

Virtual Observatory

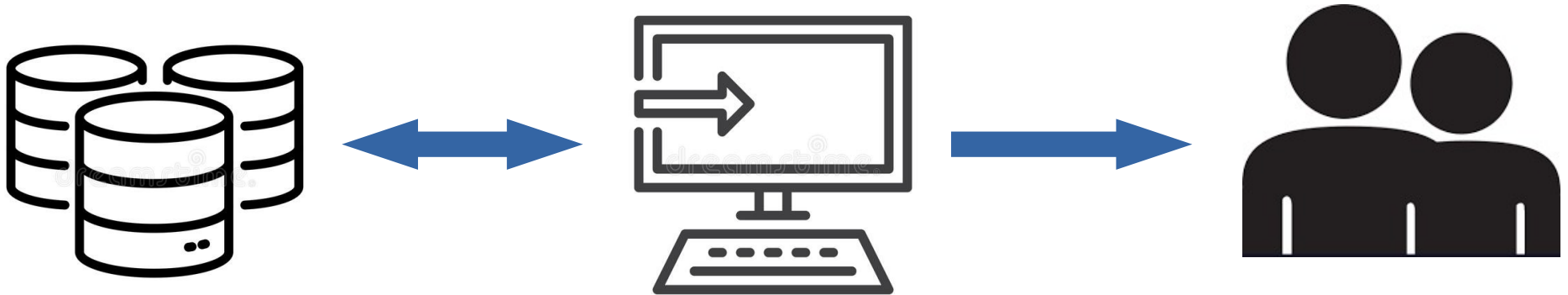
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*Faculty of Science, University of P.J. Šafárik in Košice
Institute of Physics*



What is Virtual Observatory?

connection of many different astronomical ***datasets*** and other resources and ***software tools*** that should work together and give us opportunity to analyze astronomical data



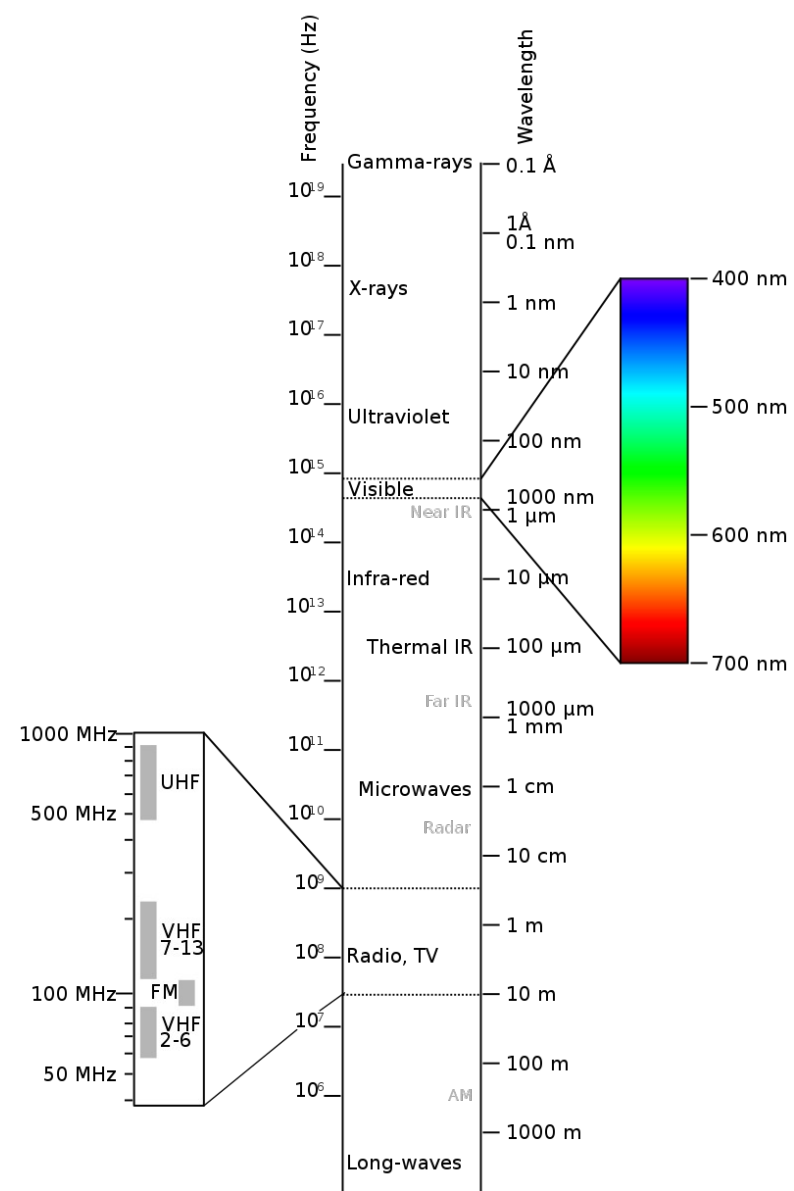
Why we need VO?

- There is a huge amount of data obtained by different instruments (ground base, space) practically in the whole spectral region
- The most of them are from surveys and big telescopes

Sky Survey Projects	Data Volume
DPOSS (The Palomar Digital Sky Survey)	3 TB
2MASS (The Two Micron All-Sky Survey)	10 TB
GBT (Green Bank Telescope)	20 PB
GALEX (The Galaxy Evolution Explorer)	30 TB
SDSS (The Sloan Digital Sky Survey)	40 TB
SkyMapper Southern Sky Survey	500 TB
PanSTARRS (The Panoramic Survey Telescope and Rapid Response System)	~ 40 PB expected
LSST (The Large Synoptic Survey Telescope)	~ 200 PB expected
SKA (The Square Kilometer Array)	~ 4.6 EB expected

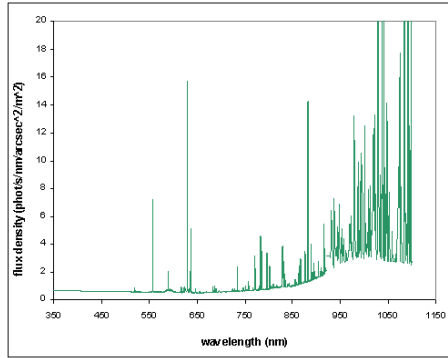
Zhang, Y and Zhao, Y 2015 Astronomy in the Big Data Era.
Data Science Journal, 14: 11, pp. 1–9,

- Data are obtained in almost all passbands, from long radio wavelengths to high-energetic gamma radiation
- Moreover we have particle radiation



We have different types of data

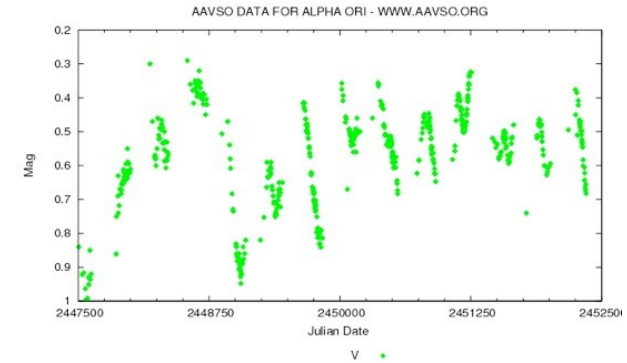
Spectra



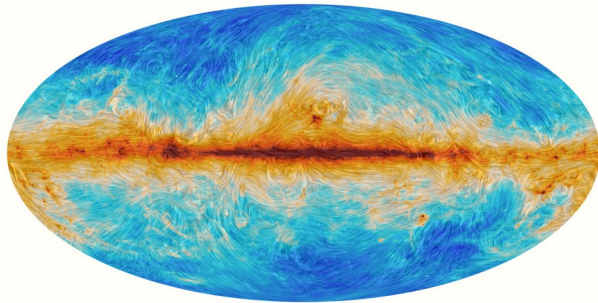
Images



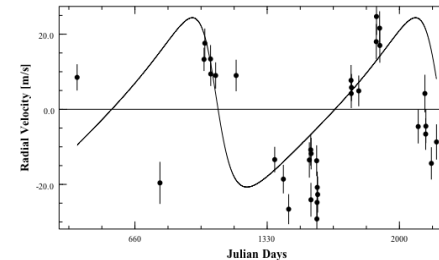
Light-curves



Polarisation maps



Radial velocities



- We have data in many different **catalogs** (HIP, GSC, SAO, USNO-B1.0, SDSS, GAIA) – problems with cross-identification
- Data are in different formats
 - most of them are in standard **FITS**, but it is quite flexible standard...
 - csv, txt, xls...
 - multi-dimensional data – data cubes

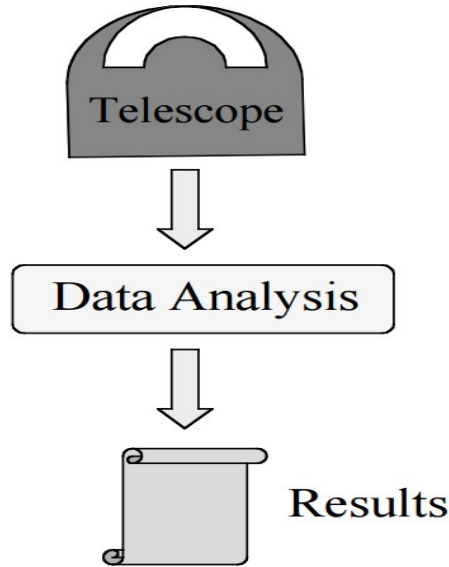
- There are **huge amount of objects** in the universe: stars, galaxies, exoplanets, nebulae, clusters, quasars, radio sources,
- **The biggest problem** – data from different instruments and telescopes have different quality and formats

Why we need VO?

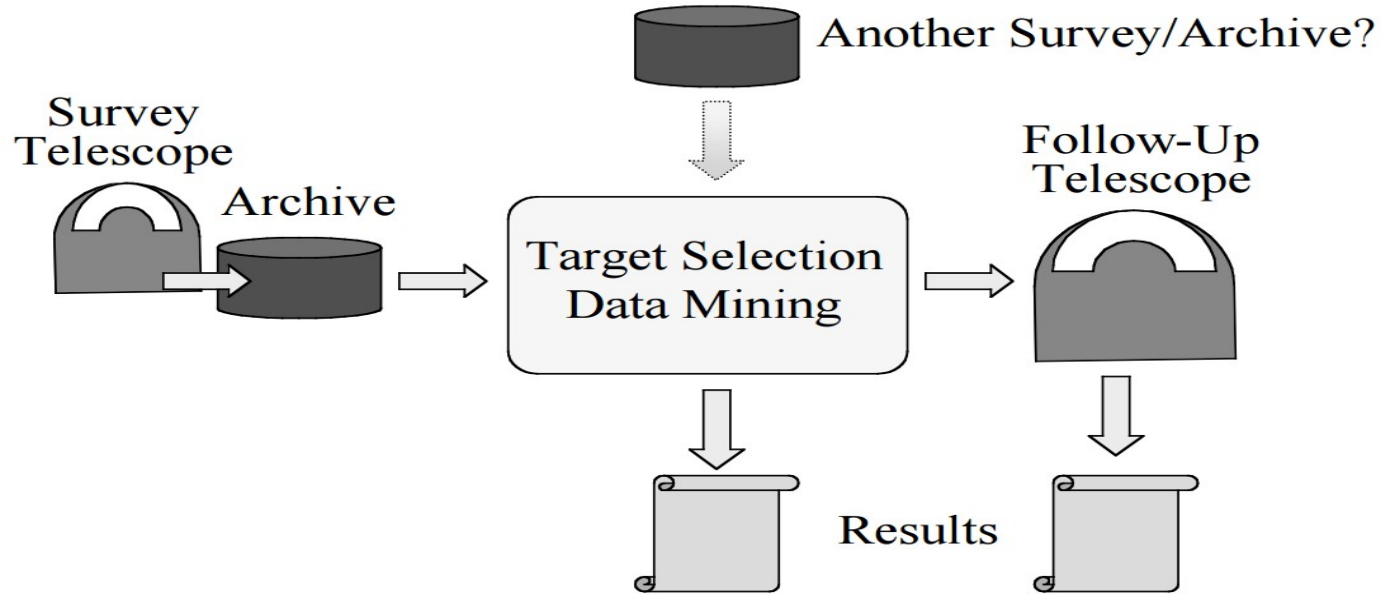
- platform for an analysis and interpretation of multi-source astronomical data in the whole spectral region with different techniques
- **Store and preserve** data
- **Develop software** for a data visualization, big data analysis, data-mining, statistics...

VO change our attitude to data gathering and analysis

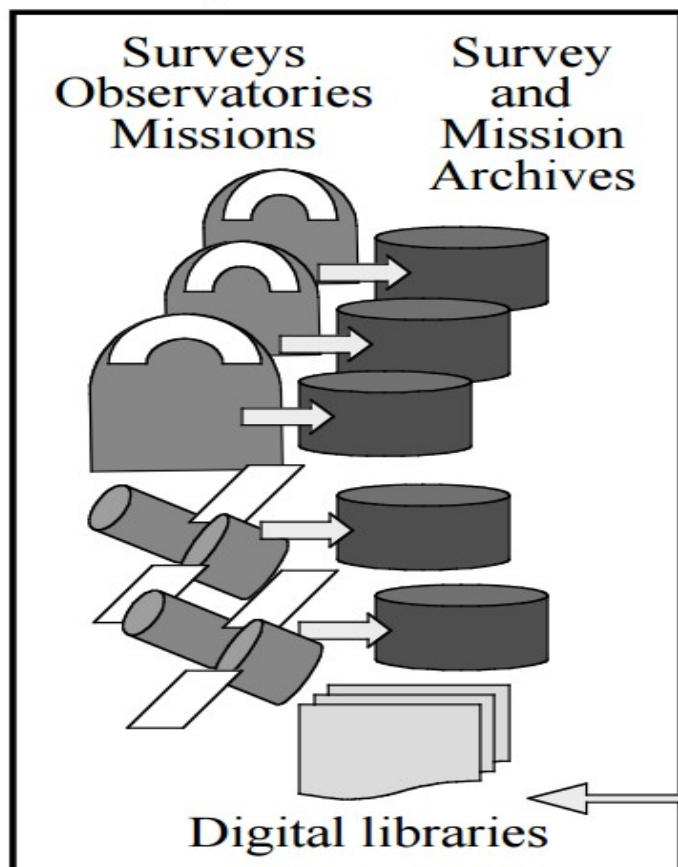
TRADITIONAL:



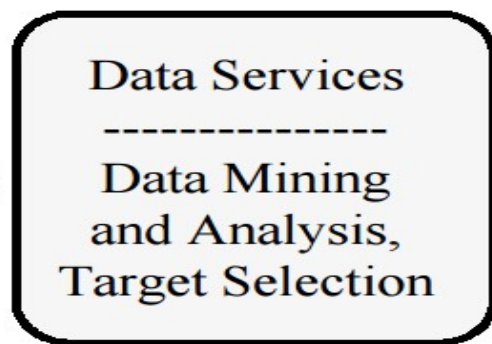
SURVEY-BASED:



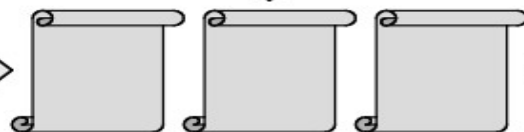
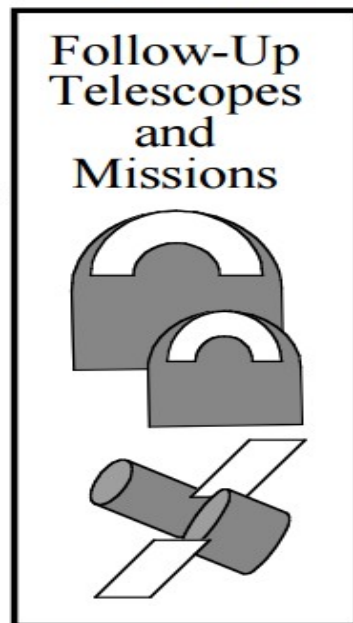
Primary Data Providers



VO



Secondary
Data
Providers

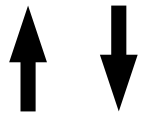
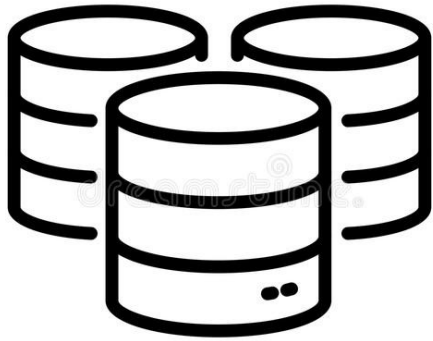


VO as an integral part
of the whole system ...

What we can expect from VO?

- Systematic research of the universe
- Discoveries of rare and/or unknown objects and phenomena
- Time changes of the objects
- High-precise cosmology, stellar astronomy, Galaxy structure
- Multivariate correlations in data

How it works?



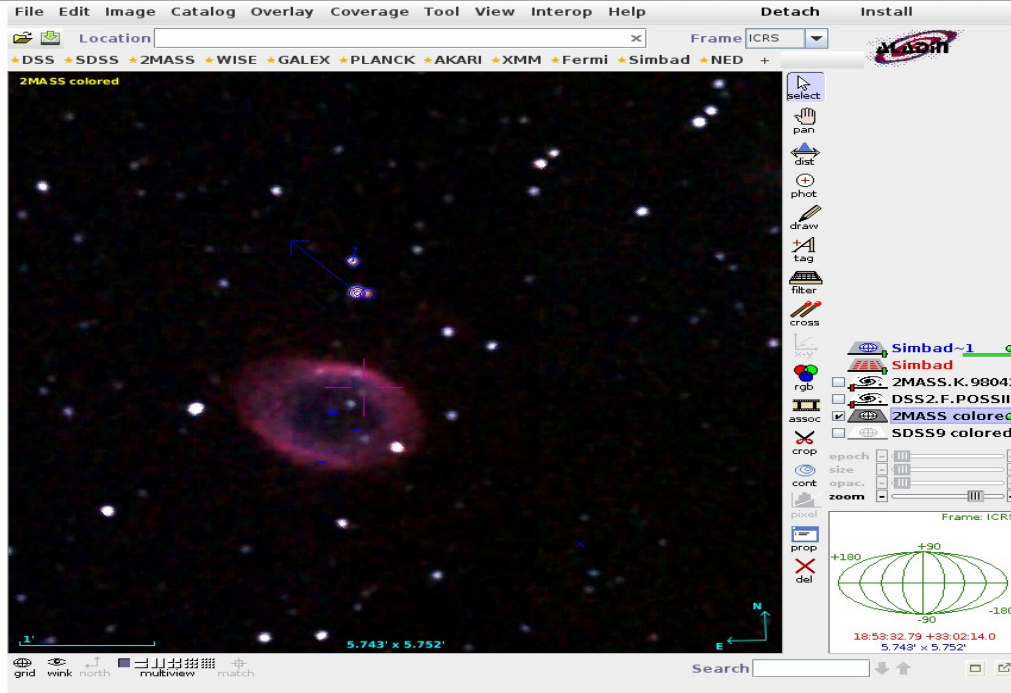
Data are stored in an arbitrary format on servers or in data centers at observatories, universities, (MySQL, PostgreSQL, Oracle...)

User send request by some software or web

Data from server are sent back to user in standardized format defined by data protocol (xml file)

Some software for VO

Aladin sky atlas



CDS X-Match Service

[X-match](#) [Tables management](#) [Documentation](#)

Choose tables to cross-match

2MASS X Tycho-2

[VizieR](#) [SIMBAD](#) [My store](#) [VizieR](#) [SIMBAD](#) [My store](#)

2MASS All-Sky Catalog of Point Sources (Cut1: 2003) 470,992,970 rows

The Tycho-2 Catalogue (Hogt 2000) 2,539,913 rows

Show options

Begin the X-Match

Visualize and manage your cross-match jobs

List of X-match jobs					
Table 1	Table 2	Options	Begin	Status	Actions
No job in list					

For the selected job(s): [Delete](#)

X-Match

SIMBAD Astronomical Database

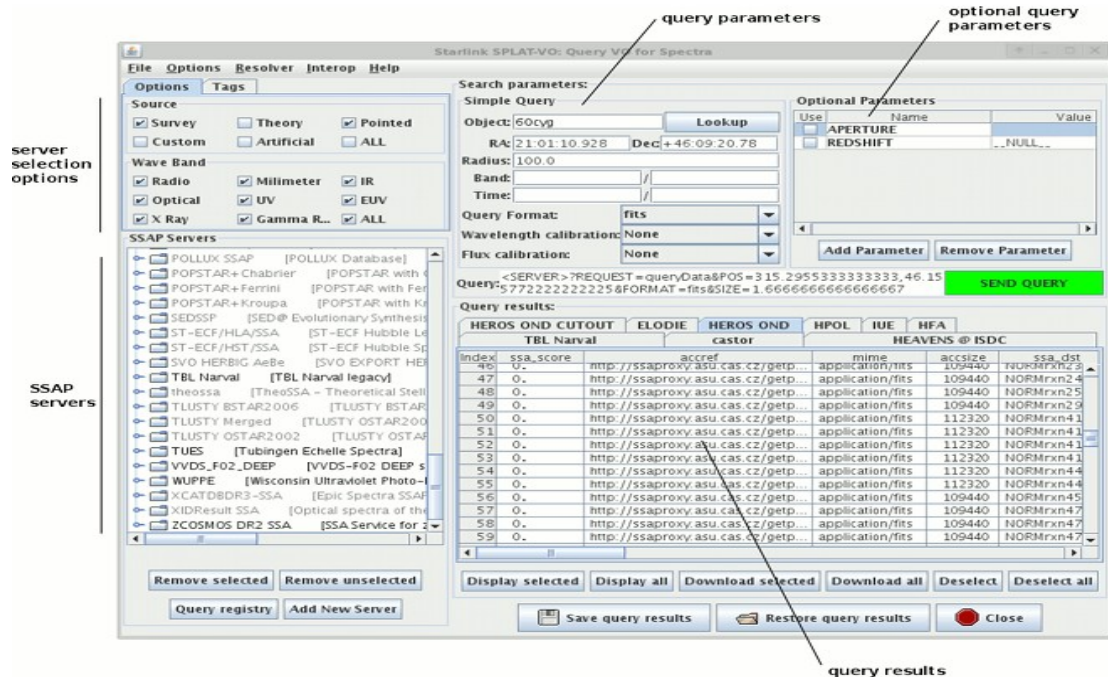
<i>Queries</i>
basic search
by identifier
by coordinates
by criteria
reference query
scripts
TAP queries
options
Display all user annotations

<i>Documentation</i>
User's guide
Query by urls
Nomenclature Dictionary
Object types
List of journals
Measurement description
Spectral type coding
User annotations documentation

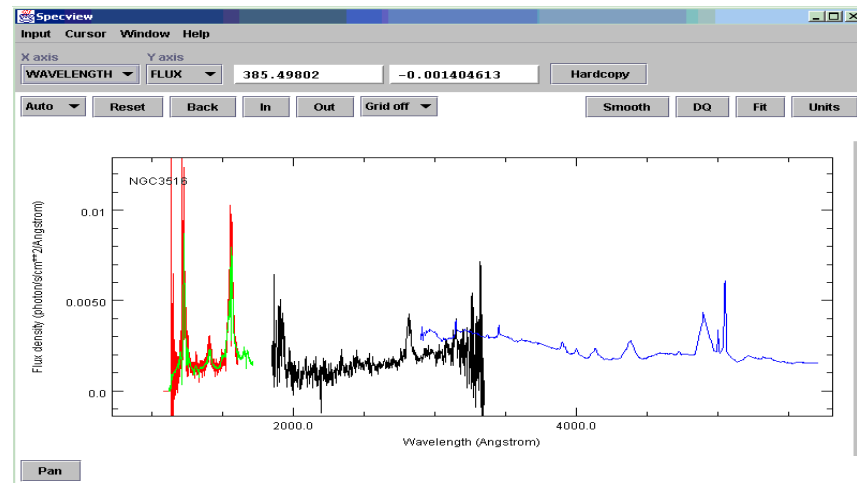
<i>Information</i>
Presentation
Acknowledgment
Release:
SIMBAD4 1.225 - Feb-2015

<i>Content</i>
The SIMBAD astronomical database provides basic data, cross-identifications, bibliography and measurements for astronomical objects outside the solar system.
SIMBAD can be queried by object name, coordinates and various criteria. Lists of objects and scripts can be submitted.
Links to some other on-line services are also provided.

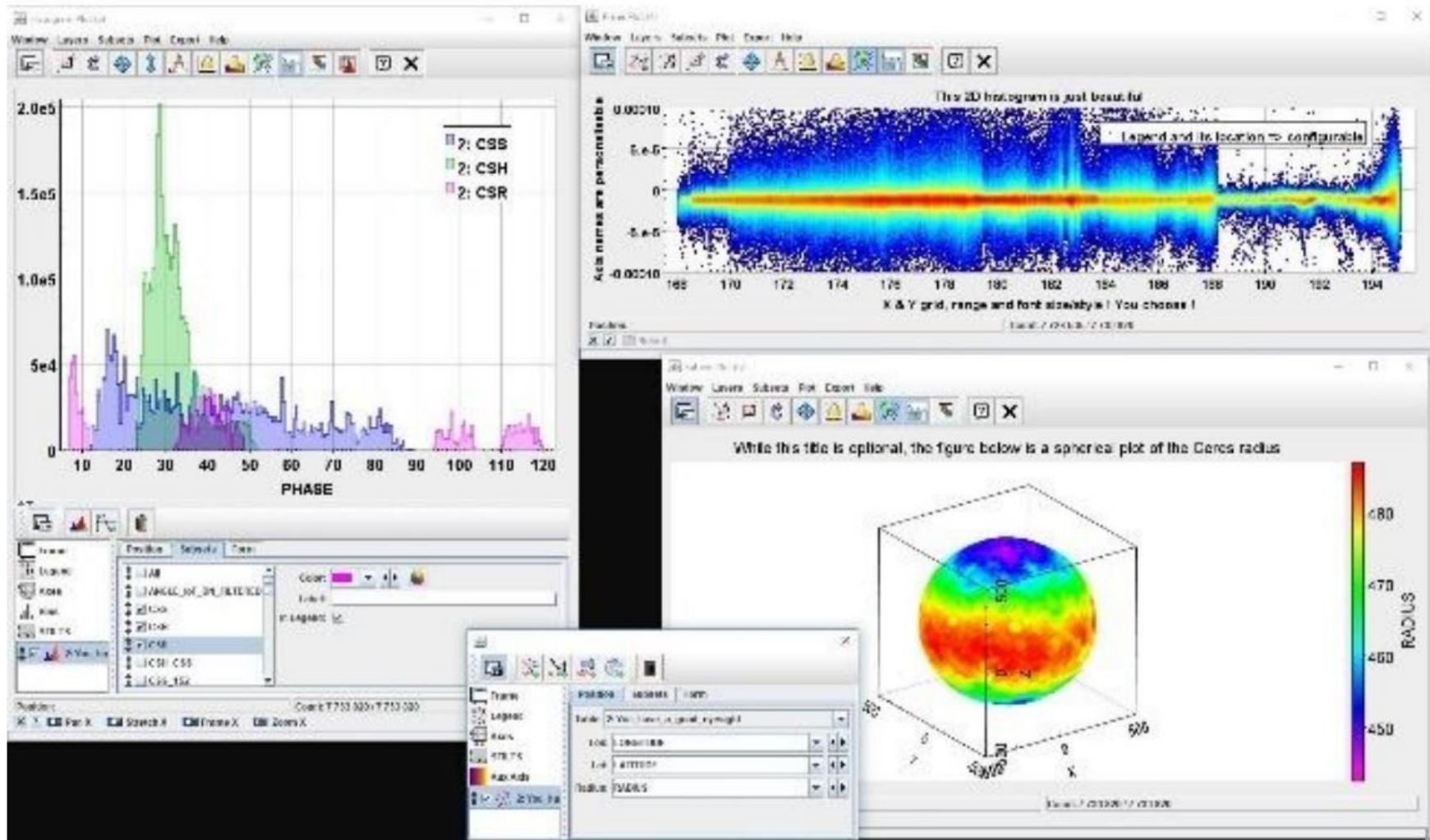
<i>Statistics</i>
Simbad contains on 2015.03.24
7,639,318 objects
21,722,406 identifiers
301,218 bibliographic references
11,115,225 citations of objects in papers



SplatVO



SpecView



TopCat

Some problems

- The most of data in VO are from large telescopes surveys and satellites
- Almost all data are images, spectra and catalog entries (positions, brightness)
- Software for data analysis is either too simple (only display data) or very complicated to use (too many unnecessary functions, user total unfriendly)

- **Small and universities** observatories (with telescopes up to 1m) and also many **amateur** astronomers have **unique data**, which cannot be obtained by large telescopes (long time series, rare events observations...)
- Data are not publicly available and there is **very high risk** of their **lost**.

- Although there is many surveys focused to time series photometry, mainly due to exoplanet search (ASAS, APASS, Catalina, NGTS, SuperWASP, Kepler, TESS,...) there is **no VO standard for time series photometry data**
- Data from each survey have their own access protocol, problems with object identifications, no standardization

SKVO

Slovak Virtual Observatory

- Platform for small telescopes (amateur, universities, ...) to contribute to whole astronomical community by VO
- The first goal was to archive and open to world photometric data from our instruments – *in slow progress*

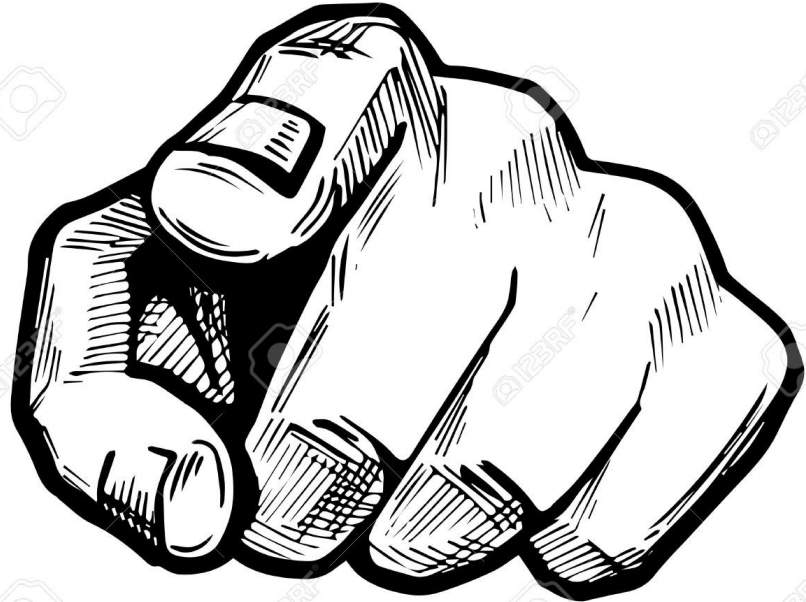
SKVO

- Next goals
 - improve transfer protocol (modification of Simple Spectral Access SSA) for photometry
 - improve web of SKVO
(`skvo.science.upjs.sk`)
 - extend for spectroscopy and images

SKVO

- Next goals
 - open for other institutions and amateurs (after successful testing)
 - develop web-based application for an analysis of photometry
 - try to enforce transfer protocol as a standard in IVOA (together with for other...)

I WANT YOU



as a volunteer on this project