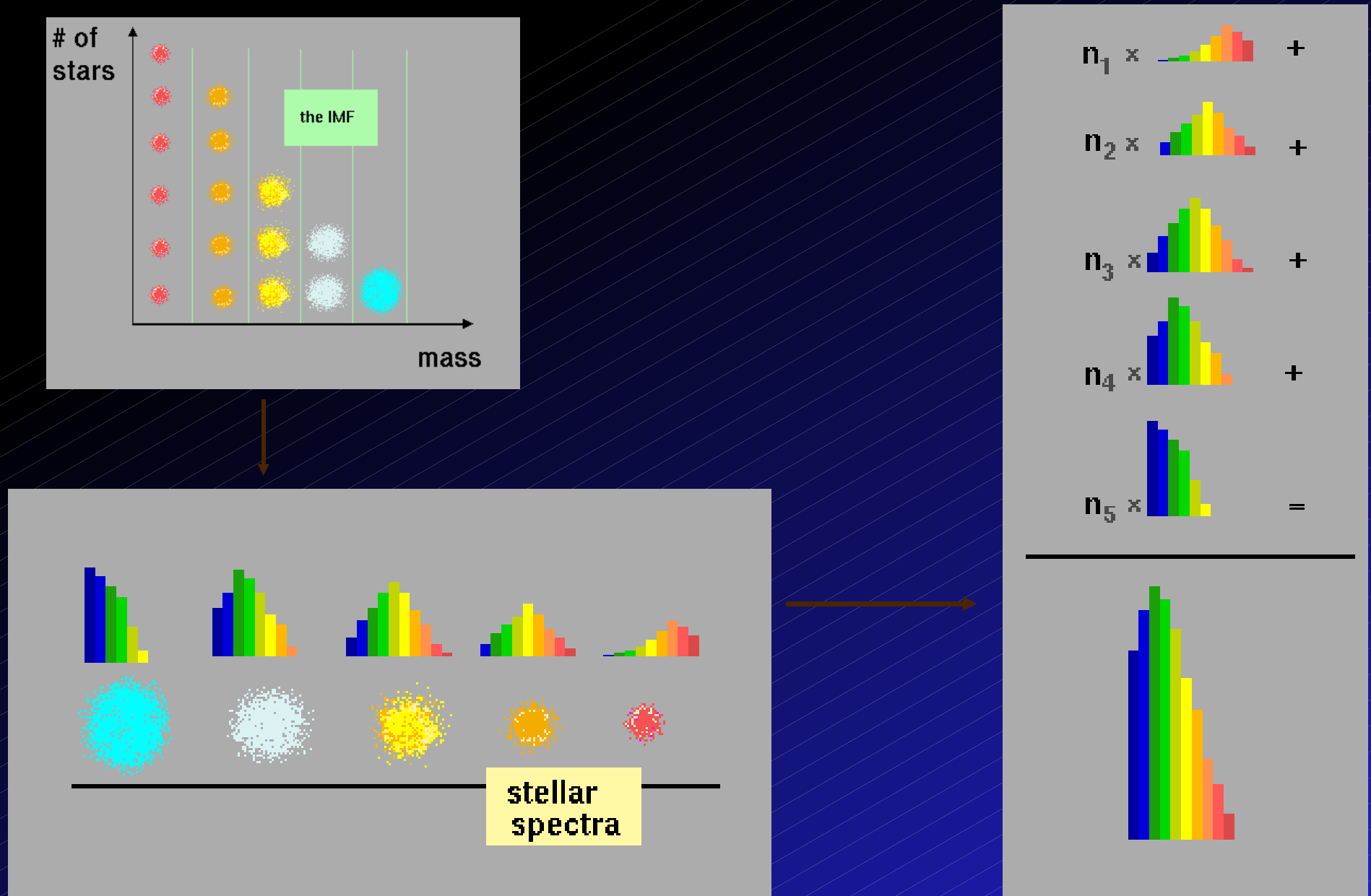


# N Body Simulations of Globular Cluster Evolution





# Stellar populations are modeled with synthesis models



# Using SimDB/SimDAP

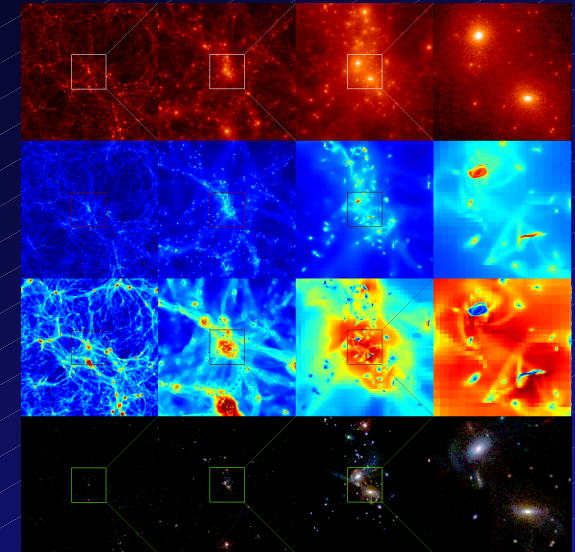
- Cosmological simulations
  - Prototypes for GalMER, Horizon
- PDR simulations
  - test implementation of Meudon PDR code
- Isochrones/evolutionary tracks
  - BaTSI
- Visualization tools
  - VisIVO

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

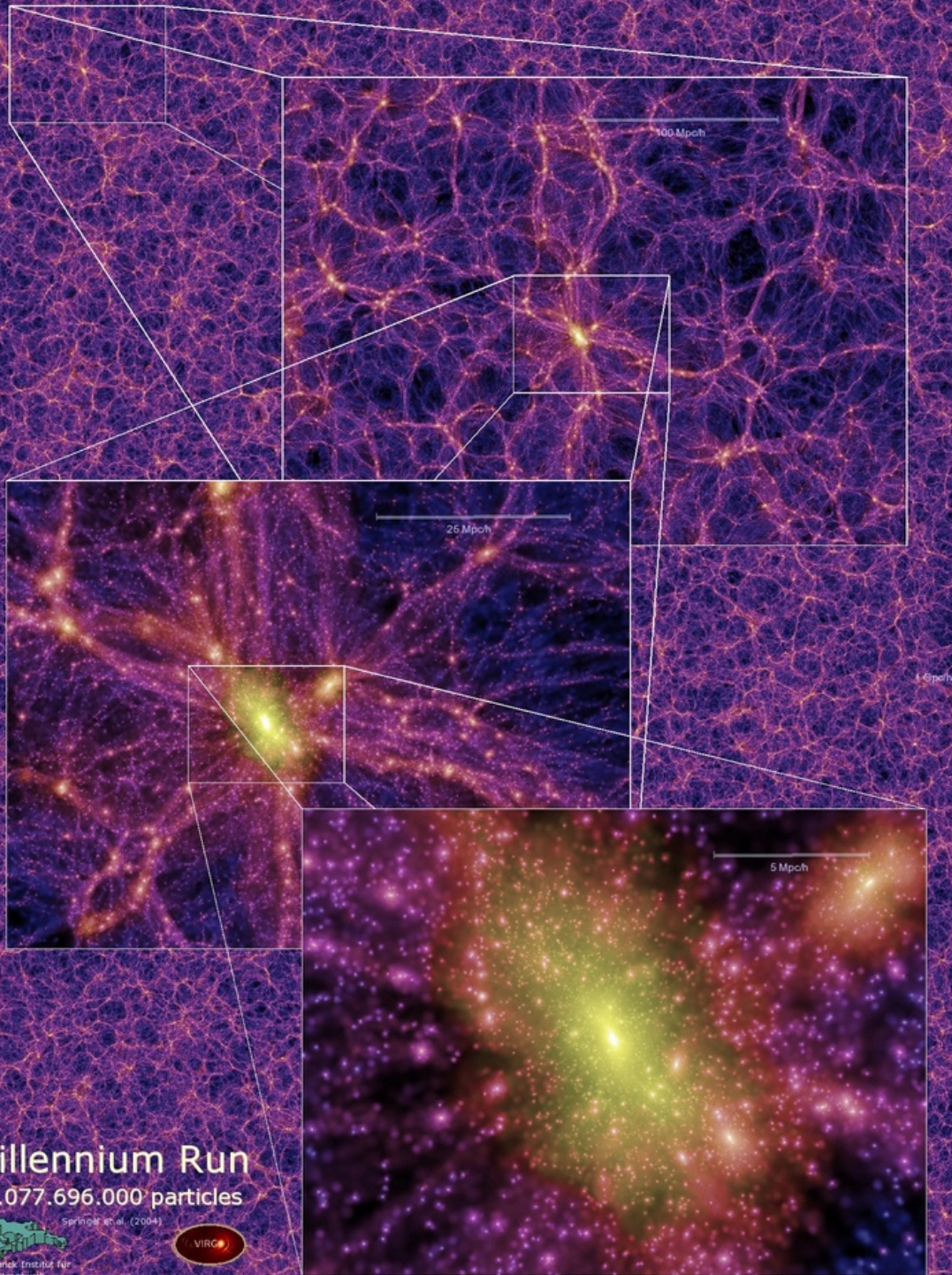
Cube 2 billion ly

One month MPSSC

25 TB

Evolution of 20 mil  
galaxies

Evolution merger tree



Millennium Run  
10.077.696.000 particles

Spring et al. (2004)



# Galaxy Merger Service - Client

**GalMer** **HORIZON PROJECT**

UFRMA Level 1 Observatory Service Center

DB Query | Query Results | Experiment | Snapshot | Description

Age: 0 Myr  
**PREVIEW**

phi: 68  
theta: 44  
Xcent: -60  
Ycent: 0  
Zoom: 2.1544  
Bright: 1189.2

Stars  
 Gas  
 D. M.

10 100

10 kpc

**TOOLS**

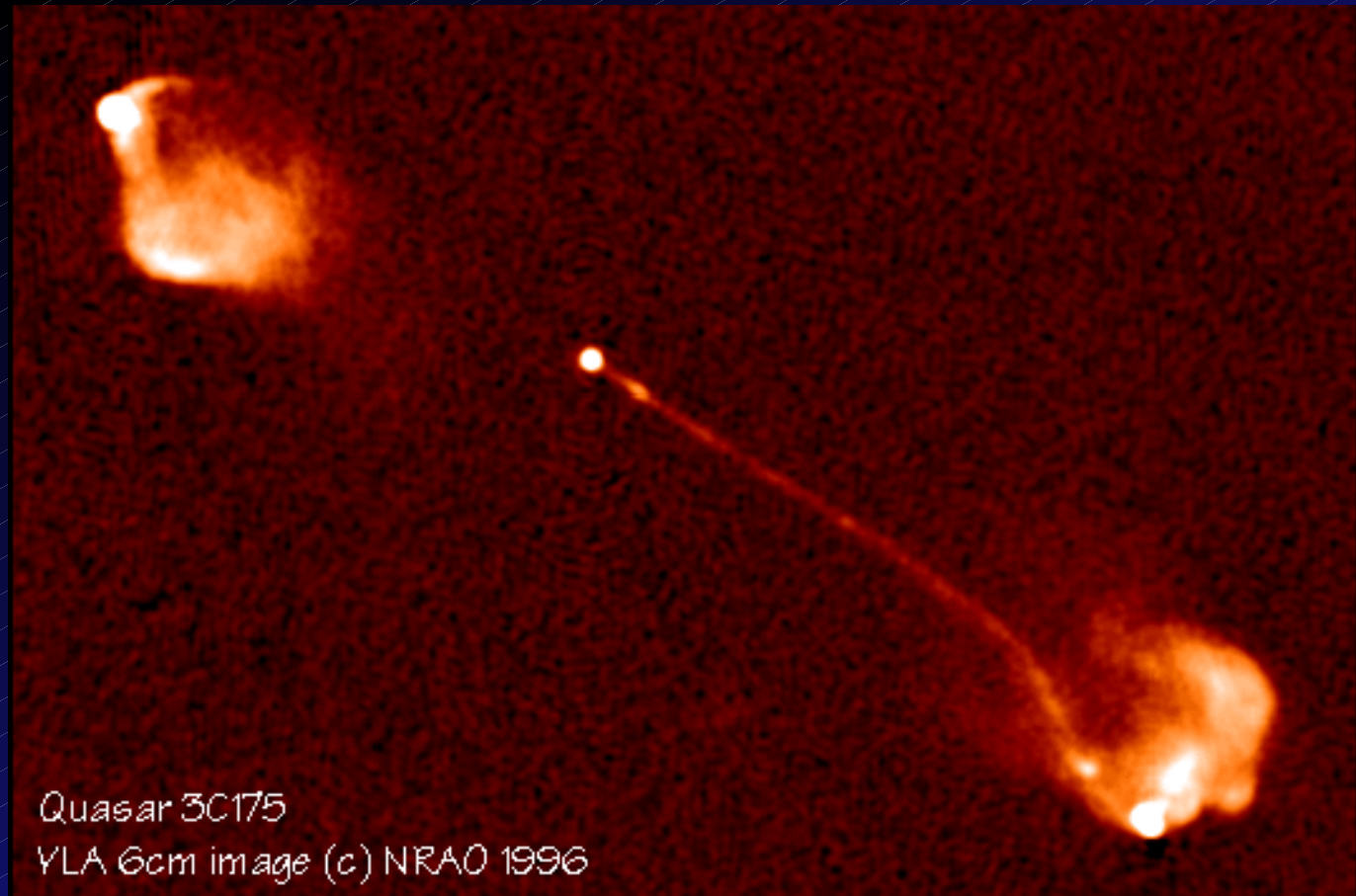
**FITS Maps**  
Total mass: [dropdown]  
Download  
In Place

**SPECTRUM**  
 Show region  
 Dust  
Download  
In YOSpec

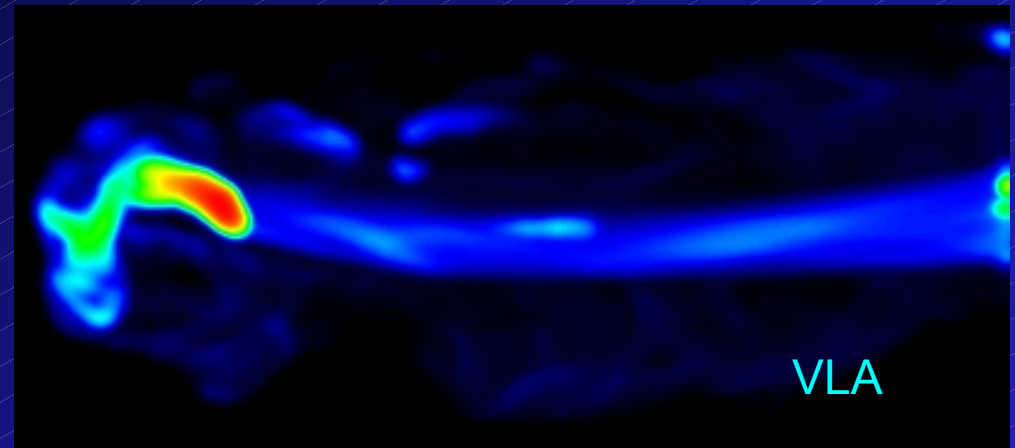
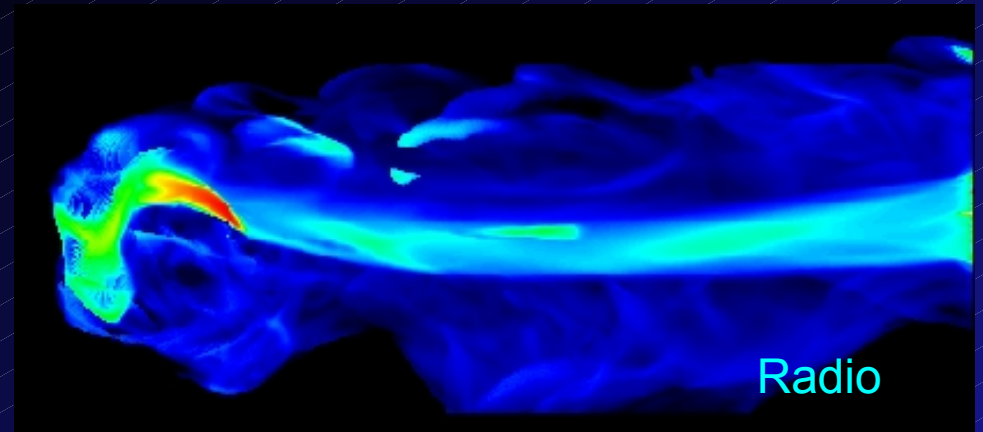
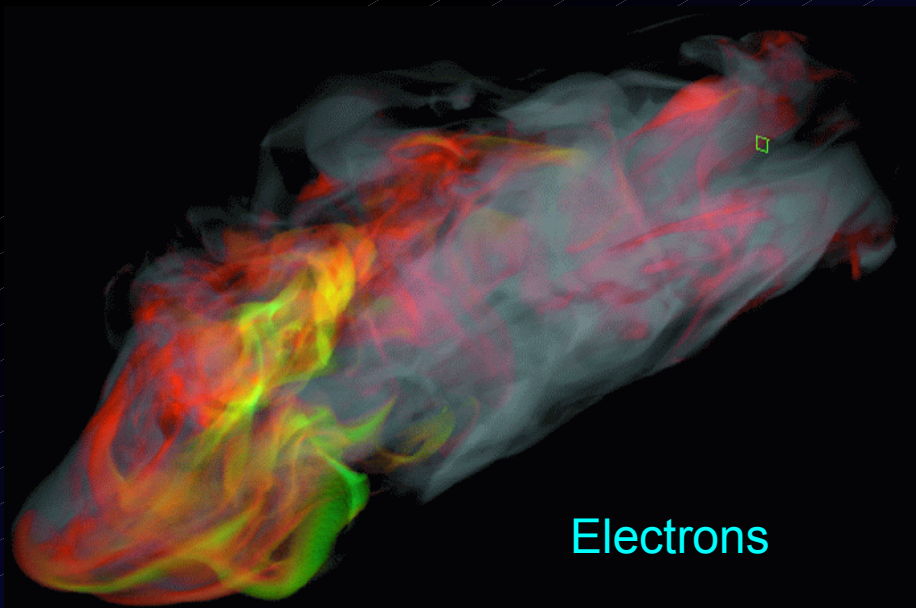


# Collimated Outflows from AGN

- 3C 175

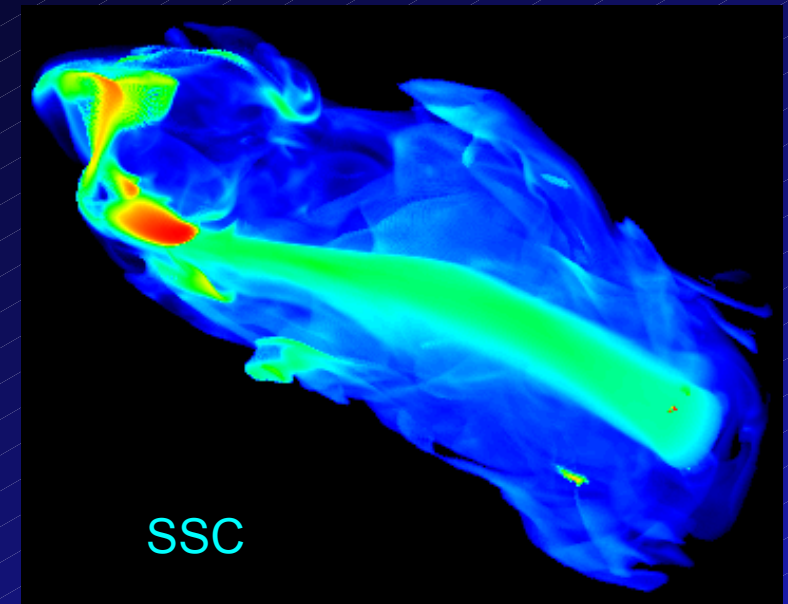
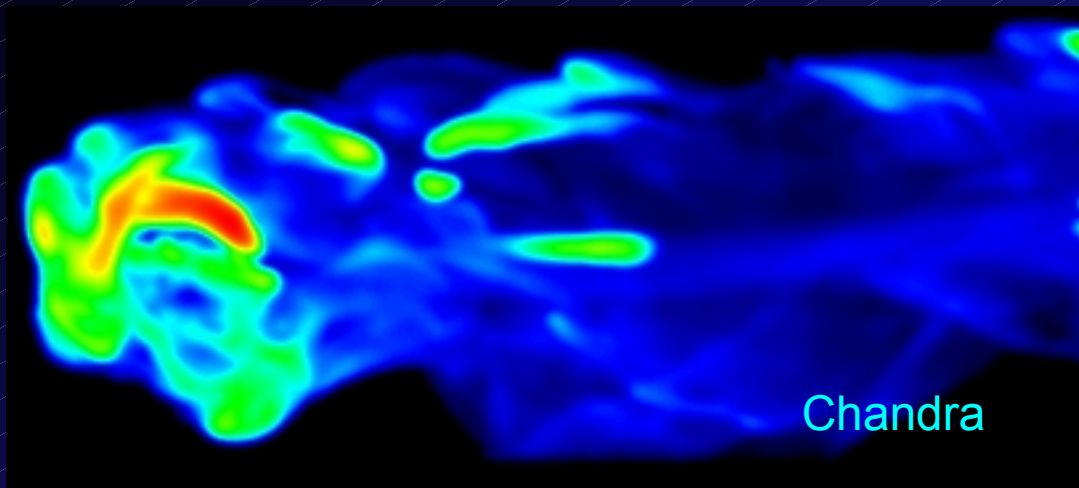
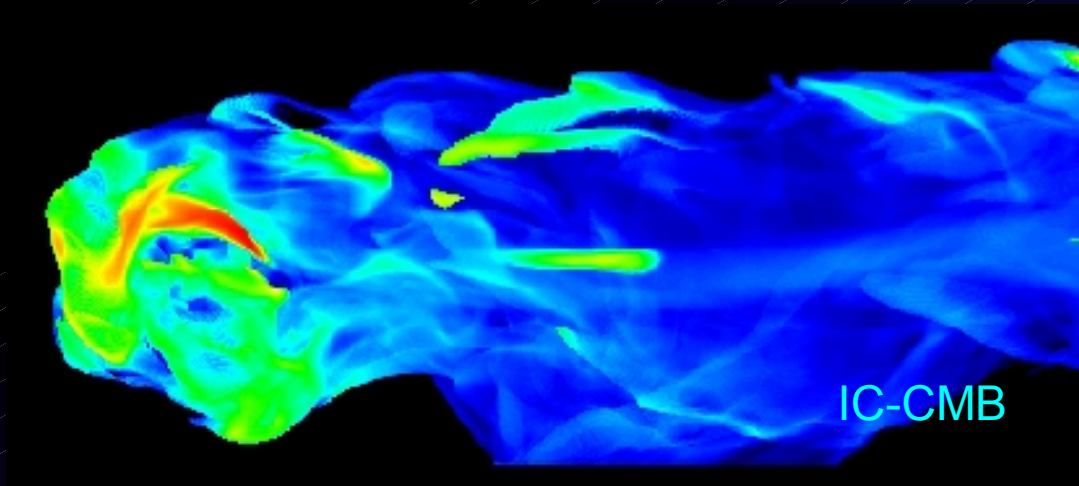


# MHD Simulations of Collimated Outflows from AGN – Virtual Telescope Observations



Compare with  
Radio  
Archives

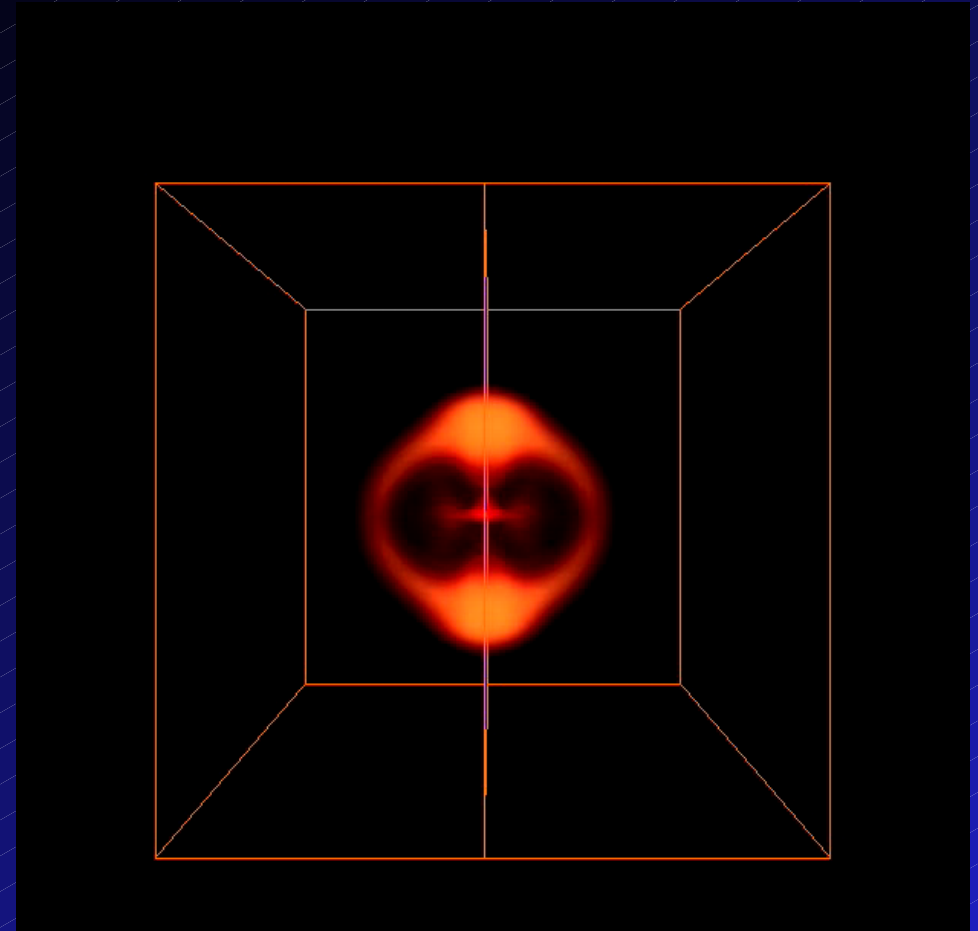
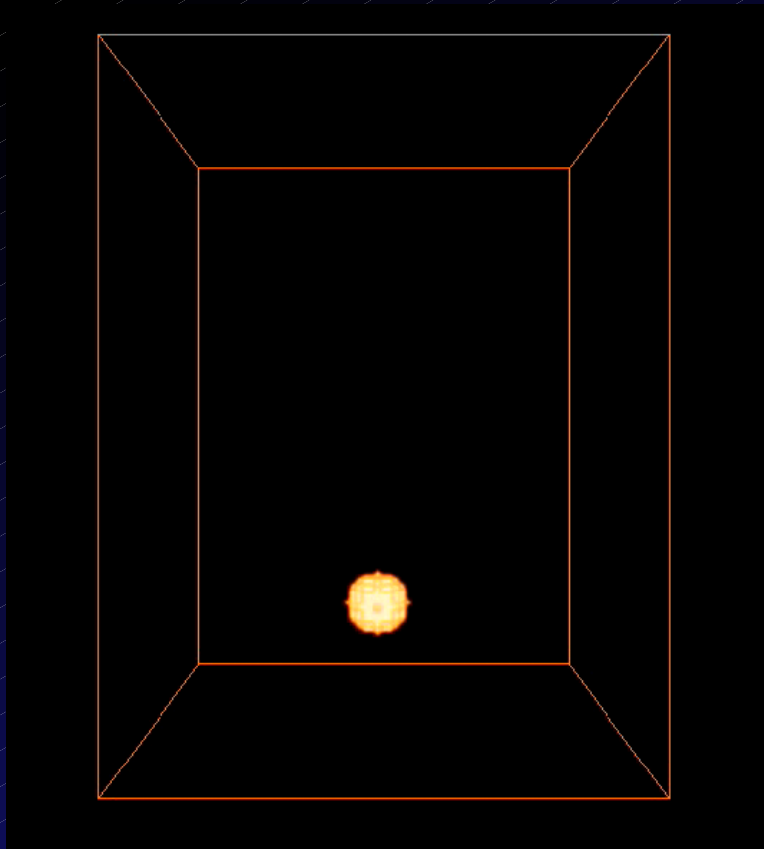
# MHD Simulations of Collimated Outflows from AGN – Virtual Telescope Observations



Compare with  
Chandra Archives

# Three Dimensional MHD Calculations

- $\beta = 3000$

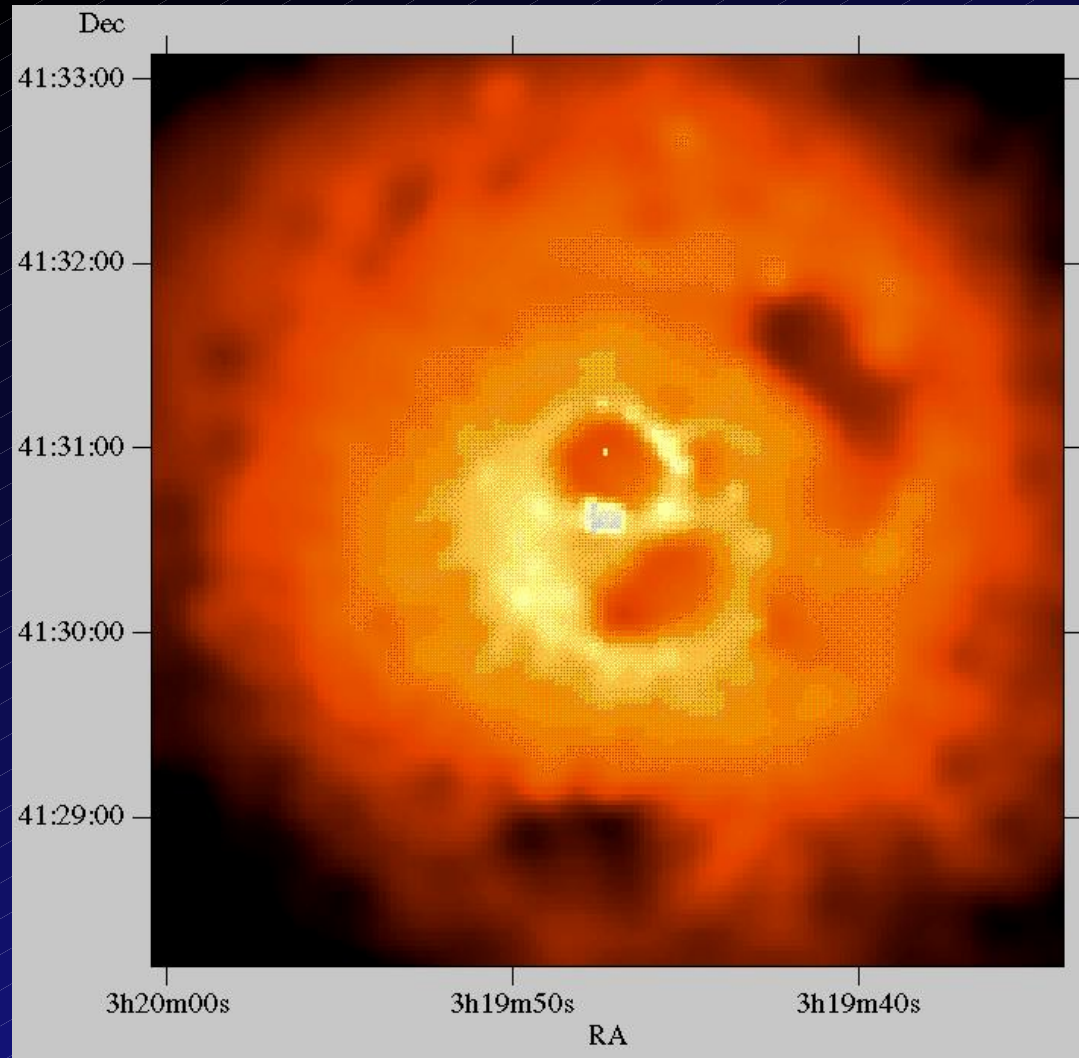




# Relic Radio Bubbles in Galaxy Clusters

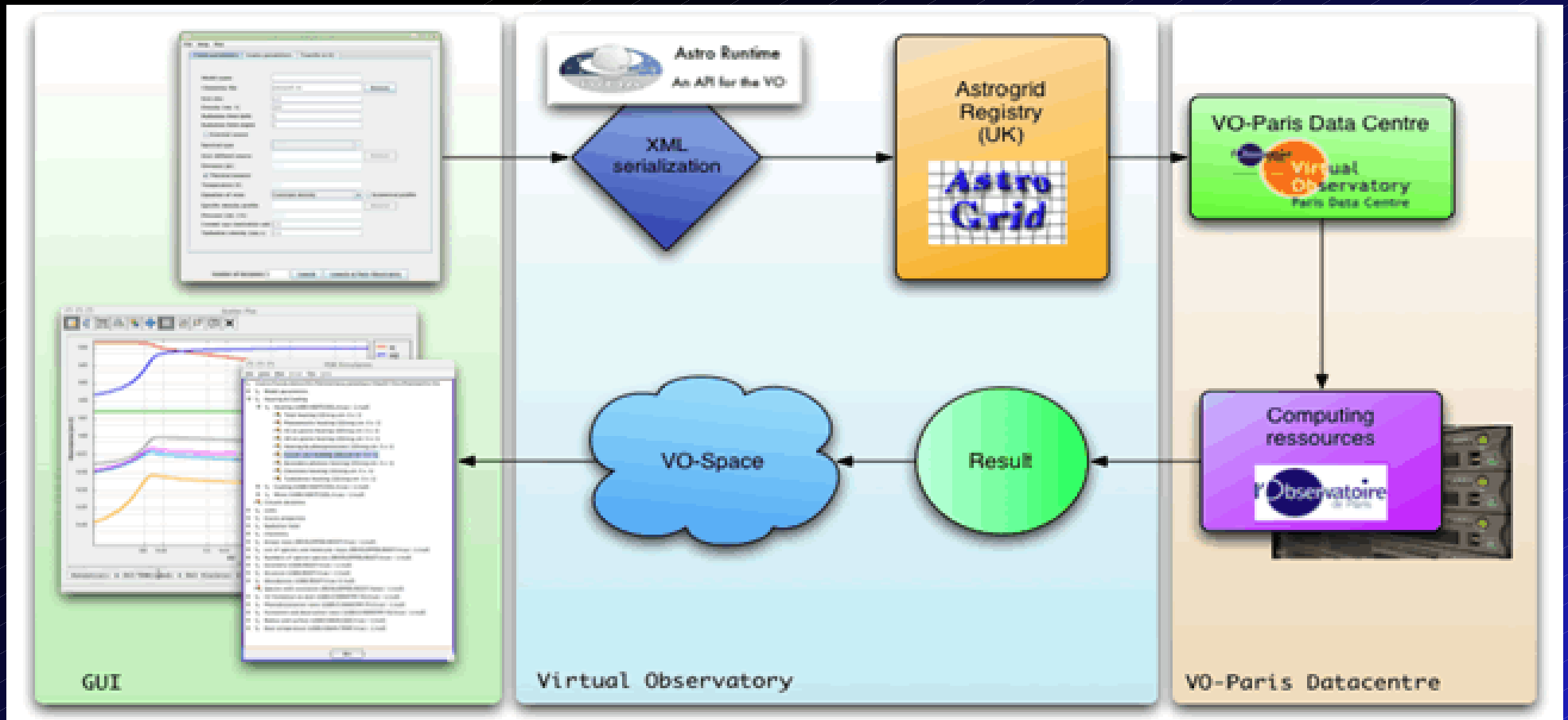
- N1275

Compare  
with  
Chandra  
Archives



Fabian et al. 2000

# PDR VO-infrasctructure



# PDR database and clients

## □ PDR Database

### Output Files

Code produces

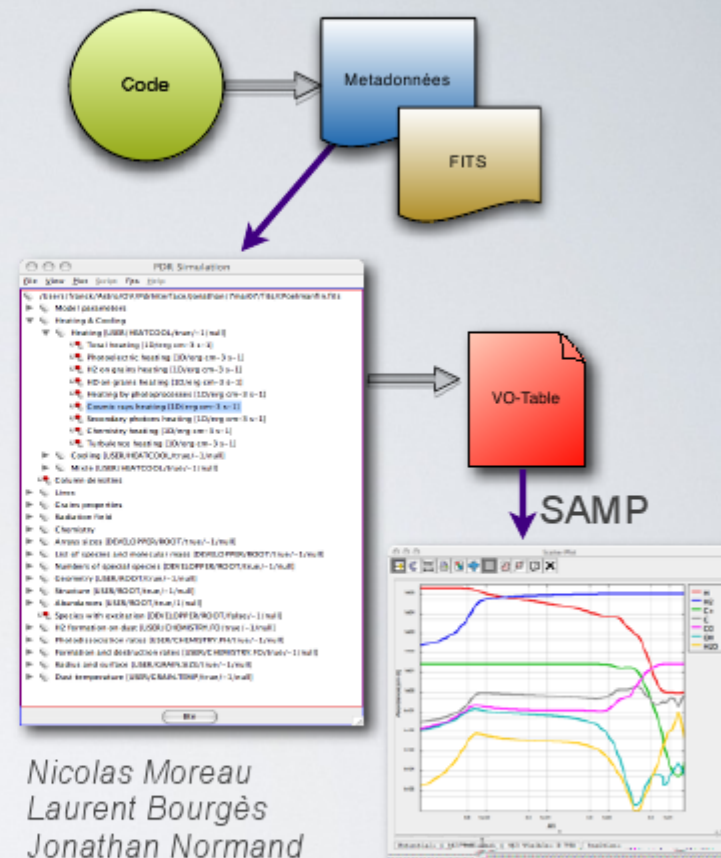
- raw data : FITS File
- XML / VO-TABLE : meta-data (name, description, units, UCD, ...)

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



Nicolas Moreau  
Laurent Bourgès  
Jonathan Normand

# PDR code via VODesktop

The screenshot shows the VO Explorer - PDR application interface. The main window displays a list of resources under the heading 'Contents of PDR - 3 resources'. The list is filtered by 'Content - Subject' (interstellar molecules), 'Coverage - Waveband' (infrared), and 'Resource Type' (CeaApplication). The selected resource is 'Meudon PDR code' with a status of 'Meudon PDR code VO-Paris' and a date of '2007-12-14'. The detailed view for this resource shows its short name, ID, type, and creation/updated dates. The description states that the Meudon PDR code is a tool to model the physics and chemistry of interstellar gas at stationary state. It also mentions that the resource describes a Remote Application (CEA) and provides a link for further information. The interface includes a sidebar with 'Resource Lists' (Examples, PDR, CEA, New Smartlist), 'Actions' (Execute Task), and 'About' (Further Info, Email Curator). The bottom of the window shows the 'Paris Datacentre' logo and the text 'Franck Le Petit LUTH - Paris Observatory'.

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

**Meudon PDR code**  
Short Name: Meudon PDR code ID: ivo:/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 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...](#)

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



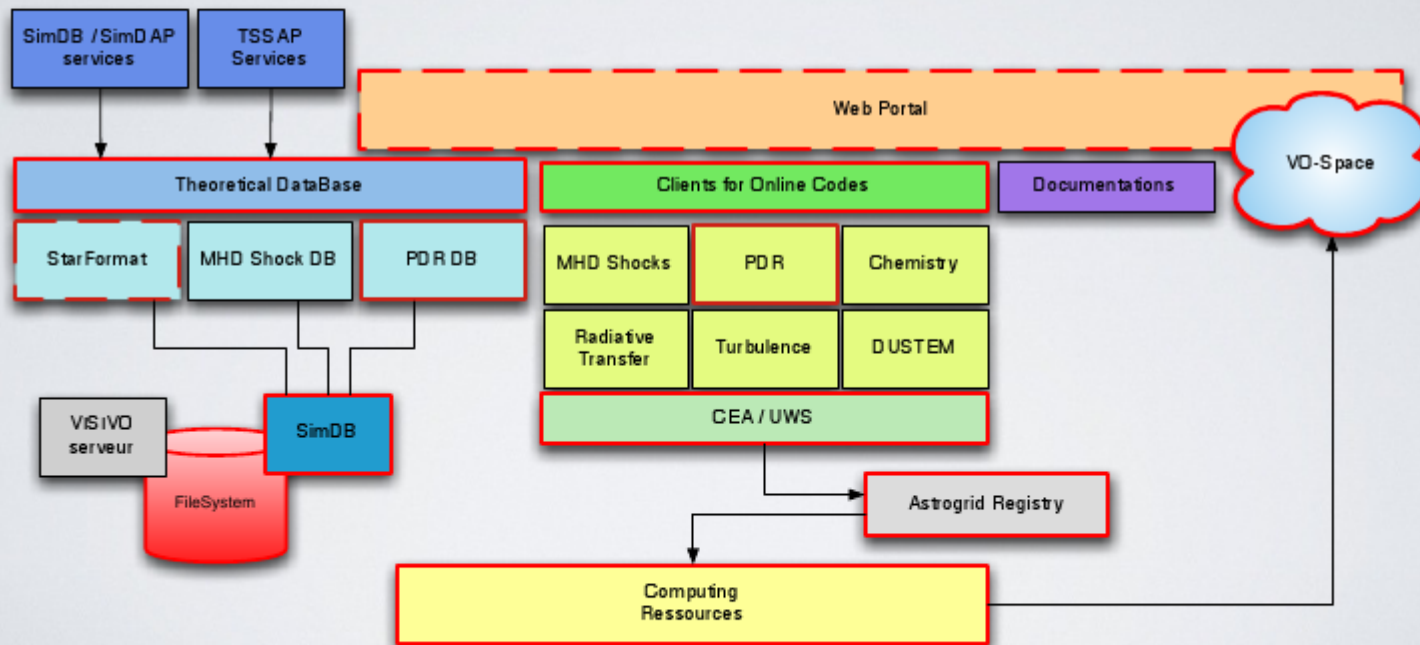
# ISM platform

## □ Interstellar Medium Platform

Bring together expertise in modeling / simulation of the ISM

Provide theoretical services about ISM

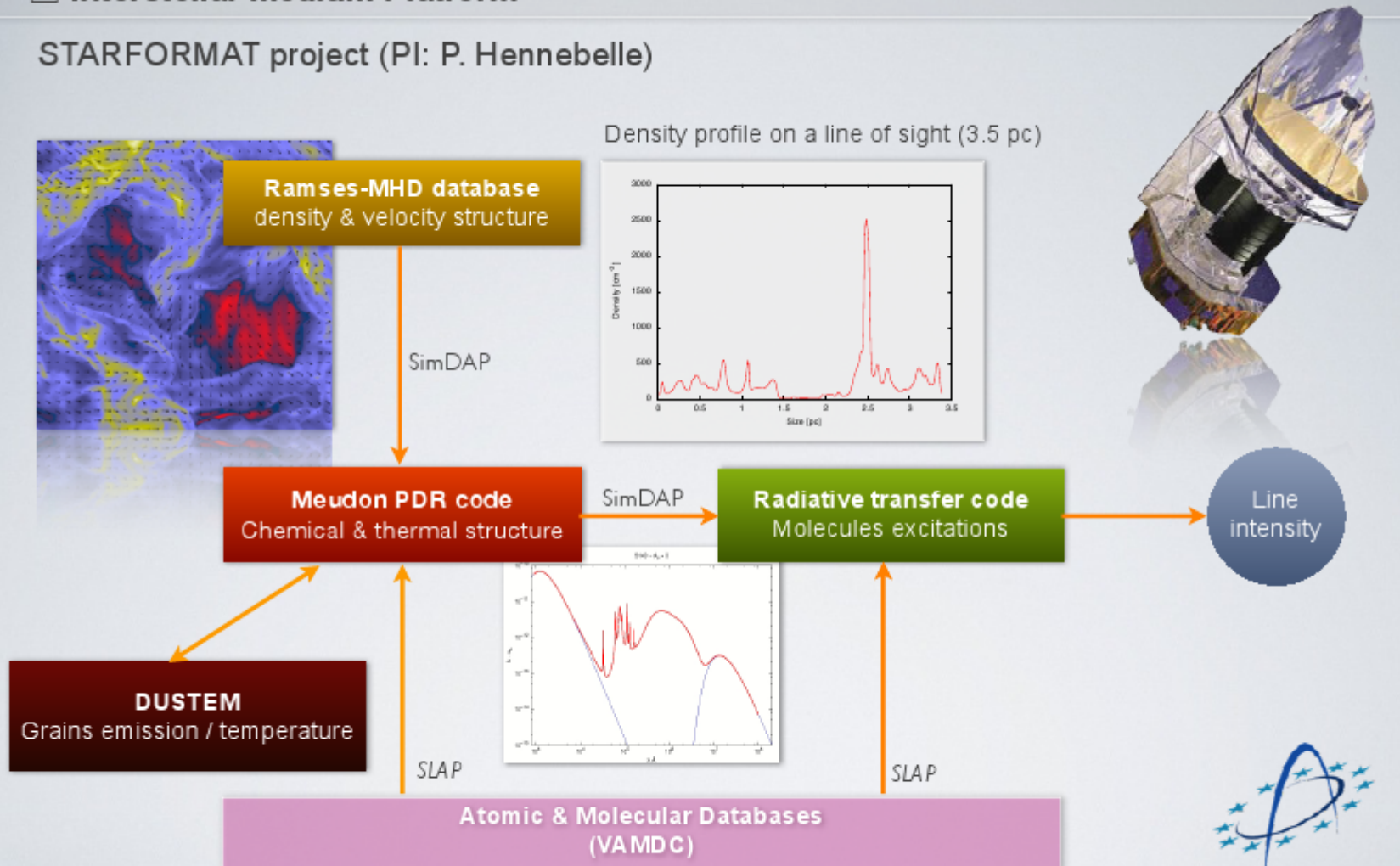
### Codes - Databases - Tools & services



# Complex join of TVO bricks

## □ Interstellar Medium Platform

STARFORMAT project (PI: P. Hennebelle)

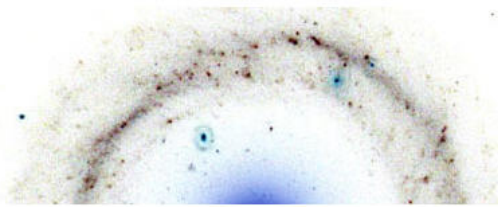




# Examples of VO Science

- 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** **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](#)

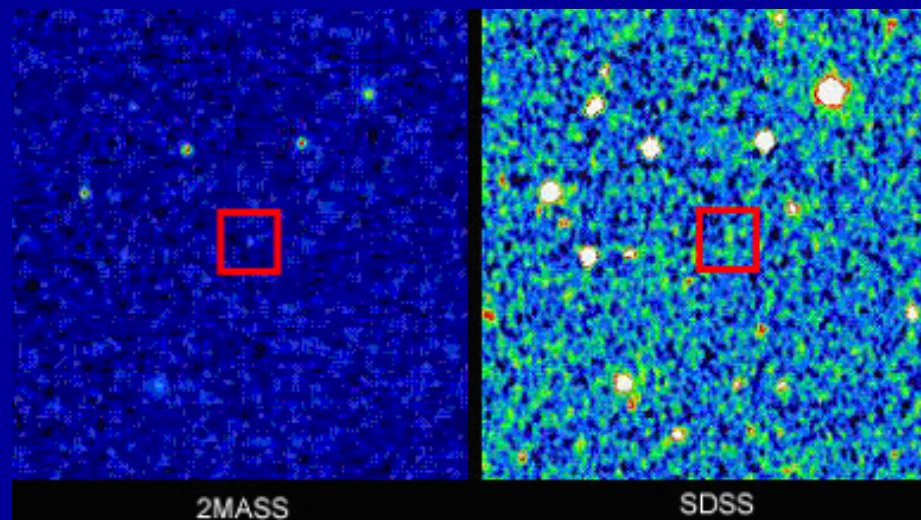
**COMMUNITY** **Data Resources**

- 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)

**PEOPLE** **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

[Contact Us](#)  
[Personnel](#)

- **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.*





## 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](#)
- [Spanish Virtual Observatory](#)
- [Italian Virtual Observatory](#)
- [Virtual Observatory India](#)

# CZVO

## 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)  
need normalization, rebinning , convolution  
(resolution) on server

Data mining – AstroNeural + Clustering

# Killer spectral applications for VO

- Use VO to find all stars with emission in given line ( $EW < 0$ ) – find the time when it was in em.
- Use VO to get 1000 spectra of the given object cut out regions around given lines, plot the lines, make a gray dynamic spectrum folded in time
- The same – search period, fold by period
- Get the unknown line ID of piece of spectra from SLAP overplotted over SSA data
- Create Light and RV curve for given period
- Fit the grid of models ( $T_{\text{eff}}$ ,  $\log g$ ) to the observed spectrum – for many stars

# VIRTUAL OBSERVATORY

